Computational Evalutions of Proton Induced Gain in a Portable Faraday Cup

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Introduction

- Protons offer increasingly popular radiation therapy alternative via localized dose distribution

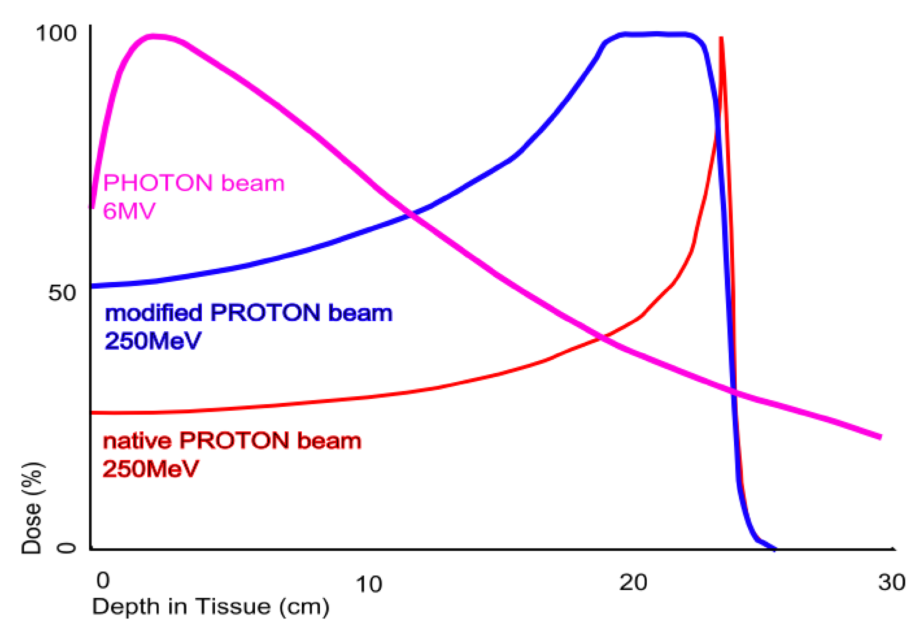

Figure 1: Bragg Peak behavior of proton beam dosimetry. Wikimedia File:BraggPeak.png.

- Calibration methods lack precision, esp. for pencil-beam scanning
- Seek feasible (vacuumless, chamberless) solution for mid-range energies
- Modeled after PMFC[1, 2]

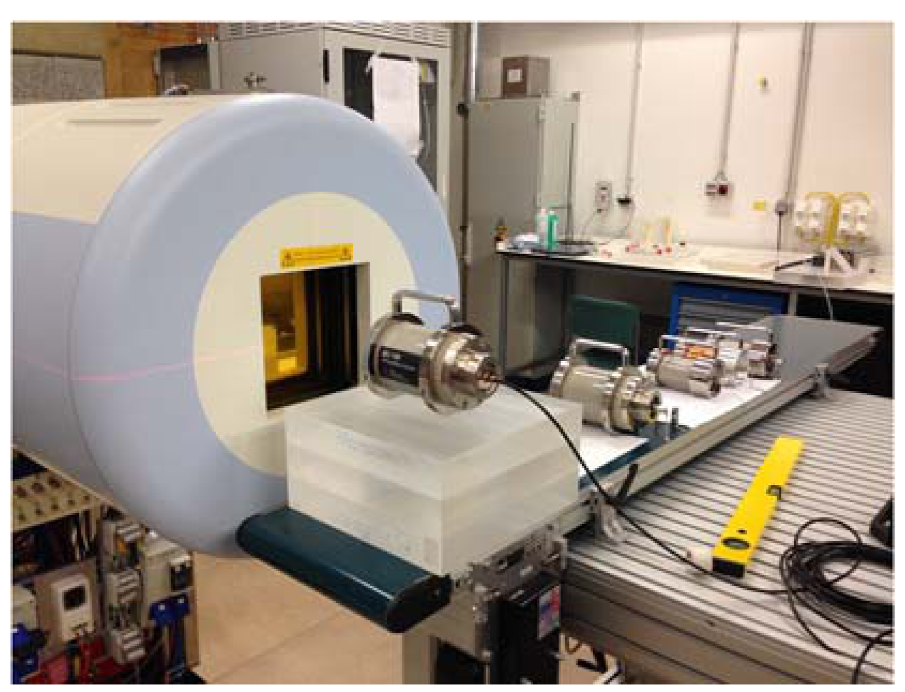

Figure 2: Experimental beamline at Heidelberg Institute of Technology

Monte Carlo Simulation

Geant4 10.1-patch01

- For each particle *Track* i per Event j of N, tally net gain

$$g_{ij} = \begin{cases} +q_i(Ne)^{-1}, & \text{if } q_i \to Cu \\ -q_i(Ne)^{-1}, & \text{if } q_i \leftarrow Cu \\ +q_i d_{\%}(Ne)^{-1}, & \text{if } q_i \to KA(d_{\%}) \\ -q_i d_{\%}(Ne)^{-1}, & \text{if } q_i \leftarrow KA(d_{\%}) \end{cases}$$

- Charge defect $= \sum_j^N \sum_i g_{ij} - 1$

Geometry Construction

Table 1: Cylindrical definitions in Geant4's DetectorConstruction.cc in both air/vaccuum

Volume	Radius (mm)	Height (mm)
Copper	30	100

	Model	Thickness (μm)
Kapton1	S59	59
	S100	100
	S200	200
Silver	+Ag/KA	12
Kapton2	+Ag/KA	62

Parameters

- FTFP-BERT2.0 Physics List
- Energy range: 70 - 250 MeV
- Gaussian beam with HIT FWHM measurements
- Particle production cutoff: 5 μm

Simulation Results

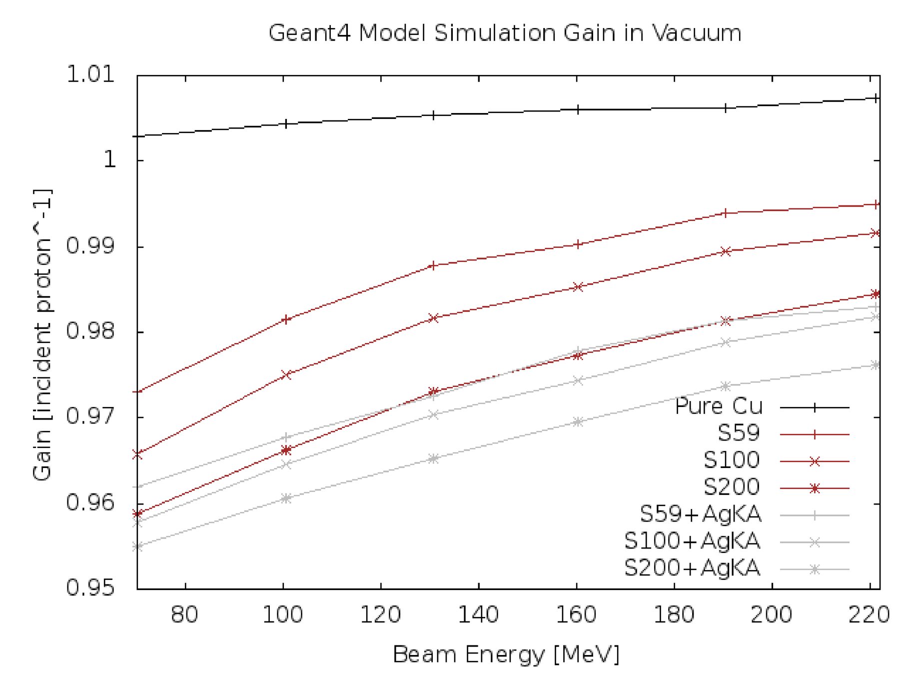

Figure 3: G4 gain output. Kapton thickness proportionately negatively contributes; Ag ground layer suppresses Kapton behavior

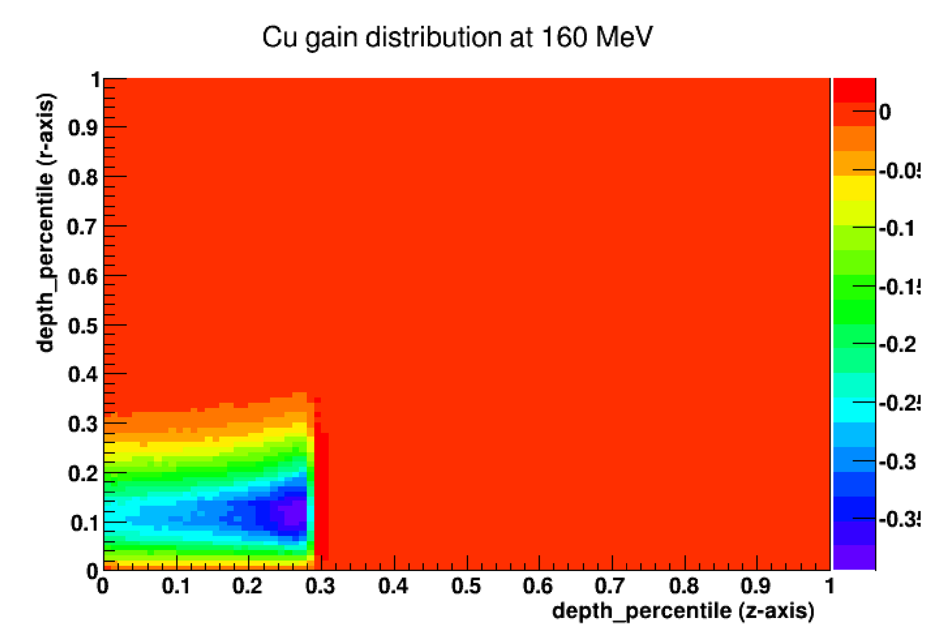

Figure 4: G4 gain distribution map. Electrons / ions straggle behind beam; inteface condition dependent upon energy (not shown).

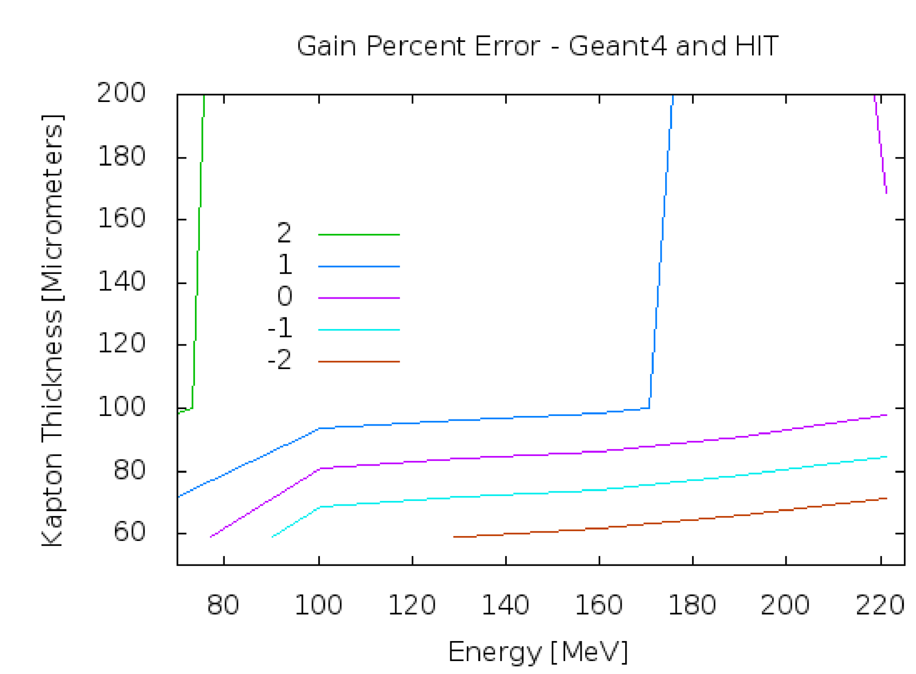

Figure 5: Percent error contours between simulation and experiment gain measurement

Discussion

- Optimal cup height, radius determined by coarse-grain MCNP6 model
- Deposition close to Cu interface (low E) results in greater backscatter
- -Ag/KA models acquire ~0% charge defect at finite Kapton thickness for various energies
- "Tertiary" electrons from (p,NpMn) reactions contribute non-linearly

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).

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