SIMULTANEOUS NEUTRON AND GAMMA IMAGING SYSTEM FOR REAL TIME RANGE AND DOSE MONITORING IN HADRON THERAPY AND OTHER APPLICATIONS

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Hadron therapy in comparison to radiation therapy is able to target the tumor thanks to the maximum dose deposition at the end of the ion trajectory and its finite penetration in matter. However, this methodology faces two important limitations related to real-time (neutron and gamma) dose monitoring and ion-beam range verification which limit the potential benefits of protons over photons.

Compton imaging represents a promising technique for Prompt Gamma (PG) imaging for range verification in hadron therapy (HT) treatments. As for neutron monitoring, a drawback of most of the available systems is that only integral off-field neutron-fluence values are registered but no information is obtained from its spatial origin. In this work we will present GN-Vision, a novel dual gamma-ray and neutron imaging system, which aims at imaging, simultaneously to the PG, the spatial origin of the slow and thermal neutron dose (<10 eV) (see Fig. 1) generated during the treatment. The proposed device can also be of interest for industrial applications as well as in nuclear security.

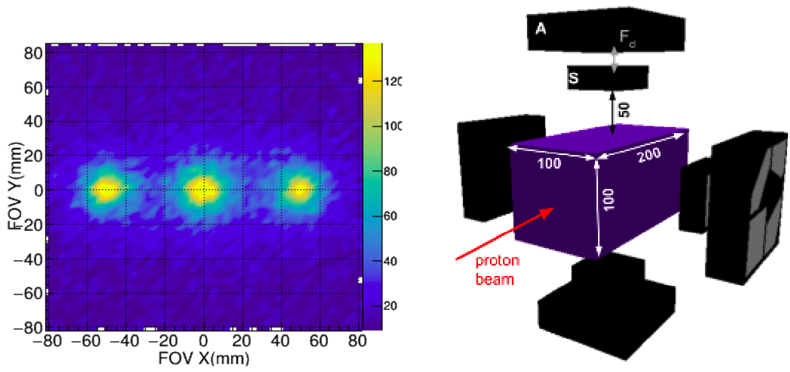

Figure 1. Left: reconstructed image for three isotropic point-like sources of 1 eV neutrons located at 20 cm. Right: Schematic diagram of the simulated geometry, as implemented in the GEANT4 code.

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The GN-Vision system has been designed following the technical developments of the i-TED detector, an array of Compton cameras that have been designed for neutron-capture experiments, in which γ-ray energies span up to 5-6 MeV, similar to the PG produced in HT. This contribution will first review the promising performance of the proposed system for PG imaging in proton therapy, studied on the basis of MC simulations of i-TED (see Fig. 1). The results indicate that this imaging system should be able to reconstruct the distal fall-off of the PG depth distribution with an accuracy of 2-3 mm for proton intensities as low as 10^8 protons, thanks to its high detection efficiency and the use of ML algorithms to compensate for the loss of full-energy events for high energy γ-rays. Then, we will describe the evolution from the i-TED detector towards the GN-Vision system and present the first conceptual results of its simultaneous neutron and gamma-ray imaging capability.