Reactor Neutrino Calculations with CONFLUX

Anosh Irani

Graduate Student, Illinois Institute of Technology

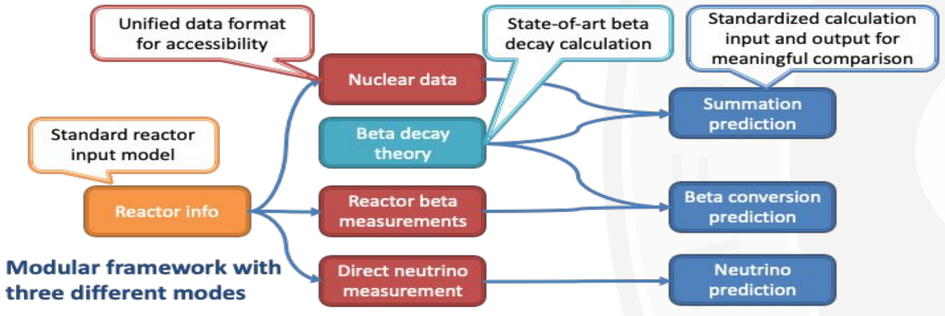
Xianyi Zhang[1], Nathaniel Bowden[1], Bryce Littlejohn[2], Sandra Bogetic[3], Leendert Hayen[4], Patrick Huber[5], Bernadette Cogswell[5]

[1]Lawrence Livermore National Lab, [2]Illinois Institute of Technology, [3]University of Tennessee Knoxville, [4]North Carolina State University, [5]Virginia Tech

Introduction and Motivation

- Antineutrino flux measurements can be used to observe reactor activity and composition for safeguards purposes.
- Accurate neutrino source term predictions are crucial to interpret these measurements.
- Past predictions utilize a variety of different methods, data sets, and assumptions, making direct comparisons between models difficult.
- CONFLUX (Calculation of Neutrino FLUX) is a reactor source term modeling software package that aims to standardize reactor neutrino flux calculations.

Technical Approach

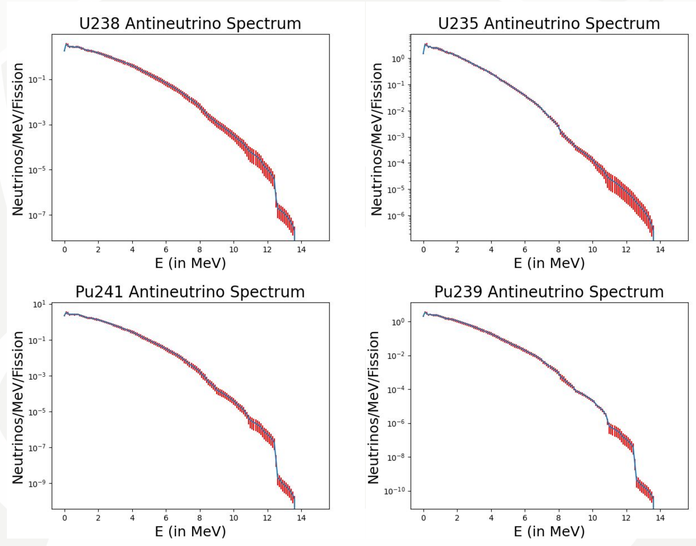


Above: framework workflow

- CONFLUX is modular, has flexible inputs/outputs, is written in python for ease of use, and can make direct cross-mode comparisons.
- CONFLUX can carry out 3 different modes of calculation: Summation, Beta-Conversion, and Direct Neutrino Measurement.
- Summation: Mode adds the spectral shape and %-contribution of all the daughter particles together
- Beta-Conversion: Mode takes the Beta spectrum, creates virtual Beta branches, and converts them into an anti-neutrino spectrum
- Direct Neutrino Measurement(planned): Mode takes direct reactor measurements, and extrapolates them to new reactor configurations

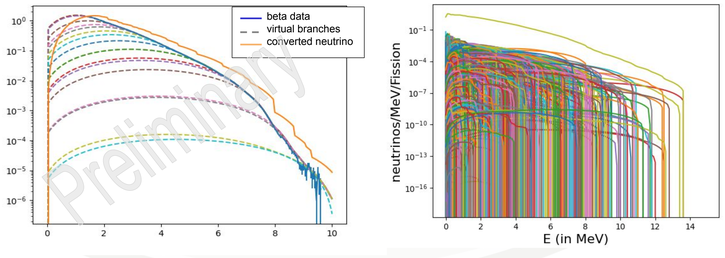
Results

- The CONFLUX framework is designed to allow straightforward inclusion of new nuclear data; included by default are ENDF/JEFF (fission yields), and ENSDF (beta decay) databases
- CONFLUX is packaged with the most up to date beta theory engine - **Beta Spectrum Generator**



Above: sample of four isotope spectra along with fission product uncertainty only

- Uncertainty calculation combines updated **fission fraction uncertainties** (corr), **constrained modeling uncertainties** (uncorr), and **beta branching** (corr) and **FPY uncertainties** (corr) to create more precise error calculations



Far Left: Conversion example with U-235 beta spectrum
Left: Summation example with U-235 beta spectrum, total spectrum in yellow

- Different modes of calculation allow for the testing of different theories, or as verification to measured spectra.

Mission Relevance

- Our work helps develop new detection methodologies relevant to NNSA's non-proliferation responsibilities.
- Our source term prediction tool is broadly applicable to all neutrino monitoring use-cases: far-field vs. near field, explosion vs. reactor, maritime vs. power reactors, etc.
- Given the substantial cost of neutrino-based prototypes and demonstrators, use case modeling, with versatile source terms, is a crucial piece for demonstrating the utility of neutrino-based methods.

MTV Impact

- MTV Support has enabled collaboration with LLNL.
- MTV provides new venues for gauging community needs/responses (like this meeting!).

Next Steps

- Implementation of direct neutrino measurement mode.

This work was funded in-part by the Consortium for Monitoring, Technology, and Verification under DOE-NNSA award number DE-NA0003920