GEM detector as beam monitor for hadron beam at National Centre for Oncological Hadron Therapy (CNAO)

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Introduction

The cancer therapy with hadron beam (hadron therapy) is spreading out all around the word due to its efficacy. The Quality Assurance (QA) is a daily task to ensure the right behaviour of the facility. In the framework of ARDENT project we tested detectors as GEM (Gas Electron Multiplier) for the measurement of the quality of the beam. Particularly the paint of a region in the X-Y directions with the beam has been performed. Here the comparison of GEM results and Radiochromic foils obtained during the July campaign are presented

Beam characteristics and GEM set up

	Carbon Beam X-Y scan 2x2 cm^2
Energy (MeV/nucl)	252
Depth in H_2O (mm)	125
Intensity (part/spot)	5e6

Table 1: Beam characteristics

Figure 1: Picture of the GEM set-up

- The X-Y scan cover with an homogeneous dose deposition the scanned area
- 2 GEM[1] detector are been tested as beam monitor in the beam line (figure 1):
  - 2x2 mm^2 pad organised in a circular anode (active area ~3x3 cm^2)
  - 3x6 mm^2 pad organised in a square anode (active area ~5x5 cm^2)
- The radiochromic foils were positioned in front of the GEM

Working point and on line analysis

In a triple GEM detector the gain follow the behavior $G \sim e^{\Sigma V_{GEMi}}$ where V_{GEMi} are the voltages applied to the single GEM foil. The High Voltage (HV) scan over the GEM foils was performed in order to choose the right working point (figure 2).

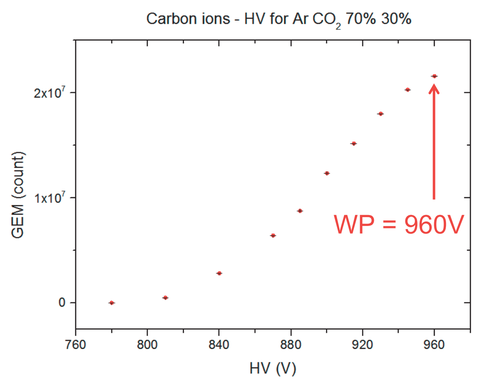

Figure 2: HV scan for carbon ions

The GEM acquisition system [2, 3] can divide an event in 240 slices of 250 ms. In this way the whole paint procedure is recorded with negligible death time [4] and could be reconstructed offline (figure 3). The result of the complete scan procedure is shown in the acquisition program (figure 4 for the 2x2 mm^2 pad anode).

Single treatment spot

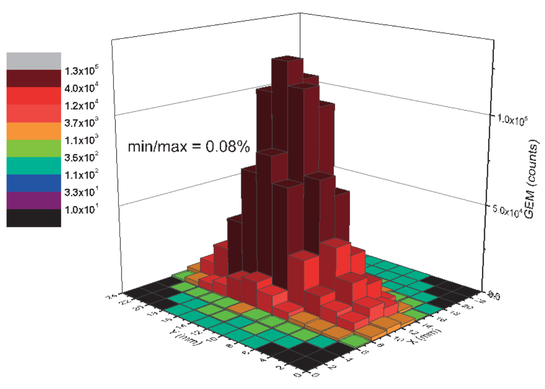

Figure 3: reconstruction of one of the slice during the paint procedure

Real time treatment reconstruction

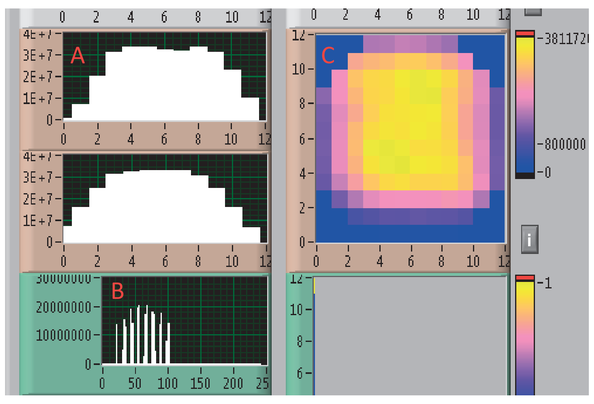

Figure 4: screenshot of part of the acquisition program showing: A horizontal and vertical profile, B timing of the beam, C result of the paint procedure

Comparison between GEM and Radiochromic foils

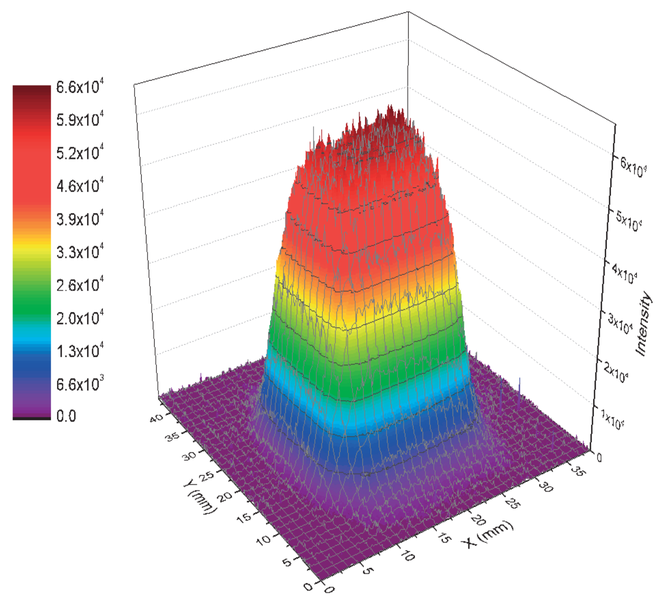

Figure 5: 2x2 cm^2 scan results for radiochromic foil

- Radiochromic foil pixel conversion: 1 pixel = 0.17 mm (figure 5)
- Rebinning of the radiochromic for comparison with the GEM with active area ~5x5 cm^2 (figure 6)
- GEM results are in good agreement with radiochromic foils

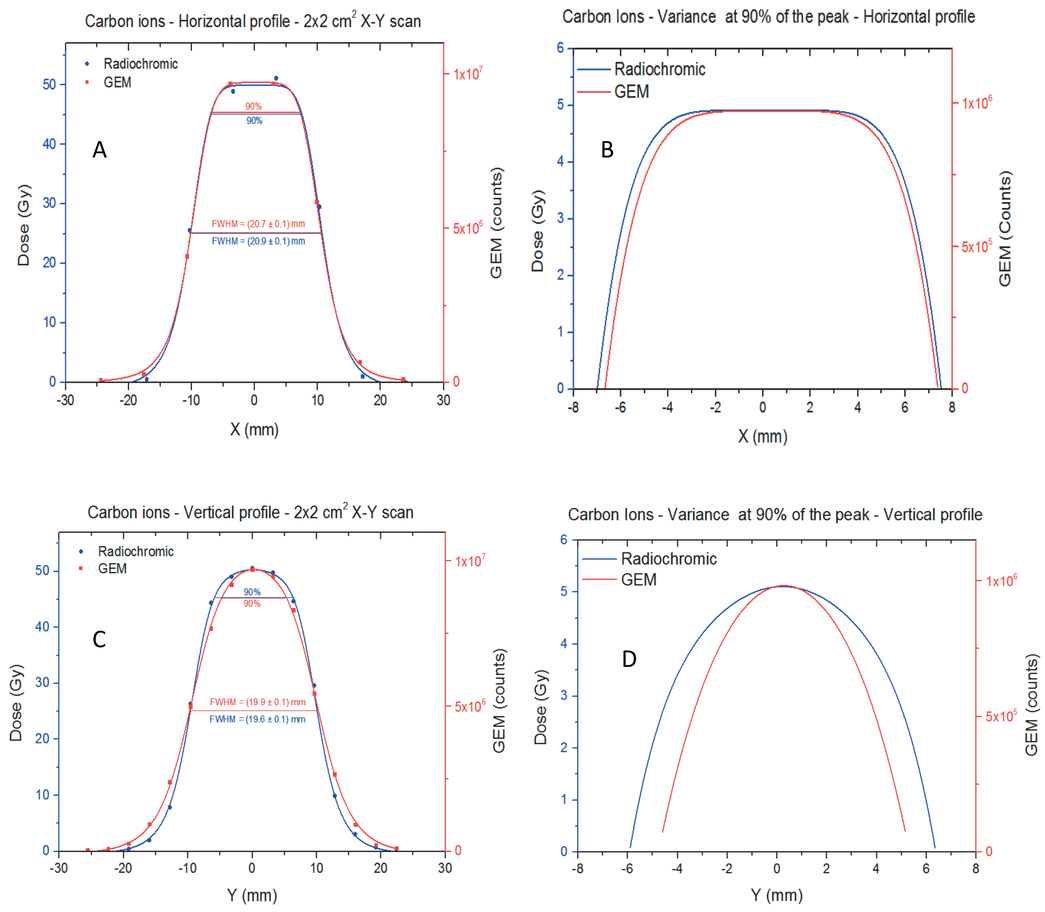

Figure 6: A and B horizontal profile, comparison and variance; C and D vertical profile, comparison and variance

Conclusions and acknowledgements

- The GEM system is able to register and reconstruct the whole paint procedure with negligible death time [4]
- The acquisition system can show online the results of the paint procedure: the horizontal and vertical profiles, the timing of the beam and the intensity in the scanned area
- The offline analysis shows a good agreement with the radiochromic foils
- This results encourage to continue the study of the application of the GEM for the QA procedure (e.g. increasing the spatial resolution)

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References

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