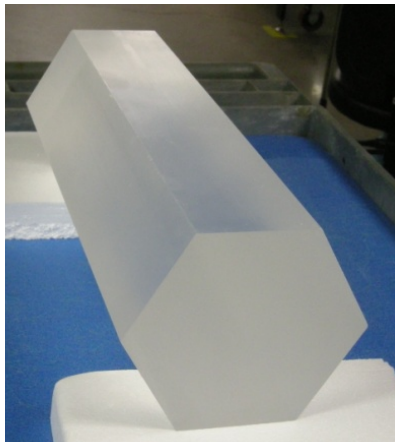
Total Absorption Spectroscopy of ^{84,85,86}Br



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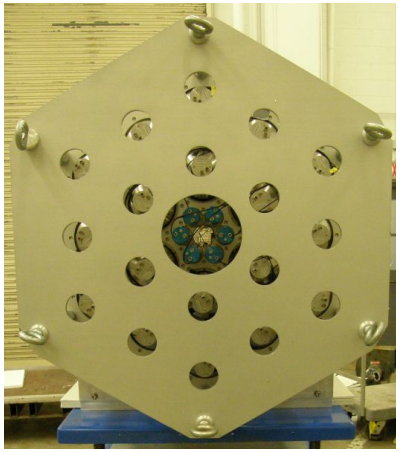
K.P. Rykaczewski (ORNL), R.K. Grzywacz (UTK/ORNL),M. Karny (ORNL/ORAU/UW), A. Fijalkowska (UT, UW), M. Wolińska-Cichocka (ORNL) , B.C. Rasco, E.F. Zganjar (LSU), J.W. Johnson , C.J. Gross (ORNL)



NS 2016
Knoxville, TN July 2016

The Pandemonium Problem

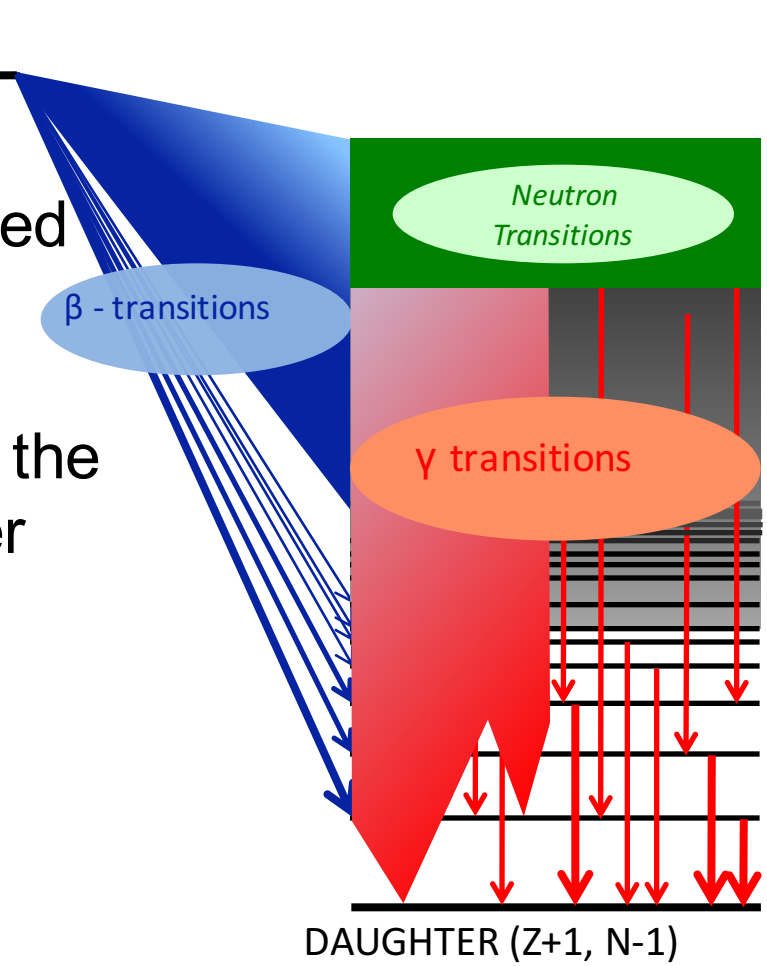
$$ {}^{Z}_{N}A \rightarrow {}^{Z+1}_{N-1}A + e^{-} + \bar{\nu} $$

- β-transitions (mostly Gamow-Teller) feed highly excited states

- Many weak β-feedings are followed by the cascades of γ-transitions in the daughter nucleus

- Weak γ-transitions are very difficult to detect with radiation detectors with low efficiency

- Hardy et. al. estimated up to 20% of energy missed above 1.7MeV

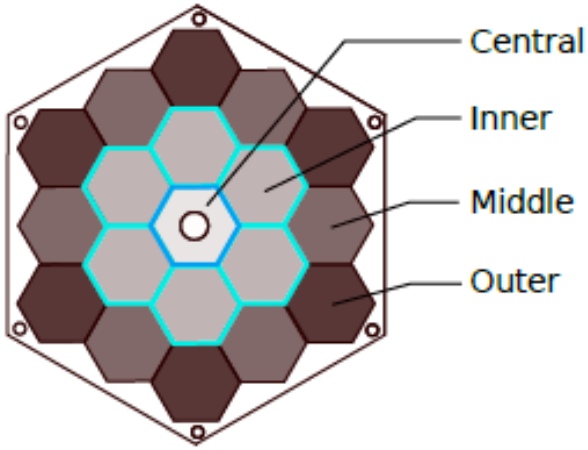


Example of the neutron-rich parent nucleus (Z,N), with many weak β-transitions and following low intensity γ-transitions.

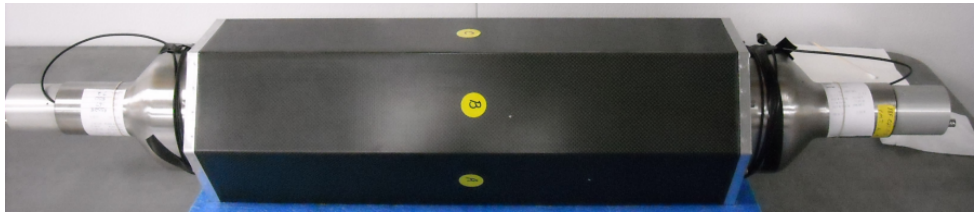
*K .Rykaczewski "Viewpoint: Conquering nuclear pandemonium" November 8, 2010, Physics **3**, 94 (2010), DOI: 10.1103/Physics.3.94*

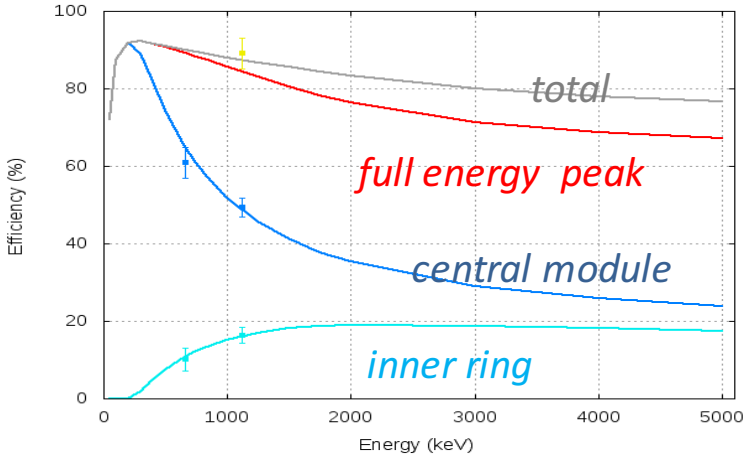
J. Hardy, L. Carraz, B. Jonson, and P. Hansen, Physics Letters B, vol. 71, no. 2, pp. 307 – 310, 1977.

Modular Total Absorption Spectrometer (MTAS)



- 19 NaI(Tl) crystals
- Wrapped to protect NaI but with minimal shielding (carbon fiber)
- PMT mounted on both ends
- Yields excellent efficiency across a broad range of energies

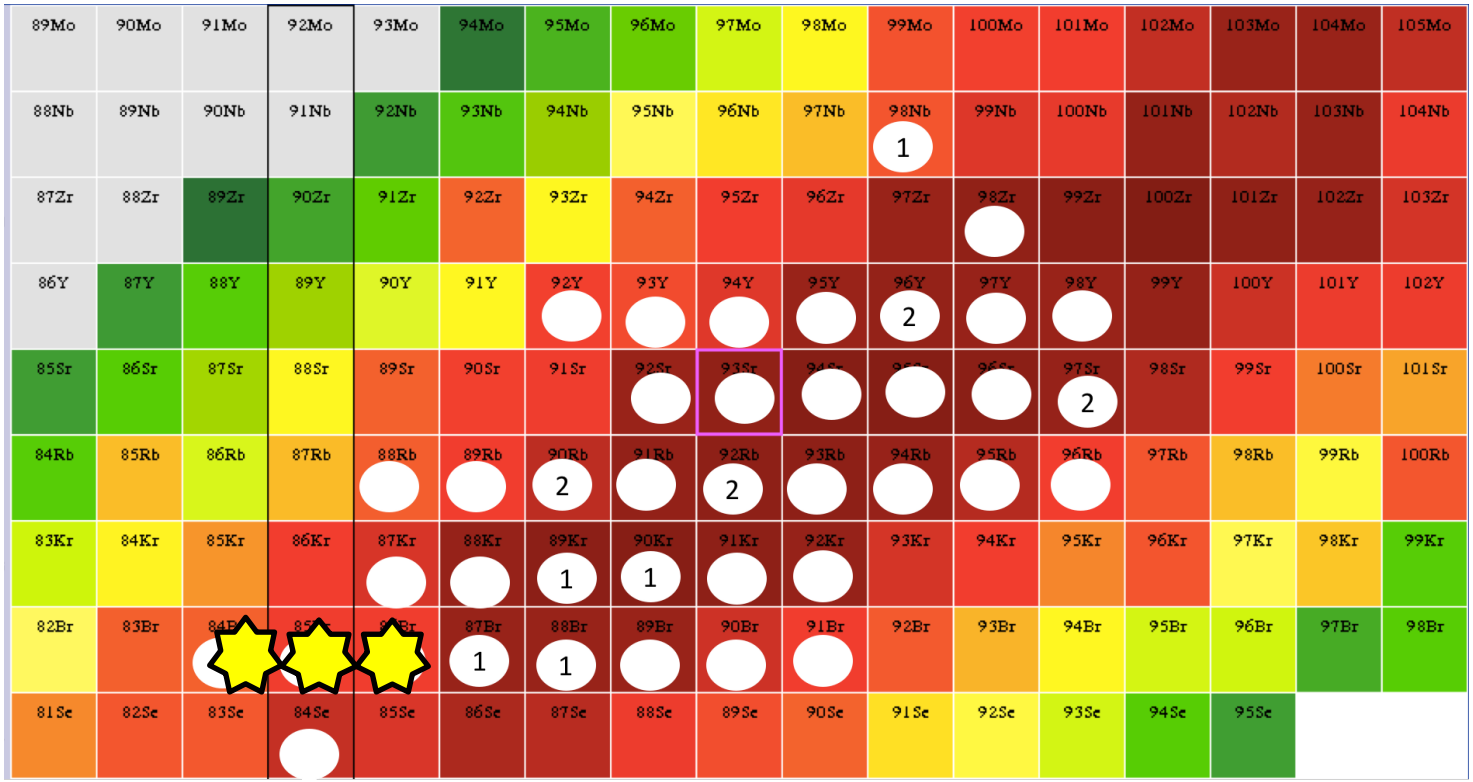




Experimental Campaigns

Jan. 2012, Mar. 2015, Oct. 2015 - Feb. 2016

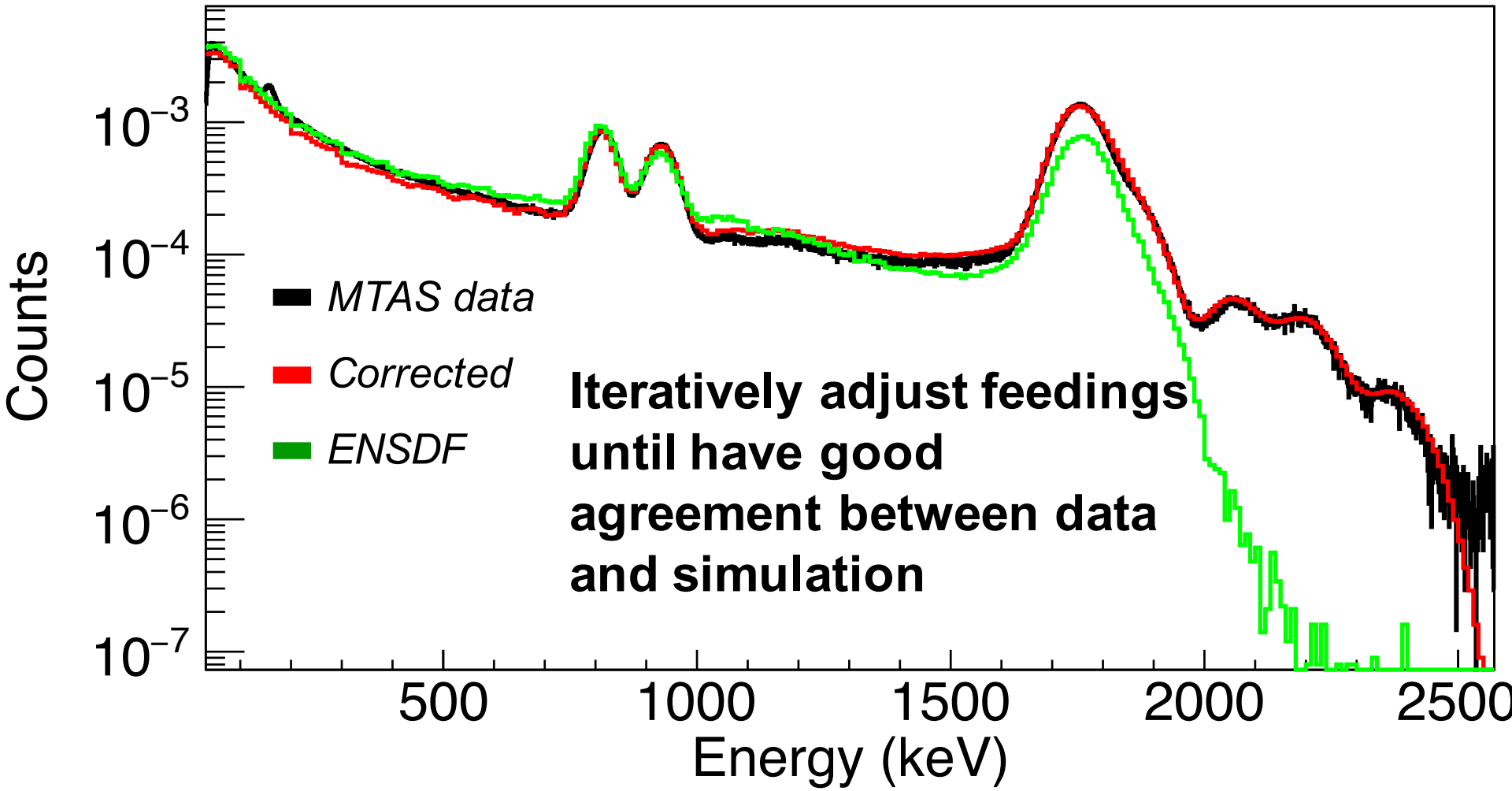
Massive effort by MTAS Team!



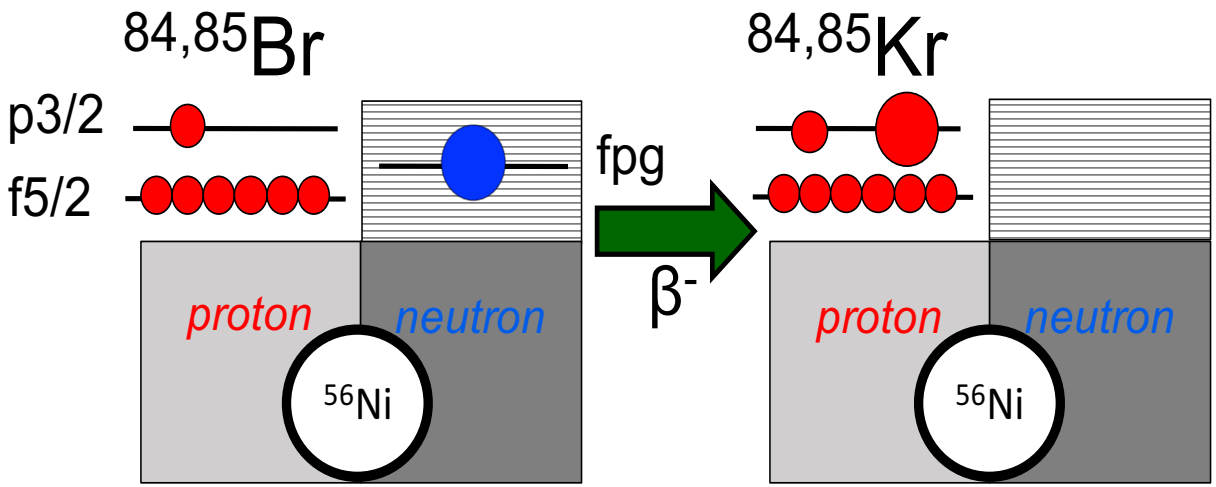
- over 70 fissions products of ^{238}U studied at HRIBF covering 64% of direct production and 34% of cumulative yield
- Many were listed as high priority needs for nuclear energy (decay heat) applications by Nichols

A.L. Nichols "Nuclear Data Requirements for Decay Heat Calculations", Lectures given at the Workshop on Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety", Trieste, Italy, 25 February - 28 March 2002.

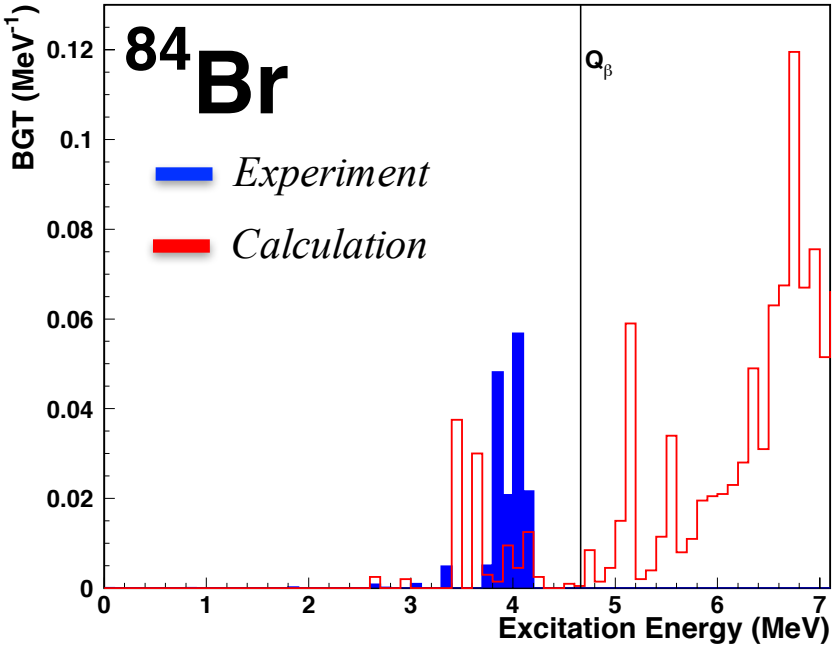
Correcting Beta feeding Using Geant4

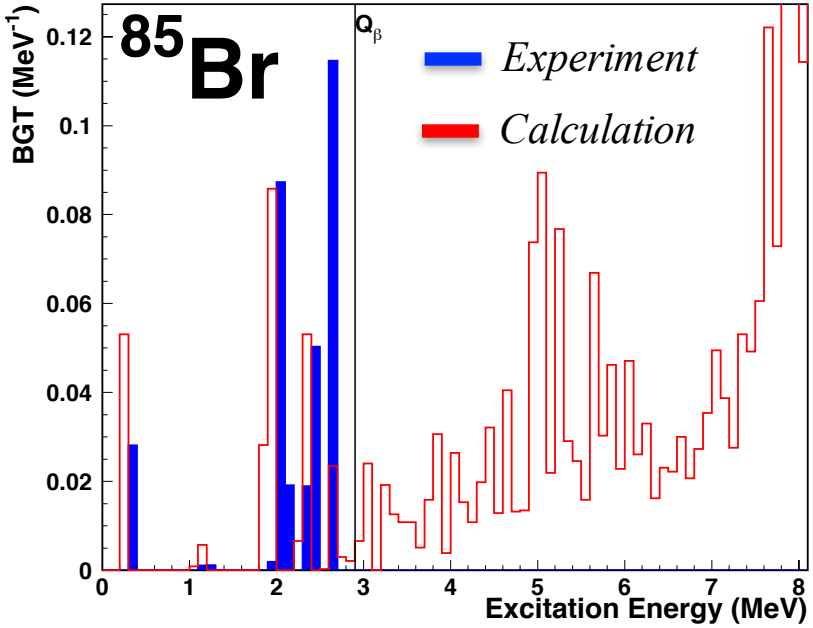


Shell Model Calculation: ^{84,85}Br



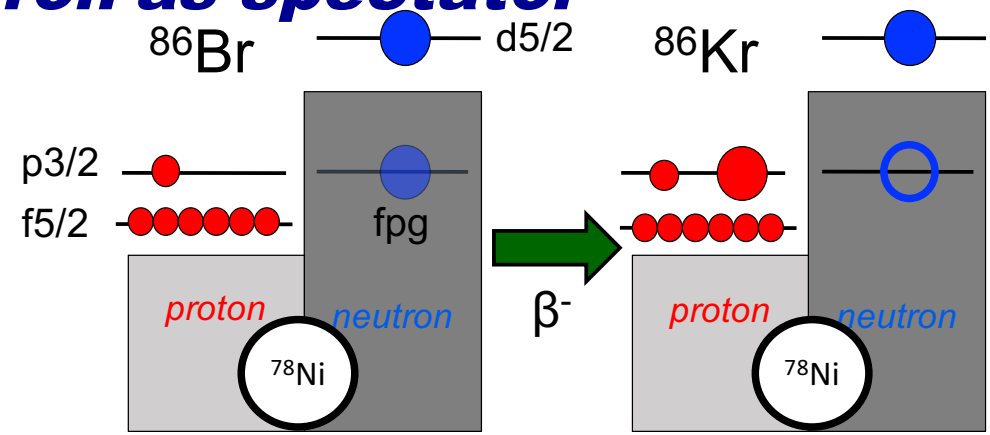
Nushell ^{56}Ni core and jj44bpn interactions

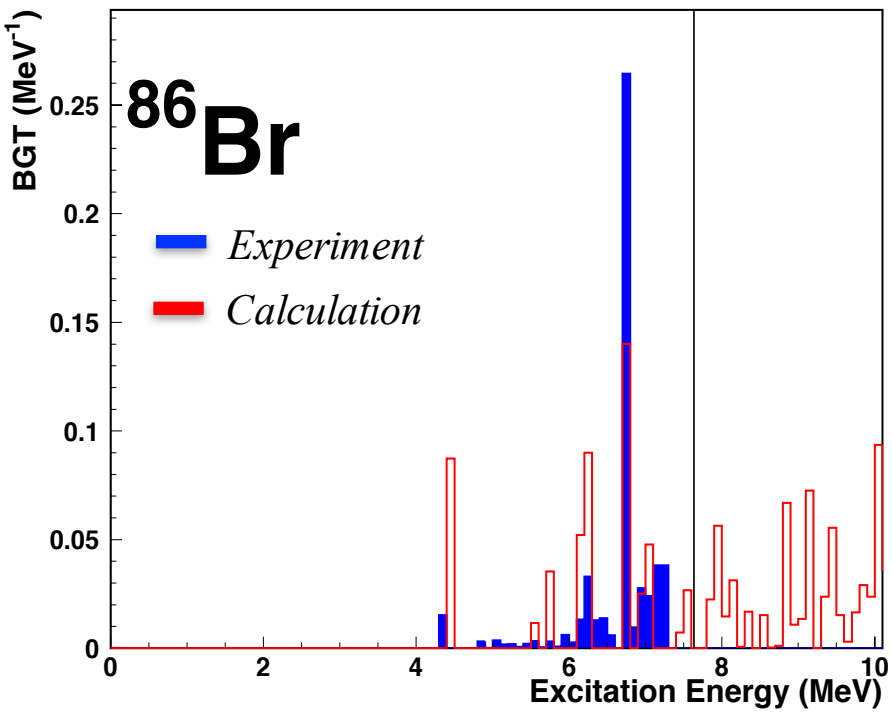




Shell Model Interpretation of ^{86}Br

d5/2 neutron as spectator





Nushell ^{56}Ni core and jj44bpn interactions

Requires 3.9MeV (N=50) shell gap

d5/2 neutrons "blocked" to make calculation tractable

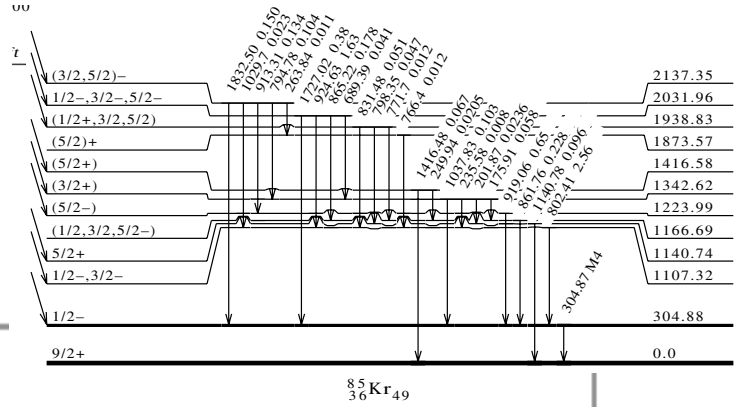
Single particle energies – experimental systematics (Grave)

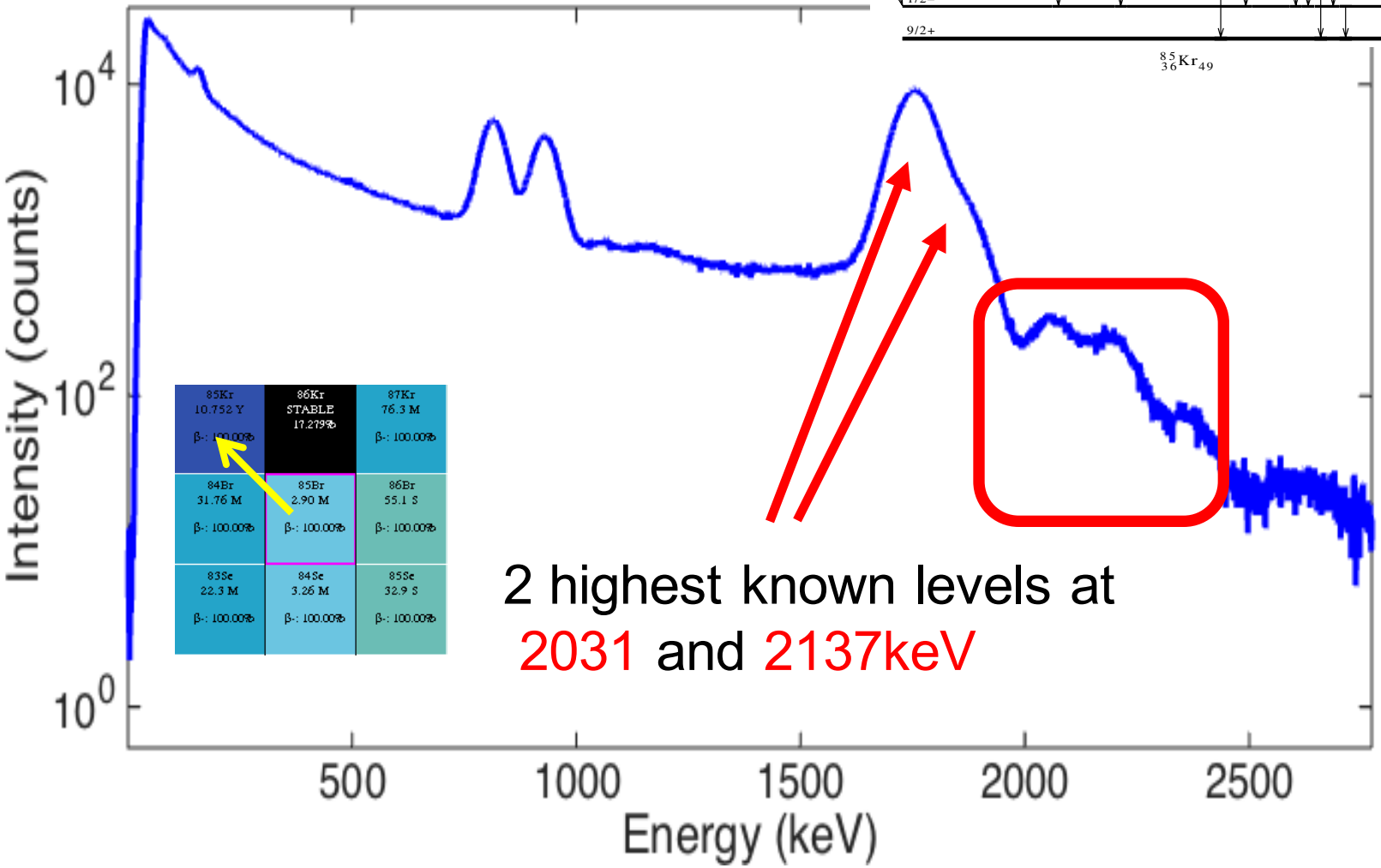
Extra Slides

Data Analysis Methods: 4 New Levels in ^{85}Br

2031keV – 305keV = 1726keV

2137keV – 305keV = 1832keV

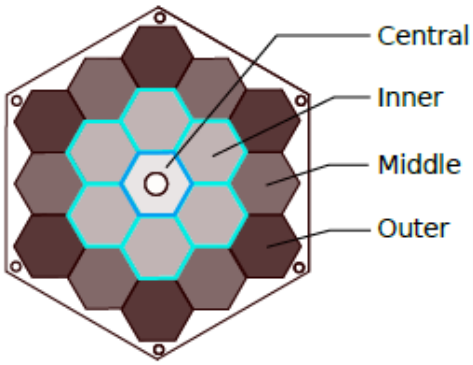


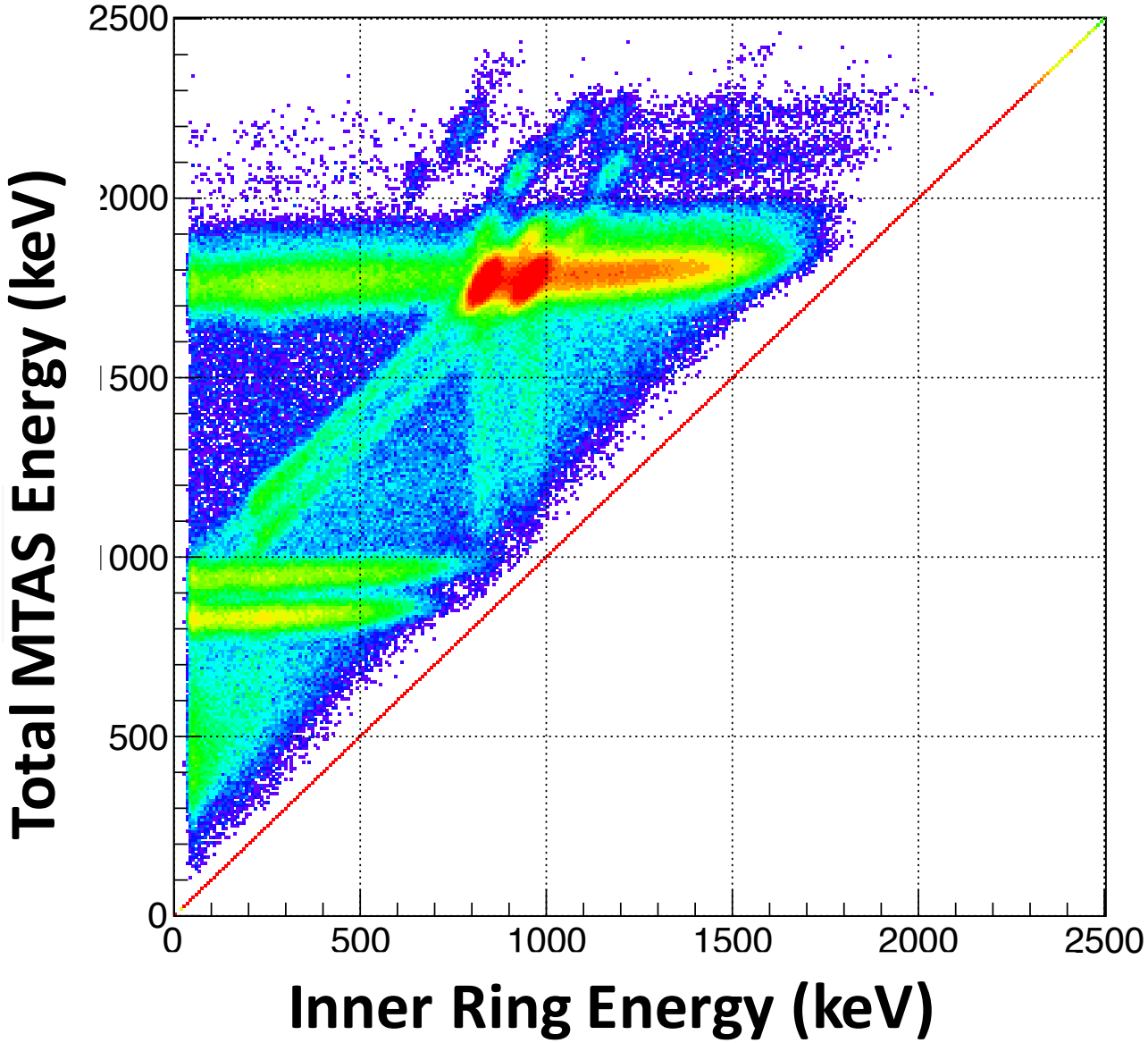


2 highest known levels at 2031 and 2137keV

Identifying Levels and de-excitations

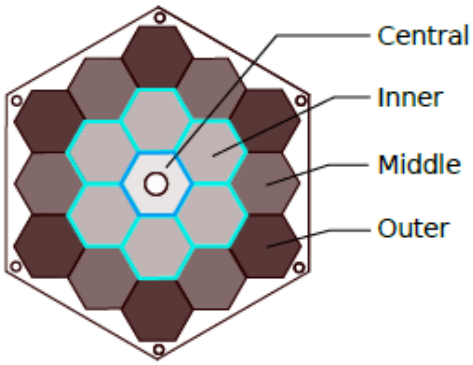
^{85}Br

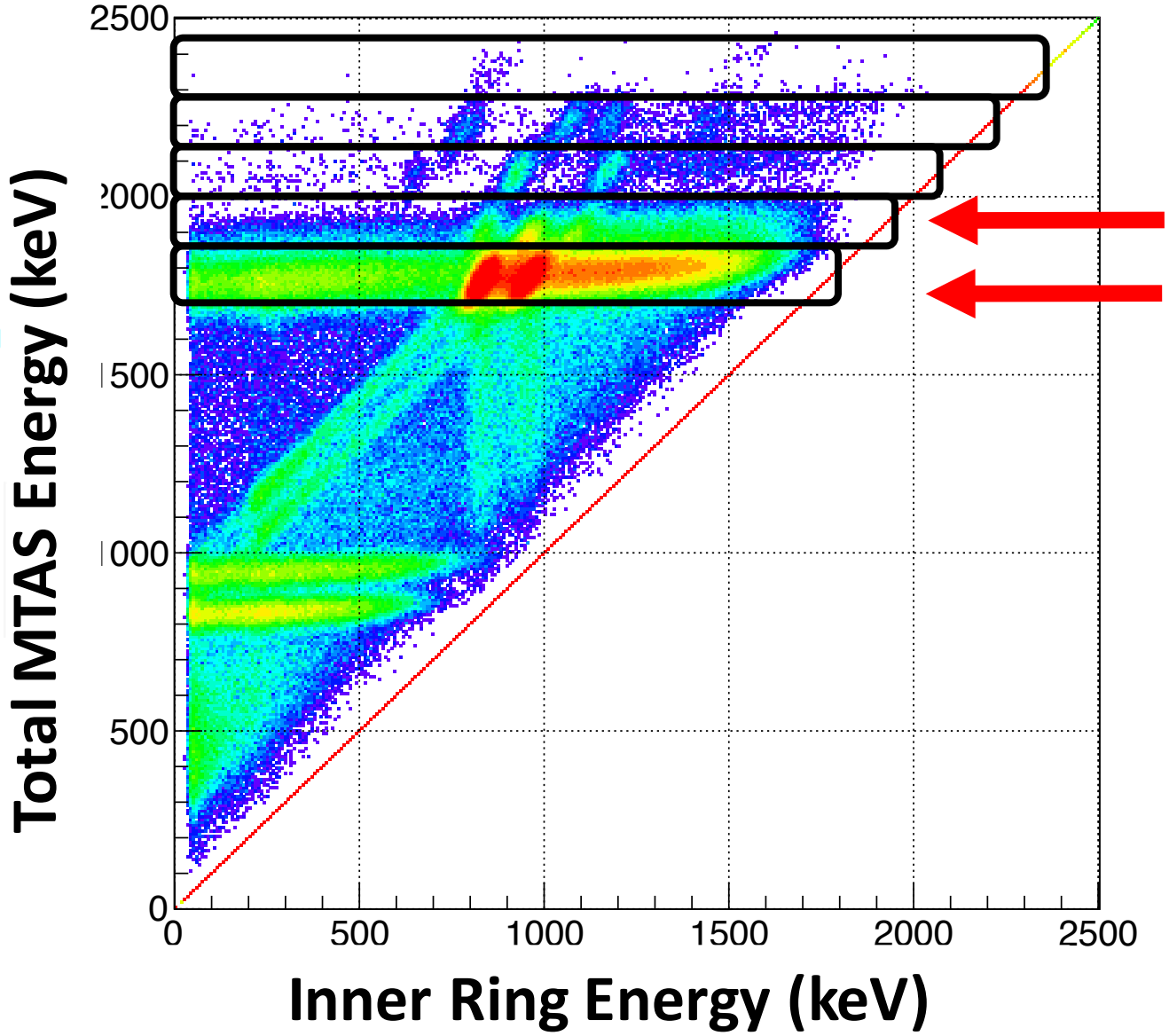




Identifying Levels and de-excitations

^{85}Br

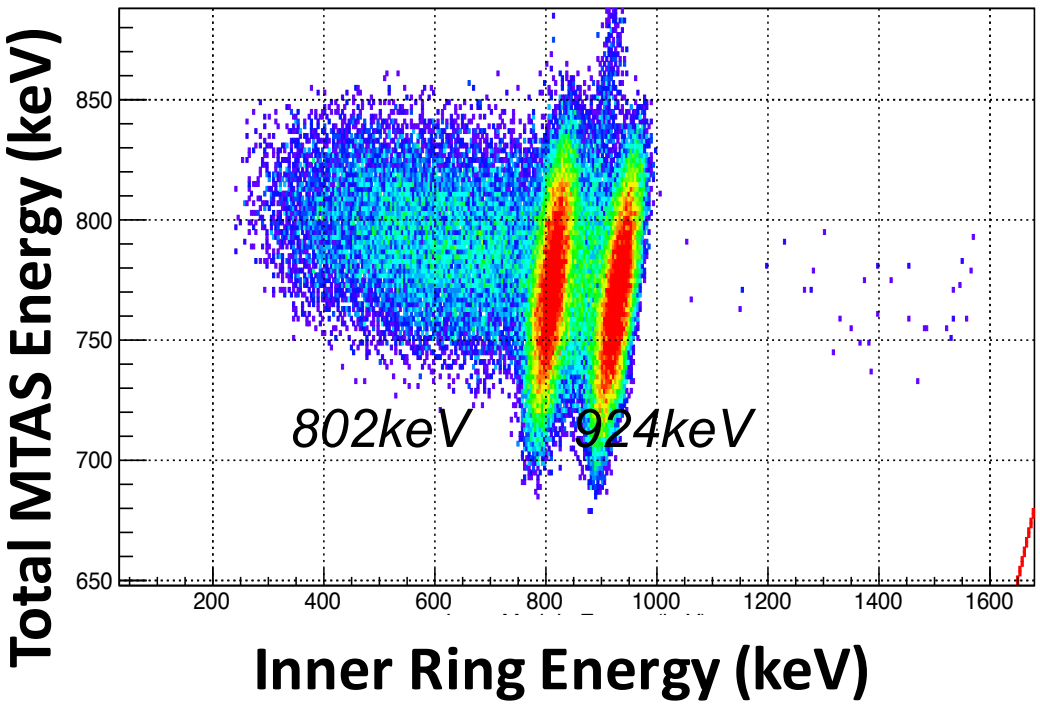


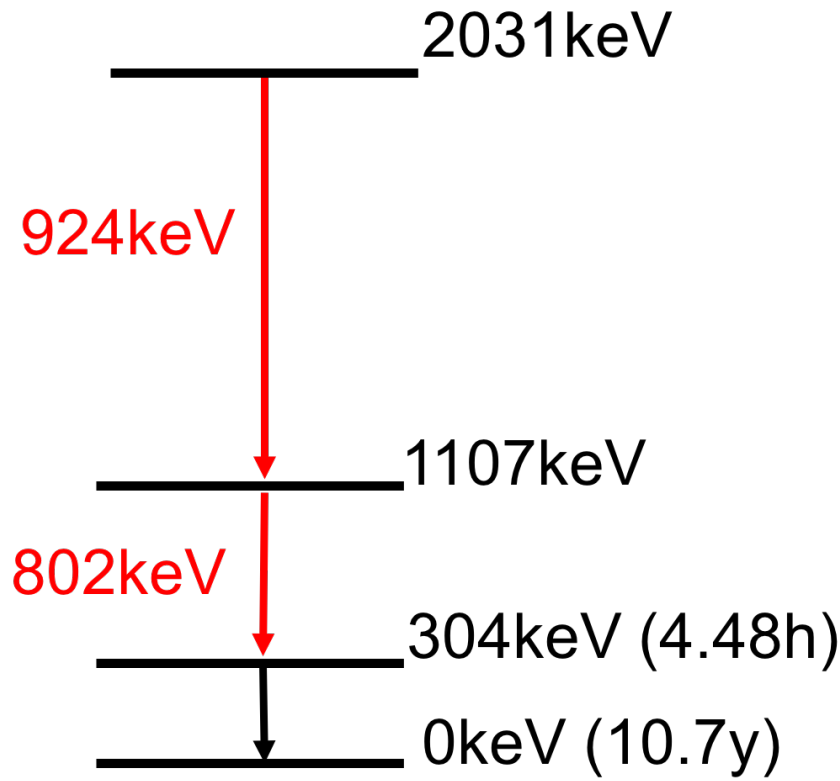


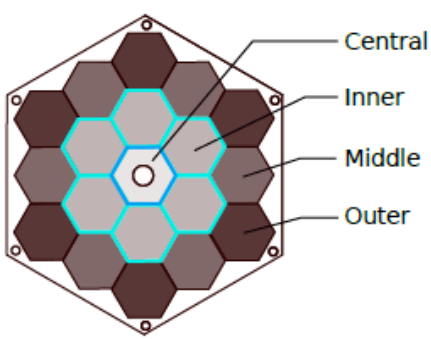
Closer Look: Level 2031

^{85}Br

2031keV – 305keV = 1726keV

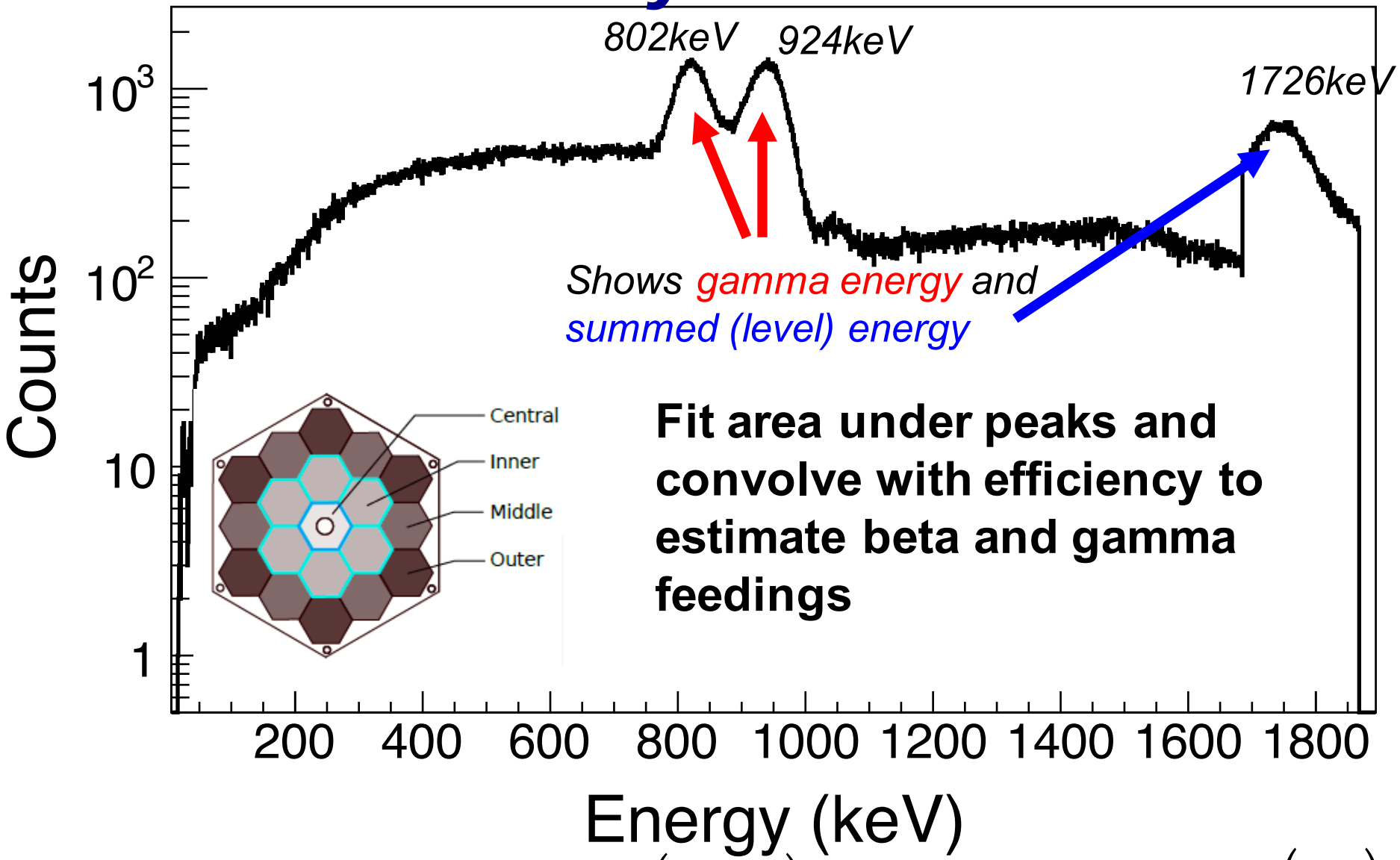






The

Estimate Beta and Gamma Feeding: Gamma-Gamma Analysis of Level 2031



Fit area under peaks and convolve with efficiency to estimate beta and gamma feedings

$$Efficiency = Efficiency_{total}\left(E_{level}\right) \cdot Efficiency_{Central/Inner}\left(E_{\gamma}\right)$$