Calibration Task Force Update

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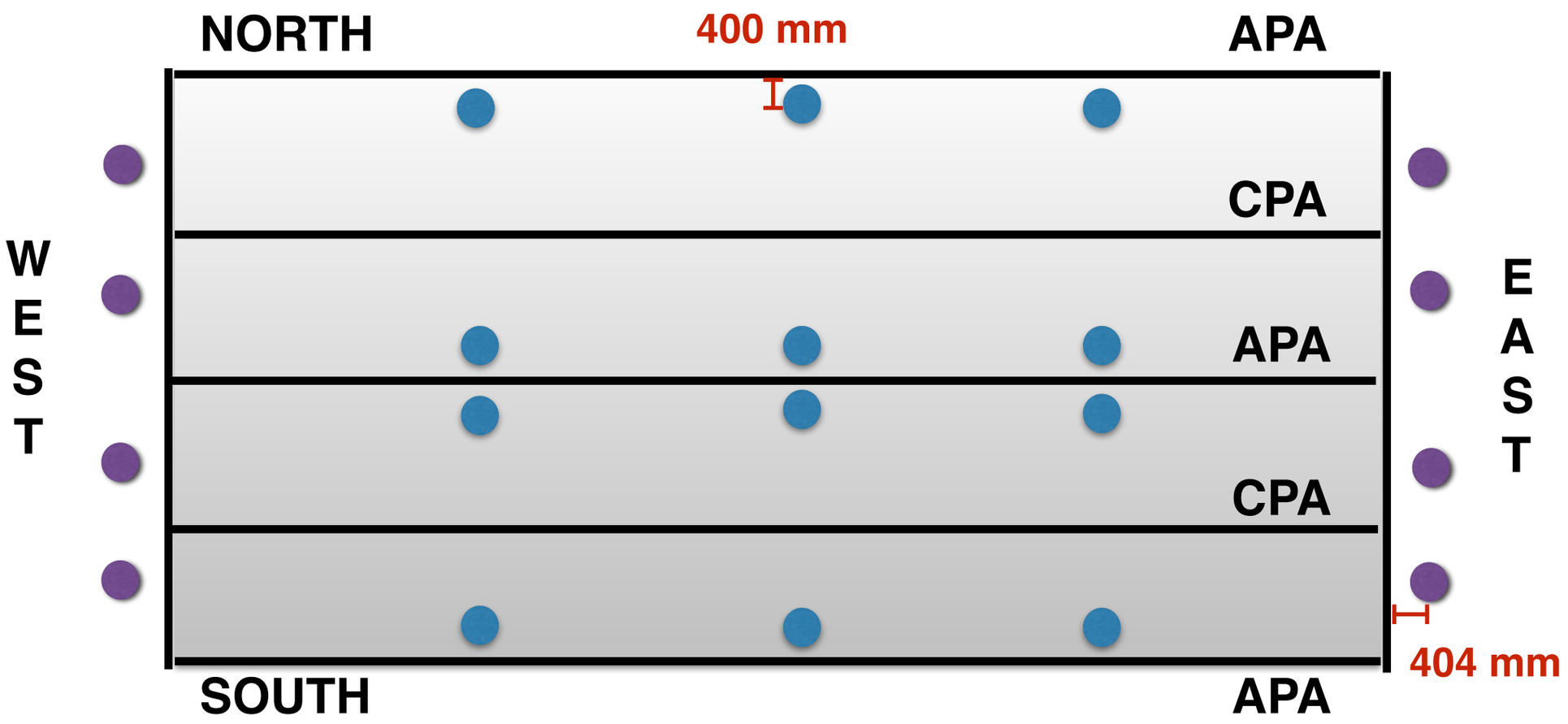
DUNE Monthly Collaboration Call
December 8, 2017

Join Calibration TF Meetings

- Subscribe to our mailing list: *"DUNE-CALIBRATION-TF"*
- We meet weekly (alternating times):
  - *Tuesdays, 8 to 9:30 am CT*
  - *Thursdays, 2 to 3:30 pm CT*
- Find us on Indico: *https://indico.fnal.gov/category/703/*
  - Under DUNE → Task Force Meetings → SP/DP Calibration
- Contact us if you would like to get involved:
  - *Conveners: Sowjanya (sgollapi@utk.edu); Kendall (mahn@pa.msu.edu)*
- If you are a calibration enthusiast, we want you there!

Calibration Feedthrough Status

Light blue: inside FC; Purple: outside FC; All ports on top of the TPC



- *All multi-purpose ports (Laser, Radioactive source etc.)*
- This updated FT proposal submitted in first week of November.
- Currently under discussions on implementation with the cryostat team

Calibrations @ DUNE Physics Week

- ***Goal:*** get more hands-on activity and recruit/engage more people for calibrations
    - While we weren't able to achieve a lot of hands-on part, DPW served as a good ***"conveners retreat"*** to brainstorm on how different physics groups should interact to achieve the goals for TDR
- Productive discussions on various topics
    - Calibrations in Technical Proposal & TDR
    - Calibrations decision making process
    - LBL+calibrations joint session
    - Reco/Sim+calibration joint session
- One hands-on activity — Alignment with Cosmics (T. Junk)

TDR Volumes

(https://indico.fnal.gov/event/15181/session/7/contribution/25/material/slides/0.pdf)

- Multiple volumes, each volume around 150 - 200 pages

- **Volumes**
  - Volume 1: Executive Summary
  - Volume 2: Physics
  - Volume 3: Single-Phase Far Detector: Overview
    - + sub-system volumes
  - Volume 4: Dual-Phase Far Detector: Overview
    - + sub-system volumes
  - CDRs: Computing and Near Detector

- Before DPW: Where does Calibration sit in these TDR volumes? What do we foresee for calibrations in the *Technical Proposal?*

Calibrations span broad

(probably easier to categorize this way for TDR purposes)

- *There is low level calibration* ***(More Detector related)***
  - E.g. detector validation; parameters for models; corrections etc.
    - Broadly, relating to TPC response and photon detector response. E.g. Electronics noise, wire response, channel gain, photon gain, PDS to TPC calibration,…
    - Electron lifetime (purity), recombination (E-field), space charge, other E-field distortions, alignment, drift velocity etc.
- *There is high-level calibration* ***(More Physics related)***
    - Standard candles for Physics. E.g. Michel electrons, Calibration with π^0 etc. Test models
    - What can calibration achieve for: Energy scale, Energy resolution, Particle ID efficiencies, Various particle responses (charged hadrons, neutrons,…)
    - What is the impact of calibration the physics program? (LBL, SN, etc)

Approach for Technical Proposal

(requires defining a calibration decision making process)

- In conjunction with collaboration input, develop a *separate section for "Calibration Strategy" in the Technical Proposal*
  - Outline the various physics arguments and provide an overview of the proposed calibration hardware.
  - State the intentions of the collaboration for calibration hardware systems (e.g. Laser, photon calibration etc.) along with strong physics motivations
- A calibration workshop planned (in March?) to converge on calibration strategy and hardware systems by the Technical Proposal timeline
- *Post Technical Proposal:* Develop the systems presented in the Technical Proposal into concrete proposal for the TDR.

Volume 3: FD-SP

Similar Structure for Volume 4: FD-DP

- **Volume 3: Single-Phase Far Detector: Overview**
  - Design Motivation
  - Cryostat and cryogenics
  - Overview of the Single-Phase Far Detector
  - ProtoDUNE-SP
  - Detector Performance

There will be a Calibration Strategy chapter here

- **Volume 3A: APAs**
- **Volume 3B: High Voltage System**
- **Volume 3C: TPC Electronics**
- **Volume 3D: Photon Detection System**
- **Volume 3E: DAQ**
- **Volume 3F: Slow Controls and Cryogenic Instrum.**
- **Volume 3G: Installation and Integration**

Details of the hardware will be presented in the corresponding consortium chapters of the TDR.

Volume 2: Physics TDR Structure

Current Outline

- Executive Summary
- Introduction to LBNF and DUNE
- Scientific Landscape
- Tools and methods employed
- Standard neutrino oscillation physics program
- GeV-scale non-accelerator physics program
- Supernova neutrino bursts and physics with low-energy neutrinos
- Precision physics with the near detector
- Additional opportunities for Beyond-Standard-Model physics
- Summary and conclusions

There will also be a section in the Physics Volume of the TDR discussing the physics-process based calibration measurements and the assumed systematic uncertainties that will be propagated to the physics sensitivities.

Calibration x Reco/Sim: Tools & Interfaces

(https://indico.fnal.gov/event/15181/session/7/contribution/27/material/slides/0.pdf)

Many Calibration quantities

TPC response model
- Argon ionization energy
- Electron drift velocity
- t_0 offsets
- Electron lifetime
- Recombination parameters
- Electric field
- Longitudinal and transverse electron diffusion
- Wire positions/geometry
- Wire field response
- Channel gain
- Overall electronics analog transfer function
- Electronic crosstalk
- Electronics noise, including correlated noise
- ADC linearity (differential and integral).

Photon detector response model:
- <similar list here>

(See Backup for more)

High level quantities
- Position reconstruction biases
- Direction reconstruction biases
- Energy scale
- Energy resolution
- Particle ID efficiencies
- Noise removal efficiencies
- …
- …

Particle response
- Charged hadron propagation
- Neutron response
- …

- Is this list complete?
- Position/time dependance?
- Needed precision?
- How to constrain? How much can you relay on external measurements?

Many Calibration sources

- Purity Monitors
- Temperature monitors
- Survey
- Current monitors
- υ_μ CC events
- Michel electrons
- Stopping muons
- Stopping protons
- Muon Crossers, APA/CPA piercers
- Ar^{39}
- Laser system
- CRT tagger
- Other radioactivity
- Michel electrons
- υ_μ CC events
- π^0 mass peak
- Other decays (K^0s…)
- Tagged events

What else??

- Keep in mind each source comes with its own challenges
- Best Strategy: Option of multiple ways to calibrate

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C. Backhouse et al.,

- Success: Use of cosmic samples to investigate alignment (T. Junk)
- Challenge: Develop tools (e.g. fhicl knobs) & interfaces (both at sim/reco levels) that propagate calibration quantities into LBL or to do standalone studies to assess impact

Calibration x LBL Group: Road to TDR

(https://indico.fnal.gov/event/15181/session/1/contribution/30/material/slides/0.pdf)

- Success: Agreed to methods of inclusion (pseudo data, parameterized uncertainty)

- Challenge: For TDR, only can include a small set of fully propagated effects (*prioritize*)

- Next steps:

  - Build a master list of systematics that calibration constraints; separate by in-situ and external knowledge (e.g. protoDUNE)

  - Take test cases (known, significant effects) and push them through to LBL to confirm handoff/interdependencies

Next Steps for TF

- Our last ***FT proposal for calibrations*** is currently being discussed with the cryostat team — ***goal to finalize by this month***.

- Future TF meetings focused on defining a calibration strategy and hardware needed by the Technical Proposal timeline
  - ***Goal:*** Present a calibration strategy at the January collaboration meeting to get collaboration wide input and key criticisms/questions
  - Not all studies can be done; we will still be driving on arguments, past experience and future projections;

- Plan for a ***calibration workshop in March*** to refine strategy and address key concerns raised — converge on a strategy for TP

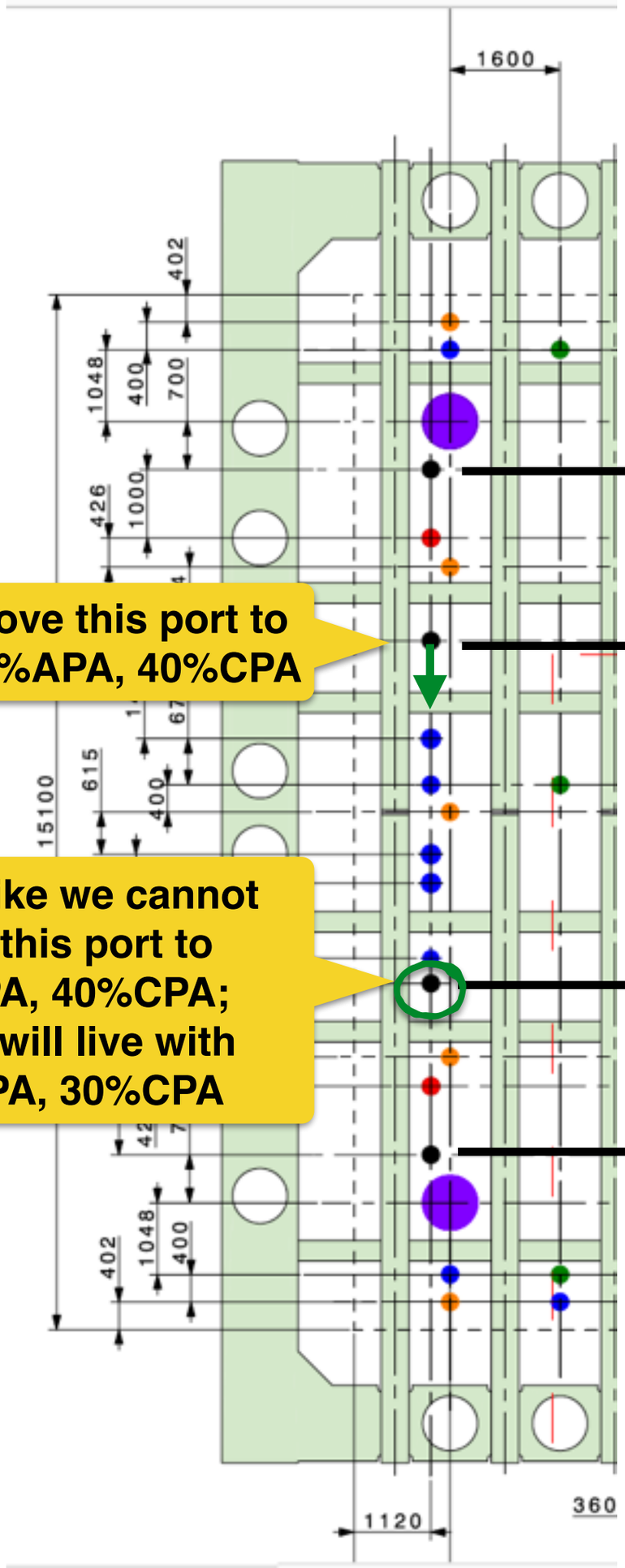
SPARES

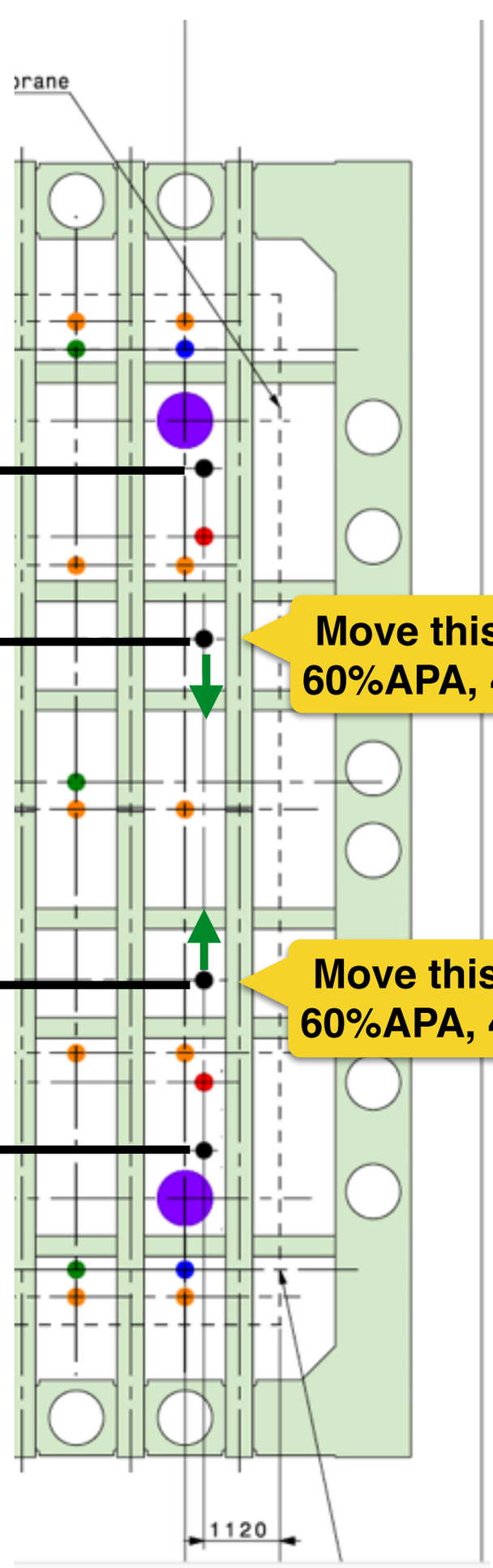
Outline

- Feedthrough Status (1 slide)
- DUNE Physics Week (DPW) Summary
  - Technical Proposal (TP)/Technical Design Report (TDR) plans for Calibration (4 slides)
  - Calibration decision making process (2 slides)
  - Interfacing with LBL & Reco/Sim (2 slides)
- Next Steps (1 slide)

WEST

EAST





Current locations

60%APA, 40%CPA

70%APA, 30%CPA

70%APA, 30%CPA

60%APA, 40%CPA

Move this port to 60%APA, 40%CPA

Seems like we cannot move this port to 60%APA, 40%CPA; So, we will live with 70%APA, 30%CPA

Move this port to 60%APA, 40%CPA

https://indico.fnal.gov/event/15181/session/1/contribution/31/material/slides/0.pdf *(from M. Bass)*

- Two Main Fitters for LBL:
  - *GLoBES* — current baseline
  - *CAFAna* — relatively new; under validation

Systematics studies

Bottom-up: re-run entire simulation/reconstruction chain with sim/detsim/physics parameters varied, rerun selections & sensitivity analysis for each variation

Resource intensive
Ready to go in both CAFAna and GLoBES

E.g. Wire spacing study

Top-down: shape, normalization systematics or modify smearing to account for underlying detector/physics effect

Difficult to relate to underlying parameters?
Ready to go in both CAFAna and GLoBES

E.g. Energy bin level systematics

Reweighting: reweighting events to account for parameter variations

Reweighting not in place in larsoft
Some reweighting possible with CAFAna