Plans for ProtoDUNE-SP Commissioning and Run

Flavio Cavanna

DUNE Collaboration Meeting

FERMILAB - 15 May 2018

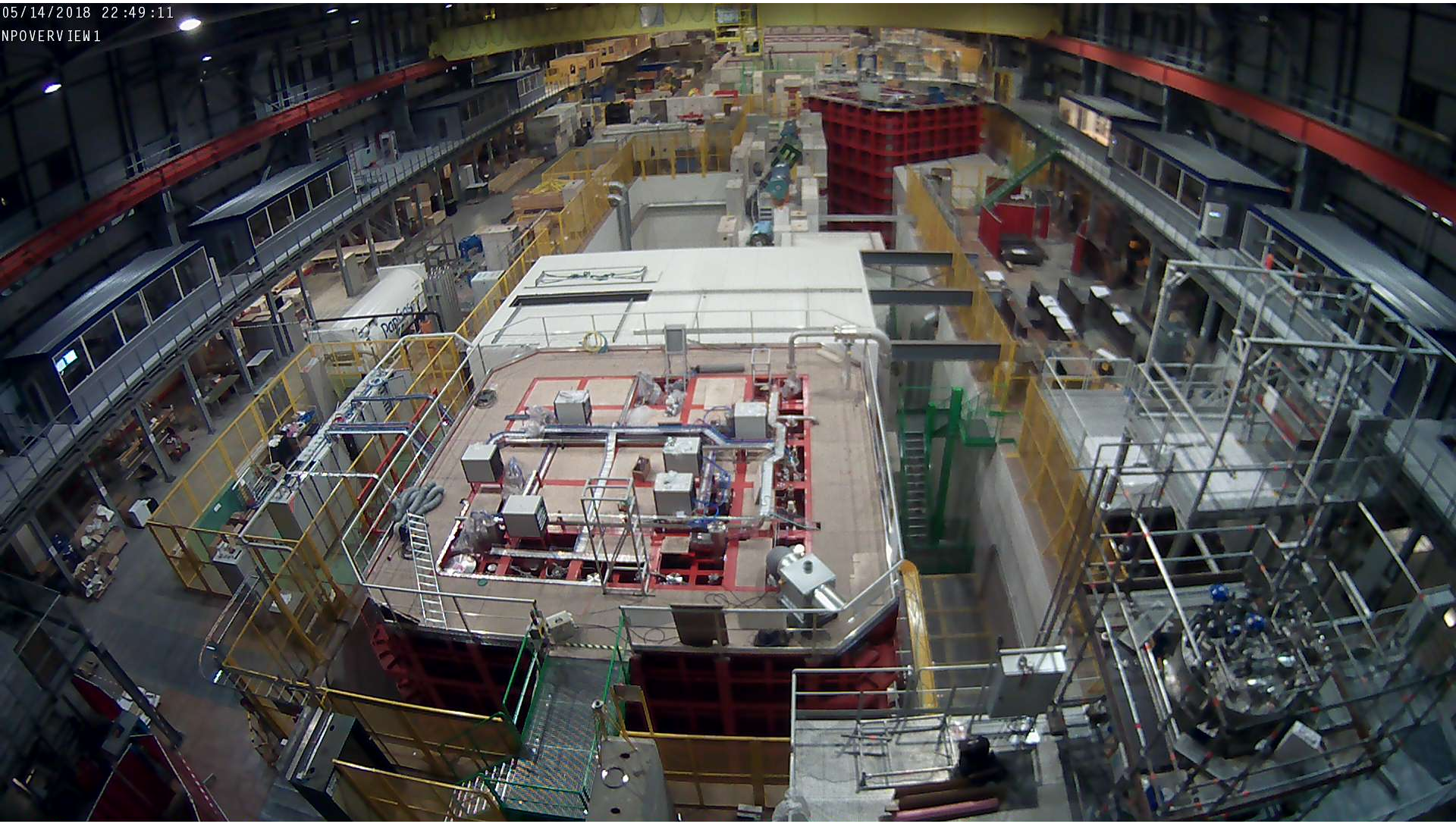
Fermilab DUNE

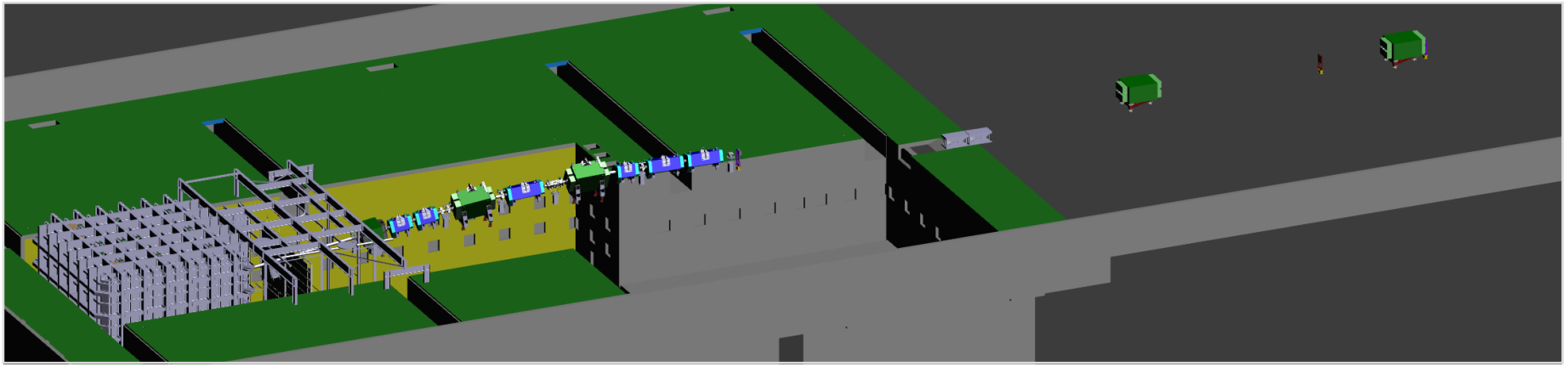
EHN1 extension -

two weeks ago…

EHN1 extension -

today





protoDUNE-SP Goals

Q1

- 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 prompt execution of data processing and reconstruction have the highest priority in DUNE

(**) Note about the Long-Term Stability Run 2019

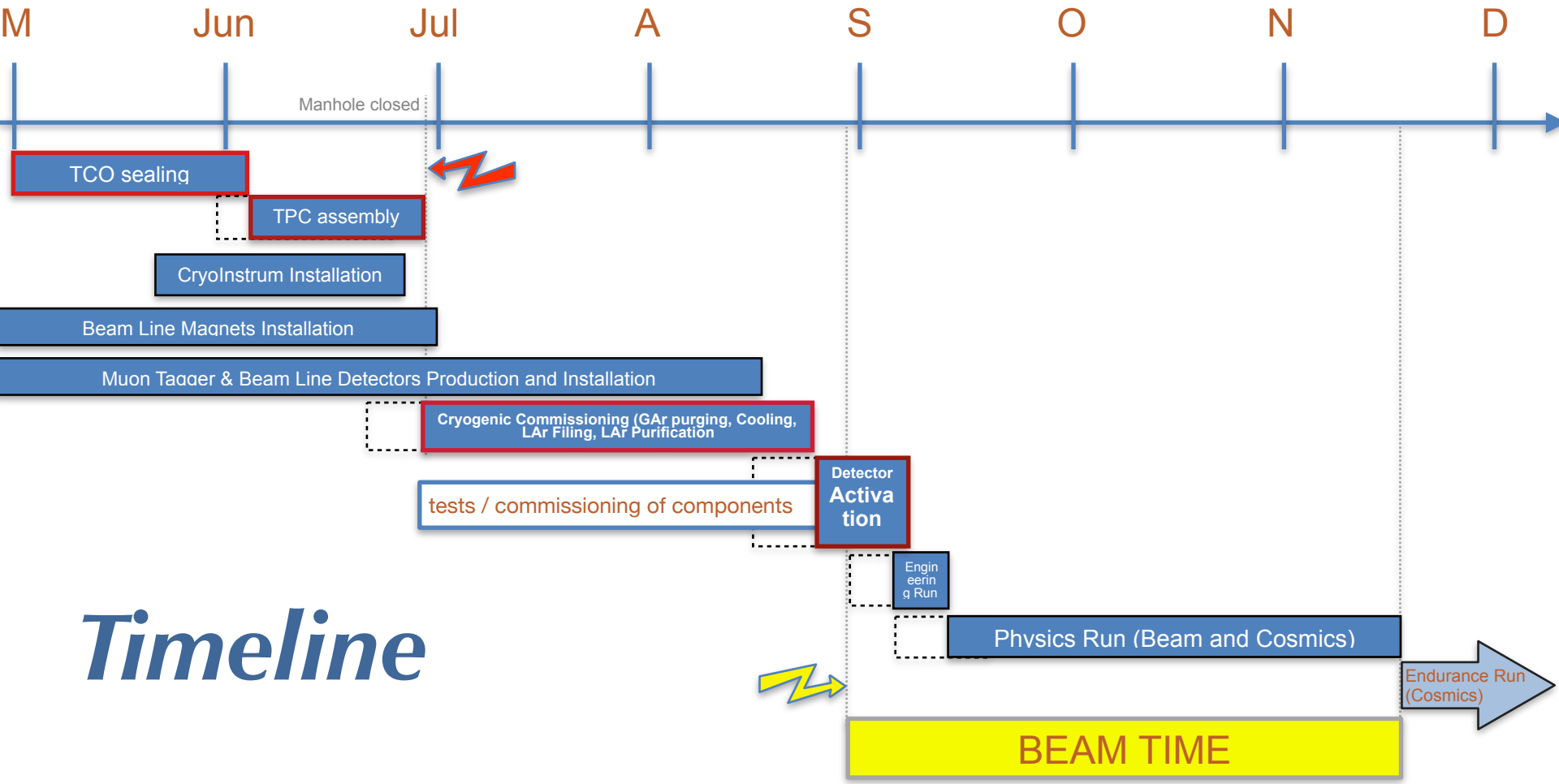
The long term stability Run with Cosmic
- 6 to 12 months extending in 2019 -
has been communicated/proposed to CERN SPSC on April 20

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

- minimal goal: maintain detector active and acquire short Cosmic Run every day
- *dedicated tests at different cryogenic system and detector operating parameters presumably to be included in the plan*

Allocation of Resources for Detector Operation and Computing in 2019 under discussion

Installation, Commissioning and the 2018 Run



Timeline

ProtoDUNE-SP Operation Plan

The timeline for operations with beam is very limited ⟹ need to have a plan which insures the highest quality detector performance and data taking efficiency.

The development of the plan is based on three main guidelines:

- take advantage of the highly qualified expertise of system experts, in particular those based at CERN and directly involved in detector construction, test, integration, installation and in data acquisition, monitoring and controls.

- provide opportunity for DUNE collaborators who have not been intimately involved in the detector construction and integration to gain experience with the liquid argon detector technology (valuable for the DUNE far detector design and construction).

- plan is subdivided into two major phases (after manholes closed by End of June):
  - Cryogenics Commissioning, BeamLine Commissioning, and **Detector Commissioning&Activation**
  - Engineering Run → **Physics Run w/ Beam** (and Cosmics)

- **Detector Commissioning/Activation *"inside the Cryostat"* teams defined for**:

  - High Voltage
  - Beam Plug
  - APA Wire Bias
  - Cold and Warm electronics
  - Photon Detectors and R/O Electronics

  - Temperature Monitoring
  - Purity Monitoring
  - Gas Analyzers
  - Cameras

  - Grounding and shielding

  - Data Acquisition
  - Detector Controls System

Requested :

- Contact person
- Expert list
- Tasks and procedures

Responses have started

As well as for

- **Commissioning operations "outside the Cryostat"** and for **start-up Data-taking:**

  - Beam Instrumentation
  - Muon Tagger
  - Trigger
  - Data Quality Monitor
  - Computing
  - Data Reconstruction and Analysis

  - Beam Line
  - Cryogenics

Responses on Plans and Procedures will enter into a ***master file*** where a global sequence of events and activities will be coordinated so that prerequisites and exclusions can be met.

Organizational Structure on the ground

CERN Neutrino Platform
M. Nessi (CERN)

ProtoDUNE-Single Phase
Coordinators
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) + Deputy (A.Zani)*

Computing
CERN IT

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

Computing
FNAL-SCD

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

APA Wire Bias
Cold and Warm Electronics

Beam Line
CERN EN-EA

Beam Instrumentation
CERN BE-BI

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

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

Trigger

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

Photon Detectors & PD R/O Electronics

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

High Voltage System
Beam Plug

Cryogenics
CERN TE-CRG

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

SlowCtrl/ DCS
CERN EP-DT-DI

Grounding and Shielding

The CERN Experimental Programme

Grey Book database

Find in Greybook...

» 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

Plan&Coordination of Commissioning/Activation

ProtoDUNE-SP Detector Activation Preparatory Meeting:

Thurs. 9:00 am CDT (16:00 CET) - Weekly

[org: *F. Resnati/CERN, R. Acciarri/FNAL* - Commissioning Leader, Run Coordinator]

Attendance: All ProtoDUNE Teams ⊕ Neutrino Platform Team ***and***

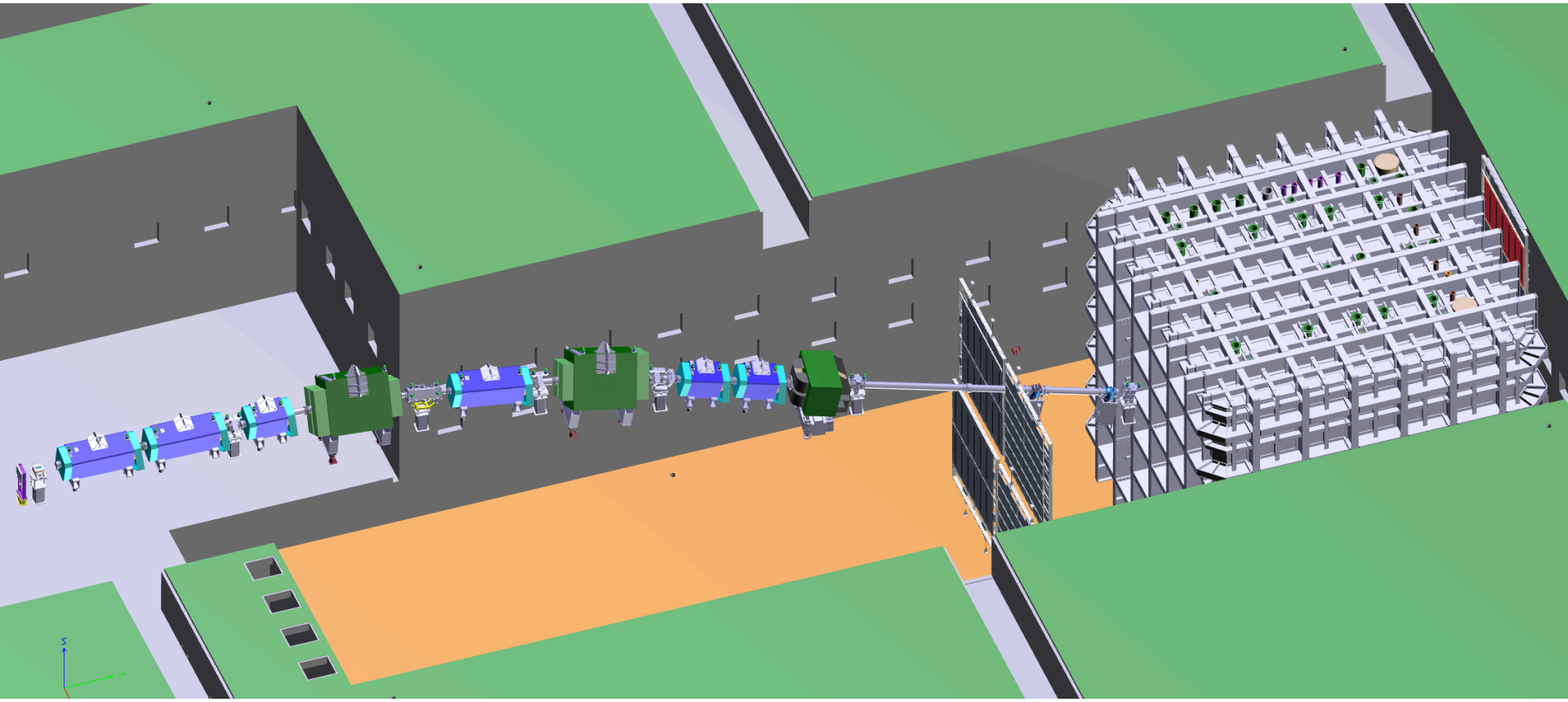
CERN Specialized Groups

Home Experiments DUNE Prototypes
ProtoDUNE single phase (NP04)

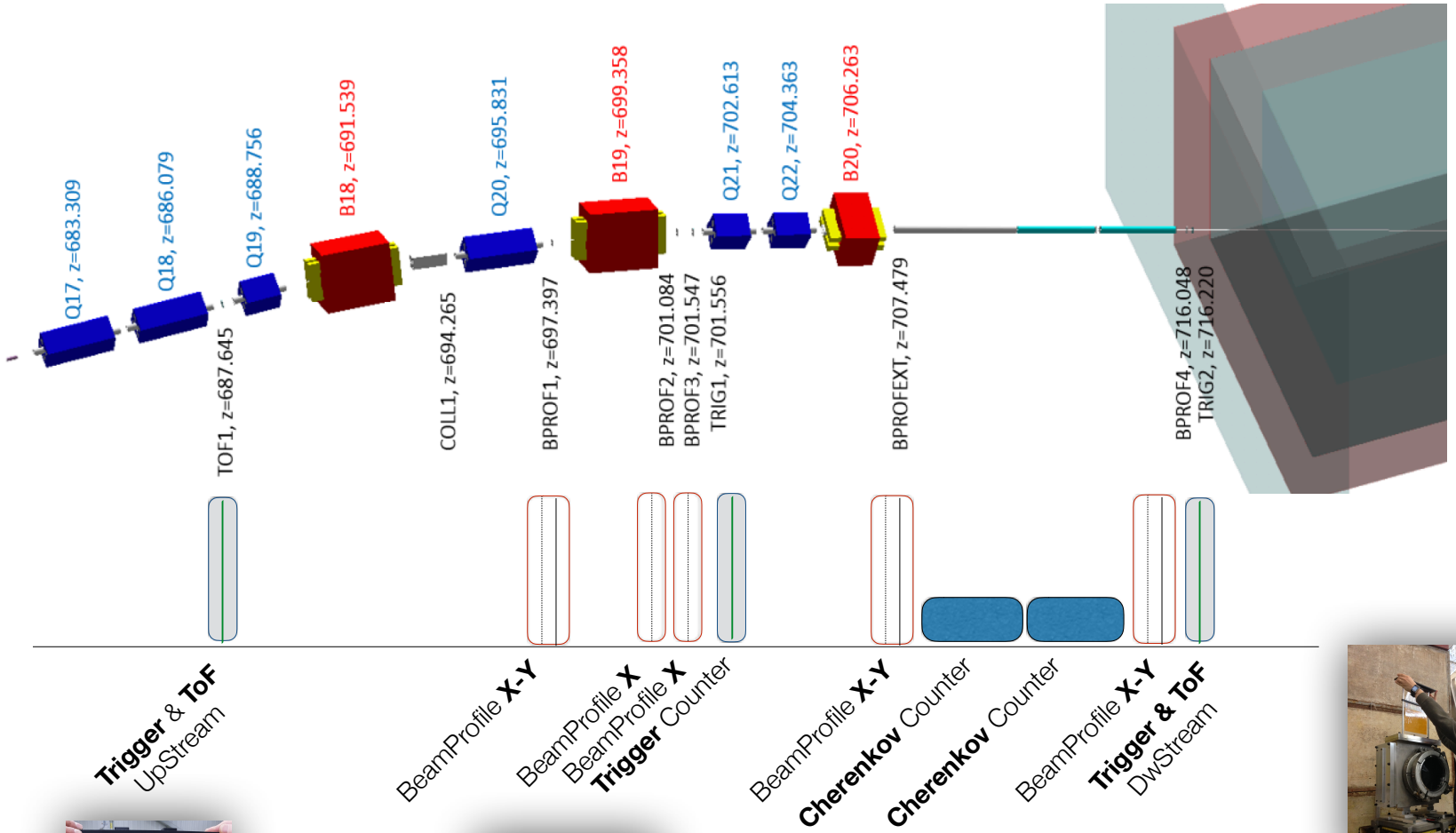
Detector Commissioning and Activation Meeting

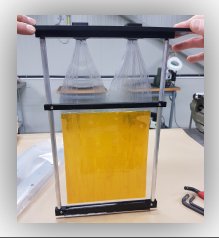
outside protoDUNE Cryostat

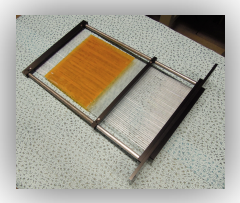
External Beam Line, Beam Detectors and Muon Tagger



- 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

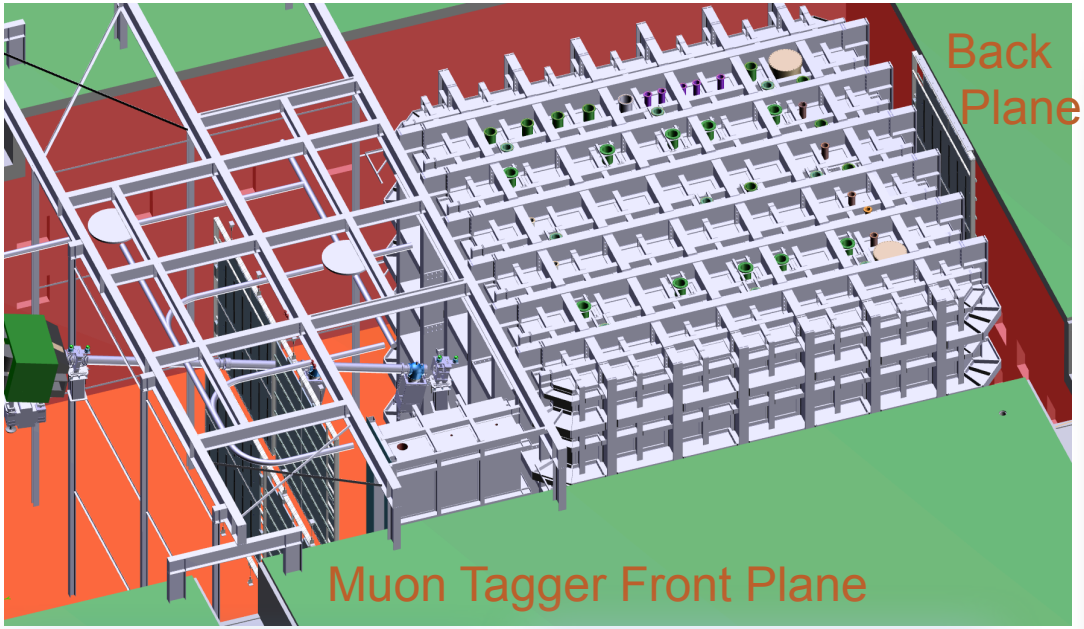
Cherenkov counters

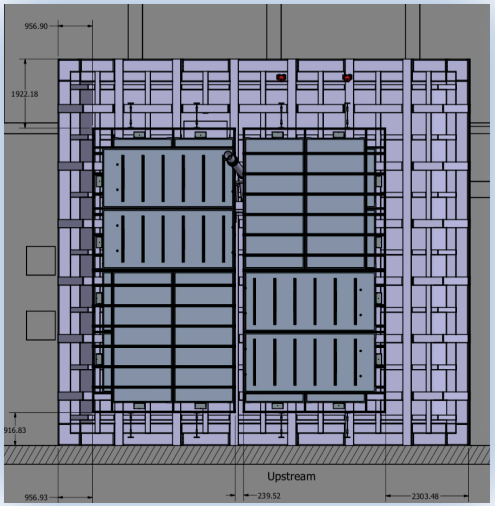
NP04/H4 Beam Line & Beamline Detectors

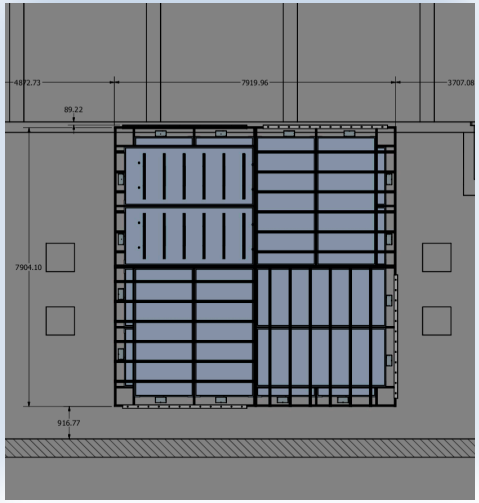
Neutrino PLATFORM

Muon Tagger

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

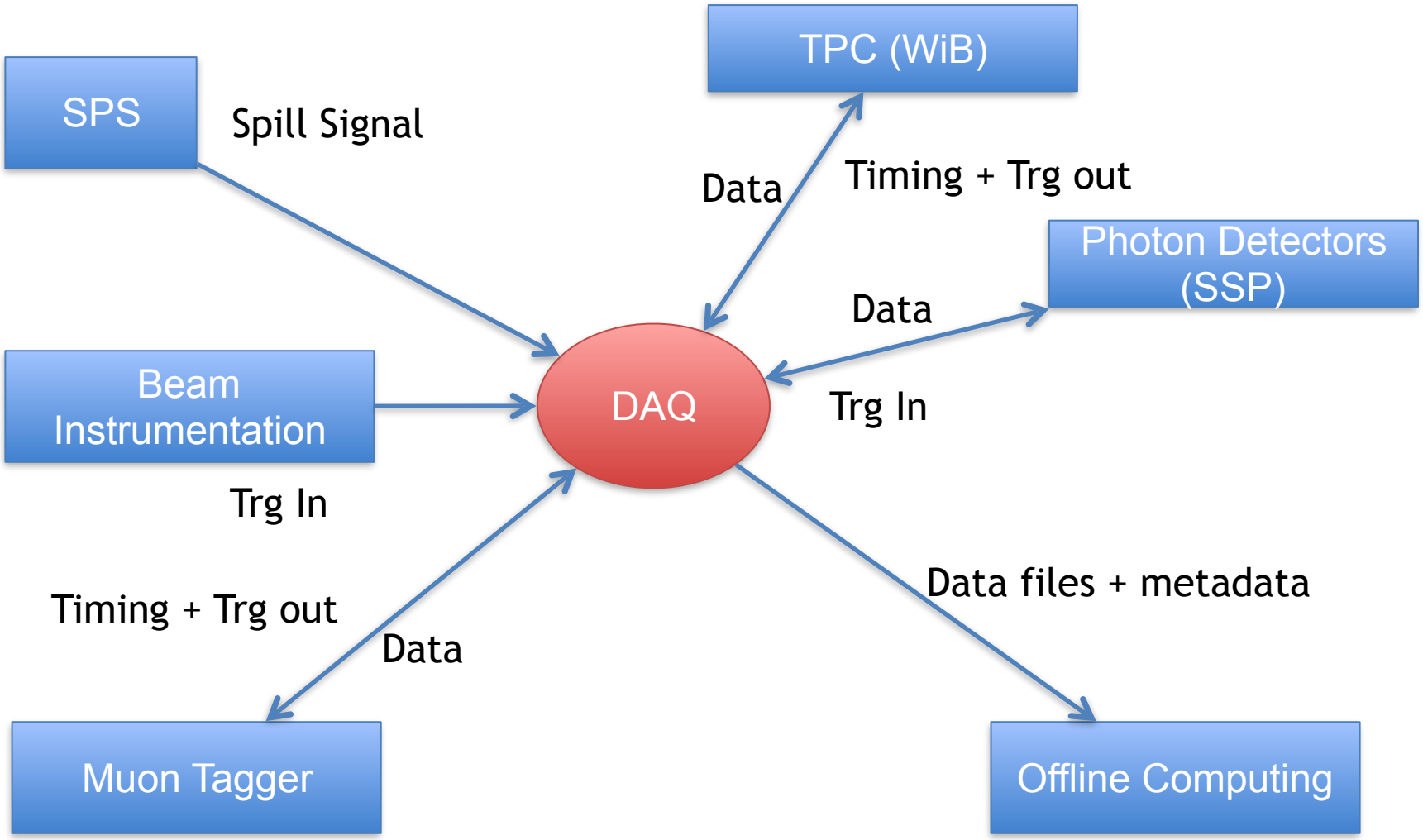


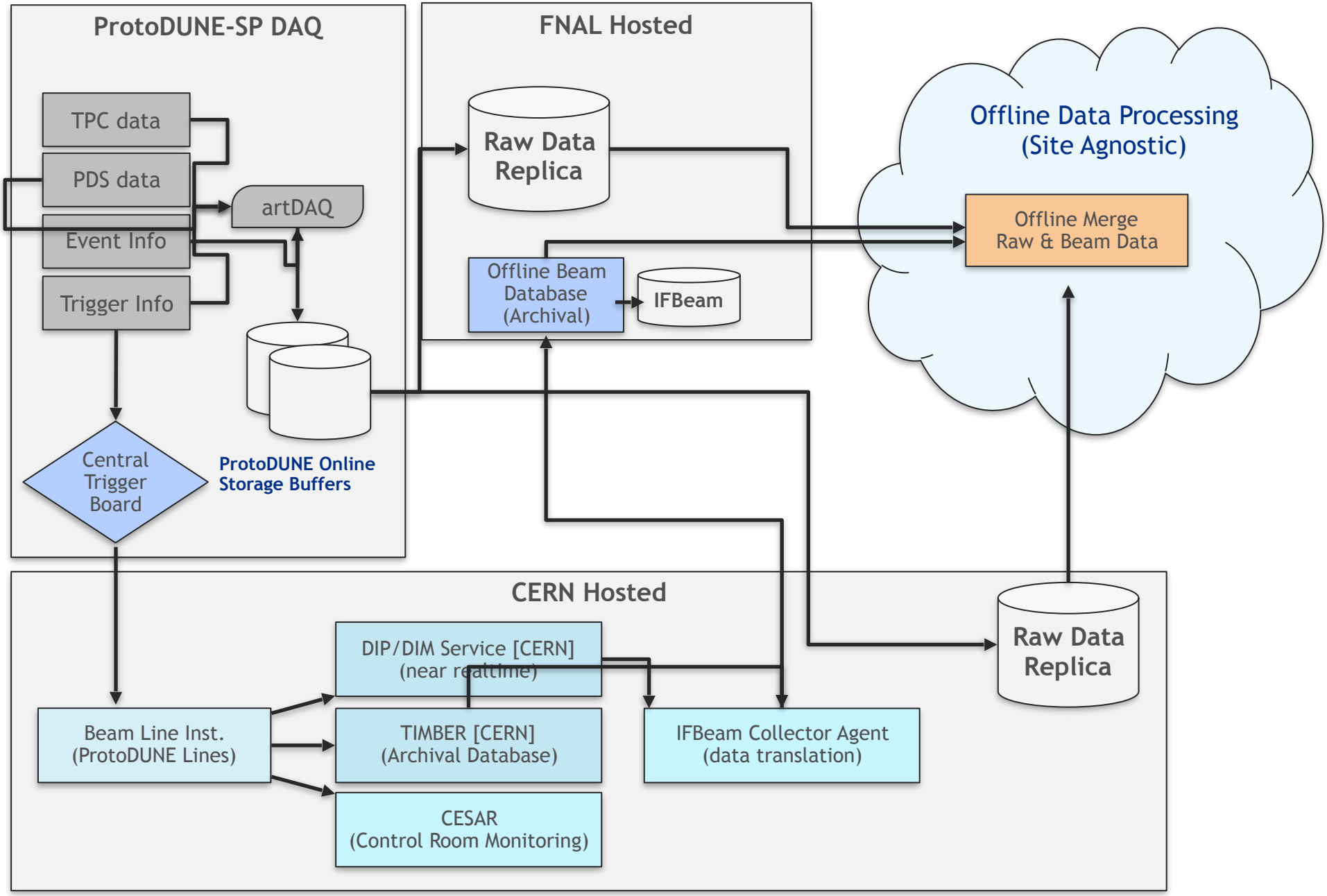




Muon Tagger Modules

Interfaces


TPC (WiB)
SPS
Spill Signal
Data
Timing + Trg out
Photon Detectors (SSP)
Data
Beam Instrumentation
DAQ
Trg In
Trg In
Timing + Trg out
Data
Data files + metadata
Muon Tagger
Offline Computing



Example of an Integrated System: ProtoDUNE Beam Inst. Readout for Offline -

Fermilab

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 TE-CRG	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 TE-CRG	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

Plan for ProtoDUNE-SP Operation

Phase 1: Detector Commissioning and Activation

System Experts on-site at CERN

[period of stay to be defined in the Commissioning Plan and Procedure,
Approved Support for travel and accommodations for non-resident provided by the DUNE project]

July 2018

In parallel to (and within the limitations from) the concurrent Cryogenic Commissioning operations, the focus of activity will be to:

- operate and run CryoInstrumentation (T-Profilers, PurMon, Cameras, GasAnlysers)
- commission as much of the detector elements as possible inside and outside the cryostat:
  - from cathode (moderate) HV ramp to bias V on the wire planes
  - from APA-CE performance tests and monitor noise levels
  - from systems local read-out to full DAQ r/o chain tests
  - from available Beam Detectors and Muon Tagger Modules tests to Trigger Logic setting and debugging
  - …
- develop and exercise the tools for detector and beamline monitoring (DQM and DCS)

August 2018

The focus of activity will be :

1. complete cryogenic commissioning and LAr purification
2. Beamline and beamline instrumentation commissioning
3. LAr Detector Commissioning

LAr DETECTOR	Commissioning
Task	**Duration**
Cathode HV ramp	1 w
Wire Planes V-bias	
CE activation	+
PD activation	
DAQ activation	
On-Line Mon	1 w (conting.)
DQM	
Data Archiving	
completed by Sept. 5 - *possibly a week earlier*	

- **Beam operations:**

August 29, 2018 (Start)

November 11, 2018 (End)

H4 Beam Time Allocation to NP04 by SPS-C:

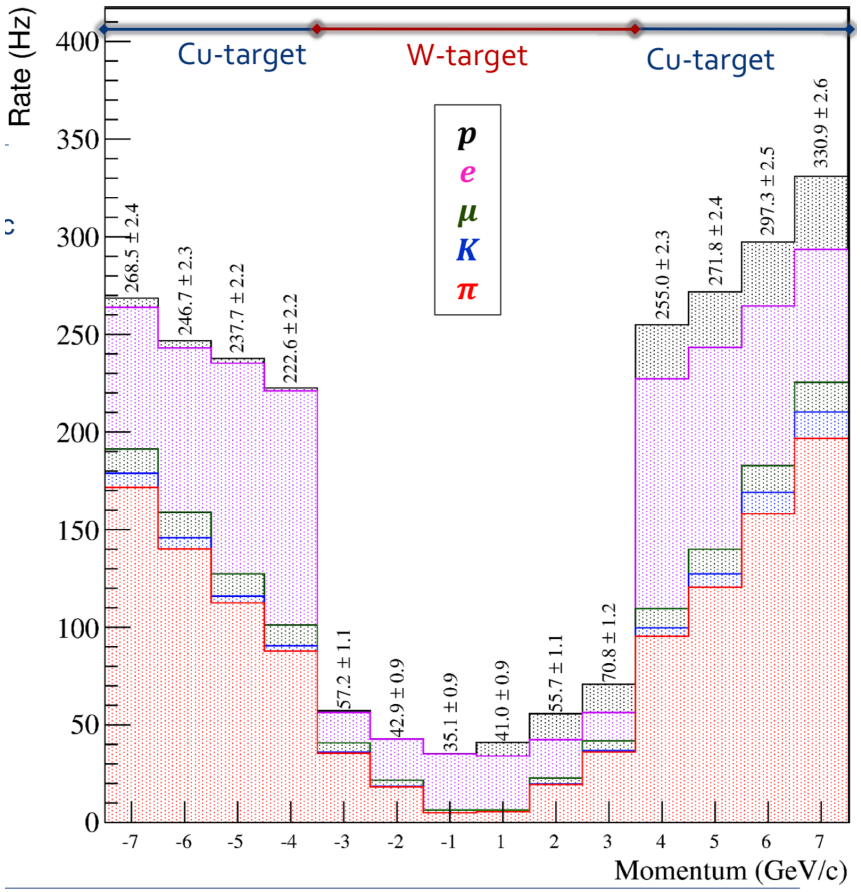
7.5 weeks (including Beam Commissioning Time) *in 4 blocks (2w + 2w + 2w + 1.5w)*

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

	Mar			Apr				Mai				Jun				Jul				Aug				Sep				Oct				Nov				Dec	
Week	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Machine															UA9 TS1 Coldex													UA9 TS2 Coldex					Coldex		RP					
North Area T2 - H2	SPS & TT20 Setup 18			NA Setup 8	HERD FIT 7	NA62 GTK 7	NA61 SHINE 14					TIC 7	Calice (Ahcal) 7		ATLAS ZDC 7	Calice (Ahcal) 7	NA61 K 60GeV/c 7	NA61 SHINE 21			AXIAL 7	KLEVER 7	LEMMA 7	CMS HGCAL 7	CMS HCAL 14	Calice (Sdhcal) 14	HERD 7	NA61 SHINE 7	CMS HGCAL	NP02 26			NA61 SHINE 28				
T2 - H4	SPS & TT20 Setup 18			NA Setup 6	NA63 9	CMS ECAL 7	GIF RD51 14		NA64 setup 7	NA64 35					CMS ECAL 7	AIDA WP14 7	SHiP Installation 7	SHiP Muon 14	SHiP Charm 7	GIF 7	GIF RD51 14		DsTau 7	NP04 setup 7	NP04 7	CMS MTD 7	NP04 14	CMS ECAL 7	NP04 14	GIF RD51 7	NP04 12	RE29 DAMPE 7	HERD 7	ATLAS ZDC 7	CaloCube 7			
T4 - H6	SPS & TT20 Setup 18			NA Setup 6	Clic pix 7	CMS Outer Tracker 9	ATLAS HGTD 7	ATLAS ITK 14	ATLAS ITK Kartel 7	RD42 7	ALICE muons 7	CERF 7	CMS Outer Tracker / AIDAwp7 7	Clic pix 7	ATLAS HGTD 7	ATLAS ITK 21		ATLAS AFP 14		ATLAS BCM 7	Clic pix 7	ATLAS ITK 14	ATLAS AFP 14		ALICE muons 7	RD42 7	AIDA WP7 7	ATLAS ITK Kartel 14	CMS Outer Tracker 7	ATLAS Strip Tk 7	Clic pix 5							
T4 - H8	SPS & TT20 Setup 18			NA Setup 6	TOTEM (+UA9) 9	ATLAS μ 7	ATLAS HV-CMOS 14	LHCb 14		ATLAS Tilecal 14	ATLAS HV-CMOS 7	TOTEM (+UA9) 7	ATLAS TRT 7	LHCb 21	crysbeam 7	CMS ITK 7	ALICE FOCAL 14		TOTEM (+UA9) 7	mu-e 7	ATLAS HV-CMOS 7	FCCee 7	TOTEM (+UA9) 7	ATLAS HV-CMOS 7	CMS ITK 7	LHCb 26		ATLAS Tilecal 14		R2E (+UA9) 7	HNX 14		NUCLEON 7			
T4 - K12	SPS & TT20 Setup 18			NA Setup 6	NA62 217																																
T6 - M2	SPS & TT20 Setup 18			NA Setup 6	NA58 COMPASS 217																																
TT41					AWAKE 21												AWAKE 21								AWAKE 21					AWAKE 21							

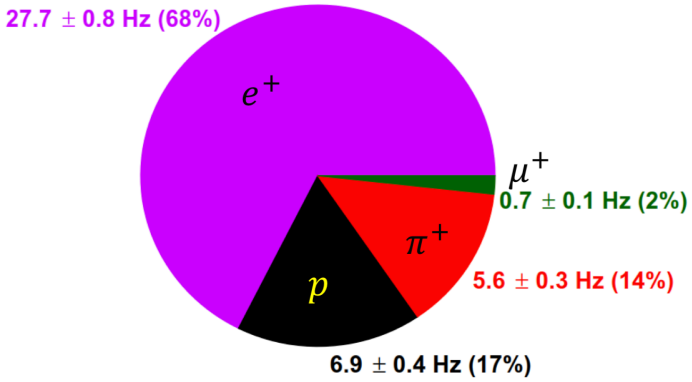
For further information contact the PS/SPS-Coordinator. Email: Sps.Coordinator@cern.ch, Tel: +41 75 411 3845.

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



Rates at 1 GeV/c

Rate with Collimator



Neutrino PLATFORM

Fermilab DUNE

- **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

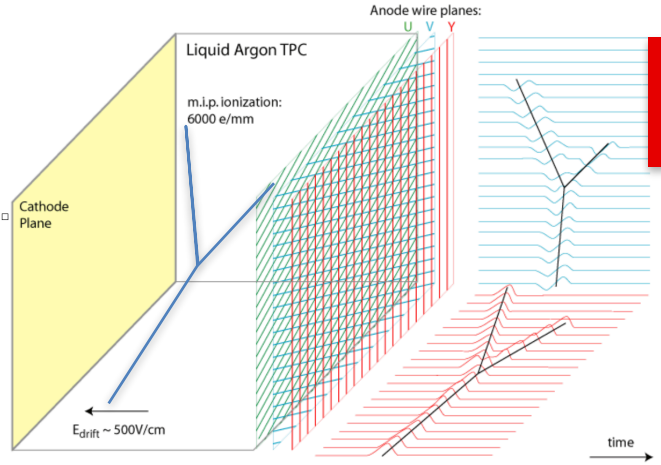
Beam Setting (Mom, Sign)	Beam Rate		Beam Time
2 GeV/c – Negative	27 Hz	50% π-, 50% e-	**1 week**

- **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	
5 GeV/c - Positive	600 k [500 k π]	25 Hz / 200 Hz	**2 week**
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

ProtoDUNE Analysis talk *by Tingjun*

Plan for ProtoDUNE-SP Operation

Phase 2: Data Taking Run with Beam (and Cosmics)

September - October - November 2018

2 shifters / 3x8hr shift / 24h/7d
Shift Team: Expert Shifter (ES) + basic shifter (S)
Shifts will be in the EHN1 Control Room.

Shifters (who are not System Experts) are expected to provide for their travel and daily expenses while at CERN through their home institution funding; however, the DUNE Operations Budget for ProtoDUNE will provide an apartment where temporary shifters may stay while on shift.

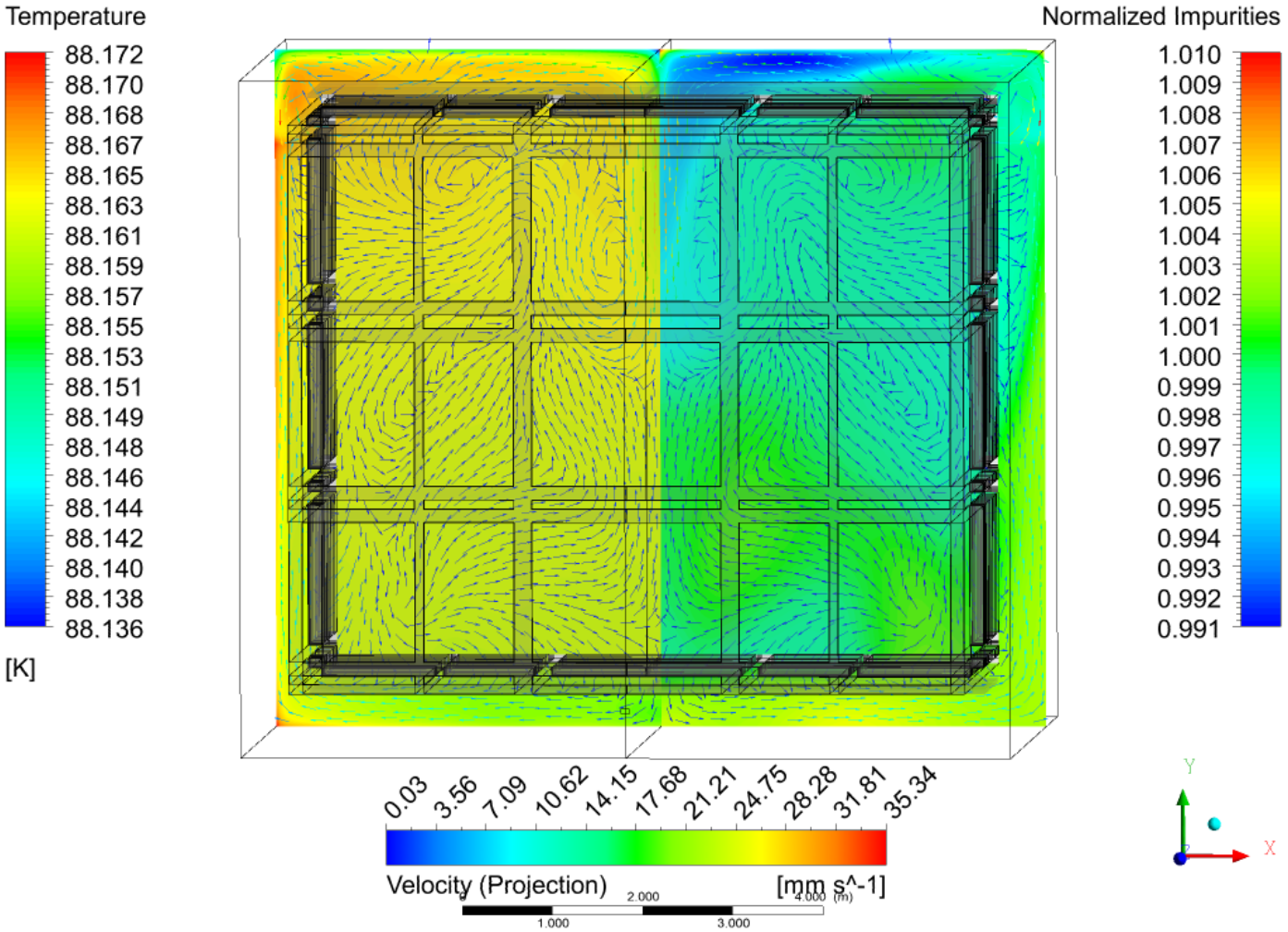
Availability and sign-up information will be managed by Maxine Hronek

SUMMARY

- ProtoDUNE SP is transitioning from **Construction/Assembly** to **Operation** (Commissioning and Run).
- **The plan for Cryo-Commissioning is in place, the plan and procedures 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

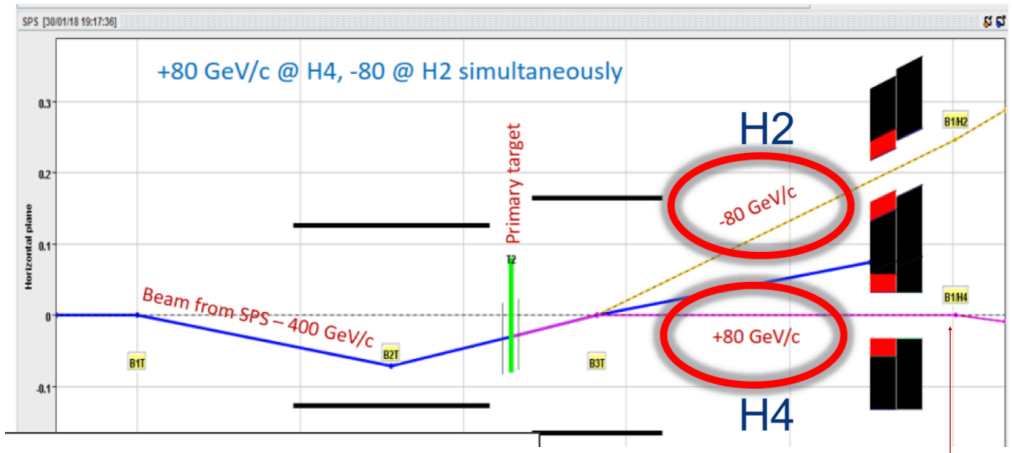


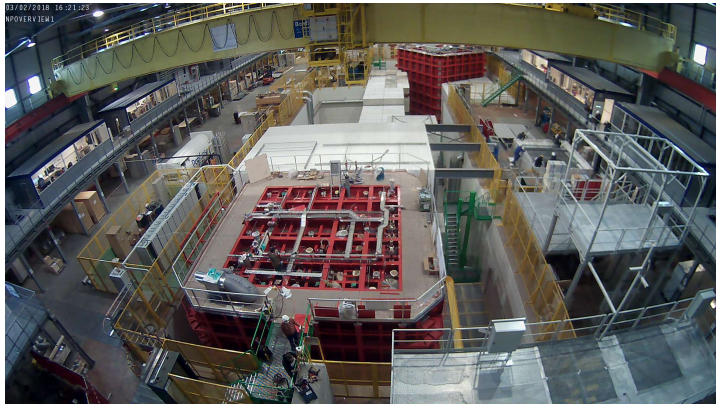
Temperature, Impurities and Velocity @ Z = 2m

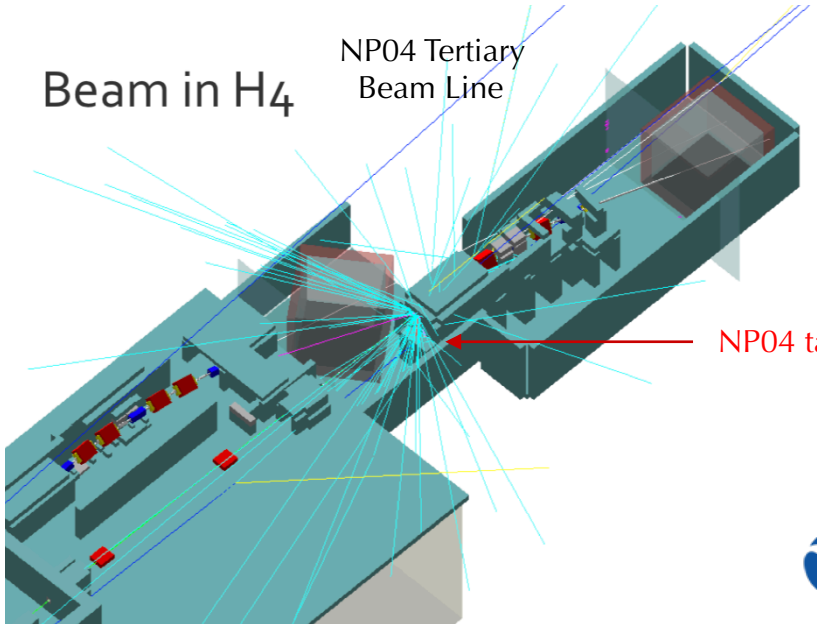
Fermilab

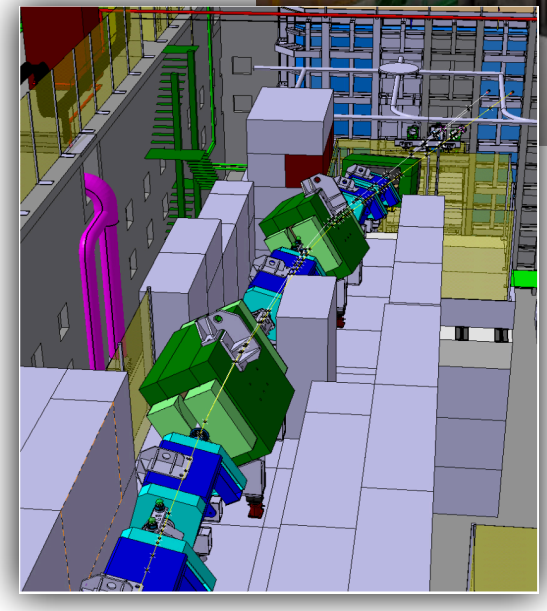
H4 (Tertiary) Beam Line

CERN SPS - North Area





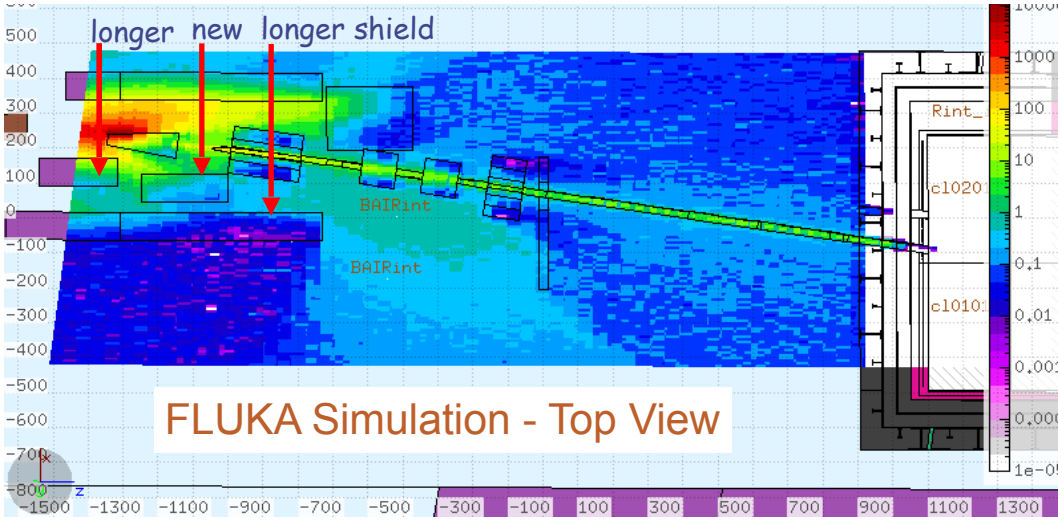




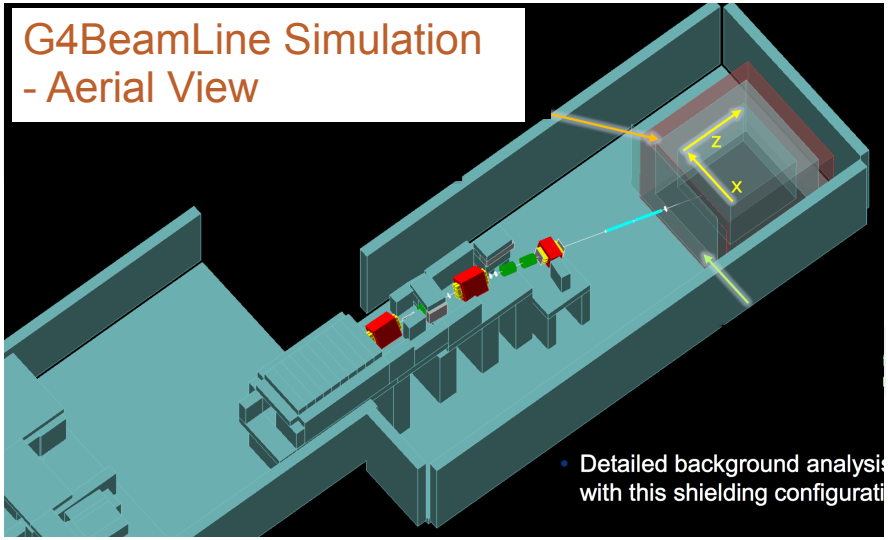
ProtoDUNE-SP Instrumentation

-*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

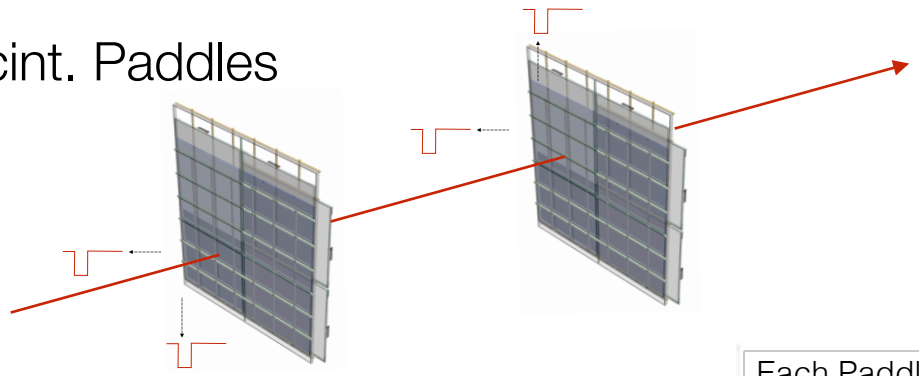


External Muon Tagger

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)

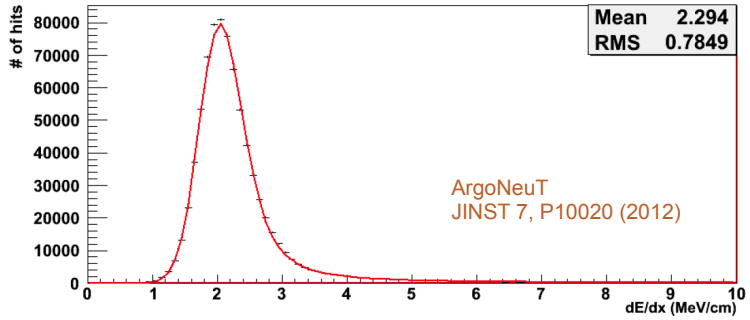


Figure 5. Energy per unit track length deposited by the beam-induced through-going muons in ArgoNeuT, corrected for the contribution of δ-rays. The error bars shown are statistical only. The results from a Landau-Gaussian fit (shown in red) are also reported.

- ➡ 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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