Prague, Czech Republic June 21-25, 2021

Contribution ID: **117** Type: **Poster**

#09-117 Progress and prospects of MACACO: a multi-layer Compton camera for range verification in hadron therapy

Thursday, June 24, 2021 4:35 PM (5 minutes)

The detection of prompt gamma-rays exiting the patient during hadron therapy treatments could provide a way to achieve online range verification, which in turn would represent a key step in tumor oncology. However, the desired detector must be able to image gamma-rays from an large source and a broad spectrum in the few MeV region, while dealing with low statistics and low signal to noise ratio. MACACO, the multi-layer Compton Camera currently being developed by the IRIS group at IFIC-Valencia, could be a suitable candidate. It features three continuous LaBr3 scintillator crystals coupled to Silicon Photomultipliers, thus maximizing the efficiency to gamma-rays detection in a compact design.

By using electronic collimation and Compton kinematics, the detector is able to recover the origin position of those incident gamma-rays interacting in any two layer combination, or in all three of them. In addition, the recent developments in software made by the group allow recovering the incident energy of the gamma-rays through spectral reconstruction algorithms, which translates into a four-dimensional imaging capability able to deal with broad gamma-rays spectra where the incident gamma-ray energy is unknown.

The different detection channels can be combined into a joint image reconstruction process, thus having increased efficiencies when compared to conventional Compton cameras. Experimentally, this joint image reconstruction has already proven to yield better quality images of complex structures, such as arrays of radioactive sources. Ongoing simulations indicate that the joint use of all measurement channels could become critical in the correct assessment of the Bragg peak distal fall-off.

The recently assembled MACACO III prototype shows significantly improved performance and is being tested at beam facilities with promising results. An energy resolution of 4.8 % at 662 keV and an angular resolution of 6.0° at 1275 keV have been achieved. In parallel, the MACACOp prototype employing TOFPET2 Petsys ASICs has been also assembled and tested. Such ASIC provides time and energy digitization of signals from each SiPM channel, and preliminary results show an enhanced coincidence time resolution of 2.2 ns (fig. 4). The latter may become a relevant feature in a hadron therapy scenario, where high rates are expected. Further tests of both prototypes in a cyclo-synchrotron facility at clinical intensities are foreseen.

Simulation studies on the background composition expected in a hadron therapy scenario have been driven by the group, and a twofold strategy of background reduction is under investigation. On the one side, a hardware approach through the addition of a silicon layer is under development, which would allow detecting primary background particles as well as escaping Compton electrons that do not fully deposit their energy in the LaBr3 detector. On the other side, a software approach through the development of dedicated neural networks for background rejection has been successfully tested. The latter has already allowed MACACO to detect 3 mm Bragg peak shifts in a proton beam with therapeutic energies, which represents another step towards the final application of the prototype.

Primary authors: ROSER, Jorge (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Mr BARRIENTOS, Luis (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Prof. BERNABÉU, Jose (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Ms BORJA-LLORET, Marina (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Mr CASAÑA, Jose Vicente (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Dr DENDOOVEN, Peter (KVI--Center for Advanced Radiation Technology, University of Groningen, Groningen, The Netherlands.); Dr GARCÍA LÓPEZ, Javier (Centro Nacional de Aceleradores (Universidad de Sevilla, CSIC and Junta de Andalucía), E-41092

Sevilla, Spain; Departamento de Física Atómica, Molecular y Nuclear, Universidad de Sevilla, E-41012 Sevilla, Spain.); Dr HUESO-GONZÁLEZ, Fernando (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Dr JIMÉNEZ-RAMOS, María del Carmen (Centro Nacional de Aceleradores (Universidad de Sevilla, CSIC and Junta de Andalucía), E-41092 Sevilla, Spain.); Dr LACASTA, Carlos (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Mr MARTÍN-LUNA, Pablo (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Dr MUÑOZ, Enrique (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Dr OZOEMELAM, Ikechi (KVI-Center for Advanced Radiation Technology, University of Groningen, Groningen, The Netherlands.); Dr ROS, Ana (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Mr SENRA, César (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Mr SOLAZ, Carles (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Ms VIEGAS, Rita (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia)); Dr LLOSÁ, Gabriela (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia))

Presenter: ROSER, Jorge (Instituto de Física Corpuscular, IFIC (CSIC-U.Valencia))

Session Classification: 09 Environmental and Medical Sciences

Track Classification: 09 Environmental and Medical Sciences