JYFL R59 Experiment: Search for new isotopes ^{220}U and ^{224}Pu and exploring the mass surface near N = 126

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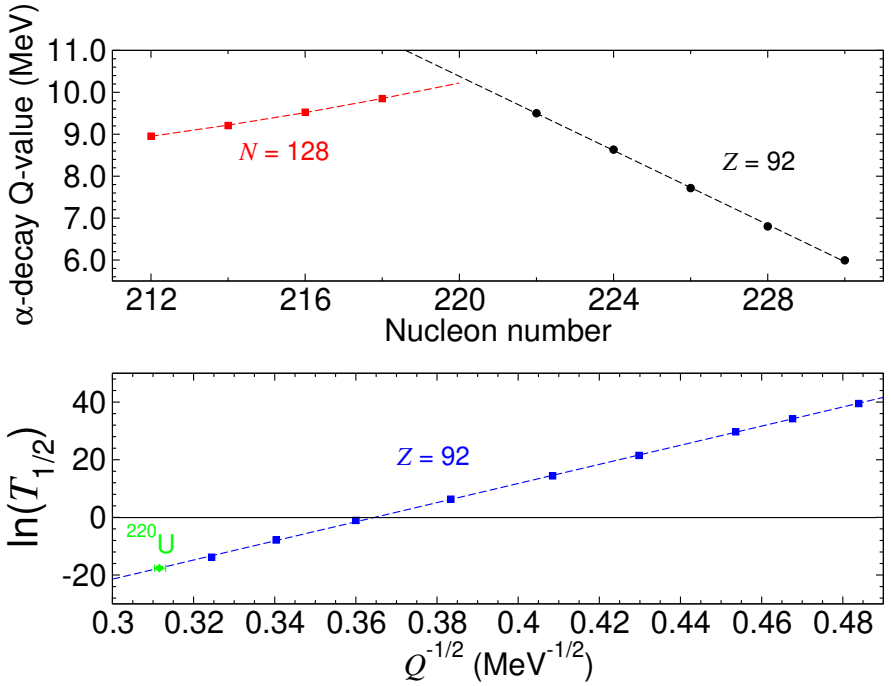
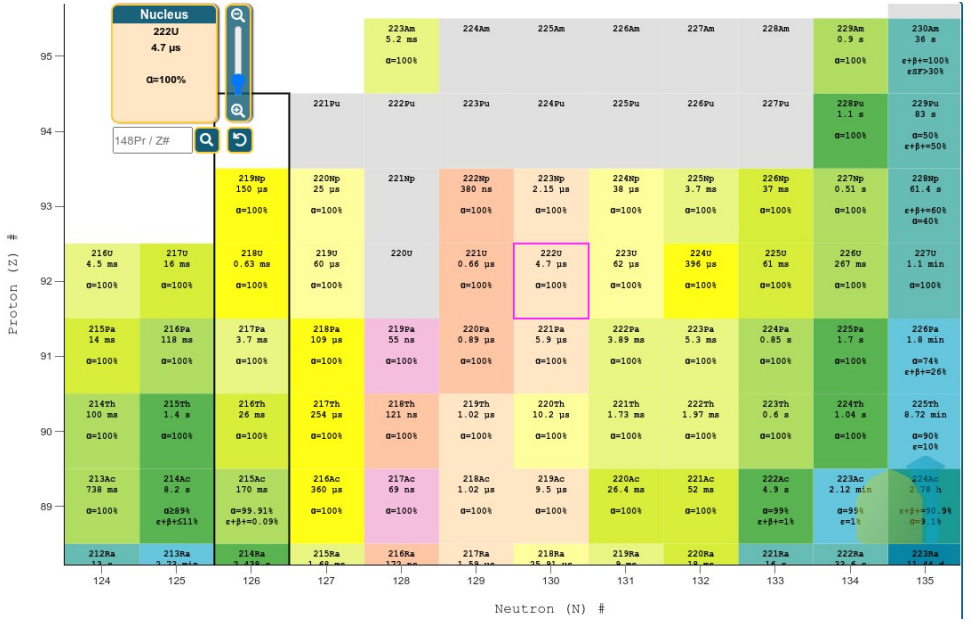
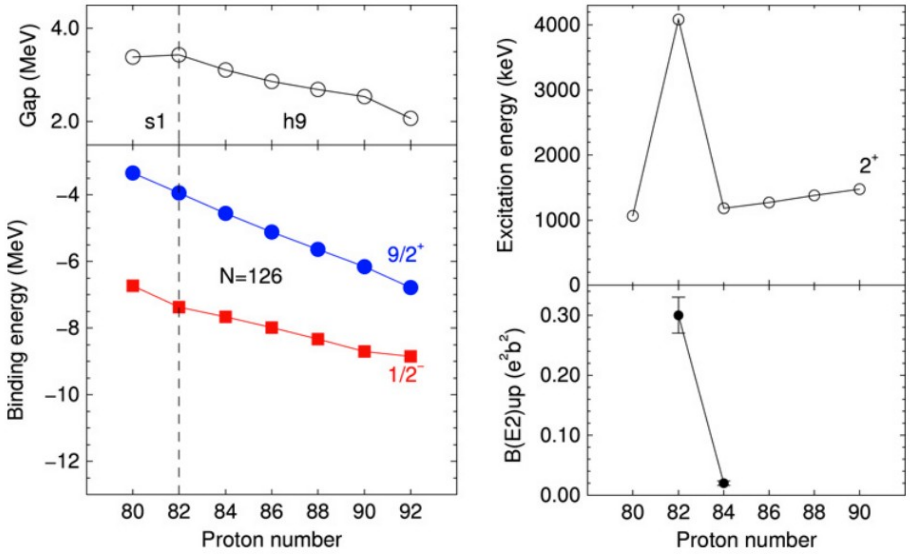
Motivation: gap in the chart of nuclides



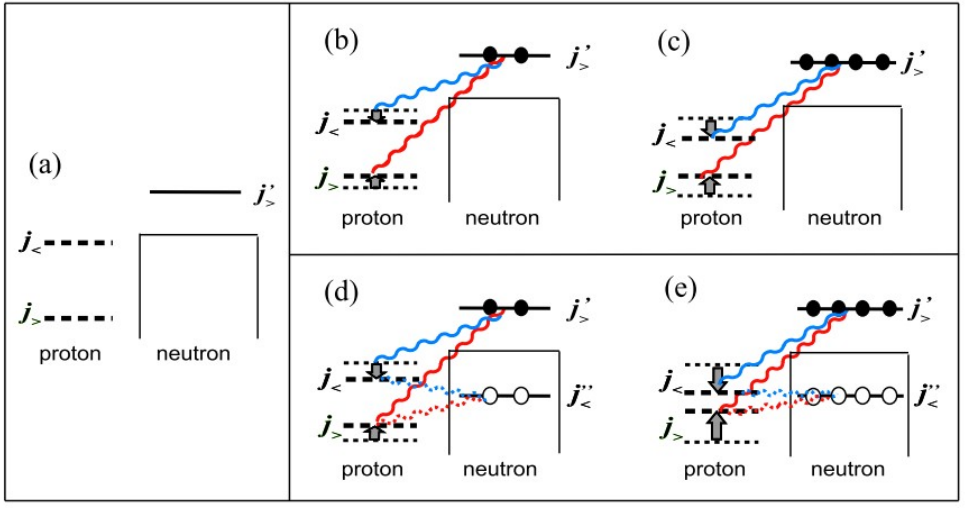


Research propsal driven by teaching

Motivation: robustness of $N = 126$ shell closure

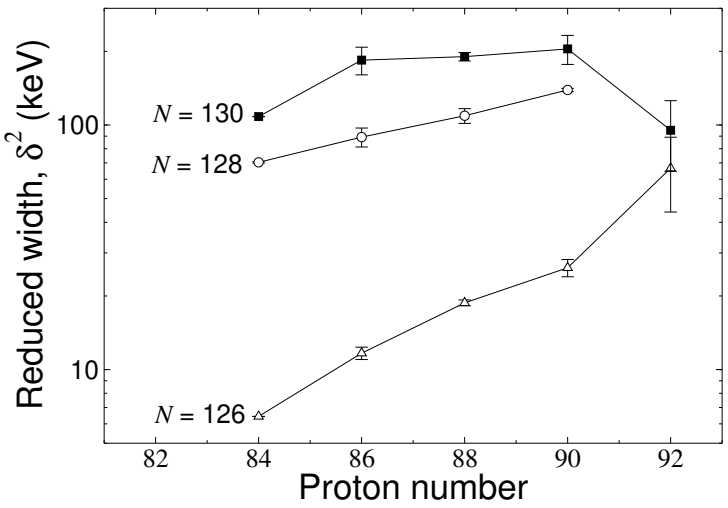


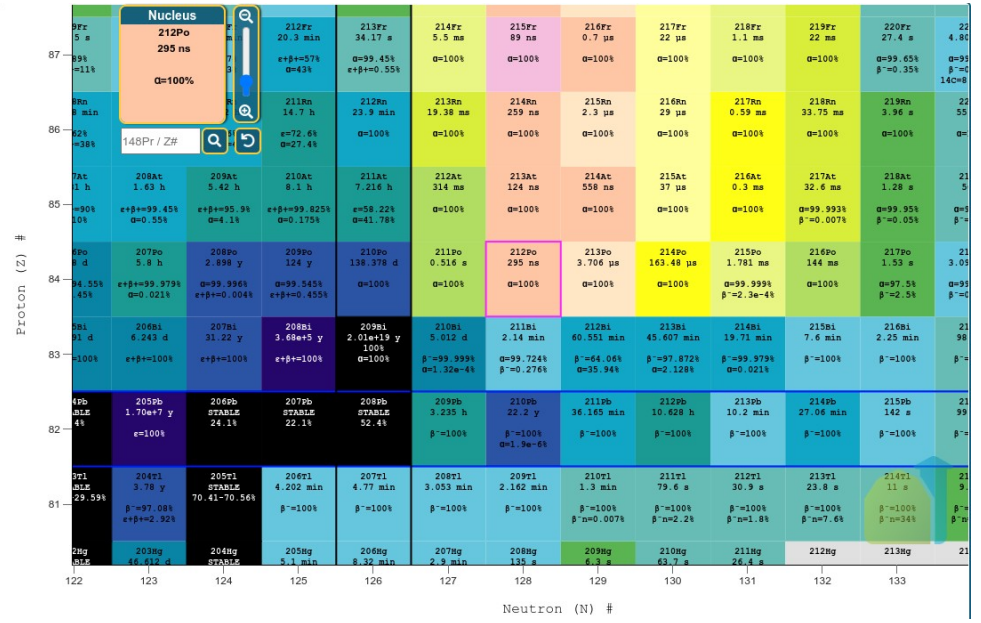
Sorlin and Porquet, Prog. Part. Nucl. Phys. **61** 602 (2008)



Otsuka and Tsunoda, J. Phys. G **43** 024009 (2016)

Motivation: robustness of $N = 126$ shell closure



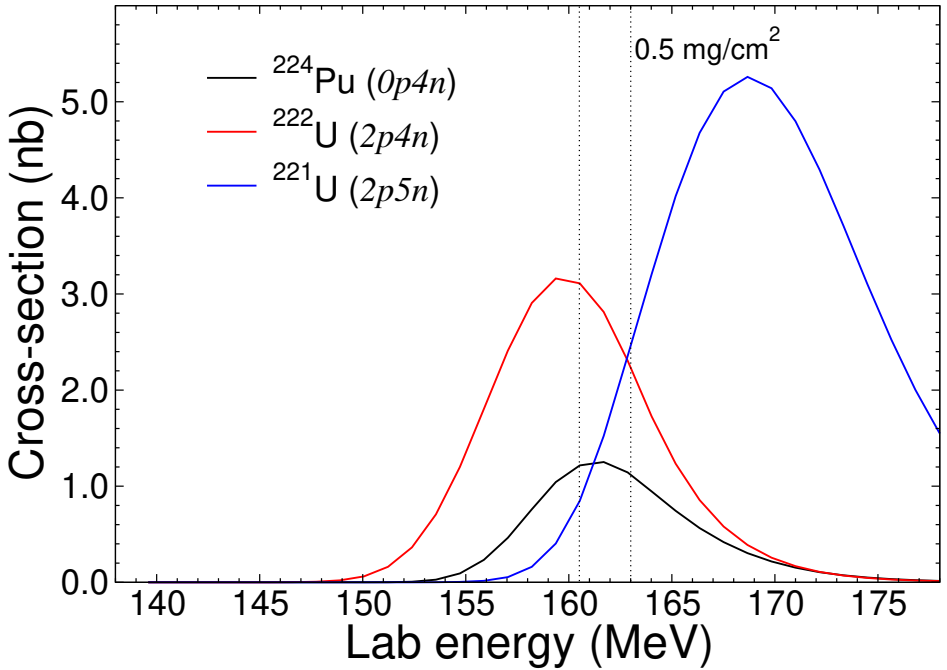


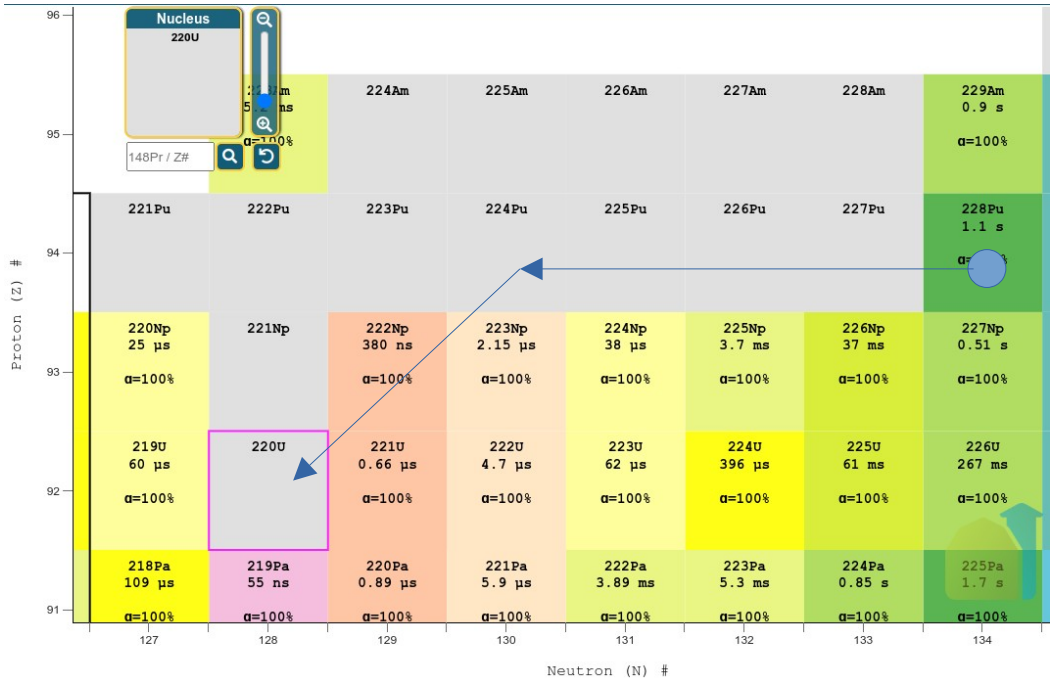
Reduced width measures the probability of alpha decay

Experiment planning: reaction

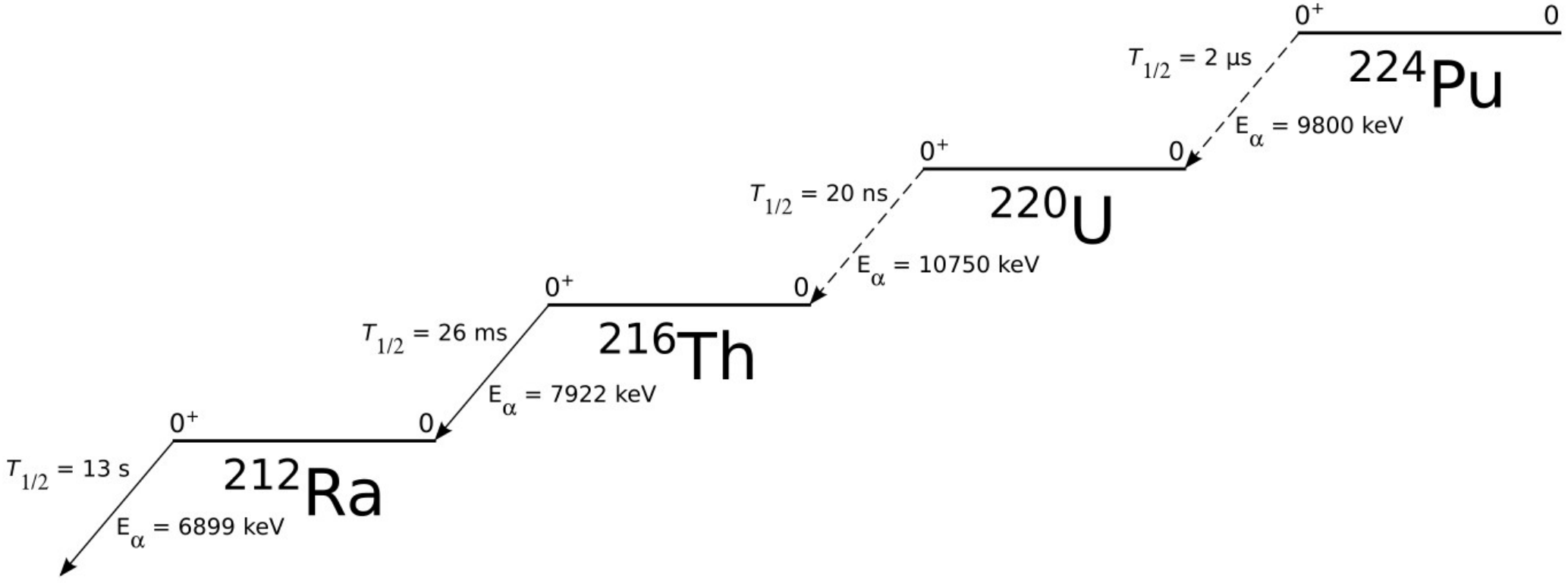
- Fusion-evaporation reactions only way in which to produce these nuclei
  - Very limited number of beam/target combinations available
- Cross sections are expected to be very low regardless of which reaction is chosen

Experiment planning: reaction





Experiment planning: reaction



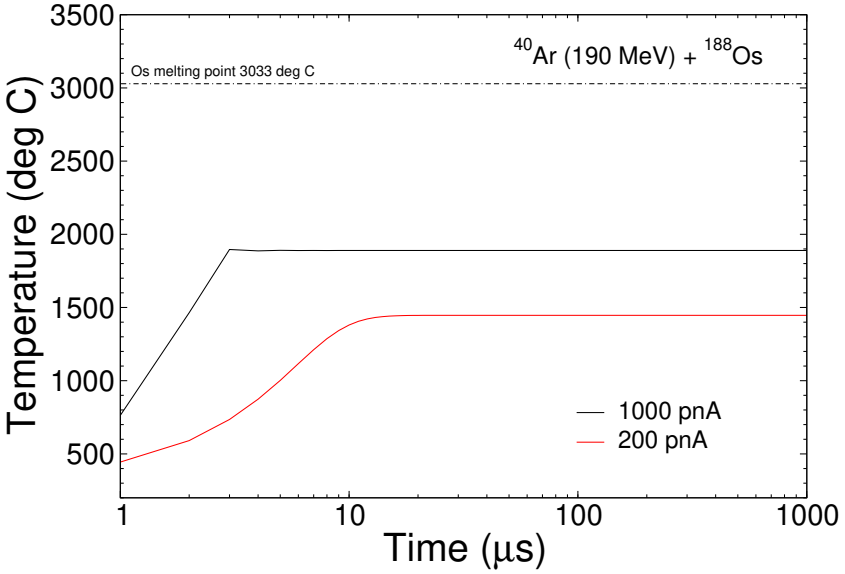
Experiment planning: reaction

- Fusion-evaporation reactions only way in which to produce these nuclei
  - Very limited number of beam/target combinations available
- Cross sections are expected to be very low regardless of which reaction is chosen
  - As a result, we need targets which can handle high beam currents

Experiment planning: rate calculations

- Reaction rate per unit time:
  - $R = N_A(m_t/m_{mol})\sigma\Phi$
  - N_A – Avogadro's number
  - m_t – mass/thickness of target material (grams/cm^2)
  - m_{mol} – molar mass of target element (grams)
  - σ – cross-section (barns or cm^2)
  - Φ – beam current (pps)

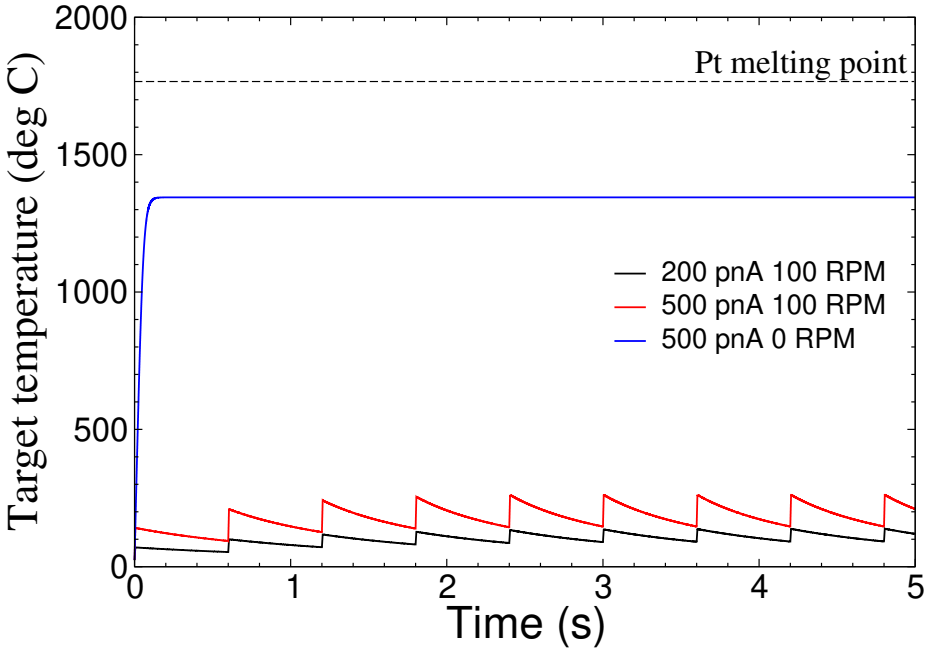
Experiment planning: reaction



Unable to obtain an osmium target

Chose to run with ^{32}S + ^{196}Pt → ^{228}Pu*

Experiment planning: reaction



Unable to obtain an osmium target

Chose to run with $^{32}S + ^{196}Pt \rightarrow ^{228}Pu^*$

Melting point for platinum is 1768 deg C

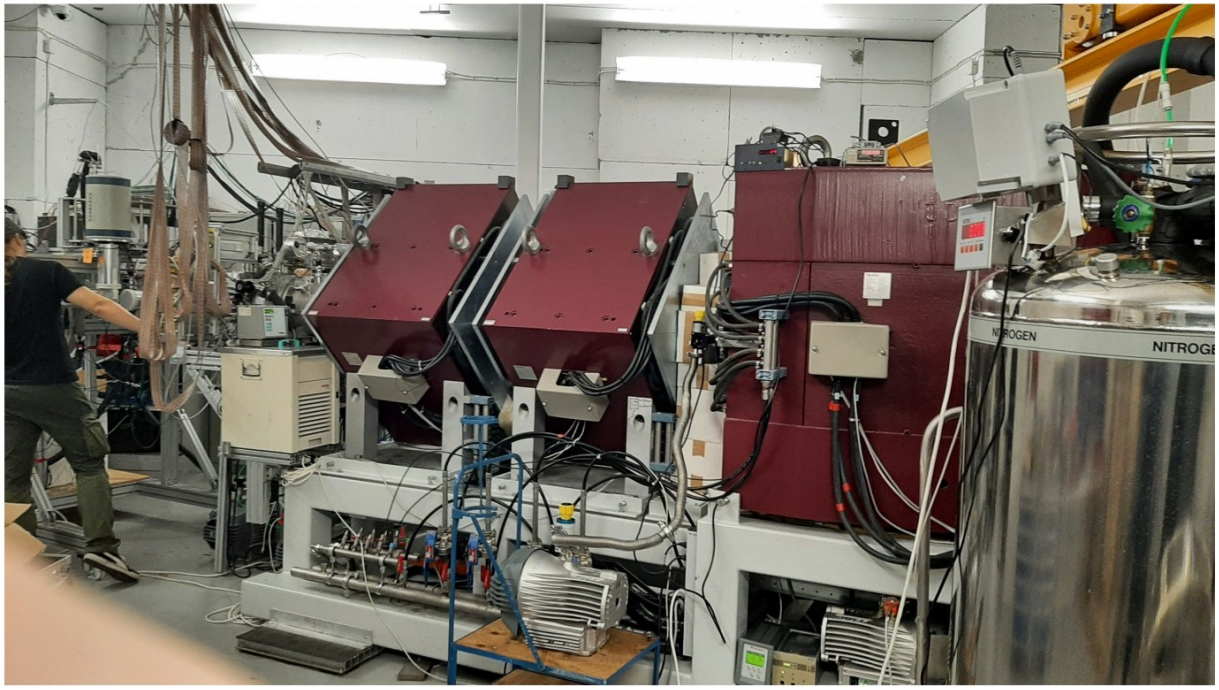
Experiment planning: facility

- Facility should be able to provide beam at the intensity required
- Offer apparatus which is capable of permitting the detection of the products of interest
- Have personnel with significant experience of performing similar experiments
- Bonus: you may already have a history with facility and personnel as collaborators

Experiment planning: facility

JYFL at the University of Jyväskylä fit all of these conditions for me

Use of RITU and “new” focal plane detection system was ideal for this study

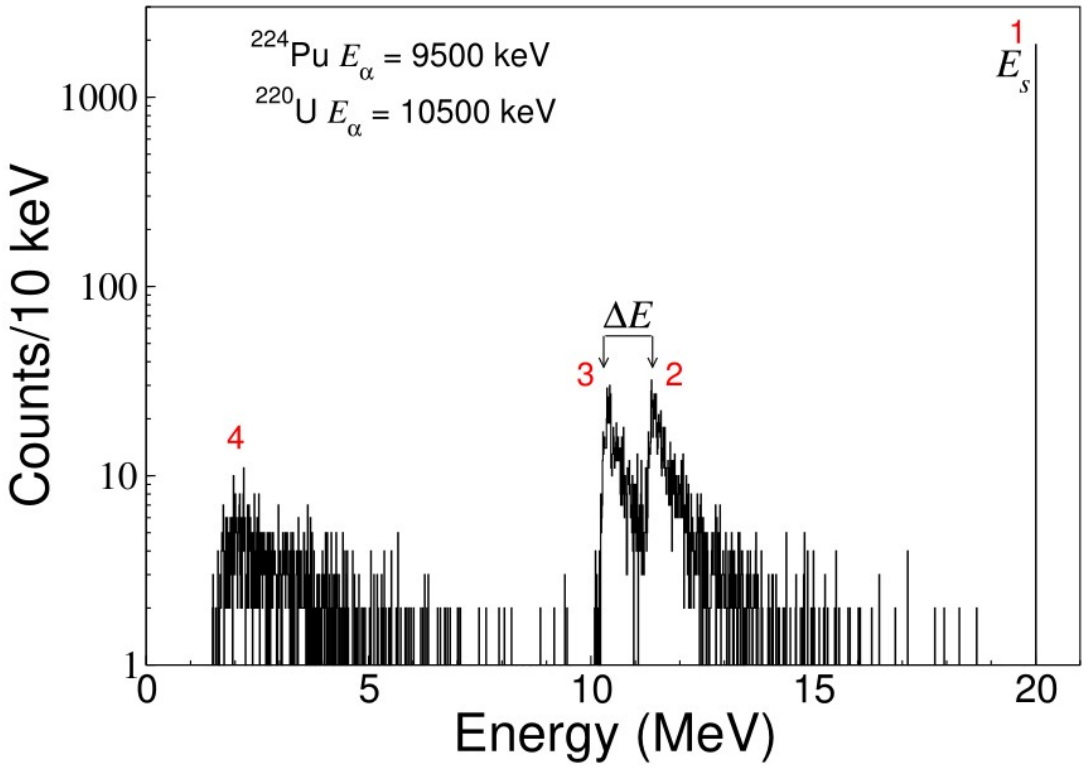


Experiment planning: simulations

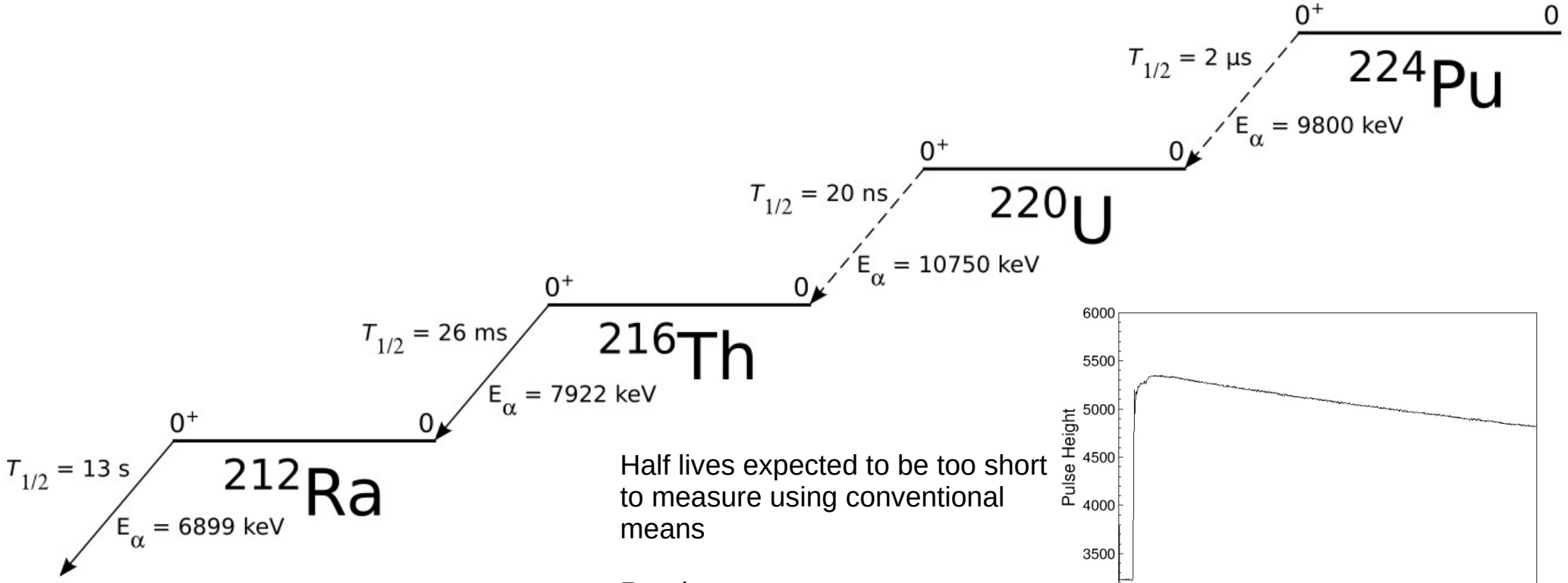
The PACs of many laboratories request that simulations be performed prior to running the experiment

This allows for a measure of feasibility to be determined which may help in their decision making

Also helps you to think carefully about possible outcomes

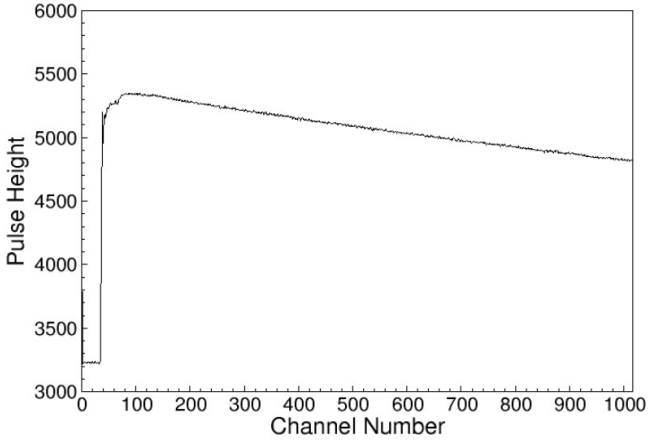


Experiment planning: apparatus

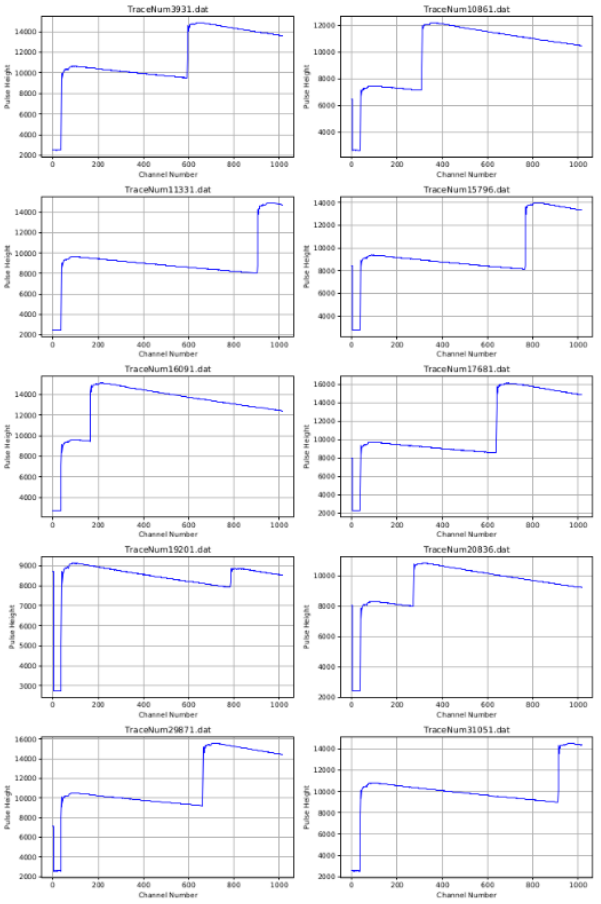


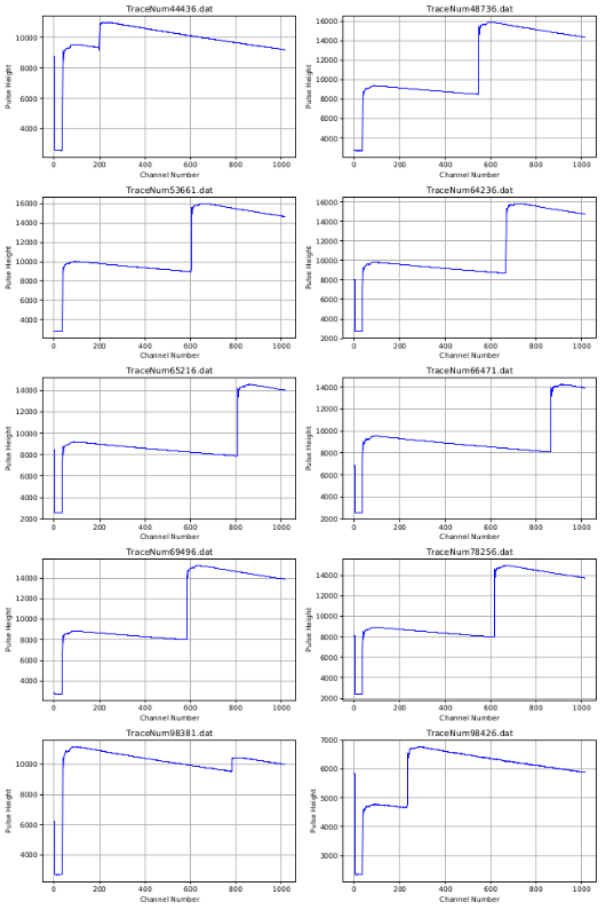
Half lives expected to be too short to measure using conventional means

Readout traces to overcome limitations due to deatime



Experimental results





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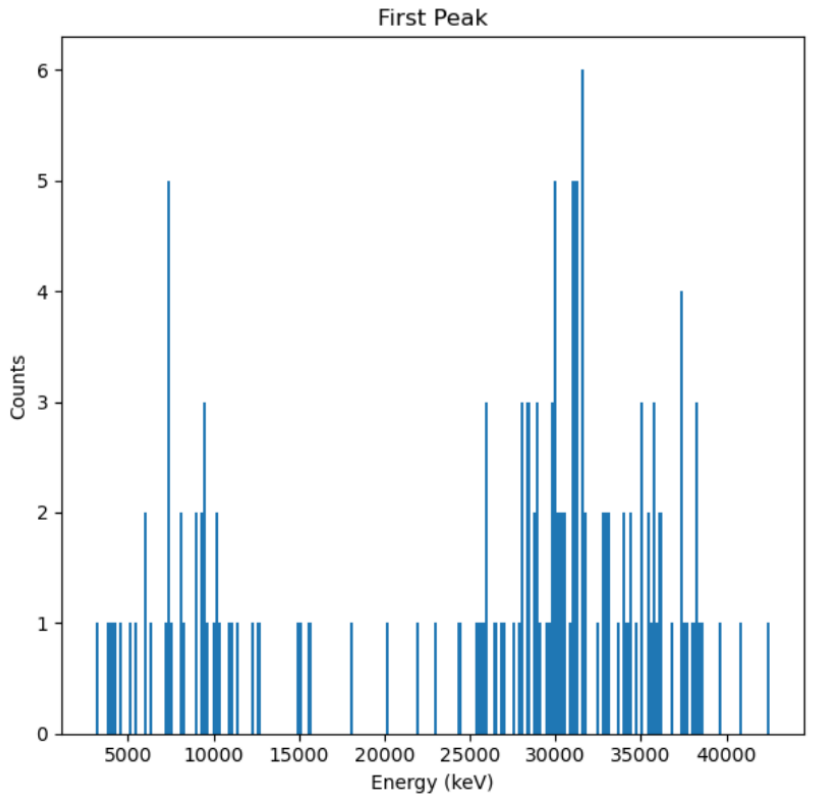

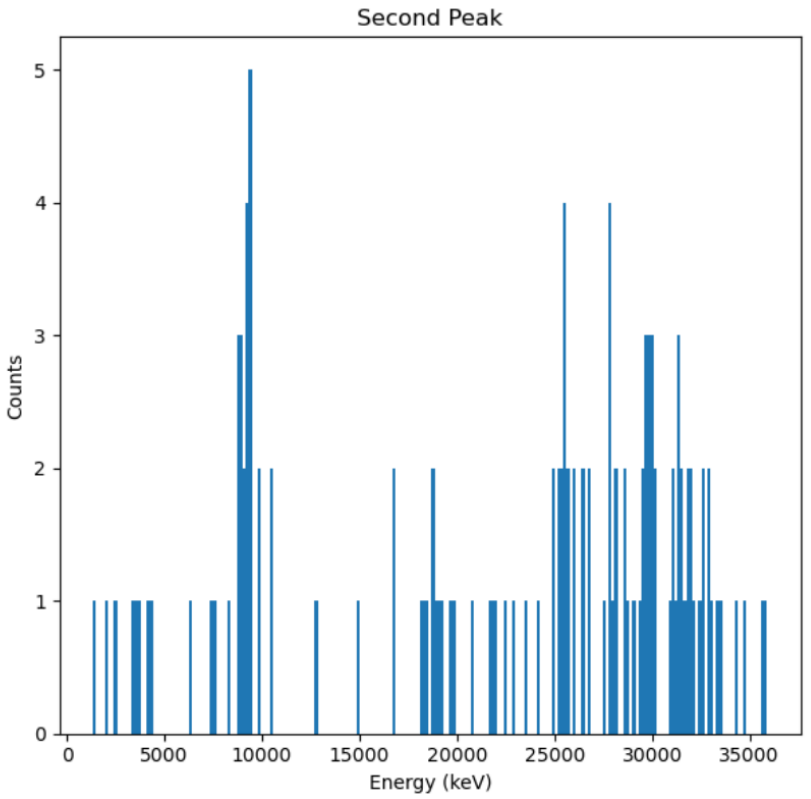

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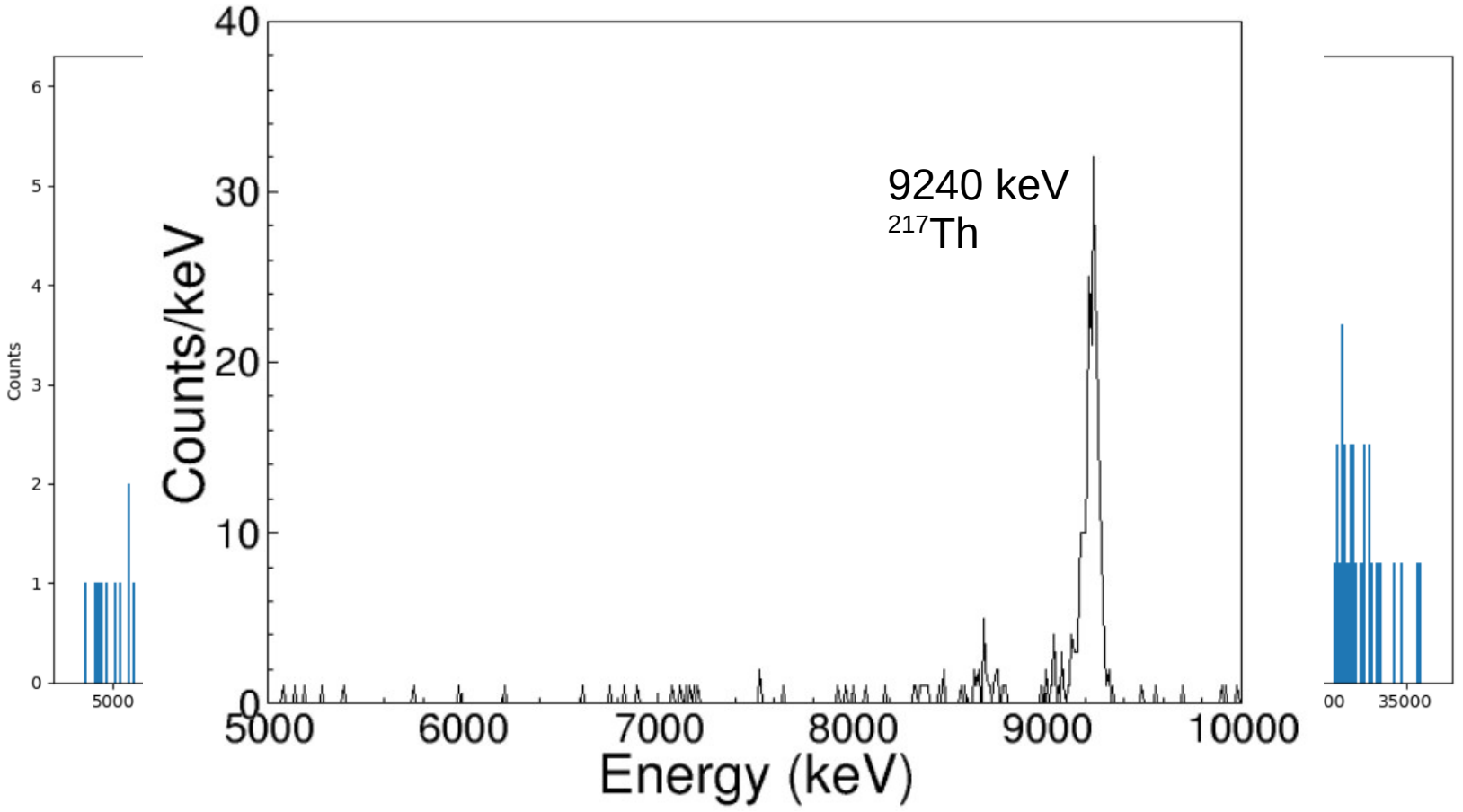
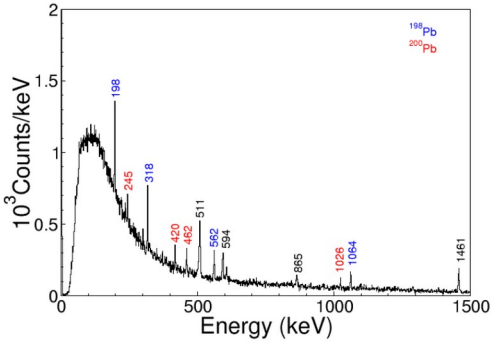
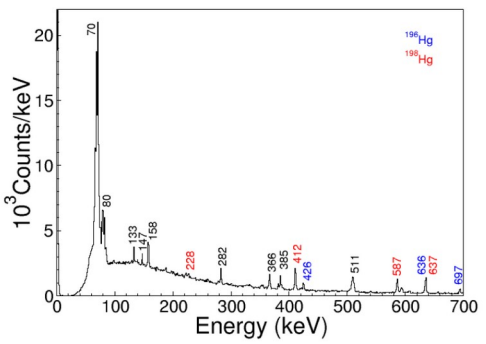
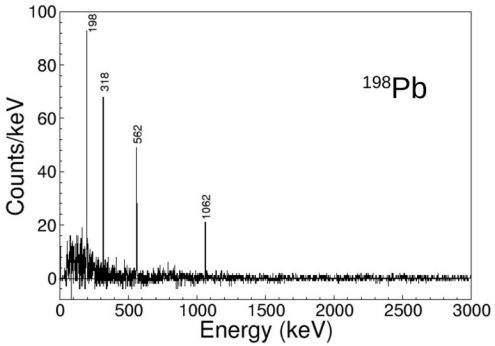
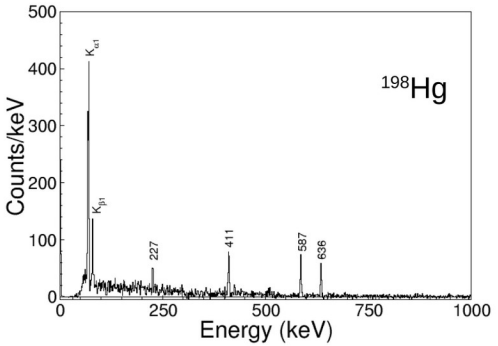


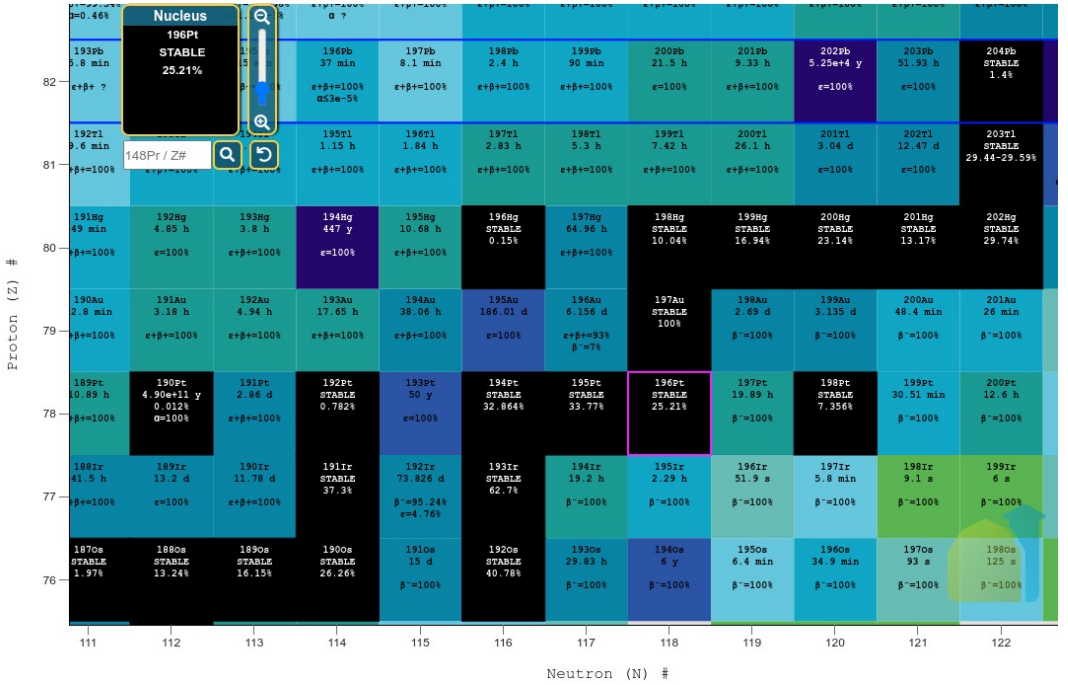
Experimental results: unexpected











Conclusions/reflections

- Challenging experiment!
  - Low cross sections with very narrow distributions
- Learned a lot of lessons
- Unlikely that we will discover ^{224}Pu or ^{220}U but will continue our analysis
- Unexpected results in the multi-nucleon transfer channels

Acknowledgements

[1]D. O'Donnell, [1]B.S. Nara Singh, [4]P. Papadakis, [2]A. McCarter, [2]B. Alayed, [2]J. Ojala, [5]J. Khuyagbaatar, [6]P. Jones, [3]P. Greenlees, [3]M. Leino, [3]R. Julin, [3]J. Uusitalo , [3]T. Grahn, [3]J. Pakarinen, [3]P. Rahkila, [3]P. Ruotsalainen, [3]J. Sarén, [3]K. Auranen, [3]A. Briscoe, [3]A.Sison, [3]M. Luoma, [3]H. Joukainen, [3]H. Jutila, [3]J. Louko, [3]A. Plaza, [3]J. Romero, [3]G. Zimba, [3]V. Bogdanoff, [3]E. Uusikylä, [3]H. Kokkonen, [3]J. Ahokas.

1. University of the West of Scotland, United Kingdom
2. University of Liverpool, United Kingdom
3. University of Jyväskylä, Finland
4. STFC Daresbury Laboratory, United Kingdom
5. GSI, Darmstadt, Germany
6. iThemba Labs, Johannesburg, South Africa