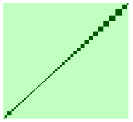
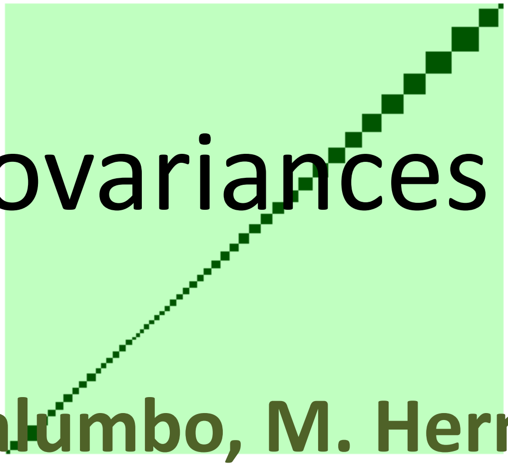


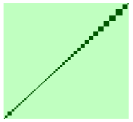


^{239}Pu covariances for assimilation

A. Palumbo, M. Herman, S. Hoblit, G. Nobre

BNL

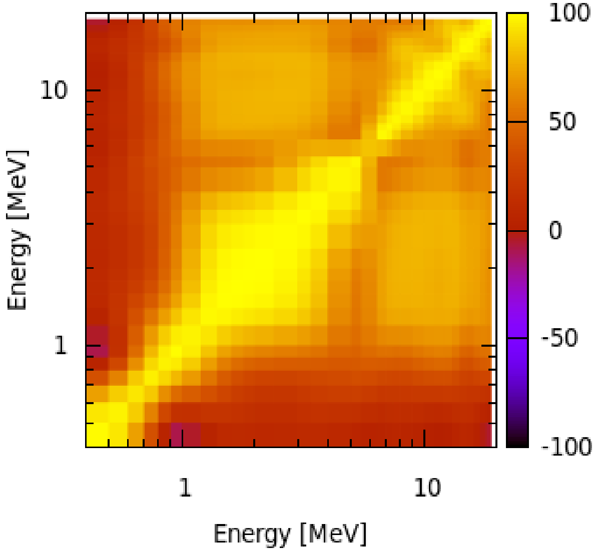
November 9, 2012



Integral & Differential measurements

JEZEBEL: Central cavity containing a canned ^{239}Pu sample

- Reactivity is sensitive to the nuclear data of the samples



Data (region below 1 MeV- 15 to 700 keV) for KALMAN:

1) **F. Tovesson and T.S. Hill – 2010 (several points)**

Parallel-plate ionization chambers
- ^{239}Pu yield ~ 800 (a.u.)

2) **ENDF/B-VII.1 (several points)**

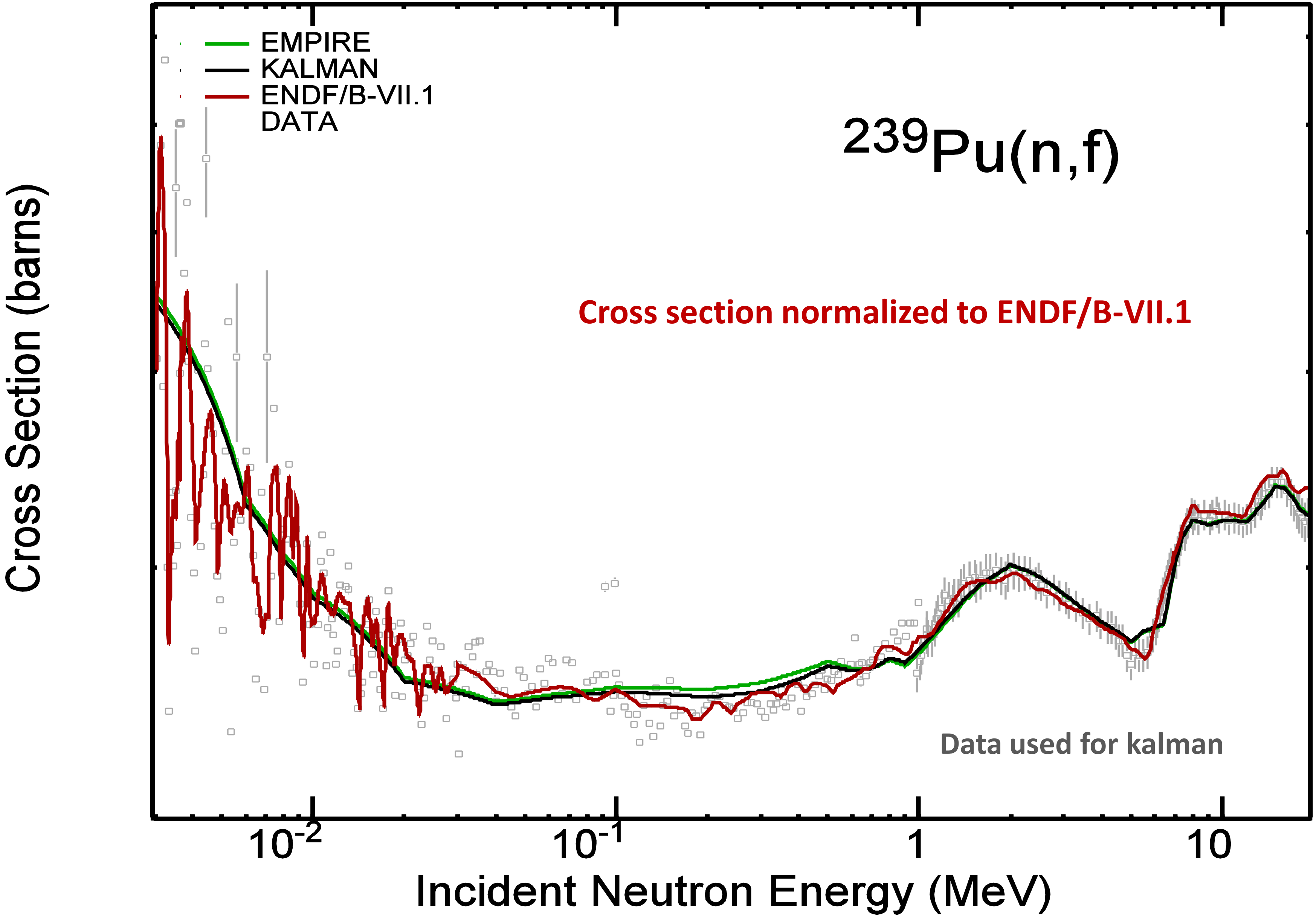
3) **K. Kari (1978 – Karlsruhe)**

Gas scintillation counters
$\delta\sigma$ = 3.2 - 4%

4) **Rochman (2006)**

Pb slowing down spectrometer
– compensated fission chamber (CFC)

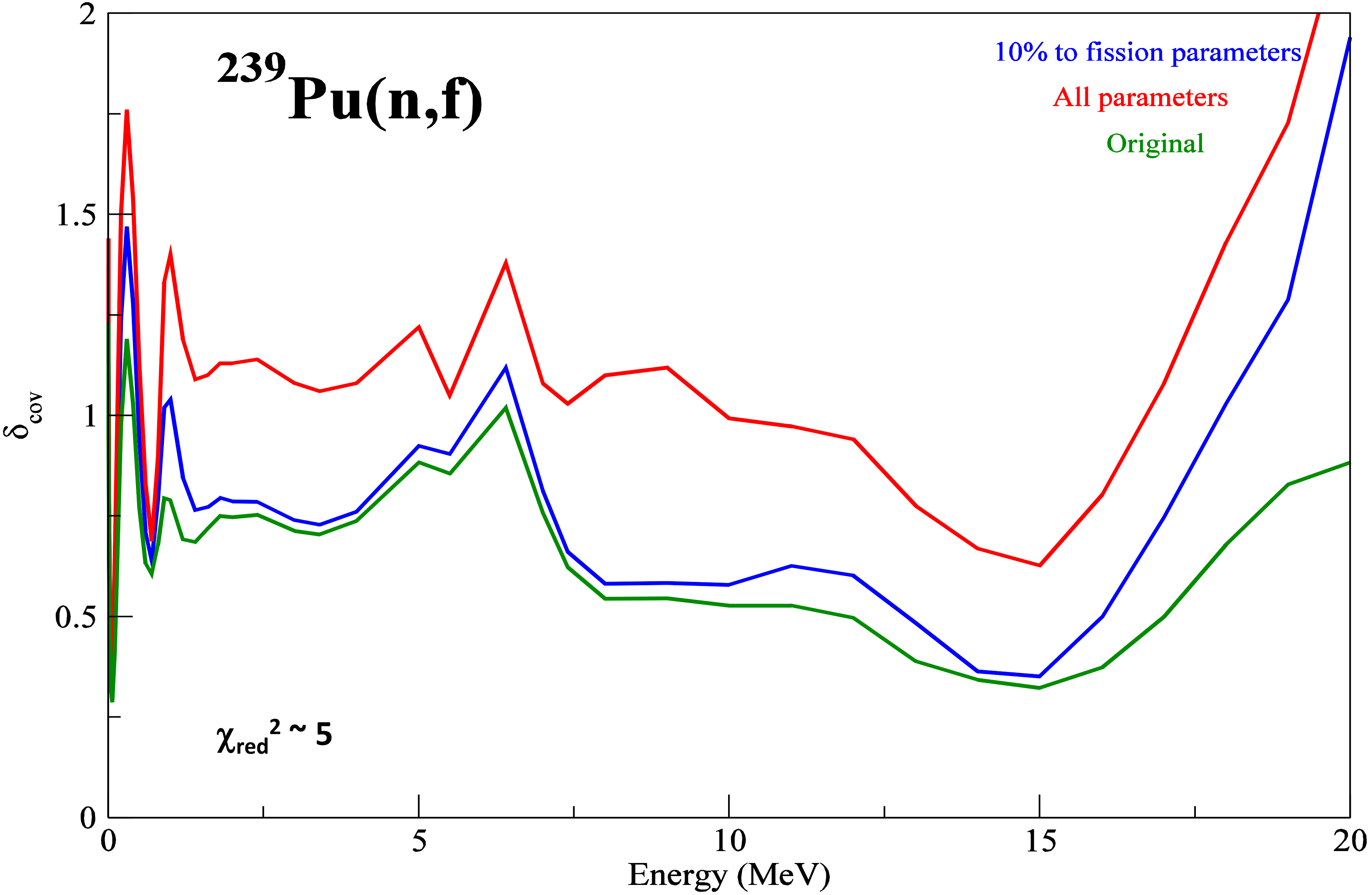
^{239}Pu(n,f)



Cross section normalized to ENDF/B-VII.1

Data used for kalman

^{239}Pu covariance



^{239}Pu covariance

PARAMETER	VALUE	VALUE (10%)	VALUE (ALL)
1ATILNO000000	9.8260E-01	9.9974E-01	1.0324E+00
2ATILNO000100	1.0058E+00	1.0480E+00	1.0519E+00
6TUNEFI000000	9.8871E-01	9.6385E-01	7.3899E-01
7TUNE000000	9.8757E-01	9.9853E-01	9.7868E-01
8TUNE000100	9.9609E-01	9.9600E-01	9.0080E-01
9TOTRED000000	1.0024E+00	1.0001E+00	9.9194E-01
10FUSRED000000	1.0006E+00	1.0002E+00	1.0111E+00
11RESNOR000000	1.0138E+00	1.0180E+00	1.1423E+00
12FISVF1000000	1.0081E+00	1.0244E+00	1.0234E+00
13FISVF1000100	9.9697E-01	9.9267E-01	9.8480E-01
16FISVF2000000	9.8333E-01	9.6278E-01	8.9805E-01
17FISVF2000100	9.9704E-01	9.7728E-01	9.9154E-01
20FISVE1000000	9.9011E-01	9.9705E-01	9.7603E-01
21FISVE1000100	9.9783E-01	9.9824E-01	9.9116E-01
23FISVE2000000	9.5411E-01	9.6688E-01	1.0204E+00
24FISVE2000100	1.0032E+00	1.0021E+00	9.2357E-01
26FISHO1000000	1.0358E+00	1.1058E+00	1.0960E+00
27FISHO1000100	9.9958E-01	9.5342E-01	9.8918E-01
30FISHO2000000	1.0100E+00	1.6392E+00	1.2115E+00
31FISHO2000100	9.9994E-01	9.8992E-01	9.9685E-01
34FISAT1000000	9.6884E-01	9.6822E-01	7.4294E-01
35FISAT1000100	1.0083E+00	1.0078E+00	1.0718E+00
37FISAT2000000	9.8668E-01	9.8058E-01	1.0385E+00
38FISAT2000100	1.0034E+00	9.8960E-01	8.9276E-01
40FISDL1000000	9.9847E-01	1.0003E+00	1.0092E+00
41FISDL1000100	9.9972E-01	9.9975E-01	9.9522E-01
43FISDL2000000	9.9271E-01	9.9492E-01	8.4172E-01
44FISDL2000100	1.0001E+00	1.0000E+00	1.0017E+00
46LDSHIF000000	1.0248E+00	1.0029E+00	1.0322E+00
47LDSHIF000100	1.0062E+00	1.0084E+00	1.0371E+00

<10% for all (and 10% for fission)

^{239}Pu covariance

Opening fission parameters – 10% (linearity conserved)

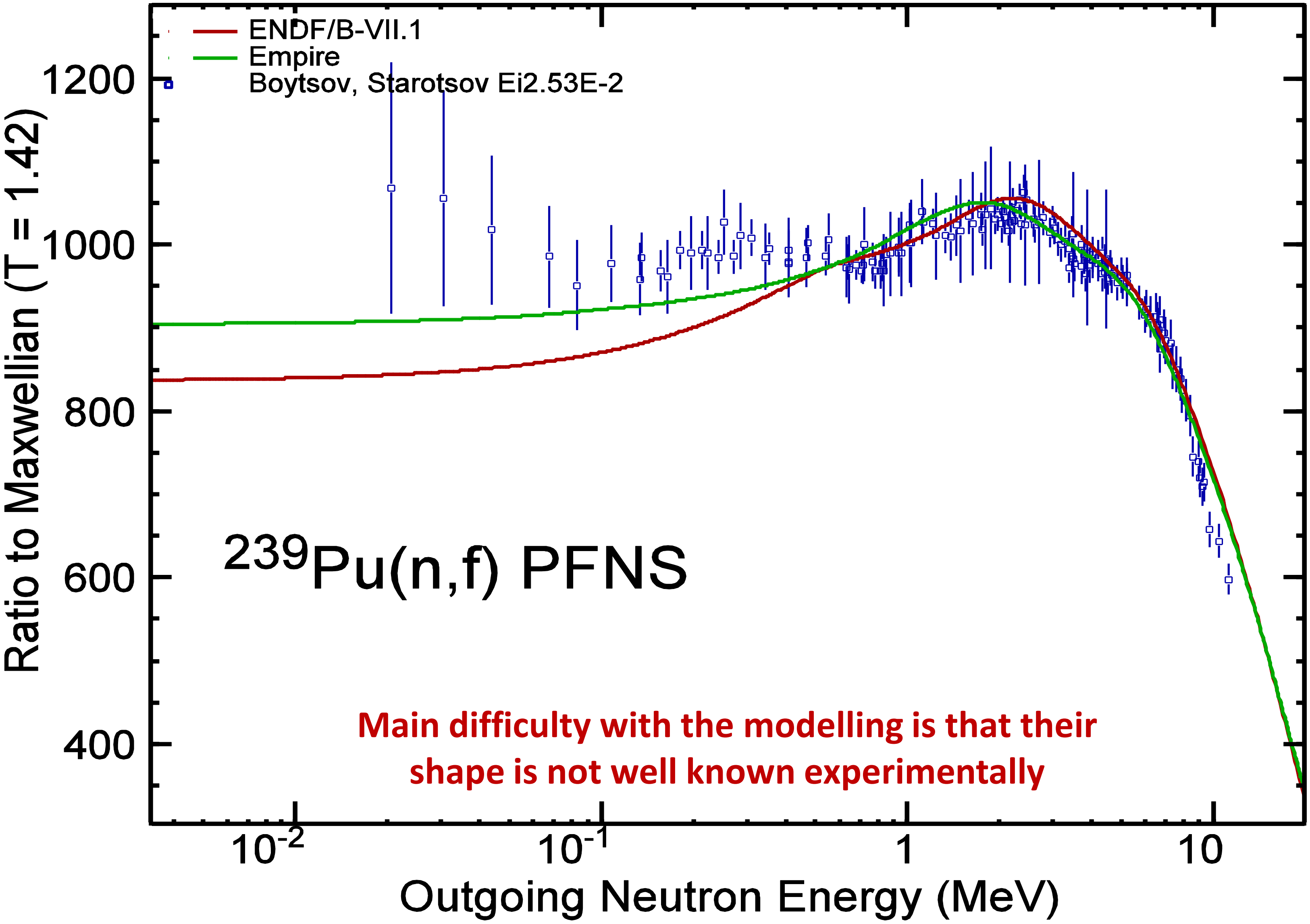
Opening all fission parameters (10% or less)– nonlinearity (some parameters)

First option (increasing fission barriers and widths by 10%) allows parameters to retain linearity while increasing uncertainties

Want to keep parameters at a minimum for both assimilation and KALMAN

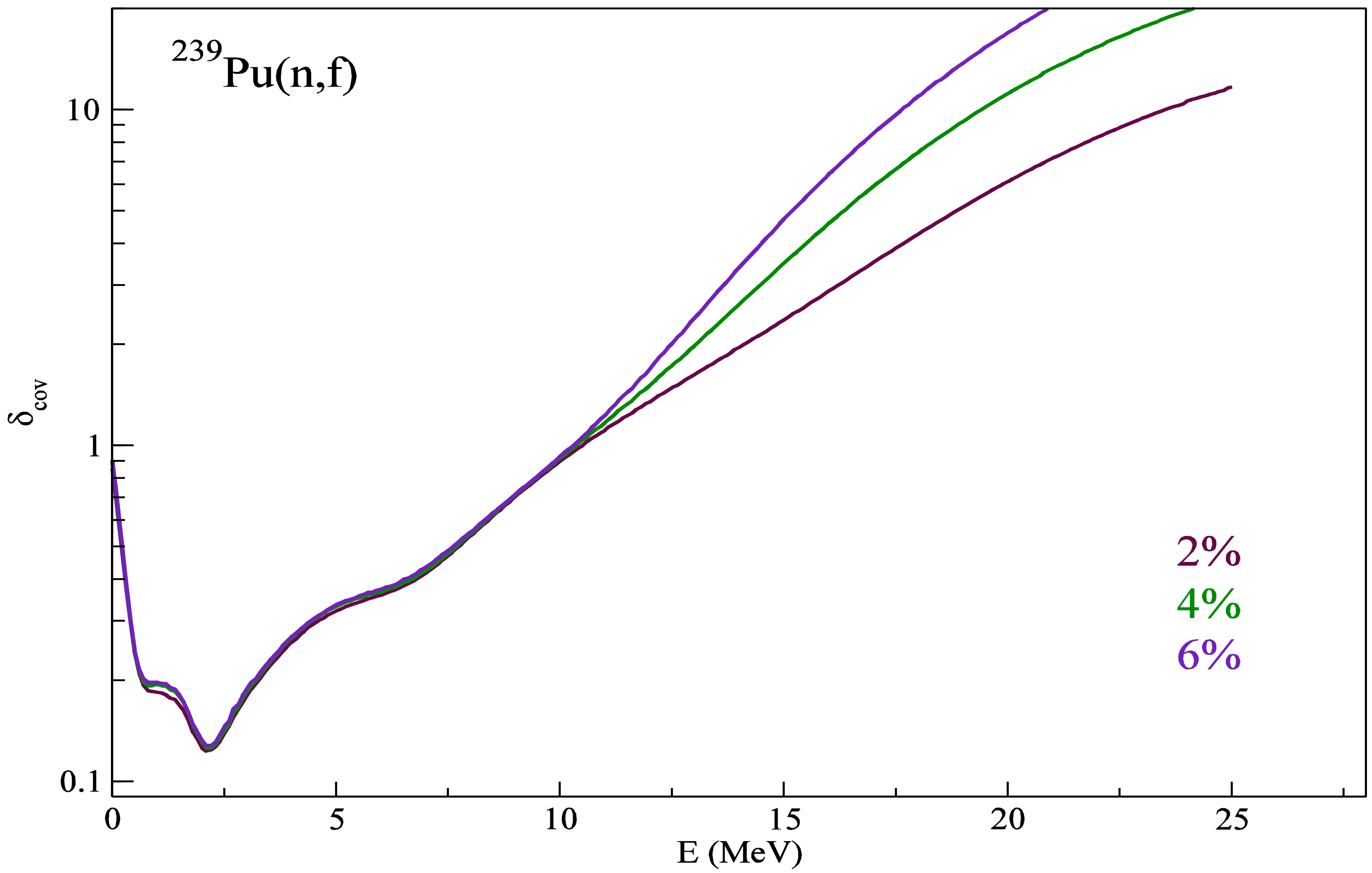
We don’t want artificial squeezing

^{239}Pu PFNS – Los Alamos

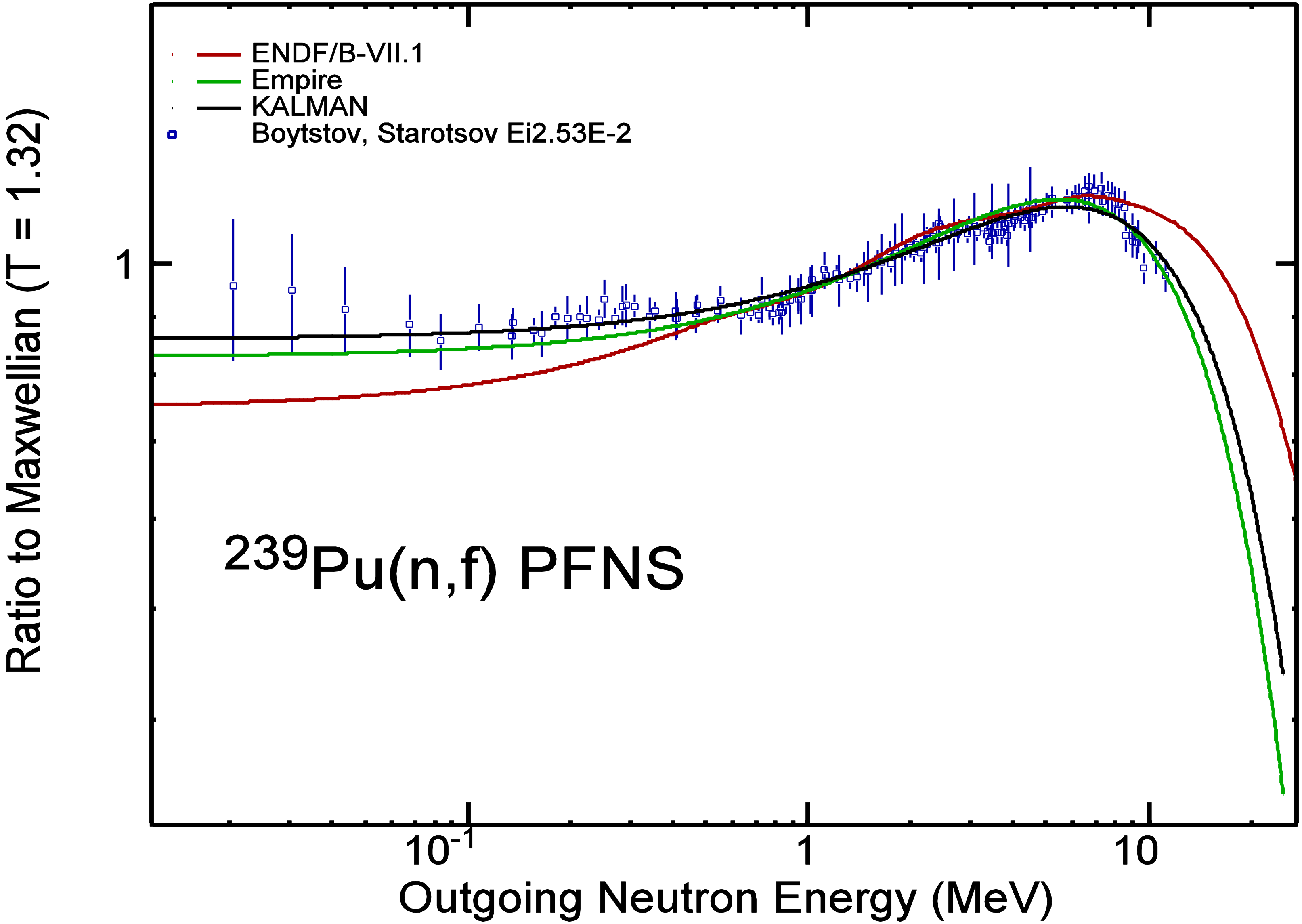


Main difficulty with the modelling is that their shape is not well known experimentally

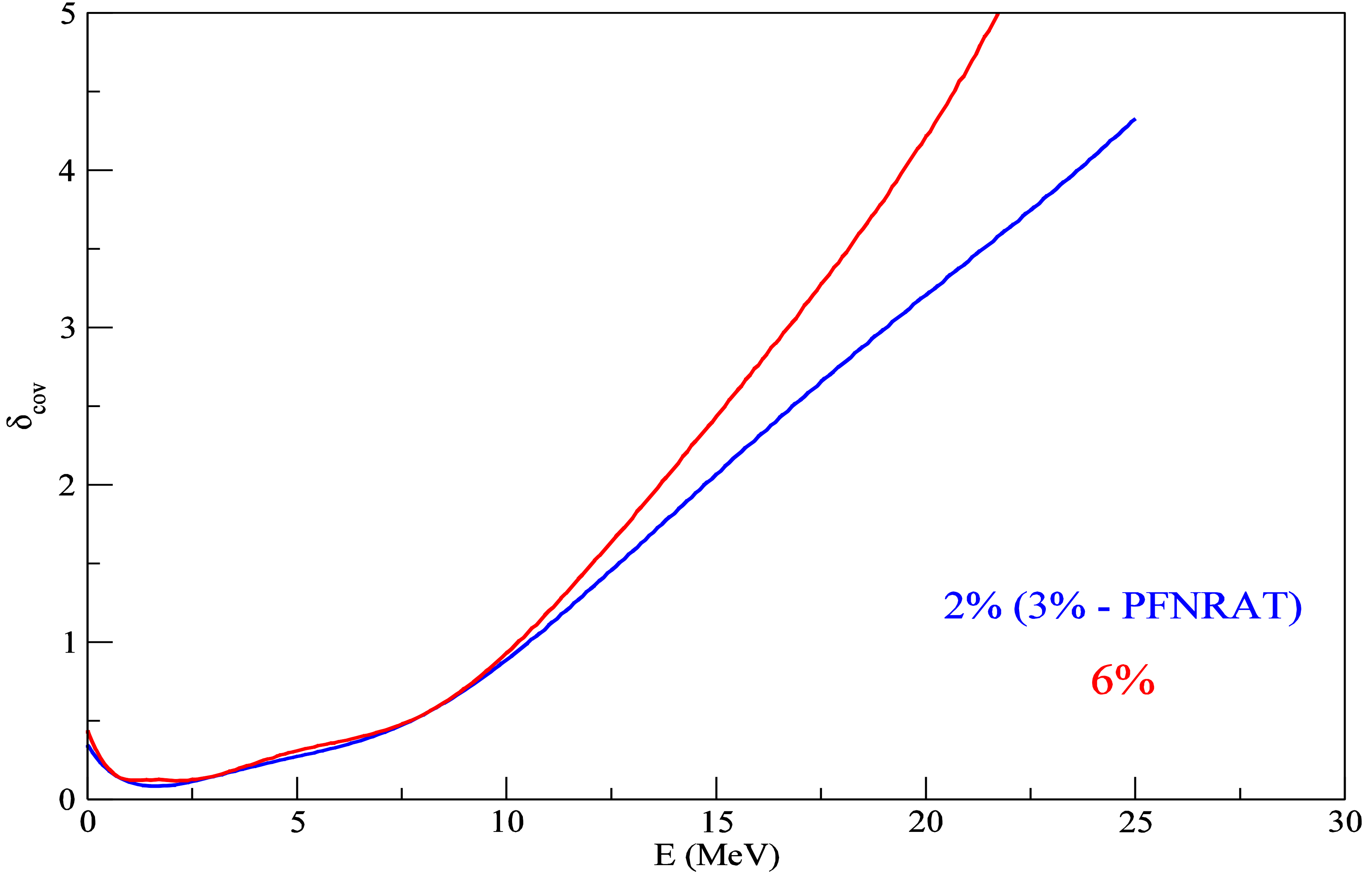
^{239}Pu PFNS covariances – LOS ALAMOS



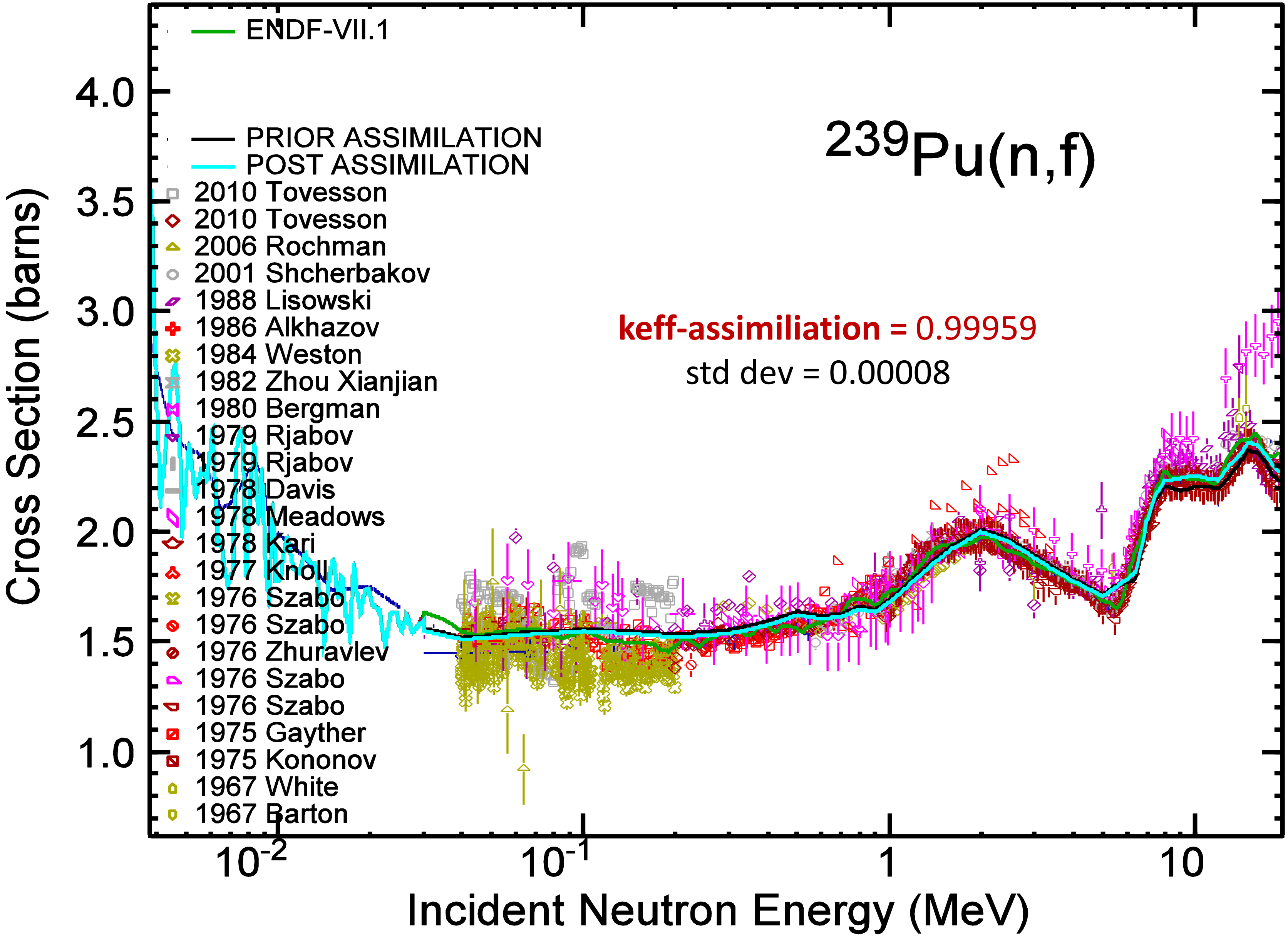
^{239}Pu PFNS - Kornilov



^{239}Pu PFNS covariances – KORNILOV



^{239}Pu(n,f)


ENDF-VII.1
PRIOR ASSIMILATION
POST ASSIMILATION
2010 Tovesson
2010 Tovesson
2006 Rochman
2001 Shcherbakov
1988 Lisowski
1986 Alkhazov
1984 Weston
1982 Zhou Xianjian
1980 Bergman
1979 Rjabov
1979 Rjabov
1978 Davis
1978 Meadows
1978 Kari
1977 Knoll
1976 Szabo
1976 Szabo
1976 Zhuravlev
1976 Szabo
1976 Szabo
1975 Gayther
1975 Kononov
1967 White
1967 Barton
^{239}Pu(n,f)
keff-assimiliation = 0.99959
std dev = 0.00008
Cross Section (barns)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Incident Neutron Energy (MeV)
10^{-2}
10^{-1}
1
10

Thank you

Conclusions

Sensitivity of the integral experiments are not sensitive to the resolved resonance region,

Further point: In the original Los Alamos model [3], thermal equilibrium between the two nascent fragments at scission is assumed, that is, *RT equals unity. However, there* is now strong evidence that this assumption fails when the excitation energy is relatively low [15,16], and that the light fragment gets a larger share of *TXE.*

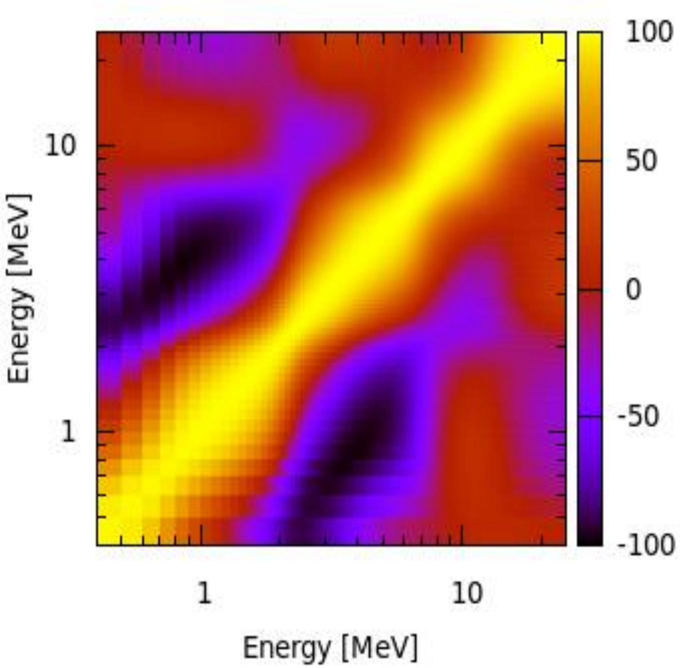
In the original Madland-Nix model [3], the assumption was made that the two nascent fragments are in thermal equilibrium, and therefore that the total excitation energy is shared according to the level density in the light and heavy fragments, respectively. This assumption was carried forward to the fully accelerated fragments, that is, once they are fully separated and that they have relaxed into their respective ground-state deformations. Experiments tend to indicate that this assumption is not usually correct, as more neutrons are emitted from the light than from the heavy fragments

PFNS

LOS ALAMOS

KORNILOV

Assumption is that the neutrons are emitted isotropically from a fission fragment moving with average kinetic energy per nucleon Ef.



Neutrons are emitted after fission fragment formation because otherwise the excitation can’t be fixed; one should have an idea about the energy share between the fragments; neutrons will be emitted as soon as the excitation energy is higher than the neutron binding energy.

Main difficulty with the modelling is that their shape is not well known experimentally