Event-by-Event Physics Modeling through Transport and Detector Response Simulations

Michael E. Rising
Monte Carlo Codes, XCP-3
Los Alamos National Laboratory

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Detector Models, Atomic Data and Stopping Powers

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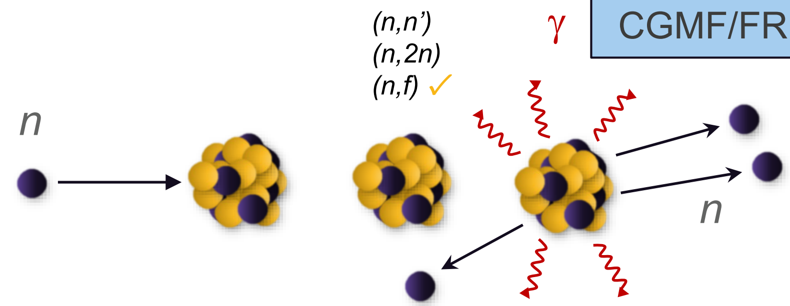
Monte Carlo Transport Codes Such as MCNP6® were Not Designed to Perform Event-by-Event Simulations

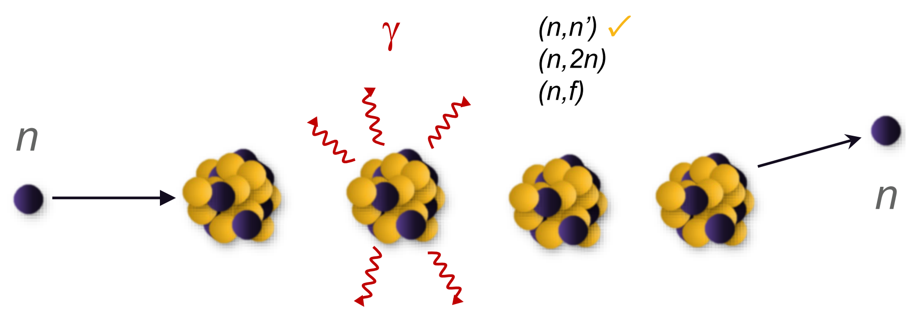
- To improve our understanding of signatures of special nuclear materials, NA-22 recently sponsored developments and integration of the correlated fission models, CGMF at LANL and FREYA at LLNL/LBNL, into the MCNP6.2 transport code
  - Full correlations
    - MCNP sampled fission reaction
    - CGMF/FREYA sampled fission particles

MCNP6 + CGMF/FREYA



- In general, more work needs to be done to better understand and be able disentangle the other reaction channels beyond fission
  - Improved nuclear data libraries
    - Better understand the separation between elastic/inelastic, (n,xn), etc.
  - Full correlations
    - MCNP sampled inelastic reaction
    - CGM sampled inelastic particles

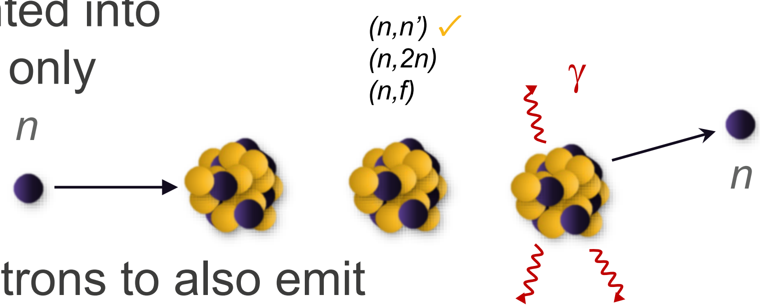
Default MCNP6



Correlated Event-by-Event Physics within the Monte Carlo Transport Simulation

- In the laboratory, it can be challenging to disentangle the elastic, inelastic, (n,xn), fission reaction channels
- For separating the fission reaction from others, CGMF, FREYA, and other fission models represent a big step forward in that direction
- We need to develop better (validated) event-by-event simulations for all competing channels, elastic, inelastic, (n,Xn), etc.
  - For example, CGM was originally implemented into MCNP for correlated gamma-ray emissions only
  - Recent changes within MCNP, allowing neutrons to also emit from CGM has complicated matters → **needs fixing and validation**
    - Detector response simulations (e.g. HPGe) using MCNP with CGM event-by-event scattering within the detector result in unexpected behavior at the present time
    - Quasi-differential neutron scattering measurements would benefit from improved simulations in both the scattering and fission reaction channels (angular emission)

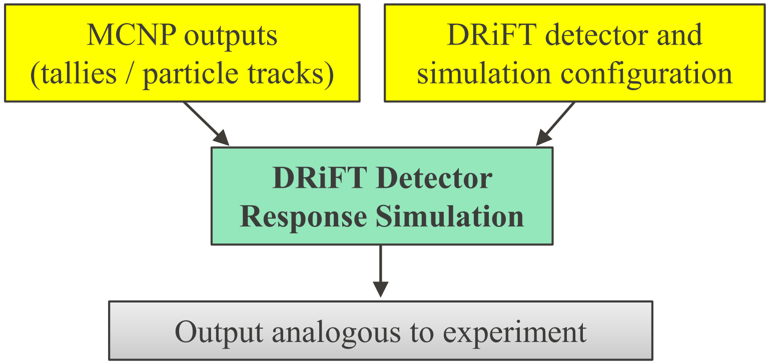
MCNP6 + CGM

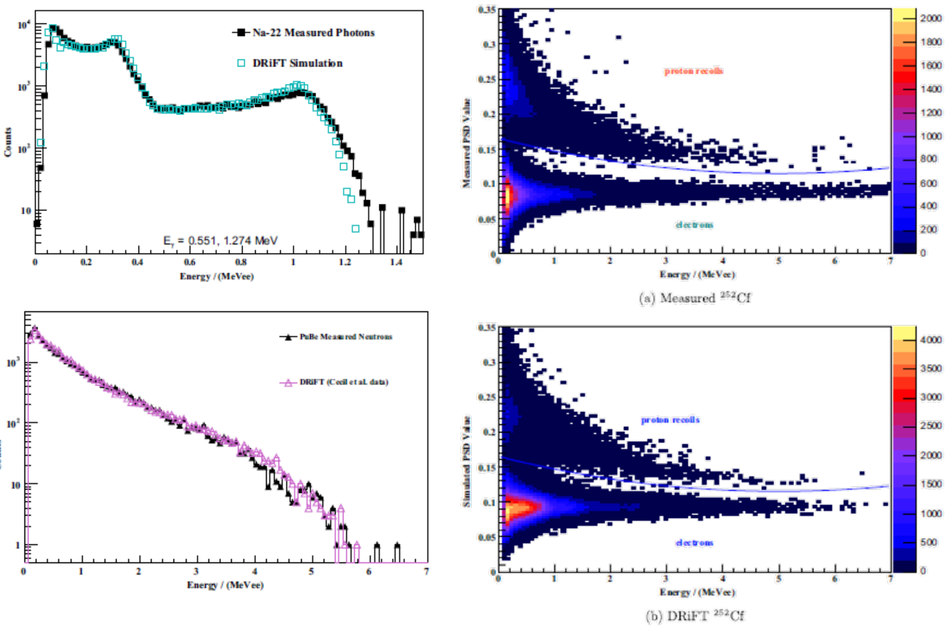


High Fidelity Detector Response Simulations and Impact for Various Applications

- General detector response simulation capabilities (beyond scintillators) need to be developed and improved
- For example, under development at LANL is the Detector Response Function Toolkit (DRiFT)
- Applications are extensive

Spontaneous fission measurements at LANL used to validate MCNP6+CGMF+DRiFT simulations

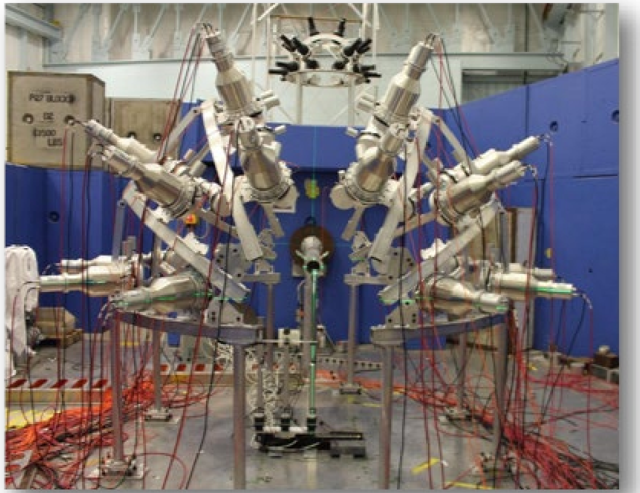




Recent scintillator simulations with DRiFT courtesy of M.J. Marcath and M.T. Andrews

Improved Interpretation of Experiments through Correlated Event-by-Event Physics Simulations

- Quasi-differential neutron scattering measurements
  - Varying thicknesses of samples
  - Multiple scattering
  - Measure all neutrons from all reaction channels
  - Compare experiment to simulation



Differential measurements at LANL's LANSCE

- An event-by-event physics model with the best known and validated physics properly integrated within a general radiation transport code and detector response capability is important for so many experiment applications

- Ultimately this can also provide,
  - A basis for future evaluations of difficult to measure scattering quantities
  - Predictive correlated physics and transport capability