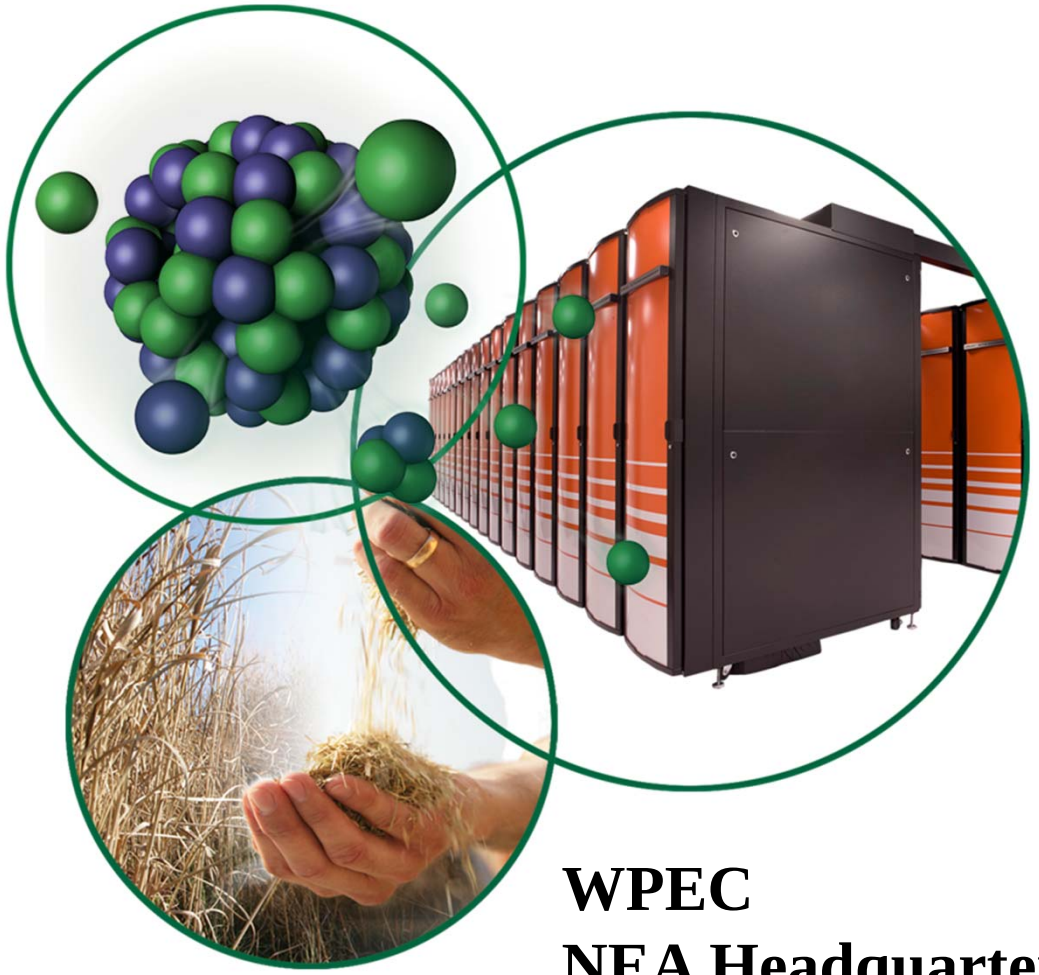
Resonance Evaluations for ^{16}O for the CIELO Project



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Presentation Objectives

- Describe procedures used to evaluate the resolved resonance parameters (RRP) included in the o16orn1.dat library;
- Choice of thermal scattering cross section;
- Choice of $^{16}O(n, \alpha)$
- Brief explanation of the RML formalism in SAMMY;
- Use of SAMMY and SAMINT codes;
- Results and discussions;

^{16}O Resonance Evaluation

- Evaluation processed with NJOY, PREPRO, AMPX and GAIA;
- It uses ENDF/B-VII.1 as the template;
- (n, total), (n, n), (n, γ), scattering, (n,α), angular distributions are obtained from RRP;
- RRP covariance is available. Not included in the library;
- Updated thermal cross section (3.778 b at 0K);
- ^{16}O(n, α) data (Giorginis, et al., IRMM) and ^{13}C(α, n) data (Harissopulos, et al.) give about 30% lower ^{16}O (n, α) cross section values than the Bair-Haas.

Thermal Cross Section

Coherent Scattering

Scattering length in terms of a^+ and a^- for spin states $I + 1/2$ and $I - 1/2$

$$a^2 = \left[\frac{I+1}{2I+1}a^+ + \frac{I}{2I+1}a^-\right]^2 + \frac{I(I+1)}{(2I+1)^2}(a^+ - a^-)^2$$

with

$$a_{coh} = \frac{I+1}{2I+1}a^+ + \frac{I}{2I+1}a^-$$

and

$$a_{inch} = \frac{[I(I+1)]^{1/2}}{2I+1}(a^+ - a^-)$$

For $I = 0$ $\qquad a = a_{coh}$

Thermal Cross Section

Coherent Scattering Length includes potential and resonance parts defined as

$$a_{coh} = a_{pot} + a_{res}$$ where

$$a_{pot} = \lim_{E \to 0} \left(\frac{\sigma_s}{4\pi} \right)^{1/2}$$ For T = 0 K

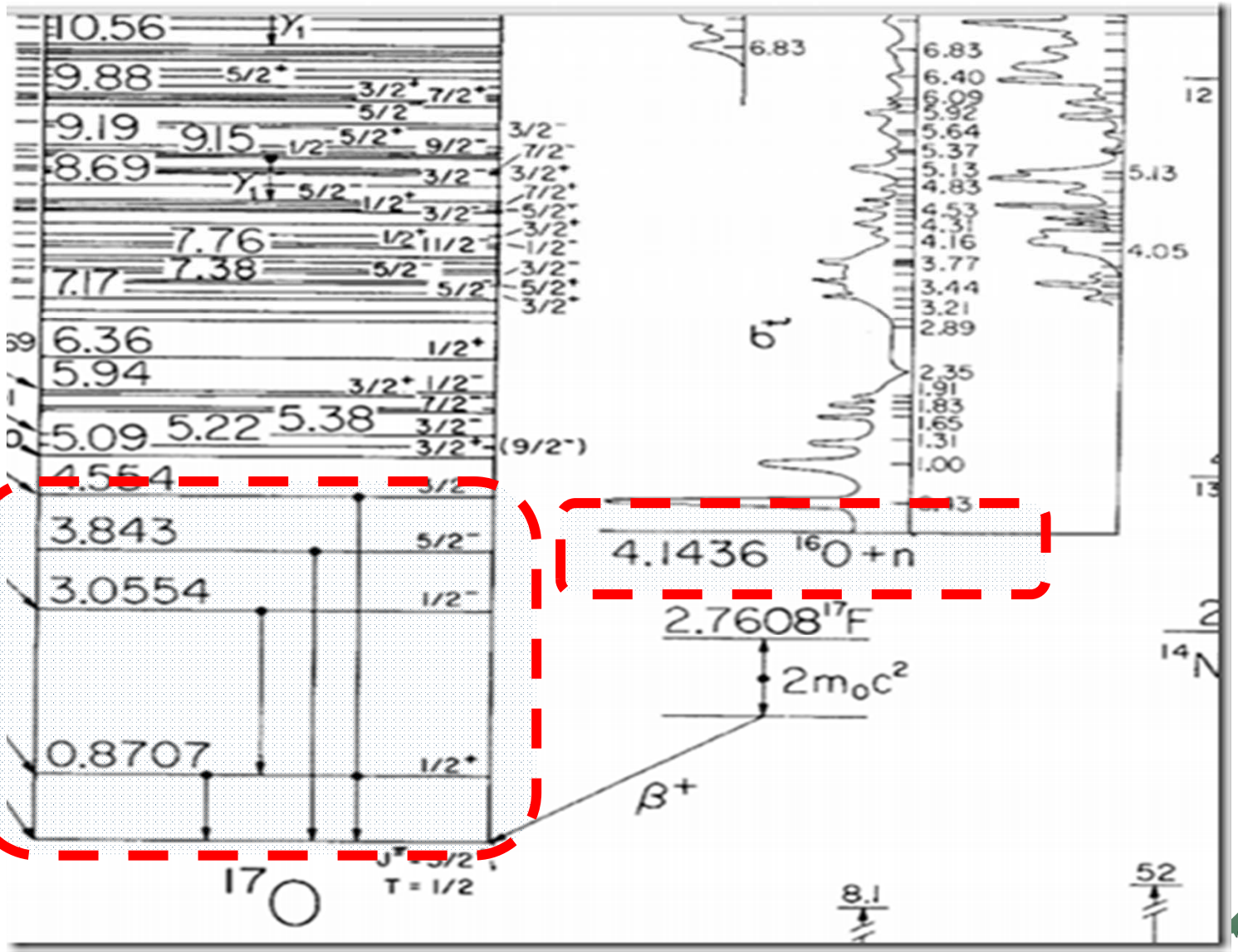
For s-wave based on the SLBW formalism

$$a_{res} = \sum_r \frac{\Gamma_n^r}{2k_r \left[(E - E_r) + \frac{i\Gamma}{2} \right]}$$

Useful information

Quantity	ORNL1 (bqrns) (T=0K)	ORNL1 (barns) (T=293.6K)	Mughabghab (barns)
σ_t	3.7784	3.8976	
σ_γ	1.7172×10^{-4}	1.6826×10^{-4}	$(1.9 +/- 0.19) \times 10^{-4}$
σ_s	3.7782	3.8974	3.761 ± 0.006
R’	-	4.15 fm	4.8 ± 0.1 fm
a_{coh}	-	5.820 fm	5.805 ± 0.005 fm
I_γ	-	3.1137×10^{-4}	$(2.7 \pm 0.3) \times 10^{-4}$

Bound Levels for ^{16}O



Bound Levels for ^{16}O

S* - separation energy
E* - compound nucleus energy
COM to Lab conversion – (A + 1) / A
E – resonance energy for ^{16}O + n
E = {(A +1) / A} * {E* - S*}

S* = 4.1436 MeV
A = 16

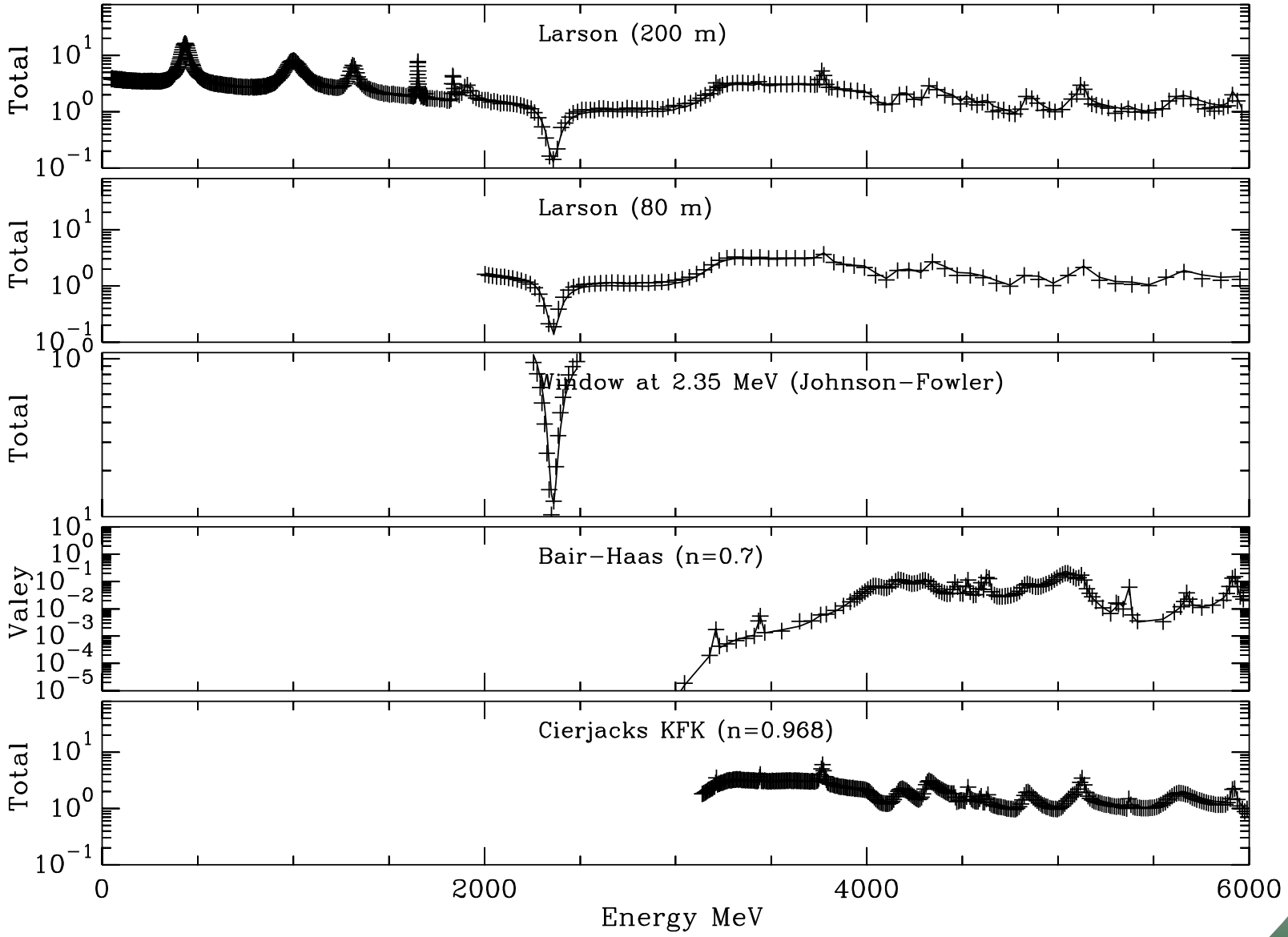
a) For E* = 0.8707 MeV
E={17/16}*{0.8707 - 4.1436}
E = -3.47746 MeV

b) For E* = 3.0554 MeV
E = {17/16}*{3.0554 - 4.1436}
E = -1.1562 MeV

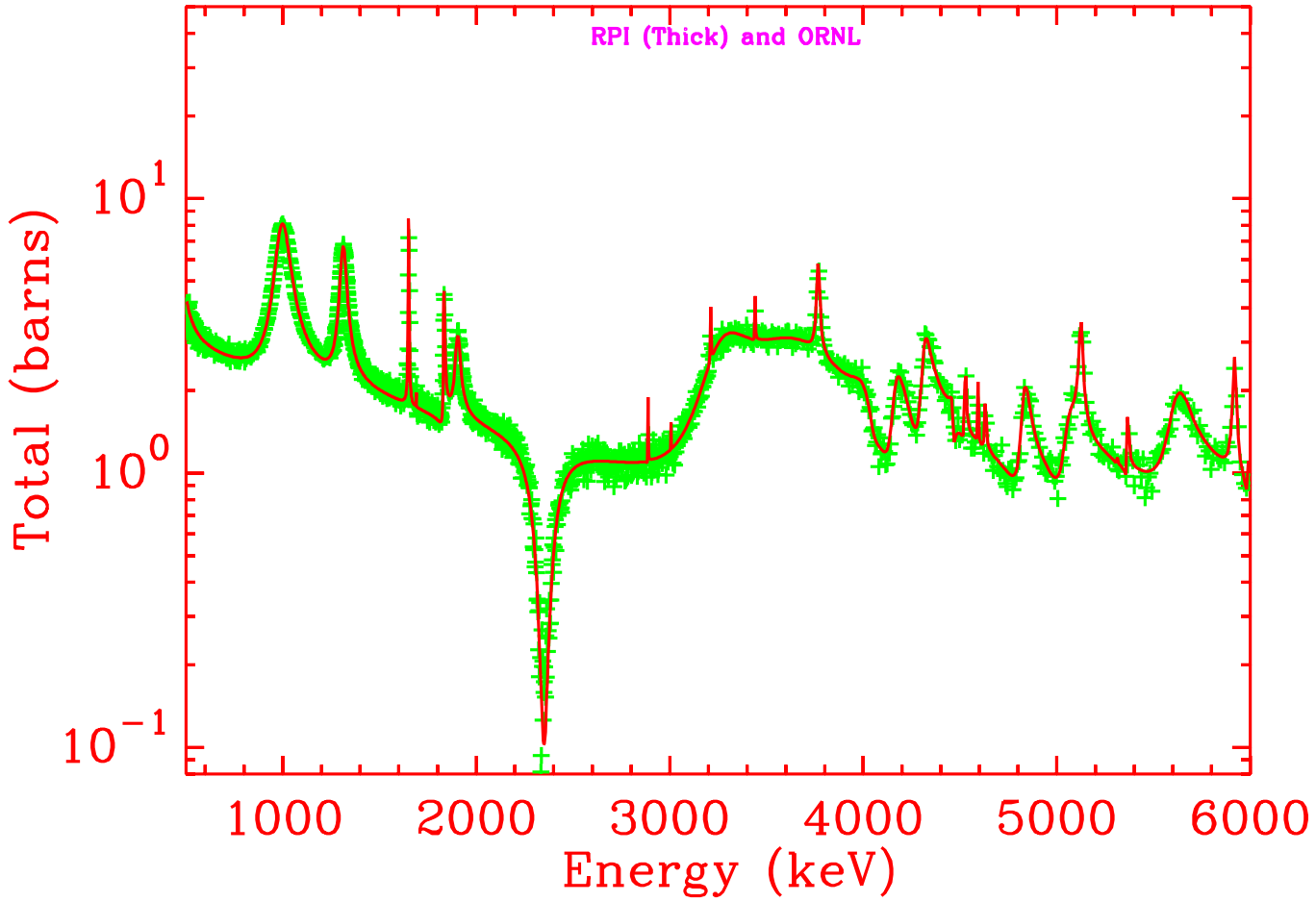
c) For E* = 3.843 MeV
E = {17/16}*{3.843 - 4.1436}
E = -0.3194 MeV

SAMMY resonance parameters

E_r	Γ_γ	Γ_n	Γ_p	Spin Group
-3477456.00	184.305000	3923179.+3	0.0000	0 0 0 0 1
-1157275.00	261.434100	13305730.0	0.0000	0 0 0 0 3
-319387.500	297.301600	92559.3200	0.0000	0 0 0 0 6
434103.9867	2700.00000	44216370.0	0.0000	0 0 0 0 3
999687.6127	250.000000	95884120.0	0.0000	0 0 0 0 4

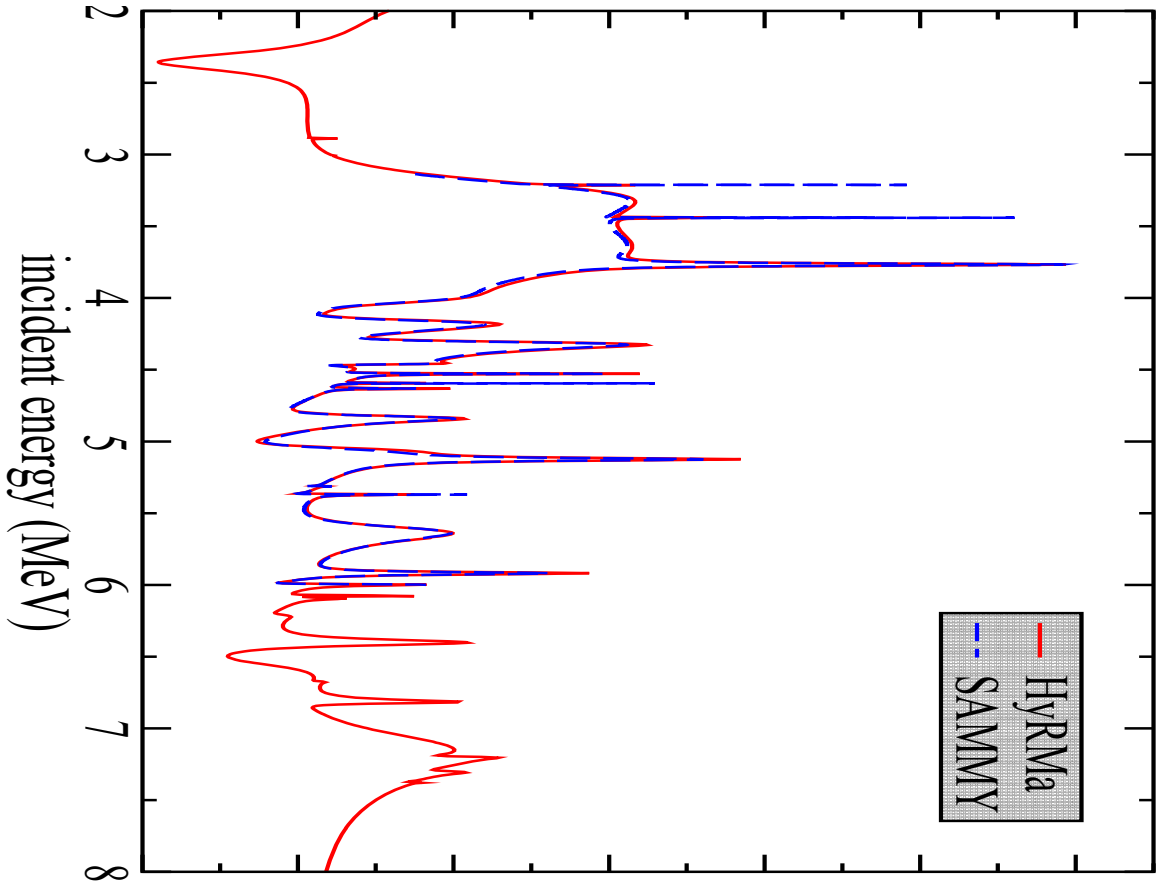

Larson (200 m)
Larson (80 m)
Window at 2.35 MeV (Johnson−Fowler)
Bair−Haas (n=0.7)
Cierjacks KFK (n=0.968)
Total
Valey
Energy MeV
0
2000
4000
6000

New total cross section measurements from RPI. SAMMY comparison including resolution effects



n+^{16}O cross section from SAMMY parameters

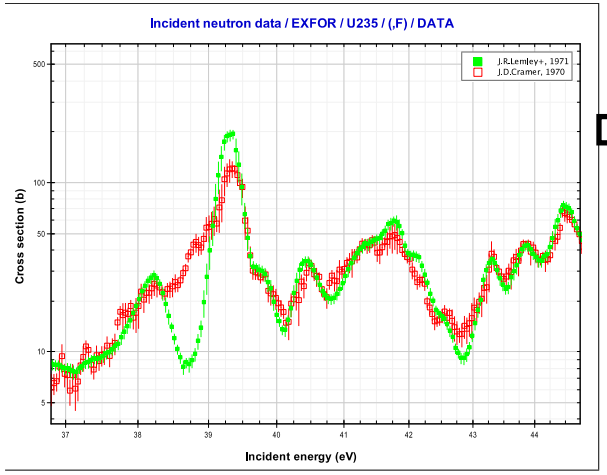
- **Here is how it compares to Leal's output:**



Results from Sofia Quaglioni

Using SAMINT with SAMMY

Differential Experimental Data



Integral Experimental Data

SAMMY

$d\sigma(E)/d\Gamma_\lambda$

SAMINT

$dk/d\Gamma_\lambda$

SAMMY

Updated Γ_λ and $\delta\Gamma$

ENDF

$dk/d\sigma(E)$

CE-TSUNAMI MCNP-6

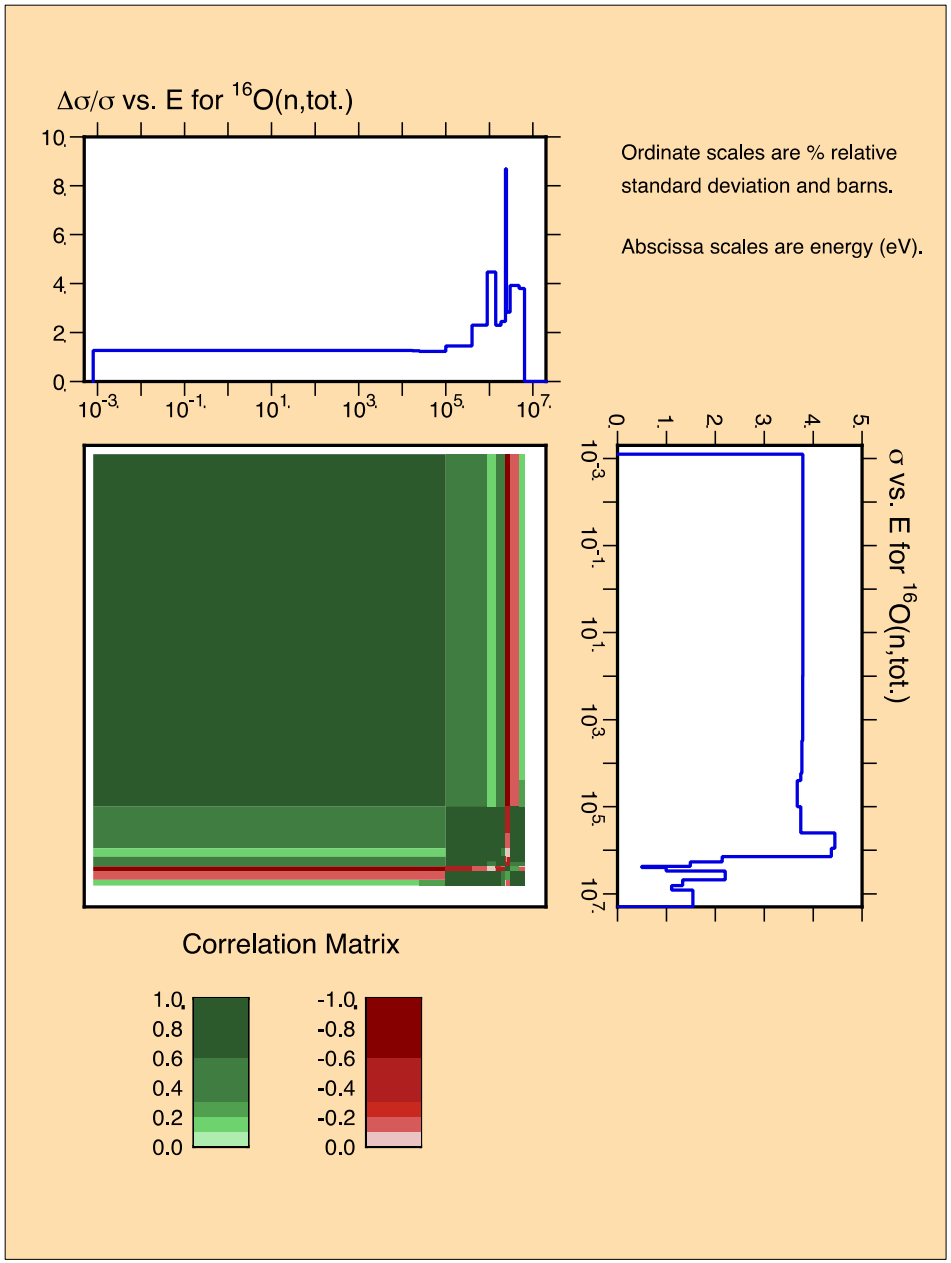
Using SAMINT with SAMMY

- **SAMMY and SAMINT were used for adjustments of the partial widths;**
- **A set of thermal benchmark sensitive to ^{16}O were were used in conjunction with the experimental differential data;**
- **Procedure very attractive for adjusting the RRP and generating RRP covariance data based on differential and integral data;**

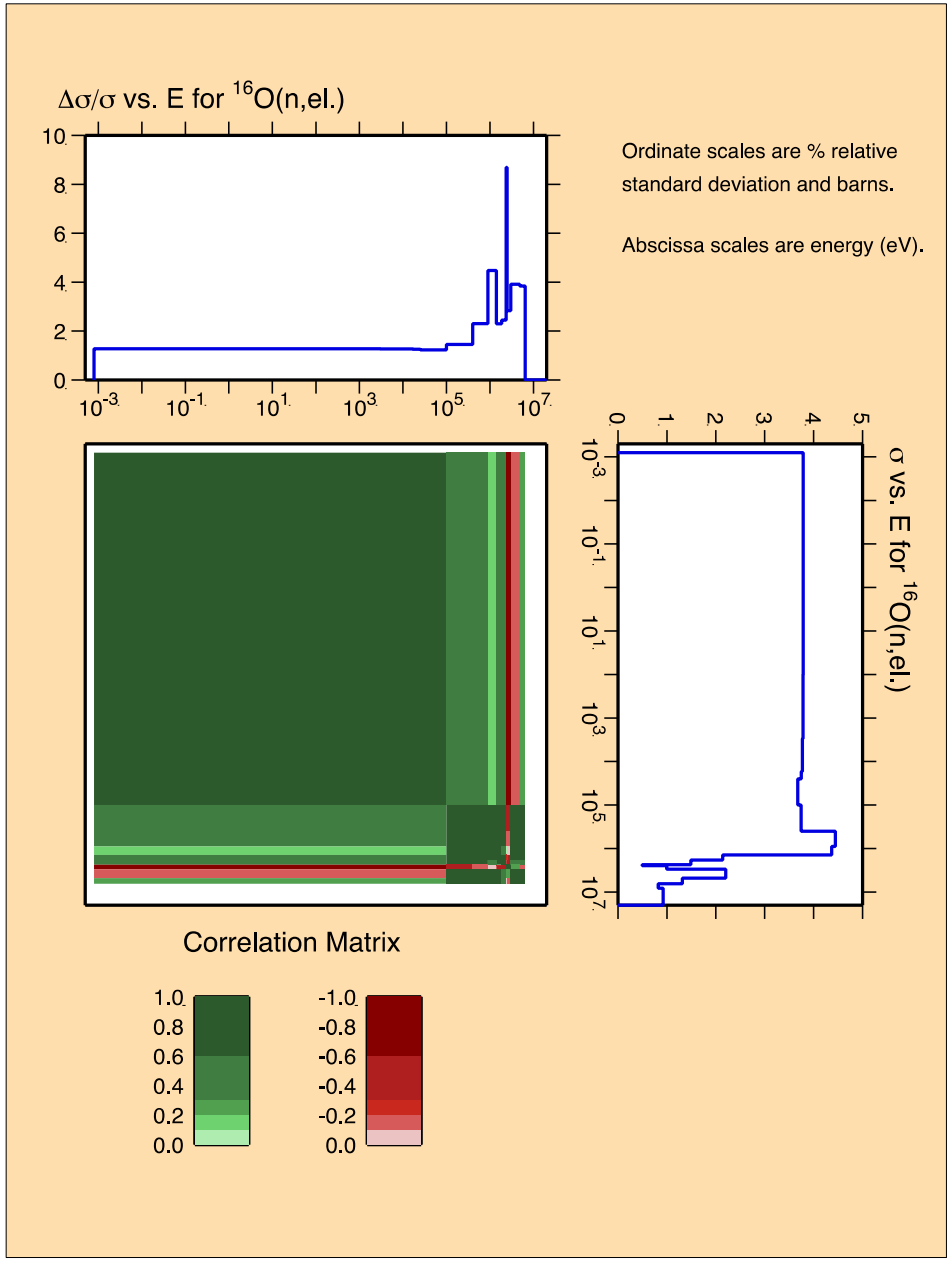
Example of a typical SAMINT input

	Exp k_{eff}	Exp. Δk_{eff}
leu-sol-therm-007-case-14.e26.o	0.99585006	0.0010000010
leu-sol-therm-007-case-30.e26.o	0.99781006	0.0010000010
leu-sol-therm-007-case-32.e26.o	0.99645006	0.0010000010
leu-sol-therm-007-case-36.e26.o	0.99885006	0.0010000010
leu-sol-therm-007-case-49.e26.o	0.99785006	0.0010000010
leu-comp-therm-008-case-11.e26.o	1.00000006	0.0010000010
leu-comp-therm-008-case-1.e26.o	1.00000006	0.0010000010
leu-comp-therm-008-case-2.e26.o	1.00000006	0.0010000010
leu-comp-therm-008-case-5.e26.o	1.00000006	0.0010000010
leu-comp-therm-008-case-7.e26.o	1.00000006	0.0010000010
leu-comp-therm-008-case-8.e26.o	1.00000006	0.0010000010
heu-sol-therm-013-case-2e26.o	0.99754000	0.0010000010
heu-sol-therm-013-case-3e26.o	0.99500000	0.0010000010
heu-sol-therm-013-case-4e26.o	0.99685006	0.0010000010

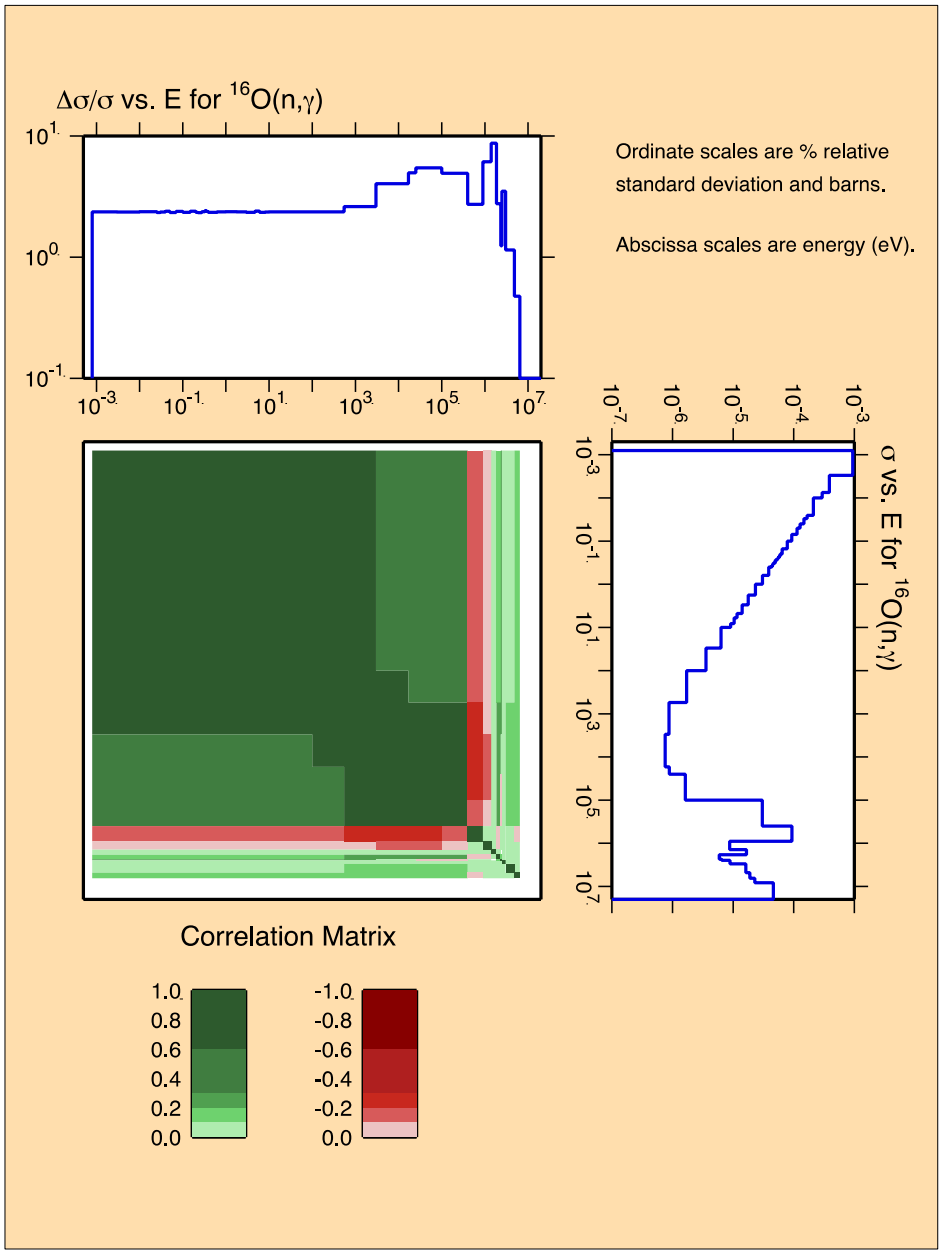
RRP Covariance for the Total Cross Section



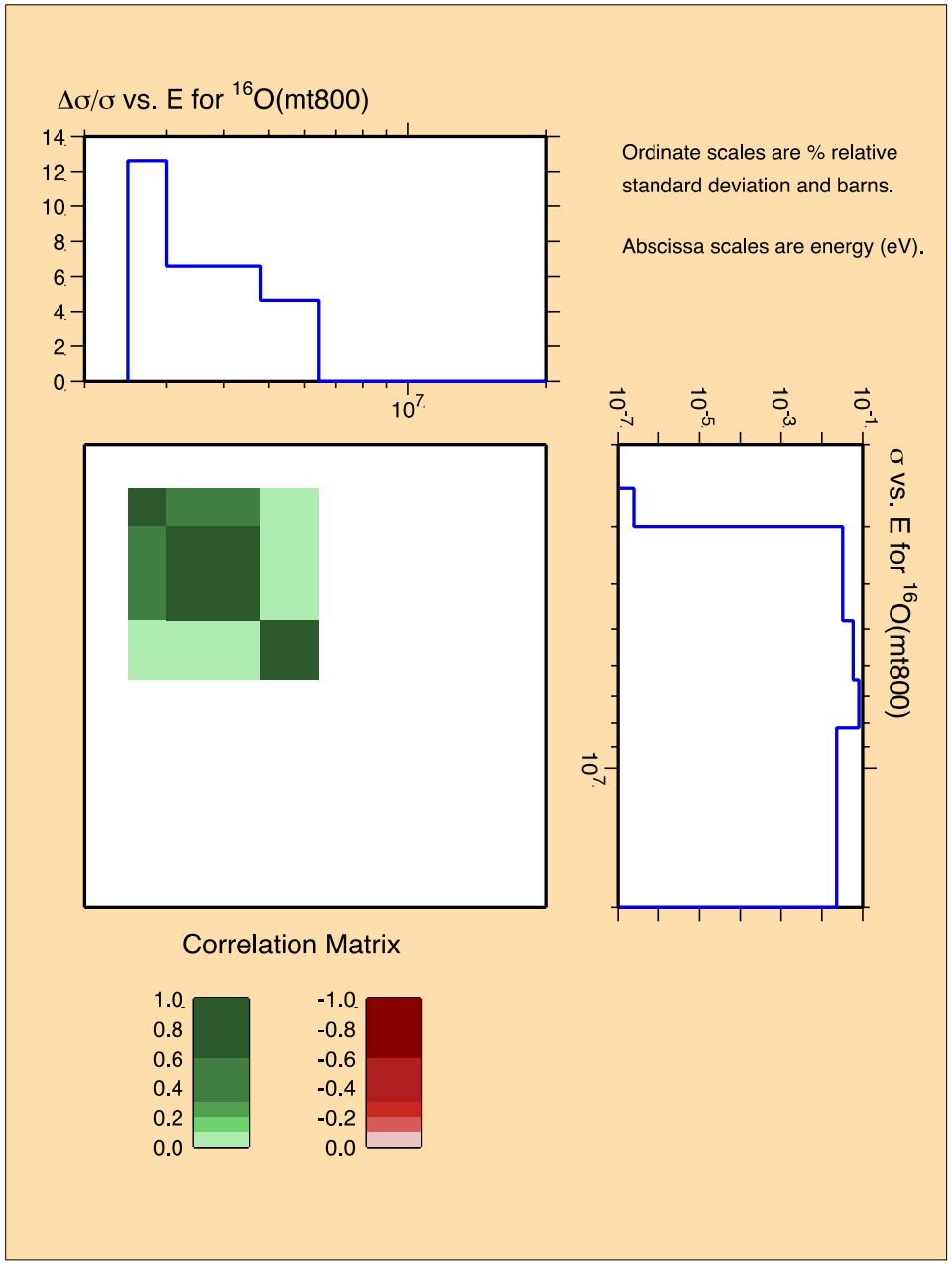
RRP Covariance for the Scattering Cross Section



RRP Covariance for the Capture Cross Section



RRP Covariance for the alpha Cross Section



General Conclusions

✓ **A library for ^{16}O was submitted to CIELO participants for testing following the guidelines established in the February 2014 conference call;**

✓ **Results from previous CIELO/NEMEA meeting incorporated in the evaluation;**

✓ **Continue work under the CIELO project;**