25th International Workshop on Radiation Imaging Detectors.

Contribution ID: **175** Type: **Poster**

Experimental LET characterization with Minipix Timepix3 for quality assurance in proton therapy

Wednesday 3 July 2024 14:41 (1 minute)

Purpose
As proton therapy is increasingly more popular around the world, there is a push towards advancement in quality assurance and control procedures that would include radiation quality besides standard physical dose verification. The spectrum of linear energy transfer (LET) of protons can provide comprehensive information on radiation quality in a given voxel. The spectral information and tracking response provided by Timepix detector technology allow for experimental high-resolution LET characterization of single protons [1] in complex and mixed radiation fields. In this work, we applied a Timepix3 detector to characterize proton LET spectra in mixed radiation fields produced in a water-equivalent phantom by clinical proton beams.

Methods
The spectral-sensitive particle tracking technique and the artificial neural network-based particle identification model allow for the experimental characterization of LET for single protons in mixed radiation fields [2, 3]. Here, we used a Minipix Timepix3 detector in Flex configuration (figure 1a) with a 300 µm silicon sensor calibrated with customized DAC settings and operated in data-driven mode. We performed measurements for a homogenous layer irradiated with a 164.6 MeV proton beam behind a solid RW3 phantom (figure 1a) with the detector sensor positioned in the middle of the layer at 45° to the beam direction (figure 1b). We compared deposited energy and LET spectra obtained based on measurements and Monte Carlo (MC) simulations performed with fast, GPU-accelerated FRED MC code [4] and implemented beam model [5].

Results
An accuracy of over 95% was obtained for proton recognition, and a broad spectrum of LET values was observed from a fraction of keV/µm to about ten keV/µm in mixed radiation fields produced by proton beam in water [1, 2]. A good agreement was obtained between measurement and simulation results for both deposited energy and proton LET spectra, as presented in figure 1 c and d, respectively.

Indico rendering error

`Could not include image: [404] Error fetching image`

Figure 1. Measurement setup at CCB IFJ PAN consisting of a solid RW3 phantom with a Minipix Timepix3 Flex detector **(a)**. Calculated (MC simulation) relative dose distribution for a homogenous layer irradiated with a 164.6 MeV proton beam with marked sensor position **(b)**. Comparison of the proton energy deposition **(c)** and LET spectra **(d)** for measurements (blue) and simulations (orange).

Conclusions
Experimental characterization of LET spectra within the clinical setting of proton therapy is needed for quality assurance and control of treatment plans that are optimized with both dose and LET. The Timepix detector provides a unique possibility of tracking individual particles in mixed radiation fields and characterizing proton LET spectra at a given point. The presented approach provides experimental solutions for LET characterization to support advancement in proton therapy treatment planning.

Acknowledgments
Work in CCB IFJ PAN was supported by the National Center for Research and Development (NCBiR) within grant No. LIDER/43/0222/L-12/20/NCBR/2021. Work in Advacam was performed in the frame of Contract No. 4000130480/20/NL/GLC/hh from the European Space Agency.

References

1. C. Granja et al. (2021), NIM-A, vol. 988, pp. 164901
2. P. Stasica et al. (2023), Phys. Med. Biol., vol. 68, no. 10, pp. 104001
3. A. Rucinski et al. (2023), Int. J. Part. Ther., vol. 10 (2), pp. 118-396
4. A. Schiavi et al. (2017), Phys. Med. Biol. vol. 62, no 18, pp. 7482–7504
5. J. Gajewski et al. (2021), Int. J. Part. Ther., vol. 10 (2), pp. 118-396

Authors: Ms STASICA, Paulina (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Dr RUCINSKI, Antoni (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Prof. BORYS, Damian (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland, Silesian University of Technology, Department of Systems Biology and Engineering, Gliwice, Poland); Prof. GRANJA, Carlos (ADVACAM, Research and Development Department, Prague, Czech Republic); Ms DE GREGORIO, Angelica (Dipartimento di Scienze di Base e Applicate per Ingegneria, Sapienza Universita di Roma, Roma, Italy); Prof. KOPEĆ, Renata (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Mr KRZEMPEK, Dawid (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Mr MAREK, Lukas (ADVACAM, Research and Development Department, Prague, Czech Republic, Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic); Dr NGUYEN, Hanh (Baylor University, Electrical and Computer Engineering Department, Waco, United States of America); Dr OANCEA, Cristina (ADVACAM, Research and Development Department, Prague, Czech Republic); Mr RACZYŃSKI, Łukasz (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Dr RYDYGIER, Marzena (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Prof. SCHIAVI, Angelo (Dipartimento di Scienze di Base e Applicate per Ingegneria, Sapienza Universita di Roma, Roma, Italy); Prof. SCHUBERT, Keith (Baylor University, Electrical and Computer Engineering Department, Waco, United States of America); Prof. SCHULTE, Reinhard (Loma Linda University, Loma Linda, CA, United States of America); Mr SUMERA, Maciej (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland); Dr GAJEWSKI, Jan (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland)

Presenter: Ms STASICA, Paulina (The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Cyclotron Centre Bronowice, Krakow, Poland)

Session Classification: Poster Session