# Stress testing the Oslo Method for heavy nuclei

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## Current Work

**Motivation**: The Oslo Method has been widely used to find the nuclear level density (NLD) and γ-ray strength function (γSF) below the neutron separation threshold $S_n$.

basic research: Models of the atomic nucleus

applications: Cross-section calculations (nuclear & astrophysics)

**What happens if some of its assumptions are violated?**
Specific problem: There is a mismatch between the intrinsic spin-parity distribution of the levels in the nucleus, and the spins-parities populated by the (d,p) reaction. This is expected to be most significant for heavy nuclei.

**Approach**: Produce synthetic data of the nuclear decay of following the $^{239}$Pu(d,p)$^{240}$Pu reaction, where input NLD, γSF and spin-parity distributions are known. Then we can infer systematic deviations by applying the Oslo Method to this data.

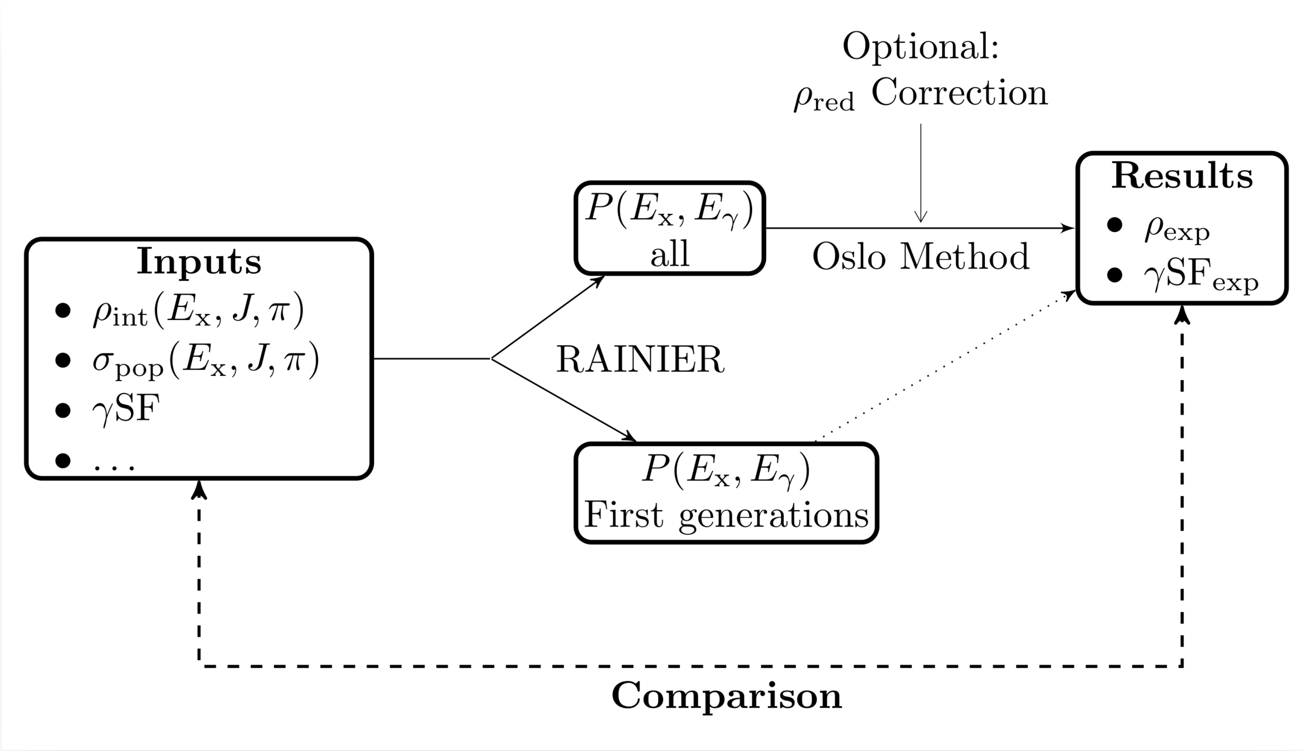



Fig: Producing synthetic data to infer systematic errors in the Oslo Method

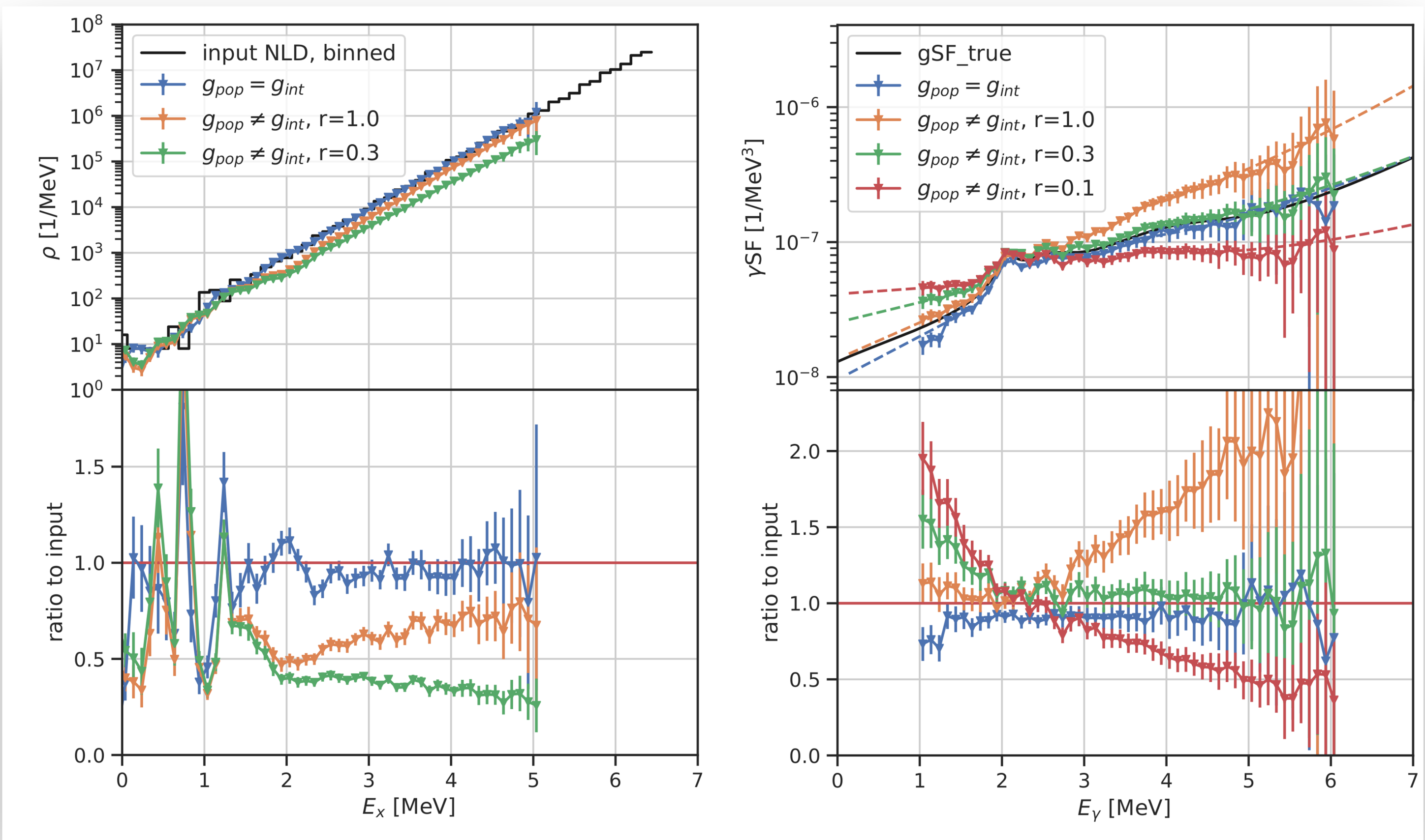



Fig: NLD and γSF extracted with the Oslo Method, (with an optional correction r) from the synthetic dataset. The populated spin distribution $g_{pop}$ was either chosen equal to the intrinsic distribution $g_{int}$ or according to the calculations for $^{239}$Pu(d,p)$^{240}$Pu

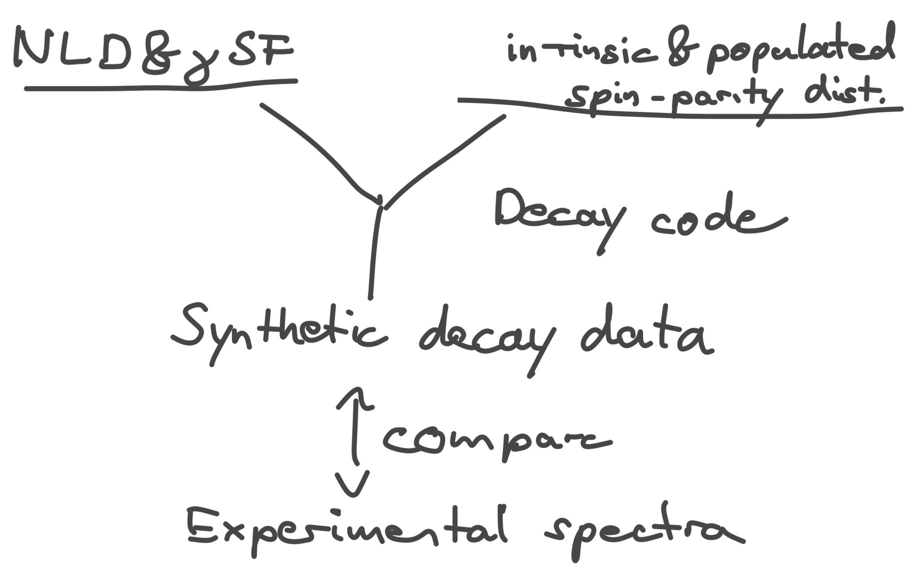
### Results

- **No systematic deviations when assumptions are fulfilled**, i.e. populating levels proportionally with intrinsic spin-parity
- **For the calculated population** from the $^{239}$Pu(d,p)$^{240}$Pu reaction, we **infer significant distortions** in the extracted nuclear level density and γ-ray strength
- In progress: Using the presented approach to correct for the deviations
- Submitted to *Proceedings of the Compound Nuclear Reactions conference 2018, Berkeley*

## Inverse Problems

need to parametrize?

**Another, more systematic approach:**
Can we find the *true* NLD and γSF (parameters) using a nuclear decay code and Markov Chain Monte Carlo methods? The goodness of fit would evaluated comparing the calculated decay data to the experimental data



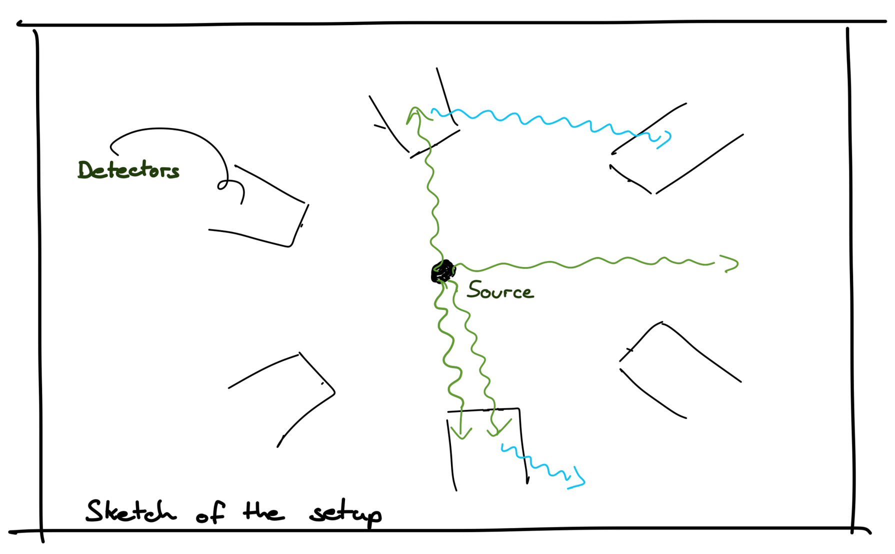

∘ How about degeneracies (≠ multiple modes): y = a·b ? degenerate

**Another project: Multidimensional unfolding via Machine Learning?**

**Challenge**: Find the true multiplicity distribution (and energy spectrum) from the measured multiplicities and energies

**Approaches**:
i) Matrix inversion
ii) *Bayesian* multidimensional unfolding: Want about 100 energy bins, and multiplicities up to at least 4, but the response matrix for 25 bins is already 500 GB large.
iii) **Can we use Machine Learning & image recognition?**

Help wanted!



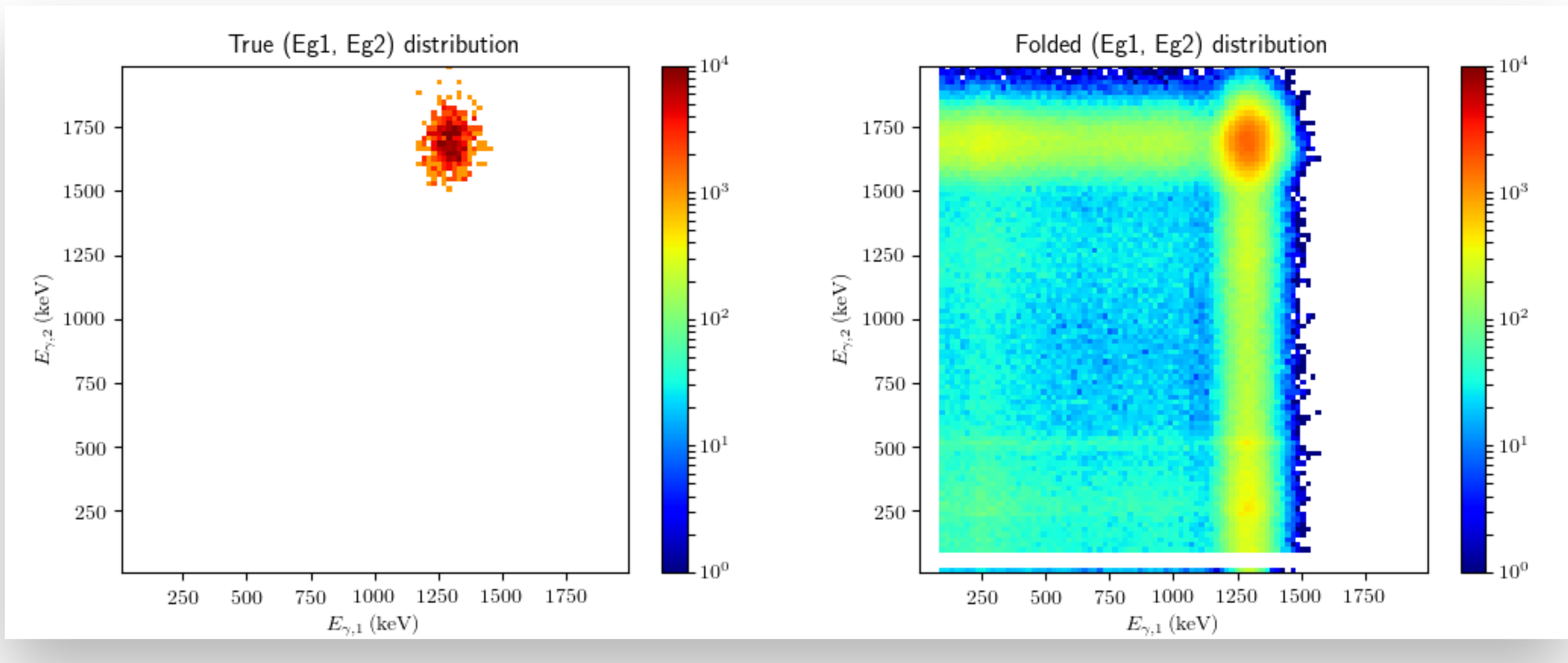




Fig: Example of the detector response for multiplicity M = 2