Online Bragg Peak monitoring for radiotherapy with ions using pixel sensors

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Overview

The properties of the ^{12}C beam make this ion especially suitable for the treatment of deep seated and radioresistant tumors and tumors close to radiosensitive tissue. One of the main advantages of ions compared to photons is their inverse depth-dose profile (Bragg-Peak). However, the attenuation of the beam and the production of fragments when traversing body tissue, can significantly affect the actual position of the Bragg Peak in the patient. Thus, a method for real-time monitoring of the Bragg-Peak would be highly beneficial for online treatment verification. Tracking the secondary particles induced by the ion beam allows the reconstruction of the dose-depth relation.

Experiments

The MIMOSA-28 (CMOS) is a silicon pixel sensor with a 2 cm^2 sensitive area that showed excellent performances in charged particle tracking [1]. Starting from the detector setup for fragmentation measurements shown before [2], the CMOS can be placed at 60 or 90 degrees with respect to the primary beam direction or immediately after the target. The intersect of the measured tracks is a good estimate for the Bragg-Peak position [3].

Status

The CMOS were successfully tested at Brookhaven National Laboratory (USA) with 1 GeV/u Iron beam.

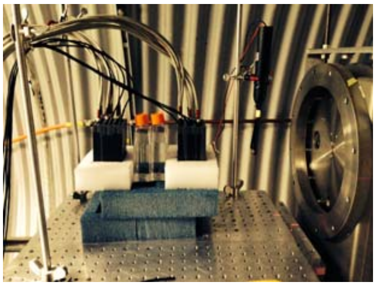

Figure 1: Example of the experimental setup used for 1GeV/u ^{56}Fe at BNL.

In Fig. 2 a map of the single hits on the sensor is shown which reproduce the beam profile.

Fig. 3 shows the different number of pixels fired by different kind of particle species. Some experiments showed a clear dependence of the release energy of the fragments and the pixels/cluster value that can be used to do particle identification.

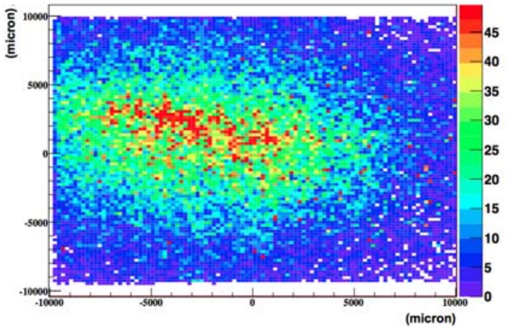

Figure 2: 2D map of the single hits on the CMOS sensor produced by 1GeV/u ^{56}Fe.

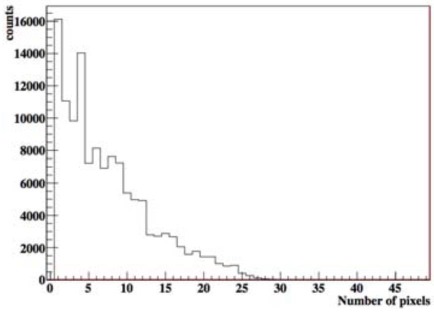

Figure 3: Cluster size distribution for 1 GeV/u ^{56}Fe.

Outlook

The method presented above was verified by experiments using PMMA targets and will be tested with an anthropomorphic phantom in March 2014 at GSI.

References

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[3] L. Piersanti et al., Measurement of charged particles yields from PMMA irradiated by a 220 MeV/u ^{12}C beam, accepted for publication in PMB 2014

* Work is part of HGS-Hire

doi:10.15120/GR-2014-1-BIOPHYSICS-50