LPNHE activities in T2K

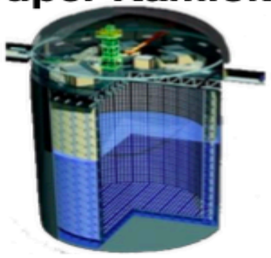
Claudio Giganti for the LPNHE neutrino group

- Strong contribution of LPNHE group on T2K-II and the Near Detector upgrade
  - CG → coordinator of ND upgrade and member of the T2K Executive Committee
  - MG → convener of the ND280 reconstruction group
  - BP → coordinator of NA61 analyses for T2K, coordinator of ND280 working group
- Our goal is to install the ND280 upgrade at J-PARC in 2023 and prepare the tools to exploit the first ND upgrade data
  - In particular we are leading the efforts for the development of the High-Angle TPCs reconstruction
- These activities are only possible thanks to the invaluable help of postdocs and PhD students (see Boris slides)
- Need to reinforce the LPNHE neutrino group to fully exploit T2K-II (and HK!)

T2K experiment

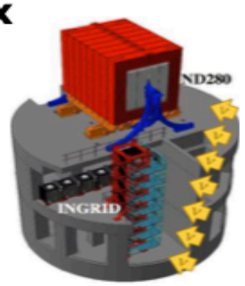
Far detector

Super Kamiokande



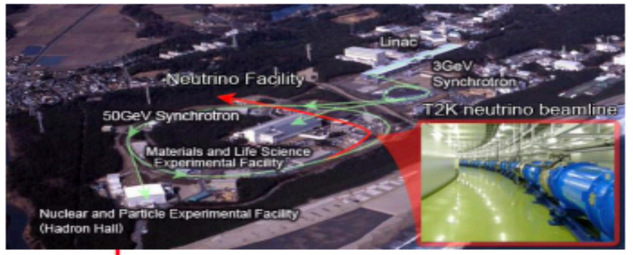
Near detector

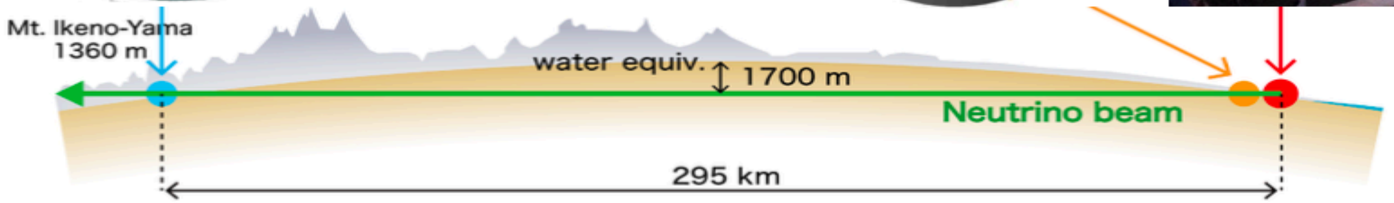
complex



J-Parc

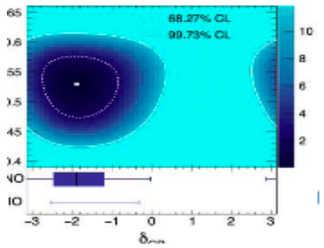
Neutrino Beam

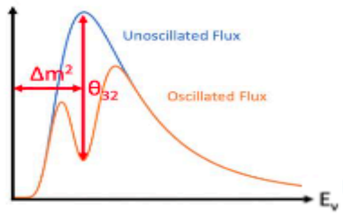




@SK

Measure oscillated beam

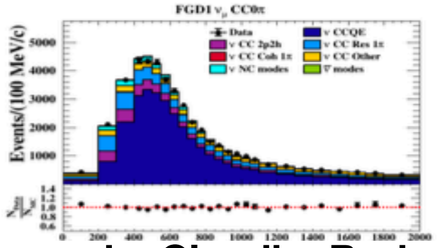




Oscillation analysis:
FD: Mathieu, Lucile, Claire
ND: Adrien, Vlada

@ND280

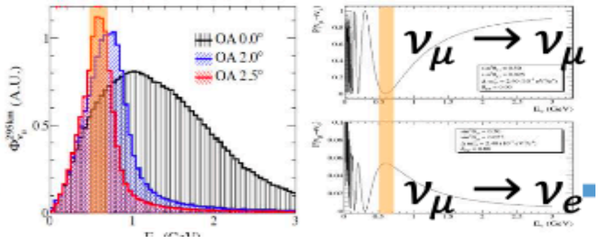
Characterize beam and ν interactions



ND280 upgrade: Claudio, Boris, Mathieu, Marco M, Marco Z
William, Adrien, Sergey, Vlada, Ulysse, Anaelle, Lavinia

@J-PARC

Create Neutrino's off-axis beam ν_μ or $\bar{\nu}_\mu$



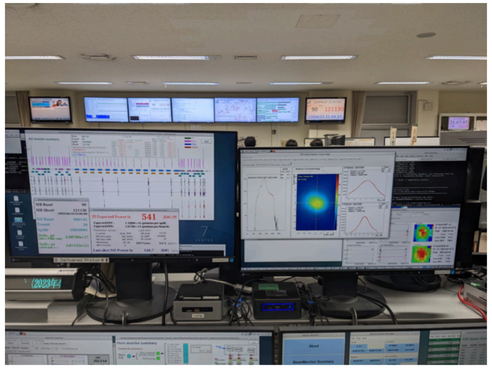
NA61: Boris, Jacques, Claire

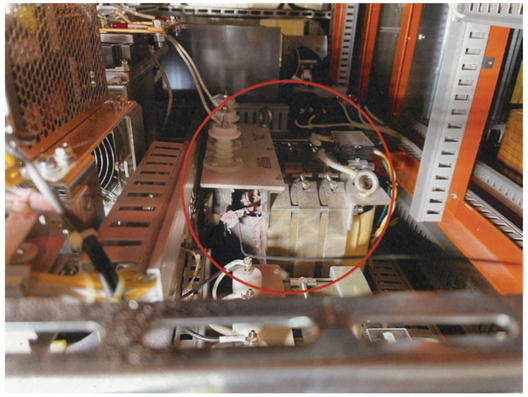
Beamline status and prospects

First continuous beam running with 1.36s repetition rate:

- 2023/4/23, 05:00 ∼ 09:00
  - Continuous running at 120-250kW
- 2023/4/23 21:00 ∼ 4/24 9:20
  - Continuous running at 390kW
- 2023/4/24 20:00∼
  - Continuous running at 540kW → T2K record beam power!
  - Beam loss in neutrino primary beamline a bit higher than previous runs (due to enlarged MR septum aperture?)
  - Generally ran smoothly at 540kW

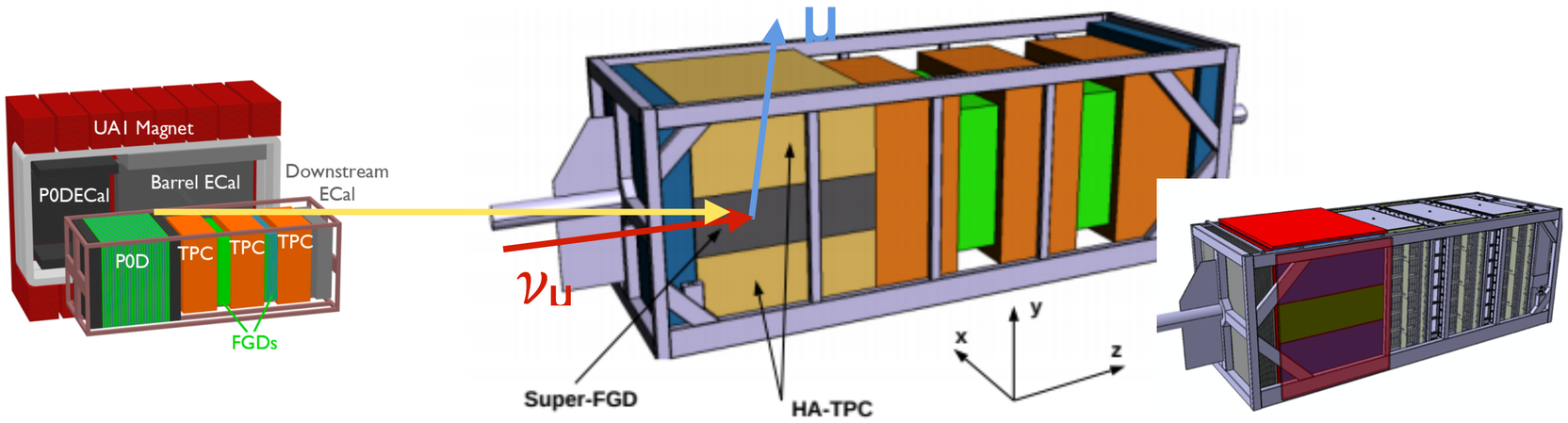
MR vacuum baking much more smooth/quick than usual



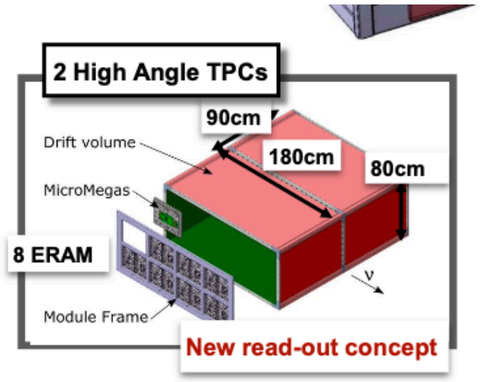


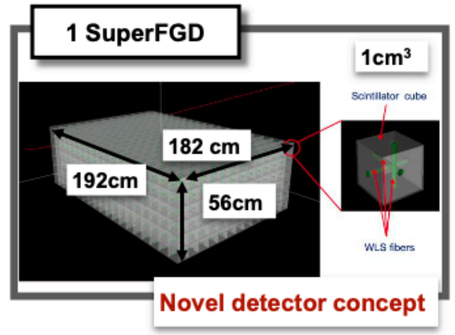
- After the long shutdown for beamline upgrade beam was restarted in April
- After 1 day of tuning we could run smoothly at 540 kW and were ready for higher beam power → fire on a new transformer for MR power supply while beam was off
- Took some time to fix it and take appropriate counter measurements
- Beam was supposed to restart in June for few days just before summer shutdown → another fire in the hadron hall…
- Continous beam from November (how much will depend on ongoing budget negociations with MEXT…)

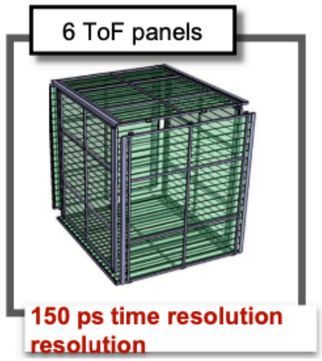
ND280 Upgrade



- One horizontal highly segmented target (Super-FGD) → Improve reconstruction of hadronic part of the interaction and of low momentum leptons
- Two new High Angle TPCs → Improve reconstruction of high angle leptons
- 6 Time Of Flight planes → Reduce backgrounds entering from outside the Super-FGD

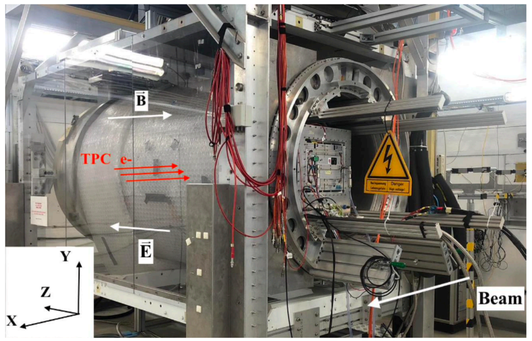


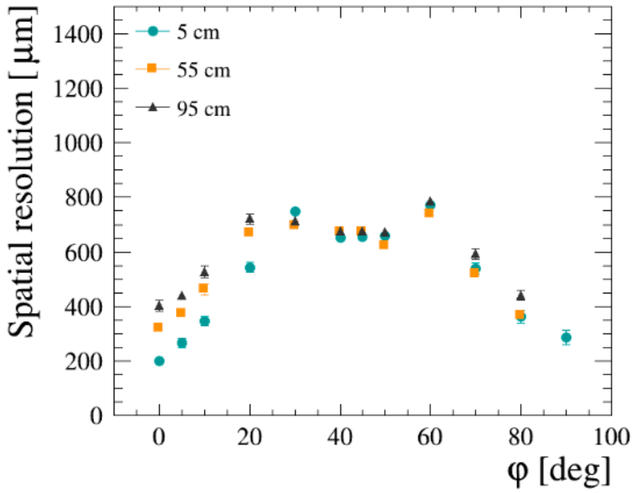


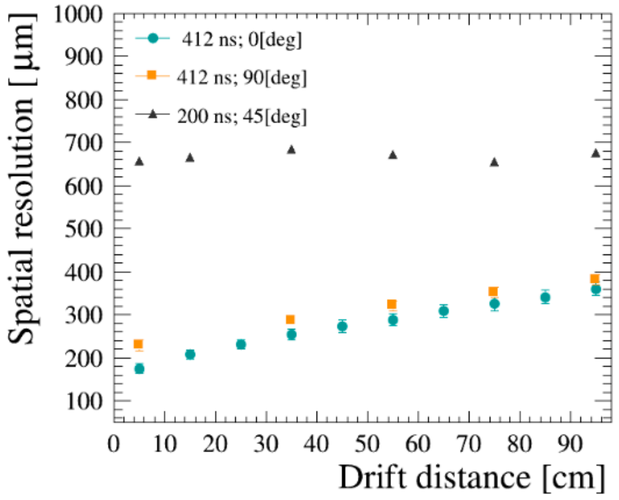


HA-TPC test beam analyses

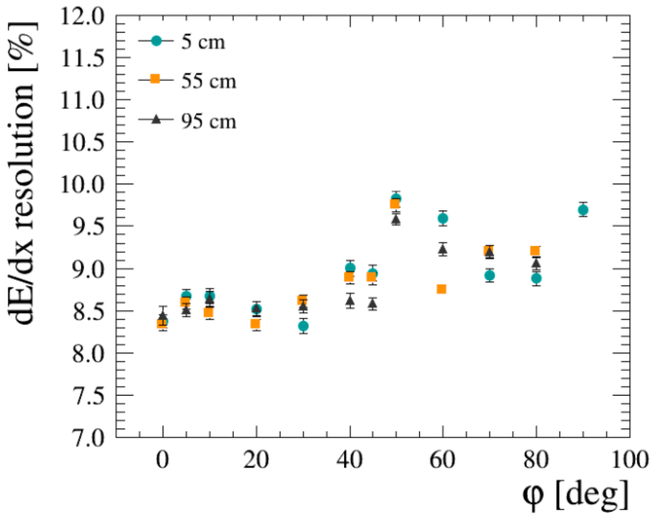
2018 CERN test beam and 2019 DESY test beam both published on PRD → Sergey corresponding author for both papers







- Test beam with the Field Cage prototype was done a
  → 1 ERAM and final TPC electronics
  - Spatial resolution between 200 and 600 µm (depending on angle and drift distance)
  - dE/dx resolution ~8% for tracks crossing one ERAM module
  - First comparisons between data and simulations implemented in the nd280 software!
- Paper published on NIM → Vlada corresponding author of the paper
  - Including description of the electronics chain → all LPNHE ITA that contributed to the project were authors of this paper



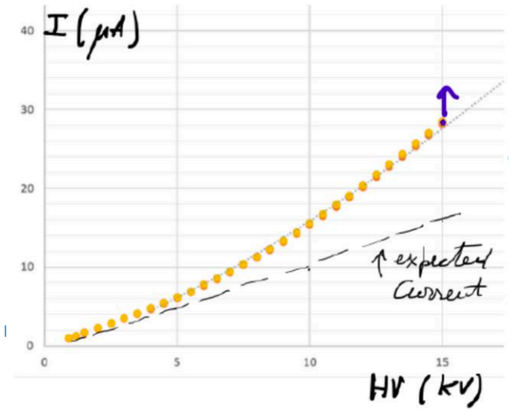
HA-TPC HV issue

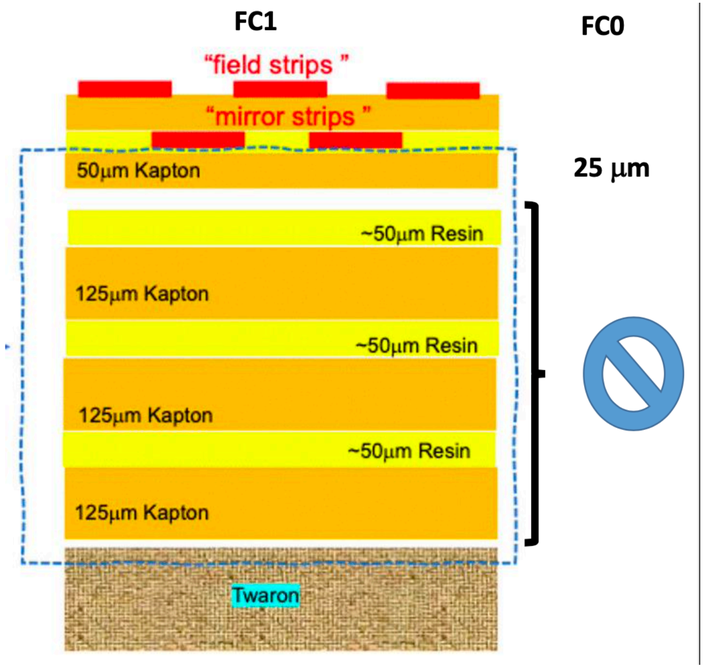
- Field cage 0 arrived at CERN in spring 2022
- Very unusual HV behaviour: non-linear and large time scales to stabilize
- Took 6-8 months to understand the problem fully and to adapt production process
  - Improved QC during each production step (samples and final FC)
  - Larger distance between mirror strips and Twaron layer
- Production of FC1 started in November 2022 and was delivered at CERN in February 2023

  FC2 was delivered in June 2023

  FC3 (for the second HATPC) is in production at NEXUS → expect it at CERN in September

  Top TPC will be shipped to J-PARC at the end of the year

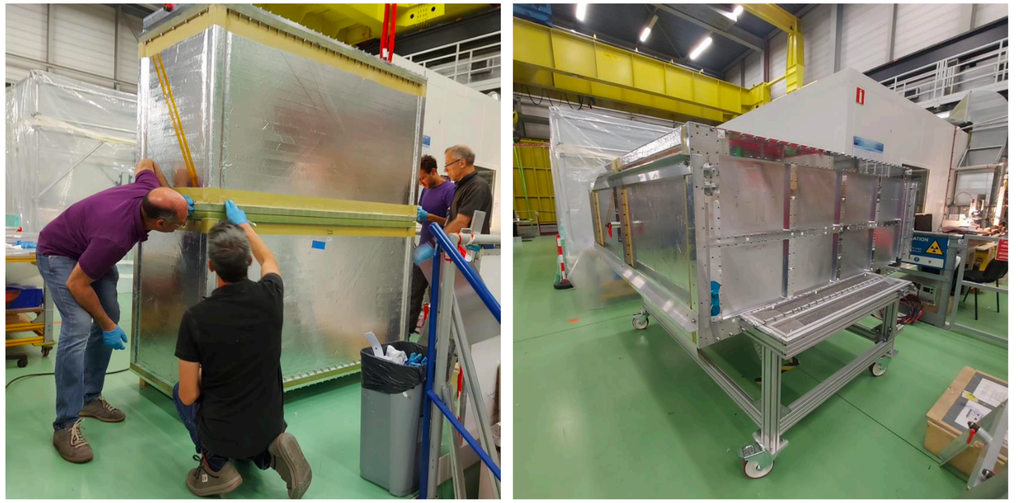




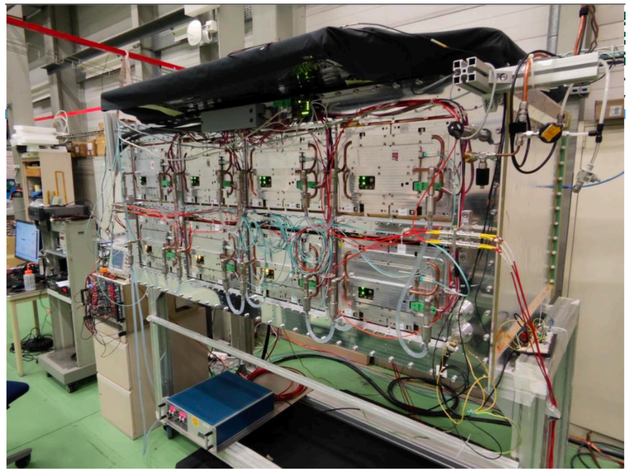
First full HATPC

- A lot of activities at CERN
- Cosmics test with FC1 done in April/May → DAQ running very stably
- First full TPC assembled in June → cosmics tests in July
- Expect to ship the HATPC to Japan at the beginning of August

Full TPC assembled at CERN in June

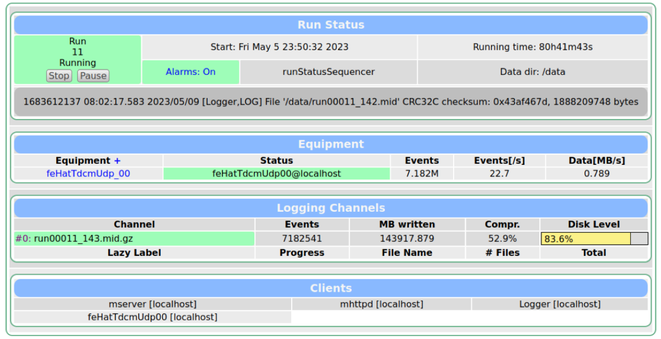


FECs cards produced at LPNHE

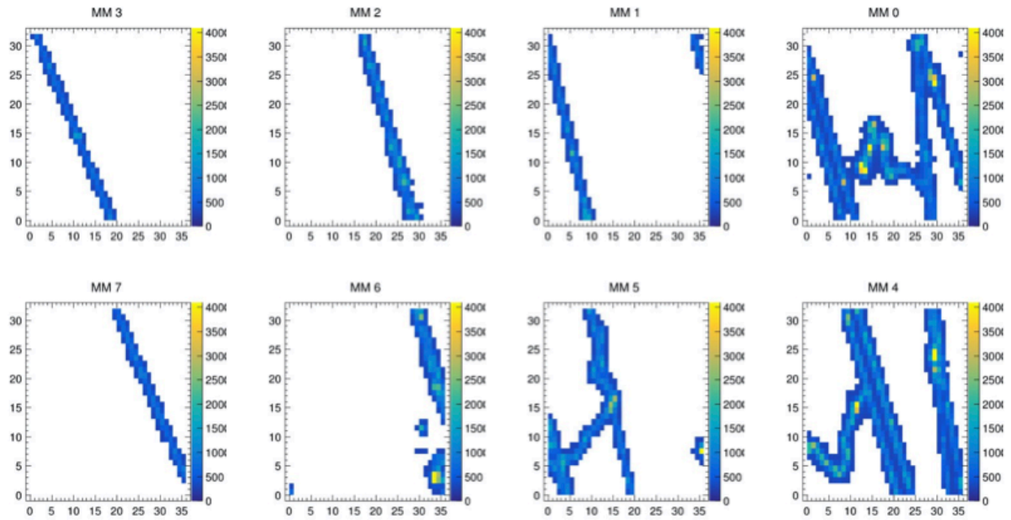


DAQ developed @LPNHE (Adrien, Mathieu)

DAQ Midas main page



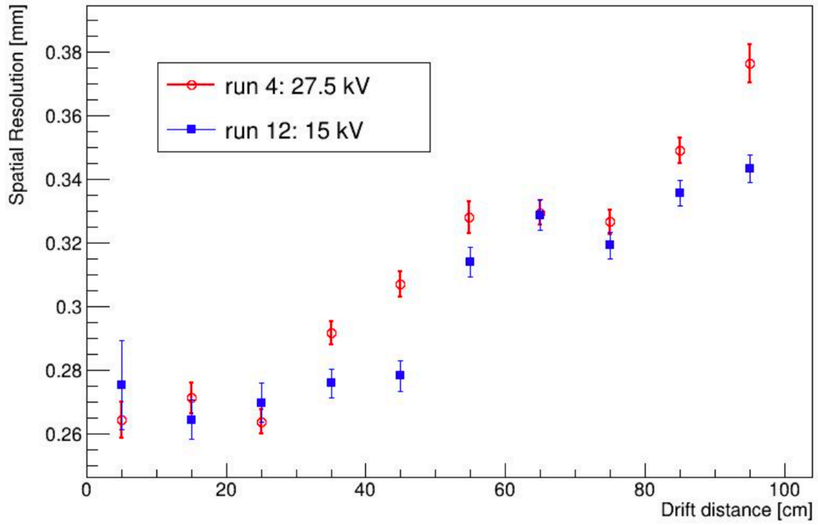
Cosmics tracks with half TPC



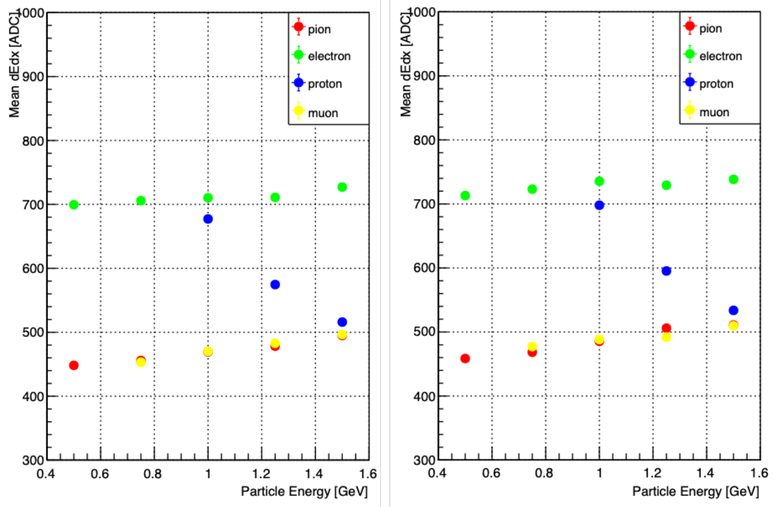
Tests at CERN

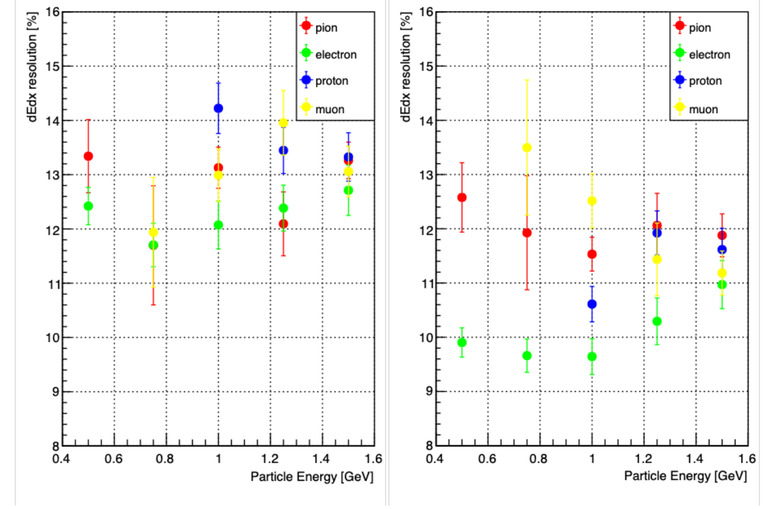
- Cosmics tests with the first half of TPC in April 2023 → Spatial resolution
- Test beam in November 2022 with a HATPC mock-up and 8 ERAM modules → dE/dx resolution

William: Spatial resolution for vertical tracks < 0.4 mm



Lavinia: dE/dx resolution and e/ μ separation



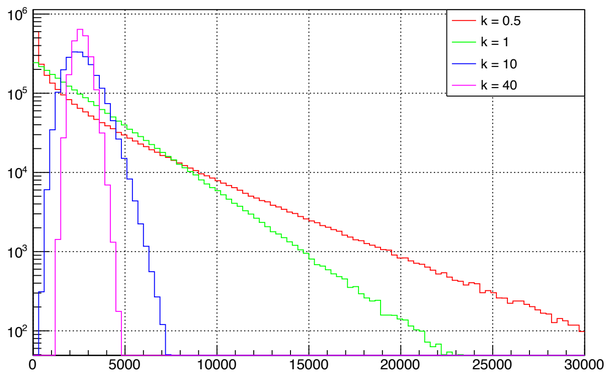


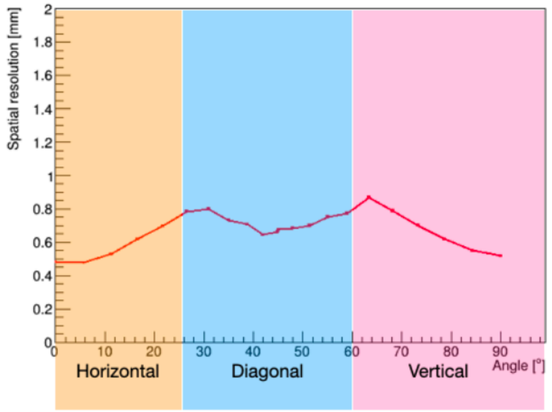
HA-TPC simulation and reconstruction

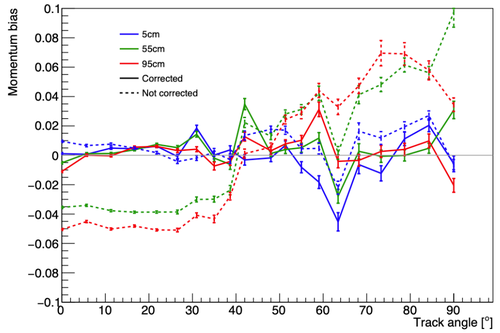
High-Angle TPC: Simulation and Reconstruction

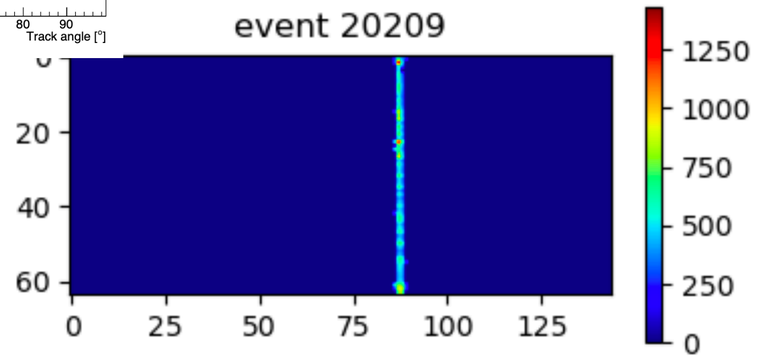
P. Billoir[1], C. Giganti[1], M. Guigue[1], A. Nehm[2], L. Russo[1], W. Saenz[1], S. Suvorov[1], U. Virginet[1] and U. Yevarouskaya[1]

[1]LPNHE, IN2P3/CNRS, Sorbonne Université, Université de Paris
[2]Johannes Gutenberg University Mainz

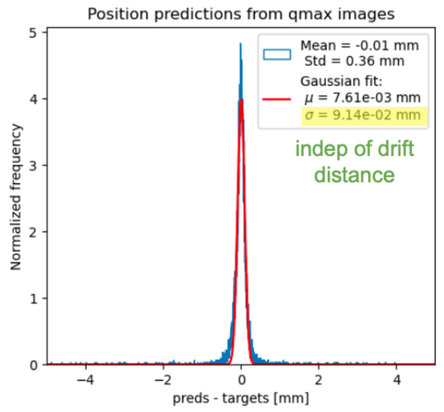


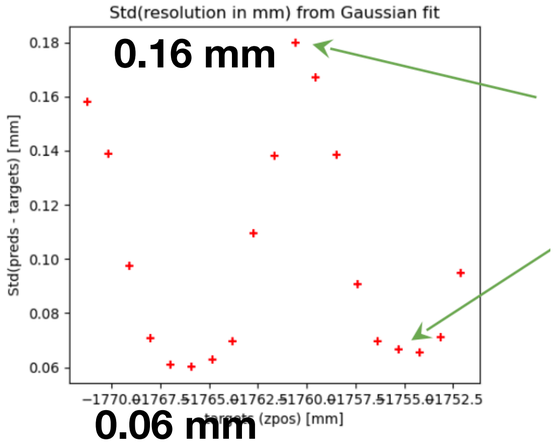






- Lavinia working on the tuning of the HATPC simulation with X-ray sources and test beam data
- Ulysse responsible for the implementation of the reconstruction algorithms developed for the test beam analyses in the ND280 software
- William working on the inclusion of the HATPC in the global reconstruction
- Anaëlle is developing new reconstruction algorithms based on machine learning
- A lot of help from Pierre Billoir for most of the above items

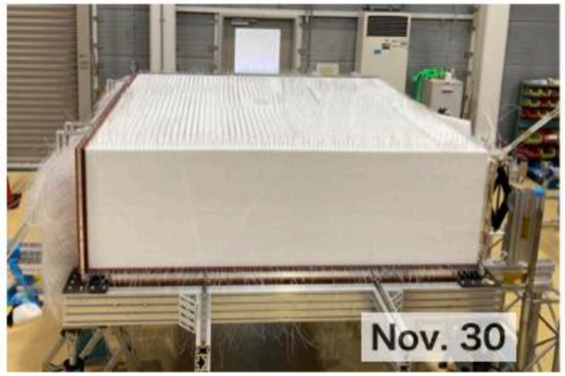




SuperFGD assembly at J-PARC

(ii) First cube layer assembly

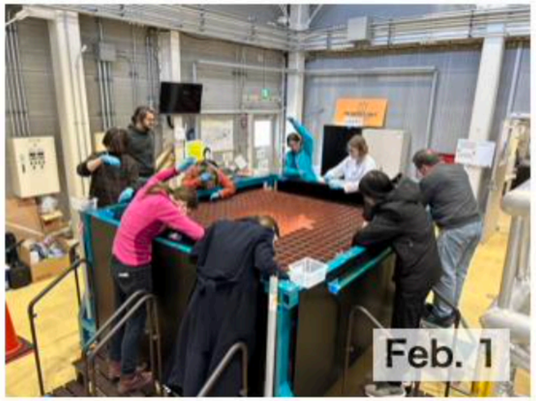
(iv) Stop panels removed



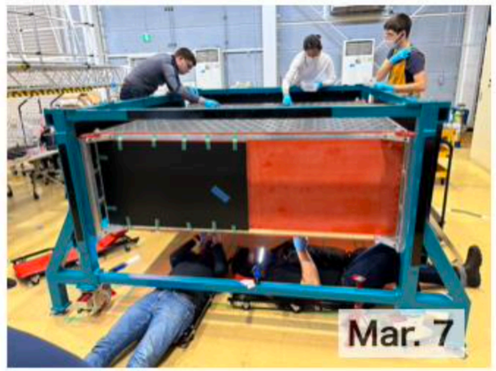
(v) Box closure

(vii) Horizontal fibers assembly

(ix) Vertical fibers assembly



(x) Top MPPCs assembly



(xii) Light barrier/cables asse

Installation at J-PARC

- After many years of work the installation of the ND280 Upgrade is imminent
- Plan to ship the first HA-TPC fully instrumented and tested at the end of July → installation in the basket at the end of August
- Installation of the Super-FGD by the end of September
- Hope to take first ND upgrade data in November
- Second TPC will be shipped to Japan in November and will be installed after the first data taking
- Very close to begin the exciting physics programme of T2K-II!
  - And to have a well understood and fully capable Near Detector for the beginning of HK
  - Support from IN2P3 of ~60 keuro/year will be needed for the T2K-II/ ND280 upgrade operations in the next 3 years