

BNL Evaluation Plans (neutron sublibrary only)

G.P.A. Nobre, D.A. Brown

National Nuclear Data Center

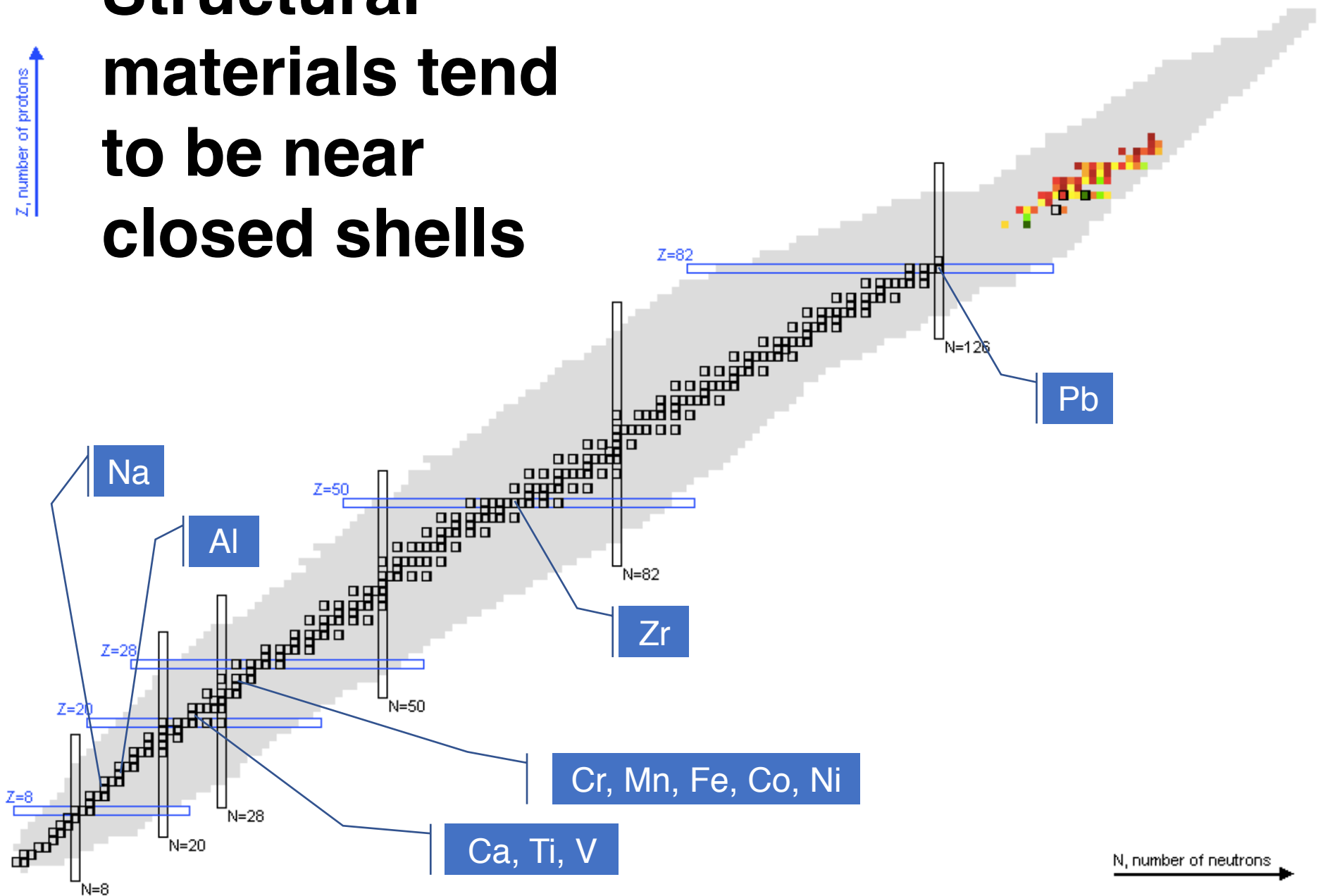
BROOKHAVEN
NATIONAL LABORATORY



BNL's plans

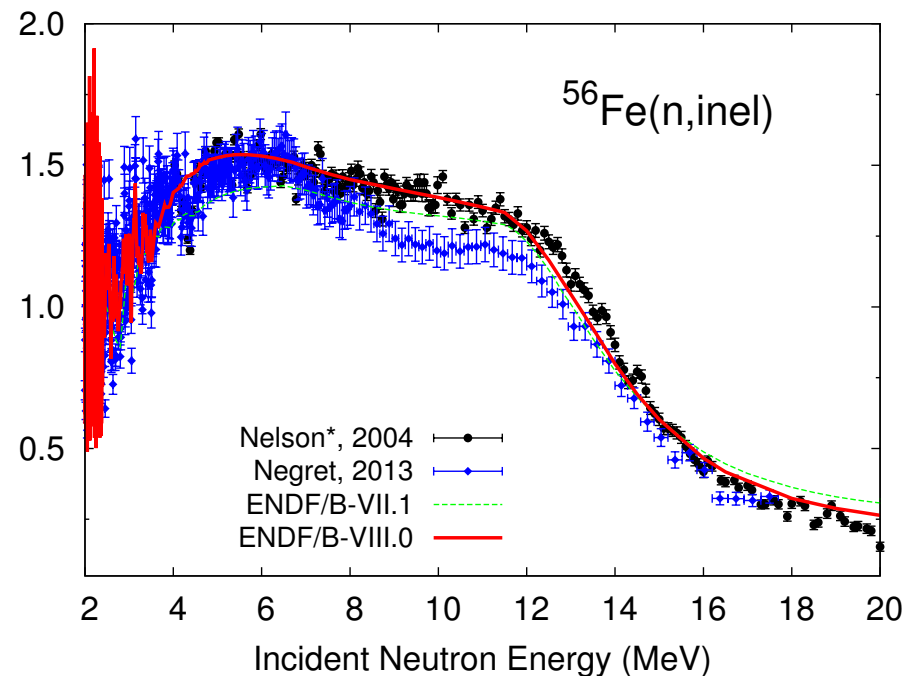
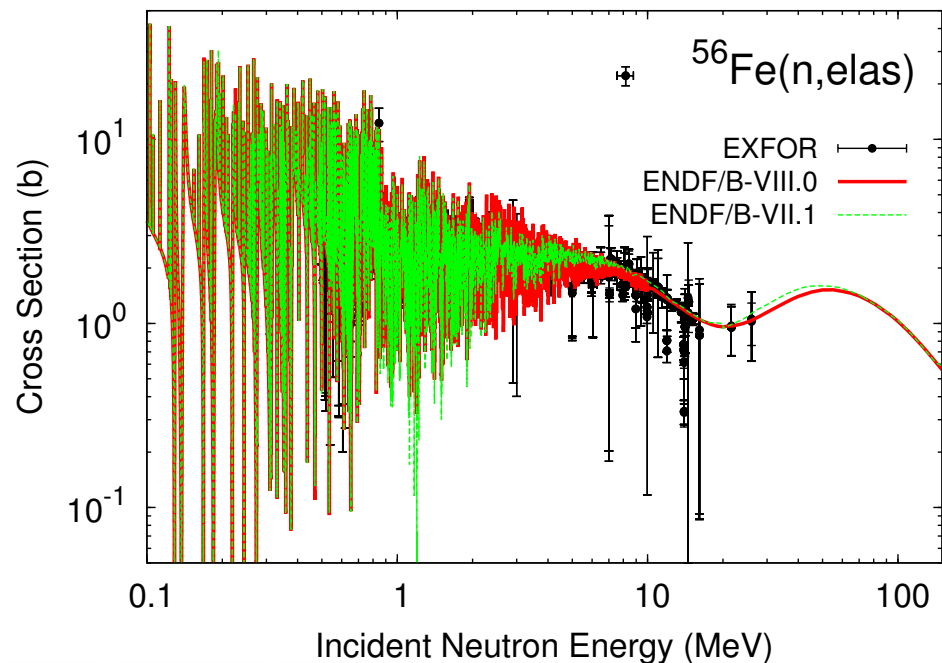
- **Cr** with input from IAEA, ORNL
- **Zr** with input from ORNL
- **Pb** with input from ORNL
- **⁸⁶Kr** with input from LBL, LLNL
- **²³⁸U(n,n')** with LBL, LANL, IAEA (Not covered here)

Structural materials tend to be near closed shells



Nuclei near closed shells have large cross section fluctuations that extend to high energies

These fluctuations dramatically impact neutron leakage and scattering



D. Brown, et al. Nucl. Data Sheets 148, 1 (2018)

M. W. Herman, et al. Nucl. Data Sheets 148, 214 (2018)

^{52}Cr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

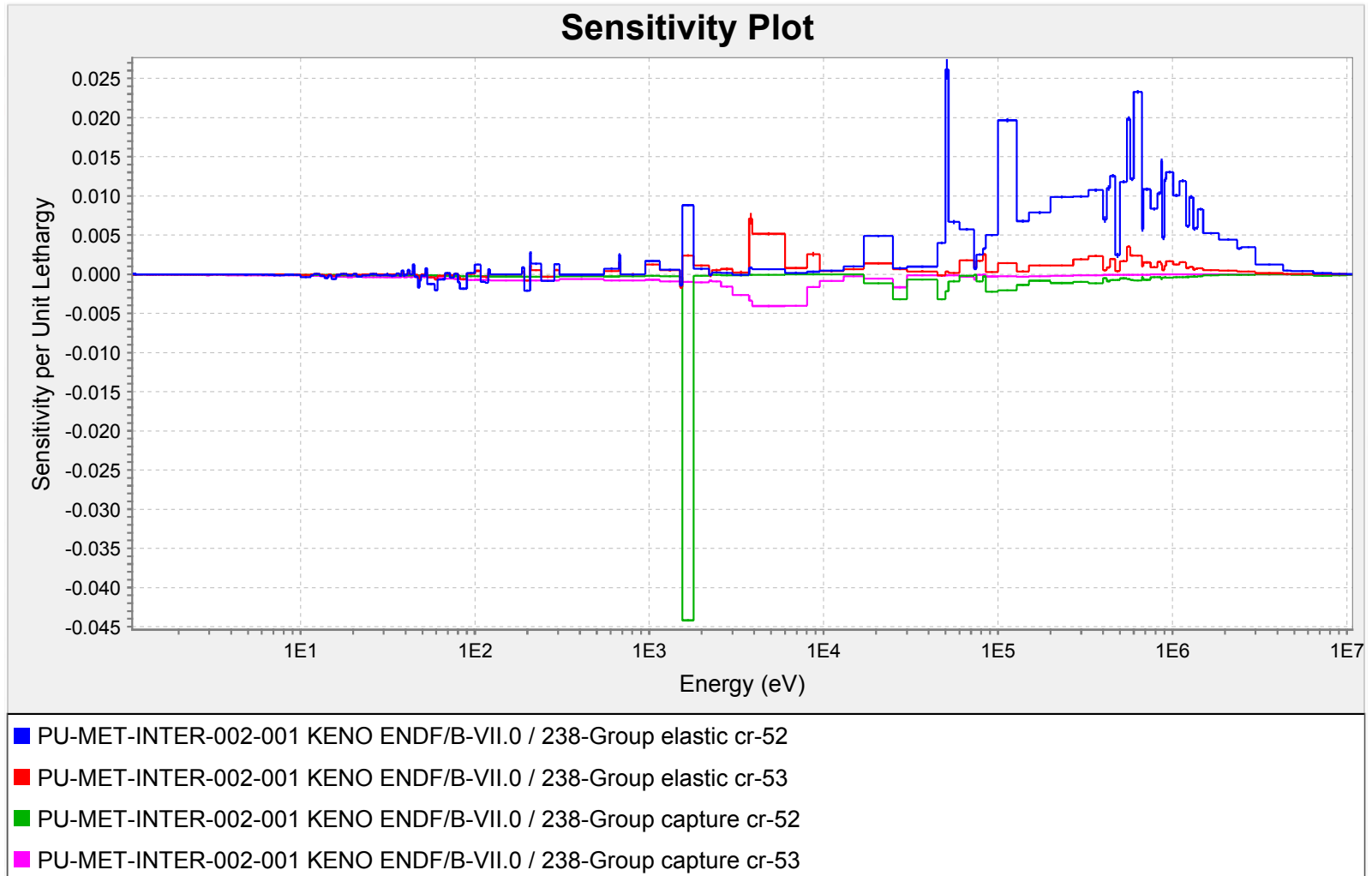
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Known deficiencies/gaps:

- Elastic angular distribution inconsistent with cross section, is from ENDF/B-V elemental evaluation
- High-resolution (n,total) exp. data from Agrawal and Carlton likely not (correctly) taken into account
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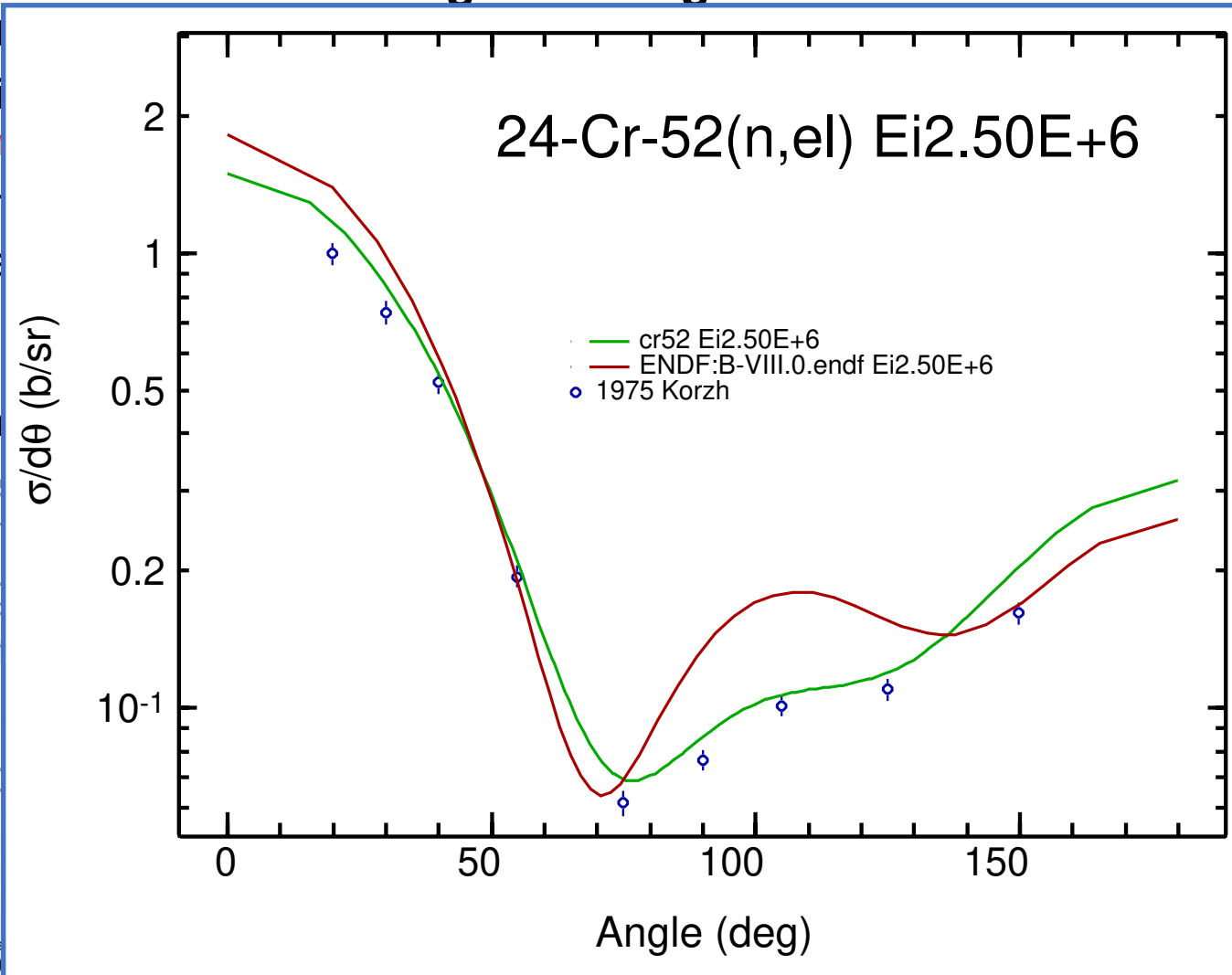
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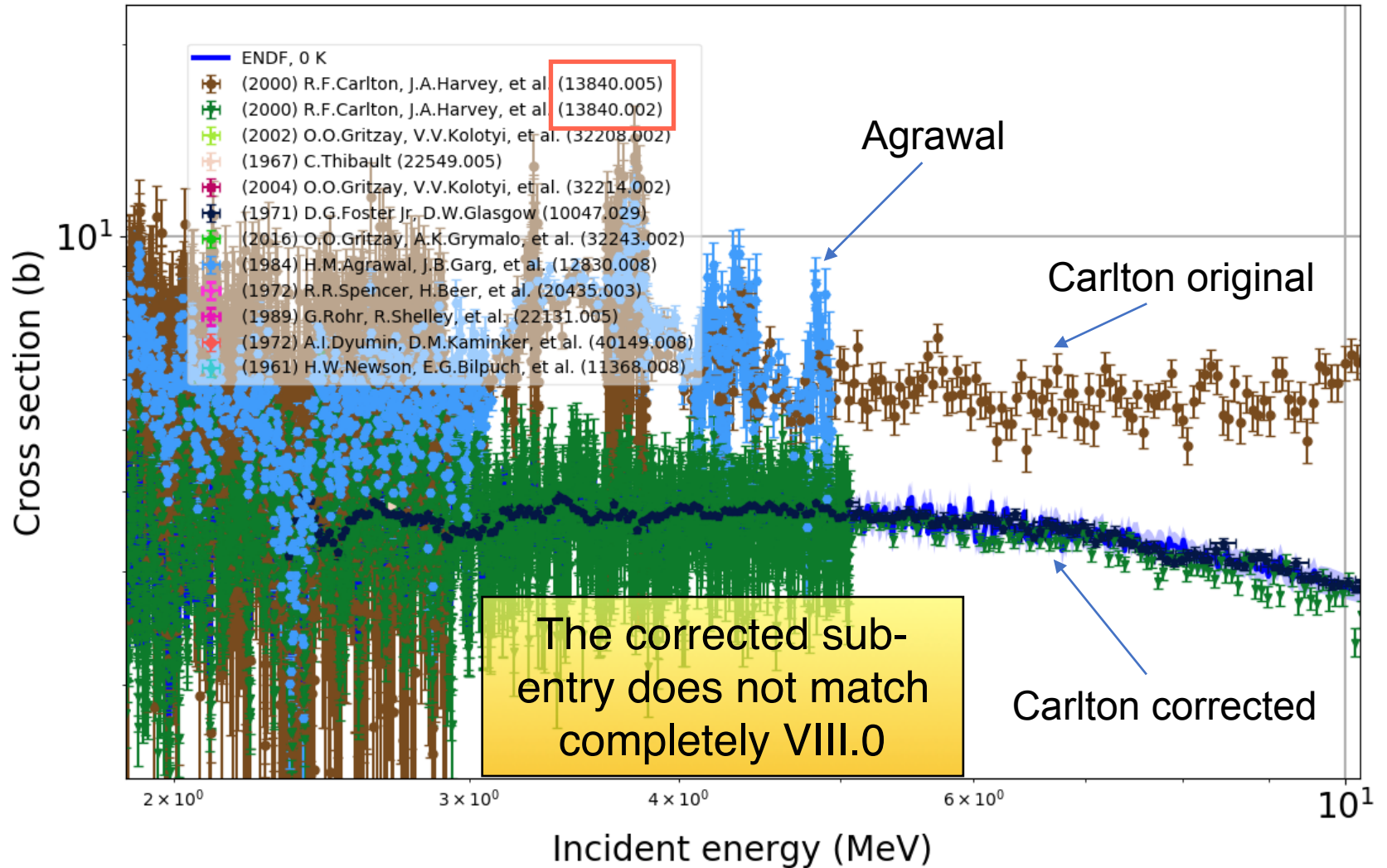
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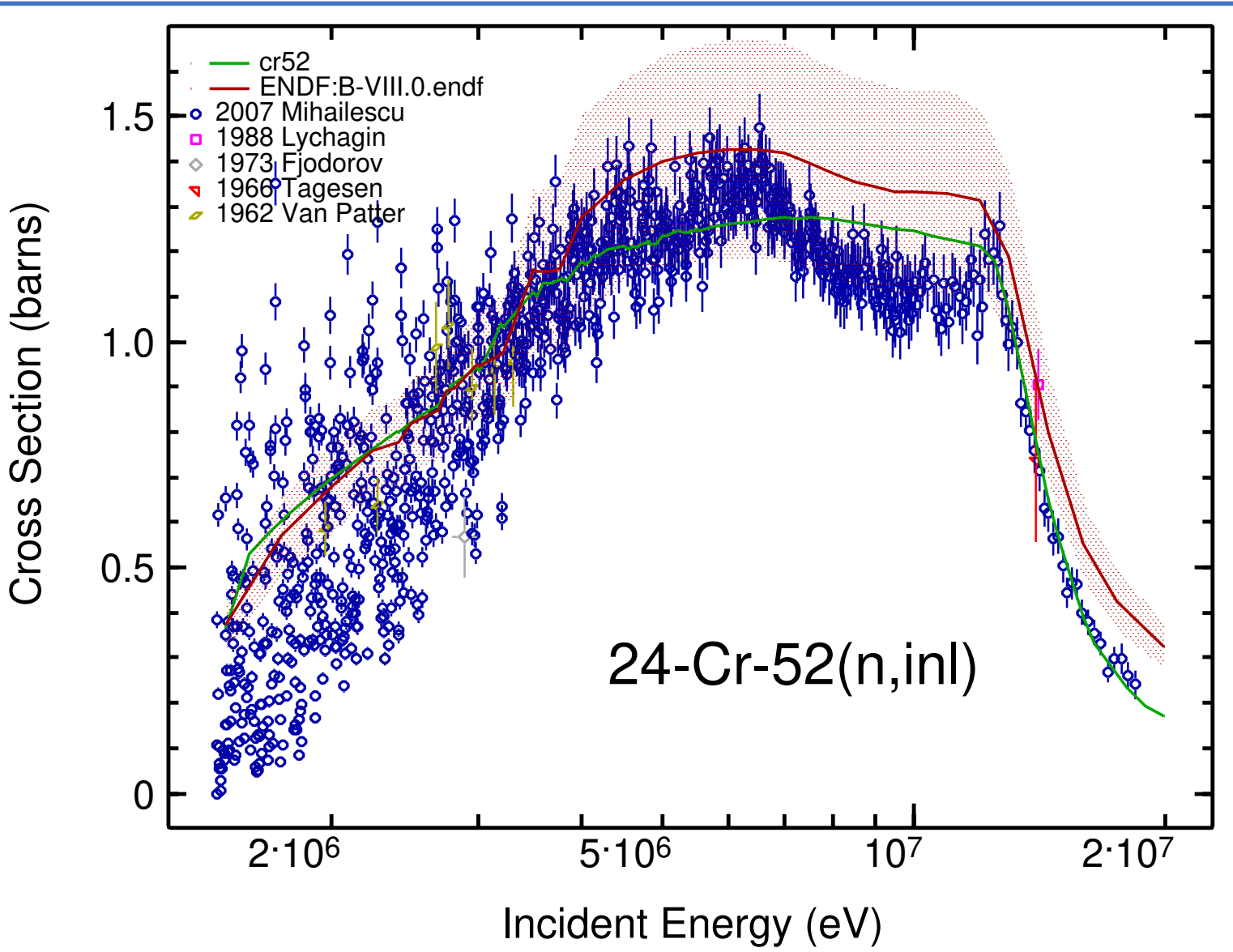
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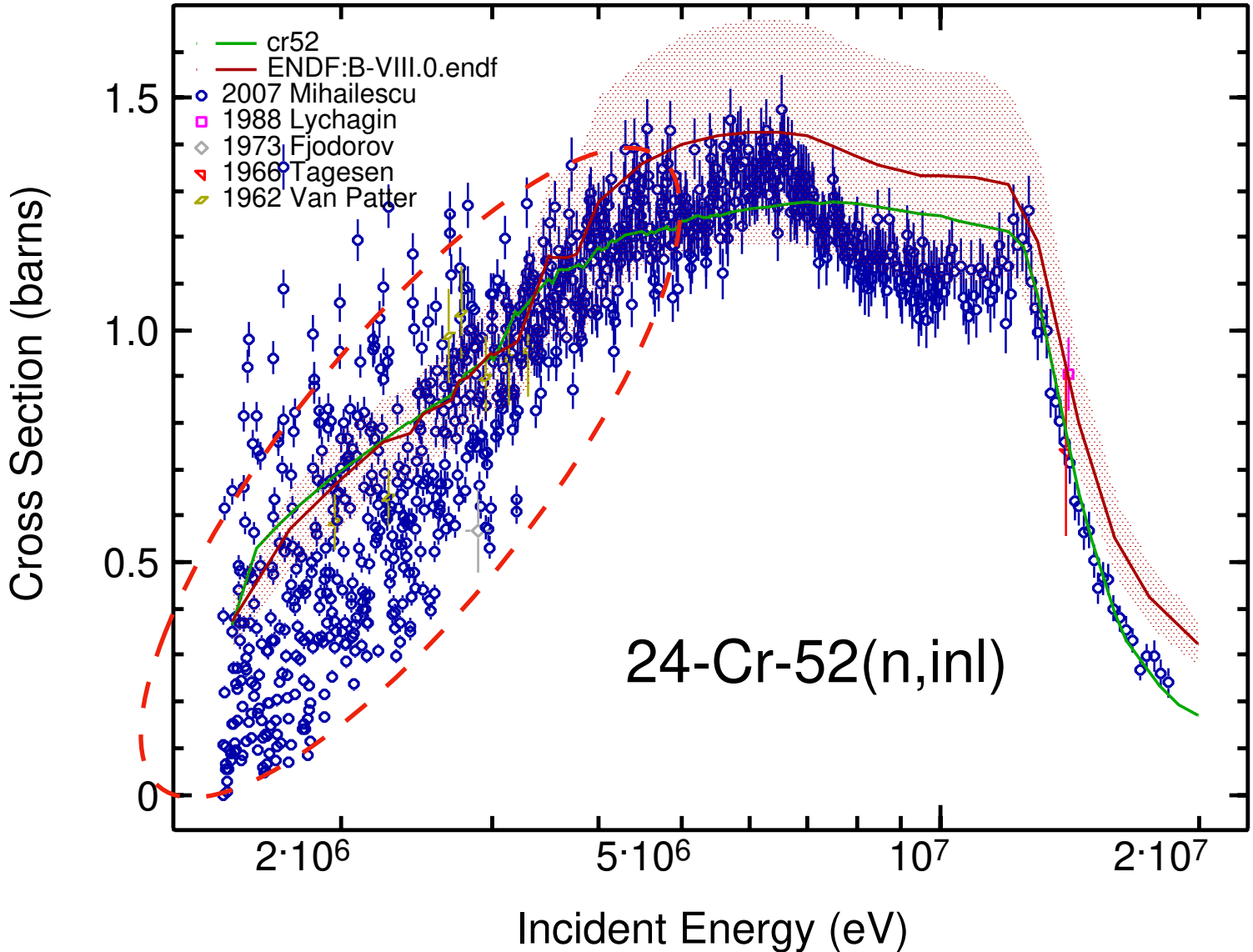
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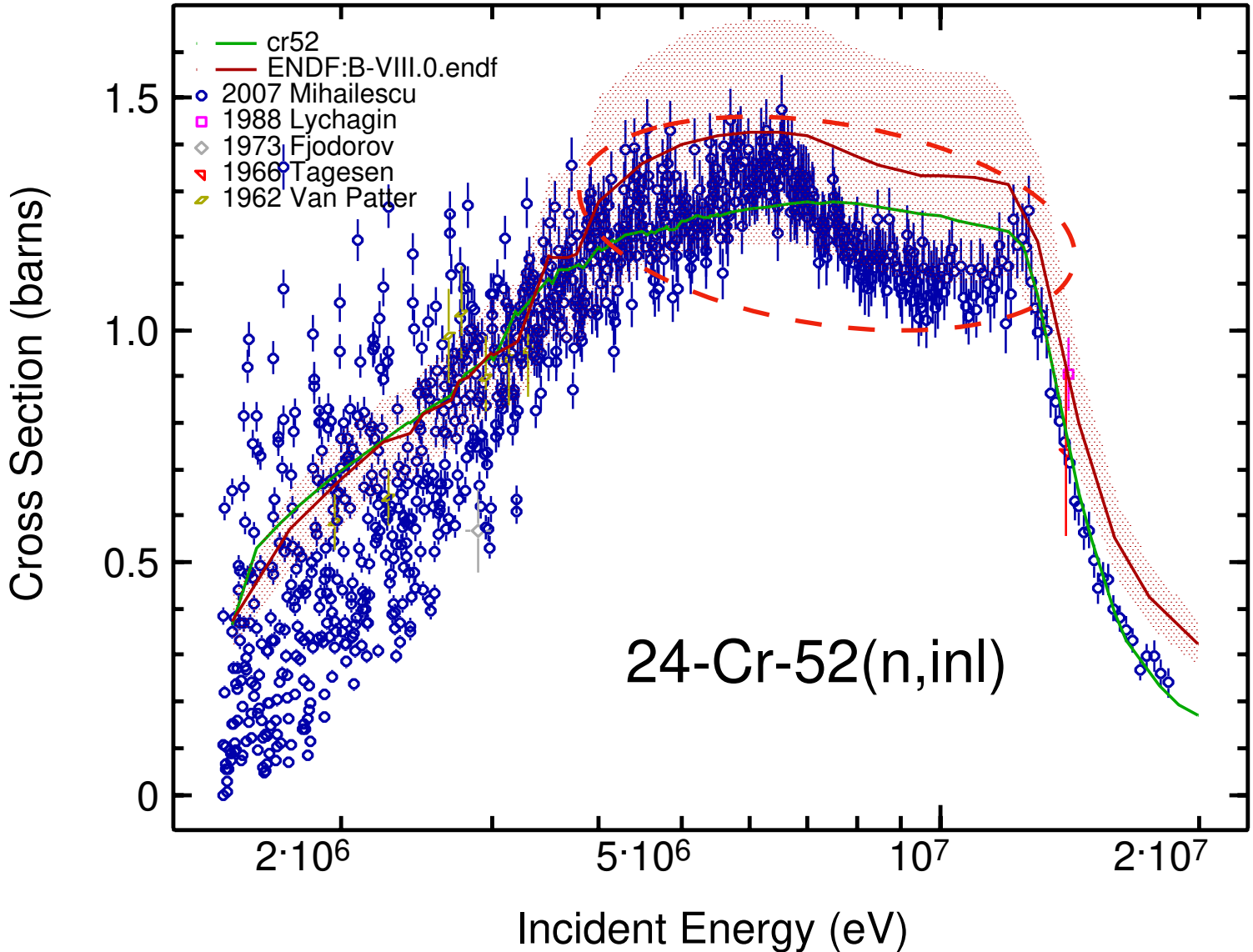
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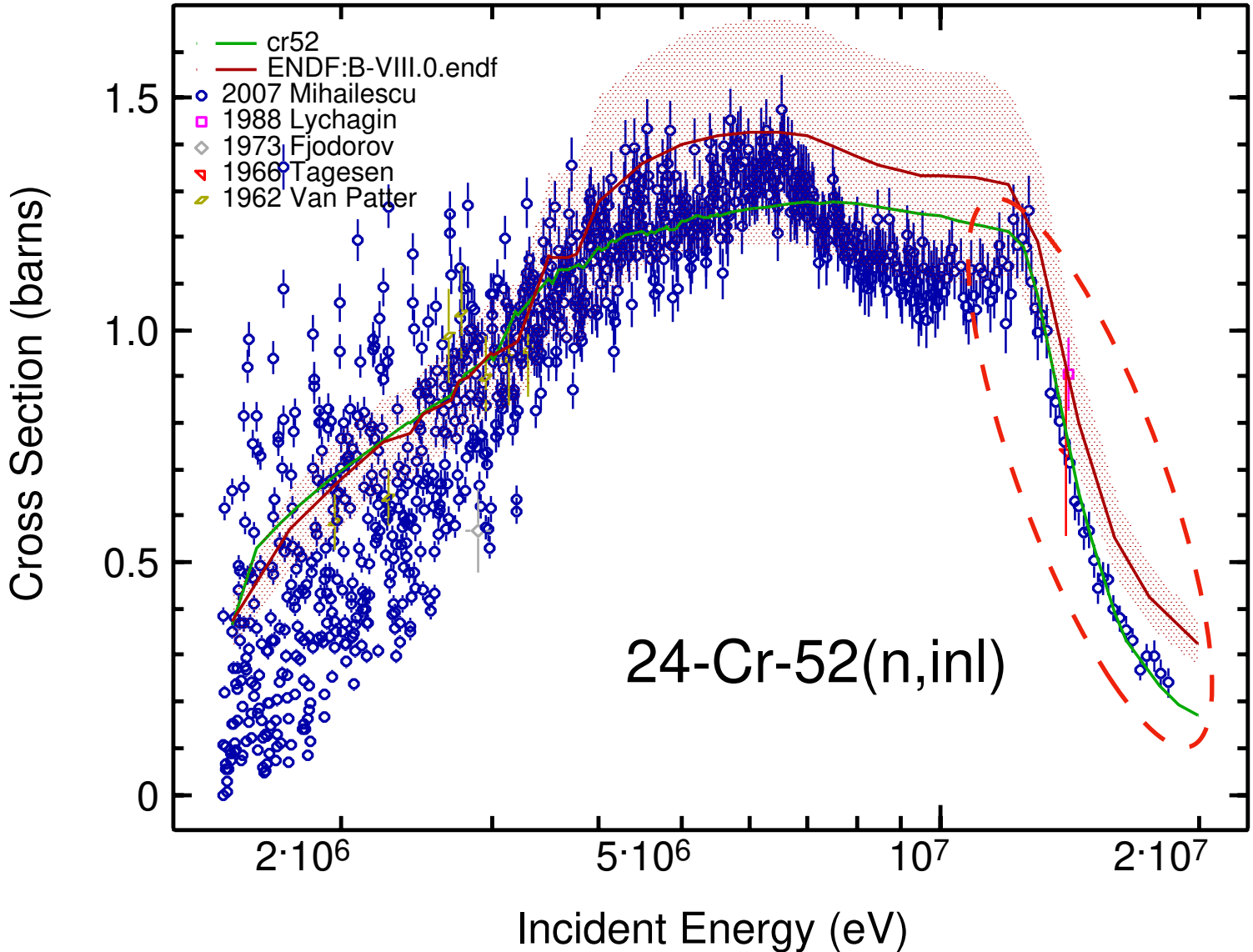
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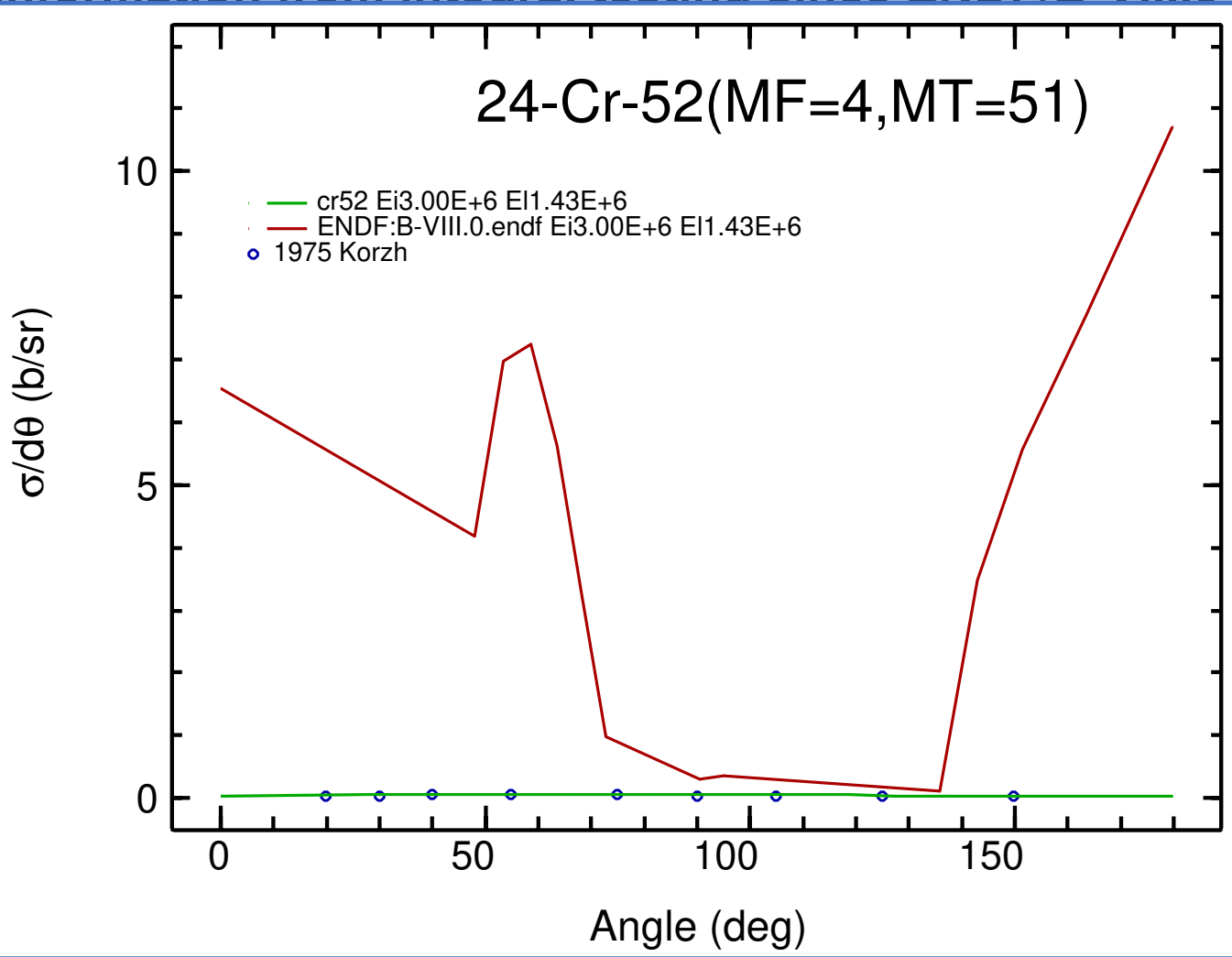
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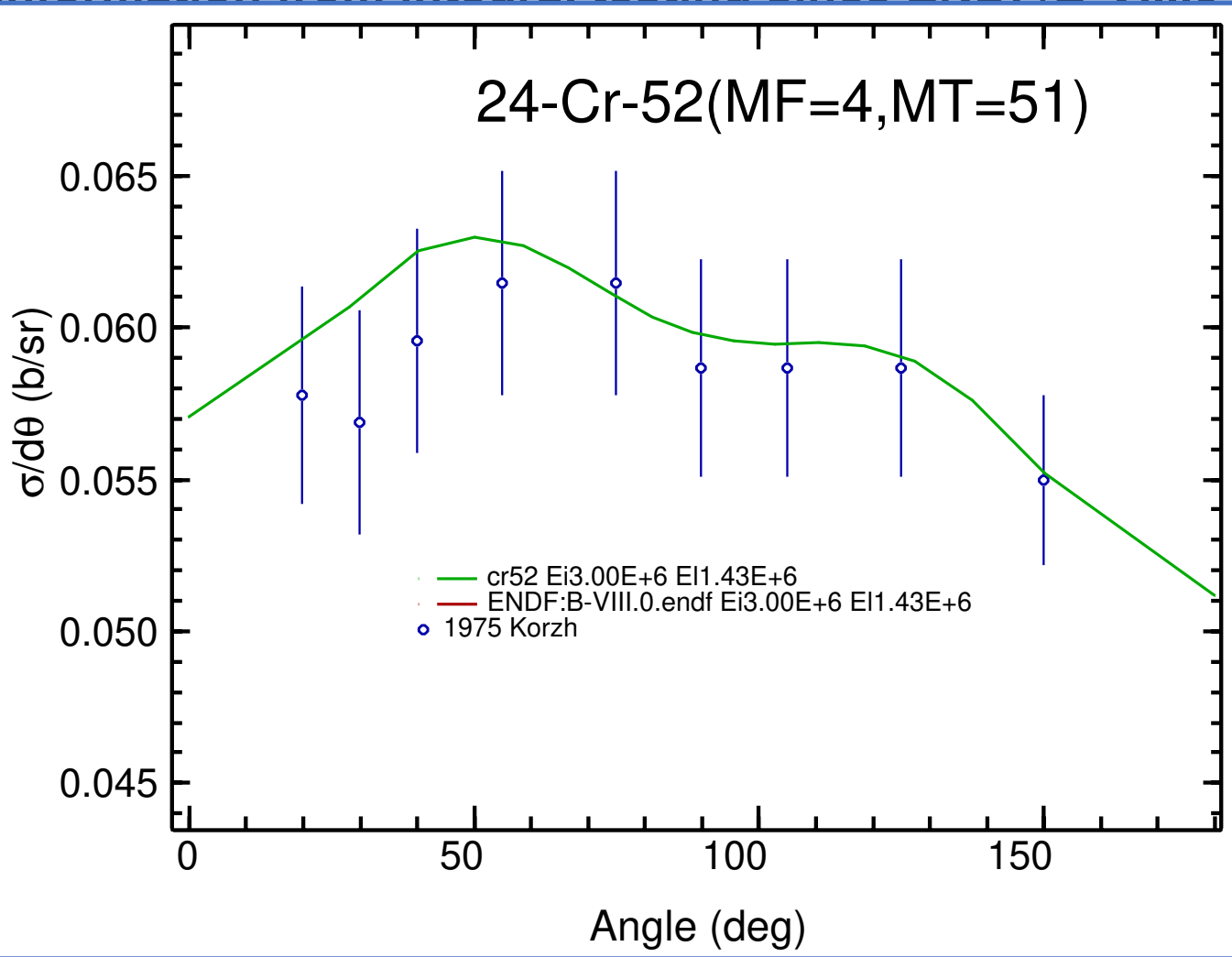


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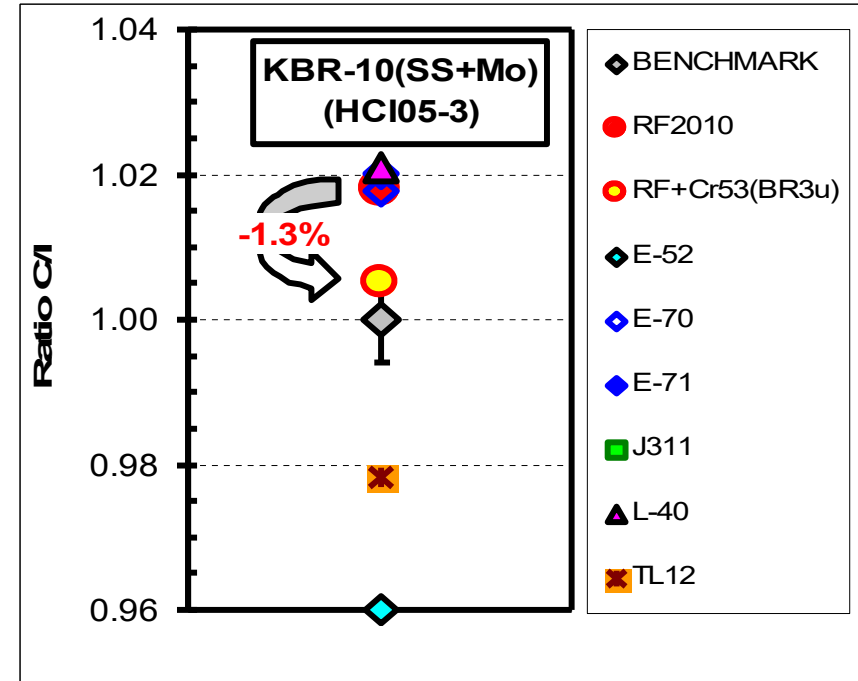
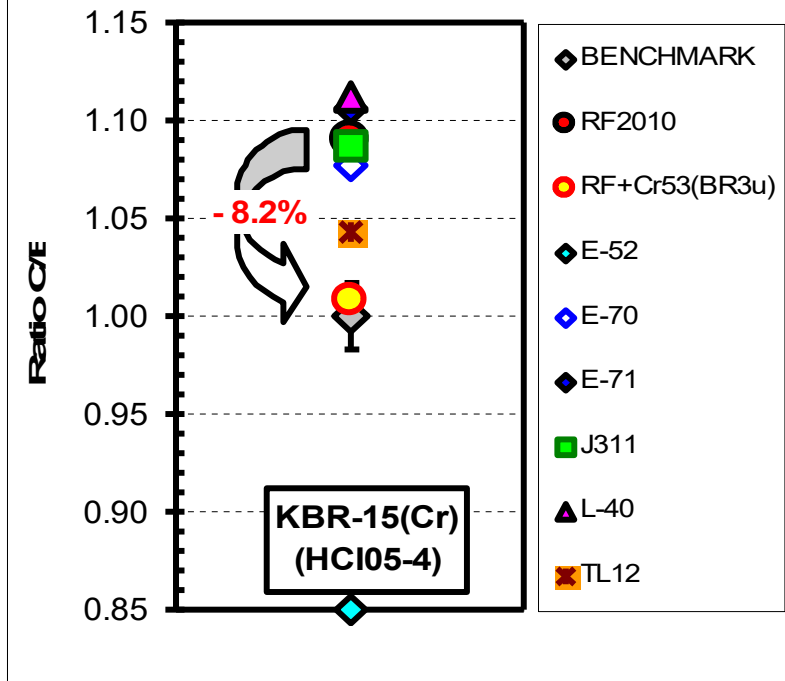
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Adjusted parameters of first ^{53}Cr resonances were embedded in ROSFOND 2010 library. Left panel shows results for HCl05-4 assembly heavily loaded by Chromium, right panel - for HCl05-3 loaded by stainless steel and Molybdenum. Benchmark for assembly loaded by natural Nickel shows C/E close to 1.

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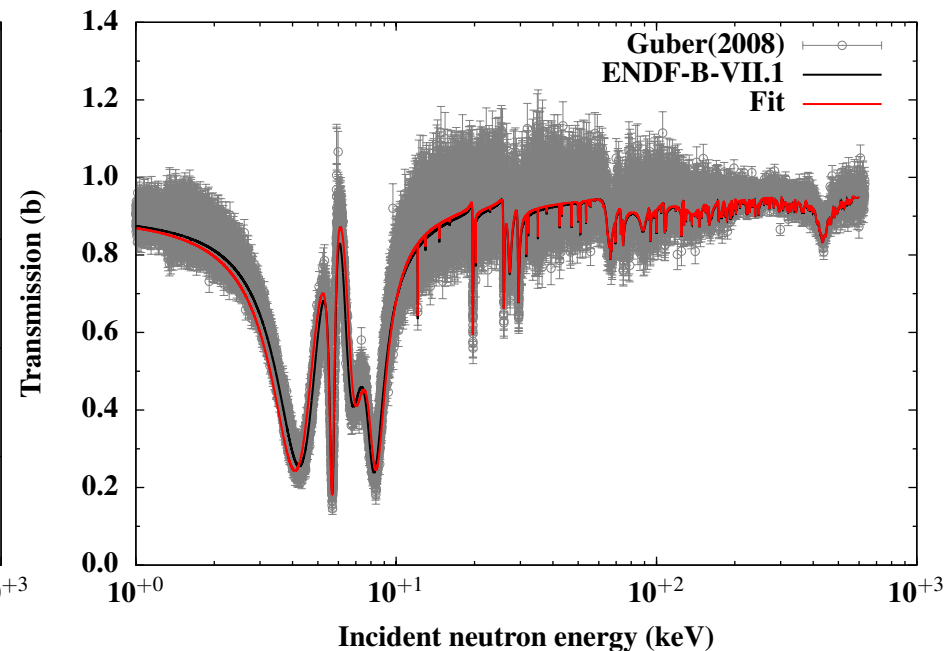
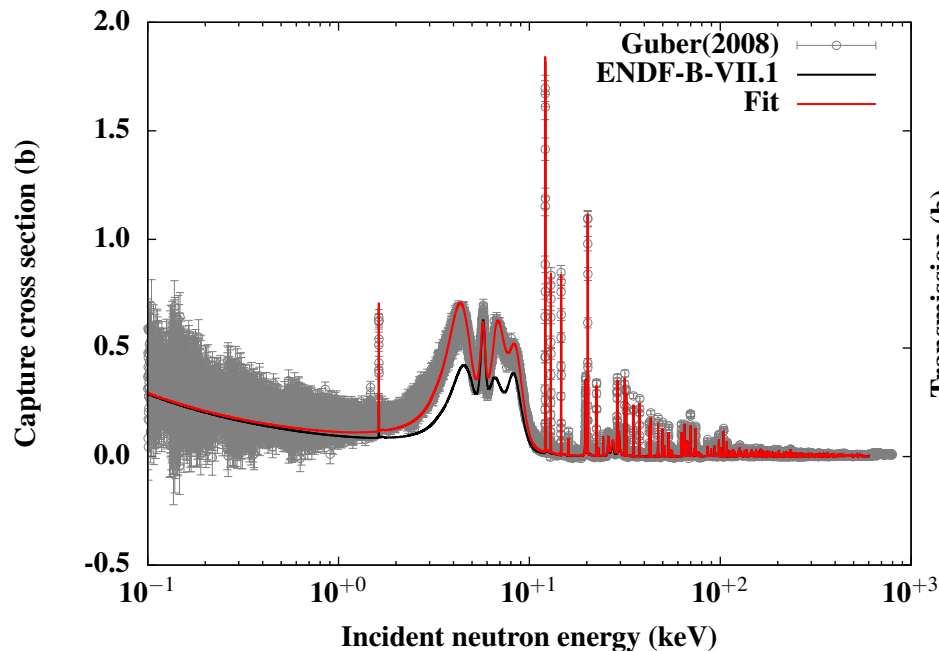
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Preliminary (re)fits of ^{53}Cr by Pigni (Mar. 2017)

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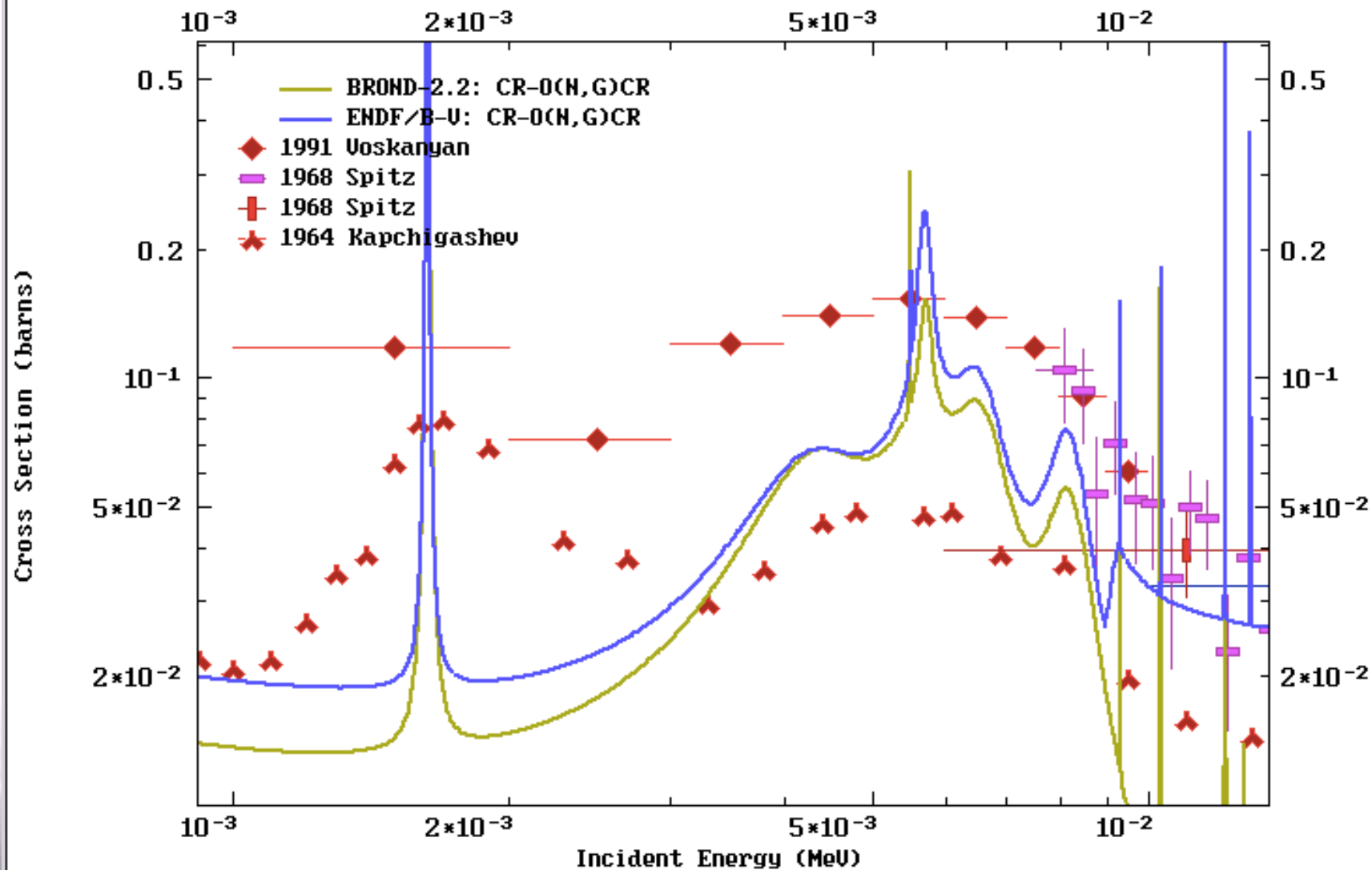
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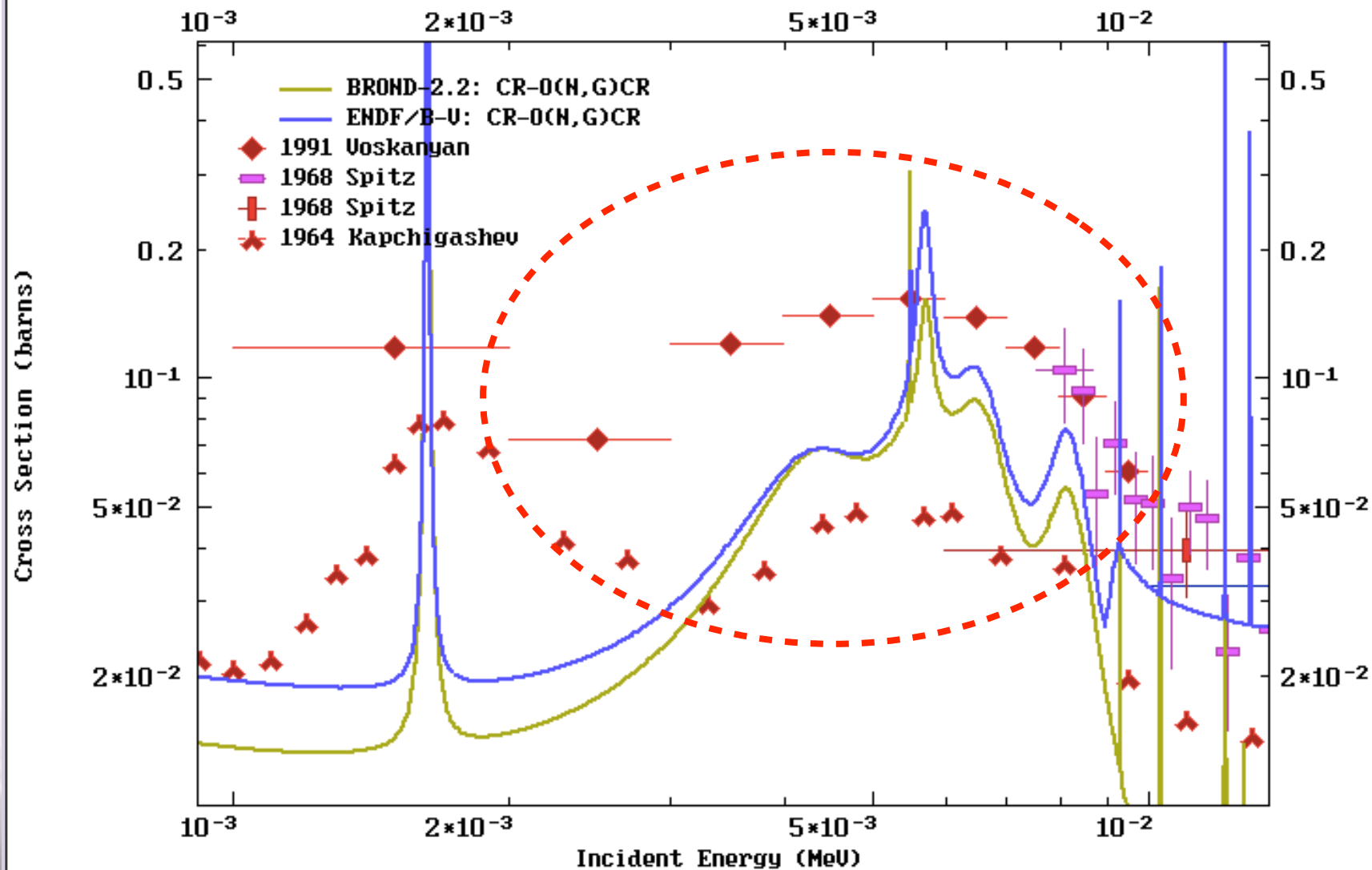
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ENDF Request 22735, 2018-10-31, 15:48:29
EXFOR Request: 70439/1, 2018-10-31 15:47:58



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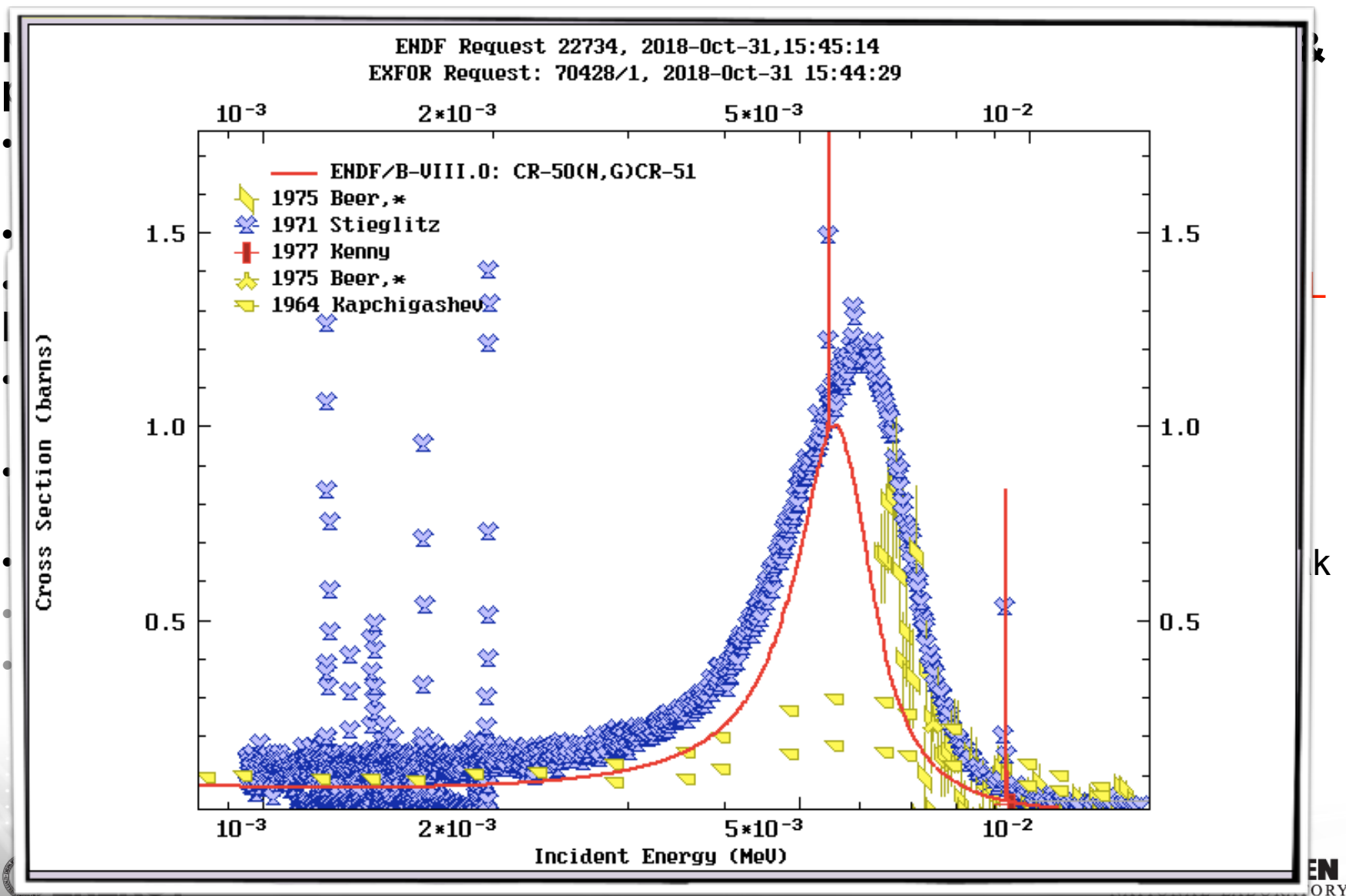
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- Exp. transmission data from Carlton for ⁵⁴Cr(n,total) not taken into account.
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Cr Plans for Next Evaluation

- **Integrator**

- Lead for RRR — ORNL, with BNL help
- Lead for Fast — BNL, with IAEA help
- Lead for Validation — IAEA/BNL

- **Team Will Involve**

- BNL, ORNL, IAEA

- **Objective**

- Consistent treatment of fluctuations and (n,n'g) data, describe capture correctly to improve integral performance

^{90}Zr Status

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- Criticality performance: any new/ unexpected findings? $^{90,91}\text{Zr}$, $S_{\alpha\beta}$ in thermal & intermediate systems [Snoj et al, Ann. Nucl. En 42, 71 (2012)]
- Neutron transmission: any new/ unexpected findings? Zr Oktavian sphere (unevaluated)
- (n,xn) activations: any new/unexpected findings? (n,2n) deficient [RPSD-2018 contrib #25362]

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections
- Last ENDF Evaluation: BNL/KAERI, 2011

- Unused: (n,n'g) data from P. Garrett et al. Phys Rev. C,68,024312 (2003)
- New data:
 - [RP] Resonance energy, 2013 G.Tagliente+, 2 points
 - (n,2n), 2016 A.A.Filatenkov, 7 points
 - (n,2n), 2016 A.A.Filatenkov, 8 points
 - (n,a),2016 A.A.Filatenkov, 7 points
 - (n,g) [RP] Resonance strength, 2013 G.Tagliente+, 2 points
 - (n,p),2016 A.A.Filatenkov, 7 points
 - (n,p), 2012 P.M.Prajapati+, 1 point
 - (n,x)89Y, 2016 A.A.Filatenkov, 6 points

^{91}Zr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? $^{90,91}\text{Zr}$, $S_{\alpha\beta}$ in thermal & intermediate systems [Snoj et al, Ann. Nucl. En 42, 71 (2012)]
- Neutron transmission: any new/unexpected findings? Zr Oktavian sphere (unevaluated)
- (n,xn) activations: any new/unexpected findings? No

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections
- Last ENDF Evaluation: BNL/KAERI, 2011
- New data:
 - [RP] Resonance energy, 2013 G.Tagliente+, 5 points
 - [RP] Resonance strength, 2013 G.Tagliente+, 5 points

^{92}Zr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**
- Neutron transmission: any new/unexpected findings? **Zr Oktavian sphere (unevaluated)**
- (n,xn) activations: any new/unexpected findings? **No**

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections
- Last ENDF Evaluation: BNL/KAERI, 2011
- New data:
 - [RP] Resonance energy, 2013 G.Tagliente+, 4 points
 - [RP] Resonance strength, 2013 G.Tagliente+, 4 points
 - (n,p), 2016 A.A.Filatenkov, 7 points

^{94}Zr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**
- Neutron transmission: any new/unexpected findings? **Zr Oktavian sphere (unevaluated)**
- (n,xn) activations: any new/unexpected findings? **$^{94}\text{Zr}(n,g)$ in IRDFF**

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections
- Last ENDF Evaluation: BNL/KAERI, 2011
- RI, thermal cross sections may need work (Trkov, Herman report (2011))

• New data:

- [RP] Resonance energy, 2013 G.Tagliente+, 2 points
- [RP] Resonance energy, 2011 G.Tagliente+, 50 points
- (n,a), 2016 B.Champine+, 5 points
- (n,a), 2016 A.A.Filatenkov, 7 points
- [RP] Reich-Moore resonance width, 2011 G.Tagliente+, 36 points
- [RP] Resonance strength, 2013 G.Tagliente+, 2 points
- [RP] Reich-Moore resonance strength, 2011 G.Tagliente+, 50 points
- [RI] Resonance integral, 2014 K.S.Krane, 1 point
- (n,g) Reaction yield, 2011 G.Tagliente+, 21724 points
- (n,g), 2013 F.Farina Arbocco+, 1 point
- (n,g), 2012 P.M.Prajapati+, 1 point

93, 95Zr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**
- Neutron transmission: any new/unexpected findings?
None known
- (n,xn) activations: any new/unexpected findings? **No**

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections

^{96}Zr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**
- Neutron transmission: any new/unexpected findings? **Zr Oktavian sphere (unevaluated)**
- (n,xn) activations: any new/unexpected findings? **$^{96}\text{Zr}(n,g)$ in IRDFF**

Known deficiencies/gaps:

- RRR, URR, Fast region inconsistent
- Elastic angular distribution inconsistent with cross sections
- Last ENDF Evaluation: BNL/KAERI, 2011
- RI, thermal cross sections may need work (Trkov, Herman report (2011))

• New data:

- [RP] Resonance energy, 2013 G.Tagliente+, 3 points
- [RP] Resonance energy, 2011 G.Tagliente+, 15 points
- (n,2n), 2016 A.A.Filatenkov, 7 points
- [RP] Reich-Moore resonance width, 2011 G.Tagliente+, 13 points
- [RP] Resonance strength, 2013 G.Tagliente+, 3 points
- [RP] Reich-Moore resonance strength, 2011 G.Tagliente+, 15 points
- (n,g) Particle multiplicity d/dE, 2011 T.Katabuchi+, 155 points
- [RI] Resonance integral, 2014 K.S.Krane, 1 point
- (n,g) Reaction yield, 2011 G.Tagliente+, 26265 points
- (n,g), 2014 F.Farina Arbocco+, 1 point
- (n,g), 2011 T.Katabuchi+, 4 points

Zr Plans for Next Evaluation

• Integrator

- Lead for RRR — ORNL, with BNL help
- Lead for Fast — BNL
- Lead for Validation — BNL can do ICSBEP benchmarks, will need help with Oktavian spheres

• Team Will Involve

- BNL, LLNL (Escher), ORNL

• Objective

- Consistent treatment of fluctuations and (n,n'g) data

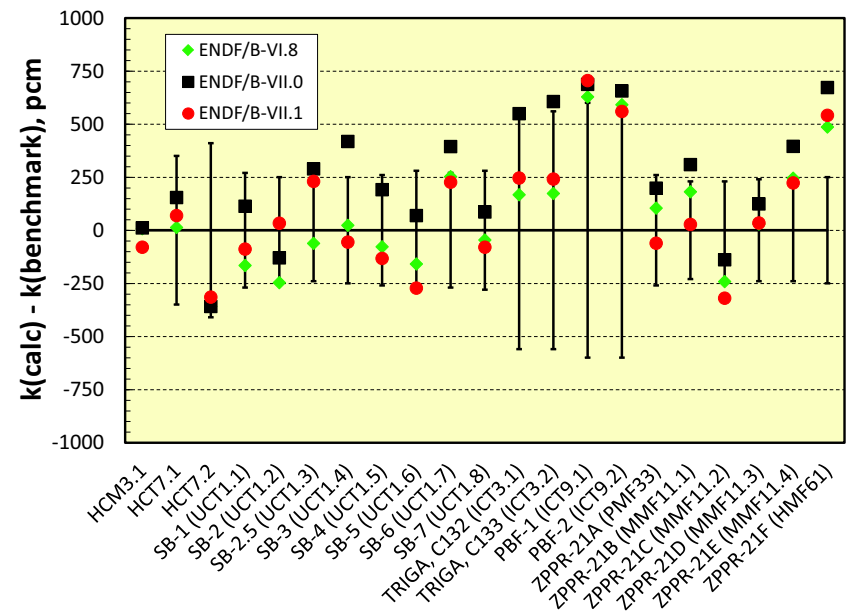


FIG. 20: Calculated eigenvalues for a suite of ICSBEP benchmarks containing zirconium.

A.C. Kahler, et al. NDS, 112, 2997 (2011)

^{204}Pb Status

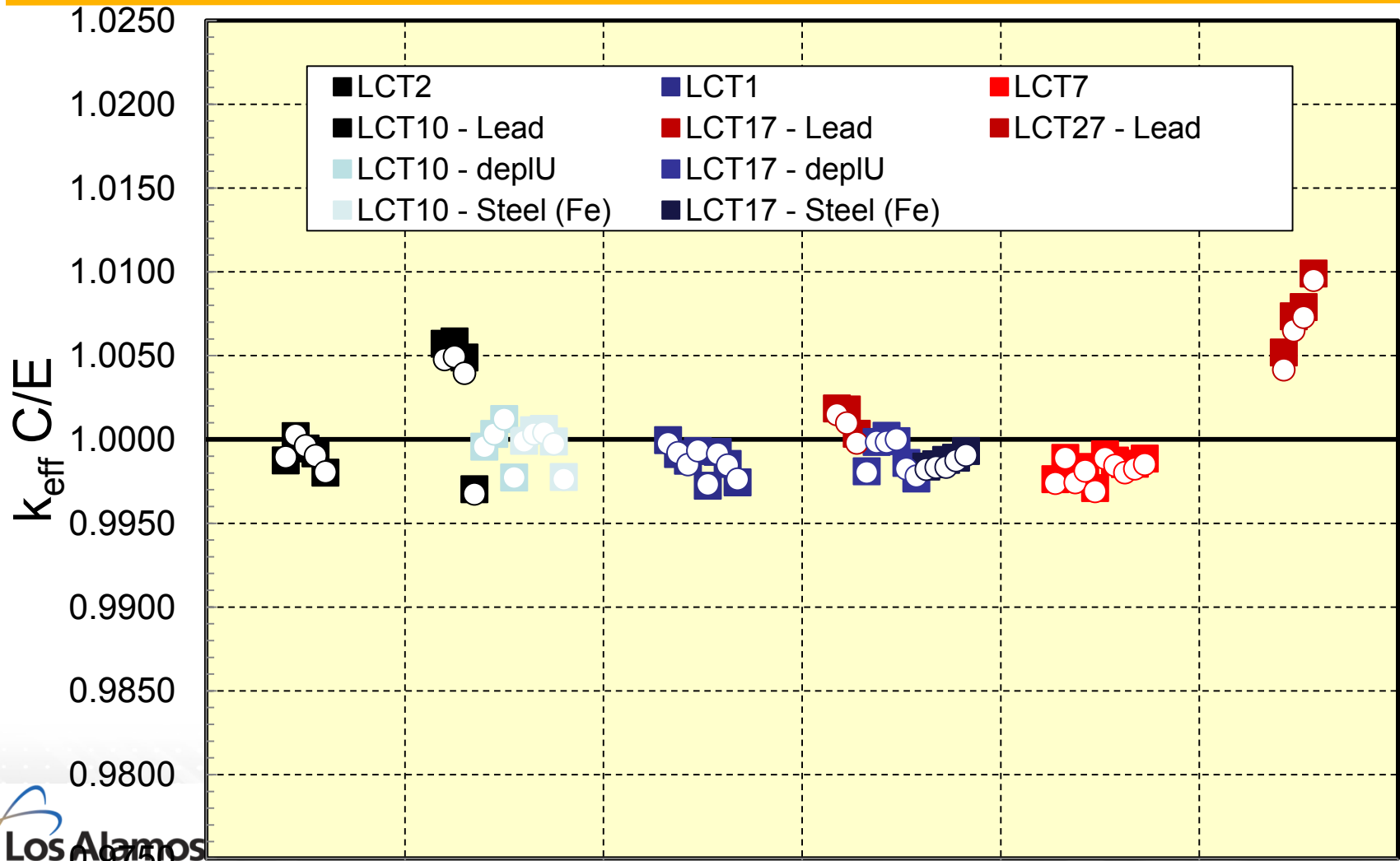
New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No, LCT's still need work**
- Neutron transmission: any new/unexpected findings? **No, e.g. Pb LLNL pulsed spheres unchanged since 2006, not great**
- (n,xn) activations: any new/unexpected findings?
 $^{204}\text{Pb}(n,n')^{204\text{m}}\text{Pb}$ in IRDFF

Known deficiencies/gaps:

- Generally poor agreement between elastic angular distributions reconstructed from RRR and from fast region OMP calculations

Fast Systems with Pb



^{206}Pb Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No, LCT's still need work**
- Neutron transmission: any new/unexpected findings? **No, e.g. Pb LLNL pulsed spheres unchanged since 2006, not great**
- (n,xn) activations: any new/unexpected findings? **No**

Known deficiencies/gaps:

- Generally poor agreement between elastic angular distributions reconstructed from RRR and from fast region OMP calculations
- New data: (n,xn γ) from Mihailescu, et al. Euratom Report 22343 (2006)
- New data: (n,xn γ) from Negret, et al. Phys. Rev. C,91,064618 (2015)

^{207}Pb Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**, **LCT's still need work**
- Neutron transmission: any new/unexpected findings? **No**, e.g. **Pb LLNL pulsed spheres unchanged since 2006, not great**
- (n, xn) activations: any new/unexpected findings? **No**

Known deficiencies/gaps:

- Generally poor agreement between elastic angular distributions reconstructed from RRR and from fast region OMP calculations
- New data: $(n, xn\gamma)$ from Mihailescu, et al. Euratom Report 22343 (2006)

^{208}Pb Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **No**, **LCT's still need work**
- Neutron transmission: any new/unexpected findings? **No**, e.g. **Pb LLNL pulsed spheres unchanged since 2006, not great**
- (n,xn) activations: any new/unexpected findings? **No**

Known deficiencies/gaps:

- Generally poor agreement between elastic angular distributions reconstructed from RRR and from fast region OMP calculations
- New data: L.C. Mihailescu, et al. "A measurement of (n,xn γ) cross sections for ^{208}Pb from threshold up to 20 MeV", Nuclear Physics A 811, pp. 1-27 (2008)

Pb Plans for Next Evaluation

• Integrator

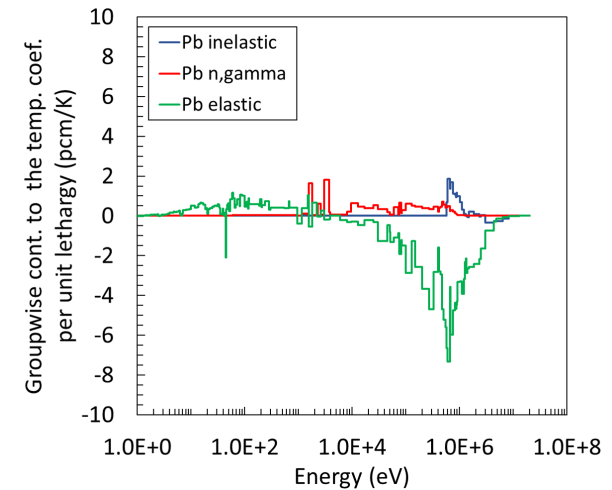
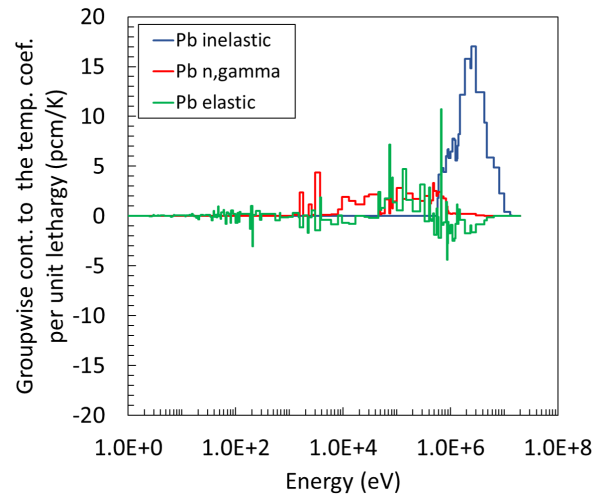
- Lead for RRR — RPI
- Lead for Fast — BNL
- Lead for Validation — ?

• Team Will Involve

- BNL, RPI, ORNL, Westinghouse

• Objective

- Consistent treatment of fluctuations and (n,n'g) data



P. German, et al. "SENSITIVITY AND UNCERTAINTY STUDIES FOR THE ALFRED LEAD COOLED FAST REACTOR CORE" PHYSOR-2018 proceedings, Cancun MX (2018)

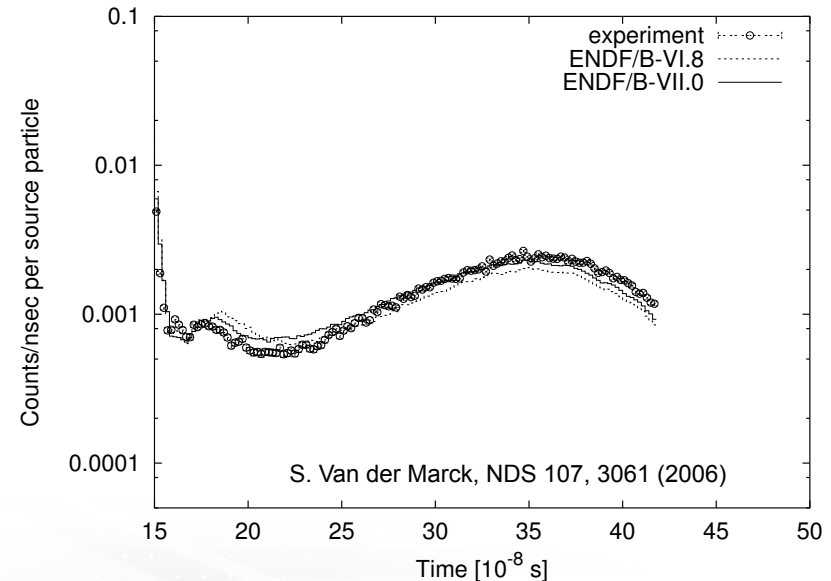


FIG. 128: Neutron spectrum for the LLNL Pulsed Sphere, Pb (1.4 mfp) benchmark, angle=39°.

^{86}Kr Status

New information from integral testing since ENDF/B-VIII.0 release & publications

- Criticality performance: any new/unexpected findings? **N/A**
- Neutron transmission: any new/unexpected findings? **N/A**
- (n,xn) activations: any new/unexpected findings? **Interest at LANL & LLNL**

Known deficiencies/gaps:

- 1 b under prediction of (n,tot) ; (n,tot) missing fluctuations above RRR, evident in Carlton data (#13149.003)
- $(n,2n)$ cross section dramatically over predicts Bhike data (#14429.003)
- (n,g) cross section above RRR has bad shape compared to Bhike (#14429.002)
- $(n,n'g)$ in bad shape compared to Fotiades (#14368.002)
- RRR hasn't been touched in long time (Mughabghab, part of SG-23, 2006)

^{86}Kr Plans for Next Evaluation

- **Integrator**

- Lead for RRR — BNL?
- Lead for Fast — BNL
- Lead for Validation — hopefully LLNL!

- **Team Will Involve**

- BNL, LLNL, LBNL (A. Lewis), FSU (E. Rubino)

- **Objective**

- Consistent treatment of fluctuations and (n,n'g) data