CORPS-G Unfolding Workshop

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Measuring Neutron Spectra

Neutral Particles, detected indirectly.

Use some system of detectors (Multi-foil Activation, Bonner Spheres)

Relationship

$$N_k + \epsilon_k = \int_E R_k(E)\phi(E)dE$$

$$N_k + \epsilon_k = \sum_i R_{ki}\phi_i, \quad k = 1, \ldots, m$$

Ill-posed, m << n

Still infinite possible solutions! How do we pick one?

Requires an Unfolding (Deconvolution) Method

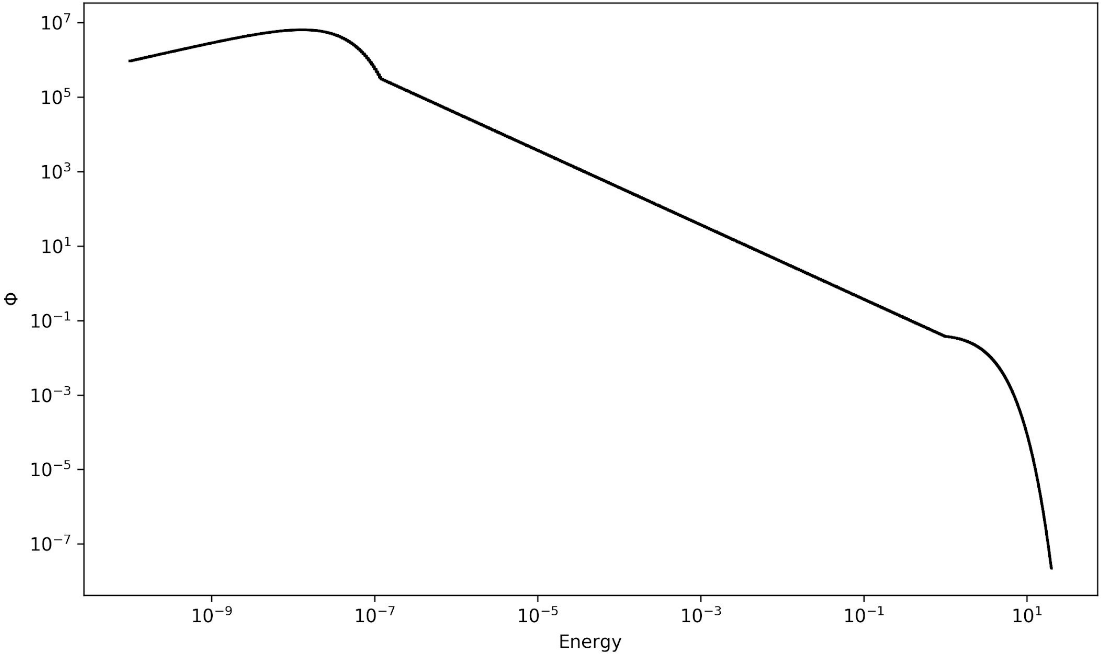
Something that produces an ‘optimal’ solution from the domain of potential solutions.

Ideally, incorporates *a priori* information into solution-finding process.

Solution Inspection

Study the solution afterward to determine if physically reasonable.

Default Spectrum



Allows *a priori* information to be included in problem.

Entropy

Measure of information

Neutrons, like gasses and thermal systems, tend towards randomness.

Unlikely to see spectral features form for no reason.

Method: Gravel (Modified Sand-II)

$$\phi_j^{k+1} = \phi_j^k exp(\frac{\sum_i W_{ji}^k \log(\frac{N_i}{\sum_{j'} R_{ij'}\phi_{j'}^k})}{\sum_i W_{ji}^k})$$

$$W_{ji}^k = \frac{R_{ij}\phi_j^k}{\sum_{j'} R_{ij'}\phi_{j'}^k}\frac{N_i^2}{\sigma_i^2}$$

Iterative, calculates measured-to-calculated response ratios, then weights with a ‘sensitivity function’.

Method: MAXED

Additional constraint:

$$\Omega = \sum_i \frac{\epsilon_i^2}{\sigma_i^2}$$

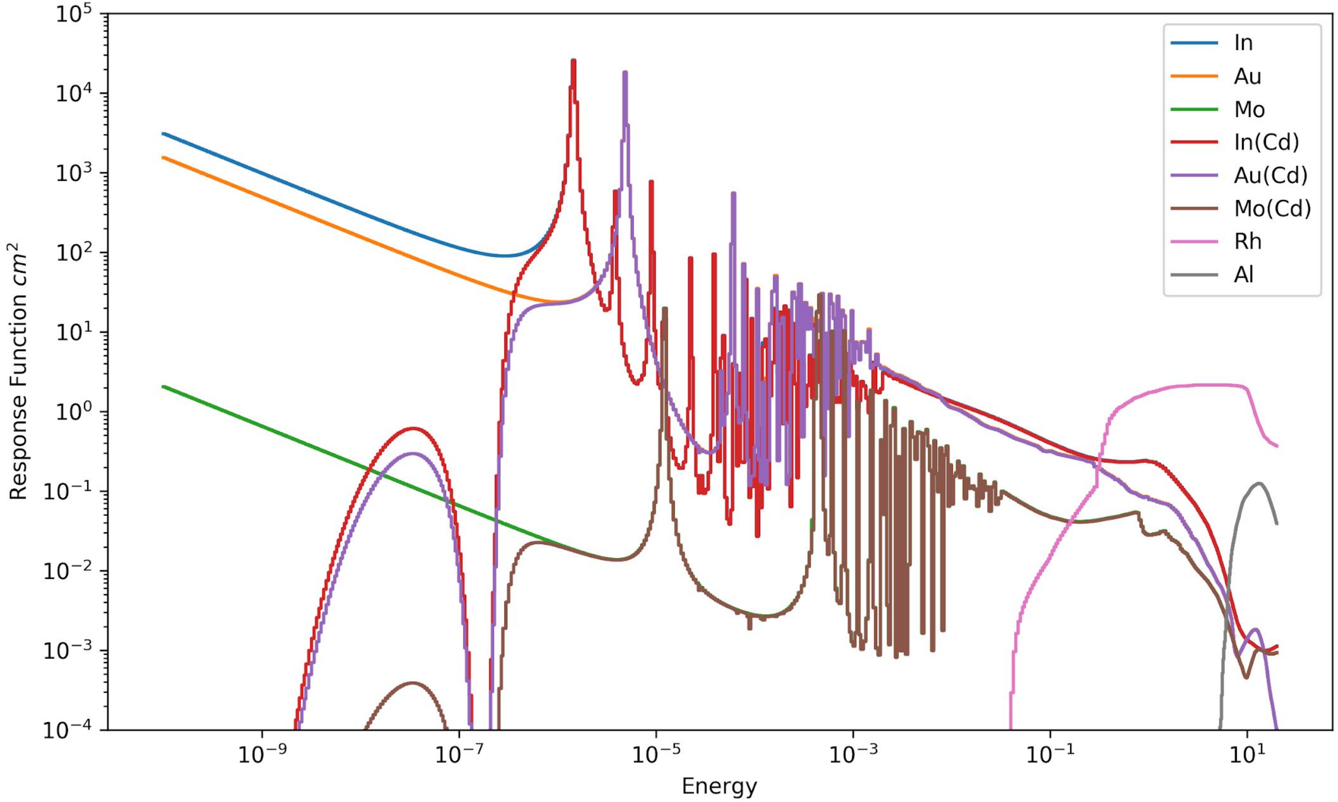
$$S = -\sum[\phi_j \ln(\frac{\phi_j}{\phi_j^{DEF}}) + \phi_j^{DEF} - \phi_j]$$

Entropy measure ‘S’, maximize with respect to.

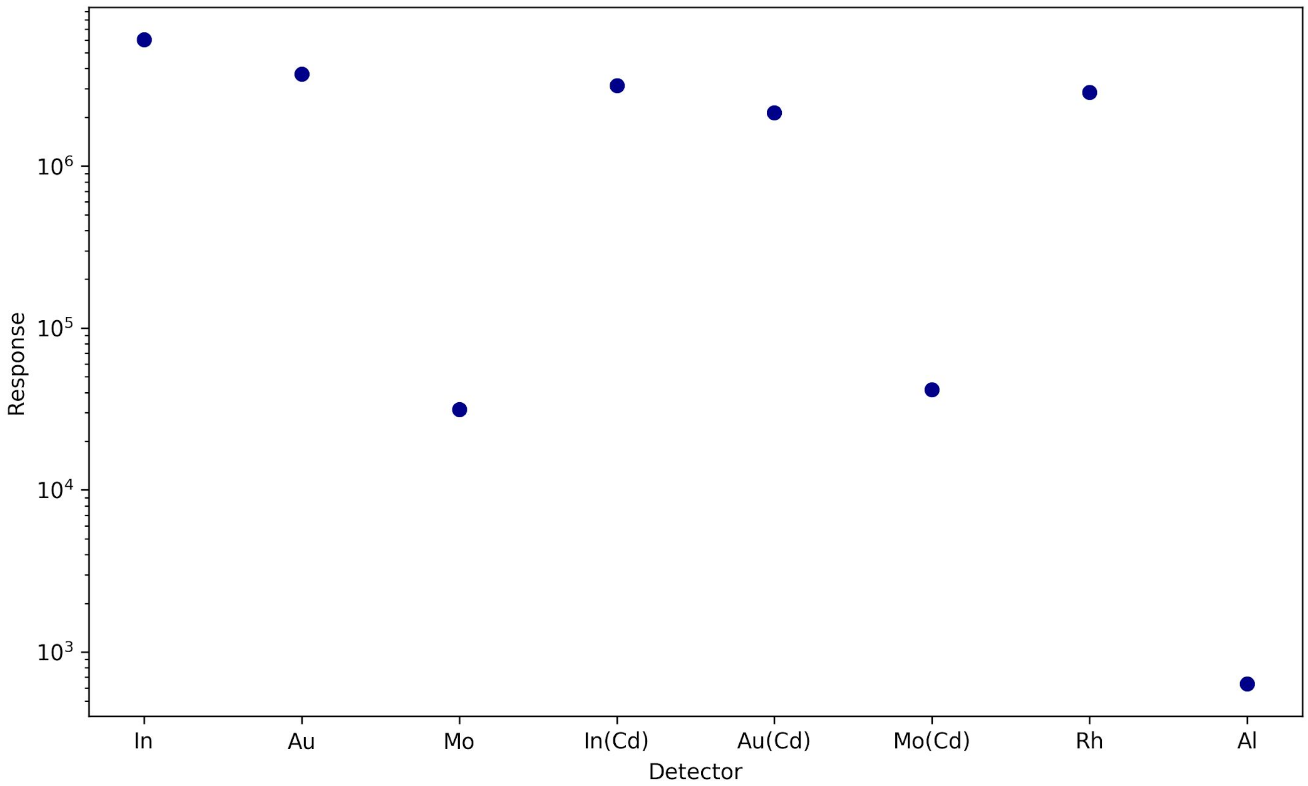
Examples

Open your favorite IDE and let’s get to work.

Response Functions



Detector Responses



Example 0: Unit Test

example0.py

- Good Default Spectrum
- Good Response Data

Do the methods give the same answer?

Example 1: Pre-NE630

example1.py

- No Default Spectrum
- Good Response Data

Can we extract anything useful here?

Example 2: Halfsies

example2.py

- Correct Default Spectrum shape, but off by factor of 2
- Good Response Data

Which algorithm performs better here?

Example 3: Mystery Peak

example3.py

- Wrong Default Spectrum shape, but correct magnitude
- True Solution has fusion peak
- Good Response Data

Is it possible to find the fusion peak in the true spectrum?

Example 4: The Outsiders

example4.py

- Good Default Spectrum
- Outlying Detector Response

Try perturbing the responses in different ways to see how your solution is affected.

Which algorithm seems more resilient to incorrect response data?

Questions?