Neutrino Flux Simulations at the ORNL Spallation Neutron Source
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CEvNS and COHERENT
Coherent elastic neutrino-nucleus scattering (CEvNS) is a neutral-current process which needs low-energy neutrinos (<50 MeV for scattering from medium-A nuclei). The COHERENT experiment uses pulsed neutrino production at the Oak Ridge National Lab (ORNL) Spallation Neutron Source (SNS) to take advantage of the neutrinos in the sub-50 MeV range. [1]

Geant4 SNS flux simulation
2015 (Geant4.10.1): Initial simulation of neutrino production at the SNS using QGSP_BERT and including [2, 3]:
- Incident protons with customizable energy and beam profile
- Liquid mercury target and surrounding structure, proton beam shielding, and target hall/detectors.

2018 (Geant4.10.4): Improved particle processing, updated detector geometry, and specialized output for COHERENT.

Future validation
We assign a 10% uncertainty to our calculated flux due to the ~2% change in simulated pion production at varying proton energies and the lack of experimental data on pion production from p + Hg in this energy range to settle any discrepancy with other models and simulations [4]. The collaboration is currently investigating possibilities for experimentally reducing uncertainties on the flux normalization, with options including:

- D₂O detector in “neutrino alley” – small cross-section uncertainty
- Measurement of pion production for p + Hg in this energy range

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References

SNS neutrino production from proton beam

Neutrino flux and varying beam energy
For 1.0 GeV protons and 8.7×10¹⁵ POT per second, we calculate a neutrino flux of 4.3×10⁷ neutrinos/cm²/s at 20 m from the Hg target [4].

Neutrino spectra in all space, 1m from target

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