STEFANIA BORDONI - NUPHYS 2019, LONDON

THE CERN NEUTRINO PLATFORM

OVERVIEW OF EXPERIMENTAL ACTIVITIES

THE CERN NEUTRINO PLATFORM

- ESPP 2013: “CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments”
- Main goal : compact the European groups around the future Short and Long Baseline Neutrino programs taking place in US & Japan
- Part of the CERN Medium Term Plan (since 2015) – **CERN acts as a hub for R&D on future technologies (HW and SW) and partner in several neutrino research programs**
- Today: 146 institutions, active CERN partnership with external facilities in US/ Japan

CENF ACTIVITIES

NP01: ICARUS refurbishing and far detector in the SBN FNAL facility

NP02: LAr double phase TPC demonstrator (ProtoDUNE DP)

NP03: PLAFOND – generic detectors R&D

NP04: LAr single phase TPC demonstrator (ProtoDUNE SP)

NP05: Baby MIND muon detector for T2K near detector facility (operational)

NP06: ENUBET project *New!*

NP07: ND280 T2K near detector upgrade *New!*

+ agreed active participation in the construction and exploitation of the LBNF/DUNE and SBN US programs

+ collaboration with DarkSide 20k experiment

NP: TOWARDS THE US

ICARUS AND THE SBN PROGRAM

NP involvements in both Near and Far Detector installations:

Far Detector (ICARUS):

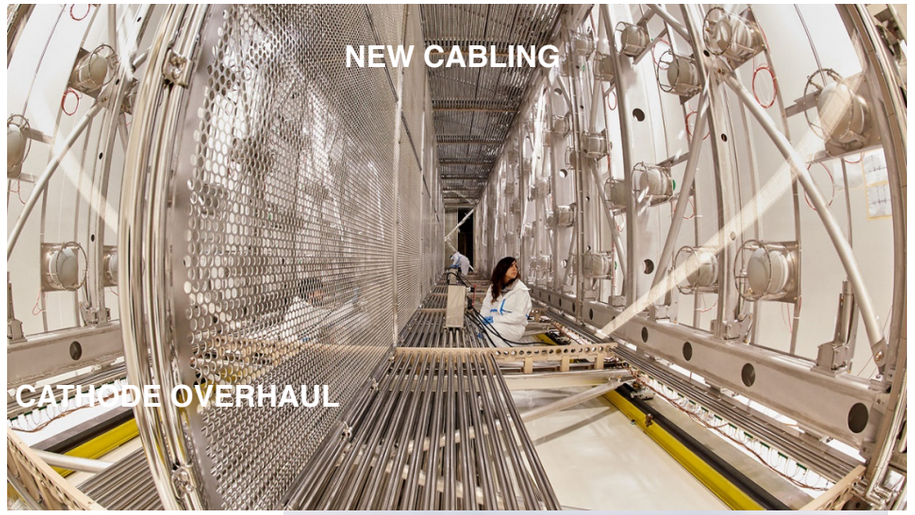
- @ CERN (2016 - 2018) : Overhauling of the ICARUS (T600) detector to adapt the detector to surface operation: Upgrade of light collection system, faster and high performance readout system, top Cosmic Ray tagger
- @FNAL :
  - Cryogenic installation recently completed (2019)
  - TPC and PMT electronics cabling finished by the Christmas break
  - Cool down expected in early January 2020

NP contribution: HV, trigger and light detection system, CRT

Near Detector:

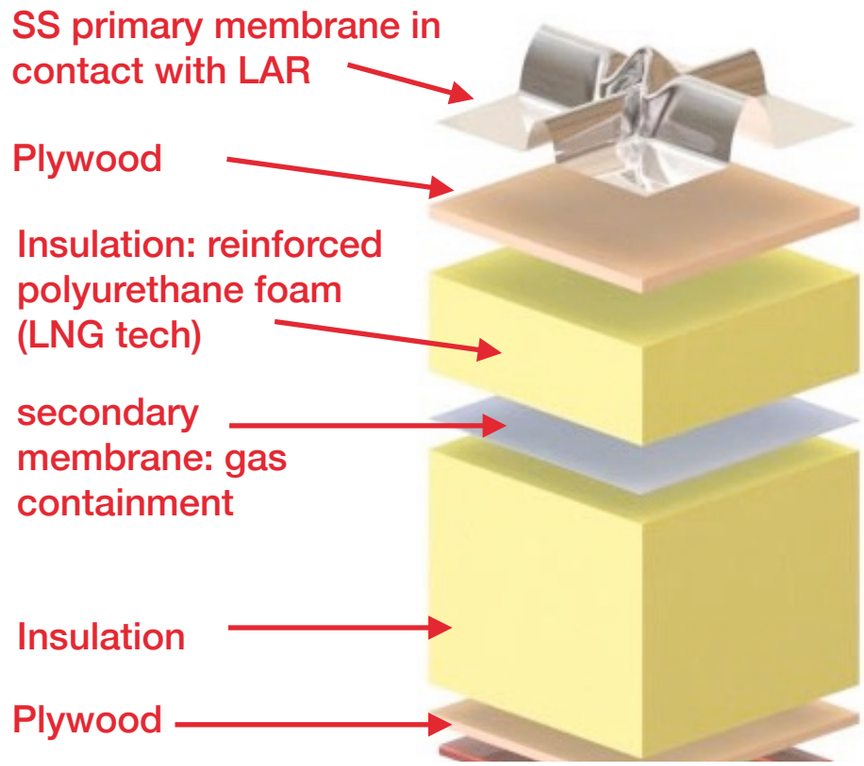
- Cryostat warm structure recently completed
- Installation of the insulation just starting

NP contribution: cryostat, cryogenics, HV system and field cage

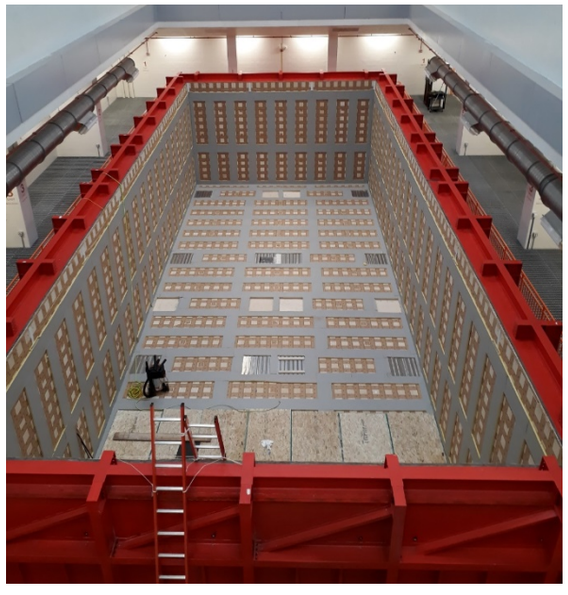


MEMBRANE CRYOSTAT TECHNOLOGY

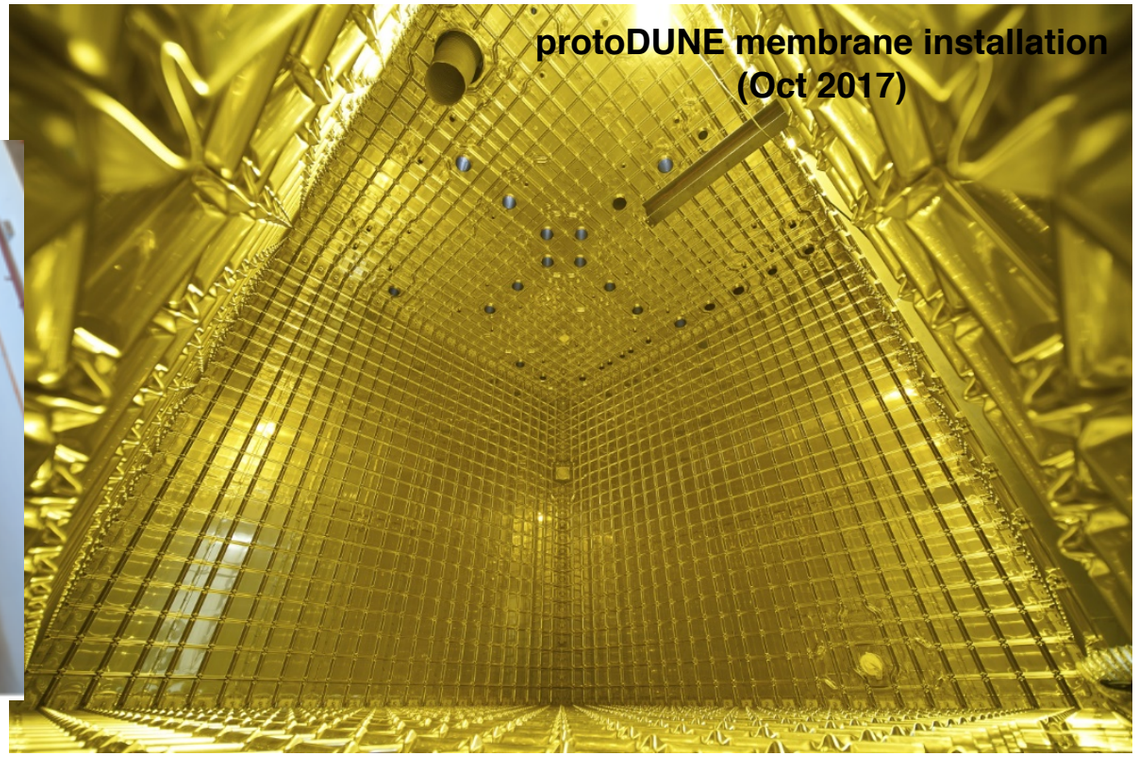
- New concept for very large dimension cryostats: no vacuum but Argon purge
- Close collaboration with industry (GTT) : membrane cryostat technology developed for LNG transport ships → re-engineered for LAr-TPC detectors
- Large employment of this new approach: protoDUNEs, DUNE, SBND, DarkSide



ICARUS: no membrane Vacuum-pumped cryostats (2017)

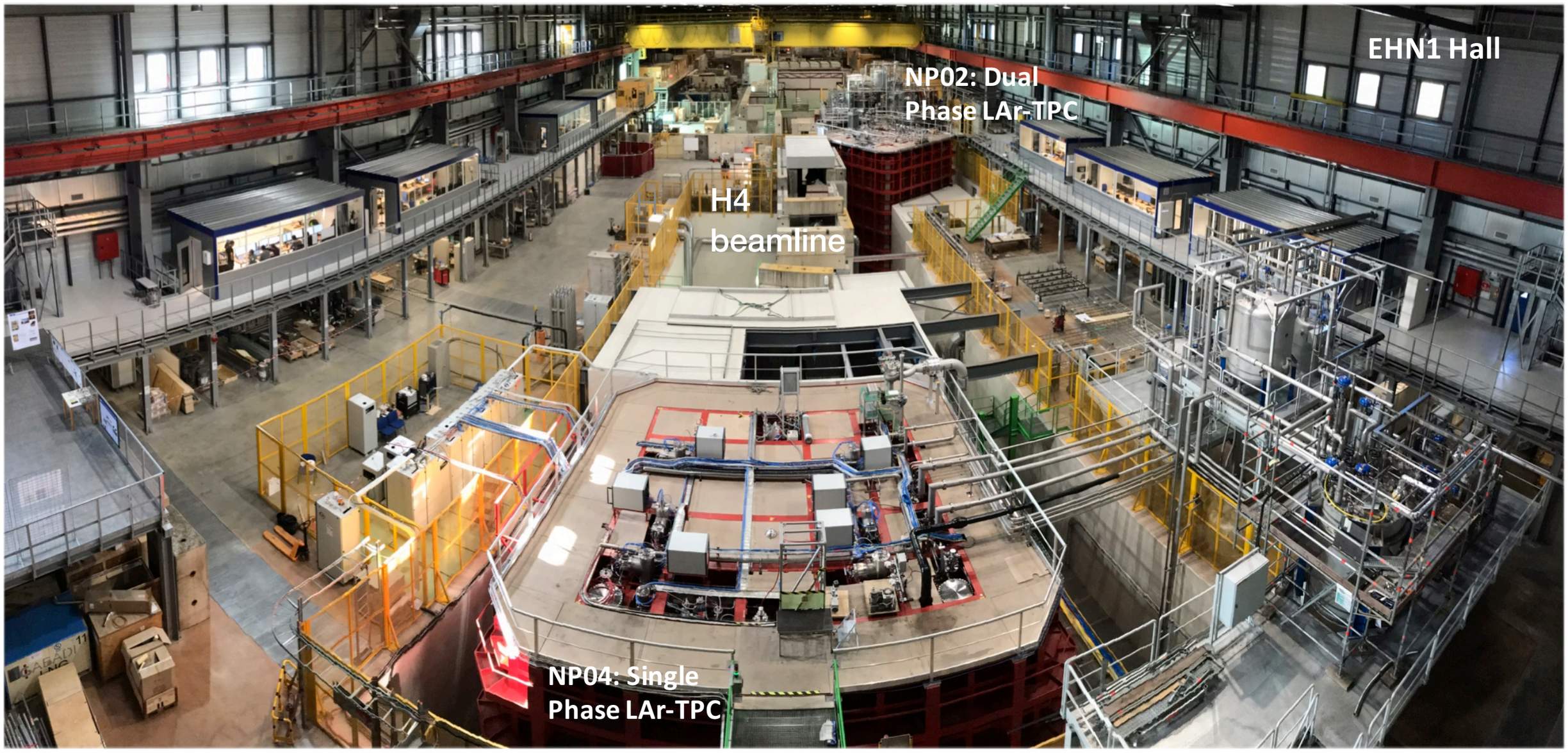


SBND warm cryostat (Nov 2019)



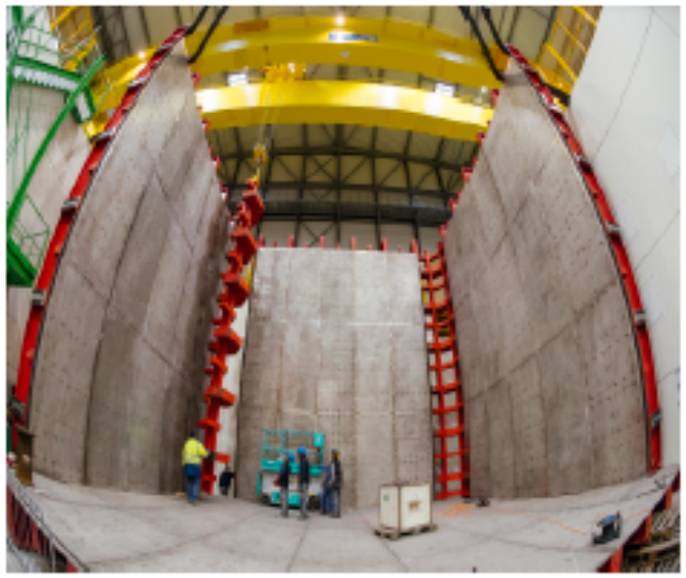
DUNE PROTOTYPES – PROTODUNES

(see also N. McConkey talk)

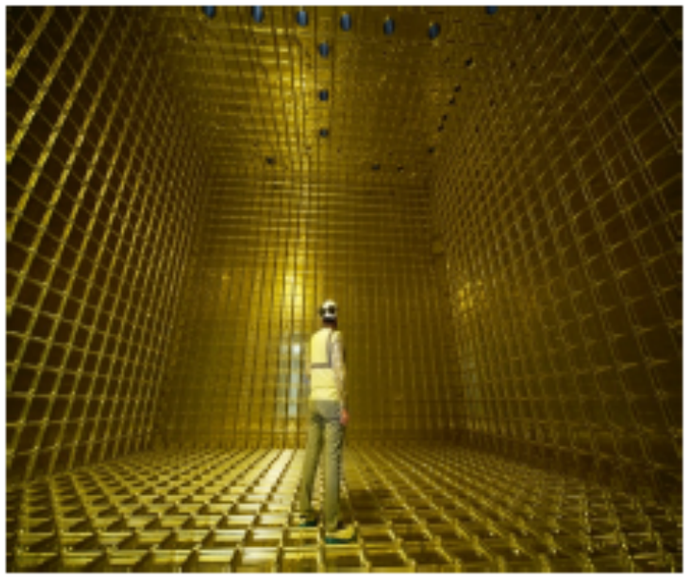


Path to ProtoDUNE SP completion in EHN1

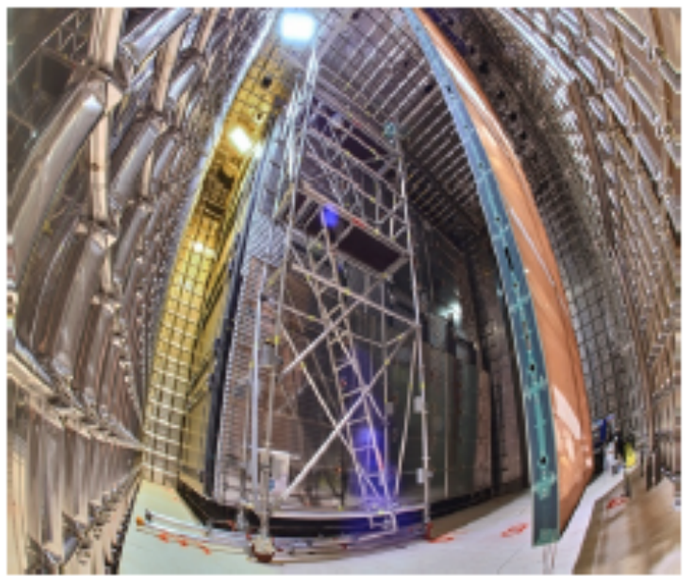
March 2016, construction of EHN1 extension



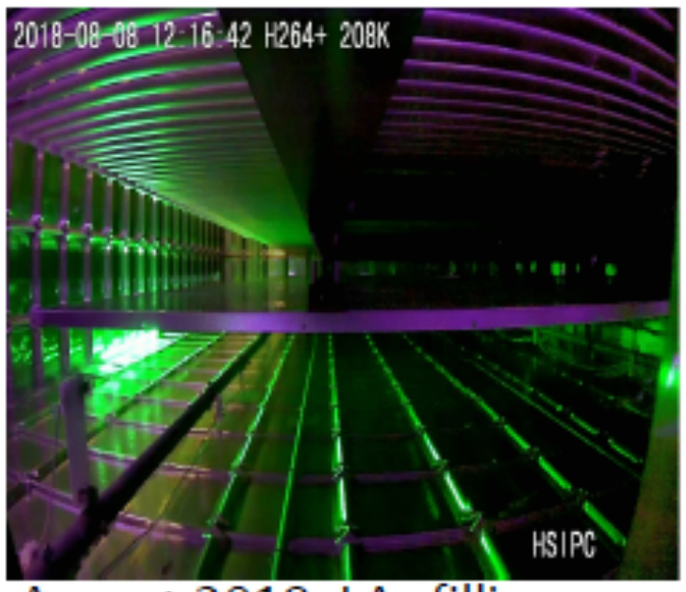
November 2016, cryostat structure assembly



September 2017, cryostat completion



February 2018, detector assembly and installation



August 2018, LAr filling and purification

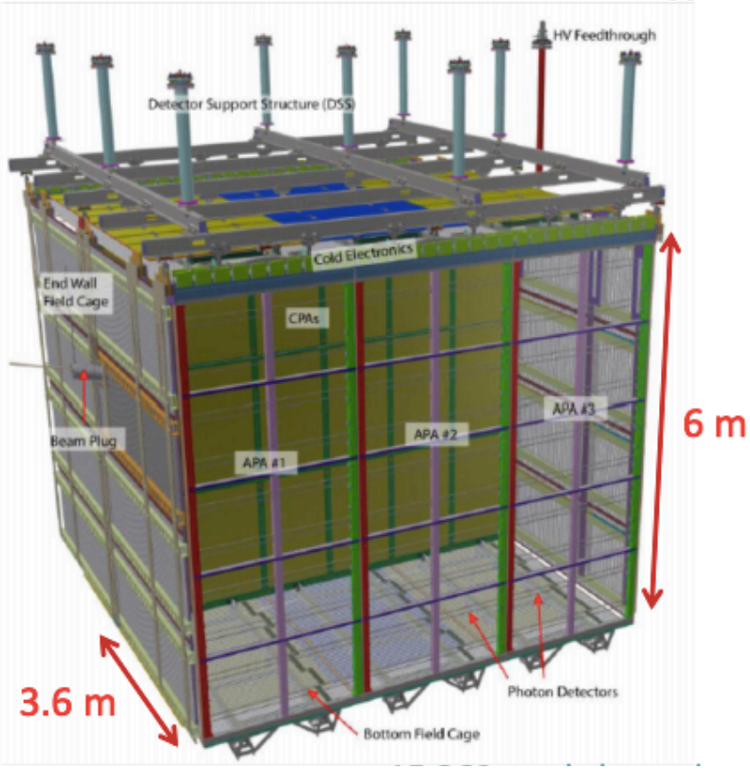
September 2018, beam ready & detector ready for beam!

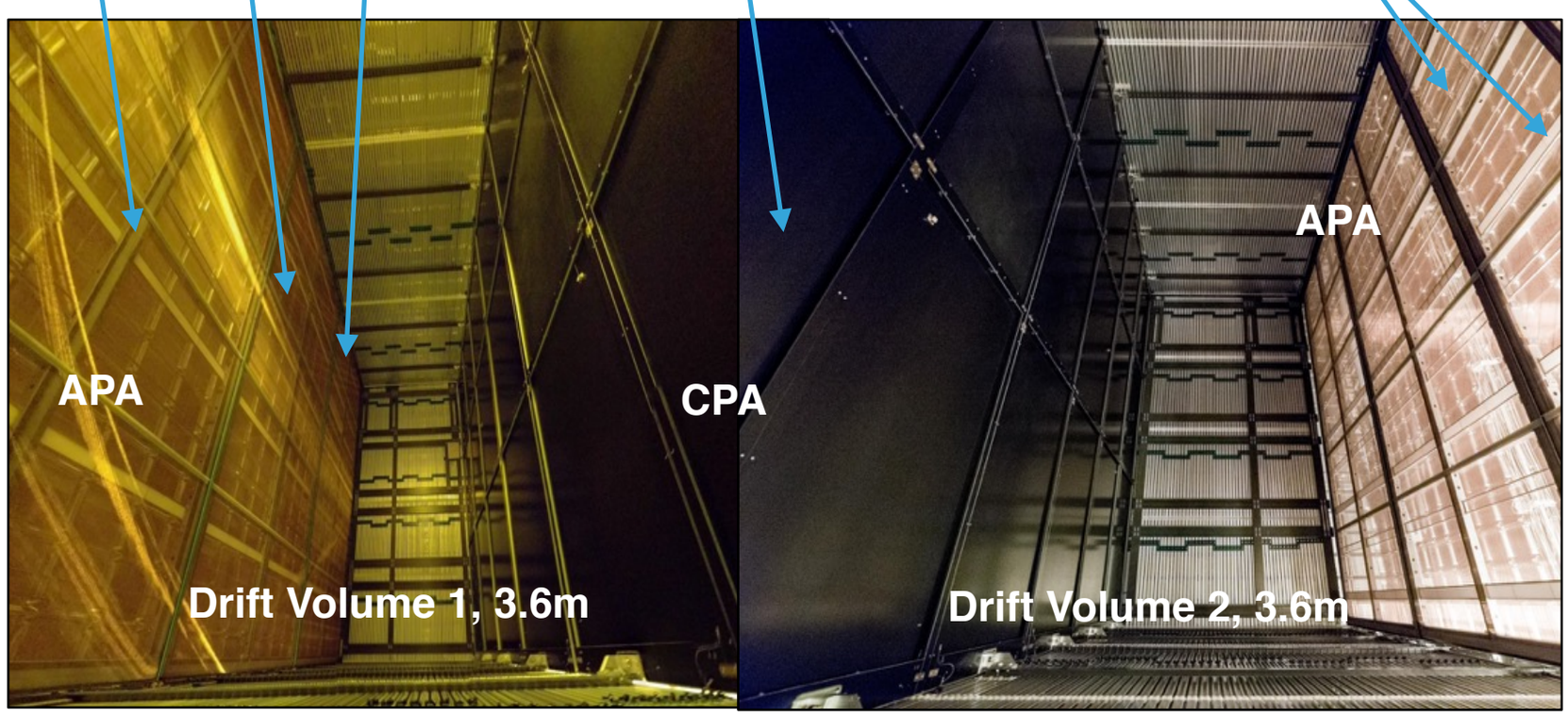
slide from F. Pietropaolo, SPSC talk April 2019

PROTODUNE-SP

DUNE

- Two drift volumes separated by a central cathode.
  - HV @ 180kV providing a 500V/cm E field
  - Maximum drift distance 3.6m (horizontally)
  - Anode (APA) with three planes of wires (15360 channels)
  - 3 Photon-detection system designs integrated into the APAs.

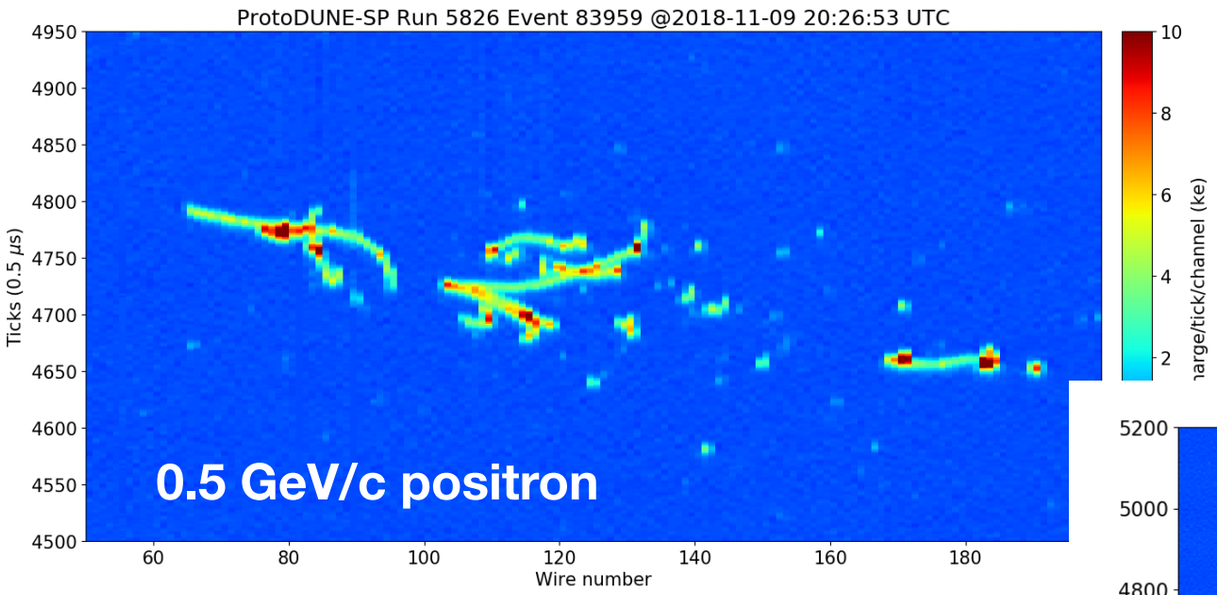


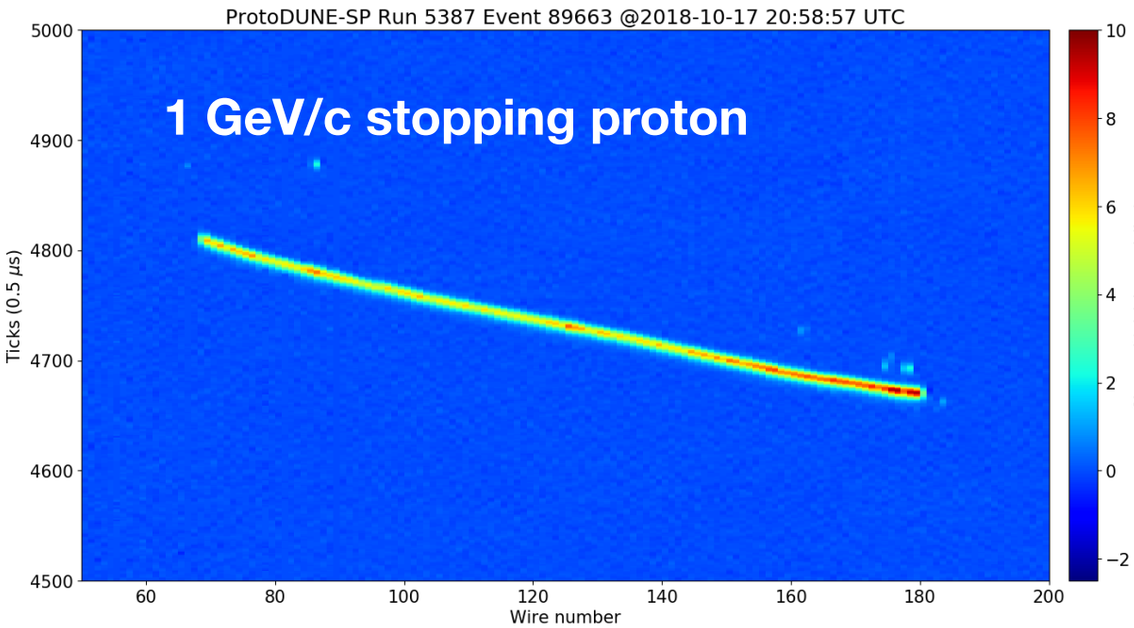


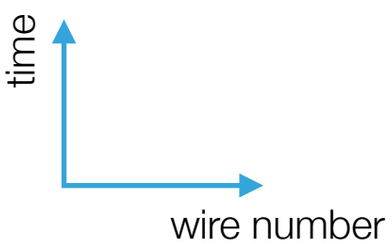
PROTODUNE-SP

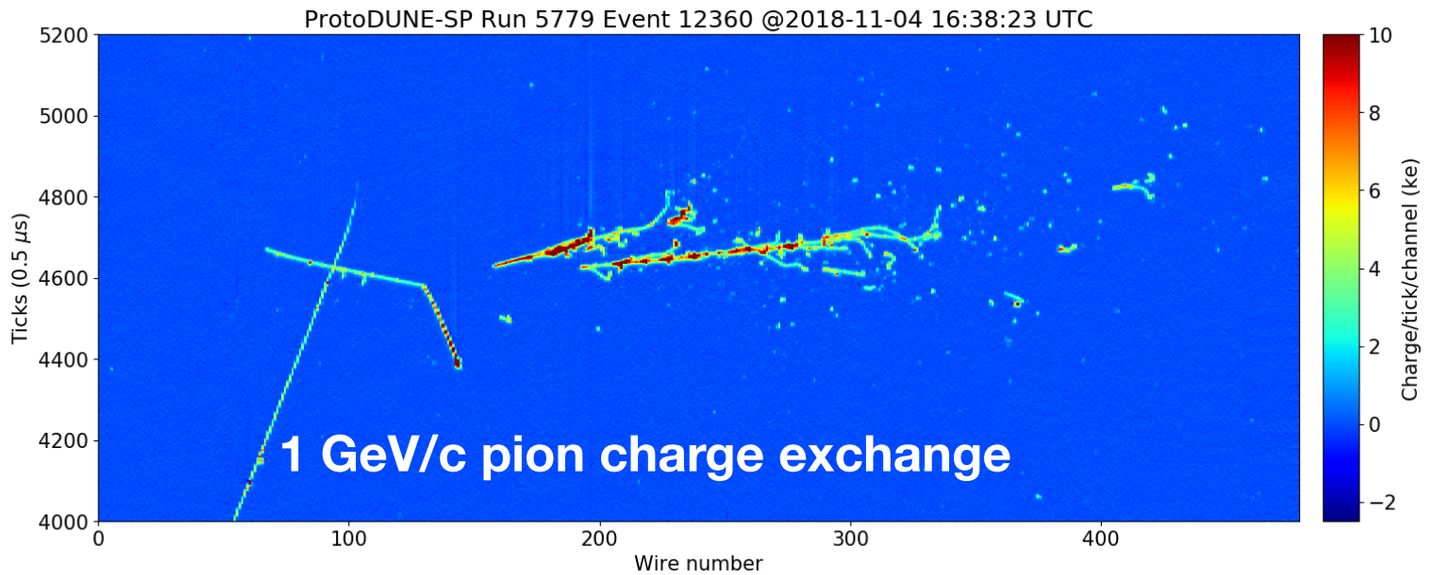
- protoDUNE-SP performances evaluated with:
  - H4-VLE beam (~4M events)
  - Extended cosmic rays data-taking (> 20M events)

LAr TPC data of unprecedented quality !









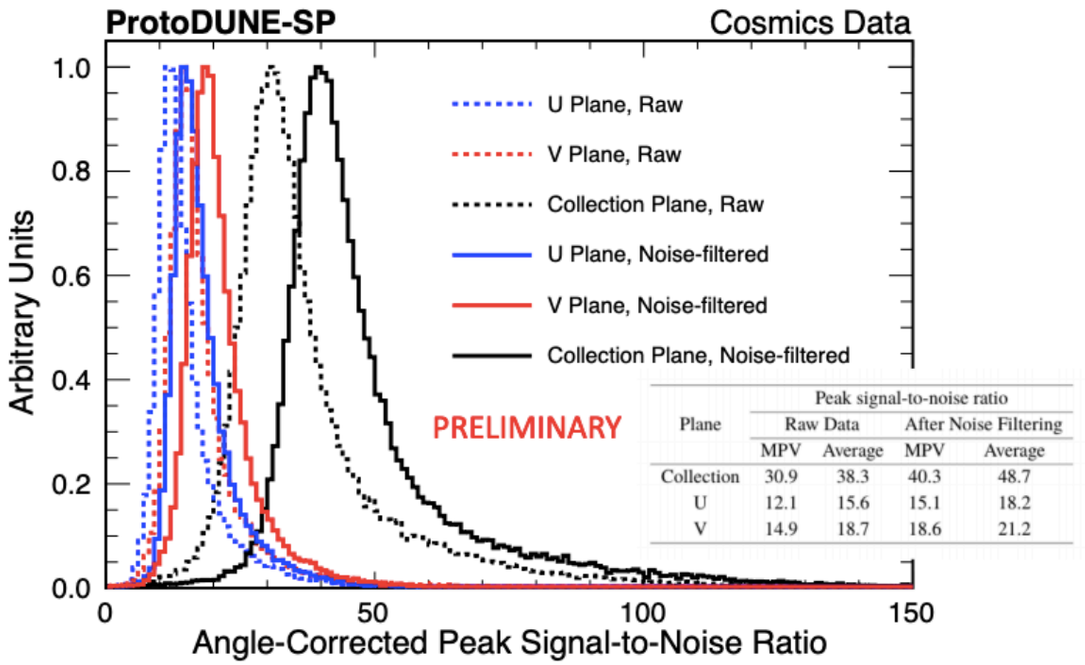
PROTODUNE-SP PERFORMANCES

Detector Parameter	Minimal Requirement	Goal	ProtoDUNE Performance
Electric Drift Field	> 250 V/cm	500 V/cm	500 V/cm*
Electron Lifetime	> 3 ms	10 ms	> 15 ms **
Electronics Noise	< 1000 enc	ALARA	550-650 enc (raw) 450-560 enc ***

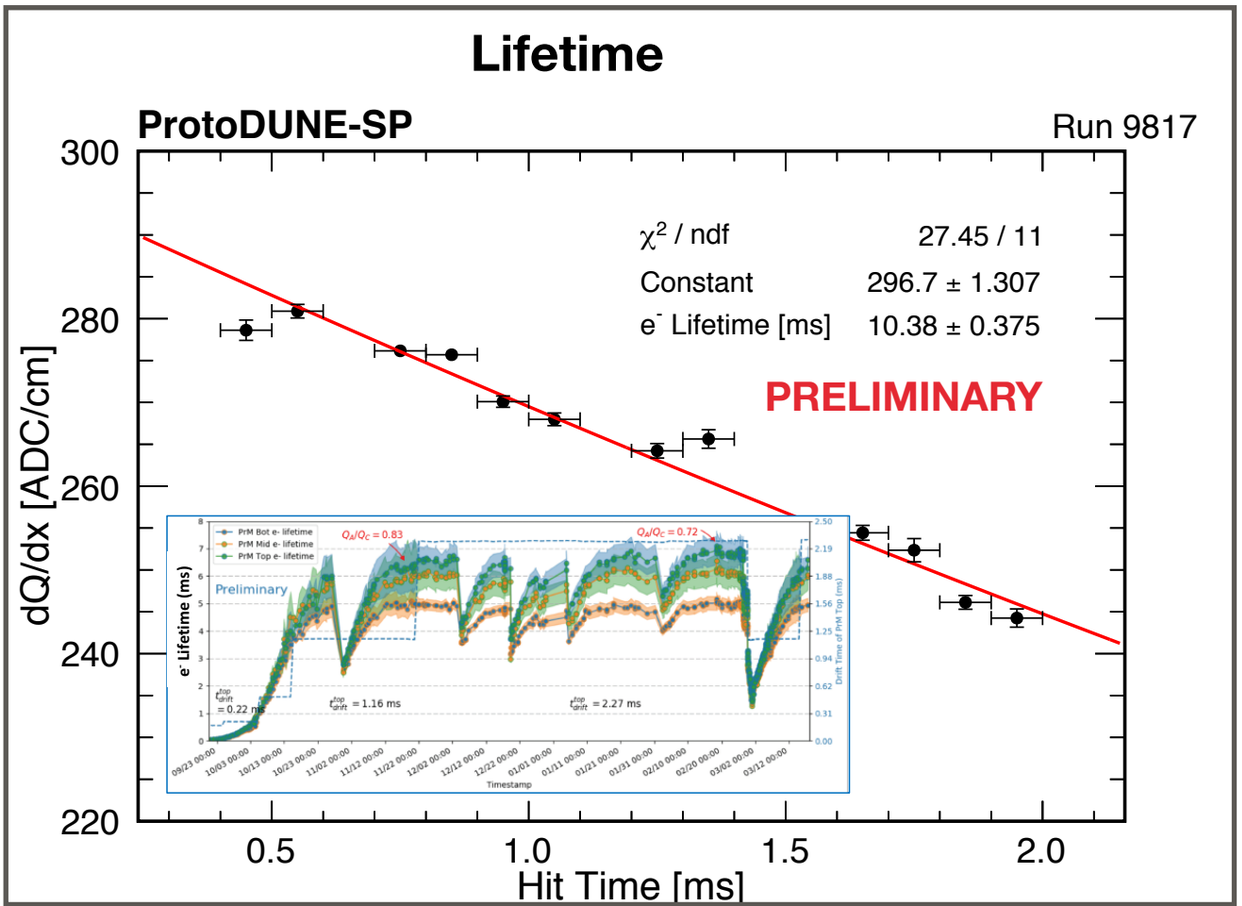
from DUNE SP TDR

* 99.5% uptime
** from analysis of tracks inside the TPC
*** after coherent noise removal

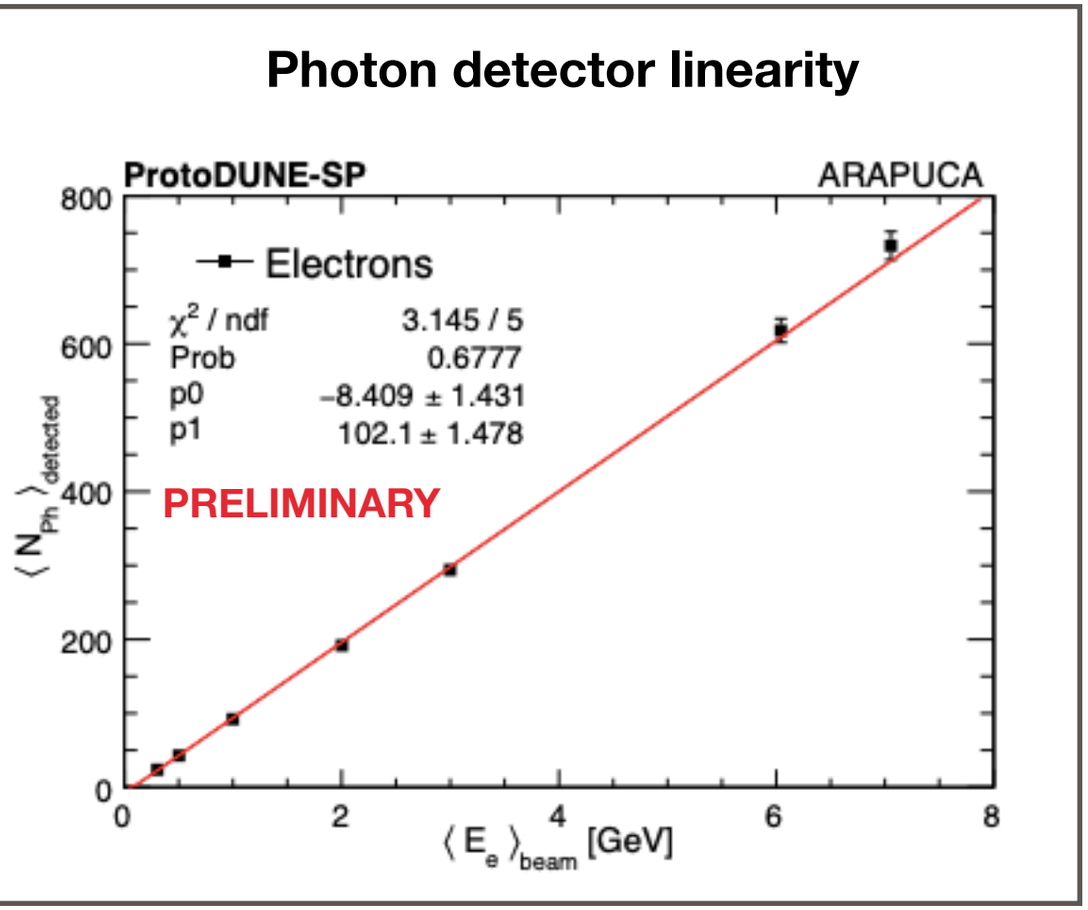
Signal-to-Noise



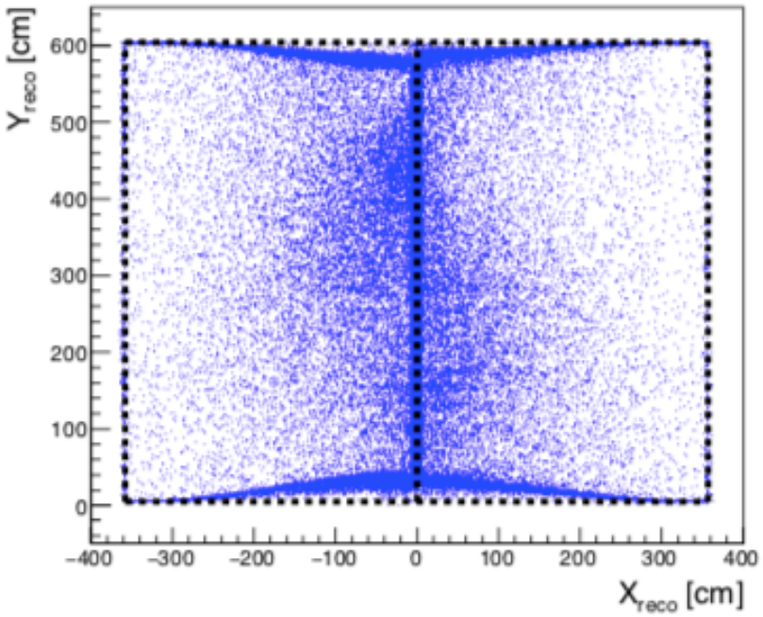
Lifetime



Photon detector linearity

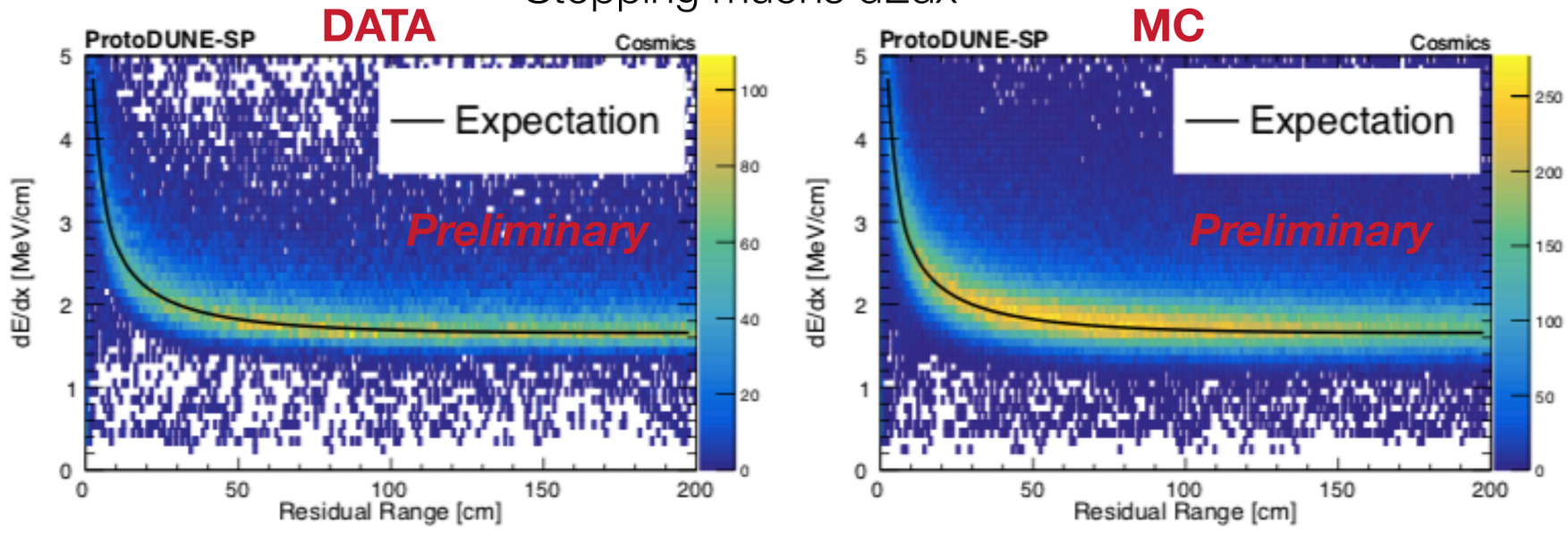


PROTODUNE-SP ANALYSIS STATUS AND PLANS

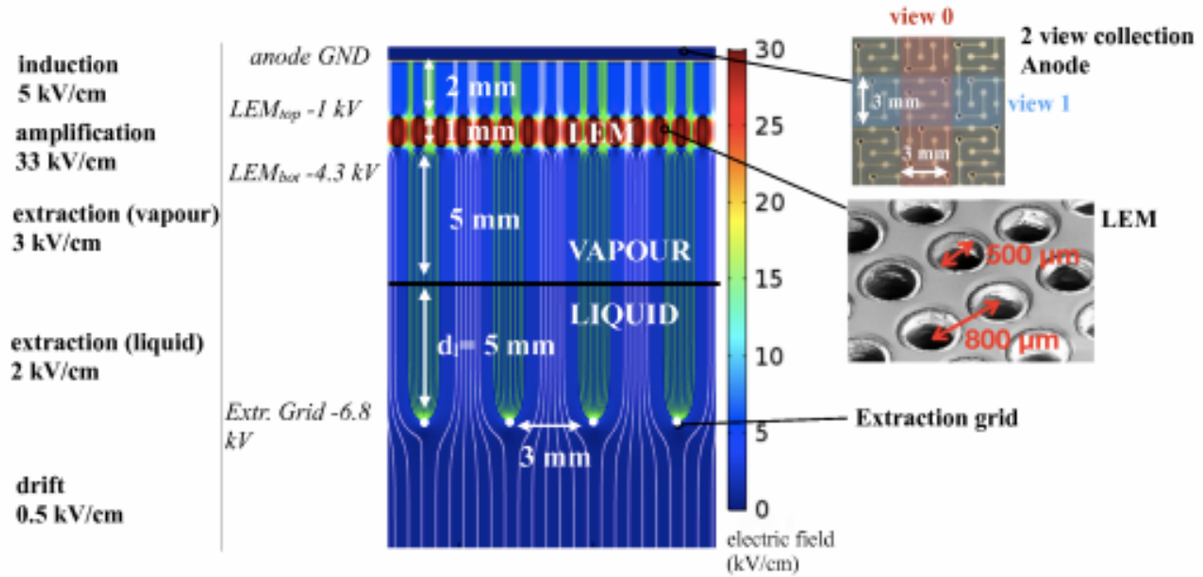


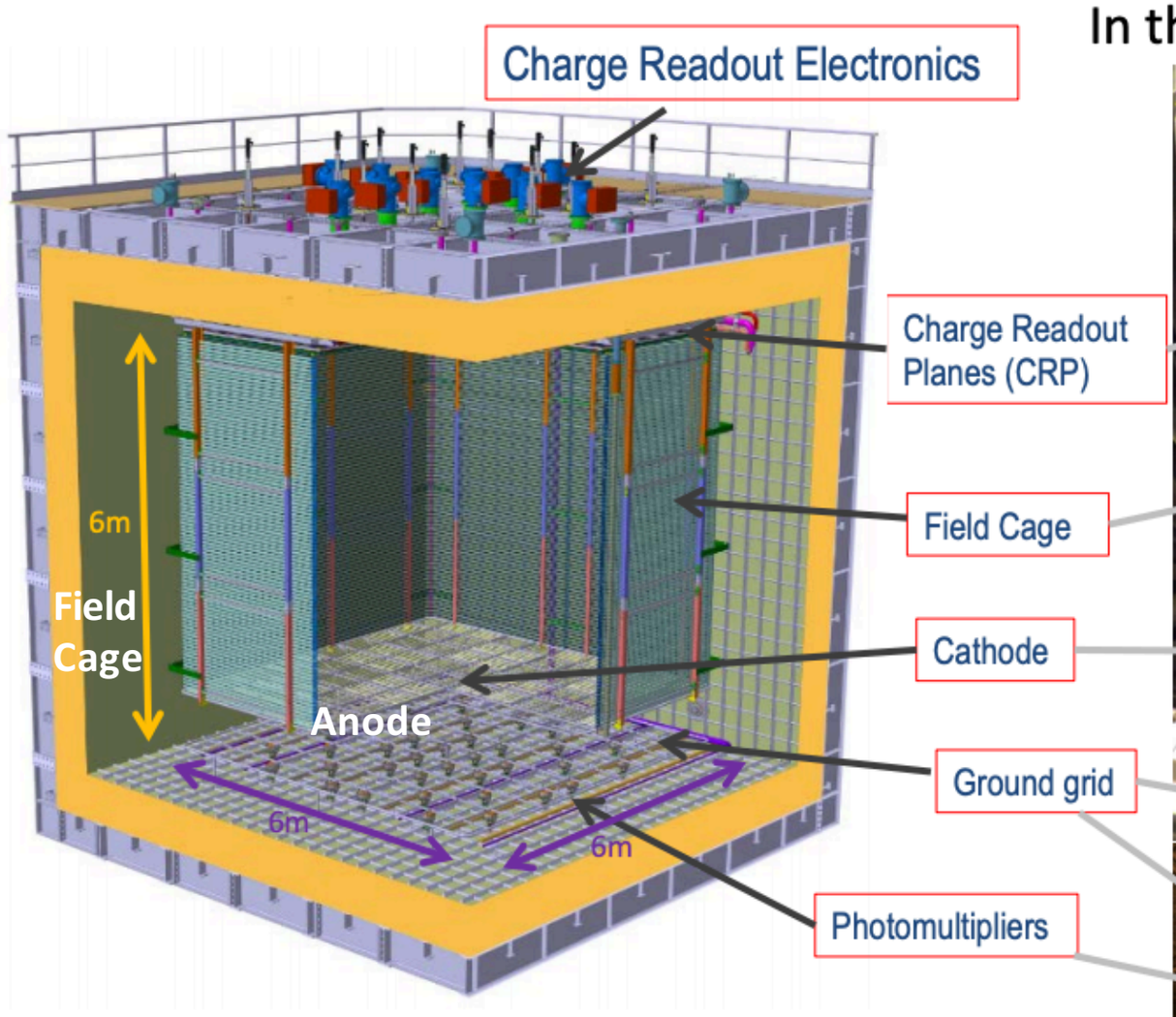
- ***First publications in preparation covering detector details and performances.***
- Large effort to understand the field distortion due to the space charge to calibrate the detector.
- Studies of detector response to μ, π, e, p ongoing. Physics analysis with beam data in progress
- Many lessons learnt which will drive the DUNE-SP final design. pDUNE-SP-II design under proposal to have a real DUNE-module-0

Stopping muons dEdx



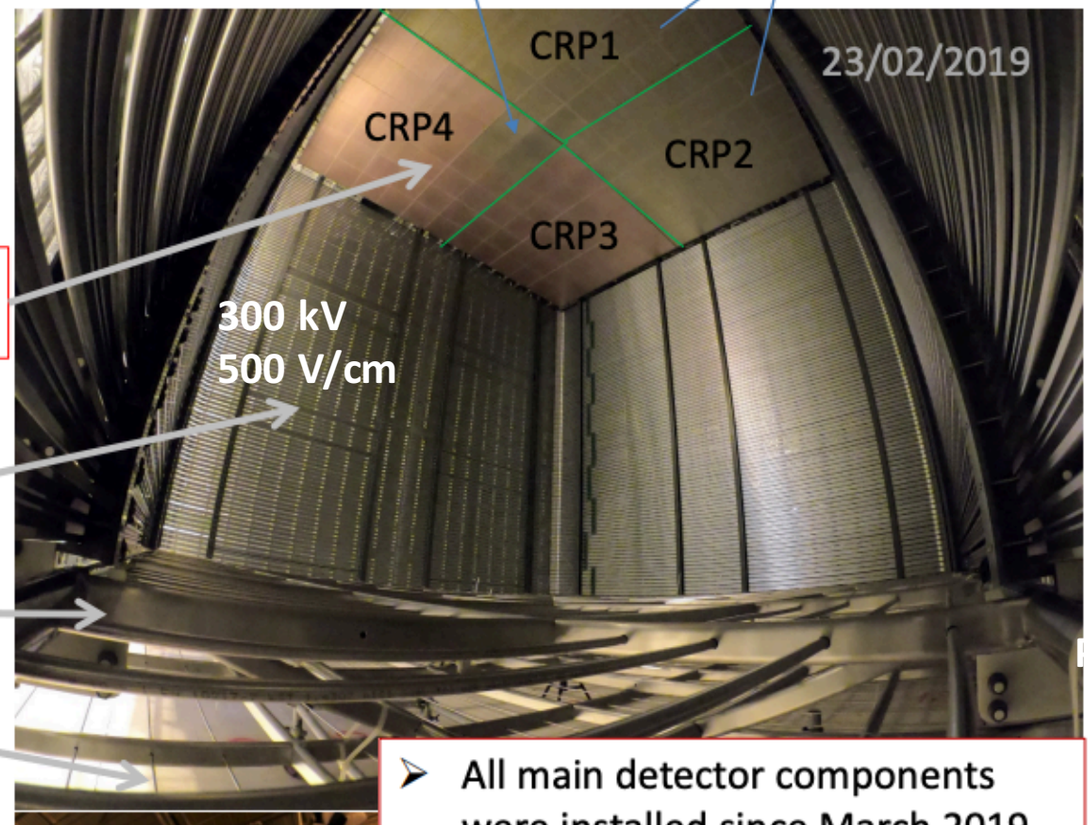
PROTODUNE-DP





courtesy of D. Duchesneau

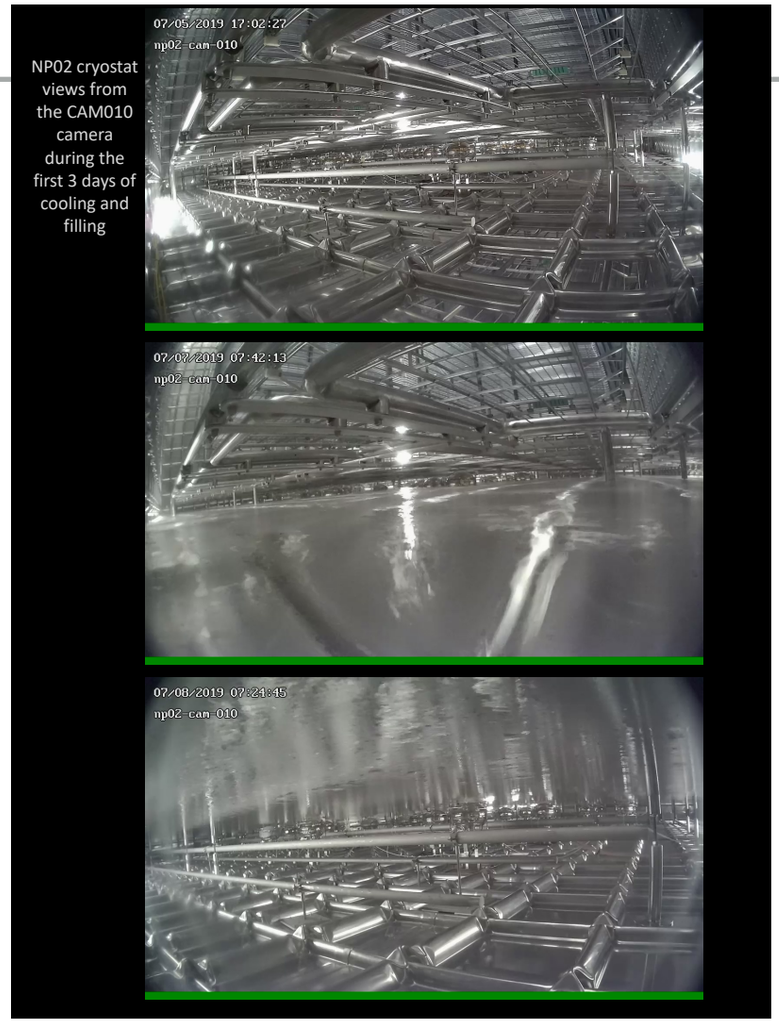
In the cryostat



- All main detector components were installed since March 2019
- TCO was closed end of May 2019
- Instrumentation completed and cleaning until June 13th
  => sealing of manhole

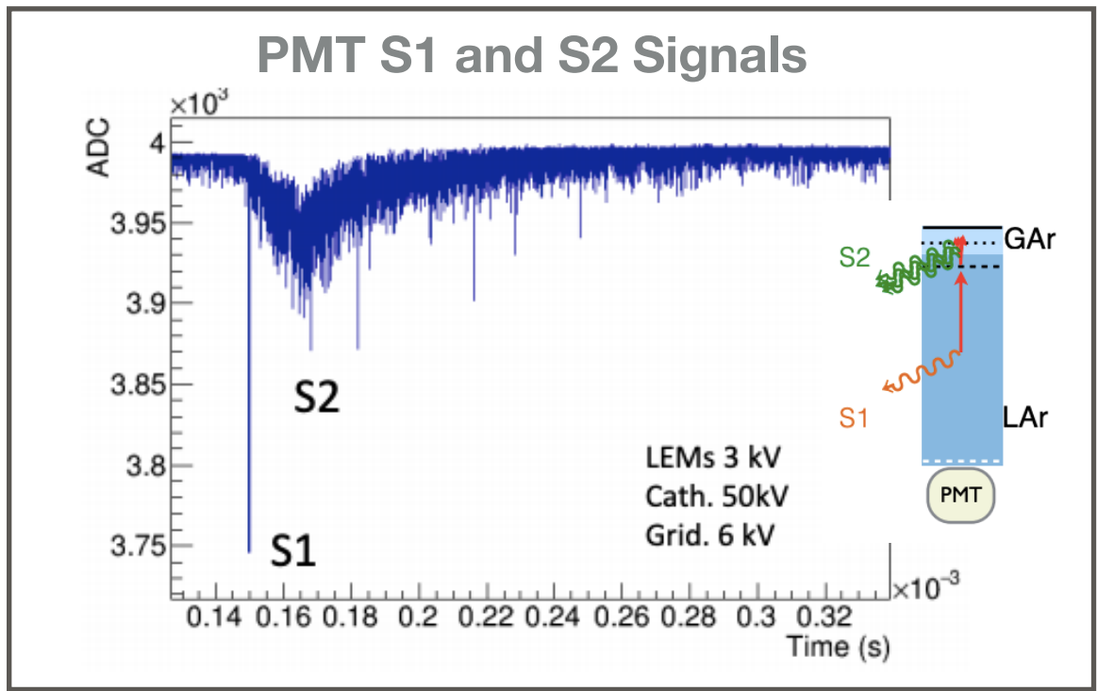
PROTODUNE-DP COMMISSIONING

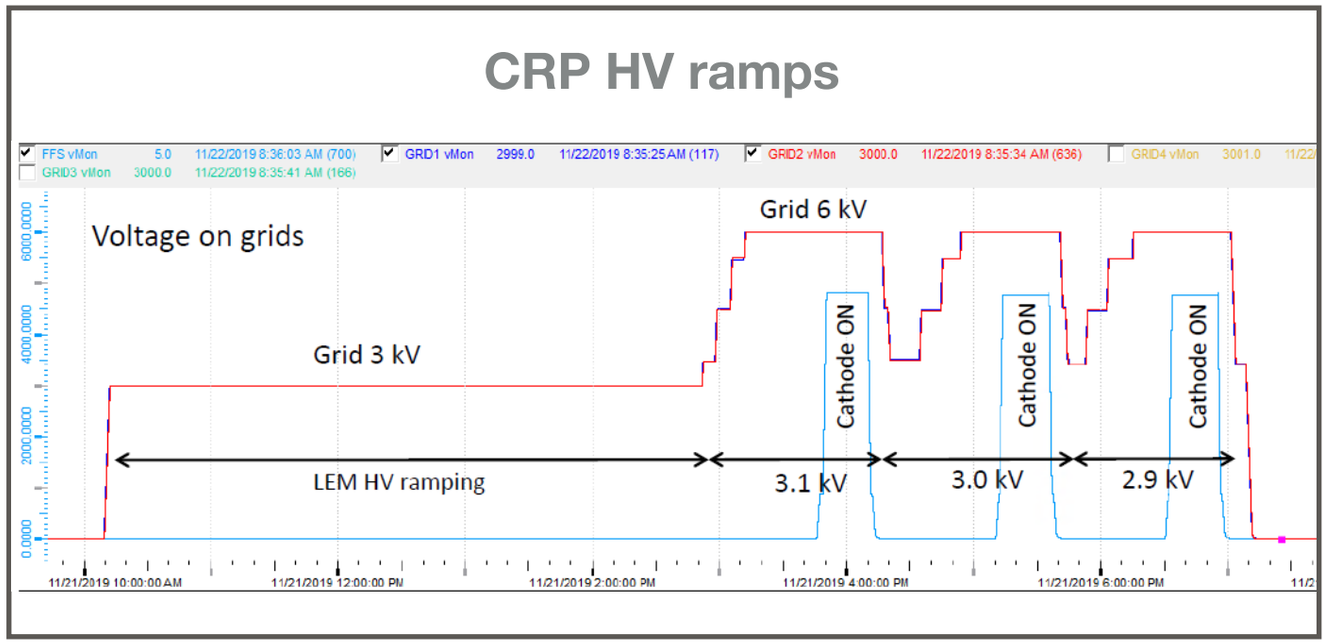
- Filling completed in early August 2019.
- Delicate system requiring gradual commissioning of each sub-system (HV, CRPs, PMTs).
- Data with cosmic since the end of August 2019 to understand the detector response
- **First milestone:** Operation of a 18 m^2 surface DP detector: HV -50kV, electron lifetime of ~2 ms, CRP voltage 7.5 kV, gain of 10 , good S1 and S2 signals from PMTs



NP02 cryostat views from the CAM010 camera during the first 3 days of cooling and filling

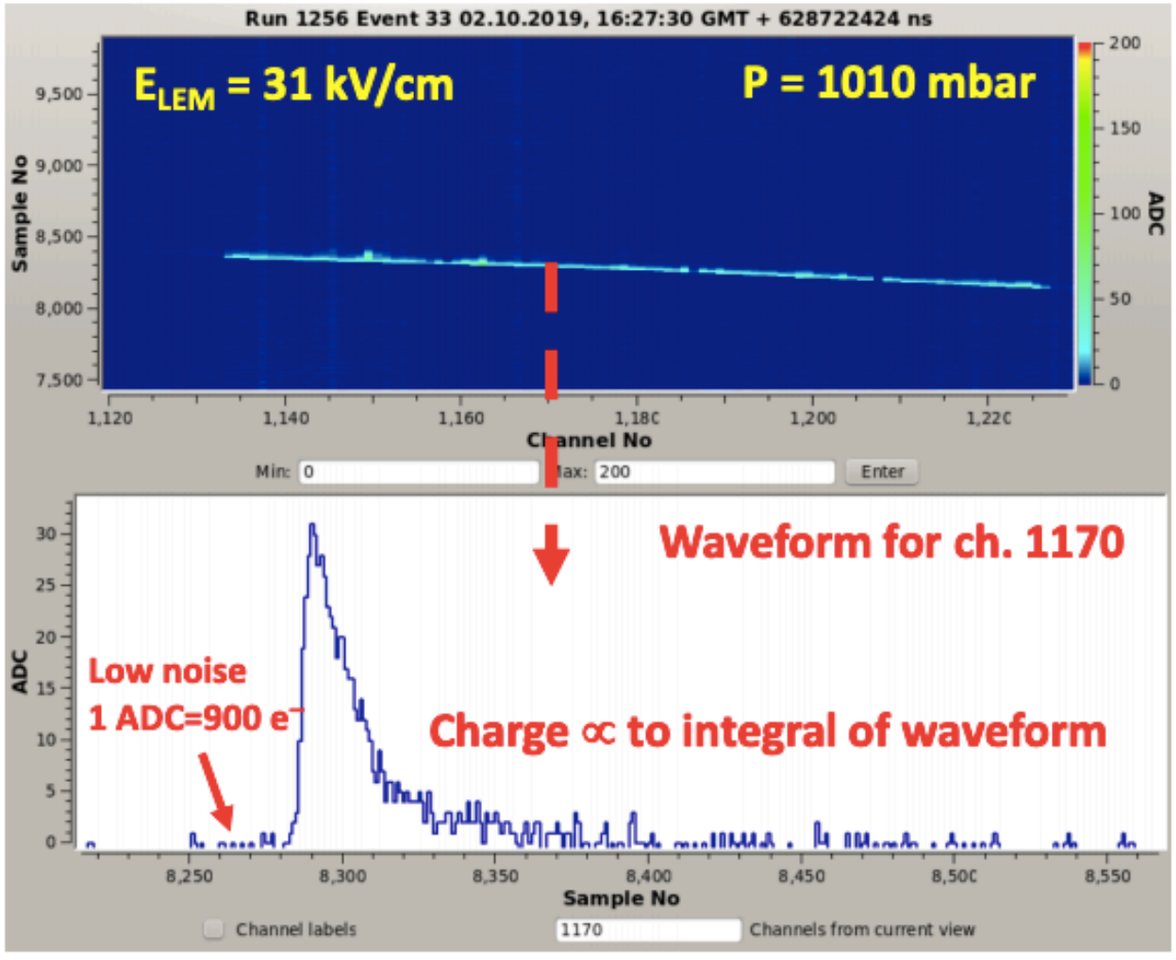
click here for a nice video!



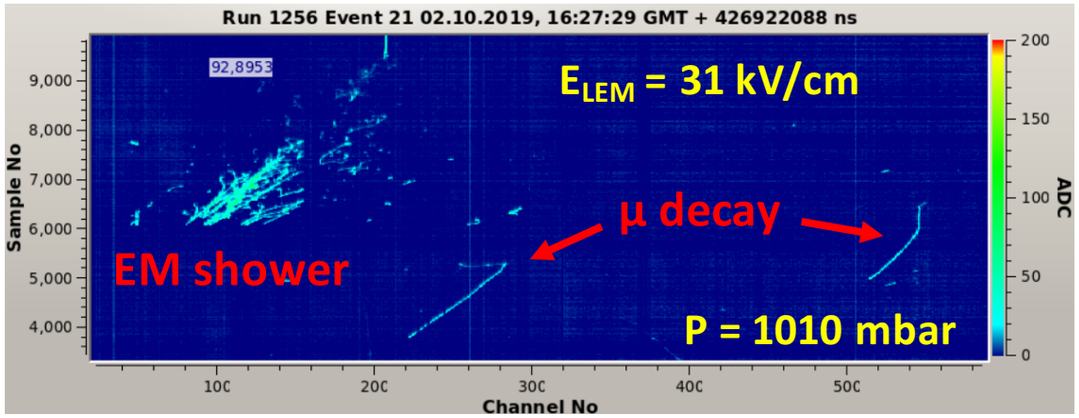


PROTODUNE-DP EVENT GALLERY

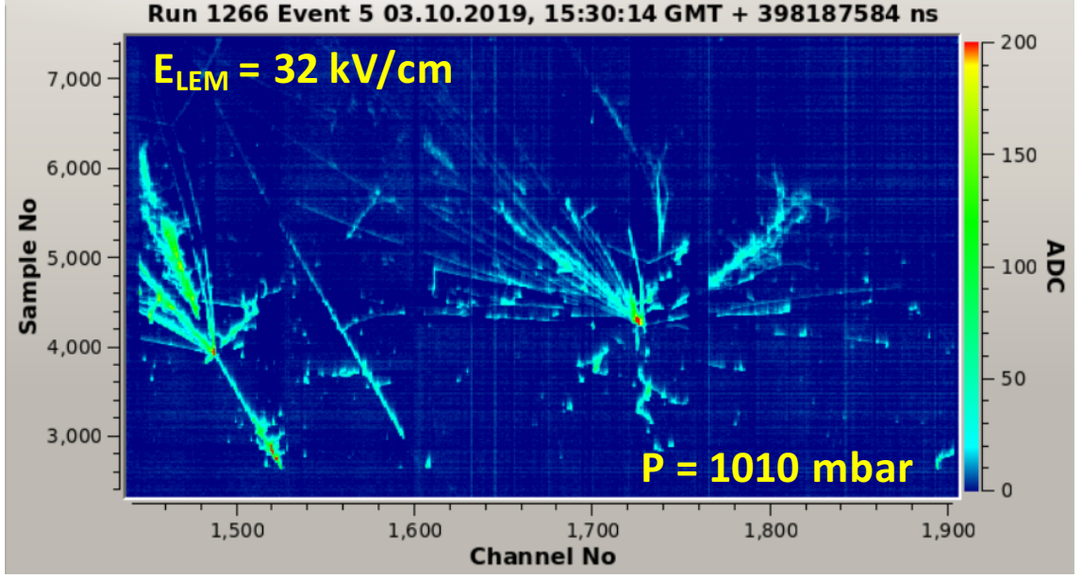
Horizontal muon track



Electromagnetic shower + two muon decays



Multiple hadronic interactions in a shower



Prospects:

- Detector operation with cosmic data till August 2020 (at least)
- Main goal : long and continuous run to test the stability of the cryogenics and detector subsystems and reach nominal running conditions

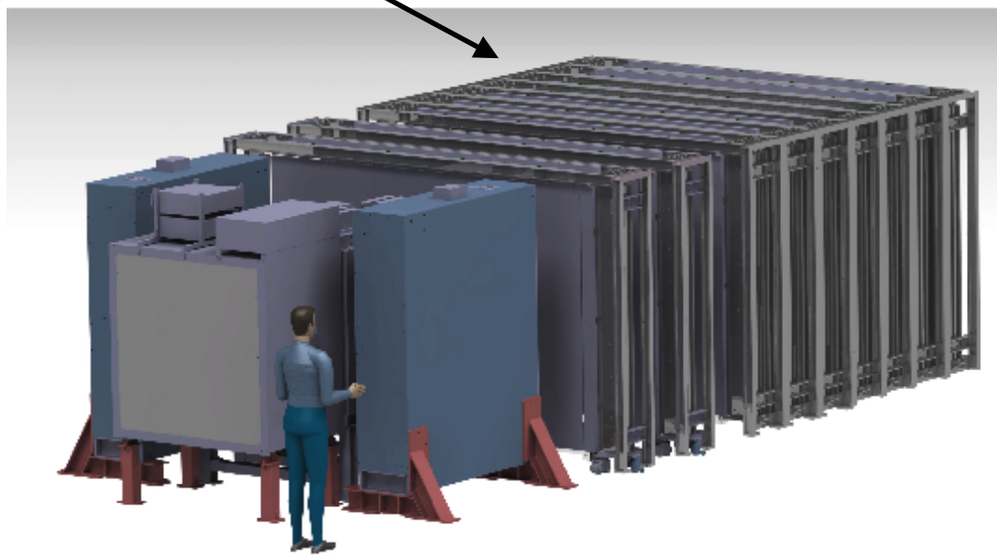
NP: TOWARDS JAPAN

BABY MIND

(see also S. Parsa poster)

A magnetised muon spectrometer for the WAGASCI experiment in Japan

- Interleaving of magnets (33) and scintillator (18) modules
  - Two-slits design magnet providing a well defined B field in the central zone
  - scintillators bars headed together mechanically in Al support frame



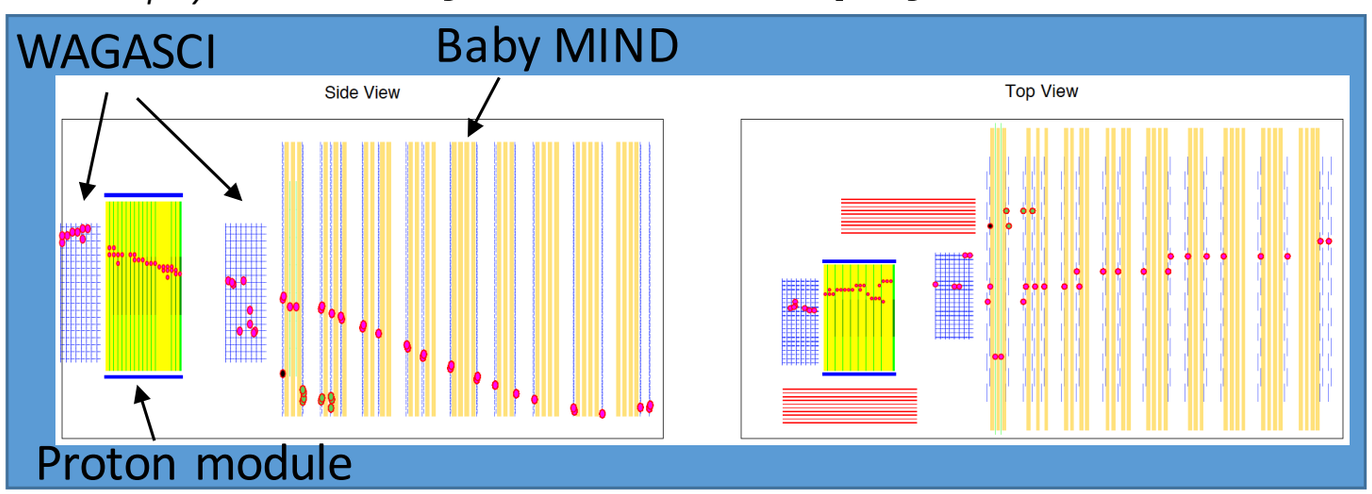
Baby MIND in test beam at CERN

Recap of the timeline :

- 2016- 2017: Construction @ CERN and test beam at the PS line (summer 2017).
- 2018 : Installation and Commissioning at JPARC
- 2019: first data in physics run

Event display

BabyMIND event display



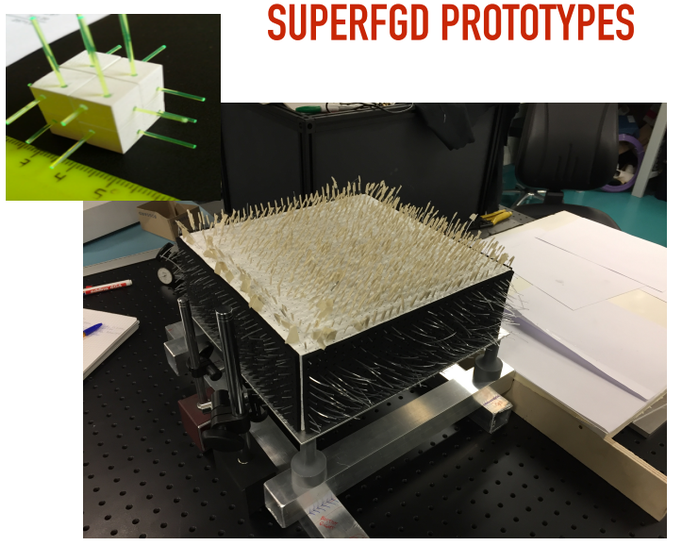
ND280 UPGRADE : T2K OFF-AXIS NEAR DETECTOR

(see also A. Ichikawa talk)

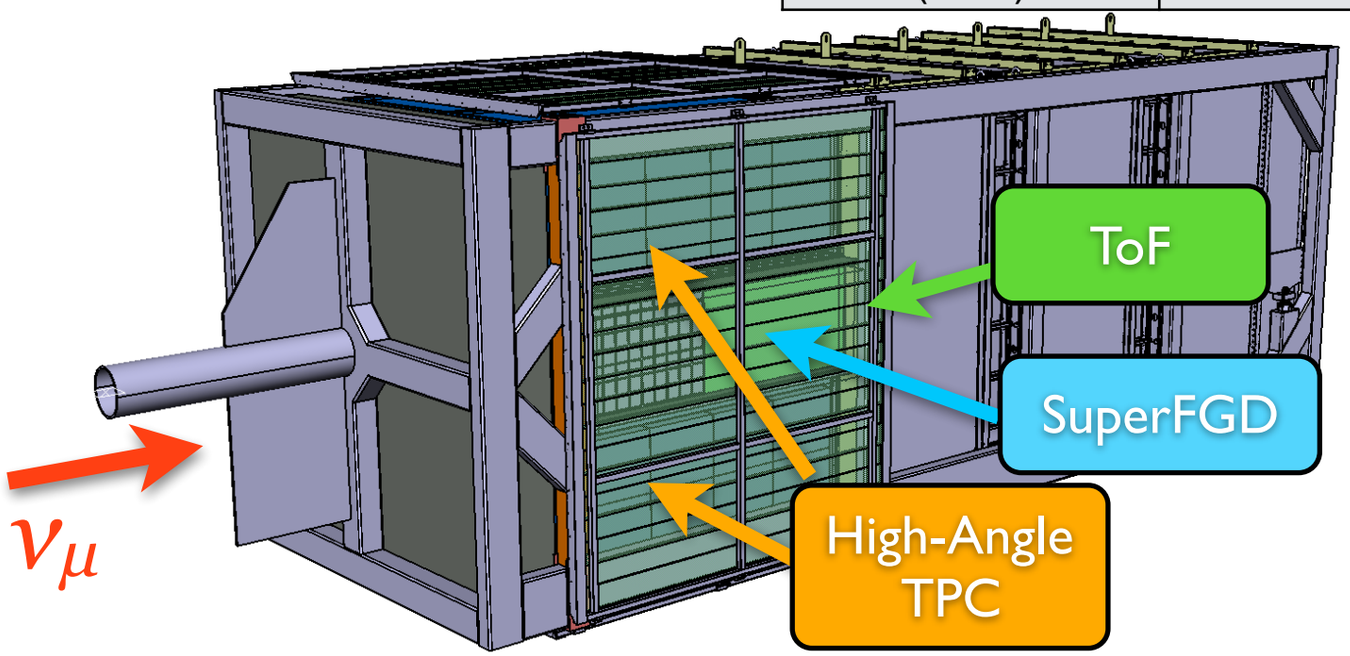
- Main goal: Increase the mass x2 and improve the detection of high-angle and backward going tracks

- Revisited design with three new elements:
  - **Horizontal active target (Fine-Grain) detector**: SuperFGD
  - Two **High-Angle TPCs**
  - **Time-of-Flight** detector around new tracker

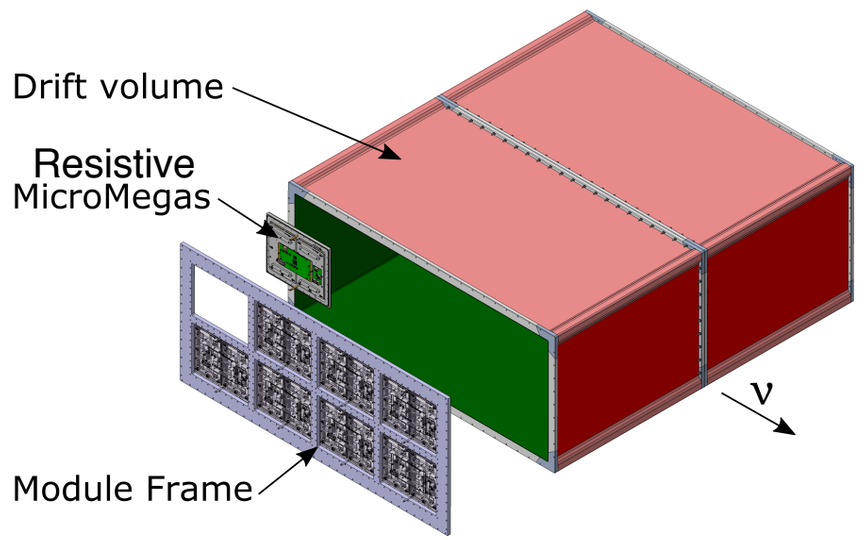
SUPERFGD PROTOTYPES



	Current	Upgrade
Target Mass (tons)	~2	~4



ATM-TPC NEW DESIGN



ND280 UPGRADE : CENF AND CERN ACTIVITIES

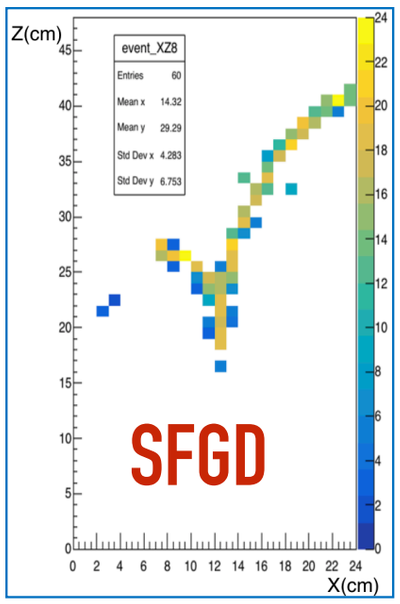
- Involvement in SuperFGD R&D (Design of the detector mechanics Scintillation light readout LED calibration system)
- Support and organisation of beam and cosmic run for both superFGD and TPCs
- TPCs : production of Resistive MM, re-design of the full ND280 gas system
- Full ToF-superFGD-TPC integration test within a basket mockup

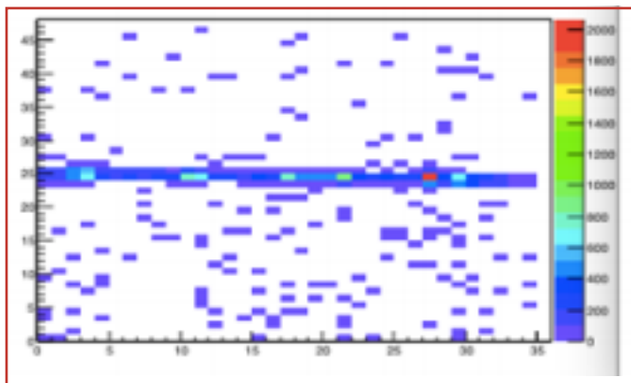
2017: Expression of Interest and proposal submitted to the CERN SPSC

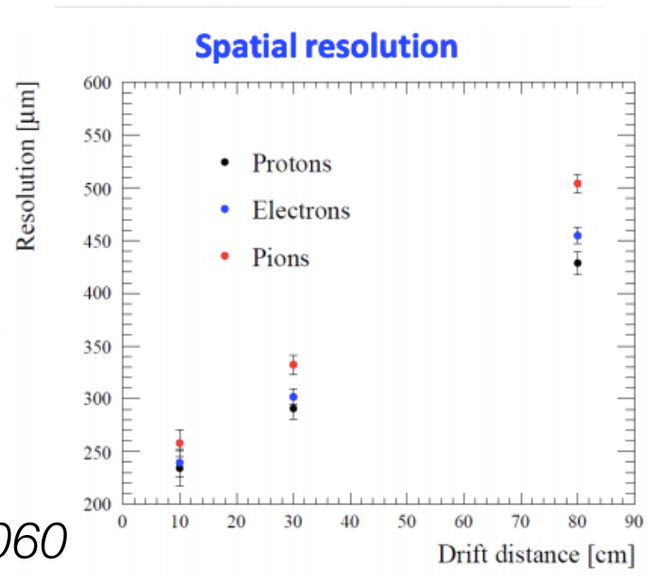
2018: CERN part of the ND280upgrade

2019: Upgrade part of the NP

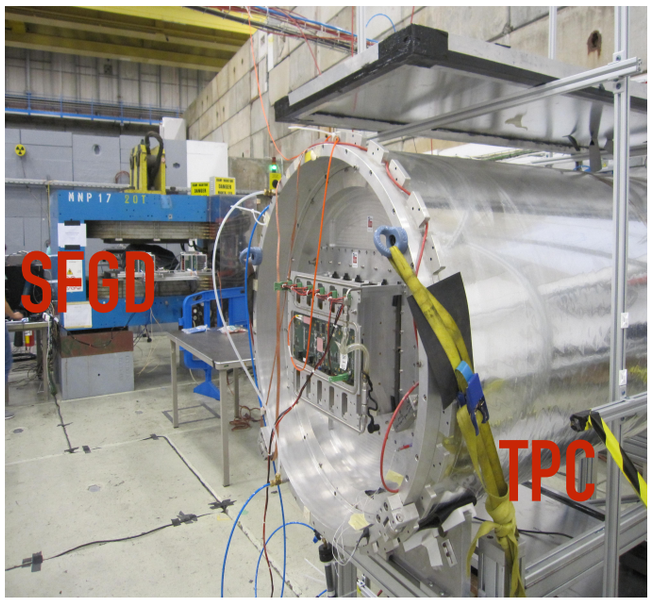
TEST BEAM AT THE EAST AREA







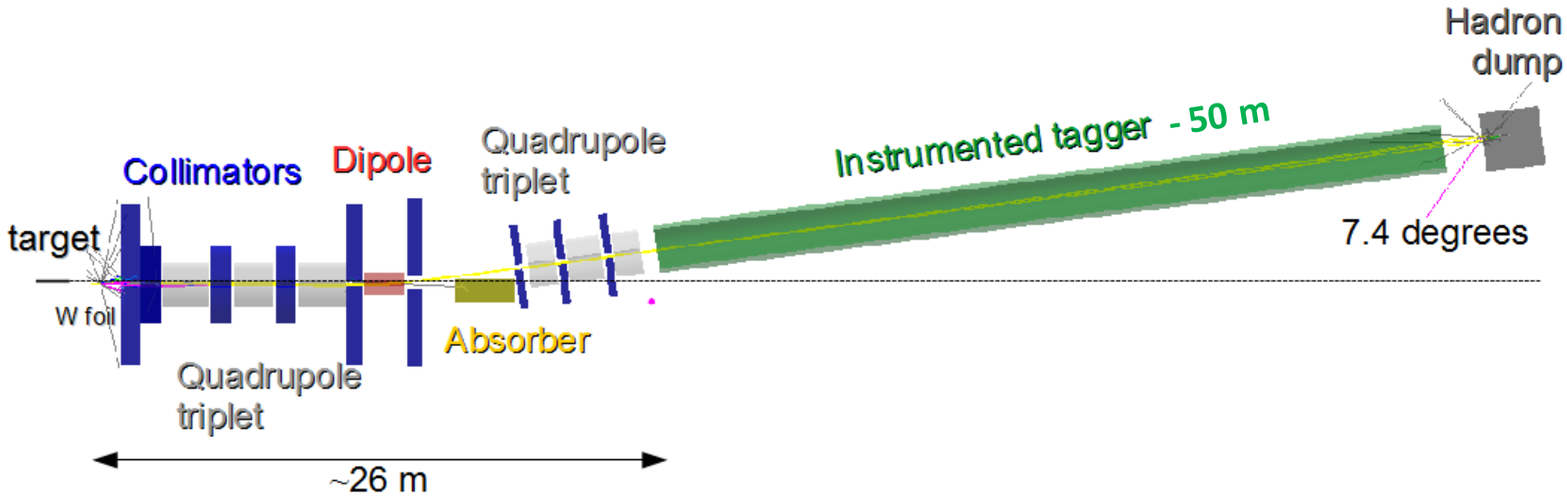
arXiv:1907.07060 (accepted by NIM)



OTHER NP ACTIVITIES

ATTRACTING NEW PARTNERS : ENUBET

(see also C.C. Delogu and A.Branca posters)



Ideal deployment:
~500 ton neutrino detector
@ 100 m from the target

ICARUS @ FNAL or pDUNE-SP/DP @ CERN

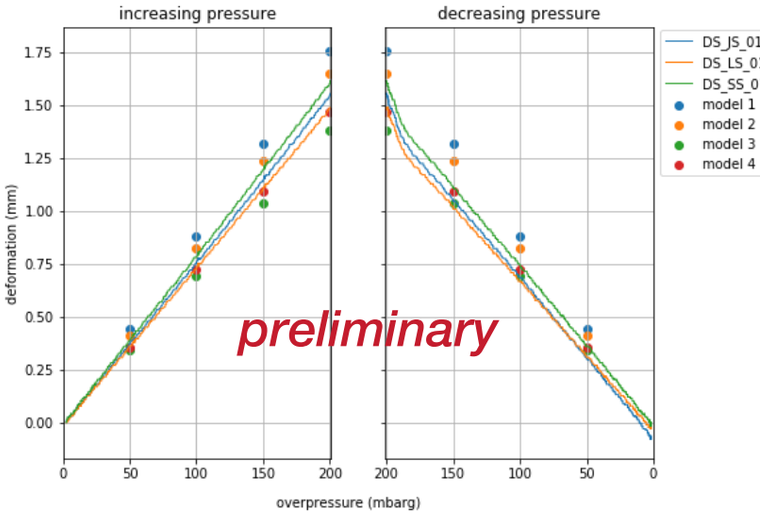
- ERC awarded project in 2016
- Beamline with enhanced precision monitoring on nu-beam fluxes by lepton tagging (@ large angle from hadron decays)
- Started in 2016, several test beam campaigns at CERN
- Goal: build and validate a demonstrator to be tested after LS2
- Since this year partner of the NP (NP06) providing support/guidance from accelerator experts

OTHER PROJECTS

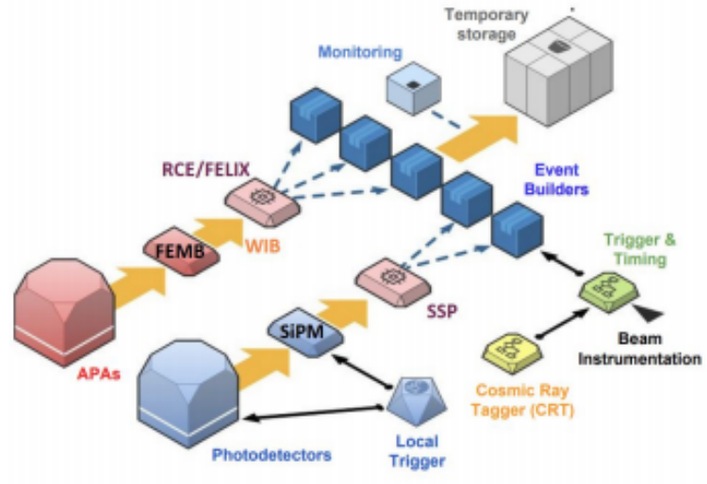
- Large variety of R&D to support large proto-detector construction and operation
- DAQ (protoDUNE, DUNE)
- H2 and H4 Tertiary beam simulation and operation
- Safety and engineering
- DarkSide
- CENF-ND and participation to the UESPP

+ Data analysis and ML approach applied to DUNE and protoDUNE data (EP-NU activities)

protoDUNE-SP pressure test



DAQ architecture for protoDUNE-SP



Input from the CENF-ND Forum to the 2020 Update of the European Strategy for Particle Physics

Research and Development for Near Detector Systems Towards Long Term Evolution of Ultra-precise Long-baseline Neutrino Experiments.

L. Alvarez Ruso[6], J. Asaadi[12], S. Bolognesi[2], S. Bordoni[*3], A. de Roeck[3], M.V. Diwan[1], T. Lux[5], D. Meloni[9], M. Nessi[3], B. Popov[10,11], E. Radicioni[7], P. Sala[13,8], F. Sanchez[4], and L. H. Whitehead[3]

[1]Physics Department, Brookhaven National Laboratory, Upton, NY, USA
[2]CEA-Saclay, Paris, France
[3]CERN, European Organization for Nuclear Research, Geneva, Switzerland
[4]University of Geneva, Geneva, Switzerland
[5]IFAE, Barcelona, Spain
[6]Instituto de Física Corpuscular (IFIC), Valencia, Spain
[7]INFN Sezione di Bari, Bari, Italy
[8]INFN Sezione di Milano Bicocca, Milano, Italy
[9]Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Roma, Italy
[10]Joint Institute for Nuclear Research, Dubna, Russia
[11]LPNHE, Paris, France
[12]Univerity of Texas at Arlington, Arlington, TX, USA

January 15, 2019

(On behalf of the CERN CENF-ND Forum)

Abstract

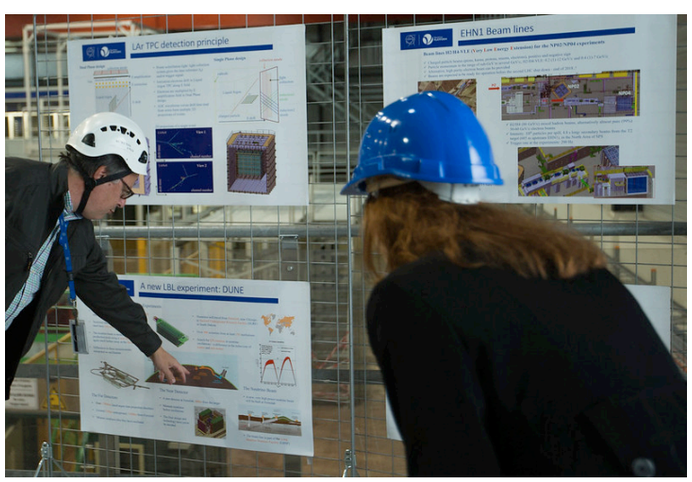
With the discovery of non-zero value of θ_{13} mixing angle, the next generation of long-baseline neutrino (LBN) experiments offers the possibility of obtaining statistically significant samples of muon and electron neutrinos and anti-neutrinos with large oscillation effects. In this document we intend to highlight the importance of Near Detector facilities in LBN experiments to both constrain the systematic uncertainties affecting oscillation analyses but also to perform, thanks to their close location, measurements of broad benefit for LBN physics goals. A strong European contribution to these efforts is possible.

ADDITIONAL

OUTREACH ACTIVITIES

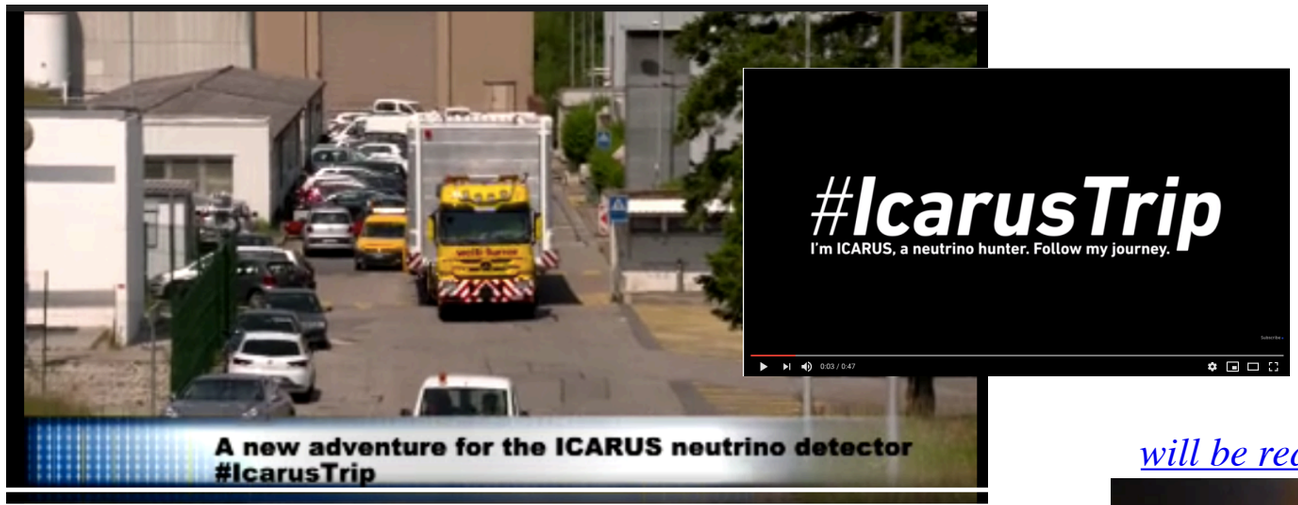
- Started in 2016, the Neutrino Platform has its own outreach group: 20 active people, regular meetings
- Series of activities:
  - Collaboration with CERN and FermiLab outreach and press divisions
  - Scientific article editing, interviews, filming, guided and professional visits
  - Participation to CERN outreach events and schools (S'cool LAB SUMMER CAMP)

This year also a Summer Student working with the CENF Secretariat to improve the Outreach web site

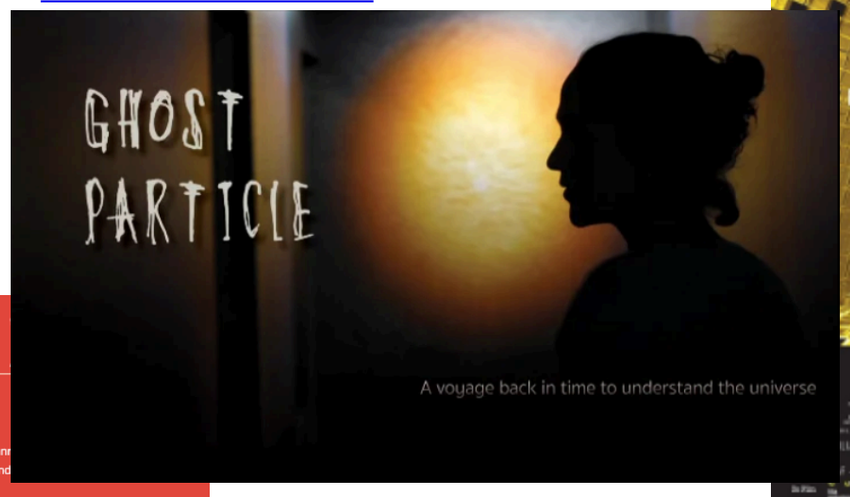


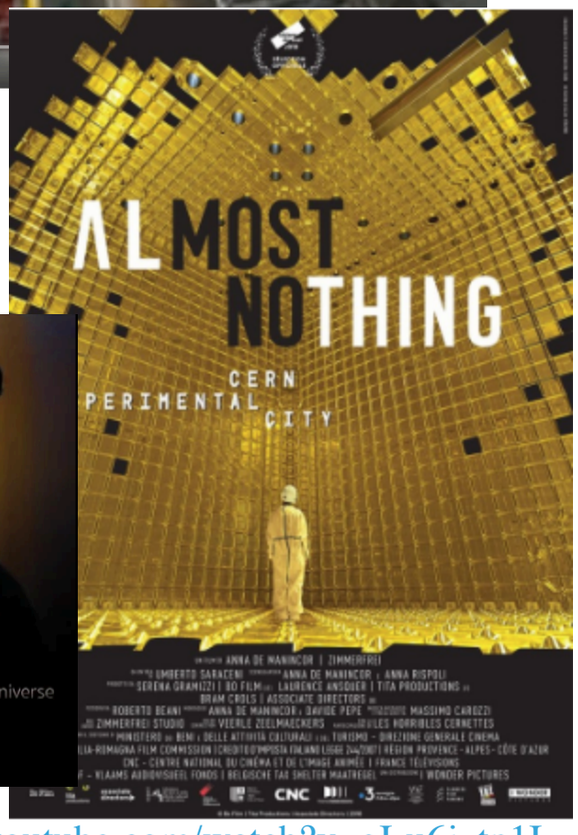
OUTREACH ACTIVITIES

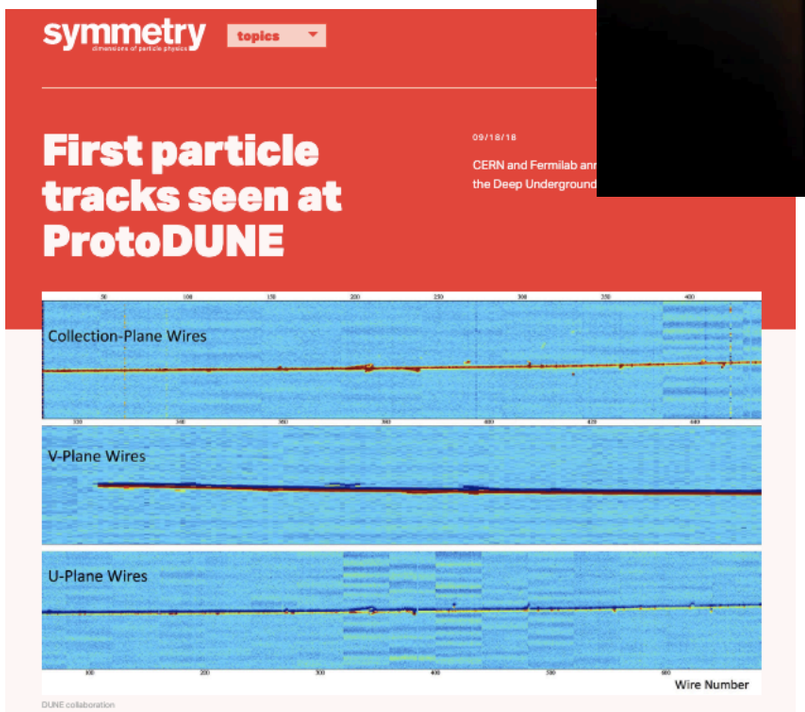
Facebook live event : https://videos.cern.ch/record/2268970



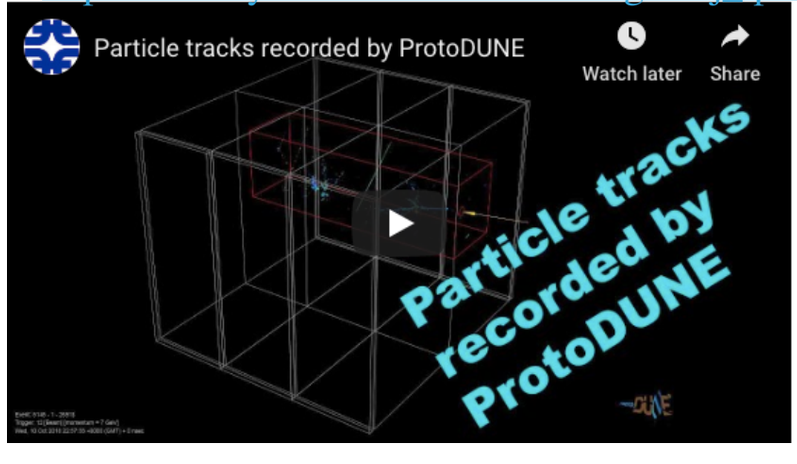
will be realised soon







https://www.youtube.com/watch?v=gI-u6j_tp1I

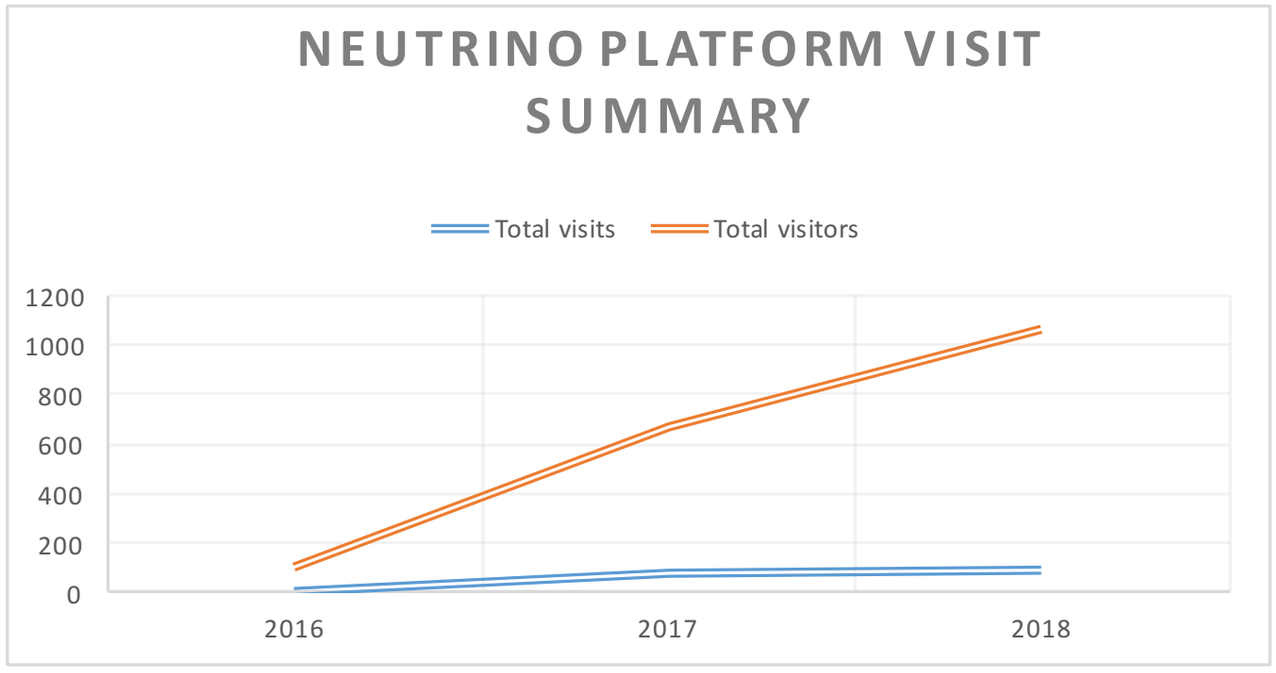


VISITS TO THE NEUTRINO EXPERIMENTAL HALL

- Visits to the neutrino hall are organised on demand:
  - Guided visits: VIP (ministries, national delegations, CERN partners, ..), Press-office, **students**
  - Professional visits : collaborators, CERN departments, industrial partners,..

TYPE OF THE VISIT / YEAR	2016	2017	2018	2019*
PROFESSIONAL VISITS	4	48	51	14
GUIDED VISITS	5	28	44	33
TOTAL NUMBER OF VISITS	**9**	**76**	**95**	**47**
TOTAL NUMBER OF VISITORS	**93**	**598**	**970**	**479**

* data referred to the period January - June 2019



DARKSIDE

New challenge: exporting the tech to Dark Matter. **Common ground: LAr-TPC tech**

- Next step in DM searches with dual-phase LAr-TPC (50 tons active mass).
- Major advantage: use of Underground Argon (UAr), depleted in β-decaying ^{39}Ar isotope: eliminate largest Ar-bkg source. Successfully demonstrated in DarkSide 50 experiment.
- Active Veto exploits standard Argon, inside cryostat *à la ProtoDUNE*.
- Acrylic vessels read by Photon Detector units (SiPM-based)

DS50 talk by Luca Pagani (Friday)

- **New R&D on cryostat, to export the technology to a much more demanding environment, in terms of radio-purity and cleanliness .**
- **Strong design integration effort, involving detector, cryostat and LNGS cavern**