ProtoDUNEs at CERN

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PAC Mtg. - FNAL

January 20, 2016

Key Recent Developments

- CERN research board met in December and, following the SPSC recommendation, officially **approved ProtoDUNE Single-Phase** (*now NP-04*) as CERN experiment at the Neutrino Platform. [The **Dual-Phase** WA105 (*now NP-02*) was already approved in 2013]

- DUNE announced a **new ProtoDUNE SP Leadership** structure and an **updated detector management structure** where both the SP and DP prototypes are symmetrically incorporated and fully integrated.

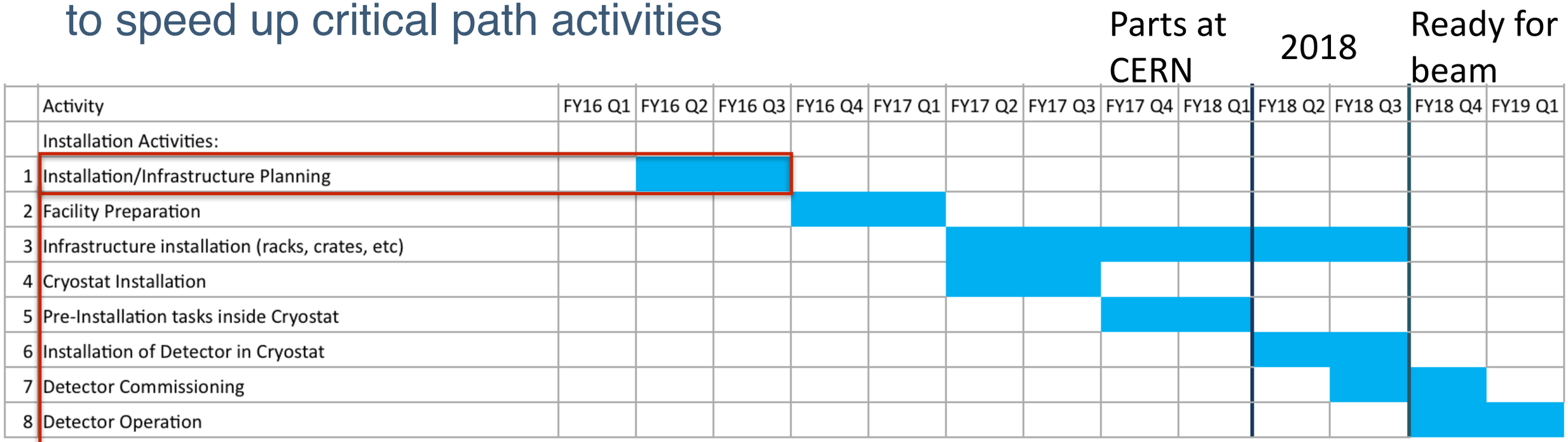
- The **CERN Neutrino Platform** is under construction. It will offer a unique infrastructure for construction and test of the two large-scale LAr prototypes at CERN.

Organizational Structure and Goals

- Building the DUNE prototypes is essential to provide input to the final design(s) for DUNE and to inform the **Technical Design Report**s due by end 2019 (and the following CD-2 review). Their installation sequences will effectively represent a real first step towards the construction of the DUNE FDs
- ProtoDUNEs (SP & DP) are **engineering prototypes** aiming to collect **physics data with charged particle beams** before LHC LongShutdown2 (end 2018).
- **Timescale is critical**
- **The protoDUNEs efforts are rapidly organizing and making very concrete progress. Their timely execution will represent an ultimate proof of readiness for FDs deployment.**
- The new ProtoDUNE Leadership/organizational structure builds upon and expands the pre-existing leadership
- An organizational document outlining key tasks and interfaces to existing working groups has been drafted and discussed at the DUNE Coll. Meeting last week.

Single-Phase ProtoDUNE
High Level schedules and short term Goals

- The DUNE management team has developed a high-level schedule for the Single-Phase ProtoDUNE for the next three years that defines the sequence of activities needed to construct, install and commission the detector on the timeline required for operation in 2018
- Plan to deploy additional resources in the recently appropriated FY16 budget to speed up critical path activities



Immediate task:

expand into detailed plan for detector integration and installation at CERN **in sync** with *EHN1-Extension* Schedule *(see next slides ☞)*

Dual-Phase ProtoDUNE / WA105
High Level schedule

Major milestones

- **September 2016**: start cryostat construction
- **April 2017**: start detector installation
- **December 2017**: seal TCO & cryostat
- **January 2018**: start cryogenic operation(cooldown+filling)
- **March 2018**: ready to collect beam data

This schedule is already fully integrated
in the EHN1 general schedule V1.5 of 10/12/2015

CERN Neutrino Platform - EHN1 Extension

M. Nessi
Nov. 20th, 2015, ECFA and EHN1-ext Planning v15, 2015-12-09

CE construction started in December 2014

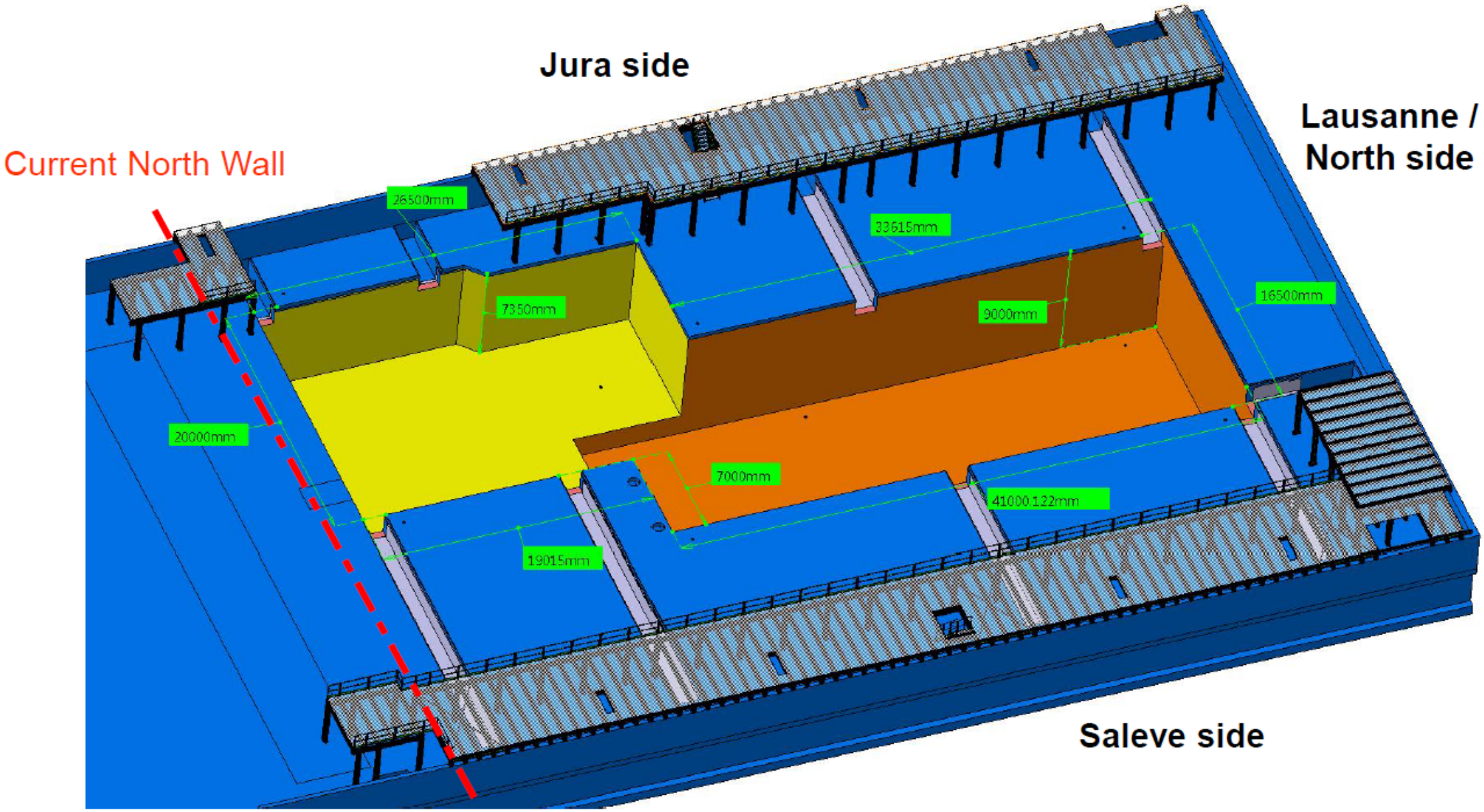
- **Target dates:**
  - CE works completed : **July 2016**
  - Infrastructure completed : **April 2017**
  - Experiments ready for beam for **2017/2018 SPS run**

- End of CE - FY16Q3 (Jul. 16)
- End Infrastructure Work - FY17Q2 (end Mar.17)
- SP cryostat ready - FY17Q3 (end Apr. 17)
- H4 Beam Line ready - FY17Q4 (Oct.17)

(to be discussed)

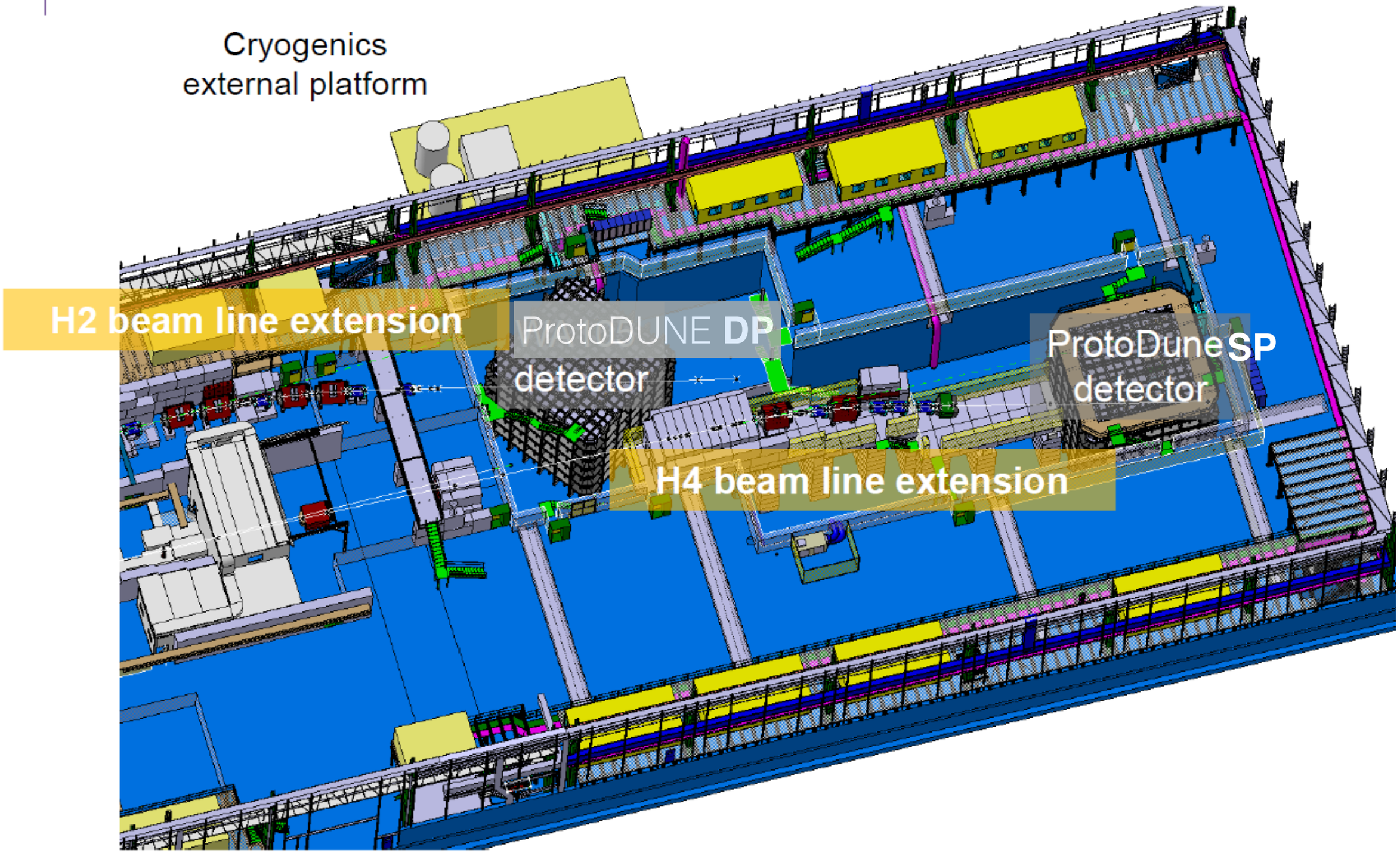
EHN1 extension The Neutrino Platform at CERN

Building as delivered by the civil engineering at the handover



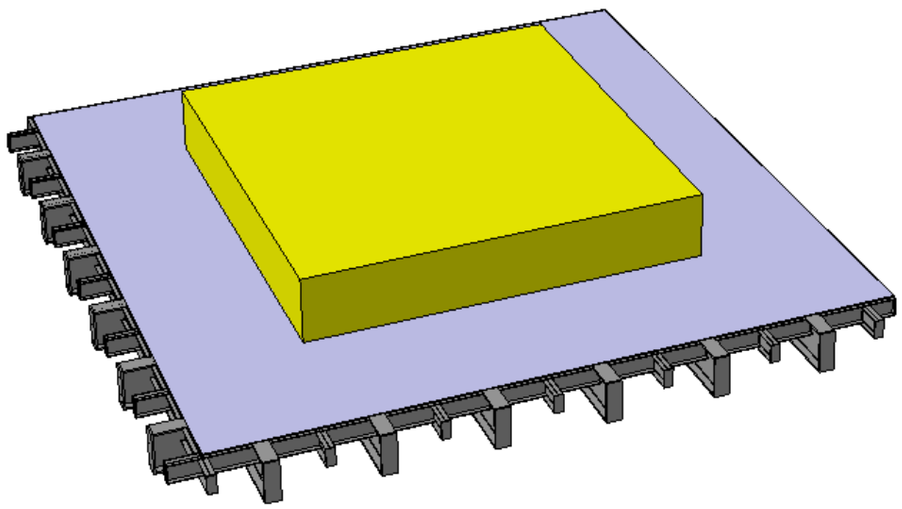
EHN1 extension integration

Courtesy V. Clerc, S. Girod EN/MEF



Cryostat vessels construction

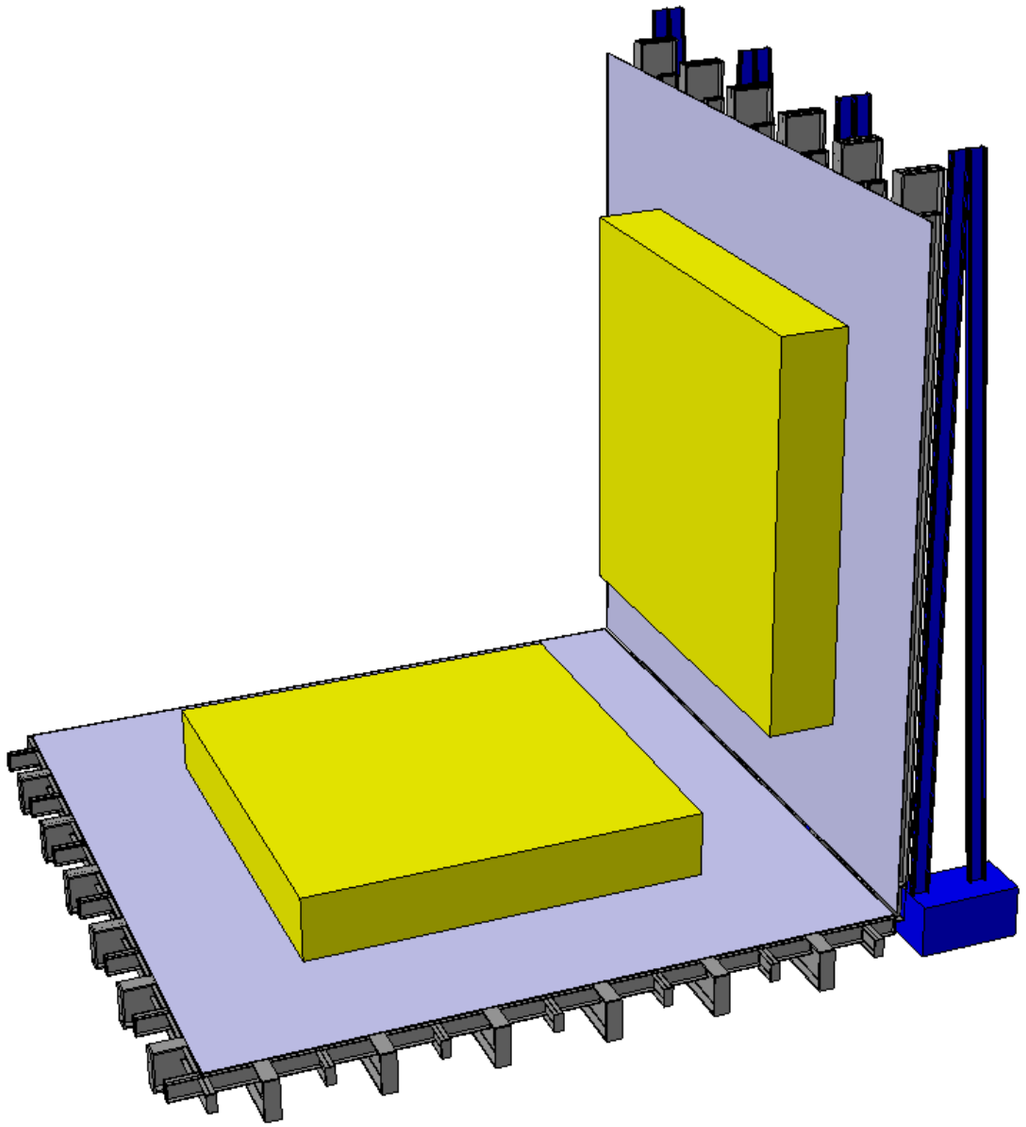
INSTALLATION



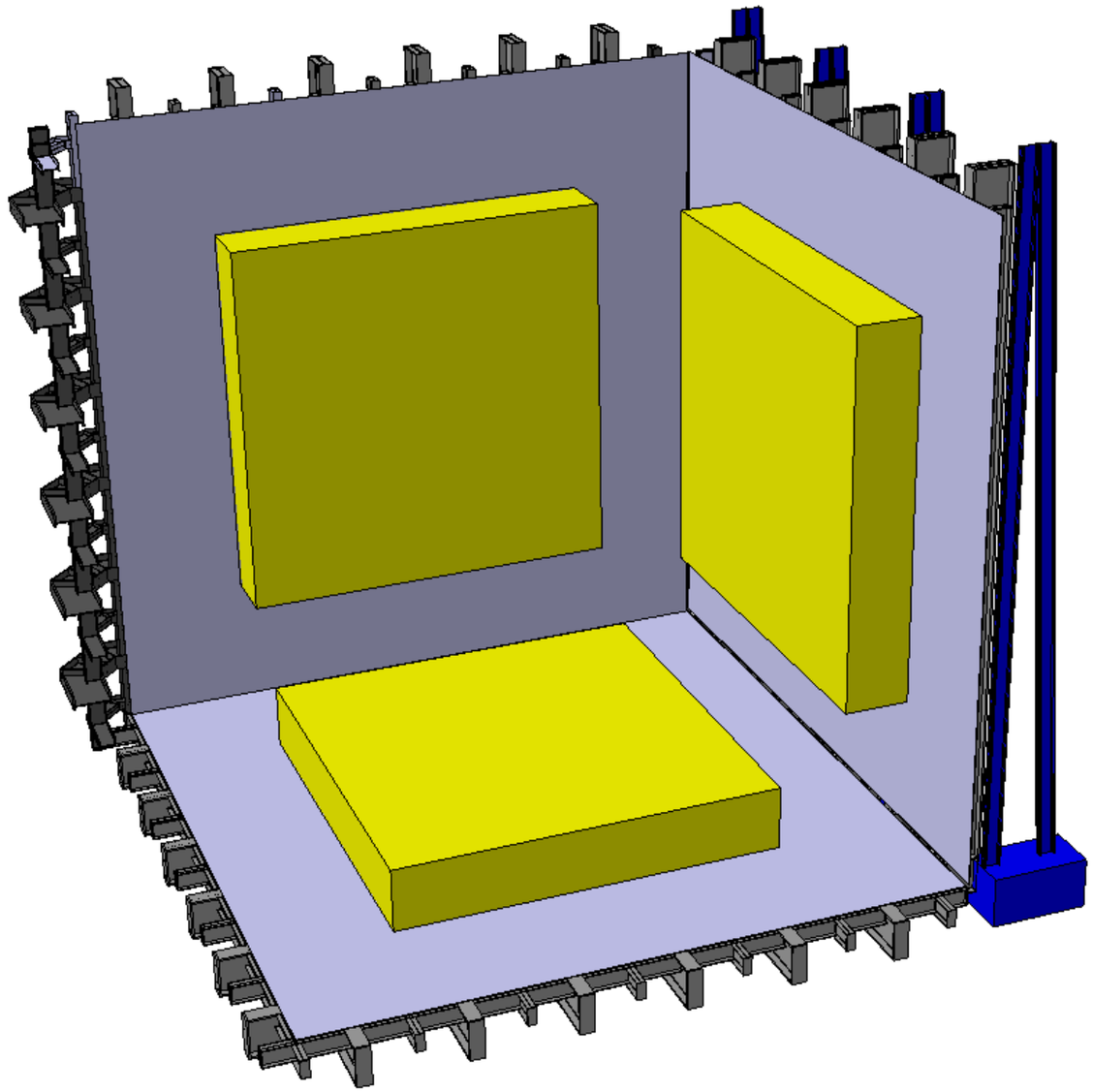
Material shown below from

ProtoDUNE Cryostat Review - FNAL 17-Dec-2015

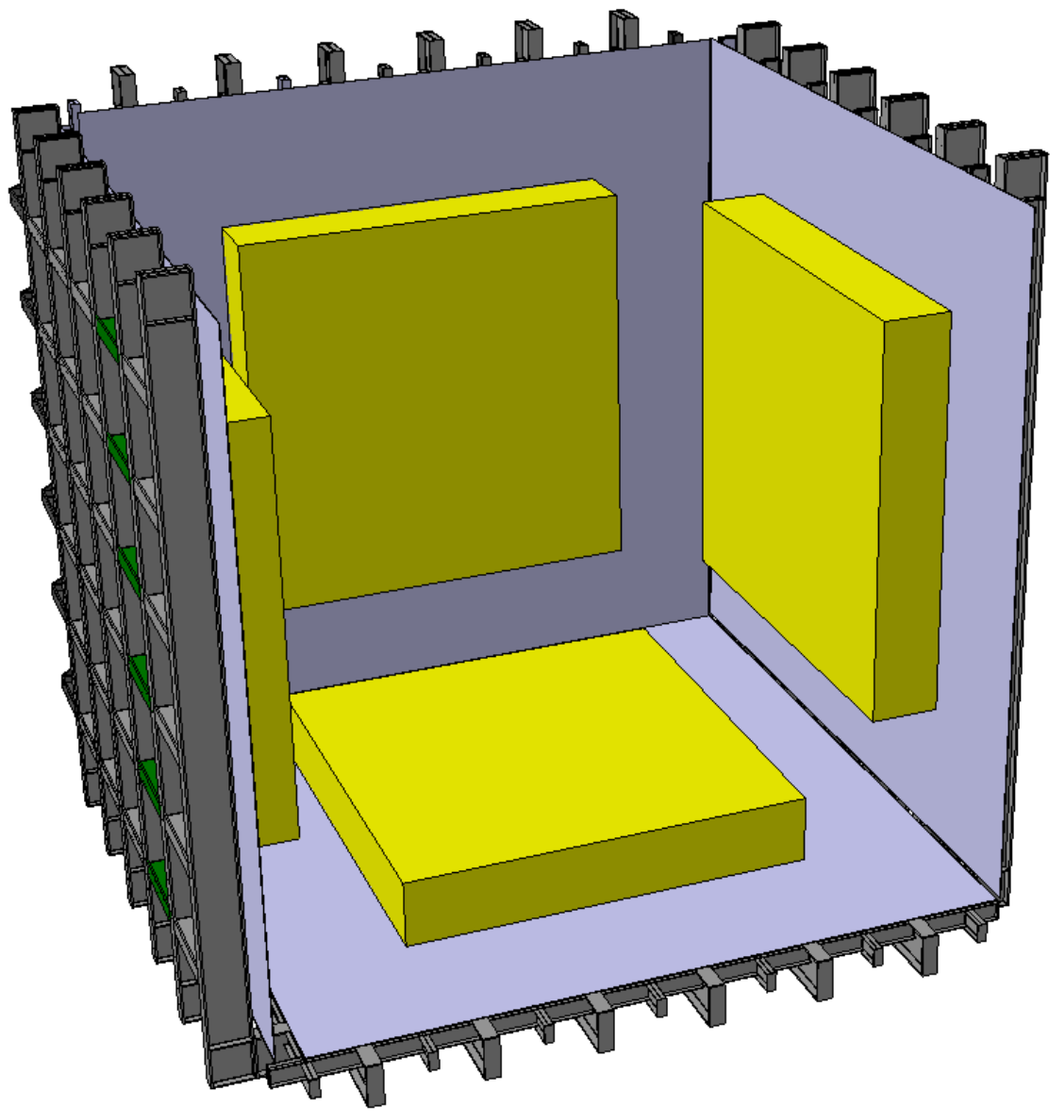
INSTALLATION



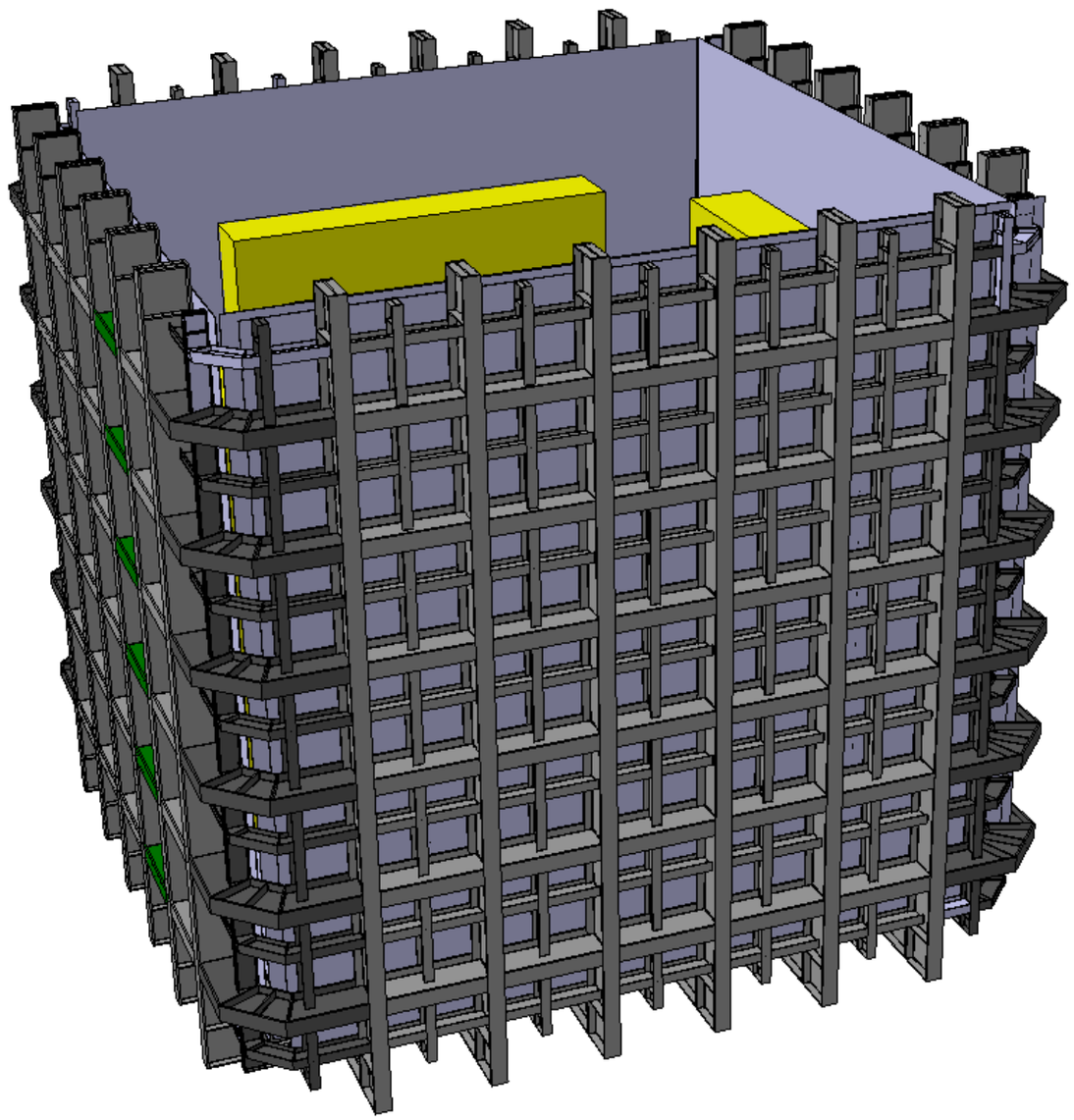
INSTALLATION



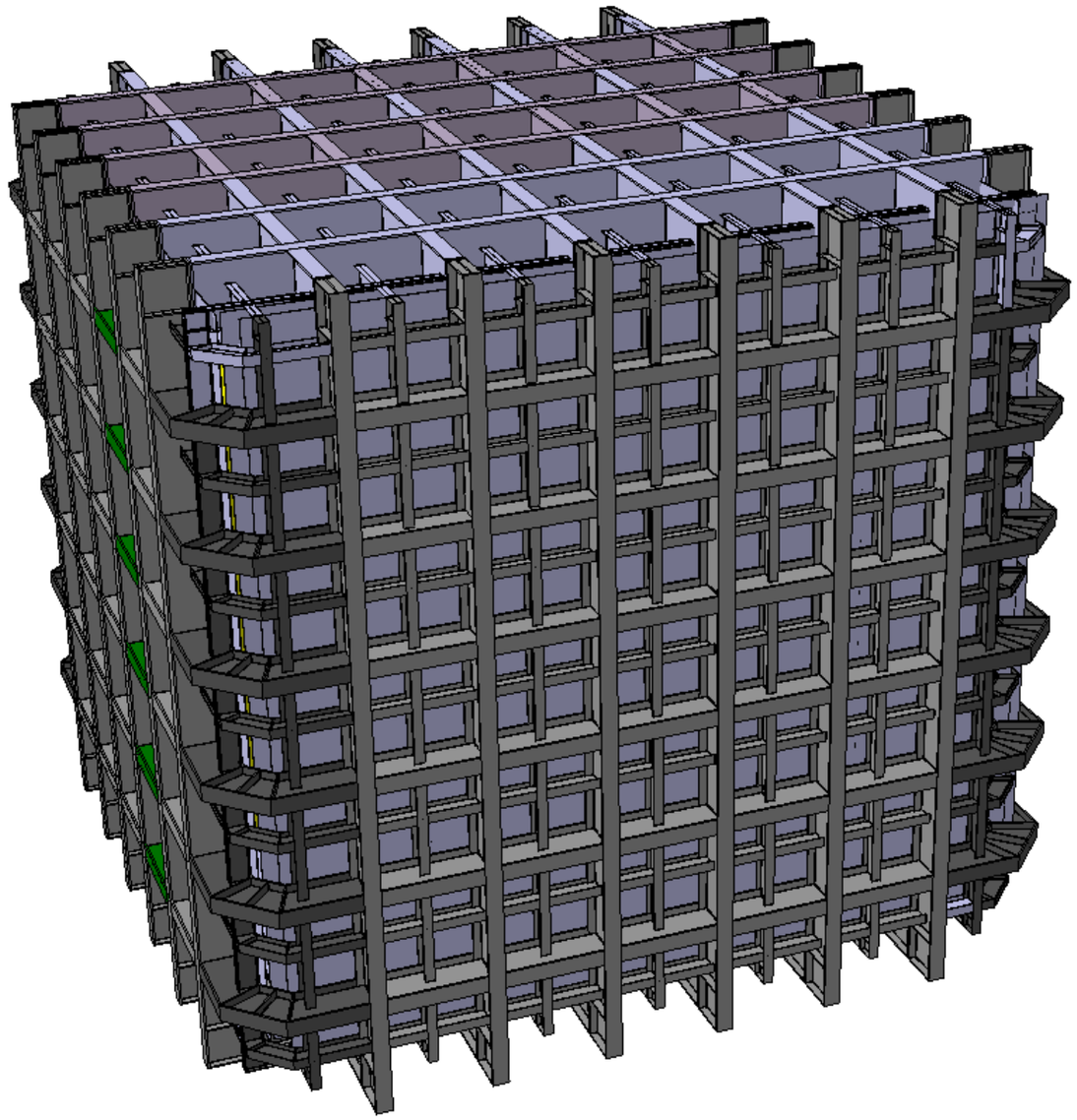
INSTALLATION



INSTALLATION



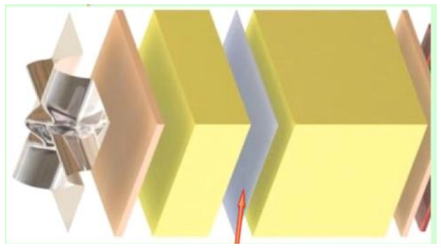
INSTALLATION



Cryostat vessel construction

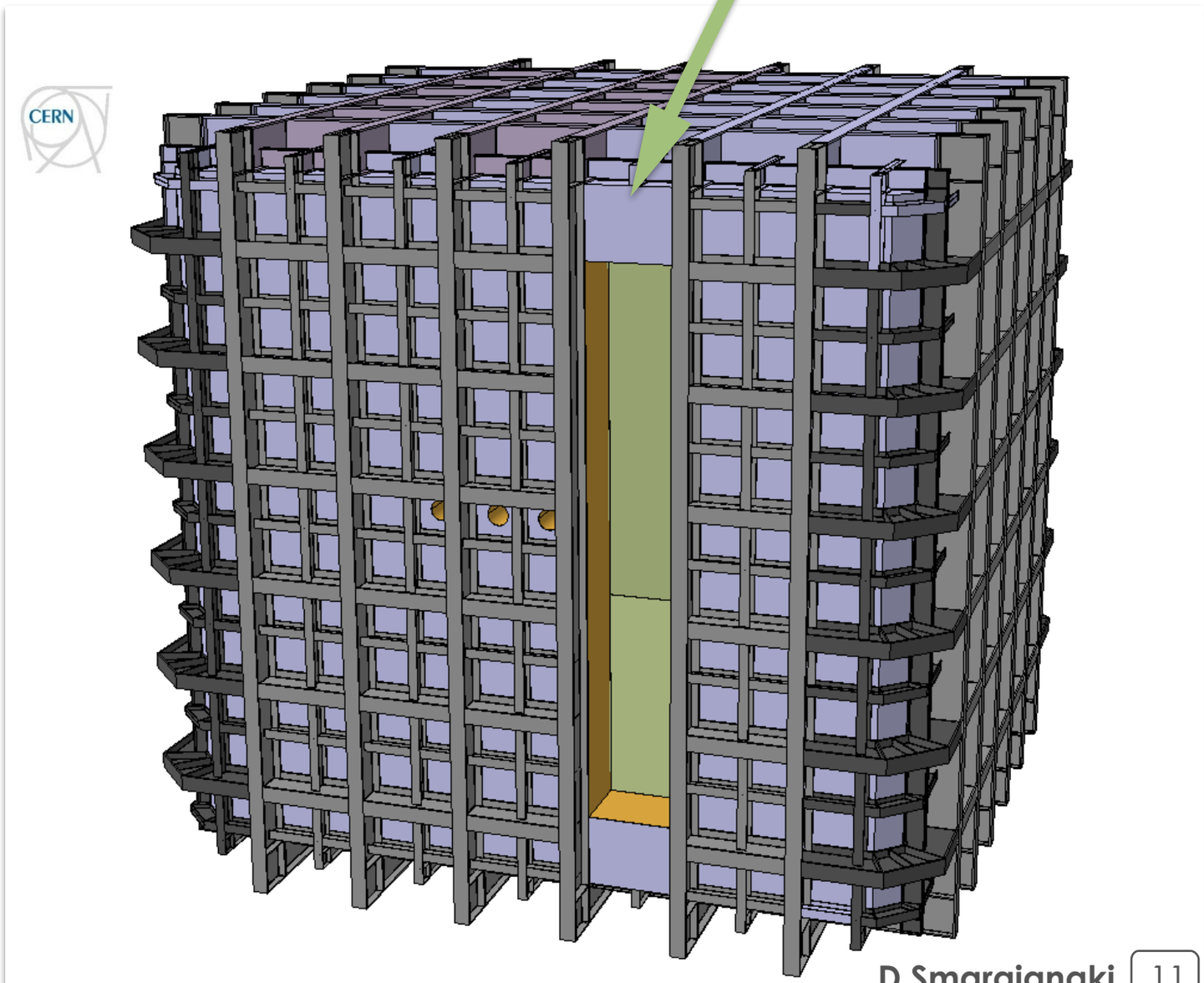
TCO: *opening of 1372mm x 7900 mm on a side wall for inner detector installation*

- Installation of the remaining insulation
- Install membrane
- Leak test cold vessel



- Installation of the TPC detector
- Close TCO

TECHNICAL CONSTRUCTION OPENING

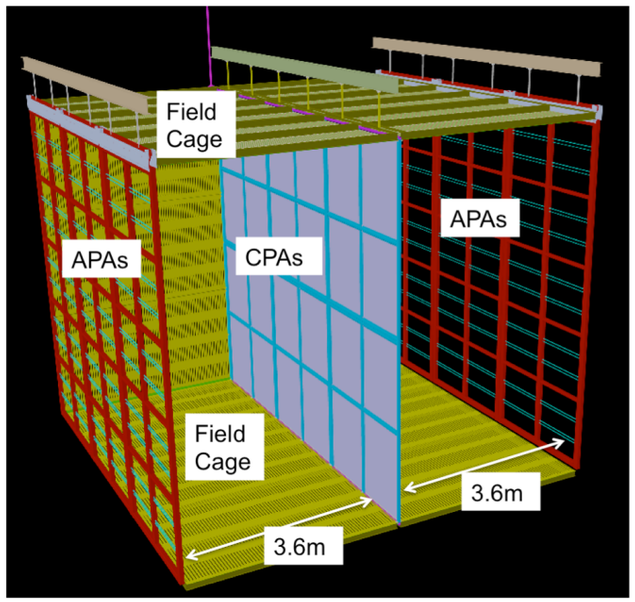


The design of the exoskeleton, the installation sequence with the pre-assembled membrane panels, the TCO and the leak test “suction” machine are all concepts that were developed in the context of WA105

Where are we today?

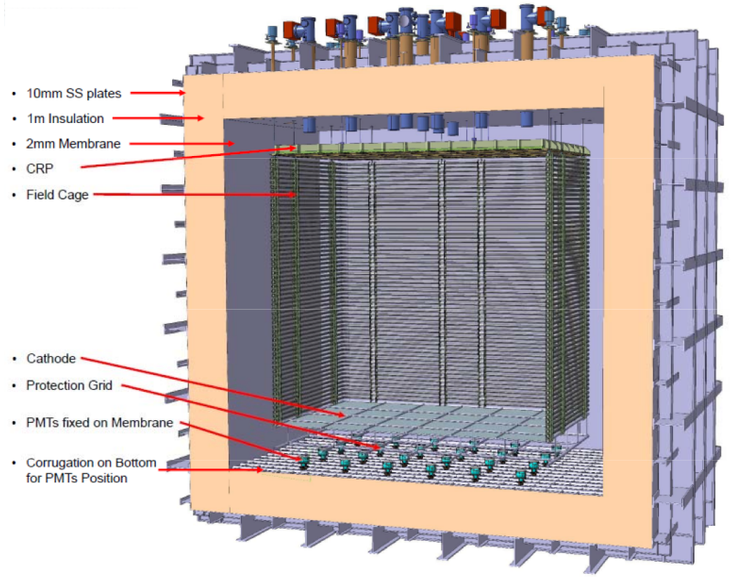
- ***The Single-Phase ProtoDUNE detector was only recently formally approved and consequently the model for funding and institutional responsibilities is not fully developed yet. Establishing this model is a major short-term goal***

Single-Phase ProtoDUNE



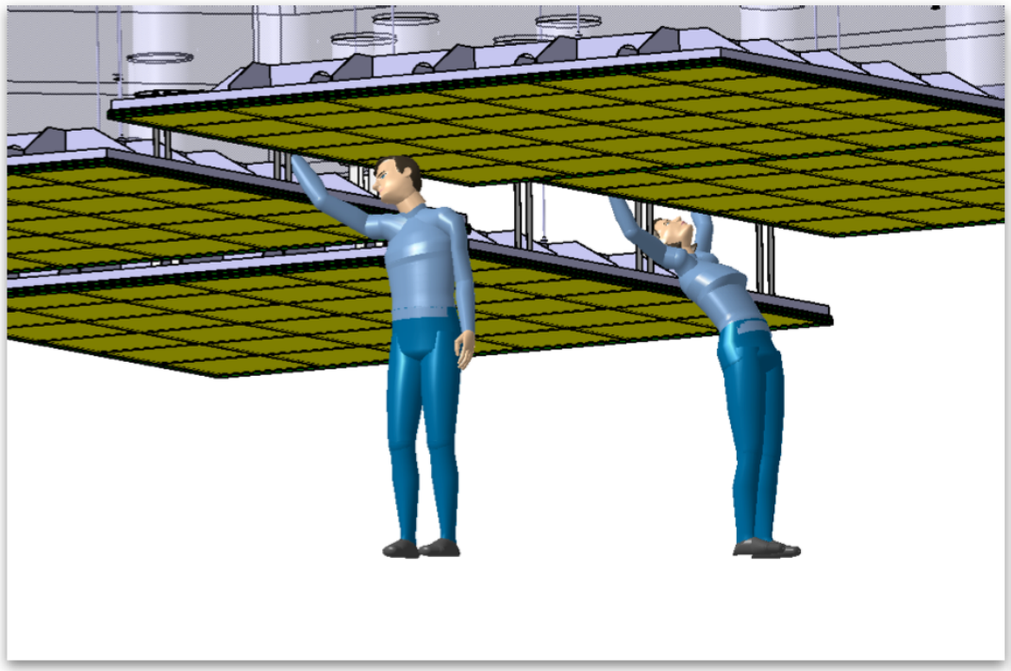
- ***Dual-Phase ProtoDUNE detector was approved prior to the formation of the DUNE collaboration, and the resources for its construction have effectively been secured***

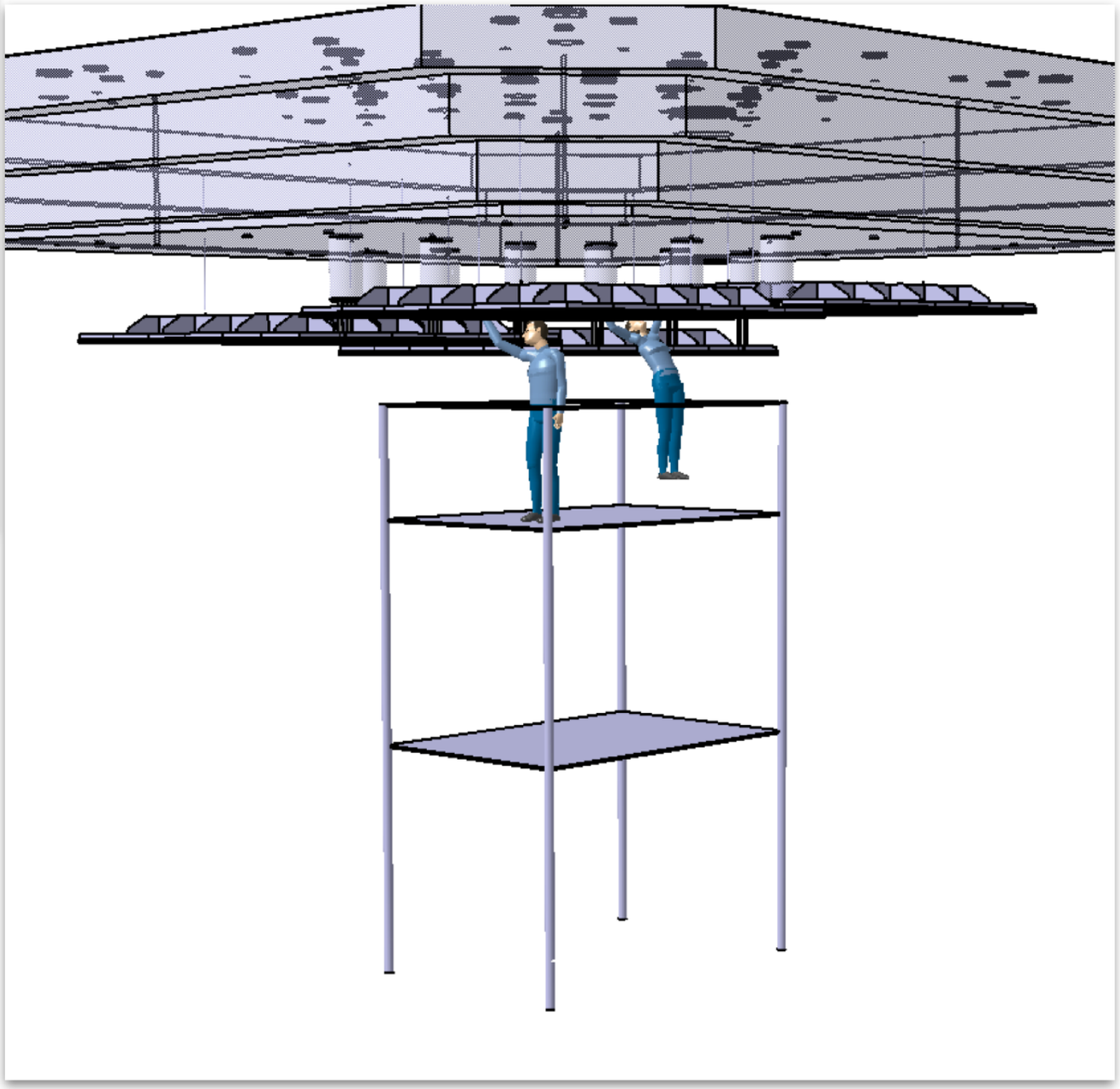
Dual-Phase ProtoDUNE

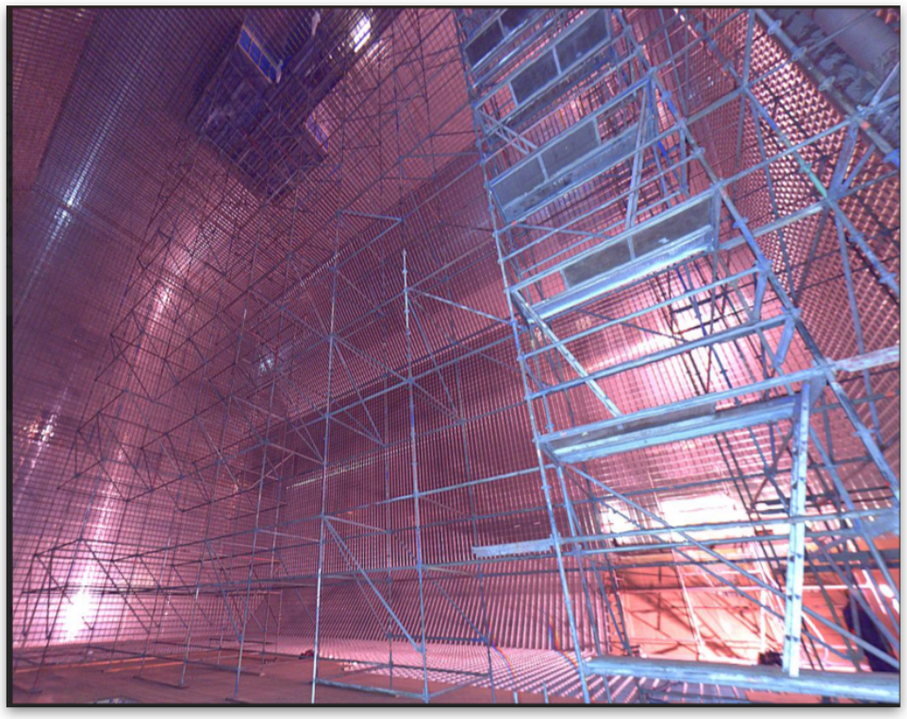


Dual-Phase ProtoDUNE

Installation of the CRP in the cryostat



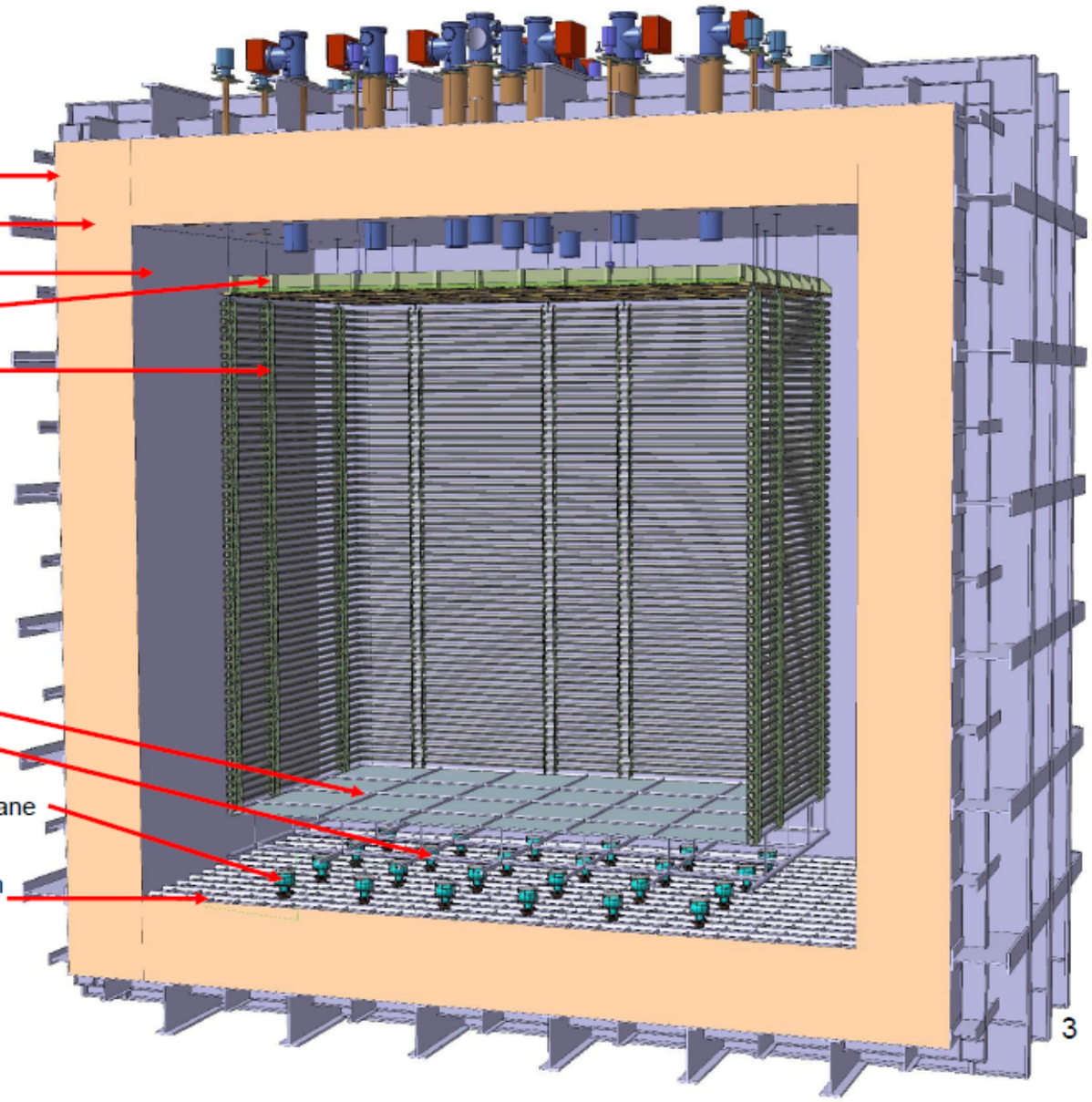


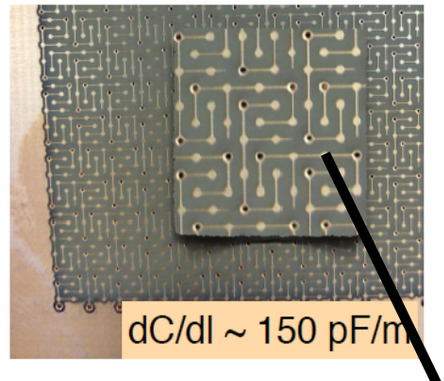


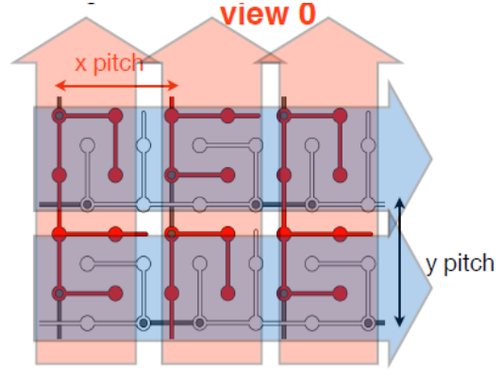
Dual-Phase ProtoDUNE

General Layout

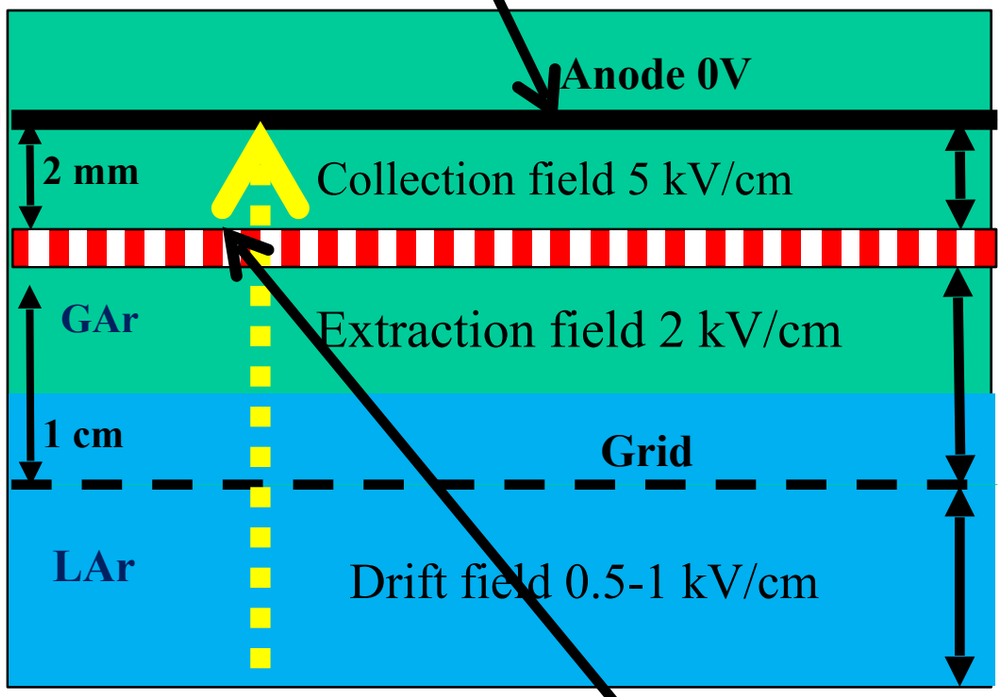
- 10mm SS plates
- 1m Insulation
- 2mm Membrane
- CRP
- Field Cage
- Cathode
- Protection Grid
- PMTs fixed on Membrane
- Corrugation on Bottom for PMTs Position



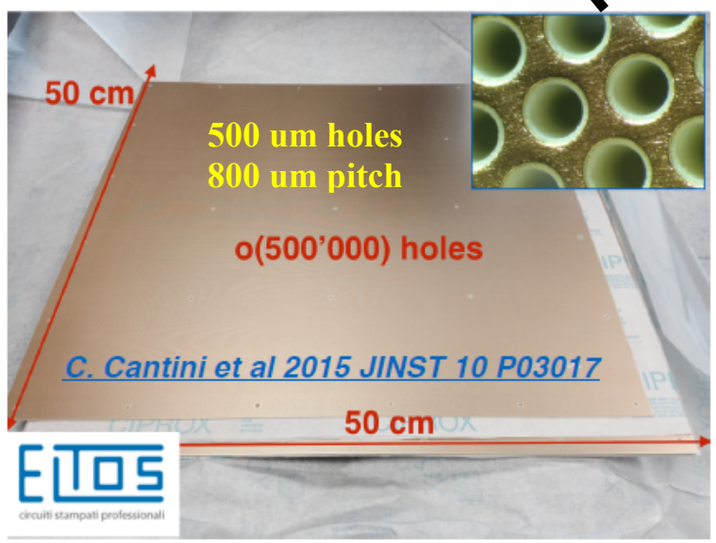




LEM (1mm)
25-35 kV/cm



50x50 cm² LEM



→ **6x6x6m³ active volume, 298 tons, 7680 readout channels**

Single-Phase ProtoDUNE TPC Construction

- APA planes: Solid engineering team in place (PSL – U. of Wisconsin) + UK funding request submitted
- Design and construction of the CPA planes and detector field cages is critical
- Scientific team to be set-up to work with engineering team on developing QA and QC/testing procedures, integration and commissioning of the APA planes at CERN

Single-Phase ProtoDUNE Cold Electronics Fabrication

- Development of front-end ASIC chips driven by BNL engineering team
- QA process to ensure the functionality and reliability of the readout electronics

Single-Phase ProtoDUNE Photon Detectors

- Studies needed to finalize the design of the detectors (critical tasks in FY16)
- Detector production is expected to take place in FY17 (currently envisioned to be based at universities)

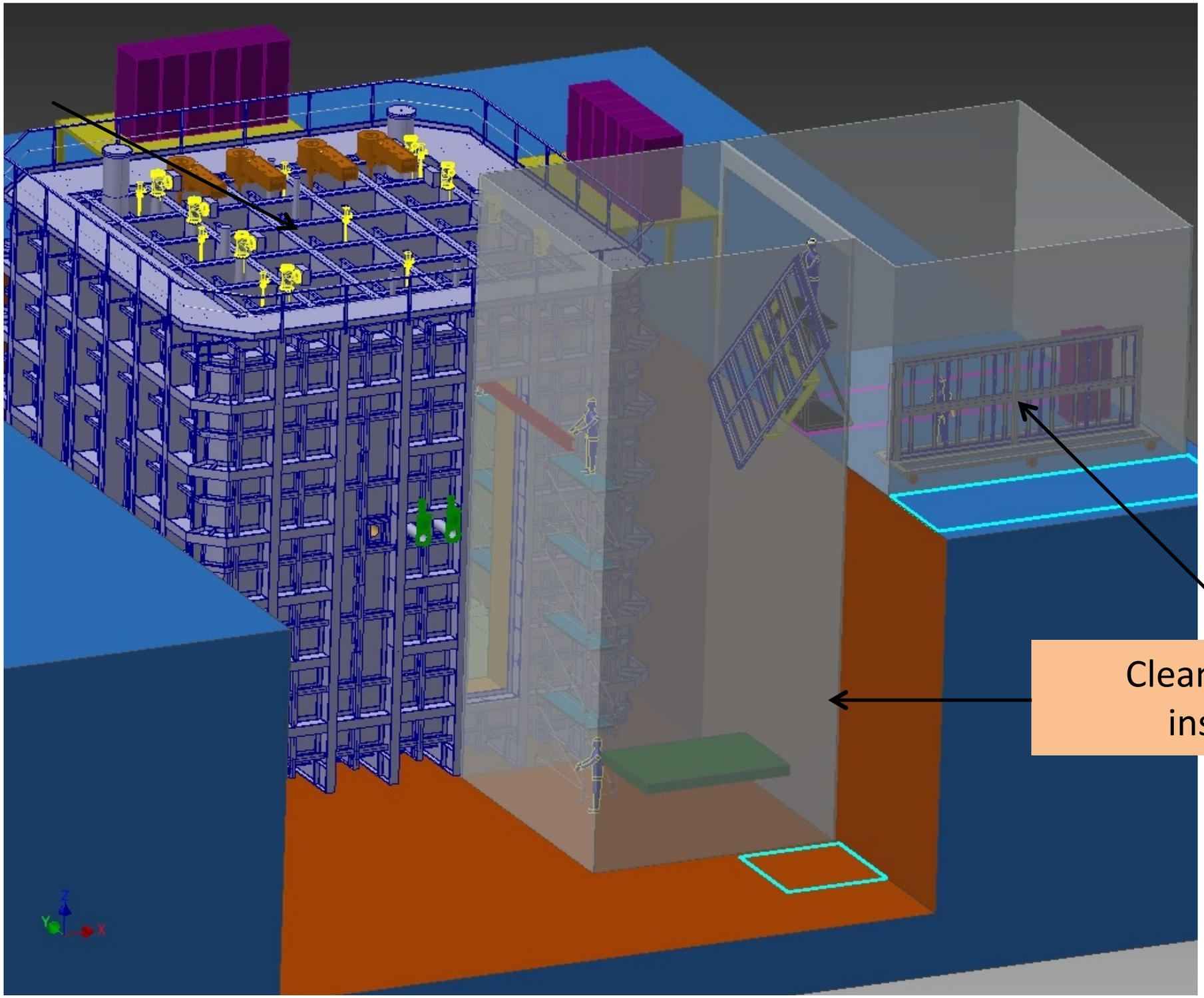
ProtoDUNE DAQ

- common solution for the Single and Dual-phase ProtoDUNE detectors may still be possible
- Next step is an envisioned two-day workshop at CERN in late February

Single-Phase ProtoDUNE Integration and test at CERN

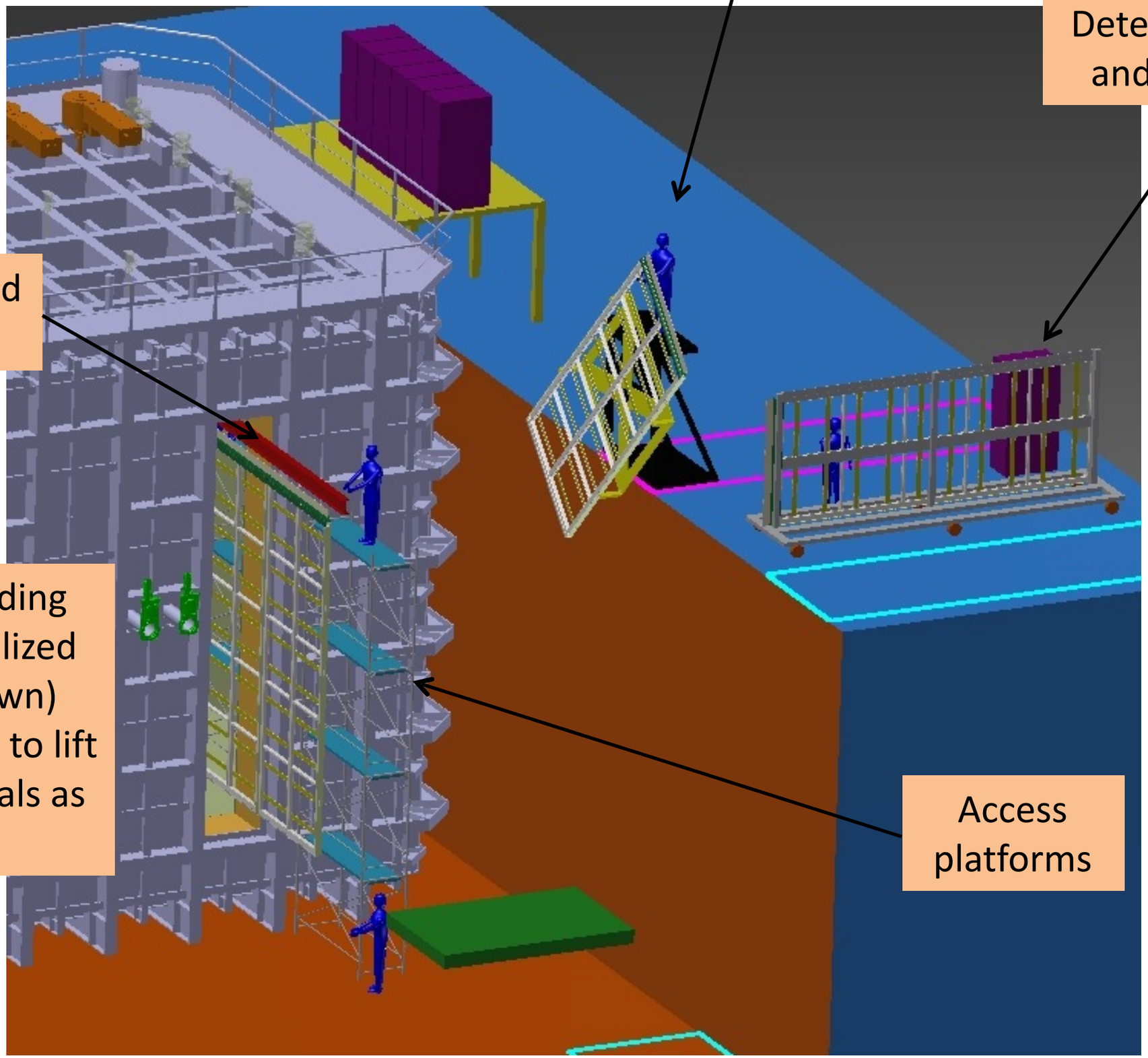
- A Full Detail-level Schedule for ProtoDUNE detector integration/test/ installation to be worked out in sync with EHN1-ext. schedule
- There is a good conceptual design of an installation process through the access openings provided in the cryostat.
- A dedicated team (tech's, eng's, phys's) to be identified and committed to the detector integration and tests

Clean and laydown space for installation



(Jack Fowler)

Material movement

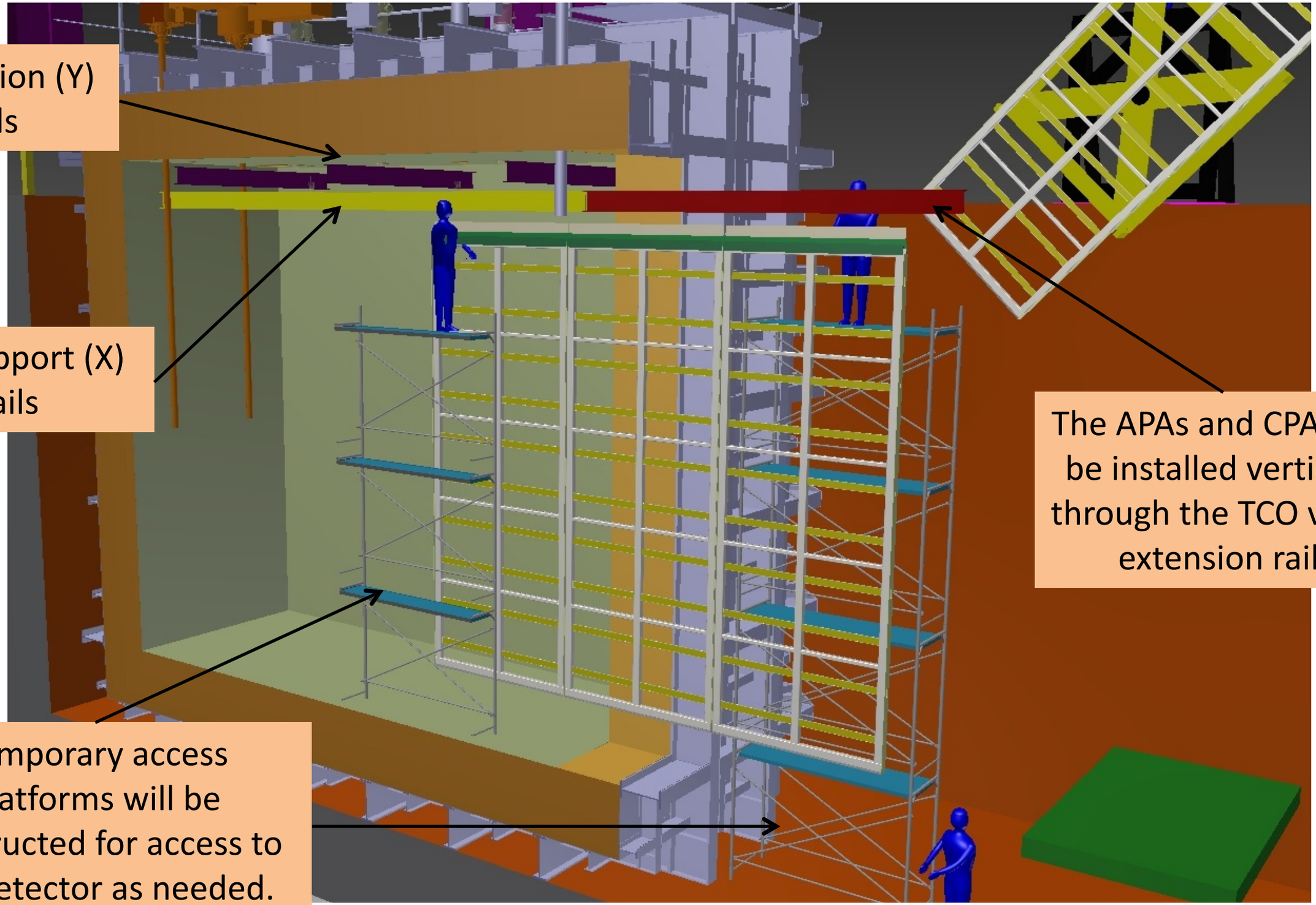


The current building crane or a specialized gantry (not shown) crane will be used to lift and move materials as needed.

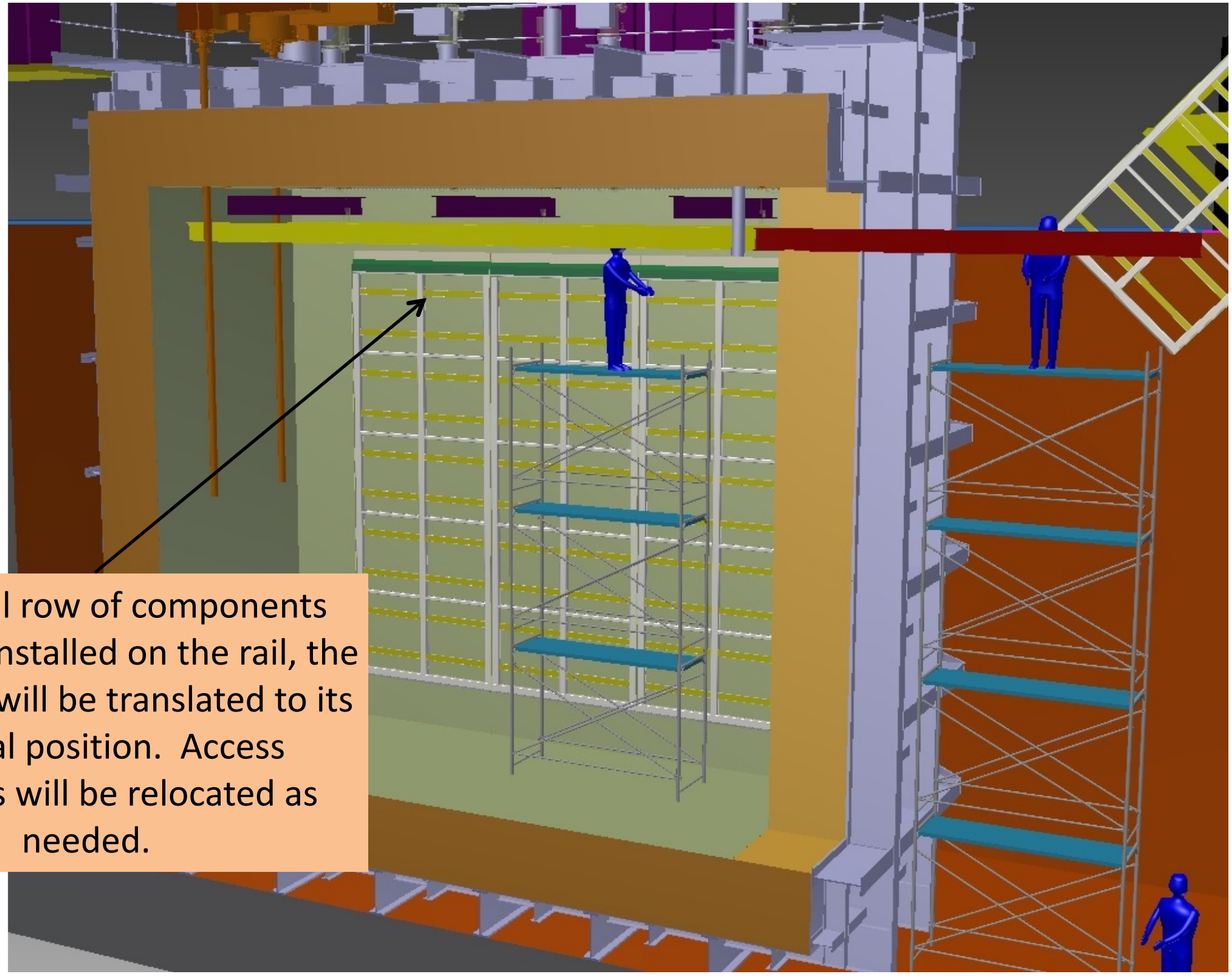
(Jack Fowler)

APA / CPA installation concept

(Jack Fowler)



Translation of APA / CPA to nominal positions

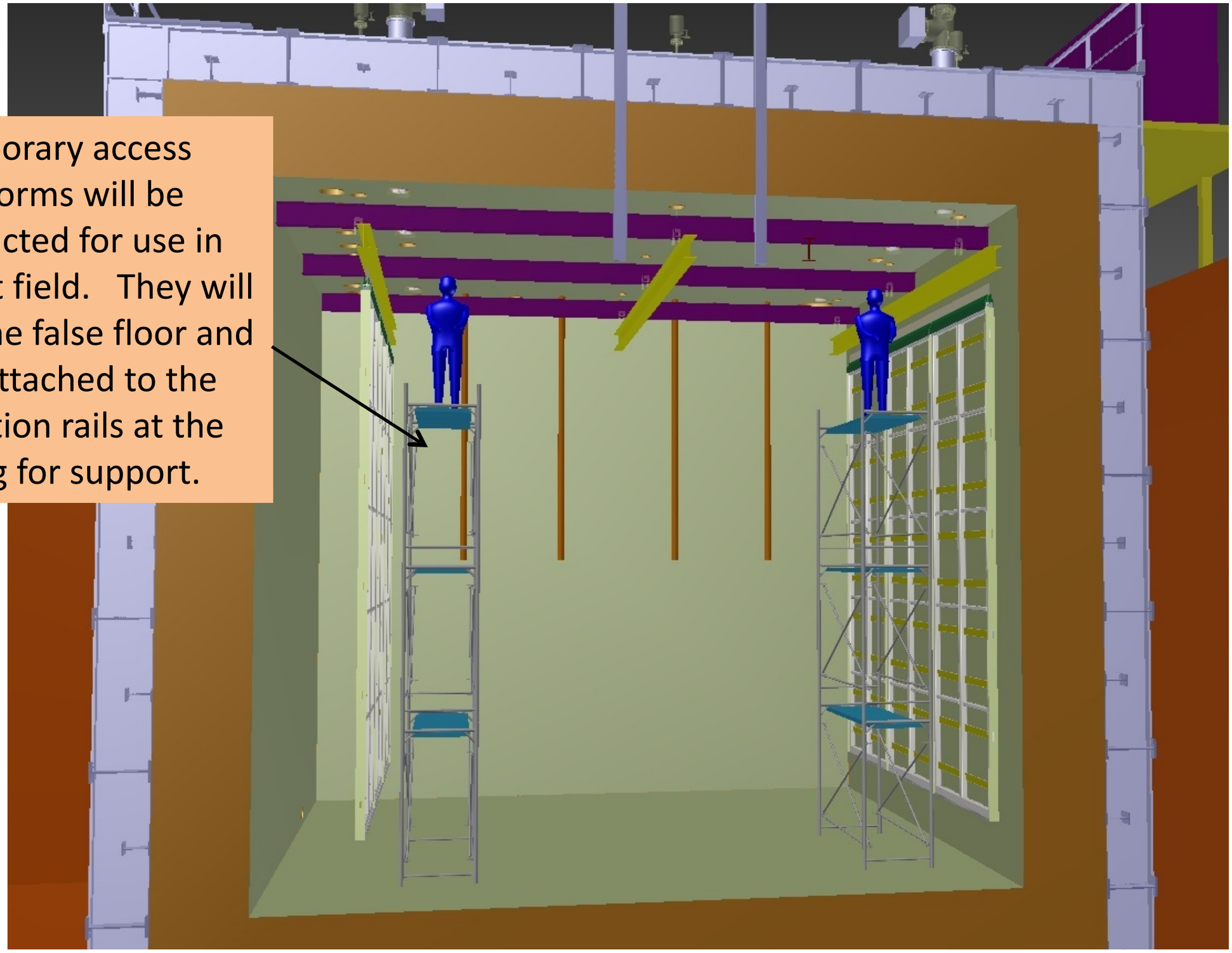


After a full row of components have been installed on the rail, the entire wall will be translated to its nominal position. Access platforms will be relocated as needed.

(Jack Fowler)

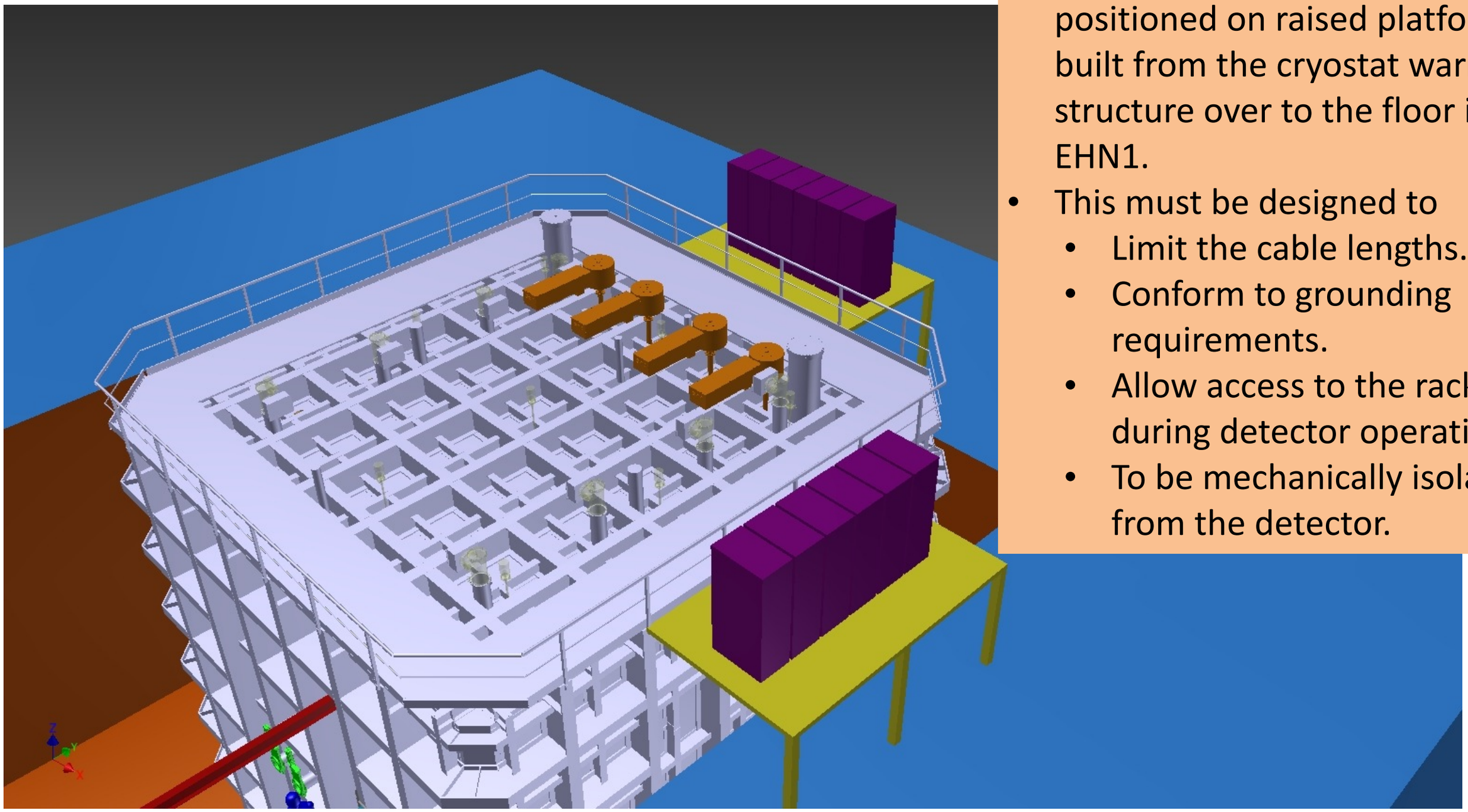
Temporary access equipment

Temporary access platforms will be constructed for use in each drift field. They will rest on the false floor and likely attached to the translation rails at the ceiling for support.



(Jack Fowler)

Possible electronics rack locations



- Electronics racks will be positioned on raised platforms built from the cryostat warm structure over to the floor in EHN1.
- This must be designed to
  - Limit the cable lengths.
  - Conform to grounding requirements.
  - Allow access to the racks during detector operation.
  - To be mechanically isolated from the detector.

(Jack Fowler)

Outlook

- ProtoDUNE(s) are the largest LAr detector being built so far. The timeline for construction is very compressed (and no float in the schedule)

  on the other hand,

- the ***technical expertise*** is robust and diffuse both in Eu and in US and the ***experience & know-how & tech. background*** collected in the last 15+ yrs in LAr is very extended and reliable
  - *with full scale LAr prototype tests and the preparation of new experimental site(s) (ICARUS 10m³ at GS, **DUNE 35ton at FNAL**)*
  - *with the construction of membrane cryostats at CERN: **WA105 3x1x1 m³ demonstrator** (almost ready)*
  - *with the construction and successful commissioning/physics-run of several LAr detectors of increasing volume (ArgoNeuT, **MicroBooNE**, ICARUS)*
  - *with the set-up of a low momentum charged particle beams and the first successful operation of LArTPC in the test beam line (**LArIAT)***

Outlook (cont'd)

- ProtoDUNE (SP) detector is similar in design and timeline to the SBND detector at FERMILAB: the development of effective synergies, the exploitation of common detector solutions, of common test tooling, and the optimal use of resources (human and financial) are the goals of the on-going DUNE and SBN management effort ***(SBND-DUNE: TPC/Cold Electronics workshop - Sept.16, DAQ and R/O electronics workshop -Nov.16)***

- ProtoDUNE **SP** and **DP** share the neutrino platform at CERN: this offers great opportunities for expanding common "infrastructures" (e.g. cryo, DAQ, computing,…) and optimal use of resources, and more in general for rejuvenating the "**Neutrino Community at CERN**" - ***A dedicated meeting at CERN is planned (Feb.'16) to discuss SinglePhase-DualPhase integration***

- FTE in the ProtoDUNE **SP** Collaboration need to grow and expand - both in US and in EU - in particular the inception of a fully dedicated and motivated contingent based at CERN is an essential condition for the success. This should include qualified human resources from US (Univ. Grp.s and FNAL) and non-US/International groups, and from new EU groups joining ProtoDUNE (***A call was made to the collaboration institutes for submissions of Expressions of Interest for contributing to the prototyping efforts***)

BackUp Slides

CERN protoDUNEs management (new)

The **DUNE prototypes form an integral part of the DUNE collaboration** and consequently their Management is embedded in the DUNE Management and organization, with a local coordination for each of the single & dual phase protoDUNE prototypes.

F.Cavanna/ FNAL

C.Touramanis /Liverpool

T.Kutter/ LSU

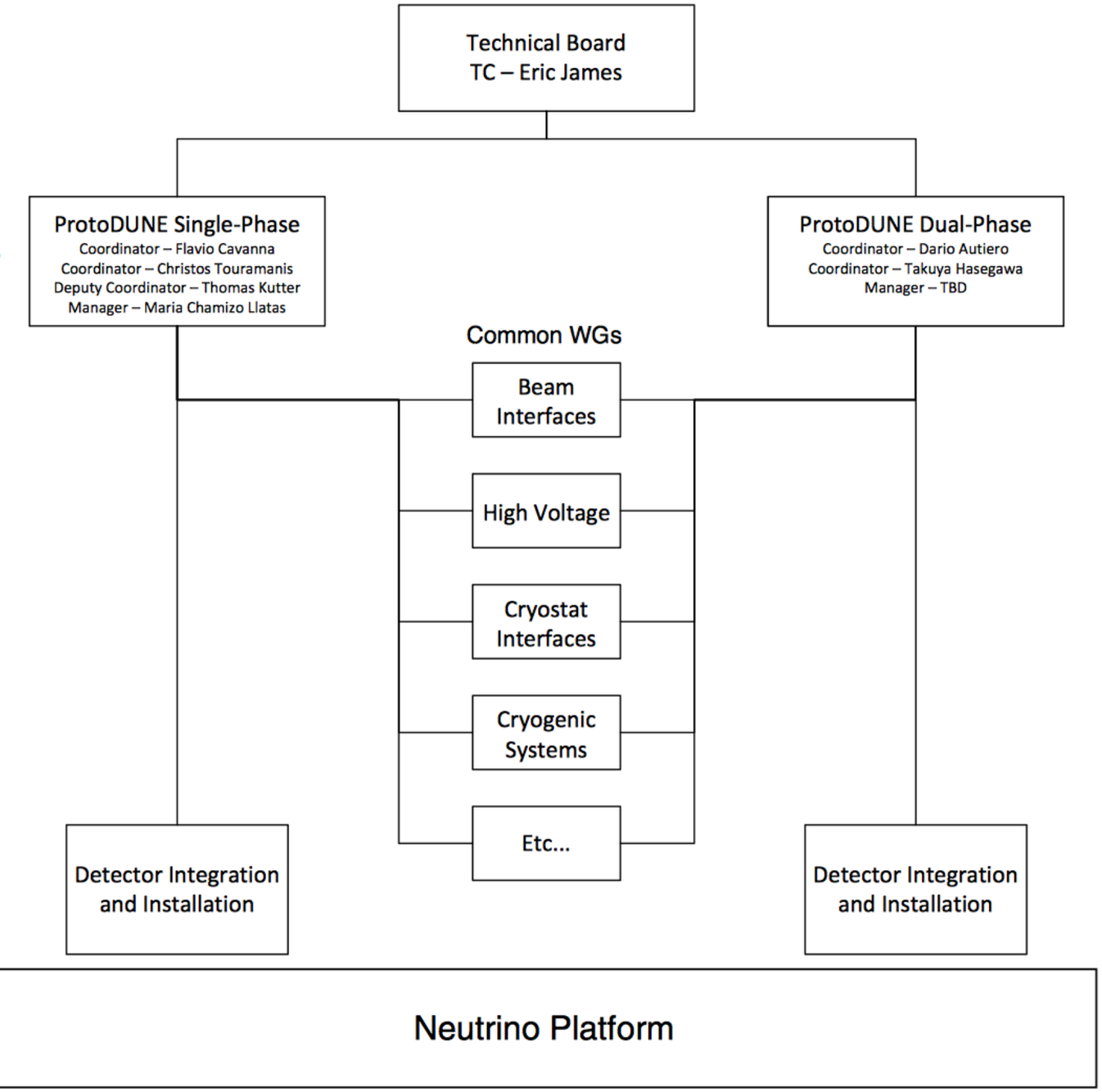
M.Chamizo/ Stony Brook (from 1.1.16)

M.Nessi/ CERN

D.Autiero/ IPNL

T.Hasegawa/ KEK

tbd

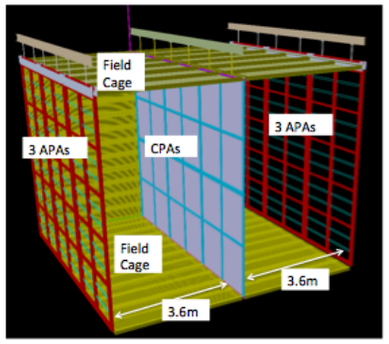


Two DUNE Priorities (now → 2019)

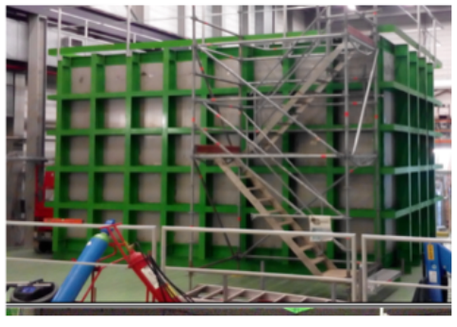
- **Two equally important priorities for DUNE from now through 2019**
  1. Prepare the **DUNE Technical Design Report** and other material towards the CD-2 review in 2019 following up on the CDR positively reviewed at CD-1 *(the Collaboration strategy towards CD-2 to be developed in the coming months)*
  2. Construction, installation, commissioning, and operation of **single- and dual-phase large scale prototypes that will provide input to the process leading to the final design(s) for the DUNE far detector modules**

35T @ FNAL

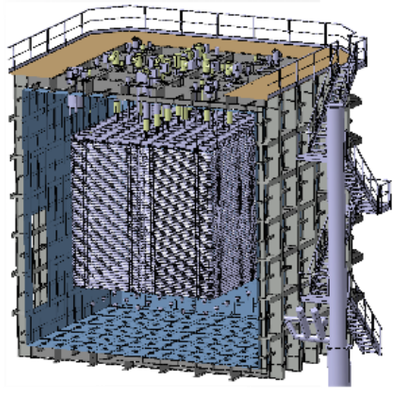
NP04@CERN



WA105 3x1x1@CERN



WA105@CERN



- *Mitigation of risks associated with current detector designs*
- *Establishment of construction facilities required for full-scale production of detector components*
- *Early detection of potential issues with construction methods and detector performance*
- *Provides required calibration of detector response to particle interactions in test beam*

- **Critical path activities to follow the planned installation of the first and subsequent 10-kton far detectors at SURF in the early 2020's**

Ongoing prototyping efforts

- **Single-phase : 35T @ FNAL**
  - Very significant and successful effort of integration in the last months
  - Significant developments in electronics/DAQ chain integration
  - Gas purge phase started; LAr filling scheduled for January 2016
  - Test of wrapped wires APA concept (resolution of ambiguities, charge collection, …), PDS, etc.
- **Dual-phase : 3x1x1m3 @ CERN**
  - First GTT membrane cryostat constructed and thoroughly tested (membrane leak rate, exoskeleton concept, tightness, etc…)
  - Detector integration starts in January 2016
  - Cryogenic operation foreseen for September 2016
  - First demonstration dual-phase performance at 10-ton scale

We would like to take the opportunity to warmly thank all Collaborators and Supporting Staff who have made this amazing progress possible. We look forward to taking and analysis the data. This will represent an important milestone for the Collaboration.

Next: the large-scale protoDUNEs

- **Timescale is critical to inform CD2 and aiming to collect physics data before LHC LS2**
- **Management is now in place (finally)**
  - New integrated and symmetric organisational structures for single- and dual-phase with highly-experienced coordination teams
  - New structure allows to take maximum advantage of the synergies between the two efforts and profit from earlier start of WA105 at CERN NP.
- **Technical organisation is in place**
  - Internal reviews e.g. cryostat internal review Dec 15, CFD review, etc…
    - feedback and actions discussed by DUNE Technical Board, then recommendations via TC to EC Board.
  - Engineering resources are critical for the timely success of the efforts (support from Labs & institutions is crucial)
- **Resources and institutional responsibilities**
  - **MoUs for WA105 & NP04 signed with CERN**
  - **Establishing a model for non-DOE funding and institutional responsibilities of single-phase protoDUNE is a major short-term goal.**
  - **Need dedicated teams stationed at CERN.**

Single phase protoDUNE

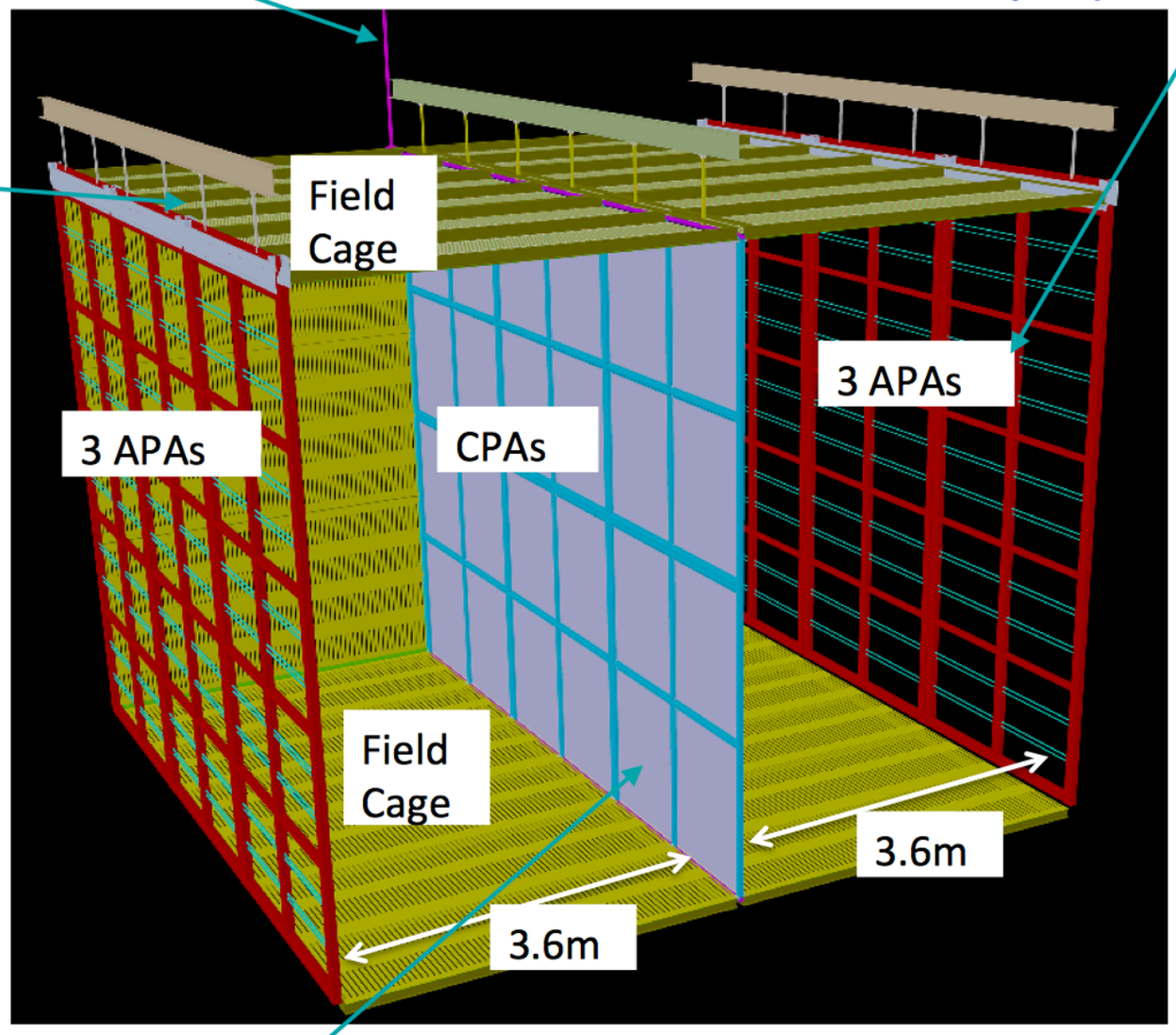
(Non-DOE funding under negotiation)

Drift HV system

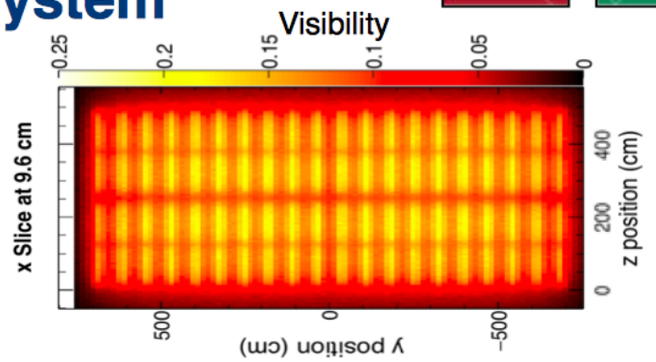
Signal feed-throughs

Anode Plane Assemblies (APA)

Field cage



Photon Detector System



Cold readout electronics

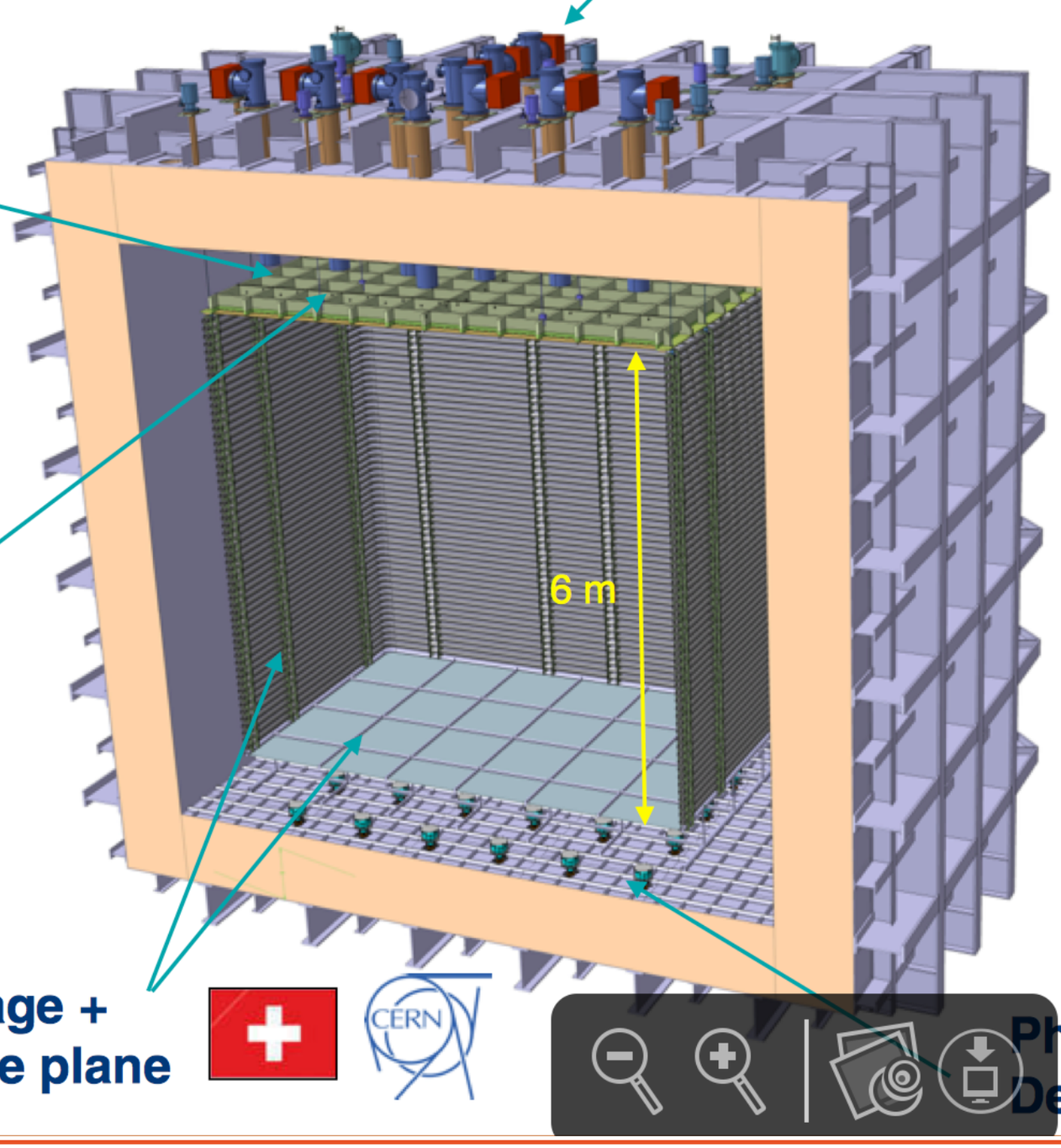
DAQ

Slow control

Cathode Plane Assemblies (CPA)

Dual phase protoDUNE

(Funding secured from FA and CERN MoU signed)



Drift HV system

Signal feed-throughs

CRP frame + hanging system

CRP readout planes

Drift cage + cathode plane

Photon Electronics

Cold readout electronics

DAQ

Online computing

Purity monitor

Slow control

Cosmic tracker

Photon Detectors

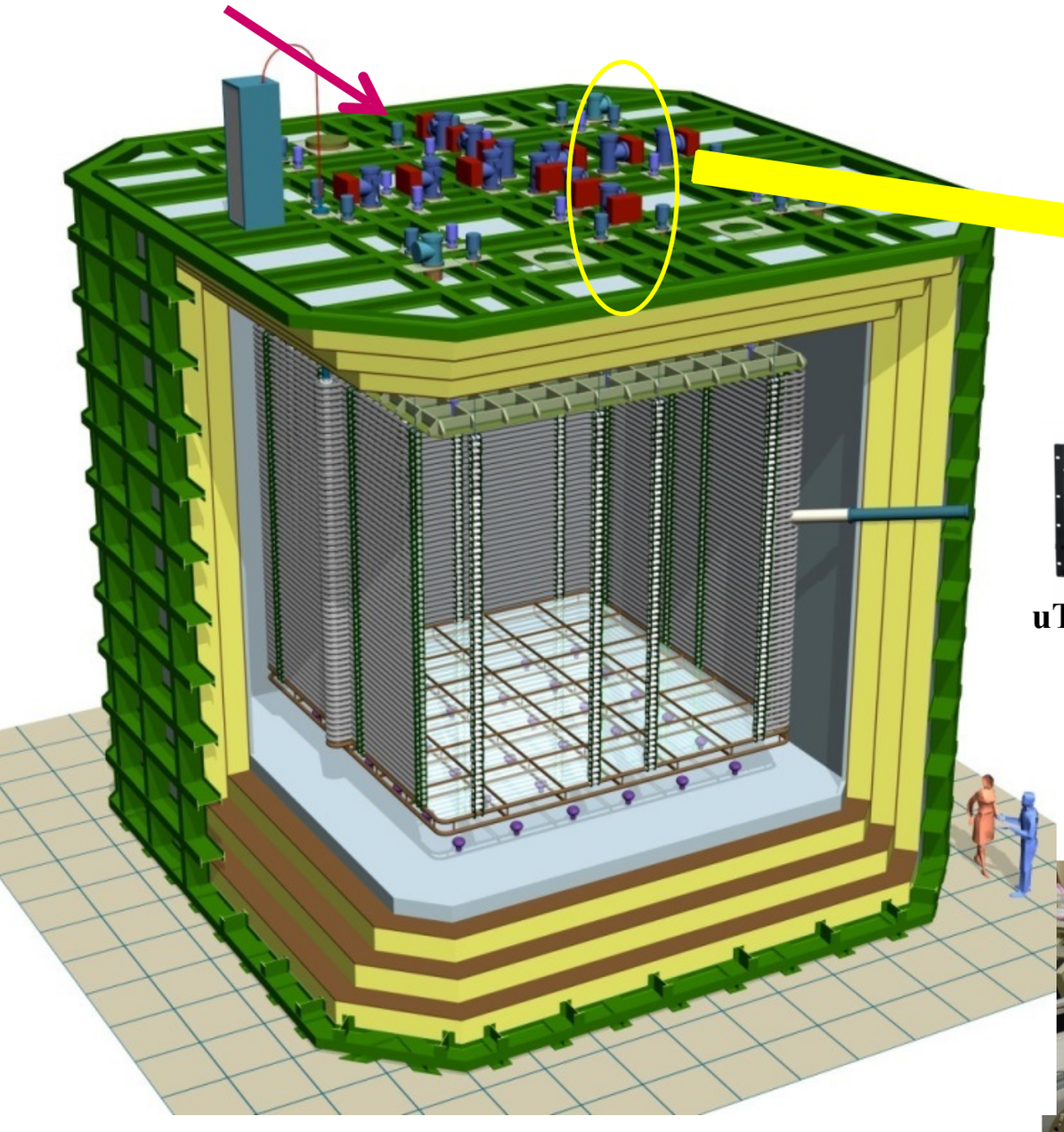
Accessible cold front-end electronics and uTCA DAQ system

Full accessibility provided by the double-phase charge readout at the top of the detector

➢ Digital electronics at warm on the tank deck:

- Architecture based on uTCA standard
- 1 crate/signal chimney, 640 channels/crate

→ 12 uTCA crates, 10 AMC cards/crate, 64 ch/card



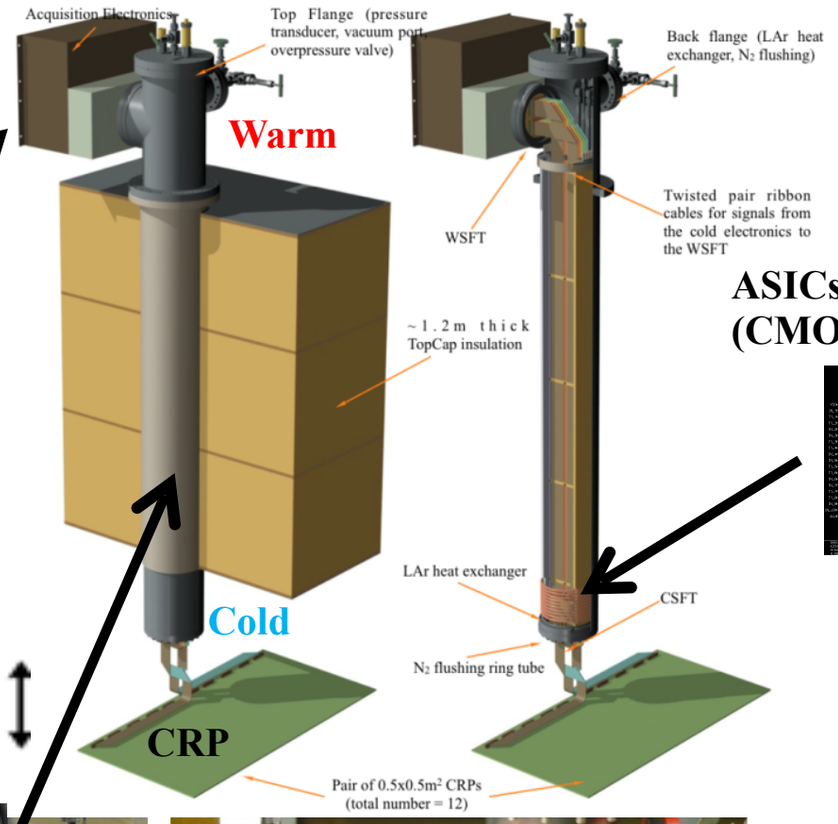
Signal chimney

uTCA crate

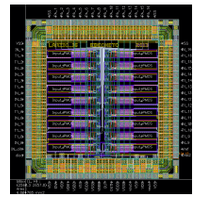
➢ Cryogenic ASIC amplifiers (CMOS 0.35um) 16ch externally accessible:

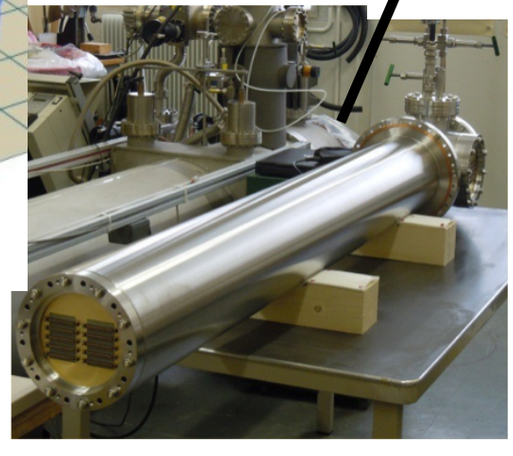
- Working at 110K at the bottom of the signal chimneys
- Cards fixed to a plug accessible from outside

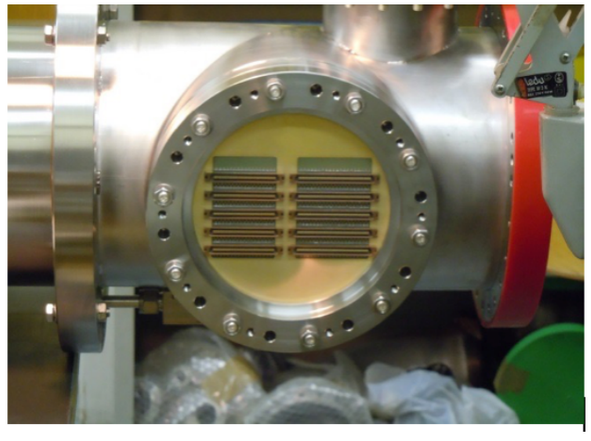
→Short cables capacitance, low noise at low T



ASICs 16 ch. (CMOS 0.35 um)







ProtoDUNEs

- CERN has made a major infrastructure investment to support these critical development activities
- It's essential that the collaboration push forward with these activities as quickly as possible to meet the goal of collecting test beam data in 2018
- Better than expected FY16 budget allows for some flexibility in accelerating critical path activities
- Schedules are still aggressive and we need to engage as much of the collaboration as possible in these activities

Timeline for CERN Resources

- In order for the ProtoDUNEs to be a success, a significant on-ground presence at CERN will be required to install, commission, and operate the detectors (estimate on order of 20-30 scientists per detector)

- The identification of the management teams who will coordinate the activities on the ground at CERN is an important first step

- The full teams need to start coming together in early 2017 to begin the process of setting up the detector infrastructure and preparing the detector integration facilities

- Complete teams will nominally need to be in place from Summer 2017 through the end of 2018

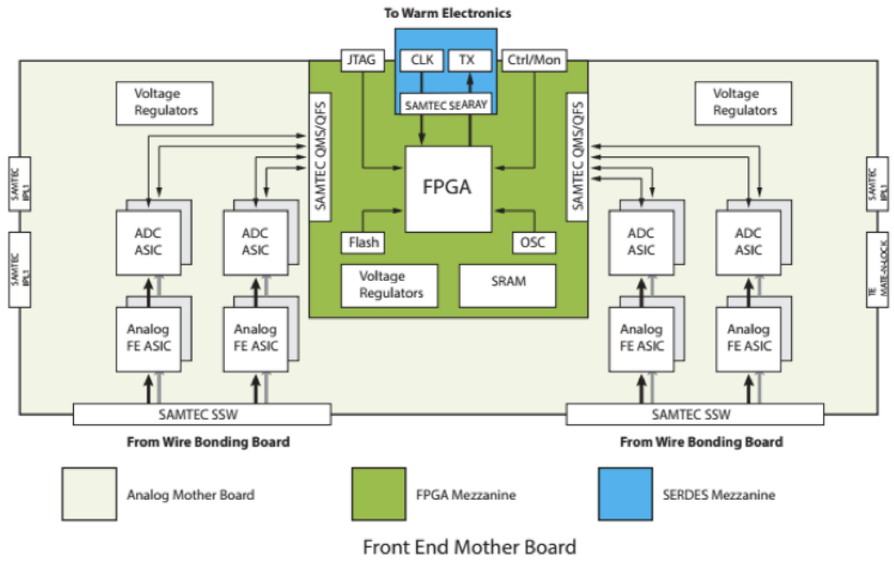
Expressions of Interest

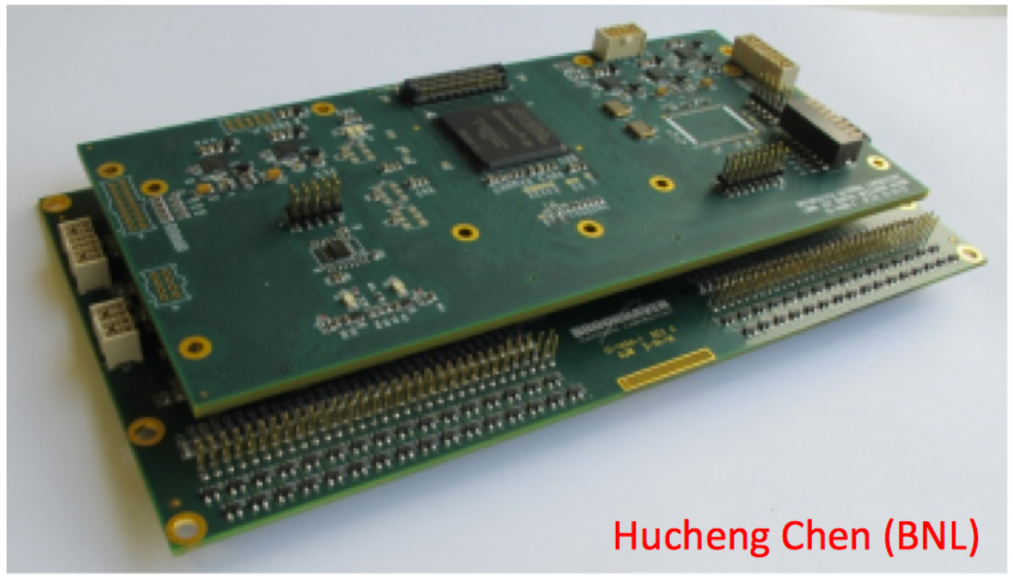
- To construct, install, commission, and operate the two ProtoDUNE detectors on the required time scale, we need to engage as many of the collaboration institutes as possible in these activities

- First step in this process is the call for Expressions of Interest from the collaboration institutes …

Electronics

Front End Motherboard (FEMB)





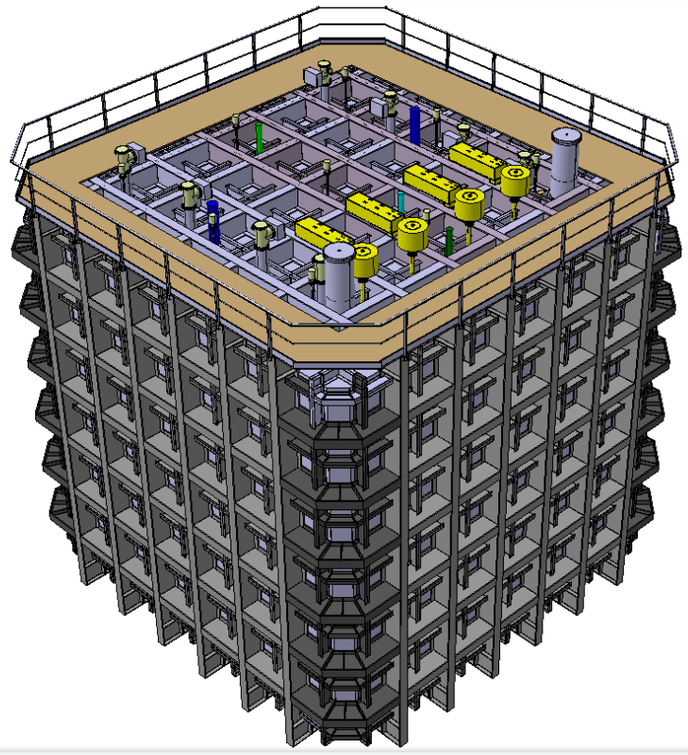
- analog motherboard
  - 8 16-channel front-end ASICs
    - gain and signal shaping
    - onboard pulse generator
  - 8 16-channel ADC ASICs
    - 12-bit ADC at 2 MS/sec
- FPGA mezzanine
  - 1 cold FPGA
    - I2C/JTAG programming + EEPROM
    - send clock/control/ programming in to ASICs
    - stream data out to warm electronics
    - DUNE FD will use COLDATA chip
- 128 total digitized channels

Electronics

- CE schedule is aggressive
  - decision on warm interface electronics needed soon
    - place for a new group to contribute immediately
  - QA/QC protocols have to start being developed now
- ProtoDUNE will benefit from 35ton and SBND
  - SBND ASIC evaluation teststand already in development
  - cold electronics board teststand already developed for 35ton
    - ASICs and FEMBs tested jointly with SBND
  - system integration teststand design is started
- by January 2017 we want to have new contributors to the CE QC effort
  - 1-2 scientists or students to participate in system integration and production readiness review
  - 2-3 students to help QC tests of production ASICs and FEMBs from April-October 2017
  - goal is for those people, along with BNL physicists, to be core of CE expertise for VST and installation/commissioning

Activity at CERN

- **Integration and on-site test of ProtoDUNE components**
- *Preparation of detector enclosure at EHN1*



- **Cryostat vessel construction**
- *Beam line installation*
- **Inner Detector(s) Installation/Assembly**