# CIELO: Goals and Timeline

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**Overview**

- **The challenges facing a broad collaboration**
- **Some integral data validation results**

**($^{235,8}$U , $^{239}$Pu, $^{56}$Fe, $^{16}$O, $^{1}$H *initially*)**

# Time-line

- **May 2013: CIELO WPEC Subgroup initiated**
  - Teams identified
- **Nov 2013: NEMEA7-CIELO: Main collaboration kick-off**
  - Refine scope of work, collaborators who will work on tasks
  - Will result in detailed work plans, time line goals, for each nucleus
- **Next 2.5 Years:**
  - Various collaboration meetings, continual email collaborative exchanges
  - engagement with validation data testers continually
  - Incorporate new IAEA standards results (fission, capture, scattering, …)
  - Explore interdependencies on criticality from the 6 CIELO nuclides
- **May 2016:**
  - Document conclusions from CIELO collaborations in WPEC report (& NDS paper?)
  - Create formatted files that embody CIELO's initial conclusions

# CIELO Expedites Evaluated Data Advances ~100 People Already Engaged from Across World

- ✓ **Pilot Project: $^{1}H$, $^{16}O$, $^{56}Fe$ $^{235,8}U$ and $^{239}Pu$**
- ✓ **Identify discrepancies – see our ND2013 Proceedings paper**
- ✓ **Establish teams of specialists**
- **Resolve/document discrepancies and create new CIELO files: Insights come from experiment, theory, and benchmark experiments**
- **Goal: best physically-justifiable cross sections, while maintaining good integral performance (k-eff criticality, reaction rates, *etc*)**

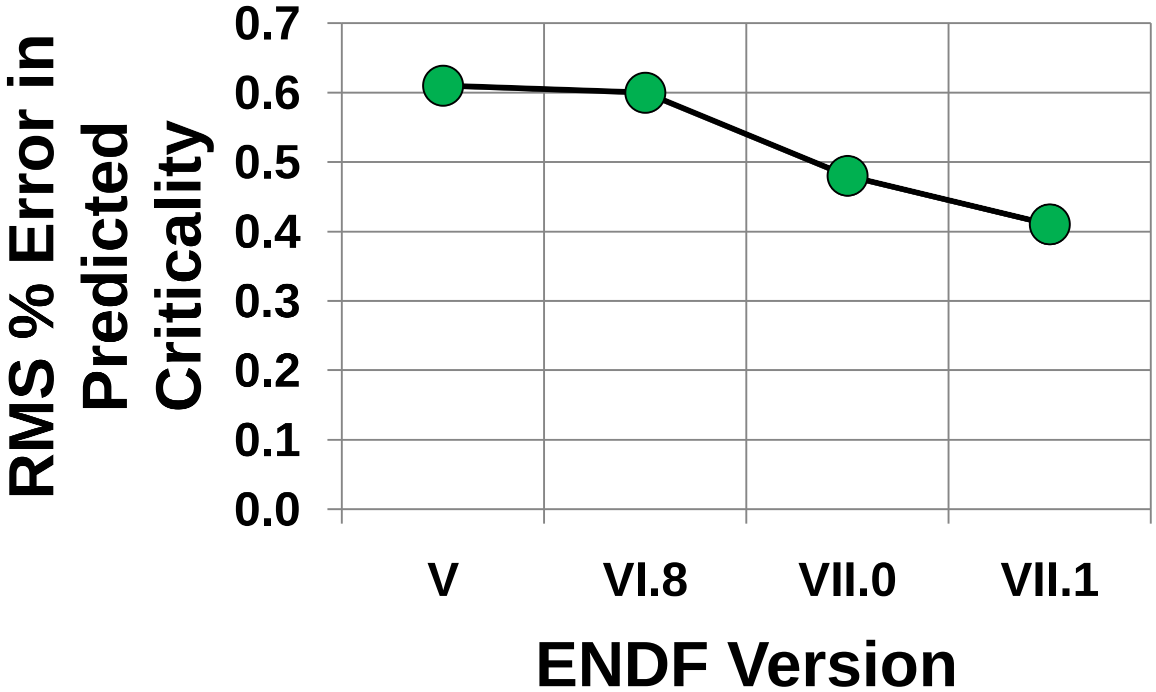
It's an opportunity to make substantial advances, with key support from NEA (Emmeric Dupont …) and IAEA (Robin Forrest …)

# CIELO:
# Rationale ….

- **Nuclear data are physical constants – there's only one correct answer! And they are used as a trusted repository for scientific data**
  - Existing ENDF, JENDL, JEFF, …. have reached a level of maturity enabling us to contemplate this next step – *they're already converging!*
- **Quality: advances will benefit from collaboration of world's experts**
  - Evaluations are extremely complex, with very broad scope
  - We are relying more on complementary expertises
- **Computational & sens./covariance advances can expedite advances**
- **We have experts in place to do this (including key retirees)**
- **Build on steps already taken through international collaborations**
  - IAEA/WPEC Standards … IAEA CRPs, NEA WPEC Working Groups …..

# Progress in Modeling Criticality in ENDF

**"Mosteller" suite of 119 critical assemblies that we track over time (MCNP6 calculations)**

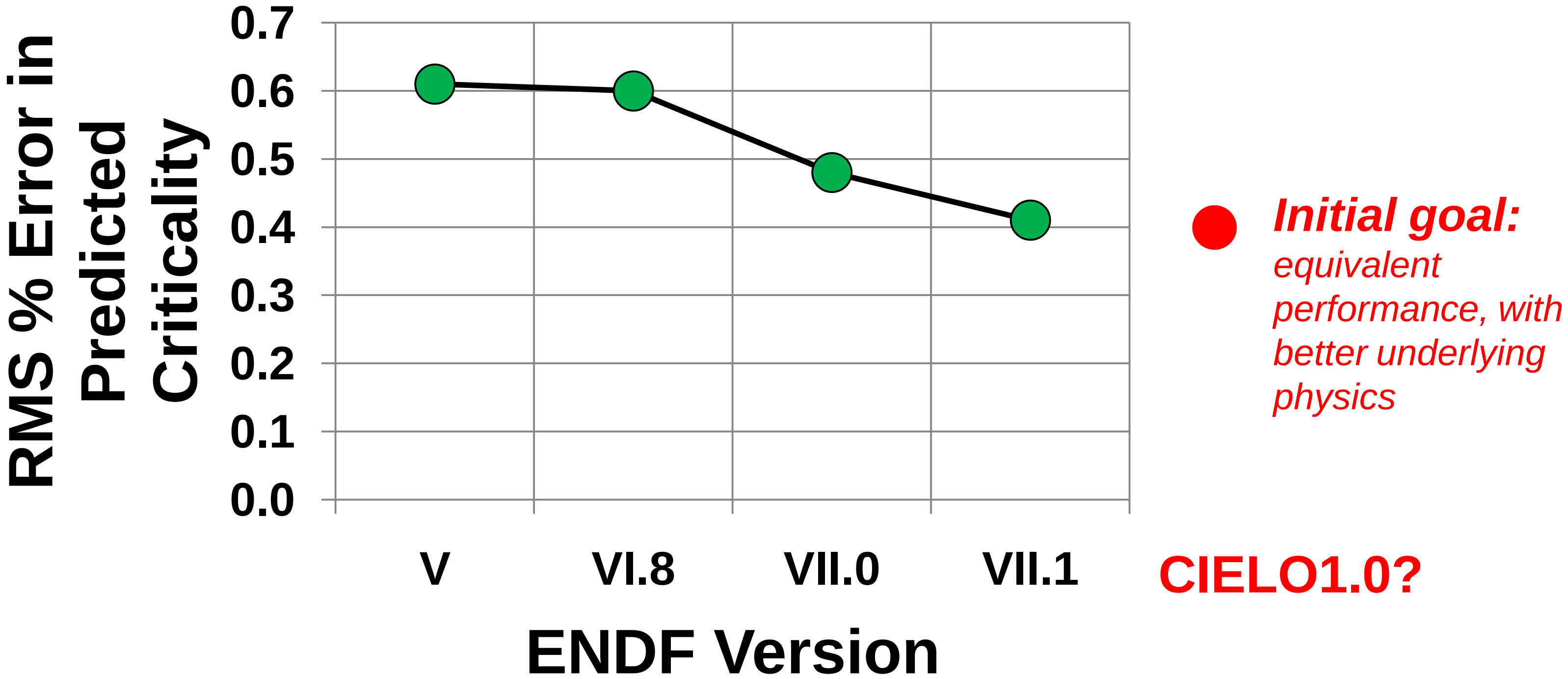



Kiedrowski

**Diminishing returns:** it is increasingly difficult to improve our overall performance using the present approaches

# Progress in Modeling Criticality in ENDF

**"Mosteller" suite of 119 critical assemblies that we track over time (MCNP6 calculations)**




**Diminishing returns:** it is increasingly difficult to improve our overall performance using the present approaches

# In Case You Didn't Think We Have Lots of Work ……

CIELO: Summary of tasks to address:

# Actinides: 239Pu, 235U, and 238U - specific issues for each nuclide are noted

## Fast Region (keVs and above to 20 MeV) - fission listed separately

Review Overall Goals, as embodied in this document and in LAUR CIELO document

Inelastic and elastic scattering - below a few MeV (eg 7)
- Review existing discrepancies between evaluations
- Collect all available experimental data
- Review various theoretical approaches, as embodied in codes (including HF, Coupled Channels, KKM, ....)
- Discuss and review optical model options
- 238U: dispersive coupled-channels OM developed at IAEA
- Seek consensus on best evaluated reprentation of data
- 238U: 238U Elastic and inelastic scattering data from RPI. Quasi differential available (mainly inelastic) from RPI from from 0.5 MeV up to 20 MeV. - EN
- 235U: New (n,xng) data to be published in PRC by Kerveno et al. (IPHC, Strasbourg (F)) could be useful to model inelastic scattering on first levels, see
- Understand implications from integral data testing on changes in inelastic scattering - especially k-eff and reaction rates (spectral indices for 85/5f etc)
- Assess covariances and implement in ENDF format
- Create ENDF formatted files

Inelastic and elastic scattering - 7-20 MeV
- Review existing discrepancies between evaluations, data, and models (including preequilibrium)
- Collect all available experimental data - including Kammerdiener's data and Baba's (U8) data
- Review various theoretical approaches, as embodied in codes (including preeq, HF, Coupled Channels, KKM, PFNS background, ...)
- Discuss and review optical model options
- Seek consensus on best evaluated reprentation of data - including possible continued use of pseudostates
- Understand implications from integral data testing on changes in inelastic scattering -especially 14 MeV pulsed spheres/transmission data
- Assess covariances and implement in ENDF format
- Create ENDF formatted files

Neutron Capture
- 239Pu: Review discrepancies between evaluations, which exceed 10% at the higher energies
- 235U: Review discrepancies between evaluations, which exceed 25% near 1 KeV (Japan'shigher result) and 10% at the higher energies
- 238U: Consider adopting 238U capture from standards - ENDF/B-VII used this, but with some small differences. Study implications from data testing of
- 238U: Monitor Standards results for any changes, based on new measurements from DANCE, nTOF, Geel
- 239Pu: Review data (very few measurements, especially above 100 keV there is just the LANL Hopkins data); See if DANCE data is available in time
- 235U: Review new DANCE data and RPI data, that appear to corroborate JENDL changes near 1 keV, but point to higher energy changes too
- Review guidance from integral PROFIL data (suggests PU9 and (maybe) U5 from ENDF should be higher), and Wallner AMS data at 25 keV and 420 keV
- Assess model calculations predictions (consisent with above inelastic scattering HF/CC/OM calculations)
- Seek consensus on best evaluated reprentation of data
- Understand implications from integral data testing on changes in capture - especially k-eff and reaction rates (spectral indices for 85/5f etc)
- Assess covariances and implement in ENDF format
- Create ENDF formatted files

n2n
- Discuss data, including discrepancies in rise from threshold, and differences near 14 MeV
- Review existing evaluations (including "GEANIE evaluation" for 239Pu), data , and calculation predictions
- 235U: New (n,xng) data to be published in PRC by Kerveno et al. (IPHC, Strasbourg (F)) could be useful to model n2n scattering, see prelim results in I
- 239Pu: Carefully note insights on n2n making 238Pu from LANL, and discuss contradictory feedback from PROFIL
- Validate any changes against n,2n reaction rates in critical assemblies, eg Fig 57 in NDS112,(2012) ENDF
- Create ENDF file and covariances

## Fission (all energies), cross sections, nubar and spectra for n,g

| | |
|---|---|
| Review Overall Goals, as embodied in this document and in LAUR CIELO document | |
| Fission Cross Section | |
| | Seek consensus that we adopt the fission cross section standard from the IAEA group |
| | Assess implications of adopting standard fission cross section on integral testing |
| | If IAEA standards team updates their value, use it; this would include any recent/forthcoming fission measurements, eg nTOF, RPI, TPC |
| | Modeling of fission would occur as part of the above inelastic/capture/n2n activities, but seek consensus that we do not use calculations in th |
| | 238U:Subthreshold fission for 238U – discrepacies between different evaluations. Lead spectrometer measurements near 70 keV suggest a p |
| prompt nubar | |
| | Review existing evaluations and experimental data, & review various theoretical approaches; 238U low energy interp fix needed in ENDF |
| | Seek to use an "unadjusted" nbar in a final evaluation, avoiding the ENDF "tweal" near an MeV that was adopted to better match Jezebel, Go |
| | Study Koning-Rochman nubar near thermal, from their optimization search (but it's 3 SD below the standards constants value) |
| | Develop a new evaluation based on a covariance analysis of the data |
| | Understand implications from integral data testing on changes in nubar - especially k-eff |
| | Create ENDF formatted files, including covariances |
| PFNS | Review work of IAEA CRP on PFNS |
| | Aim to adopt the CRP's recommendation |
| | Seek consensus on using LANL high-accuracy NUEX Pu9 and U5 data, as published in Dec NDS2011 to help define high-energy spectrum |
| | Use new PFNS measurements, especially below MeV, coming from LANSCE/Chi-nu in the coming years |
| | Use guidance on high energy tail of spectrum from dosimetry reactions (new IAEA IRDFF CRP), eg from LANL crits, Russian fast reactor, & CE |
| | As part of IAEA CRP, advance our theoretical models, and use incorporate other data (new and existing) |
| | Understand implications from integral data testing on changes in inelastic scattering - especially k-eff and reaction rates in assemblies |
| | Create ENDF formatted files, including covariances |
| PFGS | |
| | Review existing evaluations and experimental data, and various theoretical approaches |
| | Represent fission gammas separately at all energies, including above 1.09 MeV for U5 and Pu9 (an ENDF drawback), & use new data availabl |
| | Update PFGS spectra to use modern measurements from DANCE, as well as multiplicity distribution if possible |
| | Create ENDF formatted files, including covariances |
| Delayed data | |
| | Review differences in present evaluatiosn |
| | Develop plan for work needed |
| Energy Release | |
| | Compare energy release data in evaluations, for prompt n, g, fission fragments; and delayed energy release |
| | Update as necessary - eg ~ MeV level changes are implied for 239Pu from Jandel's DANCE data for 239Pu (but 235U looks good) |
| | Consider updating energy release incident-energy-depenence based on Lestone's work |

## Integral Data Testing and Validation

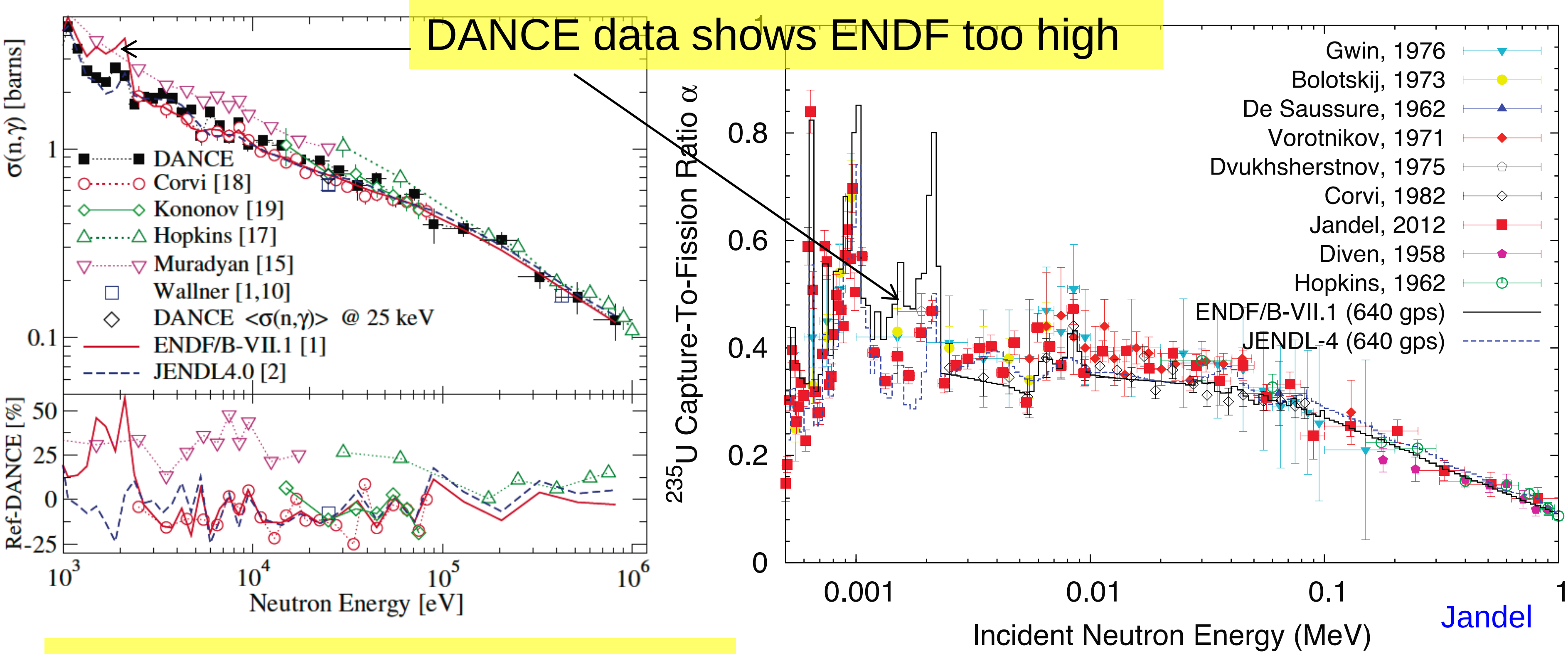
Review Overall Goals, as embodied in this document and in LAUR CIELO document

- Define suite of critical assembly, reactor, transmission, etc experiments to use in validation assessments, and observables (k-eff, rates, spectral indices)
- 238U: selection of 12 ICSBEP criticality benchmarks sensitive to elastic scattering is available from JSI/IAEA (Trkov, Capote)
- Seek to ensure good performance in data testing, which includes:
- Fast, intermediate, and thermal assemblies, k-eff
- 239Pu: Aim for (Partial?) improvement of longstanding overprediction of thermal Pu solutions
- Modeling spectral indices well in various systems (incl fast), 8f/5f, 9f,5f, 237np-f/5f, 233u-f/5f etc, see Table XXXVIII in VII.1 NDS 2011 paper
- Modeling  of post irradiation experiments (PIE) such as PROFIL (CEA) and MANTRA (INL)
- Modeling MOX experiments for mock up of LWR, eg in EOLE, Cadarache
- See if PFNS improvements give improved n2n detector responses in fast crits, eg through a softer PFNS spec aove 10 MeV
- nubar validation using multiplication subcritical measurements
- LLNL pulsed spheres
- Can we obtain improved preductions of intermediate assemblies, eg ZPR at Argonne
- Aim to maintain good prediction of crits, including new as-built high-resolution 3D MCNP Jezebel model?
- Use sensitivity metodologies for assessing changes/improvements by reaction and energy range

# $^{235}U$ :  Some  Particular Challenges

- Capture changes in resonance region, based on new LANL, RPI, CERN data (& insights from Japanese data testing)
- New PFNS results coming (IAEA CRP etc)
- Inelastic scattering discrepancies between evaluations
- Use of new IAEA Standards

# Major Advance (2): $^{235}$U Capture:
# It appears the Japanese were right near 1 keV



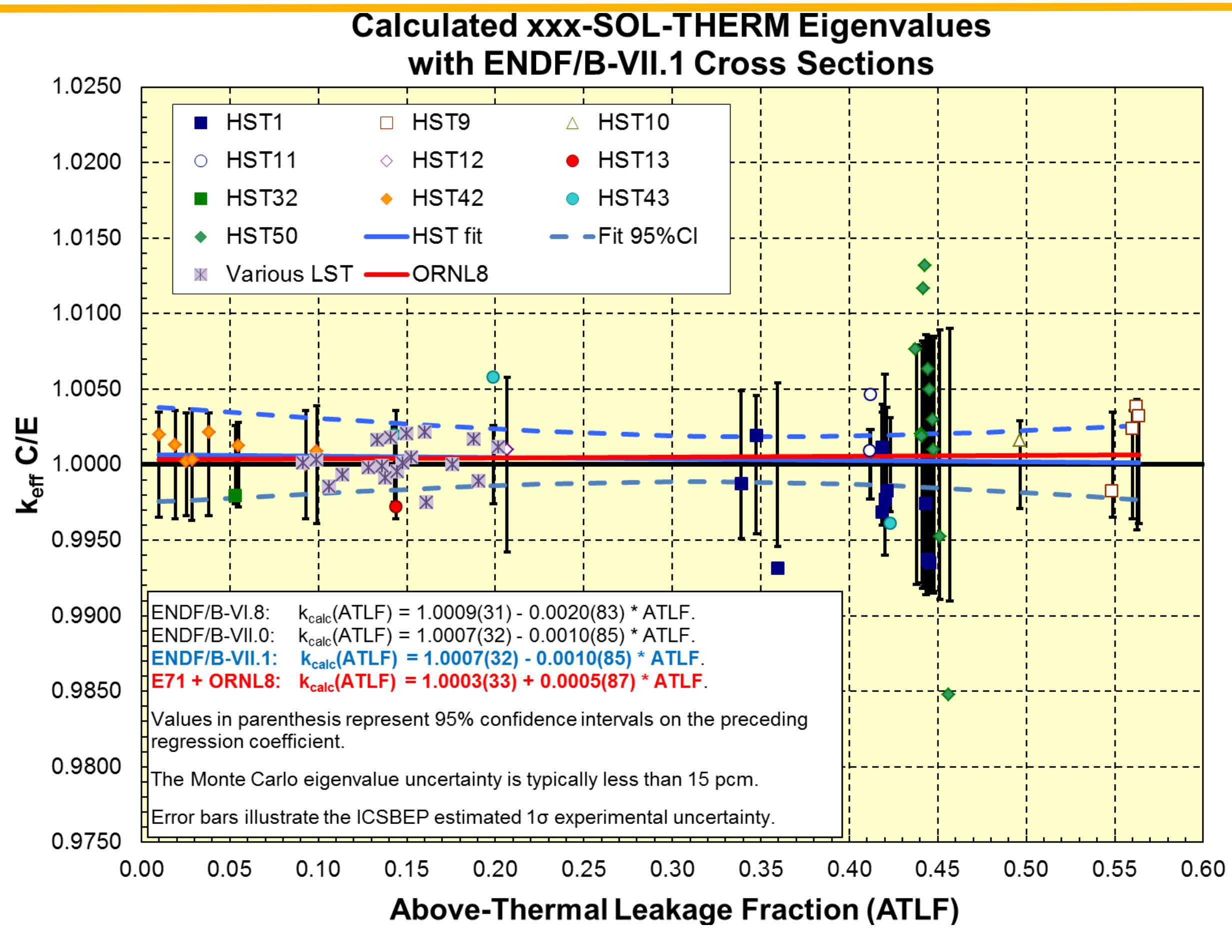

Future evaluations will include Los Alamos & RPI, n_TOF data

But Wallner AMS 25 keV has ENDF high by 5% (+/- 6%); 423 keV ENDF high by 8% +/- 8%; PROFIL fast reactor has ENDF low by 3-5%

# HST Benchmarks - LANL testing of prelim Res file

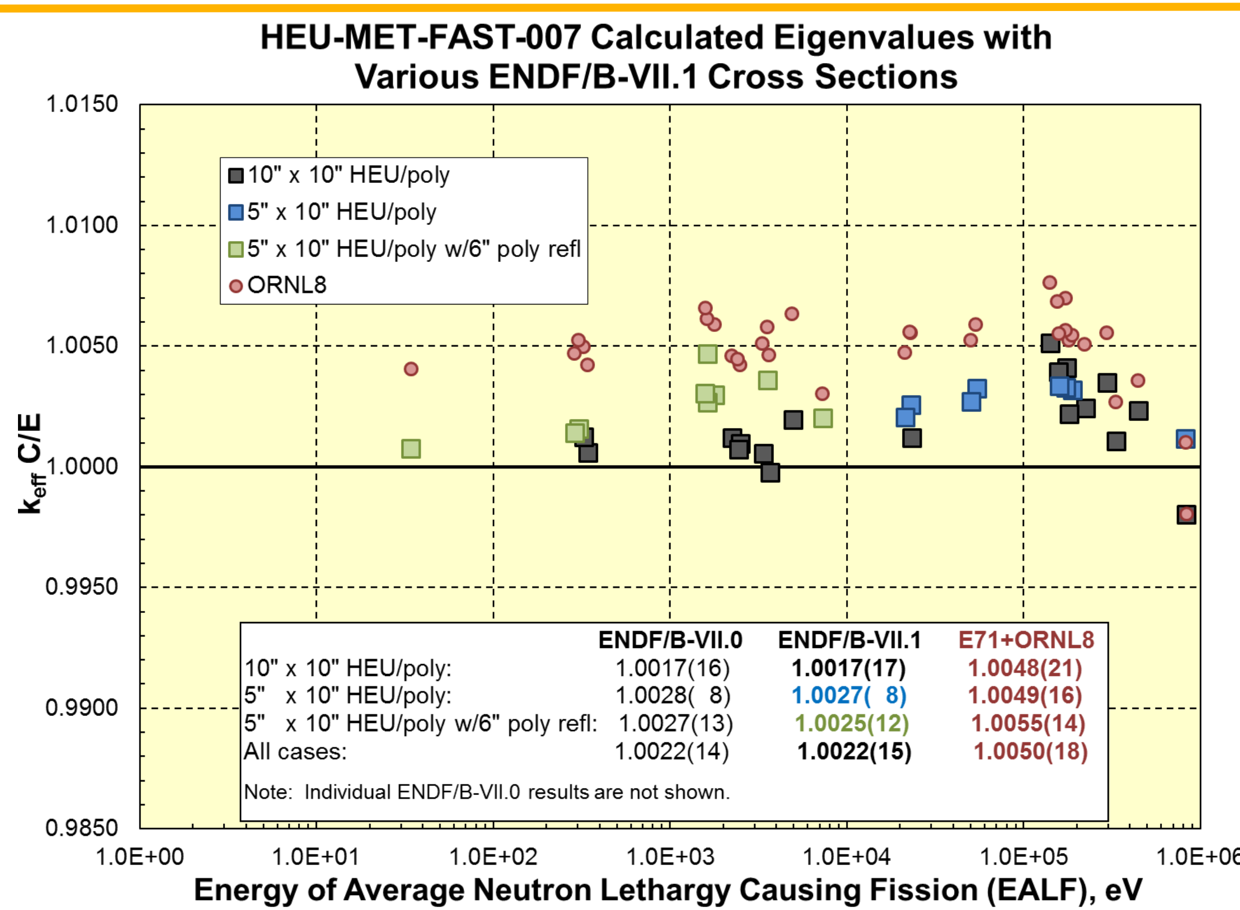
- **Regression fit to HST benchmarks versus ATLF has been excellent since ENDF/B-VI.3 (Lubitz).**

- **This excellent fit is retained with the latest (ORNL8) $^{235}$U resolved resonance file.**



# HMF7 (HEU + $CH_2$) : LANL testing of prelim Res file

- HEU + poly system tests xs data over several orders of magnitude.
- E70 & E71 results are near unity at either energy extreme but are biased high in the intermediate energy range.
- This bias is worsened with the latest ORNL8 $^{235}U$ evaluated file.



# Reaction Rates in Fast Critical Assemblies Provide Integral Test of Prompt Fission Neutron Spectrum & (n,2n) Cross Sections - *Uranium-235 data*

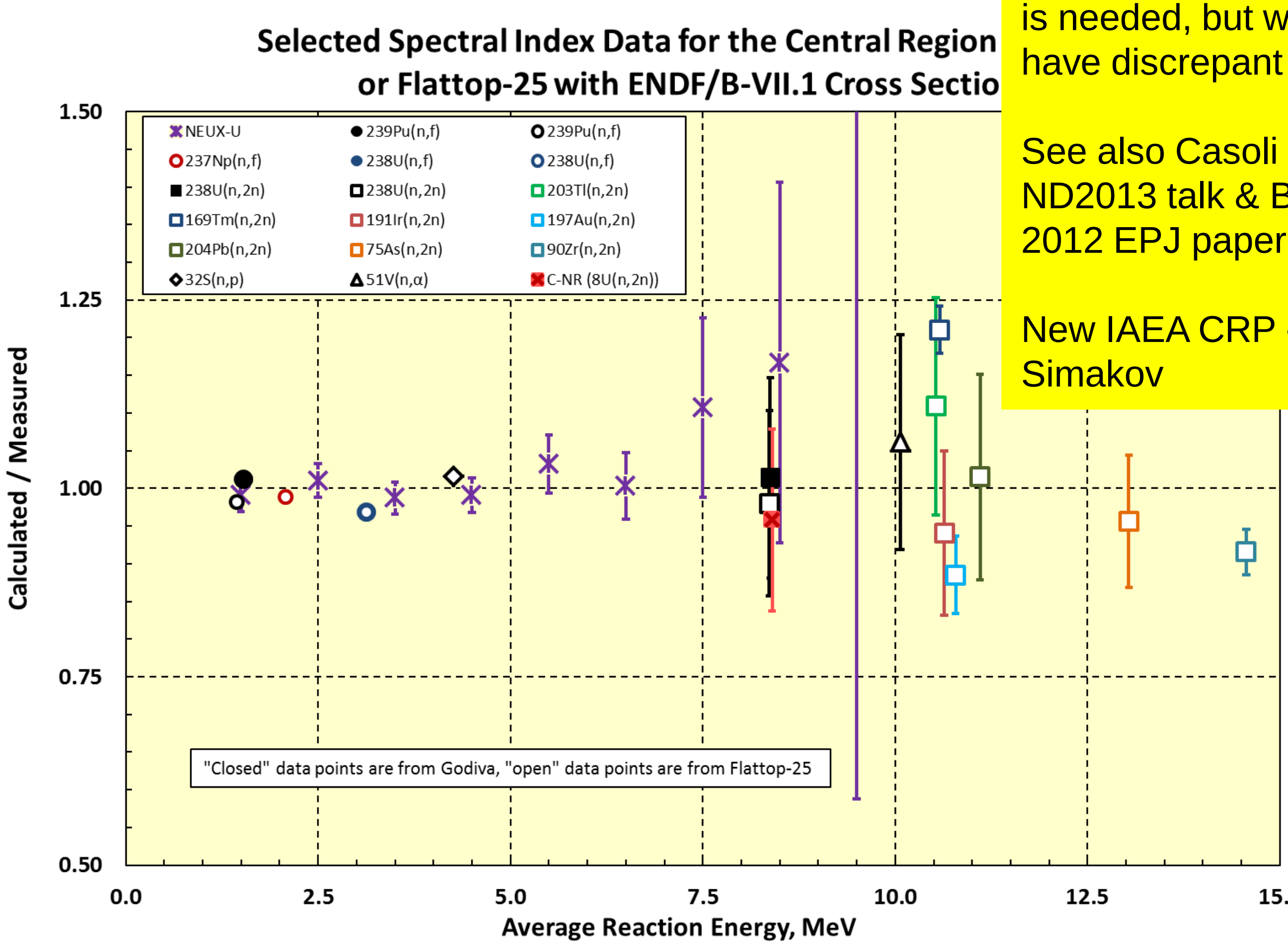
Perhaps suggests a softer ENDF spectrum is needed, but we have discrepant data.

See also Casoli ND2013 talk & Bauge 2012 EPJ paper

New IAEA CRP - Simakov

**$^{235}$U**

**With NUEX data added (Lestone)**




Similar analysis for plutonium systems – see our ND2013 proceedings paper

# More Data Testing on Preliminary 235U ORNL Res Rile

$k_{calc}$ Summary for Various Benchmarks and Cross Section Data Sets

| | | |
|---|---|---|
| GODIVA (HEU-MET-FAST-001) | | |
| Cross Section Set | Benchmark $k_{eff}$ | $k_{calc}$ |
| ENDF/B-VII.1 | | 0.99983(3) |
| E71 + ORNL8 | 1.000(1) | 0.99985(2) |
| J4 + ORNL8 | | 0.99757(2) |
| CEA + ORNL8 | | 0.99957(2) |
| | | |
| Flattop-25 (HEU-MET-FAST-028) | | |
| ENDF/B-VII.1 | | 1.00285(2) |
| JENDL-4.0 | | 0.99779(9) |
| E71 + ORNL8 | 1.0000(16) | 1.00300(13) |
| J4 + ORNL8 | | 0.99899(13) |
| CEA + ORNL8 | | 1.00040(13) |
| | | |
| Big-10 (IMF7, detailed model) | | |
| ENDF/B-VII.1 | | 1.00443(2) |
| JENDL-4.0 | | 0.99710(7) |
| E71 + ORNL8 | 1.0045(7) | 1.00471(8) |
| J4 + ORNL8 | | 0.99764(11) |
| CEA + ORNL8 | | 0.99901(11) |
| | | |

# More Data Testing on Preliminary 235U ORNL Res Rile

3

| | HMI6.1 | HMF6.2 | HMI6.3 | HMF72.3 | HMI6.4 | HMF72.1 | HMF73 |
|---|---|---|---|---|---|---|---|
| Benchmark $k_{eff}$ | 0.9977(8) | 1.0001(8) | 1.0015(9) | 1.0016(69) | 1.0016(8) | 0.9991(24) | 1.0004(16) |
| endf/b-vii.1 ealf | 4.93 keV | 10.1 keV | 23.5 keV | 40.8 keV | 79.8 keV | 223 keV | 416 keV |
| | $k_{calc}$ | | | | | | |
| ENDF/B-VII.1 | 0.99293(2) | 0.99690(2) | 1.00076(2) | 1.01236(2) | 1.00730(2) | 1.00852(1) | 1.00807(2) |
| ENDF/B-VII.1 + e5 $^{nat}$Cu | 0.99264(2) | 0.99723(2) | 1.00168(2) | 1.00762(10) | 1.00767(2) | | 0.99663(2) |
| ENDF/B-VII.1 + mit/ornl $^{63,65}$Cu | 0.99304(15) | 0.99709(15) | 1.00086(15) | 1.01254(10) | 1.00791(15) | | 1.00720(14) |
| JENDL-4.0 | 0.99810(11) | 1.00197(11) | 1.00428(11) | | 1.00569(10) | | 1.00267(9) |
| E71 + ORNL8 | 1.00188(2) | 1.00616(2) | 1.00929(2) | 1.01744(10) | 1.01196(2) | 1.00921(9) | 1.00809(1) |
| J4 + ORNL8 | 0.99629(2) | 0.99987(2) | 1.00226(2) | | 1.00451(2) | | 1.00276(2) |
| CEA + ORNL8 | 0.99578(2) | 0.99922(2) | 1.00149(2) | | 1.00390(2) | | 1.00361(1) |
| | | | | | | | |

JENDL-4.0 is $^{bo}$U only; remaining cross sections are endf/b-vii.1.

J4+ORNL8 is the $^{235}$U data set; remaining cross sections are endf/b-vii.1.

$k_{calc}$ values with a ~2 pcm uncertainty were run for 2 billion histories and include detailed multigroup tallies.

HMI6 has varying amounts of interstitial carbon; HMF72.1 has interstitial carbon steel (Fe); HMF72.3 has interstitial carbon steel (Fe) and polyethylene; HMF73 is HEU only ... all assemblies are surrounded by a thick copper reflector( i.e., HMI6, HMF72 and HMF73 are different flavors of ZEUS).

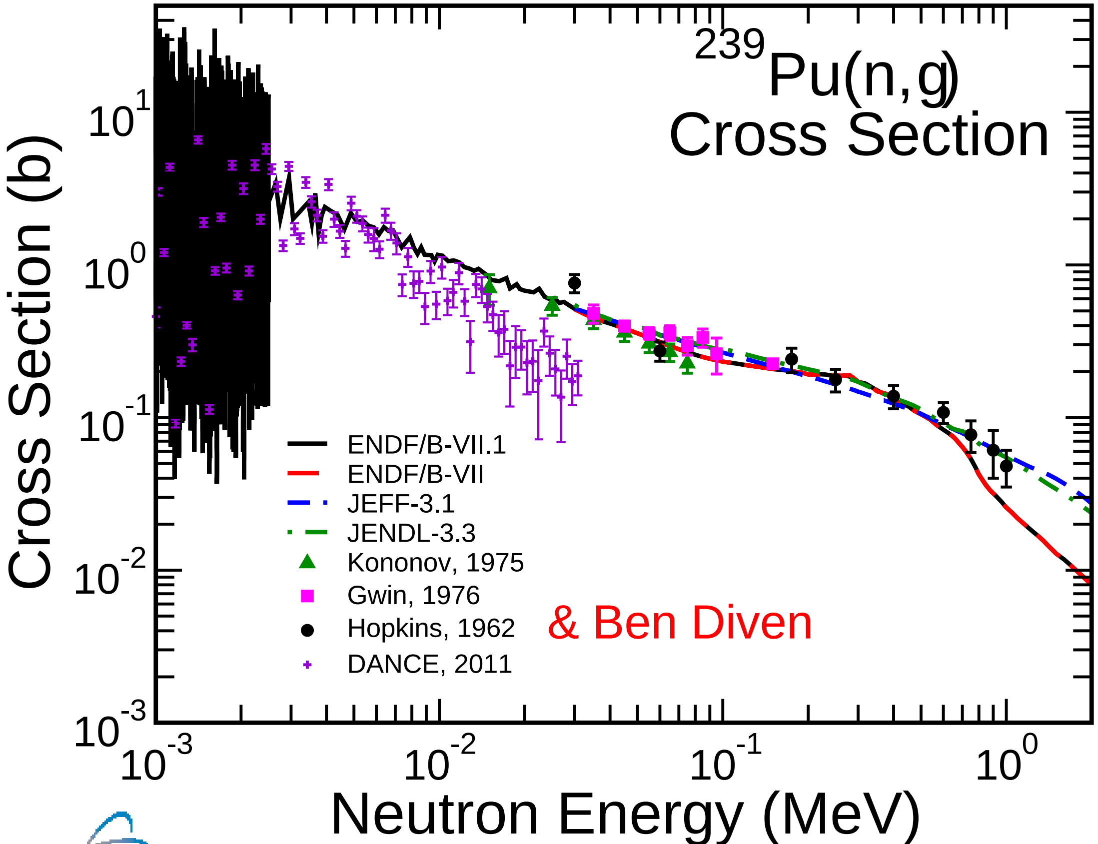
4

# $^{239}$Pu : Some Particular Challenges

- Build on the excellent WPEC subgroup 34 work from CEA & ORNL
- Capture discrepancies. We're waiting for new DANE data
- New PFNS results coming (IAEA CRP etc)
- Inelastic scattering discrepancies between evaluations
- Use of new IAEA Standards

# Plutonium Capture: Improvements Are Needed

**Existing uncertainties >15%**

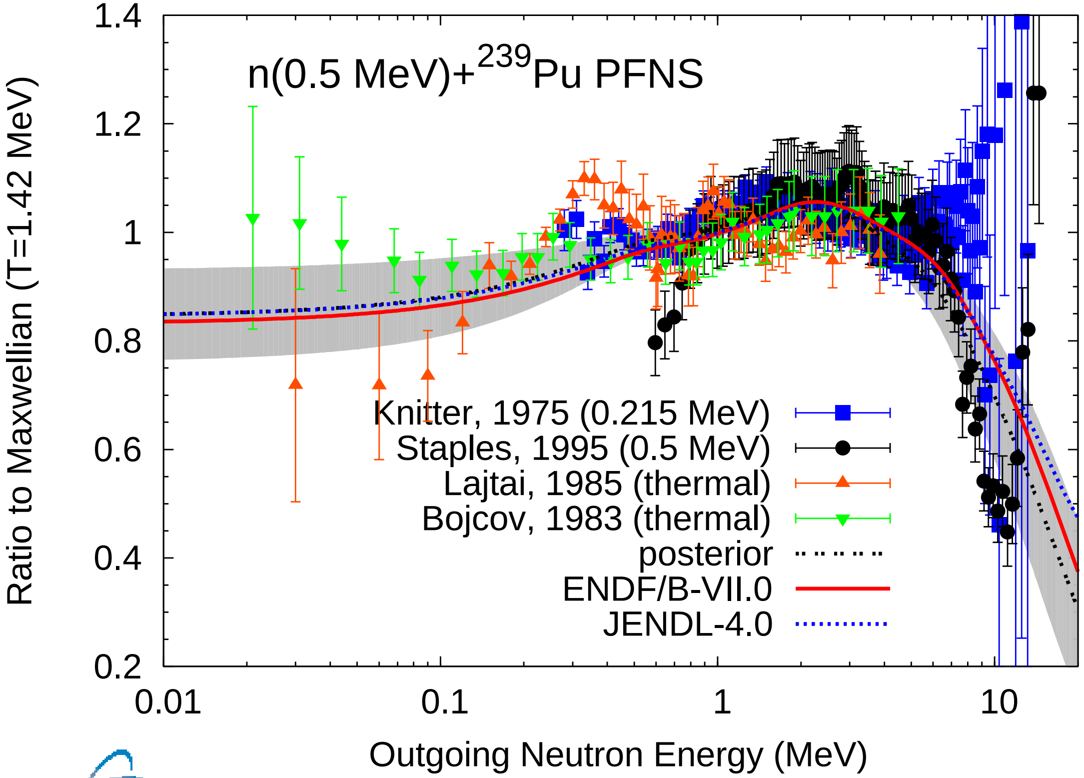


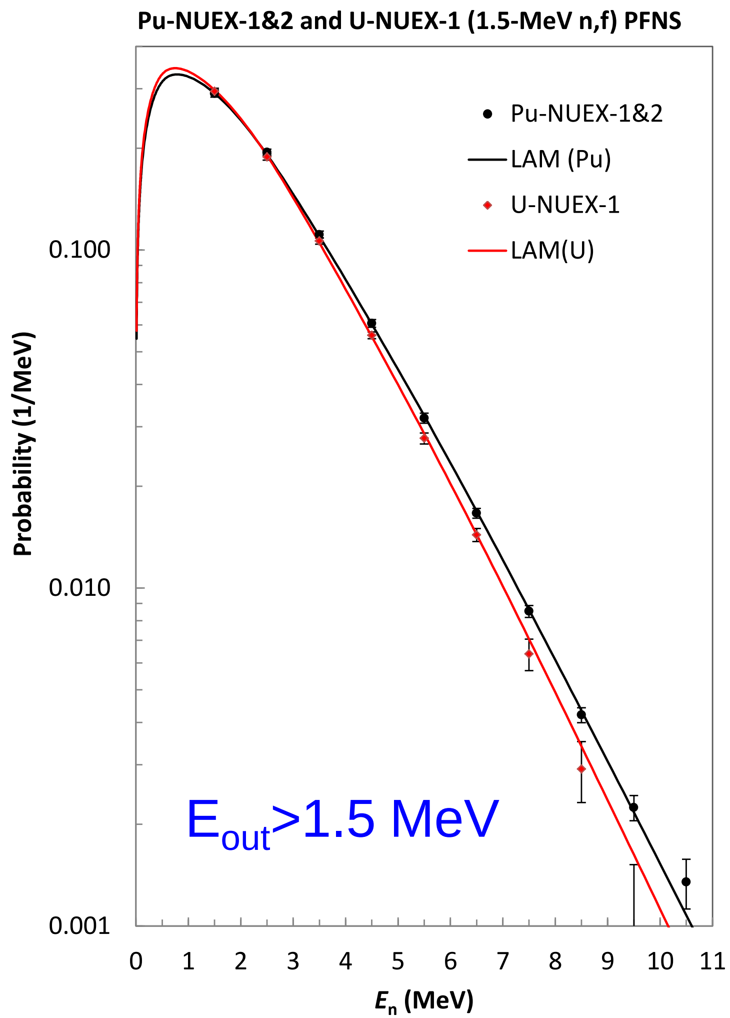

- SG33 & PROFIL (PHENIX) 239Pu(n,g) integral testing suggests B-VII is ~ 10% low over this fast reactor spectrum. Also, Ishikawa's ADJ work suggests JENDL should be raised 5-10%
- DANCE measurements planned

# Determining the Prompt Fission Neutron Spectrum (Chi): One of Our Highest Priorities & an IAEA CRP

**Large uncertainties below 1 MeV and above 5 MeV impact criticality calculations and (n,2n) transmutations**

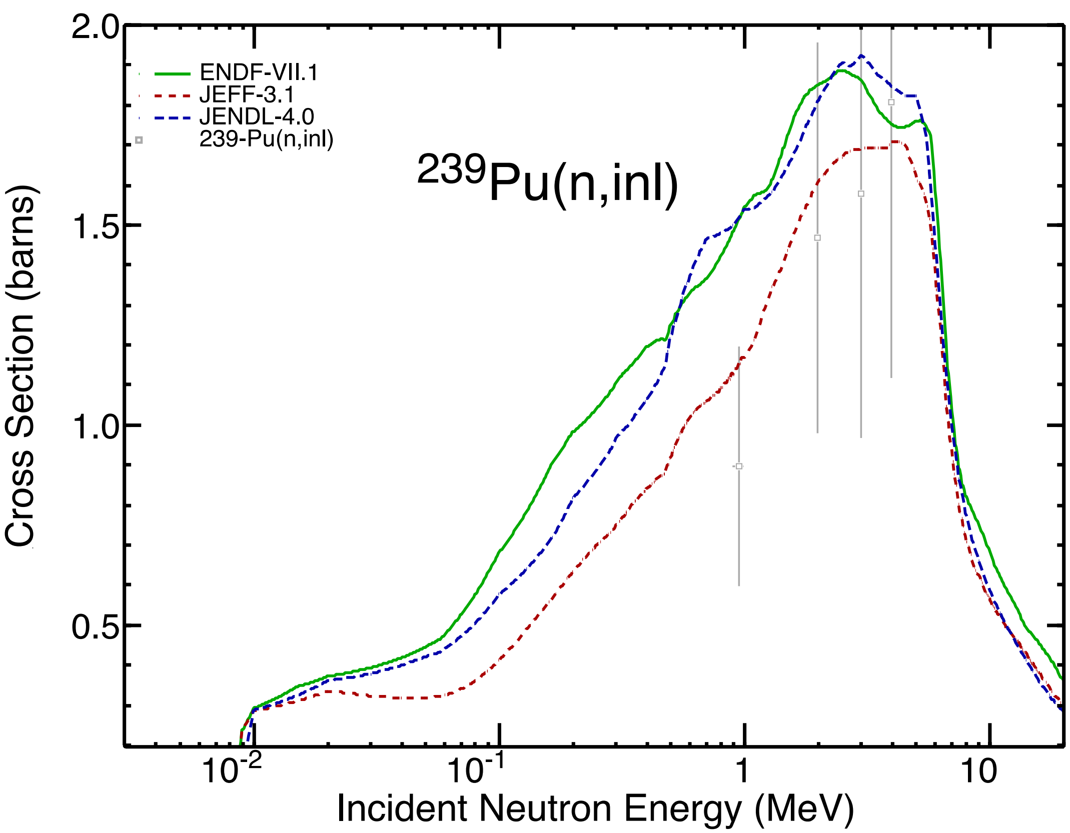
Lestone's talk: ***accurate*** underground NUEX data released by Los Alamos:




Talou, Vogt

# Major Advance (4): Actinide Elastic & Inelastic Scattering: Large Discrepancies are Starting to be Resolved




Insights from advanced coupled-channel scattering theory needed

**$^{238}$U:** Improvements have been accomplished by Capote, Trkov, using Danon's new RPI data

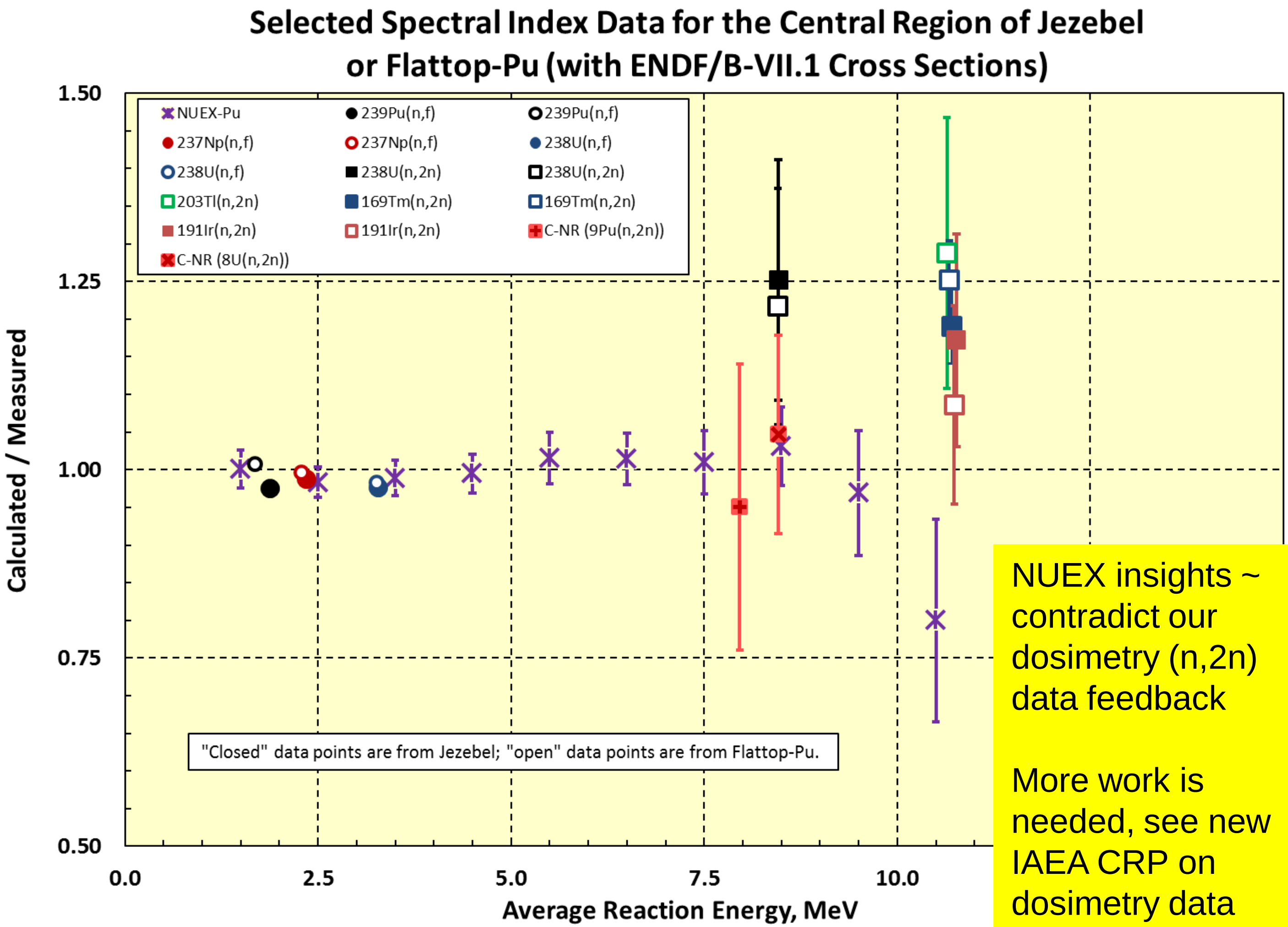
Dietrich, Thompson & Kawano determined that convergence of CC solutions is slow

Iwamoto, Romain, & Kawano have all made notable advances

# Reaction Rates in Fast Critical Assemblies Provide Integral Test of Prompt Fission Neutron Spectrum & (n,2n) Cross Sections *- Plutonium-239 PFNS Data*

**239Pu**

**With NUEX data added (Lestone)**

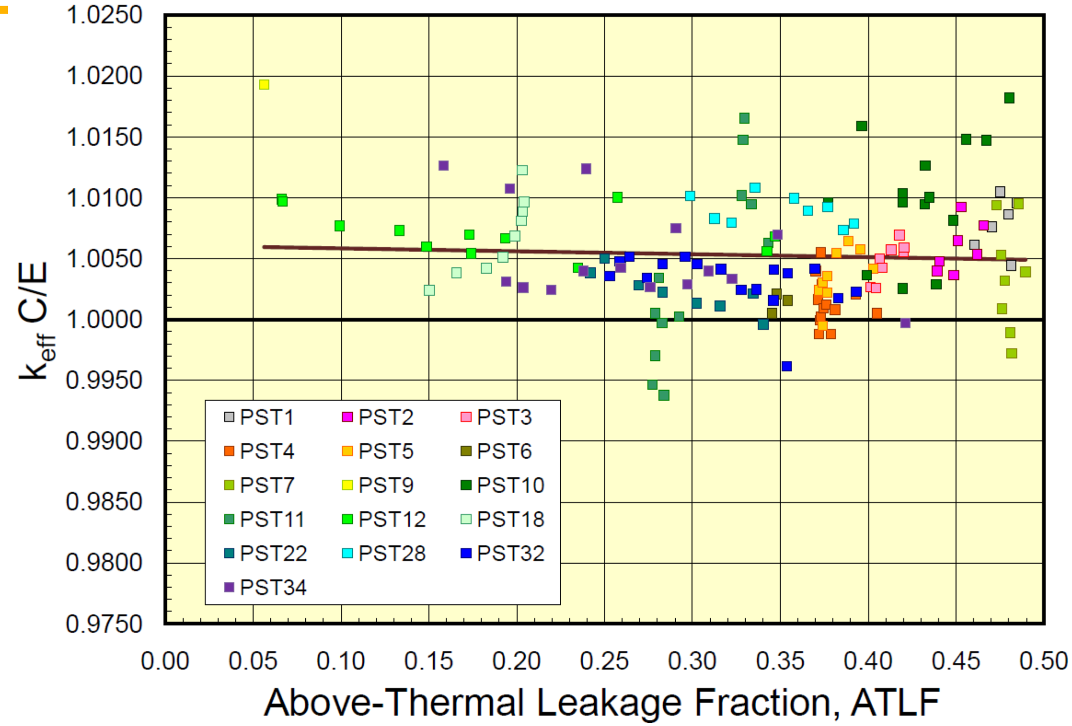



NUEX insights ~ contradict our dosimetry (n,2n) data feedback

More work is needed, see new IAEA CRP on dosimetry data validation

# Pu-SOL-THERM Benchmarks – I. Prelim LANL testing of new Subgroup 34 resonance results

- **A ~500 pcm bias in calculated PST reactivity is a long-standing issue.**
- **WPEC Sub-Group 34 was tasked with defining a new (better?) set of resolved resonance parameters for $^{239}$Pu in an attempt to resolve this issue.**
- **Can define a sub-set of these 150 benchmarks to test revised data files.**




- *Consider benchmark attributes such as (i) ATLF; (ii) $^{239}$Pu atom-% in Pu; (iii) Above-Thermal Fission Fraction (ATFF); (iv) H/Pu number density (or gPu per liter) to define this sub-set.*

## Pu-SOL-THERM Benchmarks – II. Prelim LANL testing of new Subgroup 34 resonance results

- **A set of seven Pu-SOL-THERM benchmarks have been extracted from the larger set.**
  - PST1.4 & PST12.13 span the ATLF space;
  - PST12.10 & PST34.15 span the ATFF space;
  - PST4.1 & PST18.6 span the $^{239}$Pu atom percent space;
  - PST12.10 & PST34.4 span the g Pu per liter space.

- **All benchmark experiments are performed in simple geometry**
  - PST1.4 & PST4.1 are a water-reflected spheres;
  - PST18.6, PST34.4 & PST34.15 are water-reflected cylinders;
  - PST12.10 & PST12.13 are a water-reflected slabs;

# Pu-SOL-THERM Benchmarks – III. Prelim LANL testing of new Subgroup 34 resonance results

- The E71 1.00576 $k_{calc}$ average demonstrates that the 7 benchmark subset reflects the larger population.

- Data revisions in the "Leal7a" $^{239}$Pu evaluated file have eliminated ~50% of the long-standing $k_{calc}$ bias.

**Calculated Eigenvalues[a] for a Selection of PST Assemblies Using Various $^{239}$Pu Cross Sections**

| Assembly | ENDF/B-VII.1 | JEFF-3.1.2 [b] | JENDL-4.0 [b] | Leal7a [c] + e71 | Leal7a (RR, nu, pfns only) + e71 |
|---|---|---|---|---|---|
| PST1.4 | 1.00448 | 1.00127 | 1.00588 | 1.00199 | 1.00202 |
| PST4.1 | 1.00383 | 0.99907 | 1.00482 | 1.00044 | 1.00044 |
| PST9 | 1.01939 | 1.01367 | 1.02510 | 1.01543 | 1.01546 |
| PST12.10 | 1.00412 | 0.99973 | 1.00498 | 1.00083 | 1.00080 |
| PST12.13 | 1.00955 | 1.00468 | 1.01069 | 1.00611 | 1.00620 |
| PST18.6 | 1.00472 | 1.00153 | 1.00557 | 1.00202 | 1.00208 |
| PST34.4 | 1.00258 | 0.99999 | 1.00417 | 0.99922 | 0.99937 |
| PST34.15 | 0.99742 | 0.99563 | 0.99844 | 0.99679 | 0.99707 |
| **Average** | **1.00576** | **1.00195** | **1.00746** | **1.00285** | **1.00293** |

a) MCNP calculations are for 250M histories; stochastic uncertainty is ~5 pcm.

b) JEFF-3.1.2 and JENDL-4.0 $^{239}$Pu only; remaining nuclides are ENDF/B-VII.1

c) "LEAL7a" evaluation provides revised resolved resonance parameters coupled to a joint ORNL/CEA evaluated $^{239}$Pu file; the "LEAL7a (RR,nu,pfns)" file couples just these data to the existing ENDF/B-VII.1 $^{239}$Pu file.

# 56Fe

General

- Review differences in evaluations. In ENDF/B-VII.1 RR extend up to 850 keV, but pointwise fluctuations extend up to almost 10 MeV.
- Get insights from previous evaluators on tasks to work on. For example, Trkov, Koning, Vonach, Tagesen were involved in the last European Jeff ev
- Optical model and other key modeling parameters

## Fast Region

Inelastic and elastic

- Review new data,: RPI has high-res transmission up to 2 MeV, and scattering data ("quasi differential data"), that needs an MCNP calc to compare
- Review new data:Arjan Plompen (Geel) has inelastic data (actually, gamma-production) too measured this year, from 800 keV to 5 MeV.
- Review new data: Schillebeeckx and Trkov's postdoc have made some new measurements, and reviewed existing measurements....
- Review new data: Ron Nelson (LANL) has gamma-production data for iron.
- Review new data: The Grimes et al. Ohio work should be looked at too – it is suggesting a big change for nonelastic, but that our total cross sectio
- IAEA coupled-channel OM work going on for iron.
- Pronyaev – also doing work on inelastic gamma production. At one point this was being considered as a standard (now more likely to use Ti).

Charged-particle production

- Review data, evaluations, and model predictions for (n,alpha) etc
- Data above 20 MeV may be needed too, eg for fusion applications, using new gas-production data from Haight.

Activation xs

- Review/Include activation data needed for fission/fusion

DPA
- Take advantage of insights from new IAEA CRP on damage and DPA

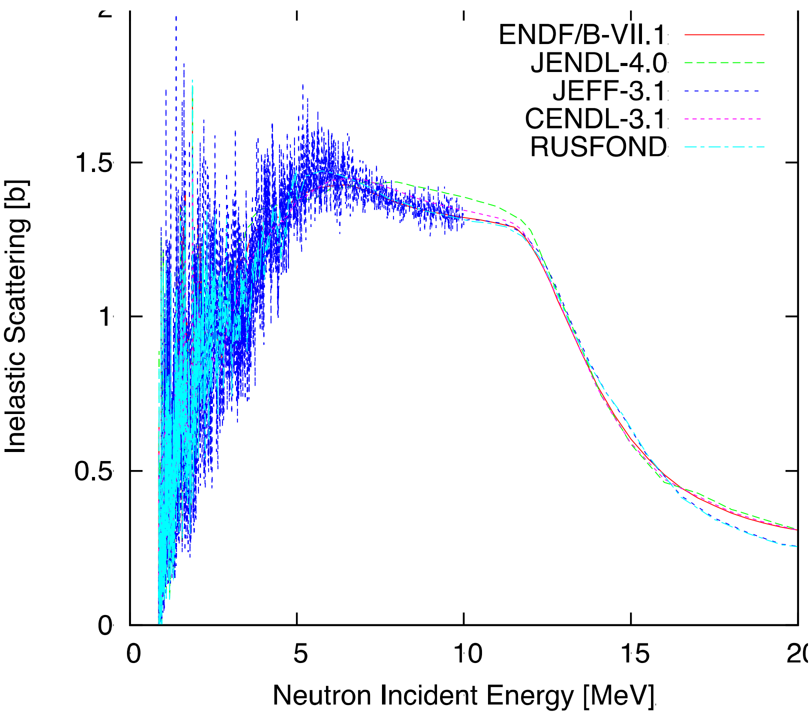
## Resonance Region, Resolved and UnResolved Parameters (hundred of keVs and below)

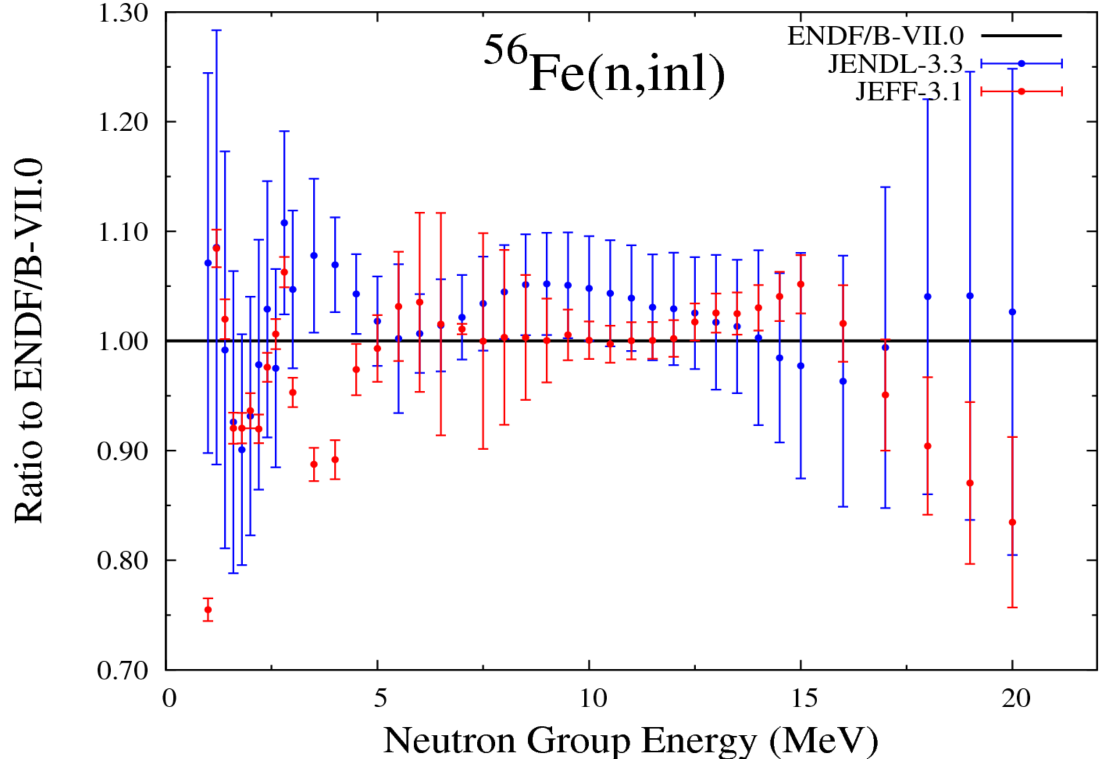
RRR & UR
- Review latest evaluation from Luiz Leal

Integral validation

- Define suite of integral tests - critical assemblies, transmission/shielding, reactor experiments, etc
- 17 benchmarks with iron as shielding material (+8 more with stainless steel) are available in the SINBAD database
- Compile feedback from recent testing - eg SG33, fast reactor COMARA experience, etc, Steven VDM's NDS 2012 benchmarking paper (which note
- Andrej Trkov has shielding  benchmarks that are relevant too. The euracos benchmark for sinbad.
- Pay attention of Fe-reflected fast critical benchmarks (+ thermal bench from CEA, e.g. PERLE experiments in EOLE)
- Use ZPR3-54, ZPR9-34, ZPR6-10 and possibly CIRANO with reaction rate distributions
- Use sensitivity metodologies for assessing changes/improvements by reaction and energy range

# $^{56}$Fe: Advances Needed in Inelastic Scattering




Herman, Palmiotti

New measurements (IRMM) & SAMMY analyses in resonance region; new Hauser-Feshbach analyses at higher energies

# $^{16}O$

Cecil Lubitz:

*“After several “preliminary” months on CIELO it’s clear that we have bitten off a big chunk. Get ready to chew.”*

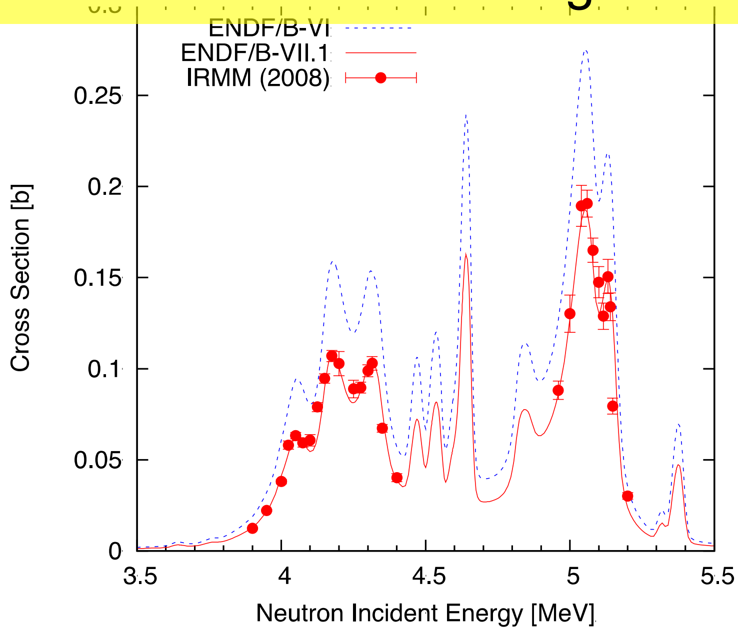
# 16O

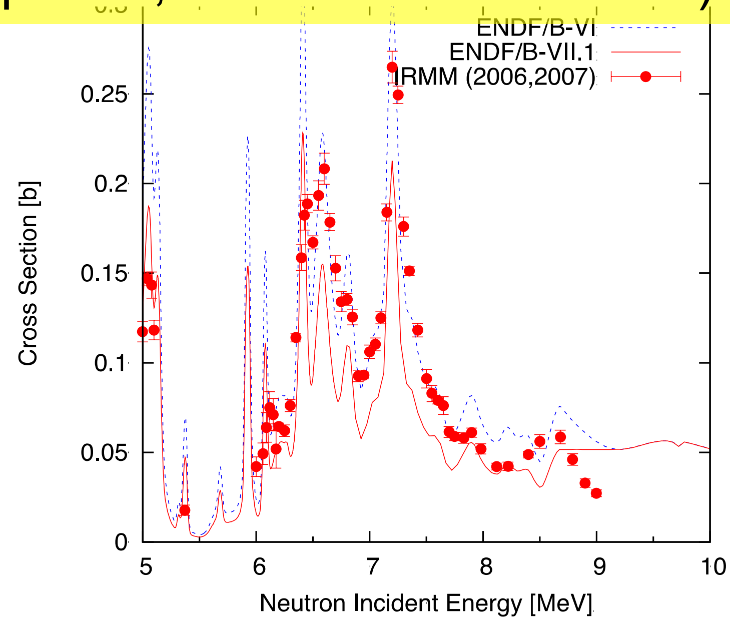
| | |
|---|---|
| General | |
| | Intercompare evaluations, and identify goals for a new evaluation |
| | JENDL is a new work (though adopts ENDF n,a); ENDF (JEFF uses ENDF) is a hydrid of KAPL work < 3.2 MeV, LANL (Hale et al) > 3.2 MeV - assess value of |
| | The 2005 ORNL work generated a resonance analysis for 16O, full R-matrix. Included angular distributions, n,alpha, and it has never been tested. Needed L |
| Total, Elastic and inelastic scattering | |
| | Compare existing evaluations and R-matrix analysis, and defie path forward |
| | At low energies, assess whether evaluations of elastic scattering indeed need to be lowered by ~3%, as proposed by Plompen, Lubitz, Roubtsov etc |
| | covariances for mubar: Need reliable anisotopic 16O scattering uncertainties. Palmiotti thinks Gerry's present uncertainties are too small on mubar. |
| Capture | ENDF adopted JENDL's capture cross section to include resonance contribution - establish consensus to use this |
| (n,a) | |
| | Review different evaluations (all largely same as ENDF) |
| | Review previous data, and agee on scales - eg Bair & Haas had renorm their original data down by ~20%; Are Johnson data the same as these? |
| | Review new data - Georginis (Geel), Khryachkov (IPPE) - contact physicists working on 13C(a,n) for astrophysics |
| | The above new data approx confirm ENDF below 6 MeV but point to changes above |
| | Intercompare R-matrix calcs (Hale, Kunieda, Leal) |
| | Seek to understand why the above R-matrix evaluations, influenced by total cross sec data, suggest ~30% higher (n,a) than most measurements |
| | Define an evaluation strategy... If theory contradicts these data, do we use data instead? Or do we conclude theory is right and measurements had a scle er |
| | Assess whether evaluations (all now based n ENDF) above ~ 6 MeV need changing, if it is concluded new Geel data are more accurate than old Davis data |
| Integral | Establish suite of integral valdation tests, including k-eff, transmission, etc |
| | 2 benchmarks sensitive to oxygen data (+11 more benchmarks with water) are available in the SINBAD database |
| | Broomstick experiment |
| | Following WPEC SG? , With the existing (n,a) evaluations perform well, for the most part, on LEU solutions, Can the new eval perform well too |
| | (n,a) impact at higher energies: Does this higher energy >6 MeV region impact any applications significantly (maybe medical applications)? Carlson notes M |
| | check astrophysics constraints on 13C(a,n) reaction rate |

# $^{16}$O. Work is Needed to Reconcile R-Matrix Theory & Data & Maintain Criticality and Transmission Performance

An interesting case of seemingly discrepant information coming from *theory* versus *experiment*!

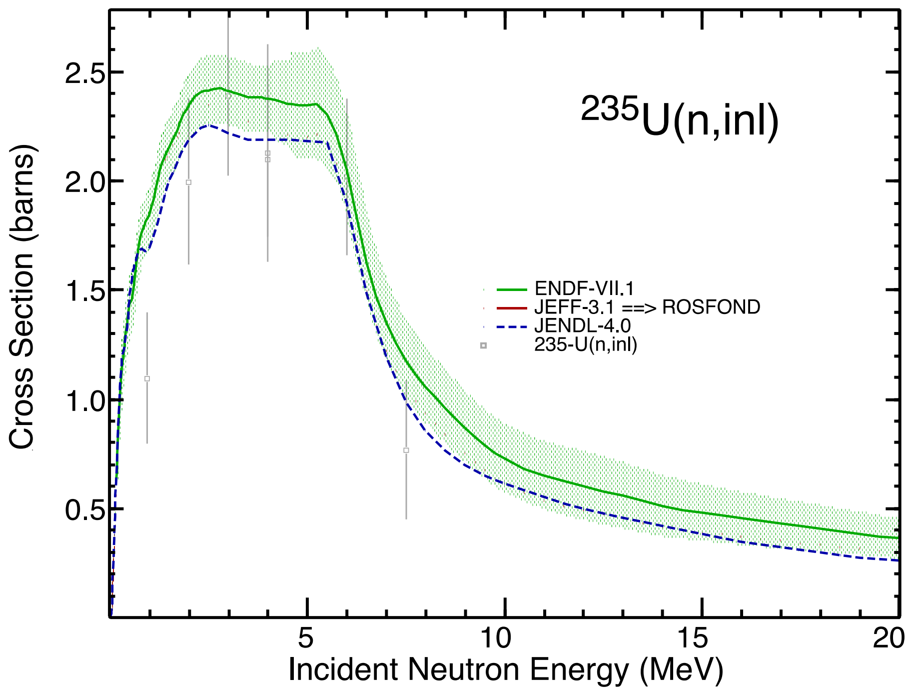
(R-matrix theory + total cross section data seems to suggest a higher (n,a) than measurements. Being an empiricist, I know who I'd bet on!).




Progress already being made by Plompen, Lubitz, Roubstov, Hale, Kunieda, Leal, Moxon, Kopecky …

# Uncertainties & Covariances for CIELO




Talou, with US covariance effort led by Oblozinsky, Smith, Herman, Hoblit:

Talou, Young, Kawano, Rising, Chadwick, DS 112, 3054 (2011)

Covariances are now available in the major evaluated libraries. This allows us to:

-Focus experiment & theory efforts

- Calculate uncertainties on integral neutronic performance

- Provide feedback on cross section updates, via “adjustment” projects (SG33) or “assimilation”

-- We’ll work with the new WPEC subgroup 39

## Summary …

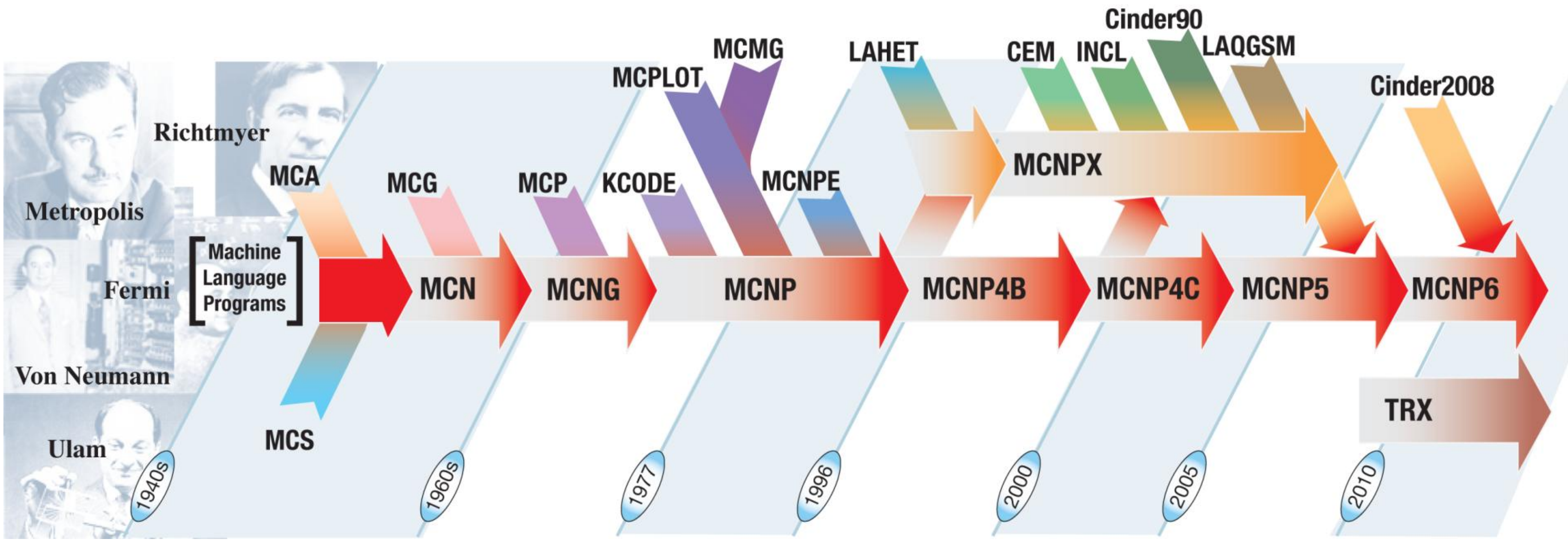
Join our CIELO collaboration

Enjoy the workshop – Thanks to IRMM & NEA/IAEA for support!

# BACKUP SLIDES

# MCNP6 Production release, 2013

- MCNP6 = MCNP5 + MCNPX + several new features
- 2 DVD set will contain 5,X & 6 + ENDF 7.1 and > 1 Gbyte of documents
- MCNP 5/X/6 Beta 2 had 2,452 copies sent out in FY12 and more than 11,000 in the last 11 years!
- See "Initial MCNP6 Release Overview" Nuclear Technology, Dec 2012



# CIELO – the 3rd Act:
# Learn from Wagner … "Begin as You Mean to Go On"

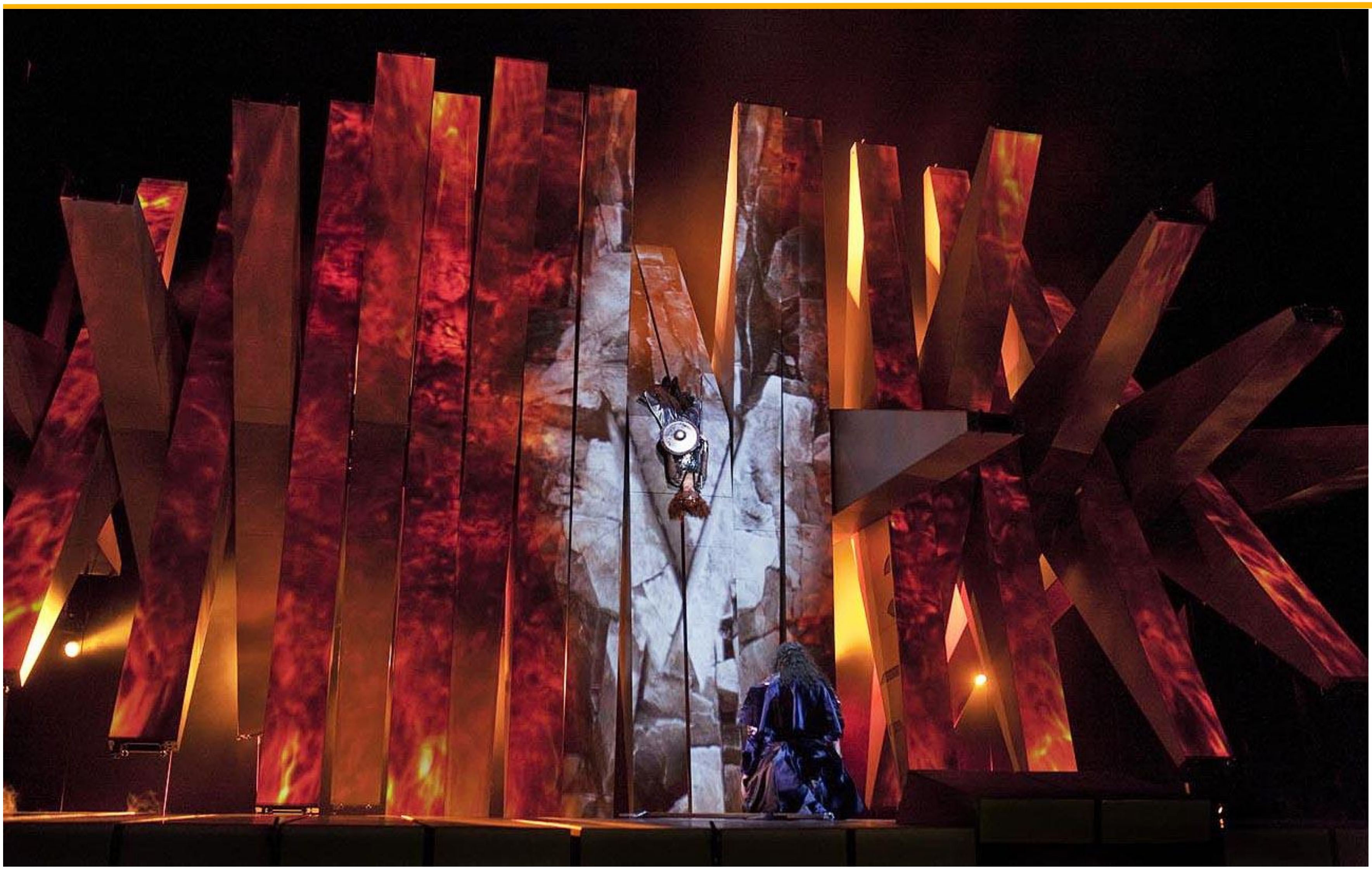


***Photo by Salazar's Opera Family Circle***