

Phase II FD/ND Meeting

□ Monday Oct 21, 2024, 9:00 AM → 10:00 AM US/Central

Optimized Vertical Drift FD Module for DUNE Phase-II:

Progress update: APEX

*the PhotonDetector extension toward 4π optical coverage
fully complementary to LArTPC charge read-out to expand the DUNE science program*

• The robustness of the APEX physics case, *with wide optical coverage with Large and Uniform LY*, is becoming more and more evident as physics simulations advance:

- LowEn: Solar neutrinos - based on PDS high/uniform LY - **Golden Channel w/ Time correlated Energy Deposit** from de-Ex gammas (\Rightarrow day-night difference **probe MSW effect**),
- LowEn: Diffuse SN Bckgd: improved sensitivity from combined Q+L

PhysicsStudies at **FSU, SBU, BNL, PNNL**

• GeV scale: **self-compensating light calorimetry** offers new and independent energy reconstruction for CPV probe: due to charge recombination and light generation in liquid argon, **light calorimetry in LArTPCs is inherently self-compensating**: the missing energy in the hadronic component is compensated for by the extra recombination luminescence compared to the electromagnetic component.

light calorimetry can achieve an energy resolution comparable to the charge imaging calorimetry.

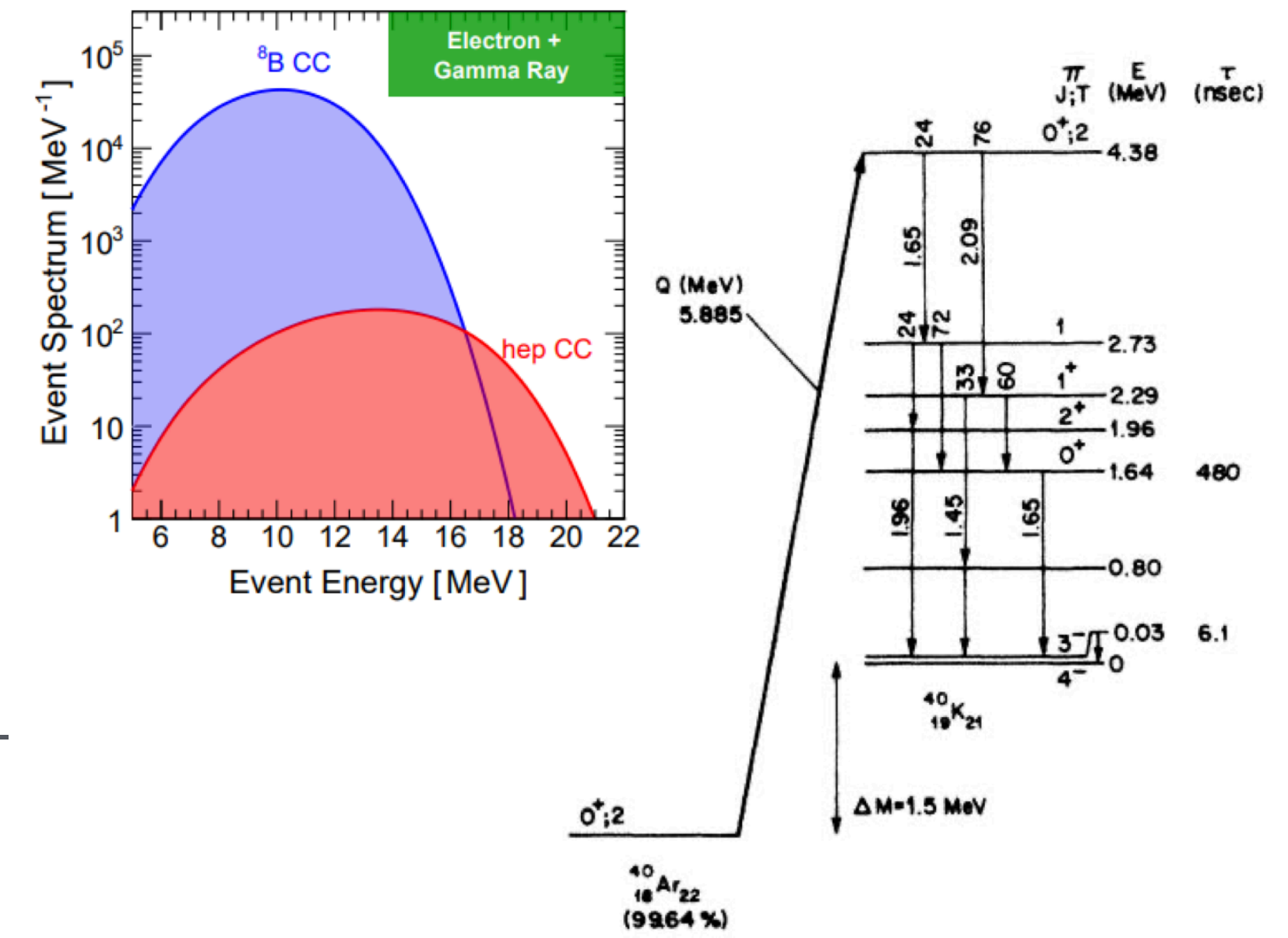
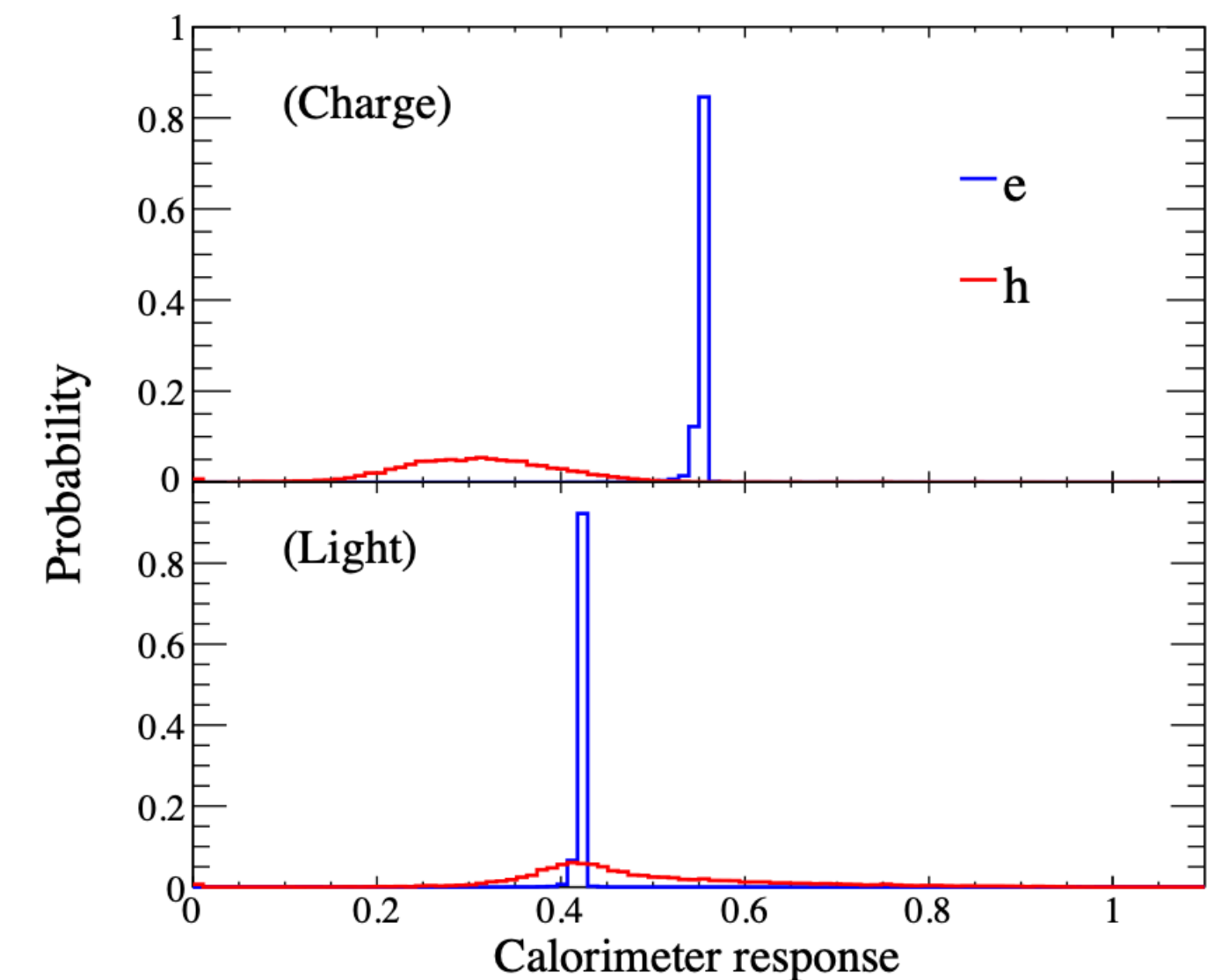


FIG. 1. Level scheme of ^{40}Ar - ^{40}K relevant to ν_e capture on argon.

<https://arxiv.org/abs/2410.04603>



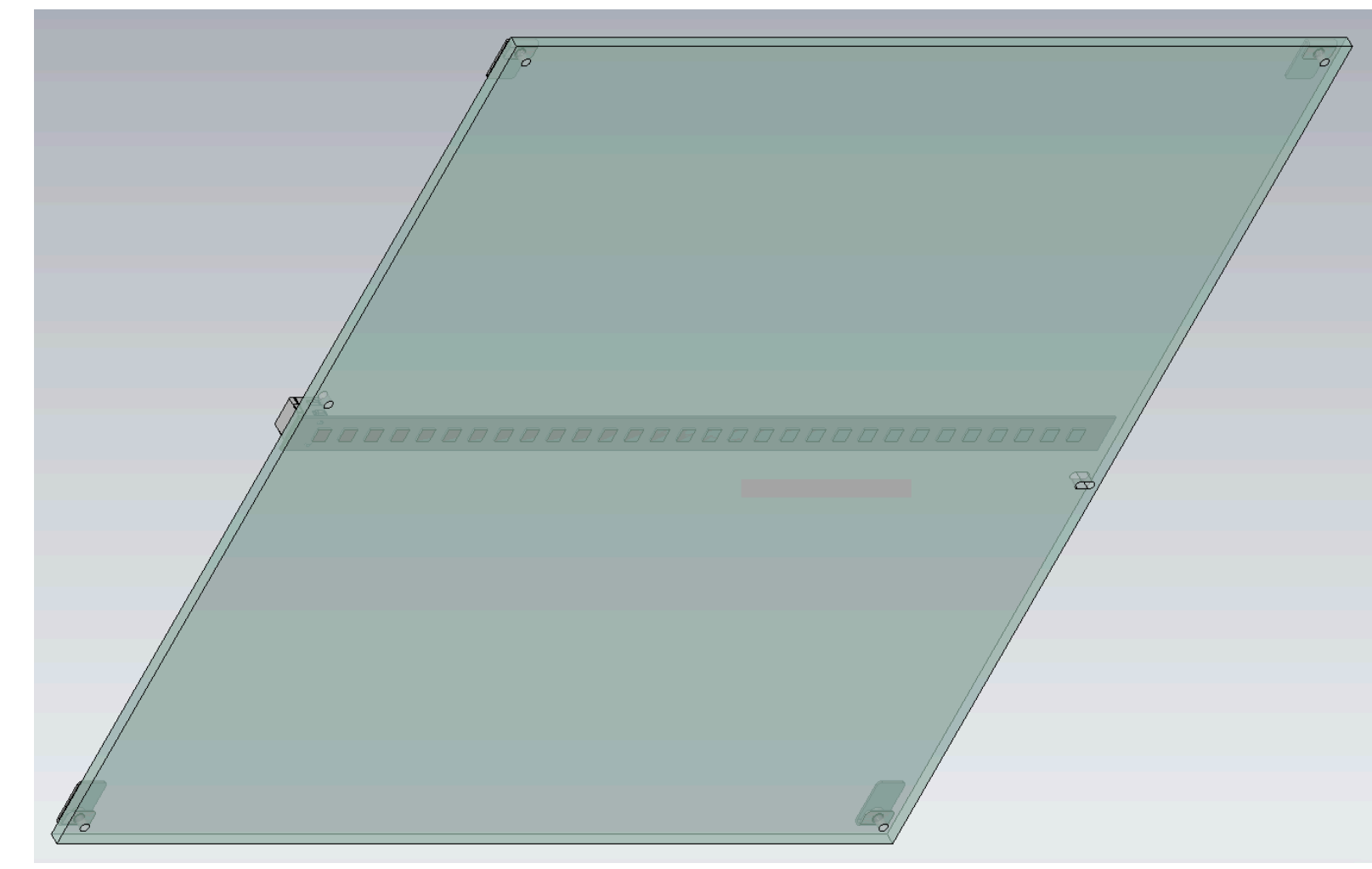
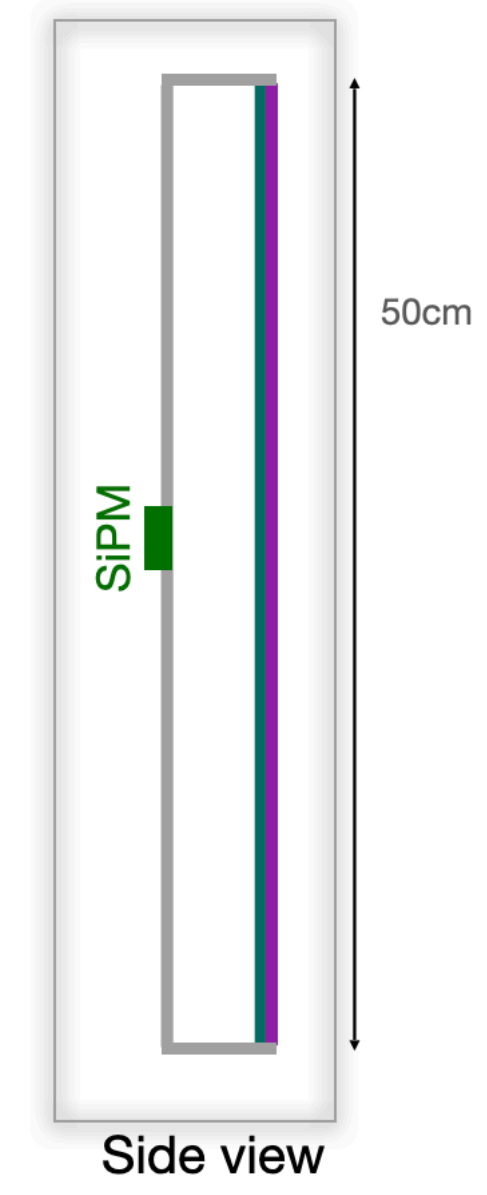
(WhitePaper) Baseline Design

- [Reflector VIKUITI foil
- WLS2
- PMMA
- Dichroic ALD
- WLS1]
- pTP film

Progress with APEX: new detector design

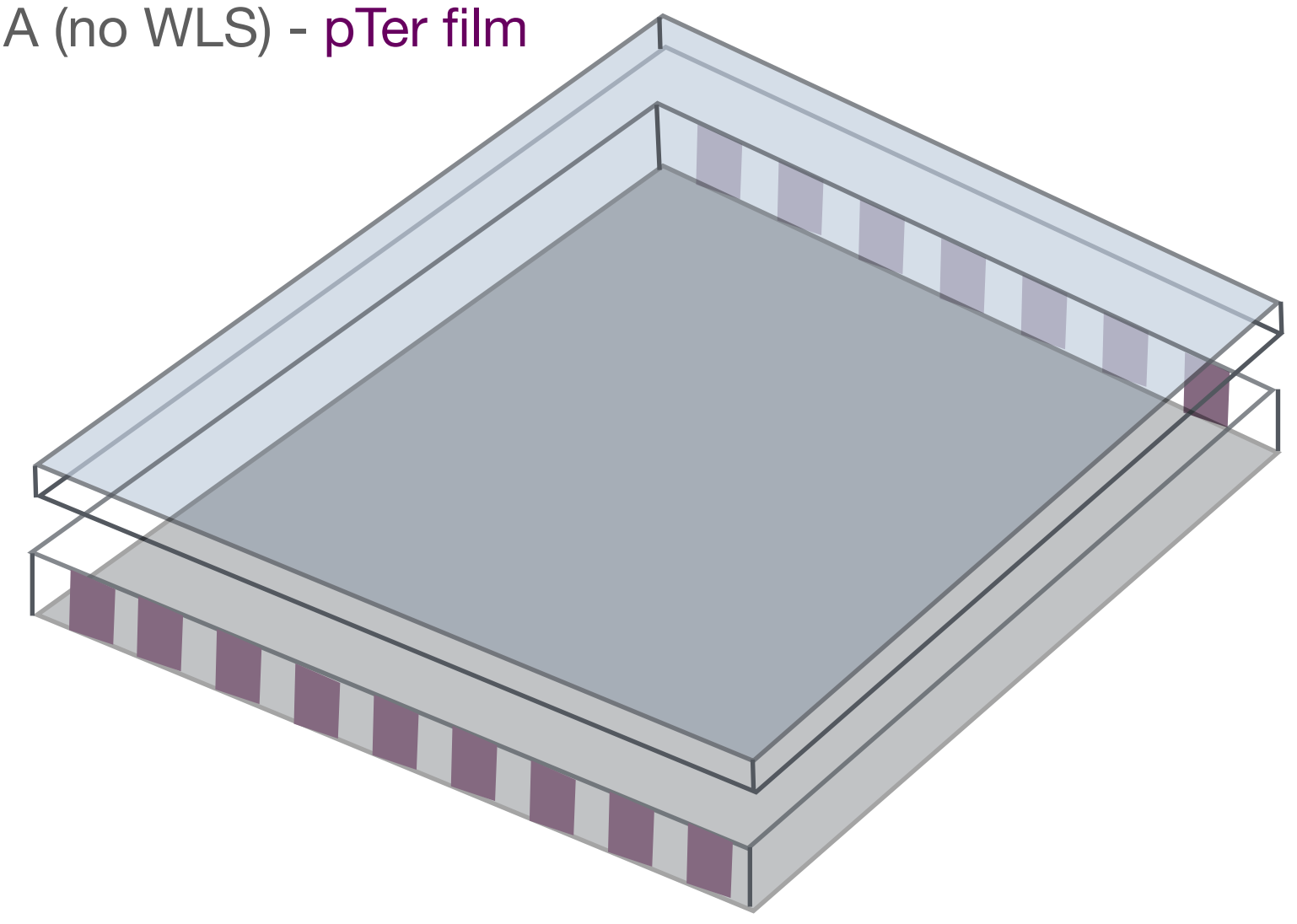
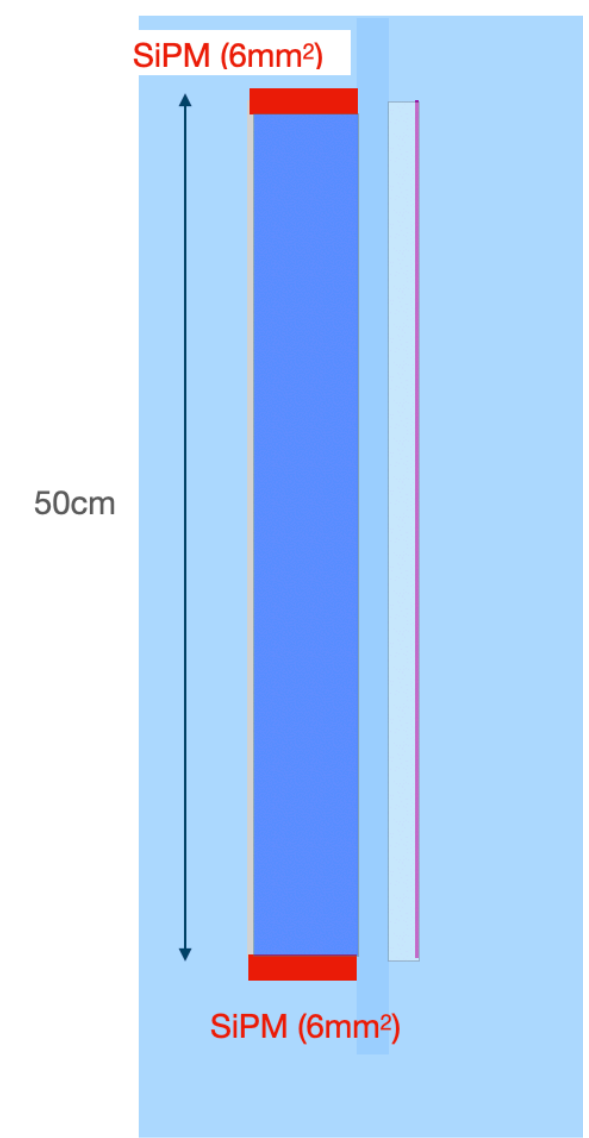
- (New) Detector design:
- increasing PhColl Effic (PCE) with no increase of SiPM coverage (SiPM on edge, double acrylic layers, no dichroic, LAr in between for **TIR**-based trapping

Simulation and Detector Conceptual Development at IFIC/Valencia (+FNAL & SBU)



- [Reflector VIKUITI foil
- WLS2 (6mm)
- PMMA(Blue)
- LAr
- 2mm
- Acrylic (2mm)
- PMMA (no WLS)
- WLS1]
- pTer film

Baseline	Side SiPMs	Side SiPMs (doubled)
PCE ~ 0.63% 30 SiPMs	PCE ~ 1.23% 30 SiPMs	PCE ~ 2.27% 60 SiPMs



APEX PD-Module -New Design

Progress with APEX: R&D for new detector design

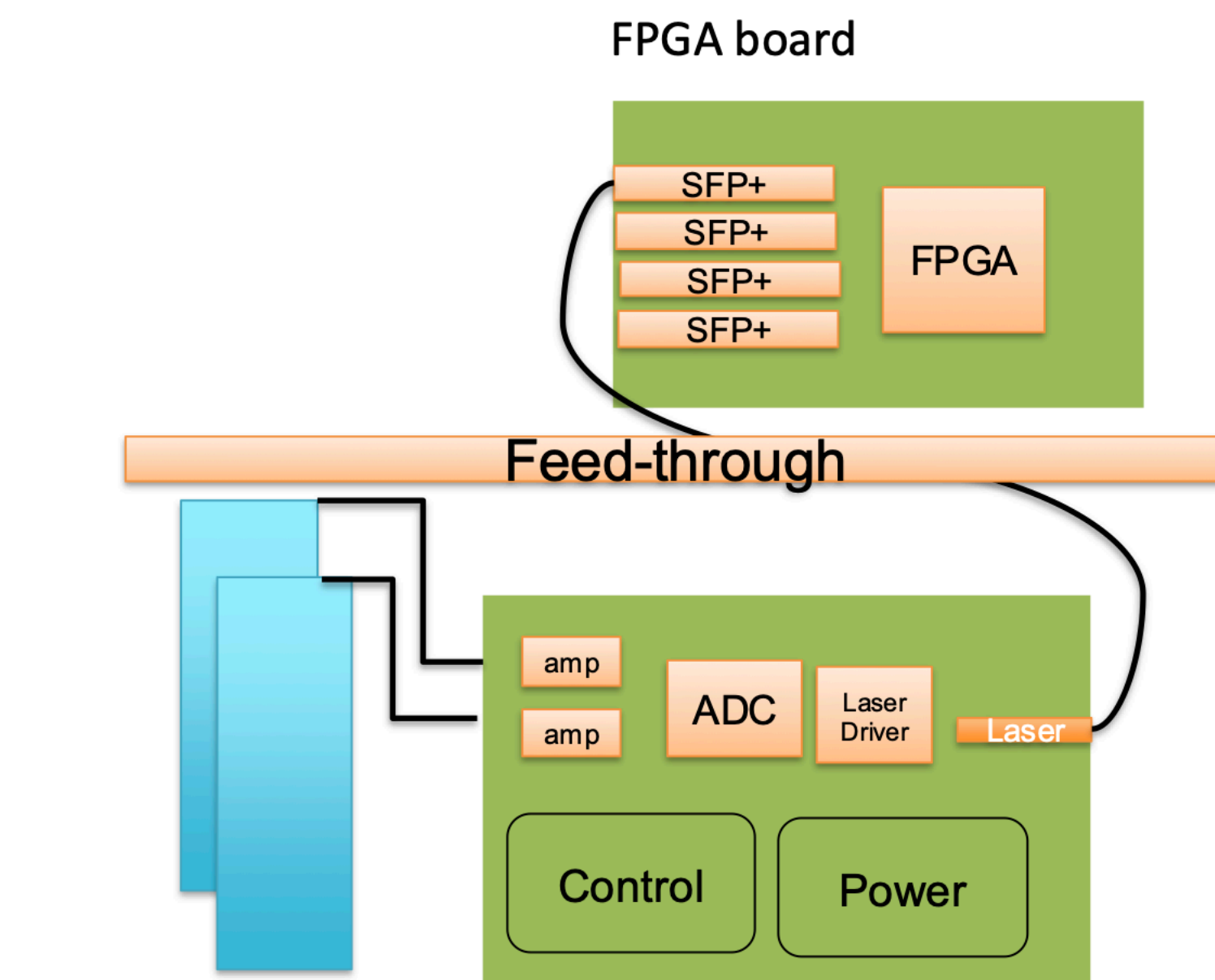
- Search for alternative, fast (industrial) methods of WLS deposition on acrylic- UV-transparent PMMA [chemical brush/spray/spincoating at SBU, at CERN and at BNL - studies also at MiBi]
- Study for alternative solutions to pTP WLS film - e.g. PEN foil lamination on acrylic or PEN plate + change to green PPMA (2nd WLS stage)

- Recent advances with Digital R/O solutions: Development at FNAL
 - ➔ New ADC available: TI ADS52J65, lower total power and reasonable channel count. **ADCs being tested, need cryogenic validation**
 - ➔ New laser available: Test the new unfocused laser diodes

Goal: use of multiple ADC channels to make the power/channel competitive with FD2 analog designs? **On going study about how to best use ~16 channels.**

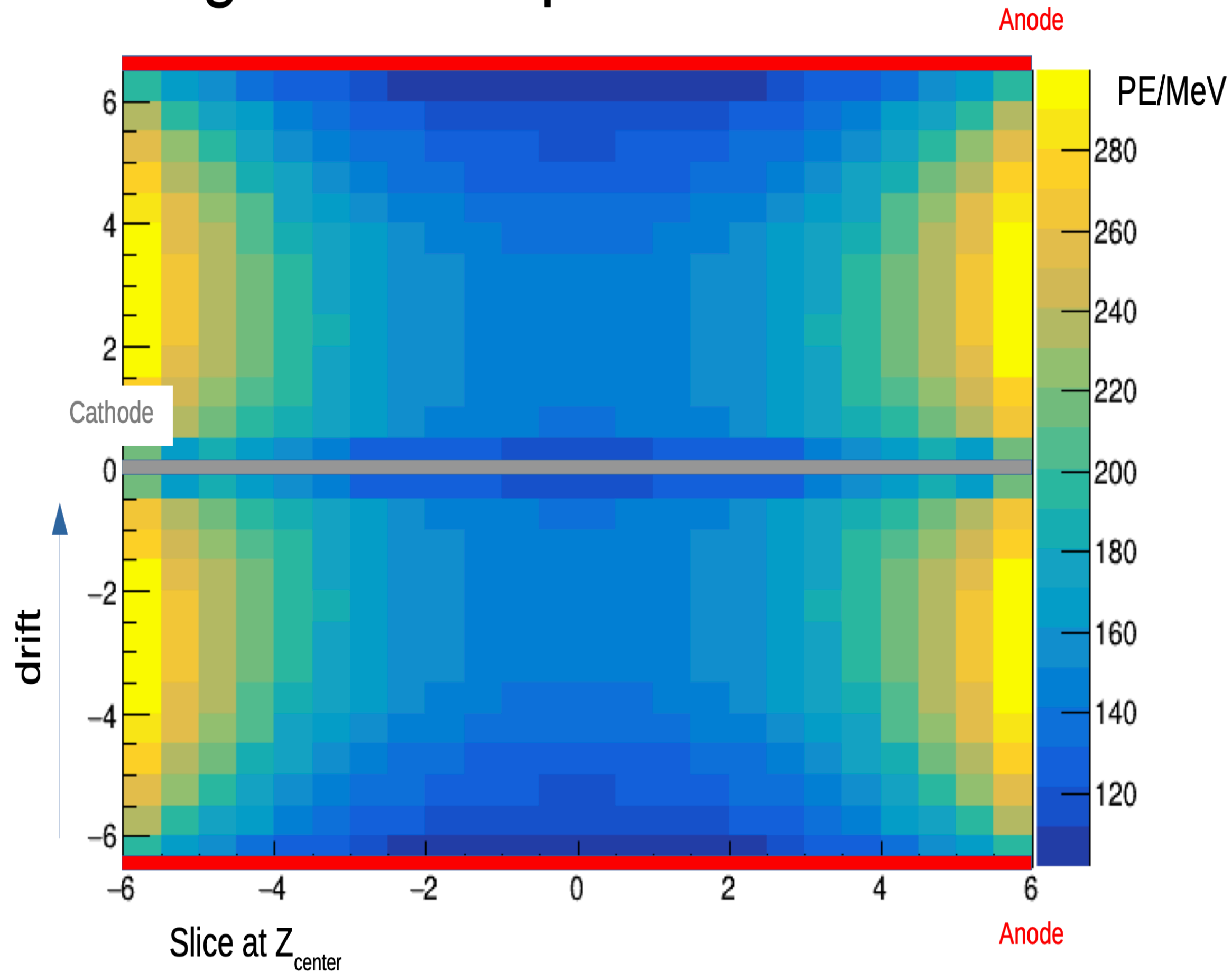
- Recent advances with DSIPM (Digital SiPMs (2D, 2.5D or 3D) solutions:
 - ➔ at FNAL and at TRIUMF/Sherbrooke (Low TRL) Opportunity for APEX

- Recent advances with DRD2 - **Liquid Detectors - Collaboration is formed and Plan for R&D finalized**
WP2, Task 2.2 Higher efficiency WLS and light collection and WP4: Scale-up Challenges: 4.3: Large-area Readout -



APEX: Light Yield map

Simulation and Studies at ITA (Br)
(and also PNNL)



53% of total light emitted @176nm
and 35% of light loss @128nm

Average LY: 173.5 PE/MeV
Min LY: 101.6 PE/MeV

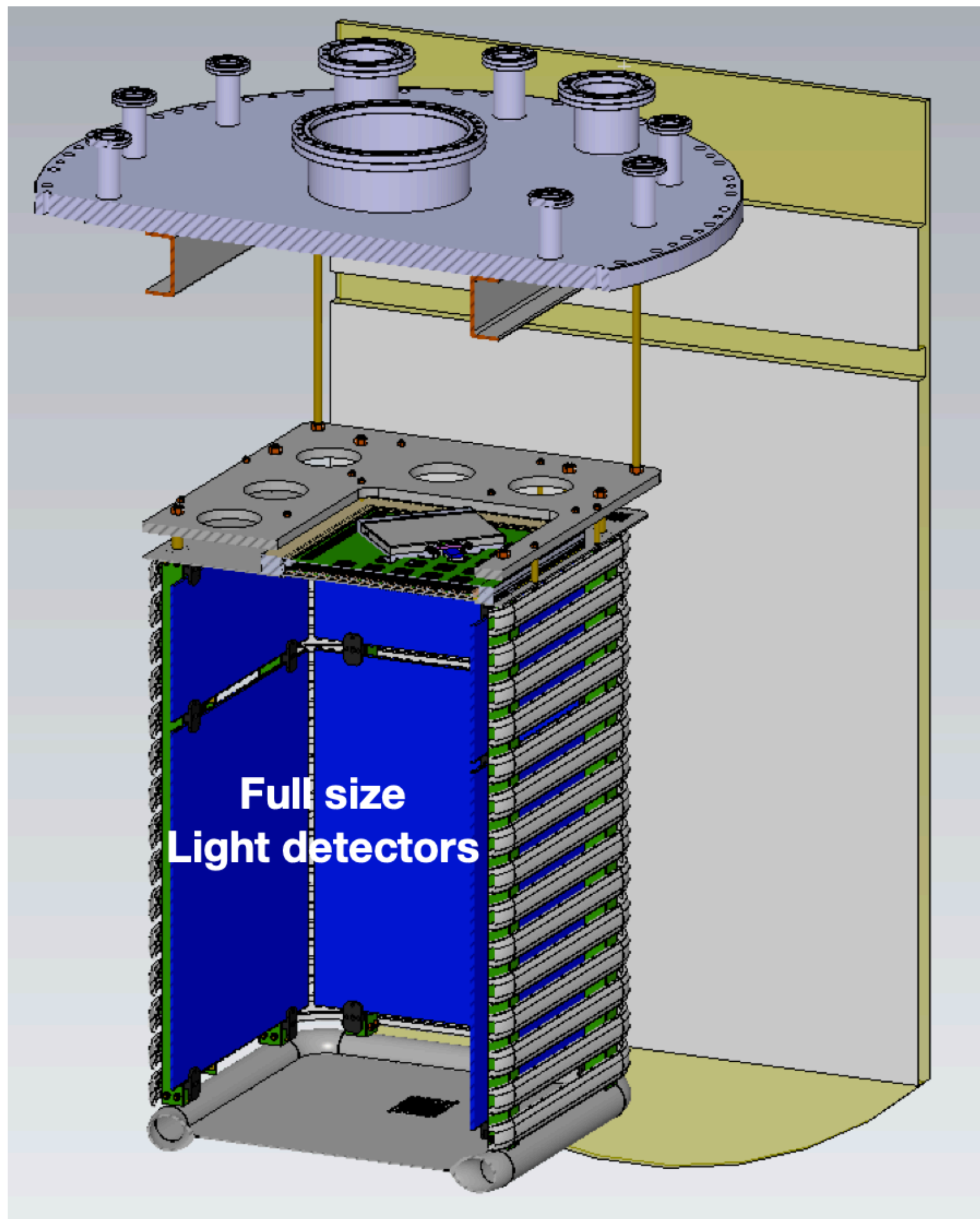
- **New LY simulations (in progress):**

- LY uniformity improvement when **PASSIVE Optical Coverage** (Reflector and WLS) on Cathode frame is implemented - *numerical results shortly..*

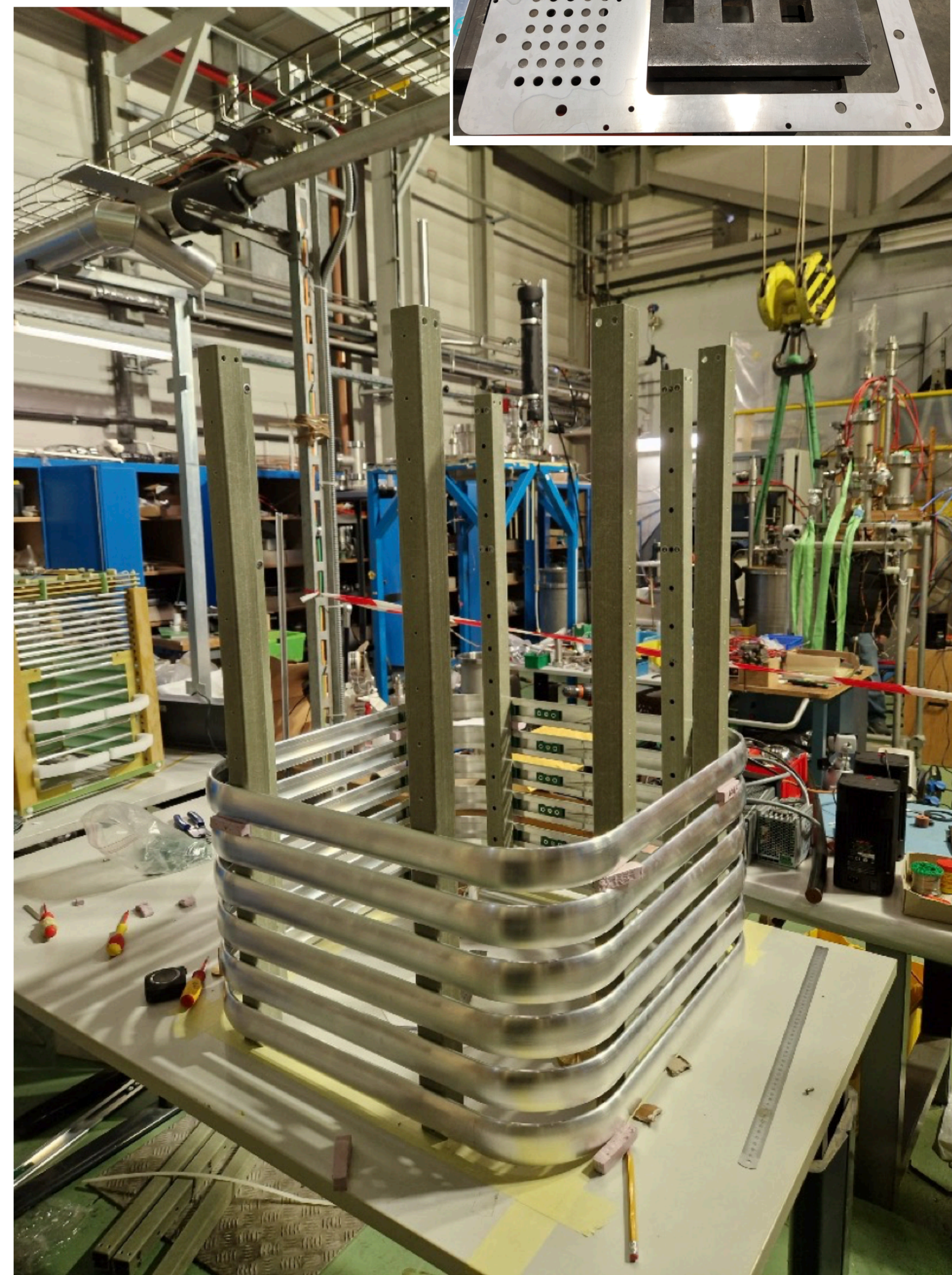
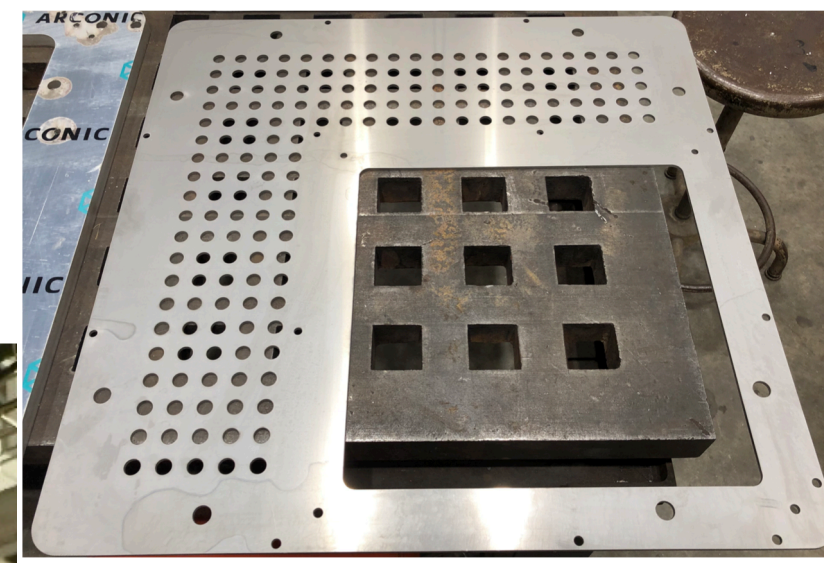
- **Under evaluation for new simulation:**

- PD-modules with different PCE (larger or smaller n. of SiPM) - distribution on FC to reduce LY in brighter regions and increase in dimmer regions
- **Active Optical Coverage** of LAr Volume behind FC-to-Membrane walls: promoting dead LAr Volume into Active Veto (to study impact of radiological background, and possible ways to reduce it)

Progress with APEX: prototype at CERN



Prototype design and Construction
At UMN, and CERN and SBU



Last week at bed. 182

2t-Prototype at CERN (bld.182)

Run-1: by end 2024

CRP+FC+Cathode (charge r/o)
+Acrylic layers(no light r/o)

- APEX Mechanical Mock-up +
- (Second) demonstration EF uniformity with insulating (charging-up) layers on FC

Run-2&3: 2025

Double Acrylic layer with
Optical R/O - PoF & SoF

- APEX full prototype