Searching for Cluster States in ^{126}Te

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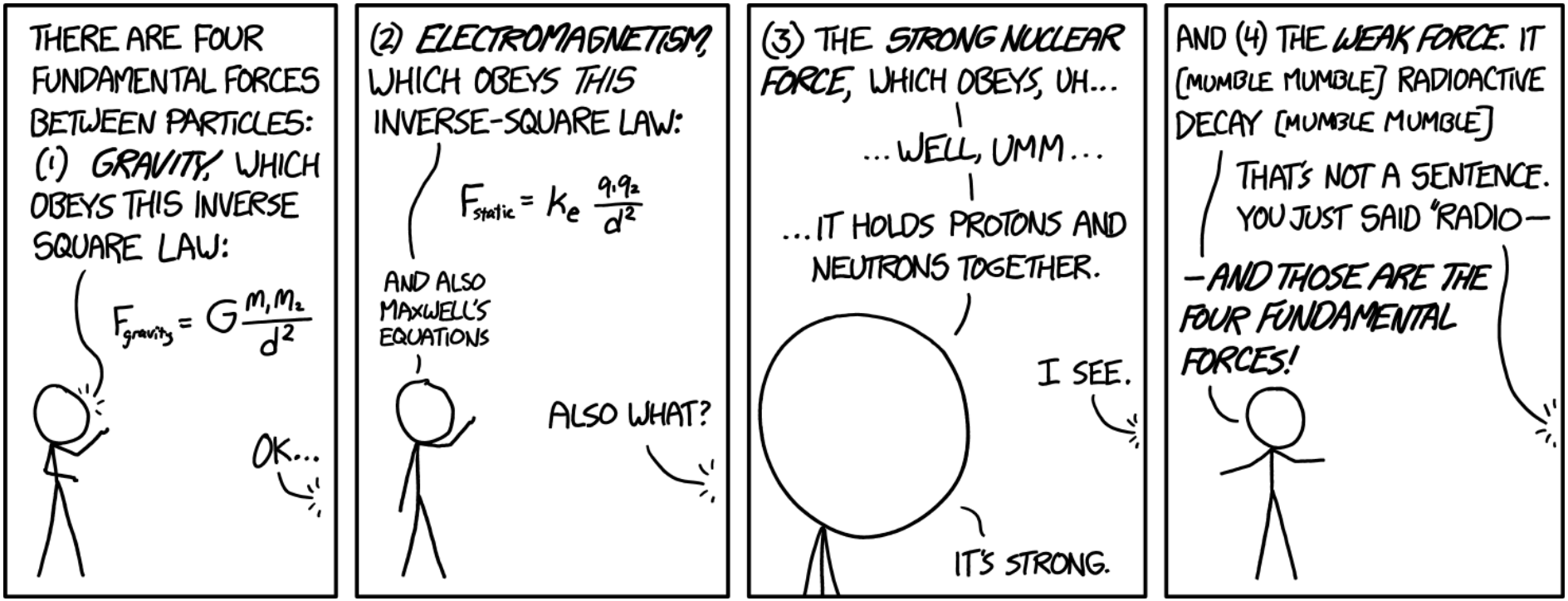
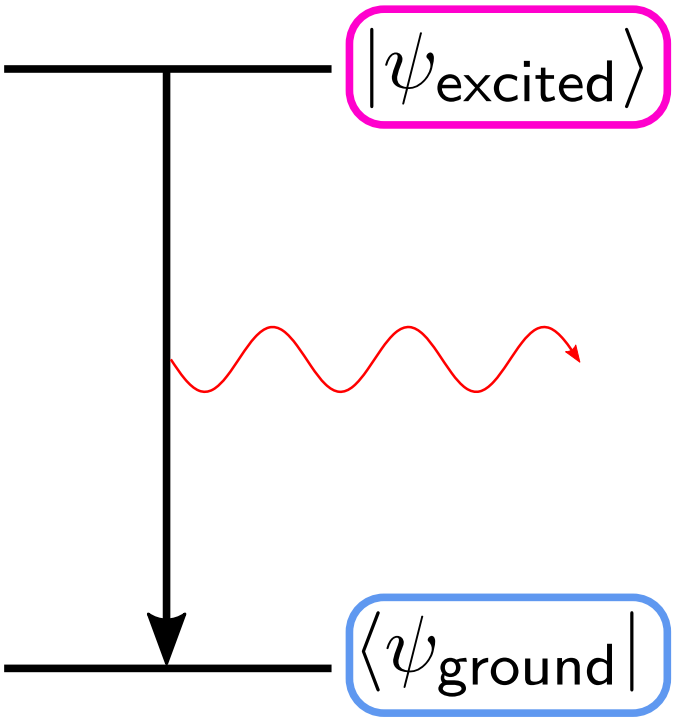
February 18, 2023

Fundamental forces of nature



https://xkcd.com/1489/

Studying the strong force using the electromagnetic force



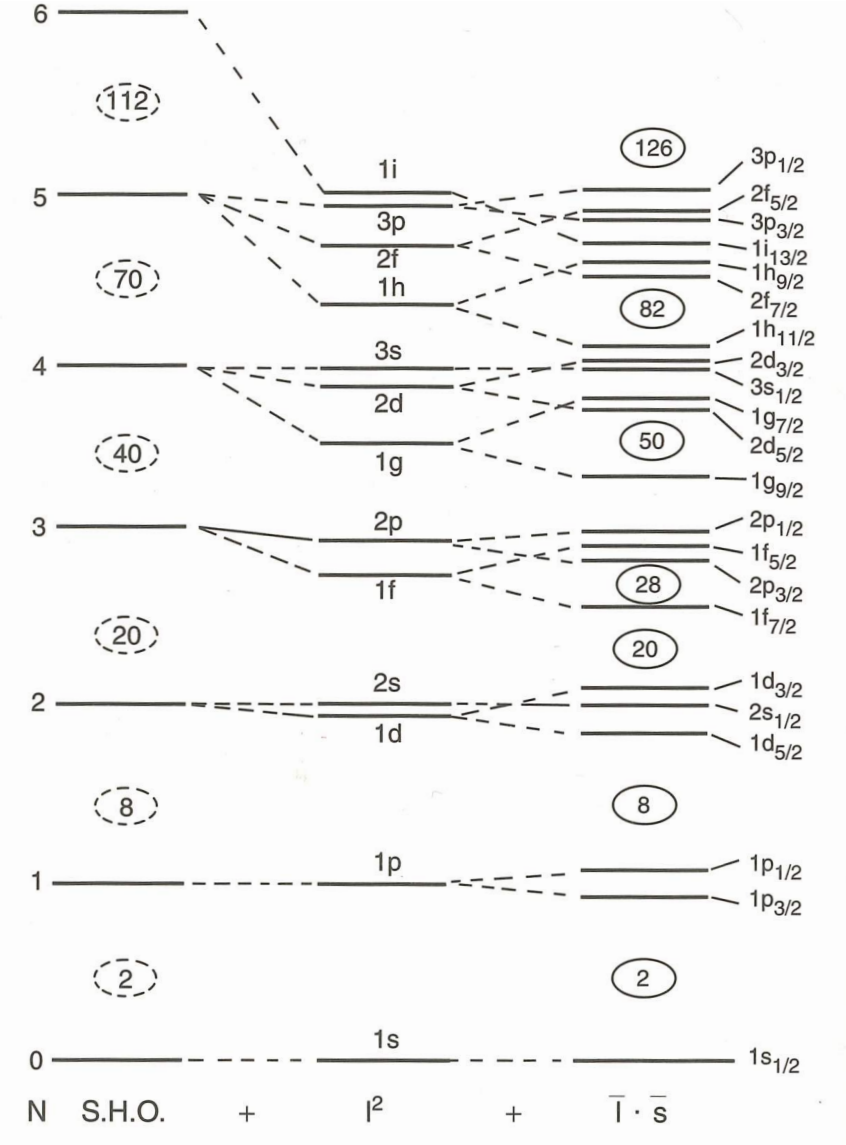
$$E_{\text{ground}} |\psi_{\text{ground}}\rangle = \hat{H} |\psi_{\text{ground}}\rangle$$

$$E_{\text{excited}} |\psi_{\text{excited}}\rangle = \hat{H} |\psi_{\text{excited}}\rangle$$

$$\langle\psi_{\text{ground}}| \hat{\pi}\hat{L} |\psi_{\text{excited}}\rangle$$

- Nuclear structure theories model strong force between nucleons.
- EM transitions provide a way to look into the nucleus.

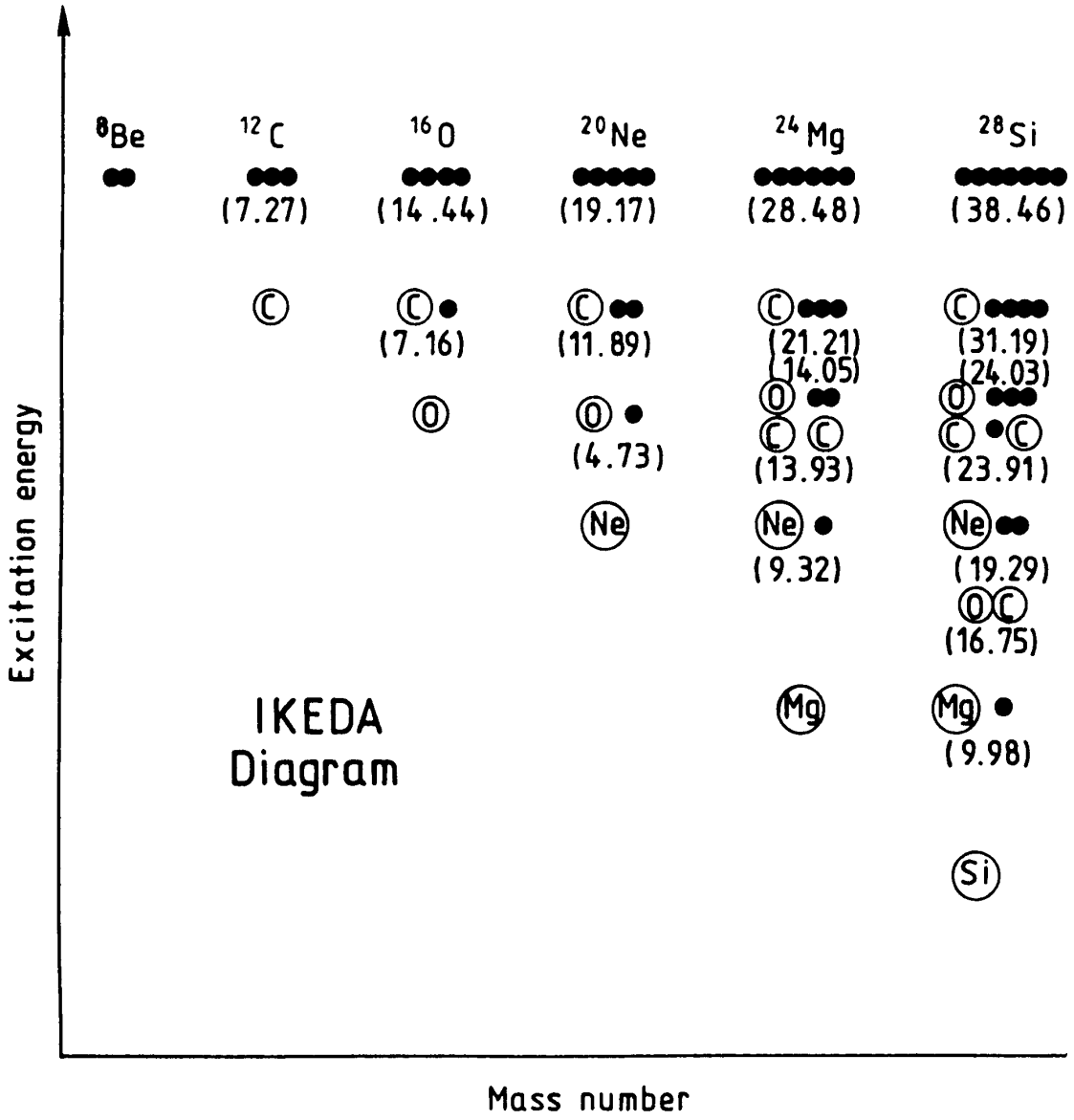
Nuclear Shell Model



Casten's Simple Perspective p.66

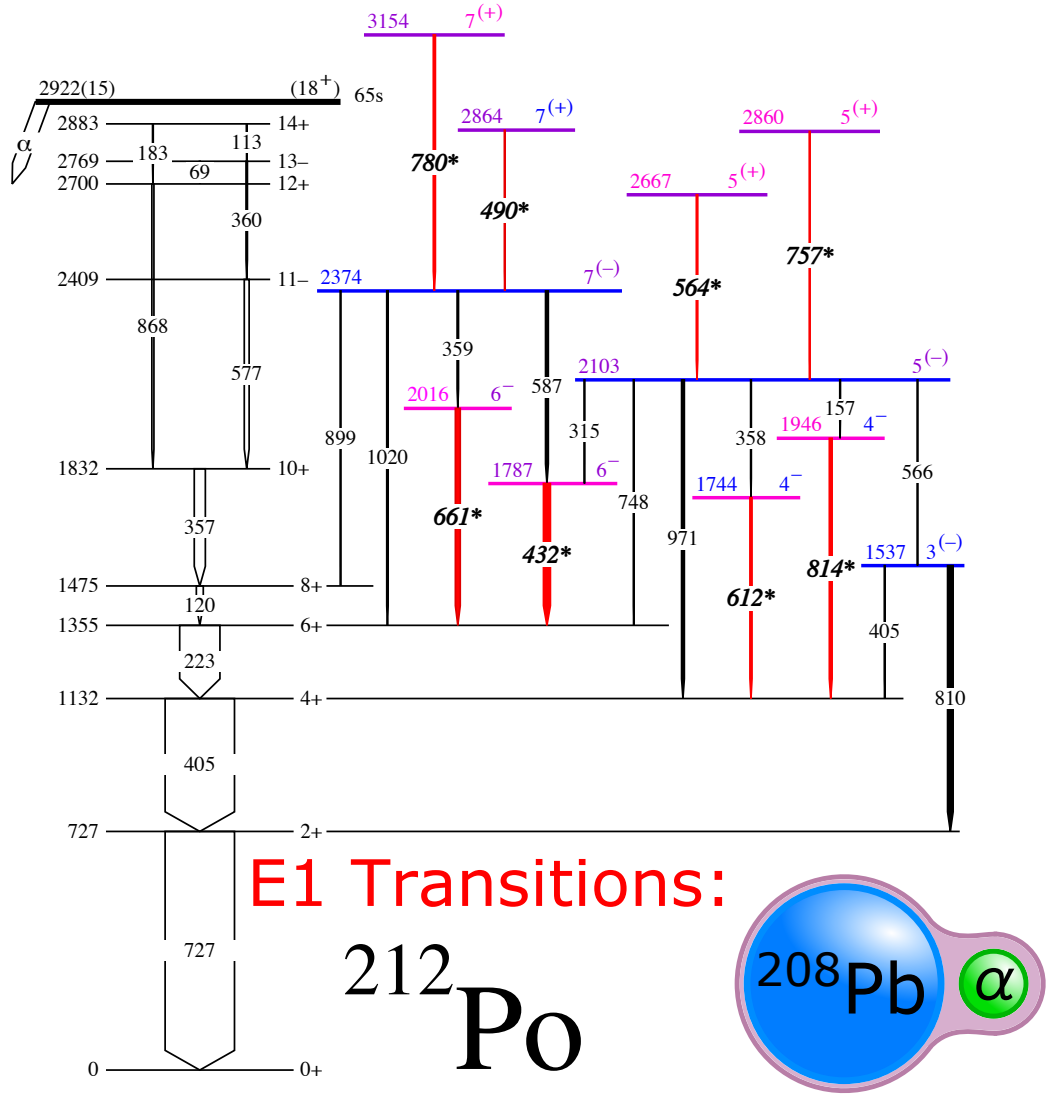
- Simple but very successful.
- Shell structure of nucleons.
- Similar to electron shells in atoms.
- Reproduces well:
  - Magic numbers.
  - G.S in near-magic nuclei.
  - and their lowly-excited states.
- But there can be other structures.

Clustering structure in light nuclei



Wolfram von Oertzen, Progress of Theoretical Physics Supplement, Volume 146, March 2002, Pages 169–178

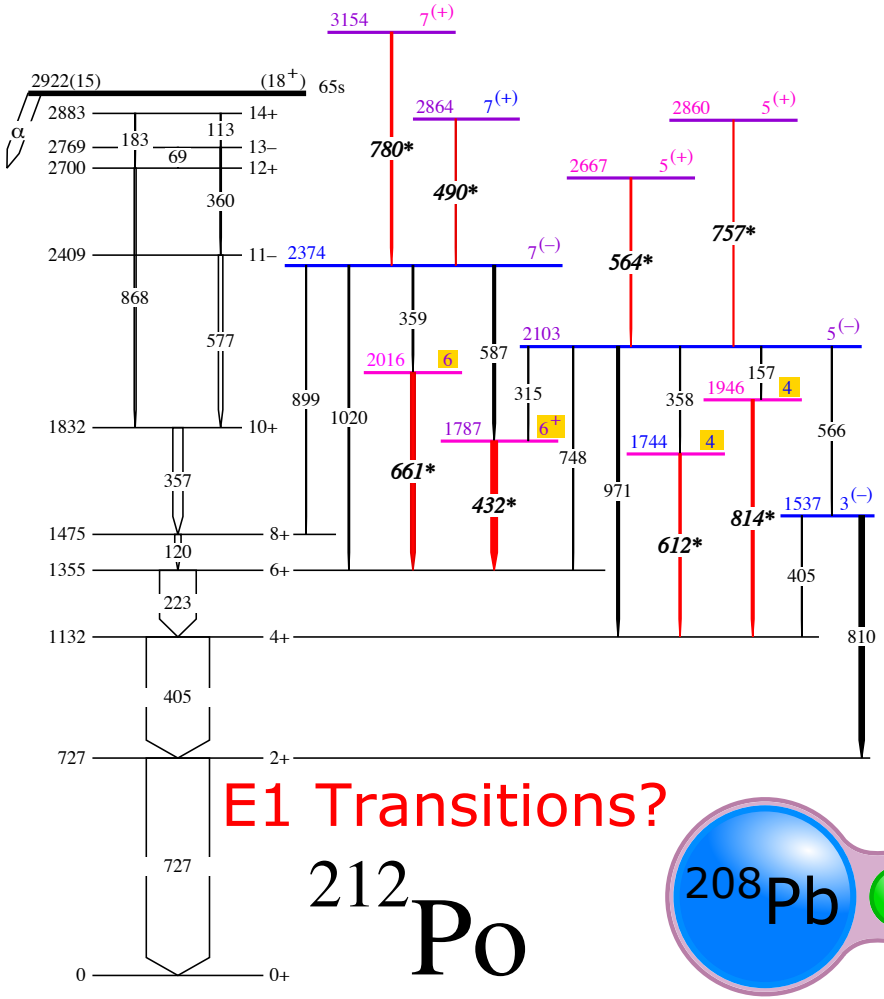
Alpha-clustering in heavy nuclei?



- Enhanced E1 transitions not explained by Shell Model.

A. Astier et al. PhysRevLett.104.042701 (2010)

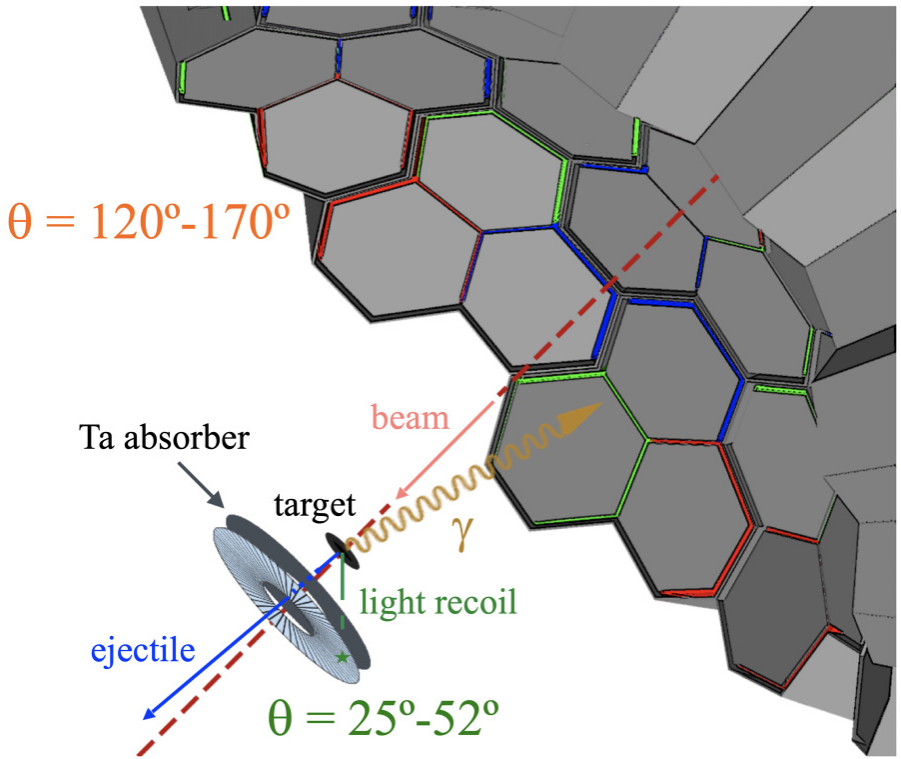
Alpha-clustering in heavy nuclei?



E1 Transitions?

^{212}Po

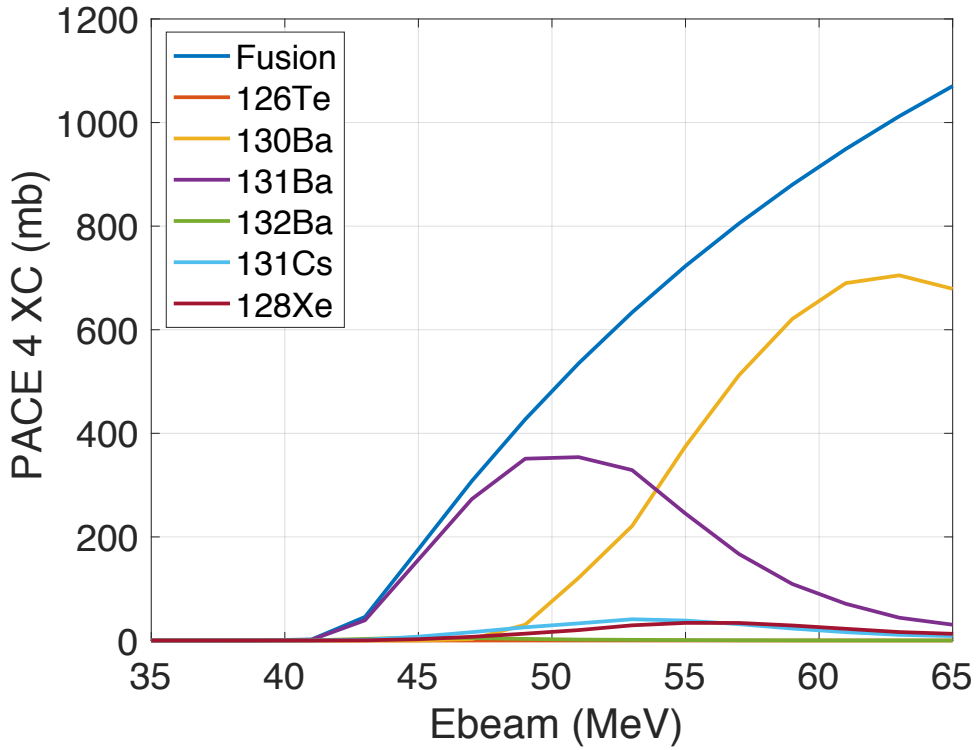
AGATA: Compton polarimetry

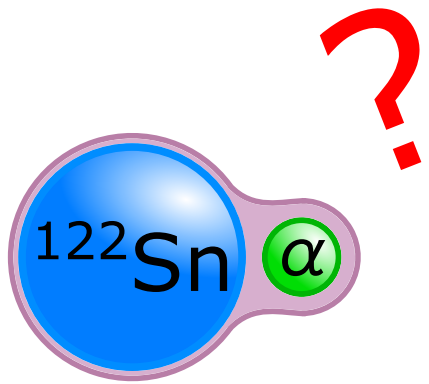


- M1 transitions are explained by Shell Model.

A. FERNÁNDEZ et al. PHYSICAL REVIEW C 104, 054316 (2021)

High production rate of ^{126}Te observed at INFN



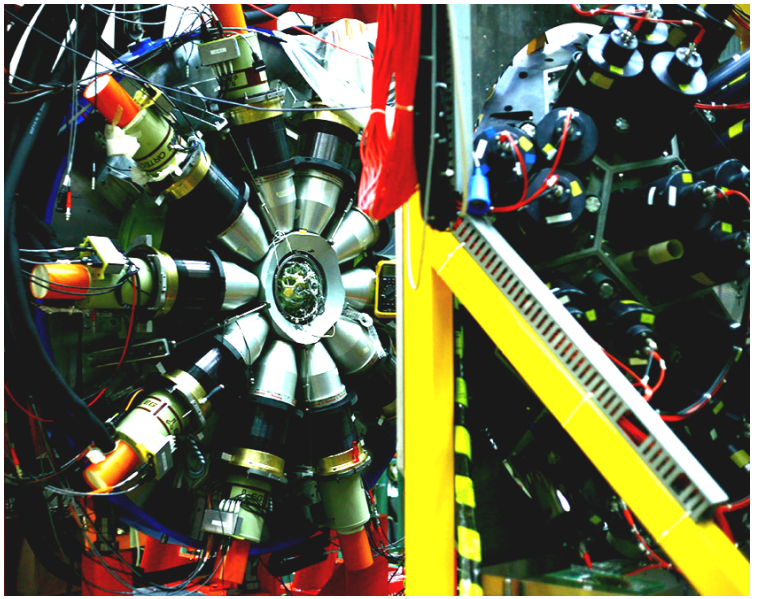


- Predicted ^{126}Te fusion-evaporation cross-section is 0.02 mb.
- Observed 11 mb, $\sim$ 500X higher.
- Alpha-transfer or incomplete fusion to suggest clustering?

Experimental setup

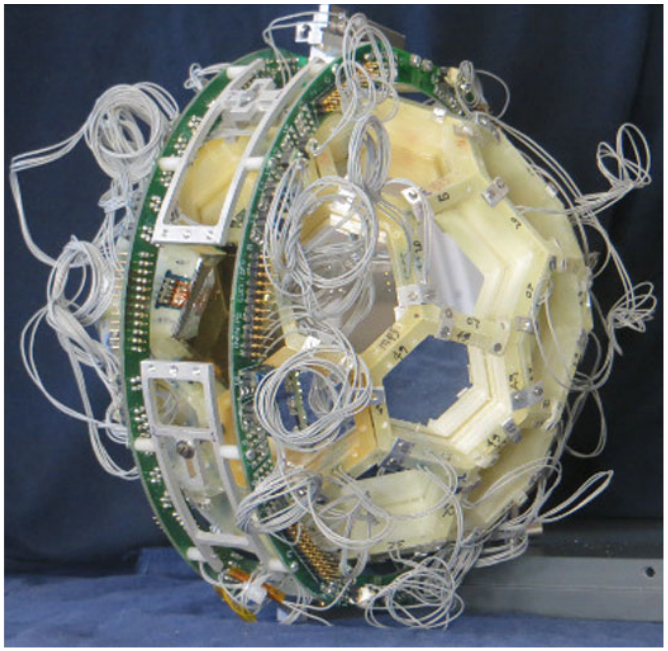
Gamma ray detection: Gamma Array of Legnaro INFN Laboratories for nuclEar spectrOscopy (GALILEO):

- Array of High-Purity Ge (HPGe) crystals with high energy resolution.
- 25 detectors for $\sim 2\pi$ coverage.



Charged particle detection and ID: EUCLIDES:

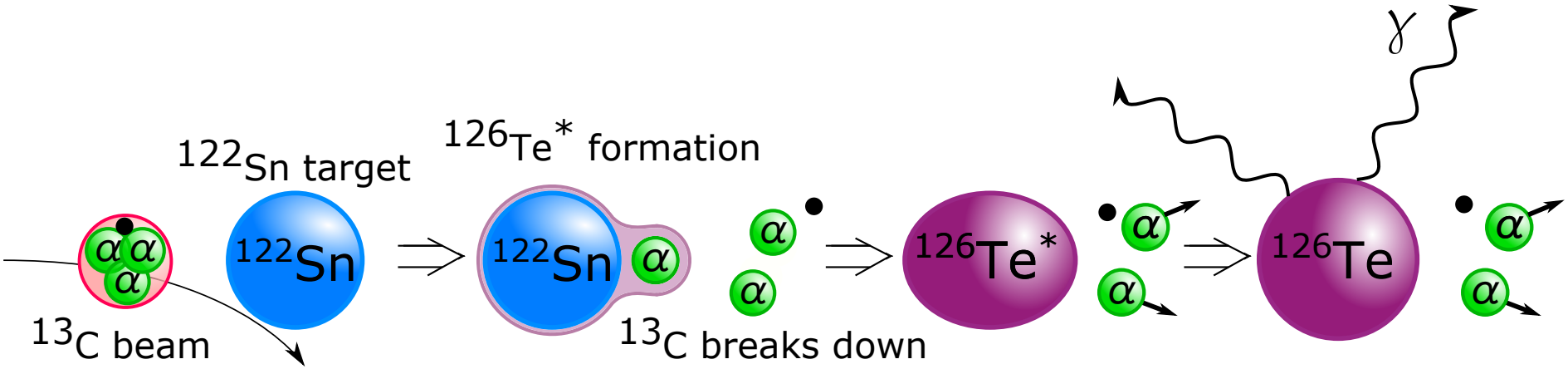
- Array of E-ΔE Si housed in the reaction chamber.
- 55-segment for $\sim 4\pi$ coverage.



Beam: 65 MeV ^{13}C onto ^{122}Sn.

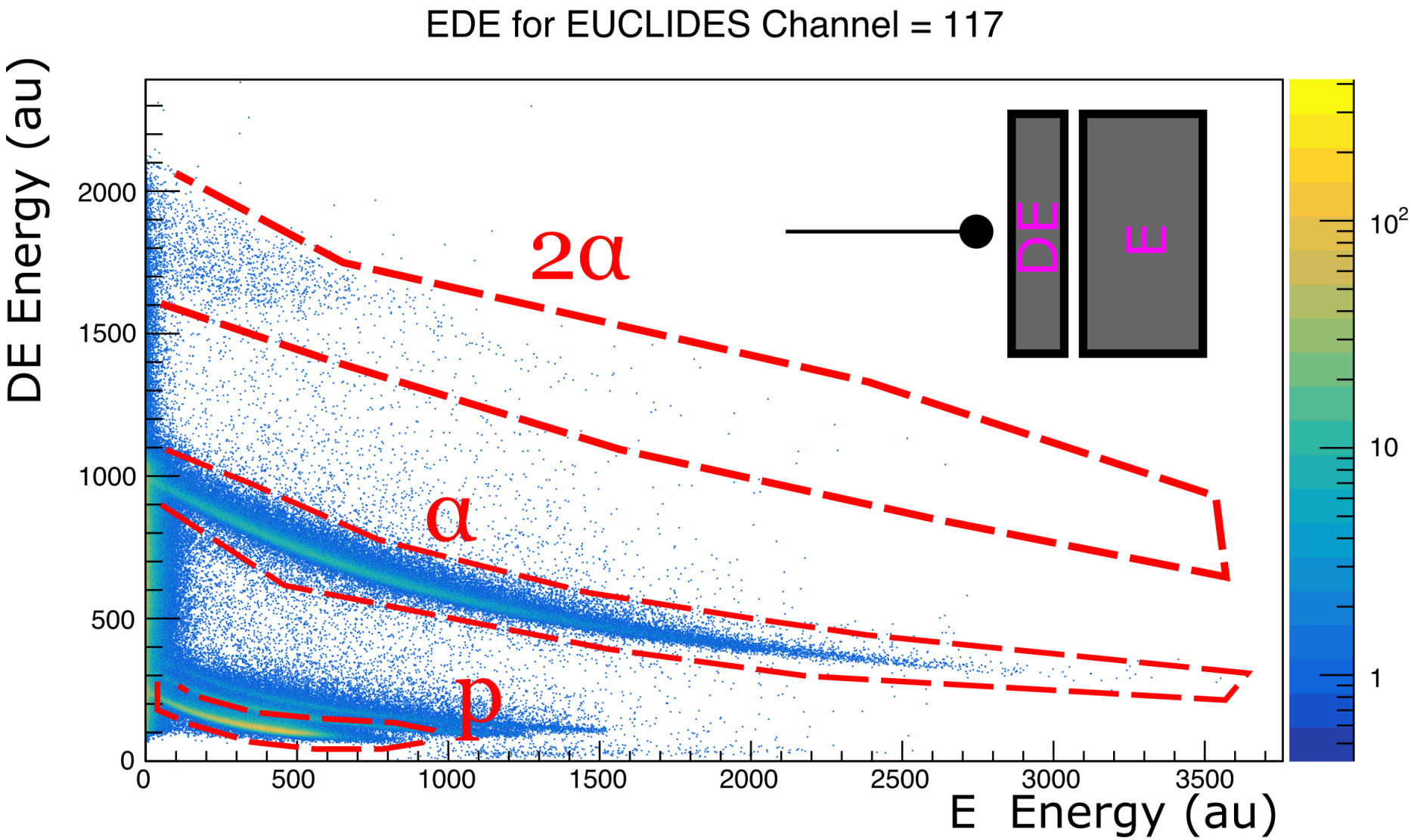
Eur. Phys. J. A (2019) 55: 47

^{126}Te production



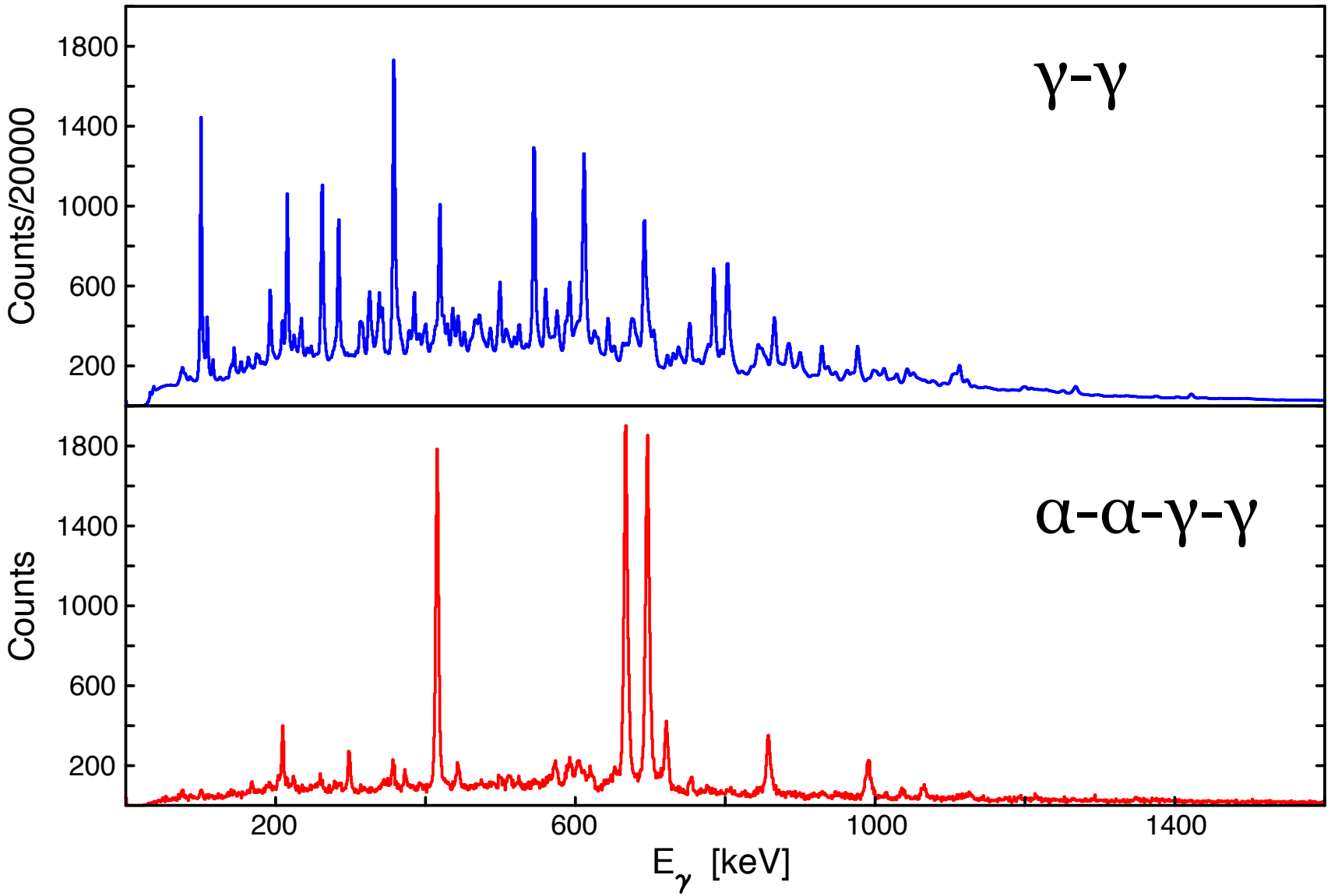
- Particle-gamma coincidence.
- Emits α's: PID to select reaction channel.

EUCLIDES Particle ID (PID) with E-ΔE



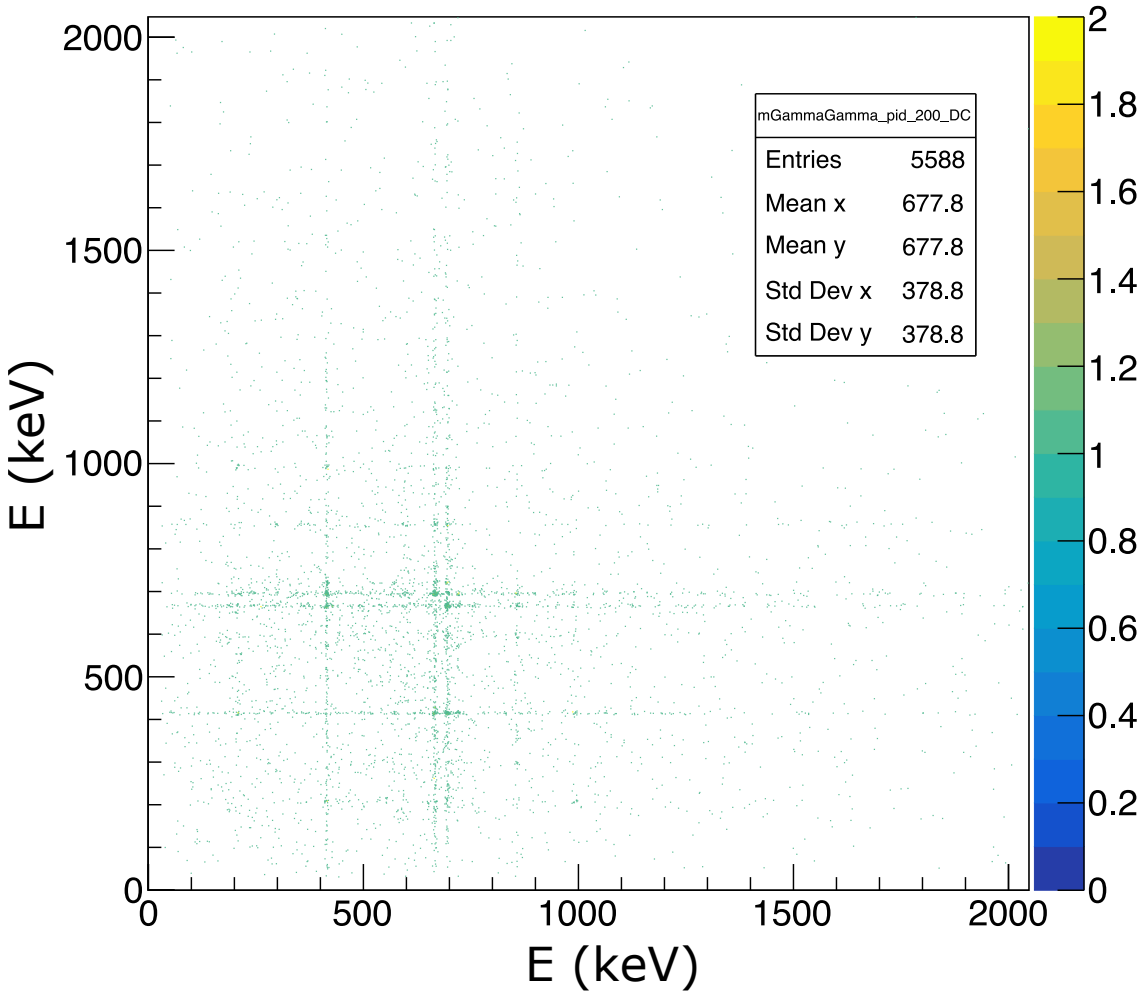
- Each detector has one ΔE layer on a E detector.

Preliminary gamma-ray spectra



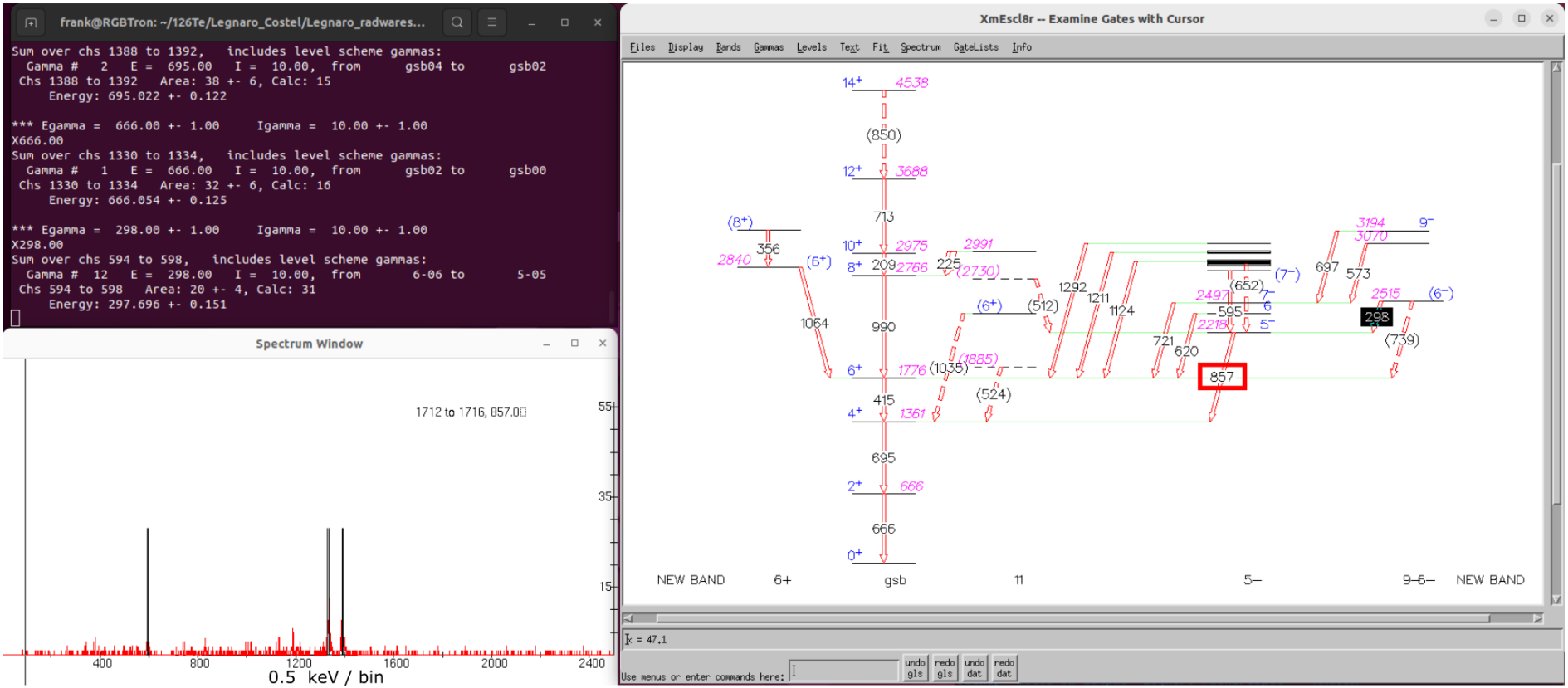
- The α-tagging with PID selects one event in 20000.

Building the level scheme from gamma-gamma coincidence



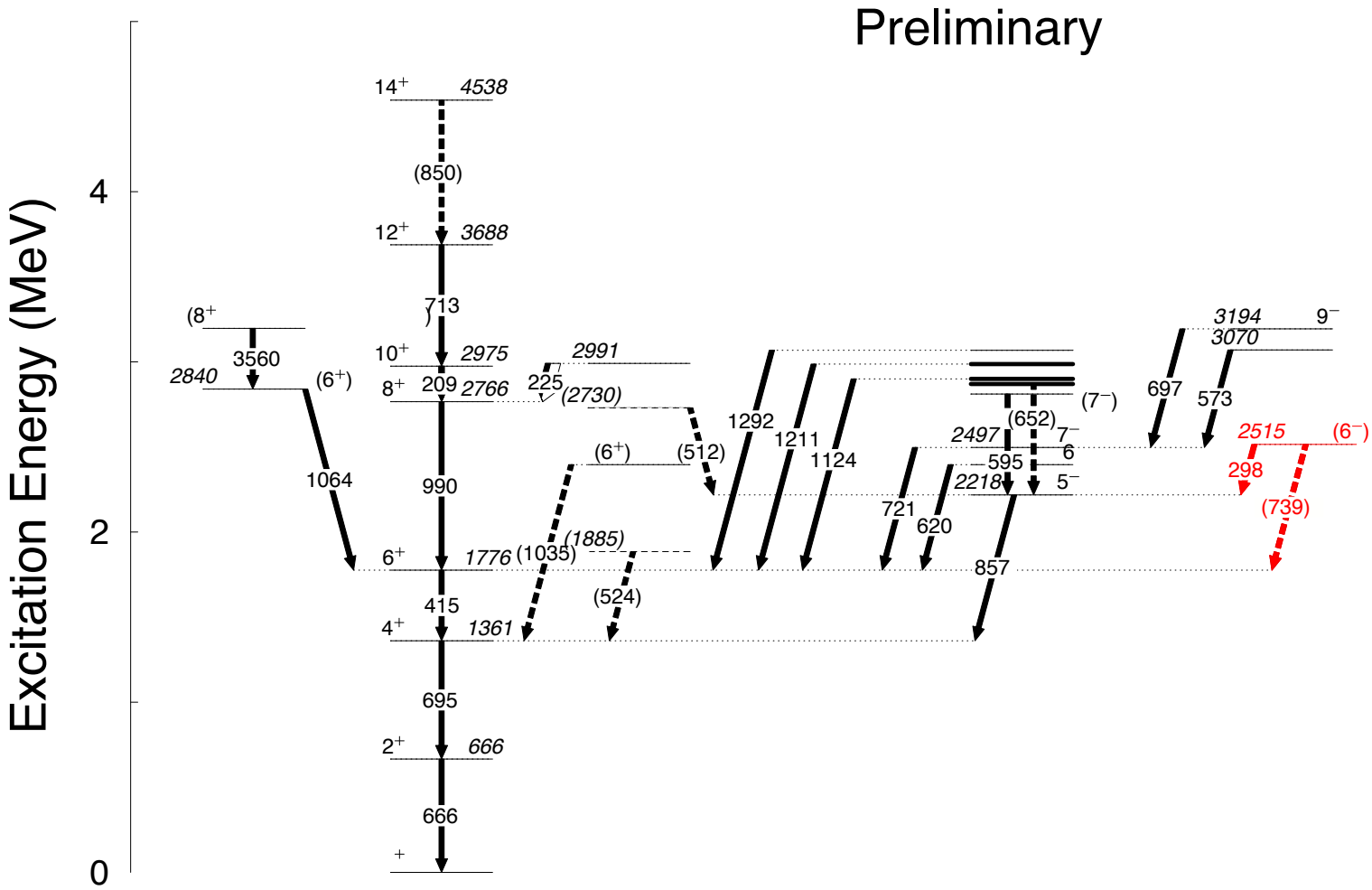
- 1 of 26 runs.
- Clean reaction channel but low statistics.

Building the level scheme from gamma-gamma coincidence



- Gating on 857 keV.
- Transitions are mostly consistent with literature.

Preliminary Level Scheme



- Work in progress, mostly consistent with literature.
- Found 1 (maybe 2) new transitions but limited by statistics.

Summary and Current Work

- ^{126}Te was populated at higher-than-predicted rates.
- Very sensitive to reaction channels with PID and coincidence.
- Extending the level scheme is heavily limited by statistics.
- Angular distribution of charged particles to come.
- Proposing a new experiment with AGATA in summer.

Acknowledgements

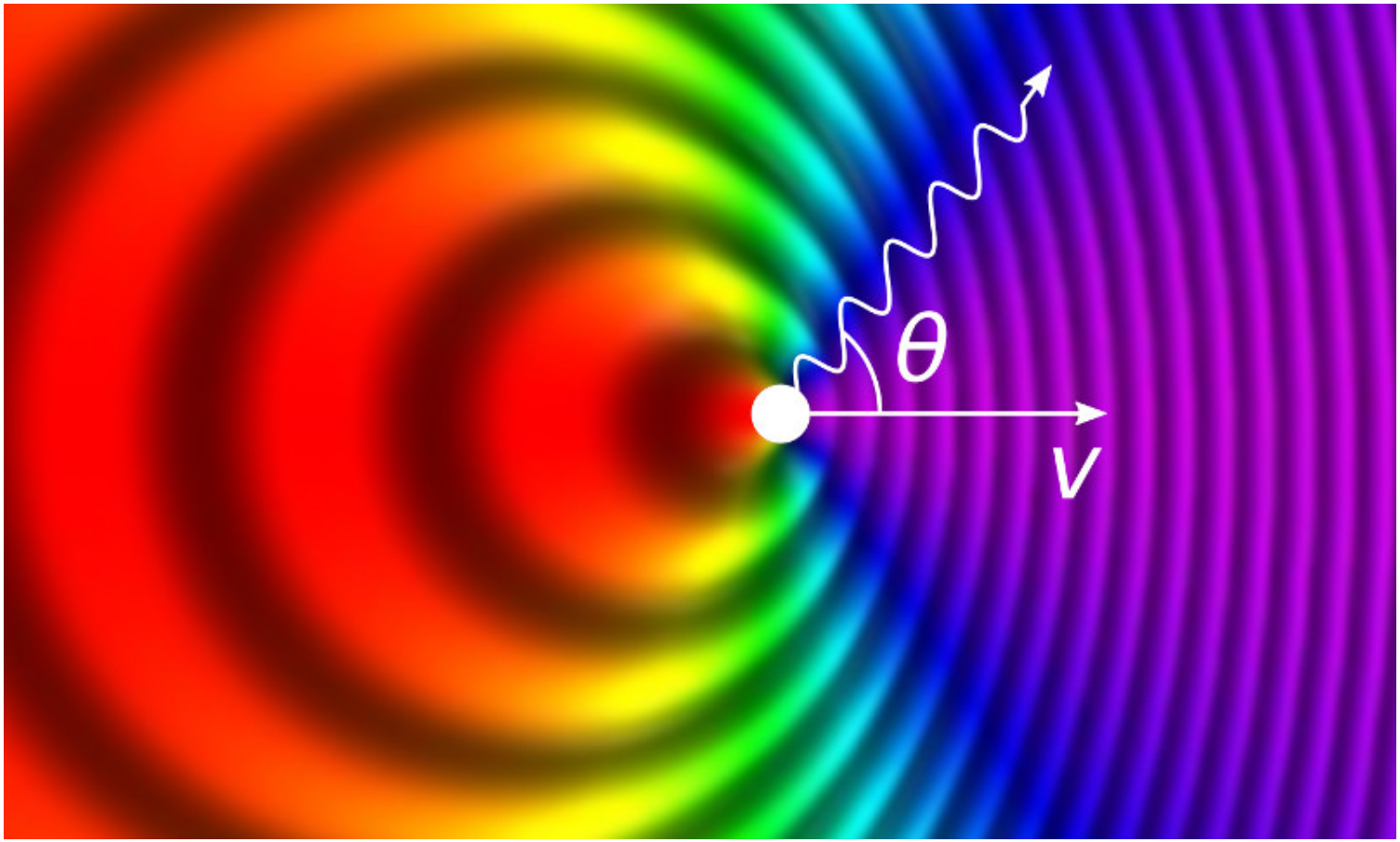
Simon Fraser University
Current: C. Andreoiu, K. Ortner, P. Spagnoletti, D. Annen,
Former: F. H. Garcia, I. Djianto

IJC Lab
C. Petrache

INFN
M. Balogh, M. Rocchini, J.J. Valiente Dobon, and the GALILEO collaboration

Travel Grants
Canadian Institute of Nuclear Physics (CINP)

Doppler Shift



$$E_{\text{Lab}} = E_0 \frac{\sqrt{1-(v/c)^2}}{1-\frac{v}{c}cos\theta}$$