Reactor Neutrino Spectrum Prediction: Nuclear Data Impacts and Interplays

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On behalf of the CONFLUX project (IIT, LLNL, UT, VT)

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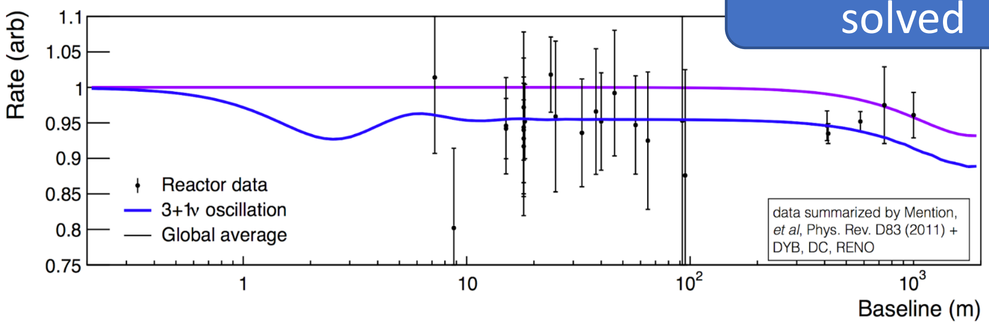
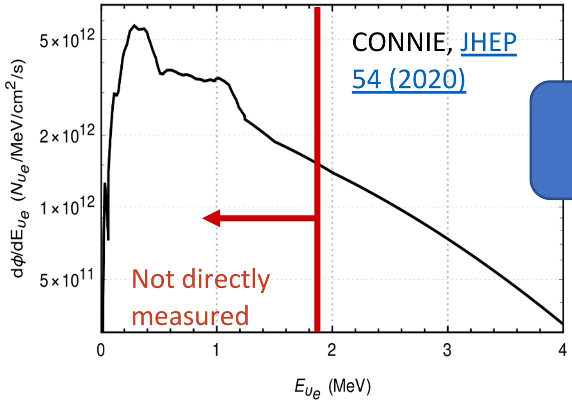
Motivations

- **Scientific and Application needs:**
  - Reactor antineutrino anomaly.
  - Reactor CEvNS flux prediction.
  - Predictions for reactor monitoring, e.g. advanced reactors.

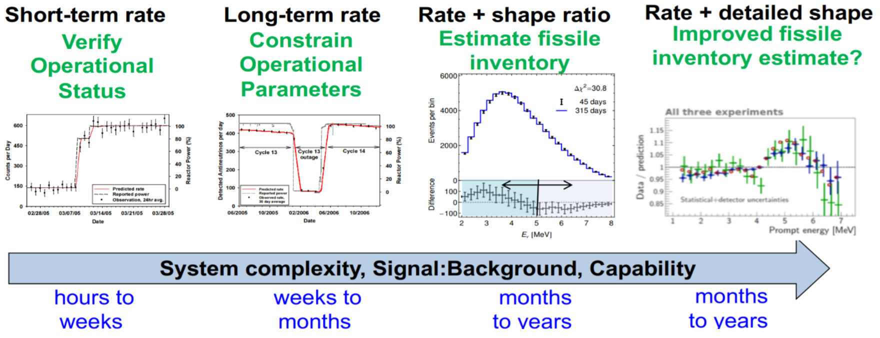
- **Structural motivations:**
  - Modern neutrino flux prediction (vs 10-40 yr-old works).
  - Build and maintain publicly available tool – with modularity and completeness.
  - Provide standard and accessible structures for full documentation of prediction inputs, facilitating comparisons and reproduction.
  - Provide standard inputs, e.g. reactor evolution & nuclear data, to lower 'barrier to entry' for neutrino community.

RAA to be solved





Expand the energy range

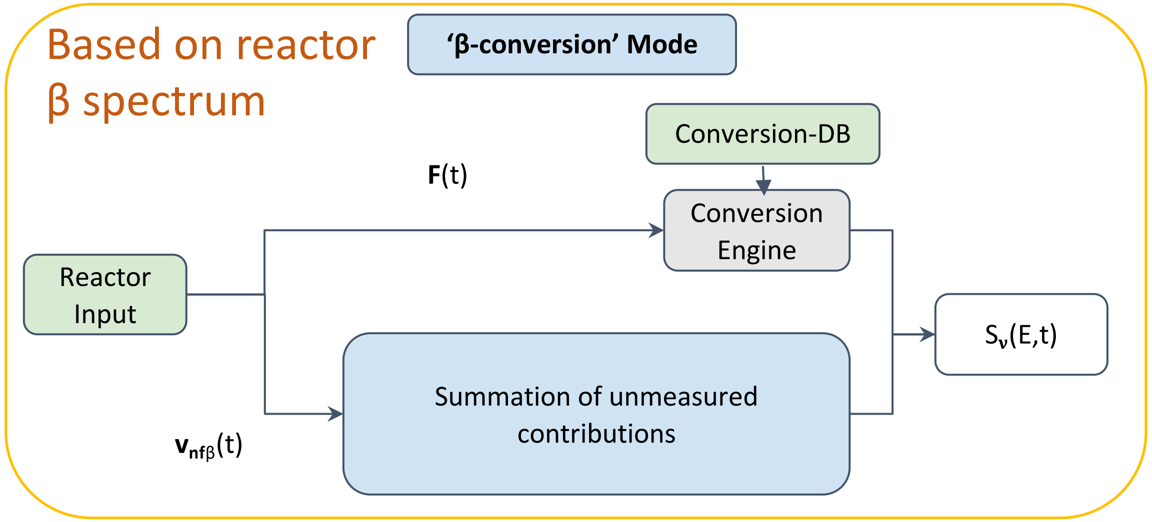


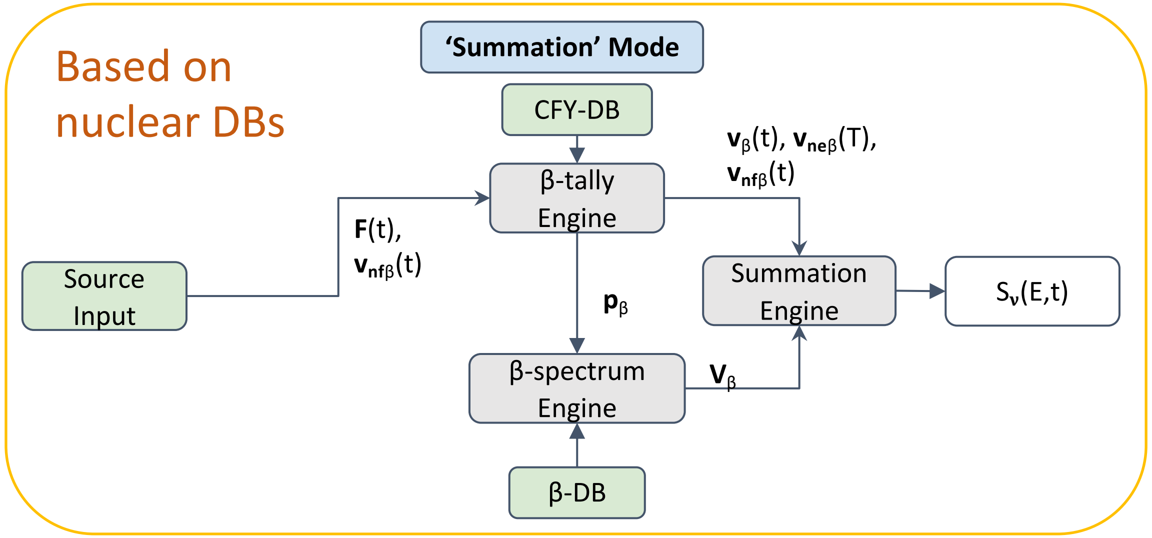
Bowden (2019)

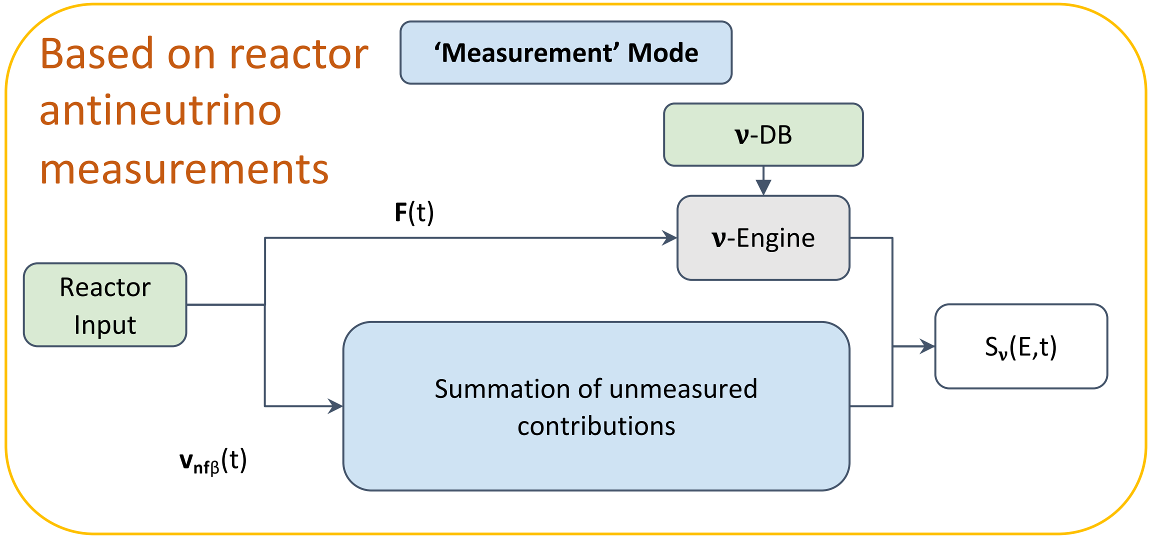
Reactor model for non-proliferation

CONFLUX - Calculation Of Neutrino FLUX

- Prediction with three different modes.
- Allows analyzers to input time dependent reactor models/compositions, including fission isotopes and non-fission contributions.
- DBs are saved in xml formats for accessibility.
- Summation is commonly used to account unmeasured isotopic contributions.

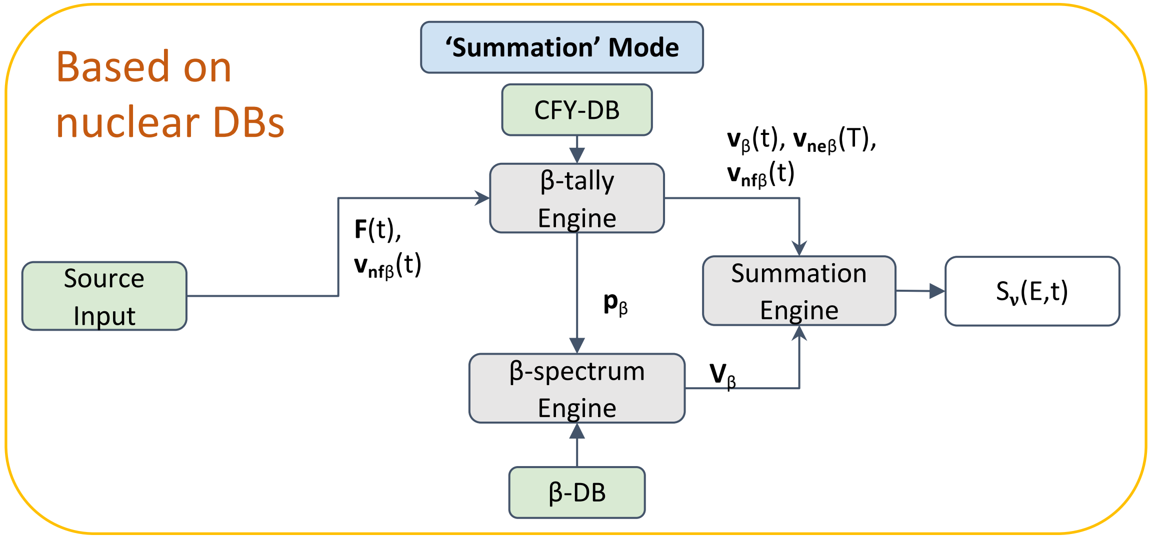






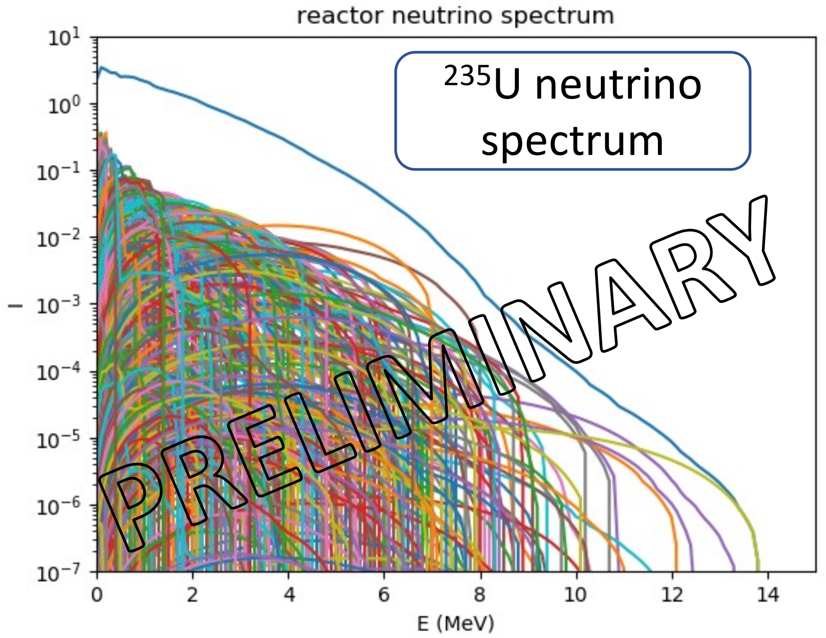
Current Focus

- Summation code under development, for it is common components for three modes
  - Inputs: time dependent reactor compositions (measurement or simulation), fission yield and beta-decay databases
  - Process: fission yields fractions, beta spectra calculations
  - Output: spectrum, flux
- Built a series readable databases from latest ENDF and ENDSF.
- Study the fidelity of reactor simulation needed for reactor neutrino calculation.



Difference with Past Works

- Flexible and time dependent reactor model.
- Full energy range (< 1.8 MeV included for CEvNS and BSM measurements).
- Use of modern databases.
- Cross-mode comparison in single package.



Needs from Nuclear Data

- Decay information of missing branches:
  - Roughly 6% of beta decay branches missing.
  - Unknown impact in the below IBD range.
- Result of pandemonium effect:
  - Biased branching fractions.
- Correlated uncertainty:
  - Correlation among fission yields needs to be accounted.
  - Program needs to calculate correlated uncertainty

Contribute to the Nuclear Data Community

- Cross-database comparisons can:
  - Investigate the difference between ENDF and JEFF.
- Cross-mode comparison in CONFLUX, or compare summation to experiments:
  - Search for deviations to prioritize beta decay measurements to be revisited.
- Support and combine the analysis among neutrino measurement

Summary

- Reactor neutrino prediction is essential to particle physics research, and application of neutrino for nuclear engineering.
- A new framework of reactor neutrino flux prediction - CONFLUX.
- All neutrino flux calculation modes relies on some degrees of summations based on nuclear DBs.
- Resolving missing branches, biases, and correlations of branch fractions are important to improve the reactor neutrino prediction.
- Precise data to calculation comparisons and cross-database comparisons of neutrino flux are important to pinpoint deviations that need more investigations.

Team

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