Status of Cr Evaluations

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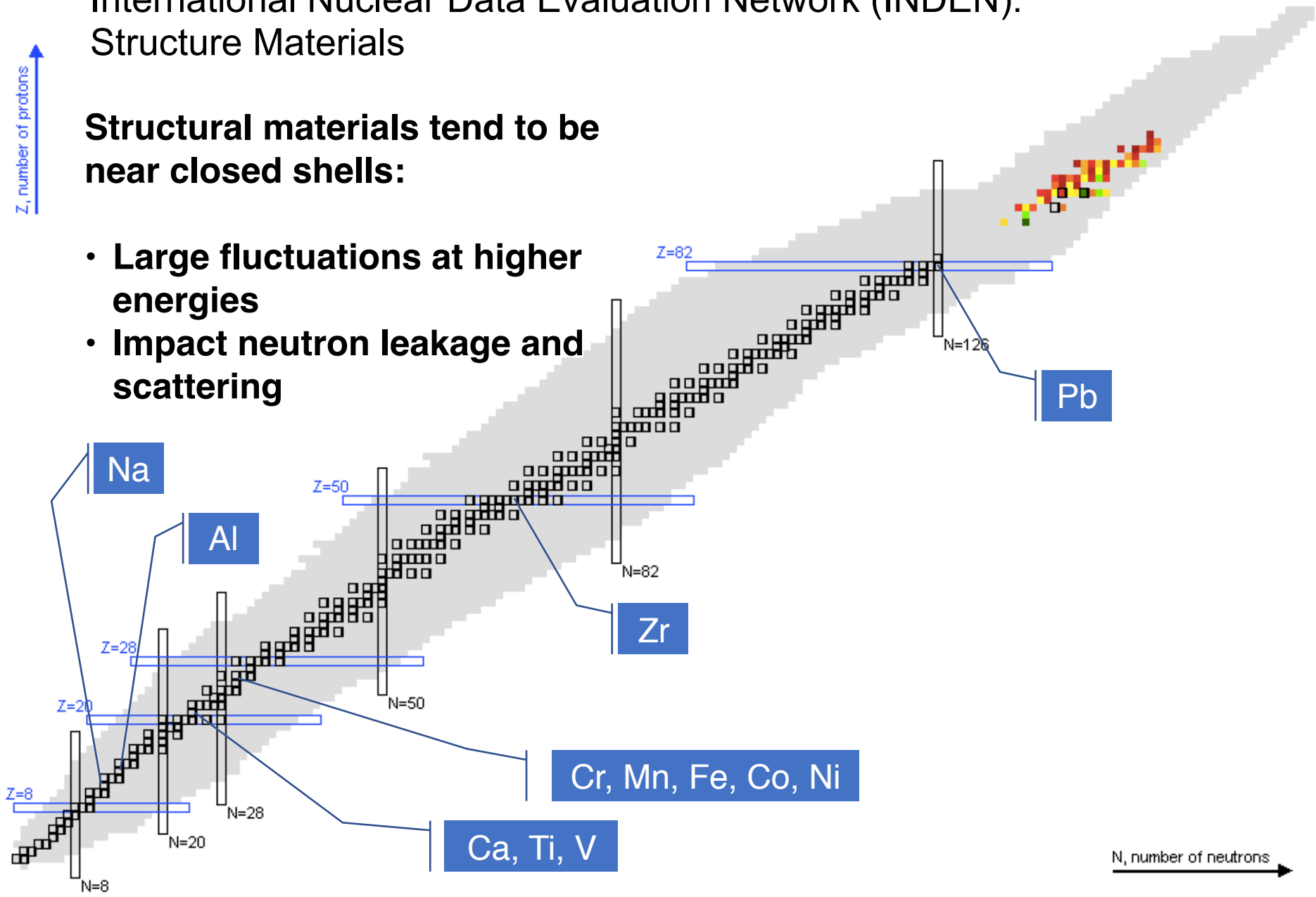
International Nuclear Data Evaluation Network (INDEN): Structure Materials

Structural materials tend to be near closed shells:

- **Large fluctuations at higher energies**
- **Impact neutron leakage and scattering**



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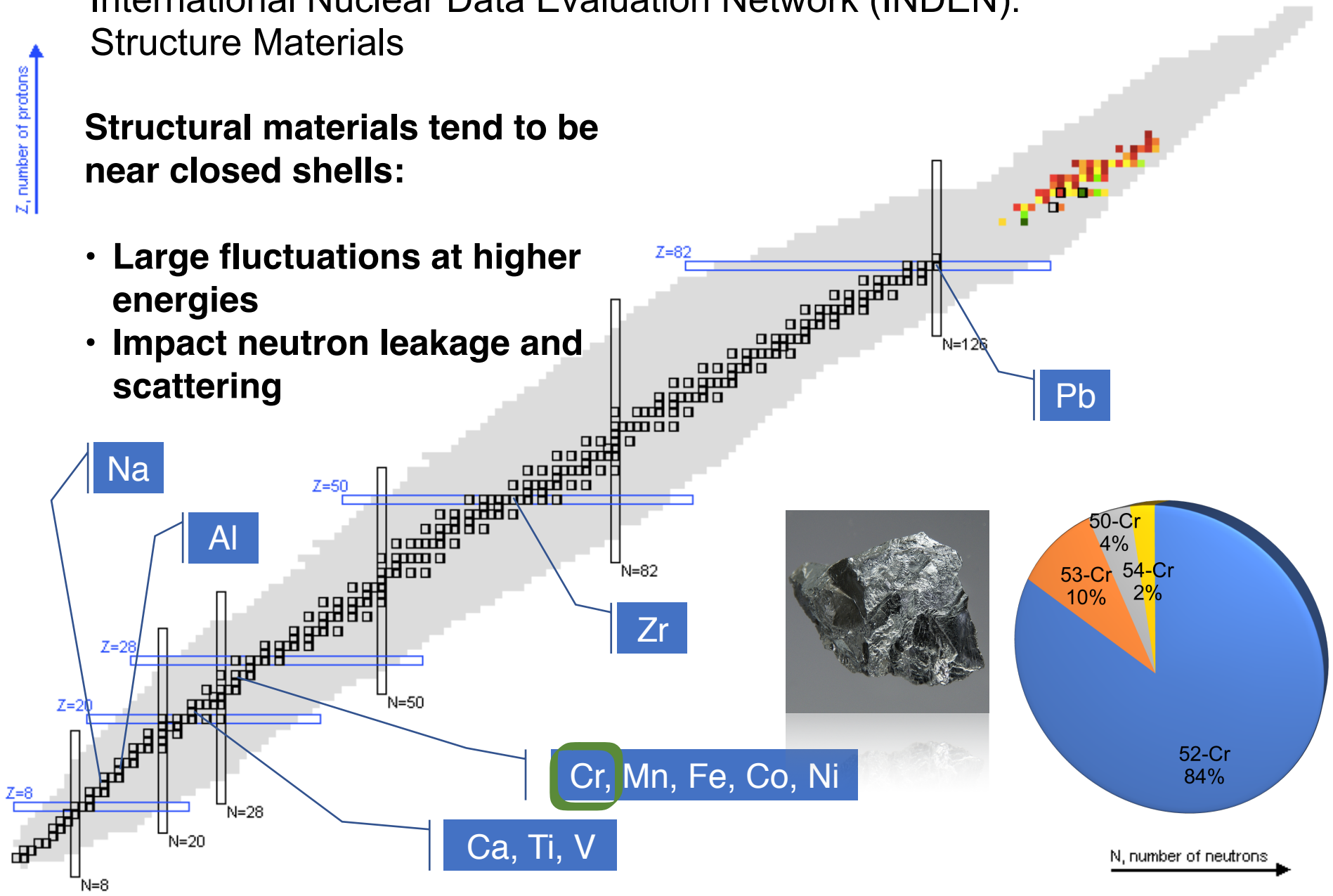
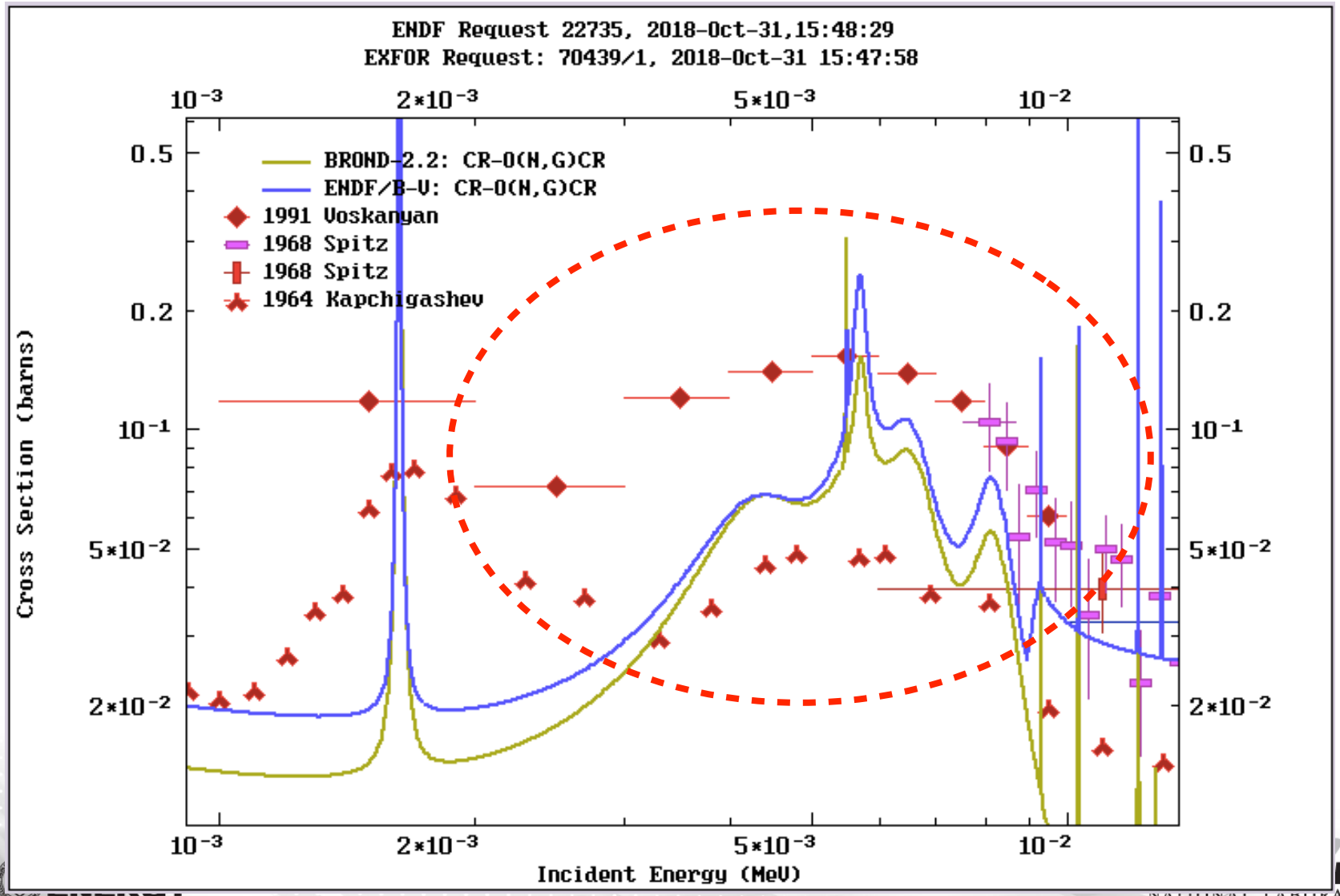
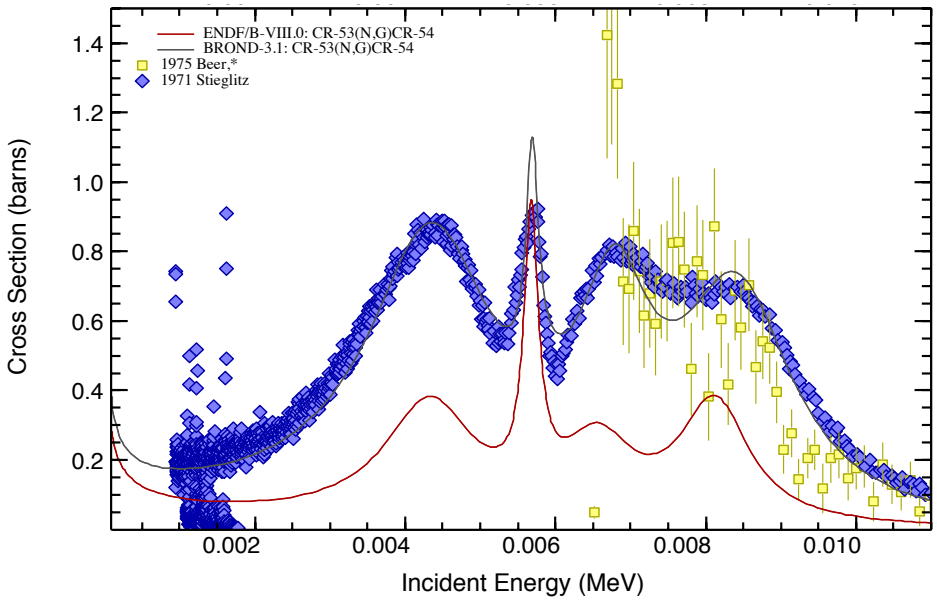


The problems with capture: ^{53,50}Cr



The problem with capture - Part I: ^{53}Cr



Inconsistency between Stieglitz 1971 (RPI) and Guber 2011 (ORNL)

BROND-3.1 “fix” does very well.

However: Pronyaev assumes MS corrections were zero and adjusted both the bound levels and scattering radius; change of thermal value

Direct capture accounts for practically 100% of the thermal value: no need for bound states

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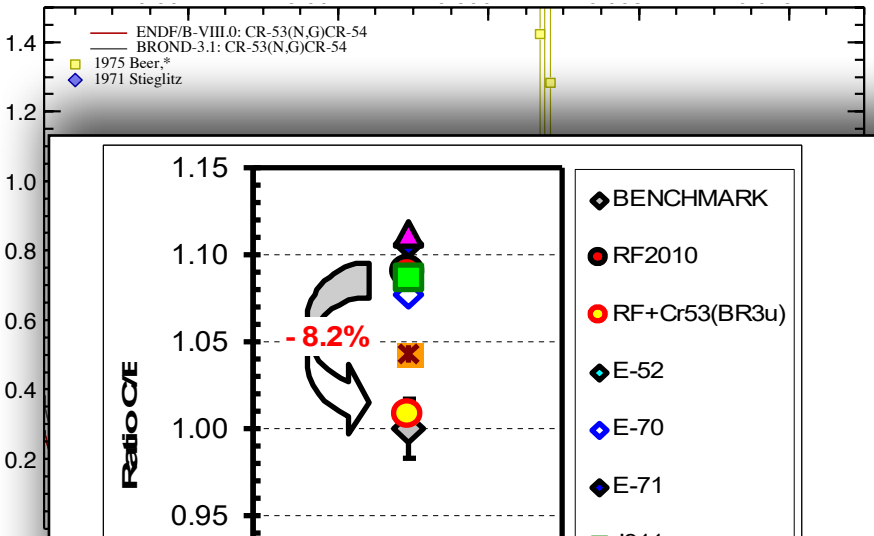

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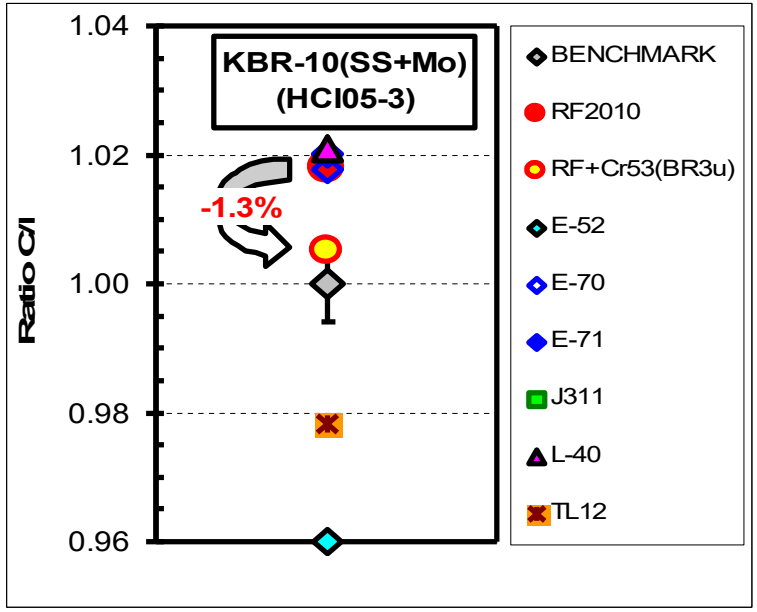

Adjusted parameters of first ^{53}Cr resonances were embedded in ROSFOND 2010 library. Left panel shows results for HCI05-4 assembly heavily loaded by Chromium, right panel - for HCI05-3 loaded by stainless steel and Molybdenum. Benchmark for assembly loaded by natural Nickel shows C/E close to 1.

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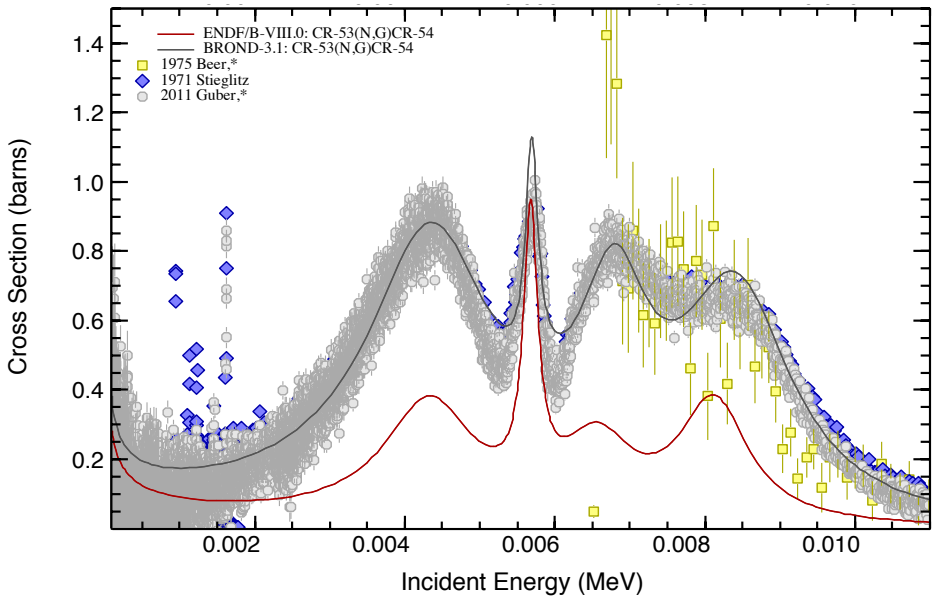

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Attempt of normalizing Guber to Stieglitz:

- Similar shape
- Correction needs to be made
- But an overall normalization will not work: different experimental corrections such as multiple-scattering (up to 80%), self-shielding, neutron sensitivity, were made, leading to energy shifts
- Not only different corrections, but it is not clear exactly which corrections were used in each case

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New experiment planned at RPI to measure ^{53,50}Cr capture; if data reaches us in time it will be immensely helpful!

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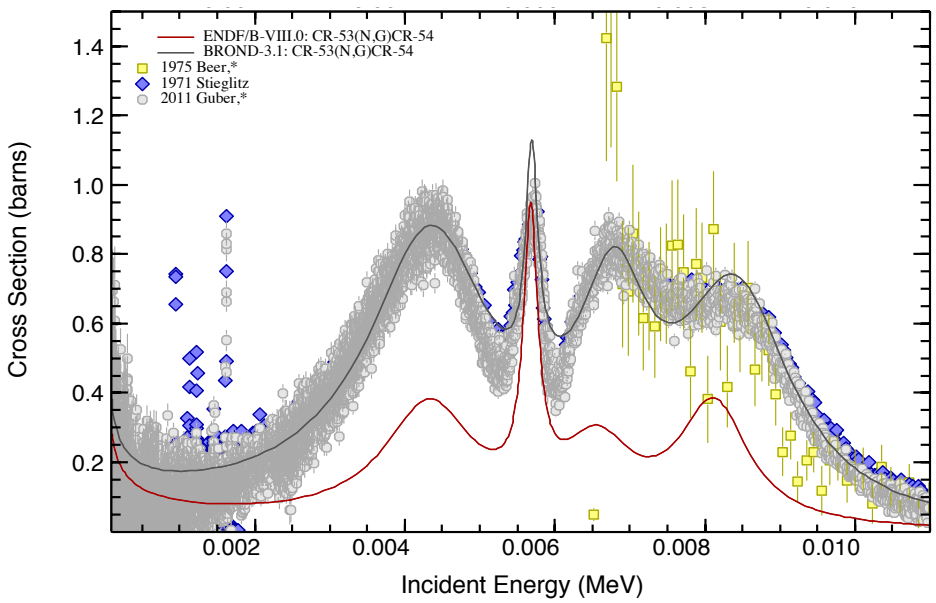

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Still open issue

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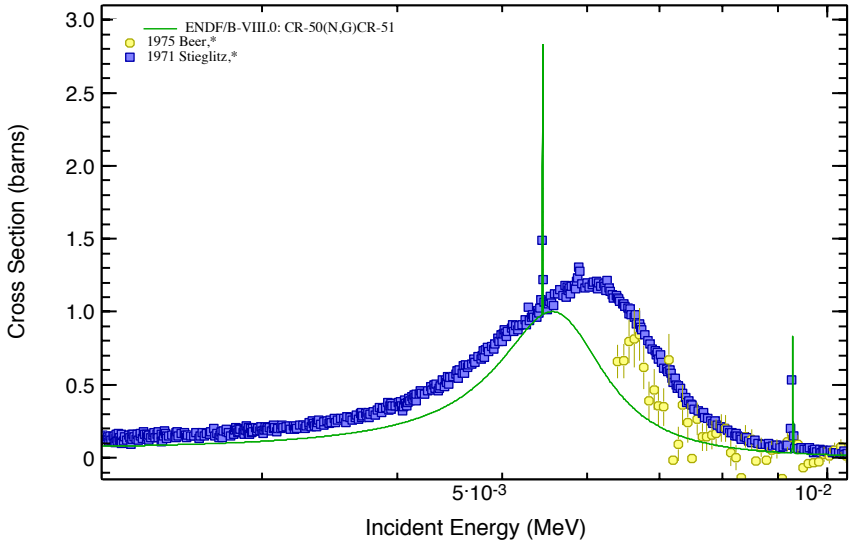
The problem with capture - Part II: ^{50}Cr



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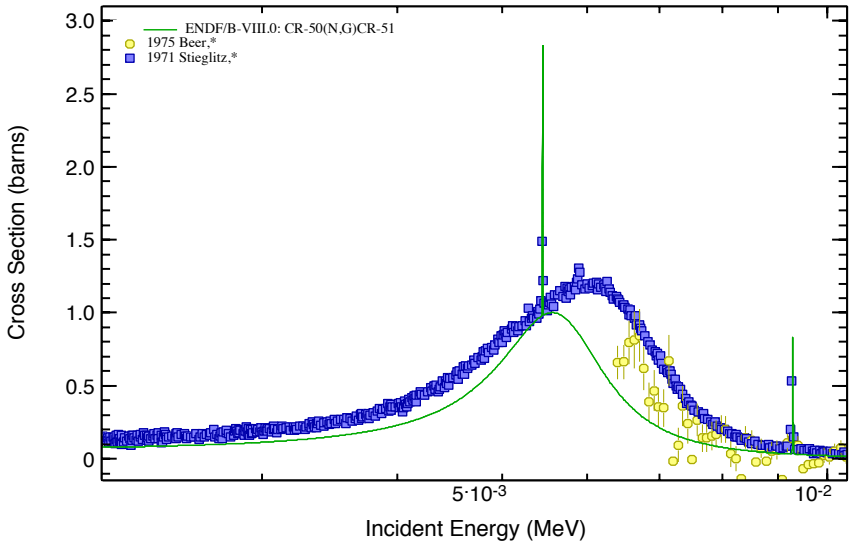

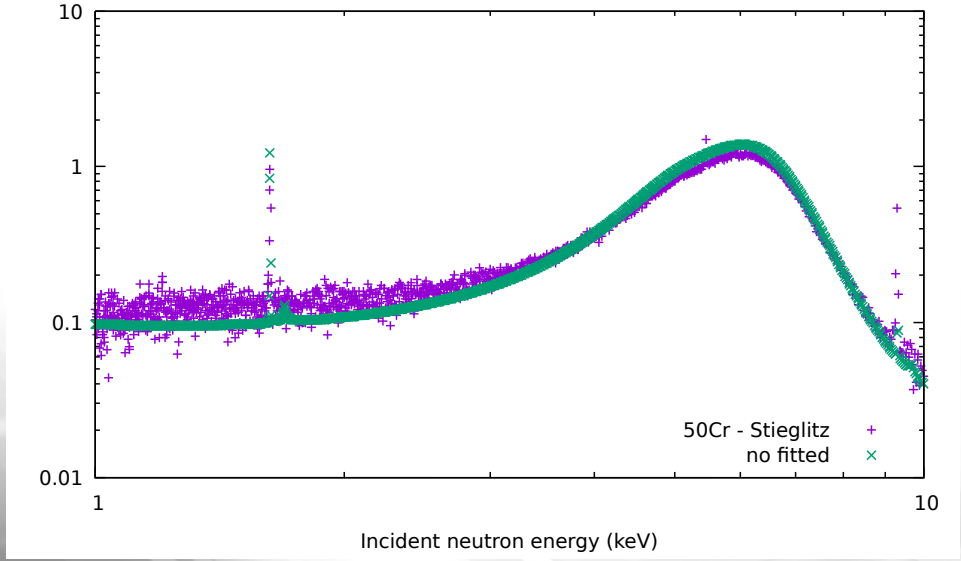

Preliminary fit by M. Pigni:

- Fitted ^{nat}Cr data in the neutron energy region 1-10 keV. In this energy window we have only ^{50}Cr and ^{53}Cr (^{52}Cr is not relevant in this region).
- With the set resonance parameter fitting the magnitude of the natural data, normalized Guber (0.48 to theoretical) and Stieglitz (0.8 to theoretical) data and, with these normalized data refined the fit also using the transmission data
- The fit of the natural data were performed using MS (analytical) corrections but we think they are small.
- For the thermal values, for now:

	^{53}Cr	^{50}Cr
Total	29.55	21.22
Elastic	7.951	2.422
Capture	21.60	18.80

The best that we can do without sorting out ^{53}Cr data!

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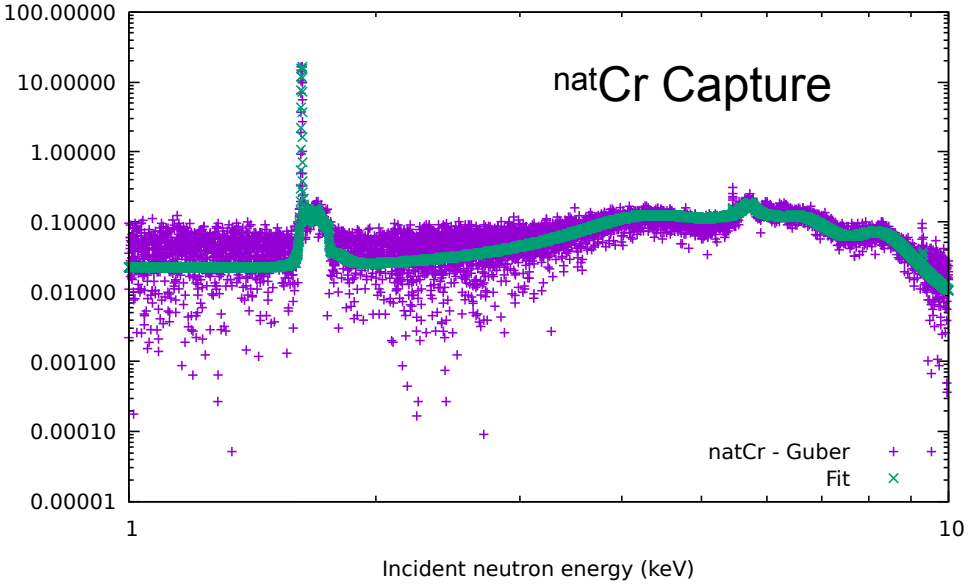
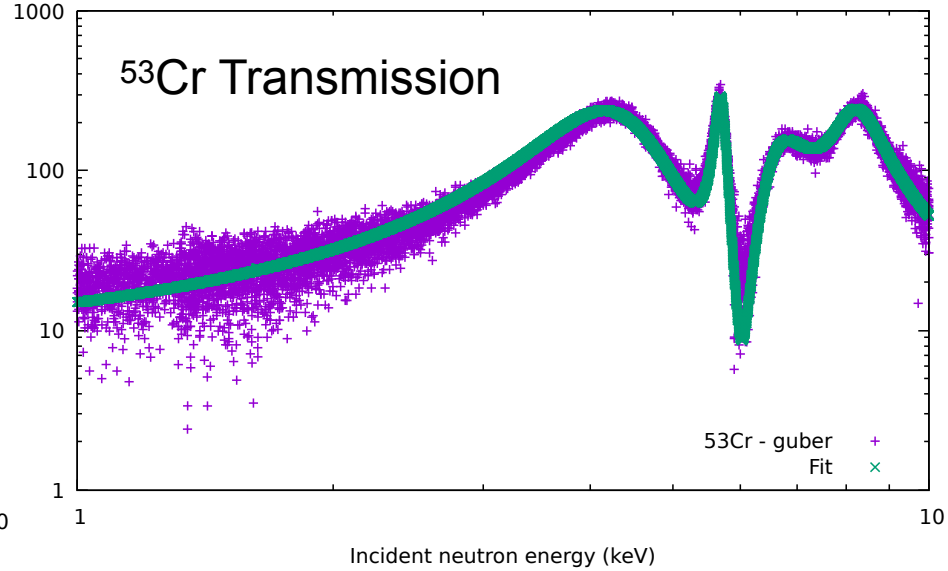
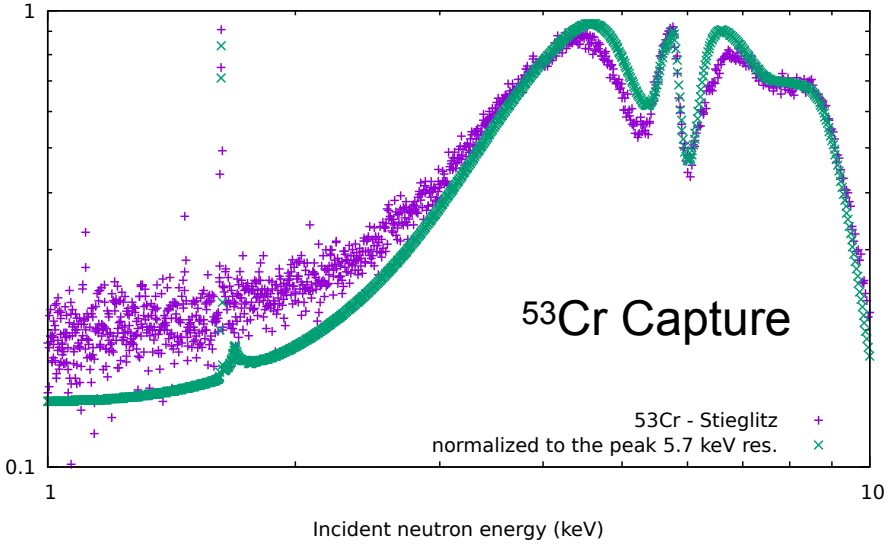
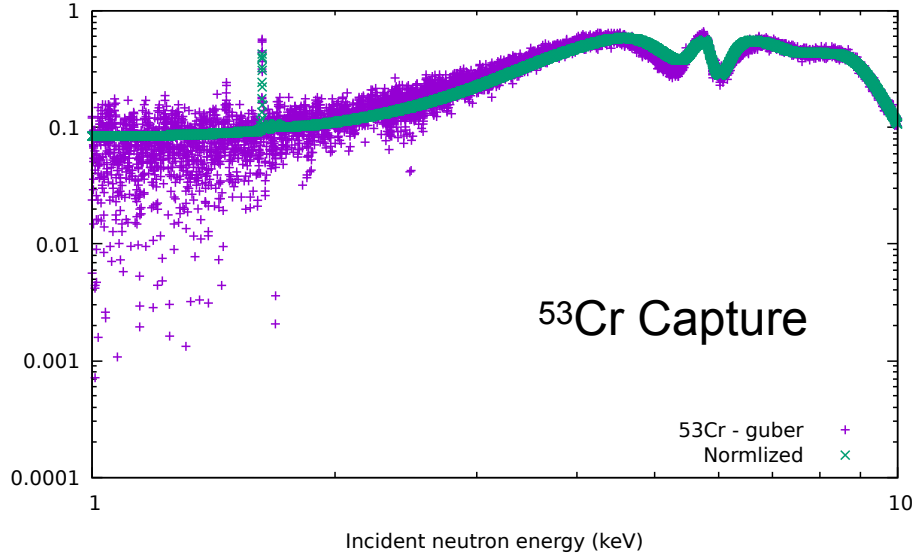
Fitting of natural Cr data

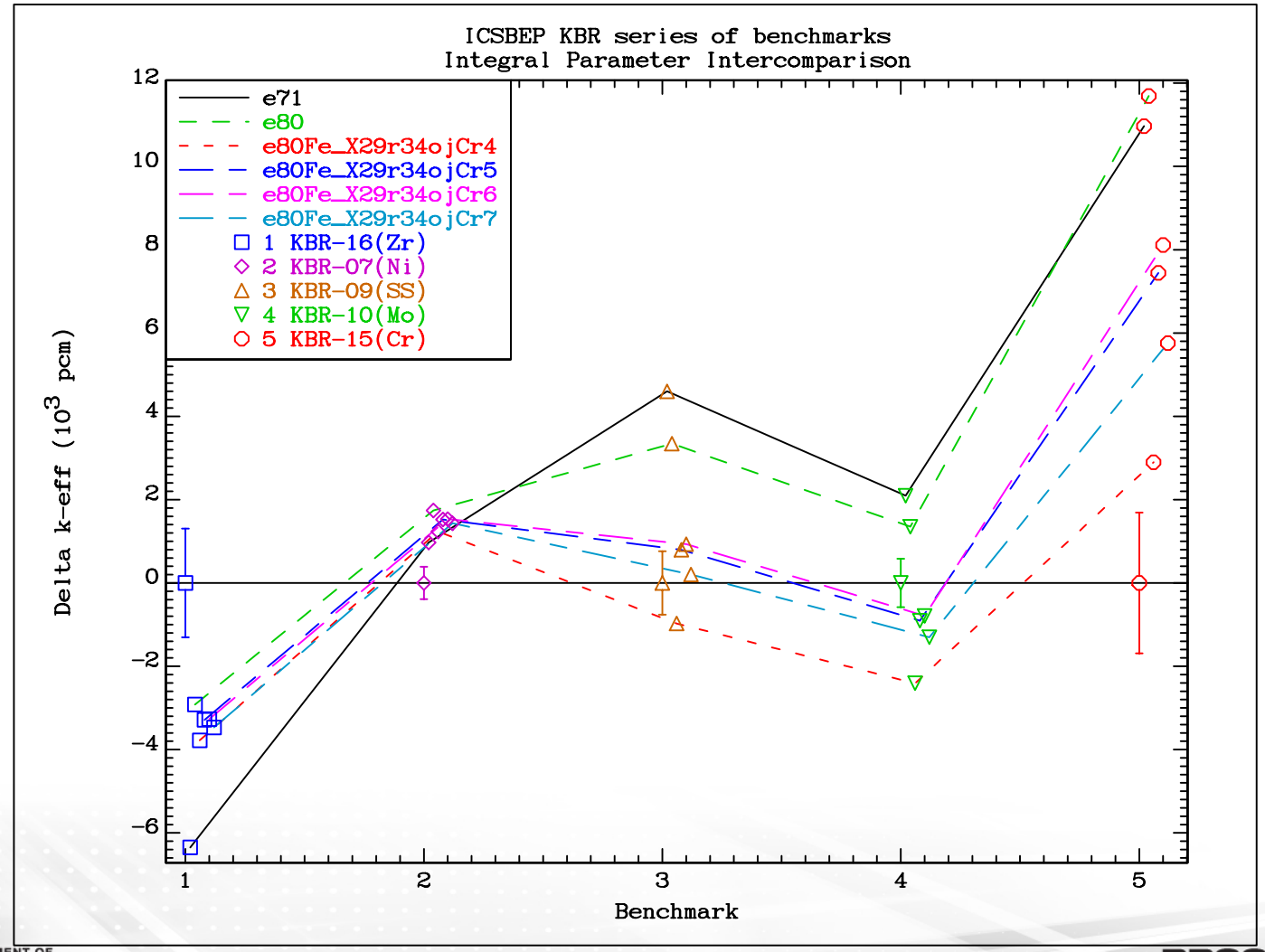








Preliminary Integral Tests



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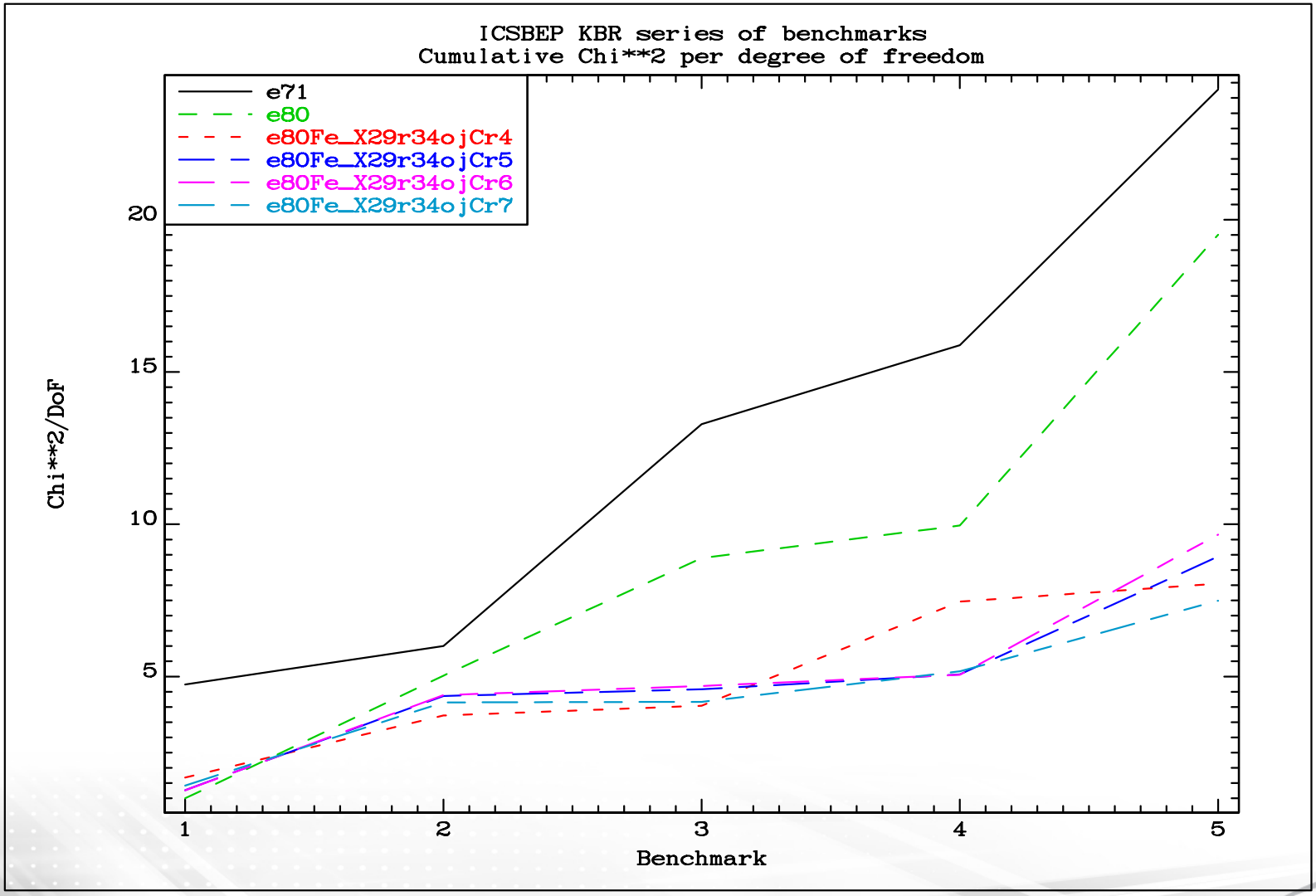
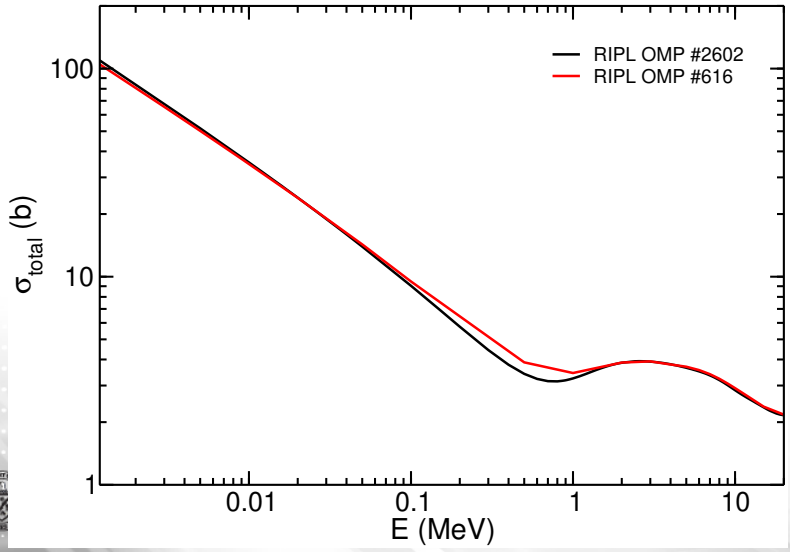
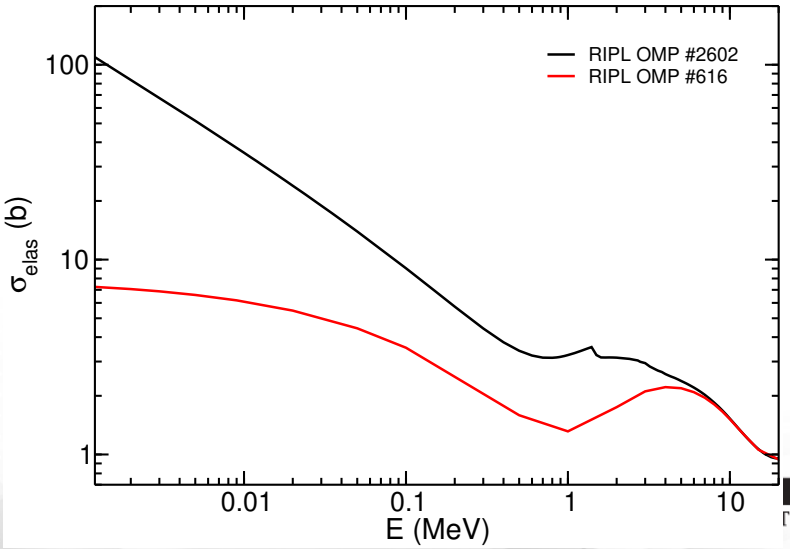


Fast region

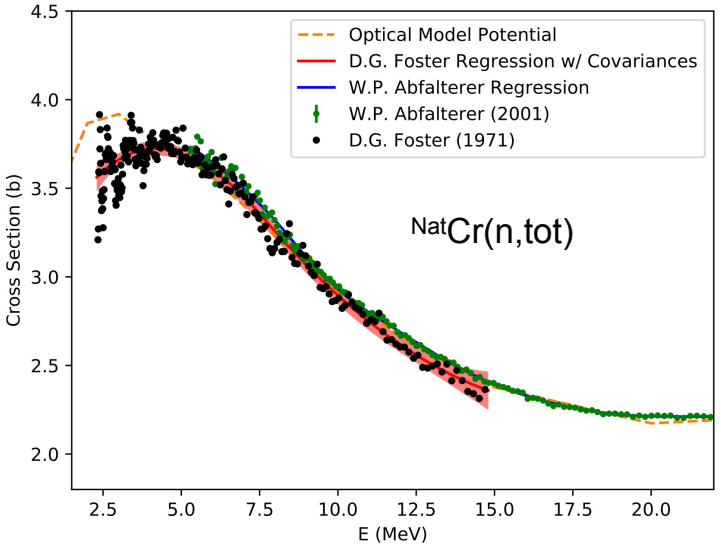
- Generated proto-evaluations for ^{52}Cr and ^{53}Cr using EMPIRE. Focused on smoothed parts of cross sections.
- Optical Model Potential
  - Using at the moment a generalized soft-rotor optical potential from ^{56}Fe (RIPL #2602).
  - New chromium-specific soft-rotor dispersive OMP fitted to the Abfalterer natural ^{nat}Cr(n,tot) data (RIPL #616).
  - However, not fully implemented yet in EMPIRE, so it is still not fully usable.
- Low-energy level densities are strongly parity asymmetric: using the RIPL-3 HFB LD as a stopgap and testing adjustments to them to improve the agreement with spectra data.
- Once the main cross sections are better defined, we will attempt to match inelastic gamma cross section data by Mihailescu et al. (Geel).

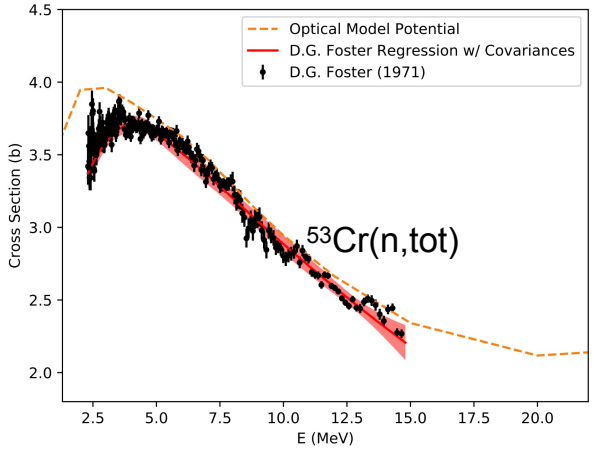


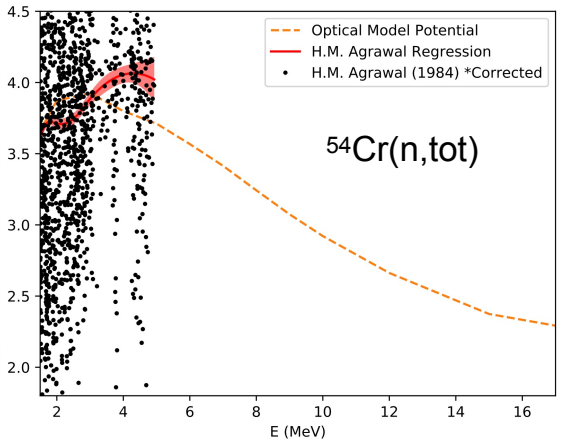


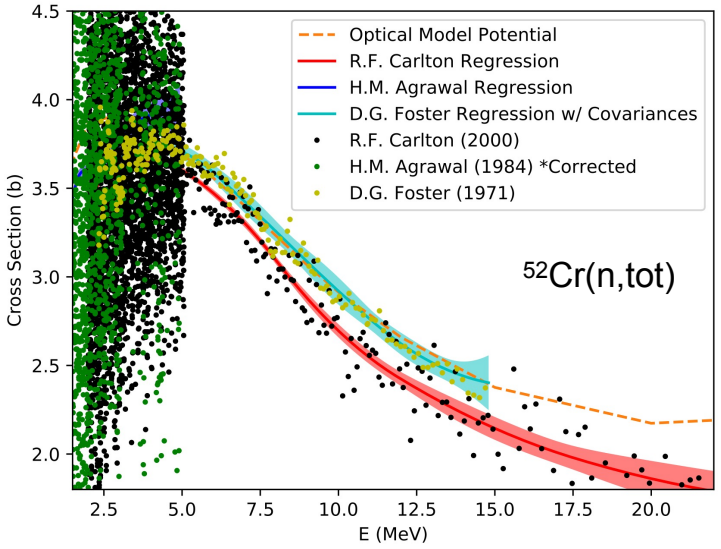
Total cross-section data

- It is important to reproduce the fluctuations, especially in the fission spectrum range, as they impact leakage and criticality. However, the fluctuations can only be taken from experiment and for ^{52,54}Cr, the best data come from a series of ORNL experiments with poor target characterization (datasets from Agrawal and Carlton).
- Making Abfalterer consistent with Foster Jr.: Covariances (J. Gutierrez, SULI Summer student)

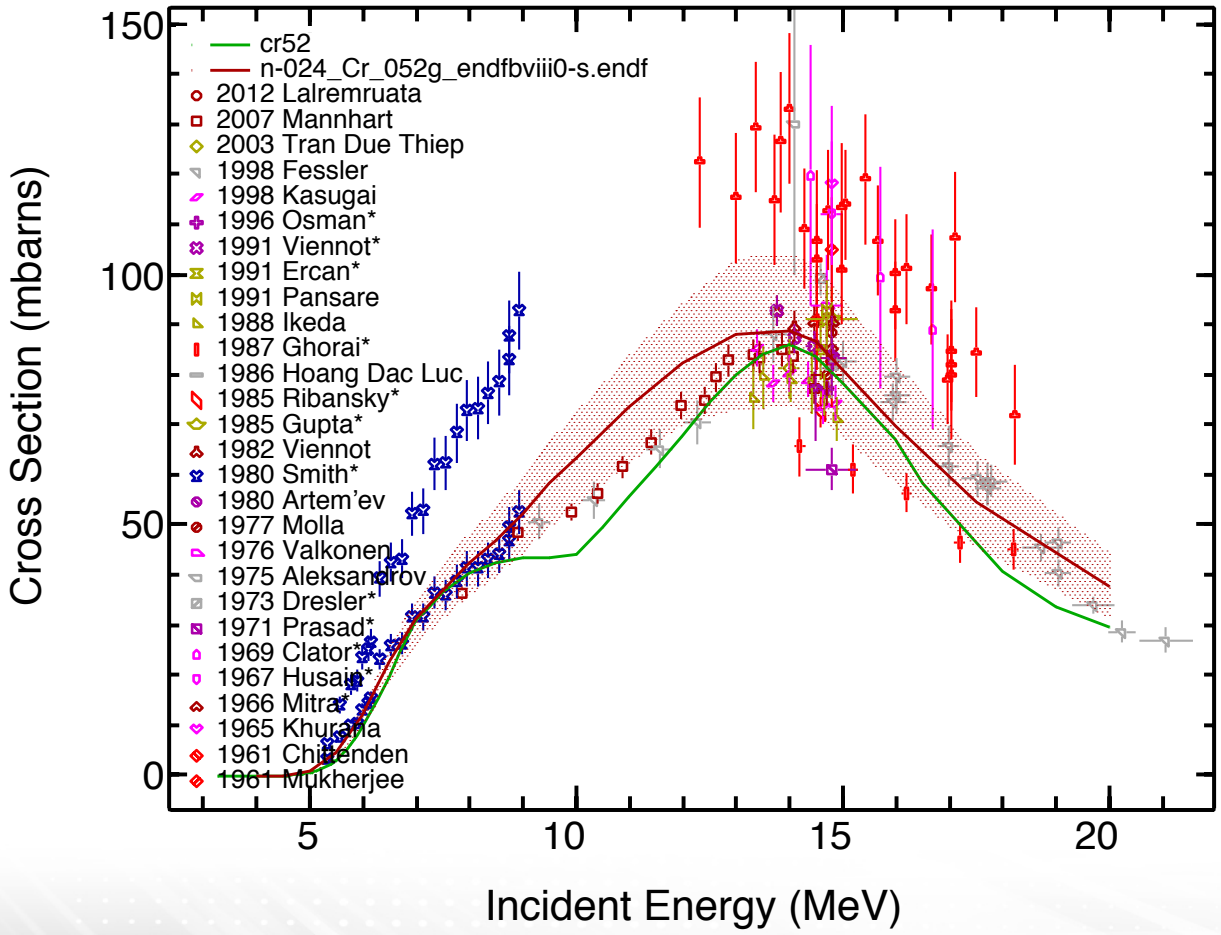








$^{52}Cr(n,p)^{52}V$



- The previous $^{52}Cr(n,p)$ dates back from ENDF/B-VI-MOD1, done by D. Larson (ORNL) in 1989
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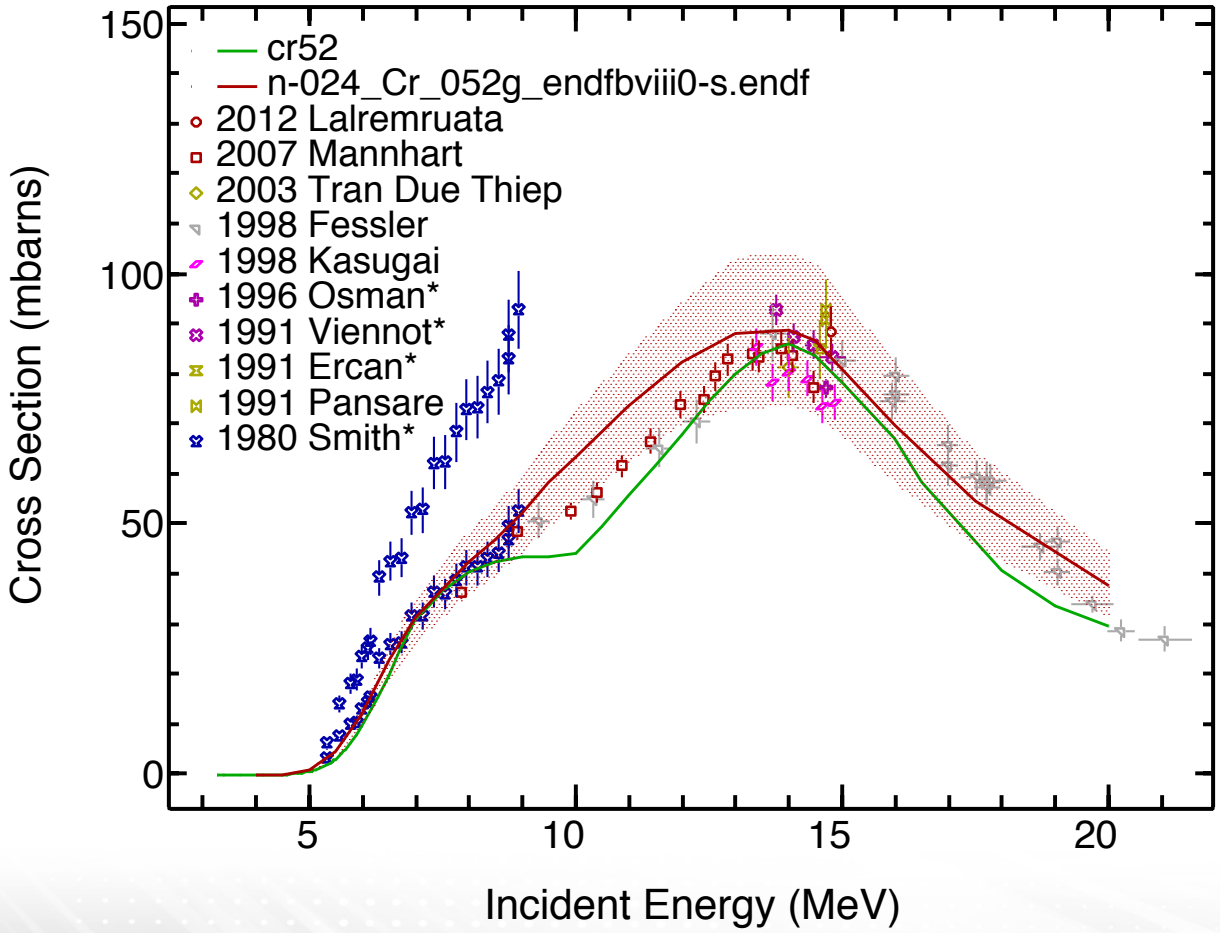

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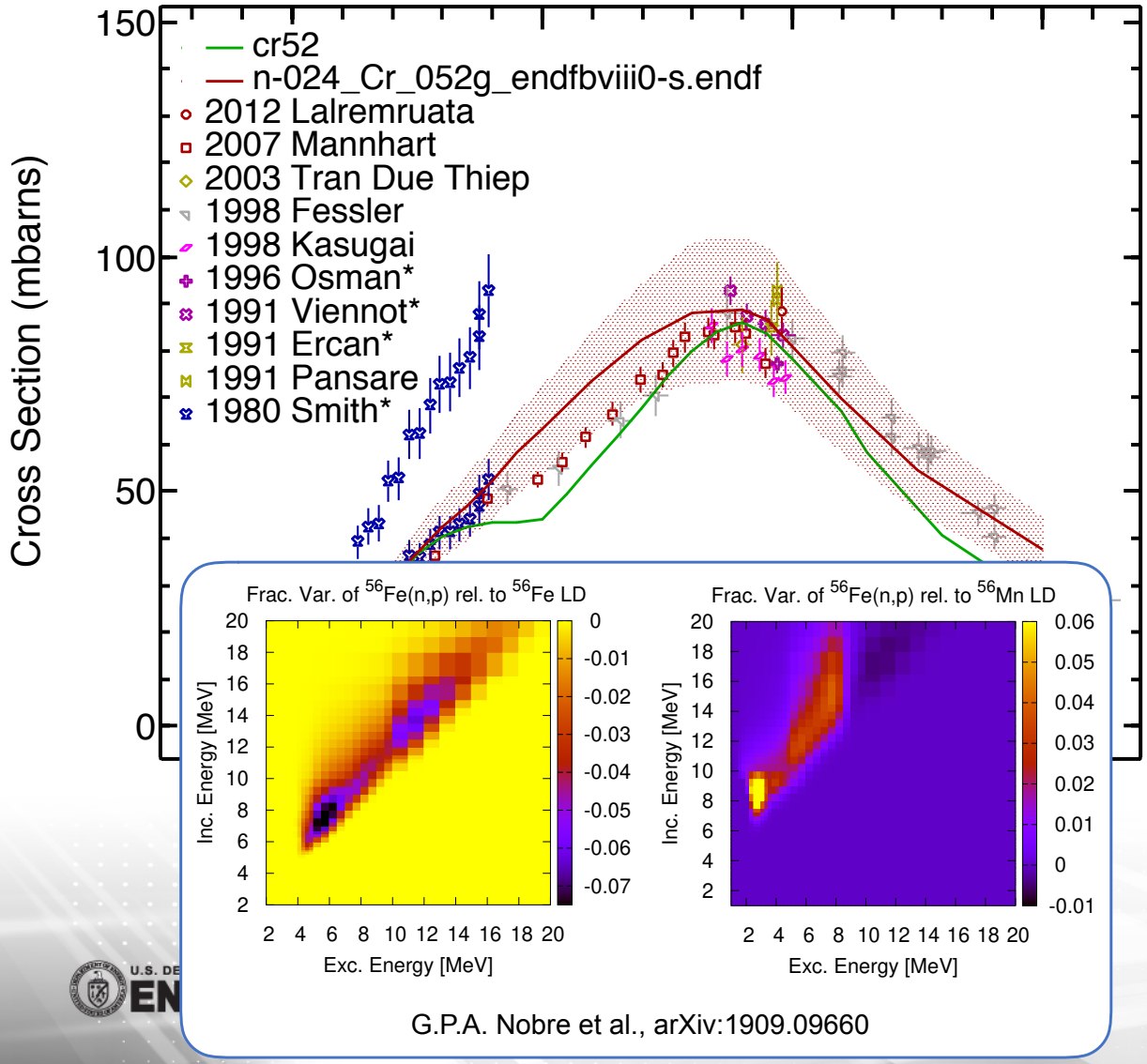

G.P.A. Nobre et al., arXiv:1909.09660

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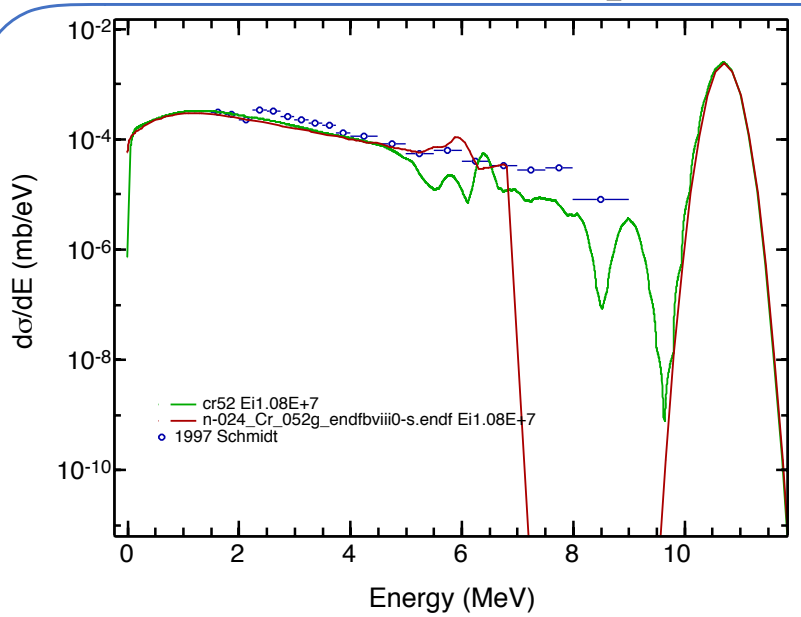
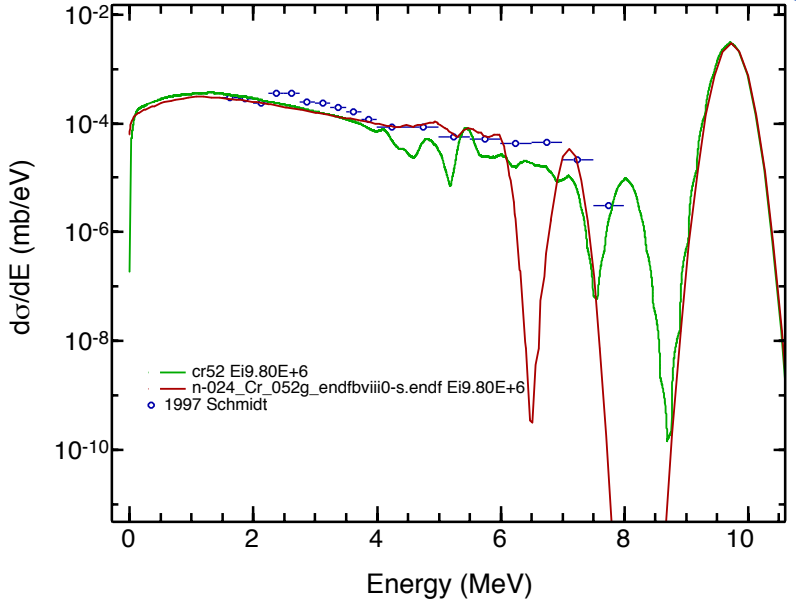
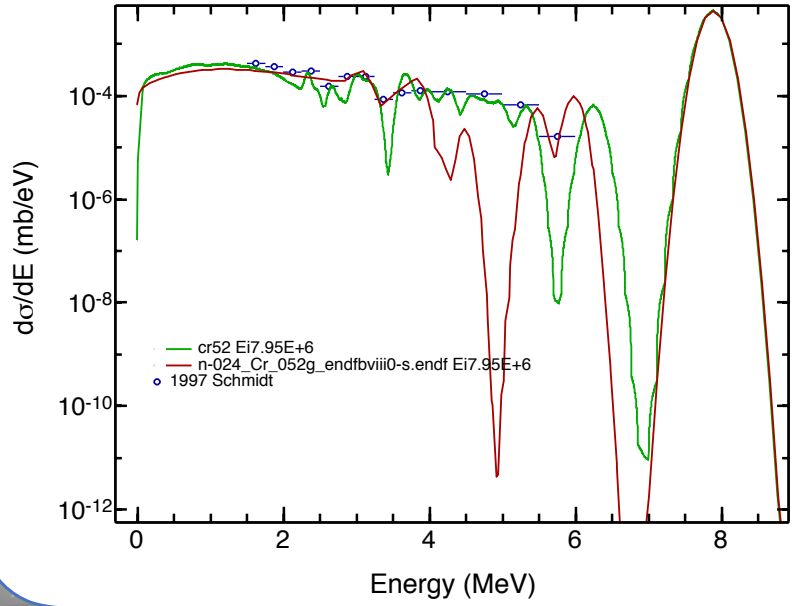
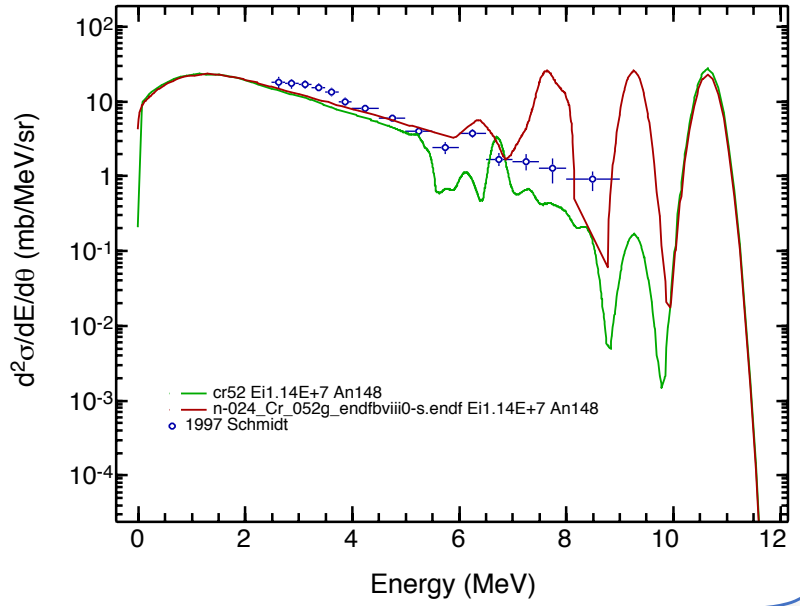
- Focusing on data more recent than previous evaluation
- We will use the approach of correlations between LD and cross sections to consistently fix details of c.s. agreement: recently developed and applied to $^{56}Fe(n,p)$

Differential spectra









Next steps

- Capture measurements on ^{50}Cr and ^{53}Cr have been added to the High Priority Request List
  - Crucial issue: From benchmarks we understand that a capture increase is needed. It has to come from differential data and evaluations.
  - New measurements in RPI: Controlled multiple-scattering and other corrections
  - In meantime, use fits from ^{Nat}Cr data to guide renormalization of ^{53,50}Cr Guber (and Stieglitz)
- Implement new soft-rotor in EMPIRE/OPTMAN: refit and fine tune fast region
  - Covariances
  - Include ^{52}Cr(n,2n) IRDFF
- Include in our integral tests benchmarks from Cadarache, France
  - MAESTRO experiment the MINERVE reactor with natural structural samples: not been published in its totality yet, but they have been analyzed and interpreted
  - PETALE neutron transmission experiment: Transmission experiment will help to validate the elastic and inelastic c.s. for Cr, Fe and Ni elements, independently, as they consist of transmission through purely isotopic blocks of the aforementioned structural materials.
- **A lot of work ahead, but we have already identified all the issues and now know what to do make the evaluation work for the right reasons!**