



JEFF-3.3 covariance application to ICSBEP using SANDY and NDaST

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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







 \times

Covariances from JANIS

🏉 NDaST

File Databases Window Help

| NDaST | | | | | | | | | | | | | | | |
|----------------------|--------------------|------------|-----------|------------|--------------|-----------|----------|--------------|----------------|---------|-----------|----------------|--|--|--|
| | Search covariances | | | | | | | | | | | | | | |
| | Nuclide 1 | Reaction 1 | Nuclide 2 | Reaction 2 | JANIS refs | | | 0 | | | | | | | |
| Constitution | Pu239 | CHI | Pu239 | CHI | JEFF-3.3~N~J | | | C | orrelation | | | | | | |
| 35 benchmarks | Pu239 | NUBAR | Pu239 | NUBAR | JEFF-3.3~N~J | | | | | | | | | | |
| 41 profiles | Pu239 | N ALPHA | Pu239 | N ALPHA | JEFF-3.3~N~J | 10 µeV | 1 meV 1 | 00 meV 10 eV | 1 keV | 100 keV | 10 MeV | | | | |
| | Pu239 | N P | Pu239 | N P | JEFF-3.3~N~J | | | | | | | 1 | | | |
| | Pu239 | N_P | Pu239 | N_ALPHA | JEFF-3.3~N~J | 1 MeV — | | | | | —1 MeV | - | | | |
| | Pu239 | N_GAMMA | Pu239 | N_GAMMA | JEFF-3.3~N~J | ω | | | | | | - | | | |
| | Pu239 | N_GAMMA | Pu239 | N_P | JEFF-3.3~N~J | 10 keV- | | | | | — 10 keV | - 0.4 | | | |
| | Pu239 | N_GAMMA | Pu239 | N_ALPHA | JEFF-3.3~N~J | Σ | | | | | | | | | |
| | Pu239 | FISSION | Pu239 | FISSION | JEFF-3.3~N~J | 100 eV− | | | | | -100 eV | - 0 | | | |
| | Pu239 | FISSION | Pu239 | N_GAMMA | JEFF-3.3~N~J | 14 | | | | | | | | | |
| | Pu239 | FISSION | Pu239 | N_P | JEFF-3.3~N~J | 00 1eV− | | | | | -1 eV | | | | |
| Perturbations | Pu239 | FISSION | Pu239 | N_ALPHA | JEFF-3.3~N~J | ¥ | | | | | | | | | |
| | Pu239 | N_2N | Pu239 | N_2N | JEFF-3.3~N~J | < 10 meV- | | | | | -10 meV | 0.6 | | | |
| | Pu239 | N_2N | Pu239 | FISSION | JEFF-3.3~N~J | | | | | | | | | | |
| | Pu239 | N_2N | Pu239 | N_GAMMA | JEFF-3.3~N~J | 100 µeV | | | | | - 100 µe\ | -1 | | | |
| | Pu239 | N_2N | Pu239 | N_P | JEFF-3.3~N~J | | | | 1 1 | | | | | | |
| | Pu239 | N_2N | Pu239 | N_ALPHA | JEFF-3.3~N~J | 10 µeV | 1 meV 1 | 00 meV 10 eV | 1 keV | 100 keV | 10 MeV | | | | |
| | Pu239 | INELASTIC | Pu239 | INELASTIC | JEFF-3.3~N~J | | | MA. | T 9437 MT 18 | | | | | | |
| | Pu239 | INELASTIC | Pu239 | N_2N | JEFF-3.3~N~J | × | | MA | 1 5467, 101 10 | • | | | | | |
| Coursiances | Rel, std dev | 4 | | | | | | | | | | | | | |
| 38 matrices | (a) filled | | | | | | | | | | | | | | |
| 50 marrices | (Inicu | 3 | | | | | | | | | | | | | |
| | 🔵 outline | 2 | | | | | | | | | | | | | |
| | | 2 | | | | | | | | | | | | | |
| | Perturbations | 1 | | | | | | | | | | | | | |
| | 🗹 display | . | | | | | | | | | | | | | |
| | solid | ~ 0 | | | | | _ | | | | | | | | |
| | 0 | -1 | | | | | | | | | | Pu239,FISSION> | | | |
| | density | | | | | | | | | | | | | | |
| | | -2 | | | | | | | | | | | | | |
| GO! | | 3 | | | | | | | | | | | | | |
| | | -0 | | | | | | | | | | | | | |
| | | -4 | | | | | | | | | | | | | |
| | | | 1E-5 1E | E-4 1E-3 | 1E-2 1E | -1 1E0 1 | E1 1E2 | 1E3 1E | 4 1E5 | 1E6 | 1E7 | | | | |
| | | | | | | Ene | rgy (eV) | | | | | | | | |
| 37 covariance matric | ces added | | | | | | | | | | | 515M of 715M | | | |
| | | | | | | | | | | | | | | | |





Covariances from JANIS

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File Databases Window Help

NDaST







SANDY

Production of *perturbed* files for brute force uncertainty propagation

- Data and covariances from JEFF-3.3
- Calculations run with MNCP







Comparison NDaST / SANDY

- Mosteller's suite
 - Jezebel
 - Plutonium benchmarks
 - D PMF6













FCD



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)





BETTER POLICIES FOR BETTER LIVES

PU-MET-FAST (correlations)

| | | | | | | | | | | | | | | | | | | | | | - 1 | 00 | |
|---|---------------------------|----------|----------|-----|----------|-----|----|-----|----------|------|----------|-----|-----|----------|----|-----|-----|-----|-----|-----|-----|----|----|
| | PU-MET-FAST-001-CASE_1 - | | | | | | | | | | | | | | | | | | | | - | | |
| | PU-MET-FAST-002-CASE_1 - | 71 | | | | | | | | | | | | | | | | | | | | | |
| | PU-MET-FAST-003-CASE103 - | 94 | 73 | | _ | | | | | | | | | | | | | | | | | | |
| | PU-MET-FAST-005-CASE_1 - | 78 | 56 | 78 | | | | | | | | | | | | | | | | | - 8 | 0 | |
| | PU-MET-FAST-006 - | - 30 | 23 | 29 | 25 | | | | | | | | | | | | | | | | | - | |
| | PU-MET-FAST-008-CASE2 - | 88 | 65 | 85 | 75 | 26 | | | | | | | | | | | | | | | | | |
| | PU-MET-FAST-009-CASE_1 - | 62 | 49 | 80 | 52 | 20 | 55 | | | | | | | | | | | | | | | | _ |
| | PU-MET-FAST-010-CASE_1 - | 35 | 28 | 34 | 29 | 99 | 30 | 23 | | | | | | | | | | | | | - 6 | 0 | 5 |
| | PU-MET-FAST-011-CASE_1 - | 87 | 62 | 82 | 74 | 25 | 79 | 52 | 30 | | | | | | | | | | | | | | Ĕ |
| ₽ | PU-MET-FAST-018-CASE_1 - | 92 | 66 | 88 | 76 | 28 | 84 | 56 | 32 | 86 | | | | | | | | | | | | | |
| | PU-MET-FAST-019 - | 88 | 80 | 87 | 73 | 27 | 81 | 56 | 32 | 83 | 96 | | | | | | | | | | | | Ъ. |
| | PU-MET-FAST-020 - | 32 | 30 | 32 | 26 | 99 | 28 | 22 | 99 | 27 | 30 | 31 | | | | | | | | | - 4 | 10 | õ |
| | PU-MET-FAST-021-CASE1 - | 93 | 65 | 90 | 76 | 27 | 84 | 59 | 32 | 87 | 99 | 95 | 29 | | | | | | | | | | S |
| | PU-MET-FAST-021-CASE2 - | 91 | 63 | 88 | 76 | 28 | 82 | 58 | 32 | 93 | 95 | 90 | 29 | 95 | | | | | | | | | |
| | PU-MET-FAST-022 - | 97 | 55 | 90 | 76 | 29 | 85 | 60 | 34 | 86 | 90 | 81 | 29 | 91 | 91 | | | | | | | | |
| | PU-MET-FAST-023 - | 94 | 54 | 89 | 78 | 28 | 85 | 59 | 33 | 87 | 91 | 83 | 29 | 92 | 91 | 97 | | | | | - 2 | 0 | |
| | PU-MET-FAST-024 - | 95 | 55 | 89 | 78 | 28 | 85 | 59 | 33 | 91 | 91 | 83 | 28 | 92 | 92 | 97 | 97 | | | | | | |
| | PU-MET-FAST-025 - | 90 | 49 | 85 | 73 | 27 | 80 | 58 | 31 | 82 | 85 | 76 | 27 | 87 | 87 | 93 | 92 | 92 | | | | | |
| | PU-MET-FAST-026 - | 74 | 38 | 71 | 61 | 22 | 67 | 48 | 25 | 70 | 71 | 64 | 22 | 73 | 75 | 76 | 77 | 76 | 94 | | | | |
| | | | | - | | 1 | - | | 1 | | | | | <u>'</u> | - | | - | | | | - (|) | |
| | | <u> </u> | <u> </u> | 10 | <u> </u> | 00 | SE | Ľ, | <u> </u> | Ľ, | <u> </u> | 010 | 020 | SE | S | 022 | 023 | 027 | 025 | 026 | | | |
| | | SAS | SAS | SE | CAS | st. | Ą | SAS | SAS | CAS | CAS | st. | st. | Ą | Ą | st. | st. | st. | st. | st. | | | |
| | | 1-0 | 5-0 | Ą | 5 | FΑ | 8 | 6 | 9 | Ľ | 8 | FA- | FA- | 21 | 21 | FA. | FA. | FA- | FA | FA- | | | |
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BETTER POLICIES FOR BETTER LIVES

PU-MET-FAST (correlations)

| | | | | | | | | | | | | | | | | | | | | | | 100 | |
|---|---------------------------|------|------|--------|------|--------|------|------|----------|------|------|------|-----------|------|------|------|--------|------|------|--------|---|-----|----|
| | PU-MET-FAST-001-CASE_1 - | | | | | | | | | | 0 | | _ | 1 | | | | | | | | 100 | |
| | PU-MET-FAST-002-CASE_1 - | 71 | | | | | | | U | 23 | 1 8 | eti | ec | tor | | | | | | | | | |
| | PU-MET-FAST-003-CASE103 - | 94 | 73 | | | | | | | | | | | | | | | | | | | | |
| | PU-MET-FAST-005-CASE_1 - | 78 | 56 | 78 | | Λ | | | Λ | | | | | | | | | | | | - | 80 | |
| | PU-MET-FAST-006 - | - 30 | 23 | 29 | 25 | | | | Π | | | | | | | | | | | | | | |
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| | PU-MET-FAST-011-CASE_1 - | 87 | 62 | 82 | 74 | 25 | 79 | 52 | 30 | | | | | | | | | | | | | | Ę |
| ₽ | PU-MET-FAST-018-CASE_1 - | 92 | 66 | 88 | 76 | 28 | 84 | 56 | 32 | 86 | | | | | | | | | | | | | |
| | PU-MET-FAST-019 - | 88 | 80 | 87 | 73 | 27 | 81 | 56 | 32 | 83 | 96 | | | | | | | | | | | | Ð. |
| < | PU-MET-FAST-020 - | 32 | 30 | 32 | 26 | 99 | 28 | 22 | 99 | 27 | 30 | 31 | \supset | > | | | | | | | - | 40 | õ |
| | PU-MET-FAST-021-CASE1 - | 93 | 65 | 90 | 76 | 27 | 84 | 59 | 32 | 87 | 99 | 95 | 29 | | | | | | | | | | 0 |
| | PU-MET-FAST-021-CASE2 - | 91 | 63 | 88 | 76 | 28 | 82 | 58 | 32 | 93 | 95 | 90 | 29 | 95 | | | | | | | | | |
| | PU-MET-FAST-022 - | 97 | 55 | 90 | 76 | 29 | 85 | 60 | 34 | 86 | 90 | 81 | 29 | 91 | 91 | | | | | | | | |
| | PU-MET-FAST-023 - | 94 | 54 | 89 | 78 | 28 | 85 | 59 | 33 | 87 | 91 | 83 | 29 | 92 | 91 | 97 | | | | | - | 20 | |
| | PU-MET-FAST-024 - | 95 | 55 | 89 | 78 | 28 | 85 | 59 | 33 | 91 | 91 | 83 | 28 | 92 | 92 | 97 | 97 | | | | | | |
| | PU-MET-FAST-025 - | 90 | 49 | 85 | 73 | 27 | 80 | 58 | 31 | 82 | 85 | 76 | 27 | 87 | 87 | 93 | 92 | 92 | | | | | |
| | PU-MET-FAST-026 - | 74 | 38 | 71 | 61 | 22 | 67 | 48 | 25 | 70 | 71 | 64 | 22 | 73 | 75 | 76 | 77 | 76 | 94 | | | ~ | |
| | | - | 1 - | - m | - | - 9 | 2 - | 1 - | <u>'</u> | - 1 | - 1 | - 6 | | | 2 - | 2 - | n m | 4 | 5 | י פ | - | 0 | |
| | | SE | SE | EIO | SE | 0- | ASE | SE, | SE | SE | SE | -01 | -02 | ASE | ASE | T-02 | T-02 | L-02 | 7-02 | -02 | | | |
| | | L-CA | 5-CA | CAS | 5-CA | -AST | 0-6 | P-CA | -CA | L-CA | S-CA | -AST | -AST | 1-0 | 1-0 | -AST | -AST | -AST | -AST | -AST | | | |
| | | 00- | 00- | 03- | 00- | Ē | 1-00 | 00- | -010 | -010 | -018 | ET-1 | ET-I | T-02 | T-02 | ET- | Ē | ET- | ET-1 | ET-1 | | | |
| | | AST | AST | ST-0 | AST | Μ'n | FAS | AST | AST | AST | AST | M-U | M-U | FAS | FAS | M-U | M-U | M-U | M-U | M-U | | | |
| | | ET-F | ET-F | L-FA | ET-F | 1 | ŢŢ. | ET-F | Ë | ET-F | ET-F | ш | ш. | ſĒŢ. | ſET. | ш | ш | ш | ш | ш | | | |
| | | M-U | M-U | ĀĒ | M-U | | PN | M-U | Ψ-n | M-U | M-U | | | PN- | PL-P | | | | | | | | |
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Pu-Met-Fast-006

U238-reflected Pu sphere







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







Nuclear Energy Agency 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