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The Revision of ISO 8529 - Neutron reference radiation fields

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Abstract

ISO Series 8529 provides guidance on neutron metrology for both primary and secondary calibration laboratories. It consists of three parts:

- Part 1: "Characteristics and methods of production" [1];
- Part 2: "Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field" [2];
- Part 3: "Calibration of area and personal dosimeters and determination of response as a function of energy and angle of incidence" [3]

The revised Part 1 was published in November 2021 as a Second Edition [4]. Changes with respect to 2001 version are discussed. Part 3 is currently under revision by ISO TC85/SC2/WG2 and is implementing new spectrum-average conversion coefficients due to the revised spectra in Part 1.

ISO 8529-1: 2021 vs. 2001 editions

Reference radionuclide sources

²⁵²Cf (Annex B) The new spectrum coincides with the ENDF/B-VIII.0 group data above 35 keV (69 groups). Below 35 keV the two groups of the ENDF/B-VIII.0 group data were replaced by 20 groups assembled by re-binning the point data with 3 bins per decade, down to 10 meV. The total number of energy groups is now 89.

- ✓ Fluence-averaged energy unchanged (2.13 MeV);
- ✓ Very little changes in the spectrum.

²⁵²Cf(D₂O) (Annex C) A new spectrum ([5], Fig. 1) was obtained by simulating an idealized assembly formally identical to that assumed by Ing and Cross [6] and reported in ISO 8529-1:2001, but using MCNP6.2 with ENDF/B-VIII.0 cross sections. Recommendation is given in the Standard to characterize each specific assembly as it is constructed.

- ✓ Fluence-averaged energy changed (0.57 MeV (2021) vs. 0.55 MeV (2001));
- ✓ Annex C shows how variations in D₂O purity and construction details may affect the field.

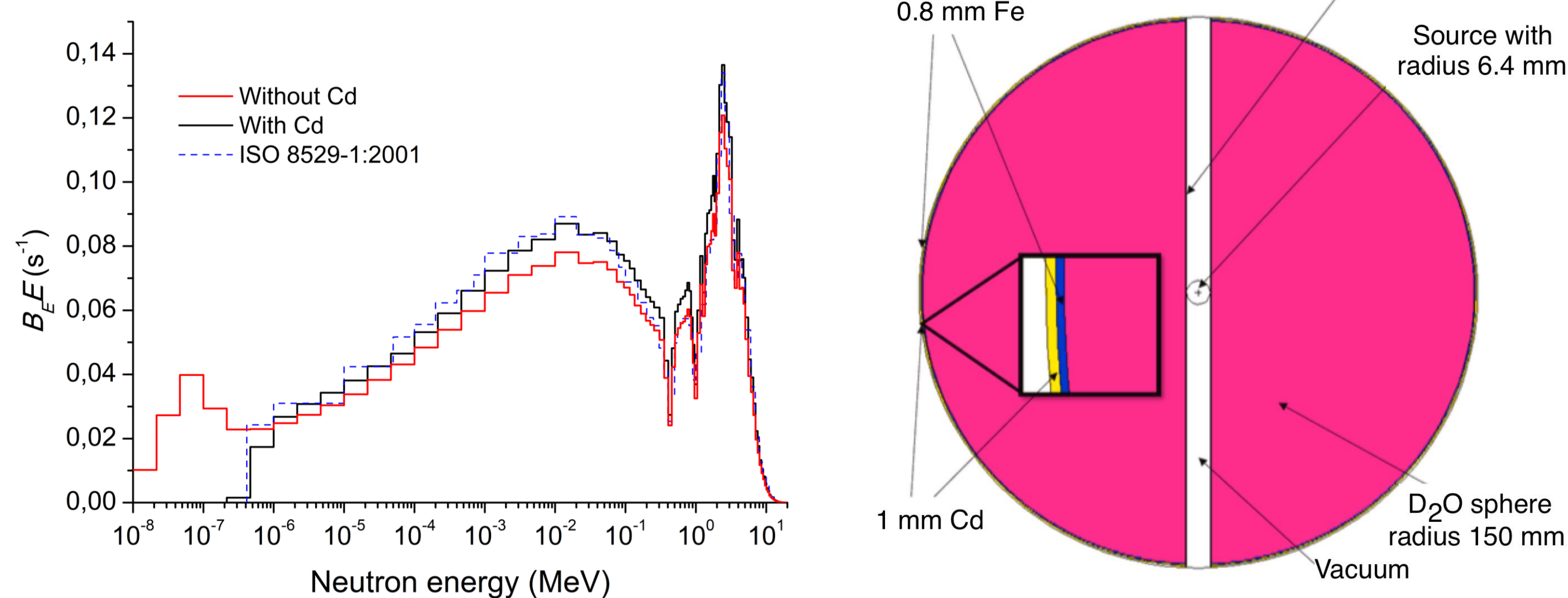


Fig. 1. ²⁵²Cf(D₂O) spectrum and construction.

²⁴¹Am-Be(α,n) (Annex D) Measurements with high-resolution spectrometers combined with Bonner spheres [7] indicate that the spectrum and spectrum-integrated quantities vary slightly as a function of the source encapsulation and amount of active material. It is recommended that the spectrum of any ²⁴¹Am-Be(α,n) source used for calibration should be measured. To facilitate users, two spectral categories have been introduced: "small" (activity typ. 37 GBq) and "large" sources (typ. 370 GBq and 555 GBq) – See Fig. 2.

- ✓ Fluence-averaged energy changed (4.17 MeV "small" and 4.05 MeV "large" vs. 4.16 MeV from 8529-1:2001)
- ✓ Revised photon / neutron $H^*(10)$ ratio: 3.5 % (2001) vs. 5 % (2001).

²⁴¹Am-B(α,n) was eliminated but the Standard says: "sources such as ²⁴¹Am-B(α,n), Pu-Li(α,n), Pu-Be(α,n), ²⁴¹Am-F(α,n), ²⁴¹Am-Li(α,n) and ²⁴⁴Cm are also used but are not addressed specifically in this document".

References

- [1] ISO 8529-1:2001. Neutron reference radiation fields — Part 1: Characteristics and methods of production.
- [2] ISO 8529-2:2000. Reference neutron radiations — Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field
- [3] ISO 8529-3:1998. Reference neutron radiations — Part 3: Calibration of area and personal dosimeters and determination of response as a function of energy and angle of incidence.
- [4] ISO 8529-1:2021. Neutron reference radiation fields — Part 1: Characteristics and methods of production.

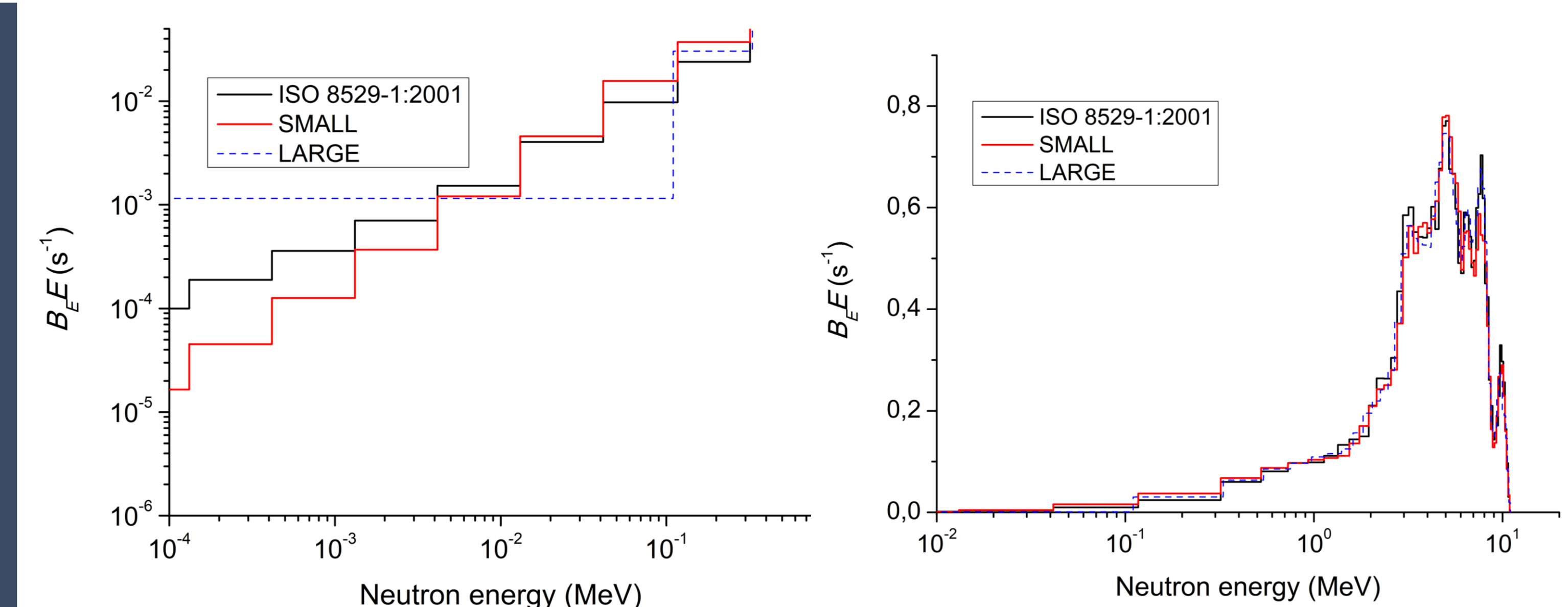


Fig. 2. ²⁴¹Am-Be spectrum: "small", "large" and "8529-1:2001".

Conversion coefficients

The Table shows the impact of the revised ²⁵²Cf and ²⁴¹Am-Be spectra on the fluence to dose equivalent conversion coefficients. Data have been proposed for the revision of ISO 8529-3.

Source	$h_{p\phi}(10;\alpha)$ in pSv cm ²						$h^*_\phi(10)$
	0°	15°	30°	45°	60°	75°	
²⁵² Cf(D ₂ O)	119	118	119	111	95,0	60,6	114
²⁵² Cf	400	397	409	389	346	230	385
²⁴¹ Am-Be "small"	412	410	426	416	385	294	393
²⁴¹ Am-Be "large"	406	404	419	409	377	287	387
²⁴¹ Am-Be 2001	411	409	424	415	383	293	391

Monoenergetic fields

- More recent data on the methods of production were included.
- The following fields were added: 8 keV from ⁴⁵Sc(p,n)⁴⁵Ti; 22.8 keV from ¹²⁴Sb-Be(γ,n); 17 MeV.

MeV	Method of production
0.002	Sc-filtered reactor beam or ⁴⁵ Sc(p,n) ⁴⁵ Ti
0.008	⁴⁵ Sc(p,n) ⁴⁵ Ti
0.024	<ul style="list-style-type: none"> • Fe/Al filtered reactor beam • ⁴⁵Sc(p,n)⁴⁵Ti (0.0274 MeV at 0°, 0.0246 MeV at 35°) • ⁷Li(p,n)⁷Be • 0.0228 MeV from ¹²⁴Sb-Be(γ,n)
0.144	Si-filtered reactor beam or T(p,n) ³ He or ⁷ Li(p,n) ⁷ Be
0.25, 0.565	T(p,n) ³ He and ⁷ Li(p,n) ⁷ Be
1.2, 2.5	T(p,n) ³ He
2.8, 5.0	D(d,n) ³ He
14.8, 17.0, 19.0	T(d,n) ⁴ He

[5] Méndez, R., Gómez-Ros, J.M., Thomas, D.J., Thompson, A. K and Bedogni, R. Rad. Phys. Chem. 2021, 184 109433

[6] Ing, H. and Cross, W.G. Health Phys. 1984, 46 (1) 97–106.

[7] Bedogni, R., Domingo, C., Roberts, N., Thomas, D.J., Chiti, M., Esposito, A., Garcia, M.J., Gentile, A., Liu, Z.Z., De-San-Pedro, M. Nucl. Instrum. Methods. 2014, 763 547–552.