

# T2K- ND280 upgrade test results

**Yury Kudenko**

**INR, Moscow**

**CERN, European Neutrino Town Meeting  
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# ND280 upgrade

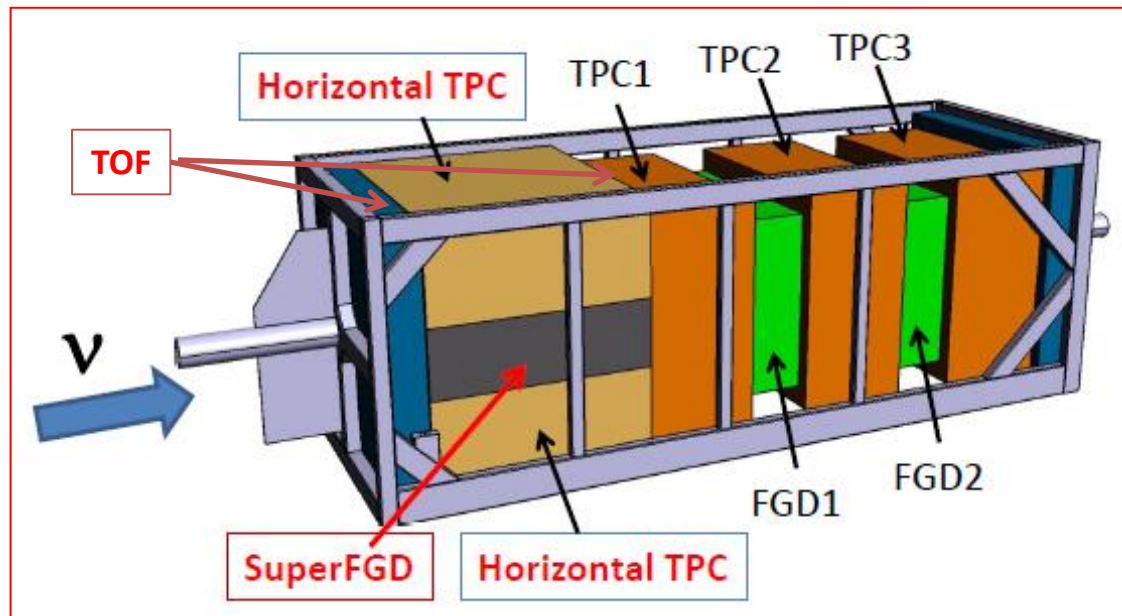
Upgrade the T2K Near Detector ND280 to reduce systematics to  $\leq 4\%$  level  
Needed for T2K-II and Hyper-K

arXiv:1609.04111

## New upstream tracker:

- Two Horizontal TPCs
- One 3D fine-grained scintillator target SuperFGD
- TOF system around new tracker

- Fully active detector
- $4\pi$  acceptance for charged particles
- Detection of low energy protons and pions
- Electron/gamma separation
- Electron neutrino studies

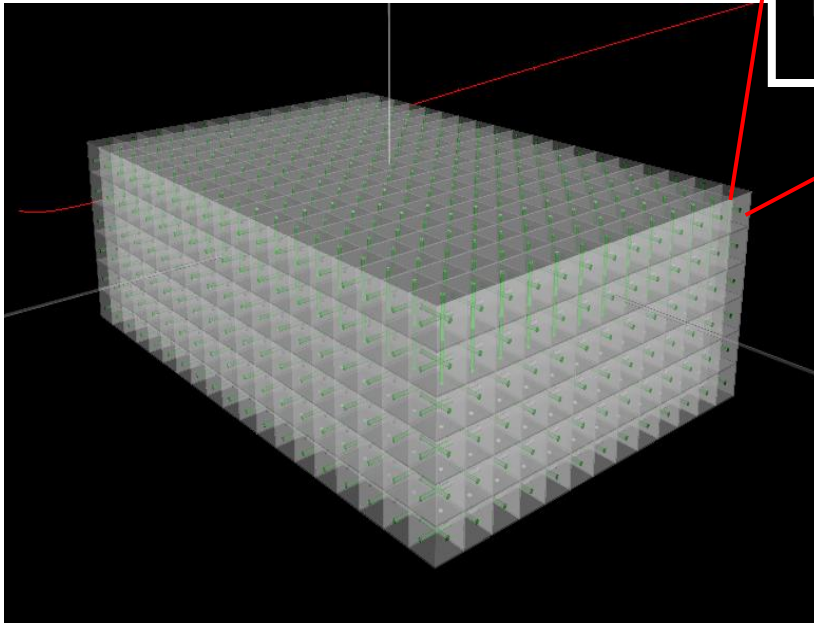
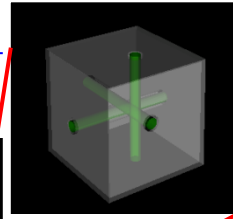
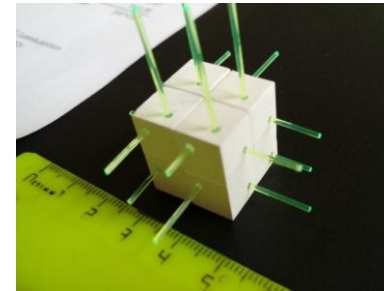




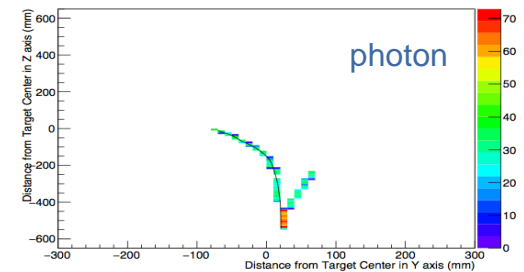
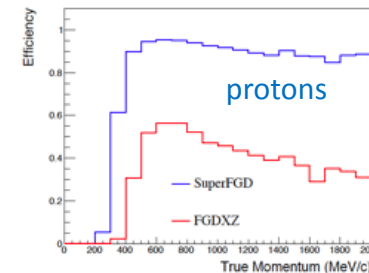
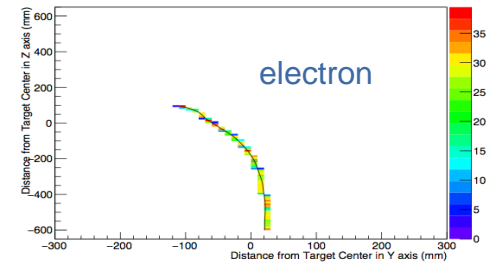
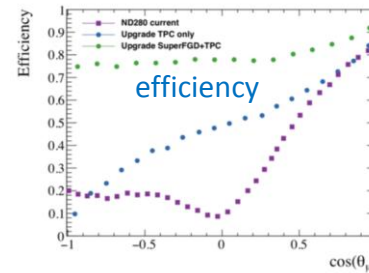
# SuperFGD

- Volume  $200 \times 200 \times 60 \text{ cm}^3$
- $2 \times 10^6$  scintillator cubes,  $1 \times 1 \times 1 \text{ cm}^3$
- Each cube has orthogonal 3 holes, diameter 1.5 mm
- 3D (x,y,z) WLS readout
- About 60000 readout WLS/MPPC channels
- Total active weight about 2 t

Fully active, highly granular,  
 $4\pi$  scintillator neutrino detector  
with 3D WLS/MPPC readout



## MC simulations





# Technology

Cubes are manufactured at Uniplast, Vladimir, Russia

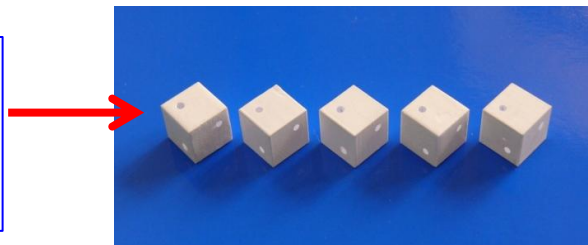
Injection molding technique



Press form with  
4 chambers



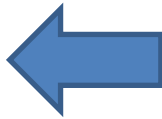
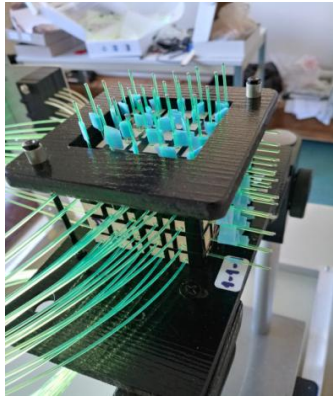
**Precision:  
each side  
 $\leq 30 \mu\text{m}$**



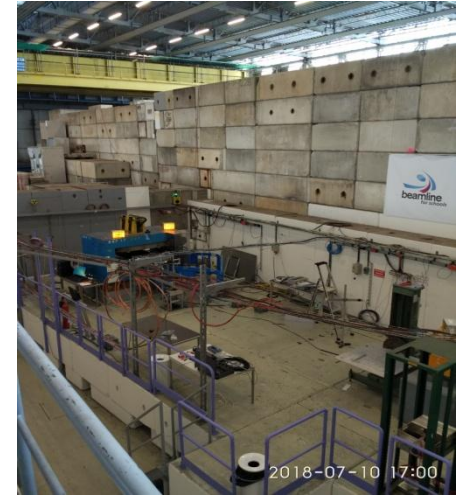


# Beam tests at CERN

T9 channel at CERN: muons, pions, protons, electrons 0.5 – 5.0 GeV



-First **small prototype**:  
 -125 cubes, 75 readout channels  
 - **Beam test October 2017**



## Large prototype

Length 48 cm

Width 24 cm

Height 8 cm

9216 cubes, each 1x1x1 cm<sup>3</sup>

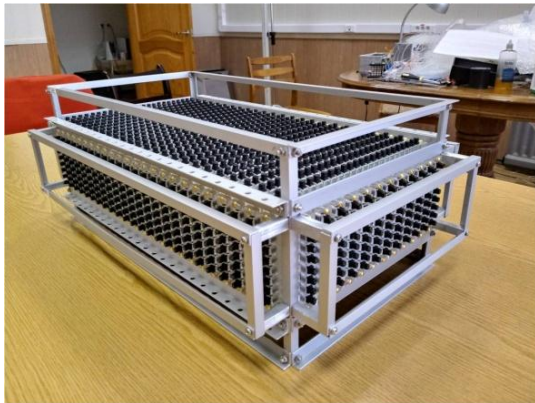
1728 Y11 WLS fibers, 1 mm diameter

Readout: 1728 MPPC's

2 beam tests:

June-July 2018

August-September 2018

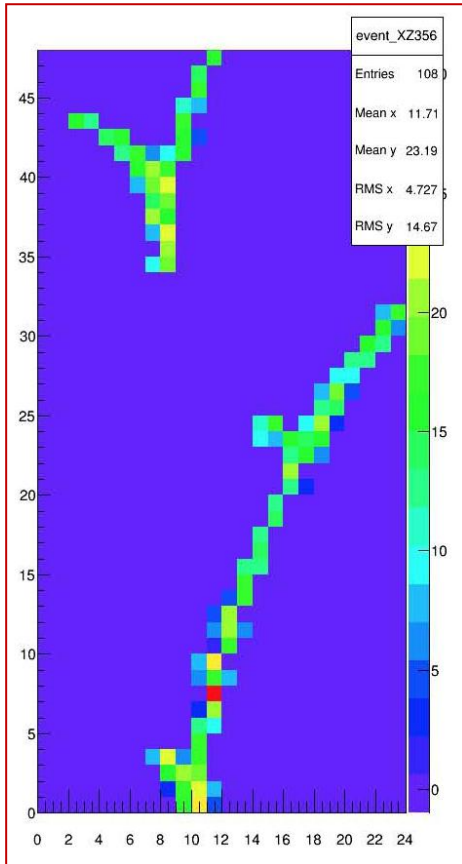




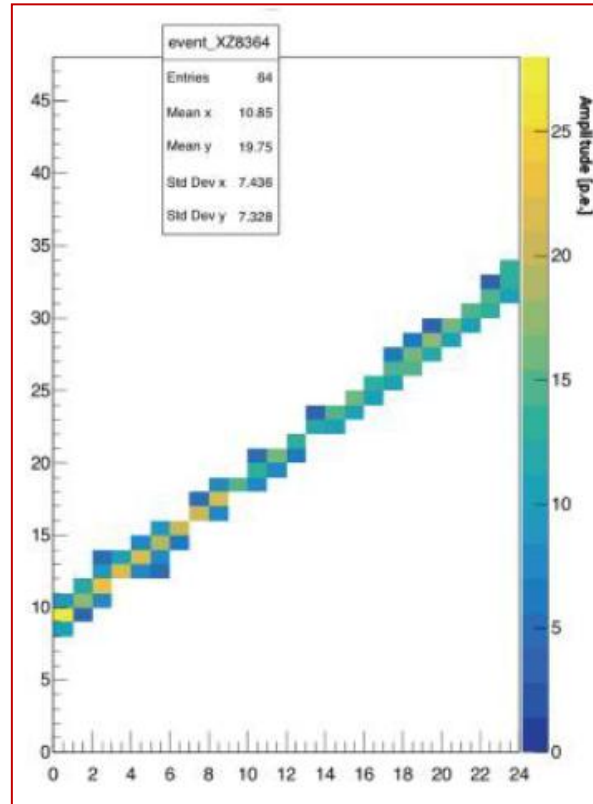
# Beam events

## Top views

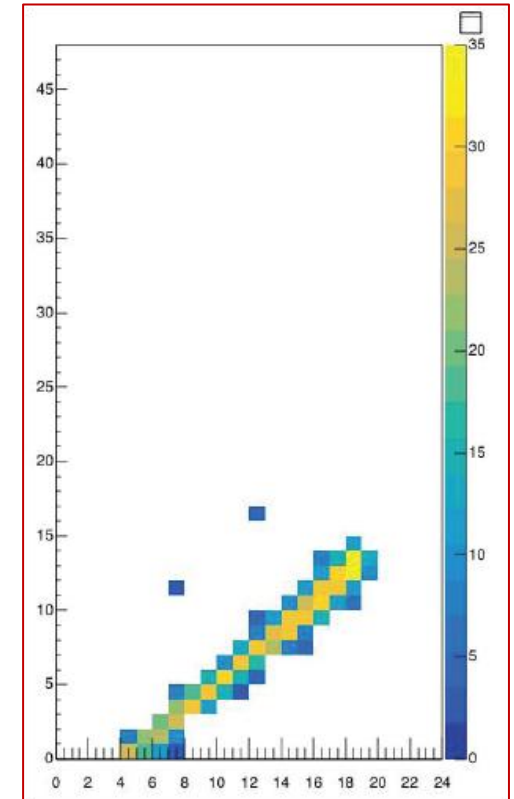
Positron, 1 GeV, B = 0.2 T



Muon, 5 GeV, 45 deg



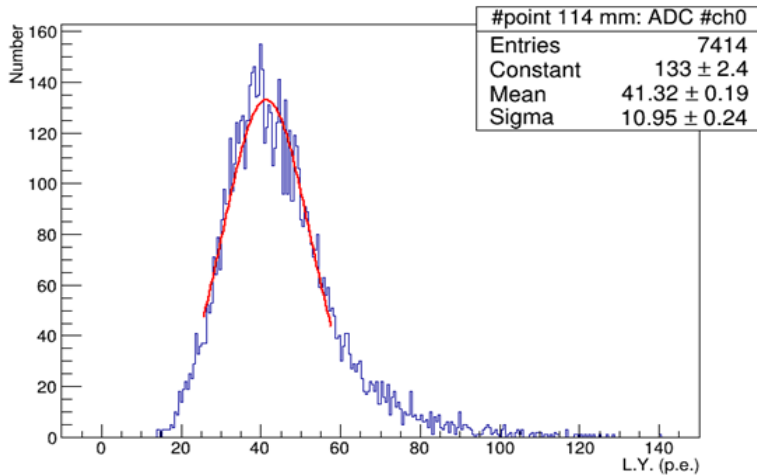
Stopped proton, 0.5 GeV, 45 deg



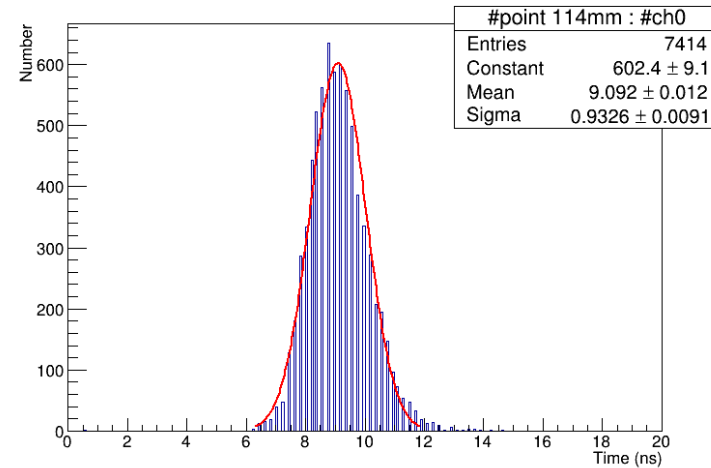


# Performance

Light yield of a MIP: 1 cube/1 fiber



Time resolution of a MIP: 1 cube/1 fiber



Light yield of 1 cube/1 fiber ~ 40 p.e./MIP

Light yield of 1 cube/2 fibers ~ 80 p.e./MIP

Time resolution ( $\sigma$ )

1 fiber: 0.92 ns

1 cube/2 fibers: 0.68 ns

2 cubes/4 fibers: 0.48 ns

3 cubes/6 fibers: 0.39 ns



# Horizontal TPC

Micromegas MM-0 mounted on the ex-HARP field cage at T9



Drift distance 1.5 m  
MM with resistive foil  
Horiz x Vert = 36 x 48 pads  
1728 pads in total  
Each pad 0.98 x 0.7 cm<sup>2</sup>  
Nominal MM voltage 340 V  
Sampling time 80 ns  
Nominal peaking time 600 ns

Beam test at CERN in August-September 2018  
Beam: muons, pions, electrons, protons  
momentum 0.5, +/-0.8, 1, 2 GeV/c

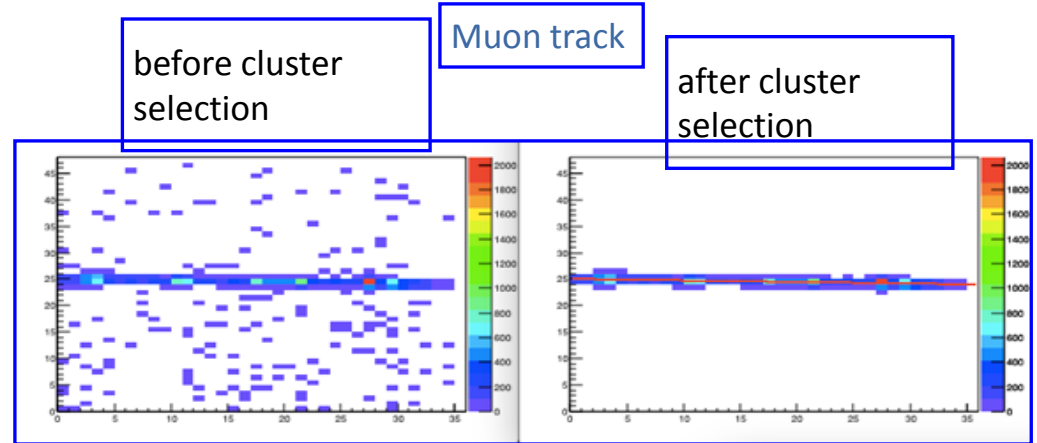
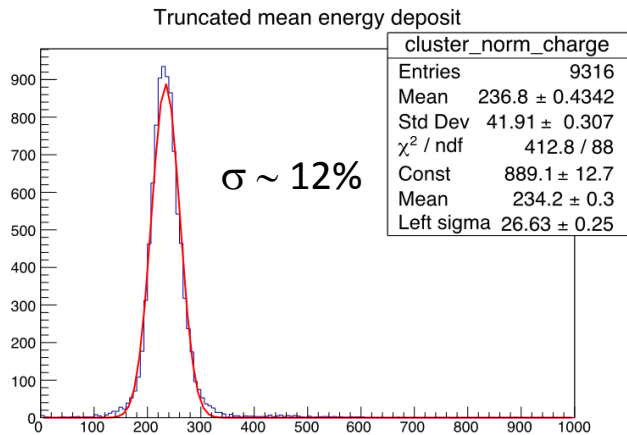




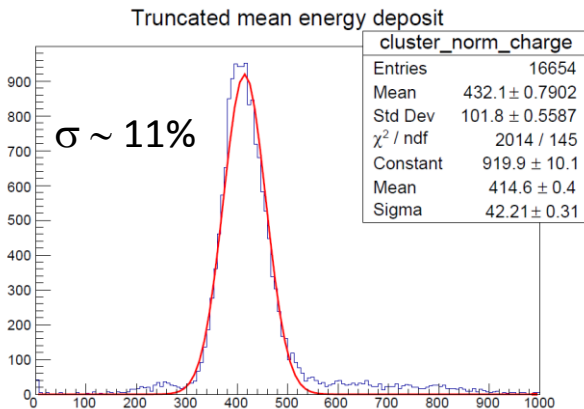
# TPC performance

Beam events

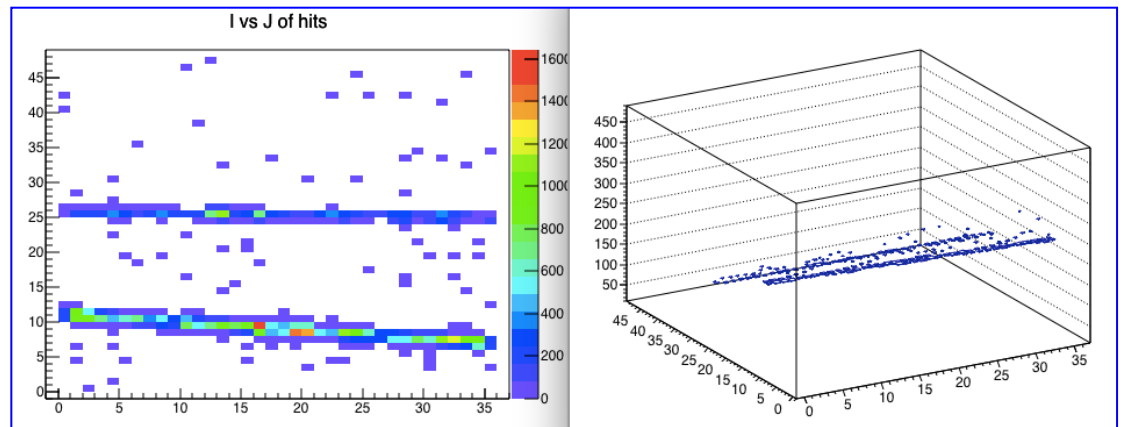
dE/dx, 2 GeV/c muons



dE/dx, electrons



2 tracks detected

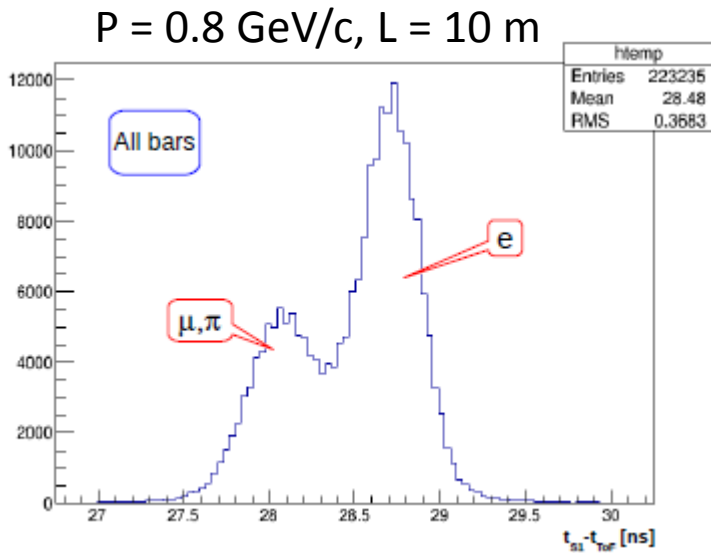
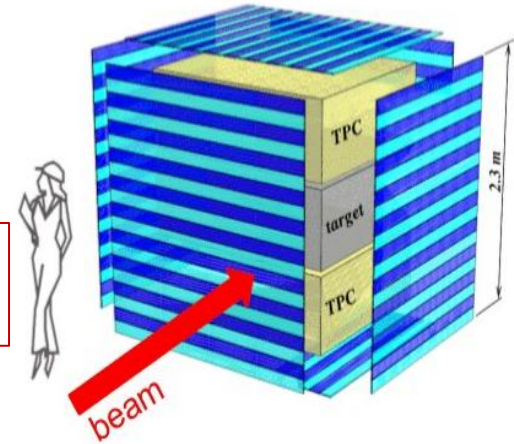




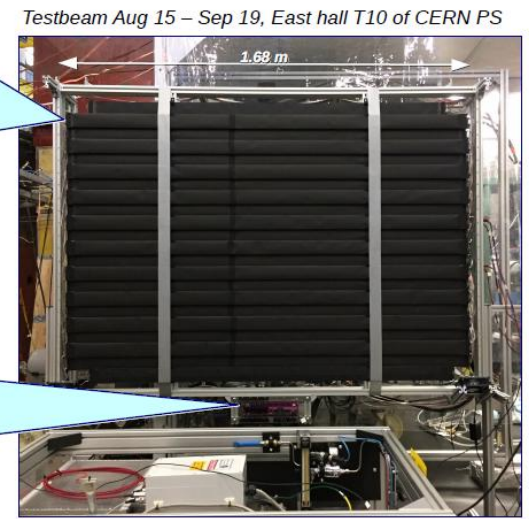
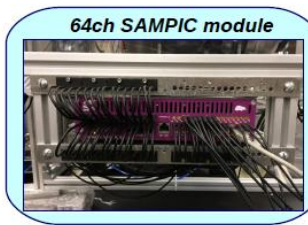
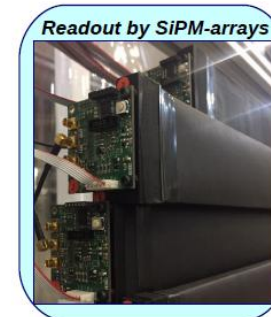
# TOF system

Time-of-Flight detector surrounds the new tracker (Super FGD + Horizontal TPCs) for better rejection of incoming background

TOF bar: cast scintillator EJ-200, 1.68 m x 6 cm x 1 cm  
readout by 8 arrays of 6x6 mm<sup>2</sup> of Hamamatsu MPPC's



Achieved time resolution  $\sigma \sim 70 \text{ ps}$





# Conclusion

**Upgrade of the T2K near detector ND280 is in progress**

**Beam tests at CERN → good performance of TPC , SuperFGD, TOF**

**Innovative technology works well**

**Production all detector components - 2019-2020**

**Assembly, installation and commissioning at J-PARC - 2021**