ID de la contribución : **26** Tipo : **Oral contribution (15'+5')**

From MACACO to FALCON: Compton camera prototypes for proton beam range verification

jueves, 22 de febrero de 2024 10:00 (15)

Proton therapy's precision in targeting tumors while minimizing damage to healthy tissues has become increasingly important in clinical settings. However, accurate in-vivo verification of proton beam range is essential due to planning and delivery uncertainties. Compton cameras (CCs) are a promising solution for this challenge.

The IRIS group at IFIC-Valencia has developed two CC prototypes: MACACO III, which uses VATA64HDR16 ASIC readout electronics, and its improved version, MACACOp, equipped with TOFPET2 ASIC. Both prototypes consist of detector modules featuring LaBr3 monolithic scintillation crystals coupled to SiPM arrays. These prototypes underwent extensive laboratory testing and high photon energy characterization [1], [2], as well as practical assessments at the Cyclotron Centre Bronowice (CCB) in Krakow, Poland. Notably, MACACOp demonstrates a significantly improved time resolution of 1.5 ns FWHM compared to MACACO III, a key advancement for effectively discriminating against neutron background [3] and random events [4] in in-vivo proton therapy monitoring.

During measurement campaigns at the CCB, where the IBA Proteus C-235 isochronous cyclotron is employed, both prototypes demonstrated their efficacy by detecting range shifts as small as 2 mm with a 90 MeV proton beam at a 60 pA current [5]. In these conditions, MACACOp outperformed MACACO III, exhibiting reduced saturation and enhanced detection capabilities.

To further enhance the system's performance, particularly in terms of efficiency and high-rate handling, an upgraded version of MACACOp, named FALCON (Fast Medical Applications Compton Camera), was developed. FALCON is a dual-plane CC; the first detector plane mirrors that of MACACOp, while the second plane comprises four secondary detector modules. This new prototype was characterized in laboratory conditions and underwent in-beam testing at the Quirónsalud proton therapy centre in Madrid, Spain.

At Quirónsalud, the IBA S2C2 imposes additional challenges, since it rapidly delivers a high concentration of protons due to its brief duty time [6]. Consequently, to avoid system saturation, the experiments were carried out using lower beam energy and current. Measurements involved irradiating an RW3 phantom with a 70 MeV monoenergetic proton beam, creating well-defined depth-dose curves ("pristine Bragg peaks"), at an instantaneous beam current of 5 nA. To assess the system's capability to detect range shifts under these conditions, the proton beam energy was varied to 79.4 MeV, corresponding to a 10 mm shift in the position of photon emission.

Energy spectra were successfully obtained in Compton mode, and the photon emission distribution at 4.439 MeV generated in the graphite target was retrievable. FALCON effectively detected the range shift, despite the challenging conditions presented by the S2C2 accelerator.

[1] R. Viegas et al., Radiat. Phys. Chem., vol. 202, 2023.
[2] L. Barrientos et al., Radiat. Phys. Chem., vol. 208, 2023.
[3] A. Biegun et al., Radiother Oncol, vol. 102, 2012.
[4] M. Borja-Lloret et al., 2023, submitted.
[5] R. Viegas et al., 2023, in preparation.
[6] J. Van de Walle et al., Cyclotrons2016.

Primary author(s) : VIEGAS, Rita (IFIC (CSIC - U. Valencia))

Co-author(s) : BARRIENTOS MAURIZ, Luis; BORJA-LLORET, Marina (IFIC (University of Valencia-CSIC)); BRZEZINSKI, Karol (IFIC/CSIC); CASAÑA COPADO, Jose Vicente (IFIC); HUESO GONZALEZ, Fernando (IFIC (CSIC - UV)); PÉREZ CURBELO, Javier (IFIC (CSIC-UV)); ROS GARCIA, Ana (IFIC (IFIMED)); ROSER MARTÍNEZ, Jorge (Instituto de Física Corpuscular (IFIC)); LLOSA, Gabriela (IFIC (CSIC-UV))

Presenter(s) : VIEGAS, Rita (IFIC (CSIC - U. Valencia))