Neutrino Flux Simulations at the ORNL Spallation Neutron Source

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Neutrino 2018

((COHERENT SNS

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]

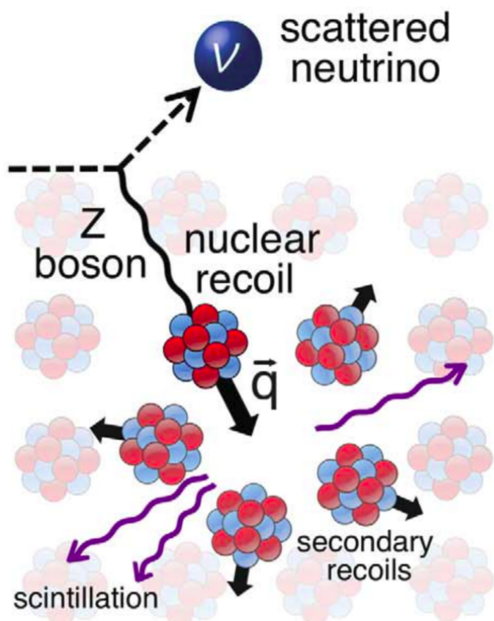
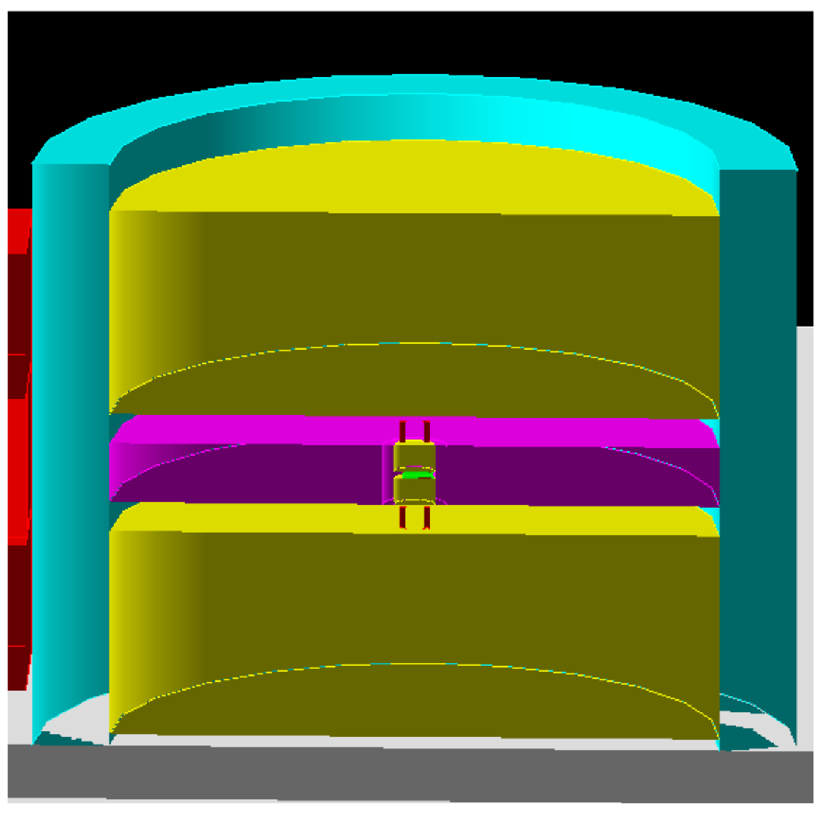


Figure from [1]

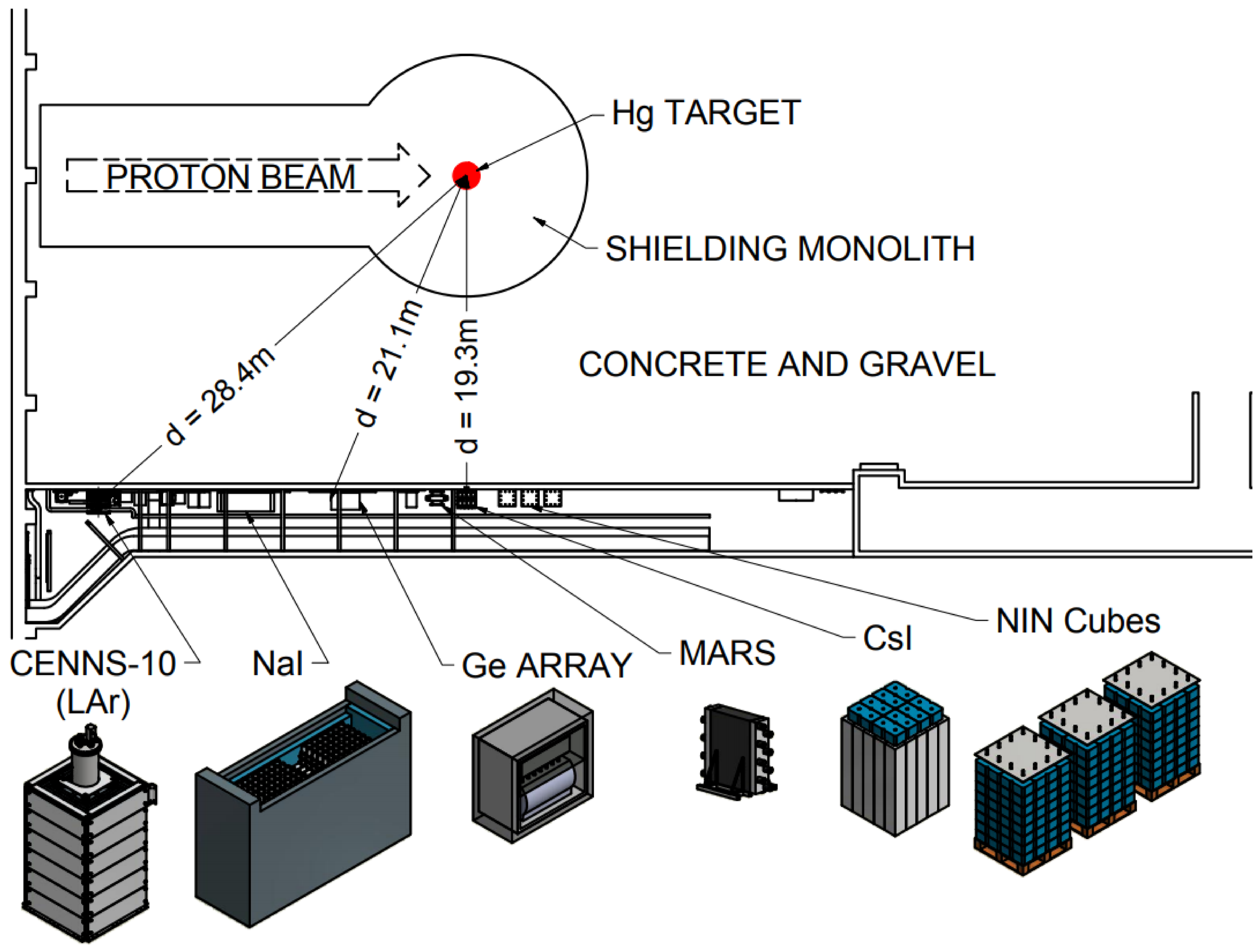
Geant4 SNS flux simulation



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:

- D_2O detector in "neutrino alley" – small cross-section uncertainty
- Measurement of pion production for p + Hg in this energy range

Acknowledgments

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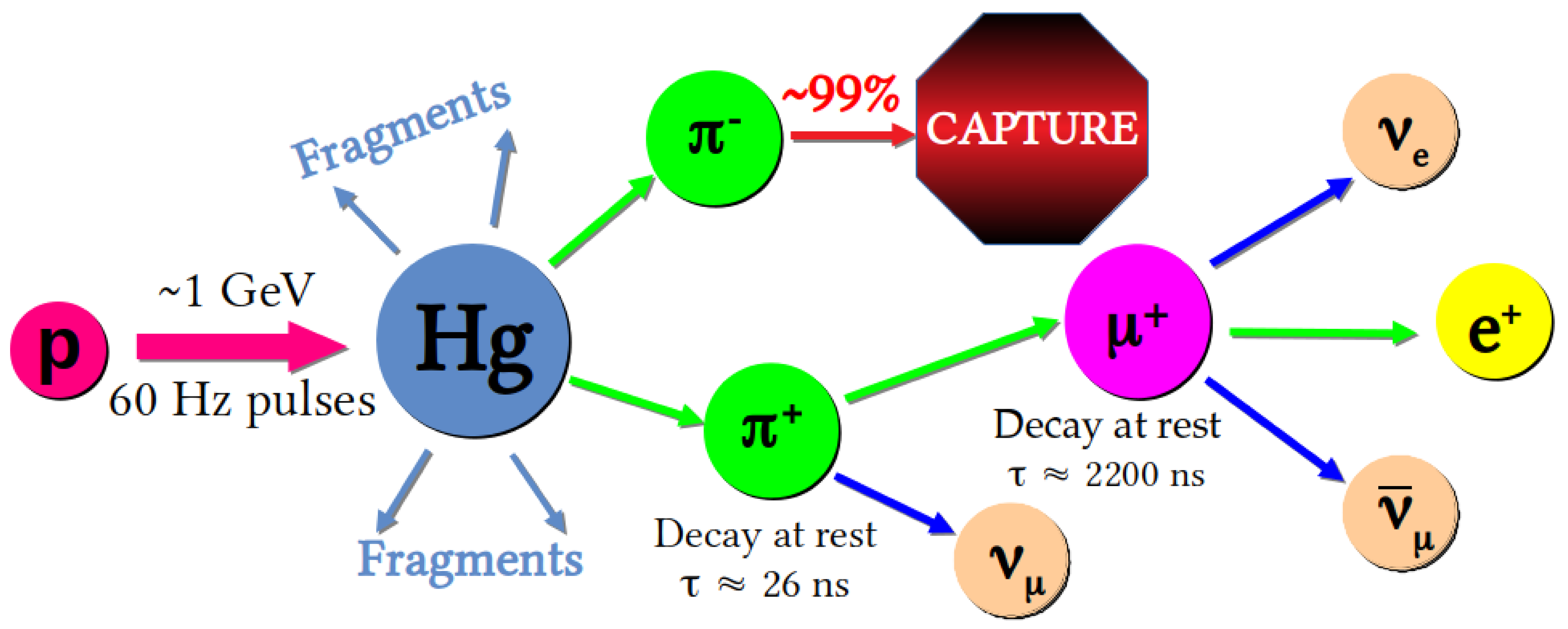
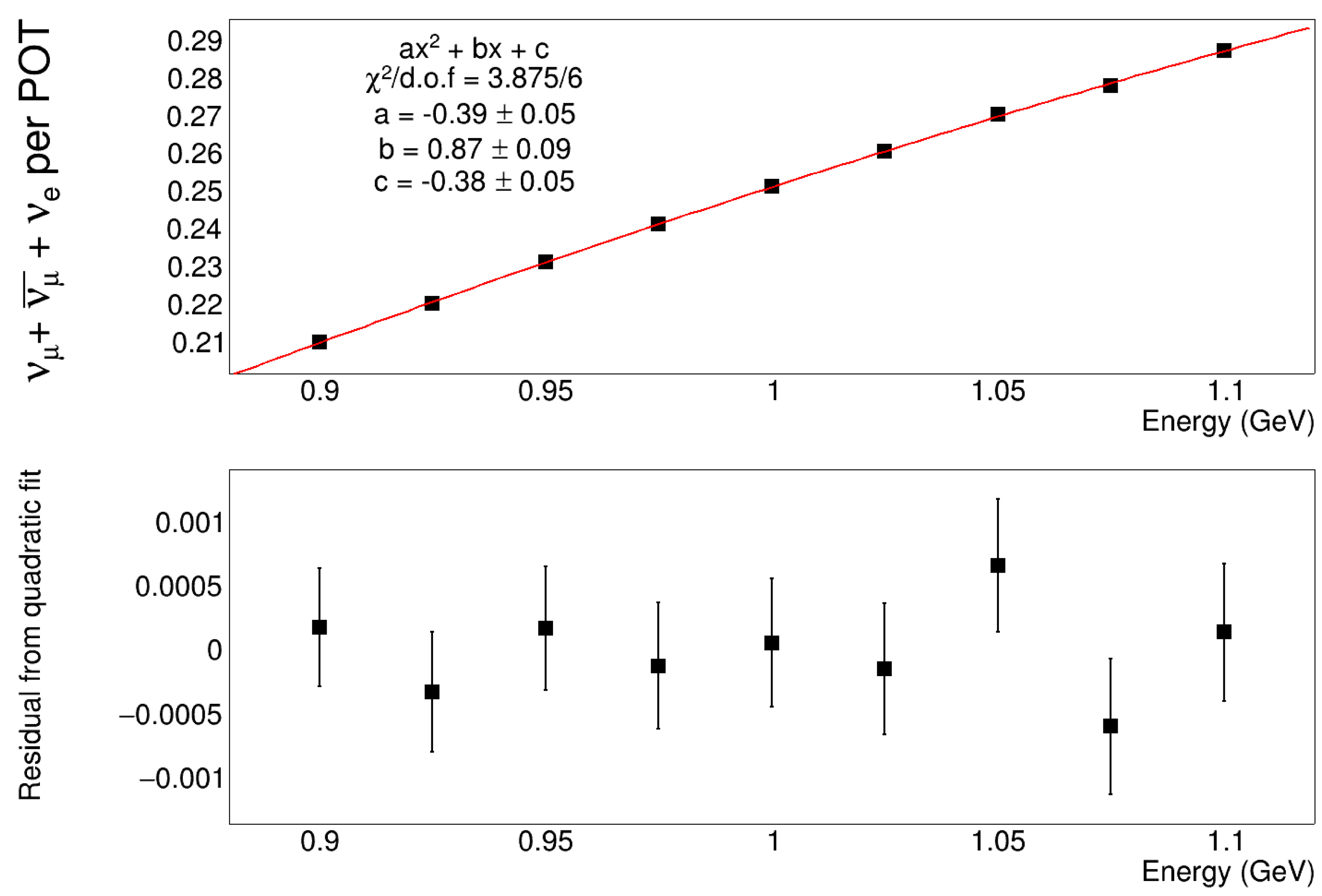
SNS neutrino production from proton beam

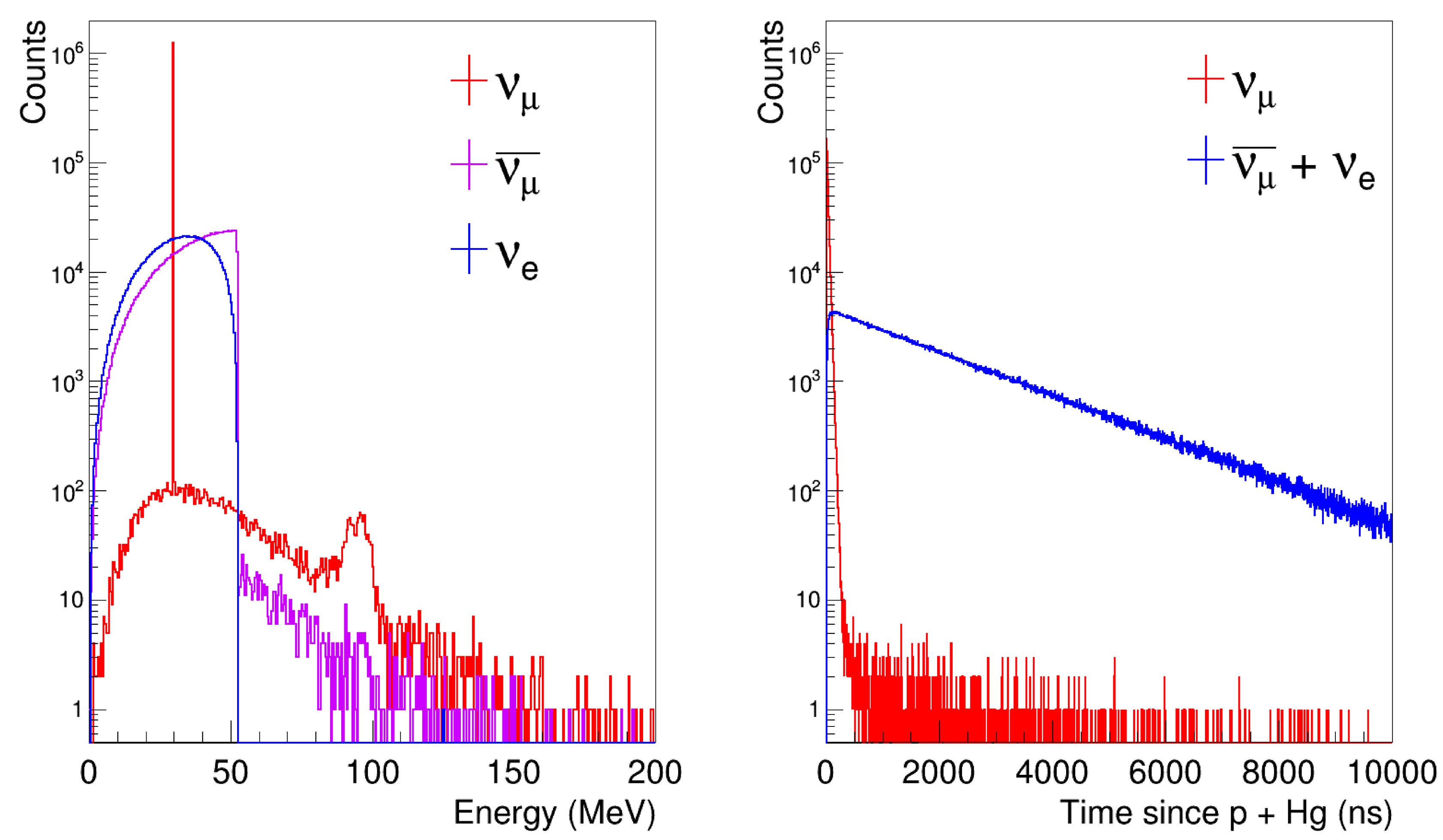


Neutrino flux and varying beam energy



For 1.0 GeV protons and 8.7×10^{15} POT per second, we calculate a neutrino flux of 4.3×10^{7} neutrinos/cm^2/s at 20 m from the Hg target [4].

Neutrino spectra in all space, 1m from target



References

[1] D. Akimov *et al.*, "Observation of coherent elastic neutrino-nucleus scattering," *Science*, vol. 357, 2017.

[2] S. Agostinelli *et al.*, "GEANT4: A Simulation toolkit," *Nucl. Instrum. Meth.*, vol. A506, pp. 250–303, 2003.

[3] D. Rimal, M. McIntyre, and H. Ray, "SNS Neutrino Flux Simulation: Technical Note," 2015.

[4] D. Akimov *et al.*, "COHERENT 2018 at the Spallation Neutron Source." arXiv:1803.09183v2, 2018.