Bragg Curves in water for 67.5 MeV protons

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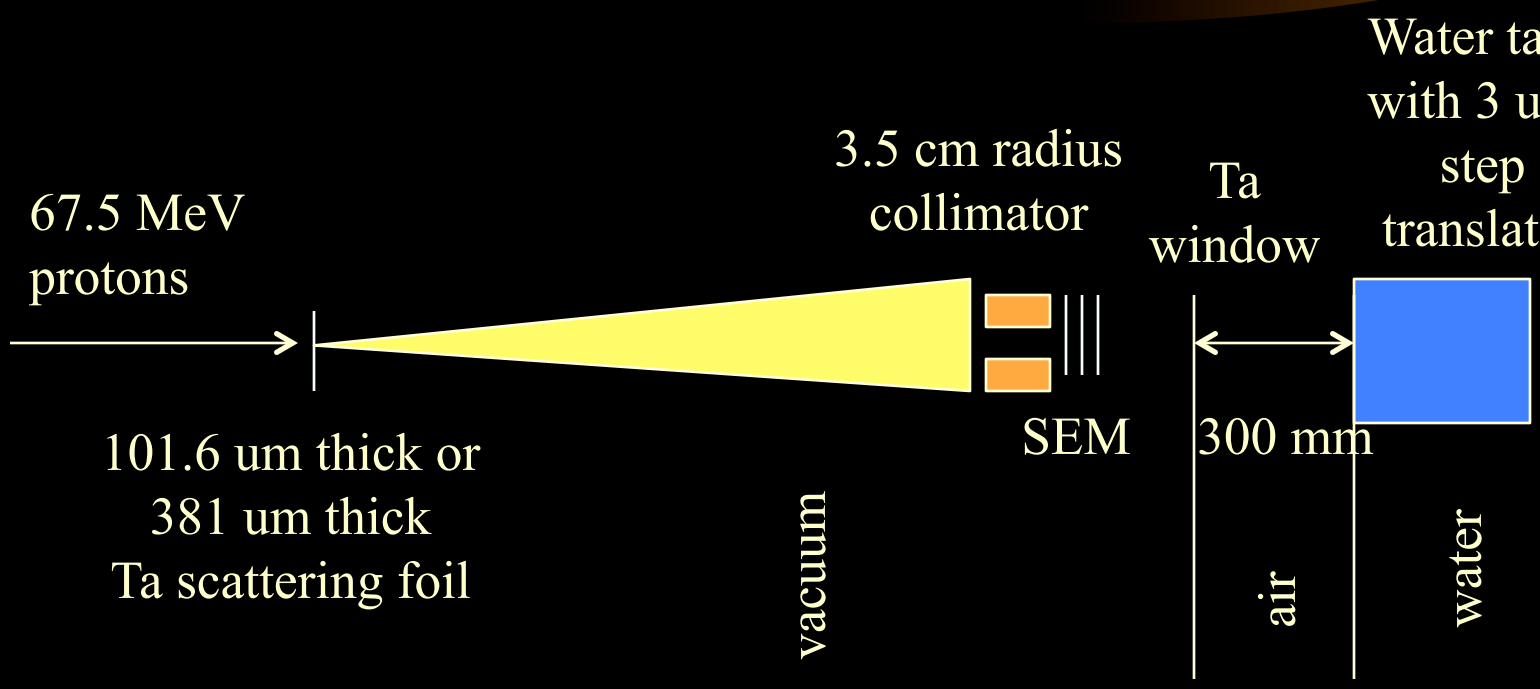
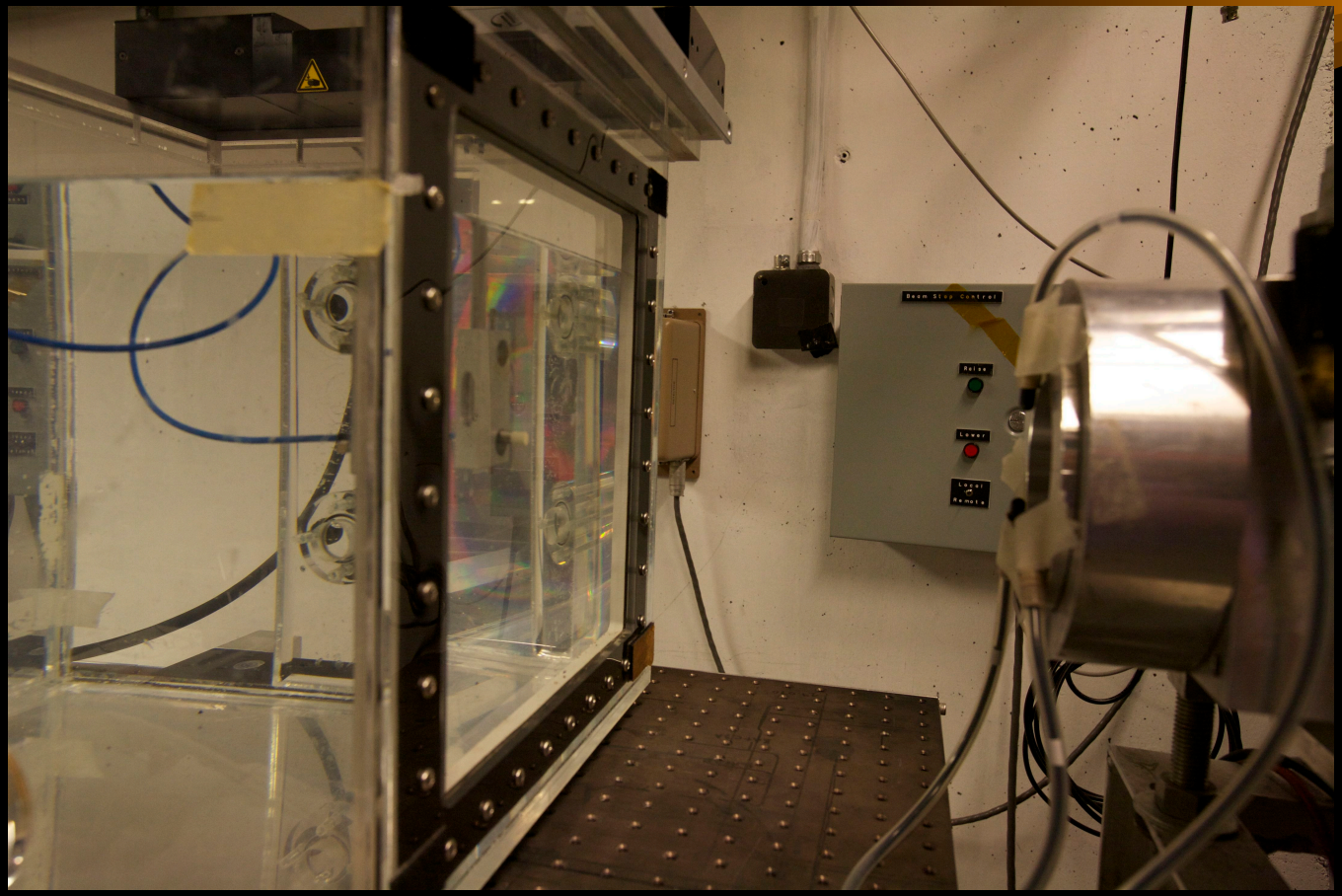
Crocker Lab Proton Beam

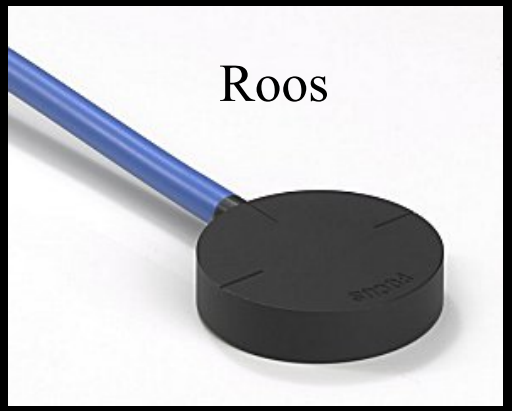


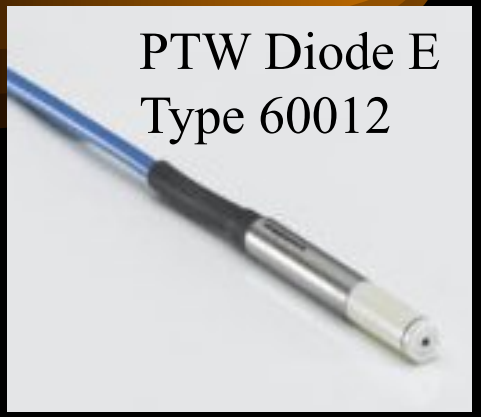
Bruce A. Faddegon, J. Shin, Carlos M. Castenada, Jose Ramos-Mendez, Inder K. Daftari, "Experimental depth dose curves of a 67.5 MeV proton beam for benchmarking and validation of Monte Carlo simulation," Med. Phys. 42(7):4199-4212, 2015, PMCID PMC4474955

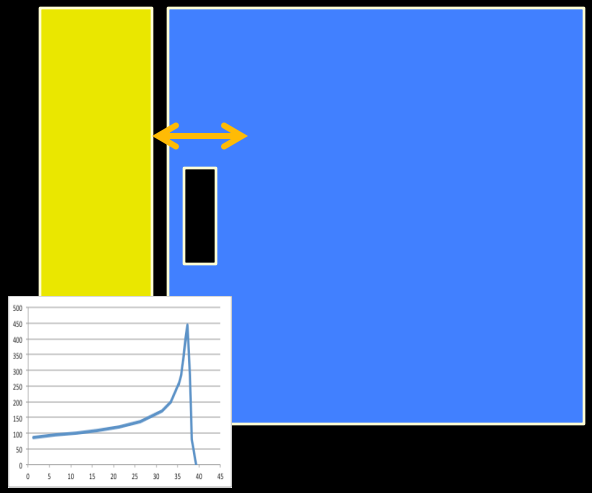
Experimental set-up

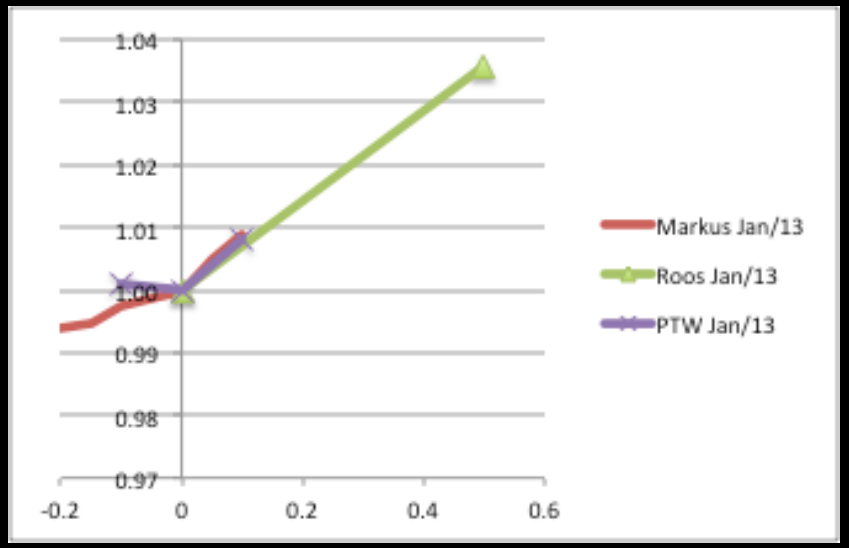


Surface position of detector determined from signal dependence on depth

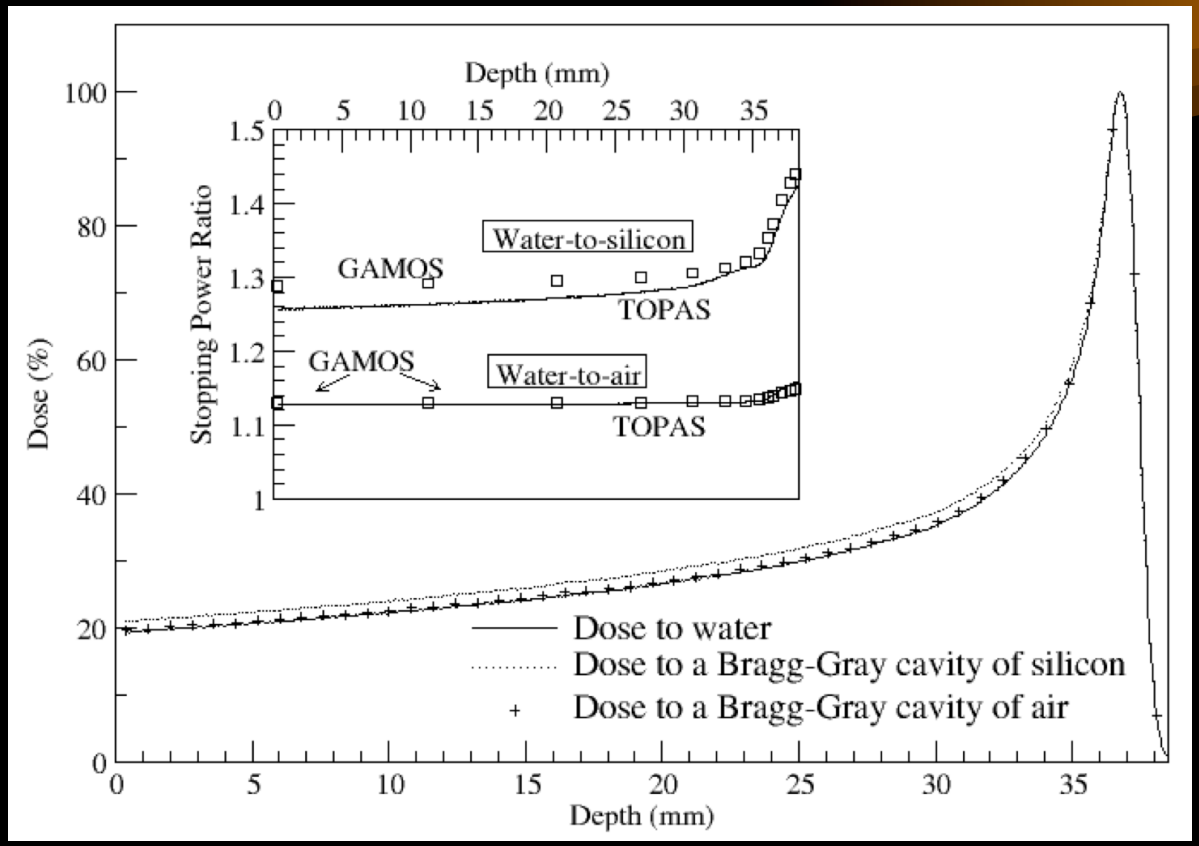






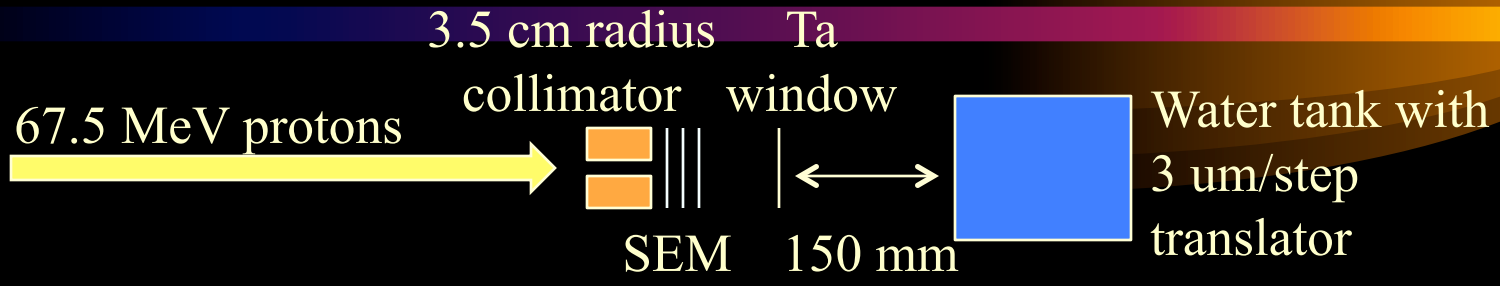


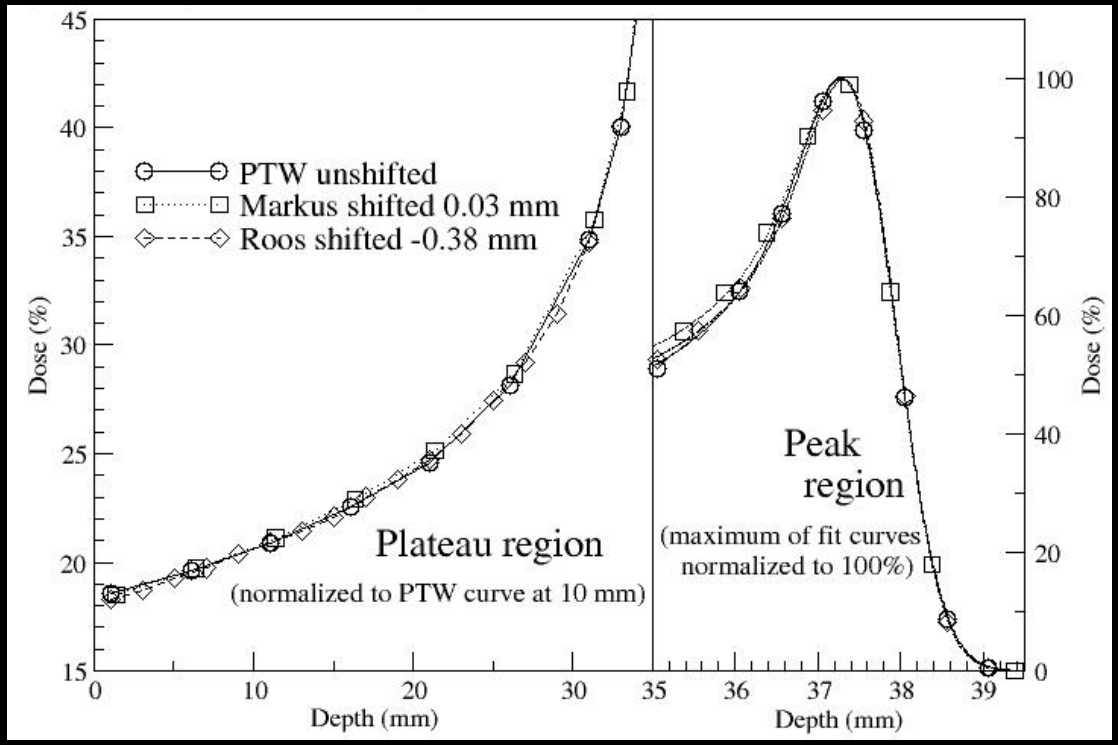
Stopping power ratio correction



GAMOS result from: *C Goma, P Andreo and J Sempau, "Spencer-Attix water/medium stopping-power ratios for the dosimetry of proton pencil beams," Phys Med Biol 58:2509-2522, 2013*

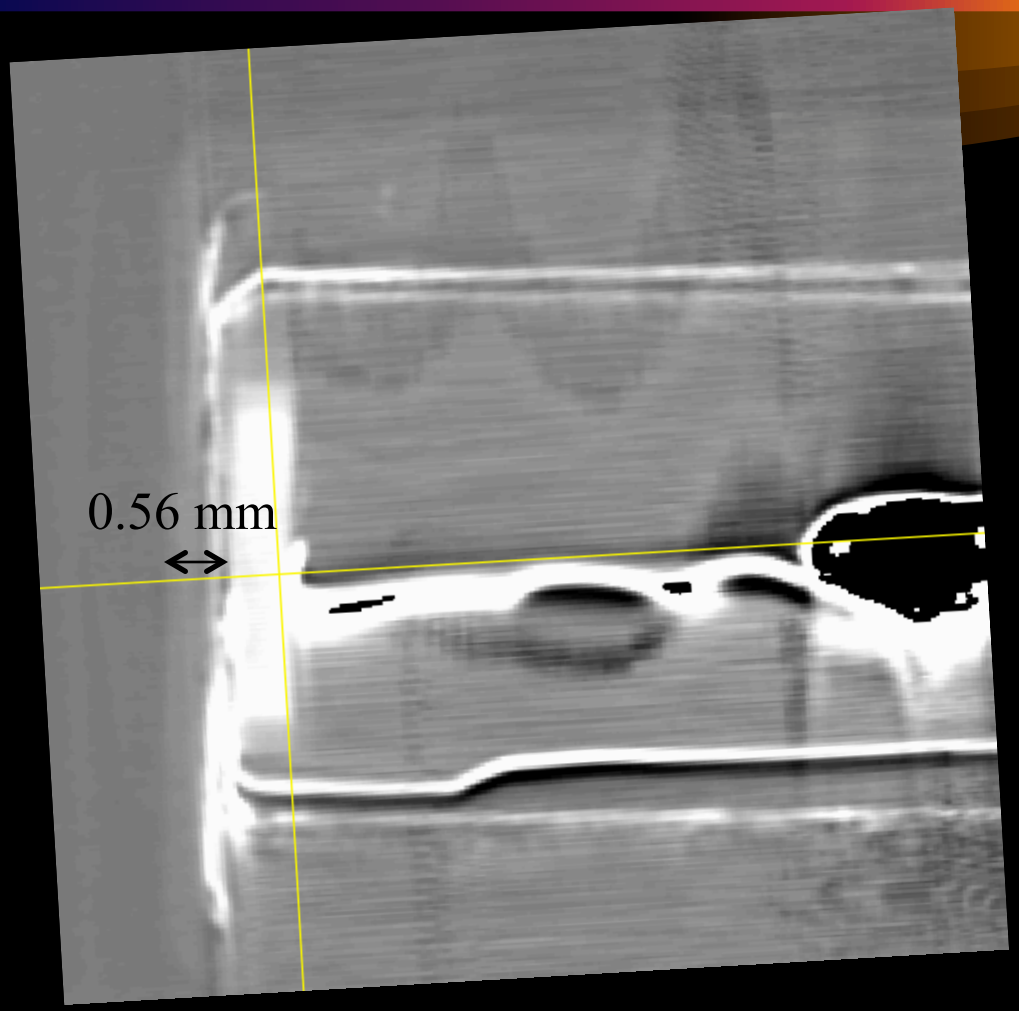
Crocker Lab Proton Eye Therapy: Preliminary Measurement



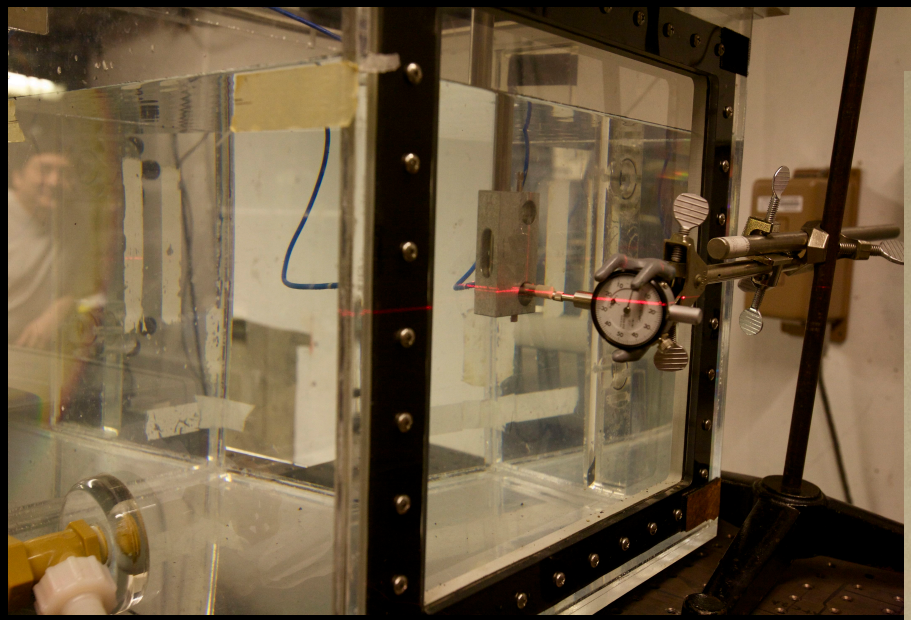


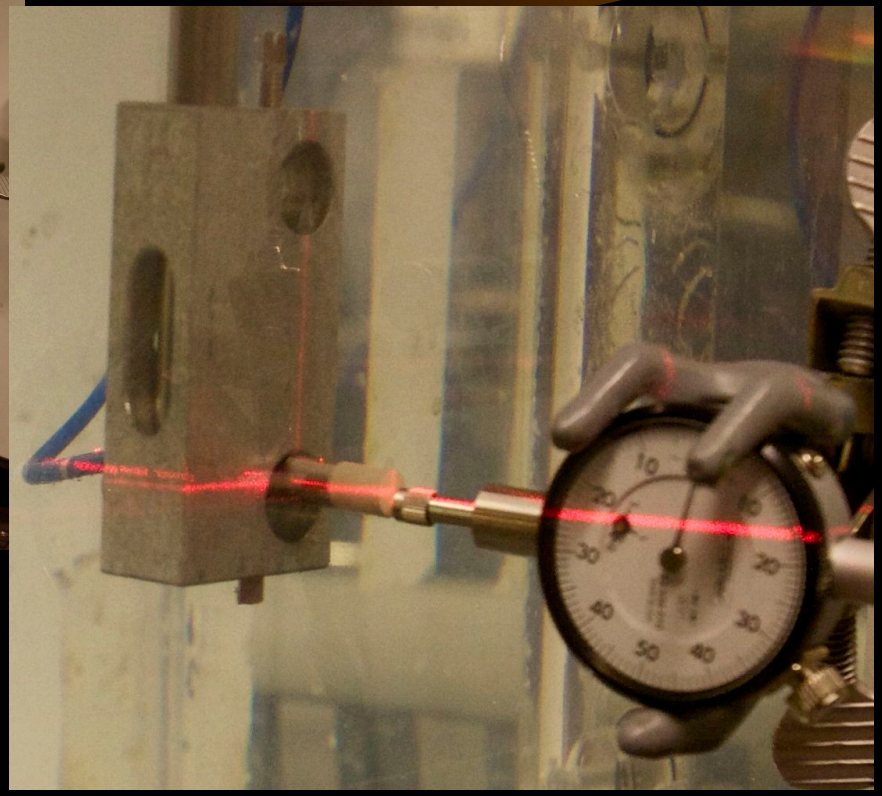
Uncertainty of peak-to-valley ratio measured with diode estimated to be 4%.

Micro-CT of IBA EFD diode

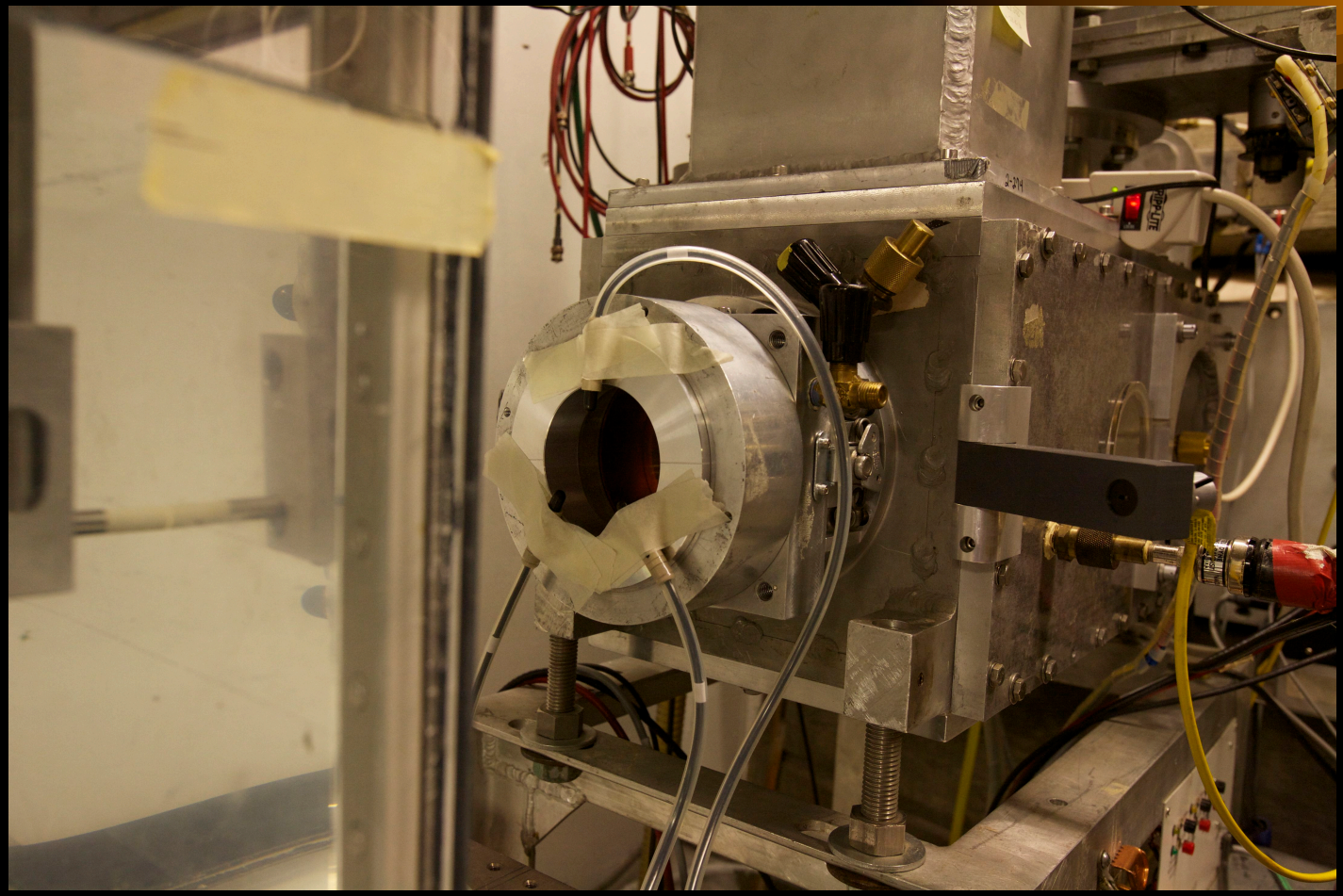


Alignment with surface: 0.25 mm mylar

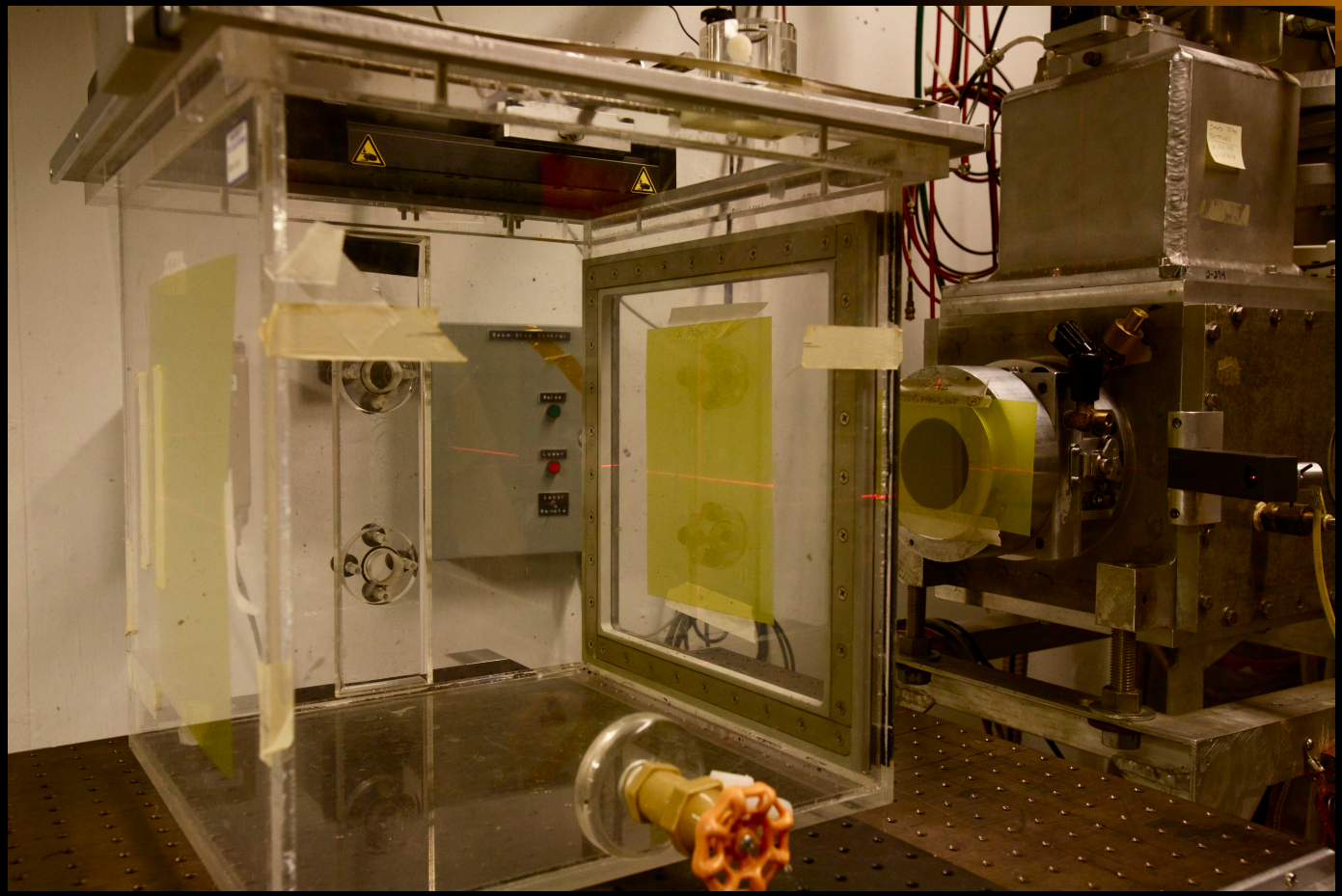




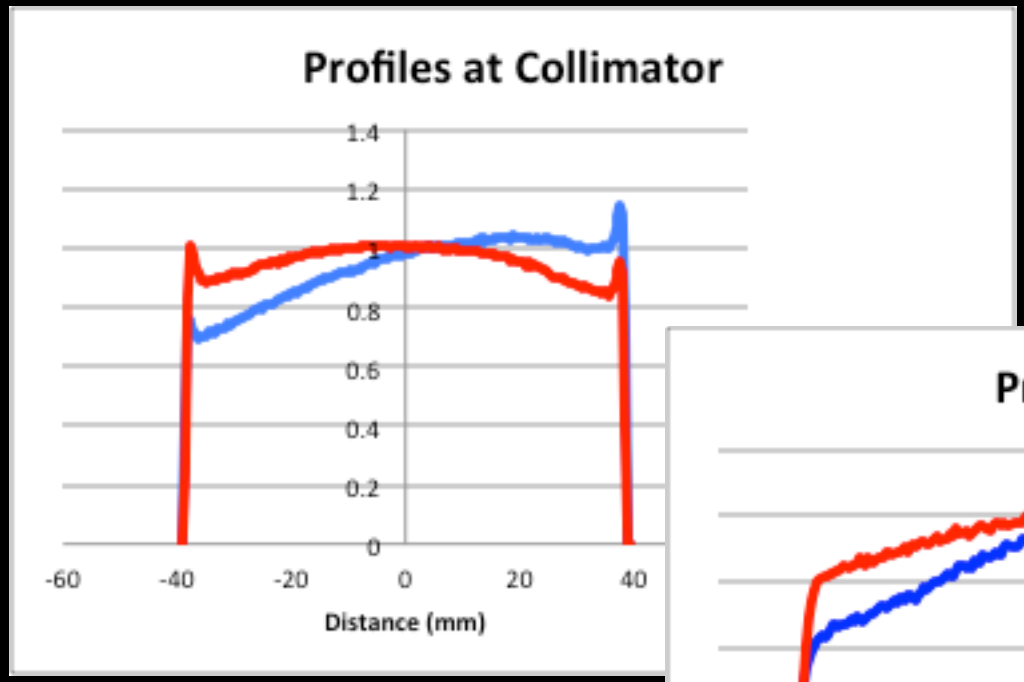
Ion chamber surface coincident with mylar, 3 reference chambers



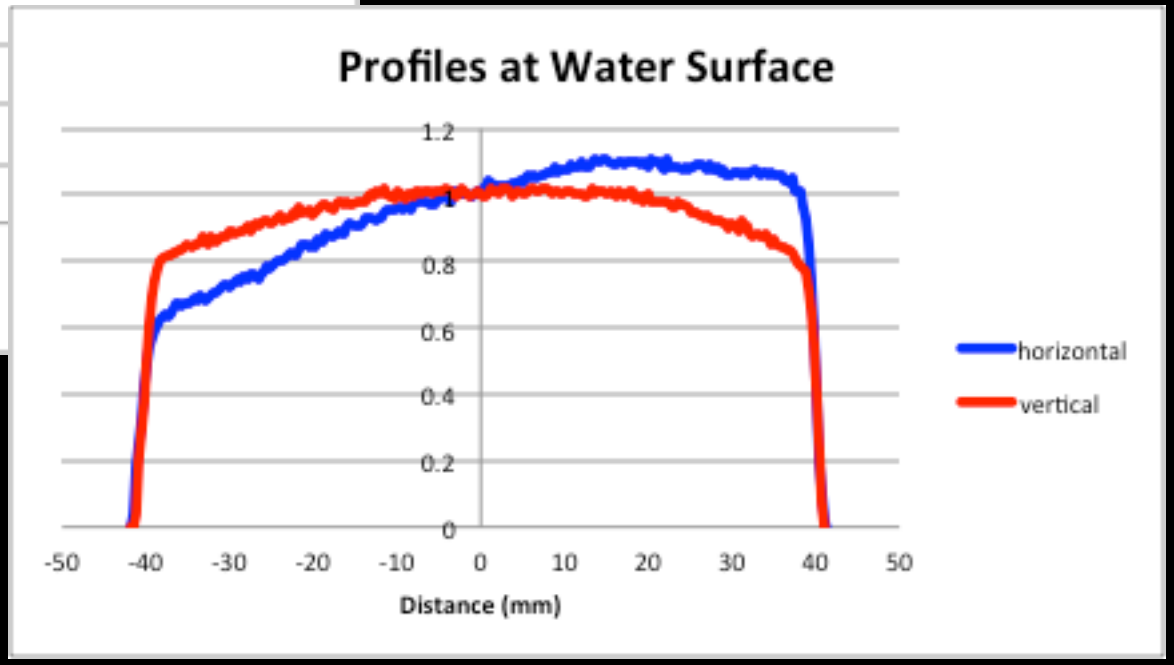
Measurement of beam flatness, symmetry and divergence



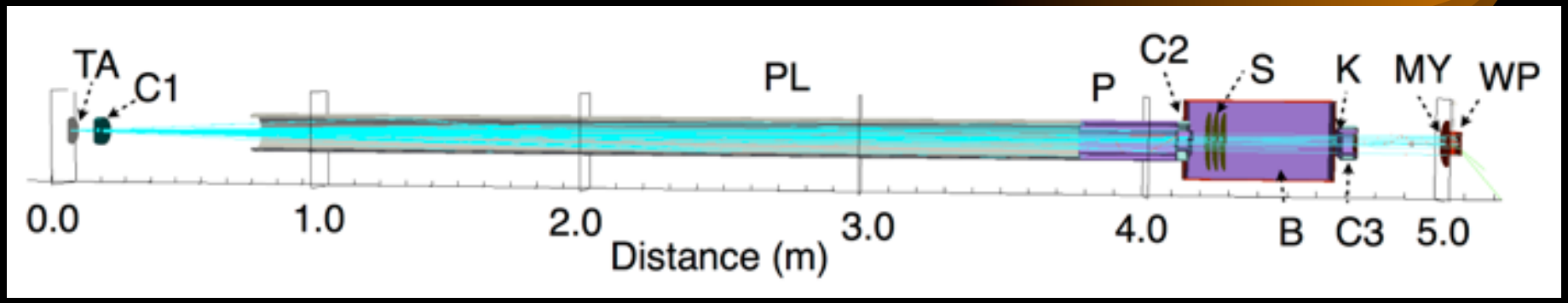
Flatness, symmetry and divergence



Profile width increase
1.6 mm over 300 mm:
0.3° divergence



Monte Carlo simulation



- TA: Ta scattering foil (101.6 um or 381 um thick)
- C1: Carbon collimator
- PL: Beam plug
- P: Beam pipe
- C2: Steel collimator
- S: Evacuated box with SEM
- K: Kapton exit window with larger steel collimator
- Air
- MY-WP: Water tank with mylar window

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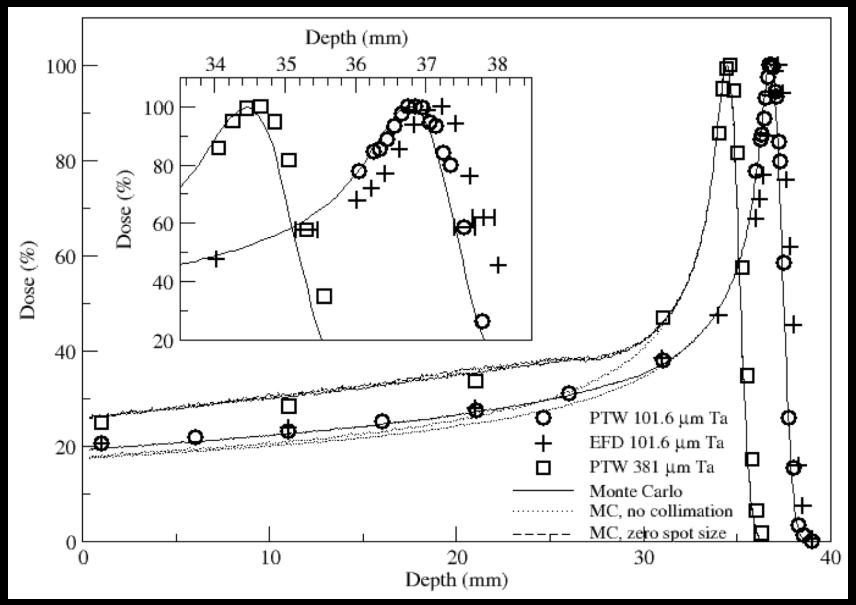
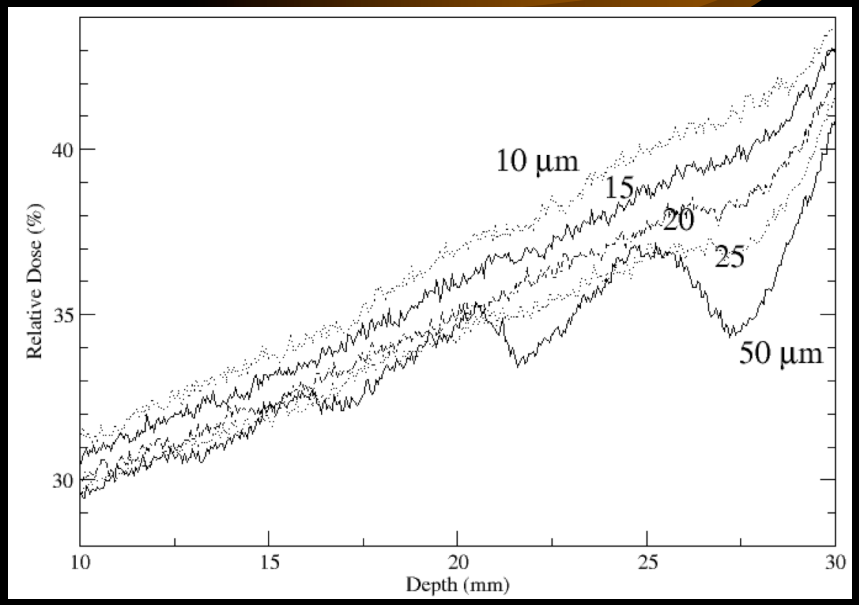
Bragg curves

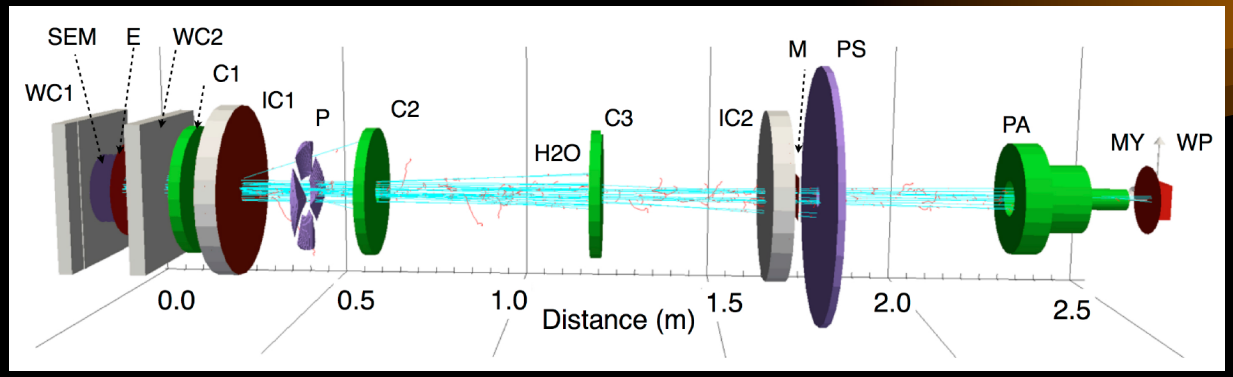


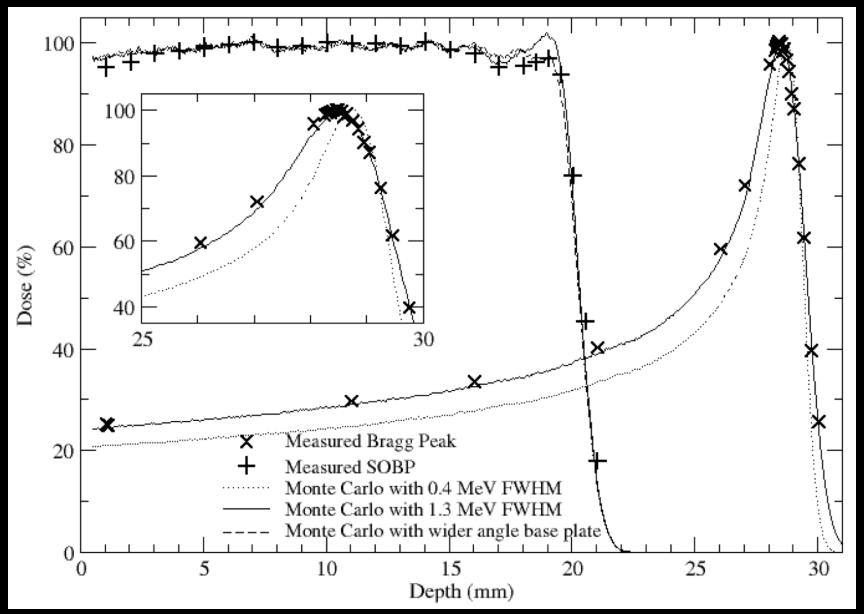
TOPAS v1.0-b9 with Geant4 v9.6.p2 with 0.02 mm range cut



Effect of changing range cut in the beam plug

Eye beam line benchmark





Conclusions

- Benchmarks were measured for a 67.5±0.1 MeV proton beam incident on 2 different thicknesses of Ta foil with 0.15 mm accuracy in depth and 4% accuracy in the peak-to-valley ratio.
  - The 0.1016 mm thick Ta foil (thinnest) provided the most accurate benchmark, having a low contribution of proton scatter from upstream of the water tank.
  - The beam penetration was less in the simulation fell than the measurement, suggesting the mean ionization potential of water is 2–5 eV higher than the 78 eV used in the simulation.
- The eye treatment beam line depth dose curves provide validation of Monte Carlo simulation of a Bragg curve and SOBP with 4%/2 mm accuracy.

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