Toward a New Evaluation of Nuclear Fission Yields: a Curated Compilation of Isomeric Yield Ratio Data From 1955 to Present

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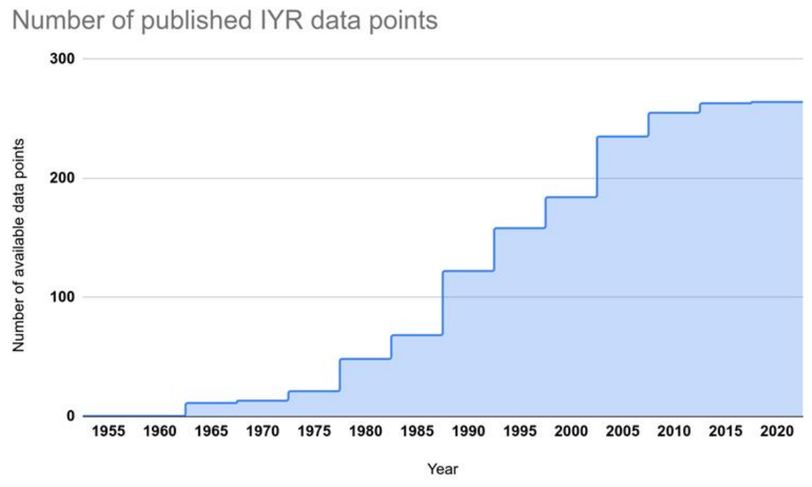
Introduction

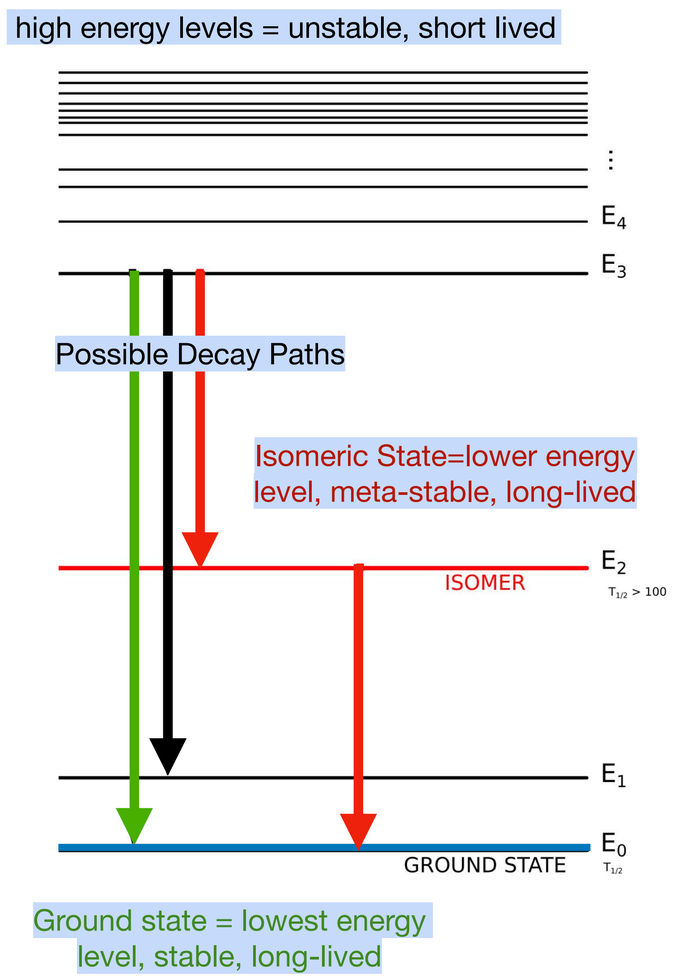
The **isomeric state** of a nuclear fission fragment is a metastable state in which the fragment is at a higher energy level than the ground state, but is relatively long-lived. The primary model in use for estimating isomeric ratios is the **Madland-England Model,** a two-parameter model developed in the late 1970's, and a significant amount of new experimental isomeric ratios have been measured in the years since. This purpose of this project was to create a data compilation of all measured isomeric yield ratios to make possible a comparison between all currently available experimental data and the Madland-England model, with the **goal of revisiting the original parameters suggested Madland and England and exploring whether they could be updated by newly available data.**



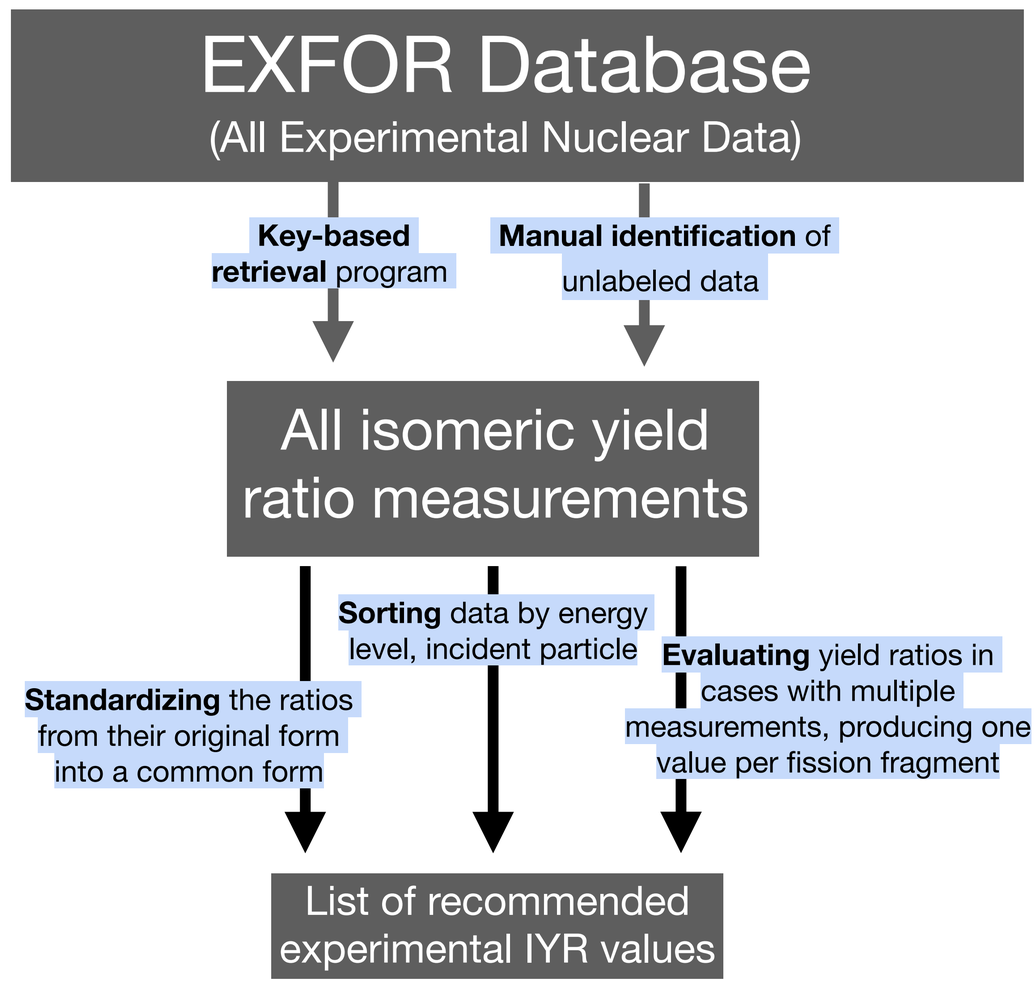
Background

- A **fission yield** is how much of a particular fission fragment (a smaller nuclide) is produced in a fission reaction.
- The majority of nuclides produced in fission are so unstable (too high energy) that they can only exist for a tiny fraction of a second. Physicists have only been able to measure the yields of nuclides that live a sufficiently long time (seconds, minutes, hours, etc.).
- If a nuclide lasts for that long, it is either in its **isomeric** or its **ground** state. The ground state is the most stable form of a nuclide.
- The **isomeric yield ratio** is the measurement of how often a certain nuclide is expected to decay into the isomeric state versus how often that nuclide decays into the ground state.
- The last evaluation of fission yield data was done in the 1990's, so it's time to do another one!

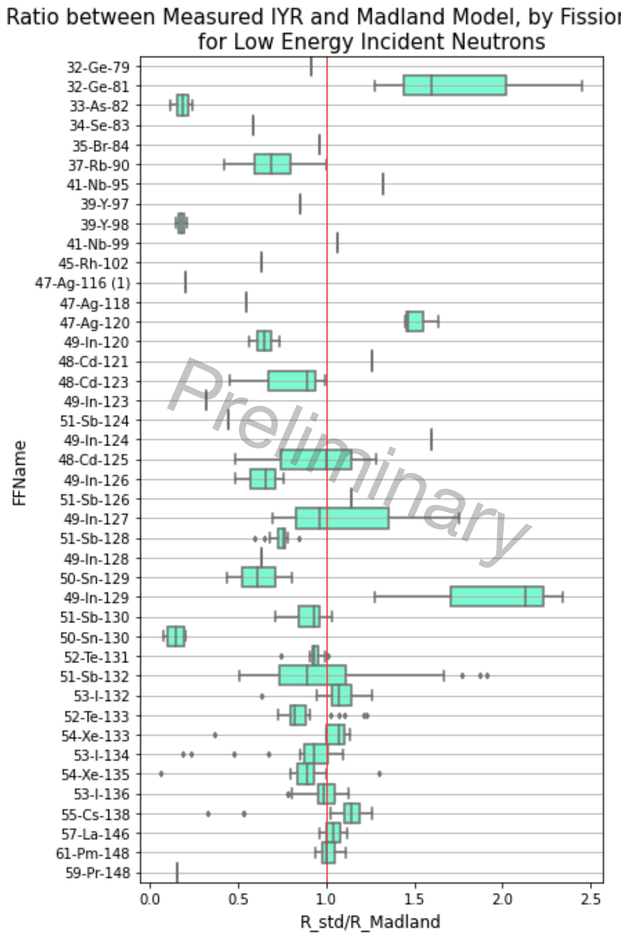
Generalized Energy Level Diagram

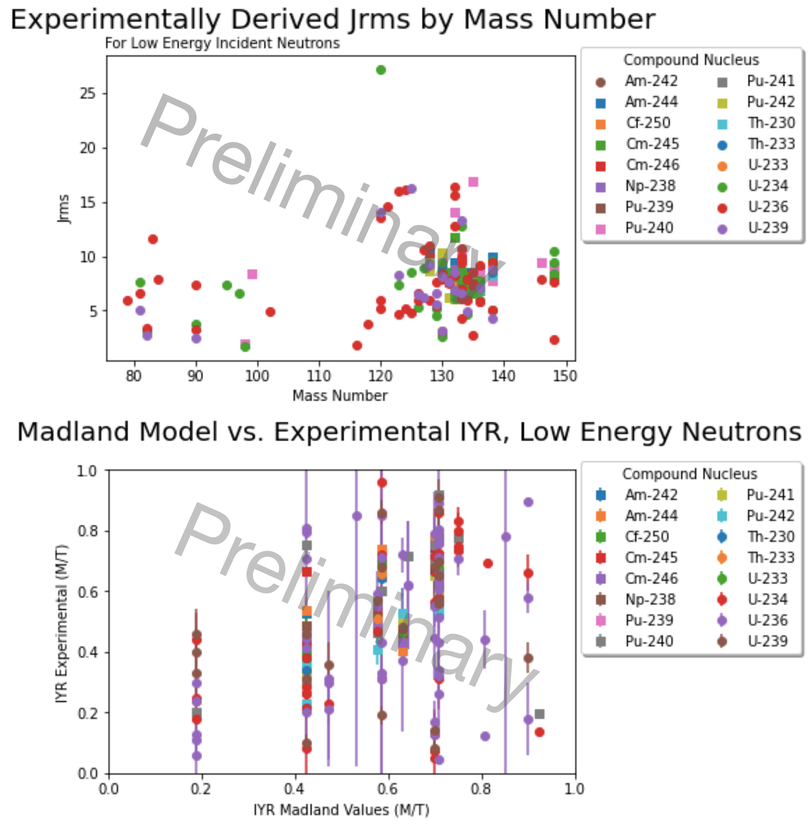


Methods



Results





- A list of all available isomeric yield ratios has been **compiled and evaluated**— will soon be ready for publication
- In the comparison of our list to the Madland model approximations, **the model was shown to be frequently inaccurate**.
- We could not **conclusively find a correlation between the model's parameters and nuclear structure,** making it hard to determine effective ways to update these parameters. This is partially due to gaps in experimental data

Conclusion/Discussion

- We have determined a recommended experimental value for every measured IYR, so **physicists and engineers will not need to search through 60+ years worth of data** and make their own evaluations.
- Knowing the probability of producing a certain nuclide at a given energy level helps engineers **predict reactor dynamics**, so **we recommend this compilation be used to identify gaps in experimental knowledge and inform further experimentation.**

Where does the Madland-England model stand in 2020?

- The model has shortcomings due to it being incredibly simplified, but due to the lack of correlation between the model's parameters and nuclear structure, **no changes can be suggested at this time**.
- **We recommend our data compilation be used for the development and testing of new models** which more accurately reflect current and future data.

References

1. Madland, D. G., & England, T. R. (1977). The influence of isomeric states on independent fission product yields. Nuclear Science and Engineering, (644), 859-865.

2. Lammer, M. (2000). Compilation and evaluation of fission yield nuclear data, Final report of a co-ordinated research project 1991-1996. IAEA-TECDOC-1168. URL http://www-pub. iaea. org/MTCD/Publications/PDF/te 1168 prn. pdf.

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