

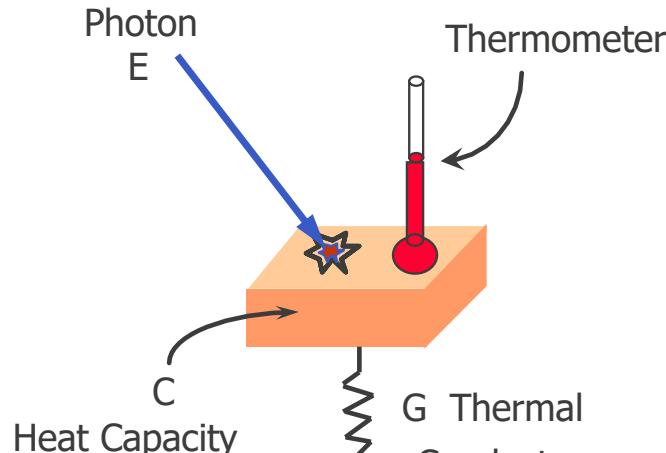


# Microcalorimetry for High Resolution X-ray, Gamma-ray, and Decay Energy Spectroscopy

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From LA-UR-21-24545

# What are microcalorimeters?

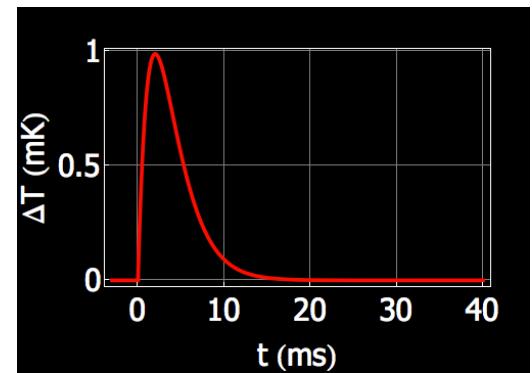
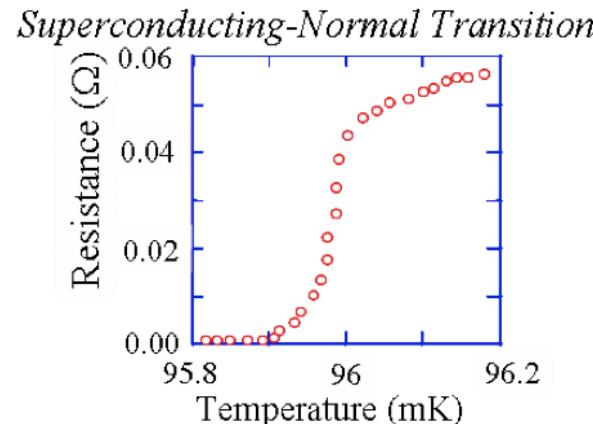


$$E = C \times \Delta T$$

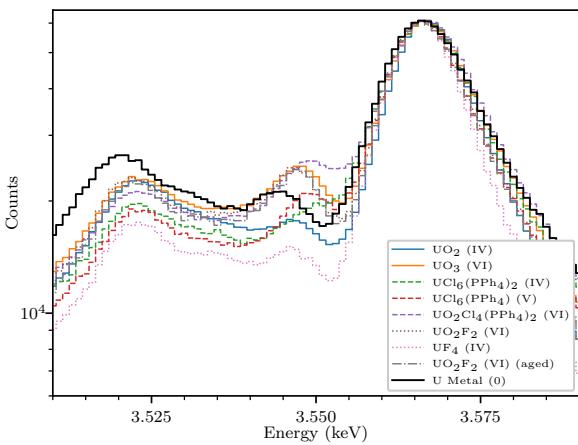
$$\Delta E \approx \sqrt{4kT^2C}$$



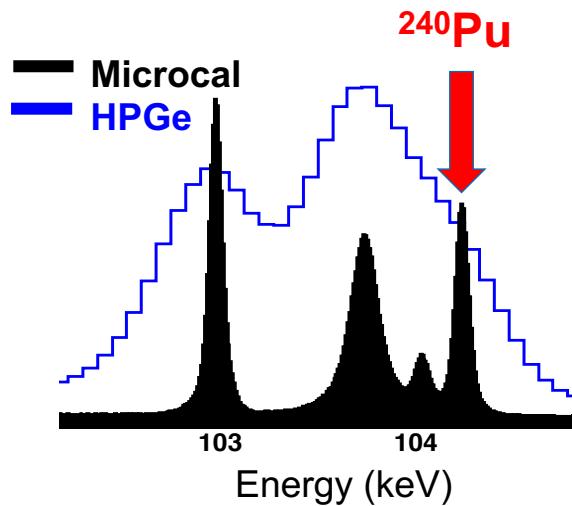
*A microcalorimeter measures the thermalized energy of individual photons, nuclear decays, etc. to create an ultra-high resolution energy spectrum (10-50x better than semiconductors)*



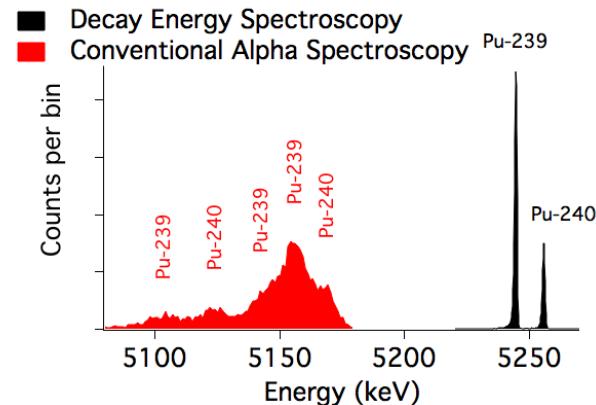
# A flexible detector technology with exceptional energy resolution



*X-ray spectroscopy*  
~0.2-30 keV



*Gamma-ray spectroscopy*  
~30-300 keV

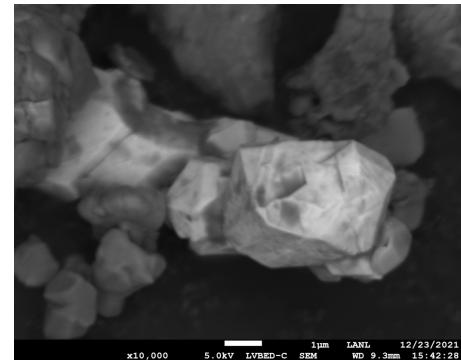
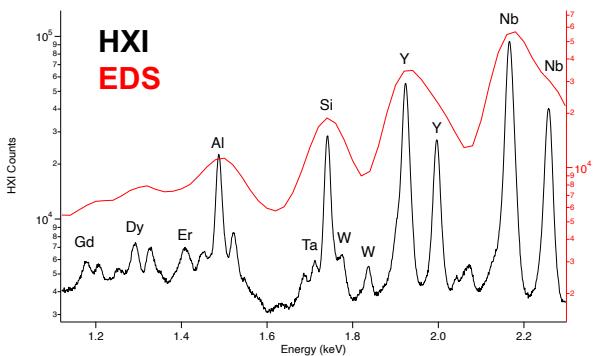
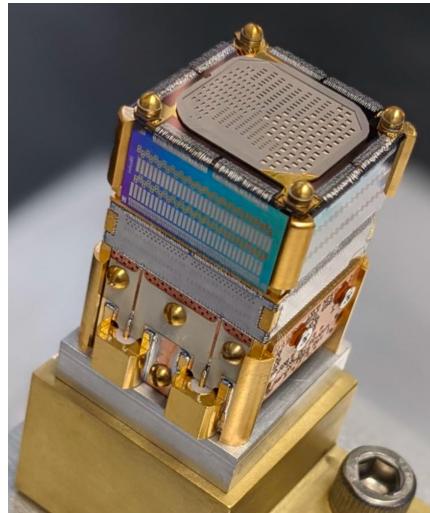


*Decay energy spectroscopy*  
~3-6 MeV



# Hyperspectral X-ray Imaging

- Commercial JEOL JSM-7200F scanning electron microscope
- Ultra-high resolution microcalorimeter spectrometer connects to standard WDS port – thousands of counts per second
- Compatible with full suite of SEM capabilities – EDS, low vacuum, backscatter electron imaging, etc.
- SEM imaging performance is not compromised

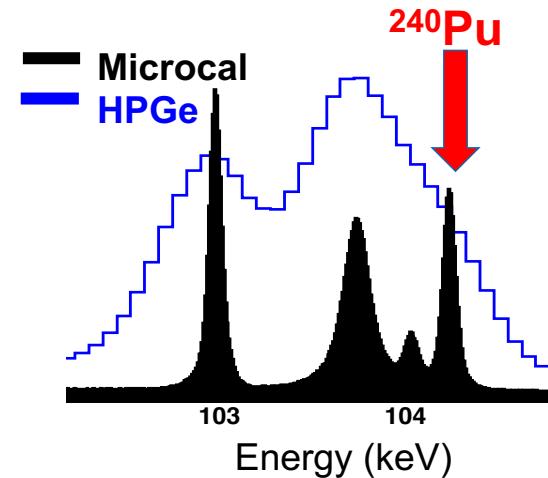
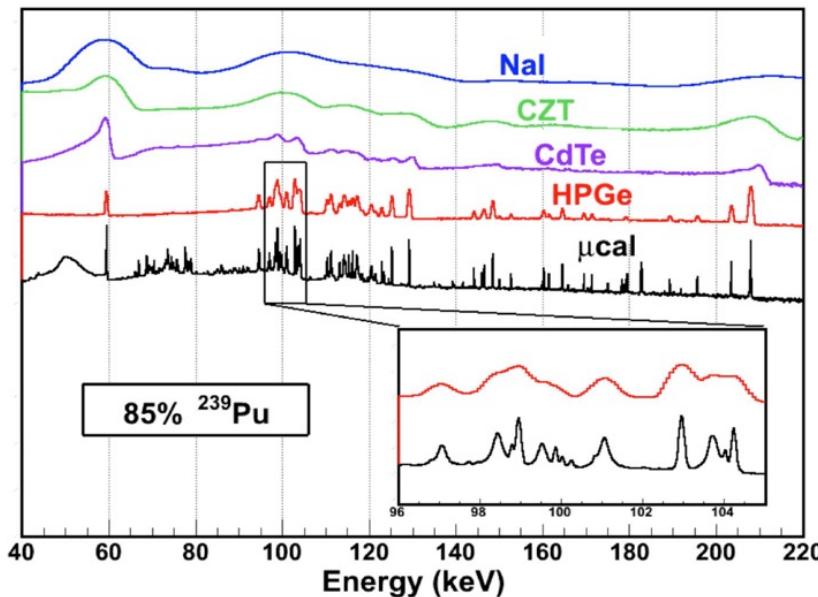


From LA-UR-22-23098



# Gamma Spectroscopy

- Improve sensitivity and uncertainty in nondestructive isotopic analysis

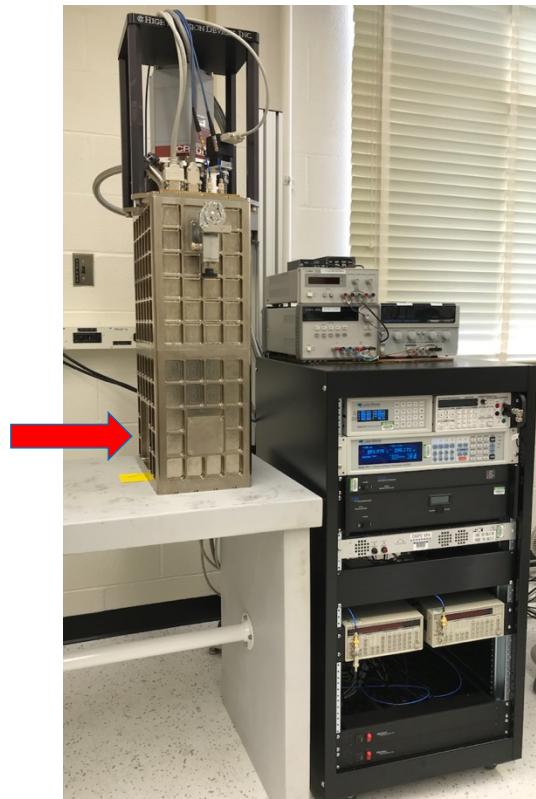


*Single pixel: 22 eV FWHM (100 keV)*  
*Large array: 50-70 eV FWHM (100 keV)*  
*Planar HPGe: ~530 eV FWHM (100 keV)*

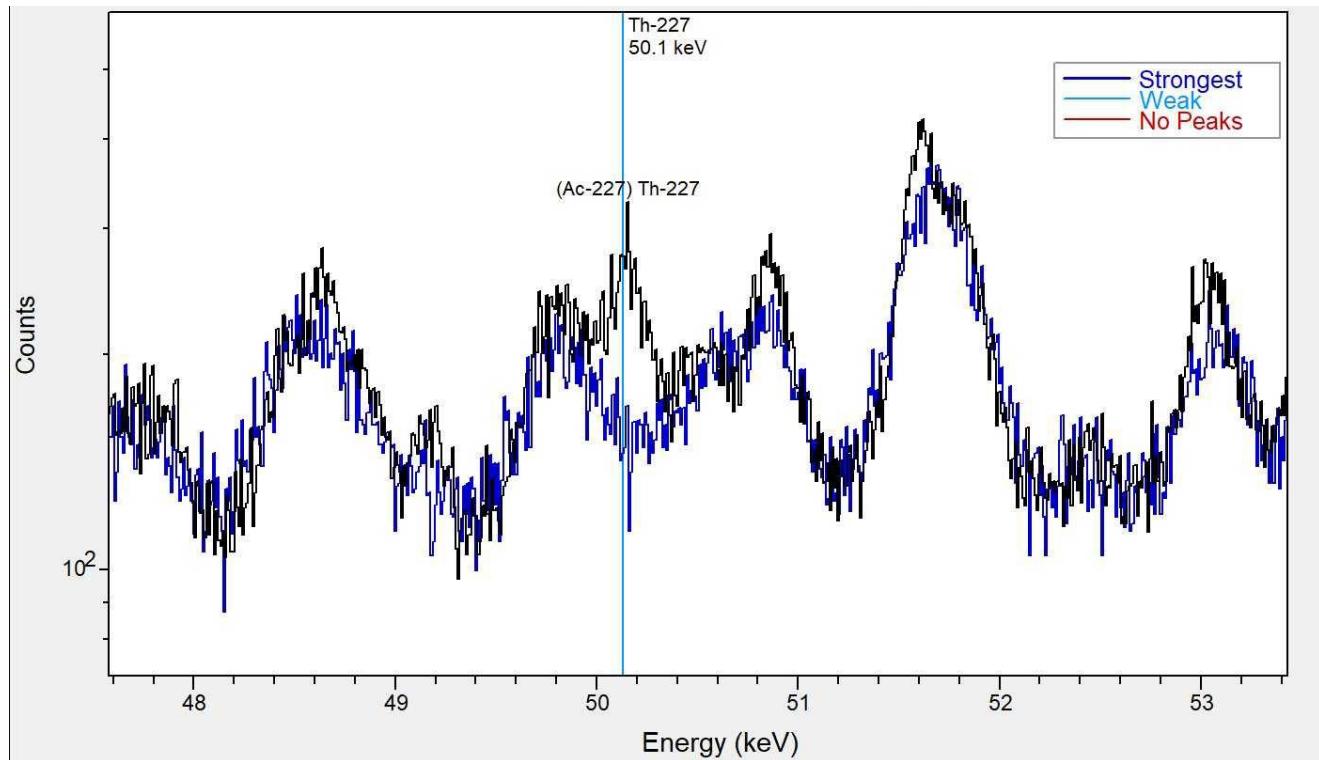


# SOFIA: Spectrometer Optimized for Facility Integrated Applications

- Samples are placed outside the cryostat, or the instrument can be moved next to a glove box or hot cell
- Power requirements similar to a large window air conditioner
- 256-pixel microwave-multiplexed transition-edge sensor array
- 65 eV FWHM typical resolution at 129 keV  
    (~8x better than HPGe)
- Capable of > 5000 counts per second



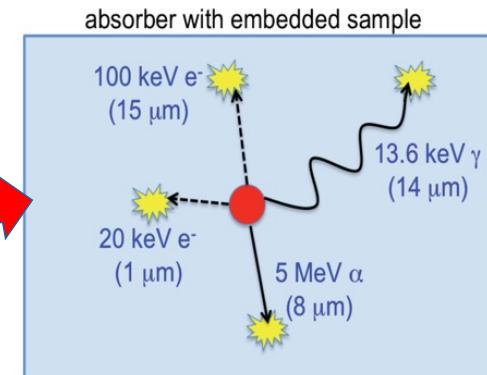
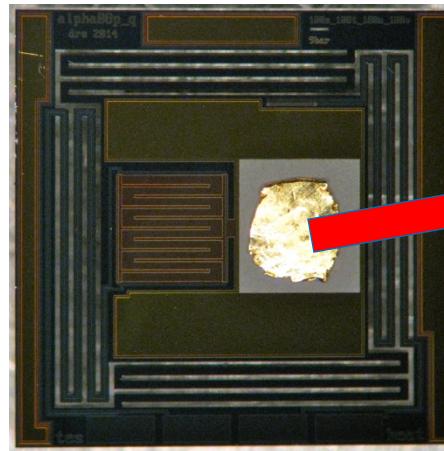
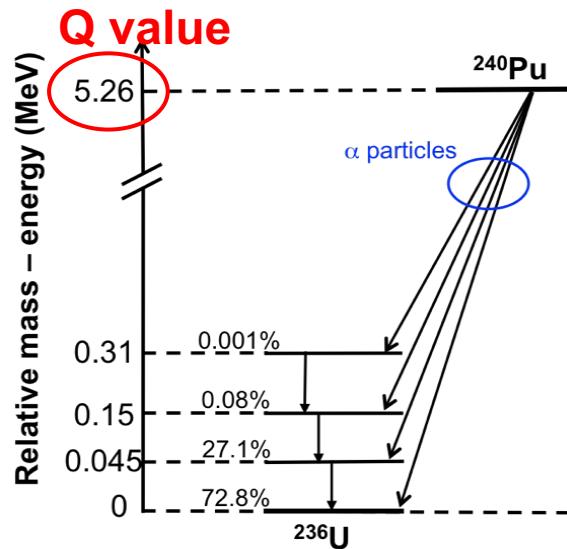
# Ac-225 product measurements



Sensitivity to Ac-227

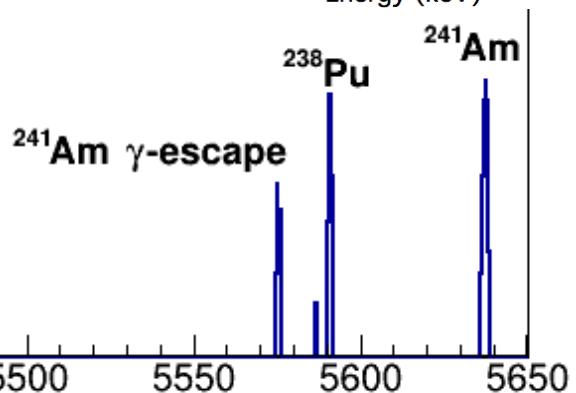
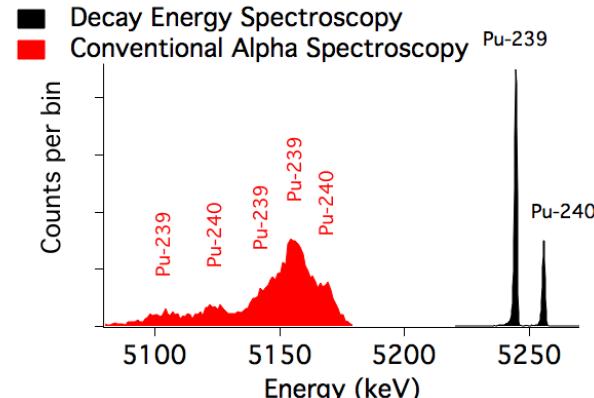
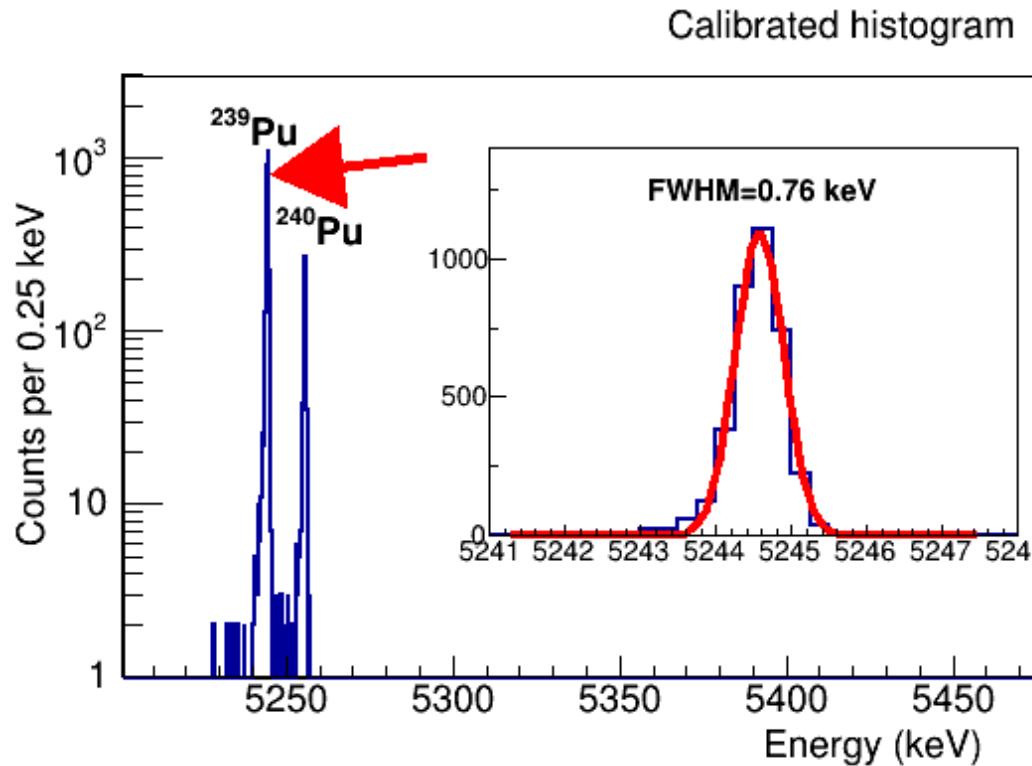
# Decay Energy Spectroscopy

- Radiometric measurement with sensitivity and precision to complement mass spectrometry
- Under evaluation for safeguards, certified reference materials, medical isotope production, nuclear forensics, basic nuclear physics



# >10x better than limit of Si alpha detectors

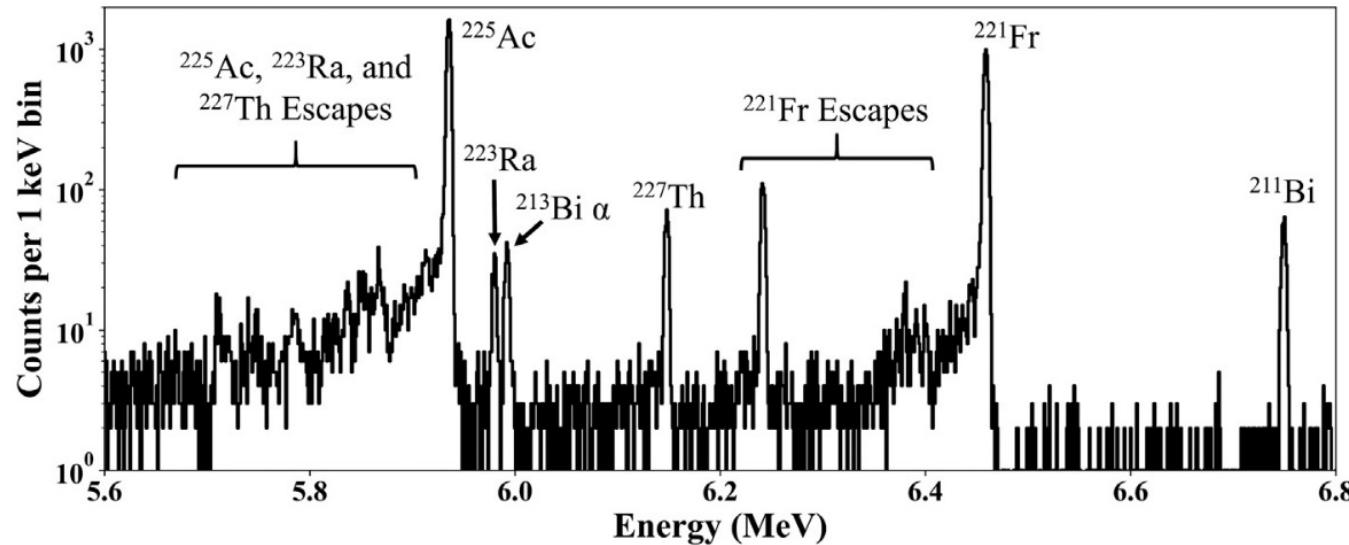
## 0.76 keV FWHM at 5.2 MeV



# $^{225}\text{Ac}$ characterization for targeted alpha therapy

A.D. Tollefson et. al., Applied Radiation and Isotopes (2021)

Accurately quantified end of bombardment  $^{227}\text{Ac}/^{225}\text{Ac}$  activity ratio



$^{225}\text{Ac}$  production sample spectrum with clear indication of  $^{227}\text{Ac}$  impurity visible from  $^{223}\text{Ra}$ ,  $^{227}\text{Th}$ , and  $^{211}\text{Bi}$  daughters



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