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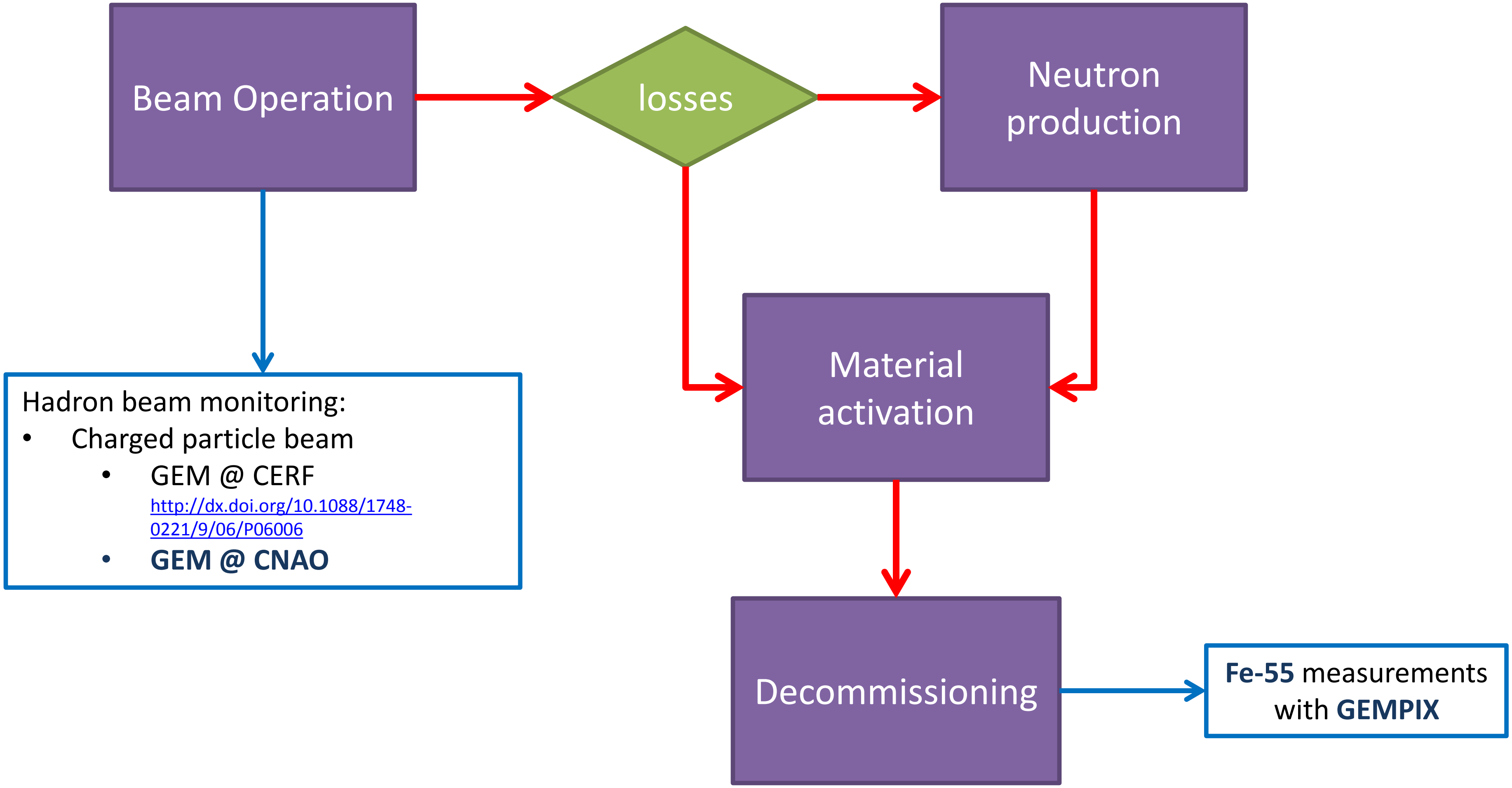
UNIVERSITÄT BERN
AEC ALBERT EINSTEIN CENTER FOR FUNDAMENTAL PHYSICS

ARDENT
Advanced Radiation Dosimetry European Network Training

CERN

A fast overview on my (thesis) subject:



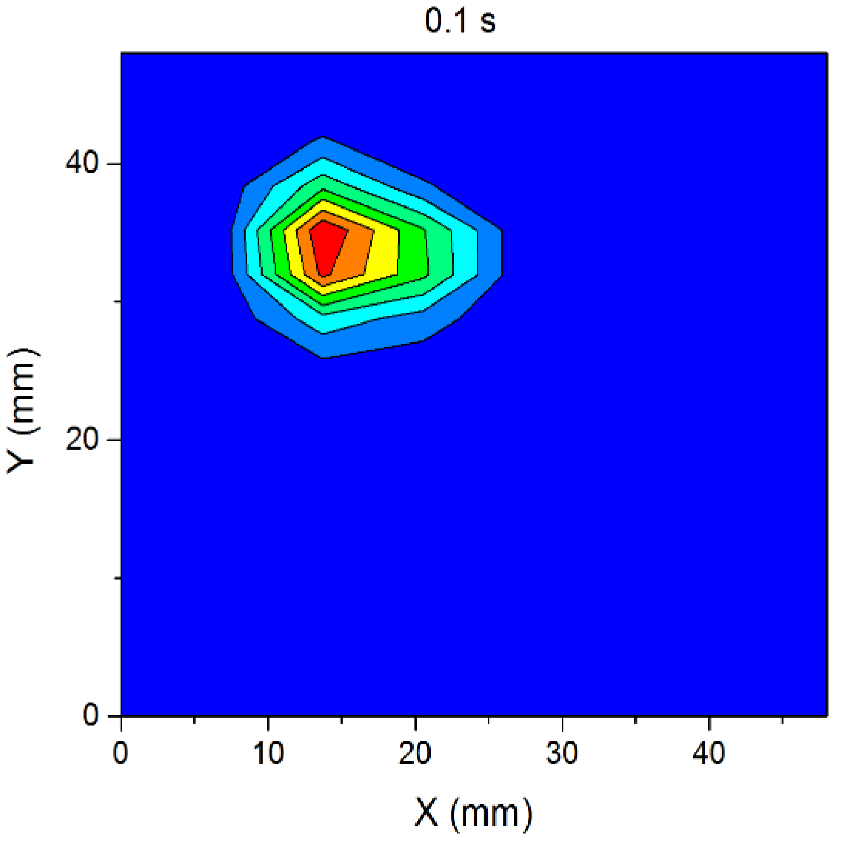
Scientific activity 2014

CNAO MEASUREMENTS

Paint procedure:

- The cancer area is scanned with the hadron beam along the X-Y axis
- The dose is uniform over the treated area
- The scan is possible also in the Z direction (not in this study)

- Offline **Triple GEM [1, 2]** reconstruction of the paint procedure.
- 43 frames of 100 ms.
- **Negligible** dead time [3]

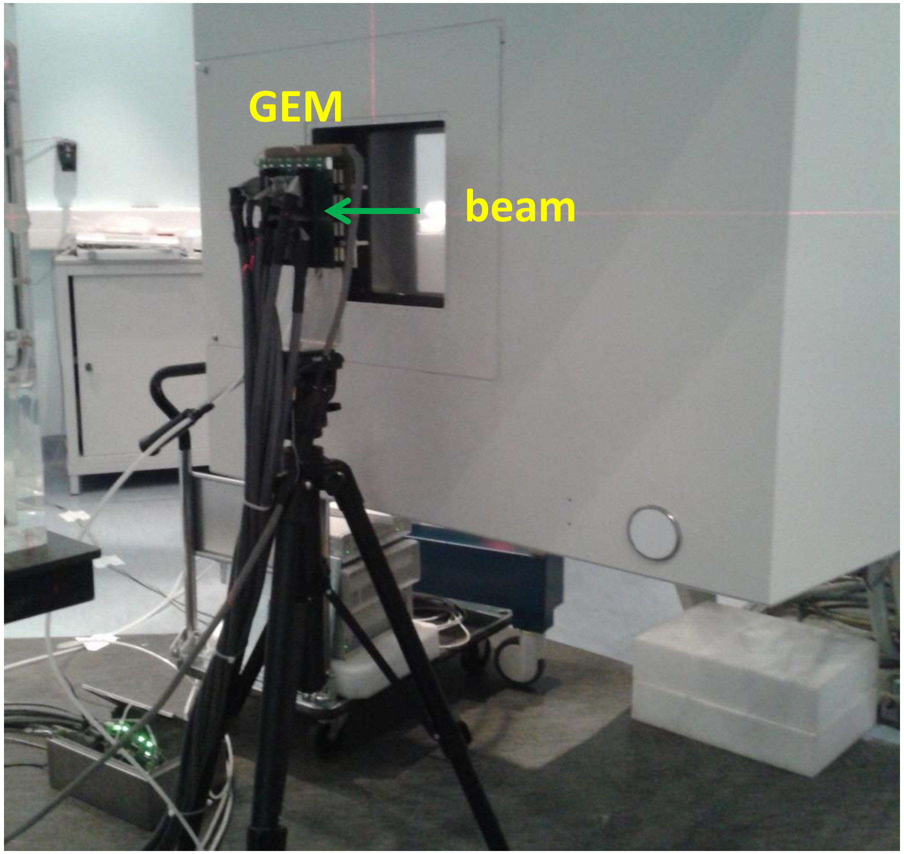


Beam characteristics

	Carbon Beam		Proton Beam
X-Y scanned area (cm^2)	2x2	4x4	2x2
Energy (MeV/nucl)	252	252	132.95
Depth in H_2O (mm)	125	125	125
Intensity (part/spot)	5e6	1e6	1e8

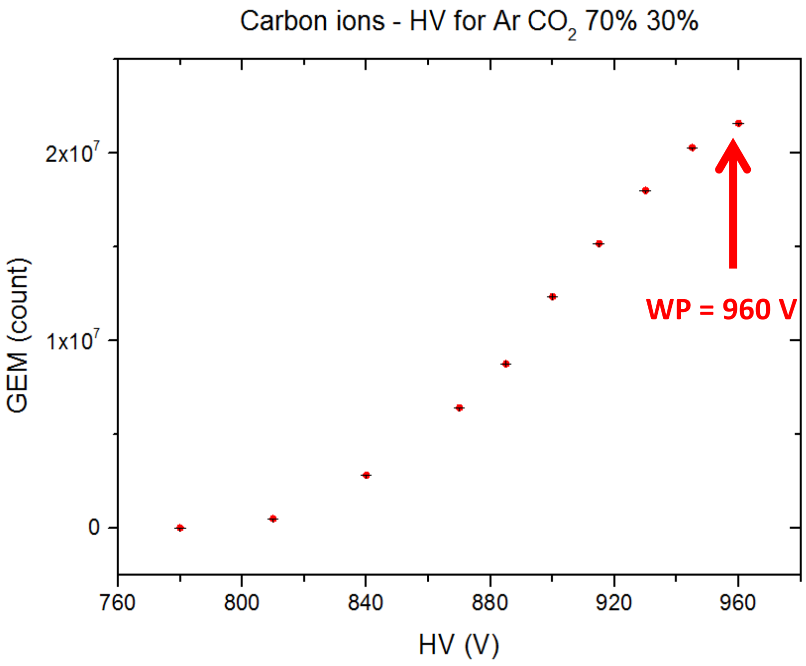
Detectors and set up for CNAO measurements

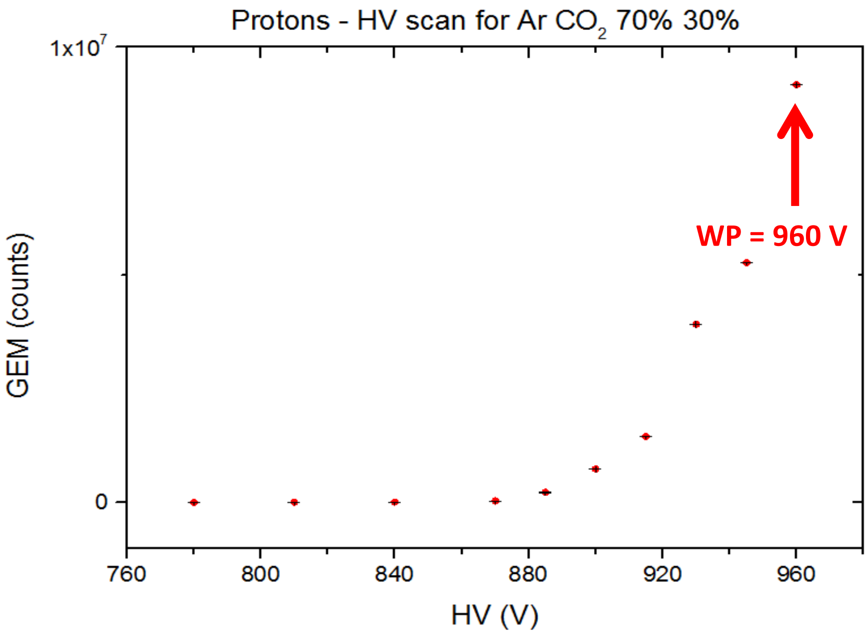
- 2 GEM detector are been tested as beam monitor in the beam line:
  - 2x2 mm^2 pad organised in a circular anode (active area ~3x3 cm^2)
  - 3x6 mm^2 pad organised in a square anode (active area ~5x5 cm^2)
- The radiochromic foils were positioned in front of the GEM



GEM working point (WP)

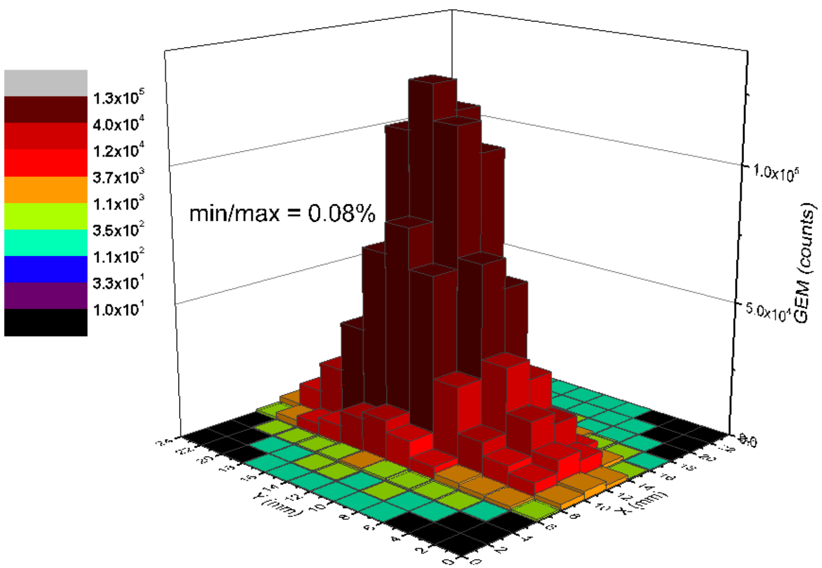
- In a triple GEM detector the gain follows the behaviour: $G \sim e^{\sum V_{GEMi}}$ where V_{GEMi} are the voltages applied to the single GEM foils
- HV scans were performed for carbon and proton beam in order to choose the right WP

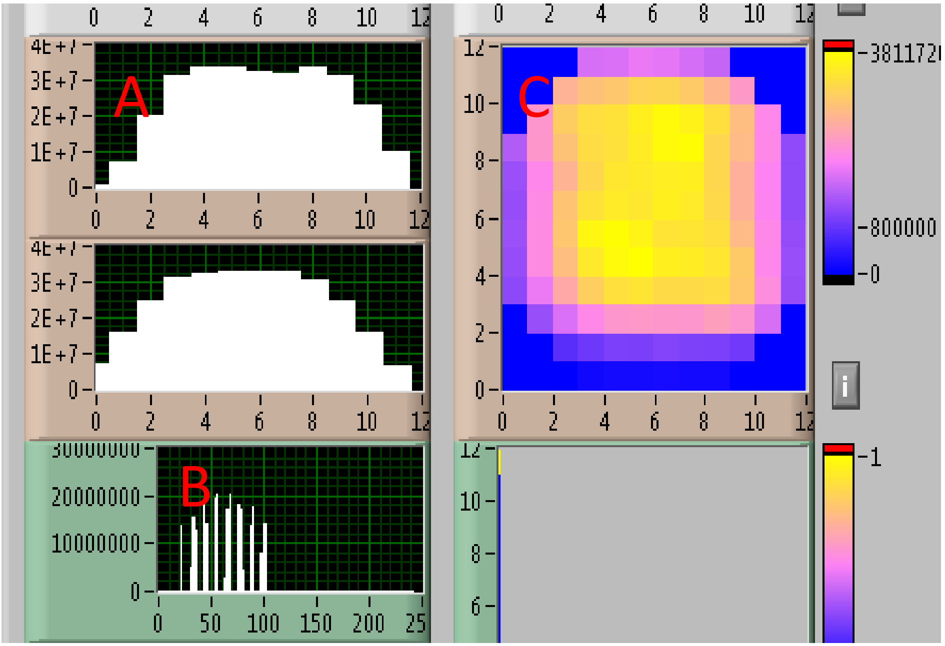


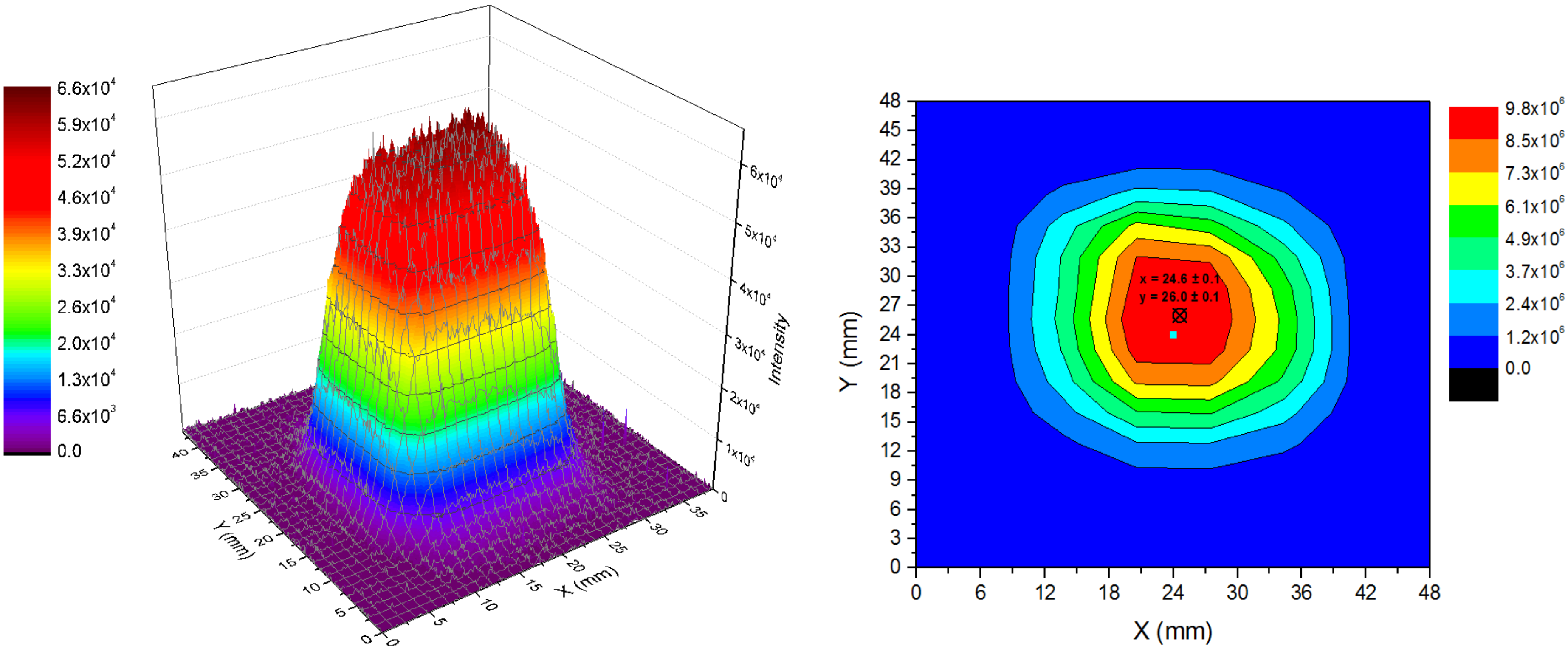


Paint procedure reconstruction with triple GEM

- The paint procedure can be recorded and reconstructed offline through the data acquisition system [4, 5]
- The result of the complete scan procedure is shown in the acquisition program



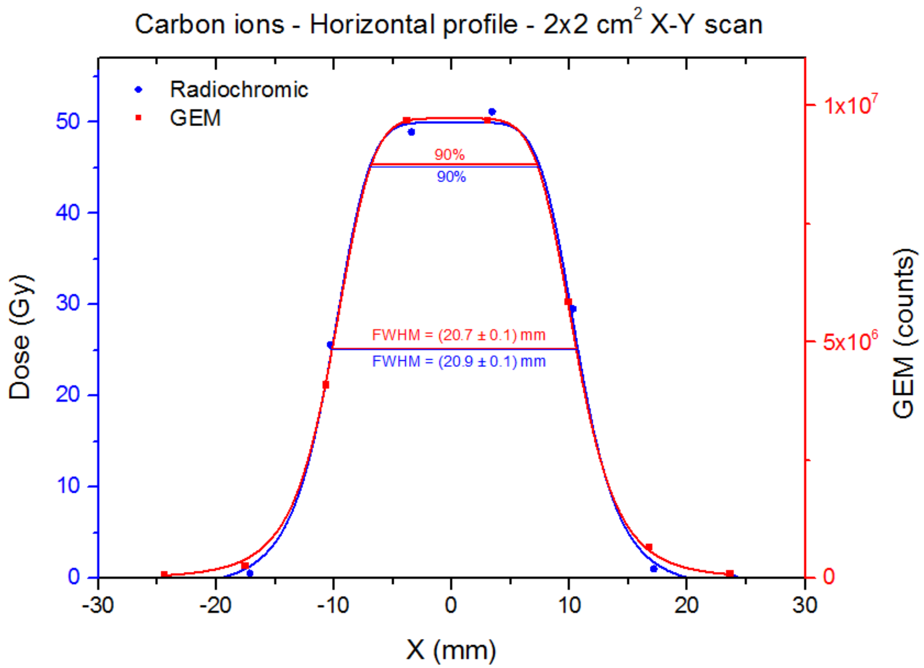


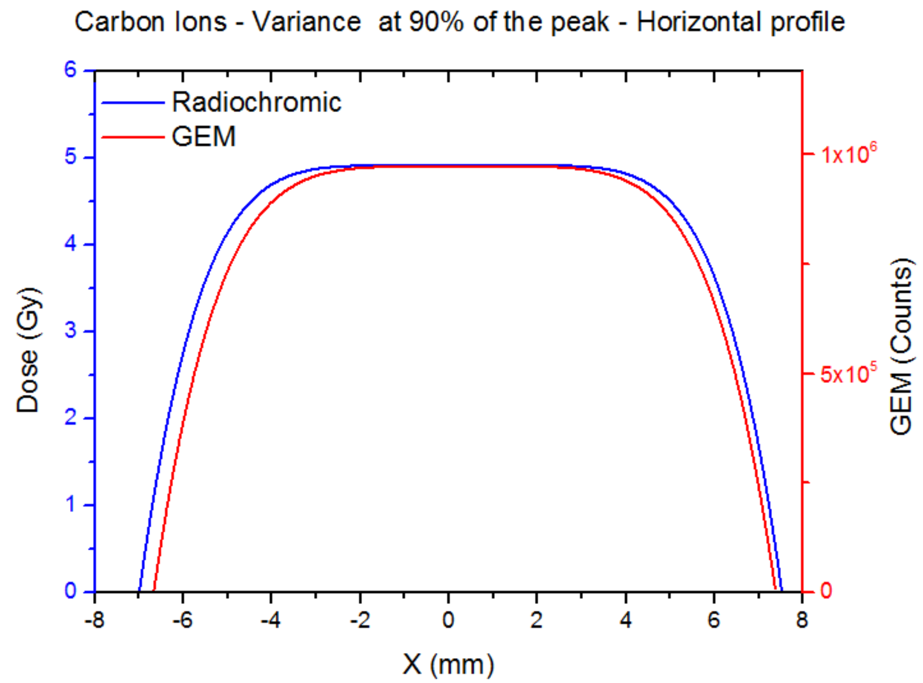


Radiochromic foil & GEM 3x6 mm^2 pads.

Beam 126 mm depth in water, 5e6 part per spot. Paint 2x2 cm^2

Pad 3x6 mm^2 X-Y scan 2x2 cm^2

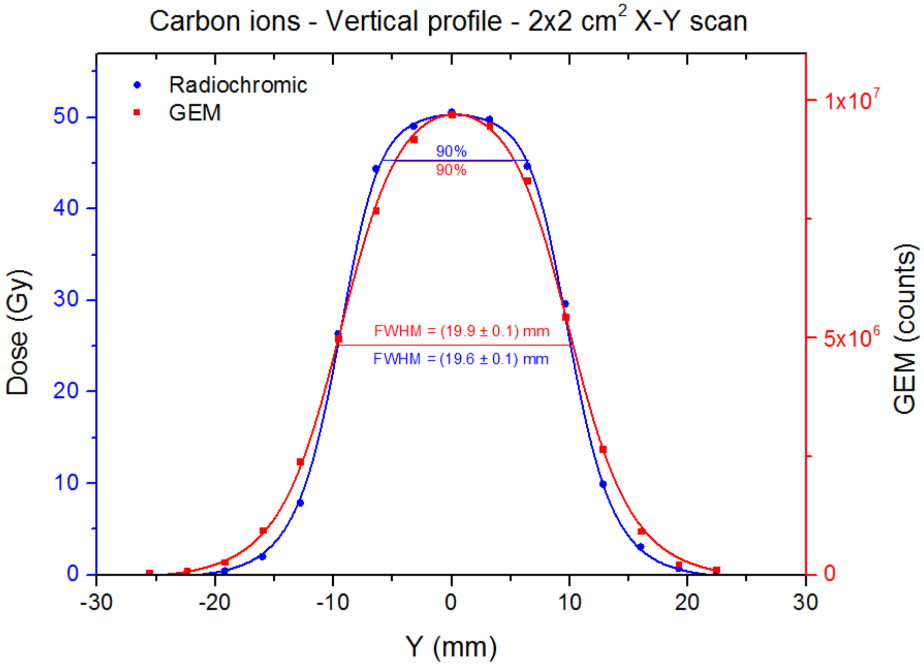


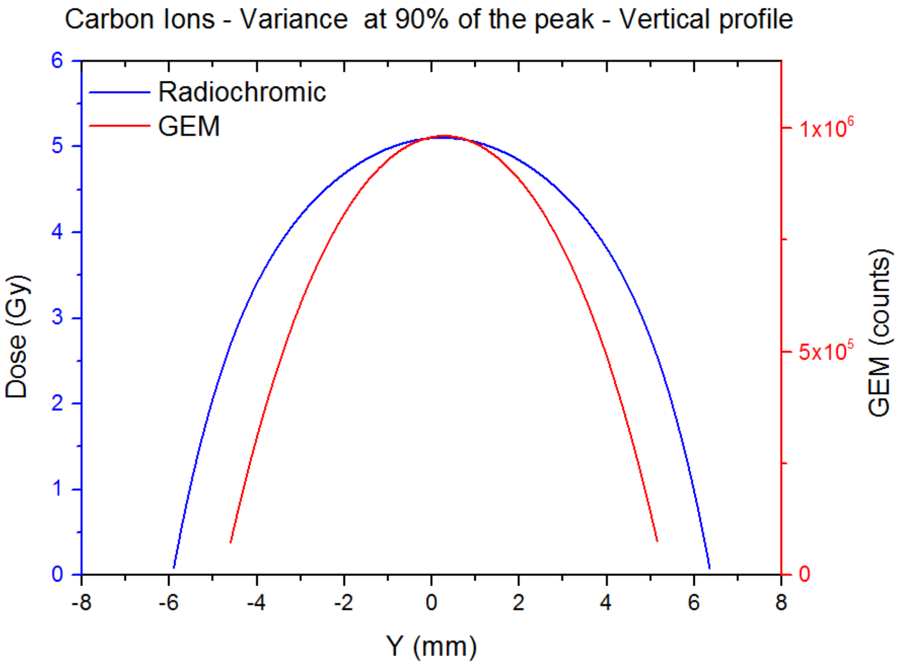


Left: horizontal profile for Radiochromic and GEM

Right: Variance at 90% of the max high (from fit)

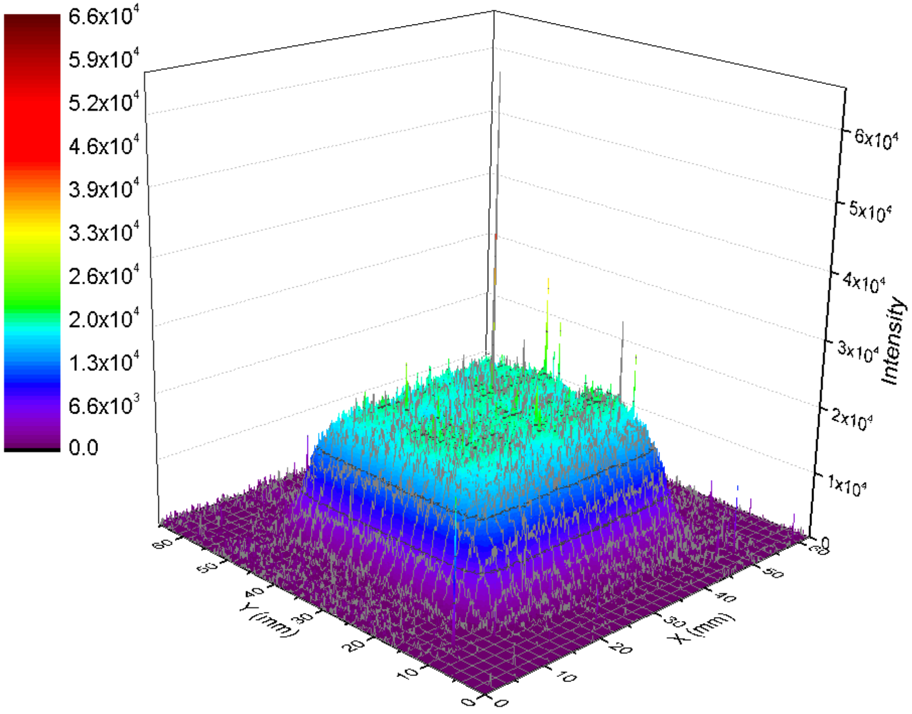
Pad 3x6 mm^2 X-Y scan 2x2 cm^2

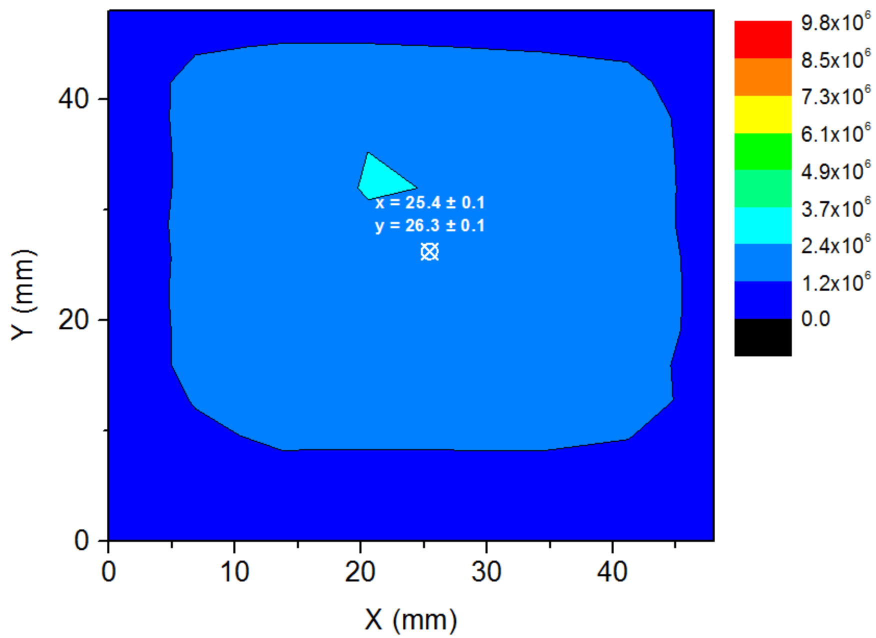




Left: Vertical profile for Radiochromic and GEM

Right: Variance at 90% of the max high (from fit) for Radiochromic and GEM

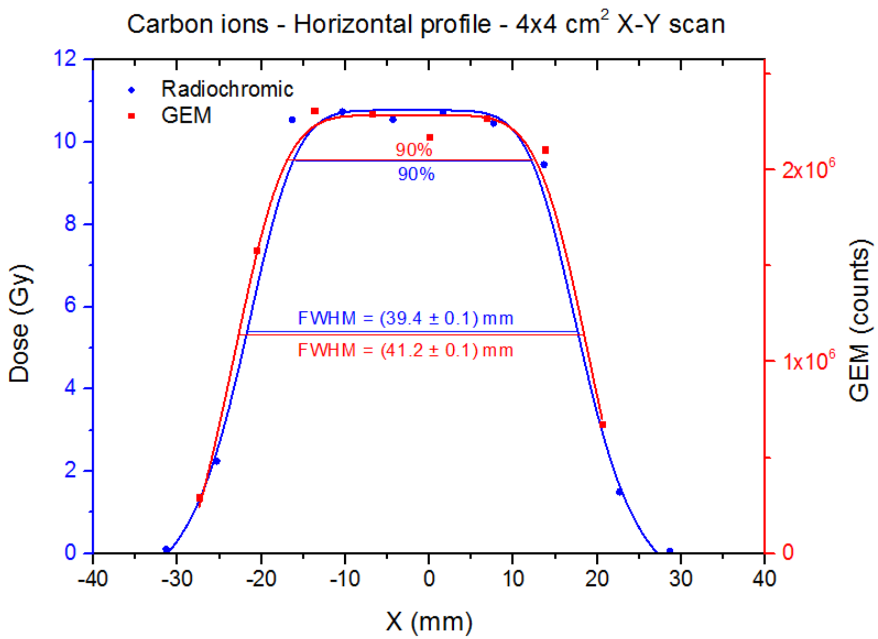


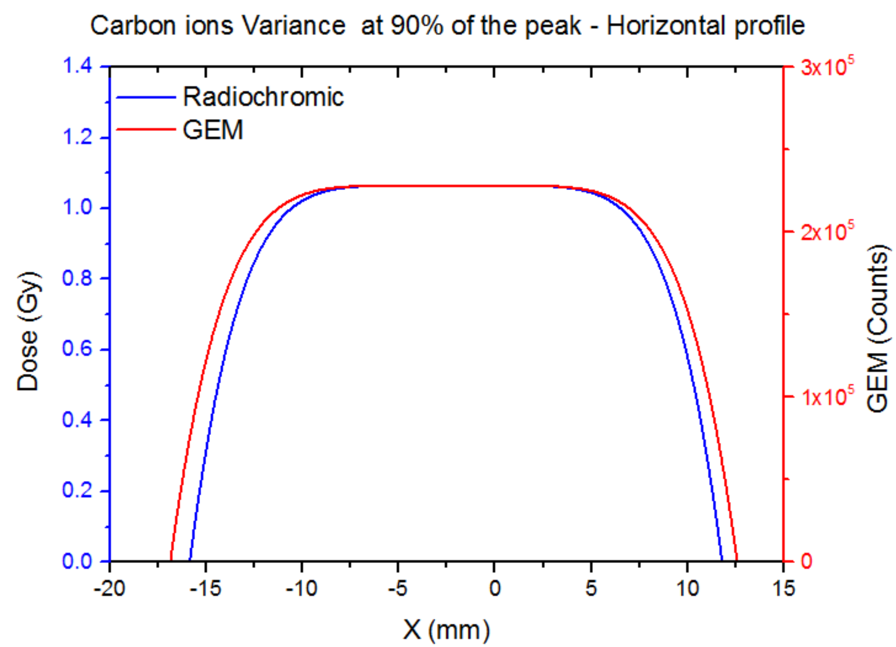


Radiochromic foil & GEM 3x6 mm^2 pads.

Beam 126 mm depth in water, 1e6 part per spot. Paint 2x2 cm^2

Pad 3x6 mm^2 X-Y scan 4x4 cm^2





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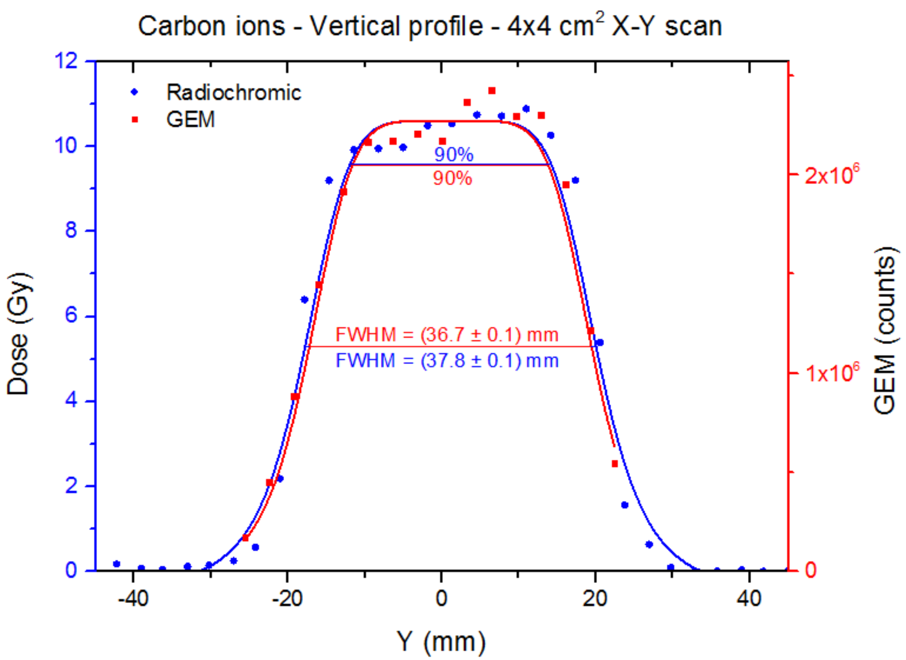
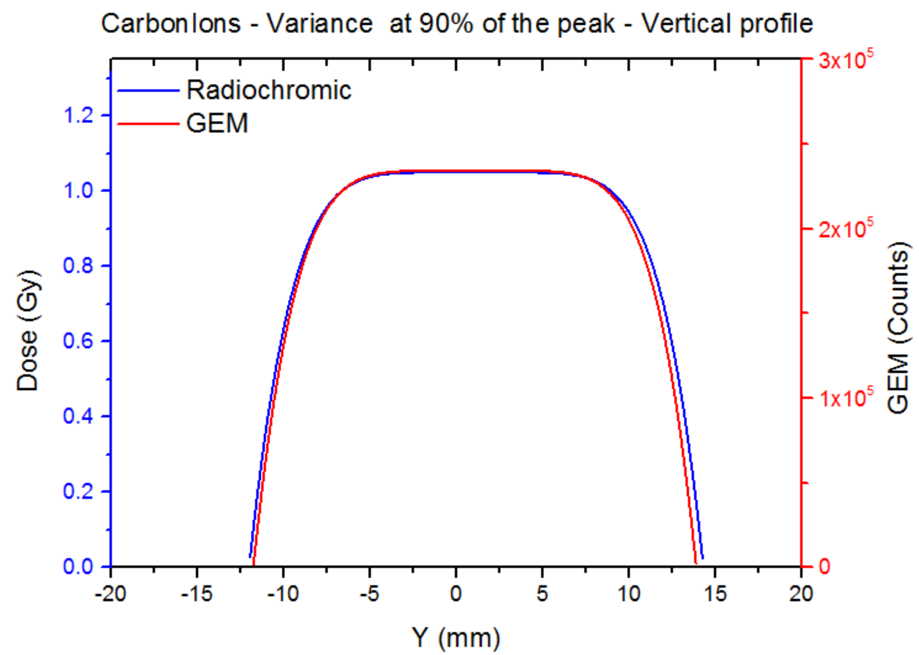
Pad 3x6 mm^2 X-Y scan 4x4 cm^2





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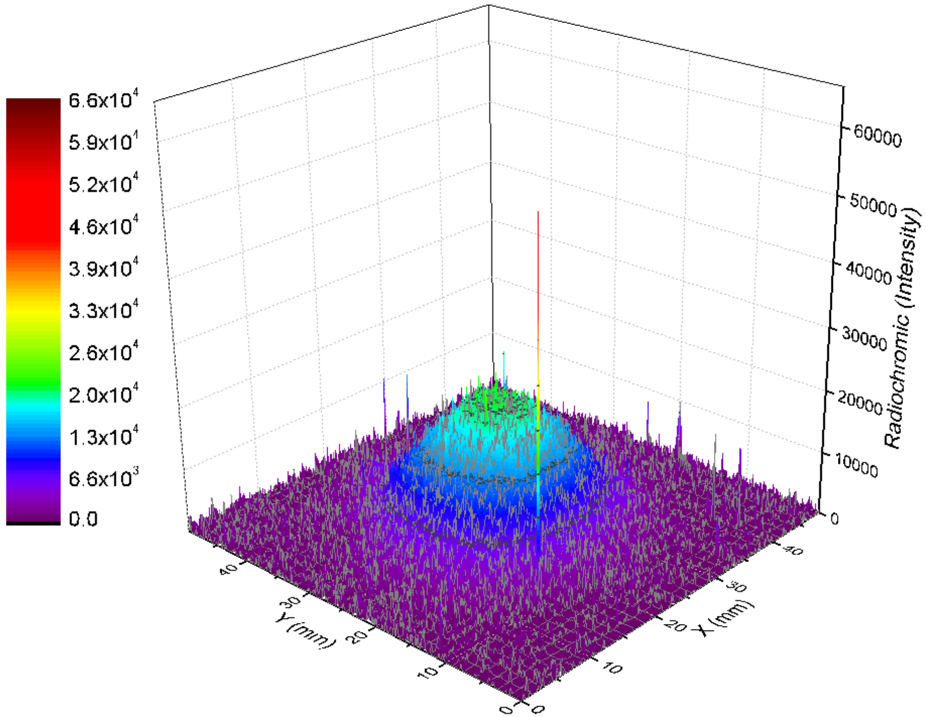
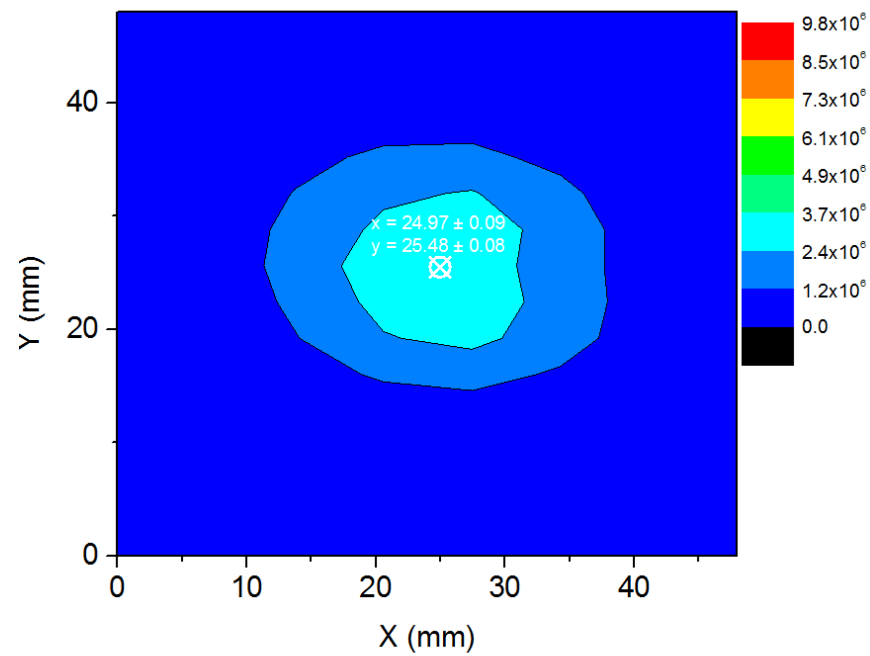
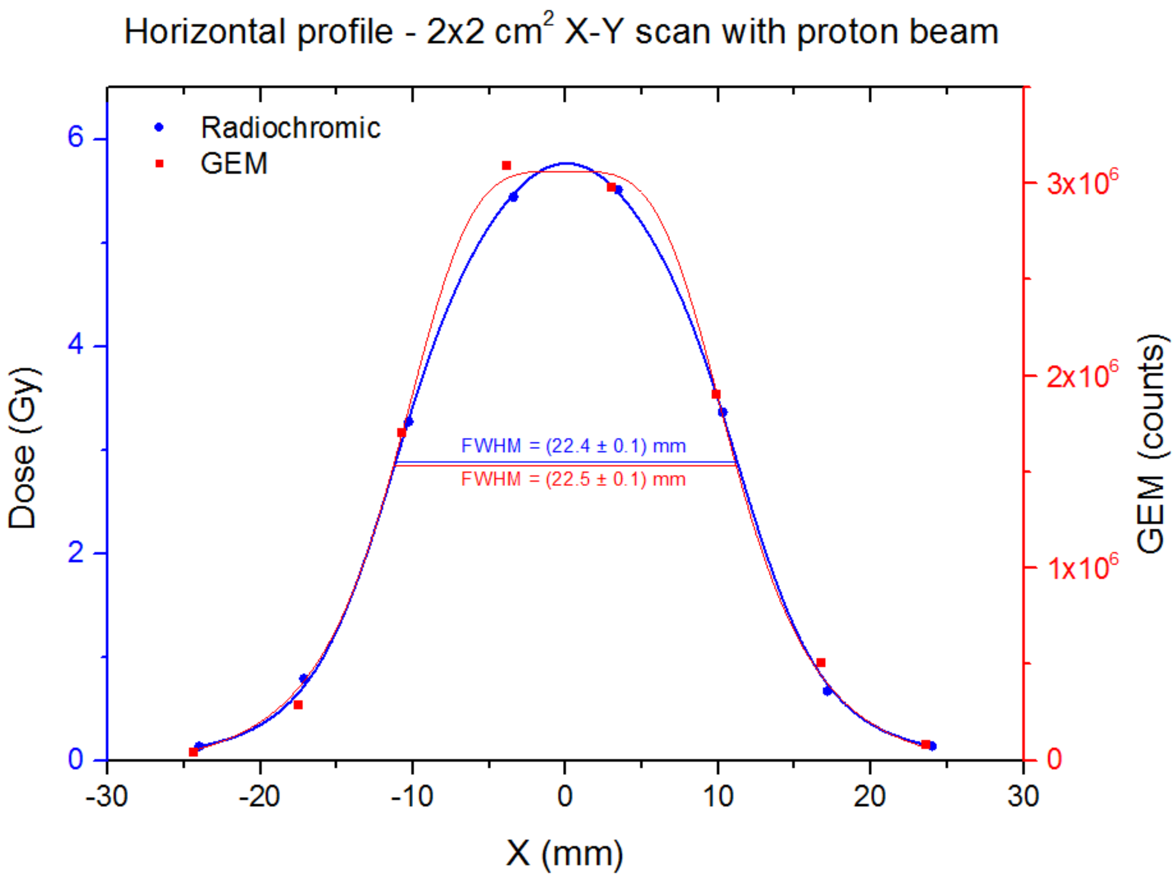




Radiochromic foil 3x6 mm^2 pads.

Beam 126 mm depth in water, 1e7 part per spot. Paint 2x2 cm^2

Pad 2x2 mm^2 X-Y scan 2x2 cm^2



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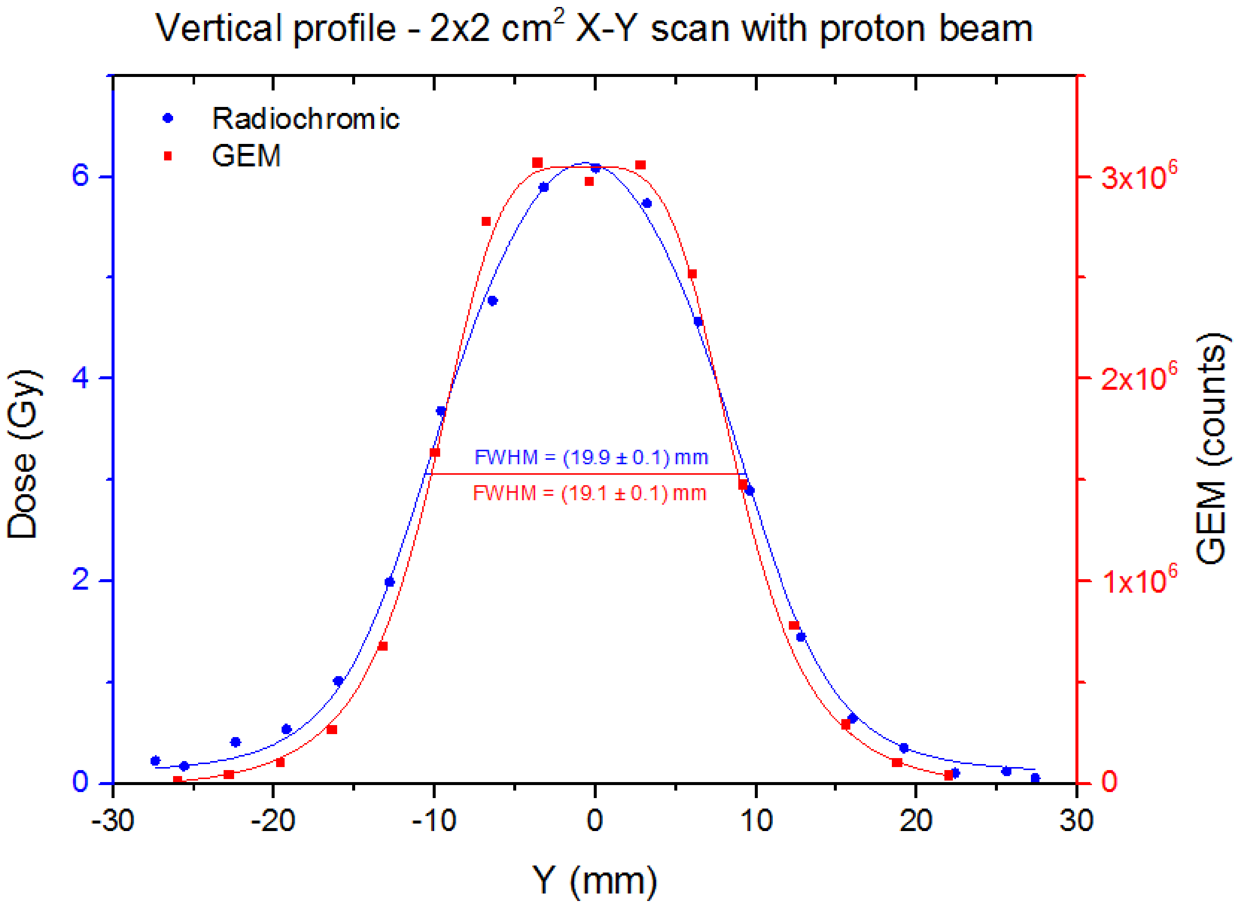
Right: Variance at 90% of the max high (from fit)

Pad 2x2 mm^2 X-Y scan 2x2 cm^2



Left: Vertical profile for Radiochromic and GEM

Right: Variance at 90% of the max high (from fit) for Radiochromic and GEM

Conclusions:

- The read out system can register the timing of the paint procedure with negligible dead time

- The timing, the profiles and the image of the complete procedure are shown on line

- The offline analysis shown a good agreement with the radiochromic foils

References:

[1] F. Sauli, *GEM: A new concept for electron amplification in gas detectors*, Nuclear Instruments and Methods in Physics Research A386, p 531, 1997

[2] M. Alfonsi et al., *The triple-Gem detector for the M1R1 muon station at LHCb*, N14-182, 2005 IEEE-NSS

[3] E. Aza et al., *The triple GEM detector as beam monitor for relativistic hadron beams*, JINST 9 P06006, 2014

[4] W. Bonivento et al., *Development of the CARIOCA front-end chip for the LHCb muon detector*, Nuclear Instruments and Methods in Physics Research A491, pp. 233–243, 2002

[5] F. Murtas et al., *Applications in beam diagnostics with triple GEM detectors*, Nucl. Instrum. Meth. A 617 (2010) 237.

Scientific activity 2014

RADIOACTIVE WASTE

Motivation

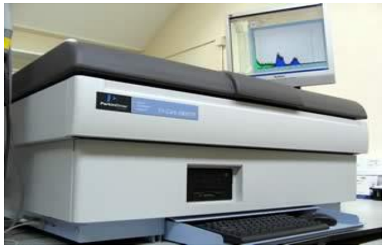
- Materials in accelerator environment are activated by radiations [1]
- In order to treat this materials after the decommissioning, it is necessary a characterization to know the nuclide population
- Gamma emitters are easily recognised by γ spectrometry
- The challenge is to measure the ^{55}Fe amount
- A detector with high efficiency to ^{55}Fe and high γ rejection to is needed

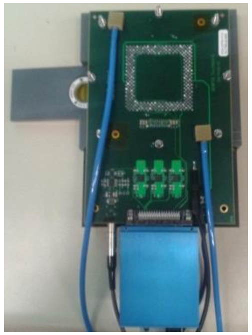
$$^{55}Fe \rightarrow {}^{55}Mn * \rightarrow (\sim 28\%)$$
$$^{55}Mn + 6keV$$

12 samples

Ext. Lab

GemPix





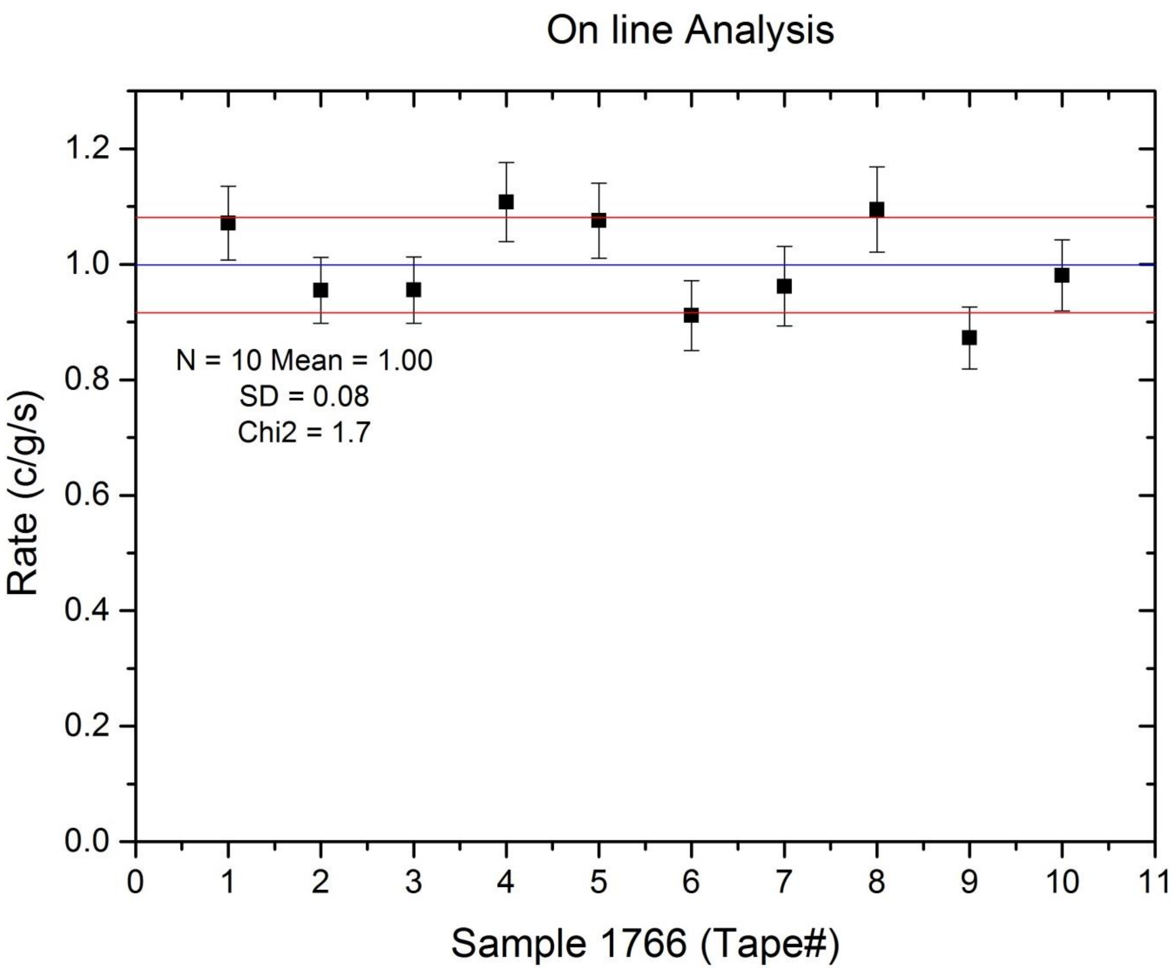
Fraiseuse **DECKEL FP4M**
Vitesse de rotation broche : 400tr/mn
Vitesse d avance : 40mm/mn
Type de fraise utilisee : Fraise d ebauche carbure monobloc MTC TiAIN 6mm Garant (ref SFS 205712 6°)

Boxes supplied by SMIPA s.r.l
Dimension: 38x38x4 mm^3
Weight: ± 0.15%

Measurements for Fe-55 concentration with **GEMPIX**:
Drift gap **11 mm**
Support conceived for measurements with samples and calibration sources

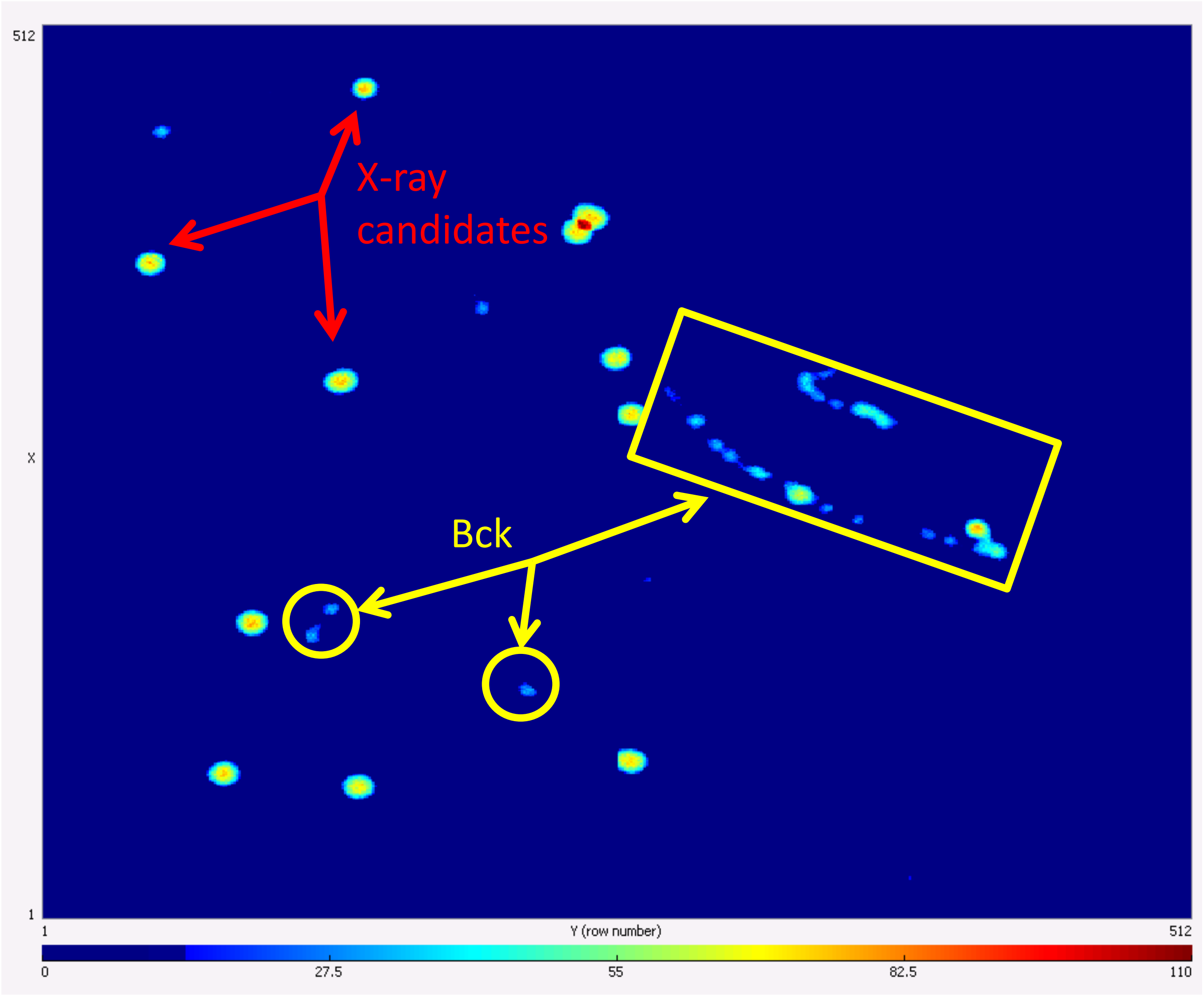
Comparison with PSI laboratories measurements (Radio Chemcal Analysis – RCA)

Sample reproducibility



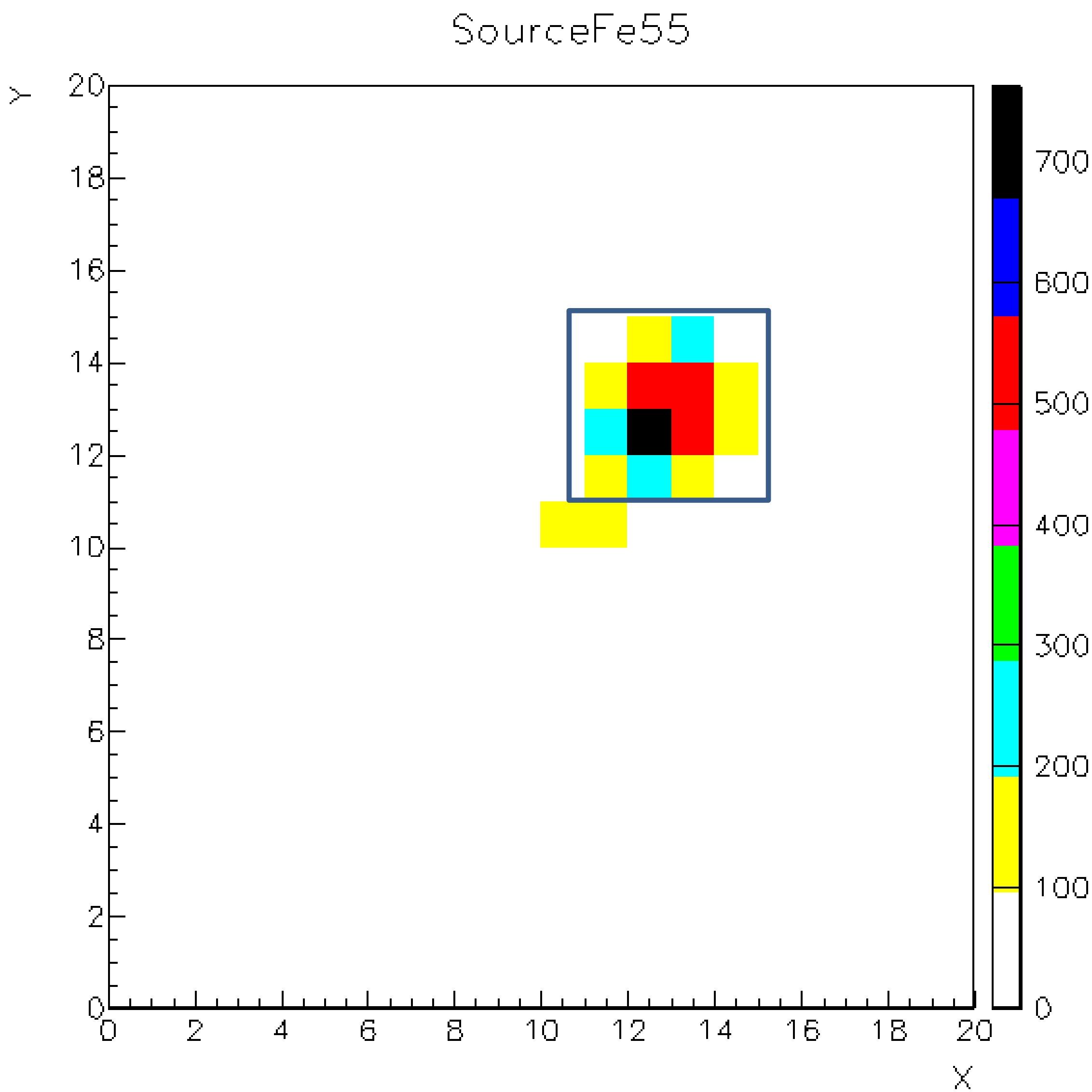
Dust obtained from
1 Sample → 10 tapes
Analysed with GEMPIX
With on line analysis.

Detector calibration



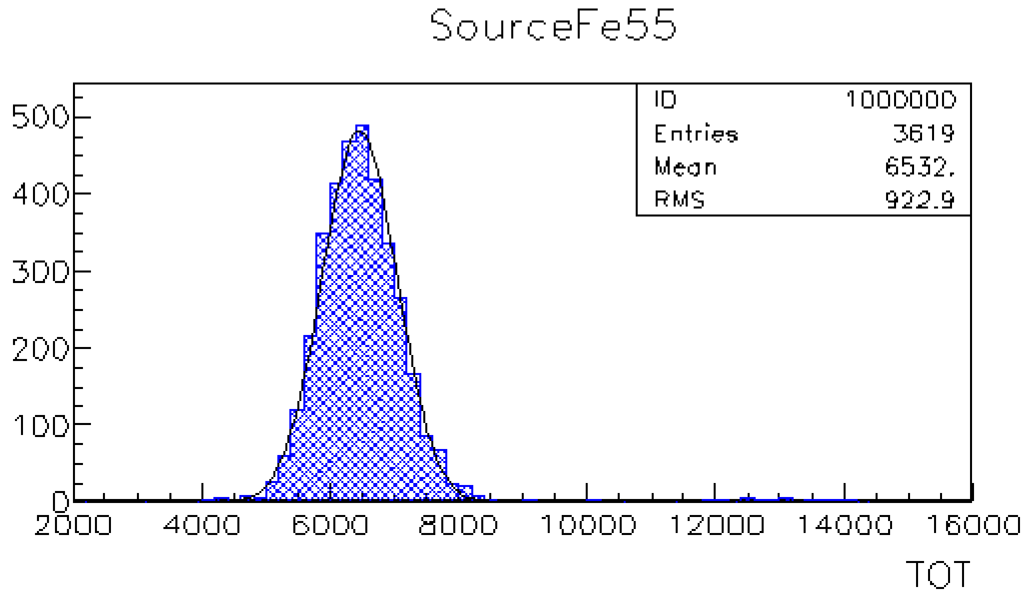
Gate: 1 s
HV 1200 V
Gas flux: 3.5 l/h
THR:
0: 393
1: 398
2: 497
3: 420
Clk: 24
Ikrum: 5
Polarization: -

Detector Calibration: cluster diameter

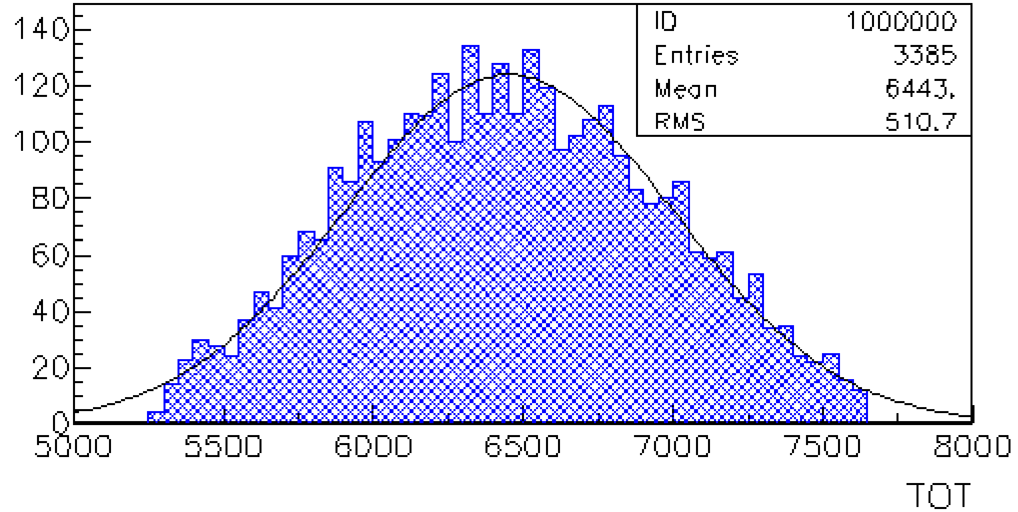


Calibration with Fe-55 source
X min: 11
X max: 15
Y min:11
Y max: 16

Detector calibration: TOT



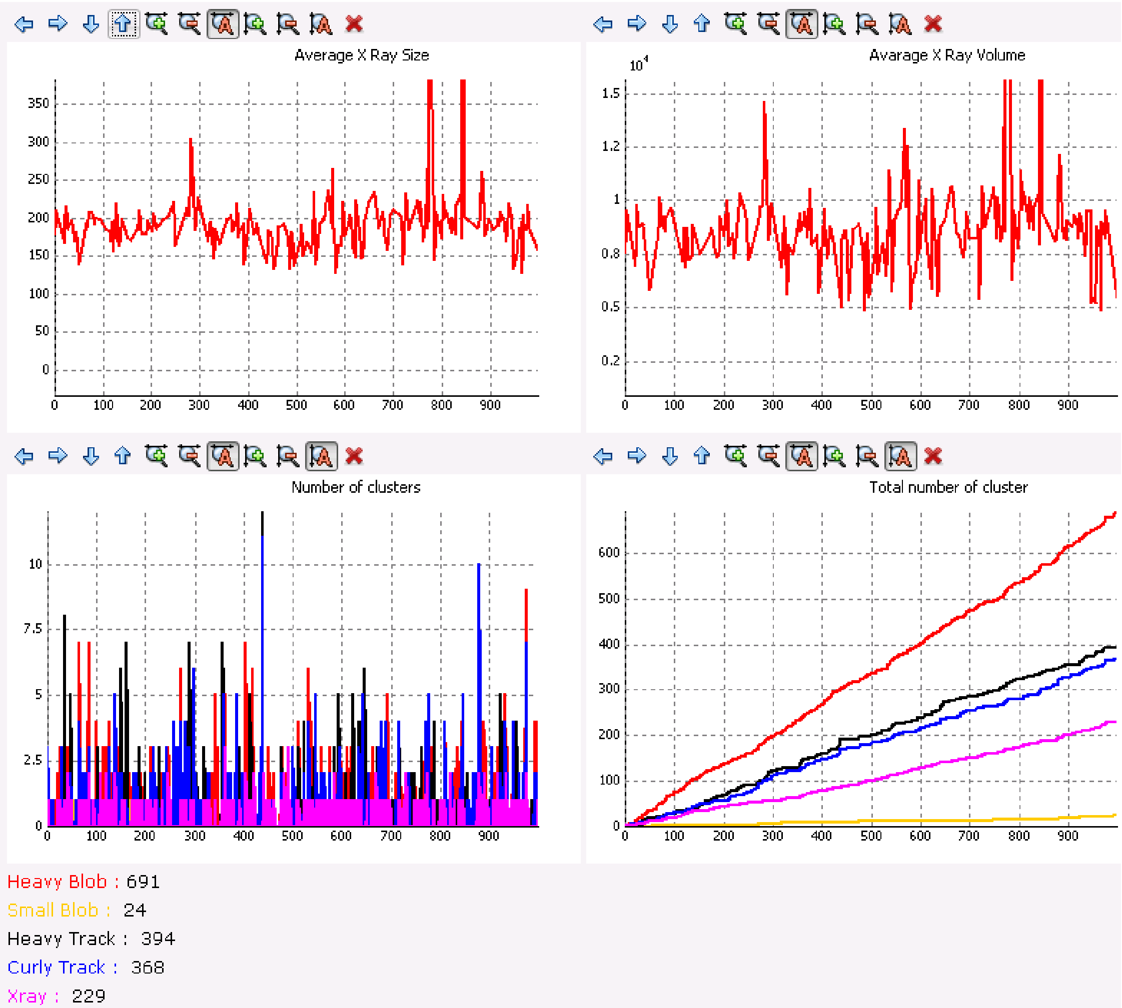
Calibration with Fe-55 source: TOT without size cut



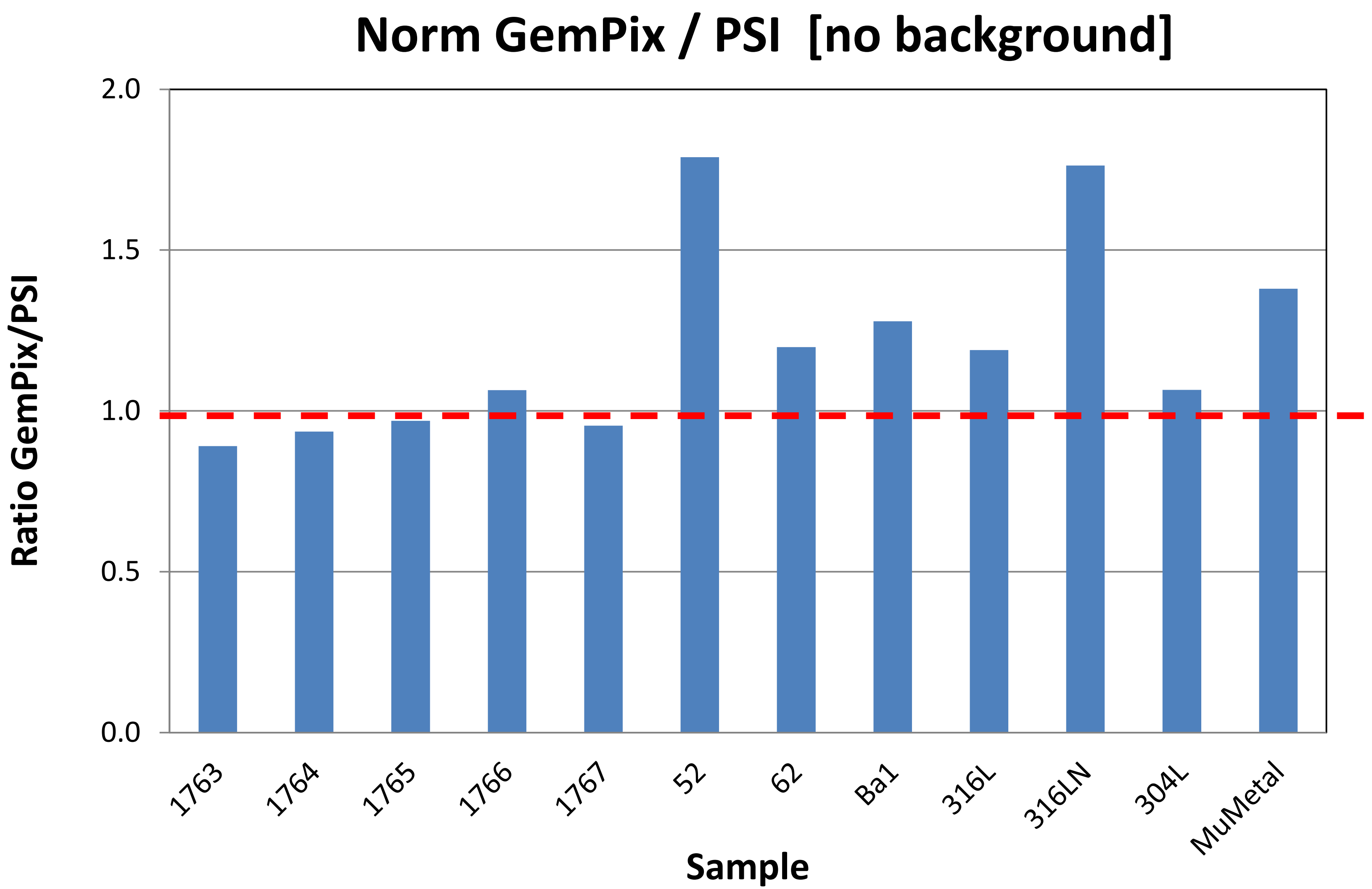
Calibration with Fe-55 source: TOT with size cut

TOT = 6451 ± 551

On line analysis



Once that the calibration values are set in the Python script, the online analysis is done


Norm GemPix / PSI [no background]
Ratio GemPix/PSI
2.0
1.5
1.0
0.5
0.0
1763
1764
1765
1766
1767
52
62
Ba1
316L
316LN
304L
MuMetal
Sample

Conclusions:

- The GEMPix can better discriminate the x-rays working on cluster recongnition and TOT

- With the python script it is possible to have an on line results after a calibration with a source

- The last result seems to be in good agreement with the external laboratory (PSI)

- The procedure is faster and cheaper than the usual RCA

References:

[1] F.P. La Torre et al., *Radiological Hazard Classification of materials in CERN's accelerators*, CERN technical note 2012 1184236