

ND280 Upgrade TPC Commissioning

Thorsten Lux

On behalf of the ND280 TPC Group

RD51 Collaboration Meeting

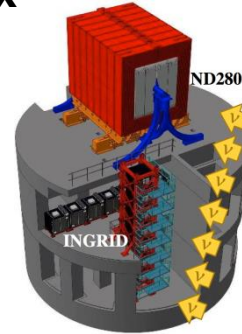
The Tokai-to-Kamioka (T2K) experiment

Far detector

Super Kamiokande

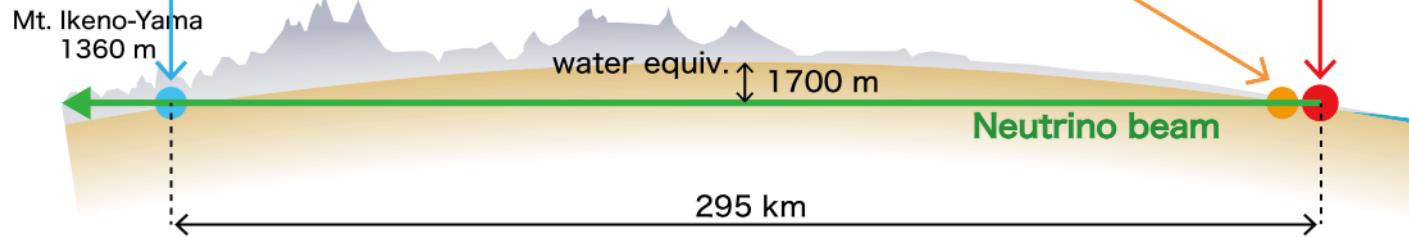
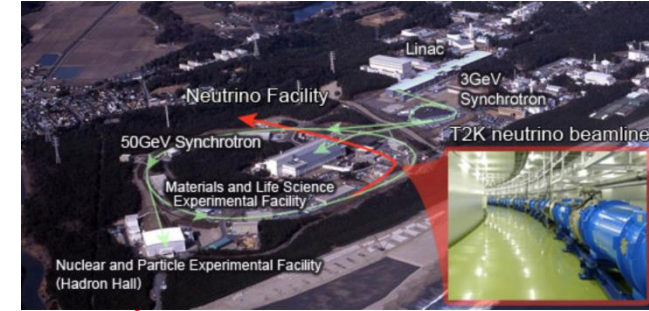


Near detector complex



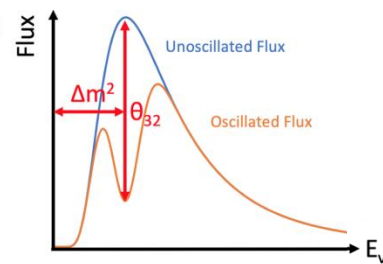
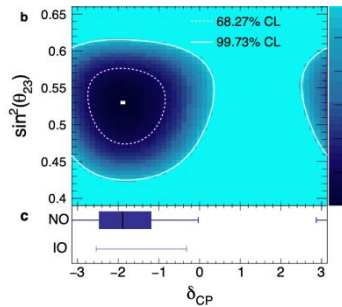
J-Parc

Neutrino Beam



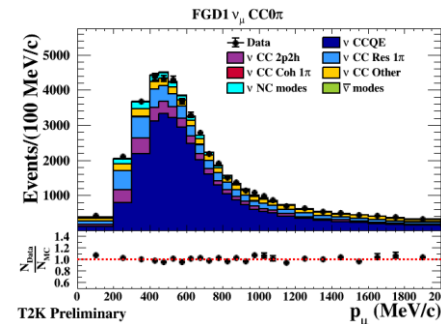
@SK

Measure oscillated beam



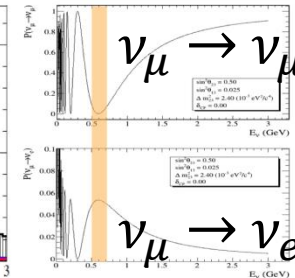
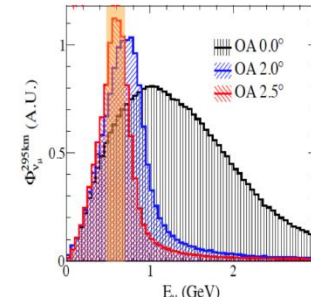
@ND280

Characterize beam and ν interactions



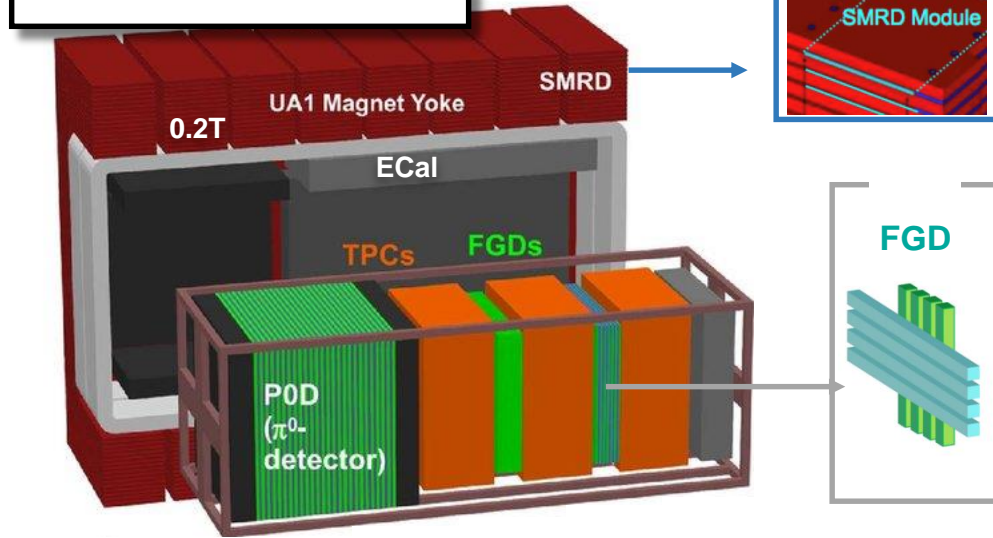
@J-PARC

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



The current ND280 detector

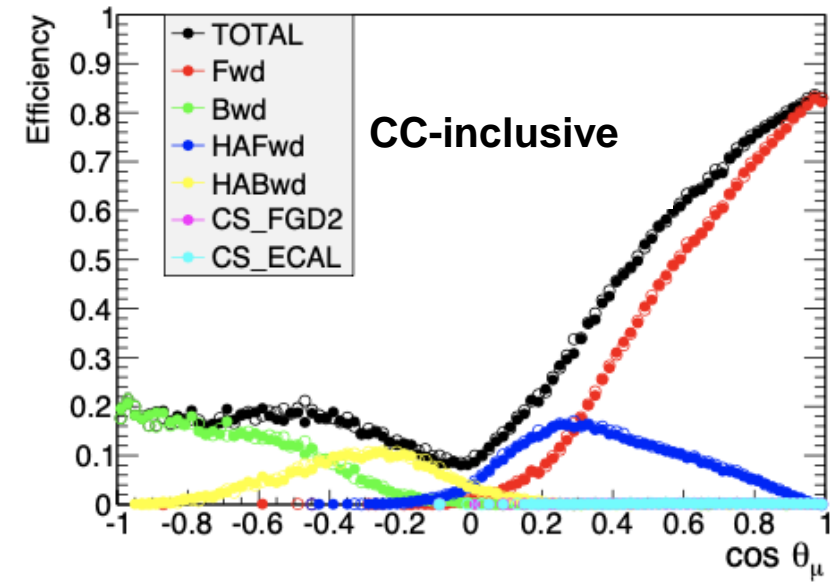
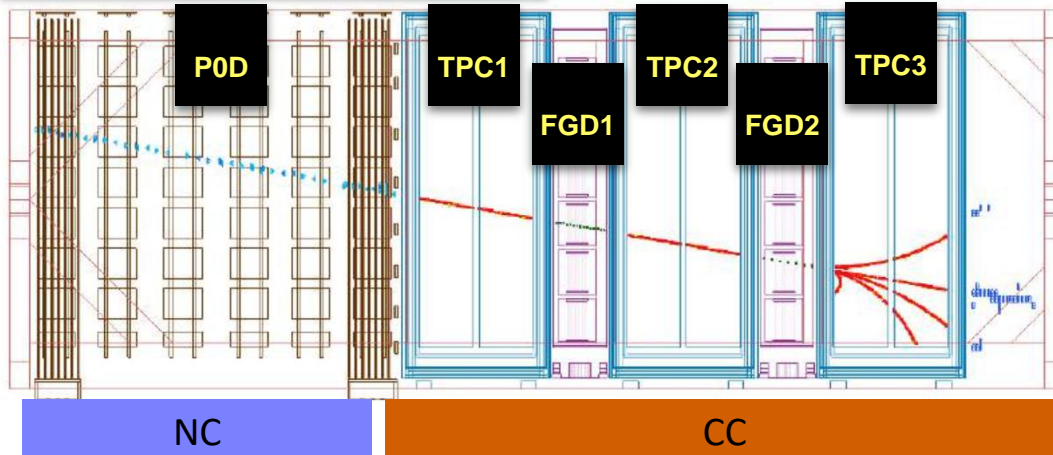
Current ND280 sketch



Current limitations

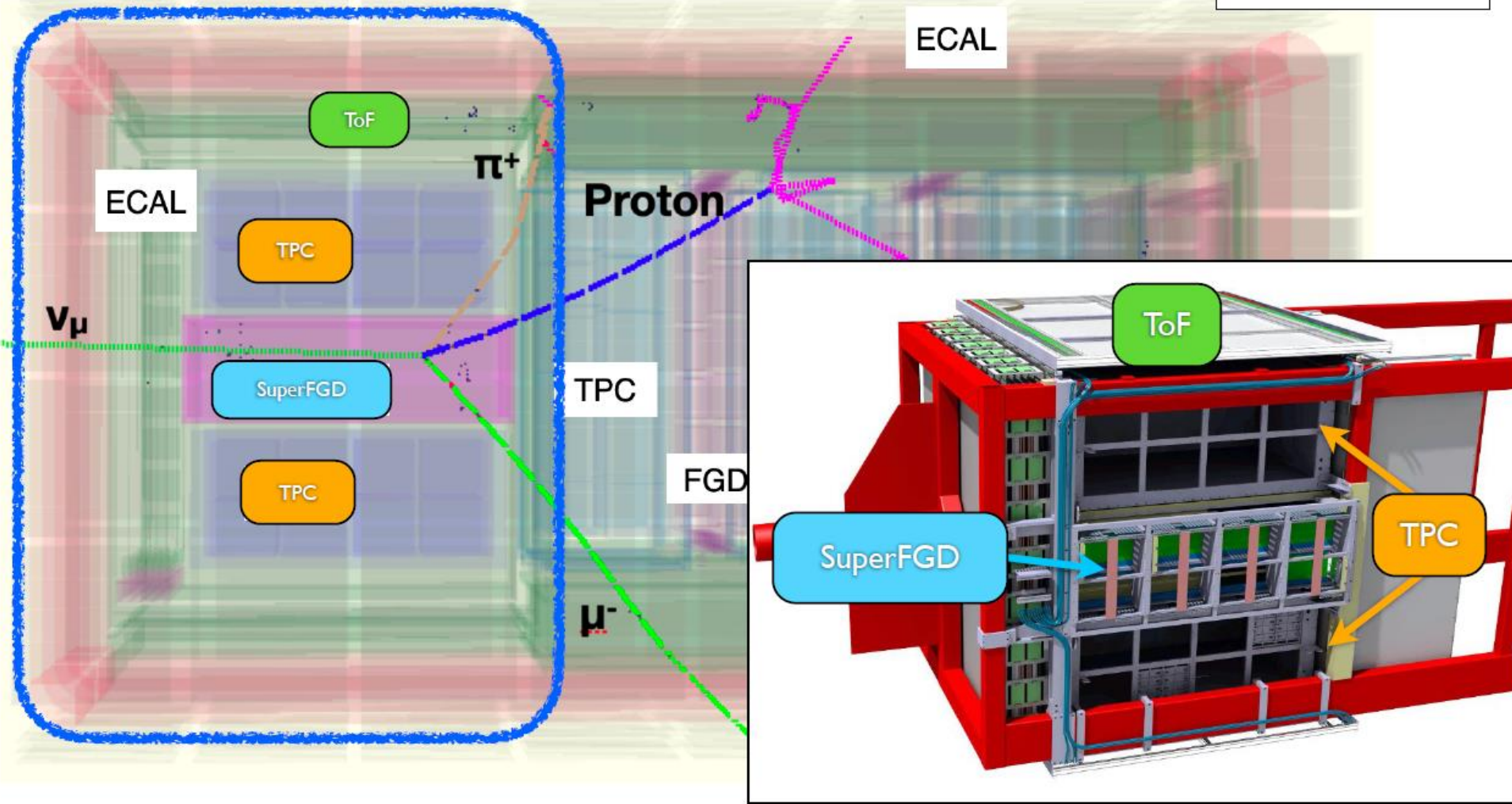
- ✦ Tracks w/o TPCs (high angle).
- ✦ Tracks w/o TPCs (low momentum).
- ✦ Limited timing information => no direction information
- ✦ No neutron info
- ✦ Poor electron/photon separation
- ✦ High detection threshold

Event display of basket elements



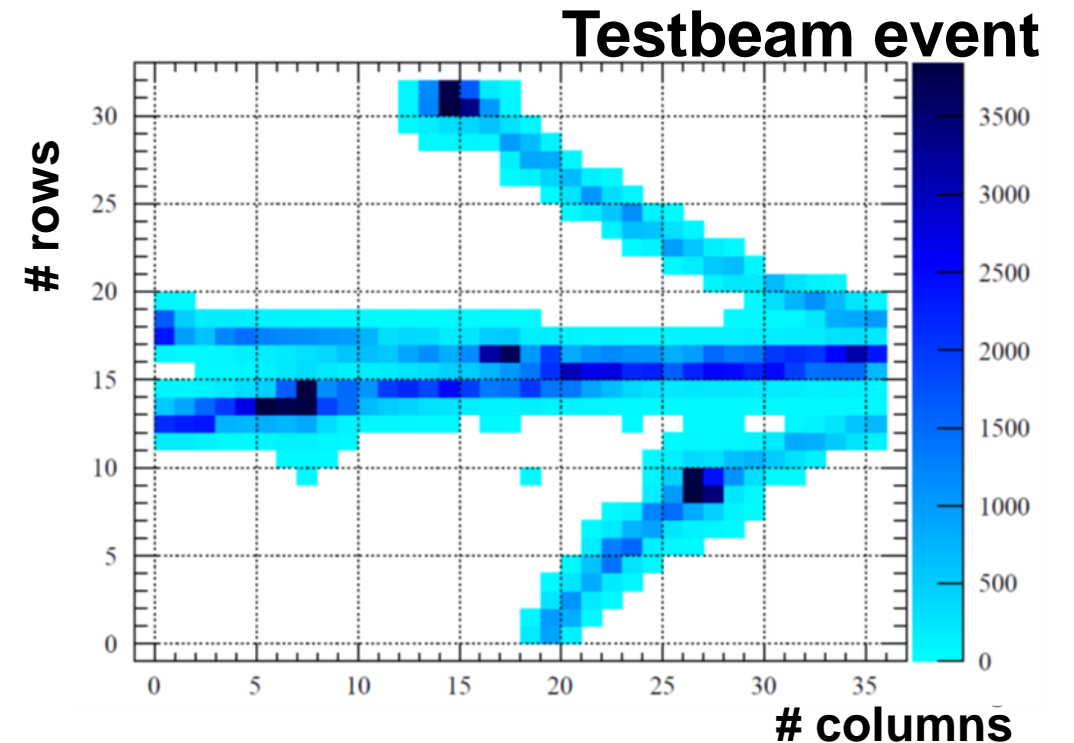
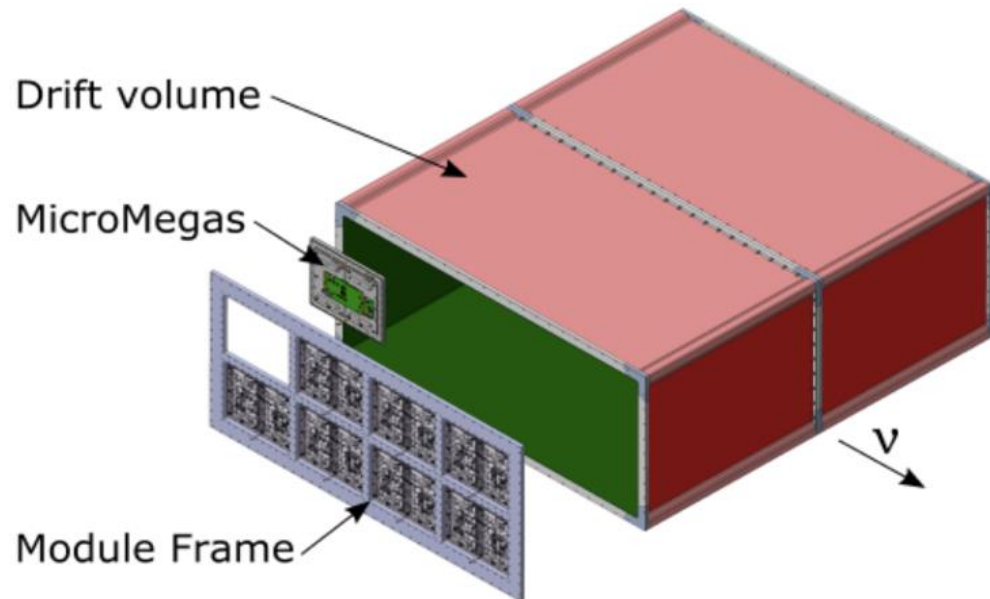
The Upgraded ND280

arXiv:1901.03750



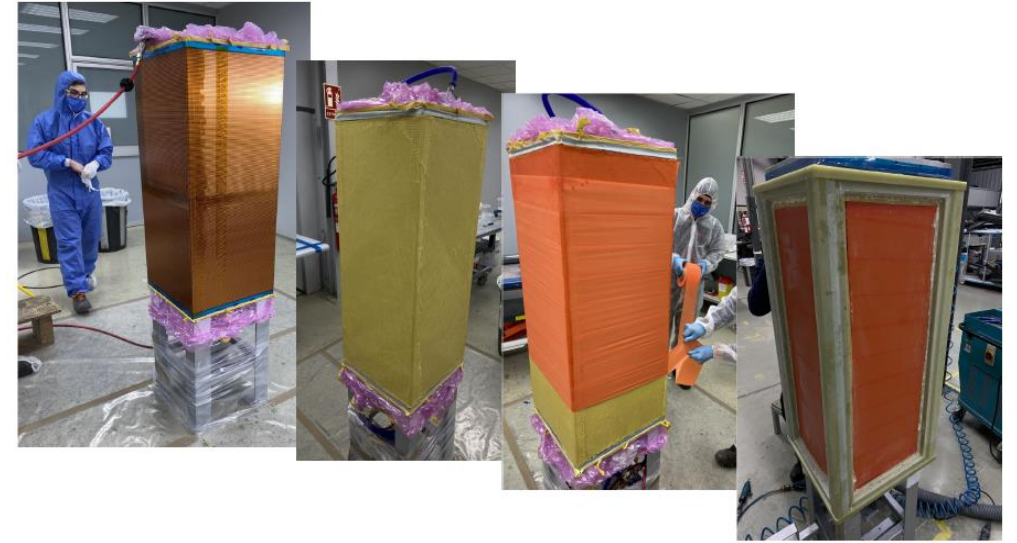
High Angle-TPCs

- 2 new TPCs being produced
- Dimensions: 1865x2000x820 mm³
- Composite materials for field cage
- Readout by 8 resistive Micromegas (ERAM) per side (novel technology)
- 1152 readout channels with 10.09x11.18 mm² pads per ERAM
- T2K gas (95 Ar, 3 CF₄, 2 iC₄H₁₀)
- Providing tracking and particle identification



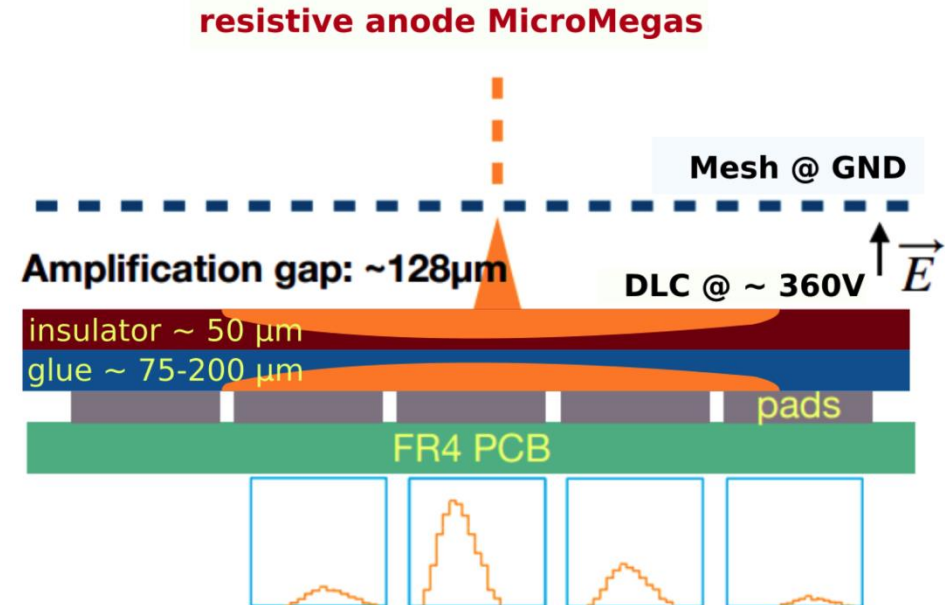
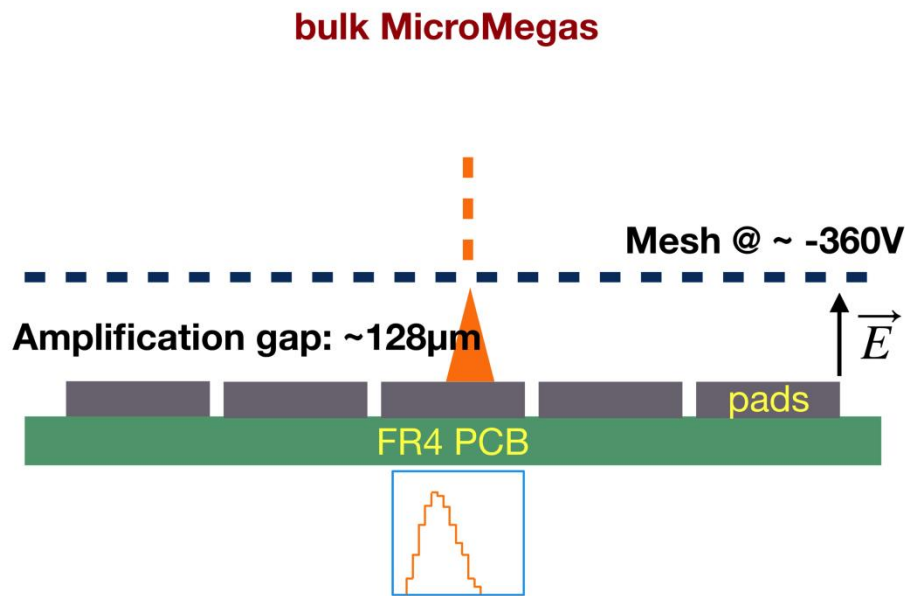
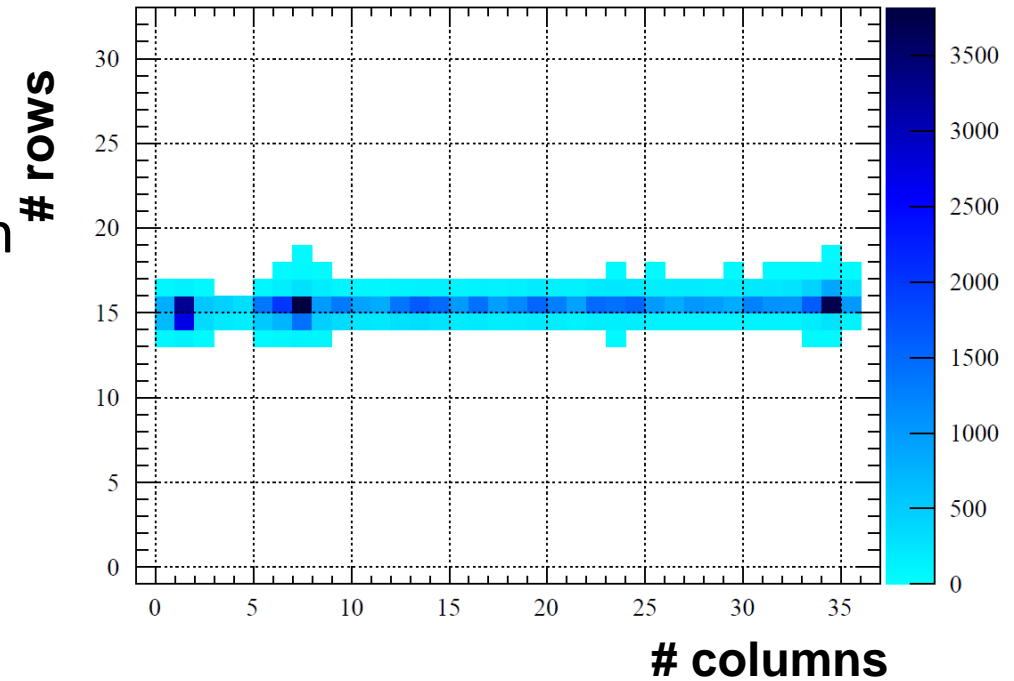
HA-TPC Field Cage

- TPC consists of 2 halves and separate cathode
- Production based on layers wrapped around mould
- 2 full length prototypes for 1 MM + several mock-ups were produced and tested
- Successfully tested before starting final production:
 - Metrology
 - HV stability in air and argon up to 35 kV
 - Gas tightness



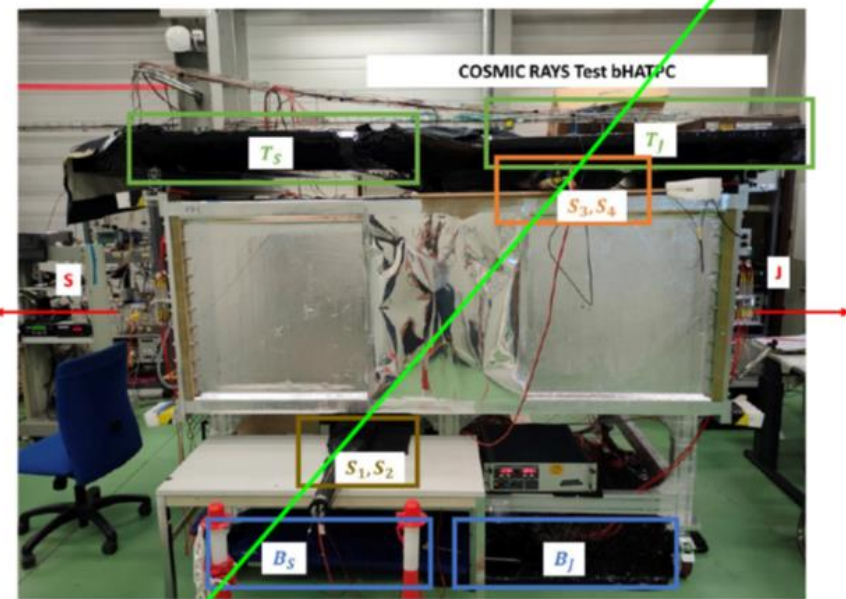
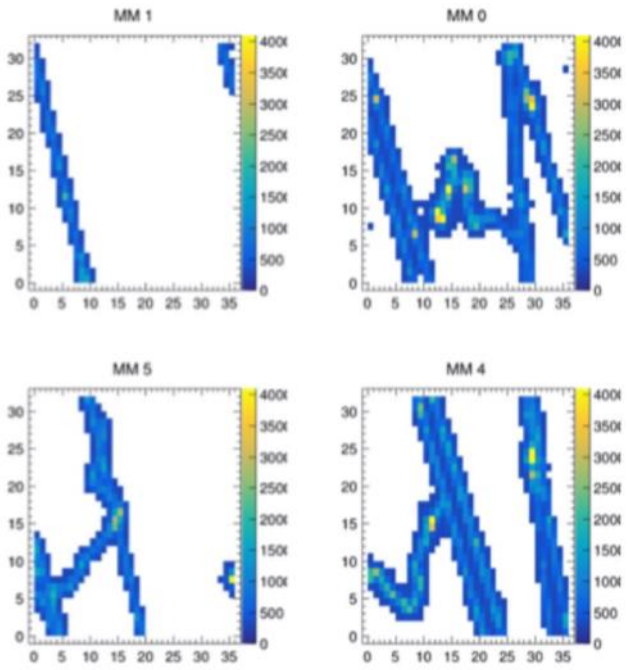
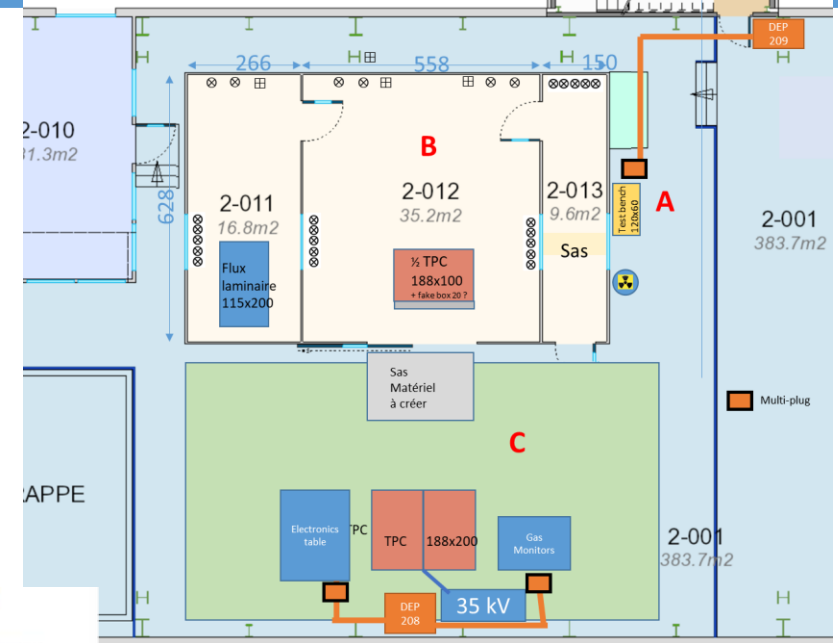
HA-TPC ERAM Modules

- ERAM : Encapsulated Resistive Anode Micromegas
- Novel resistive MM readout
- Charge over several pads => better point resolution
- 32 ERAM modules needed + 4 spares
- Various prototypes with different RC parameters produced and tested
- Operated with T2K gas: 95 Ar : 3 CF4 : 2 iC4H10
- See talk by A. Delbart for more details



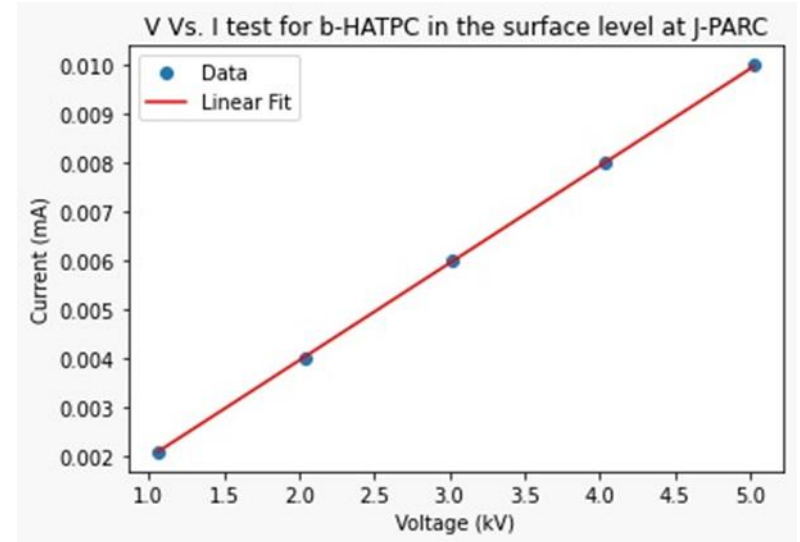
Assembly at CERN

- Assembly of the TPC was done at CERN (bldg. 182) provided by the Neutrino Platform
- Large area for assembly, metrology, testing, QC of ERAMs including high class clean room
- First commissioning performed at CERN using cosmics

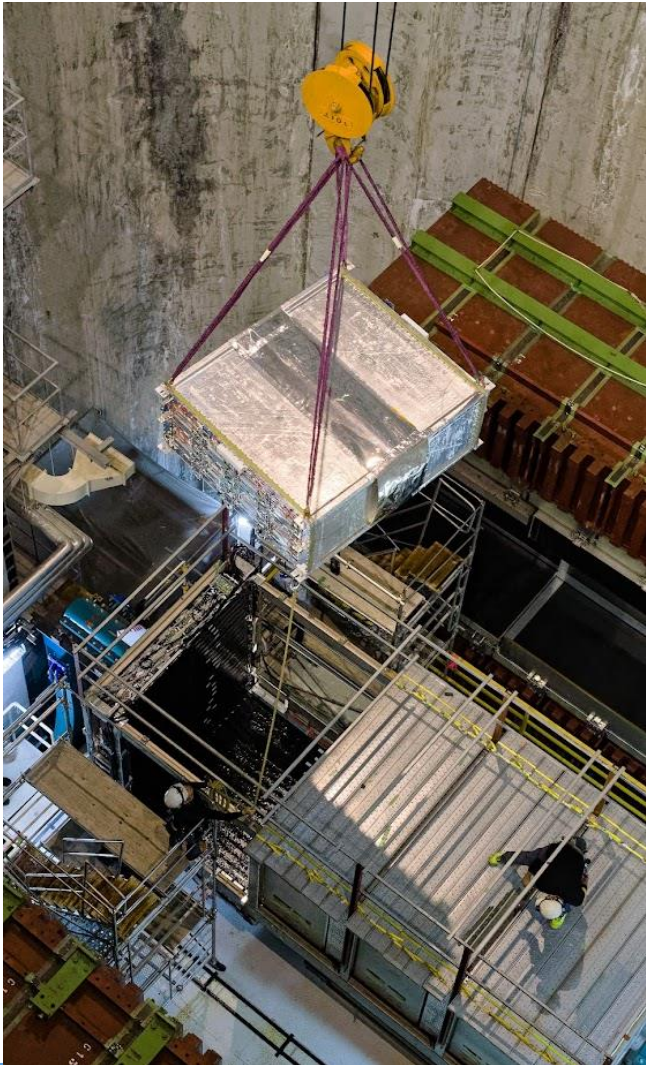


HA-TPC at J-PARC

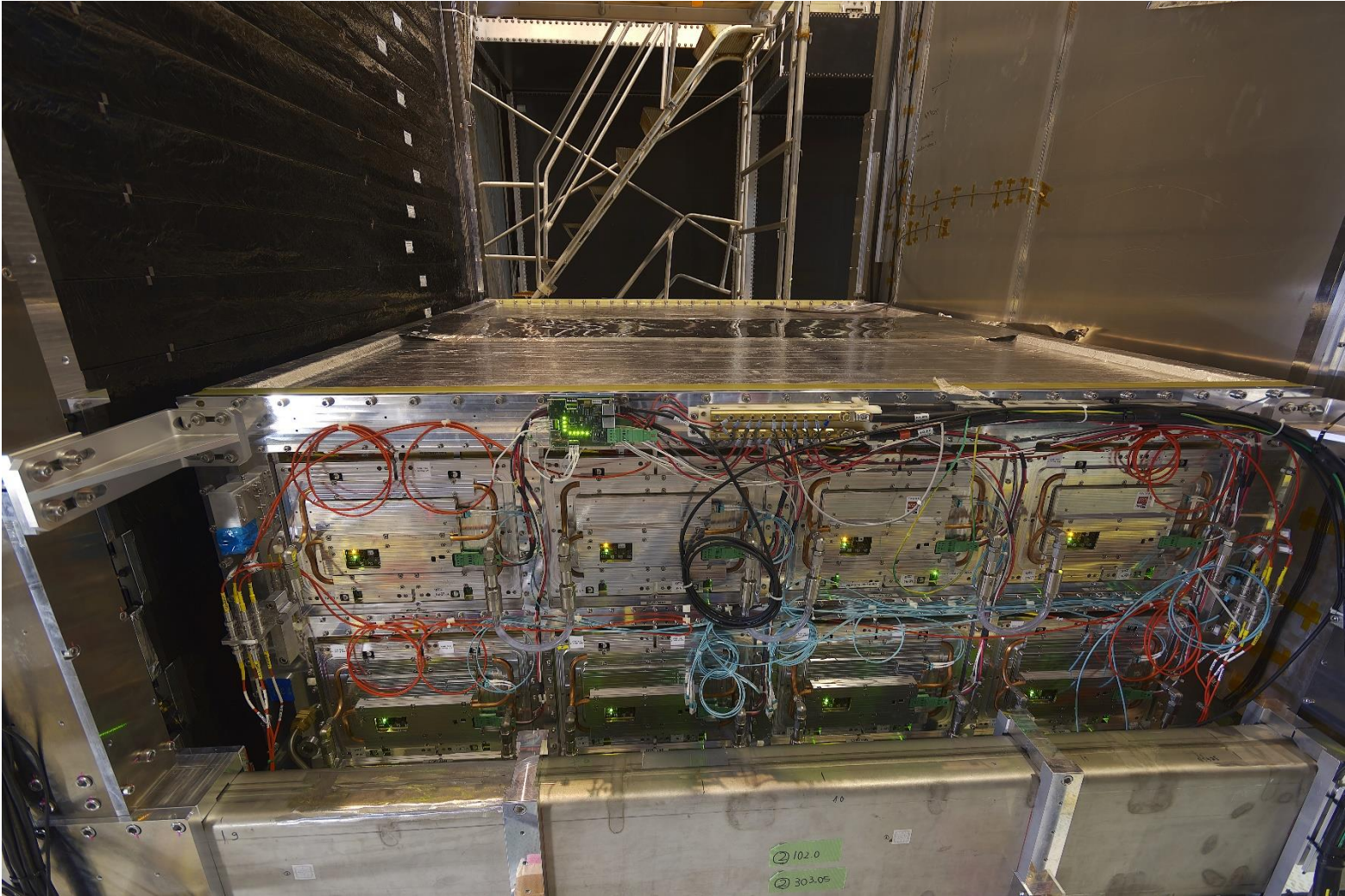
- 7th Aug: left CERN, 25th Aug.: Arrival at J-PARC
- Quality control on surface after unpacking:
 - Cathode HV => passed
 - ERAM HV => passed (with minor problems)
 - Gas tightness => passed
- => Ready to install in basket!
- 8th Sept: Installation in ND280



HA-TPC Installation

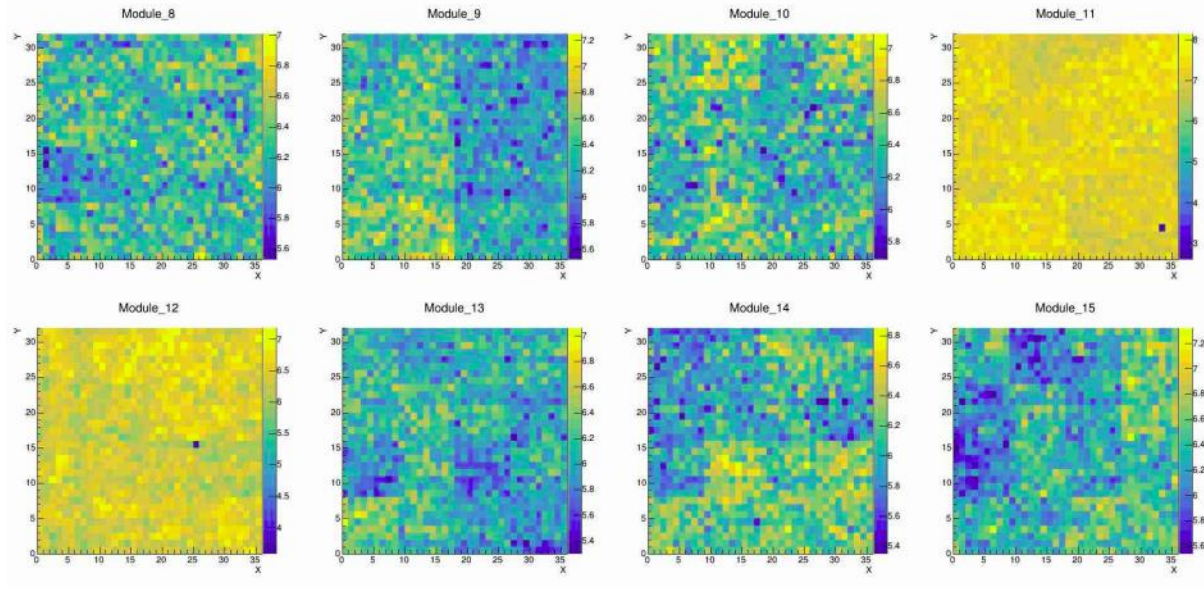


Finally in ND280

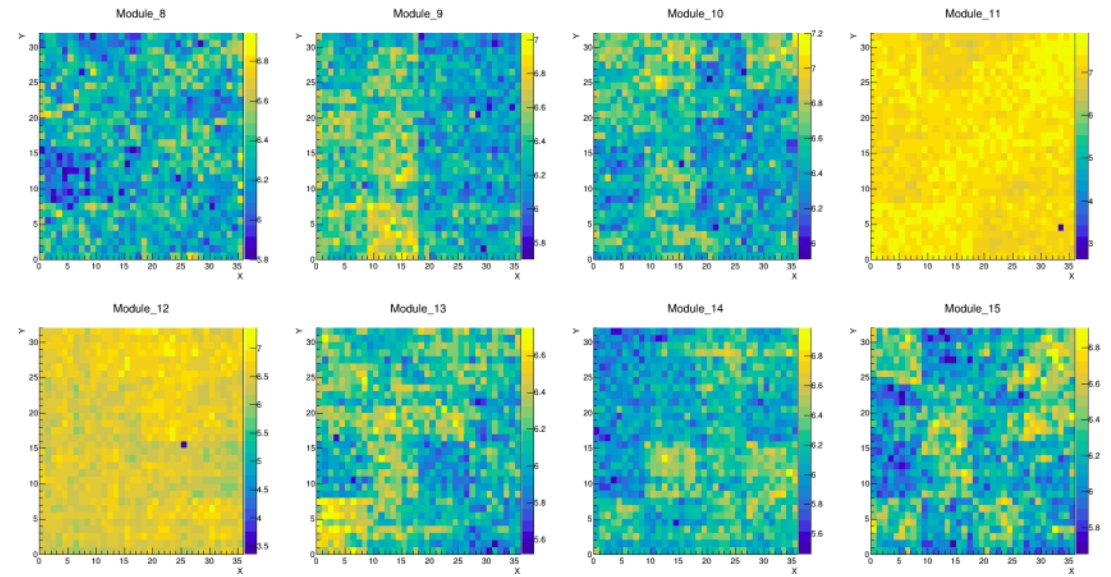


HA-TPC: Pedestal Runs

EP1 CERN



EP1 Tokai - pit

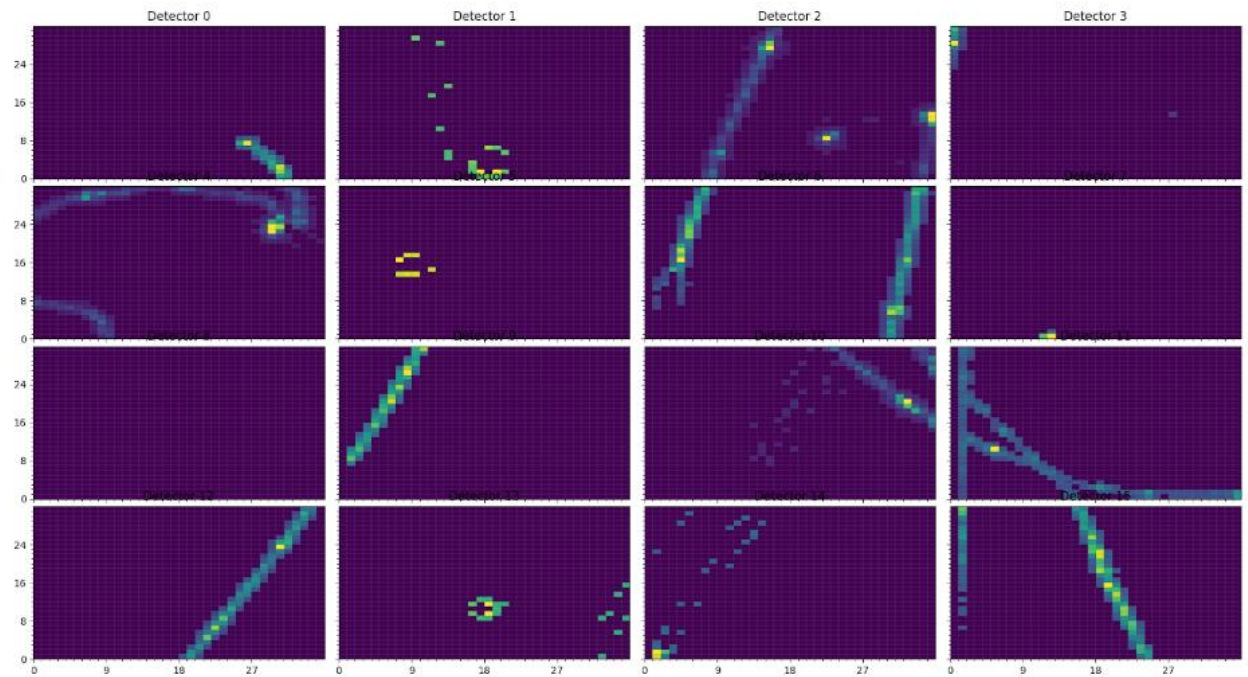
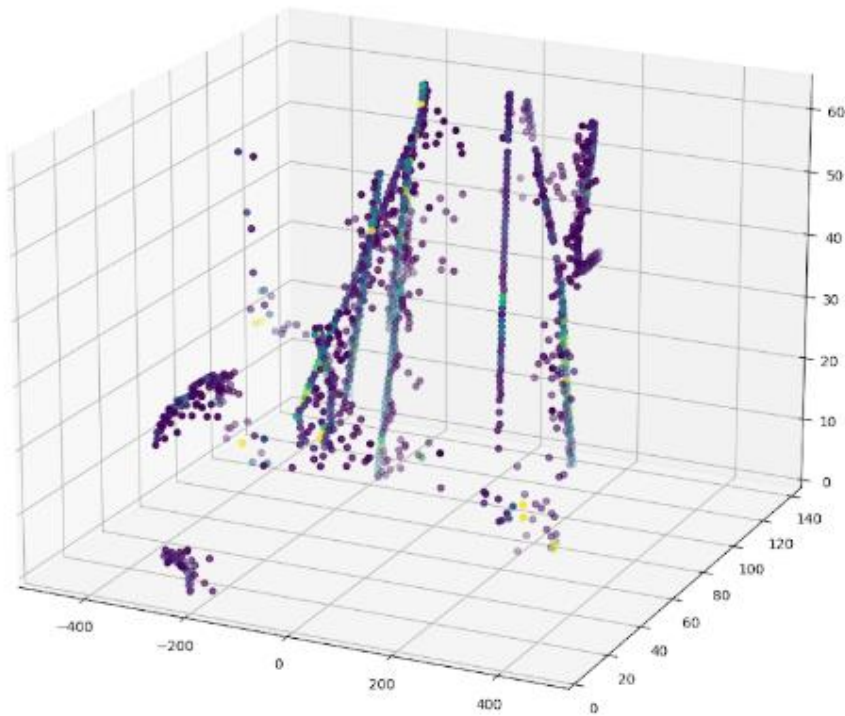


The first pedestal from the basket at J-PARC looks same as the one from CERN !!

Only 16 dead channels and all were already there at CERN.

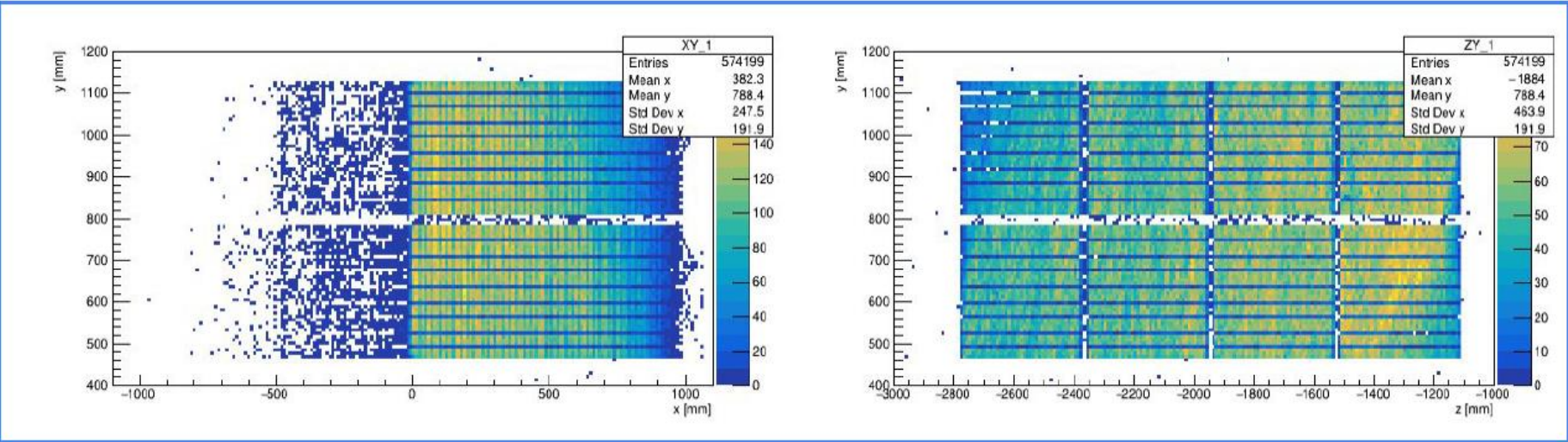
HA-TPC: First Events

Trigger provided by first 2 TOF panels:

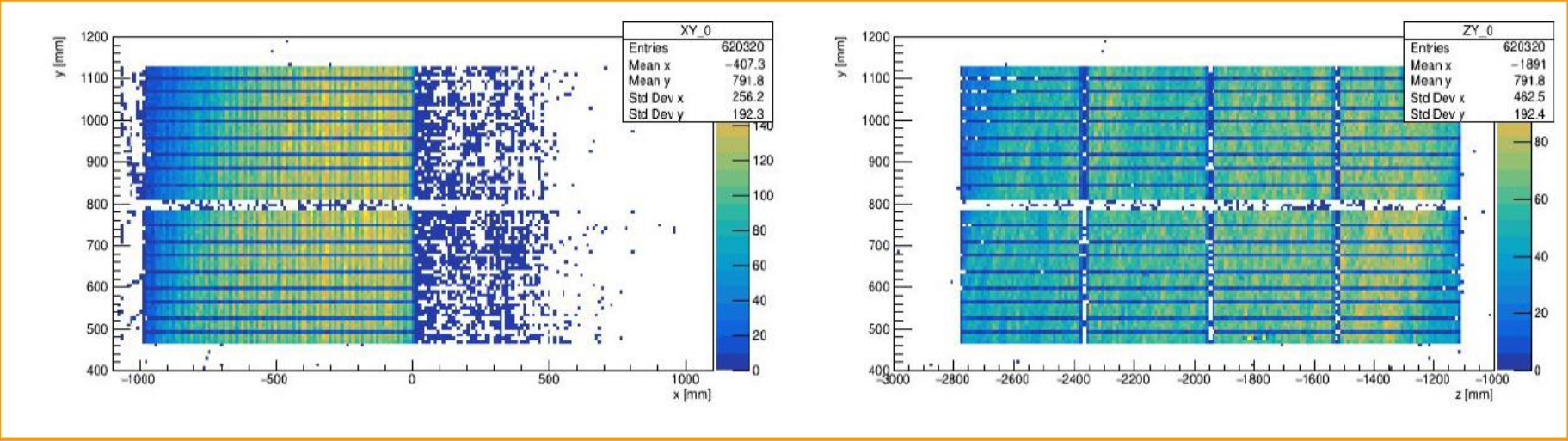


First HA-TPC Analysis

EP1 (North)



EP0 (South)

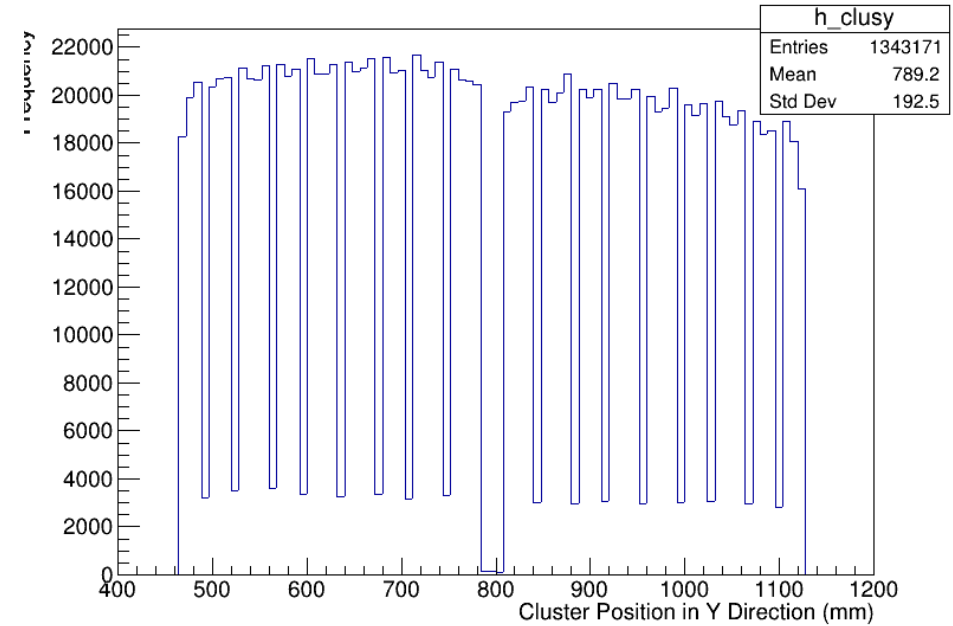


Very preliminary!

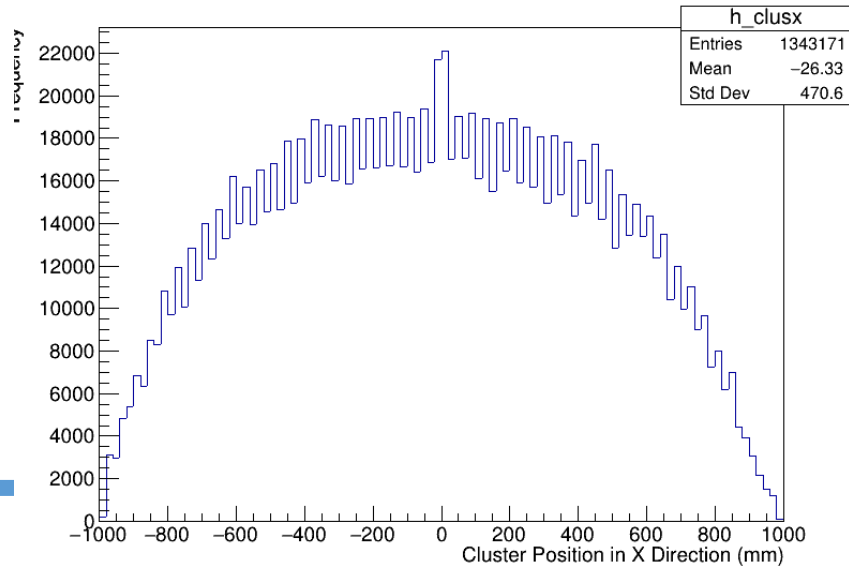
Cluster Distributions

- Using official T2K reconstruction software (still to be tuned) for first analysis
- Cluster position distributions look as expected
- ND280 coordinate system: YZ (readout plane), YZ (drift plane)

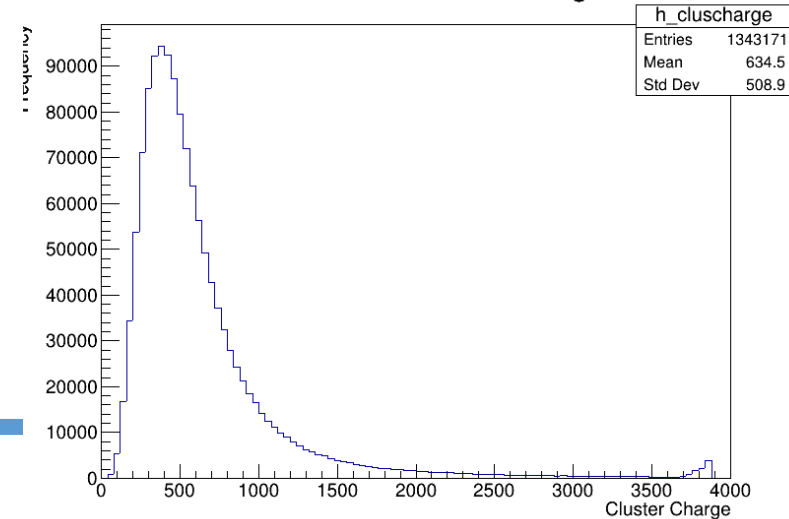
Distribution of Cluster Position Y



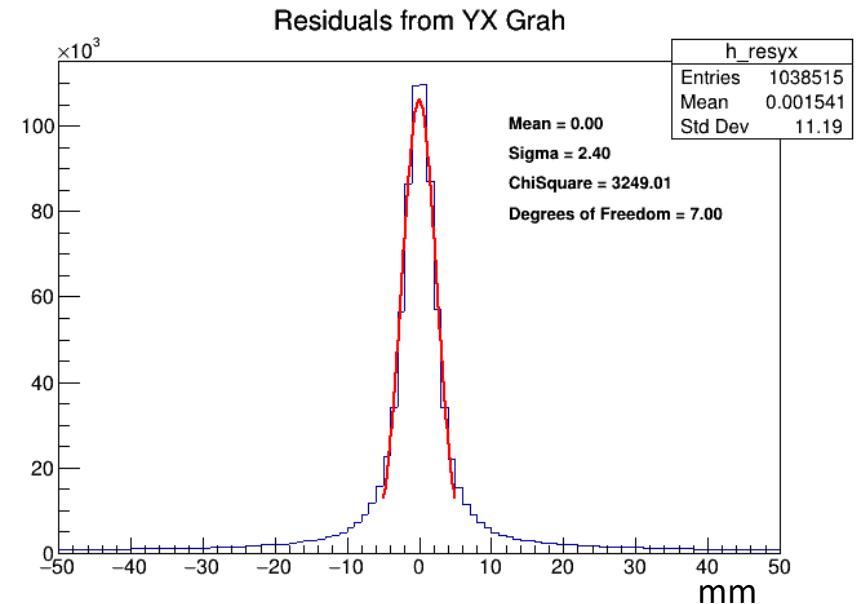
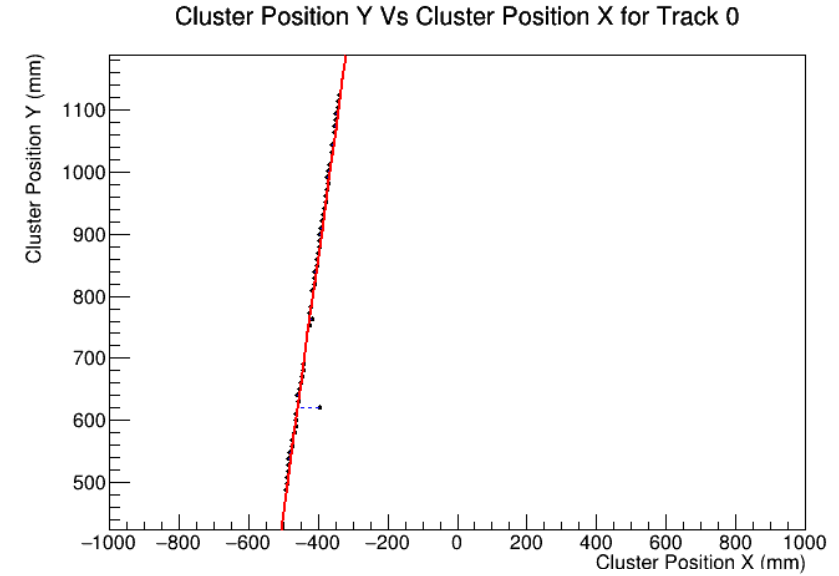
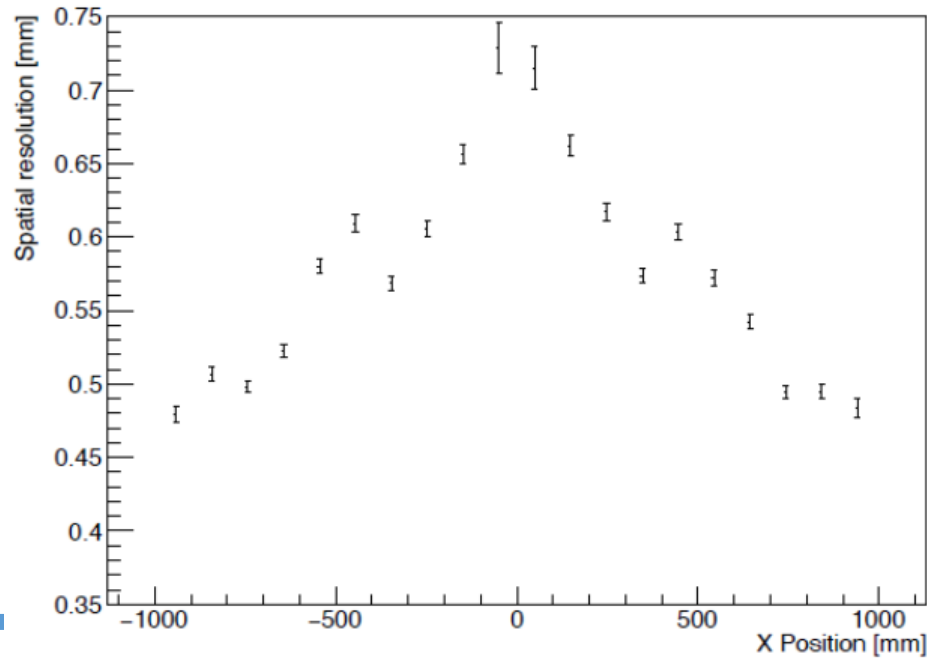
Distribution of Cluster Position X



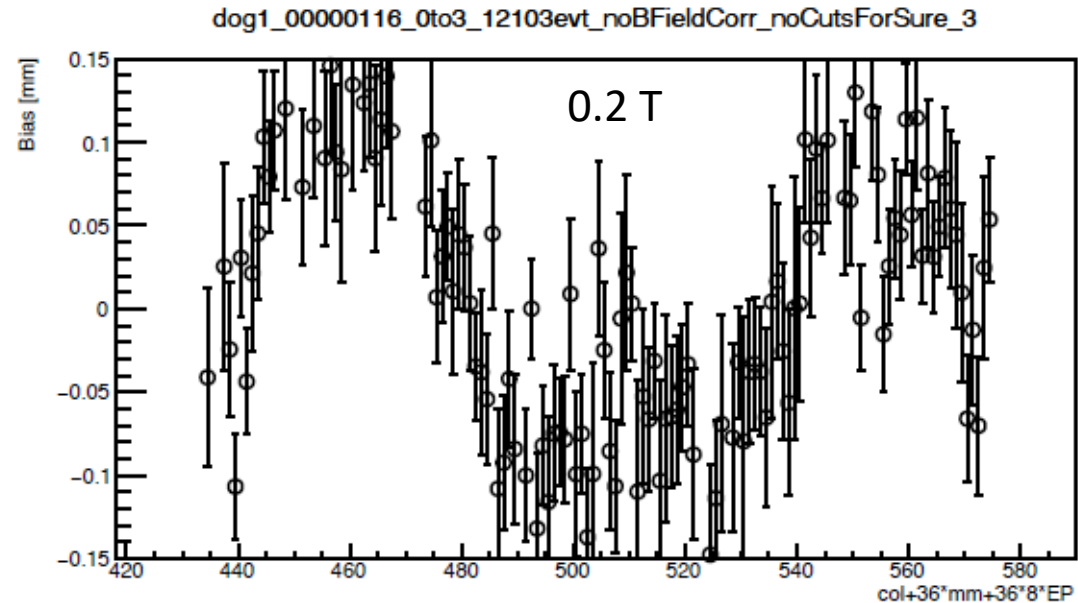
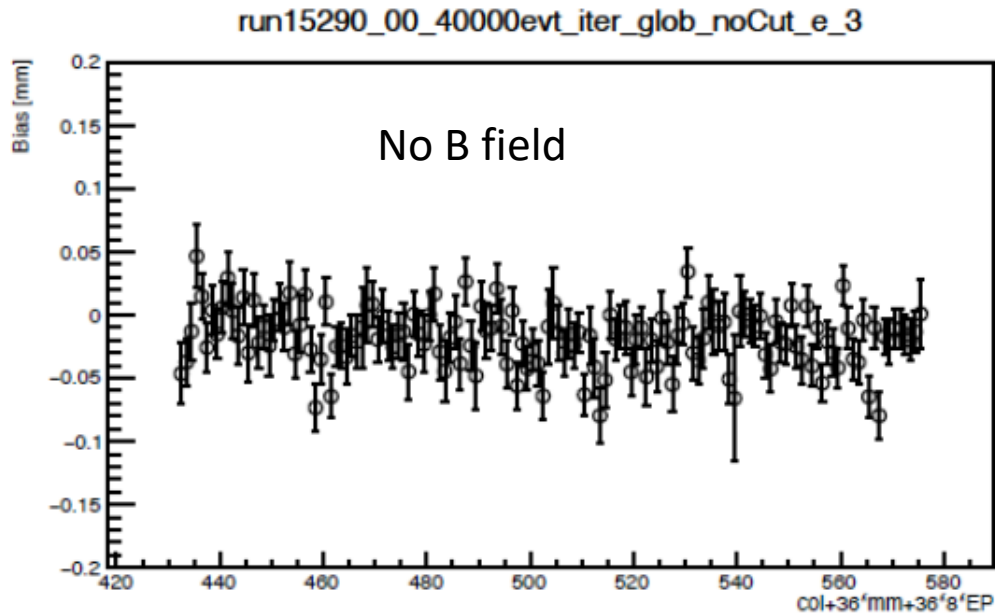
Distribution of Cluster Charge



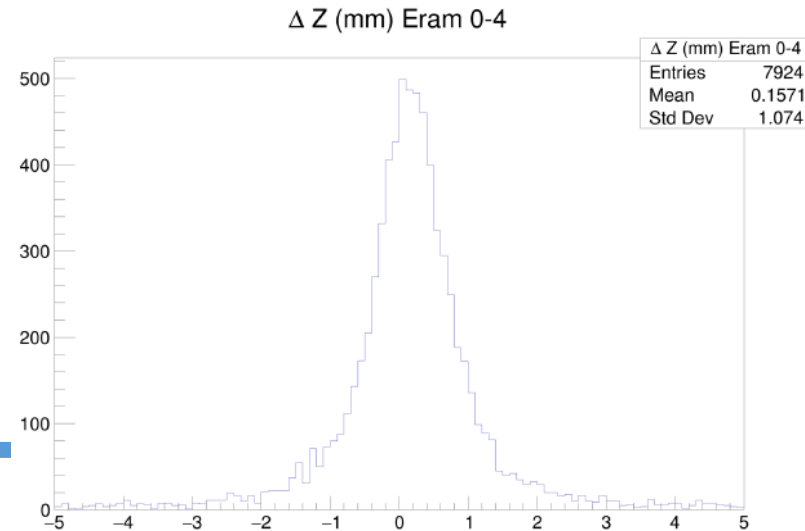
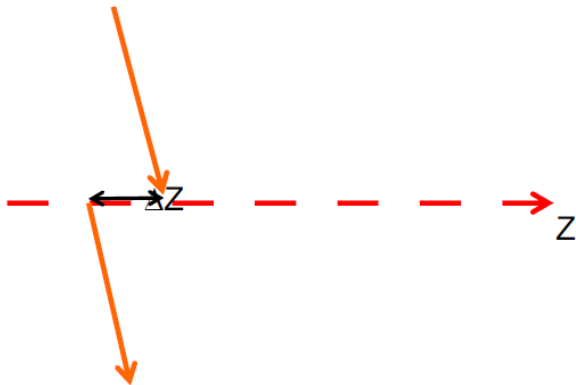
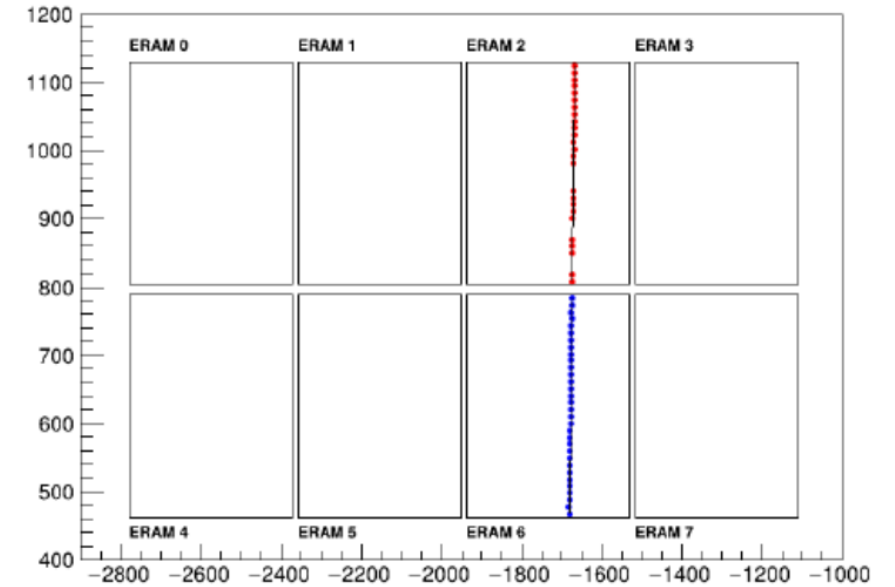
- Started to look into spatial resolution
- Circular/parabola fit for z and linear fit for x studies
- Preliminary results expected performance



- First look on bias
- Flat distribution without B field
- Large variations with B field on => well known from legacy TPCs
- B field correction will be implemented in reconstruction software

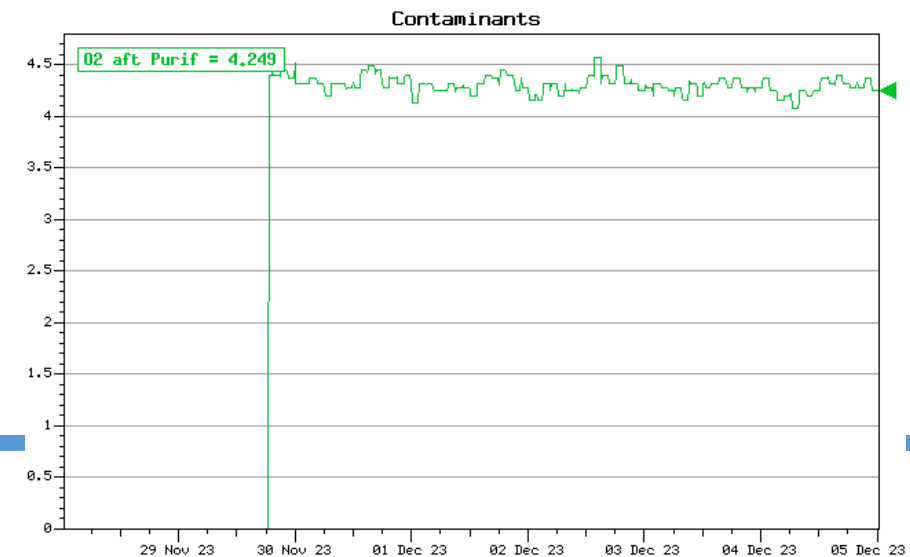


- Work to inter-align the different ERAM modules have started
- Cosmics crossing 2 ERAM used for this study
- Track in each ERAM is fitted individually
- Shifts between 60 and 300 μm observed

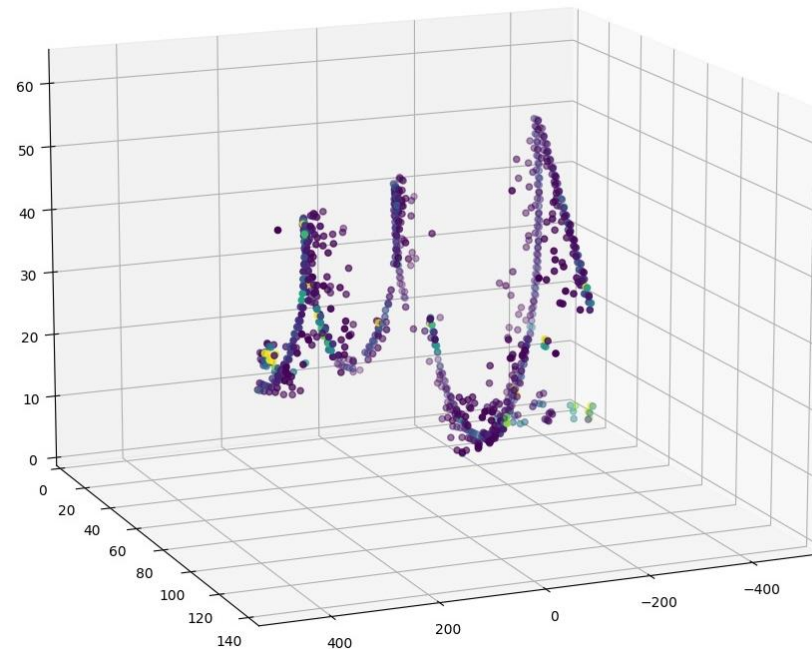
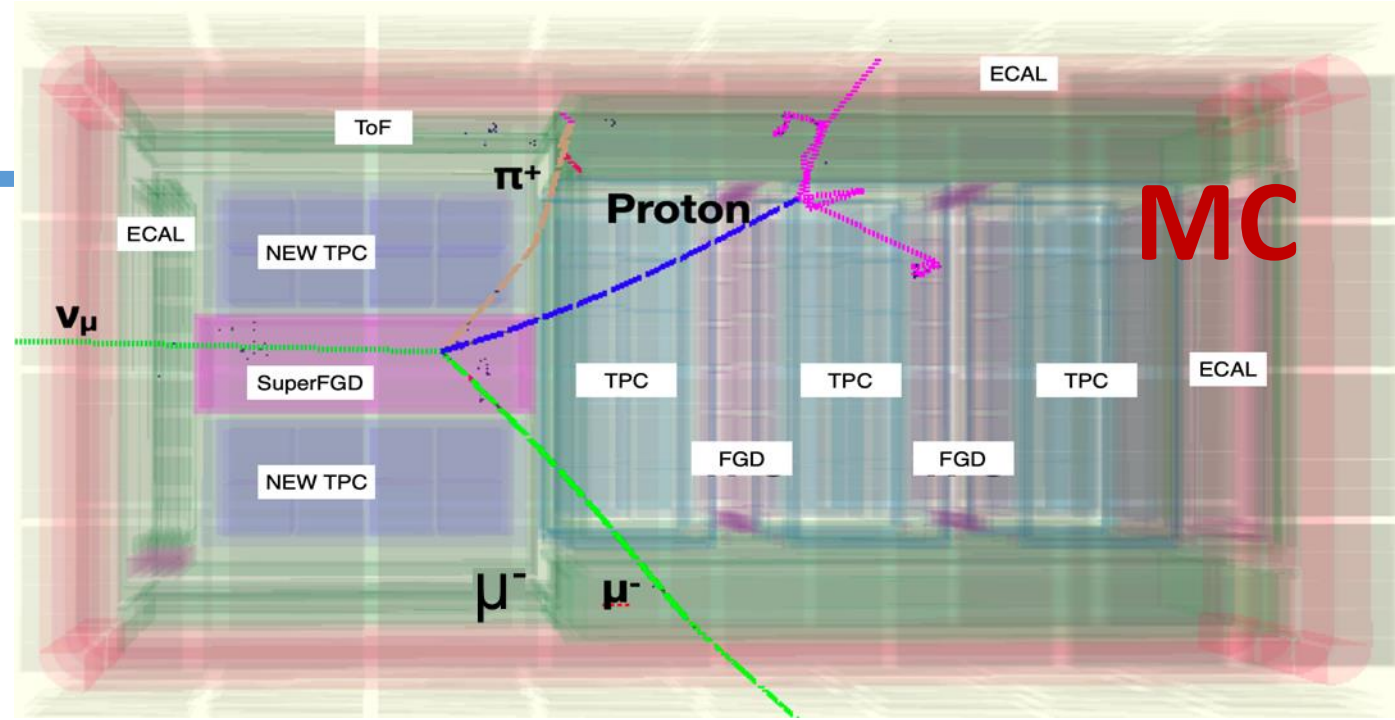
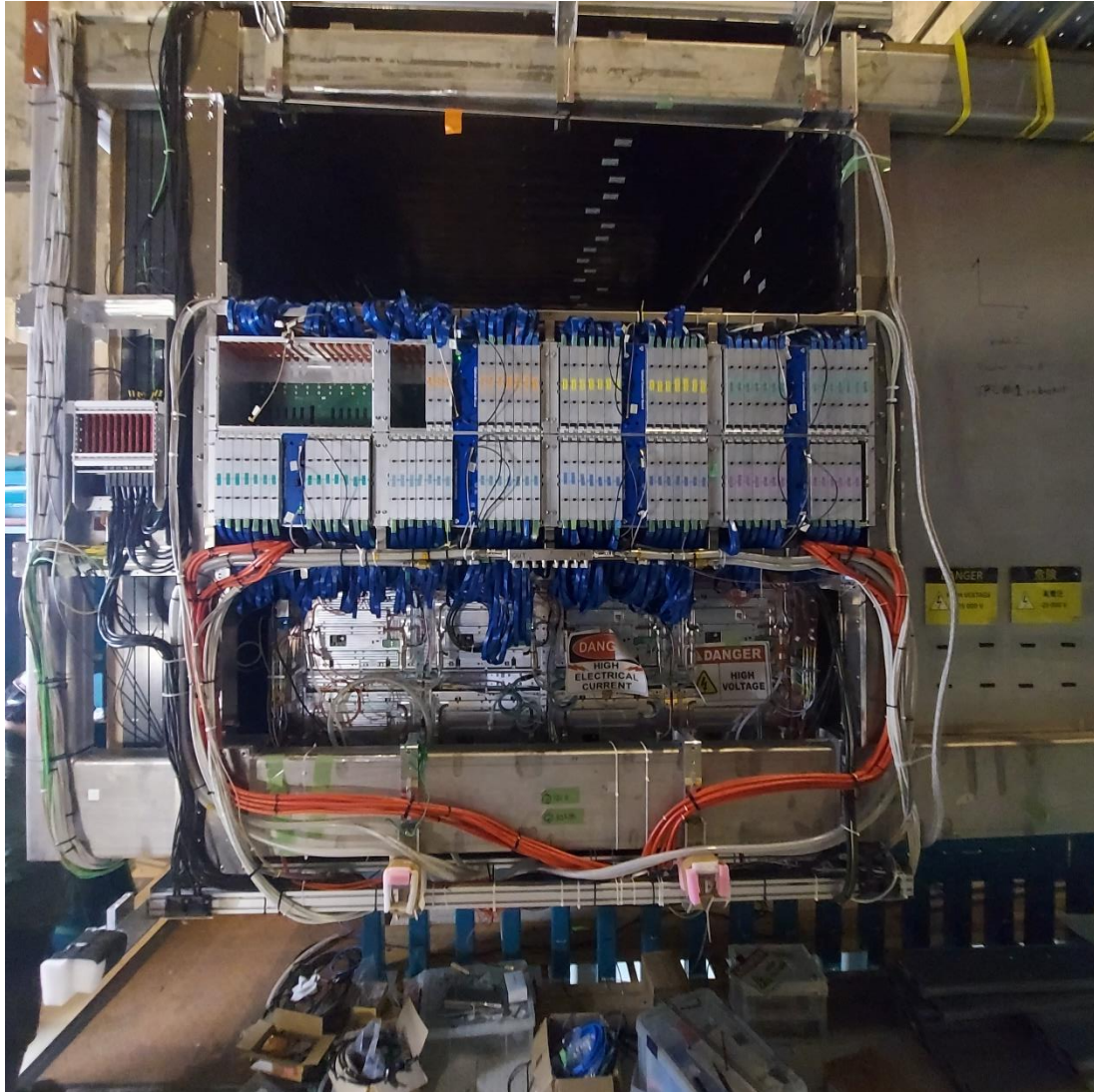


Gas System Commissioning

- Good performance also thanks to a new gas system provided by the CERN gas experts (R. Guida and team)
- Much easier to handle than the original gas system
- Very low leakage rate => ~3 times less gas required
- Very good performance observed => O₂ and H₂O reaching 5 ppm level



Now



First tracks with beam trigger observed but still working on integrated event display ...

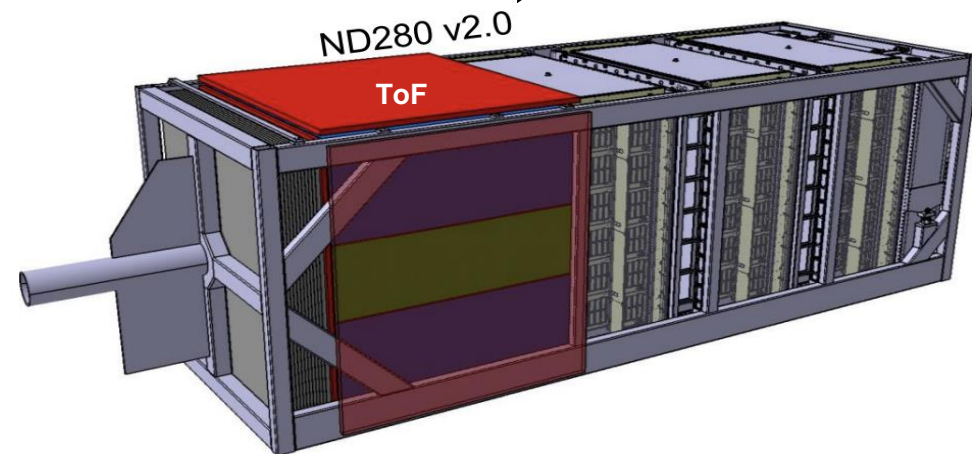
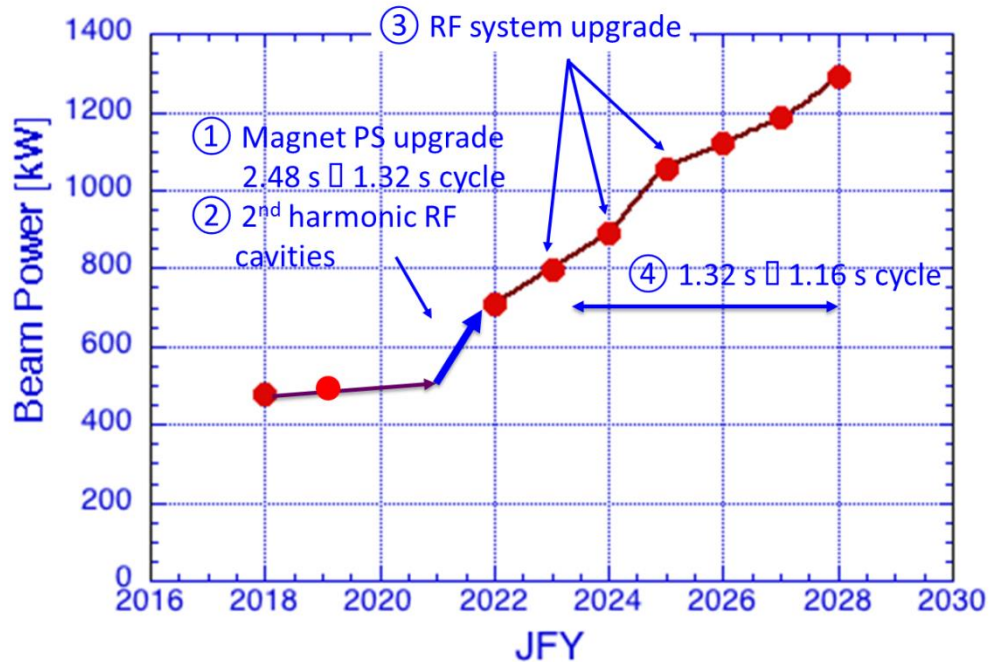
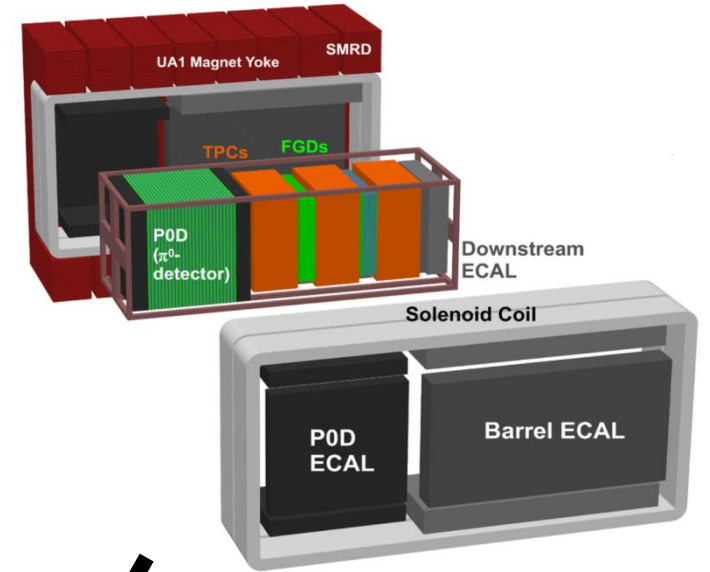
Summary and Outlook

- The first of two new TPCs for the ND280 Upgrade successfully assembled, installed and commissioned
- Light field cage based on composite materials
- Resistive MM used for the first time for a full size TPC
- Installation and commissioned went quite smoothly
- Performance and alignment studies have started
- Still a lot to do but it looks very good
- 2nd TPC assembly will start in January at CERN
- Installation planned for April 2024
- Aim: first neutrino beam with full Upgrade before summer 2024

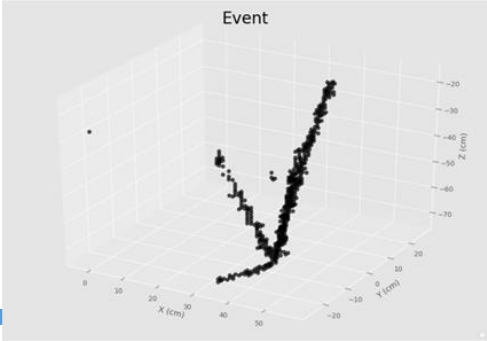
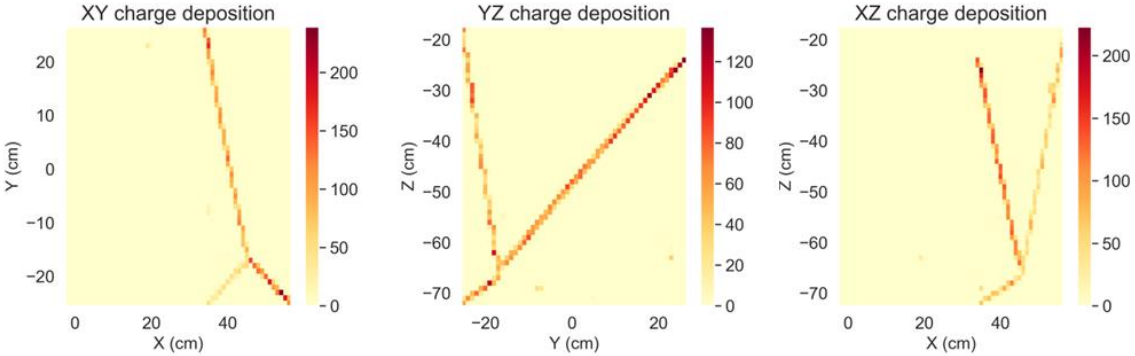
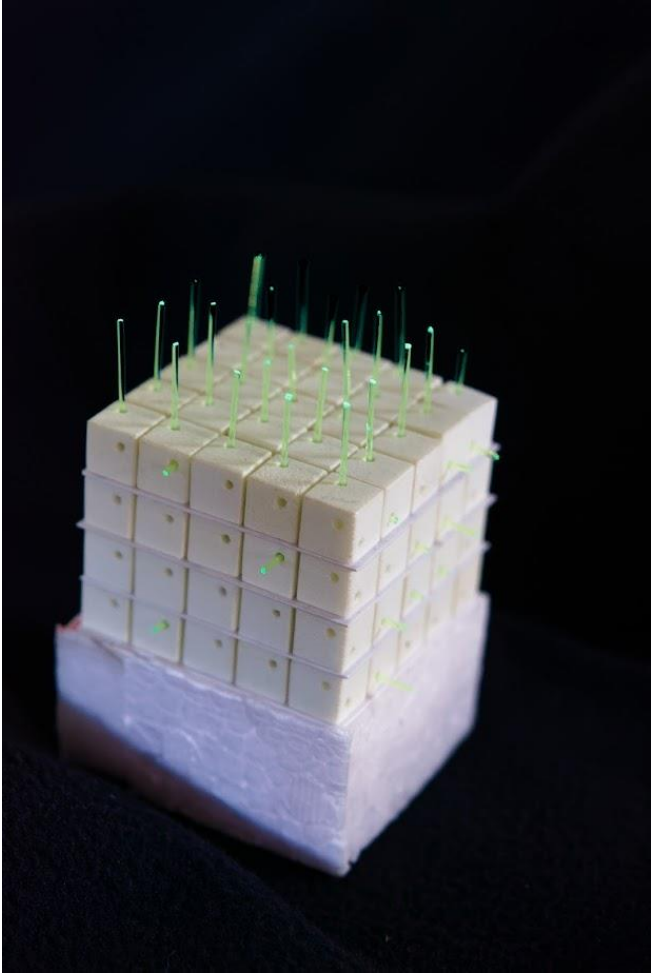
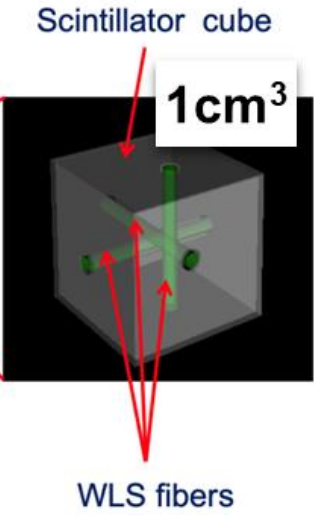
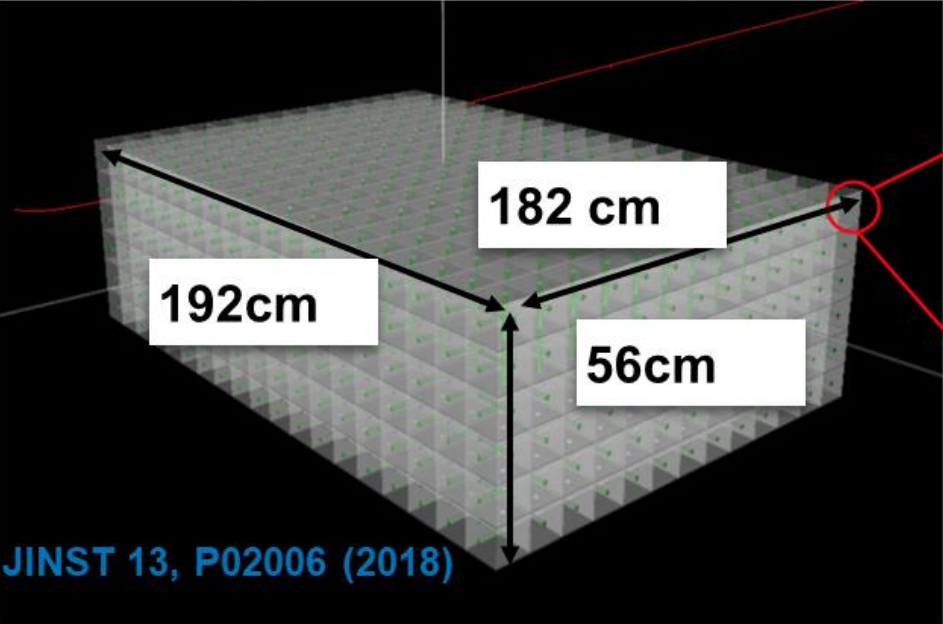
Backup Slides

T2K-II (2022-2026)

- New subdetectors for ND280
- beam power upgrade: 0.5 MW \rightarrow 1.1 MW (\rightarrow 1.3 MW HyperK)
- statistics: 3E21 POT (2018) \rightarrow 12E21 POT (2026)
- aim: systematics from 5-6% to 4%
- Aim for CPV observation in optimal scenario at 3σ



SuperFGD concept



Time-of-Flight System

