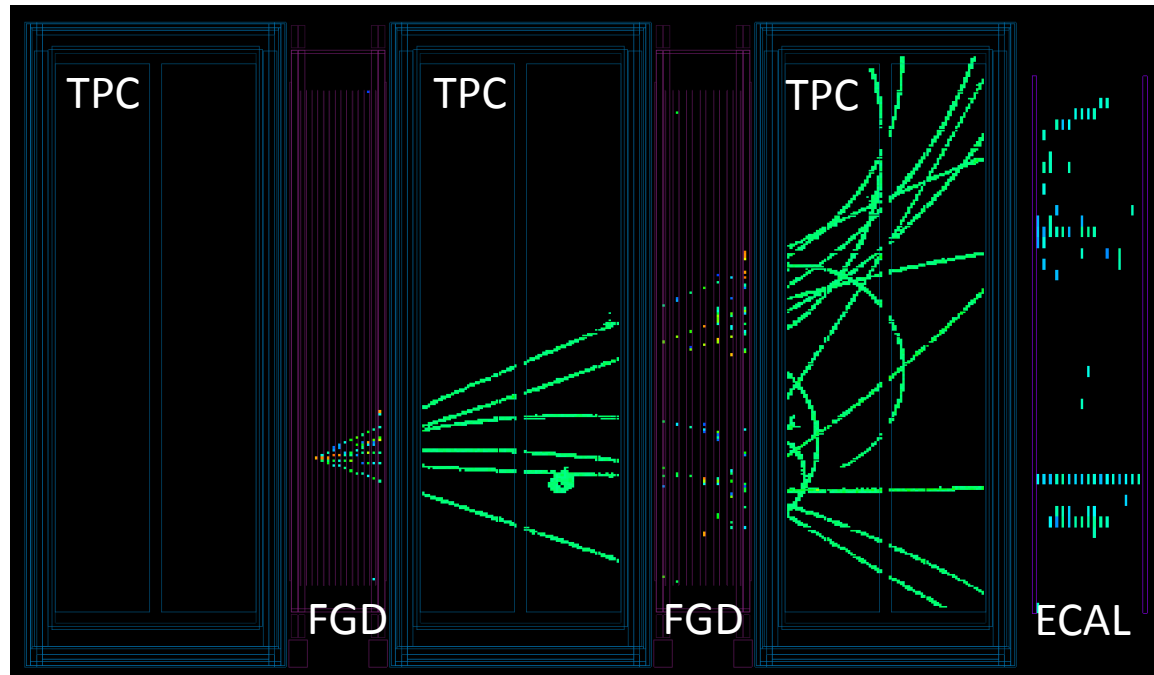


T2K Near Detector Time Projection Chambers and Calibration System

for the T2K collaboration, TPC Group

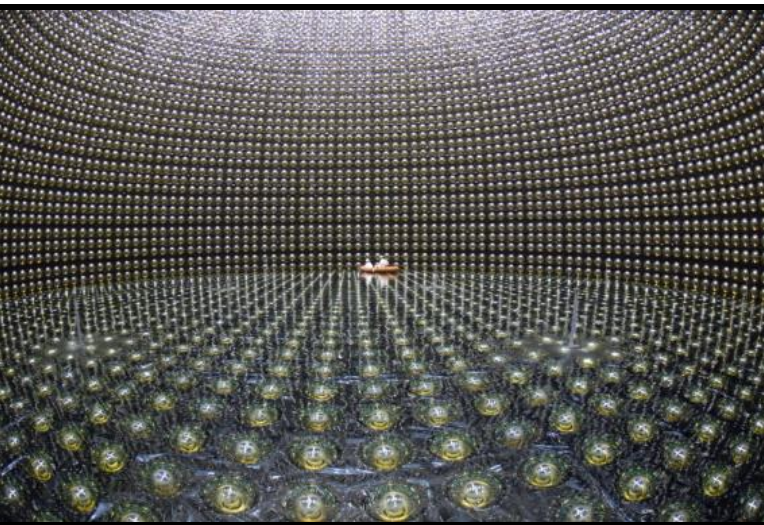


CAP Congress
Memorial University
June 13-17, 2011

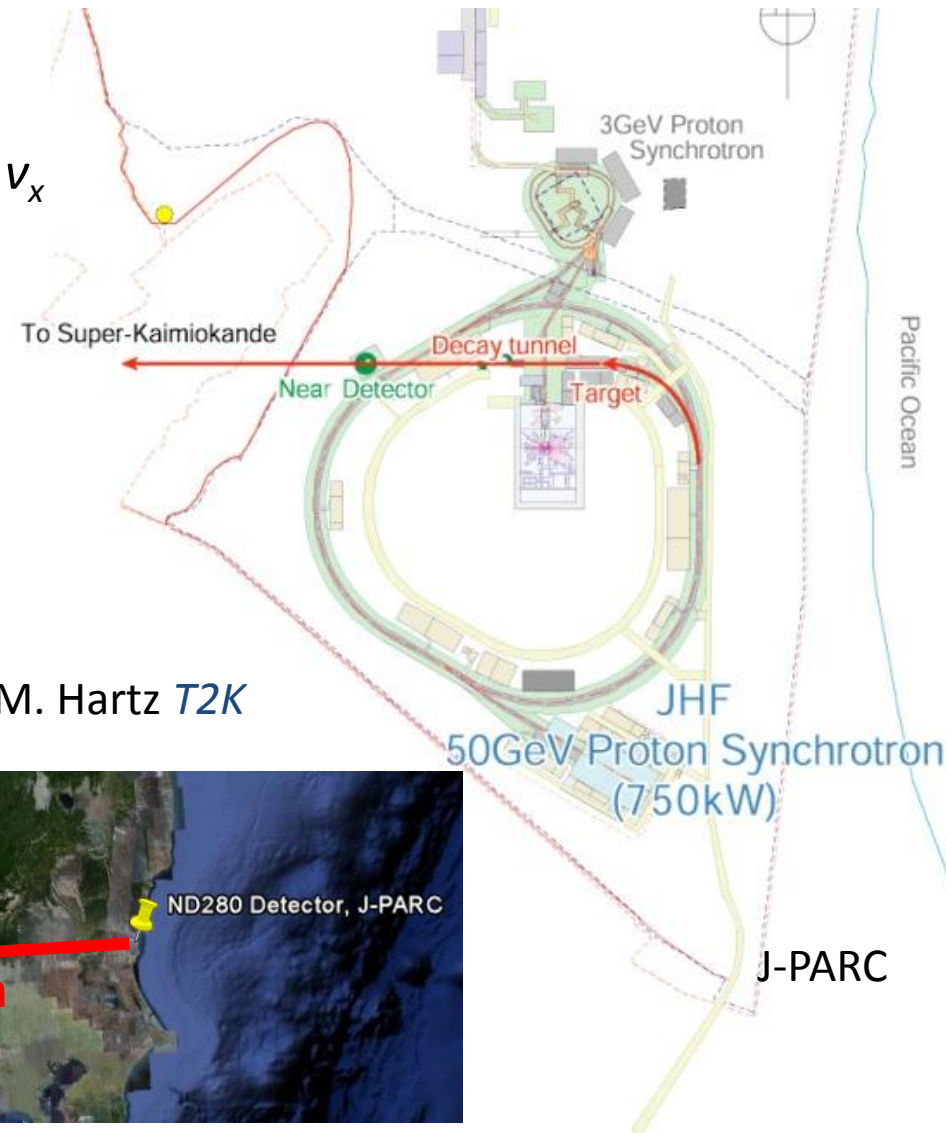
Tokai-to-Kamiokande (T2K)

○ Main goals of T2K are to measure:

- ν_μ disappearance ($\theta_{23}, \Delta m_{23}^2$): $\nu_\mu \rightarrow \nu_x$
- ν_e appearance (θ_{13}): $\nu_\mu \rightarrow \nu_e$



Super-Kamiokande



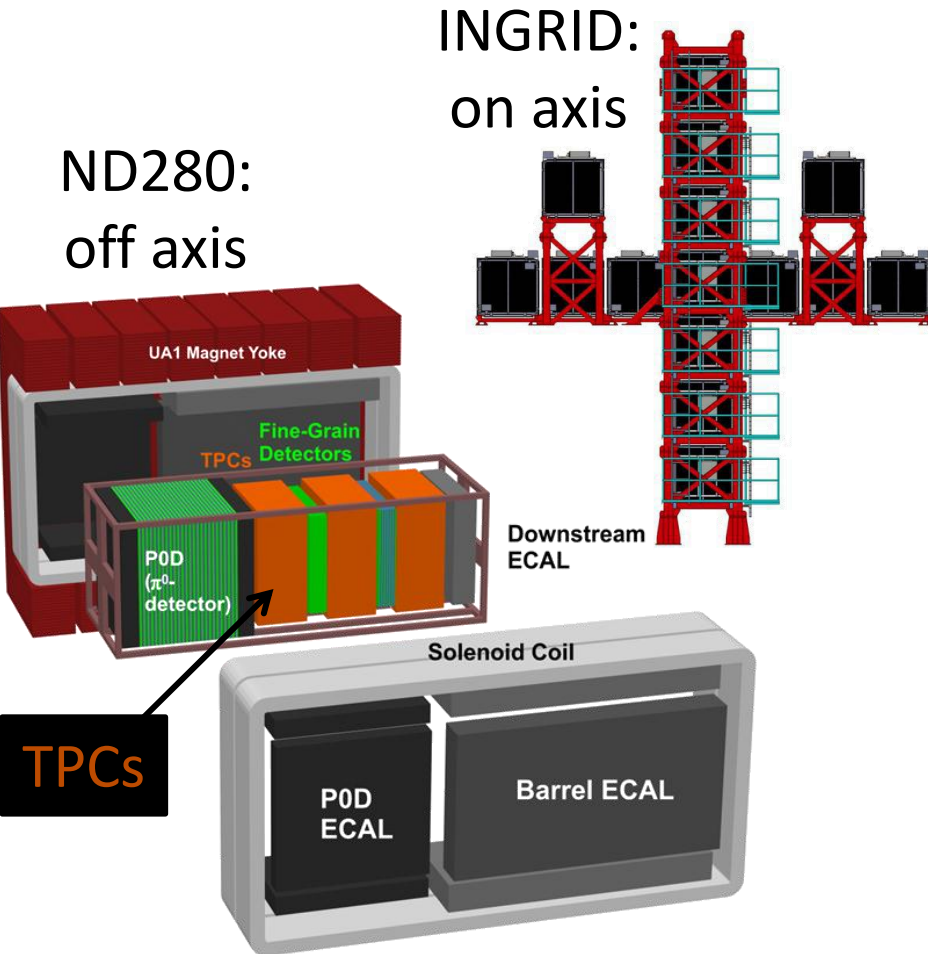
Talk: M. Hartz T2K



Near Detectors (J-PARC)

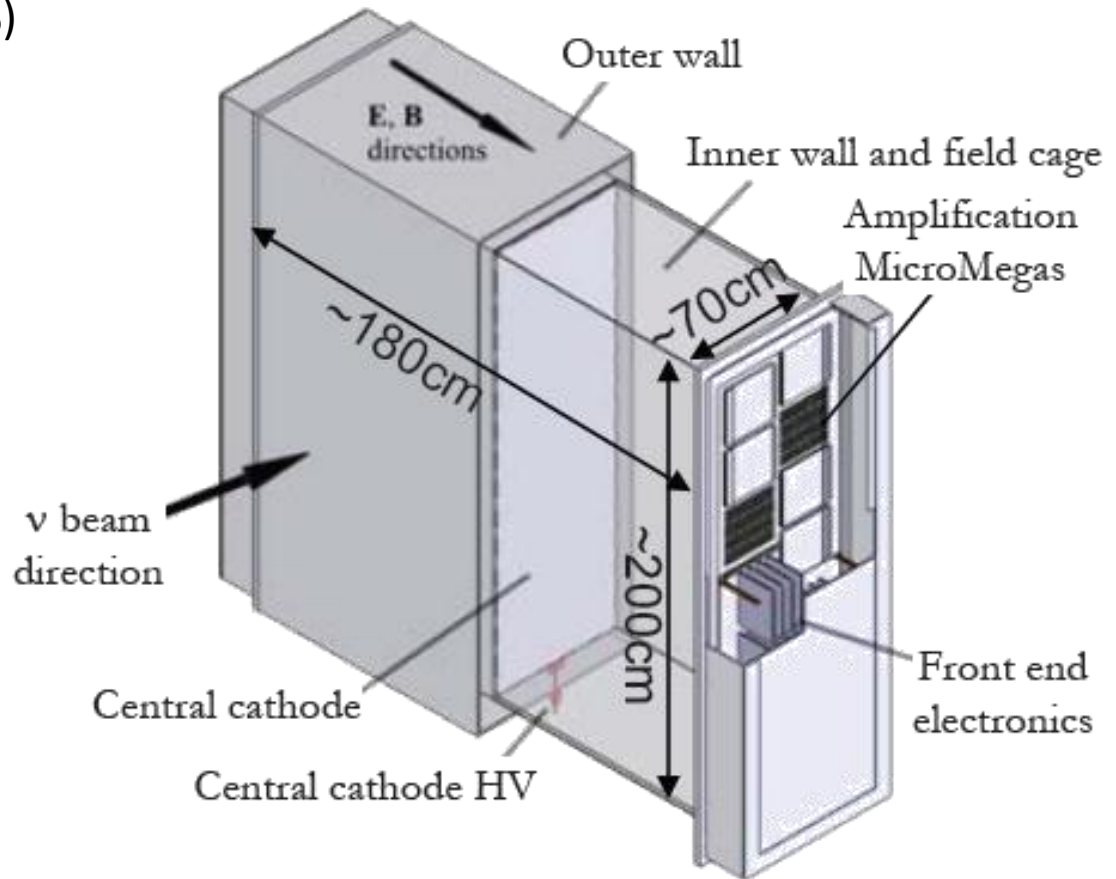
- Goal of the near detectors is to measure the beam properties before oscillation and neutrino interaction cross-sections

Talks: S. Giffin *FGDs*
K. Mahn *NDs*



Time Projection Chambers (TPC)

- Installed in fall 2009, commissioned winter 2010
- Pairs of gas boxes (drift chambers):
 - active Ar:CF₄:iC₄H₁₀ (95:3:2 %)
 - outer CO₂
- Central cathode:
2 drift regions
- Readout planes of
12 micromegas
- Main measurements:
 - momentum using track curvature
 - particle ID from energy loss

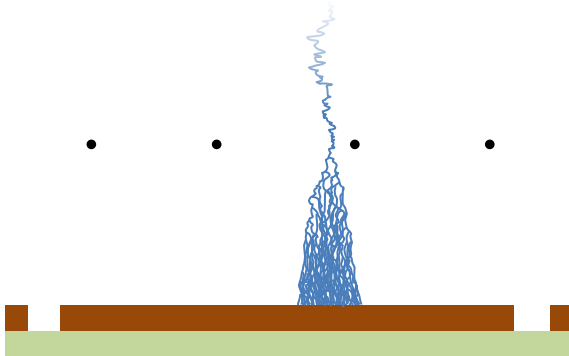
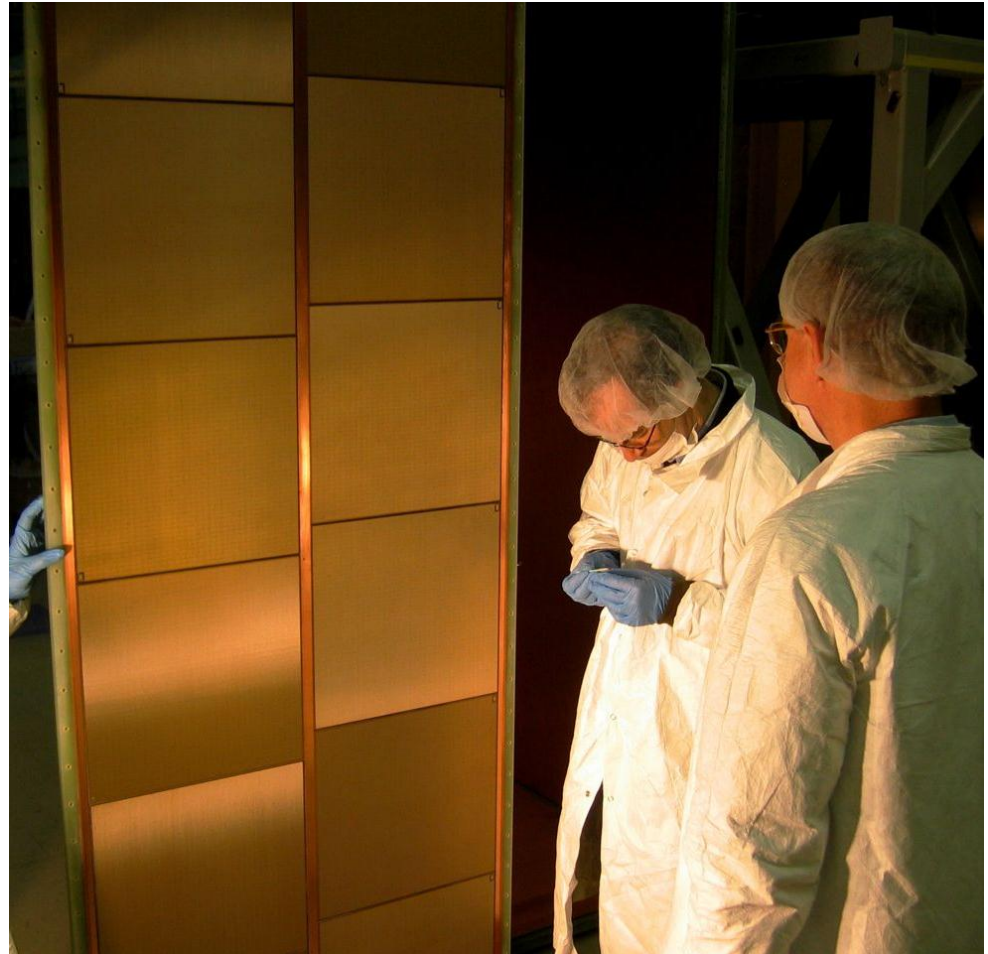


TPC PERFORMANCE

Micromegas

- TPC use 72 “bulk micromegas”:

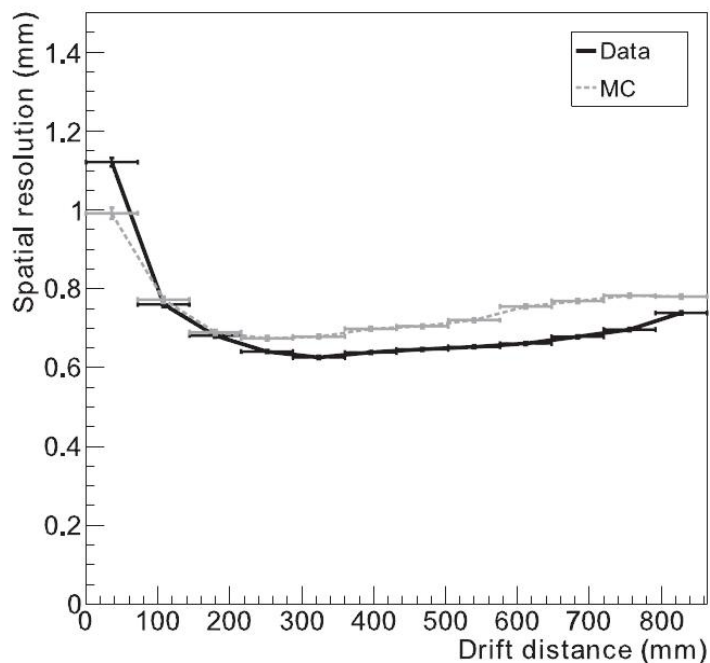
- 12 per detector end
- Pad pitch: $9.8 \times 7.0 \text{ mm}^2$
- 1726 pads per micromegas
- First use of “bulk-micromegas”
- Show good performance:
 - 0.1 spark/hour
 - $\sim 0.2\%$ of pads unused (dead or sparking)



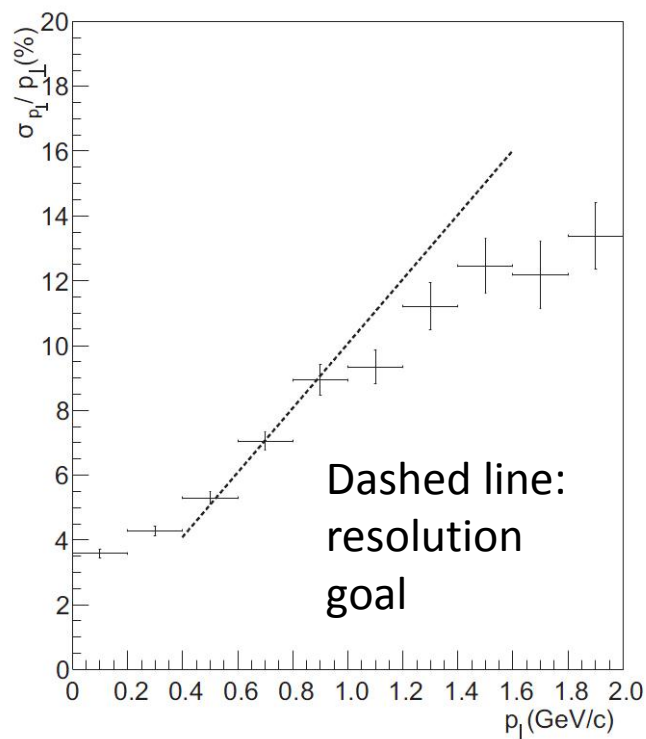
TPC Resolution

- Resolution goals for T2K TPCs:
 - Point resolution of ~ 0.7 mm, for tracks at maximum drift distance
 - Momentum resolution of $0.1 p_{\perp} / (\text{GeV}/c)$ (from spatial resolution)

Spatial Resolution



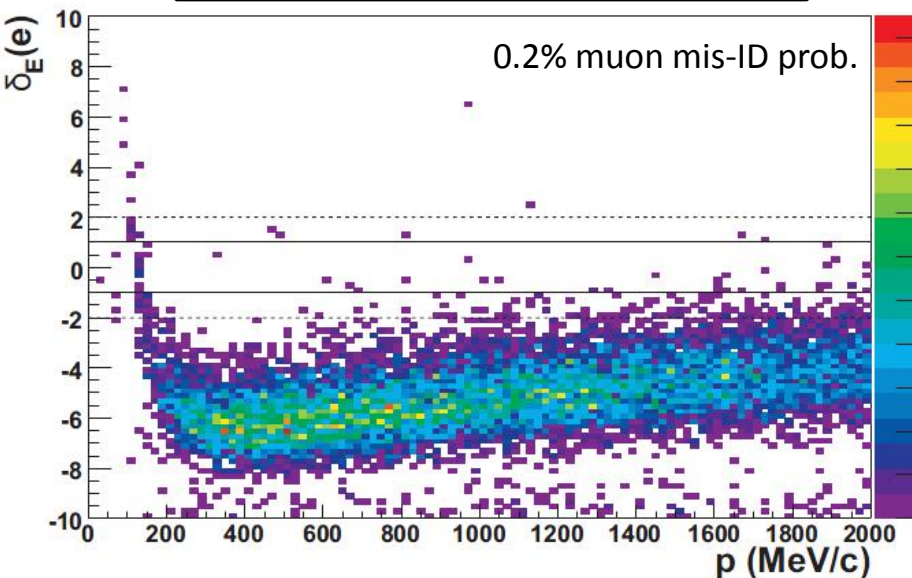
Inferred Momentum Resolution



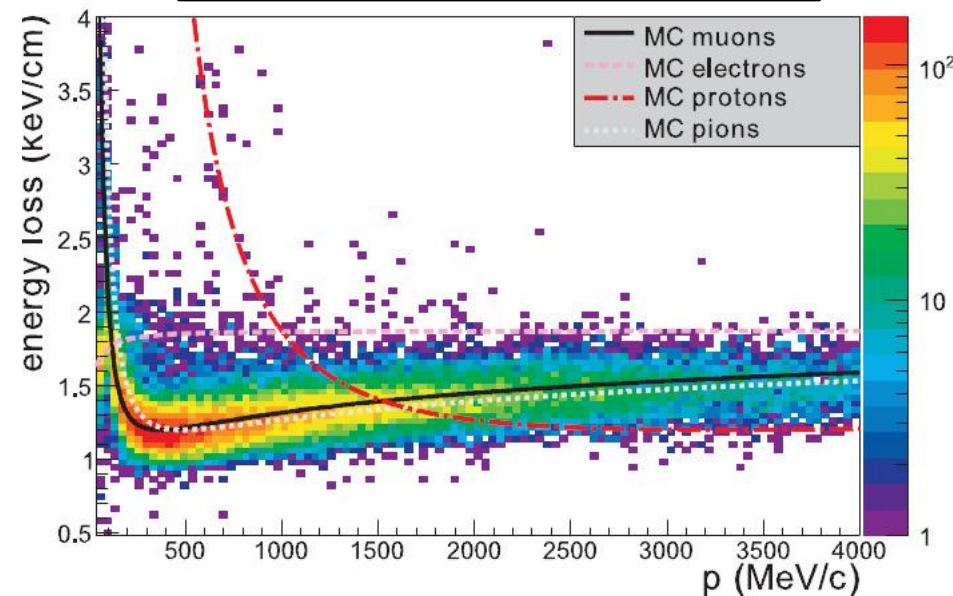
Particle ID

- The resolution of dE/dx is $7.8 \pm 0.2\%$ for minimum ionizing particles, better than the 10% requirement for the T2K TPCs.

Muons compared to expected energy loss for electrons



Energy loss vs. momentum for negatively charge particles

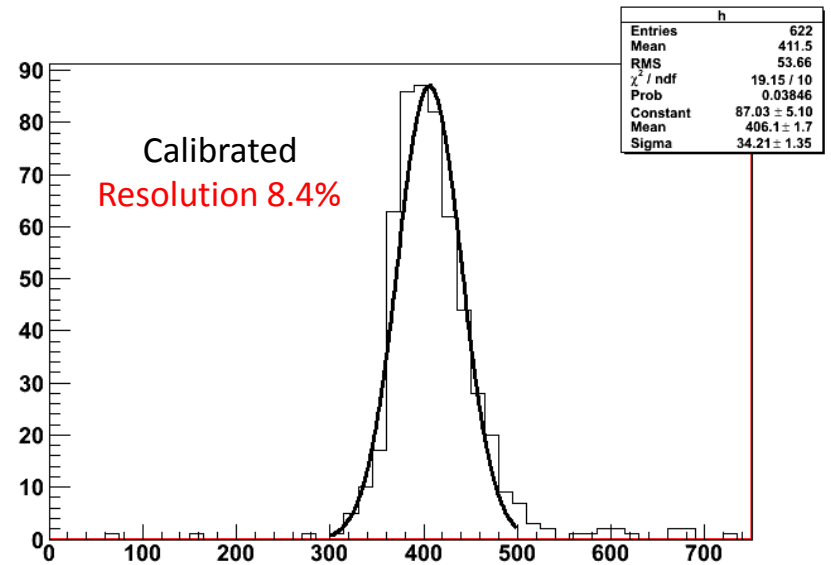
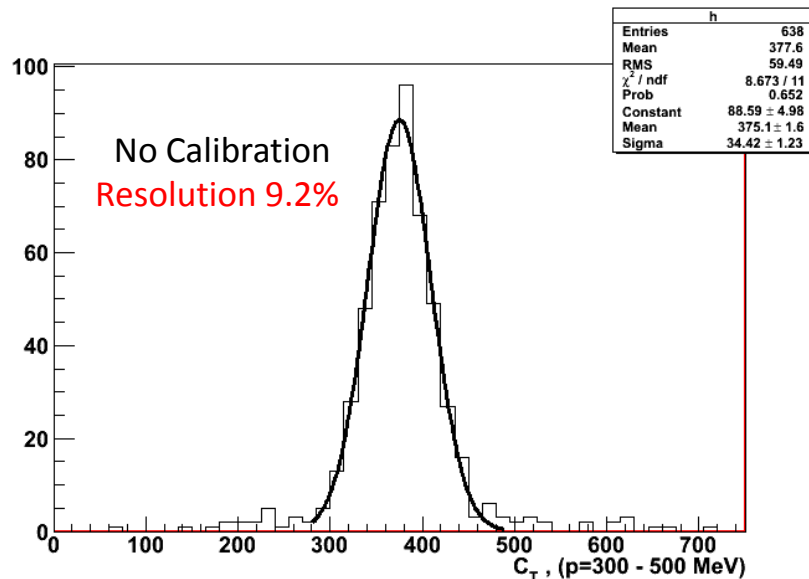


CALIBRATION

Gain Calibration

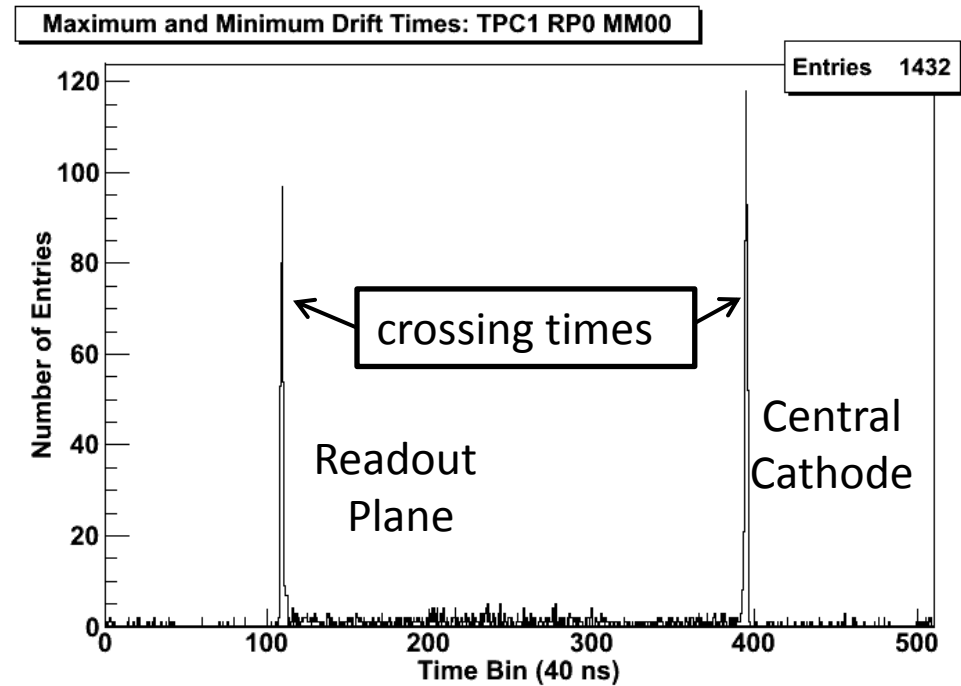
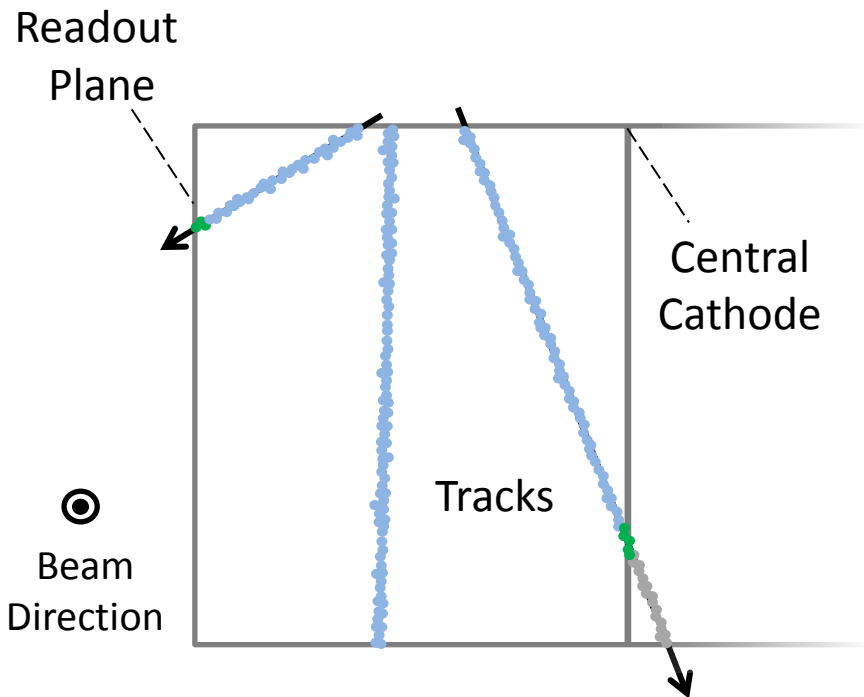
○ Aim:

- Equalizes micromegas (MM) to MM over space and time
1. Equalize pad to pad response: test measurements during production
 2. Refer all responses to a standard density:
 - a) Gain correction
 - b) dE/dx correction
 3. Equalize MM to MM: beam or cosmic tracks



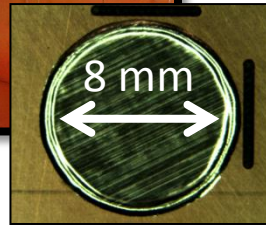
Drift Velocity Calibration

- Calculated from cosmic data
- Uses minimum and maximum signal times from cosmics crossing the TPC central cathode and readout plane (micromegas)

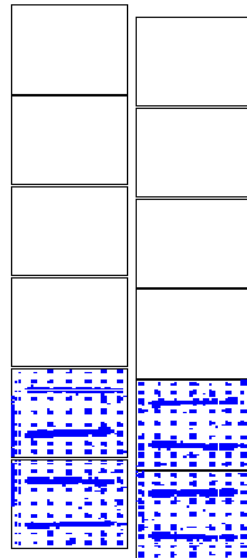
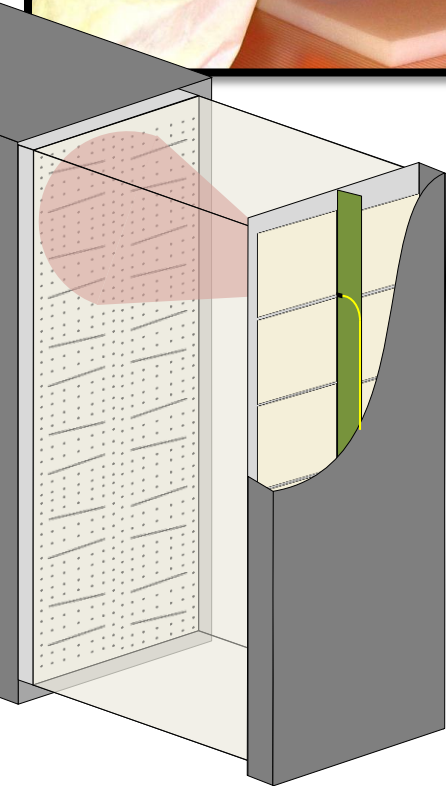


$$v_d = \frac{\text{drift vol. length}}{t_{CC} - t_{RP}}$$

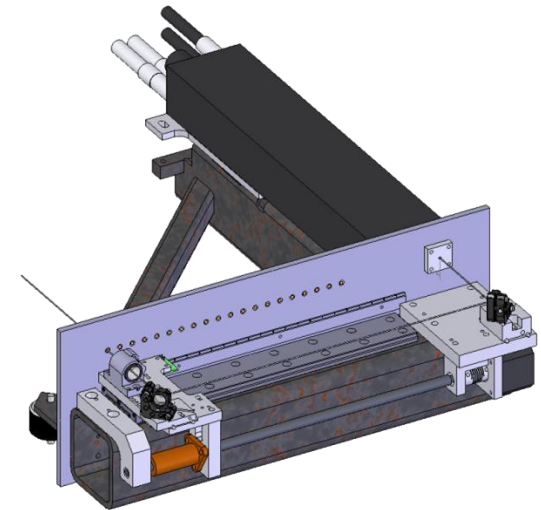
Laser Photo-electron Calibration



- UV Laser (266 nm)
- Multiplexer and 18 distribution fibres
- Targets: Al dots and strips on cathodes
- Used for:
 - Timing calibration
 - Field distortions measurements
 - General testing trigger



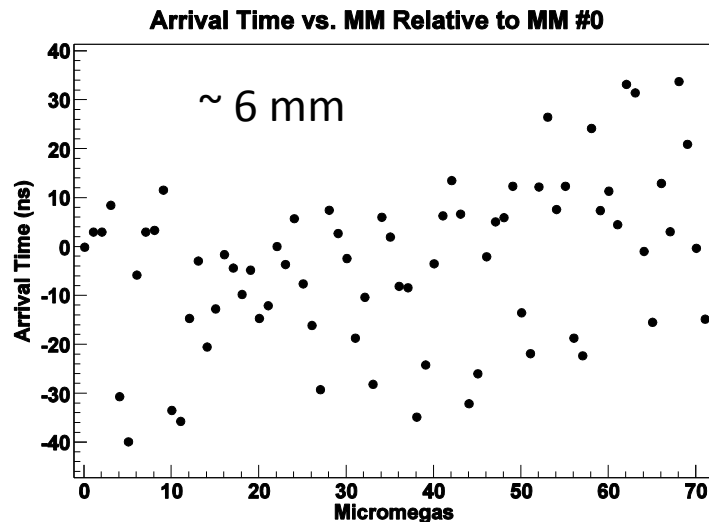
Typical single fibre event



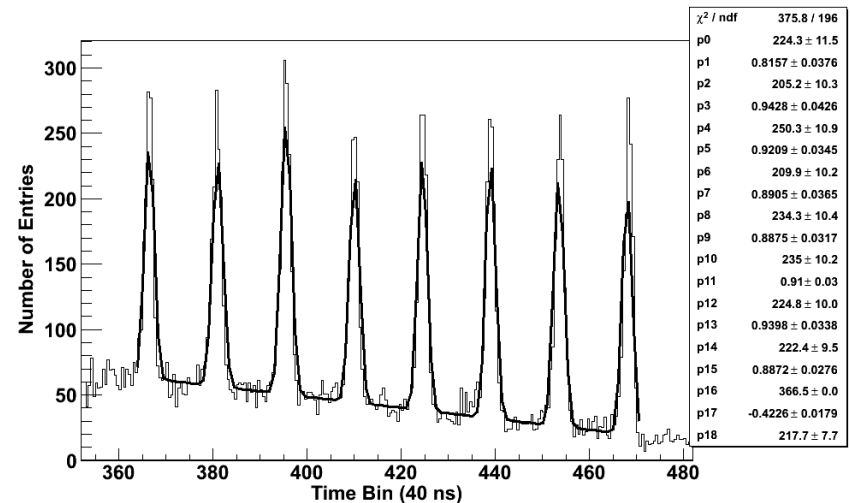
Time Calibrations

- Calibrate for phase uncertainties between the micromegas electronics
 - can cause breaks in track continuity between micromegas
 - affects alignment results
- Laser provides the phase offsets
- Cosmic and beam data, relative time axis offsets to respective triggers

Laser Base Micromegas time offsets



Beam timing measurement



Summary

- TPCs have operated well since installation in Fall 2009
- Low failure percentage on channels
- TPCs have met the performance goals set: spatial and momentum resolution, PID
- Calibrations are in place or being worked on currently

- Other T2K talks (following immediately):
 - S. Giffin: *FGDs*
 - M. Hartz: *T2K Results and Prospects*
 - K. Mahn: *Physics results, Near detectors*



Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Time projection chambers for the T2K near detectors

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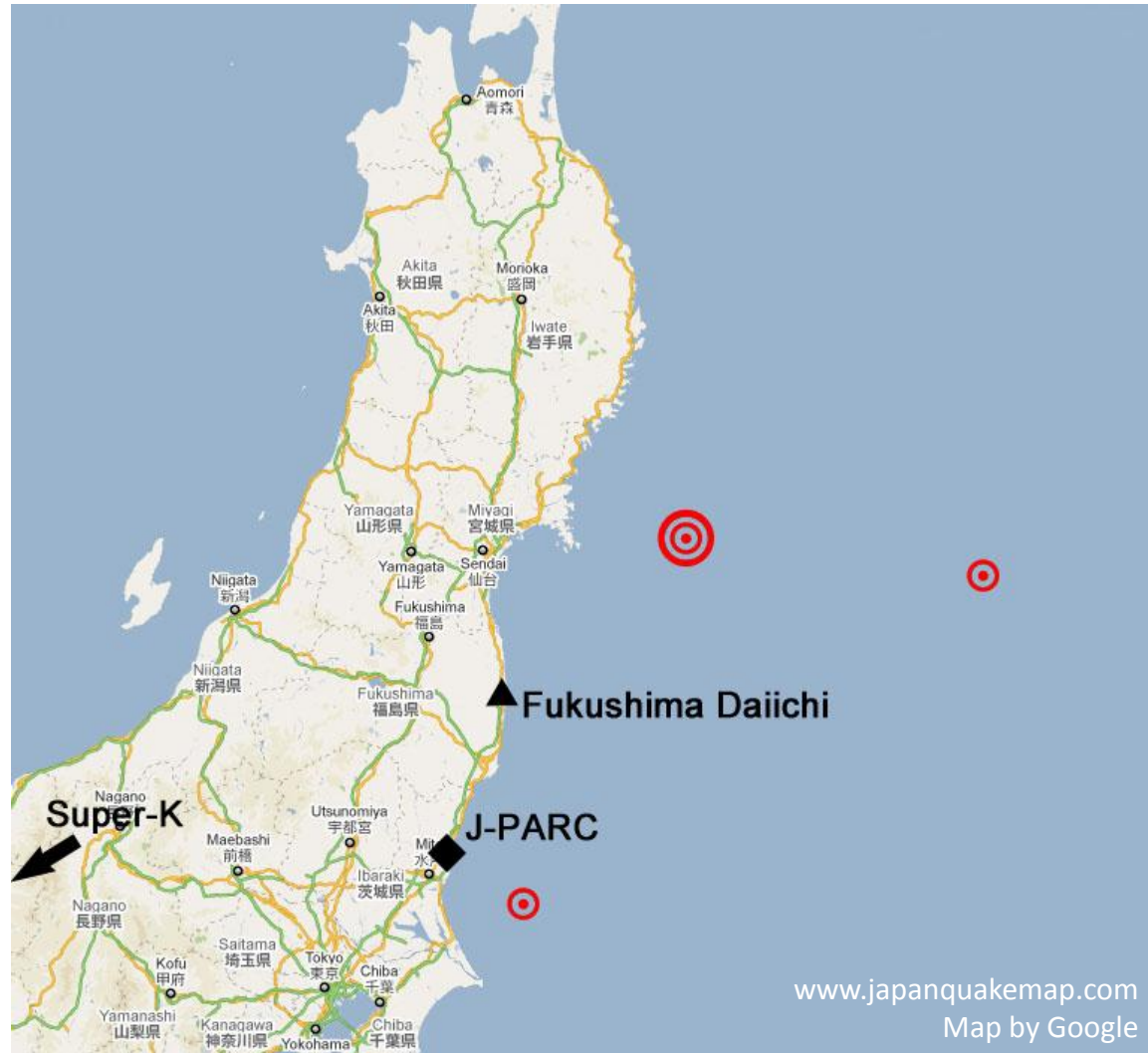
T2K paper (NIM A):
The T2K Experiment, arXiv:1106.1238

SPARE SLIDES

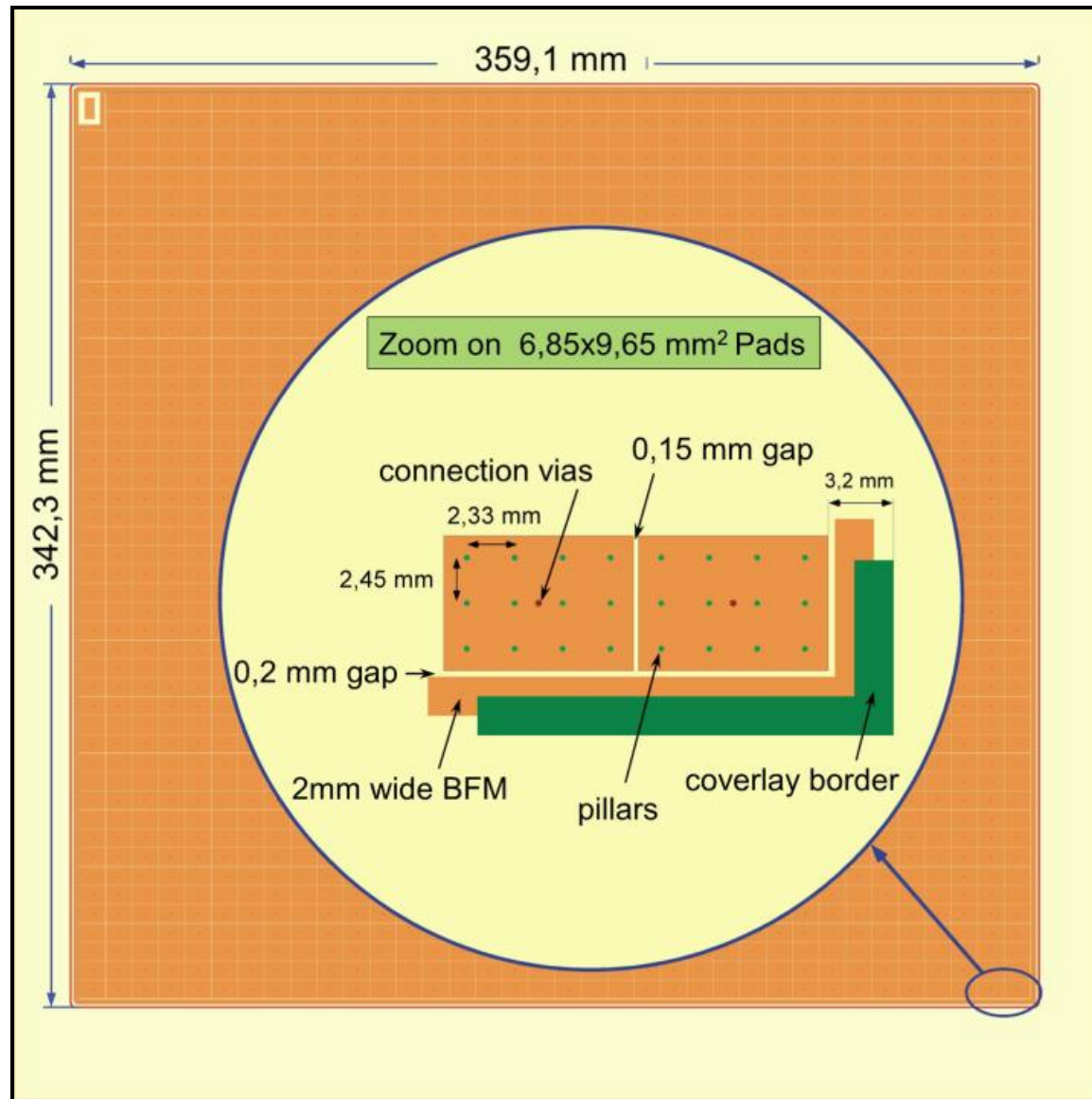
Earthquake

- Tsunami did not affect J-PARC
- No T2K collaborators were injured
- No problems with Tokai reactors

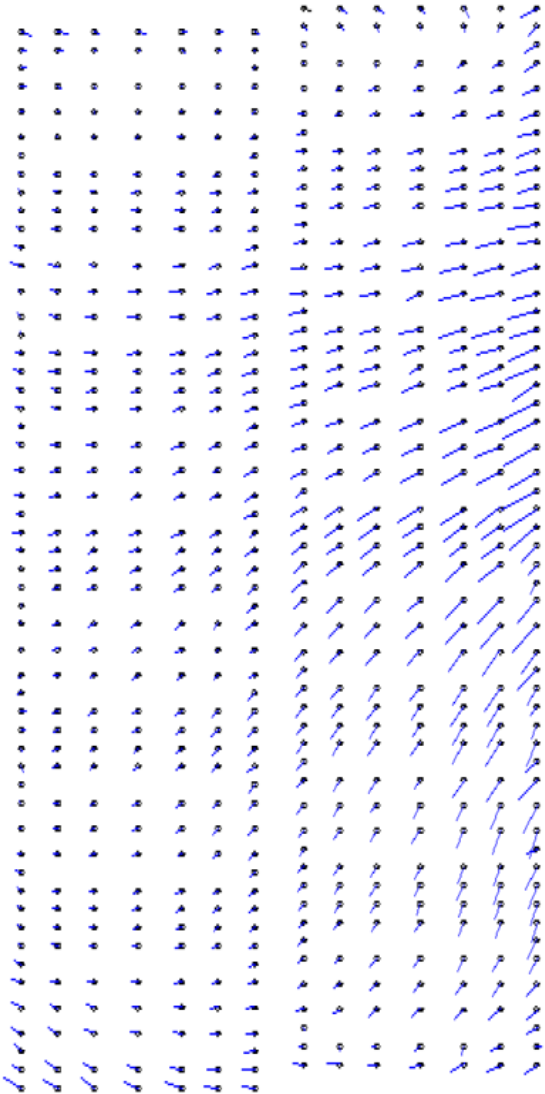
- J-PARC and T2K have started recovery work
- Recently (May) the TPCs were tested and are full functional



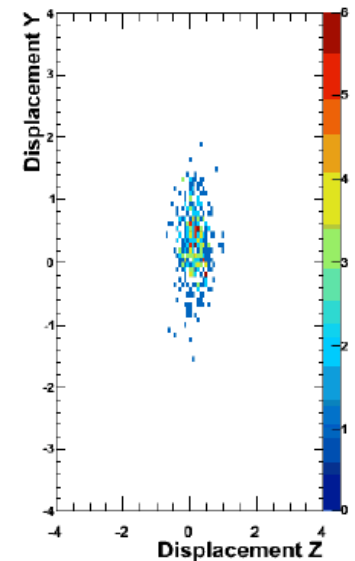
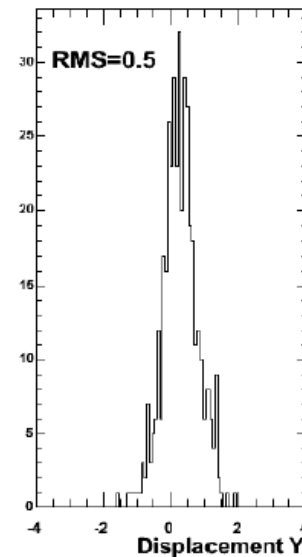
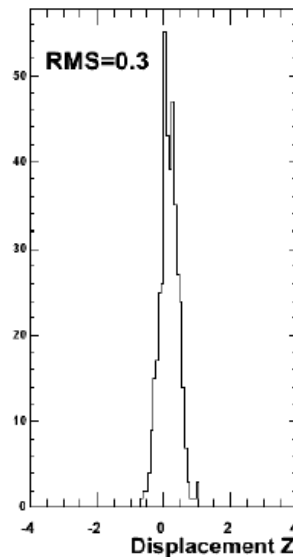
Micromegas



Distortion Measurements



- Laser dot targets are used to measure distortions
- At right is comparison of position for B field on/off (TPC #3, downstream)
- Uses charge sharing between sets of 4 pads to estimate dot centers
- Repeated measurements: stand. dev ~ 0.5 mm



Gas Monitor Chambers

- Two monitor chambers in gas system
- Small TPCs sampling input and output gas
- Gain measurements: ^{55}Fe
- Drift velocity: two ^{90}Sr

