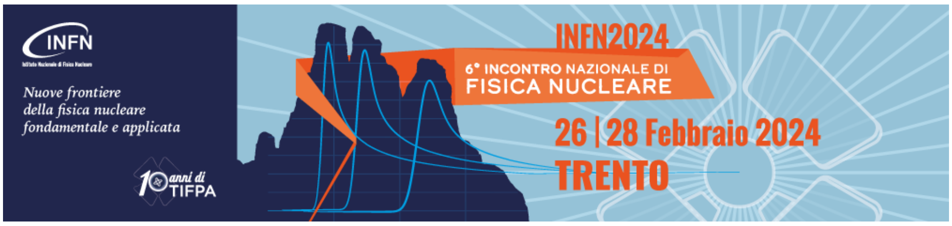

Contribution ID: **111** Type: **Oral**

Primary particles tracking integrated with secondary radiation detectors for next generation of ion beam delivery system

Monday, 26 February 2024 17:35 (20 minutes)

Introduction
Particle therapy relies on the peculiar depth dose deposition, featuring the Bragg peak to reduce the integral dose to healthy tissues. Technological improvements are needed to pursue new beam delivery modalities and develop an online verification system to ensure treatment quality. We propose an innovative beam monitor for particle therapy exploiting a silicon strip detector optimized for single particle tracking, integrated with prompt gamma detectors developed for a Range Verification System (RVS) employing Prompt Gamma Timing (PGT) technique.

Materials and Methods
A 2.7 x 2.7 cm2 silicon detector segmented in strips was developed within the INFN-MoVeIT project characterized by a frontend board named ESA-ABACUS to house six ABACUS chips wire bonded to the 144 consecutive strips featuring 180 um pitch. The ASIC channels identify the particle's crossing signal collected by each strip for a wide charge range (4-150 fC) and provide output digital pulses for each signal discriminated using a threshold.
The secondary radiation detector is based on a cylindrical monolithic Lanthanium Bromide LaBr3(Ce), 1.5 inches in diameter, from Saint Gobain, coupled to a 5x5 squared matrix of RGB Silicon PhotoMultipliers (SiPM) (total area of 24 x 24 mm2), made of microcells of 15 um size, from FBK. Optical grease is used, and the free crystal surfaces are covered by aluminum to increase the collected light. Read out of the 25 SiPM channels is made by a custom front-end board able to analogically sum the contribution of all channels. The analog signal is then amplified and converted into a digital signal using a Constant Fraction Discriminator (CFD) NIM module.
To perform the PGT measurement, the time of transit of each particle into the beam monitor and the time of arrival of each secondary prompt photon have to be precisely measured. Ideally, time resolutions of 50 ps and 100 ps are optimal for the beam monitor and the prompt photon detector, respectively.
The time measurement of each digital pulse from the beam monitor and the secondary particle detector is based on the time-to-digital conversion performed by picoTDC ASIC developed at CERN [Ref]. Moreover, the signal from the secondary radiation detector is used to trigger the acquisition and transfer to the computer only data belonging to the proper time interval, correlated to the trigger event.
The data acquisition and transfer are based on Virtex 7 FPGA and UDP protocol.

Results
The first tests of integration between the ESA_ABACUS and prompt gamma detector were performed first in the laboratory using a pulse generator to simulate the expected output from the strip detector and a radioactive source to generate a signal in the scintillator. Then a preliminary test with the CNAO carbon ion beam was done at a beam energy of 398 MeV/u and clinical intensity (10^8 carbon ions/sec).

Conclusions
A new beam delivery system for particle therapy is in progress within the INFN-SIG project to improve beam monitoring based on silicon detectors able to perform 4D particle tracking (fluence, position, shape, and energy). The timing information is also useful to boost the performance of the in-vivo range verification system based on the PGT technique. Preliminary tests were carried out at CNAO showing the feasibility of obtaining the PGT spectrum at the clinical rate.

Primary authors: MAS MILIAN, Felix (Istituto Nazionale di Fisica Nuclear / Universidade Estadual de Santa Cruz); RANJBAR, Sahar (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); DATA, Emanuele Maria (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); ABUJAMI, Mohammed (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); BERSANI, Davide (Istituto Nazionale di Fisica Nucleare); CERELLO, Piergiorgio (Istituto Nazionale di Fisica Nucleare); DONETTI, Marco (Fondazione CNAO); FADAVI MAZINANI, Mohammad (Istituto Nazionale di Fisica Nucleare); FERRERO, Veronica (Istituto Nazionale di Fisica Nucleare); GARBOLINO, Sara (Istituto Nazionale di Fisica Nucleare); FIORINA, Elisa (Istituto Nazionale di Fisica Nucleare); GALEONE, Cosimo (Istituto Nazionale di Fisica Nucleare); HOSSEINI, Mohammad Amin (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); MONTALVAN OLIVARES, Diango Manuel (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); PENNAZIO, Francesco (Istituto Nazionale di Fisica Nucleare); PULLIA, Marco (CNAO); WERNER, Julius (Institute of Medical Engineering, Universität zu Lübeck); WHEADON, Richard James (Istituto Nazionale di Fisica Nucleare); VIGNATI, Anna (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); CIRIO, Roberto (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); SACCHI, Roberto (Istituto Nazionale di Fisica Nucleare / Università degli studi di Torino); GIORDANENGO, Simona (Istituto Nazionale di Fisica Nucleare)

Presenter: MAS MILIAN, Felix (Istituto Nazionale di Fisica Nuclear / Universidade Estadual de Santa Cruz)

Session Classification: Applications of Nuclear Physics III