Contribution ID: **14** Type: **Oral contribution**

MACACO imaging system for hadron therapy treatment monitoring.

Wednesday 10 May 2023 12:25 (20 minutes)

The IRIS group of IFIC is developing a system for hadron therapy treatment monitoring through the detection of the photons emitted by the irradiated tissue. The system is composed of three planes of LaBr3 crystals coupled to SiPM arrays and operated in time coincidence. After the successful results obtained with the second prototype, MACACO II, the system performance has been improved.

The performance improvement is carried out through the development of two new prototypes with different characteristics. On one hand MACACO III has improved spatial resolution through the use of new photodetectors, and its three detector planes are operated with a single readout board, the AliVATA readout system driving the VATA64HDR16 ASIC from Ideas. On the other hand, MACACOp employs the TOFPET2 ASIC from PETSys to achieve enhanced timing resolution, dynamic range and readout speed. Improved data analysis through the use of neural networks for event selection, and image reconstruction methods to combine data obtained by the different detector pairs or all three detectors are applied to both prototypes.

The two systems have been tested at the Spanish National Accelerator Centre (CNA, Sevilla) and also in two protontherapy centres. At CNA an 18 MeV proton beam irradiated a graphite target which was moved in 1 mm steps, producing 4.4 MeV photons. Both systems were able to distinguish 1 mm variations in the reconstructed photon distribution produced at different target positions.
In the Krakow protontherapy centre, a solid water (RW3) phantom was irradiated with 90 MeV protons. The energy has been varied to 88.38 and 91.62 MeV in order tp produce +-2 mm range shifts. Also in both cases, such shifts were successfully detected by the system. In the tests at Quironsalud protontherapy centre (Madrid), with a modern accelerator that imposes more challenging conditions, imaging the photon distribution at 70 MeV proton beam was also possible.

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Session Classification: M2: Treatment Monitoring