

# T2K Near Detectors



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8<sup>th</sup> JPARC PAC  
meeting @KEK

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# Overview

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- ▶ Since the 7<sup>th</sup> PAC meeting, the near detector project has undergone a major transition:
  - ▶ March 2009: most efforts focussed at home institutions
  - ▶ July 2009: most detector elements now at JPARC (or soon to arrive) with preparation, testing, and installation underway
    - ▶ many international groups are now on-site
- ▶ There has been significant progress towards completion of the near detector complex:
  - ▶ Near detector facility at JPARC
  - ▶ Services installation
  - ▶ Detector preparation and installation
- ▶ We can now be confident that the near detectors will be ready for beam near the end of this year

# Overview

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- ▶ **Progress reports for:**
  - ▶ Near detector facility and magnet services
  - ▶ INGRID on axis detector
  - ▶ Off-axis detector:
    - ▶ SMRD, P0D, FGD, TPC, ECAL
- ▶ **Schedule for installation**
- ▶ **Readiness for beam data and analysis:**
  - ▶ near detector capabilities with data from the first year

# Near detector facility

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- ▶ All 3 buildings completed (NM, NA, NMU)
  - ▶ NA has the control room (office area) and a large working area being used to prepare the FGD and TPC detectors
  - ▶ NMU is primarily used to house gas supply and mixing systems

NMU



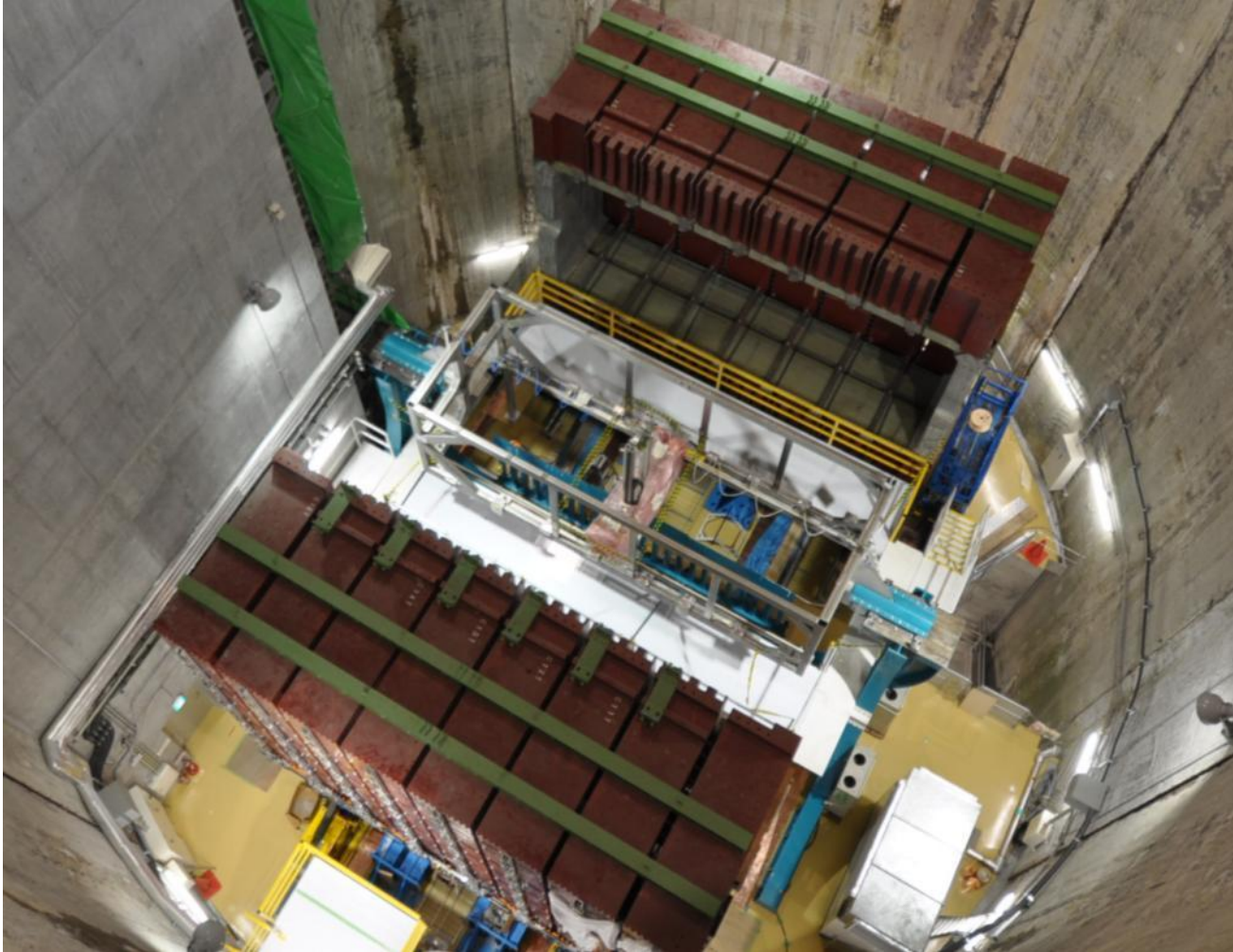
NA



# NM building progress

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- ▶ Basket, detector access, and stages installed





# Near detector facility issues

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- ▶ **NM – “cost saving” decisions**
  - ▶ concrete walls were not sealed and lower cost HVAC system without dehumidifier function was selected
  - ▶ consequences:
    - ▶ water and mineral ingress through concrete walls
    - ▶ high humidity in detector and service levels
    - ▶ mold in stairwells and elevator waiting areas
  - ▶ mitigation:
    - ▶ isolate service level with curtains and install dehumidifiers
    - ▶ installed corrosometer to evaluate if environment is corrosive
    - ▶ frequent cleaning of stairwells and elevator waiting areas

# Magnet services

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- ▶ Magnet services installed since last meeting:

- ▶ power converter
- ▶ coil current leads



- ▶ magnet water pipes from BI to IF
- ▶ cooling pipes to power supply



# Magnet services

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- ▶ **Installed (cont.)**

- ▶ Magnet control and safety system – instrumentation tested
- ▶ Magnetic field mapping device – ready to operate





# Magnet services

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- ▶ Magnet services installation in progress:
  - ▶ cooling plant



- ▶ cabling to magnet, power converter, cooling plant
- ▶ water connection to magnet and cooling plant



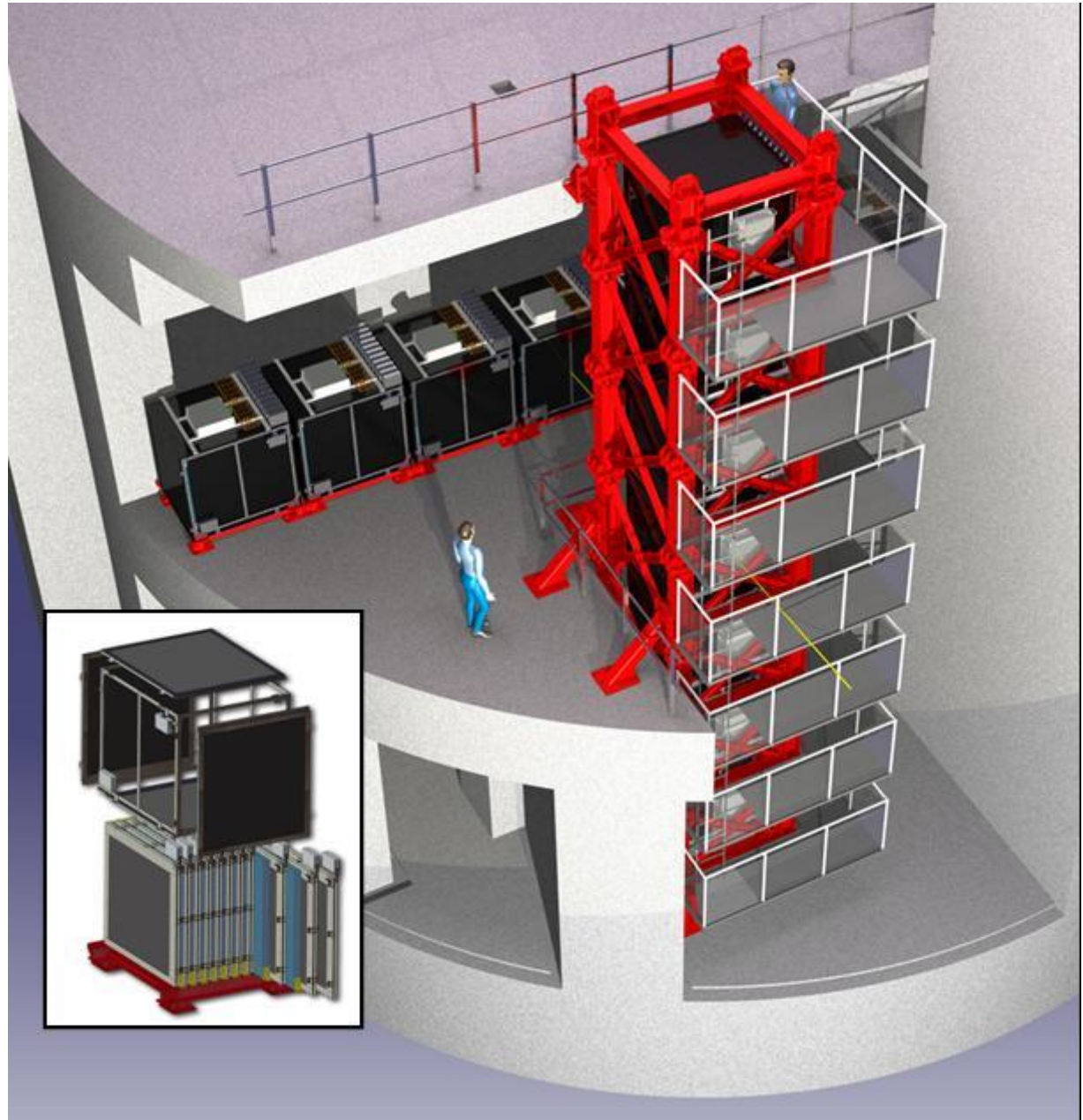
# Magnet services

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- ▶ **Schedule slippage since last meeting:**
  - ▶ Delay imposed on tendering cooling plant installation in order to sort out funding
  - ▶ First energizing was to be June 22, now planned for Aug 17
  - ▶ The detector installation in basket is moved back accordingly

# INGRID

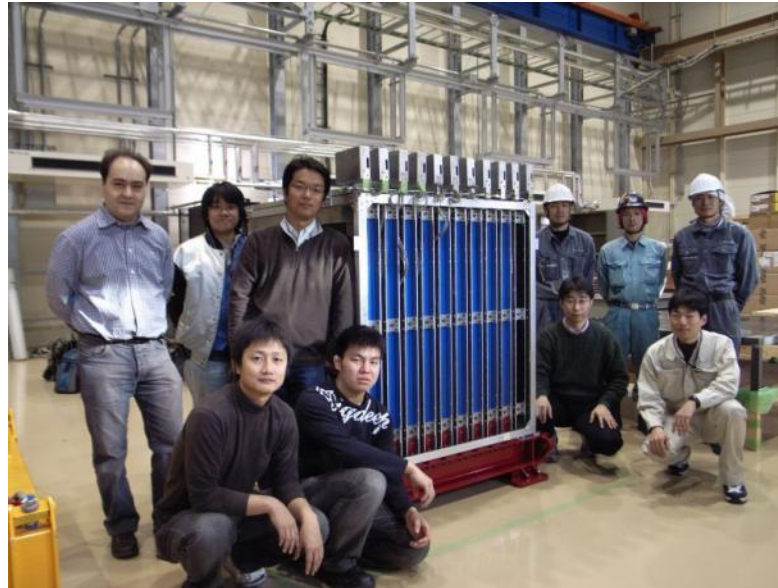
on-axis detector



# INGRID

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- ▶ First module assembled  
Feb 2009

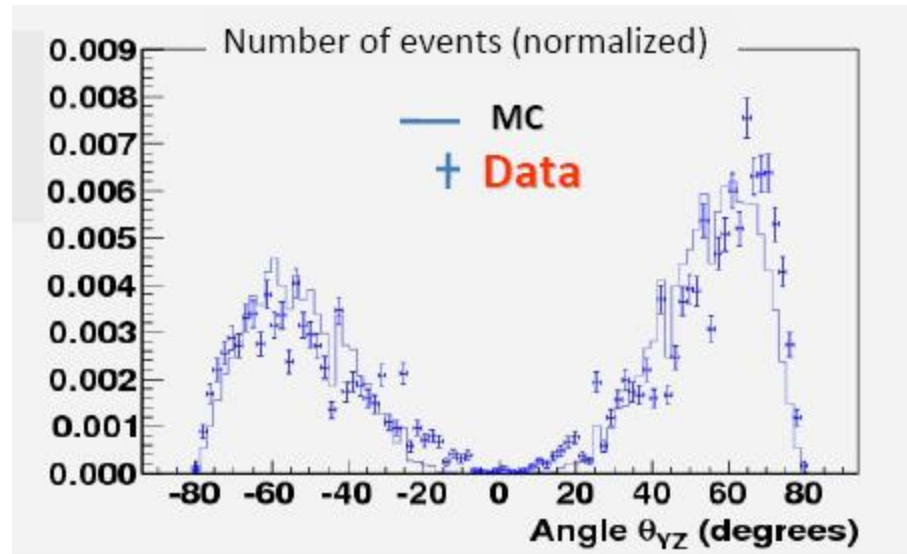
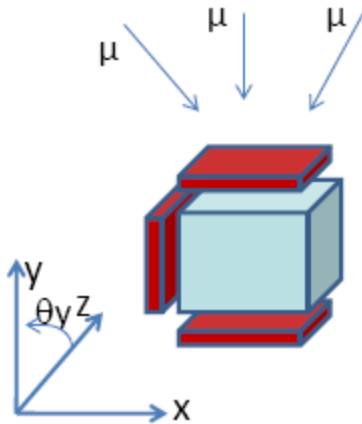


- ▶ Installed in  
March 2009



# INGRID

- ▶ Commissioned with cosmics
  - ▶ first look in agreement with simulation



- ▶ Tracking plane efficiency  $99.5 \pm 0.6 \%$

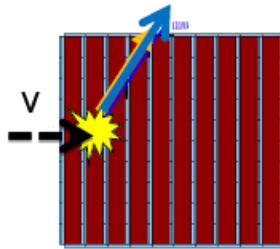


# INGRID

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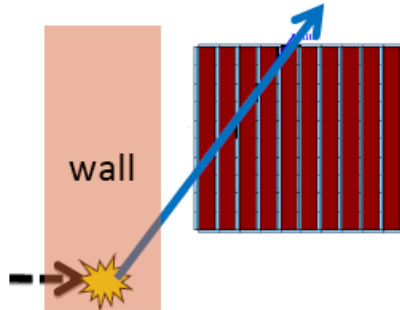
## ▶ Beam event search during beam commissioning...

Neutrino event (interaction within module)



Expected  $\sim 0.2$  events

Neutrino event (interaction in the wall)



Expected  $\sim 0.4$  events

No event in time with  
beam was seen...

# INGRID

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- ▶ Remaining 6 H-modules assembly completed on July 2



- ▶ installation completed this week
- ▶ V module assembly to be completed on August 8 and installation by mid-August
- ▶ Will be ready for the next beam commissioning in October

# SMRD – side muon range detectors

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- ▶ Assembly work started in March in LINAC building
  - ▶ assembly and instrumentation now complete
- ▶ Installation proceeding very well
  - ▶ yokes were well aligned



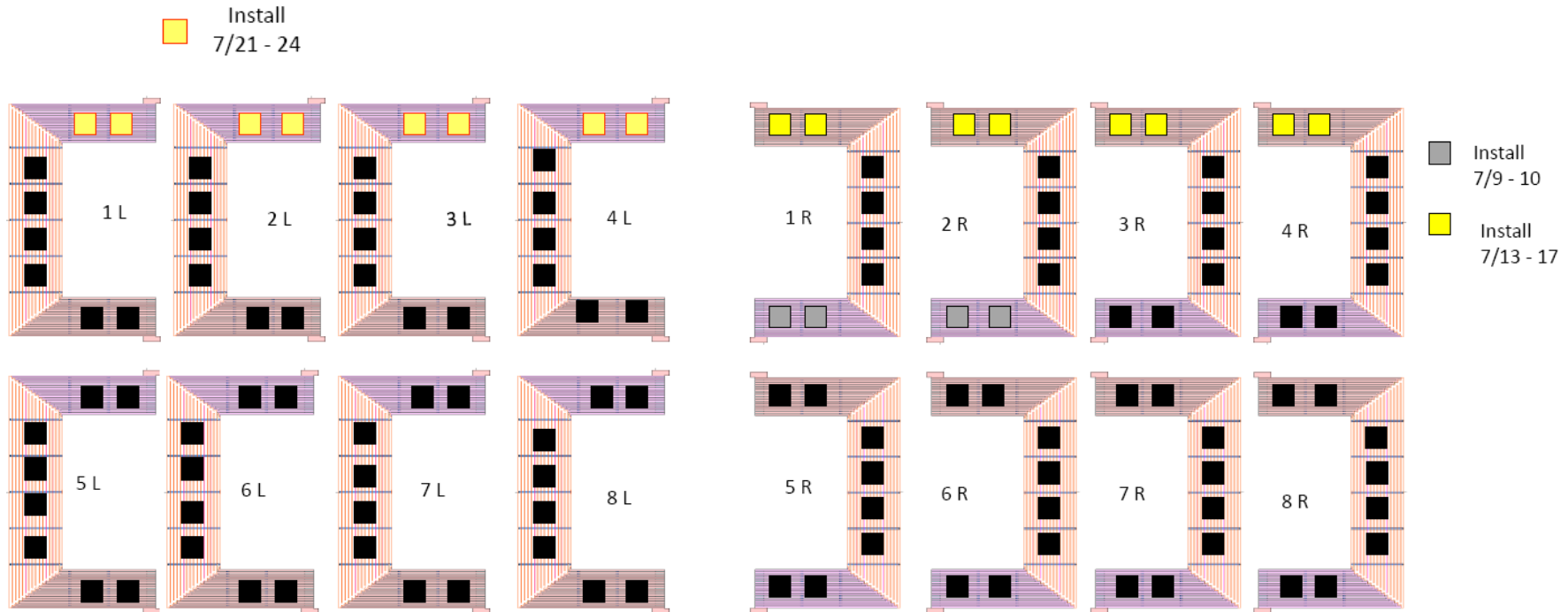
Installation of horizontal modules

Installation of vertical modules



# SMRD – side muon range detectors

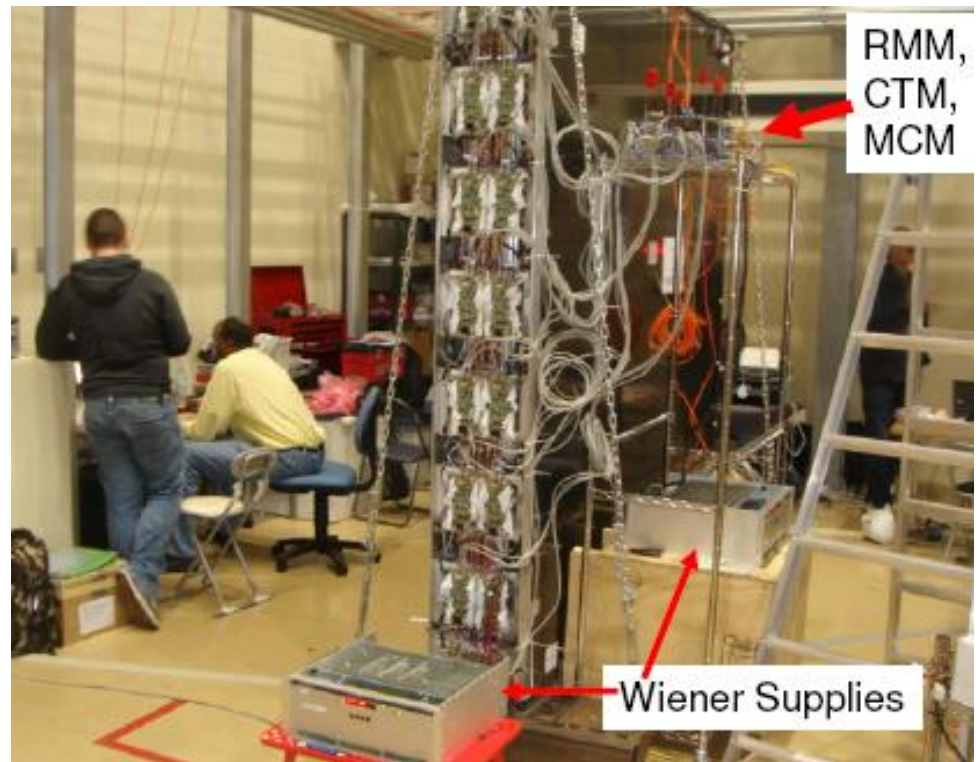
## ► Installation nearing completion...



- SMRD installation is expected to be completed by end of July
- DAQ commissioning just getting underway

# P0D – pi-zero detector

- ▶ P0D modules arrived at JPARC in late April
- ▶ Large group on site for checkout (10-12 people)
  - ▶ cosmics, light injection, water target fill tests
  - ▶ small numbers of boards and MPPCs needed to be replaced

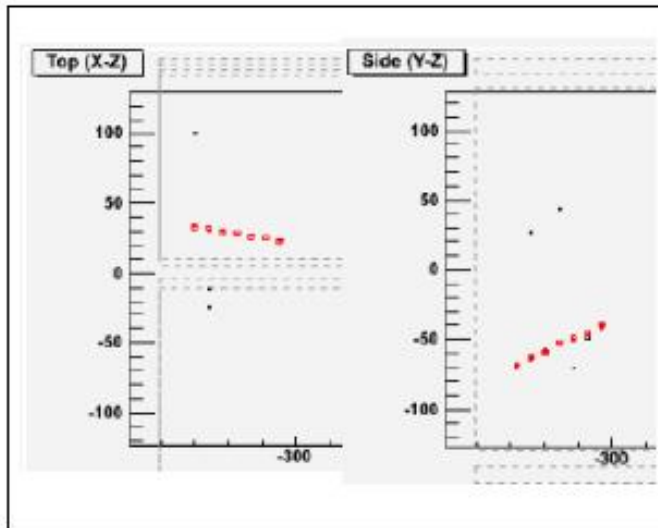




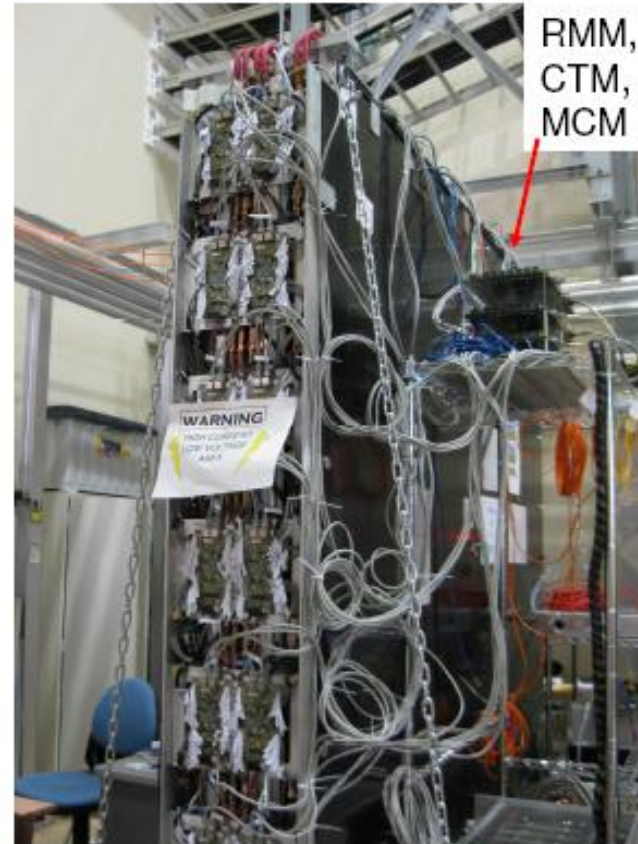
# POD – pi-zero detector

## Cosmic Ray runs with upstream ECAL

- Cosmic ray setup currently using the upstream ECAL.
- 7 layer X&Y tracking planes, 1820 detector channels, 1856 electronics channels (36 not used)
- Currently no zero suppression in data



EVENT DISPLAY of Cosmic ray track in x and y bar position versus z position.



# FGD – fine grained detectors

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- ▶ FGD #1 arrived safely on June 19
  - ▶ all channels tested in horizontal orientation
    - ▶ 5 MPPC replaced (probably connection problem)
    - ▶ 1 backplane replaced
- ▶ FGD #2 arrived safely on July 15





# FGD – fine grained detectors

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- ▶ FGD#1 tilted to vertical
- ▶ electronics being installed
  - ▶ will operate FGD#1&2 until installation in basket in October



# TPC – time projection chambers

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- ▶ 2 TPCs are completed
  - ▶ TPC0 – arrived in JPARC in June
  - ▶ TPC1 – running in test beam at TRIUMF
- ▶ TPC2 is under construction
  - ▶ hope to be ready for installation before end of year





# TPC – time projection chambers

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- ▶ TPC 0 now in cleanroom in NA building
  - ▶ overpressure leak test passed
  - ▶ central cathode HV test passed
  - ▶ re-install electronics end of July



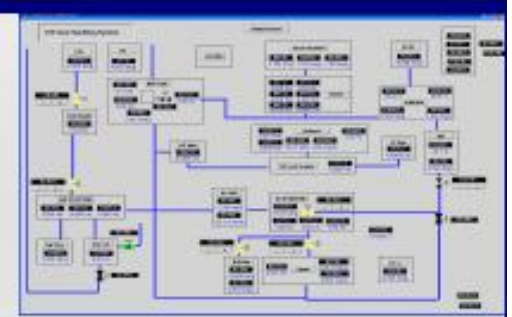
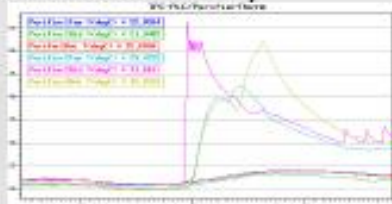


# TPC gas system

Rack on detector level to show flow I/O of detector and measure  $dP = P_{\text{detector}} - P_{\text{gap}}$



EPICS control system tests underway



Racks for below detector

Recirculation Pump

Gap CO2 Distribution

TPC gas Distribution

PLC



Racks for gas mixing building

Buffer Tank

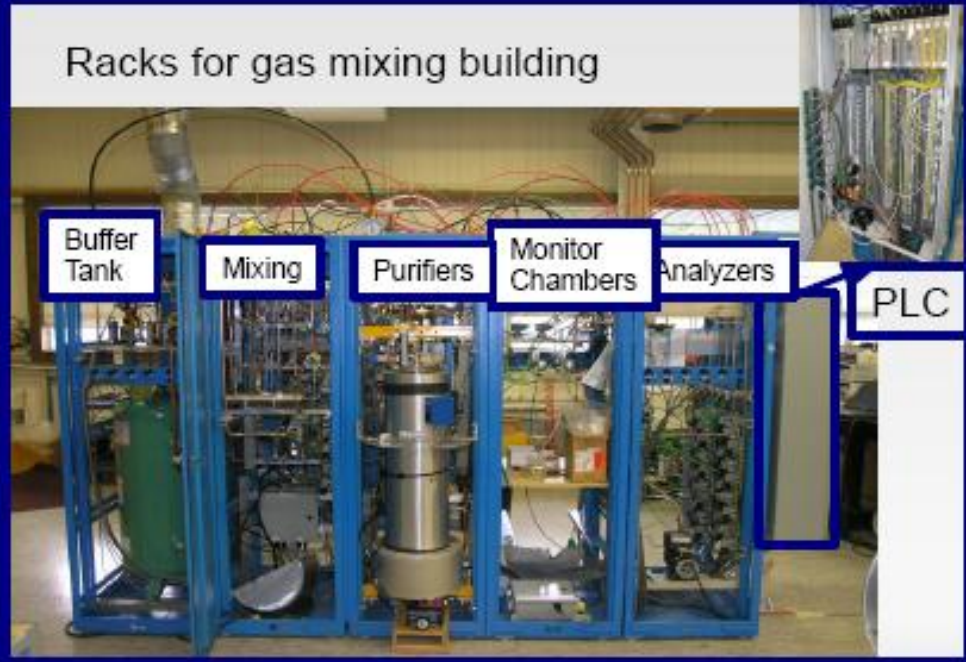
Mixing

Purifiers

Monitor Chambers

Analyzers

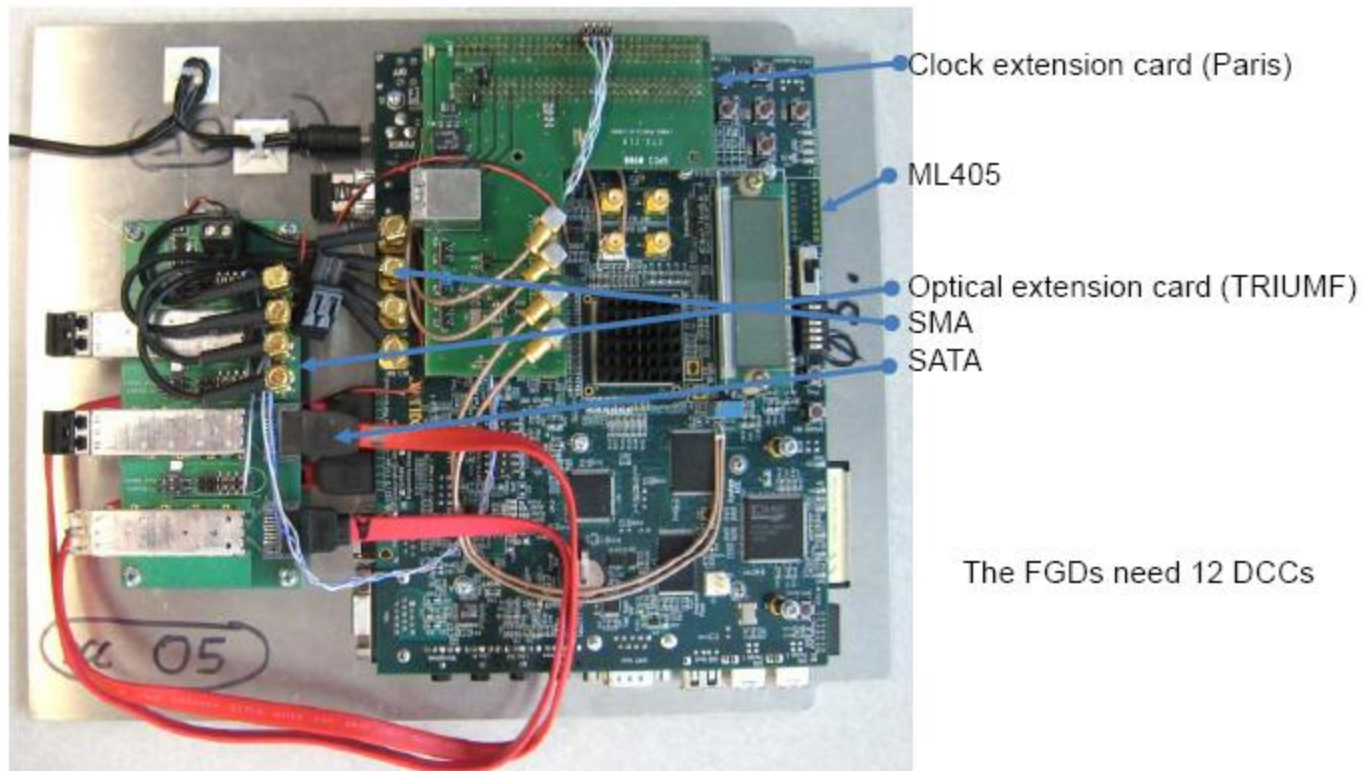
PLC



testing at TRIUMF is nearly complete – ship to JPARC later this month

# FGD and TPC backend electronics

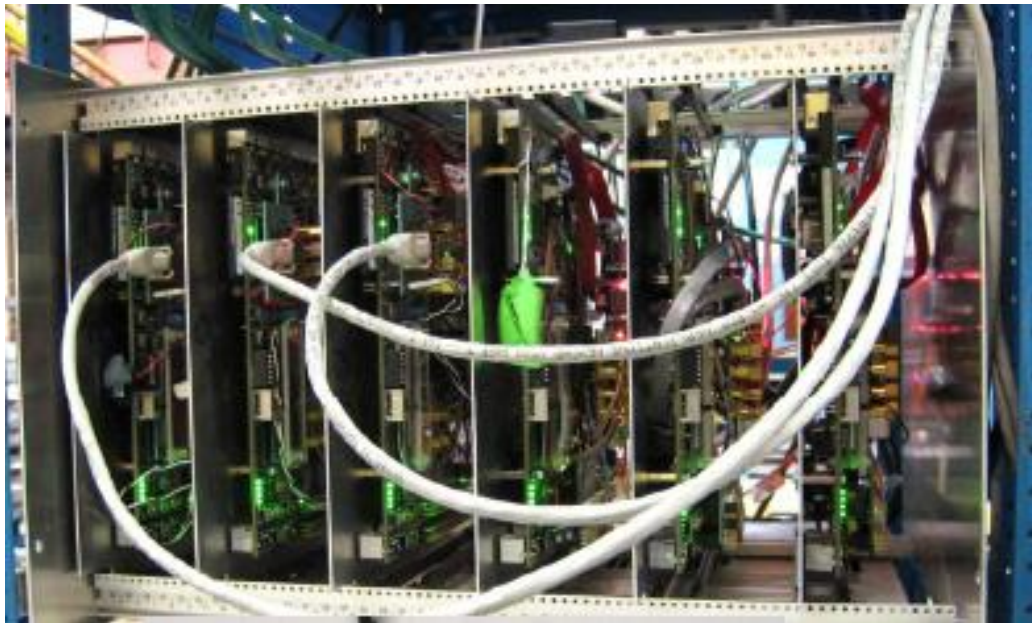
- ▶ FGD/TPC backend electronics to be done with fallback solution (Xilinx ML405 evaluation kit)



# FGD and TPC backend electronics

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- ▶ 2 crates will each hold 6 + 1 spare DCC



- ▶ FGD successfully operated with 6 DCCs at TRIUMF in May
- ▶ need longer term tests to assess reliability
  - ▶ DCC upgrade may be considered



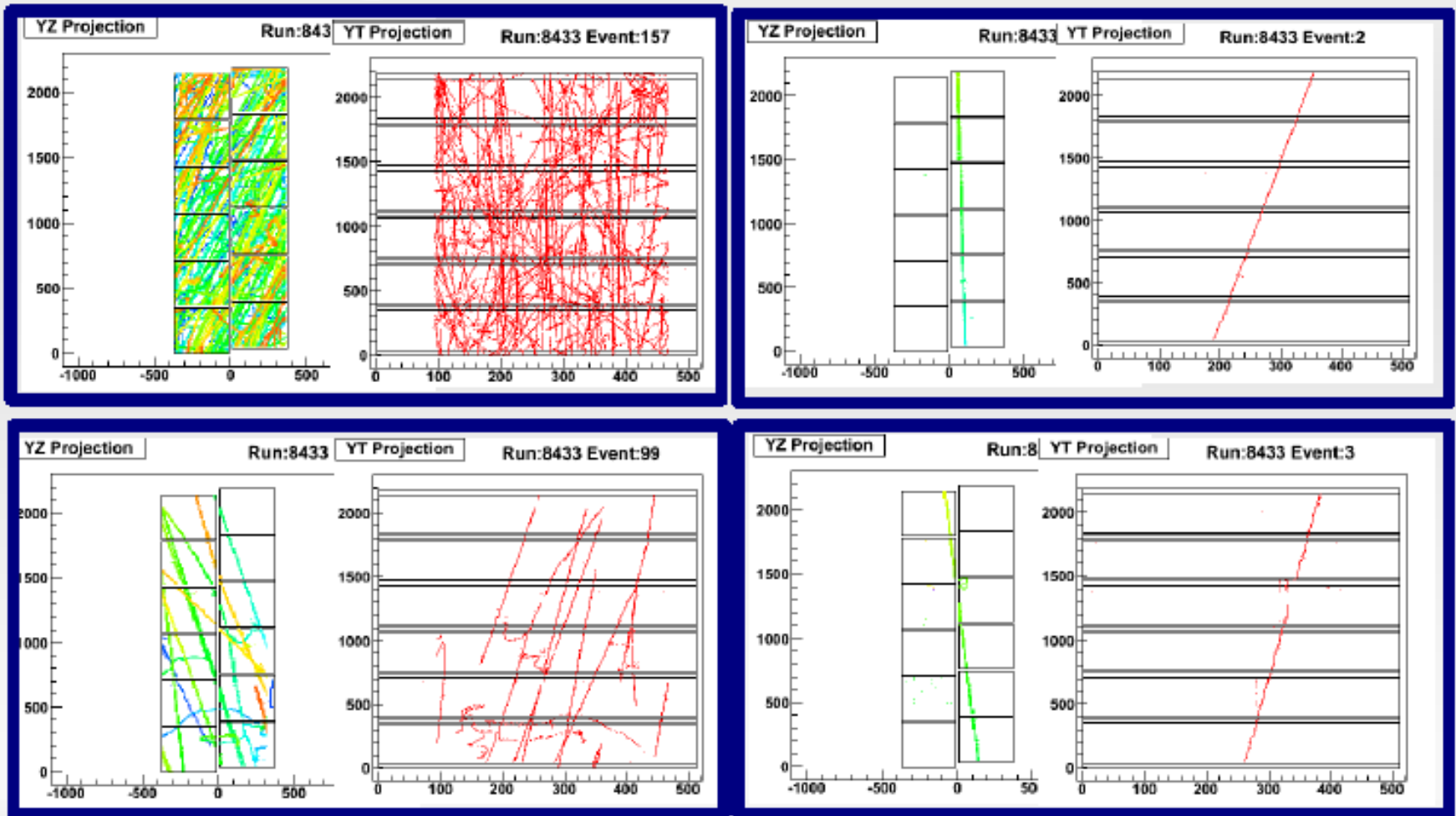
# FGD + TPC tests with beam at TRIUMF

- detector groups have accumulated months of commissioning experience already



# TPC event displays

- ▶ readout of full endplate at TRIUMF - cosmics

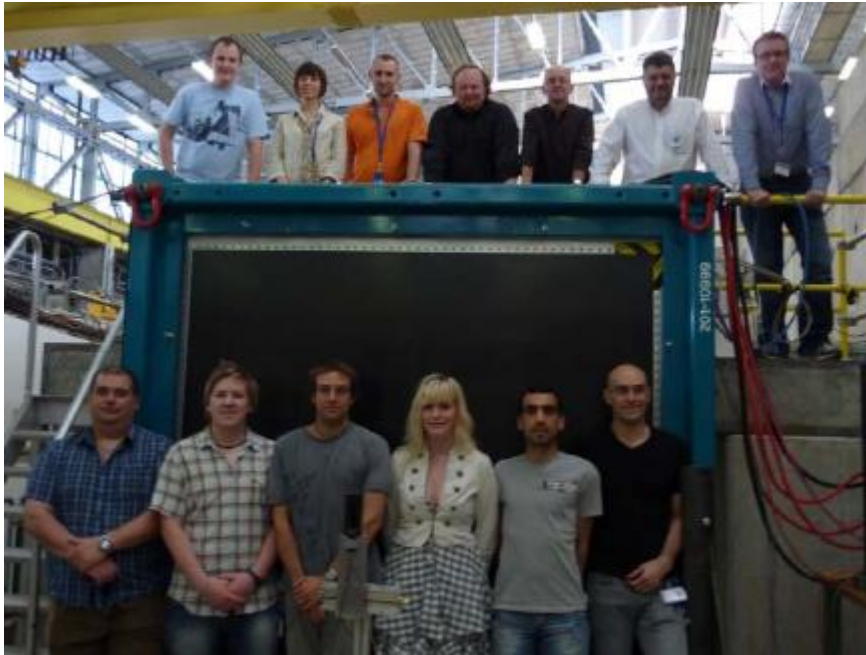




# ECAL – electromagnetic calorimeter

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- ▶ Downstream ECAL in CERN testbeam: May and June



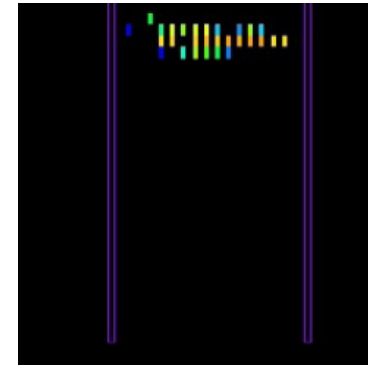
- ▶ preliminary layer efficiency for mip: 98.3%
- ▶ reconstruct angle of incidence with 3-5 degree resolution for incident angles up to 75 degrees

# ECAL – electromagnetic calorimeter

## Beam Test Statistics

No problems and more PS cycles than expected:  
accumulated 3 x (stats applied for)

<b>Up time</b>	6 weeks			
<b>#Triggers</b>	$2 \times 10^6$			
<b>Composition</b>	<b>Electrons</b>	<b>Positrons</b>	<b>Pions</b>	<b>Protons</b>
	700k	600k	400k	300k
<b>Geometry</b>	<b>Position</b>	<b>Angle (deg)</b>	<b>Triggers</b>	
	Central	0	620k	
	Off-centre	0	150k	
	Central	15	50k	
	Central	30	720k	
	Central	60	510k	
	Central	75	80k	



1.0 GeV electron



3.0 GeV pion

# Schedule for installation

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- ▶ Two large detector installations nearly complete:
  - ▶ INGRID (on-axis detector) will be completed in mid-August
  - ▶ SMRD (in magnet yokes) will be completed at the end of July
- ▶ DAQ integration is now underway
  
- ▶ Magnet schedule:
  - ▶ July 28 – Aug 14
    - ▶ commission power converter and cooling system
  - ▶ Aug 17
    - ▶ first energizing
  - ▶ Aug 26 – Sept 10
    - ▶ B-field mapping

# Schedule for installation

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- ▶ The following off-axis detectors will be ready for installation in the basket in between Sept 28 and Oct 13:
  - ▶ 4 of 4 P0D modules
  - ▶ 2 of 2 FGD modules
  - ▶ 2 of 3 TPC modules
  - ▶ 1 of 1 downstream ECAL module
- ▶ all of these detectors already have been extensively tested (and apart from P0D modules, all had beam tests)
- ▶ October and November will be used for DAQ and slow-controls integration for these detectors



# Schedule for installation

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- ▶ Detectors arriving late:
  - ▶ 3<sup>rd</sup> TPC
    - ▶ due to technical delays in the construction of the TPCs
    - ▶ may be ready for installation in December
  - ▶ 12 remaining ECAL modules
    - ▶ due to delay in securing funding (not new)
    - ▶ 2-4 modules may be ready for installation in December
    - ▶ all modules ready for installation by October 2010
- ▶ For low intensity operation, the initial measurements by the off-axis near detector will not be significantly degraded if these elements are missing:
  - ▶ CCQE selection need not use ECAL information or backward scattering particles that would be measured by the upstream TPC
  - ▶ initially, good electron identification possible without ECAL
  - ▶ these detectors are needed for detailed studies in the longer term

# Readiness for beam data

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- ▶ Individually all of the near detectors have been operating for long periods with cosmics and/or test beam
- ▶ When operated together in NM hall, new aspects include:
  - ▶ “global” issues:
    - ▶ triggering, slow control, run control, monitoring
  - ▶ beam trigger synchronization
  - ▶ event building
- ▶ DAQ integration work starts with INGRID and SMRD now and will continue with the other detectors after they are installed in September and October
  - ▶ time from now until December should be sufficient

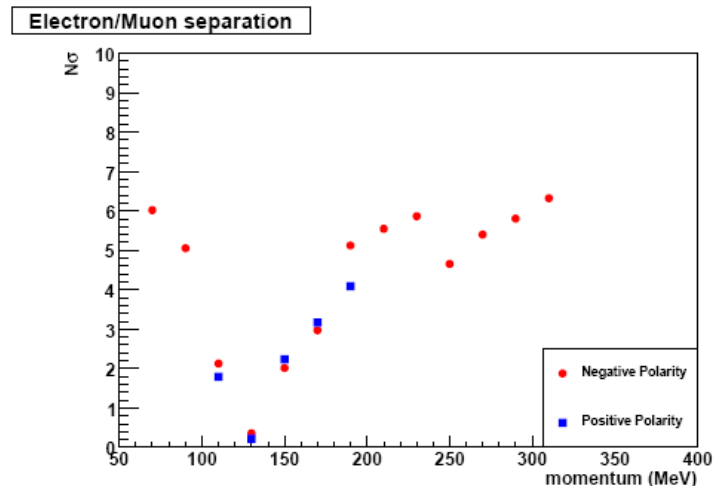
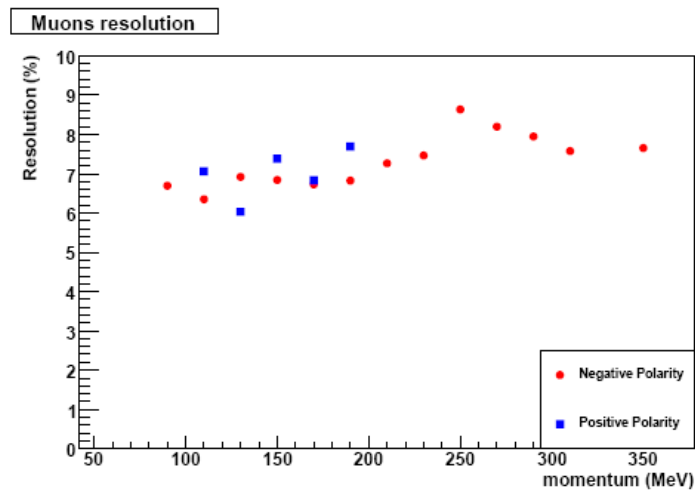
# Initial measurements from near detectors

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- ▶ **Near term goals:**
  - ▶ normalization measurements by the on-axis and off-axis detectors
    - ▶ to predict expected number of events at SK (w/o oscillation) at the ~10% level
  - ▶ muon momentum and angular distributions for different categories of events (quasi-elastic and inelastic)
    - ▶ to predict unoscillated distributions at SK
  - ▶ electron neutrino fraction in the beam (0.5% expected at peak)
    - ▶ to estimate the dominant background for  $\nu_e$  appearance

# Initial measurements from near detectors

- ▶ Analyses have been developed with simulated data samples
- ▶ Powerful electron identification by TPC has been demonstrated in test beam:



- ▶ remaining background primarily true electrons produced in  $\nu_\mu$  interactions: expect  $S/B = 1.4$ , without  $E_\nu$  cuts



# Initial measurements from near detectors

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- ▶ Should  $100 \text{ kW} \times 10^7 \text{ s}$  can be delivered, significant samples would be collected for the neutrino oscillation measurements, for example:
  - ▶ about 100-200k events selected by each INGRID module
  - ▶ ~5000 events selected by the CCQE analysis in the tracker (more than 80% purity)
  - ▶ ~1000 events selected by the  $\pi^0$  analysis in the P0D (more than 70% purity)
- ▶ If only  $30 \text{ kW} \times 30 \text{ days}$  can be delivered, the rates would be sufficient to confirm general detector performance:
  - ▶ 10-20k events in each INGRID module
  - ▶ ~500 tracker CCQE events
  - ▶ ~100 P0D  $\pi^0$  events

# Summary

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- ▶ With the significant progress towards completion of the near detectors, I think we can now be confident that we will be ready for beam near the end of this year
- ▶ With sufficient beam intensity in 2010, T2K can jump into the leading position to discover non-zero  $\theta_{13}$ 
  - ▶ The near detectors will be there to help determine the beam properties and understand low energy neutrino interactions
- ▶ We look forward to an exciting period as the experiment gets underway in the coming months