Physics Working Group Status and Charge

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IDS-NF Plenary Meeting, Arlington, VA, Oct 17–19, 2011

‡Fermilab



Standard 3-flavor oscillations

- Optimization for small θ_{13}
- Optimization for large θ_{13}

Near detector physics

- Cross section measurements
- Electroweak precision measurements

ν_{τ} contamination

New physics in the neutrino sector

- Sterile neutrinos
- New interactions
- Time-of-flight measurements



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Oscillation physics — Small θ_{13}

- Physics and optimization well understood
- Sensitivity to θ_{13} , mass hierarchy, CPV down to $\sin^2 2\theta_{13} \sim \text{few} \times 10^{-5}$
- Parameter correlations and degenerate solutions are a problem
 - Can be controlled by using two detectors @ L₁ ~ 4000 km, L₂ ~ 7500 km
- Optimum muon energy: 25 GeV
- Neutrino factory is superior to all other proposed experiments (high-γ β-beam could be competitive for some measurements)
- Things to do:
 - Mostly fine-tuning

• New ideas? Bimagic baseline?



Oscillation physics — Large θ_{13}

After T2K+MINOS, this may be the relevant case

• Double Chooz + Daya Bay + Reno can confirm this soon (in time for RDR) If θ_{13} is large ...

- CPV measurement suffers from background due to CP conserving ν_{μ} appearance \rightarrow sensitivity drops
- Low-E NuFact (LENF) seems to be best option
- Great progress in LENF studies over past couple of years Things to do:
 - Careful comparison of LENF to other experiments (β-beam, WBB, ...)



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Cross section measurements

- Questions to be answered
 - What are the next steps after Minerva?
 - What precision can be reached (systematic uncertainties in near detectors)?
 - Near detector optimization for x-section measurements?
 - What can we learn from precise x-section measurements (about neutrino physics, hadron physics, nuclear physics)?

Other near detector physics

- Precision measurement of $\sin^2 \theta_W$
- Parton distribution functions
- Other ideasw?

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• Effect of muons from $\nu_e, \nu_\mu \rightarrow \nu_\tau \rightarrow \tau \rightarrow \mu$ can be relavant in appearance and disappearance measurements

Things to do:

- Investigate impact on LENF
- Investigate impact on New Physics searches
- Should be taken into account in all future simulations



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Sterile neutrinos

- Several inconclusive hints
 - LSND / MiniBooNE
 - Reactor anomaly
 - Gallium anomaly
- Global fits in 3 + 1 and 3 + 2 models have problems

 \rightarrow some (or all) of the hints, or some of the null results may be wrong

- Many ideas for testing these hints
 - New short baseline reactor experiments
 - Radioactive source experiments
 - New experiments with accelerators (extra ND for NO ν A, Dae δ alus, ...)
 - Very Low Energy Neutrino Factory (VLENF)
- We should discuss
 - Prospects and optimization of VLENF
 - Prospects of full NuFact in high E or low E configuration (some studies already exist)
- Any experiment to test the hints must have 5σ sensitivity



New neutrino interactions

- Small in MSSM, ADD, RS ...
- But could be unique winodw to light (≲ 1 GeV) new states
 - New matter effects mediated by light new particle can be very strong in low-E processes such as coherent forward scattering without violating constraints from high-E experiments
- Phenomenology of "non-standard interactions" well understood
- Sensitivity best at high E
- Are there ways to achieve sensitivity to $\epsilon < 10^{-3}$ (near detector?)



Time-of-flight measurements

The Phantom of the OPERA: ν_{μ} in OPERA detetced 60 ns (\sim 18 m) too early.

- Innumerable comments / ideas already:
 - Why did neutrinos from SN1987A arrive on time?
 - Spontaneous Lorentz-violation if neutrinos couple to a scalar condensate?
 - ► Effects should be mediated to electrons through loops (→ constraints)
 - ▶ New decay modes (e.g. $\nu \rightarrow \nu e^+ e^-$, modified pion decay kinematics
 - Are all particles except neutrinos subluminal due to a refractive index of unknown origin?
 - Are neutrinos tachyonic?
 - Extra-dimensional shortcuts for sterile neutrinos?
 - A mistake in modelling the shape and timing of the proton bunch?
- Can be tested by MINOS, T2K, NO ν A, LBNE, etc.
- If confirmed, profound implications for all areas of physics
- What can the neutrino factory say?
 - How to configure muon bunches for rime-of-flight measurement?
 - ► High statistics, long baseline → very precise?
 - Most sensitive to any effect related to Earth matter
 - ► Wide energy range accessible → investigate E dependence

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Summary of things to do

- Large θ_{13} : Fine-tuning
- Small θ₁₃: Comparatative study and optimization of LENF
- Cross section measurements: Establish physics case
- ν_{τ} contamination: Investigate impact on LENF and new physics searches
- Beyond the Standard Model:
 - Sterile neutrinos: Discuss performance of LENF and VLENF
 - New interactions: Discuss physics case (Light new particles?)
 - Time of flight measurements: What can a NuFact say?

Thank you!