

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?

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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 *(as of 9A, 16 Sept. 2020)*

- We are tagged as primary group on 16 LOIs
- We are tagged as secondary on another 61 LOIs
- Assignments look good to us. Some bookkeeping:
 - *Expected Final Sensitivity of the NOvA Experiment to 3-Flavor Neutrino Oscillations (NF087/088)* seems to be duplicated
 - *JUNO LOI (NF034)* has been assigned to NF04 (natural sources, presumably due to its solar neutrino and geo-neutrinos program). However, perhaps NF01 is a better assignment as primary mission is reactor neutrino measurements?

NF01: Primary LOIs

Capabilities of the current program	T2K Experiment: future plans and capabilities
	The NOvA Physics Program through 2025
	Expected Final Sensitivity of the NOvA Experiment to 3-Flavor Neutrino Oscillations
	Development of a joint oscillation analysis by the NOvA and T2K collaborations
	Neutrino oscillations with IceCube-DeepCore and the IceCube Upgrade
	BSM Neutrino Oscillation Searches with 1-100 TeV Atmospheric Nu's at IceCube
Capabilities of future program	The Hyper-Kamiokande Experiment
	Long-Baseline Physics in DUNE
	Atmospheric $\nu \tau$ Appearance in the Deep Underground Neutrino Experiment
	$\nu\tau$ Reconstruction in the Deep Underground Neutrino Experiment
	Tau Neutrino Physics
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	Role of higher order maxima of oscillation prob's at long baseline neutrino experiments
	Direct Probes of the Matter Effect in Neutrino Oscillations
	Computing Neutrino Oscillations in Matter Efficiently

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	11	12	6	1	5	1	9	10	7
NF01 = x NF## = p	9	5	14	1	8	2	5	4	8
NF01 = x NF## = x	27	38	13	18	20	10	26	18	30

- 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 long baseline physics using beta beams
 - No mentions of long baseline physics using neutrino factories

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