UNCERTAINTY TREATMENT IN THE UNRESOLVED RESONANCE REGION

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Background

- Several motivations for the present investigation :

  - Uncertainty analysis of total, capture and scattering cross sections in the Unresolved Energy Region (URR). Fission process is not considered here.

  - Testing and validation of the average resonance parameters, particularly the R' as well as the s- and p-wave strength functions, in the Atlas of Neutron Resonances, S. F. Mughabghab, Elsevier, 2006, which were derived in the resolved resonance region.

  - Supplementation of information where there is a lack of data regarding these quantities in certain mass regions, needed in the covariance library.

Background

- In the description of URR and calculations of covariances reliable values of R' and average resonance parameters are needed and required.
- R' are derived by the author to a high degree of accuracy from measured precise coherent scattering lengths provided the resonance information is complete.
- The average resonance parameters, S_0, S_1, Γ_0, Γ_1 can be obtained from the RRR, as was achieved in the Atlas.

Background

- However, the accuracy of these parameters is largely dependent on the number and parity assignments of resonances. For the latter part, Bayesian analysis was carried out, which is based on the strength of resonances. This introduces some uncertainty in these determinations, particularly in the mass region around mass 90. Resonances of ^{98}Mo are prime example.

Methodology

- $\langle \sigma_t \rangle = 4\pi R^2(\sin^2\delta_0 + 3\sin^2\delta_1) + 2\pi^2\sqrt{E}(S_0\cos^2 2\delta_0 + P_1 S_1 \cos^2 2\delta_1)/k^2$

- Adopt, as a starting point, the average resonance parameters derived on the basis of resolved resonance parameters of the Atlas .

Methodology

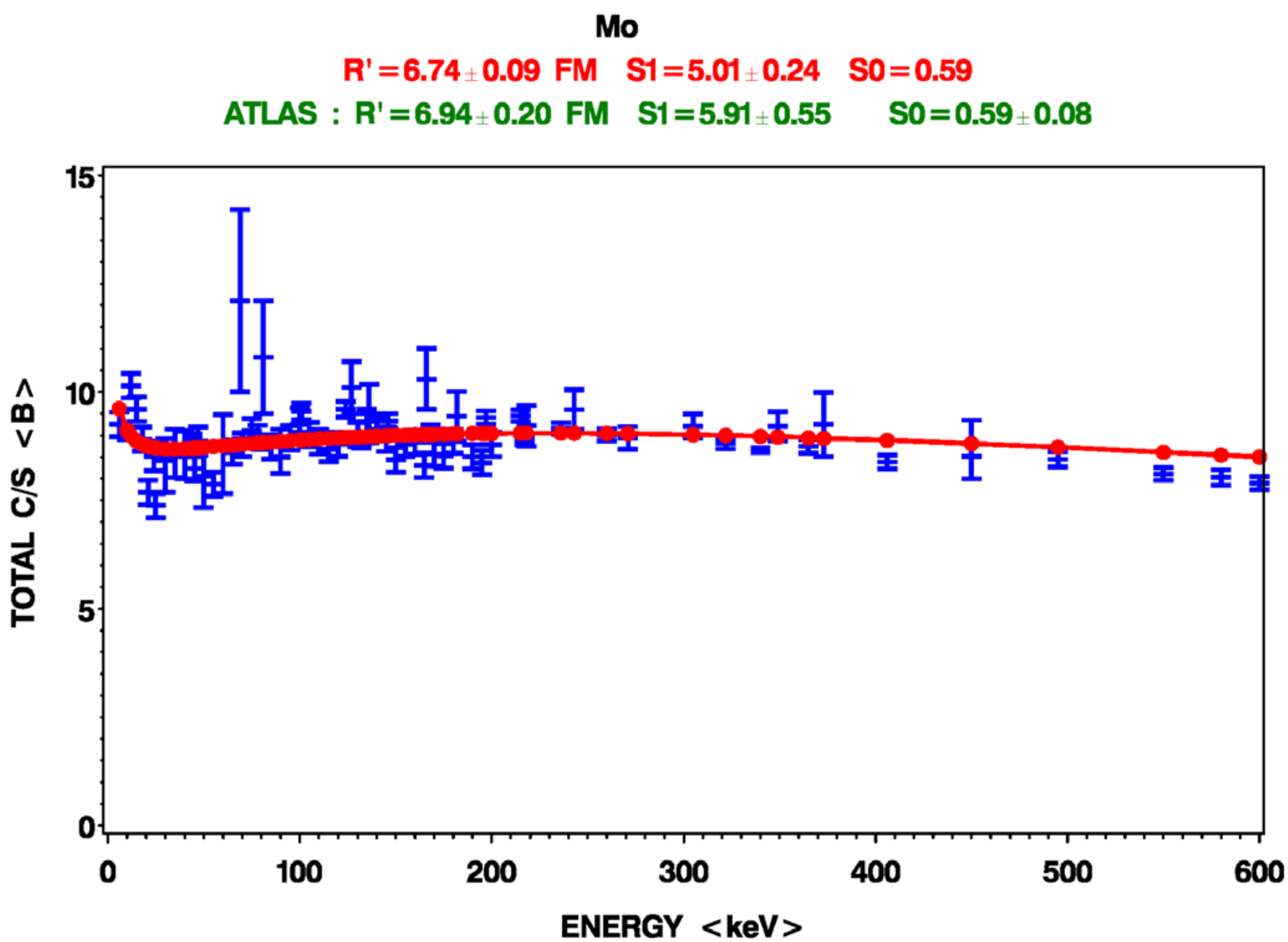
- Carry out a least-squares fit to the total cross section to derive R', the s- and p-wave strength functions.
- Calculate within the framework of Lane and Lynn the capture cross section in URR.
- Scattering cross section is then obtained by the difference of these computed values.

Methodology

- The uncertainties of the cross sections are then generated from the above relations.

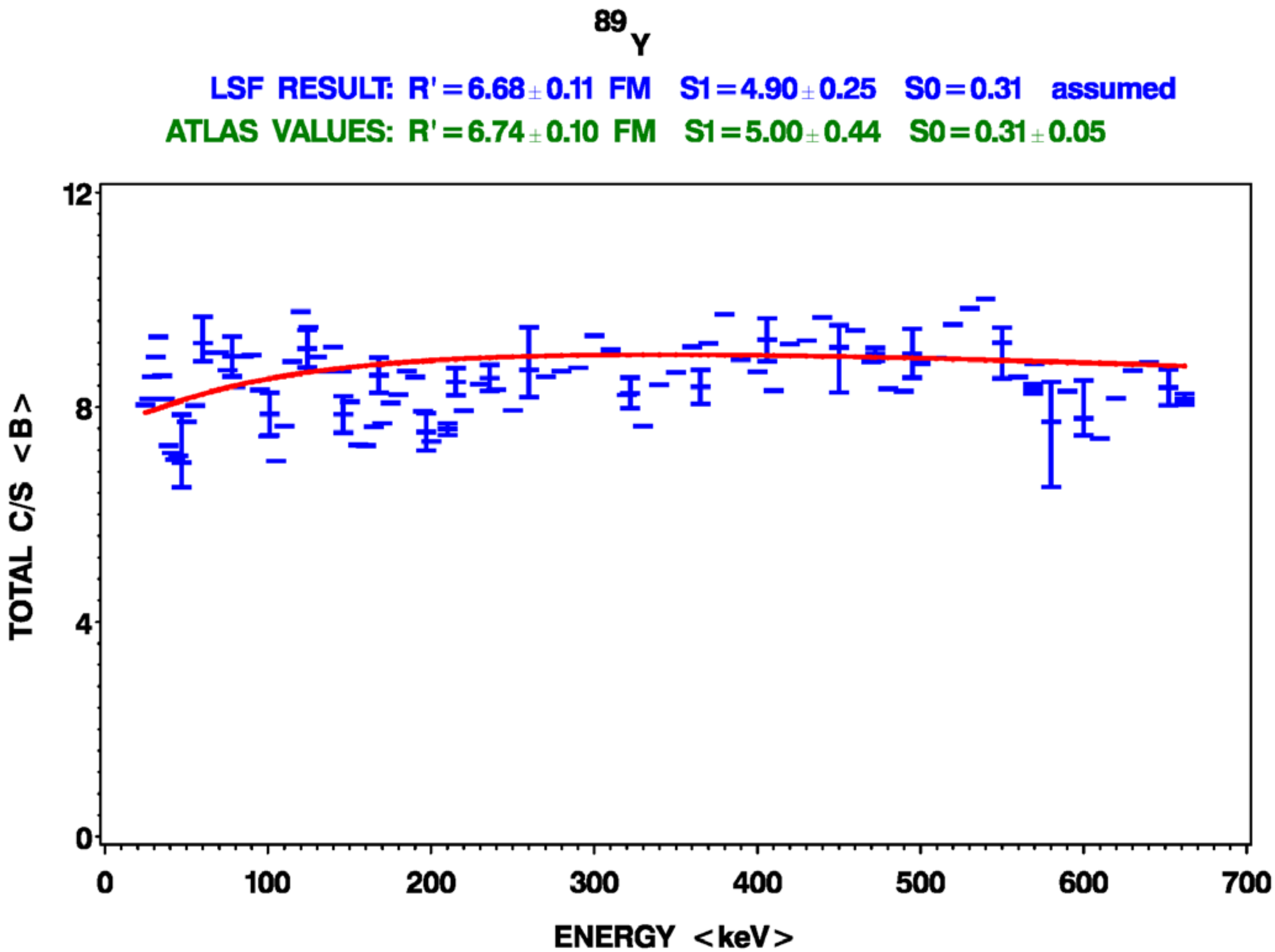
- When no data are available, as in the case of unstable nuclei, then average parameters and their uncertainties are obtained from the systematic trends.

RESULTS



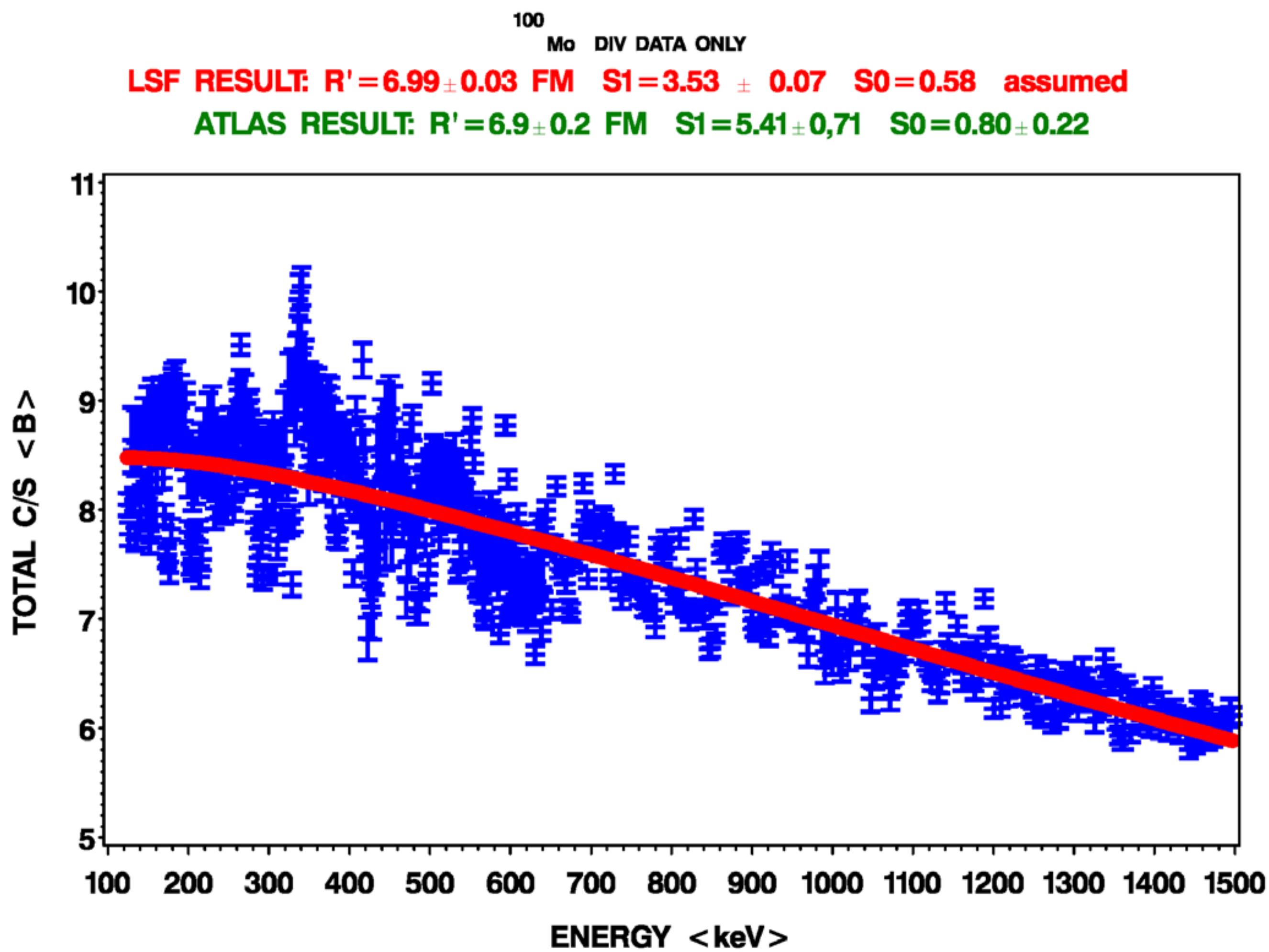
Mo
R' = 6.74 ± 0.09 FM S1 = 5.01 ± 0.24 S0 = 0.59
ATLAS : R' = 6.94 ± 0.20 FM S1 = 5.91 ± 0.55 S0 = 0.59 ± 0.08
TOTAL C/S <B>
ENERGY <keV>
0
5
10
15
0
100
200
300
400
500
600

RESULTS



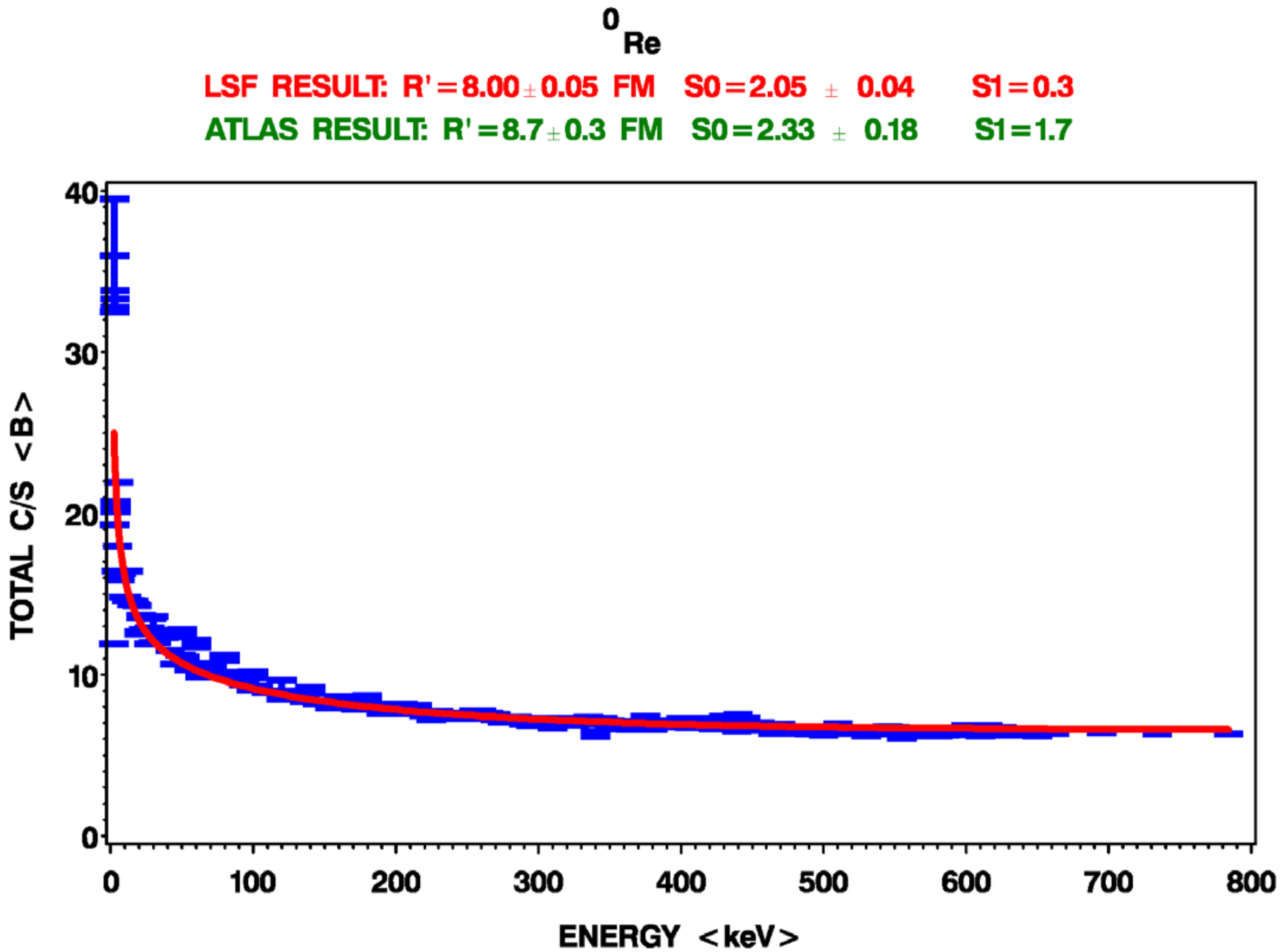
89Y
LSF RESULT: R' = 6.68 ± 0.11 FM S1 = 4.90 ± 0.25 S0 = 0.31 assumed
ATLAS VALUES: R' = 6.74 ± 0.10 FM S1 = 5.00 ± 0.44 S0 = 0.31 ± 0.05
TOTAL C/S <B>
ENERGY <keV>
0
4
8
12
0
100
200
300
400
500
600
700

RESULTS



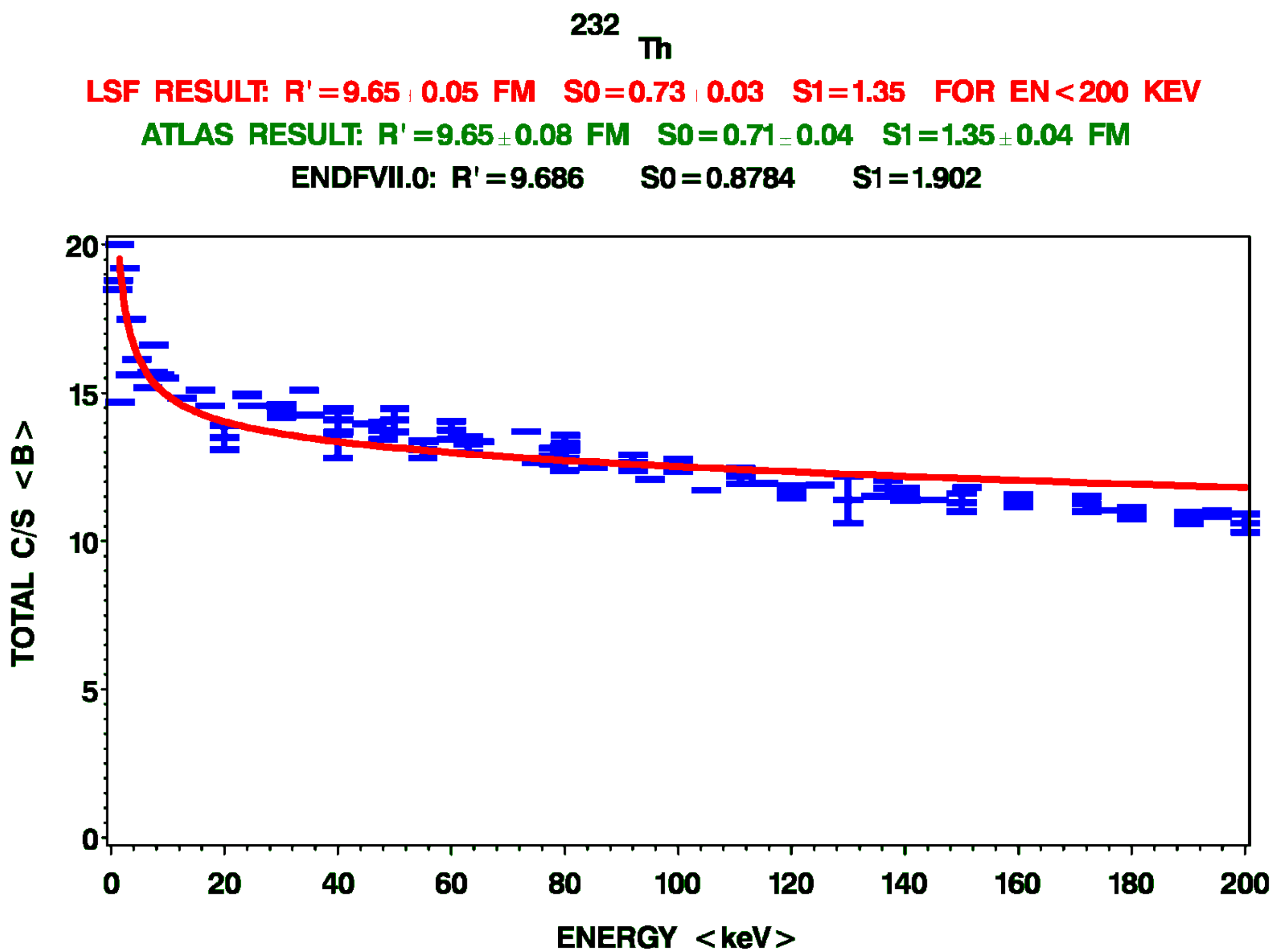
100 Mo DIV DATA ONLY
LSF RESULT: R'=6.99±0.03 FM S1=3.53 ± 0.07 S0=0.58 assumed
ATLAS RESULT: R'=6.9±0.2 FM S1=5.41±0,71 S0=0.80±0.22
TOTAL C/S <B>
ENERGY <keV>

RESULTS



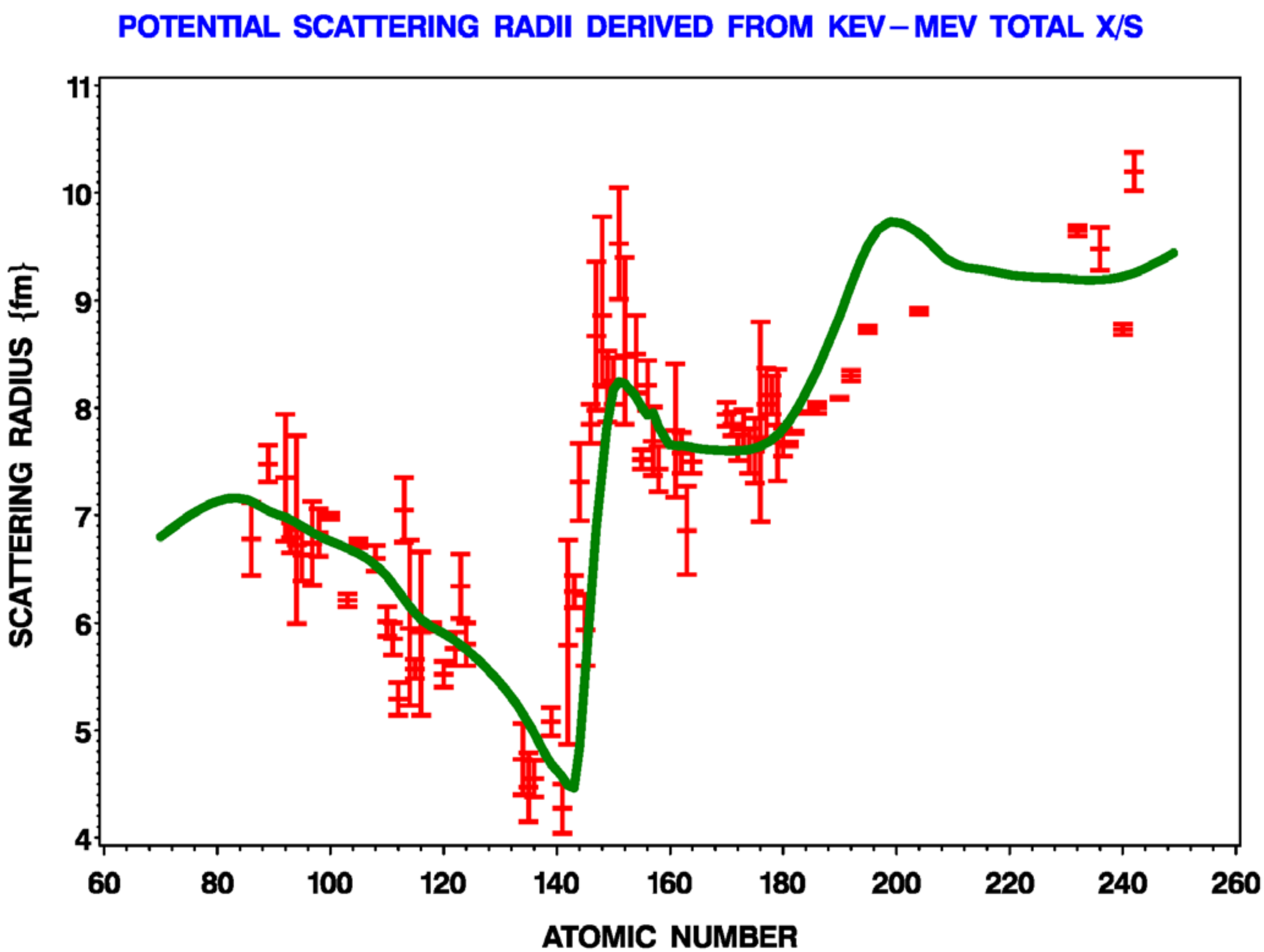
0 Re
LSF RESULT: R' = 8.00 ± 0.05 FM S0 = 2.05 ± 0.04 S1 = 0.3
ATLAS RESULT: R' = 8.7 ± 0.3 FM S0 = 2.33 ± 0.18 S1 = 1.7
TOTAL C/S <B>
0
10
20
30
40
0
100
200
300
400
500
600
700
800
ENERGY <keV>

RESULTS

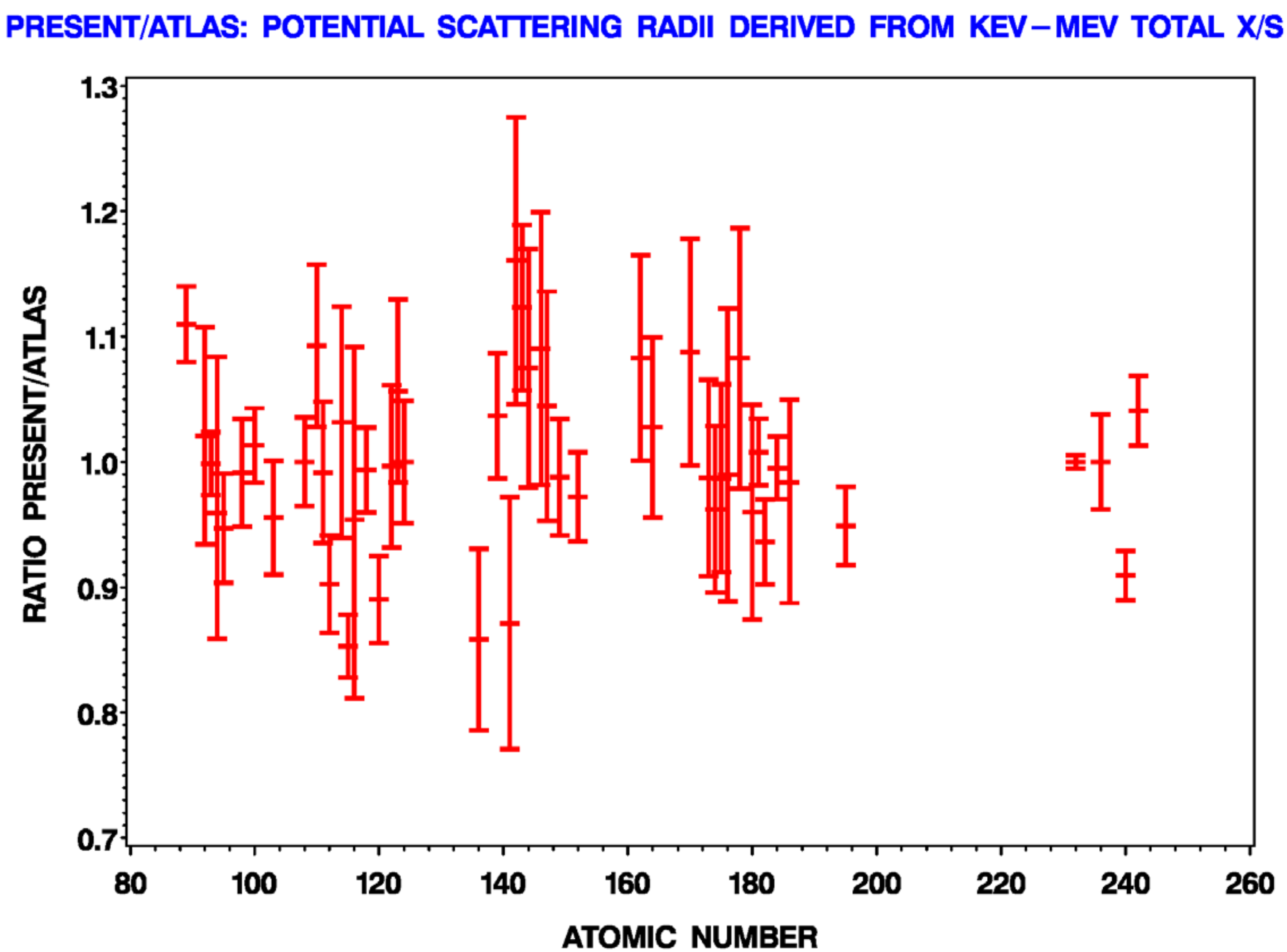


232 Th
LSF RESULT: R' = 9.65 ± 0.05 FM   S0 = 0.73 ± 0.03   S1 = 1.35   FOR EN < 200 KEV
ATLAS RESULT: R' = 9.65 ± 0.08 FM   S0 = 0.71 ± 0.04   S1 = 1.35 ± 0.04 FM
ENDFVII.0: R' = 9.686   S0 = 0.8784   S1 = 1.902
TOTAL C/S <B>
ENERGY <keV>
0
5
10
15
20
40
60
80
100
120
140
160
180
200

RESULTS

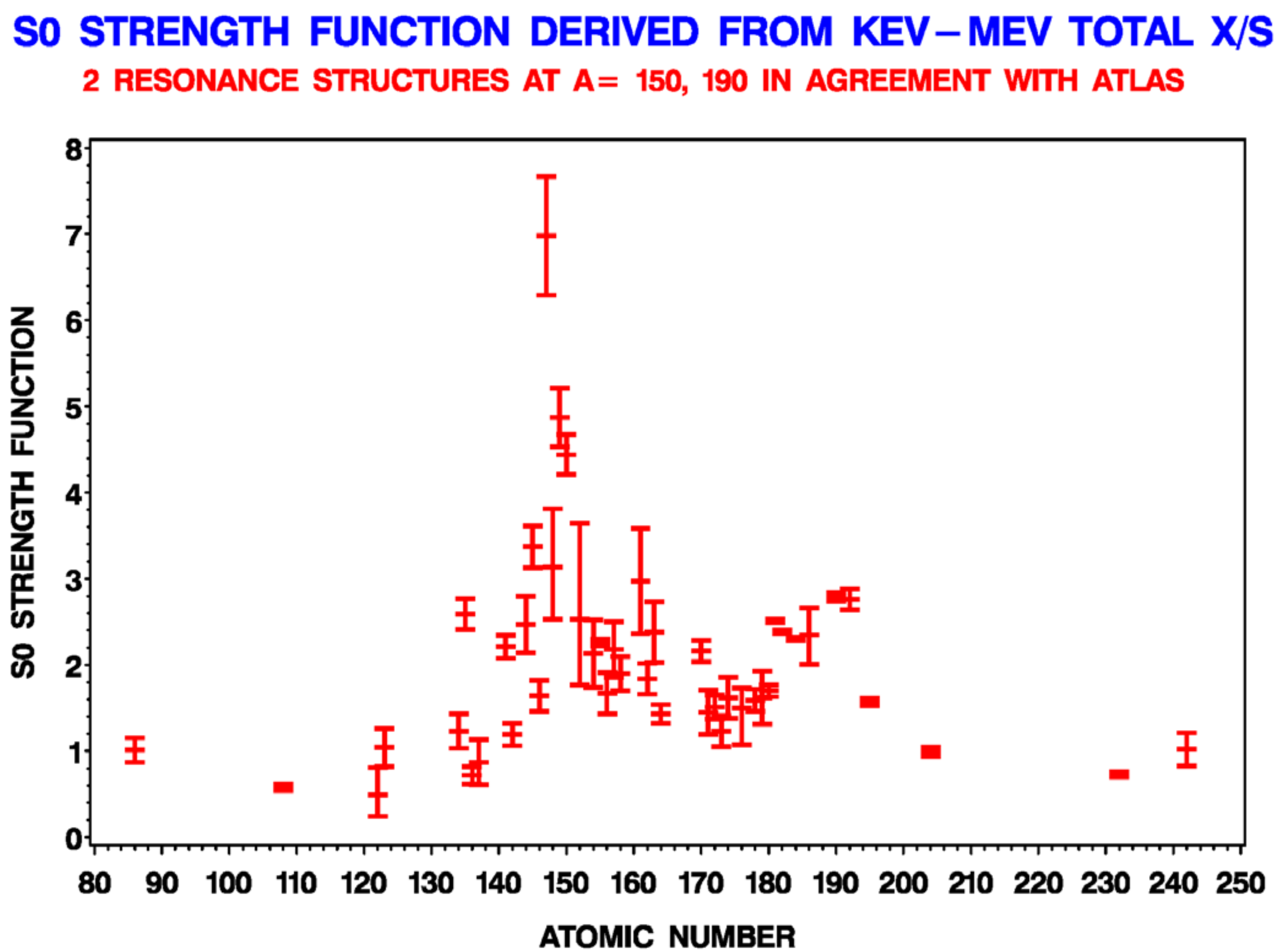

POTENTIAL SCATTERING RADII DERIVED FROM KEV–MEV TOTAL X/S
SCATTERING RADIUS {fm}
ATOMIC NUMBER
4
5
6
7
8
9
10
11
60
80
100
120
140
160
180
200
220
240
260

RESULTS



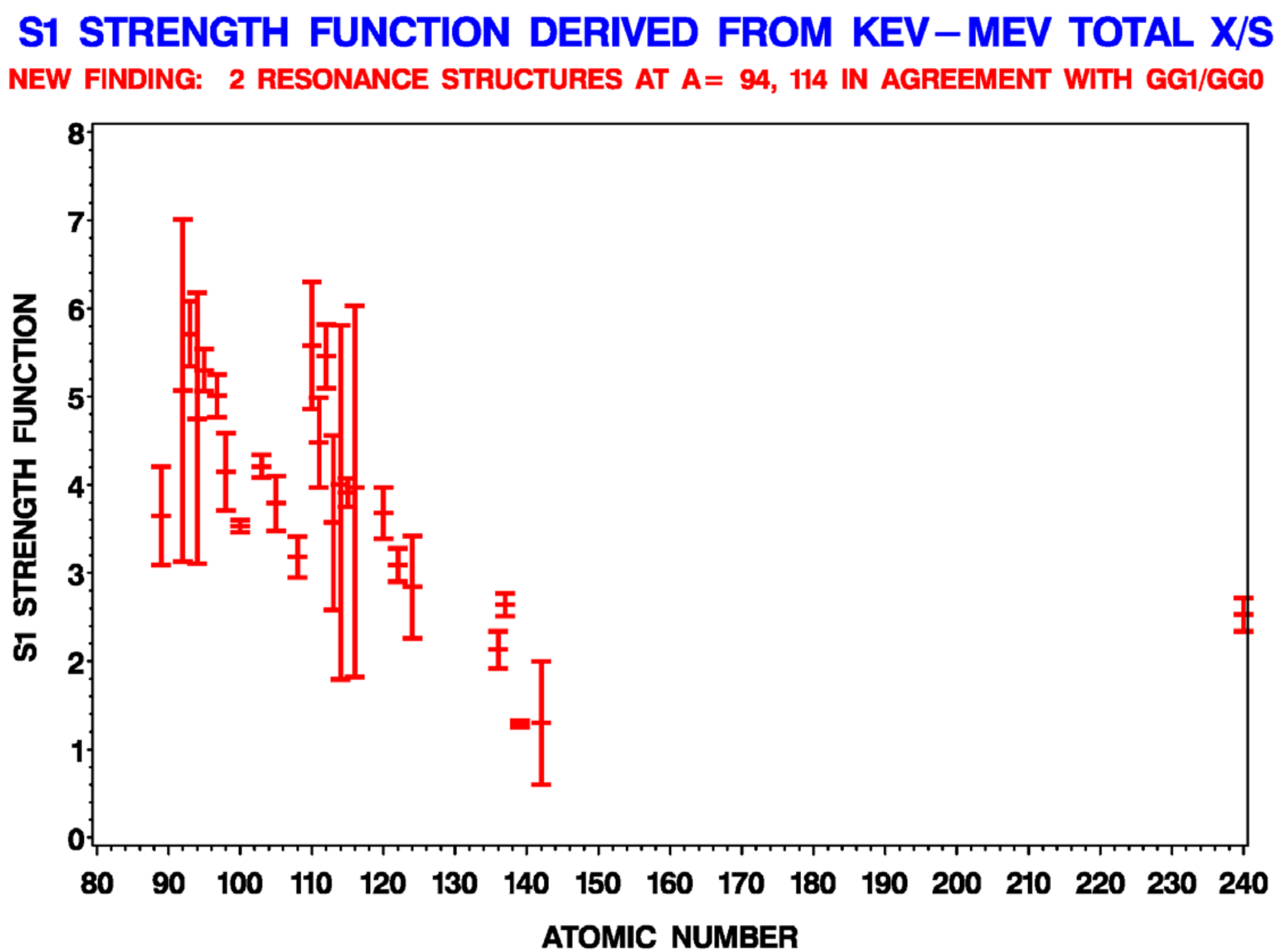
PRESENT/ATLAS: POTENTIAL SCATTERING RADII DERIVED FROM KEV–MEV TOTAL X/S
RATIO PRESENT/ATLAS
1.3
1.2
1.1
1.0
0.9
0.8
0.7
80
100
120
140
160
180
200
220
240
260
ATOMIC NUMBER

RESULTS

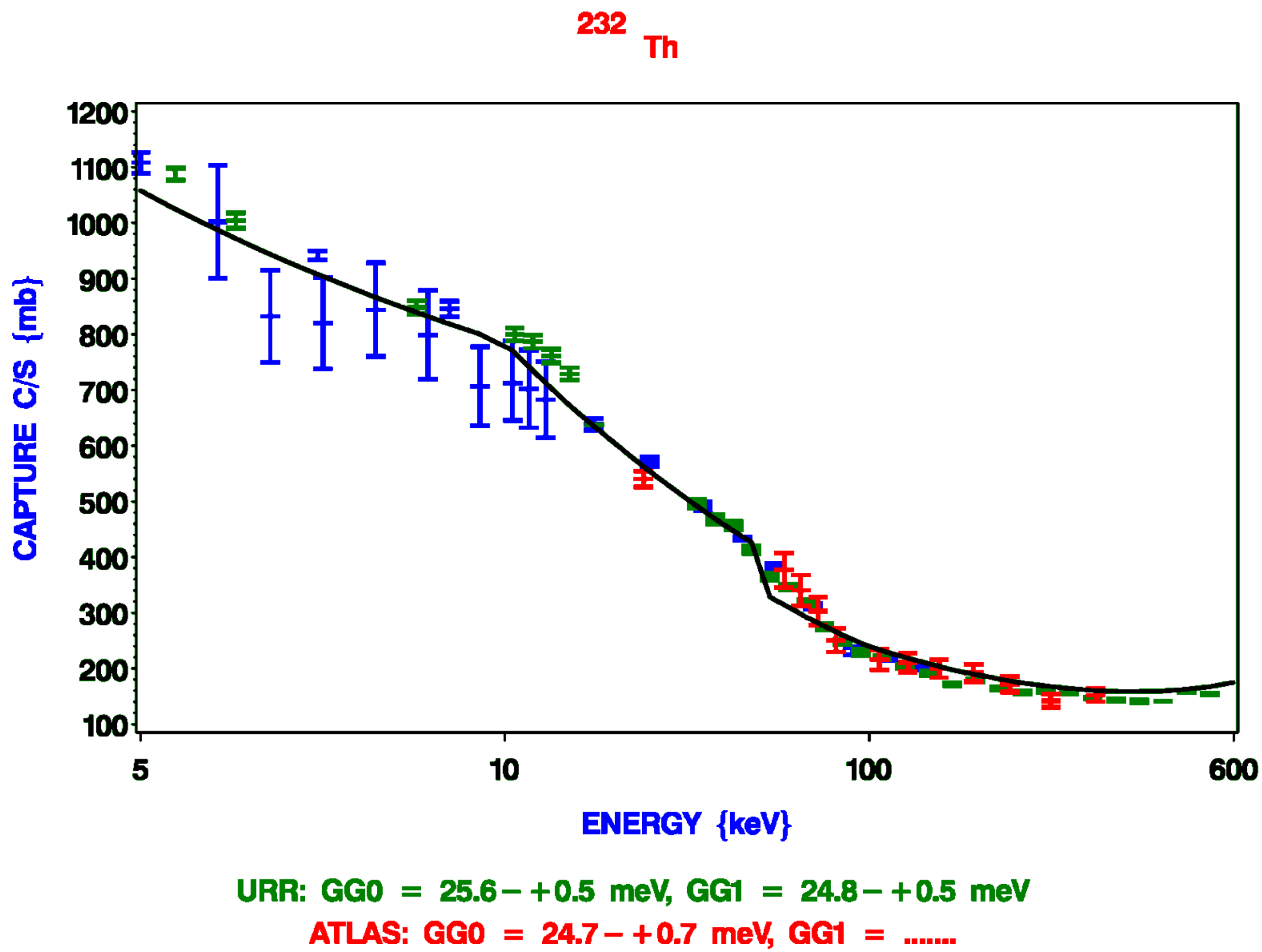


S0 STRENGTH FUNCTION DERIVED FROM KEV–MEV TOTAL X/S
2 RESONANCE STRUCTURES AT A= 150, 190 IN AGREEMENT WITH ATLAS
S0 STRENGTH FUNCTION
0
1
2
3
4
5
6
7
8
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
ATOMIC NUMBER

RESULTS


S1 STRENGTH FUNCTION DERIVED FROM KEV–MEV TOTAL X/S
NEW FINDING: 2 RESONANCE STRUCTURES AT A= 94, 114 IN AGREEMENT WITH GG1/GG0
S1 STRENGTH FUNCTION
0
1
2
3
4
5
6
7
8
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
ATOMIC NUMBER

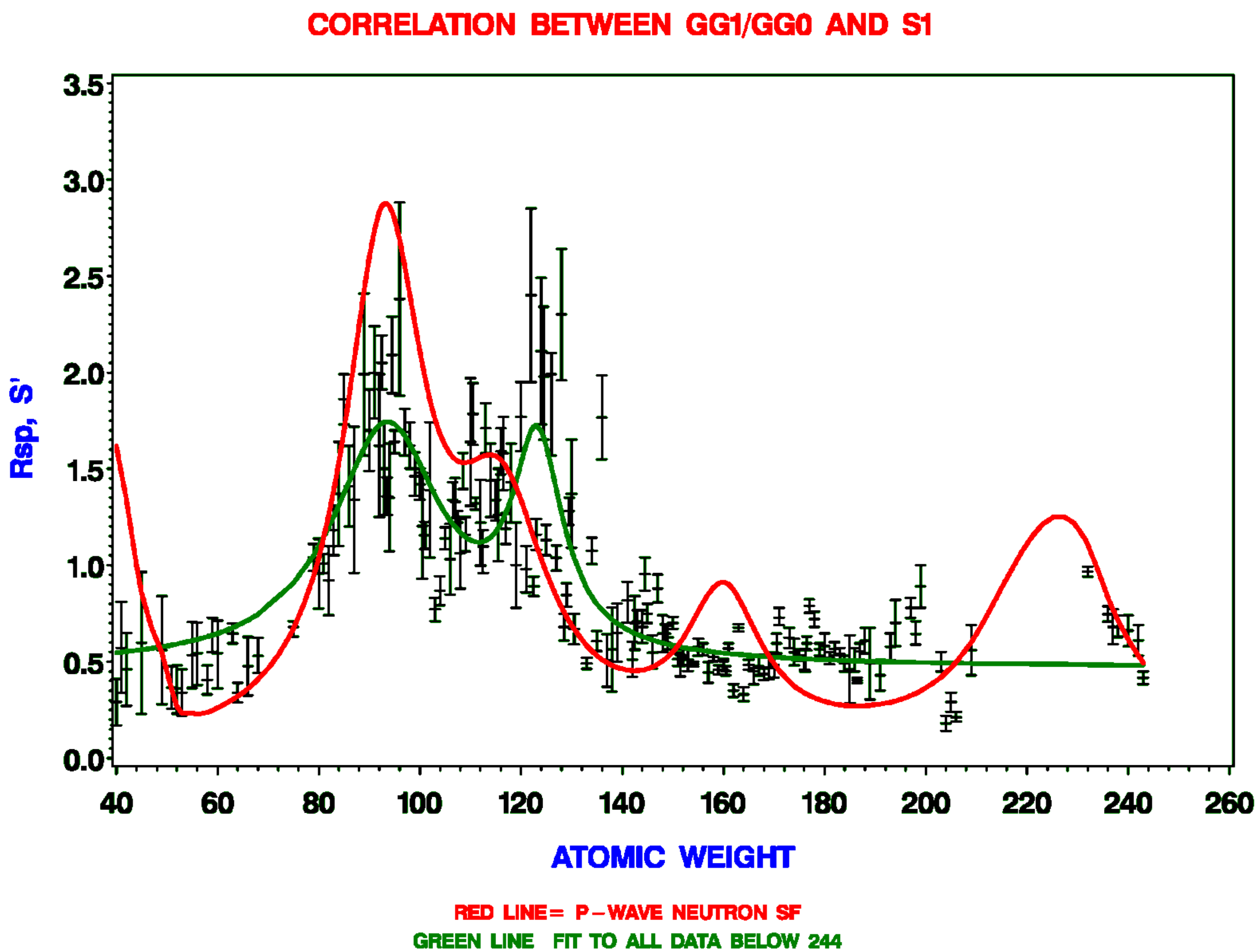
^{232}Th URR Results (CERN Data)



Average *s*- and *p*- wave radiative widths (meV)

Target	$\Gamma_{\gamma 0}$ Urr	$\Gamma_{\gamma 1}$ Urr	$\Gamma_{\gamma 0}$ Atlas	$\Gamma_{\gamma 1}$ Atlas	$\Gamma_{\gamma 1} / \Gamma_{\gamma 0}$
^{91}Zr	**108 18**	**252 16**	**134 16**	**220 32**	**1.95 0.29**
^{155}Gd	**103 4**	**58.9 4.1**	**110 3**	**...........**	**0.57 0.04**
^{205}Tl	**1320 250**	**420 130**	**1140 80**	**330 50**	**0.29 0.05**
^{232}Th	**25.6 0.5**	**24.8 0.5**	**24.8 0.5**	**...........**	**1.02 0.03**
^{124}Sn	**50 4**	**93.3 3.2**	**............**	**...........**	**1.87 0.16**

Comparison of $\Gamma_{\gamma1}/\Gamma_{\gamma0}$ with S1



Conclusion & Summary I

- **A methodology to determine uncertainties of σ_t, σ_s, and σ_γ was developed and tested on 90 isotopes and elements.**
- **In this process, *R'*, S_0 and S_1 are derived from σ_t and compared against the Atlas recommended values. Good agreement for *R'* within 6%.**
- **New results for a few *R'* are derived for the first time.**
- **A new finding is the observation of the splitting of S_1 into two peaks located at A=90 and 112**

Conclusion and Summary II

- ***This finding is correlated with the splitting of the*** **ratio of $\Gamma_{\gamma p} / \Gamma_{\gamma s}$ revealed in a previous study (ND2010).**
- **With this information and procedure, the uncertainties for σ_t, σ_s, and σ_γ** ***are computed for the AFCI materials at 3 keV and 100 keV.***

- **The ratio of $\Gamma_{\gamma p} / \Gamma_{\gamma s}$ revealed structures at A=92, 112, 124, and 230.**

Thank You for Your Attention

- Special acknowledgements to Boris Pritychenko with Power Point support