



State of the EMPIRE

M. Herman, R. Capote, C. Mattoon,
S.F. Mughabghab, P. Oblozinsky, M. Pigni,
M. Sin, A. Trkov, Young-Sik Cho, V. Zerkin*

**Email: mwherman@bnl.gov
www.nndc.bnl.gov/empire/*

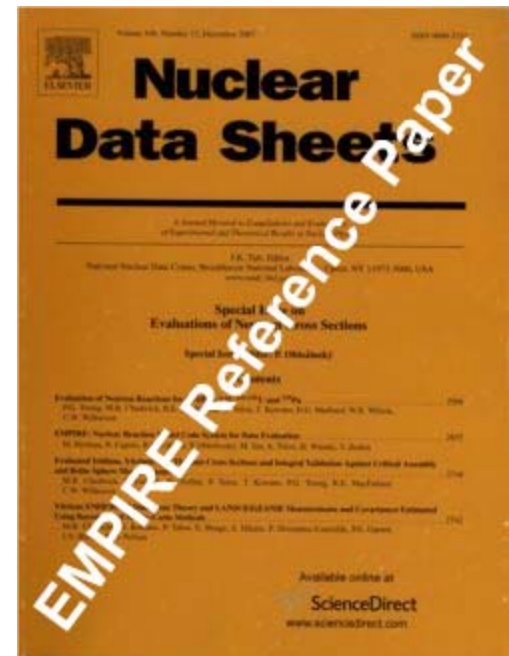
Summary of recent changes

- Resonance module
 - Parameters from Atlas of Neutron Resonances => MF2
 - Respective uncertainties => MF32
 - Reproducing thermal cross section uncertainties
- New parametrization of EGSM level densities
(EGSM = Enhanced/EMPIRE Generalized Superfluid Model)
- New fission model implemented (Phys. Rev. C 77 (2008) 054601)
- RIPL-3 updates
 - discrete levels library
 - optical model parameters
 - Microscopic level densities (HFBCS) with parity dependence

Summary of recent changes

- ECIS-2006
- Closer integration of the KALAMAN code
- Accounting for model uncertainties in covariance generation
 - Correlated sampling in Monte Carlo
 - Scaling factor in Kalman filter
- Usual improvements ...

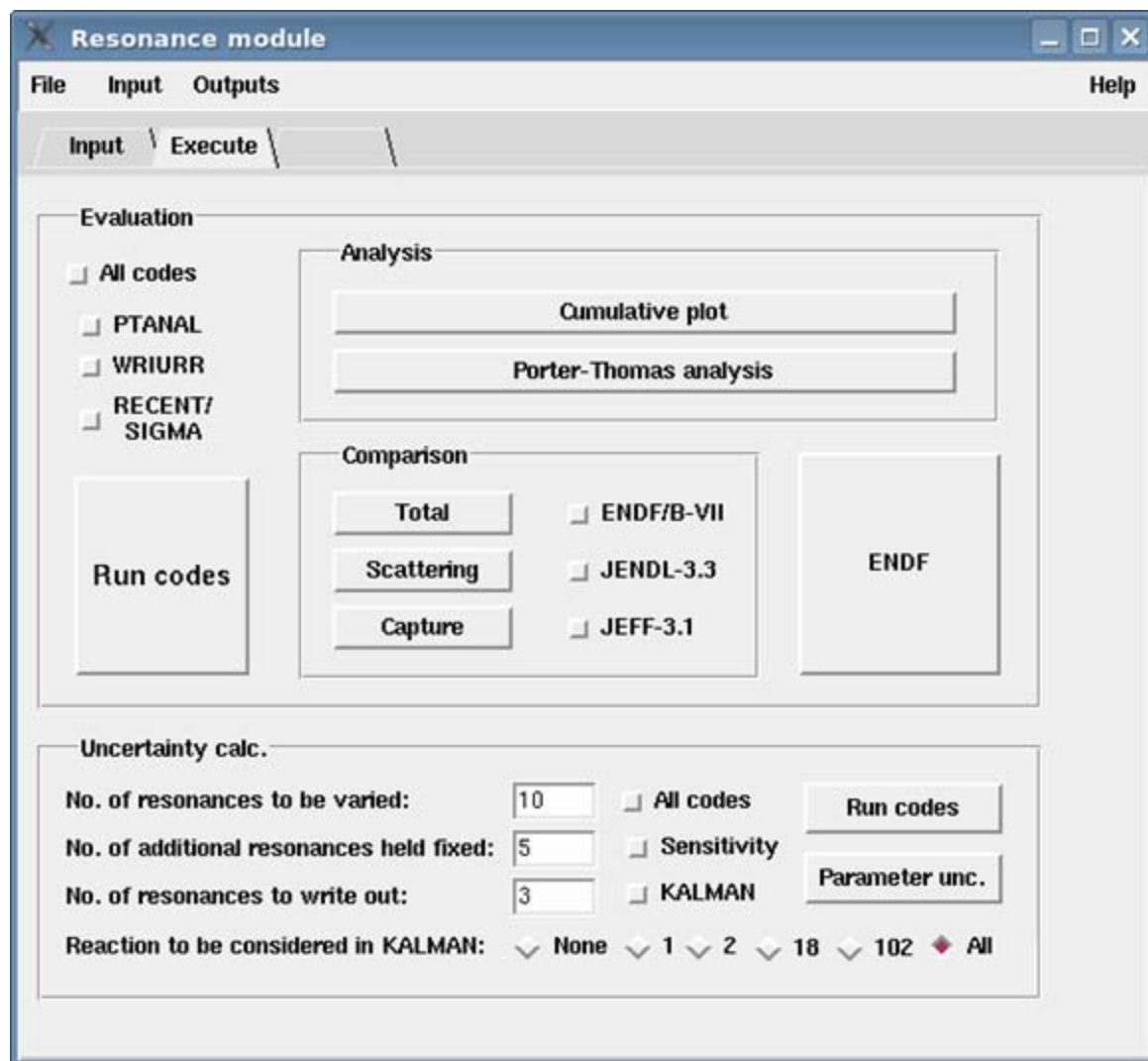
Extensive paper on EMPIRE
published in Dec. 2007.
(11 citations in SCOPUS)



Resonance module

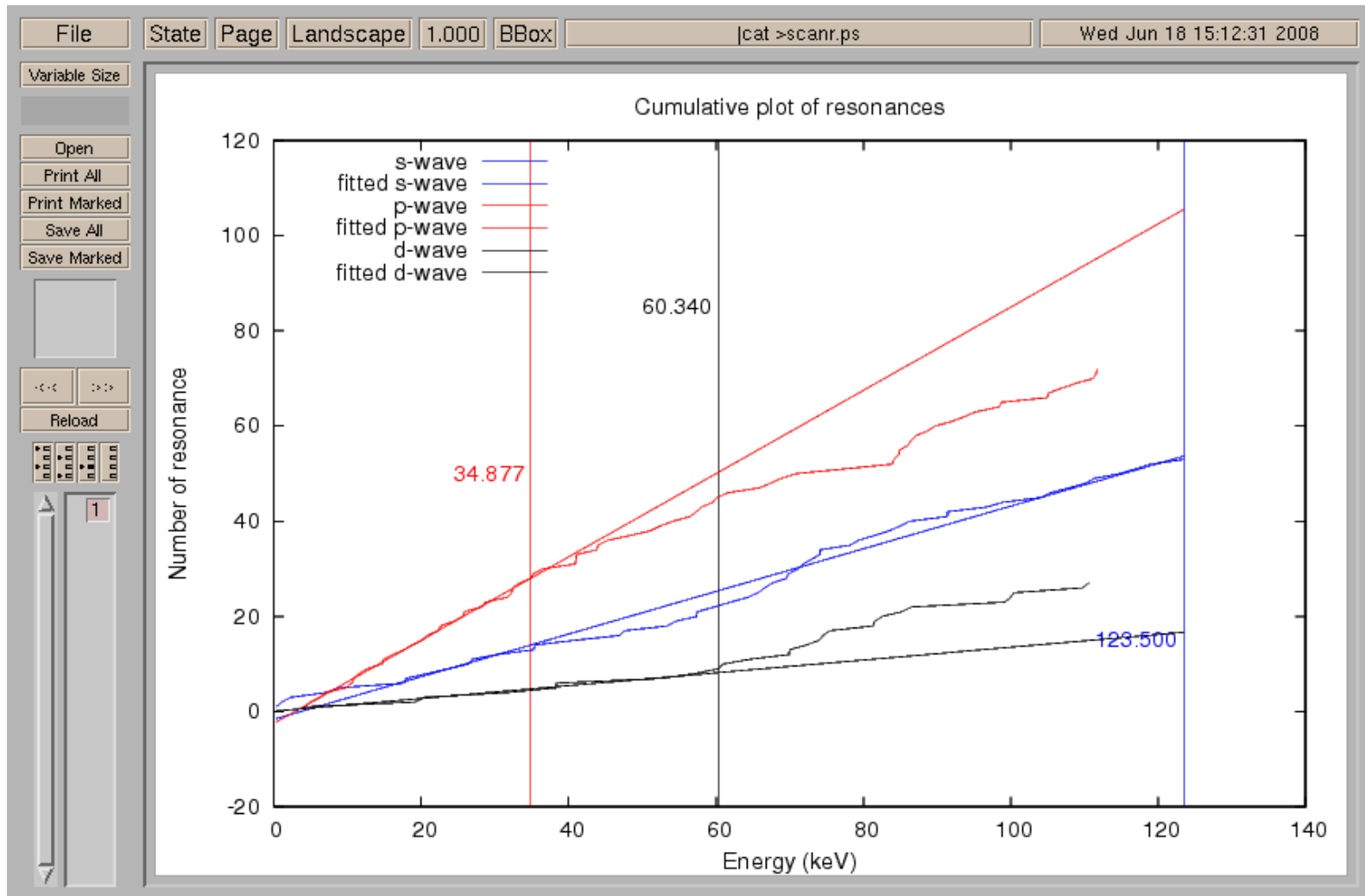
Developed by BNL/KAERI
collaboration (Young-Sik
Cho)

- Links Atlas of Neutron Resonances with ENDF library
- Statistical analysis of resonances (Porter-Thomas)
- Fills gaps
- RR & URR
- Cross section reconstruction and comparison (plots)
- Covariances in MF=32 (compact representation)
- Adjustment of uncertainties to match thermal values



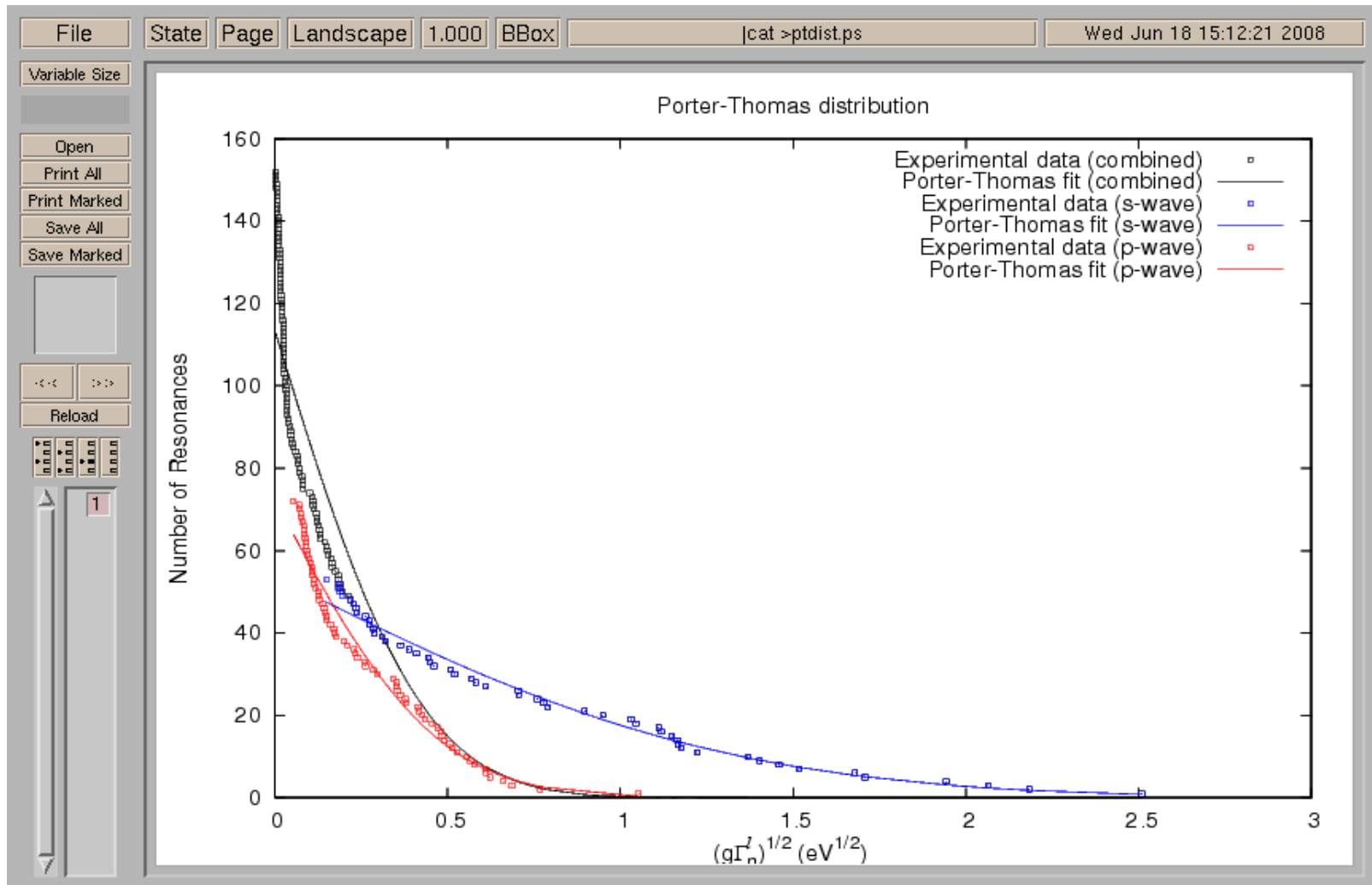
Resonance module in action

Cumulative plots of resonances



Resonance module in action

Porter-Thomas analysis

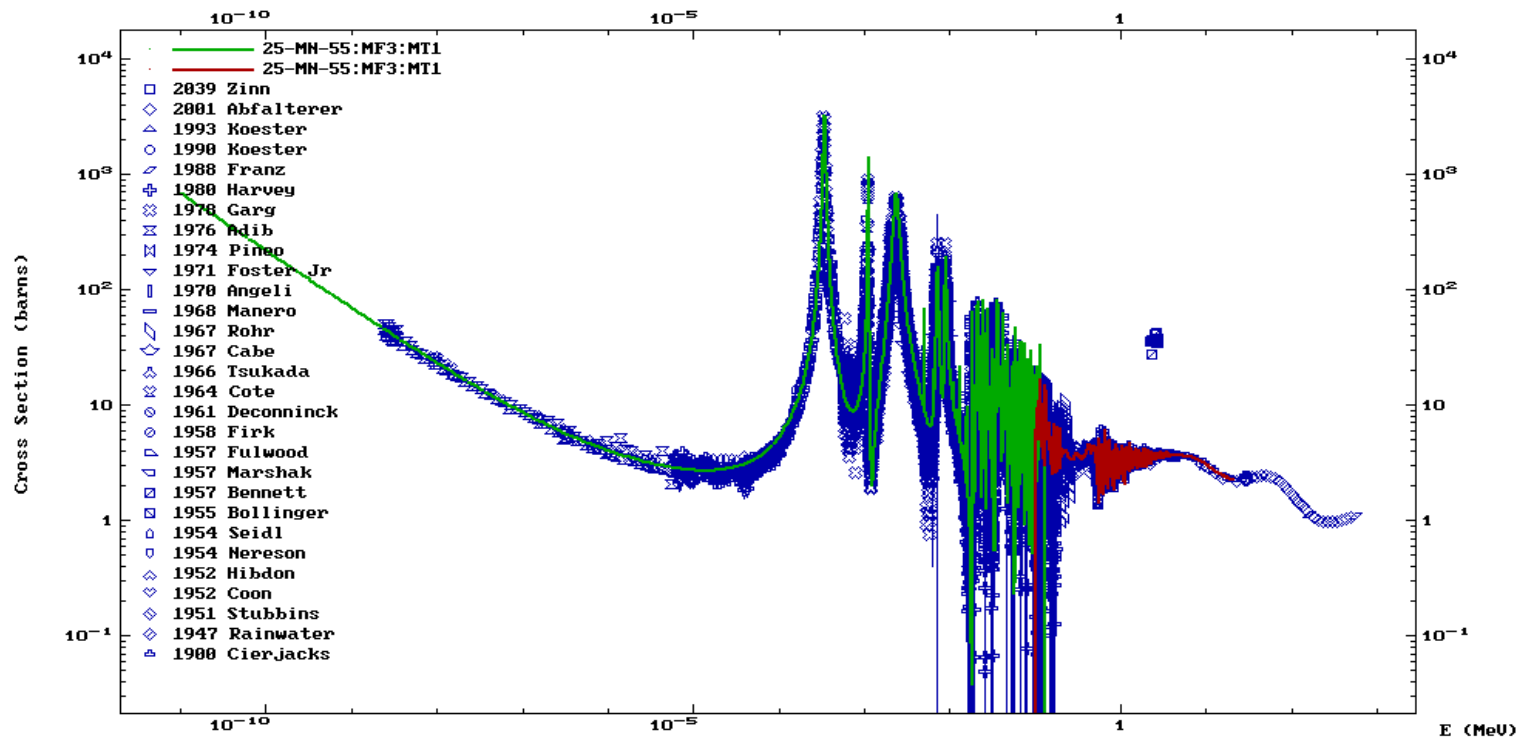


Resonance module in action

Cross section plots

Quit ^ v < > P< >P << >> Log-Y Log-X Plank yGrid xGrid Auto-Y y-Range Auto-X XY-Scale >< <> ±1% ±2% ±5% I I H B
 R Func-property Smooth Only Exclude Mrk-type Mrk-rotate T Tx Bx Inv Split SetSplit No butt Stat PS ? Menu F3 F4 F5
 Le0 Le1 Ref Save SaveAs GIF

25-MN-55(Z, T0T), , SIG



Function	Y-Max (X)	Mark:	Y (X)
1)c4.tab	3239	0.000336	
25-MN-55:	3250.4	0.0003373	
25-MN-55:	16.7236	0.111725	

Window: X=[2.05124e-12, 2803.18], Y=[0.0218269, 17820.9]

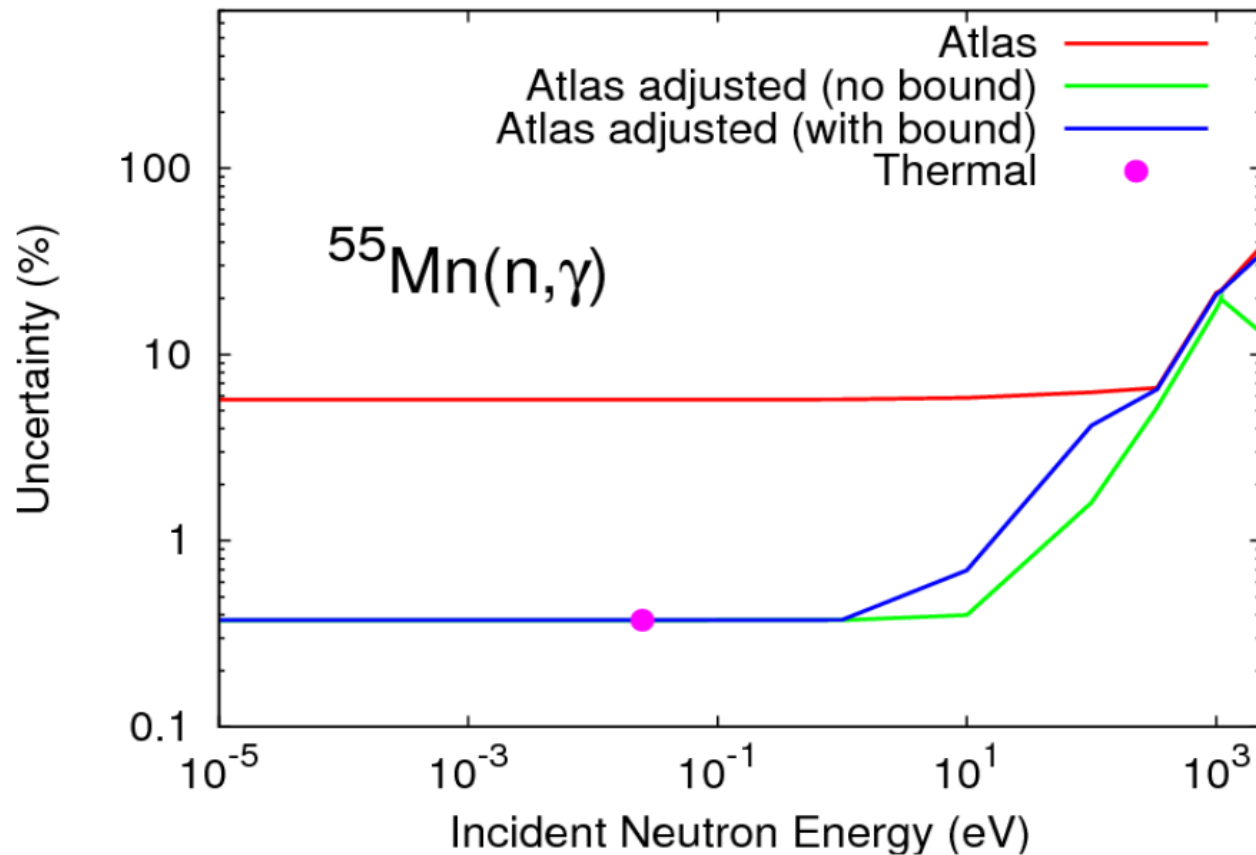
F1:Help F2:Menu ZUView-9.74.2 U.Zerkin@iaea.org

Dialogue



Resonance module in action

Parameter uncertainty adjustment to reproduce thermal value



Update of level densities

(Enhanced/EMPIRE Generalized Superfluid Model (EGSM) re-parametrized)

New

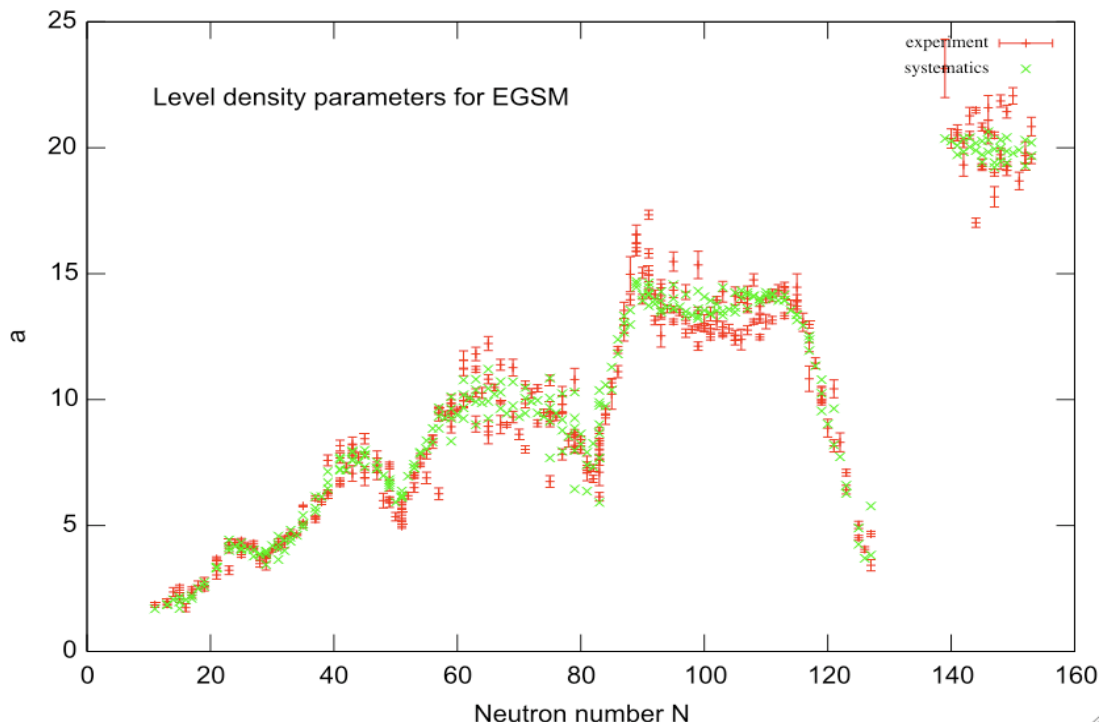
- RIPL-3 spacings of s-wave neutron resonances (D_0)
- RIPL-3 shell corrections (Myers-Swiatecki)

EGSM level densities

- BCS + Fermi gas
- Rotational energy defines spin distribution
- Spin dependent deformation (moments of inertia)
- Non-adiabatic collective enhancements

$$\bar{a} = 0.075 A - 0.004 A^{2/3}$$

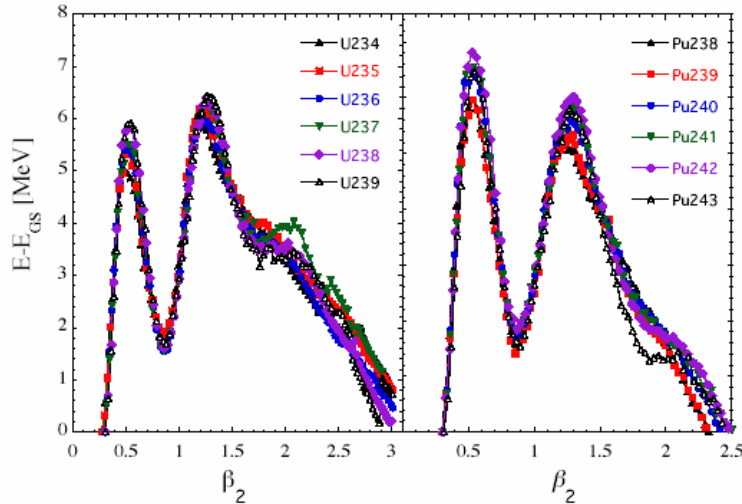
$$g = 0.575 \text{ (shell correction parameter)}$$



'Goodness' of the fit $\chi^2_{\text{red}} = 1.717$

New fission model in EMPIRE

microscopic fission barriers and level densities

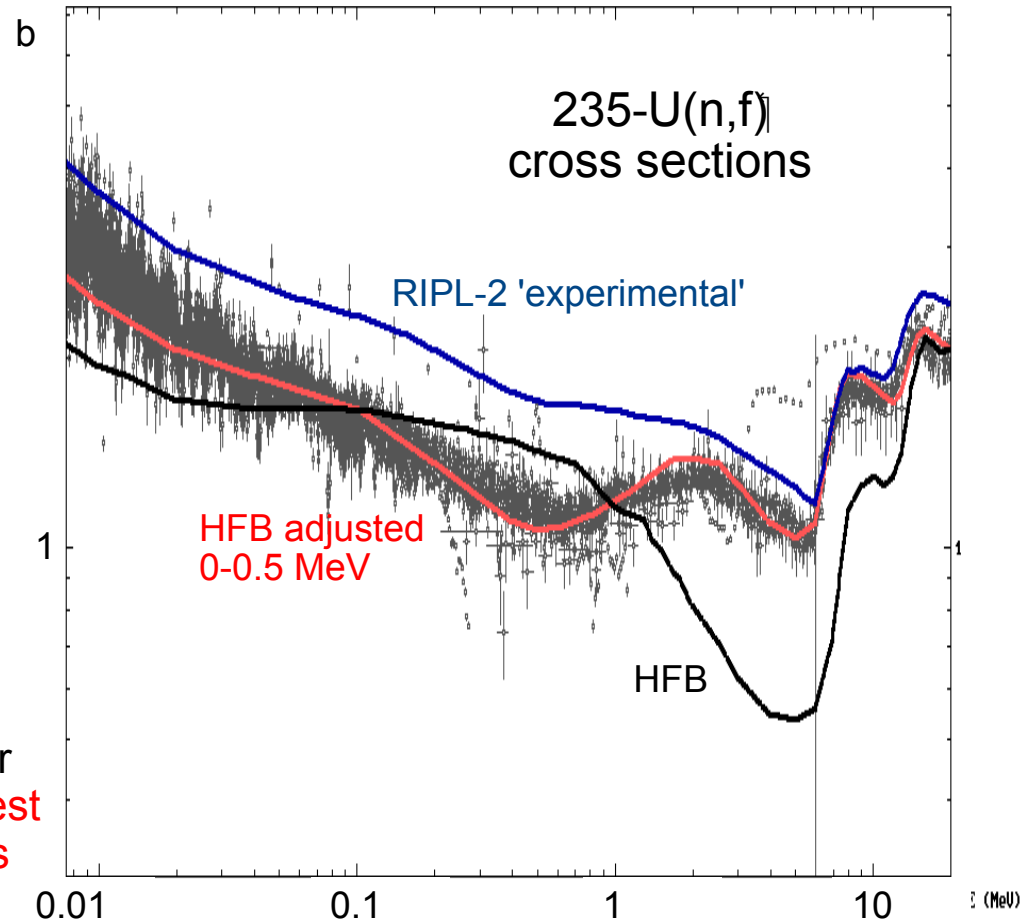


Projection of 3-D energy surfaces provided by HFB microscopic calculations along the quadrupole deformation parameter (Gorieli, RIPL3)

WKB transmission through numerical barriers.

Subroutines for smoothing, finding extrema, interpolation and integration implemented for numerically defined barriers. **EMPIRE can test microscopic fission parameters (HFB barriers and LD for RIPL-3) and use them.**

Effect of fission barriers



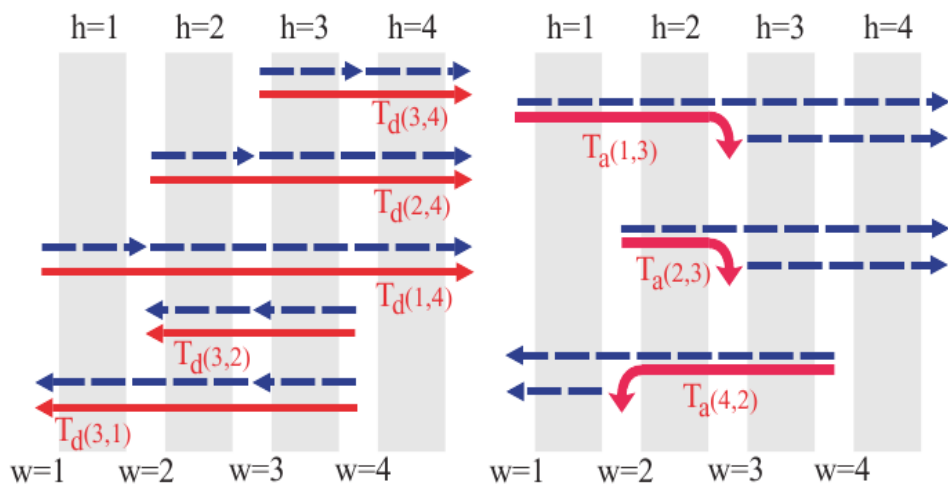
Incident neutron energy (MeV)

ROCKHAVEN
NATIONAL LABORATORY

BNL, November, 2008

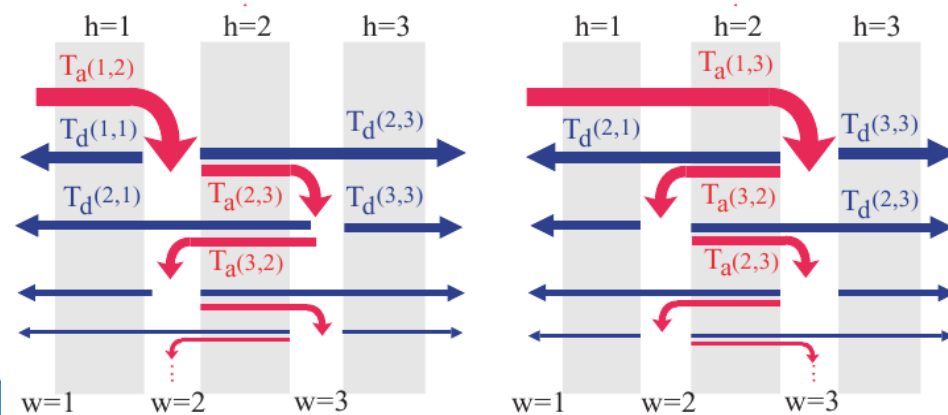
New fission model in EMPIRE

recursive treatment of transmission through multi-hump barrier



Recursive calculation of transmission coefficients

To calculate transmission through more complex barriers, as those obtained within HFB, the optical model for fission was generalized for barriers with any number of humps and absorption in all the wells by using a recursive approach.



Evolution of flux absorbed in the second and third well

Conclusions

- Emphasis on covariances
- Extending capabilities to the resonance region
- Better fission
- Improved parametrization



**State of EMPIRE
is good!**