



## Table of radionuclides (Vol. 3 - A = 3 to 244)

Marie-Martine Bé, Vanessa Chisté, Christophe Dulieu, Edgardo Browne, Coral Baglin, Valery Chechev, Nikolay Kuzmenko, Richard L Helmer, Filip Kondev, T. Desmond Macmahon

### ► To cite this version:

Marie-Martine Bé, Vanessa Chisté, Christophe Dulieu, Edgardo Browne, Coral Baglin, et al.. Table of radionuclides (Vol. 3 - A = 3 to 244). Bureau International des Poids et Mesures. , 3, 2006, 92-822-2218-7. cea-02476243

HAL Id: cea-02476243

<https://cea.hal.science/cea-02476243>

Submitted on 12 Feb 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Table of Radionuclides (Vol. 3 – A = 3 to 244)

M.-M. Bé, V. Chisté, C. Dulieu  
E. Browne, C. Baglin  
V. Chechev, N. Kuzmenco  
R. Helmer  
F. Kondev  
D. MacMahon  
K.B. Lee



2006

BUREAU INTERNATIONAL DES POIDS ET MESURES

Pavillon de Breteuil, F-92310 SÈVRES

Édité par le BIPM,  
Pavillon de Breteuil  
F-92312 Sèvres Cedex  
France

Imprimé par Reproduction Service

ISBN 92-822-2204-7 (set)  
ISBN 92-822-2218-7 (Vol. 3)

# Preface

This monograph is one of several published in a series by the Bureau International des Poids et Mesures (BIPM) on behalf of the *Comité Consultatif des Rayonnements Ionisants* (CCRI), previously known as the *Comité Consultatif pour les Etalons de Mesure des Rayonnements Ionisants* (CCEMRI). The aim of this series of publications is to review topics that are of importance for the measurement of ionizing radiation and especially of radioactivity, in particular those techniques normally used by participants in international comparisons. It is hoped that these publications will prove to be useful reference volumes both for those who are already engaged in this field and for those who are approaching such measurements for the first time.

The purpose of this monograph, number 5 in the series, is to present the recommended values of nuclear and decay data for a wide range of radionuclides. Activity measurements for more than forty of these radionuclides have already been the subject of comparisons under the auspices of Section II of the CCRI. The material for this monograph is now covered in three volumes. The first two volumes contain the primary recommended data relating to half-lives, decay modes, x-rays, gamma-rays, electron emissions; alpha- and beta-particle transitions and emissions, and their uncertainties for a set of sixty-eight radionuclides, Volume 1 for those radionuclides with mass number up to and including 150 and Volume 2 for those radionuclides with mass number over 150. Volume 3 contains the equivalent data for twenty-six additional radionuclides as listed and re-evaluation for  $^{125}\text{Sb}$  and  $^{153}\text{Sm}$ . The data have been collated and evaluated by an international working group (Decay Data Evaluation Project) led by the LNE-LNHB. The evaluators have agreed on the methodologies to be used and the CD-ROM included with this monograph contains the evaluators' comments for each radionuclide in addition to the data tables included in the monograph.

The work involved in evaluating nuclear data is on-going and the recommended values are updated on the LNHB website at [http://www.nucleide.org/DDEP\\_WG/DDEPdata.htm](http://www.nucleide.org/DDEP_WG/DDEPdata.htm). The publication of further volumes of Monographie 5 is envisaged as and when necessary to add new radionuclide data or re-evaluations in a more permanent format that can be referenced easily.

Although other data sets may still be used when evaluating radionuclide activity, use of this common, recommended data set should help to reduce the uncertainties in activity evaluations and lead to more coherent results for comparisons.

G. Moscati  
President of the CCRI

A.J. Wallard  
Director of the BIPM



## Monographie BIPM-5 – Table of Radionuclides, Volume 3

Marie-Martine BÉ, Vanessa CHISTÉ, Christophe DULIEU, Laboratoire National Henri Becquerel (LNHB), France ;

Edgardo BROWNE, Coral BAGLIN, Lawrence Berkeley National Laboratory (LBNL), USA ;

Valery CHECHEV, Nikolay KUZMENKO, Khlopin Radium Institute (KRI), Russia ;

Richard HELMER, Idaho National Engineering and Environmental Laboratory (INEEL), USA ;

Filip KONDEV, Argonne National Laboratory (ANL), USA ;

T. Desmond MACMAHON, National Physical Laboratory (NPL), U.K. ;

Kyung Beom LEE, Korea Research Institute of Standards and Science (KRISS), South Korea

## “TABLE DE RADIONUCLÉIDES”

Sommaire - Ce volume regroupe l'évaluation des radionucléides suivants :

$^3\text{H}$ ,  $^{55}\text{Fe}$ ,  $^{56}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{63}\text{Ni}$ ,  $^{65}\text{Zn}$ ,  $^{79}\text{Se}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ ,  $^{90}\text{Y}^m$ ,  $^{108}\text{Ag}$ ,  $^{108}\text{Ag}^m$ ,  $^{111}\text{In}$ ,  $^{125}\text{Sb}$ ,  $^{137}\text{Cs}$ ,  $^{153}\text{Sm}$ ,  $^{159}\text{Gd}$ ,  $^{203}\text{Pb}$ ,  
 $^{233}\text{Pa}$ ,  $^{233}\text{Th}$ ,  $^{234}\text{U}$ ,  $^{236}\text{Np}$ ,  $^{236}\text{Np}^m$ ,  $^{237}\text{U}$ ,  $^{238}\text{U}$ ,  $^{242}\text{Cm}$ ,  $^{243}\text{Am}$ ,  $^{244}\text{Cm}$ .

Les valeurs recommandées et les incertitudes associées comprennent : la période radioactive, les modes de décroissance, les émissions  $\alpha$ ,  $\beta$ ,  $\gamma$ , X et électroniques ainsi que les caractéristiques des transitions correspondantes.

## “TABLE OF RADIONUCLIDES”

Summary - This volume includes the evaluation of the following radionuclides :

$^3\text{H}$ ,  $^{55}\text{Fe}$ ,  $^{56}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{63}\text{Ni}$ ,  $^{65}\text{Zn}$ ,  $^{79}\text{Se}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ ,  $^{90}\text{Y}^m$ ,  $^{108}\text{Ag}$ ,  $^{108}\text{Ag}^m$ ,  $^{111}\text{In}$ ,  $^{125}\text{Sb}$ ,  $^{137}\text{Cs}$ ,  $^{153}\text{Sm}$ ,  $^{159}\text{Gd}$ ,  $^{203}\text{Pb}$ ,  
 $^{233}\text{Pa}$ ,  $^{233}\text{Th}$ ,  $^{234}\text{U}$ ,  $^{236}\text{Np}$ ,  $^{236}\text{Np}^m$ ,  $^{237}\text{U}$ ,  $^{238}\text{U}$ ,  $^{242}\text{Cm}$ ,  $^{243}\text{Am}$ ,  $^{244}\text{Cm}$ .

Primary recommended data comprise half-lives, decay modes, X-rays, gamma-rays, electron emissions, alpha- and beta-particle transitions and emissions, and their uncertainties.

## “TABELLE DER RADIONUKLIDE”

Zusammenfassung

$^3\text{H}$ ,  $^{55}\text{Fe}$ ,  $^{56}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{63}\text{Ni}$ ,  $^{65}\text{Zn}$ ,  $^{79}\text{Se}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ ,  $^{90}\text{Y}^m$ ,  $^{108}\text{Ag}$ ,  $^{108}\text{Ag}^m$ ,  $^{111}\text{In}$ ,  $^{125}\text{Sb}$ ,  $^{137}\text{Cs}$ ,  $^{153}\text{Sm}$ ,  $^{159}\text{Gd}$ ,  $^{203}\text{Pb}$ ,  
 $^{233}\text{Pa}$ ,  $^{233}\text{Th}$ ,  $^{234}\text{U}$ ,  $^{236}\text{Np}$ ,  $^{236}\text{Np}^m$ ,  $^{237}\text{U}$ ,  $^{238}\text{U}$ ,  $^{242}\text{Cm}$ ,  $^{243}\text{Am}$ ,  $^{244}\text{Cm}$ .

In diesem Bericht sind evaluierte Werte der Halbwertszeiten, Übergangs-wahrscheinlichkeiten und Übergangsenergien von  $\alpha$ ,  $\beta^-$ ,  $\beta^+$ , EC- und Gammaübergängen, Konversionskoeffizienten von Gammaübergängen, Emissions-wahrscheinlichkeiten von Röntgen- und Gammaquanten, Auger- und Konversions-elektronen.

## **“TABLA DE RADIONUCLEIDOS”**

Prólogo – Este volumen agrupa la evaluación de los radionucleidos siguientes :

$^3\text{H}$ ,  $^{55}\text{Fe}$ ,  $^{56}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{63}\text{Ni}$ ,  $^{65}\text{Zn}$ ,  $^{79}\text{Se}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ ,  $^{90}\text{Y}^m$ ,  $^{108}\text{Ag}$ ,  $^{108}\text{Ag}^m$ ,  $^{111}\text{In}$ ,  $^{125}\text{Sb}$ ,  $^{137}\text{Cs}$ ,  $^{153}\text{Sm}$ ,  $^{159}\text{Gd}$ ,  $^{203}\text{Pb}$ ,  
 $^{233}\text{Pa}$ ,  $^{233}\text{Th}$ ,  $^{234}\text{U}$ ,  $^{236}\text{Np}$ ,  $^{236}\text{Np}^m$ ,  $^{237}\text{U}$ ,  $^{238}\text{U}$ ,  $^{242}\text{Cm}$ ,  $^{243}\text{Am}$ ,  $^{244}\text{Cm}$ .

Los valores recomendados y las incertidumbres asociadas comprenden : el período radioactivo, los modos de desintegración, las emisiones  $\alpha$ ,  $\beta$ ,  $\gamma$ , X y electrónicas incluyendo las características de las transiciones correspondientes.

**TABLE DE RADIONUCLÉIDES**  
**TABLE OF RADIONUCLIDES**  
**TABELLE DER RADIONUKLIDE**  
**ТАБЛИЦА РАДИОНУКЛИДОВ**  
**TABLA DE RADIONUCLEIDOS**

Marie-Martine BÉ, Vanessa CHISTÉ, Christophe DULIEU, Laboratoire National Henri Becquerel (LNHB), France ;  
Edgardo BROWNE, Coral BAGLIN, Lawrence Berkeley National Laboratory (LBNL), USA ;  
Valery CHECHEV, Nikolay KUZMENKO, Khlopin Radium Institute (KRI), Russia ;  
Richard HELMER, Idaho National Engineering and Environmental Laboratory (INEEL), USA ;  
Filip KONDEV, Argonne National Laboratory (ANL), USA ;  
T. Desmond MACMAHON, National Physical Laboratory (NPL), U.K.



## TABLE DE RADIONUCLÉIDES

### INTRODUCTION

Le Laboratoire National Henri Becquerel (LNHB) a commencé l'étude des données nucléaires et atomiques qui caractérisent la décroissance des radionucléides en 1974. Ces évaluations ont fait l'objet de la publication des quatre volumes de la Table de Radionucléides [87Ta, 99Be]. Ce nouveau volume s'inscrit dans la continuation du travail précédent.

D'autre part, pour des raisons évidentes, telles la facilité de mise à jour des données ou la commodité de consultation pour les utilisateurs, le LNHB a créé une base de données informatisée. Le logiciel NUCLEIDE est la forme informatisée de cette table, il permet un accès aisément aux différentes informations à l'aide de menus déroulants atteints par un simple « clic » sur un « bouton ».

Le propos de la Table est d'étudier un nombre limité de radionucléides utiles dans le domaine de la métrologie ou dans des domaines variés d'applications (médecine nucléaire, environnement, cycle du combustible, etc.) et d'en présenter une étude complète.

Les données recommandées comprennent : la période radioactive, les modes de décroissance, les émissions  $\alpha$ ,  $\beta$ ,  $\gamma$ , X et électroniques ainsi que les caractéristiques des transitions associées.

Dans le but de mettre à jour et d'ajouter de nouvelles évaluations plus rapidement Le Laboratoire National Henri Becquerel (LNHB, France) et le Physikalisch - Technische Bundesanstalt (PTB, Germany) ont établi un accord de coopération. Ils ont ensuite été rejoints par Idaho National Engineering&Environmental Laboratory (INEEL, USA), Lawrence Berkeley National Laboratory (LBNL, USA) et Khlopin Radium Institute (KRI, Russia). Le premier travail de cette collaboration internationale a été d'établir une méthode et des règles communes d'évaluation. Les évaluations proposent des valeurs recommandées et leurs incertitudes. Ces valeurs ont été évaluées à partir des données expérimentales disponibles. A défaut, elles sont issues de calculs théoriques. Toutes les références utilisées pour l'évaluation d'un radionucléide sont listées à la fin de chaque chapitre.

Ce volume est le troisième de la Monographie 5 [04Be] publiée sous l'égide du BIPM.

### VALEURS RECOMMANDÉES ET INCERTITUDES

Les principales étapes pour l'évaluation des données et leurs incertitudes sont :

- une analyse critique de toutes les publications disponibles afin de retenir ou non une valeur et son incertitude, ramenée à l'incertitude-type composée ;
- la détermination d'une valeur recommandée qui est, selon les cas, une moyenne simple ou pondérée des valeurs issues des publications, ceci est décidé après examen du chi carré réduit. Dans le cas d'une moyenne pondérée, le poids relatif de chaque valeur est limité à 50%. L'incertitude, notée  $uc$ , est la plus grande des valeurs des incertitudes interne ou externe ; dans le cas de valeurs incompatibles elle peut être étendue pour recouvrir la valeur la plus précise.

Pour certaines applications il est nécessaire de définir une incertitude élargie, notée  $U$ , telle que :

$$U(y) = k \cdot uc(y) \quad \text{où } k \text{ est le facteur d'élargissement.}$$

La valeur de  $k$  retenue pour cette publication est :  $k = 1$ .

Les valeurs d'incertitude indiquées portent sur les derniers chiffres significatifs, ainsi :

9,230 (11) signifie  $9,230 \pm 0,011$  et

9,2 (11)  $9,2 \pm 1,1$

Si une valeur est donnée sans incertitude, cela signifie qu'elle est considérée comme douteuse. Elle est indiquée à titre indicatif et souvent a été estimée en fonction du schéma de désintégration comme étant « de l'ordre de ».

Des précisions concernant les techniques d'évaluation peuvent être obtenues dans les références [85Zi], [96He], [99In] (voir rubrique Références) ou directement auprès des auteurs.

La description physique des données évaluées est disponible dans la référence [99In].

## NUMÉROTAGE

Les niveaux d'un noyau sont numérotés, arbitrairement, de 0 pour le niveau fondamental à n pour le n<sup>ème</sup> niveau excité. Les diverses transitions sont ainsi repérées par leur niveau de départ et leur niveau d'arrivée.

Dans le cas de transition de faible probabilité qu'il n'est pas possible de situer sur le schéma de désintégration, les niveaux de départ et d'arrivée sont notés (-1,n).

Dans le cas de l'émission gamma de 511 keV qui suit une désintégration bêta plus, la notation adoptée est : (-1,-1).

## UNITÉS

Les valeurs recommandées sont exprimées :

- pour les périodes

	Unités
. en secondes pour $T_{1/2} \leq 60$ secondes	s
. en minutes pour $T_{1/2} > 60$ secondes	min
. en heures pour $T_{1/2} > 60$ minutes	h
. en jours pour $T_{1/2} > 24$ heures	d
. en années pour $T_{1/2} > 365$ jours	a

1 année = 365,242 198 jours = 31 556 926 secondes ;

- pour les probabilités de transition et nombre de particules émises, les valeurs sont données pour 100 désintégrations ;

- les énergies sont exprimées en keV.

## AVERTISSEMENT

Ce document a été imprimé en 2006, pour toutes les nouvelles évaluations et mises à jour ultérieures le lecteur se référera aux documents accessibles sur :

<http://www.nucleide.org/NucData.htm>

## TABLE OF RADIONUCLIDES

### INTRODUCTION

The evaluation of decay data for the “Table de Radionucléides” by LNHB (Laboratoire National Henri Becquerel) began in 1974, continued to 1987 and four volumes were published [87Ta] and then, in 1999, the fifth volume was published containing the revised evaluations for 30 selected radionuclides [99Be]. Moreover, LNHB developed a software (NUCLEIDE) with the objectives of making it easier to update and add data and, obviously, to offer easy access to the nuclear and atomic decay data to the user by “click on the button” facilities.

The aim of this Table is to provide recommended data for nuclides of special interest for metrology or practical applications like nuclear medicine, monitoring and reactor shielding, etc.

Primary recommended data comprise half-lives, decay modes, X-rays, gamma-rays, electron emissions, alpha- and beta-particle transitions and emissions, and their uncertainties. All the references used for the evaluations are given.

In order to update the data of the nuclides already present and to add new evaluations, the Laboratoire National Henri Becquerel (LNHB, France) and the Physikalisch-Technische Bundesanstalt (PTB, Germany) established a cooperative agreement ; they were then joined by the Idaho National Engineering&Environmental Laboratory (INEEL, USA), the Lawrence Berkeley National Laboratory (LBNL, USA) and the Khlopin Radium Institute (KRI, Russia). This international collaboration is based on an informal agreement, the initial work of this group was to discuss and to agree on a methodology to be used in these evaluations. The data and associated uncertainties were evaluated from all available experiments and taking into account theoretical considerations.

This volume is the third issue of the Monographie 5 published under the BIPM auspices.

### RECOMMENDED VALUES AND UNCERTAINTIES

The main steps for the evaluation of the data and their uncertainties are :

- a critical analysis of all available original publications in order to accept or not each value and its uncertainty reduced to the combined standard uncertainty ;
- the determination of the best value which is either the weighted or the unweighted average of the retained values, this is decided after examination of the reduced  $\chi^2$  value. For a weighted average of discrepant data, each weight is limited to 50% and, the uncertainty, designated  $uc$ , is the larger of the internal or external uncertainty values, which may be expanded to cover the most precise input value.

For some applications it may be necessary to define an expanded uncertainty, designated  $U$ , as :

$$U(y) = k \cdot uc(y) \quad \text{where } k \text{ is the coverage factor.}$$

For this publication the expanded uncertainty is computed with  $k = 1$ .

The value of the uncertainty, in parentheses, applies to the least significant digits, i.e. :

9,230 (11) means  $9,230 \pm 0,011$  and

9,2 (11)  $9,2 \pm 1,1$

A value given without an uncertainty is considered questionable. It is provided for information and often its order of magnitude is estimated from the decay scheme.

Information on evaluation methods may be obtained from references [85Zi, 96He, 99In] or directly from the authors.

Information on the meaning of physical data may be obtained from reference [99In].

## NUMBERING

Nuclear levels are arbitrarily numbered from 0 (for the ground state level) to n (for the nth excited level). All transitions are designated by their initial and final levels.

For transitions with weak emission probabilities that are not shown by an arrow in the decay scheme, the initial and final levels are noted (-1,n).

For a 511 keV gamma emission, which follows a beta plus disintegration, the adopted numbering is (-1,-1).

## UNITS

The recommended values are given :

- for half-lives :

	Symbol
. in seconds for $T_{1/2} \leq 60$ seconds	s
. in minutes for $T_{1/2} > 60$ seconds	min
. in hours for $T_{1/2} > 60$ minutes	h
. in days for $T_{1/2} > 24$ hours	d
. in years for $T_{1/2} > 365$ days	a

$$1 \text{ year} = 365,242 \text{ 198 days} = 31 \text{ 556 926 seconds}$$

- for transition probabilities and number of emitted particles, per 100 disintegrations of the parent nuclide ;

- for energies, in keV.

## CAUTION

This report was printed in 2006, new evaluations and up-dated issues will be available in the Internet :

<http://www.nucleide.org/NucData.htm>

## TABELLE DER RADIONUKLIDE

### EINLEITUNG

Die Evaluation der Zerfallsdaten für die Table de Radionucléides durch das BNM-LNHB/CEA begann im Jahre 1974, diese Arbeit wurde bis 1987 fortgesetzt, und es wurden vier Bände veröffentlicht [87Ta, 99Be]. Dieser neue Bericht kommt hinzu dem vorhergehend Arbeit.

Übrigens wurde ein Computerform der Table de Radionucléides im LPRI entwickelt. Diese Software erleichtert die Aktualisierung und die Einbeziehung weiterer Daten und ermöglicht den Zugang zu den Kern- und Atomdaten für den Anwender auf „Tastendruck“.

Der Zweck dieser Tabelle ist es, empfohlene Daten einer begrenzten Anzahl von Radionukliden für metrologische und praktische Anwendungen wie etwa in der Nuklearmedizin, der Umgebungsüberwachung, der Reaktorabschirmung usw. zur Verfügung zu stellen.

Die Datenbank umfaßt empfohlene Daten und ihre Unsicherheiten, die aus den verfügbaren Daten oder theoretischen Berechnungen gewonnen worden sind. Alle für die Evaluation benutzten Referenzen werden angegeben.

Um die schon vorliegenden Daten zu aktualisieren und neue Evaluationen schneller einbeziehen zu können, vereinbarten das Laboratoire National Henri Becquerel (LNHB, Frankreich) und die Physikalisch-Technische Bundesanstalt (PTB, Deutschland) einen Vertrag zur Zusammenarbeit. Es schlossen sich das Idaho National Engineering and Environmental Laboratory (INEEL, USA), das Lawrence Berkeley National Laboratory (LBNL, USA) und das Khlopin Radium Institut (KRI, Rußland) an. Eine der ersten Arbeiten dieser Gruppe war es, die in diesen Evaluationen benutzte Methodologie zu diskutieren und festzulegen.

### EMPFOHLENE WERTE UND UNSICHERHEITEN

Die Hauptschritte für die Evaluation der Daten und Unsicherheiten sind:

- Eine kritische Analyse aller verfügbaren Veröffentlichungen, um einen Wert und seine Unsicherheit - auf die kombinierte Standardunsicherheit zurückgeführt - zu berücksichtigen.
- Die Bestimmung eines empfohlenen Wertes, der entweder das gewichtete oder das ungewichtete Mittel der veröffentlichten Werte ist. Die Entscheidung wird nach der Prüfung des reduzierten Chi-Quadrat-Werts getroffen. Im Falle des gewichteten Mittels wird ein Gewicht, das größer ist als 50 %, auf 50 % reduziert. Die Unsicherheit, als  $uc$  bezeichnet, ist der größere Wert der inneren oder äußeren Unsicherheit. Für einen diskrepanten Datensatz ist sie so zu vergrößern, daß der genaueste Einzelwert in der Unsicherheit mit eingeschlossen ist.

Für einige Anwendungen ist es notwendig, eine vergrößerte Unsicherheit, als  $U$  bezeichnet, wie folgt zu definieren:

$$U(y) = k \cdot uc(y) \quad \text{wo } k \text{ der Erweiterungsfaktor ist.}$$

Für die vorliegende Veröffentlichung ist die erweiterte Unsicherheit mit  $k = 1$  berechnet.

Die Werte der Unsicherheit beziehen sich auf die letzten Stellen, d. h.:

9,230(11) bedeutet  $9,230 \pm 0,011$  und

9,2(11) bedeutet  $9,2 \pm 1,1$

Wenn ein Wert ohne Unsicherheit angegeben ist, bedeutet das, daß dieser Wert als fragwürdig zu betrachten ist. Er wird zur Information mitgeteilt und ist oft abgeschätzt aus dem Zerfallsschema im Sinne „in der Größenordnung von“.

Informationen über die Evaluationsprozedur können aus den Referenzen [85Zi, 96He, 99In] oder direkt von den Autoren bezogen werden.

## NUMERIERUNG

Die Kernniveaus werden willkürlich numeriert von 0 für den Grundzustand bis zu n für das n-te angeregte Niveau. Alle Übergänge werden durch ihr Ausgangs- und Endniveau gekennzeichnet. Für Übergänge mit geringen Wahrscheinlichkeiten, die nicht durch einen Pfeil im Zerfallsschema gezeigt sind, werden das Ausgangs- und Endniveau notiert. (-1, n)

Für die 511 keV-Gamma-Emission, die dem Beta Plus-Zerfall folgt, ist die angenommene Numerierung (-1, -1).

## EINHEITEN

Die empfohlenen Werte sind ausgedrückt:

- für Halbwertszeiten:

	Symbol
. in Sekunden für $T_{1/2} \leq 60$ Sekunden	s
. in Minuten für $T_{1/2} > 60$ Sekunden	min
. in Stunden für $T_{1/2} > 60$ Minuten	h
. in Tagen für $T_{1/2} > 24$ Stunden	d
. in Jahren für $T_{1/2} > 365$ Tage	a

$$1 \text{ a} = 365,242\,198 \text{ d} = 31\,556\,926 \text{ s}$$

- für Übergangswahrscheinlichkeiten und die Anzahl der emittierten Teilchen werden Werte angegeben, die sich auf 100 Zerfälle beziehen.

- die Werte der Energien sind in keV ausgedrückt.

## HINWEIS

Dieses Dokument wurde im Jahre 2006 erstellt. Alle späteren Fassungen oder neueren Evaluationen können vom Leser unter <http://www.nucleide.org/NucData.htm> abgerufen werden.

## ТАБЛИЦА РАДИОНУКЛИДОВ

### ВВЕДЕНИЕ

Оценка данных распада для Table de Radionucléides, BNM – LNHB/CEA была начата в 1974 г. и продолжалась до 1987 г. К тому времени были опубликованы четыре тома [87Ta] и затем, в 1999 г., был опубликован пятый том, содержащий ревизованные оценки для 30 выбранных радионуклидов [99Be]. Новое издание находится в русле предыдущей работы.

В дополнение в LNHB была развита компьютерная форма Table de Radionucléides (программа NUCLEIDE) с тем, чтобы обеспечить более простое обновление и дополнение данных и, очевидно, также с целью предложить пользователю более легкий доступ к ядерным и атомным данным распада путем "нажатия кнопки".

Цель настоящего издания - дать рекомендованные данные для нуклидов, представляющих специфический интерес для метрологии или практических приложений, таких как ядерная медицина, мониторинг, реакторная защита и др.

Первичные рекомендованные данные включают периоды полураспада, виды распада, характеристики X- и гамма-излучений, электронных излучений, альфа- и бета-переходов и излучений и погрешности величин этих характеристик. В книге дан полный список литературы, использованной для оценок.

Для того чтобы обновить данные по нуклидам, уже имеющимся в Table de Radionucleides, и добавить новые оценки, Национальная лаборатория им. Анри Беккереля (LNHB, Франция) и Физико-Технический Институт (PTB, Германия) заключили кооперативное соглашение. К ним затем присоединились Национальная лаборатория прикладных и экологических исследований Айдахо (INEL, США), Лоуренсовская Национальная Лаборатория Беркли (LBNL, США) и Радиевый институт им. В.Г. Хлопина (KRI, Россия). Это международное сотрудничество основано на неформальном соглашении. Первоначальная работа состояла в обсуждении и принятии согласованной методологии, которая должна быть использована в этих оценках. Данные и связанные с ними погрешности были оценены с использованием всех имеющихся в распоряжении результатов экспериментов и с учетом теоретических рассмотрений.

### РЕКОМЕНДОВАННЫЕ ЗНАЧЕНИЯ И ПОГРЕШНОСТИ

Основные шаги для оценки данных и их погрешностей следующие:

- критический анализ всех имеющихся оригинальных публикаций, чтобы принять или отвергнуть данное значение и его погрешность, приведенную к комбинированному стандартному отклонению;
- определение лучшего значения, которое является взвешенным или невзвешенным средним сохраненных величин; выбор взвешенного или невзвешенного среднего определяется анализом величины  $\chi^2$ . В случае среднего взвешенного вес каждого оригинального результата ограничивается 50 %. В качестве итоговой погрешности (ис) принимается большая из двух погрешностей среднего взвешенного: внутренней и внешней. Для расходящегося набора данных она может быть расширена, чтобы перекрыть самое точное входное значение.

Для некоторых применений может оказаться необходимым расширенная погрешность (U), выраженная как:  $U(y)=k \cdot uc(y)$ , где k - коэффициент перекрытия. Для этой публикации принято k=1.

Значение погрешности, в скобках, приводится в единицах последней значащей цифры, т.е.:

9,230(11) означает  $9,230 \pm 0,011$  и

9,2(11)  $9,2 \pm 1,1$

Если значение величины дается без погрешности, она считается сомнительной и приводится для информации. Такие величины часто оценивались из схемы распада под рубрикой "порядка".

Информацию о процедурах оценки можно получить из публикаций [85Zi, 96He, 99In] или непосредственно от авторов.

Информация о смысле физических величин может быть получена из [99In].

## НУМЕРАЦИЯ

Ядерные уровни произвольно пронумерованы от 0 для основного состояния до n для n-ого возбужденного уровня. Все переходы обозначаются по их начальному и конечному уровням.

Для слабых переходов, не показанных стрелкой в схеме распада, начальный и конечный уровни обозначаются как (-1, n).

Для гамма-излучения с энергией 511 кэВ, которое следует за бета-плюс распадом, принято обозначение (-1, -1).

## ЕДИНИЦЫ

Рекомендованные значения выражены:

- для периодов полураспада:
  - в секундах для  $T_{1/2} \leq 60$  секунд s
  - в минутах для  $T_{1/2} > 60$  секунд min
  - в часах для  $T_{1/2} > 60$  минут h
  - в сутках для  $T_{1/2} > 24$  часов d
  - в годах для  $T_{1/2} > 365$  суток a

1 год = 365,242198 суток = 31 556 926 секунд

- для вероятностей переходов и числа испускаемых частиц значения даны на 100 распадов;
- для энергий значения выражены в килоэлектронвольтах (keV).

## ПРИМЕЧАНИЕ

Этот отчет подготовлен в 2006 г. Новые оценки и обновленные результаты можно найти на сайте:  
<http://www.nucleide.org/NucData.htm>

## TABLA DE RADIONUCLEIDOS

### INTRODUCCION

El Laboratorio Nacional Henri Becquerel (LNHB) inició en 1974 el estudio de datos nucleares y atómicos que caracterizan la desintegración de radionucleidos. Esas evaluaciones han permitido la publicación de cuatro volúmenes de la Tabla de Radionucleidos [ $^{87}\text{Ta}$ ,  $^{99}\text{Be}$ ]. Este nuevo volumen es el siguiente en la continuación del estudio precedente.

Para facilitar la corrección de nueva información y mejorar la comodidad de consulta a los lectores, el LNHB a creado una base de datos en computadora. El programa NUCLEIDE permite el acceso a la Tabla de Radionucleidos con la ayuda de menues en cascada disponibles con un simple « clic » sobre una « tecla ».

El objetivo de la Tabla de Radionucleidos es el de proveer información sobre un número limitado de radionucleidos utilizados en el campo de la metrología o en campos de aplicación a otras disciplinas (medicina nuclear, medio ambiente, ciclo del combustible,etc.)

Los datos recomendados incluyen : el período radioactivote desintegración, los modos de desintegración, las emisiones  $\alpha$ ,  $\beta$ ,  $\gamma$ , X y de electrones atómicos asociados a las mismas.

Con el propósito de actualizar y agregar nuevas evaluaciones rápidamente el *Laboratoire National Henri Becquerel* (LNHB, Francia) y el *Physikalisch-Technische Bundesanstalt* (PTB , Alemania) establecieron un acuerdo de colaboración. Luego se unieron a este acuerdo el *Idaho National Engineering & Environmental Laboratory* (INEEL, USA), *Lawrence Berkeley National Laboratory* LBNL, USA) y *Khoplin Radium Institute* (KRI, Rusia). El primer trabajo de esta colaboración internacional ha sido el de establecer el método y las reglas comunes de evaluación. Las evaluaciones proponen valores recomendados e incertidumbres asociadas. Éstos valores han sido evaluados a partir de datos experimentales. En su ausencia, tales valores fueron obtenidos por cálculos teóricos. Todas las referencias utilizadas para la evaluación de un radionucleido están listadas al final de cada capítulo.

### VALORES RECOMENDADOS E INCERTIDUMBRES

Las principales etapas para evaluar datos con sus incertidumbres son:

- Un análisis crítico de todas las publicaciones disponibles con el fin de obtener un valor con su incertidumbre, considerada como incertidumbre tipo compuesta.
- La determinación de un valor recomendado que es, según el caso, una media simple o ponderada de valores obtenidos de publicaciones. Ésto es decidido luego de examinar la desviación cuadrática reducida. En el caso de una media ponderada para conjuntos de valores discrepantes, el peso estadístico relativo de cada valor es limitado a 50 %. La incertidumbre,  $uc$ , es el mayor de los valores de incertidumbres interna o externa; en el caso de conjuntos de valores discrepantes, este valor puede ser extendido con el fin de incluir el valor experimental más preciso.

Para ciertas aplicaciones, es necesario definir una incertidumbre expandida, llamada  $U$ :

$$U(y) = k \cdot uc(y) \quad \text{donde } k \text{ es el factor de expansión.}$$

El valor de  $k$  utilizado en esta publicación es :  $k = 1$ .

Los valores de incertidumbres indicados entre paréntesis corresponden a las cifras menos significativas, por ejemplo :

$$\begin{array}{lll} 9,230 (11) & \text{significa} & 9,230 \pm 0,011 \quad y \\ 9,2 (11) & \text{significa} & 9,2 \pm 1,1 \end{array}$$

Valores dados sin incertidumbres son considerados dudosos (usualmente son presentados como valores aproximados, y a menudo estimados a partir de esquemas de desintegración.

## NUMERACION

Los niveles de un núcleo están arbitrariamente numerados desde “0” (para el nivel fundamental), hasta “n” para el enésimo nivel excitado. Las diversas transiciones son así señaladas del nivel inicial al nivel final.

En el caso de una transición débil e imposible de situar en el esquema de desintegración, el nivel inicial y el final están designados con la siguiente notación : (-1, n).

En el caso de una emisión  $\gamma$  de 511 keV que sigue a una desintegración  $\beta^+$ , la notación adoptada es : (-1, -1).

## UNIDADES

Los valores recomendados son dados :

- para los períodos de desintegración :

### Unidades

. en segundos para $T_{1/2} \leq 60$ segundos	s
. en minutos para $T_{1/2} > 60$ segundos	min
. en horas para $T_{1/2} > 60$ minutos	h
. en días para $T_{1/2} > 24$ horas	d
. en años para $T_{1/2} > 365$ días	a

1 año = 365,242 198 días = 31 556 926 segundos ;

- para las probabilidades de transición y número de partículas emitidas:

- por cada 100 desintegraciones del nucleido padre.
  - para las energías:
  - en keV.

## ADVERTENCIA

Este documento ha sido imprimido en el 2006. Para obtener todas las nuevas evaluaciones actualizadas ulteriormente, el lector deberá referirse a los documentos disponibles en el Internet :

<http://www.nucleide.org/NucData.htm>

## RÉFÉRENCES

## REFERENCES

## REFERENZEN

## REFERENCIAS

[87Ta] **Table de Radionucléides**, F. Lagoutine, N. Coursol, J. Legrand. ISBN 2 7272 0078 1 (LMRI, 1982-1987).

[85Zi] **W.L. Zijp**, Netherland Energy Research Foundation, ECN, Petten, The Netherlands, Rep. ECN-179.

[96He] **R.G. Helmer**, Proceedings of the Int. Symp. "Advances in alpha-, beta- and gamma-ray Spectrometry", St. Petersburg, September 1996, p. 71.

[96Be] **M.-M. Bé, B. Duchemin and J. Lamé**. Nucl. Instrum. Methods A369 (1996) 523 and Bulletin du Bureau National de Métrologie 110 (1998).

[99In] Table de Radionucléides. Introduction, nouvelle version. Introduction, revised version. Einleitung, überarbeitete Fassung. ISBN 2 7272 0201 6, BNM-CEA/LNHB BP 52, 91 191 Gif-sur-Yvette Cedex, France.

[99Be] **M.-M. Bé, E. Browne, V. Chechev, R.G. Helmer, E. Schönfeld**. Table de Radionucléides, ISBN 2 7272 0200 8 and ISBN 2 7272 0211 3(LNHB, 1988-1999).

[04Be] **M.M. Bé, E. Browne, V. Chechev, V. Chisté, R. Dersch, C. Dulieu, R.G. Helmer, T.D. MacMahon, A.L. Nichols, E. Schönfeld**. Table of Radionuclides, Monographie BIPM-5, ISBN 92-822-2207-7 (set) and ISBN 92-822-2205-5 (CD), CEA/BNM-LNHB, 91191 Gif-sur-Yvette, France and BIPM, Pavillon de Breteuil, 92312 Sèvres, France.

and

**M.M. Bé, E. Browne, V. Chechev, V. Chisté, R. Dersch, C. Dulieu, R.G. Helmer, N. Kuzmenco, A.L. Nichols, E. Schönfeld**. NUCLEIDE, Table de Radionucléides sur CD-Rom, Version 2-2004, CEA/BNM-LNHB, 91191 Gif-sur-Yvette, France.

**AUTEURS POUR CORRESPONDANCE**

**AUTHOR'S MAIL ADDRESSES**

**ADRESSEN DER ATOREN**

**AUTORES PARA CORRESPONDENCIA**

Toutes demandes de renseignements concernant les données recommandées et la façon dont elles ont été établies doivent être adressées directement aux auteurs des évaluations.

Information on the data and the evaluation methods is available from the authors listed below.

Informationen über die Daten und Evaluationsprozeduren können bei den im folgenden zusammengestellten Autoren angefordert werden:

Todos los pedidos de información relativos a datos recomendados y la manera de establecerlos deben dirigirse directamente a los autores de las evaluaciones.

**Dr. Marie-Martine Bé**

CEA/LNHB- 602  
91191 Gif-sur-Yvette, CEDEX, France  
Tel: 33-1-69-08-46-41  
Fax: 33-1-69-08-26-19  
E-mail: [mmbe@cea.fr](mailto:mmbe@cea.fr)

**Dr. Edgardo Browne**

Lawrence Berkeley National Laboratory  
MS 88RO192, Berkeley, California 94720, USA  
Tel: (510) 486-7647  
Fax: (510) 486-5757  
E-mail: [ebrowne@lbl.gov](mailto:ebrowne@lbl.gov)

**Dr. Valery P. Chechey**

V.G. Khlopin Radium Institute  
28, 2<sup>nd</sup> Murinsky Ave., 194021 St. Petersburg, Russia  
Tel: 007 (812) 2473706  
Fax: 007 (812) 2478095  
E-mail: [chechey@atom.nw.ru](mailto:chechey@atom.nw.ru)

**Dr. Vanessa Chisté**

CEA/LNHB  
91191 Gif-sur-Yvette, CEDEX, France  
Tel: 33-1-69-08-63-07  
Fax: 33-1-69-08-26-19  
E-mail: [vanessa.chiste@cea.fr](mailto:vanessa.chiste@cea.fr)

**Dr. Filip Kondev**

Nuclear Applications and Nuclear Data Program, Technology Development Division  
Argonne National Laboratory  
9700 South Cass Ave. Argonne, ILL 60439, USA  
Tel: 1-(630) 252-4484  
Fax: 1-(630) 252-5287  
E-mail: [kondev@anl.gov](mailto:kondev@anl.gov)

**Dr. T. Desmond MacMahon**

NPL, Centre for Ionising Radiation Metrology  
Teddington,  
Middlesex, TW11 0LW, United Kingdom  
Tel: 44 20 8943 8573  
Fax: 44 20 8943 6161  
E-mail: [desmond.macmahon@npl.co.uk](mailto:desmond.macmahon@npl.co.uk)

**Dr. Eckart Schönfeld**

Physikalisch-Technische Bundesanstalt  
Bundesallee 100, 38116 Braunschweig, Germany  
Tel: 49-0531-592-6110  
Fax: 49-0531-592-6015

**Dr. Coral Baglin**

Lawrence Berkeley National Laboratory  
Berkeley, California 94720, USA  
E-mail: [cmbaglin@lbl.gov](mailto:cmbaglin@lbl.gov)

**Dr Kyung Beom Lee**

Korea Research Institute of Standards and Science (KRISS)  
P.O. Box 102  
Yusong, Taejon, 305-600, South Korea  
E-mail : [lee@kriis.re.kr](mailto:lee@kriis.re.kr)



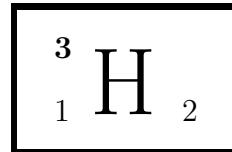
## Table of contents

List of radionuclides included in:

<b>Volume 1 – A = 1 to 150</b>			<b>Volume 2 – A = 151 to 242</b>			<b>Volume 3 – A = 3 to 244</b>		
<b>Mass</b>	<b>Nuclide</b>	<b>Page</b>	<b>Mass</b>	<b>Nuclide</b>	<b>Page</b>	<b>Mass</b>	<b>Nuclide</b>	<b>Page</b>
7	Be-7	1	152	Eu-152	1	3	H-3	1
11	C-11	7	153	Gd-153	21	55	Fe-55	5
13	N-13	11	153	Sm-153	27	56	Co-56	11
15	O-15	17	154	Eu-154	37	60	Co-60	23
18	F-18	21	155	Eu-155	59	63	Ni-63	29
24	Na-24	27	166	Ho-166	67	65	Zn-65	33
32	P-32	35	166	Ho-166m	75	79	Se-79	39
33	P-33	41	169	Yb-169	87	90	Sr-90	43
44	Sc-44	45	170	Tm-170	99	90	Y-90	47
44	Ti-44	51	177	Lu-177	107	90	Y-90m	53
46	Sc-46	57	186	Re-186	113	108	Ag108	59
51	Cr-51	63	198	Au-198	121	108	Ag-108m	67
54	Mn-54	71	201	Tl-201	129	111	In-111	75
56	Mn-56	77	203	Hg-203	135	125	Sb-125*	81
57	Co-57	83	204	Tl-204	141	137	Cs-137	91
57	Ni-57	91	208	Tl-208	147	153	Sm-153*	99
59	Fe-59	99	212	Bi-212	155	159	Gd-159	109
64	Cu-64	105	212	Pb-212	167	203	Pb-203	115
66	Ga-66	113	212	Po-212	173	233	Pa-233	123
67	Ga-67	133	216	Po-216	177	233	Th-233	133
85	Kr-85	141	220	Rn-222	183	234	U-234	147
85	Sr-85	147	224	Ra-224	189	236	Np-236	155
88	Y-88	153	226	Ra-226	195	236	Np-236m	163
89	Sr-89	161	227	Th-227	201	237	U-237	169
93	Nb-93m	167	228	Th-228	227	238	U-238	177
99	Mo-99	173	238	Pu-238	235	242	Cm-242	185
99	Tc-99m	183	240	Pu-240	247	243	Am-243	195
109	Cd-109	191	241	Am-241	257	244	Cm-244	203
110	Ag-110	199	242	Pu-242	277			
110	Ag-110m	207						
123	I-123	219						
123	Te-123m	229						
125	Sb-125	235						
129	I-129	243						
131	I-131	249						
131	Xe-131m	257						
133	Ba-133	263						
140	Ba-140	271						
140	La-140	277						

\* : updated evaluations





## 1 Decay Scheme

H-3 disintegrates 100% by beta-minus decay directly to the ground state of He-3.

*Le tritium se désintègre à 100 % par émission bêta moins vers le niveau fondamental d'hélium 3.*

## 2 Nuclear Data

$T_{1/2}(^3\text{H})$	:	12,312	(25)	a
$Q^-(^3\text{H})$	:	18,591	(1)	keV

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,0}^-$	18,591 (1)	100	Super allowed	3,05

## 3 Electron Emissions

	Energy keV	Electrons per 100 disint.
$\beta_{0,0}^-$	max: 18,564 (3)	100
$\beta_{0,0}^-$	avg: 5,68 (1)	

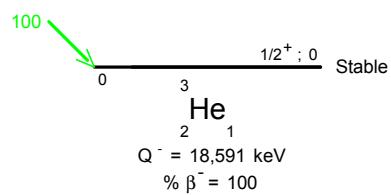
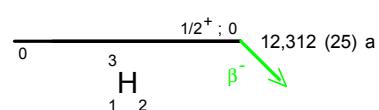
## 4 Main Production Modes

$$\left\{ \begin{array}{l} \text{Li} - 6(n,\alpha)\text{H} - 3 \\ \text{Possible impurities : none} \end{array} \right.$$

## 5 References

- E.M.MCMILLAN. Phys. Rev. 49 (1936) 875  
(Half-life)
- L.W.ALVAREZ, L.CORNOG. Phys. Rev. 56 (1939) 613  
(Half-life)
- R.D.O'NEAL, M.GOLDHABER. Phys. Rev. 58 (1940) 574  
(Half-life)
- L.W.ALVAREZ, L.CORNOG. Phys. Rev. 57 (1940) 248  
(Half-life)
- A.NOVICK. Phys. Rev. 72 (1947) 972  
(Half-life)
- M.GOLDHABER, E.S ROBINSON, R.W.SPENCE. Phys. Rev. 72 (1947) 973  
(Half-life)
- G.H.JENKS, J.A.GHORMLEY, F.H.SWEETON. Phys. Rev. 875 (1949) 701  
(Half-life)
- G.H.JENKS, F.H.SWEETON, J.A.GHORMLEY. Phys. Rev. 80 (1950) 990  
(Half-life)
- W.M.JONES. Phys. Rev. 83 (1951) 537  
(Half-life)
- W.M.JONES. Phys. Rev. 100 (1955) 124  
(Half-life)
- D.P.GREGORY, D.A.LANDSMAN. Phys. Rev. 109 (1958) 2091  
(Average beta energies)
- M.M.POPOV, *et al.* J.Nucl.Energy 9 (1959) 190, Atomnaya Energ. 4 (1958) 269  
(Half-life)
- W.L.PILLINGER, J.J.HENTGES, J.A.BLAIR. Phys. Rev. 121 (1961) 232  
(Average beta energies)
- J.F.EICHELBERGER, G.R.GROVE, L.VL.JONES. Report MLM-1160, DOE, Mound Lab., Miamisburg, Ohio. June (1963) 5  
(Half-life)
- J.S.MERRITT, J.G.V.TAYLOR. Chalk River Report AECL-2510 (1966)  
(Half-life)
- P.M.S.JONES. J. Nucl. Materials 21 (1967) 239  
(Half-life)
- K.C.JORDAN, B.C.BLANKE, W.A.DUDLEY. J. Inorg. Nucl. Chem. 29 (1967) 2129  
(Half-life)
- J.MANTEL. Int. J. Appl. Radiat. Isotop. 23 (1972) 407  
(Average beta mission energies)
- C.R.RUDY, K.C.JORDAN. Report MLM-2458, Monsanto Research Corporation, Miamisburg, Ohio. (1977)  
(Half-life)
- M.P.UNTERWEGER, *et al.* Int. J. Appl. Radiat. Isotop. 31 (1980) 611  
(Half-life)
- F.LAGOUTINE, N.COURSOL, J.LEGRAND. Table de Radionucléides, ISBN-2-7272-0078-1 (LMRI, 1982-1987) (1982)  
(Average beta energies)
- I.G.KAPLAN, G.V.SMELOV, V.N.SMUTNY. Phys. Lett. 161B (1985) 389  
(Beta end-point energy and Q value)
- E.GARCIA-TORANO, A.GRAU MALONDA. Comp. Phys. Commun. 36 (1985) 307  
(Average beta energies)
- M.J.MARTIN. A handbook of radioactivity measurements procedures, 2nd Edition, NCRP Report 58 (1985) 368  
(Average beta energies)
- T.GENKA, K.KOBAYASHI, S.HAGIWARA. Int. J. Appl. Radiat. Isotop. 38 (1987) 845  
(Average beta energies)
- J.J.SIMPSON. Phys. Rev. C. 35 (1987) 752  
(Half-life)
- S.D.BORIS, *et al.* Pis'ma Zh.Exsp.Teor.Fis.45 (1987) 267, Phys. Rev. Lett. 58 (1987) 2019  
(Q)
- H.KAWAKAMI, *et al.* Phys. Lett. B187 (1987) 198  
(Q)

- B.BUDICK, HONG LIN. Bull. Amer. Phys. Soc. 32 (1987) 1063  
(Half-life)
- B.M.OLIVER, H.FARRAR IV, M.M.BRETSCHER. Int. J. Appl. Radiat. Isotop. 38 (1987) 959  
(Half-life)
- YU.A.AKULOV, B.A.MAMYRIN *et al.* Sov. Tech. Phys. Lett. 14 (1988) 416  
(Half-life)
- A.REDONDO, R.G.H.ROBERTSON. Phys. Rev. C. 40 (1989) 368  
(Q)
- B.M.OLIVER, M.M.BRETSCHER, H.FARRAR IV. Int. J. Appl. Radiat. Isotop. 40 (1989) 199  
(Half-life)
- B.BUDICK, JIANSHENG CHEN, HONG LIN. Phys. Rev. Lett. 67 (1991) 2630  
(Half-life)
- H.BACKE, *et al.* Nucl. Phys. A553 (1993) 313c  
(Beta end-point energy)
- SUN HANCHENG, *et al.* Chin. J. Nucl. Phys. 15 (1993) 261  
(Beta end-point energy)
- B.R.S.SIMPSON, B.R.MEYER. Nucl. Instrum. Methods Phys. Res. A339 (1994) 14  
(Average beta energies)
- W.STOEFFL, D.J.DECMAN. Phys. Rev. Lett. 75 (1995) 3237  
(Beta end-point energy)
- M.-M.BÉ, E.BROWNE, V.CHECHEV. Table de Radionucléides, CEA- ISBN 2 7272 0200 8, and Comments CEA-  
ISBN 2 7272 0211 3 (1999)  
(H-3 decay data evaluation)
- M.P.UNTERWEGER, L.L.LUCAS. Appl. Rad. Isotopes 52 (2000) 527  
(Half-life)
- L.L.LUCAS, M.P.UNTERWEGER. J. Res. Nat. Inst. Stand. Technol. 104 (2000) 541  
(Half-life evaluation)
- V.P.CHECHEV, A.G.EGOROV. Appl. Rad. Isotopes 52 (2000) 601  
(Evaluation technique)
- J.BONN, B.BORNSCHEIN, L.BORNSCHEIN *et al.* Nucl. Phys. 48 (2002) 133  
(tritium beta-spectrum)
- V.M.LOBASHEV. Nucl. Phys. A719 (2003) 153c  
(Tritium beta-spectrum)
- G. AUDI, A. H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q)
- YU.A.AKULOV, B.A.MAMYRIN. Phys. Lett. B600 (2004) 41  
(Half-life)
- C.KRAUSS, B.BORNSCHEIN, L.BORNSCHEIN *et al.* Eur. Phys. J. C40 (2005) 447  
(tritium beta-spectrum)
- YU.A.AKULOV, B.A.MAMYRIN. Phys. Lett. B610 (2005) 45  
(Half-life)





## 1 Decay Scheme

Fe-55 disintegrates by electron capture. A gamma transition with a small probability ( $1,3 \times 10^{-7} \%$ ) has been observed. A background radiation, due to an inner-bremsstrahlung, with an intensity relative to K capture of  $3,24(6) \times 10^{-5}$  photons produces a continuous spectrum up to 231,21 keV.

*Le Fe-55 se désintègre par capture électronique. Une transition gamma de faible probabilité a été observée. Un rayonnement de freinage interne produit une émission radiative, dont la probabilité relative à la capture électronique K est de  $3,24(6) \times 10^{-5}$ .*

## 2 Nuclear Data

$T_{1/2}(^{55}\text{Fe})$	:	2,747	(8)	a
$Q^+(^{55}\text{Fe})$	:	231,21	(18)	keV

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft	$P_K$	$P_L$	$P_{M+}$
$\epsilon_{0,1}$	105,26 (18)	0,00000013 (1)	2nd Forbidden	14,2			
$\epsilon_{0,0}$	231,21 (18)	100	Allowed	6	0,8853 (16)	0,0983 (13)	0,0163 (8)

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}}$ $\times 100$	Multipolarity
$\gamma_{1,0}(\text{Mn})$	125,949 (10)	0,00000013 (1)	M1+(E2)

### 3 Atomic Data

#### 3.1 Mn

$\omega_K$	:	0,321	(7)
$\bar{\omega}_L$	:	0,0047	(7)
$\bar{\omega}_M$	:	0,000027	(2)
$n_{KL}$	:	1,478	(4)
$\bar{n}_{LM}$	:	1,996	(8)

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	5,88765	51
K $\alpha_1$	5,89875	100
K $\beta_3$	6,49045	{}
K $\beta_5''$	6,5352	{}
		20,5
X <sub>L</sub>		
L $\ell$	0,556	
L $\eta$	0,567	
L $\beta$	0,649 – 0,721	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	4,953 – 5,210	100
KLX	5,671 – 5,895	27,2
KXY	6,370 – 6,532	1,85
Auger L	0,47 – 0,67	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Mn)	0,47 - 0,67	140,2 (8)
e <sub>AK</sub>	(Mn)		60,1 (5)
	KLL	4,953 - 5,210	}
	KLX	5,671 - 5,895	}
	KXY	6,370 - 6,532	}

## 5 Photon Emissions

### 5.1 X-Ray Emissions

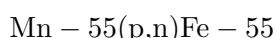
		Energy keV	Photons per 100 disint.
XL	(Mn)	0,556 — 0,721	0,524 (21)
XK $\alpha_2$	(Mn)	5,88765	8,45 (14) }
XK $\alpha_1$	(Mn)	5,89875	16,57 (27) }
XK $\beta_3$	(Mn)	6,49045	}
XK $\beta_1$	(Mn)		}
XK $\beta_5''$	(Mn)	6,5352	}
XK $\beta_4$	(Mn)		}

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Mn})$	125,949 (10)	0,00000013 (1)

## 6 Main Production Modes

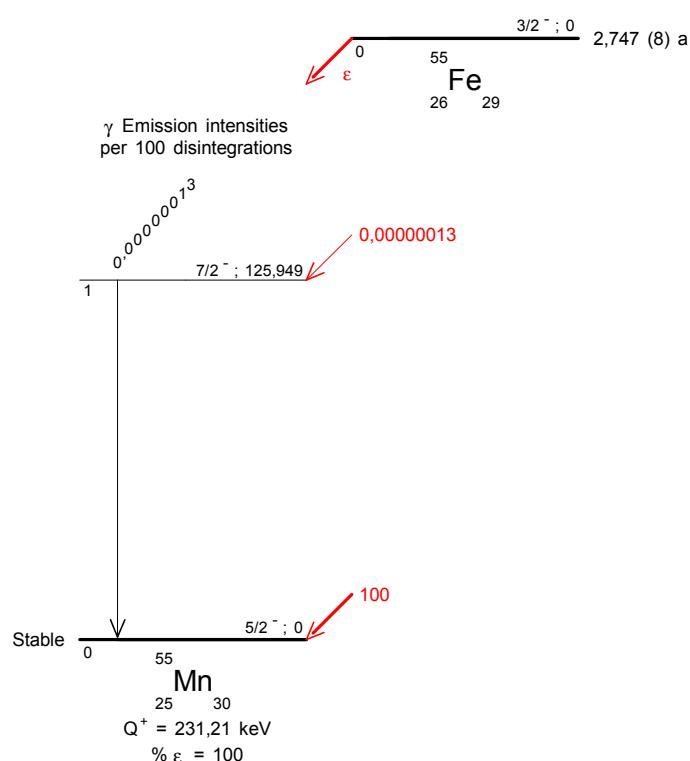
$$\left\{ \begin{array}{l} \text{Fe} - 54(n,\gamma)\text{Fe} - 55 \quad \sigma : 2,25 \text{ (1800) barns} \\ \text{Possible impurities : Fe} - 59 \end{array} \right.$$



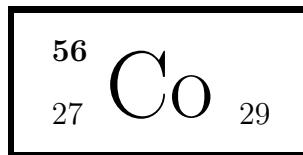
$$\left\{ \begin{array}{l} \text{Fe} - 54(d,p)\text{Fe} - 55 \\ \text{Possible impurities : Co} - 55 \end{array} \right.$$

## 7 References

- J. G. PENGRA, H. GENZ, J. P. RENIER, R. W. FINK. Phys. Rev. C5,6 (1972) 2007  
(PL/PK, PM/PL)
- L. DOBRILOVIC, D. BEK-UZAROV, M. SIMOVIC, K. BURAEI, A. MILOJEVIC. Proc. of the Internationnal Conference on Inner-shell Ionization Phenomena CONF-720404 (1973) 128  
(K fluorescence yield)
- TETSUO KITAHARA, SAKAE SHIMIZU . Phys. Rev. C11,3 (1975) 920  
(P(ionisation))
- F. P. LARKINS. At. Data Nucl. Data Tables 20,4 (1977) 338  
(Auger Electrons)
- M. H. CHEN. Phys. Rev. A21-2 (1980) 436  
(K fluorescence yield)
- H. HOUTERMANS, O. MILOSEVIC, F. REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life)
- U. KUHN, H. GENZ, W. LÖW, A. RICHTER, H. W. MÜLLER. Z. Phys. A - Atoms and Nuclei 300 (1981) 103  
(K fluorescence yield)
- D. D. HOPPES, J. M. R. HUTCHINSON, F. J. SCHIMA, M. P. UNTERWEGER. NBS-Special publication 626 (1982) 85  
(Half-life)
- F. LAGOUTINE, J. LEGRAND, C. BAC. Int. J. Appl. Radiat. Isotop. 33 (1982) 711  
(Half-life)
- D. SMITH. Nucl. Instrum. Methods 200 (1982) 383  
(PkWk)
- W. BAMBYNEK. A. Meisel Ed. Leipzig Aug. 20-23 (1984)  
(K fluorescence yield)
- A. A. KONSTANTINOV, T. E. SAZONOVA, S. V. SEPMAN, E. A. FROLOV. Metrologia 26 (1989) 205  
(K fluorescence yield)
- M. C. P. ISAAC, V. R. VANIN, O. A. M. HELENE. Z. Phys. A. 335 (1990) 243  
(Beta emission energies)
- A. KOVALIK, V. BRABEC, J. NOVAK, O. DRAGOŇ, V. M. GOROZHANKIN, A. F. NOVGORODOV, Ts. VYLOV. J. Elec. Spectro. Rel. Phenomena 50 (1990) 89  
(Auger electrons)
- J. L. CAMPBELL, J. A. MAXWELL, W. J. TEESDALE. Phys. Rev. C. 43,4 (1991) 1656  
(Double K capture probability)
- I. ZLIMEN, E. BROWNE, Y. CHAN, M. T. F. DA CRUZ, A. GARCIA, R.-M. LARIMER, K. T. LESKO, E. B. NORMAN, R. G. STOKSTAD, F. E. WIETFELDT. Phys. Rev. C. 46,3 (1992) 1136  
(Gamma Emission)
- J. H. HUBBELL, P. N. TREHAN, NIRMAL SINGH, B. CHAND, D. MEHTA, M. L. GARG, R. R. GARG, SURINDER SINGH, S. PURI. J. Phys. Chem. Ref. Data 23-2 (1994) 339  
(K fluorescence yield)
- J. MOREL, M. ETCHEVERRY, M. VALLÉE. Nucl. Instrum. Methods Phys. Res. A339 (1994) 232  
(Half-life)
- E. SCHÖNFELD, H. JANSSEN. Report PTB Ra-37 (1995)  
(L fluorescence yield, Kb/Ka)
- N. I. KARMALITSYN, T. E. SAZONOVA, A. V. ZANEVSKY, S. V. SEPMAN. Appl. Rad. Isotopes 49,9-11 (1998) 1363  
(Half-life)
- U. SCHÖTZIG. Appl. Rad. Isotopes 53 (2000) 469  
(Half-life, X-ray emission intensities)
- G. AUDI, A. H. WAPSTRA. Nucl. Phys. A729, 1 (2003) 337  
(Q)
- R. VAN AMMEL, S. POMMÉ, G. SIBBENS. Appl. Rad. Isotopes 64 (2006) 1412  
(Half-life)







## 1 Decay Scheme

Co-56 disintegrates 19.58 (11) % by beta plus emission and 80.42 (11) % by electron capture to Fe-56. Co-56 emits gamma rays with energies up to 3612 keV and the energies and emission probabilities for many of these transitions are useful for the calibration of Ge detectors.

*Le cobalt 56 se désintègre à 19,58 (11) % par émission bêta plus et à 80,42 (11) % par capture électronique vers des niveaux excités du fer 56. Le cobalt 56 émet des rayonnements gamma d'énergie allant jusqu'à 3612 keV, ce qui le rend utile pour l'étalonnage des détecteurs germanium.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{56}\text{Co}) &: 77,236 \quad (26) \quad \text{d} \\ Q^+(^{56}\text{Co}) &: 4566 \quad (2) \quad \text{keV} \end{aligned}$$

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_M$
$\epsilon_{0,15}$	107,7 (20)	0,209 (7)	Allowed	6,91	0,8766 (17)	0,1055 (14)	0,0171 (6)
$\epsilon_{0,14}$	118,4 (20)	0,0167 (5)		8,1	0,8779 (17)	0,1044 (14)	0,0169 (6)
$\epsilon_{0,13}$	171,2 (20)	0,2159 (18)	Allowed	7,32	0,8816 (17)	0,1013 (13)	0,0164 (6)
$\epsilon_{0,12}$	268 (2)	3,688 (13)	Allowed	6,49	0,8845 (16)	0,0989 (13)	0,0159 (5)
$\epsilon_{0,11}$	446,1 (20)	9,940 (18)	Allowed	6,51	0,8864 (16)	0,0972 (13)	0,0156 (5)
$\epsilon_{0,10}$	465,7 (20)	12,66 (4)	Allowed	6,44	0,8866 (16)	0,0971 (13)	0,0156 (5)
$\epsilon_{0,9}$	517,2 (20)	3,965 (15)	Allowed	7,04	0,8868 (16)	0,0969 (13)	0,0155 (5)
$\epsilon_{0,8}$	709,5 (20)	16,86 (5)	Allowed	6,69	0,8875 (16)	0,0963 (13)	0,0154 (5)
$\epsilon_{0,7}$	1120,7 (20)	21,40 (5)	Allowed	6,98	0,8882 (16)	0,0957 (13)	0,0153 (5)
$\epsilon_{0,6}$	1195,9 (20)	0,015 (5)	2nd Forbidden	10,2	0,8883 (16)	0,0957 (13)	0,0153 (5)
$\epsilon_{0,5}$	1443,1 (20)	8,99 (6)	Allowed	7,58	0,8884 (16)	0,0955 (13)	0,0153 (5)
$\epsilon_{0,4}$	1606,1 (20)	0,023 (6)	2nd Forbidden	10,26	0,8885 (16)	0,0955 (13)	0,0153 (5)
$\epsilon_{0,2}$	2480,9 (20)	2,43 (3)	Allowed	8,62	0,8888 (16)	0,0952 (13)	0,0152 (5)
$\epsilon_{0,1}$	3719,2 (20)	0,005 (3)	2nd Forbidden	11,6	0,8890 (16)	0,0951 (13)	0,0152 (5)

## 2.2 $\beta^+$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg $ft$
$\beta_{0,7}^+$	98,7 (20)	0,0080 (7)	Allowed	6,98
$\beta_{0,6}^+$	174 (2)	0,000006 (20)	2nd Forbidden	10,2
$\beta_{0,5}^+$	421,1 (20)	1,04 (2)	Allowed	7,58
$\beta_{0,4}^+$	584,1 (20)	0,0086 (22)	2nd Forbidden	10,26
$\beta_{0,2}^+$	1458,9 (20)	18,29 (16)	Allowed	8,62
$\beta_{0,1}^+$	2697,2 (20)	0,25 (17)	2nd Forbidden	11,6

## 2.3 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	P <sub><math>\gamma+ce</math></sub> $\times 100$	Multipolarity	$\alpha_T$ ( $10^{-4}$ )	$\alpha_\pi$ ( $10^{-4}$ )
$\gamma_{11,8}(\text{Fe})$	263,434 (5)	0,0234 (20)			
$\gamma_{8,7}(\text{Fe})$	411,145 (4)	0,0269 (23)			
$\gamma_{8,6}(\text{Fe})$	486,55 (11)	0,058 (3)			
$\gamma_{10,7}(\text{Fe})$	655,003 (5)	0,038 (8)			
$\gamma_{11,7}(\text{Fe})$	674,579 (5)	0,035 (5)			
$\gamma_{8,5}(\text{Fe})$	733,514 (4)	0,191 (4)	M1+E2		
$\gamma_{7,3}(\text{Fe})$	787,743 (5)	0,310 (4)	M1+E2		
$\gamma_{1,0}(\text{Fe})$	846,770 (2)	99,9702 (23)	E2	3,03 (9)	
$\gamma_{12,7}(\text{Fe})$	852,732 (4)	0,049 (3)			
$\gamma_{8,4}(\text{Fe})$	896,510 (6)	0,0704 (22)			
$\gamma_{10,5}(\text{Fe})$	977,372 (5)	1,422 (7)	M1(+E2)		
$\gamma_{11,5}(\text{Fe})$	996,948 (5)	0,116 (6)	M1+E2		
$\gamma_{5,2}(\text{Fe})$	1037,8427 (39)	14,03 (5)	M1(+E2)		
$\gamma_{9,4}(\text{Fe})$	1088,894 (9)	0,054 (4)	M1+E2		
$\gamma_{10,4}(\text{Fe})$	1140,368 (6)	0,132 (4)			
$\gamma_{11,4}(\text{Fe})$	1159,944 (6)	0,088 (3)	M1+E2		
$\gamma_{12,5}(\text{Fe})$	1175,101 (4)	2,249 (9)	M1+E2		
$\gamma_{8,3}(\text{Fe})$	1198,888 (5)	0,044 (3)			
$\gamma_{2,1}(\text{Fe})$	1238,2883 (31)	66,41 (16)	E2		
$\gamma_{13,5}(\text{Fe})$	1271,92 (6)	0,0202 (8)			
$\gamma_{15,5}(\text{Fe})$	1335,399 (30)	0,1228 (16)			
$\gamma_{7,2}(\text{Fe})$	1360,2117 (39)	4,280 (13)	M1+E2		
$\gamma_{10,3}(\text{Fe})$	1442,746 (6)	0,180 (4)			
$\gamma_{11,3}(\text{Fe})$	1462,322 (6)	0,0778 (9)			
$\gamma_{12,3}(\text{Fe})$	1640,475 (5)	0,0621 (21)			
$\gamma_{8,2}(\text{Fe})$	1771,3567 (39)	15,45 (4)	M1+E2		
$\gamma_{3,1}(\text{Fe})$	1810,757 (4)	0,639 (3)	M1+E2		
$\gamma_{9,2}(\text{Fe})$	1963,741 (8)	0,706 (4)	M1+E2		
$\gamma_{10,2}(\text{Fe})$	2015,2147 (47)	3,017 (14)	M1+E2		
$\gamma_{11,2}(\text{Fe})$	2034,7907 (47)	7,743 (13)	M1+E2	2,7	
$\gamma_{4,1}(\text{Fe})$	2113,135 (5)	0,376 (3)	M1+E2		
$\gamma_{12,2}(\text{Fe})$	2212,9437 (39)	0,385 (5)	M1+E2	4,1	
$\gamma_{5,1}(\text{Fe})$	2276,1310 (36)	0,1181 (40)	E2	4,5	
$\gamma_{15,2}(\text{Fe})$	2373,242 (30)	0,078 (6)			
$\gamma_{6,1}(\text{Fe})$	2523,09 (11)	0,063 (4)	M1+E2	4,8	
$\gamma_{7,1}(\text{Fe})$	2598,500 (4)	16,969 (40)	M1+E2	5,2	
$\gamma_{3,0}(\text{Fe})$	2657,527 (4)	0,0195 (20)	[E2]	6,3	
$\gamma_{8,1}(\text{Fe})$	3009,645 (4)	1,039 (19)	M1+E2	6,8	
$\gamma_{9,1}(\text{Fe})$	3202,029 (8)	3,205 (13)	M1+E2	7,8	

	Energy keV	P <sub>γ+ce</sub> × 100	Multipolarity	α <sub>T</sub> (10 <sup>-4</sup> )	α <sub>π</sub> (10 <sup>-4</sup> )
γ <sub>10,1</sub> (Fe)	3253,5030 (44)	7,877 (30)	E2	8,9	
γ <sub>11,1</sub> (Fe)	3273,079 (4)	1,856 (9)	M1+E2	8	
γ <sub>6,0</sub> (Fe)	3369,86 (11)	0,0103 (8)	E2	9,6	
γ <sub>12,1</sub> (Fe)	3451,232 (4)	0,943 (6)	E2	9,7	
γ <sub>13,1</sub> (Fe)	3548,05 (6)	0,1958 (16)	M1+E2	9	
γ <sub>14,1</sub> (Fe)	3600,83 (40)	0,0167 (5)			
γ <sub>15,1</sub> (Fe)	3611,53 (3)	0,00841 (40)	[E2]		10,3

### 3 Atomic Data

#### 3.1 Fe

$$\begin{aligned}\omega_K &: 0,355 \quad (4) \\ \bar{\omega}_L &: 0,0060 \quad (6) \\ n_{KL} &: 1,447 \quad (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
Kα <sub>2</sub>	6,39091	51,07
Kα <sub>1</sub>	6,40391	100
Kβ <sub>1</sub>	7,05804	{
Kβ <sub>5</sub> <sup>''</sup>	7,1083	} 20,67
X <sub>L</sub>		
Lℓ	0,615	
Lβ	– 0,792	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	5,370 – 5,645	100
KLX	6,158 – 6,400	27,4
KXY	6,926 – 7,105	1,87
Auger L	0,510 – 0,594	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Fe)	0,510 - 0,594	111,8 (8)
e <sub>AK</sub>	(Fe)		46,04 (30)
	KLL	5,370 - 5,645	}
	KLX	6,158 - 6,400	}
	KXY	6,926 - 7,105	}
$\beta_{0,2}^+$	max:	1458,9 (20)	18,29 (16)
$\beta_{0,2}^+$	avg:	631,2 (9)	
$\beta_{0,4}^+$	max:	584,1 (20)	0,0086 (22)
$\beta_{0,4}^+$	avg:	247,1 (9)	
$\beta_{0,5}^+$	max:	421,1 (20)	1,04 (2)
$\beta_{0,5}^+$	avg:	178,7 (8)	
$\beta_{0,6}^+$	max:	174 (2)	0,000006 (20)
$\beta_{0,6}^+$	avg:	76,7 (8)	
$\beta_{0,7}^+$	max:	98,7 (20)	0,0080 (7)
$\beta_{0,7}^+$	avg:	45,3 (9)	
$\beta_{0,1}^+$	max:	2697,2 (20)	0,25 (17)
$\beta_{0,1}^+$	avg:	1205,8 (10)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Fe)	0,615 — 0,792	0,581 (17)
XK $\alpha_2$	(Fe)	6,39091	7,53 (10)
XK $\alpha_1$	(Fe)	6,40391	14,75 (17)
XK $\beta_1$	(Fe)	7,05804	}
XK $\beta_5''$	(Fe)	7,1083	}

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{11,8}(\text{Fe})$	263,41 (10)	0,0234 (20)
$\gamma_{8,7}(\text{Fe})$	411,38 (8)	0,0269 (23)
$\gamma_{8,6}(\text{Fe})$	486,54 (11)	0,058 (3)
$\gamma^\pm$	511	39,21 (22)
$\gamma_{10,7}(\text{Fe})$	655,0 (8)	0,038 (8)
$\gamma_{11,7}(\text{Fe})$	674,7 (8)	0,035 (5)
$\gamma_{8,5}(\text{Fe})$	733,5085 (23)	0,191 (4)
$\gamma_{7,3}(\text{Fe})$	787,7391 (23)	0,310 (4)
$\gamma_{1,0}(\text{Fe})$	846,7638 (19)	99,9399 (23)
$\gamma_{12,7}(\text{Fe})$	852,78 (5)	0,049 (3)
$\gamma_{8,4}(\text{Fe})$	896,503 (7)	0,0704 (22)
$\gamma_{10,5}(\text{Fe})$	977,363 (4)	1,422 (7)
$\gamma_{11,5}(\text{Fe})$	996,939 (5)	0,116 (6)
$\gamma_{5,2}(\text{Fe})$	1037,8333 (24)	14,03 (5)
$\gamma_{9,4}(\text{Fe})$	1089,03 (24)	0,054 (4)
$\gamma_{10,4}(\text{Fe})$	1140,356 (7)	0,132 (4)
$\gamma_{11,4}(\text{Fe})$	1159,933 (8)	0,088 (3)
$\gamma_{12,5}(\text{Fe})$	1175,0878 (22)	2,249 (9)
$\gamma_{8,3}(\text{Fe})$	1198,78 (20)	0,044 (3)
$\gamma_{2,1}(\text{Fe})$	1238,2736 (22)	66,41 (16)
$\gamma_{13,5}(\text{Fe})$	1272,2 (6)	0,0202 (8)
$\gamma_{15,5}(\text{Fe})$	1335,380 (29)	0,1228 (16)
$\gamma_{7,2}(\text{Fe})$	1360,196 (4)	4,280 (13)
$\gamma_{10,3}(\text{Fe})$	1442,75 (8)	0,180 (4)
$\gamma_{11,3}(\text{Fe})$	1462,34 (12)	0,0778 (9)
$\gamma_{12,3}(\text{Fe})$	1640,450 (5)	0,0621 (21)
$\gamma_{8,2}(\text{Fe})$	1771,327 (3)	15,45 (4)
$\gamma_{3,1}(\text{Fe})$	1810,726 (4)	0,639 (3)
$\gamma_{9,2}(\text{Fe})$	1963,703 (11)	0,706 (4)

	Energy keV	Photons per 100 disint.
$\gamma_{10,2}(\text{Fe})$	2015,176 (5)	3,017 (14)
$\gamma_{11,2}(\text{Fe})$	2034,752 (5)	7,741 (13)
$\gamma_{4,1}(\text{Fe})$	2113,092 (6)	0,376 (3)
$\gamma_{12,2}(\text{Fe})$	2212,898 (3)	0,385 (5)
$\gamma_{5,1}(\text{Fe})$	2276,36 (16)	0,118 (4)
$\gamma_{15,2}(\text{Fe})$	2373,7 (4)	0,078 (6)
$\gamma_{6,1}(\text{Fe})$	2523,0 (8)	0,063 (4)
$\gamma_{7,1}(\text{Fe})$	2598,438 (4)	16,96 (4)
$\gamma_{3,0}(\text{Fe})$	2657,4 (8)	0,0195 (20)
$\gamma_{8,1}(\text{Fe})$	3009,559 (4)	1,038 (19)
$\gamma_{9,1}(\text{Fe})$	3201,930 (11)	3,203 (13)
$\gamma_{10,1}(\text{Fe})$	3253,402 (5)	7,87 (3)
$\gamma_{11,1}(\text{Fe})$	3272,978 (6)	1,855 (9)
$\gamma_{6,0}(\text{Fe})$	3369,69 (30)	0,0103 (8)
$\gamma_{12,1}(\text{Fe})$	3451,119 (4)	0,942 (6)
$\gamma_{13,1}(\text{Fe})$	3547,93 (6)	0,1956 (16)
$\gamma_{14,1}(\text{Fe})$	3600,71 (40)	0,0167 (5)
$\gamma_{15,1}(\text{Fe})$	3611,8 (8)	0,0084 (4)

## 6 Main Production Modes

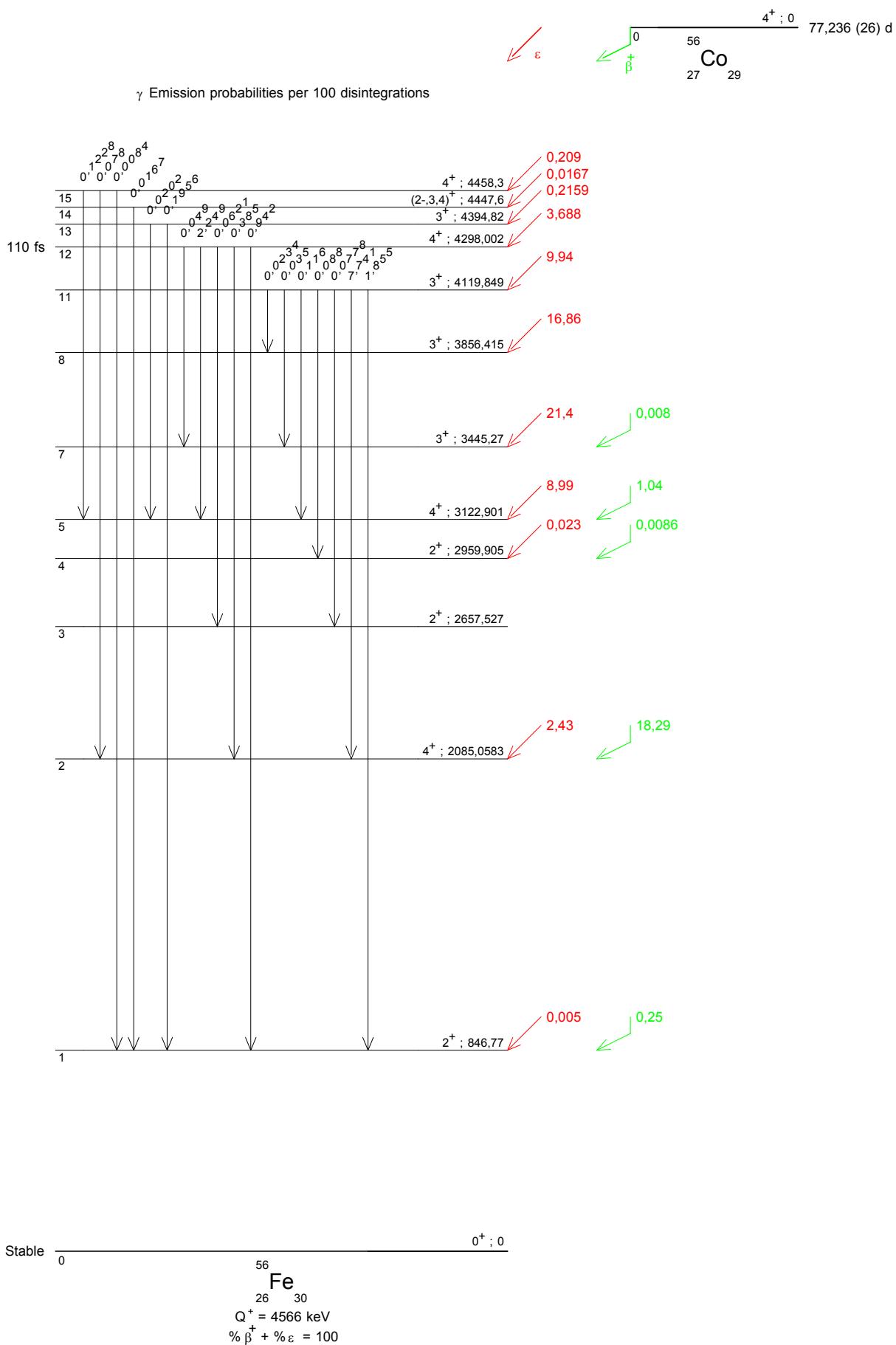
$$\left\{ \begin{array}{l} \text{Fe} - 56(\text{p},\text{n})\text{Co} - 56 \\ \text{Possible impurities : Co} - 57, \text{Co} - 58 \end{array} \right.$$

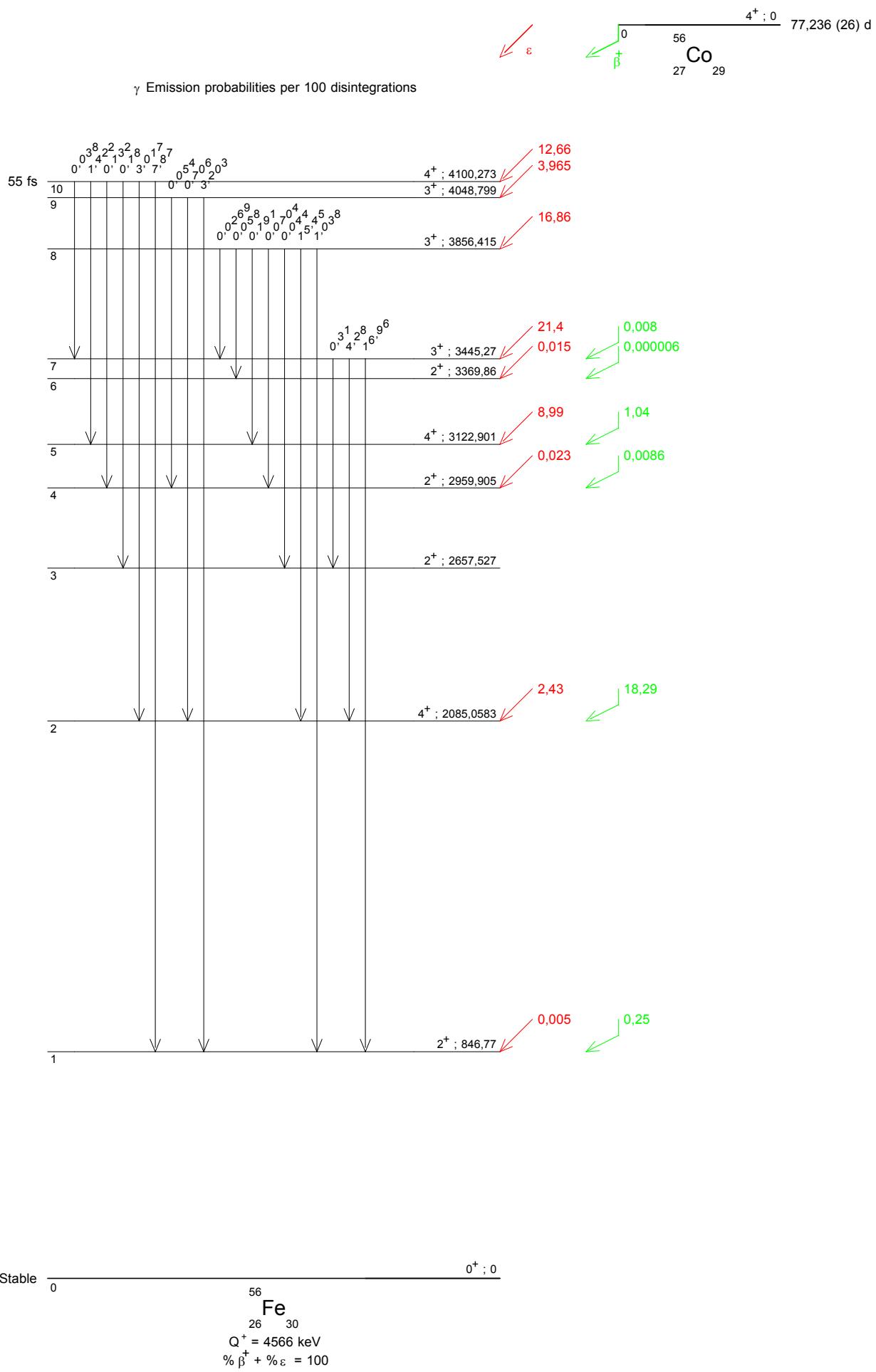
## 7 References

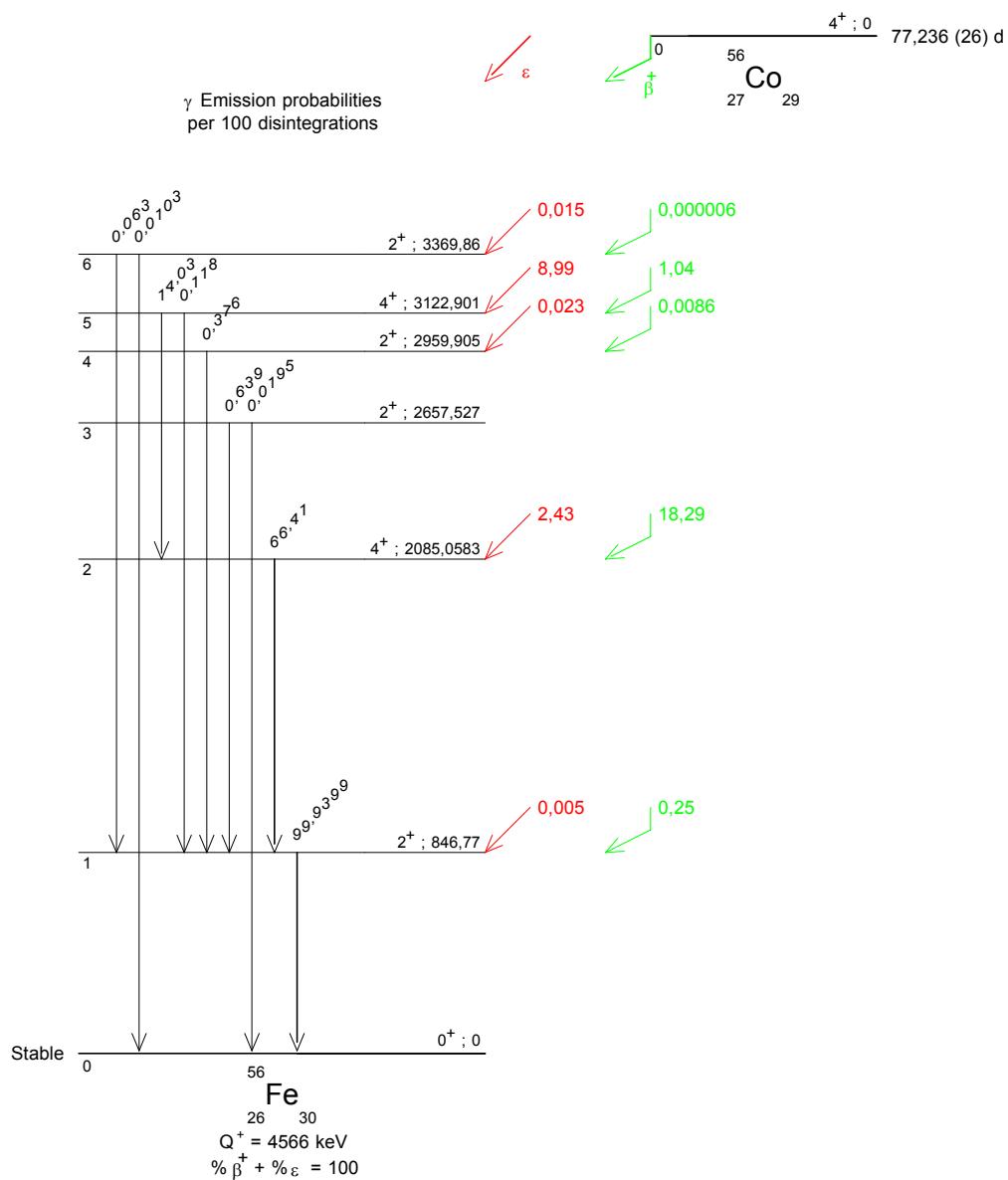
- W. H. BURGUS, G.A. COWAN, J.W. HADLEY, W. HESS, T. SHULL, M.L. STEVENSON, H.F. YORK. Phys. Rev. 95 (1954) 750  
(Half-life.)
- H. W. WRIGHT, E.I. WYATT, S.A. REYNOLDS, W.S. LYON, T.H. HANDLEY. Nucl. Sci. Eng. 2 (1957) 427  
(Half-life.)
- H. PETTERSSON, O. BERGMAN, C. BERGMAN. Ark. Fysik 29 (1965) 423  
(Relative gamma-ray emission probabilities.)
- K. W. DOLAN, D.K. McDANIELS, D.O. WELLS. Phys. Rev. 148 (1966) 1151  
(Relative gamma-ray emission probabilities.)
- M. HUGUET, H. FOREST, C. YTHIER. Comp. Rend. Acad. Sci. (Paris) 263B (1966) 1342  
(Relative gamma-ray emission probabilities.)
- R. SCHÖNEBERG, M. SCHUMACHER, A. FLAMMERSFELD. Z. Physik 192 (1966) 305  
(Relative gamma-ray emission probabilities.)
- P.H. BARKER, R.D. CONNOR. Nucl. Instrum. Methods 57 (1967) 147  
(Relative gamma-ray emission probabilities.)
- C. CHASMAN, R.A. RISTINEN. Phys. Rev. 159 (1967) 915  
(Relative gamma-ray emission probabilities.)
- R.L. AUBLE, W.C. McHARRIS, W.H. KELLY. Nucl. Phys. A91 (1967) 225  
(Relative gamma-ray emission probabilities.)
- A.H. SHER, B.D. PATE. Nucl. Phys. A112 (1968) 85  
(Relative gamma-ray emission probabilities.)

- B.H. ARMITAGE, A.T.G. FERGUSON, G.C. NEILSON, W.D.N. PRITCHARD. Nucl. Phys. A133 (1969) 241  
(Relative gamma-ray emission probabilities.)
- G. AUBIN, J. BARRETTE, M. BARRETTE, S. MONARO. Nucl. Instrum. Methods 76 (1969) 93  
(Relative gamma-ray emission probabilities.)
- H.L. SCOTT, D.M. VAN PATTER. Phys. Rev. 184 (1969) 1111  
(Relative gamma-ray emission probabilities.)
- M.E. PHELPS, D.G. SARANTITES, W.G. WINN. Nucl. Phys. A149 (1970) 647  
(Relative gamma-ray emission probabilities.)
- R.J. GHERKE, J.E. CLINE, R.L. HEATH. Nucl. Instrum. Methods 91 (1971) 349  
(Relative gamma-ray emission probabilities.)
- A.-M. GENEST. Comp. Rend. Acad. Sci. (Paris) 272 (1971) 863  
(Relative gamma-ray emission probabilities.)
- D.C. CAMP, G.L. MEREDITH. Nucl. Phys. A166 (1971) 349  
(Relative gamma-ray emission probabilities.)
- B.P. SINGH, H.C. EVANS. Nucl. Instrum. Methods 97 (1971) 475  
(Relative gamma-ray emission probabilities.)
- J.F. EMERY, S.A. REYNOLDS, E.I. WYATT, G.I. GLEASON. Nucl. Sci. Eng. 48 (1972) 319  
(Half-life.)
- B.F. PETERMAN, S. HONTZEAS, R.G. RYSTEPHANICK. Nucl. Instrum. Methods 104 (1972) 461  
(Relative gamma-ray emission probabilities.)
- S.G. BOYDELL. Doctoral Thesis, Univ. of Melbourne (1974)  
(Relative gamma-ray emission probabilities.)
- P.J. CRESSY. Nucl. Sci. Eng. 55 (1974) 450  
(Half-life.)
- S. HOFMANN. Z. Physik 270 (1974) 133  
(Relative gamma-ray emission probabilities.)
- T. KATOU. Nucl. Instrum. Methods 124 (1975) 257  
(Relative gamma-ray emission probabilities.)
- G.J. MACCALLUM, G.E. COOTE. Nucl. Instrum. Methods 124 (1975) 309  
(Relative gamma-ray emission probabilities.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, M.A. LISTENGARTEN. At. Data Nucl. Data Tables 18 (1976) 433  
(Theoretical conversion coefficients.)
- R.J. GEHRKE, R.G. HELMER, R.C. GREENWOOD. Nucl. Instrum. Methods 147 (1977) 405  
(Relative gamma-ray emission probabilities.)
- M.E. ANDERSON. Nucl. Sci. Eng. 62 (1977) 511  
(Half-life.)
- F.P. LARKINS. At. Data Nucl. Data Tables 20 (1977) 313  
(Alpha emission energies)
- F. LAGOUCHE, J. LEGRAND, C. BAC. Int. J. Appl. Radiat. Isotop. 29 (1978) 269  
(Half-life.)
- M. HAUTALA, A.A. ANTTILA, J. KEINONEN. Nucl. Instrum. Methods 150 (1978) 599  
(Relative gamma-ray emission probabilities.)
- P. SCHLÜTER, G. SOFF. At. Data Nucl. Data Tables 24 (1979) 509  
(Internal-pair formation coefficient.)
- N.M. STEWART, A.M. SHABAN. Z. Physik A296 (1980) 165  
(Relative gamma-ray emission probabilities.)
- Y. YOSHIZAWA, Y. IWATA, T. KAKU, T. KATO, J.-Z. RUAN, T. KOJIMA, Y. KAWADA. Nucl. Instrum. Methods 174 (1980) 109  
(Precise relative gamma-ray emission probabilities.)
- A.K. SHARMA, R. KAUR, H.R. VERMA, K.K. SURI, P.N. TREHAN. Proc. Indian Natl. Sci. Acad 46A (1980) 181  
(Relative gamma-ray emission probabilities.)
- A. GRÜTTER. Int. J. Appl. Radiat. Isotop. 33 (1982) 533  
(Relative gamma-ray emission probabilities.)
- W. L. ZIJP. Report ECN FYS/RASA-85/19 (1985)  
(Discrepant data. Limited Relative Statistical Weight Method.)
- E.R. COHEN, B.N. TAYLOR. Rev. Mod. Phys. 59 (1987) 1121  
(The 1986 Adjustment of the Fundamental Physical Constants.)
- G. WANG, E.K. WARBURTON, D.E. ALBURGER. Nucl. Instrum. Methods A272 (1988) 791  
(Precise gamma-ray transitions energies used in evaluation in reference 2000He14.)

- D.E. ALBURGER, E.K. WARBURTON, Z. TAO. Phys. Rev. C40 (1989) 2789  
(Half-life.)
- H. SCHRADER. Appl. Rad. Isotopes 40 (1989) 381  
(Half-life.)
- D.E. ALBURGER, E.K. WARBURTON, Z. TAO. Phys. Rev. C40 (1989) 2891  
(Relative gamma-ray emission probabilities.)
- K. T. LESKO, E. B. NORMAN, B. SUR, R.-M. LARIMER. Phys. Rev. C40 (1989) 445  
(Half-life.)
- D.E. ALBURGER, C. WESSELBORG. Phys. Rev. C42 (1990) 2728  
(Half-life.)
- R.A. MEYER. Fizika 22 (1990) 153  
(Energies and Relative gamma-ray emission probabilities.)
- M.F. JAMES, R.W. MILLS, D.R. WEAVER. UK AEA Report, Winfrith Technology Centre AE-RS-1082 (1991)  
("Normalised Residuals" technique for statistical analysis of data.)
- M.U. RAJPUT, T.D. MACMAHON. Nucl. Instrum. Methods Phys. Res. A312 (1992) 289  
("Rajeval" technique for statistical analysis of data.)
- E.FUNCK, U. SCHÖTZIG, M.J. WOODS, J.P. SEPHTON, A.S. MUNSTER, J.C.J. DEAN, P. BLANCHIS, B. CHAUVENET. Nucl. Instrum. Methods Phys. Res. A312 (1992) 334  
(Half-life.)
- U.SCHÖTZIG, H.SCHRADER, K.DEBERTIN. Proc. Int. Conf. Nuclear Data for Science and Technology, Jülich, Germany (1992) 582  
(Gamma-ray emission intensities)
- E. SCHÖNFELD, F. CHU, E. BROWNE. (1997)  
(The Program EC Capture for Calculating electron capture probabilities PK, PL, PM, and PN.)
- E. SCHÖNFELD, G. RODLOFF. Report PTB-6.11-98-1 (October) (1998)  
(Tables of the energies of K-Auger electrons for elements with atomic numbers in the range from Z=11 to Z=100.)
- JUNDE HUO. Nucl. Data Sheets 86 (1999) 315  
(Decay scheme)
- E. SCHÖNFELD, G. RODLOFF. Report PTB-6.11-99-1 (February) (1999)  
(Energies and relative emission probabilities of K x-rays for elements with atomic numbers in the range from Z=5 to Z=100.)
- R.G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Gamma energy)
- S.RAMAN, ET AL.. Nucl. Instrum. Methods Phys. Res. A454 (2000) 389  
(Gamma-ray emission intensities)
- C.M.BAGLIN, ET AL.. Nucl. Instrum. Methods Phys. Res. A481 (2002) 365  
(Intensity correction factor for Camp et al. Data)
- E. SCHÖNFELD, H. JANSSEN. (2002)  
(EMISSION (v. 3.04), a computer program for calculating emission probabilities of X-rays and Auger electrons.)
- G.L.MOLNAR, ZS.RÉVAY, T.BELGYA. Proc.11th Int. Symp. On Capture gamma-ray Spectroscopy, 2-6 Sep 2002, Pruhonice, Ed. J.Kvasil, P.Cejnar, M.Krticka. World Scientific (2003) 522  
(Gamma-ray emission intensities)
- G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)











## 1 Decay Scheme

Co-60 disintegrates by beta minus emissions to excited levels of Ni-60.

*Le cobalt 60 se désintègre par émission bêta moins vers des niveaux excités de nickel 60.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{60}\text{Co}) &: 5,2710 \quad (8) \quad \text{a} \\ Q^-(^{60}\text{Co}) &: 2823,07 \quad (21) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,3}^-$	317,32 (21)	99,88 (3)	Allowed	7,51
$\beta_{0,2}^-$	664,46 (21)	0,002	Unique 2nd Forbidden	
$\beta_{0,1}^-$	1490,56 (21)	0,12 (3)	Unique 2nd Forbidden	14,7

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$ $(10^{-4})$	$\alpha_L$ $(10^{-4})$	$\alpha_T$ $(10^{-4})$	$\alpha_\pi$ $(10^{-5})$
$\gamma_{3,2}(\text{Ni})$	347,14 (7)	0,0075 (4)	[E2]	49,9 (15)	5,03 (15)	55,7 (17)	
$\gamma_{2,1}(\text{Ni})$	826,10 (3)	0,0076 (8)	M1+45% E2	3,0 (4)	0,291 (17)	3,4 (4)	
$\gamma_{3,1}(\text{Ni})$	1173,240 (3)	99,85 (3)	E2(+M3)	1,51 (7)	0,148 (4)	1,68 (4)	0,62 (7)
$\gamma_{1,0}(\text{Ni})$	1332,508 (4)	99,9988 (2)	E2	1,15 (5)	0,113 (3)	1,28 (5)	3,4 (4)
$\gamma_{2,0}(\text{Ni})$	2158,61 (3)	0,0012 (2)	E2	0,445 (14)	0,043 (2)	0,495 (15)	
$\gamma_{3,0}(\text{Ni})$	2505,748 (5)	0,0000020 (4)	E4	0,780 (3)	0,076 (3)	0,86 (3)	

### 3 Atomic Data

#### 3.1 Ni

$\omega_K$  : 0,421 (4)  
 $\bar{\omega}_L$  : 0,0084 (4)  
 $n_{KL}$  : 1,388 (4)

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	7,46097	51,24
K $\alpha_1$	7,47824	100
K $\beta_3$	8,2647	}
K $\beta_5''$	8,3287	}
		20,84
X <sub>L</sub>		
L $\ell$	0,74	
L $\gamma$	– 0,94	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	6,26 – 6,54	100
KLX	7,20 – 7,47	27,6
KXY	8,10 – 8,32	1,9
Auger L	0,7 – 0,9	329

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Ni)	0,7 - 0,9	0,0392 (12)
e <sub>AK</sub>	(Ni)		0,0154 (5)
	KLL	6,26 - 6,54	}
	KLX	7,20 - 7,47	}
	KXY	8,10 - 8,32	}
ec <sub>3,1 K</sub>	(Ni)	1164,895 (3)	0,0151 (9)
ec <sub>1,0 K</sub>	(Ni)	1324,157 (6)	0,0115 (6)
ec <sub>1,0 <math>\alpha</math></sub>	(Ni)	310,51 (1)	0,0034 (4)
$\beta_{0,3}^-$	max:	317,32 (21)	99,88 (3)
$\beta_{0,3}^-$	avg:	95,6 (1)	
$\beta_{0,2}^-$	max:	664,46 (21)	0,002
$\beta_{0,2}^-$	avg:	274,8 (1)	
$\beta_{0,1}^-$	max:	1490,56 (21)	0,12 (3)
$\beta_{0,1}^-$	avg:	625,6 (1)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Ni)	0,74 — 0,94	0,0002
XK $\alpha_2$	(Ni)	7,46097	0,00334 (12) }
XK $\alpha_1$	(Ni)	7,47824	0,0065 (3) }
XK $\beta_3$	(Ni)	8,2647 }	
XK $\beta_1$	(Ni)		0,00136 (5) K' $\beta_1$
XK $\beta_5''$	(Ni)	8,3287 }	

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{3,2}(\text{Ni})$	347,14 (7)	0,0075 (4)
$\gamma_{2,1}(\text{Ni})$	826,10 (3)	0,0076 (8)
$\gamma_{3,1}(\text{Ni})$	1173,228 (3)	99,85 (3)
$\gamma_{1,0}(\text{Ni})$	1332,492 (4)	99,9826 (6)
$\gamma_{2,0}(\text{Ni})$	2158,57 (3)	0,0012 (2)
$\gamma_{3,0}(\text{Ni})$	2505,692 (5)	0,0000020 (4)

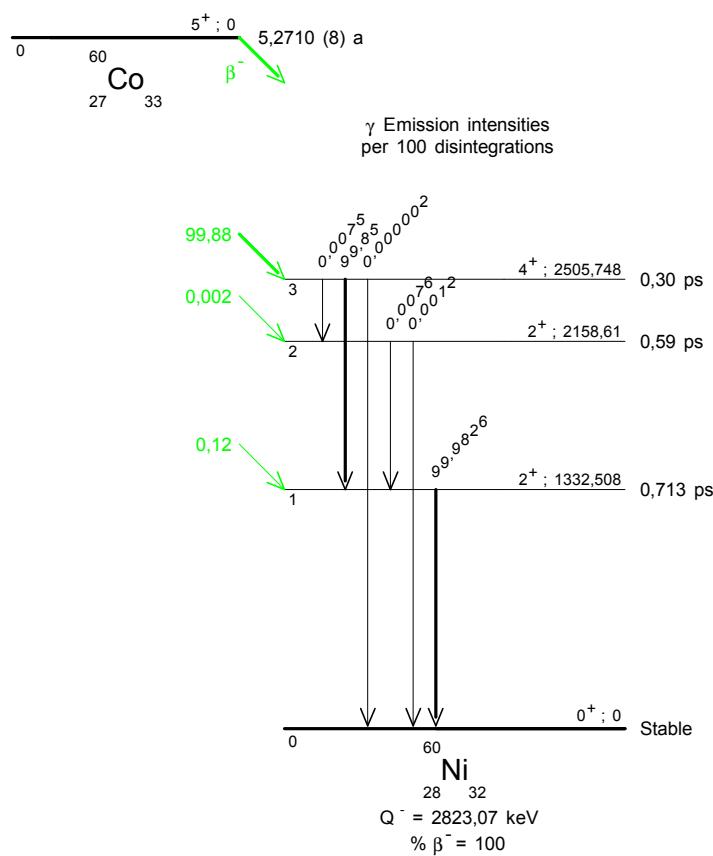
## 6 Main Production Modes

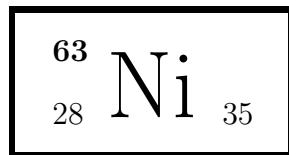
$$\left\{ \begin{array}{l} \text{Co} - 59(\text{n},\gamma)\text{Co} - 60 \quad \sigma : 18,7 \text{ (5) barns} \\ \text{Possible impurities : None.} \end{array} \right.$$

## 7 References

- J.J.LIVINGOOD, G.T.SEABORG. Rev. Mod. Phys. 12 (1940) 30  
(Half-life)
- E.SEGRÈ, C.E.WEIGAND. Phys. Rev. 75 (1949) 39  
(Half-life)
- G.L.BROWNELL, C.J.MALETSKOS. Phys. Rev. 80 (1950) 1102  
(Half-life)
- W.K.SINCLAIR, A.F.HOLLOWAY. Nature 167 (1951) 365  
(Half-life)
- J.TOBAILEM. Compt. Rend. 233 (1951) 1360  
(Half-life)
- J.KASTNER, G.N.WHYTE. Phys. Rev. 91 (1953) 332  
(Half-life)
- E.E.LOCKETT, R.H.THOMAS. Nucleonics 11,3 (1953) 14  
(Half-life)
- G.L.KEISTER, F.H.SCHMIDT. Phys. Rev. 93 (1954) 140  
(Beta emission probabilities)
- J.L.WOLFSON. Can. J. Phys. 33 (1955) 886  
(Gamma emission probabilities)
- J.L.WOLFSON. Can. J. Phys. 34 (1956) 256  
(Beta emission probabilities)
- K.W.GEIGER. Phys. Rev. 105 (1957) 1593  
(Half-life)
- J.P.KEENE, L.A.MACKENKIE, C.W.GILBERT. Phys. in Med. Biol. 2 (1958) 360  
(Half-life)
- D.C.CAMP, L.M.LANGER, D.R.SMITH. Phys. Rev. 123 (1961) 241  
(Beta emission probabilities)
- S.G.GORBICS, W.E.KUNZ, A.E.NASH. Nucleonics 21,1 (1963) 63  
(Half-life)
- S.C.ANSPACH, L.M.CAVALLO, S.B.GARFINKEL, J.M.R.HUTCHINSON, C.N.SMITH. NP-15663 (1965)  
(Half-life)
- F.LAGOUTINE, Y.LE GALLIC, J.LEGRAND. Int. J. Appl. Radiat. Isotop. 19 (1968) 475  
(Half-life)

- H.H.HANSEN, A.SPERNOL. Z. Phys. 209 (1968) 111  
(Beta emission probabilities)
- J.R.VAN HISE, D.C.CAMP. Phys. Rev. Lett. 23 (1969) 1248  
(Gamma emission probabilities)
- F.RAUCH, D.M.VAN PATTER, P.F.HINRICHSEN. Nucl. Phys. A124 (1969) 145  
(Gamma-ray energies)
- E.J.HOFFMAN, D.G.SARANTITES. Phys. Rev. 181 (1969) 1597  
(Gamma-ray energies)
- S.RAMAN. Z. Phys. 228 (1969) 387  
(Beta emission probabilities)
- W.R.DIXON, R.S.STOREY. Can. J. Phys. 48 (1970) 483  
(Gamma-ray emission energies, Gamma-ray emission probabilities)
- J.LEGRAND, C.CLEMENT. Int. J. Appl. Radiat. Isotop. 23 (1972) 225  
(Gamma-ray emission probabilities)
- G.HARBOTTLE, C.KOehler, R.WITHNELL. Rev. Sci. Instrum. 44 (1973) 55  
(Half-life)
- S.RAMAN, N.B.GOVE. Phys. Rev. C7 (1973) 1995  
(lg ft)
- B.ERLANDSSON, J.LYTTKENS, A.MARCINKOWSKI. Z. Phys. A272 (1975) 67  
(Gamma-ray energies)
- D.C.CAMP, J.R.VAN HISE. Phys. Rev. C14 (1976) 261  
(Gamma-ray energies and emission probabilities)
- M.A.LONE, C.B.BIGHAM, J.S.FRASER, H.R.SCHNEIDER, T.K.ALEXANDER, A.J.FERGUSON, A.B.MCDONALD. Nucl. Instrum. Methods 143 (1977) 33  
(Gamma emission probabilities)
- R.VANINBROUKX, G.GROSSE. Int. J. Appl. Radiat. Isotop. 27 (1977) 727  
(Half-life)
- M.FUJISHIRO. J. Nucl. Sci.Technol. 15 (1978) 237  
(Gamma emission probabilities)
- P.SCHLÜTER, G.SOFF. At. Data. Nucl. Data Tables 24 (1979) 509  
(Internal Pair Creation Coefficient)
- H.HOUTERMANS, O.MILOSEVIC, F.REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life)
- A.RYTZ. NBS-Special publication 626 (1982) 32  
(Half-life)
- A.R.RUTLEDGE, L.V.SMITH, J.S.MERRITT. Nucl. Instrum. Methods 206 (1983) 211  
(Half-life)
- K.F.WALZ, K.DEBERTIN, H.SCHRADER. Int. J. Appl. Radiat. Isotop. 34 (1983) 1191  
(Half-life)
- H.H.HANSEN. European App.Res.Rept.Nucl.Sci.Technol. 6, 4 (1985) 777  
(ICC)
- M.M.KING. Nucl. Data Sheets 48 (1986) 25  
(Spin and Parity, Multipolarities)
- S.SEUTHE, H.W.BECKER, C.ROLFS, S.SCHMIDT, H.P.TRAUTVETTER, R.W.KAVANAGH, F.B.WAANDERS. Nucl. Instrum. Methods Phys. Res. A272 (1988) 814  
(Gamma emission probabilities)
- M.P.UNTERWEGER, D.D.HOPPES, F.J.SCHIMA. Nucl. Instrum. Methods Phys. Res. A312 (1992) 349  
(Half-life)
- E.SCHÖNFELD, H.JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic Data)
- R.G.HELMER, C.VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Gamma ray energies)
- M.P.UNTERWEGER. Appl. Rad. Isotopes 56 (2002) 125  
(Half-life)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C. W. NESTOR JR., P.O. TIKKANEN, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Theoretical ICC)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)





## 1 Decay Scheme

Ni-63 decays by beta minus emission to the Cu-63 fundamental level.

*Le nickel 63 se désintègre par émission bêta moins vers le niveau fondamental de cuivre 63.*

## 2 Nuclear Data

$T_{1/2}(^{63}\text{Ni})$	:	98,7	(24)	a
$Q^-(^{63}\text{Ni})$	:	66,980	(15)	keV

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,0}^-$	66,980 (15)	100	Allowed	6,7

## 3 Electron Emissions

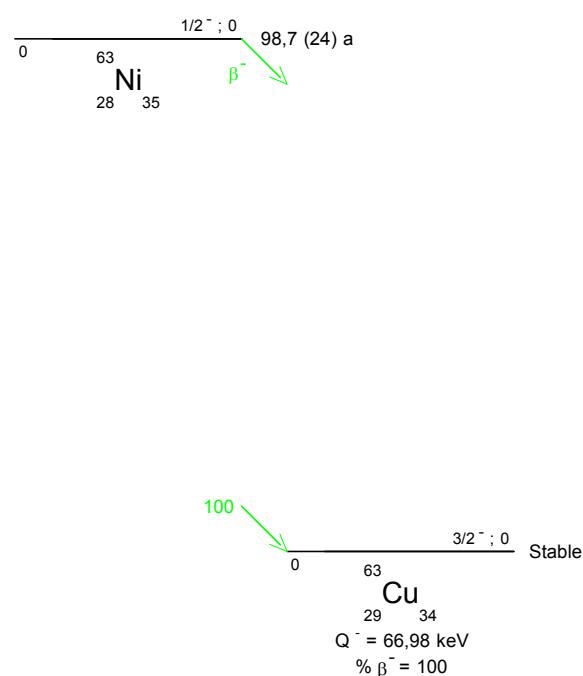
	Energy keV	Electrons per 100 disint.
$\beta_{0,0}^-$	max: 66,980 (15)	100
$\beta_{0,0}^-$	avg: 17,434 (4)	

## 4 Main Production Modes

$$\left\{ \begin{array}{l} \text{Ni} - 62(\text{n},\gamma)\text{Ni} - 63 \quad \sigma : 14,2 (3) \text{ barns} \\ \text{Possible impurities : Ni} - 57, \text{Ni} - 59, \text{Ni} - 65, \text{Ni} - 66 \end{array} \right.$$

## 5 References

- A. R. WILSON A. R.. Phys. Rev. 79 (1950) 1032-1033  
(Half-life)
- A. R. BROSI, BORKOWSKI C. J., CONN E. E., GRIESS JR J. C.. Phys. Rev. 82 (1951) 391-395  
(Half-life)
- C.C.MCMULLEN, PATE B. D., TOMLINSON R. H., YAFFE L.. Can. J. Chem. 33 (1956) 1742-1746  
(Half-life)
- IVOR L. PREISS, R. W. FINK, B. L. ROBINSON. J. Inorg. Nucl. Chem. 4 (1957) 233-236  
(End-point energy)
- D.L.HORROCK, HARKNESS A. L.. Phys. Rev. 125 (1962) 1619-1620  
(Half-life)
- S. T. HSUE, L. M. LANGER, E. H. SPEJEWESKI, S. M. TANG. Nucl. Phys. 80 (1966) 657  
(End-point energy)
- I. L. BARNES, S. B. GARFINKEL, W. B. MANN. Int. J. Appl. Radiat. Isotop. 22 (1971) 777  
(Half-life)
- D. W. HETHERINGTON, R. L. GRAHAM, M. A. LONE, J. S. GEIGER, G. E. LEE-WHITING. Phys. Rev. C36 (1987) 1504  
(End-point energy)
- H. KAWAKAMI, S. KATO, T. OHSHIMA, C. ROSENFIELD, H. SAKAMOTO, T. SATO, S. SHIBATA, J. SHIRAI, Y. SUGAYA, T. SUZUKI, K.TAKAHASHI, T. TSUKAMOTO, K UENO, K UKAI, S. WILSON, Y. YONEZAWA. Phys. Lett. 287B (1992) 45  
(End-point energy)
- T. OHSHIMA, H. SAKAMOTO, T. SATO, J. SHIRAI, T. TSUKAMOTO, Y. SUGAYA, K. TAKAHASHI, T. SUZUKI, C. ROSENFIELD, S. WILSON, K. UENO, Y. YONEZAWA, H. KAWAKAMI. Phys. Rev. D47 (1993) 4840  
(End-point energy)
- R. COLLÉ, B. Z. ZIMMERMAN. Appl. Radiat. Isot 47 (1996) 677  
(Half-life)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Phys. Instr. Meth. Phys. Res. A369 (1996) 527  
(Atomic data)
- E. HOLZSCHUH, W. KUNDIG, L. PALERMO, H. STUSSI, P. WENK. Phys. Lett. 451B (1999) 247  
(End-point energy)
- G. AUDI, A. H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)







## 1 Decay Scheme

Zn-65 disintegrates by electron capture to the 1115 keV excited level and by electron capture and beta plus emission to the ground state level of Cu-65.

*Le Zn-65 se désintègre par capture électronique vers le niveau excité de 1115 keV du Cu-65 et par capture électronique et émission bêta plus vers le niveau fondamental.*

## 2 Nuclear Data

$T_{1/2}(^{65}\text{Zn})$	:	244,01	(9)	d
$Q^+(^{65}\text{Zn})$	:	1352,1	(3)	keV

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_{M+}$
$\epsilon_{0,2}$	236,5 (3)	50,23 (11)	Allowed	5,89	0,8794 (17)	0,1027 (16)	0,0179
$\epsilon_{0,0}$	1352,1 (3)	48,35 (11)	Allowed	7,46	0,8853 (16)	0,0977 (15)	0,017

### 2.2 $\beta^+$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,0}^+$	329,9 (3)	1,421 (7)	Allowed	7,46

## 2.3 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$ $(10^{-3})$	$\alpha_L$ $(10^{-3})$	$\alpha_T$ $(10^{-3})$
$\gamma_{2,1}(\text{Cu})$	344,95 (20)	0,00256 (18)	[E2]	5,55 (17)	0,569 (19)	6,20 (19)
$\gamma_{1,0}(\text{Cu})$	770,64 (9)	0,00269 (22)	M1+0,9%E2	0,345 (10)	0,0343 (10)	0,384 (12)
$\gamma_{2,0}(\text{Cu})$	1115,549 (2)	50,23 (11)	M1+16,0%E2	0,166 (6)	0,0162 (5)	0,184 (7)

## 3 Atomic Data

### 3.1 Cu

$$\begin{aligned}\omega_K &: 0,454 \quad (4) \\ \bar{\omega}_L &: 0,0097 \quad (4) \\ n_{KL} &: 1,357 \quad (4)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	8,02792	51,33
K $\alpha_1$	8,04787	100
K $\beta_1$	8,90539	{}
K $\beta_5''$	8,9771	{}
		21,05
X <sub>L</sub>		
L $\ell$	0,811	
L $\alpha$	0,929 – 0,93	
L $\beta$	0,932 – 1,022	

#### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	6,76 – 7,12	100
KLX	7,76 – 8,05	27,8
KXY	8,73 – 8,90	1,93
Auger L	0,7 – 1,0	346

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Cu)	0,7 - 1,0	126,6 (7)
e <sub>AK</sub>	(Cu)		47,5 (4)
	KLL	6,76 - 7,12	}
	KLX	7,76 - 8,05	}
	KXY	8,73 - 8,90	}
$\beta_{0,0}^+$	max:	329,9 (3)	1,421 (7)
$\beta_{0,0}^+$	avg:	143,1 (1)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Cu)	0,811 — 1,022	1,305 (21)
XK $\alpha_2$	(Cu)	8,02792	11,76 (13) } K $\alpha$
XK $\alpha_1$	(Cu)	8,04787	22,91 (22) }
XK $\beta_1$	(Cu)	8,90539	4,82 (7) K' $\beta_1$
XK $\beta_5''$	(Cu)	8,9771	}

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{2,1}(\text{Cu})$	344,95 (20)	0,00254 (18)
$\gamma^\pm$	511	2,842 (13)
$\gamma_{1,0}(\text{Cu})$	770,64 (9)	0,00269 (22)
$\gamma_{2,0}(\text{Cu})$	1115,539 (2)	50,22 (11)

## 6 Main Production Modes

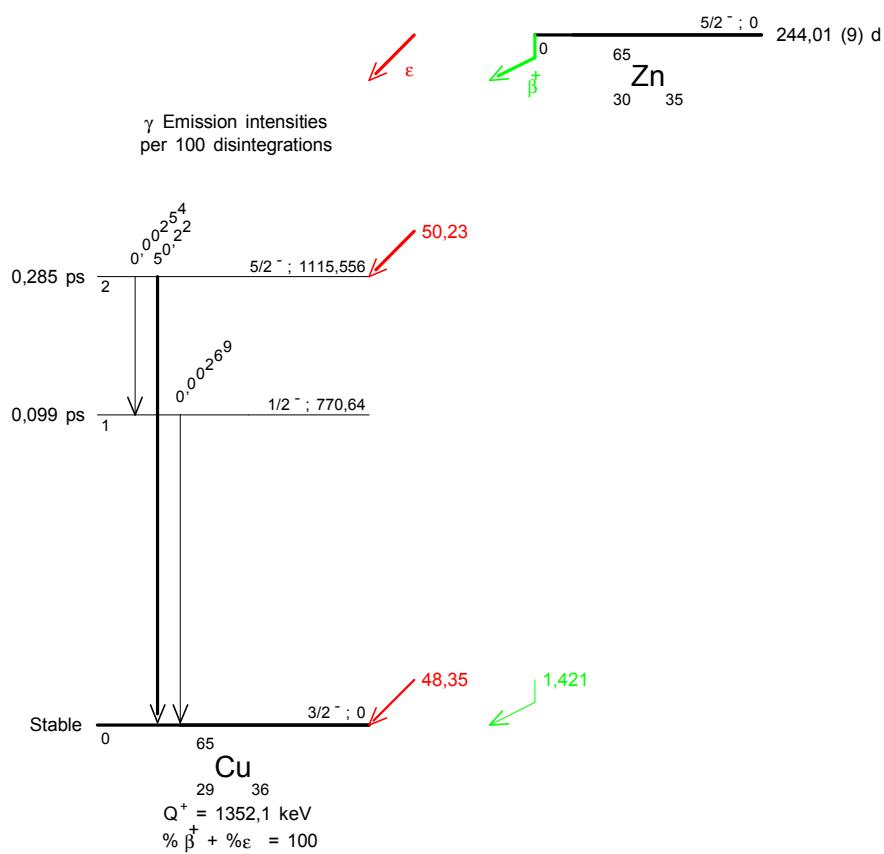
$$\left\{ \begin{array}{l} \text{Zn} - 64(\text{n},\gamma)\text{Zn} - 65 \quad \sigma : 0,76 \text{ (2) barns} \\ \text{Possible impurities : Cu} - 64, \text{Cu} - 67, \text{Zn} - 69\text{m} \end{array} \right.$$

$$\left\{ \begin{array}{l} \text{Cu} - 65(\text{p},\text{n})\text{Zn} - 65 \\ \text{Possible impurities : Cu} - 67, \text{Co} - 60 \end{array} \right.$$

## 7 References

- J.F.PERKINS, S.K.HAYNES. Phys. Rev. 92 (1953) 687  
(Electron Capture/Beta plus Ratio)
- J.TOBAILEM. J. Phys. Radium 14 (1953) 553  
(Half-life)
- K.W.GEIGER . Phys. Rev. 105 (1957) 1539  
(Half-life)
- H.W.WRIGHT, E.I.WYATT, S.A.REYNOLDS, W.S.LYON, T.H.HANDLEY. Nucl. Sci. Eng. 2 (1957) 427  
(Half-life)
- G.I.GLEASON. Phys. Rev. 113 (1959) 287  
(Gamma ray emission probabilities)
- W.M.GOOD, W.C.PEACOCK. Bull. Amer. Phys. Soc. Abstract B4 (1960) 680  
(Gamma ray emission probabilities)
- R.A.RICCI, G.CHIOSI, G.VARCACCIO, G.B.VINGIANI, R.VAN LIESHOUT. Nuovo Cim. 17 (1960) 523  
(Gamma ray emission probabilities)
- D.BERENYI. Phys. Lett. 3 (1962) 142  
(Beta plus emission probabilities)
- J.G.V.TAYLOR, J.S.MERRITT. Phys. Can., Abstract 4.5 19 (1963) 3,17  
(Gamma ray emission probabilities)
- J.V.G.TAYLOR, J.S.MERRITT. Proc. Int. Conf. Role of atomic electrons in Nuclear transformations, Warsaw CONF-233 (1963) 465  
(K X-ray emission intensities)
- S.C.ANSPACH, L.M.CAVALLO, S.B.GARFINKEL, J.M.R.HUTCHINSON, C.N.SMITH. NP-15663 (1965)  
(Half-life)
- P.S.RAO. Curr. Sci. 35 (1966) 384  
(Gamma ray emission probabilities)
- J.H.HAMILTON, S.R.AMTEY, B.VAN NOOIJEN, A.V.RAMAYYA, J.J.PINAJIAN. Phys. Lett. 19 (1966) 682  
(ICC)
- J.W.HAMMER. Z. Phys. 216 (1968) 355  
(Half-life, Gamma ray emission probabilities)
- W.BAMBYNEK, D.REHER. Z. Physik 214 (1968) 374  
(K X-ray emission intensities)
- P.H.STELSON. Nucl. Phys. A111 (1968) 331  
(Gamma ray emission probabilities)
- D.F.CRISLER, H.B.ELDRIDGE, R.KUNSELMAN, C.S.ZAIDINS. Phys. Rev. C5 (1972) 419  
(Half-life)
- E.DE ROOST, E.FUNCK, A.SPERNOL, R.VANINBROUKX. Z. Phys. 250 (1972) 395  
(Gamma ray emission probabilities, Half-life)
- A.MUKERJI, L.CHIN. Atlanta Conf. Proc. AEA-CONF-720404 (1973) 164  
(K X-ray emission intensities)
- S.RAMAN, N.B.GOVE. Phys. Rev. C7 (1973) 1995  
(lg ft)
- C.J.VISSEER, J.H.M.KARSTEN, F.J.HAASBROEK, P.G.MARAIS. Agrochemophysica 5 (1973) 15  
(Half-life)
- W.P.POENITZ, A.DEVOLPI. Int. J. Appl. Radiat. Isotop. 24 (1973) 471  
(Gamma ray emission probabilities)
- P.J.CRESSY JR. Nucl. Sci. Eng. 55 (1974) 450  
(Half-life)

- F.LAGOUTINE, J.LEGRAND, C.BAC. Int. J. Appl. Radiat. Isotop. 26 (1975) 131  
(Half-life)
- K.S.KRANE, S.S.ROSENBLUM, W.A.STEYERT. Phys. Rev. C14 (1976) 650  
(Mixing ratio)
- H.E.BOSCH, J.DAVIDSON, M.DAVIDSON, L.SZYBISZ. Z. Phys. A280 (1977) 321  
(Electron Capture/Beta plus Ratio)
- P.SCHLUTER, G.SOIFF. At. Data. Nucl. Data Tables 24 (1979) 509  
(Internal pair formation coefficient)
- D.D.HOPPES, J.M.R.HUTCHINSON, F.J.SCHIMA, M.P.UNTERWEGER. NBS-SP-626 (1982) 85  
(Half-life)
- K.DEBERTIN, U.SCHÖTZIG, K.F.WALZ. NBS-SP-626 (1982) 101  
(Gamma ray emission probabilities)
- K.F.WALZ, K.DEBERTIN, H.SCHRADER. Int. J. Appl. Radiat. Isotop. 34 (1983) 1191  
(Half-life)
- W.-D.SCHMIDT-OTT, J.LAUERWALD, U.BOSCH, H.DORNHOFER, U.J.SCHREWE,H.BEHRENS. 7th Proc. Intern. Conf. Atomic Masses Fund. Constants Darmstadt-Seeheim (1984) 210  
(Electron Capture/Beta plus Ratio)
- H.H.HANSEN. European App.Res.Rept.Nucl.Sci.Technol. 6,4 (1985) 777  
(ICC)
- U.SCHÖTZIG. Nucl. Instrum. Methods A286 (1990) 523  
(Gamma ray and Beta plus, emission probabilities)
- V.KUNZE, W.-D.SCHMIDT-OTT, H.BEHRENS. Z. Phys. A337 (1990) 169  
(Electron Capture/Beta plus Ratio)
- M.P.UNTERWEGER, D.D.HOPPES, F.J.SCHIMA. Nucl. Instrum. Methods A312 (1992) 349  
(Half-life)
- M.R.BHAT. Nucl. Data Sheets 69 (1993) 209  
(Multipolarities, Mixing Ratio, Spin and Parity)
- E.SCHÖNFELD. Report PTB-6.33-95-2 (1995)  
(PK, PL, PM theory)
- E.SCHÖNFELD, H.JANSSEN. Nucl. Instrum. Methods A 369 (1996) 527  
(K and L fluorescence yields, Auger electron emission probabilities)
- R.G.HELMER, C.VAN DER LEUN. Nucl. Instrum. Methods A450 (2000) 35  
(Gamma ray energies)
- M.P.UNTERWEGER. Appl. Rad. Isotopes 56 (2002) 125  
(Half-life)
- I.M.BAND, M.B.TRAZHASKOVSKAYA, C.W.NESTOR, S.RAMAN. At. Data Nucl. Data Tables 81, 1-2 (2002) 1  
(Theoretical ICC)
- A.LUCA, M.-N.AMIOT, J.MOREL. Appl. Rad. Isotopes 58 (2003) 607  
(Half-life)
- G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)
- H.SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life)
- R. VAN AMMEL, S.POMMÉ, G.SIBBENS. Appl. Rad. Isotopes 60 (2004) 337  
(Half-life)
- M.-M.BÉ. Report CEA R-6081 (2005)  
(Gamma-ray emission intensities)
- M.-M.BÉ. Appl. Rad. Isotopes 64 (2006) 1396  
(Gamma-ray emission intensities)





## 1 Decay Scheme

Le selenium 79 se désintègre par émission beta moins vers le niveau fondamental de brome 79.  
*Se-79 disintegrates by beta minus emission to the ground state of Br-79.*

## 2 Nuclear Data

$T_{1/2}(^{79}\text{Se})$  : 3,56 (40)  $10^5$  a  
 $Q^-(^{79}\text{Se})$  : 150,9 (17) keV

### 2.1 $\beta^-$ Transitions

Energy keV	Probability $\times 100$	Nature	lg $ft$
$\beta_{0,0}^-$ 150,9 (17)	100	1st forbidden unique	10,81

## 3 Electron Emissions

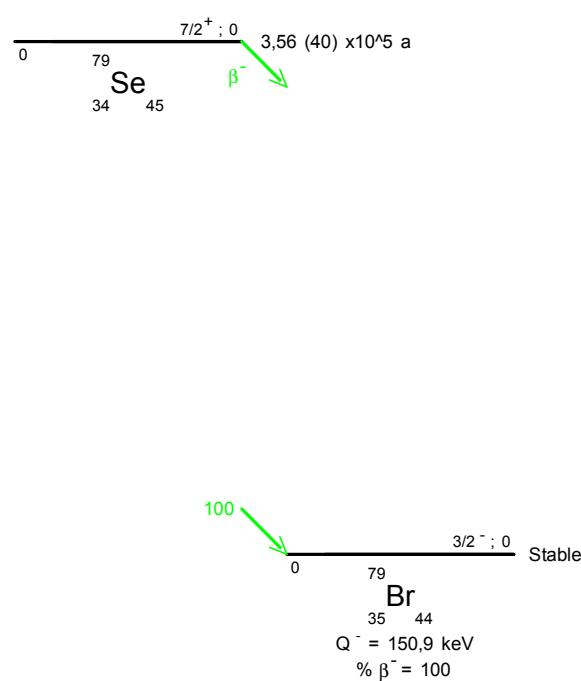
Energy keV	Electrons per 100 disint.
$\beta_{0,0}^-$ max: 150,9 (17)	100
$\beta_{0,0}^-$ avg: 52,9 (6)	

## 4 Main Production Modes

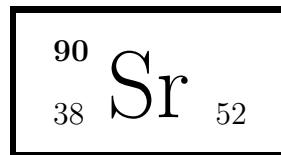
Fission product()

## 5 References

- L.E. GLENDEEN. Report MDDC 1694-C (1948)  
(Half-life)
- G.W. PARKER, *et al.* Report ORNL 499 (1949) 45  
(Half-life)
- B.SINGH. Nucl. Data Sheets 70,3 (1993) 452  
(Half-life)
- YU RUNLAN, GUO JINGRU *et al.* J. Radioanalytical and Nuclear Chemistry, Articles 96,1 (1996) 165  
(Half-life)
- JIANG SONGSHENG, GUO JINGRU *et al.* Nucl. Instrum. Methods Phys. Res. B123 (1997) 405  
(Half-life)
- MING HE, SHAN JIANG *et al.* Nucl. Instrum. Methods Phys. Res. B172 (2000) 177  
(Half-life)
- MING HE, SONGSHENG JIANG *et al.* Nucl. Instrum. Methods Phys. Res. B194 (2002) 393  
(Half-life)
- SONGSHENG JIANG, MING HE *et al.* Nucl. Instrum. Methods Phys. Res. A489 (2002) 195  
(Half-life)
- G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)
- P.BIENVENU, P. CASSETTE, G. ANDREOLETTI, M.-M. BÉ, J. COMTE, M.-C. LÉPY. To be published in Applied Radiation Isotopes (2007)  
(half-life)







## 1 Decay Scheme

Sr-90 disintegrates by beta minus emission to the ground state of Y-90 ( $T_{1/2} = 2,6684$  (13) d).  
*Le strontium 90 se désintègre par émission bêta moins vers le niveau fondamental d'yttrium 90 ( $T_{1/2} = 2,6684$  (13) d).*

## 2 Nuclear Data

$T_{1/2}(^{90}\text{Sr})$	:	28,80	(7)	a
$T_{1/2}(^{90}\text{Y})$	:	2,6684	(13)	d
$Q^-(^{90}\text{Sr})$	:	545,9	(14)	keV

### 2.1 $\beta^-$ Transitions

Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,0}^-$	545,9 (14) 100	Unique 1st Forbidden	9,3

## 3 Atomic Data

### 3.1 Y

$\omega_K$	:	0,716	(4)
$\bar{\omega}_L$	:	0,0289	(7)
$n_{KL}$	:	1,081	(4)

## 4 Electron Emissions

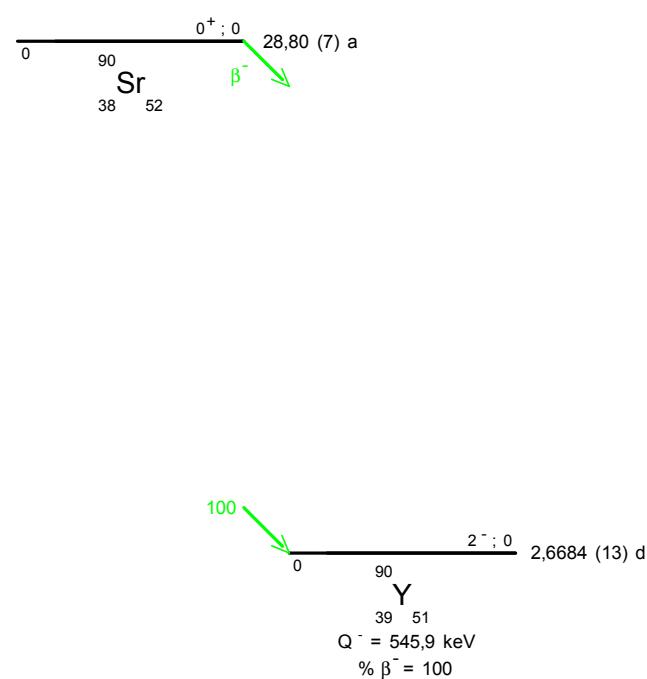
	Energy keV	Electrons per 100 disint.
$\beta_{0,0}^-$	max: 545,9 (14)	100
$\beta_{0,0}^-$	avg: 196 (1)	

## 5 Main Production Modes

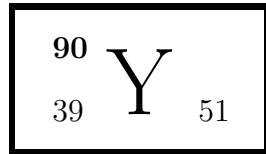
$\left\{ \begin{array}{l} \text{Fission products} \\ \text{Possible impurities : Sr - 89} \end{array} \right.$

## 6 References

- R.I. POWERS, A.F. VOIGT. Phys. Rev. 79 (1950) 175  
(Half-life.)
- D.M. WILES, R.H. TOMLINSON. Can. J. Phys. 33 (1955) 133  
(Half-life.)
- M.P. ANIKINA, R.N. IVANOV, G.M. KUKAVADZE, B.V. ERSHLER. Atomnaya Energ. 4(1958)198; J. Nucl. Energ. 9 (1959) 167  
(Half-life.)
- H. DANIEL, G.T. KASCHL, H. SCHMITT, K. SPRINGER. Phys. Rev. 136 (1964) B1240  
(beta shape factor.)
- S.C. ANSPACH, L.M. CAVALLO, S.B. GARFINKEL, J.M.R. HUTCHINSON, C.N. SMITH. N. P. - 15663 (1965)  
(Half-life.)
- K.F. FLYNN, L.E. GLEINDENIN, A.L. HARKNESS, E.P. STEINBERG. J. Inorg. Nucl. Chem. 27 (1965) 21  
(Half-life.)
- F. LAGOUTINE, J. LEGRAND, C. BAC. Int. J. Appl. Radiat. Isotop. 29 (1978) 269  
(Half-life.)
- H. RAMTHUN. Nucl. Instrum. Methods 207 (1983) 445  
(Half-life.)
- H.H. HANSEN. Int. J. Appl. Radiat. Isotop. 34 (1983) 1241  
(beta shape factor.)
- A.E. KOCHIN, M.G. KUZMINA, I.A. SOKOLOVA, P.L. MERSON. Metrologia 26 (1989) 203  
(Half-life.)
- U. SCHÖTZIG, H. SCHRADER, K. DEBERTIN. Proc. Inter. Conf. Nucl. Data for Science and Technology, Julich (1992) 562  
(Half-life.)
- R.H. MARTIN, K.I.W. BURNS, J.G.V. TAYLOR. Nucl. Instrum. Methods Phys. Res. A339 (1994) 158  
(Half-life.)
- M.J. WOODS, S.E.M. LUCAS. Nucl. Instrum. Methods Phys. Res. A369 (1996) 534  
(Half-life.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic Data)
- E. BROWNE. Nucl. Data Sheets 82 (1997) 420  
(Spin, parity, energy level.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q.)
- H. SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life.)







## 1 Decay Scheme

Y-90 disintegrates by beta minus emission mainly to the Zr-90 fundamental level.

*L'yttrium 90 se désintègre par émission bêta moins principalement vers le niveau fondamental du zirconium 90 et vers le niveau excité 1760 keV avec une probabilité de 0,017 %.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{90}\text{Y}) &: 2,6684 \quad (13) \quad \text{d} \\ Q^-(^{90}\text{Y}) &: 2279,8 \quad (17) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg $ft$
$\beta_{0,2}^-$	93,5 (17)	0,0000014 (3)	1st Forbidden	11,1
$\beta_{0,1}^-$	519,1 (17)	0,017 (6)	Unique 1st Forbidden	9,4
$\beta_{0,0}^-$	2279,8 (17)	99,983 (6)	Unique 1st Forbidden	8,05

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_T$
$\gamma_{1,0}(\text{Zr})$	1760,7 (2)	0,017 (6)	E0			4,3 (21)
$\gamma_{2,0}(\text{Zr})$	2186,282 (10)	0,0000014 (3)	E2	0,000123 (40)	0,0000133 (40)	0,000139 (40)

### 3 Atomic Data

#### 3.1 Zr

$\omega_K$	:	0,734	(4)
$\bar{\omega}_L$	:	0,0317	(8)
$n_{KL}$	:	1,062	(4)

### 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
$ec_{1,0}^{\pm}$	(Zr)	768,7 (6)	0,00319 (5)
$\beta_{0,2}^-$	max:	93,5 (17)	0,0000014 (3)
$\beta_{0,2}^-$	avg:	24,5 (5)	
$\beta_{0,1}^-$	max:	519,1 (17)	0,017 (6)
$\beta_{0,1}^-$	avg:	163,7 (6)	
$\beta_{0,0}^-$	max:	2279,8 (17)	99,983 (6)
$\beta_{0,0}^-$	avg:	926,7 (8)	

### 5 Photon Emissions

#### 5.1 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{2,0}(\text{Zr})$	2186,254 (10)	0,0000014 (3)

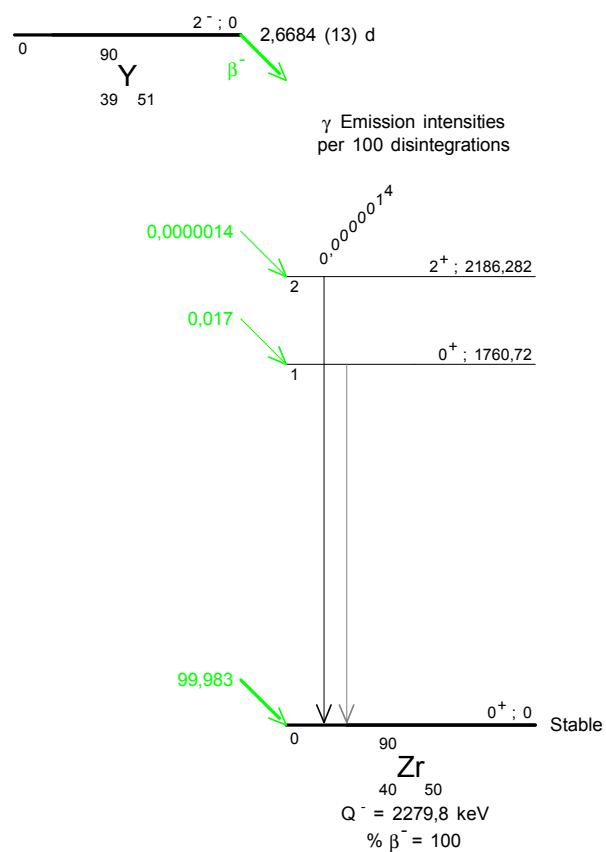
### 6 Main Production Modes

Sr – 90( $\beta^-$ )Y – 90  
 Y – 89(d,p)Y – 90m  
 Y – 90m(I.T.)Y – 90  
 Rb – 87( $\alpha$ ,n)Y – 90m  
 Y – 90m(I.T.)Y – 90  
 { Y – 89(n, $\gamma$ )Y – 90       $\sigma$  : 1,28 (2) barns  
   Possible impurities : Y – 91

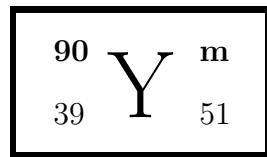
## 7 References

- M.L. POOL, J.M. CORK, R.L. THORNTON. Phys. Rev. 52 (1937) 239  
(Half-life.)
- D.W. STEWART, J.L. LAWSON, J.M. CORK. Phys. Rev. 52 (1937) 901  
(Half-life.)
- R. SAGANE, S. KOJIMA, G. MIYAMOTO, M. IKAWA. Phys. Rev. 54 (1938) 970  
(Half-life.)
- R. SAGANE, S. KOJIMA, G. MIYAMOTO, M. IKAWA. Phys. Rev. 57 (1940) 1179  
(Half-life.)
- W. BOTHE. Z. Naturforsch. 1 (1946) 173  
(Half-life.)
- A. CHETHAM-STRODE JR., E.M. KINDERMAN. Phys. Rev. 93 (1954) 1029  
(Half-life.)
- M.L. SALUTSKY, H.W. KIRBY. Anal. Chem. 27 (1955) 567  
(Half-life.)
- H.L. VOLCHOK, J.L. KULP. Phys. Rev. 97 (1955) 102  
(Half-life.)
- G. HERRMANN, F. STRASSMANN. Z. Naturforsch. 11a (1956) 946  
(Half-life.)
- T. YUASA, J. LABERRIGUE-FROLLO. J. Phys. (Paris) 18 (1957) 498  
(End-point energy.)
- D.F. PEPPARD, G.W. MASON, S.W. MOLINE. J. Inorg. Nucl. Chem. 5 (1957) 141  
(Half-life.)
- O.E. JOHNSON, R.G. JOHNSON, L.M. LANGER. Phys. Rev. 112 (1958) 2004  
(End-point energy.)
- R.L. HEATH, J.E. CLINE, C.W. REICH, E.C. YATES, E.H. TURK. Phys. Rev. 123 (1961) 903  
(Half-life, gamma-ray emission intensity.)
- R.T. NICHOLS, R.E. MCADAMS, E.N. JENSEN. Phys. Rev. 122 (1961) 172  
(End-point energy.)
- H. LANGHOFF, H.-H. HENNIES. Z. Physik 164 (1961) 166  
(Branching ratio.)
- M. NESSIN, T.H. KRUSE, K.E. EKLUND. Phys. Rev. 125 (1962) 639  
(Alpha.)
- H.R. von GUNTEN, W. SCHERLE, H. HUGLI. Nucl. - Med. (Stuttgart) 3 (1963) 417  
(Half-life.)
- S. ANDRÉ, P. DEPOMMIER. J. Phys. (Paris) 25 (1964) 678  
(End-point energy.)
- L.M. LANGER, E.H. SPEJEWSKI, D.E. WORTMAN. Phys. Rev. 135 (1964) B581  
(End-point energy.)
- H. DANIEL, G.T.H. KASCHL, H. SCHMITT, K. SPRINGER. Phys. Rev. 136 (1964) B1240  
(End-point energy.)
- P. RIEHS. Nucl. Phys. 75 (1966) 381  
(Half-life, end-point energy.)
- J.K. BIENLEIN, G. GROF, W. KREISCHE, W. LAMPERT, G. LOOS. Nucl. Phys. A92 (1967) 549  
(Half-life.)
- F. LAGOUCHE, Y. LE GALLIC, J. LEGRAND. Int. J. Appl. Radiat. Isotop. 19 (1968) 475  
(Half-life.)
- V.P. GROLL, F. GRASS, K. BUCHTELA. Radiochem. Acta 12 (1969) 152  
(Half-life.)
- J.C. VANDERLEEDEN, P.S. JASTRAM. Phys. Rev. C1 (1970) 1025  
(Branching ratio.)
- T. NAGARAJAN, M. RAVINDRANATH, K.V. REDDY. Nuovo Cim. 2A (1971) 662  
(End-point energy.)
- J. LEGRAND, *et al.* Proc. Int. Conf. Inner shell Ionization Phenom. And future applications, CONF- 720404, Vol. 3 (1972) 2167  
(K X-ray emission intensities)
- S. RAMAN, N.B. GROVE. Phys. Rev. C7 (1973) 1995  
(Gamma-ray emission intensity.)

- A. HANSER. Nucl. Instrum. Methods 107 (1973) 187  
(Gamma-ray emission intensity.)
- A. KLUGE, K. KROTH, F.J. SCHRÖDER, W. THOMAS, H. TOSCHINSKI, C. GÜNTHER. Nucl. Phys. A224 (1974) 1  
(gamma-ray emission intensity.)
- H.C. GRIFFIN. Radiochem. Radioanal. Lett. 27 (1976) 353  
(Branching ratio.)
- G.N. RAO, C. GÜNTHER. Phys. Rev. C17 (1978) 1266  
(Gamma-ray emission intensity.)
- H.H. HANSEN. Int. J. Appl. Radiat. Isotop. 34 (1983) 1241  
(End-point energy.)
- C. GREENWOOD, M.H. PUTNAM. Nucl. Instrum. Meth. Phys. Res. A337 (1993) 106  
(End-point energy.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data.)
- E. BROWNE. Nucl. Data Sheets 82 (1997) 421  
(Spin, level energy, parity, multopolarity.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C.W. NESTOR, JR., P.O. TIKKANEM, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Alpha.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q.)
- K. KOSSERT, H. SCHRADER. Appl. Rad. Isotopes 60 (2004) 741  
(Half-life)
- R.G. SELWYN, *et al.* Appl. Rad. Isotopes doi:10.1016 (2006)  
(internal pair creation coefficient)







## 1 Decay Scheme

$^{90}\text{Y}$  disintegrates 99.9981 (2) % through isomeric transitions to the  $^{90}\text{Y}$  ground state and 0.0019(2) % by beta minus emission to the 2318 keV excited state in Zr-90.

*L'yttrium 90 metastable se désexcite pour 99,9981 (2) % vers le niveau fondamental de l'yttrium 90 et se désintègre pour 0,0019 (2) % par émission bêta moins vers le niveau excité de 2318 keV du zirconium 90.*

## 2 Nuclear Data

$T_{1/2}(^{90}\text{Y}^m)$	:	3,19	(6)	h
$T_{1/2}(^{90}\text{Y})$	:	2,6684	(13)	d
$Q^-(^{90}\text{Y}^m)$	:	2961,8	(17)	keV

### 2.1 $\beta^-$ Transitions

Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,1}^-$	642,9 (17)	0,0019 (2) Unique 1st Forbidden	9,6

### 2.2 Gamma Transitions and Internal Conversion Coefficients

Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$	
$\gamma_{1,0}(\text{Y})$	202,53 (3)	99,7 (17)	M1+E2	0,0240 (7)	0,00272 (8)	0,000465 (14)	0,0272 (8)
$\gamma_{2,1}(\text{Y})$	479,51 (7)	99,671 (23)	M4(+E5)	0,0818 (25)	0,01157 (35)	0,00202 (6)	0,0957 (29)
$\gamma_{2,0}(\text{Y})$	682,04 (6)	0,329 (23)	E5	0,0190 (6)	0,00292 (9)	0,000507 (15)	0,0225 (7)
$\gamma_{1,0}(\text{Zr})$	2318,99 (2)	0,0019 (2)	E5	0,000408 (12)	0,0000463 (14)	0,00000804 (24)	0,000463 (14)

### 3 Atomic Data

#### 3.1 Y

$$\begin{aligned}\omega_K &: 0,716 \quad (4) \\ \bar{\omega}_L &: 0,0289 \quad (7) \\ n_{KL} &: 1,081 \quad (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	14,883	52,15
K $\alpha_1$	14,9581	100
K $\beta_3$	16,7268	{}
K $\beta_1$	16,7384	{}
K $\beta_5''$	16,8792	{}
K $\beta_5'$	16,8814	{}
K $\beta_2$	17,0137	{}
K $\beta_4$	17,0409	{}
		3,47

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	12,205 – 12,784	100
KLX	14,238 – 14,956	37,6
KXY	16,251 – 17,034	3,53
Auger L	1,2 – 2,3	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Y)	1,2 - 2,3	11,56 (10)
e <sub>AK</sub>	(Y)		2,78 (8)
	KLL	12,205 - 12,784	}
	KLX	14,238 - 14,956	}
	KXY	16,251 - 17,034	}
ec <sub>2,1 K</sub>	(Y)	462,47 (7)	7,45 (23)
ec <sub>2,1 L</sub>	(Y)	477,14 - 477,43	1,057 (32)
ec <sub>2,1 M</sub>	(Y)	479,12 - 479,35	0,185 (5)
$\beta_{0,1}^-$	max:	642,9 (17)	0,0019 (2)
$\beta_{0,1}^-$	avg:	231,9 (7)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Y)	1,6865 — 2,3482	0,343 (8)
XK $\alpha_2$	(Y)	14,883	2,02 (6) } K $\alpha$
XK $\alpha_1$	(Y)	14,9581	3,88 (10) }
XK $\beta_3$	(Y)	16,7268	}
XK $\beta_1$	(Y)	16,7384	} 0,973 (27) K' $\beta_1$
XK $\beta'_5$	(Y)	16,8792	}
XK $\beta'_5$	(Y)	16,8814	}
XK $\beta_2$	(Y)	17,0137	}
XK $\beta_4$	(Y)	17,0409	} 0,134 (6) K' $\beta_2$

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(Y)$	202,53 (3)	97,1 (14)
$\gamma_{2,1}(Y)$	479,51 (7)	90,97 (24)

	Energy keV	Photons per 100 disint.
$\gamma_{2,0}(\text{Y})$	682,04 (6)	0,322 (22)
$\gamma_{1,0}(\text{Zr})$	2318,958 (20)	0,0019 (2)

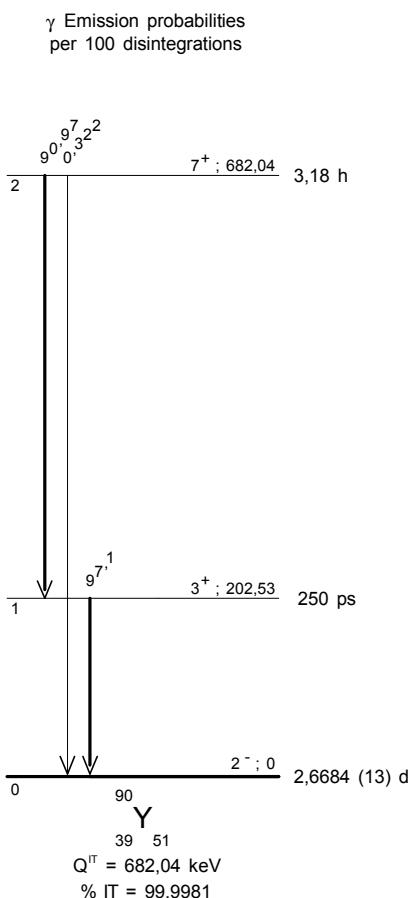
## 6 Main Production Modes

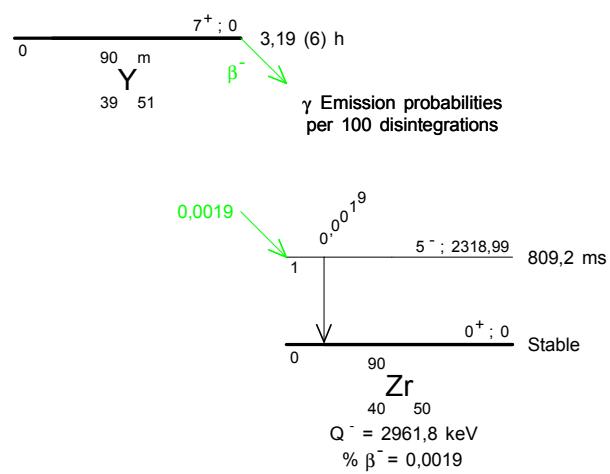
$\text{Y} - 89(\text{d},\text{p})\text{Y} - 90\text{m}$

$\text{Rb} - 87(\alpha,\text{n})\text{Y} - 90\text{m}$

## 7 References

- L. HASKIN, R. VANDENBOSCH. Phys. Rev. 123 (1961) 184  
(Half-life.)
- C. CARTER-WASCHEK, B. LINDER. Nucl. Phys. 27 (1961) 415  
(Half-life.)
- R.L. HEATH, J.E. CLINE, C.W. REICH, E.C. YATES, E.H. TURK. Phys. Rev. 123 (1961) 903  
(Half-life, gamma intensity.)
- S. ABECASIS, H. BOSCH, M.C. CARACOCHE, A. MOCOROA, H. VIGNAU. Rev. Union Mat. Arg., Asoc. Fis. Arg. 21 (1962) 104  
(Half-life.)
- C. CARTER-WASCHEK, B. LINDER. Erratum: Nucl. Phys 31 (1962) 351  
(Half-life.)
- S. ABECASIS, H. BOSCH, M.C. CARACOCHE, A. MOCOROA, H. VIGNAU. Nucl. Sci. Abstr. 17 (1963) 3732  
(Half-life.)
- H.A. GRENCH, K.L. COOP, H.O. MENLOVE, F.J. VAUGHN. Nucl. Phys. A94 (1967) 157  
(Half-life.)
- S. RAMAN, N.B. GOVE. Phys. Rev. C7 (1973) 1995  
(Gamma intensity.)
- A. HANSER. Nucl. Instrum. Methods 107 (1973) 187  
(Gamma intensity.)
- A. KLUGE, K. KROTH, F.J. SCHRÖDER, W. THOMAS, H. TOSCHINSKI, C. GÜNTHER. Nucl. Phys. A224 (1974) 1  
(Gamma intensity.)
- H.C. GRIFFIN. Radiochem. Radioanal. Lett. 27 (1976) 353  
(Branching Ratio)
- G.N. RAO, C. GÜNTHER. Phys. Rev. C17 (1978) 1266  
(Gamma intensity.)
- M.S. ANTHONY, D. OSTER, A. HACHEM. J. Radioanal. Nucl. Chem. 166 (1992) 63  
(Half-life.)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data.)
- E. BROWNE. Nucl. Data Sheets 82 (1997) 379  
(Spin, parity, gamma-ray energy, multipolarity.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C.W. NESTOR, JR., P.O. TIKKANEN, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Alpha.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q.)







## 1 Decay Scheme

Ag-108 disintegrates by electron capture (2.19 (14) %) and beta plus emission (0.283 (20) %) to excited states in Pd-108 and, by beta minus emission (97.53 (14) %) to excited states in Cd-108.  
*L'argent 108 se désintègre pour 2,19 (14) % par capture électronique et 0,283 (20) % par émission bêta plus vers les niveaux excités de palladium 108 et pour 97,53 (14) % par émission bêta moins vers le niveau excité de 632 keV et le niveau fondamental de cadmium 108.*

## 2 Nuclear Data

$T_{1/2}(^{108}\text{Ag})$	:	2,382	(11)	min
$Q^-(^{108}\text{Ag})$	:	1649	(8)	keV
$Q^+(^{108}\text{Ag})$	:	1922	(6)	keV

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,1}^-$	1016 (8)	1,63 (26)	Allowed	5,35
$\beta_{0,0}^-$	1649 (8)	95,9 (3)	Allowed	4,43

### 2.2 $\beta^+$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,1}^+$	466 (6)	0,0026 (3)	Allowed	5,46
$\beta_{0,0}^+$	900 (6)	0,28 (2)	Allowed	4,7

### 2.3 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_M$
$\epsilon_{0,6}$	382 (6)	0,00224 (27)		6,12	0,8529 (15)	0,1181 (11)	0,0242 (5)
$\epsilon_{0,5}$	481 (6)	0,0170 (21)	Allowed	5,46	0,8560 (14)	0,1157 (11)	0,0237 (5)
$\epsilon_{0,4}$	608 (6)	0,0038 (6)	Allowed	6,37	0,8585 (14)	0,1138 (11)	0,0232 (5)
$\epsilon_{0,3}$	869 (6)	0,243 (39)	Allowed	4,89	0,8611 (14)	0,1118 (11)	0,0227 (5)
$\epsilon_{0,1}$	1488 (6)	0,19 (8)	Allowed	5,46	0,8636 (14)	0,1098 (10)	0,0223 (4)
$\epsilon_{0,0}$	1922 (6)	1,73 (12)	Allowed	4,7	0,8644 (14)	0,1092 (10)	0,0221 (4)

### 2.4 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{4,2}(\text{Pd})$	383,13 (16)	0,00083 (30)					
$\gamma_{5,3}(\text{Pd})$	388,36 (7)	0,0017 (6)					
$\gamma_{1,0}(\text{Pd})$	433,938 (5)	0,46 (7)	[E2]	0,00784 (24)	0,001021 (31)	0,000192 (6)	0,00909 (27)
$\gamma_{2,1}(\text{Pd})$	497,13 (12)	0,00152 (40)					
$\gamma_{3,1}(\text{Pd})$	618,86 (5)	0,245 (39)					
$\gamma_{1,0}(\text{Cd})$	632,98 (5)	1,63 (26)	E2	0,00300 (9)	0,000380 (11)	0,0000730 (22)	0,00347 (10)
$\gamma_{4,1}(\text{Pd})$	880,26 (10)	0,00298 (48)					
$\gamma_{2,0}(\text{Pd})$	931,07 (12)	0,00048 (8)					
$\gamma_{5,1}(\text{Pd})$	1007,22 (5)	0,0126 (20)					
$\gamma_{6,1}(\text{Pd})$	1106,01 (7)	0,00130 (22)					
$\gamma_{5,0}(\text{Pd})$	1441,16 (5)	0,00269 (44)	[E2]	0,000407 (12)	0,0000469 (14)	0,00000878 (26)	0,000464 (14)
$\gamma_{6,0}(\text{Pd})$	1539,95 (7)	0,00094 (16)					

## 3 Atomic Data

### 3.1 Pd

$$\begin{aligned}\omega_K &: 0,820 & (4) \\ \bar{\omega}_L &: 0,0536 & (13) \\ n_{KL} &: 0,975 & (4)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K <sub>α2</sub>	21,0203	52,93
K <sub>α1</sub>	21,1774	100

	Energy keV	Relative probability
$K\beta_3$	23,7914	}
$K\beta_1$	23,819	}
$K\beta''_5$	24,013	27,44
$K\beta_2$	24,2994	}
$K\beta_4$	24,344	4,66

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	17,032 – 17,884	100
KLX	20,032 – 21,176	42
KXY	23,011 – 24,347	4,4
Auger L	1,7 – 3,6	

## 3.2 Cd

$$\begin{aligned}\omega_K &: 0,842 \quad (4) \\ \bar{\omega}_L &: 0,0632 \quad (16) \\ n_{KL} &: 0,953 \quad (4)\end{aligned}$$

### 3.2.1 X Radiations

	Energy keV	Relative probability
$X_K$		
$K\alpha_2$	22,9843	53,17
$K\alpha_1$	23,1738	100
$K\beta_3$	26,0615	}
$K\beta_1$	26,0958	}
$K\beta''_5$	26,304	27,87
$K\beta_2$	26,644	}
$K\beta_4$	26,702	5,07

### 3.2.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	18,556 – 19,507	100
KLX	21,873 – 23,172	43
KXY	25,171 – 26,707	4,63
Auger L	1,8 – 4,0	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Pd)	1,7 – 3,6	1,97 (4)
e <sub>AK</sub>	(Pd)		0,341 (25)
	KLL	17,032 - 17,884	}
	KLX	20,032 - 21,176	}
	KXY	23,011 - 24,347	}
e <sub>AL</sub>	(Cd)	1,8 – 4,0	0,00535 (7)
e <sub>AK</sub>	(Cd)		0,00084 (5)
	KLL	18,556 - 19,507	}
	KLX	21,873 - 23,172	}
	KXY	25,171 - 26,707	}
$\beta_{0,0}^+$	max:	900 (6)	0,28 (2)
$\beta_{0,0}^+$	avg:	401 (3)	
$\beta_{0,1}^+$	max:	466 (6)	0,0026 (3)
$\beta_{0,1}^+$	avg:	212 (3)	
$\beta_{0,1}^-$	max:	1016 (8)	1,63 (26)
$\beta_{0,1}^-$	avg:	355 (3)	
$\beta_{0,0}^-$	max:	1649 (8)	95,9 (3)
$\beta_{0,0}^-$	avg:	628 (4)	

## 5 Photon Emissions

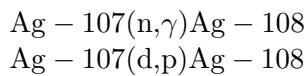
### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.	
XK $\alpha_2$	(Pd)	21,0203	0,44 (3)	} K $\alpha$
XK $\alpha_1$	(Pd)	21,1774	0,84 (6)	}
XK $\beta_3$	(Pd)	23,7914	}	
XK $\beta_1$	(Pd)	23,819	}	0,230 (16) K' $\beta_1$
XK $\beta_5''$	(Pd)	24,013	}	
XK $\beta_2$	(Pd)	24,2994	}	
XK $\beta_4$	(Pd)	24,344	}	0,0391 (30) K' $\beta_2$
XK $\alpha_2$	(Cd)	22,9843	0,00127 (6)	} K $\alpha$
XK $\alpha_1$	(Cd)	23,1738	0,00239 (11)	}
XK $\beta_3$	(Cd)	26,0615	}	
XK $\beta_1$	(Cd)	26,0958	}	0,00067 (4) K' $\beta_1$
XK $\beta_5''$	(Cd)	26,304	}	
XK $\beta_2$	(Cd)	26,644	}	
XK $\beta_4$	(Cd)	26,702	}	0,000121 (7) K' $\beta_2$

### 5.2 Gamma Emissions

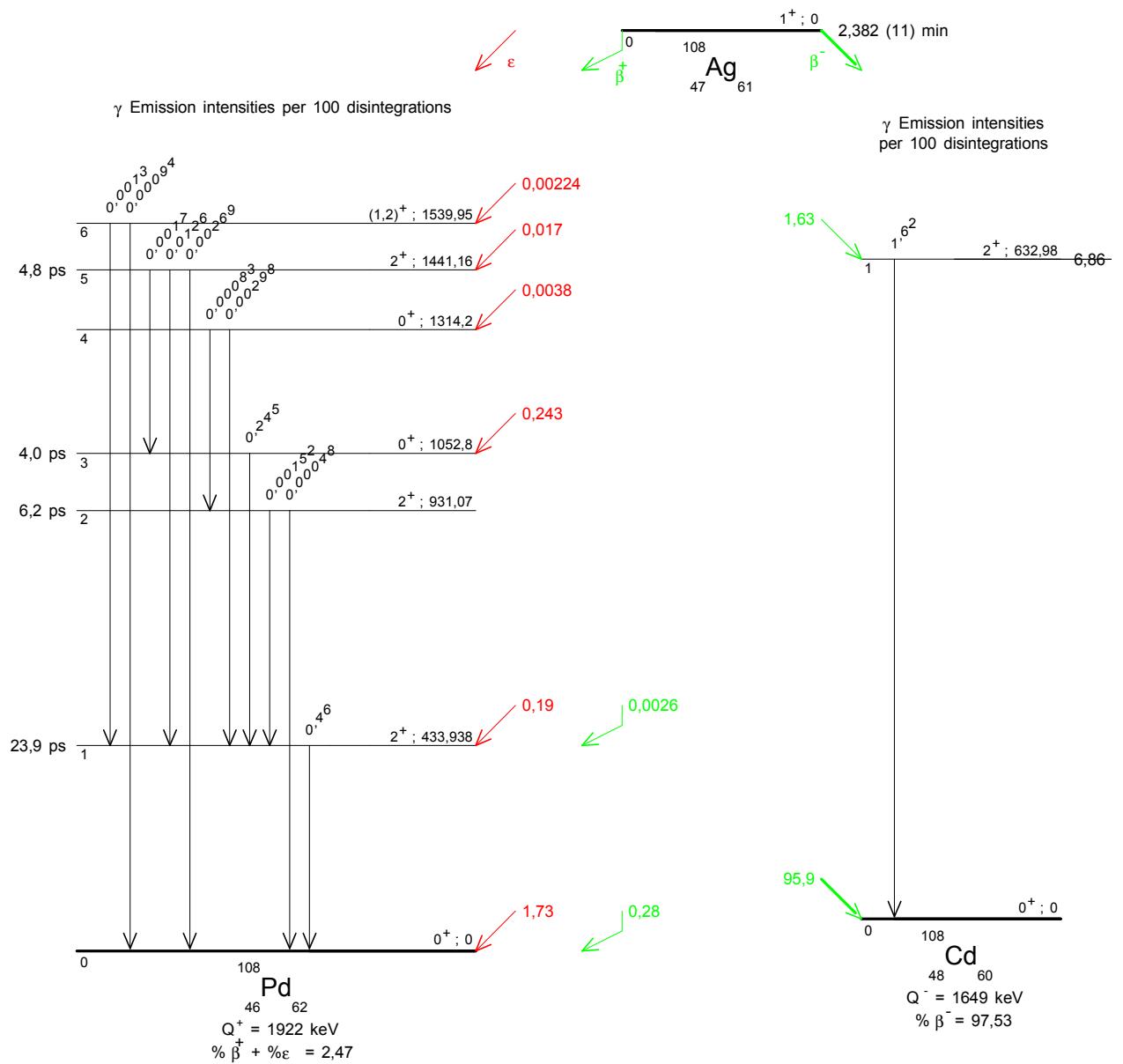
		Energy keV	Photons per 100 disint.
$\gamma_{4,2}$ (Pd)		383,13 (16)	0,00083 (30)
$\gamma_{5,3}$ (Pd)		388,36 (7)	0,0017 (6)
$\gamma_{1,0}$ (Pd)		433,938 (5)	0,46 (7)
$\gamma_{2,1}$ (Pd)		497,13 (12)	0,00152 (40)
$\gamma^{\pm}$		511	0,565 (40)
$\gamma_{3,1}$ (Pd)		618,86 (5)	0,245 (39)
$\gamma_{1,0}$ (Cd)		632,98 (5)	1,62 (26)
$\gamma_{4,1}$ (Pd)		880,26 (10)	0,00298 (48)
$\gamma_{2,0}$ (Pd)		931,07 (12)	0,00048 (8)
$\gamma_{5,1}$ (Pd)		1007,22 (5)	0,0126 (20)
$\gamma_{6,1}$ (Pd)		1106,01 (7)	0,00130 (22)
$\gamma_{5,0}$ (Pd)		1441,15 (5)	0,00269 (44)
$\gamma_{6,0}$ (Pd)		1539,94 (7)	0,00094 (16)

## 6 Main Production Modes



## 7 References

- M.L. PERLMAN, G. FRIEDLANDER. Phys. Rev. 74 (1948) 442  
(Half-life.)
- D.L. MOCK, R.C. WADDEL, L.W. FAGG, R.A. TOBIN. Phys. Rev. 74 (1948) 1536  
(Half-life.)
- M.L. PERLMAN, W. BERNSTEIN, R.B. SCHWARTZ. Phys. Rev. 92 (1953) 1236  
(Branching ratio, decay scheme.)
- G. GUEBEN. Inst. Inter. Sci. Nucl. , Monographie n. 2 (1958)  
(Half-life.)
- M.A. WAHLGREN, W.W. MEINKE. Phys. Rev. 118 (1960) 181  
(Half-life.)
- L. FREVERT. Z. Physik 169 (1962) 456  
(Branching ratio, decay scheme.)
- T.G. EBREY, P.R. GRAY. Nucl. Phys. 61 (1965) 479  
(Half-life.)
- L. FREVERT, R. SCHÖNEBERG, A. FLAMMERSFELD. Z. Physik 182 (1965) 439  
(Branching ratio, decay scheme.)
- K. OKANO, Y. KAWASE, S. UEHARA, T. HAYASHI. Nucl. Phys. A164 (1971) 545  
(Emission probabilities.)
- N.D. JOHNSON, J.H. HAMILTON, A.F. KLUK, N.R. JOHNSON. Z. Physik 243 (1971) 395  
(Emission probabilities, half-life.)
- N.C. SINGHAL, N.R. JOHNSON, E. EICHLER. Phys. Rev. C7 (1973) 774  
(Gamma energies, emission probabilities.)
- T.B. RYVES, K.J. ZIEBA. J. Phys. (London) A7 (1974) 2318  
(Half-life.)
- R.L. HEATH. Report ANCR-1000-2 (1974)  
(Half-life.)
- R.L. HAESE, F.E. BERTRAND, B. HARMATZ, M.J. MARTIN. Nucl. Data Sheets 37 (1982) 289  
(Energy level, multipolarity, spin.)
- H. YAMAMOTO, K. KAWADE, T. KATO, A. HOSOYA, M. SHIBATA, A. OSA, T. IIDA, A. TAKAHASHI. Proc. Int. Conf. Nuclear Data for Science and Technology, Jülich (1991) 565  
(Half-life)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic data.)
- J. BLACHOT. Nucl. Data Sheets 91 (2000) 135  
(Energy level, multipolarity, spin.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C. W. NESTOR JR., P.O. TIKKANEN, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Alpha)
- G. AUDI, A.H. WAPSTRA. Nucl. Phys. A729 (2003) 129  
(Q.)







## 1 Decay Scheme

Ag-108m disintegrates 90.9(6)% by electron capture to the 1771 keV excited state in Pd-108, and by 9.1(6)% through isomeric transitions (two gamma-rays in cascade) in Ag-108.

*L'argent 108 métastable se désintègre pour 90,9(6)% par capture électronique vers le niveau excité de 1771 keV de palladium 108 et se désexcite pour 9,1(6)% vers le niveau fondamental d'argent 108 selon 2 transitions gamma en cascade.*

## 2 Nuclear Data

$T_{1/2}(^{108}\text{Ag}^m)$	:	438	(9)	a
$T_{1/2}(^{108}\text{Ag})$	:	2,395	(6)	min
$Q^+(^{108}\text{Ag}^m)$	:	2031	(6)	keV

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_M$
$\epsilon_{0,3}$	260 (6)	90,9 (6)	Allowed	9,24	0,8457 (15)	0,1238 (12)	0,0256 (5)

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{2,1}(\text{Ag})$	30,309 (8)	9,1 (6)	M4	9,77 (29) 10 <sup>3</sup>	320 (10) 10 <sup>3</sup>	82,0 (25) 10 <sup>3</sup>	425 (13) 10 <sup>3</sup>
$\gamma_{1,0}(\text{Ag})$	79,131 (3)	9,1 (6)	E1	0,269 (8)	0,0336 (10)	0,00633 (19)	0,310 (9)
$\gamma_{1,0}(\text{Pd})$	433,938 (4)	90,9 (6)	[E2]	0,00784 (24)	0,001021 (31)	0,000192 (6)	0,00909 (27)
$\gamma_{2,1}(\text{Pd})$	614,31 (5)	90,8 (16)	E2	0,00291 (9)	0,000360 (11)	0,0000677 (20)	0,00335 (10)
$\gamma_{3,2}(\text{Pd})$	722,91 (5)	91,0 (16)	E2	0,00191 (6)	0,000231 (7)	0,0000434 (13)	0,00219 (7)

### 3 Atomic Data

#### 3.1 Pd

$$\begin{aligned}\omega_K &: 0,820 \quad (4) \\ \bar{\omega}_L &: 0,0536 \quad (13) \\ n_{KL} &: 0,975 \quad (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	21,0203	52,93
K $\alpha_1$	21,1774	100
K $\beta_3$	23,7914	}
K $\beta_1$	23,819	}
K $\beta_5''$	24,013	27,44
K $\beta_2$	24,2994	}
K $\beta_4$	24,344	4,66

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	17,032 – 17,884	100
KLX	20,032 – 21,176	42
KXY	23,011 – 24,347	4,4
Auger L	1,7 – 3,6	

### 3.2 Ag

$\omega_K$  : 0,831 (4)  
 $\bar{\omega}_L$  : 0,0583 (14)  
 $n_{KL}$  : 0,964 (4)

#### 3.2.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	21,9906	53,05
K $\alpha_1$	22,16317	100
K $\beta_3$	24,9118	}
K $\beta_1$	24,9427	}
K $\beta_5''$	25,146	}
K $\beta_2$	25,4567	}
K $\beta_4$	25,512	4,82

#### 3.2.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	17,79 – 18,69	100
KLX	20,945 – 22,160	42,5
KXY	24,079 – 25,507	4,51
Auger L	1,9 – 3,8	

## 4 Electron Emissions

		Energy keV		Electrons per 100 disint.
e <sub>AL</sub>	(Pd)	1,7	-	3,6
				83,1 (4)
e <sub>AK</sub>	(Pd)			14,1 (4)
	KLL	17,032	-	17,884
	KLX	20,032	-	21,176
	KXY	23,011	-	24,347
				}
e <sub>AL</sub>	(Ag)	1,9	-	3,8
				8,60 (7)
e <sub>AK</sub>	(Ag)			0,349 (27)
	KLL	17,79	-	18,69
	KLX	20,945	-	22,160
	KXY	24,079	-	25,507
				}
ec <sub>1,0 K</sub>	(Ag)	53,617	(3)	1,80 (14)
ec <sub>1,0 L</sub>	(Ag)	75,325	-	75,780
ec <sub>1,0 K</sub>	(Pd)	409,588	(4)	0,716 (22)
ec <sub>1,0 L</sub>	(Pd)	430,334	-	430,765
ec <sub>2,1 K</sub>	(Pd)	589,96	(5)	0,268 (9)
ec <sub>3,2 K</sub>	(Pd)	698,56	(5)	0,175 (6)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

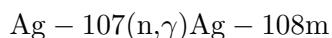
		Energy keV	Photons per 100 disint.	
XK $\alpha_2$	(Pd)	21,0203	18,38 (18)	} K $\alpha$
XK $\alpha_1$	(Pd)	21,1774	34,72 (30)	}
XK $\beta_3$	(Pd)	23,7914	}	
XK $\beta_1$	(Pd)	23,819	}	K' $\beta_1$
XK $\beta_5''$	(Pd)	24,013	}	
XK $\beta_2$	(Pd)	24,2994	}	
XK $\beta_4$	(Pd)	24,344	}	1,62 (6) K' $\beta_2$
XK $\alpha_2$	(Ag)	21,9906	0,49 (4)	} K $\alpha$
XK $\alpha_1$	(Ag)	22,16317	0,93 (7)	}

	Energy keV	Photons per 100 disint.	
XK $\beta_3$ (Ag)	24,9118	}	
XK $\beta_1$ (Ag)	24,9427	}	0,256 (19) K' $\beta_1$
XK $\beta_5''$ (Ag)	25,146	}	
XK $\beta_2$ (Ag)	25,4567	}	
XK $\beta_4$ (Ag)	25,512	}	0,045 (4) K' $\beta_2$

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{2,1}(\text{Ag})$	30,309 (8)	0,0000215 (18)
$\gamma_{1,0}(\text{Ag})$	79,131 (3)	6,9 (5)
$\gamma_{1,0}(\text{Pd})$	433,938 (5)	90,1 (6)
$\gamma_{2,1}(\text{Pd})$	614,276 (4)	90,5 (16)
$\gamma_{3,2}(\text{Pd})$	722,907 (10)	90,8 (16)

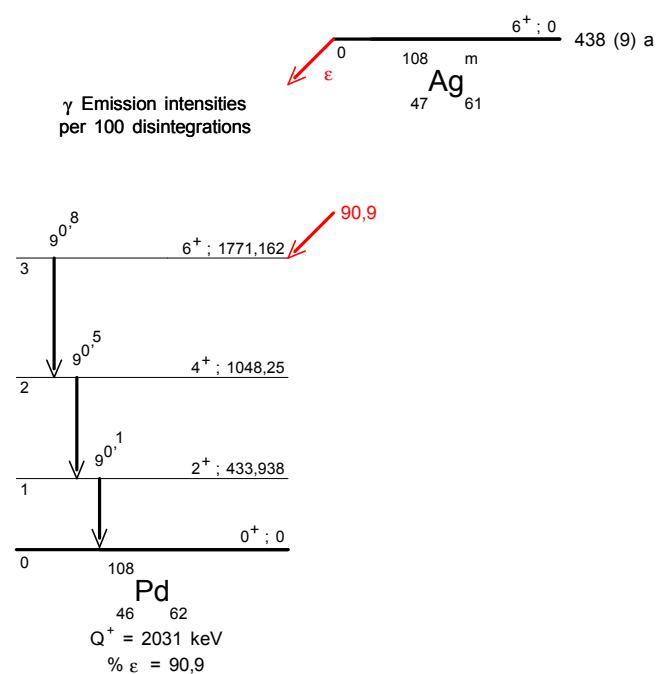
## 6 Main Production Modes

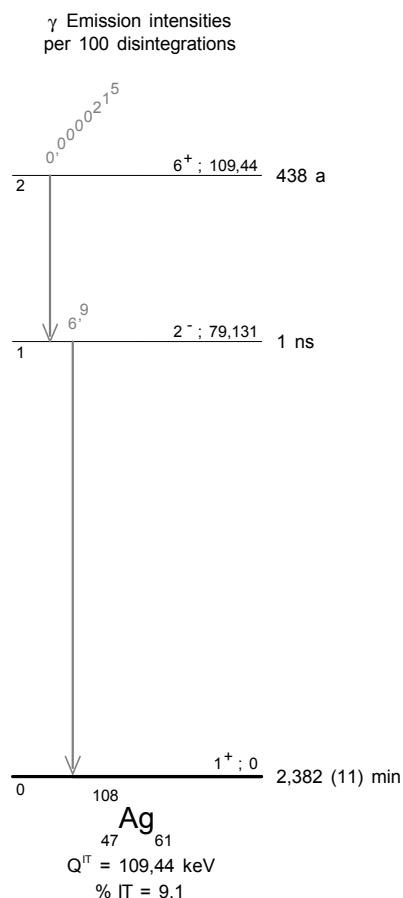


## 7 References

- M.A. WAHLGREN, W.W. MEINKE. Phys. Rev. 118 (1960) 181  
(Branching ratio.)
- O.C. KRISTNER, A.W. SUNYAR. Bull. Am. Phys. Soc. 7 (1962) 342  
(Half-life.)
- J.H. HAMILTON, J.F.W. JANSEN, P.F.A. GOUDSMIT, A.R. SATTLER. Nucl. Phys. 61 (1965) 257  
(Electron Conversion.)
- O.C. KISTNER, A.W. SUNYAR. Phys. Rev. 143 (1966) 918  
(Emission probabilities.)
- J.H. HAMILTON, A.V. RAMAYYA. Bull. Am. Phys. Soc. 13 (1968) 249  
(Energy values.)
- T.I. KRACIKOVA, B. KRACIK. Czech. J. Phys. B18 (1968) 143  
(Emission probabilities.)
- G. HARBOTTLE. Radiochim. Acta 13 (1969) 132  
(Half-life.)
- H. VONACH, M. HILLE, P. HILLE. Z. Physik 227 (1969) 381  
(Half-life.)
- J.H. HAMILTON, S.M. BRAHMAVAR, J.B. GUPTA, R.W. LIDE, P.H. STELSON. Nucl. Phys. A172 (1971) 139  
(Emission probabilities.)

- T. MORII, T. SAITO. Nucl. Instrum. Methods 131 (1975) 197  
(Energy value.)
- H. MARIA, J. DALMASSO, G. ARDISSON. Nucl. Instrum. Methods 195 (1982) 621  
(Energy value.)
- R. L. HAESE, F. E. BERTRAND, B. HARMATZ, M. J. MARTIN. Nucl. Data Sheets 37 (1982) 289  
(Gamma energy, spin, branching ratio.)
- U. SCHÖTZIG, H. SCHRADER, K. DEBERTIN. Julich Conf., Nucl. Data for Science and Technology (1992) 562  
(Half-life.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic data.)
- R.G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Energy.)
- J. BLACHOT. Nucl. Data Sheets 91 (2000) 135  
(Gamma energy, spin, branching ratio.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C.W. NESTOR JR., P.O. TIKKANEN, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Alpha)
- G. AUDI, A.H. WAPSTRA. Nucl. Phys. A729 (2003) 129  
(Q.)
- H. SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life.)







## 1 Decay Scheme

In-111 disintegrates by > 99.99% electron capture via the excited level of 416.6 keV in Cd-111 and by < 0.01% electron capture via the isomer level in Cd-111 ( $T_{1/2} = 48.5$  min) at 396.2 keV. Transitions to the ground state and the excited level of 245.4 keV in Cd-111 have not been observed.

*L'indium 111 se désintègre par capture électronique (> 99,99%) vers le niveau excité de 416 keV et vers le niveau excité de 396 keV et de 48,5 min de période du cadmium 111. Aucune transition vers le niveau de 245 keV et le niveau fondamental n'a été observée.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{111}\text{In}) &: 2,8049 \quad (4) \quad \text{d} \\ Q^+(^{111}\text{In}) &: 861,8 \quad (46) \quad \text{keV} \end{aligned}$$

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft	$P_K$	$P_L$	$P_M$
$\epsilon_{0,3}$	445 (5)	99,995 (5)	Allowed	5	0,8518 (2)	0,11835 (13)	0,02989 (4)
$\epsilon_{0,2}$	466 (5)	0,005 (5)	1st Forbidden	9	0,8524 (2)	0,1179 (2)	0,02975 (4)

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{2,1}(\text{Cd})$	150,81 (3)	0,005 (5)	E3	1,45 (3)	0,673 (14)	0,137 (3)	2,28 (5)
$\gamma_{3,1}(\text{Cd})$	171,28 (3)	99,995 (5)	M1 + 2 % E2	0,0897 (22)	0,0113 (3)	0,00217 (5)	0,1036 (24)
$\gamma_{1,0}(\text{Cd})$	245,35 (4)	100	E2	0,0524 (10)	0,00818 (16)	0,00159 (3)	0,0625 (7)

### 3 Atomic Data

#### 3.1 Cd

$$\begin{aligned}\omega_K &: 0,842 \quad (4) \\ \bar{\omega}_L &: 0,0632 \quad (16) \\ n_{KL} &: 0,953 \quad (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	22,9843	53,17
K $\alpha_1$	23,1739	100
K $\beta_3$	26,0615	}
K $\beta_1$	26,0958	}
K $\beta_5''$	26,304	}
		27,9
K $\beta_2$	26,644	}
K $\beta_4$	26,7106	}
		5,1
X <sub>L</sub>		
L $\ell$	2,77	
L $\alpha$	3,127 – 3,134	
L $\eta$	2,957	
L $\beta$	3,316 – 3,528	
L $\gamma$	3,718 – 3,95	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	18,675 – 19,636	100
KLX	21,923 – 23,172	43
KXY	25,171 – 26,028	4,63
Auger L	3,4 – 3,8	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Cd)	3,4 - 3,8	100,5 (8)
e <sub>AK</sub>	(Cd)		15,5 (4)
	KLL	18,675 - 19,636	}
	KLX	21,923 - 23,172	}
	KXY	25,171 - 26,028	}
ec <sub>3,1</sub> K	(Cd)	144,57 (3)	8,13 (20)
ec <sub>3,1</sub> L	(Cd)	167,3 - 167,7	1,02 (3)
ec <sub>3,1</sub> M	(Cd)	170,51 - 170,88	0,197 (5)
ec <sub>1,0</sub> K	(Cd)	218,64 (4)	4,93 (10)
ec <sub>1,0</sub> L	(Cd)	241,33 - 241,81	0,770 (15)
ec <sub>1,0</sub> M	(Cd)	244,58 - 244,95	0,150 (3)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Cd)	2,77 — 3,95	6,78 (14)
XK $\alpha_2$	(Cd)	22,9843	23,65 (18) }
XK $\alpha_1$	(Cd)	23,1739	44,47 (26) }
XK $\beta_3$	(Cd)	26,0615 }	
XK $\beta_1$	(Cd)	26,0958 }	12,40 (14) K' $\beta_1$
XK $\beta_5''$	(Cd)	26,304 }	
XK $\beta_2$	(Cd)	26,644 }	
XK $\beta_4$	(Cd)	26,7106 }	2,26 (7) K' $\beta_2$

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{2,1}(\text{Cd})$	150,81 (3)	0,0015 (15)
$\gamma_{3,1}(\text{Cd})$	171,28 (3)	90,61 (20)
$\gamma_{1,0}(\text{Cd})$	245,35 (4)	94,12 (6)

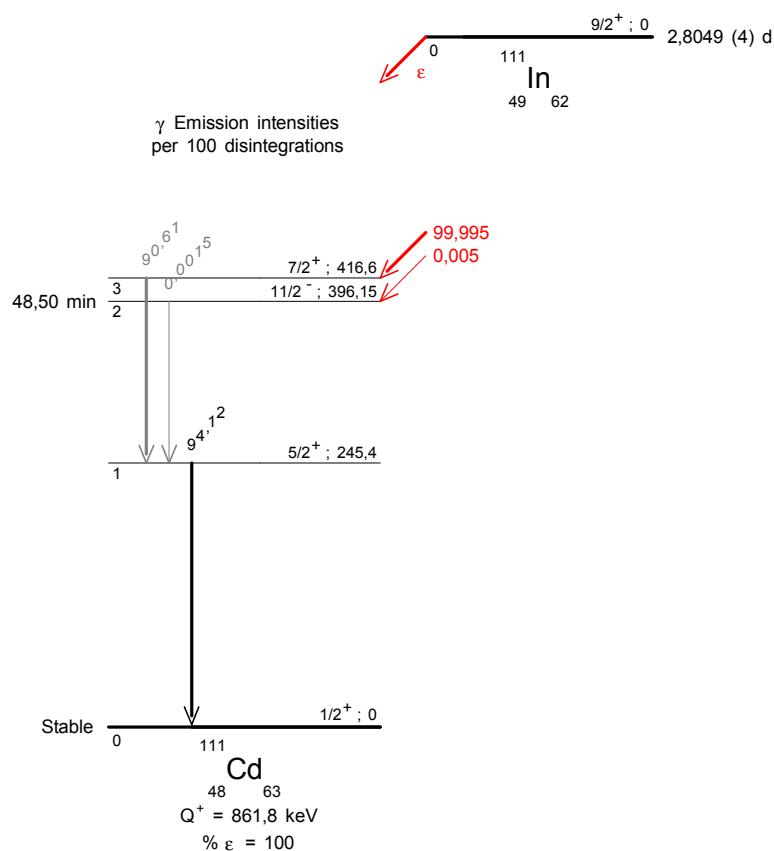
## 6 Main Production Modes

- |   |
|---|
| $\left\{ \begin{array}{l} \text{Cd} - 112(\text{p},2\text{n})\text{In} - 111 \\ \text{Possible impurities : none} \end{array} \right.$            |
| $\left\{ \begin{array}{l} \text{Cd} - 111(\text{p},\text{n})\text{In} - 111 \\ \text{Possible impurities : In} - 114\text{m} \end{array} \right.$ |

## 7 References

- M. L. WIEDENBECK. Phys. Rev. 67 (1945) 92  
(Half-life(Cd-111m).)
- N. HOLE. Arkiv. Mat. Astron. Fysik 36A (1948) N09  
(Half-life(Cd-111m).)
- A. S. HELMHOLZ, R. W. HAYWARD, C. L. McGINNIS. Phys. Rev. 75 (1949) 1469A  
(Half-life(Cd-111m), Half-life(In-111).)
- C. L. McGINNIS. Phys. Rev. 81 (1951) 734  
(Half-life(Cd-111m), Electron and gamma-ray energies and probabilities.)
- R. H. STEFFEN. Phys. Rev. 103 (1956) 116  
(Mixing Ratio (E2/M1) of gamma (3,1) transition.)
- A. MAIER. Helv. Phys. Acta 30 (1957) 611  
(Half-life(In-111).)
- P. SPARRMAN, A. MARRELIUS, T. SUNDSTROM, H. PETTERSON. Z. Phys. B192 (1966) 439  
(Gamma-ray energies and emission probabilities, ICC.)
- J. A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies.)
- P. BORNEMISZA-PAUSPERTL, J. KAROLYI, G. PETO. ATOMKI Kozlemen 10 (1968) 112  
(Half-life(Cd-111m).)
- H. LISKIEN. Nucl. Phys. A118 (1968) 379  
(Half-life(In-111).)
- F. SMEND, W. WEIRAUCH, W.-D. SCHMIDT-OTT. Z. Phys. 214 (1968) 437  
(Half-life(In-111).)
- S. E. GUREEV, T. ISLAMOV, V. S. USACHENKO. Izv. Akad. Nauk. SSSR. Ser. Fiz.- Uzb. Mat. 1 (1972) 87  
(Half-life(In-111).)
- R. A. MEYER, J. H. LANDRUM. Bull. Amer. Phys. Soc. 17 (1972) 906  
(Electron capture probability(0,2).)
- J. F. EMERY *et al.* Nucl. Sci. Eng. 48 (1972) 319  
(Half-life(In-111).)
- C. BUDZ-JORGENSEN. Phys. Rev. B8 (1973) 5411  
(Mixing Ratio (E2/M1) of gamma (3,1) transition.)
- B. P. PATHAK, S. K. MUKHERJEE. Radiochem. Radioanal. Letters 15 (1973) 187  
(T ICC of gamma (2,1) transition.)
- W. KREISCHE, W. LAMPERT. Z. Phys. 266 (1974) 51  
(Mixing Ratio (E2/M1) of gamma (3,1) transition.)
- R. L. HEATH. ANCR-1000-2 (1974)  
(Gamma-ray energies and emission probabilities.)
- G. A. SHEVELEV, A. T. TROYTSKAYA, V. M. KARTASHOV. Izv. Akad. Nauk. SSSR. Ser. Fiz. 39 (1975) 2038  
(Gamma-ray energies and emission probabilities, ICC.)
- F. P. LARKINS. At. Data Nucl. Data Tables 20 (1977) 313  
(Auger electrons energies.)
- F. RÖSEL, H. M. FRIES, K. ALDER, H. C. PAULI. At. Data Nucl. Data Tables 21 (1978) 92  
(Theoretical ICC.)
- F. LAGOUTINE, J. LEGRAND, C. BAC. Int. J. Appl. Radiat. Isotop. 29 (1978) 269  
(Half-life(In-111).)
- H. HOUTERMANS, O. MILOSEVIC, F. REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life(In-111).)

- D. D. HOPPES *et al.*. NBS-Special publication 626 (1982) 85  
(Half-life(In-111).)
- K. F. WALZ, K. DEBERTIN, H. SCHRADER. Int. J. Appl. Radiat. Isotop. 34 (1983) 1191  
(Half-life(In-111).)
- Y. KAWADA, Y. HINO. Nucl. Instrum. Methods A241 (1985) 199  
(T ICC.)
- A. R. RUTLEDGE, L. V. SMITH, J. S. MERRITT. Int. J. Appl. Radiat. Isotop. 37 (1986) 1029  
(Half-life(In-111).)
- Zs. NEMETH, L. LAKOSI, I. PAVLICSEK, A. VERES. Int. J. Appl. Radiat. Isotop. 38 (1987) 63  
(Half-life(Cd-111m).)
- M. P. UNTERWEGER, D. D. HOPPES, F. J. SCHIMA. Nucl. Instrum. Methods Phys. Res. A312 (1992) 349  
(Half-life(In-111).)
- S.F. KAFALA, T.D. MACMAHON, P.W. GRAY. Nucl. Instrum. Methods Phys. Res. A339 (1994) 151  
(Evaluation technique.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data.)
- XIAO-QIONG WEN *et al.*. Nucl. Instrum. Methods Phys. Res. A379 (1997) 478  
(Half-life(Cd-111m).)
- B. SINGH, J.L. RODRIGUEZ, S.S. WONG, J.K. TULI. Nucl. Data Sheets 84 (1998) 487  
(lg ft.)
- M.-M. BÉ, B. DUCHEMIN, J. LAME, C. MORILLON, F. PITON, E. BROWNE, V. CHECHEV, R. HELMER, E. SCHÖNFELD. Table de Radionucléide, CEA-ISBN 2-7272-0200-8 (1999)  
(In-111 decay data evaluation - 1998.)
- J. BLACHOT. Nucl. Data Sheets 100 (2003) 179  
(Cd-111 level scheme and energies.)
- G. AUDI, A. N. WAPSTRA. Nucl. Phys. A729 (2003) 337  
(Q.)
- H. SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life(In-111).)
- E.A. YAKUSHEV *et al.*. Appl. Rad. Isotopes 62 (2005) 451  
(Auger electrons.)
- S. RAMAN, M. ERTUGRUL, C.W. NESTOR JR., M.B. TRZHASKOVSKAYA. At. Data. Nucl. Data Tables 92 (2006) 207  
(Theoretical ICC.)





## 1 Decay Scheme

*Sb-125 decays by beta minus emission to levels in Te-125. The percentage of disintegrations to the Te-125m ( $T_{1/2} = 57$  d) is  $p = 22.9$  (9)%.* The two gamma emission intensities with energy 35-keV and 109-keV are given for the two nuclides being in equilibrium.

L'antimoine 125 se désintègre par émissions bêta moins vers des niveaux excités de tellure 125. Les intensités des deux émissions gamma de 35 keV et 109 keV sont données pour les deux radionucléides étant à l'équilibre. Le pourcentage de désintégrations conduisant à l'isomère de Te-125 de 57 jours de période est  $p = 22,9$  (9)%.

Le rapport au temps t des activités Te-125m / Sb-125 dans le Sb-125 initialement pur est :

$$p \times [T_1/(T_1 - T_2)] \times [1 - e^{-(\log 2 \times [(T_1 - T_2)/(T_1 \times T_2)] \times t)}]$$

T1 et T2 étant respectivement les périodes de Sb-125 et Te-125m.

Pour  $t \geq 1,6$  a, ce qui correspond à dix fois la période de Te-125m, ce rapport est égal à :

$$p \times [T_1 / (T_1 - T_2)] = 0,243 \quad (10)$$

avec  $p = 0,229$  (9).

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{125}\text{Sb}) &: 2,75855 \quad (25) \quad \text{a} \\ Q^-(^{125}\text{Sb}) &: 766,7 \quad (21) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,12}^-$	95,3 (21)	13,58 (12)	Allowed	6,93
$\beta_{0,10}^-$	124,5 (21)	5,82 (5)	Allowed	7,66
$\beta_{0,9}^-$	130,6 (21)	18,07 (19)	Allowed	7,23
$\beta_{0,7}^-$	241,5 (21)	1,251 (12)	1st forbidden	9,23
$\beta_{0,6}^-$	303,3 (21)	40,3 (4)	Allowed	8,04
$\beta_{0,5}^-$	323,1 (21)	0,089 (10)	2nd forbidden	10,79
$\beta_{0,3}^-$	444,0 (21)	7,54 (9)	1st forbidden	9,32
$\beta_{0,2}^-$	621,0 (21)	13,4 (9)	Unique 1st forbidden	9,77

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{6,5}(\text{Te})$	19,80 (6)	0,248 (9)	[M1]		9,1 (3)	1,82 (5)	11,3 (3)
$\gamma_{1,0}(\text{Te})$	35,489 (5)	88,7 (37)	M1+0,084% E2	12,1 (4)	1,64 (5)	0,329 (10)	14,3 (4)
$\gamma_{2,1}(\text{Te})$	109,276 (15)	24 (8)	M4	182 (5)	135 (4)	31 (1)	354,6 (110)
$\gamma_{9,7}(\text{Te})$	110,895 (12)	0,00125 (10)	[E1]	0,127 (4)	0,0165 (5)	0,00328 (11)	0,147 (4)
$\gamma_{10,7}(\text{Te})$	116,955 (11)	0,2964 (46)	E1	0,109 (3)	0,0141 (4)	0,00281 (8)	0,127 (4)
$\gamma_{9,6}(\text{Te})$	172,719 (8)	0,221 (10)	M1(+E2)	0,129 (4)	0,0168 (5)	0,00337 (11)	0,151 (5)
$\gamma_{3,2}(\text{Te})$	176,314 (2)	7,96 (9)	M1+26,5% E2	0,139 (4)	0,0221 (7)	0,00449 (13)	0,167 (5)
$\gamma_{10,6}(\text{Te})$	178,842 (5)	0,0405 (22)	M1+E2	0,147 (26)	0,026 (11)	0,0054 (21)	0,18 (4)
$\gamma_{10,5}(\text{Te})$	198,654 (11)	0,0152 (8)	[E2]	0,123 (4)	0,0245 (8)	0,00504 (15)	0,154 (5)
$\gamma_{7,3}(\text{Te})$	204,138 (10)	0,353 (17)	M1+72% E2	0,104 (3)	0,0189 (6)	0,00386 (11)	0,128 (4)
$\gamma_{12,6}(\text{Te})$	208,077 (5)	0,269 (9)	M1+1,1% E2	0,0791 (24)	0,0102 (3)	0,00205 (6)	0,092 (3)
$\gamma_{12,5}(\text{Te})$	227,891 (10)	0,142 (3)	(M1+E2)	0,070 (11)	0,011 (4)	0,0023 (6)	0,084 (13)
$\gamma_{9,3}(\text{Te})$	314,95 (11)	0,0043 (3)	(E1)	0,00726 (22)	0,00089 (3)	0,000179 (5)	0,00839 (30)
$\gamma_{10,3}(\text{Te})$	321,040 (4)	0,420 (4)	E1	0,00691 (21)	0,000856 (30)	0,000170 (5)	0,00798 (24)
$\gamma_{7,2}(\text{Te})$	380,452 (8)	1,548 (15)	E2	0,0154 (5)	0,00233 (7)	0,000473 (15)	0,0183 (5)
$\gamma_{5,1}(\text{Te})$	408,065 (10)	0,185 (2)	M1+69% E2	0,0129 (4)	0,00181 (5)	0,00036 (1)	0,0152 (5)
$\gamma_{6,1}(\text{Te})$	427,874 (4)	29,96 (24)	M1+22,4% E2	0,0119 (4)	0,00154 (5)	0,00031 (1)	0,0138 (4)
$\gamma_{5,0}(\text{Te})$	443,555 (9)	0,309 (4)	M1+84% E2	0,0100 (3)	0,00142 (4)	0,00029 (1)	0,0118 (4)
$\gamma_{6,0}(\text{Te})$	463,365 (4)	10,59 (9)	E2	0,0086 (3)	0,00124 (4)	0,00025 (1)	0,0102 (3)
$\gamma_{10,2}(\text{Te})$	497,37 (12)	0,0033 (3)	[M2]	0,0271 (8)	0,00373 (11)	0,00075 (2)	0,0318 (10)
$\gamma_{9,1}(\text{Te})$	600,599 (2)	17,85 (18)	E2	0,00421 (13)	0,00058 (2)	0,000116 (4)	0,00498 (15)
$\gamma_{10,1}(\text{Te})$	606,715 (3)	5,05 (5)	E2	0,00415 (13)	0,00056 (2)	0,000113 (4)	0,00485 (15)
$\gamma_{12,1}(\text{Te})$	635,950 (3)	11,38 (10)	M1+9,9% E2	0,00455 (14)	0,00057 (2)	0,000113 (5)	0,00526 (16)
$\gamma_{12,0}(\text{Te})$	671,443 (6)	1,790 (16)	E2	0,00319 (10)	0,00043 (1)	0,000086 (2)	0,00373 (11)

## 3 Atomic Data

### 3.1 Te

$$\begin{aligned}\omega_K &: 0,875 (4) \\ \bar{\omega}_L &: 0,0862 (35) \\ n_{KL} &: 0,917 (4)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	27,202	53,7
K $\alpha_1$	27,473	100
K $\beta_3$	30,945	{}
K $\beta_1$	30,996	{}
K $\beta_5''$	31,236	{ } 28,6
K $\beta_2$	31,701	{}
K $\beta_4$	31,774	{ } 6,2

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	21,804 – 22,989	100
KLX	25,814 – 27,470	45,5
KXY	29,80 – 31,81	5,1
Auger L      2,3 – 4,8		

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Te)	2,3 - 4,8	70,6 (9)
e <sub>AK</sub>	(Te)		10,5 (6)
	KLL	21,804 - 22,989	}
	KLX	25,814 - 27,470	}
	KXY	29,80 - 31,81	}
ec <sub>1,0</sub> T	(Te)	3,675 - 35,487	82,8 (35)
ec <sub>1,0</sub> K	(Te)	3,675 (5)	70,1 (32)
ec <sub>6,5</sub> L	(Te)	14,9 - 15,5	0,184 (8)
ec <sub>1,0</sub> L	(Te)	30,550 - 31,148	9,5 (4)
ec <sub>1,0</sub> M	(Te)	34,483 - 34,917	1,9 (1)
ec <sub>2,1</sub> K	(Te)	77,462 (15)	12,43 (41)
ec <sub>2,1</sub> T	(Te)	77,462 - 109,274	24 (8)
ec <sub>2,1</sub> L	(Te)	104,337 - 104,935	9,22 (32)
ec <sub>2,1</sub> M	(Te)	108,270 - 108,704	2,12 (8)
ec <sub>2,1</sub> N	(Te)	109,108 - 109,236	0,451 (16)
ec <sub>3,2</sub> K	(Te)	144,500 (2)	0,948 (29)
ec <sub>3,2</sub> L	(Te)	171,375 - 171,973	0,151 (5)
ec <sub>6,1</sub> K	(Te)	396,060 (4)	0,352 (12)
ec <sub>6,0</sub> K	(Te)	431,551 (4)	0,0901 (32)
ec <sub>9,1</sub> K	(Te)	568,785 (2)	0,0748 (24)
ec <sub>12,1</sub> K	(Te)	604,136 (3)	0,0515 (16)
$\beta_{0,12}^-$	max:	95,3 (21)	13,58 (12)
$\beta_{0,12}^-$	avg:	24,9 (6)	
$\beta_{0,10}^-$	max:	124,5 (21)	5,82 (5)
$\beta_{0,10}^-$	avg:	33,0 (6)	
$\beta_{0,9}^-$	max:	130,6 (21)	18,07 (19)
$\beta_{0,9}^-$	avg:	34,7 (6)	
$\beta_{0,7}^-$	max:	241,5 (21)	1,251 (12)

		Energy keV	Electrons per 100 disint.
$\beta_{0,7}^-$	avg:	67,5	(7)
$\beta_{0,6}^-$	max:	303,3	(21) 40,3 (4)
$\beta_{0,6}^-$	avg:	86,9	(7)
$\beta_{0,5}^-$	max:	323,1	(21) 0,089 (10)
$\beta_{0,5}^-$	avg:	93,3	(7)
$\beta_{0,3}^-$	max:	444,0	(21) 7,54 (9)
$\beta_{0,3}^-$	avg:	134,5	(8)
$\beta_{0,2}^-$	max:	621,0	(21) 13,4 (9)
$\beta_{0,2}^-$	avg:	215,5	(8)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Te)	3,3348 — 4,8228	6,56 (21)
XK $\alpha_2$	(Te)	27,202	21,0 (9) }
XK $\alpha_1$	(Te)	27,473	39,1 (15) }
XK $\beta_3$	(Te)	30,945	}
XK $\beta_1$	(Te)	30,996	}
XK $\beta_5''$	(Te)	31,236	}
XK $\beta_2$	(Te)	31,701	}
XK $\beta_4$	(Te)	31,774	2,43 (12) K' $\beta_2$

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{6,5}(\text{Te})$	19,80 (6)	0,0202 (5)
$\gamma_{1,0}(\text{Te})$	35,489 (5)	5,79 (18)
$\gamma_{2,1}(\text{Te})$	109,276 (15)	0,0683 (12)
$\gamma_{9,7}(\text{Te})$	110,895 (12)	0,00109 (9)
$\gamma_{10,7}(\text{Te})$	116,955 (11)	0,263 (4)
$\gamma_{9,6}(\text{Te})$	172,719 (8)	0,192 (9)
$\gamma_{3,2}(\text{Te})$	176,314 (2)	6,82 (7)
$\gamma_{10,6}(\text{Te})$	178,842 (5)	0,0343 (15)
$\gamma_{10,5}(\text{Te})$	198,654 (11)	0,0132 (7)
$\gamma_{7,3}(\text{Te})$	204,138 (10)	0,313 (15)
$\gamma_{12,6}(\text{Te})$	208,077 (5)	0,246 (8)
$\gamma_{12,5}(\text{Te})$	227,891 (10)	0,131 (3)
$\gamma_{9,3}(\text{Te})$	314,95 (11)	0,0043 (3)
$\gamma_{10,3}(\text{Te})$	321,040 (4)	0,416 (4)
$\gamma_{7,2}(\text{Te})$	380,452 (8)	1,520 (15)
$\gamma_{5,1}(\text{Te})$	408,065 (10)	0,182 (2)
$\gamma_{6,1}(\text{Te})$	427,874 (4)	29,55 (24)
$\gamma_{5,0}(\text{Te})$	443,555 (9)	0,305 (4)
$\gamma_{6,0}(\text{Te})$	463,365 (4)	10,48 (9)
$\gamma_{10,2}(\text{Te})$	497,37 (12)	0,0032 (3)
$\gamma_{9,1}(\text{Te})$	600,597 (2)	17,76 (18)
$\gamma_{10,1}(\text{Te})$	606,713 (3)	5,02 (5)
$\gamma_{12,1}(\text{Te})$	635,950 (3)	11,32 (10)
$\gamma_{12,0}(\text{Te})$	671,441 (6)	1,783 (16)

## 6 Main Production Modes



$$\left\{ \begin{array}{l} \text{Sn} - 125m(\beta^-)\text{Sb} - 125 \\ \text{Possible impurities : Half-life} = 9,7 \text{ min} \end{array} \right.$$

$$\left\{ \begin{array}{l} \text{Sn} - 124(n,\gamma)\text{Sn} - 125 \quad \sigma : 0,004 (2) \text{ barns} \\ \text{Possible impurities : Half-life} = 9,5 \text{ d} \end{array} \right.$$

$$\left\{ \begin{array}{l} \text{Sn} - 125(\beta^-)\text{Sb} - 125 \\ \text{Possible impurities : Sn} - 113, \text{Sn} - 117m, \text{Sn} - 119m, \text{Sn} - 121m, \text{Sn} - 123m, \text{Sn} - 125 \end{array} \right.$$

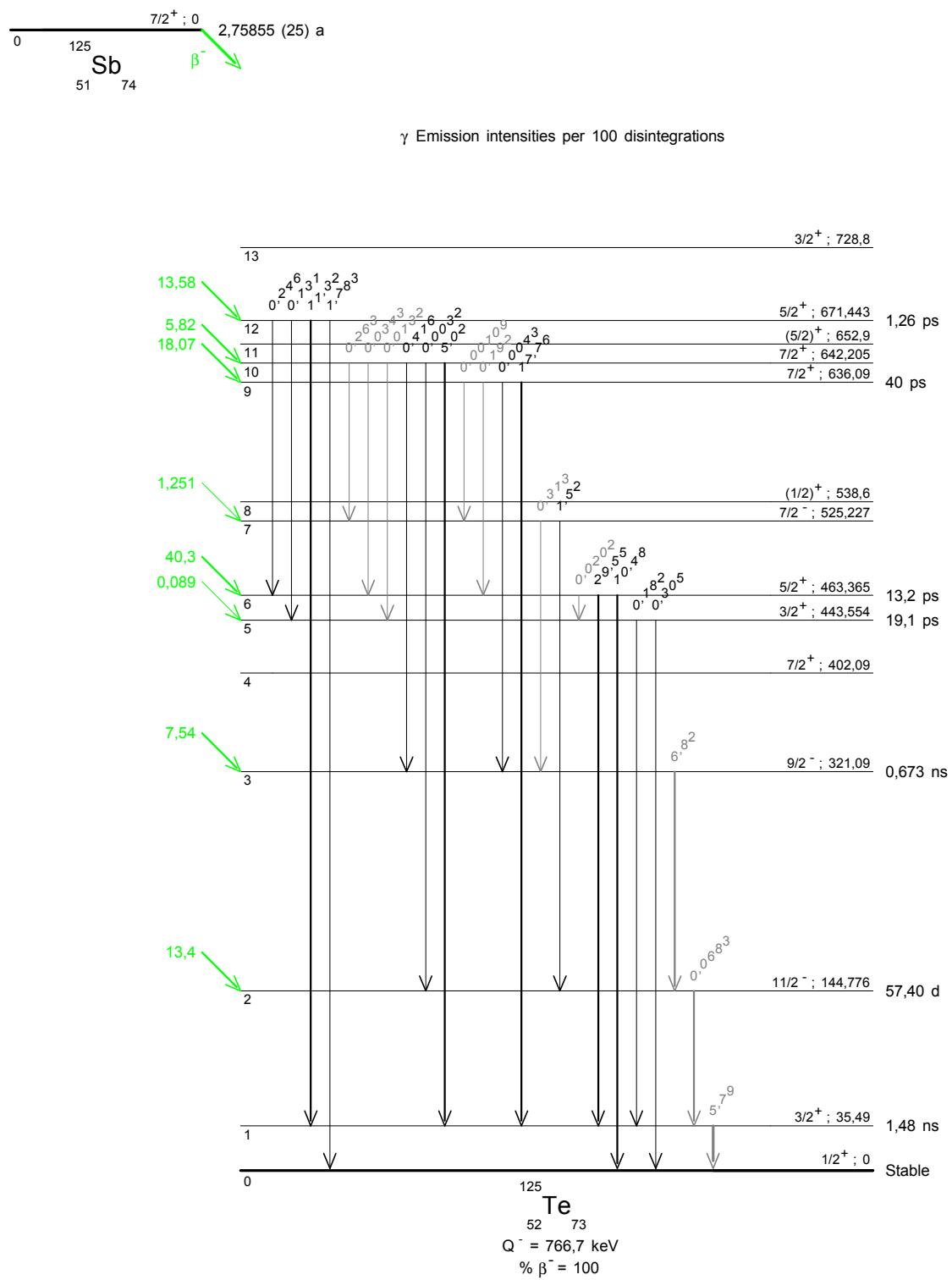
$$\left\{ \begin{array}{l} \text{Fission product}() \\ \text{Possible impurities : Sb} - 121m, \text{Sn} - 125 \end{array} \right.$$

## 7 References

- G. R. LEADER, W. H. SULLIVAN. NNES 9 (1950) 934  
(Half-life)
- R. S. NARCISI. Thesis, Harvard University, AECU 4336 (1959)  
(Beta emission probabilities)
- E. H. KLEHR, A. F. VOIGT. J. Inorg. Nuclear Chem. 16 (1960) 8  
(Half-life)
- E. I. WYATT, S. A. REYNOLDS, T. H. HANDLEY, W. S. LYON, H. A. PARKER. Nucl. Sci. Eng. 11 (1961) 74  
(Half-life)
- G. ANDERSSON, G. RUDSTAM, G. SORENSEN. Ark. Fys. 28 (1965) 37  
(Half-life level)
- K. F. FLYNN, L. E. GLENDEENIN, E. P. STEINBERG. Nucl. Sci. Eng. 22 (1965) 416  
(Half-life)
- T. INAMURA, T. IWASHITA, S. KAGEYAMA. J. Phys. Soc. Japan 21 (1966) 2425  
(Half-life level)
- F. O. LAWRENCE, W. R. DANIELS, D. C. HOFFMAN. J. Inorg. Nucl. Chem. 28 (1966) 2477  
(Half-life)
- C. HOHENEMSER, R. ROSNER. Nucl. Phys. A109 (1968) 364  
(Half-life level)
- H. SERGOLLE. Compt. Rend. 267B (1968) 1042  
(Gamma emission probabilities)
- J. KOWNACKI, J. LUDZIEJEWSKI, M. MOSZYNSKI. Nucl. Phys. A113 (1968) 561  
(Half-life level)
- P. R. CHRISTENSEN, A. BERINDE, I. NEAMU, N. SCINTEI. Nucl. Phys. A129 (1969) 337  
(Gamma energy and probability)
- R. R. HOSANGDI, P. N. TANDON, S. H. DEVARE. Indian J. Pure Appl. Phys. 7 (1969) 604  
(Half-life level)
- D. S. ANDREEV, V. K. BONDAREV, L. N. LAPERIN, A. Z. ILYASOV, I. K. LEMBERG. Bull. Acad. Sci. USSR, Phys. Ser. 32 (1969) 225  
(Gamma emission probabilities, multipolarity)
- L. D. WYLY, J. B. SALZBERG, E. T. PATRONIS, JR., N. S. KENDRICK, C. H. BRADEN. Phys. Rev. C1 (1970) 2062  
(Multipolarity)
- B. BENGSTON, M. MOSZYNSKI. Nucl. Instrum. Methods 85 (1970) 133  
(Half-life level)
- M. M. BAJAJ, S. L. GUPTA, N. K. SAHA. Proc. Natl. Inst. Sci. India 36A (1970) 176  
(Half-life level)
- T. S. NAGPAL, R. E. GAUCHER. Can. J. Phys. 48 (1970) 2978  
(Gamma energy and probability, multipolarity)
- A. MARELIUS, J. LINDSKOG, Z. AWWAD, K. G. VALIVAARA, S. E. HAGGLUND, J. PIHL. Nucl. Phys. A148 (1970) 433  
(Half-life level)
- K. S. KRANE, J.R. SITES, W. A. SEYERT. Phys. Rev. C4 (1971) 565  
(Multipolarity)
- M. ROTS, R. SILVERANS, R. COUSSEMENT. Nucl. Phys. A170 (1971) 240  
(Multipolarity)
- G. SATYANARAYANA, V. LAKSHMINARAYANA. Curr. Sci. (India) 40 (1971) 458  
(Multipolarity)
- E. E. BERLOVICH, V. V. LUKASHEVICH, A. V. POPOV, V. M. ROMANOV. Sov. J. Nucl. Phys. 12 (1971) 117  
(Half-life level)
- T. BADICA, S. DIMA, A. GELBERG, I. POPESCU. Z. Phys. 249 (1972) 321  
(Multipolarity)
- G. SATYANARAYANA, V. V. RAMAMURTY, V. LAKSHMINARAYANA. J. Phys. (London) A5 (1972) 1243  
(Half-life level)
- G. SATYANARAYANA, V. LAKSHMINARAYANA, D. S. MURTY. Can. J. Phys. 50 (1972) 600  
(Half-life level)
- B. BENGSTON, M. MOSZYNSKI. Nucl. Instrum. Methods 100 (1972) 293  
(Half-life level)

- D. S. BRENNER, M. L. PERLMAN. Nucl. Phys. A181 (1972) 207  
(Multipolarity)
- J. B. GUPTA, N. C. SINGHAL, J. H. HAMILTON. Z. Phys. 261 (1973) 137  
(Gamma energy and probability)
- P. ILA, K. SUDHAKAR, K. L. NARASIMHAM, V. LAKSHMINARAYANA. Curr. Sci. (India) 43 (1974) 176  
(Gamma probability)
- B. MARTIN, D. MERKERT, J. L. CAMPBELL. Z. Phys. A274 (1975) 15  
(Multipolarity)
- W.B. WALTERS, R.A. MEYER. Phys. Rev. C14 (1976) 1925  
(Gamma energy and probability)
- I. M. BAND, M. B. TRZHASKOVSKAYA, M. A. LISTENGARTEN. Atomic Data Nucl. Data Tables 18 (1976) 433  
(Internal Conversion Coefficient)
- R.J. GEHRKE, R.G. HELMER, R.C. GREENWOOD. Nucl. Instrum. Methods 147 (1977) 405  
(Gamma probability)
- G. ARDISSON, K. ABDMEZIEM. Radiochem. Radioanal. Lett. 29 (1977) 1  
(Gamma probability)
- F. LAGOUTINE, J. LEGRAND, C. BAC. Int. J. Appl. Radiat. Isotop. 29 (1978) 269  
(Half-life level)
- F. RÖSEL, H. M. FRIES, K. ALDER, H. C. PAULI. Atomic Data Nucl. Data Tables 21 (1978) 92  
(Internal Conversion Coefficients)
- R. PRASAD. Czech. J. Phys. B29 (1979) 737  
(Gamma probability)
- H. HOUTERMANS, O. MILOSEVIC, F. REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life)
- W. M. RONEY, JR., W. A. SEALE. Nucl. Instrum. Methods 171 (1980) 389  
(Gamma probability)
- K. SINGH, H. S. SAHOTA. Indian J. Phys. 56A (1982) 291  
(Multipolarity)
- P. MUKHERJEE, S. BHATTACHARYA, S. SARKAR, I. MUKHERJEE, B. K. DASMAHAPATRA. Phys. Rev. C25 (1982) 2120  
(Multipolarity)
- K. F. WALZ, K. DEBERTIN, H. SCHRADER. Int. J. Appl. Radiat. Isotop. 34 (1983) 1191  
(Half-life)
- K. SINGH, H. S. SAHOTA. Indian J. Pure Appl. Phys. 21 (1983) 19  
(Gamma probability)
- Y. IWATA, M. YASUHARA, K. MAEDA, Y. YOSHIZAWA. Nucl. Instrum. Methods 219 (1984) 123  
(Gamma-ray emission intensities)
- WANG XINLIN, LI XIAODI, DU HONGSHAN. Chin. J. Nucl. Phys. 8 (1986) 371  
(Gamma probability)
- A. M. GEIDELMAN, YU. S. EGOROV, N. K. KUZMENKO, V. G. NEDOVESOV, V. P. CHECHEV, G. E. SHUKIN. Proc. Intern. Conf. Nuclear Data for Science and Technology, Mito, Japan (1988) 909  
(Half-life level)
- L. LONGORIA-GANDARA, M. U. RAJPUT, T. D. MAC MAHON. Nucl. Instrum. Methods Phys. Res. A286 (1990) 529  
(Gamma probability evaluation)
- R. G. HELMER. Appl. Radiat. Isot. 41 (1990) 75  
(Gamma energy and probability)
- ZS. NEMETH, A. VERES. Nucl. Instrum. Methods Phys. Res. A286 (1990) 601  
(Theoretical conversion coefficients for M4 transitions)
- C. C. DEY, B. K. SINHA, R. BHATTACHARYA. Nuovo Cim. 105A (1992) 523  
(Half-life level)
- N. I. FAWWAZ, N. M. STEWART. J. Phys. (London) G19 (1993) 113  
(Gamma probability)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data)
- C. C. DEY, B. K. SINHA, R. BHATTACHARYA. Can. J. Phys. 75 (1997) 591  
(Multipolarity)
- M. SAINATH, K. VENKATARAMANIAH. Nuovo Cim. 111A (1998) 223  
(Multipolarity)

- M. SAINATH, K. VENKATARAMANIAH, P. C. SOOD. Phys. Rev. C58 (1998) 3730  
(Gamma energy and probability, multipolarity)
- M. ROTETA, E. GARCIA-TORANO. Appl. Radiat. Isot. 49 (1998) 1349  
(Multipolarity)
- A. GRAU CARLES, L. RODRIGUEZ BARQUERO, A. JIMENEZ DE MINGO. Appl. Radiat. Isot. 49 (1998) 1377  
(Beta probability)
- B. SINGH, J. L. RODRIGUEZ, S. S. M. WONG, J. K. TULI. Nucl. Data Sheets 84 (1998) 487  
(log ft sys.)
- J. KATAKURA. Nucl. Data Sheets 86 (1999) 955  
(Evaluation)
- M. SAINATH, K. VENKATARAMANIAH, P.C. SOOD. Pramana 53 (1999) 289  
(Multipolarity)
- R.G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Gamma energy)
- M.P. UNTERWEGER. Appl. Radiat. Isot. 56 (2002) 125  
(Half-life)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)
- M.J. WOODS, S.M. COLLINS. Appl. Radiat. Isot. 60 (2004) 257  
(Half-life evaluation)







## 1 Decay Scheme

Cs-137 disintegrates by beta minus emission to the ground state of Ba-137 (5,6 %) and via the 661 keV isomeric level of Ba-137 (94,4 %) which has a half-life of 2,55 min.

*Le césum 137 se désintègre par émission bêta moins vers le niveau fondamental de barium 137 (5,6 %) ainsi que vers le niveau isomère de 661 keV (94,4 %) et de 2,55 min de période.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{137}\text{Cs}) &: 30,05 \quad (8) \quad \text{a} \\ Q^-(^{137}\text{Cs}) &: 1175,63 \quad (17) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,2}^-$	513,97 (17)	94,36 (28)	Unique 1st Forbidden	9,63
$\beta_{0,1}^-$	892,1 (2)	0,00061 (8)	Unique 2nd Forbidden	15,64
$\beta_{0,0}^-$	1175,63 (17)	5,64 (28)	2nd Forbidden	12,06

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Ba})$	283,5 (1)	0,00061 (8)	[M1,E2]	0,046 (3)	0,0073 (10)	0,0015 (2)	0,0557 (13)
$\gamma_{2,0}(\text{Ba})$	661,659 (3)	94,36 (20)	M4	0,0896 (15)	0,0167 (5)	0,1102 (19)	

### 3 Atomic Data

#### 3.1 Ba

$$\begin{aligned}\omega_K &: 0,900 \quad (4) \\ \bar{\omega}_L &: 0,110 \quad (5) \\ n_{KL} &: 0,888 \quad (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	31,8174	54,28
K $\alpha_1$	32,1939	100
K $\beta_3$	36,3045	}
K $\beta_1$	36,3786	}
K $\beta_5''$	36,654	}
K $\beta_2$	37,258	}
K $\beta_4$	37,312	}
KO <sub>2,3</sub>	37,425	}
X <sub>L</sub>		
L $\ell$	3,954	
L $\gamma$	– 5,809	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	25,314 – 26,786	100
KLX	30,095 – 32,179	47,7
KXY	34,86 – 37,41	5,7
Auger L	2,6 – 5,8	

## 4 Electron Emissions

		Energy keV		Electrons per 100 disint.
e <sub>AL</sub>	(Ba)	2,6	-	5,8
				7,28 (12)
e <sub>AK</sub>	(Ba)			0,76 (4)
	KLL	25,314	-	26,786
	KLX	30,095	-	32,179
	KXY	34,86	-	37,41
ec <sub>2,0 T</sub>	(Ba)	624,218	-	661,644
ec <sub>2,0 K</sub>	(Ba)	624,218		(3)
ec <sub>2,0 L</sub>	(Ba)	655,670	-	656,412
$\beta_{0,2}^-$	max:	513,97	(17)	94,36 (28)
$\beta_{0,2}^-$	avg:	174,32	(6)	
$\beta_{0,1}^-$	max:	892,1	(2)	0,00061 (8)
$\beta_{0,1}^-$	avg:	300,57	(8)	
$\beta_{0,0}^-$	max:	1175,63	(17)	5,64 (28)
$\beta_{0,0}^-$	avg:	416,26	(8)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Ba)	3,954 — 5,809	0,90 (5)
XK $\alpha_2$	(Ba)	31,8174	1,95 (4)
XK $\alpha_1$	(Ba)	32,1939	3,59 (7)
XK $\beta_3$	(Ba)	36,3045	}
XK $\beta_1$	(Ba)	36,3786	}
XK $\beta_5''$	(Ba)	36,654	}
XK $\beta_2$	(Ba)	37,258	}
XK $\beta_4$	(Ba)	37,312	}
XKO <sub>2,3</sub>	(Ba)	37,425	0,266 (8)
			K' $\beta_2$

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Ba})$	283,5 (1)	0,00058 (8)
$\gamma_{2,0}(\text{Ba})$	661,657 (3)	84,99 (20)

## 6 Main Production Modes

Fission product.

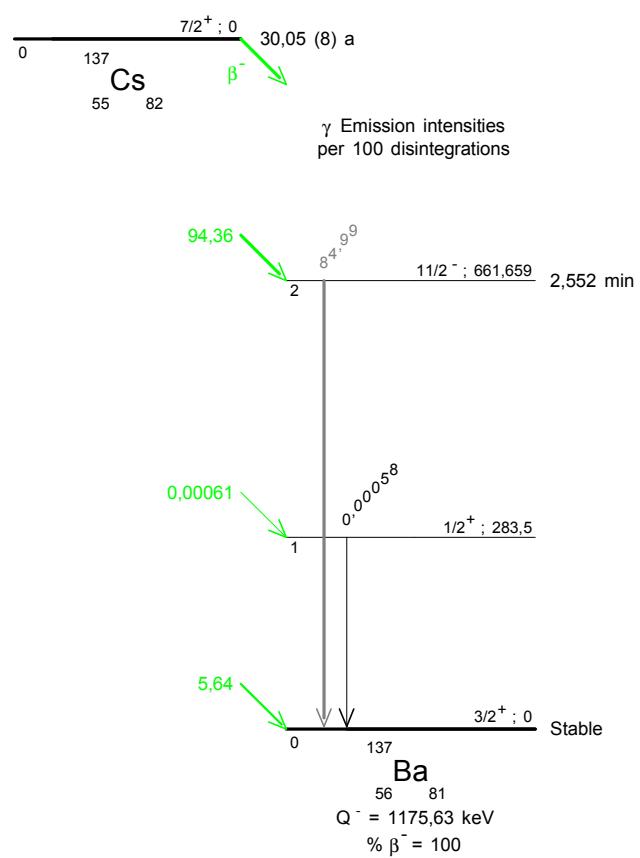
## 7 References

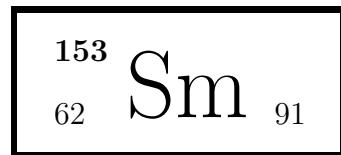
- M.A.WAGGONER. Phys. Rev. 82 (1951) 906  
(K ICC)
- R.L.HEATH. Phys. Rev. 87 (1952) 1132  
(K ICC)
- V.M.DOLISHNYUK, G.M.DRABKIN, V.I.ORLOV, L.I.RUSINOV. Doklady Akad.Nauk SSSR 92 (1953) 1141  
(K ICC)
- T.AZUMA. J. Phys. Soc. Jap. 9 (1954) 1  
(K ICC)
- J.VERHAEGHE, J.DEMUYNCK. Compt. Rend. 239 (1954) 1374  
(K/L)
- F.BROWN, G.R.HALL, A.J.WALTER. J. Inorg. Nucl. Chem. 1 (1955) 241  
(Half-life)
- D.M.WILES, R.H.TOMLINSON. Phys. Rev. 99 (1955) 188  
(Half-life)
- F.K.MCGOWAN, P.H.STELSON. Phys. Rev. 107 (1957) 1674  
(K ICC)
- R.A.RICCI. Physica 23 (1957) 693  
(ICC, Beta emission probabilities)
- A.J.MOSES, H.D.COOK. Report TID-7568 part 2 (1958) 192  
(Half-life)
- Y.YOSHIZAWA. Nucl. Phys. 5 (1958) 122  
(K ICC, Beta emission probabilities)
- A.H.WAPSTRA, G.J.NIJGH, N.SALOMONS-GROBBEN, L.T.M.ORNSTEIN. Nucl. Phys. 9 (1959) 538  
(K ICC)
- S.HULTBERG, R STOCKENDAL. Ark. Fysik 14 (1959) 565  
(K ICC)
- C.DE VRIES, E.J.BLEEKER, N.SALOMONS-GROBBEN. Nucl. Phys. 18 (1960) 454  
(K ICC)
- W.BEUSCH. Helv. Phys. Acta 33 (1960) 363  
(Double particle emission )
- H.FARRAR, A.K.DASGUPTA, R.H.TOMLINSON. Can. J. Chem. 39 (1961) 681  
(Half-life)
- M.P.GLAZUNOV, A.I.GRIVKOVA, B.A.ZAITSEV, V.A.KISELEV. Atomic Energy 10 (1961) 622  
(Half-life)
- S.HULTBERG, D.J.HOREN, J.M.HOLLANDER. Nucl. Phys. 28 (1961) 471  
(K ICC)
- J.S.GEIGER, R.L.GRAHAM, F.BROWN. Can. J. Phys. 40 (1962) 1258  
(K/L)

- H.DANIEL, H.SCHMITT. Z. Phys. 168 (1962) 292  
(ICC, Beta emission probabilities)
- D.G.FLEISHMAN, I.V.BUROVINA, V.P.NESTEROV. Atomic Energy 13 (1962) 1225  
(Half-life)
- H.E.BOSCH, T.URSTEIN. Nucl. Instrum. Methods 24 (1963) 109  
(ICC)
- B.F.RIDER, J.P.PETERSON, JR, C.P.RUIZ. Nucl. Sci. Eng. 15 (1963) 284  
(Half-life)
- S.G.GORBICS, W.E.KUNZ, A.E.NASH. Nucleonics 21,1 (1963) 63  
(Half-life )
- H.D.COOK, C.J.RETTGER, W.J.SEWALK. Report WAPD-BT-30 (1964)  
(Half-life)
- H.U.GERSCH, E.HENTSCHEL, P.GIPPNER, W.RUDOLPH. Nucl. Instrum. Methods 25 (1964) 314  
(K/L)
- Y.Y.CHU, M.L.PERLMAN. Phys. Rev. 135 (1964) B319  
(K/L)
- M.R.RAO, S.JNANANANDA. Nucl. Instrum. Methods 36 (1965) 261  
(ICC)
- K.F.FLYNN, L.E.GLENDEENIN, A.L.HARKNESS, E.P.STEINBERG. J. Inorg. Nucl. Chem. 27 (1965) 21  
(Half-life)
- R.E.LEWIS, R.E.MCHENRY, T.A.BUTLER. Trans. Amer. Nucl. Soc. 8 (1965) 79  
(Half-life)
- J.MERRITT, J.G.V.TAYLOR. Anal. Chem. 37 (1965) 351  
(ICC, Gamma emission probabilities, Beta emission probabilities)
- D.PARSIGNAULT. Thesis, Univ. Paris and Report CEA-R-2631 (1965)  
(Total and K ICC)
- S.A.REYNOLDS. ORNL-3889 (1966) 57  
(Half-life)
- M.R.RAO, S.JNANANANDA. Phys. Abstr. 69 (1966) 666  
(ICC)
- S.T.HSUE, L.M.LANGER, E.H.SPEJEWSKI, S.M.TANG. Nucl. Phys. 80 (1966) 657  
(K ICC)
- S.HULTBERG, A.A.BARTLETT, J.H.HAMILTON. Ed. Academic Press, Inc, New York (1966) 141  
(K ICC, Beta shape)
- S.T.HSUE, L.M.LANGER, S.M.TANG. Nucl. Phys. 86 (1966) 47  
(Beta emission probabilities)
- E.BALDINGER, E.HALLER. Helv. Phys. Acta 40 (1967) 800  
(K ICC)
- H.H.HANSEN, M.DELABAYE. CONF-661012 (1967) 361  
(K ICC)
- J.L.WOLFSON, A.J.COLLIER. Nucl. Phys. A112 (1968) 156  
(Beta emission energies)
- S.A.REYNOLDS, J.F.EMERY, E.I.WYATT. Nucl. Sci. Eng. 322 (1968) 46  
(Half-life)
- A.LJUBICIC, B.HRASTNIK, K.ILAKOVAC, V.KNAPP, B.VOJNOVIC. Phys. Rev. 187 (1969) 1512  
(Double particle emission)
- H.H.HANSEN, G.LOWENTHAL, A.SPERNOL, W.VAN DER EIJK, R.VANINBROUKX. Z. Phys. 218 (1969) 25  
(ICC, Gamma and beta emission probabilities)
- H.SCHNEUWLY, L.SCHELENBERG, O.HUBER, W.LINDT. Helv. Phys. Acta 42 (1969) 743  
(Beta minus shape)
- G.HARBOTTLE. Radiochim. Acta 13 (1970) 132  
(Half-life)
- K.F.WALZ, H.M.WEISS. Z. Naturforsch. 25a (1970) 921  
(Half-life)
- J.P.BRETHON. Report CEA-R-4196 (1971)  
(K ICC)
- J.L.CAMPBELL, H.J.SMITH, I.K.MACKENZIE. Nucl. Instrum. Methods 92 (1971) 237  
(X-ray emission probabilities)
- A.LJUBICIC, B.HRASTNIK, K.ILAKOVAC, M.JURCEVIC, I.BASAR. Phys. Rev. C3 (1971) 824  
(Double particle emission)

- A.LJUBICIC, M.JURCEVIC, K.ILAKOVAC, B.HRASTNIK. Phys. Rev. C3 (1971) 831  
(Double particle emission)
- F.T.PORTER, M.S.FREEDMAN, F.WAGNER,JR. Phys. Rev. C3 (1971) 2246  
(Double particle emission)
- J.F.EMERY, S.A.REYNOLS, E.I.WYATT, G.I.GLEASON. Nucl. Sci. Eng. 48 (1972) 319  
(Half-life)
- L.A.DIETZ, C.F.PACHUCKL. J. Inorg. Nucl. Chem. 35 (1973) 1769  
(Half-life)
- J.A.CORBETT. Nucl. Eng. Int. 18 (1973) 715  
(Half-life)
- J.B.WILLETT, G.T.EMERY. Ann. Phys. New York 78 (1973) 496  
(K ICC)
- J.LEGRAND, J.P.BRETHON, F.LAGOUTINE. Report CEA R-4428 (1973)  
(ICC Half-life, Gamma emission probabilities, Beta emission probabilities)
- I.W.GOODIER, J.L.MAKEPEACE, L.E.STUART. Int. J. Appl. Radiat. Isotop. 26 (1975) 490  
(ICC, Gamma and beta emission probabilities)
- G.L.BORCHERT. Z. Naturforsch 31a (1976) 387  
(Gamma-ray energies)
- F.RÖSEL, H.M.FRIES, K.ALDER, H.C.PAULI. At. Data. Nucl. Data Tables 21 (1978) 91 and 292  
(ICC)
- P.CHRISTMAS, P.CROSS. Metrologia 14 (1978) 157  
(ICC)
- W.H.GRIES, J.STEYN. Nucl. Instrum. Methods 152 (1978) 459  
(Half-life, Beta emission probabilities)
- K.Y.GROMOV, T.KRETSU, V.V.KUZNETSOV, G.MAKARIE. Izv. Akad. Nauk SSSR. Ser. Fiz. 42 (1978) 790  
(ICC, Half-life, Gamma emission probabilities, Beta emission probabilities)
- K.Y.GROMOV, T.KRETSU, V.V.KUZNETSOV, G.MAKARIE. Bull. Ac. Sci. USSR. Phys. Ser. 42,4 (1978) 85  
(ICC, Half-life, Gamma emission probabilities, Beta emission probabilities)
- J.S.MERRITT, F.H.GIBSON. Report AECL-6203 (1978)  
(Gamma emission probabilities)
- A.R.RUTLEDGE, L.V.SMITH, J.S.MERRITT. AECL-6692 (1980)  
(Half-life)
- H.HOUTERMANS, O.MILOSEVIC, F.REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life)
- A.R.RUTLEDGE, J.S.MERRITT, L.V.SMITH. AECL-6788 (1980) 45  
(Half-life)
- D.D.HOPPES, J.M.R.HUTCHINSON, F.J.SCHIMA, M.P.UNTERWEGER. NBS-SP-626 (1982) 85  
(Half-life)
- A.R.RUTLEDGE, L.V.SMITH, J.S.MERRITT. NBS-SP-626 (1982) 5  
(Half-life)
- K.F.WALZ, K.DEBERTIN, H.SCHRADER. Int. J. Appl. Radiat. Isotop. 34 (1983) 1191  
(Half-life)
- H.BEHRENS, P.CHRISTMAS. Nucl. Phys. 399 (1983) 131  
(ICC, Gamma emission probabilities)
- H.H.HANSEN. European App.Res.Rept.Nucl.Sci.Technol. 6,4 (1985) 777  
(ICC)
- D.MEHTA, S.SINGH, H.R.VERMA, N.SINGH, P.N.TREHAN. Nucl. Instrum. Methods Phys. Res. A254 (1987) 578  
(X-Ray emission probabilities)
- R.H.MARTIN, J.G.V.TAYLOR. Nucl. Instrum. Methods Phys. Res. A286 (1990) 507  
(Half-life)
- M.J.WOODS. Nucl. Instrum. Methods Phys. Res. A286 (1990) 576  
(Half-life)
- ZS.NEMETH, A.VERES. Nucl. Instrum. Methods Phys. Res. A286 (1990) 601  
(K ICC, T ICC)
- W.BAMBYNEK, T.BARTA, R.JEDLOVSZKY, P.CHRISTMAS, N.COURSOL, K.DEBERTIN, R.G.HELMER, A.L.NICHOLS,  
F.J.SCHIMA, Y.YOSHIZAWA. IAEA-TECDOC-619 (1991)  
(Half-life analysis)
- M.U.RAJPUT, T.D.MACMAHON. Nucl. Instrum. Methods Phys. Res. A312 (1992) 289  
(Half-life analysis)

- V.K.BASENKO, A.N.BERLIZOV,G A.PROKOPETS. Bull. Russian Acad. Sci. 56,1 (1992) 94  
(Gamma emission probabilities)
- M.P.UNTERWEGER, D.D.HOPPES, F.J.SCHIMA. Nucl. Instrum. Methods Phys. Res. A312 (1992) 349  
(Half-life)
- J.-J.GOSTELY. Int. J. Appl. Radiat. Isotop. 43 (1992) 949  
(Half-life)
- I.M.BAND, M.B.TRZHASKOVSKAYA. At. Data. Nucl. Data Tables 55 (1993) 43  
(Conv. Elec. emission probabilities)
- V.K.BASENKO, A.N.BERLIZOV, G.A.PROKOPETS. Bull. Russian Acad. Sci. 57 (1993) 55  
(Gamma emission probabilities)
- S.I.KAFALA, T.D.MACMAHON, P.W.GRAY. Nucl. Instrum. Methods Phys. Res. A339 (1994) 151  
(Half-life analysis)
- I.BIKIT, I.ANICIN, J.SLIVKA, M.KRMAR, J.PUZOVIC, LJ.CONKIC. Phys. Rev. C54 (1996) 3270  
(Gamma emission probabilities)
- SCHÖNFELD, H.JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic Data)
- J.K.TULI. Nucl. Data Sheets 81 (1997) 579  
(Spin, level half-life)
- B.K.WAGNER, P.E.GARRETT, M.YEH, S.W.YATES. Private Communication (1997)  
(Gamma emission probabilities)
- M.-M.BÉ, E.BROWNE, V.CHECHEV, R.HELMER, E.SCHÖNFELD. Table de Radionucléides, CEA- ISBN 2 7272 0200  
8, and Comments CEA-ISBN 2 7272 0211 3 (1999)  
(Cs-137 decay data evaluation)
- R.G.HELMER, C.VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Gamma ray energies)
- O.HELENE, V.R.VANIN. Nucl. Instrum. Methods Phys. Res. A481 (2002) 626  
(Half-life analysis)
- G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)
- H.SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life analysis)
- M.J.WOODS, S.M.COLLIERS. Appl. Rad. Isotopes 60 (2004) 257  
(Half-life analysis)





## 1 Decay Scheme

Sm-153 disintegrates via 3 main branches and at least 15 others very weak branches by 100% beta-emission to levels in Eu-153.

*Le samarium 153 se désintègre, par émission bêta moins, vers l'europtium 153 avec 3 branchements principaux et au moins 15 autres de faible intensité.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{153}\text{Sm}) &: 1,92855 \quad (5) \quad \text{d} \\ Q^-(^{153}\text{Sm}) &: 807,6 \quad (7) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,18}^-$	44,0 (7)	0,000044 (12)		8,9
$\beta_{0,17}^-$	47,2 (8)	0,00098 (5)		7,9
$\beta_{0,16}^-$	88,9 (8)	0,00143 (10)	Allowed	8,4
$\beta_{0,15}^-$	94,5 (8)	0,0141 (5)		7,4
$\beta_{0,14}^-$	101,0 (8)	0,0241 (7)	Allowed	7,3
$\beta_{0,13}^-$	106,1 (8)	0,0076 (6)		8,8
$\beta_{0,12}^-$	113,4 (7)	0,0221 (8)	Allowed	7,4
$\beta_{0,11}^-$	125,7 (7)	0,0083 (6)	1st forbidden	7,9
$\beta_{0,10}^-$	149,9 (8)	0,00090 (6)		9,3
$\beta_{0,9}^-$	171,1 (7)	0,0641 (6)	1st forbidden	7,5
$\beta_{0,8}^-$	172,9 (8)	0,0565 (7)	Allowed	7,6
$\beta_{0,7}^-$	222,6 (8)	0,00227 (5)		9,4
$\beta_{0,6}^-$	537,8 (7)	0,0216 (3)	2nd forbidden	11
$\beta_{0,5}^-$	634,7 (7)	30,4 (8)	Allowed	6,7
$\beta_{0,4}^-$	656,0 (7)	0,042 (8)	Unique 1st forbidden	10
$\beta_{0,3}^-$	704,7 (7)	49,2 (17)	Allowed	6,7

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,2}^-$	710,2 (7)	0,62 (8)	1st forbidden	8,6
$\beta_{0,0}^-$	807,6 (7)	19,5 (15)	Allowed	7,3

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{2,1}(\text{Eu})$	14,06383 (24)		E1		8,43 (25)	1,90 (6)	10,78 (32)
$\gamma_{3,1}(\text{Eu})$	19,81296 (21)	0,34 (7)	E2		2490 (70)	578 (17)	3220 (100)
$\gamma_{4,2}(\text{Eu})$	54,1947 (5)	0,036 (8)	M1+E2	6,19 (19)	9,30 (28)	2,17 (7)	18,2 (5)
$\gamma_{4,1}(\text{Eu})$	68,2585 (12)	0,0023 (7)	E1	0,648 (19)	0,1040 (31)	0,0225 (7)	0,781 (23)
$\gamma_{5,3}(\text{Eu})$	69,67300 (13)	29,5 (8)	M1+1,82%E2	4,37 (13)	0,719 (22)	0,1571 (47)	5,28 (16)
$\gamma_{5,2}(\text{Eu})$	75,42213 (21)	0,296 (13)	E1+0,3%M2	0,610 (18)	0,1111 (33)	0,0245 (7)	0,752 (23)
$\gamma_{1,0}(\text{Eu})$	83,36717 (17)	0,915 (35)	M1+40%E2	2,30 (7)	1,119 (34)	0,258 (8)	3,74 (11)
$\gamma_{5,1}(\text{Eu})$	89,48595 (21)	0,57 (6)	M1+5,8%E2	2,10 (6)	0,383 (11)	0,0845 (25)	2,59 (8)
$\gamma_{6,5}(\text{Eu})$	96,8838 (7)	0,024 (4)	M1+E2	1,475 (44)	0,68 (2)	0,1570 (47)	2,35 (10)
$\gamma_{2,0}(\text{Eu})$	97,43100 (21)	0,999 (19)	E1	0,254 (8)	0,0382 (11)	0,00823 (25)	0,302 (9)
$\gamma_{3,0}(\text{Eu})$	103,18012 (17)	78,5 (15)	M1+1,4%E2	1,417 (43)	0,213 (6)	0,0462 (14)	1,69 (5)
$\gamma_{6,4}(\text{Eu})$	118,1105 (10)	0,00027 (7)	[E1]	0,1516 (45)	0,0223 (7)	0,00479 (14)	0,180 (5)
$\gamma_{4,0}(\text{Eu})$	151,6257 (5)	0,01128 (30)	E1	0,0775 (23)	0,01112 (33)	0,00239 (7)	0,0916 (27)
$\gamma_{6,3}(\text{Eu})$	166,5568 (15)	0,00085 (8)	[E2]	0,263 (8)	0,1034 (31)	0,0238 (7)	0,396 (12)
$\gamma_{6,2}(\text{Eu})$	172,3060 (7)	0,000426	(E1)	0,0551 (17)	0,00782 (23)	0,00168 (5)	0,065 (2)
$\gamma_{5,0}(\text{Eu})$	172,85320 (13)	0,1012 (30)	M1+40%E2	0,293 (9)	0,0638 (19)	0,01427 (43)	0,375 (11)
$\gamma_{7,5}(\text{Eu})$	412,17 (15)	0,00191 (5)					
$\gamma_{12,6}(\text{Eu})$	424,45 (11)	0,00195 (6)					
$\gamma_{14,6}(\text{Eu})$	436,89 (9)	0,00158 (5)					
$\gamma_{15,6}(\text{Eu})$	443,38 (20)	0,00041 (32)					
$\gamma_{8,5}(\text{Eu})$	461,81 (12)	0,00158 (26)					
$\gamma_{9,5}(\text{Eu})$	463,62 (10)	0,01270 (24)					
$\gamma_{10,5}(\text{Eu})$	484,82 (14)	0,00038 (3)					
$\gamma_{7,2}(\text{Eu})$	487,59 (15)	0,00036					
$\gamma_{11,5}(\text{Eu})$	509,06 (10)	0,00190 (18)					
$\gamma_{12,5}(\text{Eu})$	521,34 (11)	0,0067 (1)					
$\gamma_{8,3}(\text{Eu})$	531,47 (12)	0,0544 (7)					
$\gamma_{9,3}(\text{Eu})$	533,29 (10)	0,0294 (5)					
$\gamma_{9,2}(\text{Eu})$	539,04 (10)	0,02070 (21)					
$\gamma_{12,4}(\text{Eu})$	542,56 (11)	0,00234 (10)					
$\gamma_{16,5}(\text{Eu})$	545,84 (14)	0,0009 (1)					
$\gamma_{14,4}(\text{Eu})$	555,01 (9)	0,0047 (1)					
$\gamma_{10,1}(\text{Eu})$	574,31 (14)	0,00016 (5)					
$\gamma_{11,3}(\text{Eu})$	578,73 (10)	0,0034 (5)					
$\gamma_{11,2}(\text{Eu})$	584,48 (10)	0,00107 (3)					
$\gamma_{17,5}(\text{Eu})$	587,54 (17)	0,00048 (4)					
$\gamma_{12,3}(\text{Eu})$	591,01 (11)	0,00122 (9)					
$\gamma_{12,2}(\text{Eu})$	596,76 (11)	0,0099 (8)					
$\gamma_{13,3}(\text{Eu})$	598,28 (24)	0,0020 (1)					
$\gamma_{11,1}(\text{Eu})$	598,51 (8)	0,0020 (1)					
$\gamma_{14,3}(\text{Eu})$	603,45 (9)	0,0049 (6)					
$\gamma_{13,2}(\text{Eu})$	604,03 (24)	0,0049 (6)					
$\gamma_{14,2}(\text{Eu})$	609,20 (9)	0,0129 (4)					
$\gamma_{15,3}(\text{Eu})$	609,95 (20)	0,0129 (4)					
$\gamma_{16,3}(\text{Eu})$	615,51 (14)	0,00050 (6)					
$\gamma_{15,2}(\text{Eu})$	615,69 (20)	0,00050 (6)					
$\gamma_{13,1}(\text{Eu})$	618,09 (24)	0,00067 (6)					

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{15,1}(\text{Eu})$	629,75 (20)	0,000099 (15)					
$\gamma_{8,0}(\text{Eu})$	634,66 (12)	0,000050 (3)					
$\gamma_{9,0}(\text{Eu})$	636,47 (10)	0,00195 (7)					
$\gamma_{17,3}(\text{Eu})$	657,21 (7)	0,00037 (2)					
$\gamma_{10,0}(\text{Eu})$	657,67 (25)	0,00037 (2)					
$\gamma_{17,2}(\text{Eu})$	662,96 (17)	0,00007 (7)					
$\gamma_{17,1}(\text{Eu})$	677,02 (17)	0,000044 (15)					
$\gamma_{11,0}(\text{Eu})$	681,88 (8)	0,00015 (12)					
$\gamma_{12,0}(\text{Eu})$	694,19 (11)	0,000020 (6)					
$\gamma_{13,0}(\text{Eu})$	701,46 (24)	0,000029 (6)					
$\gamma_{14,0}(\text{Eu})$	706,63 (9)	0,000023 (12)					
$\gamma_{15,0}(\text{Eu})$	713,12	0,000231 (20)					
$\gamma_{16,0}(\text{Eu})$	718,69 (14)	0,000025 (5)					
$\gamma_{17,0}(\text{Eu})$	760,39 (17)	0,000032 (5)					
$\gamma_{18,0}(\text{Eu})$	763,8 (8)	0,000044 (12)					

### 3 Atomic Data

#### 3.1 Eu

$$\begin{aligned}\omega_K &: 0,929 (4) \\ \bar{\omega}_L &: 0,168 (7) \\ n_{KL} &: 0,853 (4)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	40,9024	55,42
K $\alpha_1$	41,5427	100
K $\beta_3$	46,904	}
K $\beta_1$	47,0384	}
K $\beta_5''$	47,373	}
		31,5
K $\beta_2$	48,257	}
K $\beta_4$	48,386	}
KO <sub>2,3</sub>	48,497	8,13
X <sub>L</sub>		
L $\ell$	5,175	
L $\alpha$	5,815 – 5,8461	
L $\eta$	5,8149	
L $\beta$	6,4365 – 6,9193	
L $\gamma$	7,2538 – 7,791	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	32,24 – 34,38	100
KLX	38,59 – 41,52	51
KXY	44,9 – 48,5	6,5
Auger L	3,4 – 7,8	1870

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
eAL	(Eu)	3,4 - 7,8	53,0 (5)
eAK	(Eu)		4,47 (28)
	KLL	32,24 - 34,38	}
	KLX	38,59 - 41,52	}
	KXY	44,9 - 48,5	}
ec <sub>3,1</sub> L	(Eu)	11,76 - 12,84	0,26 (6)
ec <sub>3,1</sub> M	(Eu)	18,00 - 18,68	0,061 (13)
ec <sub>5,3</sub> T	(Eu)	21,154 - 69,650	24,8 (8)
ec <sub>5,3</sub> K	(Eu)	21,154 (2)	20,5 (6)
ec <sub>5,2</sub> K	(Eu)	26,903 (2)	0,103 (5)
ec <sub>1,0</sub> K	(Eu)	34,848 (1)	0,444 (19)
ec <sub>5,1</sub> K	(Eu)	40,967 (1)	0,332 (33)
ec <sub>2,0</sub> K	(Eu)	48,912 (1)	0,195 (7)
ec <sub>3,0</sub> T	(Eu)	54,661 - 103,160	49,3 (15)
ec <sub>3,0</sub> K	(Eu)	54,661 (1)	41,4 (13)
ec <sub>5,3</sub> L	(Eu)	61,62 - 62,69	3,37 (11)
ec <sub>5,3</sub> M	(Eu)	67,90 - 68,54	0,737 (23)
ec <sub>5,3</sub> N	(Eu)	69,31 - 69,54	0,168 (5)
ec <sub>1,0</sub> L	(Eu)	75,31 - 76,39	0,216 (9)
ec <sub>5,1</sub> L	(Eu)	81,43 - 82,51	0,061 (6)
ec <sub>3,0</sub> L	(Eu)	95,13 - 96,20	6,22 (18)
ec <sub>3,0</sub> M	(Eu)	101,40 - 102,05	1,349 (42)
ec <sub>3,0</sub> N	(Eu)	102,82 - 103,05	0,309 (9)
$\beta_{0,18}^-$	max:	44,0 (7)	0,000044 (12)
$\beta_{0,18}^-$	avg:	11,1 (3)	
$\beta_{0,17}^-$	max:	47,2 (8)	0,00098 (5)
$\beta_{0,17}^-$	avg:	12,0 (2)	

		Energy keV	Electrons per 100 disint.
$\beta_{0,16}^-$	max:	88,9 (8)	0,00143 (10)
$\beta_{0,16}^-$	avg:	23,1 (2)	
$\beta_{0,15}^-$	max:	94,5 (8)	0,0141 (5)
$\beta_{0,15}^-$	avg:	24,6 (2)	
$\beta_{0,14}^-$	max:	101,0 (8)	0,0241 (7)
$\beta_{0,14}^-$	avg:	26,4 (3)	
$\beta_{0,13}^-$	max:	106,1 (8)	0,0076 (6)
$\beta_{0,13}^-$	avg:	27,8 (2)	
$\beta_{0,12}^-$	max:	113,4 (7)	0,0221 (8)
$\beta_{0,12}^-$	avg:	29,8 (2)	
$\beta_{0,11}^-$	max:	125,7 (7)	0,0083 (6)
$\beta_{0,11}^-$	avg:	33,2 (2)	
$\beta_{0,10}^-$	max:	149,9 (8)	0,00090 (6)
$\beta_{0,10}^-$	avg:	40,1 (2)	
$\beta_{0,9}^-$	max:	171,1 (7)	0,0641 (6)
$\beta_{0,9}^-$	avg:	46,1 (2)	
$\beta_{0,8}^-$	max:	172,9 (8)	0,0565 (7)
$\beta_{0,8}^-$	avg:	46,7 (2)	
$\beta_{0,7}^-$	max:	222,6 (8)	0,00227 (5)
$\beta_{0,7}^-$	avg:	61,3 (3)	
$\beta_{0,6}^-$	max:	537,8 (7)	0,0216 (3)
$\beta_{0,6}^-$	avg:	164,7 (3)	
$\beta_{0,5}^-$	max:	634,7 (7)	30,4 (8)
$\beta_{0,5}^-$	avg:	199,7 (3)	
$\beta_{0,4}^-$	max:	656,0 (7)	0,042 (8)
$\beta_{0,4}^-$	avg:	221,2 (3)	
$\beta_{0,3}^-$	max:	704,7 (7)	49,2 (17)
$\beta_{0,3}^-$	avg:	225,3 (3)	
$\beta_{0,2}^-$	max:	710,2 (7)	0,62 (8)
$\beta_{0,2}^-$	avg:	227,4 (3)	
$\beta_{0,0}^-$	max:	807,6 (7)	19,5 (15)
$\beta_{0,0}^-$	avg:	264,3 (3)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.	
XL	(Eu)	5,175 — 7,791	10,88 (21)	
XK $\alpha_2$	(Eu)	40,9024	16,6 (4)	} K $\alpha$
XK $\alpha_1$	(Eu)	41,5427	30,0 (7)	}
XK $\beta_3$	(Eu)	46,904	}	
XK $\beta_1$	(Eu)	47,0384	}	K' $\beta_1$
XK $\beta_5''$	(Eu)	47,373	}	
XK $\beta_2$	(Eu)	48,257	}	
XK $\beta_4$	(Eu)	48,386	}	K' $\beta_2$
XKO <sub>2,3</sub>	(Eu)	48,497	}	

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{3,1}$ (Eu)	19,81296 (21)	0,000105 (22)
$\gamma_{4,2}$ (Eu)	54,1936 (12)	0,0019 (4)
$\gamma_{4,1}$ (Eu)	68,2574 (12)	0,0013 (4)
$\gamma_{5,3}$ (Eu)	69,67300 (13)	4,691 (41)
$\gamma_{5,2}$ (Eu)	75,42213 (23)	0,169 (7)
$\gamma_{1,0}$ (Eu)	83,36717 (21)	0,193 (6)
$\gamma_{5,1}$ (Eu)	89,48595 (22)	0,158 (15)
$\gamma_{6,5}$ (Eu)	96,8824 (7)	0,007 (1)
$\gamma_{2,0}$ (Eu)	97,43100 (21)	0,767 (14)
$\gamma_{3,0}$ (Eu)	103,18012 (17)	29,19 (16)
$\gamma_{6,4}$ (Eu)	118,1105 (10)	0,00023 (6)
$\gamma_{4,0}$ (Eu)	151,6244 (12)	0,01033 (27)
$\gamma_{6,3}$ (Eu)	166,5546 (15)	0,00061 (6)
$\gamma_{6,2}$ (Eu)	172,3032 (13)	0,0004
$\gamma_{5,0}$ (Eu)	172,85307 (21)	0,0736 (21)
$\gamma_{7,5}$ (Eu)	412,05 (20)	0,00191 (5)
$\gamma_{12,6}$ (Eu)	424,4 (3)	0,00195 (6)
$\gamma_{14,6}$ (Eu)	436,9 (3)	0,00158 (5)
$\gamma_{15,6}$ (Eu)	443,2 (5)	0,00041 (32)
$\gamma_{8,5}$ (Eu)	462,0 (3)	0,00158 (26)
$\gamma_{9,5}$ (Eu)	463,6 (2)	0,01270 (24)
$\gamma_{10,5}$ (Eu)	485,0 (2)	0,00038 (3)
$\gamma_{7,2}$ (Eu)	487,75 (23)	0,00036
$\gamma_{11,5}$ (Eu)	509,15 (20)	0,00190 (18)
$\gamma_{12,5}$ (Eu)	521,30 (25)	0,0067 (1)

	Energy keV	Photons per 100 disint.
$\gamma_{8,3}(\text{Eu})$	531,40 (15)	0,0544 (7)
$\gamma_{9,3}(\text{Eu})$	533,2 (2)	0,0294 (5)
$\gamma_{9,2}(\text{Eu})$	539,1 (2)	0,02070 (21)
$\gamma_{12,4}(\text{Eu})$	542,7 (2)	0,00234 (10)
$\gamma_{16,5}(\text{Eu})$	545,75 (15)	0,0009 (1)
$\gamma_{14,4}(\text{Eu})$	554,94 (10)	0,0047 (1)
$\gamma_{10,1}(\text{Eu})$	574,1 (3)	0,00016 (5)
$\gamma_{11,3}(\text{Eu})$	578,75 (20)	0,0034 (5)
$\gamma_{11,2}(\text{Eu})$	584,55 (20)	0,00107 (3)
$\gamma_{17,5}(\text{Eu})$	587,60 (25)	0,00048 (4)
$\gamma_{12,3}(\text{Eu})$	590,96 (20)	0,00122 (9)
$\gamma_{12,2}(\text{Eu})$	596,7 (2)	0,0099 (8)
$\gamma_{13,3}(\text{Eu})$	598,3 (3)	0,0020 (1)
$\gamma_{11,1}(\text{Eu})$	598,54 (10)	0,0020 (1)
$\gamma_{14,3}(\text{Eu})$	603,6 (4)	0,0049 (6)
$\gamma_{13,2}(\text{Eu})$	604,03 (24)	0,0049 (6)
$\gamma_{14,2}(\text{Eu})$	609,5 (3)	0,0129 (4)
$\gamma_{15,3}(\text{Eu})$	609,95 (20)	0,0129 (4)
$\gamma_{16,3}(\text{Eu})$	615,51 (14)	0,00050 (6)
$\gamma_{15,2}(\text{Eu})$	615,8 (4)	0,00050 (6)
$\gamma_{13,1}(\text{Eu})$	617,9 (3)	0,00067 (6)
$\gamma_{15,1}(\text{Eu})$	630,5 (4)	0,000099 (15)
$\gamma_{8,0}(\text{Eu})$	634,8 (3)	0,00050 (3)
$\gamma_{9,0}(\text{Eu})$	636,5 (2)	0,00195 (7)
$\gamma_{17,3}(\text{Eu})$	657,21 (7)	0,00037 (2)
$\gamma_{10,0}(\text{Eu})$	657,55 (25)	0,00037 (2)
$\gamma_{17,2}(\text{Eu})$	662,4 (6)	0,00007 (7)
$\gamma_{17,1}(\text{Eu})$	677,0 (3)	0,000044 (15)
$\gamma_{11,0}(\text{Eu})$	682,0 (6)	0,00015 (12)
$\gamma_{12,0}(\text{Eu})$	694,1 (3)	0,000020 (6)
$\gamma_{13,0}(\text{Eu})$	701,8 (4)	0,000029 (6)
$\gamma_{14,0}(\text{Eu})$	706,8 (5)	0,000023 (12)
$\gamma_{15,0}(\text{Eu})$	713,9 (3)	0,000231 (20)
$\gamma_{16,0}(\text{Eu})$	719,0 (4)	0,000025 (5)
$\gamma_{17,0}(\text{Eu})$	760,5 (4)	0,000032 (5)
$\gamma_{18,0}(\text{Eu})$	763,8 (6)	0,000044 (12)

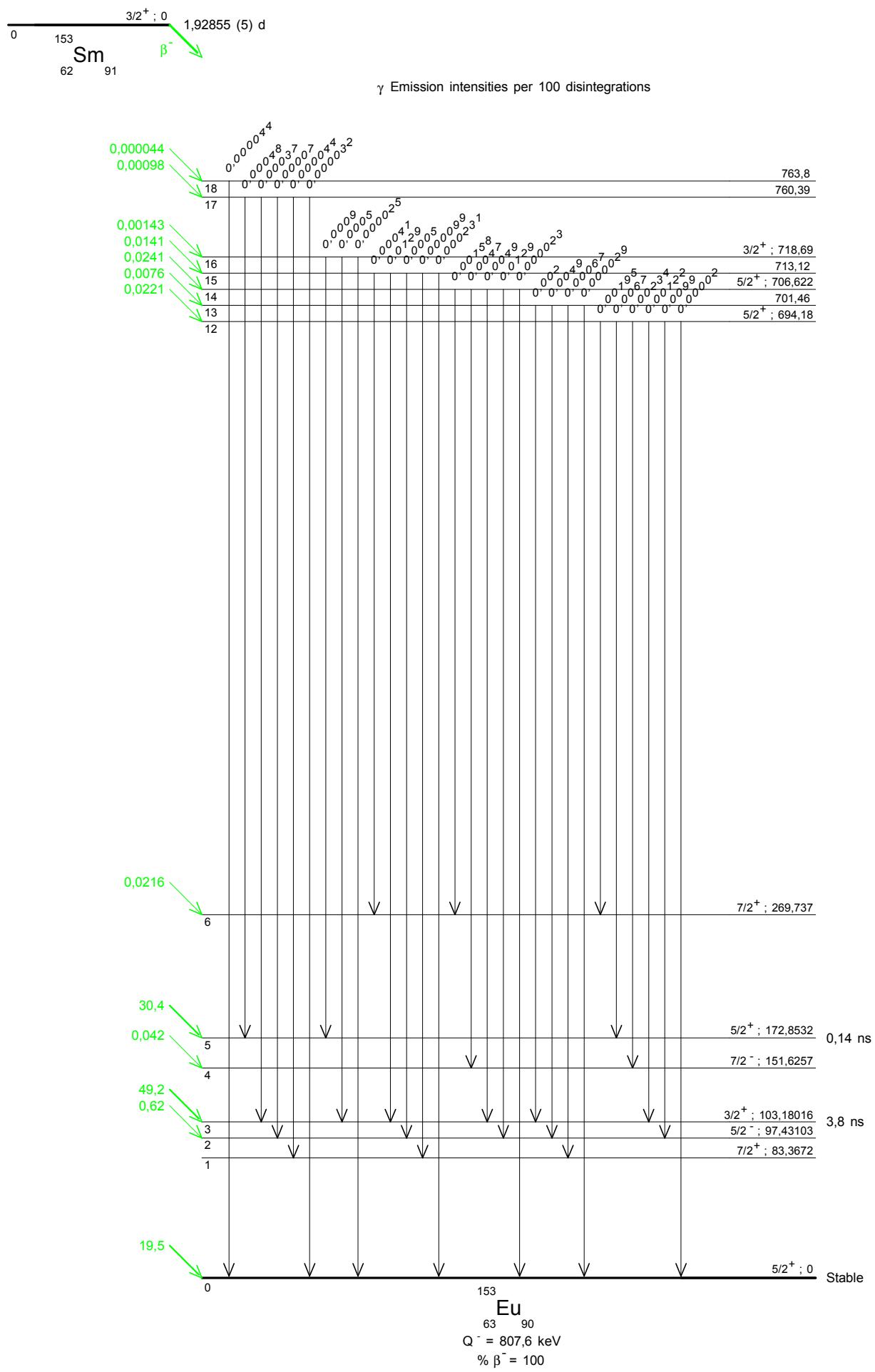
## 6 Main Production Modes

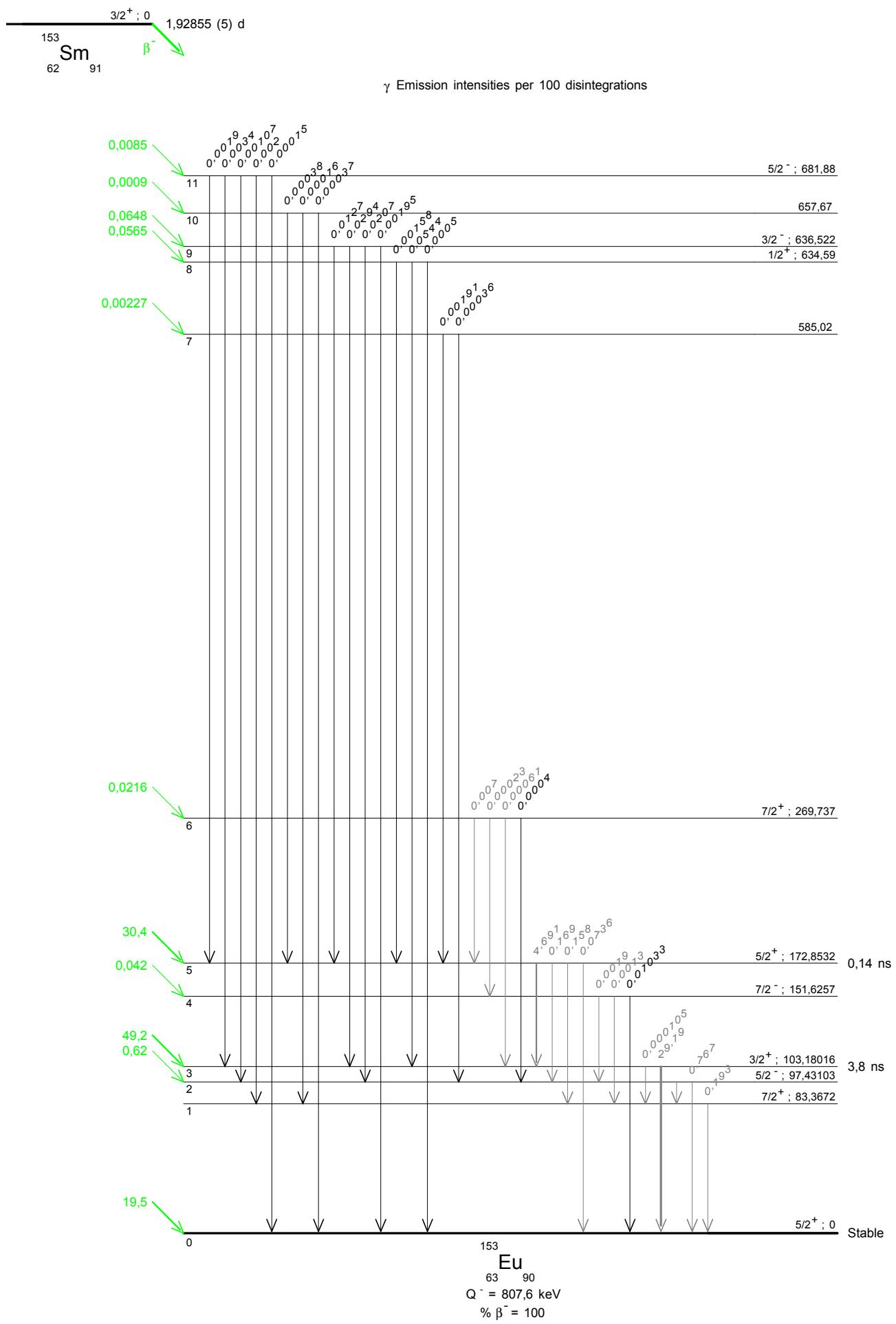
Sm – 152(n, $\gamma$ )Sm – 153       $\sigma$  : 206 barns  
Nd – 150( $\alpha$ ,n)Sm – 153

## 7 References

- M. E. LEE, R. KATZ. Phys. Rev. 93 (1954) 155  
(Half-life)
- J. M. CORK, M. K. BRICE, R. G. HELMER, R. M. WOODS. Phys. Rev. 110 (1958) 526  
(Half-life)

- E. I. WYATT, S. A. REYNOLDS, T. H. HANDLEY, W. S. LYON, H. A. PARKER. Nucl. Sci. Eng. 11 (1961) 74  
(Half-life)
- R. E. GREEN, W. H. WALKER. Can. J. Phys. 39 (1961) 1216  
(Half-life)
- E. MONNAND, A. MOUSSA. Nucl. Phys. 25 (1961) 292  
(L1/L2/L3, eA, KXY/KLX/KLL, E2/M1 for 70/83, Conv. Elec.)
- T. SUTER, P. REYES-SUTER, S. GUSTAFSON, I. MARKLUND. Nucl. Phys. 29 (1962) 33  
(Gamma emission probabilities, mixing ratios, Gamma ray energies, Conv. Elec. emission energies, Conv. Elec. emission probabilities, K ICC)
- M. J. CABELL. J. Inorg. Nucl. Chem. 24 (1962) 749  
(Half-life)
- D. C. HOFFMAN. J. Inorg. Nucl. Chem. 25 (1963) 1196  
(Half-life)
- P. ALEXANDER. Phys. Rev. 134 (1964) B499  
(Gamma emission probabilities)
- P. H. BLICHERT-TOFT, E. G. FUNK, J. W. MIHELICH. Nucl. Phys. 79 (1966) 12  
(Gamma emission probabilities)
- R. SMITHER, E. BIEBER, T. VON EGIDY, W. KAISER, K. WIEN. Phys. Rev. 187 (1969) 1632  
(Gamma emission probabilities)
- Y. PATIN. Compt. Rend. 268B (1969) 574  
(Gamma emission probabilities, Gamma ray energies)
- J. UNGRIN, M. W. JOHNS. Nucl. Phys. A127 (1969) 353  
(Gamma emission probabilities, Gamma ray energies)
- K. MUHLBAUER. Z. Phys. 230 (1970) 18  
(Gamma ray energies)
- Y. Y. CHU, E. M. FRANZ, G. FRIEDLANDER. Phys. Rev. C1 (1970) 1826  
(Half-life)
- S. BABA, H. BABA, H. NATSUME. J. Inorg. Nucl. Chem. 33 (1971) 589  
(Half-life)
- S. ABDEL-MALAK, S. M. DARWISH, M. ABOU-LEILA, N. WALLEY EL-DIN, A. M. HASSAN. Z. Phys. A322 (1985) 163  
(Gamma emission probabilities and energies)
- B. M. COURSEY, D. D. HOPPES, F. J. SCHIMA, M. P. UNTERWEGER. Appl. Rad. Isotopes 38 (1987) 31  
(Gamma emission probabilities)
- B. CHAND, J. GOSWAMY, D. MEHTA, N. SING, P. N. TREHAN. Appl. Rad. Isotopes 43 (1992) 997  
(Gamma emission probabilities)
- M. P. UNTERWEGER, D. D. HOPPES, F. J. SCHIMA. Nucl. Instrum. Methods Phys. Res. A312 (1992) 349  
(Half-life)
- B. M. COURSEY, J. M. CALHOUN, J. CESSNA, D. B. GOLAS, F. J. SCHIMA, M. P. UNTERWEGER. Nucl. Instrum. Methods Phys. Res. A339 (1994) 26  
(Half-life)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 572  
(P(KBeta)/P(KAlpha), P(KLX)/P(KLL), P(KXY)/P(KLL))
- N. E. BOWLES, S. A. WOODS, D. H. WOODS, S. M. JEROME, M. J. WOODS, P. DE LAVISON, S. LINEHAM, J. KEIGHTLEY, J. POUPAKI. Appl. Rad. Isotopes 49 (1998) 1345  
(Half-life)
- R. G. HELMER. Nucl. Data Sheets 83 (1998) 285  
(Multipolarities)
- R. G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Methods Phys. Res. A450 (2000) 35  
(Gamma ray energies)
- G. AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q)
- H. SCHRADER. Appl. Rad. Isotopes 60 (2004) 317  
(Half-life)
- M.C.LÉPY, M.-N.AMIOT, M.-M.BÉ, P.CASSETTE. Appl. Rad. Isotopes 64 (2006) 1428  
(Gamma and X-ray emission intensities)







## 1 Decay Scheme

Gd-159 decays by beta minus emission to levels in Tb-159.

*Le gadolinium 159 se désintègre par émission bêta moins vers des niveaux excités du terbium 159.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{159}\text{Gd}) &: 18,479 \quad (7) \quad \text{h} \\ Q^-(^{159}\text{Gd}) &: 970,5 \quad (7) \quad \text{keV} \end{aligned}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,9}^-$	79,3 (7)	0,0009 (4)	Allowed	8,08
$\beta_{0,8}^-$	115,5 (7)	0,0162 (5)	Allowed	7,31
$\beta_{0,7}^-$	296,3 (7)	0,00388 (10)	1st Forbbiden	9,22
$\beta_{0,6}^-$	352,9 (7)	0,0300 (9)	1st Forbbiden	8,58
$\beta_{0,5}^-$	389,7 (7)	0,0626 (8)	1st Forbbiden	8,41
$\beta_{0,4}^-$	607,0 (7)	12,19 (6)	Allowed	6,76
$\beta_{0,3}^-$	622,2 (7)	0,315 (4)	1st Forbbiden	8,39
$\beta_{0,2}^-$	833,0 (7)	0,012 (9)	Unique 1st Forbbiden	10,6
$\beta_{0,1}^-$	912,5 (7)	29,6 (12)	1st Forbbiden	6,99
$\beta_{0,0}^-$	970,5 (7)	57,8 (12)	1st Forbbiden	6,73

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Tb})$	58,0000 (22)	30,13 (7)	M1+1,4%E2	9,14 (27)	1,55 (5)	0,343 (10)	11,1 (3)
$\gamma_{2,1}(\text{Tb})$	79,5132 (27)	0,2532 (11)	M1+1,56%E2	3,66 (11)	0,584 (18)	0,129 (4)	4,41 (13)
$\gamma_{2,0}(\text{Tb})$	137,515 (5)	0,01188 (15)	[E2]	0,474 (14)	0,277 (8)	0,0653 (19)	0,833 (25)
$\gamma_{3,2}(\text{Tb})$	210,783 (3)	0,0246 (14)	[M1,E2]	0,18 (3)	0,039 (7)	0,0089 (16)	0,23 (7)
$\gamma_{4,2}(\text{Tb})$	226,0406 (18)	0,2244 (21)	E1	0,0290 (9)	0,00414 (12)	0,00089 (3)	0,0343 (10)
$\gamma_{8,6}(\text{Tb})$	237,341 (5)	0,00792 (16)	[E1]	0,0256 (8)	0,00364 (11)	0,00079 (2)	0,0302 (9)
$\gamma_{9,6}(\text{Tb})$	273,62 (12)	0,00071 (41)	[E1]	0,0178 (5)	0,00251 (8)	0,00055 (2)	0,0210 (6)
$\gamma_{8,5}(\text{Tb})$	274,163 (19)	0,0058 (4)	[E1]	0,0177 (5)	0,00250 (8)	0,00054 (2)	0,0209 (6)
$\gamma_{3,1}(\text{Tb})$	290,2865 (25)	0,0353 (5)	[M1,E2]	0,075 (23)	0,014 (1)	0,0031 (1)	0,093 (29)
$\gamma_{4,1}(\text{Tb})$	305,5492 (20)	0,0630 (7)	E1	0,0135 (4)	0,00189 (6)	0,000411 (12)	0,0159 (5)
$\gamma_{3,0}(\text{Tb})$	348,2807 (18)	0,2553 (25)	M1+16%E2	0,056 (2)	0,0084 (3)	0,00180 (5)	0,067 (2)
$\gamma_{4,0}(\text{Tb})$	363,5430 (18)	11,90 (5)	E1	0,00882 (26)	0,00123 (4)	0,000266 (8)	0,0104 (3)
$\gamma_{7,2}(\text{Tb})$	536,730 (17)	0,00164 (5)	M1+E2	0,0200 (6)	0,00280 (8)	0,00061 (2)	0,0236 (7)
$\gamma_{6,1}(\text{Tb})$	559,624 (6)	0,0225 (6)	M1+E2	0,0152 (5)	0,0022 (2)	0,00040 (9)	0,019 (3)
$\gamma_{5,0}(\text{Tb})$	580,809 (6)	0,0703 (8)	[M1,E2]	0,012 (4)	0,0018 (6)		0,015 (5)
$\gamma_{7,1}(\text{Tb})$	616,234 (18)	0,00191 (8)	(M1)	0,0142 (4)	0,00197 (6)	0,00042 (2)	0,0167 (5)
$\gamma_{6,0}(\text{Tb})$	617,616 (8)	0,0162 (5)	(M1)	0,0141 (4)	0,00196 (6)	0,00043 (2)	0,0166 (5)
$\gamma_{7,0}(\text{Tb})$	674,26 (5)	0,000320 (22)	(M1)	0,0113 (3)	0,00157 (5)	0,00034 (1)	0,0133 (4)
$\gamma_{9,2}(\text{Tb})$	753,74 (6)	0,00018 (2)	[E1]	0,00177 (5)	0,000236 (7)	0,000051 (2)	0,00207 (6)
$\gamma_{8,0}(\text{Tb})$	854,949 (20)	0,00246 (14)	[E1]	0,00138 (4)	0,000183 (5)	0,000040 (1)	0,00162 (5)

## 3 Atomic Data

### 3.1 Tb

$$\begin{aligned}\omega_K &: 0,935 (4) \\ \bar{\omega}_L &: 0,186 (8) \\ n_{KL} &: 0,847 (4)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	43,7447	55,77
K $\alpha_1$	44,4821	100
K $\beta_3$	50,23	{}
K $\beta_1$	50,383	{}
K $\beta_2$	51,724	{}
K $\beta_4$	51,849	{}
		8,3

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	34,398 – 36,773	100
KLX	41,243 – 44,456	52,1
KXY	48,06 – 51,95	6,7
Auger L	3,58 – 8,70	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Tb)	3,58 - 8,70	0,195 (5)
e <sub>AK</sub>	(Tb)		1,49 (11)
	KLL	34,398 - 36,773	}
	KLX	41,243 - 44,456	}
	KXY	48,06 - 51,95	}
ec <sub>1,0 T</sub>	(Tb)	6,004 - 57,715	27,64 (80)
ec <sub>1,0 K</sub>	(Tb)	6,004 (1)	22,8 (9)
ec <sub>2,1 K</sub>	(Tb)	27,518 (1)	0,17 (7)
ec <sub>1,0 L</sub>	(Tb)	49,292 - 50,486	3,86 (16)
ec <sub>1,0 M</sub>	(Tb)	56,032 - 56,389	0,85 (4)
ec <sub>1,0 N</sub>	(Tb)	57,602 - 57,715	0,235 (10)
ec <sub>4,0 K</sub>	(Tb)	311,547 (2)	0,104 (3)
$\beta_{0,9}^-$	max:	79,3 (7)	0,0009 (4)
$\beta_{0,9}^-$	avg:	20,54 (19)	
$\beta_{0,8}^-$	max:	115,5 (7)	0,0162 (5)
$\beta_{0,8}^-$	avg:	30,43 (20)	
$\beta_{0,7}^-$	max:	296,3 (7)	0,00388 (10)
$\beta_{0,7}^-$	avg:	83,82 (22)	
$\beta_{0,6}^-$	max:	352,9 (7)	0,0300 (9)
$\beta_{0,6}^-$	avg:	101,84 (23)	
$\beta_{0,5}^-$	max:	389,7 (7)	0,0626 (8)
$\beta_{0,5}^-$	avg:	113,8 (2)	
$\beta_{0,4}^-$	max:	607,0 (7)	12,19 (6)
$\beta_{0,4}^-$	avg:	189,0 (3)	
$\beta_{0,3}^-$	max:	622,2 (7)	0,315 (4)
$\beta_{0,3}^-$	avg:	194,5 (3)	
$\beta_{0,2}^-$	max:	833,0 (7)	0,012 (9)

		Energy keV	Electrons per 100 disint.
$\beta_{0,2}^-$	avg:	283,9	(3)
$\beta_{0,1}^-$	max:	912,5	(7) 29,6 (12)
$\beta_{0,1}^-$	avg:	304,1	(3)
$\beta_{0,0}^-$	max:	970,5	(7) 57,8 (12)
$\beta_{0,0}^-$	avg:	326,9	(3)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.	
XK $\alpha_2$	(Tb)	43,7447	6,09 (25)	} K $\alpha$
XK $\alpha_1$	(Tb)	44,4821	10,9 (5)	}
XK $\beta_3$	(Tb)	50,23	}	
XK $\beta_1$	(Tb)	50,383	}	K' $\beta_1$
XK $\beta_2$	(Tb)	51,724	}	
XK $\beta_4$	(Tb)	51,849	}	K' $\beta_2$

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Tb})$	58,0000 (22)	2,49 (7)
$\gamma_{2,1}(\text{Tb})$	79,5132 (27)	0,0468 (11)
$\gamma_{2,0}(\text{Tb})$	137,515 (5)	0,00648 (15)
$\gamma_{3,2}(\text{Tb})$	210,783 (3)	0,0200 (14)
$\gamma_{4,2}(\text{Tb})$	226,0406 (18)	0,2170 (21)
$\gamma_{8,6}(\text{Tb})$	237,341 (5)	0,00769 (16)
$\gamma_{9,6}(\text{Tb})$	273,62 (12)	0,0007 (4)
$\gamma_{8,5}(\text{Tb})$	274,163 (19)	0,0057 (4)
$\gamma_{3,1}(\text{Tb})$	290,2865 (25)	0,0323 (5)
$\gamma_{4,1}(\text{Tb})$	305,5492 (20)	0,0620 (7)
$\gamma_{3,0}(\text{Tb})$	348,2807 (18)	0,2393 (25)
$\gamma_{4,0}(\text{Tb})$	363,5430 (18)	11,78 (5)
$\gamma_{7,2}(\text{Tb})$	536,730 (12)	0,00160 (5)
$\gamma_{6,1}(\text{Tb})$	559,623 (6)	0,0221 (6)
$\gamma_{5,0}(\text{Tb})$	580,808 (6)	0,0693 (7)
$\gamma_{7,1}(\text{Tb})$	616,233 (18)	0,00188 (8)
$\gamma_{6,0}(\text{Tb})$	617,615 (8)	0,0159 (5)

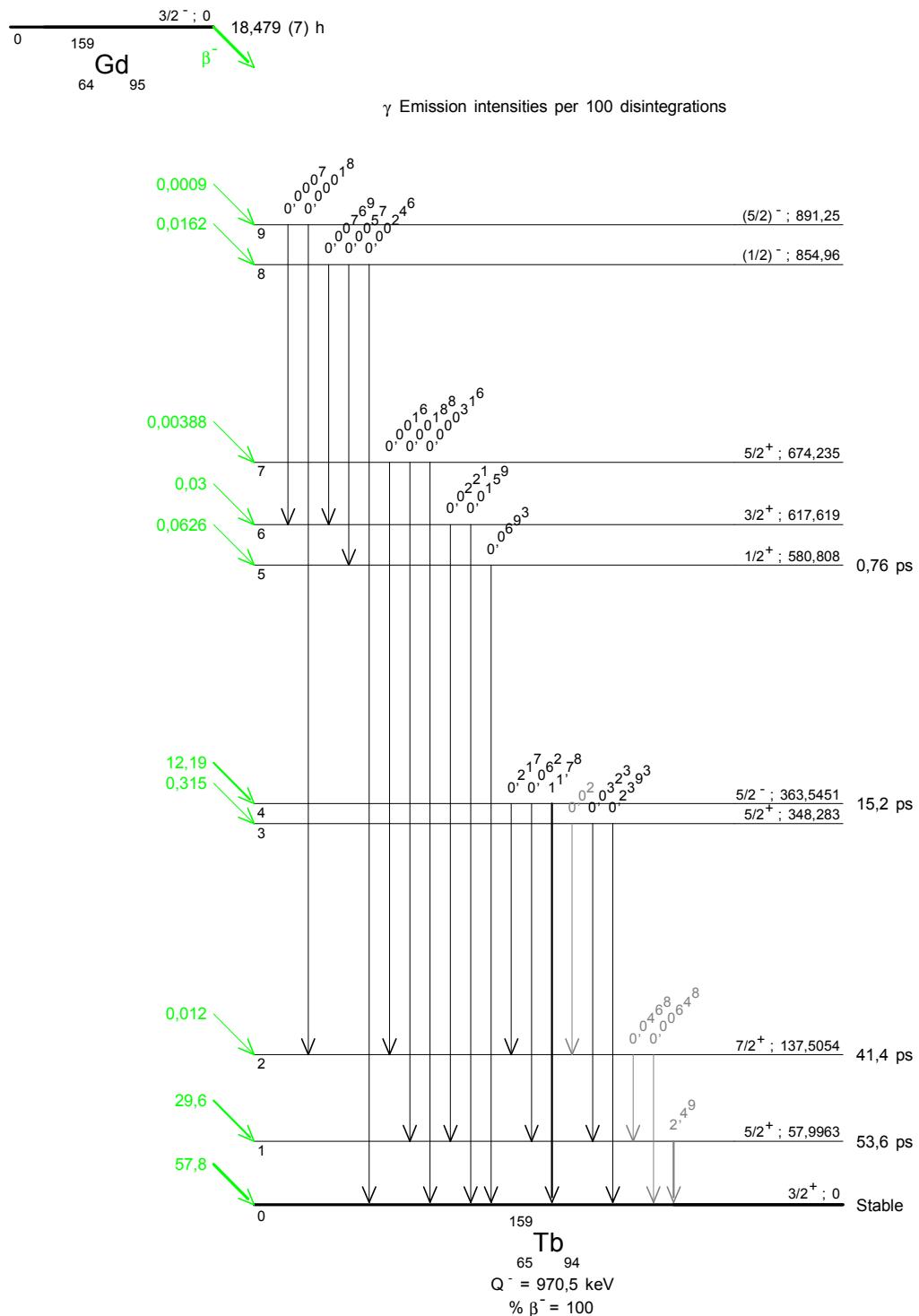
	Energy keV	Photons per 100 disint.
$\gamma_{7,0}(\text{Tb})$	674,26 (5)	0,000316 (22)
$\gamma_{9,2}(\text{Tb})$	753,74 (6)	0,00018 (2)
$\gamma_{8,0}(\text{Tb})$	854,947 (20)	0,00246 (14)

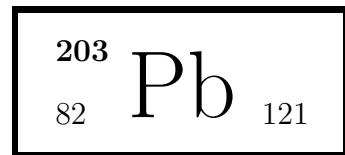
## 6 Main Production Modes

Gd – 158(n, $\gamma$ )Gd – 159

## 7 References

- N. L. KRISBERG, M. L. POOL, C. T. HIBDON. Phys. Rev. 74 (1948) 1249  
(Half-life)
- F. D. S. BUTEMENT. Phys. Rev. 75 (1948) 1276  
(Half-life)
- R. G. WILLE, R. W. FINK. Phys. Rev. 118 (1960) 242  
(Half-life)
- L. PERSSON. Ark. Fysik 25 (1964) 307  
(Gamma intensity)
- L. FUNKE, H. GRABER, K.-H. KAUN, H. SODAN, L. WERNER. Nucl. Phys. 70 (1965) 353  
(Gamma intensity)
- W. R. DANIELS, D. C. HOFFMAN. J. Inorg. Nucl. Chem 28 (1966) 2424  
(Half-life)
- J. C. HILL, M.L. WIEDENBECK. Nucl. Phys. A 111 (1968) 457  
(Gamma energy)
- R. A. BROWN, K. I. ROULSTON, G. T. EWAN, G. I. ANDERSSON. Can. J. Phys. 47 (1969) 1017  
(Gamma energy and probability)
- N. B. BADALOV, S. O. OMANOV. Proc. 25th Ann. Conf. Nucl. Spectrosc. and Structure At. Nuclei, Leningrad (1975) 120  
(Beta probability)
- S. M. DARWISH, S. ABDEL-MALAK, M. ABOU-LEILA, S. M. EL-BAHI, A. M. HASSAN. Nucl. Sci. J. (Taiwan) 22 (1985) 83  
(Gamma intensity)
- N. M. STEWART, N. I. FAWWAZ, F. S. RADHI. Z. Phys. A 348 (1994) 9  
(Gamma intensity)
- M. MORALLES, P. R. PASCHOLATI, V. R. VANIN, O. HELENE. Appl. Rad. Isotopes 46 (1995) 133  
(Gamma energy and intensity)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. 369 (1996) 527  
(Atomic data)
- E. SCHÖNFELD, H. JANSSEN. Report PTB-6.11-1999-1 (1999)  
(X-ray intensity)
- N. MARNADA, H. MIYAHARA, N. UEDA, N. HAYASHI, K. IKEDA. Appl. Rad. Isotopes 54 (2001) 695  
(Gamma intensity and probability)
- G. AUDI, A. H. WAPSTRA, C. THIBAULT. Nucl. Phys. A 729 (2003) 337  
(Q)





## 1 Decay Scheme

Pb-203 disintegrates by electron capture to Tl-203 via excited levels.

*Le plomb 203 se désintègre par capture électronique vers des niveaux excités du thallium 203.*

## 2 Nuclear Data

$$\begin{aligned} T_{1/2}(^{203}\text{Pb}) &: 51,929 \quad (10) \quad \text{h} \\ Q^+(^{203}\text{Pb}) &: 975 \quad (6) \quad \text{keV} \end{aligned}$$

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_{M+}$
$\epsilon_{0,2}$	294 (6)	4,80 (8)	Unique 1st Forbidden	6,812	0,7076 (32)	0,2168 (22)	0,0756 (9)
$\epsilon_{0,1}$	696 (6)	95,20 (12)	1st Forbidden	6,404	0,7786 (4)	0,1661 (3)	0,0552 (1)

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Tl})$	279,1952 (10)	99,24 (9)	M1 + E2	0,164 (1)	0,04837 (48)		0,2261 (8)
$\gamma_{2,1}(\text{Tl})$	401,320 (3)	4,04 (8)	M1 + 0,09 % E2	0,1464 (21)	0,0245 (4)	0,00572 (8)	0,1784 (25)
$\gamma_{2,0}(\text{Tl})$	680,515 (3)	0,765 (18)	E2	0,01065 (15)	0,00250 (4)	0,000605 (9)	0,01393 (20)

### 3 Atomic Data

#### 3.1 Tl

$$\begin{aligned}\omega_K &: 0,963 \quad (4) \\ \bar{\omega}_L &: 0,367 \quad (15) \\ n_{KL} &: 0,812 \quad (5)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	70,8327	59,24
K $\alpha_1$	72,8738	100
K $\beta_3$	82,116	}
K $\beta_1$	82,5756	}
K $\beta_5''$	83,0456	} 34,01
K $\beta_5'$	83,1417	}
K $\beta_2$	84,867	}
K $\beta_4$	85,1357	} 10,1
KO <sub>2,3</sub>	85,444	}
X <sub>L</sub>		
L $\ell$	8,9531	
L $\alpha$	10,1718 – 10,2679	
L $\eta$	10,9942	
L $\beta$	11,8117 – 12,9566	
L $\gamma$	13,8528 – 14,7362	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	54,587 – 59,954	100
KLX	66,37 – 72,86	55,4
KXY	78,12 – 85,50	7,67
Auger L	5,43 – 10,93	

## 4 Electron Emissions

		Energy keV		Electrons per 100 disint.
e <sub>AL</sub>	(Tl)	5,43	- 10,93	57,9 (6)
e <sub>AK</sub>	(Tl)			3,4 (4)
KLL		54,587	- 59,954	}
KLX		66,37	- 72,86	}
KXY		78,12	- 85,50	}
ec <sub>1,0</sub> K	(Tl)	193,665	(1)	13,27 (12)
ec <sub>1,0</sub> L	(Tl)	263,8485	- 266,5377	3,912 (46)
ec <sub>1,0</sub> M	(Tl)	275,4911	- 276,8059	1,254 (18)
ec <sub>2,1</sub> K	(Tl)	315,790	(3)	0,502 (13)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Tl)	8,9531 — 14,7362	33,2 (6)
XK $\alpha_2$	(Tl)	70,8327	25,61 (19) }
XK $\alpha_1$	(Tl)	72,8738	43,24 (25) }
XK $\beta_3$	(Tl)	82,116	}
XK $\beta_1$	(Tl)	82,5756	}
XK $\beta''_5$	(Tl)	83,0456	}
XK $\beta'_5$	(Tl)	83,1417	}
XK $\beta_2$	(Tl)	84,867	}
XK $\beta_4$	(Tl)	85,1357	}
XKO <sub>2,3</sub>	(Tl)	85,444	4,37 (11) K' $\beta_2$

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Tl})$	279,1952 (10)	80,94 (5)
$\gamma_{2,1}(\text{Tl})$	401,320 (3)	3,43 (6)
$\gamma_{2,0}(\text{Tl})$	680,515 (3)	0,754 (18)

## 6 Main Production Modes

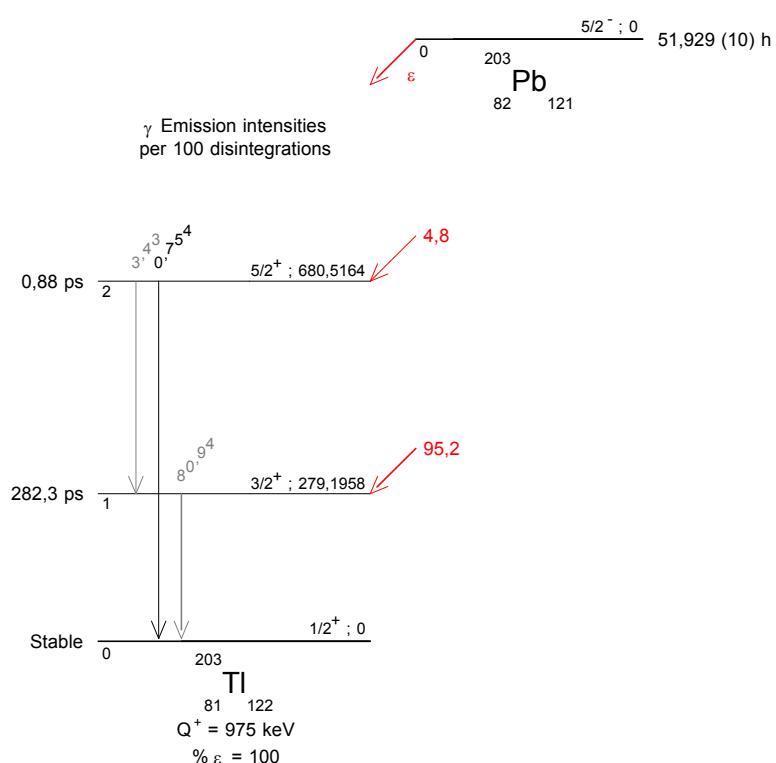
Tl – 203(d,2n)Pb – 203  
 Tl – 203(p,n)Pb – 203  
 Tl – 203(He – 3,3n)Bi – 203  
 Bi – 203(E.C.)Pb – 203  
 Hg – 202( $\alpha$ ,3n $\gamma$ )Pb – 203  
 Pb – 205(p,t)Pb – 203  
 Hg – 204( $\alpha$ ,5n)Pb – 203  
 Hg – 202( $\alpha$ ,3n)Pb – 203  
 Pb – 204( $\gamma$ ,n)Pb – 203  
 Pt – 198(Be – 9,4n)Pb – 203

## 7 References

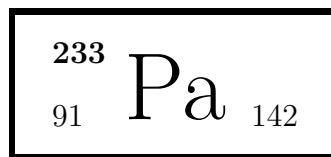
- K. FAJANS, A. F. VOIGT. Phys. Rev. 60 (1941) 619  
 (Half-life (Pb-203))
- R. L. HEATH, P. R. BELL. Phys. Rev. 87 (1952) 176A  
 (Conversion coefficient.)
- J. R. PRESCOTT. Proc. Phys. Soc. (London) A67 (1954) 254  
 (Half-life (Pb-203), gamma energy and intensities.)
- S. THULIN, K. NYBÖ. Ark. Fysik 7 (1954) 289  
 (Conversion coefficient.)
- A. H. WAPSTRA, D. MAEDER, G. J. NIJGH, L. TH. M. ORNSTEIN. Physica 20 (1954) 169  
 (Conversion coefficient, E.C. branching, gamma energy and intensities.)
- R. E. AZUMA, G. M. LEWIS. Phil. Mag. 46 (1955) 1034  
 (Half-life (279 keV))
- R. K. DOERNER, A. H. WEBER. Phys. Rev. 99 (1955) 672A  
 (Conversion coefficient.)
- N. MARTY. Comp. Rend. Acad. Sci. (Paris) 240 (1955) 291  
 (Conversion coefficient.)
- C. NORDLING, K. SIEGBAHN, E. SOKOLOWSKI. Nucl. Phys. 1 (1956) 326  
 (Conversion coefficients.)
- Z. O'FRIEL, A. H. WEBER. Phys. Rev. 101 (1956) 1076  
 (Conversion coefficient.)
- A. H. WAPSTRA, G. J. NIJGH. Nucl. Phys. 1 (1956) 245  
 (Conversion coefficients.)
- J. L. WOLFSON. Can. J. Phys. 34 (1956) 256  
 (Conversion coefficient.)
- E. E. BERLOVICH, G. V. DUBINKIN. Soviet Phys. JETP 5 (1957) 164  
 (Half-life (279 keV))
- A. A. BARTLETT, G. REBKA. Bull. Am .Phys. Soc. 3,2 (1958) 64  
 (Half-life (Pb-203))
- G. J. NIJGH, A. H. WAPSTRA, L. TH. M. ORNSTEIN, N. SALOMONS-GROBBEN, J. R. HUIZENGA. Nucl. Phys. 9 (1958) 528  
 (Conversion coefficients, gamma energy.)
- B. I. DEUTCH, N. GOLDBERG. Phys. Rev. 117 (1960) 818  
 (401-keV mixing ratio.)
- S. GORODETZKY, R. MANQUENOUILLE, R. RICHERT, A. KNIPPER. Comp. Rend. Acad. Sci. (Paris) 251 (1960) 65  
 (Half-life (279 keV))
- B. JOHANSSON, T. ALVÄGER. Ark. Fysik 17 (1960) 163  
 (Half-life (279 keV))
- E. C. B. PEDERSON, R. E. BELL. Nucl. Phys. 21 (1960) 393  
 (Half-life (279 keV))
- R. W. PEELLE. ORNL 3016 (1960) 116  
 (Conversion coefficients)

- M. K. RAMASWAMY, P. S. JASTRAM. Nucl. Phys. 15 (1960) 510  
(Conversion coefficients)
- R. STOCKENDAL. Ark. Fysik 17 (1960) 579  
(Conversion coefficient.)
- E. BASHANDY, T. R. GERHOLM, J. LINDSKOG. Ark. Fysik 17 (1960) 421  
(Half-life (279 keV))
- A. SCHWARZSCHILD, J. V. KANE. Phys. Rev. 122 (1961) 854  
(Half-life (279 keV))
- T. R. GERHOLM, B. G. PETTERSSON, B. VAN NOOIJEN, Z. GRABOWSKI. Nucl. Phys. 24 (1961) 177  
(401-keV mixing ratio)
- J. P. HURLEY, J. M. FERGUSON. Nucl. Phys. 27 (1961) 75  
(Conversion coefficients)
- L. PERSSON, Z. SUJKOWSKI. Ark. Fysik 19 (1961) 309  
(Half-life (Pb-203))
- Z. SUJKOWSKI. Ark. Fysik 20 (1961) 243  
(Conversion coefficient.)
- TH. J. DE BOER, H. VOORTHUIS, J. BLOK. Physica 28 (1962) 417  
(Half-life (279 keV))
- J. P. HURLEY, J. M. FERGUSON. Addendum: Nucl. Phys. 31 (1962) 690  
(Conversion coefficients)
- J. G. V. TAYLOR. Can. J. Phys. 40 (1962) 383  
(Conversion coefficient.)
- R. BURMEISTER, H. GRABER, J. SCHINTLMEISTER, R. WEIBRECHT. Nucl. Phys. 42 (1963) 56  
(Conversion coefficients)
- W. L. CROFT, B.-G. PETTERSSON, J. H. HAMILTON. Nucl. Phys. 48 (1963) 267  
(Conversion coefficient.)
- C. J. HERRLANDER, R. L. GRAHAM. Nucl. Phys. 58 (1964) 544  
(401-keV mixing ratio, conversion coefficients, gamma energies)
- R. ROUGNY, J. J. SAMUEL, A. SARAZIN. J. de Physique 25 (1964) 989  
(Half-life (279 keV))
- E. C. B. PEDERSON, R. E. BELL. Corrigendum: Nucl. Phys. 29 (1964) 694  
(Half-life (279 keV))
- E. KARLSSON, E. MATTHIAS, S. GUSTAFSSON, K. JOHANSSON, A. G. SVENSSON, S. OGAZA, P. DA ROCHA ANDRADE. Nucl. Phys. 61 (1965) 582  
(401-keV mixing ratio.)
- M. RAJA RAO, S. JNANANANDA. Nucl. Instrum. Meth. 35 (1965) 261  
(Conversion coefficients.)
- A. WALTHERT, E. BAUMGARTNER, P. HUBER. Helv. Phys. Acta 38 (1965) 514  
(Half-life (279 keV))
- H. E. BOSCH, E. SZICHMAN, A. BASEGGIO, R. DOLINKUE. Nucl. Instrum. Meth. 52 (1967) 289  
(Conversion coefficients)
- J. C. PALATHINGAL, M. L. WIEDENBECK. Nucl. Phys. A101 (1967) 193  
(Half-life (279 keV))
- M. S. RAJPUT. Current Sci. (India) 37 (1968) 639  
(Conversion coefficient)
- H. S. SAHOTA, B. S. GHUMAN, B. S. SOOD. Current Sci. (India) 37 (1968) 42  
(Conversion coefficients)
- J. E. CLINE. IN 1130 (1969) 39  
(Gamma energies)
- K.F. WALZ, H. M. WEISS, E. FUNCK. PTB Jahresbericht (1971) 150  
(Conversion coefficient.)
- G. A. CHACKETT, K. F. CHACKETT, J. B. WELBORN. Int. J. Appl. Radiat. Isotop. 22 (1971) 715  
(Half-life (Pb-203))
- H. H. HANSEN, D. MOUCHEL. Z. Physik 267 (1974) 371  
(Conversion coefficients)
- R. G. HELMER, R. C. GREENWOOD, R. J. GEHRKE. Nucl. Instrum. Meth. 155 (1978) 189  
(Gamma energies)
- H. HOUTERMANS, O. MILOSEVIC, F. REICHEL. Int. J. Appl. Radiat. Isotop. 31 (1980) 153  
(Half-life (Pb-203))

- D. D. HOPPES. NBS - SP 626 (1982) 85  
(Half-life (Pb-203))
- H. H. HANSEN. European Appl. Res. Rept. Nucl. Sci. Technol. 6 (1985) 777  
(Conversion coefficients)
- Zs. NÉMETH, T. SEKINE, Y. YOSHIHARA. Appl. Rad. Isotopes 40 (1989) 519  
(E. C. branching, gamma intensities)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic data)
- E. SCHÖNFELD, H. JANSSEN. Appl. Rad. Isotopes 52 (2000) 955  
(Conversion coefficient)
- R. G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Meth. Phys. Res. A450 (2000) 35  
(Gamma energies)
- K. LINDBERG, F. NEUMANN, D. GALAVIZ, T. HARTMANN, P. MOHR, K. VOGT, S. VOLZ, A. ZILGES. Phys. Rev. C63 (2001) 047307  
(Half-life (Pb-203))
- M. P. UNTERWEGER. Appl. Rad. Isotopes 56 (2002) 125  
(Half-life (Pb-203))
- G. AUDI, A. H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q)
- F. G. KONDEV. Nucl. Data Sheets 105 (2005) 1  
(Spin, parity, multipolarity, level energy)
- S. RAMAN, M. ERTUGRUL, C. W. NESTOR, JR., M. B. TRZHASKOVSKAYA. At. Data. Nucl. Data Tables 92 (2006) 207  
(Theoretical ICC)







## 1 Decay Scheme

Pa-233 disintegrates by beta minus emissions to levels in U-233.

Le protactinium 233 se désintègre par émission bêta moins vers des niveaux excités et le niveau fondamental de l'uranium 233.

## 2 Nuclear Data

$T_{1/2}(^{233}\text{Pa})$	:	26,98	(2)	d
$T_{1/2}(^{233}\text{U})$	:	159,2	(2)	$10^3$ a
$Q^-(^{233}\text{Pa})$	:	570,1	(20)	keV

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg $ft$
$\beta_{0,11}^-$	114,1 (20)	0,0011 (2)	1st forbidden	10
$\beta_{0,10}^-$	154,3 (20)	25,3 (11)	1st forbidden	6
$\beta_{0,9}^-$	171,5 (20)	15,5 (9)	1st forbidden	6,4
$\beta_{0,8}^-$	189,8 (20)	0,020 (3)	1st forbidden unique	9,4
$\beta_{0,7}^-$	229,6 (20)	25,6 (29)	1st forbidden	6,6
$\beta_{0,6}^-$	249,4 (20)	0,020 (2)	2nd forbidden	9,8
$\beta_{0,5}^-$	258,2 (20)	26,7 (29)	1st forbidden	6,7
$\beta_{0,4}^-$	268,1 (20)	0,010 (2)	Allowed	10,2
$\beta_{0,3}^-$	271,3 (20)	0,12 (5)	Allowed	9
$\beta_{0,1}^-$	529,8 (20)	$\approx 3,4$	1st forbidden unique	9
$\beta_{0,0}^-$	570,1 (20)	$\approx 3,3$	1st forbidden	8,5

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{10,9}(\text{U})$	17,2 (1)	2	M1 + E2			373 (12)	498 (15)
$\gamma_{7,5}(\text{U})$	28,559 (10)	22,1 (27)	M1 + E2		230 (10)	59,4 (26)	310 (13)
$\gamma_{1,0}(\text{U})$	40,349 (5)	17,0 (28)	M1 + E2		427 (40)	117 (11)	584 (54)
$\gamma_{7,3}(\text{U})$	41,663 (10)	0,031 (7)	(E1)		0,93 (2)	0,235 (5)	1,24 (3)
$\gamma_{2,1}(\text{U})$	51,8 (5)	0,05 (4)	(M1+ E2)		99 (60)	28 (17)	136 (80)
$\gamma_{10,7}(\text{U})$	75,269 (10)	16,1 (11)	M1+E2		8,6 (6)	2,10 (17)	11,4 (8)
$\gamma_{9,5}(\text{U})$	86,595 (10)	16,0 (9)	M1+E2		5,32 (10)	1,29 (3)	7,06 (14)
$\gamma_{2,0}(\text{U})$	92,1 (5)	0,041 (21)	(E2)		14,2 (30)	3,98 (8)	19,6 (4)
$\gamma_{10,5}(\text{U})$	103,86 (1)	4,44 (16)	M1+ E2		3,17 (14)	0,77 (4)	4,21 (18)
$\gamma_{6,2}(\text{U})$	228,57 (5)	0,0042 (7)					
$\gamma_{7,2}(\text{U})$	248,38 (4)	0,0818 (15)	( E2)	0,104 (2)	0,175 (4)	0,0479 (10)	0,344 (7)
$\gamma_{3,1}(\text{U})$	258,45 (2)	0,0289 (6)	(E1)	0,0430 (9)	0,00856 (17)	0,0207 (4)	0,0544 (11)
$\gamma_{5,1}(\text{U})$	271,555 (10)	0,406 (4)	E2	0,089 (2)	0,123 (3)	0,0334 (7)	0,256 (5)
$\gamma_{6,1}(\text{U})$	280,61 (5)	0,011 (2)					
$\gamma_{8,2}(\text{U})$	288,42 (10)	0,016 (3)					
$\gamma_{3,0}(\text{U})$	298,81 (2)	0,12 (5)	(E1)	0,0314 (6)	0,00609 (12)	0,00147 (3)	0,0394 (8)
$\gamma_{7,1}(\text{U})$	300,129 (5)	12,3 (4)	M1+ E2	0,70 (2)	0,133 (4)	0,033 (1)	0,87 (2)
$\gamma_{4,0}(\text{U})$	301,99 (10)	0,010 (2)					
$\gamma_{5,0}(\text{U})$	311,904 (5)	68,8 (8)	M1+ E2	0,64 (2)	0,126 (4)	0,031 (1)	0,80 (2)
$\gamma_{6,0}(\text{U})$	320,73 (10)	0,0051 (4)					
$\gamma_{7,0}(\text{U})$	340,476 (5)	7,24 (10)	M1+ E2	0,50 (2)	0,103 (3)	0,022 (1)	0,62 (2)
$\gamma_{10,1}(\text{U})$	375,404 (5)	0,751 (8)	E2	0,0486 (10)	0,0359 (7)	0,00962 (19)	0,0974 (19)
$\gamma_{8,0}(\text{U})$	380,28 (10)	0,0037 (9)					
$\gamma_{9,0}(\text{U})$	398,492 (5)	1,525 (15)	E2	0,0434 (9)	0,0291 (6)	0,00775 (15)	0,0829 (17)
$\gamma_{10,0}(\text{U})$	415,764 (5)	1,993 (18)	M1+E2	0,097 (8)	0,0326 (16)	0,00837 (25)	0,141 (9)
$\gamma_{11,0}(\text{U})$	455,96 (10)	0,0011 (2)					

## 3 Atomic Data

### 3.1 U

$$\begin{aligned}\omega_K &: 0,970 (4) \\ \bar{\omega}_L &: 0,500 (19) \\ n_{KL} &: 0,794 (5)\end{aligned}$$

### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	94,666	62,47
K $\alpha_1$	98,44	100
K $\beta_3$	110,421	}
K $\beta_1$	111,298	}
K $\beta_5''$	111,964	}
		36,08
K $\beta_2$	114,407	}
K $\beta_4$	115,012	}
KO <sub>2,3</sub>	115,377	}
X <sub>L</sub>		
L $\ell$	11,619	
L $\alpha$	13,438 – 13,615	
L $\eta$	15,399	
L $\beta$	15,727 – 18,206	
L $\gamma$	19,507 – 20,714	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	71,776 – 80,954	100
KLX	88,153 – 98,429	59,6
KXY	104,51 – 115,59	8,88
Auger L	0,1 – 21,6	

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(U)	0,1 - 21,6	41,5 (10)
e <sub>AK</sub>	(U)		0,95 (13)
	KLL	71,776 - 80,954	}
	KLX	88,153 - 98,429	}
	KXY	104,51 - 115,59	}
ec <sub>7,5</sub> L	(U)	6,80 - 11,39	16,3 (19)
ec <sub>10,9</sub> M	(U)	11,65 - 13,65	1,5
ec <sub>1,0</sub> L	(U)	18,59 - 23,18	12,4 (21)
ec <sub>7,5</sub> M	(U)	23,01 - 25,01	4,2 (5)
ec <sub>1,0</sub> M	(U)	34,8 - 36,8	3,4 (6)
ec <sub>10,7</sub> L	(U)	53,51 - 58,10	11,2 (9)
ec <sub>9,5</sub> L	(U)	64,84 - 69,43	10,6 (6)
ec <sub>10,7</sub> M	(U)	69,72 - 71,72	2,73 (23)
ec <sub>9,5</sub> M	(U)	81,05 - 83,05	2,57 (15)
ec <sub>10,5</sub> L	(U)	82,10 - 86,69	2,70 (12)
ec <sub>10,5</sub> M	(U)	98,31 - 100,31	0,66 (3)
ec <sub>7,1</sub> K	(U)	184,527 (5)	4,62 (20)
ec <sub>5,0</sub> K	(U)	196,302 (2)	24,5 (8)
ec <sub>7,0</sub> K	(U)	224,874 (2)	2,23 (9)
ec <sub>7,1</sub> L	(U)	278,37 - 282,96	0,88 (3)
ec <sub>9,0</sub> K	(U)	282,890 (5)	0,0611 (13)
ec <sub>5,0</sub> L	(U)	290,15 - 294,74	4,82 (16)
ec <sub>7,1</sub> M	(U)	294,58 - 296,58	0,22 (1)
ec <sub>10,0</sub> K	(U)	300,162 (7)	0,170 (13)
ec <sub>5,0</sub> M	(U)	306,36 - 308,35	1,190 (39)
ec <sub>7,0</sub> L	(U)	318,72 - 323,31	0,460 (14)
ec <sub>7,0</sub> M	(U)	334,93 - 336,93	0,098 (5)
ec <sub>10,0</sub> L	(U)	394,01 - 398,60	0,057 (30)
$\beta_{0,11}^-$	max:	114,1 (20)	0,0011 (2)
$\beta_{0,11}^-$	avg:	29,8 (5)	
$\beta_{0,10}^-$	max:	154,3 (20)	25,3 (11)
$\beta_{0,10}^-$	avg:	40,9 (5)	
$\beta_{0,9}^-$	max:	171,5 (20)	15,5 (9)
$\beta_{0,9}^-$	avg:	45,7 (5)	
$\beta_{0,8}^-$	max:	189,8 (20)	0,020 (3)
$\beta_{0,8}^-$	avg:	50,9 (6)	
$\beta_{0,7}^-$	max:	229,6 (20)	25,6 (29)
$\beta_{0,7}^-$	avg:	62,4 (6)	
$\beta_{0,6}^-$	max:	249,4 (20)	0,020 (2)
$\beta_{0,6}^-$	avg:	68,2 (6)	
$\beta_{0,5}^-$	max:	258,2 (20)	26,7 (29)

		Energy keV	Electrons per 100 disint.
$\beta_{0,5}^-$	avg:	70,8 (6)	
$\beta_{0,4}^-$	max:	268,1 (20)	0,010 (2)
$\beta_{0,4}^-$	avg:	73,7 (6)	
$\beta_{0,3}^-$	max:	271,3 (20)	0,12 (5)
$\beta_{0,3}^-$	avg:	74,6 (6)	
$\beta_{0,1}^-$	max:	529,8 (20)	3,4
$\beta_{0,1}^-$	avg:	156,1 (6)	
$\beta_{0,0}^-$	max:	570,1 (20)	3,3
$\beta_{0,0}^-$	avg:	169,6 (6)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(U)	11,619 — 20,714	41,5 (10)
XK $\alpha_2$	(U)	94,666	9,09 (25) } K $\alpha$
XK $\alpha_1$	(U)	98,44	14,6 (4) }
XK $\beta_3$	(U)	110,421	}
XK $\beta_1$	(U)	111,298	} 5,25 (21) K' $\beta_1$
XK $\beta_5''$	(U)	111,964	}
XK $\beta_2$	(U)	114,407	}
XK $\beta_4$	(U)	115,012	} 1,80 (8) K' $\beta_2$
XKO <sub>2,3</sub>	(U)	115,377	}

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{10,9}(U)$	17,2 (1)	0,0041
$\gamma_{7,5}(U)$	28,559 (10)	0,071 (8)
$\gamma_{1,0}(U)$	40,349 (5)	0,029 (4)
$\gamma_{7,3}(U)$	41,663 (10)	0,014 (3)
$\gamma_{2,1}(U)$	51,8 (5)	0,0004 (2)

	Energy keV	Photons per 100 disint.
$\gamma_{10,7}(\text{U})$	75,269 (10)	1,30 (3)
$\gamma_{9,5}(\text{U})$	86,595 (10)	1,99 (11)
$\gamma_{2,0}(\text{U})$	92,1 (5)	0,002 (1)
$\gamma_{10,5}(\text{U})$	103,86 (1)	0,853 (6)
$\gamma_{6,2}(\text{U})$	228,57 (5)	0,0042 (7)
$\gamma_{7,2}(\text{U})$	248,38 (4)	0,0609 (11)
$\gamma_{3,1}(\text{U})$	258,45 (2)	0,0274 (6)
$\gamma_{5,1}(\text{U})$	271,555 (10)	0,323 (3)
$\gamma_{6,1}(\text{U})$	280,61 (5)	0,011 (2)
$\gamma_{8,2}(\text{U})$	288,42 (10)	0,016 (3)
$\gamma_{3,0}(\text{U})$	298,81 (2)	0,12 (5)
$\gamma_{7,1}(\text{U})$	300,129 (5)	6,60 (21)
$\gamma_{4,0}(\text{U})$	301,99 (10)	0,010 (2)
$\gamma_{5,0}(\text{U})$	311,904 (5)	38,25 (23)
$\gamma_{6,0}(\text{U})$	320,73 (10)	0,0051 (4)
$\gamma_{7,0}(\text{U})$	340,476 (5)	4,47 (3)
$\gamma_{10,1}(\text{U})$	375,404 (5)	0,684 (7)
$\gamma_{8,0}(\text{U})$	380,28 (10)	0,0037 (9)
$\gamma_{9,0}(\text{U})$	398,492 (5)	1,408 (14)
$\gamma_{10,0}(\text{U})$	415,764 (5)	1,747 (7)
$\gamma_{11,0}(\text{U})$	455,96 (10)	0,0011 (2)

## 6 Main Production Modes

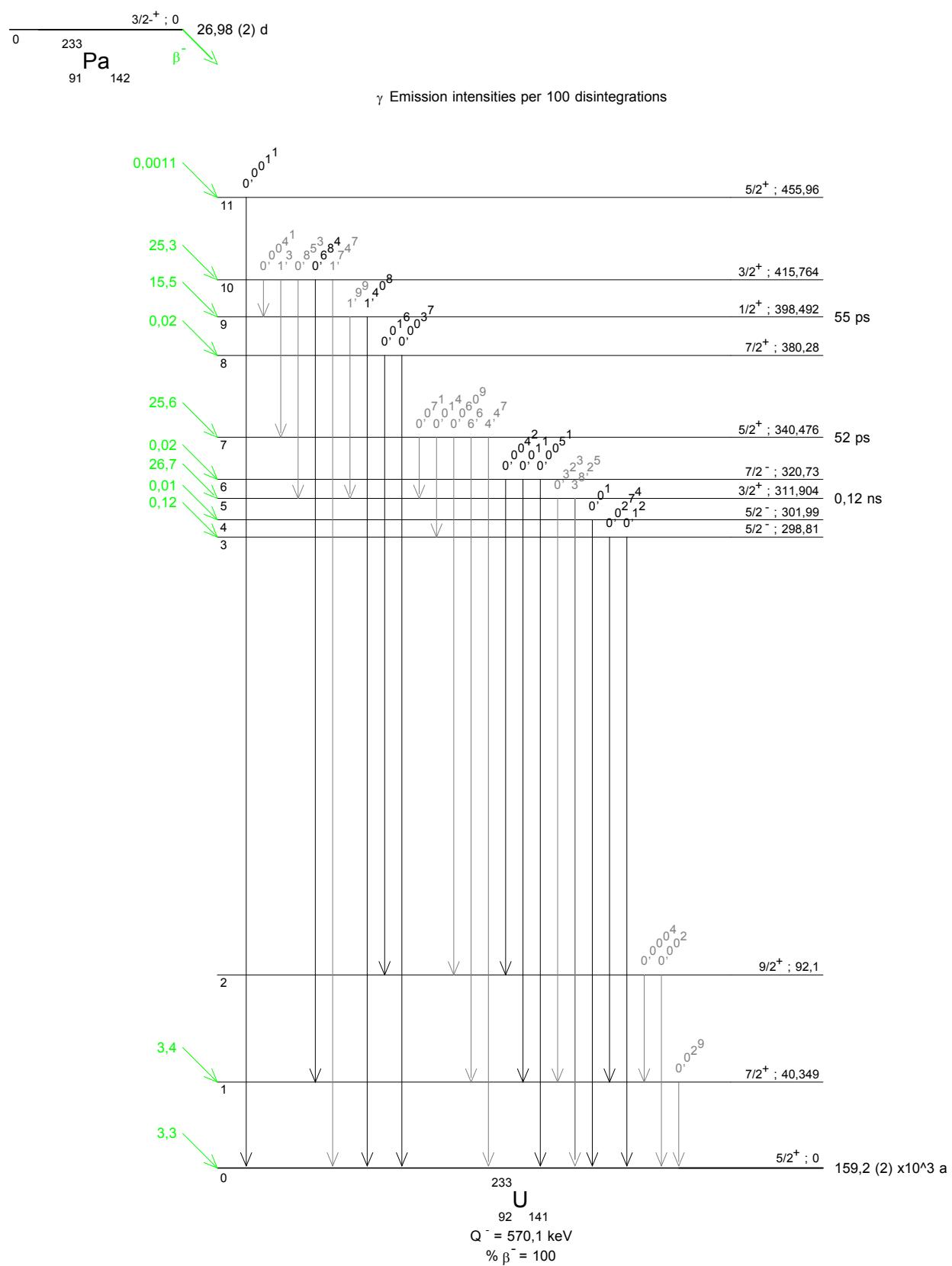
$$\left\{ \begin{array}{l} \text{Th} - 232(n,\gamma)\text{Pa} - 233 \\ \text{Possible impurities : Th} - 233, \text{Th} - 234 \end{array} \right.$$

## 7 References

- A.V. GROSSE, E.T. BOOTH, J.R. DUNNING. Phys. Rev 59 (1941) 322 (Half-life)
- C.I. BROWNE JR. Thesis, Univ. California (1952) (Gamma ray energies)
- W.D. BRODIE. Proc. Phys. Soc.(London) 67A (1954) 397 (Measured energies and probabilities of beta transitions)
- ONG PING HOK, P. KRAMER. Physica 21 (1955) 676 (Measured energies and probabilities of beta-transitions)
- L.D. MC ISAAC, E.C. FREILING. Nucleonics 14 (1956) 65 (Half-life)
- H.W. WRIGHT, E.T. WYATT, S.A. REYNOLDS, W.S. LYON, T.H. HANDLEY. Nucl. Sci. Eng. 2 (1957) 427 (Half-life)
- J.P. UNIK. Thesis, Univ. California (1960); UCRL-9105 (1960) (Measured energies and probabilities of beta-transitions)
- R.G. ALBRIDGE, J.M. HOLLANDER, C.J. GALLAGHER, J.H. HAMILTON. Nucl. Phys. 27 (1961) 529 (Gamma ray energies and multipolarities, E2 admixtures)

- G. SCHULTZE, J. AHLF. Nucl.Phys. 30 (1962) 163  
(Multipolarities, E2 admixtures)
- K.M. BISGARD, P. DAHL, P. HORNSHOJ, A.B. KNUTSEN. Nucl. Phys. 41 (1963) 21  
(Multipolarities, E2 admixtures)
- S. BJØRNHOLM, M. LEDERER, F. ASARO, AND I. PERLMAN. Phys. Rev. 130 (1963) 2000  
(Energies and probabilities of beta transitions)
- M.J. ZENDER. Thesis, Vanderbilt Univ. (1966)  
(Multipolarities, E2 admixtures)
- J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies)
- C. BRIANÇON, C.-F. LEANG, P. PARIS. Compt. Rend. 264B (1967) 1522  
(Gamma ray energies)
- S.G. MALMSKOG, M. HOJEBERG. Ark. Fys. 35 (1968) 197  
(Gamma ray energies)
- Z. T.von EGIDY, O.W.B. SCHULT, W. KALLINGER, D. BREITIG, R.P. SHARMA, H.R. KOCH, H.A. BAADER. Naturforsch. 26a (1971) 1092  
(Gamma ray energies)
- M. DE BRUIN, P.J.M. KORTHOVEN. J. Radioanal. Chem. 10 (1972) 125  
(Gamma ray energies)
- T. VALKEAPAA, A. SIVOLA, G. GRAEFFE. Phys. Fenn. 9 (1973) 43  
(Gamma ray energies and emission probabilities)
- F.P. LARKINS. Atomic Data and Nuclear Data Tables. 20 (1977) 313  
(Auger electron energies)
- I.M. BAND, M.B. TRZHASKOVSKAYA. Special report of Leningrad nuclear physics institute (1978)  
(Theoretical ICC)
- W.P. POENITZ, D.I. SMITH. United States Dept. of Energy, Washington DC, Rep. ANL/NDM-42 (1978)  
(Gamma ray emission probabilities)
- R.J. GEHRKE, R.G. HELMER, C.W. REICH. Nucl. Sci. Eng. 70 (1979) 298  
(X- and gamma ray emission probabilities)
- R. VANINBROUKX, G. BORTELS, B. DENECKE. Int. J. Appl. Radiat. Isotop. 35 (1984) 905  
(X- and gamma ray emission probabilities)
- R.T. JONES, J.S. MERRITT, A. OKAZAKI. Nucl. Sci. Eng. 93 (1986) 171  
(Half-life)
- K.S. KRANE. Nucl. Phys. A459 (1986) 1  
(Multipolarities, E2 admixtures)
- F. LAGOUTINE, N. COURSOL AND J. LEGRAND. Table de Radionucleides, ISBN-2-7272-0078-1 (LMRI, 1982-1987)  
(1987)  
(Energy of Auger electrons)
- S.A. WOODS, P. CHRISTMAS, P. CROSS, S.M. JUDGE, W. GELLETLY. Nucl. Instrum. Meth. Phys. Res. A264 (1988) 333  
(Gamma ray energies)
- E. BROWNE, B. SUR, E.B. NORMAN. Nucl. Phys. A501 (1989) 477  
(Experimental ICC, gamma multipolarities, beta transition probabilities)
- Y.A. AKOVALI. Nucl. Data Sheets 59 (1990) 263  
(Decay data evaluations, multipolarities, E2 admixtures)
- M.C. KOUASSI, C. ARDISSON-MARSOL, G. ARDISSON. J. Phys. (London) G16 (1990) 1881  
(Level scheme, multipolarities, absolute KX-ray emission probability and gamma-ray energies)
- M.U. RAJPUT, T.D. MACMAHON. Nucl. Instrum. Meth. Phys. Res. A312 (1992) 289  
(Evaluation technique)
- C.I. BLAND, J. MOREL, M.E. ETCHEVERY, M.C. LÉPY. Nucl. Instrum. Meth. Phys. Res. A 312 (1992) 323  
(L X-ray emission probability)
- I.M. BAND, M.B. TRZHASKOVSKAYA. At. Data. Nucl. Data Tables 55 (1993) 43  
(Theoretical ICC)
- M.C. LÉPY, B. DUCHEMIN, J. MOREL. Nucl. Instrum. Meth. Phys. Res. A 353 (1994) 10  
(L X-ray energies and emission probabilities)
- M.C. LÉPY, K. DEBERTIN. Nucl. Instrum. Meth. Phys. Res. A 339 (1994) 218  
(L X-ray energies and emission probabilities)
- P.N. JOHNSTON, P.A. BURNS. Nucl. Instrum. Meth. Phys. Res. A 361 (1995) 229  
(L X-ray energies and emission probabilities)

- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic data)
- E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX ray energies and relative emission probabilities)
- YU.S. POPOV, G.A. TIMOFEEV. Radiokhimiya 41,1 (1999) 27  
(Half-life)
- V.P. CHECHEV, A.G. EGOROV. Appl. Rad. Isotopes 52 (2000) 601  
(Evaluation technique)
- A. LUCA, M. ETCHEVERRY, J. MOREL. Appl. Rad. Isotopes 52 (2000) 481  
(Gamma-ray emission probabilities)
- K. USMAN, T.D. MACMAHON. Appl. Rad. Isotopes 52 (2000) 585  
(Half-life)
- D. SMITH, M.I. WOODS, D.H. WOODS. Preliminary Report, NPL, Teddington, 2000 (2000)  
(Gamma-ray and X-ray emission probabilities)
- U. SCHÖTZIG, E. SCHÖNFELD, H. JANSSEN. Appl. Rad. Isotopes 52 (2000) 883  
(Gamma-ray and X-ray emission probabilities)
- S.A. WOODS, D.H. WOODS, P. DE LAVISON, S.M. JEROME, J.L. MAKEPEACE, M.J. WOODS, L.J. HUSBAND, S. LINEHAM. Appl. Rad. Isotopes 52 (2000) 475  
(Gamma-ray emission probabilities)
- A. LUCA, S. SERMAN, K. IAKOVLEV, G. SHCHUKIN, M. ETCHEVERRY, J. MOREL. Appl. Rad. Isotopes 56 (2002) 173  
(Gamma-ray and X-ray emission probabilities)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q value)
- G. SHCHUKIN, K. IAKOVLEV, J. MOREL. Appl. Rad. Isotopes 60 (2004) 239  
(Gamma-ray emission probabilities)
- X. HUANG, P. LIU, B. WANG. Appl. Rad. Isotopes 62 (2005) 797  
(Evaluation of Pa-233 decay data)
- B. SINGH, J.K. TULI. Nucl. Data Sheets 105 (2005) 109  
(Nuclear data sheets A = 233)







## 1 Decay Scheme

Th-233 decays by beta minus emission to levels in Pa-233.

Le thorium 233 se désintègre par émission beta moins vers des niveaux excités du protactinium 233.

## 2 Nuclear Data

$$T_{1/2}(^{233}\text{Th}) : 22,15 \quad (15) \quad \text{min}$$

$$T_{1/2}(^{233}\text{Pa}) : 26,975 \quad (13) \quad \text{d}$$

$$Q^-(^{233}\text{Th}) : 1243,1 \quad (14) \quad \text{keV}$$

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg $ft$
$\beta_{0,20}^-$	224,4 (14)	0,056		6,6
$\beta_{0,19}^-$	258,3 (14)	0,32	allowed	6
$\beta_{0,18}^-$	431,5 (14)	0,54	allowed	6,5
$\beta_{0,17}^-$	478,5 (14)	1,58	allowed	6,2
$\beta_{0,16}^-$	573,2 (14)	0,02	1st forbidden	8,3
$\beta_{0,15}^-$	657,6 (14)	0,22	allowed	7,5
$\beta_{0,14}^-$	689,2 (14)	1,7	allowed	6,7
$\beta_{0,13}^-$	788,7 (14)	0,27	allowed	7,7
$\beta_{0,12}^-$	795,3 (14)	1,18	1st forbidden	7
$\beta_{0,11}^-$	985,8 (14)	0,08	1st forbidden unique	8,5
$\beta_{0,8}^-$	1041,4 (14)	0,04	allowed	8,9
$\beta_{0,7}^-$	1073,9 (14)	0,9	allowed	7,6
$\beta_{0,5}^-$	1148,4 (14)	16	allowed	6,4
$\beta_{0,1}^-$	1236,4 (14)	46	1st forbidden	6,1
$\beta_{0,0}^-$	1243,1 (14)	34	1st forbidden	6,3

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{(-1,1)}(\text{Pa})$							
$\gamma_{1,0}(\text{Pa})$	6,65 (5)	48	(M1)			2231	3016
$\gamma_{5,4}(\text{Pa})$	8,22 (5)	19					
$\gamma_{6,4}(\text{Pa})$	17,40 (5)						
$\gamma_{4,2}(\text{Pa})$	29,373 (10)	10,3	E1		2,32	0,6	3,12
$\gamma_{6,2}(\text{Pa})$	46,53 (4)						
$\gamma_{2,0}(\text{Pa})$	57,10 (2)	9,72	E2		131	36,1	180
$\gamma_{3,1}(\text{Pa})$	63,92 (6)	0,084	(E2)		76	21	104
$\gamma_{3,0}(\text{Pa})$	70,49 (10)	0,032	[M1+E2]		2,8	7,7	39
$\gamma_{7,5}(\text{Pa})$	74,51 (5)	0,6	[M1]		7,96	1,93	10,6
$\gamma_{(-1,42)}(\text{Pa})$	80						
$\gamma_{4,0}(\text{Pa})$	86,477 (10)	6,7	E1		1,13 (4)	0,22 (4)	1,43 (8)
$\gamma_{5,1}(\text{Pa})$	87,99 (3)	0,21	[E1]		0,13	0,032	0,17
$\gamma_{5,0}(\text{Pa})$	94,66 (5)	0,9	E1		0,11	0,026	0,15
$\gamma_{(-1,2)}(\text{Pa})$	105,2 (1)	0,043					
$\gamma_{9,6}(\text{Pa})$	108,5 (1)	0,0029	M1+E2		2,8	0,69	3,8
$\gamma_{8,4}(\text{Pa})$	115,14 (5)	0,0253	[M1+E2]	5,7	3,5	0,94	10,5
$\gamma_{9,5}(\text{Pa})$	117,692 (20)	0,021	M1+E2	10,1	2,3	0,56	13,2
$\gamma_{8,3}(\text{Pa})$	131,101 (25)	0,084	E1	0,21	0,049	0,012	0,26
$\gamma_{10,6}(\text{Pa})$	134,285 (20)	0,021	[M1+E2]	6,6	1,57	0,39	8,5
$\gamma_{9,3}(\text{Pa})$	141,74 (10)						
$\gamma_{10,5}(\text{Pa})$	143,23 (2)	0,11	M1+E2	5,47	1,28	0,319	7,07
$\gamma_{10,4}(\text{Pa})$	151,409 (20)	0,056	M1+E2	3,72	1,14	0,29	5,14
$\gamma_{11,6}(\text{Pa})$	153,49 (18)	0,077	[E1]	0,14	0,032	0,0079	0,18
$\gamma_{9,2}(\text{Pa})$	155,239 (20)	0,001	E1	0,14	0,032	0,0077	0,18
$\gamma_{7,1}(\text{Pa})$	162,504 (12)	0,17	[E1]	0,127	0,028	0,0068	0,16
$\gamma_{11,5}(\text{Pa})$	162,504	0,2	[E1]	0,127	0,028	0,0068	0,16
$\gamma_{7,0}(\text{Pa})$	169,159 (10)	0,39	[E1]	0,12	0,025	0,0061	0,15
$\gamma_{11,4}(\text{Pa})$	170,60 (6)	0,15	[E1]	0,113	0,025	0,0059	0,14
$\gamma_{17,15}(\text{Pa})$	179,05 (8)	0,17	(M1+E2)	2,82	0,641	0,16	3,62
$\gamma_{10,2}(\text{Pa})$	180,76 (3)	0,0008	[E1]	0,099	0,021	0,0052	0,13
$\gamma_{11,3}(\text{Pa})$	186,80 (18)	0,11	(M1+E2)	1,57	0,55	0,14	2,3
$\gamma_{12,11}(\text{Pa})$	190,552 (14)	0,59	M1	2,8	0,54	0,13	3,5
$\gamma_{8,1}(\text{Pa})$	194,97 (7)	0,18	E1	0,081	0,017	0,004	0,103
$\gamma_{8,0}(\text{Pa})$	201,62 (5)	0,033	E1	0,076	0,016	0,0037	0,096
$\gamma_{17,14}(\text{Pa})$	210,67 (8)	0,092	(M1+E2)	1,16	0,37	0,094	1,62
$\gamma_{(-1,3)}(\text{Pa})$	211,3 (2)	0,019					
$\gamma_{9,0}(\text{Pa})$	212,34 (5)	0,0016	E1	0,067	0,014	0,0033	0,085
$\gamma_{13,10}(\text{Pa})$	216,54 (8)	0,038	(M1+E2)	1,09	0,29	0,074	1,5
$\gamma_{18,15}(\text{Pa})$	226,1 (2)	0,072	M1+(E2)	1,74	0,33	0,079	2,15
$\gamma_{10,0}(\text{Pa})$	237,86 (2)	0,0023	[E1]	0,052	0,011	0,0025	0,062
$\gamma_{12,8}(\text{Pa})$	246,14 (6)		[E1]	0,048	0,0095	0,0023	0,061
$\gamma_{11,1}(\text{Pa})$	250,65 (16)	0,0062	[E2]	0,105	0,16	0,044	0,32
$\gamma_{13,8}(\text{Pa})$	252,78 (9)	0,029	[M1+E2]	1,12	0,229	0,0559	1,39
$\gamma_{11,0}(\text{Pa})$	257,30 (15)	0,13	[M1+E2]	0,66	0,19	0,047	0,9
$\gamma_{18,14}(\text{Pa})$	257,7 (2)						
$\gamma_{(-1,4)}(\text{Pa})$	278,7 (4)	0,0078					
$\gamma_{13,7}(\text{Pa})$	285,24 (7)	0,042	(M1+E2)	0,79	0,16	0,039	0,99
$\gamma_{15,10}(\text{Pa})$	347,64 (6)	0,019	[M1]	0,54	0,099	0,024	0,67
$\gamma_{13,5}(\text{Pa})$	359,74 (4)	0,12	M1				
$\gamma_{12,4}(\text{Pa})$	361,285 (22)	0,039	[E1]	0,021	0,0039	0,00093	0,26
$\gamma_{13,4}(\text{Pa})$	367,92 (7)	0,0074	[M1]	0,46	0,086	0,021	0,56
$\gamma_{12,3}(\text{Pa})$	377,27 (11)	0,057	[M1+E2]	0,39	0,076	0,019	0,49
$\gamma_{19,15}(\text{Pa})$	398,8 (5)	0,021	[M1]	0,36	0,069	0,016	0,46
$\gamma_{(-1,5)}(\text{Pa})$	408,8 (5)	0,0038					
$\gamma_{16,11}(\text{Pa})$	412,5 (5)	0,019	(M1)	0,33	0,063	0,015	0,42
$\gamma_{(-1,6)}(\text{Pa})$	418,4 (5)	0,012					

	Energy keV	$P_{\gamma+ce} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{19,14}(\text{Pa})$	430,9 (4)	0,032	(M1)	0,29	0,056	0,0015	0,37
$\gamma_{20,15}(\text{Pa})$	433,2 (4)	0,015					
$\gamma_{(-1,7)}(\text{Pa})$	435,0 (5)						
$\gamma_{12,1}(\text{Pa})$	440,94 (4)	0,31	(M1+E2)	0,25	0,049	0,012	0,32
$\gamma_{12,0}(\text{Pa})$	447,762 (20)	0,19	(M1+E2)	0,26	0,048	0,012	0,31
$\gamma_{(-1,8)}(\text{Pa})$	454,2 (5)	0,04					
$\gamma_{14,5}(\text{Pa})$	459,222 (7)	1,835	M1	0,249	0,0465	0,0013	0,32
$\gamma_{14,4}(\text{Pa})$	467,40 (6)	0,021	[M1, E2]	0,14	0,03	0,007	0,18
$\gamma_{(-1,9)}(\text{Pa})$	473,9 (5)	0,0035					
$\gamma_{15,5}(\text{Pa})$	490,80 (6)	0,22	M1	0,21	0,038	0,0094	0,26
$\gamma_{(-1,10)}(\text{Pa})$	497,1 (4)	0,021					
$\gamma_{15,4}(\text{Pa})$	499,02 (4)	0,26	M1	0,19	0,038	0,0089	0,25
$\gamma_{(-1,11)}(\text{Pa})$	505,5 (6)	0,0049					
$\gamma_{(-1,12)}(\text{Pa})$	513,4 (4)	0,02					
$\gamma_{(-1,13)}(\text{Pa})$	517,0 (4)	0,0068					
$\gamma_{17,10}(\text{Pa})$	526,69 (6)	0,007	[M1, E2]	0,1	0,021	0,005	0,13
$\gamma_{(-1,14)}(\text{Pa})$	531,8 (4)	0,0042					
$\gamma_{17,9}(\text{Pa})$	552,21 (8)	0,027	[M1]	0,09	0,019	0,0046	0,11
$\gamma_{(-1,15)}(\text{Pa})$	554,9 (5)	0,0035					
$\gamma_{17,8}(\text{Pa})$	562,93 (8)	0,083	M1	0,15	0,027	0,0065	0,18
$\gamma_{18,10}(\text{Pa})$	573,7 (4)	0,049	[M1]	0,14	0,025	0,0062	0,17
$\gamma_{17,7}(\text{Pa})$	595,39 (6)	0,19	(M1)	0,125	0,023	0,0056	0,16
$\gamma_{18,9}(\text{Pa})$	599,3 (2)	0,054	M1	0,13	0,023	0,0055	0,16
$\gamma_{18,8}(\text{Pa})$	610,0 (3)	0,097	[M1]	0,12	0,022	0,0052	0,15
$\gamma_{18,7}(\text{Pa})$	642,4 (2)	0,032	[M1]	0,11	0,019	0,0045	0,13
$\gamma_{16,1}(\text{Pa})$	663,3 (5)	0,0027	[M1]	0,094	0,018	0,0042	0,12
$\gamma_{16,0}(\text{Pa})$	669,9 (5)	0,0019	(M1)				
$\gamma_{17,5}(\text{Pa})$	669,902 (16)	0,76	M1+E2	0,092	0,017	0,00415	0,12
$\gamma_{17,4}(\text{Pa})$	678,04 (10)	0,087	[M1,E2]				
$\gamma_{(-1,16)}(\text{Pa})$	681,2 (6)	0,016					
$\gamma_{(-1,17)}(\text{Pa})$	698,5 (6)	0,012					
$\gamma_{(-1,18)}(\text{Pa})$	703,7 (6)	0,011					
$\gamma_{18,6}(\text{Pa})$	707,8 (3)	0,01	[E2]	0,014	0,0046	0,0012	0,021
$\gamma_{18,5}(\text{Pa})$	717,0 (2)	0,061	[M1]	0,076	0,014	0,0033	0,094
$\gamma_{18,4}(\text{Pa})$	725,1 (2)	0,09	[M1]	0,074	0,014	0,0033	0,092
$\gamma_{18,3}(\text{Pa})$	741,1 (2)	0,031	[E1]	0,0051	0,00087	0,0002	0,0063
$\gamma_{(-1,19)}(\text{Pa})$	744,9 (5)	0,0068					
$\gamma_{(-1,20)}(\text{Pa})$	751,6 (6)	0,0024					
$\gamma_{17,1}(\text{Pa})$	757,90 (7)	0,042					
$\gamma_{17,0}(\text{Pa})$	764,55 (6)	0,12					
$\gamma_{(-1,21)}(\text{Pa})$	774,0 (4)	0,014					
$\gamma_{19,8}(\text{Pa})$	783,2 (5)	0,0065	[M1]	0,06	0,011	0,0027	0,075
$\gamma_{(-1,22)}(\text{Pa})$	784,2 (5)	0,0049					
$\gamma_{18,1}(\text{Pa})$	804,8 (4)	0,031	[E1]	0,0043	0,00074	0,00018	0,0054
$\gamma_{20,9}(\text{Pa})$	806,4 (5)	0,013					
$\gamma_{18,0}(\text{Pa})$	811,6 (2)	0,0079	[E1]	0,0044	0,00073	0,00018	0,0053
$\gamma_{19,7}(\text{Pa})$	815,9 (4)	0,028	(M1)	0,0023	0,0099	0,0023	0,067
$\gamma_{20,8}(\text{Pa})$	817,0 (6)	0,016					
$\gamma_{(-1,23)}(\text{Pa})$	832,0 (3)	0,0081					
$\gamma_{(-1,24)}(\text{Pa})$	846,8 (7)	0,0014					
$\gamma_{20,7}(\text{Pa})$	849,5 (5)	0,0047					
$\gamma_{(-1,25)}(\text{Pa})$	870,7 (7)	0,0021					
$\gamma_{(-1,26)}(\text{Pa})$	874,0 (5)	0,0062					
$\gamma_{19,6}(\text{Pa})$	880,9 (5)	0,0078		0,01	0,0027	0,00065	0,012
$\gamma_{19,5}(\text{Pa})$	890,1 (5)	0,15	[M1]	0,044	0,0078	0,0018	0,048
$\gamma_{19,4}(\text{Pa})$	898,3 (5)	0,0034	[M1]	0,043	0,0077	0,0018	0,048
$\gamma_{(-1,27)}(\text{Pa})$	918,9 (5)	0,007					
$\gamma_{(-1,28)}(\text{Pa})$	935,2 (7)	0,049					
$\gamma_{(-1,29)}(\text{Pa})$	941,9 (8)	0,0078					

	Energy keV	$P_{\gamma+ce} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{20,3}(\text{Pa})$	948,3 (5)	0,0075					
$\gamma(-1,30)(\text{Pa})$	955 (1)	0,0054					
$\gamma(-1,31)(\text{Pa})$	960,8 (8)	0,0068					
$\gamma(-1,32)(\text{Pa})$	962,8 (9)	0,0014					
$\gamma(-1,33)(\text{Pa})$	968,2 (9)	0,0011					
$\gamma_{19,1}(\text{Pa})$	978,2 (5)	0,0075	[E1]	0,0032	0,00052	0,00012	0,0036
$\gamma_{19,0}(\text{Pa})$	984,8 (5)	0,0014	[E1]	0,0031	0,00051	0,00012	0,0036
$\gamma(-1,34)(\text{Pa})$	994 (1)	0,00094					
$\gamma(-1,35)(\text{Pa})$	1001 (1)	0,0012					
$\gamma(-1,36)(\text{Pa})$	1007 (1)	0,0028					
$\gamma(-1,37)(\text{Pa})$	1011 (1)	0,004					
$\gamma(-1,38)(\text{Pa})$	1026,5 (10)	0,0081					
$\gamma(-1,39)(\text{Pa})$	1092,5 (10)	0,007					
$\gamma(-1,40)(\text{Pa})$	1144 (1)	0,0029					
$\gamma(-1,41)(\text{Pa})$	1201 (1)	0,007					

### 3 Atomic Data

#### 3.1 Pa

$$\begin{aligned}
 \omega_K &: 0,970 & (4) \\
 \bar{\omega}_L &: 0,488 & (18) \\
 \bar{\omega}_M &: 0,0477 \\
 n_{KL} &: 0,795 & (5) \\
 \bar{n}_{LM} &: 1,186
 \end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	92,288	62,14
K $\alpha_1$	95,869	100
K $\beta_3$	107,595	}
K $\beta_1$	108,422	}
K $\beta_5''$	109,072	} 34,78
K $\beta_2$	111,405	}
K $\beta_4$	111,87	} 11,22
KO <sub>2,3</sub>	112,38	}
X <sub>L</sub>		
L $\ell$	11,3676	
L $\alpha$	13,1215 – 13,2887	
L $\eta$	14,9488	
L $\beta$	15,3584 – 17,6655	
L $\gamma$	18,9396 – 20,1126	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	70,081 – 78,822	100
KLX	88,03 – 95,56	60
KXY	101,78 – 112,30	8,76
Auger L      5,9 – 20,9		

## 4 Electron Emissions

		Energy keV		Electrons per 100 disint.
eAL	(Pa)	5,9 - 20,9		9,2
eAK	(Pa)			0,051
	KLL	70,081 - 78,822	}	
	KLX	88,03 - 95,56	}	
	KXY	101,78 - 112,30	}	
ec <sub>1,0</sub> M	(Pa)	1,29 - 3,21		35,7
ec <sub>4,2</sub> L	(Pa)	8,27 - 12,64		5,8
ec <sub>4,2</sub> M	(Pa)	24,01 - 25,93		1,5
ec <sub>10,5</sub> K	(Pa)	30,6 (1)		0,076
ec <sub>2,0</sub> L	(Pa)	36,00 - 40,37		7,1
ec <sub>3,1</sub> L	(Pa)	42,82 - 47,19		0,061
ec <sub>2,0</sub> M	(Pa)	51,74 - 53,66		2
ec <sub>7,5</sub> L	(Pa)	53,41 - 57,78		0,41
ec <sub>4,0</sub> L	(Pa)	65,37 - 69,74		3,05
ec <sub>17,15</sub> K	(Pa)	66,45 (8)		0,11
ec <sub>5,0</sub> L	(Pa)	73,48 - 77,85		0,088
ec <sub>11,3</sub> K	(Pa)	74,20 (18)		0,1
ec <sub>4,0</sub> M	(Pa)	81,12 - 83,04		0,59
ec <sub>11,0</sub> K	(Pa)	144,7 (15)		0,082
ec <sub>12,1</sub> K	(Pa)	328,34 (4)		0,059
ec <sub>14,5</sub> K	(Pa)	346,626 (7)		0,35
ec <sub>14,5</sub> L	(Pa)	438,117 - 442,489		0,065
ec <sub>17,5</sub> K	(Pa)	557,306 (16)		0,062
$\beta_{0,20}^-$	max:	224,4 (14)		0,056
$\beta_{0,20}^-$	avg:	61		
$\beta_{0,19}^-$	max:	258,3 (14)		0,32
$\beta_{0,19}^-$	avg:	71		

		Energy keV	Electrons per 100 disint.
$\beta_{0,18}^-$	max:	431,5	(14) 0,54
$\beta_{0,18}^-$	avg:	124	
$\beta_{0,17}^-$	max:	478,5	(14) 1,58
$\beta_{0,17}^-$	avg:	140	
$\beta_{0,16}^-$	max:	573,2	(14) 0,02
$\beta_{0,16}^-$	avg:	171	
$\beta_{0,15}^-$	max:	657,6	(14) 0,22
$\beta_{0,15}^-$	avg:	200	
$\beta_{0,14}^-$	max:	689,2	(14) 1,7
$\beta_{0,14}^-$	avg:	211	
$\beta_{0,13}^-$	max:	788,7	(14) 0,27
$\beta_{0,13}^-$	avg:	246	
$\beta_{0,12}^-$	max:	795,3	(14) 1,18
$\beta_{0,12}^-$	avg:	248	
$\beta_{0,11}^-$	max:	985,8	(14) 0,08
$\beta_{0,11}^-$	avg:	317	
$\beta_{0,8}^-$	max:	1041,4	(14) 0,04
$\beta_{0,8}^-$	avg:	338	
$\beta_{0,7}^-$	max:	1073,9	(14) 0,9
$\beta_{0,7}^-$	avg:	350	
$\beta_{0,5}^-$	max:	1148,4	(14) 16
$\beta_{0,5}^-$	avg:	378	
$\beta_{0,1}^-$	max:	1236,4	(14) 46
$\beta_{0,1}^-$	avg:	411	
$\beta_{0,0}^-$	max:	1243,1	(14) 34
$\beta_{0,0}^-$	avg:	414	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Pa)	11,3676 — 20,1126	8,8
XK $\alpha_2$	(Pa)	92,288	0,48 } K $\alpha$
XK $\alpha_1$	(Pa)	95,869	0,78 }
XK $\beta_3$	(Pa)	107,595	}
XK $\beta_1$	(Pa)	108,422	} 0,28 K' $\beta_1$
XK $\beta_5''$	(Pa)	109,072	}

		Energy keV	Photons per 100 disint.	
XK $\beta_2$	(Pa)	111,405	}	
XK $\beta_4$	(Pa)	111,87	}	0,095
XKO <sub>2,3</sub>	(Pa)	112,38	}	K' $\beta_2$

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}$ (Pa)	6,65 (5)	0,016
$\gamma_{4,2}$ (Pa)	29,373 (10)	2,5
$\gamma_{2,0}$ (Pa)	57,10 (2)	0,054
$\gamma_{3,1}$ (Pa)	63,92 (6)	0,0008
$\gamma_{3,0}$ (Pa)	70,49 (10)	0,0008
$\gamma_{7,5}$ (Pa)	74,51 (5)	0,052
$\gamma_{4,0}$ (Pa)	86,477 (10)	2,7
$\gamma_{5,1}$ (Pa)	87,99 (3)	0,18
$\gamma_{5,0}$ (Pa)	94,65 (5)	0,8
$\gamma_{(-1,2)}$ (Pa)	105,2 (1)	0,043
$\gamma_{9,6}$ (Pa)	108,5 (1)	0,0006
$\gamma_{8,4}$ (Pa)	115,14 (5)	0,0022
$\gamma_{9,5}$ (Pa)	117,692 (20)	0,0015
$\gamma_{8,3}$ (Pa)	131,101 (25)	0,066
$\gamma_{10,6}$ (Pa)	134,285 (20)	0,0022
$\gamma_{10,5}$ (Pa)	143,23 (2)	0,014
$\gamma_{10,4}$ (Pa)	151,409 (20)	0,009
$\gamma_{11,6}$ (Pa)	153,49 (18)	0,066
$\gamma_{9,2}$ (Pa)	155,239 (20)	0,0009
$\gamma_{7,1}$ (Pa)	162,504 (12)	0,15
$\gamma_{11,5}$ (Pa)	162,504	0,17
$\gamma_{7,0}$ (Pa)	169,159 (10)	0,34
$\gamma_{11,4}$ (Pa)	170,60 (6)	0,13
$\gamma_{17,15}$ (Pa)	179,05 (8)	0,038
$\gamma_{10,2}$ (Pa)	180,76 (3)	0,0007
$\gamma_{11,3}$ (Pa)	186,80 (18)	0,034
$\gamma_{12,11}$ (Pa)	190,552 (14)	0,13
$\gamma_{8,1}$ (Pa)	194,97 (7)	0,16
$\gamma_{8,0}$ (Pa)	201,62 (5)	0,031
$\gamma_{17,14}$ (Pa)	210,67 (8)	0,035
$\gamma_{(-1,3)}$ (Pa)	211,3 (2)	0,019
$\gamma_{9,0}$ (Pa)	212,34 (5)	0,0015
$\gamma_{13,10}$ (Pa)	216,54 (8)	0,015
$\gamma_{18,15}$ (Pa)	226,1 (2)	0,023
$\gamma_{10,0}$ (Pa)	237,86 (2)	0,0021
$\gamma_{11,1}$ (Pa)	250,65 (16)	0,0047
$\gamma_{13,8}$ (Pa)	252,78 (9)	0,012

	Energy keV	Photons per 100 disint.
$\gamma_{11,0}(\text{Pa})$	257,30 (15)	0,068
$\gamma_{(-1,4)}(\text{Pa})$	278,7 (4)	0,0078
$\gamma_{13,7}(\text{Pa})$	285,24 (7)	0,021
$\gamma_{15,10}(\text{Pa})$	347,64 (6)	0,012
$\gamma_{13,5}(\text{Pa})$	359,74 (4)	0,12
$\gamma_{12,4}(\text{Pa})$	361,285 (22)	0,038
$\gamma_{13,4}(\text{Pa})$	367,92 (7)	0,0047
$\gamma_{12,3}(\text{Pa})$	377,27 (11)	0,038
$\gamma_{19,15}(\text{Pa})$	398,8 (5)	0,014
$\gamma_{(-1,5)}(\text{Pa})$	408,8 (5)	0,0038
$\gamma_{16,11}(\text{Pa})$	412,5 (5)	0,013
$\gamma_{(-1,6)}(\text{Pa})$	418,4 (5)	0,012
$\gamma_{19,14}(\text{Pa})$	430,9 (4)	0,023
$\gamma_{20,15}(\text{Pa})$	433,2 (4)	0,015
$\gamma_{12,1}(\text{Pa})$	440,94 (4)	0,23
$\gamma_{12,0}(\text{Pa})$	447,762 (20)	0,15
$\gamma_{(-1,8)}(\text{Pa})$	454,2 (5)	0,04
$\gamma_{14,5}(\text{Pa})$	459,222 (7)	1,4
$\gamma_{14,4}(\text{Pa})$	467,40 (6)	0,018
$\gamma_{(-1,9)}(\text{Pa})$	473,9 (5)	0,0035
$\gamma_{15,5}(\text{Pa})$	490,80 (6)	0,17
$\gamma_{(-1,10)}(\text{Pa})$	497,1 (4)	0,021
$\gamma_{15,4}(\text{Pa})$	499,02 (4)	0,21
$\gamma_{(-1,11)}(\text{Pa})$	505,5 (6)	0,0049
$\gamma_{(-1,12)}(\text{Pa})$	513,4 (4)	0,02
$\gamma_{(-1,13)}(\text{Pa})$	517,0 (4)	0,0068
$\gamma_{17,10}(\text{Pa})$	526,69 (6)	0,0063
$\gamma_{(-1,14)}(\text{Pa})$	531,8 (4)	0,0042
$\gamma_{17,9}(\text{Pa})$	552,21 (8)	0,024
$\gamma_{(-1,15)}(\text{Pa})$	554,9 (5)	0,0035
$\gamma_{17,8}(\text{Pa})$	562,93 (8)	0,07
$\gamma_{18,10}(\text{Pa})$	573,7 (4)	0,042
$\gamma_{17,7}(\text{Pa})$	595,39 (6)	0,16
$\gamma_{18,9}(\text{Pa})$	599,3 (2)	0,047
$\gamma_{18,8}(\text{Pa})$	610,0 (3)	0,085
$\gamma_{18,7}(\text{Pa})$	642,4 (2)	0,028
$\gamma_{16,1}(\text{Pa})$	663,3 (5)	0,0024
$\gamma_{16,0}(\text{Pa})$	669,9 (5)	0,0019
$\gamma_{17,5}(\text{Pa})$	669,902 (16)	0,68
$\gamma_{17,4}(\text{Pa})$	678,04 (10)	0,087
$\gamma_{(-1,16)}(\text{Pa})$	681,2 (6)	0,016
$\gamma_{(-1,17)}(\text{Pa})$	698,5 (6)	0,012
$\gamma_{(-1,18)}(\text{Pa})$	703,7 (6)	0,011
$\gamma_{18,6}(\text{Pa})$	707,8 (3)	0,012
$\gamma_{18,5}(\text{Pa})$	717,0 (2)	0,056
$\gamma_{18,4}(\text{Pa})$	725,1 (2)	0,087
$\gamma_{18,3}(\text{Pa})$	741,1 (2)	0,031

	Energy keV	Photons per 100 disint.
$\gamma_{(-1,19)}$ (Pa)	744,9 (5)	0,0068
$\gamma_{(-1,20)}$ (Pa)	751,6 (6)	0,0024
$\gamma_{17,1}$ (Pa)	757,90 (7)	0,042
$\gamma_{17,0}$ (Pa)	764,55 (6)	0,12
$\gamma_{(-1,21)}$ (Pa)	774,0 (4)	0,014
$\gamma_{19,8}$ (Pa)	783,2 (5)	0,0061
$\gamma_{(-1,22)}$ (Pa)	784,2 (5)	0,0049
$\gamma_{18,1}$ (Pa)	804,8 (4)	0,031
$\gamma_{20,9}$ (Pa)	806,4 (5)	0,013
$\gamma_{18,0}$ (Pa)	811,6 (2)	0,0078
$\gamma_{19,7}$ (Pa)	815,9 (4)	0,028
$\gamma_{20,8}$ (Pa)	817,0 (6)	0,016
$\gamma_{(-1,23)}$ (Pa)	832,0 (3)	0,0081
$\gamma_{(-1,24)}$ (Pa)	846,8 (7)	0,0014
$\gamma_{20,7}$ (Pa)	849,5 (5)	0,0047
$\gamma_{(-1,25)}$ (Pa)	870,7 (7)	0,0021
$\gamma_{(-1,26)}$ (Pa)	874,0 (5)	0,0062
$\gamma_{19,6}$ (Pa)	880,9 (5)	0,0078
$\gamma_{19,5}$ (Pa)	890,1 (5)	0,14
$\gamma_{19,4}$ (Pa)	898,3 (5)	0,0033
$\gamma_{(-1,27)}$ (Pa)	918,9 (5)	< 0,007
$\gamma_{(-1,28)}$ (Pa)	935,2 (7)	0,049
$\gamma_{(-1,29)}$ (Pa)	941,9 (8)	0,0078
$\gamma_{20,3}$ (Pa)	948,3 (5)	0,0075
$\gamma_{(-1,30)}$ (Pa)	955 (1)	0,0054
$\gamma_{(-1,31)}$ (Pa)	960,8 (8)	0,0068
$\gamma_{(-1,32)}$ (Pa)	962,8 (9)	0,0014
$\gamma_{(-1,33)}$ (Pa)	968,2 (9)	0,011
$\gamma_{19,1}$ (Pa)	978,2 (5)	0,0075
$\gamma_{19,0}$ (Pa)	984,8 (5)	0,0014
$\gamma_{(-1,34)}$ (Pa)	994 (1)	0,00094
$\gamma_{(-1,35)}$ (Pa)	1001 (1)	0,0012
$\gamma_{(-1,36)}$ (Pa)	1007 (1)	0,0028
$\gamma_{(-1,37)}$ (Pa)	1011 (1)	0,004
$\gamma_{(-1,38)}$ (Pa)	1026,5 (10)	0,0081
$\gamma_{(-1,39)}$ (Pa)	1092,5 (10)	< 0,007
$\gamma_{(-1,40)}$ (Pa)	1144 (1)	0,0029
$\gamma_{(-1,41)}$ (Pa)	1201 (1)	< 0,007

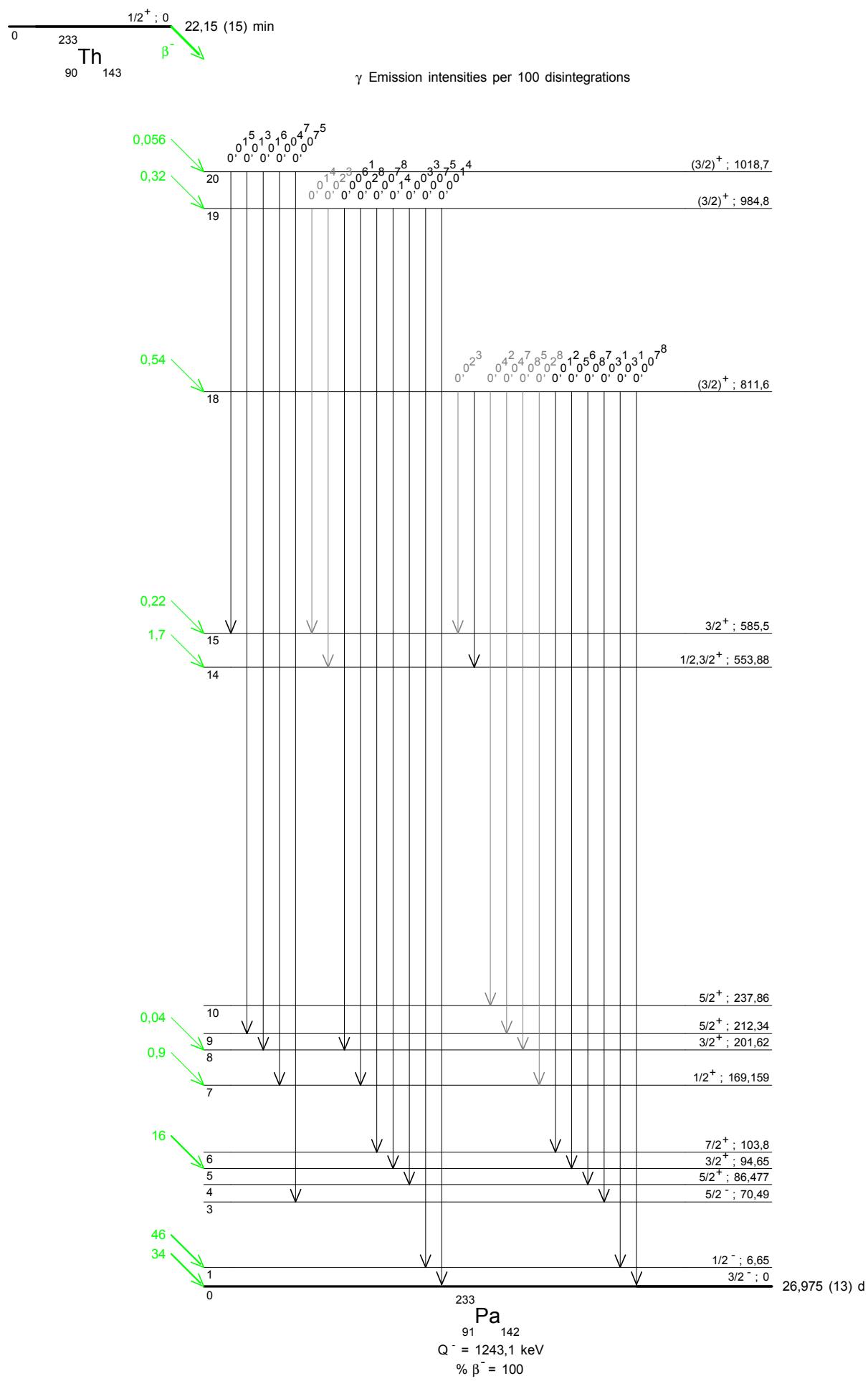
## 6 Main Production Modes

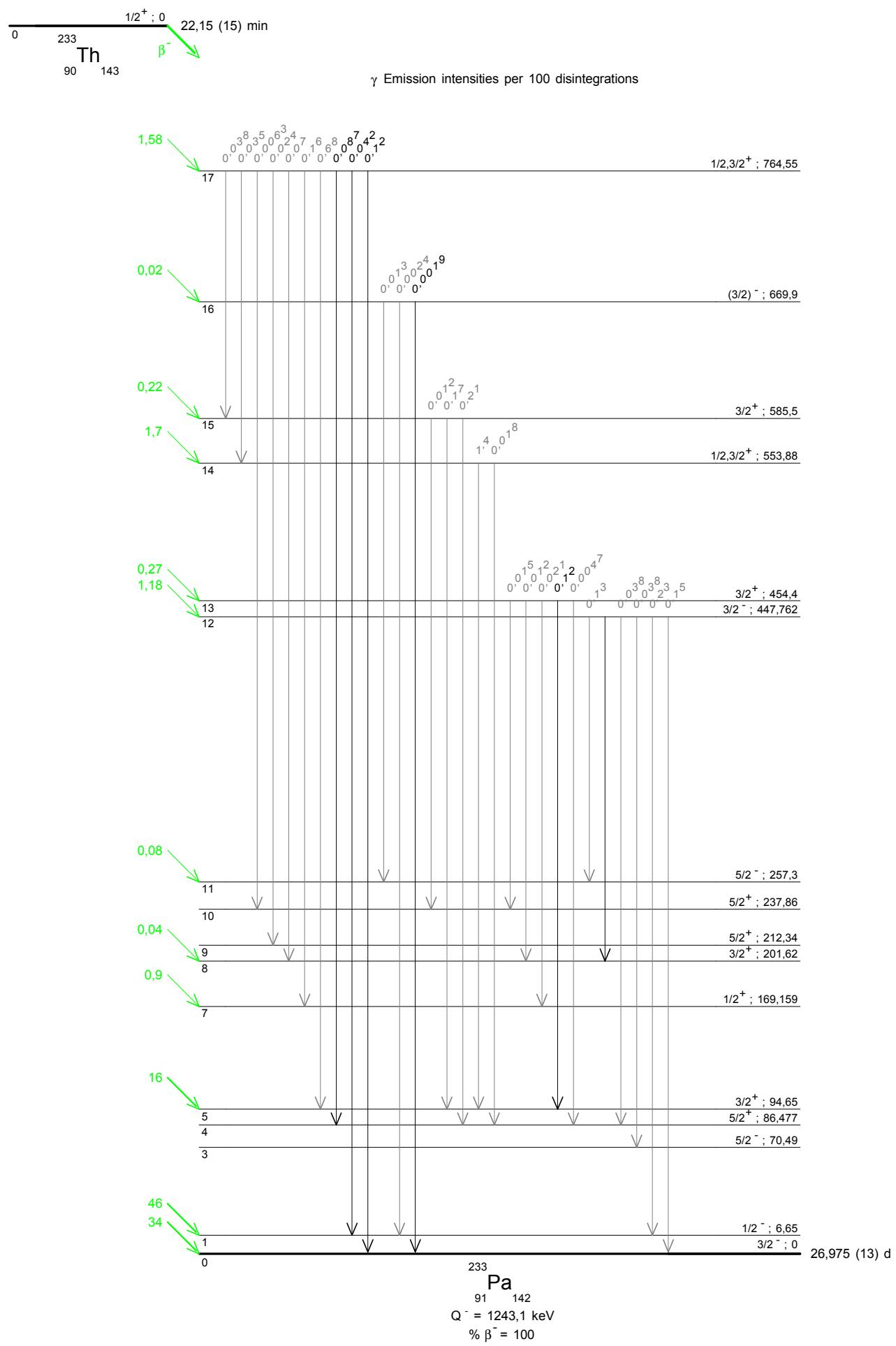
$$\left\{ \begin{array}{l} \text{Th} - 232(n,\gamma)\text{Th} - 233 \\ \text{Possible impurities : Th} - 232, \text{Th} - 234 \end{array} \right.$$

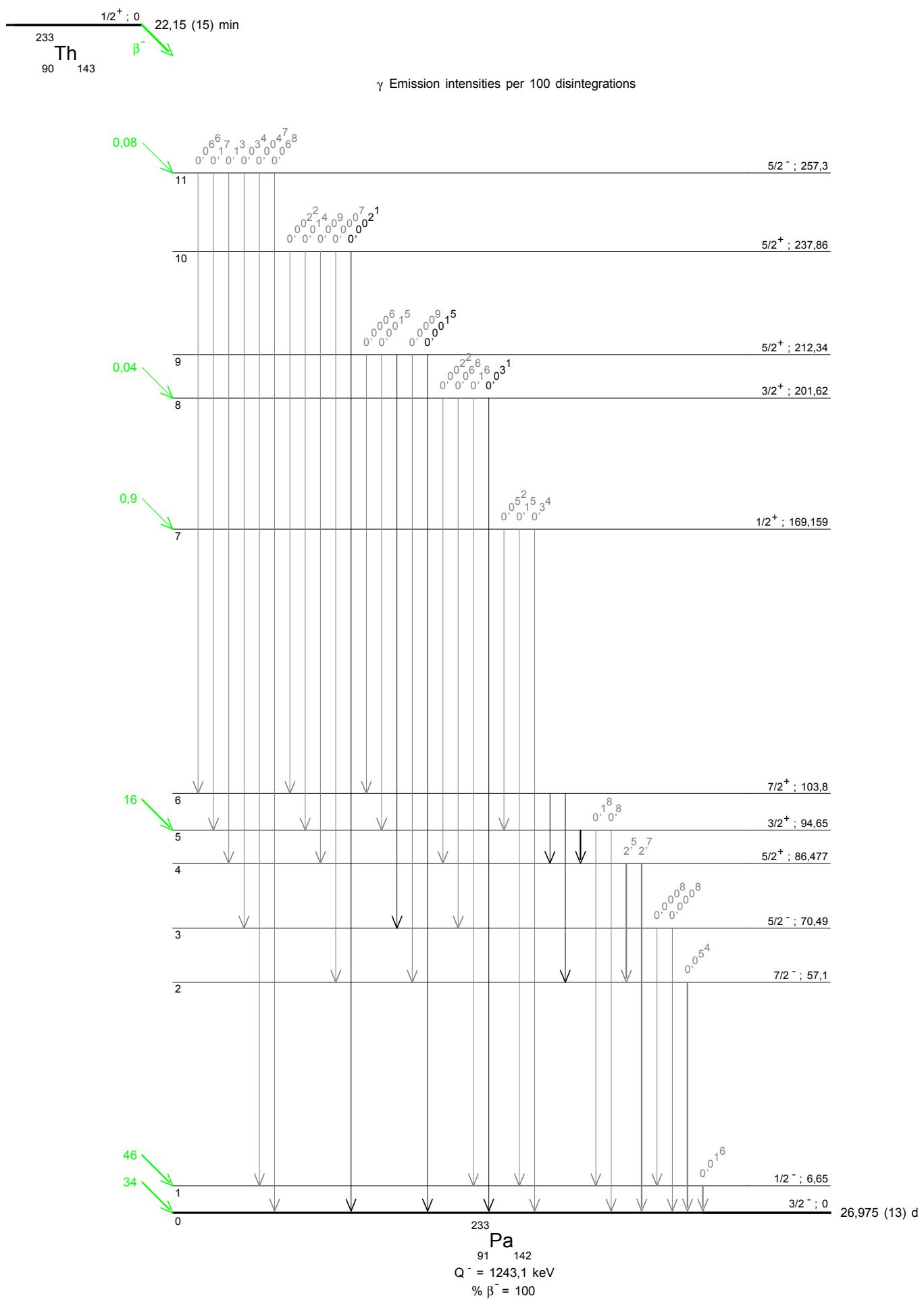
## 7 References

- W.C. RUTLEDGE, J.M. CORK, S.B. BURSON. Phys. Rev. 86 (1952) 775

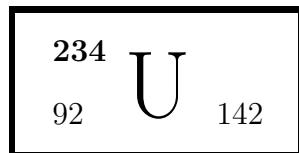
- (Half-life)
  - E.N. JENKINS. Analyst 80 (1955) 301  
(Half-life)
  - B.J. DROPSKY, L.M. LANGER. Phys. Rev. 108 (1957) 90  
(Half-life)
  - M.S. FREEDMAN, D.W. ENGELKEMEIR, F.T. PORTER, F. WAGNER, JR., AND P.DAY. Priv.Comm., unpublished (1957)  
(Gamma ray emission probabilities)
  - J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies)
  - R. DAMS, F. ADAMS. Radiochim. Acta 10 (1968)  
(Gamma-ray energies)
  - E. BROWNE, F. ASARO. UCRL-17989, p 1 (1968)  
(Gamma-ray energies)
  - W. HOEKSTRA. Thesis, Technische Hogeschool, Delft. (1969)  
(Half-life, KX- ray emission probabilities , gamma - ray relative probabilities)
  - J.M. VARA, R. GAETA. Nucl. Phys. A130 (1969) 586  
(Gamma-ray energies)
  - C.SEBILLE, G.BASTIN, C.F.LEANG, R.PIEPENBRING, M.F. PERRIN. Compt. Rend A270 (1970) 354  
(Gamma-ray energies)
  - C.SEBILLE-SCHUCK. Thesis, Paris Univ. (1972); FRNC-TH-255 (1972) (1972)  
(Gamma - ray relative probabilities)
  - M. DE BRUIN, P.J.M. KORTHOVEN. J. Radioanal. Chem. 10 (1972) 125  
(Gamma-ray energies)
  - T VON EGIDY, O.W.B. SCHULT, D. RABENSTEIN, J.R. ERSKINE, O.A. WASSON, R.E. CHRIEN, D. BREITIG, R.P. SHARMA, H.A. BAADER, H.R. KOCH. Phys. Rev. C6 (1972) 266  
(Gamma-ray energies)
  - P. JEUCH. Thesis, Tech Univ Munchen. (1976)  
(Gamma-ray multipolarities, conversion electron characteristics)
  - M.SKALSEY, R.D.CONNOR. Can.J.Phys. 54 (1976) 1409  
(Gamma-ray energies)
  - F.P.LARKINS. At. Data Nucl. Data Tables 20 (1977) 313  
(Auger electron energies)
  - F.ROSEL, H.M.FRIESS, K.ALDER AND H.C.PAULI. At. Data Nucl. Data Tables 21 (1978) 92  
(Theoretical ICC)
  - I.M.BAND, M.B.TRZHASKOVSKAYA. Special report of Leningrad nuclear physics institute, 1978 (1978)  
(Theoretical ICC)
  - L.GONZALEZ, R.GAETA, E.VANO, J.M.LOS ARCOS. Nucl.Phys. A324 (1979) 126  
(Gamma-ray energies)
  - H.G.BORNER, G.BARREAU, W.F.DAVIDSON, P.JEUCH, T.VON EGIDY, J.ALMEIDA, D.H.WHITE. Nucl. Instrum. Methods 166 (1979) 251  
(Gamma-ray energies)
  - F.LAGOUTINE, N.COURSOL AND J. LEGRAND. ISBN-2-7272-0078-1 (1987)  
(Energy of Auger electrons)
  - S.A.WOODS, P.CHRISTMAS, P.CROSS, S.M.JUDGE, W.GELLETLY. Nucl.Instrum.Methods Phys.Res. A264 (1988) 333  
(Gamma ray energies, ICC for gamma (4,0))
  - A.ABZOUI,, M.S.ANTONY, V.B.NDOCKO NDONGUE. J. Radioanal. Nucl. Chem. 135 (1989) 1  
(Half-life)
  - Y.A.AKOVALI. Nucl.Data Sheets 59 (1990) 263  
(Decay scheme, gamma ray emission probabilities, multipolarities, E2 admixtures)
  - E.SCHÖNFELD, H.JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data)
  - K.USMAN, T.D.MACMAHON, S.I.KAFALA. Appl. Rad. Isotopes 49 (1998) 1329  
(Half-life)
  - E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1, Braunschweig, February 1999 (1999)  
(KX ray energies and relative emission probabilities)
  - G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl.Phys. A729 (2003) 337  
(Q value)











## 1 Decay Scheme

U-234 disintegrates by alpha emission mostly to the 53.2-keV level and to the ground state level of Th-230. Branching of U-234 decay by spontaneous fission is  $1,6(2) \times 10^{-9} \%$ .

*L'uranium 234 se désintègre par émission alpha, principalement vers le niveau excité de 53,20 keV et le fondamental du thorium 230. Le rapport de branchement de décroissance par fission spontanée est  $1,6(2) \times 10^{-9} \%$ .*

## 2 Nuclear Data

$T_{1/2}(^{234}\text{U})$	:	2,455	(6)	$10^5$ a
$T_{1/2}(^{230}\text{Th})$	:	75,38	(30)	$10^3$ a
$Q^\alpha(^{234}\text{U})$	:	4857,7	(7)	keV

### 2.1 $\alpha$ Transitions

	Energy keV	Probability $\times 100$	F
$\alpha_{0,5}$	4180,1 (7)	0,000007	63
$\alpha_{0,4}$	4222,8 (7)	0,000026	39
$\alpha_{0,3}$	4349,6 (7)	0,00004 (1)	288
$\alpha_{0,2}$	4683,6 (7)	0,210 (2)	21
$\alpha_{0,1}$	4804,5 (7)	28,42 (2)	1,1
$\alpha_{0,0}$	4857,6 (7)	71,37 (2)	1

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Th})$	53,20 (2)	28,7 (13)	E2		167 (5)	45,6 (14)	228 (7)
$\gamma_{2,1}(\text{Th})$	120,900 (36)	0,228 (48)	E2	0,244 (7)	3,42 (10)	0,940 (28)	4,92 (15)
$\gamma_{3,1}(\text{Th})$	454,96 (5)	0,000025 (6)	E1	0,01235 (37)	0,00220 (7)	0,000525 (16)	0,01526 (46)
$\gamma_{5,2}(\text{Th})$	503,5 (1)	0,00000095	[E2]	0,0264 (8)	0,01141 (34)	0,00296 (9)	0,0418 (13)
$\gamma_{3,0}(\text{Th})$	508,16 (5)	0,0000152 (39)	E1	0,00991 (30)	0,00174 (5)	0,000415 (12)	0,01221 (37)
$\gamma_{4,1}(\text{Th})$	581,7 (1)	0,000012 (5)	E2	0,0202 (6)	0,00734 (22)	0,00188 (6)	0,0300 (9)
$\gamma_{5,1}(\text{Th})$	624,4 (1)	0,00005	E0+E2+M1				5,1 (20)
$\gamma_{4,0}(\text{Th})$	634,9 (1)	0,000014 (7)	E0				
$\gamma_{5,0}(\text{Th})$	677,6 (1)	0,000001	[E2]	0,01526 (46)	0,00475 (14)	0,001204 (36)	0,0216 (6)

## 3 Atomic Data

### 3.1 Th

$$\begin{aligned}\omega_K &: 0,969 (4) \\ \bar{\omega}_L &: 0,476 (18) \\ n_{KL} &: 0,797 (5)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	89,9566	61,82
K $\alpha_1$	93,3479	100
K $\beta_3$	104,8172	}
K $\beta_1$	105,602	}
K $\beta_5''$	106,1564	}
K $\beta_5'$	106,3149	35,58
K $\beta_2$	108,581	}
K $\beta_4$	108,953	}
KO <sub>2,3</sub>	109,442	11,99
X <sub>L</sub>		
L $\ell$	11,118	
L $\alpha$	12,808 – 12,967	
L $\eta$	14,509	
L $\beta$	14,972 – 16,4253	
L $\gamma$	18,363 – 19,504	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	68,406 – 76,745	100
KLX	83,857 – 93,345	58,8
KXY	99,29 – 109,64	8,64
Auger L	5,8 – 20,3	

## 4 $\alpha$ Emissions

	Energy keV	Probability $\times 100$
$\alpha_{0,5}$	4108,6 (7)	0,000007
$\alpha_{0,4}$	4150,6 (7)	0,000026
$\alpha_{0,3}$	4275,2 (7)	0,00004 (1)
$\alpha_{0,2}$	4603,5 (7)	0,210 (2)
$\alpha_{0,1}$	4722,4 (7)	28,42 (2)
$\alpha_{0,0}$	4774,6 (7)	71,37 (2)

## 5 Electron Emissions

	Energy keV	Electrons per 100 disint.
eAL	(Th) 5,8 - 20,3	10,8 (4)
eAK	(Th) 68,406 - 76,745 } 83,857 - 93,345 } 99,29 - 109,64 }	0,00029 (5)
ec <sub>1,0</sub> L	(Th) 32,7 - 36,9	20,9 (12)
ec <sub>1,0</sub> M	(Th) 48,0 - 49,9	5,70 (32)
ec <sub>1,0</sub> N	(Th) 51,9 - 52,9	1,53 (9)
ec <sub>2,1</sub> L	(Th) 100,4 - 104,6	0,132 (12)

## 6 Photon Emissions

### 6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.	
XL	(Th)	11,118 — 19,504	10,2 (4)	
XK $\alpha_2$	(Th)	89,9566	0,00269 (25)	} K $\alpha$
XK $\alpha_1$	(Th)	93,3479	0,0044 (4)	}
XK $\beta_3$	(Th)	104,8172	}	
XK $\beta_1$	(Th)	105,602	}	K' $\beta_1$
XK $\beta_5''$	(Th)	106,1564	}	
XK $\beta_5'$	(Th)	106,3149	}	
XK $\beta_2$	(Th)	108,581	}	
XK $\beta_4$	(Th)	108,953	}	K' $\beta_2$
XKO <sub>2,3</sub>	(Th)	109,442	}	

### 6.2 Gamma Emissions

		Energy keV	Photons per 100 disint.
$\gamma_{1,0}$ (Th)		53,20 (2)	0,1253 (40)
$\gamma_{2,1}$ (Th)		120,90 (4)	0,0386 (32)
$\gamma_{3,1}$ (Th)		454,96 (5)	0,000025 (6)
$\gamma_{5,2}$ (Th)		503,5 (1)	0,00000095
$\gamma_{3,0}$ (Th)		508,16 (5)	0,0000150 (39)
$\gamma_{4,1}$ (Th)		581,7 (1)	0,000012 (5)
$\gamma_{5,1}$ (Th)		624,4 (1)	0,00000082
$\gamma_{5,0}$ (Th)		677,6 (1)	0,000001

## 7 Main Production Modes

U – 238 decay

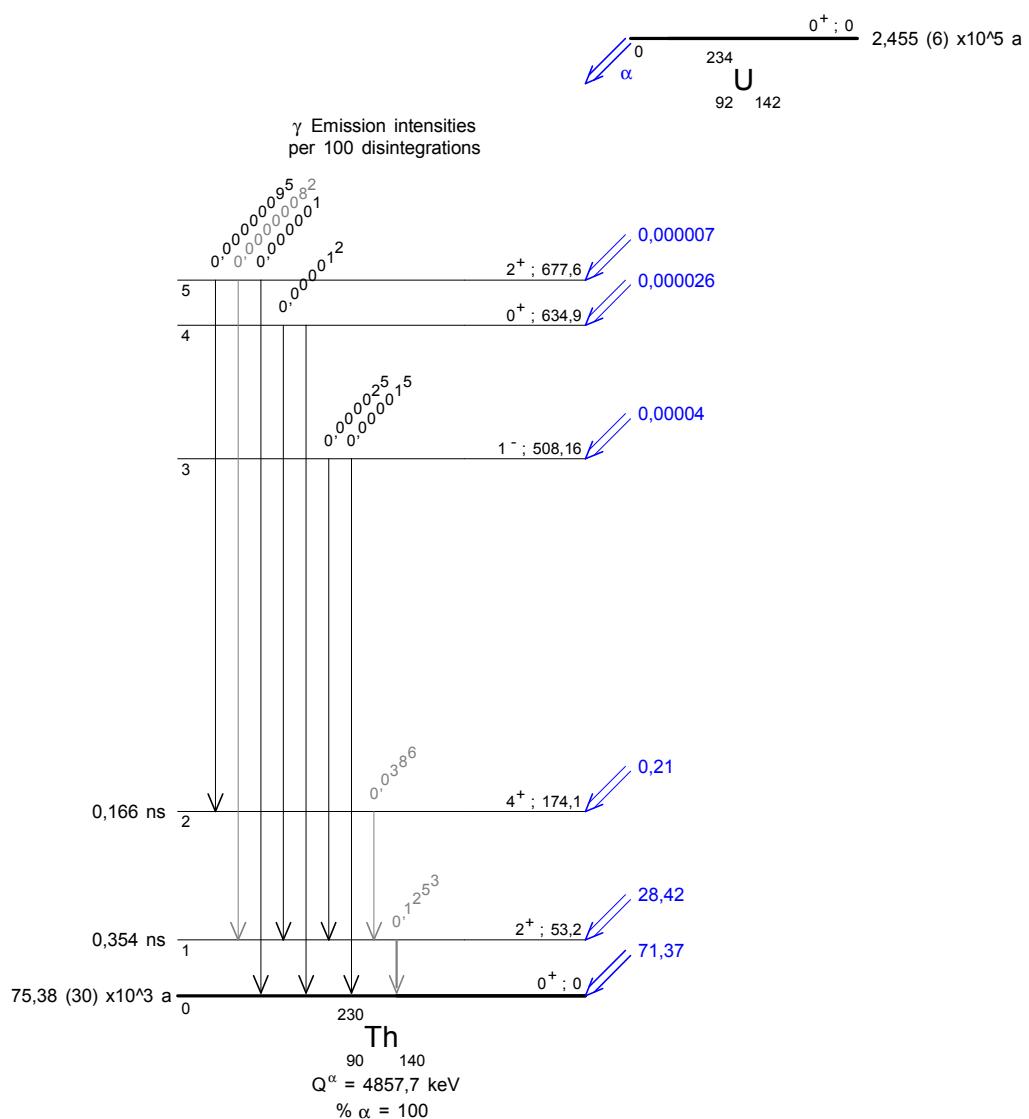
Pu – 238 decay

## 8 References

- A.O. NIER. Phys. Rev. 55 (1933) 150  
(U-234 half-life.)
- M. CURIE, S. COTELLE. Comp. Rend. Acad. Sci. (Paris) 190 (1930) 1289  
(Th-230 half-life.)
- O. CHAMBERLAIN, D. WILLIAMS, P. YUSTER. Phys. Rev. 70 (1946) 580  
(U-234 half-life.)

- E.K. HYDE. NNES 14B (1949) 1435  
(Th-230 half-life.)
- A.C. KIENBERGER. Phys. Rev. 76 (1949) 1561  
(U-234 half-life.)
- A.S. GOLDIN, G.B. KNIGHT, P.A. MACKLIN, R.L. MACKLIN. Phys. Rev. 76 (1949) 336  
(U-234 half-life.)
- E. BALDINGER, P. HUBER. Helv. Phys. Acta 22 (1949) 365  
(U-234 half-life.)
- E.H. FLEMING JR., A. GHIORSO, B.B. CUNNINGHAM. Phys. Rev. 88 (1952) 642  
(U-234 half-life.)
- A.C. KIENBERGER. Phys. Rev. 87 (1952) 520  
(U-234 half-life.)
- A. GHIORSO, G.H. HIGGINS, A.E. LARSH, G.T. SEABORG, S.G. THOMPSON. Phys. Rev. 87 (1952) 163  
(SF half-life.)
- S.A. BARANOV, A.G. ZELENKOV, V.M. KULAKOV. Bull. Acad. Sci. USSR, Phys. Ser. 24 (1960) 1045  
(Alpha emission.)
- R.W. ATTREE, M.J. CABELL, R.L. CUSHING, J.J. PIERONI. Can. J. Phys. 40 (1961) 194  
(Th-230 half-life.)
- G.E. KOCHAROV, G.A. KOROLEV. Bull. Acad. Sci. USSR, Phys. Ser. 25 (1961) 227  
(Alpha emission.)
- S. BJORNHOLM, M. LEDERER, F. ASARO, I. PERLMAN. Phys. Rev. 130 (1963) 2000  
(Alpha emission.)
- W.R. NEAL, H.W. KRANER. Phys. Rev. 137 (1965) B1164  
(53- and 174-kev levels half-life.)
- P.H. WHITE, G.J. WALL, F.R. PONTET. J. Nucl. En. A/B 19 (1965) 33  
(U-234 half-life.)
- I. AHMAD. UCRL 16888 (1966)  
(Gamma energy and intensity.)
- G.C. HANNA, C.H. WESTCOTT, H.D. LEMMEL, B.R. LEONARD JR., J.S. STORY, P.M. ATTREE. At. Energy Rev. 7,4 (1969) 3  
(U-234 half-life.)
- J.W. MEADOWS. ANL 7610 (1970) 44  
(U-234 half-life.)
- P. DE BIEVRE, K.F. LAUER, Y. LE DUIGOU, H. MORET, G. MUSCHENBORN, J. SPAEPEN, A. SPERNOL, R. VANINBROUKX, V. VERDINGH. Chem. Nucl. Data, Canterbury (1971) 221  
(U-234 half-life.)
- M. LOUNSBURY, R.W. DURHAM. Chem. Nucl. Data, Canterbury (1971) 215  
(U-234 half-life.)
- M. SCHMORAK, C.E. BEMIS JR., M.J. ZENDER, N.B. GOVE, P.F. DITTMER. Nucl. Phys. A178 (1972) 410  
(Gamma energy.)
- H.W. TAYLOR. Int. J. Appl. Radiat. Isotop. 24 (1973) 593  
(Gamma energy.)
- R.L. HEATH. ANCR 1000-2 (1974) 14  
(Gamma intensity and energy.)
- C.E. BEMIS JR., L. TUBBS. ORNL - 5297 (1977) 93  
(X-ray emission.)
- A.M. GEIDEL'MAN, YU. S. EGOROV, A.V. LOVTSYUS, V.I. ORLOV, L.D. PREOBRAZHENS'KAYA, M.V. RYZHINSKII, A.V. STEPANOV, A.A. LIPOVSKII, YU. V. Khol'NOV, B.N. BELYAEV, M.K. ADBULLAKHATOV, G.A. AKOPOV, V.S. BELYKH, E.A. GROMOVA ET AL.. Bull. Acad. Sci. USSR, Phys. Ser. 44,5 (1980) 23  
(U-234 half-life.)
- J.W. MEADOWS, R.J. ARMANI, E.L. CALLIS, A.M. ESSLING. Phys. Rev. C22 (1980) 750  
(Th-230 half-life.)
- H.R. von GUNTEN, A. GRÜTTER, H.W. REIST, M. BAGGENSTOS. Phys. Rev. C23 (1981) 1110  
(SF half-life.)
- N.E. HOLDEN. BNL - NCS 51320 (1981)  
(U-234 half-life.)
- Y.A. AKOVALI. Nucl. Data Sheets 40 (1983) 523  
(Spin, parity, Energy level.)
- W.P. POENITZ, J.W. MEADOWS. ANL - NDM 84 (1983) 33  
(U-234 half-life.)

- M. DIVADEENAM, J.R. STEHN. Ann. Nucl. Energy 11 (1984) 375  
(U-234 half-life.)
- R. VANINBROUKX, G. BORTELS, B. DENECKE. Int. J. Appl. Radiat. Isotop. 35 (1984) 1081  
(X-ray, alpha and gamma emission.)
- W.P. POENITZ, J.W. MEADOWS. IAEA - TECDOC 335 (1985) 485  
(U-234 half-life.)
- E.J. AXTON. IAEA - TECDOC 335 (1985) 214  
(U-234 half-life.)
- A. LORENTZ, A.L. NICHOLS. IAEA - Tech. Rep. 261 (1986) 63  
(U-234 half-life, gamma et alpha intensity.)
- G. BORTELS, P. COLLAERS. Appl. Rad. Isotopes 38 (1987) 831  
(Alpha emission.)
- S. WANG, P.B. BRICE, S.W. BARWICK, K.J. MOODY, E.K. HULET. Phys. Rev. C36 (1987) 2717  
(SF half-life.)
- N.E. HOLDEN. Pure and Appl. Chem. 61 (1989) 1483  
(U-234 half-life.)
- A. RYTZ. At. Data. Nucl. Data Tables 47 (1991) 205  
(Alpha energy.)
- Y.A. AKOVALI. Nucl. Data Sheets 69 (1993) 155  
(Spin, parity, Energy level.)
- Y.A. AKOVALI. Nucl. Data Sheets 71 (1994) 181  
(Spin, parity, Energy level.)
- P.N. JOHNSTON, P.A. BURNS. Nucl. Instrum. Meth. Phys. Res. A361 (1995) 229  
(X-ray emission.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic Data.)
- I.M. BAND, M.B. TRZHASKOVSKAYA, C.W. NESTOR JR., P.O. TIKKANEN, S. RAMAN. At. Data. Nucl. Data Tables 81 (2002) 1  
(Alpha.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q.)







## 1 Decay Scheme

Np-236 decays 87,8(6) % by electron capture to U-236, 12,0(6) % by beta minus emission to Pu236 and 0,16(6)% by alpha emission to Pa-232.

*Le neptunium 236 se désintègre majoritairement (87,8 %) par capture électronique vers l'uranium 236 et par transition beta moins (12 %) vers le plutonium 236. Une faible branche par transition alpha vers le protactinium 232 est possible.*

## 2 Nuclear Data

$T_{1/2}(^{236}\text{Np})$	:	1,55	(8)	$10^5$ a
$T_{1/2}(^{236}\text{U})$	:	23,42	(4)	$10^6$ a
$T_{1/2}(^{236}\text{Pu})$	:	2,87	(1)	a
$T_{1/2}(^{232}\text{Pa})$	:	1,31	(2)	d
$Q^-(^{236}\text{Np})$	:	480	(50)	keV
$Q^+(^{236}\text{Np})$	:	930	(50)	keV
$Q^\alpha(^{236}\text{Np})$	:	5010	(50)	keV

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$	$P_K$	$P_L$	$P_{M+}$
$\epsilon_{0,6}$	80 (50)	$\approx 0,096$	allowed	14,6	0	0,6	0,4
$\epsilon_{0,3}$	620 (50)	87,8 (43)	1st forbidden	14,1	0,726 (8)	0,201 (5)	0,073 (2)
$\epsilon_{0,2}$	780 (50)	< 4,4	1st forbidden unique	> 15,9	0,74	0,19	0,07

## 2.2 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,3}^-$	170 (50)	11,8 (12)	1st forbidden	14,5
$\beta_{0,2}^-$	330 (50)	< 1,6	1st forbidden unique	> 16

## 2.3 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Pu})$	44,63 (10)	12,0 (6)	E2		540 (11)	151 (3)	743 (15)
$\gamma_{1,0}(\text{U})$	45,242 (3)	87,8 (6)	E2		429 (9)	118,6 (24)	589 (12)
$\gamma_{5,4}(\text{U})$	56,6 (5)	$\approx 0,08$	(E2)		145 (3)	40,2 (8)	199 (4)
$\gamma_{2,1}(\text{Pu})$	102,82 (2)	12,0 (6)	E2		10,1 (2)	2,82 (6)	13,9 (3)
$\gamma_{6,5}(\text{U})$	104,1	$\approx 0,096$	E2		8,05 (16)	2,23 (5)	11,0 (2)
$\gamma_{2,1}(\text{U})$	104,234 (6)	87,8 (6)	E2		8,00 (16)	2,22 (5)	11,0 (2)
$\gamma_{3,2}(\text{Pu})$	158,35 (2)	11,8 (12)	E2	0,193 (4)	1,41 (3)	0,395 (8)	2,14 (4)
$\gamma_{3,2}(\text{U})$	160,307 (3)	87,8 (43)	E2	0,208 (4)	1,13 (2)	0,313 (7)	1,76 (4)
$\gamma_{4,2}(\text{U})$	538,11 (10)	$\approx 0,0008$	E3	0,0622 (13)	0,0587 (12)	0,0160 (4)	0,143 (3)
$\gamma_{5,2}(\text{U})$	594,5 (3)	$\approx 0,008$					
$\gamma_{4,1}(\text{U})$	642,35 (9)	$\approx 0,068$	E1+(M2+E3)	0,112 (10)	0,031 (3)	0,0080 (8)	0,15 (2)
$\gamma_{4,0}(\text{U})$	687,60 (5)	$\approx 0,021$	E1+(M2+E3)	0,219 (12)	0,068 (6)	0,018 (2)	0,31 (2)
$\gamma_{6,2}(\text{U})$	699						

## 3 Atomic Data

### 3.1 U

$$\begin{aligned}\omega_K &: 0,970 \quad (4) \\ \bar{\omega}_L &: 0,500 \quad (19) \\ \bar{\omega}_M &: 0,050 \quad (5) \\ n_{KL} &: 0,794 \quad (5)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	94,666	62,47
K $\alpha_1$	98,44	100
K $\beta_3$	110,421	{}
K $\beta_1$	111,298	{}
K $\beta_5''$	111,964	{}
		36,08

	Energy keV	Relative probability
K $\beta_2$	114,407	}
K $\beta_4$	115,012	}
KO <sub>2,3</sub>	115,377	}
X <sub>L</sub>		
L $\ell$	11,618	
L $\alpha$	13,438 – 13,614	
L $\eta$	15,399	
L $\beta$	15,726 – 18,206	
L $\gamma$	19,507 – 20,714	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	71,776 – 80,954	100
KLX	88,153 – 98,429	59,6
KXY	104,51 – 115,59	8,88
Auger L	6,4 – 21,6	

### 3.2 Pu

$\omega_K$	:	0,971	(4)
$\bar{\omega}_L$	:	0,521	(20)
$\bar{\omega}_M$	:	0,555	(5)
$n_{KL}$	:	0,790	(5)

#### 3.2.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	99,525	63,17
K $\alpha_1$	103,734	100
K $\beta_3$	116,244	}
K $\beta_1$	117,228	}
K $\beta_5''$	117,918	}
K $\beta_2$	120,54	}
K $\beta_4$	120,969	}
KO <sub>2,3</sub>	121,543	}
X <sub>L</sub>		
L $\ell$	12,124	
L $\alpha$	14,083 – 14,279	
L $\eta$	16,334	
L $\beta$	16,498 – 19,331	
L $\gamma$	20,708 – 21,984	

#### 3.2.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	75,263 – 85,357	100
KLX	92,607 – 103,729	60,6
KXY	109,93 – 121,78	9,18
Auger L	6,6 – 23,0	

## 4 Electron Emissions

		Energy keV		Electrons per 100 disint.
e <sub>AL</sub>	(U)	6,4	-	21,6
e <sub>AK</sub>	(U)			128,8 (19)
	KLL	71,776	-	80,954
	KLX	88,153	-	98,429
	KXY	104,51	-	115,59
e <sub>AL</sub>	(Pu)	6,6	-	23,0
e <sub>AK</sub>	(Pu)			10,9 (6)
	KLL	75,263	-	85,357
	KLX	92,607	-	103,729
	KXY	109,93	-	121,78
ec <sub>1,0</sub> L	(Pu)	21,53	-	26,57
ec <sub>1,0</sub> L	(U)	23,484	-	28,074
ec <sub>3,2</sub> K	(Pu)	36,56		(2)
ec <sub>3,2</sub> T	(Pu)	36,56	-	158,34
ec <sub>1,0</sub> M	(Pu)	38,70	-	40,86
ec <sub>1,0</sub> M	(U)	39,694	-	41,690
ec <sub>3,2</sub> T	(U)	44,705	-	160,298
ec <sub>3,2</sub> K	(U)	44,705		(3)
ec <sub>2,1</sub> L	(Pu)	79,72	-	84,76
ec <sub>2,1</sub> L	(U)	82,476	-	87,066
ec <sub>2,1</sub> M	(Pu)	96,89	-	99,04
ec <sub>2,1</sub> M	(U)	98,686	-	100,680
ec <sub>3,2</sub> L	(Pu)	135,25	-	140,29
ec <sub>3,2</sub> L	(U)	138,549	-	143,139
ec <sub>3,2</sub> M	(Pu)	152,42	-	154,57
ec <sub>3,2</sub> M	(U)	154,759	-	156,760
$\beta_{0,3}^-$	max:	170		(50)
$\beta_{0,3}^-$	avg:	46		(15)
$\beta_{0,2}^-$	max:	330		(50)
$\beta_{0,2}^-$	avg:	99		(15)
				11,8 (12)
				1,6
				9,9 (5)

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.	
XL	(U)	11,618 — 20,714	117,5 (30)	
XK $\alpha_2$	(U)	94,666	20,2 (3)	} K $\alpha$
XK $\alpha_1$	(U)	98,44	32,4 (5)	}
XK $\beta_3$	(U)	110,421	}	
XK $\beta_1$	(U)	111,298	}	K' $\beta_1$
XK $\beta_5''$	(U)	111,964	}	
XK $\beta_2$	(U)	114,407	}	
XK $\beta_4$	(U)	115,012	}	K' $\beta_2$
XKO <sub>2,3</sub>	(U)	115,377	}	
XL	(Pu)	12,124 — 21,984	12,2 (5)	
XK $\alpha_2$	(Pu)	99,525	0,210 (22)	} K $\alpha$
XK $\alpha_1$	(Pu)	103,734	0,33 (4)	}
XK $\beta_3$	(Pu)	116,244	}	
XK $\beta_1$	(Pu)	117,228	}	K' $\beta_1$
XK $\beta_5''$	(Pu)	117,918	}	
XK $\beta_2$	(Pu)	120,54	}	
XK $\beta_4$	(Pu)	120,969	}	K' $\beta_2$
XKO <sub>2,3</sub>	(Pu)	121,543	}	

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Pu})$	44,63 (10)	0,0161 (9)
$\gamma_{1,0}(\text{U})$	45,242 (3)	0,149 (3)
$\gamma_{5,4}(\text{U})$	56,6 (5)	0,0004
$\gamma_{2,1}(\text{Pu})$	102,82 (2)	0,81 (6)
$\gamma_{6,5}(\text{U})$	104,1 (10)	0,008
$\gamma_{2,1}(\text{U})$	104,23 (2)	7,32 (13)
$\gamma_{3,2}(\text{Pu})$	158,35 (2)	3,8 (4)
$\gamma_{3,2}(\text{U})$	160,33 (2)	31,8 (15)
$\gamma^\pm$	511	185 (9)
$\gamma_{4,2}(\text{U})$	538,11 (10)	0,0007
$\gamma_{5,2}(\text{U})$	594,5 (3)	0,008
$\gamma_{4,1}(\text{U})$	642,35 (9)	0,059
$\gamma_{4,0}(\text{U})$	687,60 (5)	0,016

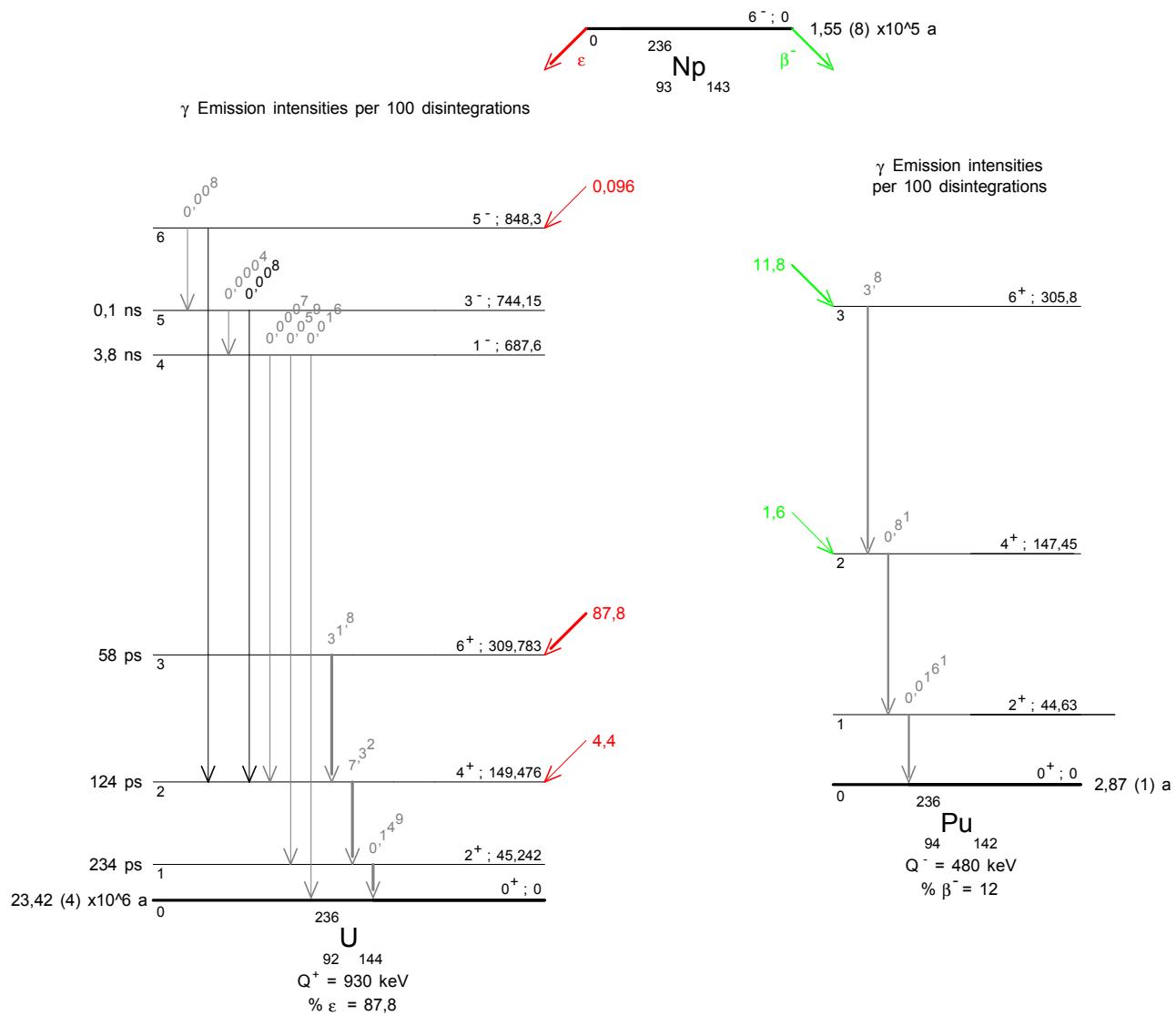
## 6 Main Production Modes

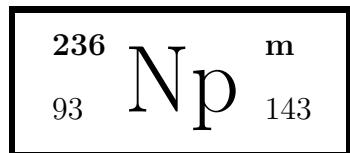
U – 235(d,n)Np – 236

U – 235( $\alpha$ ,p,2n)Np – 236

## 7 References

- J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies)
- C.M. LEDERER, J.M. JAKLEVIC, S.G. PRUSSIN. Nucl. Phys A135 (1969) 36  
(Relative intensities of gamma rays)
- R. GUNNINK, R.J. MORROW. In: UCRL 51087 (1971). (1971)  
(Emission probabilities of gamma-rays in the decay of 240Pu)
- O. DRAGOUN, Z. PLAJNER, F. SCHMUTZLER. NDT A9 (1971) 119  
(aM / aL and aNO / aM)
- B.S. DZHELEPOV, L.N. ZYRYANOVA, YU.P. SUSLOV. Beta-processes, 1972, Nauka, Leningrad (1972)  
(Fractional probabilities in L-electron capture)
- D.W. ENGELKEMEUR, J.E. GINDLER. J. Inorg. Nucl. Chem. 34 (1972) 1799  
(Half-life)
- H. OTTMAR, P. MATUSSEK, I. PIPER. Proc Int Symp Neutron Capture Gamma Ray Spectr. and Related Topics, 2nd, Petten, The Netherlands 1974, Reactor Centrum Nederland, p 658 1975 (1975) 658  
(Emission probabilities of gamma-rays in the decay of 240Pu)
- T. DRAGNEV, K. SCHARF. Intern. J. Appl. Radiat. Isotop 26 (1975) 125  
(Gamma ray emission probabilities in the decay of 240Pu)
- R. GUNNINK, J.E. EVANS, A.L. PRINDLE. UCRL-52139 (1976). (1976)  
(Gamma ray emission probabilities in the decay of 240Pu)
- W.L. POSTHUNUS, K.E.G. LÖBNER, I. PIPER E.A., Z. Physik A281 (1977) 717  
(ICC measurements)
- F.P. LARKINS. Atomic Data and Nuclear Data Tables 20 (1977) 313  
(Auger electron energies)
- M.R. SCHMORAK. Nucl. Data Sheets 31 (1980) 283  
(Systematics of nuclear level properties)
- I. AHMAD, J. HINES, J.E. GINDLER. Phys. Rev. C27 (1983) 2239  
(Gamma-ray relative intensities and energies, KX-ray energies)
- F. LAGOUTINE, N. COURSOL, J. LEGRAND. ISBN-2-7272-0078-1 (LMRI, 1982-1987). (1987)  
(Energies of Auger electrons)
- M.R. SCHMORAK. Nucl. Data Sheets 63 (1991) 139  
(Decay scheme, gamma-ray multipolarities)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data)
- R.B. FIRESTONE. Table of Isotopes, Eighth Edition, Volume II: A=151-272, (1996)  
(Decay scheme, LX ray energies, multipolarities)
- E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX-ray energies and relative emission probabilities.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q values)
- M.-M. BÉ, V. CHISTE, C. DULIEU, E. BROWNE, V. CHECHEV, N. KUZMENKO, R. HELMER, A. NICHOLS, E. SCHÖNFELD, R. DERSCH. Table of Radionuclides, Vol.2. A = 151 to 242. 240Pu. Bureau International des Poids et Mesures, 2004 (2004)  
(Recommended Data)





## 1 Decay Scheme

Np-236m (isomer state of 236Np, J=1, E1 =60 keV) decays 53(1) % by electron capture to U-236 and 47(1) % by beta minus emission to Pu-236.

*Le neptunium 236 isomère se désintègre par capture électronique (53%) vers l'uranium 236 et par transition beta moins vers le plutonium 236.*

## 2 Nuclear Data

$T_{1/2}(^{236}\text{Np}^m)$	:	22,5	(4)	h
$T_{1/2}(^{236}\text{U})$	:	23,42	(4)	$10^6$ a
$T_{1/2}(^{236}\text{Pu})$	:	2,87	(1)	a
$Q^-(^{236}\text{Np}^m)$	:	537	(8)	keV
$Q^+(^{236}\text{Np}^m)$	:	993	(13)	keV

### 2.1 Electron Capture Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft	$P_K$	$P_L$	$P_{M+}$
$\epsilon_{0,4}$	306 (13)	1,64 (9)	1st forbidden	7,3	0,621 (10)	0,274 (7)	0,105 (3)
$\epsilon_{0,1}$	948 (13)	8,3 (30)	allowed	7,8	0,751 (1)	0,184 (1)	0,0652 (1)
$\epsilon_{0,0}$	993 (13)	43,1 (32)	allowed	7,1	0,753 (1)	0,182 (1)	0,0646 (1)

### 2.2 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	lg ft
$\beta_{0,1}^-$	492 (8)	11 (4)	allowed	7,2
$\beta_{0,0}^-$	537 (8)	36 (4)	allowed	6,8

## 2.3 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Pu})$	44,63 (10)	11,2 (37)	E2		540 (11)	151 (3)	743 (15)
$\gamma_{1,0}(\text{U})$	45,242 (3)	9,6 (30)	E2		429 (9)	118,6 (24)	589 (12)
$\gamma_{2,1}(\text{U})$	104,234 (15)	0,0143 (17)	E2		8,00 (16)	2,22 (5)	11,0 (2)
$\gamma_{4,2}(\text{U})$	538,11 (10)	0,0143 (17)	E3	0,0622 (13)	0,0587 (12)	0,0160 (4)	0,143 (3)
$\gamma_{4,1}(\text{U})$	642,35 (9)	1,24 (8)	E1+(M2+E3)	0,112 (10)	0,031 (3)	0,0080 (8)	0,15 (2)
$\gamma_{4,0}(\text{U})$	687,60 (5)	0,383 (28)	E1	0,219 (12)	0,068 (6)	0,018 (2)	0,31 (2)

## 3 Atomic Data

### 3.1 U

$$\begin{aligned}\omega_K &: 0,970 \quad (4) \\ \bar{\omega}_L &: 0,500 \quad (19) \\ \bar{\omega}_M &: 0,050 \quad (5) \\ n_{KL} &: 0,794 \quad (5)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
$X_K$		
$K\alpha_2$	94,666	62,47
$K\alpha_1$	98,44	100
$K\beta_3$	110,421	{}
$K\beta_1$	111,298	{}
$K\beta_5''$	111,964	{}
		36,08
$K\beta_2$	114,407	{}
$K\beta_4$	115,012	{}
$KO_{2,3}$	115,377	{}
		12,34
$X_L$		
$L\ell$	11,618	
$L\alpha$	13,438 – 13,614	
$L\eta$	15,399	
$L\beta$	15,726 – 18,206	
$L\gamma$	19,507 – 20,714	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	71,776 – 80,954	100
KLX	88,153 – 98,429	59,6
KXY	104,51 – 115,59	8,88
Auger L		
	6,4 – 21,6	

### 3.2 Pu

$$\begin{aligned}\omega_K &: 0,971 \quad (4) \\ \bar{\omega}_L &: 0,521 \quad (20) \\ \bar{\omega}_M &: 0,555 \quad (5) \\ n_{KL} &: 0,790 \quad (5)\end{aligned}$$

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(U)	6,4 – 21,6	21,7 (15)
e <sub>AK</sub>	(U)		1,03 (17)
	KLL	71,776 - 80,954	}
	KLX	88,153 - 98,429	}
	KXY	104,51 - 115,59	}
e <sub>AL</sub>	(Pu)	6,6 – 23,0	3,8 (14)
ec <sub>1,0</sub> L	(Pu)	21,53 - 26,57	8 (3)
ec <sub>1,0</sub> L	(U)	23,484 - 28,074	6,9 (22)
ec <sub>1,0</sub> M	(Pu)	38,70 - 40,86	2,2 (8)
ec <sub>1,0</sub> M	(U)	39,694 - 41,690	1,9 (6)
ec <sub>4,1</sub> K	(U)	526,75 (9)	0,121 (13)
ec <sub>4,0</sub> K	(U)	572,00 (5)	0,064 (6)
$\beta_{0,1}^-$	max:	492 (8)	11 (4)
$\beta_{0,1}^-$	avg:	143 (3)	
$\beta_{0,0}^-$	max:	537 (8)	36 (4)
$\beta_{0,0}^-$	avg:	158 (3)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(U)	11,618 — 20,714	21,3 (18)
XK $\alpha_2$	(U)	94,666	9,9 (10)
XK $\alpha_1$	(U)	98,44	15,8 (15)
XK $\beta_3$	(U)	110,421	}
XK $\beta_1$	(U)	111,298	}
XK $\beta_5''$	(U)	111,964	}
XK $\beta_2$	(U)	114,407	}
XK $\beta_4$	(U)	115,012	5,7 (6)
XKO <sub>2,3</sub>	(U)	115,377	K' $\beta_2$
XL	(Pu)	12,124 — 21,984	4,2 (16)

### 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Pu})$	44,63 (10)	0,015 (5)
$\gamma_{1,0}(\text{U})$	45,242 (3)	0,016 (5)
$\gamma_{2,1}(\text{U})$	104,234 (6)	0,00119 (14)
$\gamma^\pm$	511	
$\gamma_{4,2}(\text{U})$	538,11 (10)	0,0125 (15)
$\gamma_{4,1}(\text{U})$	642,35 (9)	1,08 (6)
$\gamma_{4,0}(\text{U})$	687,60 (5)	0,292 (21)

## 6 Main Production Modes

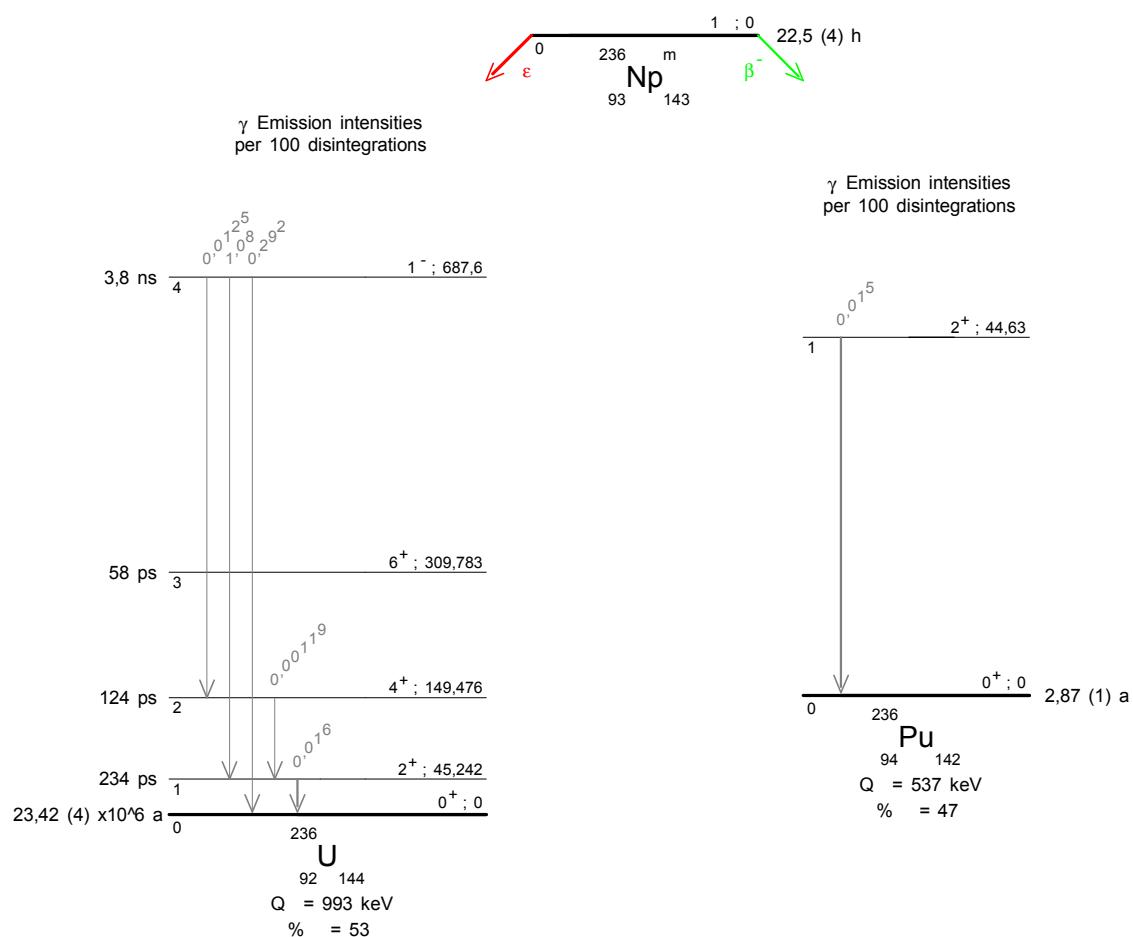
U – 235(d,n)Np – 236m

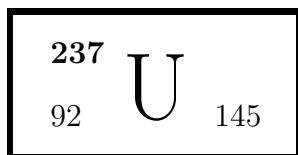
U – 235( $\alpha$ ,p,2n)Np – 236m

## 7 References

- R.A.JAMES, A.E.FLORIN, H.H.HOPKINS, JR., A.GHIORSO. NNES 14B (1949) 1604 (Half-life)
- P.R. GRAY. Phys.Rev. 101 (1956) 1306  
(Relative probability of K-electron capture in the decay of 236m-Np)
- J.E. GINDLER, R.K. SJOBLOM. J. Inorg. Nucl. Chem. 12 (1959) 8  
(Probabilities of beta transitions)
- J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies)

- C.M. LEDERER, J.M. JAKLEVIC, S.G. PRUSSIN. Nucl. Phys. A135 (1969) 36  
(Relative intensities of gamma rays)
- R. GUNNINK, R.J. MORROW. In: UCRL 51087 (1971)  
(Emission probabilities of gamma-rays in the decay of 240Pu)
- O. DRAGOUN, Z. PLAJNER, F. SCHMUTZLER. NDT A9 (1971) 119  
(aM / aL and aNO / aM)
- B.S. DZHELEPOV, L.N. ZYRYANOVA, YU.P. SUSLOV. Beta-processes, 1972, Nauka, Leningrad (1972)  
(Fractional probabilities in L-electron capture)
- T. DRAGNEV, K. SCHARF. Intern. J. Appl. Radiat. Isotop. 26 (1975) 125  
(Gamma ray emission probabilities in the decay of 240Pu)
- H. OTTMAR, P. MATUSSEK, I. PIPER. Proc Int Symp Neutron Capture Gamma Ray Spectr. and Related Top., 2nd, Petten, Netherlands1974, K. Abrahams e.a., Eds, Reactor Centrum Nederland (1975) 658  
(Emission probabilities of gamma-rays in the decay of 240Pu)
- R. GUNNINK, J.E. EVANS, A.L. PRINDLE. UCRL-52139 (1976)  
(Emission probabilities of gamma-rays in the decay of 240Pu)
- W.L. POSTHUNUS, K.E.G. LÖBNER, I. PIPER E.A.. Z. Phys. A181 (1977) 717  
(ICC measurements)
- F.P. LARKINS. Atomic Data and Nuclear Data Tables. 20 (1977) 313  
(Auger electron energies)
- E.A.GROMOVA, S.S.KOVALENKO, YU.A.NEMILOV, YU.A.SELITSKY, A.V.STEPANOV, A.M.FRIDKIN, V.B.FUNSHTEIN, V.A.YAKOVLEV, G.V.VALSKY, G.A.PETROV. Sov.At.Energy 56 (1984) 230  
(Half-life)
- F. LAGOUTINE, N. COURSOL, J. LEGRAND. ISBN-2-7272-0078-1 (LMRI, 1982-1987). (1987)  
(Energy of Auger electrons)
- M.R.SCHMORAK. Nucl.Data Sheets 63 (1991) 139  
(Decay scheme, gamma ray multipolarities)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data)
- R.B. FIRESTONE. Table of Isotopes, Eighth Edition, Vol.II: A=151-272, V.S. Shirley, C.M. Baglin, S.Y.F. Chu, and J. Zipkin, 1996, 1998, 1999 (1996)  
(Decay scheme, LX ray energies, multipolarities)
- E. SCHONFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX-ray energies and relative emission probabilities)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q values)
- M.-M. BÉ, V. CHISTE, C. DULIEU, E. BROWNE, V. CHECHEV, N. KUZMENKO, R. HELMER, A. NICHOLS, E. SHONFELD, R. DERSCH. . Table of Radionuclides, Vol.2. A = 151 to 242. 240Pu. Bureau International des Poids et Mesures, 2004 (2004)  
(Recommended Data by the Decay Data Evaluation Project working group)





## 1 Decay Scheme

U-237 disintegrates by beta minus emission to the levels in Np-237.

*L'uranium 237 se désintègre par émission bêta moins vers des niveaux excités du neptunium 237.*

## 2 Nuclear Data

$T_{1/2}(^{237}\text{U})$	: 6,749 (16) d
$T_{1/2}(^{237}\text{Np})$	: 2,14 (1) $10^6$ a
$Q^-(^{237}\text{U})$	: 518,6 (6) keV

### 2.1 $\beta^-$ Transitions

	Energy keV	Probability $\times 100$	Nature	$\lg ft$
$\beta_{0,9}^-$	147,7 (6)	1,3 (7)	allowed	7,32
$\beta_{0,7}^-$	186,2 (6)	2,9 (7)	super-allowed	7,28
$\beta_{0,6}^-$	237,2 (6)	48,1 (25)	1st forbidden	6,39
$\beta_{0,5}^-$	251,1 (6)	40,7 (32)	1st forbidden	6,54
$\beta_{0,2}^-$	459,1 (6)	7 (6)	1st forbidden unique	8,1

### 2.2 Gamma Transitions and Internal Conversion Coefficients

Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{9,8}(\text{Np})$	2,3	0,232 (5)				
$\gamma_{6,5}(\text{Np})$	13,81 (4)	48,7 (25)	M1 + 0,1% E2		364 (13)	491 (16)
$\gamma_{2,1}(\text{Np})$	26,3446 (2)	22 (5)	E1	6 (2)	1,6 (2)	8 (2)
$\gamma_{4,3}(\text{Np})$	27,020 (7)	0,7 (4)				

	Energy keV	$P_{\gamma+ce} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Np})$	33,1963 (3)	23 (3)	M1 + 1,66% E2		130 (18)	33 (5)	175 (19)
$\gamma_{9,7}(\text{Np})$	38,54 (3)	0,9 (6)	M1 + 15% E2		205 (82)	55 (22)	279 (112)
$\gamma_{3,1}(\text{Np})$	42,704 (5)	$\approx 0,64$	M1 + 1,66% E2		55,6 (11)	13,9 (3)	74,4 (15)
$\gamma_{4,2}(\text{Np})$	43,420 (3)	4,3 (4)	M1 + 16,6% E2		131 (7)	35,1 (19)	178 (10)
$\gamma_{7,6}(\text{Np})$	51,01 (3)	0,63 (12)	E1		0,560 (12)	0,014 (3)	0,748 (15)
$\gamma_{2,0}(\text{Np})$	59,5409 (1)	74 (3)	E1		0,84 (6)	0,226 (7)	1,16 (3)
$\gamma_{7,5}(\text{Np})$	64,83 (2)	1,80 (3)	E1		0,299 (6)	0,0742 (15)	0,398 (8)
$\gamma_{4,1}(\text{Np})$	69,76 (3)	0,0013 (3)	(E1)		0,246 (5)	0,0611 (12)	0,328 (7)
$\gamma_{3,0}(\text{Np})$	75,8 (2)	$\approx 0,05$	(E2)		38,8 (8)	10,8 (2)	53,40 (11)
$\gamma_{4,0}(\text{Np})$	102,98 (2)	0,0072 (10)	E1		0,0891 (18)	0,0219 (4)	0,119 (3)
$\gamma_{(-1,1)}(\text{Np})$	114,09 (5)						
$\gamma_{5,4}(\text{Np})$	164,61 (2)	5,00 (11)	E2	0,189 (4)	1,093 (20)	0,304 (6)	1,69 (4)
$\gamma_{5,2}(\text{Np})$	208,00 (1)	84,6 (19)	M1 + 2,4% E2	2,34 (5)	0,472 (10)	0,115 (3)	2,97 (7)
$\gamma_{6,2}(\text{Np})$	221,80 (4)	0,0315 (13)	E2	0,127 (3)	0,304 (6)	0,0838 (17)	0,544 (11)
$\gamma_{5,1}(\text{Np})$	234,40 (4)	0,198 (17)	M2	5,512 (12)	1,94 (4)	0,51 (1)	8,15 (16)
$\gamma_{5,0}(\text{Np})$	267,54 (4)	1,5 (4)	E1 + 19,4% M2	0,73 (4)	0,237 (12)	0,062 (4)	1,05 (5)
$\gamma_{8,3}(\text{Np})$	292,77 (6)	0,0030 (7)	(E2)	0,0783 (16)	0,0990 (19)	0,0270 (6)	0,214 (4)
$\gamma_{8,2}(\text{Np})$	309,1 (3)	$\approx 0,00027$	(E1)				
$\gamma_{7,0}(\text{Np})$	332,36 (4)	1,373 (19)	E2	0,0622 (12)	0,0610 (12)	0,0165 (4)	0,145 (3)
$\gamma_{8,1}(\text{Np})$	335,38 (4)	0,162 (4)	M1 + 17,5% E2	0,538 (11)	0,113 (2)	0,0278 (6)	0,689 (14)
$\gamma_{9,1}(\text{Np})$	337,7 (2)	0,0101 (6)	(E2)	0,0604 (12)	0,0575 (12)	0,0156 (3)	0,139 (3)
$\gamma_{(-1,2)}(\text{Np})$	340,45	0,0016 (3)					
$\gamma_{8,0}(\text{Np})$	368,59 (4)	0,0674 (28)	M1 (+ E2)	0,493 (10)	0,0963 (20)	0,0233 (5)	0,621 (13)
$\gamma_{9,0}(\text{Np})$	370,94 (3)	0,167 (3)	M1 + 15,6% E2	0,416 (8)	0,0861 (17)	0,0210 (4)	0,531 (11)

### 3 Atomic Data

#### 3.1 Np

$$\begin{aligned}\omega_K &: 0,971 (4) \\ \bar{\omega}_L &: 0,511 (20) \\ n_{KL} &: 0,791 (5)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	97,069	62,82
K $\alpha_1$	101,059	100
K $\beta_3$	113,303	}
K $\beta_1$	114,234	}
K $\beta_5''$	114,912	} 36,465
K $\beta_2$	117,463	}
K $\beta_4$	117,876	} 12,544
KO <sub>2,3</sub>	118,429	}

	Energy keV	Relative probability
X <sub>L</sub>		
L $\ell$	11,89	
L $\alpha$	13,76 – 13,94	
L $\eta$	15,88	
L $\beta$	16,13 – 17,99	
L $\gamma$	20,12 – 22,2	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	73,50 – 83,13	100
KLX	90,36 – 97,28	60,2
KXY	107,10 – 114,58	9,06
Auger L	5,04 – 13,52	56,1

## 4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Np)	5,04 – 13,52	48,8 (26)
e <sub>AK</sub>	(Np)		1,47 (21)
	KLL	73,50 – 83,13	}
	KLX	90,36 – 97,28	}
	KXY	107,10 – 114,58	}
ec <sub>2,1</sub> L	(Np)	3,918 – 8,735	14,6 (50)
ec <sub>6,5</sub> M	(Np)	8,07 – 10,15	36,0 (19)
ec <sub>1,0</sub> L	(Np)	10,769 – 15,586	16,9 (24)
ec <sub>9,7</sub> L	(Np)	16,11 – 20,93	0,7 (5)
ec <sub>3,1</sub> L	(Np)	20,277 – 25,094	0,47
ec <sub>2,1</sub> M	(Np)	20,606 – 22,681	3,9 (5)
ec <sub>4,2</sub> L	(Np)	20,996 – 25,813	3,1 (3)
ec <sub>1,0</sub> M	(Np)	27,457 – 29,532	4,3 (7)
ec <sub>7,6</sub> L	(Np)	28,58 – 33,40	0,20 (4)
ec <sub>9,7</sub> M	(Np)	32,80 – 34,88	0,18 (13)
ec <sub>3,1</sub> M	(Np)	36,965 – 39,040	0,12
ec <sub>2,0</sub> L	(Np)	37,114 – 41,931	28,6 (22)
ec <sub>4,2</sub> M	(Np)	37,684 – 39,759	0,84 (8)

		Energy keV	Electrons per 100 disint.
ec <sub>7,5</sub> L	(Np)	42,40 - 47,22	0,385 (9)
ec <sub>5,4</sub> K	(Np)	45,94 (2)	0,352 (9)
ec <sub>2,0</sub> M	(Np)	53,802 - 55,877	7,7 (3)
ec <sub>7,5</sub> M	(Np)	59,09 - 61,17	0,095 (2)
ec <sub>5,2</sub> K	(Np)	89,331 (10)	49,8 (13)
ec <sub>5,1</sub> K	(Np)	115,73 (4)	0,119 (10)
ec <sub>5,4</sub> L	(Np)	142,18 - 147,00	2,03 (5)
ec <sub>5,0</sub> K	(Np)	148,87 (4)	0,53 (3)
ec <sub>5,4</sub> M	(Np)	158,87 - 160,95	0,565 (14)
ec <sub>5,2</sub> L	(Np)	185,573 - 190,390	10,1 (3)
ec <sub>5,2</sub> M	(Np)	202,261 - 204,336	2,45 (7)
ec <sub>7,0</sub> K	(Np)	213,69 (4)	0,0746 (17)
ec <sub>8,1</sub> K	(Np)	216,71 (4)	0,0515 (16)
ec <sub>5,0</sub> L	(Np)	245,11 - 249,93	0,171 (9)
ec <sub>7,0</sub> L	(Np)	309,93 - 314,75	0,0731 (17)
$\beta_{0,9}^-$	max:	147,7 (6)	1,3 (7)
$\beta_{0,9}^-$	avg:	39,0 (2)	
$\beta_{0,7}^-$	max:	186,2 (6)	2,9 (7)
$\beta_{0,7}^-$	avg:	49,8 (2)	
$\beta_{0,6}^-$	max:	237,2 (6)	48,1 (25)
$\beta_{0,6}^-$	avg:	64,5 (2)	
$\beta_{0,5}^-$	max:	251,1 (6)	40,7 (32)
$\beta_{0,5}^-$	avg:	68,6 (2)	
$\beta_{0,2}^-$	max:	459,1 (6)	7 (6)
$\beta_{0,2}^-$	avg:	137,6 (2)	

## 5 Photon Emissions

### 5.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Np)	11,89 — 22,2	51,3 (3)
XK $\alpha_2$	(Np)	97,069	14,7 (4) } K $\alpha$
XK $\alpha_1$	(Np)	101,059	23,4 (6) }
XK $\beta_3$	(Np)	113,303	}
XK $\beta_1$	(Np)	114,234	} 8,50 (27) K' $\beta_1$
XK $\beta_5''$	(Np)	114,912	}
XK $\beta_2$	(Np)	117,463	}
XK $\beta_4$	(Np)	117,876	} 2,92 (10) K' $\beta_2$
XKO <sub>2,3</sub>	(Np)	118,429	}

## 5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{6,5}(\text{Np})$	13,81 (2)	0,099 (4)
$\gamma_{2,1}(\text{Np})$	26,3446 (2)	2,43 (6)
$\gamma_{1,0}(\text{Np})$	33,1963 (3)	0,130 (5)
$\gamma_{9,7}(\text{Np})$	38,54 (3)	0,0033 (20)
$\gamma_{3,1}(\text{Np})$	42,704 (5)	0,0085
$\gamma_{4,2}(\text{Np})$	43,420 (3)	0,024 (2)
$\gamma_{7,6}(\text{Np})$	51,01 (3)	0,36 (7)
$\gamma_{2,0}(\text{Np})$	59,5409 (1)	34,1 (8)
$\gamma_{7,5}(\text{Np})$	64,83 (2)	1,286 (17)
$\gamma_{4,1}(\text{Np})$	69,76 (3)	0,00095 (19)
$\gamma_{3,0}(\text{Np})$	75,8 (2)	0,00091
$\gamma_{4,0}(\text{Np})$	102,98 (2)	0,0064 (9)
$\gamma_{5,4}(\text{Np})$	164,61 (2)	1,86 (3)
$\gamma_{5,2}(\text{Np})$	208,00 (1)	21,3 (3)
$\gamma_{6,2}(\text{Np})$	221,80 (4)	0,0204 (8)
$\gamma_{5,1}(\text{Np})$	234,40 (4)	0,0216 (18)
$\gamma_{5,0}(\text{Np})$	267,54 (4)	0,721 (10)
$\gamma_{8,3}(\text{Np})$	292,77 (6)	0,0025 (7)
$\gamma_{8,2}(\text{Np})$	309,1 (3)	0,00027
$\gamma_{7,0}(\text{Np})$	332,36 (4)	1,199 (16)
$\gamma_{8,1}(\text{Np})$	335,38 (4)	0,0958 (22)
$\gamma_{9,1}(\text{Np})$	337,7 (2)	0,0089 (5)
$\gamma_{(-1,2)}(\text{Np})$	340,45	0,0016 (3)
$\gamma_{8,0}(\text{Np})$	368,59 (4)	0,0416 (17)
$\gamma_{9,0}(\text{Np})$	370,94 (3)	0,109 (2)

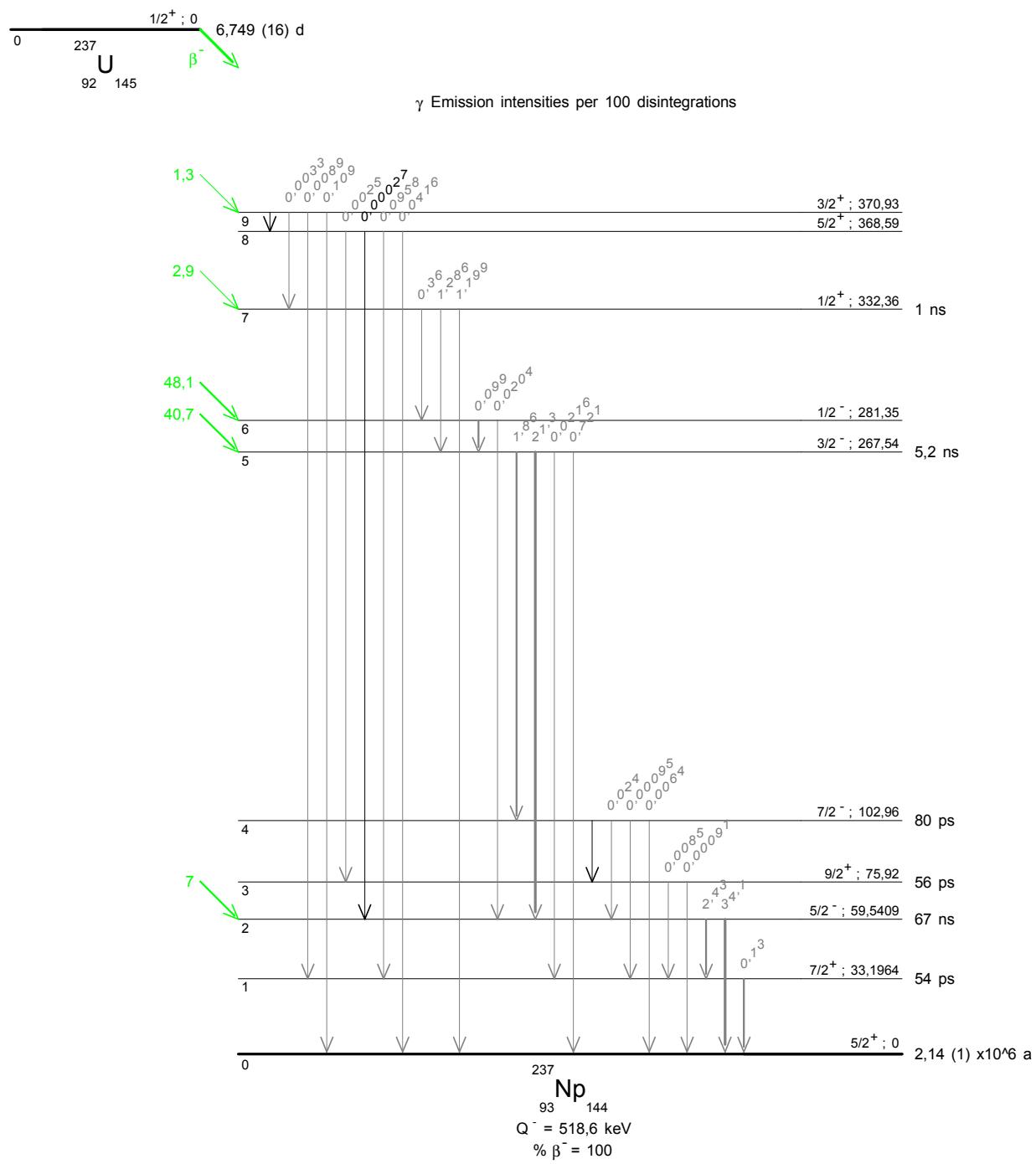
## 6 Main Production Modes

$$\left\{ \begin{array}{l} \text{U} - 236(n,\gamma)\text{U} - 237 \\ \text{Possible impurities : U} - 236, \text{U} - 238 \end{array} \right.$$

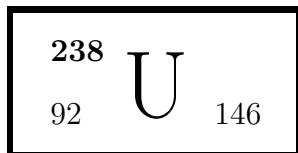
## 7 References

- L. MELANDER, H. SLATIS. Arkiv Mat. Astron. Fysik 36A (1948) No 15  
(Half-life , energies and probabilities of beta transitions.)
- F. WAGNER JR., M.S. FREEDMAN, D.W. ENGELKEMEIR, J.R. HUIZENGA. Phys. Rev. 89 (1953) 502  
(Half-life , energies and probabilities of beta transitions.)
- J.O. RASMUSSEN, F.L. CANAVAN, J.M. HOLLANDER. Phys. Rev. 107 (1957) 141  
(Energies and probabilities of beta transitions.)
- M.J. CABELL, T.A. EASTWOOD, P.J. CAMPION. J. Nucl. Energy 7 (1958) 81  
(Half-life.)
- P.S. SAMOILOV. Izvest. Akad. Nauk SSSR, Ser. Fiz. 23 (1959) 1416  
(Gamma transition multipolarities.)

- F. ASARO, F.S. STEPHENS, J.M. HOLLANDER, I. PERLMAN. Phys. Rev. 117 (1960) 492  
(ICC for the anomalously converted gamma-transitions.)
- E. AKATSU, T. KUROYANAGI, T. ISHIMORI. Radiochim. Acta 2 (1963) 1  
(Gamma-ray energies.)
- J.L. WOLFSON, J.J.H. PARK. Can. J. Phys. 42 (1964) 1387  
(E2/M1 admixters.)
- C.M. LEDERER, J.K. POGGENBURG, F. ASARO, J.O. RASMUSSEN, I. PERLMAN. Nucl. Phys. 84 (1966) 481  
(Gamma-ray energies and emission probabilities, alpha emission energies and probabilities.)
- T. YAMAZAKI, J.M. HOLLANDER. Nucl. Phys. 84 (1966) 505  
(Gamma ray and X-ray energies and multipolarities, E2 admixtures, relative probability of conversion electrons.)
- L.N. KONDRADEV, E.E. TRETYAKOV. Bull. Acad. Sci. USSR, Phys. Ser. 30 (1967) 393  
(E2/M1 admixters.)
- R. DAMS, F. ADAMS. Radiochim. Acta 10 (1968) 1  
(Gamma-ray energies.)
- J.E. CLINE. IN-1448 Rev. (1971)  
(Gamma-ray energies and emission probabilities.)
- R. GUNNINK, J.E. EVANS, A.L. PRINDE. UCRL-52139 (1976)  
(Gamma-ray energies and emission probabilities.)
- F.P. LARKINS. Atomic Data Nucl. Data Tables 20 (1977) 313  
(Auger electron energies.)
- I.M. BAND, M.B. TRZHASKOVSKAYA. Special report of Leningrad Nuclear Physics Institute (1978)  
(Theoretical ICC.)
- A.V. BUSHUEV, O.V. MATVEEV, V.N. OZERKOV, V.V. CHACHIN. INDC(CCP)-193/G (1982) 30  
(Gamma-ray emission probabilities.)
- M.F. BANHAM. Priv.Comm., quoted by 1986LoZT (1984)  
(Gamma-ray emission probabilities.)
- H. WILLMES, T. ANDO, R.J. GEHRKE. Int. J. Appl. Radiat. Isotop. 36 (1985) 123  
(X-ray and gamma-ray emission probabilities.)
- R.G. HELMER, C.W. REICH. Int. J. Appl. Radiat. Isotop. 36 (1985) 117  
(Gamma-ray emission probabilities.)
- F. LAGOUTINE, N. COURSOL, J. LEGRAND. Table de Radionucleides, ISBN-2-7272-0078-1 (LMRI, 1982-1987)  
(1987)  
(Energy of Auger electrons.)
- I.M. BAND, M.B. TRZHASKOVSKAYA. At. Data Nucl. Data Tables 55 (1993) 43  
(Theoretical ICC.)
- Y.A. AKOVALI. Nucl.Data Sheets 74 (1995) 461  
(Decay scheme.)
- P.N. JOHNSTON. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 107  
(ICC for the anomalously converted gamma-transitions.)
- R. YANEZ, W. LOVELAND, D.J. MORRISSEY, K. ALEKLETT, J.O. LILJENZIN, E. HAGEBO, D. JERRESTAM, L. WESTERBERG. Phys. Lett. B376 (1996) 29  
(Gamma-ray energies.)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic data.)
- A. KOVALIK, E.A. YAKUSHEV, V.M. GOROZHANKIN, A.F. NOVGORODOV, M. RYSAVY. J. Phys. (London) G24 (1998) 2247  
(Gamma transition multipolarities.)
- E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX ray energies and relative emission probabilities.)
- R.G. HELMER, C. VAN DER LEUN. Nucl. Instrum. Meth. Phys. Res. A450 (2000) 35  
(Gamma-ray energies.)
- E. SCHÖNFELD, U. SCHÖTZIG. Appl. Radiat. Isot. 54 (2001) 785  
(X-ray emission probabilities.)
- G. AUDI, A.H. WAPSTRA, AND C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q value.)







## 1 Decay Scheme

U-238 disintegrates by alpha emission to two excited levels and to the ground state of Th-234. Branching of U-238 decay by spontaneous fission is 5,45 (4) E-05 %.

*L'uranium 238 se désintègre par émission alpha, principalement vers un niveau excité et le fondamental du thorium 234. Le rapport de branchement par fission spontanée est 5,45 (4)E-05 %.*

## 2 Nuclear Data

$T_{1/2}(^{238}\text{U})$	:	4,468	(5)	$10^9$ a
$T_{1/2}(^{234}\text{Th})$	:	24,10	(3)	d
$Q^\alpha(^{238}\text{U})$	:	4269,7	(29)	keV

### 2.1 $\alpha$ Transitions

	Energy keV	Probability $\times 100$	F
$\alpha_{0,2}$	4106,7 (29)	0,13 (3)	24
$\alpha_{0,1}$	4220,2 (29)	22,33 (50)	1,33
$\alpha_{0,0}$	4269,7 (29)	77,54 (50)	1

### 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Th})$	49,55 (6)	22,46 (50)	E2		235 (7)	64,4 (19)	321 (10)
$\gamma_{2,1}(\text{Th})$	113,5 (1)	0,13 (3)	[E2]	0,219 (7)	4,57 (14)	1,257 (38)	6,47 (19)

### 3 Atomic Data

#### 3.1 Th

$$\begin{aligned}\omega_K &: 0,969 \quad (4) \\ \bar{\omega}_L &: 0,476 \quad (18) \\ n_{KL} &: 0,797 \quad (5)\end{aligned}$$

##### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	89,9566	61,82
K $\alpha_1$	93,3479	100
K $\beta_3$	104,8172	}
K $\beta_1$	105,602	}
K $\beta_5''$	106,1564	} 35,58
K $\beta_5'$	106,3149	}
K $\beta_2$	108,581	}
K $\beta_4$	108,953	} 11,99
KO <sub>2,3</sub>	109,442	}
X <sub>L</sub>		
L $\ell$	11,118	
L $\alpha$	12,8085 – 12,967	
L $\eta$	14,509	
L $\beta$	14,972 – 17,1383	
L $\gamma$	18,3633 – 19,504	

##### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	68,406 – 76,745	100
KLX	83,857 – 93,345	58,8
KXY	99,29 – 109,64	8,64
Auger L	5,8 – 20,3	

## 4 $\alpha$ Emissions

	Energy keV	Probability $\times 100$
$\alpha_{0,2}$	4038 (5)	0,13 (3)
$\alpha_{0,1}$	4151 (5)	22,33 (50)
$\alpha_{0,0}$	4198 (3)	77,54 (50)

## 5 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Th)	5,8 - 20,3	8,43 (25)
e <sub>AK</sub>	(Th)		0,00012 (4)
	KLL	68,406 - 76,745	}
	KLX	83,857 - 93,345	}
	KXY	99,29 - 109,64	}
ec <sub>1,0</sub> L	(Th)	29,08 - 33,20	16,3 (8)
ec <sub>1,0</sub> M	(Th)	44,37 - 46,22	4,46 (21)
ec <sub>1,0</sub> N	(Th)	48,22 - 49,22	1,19 (6)
ec <sub>2,1</sub> L	(Th)	93,0 - 97,2	0,080 (22)

## 6 Photon Emissions

### 6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Th)	11,118 — 19,504	7,94 (28)
XK $\alpha_2$	(Th)	89,9566	0,00109 (30) }
XK $\alpha_1$	(Th)	93,3479	0,0018 (5) }
XK $\beta_3$	(Th)	104,8172	}
XK $\beta_1$	(Th)	105,602	0,00063 (17) K' $\beta_1$
XK $\beta_5''$	(Th)	106,1564	}
XK $\beta_5'$	(Th)	106,3149	}
XK $\beta_2$	(Th)	108,581	}
XK $\beta_4$	(Th)	108,953	0,00021 (6) K' $\beta_2$
XKO <sub>2,3</sub>	(Th)	109,442	}

## 6.2 Gamma Emissions

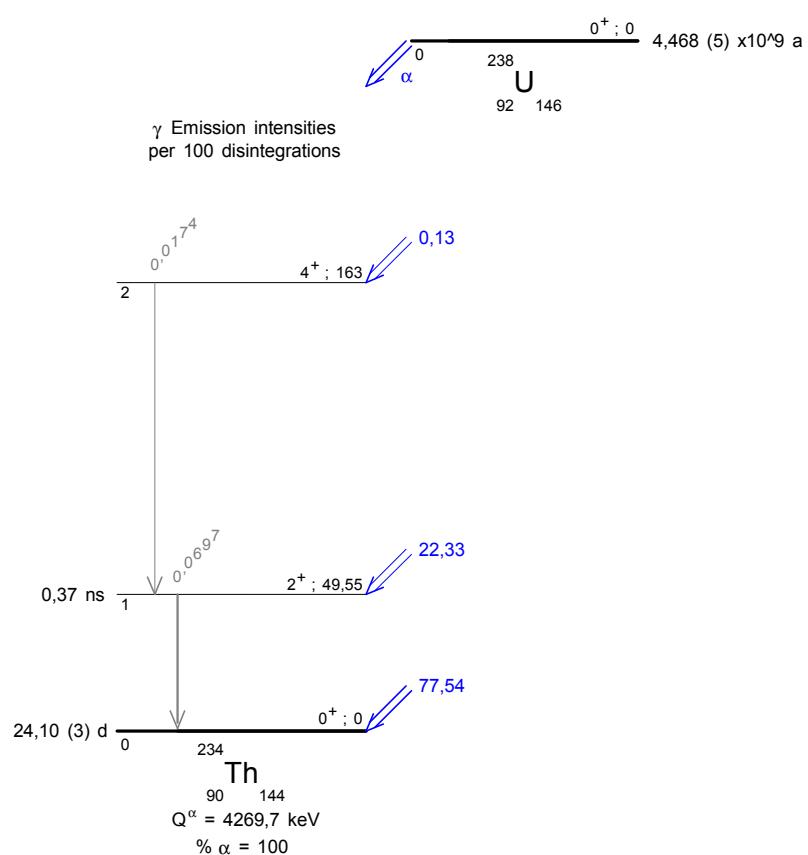
	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Th})$	49,55 (6)	0,0697 (26)
$\gamma_{2,1}(\text{Th})$	113,5 (1)	0,0174 (47)

## 7 References

- C.A. KIENBERGER. Phys. Rev. 76 (1949) 1561  
(Half-life.)
- W.J. WHITEHOUSE, W. GALBRAITH. Philos. Mag. 41 (1950) 429  
(S.F. half-life.)
- E. SEGRÈ. Phys. Rev. 86 (1952) 21  
(S.F. half-life.)
- A.F. KOVARIK, N.A. ADAMS JR.. Phys. Rev. 98 (1955) 46  
(Half-life.)
- P. KURODA, R.R. EDWARDS, F.T. ASHIZAWA. J. Chem. Phys. 25 (1956) 603  
(S.F. half-life.)
- P. KURODA, R.R. EDWARDS. J. Inorg. Nucl. Chem. 3 (1957) 345  
(S.F. half-life.)
- F.L. CLARK, H.J. SPENCER-PALMER, R.N. WOODWARD. J.S. Africain Chem. Inst. 10 (1957) 62  
(Half-life.)
- R.B. LEACHMAN, H.W. SCHMITT. J. Nucl. Energy 1 (1957) 38  
(Half-life.)
- P.L. PARKER, P.K. KURODA. J. Inorg. Nucl. Chem. 5 (1958) 153  
(S.F. half-life.)
- J. STEYN, F.W.E. STRELOW. Proc. Symp. Metrology Radionucl., Vienna, Austria (1959) 155  
(Half-life.)
- B.D. KUZ'MINOV, L.S. KUTSAEVA, V.G. NESTEROV, L.I. PROKHOROVA, G.P. SMIRENKIN. Sov. Phys. - JETP 37 (1959) 290  
(S.F. half-life.)
- G.E. KOCHAROV, A.P. KOMAR, G.A. KOROLEV. Sov. Phys. - JETP 36 (1959) 48  
(Alpha probability.)
- G.E. KOCHAROV, G.A. KOROLEV. Bull. Acad. Sci. USSR, Phys. Ser. 25 (1961) 227  
(Alpha probability.)
- R.L. FLEISCHER, P.B. PRICE. Phys. Rev. 133 (1964) B63  
(S.F. half-life.)
- A. SPADAVECCHIA, B. HAHN. Helv. Phys. Acta 40 (1967) 1063  
(S.F. half-life.)
- J.H. ROBERTS, R. GOLD, R.J. ARMANI. Phys. Rev. 174 (1968) 1482  
(S.F. half-life.)
- D. GALLIKER, E. HUGENTOBLER, B. HAHN. Helv. Phys. Acta 43 (1970) 593  
(S.F. half-life.)
- A.H. JAFFEY, K.F. FLYNN, L.E. GLENDEENIN, W.C. BENTLEY, A.M. ESSLING. Phys. Rev. C4 (1971) 1889  
(Half-life.)
- W.M. THURY. Acta Physica Austriaca 33 (1971) 375  
(S.F. half-life.)
- M.P.T. LEME, C. RENNER, M. CATTANI. Nucl. Instrum. Methods 91 (1971) 577  
(S.F. half-life.)
- J.D. KLEEMAN, J.F. LOVERING. Geochimica et Cosmochimica Acta 35 (1971) 637  
(S.F. half-life.)

- H.A. KHAN, S.A. DURRANI. Radiation Effects 17 (1973) 133  
(S.F. half-life.)
- K.N. IVANOV, K.A. PETRZHAK. Sov. At. Energ. 36 (1974) 514  
(S.F. half-life.)
- V. EMMA, S. LO NIGRO. Nucl. Instrum. Methods 128 (1975) 355  
(S.F. half-life.)
- G.A. WAGNER, G.M. REIMER, B.S. CARPENTER, H. FAUL, R. VAN DER LINDEN, R. GIJBELS. Geochimica et Cosmochimica Acta 39 (1975) 1279  
(S.F. half-life.)
- K. THIEL, W. HERR. Earth and Planetary Science Lett. 30 (1976) 50  
(S.F. half-life.)
- M. KASE, J. KIKUCHI, T. DOKE. Nucl. Instrum. Methods 154 (1978) 335  
(S.F. half-life.)
- D.M.C. RIZZO. An. Acad. Bras. Ciênc. 50 (1978) 303  
(S.F. half-life.)
- E.R.V. SPAGGIARI. An. Acad. Bras. Ciênc. 52 (1980) 213  
(S.F. half-life.)
- A.G. POPEKO, G.M. TER-AKOPIAN. Nucl. Instrum. Methods 178 (1980) 163  
(S.F. half-life.)
- Z.N.R. BAPTISTA, M.S.M. MANTOVANI, F.B. RIBEIRO. An. Acad. Bras. Ciênc. 53 (1981) 437  
(S.F. half-life.)
- H.G. DE CARVALHO, J.B. MARTINS, E.L. MEDEIROS, O.A.P. TAVARES. Nucl. Instrum. Methods 197 (1982) 417  
(S.F. half-life.)
- S.N. BELEN'KII, M.D. SKOROKHATOV, A.V. ETENKO. Sov. At. Energ. 55 (1983) 528  
(S.F. half-life.)
- Y.A. AKOVALI. Nucl. Data Sheets 40 (1983) 523  
(Spin, parity, energy level, multipolarity.)
- J.-C. ROY, L. BRETON, J.-E. CÔTÉ, J. TURCOTTE. Int. J. Appl. Radiat. Isotop. 35 (1984) 899  
(Gamma probability.)
- R. VARTANIAN. Helv. Phys. Acta 57 (1984) 416  
(S.F. half-life.)
- R. VARTANIAN. Helv. Phys. Acta 57 (1984) 292  
(S.F. half-life.)
- M.P. IVANOV, G.M. TER-AKOPIAN, B.V. FEFILOV, A.S. VORONIN. Nucl. Instrum. Methods Phys. Res. A234 (1985) 152  
(S.F. half-life.)
- B. AL-BATAINA, J. JÄNECKE. Radiochimica Acta 42 (1987) 159  
(Half-life.)
- K. KOMURA, M. YAMAMOTO, K. UENO. Nucl. Instrum. Methods Phys. Res. A295 (1990) 461  
(Gamma probability.)
- A. RYTZ. At. Data. Nucl. Data Tables 47 (1991) 205  
(Alpha energy.)
- B. DUCHEMIN, N. COURSOL, M.M. BÉ. Nucl. Instrum. Methods Phys. Res. A339 (1994) 146  
(Alpha and gamma probabilities.)
- Y.A. AKOVALI. Nucl. Data Sheets 71 (1994) 181  
(Spin, parity, energy level, multipolarity.)
- E. SCHÖNFELD, H. JANSEN. Nucl. Instrum. Meth. Phys. Res. A369 (1996) 527  
(Atomic Data.)
- H. RUELLAN, M.C. LÉPY, M. ETCHEVERRY, J. PLAGNARD, J. MOREL. Nucl. Instrum. Methods Phys. Res. A369 (1996) 651  
(Gamma probability.)
- I. ADSLEY, J.S. BACKHOUSE, A.L. NICHOLS, J. TOOLE. Appl. Rad. Isotopes 49 (1998) 1337  
(Gamma probability.)
- N.E. HOLDEN, D.C. HOFFMAN. Pure Appl. Chem. 72 (2000) 1525  
(S.F. half-life.)
- E. GARCIA-TORAÑO. Appl. Rad. Isotopes 52 (2000) 591  
(Alpha probability.)
- F.E. CHUKREEV, V.E. MAKARENKO, M.J. MARTIN. Nucl. Data Sheets 97 (2002) 123  
(Spin, parity, energy level, multipolarity.)

- I.M. BAND, M.B. TRZHASKOVSKAYA, C.W. NESTOR, JR., P.O. TIKKANEN, S. RAMAN. Atomic Data and Nuclear Data Tables 81 (2002) 1  
(alpha)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 129  
(Q)
- J.C. HADLER, G. BIGAZZI, S. GUEDES, P.J. IUNES, M. ODDONE, C.A. TELLO, S.R. PAULO. J. Radioanal. Nucl. Chem. 256 (2003) 155  
(S.F. half-life.)
- R. SCHÖN, G. WINKLER, W. KUTSCHERA. Appl. Rad. Isotopes 60 (2004) 263  
(Half-life.)







## 1 Decay Scheme

Cm-242 decays 100% by alpha transitions to Pu-238 and by spontaneous fission with branching fraction of 6.36 (14) E-6 %.

*Le curium 242 se désintègre à 100% par transition alpha vers le plutonium 238 et par fission spontanée pour 6,36 (14)E-06 %.*

## 2 Nuclear Data

$T_{1/2}(^{242}\text{Cm})$	:	162,86	(8)	d
$T_{1/2}(^{238}\text{Pu})$	:	87,74	(3)	a
$Q^\alpha(^{242}\text{Cm})$	:	6215,56	(8)	keV

### 2.1 $\alpha$ Transitions

	Energy keV	Probability $\times 100$	F
$\alpha_{0,15}$	4951,27 (24)	0,00000052 (14)	6
$\alpha_{0,14}$	4986,87 (24)	0,00000055 (15)	10
$\alpha_{0,13}$	5089,77 (19)	0,00000031 (10)	88
$\alpha_{0,12}$	5186,94 (10)	0,00000037 (10)	32
$\alpha_{0,11}$	5197,0 (3)	$\leq 0,00000002$	$\geq 700$
$\alpha_{0,10}$	5232,56 (12)	0,00000017 (5)	137
$\alpha_{0,9}$	5252,84 (11)	0,000000113 (21)	278
$\alpha_{0,8}$	5274,13 (12)	0,0000035 (7)	12
$\alpha_{0,7}$	5452,34 (15)	$\leq 0,000000022$	$\geq 24000$
$\alpha_{0,6}$	5554,28 (14)	0,000013 (3)	1700
$\alpha_{0,5}$	5610,48 (11)	0,00025 (5)	183
$\alpha_{0,4}$	5701,94 (18)	0,00002	7500
$\alpha_{0,3}$	5912,14 (11)	0,0046 (5)	458
$\alpha_{0,2}$	6069,56 (10)	0,034 (2)	390
$\alpha_{0,1}$	6171,48 (9)	25,94 (7)	1,733
$\alpha_{0,0}$	6215,56 (8)	74,06 (7)	1

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ $\times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Pu})$	44,08 (3)	25,98 (7)	E2		570 (12)	159 (3)	785 (16)
$\gamma_{2,1}(\text{Pu})$	101,92 (4)	0,039 (2)	E2		10,5 (2)	2,93 (6)	14,4 (3)
$\gamma_{3,2}(\text{Pu})$	157,42 (9)	0,0046 (5)	[E2]	0,186 (4)	1,45 (3)	0,405 (8)	2,18 (4)
$\gamma_{4,3}(\text{Pu})$	210,20 (14)	0,000002	E2	0,137 (3)	0,414 (8)	0,115 (2)	0,706 (14)
$\gamma_{8,5}(\text{Pu})$	336,36 (15)	0,0000007 (3)	[E1]	0,0256 (5)	0,00502 (10)	0,00122 (3)	0,0322 (7)
$\gamma_{9,5}(\text{Pu})$	357,64 (7)	0,000000054 (11)	M1 + E2	0,132 (10)	0,060 (5)	0,0158 (12)	0,213 (16)
$\gamma_{7,3}(\text{Pu})$	459,8 (2)	0,00000006 (3)					
$\gamma_{6,2}(\text{Pu})$	515,25 (19)	0,0000046 (12)	E1+M2	0,017 (3)	0,0037 (7)	0,00092 (17)	0,022 (4)
$\gamma_{5,1}(\text{Pu})$	561,02 (10)	0,00015 (4)	E1	0,00928 (19)	0,00169 (4)	0,000407 (8)	0,0115 (2)
$\gamma_{5,0}(\text{Pu})$	605,04 (10)	0,000105 (30)	E1	0,00806 (16)	0,00146 (3)	0,000350 (7)	0,0100 (2)
$\gamma_{6,1}(\text{Pu})$	617,20 (12)	0,0000079 (21)	E1+M2	0,0095 (11)	0,00185 (22)	0,00045 (5)	0,0120 (14)
$\gamma_{7,2}(\text{Pu})$	617,22 (13)	0,00000016	E1+M2				
$\gamma_{10,2}(\text{Pu})$	837,01 (15)	0,00000019 (6)	[E2]	0,0125 (3)	0,00366 (8)	0,00093 (2)	0,0174 (4)
$\gamma_{12,2}(\text{Pu})$	882,63 (3)	0,00000068 (15)	(E2)	0,0114 (2)	0,00320 (7)	0,00081 (2)	0,0157 (3)
$\gamma_{8,1}(\text{Pu})$	897,33 (10)	0,000022 (6)	(E2)	0,0111 (2)	0,00308 (6)	0,00078 (2)	0,0152 (3)
$\gamma_{9,1}(\text{Pu})$	918,7 (2)	0,00000054 (15)	E1	0,00383 (8)	0,00066 (1)	0,000158 (3)	0,0047 (1)
$\gamma_{10,1}(\text{Pu})$	938,91 (10)	0,0000009 (3)	E0+E2				4,4 (4)
$\gamma_{8,0}(\text{Pu})$	941,5 (2)		E0				
$\gamma_{9,0}(\text{Pu})$	962,8 (2)	0,00000053 (15)	E1	0,00353 (7)	0,00061 (1)	0,000145 (3)	0,00433 (9)
$\gamma_{11,1}(\text{Pu})$	974,5 (3)	0,0000002	E1+M2				
$\gamma_{13,2}(\text{Pu})$	979,8 (2)	0,00000026 (8)					
$\gamma_{10,0}(\text{Pu})$	983,0 (3)	0,00000050 (18)	[E2]	0,00945 (19)	0,00246 (5)	0,00062 (1)	0,0128 (3)
$\gamma_{12,1}(\text{Pu})$	984,5 (1)	0,0000020 (6)	M1+E2	0,00948 (19)	0,00246 (5)	0,00062 (1)	0,0128 (3)
$\gamma_{12,0}(\text{Pu})$	1028,5 (2)	0,0000016 (5)	E2	0,00874 (18)	0,00221 (5)	0,00055 (1)	0,0117 (2)
$\gamma_{13,1}(\text{Pu})$	1081,7 (3)	0,00000005 (2)					
$\gamma_{15,2}(\text{Pu})$	1118,3 (3)	0,00000017 (9)	[E2]	0,00756 (15)	0,00182 (4)	0,00045 (1)	0,0100 (2)
$\gamma_{14,1}(\text{Pu})$	1184,6 (3)	0,00000050 (15)	E2	0,00685 (14)	0,00160 (3)	0,00040 (1)	0,0090 (2)
$\gamma_{15,1}(\text{Pu})$	1220,2 (3)	0,00000035 (11)	E0+E2+(M1)				0,26 (3)
$\gamma_{14,0}(\text{Pu})$	1228,7 (3)		E0				

## 3 Atomic Data

### 3.1 Pu

$$\begin{aligned} \omega_K &: 0,971 (4) \\ \bar{\omega}_L &: 0,521 (20) \\ n_{KL} &: 0,790 (5) \end{aligned}$$

### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	99,525	63,17
K $\alpha_1$	103,734	100
K $\beta_3$	116,244	}
K $\beta_1$	117,228	}
K $\beta_5''$	117,918	}
K $\beta_2$	120,54	}
K $\beta_4$	120,969	}
KO <sub>2,3</sub>	121,543	}
X <sub>L</sub>		
L $\ell$	12,12	
L $\alpha$	14,087 – 14,282	
L $\eta$	16,333	
L $\beta$	16,5 – 19,33	
L $\gamma$	20,71 – 23,07	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	75,2 – 85,3	100
KLX	92,6 – 103,6	60,6
KXY	109,8 – 121,5	9,2
Auger L	6,1 – 22,9	

## 4 $\alpha$ Emissions

	Energy keV	Probability $\times 100$
$\alpha_{0,15}$	4869,43 (23)	0,00000052 (14)
$\alpha_{0,14}$	4904,44 (23)	0,00000055 (15)
$\alpha_{0,13}$	5005,64 (19)	0,00000031 (10)
$\alpha_{0,12}$	5101,21 (10)	0,00000037 (10)
$\alpha_{0,11}$	5111,1 (3)	$\leq 0,0000002$
$\alpha_{0,10}$	5146,07 (12)	0,00000017 (5)
$\alpha_{0,9}$	5165,95 (16)	0,000000113 (21)

	Energy keV	Probability $\times 100$
$\alpha_{0,8}$	5186,95 (12)	0,000035 (7)
$\alpha_{0,7}$	5366,22 (15)	$\leq 0,00000022$
$\alpha_{0,6}$	5462,47 (14)	0,000013 (3)
$\alpha_{0,5}$	5517,75 (11)	0,00025 (5)
$\alpha_{0,4}$	5607,76 (16)	0,00002
$\alpha_{0,3}$	5816,39 (11)	0,0046 (5)
$\alpha_{0,2}$	5969,24 (9)	0,034 (2)
$\alpha_{0,1}$	6069,37 (9)	25,94 (7)
$\alpha_{0,0}$	6112,72 (8)	74,06 (7)

## 5 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Pu)	6,1 - 22,9	9,0 (5)
e <sub>AK</sub>	(Pu)		0,0000079 (17)
	KLL	75,2 - 85,3	}
	KLX	92,6 - 103,6	}
	KXY	109,8 - 121,5	}
ec <sub>1,0</sub> L	(Pu)	20,98 - 26,02	18,8 (6)
ec <sub>1,0</sub> M	(Pu)	38,15 - 40,31	5,25 (15)
ec <sub>2,1</sub> L	(Pu)	78,82 - 83,86	0,0263 (16)
ec <sub>2,1</sub> M	(Pu)	95,99 - 98,15	0,0074 (4)
ec <sub>3,2</sub> K	(Pu)	35,63 (5)	0,00027 (3)
ec <sub>3,2</sub> L	(Pu)	134,32 - 139,36	0,00210 (24)
ec <sub>3,2</sub> M	(Pu)	151,49 - 152,65	0,00059 (7)

## 6 Photon Emissions

### 6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Pu)	12,12 — 23,07	9,8 (5)
XK $\alpha_2$	(Pu)	99,525	0,000079 (13) }
XK $\alpha_1$	(Pu)	103,734	0,000125 (21) }

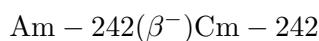
		Energy keV	Photons per 100 disint.	
XK $\beta_3$	(Pu)	116,244	}	
XK $\beta_1$	(Pu)	117,228	}	0,000045 (8) K' $\beta_1$
XK $\beta_5''$	(Pu)	117,918	}	
XK $\beta_2$	(Pu)	120,54	}	
XK $\beta_4$	(Pu)	120,969	}	0,000016 (3) K' $\beta_2$
XKO <sub>2,3</sub>	(Pu)	121,543	}	

## 6.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Pu})$	44,08 (3)	0,0330 (7)
$\gamma_{2,1}(\text{Pu})$	101,92 (4)	0,00251 (14)
$\gamma_{3,2}(\text{Pu})$	157,42 (9)	0,00145 (16)
$\gamma_{4,3}(\text{Pu})$	210,20 (14)	0,000012
$\gamma_{8,5}(\text{Pu})$	336,36 (15)	0,0000007 (3)
$\gamma_{9,5}(\text{Pu})$	357,64 (7)	0,000000045 (9)
$\gamma_{7,3}(\text{Pu})$	459,8 (2)	0,00000006 (3)
$\gamma_{6,2}(\text{Pu})$	515,25 (19)	0,0000045 (12)
$\gamma_{5,1}(\text{Pu})$	561,02 (10)	0,00015 (4)
$\gamma_{5,0}(\text{Pu})$	605,04 (10)	0,000105 (30)
$\gamma_{7,2}(\text{Pu})$	617,22 (13)	0,00000016
$\gamma_{6,1}(\text{Pu})$	617,22 (12)	0,0000079 (21)
$\gamma_{10,2}(\text{Pu})$	837,01 (15)	0,00000019 (6)
$\gamma_{12,2}(\text{Pu})$	882,63 (3)	0,000000067 (15)
$\gamma_{8,1}(\text{Pu})$	897,33 (10)	0,000022 (6)
$\gamma_{9,1}(\text{Pu})$	918,7 (2)	0,00000054 (15)
$\gamma_{10,1}(\text{Pu})$	938,91 (10)	0,00000018 (6)
$\gamma_{9,0}(\text{Pu})$	962,8 (2)	0,00000053 (15)
$\gamma_{11,1}(\text{Pu})$	974,5 (3)	0,0000002
$\gamma_{13,2}(\text{Pu})$	979,8 (2)	0,00000026 (8)
$\gamma_{10,0}(\text{Pu})$	983,0 (3)	0,00000050 (18)
$\gamma_{12,1}(\text{Pu})$	984,5 (1)	0,00000020 (6)
$\gamma_{12,0}(\text{Pu})$	1028,5 (2)	0,00000016 (5)
$\gamma_{13,1}(\text{Pu})$	1081,7 (3)	0,00000005 (2)
$\gamma_{15,2}(\text{Pu})$	1118,3 (3)	0,00000017 (9)
$\gamma_{14,1}(\text{Pu})$	1184,6 (3)	0,00000050 (15)
$\gamma_{15,1}(\text{Pu})$	1220,2 (3)	0,00000028 (9)

## 7 Main Production Modes

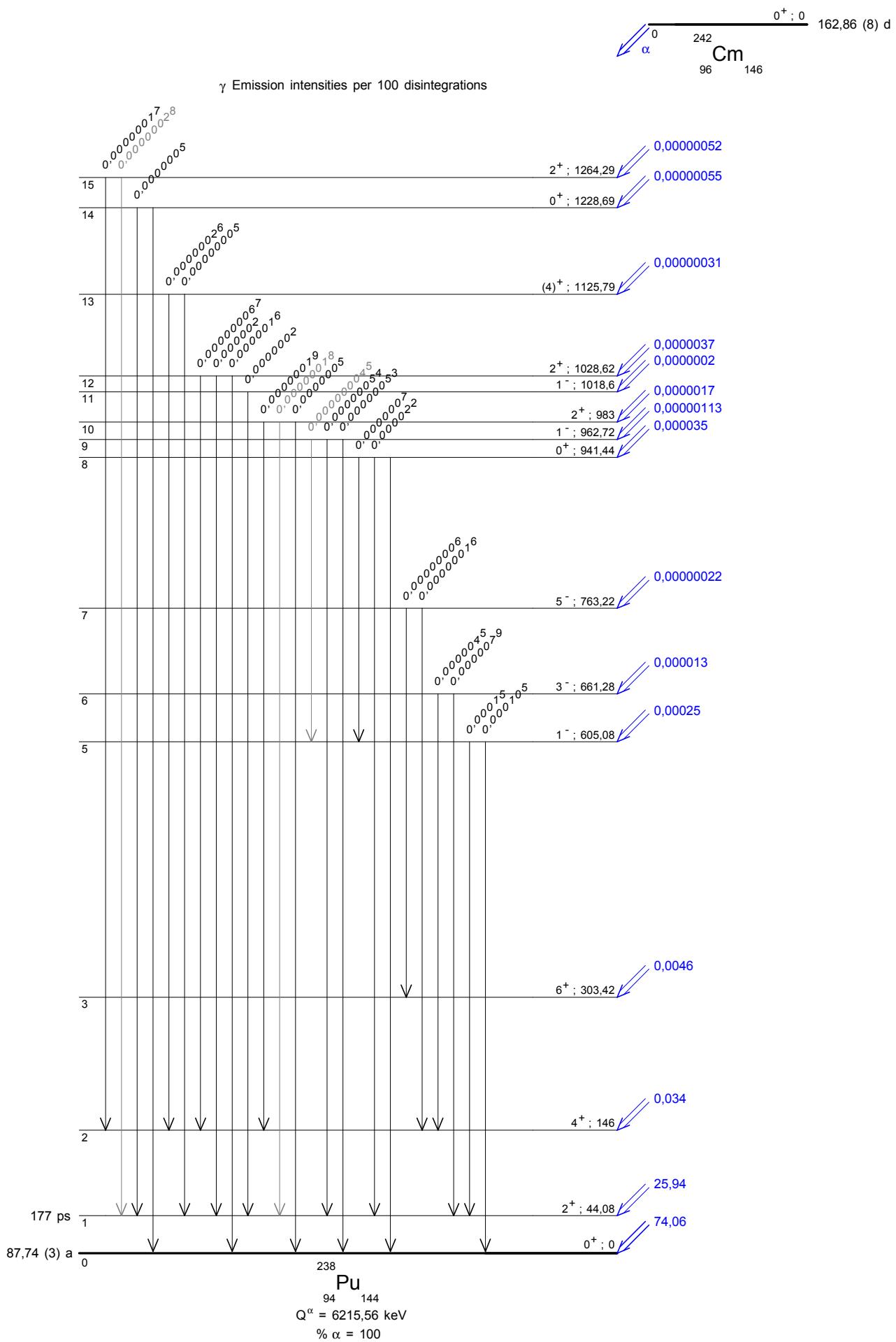
$$\left\{ \begin{array}{l} \text{Am} - 241(\text{n},\gamma)\text{Am} - 242 \\ \text{Possible impurities : Am} - 241, \text{Cm} - 243, \text{Cm} - 244 \end{array} \right.$$

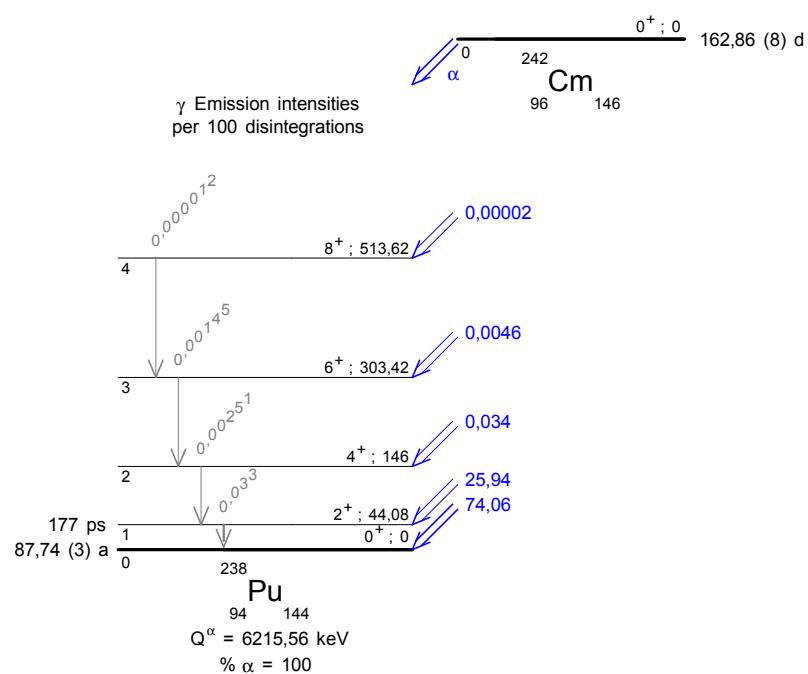


## 8 References

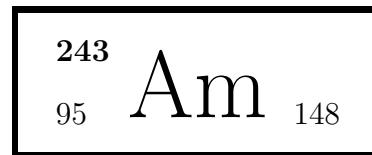
- G.C. HANNA, B.G. HARVEY AND N. MOSS. Phys. Rev. 78 (1950) 617  
(Half-life.)
- G.C. HANNA, B.G. HARVEY, N. MOSS AND P.R. TUNNICLIFFE. Phys. Rev. 81 (1951) 466  
(SF half-life)
- D.C. DUNLAVEY, G.T. SEABORG. Phys. Rev. 87 (1952) 165  
(Conversion electron measurements, gamma-ray multipolarities.)
- F. ASARO, S.G. THOMPSON AND I. PERLMAN. Phys. Rev. 92 (1953) 694  
(Alpha emission energies and probabilities.)
- K.M. GLOVER, J. MILSTED. Nature 173 (1954) 1238  
(Half-life.)
- W.P. HUTCHINSON, A.G. WHITE. Nature 173 (1954) 1238  
(Half-life.)
- S.A. BARANOV, K.N. SHLYAGIN. J. Nuclear Energy 3 (1956) 132  
(Conversion electron measurements, gamma-ray multipolarities.)
- W.G. SMITH, J.M. HOLLANDER. Phys. Rev. 101 (1956) 746  
(Gamma-ray energies and multipolarities.)
- L.N. TREIMAN, R.A. PENNEMAN AND B. BEVAN. unpublished, cited in Ref.: J. Inorg. Nucl. Chem. 5 (1957) 6  
(Half-life.)
- L.N. KONDRADEV, V.B. DEDOV AND L.L. GOLDIN. Izvest. Akad. Nauk SSSR, Ser. Fiz. 22 (1958) 99  
(Alpha emission energies and probabilities)
- F. ASARO, I. PERLMAN. UCRL-9566 (1960) 50  
(Conversion electron measurements, gamma-ray multipolarities.)
- C.M. LEDERER. UCRL-11028 (1963)  
(Absolute gamma-ray emission probabilities.)
- B.S. DZHELEPOV, R.B. IVANOV, V.G. NEDOVESOV AND V.P. CHECHEV. Soviet Phys. JETP 18 (1964) 937  
(Alpha emission energies and probabilities.)
- G.G. AKALAEV, N.A. VARTANOV AND P.S. SAMOILOV. NP-14688 (1965)  
(Conversion electron measurements, gamma-ray multipolarities.)
- K.F. FLYNN, L.E. GLENDEEN AND E.P. STEINBERG. Nucl. Sci. Eng. 22 (1965) 416  
(Half-life.)
- S.A. BARANOV, Y.F. RODIONOV, V.M. KULAKOV AND V.M. SHATINSKII. Soviet J. Nucl. Phys. 4 (1967) 798  
(Alpha emission energies and probabilities.)
- R.J. ARMANI, R. GOLD. Proc. Symp. Standardization of Radionuclides, Intern. At. Energy Agency, Vienna (1967) 621  
(SF half-life.)
- J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies.)
- J. BYRNE, R.J.D. BEATTIE, S. BENDA AND I. COLLINGWOOD. J. Phys. B3 (1970) 1166  
(Experimental LX-ray absolute emission probability.)
- B. GRENNBERG, A. RYTZ. Metrologia 7 (1971) 65  
(Alpha emission energies.)
- J.C. POST, A.H.W. ATEN JR.. Radiochim. Acta 15 (1971) 205  
(Gamma-ray energies.)
- K.L. SWINTH. IEEE Trans. Nucl. Sci. 18 (1971) 125  
(Experimental LX-ray absolute emission probability)
- S.A. BARANOV, V.M. SHATINSKII AND V.M. KULAKOV. Sov. J. Nucl. Phys. 14 (1972) 614  
(Alpha emission energies.)
- I. AHMAD, R.K. SJOBLOM, R.F. BARNES, F. WAGNER JR. AND P.R. FIELDS. Nucl. Phys. A186 (1972) 620  
(Gamma-ray energies.)

- W.J.B. WINTER, A.H. WAPSTRA, P.F.A. GOUDSMIT AND J. KONIJN. Nucl. Phys. A197 (1972) 417  
(Gamma-ray energies.)
- W.J. KERRIGAN, C.J. BANICK. J. Inorg. Nucl. Chem. 37 (1975) 641  
(Half-life.)
- H. DIAMOND, W.C. BENTLEY, A.H. JAFFEY AND K.F. FLYNN. Phys. Rev. C15 (1977) 1034  
(Half-life.)
- I.M. BAND, M.B. TRZHASKOVSKAYA. Special report of Leningrad nuclear physics institute, (1978)  
(Theoretical internal conversion coefficients.)
- HUAN-QIAO CHANG, JIN-CHENG XU AND TONG-QING WEN. Chin. J. Nucl. Phys. 1 (1979) 21  
(SF half-life.)
- J.K. DICKENS, J.W. McCONNELL. Phys. Rev. C22 (1980) 1344  
(Experimental X-ray energies.)
- A.V. JADHAV, K.A. MATHEW, K. RAGHURAMAN AND C.K. SIVARAMAKRISHNAN. Proc. of the Nucl. Chem. and Radiochem. Symp., Waltair (1980) 184  
(Half-life.)
- C.M. LEDERER. Phys. Rev. C24 (1981) 1175  
(Gamma-ray energies and probabilities.)
- S. USUDA, H. UMEZAWA. J. Inorg. Nucl. Chem. 43 (1981) 3081  
(Half-life.)
- S.K. AGGARWAL, A. V. JADHAV, S. A. CHITAMBAR. Radiochem. Radioanal. Lett. 54 (1982) 99  
(Half-life.)
- G. BARREAU, H.G. BORNER, T. VON EGIDY AND R.W. HOFF. Z. Physik A308 (1982) 209  
(Experimental X-ray energies.)
- K. RAGHURAMAN, N.K. CHAUDHURI, A.V. JADHAV, C.K. SIVARAMAKRISHNAN AND R.H. IYER. Radiochem. Radioanal. Lett. 55 (1982) 1  
(SF half-life.)
- H. UMEZAWA. INDC(NDS)-138/GE (1982) 32  
(SF half-life.)
- R.A.P. WILTSHERE. Nucl. Instrum. Methods 223 (1984) 535  
(Half-life)
- A.G. ZELENKOV, V.A. PCHELIN, YU. F. RODIONOV, L.V. CHISTYAKOV, V.S. SHIRYAEV AND V.M. SHUBKO. Sov. At. Engergy 60 (1986) 492  
(SF half-life.)
- A. LORENZ. IAEA Tech. Rept. Ser. 261 (1986)  
(Half-life evaluation.)
- S. USUDA, H. UMEZAWA. Int. J. Radiat. Appl. Instr. D16 (1989) 247  
(SF half-life.)
- YU.S. POPOV, I.B. MAKAROV, D.KH. SRUROV AND E.A. ERIN. Sov. J. Radiochemistry 32 (1990) 425  
(Experimental relative LX-ray emission probabilities.)
- A. RYTZ. At. Data. Nucl. Data Tables 47 (1991) 205  
(Alpha-emission energies.)
- I.M. BAND, M.B. TRZHASKOVSKAYA. At. Data. Nucl. Data Tables 55 (1993) 43  
(Theoretical internal conversion coefficients.)
- P.N. JOHNSTON, P.A. BURNS. Nucl. Instrum. Methods Phys. Res. A361 (1995) 229  
(Experimental relative LX-ray emission probabilities.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data.)
- J. YANG, J. NIR. Nucl. Instrum. Methods Phys. Res. A413 (1998) 239  
(Alpha-transition probabilities.)
- E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX-ray energies and relative emission probabilities.)
- N.E. HOLDEN, D.C. HOFFMAN. Pure Appl. Chem. 72 (2000) 1525  
(SF half-life)
- F.E. CHUKREEV, V.E. MAKARENKO AND M.J. MARTIN. Nucl. Data Sheets 97 (2002) 129  
(Nuclear data evaluation for A=238.)
- G. AUDI, A.H. WAPSTRA AND C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q value.)









## 1 Decay Scheme

Am-243 decays by emission of alpha particles to Np-239, with a minute branch of 3.8 (7) E-09 % by spontaneous fission.

*L'américium 243 se désintègre par émission alpha vers le neptunium 239. Un faible branchement (3,8 (7) E-09 %) par fission spontanée existe.*

## 2 Nuclear Data

$T_{1/2}(^{243}\text{Am})$	:	7370	(17)	a
$T_{1/2}(^{239}\text{Np})$	:	2,355	(4)	d
$Q^\alpha(^{243}\text{Am})$	:	5438,8	(10)	keV

### 2.1 $\alpha$ Transitions

	Energy keV	Probability $\times 100$	F
$\alpha_{0,16}$	4774 (3)	0,0017 (5)	7,2
$\alpha_{0,15}$	5001 (3)	0,000085	5400
$\alpha_{0,14}$	5013 (3)	0,00018	3000
$\alpha_{0,13}$	5029 (3)	0,00034	2000
$\alpha_{0,12}$	5081 (3)	0,0018 (4)	900
$\alpha_{0,11}$	5092 (3)	0,0018	
$\alpha_{0,10}$	5113 (3)	0,0039 (6)	700
$\alpha_{0,9}$	5119 (3)	0,0039	
$\alpha_{0,8}$	5173 (5)	0,0055 (6)	1100
$\alpha_{0,7}$	5199 (1)	0,010 (1)	900
$\alpha_{0,6}$	5268 (1)	1,383 (7)	17,7
$\alpha_{0,4}$	5320,9 (10)	11,46 (5)	4,71
$\alpha_{0,3}$	5363,6 (10)	86,74 (5)	1,14
$\alpha_{0,1}$	5410 (1)	0,192 (3)	95
$\alpha_{0,0}$	5438,9 (23)	0,240 (3)	1120

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Np})$	31,130 (21)	9,3 (11)	M1 + 0,06% E2		144 (12)	36 (3)	193 (15)
$\gamma_{4,3}(\text{Np})$	43,1	10,5	M1 + 12,6% E2		118 (4)	31,5 (9)	161 (5)
$\gamma_{3,1}(\text{Np})$	43,53 (2)	12,7 (3)	E1	0,868 (26)	0,22 (1)	1,16 (3)	
$\gamma_{6,5}(\text{Np})$	50,62	0,011 (2)	(E1)	0,59 (2)	0,150 (5)	0,783 (20)	
$\gamma_{6,4}(\text{Np})$	55,18	1,51 (44)	M1 + 26,5% E2		65 (19)	18 (5)	89 (26)
$\gamma_{3,0}(\text{Np})$	74,66 (2)	86,0 (16)	E1		0,21 (1)	0,052 (2)	0,28 (1)
$\gamma_{4,1}(\text{Np})$	86,71 (2)	0,41 (1)	E1		0,140 (4)	0,035 (1)	0,19 (1)
$\gamma_{6,3}(\text{Np})$	98,5	0,26 (4)	(E2)		11,5 (3)	3,2 (1)	15,9 (5)
$\gamma_{4,0}(\text{Np})$	117,84 (15)	0,62 (5)	E1		0,064 (2)	0,0160 (5)	0,089 (3)
$\gamma_{6,1}(\text{Np})$	141,90 (6)	0,14 (1)	E1	0,174 (5)	0,040 (1)	0,0097 (3)	0,227 (7)
$\gamma_{7,2}(\text{Np})$	169	0,001	(E1)	0,117 (4)	0,0255 (1)	0,0062 (2)	0,151 (5)
$\gamma_{9,5}(\text{Np})$	195	0,001	(E1)	0,084 (3)	0,0178 (1)	0,0043 (1)	0,108 (3)

## 3 Atomic Data

### 3.1 Np

$$\begin{aligned}\omega_K &: 0,971 (4) \\ \bar{\omega}_L &: 0,511 (20) \\ n_{KL} &: 0,791 (5)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	97,069	62,82
K $\alpha_1$	101,059	100
K $\beta_3$	113,303	}
K $\beta_1$	114,234	}
K $\beta_5''$	114,912	}
		36,21
K $\beta_2$	117,463	}
K $\beta_4$	117,876	}
KO <sub>2,3</sub>	118,429	}
X <sub>L</sub>		
L $\ell$	11,871	
L $\alpha$	13,671 – 13,946	
L $\eta$	15,861	
L $\beta$	16,109 – 17,992	
L $\gamma$	20,784 – 21,491	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	73,501 – 83,134	100
KLX	90,358 – 101,054	60,2
KXY	107,19 – 118,66	9,06
Auger L		
	6,04 – 13,52	

## 4 $\alpha$ Emissions

	Energy keV	Probability $\times 100$
$\alpha_{0,16}$	4695 (3)	0,0017 (5)
$\alpha_{0,15}$	4919 (3)	0,000085
$\alpha_{0,14}$	4930 (3)	0,00018
$\alpha_{0,13}$	4946 (3)	0,00034
$\alpha_{0,12}$	4997 (3)	0,0018 (4)
$\alpha_{0,11}$	5008 (3)	0,0018
$\alpha_{0,10}$	5029 (3)	0,0039 (6)
$\alpha_{0,9}$	5035 (3)	0,0039
$\alpha_{0,8}$	5088 (5)	0,0055 (6)
$\alpha_{0,7}$	5113 (1)	0,010 (1)
$\alpha_{0,6}$	5181 (1)	1,383 (7)
$\alpha_{0,4}$	5233,3 (10)	11,46 (5)
$\alpha_{0,3}$	5275,3 (10)	86,74 (5)
$\alpha_{0,1}$	5321 (1)	0,192 (3)
$\alpha_{0,0}$	5349,4 (23)	0,240 (3)

## 5 Electron Emissions

	Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Np) 6,04 - 13,52	23,2 (5)
e <sub>AK</sub>	(Np)	0,00059 (7)
	KLL 73,501 - 83,134	}
	KLX 90,358 - 101,054	}
	KXY 107,19 - 118,66	}

		Energy keV	Electrons per 100 disint.
ec <sub>1,0</sub> L	(Np)	8,713 - 13,530	6,9 (8)
ec <sub>4,3</sub> L	(Np)	20,673 - 25,490	7,67 (26)
ec <sub>3,1</sub> L	(Np)	21,103 - 25,920	5,11 (18)
ec <sub>1,0</sub> M	(Np)	25,401 - 27,476	1,7 (2)
ec <sub>1,0</sub> N	(Np)	29,639 - 30,737	0,47 (5)
ec <sub>6,4</sub> L	(Np)	32,753 - 37,570	1,10 (33)
ec <sub>4,3</sub> M	(Np)	37,361 - 39,436	2,05 (6)
ec <sub>3,1</sub> M	(Np)	37,791 - 39,866	1,30 (6)
ec <sub>4,3</sub> N	(Np)	41,599 - 42,697	0,57 (2)
ec <sub>3,1</sub> N	(Np)	42,029 - 43,127	0,35 (1)
ec <sub>6,4</sub> M	(Np)	49,441 - 51,516	0,30 (9)
ec <sub>3,0</sub> L	(Np)	52,233 - 57,050	14,1 (7)
ec <sub>6,4</sub> N	(Np)	53,679 - 54,777	0,08 (2)
ec <sub>3,0</sub> M	(Np)	68,921 - 70,996	3,49 (15)
ec <sub>3,0</sub> N	(Np)	73,159 - 74,257	0,94 (3)
ec <sub>6,3</sub> L	(Np)	76,073 - 80,890	0,17 (2)
ec <sub>6,3</sub> M	(Np)	92,761 - 94,836	0,05 (1)

## 6 Photon Emissions

### 6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Np)	11,871 — 21,491	17,8 (4)
XK $\alpha_2$	(Np)	97,069	0,0058 (5) } K $\alpha$
XK $\alpha_1$	(Np)	101,059	0,0093 (7) }
XK $\beta_3$	(Np)	113,303	}
XK $\beta_1$	(Np)	114,234	} 0,00338 (26) K' $\beta_1$
XK $\beta_5''$	(Np)	114,912	}
XK $\beta_2$	(Np)	117,463	}
XK $\beta_4$	(Np)	117,876	} 0,00116 (9) K' $\beta_2$
XKO <sub>2,3</sub>	(Np)	118,429	}

## 6.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Np})$	31,13 (3)	0,048 (4)
$\gamma_{4,3}(\text{Np})$	43,1	0,065
$\gamma_{3,1}(\text{Np})$	43,53 (2)	5,89 (10)
$\gamma_{6,5}(\text{Np})$	50,6	0,0062 (10)
$\gamma_{6,4}(\text{Np})$	55,18	0,0168 (11)
$\gamma_{3,0}(\text{Np})$	74,66 (2)	67,2 (12)
$\gamma_{4,1}(\text{Np})$	86,71 (2)	0,346 (9)
$\gamma_{6,3}(\text{Np})$	98,5	0,0151 (21)
$\gamma_{4,0}(\text{Np})$	117,60 (15)	0,57 (5)
$\gamma_{6,1}(\text{Np})$	141,90 (6)	0,115 (8)
$\gamma_{7,2}(\text{Np})$	169	0,0012
$\gamma_{9,5}(\text{Np})$	195	0,00085

## 7 Main Production Modes

Multiple neutron capture from Pu – 239()

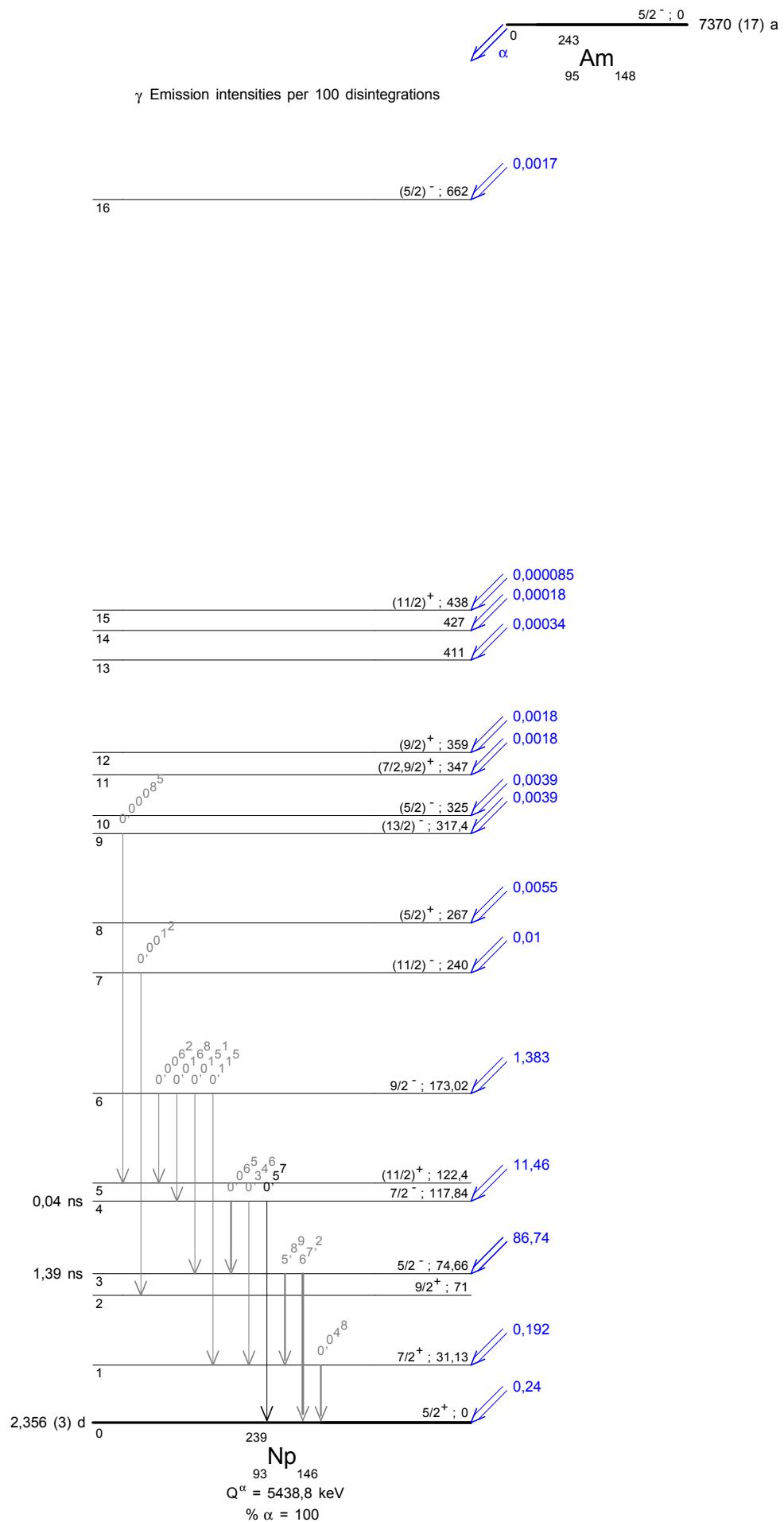
Multiple neutron capture from U – 238()

## 8 References

- F. STEPHENS, J. HUMMEL, F. ASARO. Phys. Rev. 98 (1955) 261  
(Am-243 alpha-particle emission probabilities.)
- J.P. HUMMEL. Thesis. Univ. of California - UCRL-3456 (1956)  
(Am-243 alpha-particle emission probabilities.)
- R.F. BARNES, D.J. HENDERSON, A.L. HARKNESS, H. DIAMOND. J. Inorg. Nucl. Chem. 9 (1959) 105  
(Am-243 half-life.)
- F. ASARO, F.S. STEPHENS, J.M. HOLLANDER, I. PERLMAN. Phys. Rev. 117 (1960) 492  
(Am-243 gamma-ray emission probabilities.)
- A.B. BEADLE, D.F. DANCE, K.M. GLOVER, J. MILSTED. J. Inorg. Nucl. Chem. 12 (1960) 359  
(Am-243 half-life.)
- S.A. BARANOV, V.M. KULAKOV, V.M. SHATINSKY. Nucl. Phys. 56 (1964) 252  
(Am-243 alpha-particle energies and emission probab)
- B.A. GOVDEV, B.B. ZAKHVATAEV, V.I. KUZNETSOV, V.P. PERELYGIN, S.V. PIROZKOV, E.G. CHUDINOV, I.K. SHVETSOV. Sov. Radiochem. 8 (1966) 459  
(Spontaneous fission branching)
- C.M. LEDERER, J.K. POGGENBURG, F. ASARO, J.O. RASMUSSEN, I. PERLMAN. Nucl. Phys. 84 (1966) 481  
(Am-243 alpha-particle emission probabilities.)
- J.R. VAN HISE, D. ENGELKEMEIR. Phys. Rev. 171 (1968) 1325  
(Am-243 gamma-ray energies and emission probabilities.)
- S.A. BARANOV, V.M. KULAKOV, V.M. SHATINSKII. Sov. J. Nucl. Phys. 7 (1968) 442  
(Am-243 alpha-particle energies.)
- G. BERZINS, M.E. BUNKER, J.W. STARNER. Nucl. Phys. A114 (1968) 512  
(Am-243 half-life.)
- D. ENGELKEMEIR. Phys. Rev. 181 (1969) 1675  
(Am-243 gamma-ray energies.)

- B.M. ALEKSANDROV, O.I. GRIGOREV, N.S. SHIMANSKAYA. Soviet J. Nucl. Phys. 10 (1970) 8  
(Am-243 gamma-ray emission probabilities.)
- I. AHMAD, M. WAHLGREN. Nucl. Instrum. Methods 99 (1972) 333  
(Am-243 gamma-ray emission probabilities.)
- V.G. POLYUKOV, G.A. TIMOFEEV, P.A. PRIVALOVA, V.Y. GABESKIRIYA, A.P. CHETVERIKOV. Sov. At. Energ. 37 (1975) 1103  
(Am-243 half-life.)
- J.C. PATE, K.R. BAKER, R.W. FINK, D.A. MCCLURE, N.S. KENDRICK JR.. Z. Phys. A272 (1975) 169  
(Am-243 gamma-ray energies and emission probabilities.)
- D.I. STAROZHUKOV, Y.S. POPOV, P.A. PRIVALOVA. Sov. At. Energy 42 (1977) 355  
(Am-243 gamma-ray emission probabilities.)
- F.P. LARKINS. At. Data Nucl. Data Tables 20 (1977) 311  
(Atomic electron binding energies.)
- F. RÖSEL, H.M. FRIES, K. ALDER, H.C. PAULI. At. Data Nucl. Data Tables 21 (1978) 92  
(gamma-ray theoretical internal conversion coefficients.)
- Y.S. POPOV, D.I. STAROZHUKOV, V.B. MISHENEV, P.A. PRIVALOVA, A.I. MISHCHENKO. Sov. At. Energy 46 (1979) 123  
(Am-243 gamma-ray emission probabilities.)
- S.K. AGGARWAL, A.R. PARAB, H.C. JAIN. Phys. Rev. C22 (1980) 767  
(Am-243 half-life.)
- I. AHMAD. Nucl. Instrum. Methods 193 (1982) 9  
(Am-243 gamma-ray energies and emission probabilities.)
- R. VANINBROUKX, G. BORTELS, B. DENECKE. Int. J. Appl. Radiat. Isotop. 35 (1984) 1081  
(Am-243 gamma-ray emission probabilities.)
- W.L. ZIJP. Report ECN FYS/RASA-85/19 (1985)  
(Discrepant Data - Limited Relative Statistical Weight Method.)
- A. LORENZ. IAEA Tech. Rept. Ser. 261 (1986)  
(Am-243 recommended half-life.)
- E. BROWNE. Nucl. Instrum. Methods Phys. Res. A265 (1988) 541  
(Uncertainties in alpha-particle emission probabilities.)
- W. BAMBYNEK, T. BARTA, R. JEDLOVSZKY, P. CHRISTMAS, N. COURSOL, K. DEBERTIN, R.G. HELMER, A.L. NICHOLS, F.J. SCHIMA, Y. YOSHIZAWA. IAEA-TECDOC-619 (1991)  
(Am-243 recommended half-life.)
- A. RYTZ. At. Data Nucl. Data Tables 47 (1991) 205  
(Am-243 alpha-particle energies.)
- E. GARCIA-TORANO, M.L. ACENA, G. BORTELS, D. MOUCHEL. Nucl. Instrum. Methods Phys. Res. A312 (1992) 317  
(Am-243 alpha-particle energies and emission probabilities.)
- Y.A. AKOVALI. Nucl. Data Sheets 66 (1992) 897  
(Am-243 recommended half-life.)
- S.A. WOODS, D.H. WOODS, M.J. WOODS, S.M. JEROME, M. BURKE, N.E. BOWLES, S.E.M. LUCAS, C. PATON. Nucl. Instrum. Methods Phys. Res. A369 (1996) 472  
(Am-243 gamma-ray emission probabilities.)
- A.M. SANCHEZ, P.R. MONTERO, F.V. TOME. Nucl. Instrum. Methods Phys. Res. A369 (1996) 593  
(Am-243 alpha-particle energies and emission probabilities.)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data, X-rays, Auger electrons.)
- D. SARDARI, T.D. MAC MAHON, S.P. HOLLOWAY. Nucl. Instrum. Methods Phys. Res. A369 (1996) 486  
(Am-243 gamma-ray energies and emission probabilities.)
- JICHUN YANG, JIANZHONG NI. Nucl. Instrum. Methods Phys. Res. A413 (1998) 239  
(Alpha emission intensities)
- E. SCHÖNFELD, G. RODLOFF. Report PTB-6.11-98-1, Braunschweig (1998)  
(Auger electron energies.)
- Y.A. AKOVALI. Nucl. Data Sheets 84 (1998) 1  
(Alpha decay. Radius parameter of even-even nuclei.)
- V.M. GOROZHANKIN, N. COURSOL, E.A. YAKUSHEV. ICC99A computer program for interpolating internal conversion coefficients from Hager and Seltzer, R (1999)  
(Internal conversion coefficients.)
- E. SCHÖNFELD, H. JANSSEN. Applied Radiation Isotopes 52 (2000) 595  
(X-ray and Auger electron emission probabilities.)

- F. DAYRAS. Nucl. Instrum. Methods Phys. Res. A490 (2002) 492  
(Am-243 alpha-particle energies and emission probabilities.)
- R. SAMPATHKUMAR, P.C. KALSI, A. RAMASWAMI. J. Radioanal. Nucl. Chem. 253 (2002) 523  
(Am-243 spontaneous fission branching.)
- G. AUDI, A.H. WAPSTRA, C. THIBAULT. Nucl. Phys. A729 (2003) 337  
(2003 Atomic Mass Adjustment.)
- E. BROWNE. Nucl. Data Sheets 98 (2003) 665  
(Evaluated data (ENSDF) for nuclei with A=239.)





## 1 Decay Scheme

Cm-244 decays 100% by alpha transitions to Pu-240 and by spontaneous fission with branching fraction of 1.36 (1) E-4 %.

*Le curium 244 se désintègre par émission alpha et par fission spontanée dans une proportion de 1,36 (1) E-4%.*

*Le nombre moyen de neutrons émis par fission spontanée est de 2,731 (20).*

*Le nombre de neutrons émis pour 100 désintégrations de Cm-244 est : 3,71 (5) E-4%.*

## 2 Nuclear Data

$T_{1/2}(^{244}\text{Cm})$	:	18,11	(3)	a
$T_{1/2}(^{240}\text{Pu})$	:	6561	(7)	a
$Q^\alpha(^{244}\text{Cm})$	:	5901,74	(5)	keV

### 2.1 $\alpha$ Transitions

	Energy keV	Probability $\times 100$	F
$\alpha_{0,9}$	4963,68 (8)	0,0000047 (11)	33
$\alpha_{0,8}$	5001,42 (7)	0,000050 (5)	5,6
$\alpha_{0,7}$	5041,03 (9)	0,000149 (16)	3,5
$\alpha_{0,6}$	5252,89 (7)	0,0000042 (30)	3100
$\alpha_{0,5}$	5304,40 (7)	0,000055 (9)	500
$\alpha_{0,4}$	5362,2	0,00004	
$\alpha_{0,3}$	5607,42 (6)	0,00352 (18)	512
$\alpha_{0,2}$	5760,05 (5)	0,0204 (15)	636
$\alpha_{0,1}$	5858,92 (5)	23,3 (4)	1,94
$\alpha_{0,0}$	5901,74 (5)	76,7 (4)	1

## 2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+\text{ce}} \times 100$	Multipolarity	$\alpha_K$	$\alpha_L$	$\alpha_M$	$\alpha_T$
$\gamma_{1,0}(\text{Pu})$	42,824 (8)	23,3 (4)	E2		656 (13)	183 (4)	904 (18)
$\gamma_{2,1}(\text{Pu})$	98,860 (13)	0,0240 (15)	E2		12,06 (24)	3,44 (7)	16,6 (3)
$\gamma_{3,2}(\text{Pu})$	152,63 (2)	0,00356 (18)	(E2)	0,189 (4)	1,66 (3)	0,465 (9)	2,48 (5)
$\gamma_{4,3}(\text{Pu})$	202,4	0,00004	(E2)	0,144 (3)	0,486 (10)	0,135 (3)	0,813 (16)
$\gamma_{8,6}(\text{Pu})$	251,47 (6)	0,0000121 (24)	(E1)	0,0476 (10)	0,00982 (20)	0,00239 (5)	0,0606 (12)
$\gamma_{7,5}(\text{Pu})$	263,37 (8)	0,000065 (10)	(E1)	0,0430 (9)	0,00880 (18)	0,00214 (4)	0,0547 (11)
$\gamma_{9,6}(\text{Pu})$	289,21 (7)	0,0000006 (3)	E2+M3				
$\gamma_{8,5}(\text{Pu})$	302,98 (6)	0,0000200 (31)	(E1)	0,0318 (7)	0,00636 (13)	0,00154 (3)	0,0403 (8)
$\gamma_{9,5}(\text{Pu})$	340,72 (7)	0,0000019 (9)					
$\gamma_{6,2}(\text{Pu})$	507,16 (5)	0,0000088 (28)	(E1)	0,01124 (23)	0,00208 (4)	0,00050 (1)	0,01423 (29)
$\gamma_{5,1}(\text{Pu})$	554,52 (4)	0,000088 (11)	(E1)	0,00949 (19)	0,00174 (4)	0,000417 (9)	0,01179 (24)
$\gamma_{5,0}(\text{Pu})$	597,34 (4)	0,000054 (7)	(E1)	0,00826 (17)	0,00150 (3)	0,000359 (7)	0,01024 (21)
$\gamma_{6,1}(\text{Pu})$	606,03 (4)	0,0000081 (14)					
$\gamma_{8,2}(\text{Pu})$	758,63 (5)	0,0000141 (20)	(E2)	0,0148 (3)	0,00473 (9)	0,001211 (24)	0,0211 (4)
$\gamma_{7,1}(\text{Pu})$	817,89 (7)	0,000069 (9)	(E2)	0,0130 (3)	0,00389 (8)	0,000989 (20)	0,0182 (4)
$\gamma_{8,1}(\text{Pu})$	857,50 (4)	0,0000057 (8)					
$\gamma_{7,0}(\text{Pu})$	860,71 (7)	0,0000082 (20)	(E0)				
$\gamma_{9,1}(\text{Pu})$	895,24 (6)	0,0000018 (6)	E1+M2				
$\gamma_{8,0}(\text{Pu})$	900,32 (4)	0,0000013 (6)					
$\gamma_{9,0}(\text{Pu})$	938,06 (6)	0,0000004 (4)					

## 3 Atomic Data

### 3.1 Pu

$$\begin{aligned}\omega_K &: 0,971 \quad (4) \\ \bar{\omega}_L &: 0,521 \quad (20) \\ \bar{\omega}_M &: 0,0555 \quad (5) \\ n_{KL} &: 0,790 \quad (5)\end{aligned}$$

#### 3.1.1 X Radiations

	Energy keV	Relative probability
X <sub>K</sub>		
K $\alpha_2$	99,525	63,17
K $\alpha_1$	103,734	100
K $\beta_3$	116,244	}
K $\beta_1$	117,228	}
K $\beta_5''$	117,918	}
		36,36
K $\beta_2$	120,54	}
K $\beta_4$	120,969	}
KO <sub>2,3</sub>	121,543	12,61

	Energy keV	Relative probability
X <sub>L</sub>		
L $\ell$	12,125	
L $\alpha$	14,083 – 14,279	
L $\eta$	16,334	
L $\beta$	16,499 – 19,331	
L $\gamma$	20,708 – 21,984	

### 3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	75,263 – 85,357	100
KLX	92,607 – 103,729	60,6
KXY	109,93 – 121,78	9,18
Auger L	6,1 – 22,9	

## 4 $\alpha$ Emissions

	Energy keV	Probability $\times 100$
$\alpha_{0,9}$	4882,12 (8)	0,0000047 (11)
$\alpha_{0,8}$	4919,24 (7)	0,000050 (5)
$\alpha_{0,7}$	4958,20 (9)	0,000149 (16)
$\alpha_{0,6}$	5166,58 (7)	0,0000042 (30)
$\alpha_{0,5}$	5217,24 (7)	0,000055 (9)
$\alpha_{0,4}$	5315,3	0,00004
$\alpha_{0,3}$	5515,29 (6)	0,00352 (18)
$\alpha_{0,2}$	5665,41 (5)	0,0204 (15)
$\alpha_{0,1}$	5762,65 (5)	23,3 (4)
$\alpha_{0,0}$	5804,77 (5)	76,7 (4)

## 5 Electron Emissions

		Energy keV	Electrons per 100 disint.
e <sub>AL</sub>	(Pu)	6,1 - 22,9	8,1 (4)
e <sub>AK</sub>	(Pu)		0,0000059 (6)
	KLL	75,263 - 85,357	}
	KLX	92,607 - 103,729	}
	KXY	109,93 - 121,78	}
ec <sub>1,0 T</sub>	(Pu)	19,70 - 39,05	23,3 (8)
ec <sub>1,0 L</sub>	(Pu)	19,720 - 24,767	16,9 (6)
ec <sub>1,0 M</sub>	(Pu)	36,891 - 39,049	4,72 (16)

## 6 Photon Emissions

### 6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(Pu)	12,125 — 21,984	8,77 (6)
XK $\alpha_2$	(Pu)	99,525	0,000059 (5) } K $\alpha$
XK $\alpha_1$	(Pu)	103,734	0,000094 (5) }
XK $\beta_3$	(Pu)	116,244	}
XK $\beta_1$	(Pu)	117,228	} 0,0000341 (17) K' $\beta_1$
XK $\beta_5''$	(Pu)	117,918	}
XK $\beta_2$	(Pu)	120,54	}
XK $\beta_4$	(Pu)	120,969	} 0,0000116 (6) K' $\beta_2$
XKO <sub>2,3</sub>	(Pu)	121,543	}

### 6.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}(\text{Pu})$	42,824 (8)	0,0258 (7)
$\gamma_{2,1}(\text{Pu})$	98,860 (13)	0,00136 (9)

	Energy keV	Photons per 100 disint.
$\gamma_{3,2}(\text{Pu})$	152,63 (2)	0,00102 (5)
$\gamma_{4,3}(\text{Pu})$	202,4	0,000022
$\gamma_{8,6}(\text{Pu})$	251,47 (6)	0,0000114 (23)
$\gamma_{7,5}(\text{Pu})$	263,37 (8)	0,000062 (9)
$\gamma_{9,6}(\text{Pu})$	289,21 (7)	0,0000006 (3)
$\gamma_{8,5}(\text{Pu})$	302,98 (6)	0,000019 (3)
$\gamma_{9,5}(\text{Pu})$	340,72 (7)	0,0000018 (9)
$\gamma_{6,2}(\text{Pu})$	507,16 (5)	0,0000087 (28)
$\gamma_{5,1}(\text{Pu})$	554,52 (4)	0,000087 (11)
$\gamma_{5,0}(\text{Pu})$	597,34 (4)	0,000053 (7)
$\gamma_{6,1}(\text{Pu})$	606,03 (4)	0,0000081 (14)
$\gamma_{8,2}(\text{Pu})$	758,63 (5)	0,0000138 (19)
$\gamma_{7,1}(\text{Pu})$	817,89 (7)	0,000068 (9)
$\gamma_{8,1}(\text{Pu})$	857,50 (4)	0,0000057 (8)
$\gamma_{9,1}(\text{Pu})$	895,24 (6)	0,0000018 (6)
$\gamma_{8,0}(\text{Pu})$	900,32 (4)	0,0000013 (6)
$\gamma_{9,0}(\text{Pu})$	938,06 (6)	0,0000004 (4)

## 7 Main Production Modes

Multiple n capture (U – 238,)

Multiple n capture (Pu – 239,)

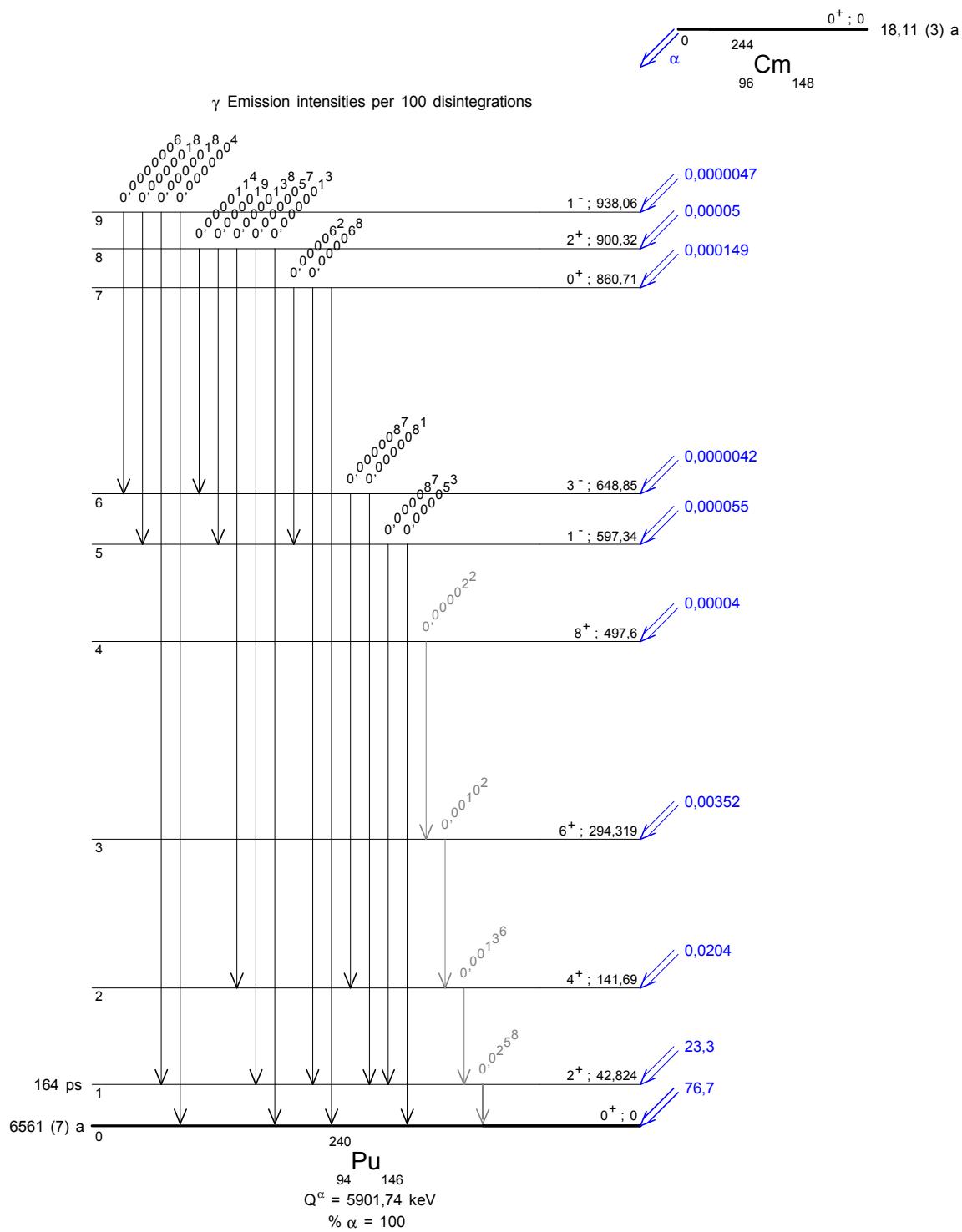
Multiple n capture (Am – 243,)

## 8 References

- A. GHIORSO, G.H. HIGGINS, A.E. LARSH, G.T. SEABORG, S.G. THOMPSON. Phys. Rev. 87 (1952) 163 (SF half-life)
- C.M. STEVENS, M.H. STUDIER, P.R. FIELDS, J.F. MECH, P.A. SELLERS, A.M. FRIEDMAN, H. DIAMOND, J.R. HUIZENGA. Phys. Rev. 94 (1954) 974 (Half-life)
- A.M. FRIEDMAN, A.L. HARKNESS, P.R. FIELDS, M.H. STUDIER, J.R. HUIZENGA. Phys. Rev. 95 (1954) 1501 (Half-life)
- J.P. HUMMEL. Thesis, Univ. California (1956), UCRL-3456 (1956) (alpha-transition probabilities)
- W.G. SMITH, J.M. HOLLANDER. Phys.Rev. 101 (1956) 746 (Conversion electron measurements, gamma ray multipolarities)
- F. ASARO, I. PERLMAN. Priv. Comm. (1960) (1960) (alpha-transition probabilities, alpha-emission energies)
- W.T. CARNALL, S. FRIED, A.L. HARKNESS. J. Inorg. Nuclear Chem., 17 (1961) 12 (Half-life)
- S. BJORNHOLM, C.M. LEDERER, F. ASARO, I. PERLMAN. Phys.Rev. 130 (1963) 2000 (E0 gamma and alpha transition probabilities)

- B.S. DZHELEPOV, R.B. IVANOV, V.G. NEDOVESOV, V.P. CHECHEV. Soviet Phys. JETP 18 (1964) 937  
(alpha-transition probabilities, alpha-emission energies)
- L.Z. MALKIN, I.D. ALKHAZOV, A.S. KRIVOKHATSKII, K.A. PETRZHAK, L.M. BELOV. Soviet J. At. Energy 16 (1964) 170  
(SF half-life)
- D. METTA, H. DIAMOND, R.F. BARNES, J. MILSTED, J. GRAY JR, D.J. HENDERSON, C.M. STEVENS. J. Inorg. Nucl. Chem. 27 (1965) 33  
(SF half-life)
- R.J. ARMANI, R. GOLD. Proc. Symp Stand. of Radionucl., Vienna, 1966, IAEA, Vienna, 1967 (1967) 621  
(SF half-life)
- J.A. BEARDEN. Rev. Mod. Phys. 39 (1967) 78  
(X-ray energies)
- S.A. BARANOV, Y.F. RODIONOV, V.M. KULAKOV, V.M. SHATINSKII. Soviet J. Nucl. Phys. 4 (1967) 798  
(alpha-transition probabilities, alpha-emission energies)
- C.M. LEDERER. Priv. Comm., 1967, quoted in 1978LeZA (1967)  
(Gamma ray energies and probabilities)
- C.L. DUKE, W.L. TALBERT JR. Phys. Rev. 173 (1968) 1125  
(Conversion electron measurements, gamma ray multipolarities)
- W.C. BENTLEY. J. Inorg. Nucl. Chem. 30 (1968) 2007  
(Half-life)
- M. SCHMORAK. Priv. Comm., quoted in Nucl. Data Sheets B4, 661 (1970) (1969)  
(Gamma ray energies and probabilities)
- D.M. BARTON, P.G. KOONTZ. J. Inorg. Nucl. Chem. 32 (1970) 769  
(SF half-life)
- B. GRENNBERG, A. RYTZ. Metrologia 7 (1971) 65  
(Alpha-particle energies)
- I. AHMAD, R.F. BARNES, R.K. SJOBLOM, P.R. FIELDS. J. Inorg. Nucl. Chem. 34 (1972) 3335  
(Gamma ray energies)
- J.D. HASTINGS, W.W. STROHM. J. Inorg. Nucl. Chem. 34 (1972) 3597  
(SF half-life)
- W.J. KERRIGAN, R.S. DORSETT. J. Inorg. Nucl. Chem. 34 (1972) 3603  
(Half-life)
- M. SCHMORAK, C.E. BEMIS, JR., M.J. ZENDER, N.B. GOVE, P.F. DITTNER. Nucl. Phys. A178 (1972) 410  
(Gamma ray energies and probabilities)
- H.J. SPECHT, J. WEBER, E. KONECNY, AND D. HEUNEMANN. Phys. Lett. 41B (1972) 43  
(Level energies)
- C.M. LEDERER, V.S. SHIRLEY, E. BROWNE, J.M. DAIRIKI, R.E. DOEBLER, A.A. SHIHAB-ELDIN, L.J. JARDINE, J.K. TULI, A.B. BUYRN. Table of Isotopes, 7th Ed. J. Willey & Sons, N.-Y., 1978 (1978)  
(Gamma ray energies and probabilities)
- I.M. BAND, M.B. TRZHASKOVSKAYA. Special report of Leningrad nuclear physics institute (1978)  
(Theoretical internal conversion coefficients)
- J.K. DICKENS, J.W. McCONNELL. Phys. Rev. C22 (1980) 1344  
(Experimental X-ray energies)
- H.-C. HSEUH, E.-M. FRANZ, P.E. HAUSTEIN, S. KATEOFF, L.K. PEKER. Phys. Rev. C23 (1981) 1217  
(Gamma ray energies and probabilities)
- G. BARREAU, H.G. BORNER, T. VON EGIDY, R.W. HOFF. Z. Phys. A308 (1982) 209  
(Experimental X-ray energies)
- V.G. POLYUKHOV, G.A. TIMOFEEV, V.V. KALYGIN, P.A. PRIVALOVA. Sov. Radiochem. 24 (1982) 408  
(Half-life)
- P.A. BURNS, P.N. JOHNSTON, AND J.R. MORONEY. Priv. Comm. (1984), quoted in 1986LoZT (1984) 147  
(alpha-transition probabilities)
- J. PEARCEY, S.A. WOODS, P. CHRISTMAS. Nucl. Instrum. Methods Phys. Res. A286 (1990) 563  
(Conversion electron measurements, gamma ray multipolarities)
- YU.S. POPOV, I.B. MAKAROV, D.KH. SRUROV, E.A. ERIN. Cov. J. Radiochemistry 32 (1990) 425  
(Experimental relative LX-ray emission probabilities)
- A. RYTZ. At. Data Nucl. Data Tables. 47 (1991) 205  
(Alpha-emission energies)
- E.A. FROLOV. Appl. Rad. Isotopes 43 (1992) 211  
(Alpha-emission energies)

- I.M.BAND, M.B.TRZHASKOVSKAYA. At. Data and Nucl. Data Tables 55 (1993) 43  
(Theoretical internal conversion coefficients)
- A.K. PANDEY, R.C. SHARMA, P.C. KALSI, R.H. IYER. Nucl. Instrum. Methods Phys. Res. B82 (1993) 151  
(SF half-life)
- P.N. JOHNSTON, P.A. BURNS. Nucl. Instrum. Methods Phys. Res. A361 (1995) 229  
(LX-ray emission probabilities)
- E. SCHÖNFELD, H. JANSSEN. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527  
(Atomic data)
- C.C. BUENO, J.A.C. GONCALVES, M. DAMY DE S.SANTOS. Nucl. Instrum. Methods Phys. Res. A371 (1996) 460  
(Alpha-transition probabilities)
- A.M. SANCHEZ, P.R. MONTERO, F.V. TOME. Nucl. Instrum. Methods Phys. Res. A369 (1996) 593  
(Alpha-transition probabilities)
- J. KASAGI, H. YAMAZAKI, N. KASAJIMA, T. OHTSUKI, H.YUKI. J. Phys.(London) G23 (1997) 1451  
(Alpha-transition probabilities)
- E. GARCIA-TORANO. Appl. Rad. Isotopes 49 (1998) 1325  
(Alpha-transition probabilities, alpha-emission energies)
- J. YANG, J. NI. Nucl. Instrum. Methods Phys. Res. A413 (1998) 239  
(Alpha-transition probabilities)
- E. SCHÖNFELD, G. RODLOFF. PTB-6.11-1999-1999-1, Braunschweig, February 1999 (1999)  
(KX-energies and relative emission probabilities)
- N.E. HOLDEN, D.C. HOFFMAN. Pure Appl. Chem. 72 (2000) 1525  
(Spontaneous fission half-life)
- F. DAYRAS. Nucl. Instrum. Methods Phys. Res. A490 (2002) 492  
(Alpha-transition probabilities)
- G.AUDI, A.H.WAPSTRA, C.THIBAULT. Nucl. Phys. A729 (2003) 337  
(Q value)
- F.E. CHUKREEV, BALRAJ SINGH. Nuclear Data Sheets 103 (2004) 325  
(Decay scheme, 240Pu level energies, gamma ray multipolarities and probabilities)



Reproduction Service  
30, Boulevard Verd-de-Saint-Julien  
92190 MEUDON

Achevé d'imprimer : décembre 2006  
Imprimé en France

ISBN 92-822-2204-7 (set)  
ISBN 92-822-2218-7 (Vol. 3)  
ISBN 92-822-2219-5 (Vol. 3 – CD)