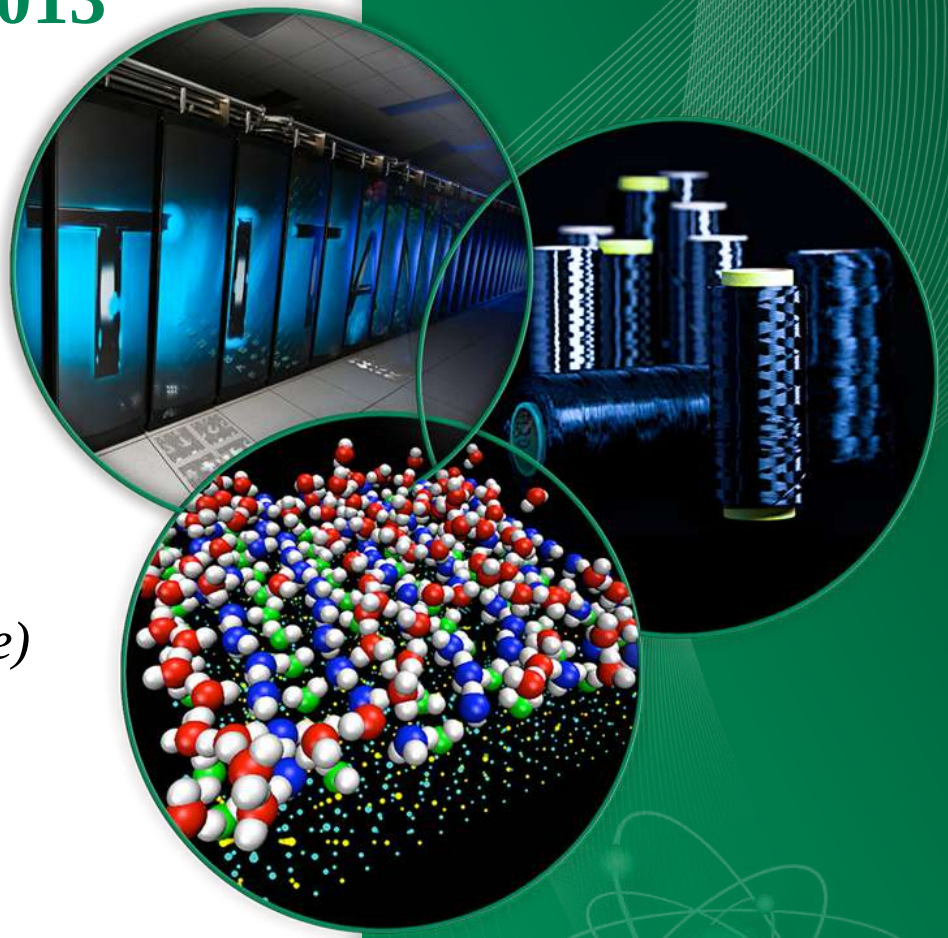
ORNL Nuclear Data Evaluation Accomplishments for FY 2013



L. Leal, V. Sobes, M. Pigni, K. Guber, G. Arbanas, D. Wiarda, M. Dunn *(ORNL)*

and

E. Ivanov, T. Ivanova, E. Letang *(Institut de Radioprotection et de Surete Nucleaire)*

2014 ANS Winter Meeting

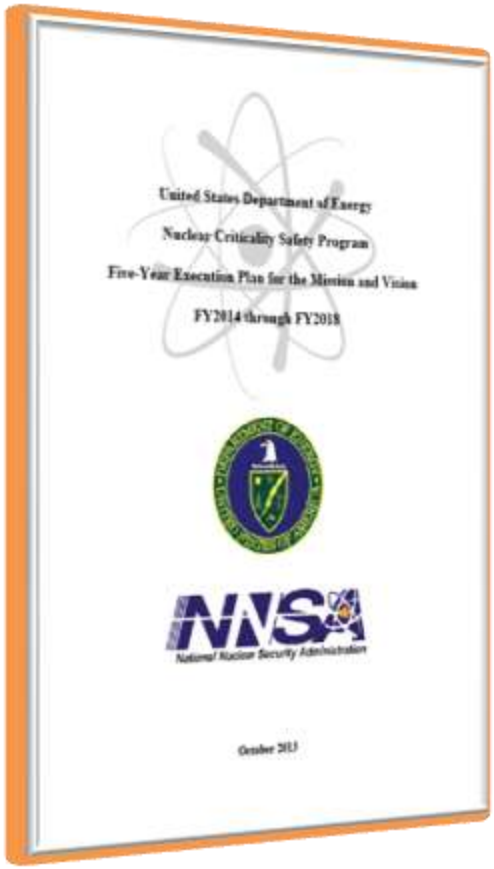
November 9-14, 2014

OUTLINE

- Present ORNL nuclear data evaluation work to address NCSP nuclear data needs;
- Data analysis and evaluation performed with the computer code SAMMY. All evaluations done using LRF=7;
- ORNL and French institution collaboration:
  Institute for Radiological Protection and Nuclear Safety (IRSN);
- CIELO project;
- Conclusions;

NCSP Nuclear Data Work Plan

5 Year Plan



Appendix B
Nuclear Data

Priority Needs / Additional Needs	Thermal scattering (BeO, HF, D_2O, SiO_2, CH_2, C_2F_4, $C_5O_2H_8$, etc.), ^{239}Pu, Cr, ^{237}Np, Pb, W, ^{55}Mn, Ti, ^{240}Pu, Fe, ^{58}Ni, ^{60}Ni, ^{63}Cu, ^{65}Cu / ^{233}U, Th, Be, ^{51}V, Zr, F, K, Ca, Mo, Na, La
Completed Evaluations	Minor Actinides , SiO_2, ^{55}Mn, ^{180,128,183,184,186}W , ^{239}Pu , ^{50,52,53,54}Cr , ^{58,60}Ni , ^{55}Mn , ^{39,41}K, ^{19}F

Measurements

Materials	Pre-FY2013	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Post-FY2019
Calcium (Ca)									
Cerium (Ce)									
Copper (Cu)									
Dysprosium (Dy)									
Gadolinium (Gd)									
Iron (Fe)									
Strontium (Sr)									
Tungsten (W)									
Vanadium (V)									
Zirconium (Zr)									
Polyethylene (CH_2)			H_2O / CH_2						

Complete Evaluations

Materials	Pre-FY2013	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Post-FY2019
Calcium (Ca)									
Cerium (Ce)									
Cobalt (Co)									
Copper (Cu)									
Dysprosium (Dy)									
Gadolinium (Gd)									
Iron (Fe)									
Lead (Pb)									
Nickel (Ni)									
Oxygen (O)									
Plutonium-239									
Strontium (Sr)									
Tungsten (W)									
Uranium-235									
Uranium-238									
Vanadium (V)									
Zirconium (Zr)									
Polyethylene (CH_2)									
	ORNL		RPI		LANL				

- Requests for additional IE measurements: Ni, Mo, Cr (Fe-Cr alloys), Mn in intermediate energy range (VNIITF, NCERC).
- Request for measurements and evaluation of angular distributions at high energy for Cu.
- Continuing need for thermal scattering data.

ORNL Resonance Evaluations and deliverables

	Energy Range	Resonance Covariance Evaluation	Target date to deliver the evaluation
$^{63,65}Cu$	Thermal to 300 keV	Yes	Completed
^{182}W	Thermal to 10 keV	Yes	FY2014
^{183}W	Thermal to 5 keV	Yes	FY2014
^{184}W	Thermal to 10 keV	Yes	FY2014
^{186}W	Thermal to 10 keV	Yes	FY2014
^{56}Fe	Thermal to 2 MeV	Yes	FY15
^{239}Pu	Thermal to 2.5 keV	Use ENDF/B-VII.1 (FILE33)	Completed
^{235}U	Thermal to 2.25 keV	Use ENDF/B-VII.1 (FILE33)	FY2014

Collaborative International Evaluated Library Organization
CIELO

ORNL Planned Evaluations

	Energy Range	Resonance Covariance Evaluation	Target date for delivery the evaluation
Ca	^{40}Ca (96.95 %) ^{44}Ca (2.086 %)	Yes	FY2015
Ce	^{140}Ce (88.450 %) ^{142}Ce (11.114 %)	Yes	FY2015
Dy	^{161}Dy (18.889 %) ^{162}Dy (25.475 %) ^{163}Dy (24.896 %) ^{164}Dy (28.260 %)	Yes	FY2015
Gd	^{155}Gd (14.80 %) ^{156}Gd (20.47 %) ^{157}Gd (15.65 %) ^{158}Gd (24.84 %) ^{160}Gd (21.86 %)	Yes	FY2015
CH_2	Thermal Scattering S(α,β)	-	FY2015

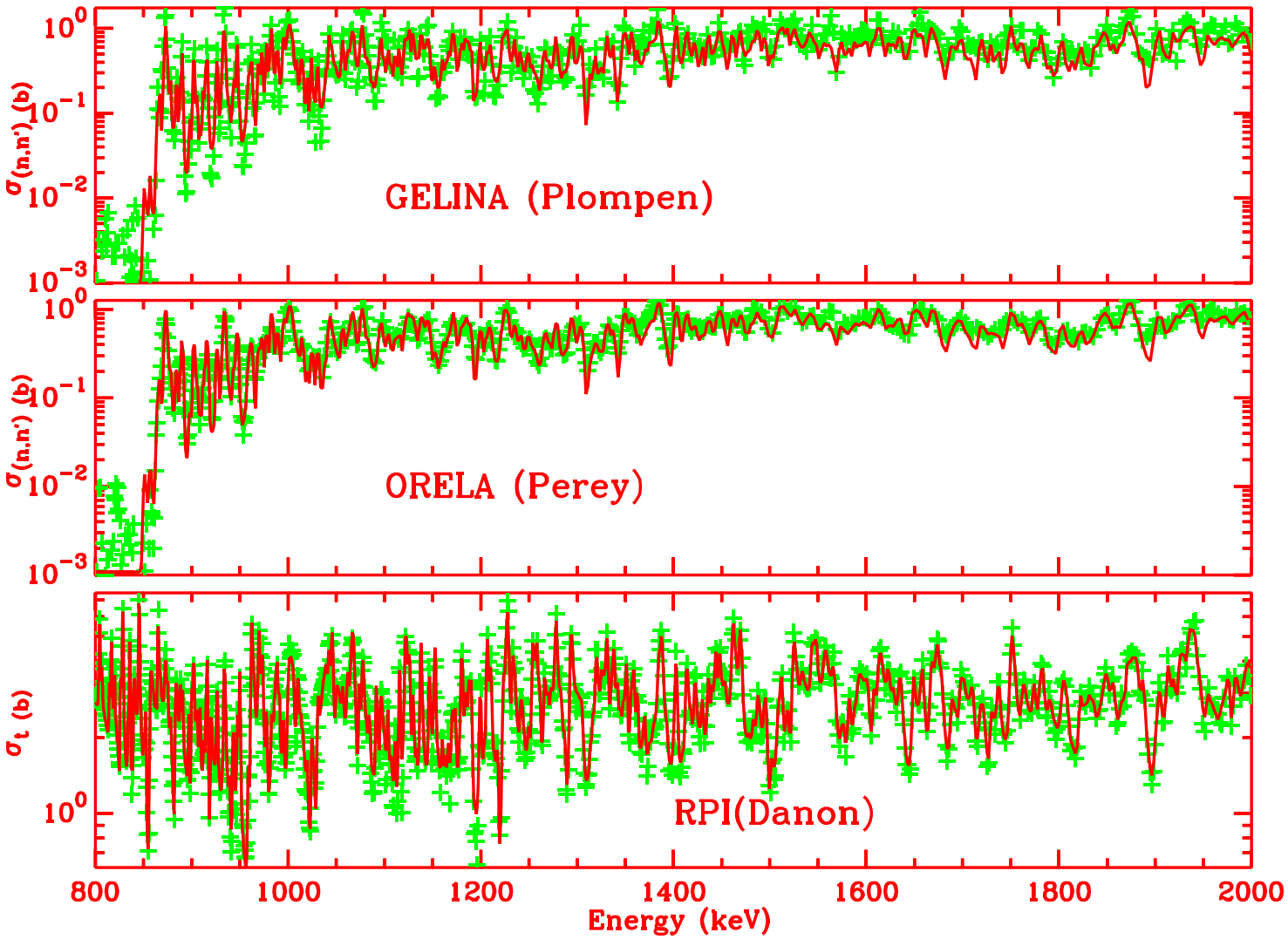
^{56}Fe Evaluation in the Resolved Resonance Region up to 2 MeV

- New high resolution transmission measurements done at the RPI extending the resonance region up to 5 MeV (Yaron Danon)
- New inelastic cross-section measurements done at IRMM/GELINA (Arjan Plompen)
- Use the SAMMY/RML feature to include inelastic channel in the R-matrix analysis
- Compare the cross section processed with SAMMY, NJOY, AMPX, PREPRO, and GAIA using the evaluated iron resonance parameters

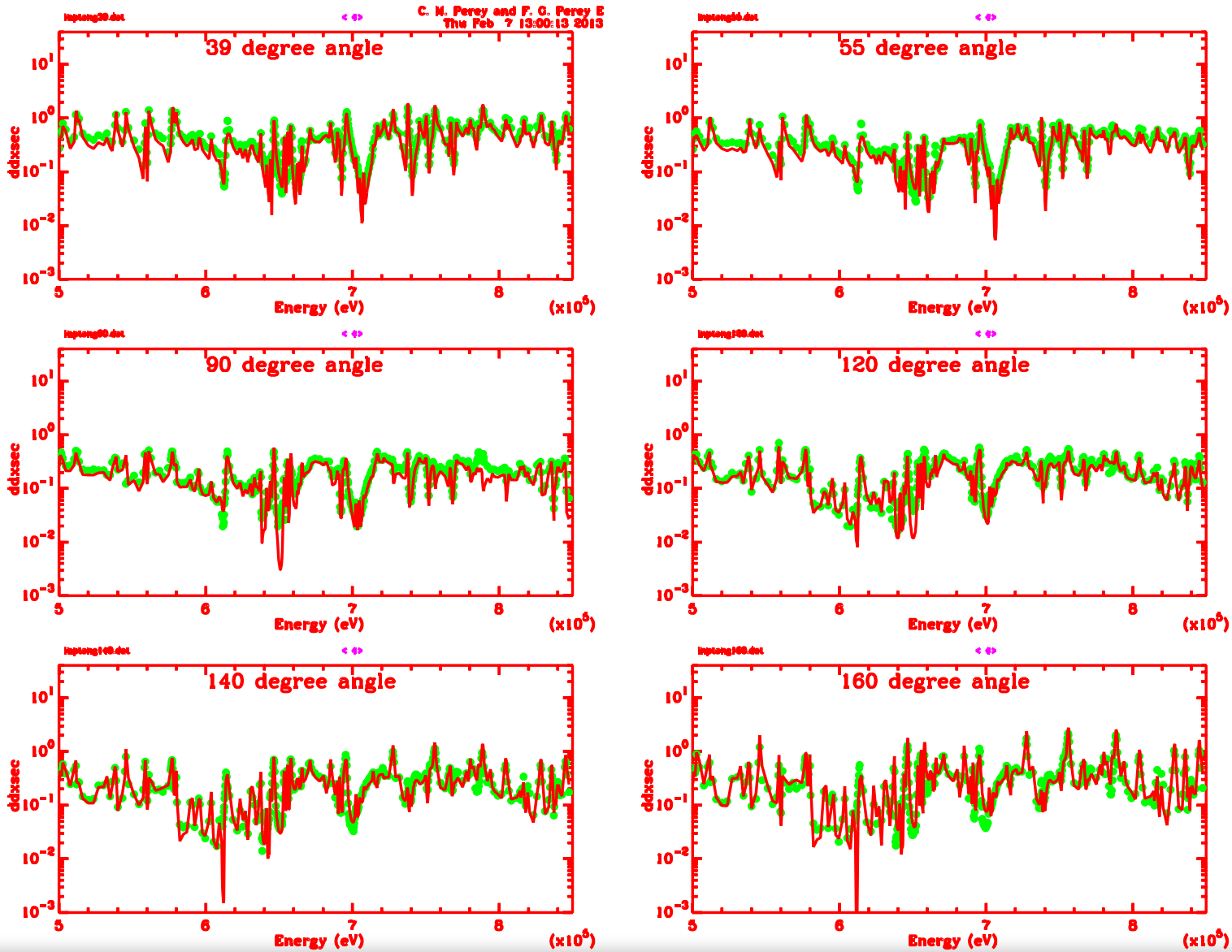
Experimental Data for the n+^{56}Fe Interaction

Reference	Energy Range	Facility	TOF (meters)	Measurement
Harvey (1987)	20 keV – 2 MeV	ORELA	201.575	Transmission
Perey (1990)	120 keV – 850 keV	ORELA	201.575	Transmission
Cornelis (1982)	500 keV – 2 MeV	GELINA	387.713	Transmission
Danon (2012) (three thicknesses)	500 keV – 2 MeV	RPI	249.740	Transmission
Perey (1990)	850 keV – 1.5 MeV	ORELA	201.575	Inelastic
Plompen (2011)	850 keV – 2 MeV	GELINA	198.686	Inelastic
Spencer (1994)) (two thicknesses)	10 eV – 650 KeV	ORELA	40.0	Capture
Perey (1990)	850 keV – 1.5 MeV	ORELA	200.191	elastic
Cabé (1967)	500 keV – 1.2 MeV	Université de Louvain (Van de Graaff)	~ 1	elastic
O.A.Shcherbakov (1977)	0.001 eV – 10 eV	TOF/Russia	9.5	Total
O.A.Shcherbakov (1977)	0.001 eV – 10 eV	TOF/Russia	9.5	Capture

Comparison of SAMMY Fits for Total and Inelastic ^{56}Fe data.



Comparison of SAMMY Fits to Perey Differential Elastic ^{56}Fe data



ALARM-CF-FE-SHIELD-001 - ICSBEP

Neutron and photon leakage spectra from Cf-252 source at the center of six iron spheres of diameters of 20, 30, 40, 50, 60, and 70-cm (IPPE, Russia)

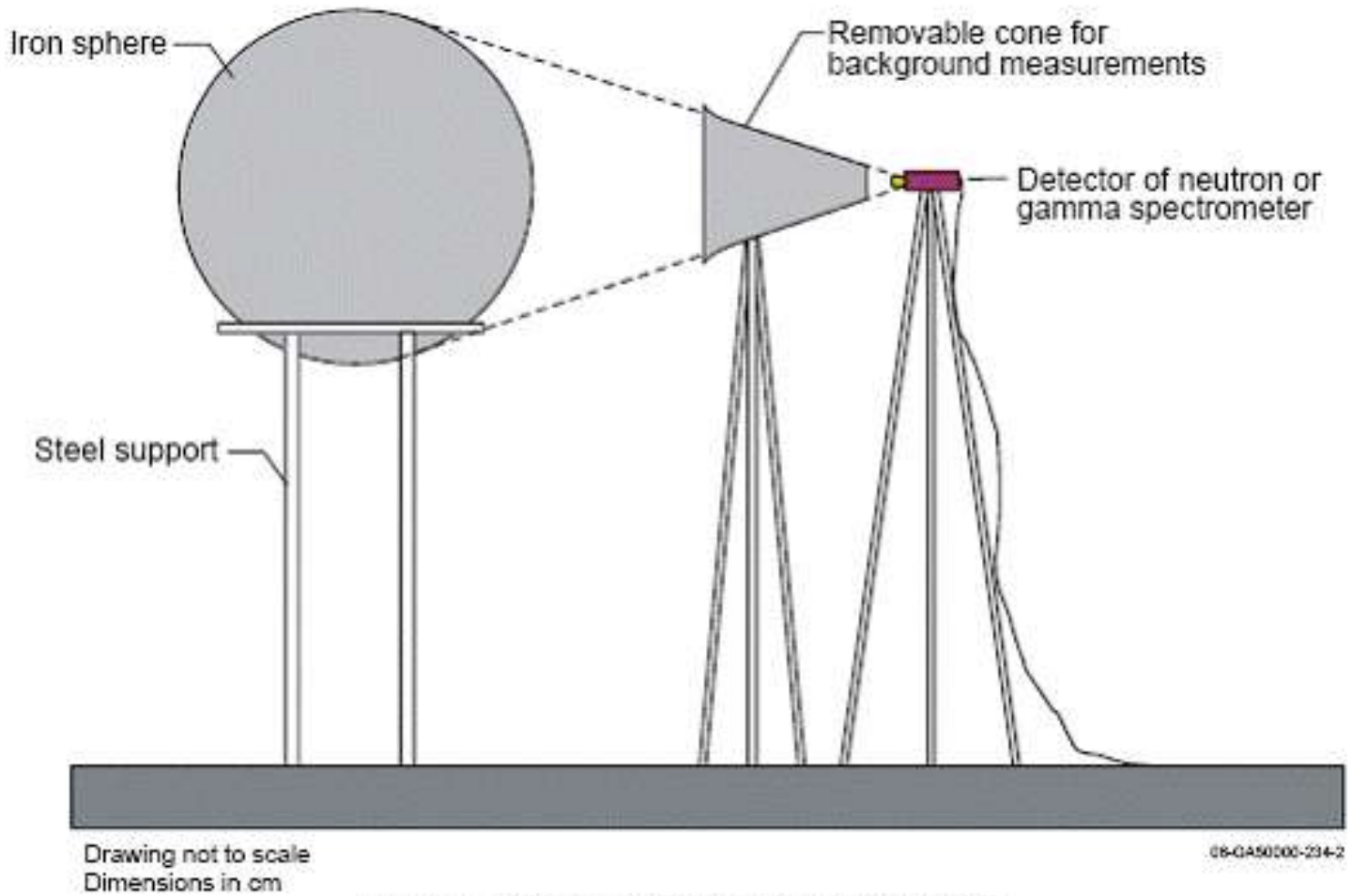
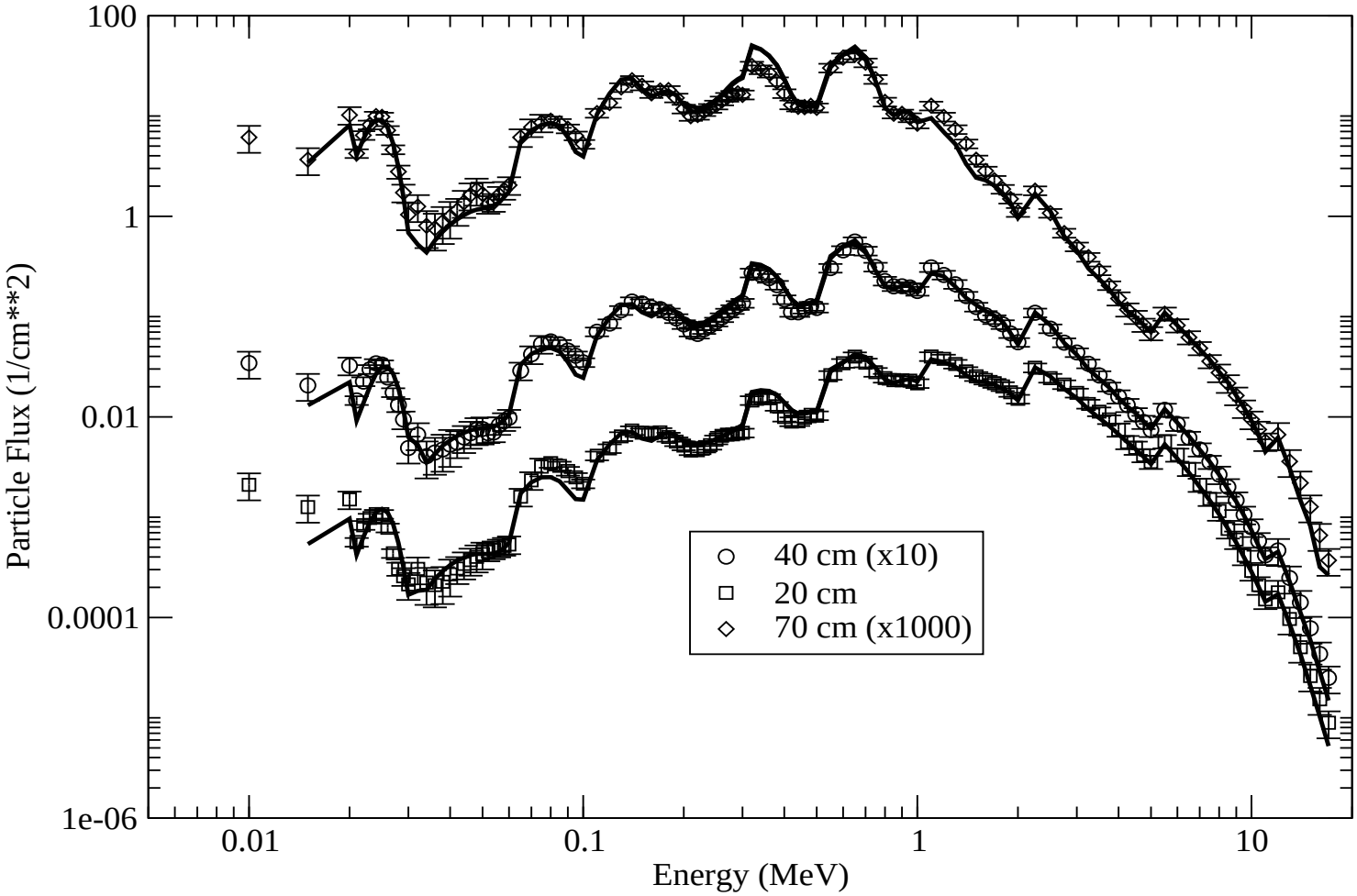


Figure 1. Scheme of Experimental Installation.

^{56}Fe Benchmark Calculations Results



^{235}U Issues and Resolutions:

Issues:

Overestimation of ^{235}U capture cross-section in the resonance region range (0.1 to 2.5 keV).

Recommend:

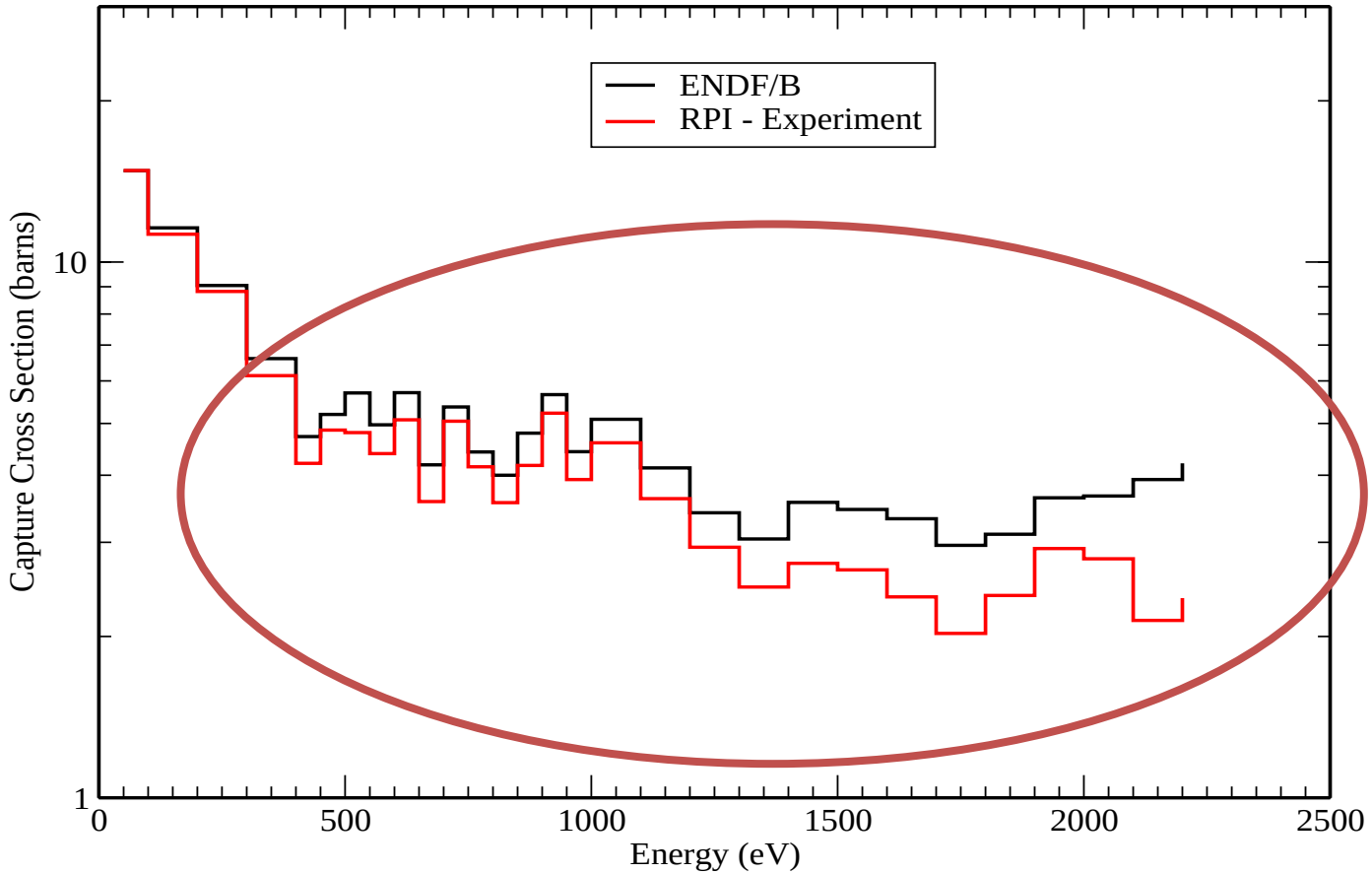
1. New measurements of capture and fission cross-section in the keV region
2. Perform new resonance analysis in the 0.1 to 2.5 keV region
3. Investigate the reason for the overestimation of criticalities for some benchmarks

^{235}U Issues and Resolutions:

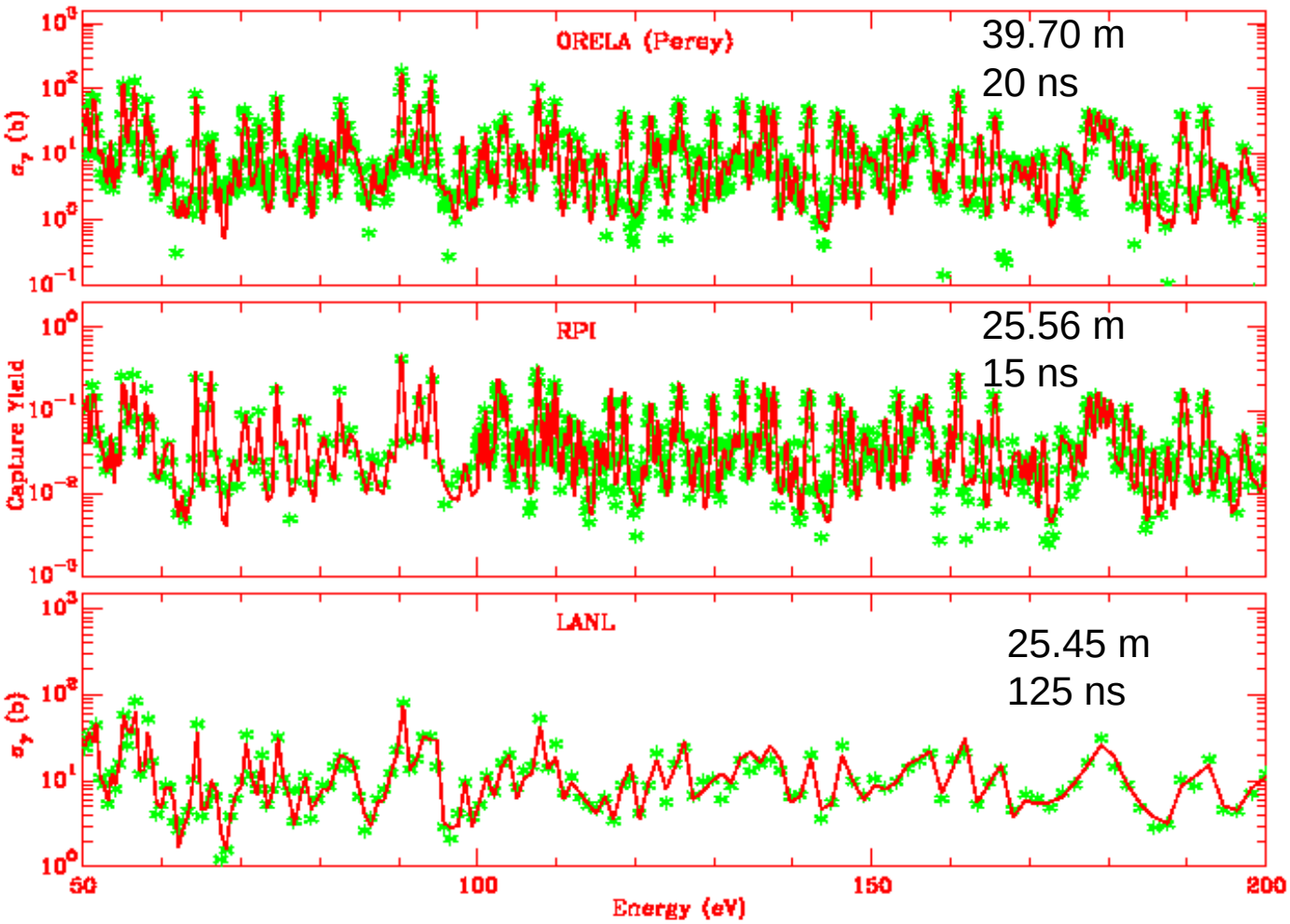
Resolution:

- ✓ New data measurements from RPI (capture and fission yields) (kind of alpha measurements)
- ✓ New capture data from LANL
- ✓ Use SAMMY code for fitting the new data
- ✓ Test the new evaluation in benchmark calculations:
  - ZEUS benchmarks
  - Use JENDL4 as the template
- ✓ Benchmark Calculations done with MCNP with everything else from ENDF/B-VII.1

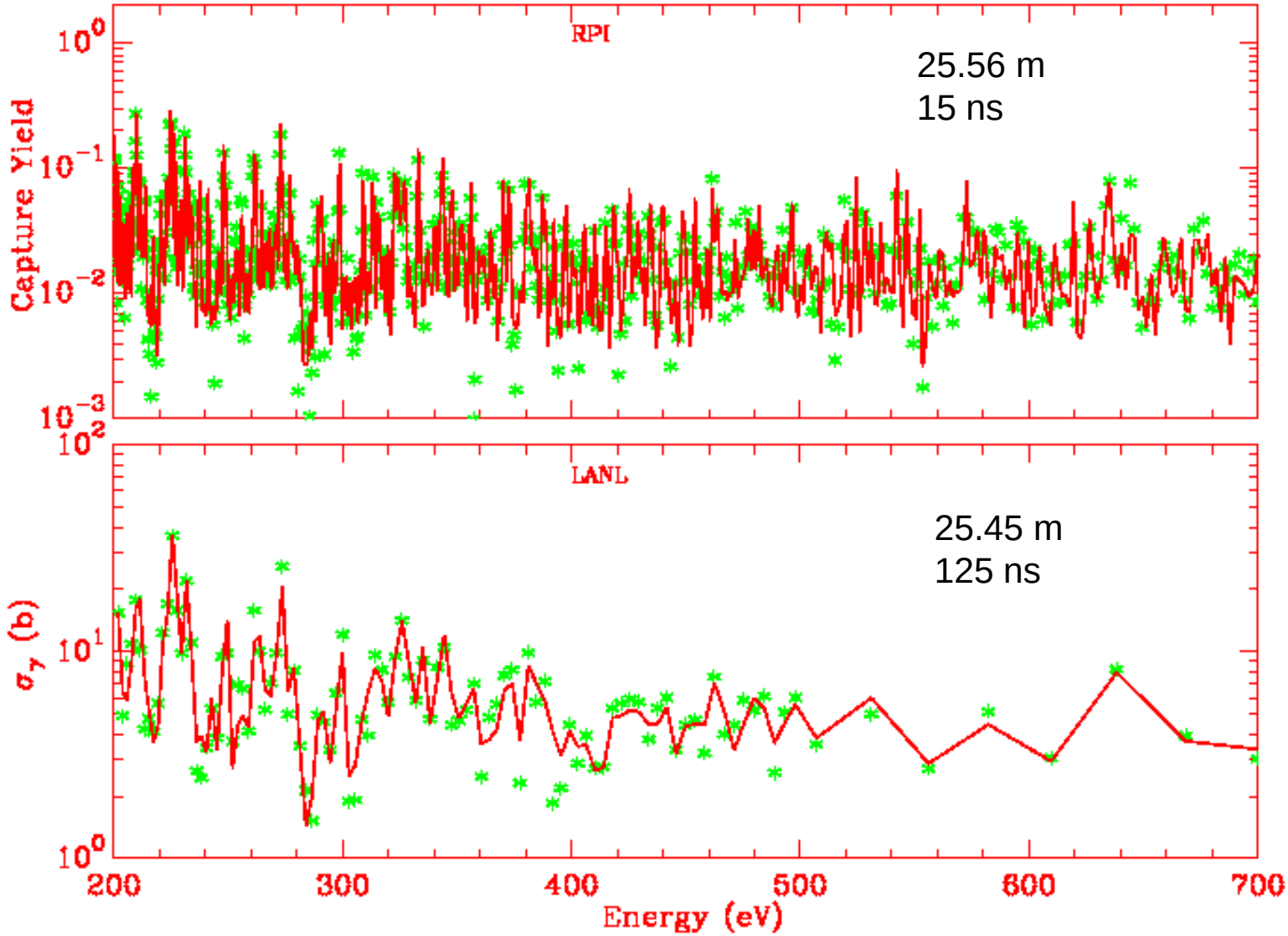
RPI capture data and ENDF evaluation (SG29 prediction confirmed)



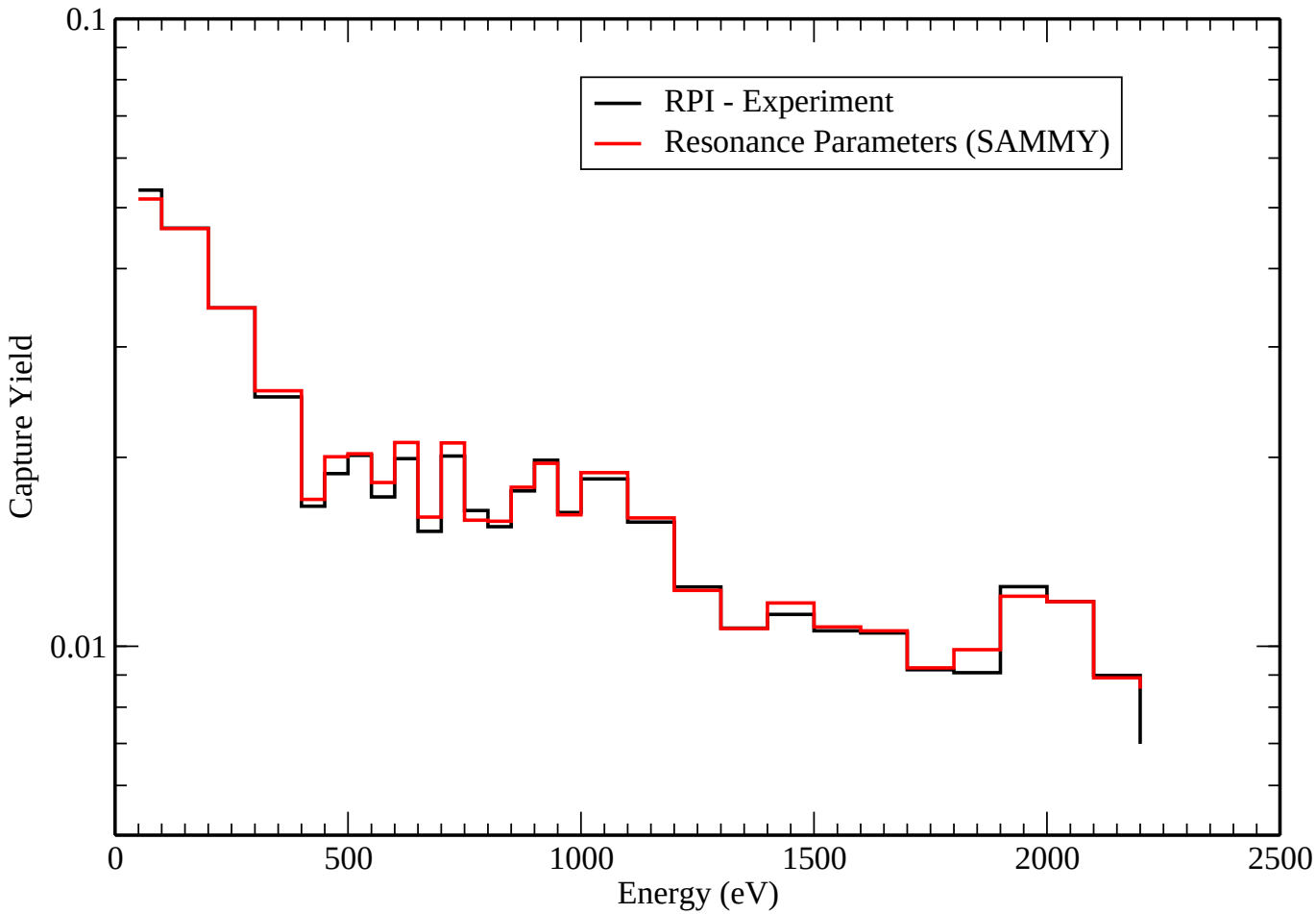
ORNL, RPI and LANL Capture Data



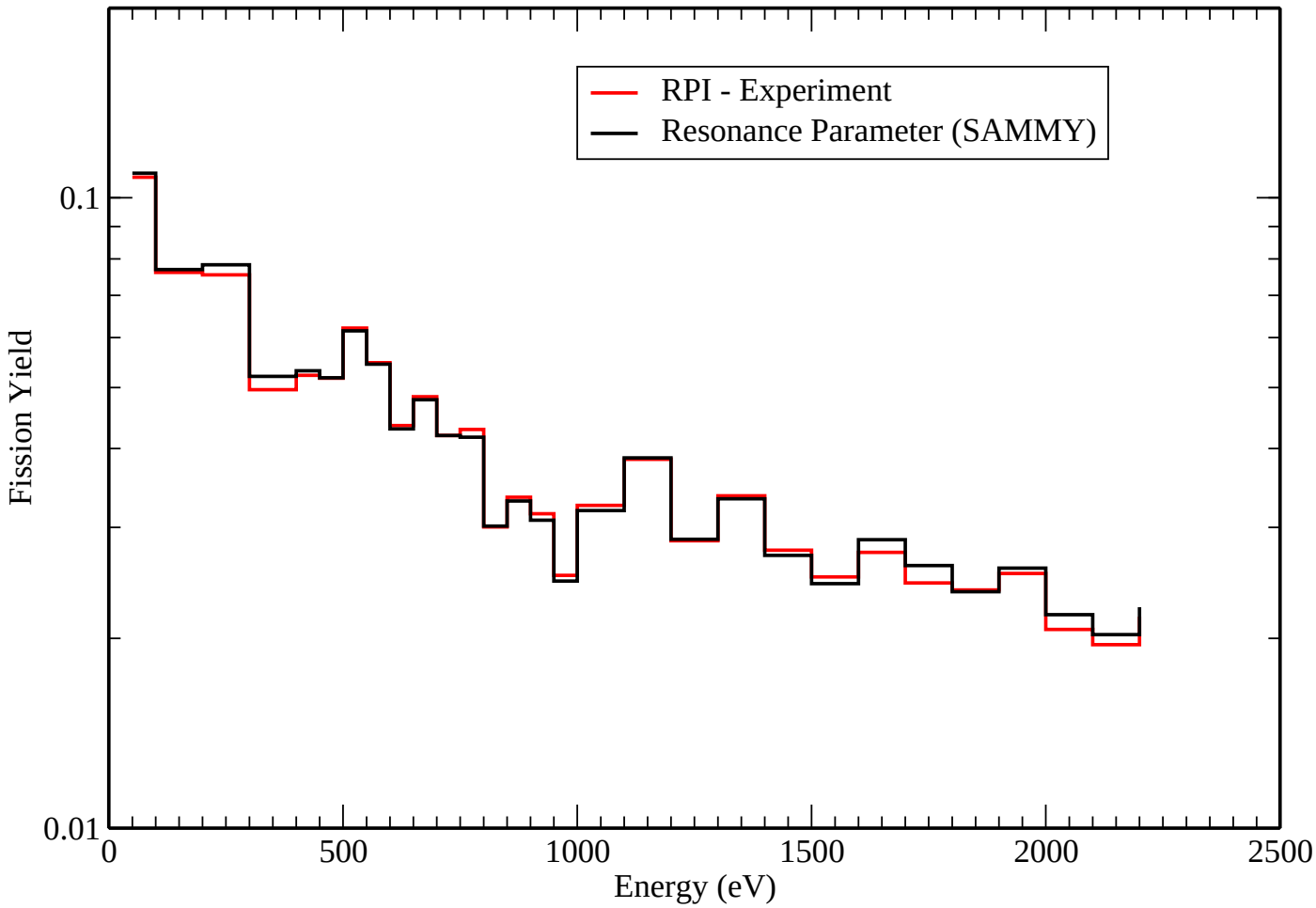
RPI and LANL Capture Data



Fit of the RPI Capture Data



Fit of the RPI Fission data



ICSBEP Benchmark Calculations
The HEU-MET-INTER-006 cases (ZEUS)

Intermediate Energy Benchmark:
Designed to test the ^{235}U cross sections in the intermediate energy range.

ISCEB description:

- ✓ heu-met-inter-006-1 (ZEUS1)
- ✓ heu-met-inter-006-2 (ZEUS2)
- ✓ heu-met-inter-006-3 (ZEUS3)
- ✓ heu-met-inter-006-4 (ZEUS4)

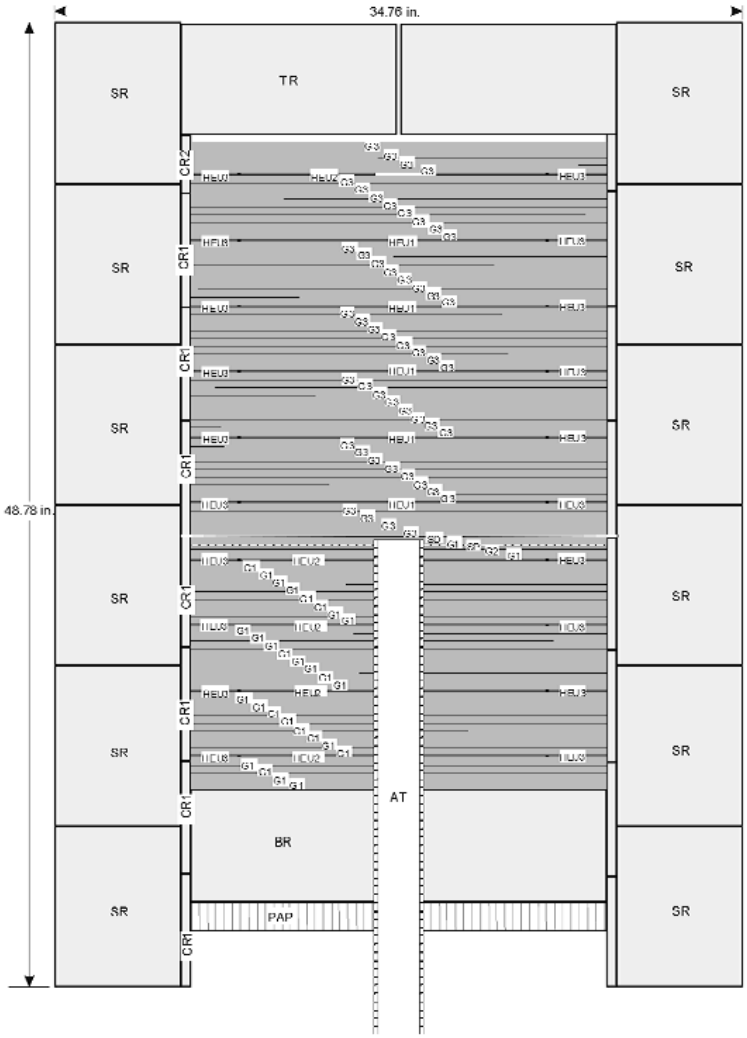
ICSBEP Benchmark Calculations
The HEU-MET-INTER-006 cases (ZEUS)

- Designed to test the ^{235}U cross sections in the intermediate energy range;

- Critical experiments of highly enriched uranium platters moderated by graphite and reflected by copper. The experiments were done at the Los Alamos National Laboratory. They are included in the ICSBEP and identified as HEU-MET-INTER-006 and are referred to as ZEUS benchmark systems.

04-GA50001-183

Vertical Slice through the ZEUS assembly



BR = Bottom Reflector
CR = Corner Reflector
SR = Side Reflector
TR = Top Reflector

AT = Alignment Tube
G = Graphite Platter
HEU = HEU Platter
PAP = Platen
SD = Diaphragm

The HEU-MET-INTER-006 cases (ZEUS)

Case Number	k_{eff}	EALF (keV)	Intermediate-Energy Fission Fraction
1 (ZEUS1)	0.9977 ± 0.0008	4.44	0.730
2 (ZEUS2)	1.0001 ± 0.0008	9.45	0.698
3 (ZEUS3)	1.0015 ± 0.0008	22.80	0.636
4 (ZEUS4)	1.0016 ± 0.0008	80.80	0.503

EALF: Energy Average Lethargy Causing Fission

The HEU-MET-INTER-006 cases (ZEUS)

Case Number	k_{eff}	EALF (keV)	Intermediate-Energy Fission Fraction
1 (ZEUS1)	0.9977 ± 0.0008	4.44	0.730
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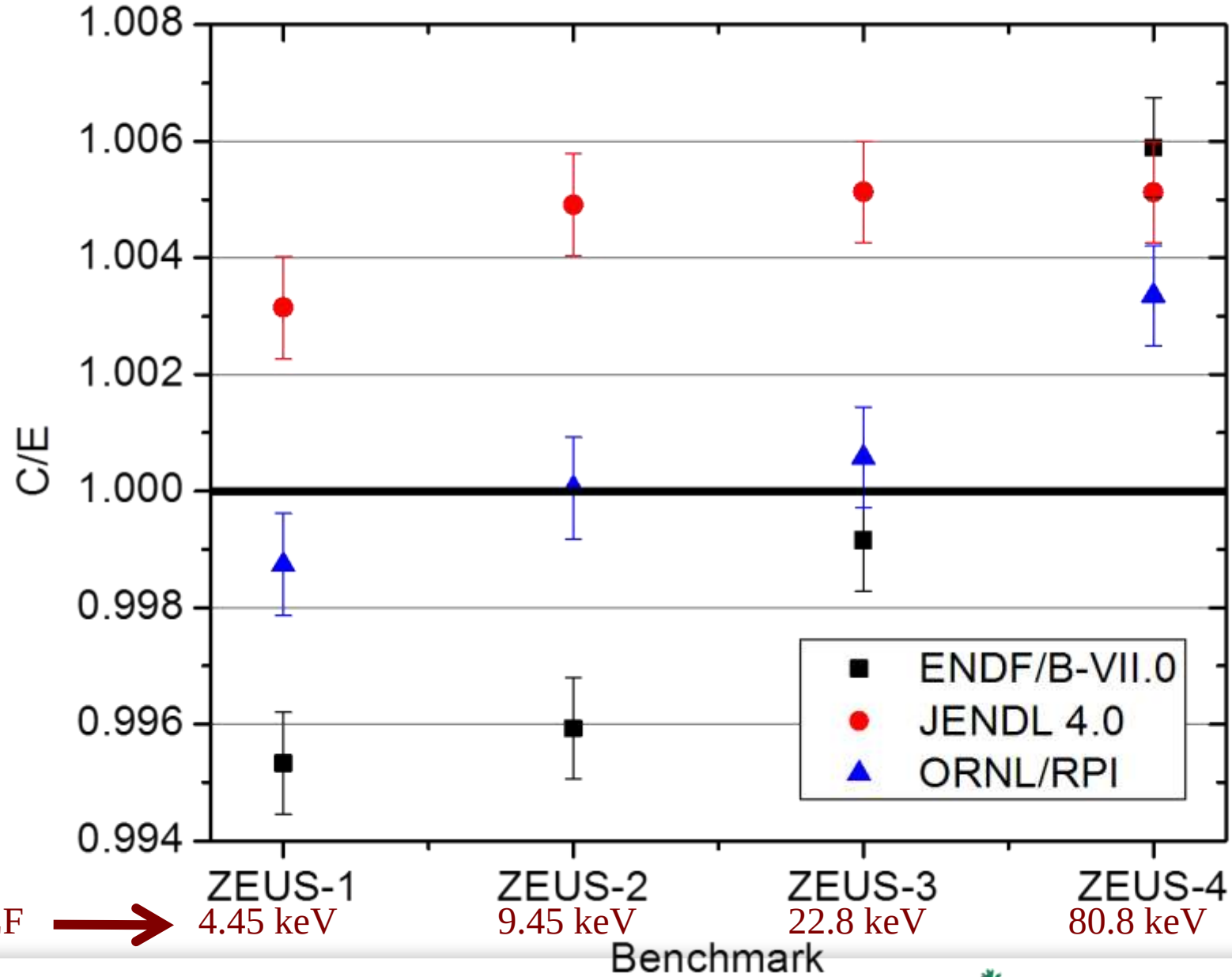
3 (ZEUS3)	1.0015 ± 0.0008	22.80	0.636
4 (ZEUS4)	1.0016 ± 0.0008	80.80	0.503

EALF: Energy Average Lethargy Causing Fission

The HEU-MET-INTER-006 cases (ZEUS)

Case Number	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII.0	JENDL4	ORNL
1 (ZEUS1)	0.9977 ± 0.0008	0.99304 ± 0.00035	1.00084 ± 0.00036	0.99644 ± 0.00035
2 (ZEUS2)	1.0001 ± 0.0008	0.99603 ± 0.00035	1.00501 ± 0.00036	1.00015 ± 0.00035
3 (ZEUS3)	1.0015 ± 0.0008	1.00065 ± 0.00035	1.00664 ± 0.00034	1.00208 ± 0.00033
4 (ZEUS4)	1.0016 ± 0.0008	1.00750 ± 0.00031	1.00673 ± 0.00034	1.00496 ± 0.00031

The HEU-MET-INTER-006 cases (ZEUS)



EALF → 4.45 keV 9.45 keV 22.8 keV 80.8 keV

Summary of Evaluation Accomplishments

- ORNL resonance evaluations on schedule per the NCSP Five Year Plan
- ^{63,65}Cu evaluations completed and delivered to NNDC—Vladimir Sobes completed Ph.D. dissertation
- Completed measurement and resonance analysis work for 4 tungsten isotopes (^{182,183,184,186}W)— evaluations delivered to NNDC
- Completed novel work on ^{56}Fe resonance evaluation to produce angular distributions from resonance parameters
  - Resonance parameters represented very the differential experimental data
  - Benchmark testing with IRSN showing excellent results
- Completed preliminary ^{235}U evaluation
  - Includes new measured data from RPI and LANSCE in the low keV region
  - Testing in progress to finalize the evaluation within the CIELO project

Conclusions

✓ Evaluations on the schedule according to the five year plan;

✓ Evaluation sent to BNL for inclusion in ENDF;

✓ Plan for future evaluations pretty much in the NCSP five year plan schedule;

Questions???