

# Matching experimental results and GEF predictions

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## Thoughts about using GEF as an evaluation tool

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# The Problem

- Experimental data cannot directly be used.
- Model is needed for application of nuclear data, because
  - experimental data need to be verified by evaluation,
  - experimental data are incomplete (common problem),
  - experimental data are not specific enough (problem of SOFIA and VAMOS experiment, e.g.  $E^*$ ,  $I$  distribution).

# **Application of GEF**

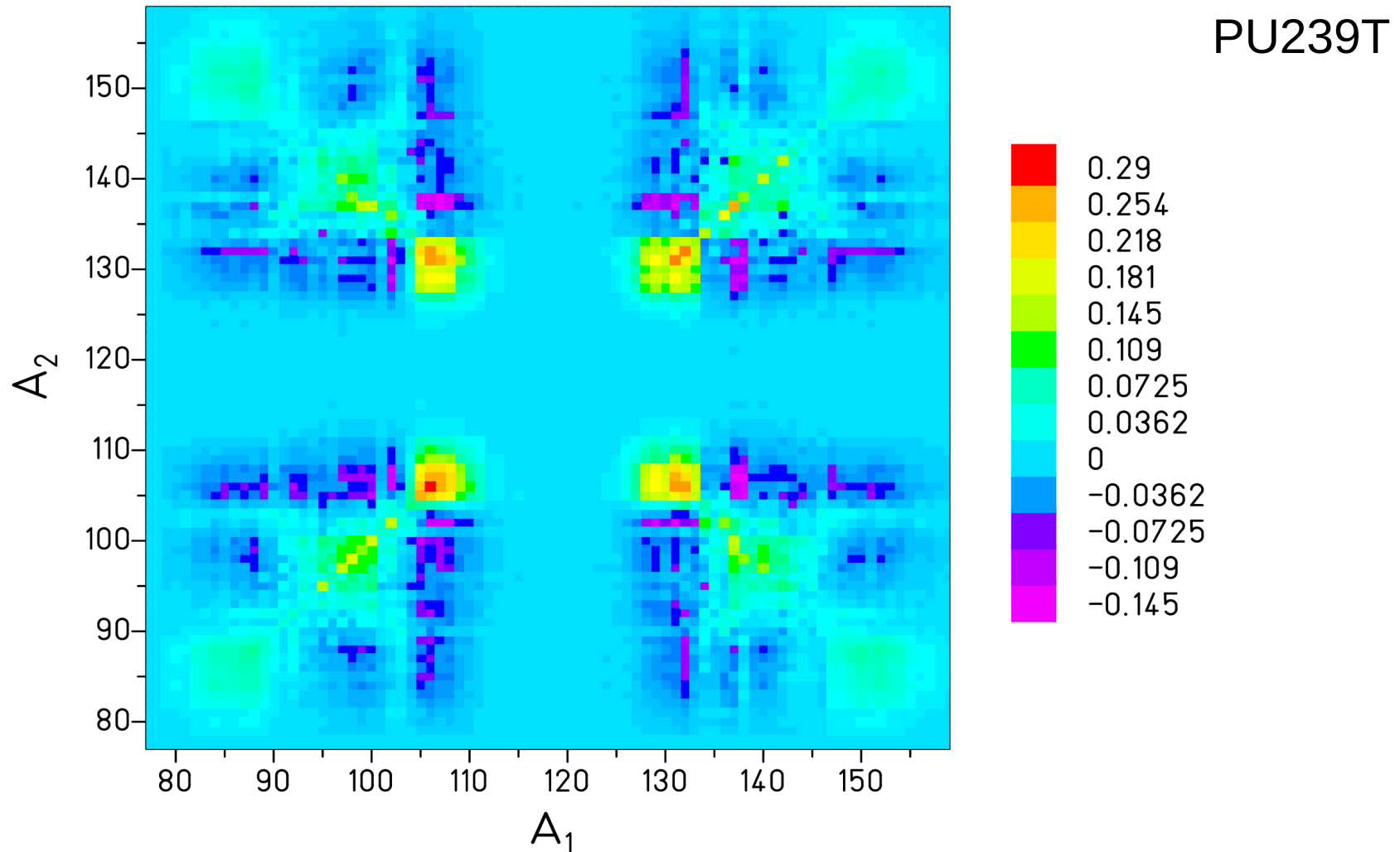
# GEF replaces Wahl's systematic of fission yields

- Less parameters ( $< 1/100$ )  $\leftrightarrow$  more physics (rigid theoretical frame)
- Requirements:
  - High demand on precision of GEF (comparable to Wahl's systematic)
    - Realistic modeling of the fission process required.
    - Careful adjustment of GEF to "good" data, elimination of "bad" data.
- Benefit (compared to Wahl):
  - Covers larger variety of fission observables.
  - Consistent model for all cases with unique parameter set.
  - Parameters have physical meaning.
  - Provides "optimum" parameters  $P_i$  with uncertainties and eventually correlations (complex and time consuming), uncertainties and correlations of fission observables (direct).

# Link between different fission quantities

- GEF provides correlations between almost all fission observables.
- Decay algorithm of GEF provides the link between independent and cumulative yields.
- Additionally, the link between fission observables and integral data can be established.

# GEF: Covariance matrix (fragment masses)



Determined by the inner logic of the model.  
Basically different from experimental covariances!

# Combination of experimental data and GEF predictions

- Method for finding "best values" of fission quantities:
  - Construction of multivariate distributions ( $W$ ) from experiment and GEF for considered observables
    - Independent yields, including isomers ( $iy$ )
    - Cumulative yields ( $cy$ ), and others (including covariances between different kind of observables!)
  - Building the log-likelihood functions  $L = \log(W)$ 
    - $L_{\text{exp}} = (L_{iy}, cy, \dots)_{\text{exp}}$
    - $L_{\text{GEF}} = (L_{iy}, cy, \dots)_{\text{GEF}}$
  - Determining the optimum values of the observables  $X_i(\text{opt})$  that maximize the common log-likelihood function:
    - $\text{Max}(L_{\text{exp}} + L_{\text{GEF}})$  provides  $X_i(\text{opt})$
    - "Best matching" of experimental and theoretical information.

- Method for finding "combined" uncertainties and covariances of fission quantities
  - Uncertainties and covariances of experimental data and GEF results are of different nature.
  - Experimental covariances are specific to one system and have technical character.
  - GEF covariances are valid for all systems and represent the physics of the GEF model and “trivial” consistency conditions.
  - Direct combination of covariances from experiment and GEF is doubtful!

– Alternative idea:

- Deduce "adapted" uncertainties of GEF parameters from uncertainties and covariances of experimental data, valid for a specific system.
  - Problem: difficult and time consuming.
  - Benefit: Consistent model covariances of fission observables with experimental justification.
- Use only correlation coefficients from GEF.
  - Advantage: They are almost independent from the absolute uncertainties.
- Calculate "optimum" values of fission observables and uncertainties.
- Use "adapted" covariances of fission observables from GEF only.

- It is mandatory to consider the correlations of the experimental values.
  - Assumption of independence leads to unrealistically small uncertainties!
- It is important to include all information in one step in order not to lose the manifold correlations.
  - Maximizing the full likelihood function  $L = \sum L_i$

# Conclusion and outlook

- GEF is the first physical model that calculates fission observables with a precision comparable with locally adjusted empirical models.
- Uncertainties and covariances from GEF have a specific character:
  - they unite the information of all available experiments, they comprise the rigid theoretical frame of GEF, and they provide “trivial” conditions of consistency.
- This offers new opportunities for improving evaluation, but it requires also new methods.
- Estimation of “best matching” values straightforward.
- Estimation of covariances from adapted GEF only?

- GEF makes results from experiments with limited resolution or large gaps (e.g. in  $E^*$ ) usable for specific applications.  
(Benchmarking with all available data assures that GEF results for specific conditions, e.g. for well defined  $E^*$ , are reliable.)
- **Nuclear-data tables → GEF calculations (?)**
- Common effort of GEF developers, evaluators and users is needed.

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