

JEFF-3.3 covariance application to ICSBEP using SANDY and NDaST

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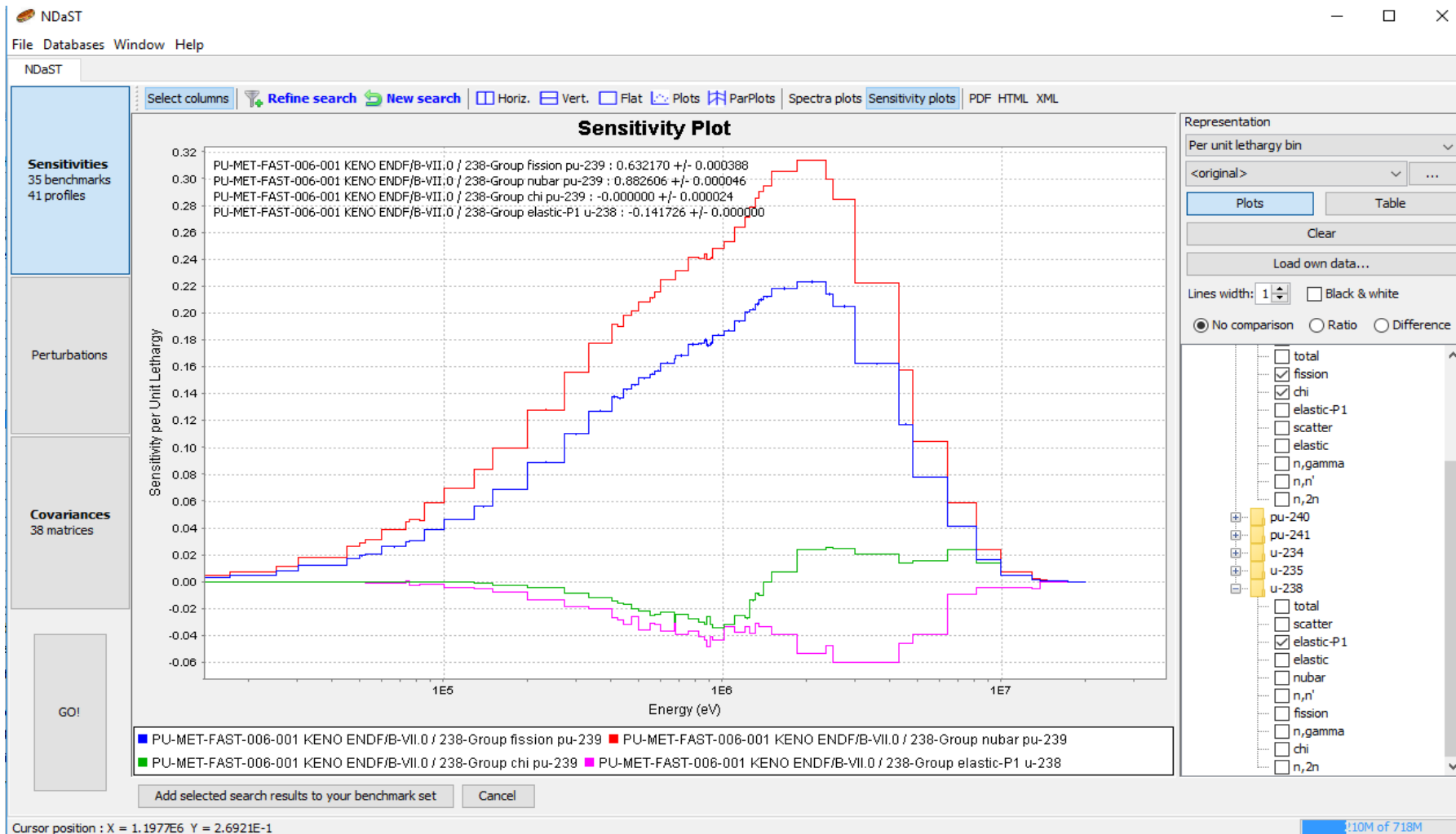
WPEC SG44: Nuclear Data Week – November 2018

Objectives

- Code comparison for uncertainty quantification on a selection of ICSBEP cases
- Focus on newly implemented features (P1 elastic)
- Identification of shortcomings in data and methodologies

NDaST	SANDY
Sensitivity tool	Nuclear data sampling tool
Java-based software	Python package

Sensitivities from DICE



Covariances from JANIS

NDaST - □ ×

File Databases Window Help

NDaST

Search covariances

Clear

Nuclide 1	Reaction 1	Nuclide 2	Reaction 2	JANIS refs
Pu239	CHI	Pu239	CHI	JEFF-3.3~N~J...
Pu239	NUBAR	Pu239	NUBAR	JEFF-3.3~N~J...
Pu239	N_ALPHA	Pu239	N_ALPHA	JEFF-3.3~N~J...
Pu239	N_P	Pu239	N_P	JEFF-3.3~N~J...
Pu239	N_P	Pu239	N_ALPHA	JEFF-3.3~N~J...
Pu239	N_GAMMA	Pu239	N_GAMMA	JEFF-3.3~N~J...
Pu239	N_GAMMA	Pu239	N_P	JEFF-3.3~N~J...
Pu239	N_GAMMA	Pu239	N_ALPHA	JEFF-3.3~N~J...
Pu239	FISSION	Pu239	FISSION	JEFF-3.3~N~J...
Pu239	FISSION	Pu239	N_GAMMA	JEFF-3.3~N~J...
Pu239	FISSION	Pu239	N_P	JEFF-3.3~N~J...
Pu239	FISSION	Pu239	N_ALPHA	JEFF-3.3~N~J...
Pu239	N_2N	Pu239	N_2N	JEFF-3.3~N~J...
Pu239	N_2N	Pu239	FISSION	JEFF-3.3~N~J...
Pu239	N_2N	Pu239	N_GAMMA	JEFF-3.3~N~J...
Pu239	N_2N	Pu239	N_P	JEFF-3.3~N~J...
Pu239	N_2N	Pu239	N_ALPHA	JEFF-3.3~N~J...
Pu239	INELASTIC	Pu239	INELASTIC	JEFF-3.3~N~J...
Pu239	INELASTIC	Pu239	N_2N	JEFF-3.3~N~J...

Sensitivities
35 benchmarks
41 profiles

Perturbations

Covariances
38 matrices

Rel. std dev
 filled
 outline

Perturbations
 display

solid
 density

GO!

37 covariance matrices added

Correlation

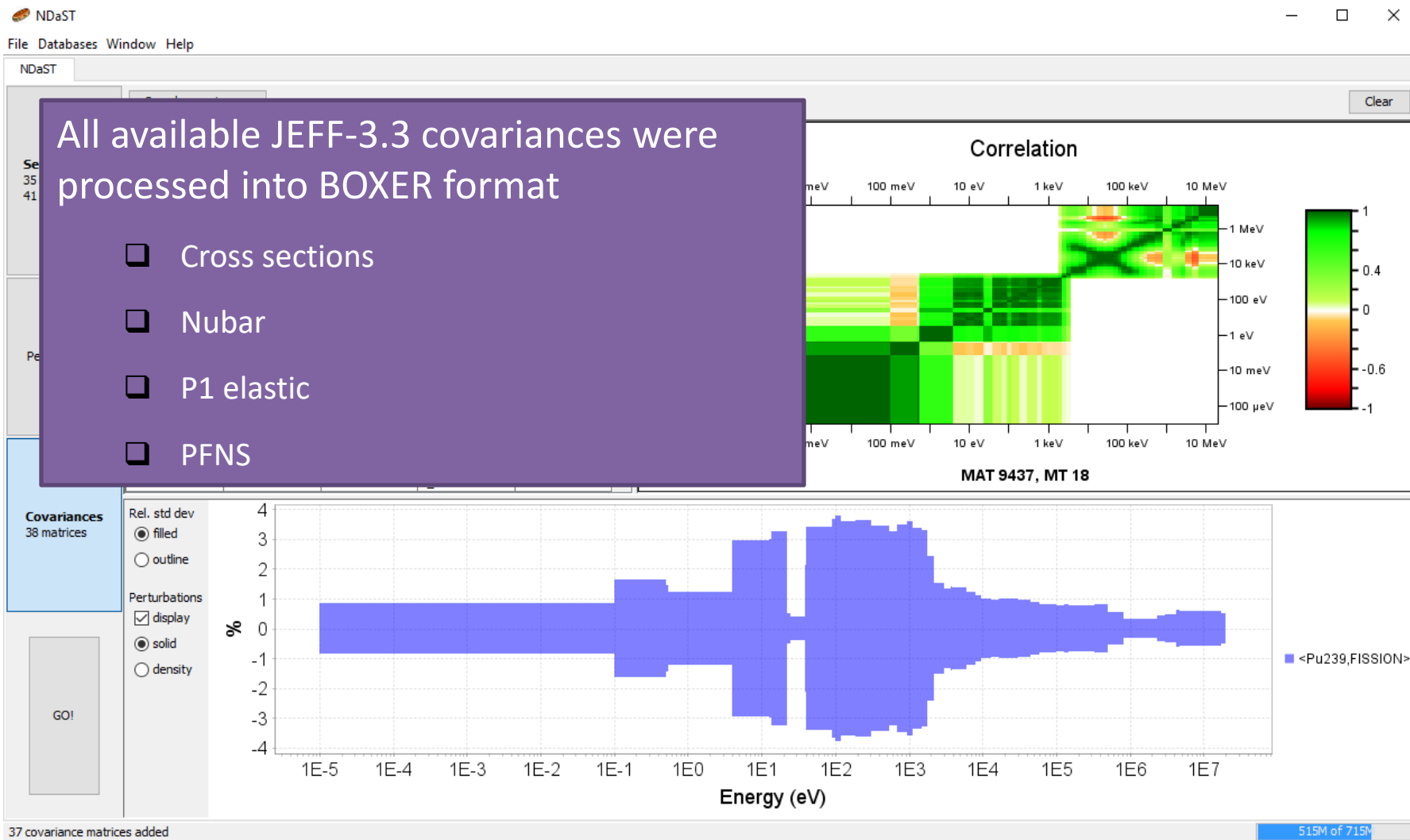
MAT 9437, MT 18

MAT 9437, MT 18

<Pu239,FISSION>

515M of 715M

Covariances from JANIS



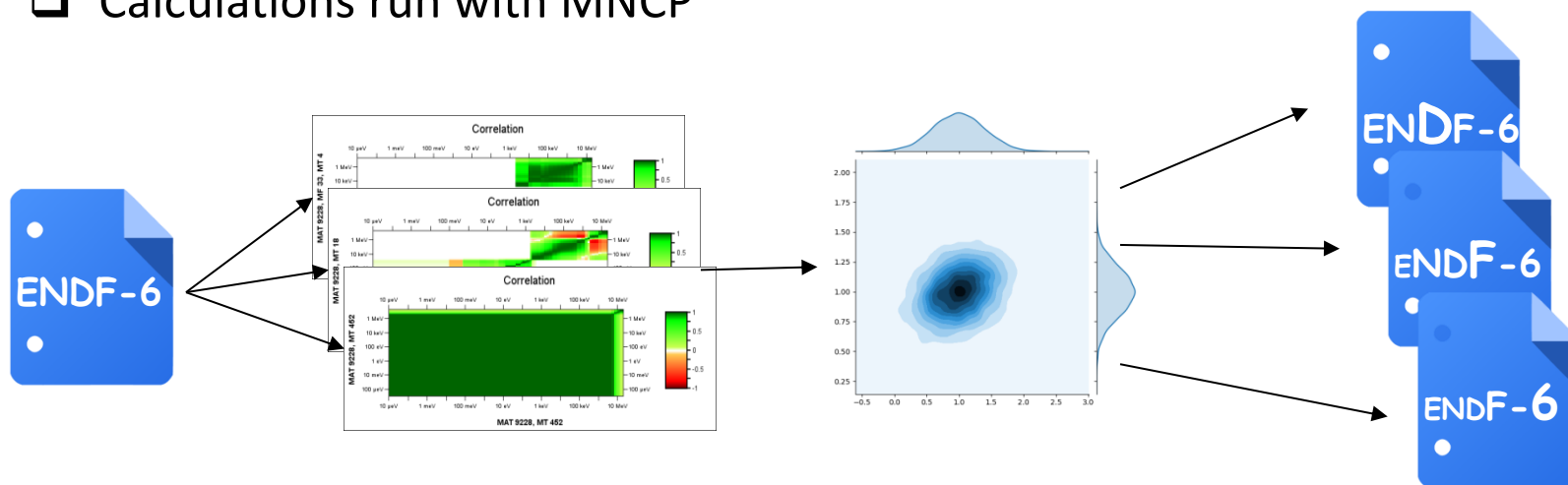
SANDY

- Production of *perturbed* files for brute force uncertainty propagation

$$\begin{array}{l}
 x_1^{(1)}, x_2^{(1)}, \dots, x_3^{(1)} \longrightarrow f(x_1^{(1)}, x_2^{(1)}, \dots, x_3^{(1)}) \longrightarrow y^{(1)} \\
 x_1^{(2)}, x_2^{(2)}, \dots, x_3^{(2)} \longrightarrow f(x_1^{(2)}, x_2^{(2)}, \dots, x_3^{(2)}) \longrightarrow y^{(2)} \\
 \vdots \\
 x_1^{(N)}, x_2^{(N)}, \dots, x_3^{(N)} \longrightarrow f(x_1^{(N)}, x_2^{(N)}, \dots, x_3^{(N)}) \longrightarrow y^{(N)}
 \end{array}
 \left. \vphantom{\begin{array}{l} \\ \\ \\ \end{array}} \right\} COV_y$$

- Data and covariances from JEFF-3.3

- Calculations run with MNCP



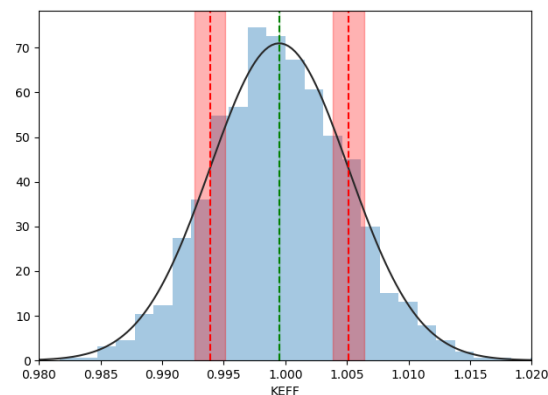
Comparison NDaST / SANDY

Mosteller's suite

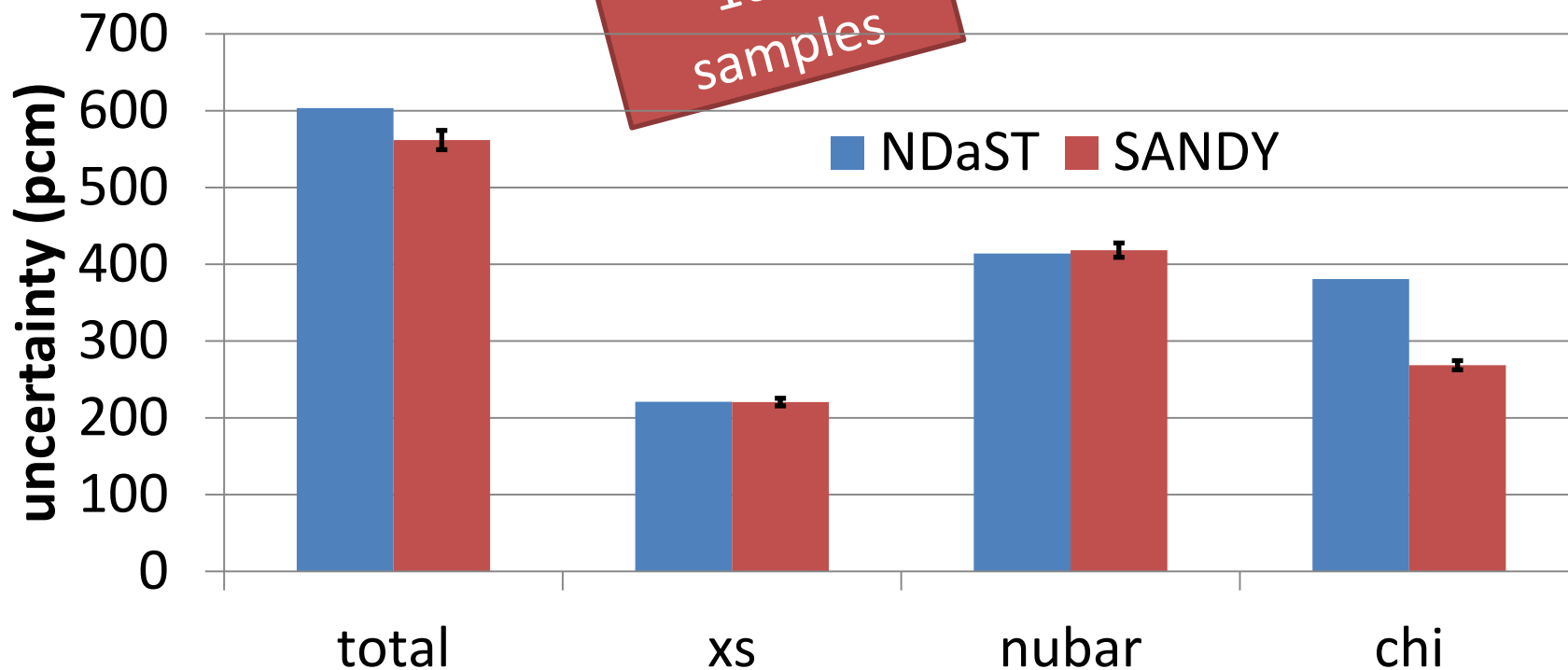
- Jezebel
- Plutonium benchmarks
- PMF6

Jezebel

- Comparison NDaST / SANDY for Pu239
- No covariances for angular distributions

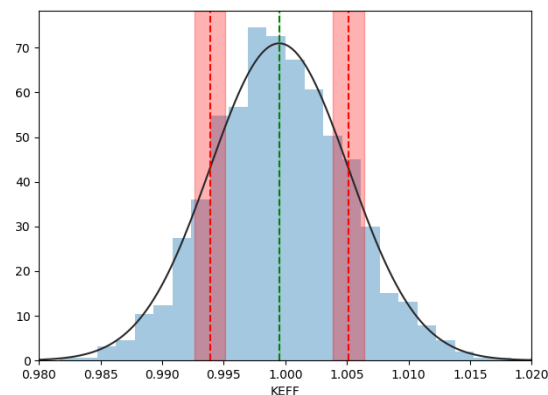


1000 samples

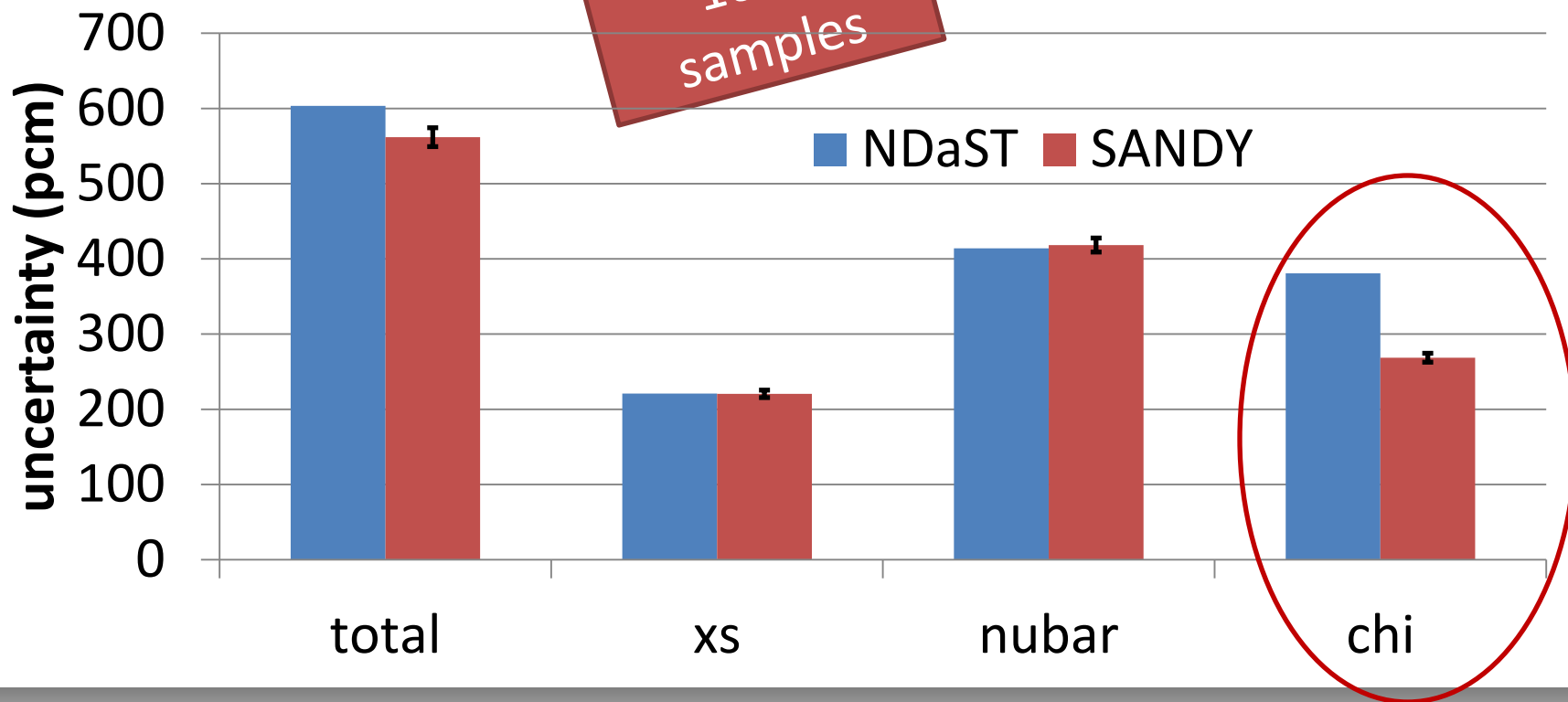


Jezebel

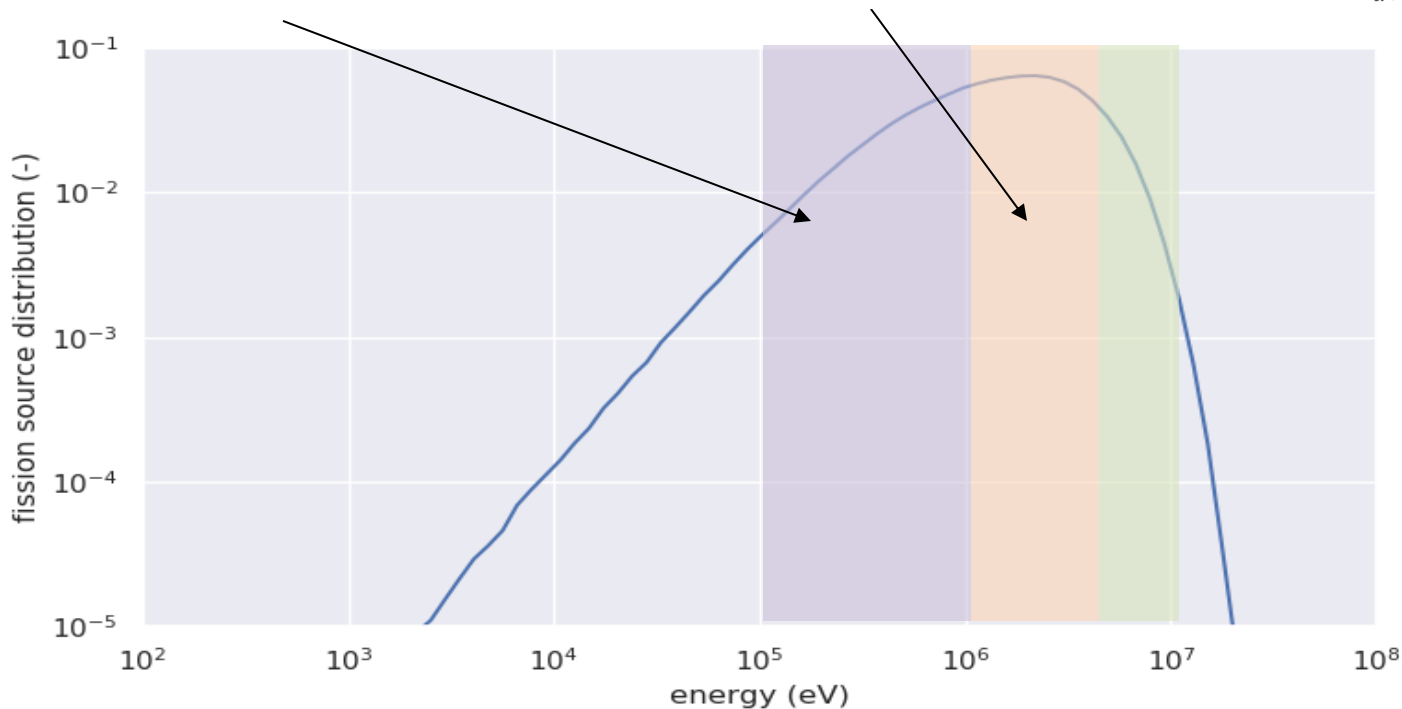
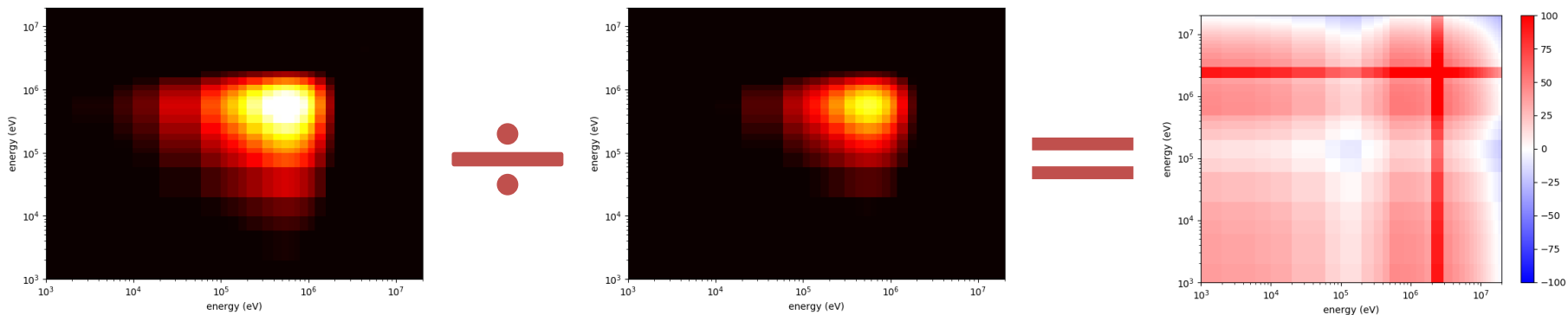
- Comparison NDaST / SANDY for Pu239
- Discrepancy for PFNS



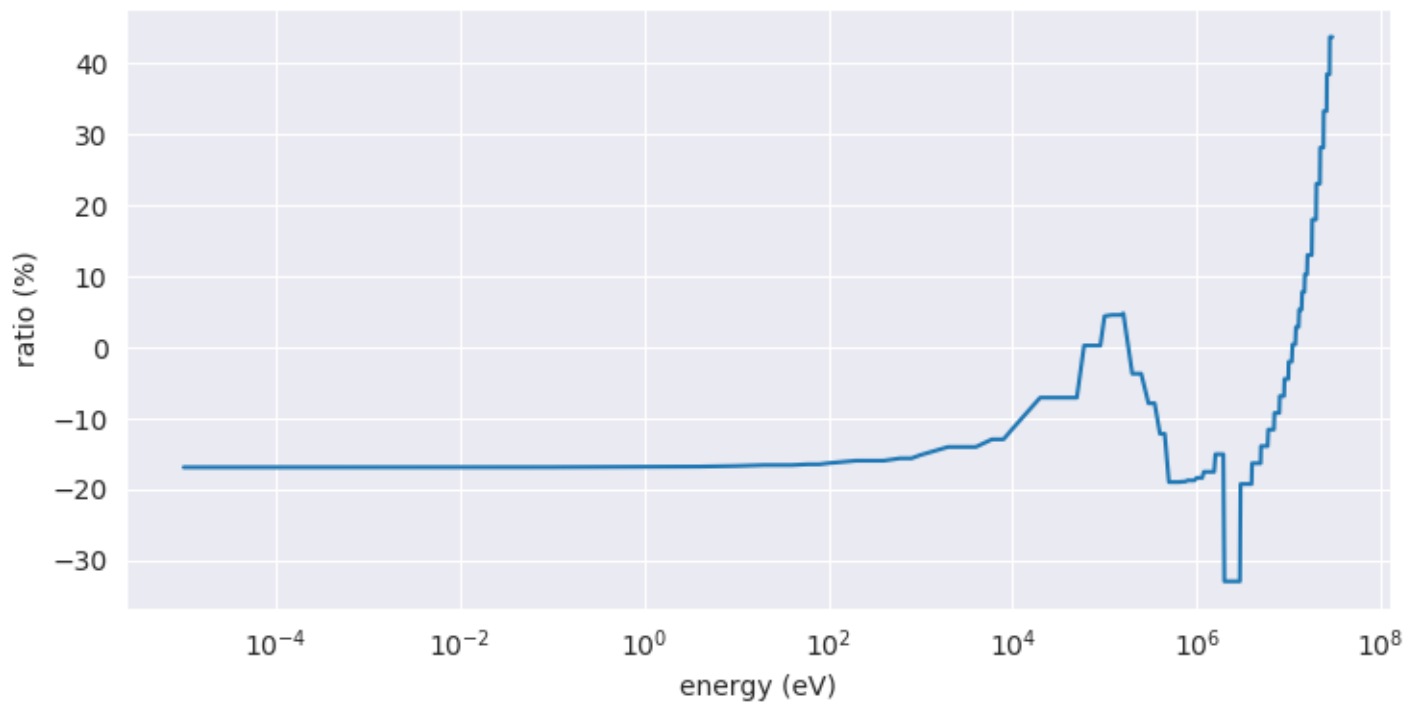
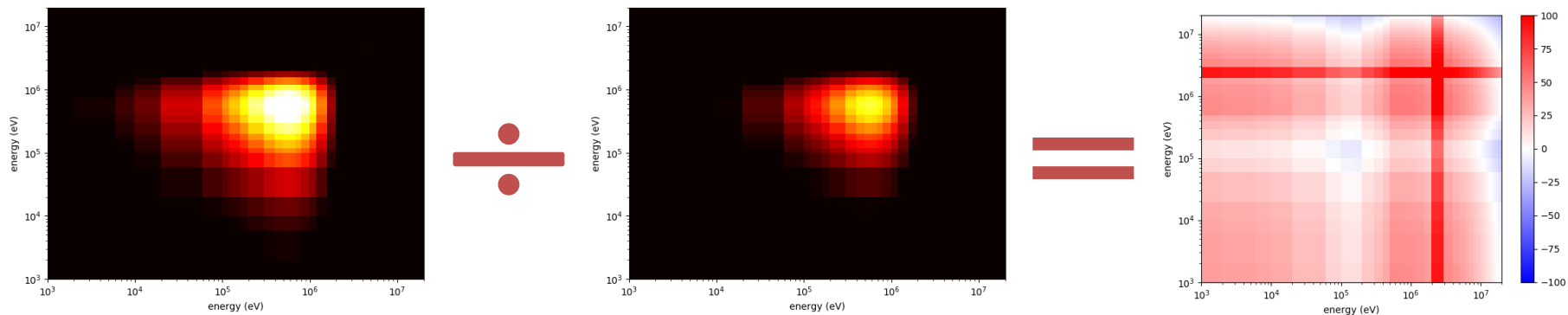
1000 samples



Different PFNS covariance matrices

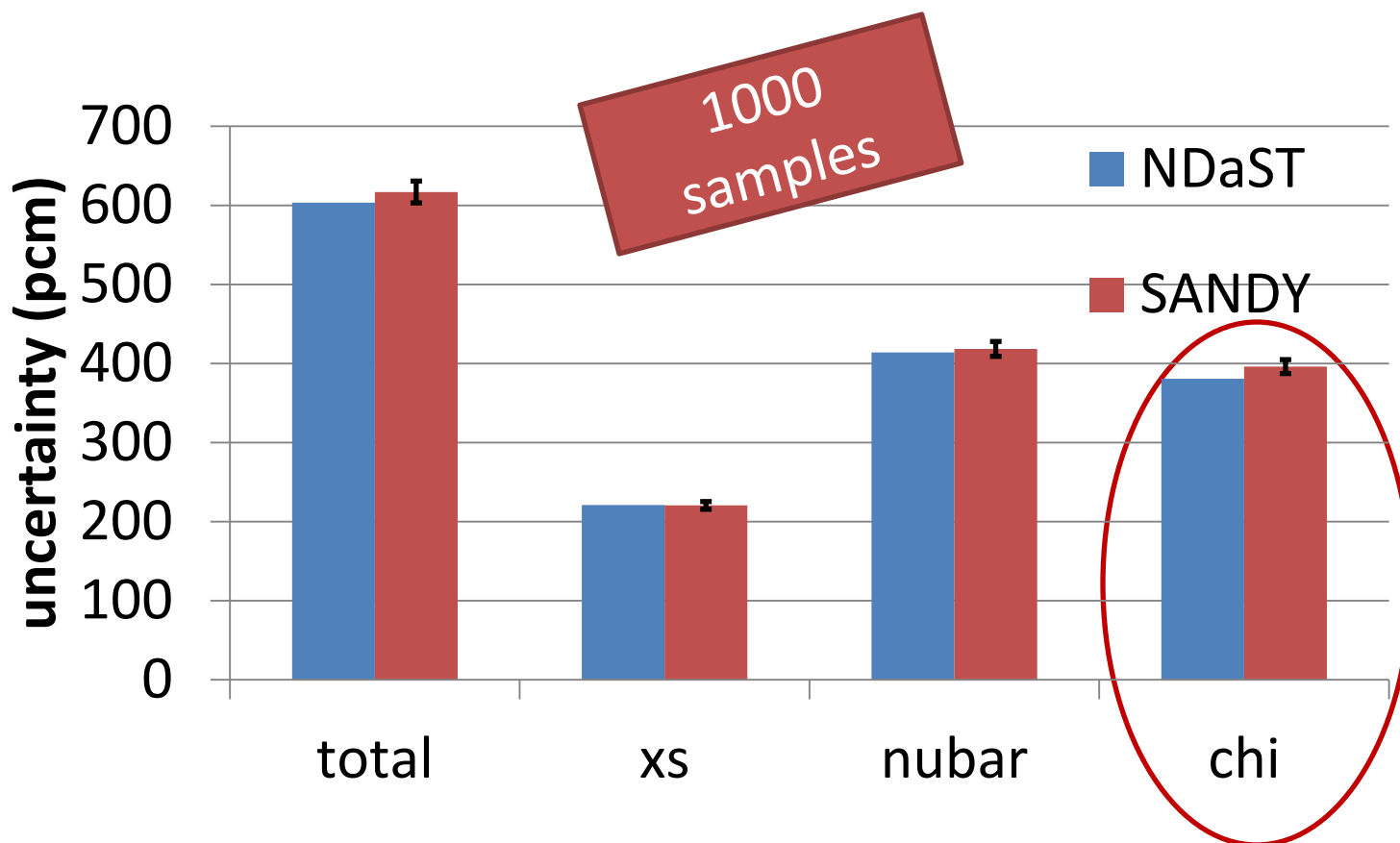


Different PFNS covariance matrices

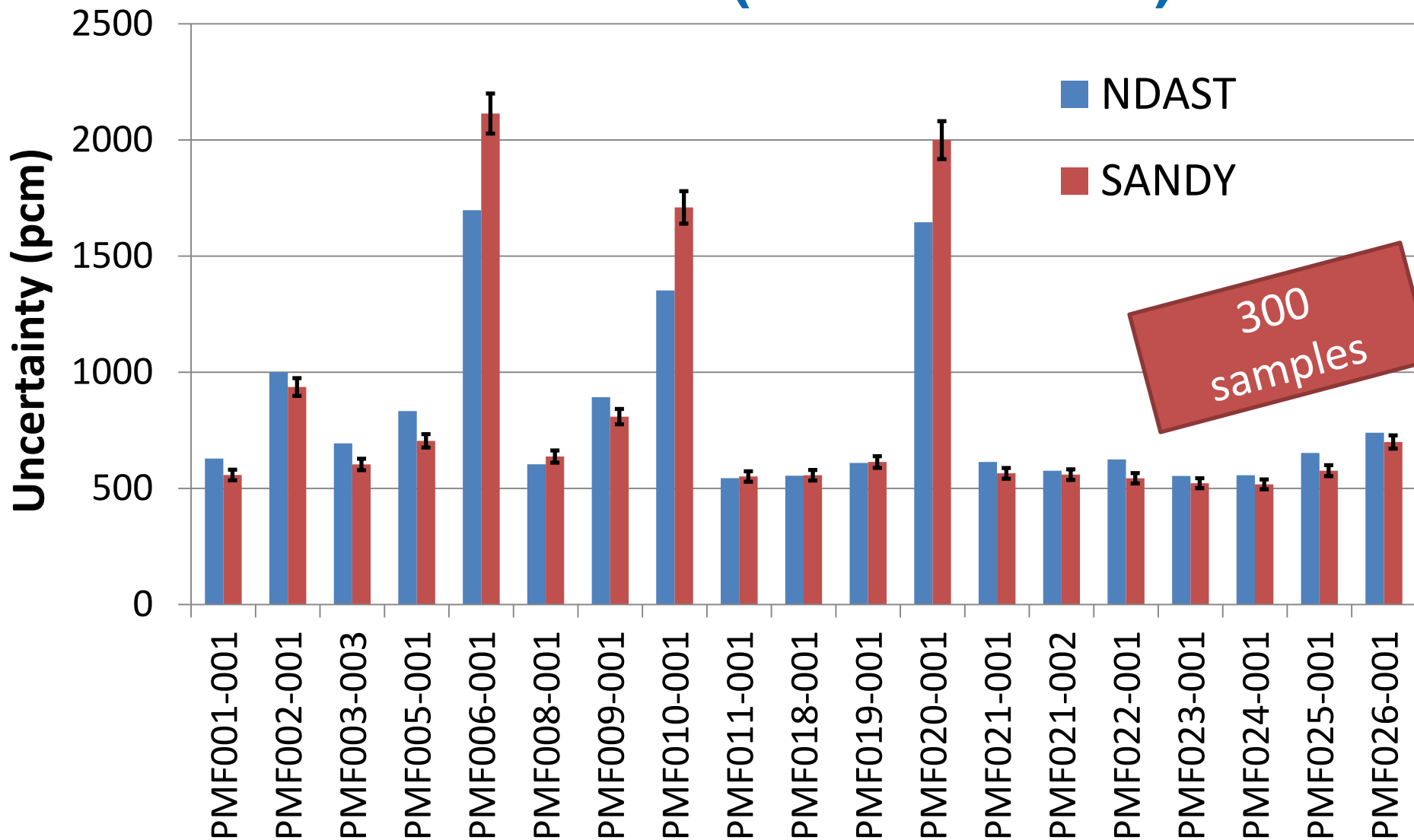


Jezebel

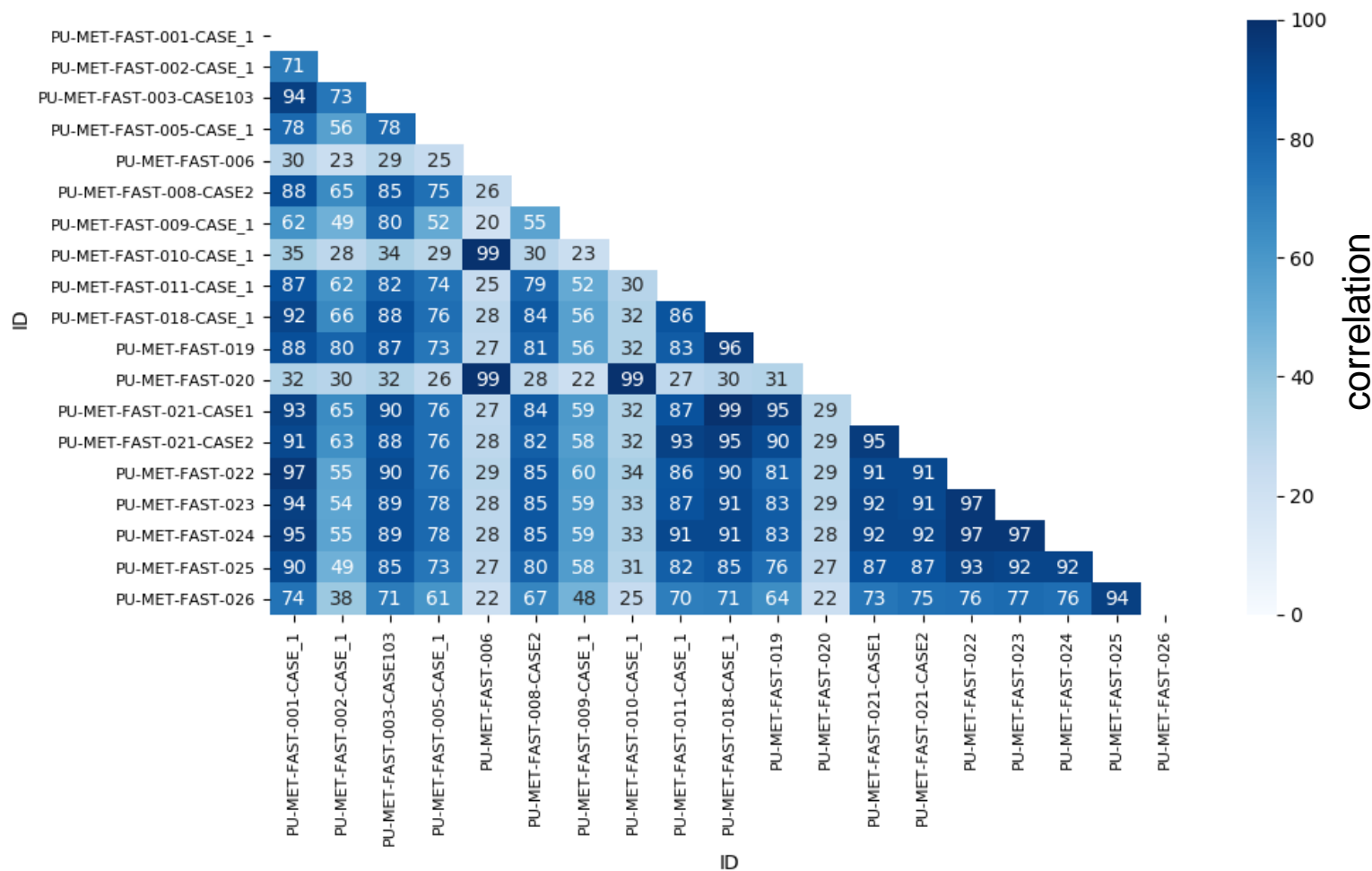
- NDaST results can be reproduced by SANDY sampling from only one covariance matrix



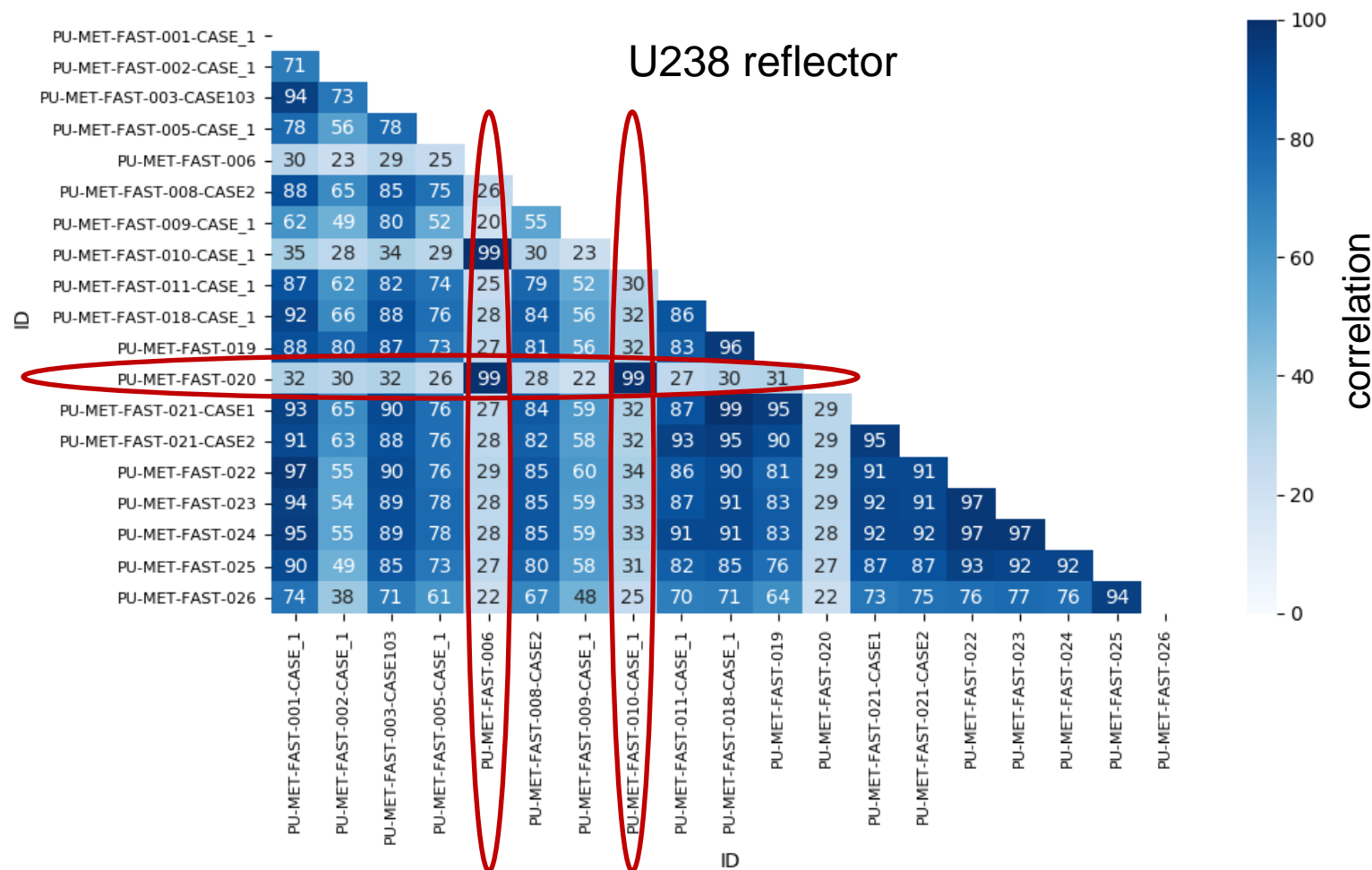
PU-MET-FAST (uncertainties)



PU-MET-FAST (correlations)

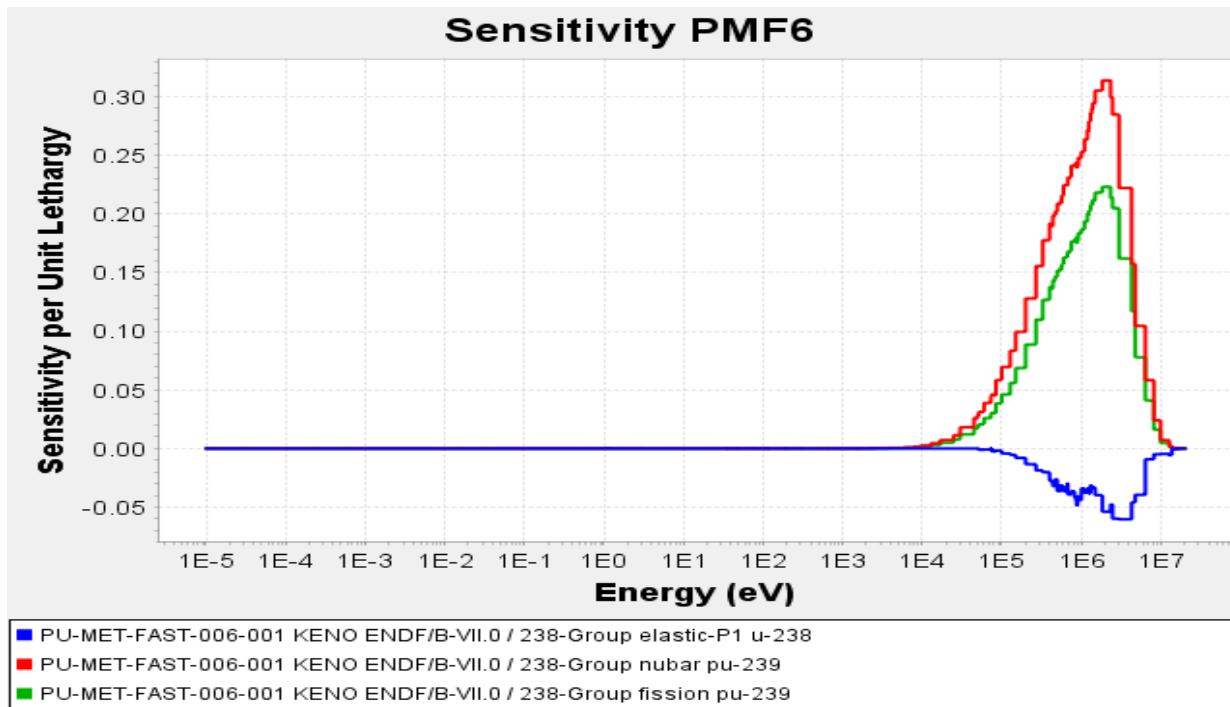
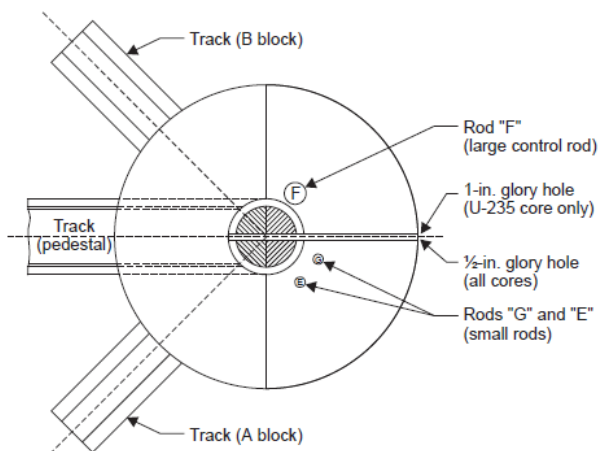


PU-MET-FAST (correlations)



Pu-Met-Fast-006

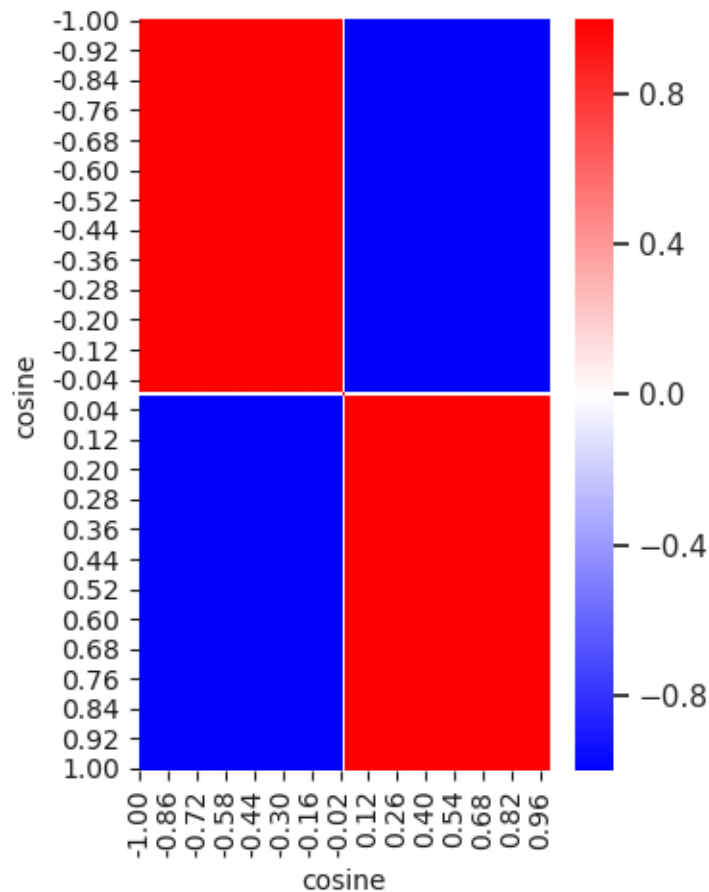
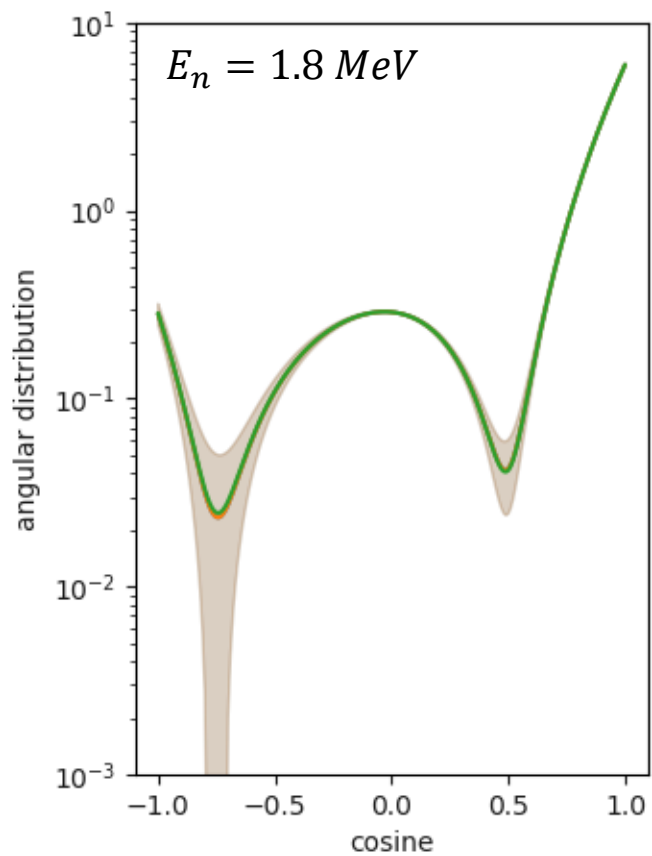
U238-reflected Pu sphere



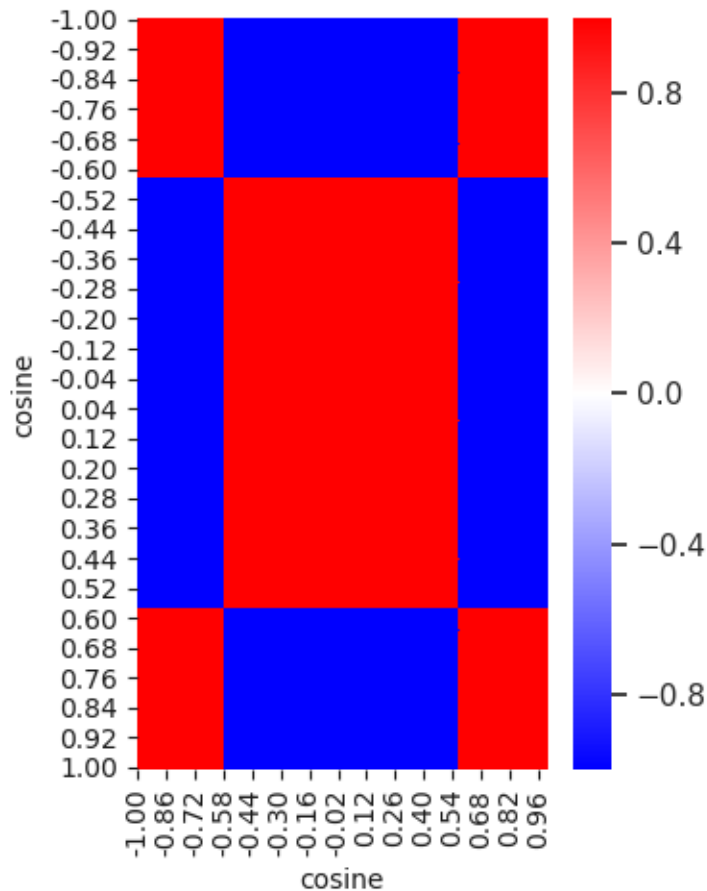
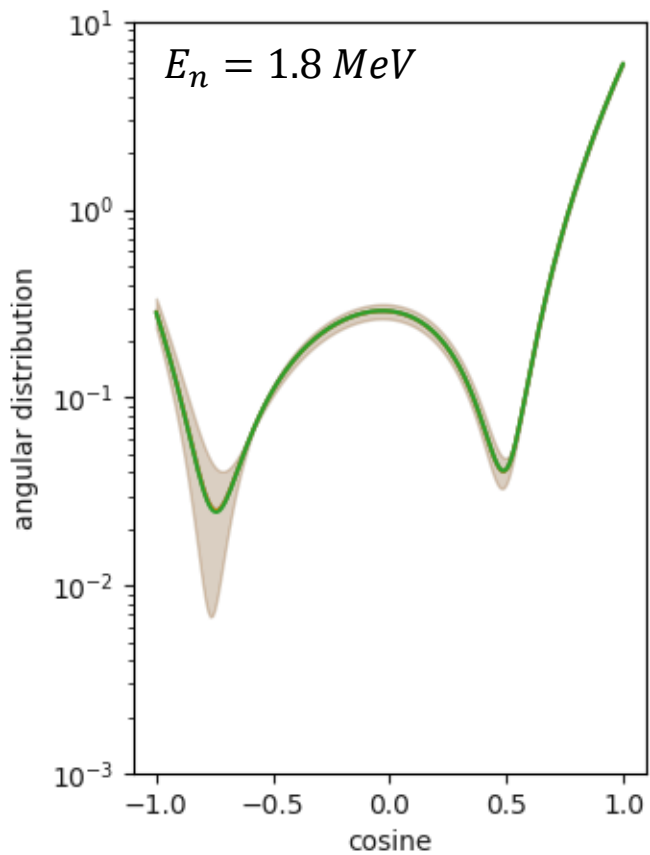
stdev SANDY = 2056 ± 555 pcm
stdev NDaST = 1382 pcm

P1 to P6
only elastic P1

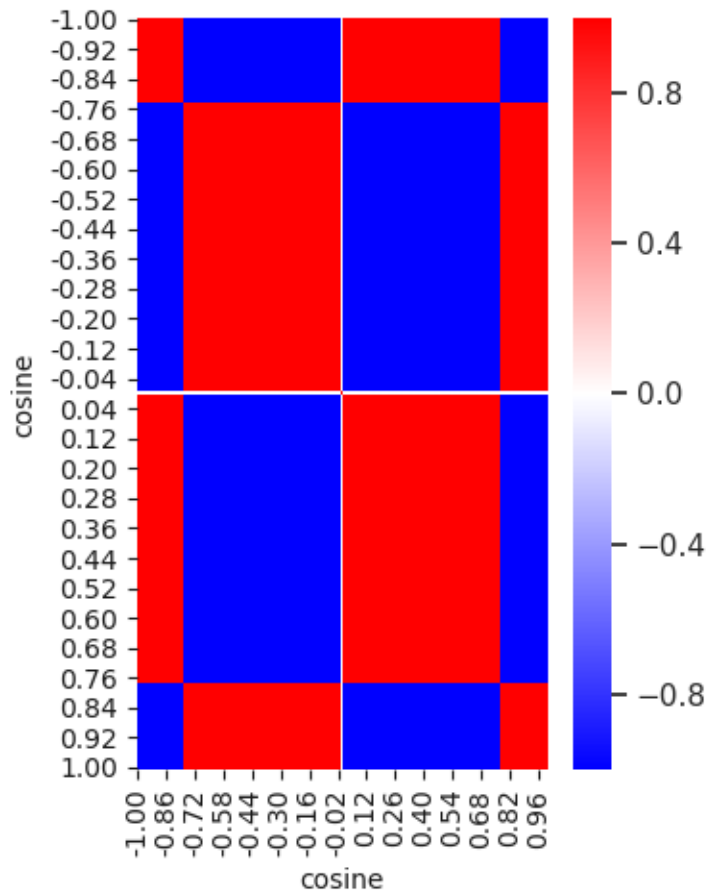
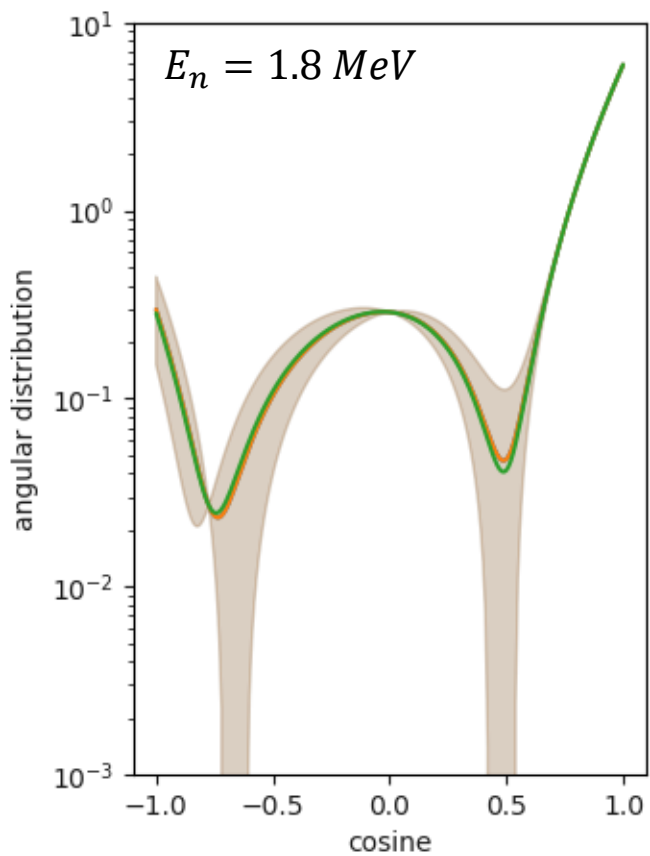
P1 covariance



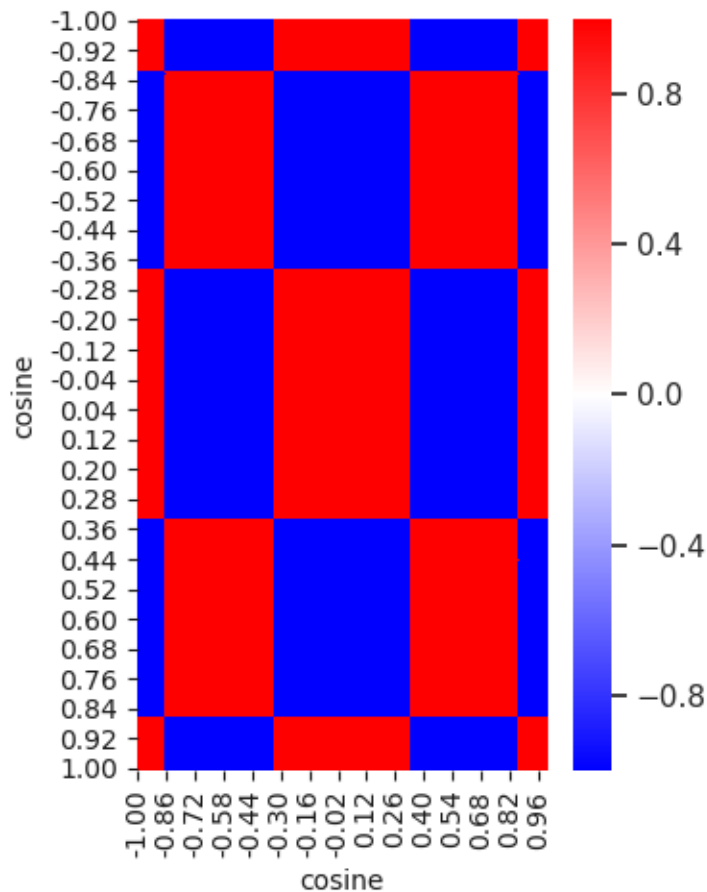
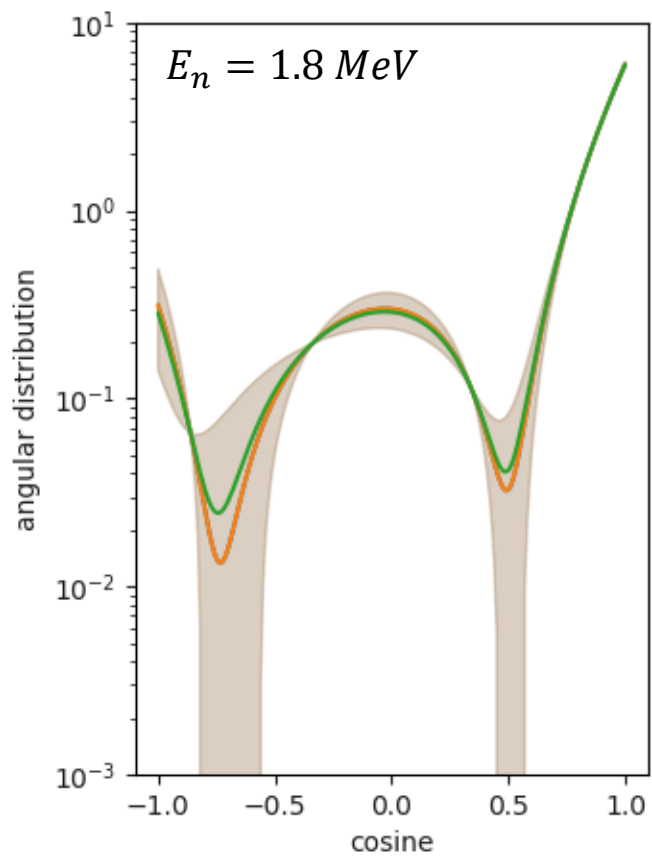
P2 covariance



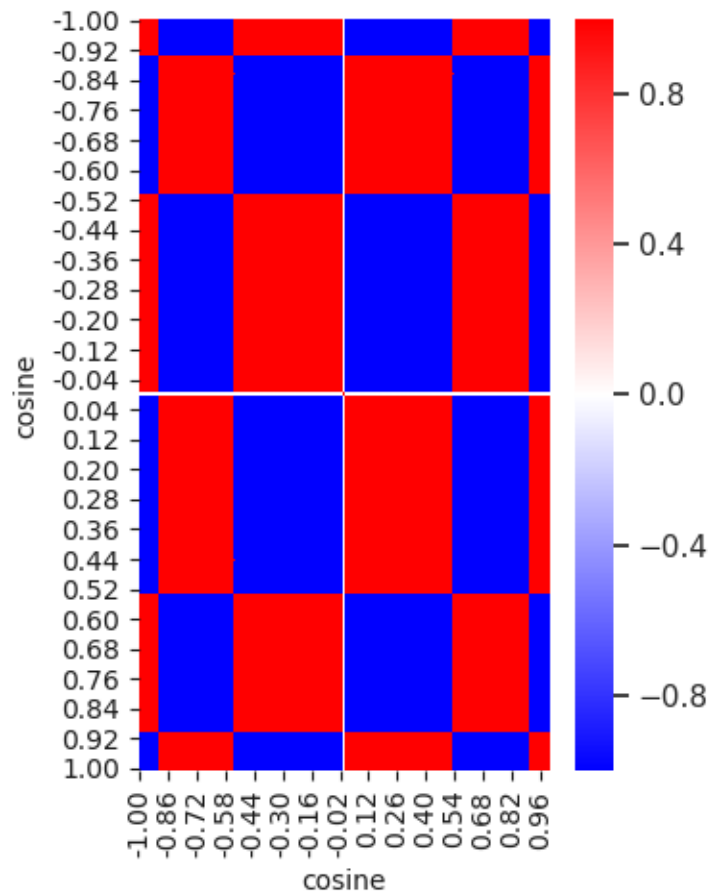
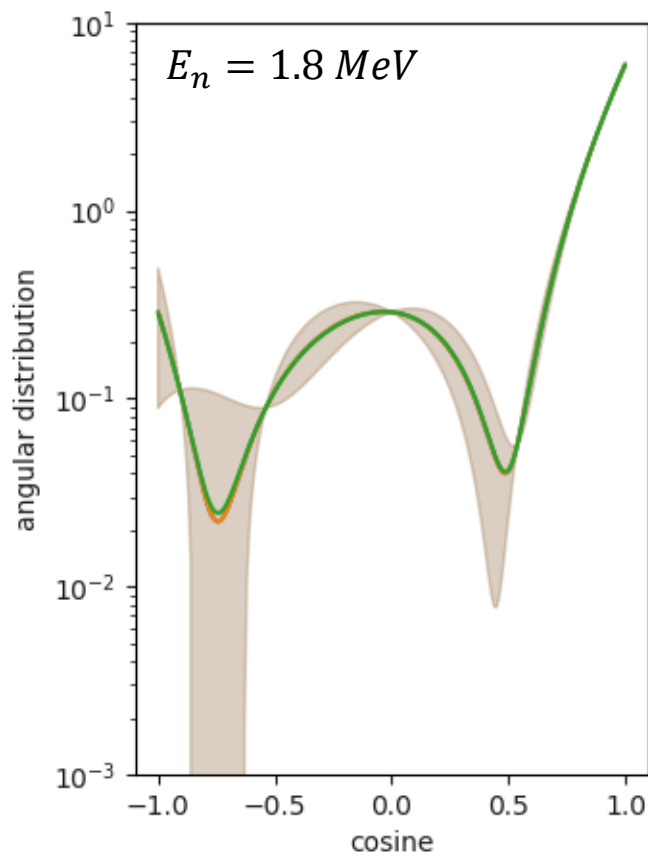
P3 covariance



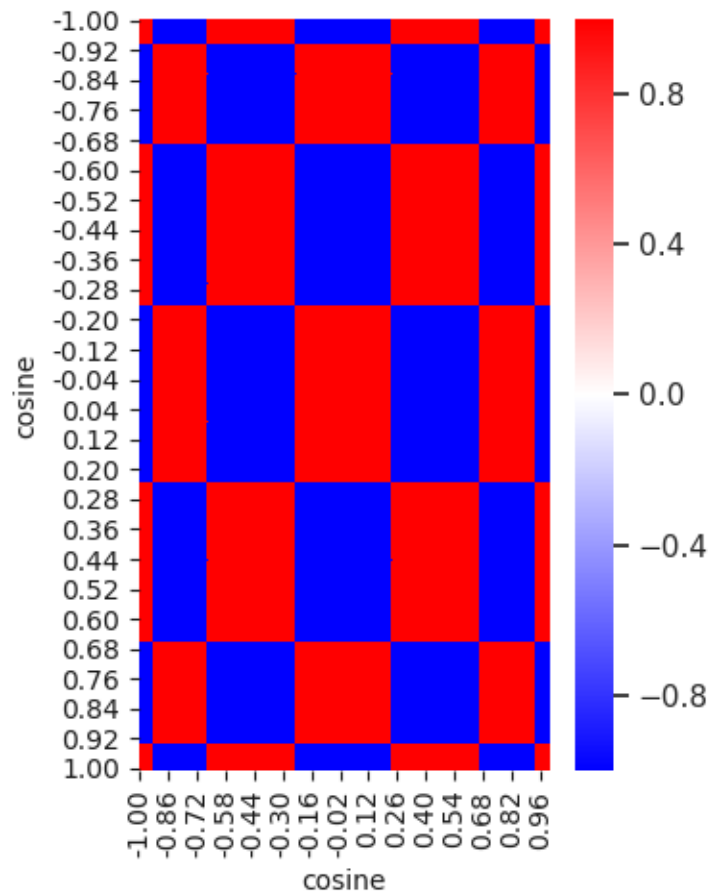
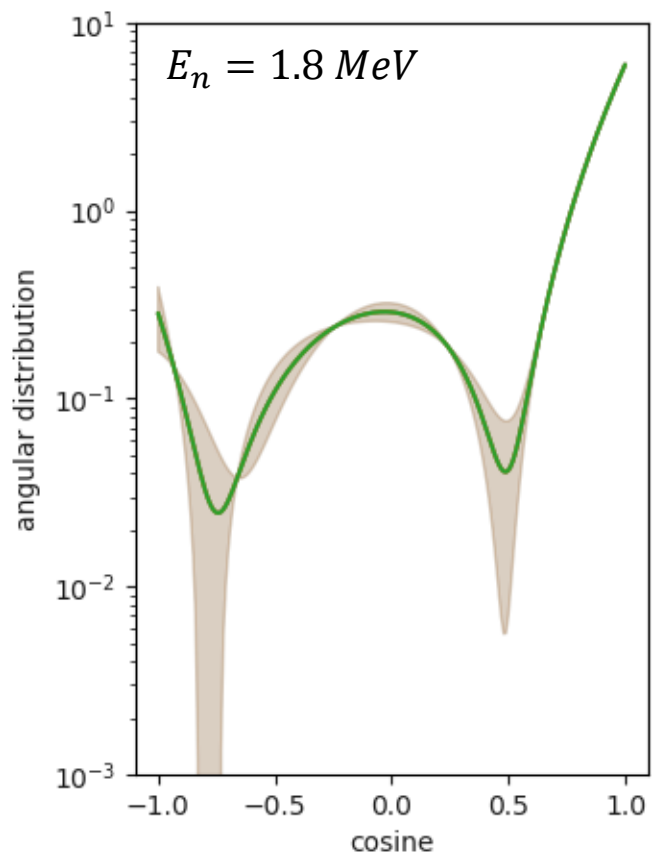
P4 covariance



P5 covariance

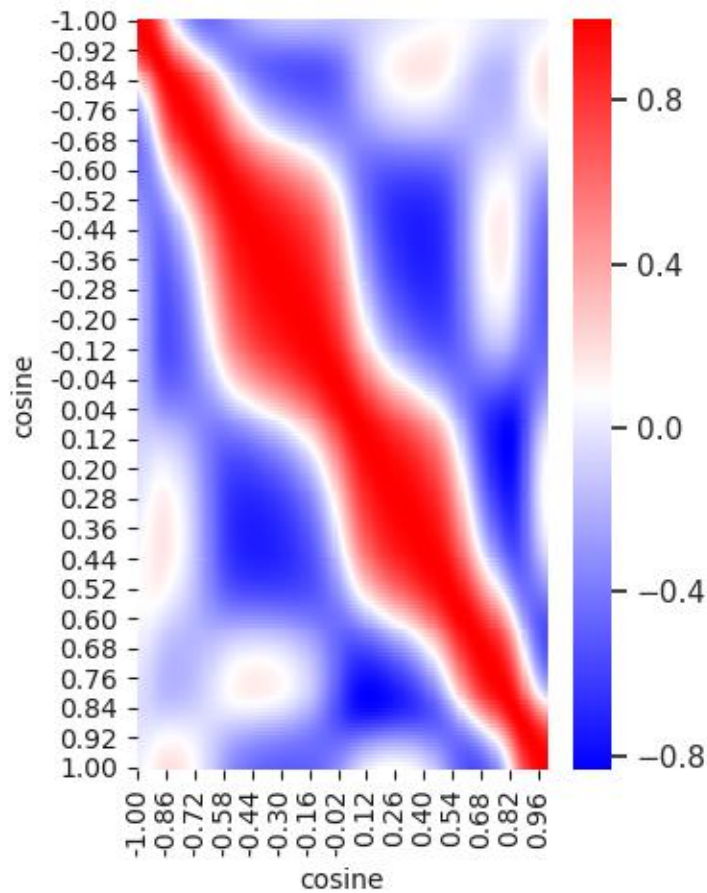
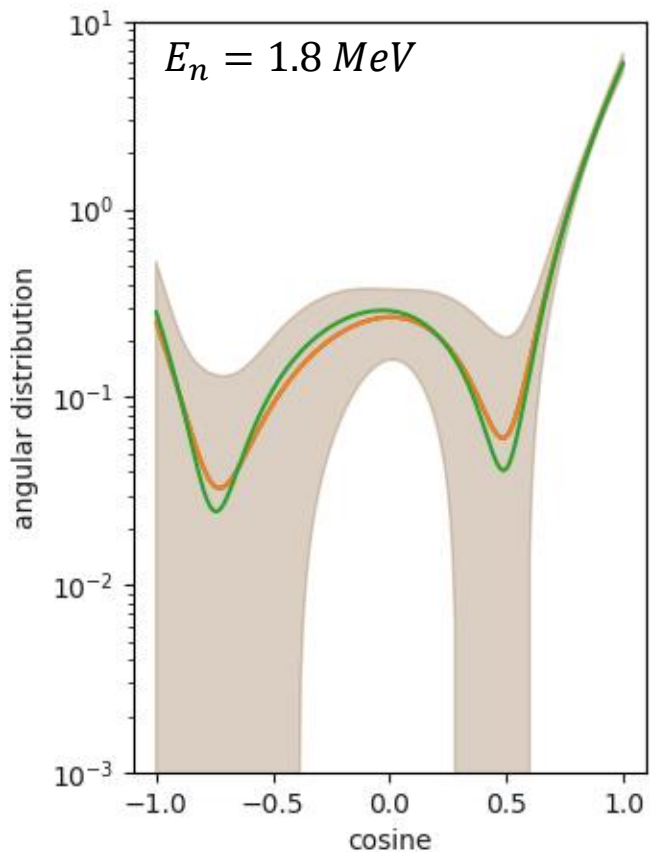


P6 covariance



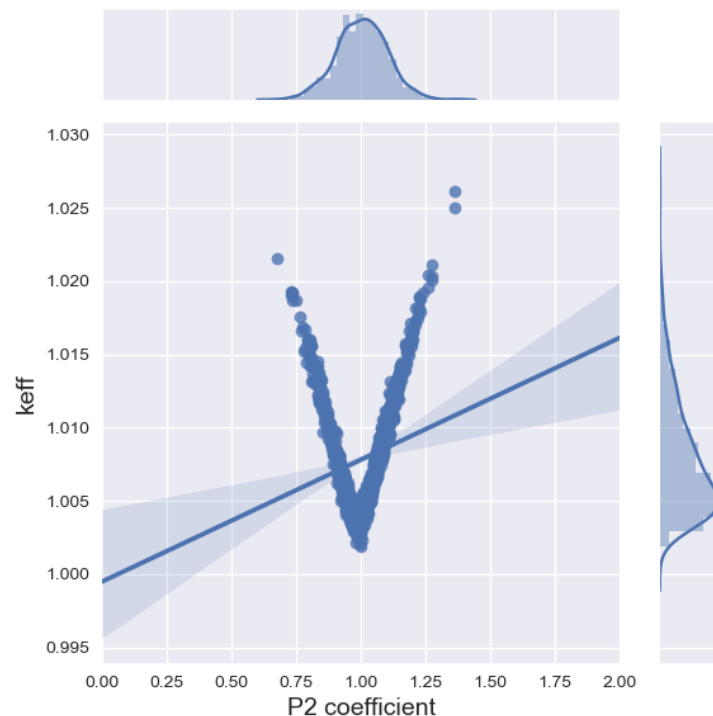
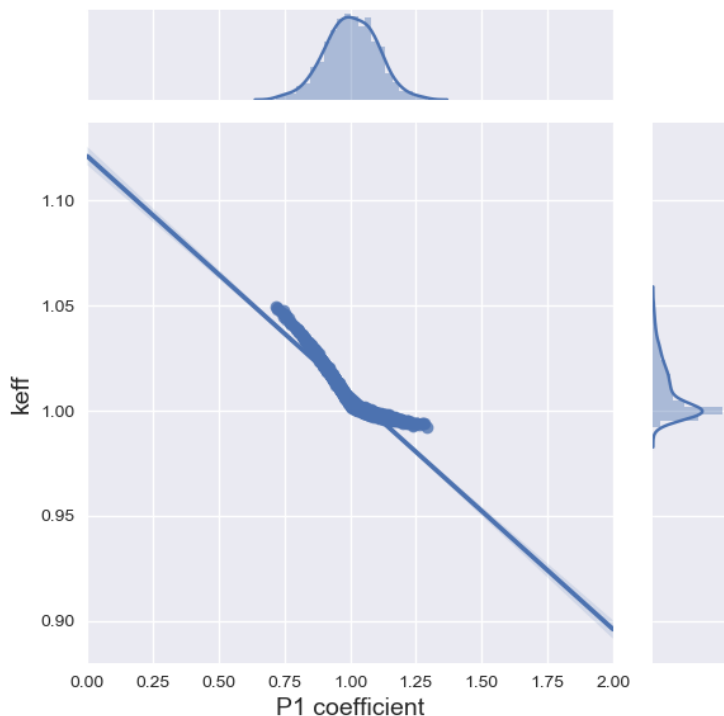
All P covariances

- NDaST results can be reproduced by SANDY sampling from only P1



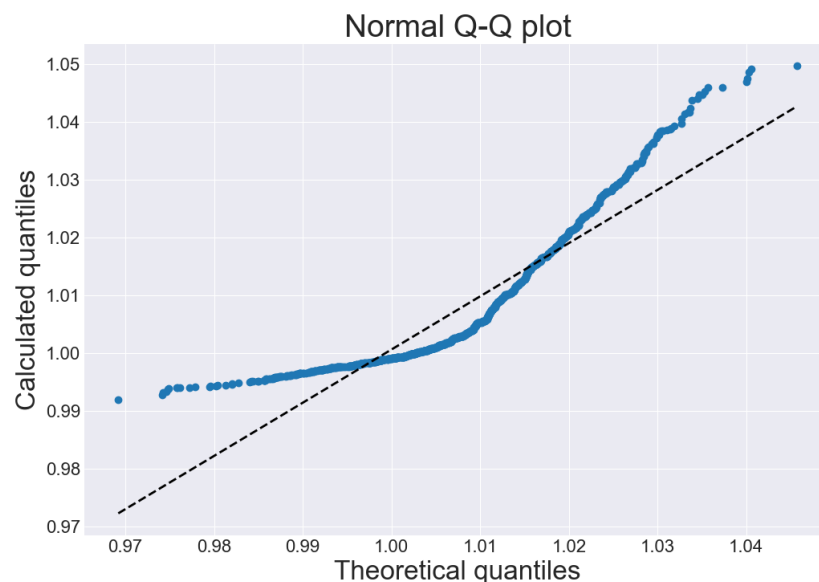
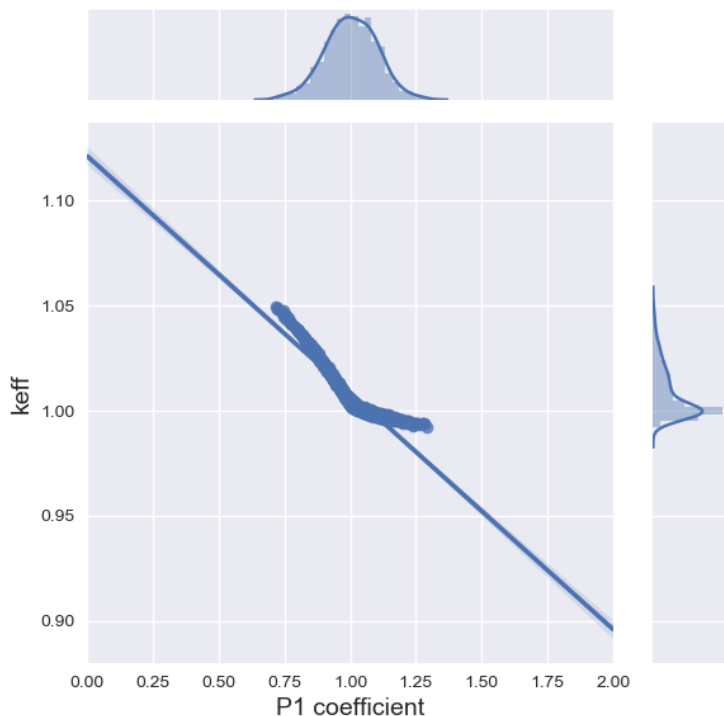
Sensitivity to P1-P2 coefficients

- ❑ 10% std dev over all neutron energies
- ❑ Strong non-linearity (mean shift, non-Normal PDF)
- ❑ Null-hypothesis of Normal distribution is rejected



Sensitivity to P1-P2 coefficients

- ❑ Strong non-linearity (mean shift, non-Normal PDF)
- ❑ Very large uncertainty
- ❑ Null-hypothesis of Normal distribution is rejected



Conclusions

- ❑ JEFF-3.3 covariances were analyzed and propagated with NDaST and SANDY+MCNP for a suite of ICSBEP cases
- ❑ SANDY validates NDaST results for PMF
- ❑ Energy distribution covariances should be weighed on the fission rate
- ❑ Covariances for $P > 1$ can be significant for systems such as PMF6
- ❑ The format for angular distribution covariances should be addressed to avoid non-physical correlations