

SG50: Data Formats for the URR and Covariance

Jesse Brown[†]

Yaron Danon^{*}

Klaus Guber[†]

Marco Pigni[†]

[†] Oak Ridge National Laboratory

^{*} Rensselaer Polytechnic Institute

ORNL is managed by UT-Battelle, LLC
for the US Department of Energy



U.S. DEPARTMENT OF
ENERGY

Main Priorities

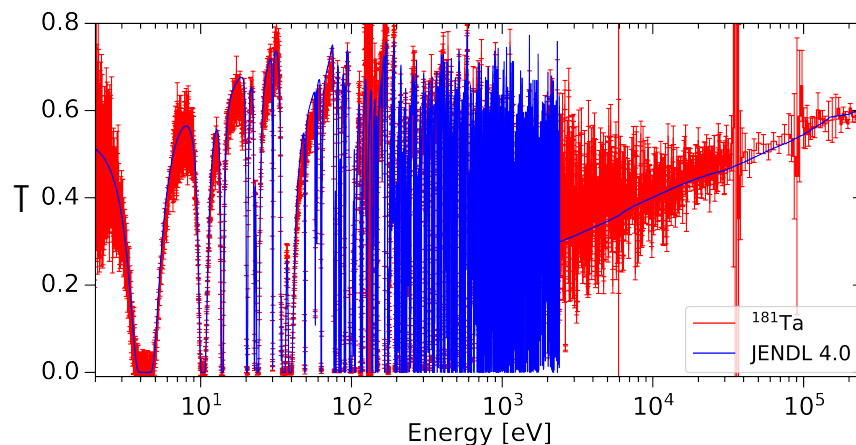
- Reproducibility
 - Experimental data and uncertainties/correlations
 - Raw (e.g. count rate) -> Reduced data (T, Y, SI, σ_x , etc.)
 - Strict QA
 - Procedure/algorithm used for reduction
 - Publication accessible and/or detail data reduction?
 - Good example: AGS Manual
 - Bad example: Harvey's Ta T data (U-238 pub.)
- Machine readable and standardized
- Covariance
- AMARA (As Much As Reasonably Achievable)

Differential URR measurement

- Raw
 - $T: \frac{C_S - B_S}{C_O - B_O}$
 - $Y: \eta \frac{C - B}{\phi}$
 - $Sl, \sigma_t(E), \sigma_\gamma(E), \text{ etc.}$
- Variance & Covariance
- Low statistical error (Obvious)
- High resolution (Less obvious)
- Absolute measu. preferable (to ratio w.r.t. known) (very difficult, gray area)

Additional URR data

- Maxwellian Averaged Cross Sections (MACS)
- Strength functions
- Average RRR pars
- Etc.



Compact covariance storage: example

- SAMMY and AGS have very similar formats
- Would be better with a standard format: JSON, HDF5, YAML, etc.

6.662081e+00	4.087922e-02	2.470318e-05	6.232582e-19	-4.900305e-22	-2.409107e-22	-1.119375e-02	-5.503116e-03	6.035614e-01	-2.758872e-22	5.653657e-01	-3.543796e-22
6.656547e+00	4.156394e-02	2.505857e-05	6.192802e-19	-4.803462e-22	-2.417062e-22	-1.120652e-02	-5.639030e-03	6.152569e-01	-2.704349e-22	5.787546e-01	-3.555498e-22
6.651019e+00	4.333359e-02	2.706003e-05	6.550508e-19	-5.103296e-22	-2.546248e-22	-1.215994e-02	-6.067101e-03	6.205412e-01	-2.873156e-22	5.802409e-01	-3.745530e-22
6.645499e+00	3.690454e-02	2.248952e-05	5.32793e-19	-4.572132e-22	-1.976412e-22	-1.07412e-02	-4.930011e-03	5.397218e-01	-2.572237e-22	4.930071e-01	-2.870992e-22
6.639985e+00	4.311301e-02	2.640233e-05	6.146239e-19	-4.72342e-22	-2.440198e-22	-1.070331e-02	-4.631791e-03	5.397709e-01	-2.373853e-22	4.948098e-01	-2.684040e-22
6.628979e+00	3.567854e-02	2.109846e-05	4.701754e-19	-3.949688e-22	-1.712552e-22	-1.023999e-02	-4.439973e-03	5.359915e-01	-2.223674e-22	4.930873e-01	-2.519164e-22
6.623486e+00	4.267049e-02	2.583469e-05	5.639332e-19	-4.313743e-22	-2.214563e-22	-1.142233e-02	-5.863929e-03	6.275973e-01	-2.428637e-22	5.919506e-01	-3.257623e-22
6.619400e+00	3.970000e-02	2.387722e-05	5.105326e-19	-4.060129e-22	-1.944142e-22	-1.098005e-02	-5.257660e-03	5.886379e-01	-2.285853e-22	5.492900e-01	-2.859832e-22
6.613191e+00	3.720000e-02	2.209073e-05	4.626633e-19	-3.792820e-22	-1.717149e-22	-1.047589e-02	-4.742819e-03	5.574955e-01	-2.135358e-22	5.162904e-01	-2.525926e-22
6.607048e+00	4.62793e-02	2.865914e-05	5.879405e-19	-4.341821e-22	-2.363391e-22	-1.224798e-02	-6.666967e-03	6.668116e-01	-2.440000e-22	6.336691e-01	-3.476549e-22
6.606680e+00	3.937018e-02	2.371843e-05	4.766189e-19	-3.812168e-22	-1.802634e-22	-1.098319e-02	-5.193547e-03	5.826950e-01	-2.100000e-22	5.424567e-01	-2.651674e-22
6.599170e+00	3.674850e-02	2.146260e-05	4.224571e-19	-3.436415e-22	-1.574606e-22	-1.011175e-02	-4.633323e-03	5.890000e-01	-2.934702e-22	5.202984e-01	-2.316246e-22
6.591571e+00	4.715000e-02	2.942682e-05	5.673599e-19	-4.115198e-22	-2.304428e-22	-1.236731e-02	-6.925440e-03	6.865100e-01	-2.316856e-22	6.527809e-01	-3.389814e-22
6.585166e+00	3.178993e-02	2.426586e-05	4.582747e-19	-3.677068e-22	-1.724930e-22	-1.128627e-02	-5.290000e-03	5.880074e-01	-2.070189e-22	5.400503e-01	-2.537372e-22
6.579100e+00	4.980013e-02	2.470929e-05	4.570937e-19	-3.449273e-22	-1.802757e-22	-1.081280e-02	-5.900000e-03	6.307769e-01	-1.941941e-22	5.983760e-01	-2.651855e-22
6.572000e+00	3.895474e-02	2.335825e-05	4.232530e-19	-3.388251e-22	-1.593719e-22	-1.084800e-02	-4.750000e-03	5.788469e-01	-1.907585e-22	5.387406e-01	-2.344361e-22
6.566000e+00	4.250000e-02	2.184331e-05	3.876973e-19	-3.172914e-22	-1.432227e-22	-1.075260e-02	-4.683305e-03	5.551442e-01	-1.786350e-22	5.141479e-01	-2.106806e-22
6.561520e+00	4.250000e-02	2.589395e-05	4.501811e-19	-3.437324e-22	-1.756300e-22	-1.149566e-02	-5.865507e-03	6.257479e-01	-1.935213e-22	5.895501e-01	-2.583530e-22
6.558000e+00	4.67780e-02	2.867845e-05	4.883814e-19	-3.532953e-22	-1.970000e-22	-1.205054e-02	-6.750183e-03	6.806615e-01	-1.989052e-22	6.506086e-01	-2.911116e-22
6.549000e+00	3.750000e-02	2.245557e-05	3.745778e-19	-3.063721e-22	-1.400000e-22	-1.067289e-02	-4.811972e-03	5.575884e-01	-1.724875e-22	5.153399e-01	-2.031903e-22
6.547290e+00	3.920000e-02	2.443765e-05	3.992931e-19	-3.880000e-22	-1.42567e-22	-1.170118e-02	-5.203703e-03	5.617278e-01	-1.851576e-22	5.144456e-01	-2.151436e-22
6.541905e+00	3.674000e-02	2.247140e-05	3.596472e-19	-3.150000e-22	-1.288711e-22	-1.102647e-02	-4.682914e-03	5.349623e-01	-1.708378e-22	4.874487e-01	-1.895694e-22
6.536520e+00	4.674000e-02	2.508439e-05	3.574000e-19	-3.530000e-22	-1.450716e-22	-1.189953e-02	-5.384026e-03	5.714524e-01	-1.805150e-22	5.246030e-01	-2.134003e-22
6.531141e+00	3.779440e-02	2.274509e-05	3.474000e-19	-2.851209e-22	-1.286193e-22	-1.080731e-02	-4.875227e-03	5.591776e-01	-1.695231e-22	5.164325e-01	-1.891990e-22
6.525769e+00	3.967609e-02	2.459806e-05	3.600000e-19	-3.005858e-22	-1.367002e-22	-1.163647e-02	-5.292026e-03	5.711441e-01	-1.692298e-22	5.256925e-01	-2.010860e-22
6.520404e+00	3.768602e-02	2.274945e-05	3.351768e-19	-2.746487e-22	-1.228466e-22	-1.085911e-02	-4.857131e-03	5.558774e-01	-1.546272e-22	5.123718e-01	-1.807073e-22
6.515046e+00	4.479377e-02	2.770558e-05	3.998381e-19	-2.988091e-22	-1.574663e-22	-1.206631e-02	-6.358700e-03	6.476426e-01	-1.682295e-22	6.121861e-01	-2.316329e-22
6.501678e+00	1.986256e-02	2.410654e-05	3.303591e-19	-2.624825e-22	-1.239045e-22	-1.117355e-02	-5.274459e-03	5.837842e-01	-1.477777e-22	5.427264e-01	-1.822636e-22

uncertainties on data-reduction parameters
1.141742e+03 2.187553e-05 2.402340e-02 5.576764e-02 1.000000e+00 1.000000e+00 1.600000e-02 8.000000e-03 1.800000e-02 5.000000e-03

Correlation for data-reduction parameters
1.424059e-01
0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00

Systematic Derivatives
Systematic Cov.

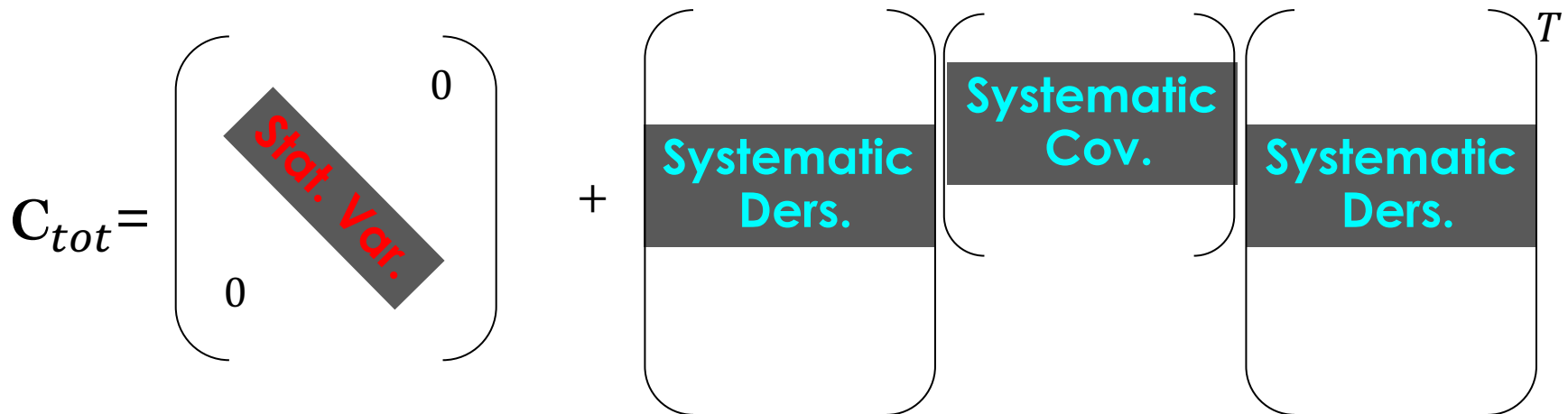
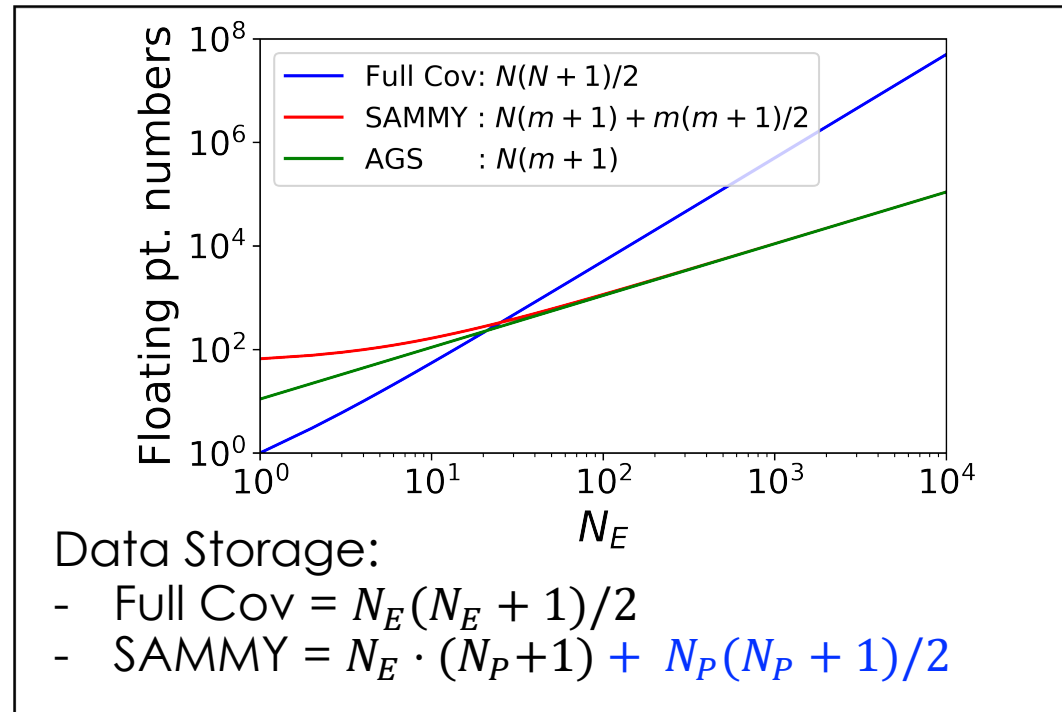
Compact covariance storage: example

$$T = \frac{\alpha_1 C_s + \alpha_2 k_s B + B O_s}{\alpha_3 C_o + \alpha_4 k_o B + B O_o},$$

$$B = a e^{-bt}$$

$$C_{tot} = C_{stat} + C_{sys}$$

$$C_{tot} = C_{stat} + S M S^T$$



We should also keep in mind...

- What tools are used to reduce raw data? Availability?
 - Typically in-house codes...
 - AGL/AGS @ Geel
 - RPIXDR/TRANS @ RPI
 - **ROOT** @ CERN (maybe LANL too)
 - There are more...
- What tool will use this data? Availability?
 - **SAMMY (FITACS)***
 - **EMPIRE**
 - REFIT (NEA & RSICC)
 - EDA, CoH3
 - CONRAD
 - **TALYS**

Sorry if I missed your code...

Blue = Open Source

Evaluator wishes for future work:

- How do these data systematically compare to other data?
- Reduce correlations to other x.s.

Acknowledgments

- NDCS group
- This work was supported by the Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

ROOT: <https://root.cern/releases/release-62202/>

SAMMY: <https://code.ornl.gov/RNSD/SAMMY>

EMPIRE: <https://www-nds.iaea.org/empire/index.html>

TALYS: https://tendl.web.psi.ch/tendl_2019/talys.html