The Atlas of Gamma-ray Spectra from the Inelastic Scattering of Reactor Fast Neutrons

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The “Baghdad Atlas” [1] is a large compilation of identified gamma-ray intensities from a fast reactor spectrum

- The neutron source was the Al-Tuwaitha research facility outside of Baghdad in the 1970s
  - A low-energy filter was used to simulate a fast reactor spectrum
- All intensities were measured in reference to the 847 keV gamma ray in ^{56}Fe
- A single Ge(Li) detector at 90^{o} measured the gamma rays from 105 targets
- Uncertainties
  - Flux
  - Statistics
  - Detector efficiency
  - Non-linearity in energy
  - Gamma-ray self-absorption
  - Sample

No model of the reactor, so this is determined by fitting

Provided by the experimentalists (at 2-sigma)

Given with the normalization to ^{56}Fe

^{26}Fe

E_γ	I_γ	A_Z	E_i
1165.9(6)	0.08(3)		
1173.?(8)	0.25(10)		6
1175.0(8)	0.15(10)		4
1238.3(2)	10.5(5)	^{58}Fe	2085.1
		^{56}Fe	4395.4
1298.9(4)	0.12(4)		
1303.2(3)	0.64(10)		
1334.6(4)	0.18(3)		
1386.6(10)	0.06(3)		
1434.2(10)	0.05(2)	^{55}Fe	1408.2

3% uncertainty

25% uncertainty

[1] A. M. Demidov, et. al., Atlas of Gamma-ray Spectra from the Inelastic Scattering of Reactor Fast Neutrons, Moscow, Atomizdat (1978)

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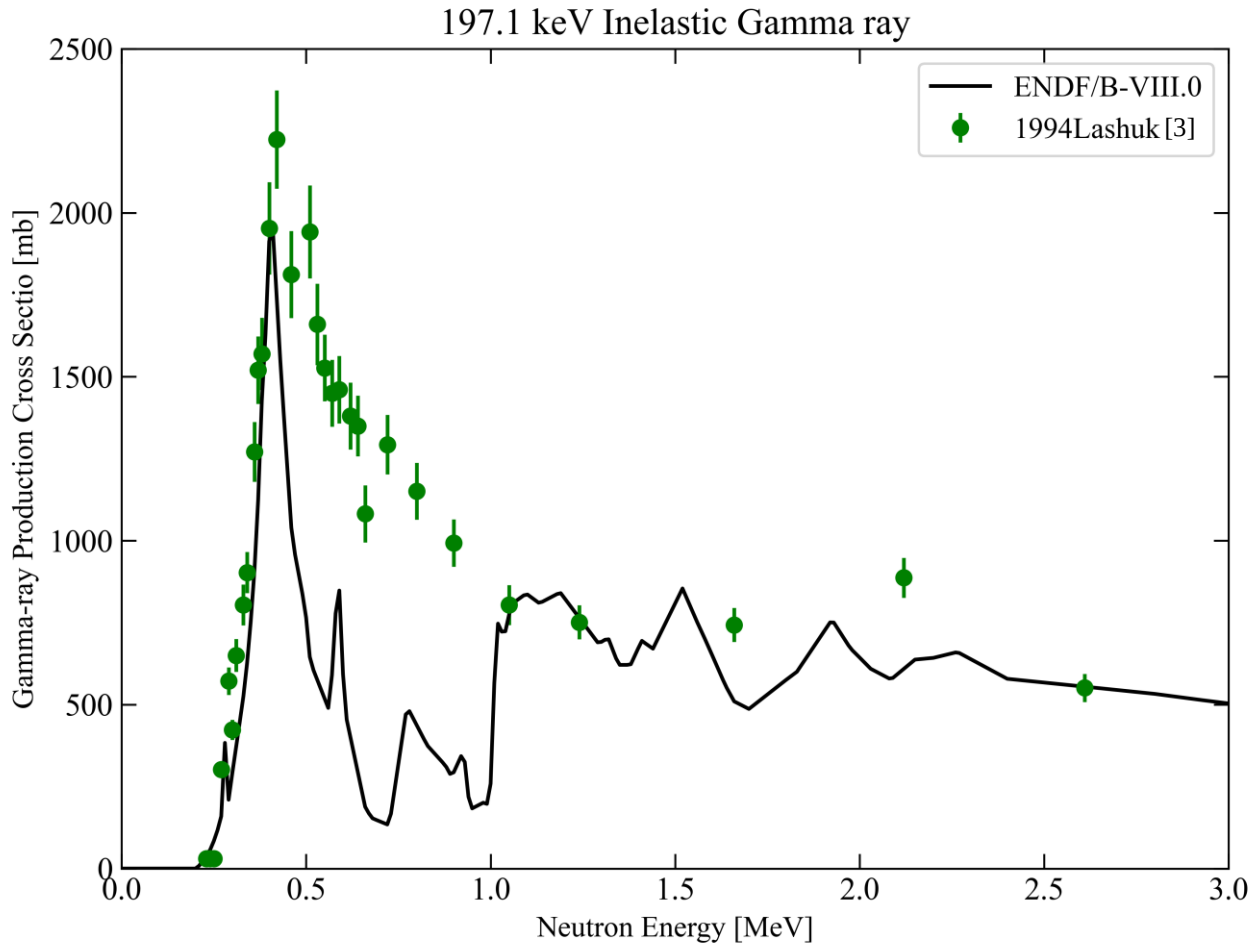
The Baghdad Atlas provides a broad ability to uncover problems in evaluated inelastic cross sections

- The Atlas tests elastic and inelastic scattering and discrete and statistical structure
- ^{19}F inelastic scattering was shown to be problematic using machine learning on k_{eff} benchmarks [2]
- The Atlas can also find the problem, based on the 197.1 keV gamma:
  - With a preliminary flux shape, the ENDF/B-VIII.0 value is **around 50% lower** than the Atlas value.



[2] Neudecker, et. al., NDS 167 (2020)
[3] EXFOR entry 41186

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The Atlas data tables are already available and the flux will be published soon

- A digitized version of the database is available at nucleardata.berkeley.edu/atlas

- A future publication will detail the flux shape that should be used
  - We don't have an MCNP input – the setup is not well characterized
  - Instead, the flux shape is fit based on the ^{56}Fe values

- A new database should be developed for "quasi-differential" benchmarks
  - Differential in reaction, but integral in energy
  - More benchmarks like the Baghdad Atlas need to be created, with:
    - More modern technology
    - Well-characterized neutron sources and experimental setups
    - Neutron spectra that are directly relevant to applications
      - The ENDF format does not allow for direct calculation of gamma-ray cross sections to compare to the Atlas values for many isotopes

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