Measurement of 254 eV Nuclear Recoils in Germanium

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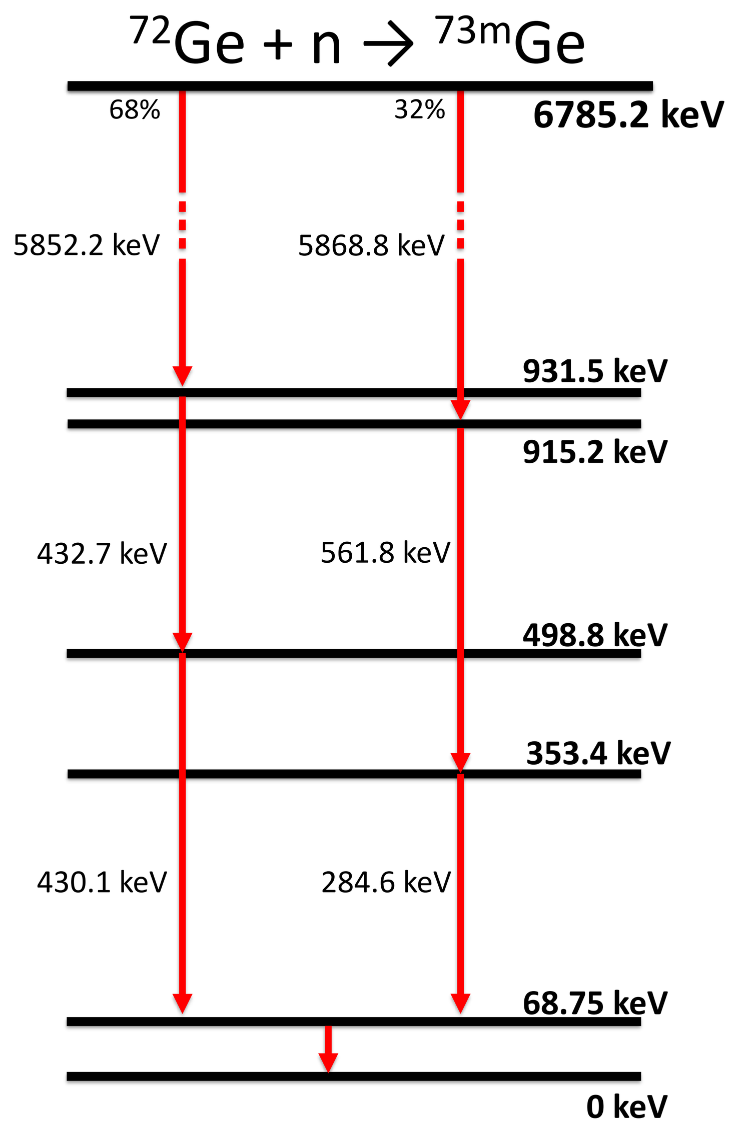
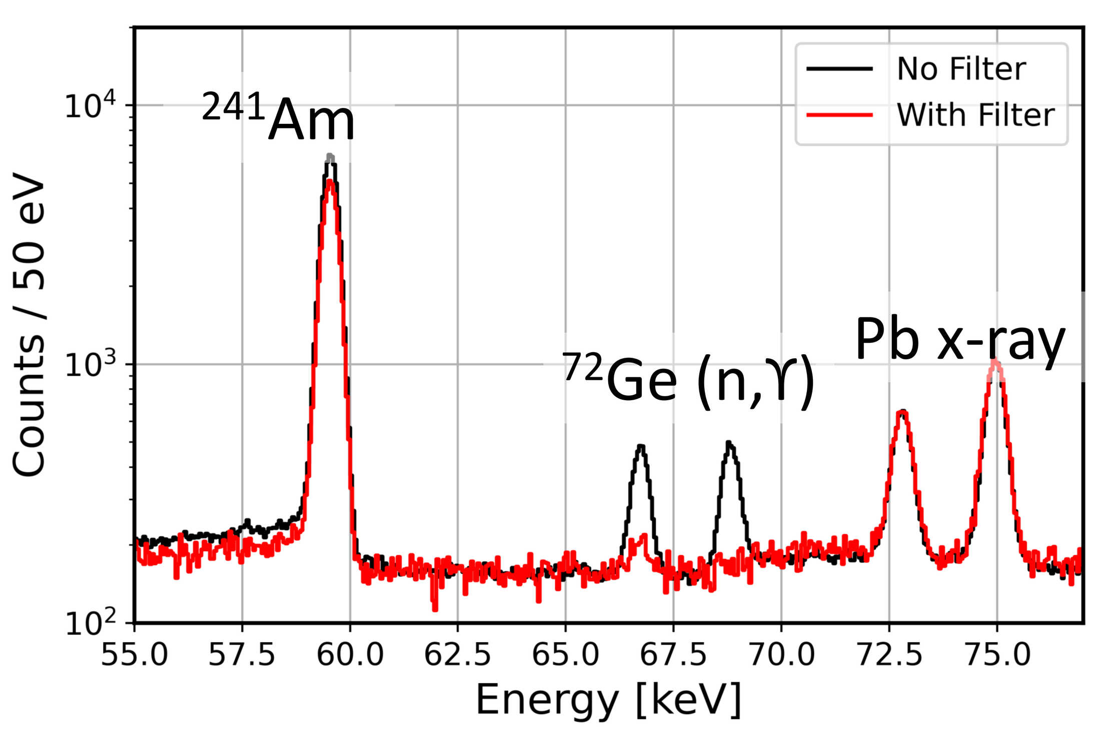
Introduction and Motivation

- Nuclear recoils key signature of neutrinos, dark matter, fission, etc.
  - Low energy regime not well characterized
- Mechanisms of single atomic displacement not well understood.
  - Individual Frenkel Pairs

Nuclear Level Structure



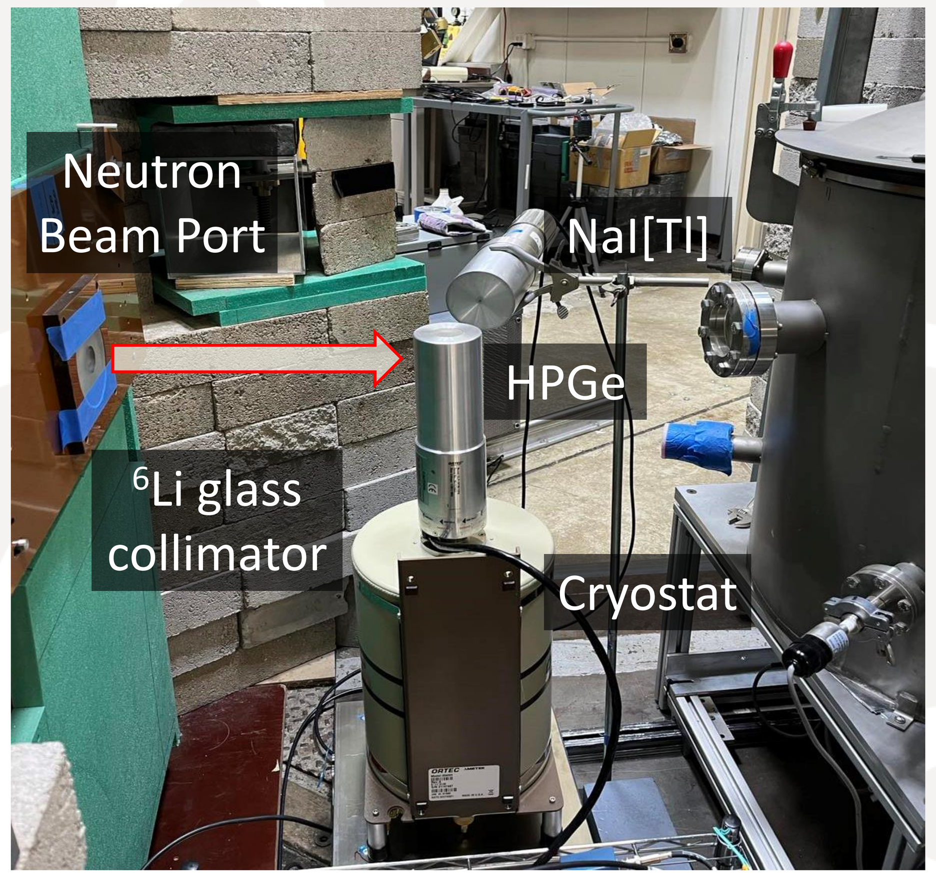
- 5.8 MeV Y-ray produces 254.1 eV nuclear recoil.
  - 1.5 eV spread in kinetic energy
- Recoil measured summed with internally captured 68.75 keV Y-ray
- 25% detection efficiency for 2cc crystal.
  - Small detector required.



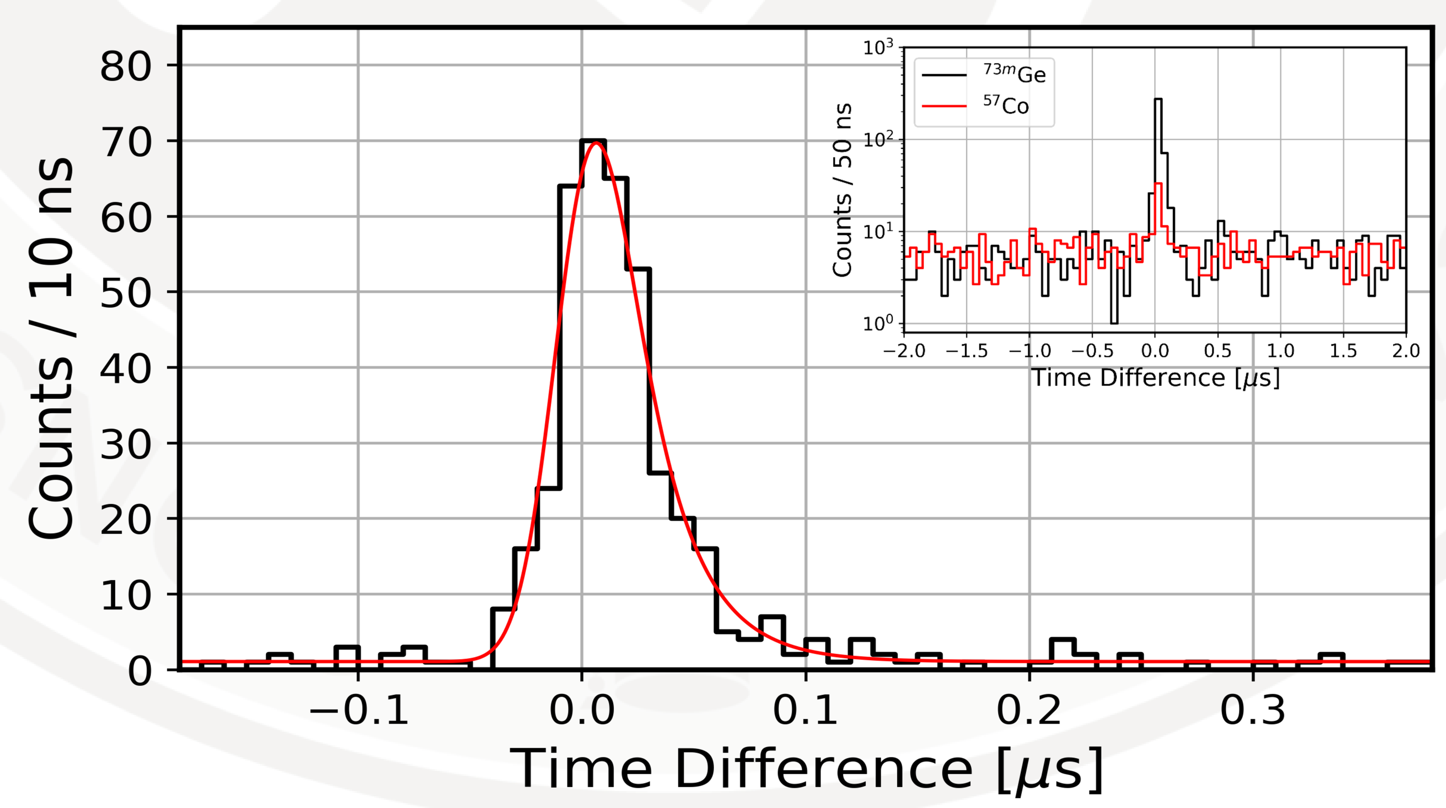
- ^{241}Am ϒ and Pb x-ray in-situ calibration
- Capture reaction highly correlated with neutron signal

Technical Approach

- ^{72}Ge (n,Y) populates 6.8 MeV excited state.
- Emission of 5.8 MeV Y-ray produces 254 eV nuclear recoil. Nuclear recoil measured with 68.75 keV transition to ground.
- HPGe detector measures nuclear recoil and self absorbed 68.75 keV Y-ray
- NaI[Tl] backing detector tags 5.8MeV Y-ray

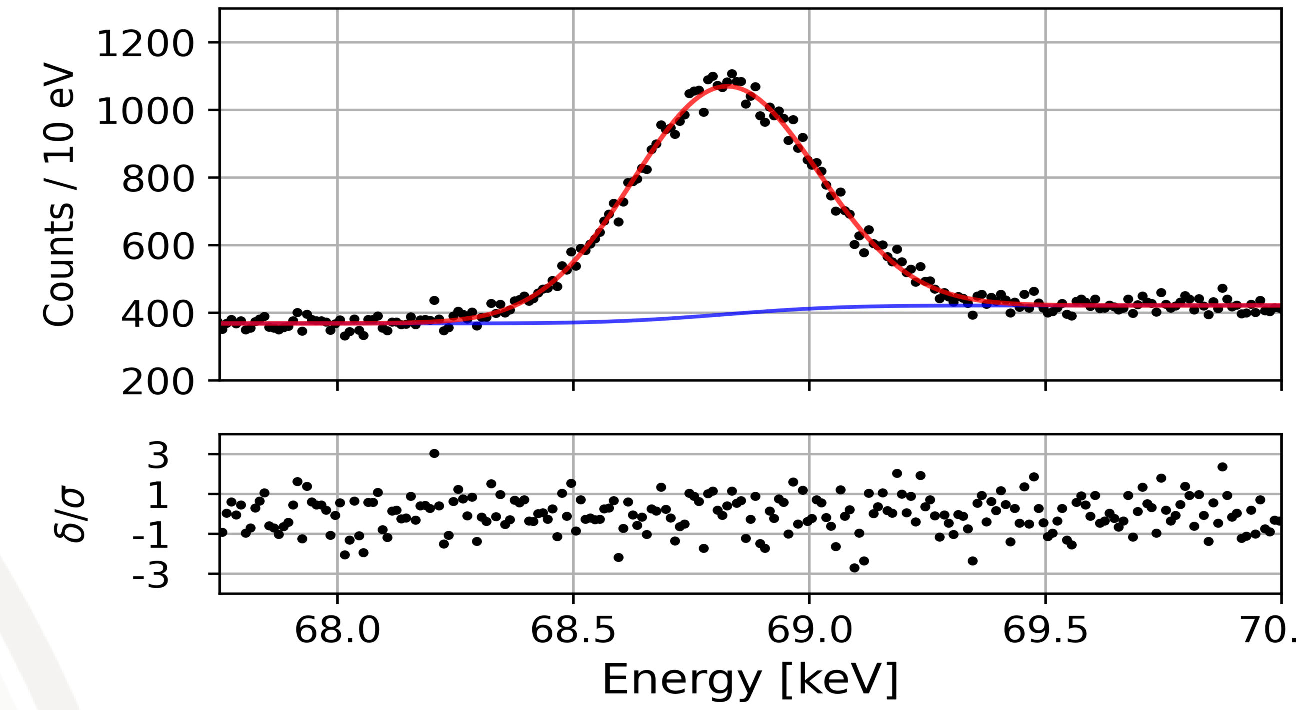


Y-Coincidence



- Half-Life of nuclear state(s) T =9.3 ns
  - Important for interpretation of past experimental data

Y + Recoil Energy



Study	Y + Recoil	Ionization Yield	Quenching Factor
This Work	68.818(2) keV	65.5(21) eV	25.8 %
UChicago	68.811(1) keV	57.8(41) eV	22.7 %
Brookhaven	68.793(3) keV	39.5(52) eV	15.5 %
Lindhard Theory	-	36.2 eV	14.3%

Conclusion & Next Steps

- Strong evidence for enhanced quenching
- Novel nuclear-atomic interactions probed
- Measurement of 68.75 keV nuclear level underway
- Collaboration with material physicists for model and simulation development

MTV Impact

- MTV funded project
- Student lead grant proposal and experiment -> Huge career experience benefit

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