NF06: Neutrino Interaction Cross-Sections Topical Group

Jonathan Asaadi(jonathan.asaadi@gmail.com), Baha Balantekin (baha@physics.wisc.edu),
Kendall Mahn (mahn@msu.edu), Jason Newby (newbyrj@ornl.gov)

And Much thanks to our Early Career members:
Steve Gardiner (gardiner@fnal.gov), Tanaz Mohayai (mtanaz@fnal.gov)
Vishvas Pandey (vishvaspandey@gmail.com), Jacob Zettlemoyer (jzettle@fnal.gov)

Primary questions to be answered in the report:

- What are the neutrino cross sections needed to meet the needs of the neutrino experimental and theoretical community in the next decade?

- What are the facilities, neutrino sources, detector technologies, computational tools, theoretical input, and event generators required to make those measurements?

White Papers status

Electron Scattering Workshop (Dec 2020) https://indico.fnal.gov/event/46620/

- Define the role of electron scattering data and collate the run plans of various efforts for users to compare/contrast. Included perspectives from nuclear and astro physics of broad interest.
- Whitepaper outline based on the workshop - *see backup* - *contact Kendall + Vishvas to join!*

Neutrino Scattering on Hydrogen and Deuterium

- Define the status and possible options for future H/D measurements with neutrino beams
- Whitepaper formed from LOI, *contact Richard Hill (richard.hill@uky.edu) and Tom Junk (trj@fnal.gov) to join! See backup slides*

White Papers status, cont'd

NF06 Contribution to Theory Workshop in August 2021

- Theory white paper underway - *contact Saori Pastore (saori.pastore@gmail.com) for details*

Soliciting other possible white papers - contact us with your ideas!

- In contact with community groups such as NuSTEC
- Other papers may be on specific programs (SNS, fixed target at FNAL) or topics (tau neutrinos)

Planned Workshops

Low Energy Neutrino Workshop (Planned for Nov 2021)

- Explore connections between Low Energy Neutrino Nucleus scattering physics and corresponding electron-nucleus scattering
  - CEvNS, 10s of MeV inelastic nu scattering, kaon-decay at rest, ...
  - Parity Violating Electron Scattering, low energy electron scattering
  - Needs for DUNE LE/SN program
- Workshop will define scope of Whitepaper, some content will be included in electron scattering WP + CEvNS paper

Generator Workshop (Planning for Nov 2021)

- Discussion-based, will be survey driven
- Will discuss a white paper, which may be a reflection of current status, challenges

Backup

Snowmass Measurements White Paper: Neutrino Scattering on Hydrogen and Deuterium

Letter of Interest:

https://www.snowmass21.org/docs/files/summaries/NF/SNOWMASS21-NF6_NF3-TF11_TF5_LauraFields_RichardHill_TomJunk-165.pdf

Authors of the LOI:

Luis Alvarez-Ruso, Leo Bellantoni, Alan Bross,
Linda Cremonesi, Kirsty Duffy, Steven Dytman, Laura Fields,
Diego González-Díaz, Mikhail Gorshteyn, Richard Hill,
Thomas Junk, Huey-Wen Lin, Xianguo Lu, Jorge Morfín, Jonathan Paley,
Vishvas Pandey, Gil Paz, Roberto Petti, Ryan Plestid,
Bryan Ramson, Rederico Sanchez Nieto, and Oleksandr Tomalak

More authors are welcome!

Motivation for Better Neutrino on Hydrogen and Deuterium Data

- Neutrino cross sections measured by the ANL, BNL, FNAL and BEBC bubble chambers provides an important basis for generators

- Scattering on hydrogen is unaffected by Fermi motion.

- Predictions of cross sections are theoretically clean – can use scattering to measure flux with less uncertainty than if we only had an argon or a carbon target.

- Uncertainties on ratios of neutrino to antineutrino cross sections are an important part of DUNE's error budget. Providing an anchor with hydrogen with a known ratio can reduce that.

- Deuterium provides neutron data with a particularly simple nucleus.

- Comparisons of cross sections with theoretical predictions (lattice) can open up tests for new physics -- anomalous couplings and interactions.

Hydrogen/Deuterium Experimental Options

1) Measure neutrino-H interactions using hydrocarbons in SAND with carbon target subtraction and transverse imbalance kinematics
    - low-cost
    - already one of the designs considered for SAND.
    - The eventual precision is not yet known
    - No measurements on D

2) Put a H/D-rich gas in ND-GAr
    - We'd have to build ND-GAr
    - The gas would have to be a mixture with other elements
    - pure H2/D2 is not permitted for safety
    - may sacrifice GAr running for the H2/D2-rich gas running

Hydrogen/Deuterium Experimental Options

3) Build another hall upstream of the LBNF near detector hall and install a bubble chamber
   - Need and auxiliary calorimeters and muon detectors
   - Expensive, but gives us a lot of physics reach

4) Build a new hall on the surface at the near site -- install a bubble chamber and auxiliary detectors
   - Cheaper than going underground
   - Lower flux off-axis
   - Not the same energy spectrum sent to the Far Detector

5) Build a H2/D2 target in the Booster Neutrino Beam
   - 15 Hz beam timing format not conducive to bubble chamber operation
   - lower-energy beam
   - Less expensive
   - Can do this any time

Hydrogen/Deuterium Experimental Options

6) Build a polarized H2/D2 target/detector

- Existing polarized targets for electron and proton scattering are much smaller than is needed for neutrino measurements.
- Measurements are exciting and as yet untouched.
- Need low temperatures, high B field
- Dynamic Nuclear Polarization (DNP) a common technique
- Need the target and detector to be integrated
  due to short, highly-curved tracks
- Likely need a new hall to make one big enough.

Electron scattering white paper outline

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