DUNE Calibration WG Kick-off Meeting

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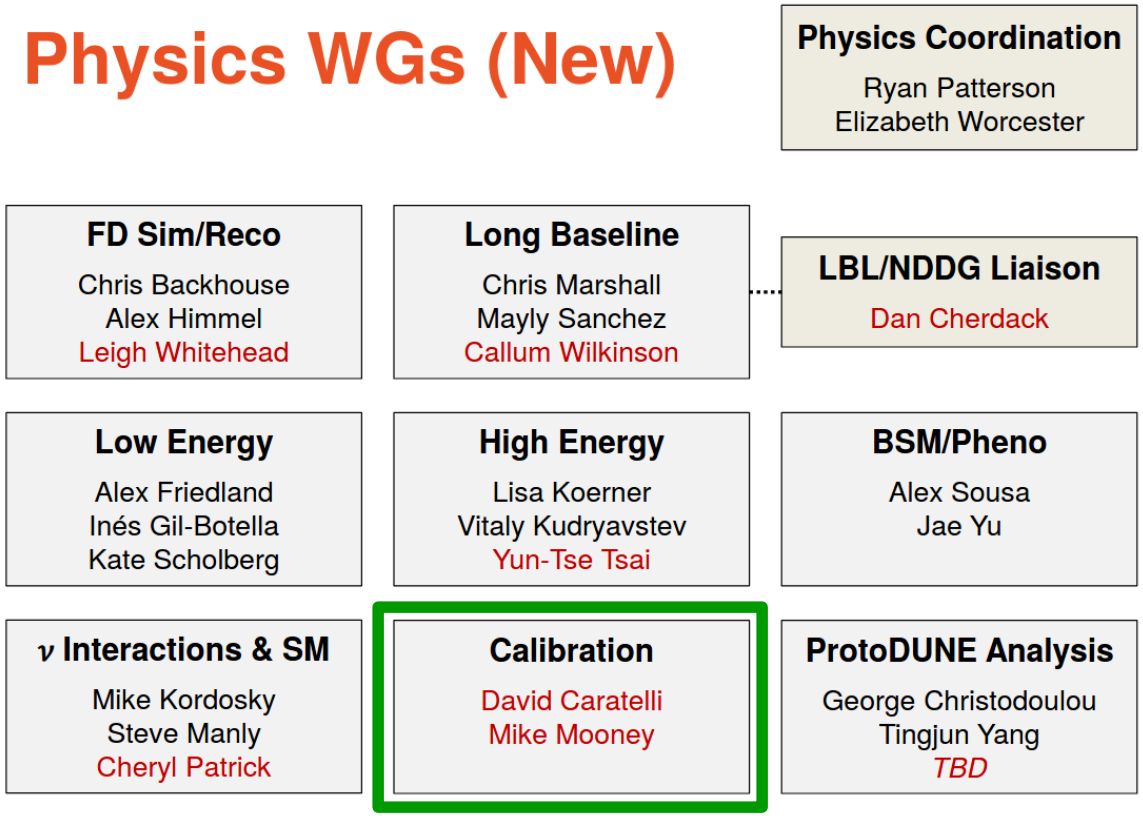
DUNE Calibration Working Group Meeting

January 10th, 2020

Introduction



R. Patterson
E. Worcester

- As announced at November collaboration call, Calibration WG is new working group in DUNE physics structure
  - Replaces Calibration Task Force, which has completed its scope; thanks to Sowjanya Gollapini and Kendall Mahn for their work!

Logistics

- WG mailing list: **dune-physics-calibration@fnal.gov**
  - Please sign up via FNAL LISTSERV if you haven't already
  - **Currently 63 members!**
  - Moving forward we will only use this mailing list to make meeting announcements
- Previously sent around a Doodle poll to WG mailing list members and also Calibration Task Force mailing list to schedule a meeting time
  - Meeting time: **2pm-3pm CT**
  - This will be a bi-weekly meeting
  - Unfortunately an afternoon meeting time, making it harder for non-US people to contribute
    - Please email David/Mike if you have concerns about this and we can try to find a solution

WG Goals

- Some preliminary thoughts about goals of the group (please give us your feedback/thoughts!):
  - (1) Develop strategy for low-level calibrations at DUNE
    - Electron lifetime measurement, electric field distortions, etc.
  - (2) Develop strategy for high-level calibrations, making use of "standard candles" to probe particle-level detector systematics
    - Use of Michel electrons, $\pi^0 \rightarrow \gamma\gamma$ decays, ^{39}Ar beta decays, etc.
  - (3) Evaluate impact on DUNE physics measurements/sensitivities
    - Includes LBL, SNB, BNV physics; in principle all DUNE physics
- Requires coordination with Calibration HW Consortium
  - What is the complementarity of dedicated calibration hardware and using nominal event data in accomplishing (1) and (2)?
- Communication with other physics WGs essential for (3)

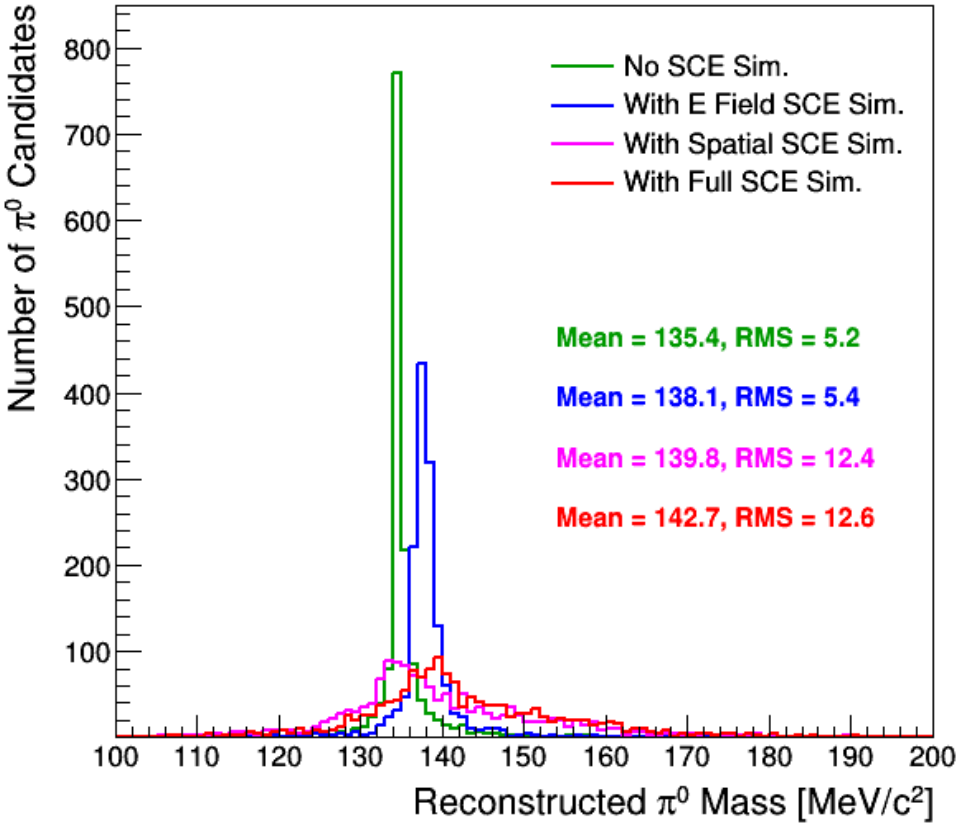
Low-level Calibrations

- Want to calibrate several low-level detector effects that impact particle reconstruction and particle energy scale
  - Electron lifetime – can we do a calibration with sufficient temporal/spatial precision? Can ^{39}Ar beta decays help here?
  - Electron-ion recombination – do we need to measure in-situ? Use measurements at ProtoDUNE? Other measurements (NEST)?
  - Space charge effects (SCE) – bigger deal at ProtoDUNEs, less so for ND/FD LArTPCs… but other electric field distortions may arise from e.g. partial HV failure? Also, SCE large in dual phase!
  - TPC noise, electronics gain, signal shape (field/electronics) – study with cosmic muons and/or ^{39}Ar? External measurements?
  - What about light-related calibrations? ND/FD differences? etc.
- Goal is **1%** for total energy scale bias allowance (to our knowledge, current LBL physics requirement)
  - Is it possible? Is it necessary? **Our task to investigate**

High-level Calibrations

- Also want to procure samples of "standard candles" to study particle-level quantities such as energy scale – examples:
  - Cosmic muons – many uses such as field distortions, signal shape, electron lifetime… but not many (~3000/day/10-kt); dramatically fewer stopping muons for detector studies (~30/day/10-kt)
  - Michel electrons – for low-energy electrons, but ~20/day/10-kt
  - $\pi^0 \rightarrow \gamma\gamma$ decays – handle on high-energy electrons, but will we have enough in the FD? Can/should we use sample at ProtoDUNEs?
  - Delta rays? Correlation between opening angle and energy for data-driven energy calibration handle?
  - ^{39}Ar beta decays – tons available for gain/lifetime/recombination studies, but do we need alternative trigger scheme to get enough?
- Again… goal is **1%** for total energy scale bias allowance (to our knowledge, current LBL physics requirement)
  - Is it possible? Is it necessary? **Our task to investigate**

Low-level + High-level



ProtoDUNE-SP study of SCE impact on π^0 mass by M. Mooney

- Low-level calibrations and high-level calibrations may have interplay – e.g. π^0 mass being impacted by electric field distortions (such as SCE) if not corrected!

Physics Sensitivity Impact

- Third goal is to work together with other physics WGs to determine impact of detector systematics on physics measurements and sensitivities
  - Detector calibrations impact **all** physics measurements at DUNE
- Loosely speaking, two items here:
  - Determine realistic values for e.g. energy scale bias/resolution uncertainties for use as inputs in calculating sensitivities
    - Consider two cases: **with** and **without** calibrations applied
  - Carry out sensitivity calculations specifically studying impact of detector systematics
- Likely the first item above is most appropriate for scope of Calibration WG
- Potentially can aid with second item (to be discussed)

DUNE TDR as Benchmark

Table 5.9: Uncertainties applied to the energy response of various particles. p_0, p_1, and p_2 correspond to the constant, square root, and inverse square root terms in the energy response parameterization given in Equation 5.12. All are treated as uncorrelated between the ND and FD.

Particle	p_0	p_1	p_2
all (except muons)	2%	1%	2%
μ (range)	2%	2%	2%
μ (curvature)	1%	1%	1%
p, $\pi^{\pm}$	5%	5%	5%
e, γ, π^0	2.5%	2.5%	2.5%
n	20%	30%	30%

$$E'_{rec} = E_{rec} \times (p_0 + p_1\sqrt{E_{rec}} + \frac{p_2}{\sqrt{E_{rec}}})$$

- We currently have estimates for particle-level energy response uncertainties (see Physics Volume of DUNE TDR), but need to better pin these down in the context of how (and how well) we perform calibrations – ProtoDUNEs will help!

WG Scope

- Still defining scope of WG; some preliminary thoughts here
  - Your input is welcome on this!
- Assuming we focus on both calibrations involving TPC and light collection system
- Closely follow calibrations at ProtoDUNEs; being done informally by Mike's current involvement, at least
  - Need to do this in order to test out, and evaluate, calibration strategies ahead of DUNE
- Include focus on ND as well as FD? Preliminary thought is that this is a good idea
  - A lot of synergy between FD calibrations and ND LArTPC calibrations
  - Less so for the other (non-LAr) ND subdetectors

BACKUP SLIDES