ND design studies/worries

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This talk is a simple distillation of an email thread for discussion purposes.

Background

- ND workshop in March kicked off a process to specify a conceptual design of the ND for an end of year CDR
- With information and tools from NDTF, how do we define the needed features of the detector?
- What qualitative and quantitative studies are most important to determine the features?
- How do we do them?

Usure of my audience here. Many people know all this!

Before going on... an apology

- I was not on LBNE, like half of DUNE.
  - Steve Manly too.
- I do not know everything that was done and not done
- I don't even know everything that is/was done and not done on DUNE
  - <rant> lack of a decent unified document handling system exacerbates all this </rant>
- Please help correct me by citing studies and documents
  - A step beyond “this was studied” please. Pretty please?

“The analysis”

- We need some way of determining the effect of feature X on physics.
  - “physics”=delta-CP? We still agree?
- Concept is to comparing sensitivity with competing features X and X' by changing ND inputs
  - it is easy to let perfect be the enemy of good here, try to concentrate on the leading order effect of X vs X'
- NDTF had a procedure (VALOR fits) for doing “the analysis”
  - Ability to redo quickly in the near future?
  - Other technology? Critical to discuss this.
  - Example studies in this talk meant to drive discussion.
- Possible that the “the analysis” concept isn't right for all X vs X'
  - Clever ideas and shortcuts please?
  - Maybe NDTF outputs can be reinterpreted?

Magnetic field for muons?

- Do we need a B field for muons and if so what kind?
- Compare options, demonstrate physics consequences.
  - Full B field in vertex region as in ref design.
  - Downstream spectrometer, like MINOS ND (25deg angular acceptance for p>1GeV, similar q/p res.)
  - Range stack (no B, no charge ID, p via range for <5 GeV)
- Proposal: have default osc analysis, implement scenarios above, see how sensitivity changes.
  - *Discussion of tools & methods here?*
- Do FGT and gas TPC fail to work without vertex B?
  - PID and E reconstruction totally broken? Better off with just LAr or scint with HCAL?

We may all have a “gut feeling” here, but it's important to demonstrate the physics consequences since the B-field system could be very expensive and may dominate the design of the ND hall.

Magnetic field for electrons?

- Do we need a B field for electrons?
  - Assume means vertex B.
- Could can we live without charge ID for nue and nuebar?
  - Rerun analysis with unresolved nue+nuebar sample?

Another B field concern?

- Does having a B field with a LAr detector spoil an ND/FD systematics cancellation?
  - Maybe reconstruction efficiency for shorter tracks?
  - Hadronic system measurement?
- Can't we just turn the field off for a while?
- Energy reconstruction will be quite different in any case
  - Tracks & energy exiting the ND will be contained in FD
  - vise versa: FD will have side exiting muons that we probably(?) won't want to toss out.
- I am skeptical we would get obvious direct cancellation (ala MINOS and NOvA).
  - Cross-sections (modulo acceptance differences → want ND to be superset of FD) and “nuclear effects” much more likely.

ν e → ν e measurement

- Assuming ideal detector performance and reasonable statistics, what is the effect on physics?
  - Rerun the analysis w/o this information. If it doesn't matter we should not let it drive the requirements.
- Do something totally crude, like a 1 or 2 bin spectrum. Is it a killer?
- What are the detector requirements to get a good flux constraint?
  - E & θ resolution.
  - Local beam divergence and uncertainty on simulation of it.
  - If we need spectrum information, rerun the analysis with more modest performance.

See recent work by Chris Marshal in NDWG meetings

Missing pT information

- To what extent does this provide CC vs NC discrimination?
  - Preliminary studies (C Marshall) say not much?
  - What can “full kinematic” information (R Petti) do?
- Did the NDTF even use this information?
  - If not, didn't the physics performance look OK? Do we not believe it?
  - Can we define a simplified study which will quantify the impact on physics?
- CC coherent pion scattering kinematics can resolve local beam divergence
  - If $\nu\ e \rightarrow \nu\ e$ spectral info is needed and limited by divergence, then this would be worth a study.
  - Maybe a study with perfect reconstruction could demonstrate needed statistics?

FD vs FD analysis

- Question: To what extent do the highly correlated ND numu and nue samples reduce systematics due to
  - cross-sections / nuclear effects
  - energy resolutions
  - reconstruction efficiencies
- *To what extent can the FD go it alone?*
  - Imminent excommunication?
  - If the nuclear effects/cross-sections have a high degree of cancellation it could influence the need for Ar in an ND.
  - I am skeptical. but perhaps we can cheaply address this. Maybe the answer is already known.

Pileup

- General feeling that ND must have a fast tracking option? (FGT, scintillator)
  - Need studies to make this definitive
- How to deal with it in LAr/GAr tpc?
  - Can we run TPC at nominal intensity? If not, can we turn down the intensity by ~x10? How much exposure does this sacrifice?
- Effect of pileup on calorimetry? Especially γ.
  - I believe this will need to be looked at as we get more specific about a design since it depends critically on the size of the tracking volume, it's speed, what it's made of, and the material around the volume.

Closing thoughts and worries

- This talk wasn't comprehensive.
- There is a lot of NDTF work that I/we still need to digest.
- What is the short-term availability of VALOR? What replaces it, if anything?
- Questions of “framework”. Do we need to ensure there is one now?
- **People.**
  - We have a mix of relatively specific and not-so-specific studies that can be matched to groups with different capabilities.
  - Now is a good time to get involved.