Photofission Delayed Neutron Re-interrogation for Detecting SNM: Establish Simulation Capability

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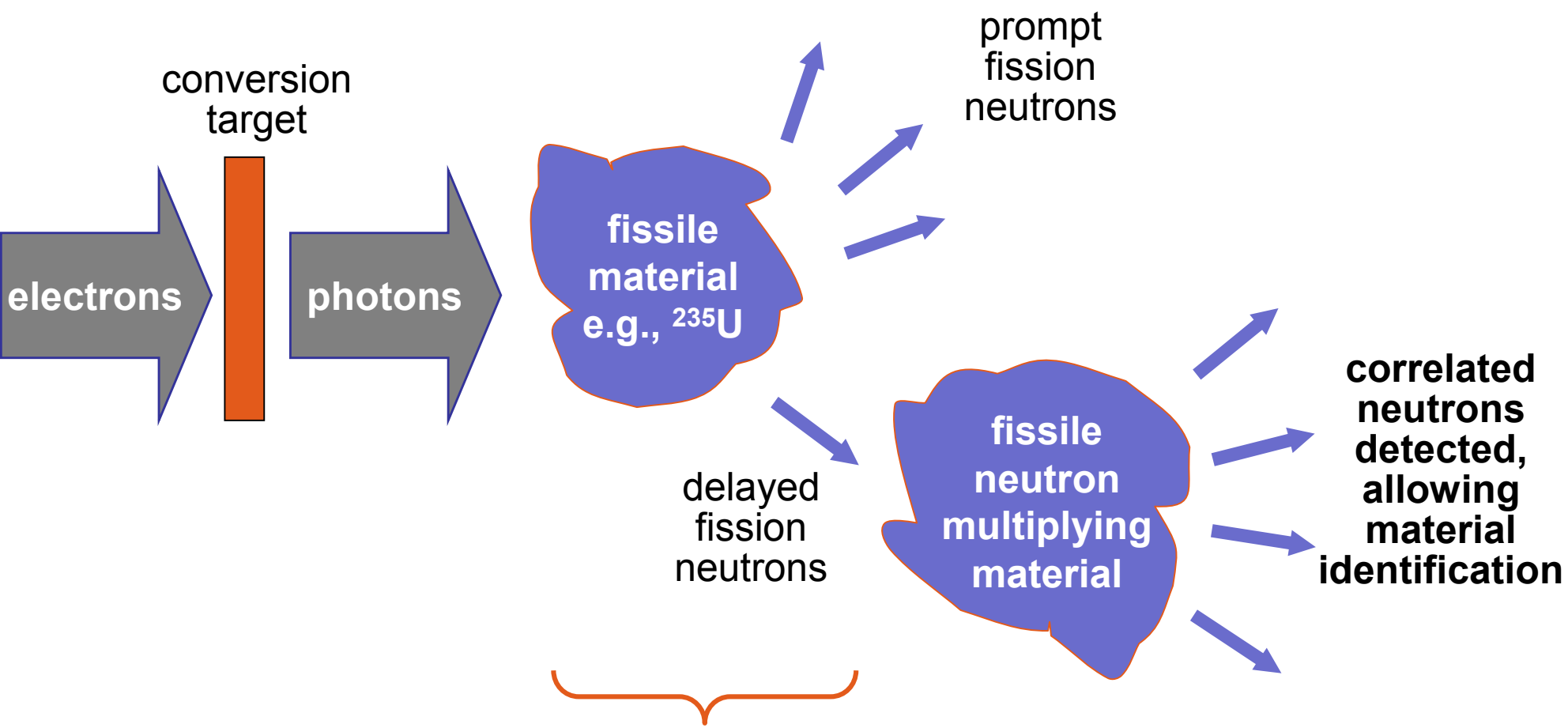
Proposal to develop MCNP, together with photonuclear and delayed neutron cross section databases, for interpreting experiments and developing interrogation technology, for users in Emergency Response & Homeland Security

Delayed Neutron Re-interrogation



MCNP simulation and photoneutron cross section data need to be developed

Scheme for detecting SNM (including ^{235}U)

- **Photons produced by accelerated electrons incident on a bremsstrahlung conversion target (eg NIS's betatron), will introduce photonuclear reactions in fissile materials**

- **Photofission produces both prompt neutrons and delayed neutrons (following beta-decay of fission products)**

- **Presence of delayed neutrons is indicative of special nuclear materials (SNM)**

- **Subsequent multiplication of the neutrons by SNM, and detection of these multiplied neutrons, can be used to determine whether ^{235}U, ^{239}Pu, ^{237}Np, *etc.***

  - NIS is undertaking experiments to develop this technology
  - A modeling/simulation capability is needed

Photonuclear modeling and cross sections: Existing capabilities & Future needs

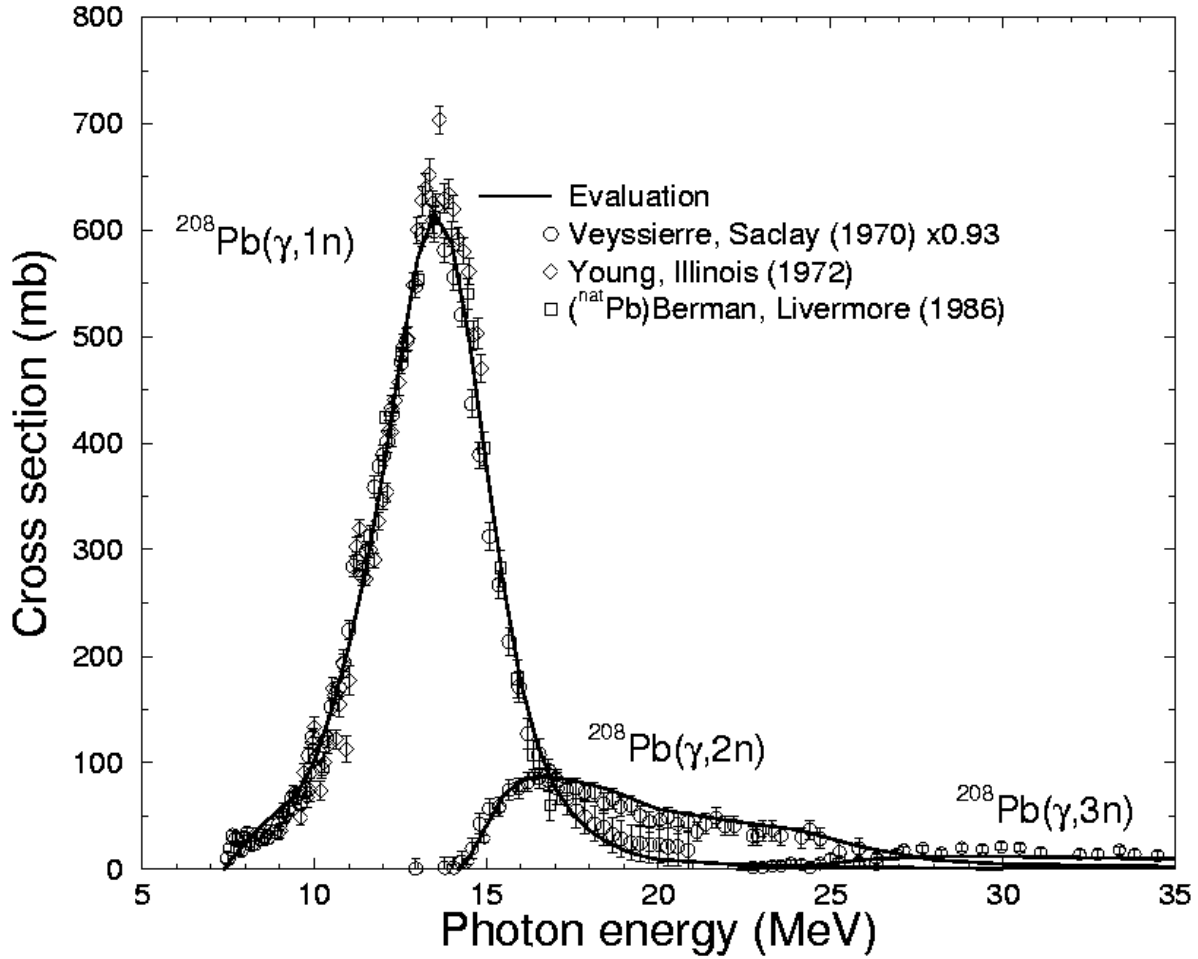
Existing photonuclear cross sections & databases:

- **GNASH nuclear reaction code in T-16 has been extended to model photonuclear cross sections (x/s), and predict x/s & spectra of emitted neutrons (and other ejectiles)**
- **Limited (12) set of LANL cross section ENDF evaluations developed for accelerator & target materials (DARHT project)**
- **Large (>150) set of evaluations produced under an IAEA collaboration (led by Los Alamos)**

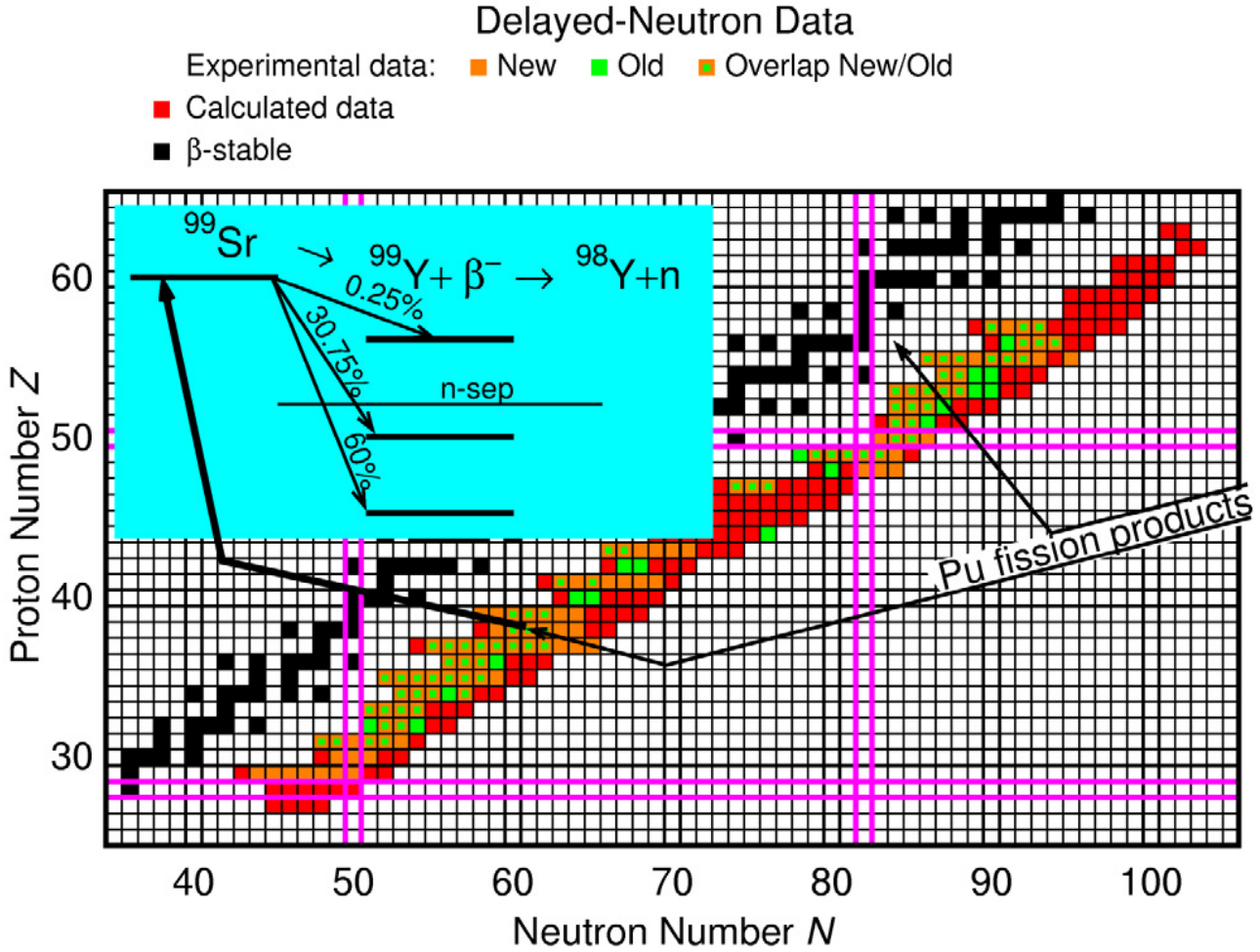
Future needs:

- **No Los Alamos ENDF databases exist yet for actinide photonuclear cross sections – these need to be developed**
- **No ENDF photonuclear databases contain delayed-neutron data – need to be developed**

Example of existing LANL photoneutron cross section databases: GNASH modeling



LANL Moller-Nix model for predicting delayed-neutron properties



Photonuclear Transport in MCNP: Existing Capabilities & Future needs

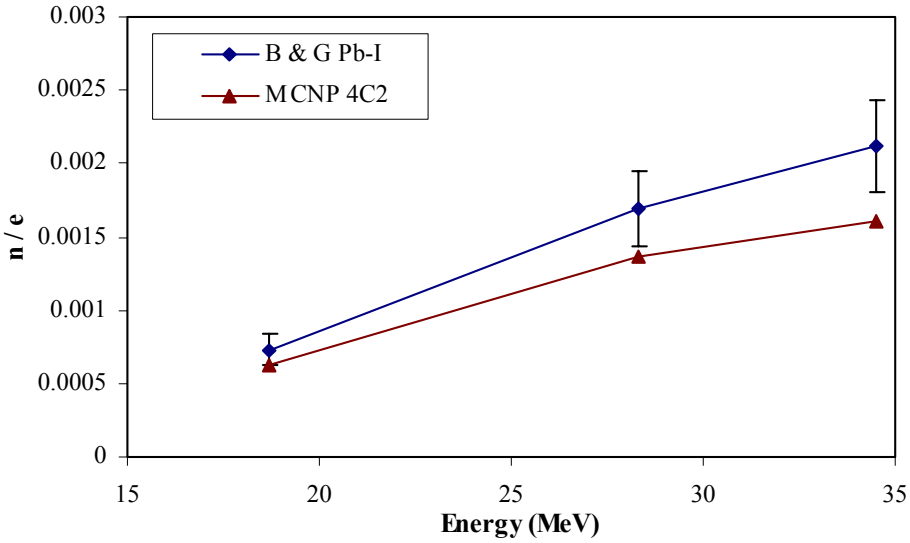
Existing MCNP photonuclear transport capability

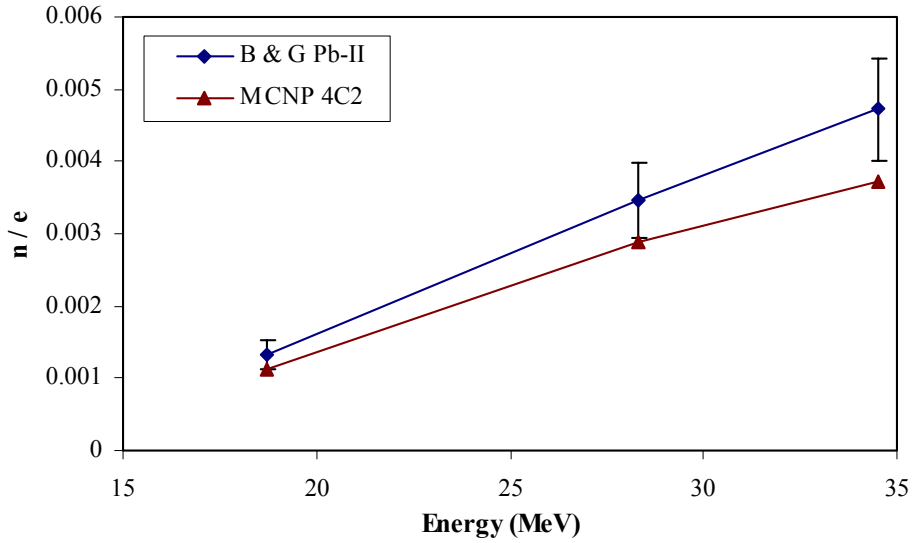
- **MCNP has recently been extended to handle fully-coupled photoneutron transport**
- **MCNP uses T-16's ENDF photonuclear databases**
- **The capability was successfully validated against thick-target neutron production measurements from electron-photon sources**

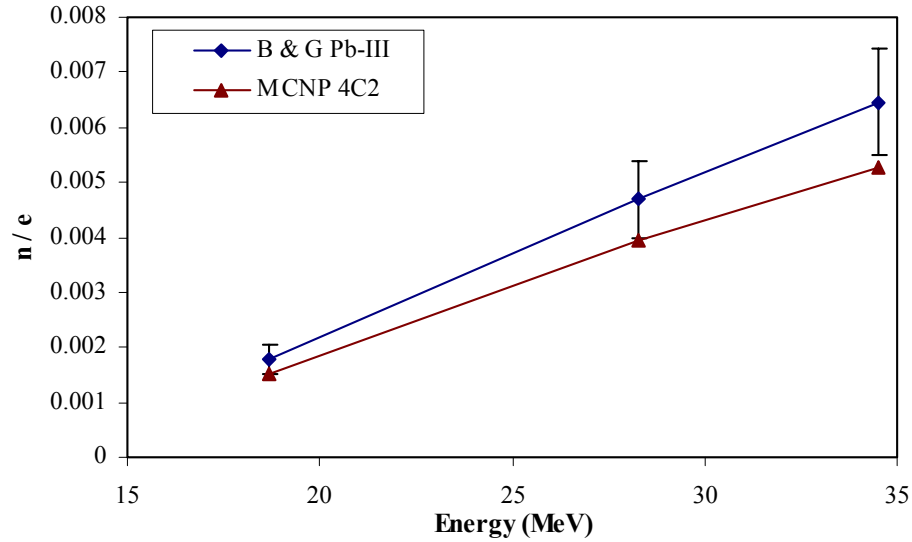
Future needs:

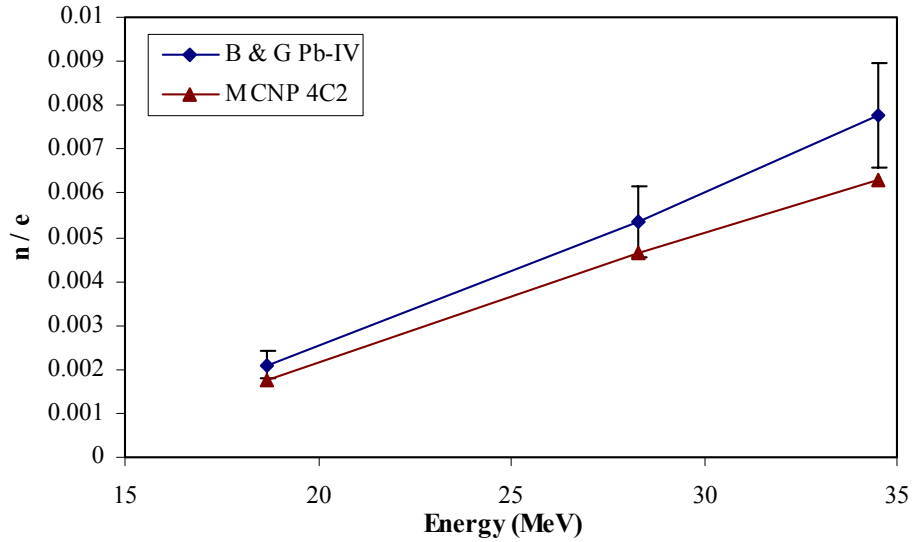
- **MCNP does not yet have an ability to simulate delayed-neutron photonuclear data. Library formats and code functionality need to be developed**

Neutron Yield per Electron Incident on a Lead Target









Proposal

Fast-response (1-year) for approximate modeling capability

- Evaluate delayed neutron production (number, energy, time-dependence), by approximating photon-induced data by known neutron-induced data
- Integrate these data into existing actinide ENDF databases (from Russia), and process with NJOY for applications
- Develop MCNP ability to use delayed-neutron data
- Work with NIS on use of these data to analyze measurements

Accurate comprehensive capability (3 years):

- Develop high-quality LANL actinide photonuclear ENDF databases (^{235,8}U, ^{239}Pu, ^{237}Np)
- Evaluate delayed-neutron photonuclear data, using existing measurements and model calculations (that model fission yields, beta decay, and delayed neutron fractions (Pn))
- Provide correlated-event MCNP simulation ability to assist NIS identification of material-type