# MicroMeGas TPC R&D for T2K

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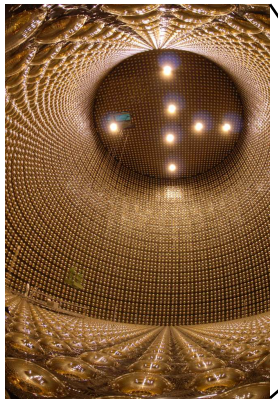
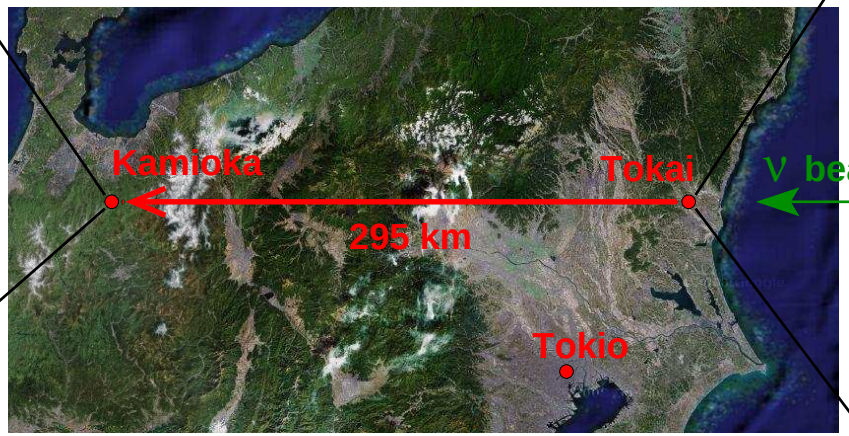
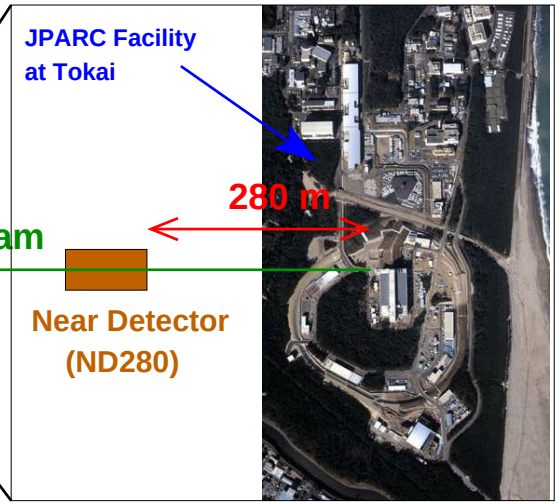
# The T2K experiment and ND280 detector



***SupeKamiokande***

*250 kTon Water Cherenkov Detector*




## Measure $\nu_\mu$ disappearence

- more accurate determination of the "atmospheric" parameters $\theta_{23}$ and $\Delta m_{23}$:

  $\delta(\sin^2 2\theta_{23}) \simeq 0.01$ $\qquad$ $\delta(\Delta m^2_{23}) \simeq 3 \cdot 10^{-5} eV$

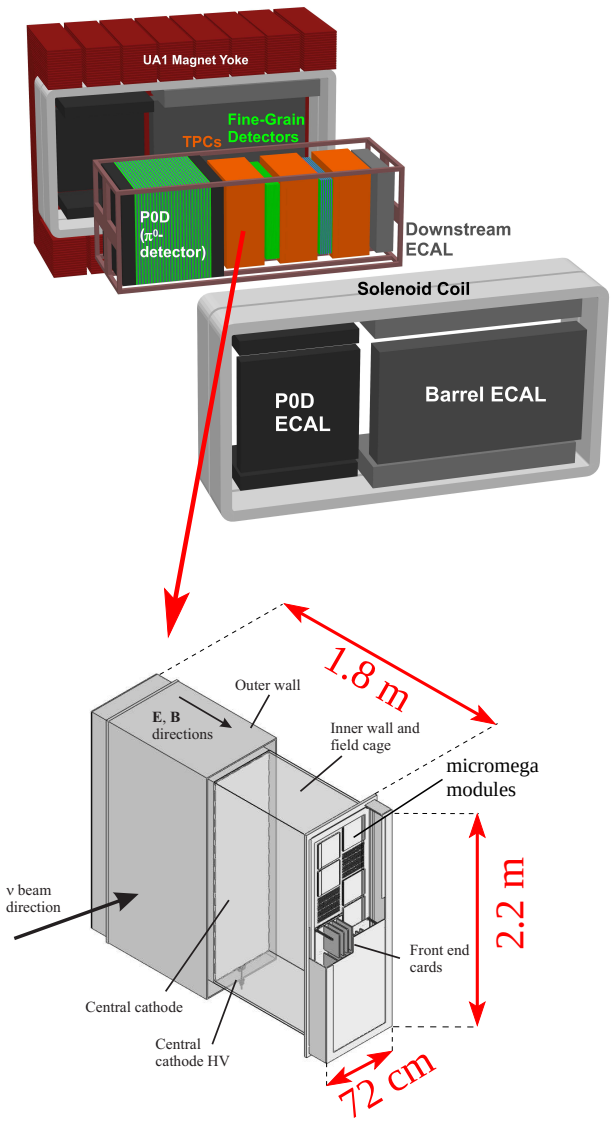
- SK, K2K, MINOS:

  $\delta(\sin^2 2\theta_{23}) \simeq 0.04$ $\qquad$ $\delta(\Delta m^2_{23}) \simeq 2 - 3 \cdot 10^{-4} eV$

## Search for $\nu_\mu \rightarrow \nu_e$ appearence

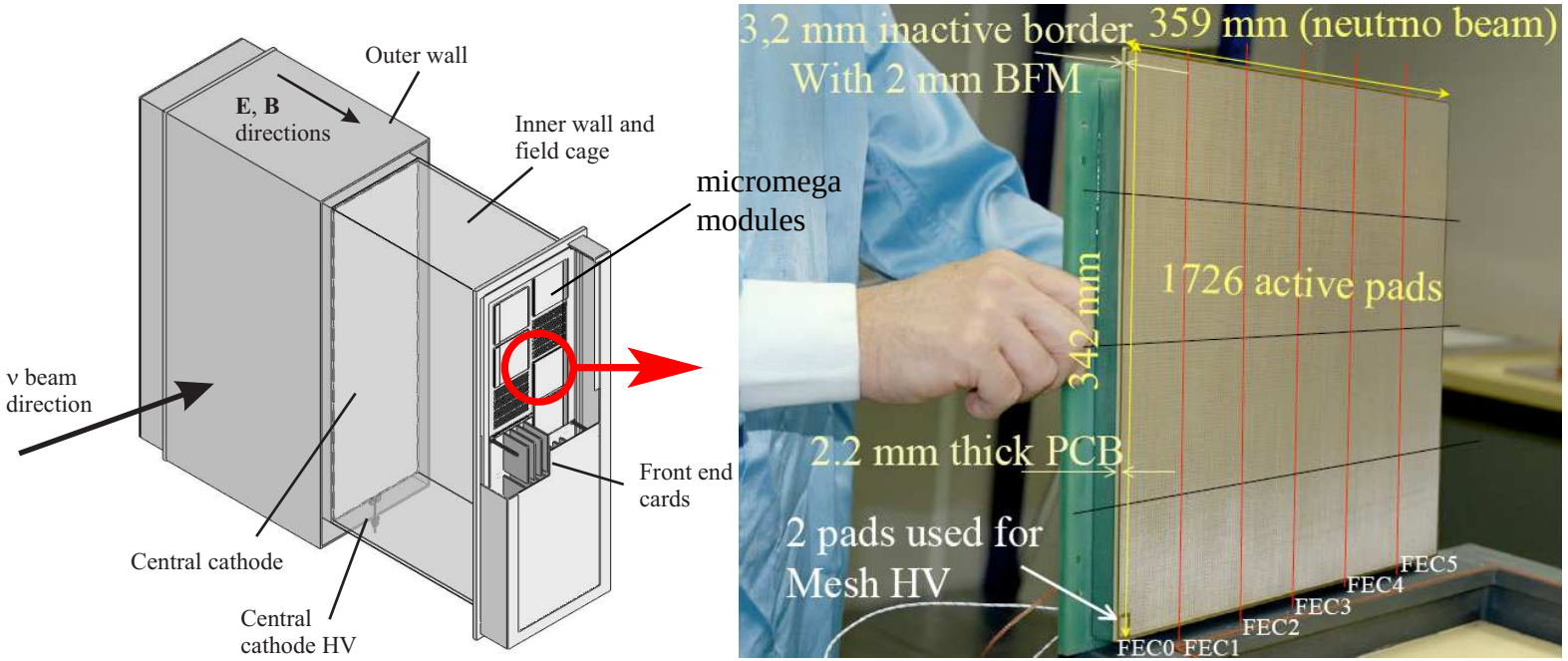
- better sensitivity on $\theta_{13}$ measurement $\rightarrow \sin^2 2\theta_{13} \sim 0.008$ (90% CL)
- presently: $\sin^2 2\theta_{13} < 0.14$ (90% CL)

# The ND280 detector




- ND280 main goals:
  - Neutrino beam characterization (energy, direction, . . . )
  - Neutrino interactions (cross-section$\times$flux, nuclear effects, . . . )
  - Measure the beam $\nu_e$ fraction
  - Study background processes for the $\nu_\mu / \nu_e$ oscillations measurement at SK
- Particle tracking with TPC detectors
  - 3D tracking with very low material density
  - Excellent particle identification via dE/dx
    - $3\sigma$ $e/\mu$ separation required in 0.3-1 GeV/c range
    - dE/dx resolution $<$ 10% for particles up to 1 GeV
  - Momentum determination through deflection in a transversal 0.2T magnetic field
    - resolution must be better than 10% @ 1GeV/c
    - momentum bias must be lower than 2%
- $\sim$0.9m long drift volume filled with $Ar:CF_4:iC_4H_{10}$ (95:3:2) - E=200 V/cm

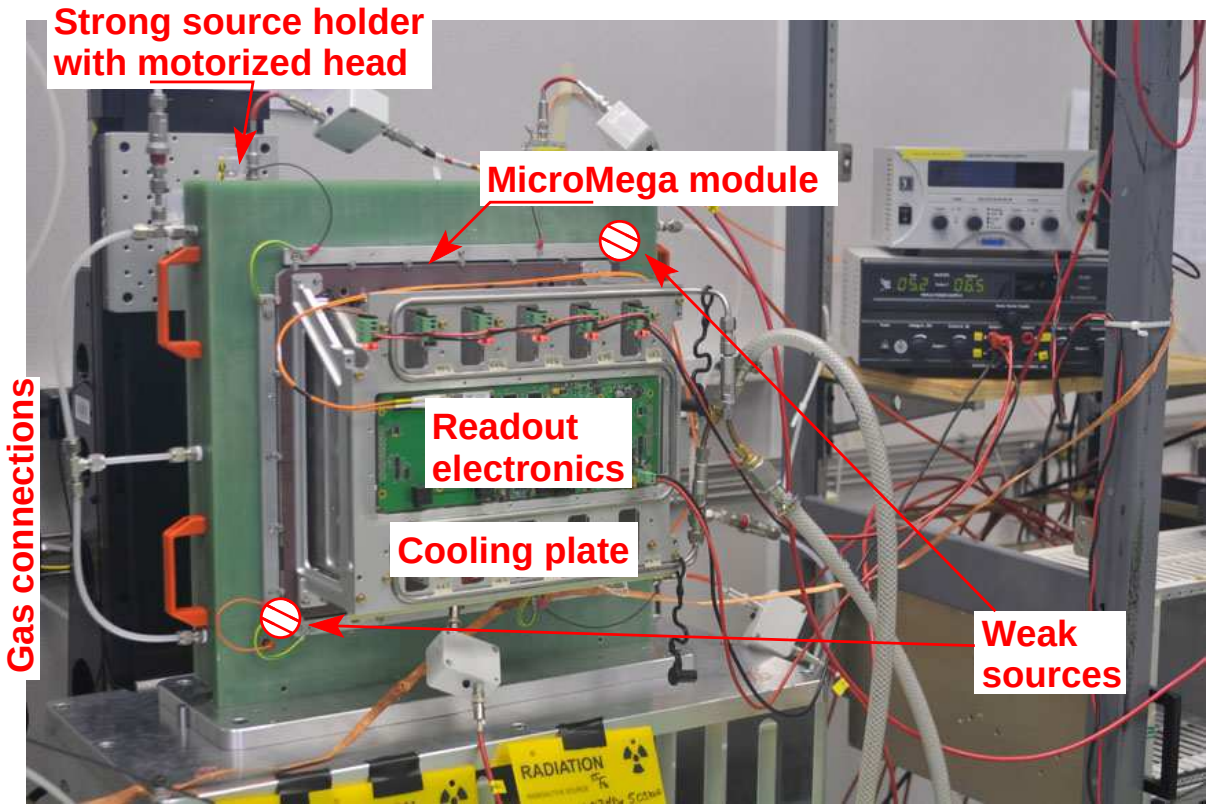
# Bulk Micromegas for TPC readout




- First large-size TPC with Micro Pattern Gas Detector (MPGD) readout
- Signals detected by 35 $\times$ 36 cm$^2$ BULK-MicroMegas ($\sim$ 10 m$^2$ total surface)
  - Small geometrical dead zones and uniform response over the full active surface
  - 9.7 $\times$ 6.9 cm$^2$ pads (1726/module), readout based on AFTER ASICs
  - 72 modules in total for 3 TPCs, 125k readout channels
  - Spatial resolution $\sim$ 600 $\mu$m (measured with Harp field cage @ 90 cm drift distance)
- Each module is validated and characterized before installation $\rightarrow$ dedicated test bench at CERN

# The T2K Micromegas TestBench

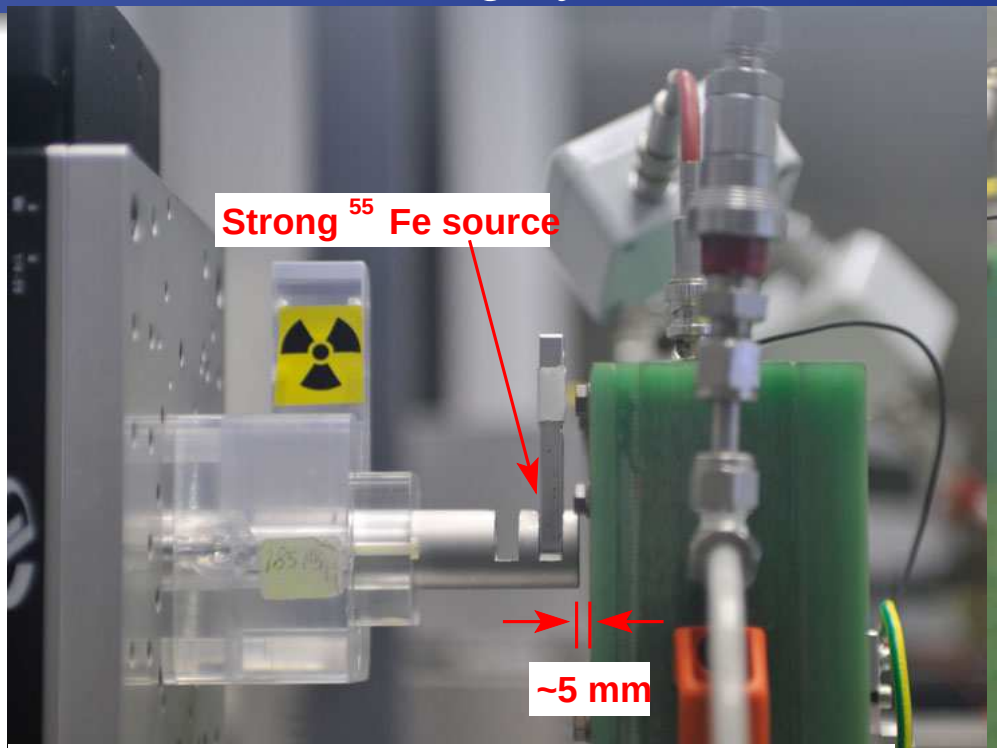
Main goal: determine the quality, the signal amplitude mapping and the energy resolution of a given bulk micromegas module

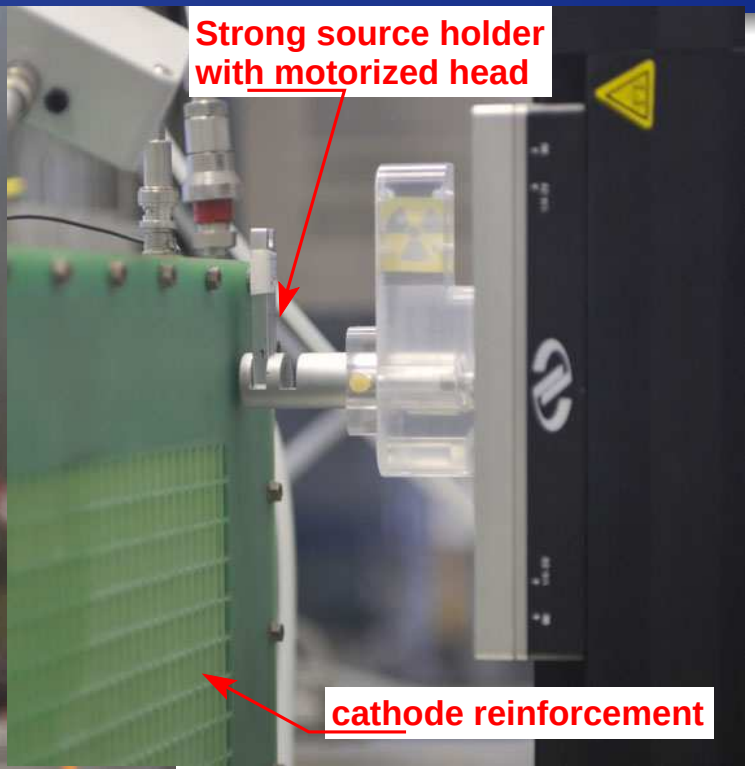


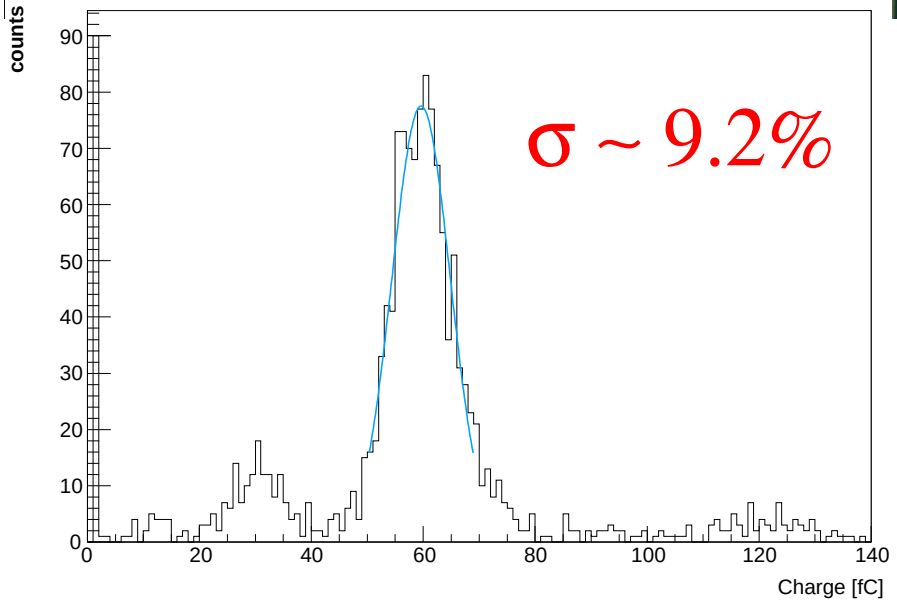

The detectors are characterized by scanning the active surface with a strong $^{55}$Fe source (5.9 keV photons)

The modules are mounted in a gas-tight box providing a 4 cm thick drift volume

# Automated scanning system




← typical single-pad amplitude spectrum from 5.9 keV photons

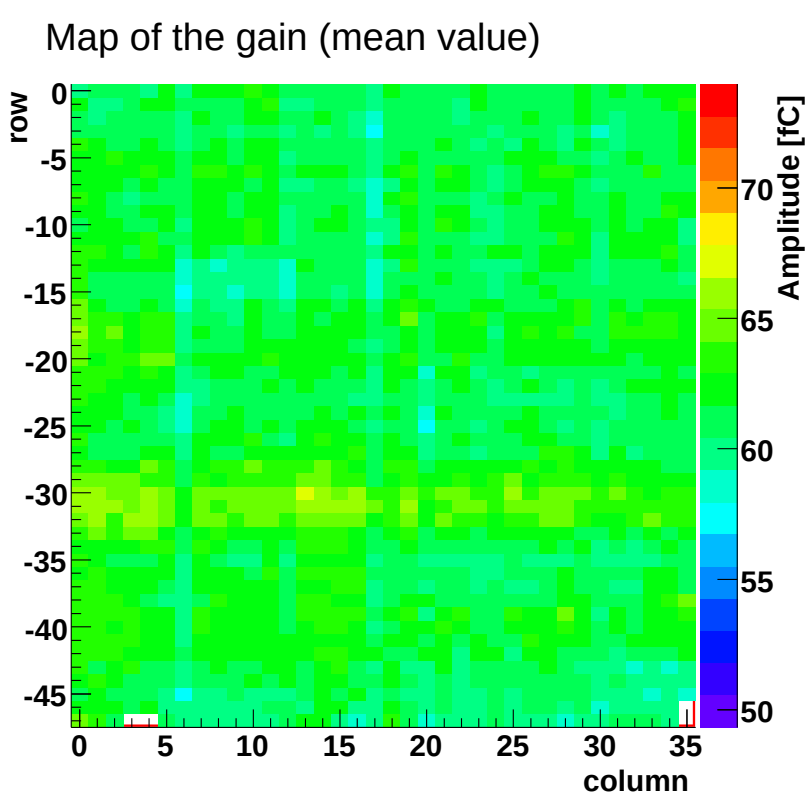
- Mean value: gain
- Peak width: energy resolution

One module can be completely scanned in ∼ 6 hours

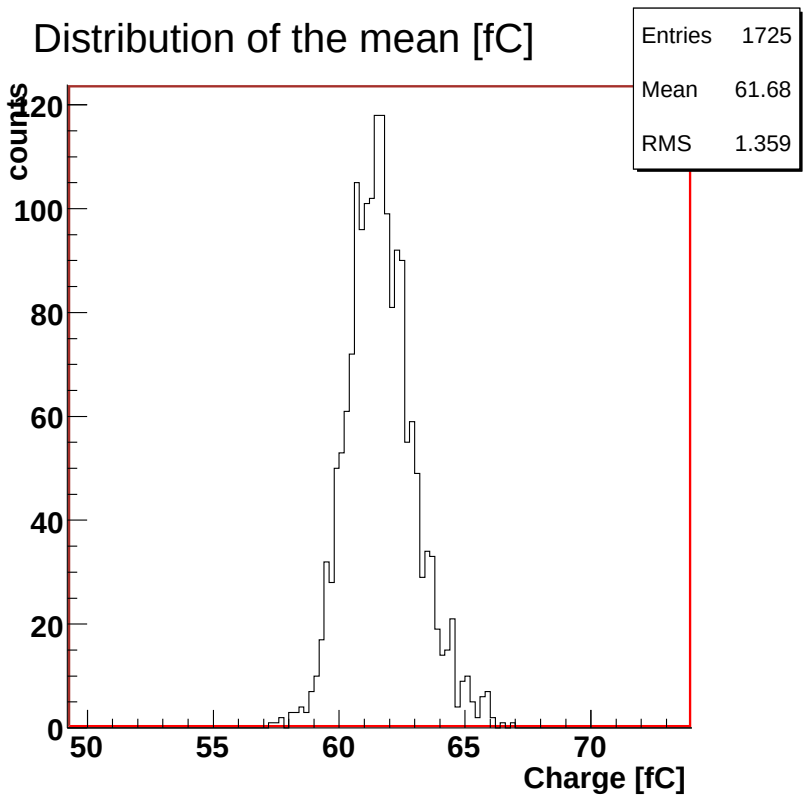
# Test results: pad-by-pad signal amplitude

- Robust and reliable: only one faulty pad observed up to now
- Gain dispersion between 2-3% RMS

Amplitude map



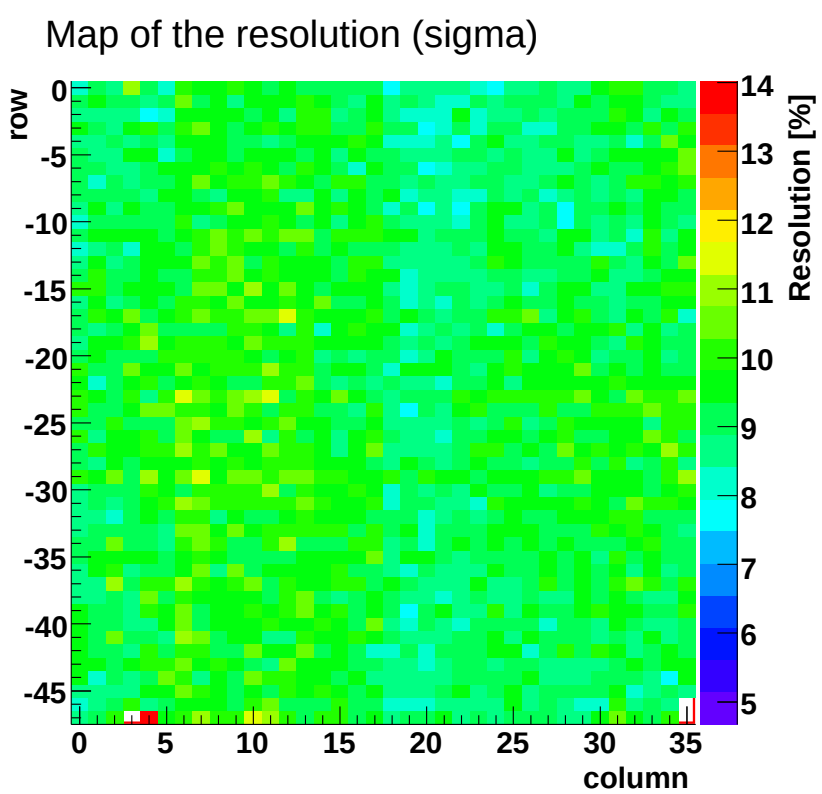

Ampl. distribution (dispersion: 2-3% RMS)



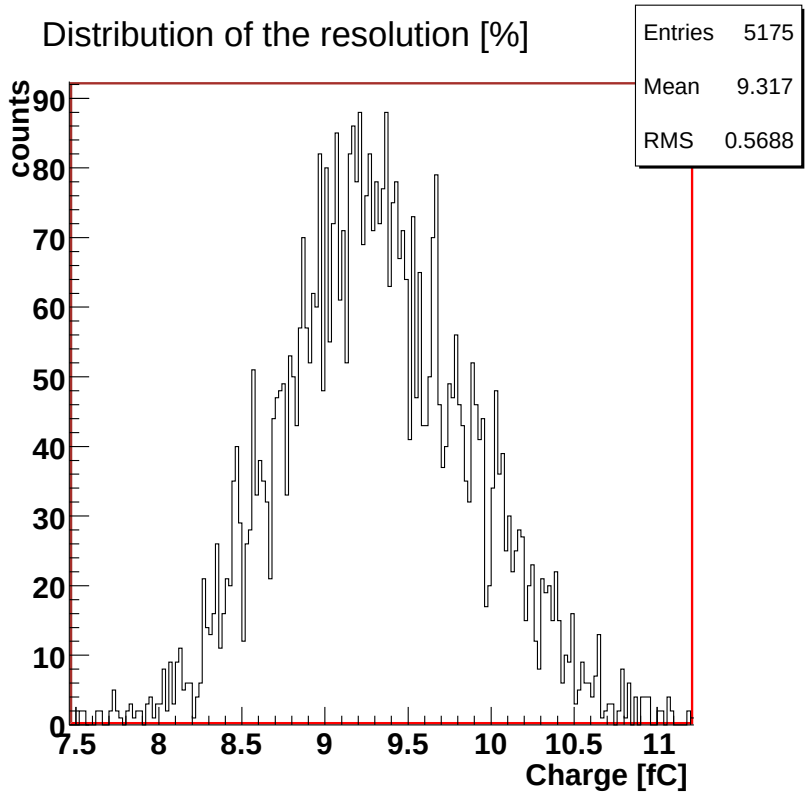
# Test results: energy resolution

- No appreciable edge effects
- Energy resolution for 5.9 keV photons is $\sim$ 9% for all tested modules

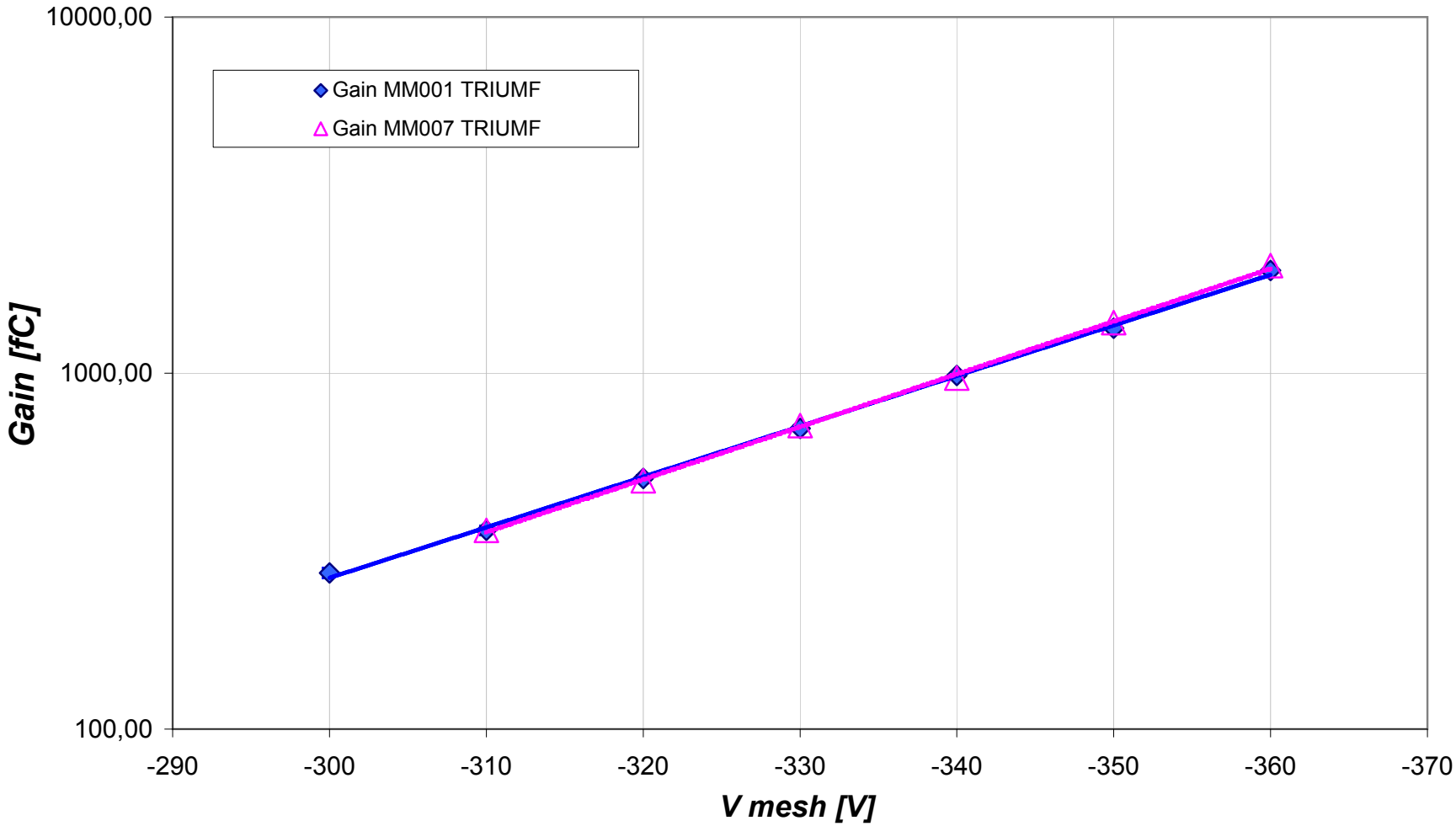
Resolution map




Resolution (mean$\sim$9.3%)

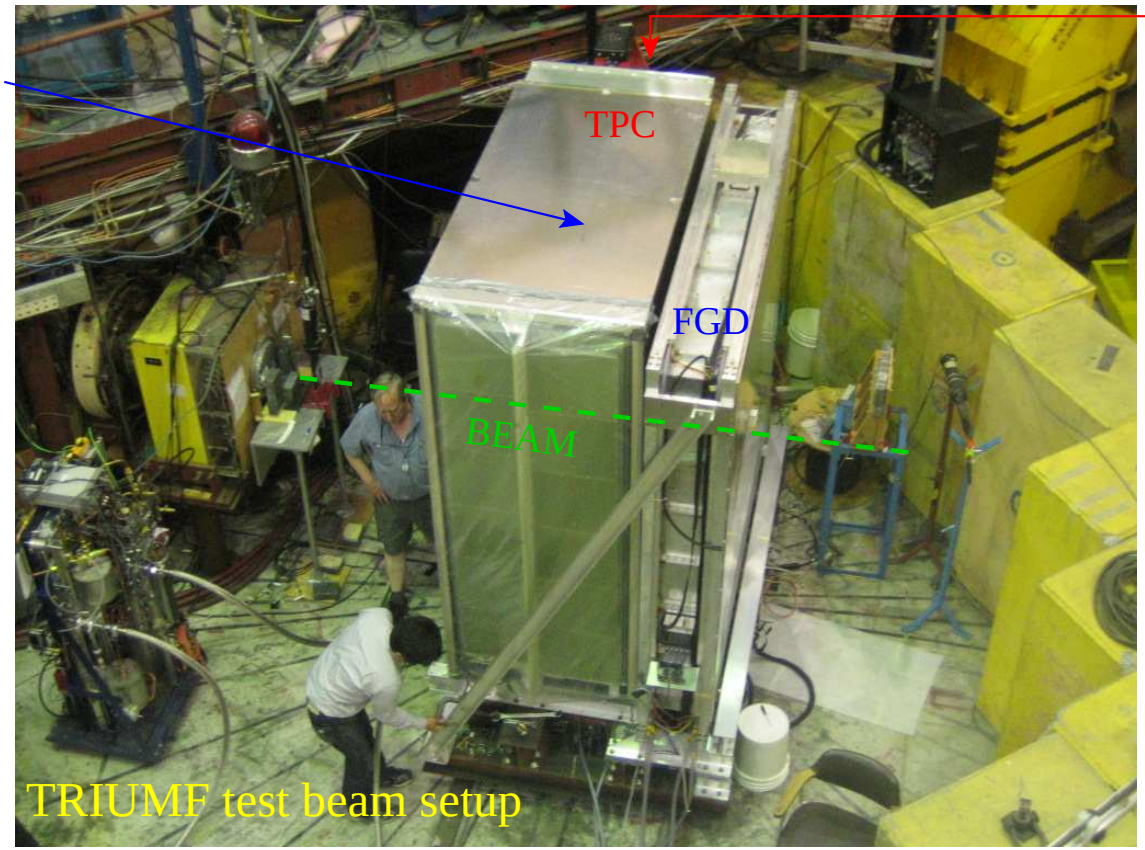


# Gas gain measurement



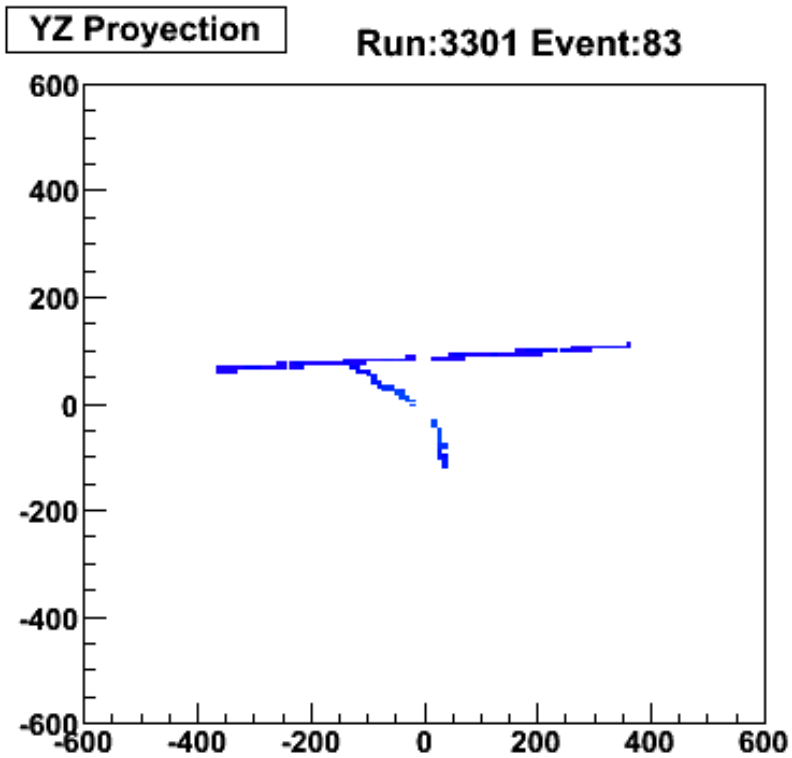
# Test of first TPC module @ TRIUMF

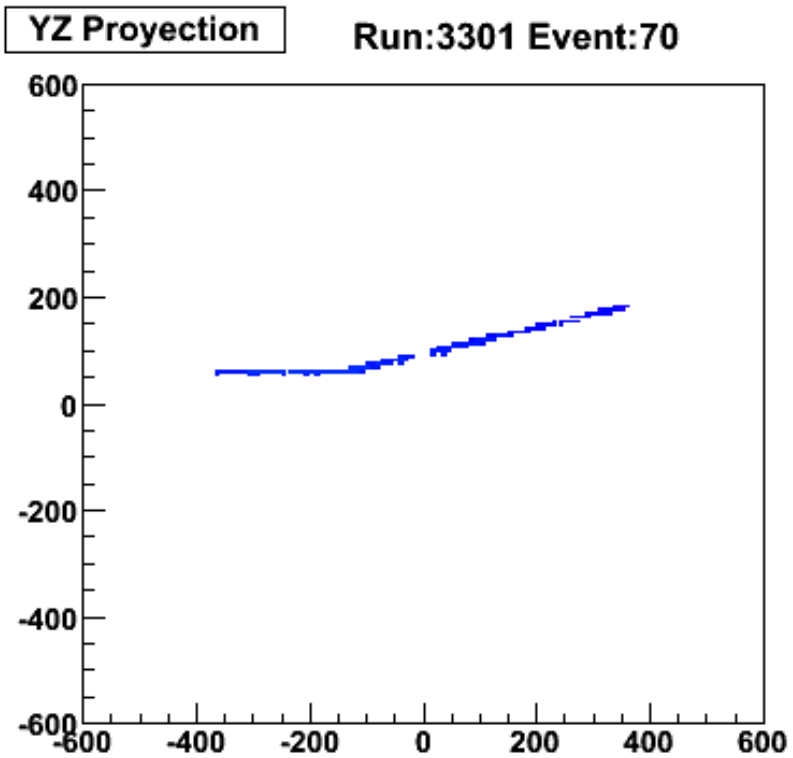
- A beam test has been set-up at TRIUMF (Vancouver) in early September
- Two detectors equipped with electronics mounted on the first ND280 TPC module
- Data have been collected with a secondary beam
  - Mostly composed of pions, muons and electrons
  - Beam momentum adjustable in the range 150-400 MeV/c
- Stable operation of detectors and electronics ($\sim$.1 sparks/hour/detector with beam)
- Data analysis is in progress (see next slides)



# First tracks

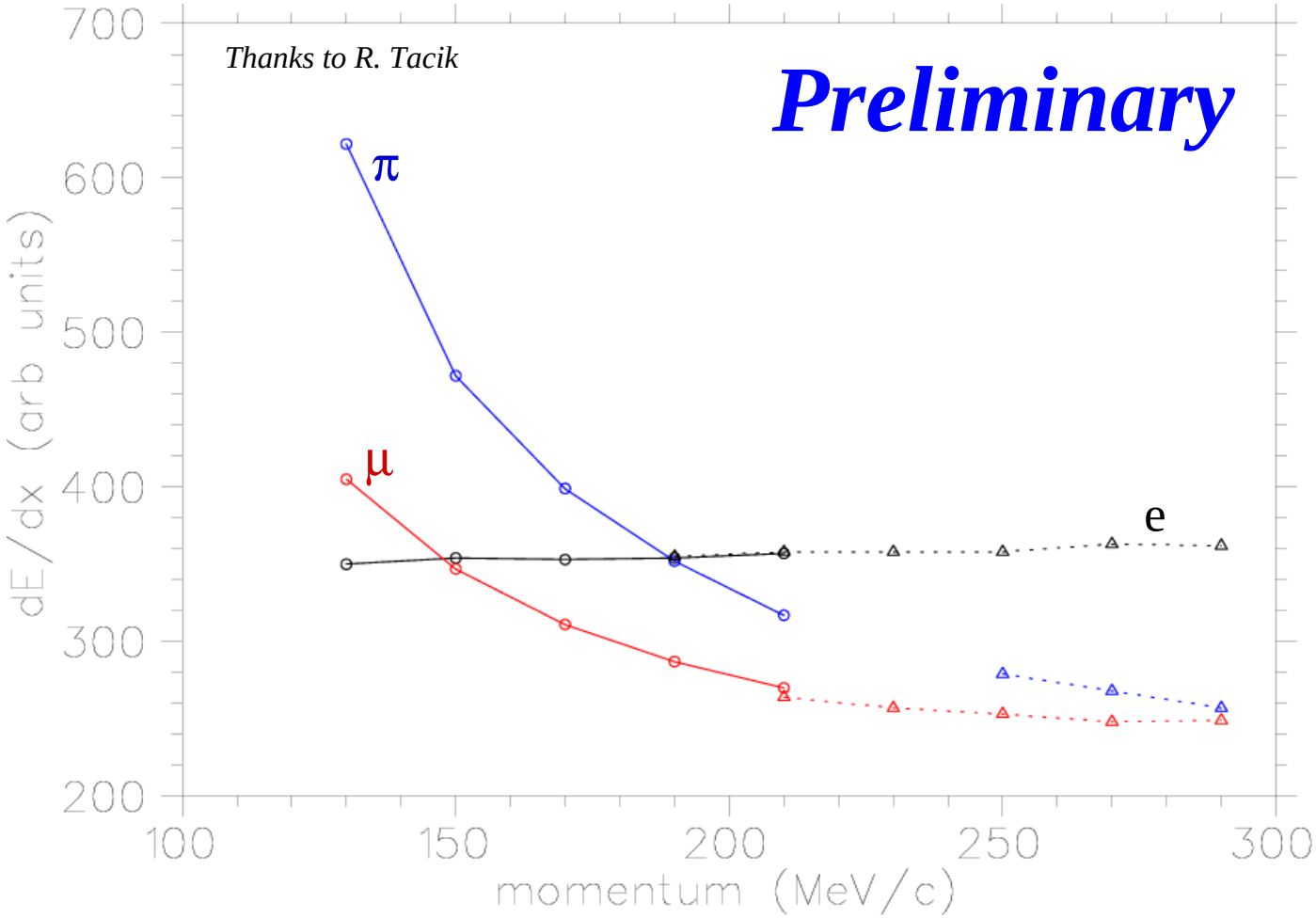
150 MeV/c beam, mixture of pions, muons and electrons



# Preliminary results for dE/dx

- Analysis of beam test data is still preliminary and simplified
- Nevertheless, the separation between e and $\mu$ is already visible



# Conclusions and outlook

- Production and test of Bulk Micromegas detectors for the ND280 TPCs is ongoing - 72 modules need to be validated and installed by summer 2009 (+ some spares)
- A dedicated test bench has been set-up at CERN, imploying an $^{55}$Fe source with motorized holder that allows precise scans in semi-automated mode
  - Systematic tests of MM modules now started
  - 12 detectors from final production already validated
- Production process delivers reliable and high-quality detectors
  - One faulty pad found so far
  - Gain uniformity better than 3% RMS
  - Energy resolution $\sim$ 9% RMS @ 5.9keV
- The first TPC module, equipped with two MM detectors, has been tested at Triumf in September 2008
  - Nominal voltage and gas mixture, stable operation of detectors and electronics
  - Tracks already seen in TPC
  - Readout plane is now fully equipped with 12 MM detectors and data taking is restarting
- The installation of 3 TPCs at JPARC is planned for August 2009