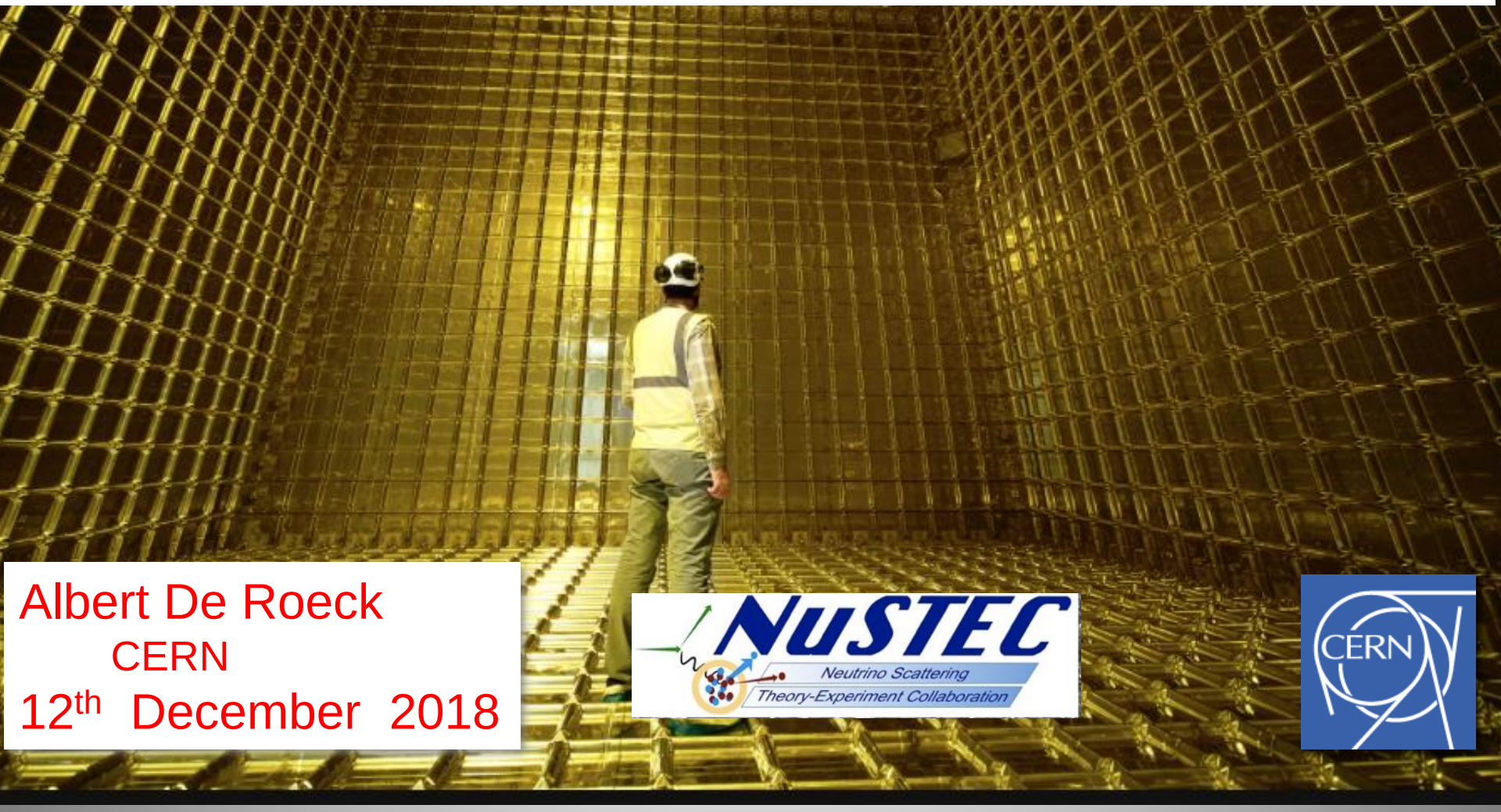
CERN Neutrino Platform & CERN Neutrino Activities



Albert De Roeck
CERN
12th December 2018

NuSTEC
Neutrino Scattering
Theory-Experiment Collaboration

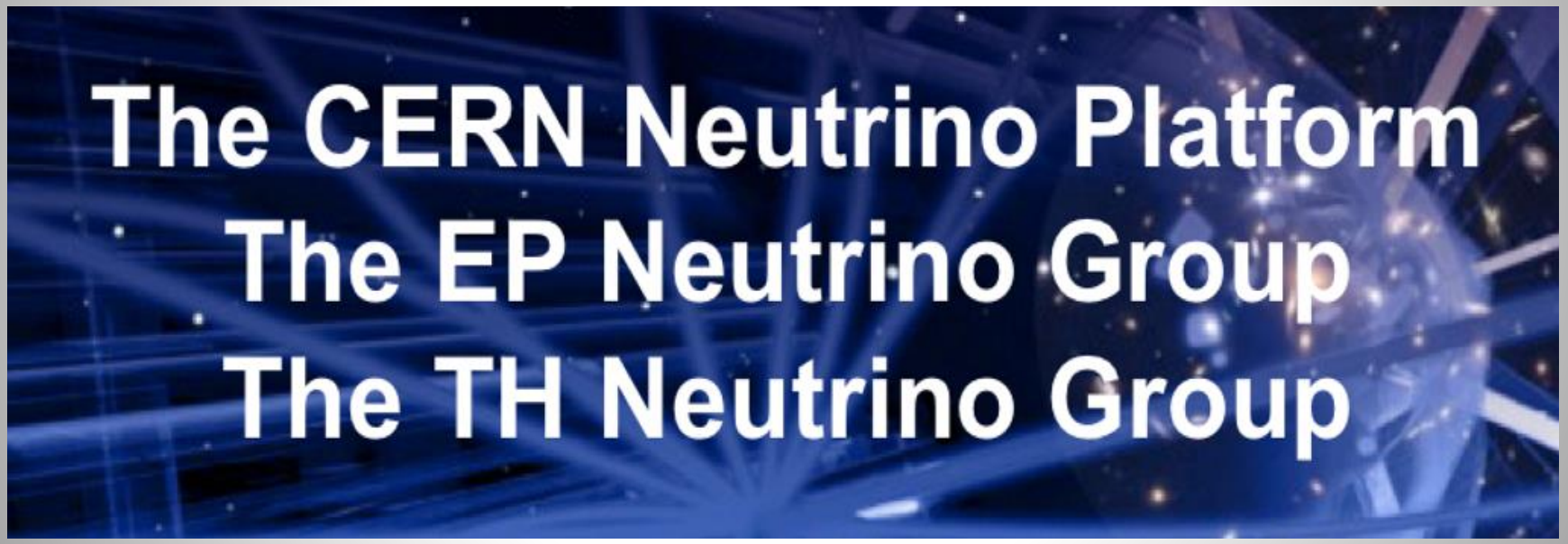
CERN

Outline

- Neutrino Activities @ CERN
- Ongoing Projects
  - DUNE & ProtoDune
  - T2K Upgrade
  - ICARUS and FNAL SBL
  - NA61
- The Near Detector Forum
- Further activities and plans
- Summary

Neutrinos at CERN

Three recent activities at CERN on neutrinos



The Neutrino Platform

- There are six projects currently part of the Neutrino Platform
  - NP01: WA104, ICARUS as a far detector for the FNAL SBN
  - NP02: ProtoDUNE dual-phase WA105 and 3x1x1 demonstrator
  - NP03: PLAFOND, generic R&D framework
  - NP04: ProtoDUNE single-phase
  - NP05: Baby Mind, a muon spectrometer for T2K's WAGASCI detector
  - Argon Cube: Modular LArTPC R&D
- Further projects in the pipeline: T2K ND280 upgrade, DUNE ND, ENUBET…
- CENF-ND effort for collaboration on near detectors for future long baseline neutrino experiments

Watched over by the SPSC…

The EP- Neutrino Group @ CERN

- European Strategy 2013: -> Neutrino effort @ CERN-> Platform
- In view of the effort in the established neutrino platform a new group was created in fall 2016
- EP group focus at present on
  - Experimental neutrino physics -> take part in experiments. So far DUNE and ICARUS/SBN at FNAL. Recently exploring the T2K-upgrade and accepted with 'limited membership' in NA61
  - Focal point for activities for the neutrino community in Europe
  - Collaborate with the neutrino platform on ProtoDUNE (data analysis, computing, simulations, reconstruction, beamline optimization, physics analysis…)
  - Collaborate with the platform on detectors R&D, test beams
  - Liaise with CERN-TH neutrino group on the physics program
  - Organize workshops for the Neutrino community
  - Recently: Special focus on near detector challenges

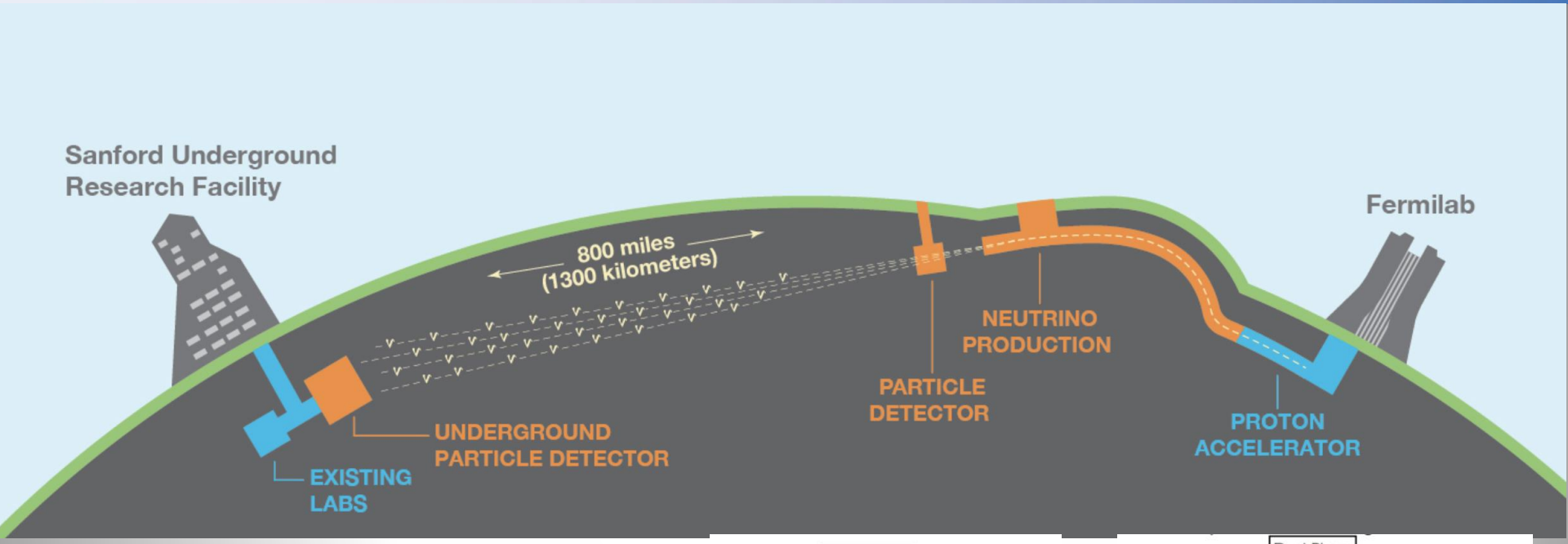
The TH- Neutrino Group @ CERN

- Neutrino Experimental TH effort since spring 2016
- Virtual group, ie most people not at CERN
  - Joachim Kopp and Jacobo-Lopez Pacvon plus visitors, expanding..
- TH group focus at present
  - Organizing TH Institutes and Workshop
  - Examples:
    - Near Detector Physics at Neutrino Experiments (July '18)

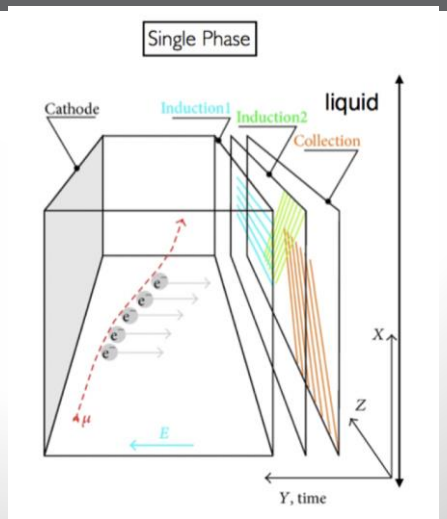
      https://indico.cern.ch/event/721473/
    - Neutrino Platform Week (January '18)

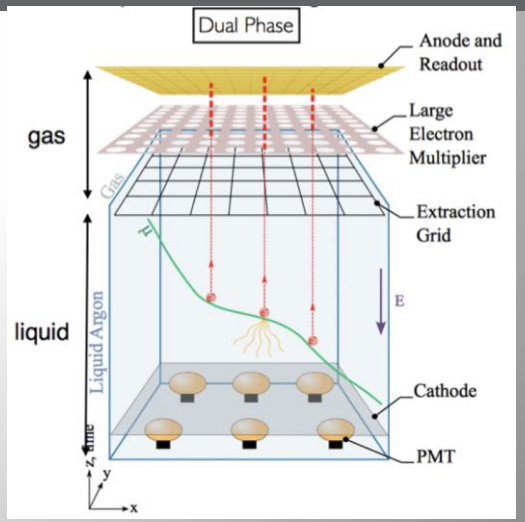
      https://indico.cern.ch/event/645835/
  - So far no strong attention to/ focus on neutrino-nucleus interactions. Apply for TH visitor!
- Liaise with CERN-EP neutrino group on the physics program.

The DUNE Experiment



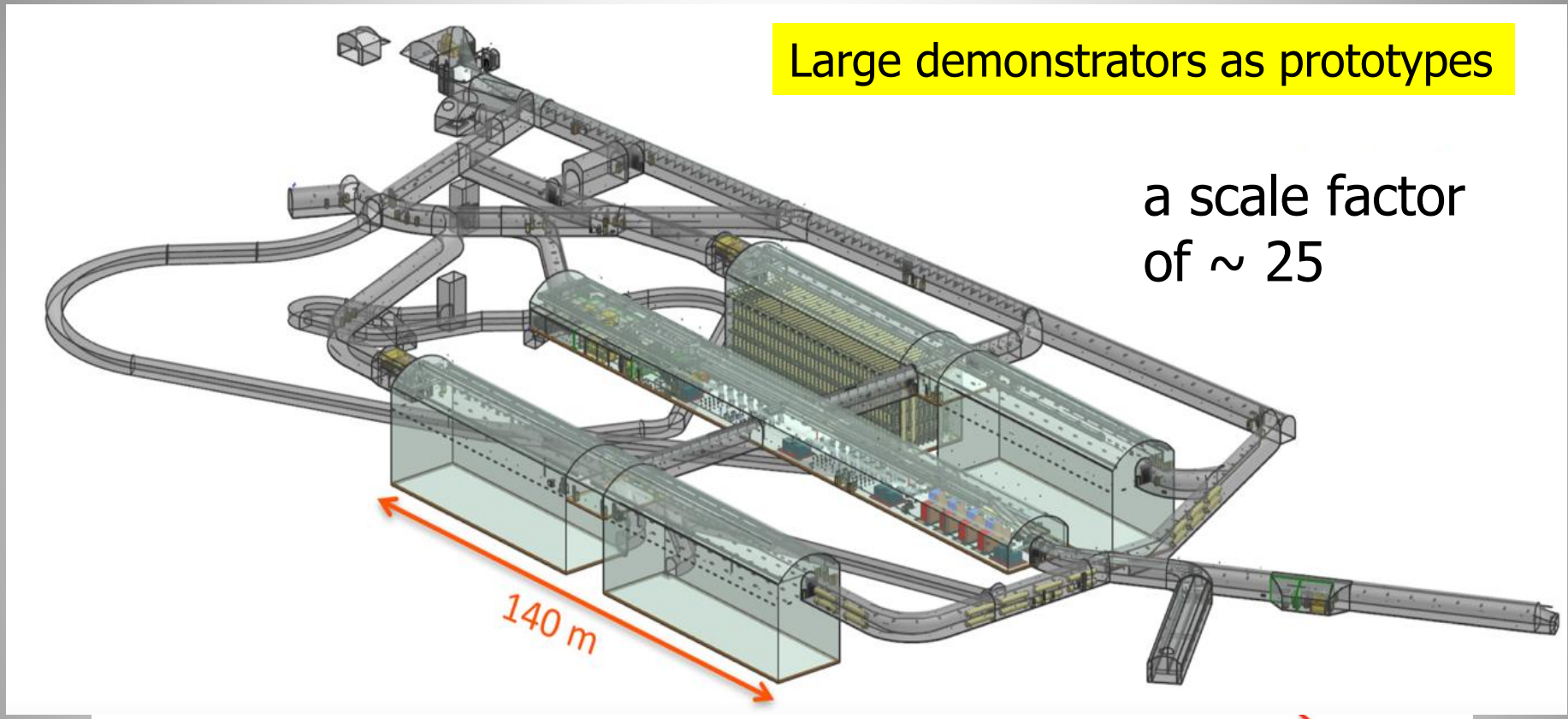
More than 1100 collaborators

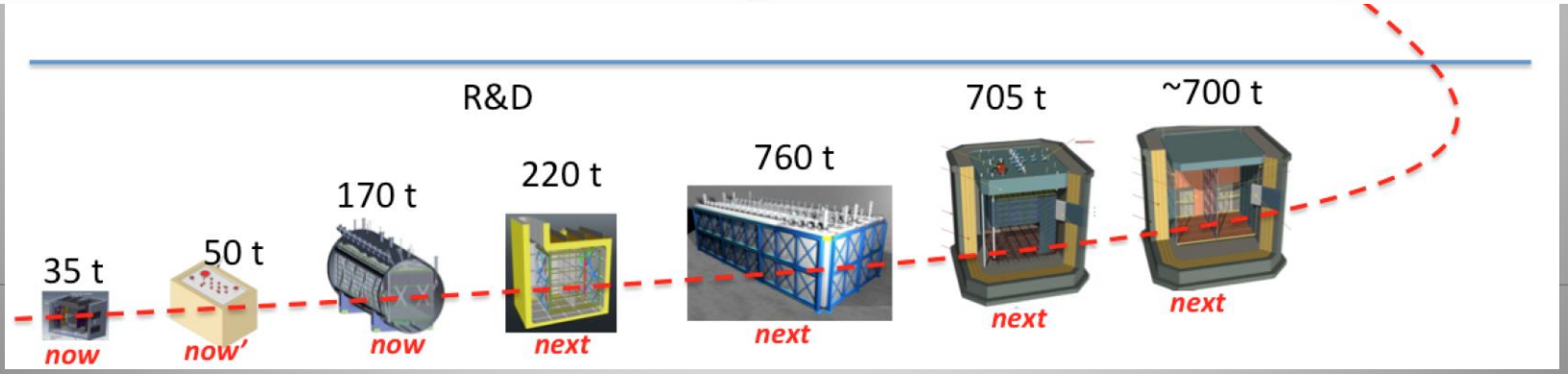




Far Detector Technology: LArTPC

DUNE LarTPCs: Step by Step Approach



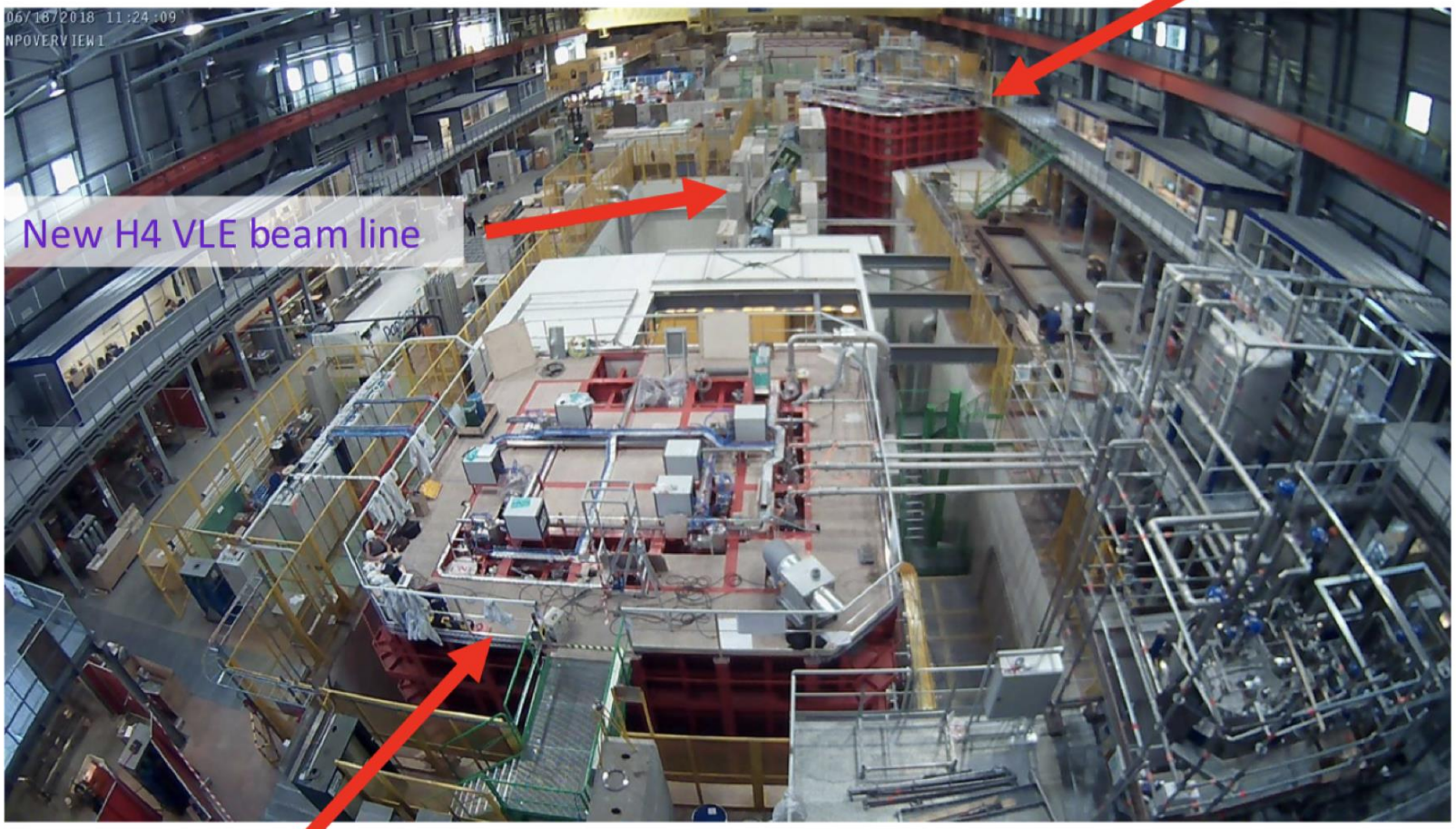


ProtoDUNE Area

Next step : ~800 ton LAr prototypes

ProtoDUNE

- The two ProtoDUNEs are hosted at the EHN1 extention



Keep up to date here: http://cenf-ehn1-np.web.cern.ch/multimedia/images

ProtoDUNE

- Very large involvement from both the Neutrino Platform and the EP Neutrino group
  - The main focus for many members of the group for the coming months of data taking

- Many important leadership roles:
  - Run coordination
  - Computing
  - Beam simulation
  - Data quality monitoring
  - Event reconstruction
  - Data analysis

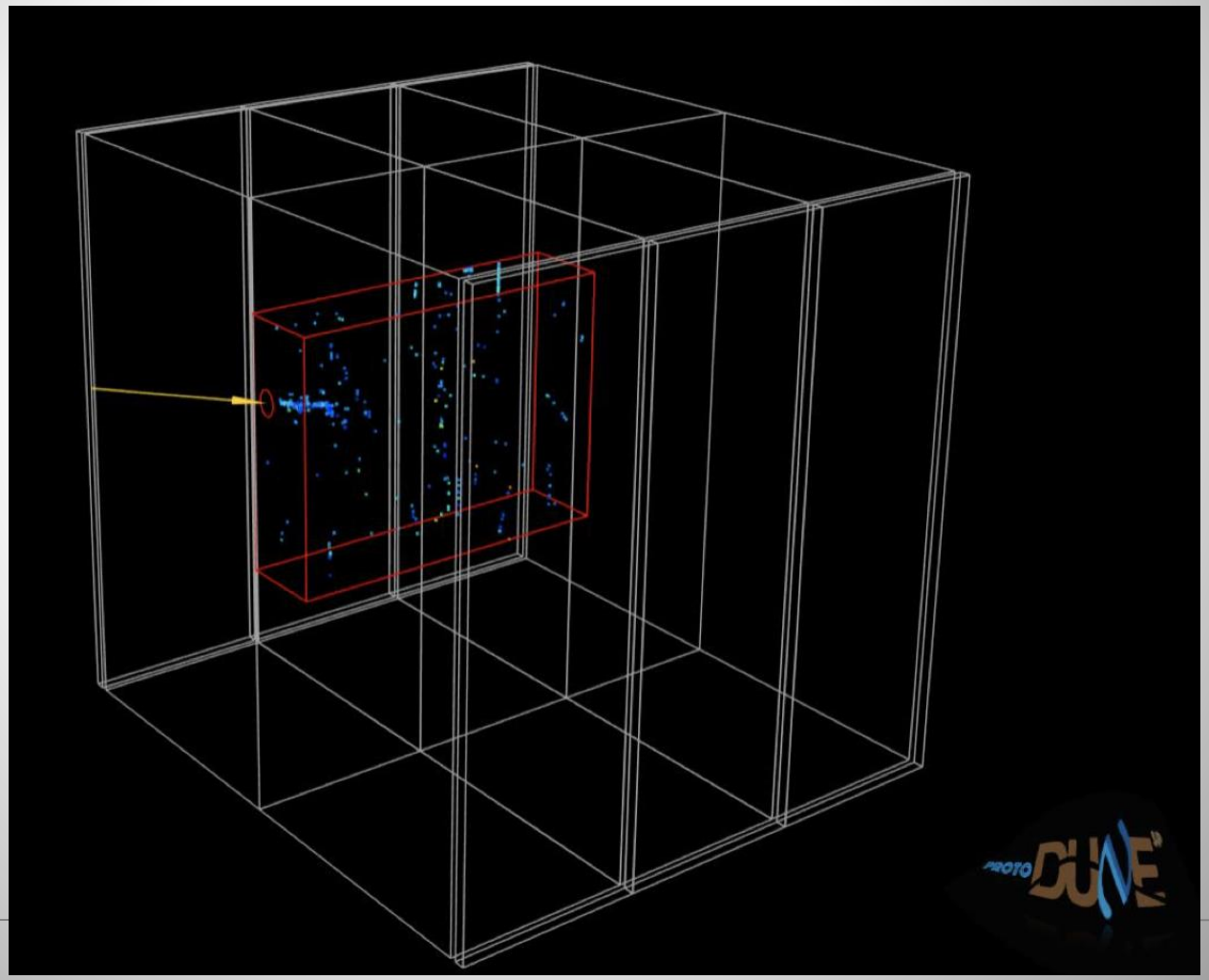
ProtoDUNE

Nominal HV of 180 kV reached

21 Sep 2019

The Beam…

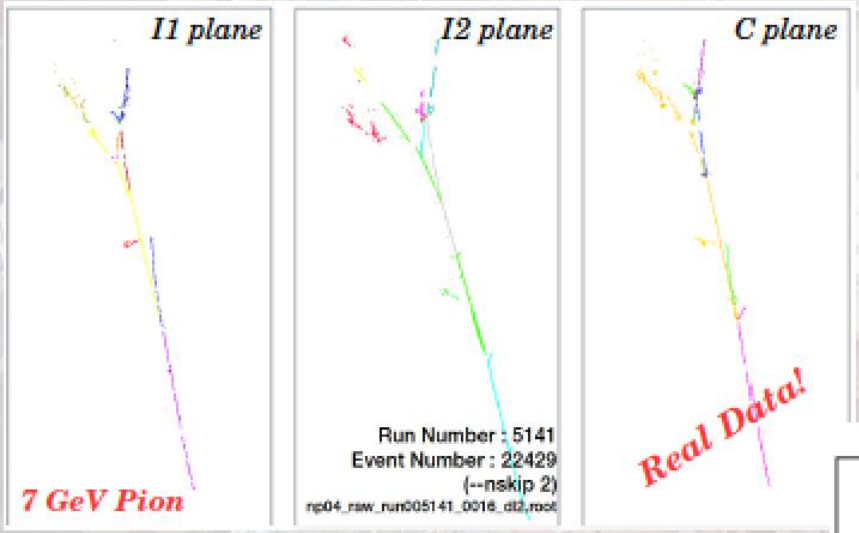
2 October: first glimpse of the beam (1 GeV positron)
…Very faint as the purity was only just enough



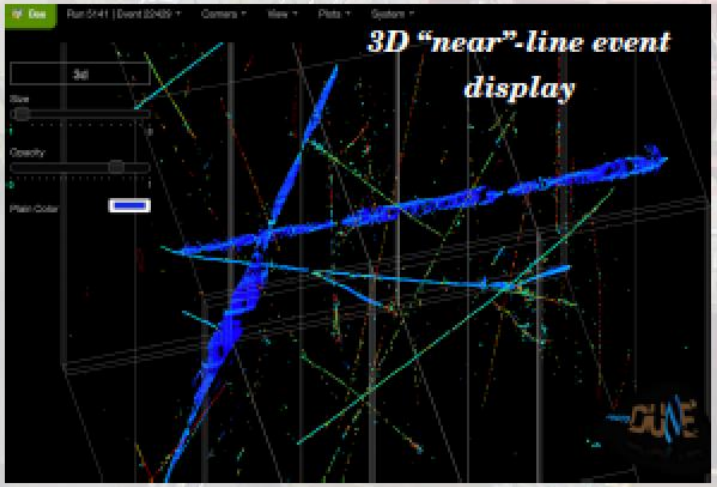
Events in the LarTPC

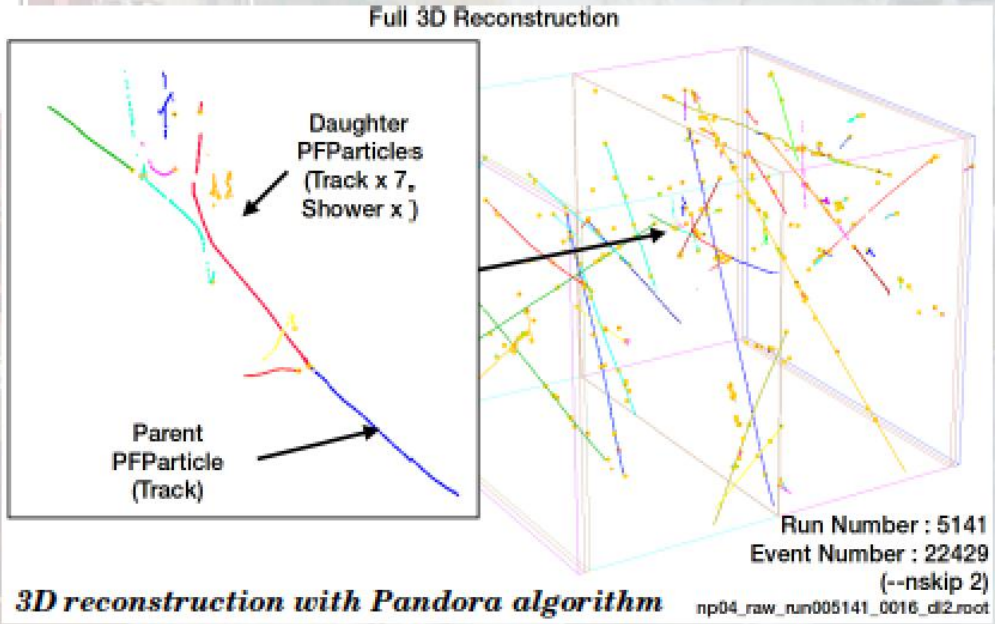
ProtoDUNE provides a test bed to develop the LAr event reconstruction algorithms to be used in DUNE

Test Beam Data



- 7 GeV Pion from beam reconstructed with Pandora algorithm both in 2D and 3D
- The algorithm correctly distinguish parent from daughter particle and identify it as a beam event...





Events in the LarTPC

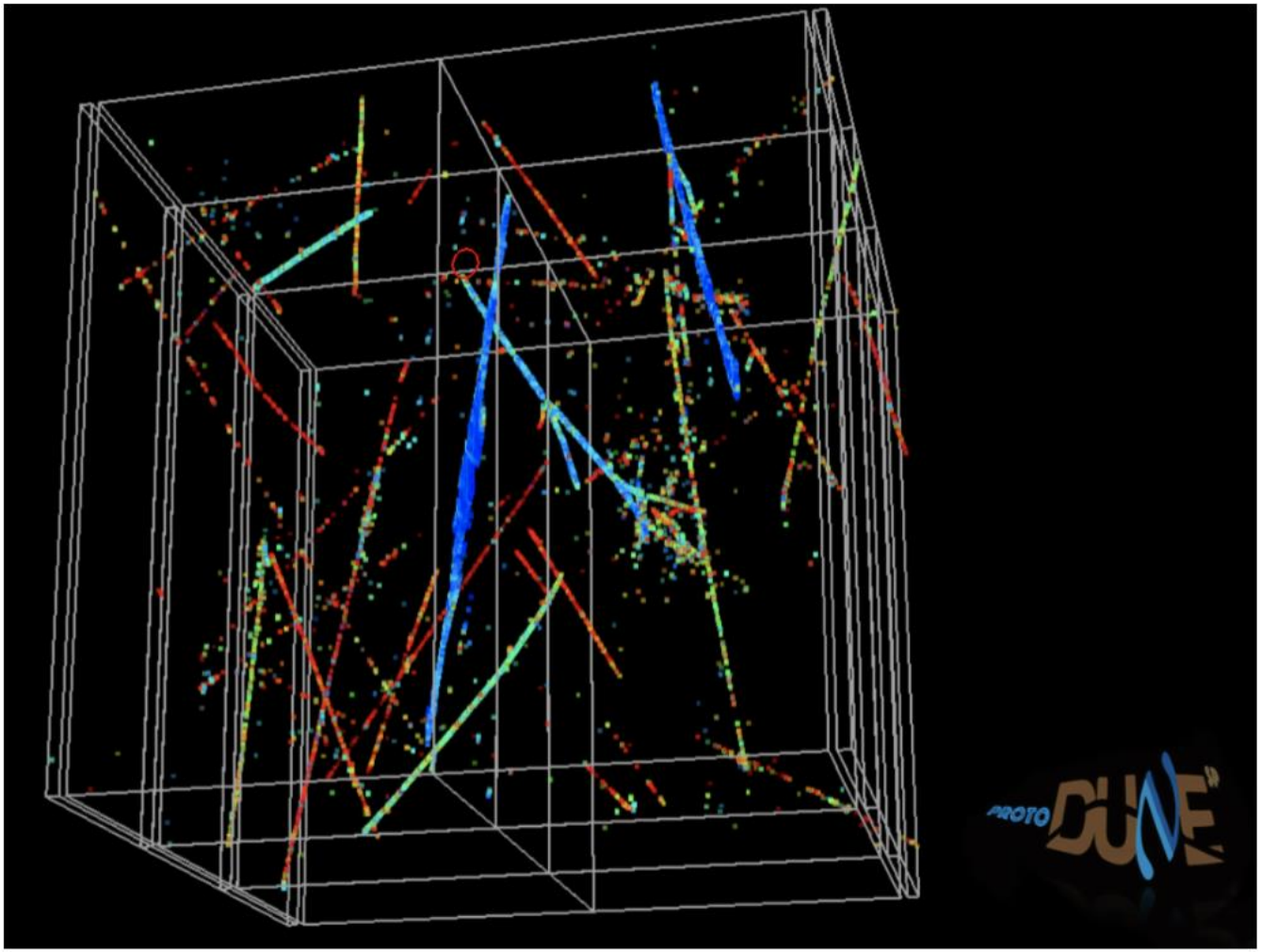
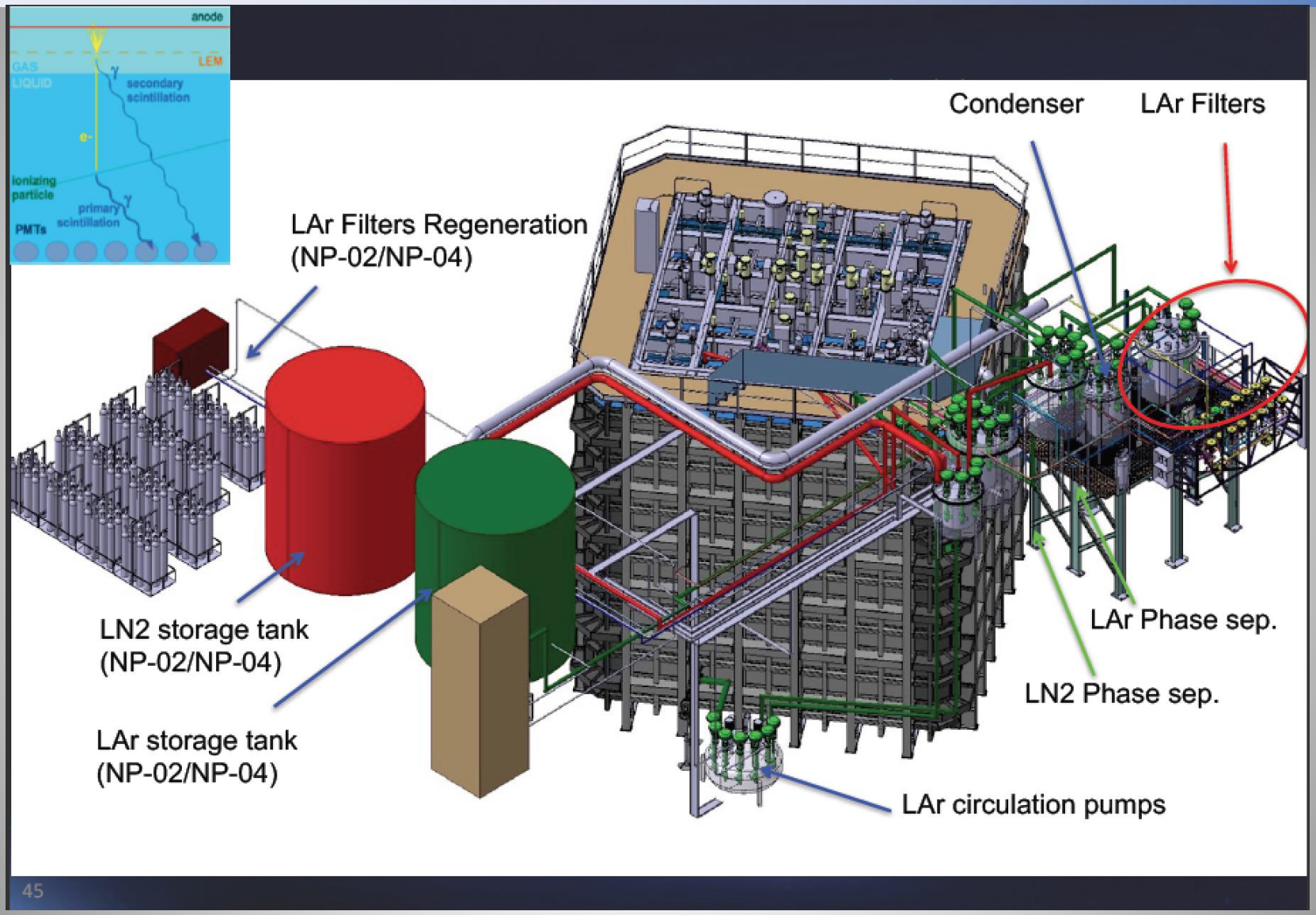


Figure 3: A reconstructed test-beam π^+ (entering the TPC from the red circle) interacting inside ProtoDUNE-SP with a number of coincident cosmic ray muons.

Double Phase DUNE Prototype

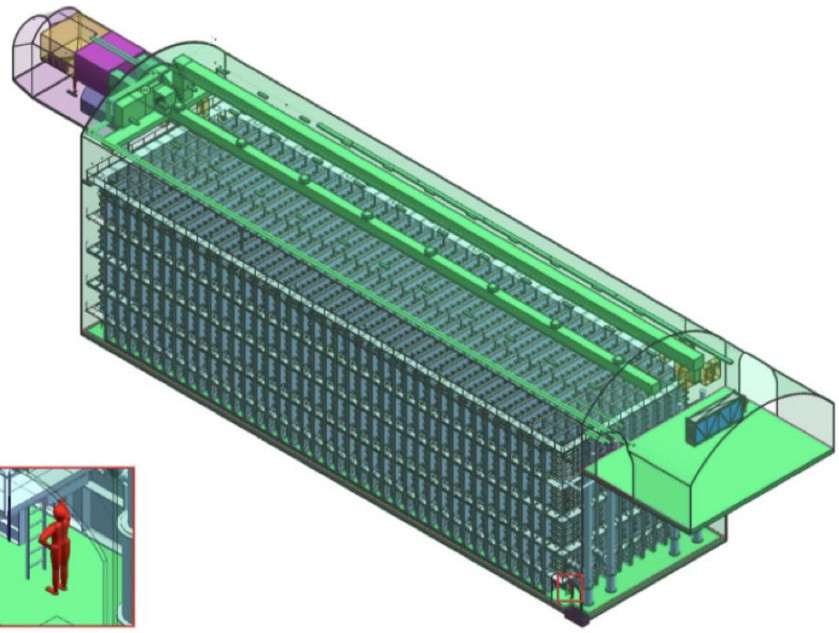


DP ProtoDUNE installation ongoing. Cryostat closure foreseen in January 2019

DUNE

- CERN responsible for the design and construction of the DUNE FD cryostat
  - Close collaboration with GTT to port their LNG transport ship technology to LAr detectors
  - These will be approximately 20 times larger than the ProtoDUNE cryostats

- Strong involvement in the HV system for both technologies:
  - HV feedthroughs
  - Cathode
  - Field cages
  - Monitoring



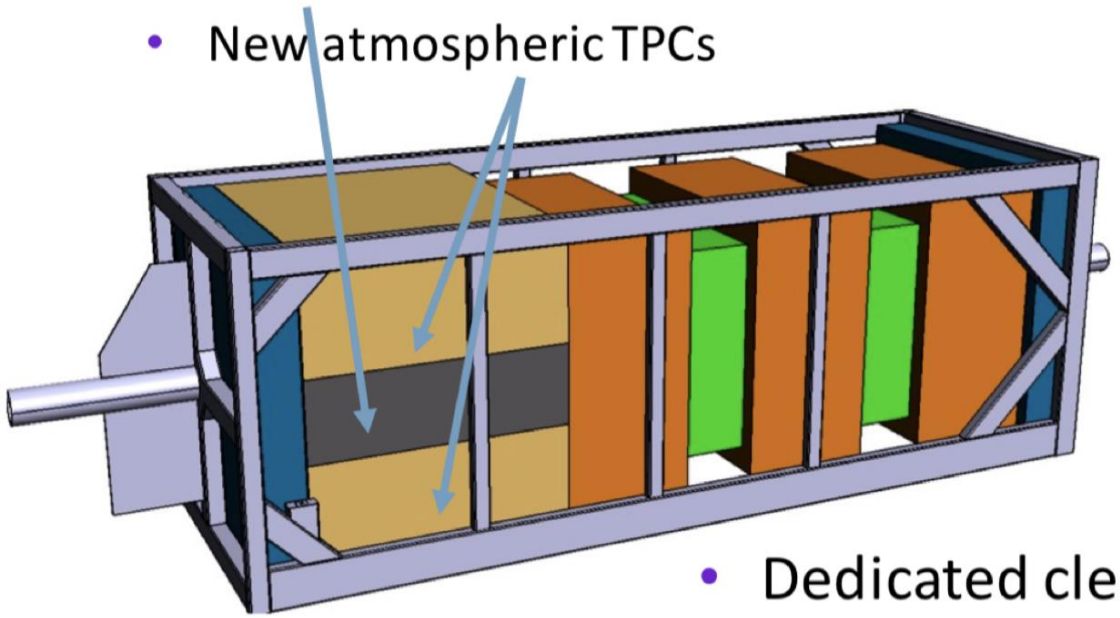
Further activities
- Near Detector Technology tests

T2K ND280 Upgrade

Since start of 2018: Exploring the option to participate in T2K-Upgrade

the T2K ND280 Upgrade project

- Specific involvement in:
  - SuperFGD
  - New atmospheric TPCs



The T2K-ND280 upgrade proposal

P. Hamacher-Baumann, L. Koch, T. Radermacher, S. Roth, J. Steinmann

RWTH Aachen University, III. Physikalisches Institut, Aachen, Germany

V. Berardi, M.G. Catanesi, R.A. Intonti, L. Magaletti, E. Radicioni

INFN and Dipartimento Interateneo di Fisica, Bari, Italy

O. Beltramello, S. Bordoni, R. de Oliveira, A. De Roeck, R. Guida, D. Mladenov, M. Nessi, F. Pietropaolo, F. Resnati

CERN, Geneva, Switzerland

A. Marino, Y. Nagai, E. D. Zimmerman

University of Colorado at Boulder, Department of Physics, Boulder, Colorado, U.S.A.

C. Bronner, Y. Hayato, M. Ikeda, Y. Kataoka, M. Nakahata, Y. Nakajima, Y. Nishimura, H. Sekiya

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S.Fedotov, M.Khabibullin, A.Khotjantsev, A.Kostin, Y.Kudenko, A.Mefodiev, O.Mineev, A.Smirnov, S.Suvorov, N.Yershov

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J. Boix, M. Cavalli-Sforza, C. Jesus, M. Leyton, T. Lux, J. Mundet, F. Sanchez

Institut de Fisica d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Bellaterra Spain

E. Atkin, P.J. Dunne, P. Jonsson, R.P. Litchfield, K.R. Long, W. Ma, T. Nonnenmacher, J. Pasternak, J. Pozimski, A. Sztuc, Y. Uchida, W. Shorrock, M.O. Wascko, C.V.C. Wret

Imperial College, London, United Kingdom

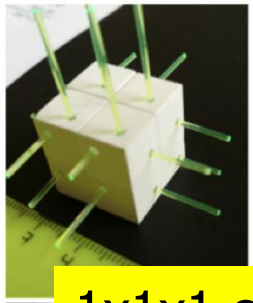
CERN-SPSC-2018-001 / SPSC-P-357
09/01/2018

- Dedicated clean area at EHN1 for continued ND280 upgrade tests with cosmic rays

Data taking: ~ 2021

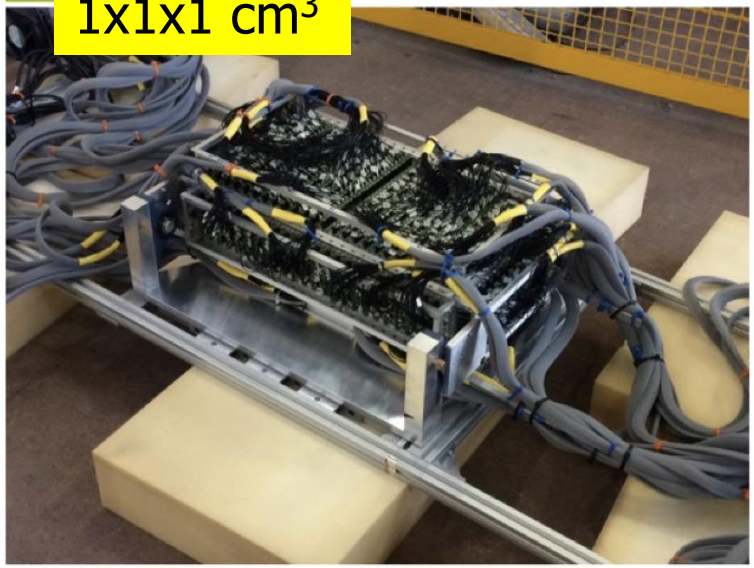
ND280 Upgrade Testbeams

- Prototypes of the new TPCs and the Super-FGD were tested in the T9 testbeam this summer

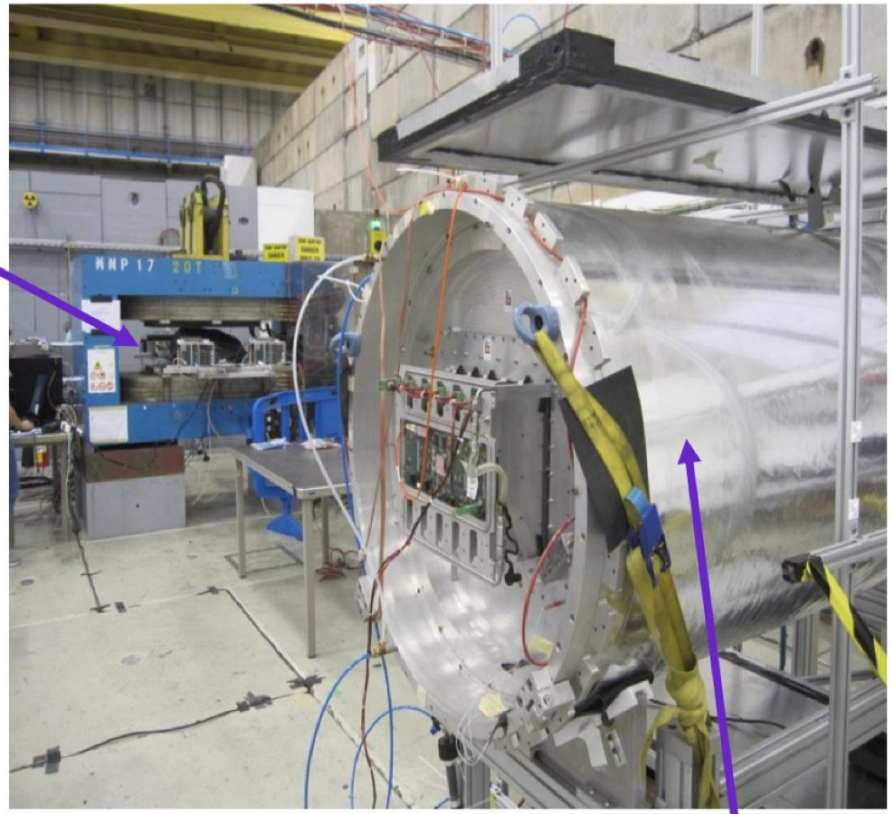


SuperFGD located inside MNP17 magnet in B-field between 0.2 and 0.7T

1x1x1 cm^3



Concept described in JINST 13 P02006 2018



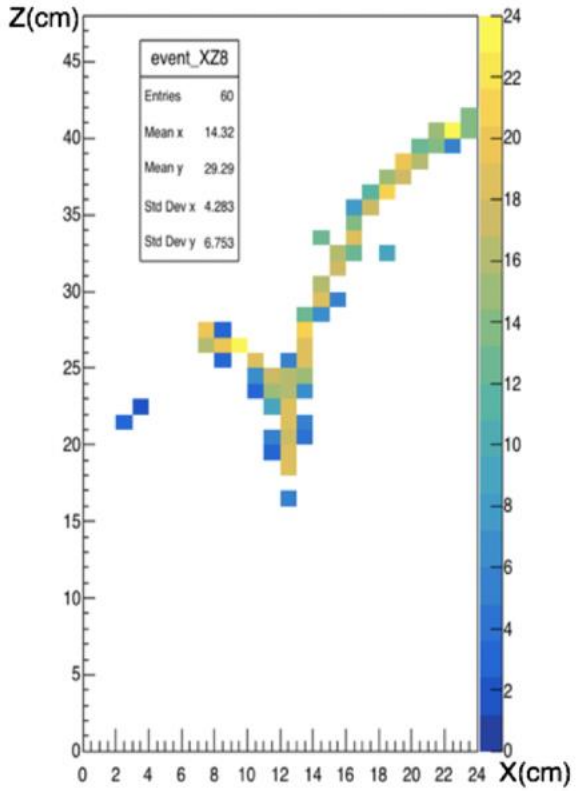
TPC upstream of the SuperFGD

ATTRACT proposal for 3D cube printing. Also relevant for DUNE ND design studies

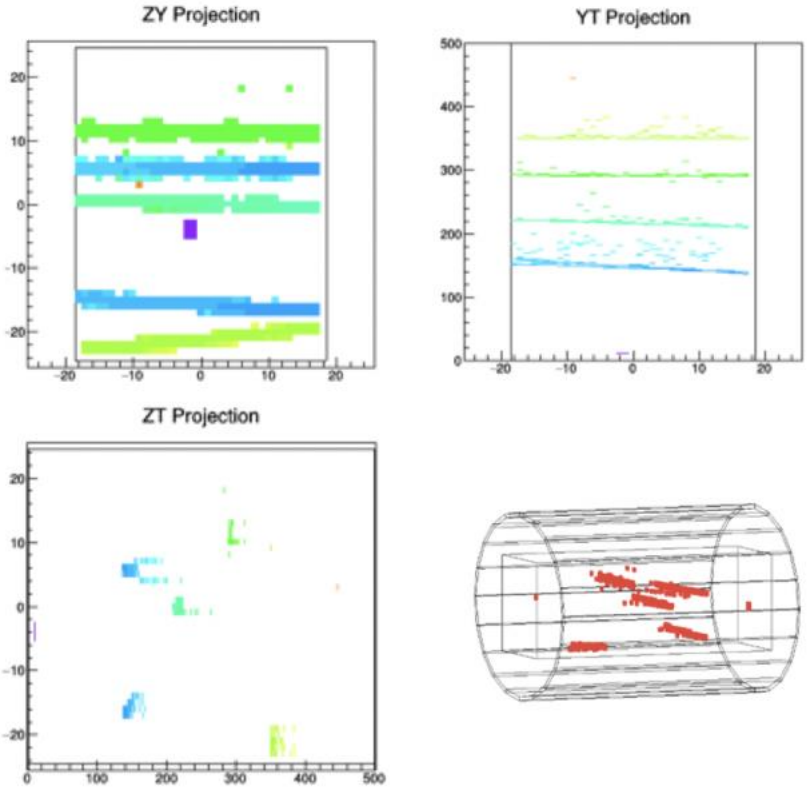
ND280 Upgrade Testbeams

- Prototypes of the new TPCs and the SuperFGD were tested in the T9 testbeam this summer

Photon conversion in the SuperFGD



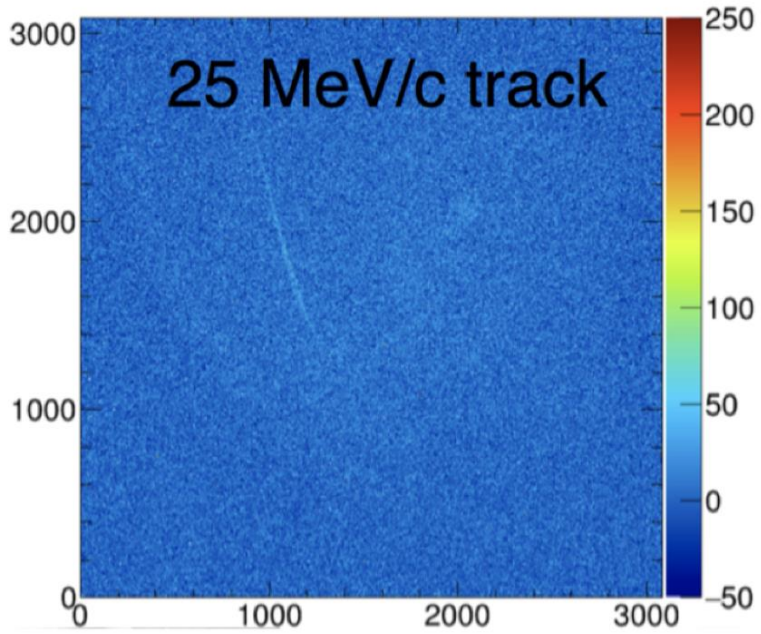
Electrons in the TPC during photon beam



High Pressure Argon TPG

- Prototype high pressure argon TPC currently in the T10 testbeam

- Designed to make neutrino cross section measurements with a very low energy threshold on final state particles (particularly protons)

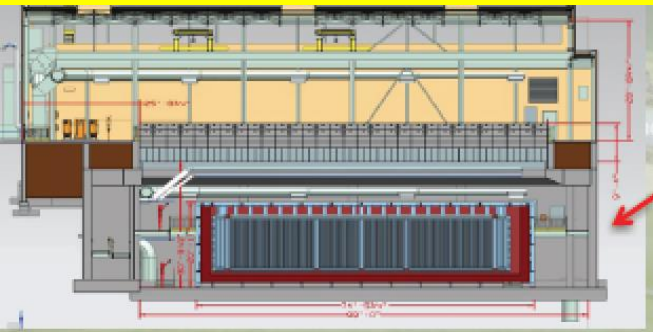


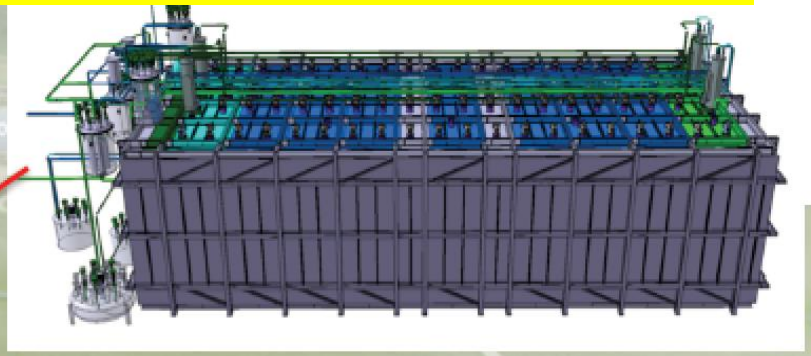
Also relevant for DUNE ND design studies

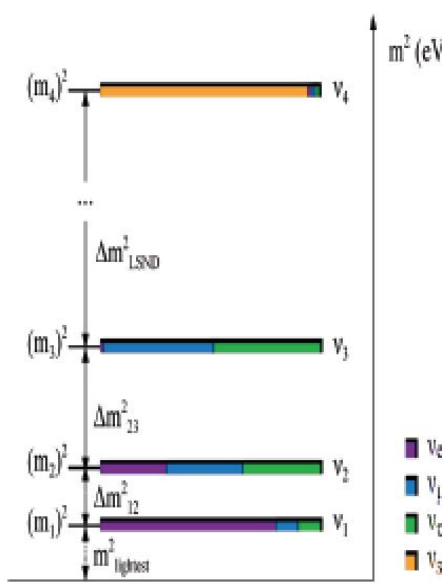
SBL @ FNAL

A Multi-detector program will address the unexplained anomalies which together could be hinting at new physics (steriles?)

Installation has been delayed till end 2018
Filling and commissioning to starting 2019. Data 2nd part of 2019







MiniBooNE/LSND Excess??

ICARUS T600	MicroBooNE	SBND
476t Active Mass	89t Active Mass	112t Active Mass

Protons

EP Neutrino Group and NA61/SHINE

EP-Nu has been invited as a limited member of NA61/SHINE experiment. This does not involve financial contributions.

EP-Nu will only contribute to the Neutrino aspect of the program eg studies (measurements/reconstruction/ deep learning techniques) on hadro-production eg on a mock DUNE/T2K target

- Also recently co-signed an addendum to the NA61/SHINE proposal to the SPSC

The NA61/SHINE Collaboration:

A. Aduszkiewicz[18], E.V. Andronov[24], T. Antićić[3], N. Antoniou[8], B. Baatar[22], M. Baszczyk[16], S. Bhosale[13], A. Blondel[26], M. Bogomilov[2], A. Brandin[23], A. Bravar[26], W. Bryliński[20], J. Brzychczyk[15], S.A. Bunyatov[22], O. Busygina[21], A. Bzdak[16], S. Cao[10], H. Cherif[7], P. Christakoglou[8], M. Ćirković[25], T. Czopowicz[20], A. Damyanova[26], A. Datta[29], N. Davis[13], M. Deveaux[7], F. Diakonos[8], P. von Doetinchem[29], W. Dominik[18], P. Dorosz[16], J. Dumarchez[4], R. Engel[5], G.A. Feofilov[24], L. Fields[27], Z. Fodor[9,19], M. Friend[10], A. Garibov[1], M. Gaździcki[7,12], M. Golubeva[21], K. Grebieszkow[20], F. Guber[21], A. Haesler[26], T. Hasegawa[10], A.E. Hervé[5], S.N. Igolkin[24], A. Ivashkin[21], S.R. Johnson[28], K. Kadija[3], A. Kapoyannis[8], E. Kaptur[17], M. Kiełbowicz[13], V.A. Kireyeu[22], V. Klochkov[7], T. Kobayashi[10], V.I. Kolesnikov[22], D. Kolev[2], A. Korzenev[26], V.N. Kovalenko[24], K. Kowalik[14], S. Kowalski[17], M. Koziel[7], A. Krasnoperov[22], W. Kucewicz[16], M. Kuich[18], A. Kurepin[21], D. Larsen[15], A. László[9], T.V. Lazareva[24], M. Lewicki[19], K. Łojek[15], B. Łysakowski[17], V.V. Lyubushkin[22], M. Maćkowiak-Pawłowska[20], Z. Majka[15], B. Maksiak[20], A.I. Malakhov[22], D. Manić[25], A. Marchionni[27], A. Marcinek[13], A.D. Marino[28], K. Marton[9], H.-J. Mathes[5], T. Matulewicz[18], V. Matveev[22], G.L. Melkumov[22], A.O. Merzlaya[15], B. Messerly[30], Ł. Mik[16], S. Morozov[21,23], S. Mrówczyński[12], Y. Nagai[28], T. Nakadaira[10], M. Naskręt[19], V. Ozvenchuk[13], A.D. Panagiotou[8], V. Paolone[30], M. Pavin[4,3], O. Petukhov[21,23], R. Płaneta[15], P. Podlaski[18], B.A. Popov[22,4], M. Posiadała[18], D.S. Prokhorova[24], S. Puławski[17], J. Puzović[25], W. Rauch[6], M. Ravonel[26], R. Renfordt[7], E. Richter-Wąs[15], D. Röhrich[11], E. Rondio[14], M. Roth[5], B.T. Rumberger[28], A. Rustamov[1,7], M. Rybczynski[12], A. Rybicki[13], A. Sadovsky[21], K. Sakashita[10], K. Schmidt[17], T. Sekiguchi[10], I. Selyuzhenkov[23], A.Yu. Seryakov[24], P. Seyboth[12], A. Shukla[29], M. Słodkowski[20], A. Snoch[7], P. Staszel[15], G. Stefanek[12], J. Stepaniak[14], M. Strikhanov[23], H. Ströbele[7], T. Šuša[3], M. Tada[10], A. Taranenko[23], A. Tefelska[20], D. Tefelski[20], V. Tereshchenko[22], A. Toia[7], R. Tsenov[2], L. Turko[19], R. Ulrich[5], M. Unger[5], F.F. Valiev[24], M. Vassiliou[8], D. Veberič[5], V.V. Vechernin[24], M. Walewski[18], A. Wickremasinghe[30], Z. Włodarczyk[12], A. Wojtaszek-Szwarc[12], O. Wyszyński[15], L. Zambelli[4,10], E.D. Zimmerman[28], and R. Zwaska[27]

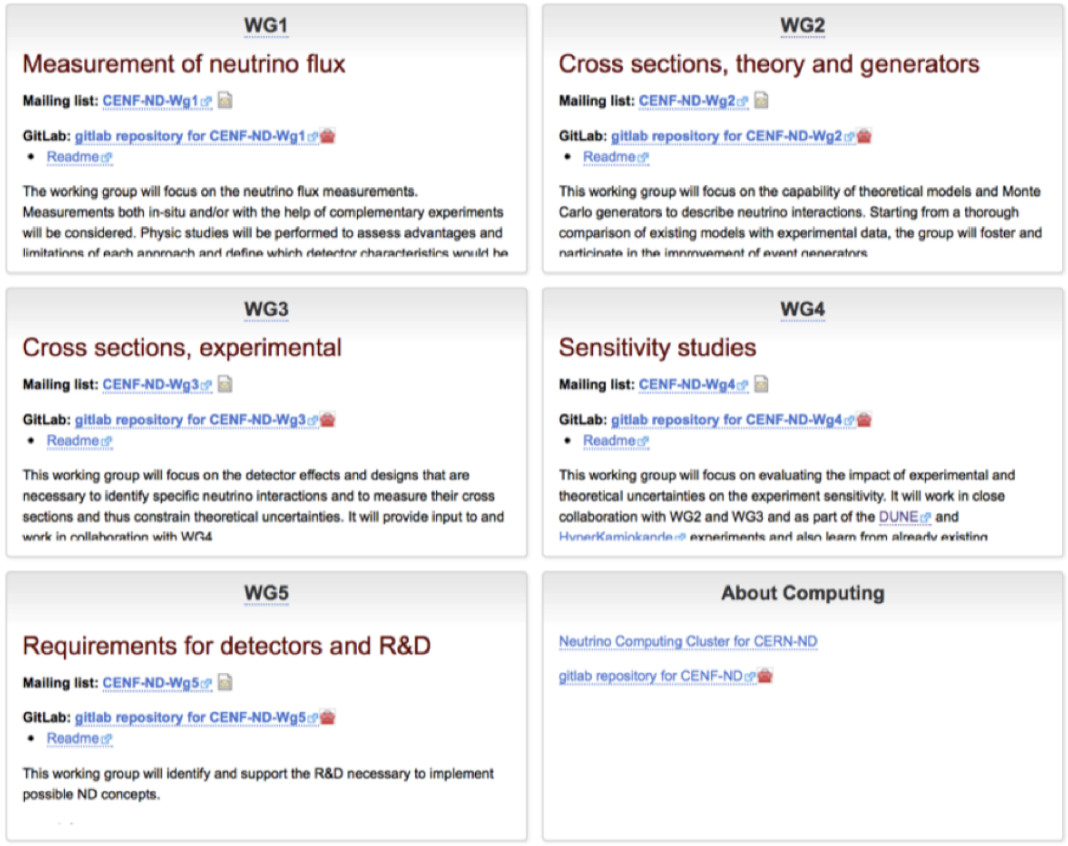
The CERN Team:

Nektarios Benekos (EP-NU), Stefania Bordoni (EP-NU), Nikolaos Charitonidis (EN)[1], Reyes Fernandez (BE), Umut Kose (EP-NU), Paolo Martinengo (EP-DT), Albert de Roeck (EP-NU), Davide Sgalaberna (EP-NU), Alfons Weber (EP-NU), Leigh Whitehead (EP-NU)

CENF-ND Near Detector Forum

Generic study of near detector topics to engage (European) community

- Set up to foster collaboration within Europe and beyond for the development of Near Detectors for future long-baseline neutrino oscillation experiments
- Five working groups dedicated to different aspects of NDs
- Organizers
  - Paola Sala
  - Stefania Bordoni
  - Alfons Weber
  - Marco Zito

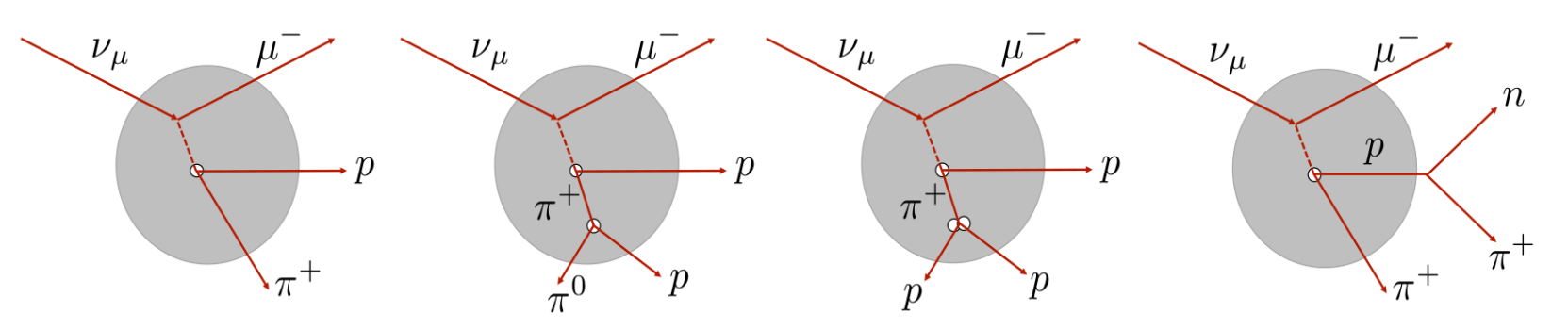


https://twiki.cern.ch/twiki/bin/view/CENF/NearDetector

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

- Hub to provide support to the ongoing efforts of the LBN collaborations, strengthen the European support, attract new institutes, endorse participation from Japanese and American Institutes.
- Work organised in 5 WGs (flux, cross-section, R&D..) in close collaboration with existing frameworks and groups
- Activity started in July 2017, more than 100 participants registered
- Video meetings, Workshop at CERN, visiting and projects for student are organized.
- ESG contribution planned for December 2018

Pion-Argon Interaction Cross Sections



- Use the 2018 SP-DUNE beam data for tuning of hadron nucleus interactions and nucleon structure models
- Measure inclusive and exclusive cross sections
- Contribute to reduce the systematics for future Neutrino measurements

arXiv:1706.07081

2018: ProtoDUNE TDR Plans

- Beams of e, mu, and hadrons (pions, proton, kaons)
- Beam energies from 0.5 to GeV
- Inclusive and exclusive pion-Argon cross sections
- …proton-Argon cross sections
- …electron-Argon cross sections

arXiv:1706.07081

Momentum Bins (GeV/c)	# of Spills per Bin	# e^+ per Bin	Beam Time per Bin (days)
0.5, 06, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7	5000	300K	1.4

Possible run scenario

P (GeV/c)	# of Spills	# of e^+	# of K^+	# of μ^+	# of p	# of π^+	Total # of Events	Beam Time (days)
1	70K	84K	≈ 0	70K	689K	625K	1.5M	19.4 days
2	16K	19K	9K	36K	336K	572K	1.0M	4.4 days
3	13K	16K	26K	17K	181K	540K	780K	3.6 days
4	11K	13K	19K	16K	107K	510K	660K	3.1 days
5	11K	13K	29K	13K	96K	510K	660K	3.1 days
6	11K	13K	36K	12K	94K	510K	660K	3.1 days
7	11K	13K	42K	8K	87K	510K	660K	3.1 days
Total	143K	171K	161K	172K	1.6M	3.8M	5.9M	39.7 days

2018: ProtoDUNE Data Taking

of triggers for each particle type for the different beam energies

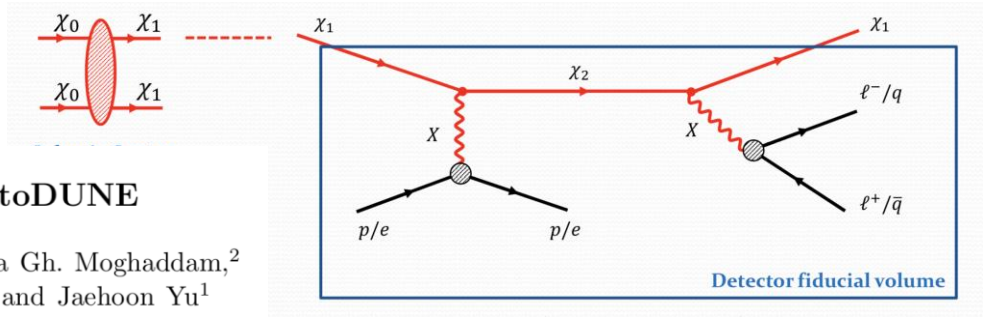
	Cumulative Triggers	Cumulative Pi-like Triggers	Cumulative Proton-like Triggers	Cumulative E-like Triggers	Cumulative K-like Trig
7 GeV	343707	58429	112971	28248	
1 GeV	381843	420863	262734	0	
2 GeV	333067	128115	173567	5432	
6 GeV	394543	70183	197023	27930	
3 GeV	284111	107560	113241	15618	
0.5 GeV	1563	1563	296308	0	
0.3 GeV	0	0	242528	0	

Source:

https://docs.google.com/spreadsheets/d/1O4o9_q8F-KynQltKDAfmco3e_s1eKItFkzZ4-g_Vls0/htmlview#gid=0

Physics with ProtoDUNEs

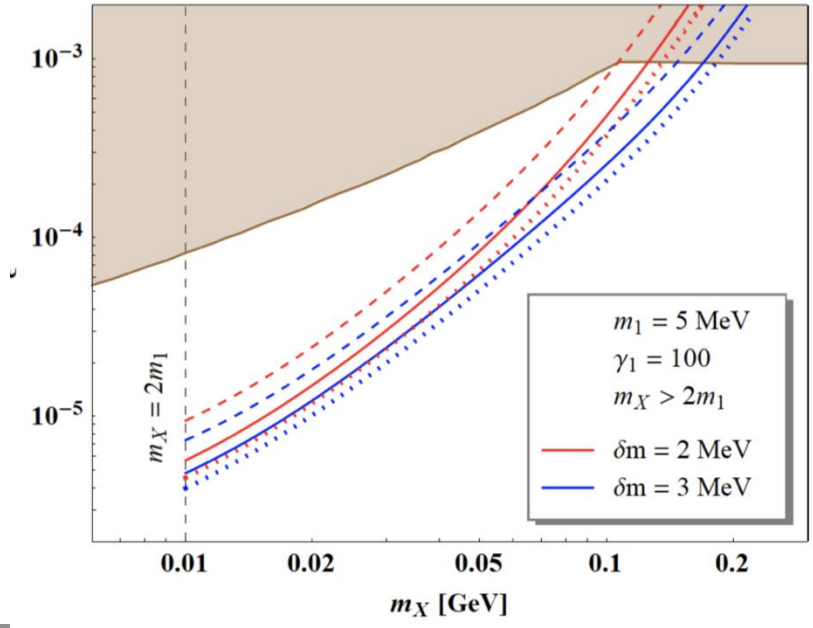
- A search for boosted dark matter: two component non-minimal dark matter model. χ_0 stable DM, χ_1 interacts with the SM particles:

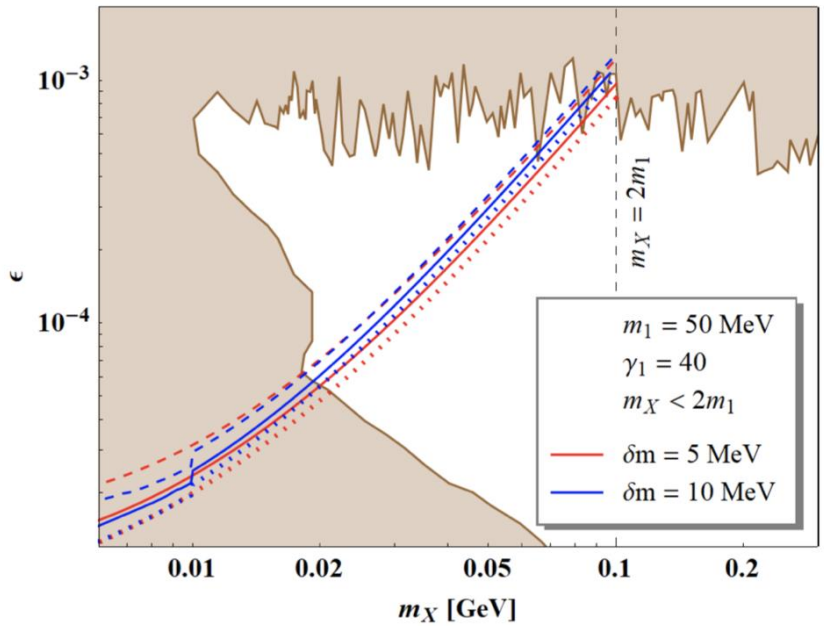


Search for Boosted Dark Matter at ProtoDUNE

Animesh Chatterjee,[1] Albert De Roeck,[2] Doojin Kim,[3] Zahra Gh. Moghaddam,[2] Jong-Chul Park,[4] Seodong Shin,[5,6] Leigh H. Whitehead,[2] and Jaehoon Yu[1]

arXiv:1803.03264



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Science & Technology Facilities Council
νSTORM
K. Long; 19 October 2018
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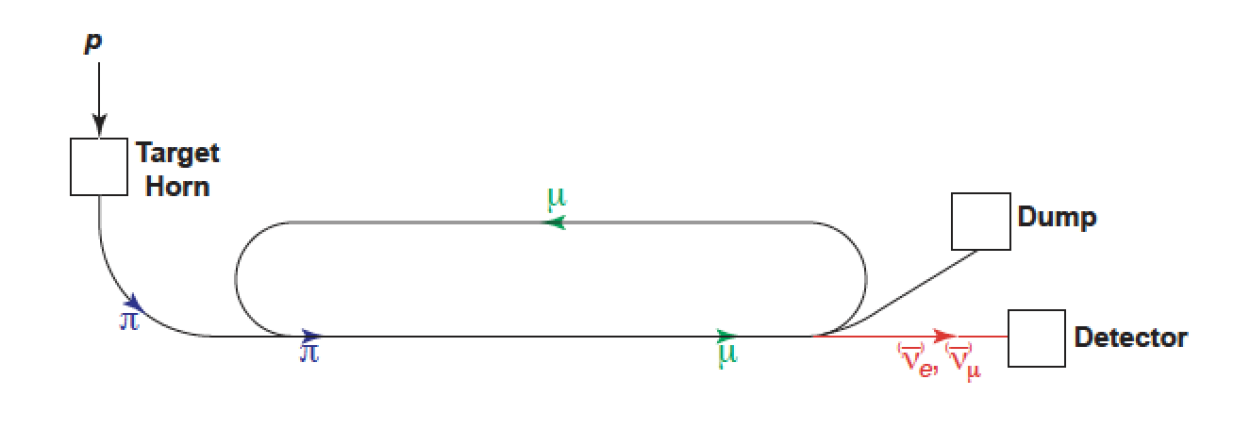
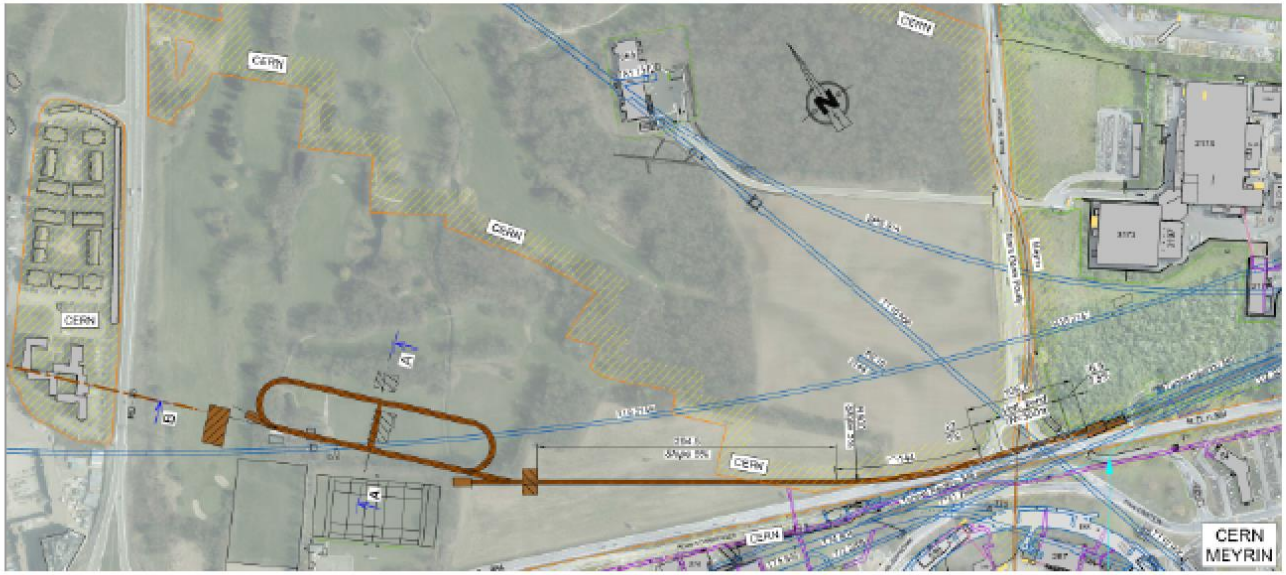
NuStorm Study

- NuSTORM@ CERN has been studied for the European Strategy Update in the context of the Physics Beyond Colliders working group
- It is not actually part of the PBC document other than just being mentioned
- A separate NuSTORM ESPP document will be submitted before 18 Dec (10 pages) –> Ken Long
- An accompanying longer document in preparation. Contains an accelerator detailed study of NuSTORM @ CERN using the SPS
- Conclusion: the existing CERN infrastructure is well tailored to implement and host NuSTORM

NuSTORM @ CERN



~ 3 km



Summary

- CERN offers a platform for neutrino detector R&D and construction. The EP-NU group engages with the neutrino analyses in experiments. The group is still growing…
- Present projects: ICARUS/SBN, DUNE & ProtoDUNE, T2K-Upgrade, Near Detector Forum and ND detector R&D, NA61. Plan to keep on top of deep learning technique
- ProtoDUNE data from beams is arriving! (Single Phase). Actively involved in data analysis and preparation of hadron-Argon cross section measurements -> physics papers
- SPSC called for future projects for Neutrino Platform…