Computational Evalutions of Proton Induced Gain in a Portable Faraday Cup

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Abstract

- Current proton beam calibration methods lack precision, esp. for pencil-beam scanning
- Seek feasible (vacuumless, chamberless) solution for $70-250MeV$ beam energy: Portable Faraday Cup (PFC)

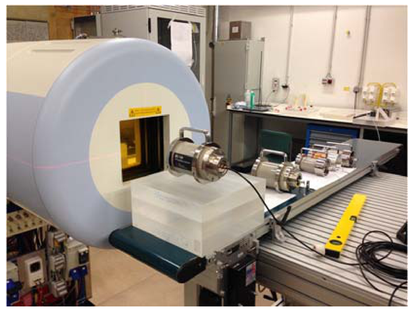

Fig 1: Experimental beamline at Heidelberg Institute of Technology

- Kapton insulator to capture backscattered electrons
- PFC radius determined by MCNP6 model

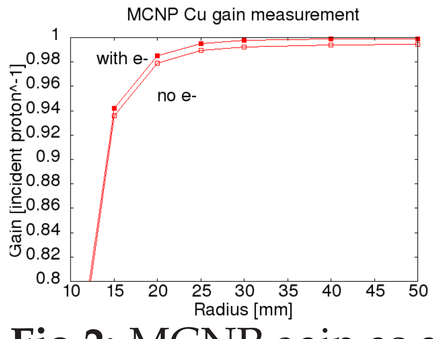

Fig 2: MCNP gain as a function of PFC radius

Methodology

PFC Geometry

- Cu cylinder (10cm x 3 cm)
- Kapton film (59-200 μm)
- Ag ground (12 μm)
- Kapton outer film (62 μm)

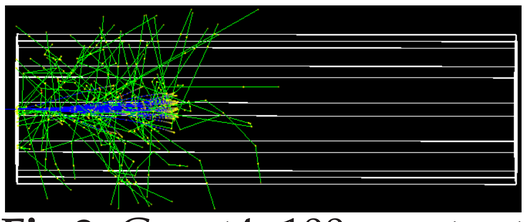

Fig 3: Geant4- 100 events at 160 MeV in S59

Gain Contribution

- Net charge on Cu per p+
- Mirror charge $\propto$ depth in Kapton $d_{\%,j}$
- For each charge q_j per event i, tally net gain

$$g_{ij} = \begin{cases} \pm q_j/e, & \text{if } q_j \rightleftharpoons Cu \\ \pm q_j d_{\%,j}/e, & \text{if } q_j \rightleftharpoons KA(d_{\%,j}) \end{cases}$$

Parameters

- Energy range: $70-250MeV$
- Beam FWHM: $22.8-8.1mm$
- Production cutoff: 5 μm
- Models: S59, S100, S200 (Kapton thicknesses)

Results

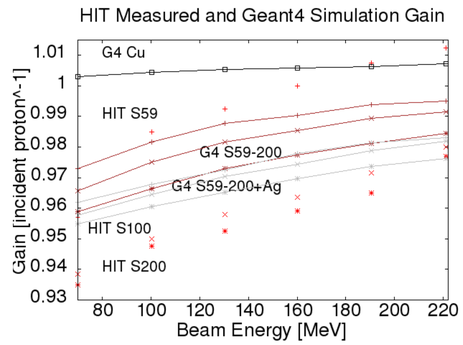

Fig 4: G4, HIT gain [3], all increase with energy. Cu shows positive gain, KA lowers gain with thickness; Ag lowers gain, suppresses this spread. HIT-S59 breaks trend, crosses 1.

	S59	S100	S200
-Ag	$1.1-3.0$	$1.4-3.7$	$2.0-4.4$
+Ag	$2.4-4.1$	$2.5-4.5$	$2.9-4.8$

Table 1: G4 model gain percent error relative to G4 Cu

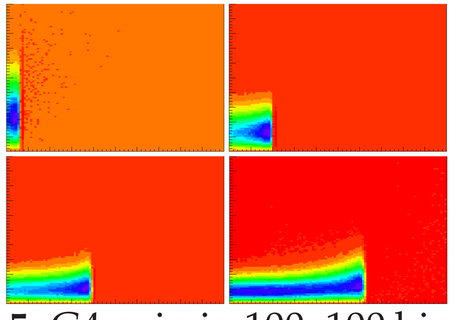

Fig 5: G4 gain in 100x100 bins at 70, 130, 190, 250 MeV. Bins append charge deposits (red) and subtract removals (blue) (unnormalized).

Conclusions

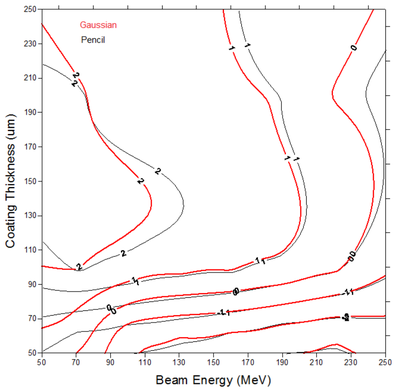

Fig 5: G4, HIT gain % error

- Agreement within 3%
- MCNP insufficient to optimize without p+ secondary electrons
- Future work: characterize multilayer PFC

References

[1] B. Gottschalk. "A Poor Man's Faraday Cup". Abstracts XIX PTCOG Meeting, Cambridge, MA, 13 (1993).

[2] E. Cascio and B. Gottschalk. "A Simplified Vaccuumless Faraday Cup for the Experimental Beamline at the Francis H. Burr Proton Therapy Center". *IEEE Radiation Effects Data Workshop*, p.155–161, (2009).

[3] J. Gordan and L. Magallanes. "Evaluation of Current Measuring Beam Stop". Proprietary Calculuations, (2014).

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