Iron Covariances

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CIELO-Iron collaboration

BNL, CNDC, IAEA, IRM, JSI, LANL, ORNL, RPI, IRSN

- Exp. data analysis: CNDC
- Resonance range: ORNL & IRSN & BNL & IAEA
- Fast neutron range: EMPIRE (BNL, IAEA)
- File assembly: IAEA, BNL
- Testing: IAEA, RPI, BNL, LANL, JSI

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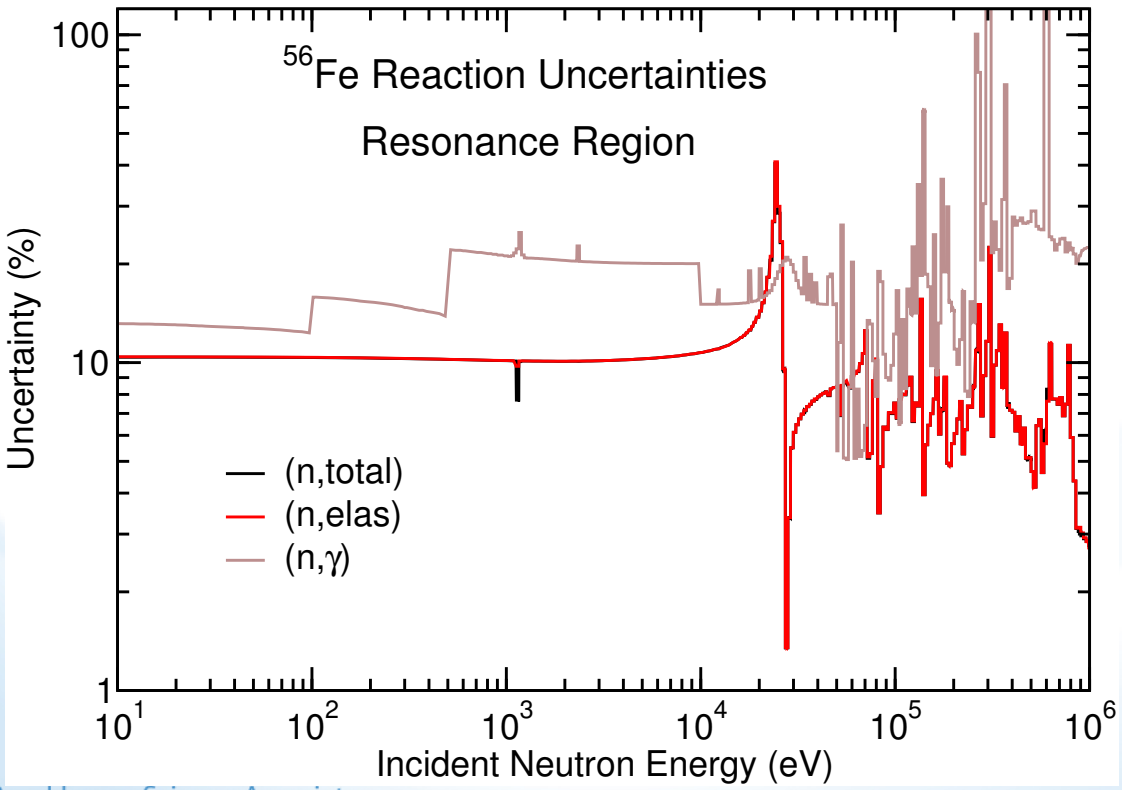
2. IAEA, Vienna, Austria
3. ORNL, Oak Ridge, TN, USA
4. EC-JRC-IRMM, Geel, Belgium
5. RPI, Troy, NY, USA
6. CNDC, Beijing, P.R.China
7. CIAE, Beijing, P.R.China
8. IRSN, Paris, France
9. ITA, Sao José dos Campos, Brazil
10. Bucharest University, Bucharest-Magurele, Romania

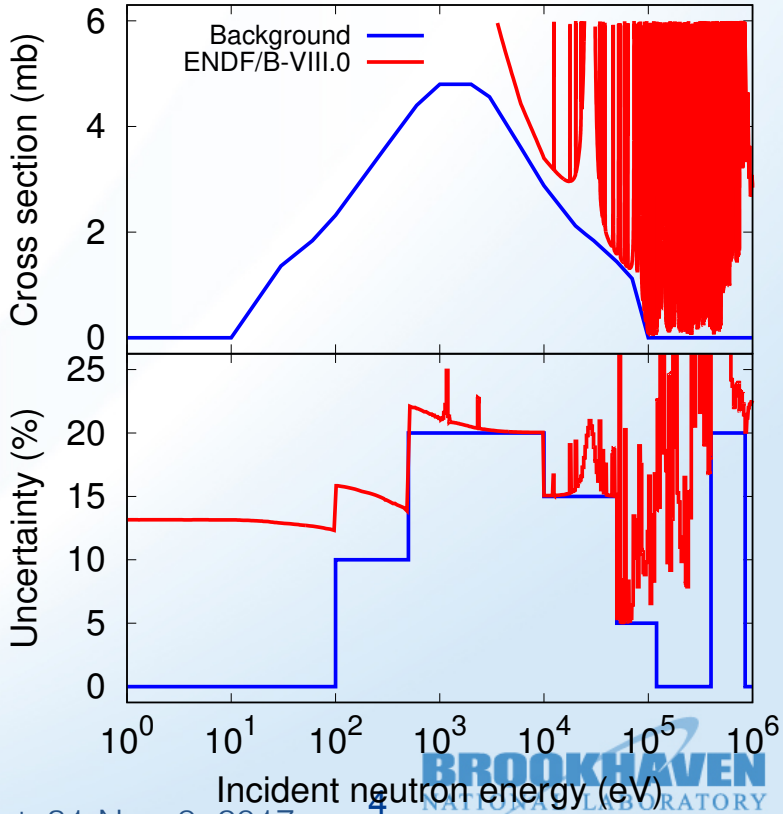
Covariances in ^{56}Fe Resonance Region

- Resonances from Fröhner's evaluation were adopted: covariances on res. parameters have been lost
- Capture background in the 24 keV resonance window
- Instead of re-fitting resonances: more pragmatic approach
- Covariances for RRR were generated using EMPIRE's resonance module: Matching resonance parameters in evaluation with respective uncertainties in Atlas of Neutron Resonances
- Uncertainties of negative res. parameters were set at the values that reproduce unc. of the thermal constants
- Strong correlation was assumed among the $\Gamma\gamma$ widths
- MF=32 → NJOY → MF=33

Background in (n,g) covariances

- Uncertainties for total and elastic were reasonable
- Capture uncertainties systematically low
  - in the capture window, where the capture background was added
  - near the top of the resonance region: suspicion of missing resonances
- "Background covariance" added to the MF=33 covariance





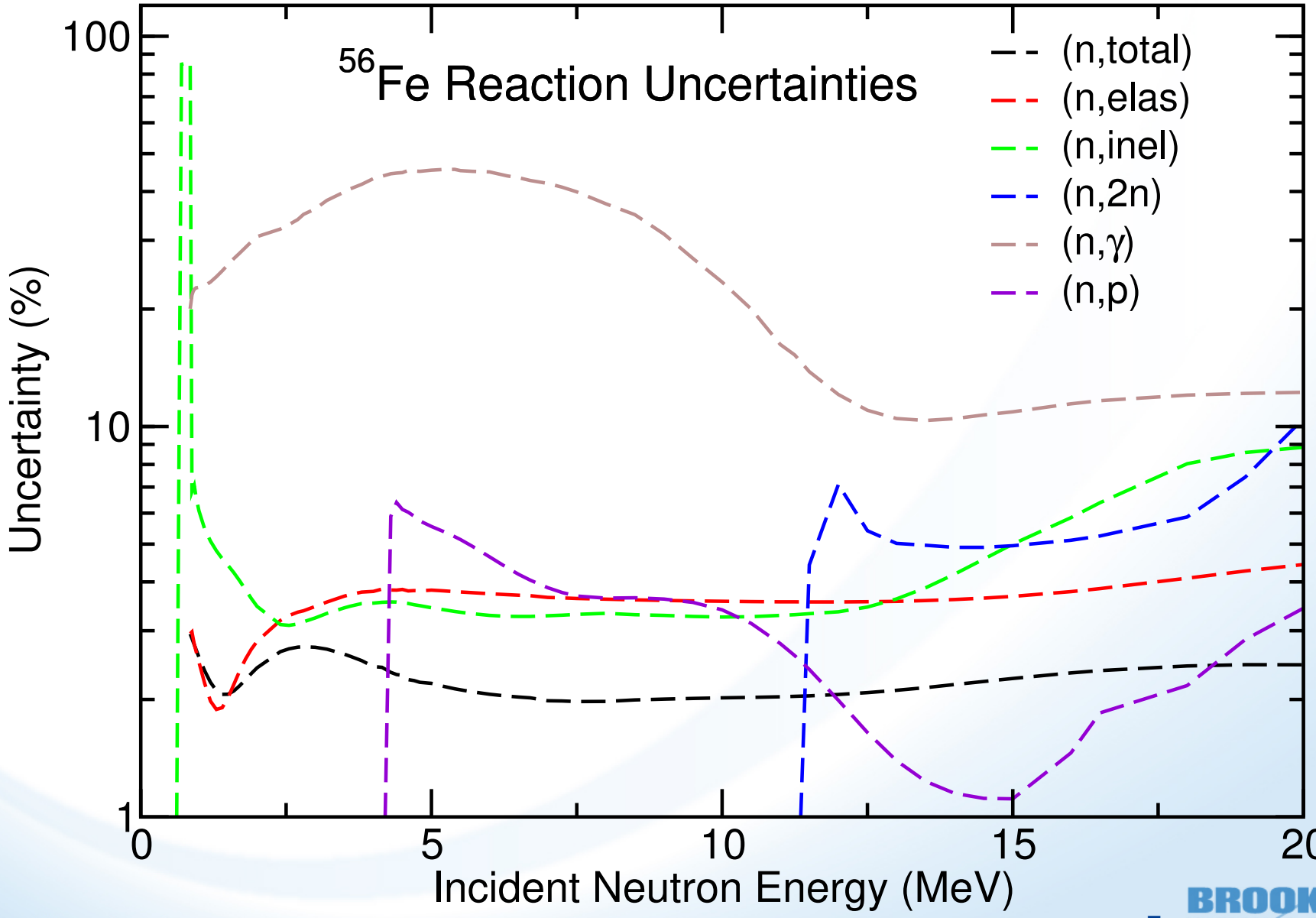
Uncertainties in fast neutron range

- Uncertainties relative to **averaged** cross sections: do not aim to cover fluctuations
- Covariances were obtained from Kalman: experimental uncertainties and model constraints
- Most reliable experimental data sets selected
- 1.8% systematic uncertainty square-added to the reported statistical uncertainties for Abfalterer's total data
- Experiment weights normalized so that $\chi 2 \approx 1$ for each experiment:
  - Account for unknown systematic uncertainties
  - Eliminate impact of asymmetry related to very different number of points
- Experimental correlation set to 45%

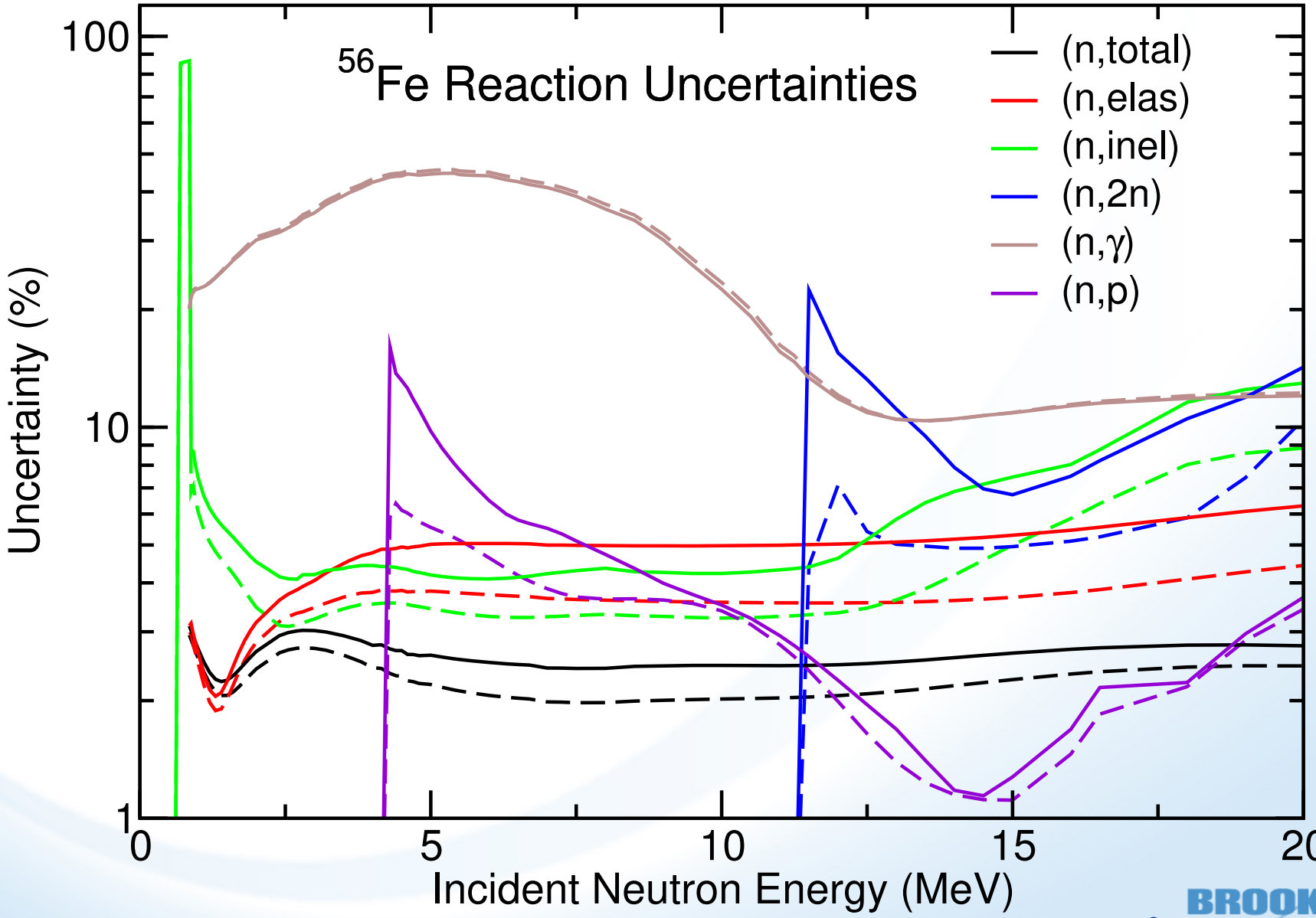
Uncertainties in fast neutron range

- Open initial model parameter uncertainties (100%)
  - Restrict initial model parameter uncertainties if not restricted by exp. data in the first Kalman run
- For (n,p):
  - Use IRDFF uncertainties as experimental (we could use full IRDFF covariance)
  - Increase IRDFF data weight to force reduction of final uncertainties to agree with IRDFF
- Covariances estimated for MT=1, 2, 4, 5, 16, 102, 103 (no 107!, no angular distr.)
- Cross-correlations calculated but not formatted (full covariance matrix, including all residue production cross sections, is 86 Mb!)
- Improvement since $\beta 5$: Increased number of varied model parameters (more degrees of freedom at high energies)

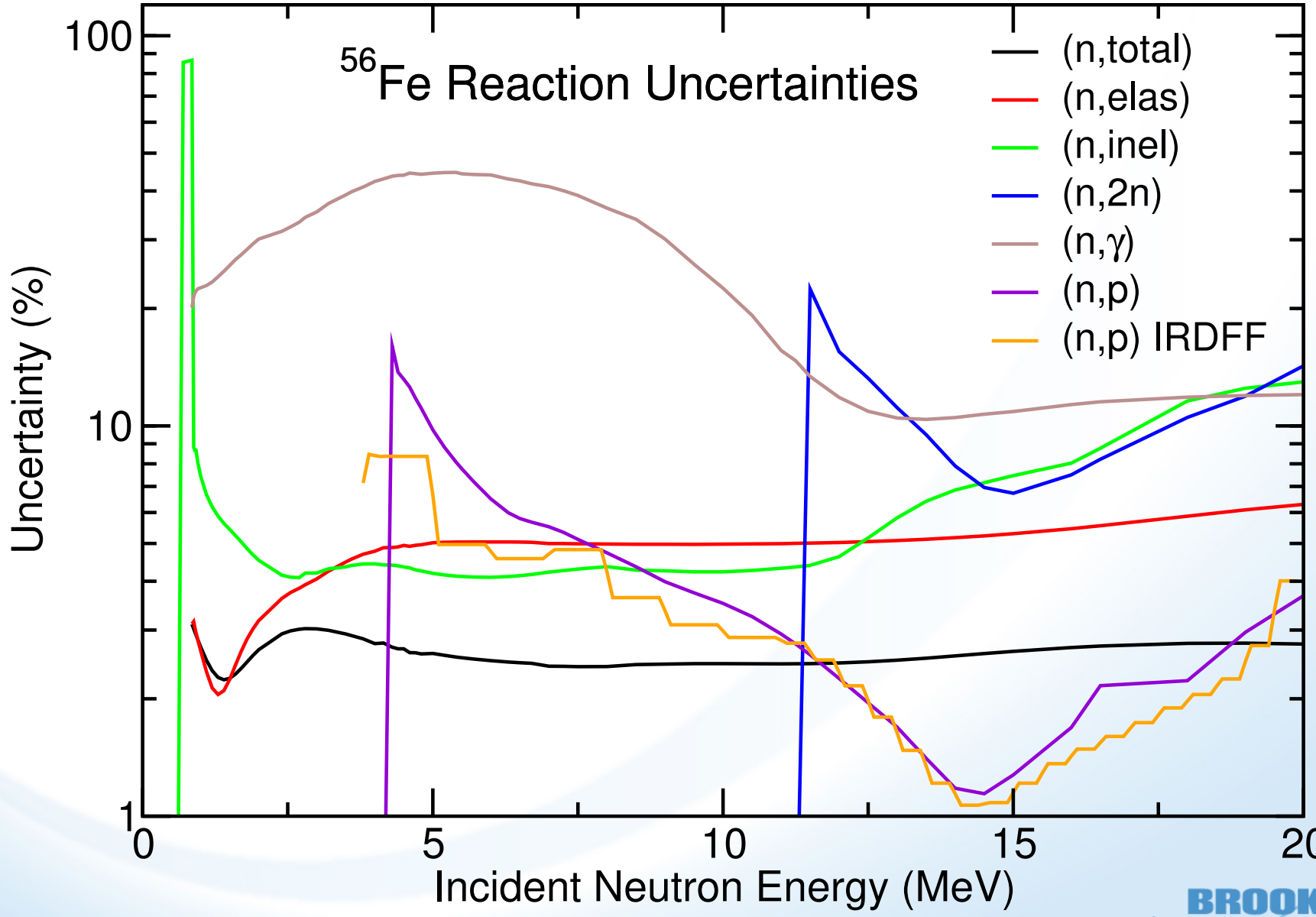
Comparison with $\beta 5$



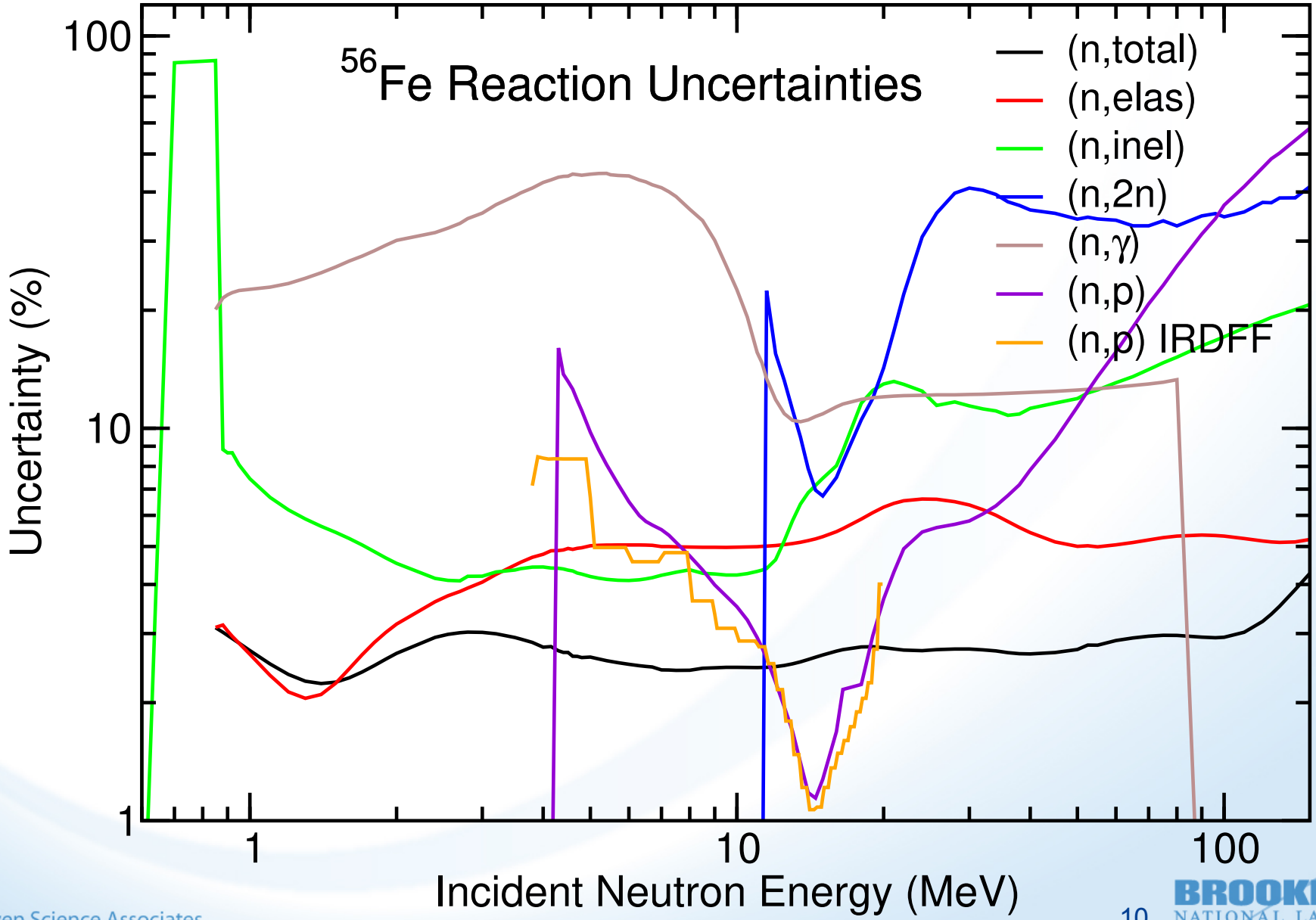
Comparison with $\beta 5$



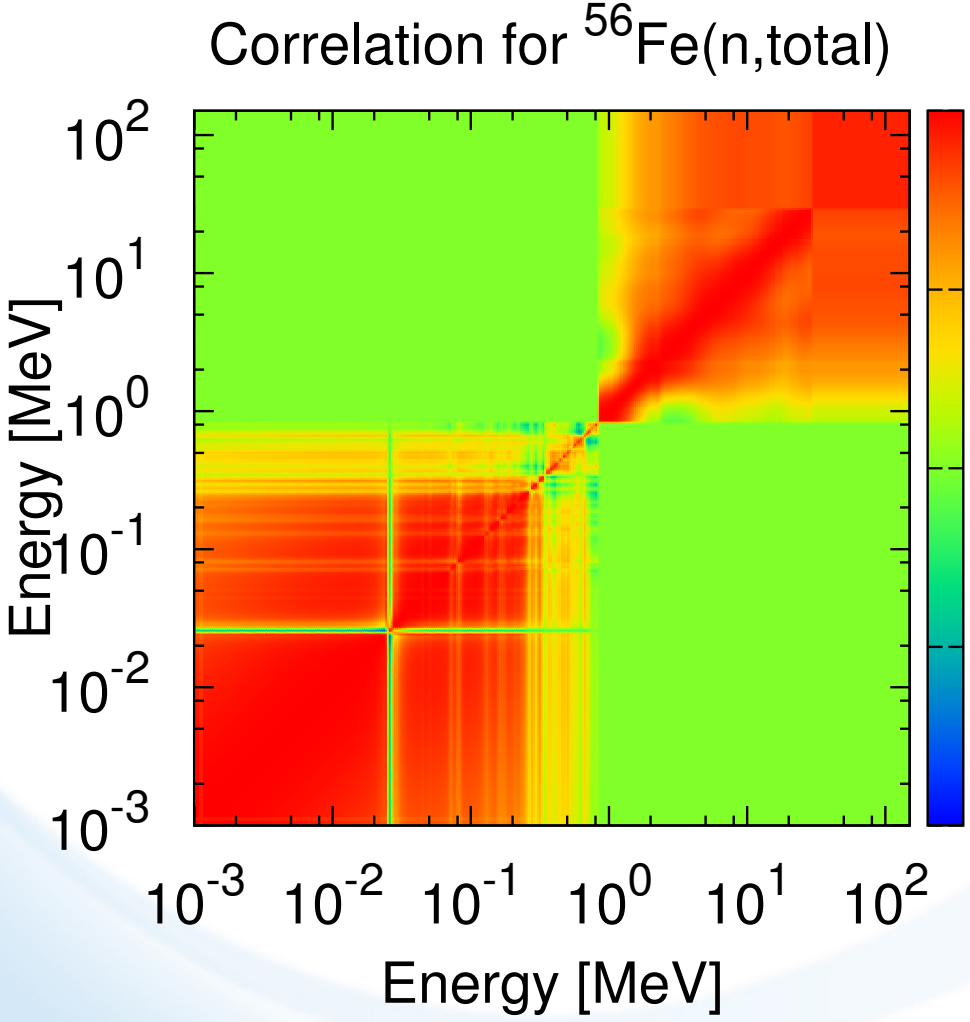
Comparison with IRDFF

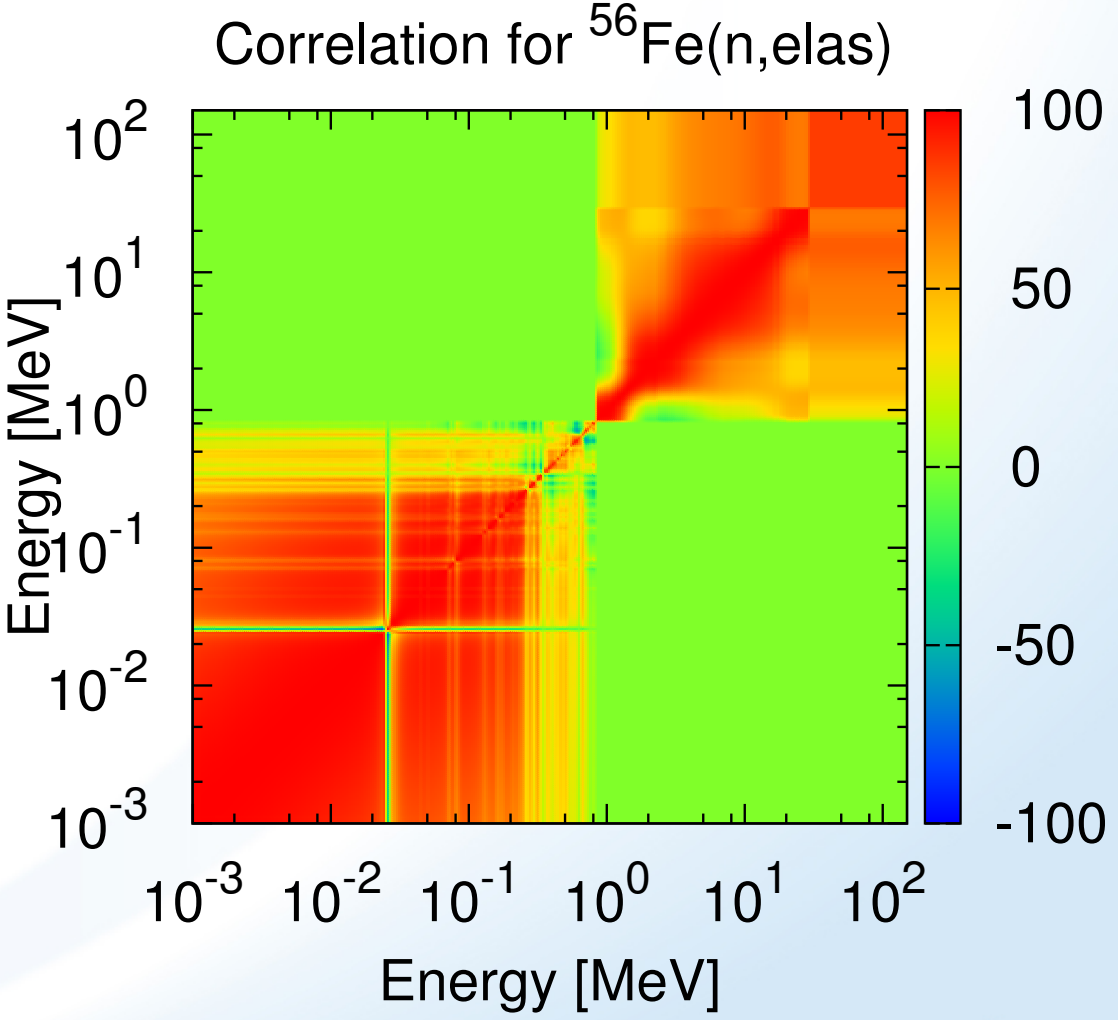


Uncertainties at high energies

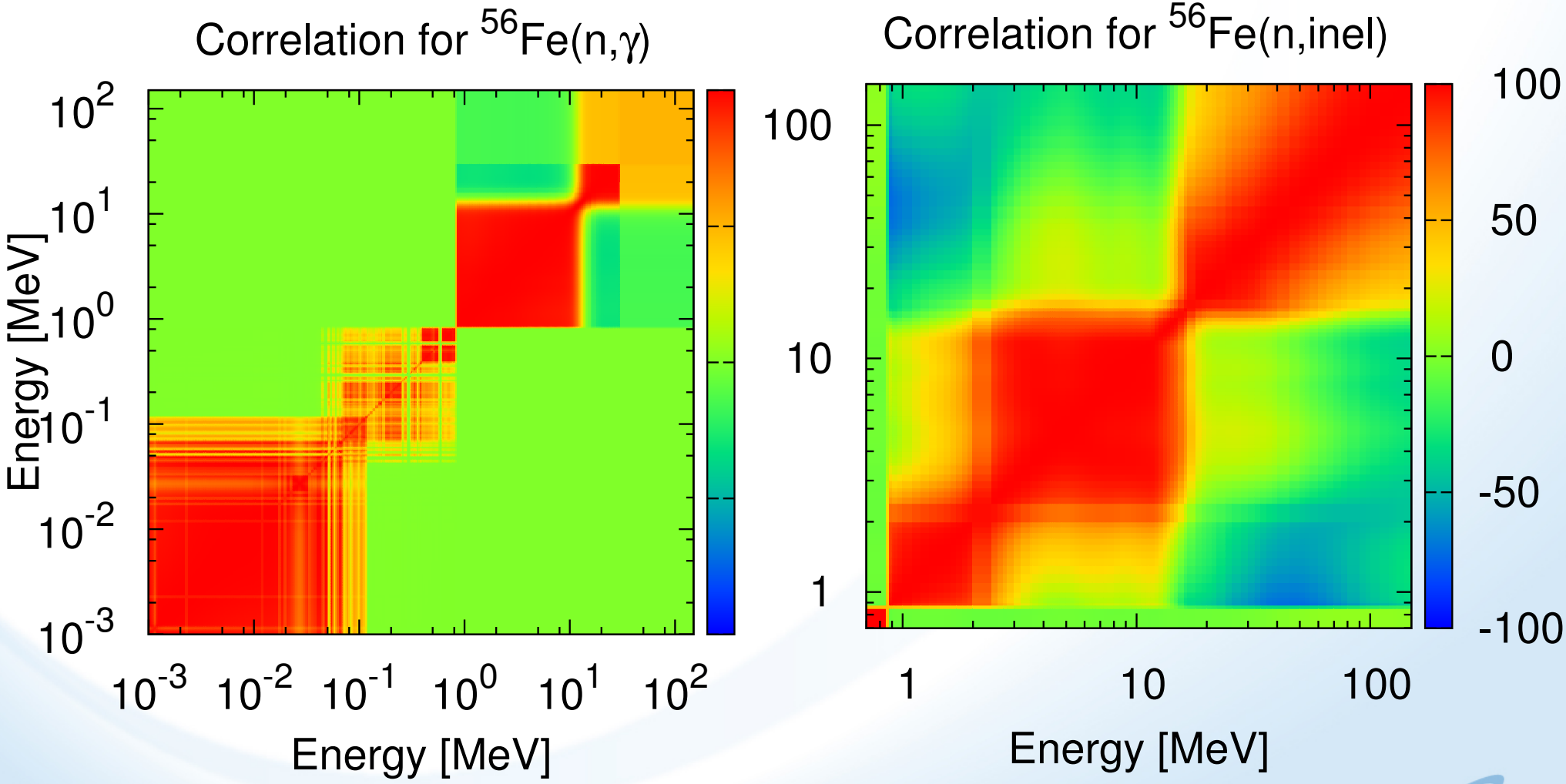


Covariance plots

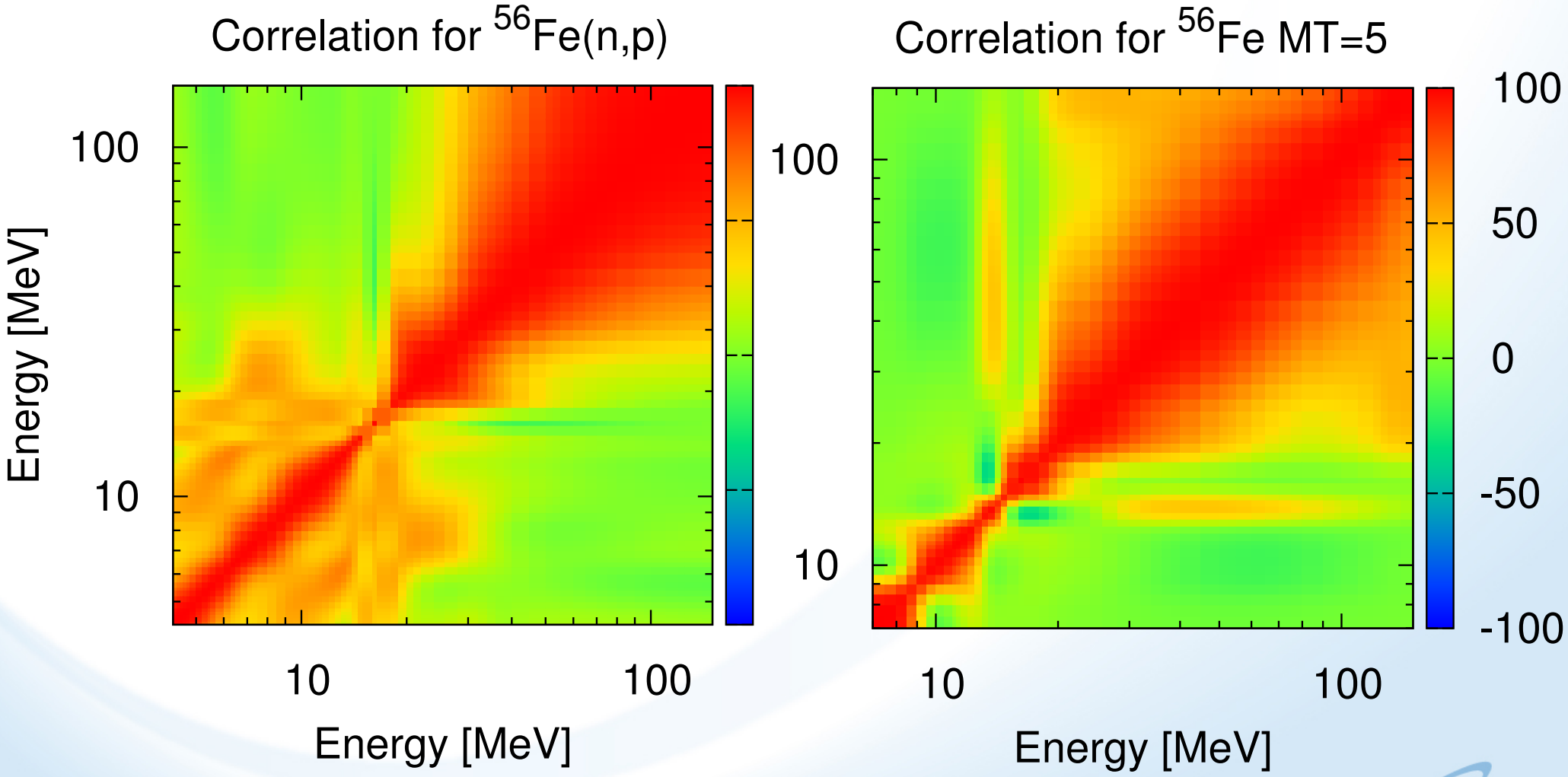




Covariance plots



Covariance plots



Uncertainties “To do” list

- Complete covariances for minor isotopes
- Format and include cross-reaction correlations for the considered reaction channels
- Observations:
  - Resulting uncertainties are very reasonable thanks to the modified experiment weights
  - If model parameters are well constrained by the experimental data the result does not depend on the initial parameter uncertainty
  - The procedure is relatively solid - modification of experiment weights has limited effect on the uncertainties, since covariance of model parameters that determines cross section covariances, is constrained also by other experimental data
  - It is, however, necessary to use global uncertainty estimates to constrain those model parameters that are not sufficiently constrained by exp. data

Conclusions

- CIELO collaboration led to a new set of evaluations for main iron isotopes, with consistent covariances
- RRR needed a “covariance background”, consistent with the capture cross section background
- Reasonable uncertainties for all reactions in both resonance and fast regions
- Uncertainties are stable regarding changes in model parameters
- Reproducible method
- Changed covariances since $\beta 5$: they were good before but are better and more reasonable now
- Minors: Same method for fast; not so simple for resonances