ENDF/B-VIII.0 Evaluations for Carbon, Oxygen, and the Light-Element Standards

Nuclear Data Week

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Brookhaven National Laboratory

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Outline

- **ENDF/B-VIII.0 ^{16}O evaluation**
  - Low-energy scattering cross sections
  - ^{13}C(α,n) and ^{16}O(n,α_0) cross sections
  - Fits, data renormalizations, etc.
  - Differences with VII.1
  - Data testing, plans for β4
- **ENDF/B-VIII.0 ^{12,13}C evaluations**

- **Light-element standards (^{1}H, ^{6}Li, ^{10}B, C)**

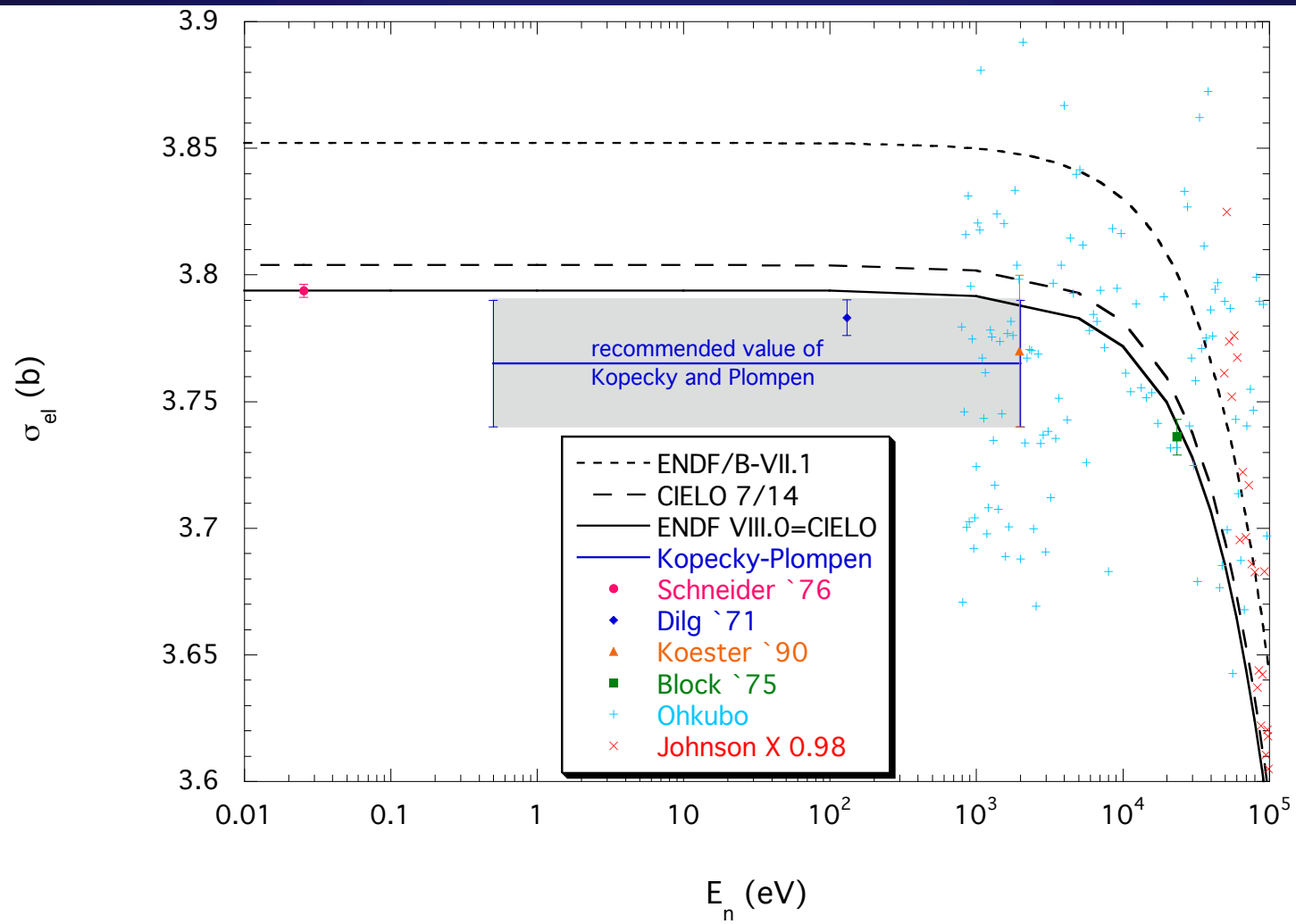
R-Matrix Analysis of Reactions in the ^{17}O System

channel	a_c (fm)	l_{max}
n+^{16}O	4.4	4
α+^{13}C	5.4	5

Reaction	Energies (MeV)	# data points	Data types
$^{16}O(n,n)^{16}O$	$E_n = 0 – 7$	2540	σ_T, $\sigma(\theta)$, $P_n(\theta)$
$^{16}O(n,\alpha)^{13}C$	$E_n = 2.35 – 5$	672	σ_{int}, $\sigma(\theta)$, $A_n(\theta)$
$^{13}C(\alpha,n)^{16}O$	$E_\alpha = 0 – 5.4$	870	σ_{int}
$^{13}C(\alpha,\alpha)^{13}C$	$E_\alpha = 2 – 5.7$	1168	$\sigma(\theta)$
total		5250	8

χ^2 per degree of freedom = 1.68

n+^{16}O Elastic Scattering Cross Section

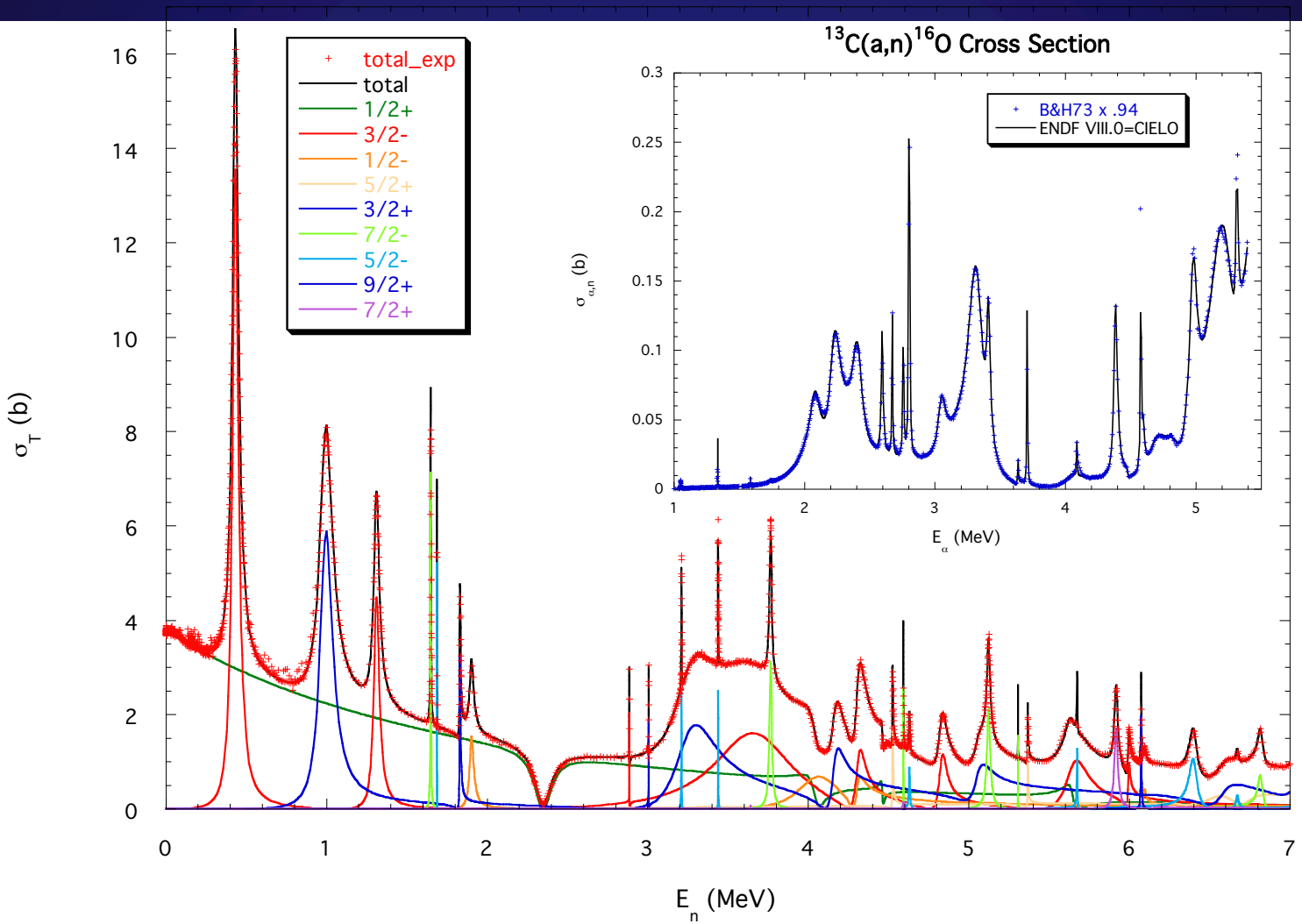


Total Cross Section Data

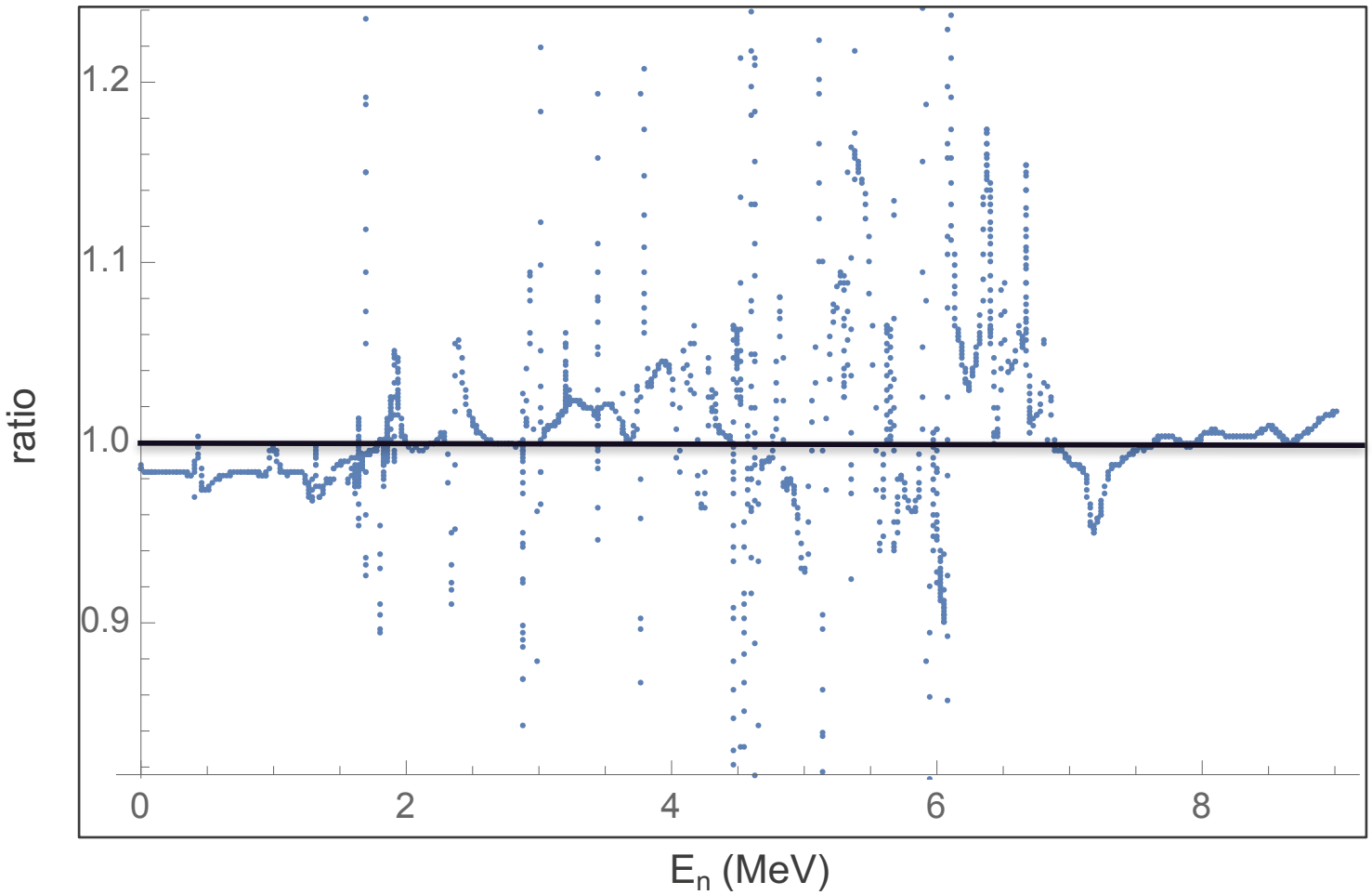
Authors (n,n):	Energy Range	Energy Shift	Normalization
Schneider	0.0253 eV	0	1.0 (fixed)
Dilg,Koester,Block	0.13 – 23.5 keV	0	1.0 (fixed)
Ohkubo (corr. for H)	0.8 – 935 keV	0	0.9989
Johnson & Fowler (including LOX)	49 – 3139 keV	0	0.9799
Cierjacks et al.	3.143 – 7.0 MeV	0	1.0378

Authors (α,n):	Energy Range	Energy Shift	Normalization
Drotleff et al.	346 – 1389 keV	0	1.0 (fixed)
Heil et al.	416–899 keV	0	1.0 (fixed)
Kellogg	445–1045 keV	0	1.506
Bair and Haas	0.997–5.402 MeV	-4 keV	0.9410

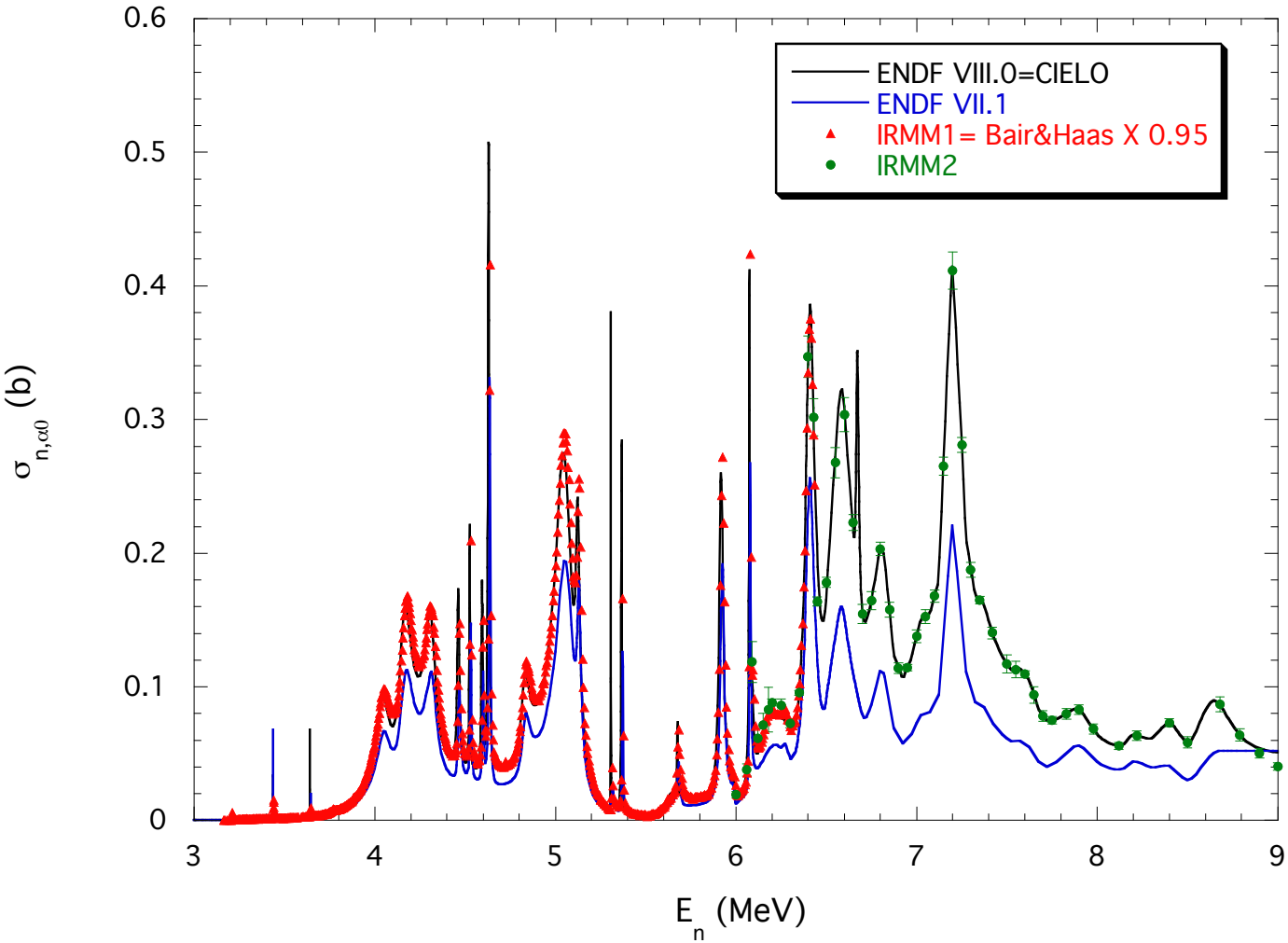
Integrated (total) Cross Sections



Ratio of ENDF/B-VIII.0/VII.1 σ_T for Oxygen



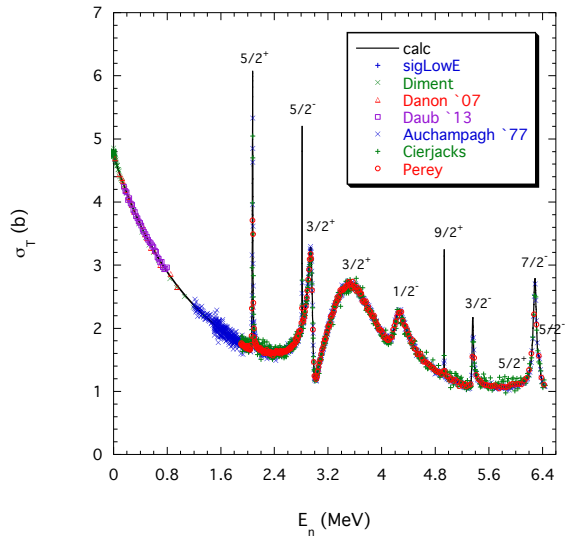
$^{16}O(n,\alpha_0)^{13}C$ Cross Section

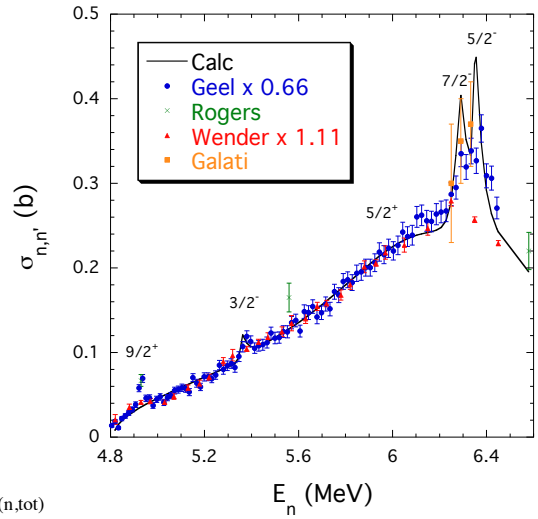


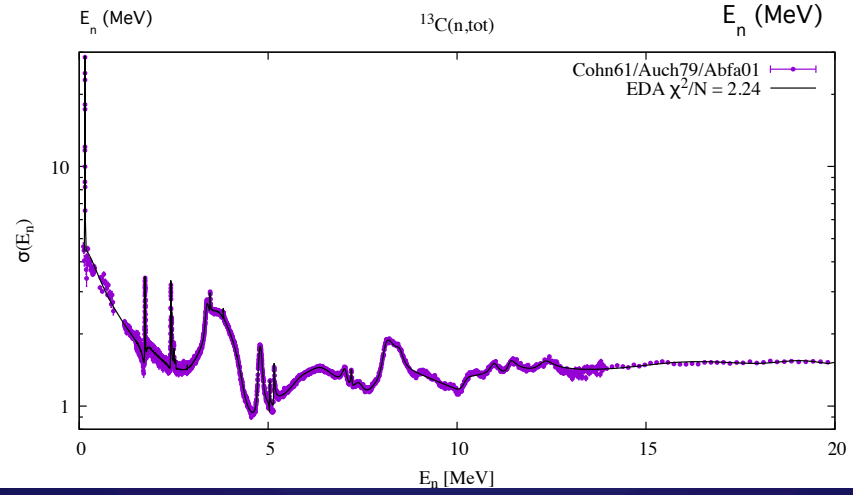
Summary for n+^{16}O

- The low-energy scattering cross sections are now in good agreement with high-precision measurements by Schneider, Koester, and Block.
- The (n,α_0) cross section agrees with the data of B&H73, IRMM07 (Giorginis) at a normalization scale (0.94) consistent with unitarity.
- Post-analysis check showed good agreement (≤ 1% on energy-binned cross-section ratios) with RPI σ_T data.
- The evaluated ENDF/BVIII.0-β3 file extends to 150 MeV, and is the same as ENDF/B VII.1 above 9 MeV (except for capture).
- Despite large changes in the cross sections from VII.1 to VIII.0, changes in the benchmarks are of the order of 100 pcm.
- Further work for β4: improve capture cross section above 1st resonance; update covariances for all reactions.

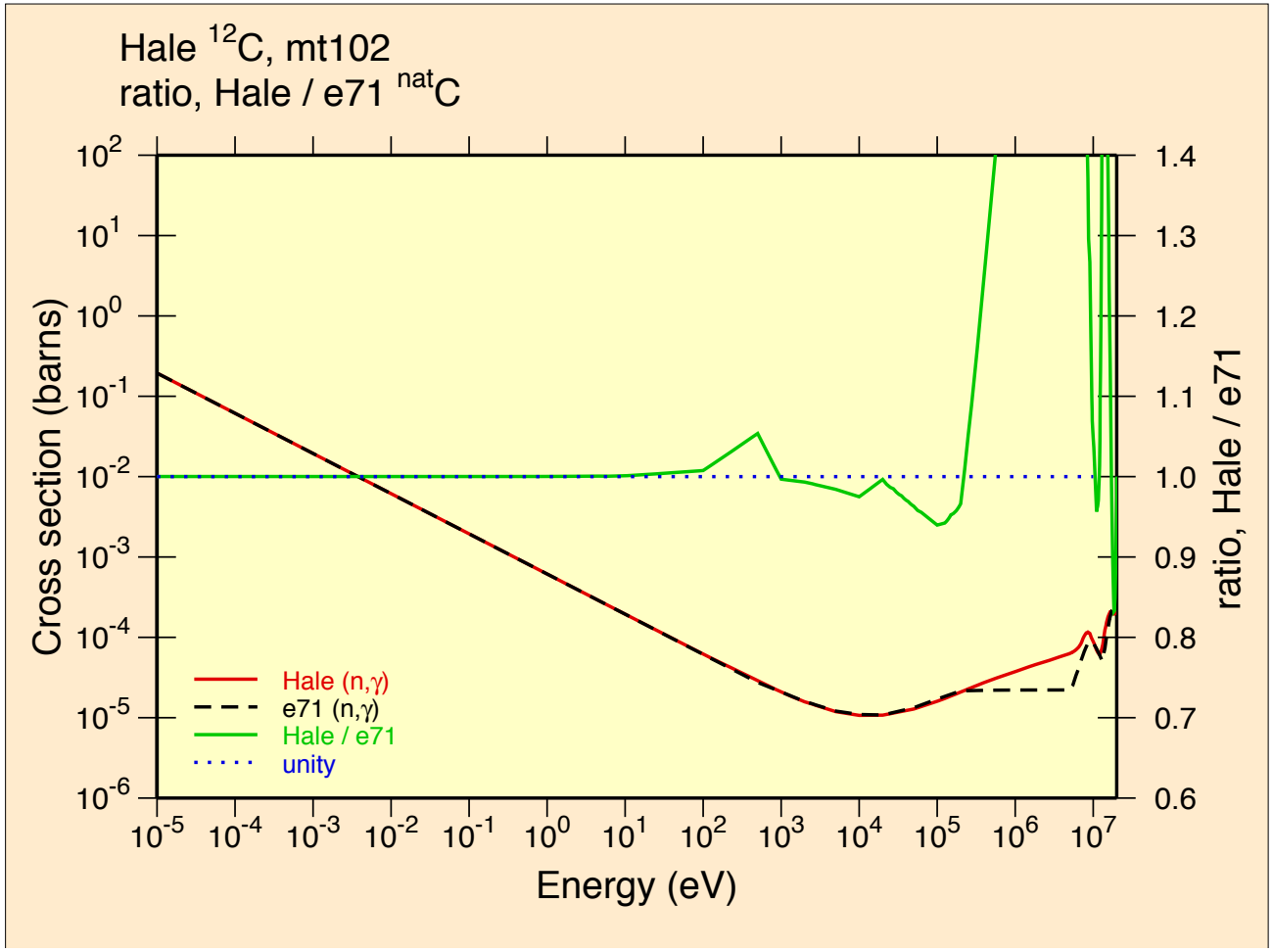
n+^{12,13}C Cross Sections



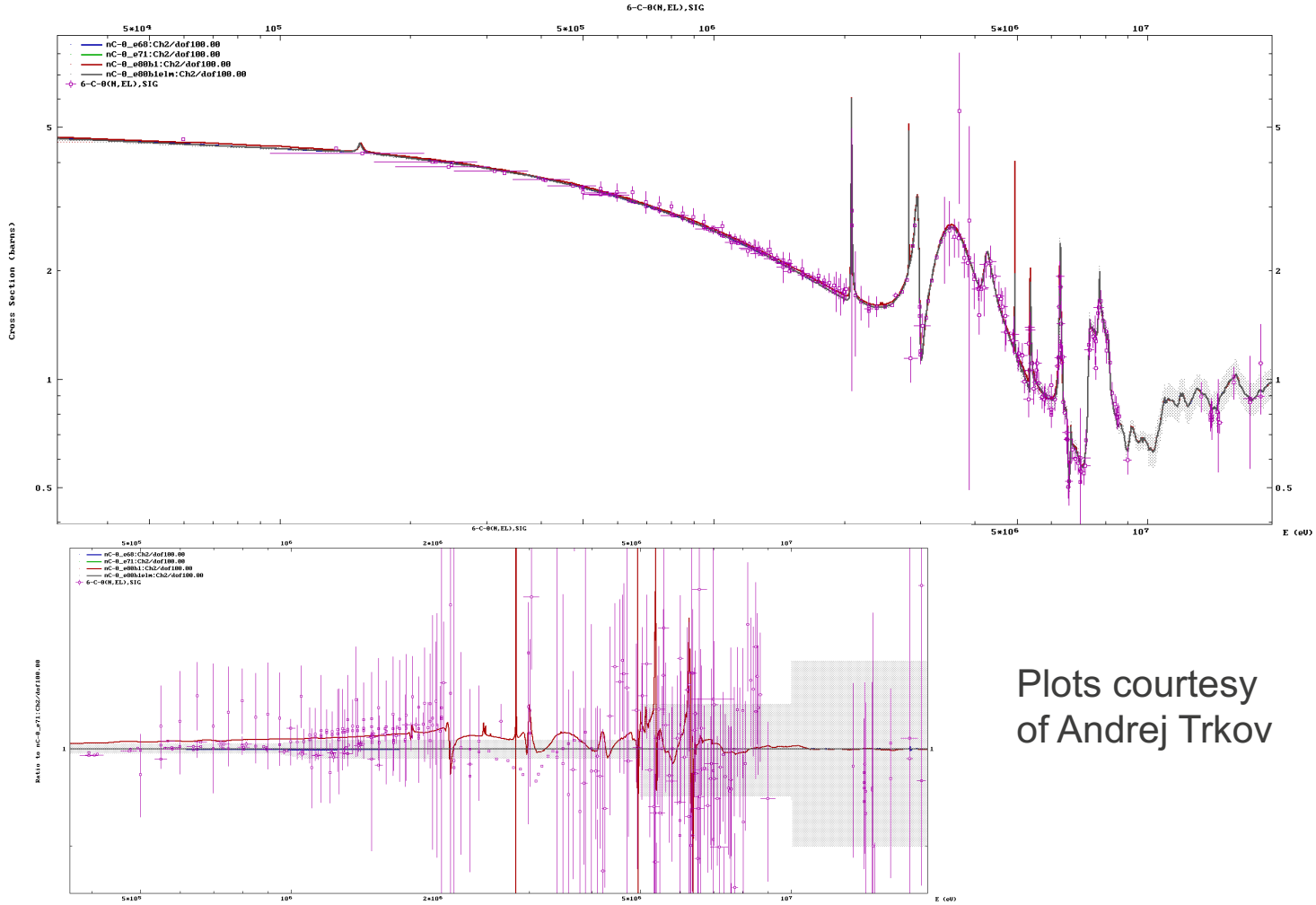




$^{12}C(n,\gamma)^{13}C$ Cross Section



Elastic Cross Section for Natural Carbon



Plots courtesy of Andrej Trkov

Summary for $^{12,13}C$

- The ^{13}C EDA analysis gives a good fit to all the n+^{12}C data included at energies up to about 6.5 MeV.
- More channels have been added to the ^{14}C analysis in extending it to higher energies (20 MeV). Above that energy, we plan to merge with the existing evaluation in the TENDL file.
- The $^{12,13}C(n,\gamma)$ cross sections have been improved, and give better agreement with the MACS in the KADoNIS data base (J.-C. Sublet).
- The elastic scattering cross section for natural carbon becomes ~ 2% larger than ENDF/B VII.1 around 2 MeV. That difference exceeds the maximum estimated uncertainty (0.6%) of the standard cross section at the upper end of its energy range (1.8 MeV), but may be in better agreement with the measurements.

Analyses for the Light-Element Standards

- n-p scattering: N-N analysis goes up to 100 MeV; plan to to extend it to 200 MeV.
- ^{6}Li(n,t): ^{7}Li analysis gives excellent fits (χ^2/ν=1.36) to data up to 4 MeV.
- ^{10}B(n,α): ^{11}B analysis gives excellent fits (χ^2/ν=1.14) to data up to 1 MeV.
- Natural carbon: σ_{el} increased ~2% at 2 MeV, as already shown.