

Neutrino Physics Frontier

NF01: Neutrino Oscillations

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NF01: Neutrino Oscillations

- ◆ Probes of the six standard oscillation parameters using available and new sources; natural and artificial.
- ◆ Extensions to BSM physics which may impact or be observable through oscillations

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} 1 & & \\ & c_{23} & s_{23} \\ & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & & s_{13}e^{-i\delta} \\ & 1 & \\ -s_{13}e^{i\delta} & & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & \\ -s_{12} & c_{12} & \\ & & 1 \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

$$P_{\alpha\beta} = \sin^2(2\theta) \sin^2\left(1.27 \Delta m^2 [\text{eV}^2] \frac{L [\text{km}]}{E [\text{GeV}]}\right)$$

$$|\Delta m_{32}^2| \equiv |m_3^2 - m_2^2| \simeq 2 \times 10^{-3} \text{ eV}^2$$

$$\Delta m_{31}^2 \simeq \Delta m_{32}^2$$

$$\Delta m_{21}^2 \simeq 8 \times 10^{-5} \text{ eV}^2$$

$$\nu_\mu \rightarrow \nu_\mu$$

$$\nu_\mu \rightarrow \nu_\tau$$

atmospheric and
long baseline

$$\nu_e \rightarrow \nu_e$$

$$\nu_\mu \rightarrow \nu_e$$

reactor and
long baseline

$$\nu_e \rightarrow \nu_e$$

$$\nu_e \rightarrow \nu_\mu + \nu_\tau$$

solar and
reactor

- ◆ Questions: Mass ordering, Nature of ν_3 - θ_{23} octant, Is CP violated?
- ◆ Precision: Is there an underlying order to these parameters? Is there more to this picture?

NF01: Neutrino Oscillations

Workshops throughout the fall

- We have planned a series of “mini-workshops” throughout the fall to collect community input. These are 90 minute programs consisting of ~60 minutes of presentations and 30 minutes of Q&A.
- We are organizing these around three approximate time-scales:
 - “Near term” program (<2030) that we expect to carry us through this decade and set the stage for the future program.
 - “Mid term” (2030-2040) which we expect to generate results in the next decade
 - “Long term” (>2040) which we expect to generate results after the next decade.

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Letters of Intent

- We are tagged as primary group on 13 LOIs
- We are tagged as secondary on another 64 LOIs
- Assignments look good to us, but two questions:
 - **JUNO LOI (NF034)** has been assigned to NF04 (natural sources). Perhaps NF01 is a better assignment?
 - **Physics Opportunities with ANNIE (NF139)** has been assigned to us. Perhaps NF06 (cross-sections) is a better match?

NF01: Primary LOIs

Capabilities of the current program

The NOvA Physics Program through 2025

Expected Final Sensitivity of the NOvA Experiment to 3-Flavor Neutrino Oscillations

T2K Experiment: future plans and capabilities

Development of a joint oscillation analysis by the NOvA and T2K collaborations

Capabilities of future program

Neutrino oscillations with IceCube-DeepCore and the IceCube Upgrade

Long-Baseline Physics in DUNE

Atmospheric $\nu\tau$ Appearance in the Deep Underground Neutrino Experiment

The Hyper-Kamiokande Experiment

Extensions of / Additions to the future program

Interest to capitalize on the Long Baseline Neutrino Facility (LBNF) investment

Long-Baseline Neutrinos at THEIA

Theory/pheno of neutrino oscillations

Direct Probes of the Matter Effect in Neutrino Oscillations

Role of higher order maxima of oscillation probabilities at long baseline neutrino experiments

Supporting measurements

Physics Opportunities in ANNIE

Overlap of NF01 with other working groups

	NF02 Steriles	NF03 BSM	NF04 Natural Sources	NF05 Properties	NF06 Cross- sections	NF07 Applications	TF11 Theory	NF09 Artificial Sources	NF10 Detectors
NF01 = p NF## = x	6	8	4	0	4	0	4	7	5
NF01 = x NF## = p	10	5	13	1	6	2	5	2	7
NF01 = x NF## = x	31	43	17	19	23	10	32	22	33

- Some themes of the overlaps:
 - Sterile neutrinos searches / short baseline oscillations
 - Cross-section measurements which support oscillation measurements
 - Studies of oscillations involving tau neutrinos
 - New beam facilities
- Some gaps we noticed:
 - No mentions of beta beams for long baseline physics
 - No mentions of neutrino factories for long baseline physics

Possible themes for white papers

- Theory motivation for precision oscillation measurements. Possibly joint with TF11
- DUNE “4th module” and other ideas. Possibly joint with NF04, NF10
- Cross-section measurements to support oscillations. Possibly joint with NF06
- Roles of near detectors in oscillation experiments.
- Capabilities of new sources. Possibly joint with NF09.

Goal for CMP is to see which of these have traction,