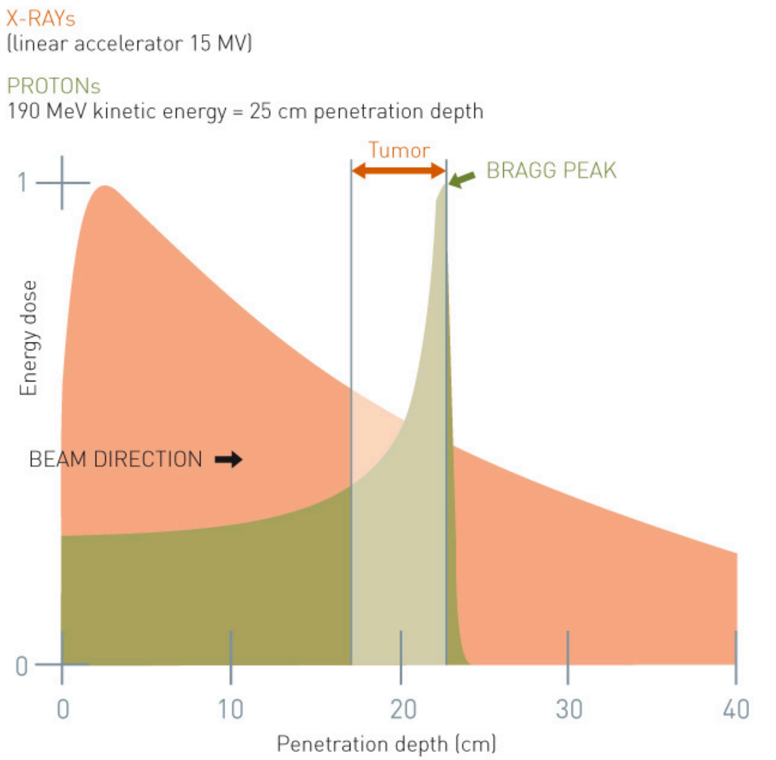
Gamma spectroscopy of ^{92}Mo marker for range verification in proton therapy

Presented by Eva Kasanda

UNIVERSITY of GUELPH

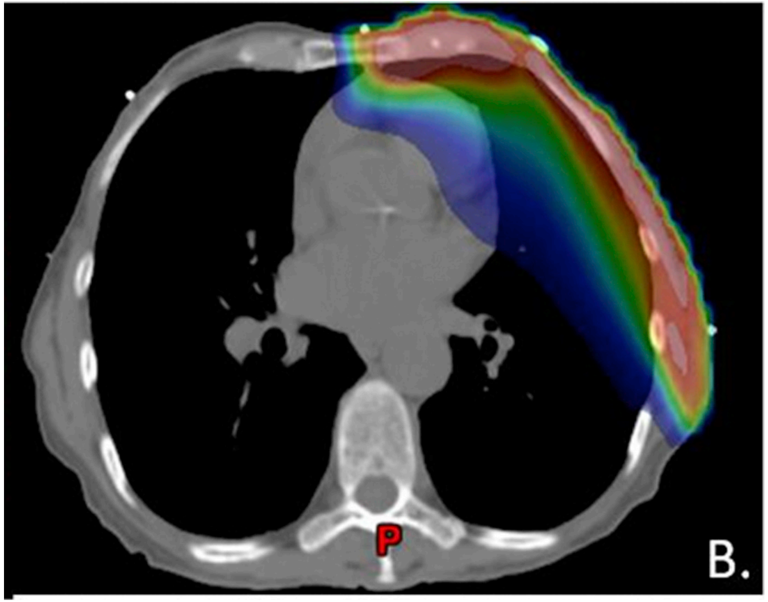
Advantages of Proton Therapy

- Protons deposit the majority of their energy at the end of their trajectory
- Less radiation is delivered to healthy tissue compared to conventional therapy



Proton Therapy for Breast Cancers

Conventional RT



Proton RT

Bradley, J. A. et al. International Journal of Radiation Oncology, 95 (1), 411 - 421

Dose-Monitoring and Range Verification

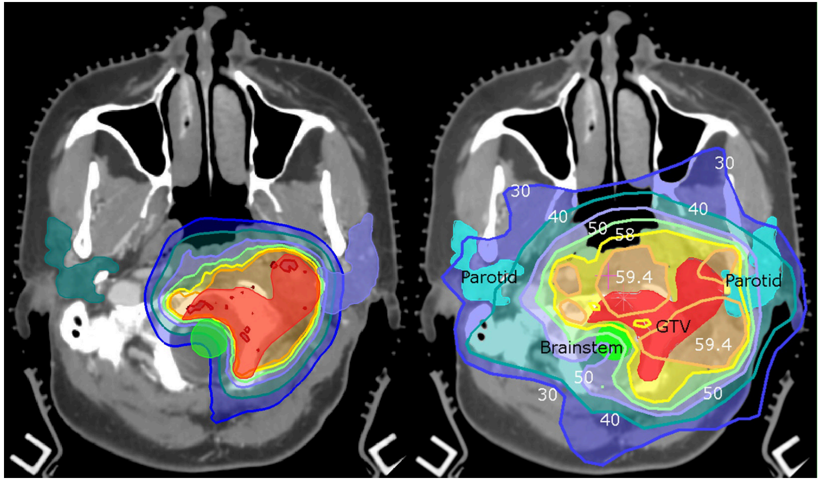
Major contributors to range uncertainty:

- Breathing motion
- Variance in beam energy
- **Tissue stopping powers**

Total range uncertainty: **> 1 mm**.

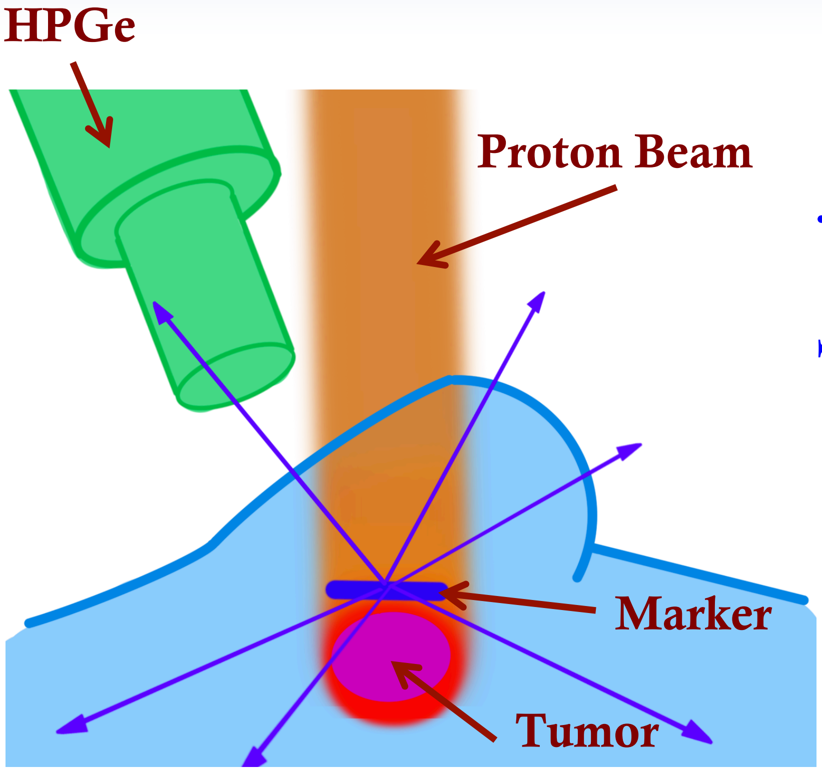
Expected range uncertainties:

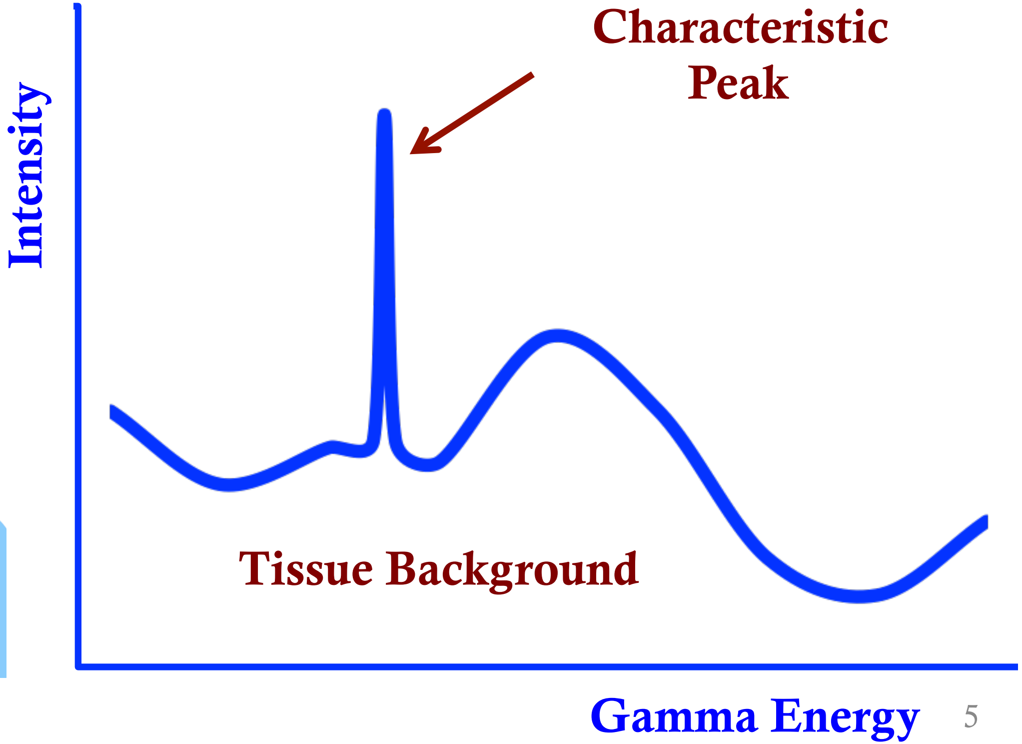
- brain (10cm) -- 0.14cm
- prostate (15cm) -- 0.33cm



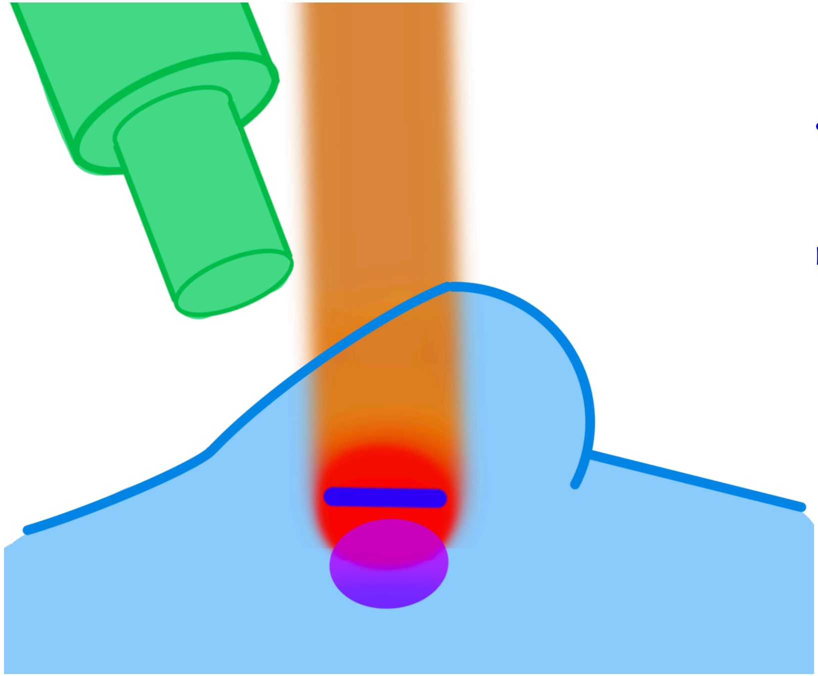
B. Schaffner and E. Pedroni. Phys. Med. Biol. 43 (1998) 1579–1592

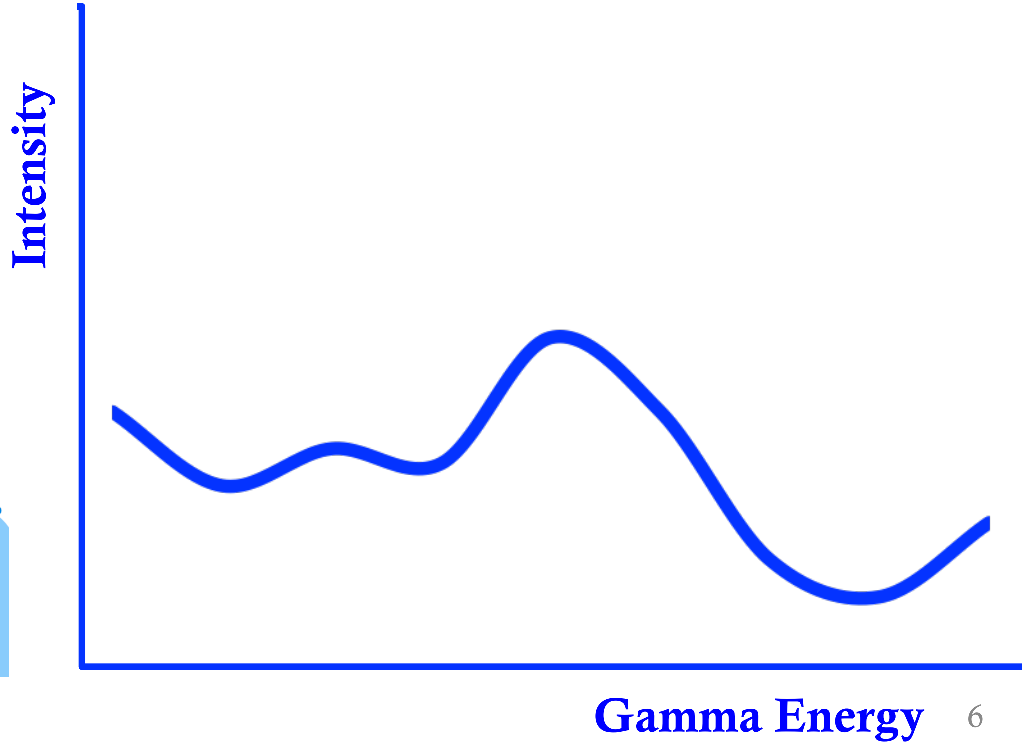
Using prompt γ -spectroscopy to measure range



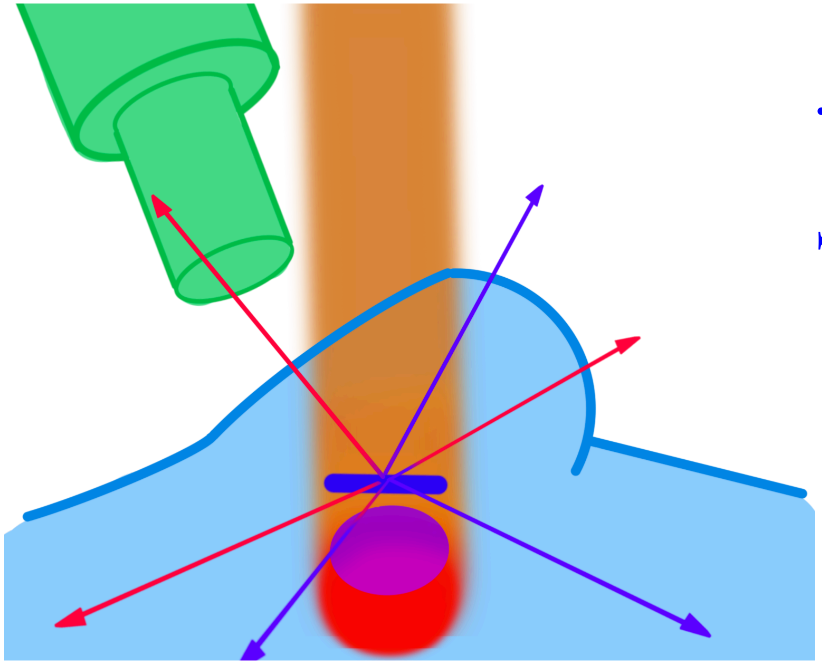


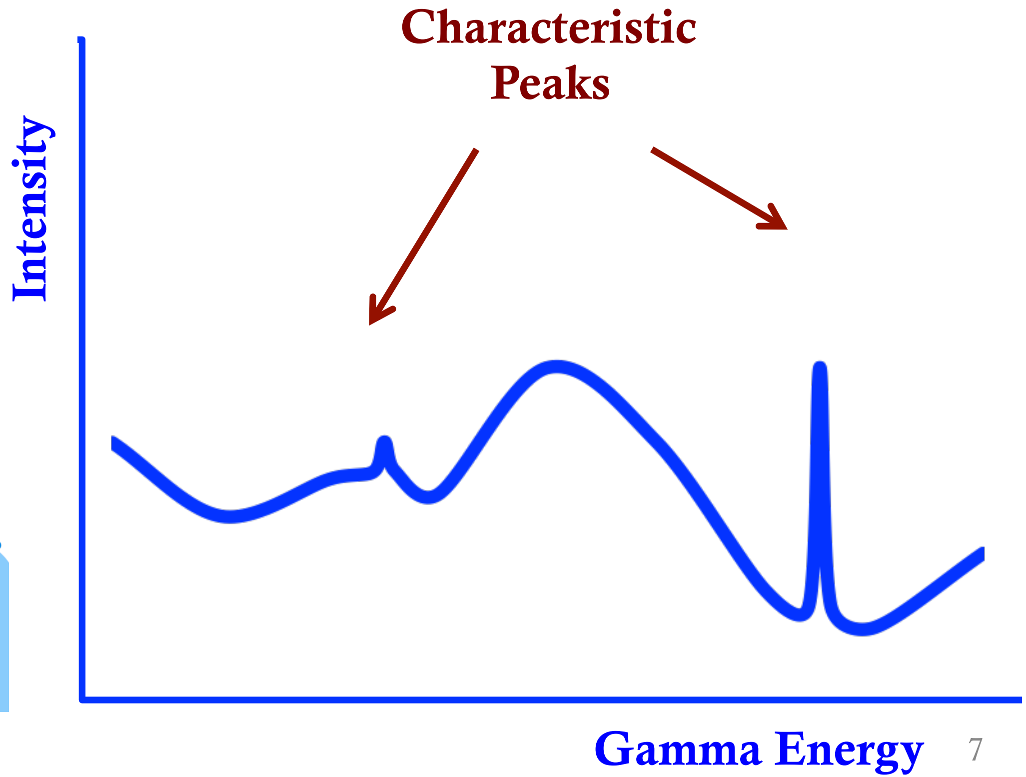
Using prompt γ -spectroscopy to measure range



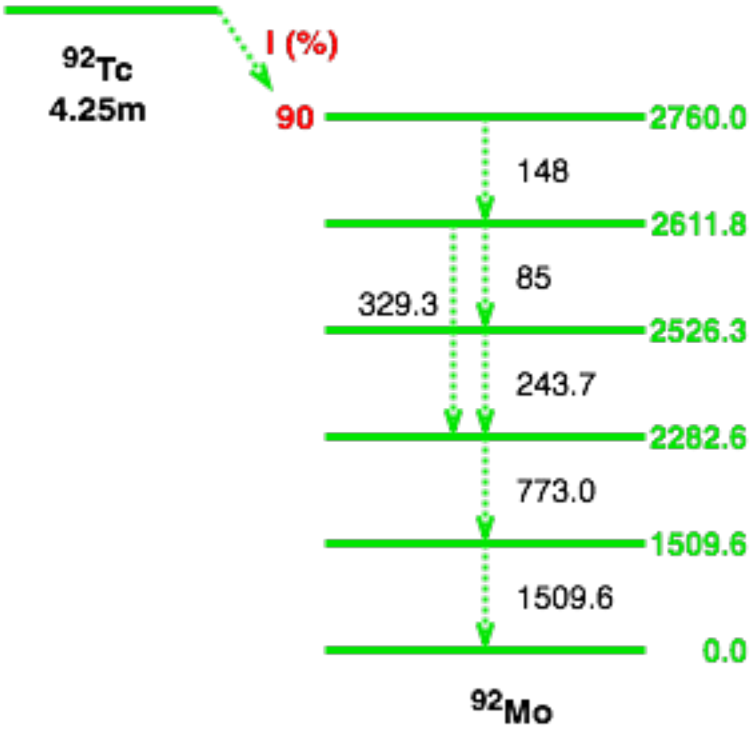


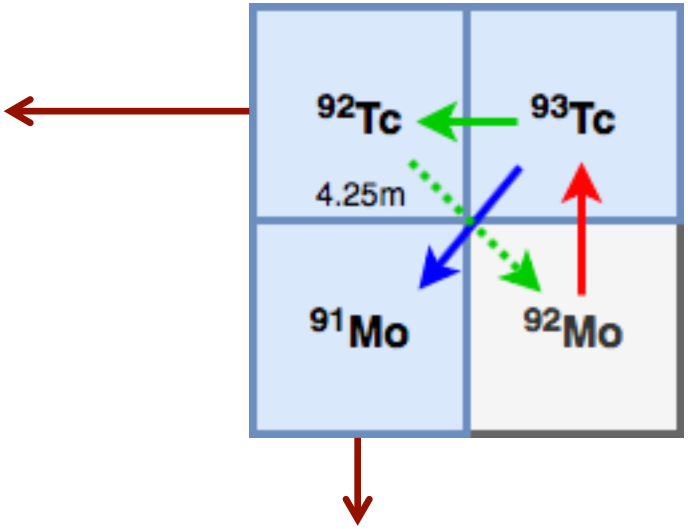
Using prompt γ -spectroscopy to measure range

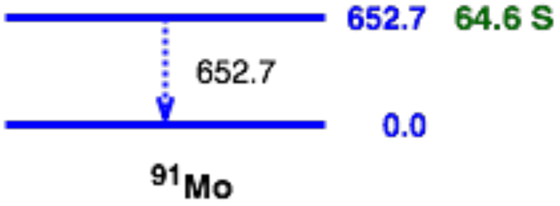




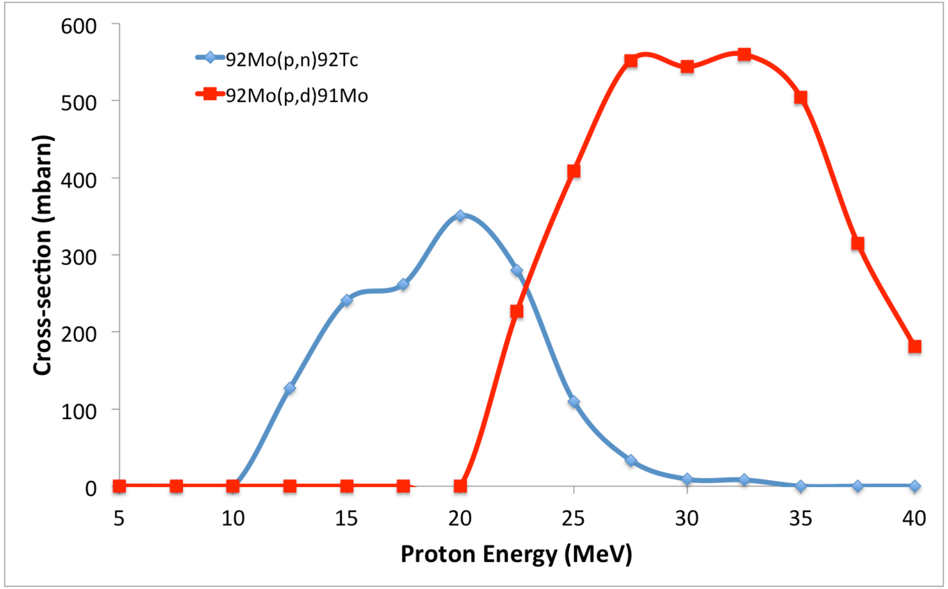
The beauty of ^{92}Mo



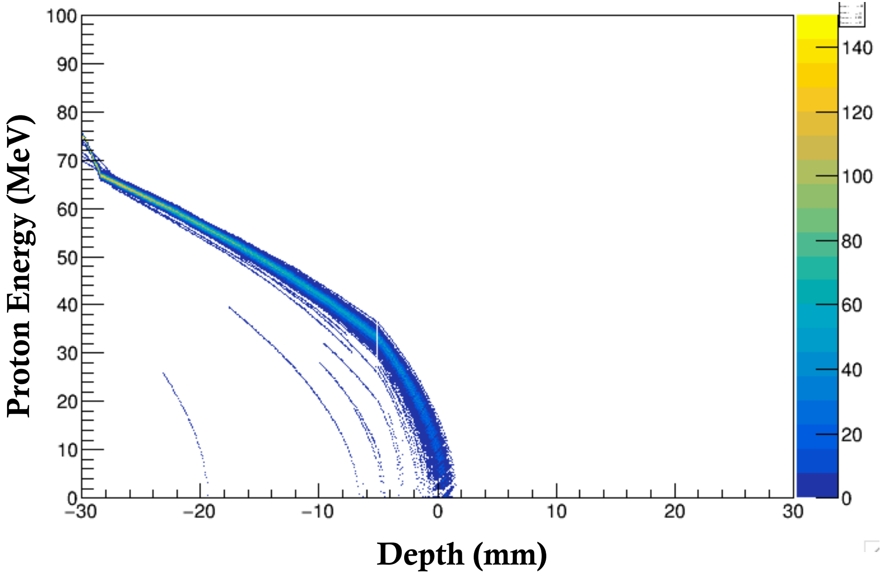




Range-dependence of signal



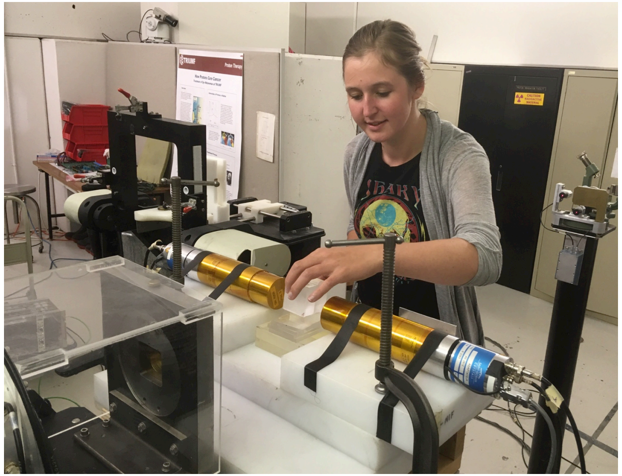
PACE cross-sections of “92Mo + p” fusion-evaporation reactions

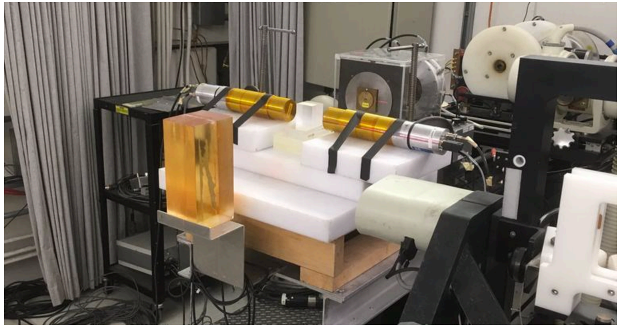


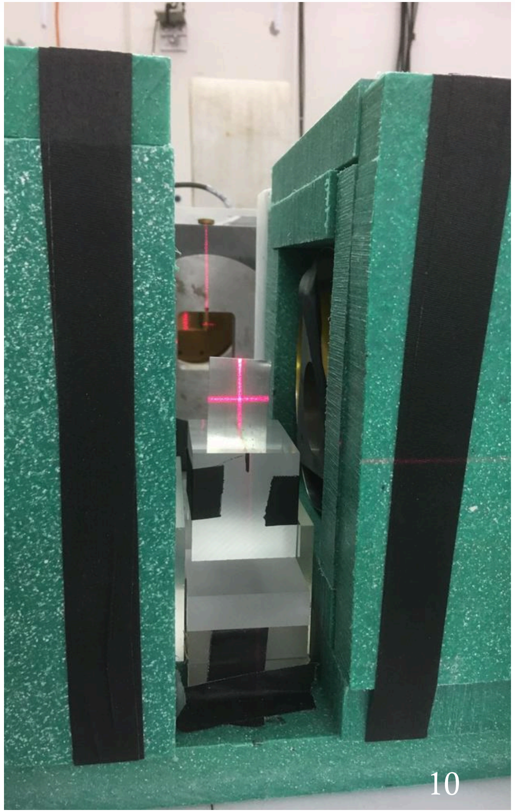
GEANT4 Simulation of proton energy as a function of depth in tissue

Experiment M1780 at TRIUMF

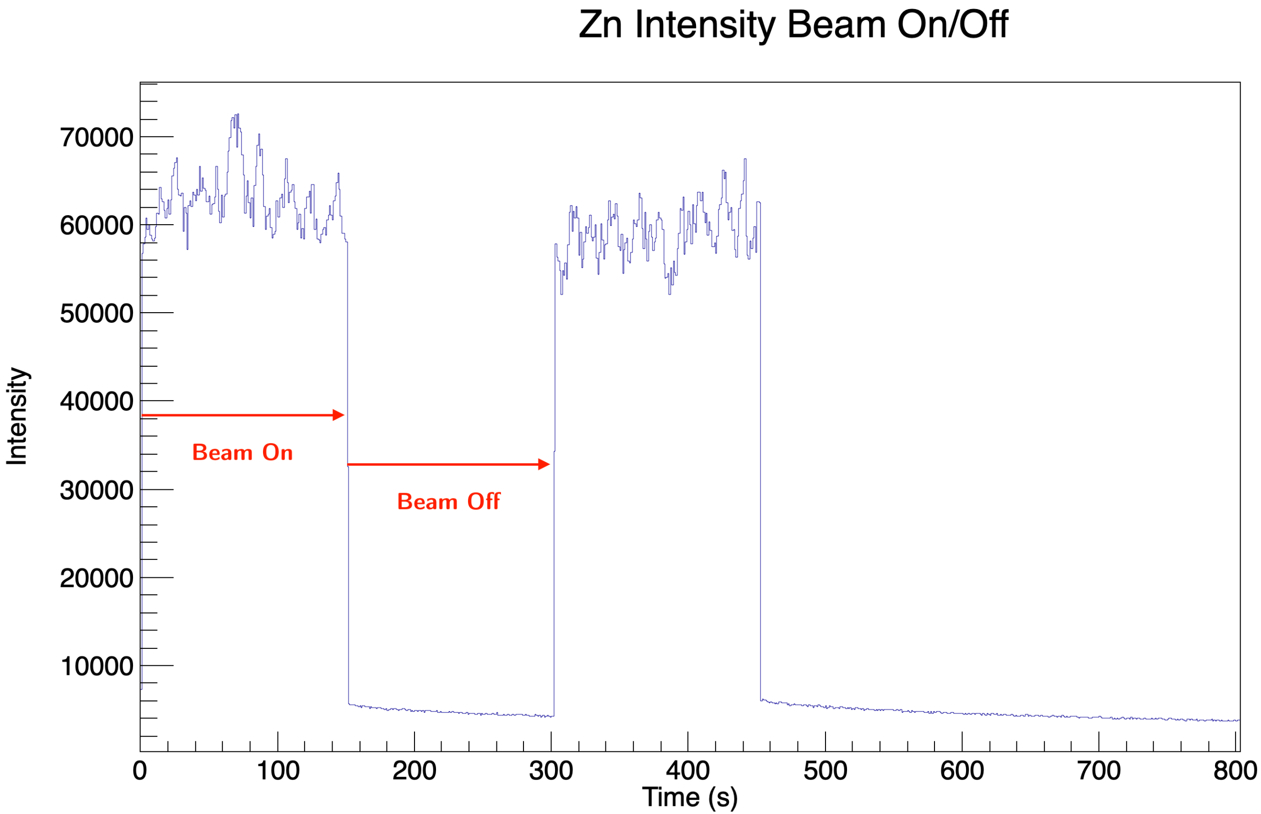
- Measurement took place in Proton Irradiation Facility (PIF)
- Performed prompt and delayed measurements on proton-activated Au, Zn, Ni, and Mo foils.
- 2 Compton-shielded (BGO) $LaBr_3$ scintillators
  - Energy resolutions: 3.8%, 3.6%
  - Intrinsic efficiencies: 3%, 6%
- CAEN Desktop Digitizer



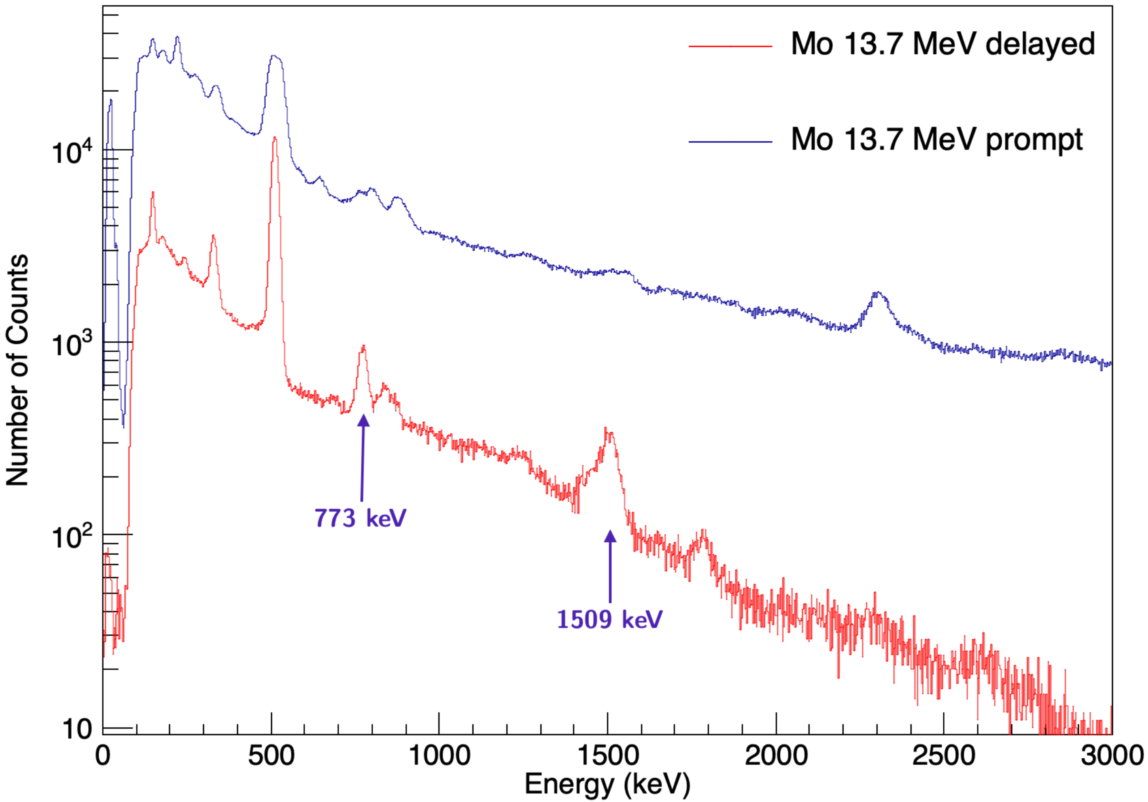




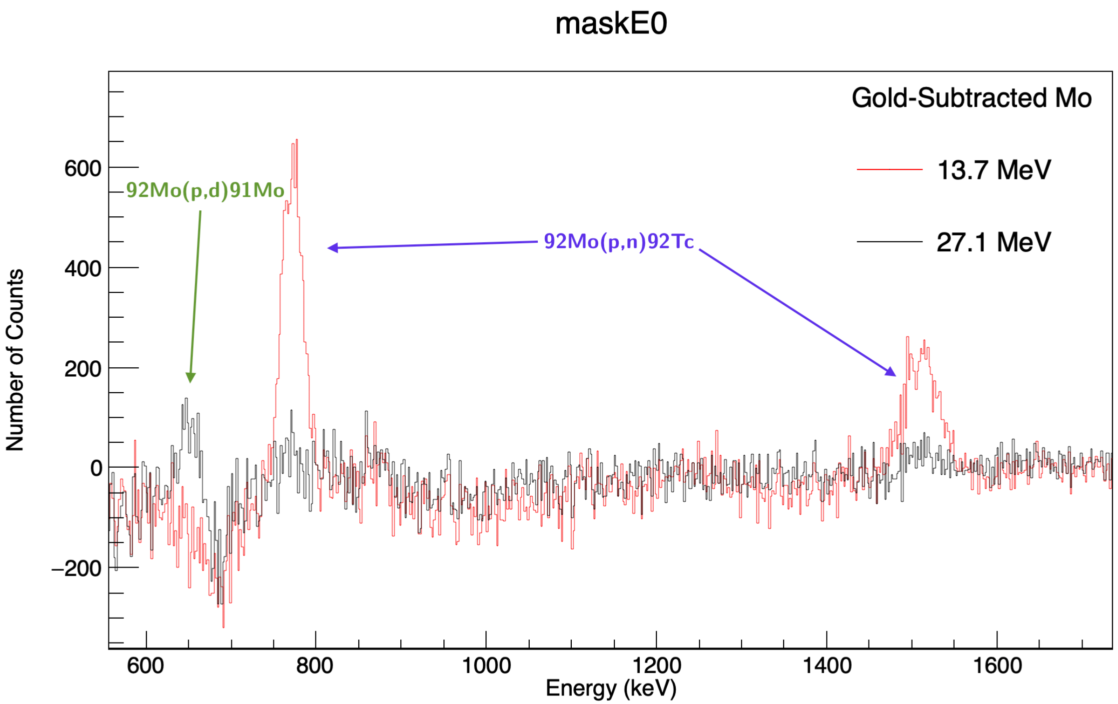
Pulsed Beam Dose Delivery



Experimental Results



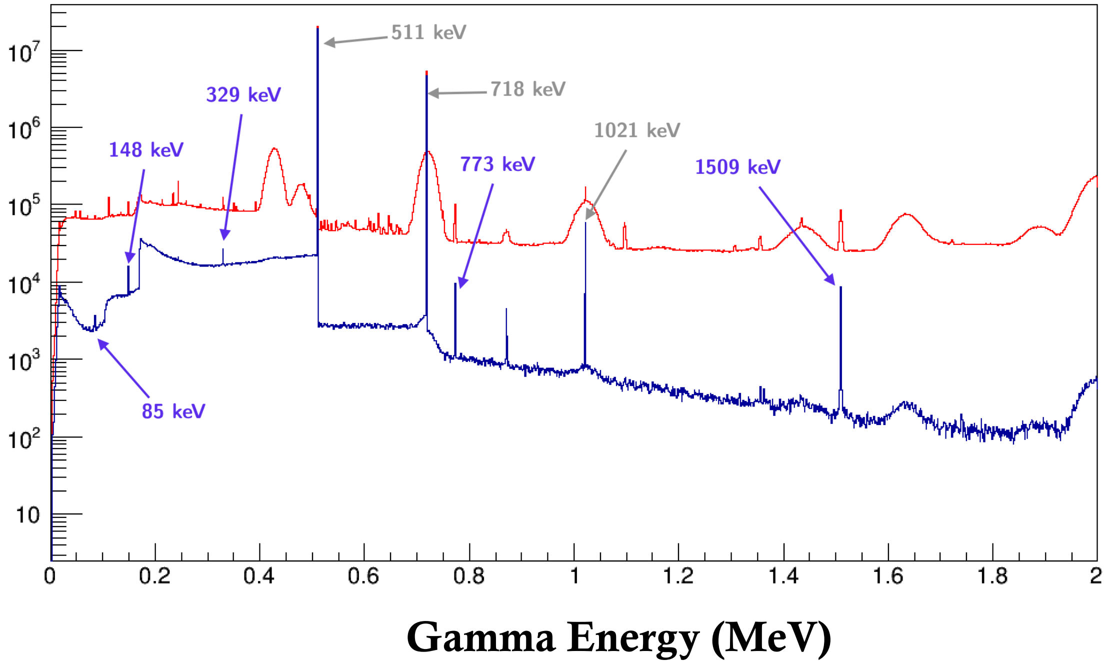
Experimental Results



- Identified 6 strongest peaks from 92Tc decay
- Identified 653 keV isomeric state of 91Mo
- Took measurements at data rates of 400 kHz in each detector

Outlook

- HPGe detectors
  - Gamma & neutron shielding
- Simulating ^{91}Mo isomeric state
- FLUKA simulation of neutron flux



Acknowledgements

Dennis Muecher
Christina Burbadge
Vinzenz Bildstein
Joseph Turko
Devin Hymers

Cornelia Hoehr
Bruno Olaizola

UNIVERSITY of GUELPH

TRIUMF