

A New Evaluation of Nuclear Fission Yield Ratios: Isomeric Yield Ratios and Energy Dependency

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COLLECTING DATA FOR THE EVALUATION: TWO FOCUSES

1. Isomeric Yield Ratios

- The amount of measured IYR values has doubled since the last evaluation
- **Goal: Determine recommended experimental isomeric ratios for evaluation**

$$\text{IYR} = \frac{\text{Metastable yield}}{\text{Metastable} + \text{Ground yield}}$$

2. Energy Dependence of Uranium 238

- Open question of fission yields: how does the incident particle energy impact the yield of different fission products of U-238?

ISOMERIC YIELD RATIOS

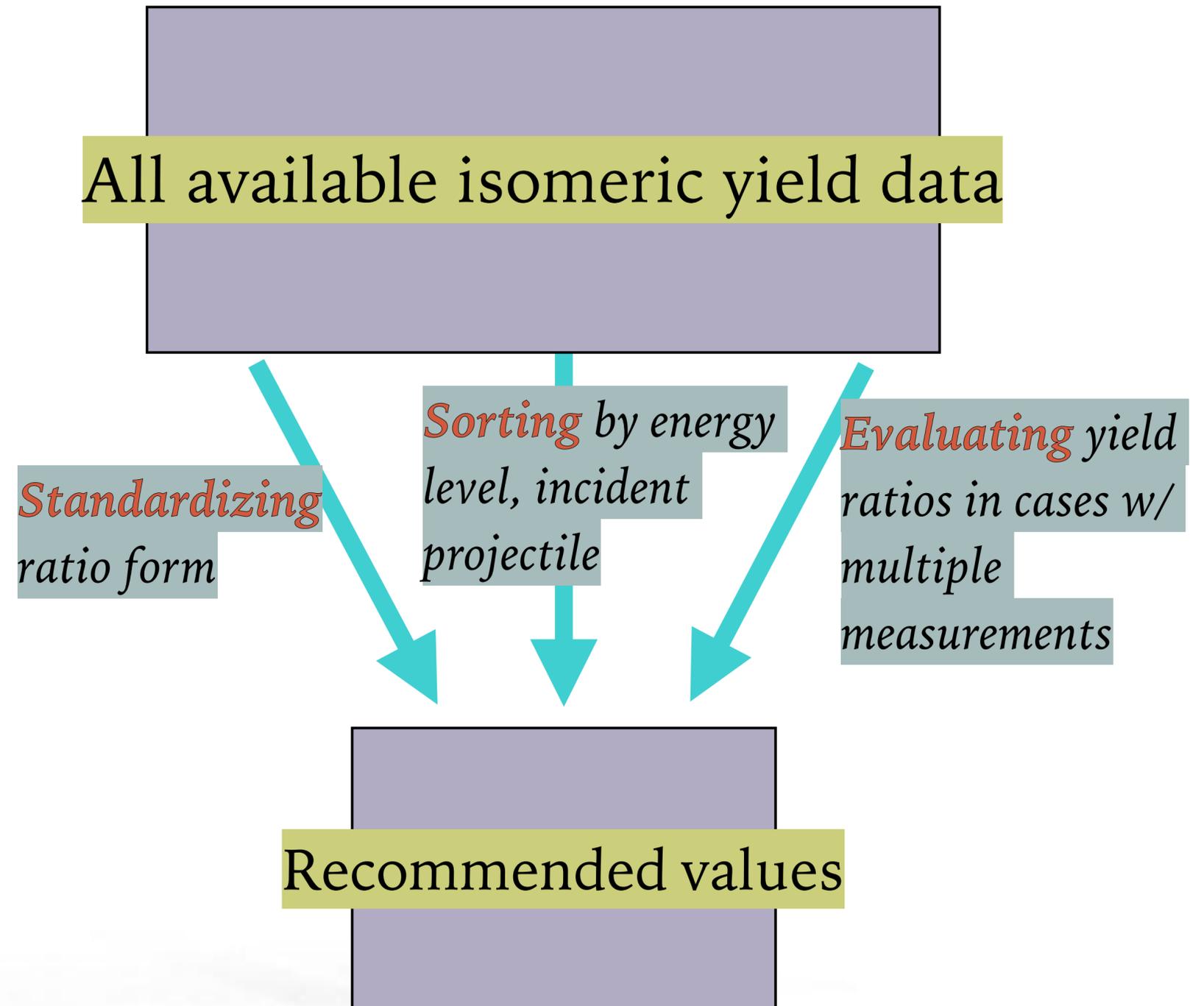
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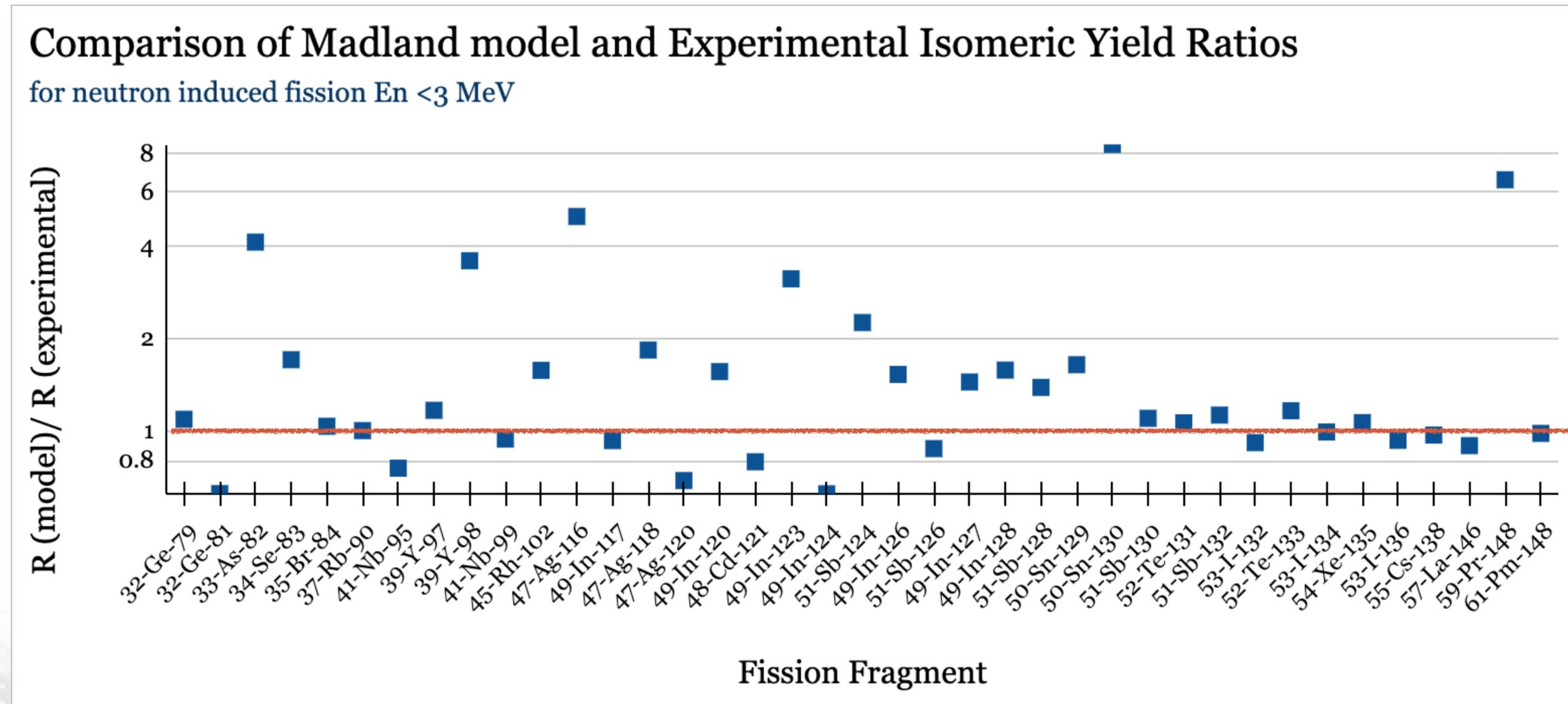
EXPERIMENTALLY MEASURED RATIOS

- All isomeric yields reported in EXFOR were compiled with an automated program
- Supplemented by England and Rider compilation
- 545 isomeric yields collected, 270 neutron-induced
- Standardized into M/T form
- Determined a single recommended experimental yield for fission fragments with several experimental values available



ISOMERIC RATIOS & THE MADLAND-ENGLAND MODEL

- We compared the available experimental data to the M&E model predictions, aiming to update the model with our new insights.
- Original was developed with very little experimental data (<50 available data points)
- We observed inconsistencies with newer experimental data

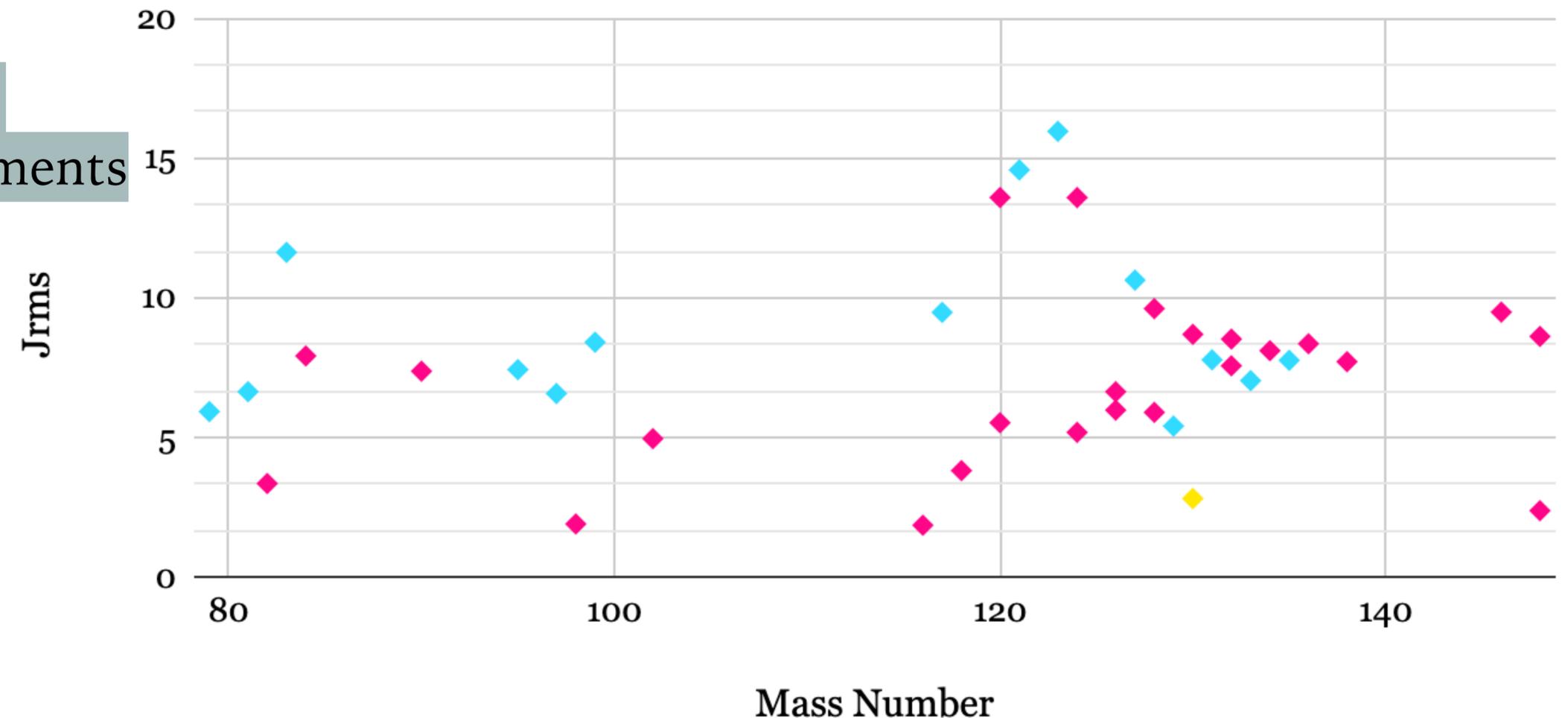


LOOKING FOR TRENDS AMONG ISOMERIC RATIOS IN NUCLEAR STRUCTURE

Dependence of J_{rms} on Fission Fragment Mass Number

For <3 MeV neutron induced fission

◆ Odd-Odd ◆ Odd-Mass ◆ Even-Even



J_{rms} = the average of the spin distribution of the fission fragments

- We could not observe a clear trend that would determine the relationship between the IYR and the mass number, p-factor or spin difference of the FF.

ENERGY DEPENDENCE OF U-238 FISSION YIELDS

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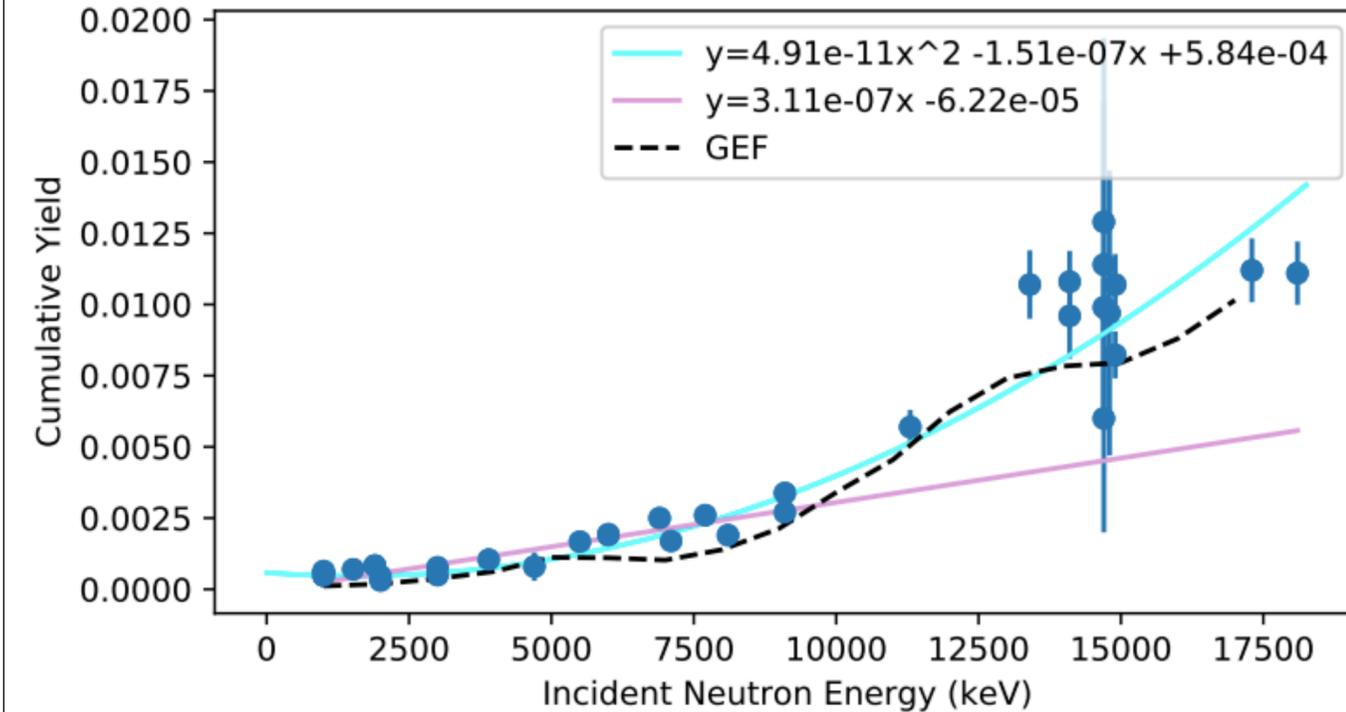
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STUDYING ENERGY DEPENDENCE OF U-238

- Separate datasets produced for studying the effect of energy level on cumulative and independent yields
- FY(En) plots were created for all nuclides
 - GEF model calculations compared to data.
 - General trend observed of negative slopes closer to heavy and light mass peaks, positive slopes farther from fragment distribution peaks

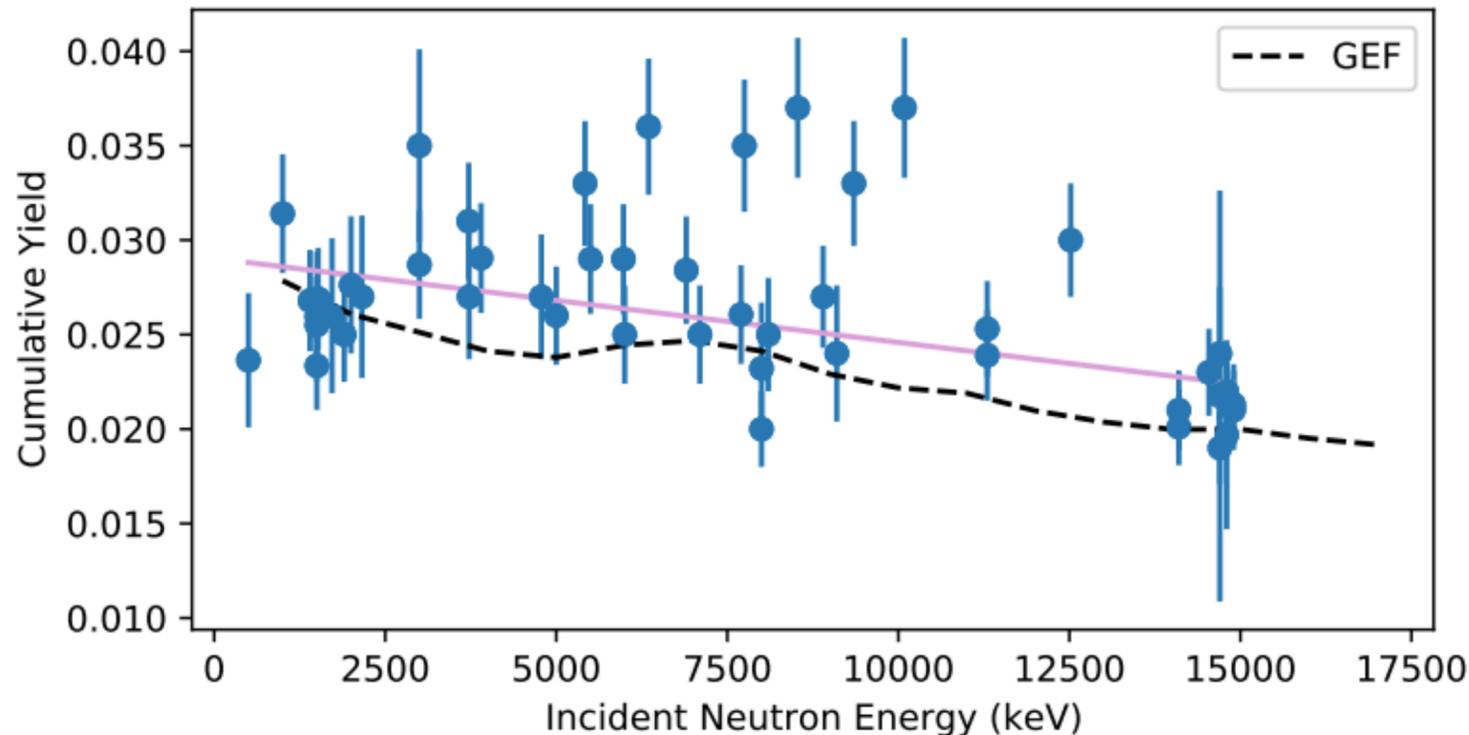
Energy Dependence of Ag-111

Quad Fit χ^2 value: 153.416, Reduced χ^2 value: 4.649
Linear Fit χ^2 value: 504.991, Reduced χ^2 value: 15.303



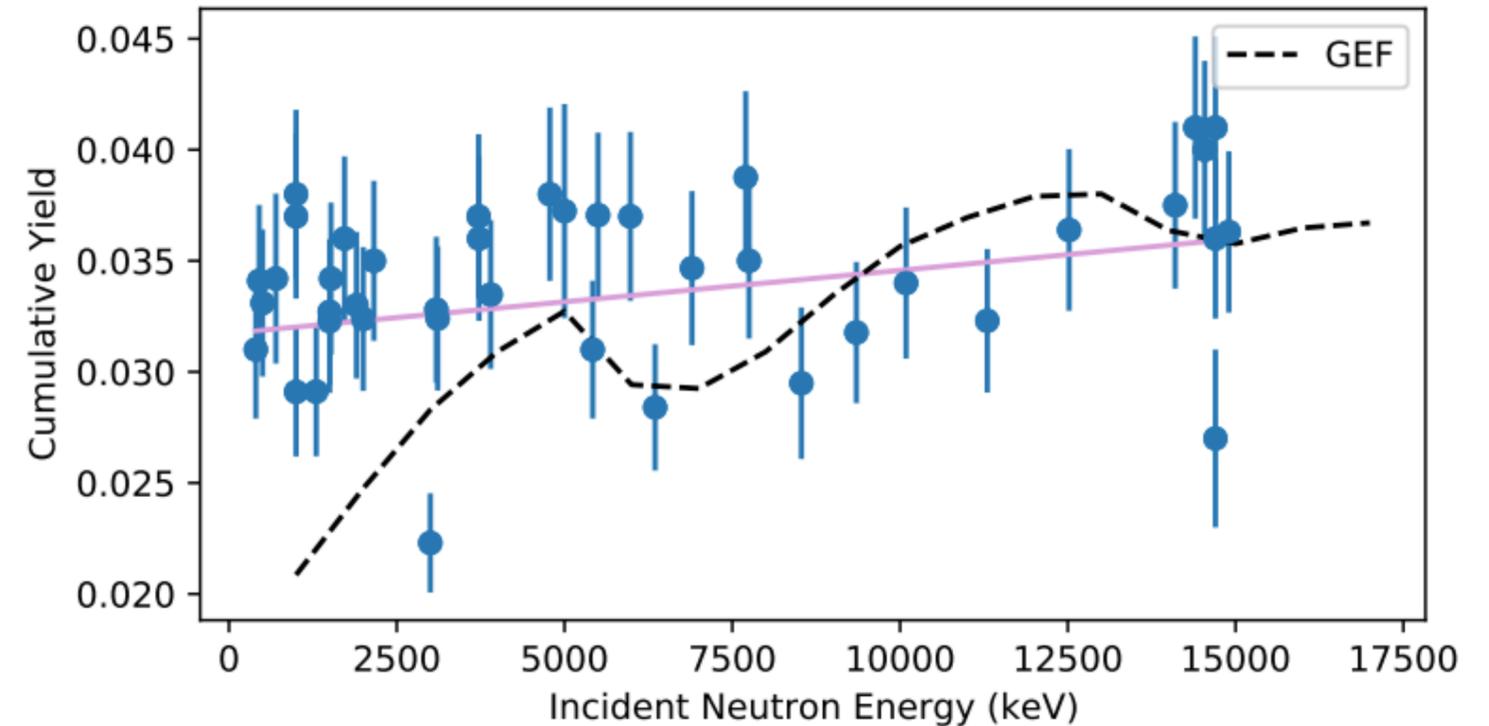
Energy Dependence of Nd-147

Line equation: $y=-4.45e-07x + 2.90e-02$
 χ^2 value: 85.259
Reduced χ^2 value: 1.814



Energy Dependence of I-131

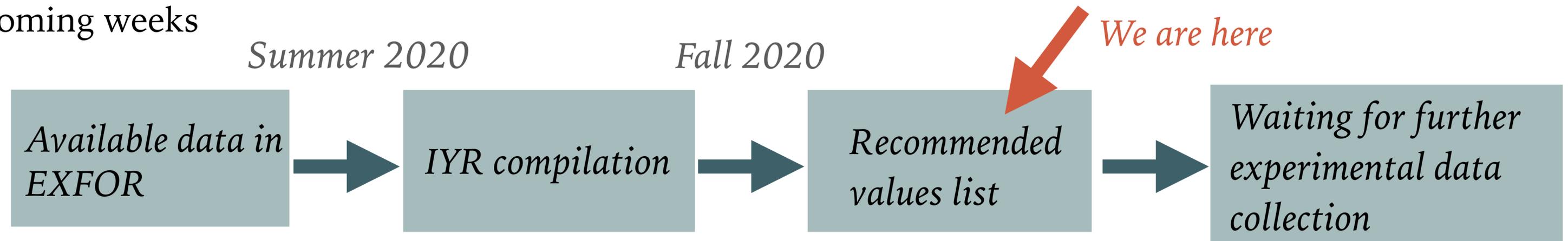
Line equation: $y=2.84e-07x + 3.17e-02$
 χ^2 value: 55.226
Reduced χ^2 value: 1.381



PROGRESS IN FISSION YIELD DATA

Current state of isomeric yield ratios

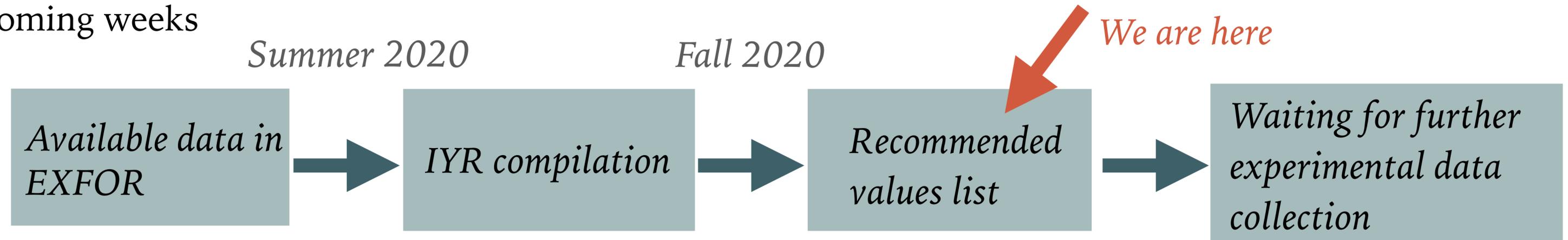
- ▶ Produced a single IYR for every measured fission fragment at a given energy. This can be considered a recommended experimental IYR value.
- ▶ Full list of experimental data and recommended values expected to be published in full report in the coming weeks



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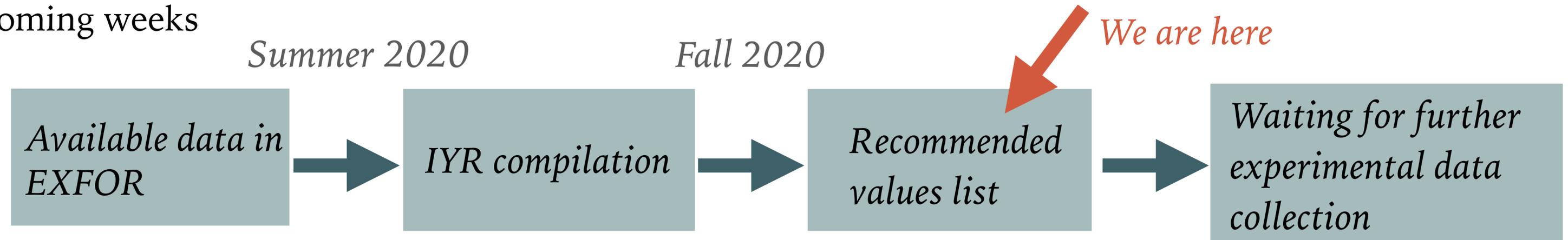
Energy Dependence of U-238: A work in progress

- Plotted FY(En) for 199 cases, across cumulative and independent yields
- Graphs will be compared to ones coming from fission models (e.g. GEF)
- More target nuclides to be graphed similarly over the next several months (Pu-241)

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Questions?

ACKNOWLEDGEMENTS

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I would also like to thank Elizabeth Ricard-McCutchan, Andrea Mattera, Alejandro Sonzogni, Ryan Lorek, David Brown, and Daniel Potemkin

EXTRA

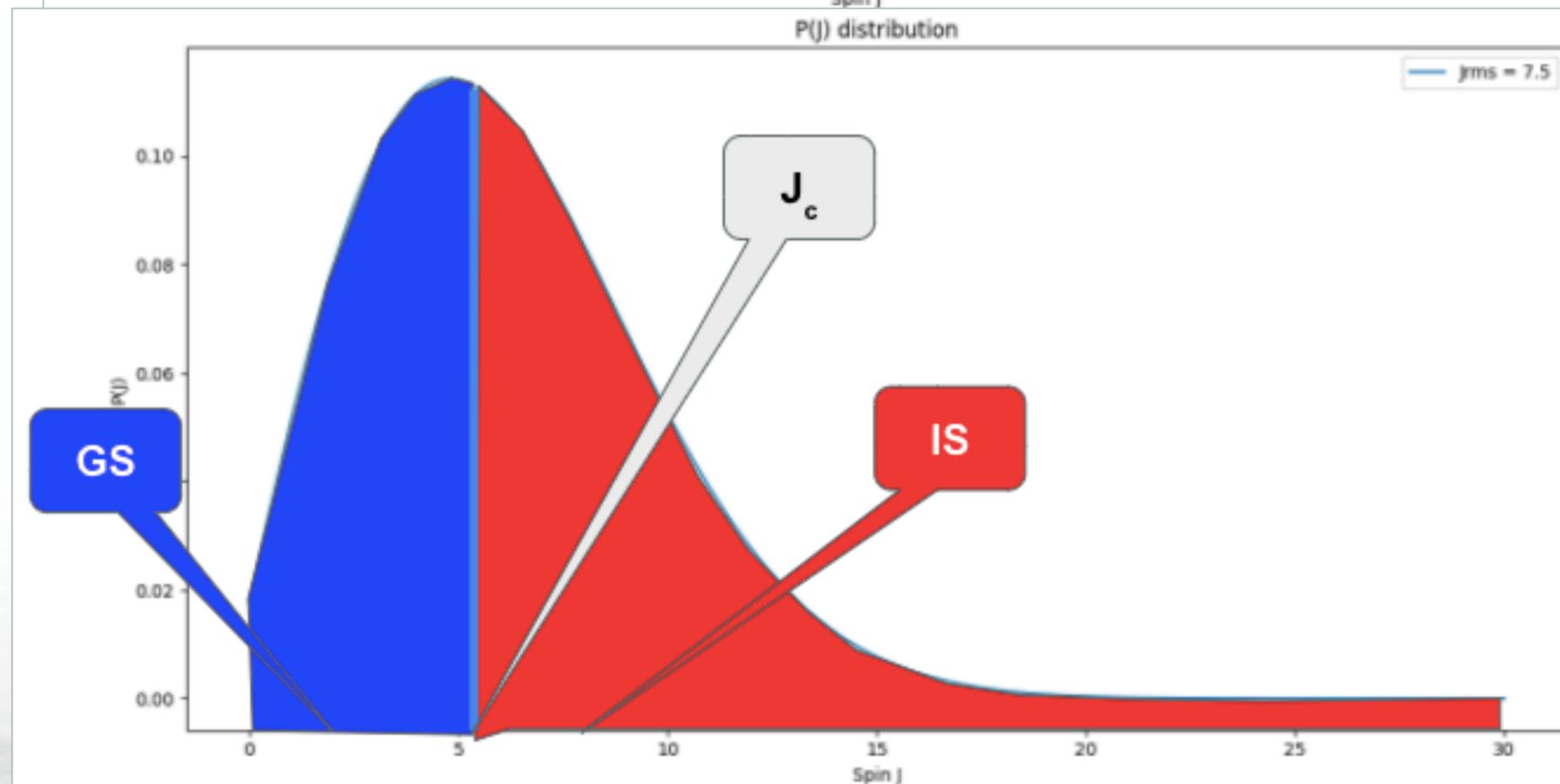
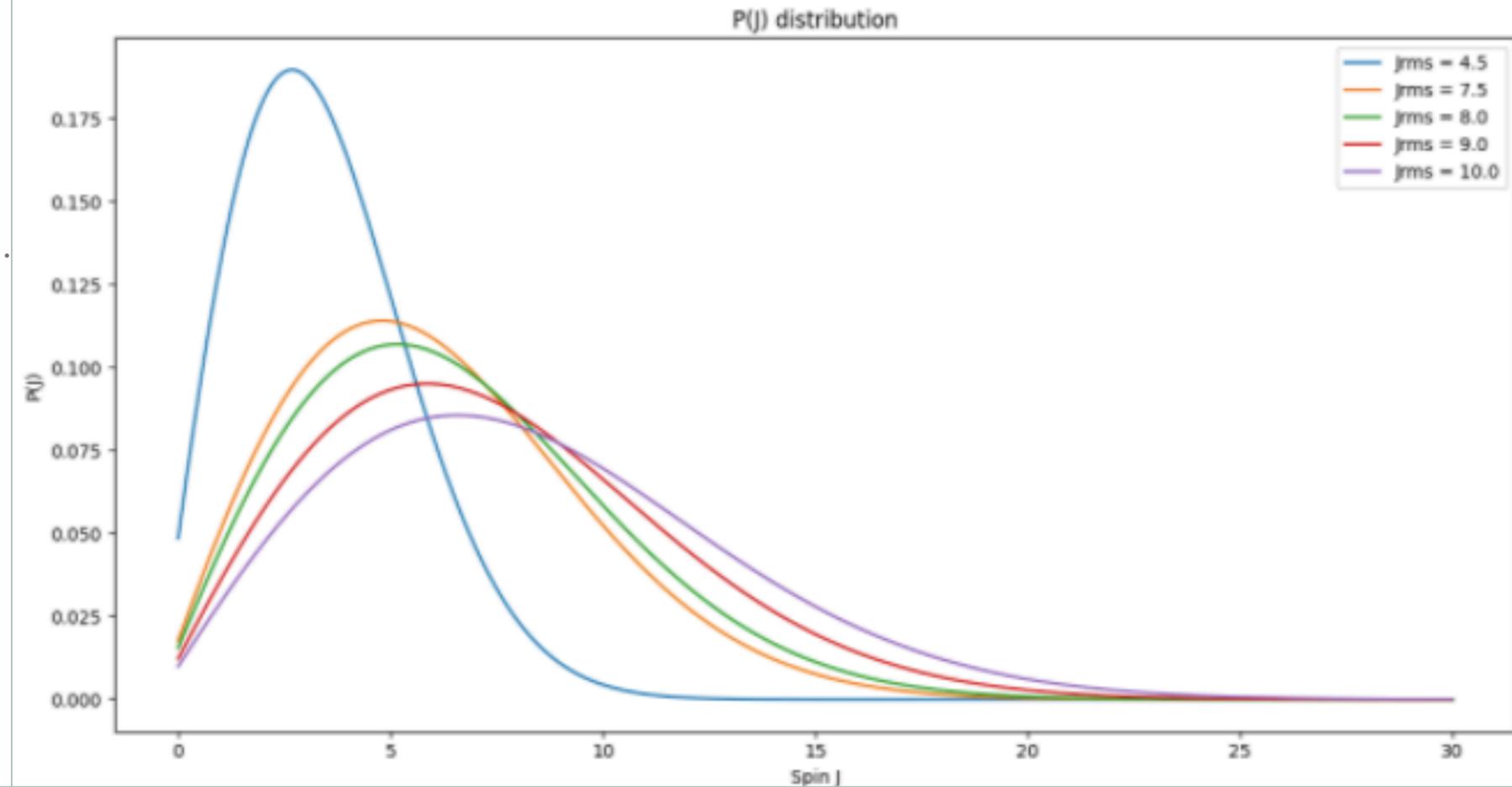
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EXTRA: MADLAND-ENGLAND MODEL

- Model published in 1977, uses incident neutron energy to determine J_{rms} values
- Main assumptions of model: isomeric yield ratio is determined by spin distribution, parameterized as J_{rms} . J_{rms} will be a constant for all fission fragments created with the same incident energy.
- Uses given J_{rms} constant, J_m and J_g of fission fragment to calculate IYR prediction.
- Primary method for determining isomeric yields in evaluated nuclear data libraries (ENDF and JEFF) where no experimental data exists

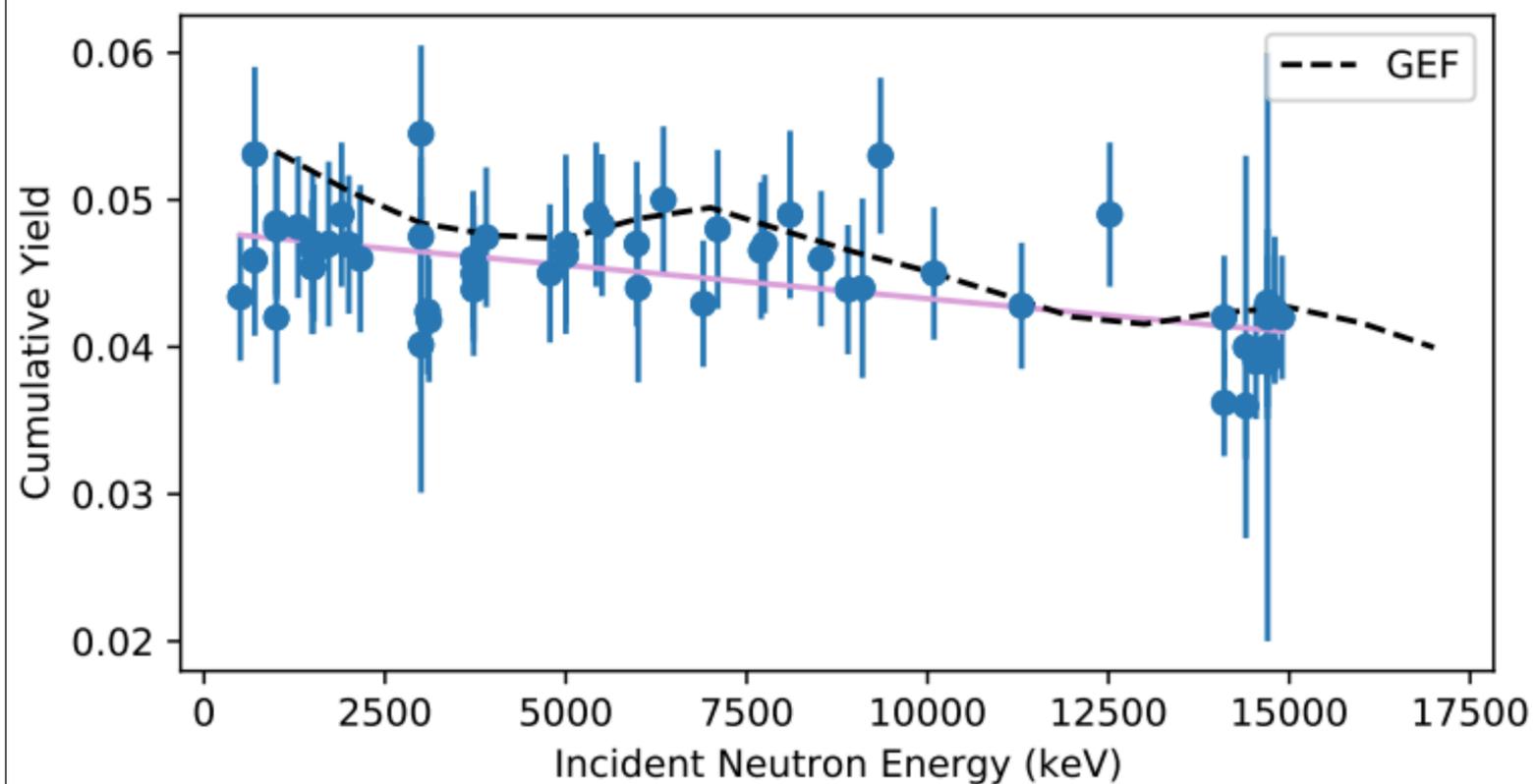


Energy Dependence of Ce-143

Line equation: $y = -4.55e-07x + 4.78e-02$

Chi² value: 23.503

Reduced Chi² value: 0.427



Energy Dependence of Ba-143

Line equation: $y = -6.55e-07x + 7.38e-02$

Chi² value: 0.0

Reduced Chi² value: 0.0

