STEFANIA BORDONI - GDR JUNE 2019 , PARIS

THE CERN NEUTRINO PLATFORM

OVERVIEW OF EXPERIMENTAL AND OUTREACH 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 (now at FNAL almost ready for operation)

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

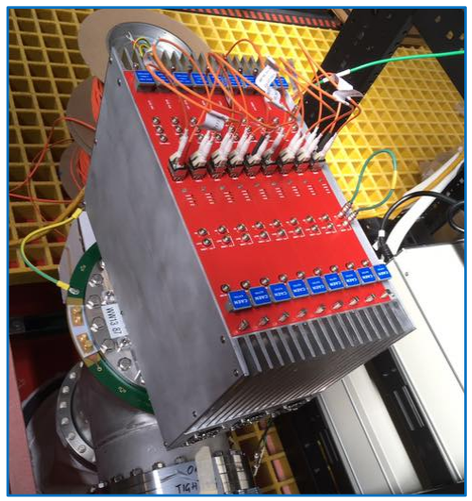
+ collaboration with DarkSide 20k experiment

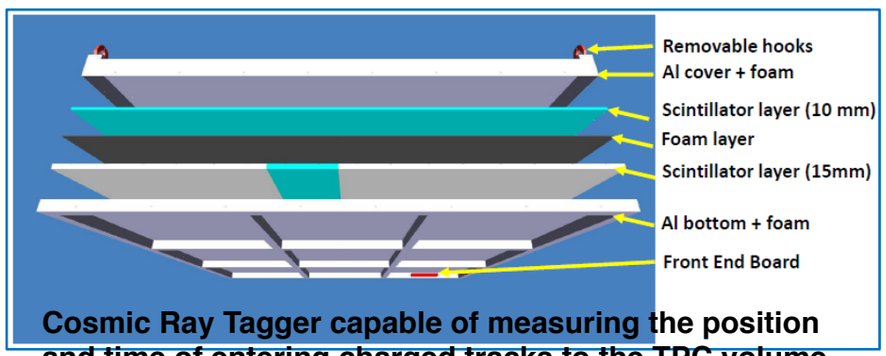
NP: TOWARDS THE US

ICARUS REFURBISHMENT AT CERN

- Overhauling of the ICARUS (T600) detector : new technology developments to adapt the detector to surface operation
  - Upgrade of light collection system
  - Faster and high performance readout system
  - Top Cosmic Ray tagger (with INFN)
- Shipped to US to be part of the SBN program at FNAL

New warm electronics chain, Tested extensively @ CERN in a 50l set-up with cosmic muons

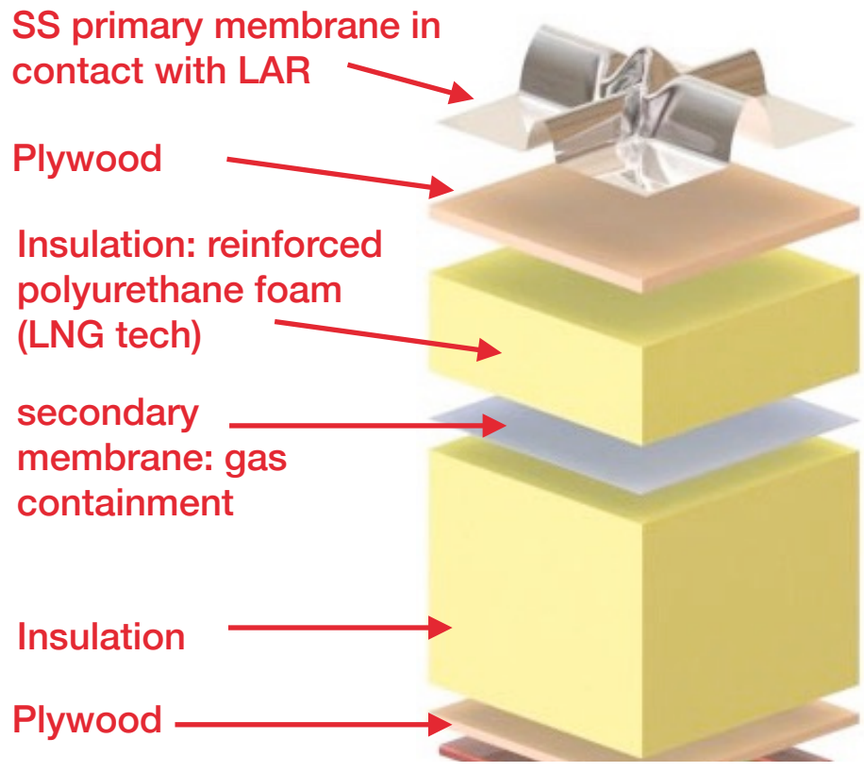




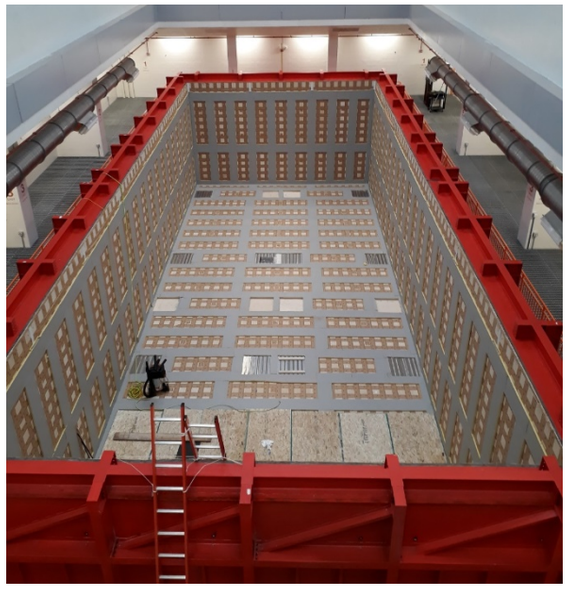
Cosmic Ray Tagger capable of measuring the position and time of entering charged tracks to the TPC volume.

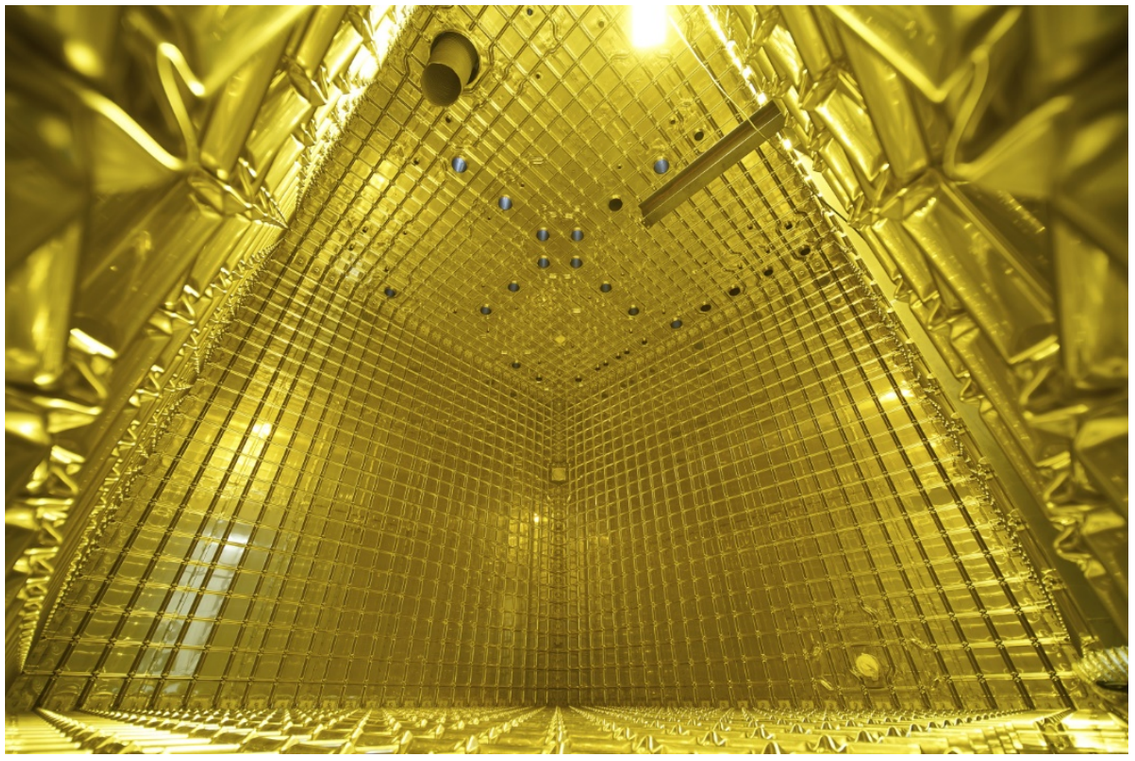
MEMBRANE CRYOSTAT TECHNOLOGY

- 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

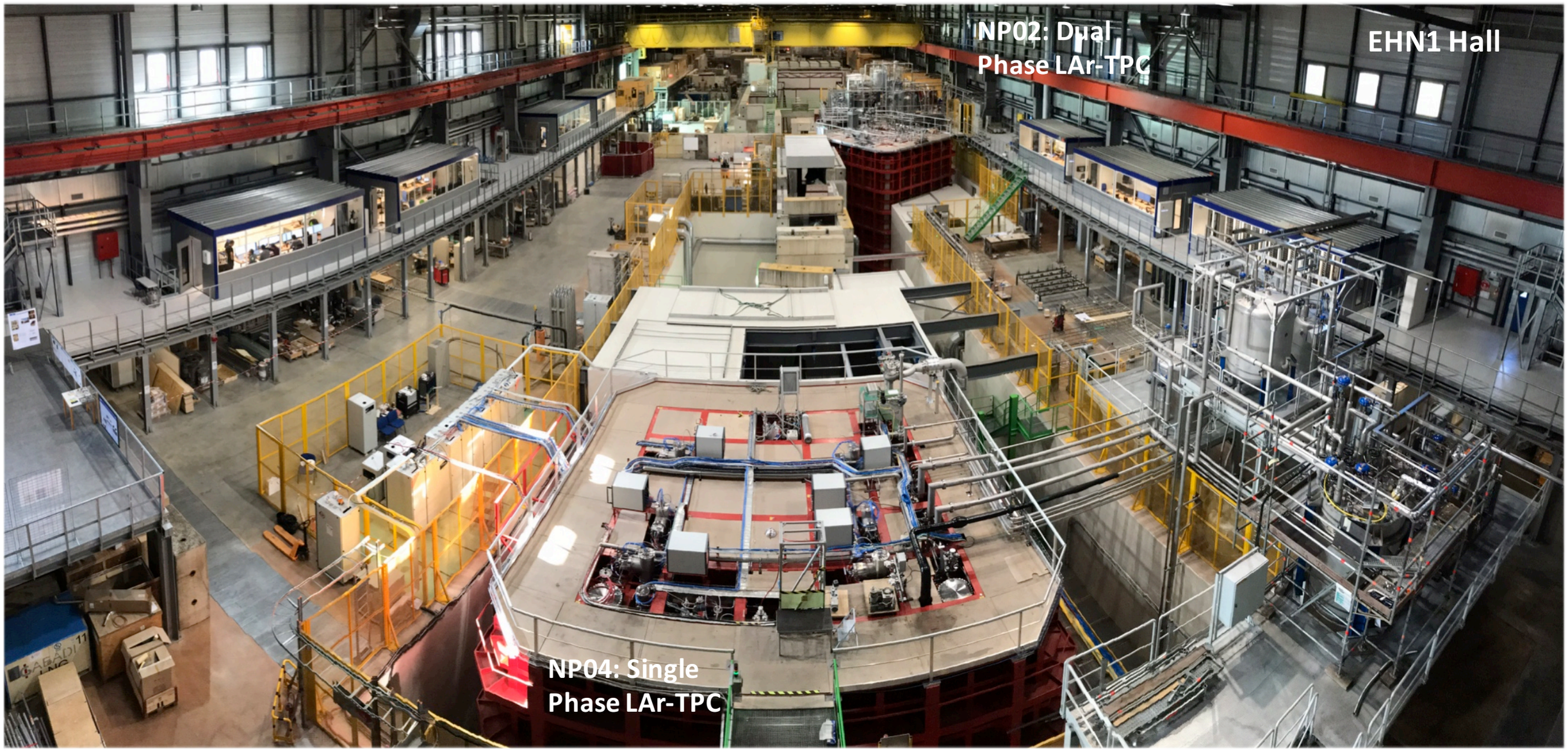


ICARUS: no membrane
Vacuum-pumped cryostats



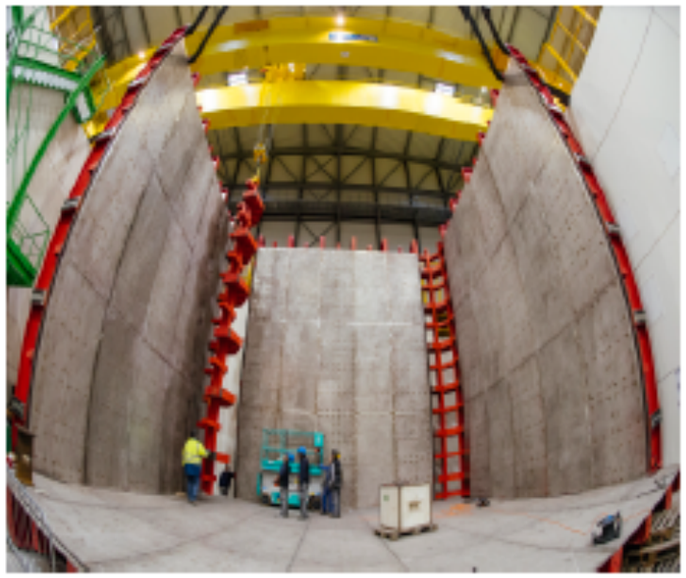


DUNE PROTOTYPES – PROTODUNES

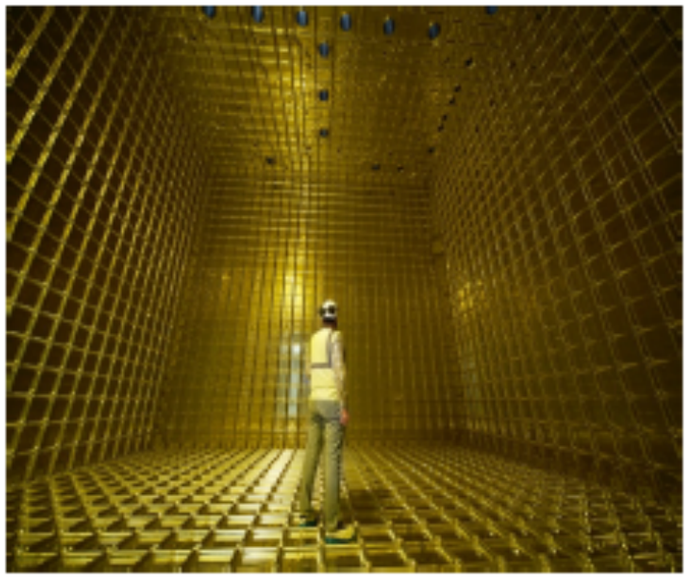


Path to ProtoDUNE SP completion in EHN1

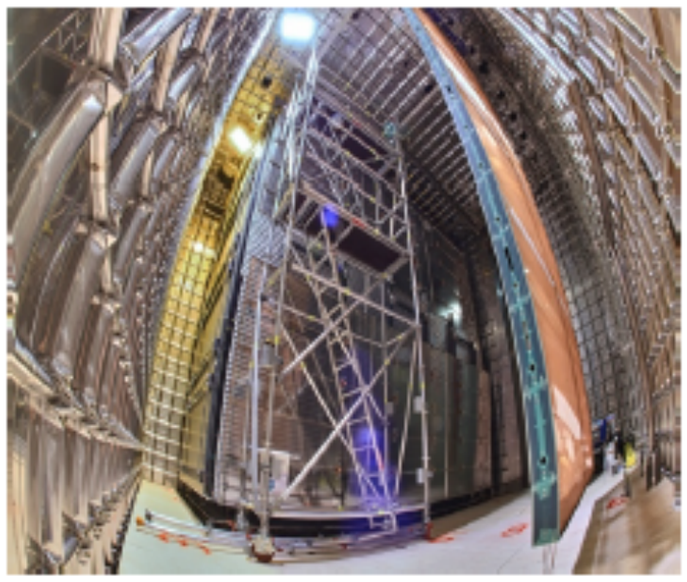
March 2016, construction of EHN1 extension



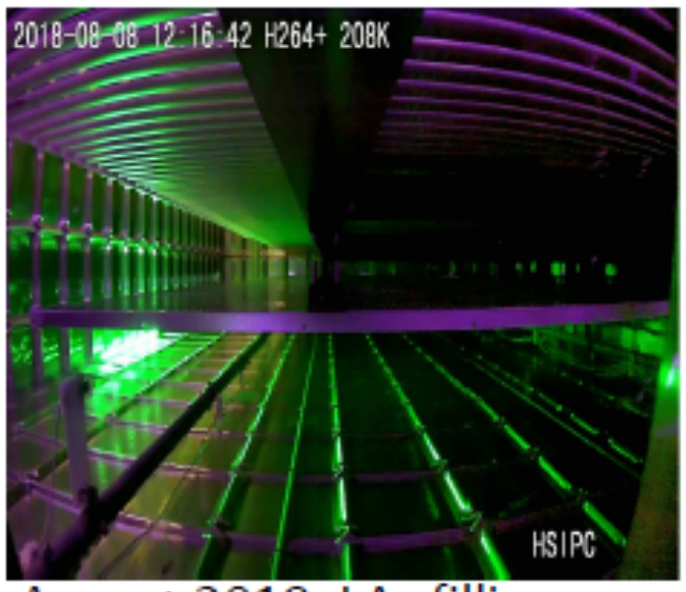
November 2016, cryostat structure assembly



September 2017, cryostat completion



February 2018, detector assembly and installation



August 2018, LAr filling and purification

September 2018, beam ready & detector ready for beam!

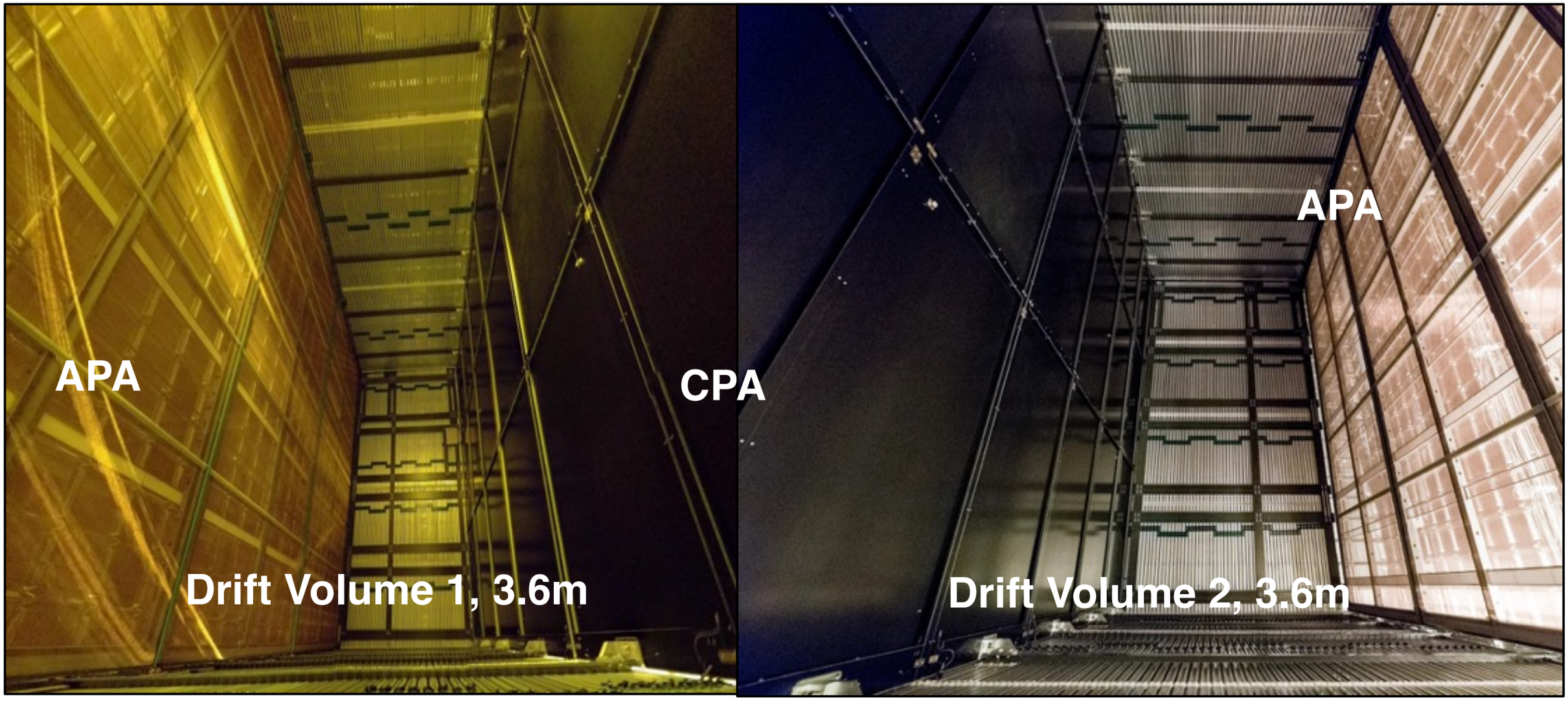
slide from F. Pietropaolo, SPSC talk April 2019

PROTODUNE-SP

6 x Anode **P**lane **A**ssembly

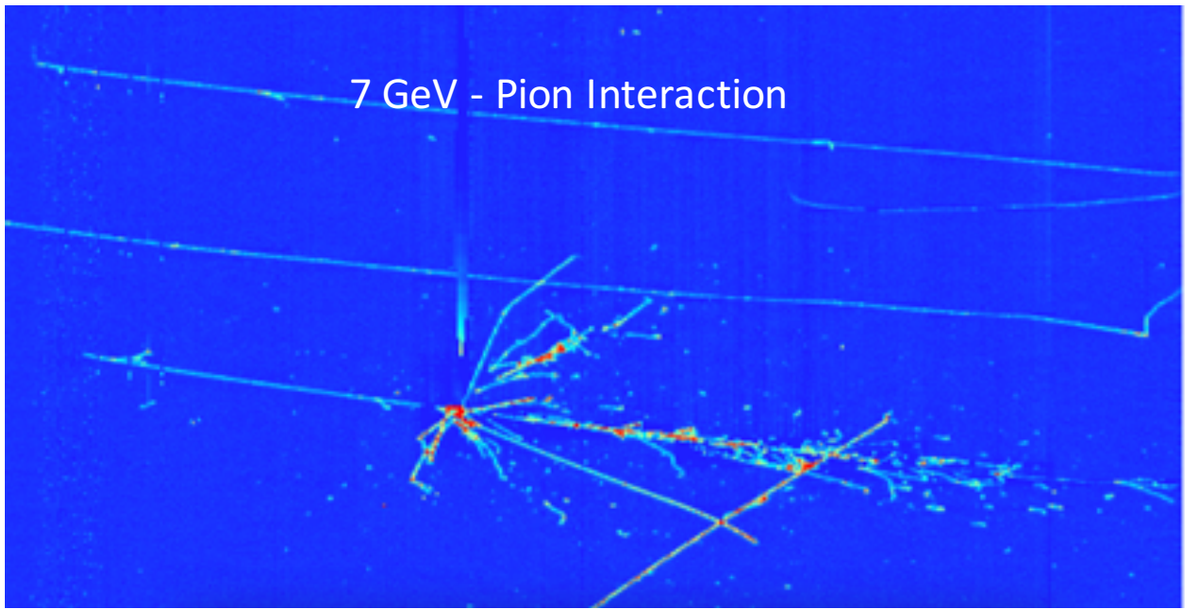
Cathode **P**lane **A**ssembly

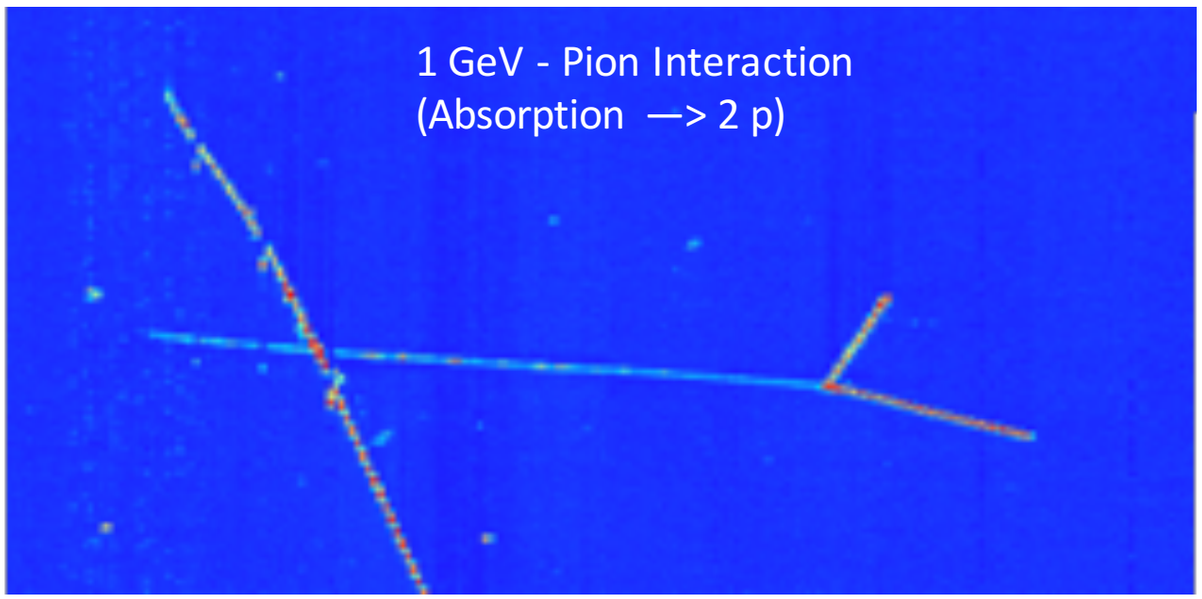
Photon **D**etection



PROTODUNE-SP

- protoDUNE-SP performances tested with H4-VLE beam extended with cosmic rays data-taking over the whole current year
- Over 4M of beam events collected and 20M of cosmic rays events!
- LAr TPC data of unprecedented quality





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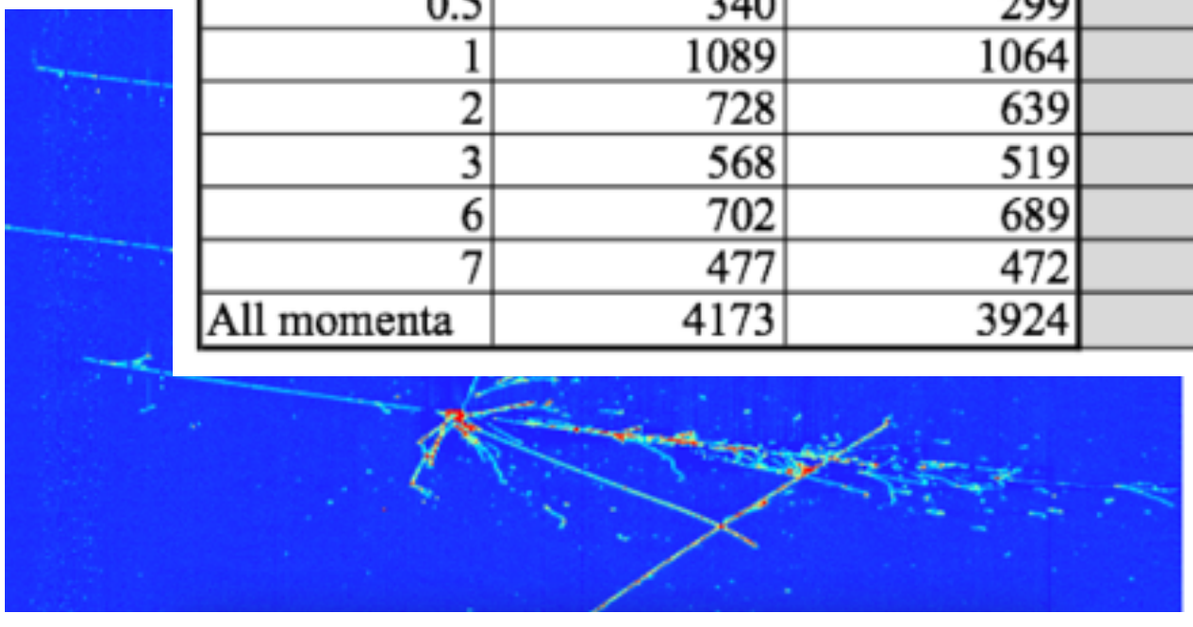
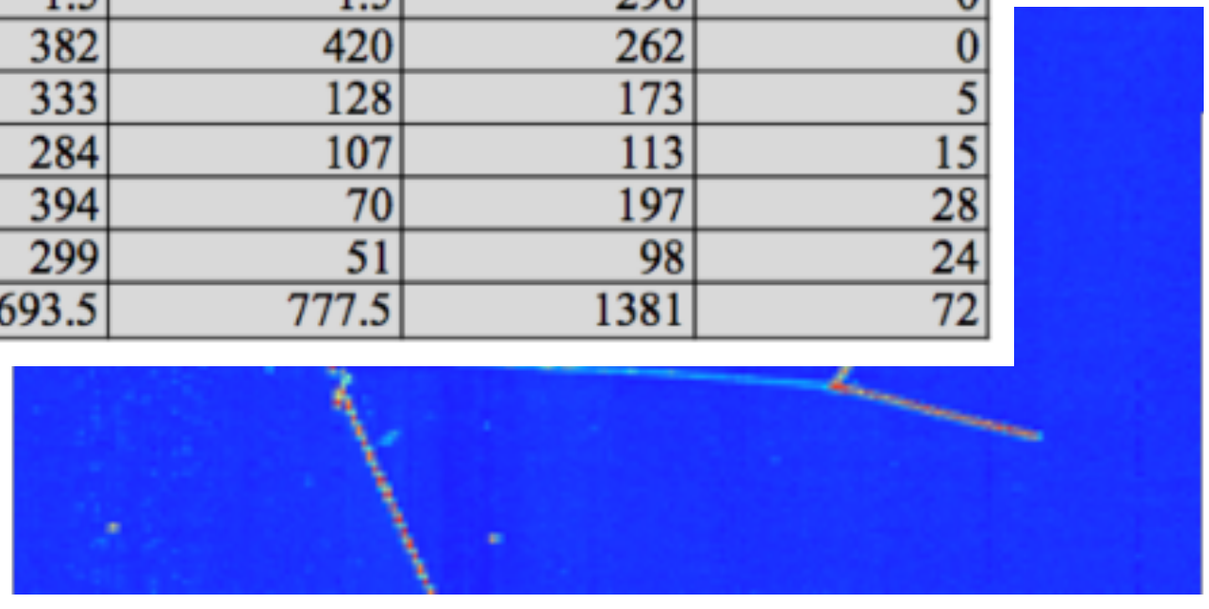
Momentum (GeV/c)	Total Triggers Recorded (K)	Total Triggers Expected (K)	Expected Pi trig. (K)	Expected Proton Trig. (K)	Expected Electron Trig. (K)	Expected Kaon Trig. (K)
0.3	269	242	0	0	242	0
0.5	340	299	1.5	1.5	296	0
1	1089	1064	382	420	262	0
2	728	639	333	128	173	5
3	568	519	284	107	113	15
6	702	689	394	70	197	28
7	477	472	299	51	98	24
All momenta	4173	3924	1693.5	777.5	1381	72

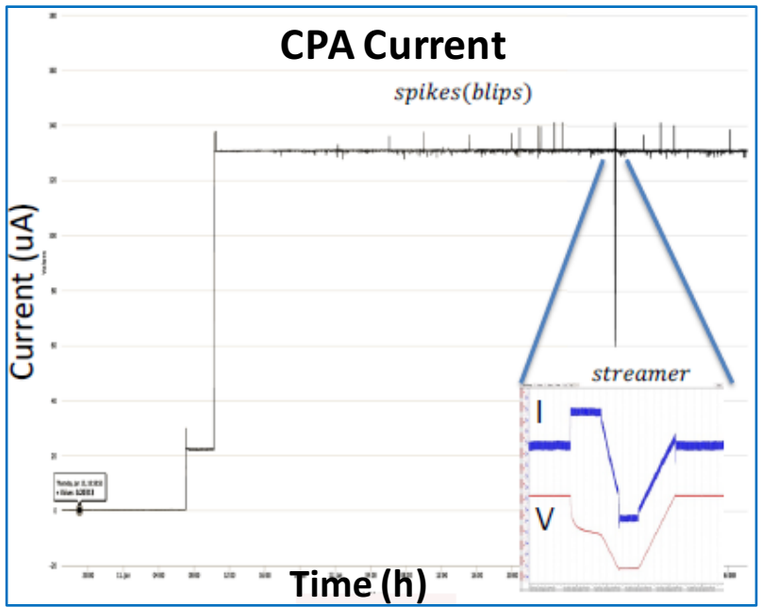




PROTODUNE-SP PERFORMANCES

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	> 7 ms *
Electronics Noise	< 1000 enc	ALARA	450-750 enc

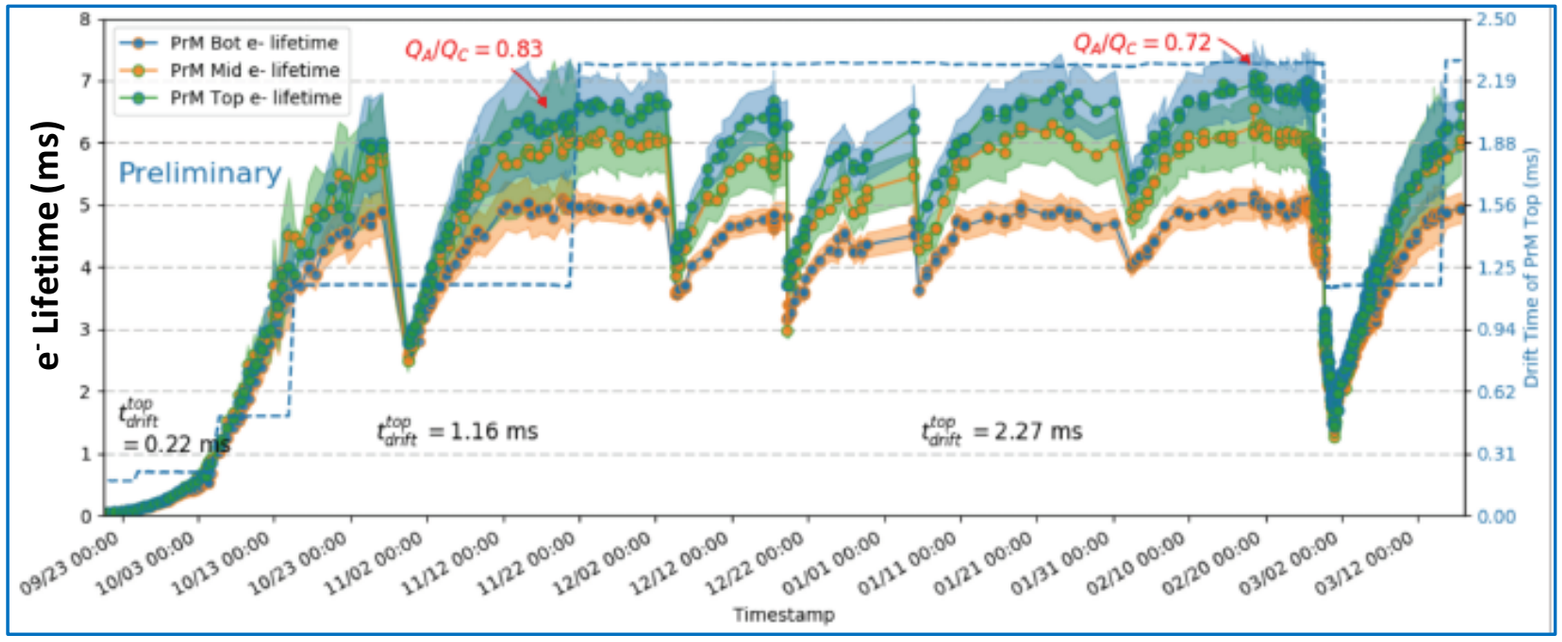
*= Saturation limit of the Purity Monitors – real value more likely around 10 ms



HV stable at 500 V/cm – 180 kV on cathode – 98% live-time

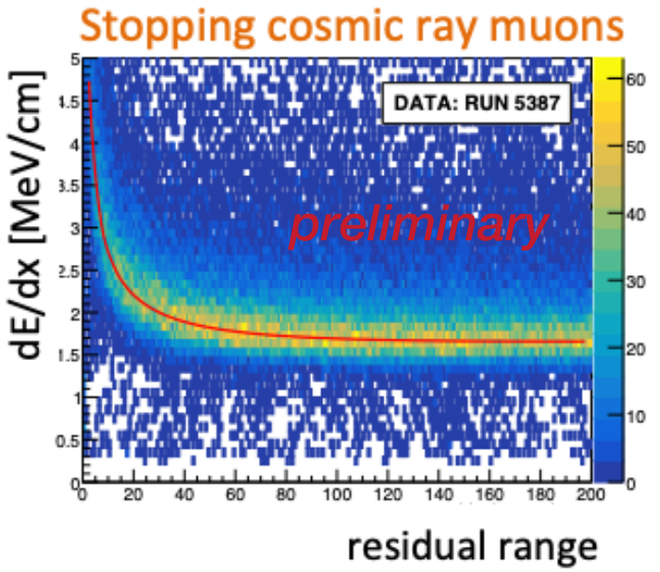
Two classes of instabilities: spikes and streamers

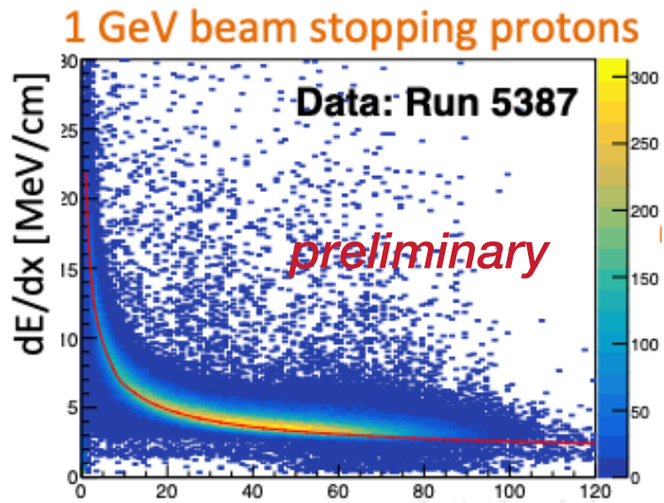
- No correlation of HV stability with LAr purity
- Extensive lifetime studies – main sources of impurities is outgassing in warm phase

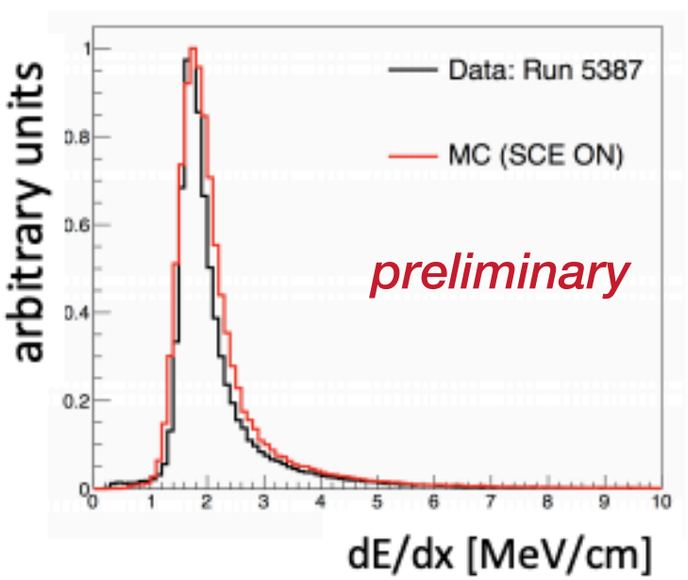


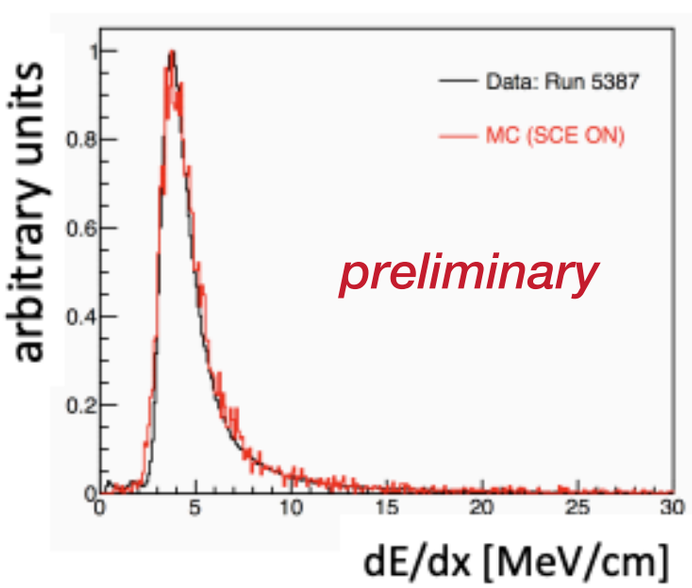
PROTODUNE-SP ANALYSIS STATUS AND PLANS

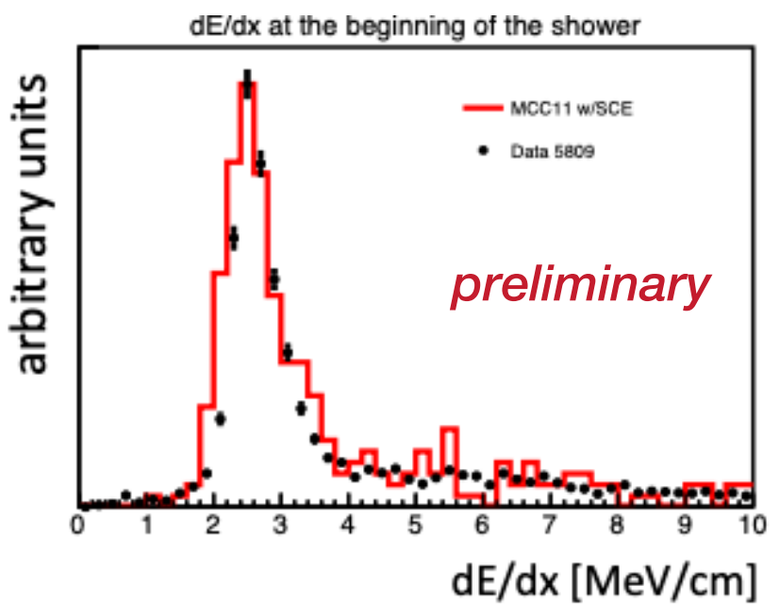
- First data/MC comparison for dE/dx distributions per particle species
- Detector calibration in progress
- First publications in preparation (detector and performance papers).
- Physics analysis with beam data in progress: inclusive pion cross-section







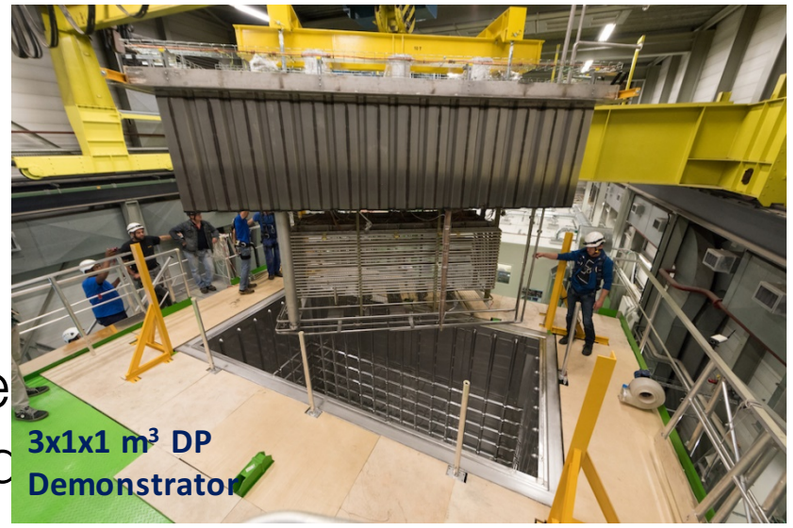




PROTODUNE-SP ANALYSIS STATUS AND PLANS

- ProtoDUNE : very successful experience! in less than 3 years, from scratch to an operating detector
- Many lessons learnt which are driving the final design of the first DUNE module
  - field cage
  - Photodetection system
  - Cold electronics
  - monitoring (cameras, sensors, purity monitors..)
- Run II in 2021 to test the final design : ***DUNE module 0***

PROTODUNE-DP

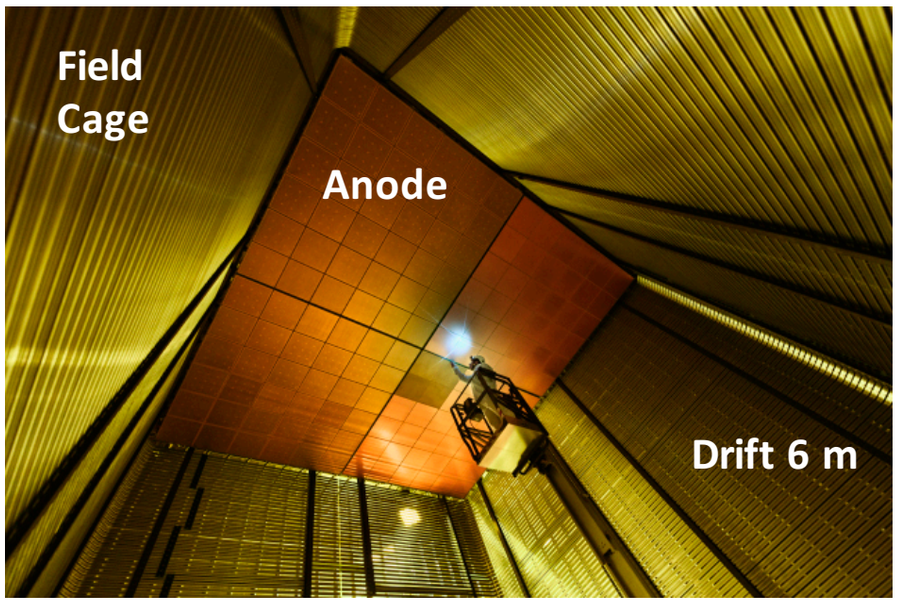


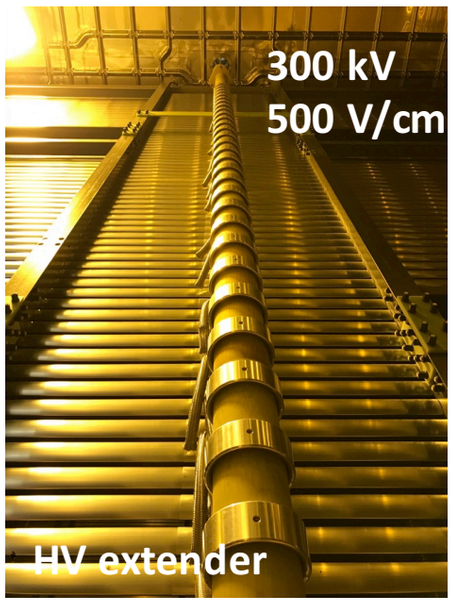
- Demonstrator constructed and operated in 2017.
- ProtoDUNE DP Installation completed. Final readout plane tested by end of 2018. Field Cage/Cathode/PMTs installed
- Monitoring systems recently installed (Cameras, Purity Monitors, Temperature sensors)

Commissioning (purge, cooldown) starting. HV on by mid August 2019.

More critical technology (LEM amplifiers stability, very HV=600 kV): more R&D in the future to be ready for a final DUNE detector.

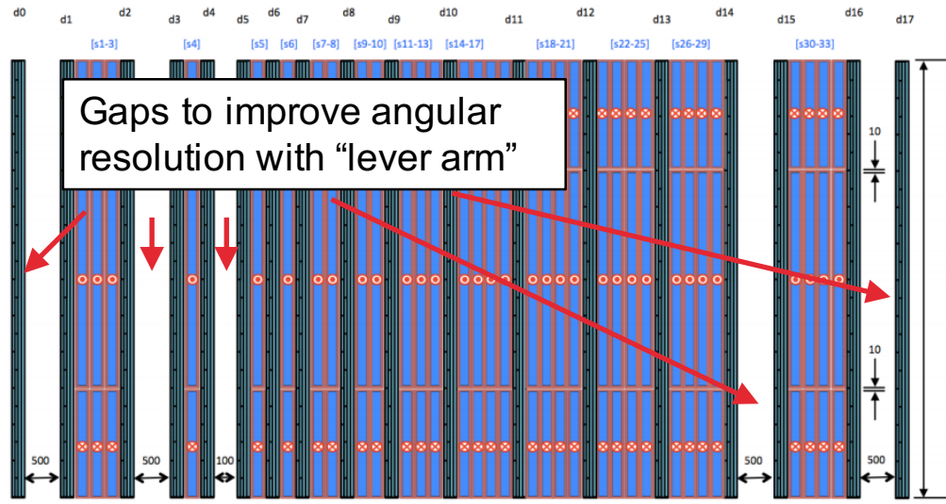
Environmental conditions (liquid purity, space charge effects, positive ions back drift into the liquid, …) are the critical points to be experimentally addressed and understood.





NP: TOWARDS JAPAN

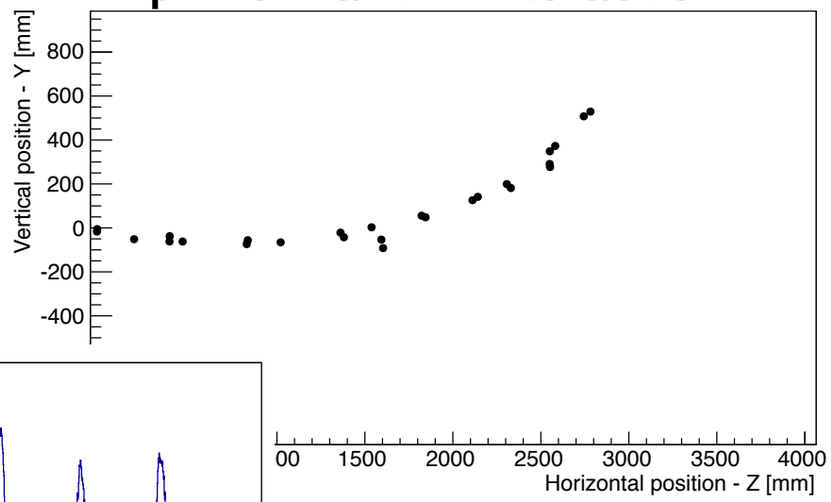
BABY MIND



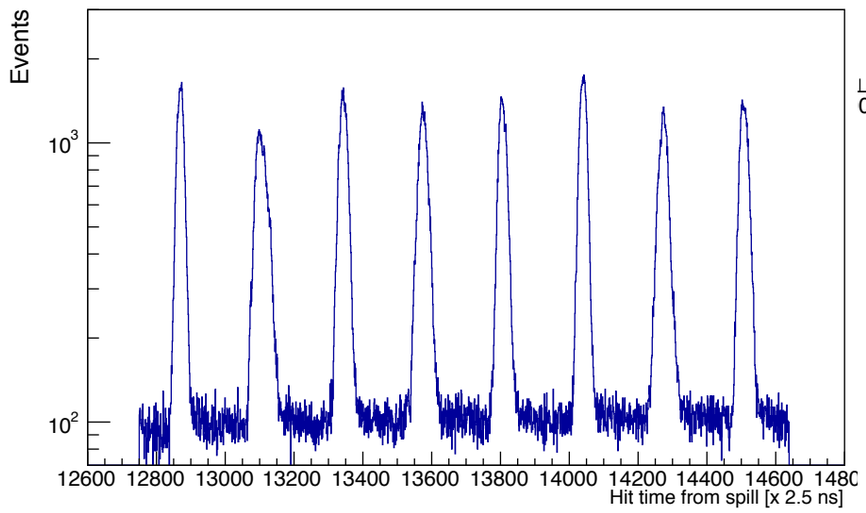
A magnetised muon spectrometer for the WAGASCI exp. in Japan

- 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
- Construction @ CERN and test beam at the PS line in summer 2017.
- Commissioning at JPARC in 2018 and **first physics run in 2019**

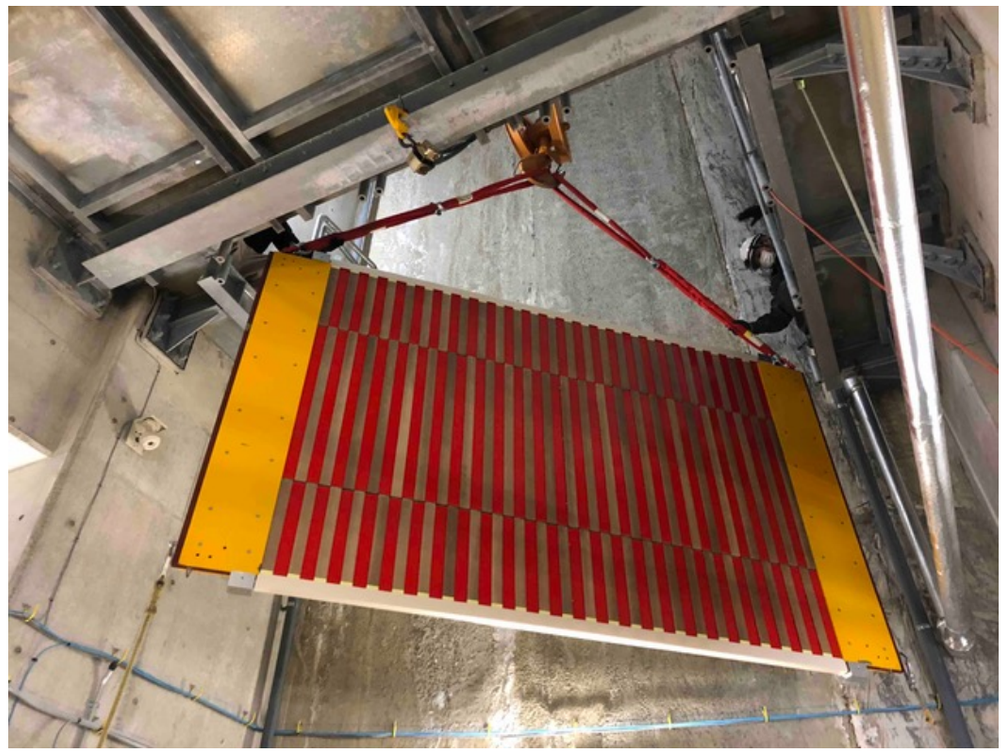
μ^+ from anti-ν interaction



T2K beam structure



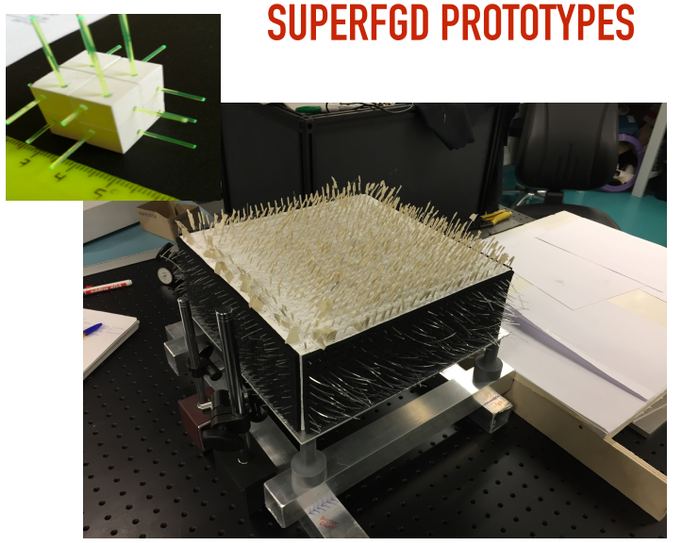
A magnet module built at CERN

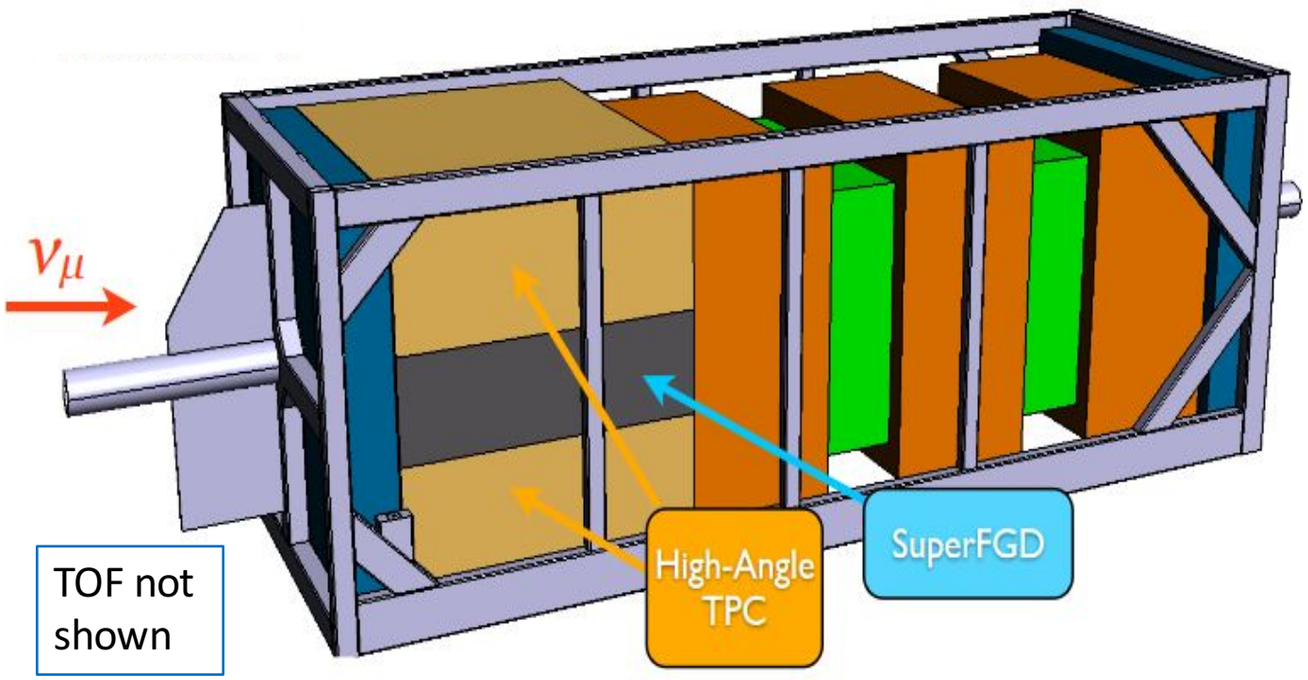


ND280 UPGRADE : T2K OFF-AXIS NEAR DETECTOR

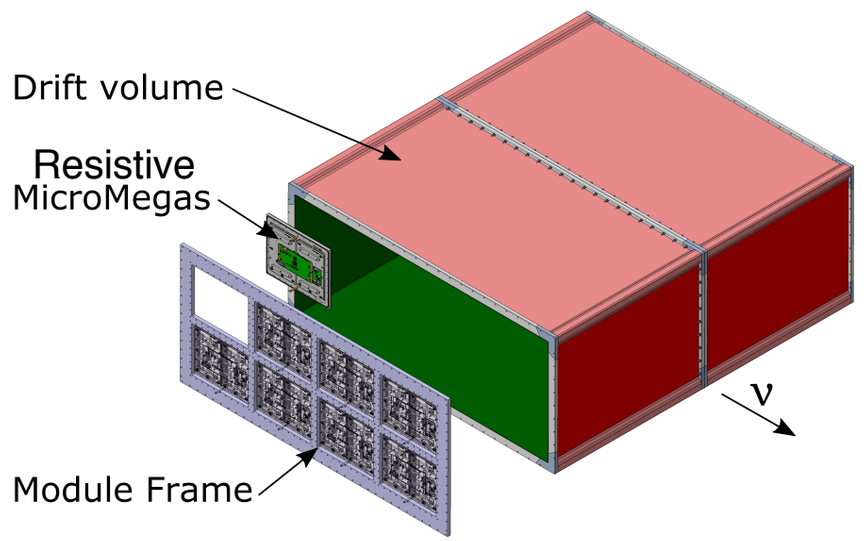
- Present ND280 detector
- One big limitation: poor acceptance for high-angle and backward going tracks
- Revisited design with three new elements:
  - **Horizontal active target (Fine-Grain) detector**: SuperFGD
  - Two **High-Angle TPCs**
  - **Time-of-Flight** detector around new tracker

SUPERFGD PROTOTYPES





ATM-TPC NEW DESIGN



ND280 UPGRADE : CENF AND CERN ACTIVITIES

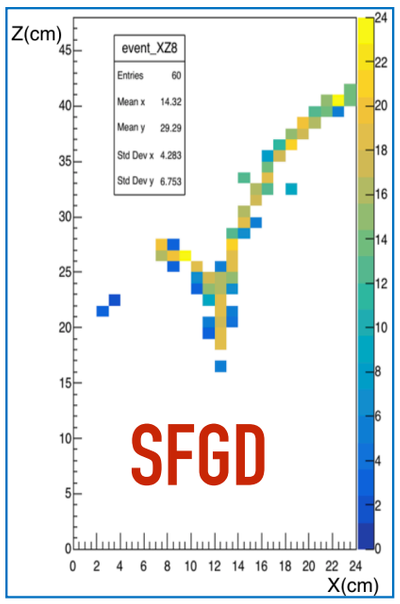
- Involvement in SuperFGD R&D:
  - Design of the detector mechanics
  - Scintillation light readout
  - LED calibration system
- Support and organisation of beam and cosmic run for both superFGD and TPCs
- Resistive MM production
- Re-design of the full ND280 gas system

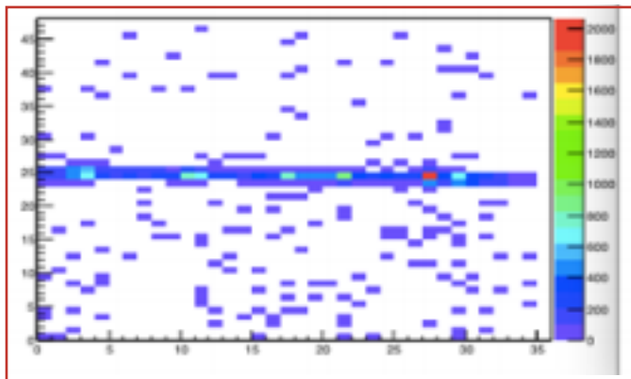
Since 2017: Expression of Interest and proposal submitted to the CERN SPSC

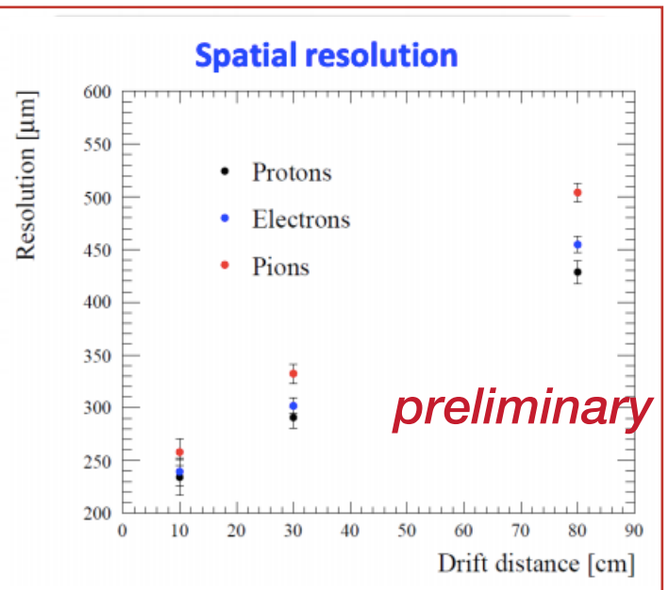
2018: CERN part of the ND280upgrade

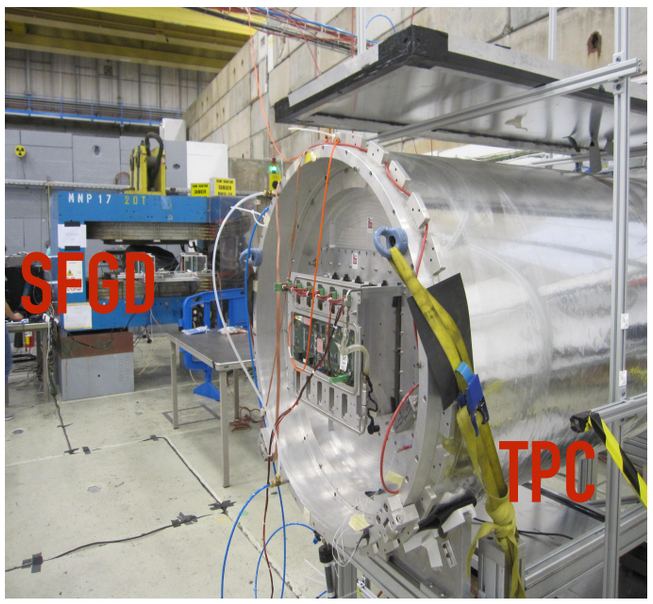
2019: CERN part of T2K

TEST BEAM AT THE EAST AREA







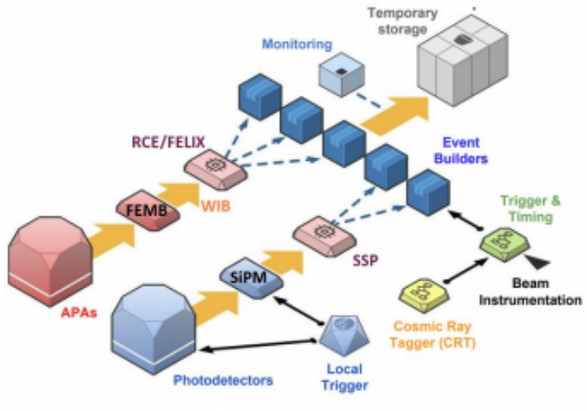


OTHER NP ACTIVITIES

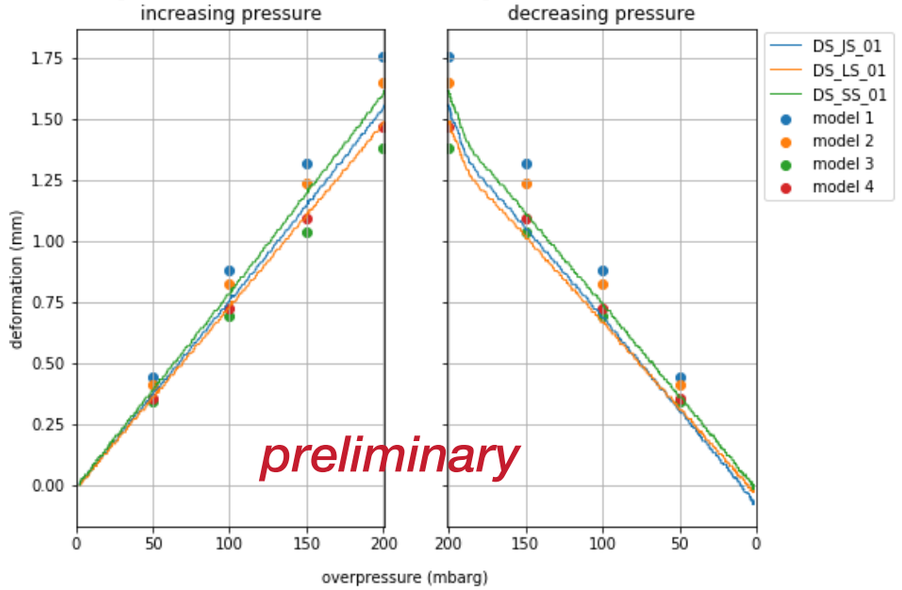
OTHER PROJECTS

- DAQ (protoDUNE, DUNE)
- H2 and H4 Tertiary beam simulation and operation
- Safety and engineering
- EnuBet
- DarkSide

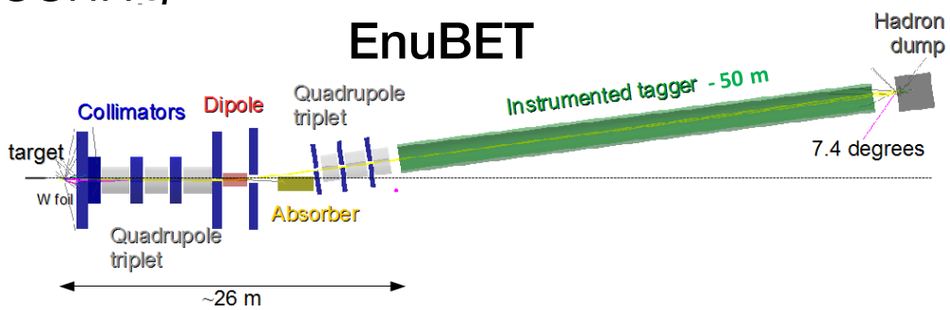
DAQ architecture for protoDUNE-SP



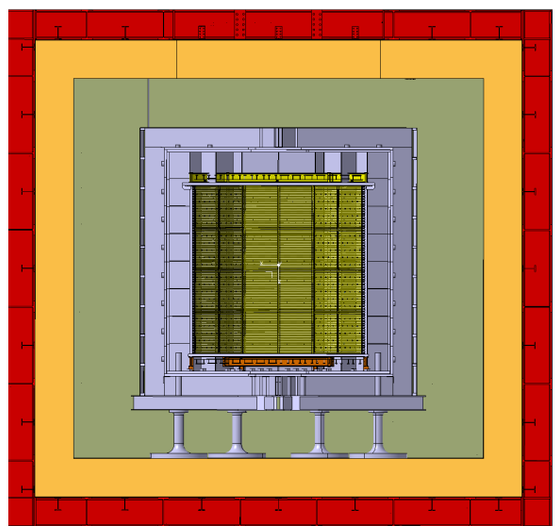
protoDUNE-SP pressure test



EnuBET



DarkSide



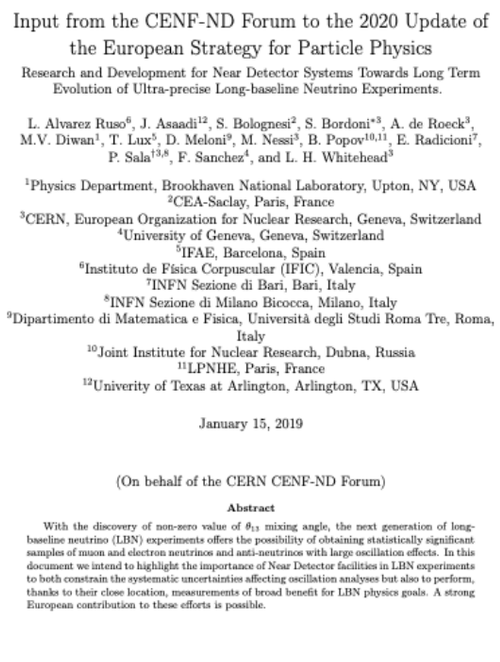
+ Data analysis and ML approach applied to DUNE and protoDUNE data (EP-NU activities)

NEAR DETECTOR FORUM

A collaborative effort toward the design of a Near Detector for the new generation o
neutrino oscillation LBL experiment

https://twiki.cern.ch/twiki/bin/view/CENF/NearDetector

- The CENF-ND forum is set to provide **support** to the ongoing efforts of the DUNE and HK collaborations in conceiving their Near Detectors.
- The goal of the forum is to **strength** the European support, **attract** new institutes, **endorse** participation from Japanese and American Institutes.
- A document has been submitted to the call for input to the Update of ESPP (#106).
- Proposal to built a sub-GeV beam line at CERN recently submitted to the SPSC



arXiv:1901.04346v1 [physics.ins-det] 14 Jan 2019

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[†3,8], 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.

Expression of interest for a sub-GeV low Energy beamline at the CERN North Area

L. Alvarez-Ruso , C. Andreopoulos , B. Andrieu , A. Arbuzov , J. Asaadi , M. Barbaro , N. Benekos , O. Benhar , V. Berardi , P. Bernardini , S. Bertolucci , V. Bhatnagar , J. Bian , B. Bilki , A. Blondel , E. Blucher , S. Bolognesi , T. Bolton , M. Bonesini , S. Bordoni , A. Bross , V. Buescher , J. Caballero Carreteras , G. Catanesi , G. Christodoulou , G. Collazuol , A. De Roeck , G. De Rosa , S. Dennis , F. Di Lodovico , L. Di Noto , M. Diwan , M. Dracos , T. Ekelof , A. Ereditato , P. Fernandez , F. Ferraro , C. Giganti , D. Gonzalez Diaz , M. Guigue , S. Hallsjo , M. Hartz , T. Hasegawa , Y. Hayato , M. Hernandez Gamazo , G. Horton-Smith , N. Jachowicz , C. Jung , Y. Kataoke , T. Katori , A. Kayis Topaksu , A. Konaka , U. Kose , Y. Kudenko , M. Lokajicek , K. Long , A. Longhin , T. Lux , J. Maneira , S. Manly , C. Mariani , M. Martini , L. Masetti , N. Mauri , G. Megias Vazquez , D. Meloni , P. Mermod , E. Messomo , S. Mishra , U. Mosel , J. Nachtman , Y. Nagai , M. Nessi , Y. Onel , V. Palladino , M. Pallavicini , V. Pandey , V. Paolone , L. Patrizii , A. Penzo , R. Petti , B. Popov , M. Potekhin , E. Radicioni , G. Ricciardi , C. Riccio , M. Roda , B. Roe , S. Roth , I. Ruiz , P. Sala , G. Salamanna , F. Sanchez , D. Sgalaberna , F. Simon , J. Sinclair , J. Sobczyk , P. Soler Jermyn , L. Stanco , M. Stipcevic , A. Surdo , M. Tenti , F. Terranova , M. Thomson , C. Touramanis , R. Tsenov , A. Weber , L. Whitehead , M. Wilking , M. Wurm , M. Yokoyama , M. Zeyrek , and M. Zito

the CENF-ND forum

June 4, 2019

Abstract

This document summarises the interest collected among the accelerator-based neutrino community for a sub-GeV beamline at CERN. Such beamline will allow to characterise the response of a variety of detector technology to particles in the momentum range typical for the products of neutrino interactions. The document is proposed by the CENF Near Detector forum, a Neutrino Platform activity meant to support the European effort on neutrino experiments and strength the collaboration with Japanese and American Institutes.

R&D ACTIVITIES

First measurement of group velocity of 128 nm photons in LAr

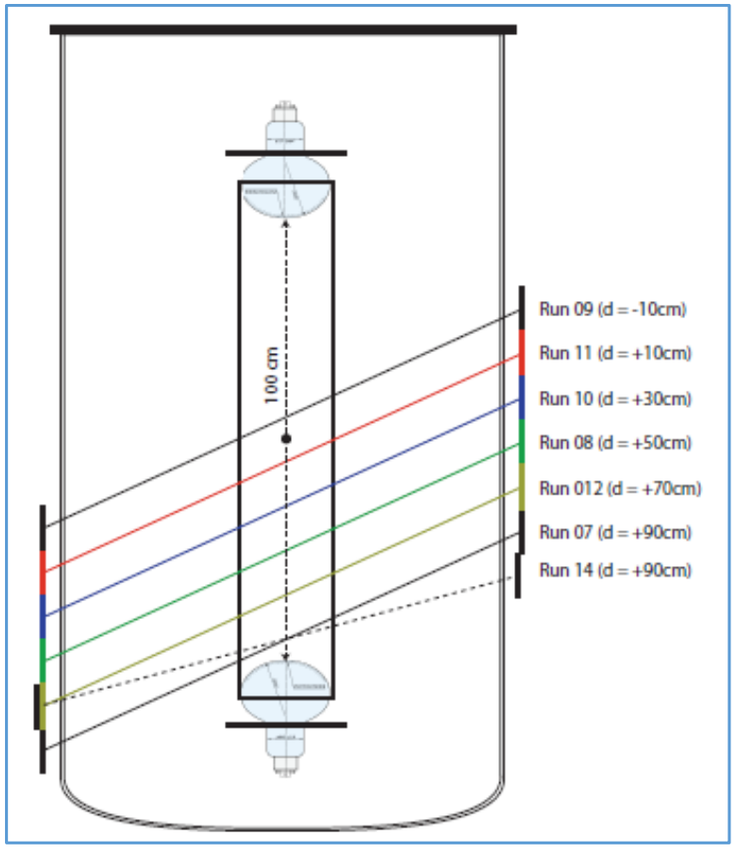
- Setup made of 2 PMTs facing each other in LAr bath.
- Trigger with cosmic rays, detected by external scintillators: different heights and track slopes.
- Relative measurement (Δs vs Δt)

$1/v_g$ = 7.50 ± 0.07 (stat) ns/m

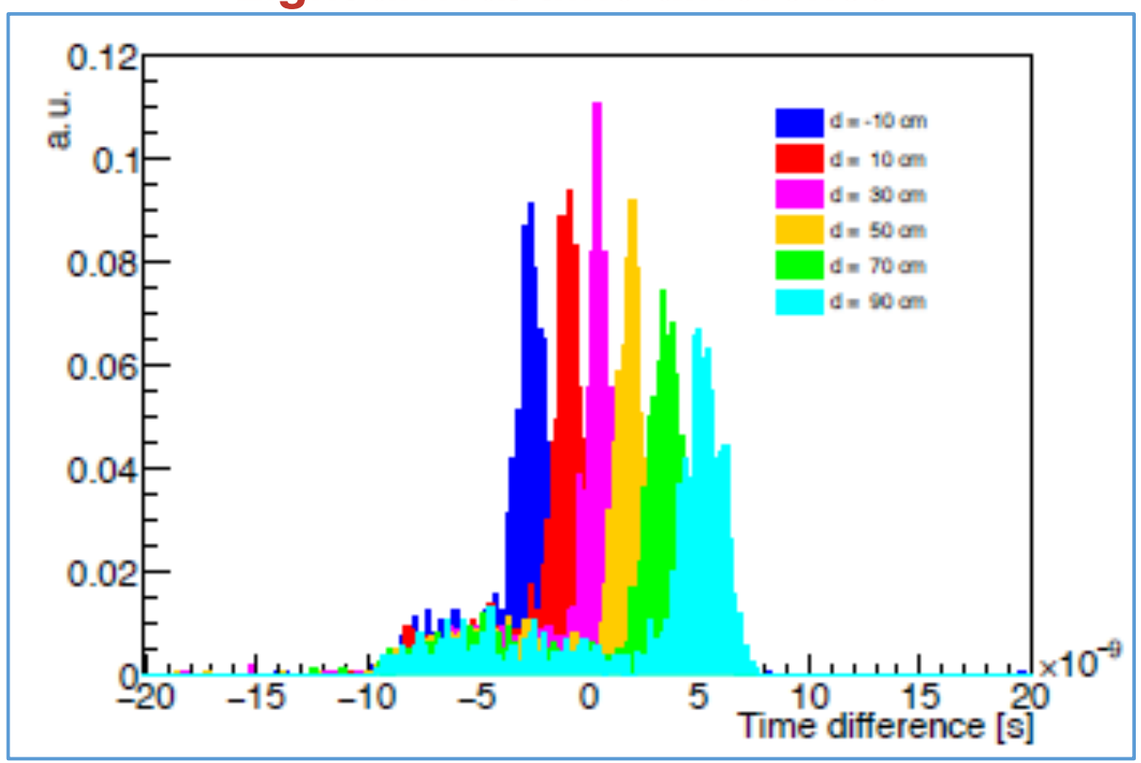
- Combination with existing measurements @ higher λ to derive:

n = 1.369 ± 0.004 **ℓ_{Ray} = 91.0 ± 2.8 cm**

cartoon of the experimental setup



Light arrival time difference



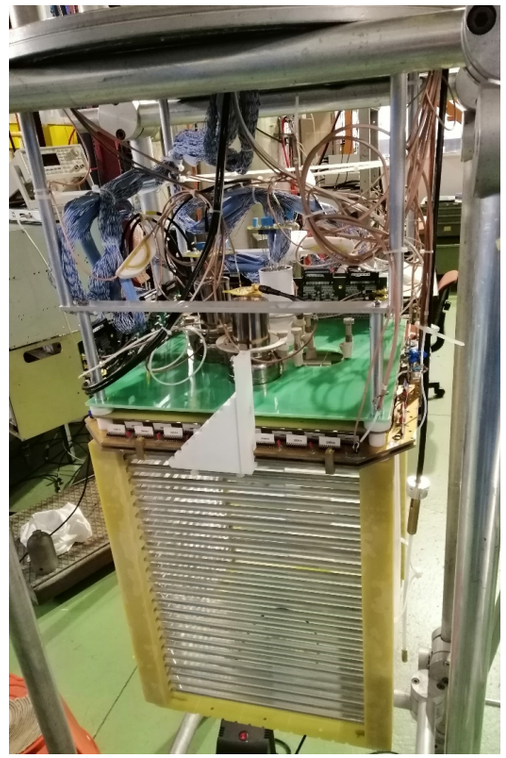
PMT positioned in the experimental setup

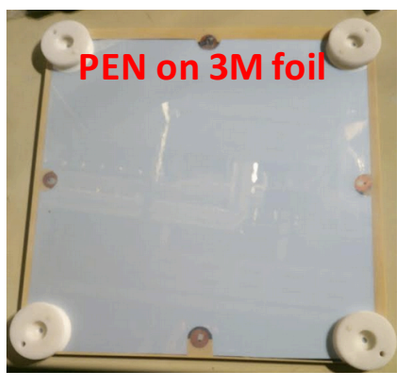
paper in preparation (to be submitted to JINST)

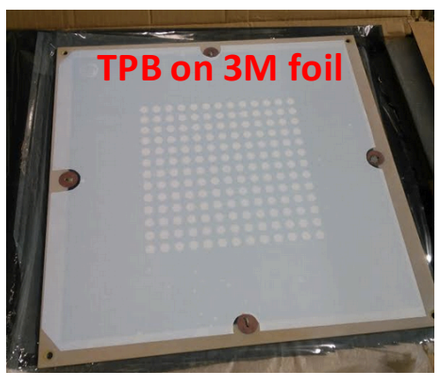
R&D ACTIVITIES

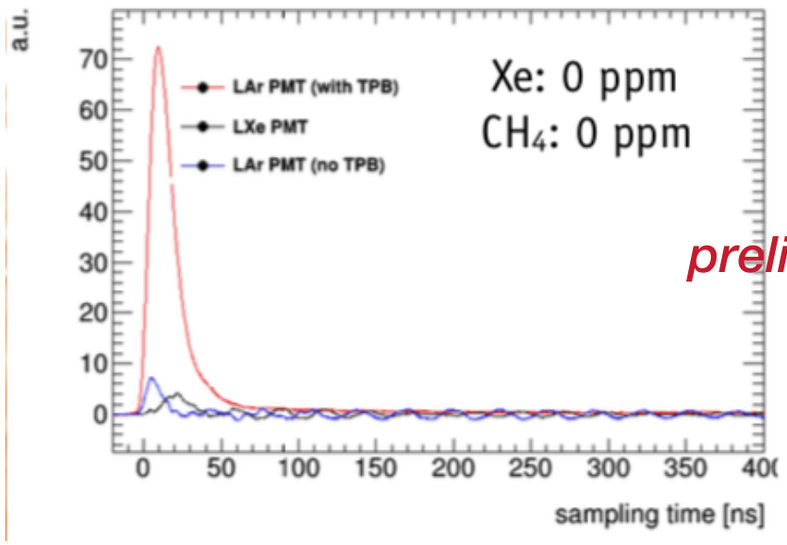
Small LAr-TPC (50 liters Icarus Chamber (FLIC) with its own recirculation system, used to test new technologies and materials. **Almost 30 year old set-up.**

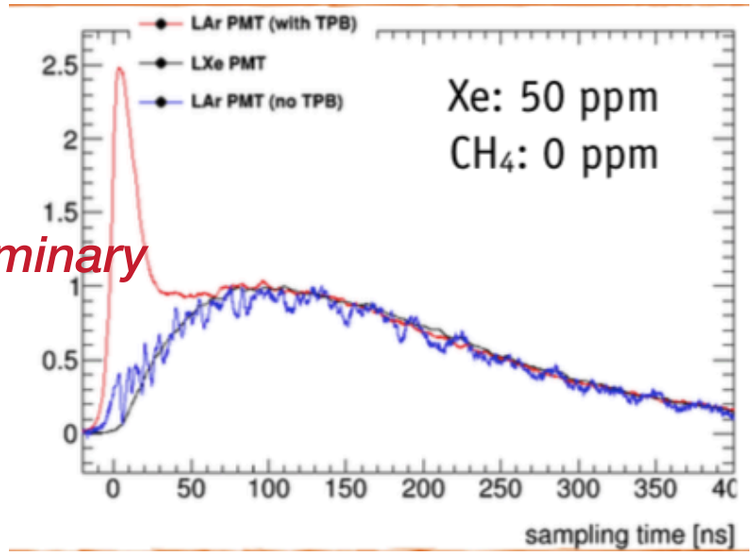
- Cold / hybrid electronics solutions for LAr-TPCs (ICARUS)
- Tests of Very High Voltage (VHV) power supplies/cables/ feedthroughs for DUNE program (300 kV)
- Selection and tests of new materials for ProtoDUNE/DUNE design (Aluminum/G10 field cage, resistive cathodes with kapton)
- New wls materials: PEN vs TPB (DUNE, DS20k)
- Xe doping in Liquid Argon (DUNE, DS20k)









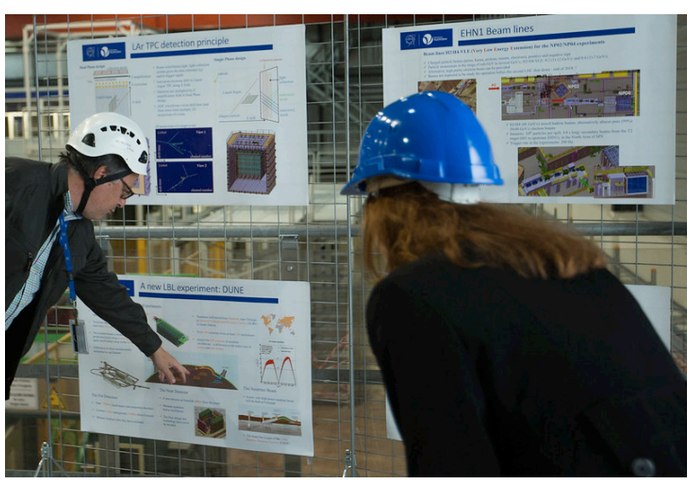


preliminary

OUTREACH ACTIVITIES

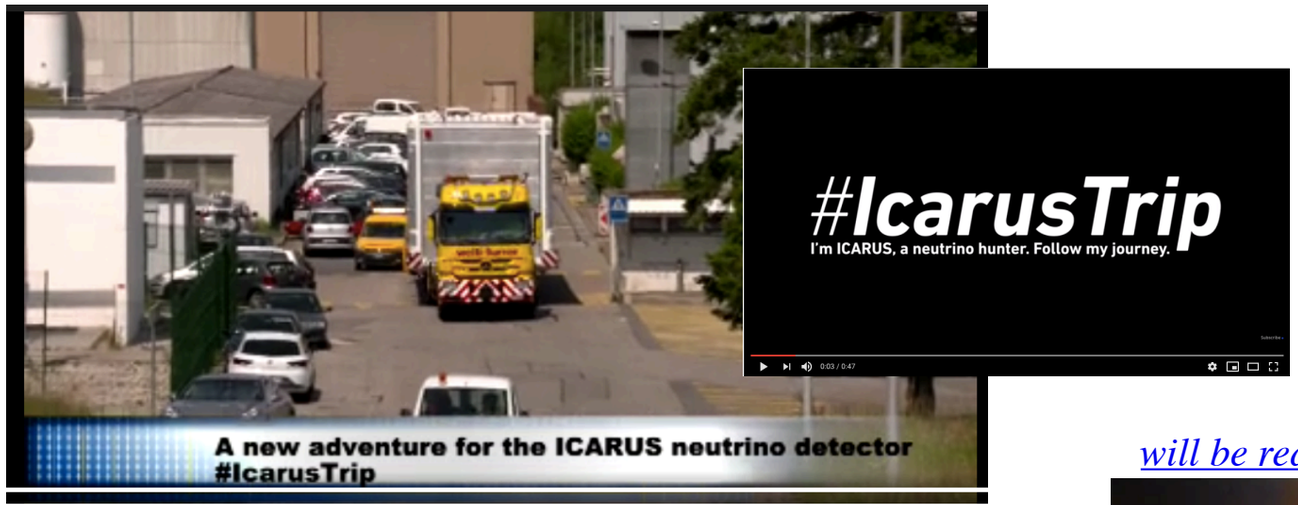
- Started in 2016, the Neutrino Platform has its own outreach group: 20 active people, regular meetings
- Series of activities:
  - Collaboration with CERN and FermiLab outreach and press divisions
  - Scientific article editing, interviews, filming, guided and professional visits
  - Participation to 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

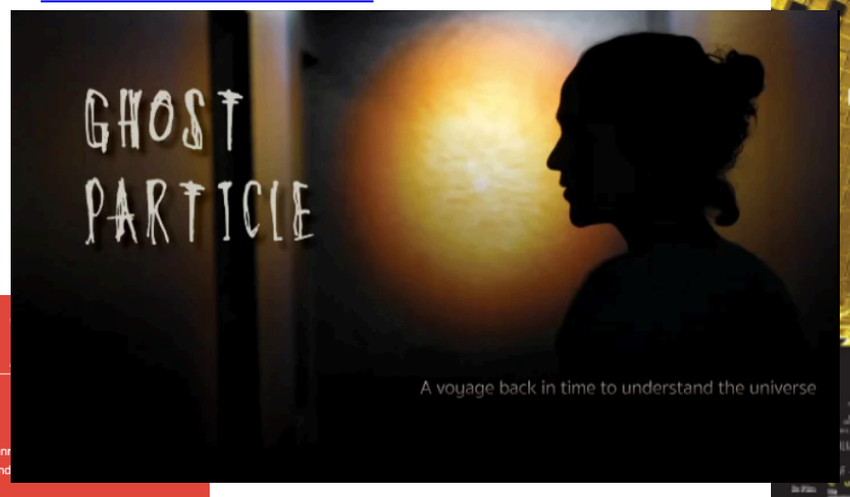


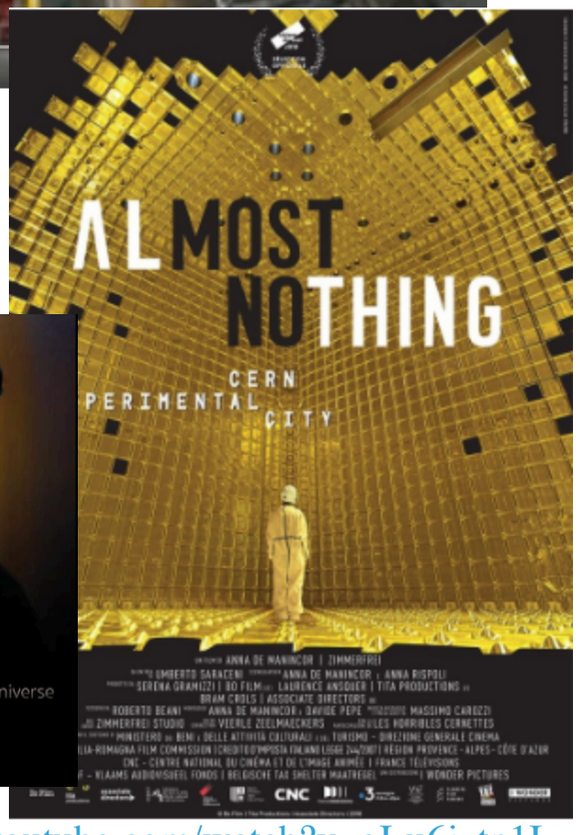
OUTREACH ACTIVITIES

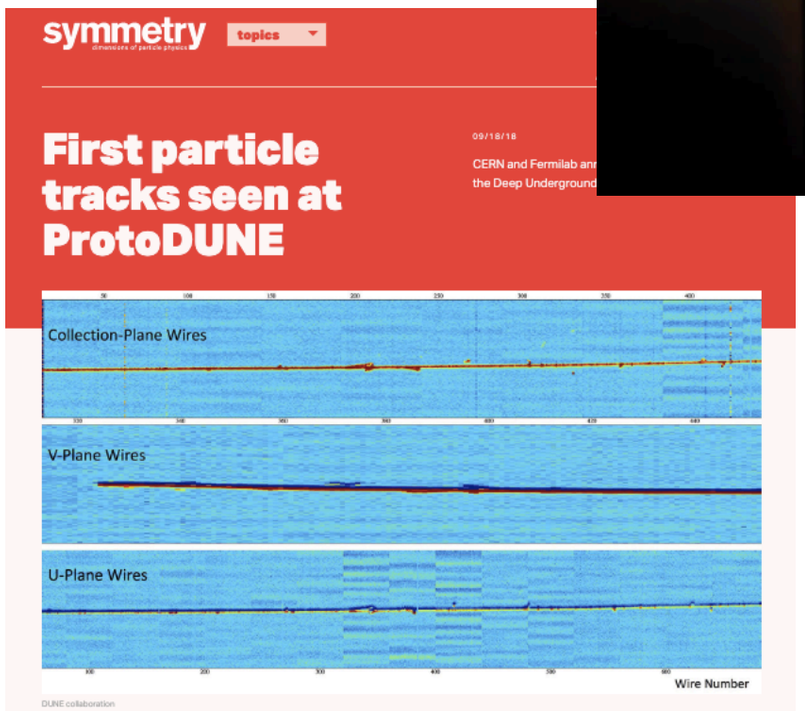
Facebook live event : https://videos.cern.ch/record/2268970



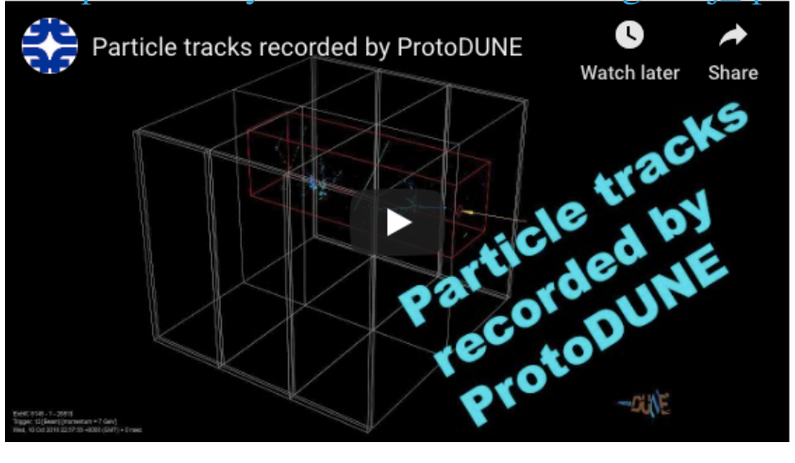
will be realised soon







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

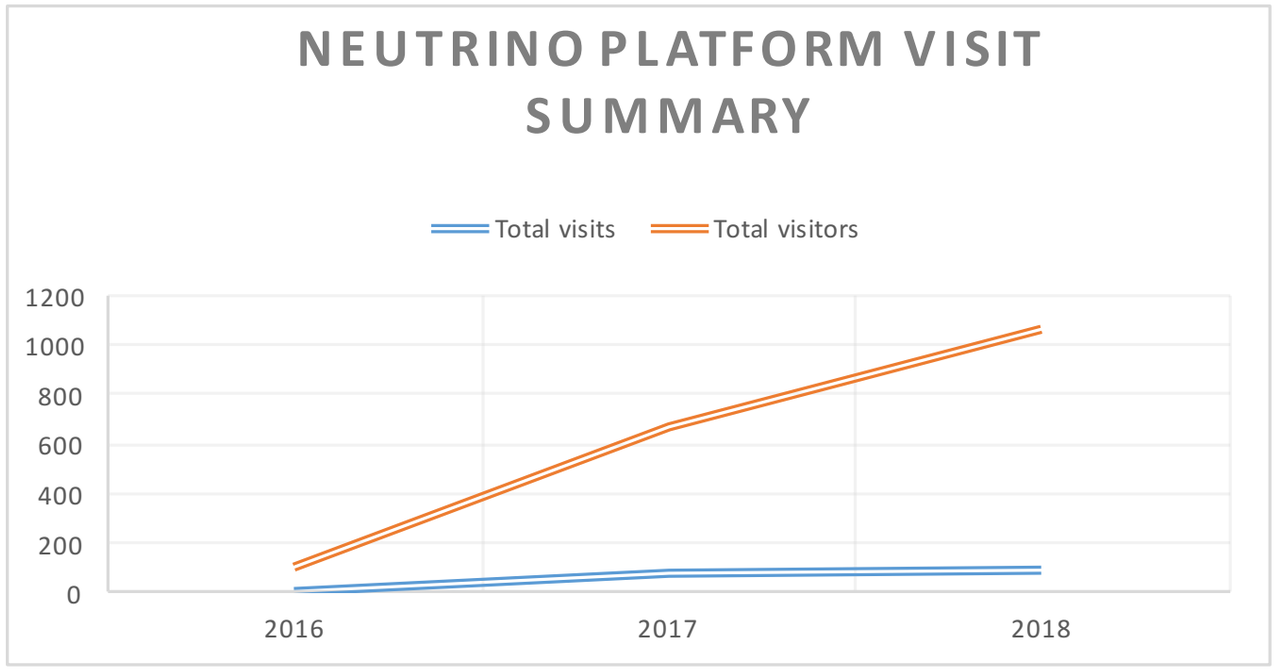


VISITS TO THE NEUTRINO EXPERIMENTAL HALL

- 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



OUTREACH : CERN OPEN DAYS

14 -15th September 2019

- A number of activities have been organised at the Neutrino experimental hall
  - All-time activities:
    - Guided visits
    - Help us with the data taking of ProtoDUNE !
    - (proto)DUNE view from *inside*
    - *Guess who?*
  - Scheduled activities:
    - build and operate a cloud chamber
    - cosmic rain : detection of cosmic rays with a plastic scintillator detector
    - crazy cryo: show of material behaviour while in cryogenics

CERN OPEN DAYS

14 -15th September 2019

CERN OPENDAYS

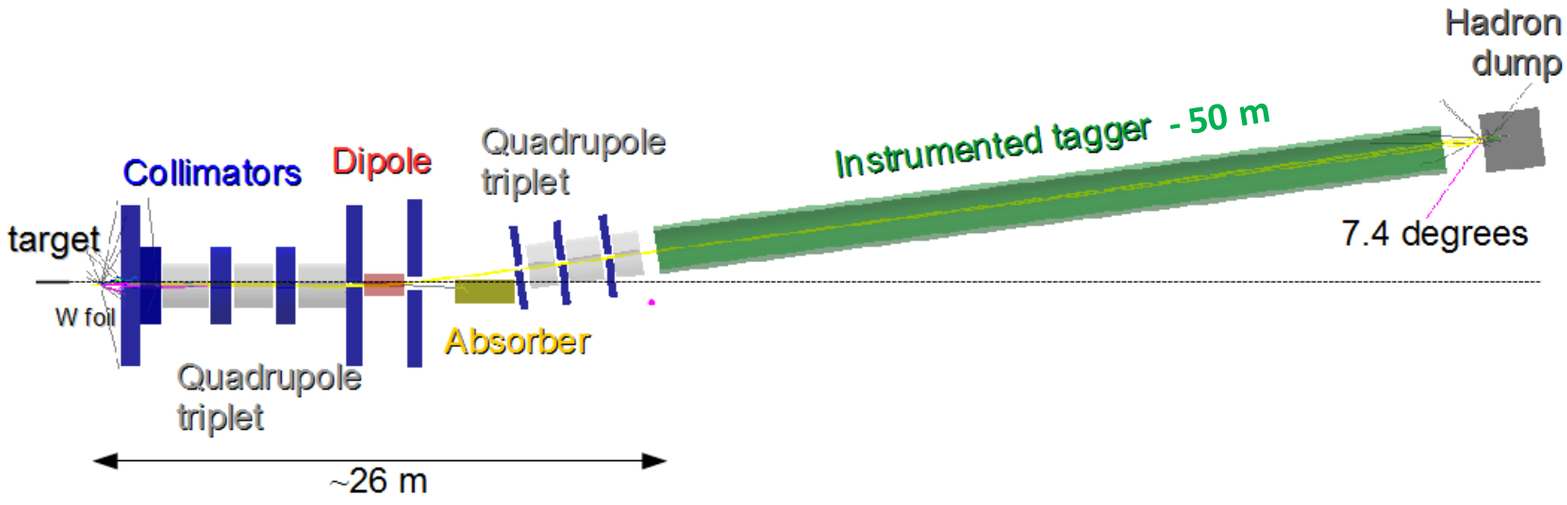
▸ Explore the future with us
▸ Explorez le futur avec nous

https://opendays.cern/

Volunteers to help us to liven up those days are welcome ! Sign up here:
https://home.cern/news/news/cern/cern-open-days-become-volunteer

ADDITIONAL

ATTRACTING NEW PARTNERS : ENUBET



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): CERN will provide support/guidace from accelerator experts

Going Dark – DarkSide 20k

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**