Plans for ProtoDUNE-SP Commissioning and Run

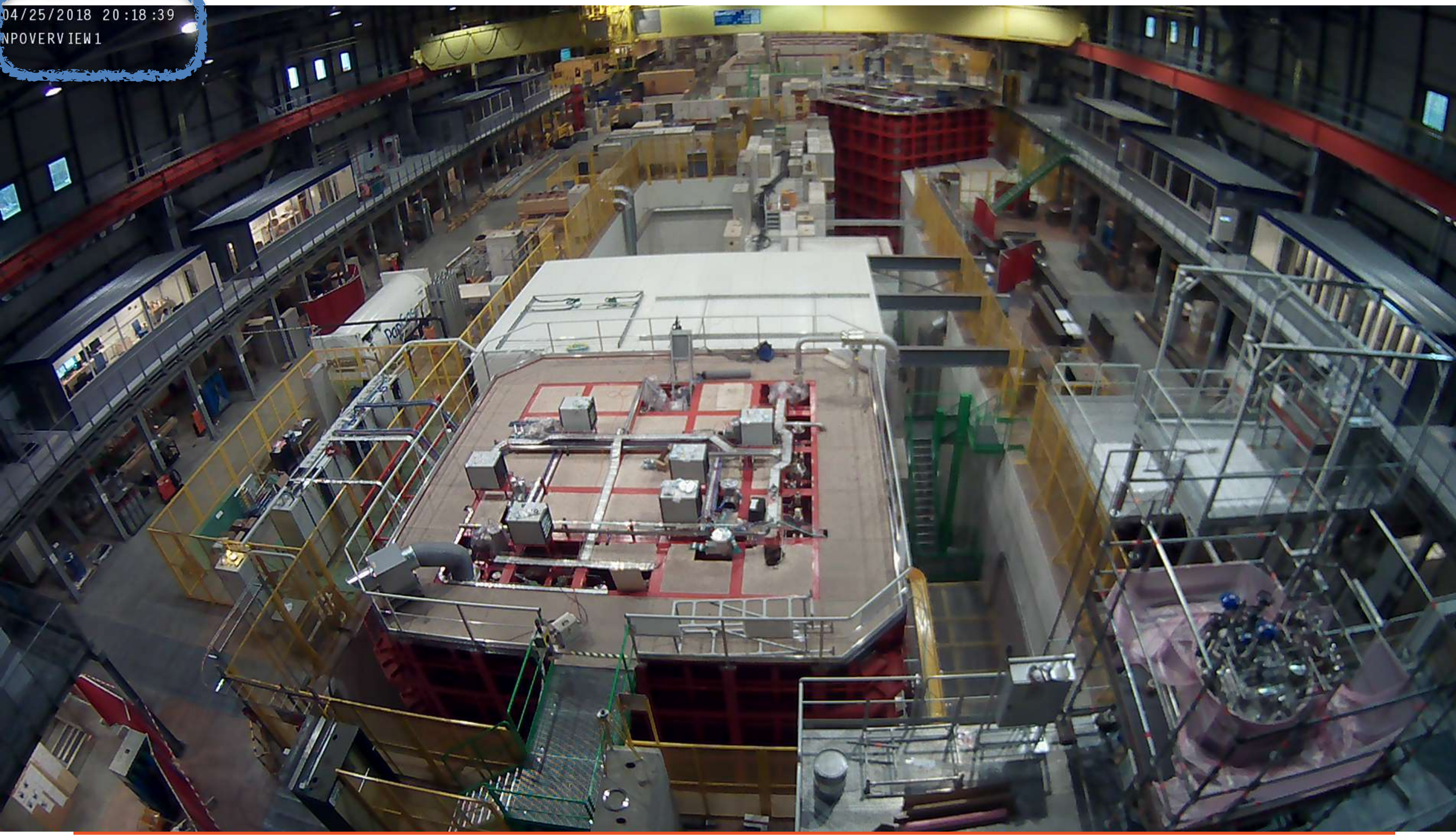
Flavio Cavanna

ProtoDUNE-SP Data Exploitation Readiness Review

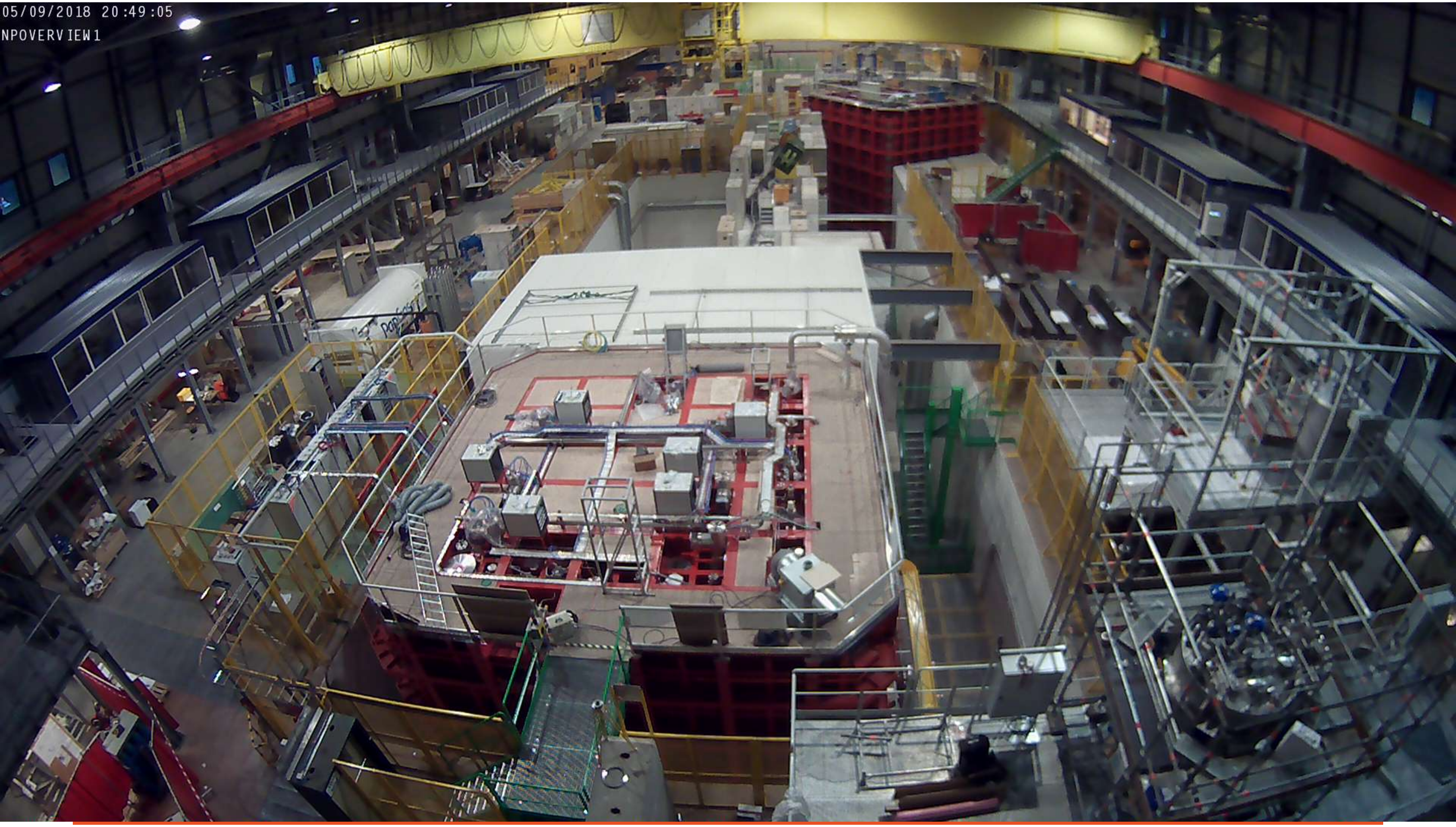
FERMILAB - 10 May 2018

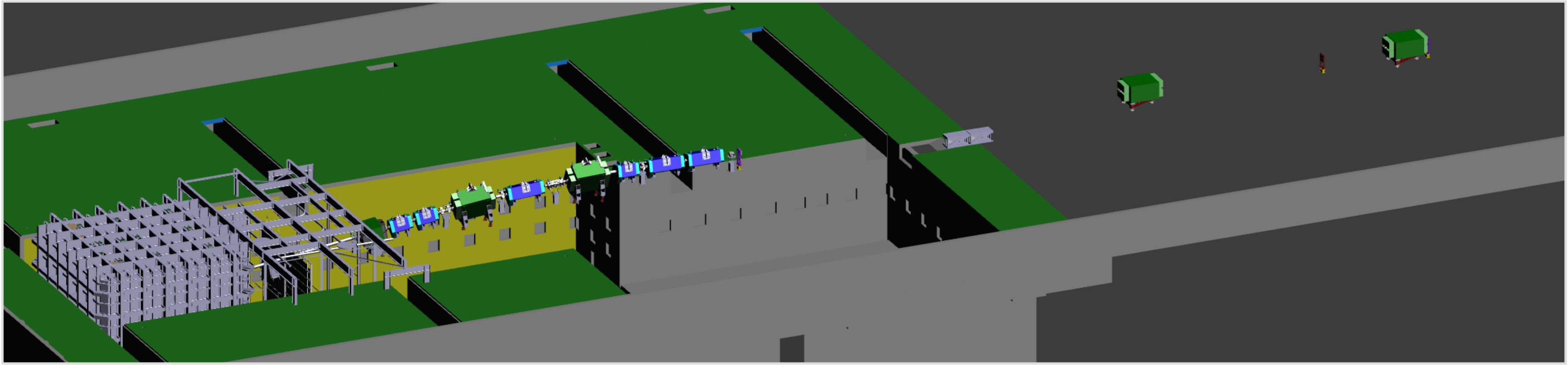
EHN1 extension -

two weeks ago…



EHN1 extension - today





Q1

protoDUNE-SP Goals

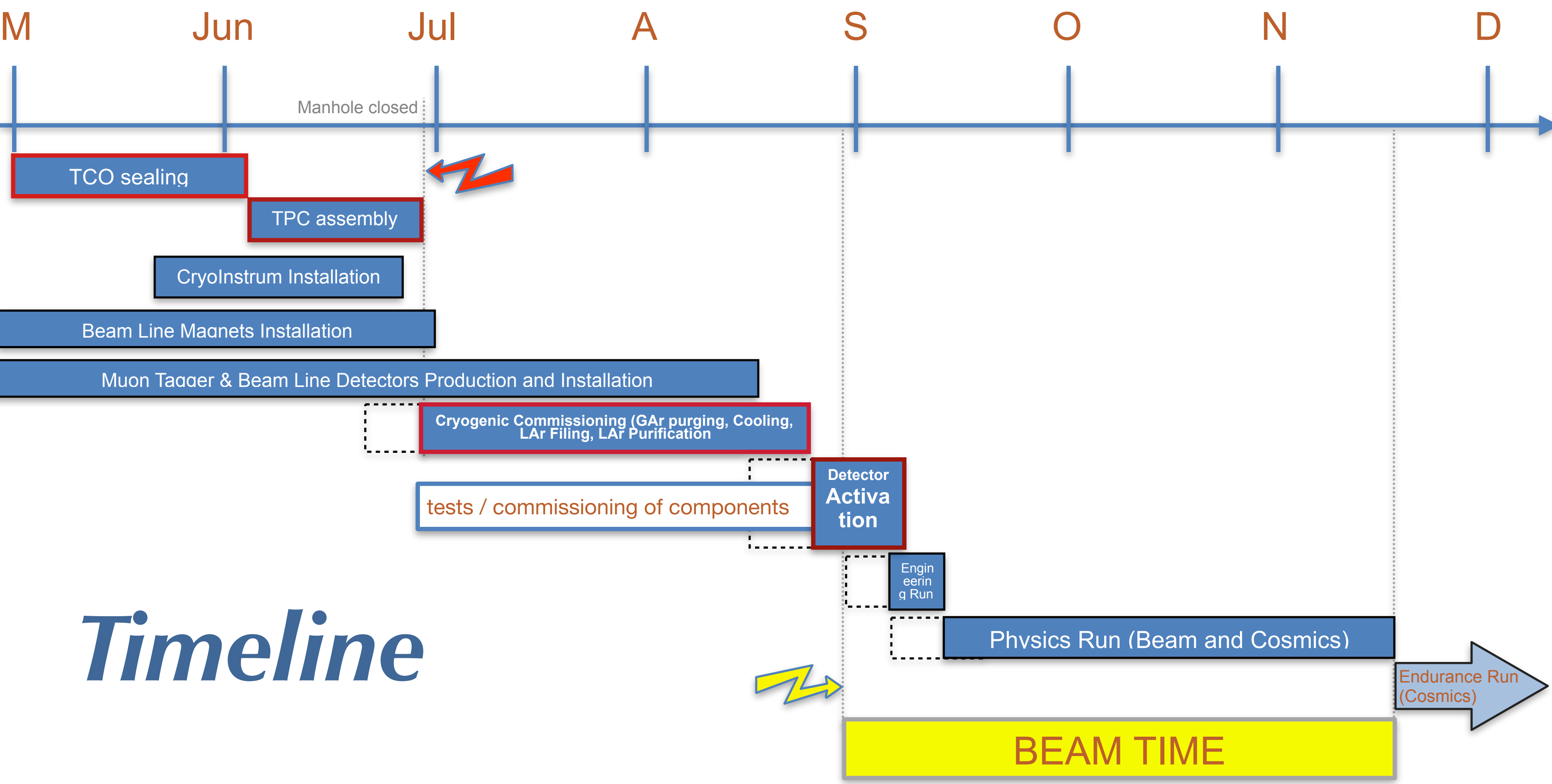
- Prototyping production and installation procedures for DUNE far Detector Design *[task of the ongoing effort]*
- Validate design from perspective of basic detector performance
- Accumulate test-beam data to understand/calibrate response of detector to different ptcl. species
- Demonstrate long term operational stability of the detector

and the Programme:

- 2018: Detector activation, **Test-Beam Run** + Cosmics
- 2019: endurance Run with Cosmics (long term stability)
- 2020: continuing Operation (Cosmics) if desired
- 2021: keep open the option of recording Test Beam data after CERN LS2
- 2022: *no Operation is foreseen in and beyond 2022*.

Detector commissioning and activation, data acquisition with Beams and the execution of data processing and reconstruction have the highest priority in DUNE. DUNE Project Resources available

Installation, Commissioning and 2018 Run



Note about the Long-Term Stability Run 2019

The long term stability Run with Cosmic
- 6 to 12 months extending in 2019 -
has been communicated/proposed to CERN SPSC on April 20

[not clear if need an approval - *no beam time is required* - or an authorization, probably just an acknowledgment from the SPSC]

The plan for the long term stability Run is not finalized yet

- minimal goal: maintain detector active
  acquire short Cosmic Run every day

- dedicated tests at different cryogenic system and detector operating parameters presumably to be included in the plan

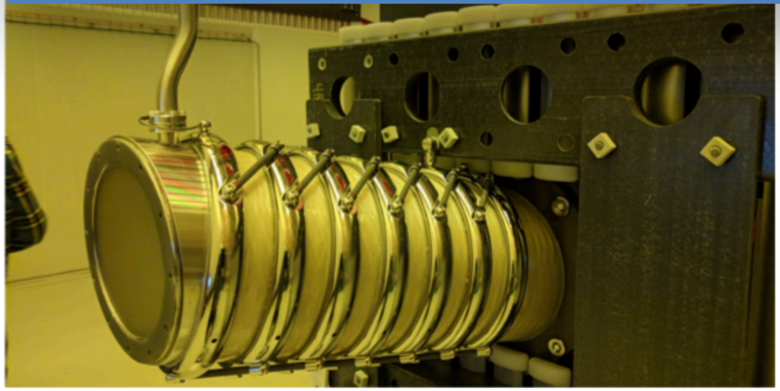
Resources for Detector Operation and Computing in 2019 not allocated yet in current (or expected) budget

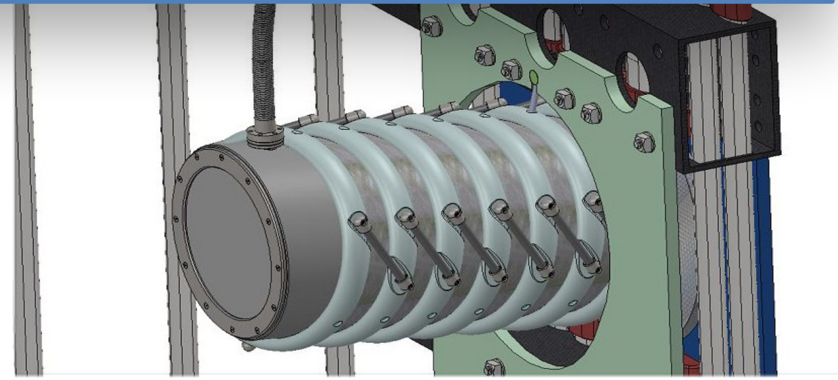
Q2

inside protoDUNE Cryostat

LArTPC Detector completed:

To operate LArTPC on charged particle beams the upstream wall of the Field Cage is modified with the installation of a ``Beam Plug" (beam pipe extensions inside the Cryostat)

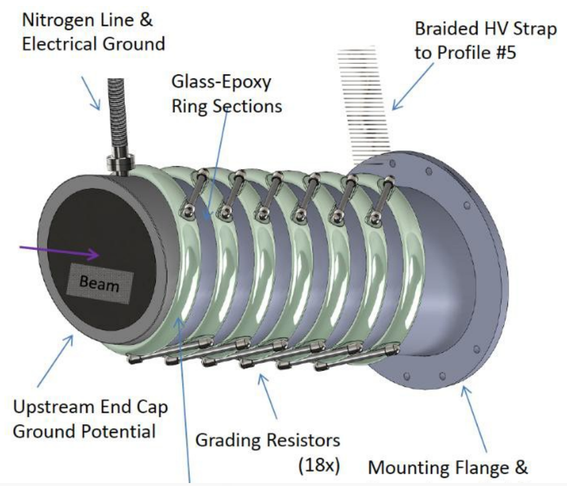


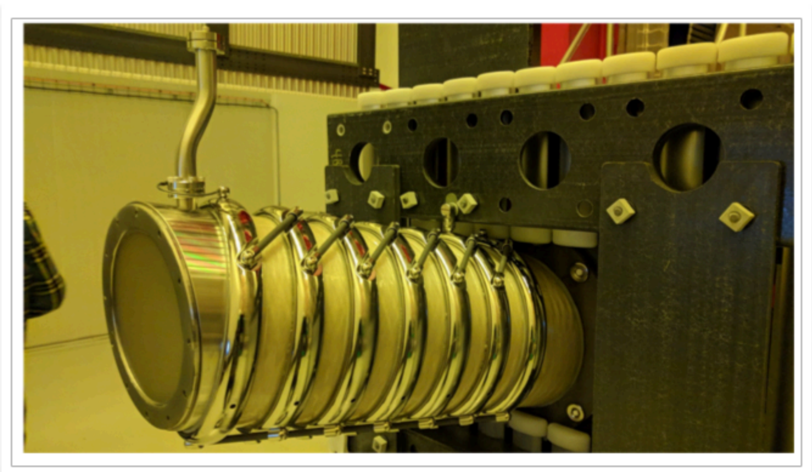


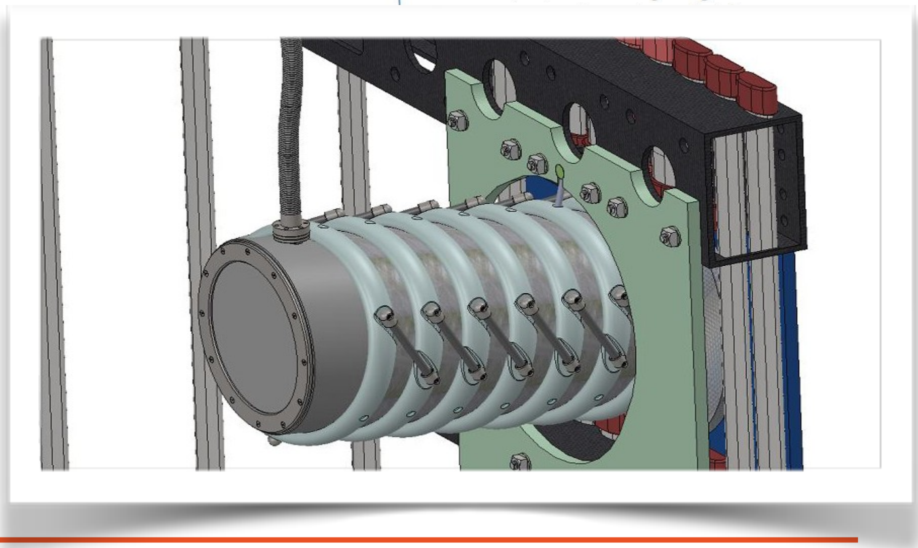
Lawrence Berkeley National Laboratory

	w/ BP	w/out BP
Material Budget	$0.1X_0$, $0.01\ \lambda$	$3.5X_0$, $0.9\ \lambda$

- The “Beam Plug”: a hollow pipe to displace the amount of inactive LAr - 𝕃~*50 cm* - upstream the front face of the TPC active volume, along the flight line of the beam particles.
- A resistor chain along the pipe for voltage degradation from the Field Cage HV to Ground Cryostat wall





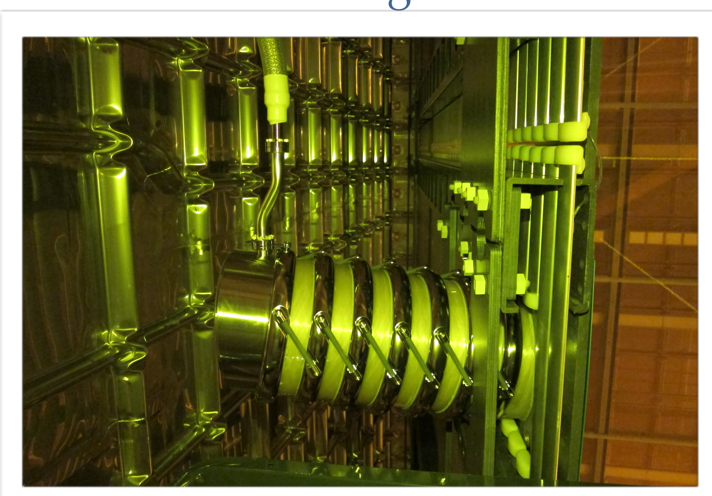


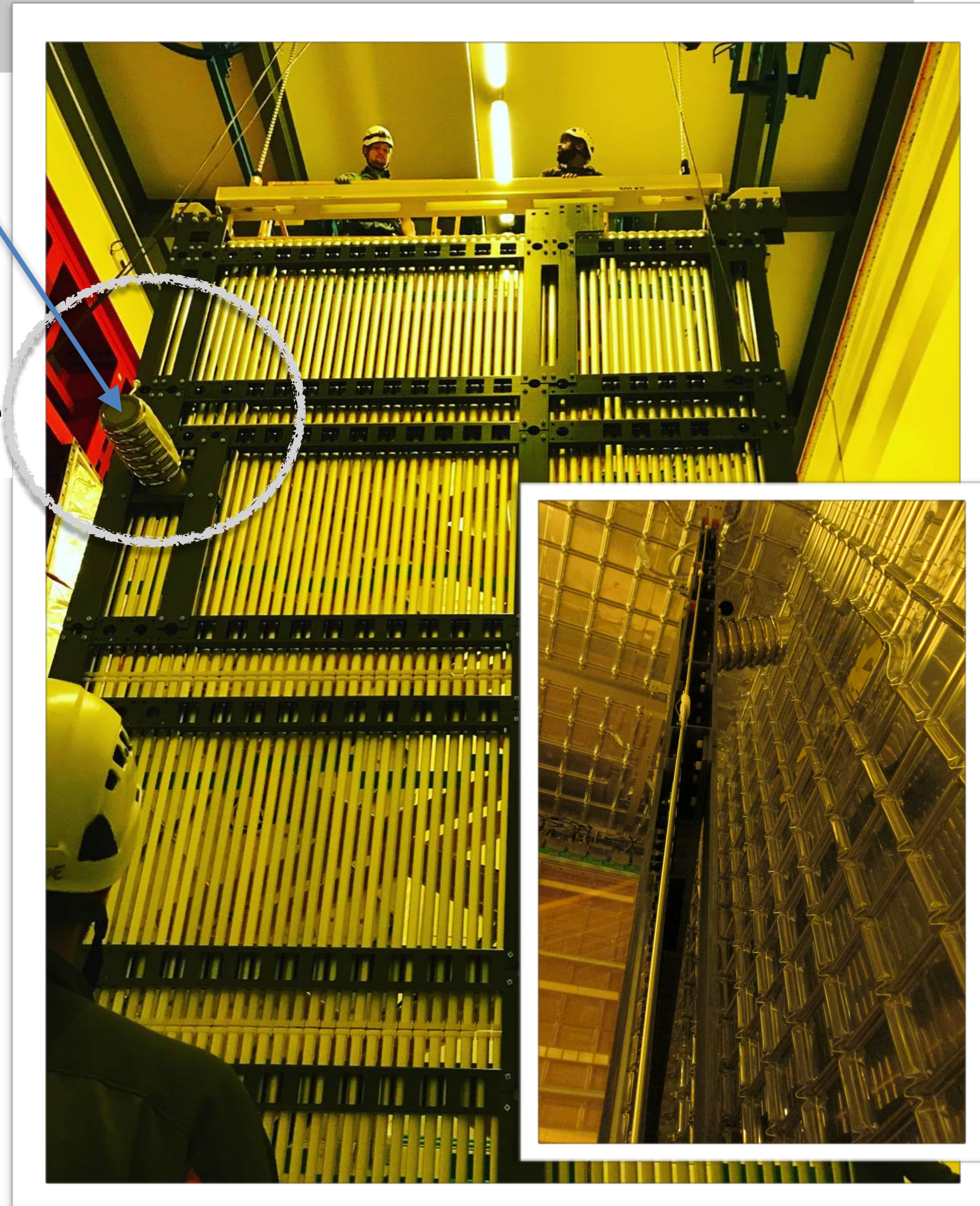
- Installation inside the Cryostat
  - Beam Plug

incident
Beam

Beam Plug:

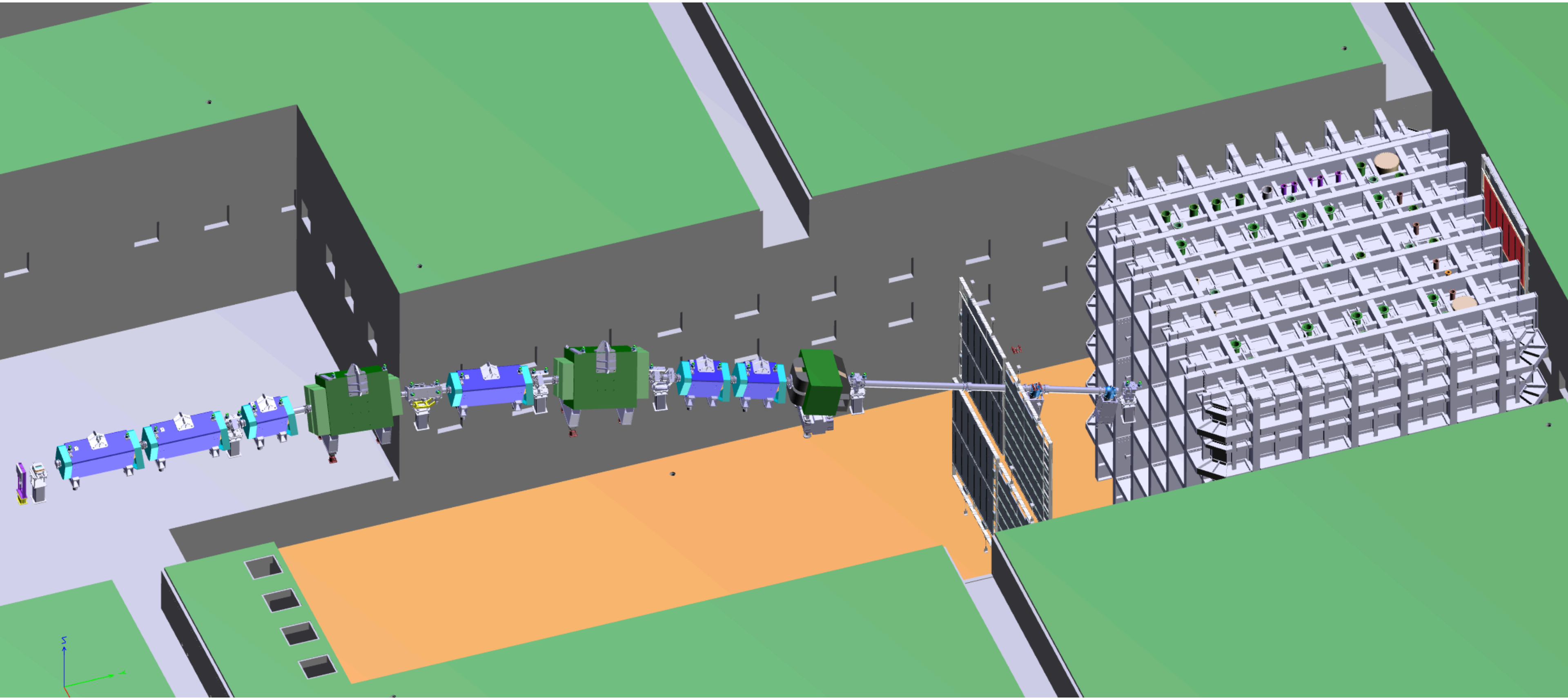
- Successfully installed onto its End Wall panel of the Field Cage
- It includes structural support, three parallel resistor chains, HV and ground connection, and hose extension for N2 gas.



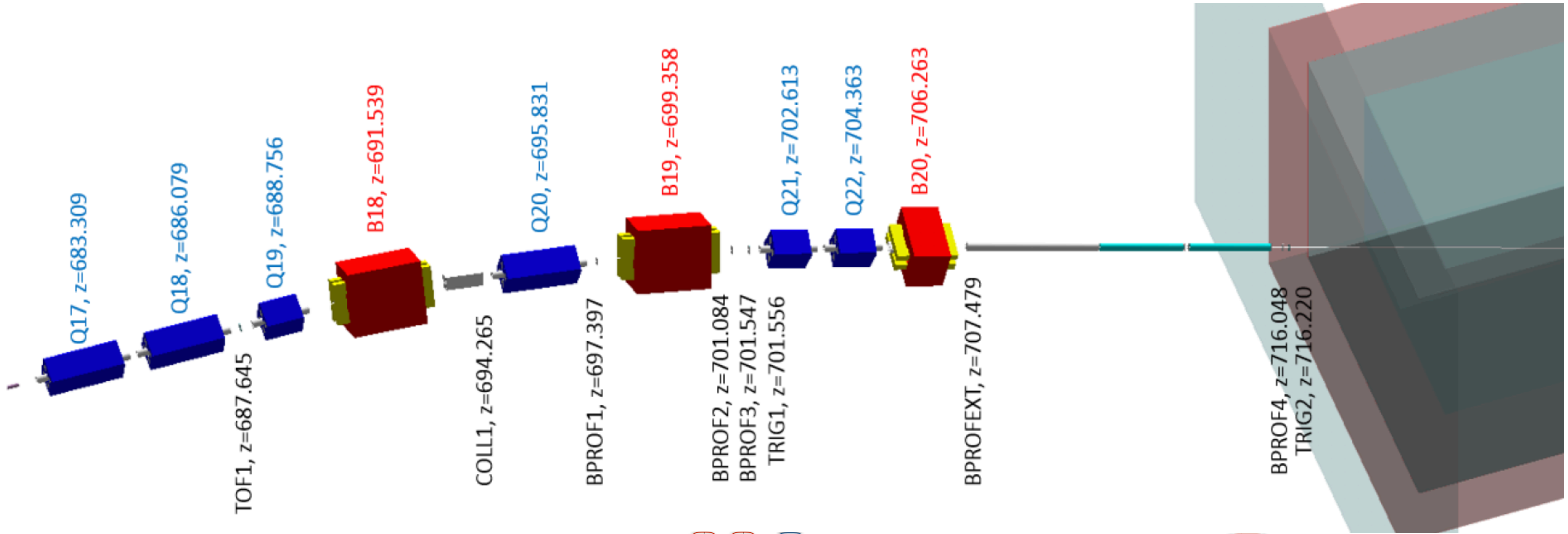


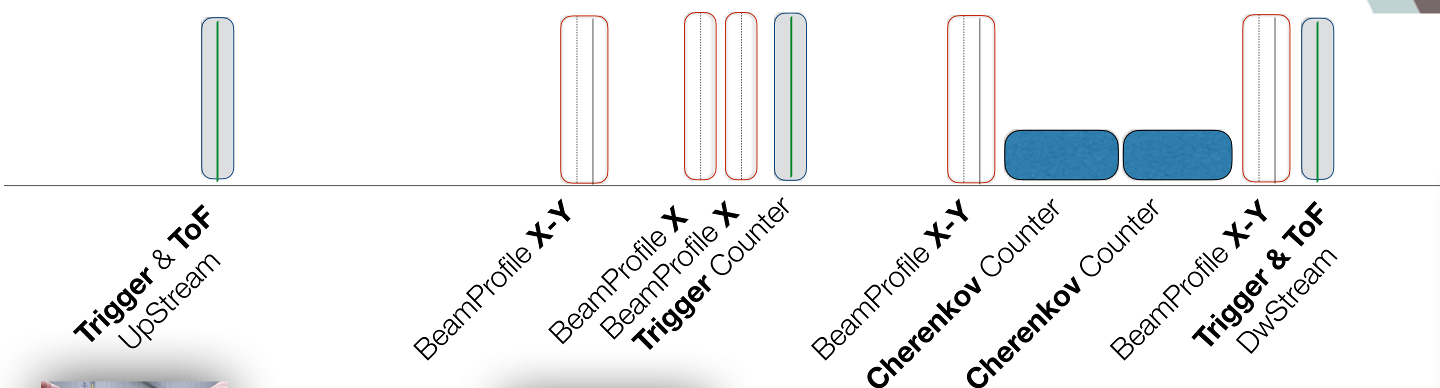
outside protoDUNE Cryostat

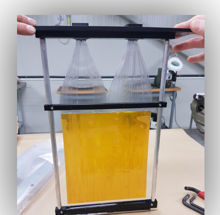
External Beam Line, Beam Detectors and Muon Tagger



- many opportunities for fast trigger combinations from Beam instrumentation - Muon Tagger (and internal Photo-Detector)
- opportunity to trigger or veto TPC readout for beam halo muons







Blue: quadrupoles.
Red: bending magnets

Boxes: Beam detector supports

Beam Profile X,Y = Scint. Fibre Tracker
Trigger & Time-of-Flight detector =
= Scint. Fibre paddle

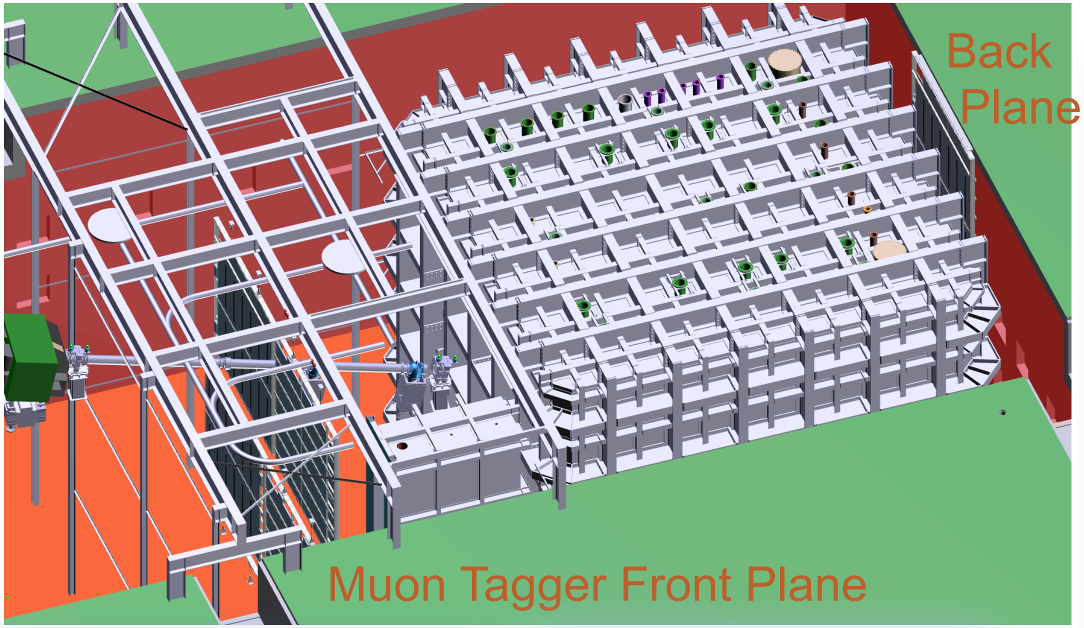
Cherenkov counters

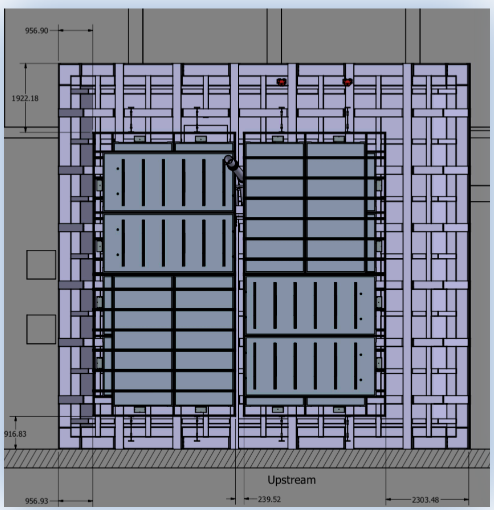
NP04/H4 Beam Line & Beamline Detectors

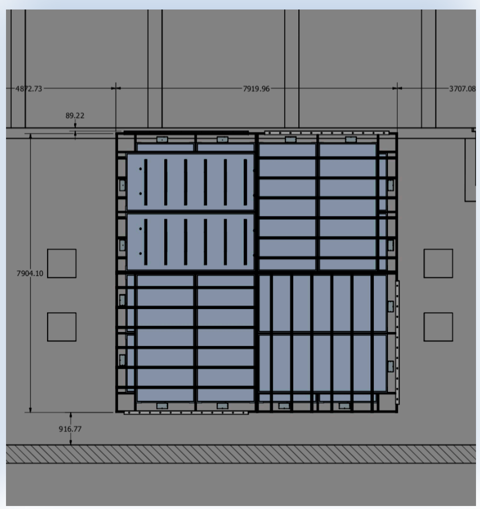
Neutrino PLATFORM

Muon Tagger

U of Chicago, Virginia Tech,
U Minnesota, U Rochester, FNAL







Muon Tagger Modules

Cryogenic Commissioning Plan

CRYOGENICs					
Task	**Duration**	**Specs**	**Tech Resp**	**Shift Resp**	**Monitoring**
GAr Purging	1w + 1w (conting.)	- 20 Vol/day - leaks checks and repairs	CERN-NP	CERN-NP	
Safety Clearance	1d	All documentation ready	CERN-NP		
Cooling	1 w	- 1 K/hr, $\Delta T \approx 200$ K	CERN-NP	CERN-NP	Temp
LAr Filling	3 w + 1 w (conting.)	- **~550 kL** - 2 trucks/day into 2x20000 L storage dewars - 40000L/day, 5 days/week	CERN-NP	CERN-NP + ProtoDUNE-SP	Temp T-Gradient LAr Level
LAr Recirc. & Purific.	1w (conting.)	*Goals:* Stable Cryo Cond. $\tau_e \approx 2$ms	CERN-NP pDUNE-SP	ProtoDUNE-SP + CERN-NP	T-Gradient LAr Purity

Start: last week of June
End: last week of Aug.

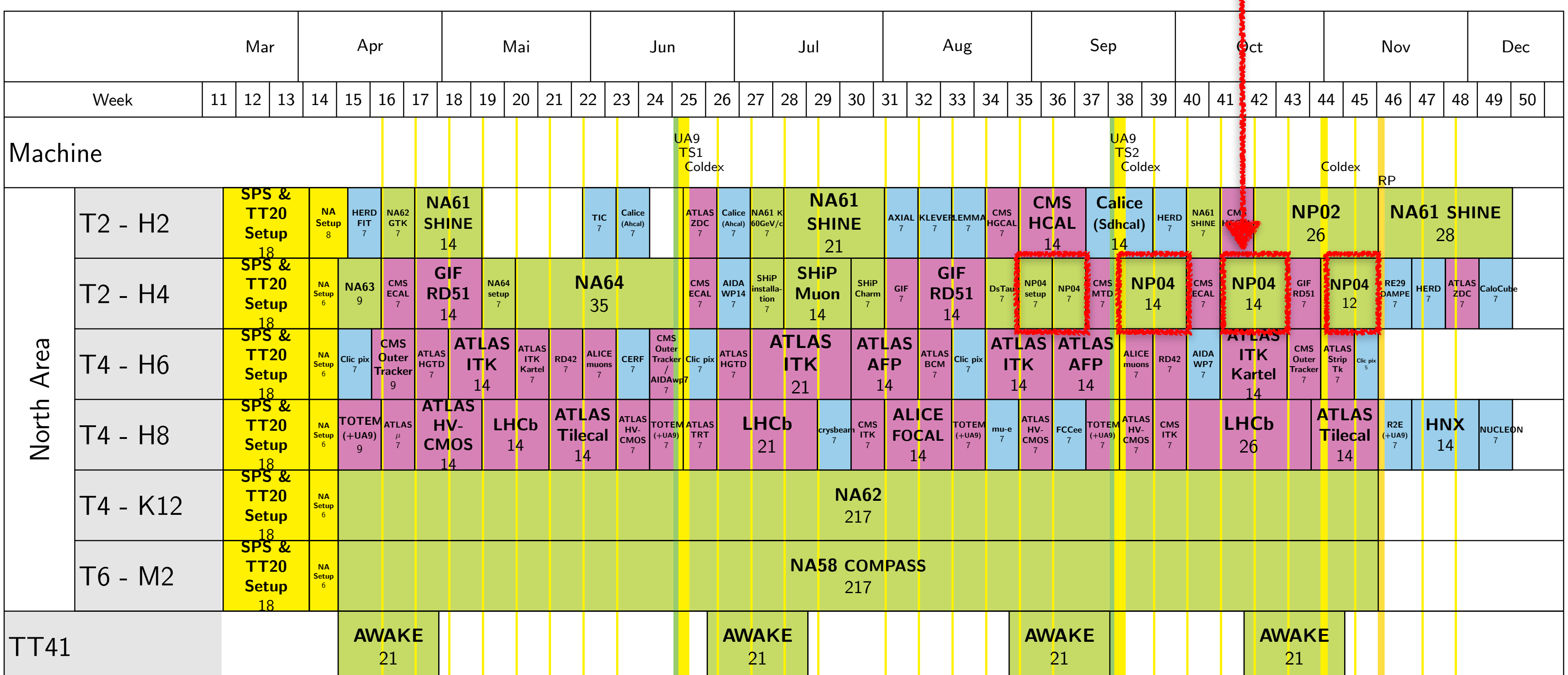
3+ weeks built-in contingency

- **Beam operations:**
  - **August 29, 2018 (Start)**
  - **November 11, 2018 (End)**

H4 Beam Time Allocation to NP04 by SPS-C:

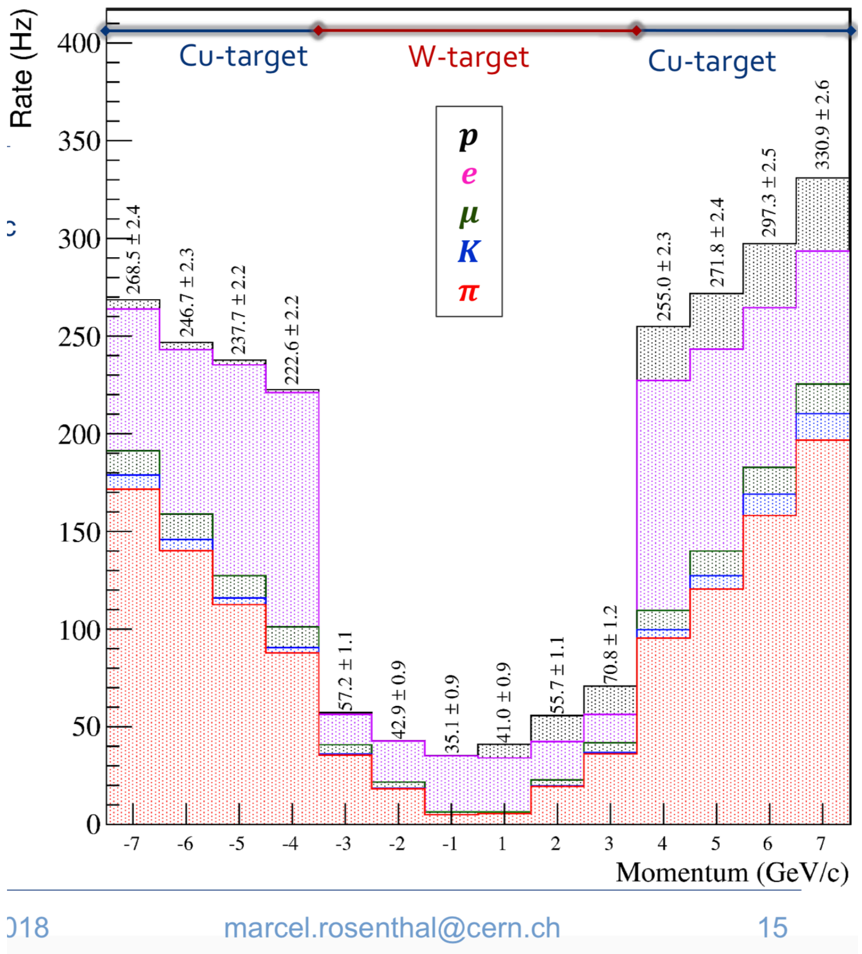
7.5 weeks (including Beam Commissioning Time) ***in 4 blocks (2w + 2w + 2w + 1.5w)***

schedule issue date: 26-Jan-2018 Version: 1.0 LHC Exp. PS/SPS Exp. Other Exp. INT Exp.

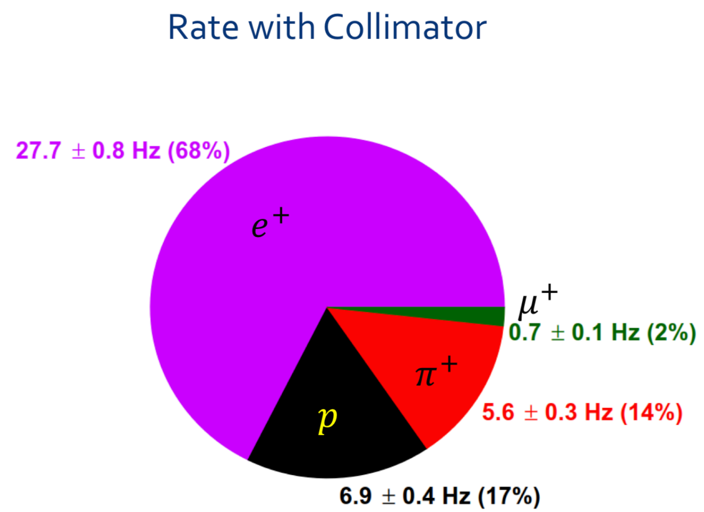


For further information contact the PS/SPS-Coordinator. Email: Sps.Coordinator@cern.ch, Tel: +41 75 411 3845.

Expected Rates (H4 beam line MC Calculation): normalized to 10^6 pions on target per spill (4.8 s)



Rates at 1 GeV/c



- **Engineering Run:**
  - Beam-line detectors activation and DAQ sync,
  - Beam Trigger activation/test/debug,
  - Secondary (Pion) Beam Intensity Tuning (measure/mitigation Muon Halo in LArTPC) ⇨ StartUp Physics Run

Beam Setting (Mom, Sign)	Beam Rate		Beam Time
2 GeV/c – Negative	27 Hz	50% π-, 50% e-	**1 week**

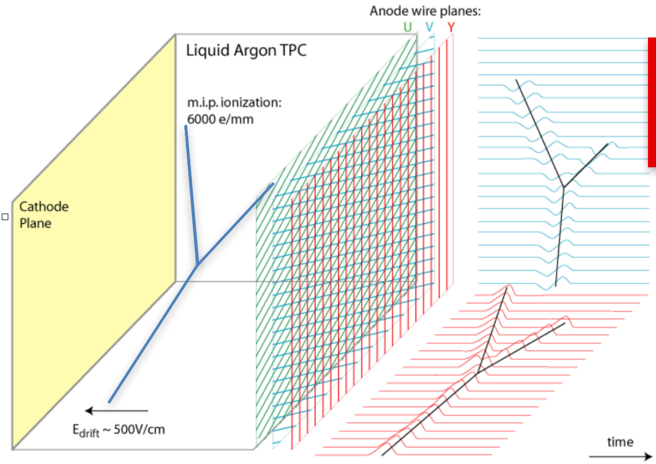
- **Physics Run**
  [expected 3000 spill/day]:

  ➡Hadron Beam - Goals:
  ≥ 500 k Pion evt per momentum setting
  ≥ 100 k Proton evt per momentum setting

  ➡Electron Beam - Goal:

  ≥ 75 k Electron evt per energy setting

Hadron Beam *Cu Target*			
Beam Setting (Mom, Sign)	**Accumul. Stat. (goal)**	**Trig. Rate/Beam Rate**	**Beam Time**
2 GeV/c - Positive	750 k [500 k π]	25 Hz / 38 Hz	**1 week**
3 GeV/c - Positive	750 k [500 k π]	25 Hz / 56 Hz	
no beam	-	-	1 week
1 GeV/c - Positive	1 M [500 k π]	25 Hz / 27 Hz	**2 week**
no beam	-	-	1 week
4 GeV/c - Positive	600 k [500 k π]	25 Hz / 196 Hz	**2 week**
5 GeV/c - Positive	600 k [500 k π]	25 Hz / 200 Hz	
6 GeV/c - Positive	600 k [500 k π]	25 Hz / 226 Hz	
7 GeV/c - Positive	600 k [500 k π]	25 Hz / 252 Hz	
no beam	-	-	1 week
Electron Beam *Pb Target*			
Energy Ramp: **0.5, 0.6, 0.7, 0.8, 0.9,** **1., 2., 3., 4., 5., 6., 7. GeV**	75 k per En. setting 900 k Tot.	25 Hz / 60 Hz	**1.5 week**



TPC DATA

DAQ

Raw data decoding

Raw Data

Noise filtering, Stuck code mitigation, Deconvolution

Deconvoluted Data

Hit finding, Disambiguation
PMA, Pandora, WireCell, PD, CNN

Reconstructed Data

dQ/dx and dE/dx calibration

Calibrated Data

Detector Performance and Physics Analysis

Path to inform the DUNE design

Organizational Structure on the ground

CERN Neutrino Platform
M. Nessi (CERN)

ProtoDUNE-Single Phase
G. Rameika (FNAL), C. Touramanis (UK-Liverpool), FLC (FNAL)
Liaison w/ CERN IT, FNAL SCD, DUNE Computing in matter of Computing Resources *(A. Dell'Acqua/CERN)*

Commissioning Leader, Run Coordinator *(F. Resnati/CERN, R. Acciarri/FNAL)*

Computing
CERN IT

DUNE SW&Computing
A.Norman (FNAL-SCD), H. Shellman (Oregon SU)

DRA
(Data Reco and Analysis)
T Yang (FNAL), G. Christodoulou (CERN)

DAQ
G. Lehman (CERN)
K. Hennessy (UK-Liverpool)

DQM Infrastructure
(Data Quality Monitor)
M. Potekhin (BNL)

Beam Line
CERN EN-EA

Beam Instrumentation
CERN BE-BI

Beam Instrumentation
P. Sala (CERN)
J. Paley (FNAL)

Muon Tagger
E. Blucher (U Chicago)
C. Mariani (VT)

Cryogenics
CERN TE-CRG

CryoIntrumentation
S. Pordes (FNAL)
A. Cervera (Spain-Valencia)

SlowCtrl/ DCS
CERN EP-DT-DI

Find in Greybook...

The CERN Experimental Programme

Grey Book database

» NP04

Welcome | Experiments & Projects | Institutes | Participants

RESEARCH PROGRAMME

- LHC
- SPS
- PS
- AD
- ISOLDE Facility
- Irradiation Facility
- Neutrino Platform
- GRADE
- CTF3
- R&D
- Non-accelerator experiments

RESEARCH ACTIVITIES

- Experiments and Projects under Study
- Recognized Experiments
- Completed Experiments

RELATED LINKS

- EP Department

NP04/ProtoDUNE-SP

Prototype of a Single-Phase Liquid Argon TPC for DUNE

SYNONYM:	ProtoDUNE-SP
RESEARCH PROGRAMME:	Neutrino Platform
APPROVED:	28-09-2016
BEAM:	
STATUS:	Preparation

Overview | Institutes | Participants

SPOKESPERSON:	Christofas TOURAMANIS Flavio CAVANNA
DEPUTY SPOKEPERSON(S):	
CONTACT PERSON:	Simona KRIVA
TECHNICAL COORDINATOR:	
RESOURCES COORDINATOR:	
GROUP LEADER IN MATTERS OF SAFETY (GLIMOS):	
DEPUTY GLIMOS:	
DEPARTMENTAL FLAMMABLE GAS SAFETY OFFICER (FGSO):	
DEPARTMENTAL CRYOGENICS OFFICER (CSO):	
EXPERIMENT SECRETARIAT E-MAIL:	cenf.secretariat@cern.ch
EXPERIMENT SECRETARIAT WEB SITE:	

NUMBER OF INSTITUTES:	42
NUMBER OF AUTHORS:	7
NUMBER OF PARTICIPANTS:	164
NUMBER OF COUNTRIES:	6

Status history

Status	Start date	End date
Preparation	22-02-2016	

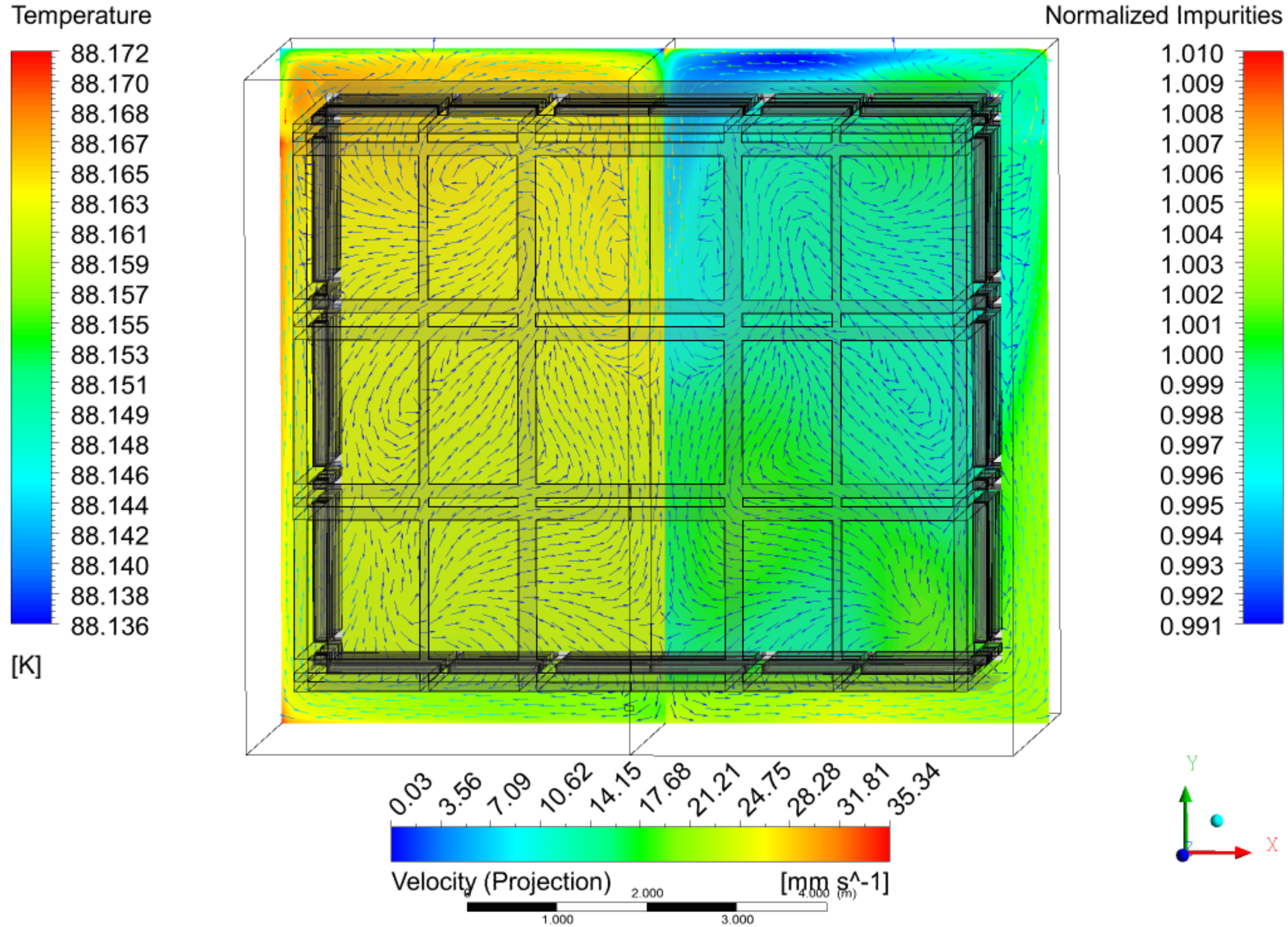
TODAY

SUMMARY

- ProtoDUNE SP is transitioning from **Construction/Assembly** to **Operation** (Commissioning and Run).
- **Installation** of auxiliary instrumentation in progress: cryo-monitoring devices inside the cryostat and external detectors for beam and cosmic trigger formation.
- **The plan for Cryo-Commissioning is in place, the plan for detector commissioning&activation is being developed, SPS Beam Time is allocated, basic Run Plan defined -** fine tuning & swap w/ other SPS users or parasitic time under discussion
- *Highest priority:*
  - DAQ and Off-line SW readiness for timely exploitation of beam and cosmic data.
  - Careful and prompt evaluation of Detector Performance to inform DUNE design and TDR.
- Several Physics topics of interest for longer term studies and Analysis

BACKUP Slides

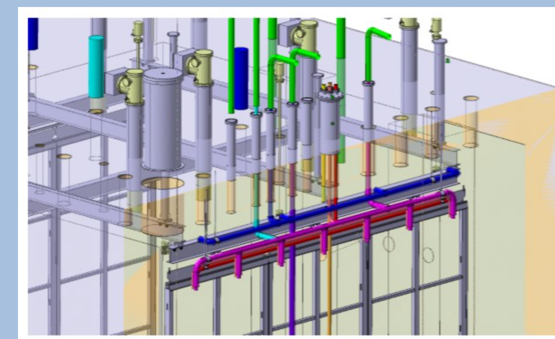
ProtoDUNE Liquid Argon Flow Simulations



Temperature, Impurities and Velocity @ Z = 2m

Fermilab

inside protoDUNE Cryostat



Cryo Instrumentation:

Three high-resolution Detector vertical strings to monitor LAr properties during Cryogenic Commissioning (cooling, filling, recirculation, ..) and during the Run (providing data necessary for LArTPC calibration)

Purity Monitor System

O(100 ppt) resolution

O(1mK) resolution

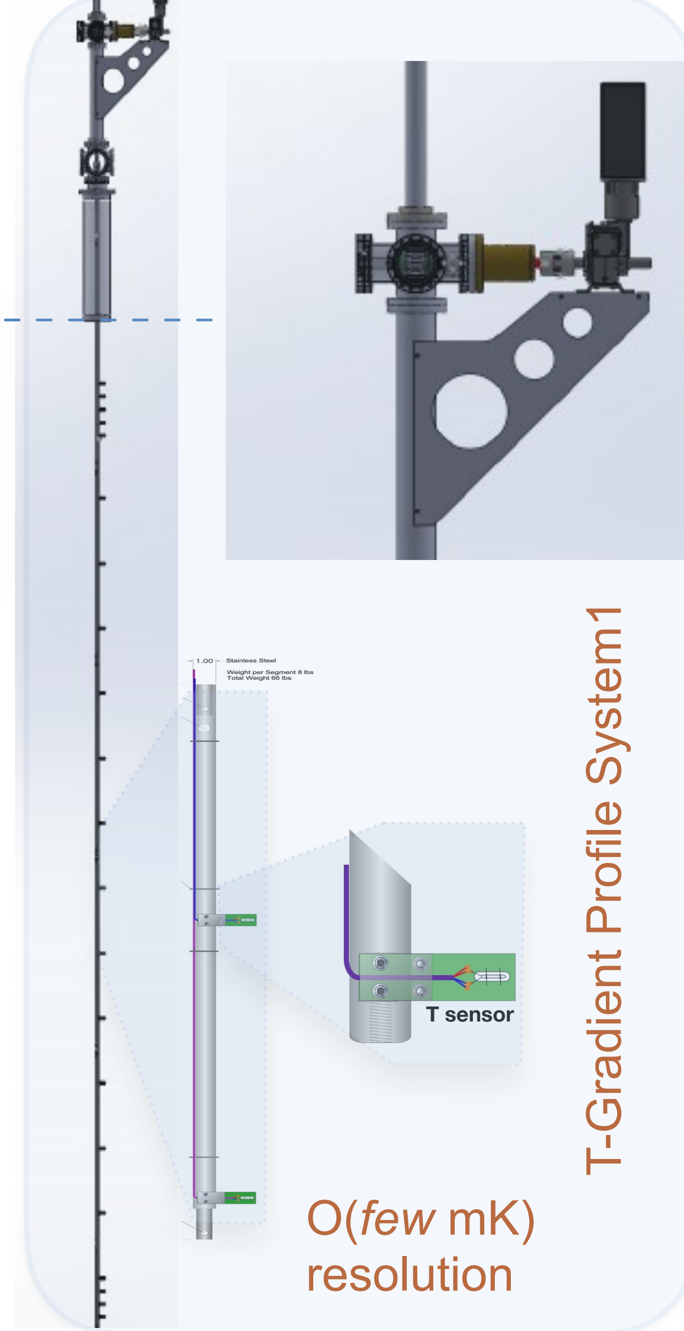
T-Gradient Profile System2

level

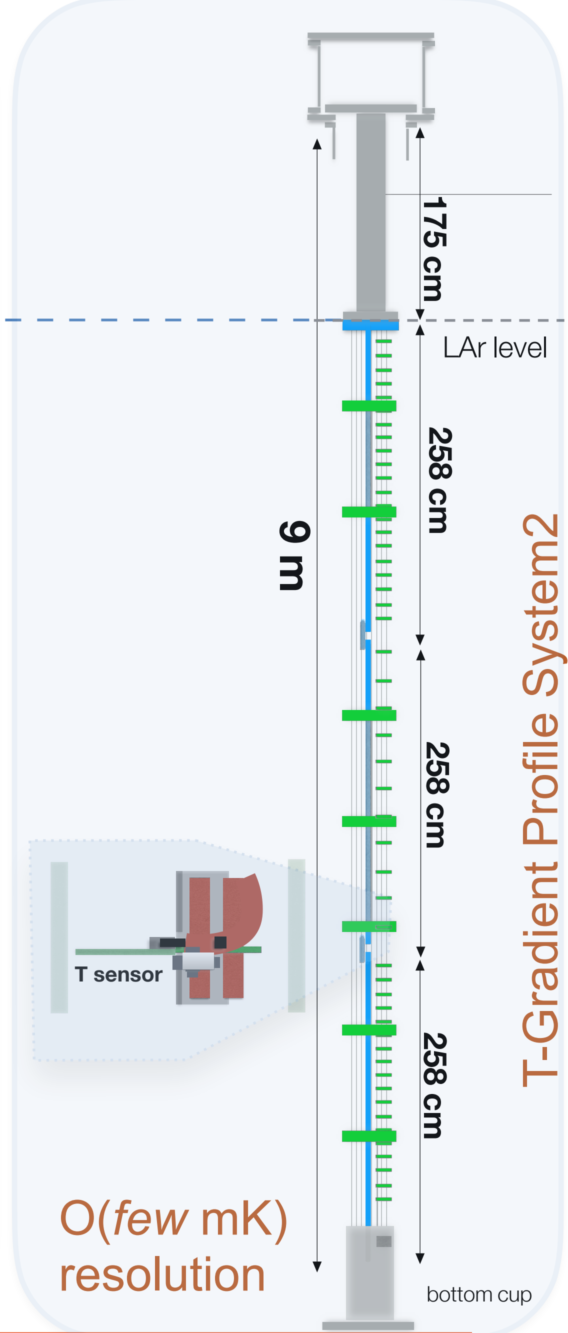
O(1mK) resolution

bottom cup

Purity Monitor System
O(100 ppt)
resolution



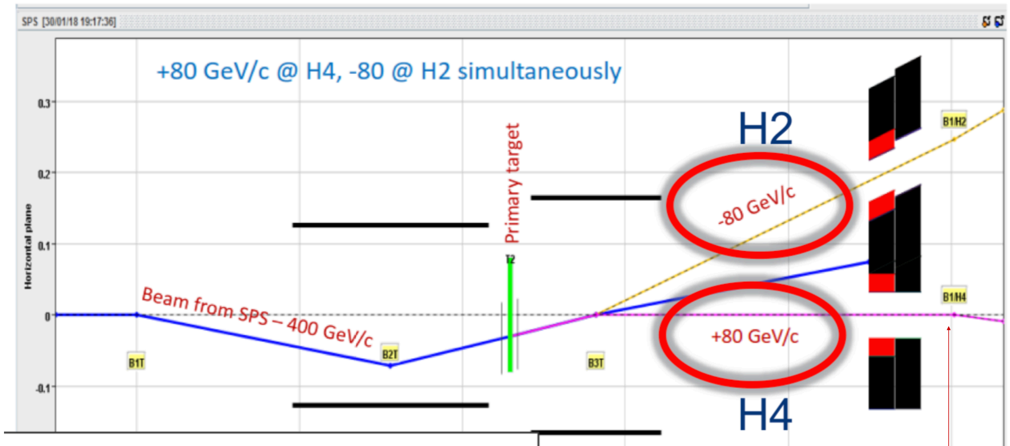
T-Gradient Profile System1
T sensor
O(*few* mK)
resolution

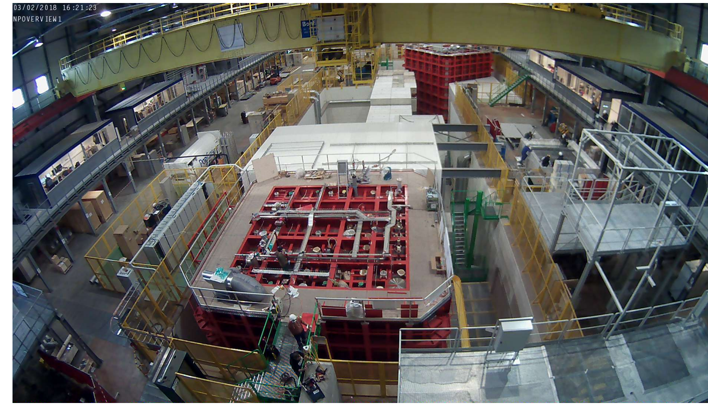


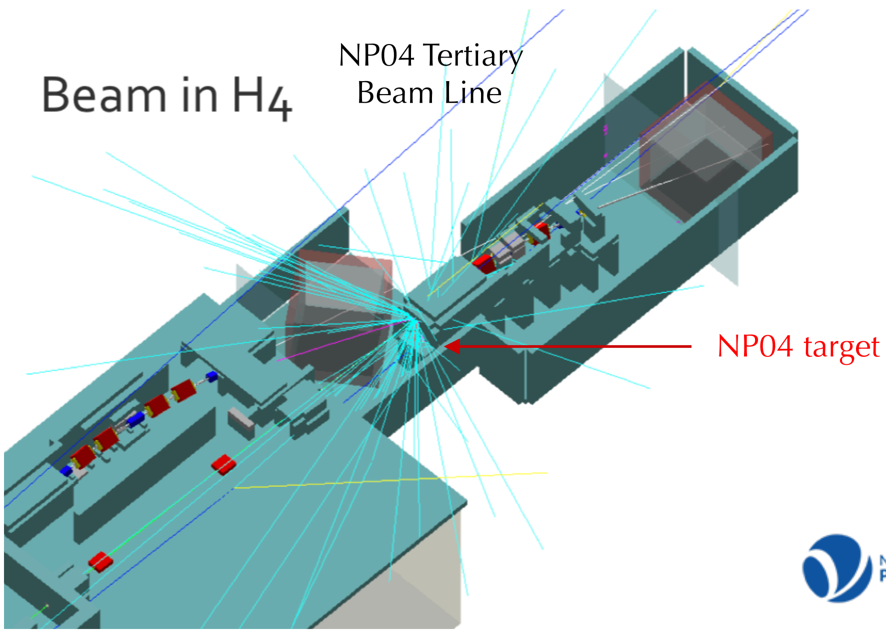
T-Gradient Profile System2
175 cm
LAr level
9 m
258 cm
258 cm
258 cm
T sensor
bottom cup
O(*few* mK)
resolution

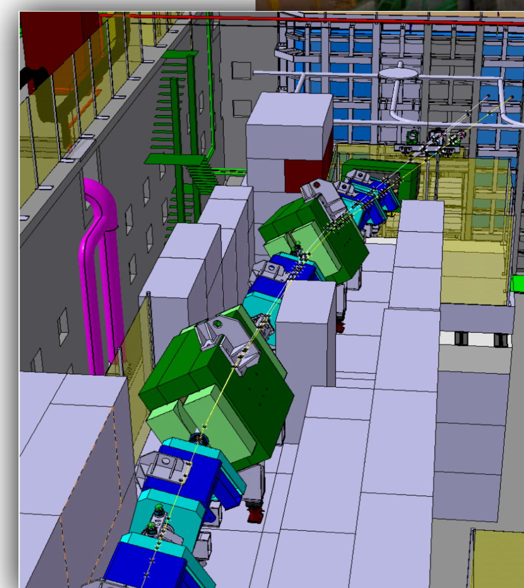
H4 (Tertiary) Beam Line

CERN SPS - North Area





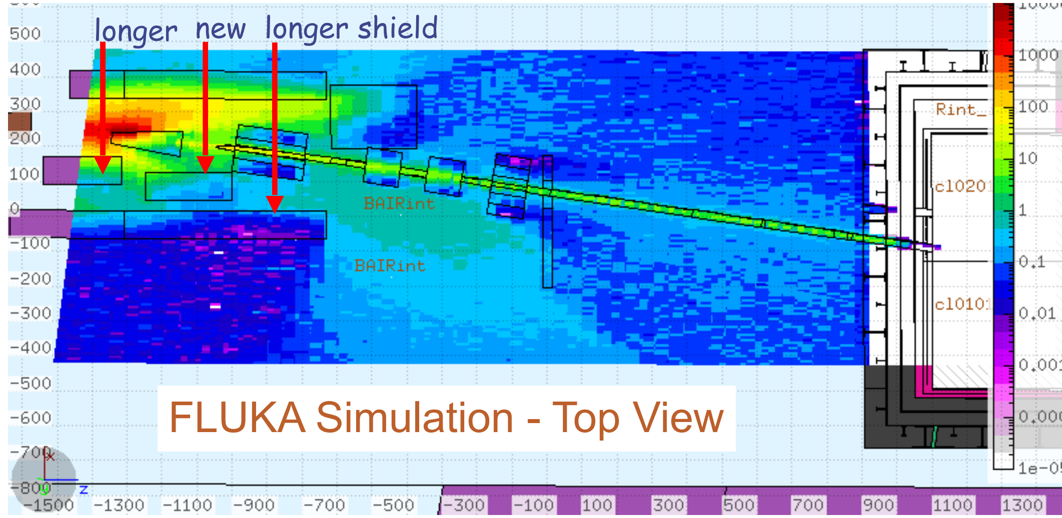




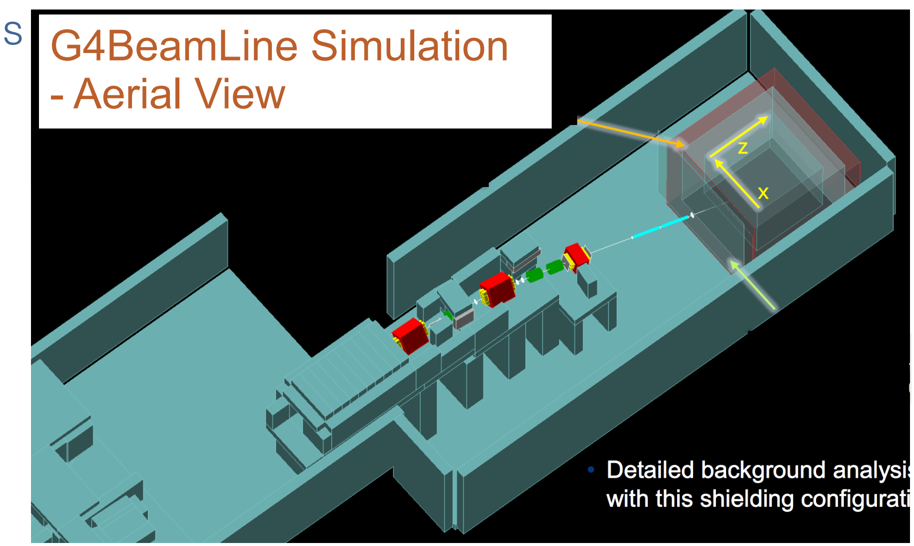
ProtoDUNE-SP Instrumentation

-*Beam Instrumentation:*

- **H4 beam line model including concrete shielding**: substantial reduction of background particle rate at TPC front



- Precise **field map calculation for H4 magnets**, important for the muon background calculations
- Exact **bending magnet geometry** completed.
- Optimization of **beam pipe geometry** and dimensions
- Final H4 **beam position** decision taken by ProtoDUNE-SP (NP04) Collaboration

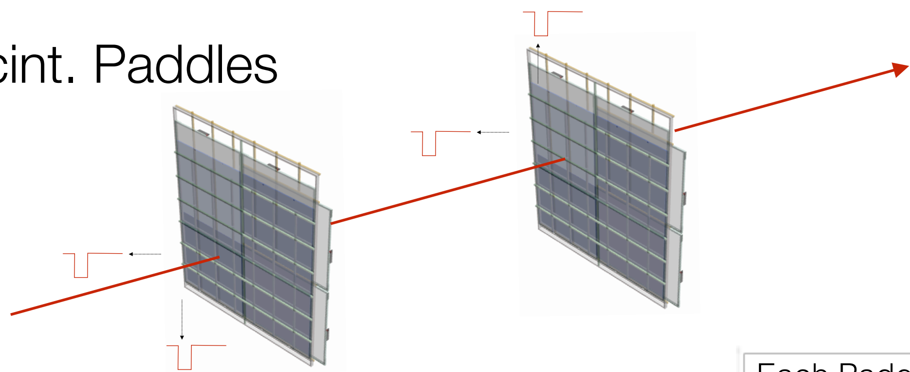


External Muon Tagger

Trigger logic using coincidence signals from upstream and downstream modules

A FAST NIM signal is generated when a coincidence is found btw the two layers of the hit paddle

2 Hor Scint. Paddles



2 Vert

CRT Module

Each Paddle is made by TWO scintillator planes segmented in 5 cm wide strips (staggered).

- **during beam spill (BeamOn):**
  - ➡ Muon Tagger stand-alone trigger ⇨ ***hor-muon halo** trigger* for LAr TPC Calibration (e-lifetime, SCE)
  - ➡ in “anti-combination” w/ beam counter trigger ⇨ ***veto*** TPC readout in case of pile-up or halo/punch-through
- **out of beam spill (CosmicOn):**
  - ➡ Muon Tagger stand-alone trigger ⇨ ***hor-muon cosmic trigger*** for LAr TPC Calibration (e-lifetime, SCE)
  - ➡ in combination w/ internal PhDet trigger ⇨ *special* ***cosmic event trigger*** (cosmic ray induced muon bundles or electromagnetic cascades in atmosphere)

Summary: (possibly available) Fast Trigger Inputs

Input	Source
BeamON	Spill beam gate
Trig1, Trig2	BI: Trigger Counters
USTOF, DSTOF	BI: Upstream, Downstream Time of Flight
BPXY1, BPXY2	BI: BeamProfile X-Y (closer to Det)
C1, C2	BI: Trigger Counters

Input	Source
CosmicON	Cosmic post-beam gate
USMTModJ1 Q1-4, USMTModJ2 Q1-4, USMTModS1 Q1-4, USMTModS2 Q1-4	CRT: Upstream, Jura Up/ Dw Module Quadrant 1-4, Upstream, Saleve Up/Dw Module Quadrant 1-4
DSMTModJ1 Q1-4, DSMTModJ2 Q1-4, DSMTModS1 Q1-4, DSMTModS2 Q1-4	CRT: Downstream, Jura Up/Dw Module Quadrant 1-4, Downstream, Saleve Up/ Dw Module Quadrant 1-4

Input	Source
PDAPAS1-3 PDAPAJ1-3	PD: APA Jura Side 1-3, APA Saleve 1-3 (m-majority out of 10 PD bars)
MichelAPAS1-3 MichelAPAJ1-3	PD: APA Jura Side 1-3, APA Saleve 1-3 (delayed Michel signal)

examples of possible Trigger Outputs

Path	Trigger Requirements ON	Required OFF
1	BeamON+Trig1+Trig2+USTOF+DSTOF	-USMTModS1Q1
2	BeamON+Trig1+Trig2+USTOF+DSTOF+BPXY1+BPXY2	-USMTModS1Q1
3	BeamON+Trig1+Trig2+USTOF+DSTOF+BPXY1+BPXY2+C1	-C2 -USMTModS1Q1

4	BeamON+USMTModJ1Q1+DSMTModJ1Q1+PDAPAS1+PDAPAS2+PDAPAS3	
5	CosmicON+USMTModJ1Q1+DSMTModJ1Q4+PDAPAS1+PDAPAS2+PDAPAS3	-BEAMON
6	CosmicON+MichelAPAJ2	-BEAMON

Detector Performance & Calibration

- **Core calibration:**

  convert dQ/dx (ADC/cm)

  to dE/dx (MeV/cm)

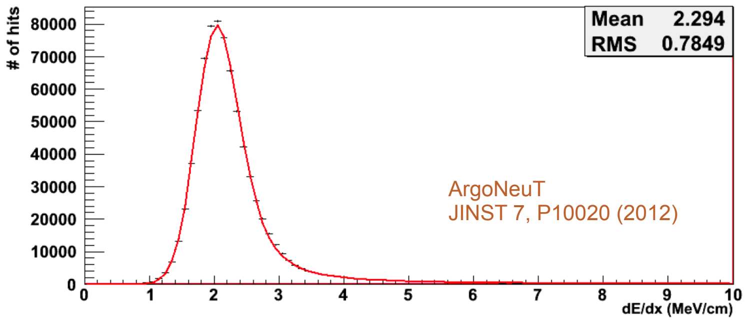


Figure 5. Energy per unit track length deposited by the beam-induced through-going muons in ArgoNeuT, corrected for the contribution of δ-rays. The error bars shown are statistical only. The results from a Landau-Gaussian fit (shown in red) are also reported.

➡ Electronics calibration

➡ **Space charge effects**

➡ Electron lifetime

➡ Recombination effects

➡ Muon/Pion based calibrations

- **S/N characterization**
  - S(⟨dE/dx⟩)/N(Ped-rms)
  - all TPC-wire/CE-channels

protoDUNE basic Detector performance fundamental to inform DUNE design:

- **e-lifetime ➡ Cryogenic system stability and recirculation/purification efficiency**
- **⟨dE/dx⟩ ➡APA (TPC) design geometry**
- **⟨dE/dx⟩ ➡Field Cage (EF uniformity)**
- **S/N ➡ CE noise level and performance**
- **SCE mapping ➡ overall detector capability to provide high quality data for Physics analysis**

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