Los Alamos NATIONAL LABORATORY

Photonuclear data processing and validation for ENDF/B-VIII.1

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Outline

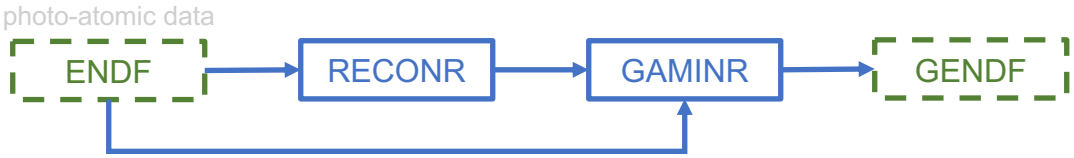
- Processing photonuclear data with NJOY2016
- Experimental data for validation
- Other validation exercises

Photo-atomic and photo-nuclear data in ENDF

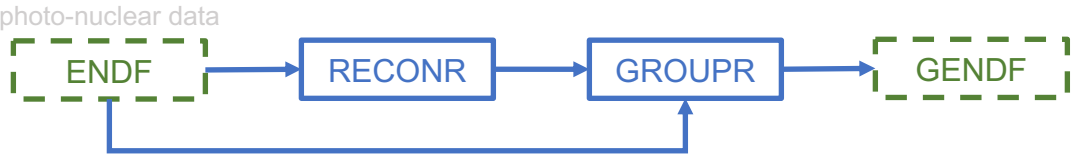
- Photo-atomic and photo-nuclear data have their own distinct sub-library
  - Photo-atomic data is given for elements (photons interact with the electron cloud)
  - Photo-nuclear data is given for nuclides (photons interact with the nucleus)
- ENDF files use distinctly different formats for these sub-libraries
  - Photo-atomic sub-library (NSUB=3)
    - MF23 for smooth cross sections
    - MF27 for coherent scattering form factors and incoherent scattering functions
    - MF26 for secondary particle distributions
  - Photo-nuclear sub-library (NSUB=0)
    - Essentially the same as incident neutron and incident charged particle sub-libraries
    - MF3 for cross section data
    - MF4-MF6 for secondary particle distribution data
    - MF31-MF40 for covariance data

Processing modules in NJOY2016

Multigroup photo-atomic data



Multigroup photo-nuclear data



Continuous energy photo-atomic data

Continuous energy photo-nuclear data

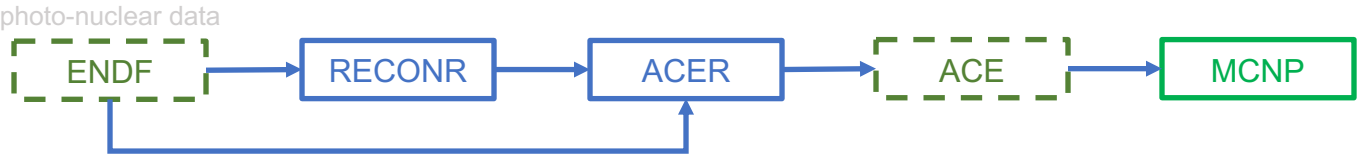


Photo-atomic and photo-nuclear ACE libraries

- Official ACE libraries for MCNP: https://nucleardata.lanl.gov
- Photo-atomic libraries
  - Multiple photo-atomic libraries have been released since 1982
  - Most recent version: MCPLIB63 and MCPLIB84 released in 2012
- Photo-nuclear libraries
  - LA150U released in 2000 and updated in 2001 (for a limited number of nuclides)
  - endf70u was released with MCNPX and contains more nuclides

- Our long term goal: a new photo-nuclear ACE library based on ENDF/B-VIII.1
  - Work on improving processing (NJOY2016.64 and 2016.66)
  - Work on adding the photo-nuclear format to the ACE format specifications
  - Work on verification and validation for such a new library

Recent work on photo-nuclear data processing

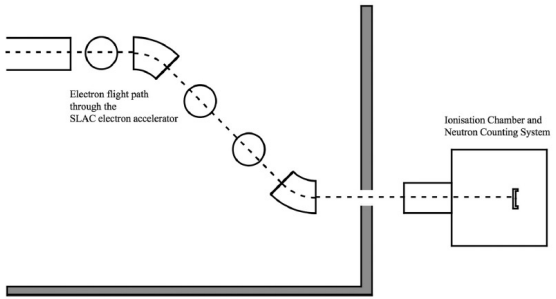
- Traditional photo-nuclear data
  - Secondary photon distributions traditionally given using the LAW=1 LANG=1 format
  - Traditionally using a single Legendre coefficient (i.e. isotropic distribution)
  - This assumption was hardcoded in NJOY2016's ACER module
- And then the IAEA-2019 library was released (August 2020)
  - Secondary distributions are using anisotropic Legendre expansion

- A major update for photo-nuclear data processing: NJOY2016.66
  - Secondary photon distributions now translated into ACE LAW=61
  - Properly handle photo-fission neutron multiplicity data when MF6/MT18 is used
- Please note: only MCNP6.3 is capable of using the photonuclear ACE files produced by NJOY2016.66

Validation against experimental data

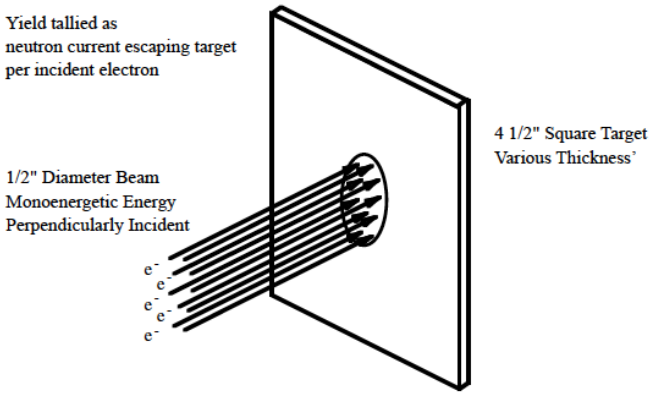
- Experimental data and benchmarks for validation
  - Requires demonstratable sensitivity to photo-nuclear interactions

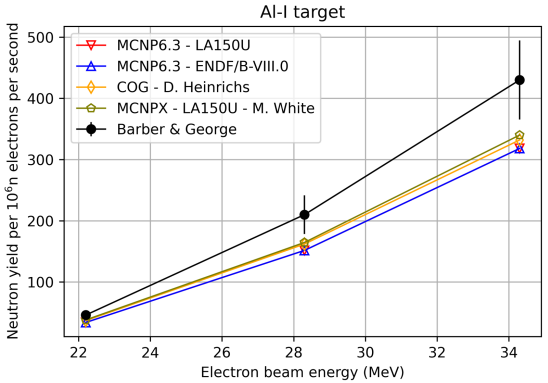
- Barber and George (1959) has been used in the past
  - Neutron yields from targets bombarded by electrons
  - C, Al, Cu, Ta, Pb and U targets
  - Electron beam energies between 15 and 40 MeV
  - 62 measurements were performed

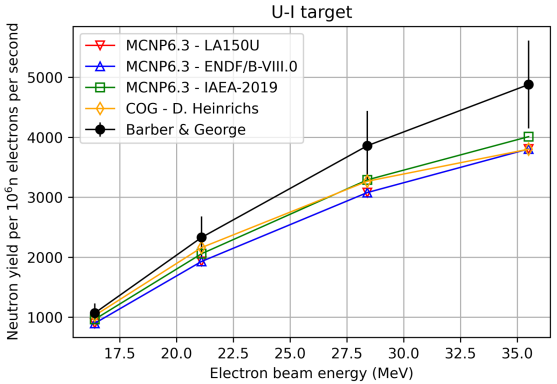


Validation against experimental data

- Preliminary MCNP 6.3 simulation results
  - Electron, photon and neutron transport
  - Using LA150U, ENDF/B-VIII.0 and IAEA-2019 photonuclear data







Other validation exercises

- The Barber and George measurements are a good star, but we would like to have more
- Another option is data comparison
  - Compare the impact of using the ENDF/B-VIII.0 versus the IAEA-2019 library through “probing”
  - Tallying particle spectra outside a disk bombarded mono-energetic photon or electron beam
- For example:
  - Pu239 disk in a 14 and 20 MeV photon beam