

Long term physics plan

DUNE

SLAC neutrino group
Future planning 2024

What physics are we interested in DUNE

- Neutrino oscillation: mass ordering, δ_{CP} ...
 - Accelerator neutrinos
 - Atmospheric neutrinos
 - Sterile neutrino
- MeV-scale astroparticle
 - Supernova neutrino
 - Solar neutrinos
- Exotic physics
 - Cosmogenic sources (FD only)
 - Rare processes in FD
 - Beam produced exotic particles (ND only)

- DUNE detectors we are involved in: DUNE ND-LAr, TMS, FD?

DUNE Far Detector Physics (non-beam)

Atmospheric neutrino oscillation measurements, search for BSM

Timeline & Milestones:

- First atmospheric neutrino oscillation measurement with full simulation+reconstruction chain published in 2025
 - Pandora + state-of-art reconstruction + CVN-based classification
 - Use samples with FD1 (horizontal drift), 1x2x6 APA
 - Possibly a reconstruction-oriented paper and a measurement with sub-GeV neutrinos (CP-violation)
- First BSM search with full simulation+reconstruction chain, boosted dark matter, posted on arXiv (hopefully) in the end of 2024 and published in 2025
- Boosted axion search published in 2025
- Yun-Tse planning to step down from the A&E convenership around this time
 - Will focus on supernova neutrino and exotic physics (low-energy physics group)
- Search for proton decays - publication timeline TBD
- Publication beyond 2025: more ML-based reconstruction and selection for atmospheric neutrinos, ν_τ measurements, search for neutron-antineutron transformation, data management studies, t_0 studies, samples with FD2 (vertical drift) and/or with the entire module, etc.

DUNE Far Detector Physics (non-beam)

Challenges

- Human resources, performances of reconstruction algorithms
- Systematic uncertainties, especially for the phase space not common with the LBL analyses; e.g. cross section at neutrino energy $> 10\text{GeV}$, neutrino flux

Opportunities for future engagements

- Atmospheric neutrino oscillation measurements expected to be the first DUNE physics measurement
- SPINE & ML-based selection
- Physics in sub-GeV regime

Physics with DUNE ND w/TMS

- “Cross-sections”
 - Parton Density Functions
 - Strange sea near charm threshold (note: some measurements show that the strange sea is actually larger than the up/down sea. This could sort this out)
 - Charm and anticharm have different thresholds at these Q^2 's. That complicates things, but may be an advantage in sorting this out.

Physics with DUNE ND w/TMS 2

- Nuclear A dependence
 - We can compare interactions on argon (ND-LAr), iron (TMS only) and possibly air (between the two).
 - A half meter of air gives us 1 event/minute or so.
 - We can think about placing targets in the air gap as well
 - This is part of SAND's program - but with very different systematics
 - We only need to measure ratios, we can restrict our analysis to CC events and can use TMS track length (with a small ND-LAr correction) to compare the samples to reduce systematics.
- Exotica
 - The analyses assuming ND-GAr really should be redone assuming TMS
 - Tom likes the idea of a tachyon search (even though there are no tachyons)

Do we want to do accelerator neutrino oscillation?

- Yes?
- What about PRISM?
 - It's a very interesting oscillation analysis idea with some technical aspects we can explore
 - The ND to FD flux spectrum mapping
 - The ND to FD detector response mapping
 - We are heavily involved in ND project
 - To some degree, we are familiar with ND-LAr and TMS(?) hardware and software
 - Not many people actively working on PRISM
 - Hiro came up with the idea?
- What about systematic work for oscillation measurement?
 - A looooooot to do until a mature analysis
 - Detector, neutrino interactions
 - See yesterday's talk

From 2x2 to ND-LAr

- 2x2 measurements: ν_e , pion production, neutron recoil etc
- Technology demonstration:
 - Charge-light matching?
 - Neutron recoil?
 - ν_e selection
- Transfer from one of the leading institutes for 2x2 to one of the leading institutes for ND-LAr
 - Is it something people are interested in?
 - What is required?

More

- [From now to ~2030] Supporting experiments: detector tests, beam tests (hadron experiments; I don't think any neutrino experiments will be running after 2x2 and SBN)
- Is the DUNE physics program appealing enough for the group to go on another decade?
- What are our main physics focuses on DUNE?
- Are there other experiments/physics topics people are interested in working on?