

#### Development and experimental validation of TPS software to determine the dose outside the radiation beam

Igor Bessières, jean-marc bordy, Bénédicte Poumarède

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## **Development and experimental validation of** treatment planning system software to determine the whole-body dose in radiotherapy

energie atomique · energies alternatives

**BESSIERES** Igor <sup>1</sup> BORDY Jean-Marc<sup>2</sup> **POUMAREDE** Bénédicte <sup>3</sup>

UNIVERSITÉ PARIS-SUD 11

EURADOS

CED List

<sup>1</sup>CEA, LIST, DCSI, Laboratoire Modélisation, Simulation et Systèmes, F-91191 Gif-Sur-Yvette, France. <sup>2</sup>CEA, LIST, LNHB, F-91191 Gif-Sur-Yvette, France. <sup>3</sup>CEA, LIST, DCSI, F-91191 Gif-Sur-Yvette, France.

## igor.bessieres@cea.fr

### MOTIVATION

- In the fight against cancers, radiotherapy remains the most powerful and widespread technique.
- Risk of generating second cancers and heart diseases after a first treatment due
- to **x-rays leakages** and **scattered radiations** that depose **out-of-field dose**<sup>1</sup>.
- At the moment, TPS optimize the effectiveness of radiation therapy,



based on dose distributions in the target volume, but the dose distributions to distant organs are not provided.

• It could help the therapist to know the peripheral dose before the treatment in order to predict and **reduce the iatrogenic effects**.

> Our solution: develop a Monte Carlo tool giving the whole-body dose in a reasonable time. The peripheral dose is low and consequently difficult to simulate with a small statistical uncertainty.

## **MATERIAL and METHODS**

#### Code:

- Tool based on the *Penelope*<sup>2</sup> Monte Carlo particle transport code, high accuracy on the dose deposition.
- Calculation of the dose at any part of the patient's body while carrying out treatment planning.
- Implementation of variance reduction techniques to improve the efficiency: better uncertainty for the same simulation time.



#### **Experimental validation:**

On the GE Saturne 43 conventionnal linac on a specific large water tank at 6, 12 and 20 MV with a 10 × 10 cm<sup>2</sup> field at the French Primary Standard Laboratory (done) and an IMRT accelerator on an anthropomorphic phantom (autumn 2011).

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Use of the OSL (Optically Stimulated Luminescence) dosimeters: *Nanodot* from *LCIE Landauer*.

#### **RESULTS**

Measurements and calculations on the *Saturne* 43:

Considering that the ionization chamber dose is the reference value,



**OSL over-estimate the dose** at large distance from the beam centre. It is due to the energy dependence of the dosimeter's response at low energies.

The *Penelope* code fits better (mean error 3 %) with the reference than the MCNPX code (mean error 30 %).

But *Penelope* is too slow and time consuming for a clinical application (26 hours on 108 processors to calculate the dose in the water tank).

Consequently, we need to accelerate the calculation by implementing the Dxtran variance reduction technique.



#### **OSL energy dependence correction:**



Importance of low energy photons far from the field (*Penelope* calculations).

• Implementation of the pseudo deterministic transport variance reduction technique in Penelope (in progress).



Energy spectra in the water tank

After correcting the energy dependence, the OSL dosimeters will give satisfaying results so that they could be used to validate the code in a real IMRT configuration.

Region

of interest

Deterministic

Initial particle

particle (DXTRAM

Non deterministic

particle

(S1)

DXTRAN

Sphere

OUTLOOK



#### REFERENCES

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2. Salvat F, Fernandez-Varea J-M, Acosta E & Sempau J, 2001, PENELOPE - A Code System for Monte Carlo Simulation of Electron and Photon Transport

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