

# CIELO: SG40 Progress, at WPEC May 2014

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& CIELO Collaboration  
*LANL*

*(Next CIELO collaboration with CSEWG, Nov 3-7 week, 2014)*

# SUMMARY: CIELO Pilot progress, & joint SG39-40 meeting

- ◆ Collaboration teams for  $^1\text{H}$ ,  $^{16}\text{O}$ ,  $^{56}\text{Fe}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$  making good progress, and many starter-files have been made
  - ◆  $^1\text{H}$ : standard is being extended from 20-200 MeV.
  - ◆  $^{16}\text{O}$ : changes to (n,a) and (n,tot); starter files coming
  - ◆  $^{56}\text{Fe}$ : New LRF7 resonance analysis performing well.
  - ◆ Resonance region: excellent progress made by ORNL, Cadarache, Geel, and starter files made for  $^{56}\text{Fe}$ ,  $^{235,8}\text{U}$ ,  $^{239}\text{Pu}$
  - ◆ Actinides: fast - focus on inelastic. New capture having impacts.
    - PFNS issues remain open
  - ◆ Sg40 collaboration involves attention to credible covariances, and feedback from adjustment results (e.g.  $^{239}\text{Pu}$  capture)
    - caution re. adjustment feedback (except single-effect exp)
- convergence in ENDF, JENDL adjustment feedback is rare.

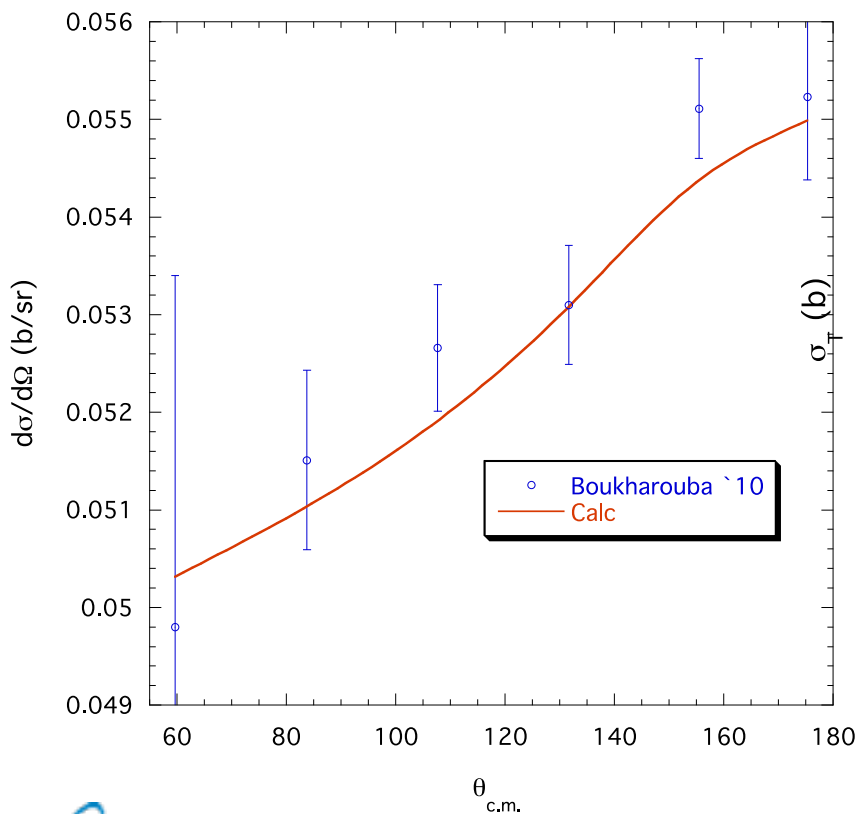
# <sup>1</sup>H updated Standards - WPEC May 2014 report

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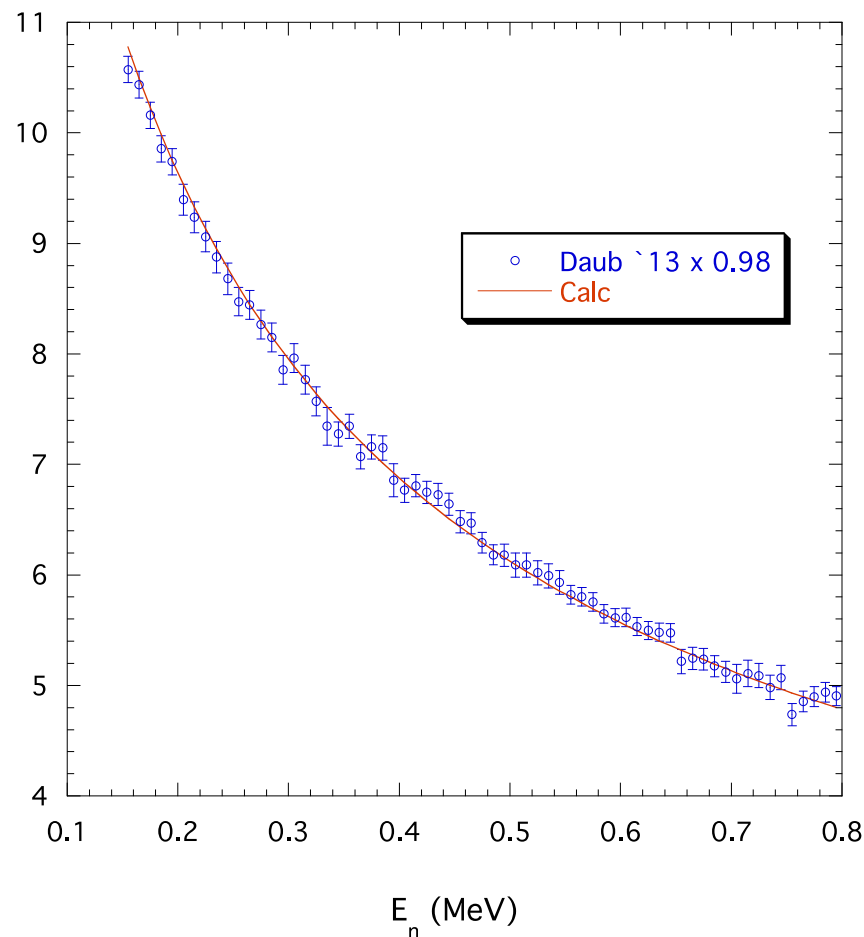
- ◆ Work by Hale, Paris (Los Alamos)
- ◆ Builds on previous EDA R-matrix analysis used for ENDF & IAEA standards, but now:
  - ◆ Has an enhanced measurement database
  - ◆ Uses new data (e.g. from RPI, and from Ohio - 14.8 any diet)
  - ◆ Being extended from 20 to 200 MeV
- ◆ New file will be made later this year, including covariances
- ◆ (Preliminary results suggest only very small changes compared to the existing Standards.

# $^1\text{H}$ recent data added to analysis

n-p Differential Cross Section at 14.9 MeV



n-p Total Cross Section



## <sup>16</sup>O - WPEC May 2014 report

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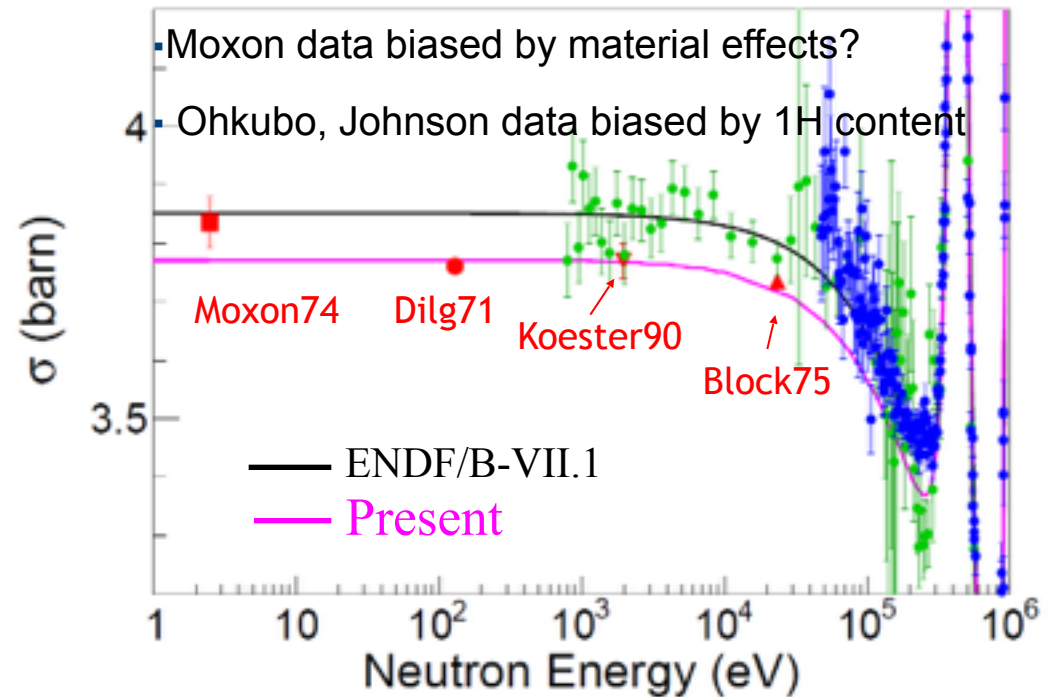
- ◆ Work by Plompen, Lubitz, Kunieda, Hale, Paris, Leal, *etc*
- ◆ <sup>16</sup>O(n,α): R-matrix teams concluding a higher (n,α), more like ENDF/B-VI.8 is perhaps correct
  - ◆ Given by R-matrix & unitarity
  - ◆ Supported by ***newly-revised*** Geel (Georginis) data
- ◆ At least 2 files will be tested (which will use ~3% lower total cross section at low energies, as concluded by Plompen, Lubitz, *et al*:
  - ◆ *Hale file, & a Lubitz - Leal file variant*
- ◆ New files for testing will be distributed soon
  - ◆ Then, a suite of key integral experiments and crits for data testing will be defined
- ◆ We will need to focus on scattering angular distributions

# <sup>16</sup>O. Progress in Understanding Low-Energy Total Cross Section

- Work from Kunieda, Plompen, Lubitz and team

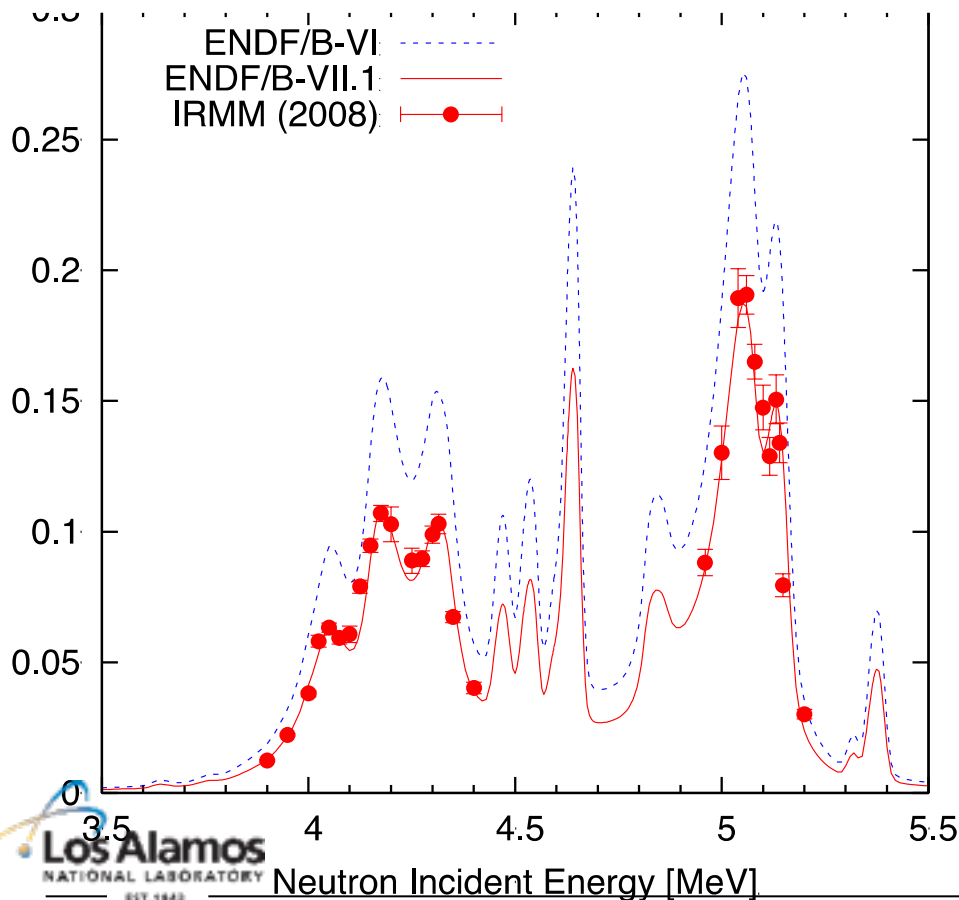
Contributions of H in the sample were estimated by R-matrix fitting to the experimental data.

Exp.	Factor to $\sigma$
Johnson+ (1974)	0.01665 ( $\pm$ 6.02%)
Ohkubo (1984)	0.00988 ( $\pm$ 8.38%)

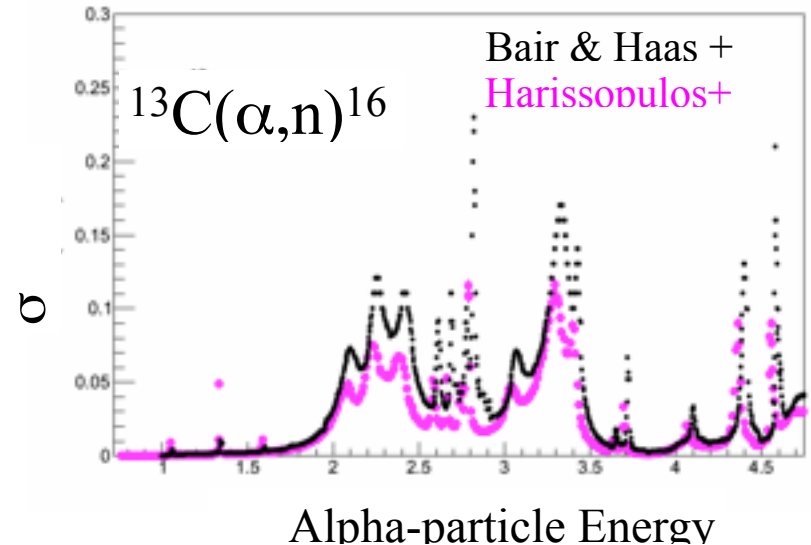


# <sup>16</sup>O. Progress in Reconciling R-Matrix Theory & Data? Longer Term - TPC experiment?

- IRMM data now to be revised up by Georginis
- evaluation likely to increase close to VI.8

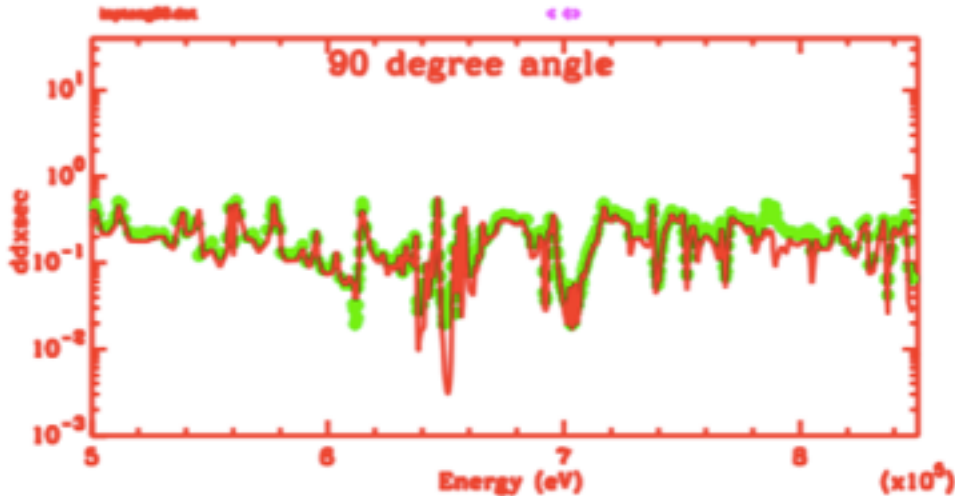


- Team thinks orig Bair & Haas correct
- Harissopoulos off by ~ 50% ?



# $^{56}\text{Fe}$ : Resonance Analysis Progress up to 2 MeV

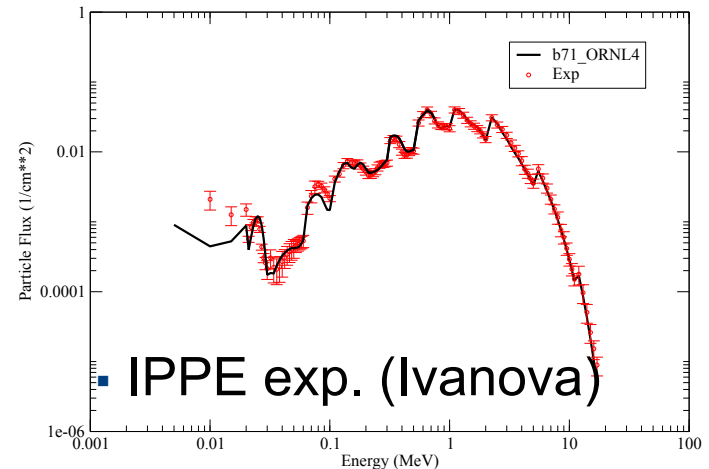
- New high resolution transmission measurements at RPI extending the resonance region up to 5 MeV
- New inelastic cross-section measurements done at GEEL
- Extend the resolved resonance region from 850 keV to 2.0 MeV
- Include new transmission measurements and inelastic cross section data
- Use the extended (RML=7) R-matrix formalism in the SAMMY code for fitting the experimental data



Benchmark	Benchmark $k_{eff}$	E71 $k_{eff}$	E71 EAL	E71 EAF	E71 $k_{eff}$ CE	E71+ORNL4 $^{56}\text{Fe} k_{eff}$	E71+ORNL4 $^{56}\text{Fe} k_{eff}$ CE
HMF13	0.9990	0.99726	1.3648	7.66330E-01	0.99926	0.99743	0.99843
		rem →	rem, but original m4/m2 →	0.99941	0.99850	0.99970	
HMF21	1.0000	0.99748	1.3620	7.37680E-01	0.99748	0.99732	0.99732
		rem →	rem, but original m4/m2 →	0.99720	0.99885	0.99885	
HMF24	0.9990	0.99827	1.1685	6.54780E-01	0.99827	0.99855	0.99855
HMF87	0.9987	0.99841	1.3448	7.51180E-01	0.99871	0.99855	0.99885
HMF88.1	0.9993	0.99874	0.9107	1.32870E-02	0.99744	0.99708	0.99776
HMF88.2	0.9993	0.99871	0.7620	2.14330E-03	0.99741	0.99662	0.99732
PMF25	1.0000	0.99879	1.8069	1.18800E+00	0.99879	0.99876	0.99876
		rem →	rem, but original m4/m2 →	0.99890	0.99892	0.99897	
PMF26	1.0000	0.99843	1.7358	1.09250E+00	0.99843	0.99885	0.99885
PMF28	1.0000	0.99898	1.7198	1.06880E+00	0.99898	0.99927	0.99927
PMF32	1.0000	0.99858	1.8184	1.18880E+00	0.99858	0.99885	0.99885
		rem →	rem, but original m4/m2 →	0.99877	0.99736	1.00027	

Previously obtained good eigenvalues are retained ... rem results suggest cross section revisions and new angular distribution results undo each other!

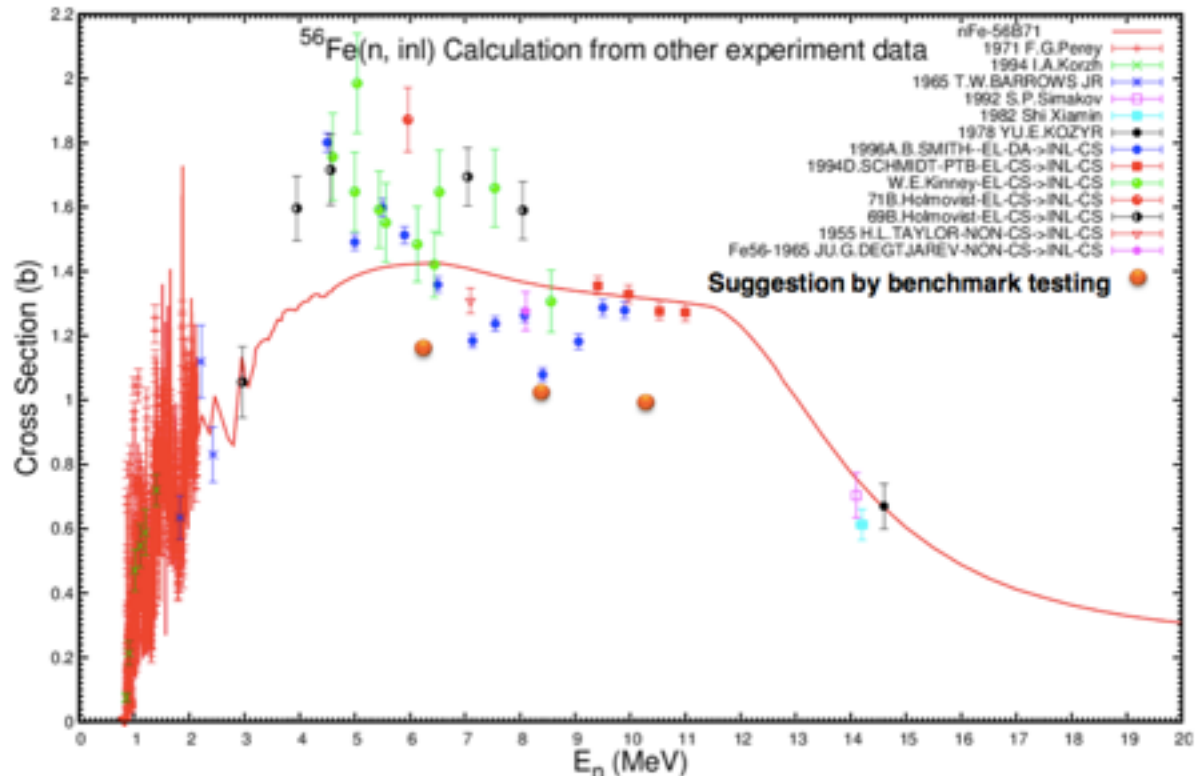
Case: 20 cm (Cf-252 neutron source)



IPPE exp. (Ivanova)

## $^{56}\text{Fe}$ : Fast Range - BNL and collaborators....

- Many issues to work, as a new high energy evaluation is developed
- Jing Qian: Conclusions from Ohio experiment on inelastic problematic?



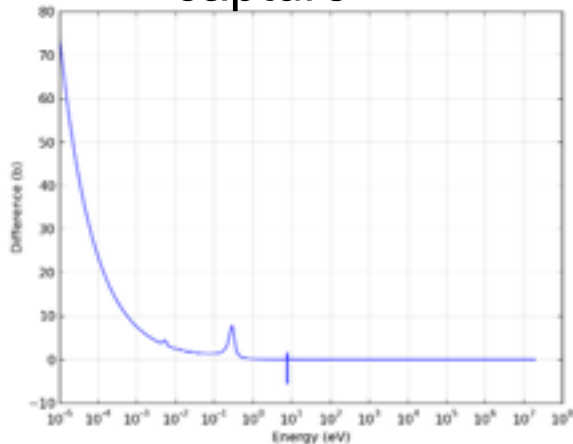
<sup>239</sup>Pu SG34 resonance analysis from Cadarache, Oak Ridge, Cadatache -  
WPEC May 2014 report

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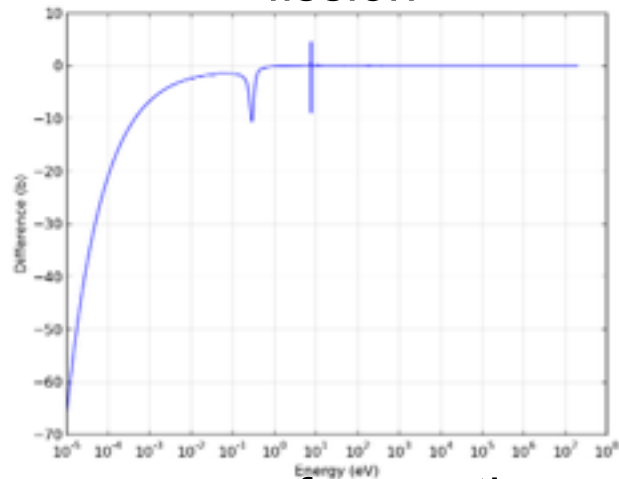
- ◆ SG34: new RR to 2.5 keV & covariances; a better n,gf understanding, with implications on nubar fluctuations; PFNS was studied too
- ◆ Thermal values: cap 270.1, fiss 747.2, and nu-prompt=2.868. The SG 34=3.1.1 has a nubar slightly lower than ENDF, which was already one s.d. below the standard (& *thus now 3.4 s.d below standards*).
- ◆ New measurements are proposed - transmission for first 0.3 eV resonance; capture ... (new IRRM fission, & Los Alamos capture data). There may be a need to extend the resolved range to higher energies owing to the fluctuating cross sections.
- ◆ PFNS: Using Kornilov/Maslov decreases the mean energy, and increases the crits by 800/400 pcm.
- ◆ Lubitz studying adjustments (Noguere notes this was done already by them!). Initial approach (on VII,1): incr. capture, decr, fission, decreasing nubar, hardening chi, but within ~13% of 1-sigma

# $^{239}\text{Pu}$ Adjustments from Cecil Lubitz & Paul Romano (Study Based on VII.1. More Work is Planned here)

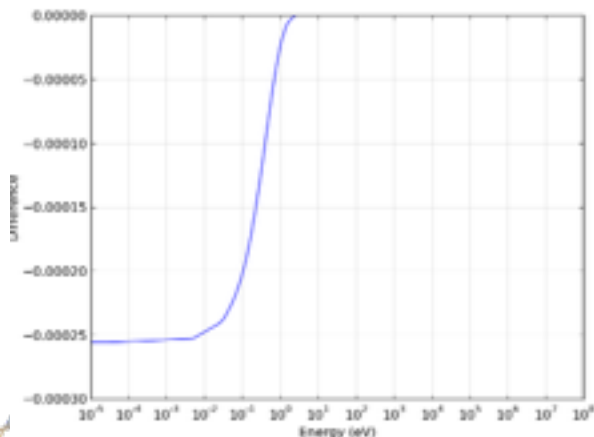
- capture



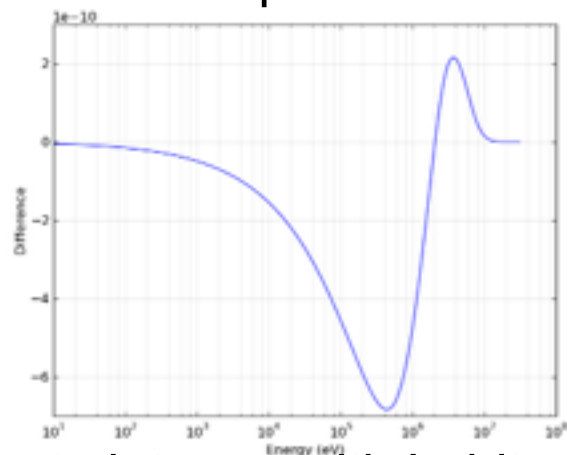
- fission



- nubar

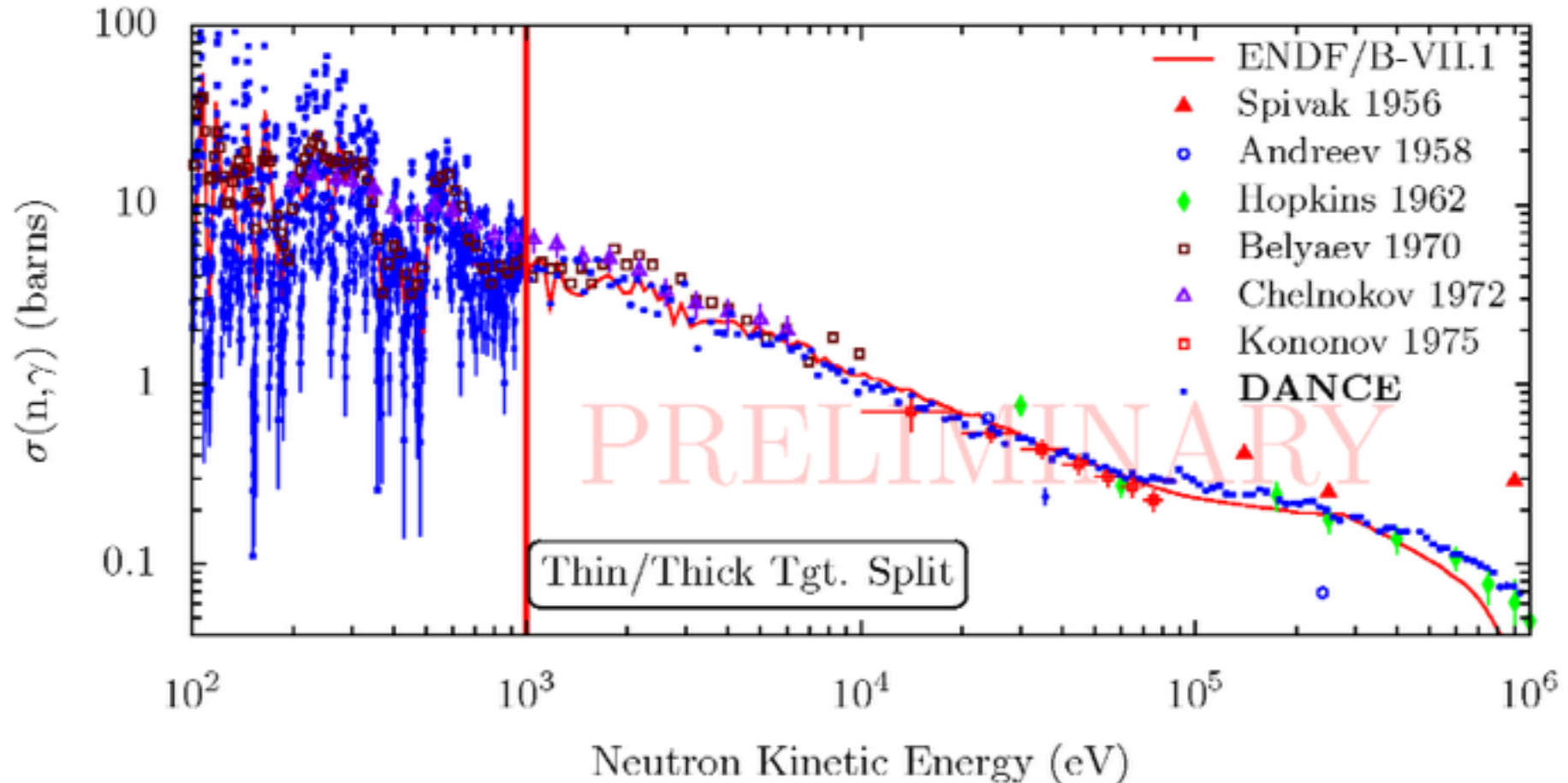


- pfns - anti-maslovian!



- We need SG34 team to interact with Lubitz on tweaks

# Preliminary LANL Results for $^{239}\text{Pu}$ – finalized later this year. Sammy analysts should interact with Shea here.



- Backgrounds still being investigated
- Expect 4% uncertainty at 10 keV similar to Jandel work on U5

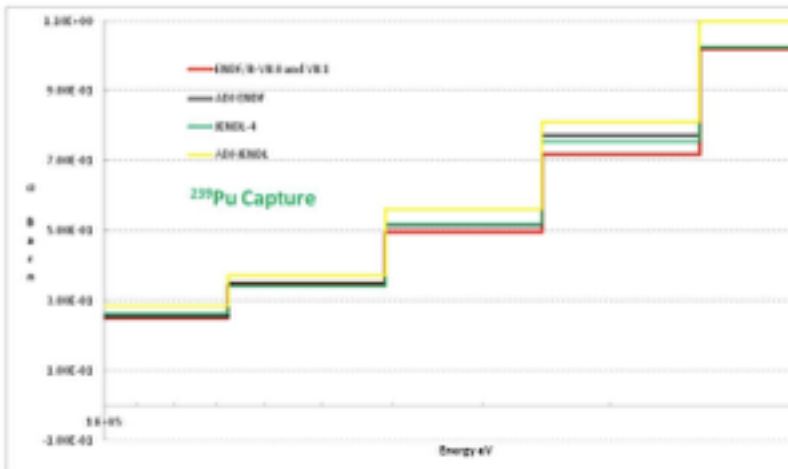
## $^{239}\text{Pu}$ : Fast region, & testing. WPEC May 2014 report

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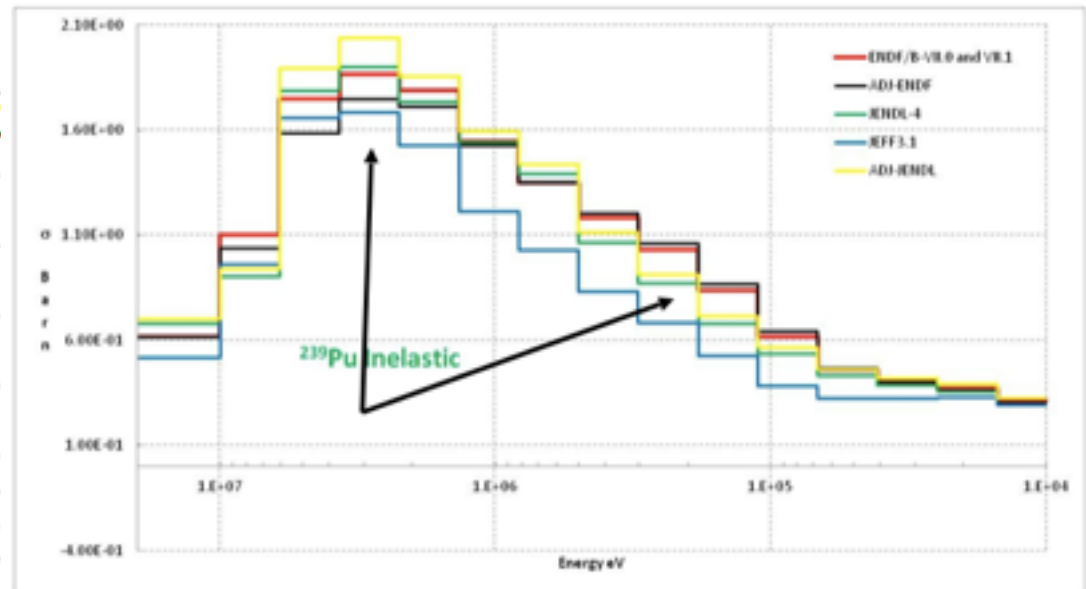
- ◆ Kawano has been focusing on Pu inelastic scattering, in collaboration with CEA, IAEA. We also have new  $^{239}\text{Pu}$  capture data from LosAlamos. A trial file will be made later this year.
- ◆ CIELO starter file built that combines ENDF/B-VII.1 with SG34.
- ◆ Kahler testing CIELO-version0 (=TK1a) as expected reproduces SG34 for thermal systems: improved performance for solution criticals.
- ◆ Trial PFNS from Talou added for testing (version1=TK1). Thermals show a 100-400 pcm increase, reflecting something that is known, i.e. a softer thermal PFNS increases calculated criticality
- ◆ To investigate the potential sensitivity of threshold dosimetry calculations to scattering cross sections, we will calculate results for JEFF3.1 (which has v. different inelastic cf. ENDF)

# Examples of Feedback from SG39 Adjustment Project (Results V. Sensitive to Starting Evaluated Cross Sections & Covariances)

- ◆ Sometimes convergent feedback: e.g.  $^{239}\text{Pu}$  capture
- ◆ sometimes divergence - e.g. inelastics *diverged* near 2-3 MeV
- ◆ esp. valuable feedback from single-effect integral experiments, e.g.  $^{239}\text{Pu}(n,g)$



• Above 10 keV, increase of capture both in JENDL and ENDF (see detailed JAEA study)



- JEFF Values often discrepant with respect to ENDF and JENDL
- After adjustment, significant discrepancies between ENDF and JENDL in the range 2-3MeV (adjustments in opposite directions) and -300-600 keV
- Probably need of specific integral experiments (flat or steep adjoint flux etc)

## $^{238}\text{U}$ : resonance analysis from Geel - WPEC May 2014 report

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- ◆ Builds on previous work by Derrien et al, used in ENDF, JEFF, ...
- ◆ Uses new REFIT analysis of new data from:
  - ◆ Geel (Capture from Geel, Transmission from Dresden)
  - ◆ nTOF (BaF2 capture, + C6D6 data still being worked)
  - ◆ LANSCE/DANCE
- ◆ Uses much older data, e.g. from Oak Ridge
- ◆ Attention is paid to the capture cross section Standard eval.
- ◆ Unresolved data presently extends to 100 keV
- ◆ A file for testing will be provided to Trkov, to be combined with the IAEA higher energy data, for testing

# $^{238}\text{U}$ fast analysis from IAEA - WPEC May 2014 report

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- ◆ A test file has been made by Capote and Trkov (building upon ENDF/B-VII.1) - ib33.
  - ◆ overall, data testing looks encouraging.
  - ◆ Reaction rate testing has been done, for validation
  - ◆ Flattop-25  $^{31}\text{P}(n,p)$  &  $^{235}\text{f}$  ratios look pretty good - but they depend upon transport effect (i.e.  $^{238}\text{U}$  cross sections for transport have an effect on the results above 10-12 MeV, so one should be cautious in inferring information about PFNS there). Morgan White will motivate new flattop measurements.
- ◆ Fast region will be merged with new Geel evaluation when ready

# $^{238}\text{U}$ fast analysis from IAEA - Kahler/Trkov MCNP calks

<b>Correctly broadened!</b>					
Benchmark	Benchmark $k_{\text{eff}}$	E71 $k_{\text{eff}}$	E71 $k_{\text{eff}}$ C/E	E71+"ib33" $^{238}\text{U}$ $k_{\text{eff}}$	E71+"ib33" $^{238}\text{U}$ $k_{\text{eff}}$ C/E
HEU-28 (Flattop-25)	1.0000	1.00299	1.00299	1.00222	1.00222
IMF7 (Big-10, detailed model)	1.0046	1.00447	0.99987	1.00557	1.00097
IMF1.1	0.9988	1.00025	1.00145	0.99911	1.00031
IMF1.4	0.9990	1.00147	1.00247	1.00030	1.00130
PMF6 (Flattop Pu)	1.0000	1.00085	1.00085	1.00059	1.00059

- Excellent performance

## <sup>235</sup>U: resonance analysis from Oak Ridge, Cadatache - WPEC May 2014 report

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- ◆ SAMMY analysis to 2.25 keV. Builds on WPEC sg. 29 findings (that ENDF capture should be reduced near 1 keV). Uses new:
  - ◆ DANCE (Jandel) - lower resolution
  - ◆ RPI - in 500 eV to 3 keV, lower than ENDF.
- ◆ Fitting was also done for eta, and integral K1, Westcott factor, and capture resonance integral, into SAMMY
- ◆ Benchmarks FCA, Zeus, support these changes, & HMI-1 with iron. Noguere has updated unres. res. 2.25-25 keV & Profil data.
- ◆ IAEA working to make <sup>235</sup>U thermal PFNS a standard; work will be needed to see if this can be accommodated with other tweaks.
- ◆ A file for testing was made (fused with JENDL). We need to make merged file with ENDF, and with Romain's new high energy file.



◆ Need to see performance for sodium-void Japanese expts

## $^{235}\text{U}$ fast analysis from CEA/BIII - WPEC May 2014 report

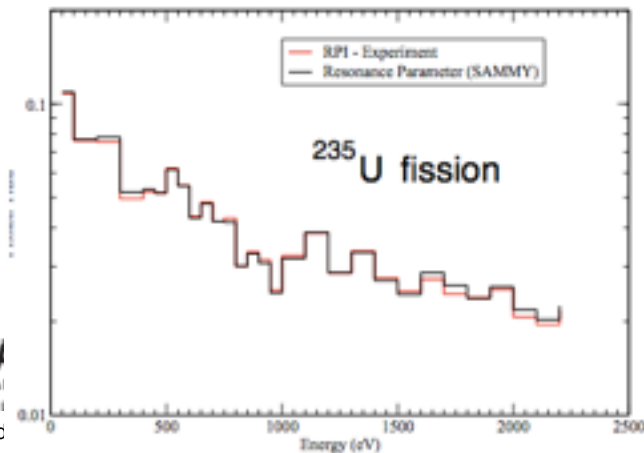
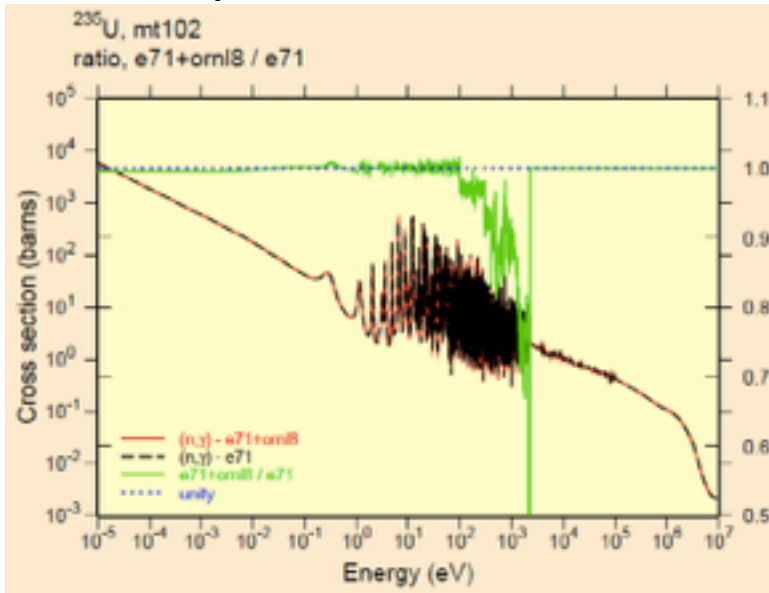
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- ◆ Collaboration meeting held on inelastic scattering at BIII (with Kawano, Capote) for all actinides, including Pu. Part of the difference was traced to JEFF having a higher total cross section for  $^{239}\text{Pu}$ . More work is needed still, though, since this does not explain the inelastic differences (a Morillon Pu chi was tried too - somewhat maslovian -).
- ◆  $^{235}\text{U}$  inelastic is smaller than for ENDF, JENDL.
- ◆ Capture is being worked on
- ◆ Draft file will be available at the end of the summer.

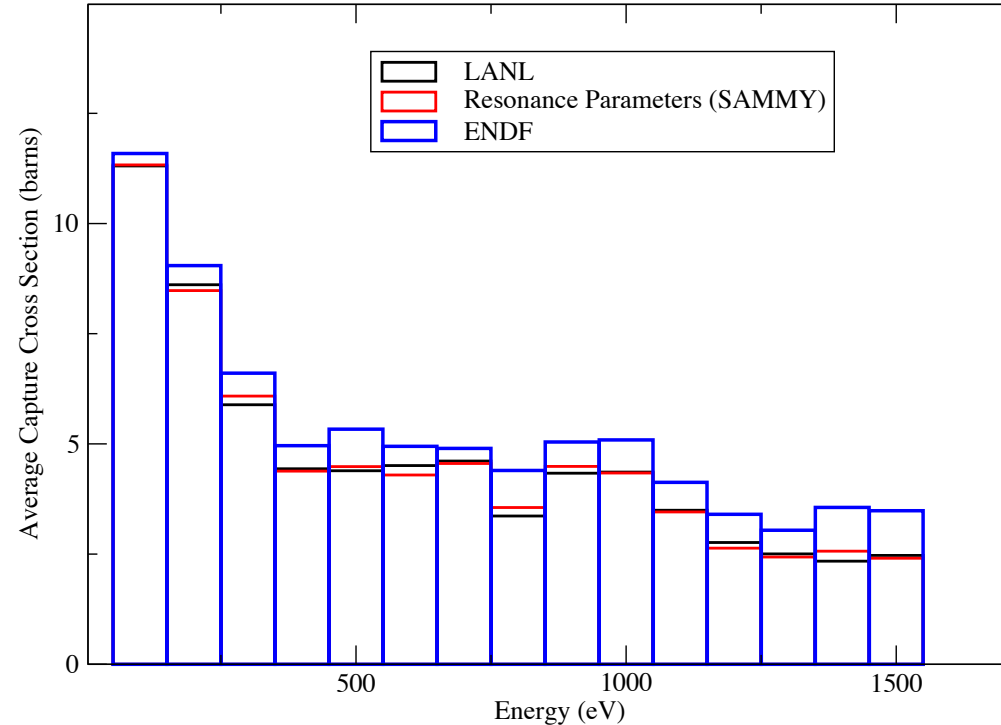
(Preliminary testing of ORNL8 file shows some performance degradation (over-prediction) of poly-reflected HMF benchmarks, owing to the reduced capture below 2 keV. HST good performance in VII was preserved)

# <sup>235</sup>U capture: New LANL/DANCE & RPI data impacting SAMMY As Suggested by Japanese Colleagues

- Previous problem in ENDF/B-VII



U-235 SAMMY fitting of LANL Capture Data



- Sammy RR analysis (CIELO starter file)
- Matches new DANCE and RPI data
- Higher capture could have a big impact
- But DANCE > VII.1 from 2.5 - ~80 keV**

# JENDL adjustment feedback -<sup>239</sup>Pu

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- ◆ <sup>239</sup>Pu capture above 3 keV increased by 9%. this was influenced by ZPPR-9 (keff, C28/F49, F28/F49), [& adding Jezebel criticality does not prevent this adjustment, because other things then change]
  - ◆ (the Profil feedback also suggesting a capture increase is a different study, from Palmiotti)
- ◆ <sup>239</sup>Pu fission is adjusted with a decrease of 0.5%
- ◆ elastic increased by 2%
- ◆ inelastic - increased by 10% at maximum, and compensates the PFNS spectrum hardening adjustment
- ◆ fission spectrum - hardened by 4% (at 10 MeV out 4% higher, and 0.1 MeV out, 4% lower) - just for fast systems
  - ◆ (anti-maslovian effect)
- ◆ Decreases prompt nubar by 0.2%

## ENDF adjustment feedback -239Pu (VII.0 +Commara 2.0 starting point)

Based on Fast Integral Experiments, incl COSMO, PROFII, TRAPU reaction rate expos

5 More crit masses - ZPR34,53,54, cirano 2a,2b assemblies. Have chi for 5,8U unc from jendl and p1

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- ◆ Inelastics 238U, 239Pu, reduced in the 1-5 MeV range; 235U doesn't change
  - ◆ especially at the peak of the inelastic
- ◆ 239Pu capture is increased by 5-10% from 1 keV-50 keV (Profil) - apparently confirming JENDL - a single effect experiment
- ◆ 239Pu fission covariances - smaller than variation in evaluations
- ◆ 235U capture doesn't change much - but they didn't have the FCA-type experiments from Japan that are sensitive to them
- ◆ PFNS - unchanged really
- ◆ Profil - 239Pu n2n increased ; 238U n2n reduced by a few percent
- ◆ 56Fe - inelastic lowered slightly; capture at 1.2 keV lowered slightly
- ◆ New Mantra INL experiment (irradiating pure samples of many actinides) in ATR reactor. Samples in different spectra were made. Data coming out soon - analyzed with AMS at argonne, and also standard spectroscopy. Mantra-2 is planned.

Warning was given - of compensating errors that might bias conclusions, including weaknesses owing to missing experiments, and missing covariances: secondary energy distributions for inelastic scattering, P1 for elastic, etc.

# Dupont/NEA Comparison of SG39 Results

- ◆ graphs made of prior and posterior cross section for INL and JAEA results
- ◆ show posterior JAEA/INL to see where they ended up. More graphs will be made to see the extent to which they converged.
- ◆ capture  $^{239}\text{Pu}$  - jendl adjusted is higher by 5-10% in 20 keV- 200 keV (and lower at lower energies, 2-10 keV since JENDL did not include the PROFIL adjustment!)

# Salvatores Comparison of SG39 Results

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- ◆ 238U inelastic: JEFF discrepant wrt ENDF and JENDL. Jeff higher near peak above a few MeV. Adjustments suggest ENDF decreased.
- ◆ Not much evidence of convergence as one looks at posterior files for ENDF, JENDL, JEFF
- ◆ PROFIL 235U capture data should be investigated with Profil and Mantra, to see how the updated Sammy (using DANCE, RPI data) perform. Profil had suggested a few-percent under prediction of ENDF. How does the result change? Mantar has at least 3 tailored spectra, including fast.
- ◆ Profil drives 239Pu capture up in the say 1-10 keV region.
- ◆ At 2 keV fission in 239Pu is quite a bit higher than JENDL (a fluctuation) - about a 10% difference in one bin near 2 keV!
- ◆ Pu inelastic - JEFF a lot lower, and post-adjustment changes significant
- ◆ Chi JENDL and ENDF differ significantly at the very high energies - at 20 MeV out, chi in JENDL one order of mag higher!
- ◆ Need complete covariance data, including on secondary neutron energy distributions and angular distributions, as well as key correlations amongst reactions and isotopes (e.g. u5 fission impact)

# JENDL adjustment feedback -238U

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- ◆ 238U captures - adjusted within 2%
- ◆ mu-av decreased by 8%. Want to see convergence in the major libraries
- ◆ elastic increased by 2%

# JENDL adjustment feedback -235U

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- ♦ 235U captures - decreased near 1 keV (as in new CIELO, and in JENDL4)
- ♦ fission - no feedback

# JENDL adjustment feedback -<sup>56</sup>Fe

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- ♦ elastic - no feedback