

Summary of ND-GAr Workshop – I

DUNE ND Meeting, Jan 20, 2021
A. Marino, U Colorado Boulder

Workshop Details

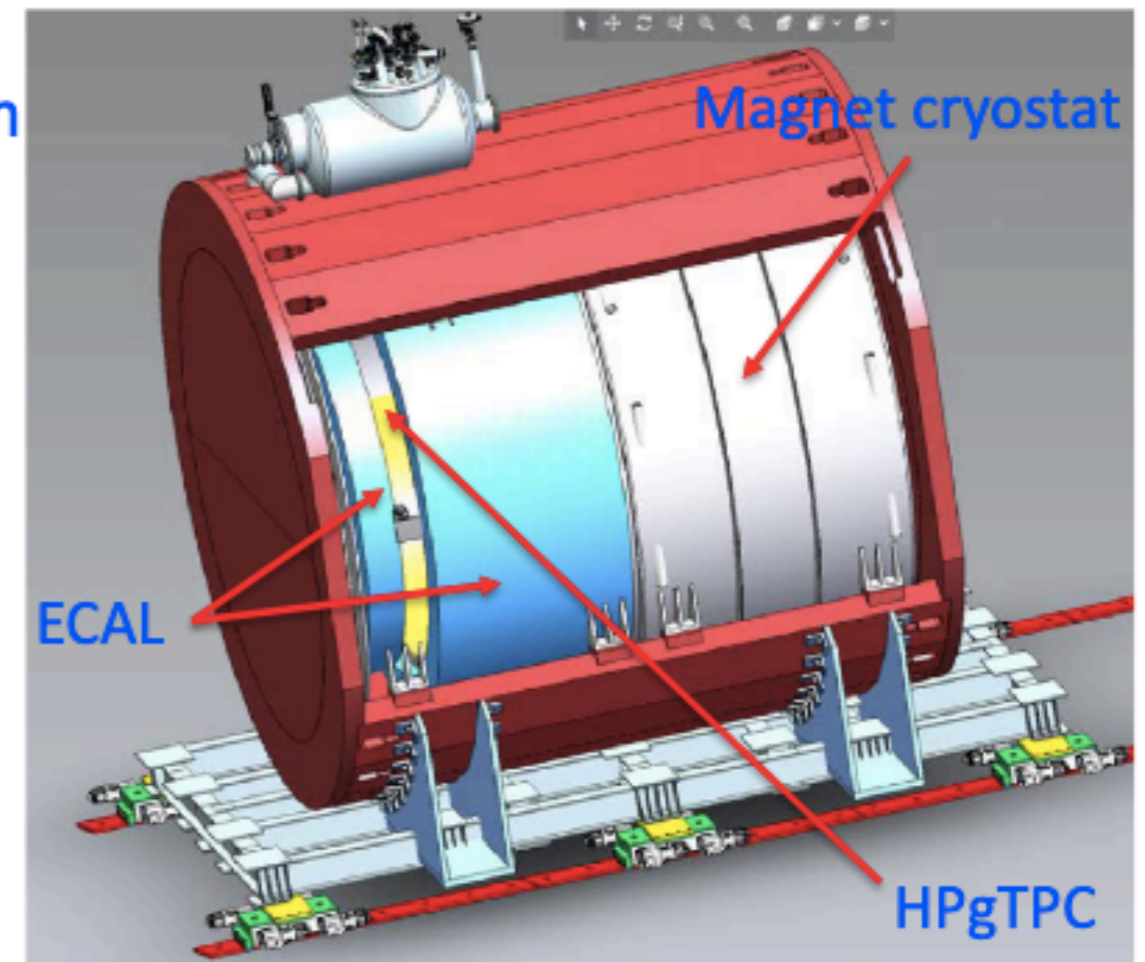
- Virtual Workshop on ND GAr from Jan 11–13
 - <https://indico.fnal.gov/event/47020/>
 - Slides and recordings of most talks available on indico page
 - Intended as a working meeting, with an informal agenda including discussion time in breakout rooms
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- 83 registered participants, thanks to all who attended
 - Very successful!

Workshop Structure

- Monday:
 - ▶ Plenary talk with an overview of current ND-GAr design and interfaces; Discussion of key questions to be answered
 - ▶ Three breakout sessions: Mechanical, Electronics, Physics/Simulations
- Tuesday:
 - ▶ Three breakout sessions: Mechanical, Electronics, Physics/Simulations
 - ▶ Plenary session with summaries from each breakout group
- Wednesday:
 - ▶ Two breakout sessions: Mechanical, Physics/Simulations
 - ▶ Plenary session with summaries from each breakout group, discussion of high priority items and (briefly) funding

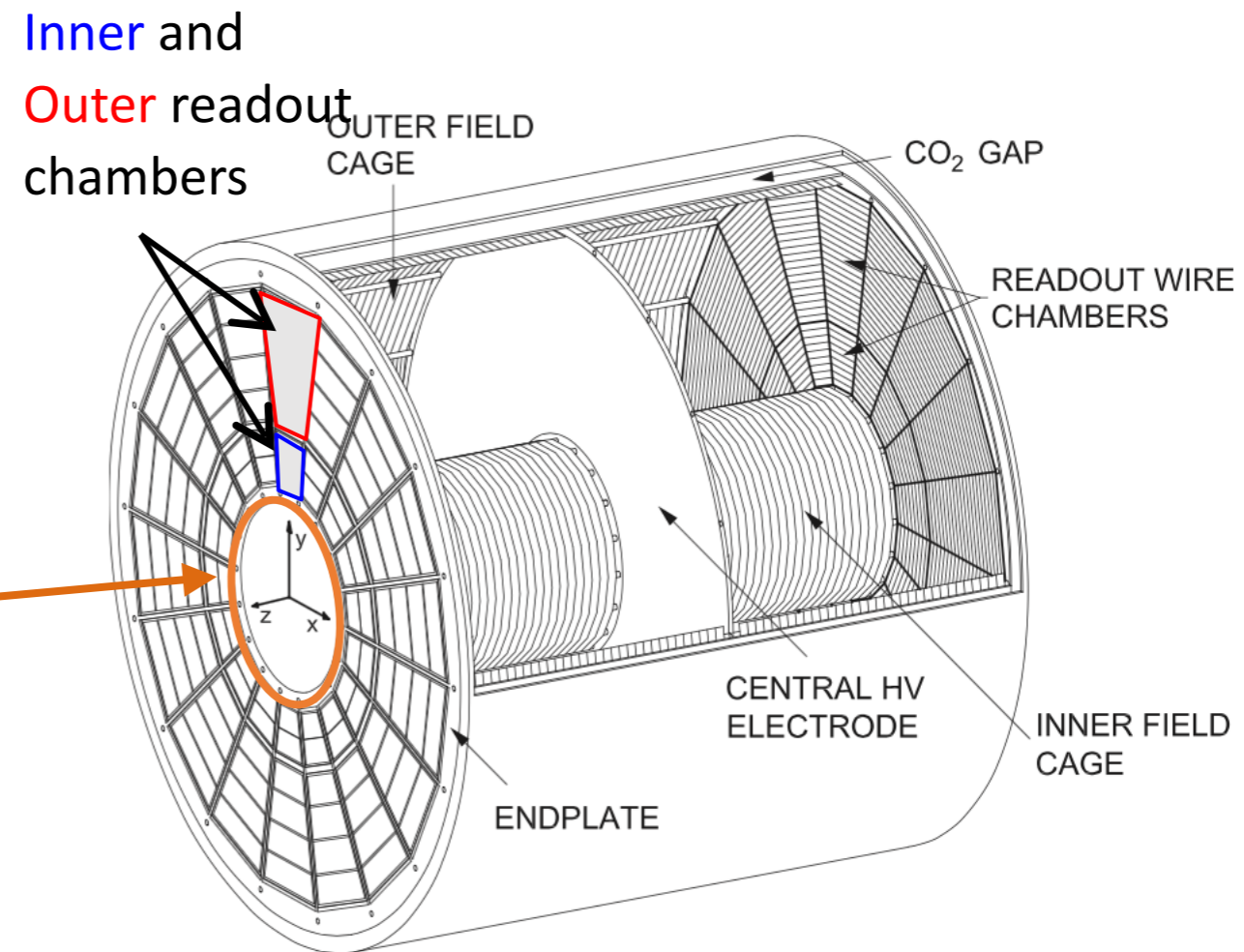
ND-GAr Reference Design

- Magnetized volume including high-pressure (10 atm) gaseous argon TPC + ECAL. Plus external muon tagger
 - Copy of ALICE TPC (5m in diameter X 5m long active)
 - 1t fiducial target mass
 - 0.5T field
- HPgTPC surrounded by high-performance ECAL
 - Inside PV
 - Optimization study underway
- Muon tagger
 - Outside return Fe
 - Scintillator, RPCs or MicroMegas (tbd)



HPgTPC Concept

- Concept based on ALICE TPC
- ALICE is upgrading their **inner** and **outer** readout chambers (ROCs) during the CERN long shutdown, old chambers available for DUNE
- In ALICE, this is **central region** is instrumented with a silicon vertex tracker. We would need to build a new readout chamber to fill this region on both ends of the cylinder



Key Questions

- Lots of details in workshop slides and meeting notes
- Listing some of the major questions that were discussed in each area

Key Questions – Mech, HV, Gas

- Should the TPC have single or double drift volume?
- Scintillation light detection (develop concrete R&D plan to narrow down the gas mix options)
- What are the desired calibration systems and how do they interface?
- Should the HV degrader gas volume be separate from the main volume, and a different gas?
- What are the mechanical/structural interfaces between the magnet, ECAL, and TPC?

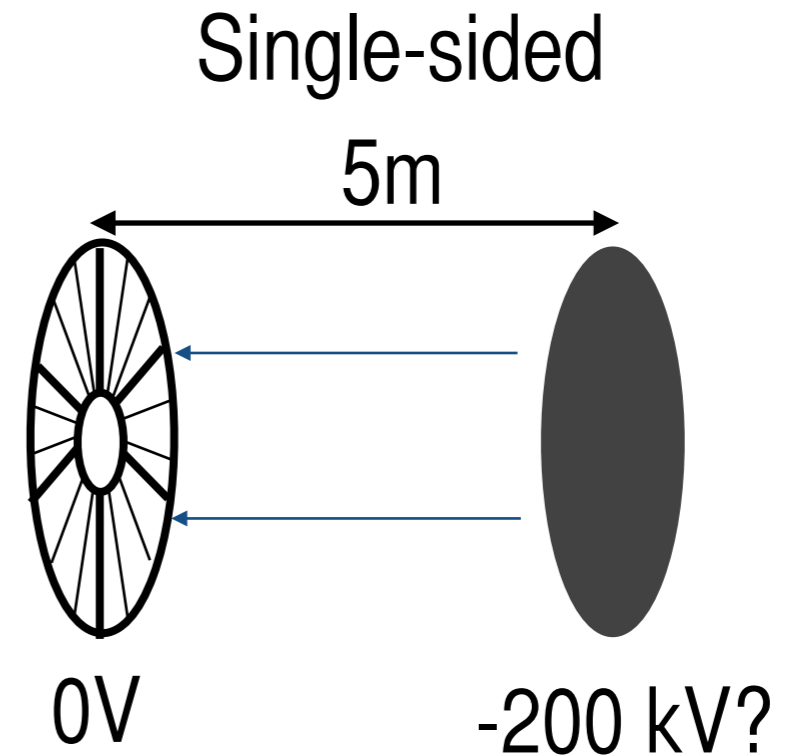
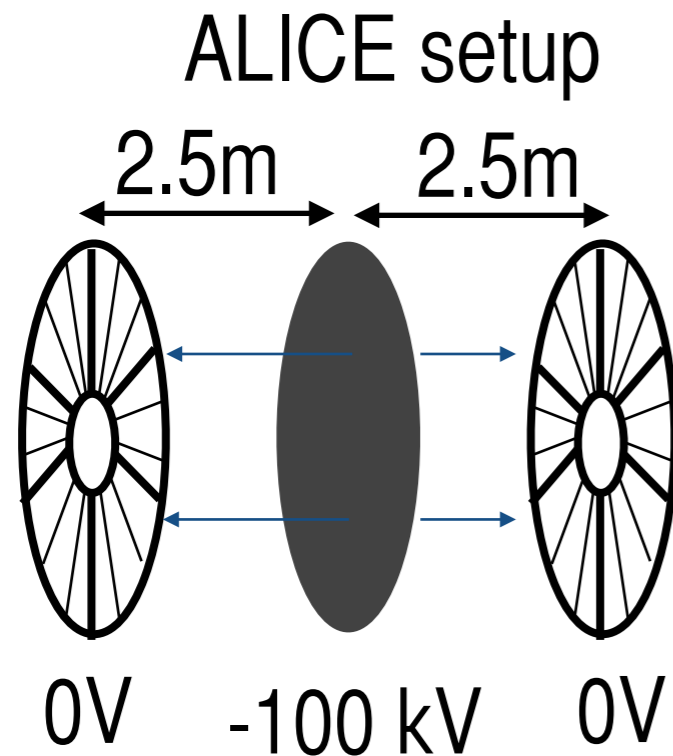
Key Questions -Electronics

- What are the design, R&D and prototyping plans for the Front-end electronics for TPC & ECAL?
- What is the maximum heat load we can tolerate without cooling? With cooling?
- ASIC options
- Frequency needs?
- What are the anticipated cable counts for the various systems and the corresponding number of feedthroughs into the pressure vessel?

Key Questions – Simulations and Physics Studies

- Should the TPC have single or double drift volume? Can we rearrange chamber to fill central hole?
- What optimization needs to be done for ND-GAr-Lite?
- We need a noise model in GArSoft and a hit threshold. What is the S/N requirement? What is the dynamic range requirement on the electronics?
- What is the electron drift specification (diffusion, electron lifetime)?
- What are the calibration needs?
- Can we use NEST to simulate ionization and scintillation?
- What needs to be done in order to interface different generators to the ND simulation?

Single-Sided vs Double-Sided readout

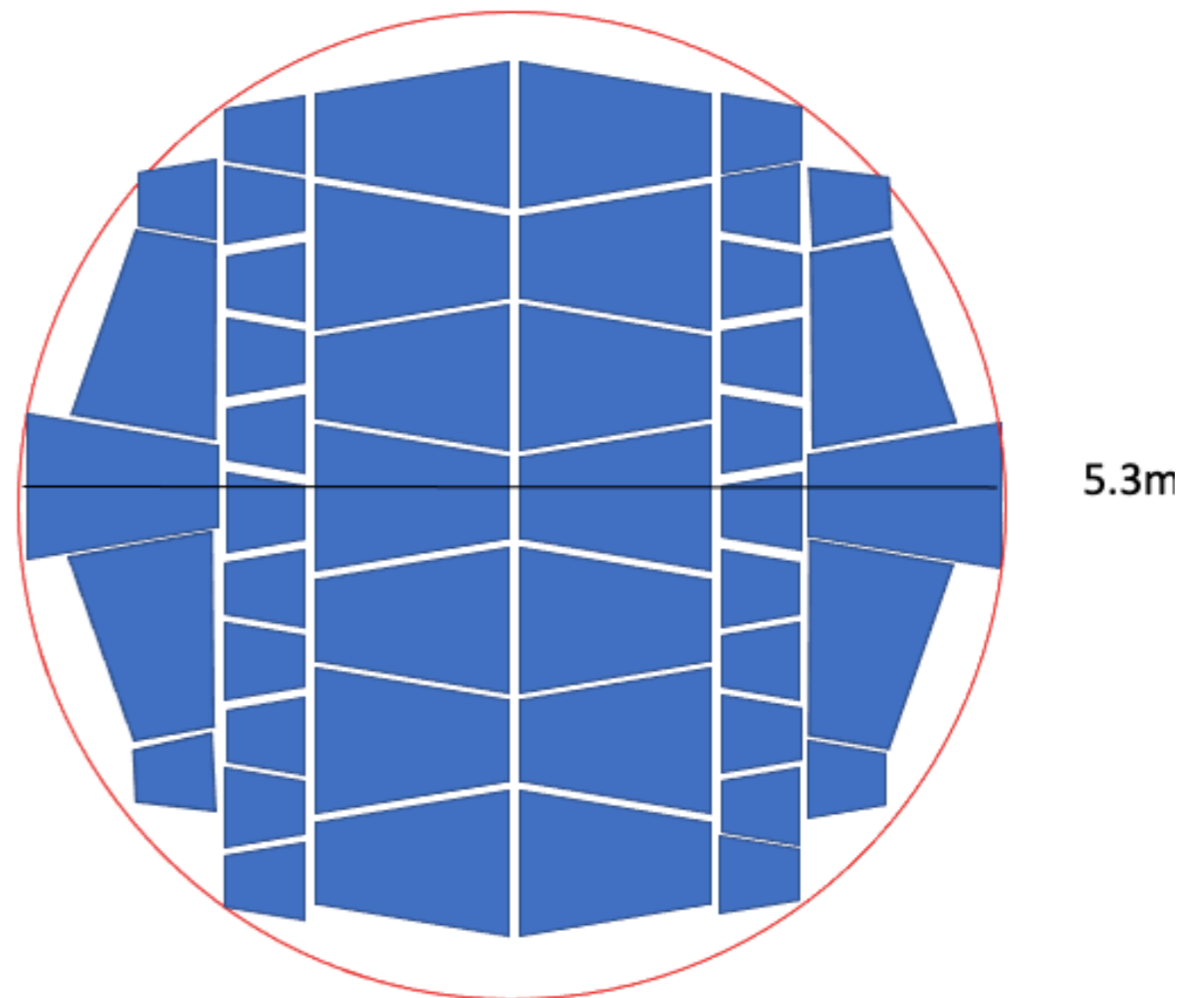


- Only maybe 1 spare ALICE chamber at the moment. A 2-sided readout leaves space for a light collection system behind a semi-transparent electrode, and gives us spare readout chambers

Single-sided readout with rearranged IROCs and OROCs

- Single-sided readout allow for spares, and potentially can fill the central hole
- But must understand impact of non-uniform pad sizes

Quick layout concept from
Diego González-Diáz



Scintillation Study Plans

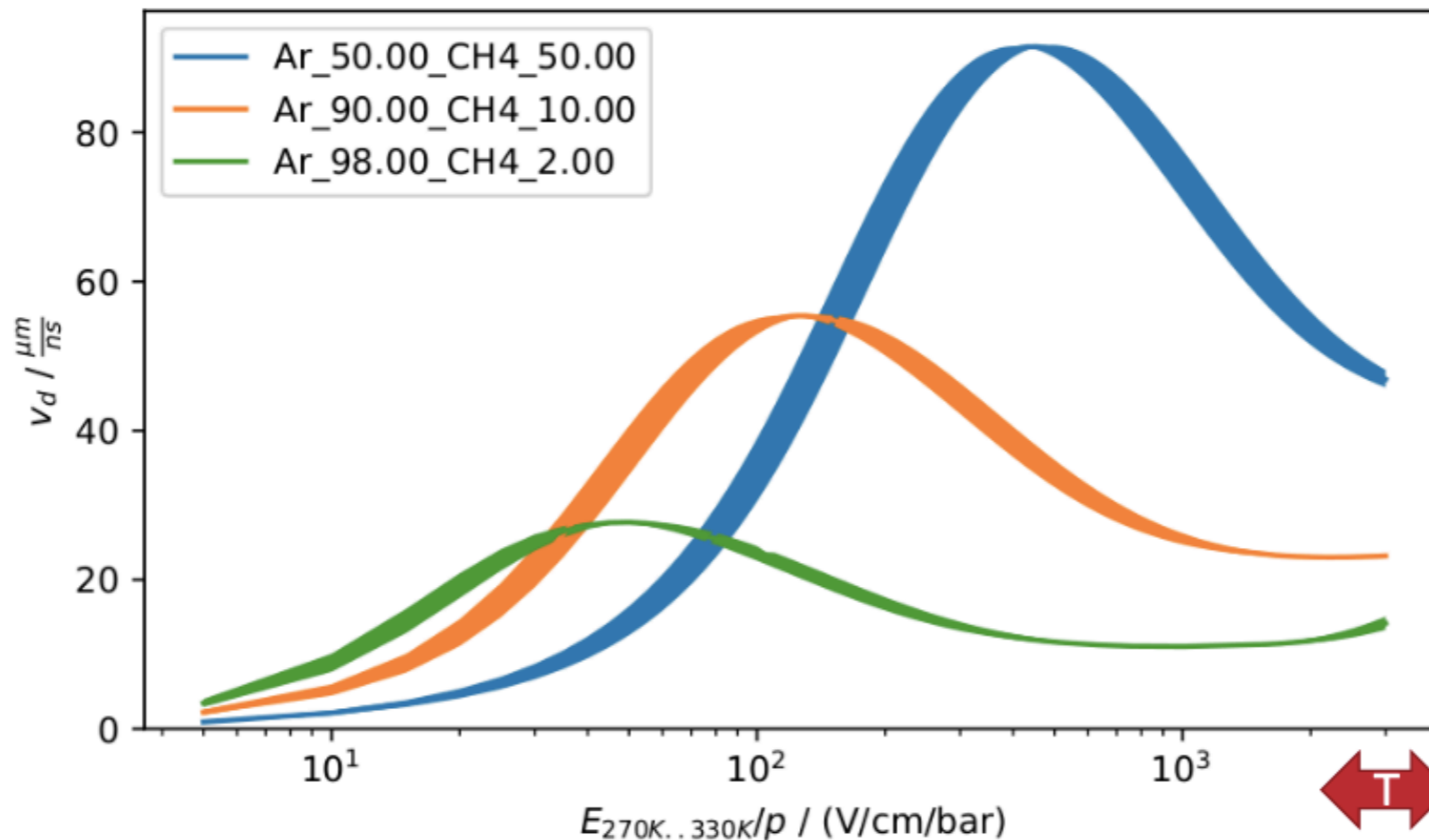
- Argon scintillates in UV, but this must be wavelength shifted to give a stable gain in the chambers
- Mixture optimized for scintillation wavelength shifting could also reduce the chamber gas gain. So must perform studies to balance these.
- Strategy:
 - ▶ Start with Ar-N₂ and Ar-CF₄
 - ▶ Might also be able to think about adding a third species as a quencher to improve gain stability.
 - ▶ Need to study outgassing in Ar of photodetectors. Can possibly do this in a test stand at FNAL or Santiago.

Impact of gas temp

Impact of Temperature on Electron Drift Velocity

Philip Hamacher-Baumann

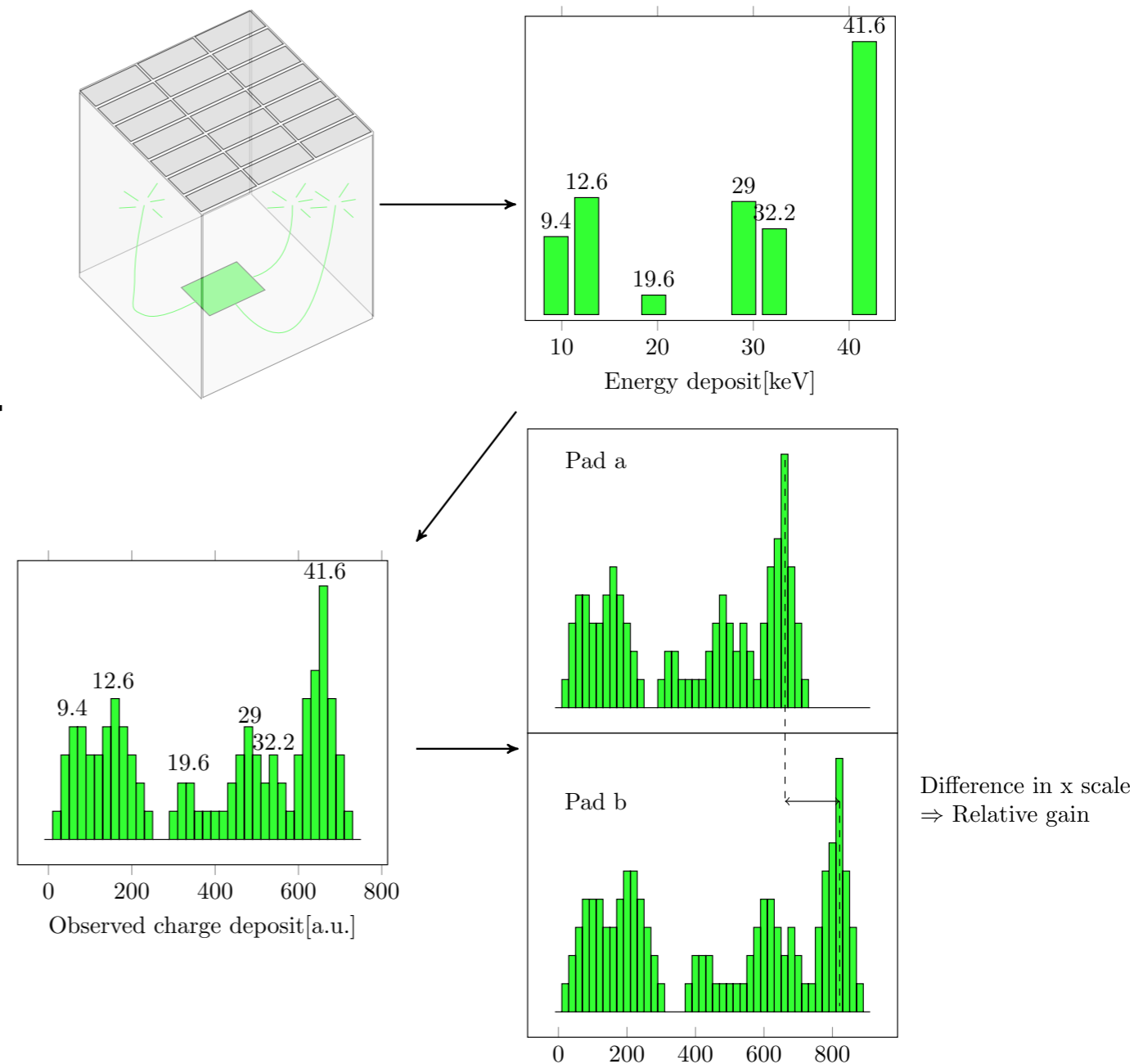
Assuming a (hopefully) too wide span of possible TPC temperatures



- Suggestion to try to operate at peak if possible. Reduces temp control requirements. Must see how this interacts with scintillation mixtures

Chamber Gain Calibration

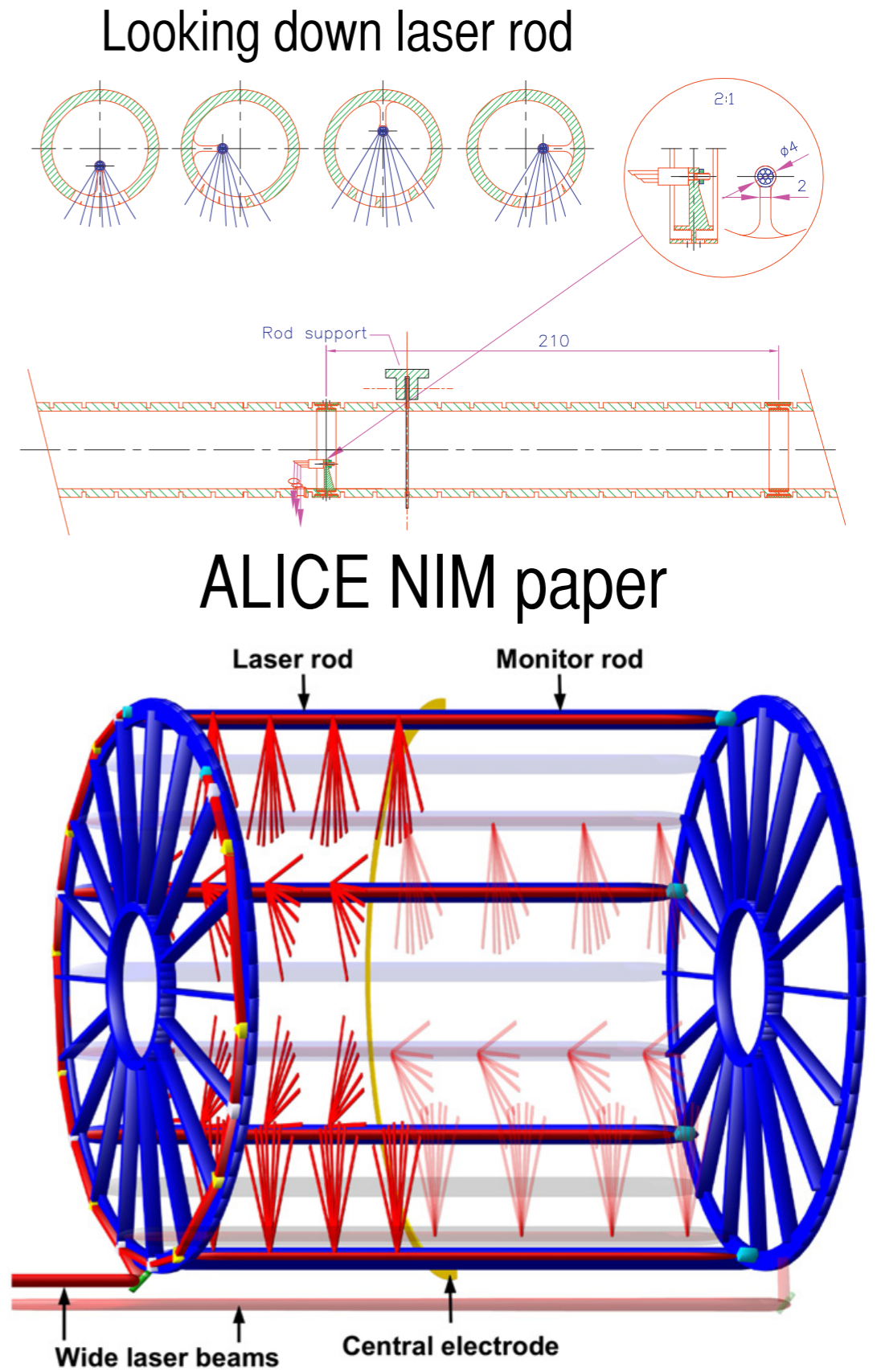
- In-situ check with $^{83}_{36}\text{Kr}$ calibrate for gas gain effects
 - ▶ In ALICE performed for ~1 week/yr
 - ▶ Look for Kr clusters in data.
 - ▶ Accumulate a spectrum for each pad and fit to spectrum to determine relative gain
 - ▶ How large of a signal do we expect?



From M. Naskret, masters thesis on
NA61 Kr calibration

ALICE Laser Calibration System

- Pulses of 266 nm UV light
- Laser beams entered the endcaps
- Mirror bundles generated a “fan” of light
- 4 different z positions in each half of the TPC (~ 80 cm apart)
- All metallic surfaces inside the TPC, which are hit by stray laser light, emit electrons. So also a signal from the central aluminized mylar electrode.
- Do we need an ALICE-like system or can we just use integrated signal from the central electrode?
 - ▶ Probably want something ALICE-like, especially for a single 5 m drift

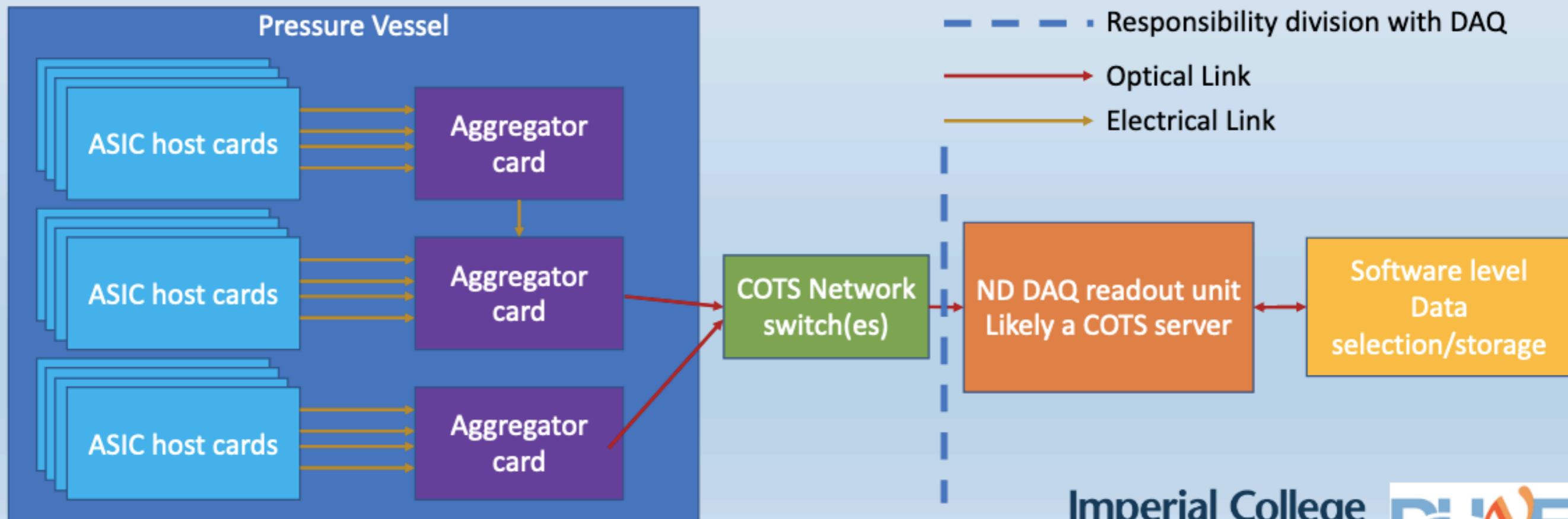


Electronics System

Patrick Dunne

System design

- Number of feedthroughs on pressure vessel will be limiting and we want to limit the analogue signal path length
 - Therefore must digitize and zero-suppress inside vessel before sending out of vessel
- Design underway of aggregator cards in UK and of ASIC host cards in USA
- Timing information will also need passing in to aggregator cards



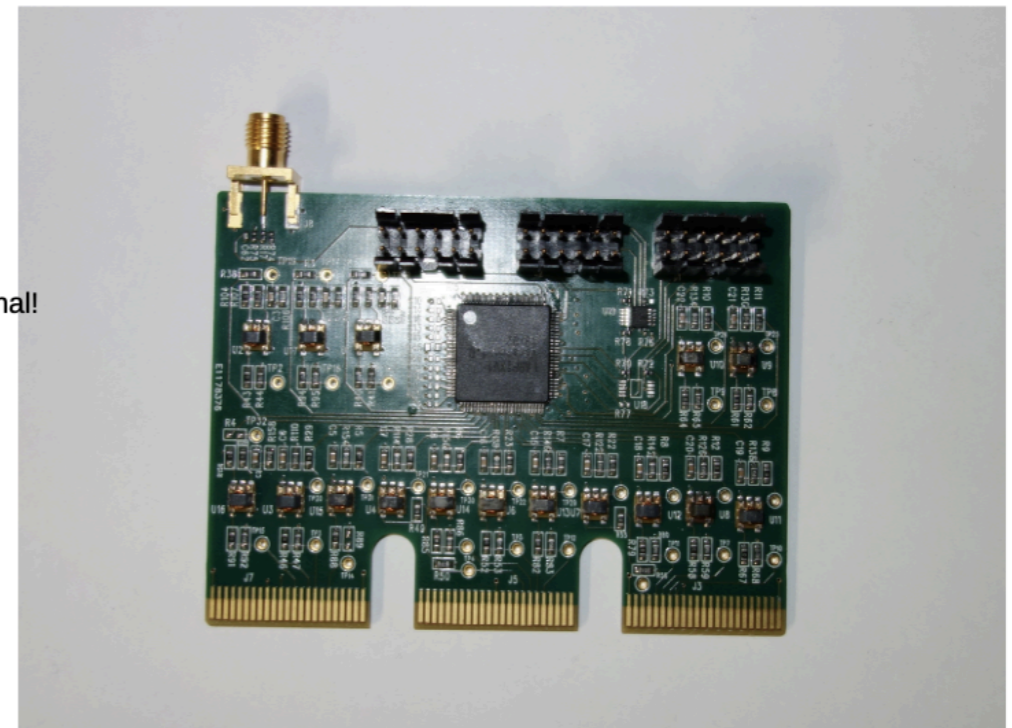
Electronics Status and Questions

- Design of HPgTPC readout electronics is underway with some early prototypes starting to be available for some components
- Do we need full waveforms? Can we record just a fraction?
- Time sampling needs (impact longitudinal position accuracy)
- Details of occupancy from simulation efforts will be essential for optimizing system design
- What is thermal budget?

Donna Naples

Assembled PCB (v1 LArPix ASIC)

NOT final!



Simulation Needs

Tom Junk

First round of prioritization done

Items to discuss and prioritize

- Simulation
 - ND-GAr-Lite
 - Software, event generation interface with LAr-ND, (SAND?)
 - Generator interface (We have GENIE – Chris M. can run NuWRO, would like more; can be done via reweighting)
 - Muon Catcher
 - Central Readout Chamber (CROC)
 - Single Drift option -- *slides from Leo*
 - Noise modeling and hit threshold study
 - Scintillation Light simulation in ND-GAr. Use NEST?
 - How much truth info to store? (MCParticle trajectories are big)
 - space charge and positive ion drift (probably negligible but can we prove it?)

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Items to discuss and prioritize

- Reconstruction
 - Optimize track and cluster finding and resolution; Look into pattern recognition failures and optimize fit; picking out kinks.
 - Reconstruct K_S , Λ in a dense environment (not just pure K_S) – Needs separation from primary vertex
 - Study PID in real simulation. Lots of handles. dE/dx, curvature vs. range, scattering, ECAL match, muon tagger system
 - Charge kaon reconstruction (need for proton decay?) has a kink in $K^+ \rightarrow \mu^+$, $K^+ \rightarrow \pi^+ X$
 - Characterize performance as reco is optimized
 - Reconstruct photon conversions in TPC volume
 - Incorporate scintillation light (not yet simulated or detected)

Items to discuss and prioritize

Leo Bellantoni

- Physics
 - Samples
 - Simulation of L+G Ar w/ rock μ : needs latest geometry – sufficient for all needs through TDR?
See Federico's slides – we have a good start.
 - Full spill – for MPD reco work
 - Prism: off-axis samples needed
 - Single interaction (no ECAL etc. activity) – for MPD reco work
 - Special interaction samples (coherent pion, numu, nue, NC, npi)

Items to discuss and prioritize

Leo Bellantoni

- Analyses
 - Muons-from-LAr selection, efficiency, background, and energy scale and resolution
 - ND-GAr-Lite
 - ND-GAr
 - ND-GAr event selection optimization
 - numuCC (Tanaz spoke yesterday)
 - nueCC
 - NC
 - Efficiency and background calculation (backgrounds to NC from neutrons from ECAL were brought up. Some NC events have very little charged activity at the primary)
 - Prism with ND-GAr oscillation analysis (CAFAna samples for LBLPWG)
 - Energy scale and resolution
 - PID optimization and performance characterization
 - BSM

High Priority Action Items

- Mechanical/Gas
 - ▶ Single-sided drift vs double-sided drift
 - ▶ Scintillation studies
- Electronics
 - ▶ Test prototype ASICs in test stands
 - ▶ Prototype aggregator cards
- Simulations and Physics Studies
 - ▶ ND GAR-lite simulations, optimize the plane geometry
- Globally: Form a Calibration Task Force to define calibration requirements and strategy

Connect with us!

- ▶ Weekly ND-GAr meeting on Monday 11 AM Central / 6 PM Central Europe. Mailing list: dune-nd-gastpc@listserv.fnal.gov (Can request to join via “DUNE At Work”.)
- ▶ Also periodic gas tune meetings are organized by Diego González-Diáz. Mailing list: dune-nd-gastpc-tune@listserv.fnal.gov
- ▶ Also an ND Reco/Sim Physics Working Group is being formed (across the whole ND). They are currently selecting a new time (contact Matthew Muether). Mailing list: dune-nd-sw-integration@listserv.fnal.gov
- ▶ Also a HPGPTC test mailing list: dune-hpgtpc-tests@listserv.fnal.gov
- ▶ Also bi-weekly magnet meetings on Friday: dune-nd-magnet@listserv.fnal.gov