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# BNL Covariance Effort

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# We are developing broad capabilities

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## Covariance evaluation methodology, all under EMPIRE

- Fast neutron region, combines modeling and data
- Resonance region, based on Atlas of Neutron Resonances

## Evaluations

- Sophisticated    8 isotopes of Gd
- Medium            55Mn and 90Zr
- Simple            35 materials for SG26, 307 materials for Low-Fidelity

## Visualization and plotting

- New Sigma interface

## Processing

- NJOY-99
- PUFF-IV

# BNL covariance capabilities cnt'd

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## Covariance Projects

- Covariances for WPEC Subgroup 26
- Low-fidelity covariance project
- GNEP covariance library

## Additional activities

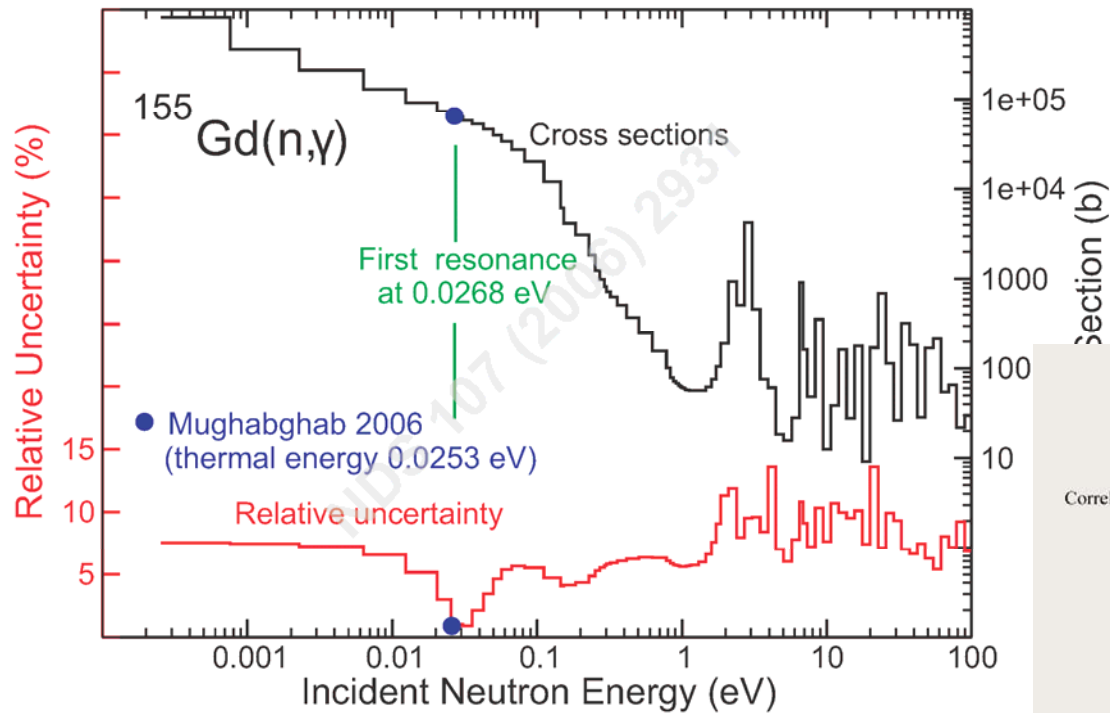
- Covariance Workshop, Port Jeff, June 2008
- Special Issue of Nuclear Data Sheets on Covariances

## Staff involved

- Herman, Mattoon, Mughabghab, Oblozinsky, Pigni (methodology, evaluations)
- Arcilla, Sonzogni, Pritychenko (processing, Sigma)
- Active collaboration with several external scientists (Cho, ...)

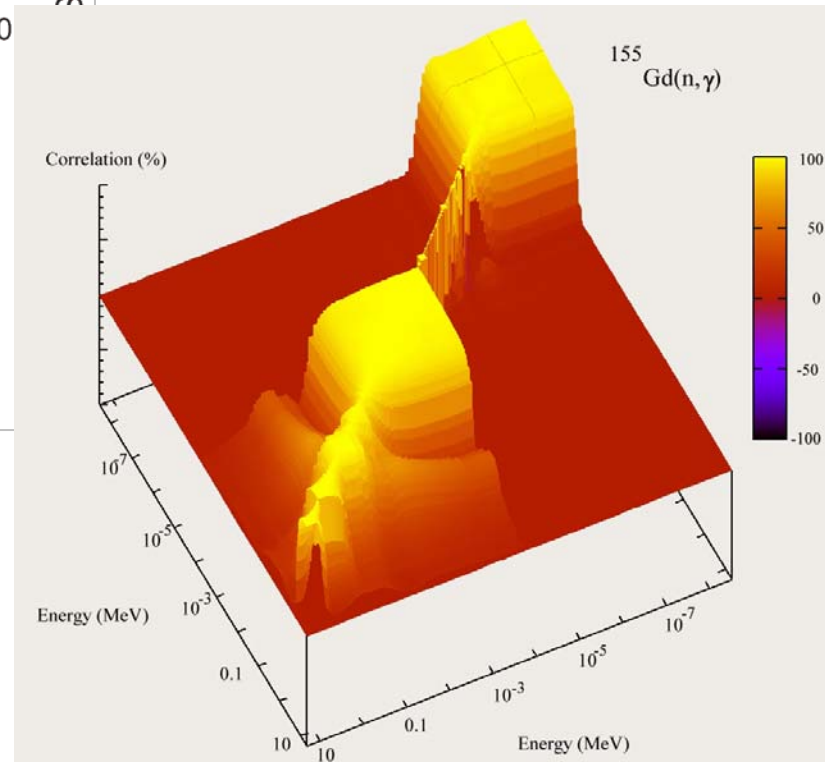
# Sample covariances for ENDF/B-VII.0

8 isotopes of Gd: BNL – ORNL collaboration in 2006



Show case for ENDF/B-VII.0:

- Simultaneous evaluation
- Complete isotopic chain
- Cross sections
- Covariances

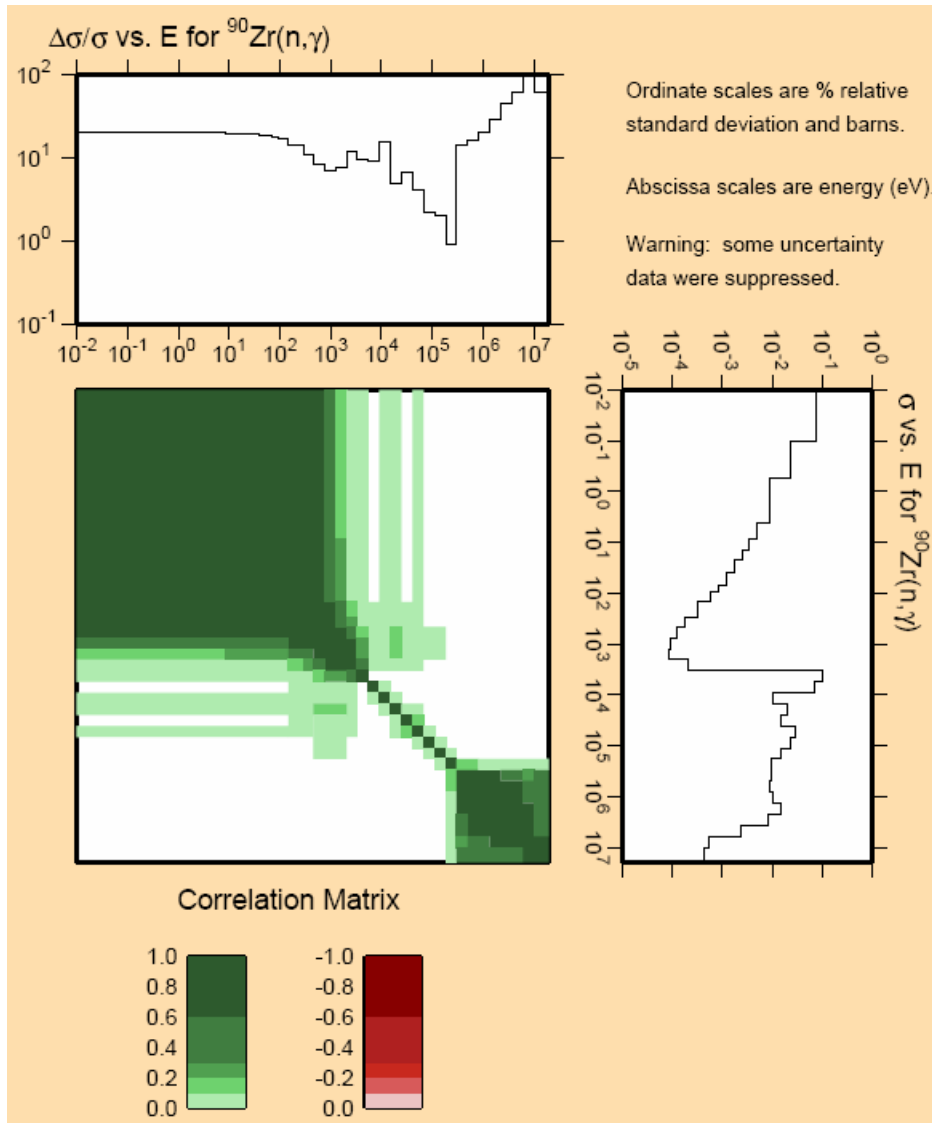
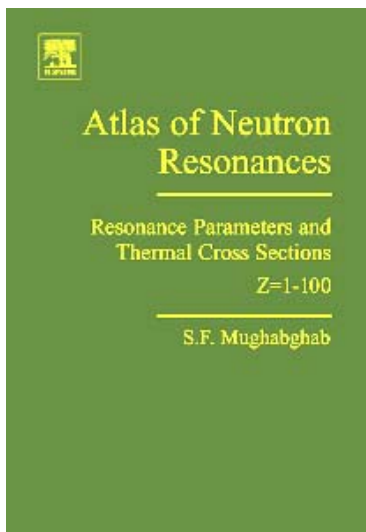


# Example of new covariances

## $^{90}\text{Zr}$ by BNL in 2008

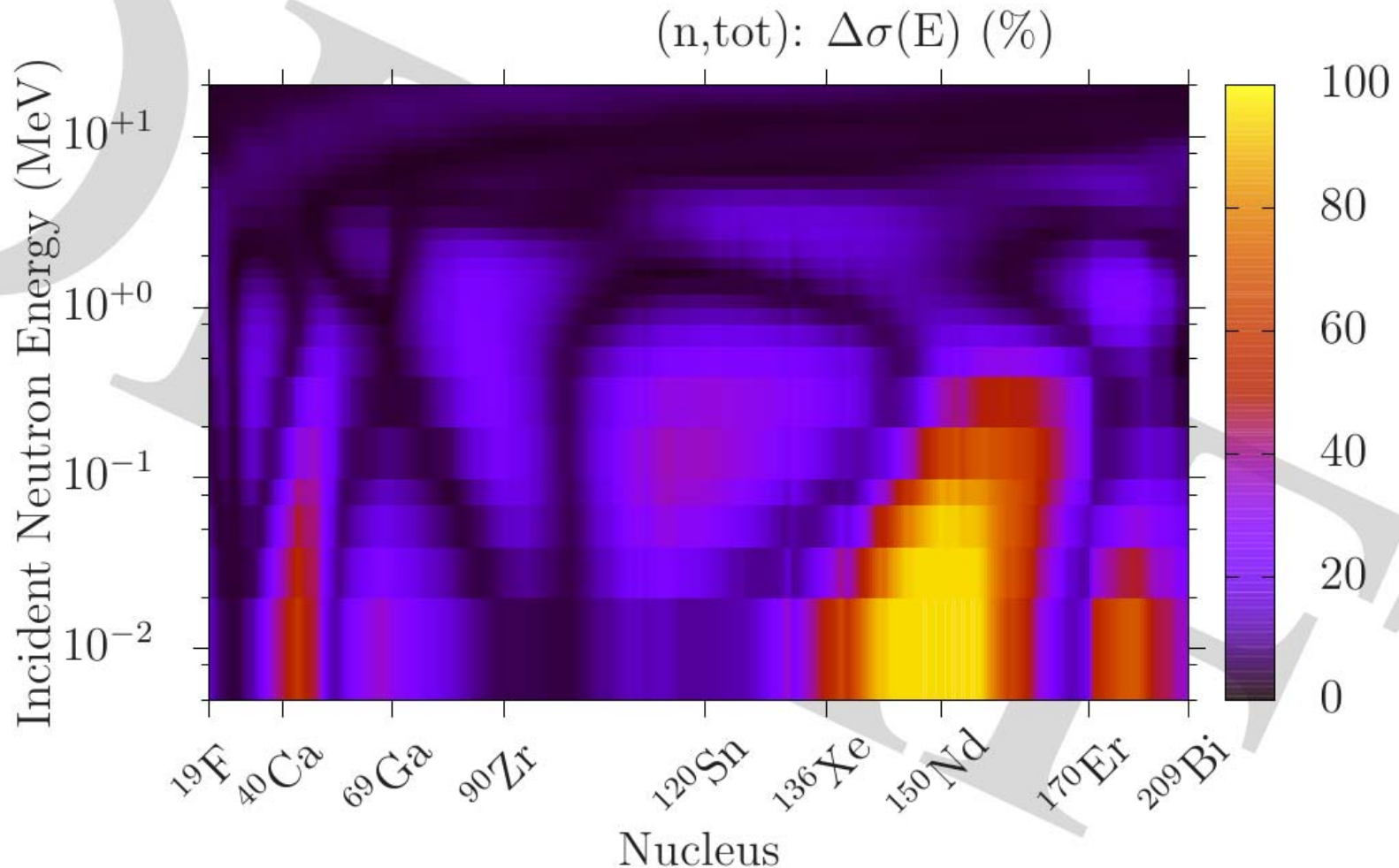
Produced by new covariance modules in EMPIRE:

- Low energy region: Atlas of Neutron Resonances + thermal and resonance region adjusted, MF32
- Fast region: modeling + experimental data, MF33



# Model-based estimates for 307 materials

BNL contribution to low-fidelity project, 2007-2008



# Sigma: Covariance retrieval and plotting

## Direct visualization of MF33



Evaluated Nuclear Data File (ENDF) Retrieval & Plotting



Periodic Table Browse

Directory Tree Browse

Basic Retrieval

Advanced Retrieval

Plot Cart

Computations **NEW**

Select first a library, then a sublibrary and finally click on a chemical element to obtain results.

Data is available for materials with a cyan background.

Library:

Sublibrary:

0	1																	2
n	H																	He
	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
	11	12											13	14	15	16	17	18
	Na	Mg											Al	Si	P	S	Cl	Ar
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	87	88	89	104	105	106	107	108	109	110	111							
	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							
		58	59	60	61	62	63	64	65	66	67	68	69	70	71			
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
		90	91	92	93	94	95	96	97	98	99	100	101	102	103			
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

Results for  
Z=77

191

193

(n,2np)	Interpreted	
(n,n <sub>e</sub> )	Interpreted	
(n,γ)	Interpreted	
Radioactivity and fission yields:		
(n,2n)	Interpreted	
(n,3n)	Interpreted	
Cross sections for radionuclides prod.:		
(n,2n)	Interpreted	
(n,3n)	Interpreted	
Mult. for γ production:		
(n,n' <sub>γ</sub> )	(click to expand)	
dσ/dω for γ production:		
(n,n' <sub>γ</sub> )	(click to expand)	
Cross section covariances:		
(n,total)	Interpreted	Plot
(n,elastic)	Interpreted	Plot
(n,inelastic)	Interpreted	Plot
(n,2n)	Interpreted	Plot
(n,γ)	Interpreted	Plot
(n,p)	Interpreted	Plot

Click  
to plot

New in version 2.0:

- Angular distributions of emitted neutrons (if available in MF=4)
- Energy distributions of emitted neutrons and photons (if available in MF=5)
- Computations (mathematical operations) on cross sections (MF=3)

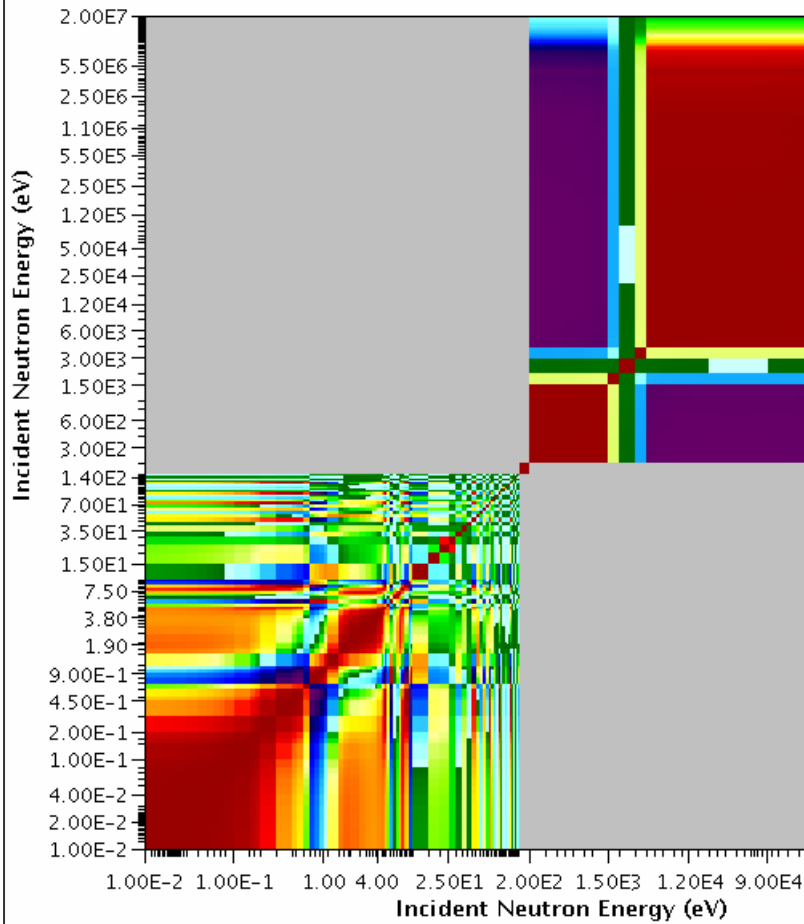
In pipeline for 3.0: Energy-angle distributions (MF=6), covariances (MF=33)

Database Manager: Mike Herman, NNDC, Brookhaven National Laboratory

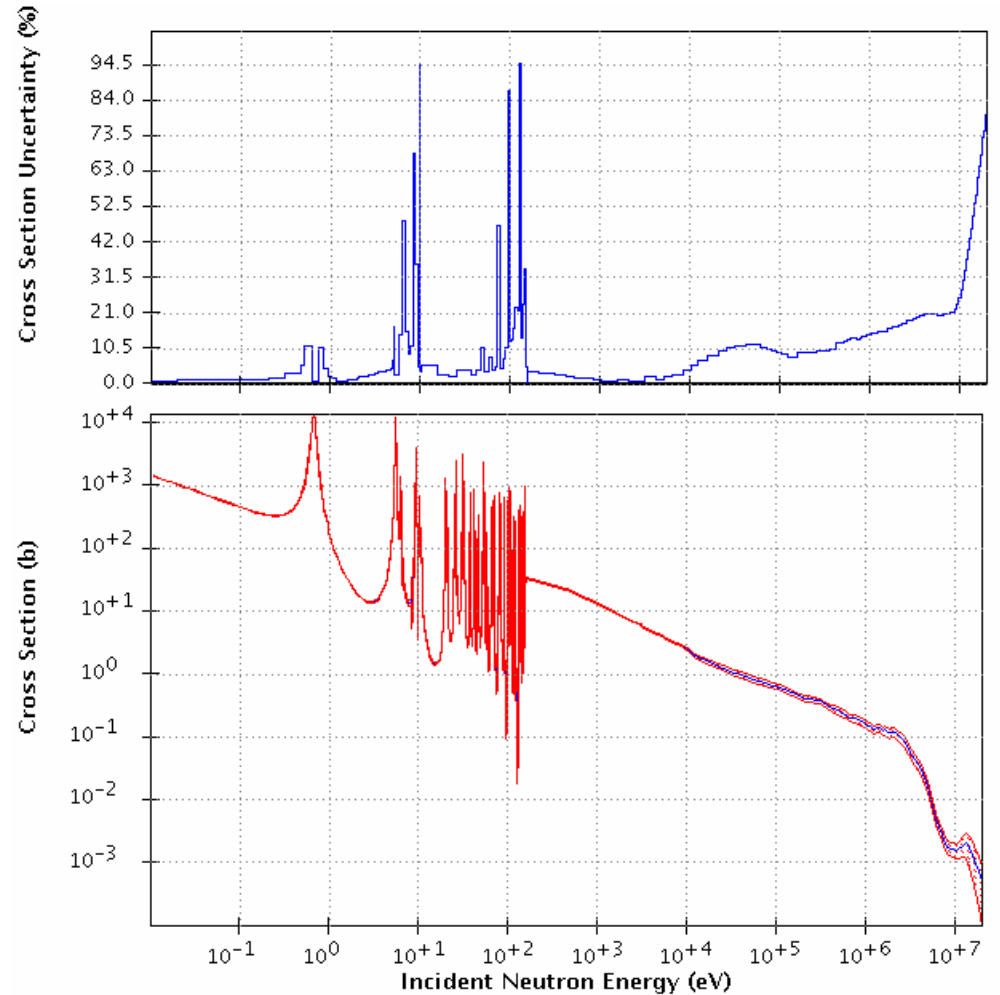
Web and Programming: B. Pritychenko, A.A. Sonzogni, NNDC, Brookhaven National Laboratory

Data Source: CSEWG and NEA-WPEC

77-Ir-191(n,gamma) ENDF/B-VII.0



Correlations, % uncertainties, and cross section with uncertainty band plots





# Covariance processing

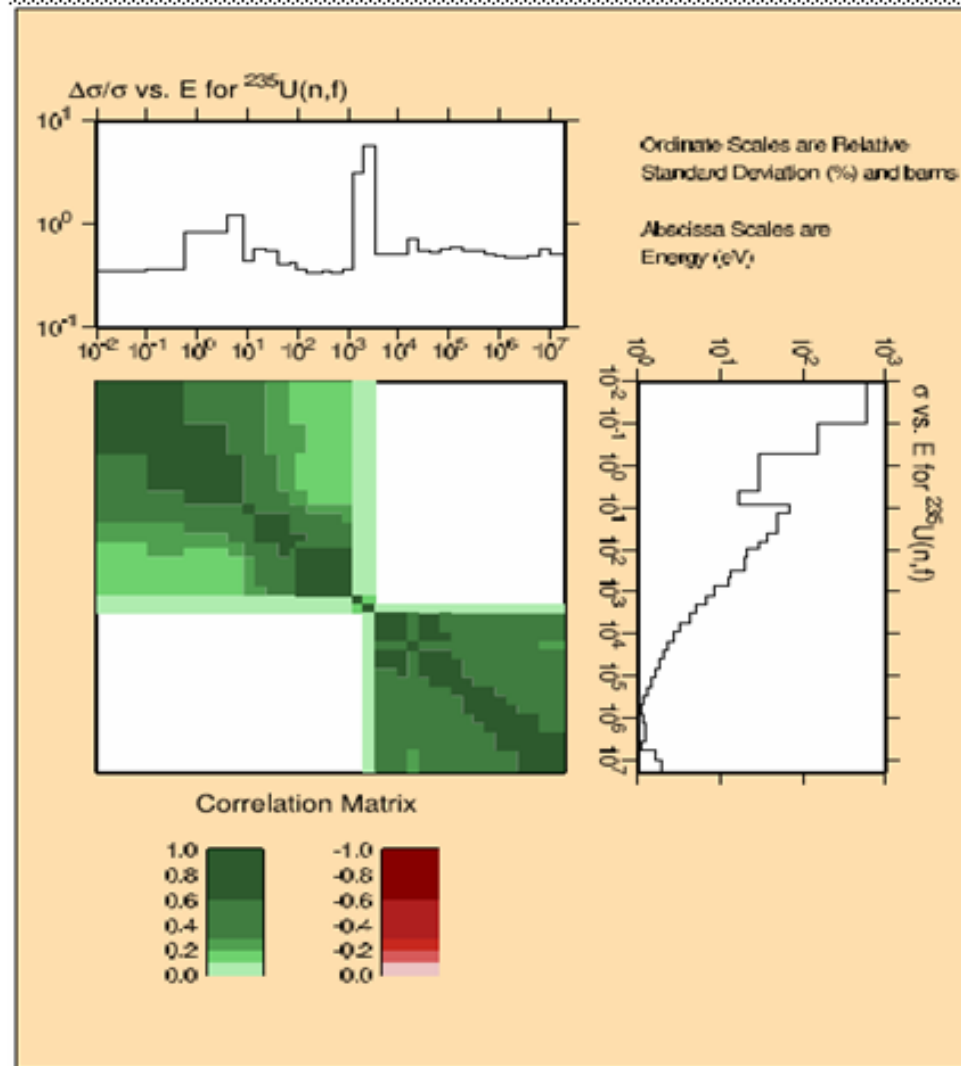
## NJOY-99 and PUFF-IV

Probably the only lab actively using both NJOY-99 and PUFF-IV. These codes have somewhat different capabilities.

Having two processing codes is important: we get more confidence in the results.

The codes are used to check new evaluations, before inclusion into ENDF/A.

### 235-U(n,f) by ORNL-LANL 2008



# Conclusions

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Our covariance capabilities allow active participation in covariance evaluation effort and providing support as the data center:

- Covariance evaluation methodology, all under EMPIRE
- Evaluations
- Visualization and plotting
- Processing