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Nuclear Resonance Fluorescence states in ^{239}Pu

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**Nuclear Resonance Fluorescence states in
 ^{239}Pu**



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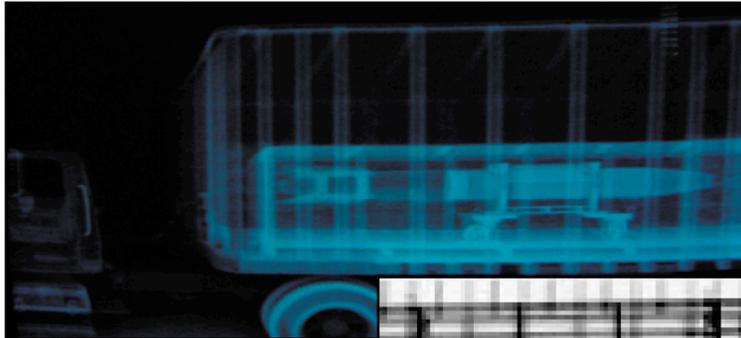
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Outline

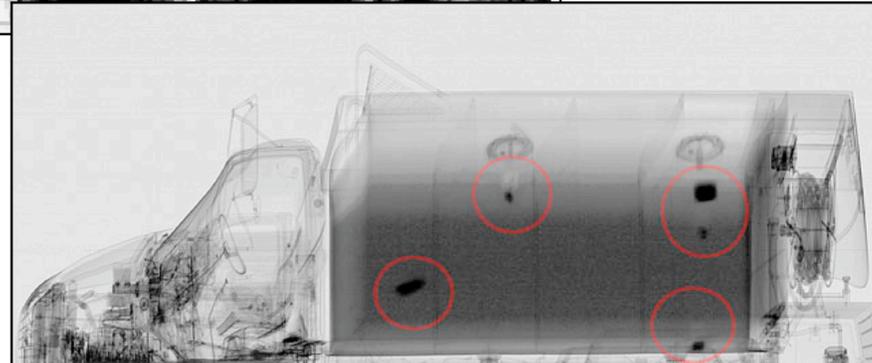
- Motivation and Background
- NRF measurements on Pu
 - MIT
 - UCSB
- Summary



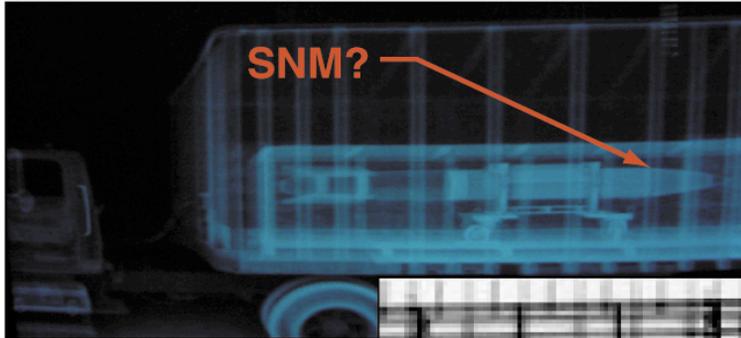
Current systems: radiography



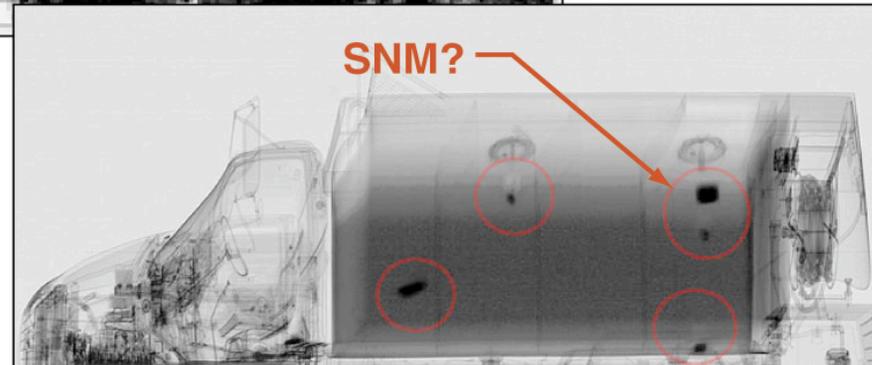
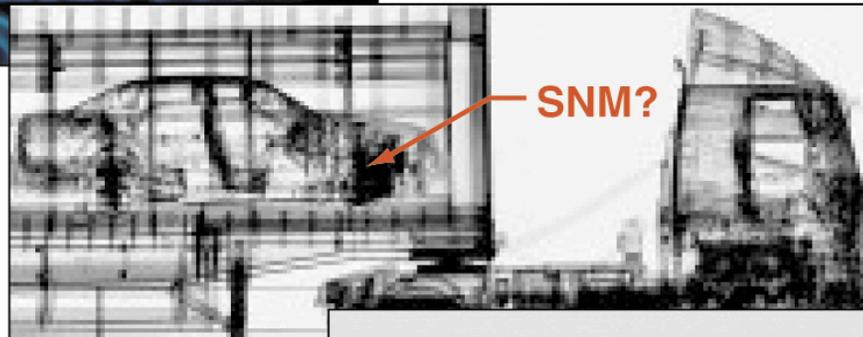
Visually powerful, but is far from perfect for SNM detection



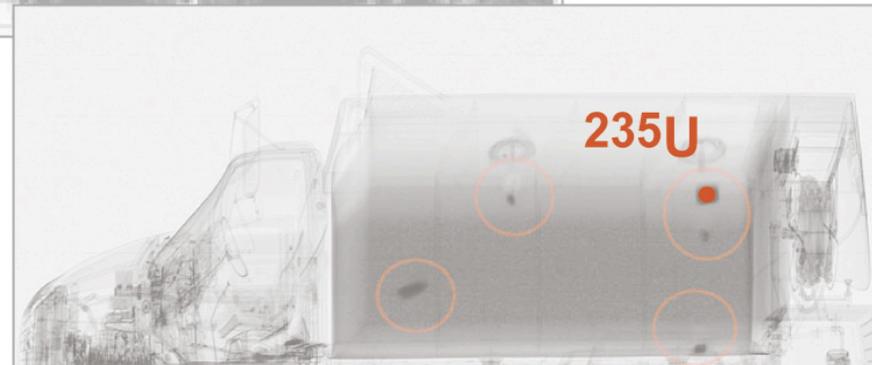
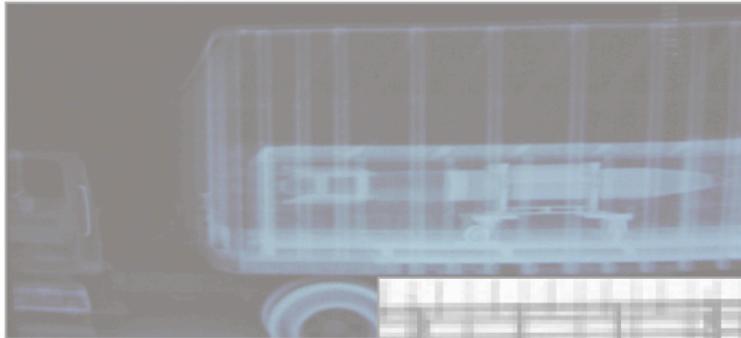
Limitation: density silhouette



Visually powerful, but is far from perfect for SNM detection



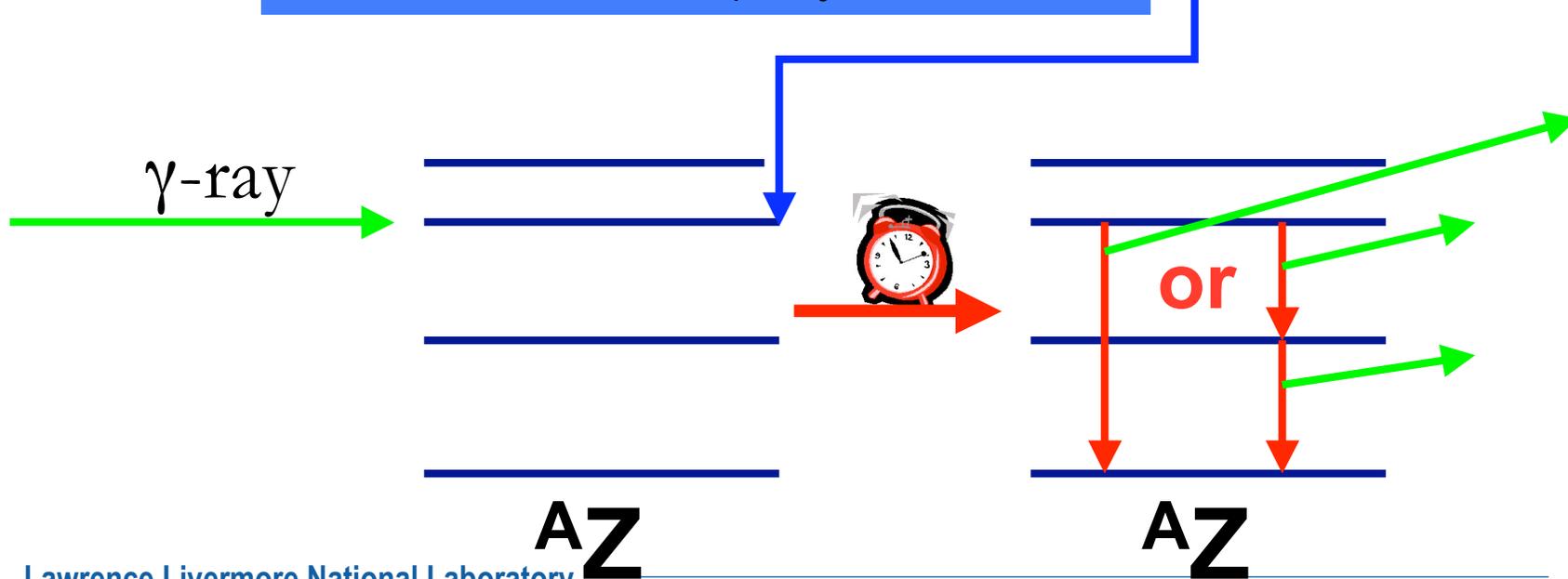
NRF \Rightarrow isotopic sensitivity



Nuclear Resonance Fluorescence (NRF)

- An energetic photon (γ -ray) at a resonant energy of a particular isotope can excite that isotope.
- The excited nucleus then will decay by emitting a set of γ -rays
- Dipole excitations (e.g. scissors mode)

Level sensitive to γ -ray excitations



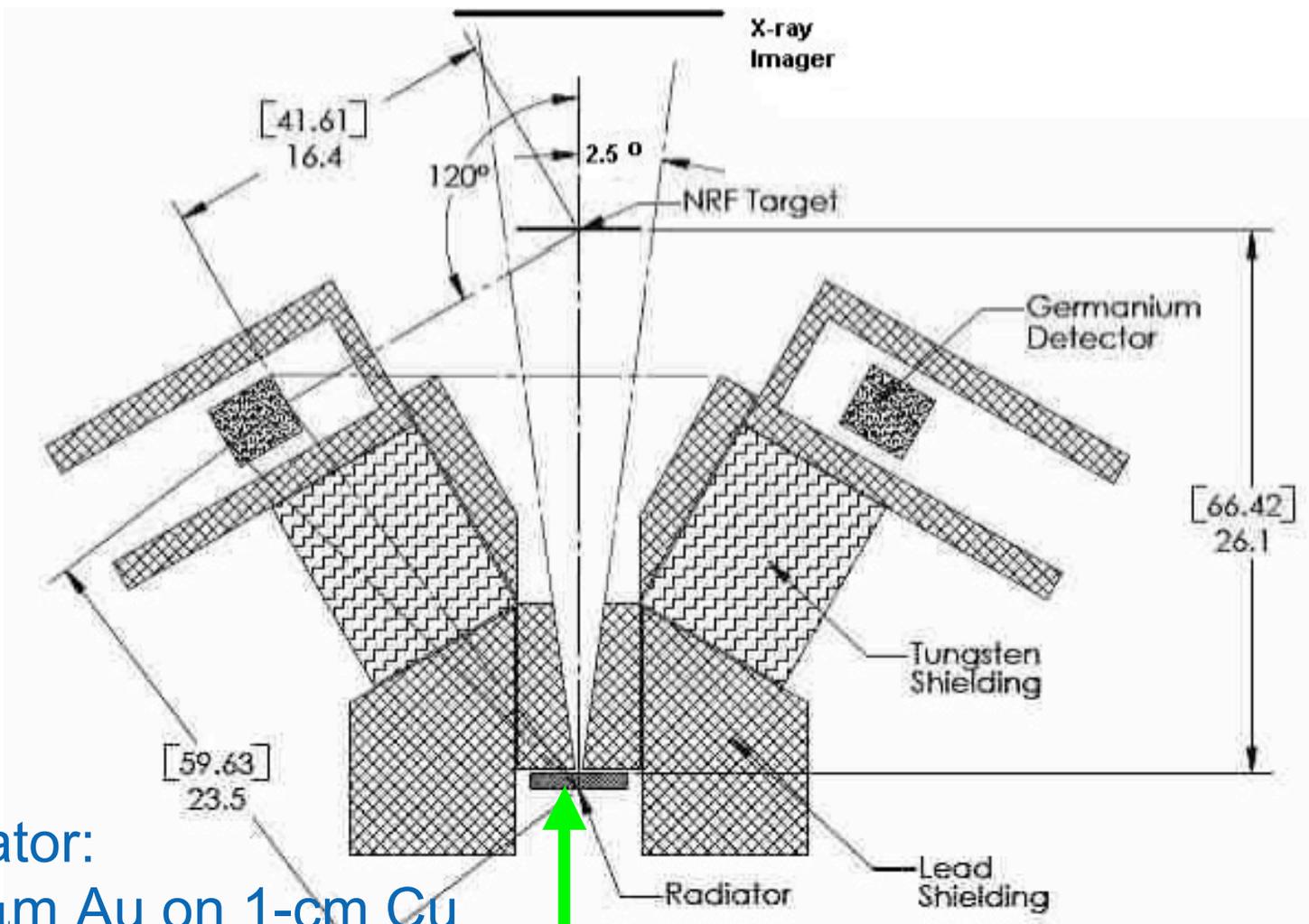
Pu target:

Pu Mass: 3.8-grams
Diameter: 1.4-cm
Thickness: 1.5-mm

Nitronic-40 holder: 25-g (63%Fe, 21%Cr, 6%Ni, 9%Mn)

We used 2 of these lollipops for 7.5 g of Pu

Experimental Setup: (*Passport*)

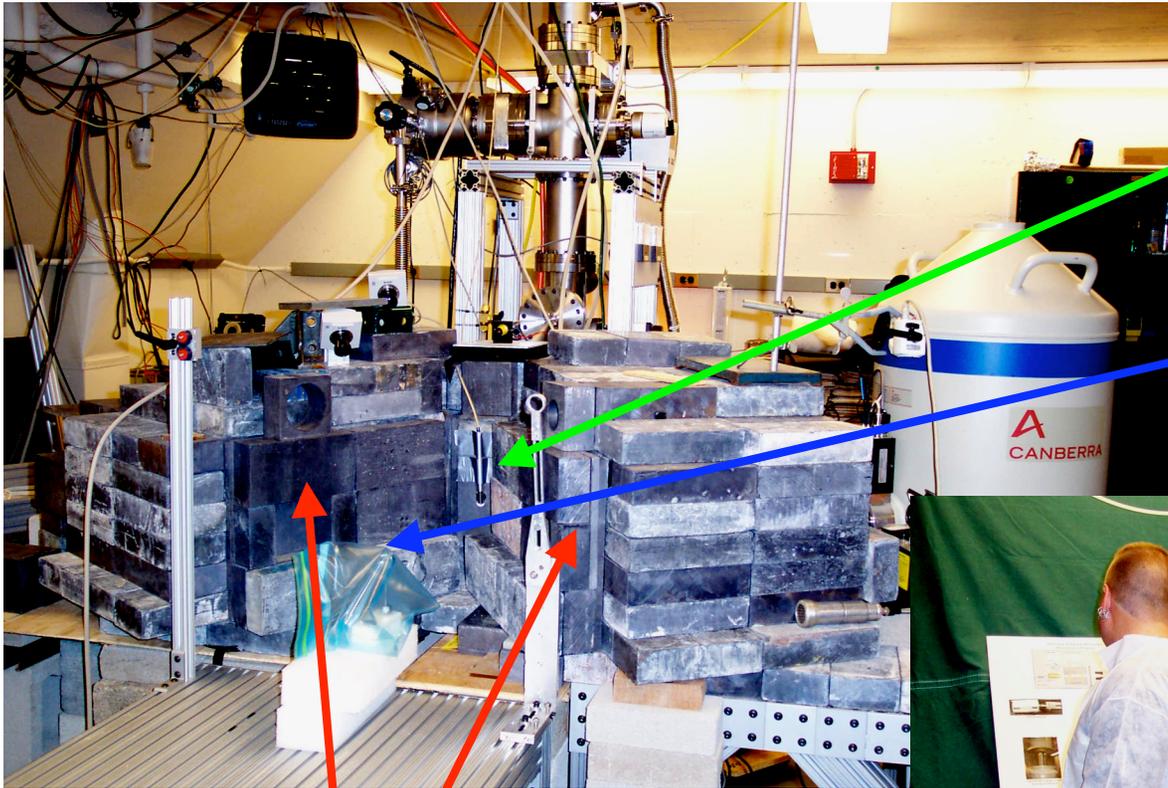


Radiator:
102- μm Au on 1-cm Cu
(cooling and e-cleanup)

e-beam



Experimental End Station



Collimator/Radiator

NRF target

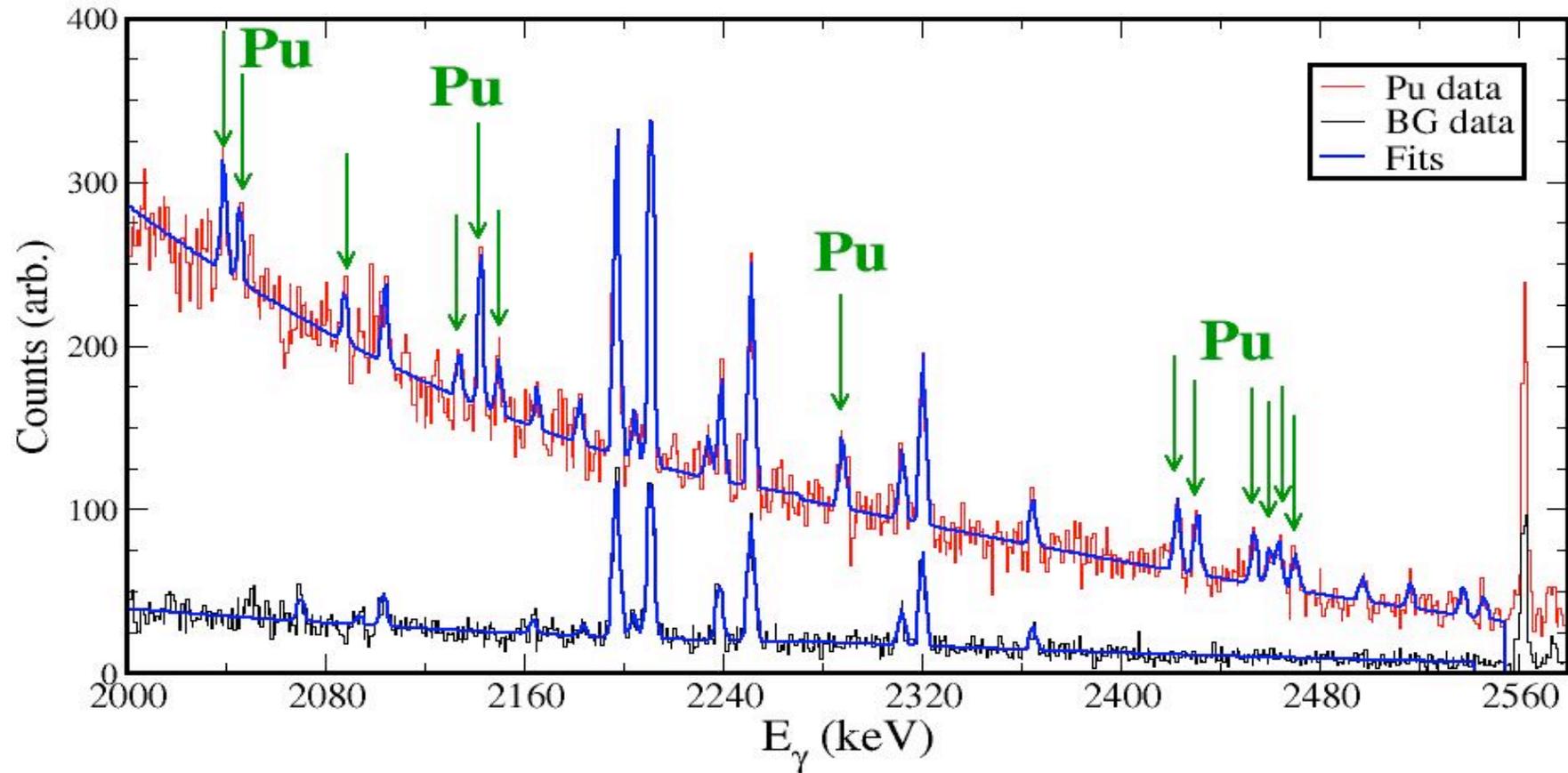
HPGe

X-ray Imager



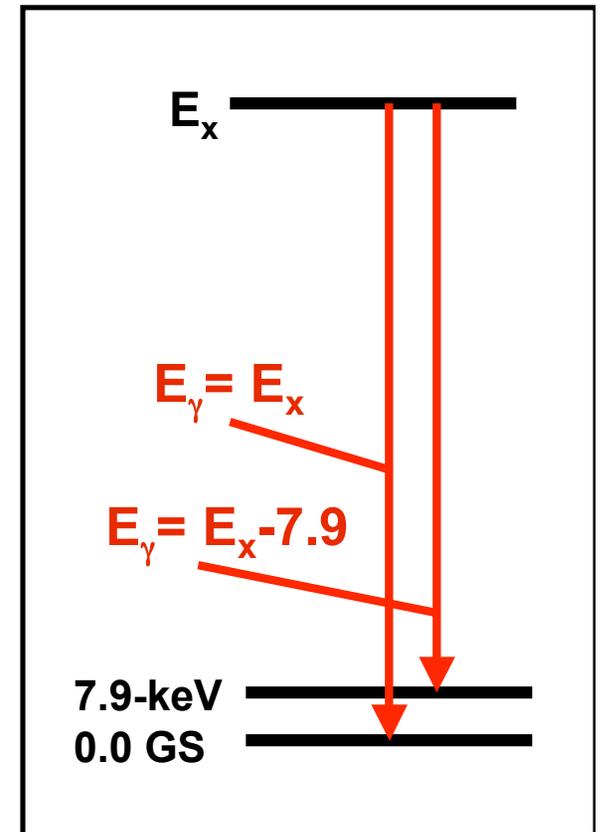
NRF measurements (2.8 MeV e.p.)

NRF measurement on Pu at MIT with bremsstrahlung source



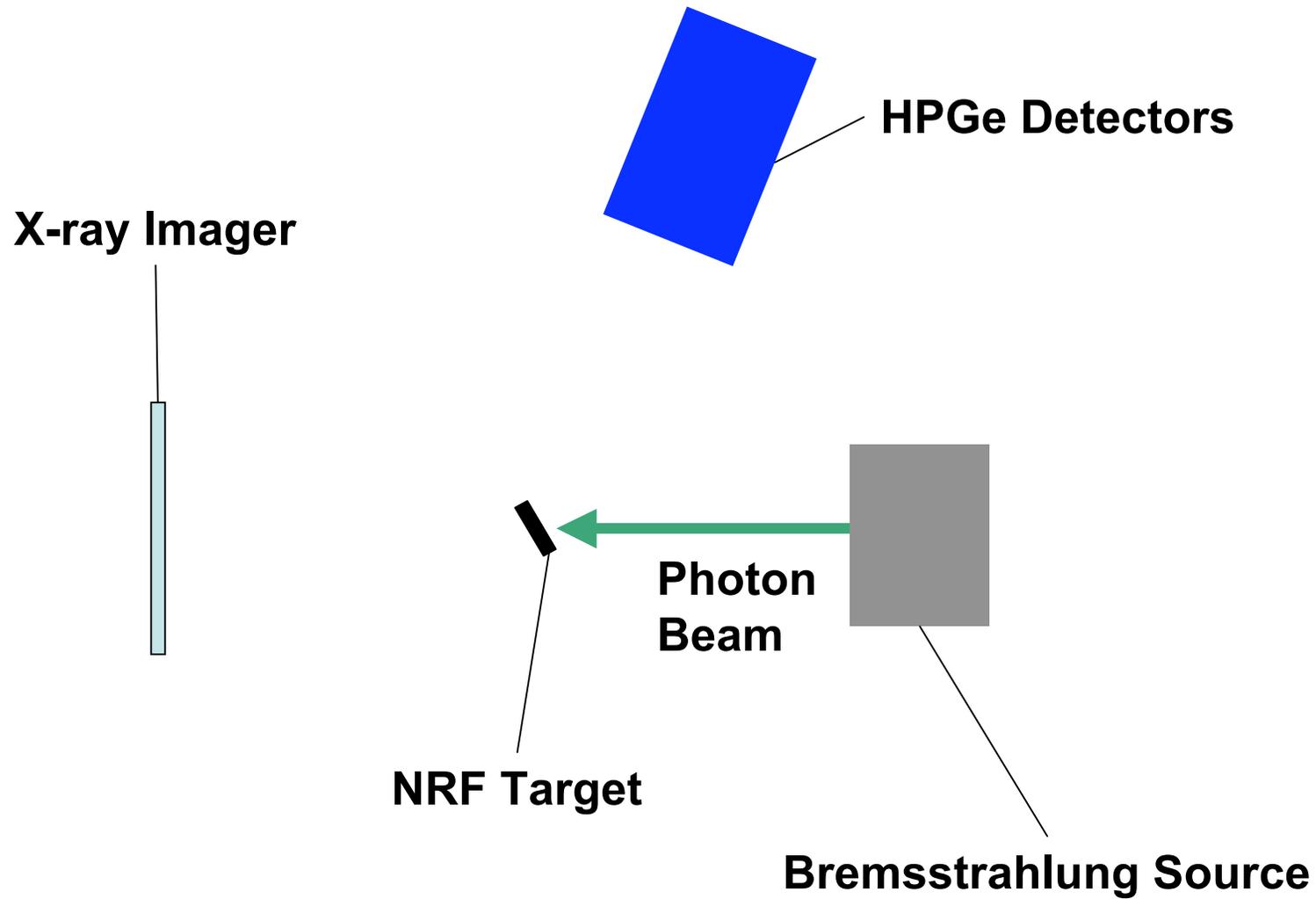
NRF results for ^{239}Pu

<u>Transition Energy</u>	<u>Sigma</u>	<u>Cross-section (eV barns)</u>
2040.25(33)	5.8	8(2)
2046.89(33)	4.2	5(2)
2089.14(34)	3.7	4(2)
2135.00(34)*	3.5	4(2)
2143.56(34)*	9.7	13(2)
2150.98(34)*	4.2	5(2)
2289.02(34)	6.2	8(2)
2423.48(35)**	7.2	10(2)
2431.66(35)**	6.3	9(3)
2454.37(35)	6.2	9(3)
2460.46(35)	4.7	6(4)
2464.60(35)	5.7	8(4)
2471.07(35)	4.6	6(2)



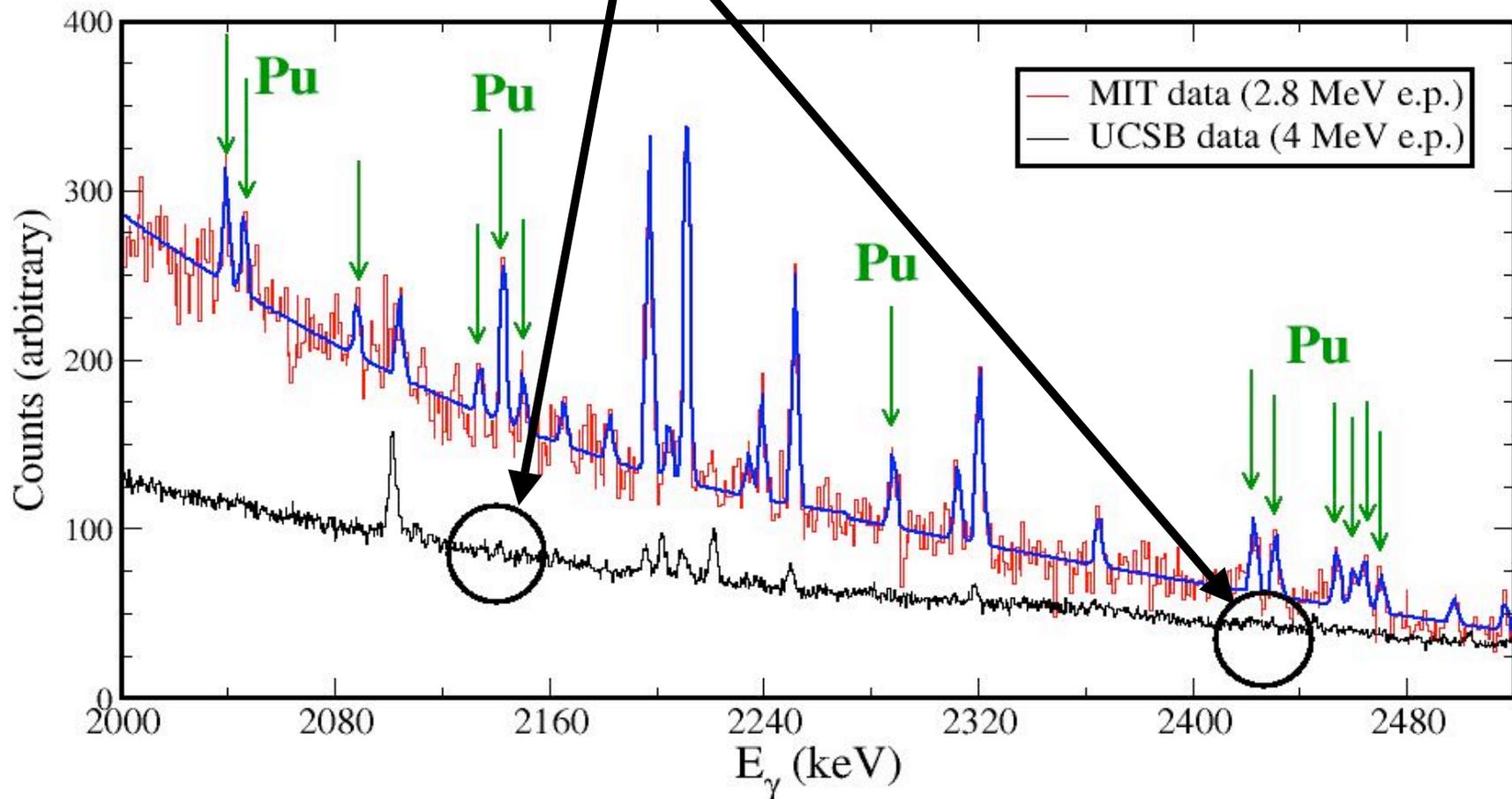
Systematics imply these resonances are magnetic dipole

UCSB setup

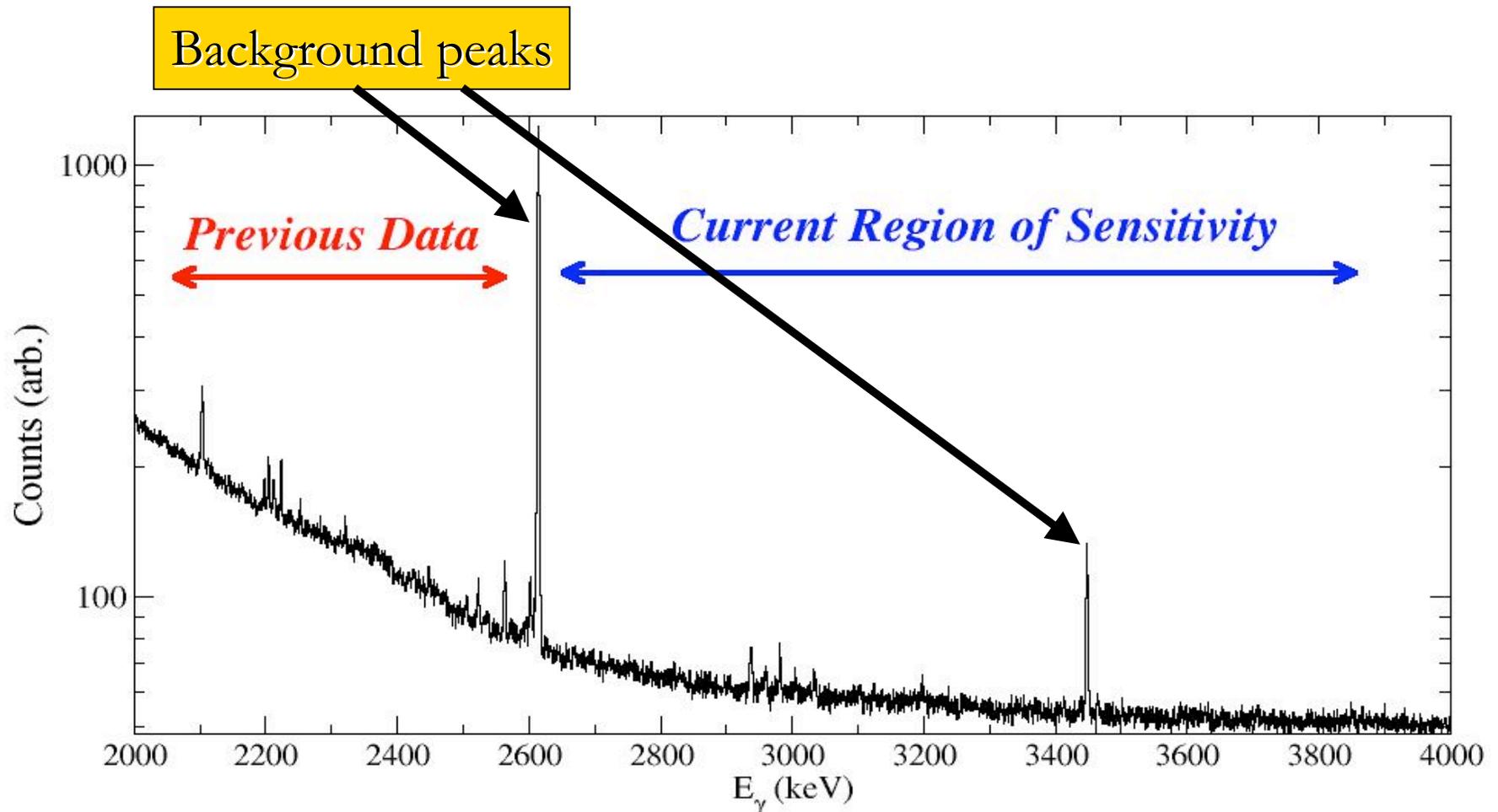


Best data collected at 4.0 MeV

Evidence of previously measured states



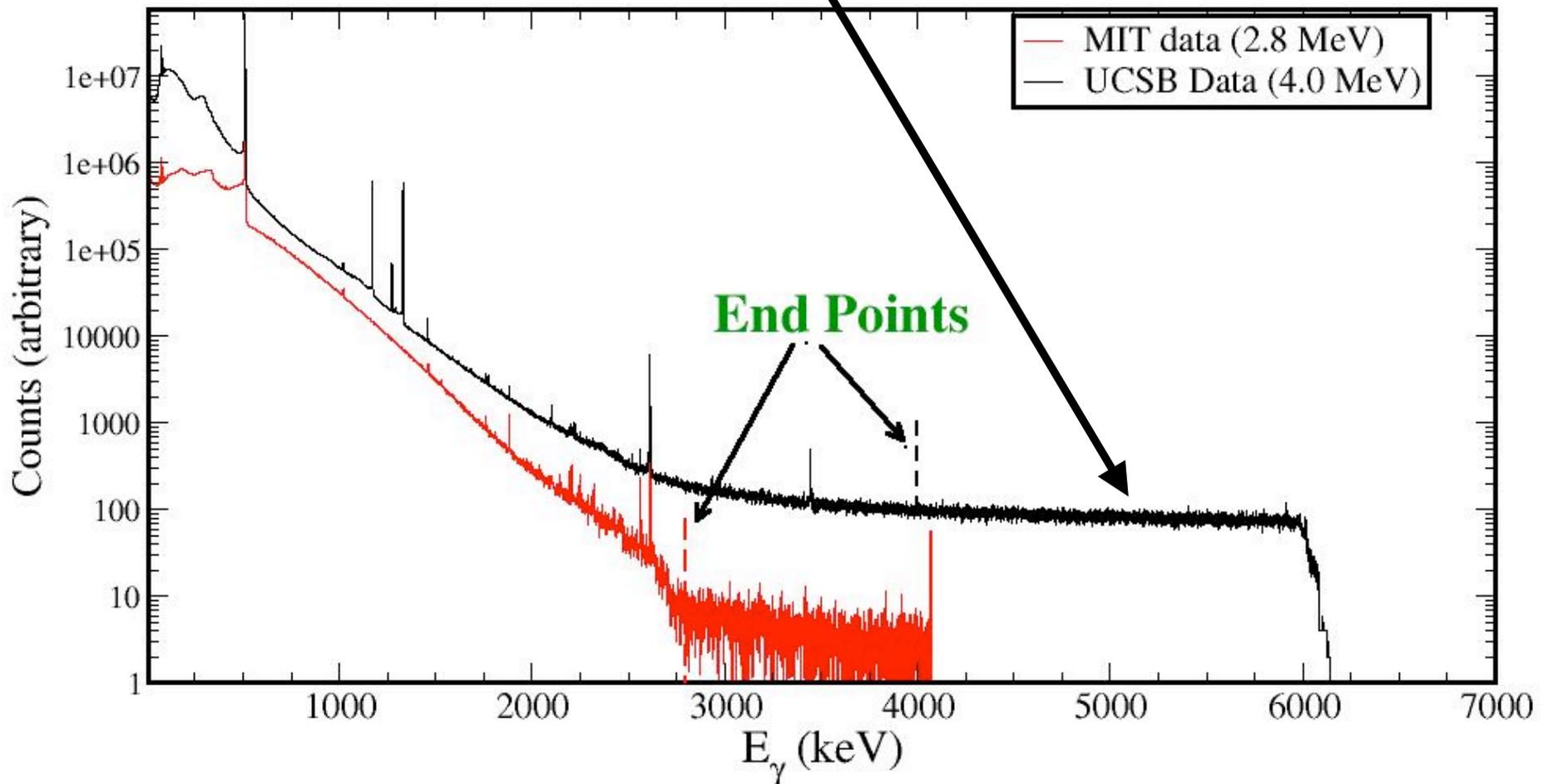
Region of best sensitivity (analysis is ongoing)



NRF peaks expected to be small

Background Issues

Evidence of neutron capture scattering



Summary

- NRF measurements have been performed on ^{239}Pu < 2.5 MeV
 - PRC/RC is in publication (Phys. Rev. C **78** 041601 (2008))
- NRF measurements have been performed on ^{239}Pu > 2.5 MeV
- Backgrounds indicate unexpected neutron capture scattering
 - Return to UCSB and perform background runs at 4.0 MeV
 - Need about 48 hours worth of data to match the data statistics
- Analysis is just beginning
 - Spectra are corrected for deadtime, efficiency, and summed.
 - Waiting for background spectrum.
 - Detailed analysis will be performed by UC Berkeley graduate student, James McFarland.
 - Peer-reviewed article to follow



Collaboration

- M.S. Johnson, D.P. McNabb, C.A. Hagmann, E.B. Norman, *LLNL*
- W. Bertozzi, S.E. Korbly, R.J. Ledoux, W.H. Park, *Passport Systems Inc.*
- UC Berkeley, graduate students and postdocs: Bethany Lyles, Erik Swanberg, Kayla Evans, Ragnar Stroberg, James McFarland (analyzing data)
- *Facilities at UCSB and HVRL/MIT*

