WANDA 2020 Neutron Induced Gamma Production and Gamma Decay Session

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U.S. DEPARTMENT OF ENERGY | Office of Science

Co-chairs: A. Lewis, A. Sonzogni

This topic has been a perennial favorite of these meetings…

NDNCA (2015)

1. Dosimetry Standards
2. Fission
3. Decay Data and γ-Branching Ratios
4. ***Neutron Transport Covariance Reduction***
5. Expanded Integral Validation
6. Antineutrinos from Reactors

NDREW (2019)

- Uncertainty, Sensitivity, and Covariance
- ***Neutron Capture and Associated Spectra***
- Fission I, Independent and Cumulative Yields
- Gamma-Induced Reactions
- ***Inelastic Neutron Scattering & Assoc. Spectra***
- ***Fission II, Prompt Gammas and Neutrons***
- (α,n) Reactions
- Targets, Facilities and Detector Systems
- Fission III, Decay Data
- Development of Benchmark Exercises
- Data Processing & Transport Code Needs
- Actinide Cross Sections

NDEM (2016)

- Improving the Pipeline infrastructure
- Improved Covariance Data
- ***Inelastic Scattering on actinides***
- ***Capture gamma spectra***
- Improved Fission yields
- Target Prod. to Support ND Experiments

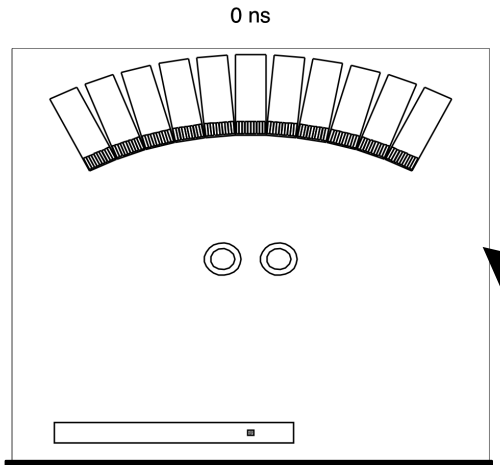
WANDA (2019)

- Nuclear Data for Isotope Production
- Safeguards
- Materials Damage
- Nuclear Data for Nuclear Energy
- ***(n,x) reactions***
- Atomic Data, NRF Data

WANDA (2020)

- Covariance/Uncertainty/Sensitivity/Validation
- Nuclear Data for Isotope Prod. and Targetry needs
- Machine Learning/Artificial Intelligence
- Detector Models, Atomic Data & Stopping Powers
- Scattering, Transport and Shielding
- ***Neutron induced gammas and gamma decay***

We saw that prompt (n,xγ) data was valuable for hydrocarbon production, carbon sequestration, space exploration and nonproliferation



Active Interrogation

McConchie

Ayllon

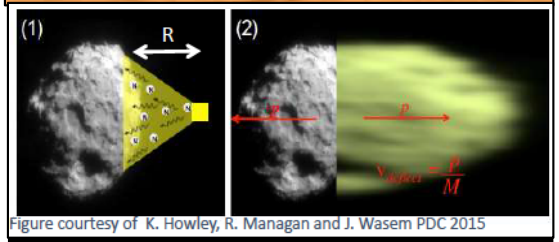
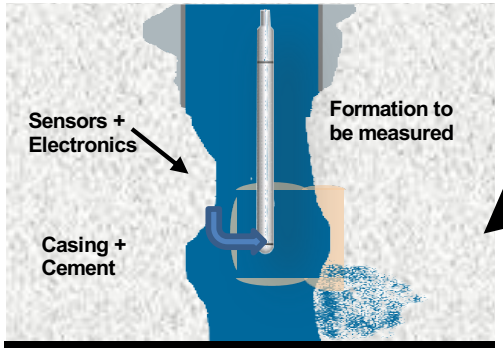


Figure courtesy of K. Howley, R. Managan and J. Wasem PDC 2015

Ressler

Space Exploration & Planetary Defense

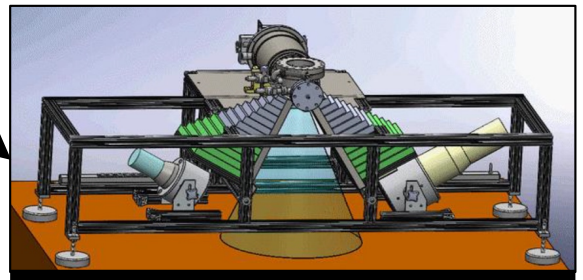
(n,xγ) data



Oil Well Logging

Mauborgne

Ayllon



Carbon Sequestration

The status of measured nuclear (n,xγ) data across the chart of nuclides from NSR since 1950

Reaction	Quantity	# of ref.
(n,γ)	all	6278
(n,γ)	thermal	4270
(n,γ)	thermal+γ-spec	1294
(n,γ)	epithermal	37
(n,γ)	epithermal+γ-spec	26
(n,γ)	keV+γ-spec	522
(n,γ)	MeV+γ-spec	369

Reaction	Quantity	# of ref.
(n,n')	all	2157
(n,n')	γ-spec	781
(n,n')	14 MeV	92
(n,n')	14 MeV+γ-spec	14

The data collected reflects the interest and capabilities available over the last 71 years

Reaction	Quantity	# of ref.
(n,np)	All	163
(n,np)	14 MeV	12
(n,np)	γ-spec	13
(n,nα)	γ-spec	13

Reaction	Quantity	# of ref.
(n,2n)	all	956
(n,2n)	γ-spec	224
(n,2n)	14 MeV	90
(n,2n)	14 MeV+γ-spec	21

Reaction	Quantity	# of ref.
(n,f)	all	3113
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…BUT much of that was NOT focused on γ-ray production

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At least this looks pretty good, right?

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(n,f)	***γ-spec-^{238}U-HPGe***	***2***
(n,f)	***γ-spec-^{239}Pu-HPGe***	***1***

Nope ☹{

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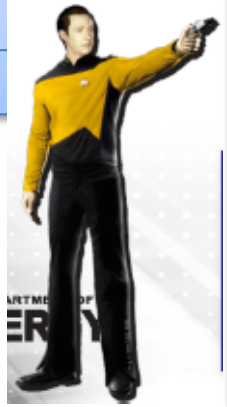
What do we need?

More Data! (G. Nobre)



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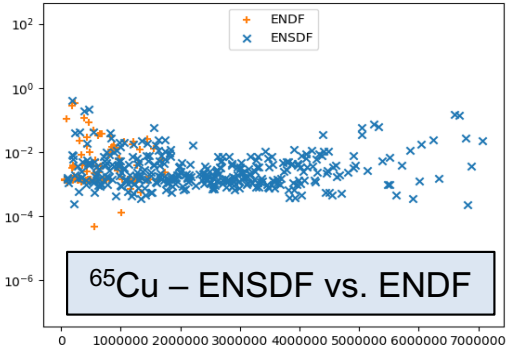
The existing data has lots of problems (McCutchan, Nobre, Lewis)

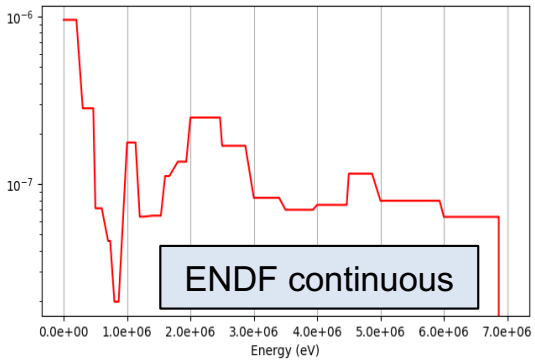
- **There are numerous inconsistencies between ENSDF and ENDF**

  ENSDF doesn't have cross sections

  ENDF has discrete and continuum γ's

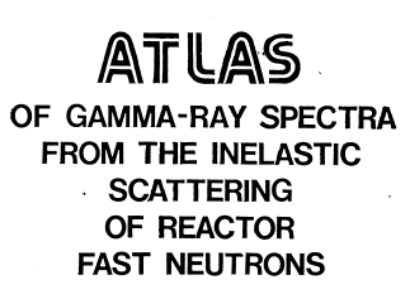
  but is focused on <u>transport, not spectra</u>

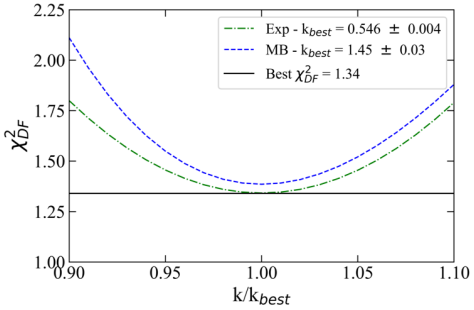


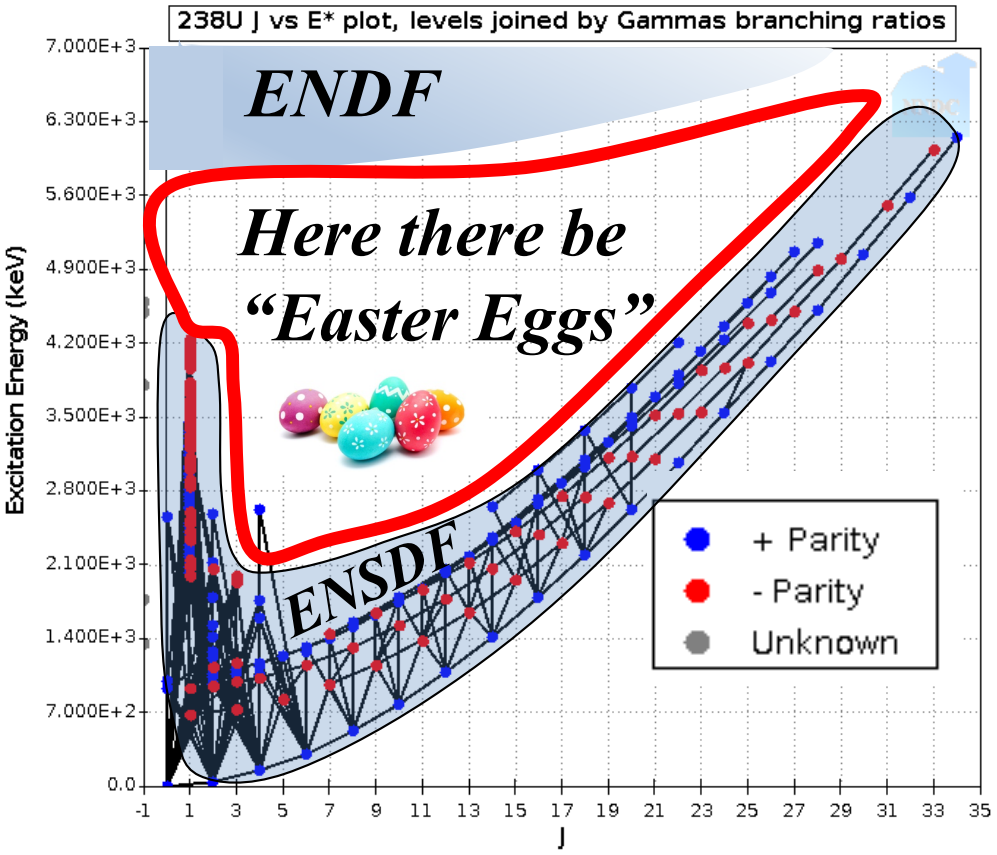


- **There are no (n_{fast}, $x\gamma_{spectral}$) benchmark**

  The Baghdad Atlas might help, but work is needed in determining the spectrum



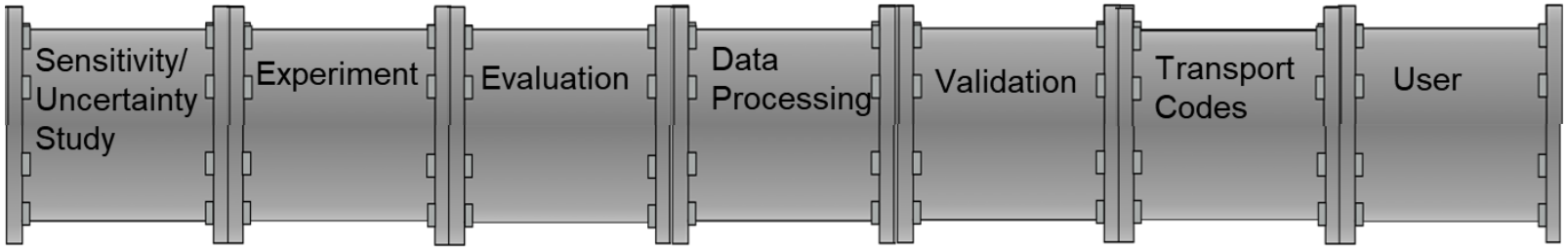




A consistent modeling treatment and database format (GNDS) is needed to address data throughout this region

A Path Forward – Formation of the Gamma Rays Induced by Neutrons (GRIN) task force ☺

- Modeled on CRP/WPEC SG structure
- Charge - Address outstanding needs throughout the pipeline:
  - ***Sensitivity Study for Active Interrogation*** (ORNL).
  - ***Compilation*** - Address missing/discrepant data between ENSDF and ENDF
  - ***New Experimental data*** – Clearly needed for (n,xγ) for $E_n \leq 14$ MeV. Consistency between scattered neutron- and γ-ray data a must.
  - ***Evaluation*** – Put (n,xγ) into the evaluation process, conserving energy and angular momentum. *Don't just "paste" γ-ray spectra into ENDF* (Is there a ***processing*** issue here?)
  - ***Validation*** – New high energy benchmarks (extend Baghdad Atlas range)



We wrote a detailed summary for the proceedings