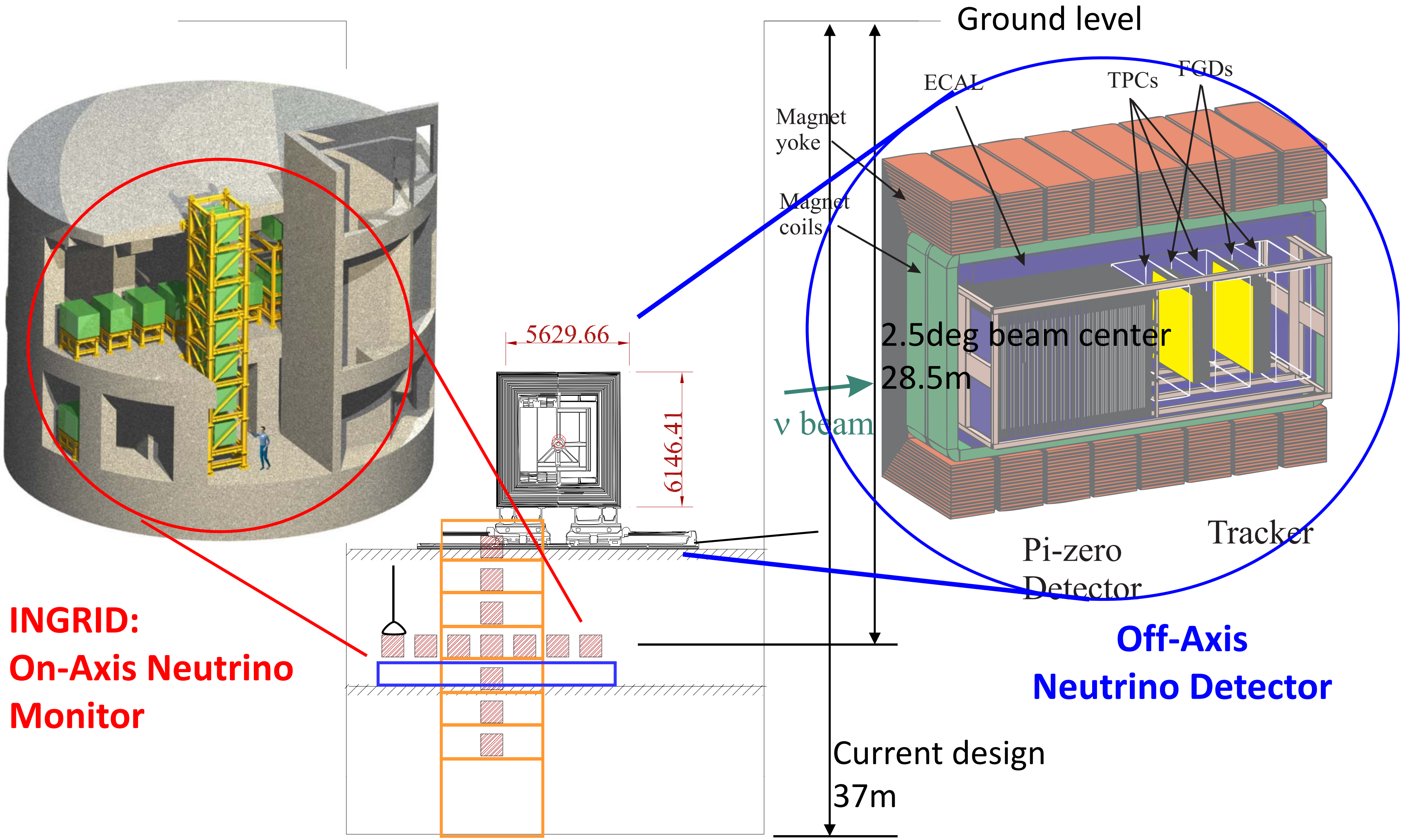
J-PARC PAC
July 6th, 2007
@KEK

T2K Status Report (3)
ND280

T. Nakaya (Kyoto)
for the T2K collaboration

ND280 Neutrino Detectors
(Experimental Hall with 2 floors + 1 Stage)



Outline

1. ND280 Schedule Update
    1. Integration Schedule
    2. Magnet Status
2. Key Technologies
    1. Photo-Sensor
    2. TPC with Micro-Megas (and dE/dx performance)
3. Status of Full Simulation/Reconstruction
4. Physics studies
    1. Water Cross sections extrapolation
    2. π^0 measurement
    3. μ/e separation by TPC
5. ND280 sub-detector status

    INGRID, FGD, TPC, P0D, ECAL, SMRD, DAQ, Electronics
6. Future WORKS!

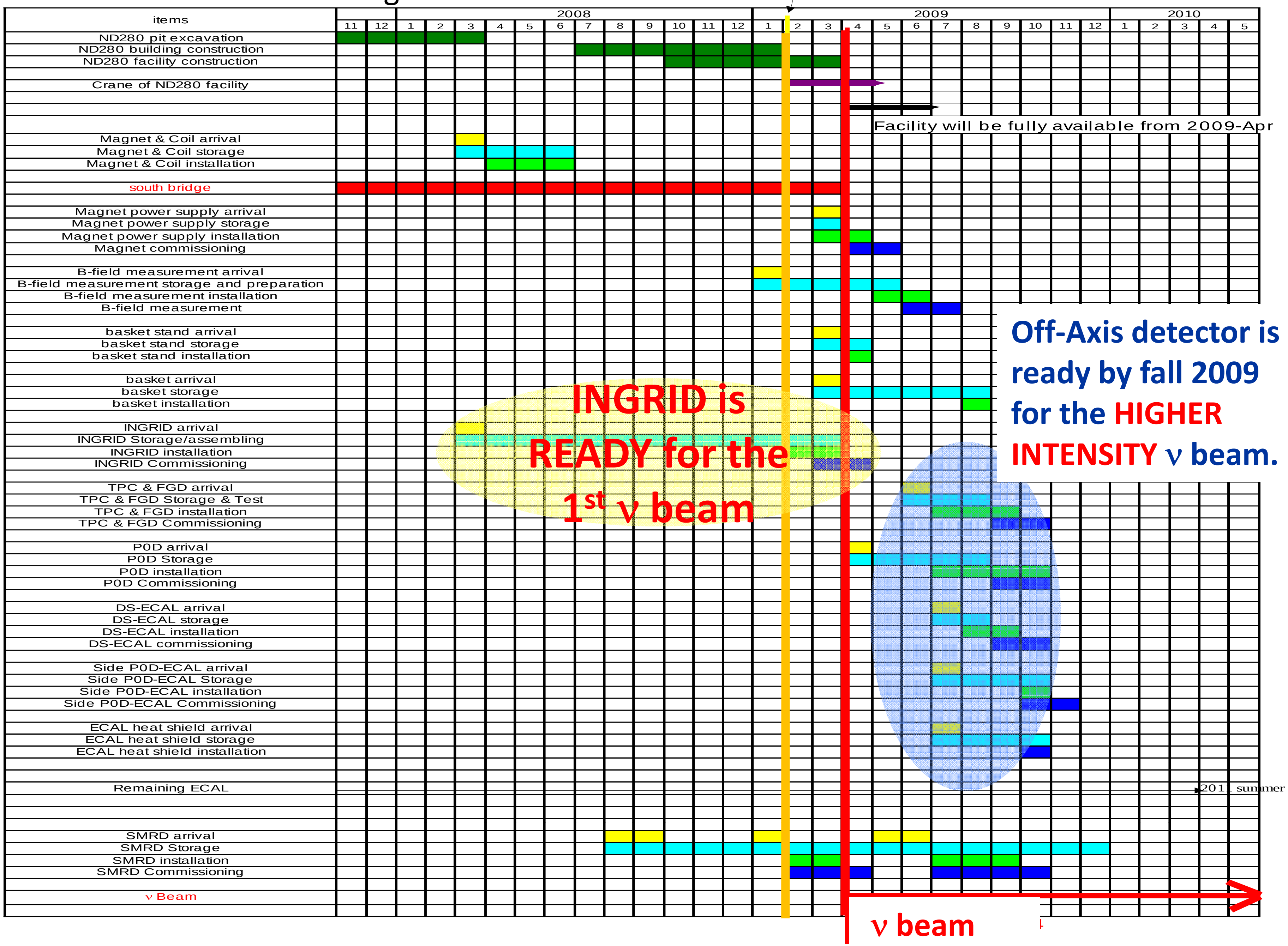
1. ND280 Schedule Update

Update Status

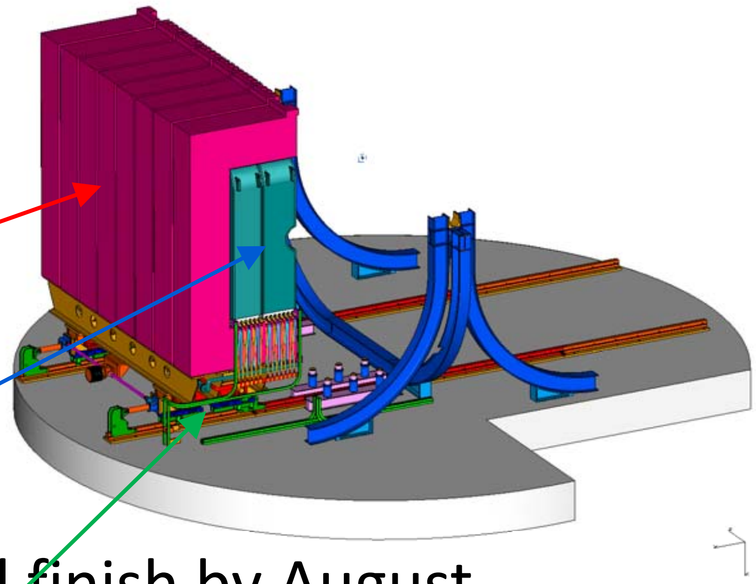
- South bridge in the J-PARC site is available until March 2009.
  - The Magnet can be transported without the time constraint.
- ND280 facility is contracted.
  - It is ready for installation with a crane and temporary power from February 2009.
  - The full facility is ready before April 2009.
- ND280 Off-axis detector
  - The detailed procedures of magnet transportation from CERN to J-PARC is processing.
  - The magnetic field measurement will be performed and the time is scheduled.
  - A part of ECAL (DS-ECAL) will be installed in summer 2009.

ND280 Facility is READY for installation

ND280 Integration Schedule



Magnet Status



- **Yokes**
  - Refurbishment started, and will finish by August. Shipping preparation (grease up, wrapping etc.) will be performed in August.
- **Coils**
  - Refurbishment just starts .
- **Moving system**
  - Aachen group takes the responsibility.
  - Carriages will be shipped to Aachen in July for assembling and testing.

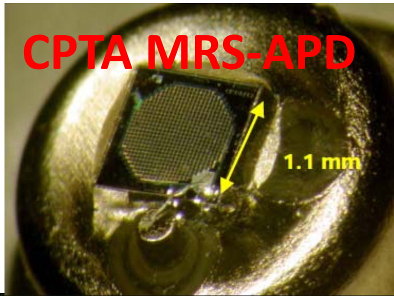

COIL
LIEBHERR

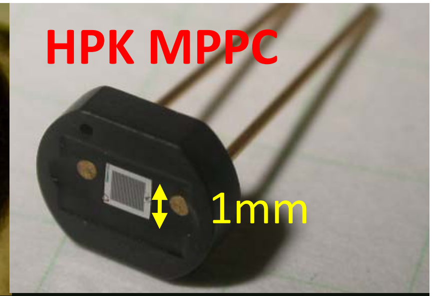
Shipment

- The document for tendering process is prepared.
- Magnet components (Yoke, Coil, and moving system) will (must) arrive at J-PARC before April 2008 for installation.

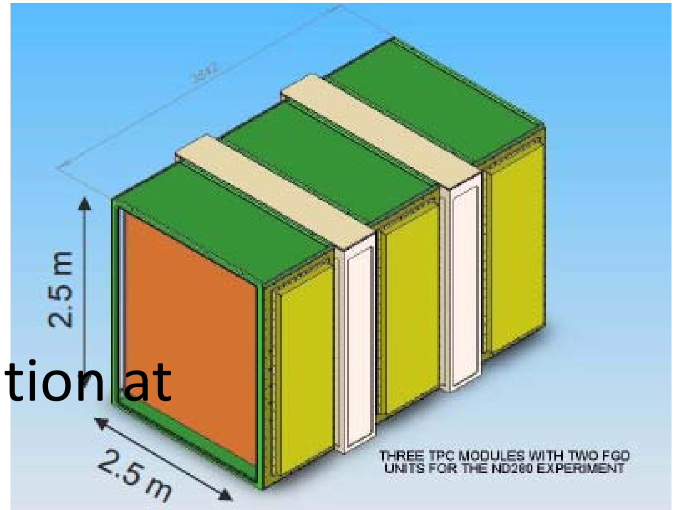
2. Key Technologies 1

- Photon-Sensors:
  - HPK MPPC
  - CPTA MRS-APD
- We (and PD07 participants) have a confidence that HPK MPPC is suitable for T2K-ND280.
  - All performances are acceptable.
  - We continue the lifetime test.
  - We have not done the simulation studies to estimate the acceptable device failure rate.
    - The devices of *O*(100) is never broken so far.
  - HPK MPPC will be ordered in fall 2007.

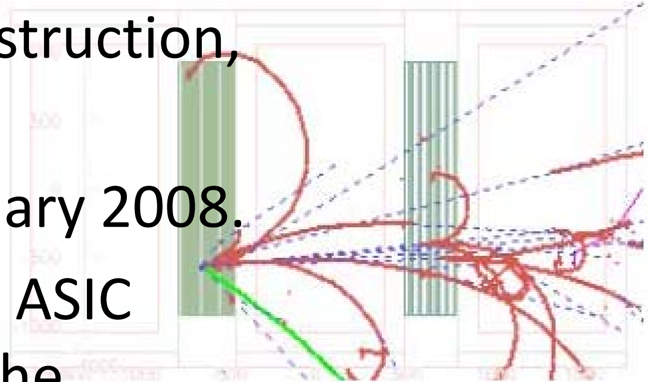


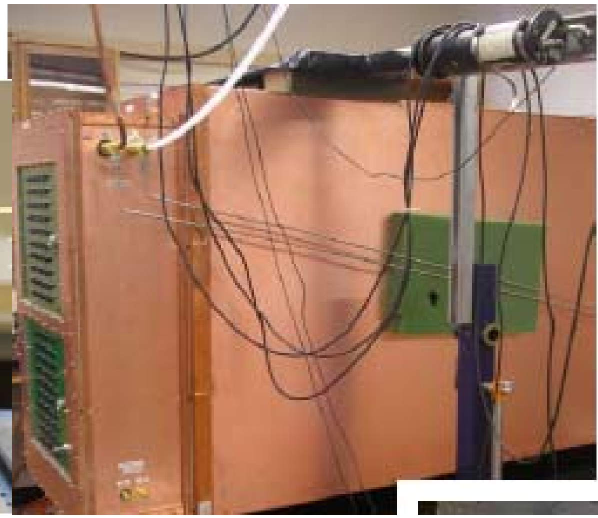


2. Key Technology 2



- TPC
  - MicroMegas Production is under preparation at CERN starting in fall 2007.
  - Full-size module proto-type is under construction, and will be tested by the end of 2007.
  - Final module production will start in January 2008.
  - TPC electronics with the special designed ASIC (AFTER chip) is progressing according to the schedule.

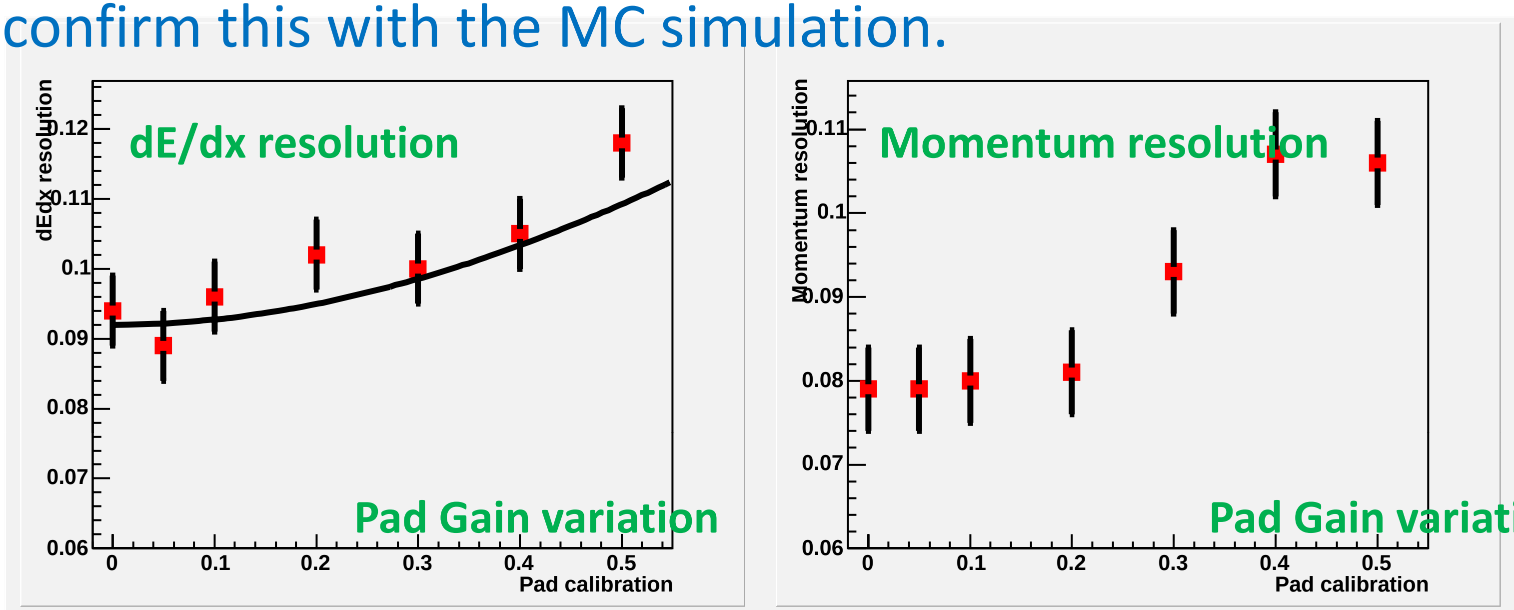




PAC minutes:

(4) The TPC plays a key role in momentum measurements and particle identification. In order to get good dE/dx resolution, the gain uniformity is essential. Therefore, it is mandatory to establish an adequate in-situ gain calibration method.

- The dE/dx measurement is insensitive to channel to channel gain variations . We expect to achieve gain uniformity much better than this. The gain will be monitored by several in-situ schemes (cosmics, photo-electron calibration, monitor chamber).up to ~20% since ionization fluctuation is as large as 50%
- We confirm this with the MC simulation.



3. Status of Full Simulation/Reconstruction

- The full simulation of ND280 detectors is not ready yet.
  - The goal of the first release of ND280 full-simulation is the end of August.
  - After the release, we will make the first large MC samples with the full detector simulation toward the T2K meeting (9/26-29).

T2K Offline Software Group:
Yoshi Uchida, Clark McGrew

Data Management: **Y. Uchida, C. McGrew**					
Physics Calibration: **A. Cervera**	**FGD:**	**TPC:** A. Cerve	**P0D:** C. McGr	**ECAL** S. Boy	**SMRD:**
Detector Simulation: **C. McGrew**	**FGD:** P. Gumpli	**TPC:** P. Gumpli	**P0D:** C. McGr	**ECAL:** D. Payne	**SMRD:** P. Prezewlocki
Event Reconstruction: **F. Sanchez**	**FGD:** T. Lindn	**TPC:** F. Sanch	**P0D:** C. McGr	**ECAL** A. Vache	**SMRD:** P. Prezewlocki
Analysis Framework: **Y. Uchida**					
Release Management: **N. McCauley**					
Hardware: **I. Bertram**					

- Preparation of the offline software is one of the highest-priority tasks in T2K.
- Please give us more time because the software preparation is a tremendous work.

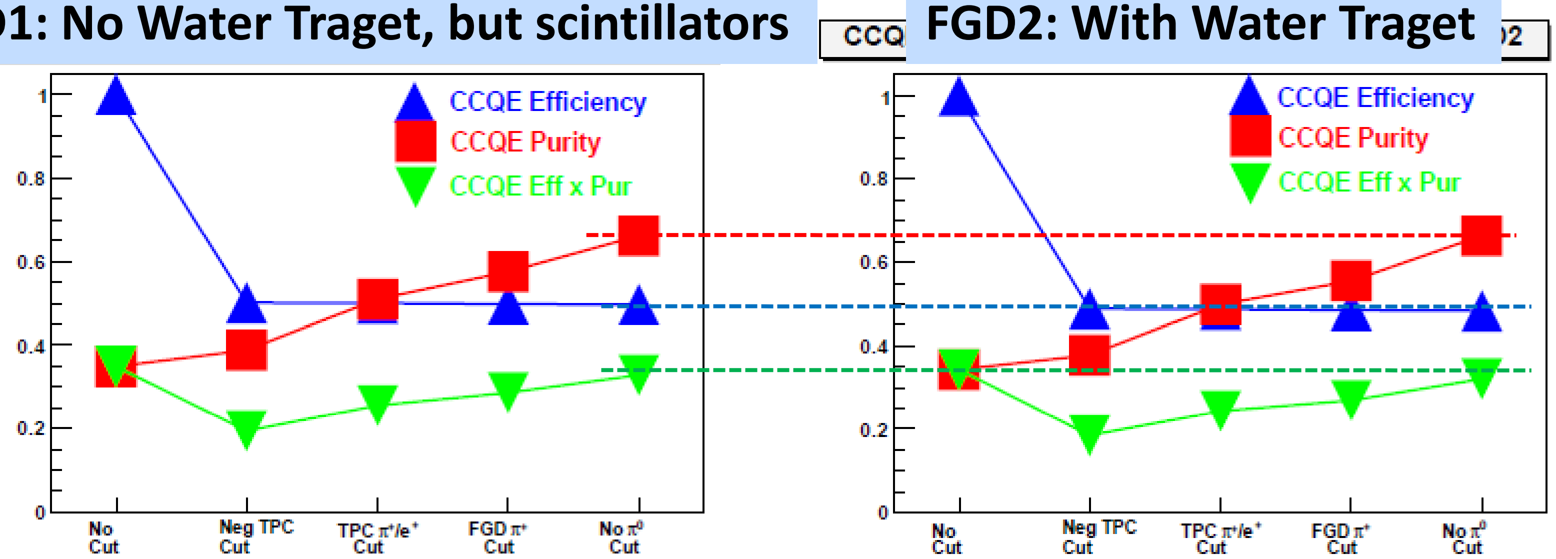
4. Physics studies

- Water Cross Sections Extrapolation (FGD):
  - We have two FGD detectors: one with water target (~50%) and the other without water target.
  - Our strategy is to watch the difference of event rates between two almost identical detectors.
  - FGD simulations tells the detector difference is very small.

$$R_{Water} = \frac{N_\nu^2 - N_\nu^1 \left(\frac{M_2}{M_1}\right)\left(\frac{\varepsilon_2}{\varepsilon_1}\right)}{M_{water} \cdot \varepsilon_2}$$

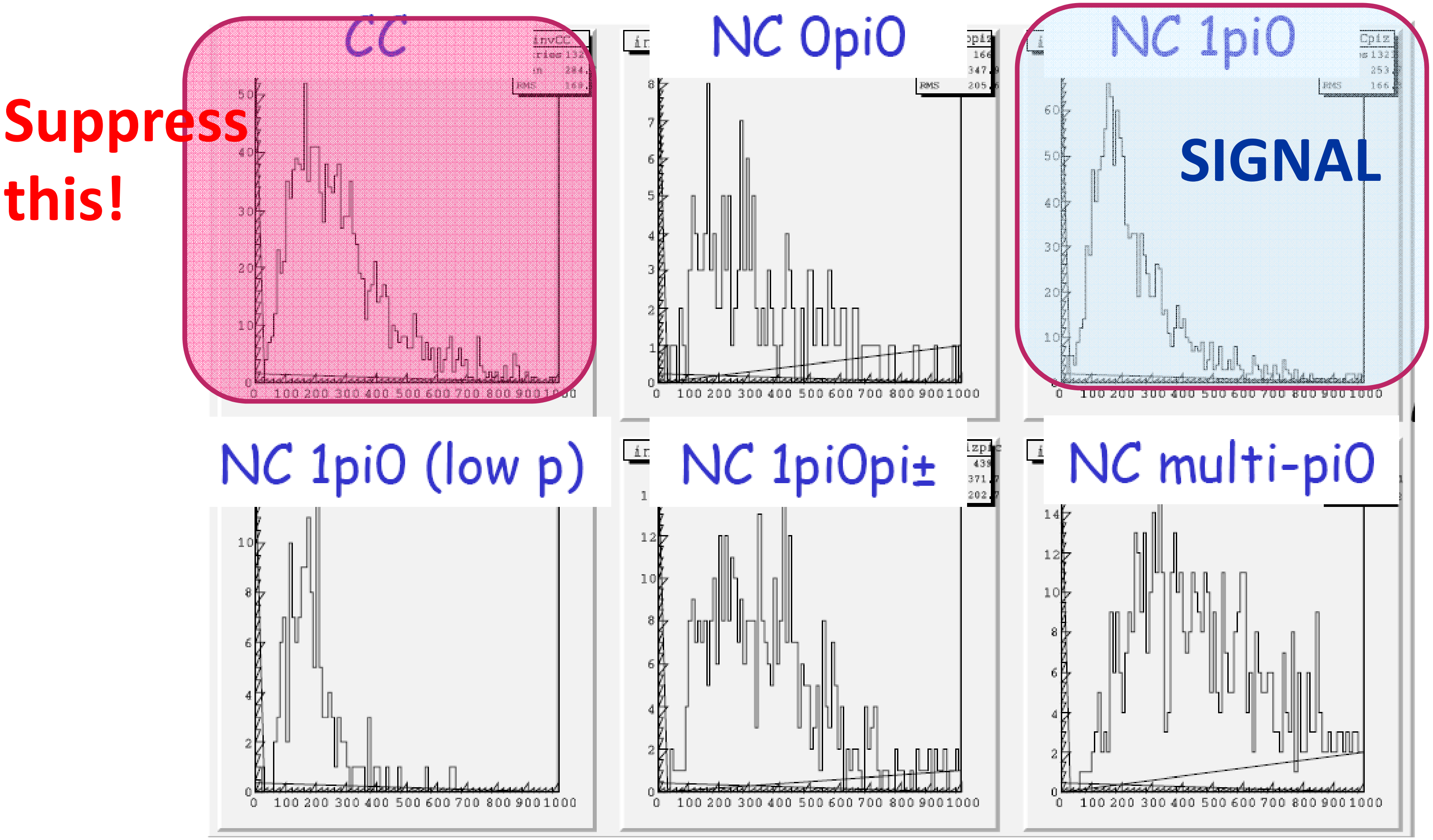
FGD1: No Water Traget, but scintillators

FGD2: With Water Traget

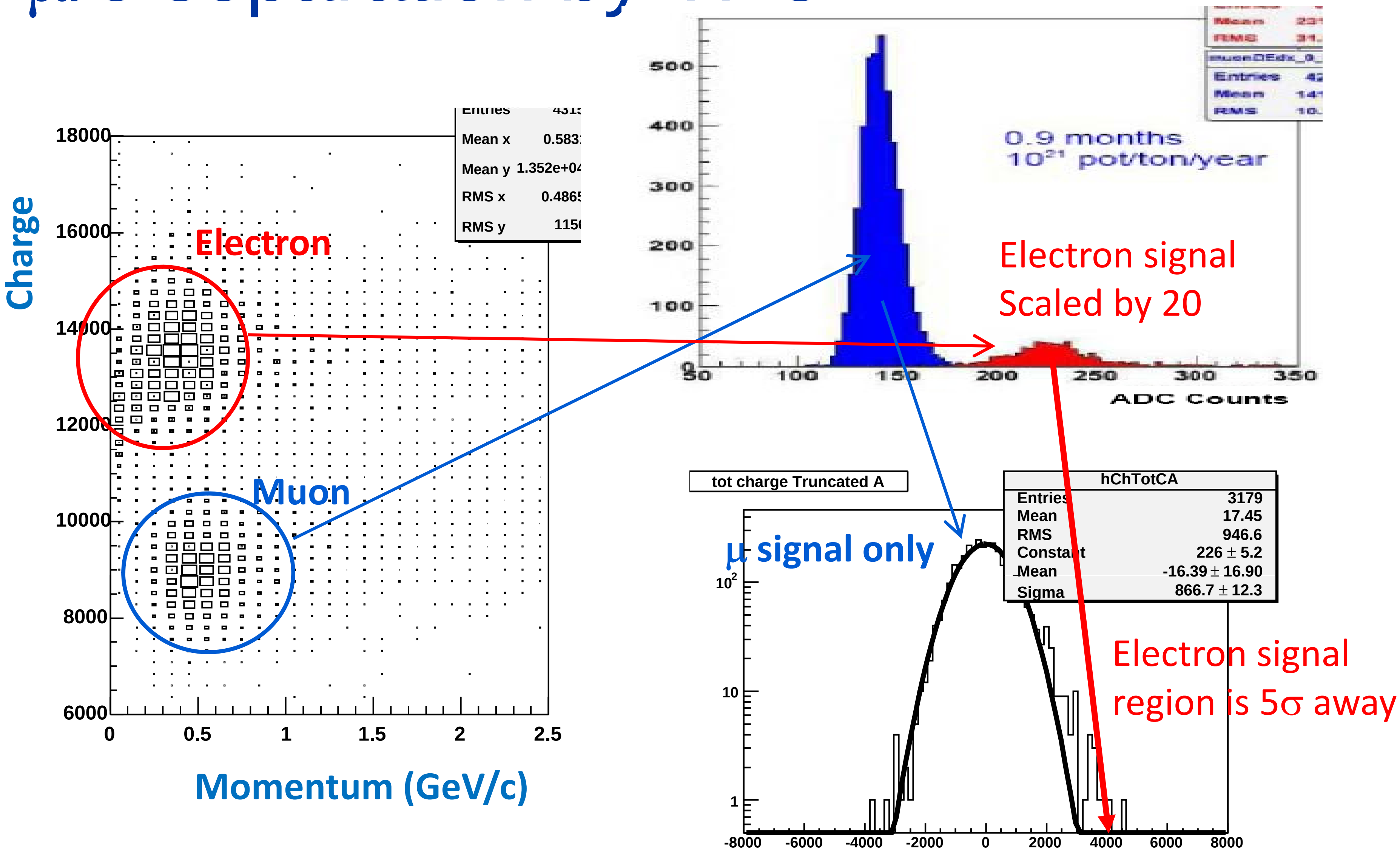


π^0 measurement

- Under progress to improve the π^0 measurements.
  - Reconstructed Invariant Mass



μ/e separation by TPC



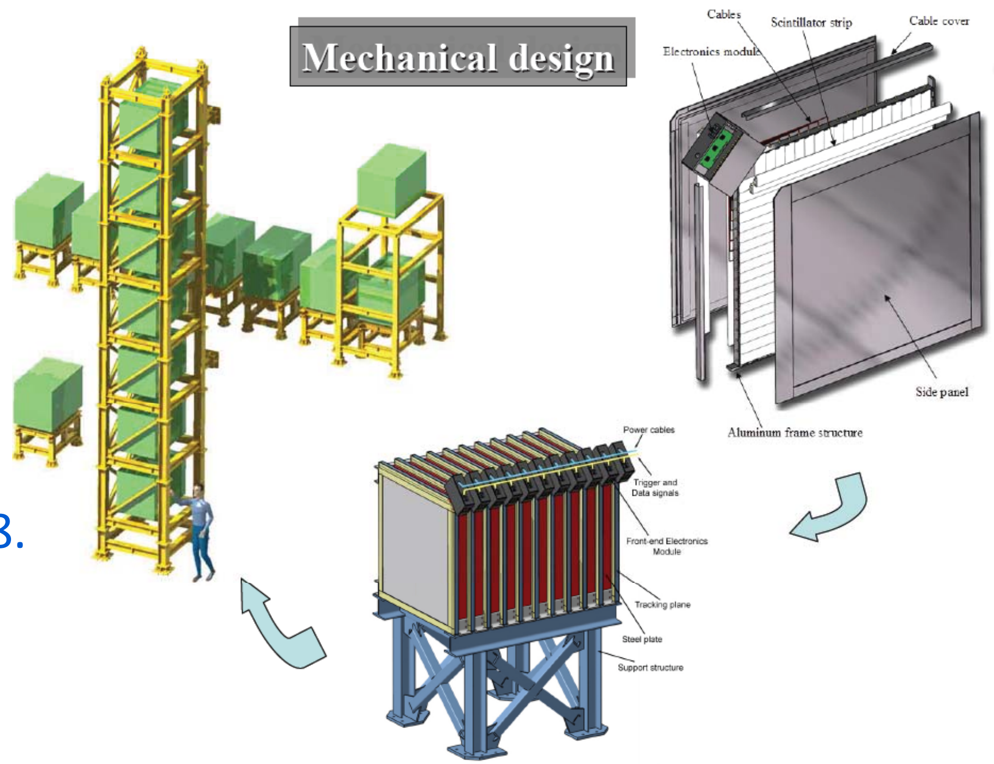
- **μ rejection by a factor of 10^4 is possible.**

5. ND280 sub-detector status

- INGRID
- P0D
- FGD
- (TPC: Reported at page 10 and 11)
- ECAL
- SMRD
- (Photo-sensors: Reported at page 9)
- DAQ
- Electronics

INGRID (Neutrino Beam Monitor)

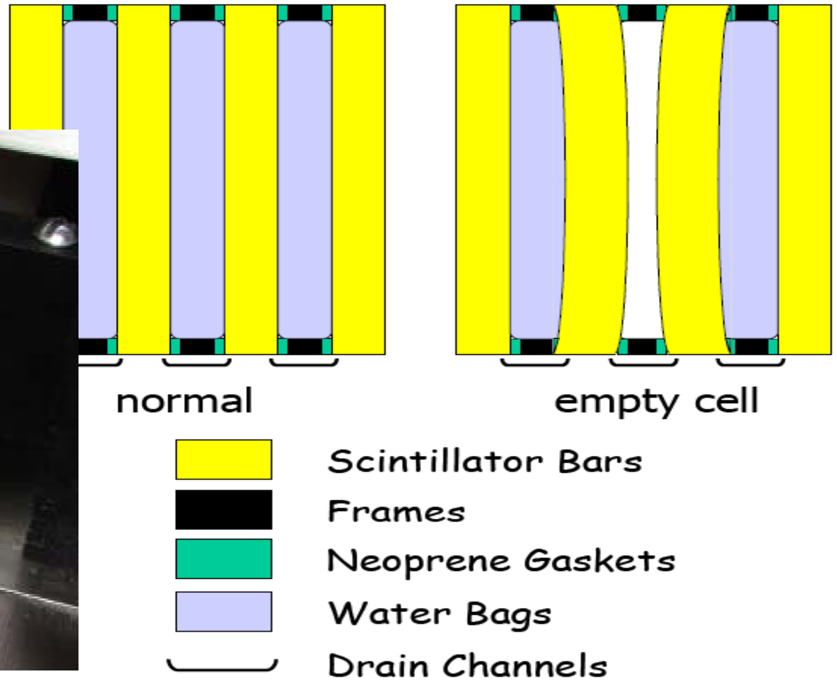
- The detector will be ready before the 1st neutrino beam (April 2009).
  - Milestone & Schedule
    - So far,
      - WLS fibers in our hand
    - 2007 purchase-order
      - Scintillators
      - Photo-Sensor (HPK MPPC)
      - Irons
    - Proto-type production in 2007
    - 2008 purchase-order
      - Electronics + DAQ
    - Detector assembly
      - will be happen in summer 2008.
    - Installation, Commissioning
      - will be happen in January 2009

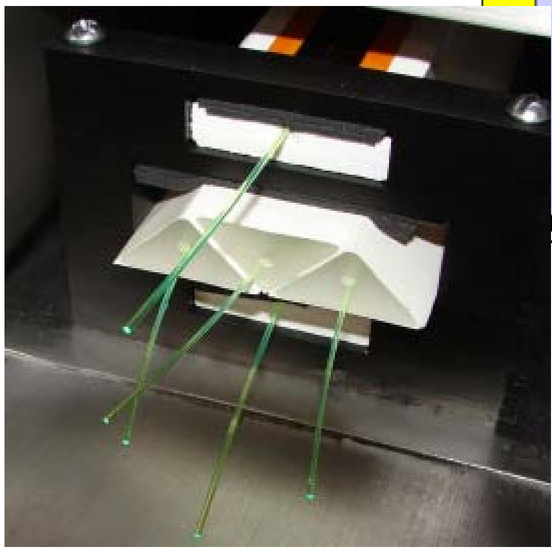


P0D

- Water bag survival test
- Can P0D module support the water bag?
  - Proto-type testing.
- Proto-type test of
  - Scintillators
  - WLS fibers
  - Photo-sensors

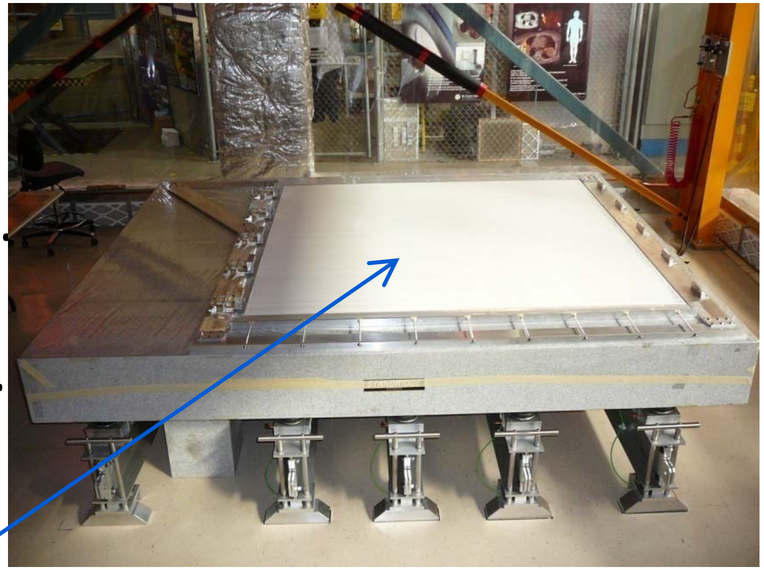
  at FNAL test beam line.





FGD

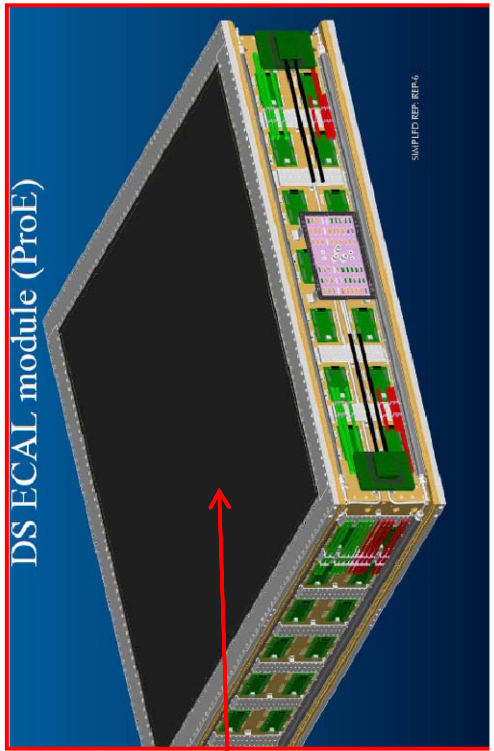
- All scintillator bars have been produced.
  - Bar-to-bar light yield is constant to 5%.
- WLS fibers have been mirrored at FNAL.
- FGD electronics is fully funded.
- The first 6 XY scintillator modules have now been glued and machined (total 24).
- The first prototype front-end board has been delivered and is being tested.
- Construction remains on schedule for completion by <u>May 2008</u>, with commissioning tests at TRIUMF later in 2008.

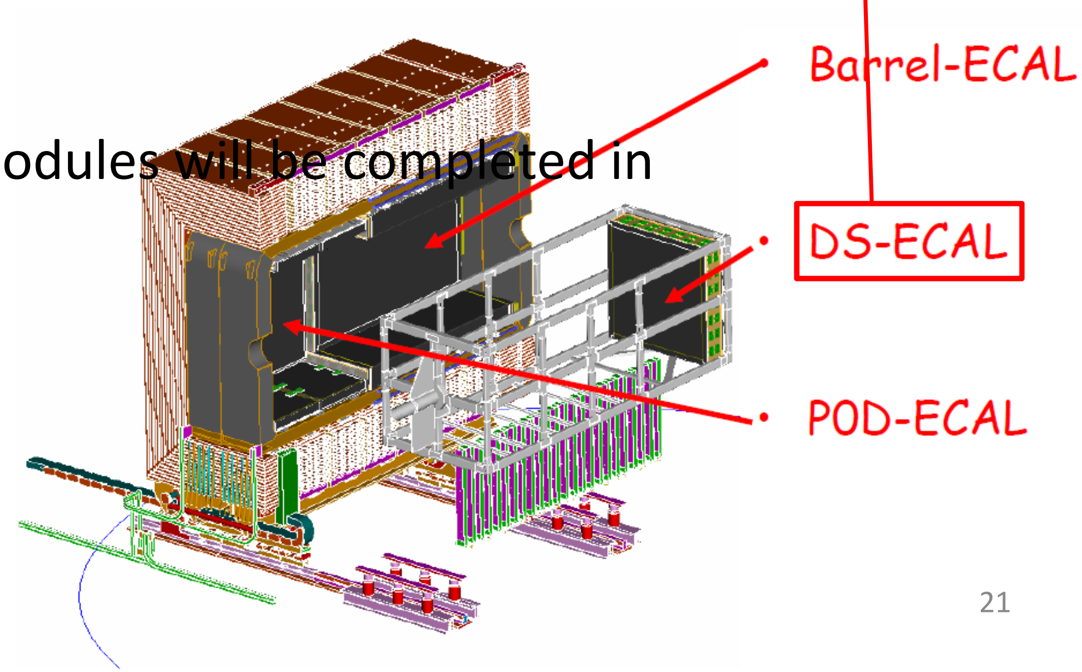


ECAL

Staged ECAL Production

- DS-ECAL
  - The lead sheets, scintillator bars, and wls fibers, are now all ordered.
    - Scintillators production & WLS fibers mirroring at FNAL.
  - The assembly room at Lancaster University is ready.
  - The final design review is at Daresbury on July 12.
  - Test beam at CERN in 2009.
  - The production schedule is on track for installation in 2009
- Barrel-ECAL & P0D-ECAL
  - Detailed design of ECAL modules will be completed in 2007.
  - Install in summer 2011.

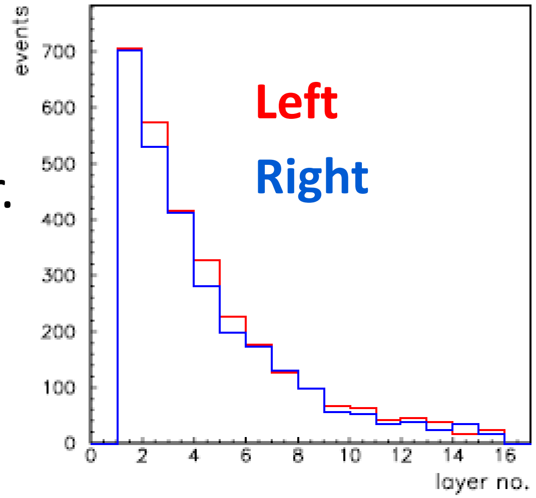


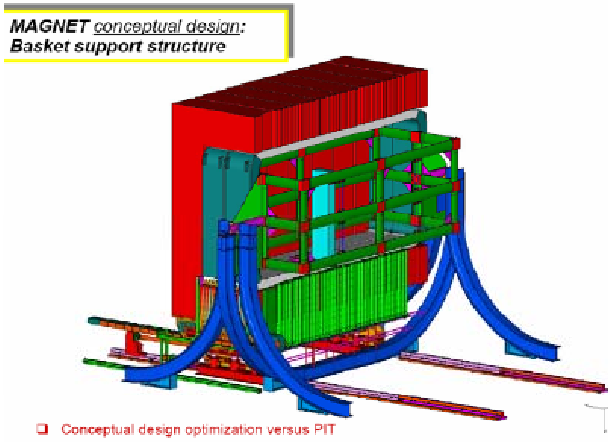


SMRD

- The extrusion of the first 1000 scintillators (~50%) will start on August 15
  - Delivery of first scintillators in early September.
- WLS fiber for production arrived at INR, Moscow
  - Long term test of bend fibers do not show any performance degradation
- Design of module end-cap has progressed.
  - A prototype by mid-July
  - Finalizing the design this summer.

SMR layer modules hits for ν events.





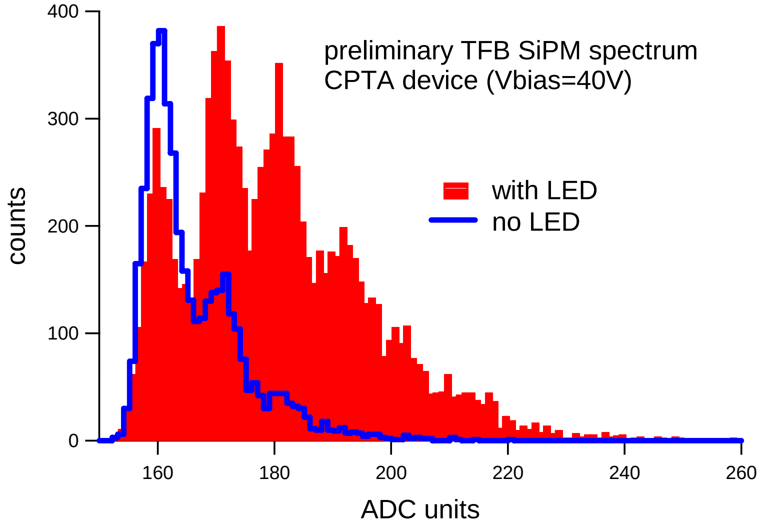
Coils present top and bottom
NO coils left and right

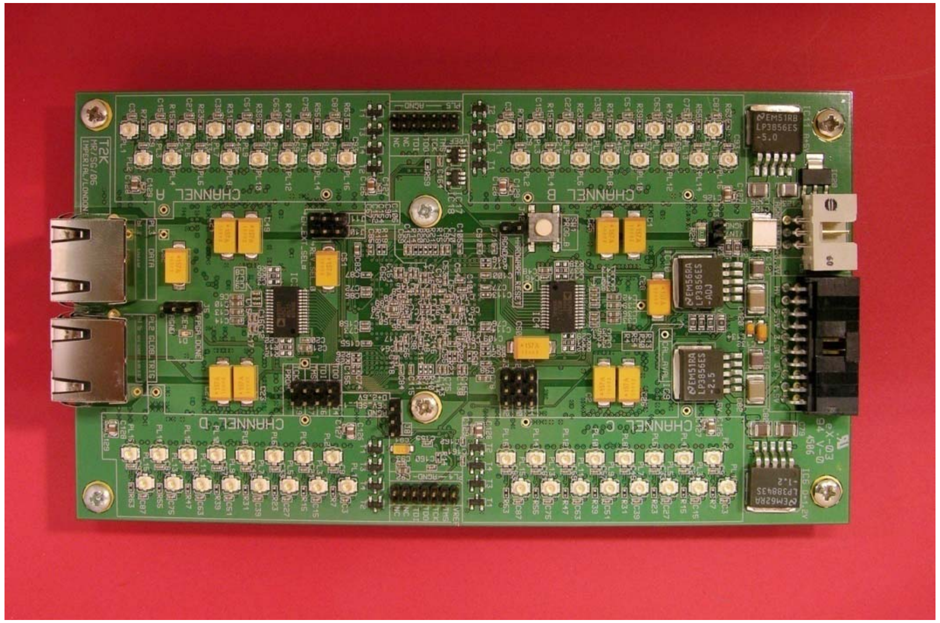
Optimization of module allocation

	Left/right		Top/bottom		# modules
	layers	modules	Layers	modules	
Ring 8	6	48	3	24	72
Ring 7	6	48	3	24	72
Ring 6	4	32	3	24	56
Ring 5	3	24	3	24	48
Ring 4	3	24	3	24	48
Ring 3	2	16	3	24	40
Ring 2	2	16	3	24	40
Ring 1	2	16	3	24	40
Total		**224**		**192**	**416**

Electronics (Trip-T system)

- The proto-type of the front-End board for MPPC is tested.
  - Most of firmware are implemented.
- The backend electronics is also under progress.
- The trigger module is also underdevelopment.

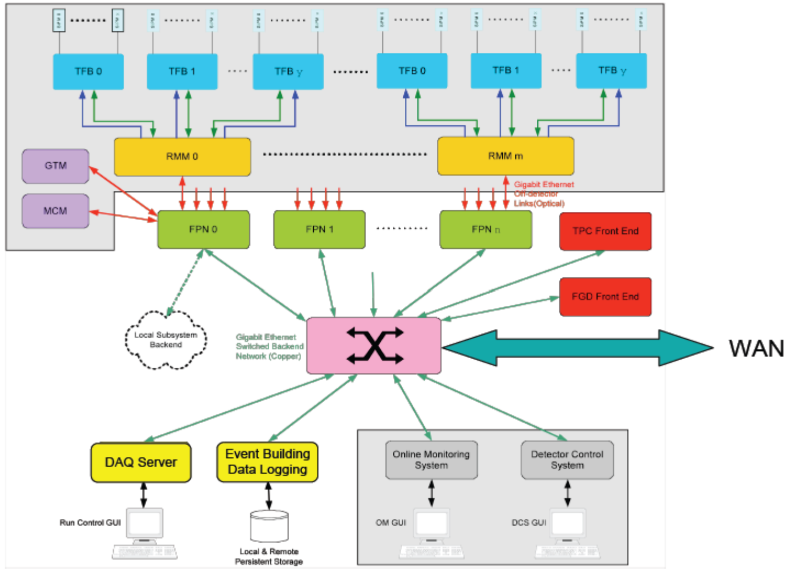




DAQ

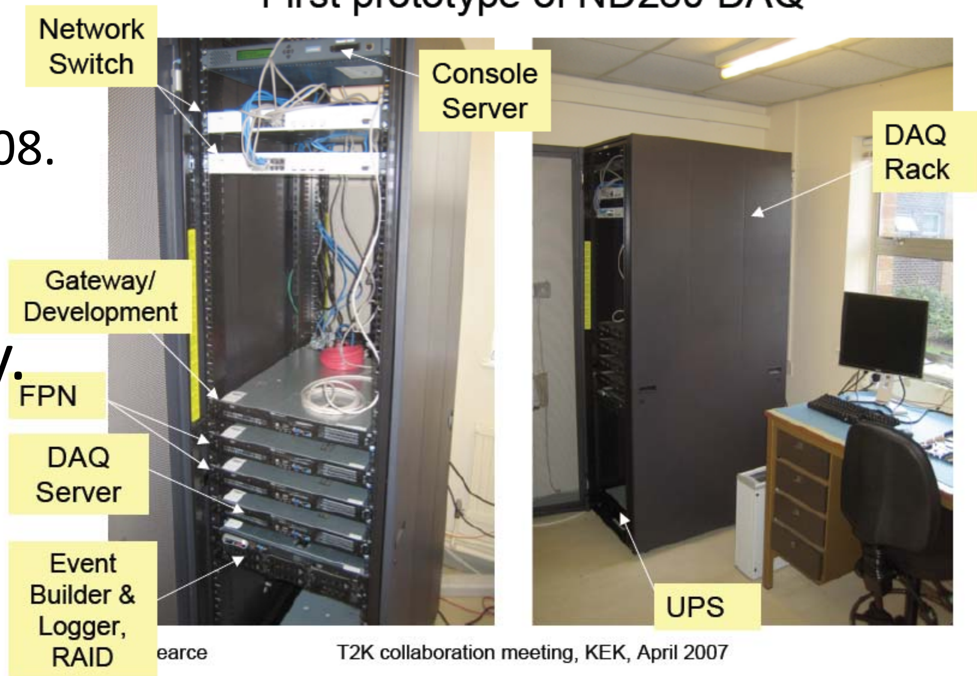
- Electronics/Interface for TPC and FGD readout work just starting.
  - Will use the system for TPC/FGD test beam in 2008.
- Electronics/Interface for Trip-T system is under development.
  - Vertical slice test at RAL
    - Mirror of final system including all components.
  - The system will be used
    - for ECAL module scanner in 2008.
    - for ECAL test beam in 2009.
- Integration on Global/Trip-T/TPC/FGD DAQ is under way.

Schematic of DAQ architecture



Vertical Slice at RAL

First prototype of ND280 DAQ



6. Future Works

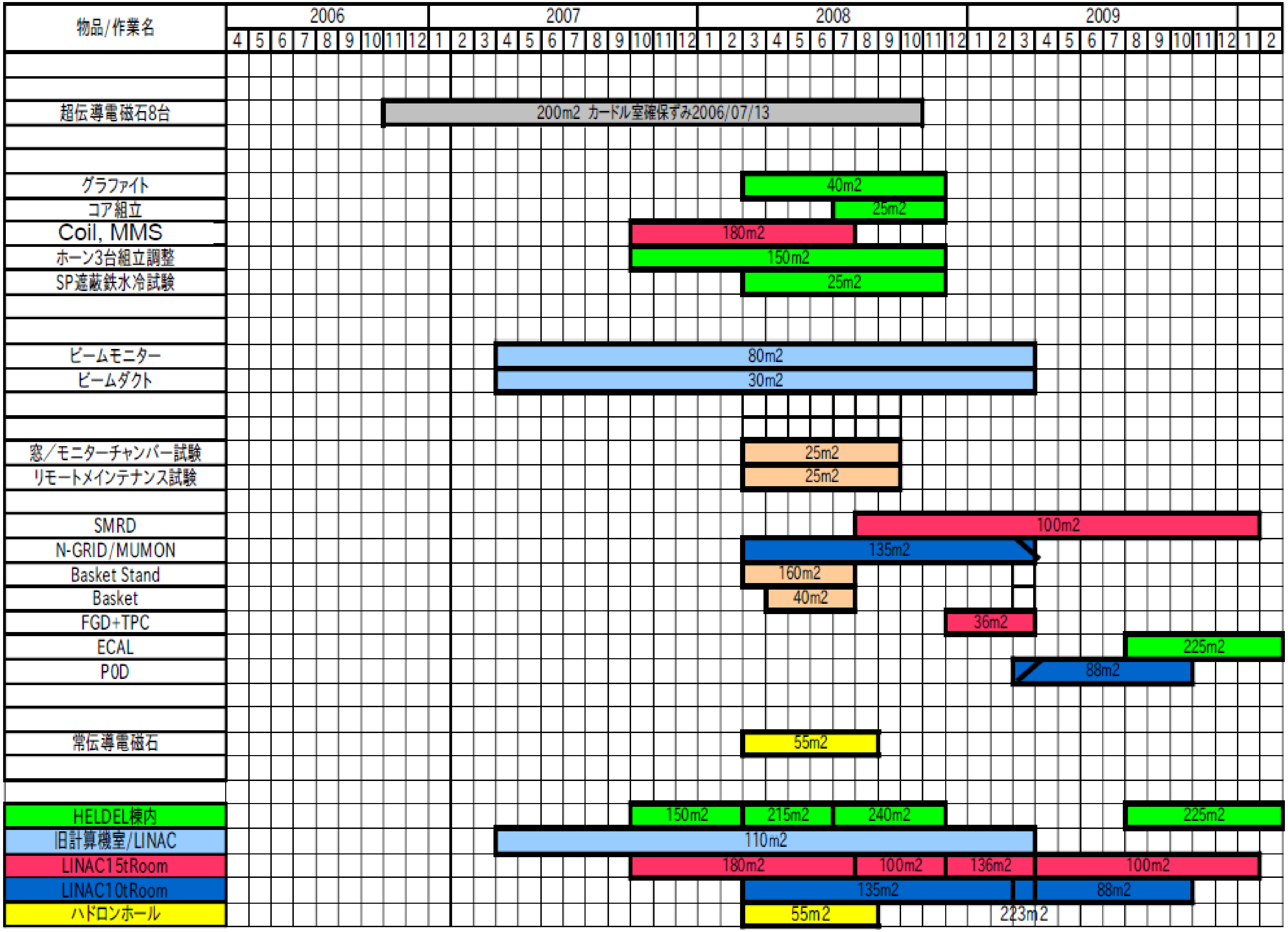
Tasks of highest priorities are

- Magnet transportation from CERN to J-PARC is one of the big challenge in JFY2007.
- More professional work on ND280 integration is on-going with the ND280 facility construction.
- Most of the sub-detector system will be tested with the proto-type in 2007, and mass production in 2008.
- INGRID detector will be ready for the 1st neutrino beam (beam commissioning) in April 2009.
- Off-axis detectors will be installed in summer 2009, and be ready for the higher intensity neutrino beam in fall 2009.

ND280 will observe neutrino events *two years from now.*

Backup

Schedule


物品/作業名
2006
2007
2008
2009
超伝導電磁石8台
200m2 カードル室確保ずみ2006/07/13
グラファイト
40m2
コア組立
25m2
Coil, MMS
180m2
ホーン3台組立調整
150m2
SP遮蔽鉄水冷試験
25m2
ビームモニター
80m2
ビームダクト
30m2
窓／モニターチャンバー試験
25m2
リモートメインテナンス試験
25m2
SMRD
100m2
N-GRID/MUMON
135m2
Basket Stand
160m2
Basket
40m2
FGD+TPC
36m2
ECAL
225m2
POD
88m2
常伝導電磁石
55m2
HELDEL棟内
150m2
215m2
240m2
225m2
旧計算機室/LINAC
110m2
LINAC15tRoom
180m2
100m2
136m2
100m2
LINAC10tRoom
135m2
88m2
ハドロンホール
55m2
223m2

Magnet

Magnet related tasks

1. Engineering of magnet (including seismic analysis - very different)
2. Dismantling yokes and refurbishing yokes, coils & carriages at CERN
3. Shipment of yokes, coils and carriages to Tokai
4. New rails, rollers, damping springs & moving system
5. New power supply and power cables
6. New slow control system
7. New cooling-water system
8. Re-mounting of yokes
9. Yokes installation including new alignment constraints (SMRD)
10. Coils installation including new preparation for ECAL support 2008.06
11. Finish installation
12. Magnet test & pre-commissioning 2009.04
13. Field map measurement

2. Refurbishing at CERN

- ☑ Hole drilling for insertion of dowel-pins
- ☑ All "C" marked with well identifiable labels
- ☑ Dismantling of all C's for shipment in iso-containers
- ☐ Deposit all parts using CERN crane shared with LHC installation: almost done
- ☐ C refurbishment tender - ready
- ☐ C refurbishment - planned during summer 07
- ☑ Refurbishment of carriages
- ☐ Refurbishment coils - work being organized. Execution in summer.

TPC question from review

From PAC minutes: Jan 2007

- 4) The TPC plays a key role in momentum measurements and particle identification. In order to get good dE/dx resolution, the <u>gain uniformity</u> is essential. Therefore, it is mandatory to establish an adequate in-situ gain calibration method.

Answer

- Ionization fluctuations along the length of the track are very large. For the ~1 cm samples collected by the TPC pads, the signals have an RMS of > 50%. By collecting a large number of samples, the dE/dx resolution for a track is reduced to < 10%.
  - The dE/dx measurement is therefore insensitive to channel to channel gain variations up to about 20%. We expect to achieve gain uniformity better than this, even without calibration. A calibration step will nevertheless be done with the micromegas modules outside of the TPC, and there is no reason to expect that the relative pad gains to change with time.

Answer cont.

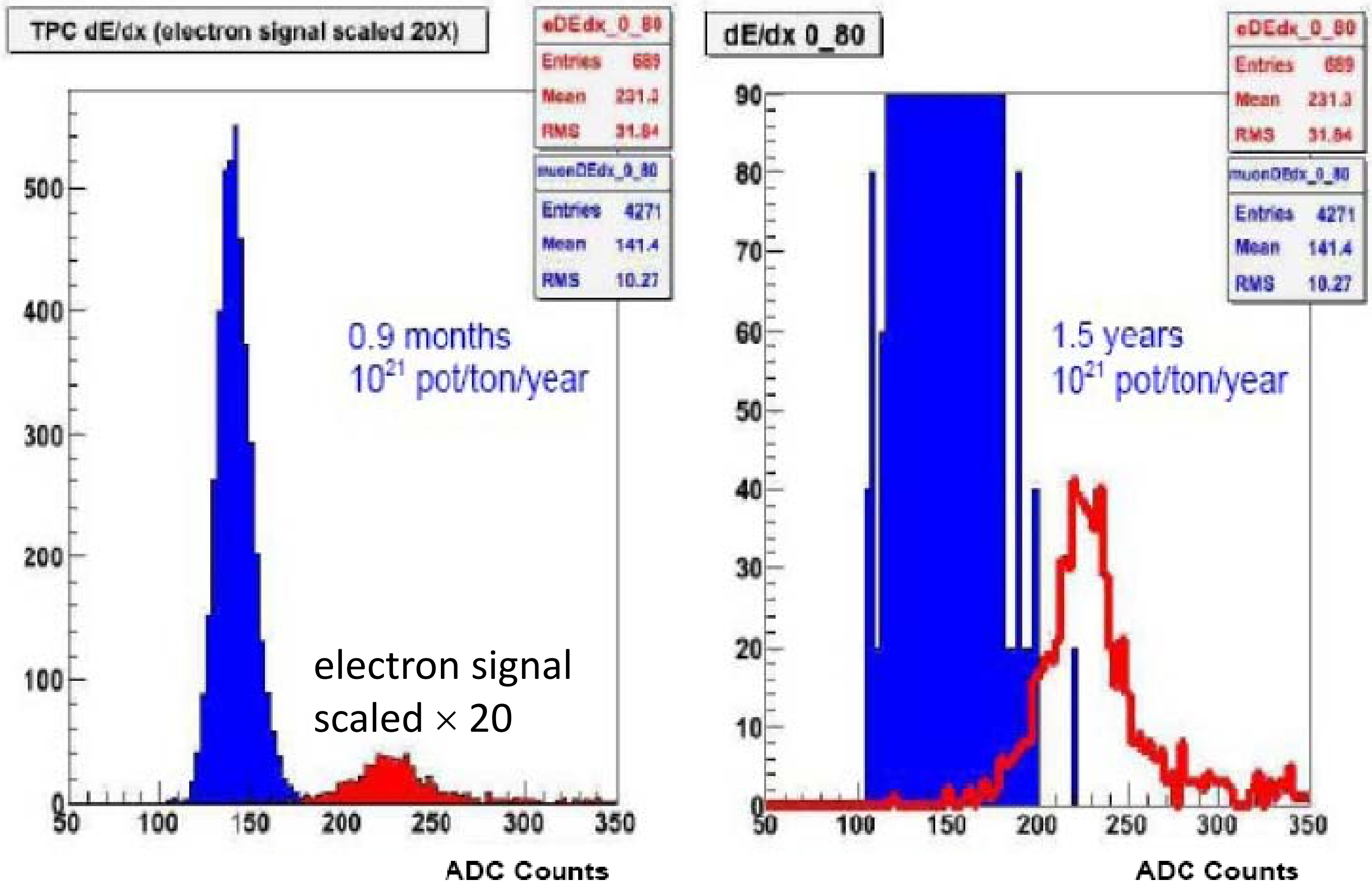
- Gain uniformity from pad to pad is not a serious concern for dE/dx performance
  - nor is it a concern for momentum resolution
  - this has been confirmed by two separate simulation studies
- It is important, however, to monitor the overall gain of the micromegas modules – particularly as it can vary by ~ 10% with pressure variations.

Monitoring the overall gain

- There are several in-situ schemes to measure the gain as a function of time:
  – cosmics and beam particles
  – photo-electron calibration system
    - aluminum targets placed on central cathode are flashed by a diffuse UV laser pulse
  – in-line gas property monitor chamber
    - small TPC with micromegas readout module and radioactive source

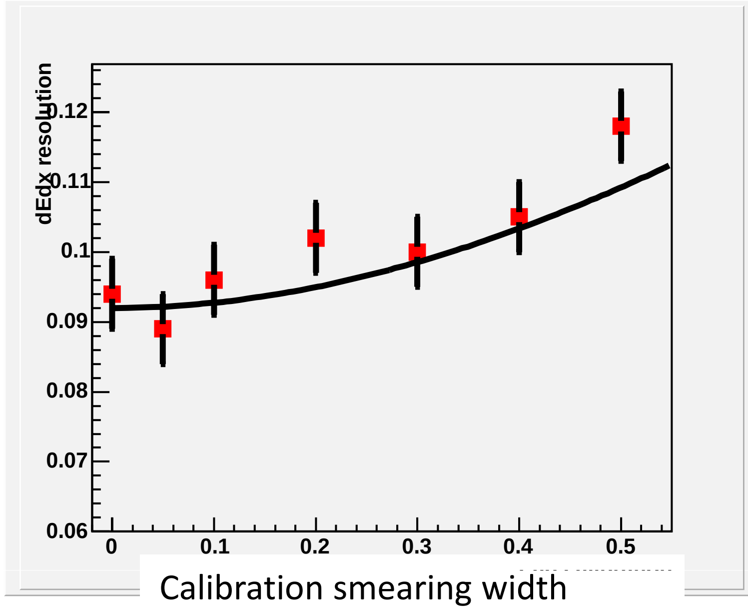
e/μ separation by dE/dx

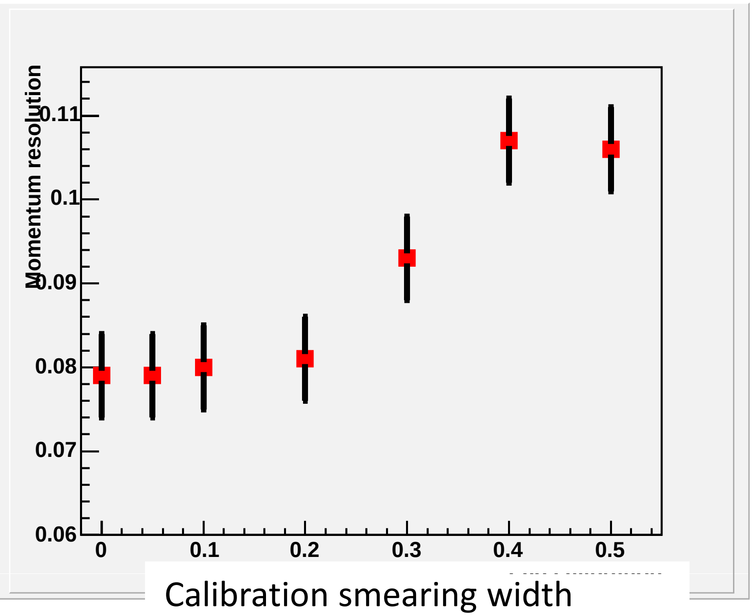
Geant4 simulation



Pad gain calibration

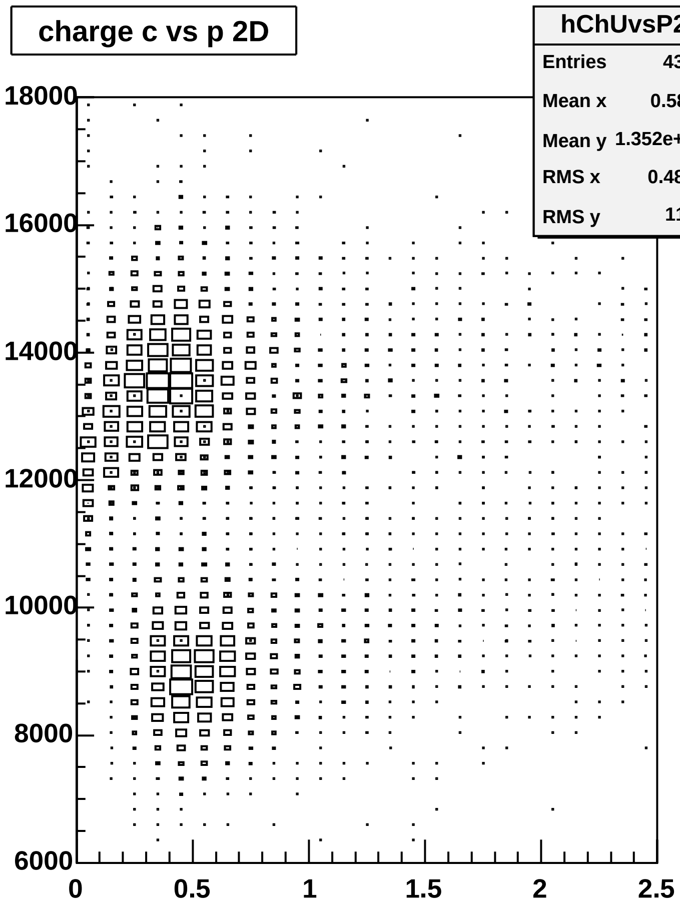
- Smear charge measured by each pad by a constant factor (sampled from a gaussian)
- How does this impact : dE/dx and momentum (in 1-1.x GeV/c bin) resolution ?





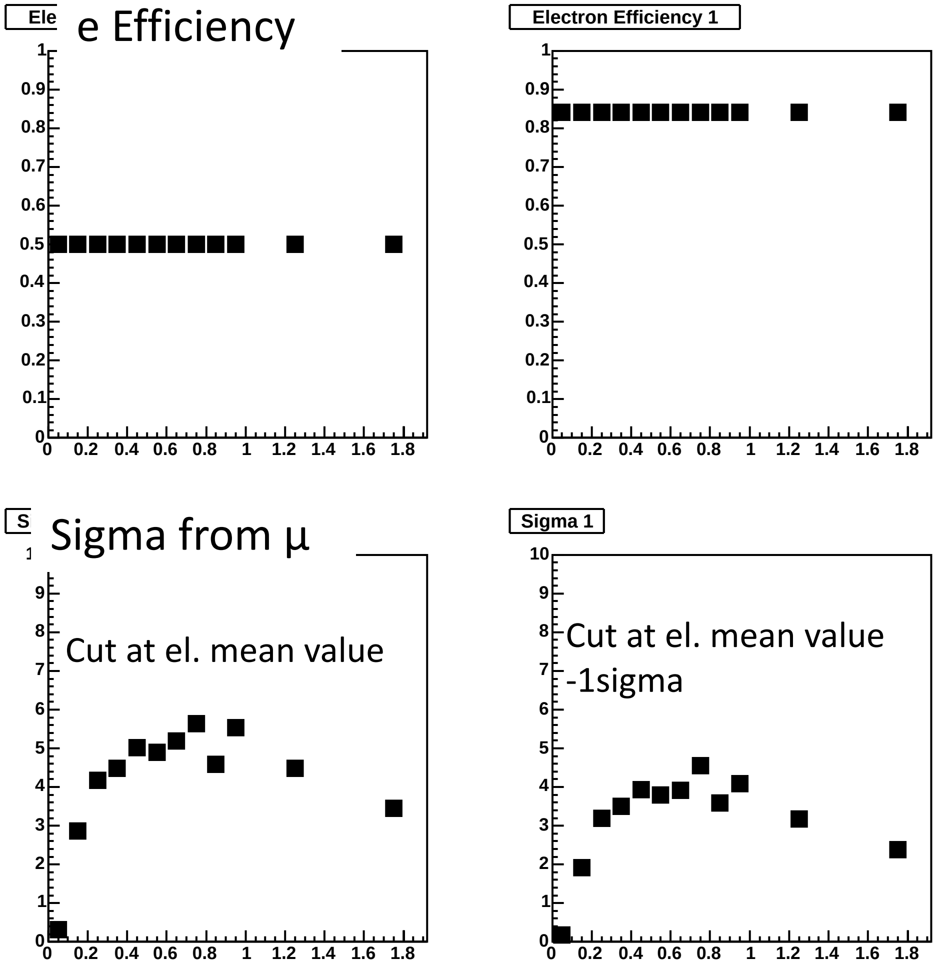
- => 10 % smearing has negligible effect on either dE/dx or momentum !

dE/dx electrons and muons

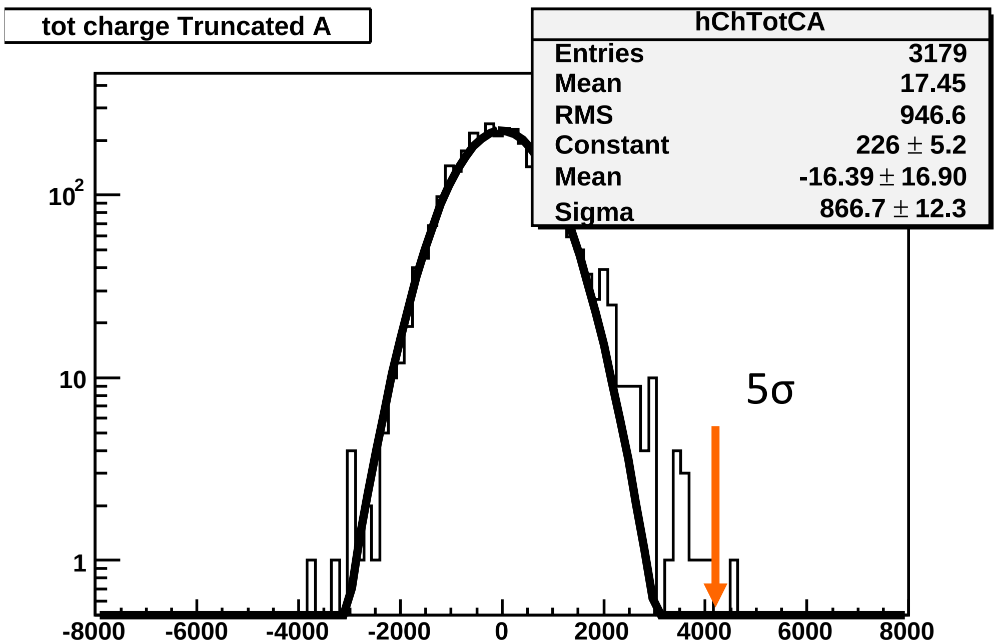


Clear separation but needs factor 10-3 to reject muons and measure nu-e contamination !

e-μ separation-1



e-μ separation-2



- Rejection factors of o(10-4) can be achieved.
- Needs to be optimized (more studies) and verified with data

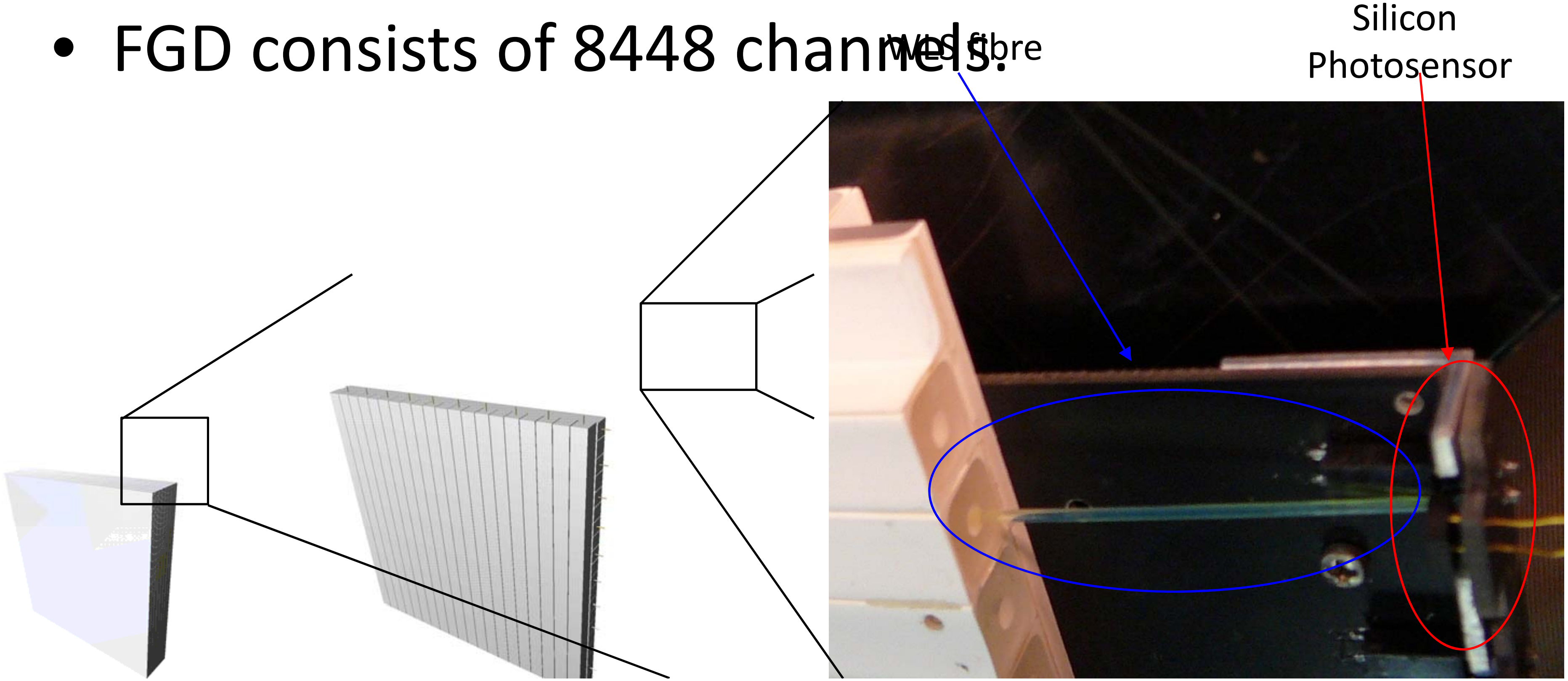
Conclusions

- dE/dx resolution below 10 % (9% for muons, 7% for electrons) can be achieved
- Pad gain smearing up to 10% has no impact on performances. Set a goal of 5 % for systematic MM calibrations at CERN (?)
- Tails beyond Gaussian assumptions needs to be evaluated to assess pid performances
- Further improvements :
  - Filter pads on MM borders
  - Gap correction
- Clean muons samples (from Ecal or SMRD) needed to control the pid purity

FGD

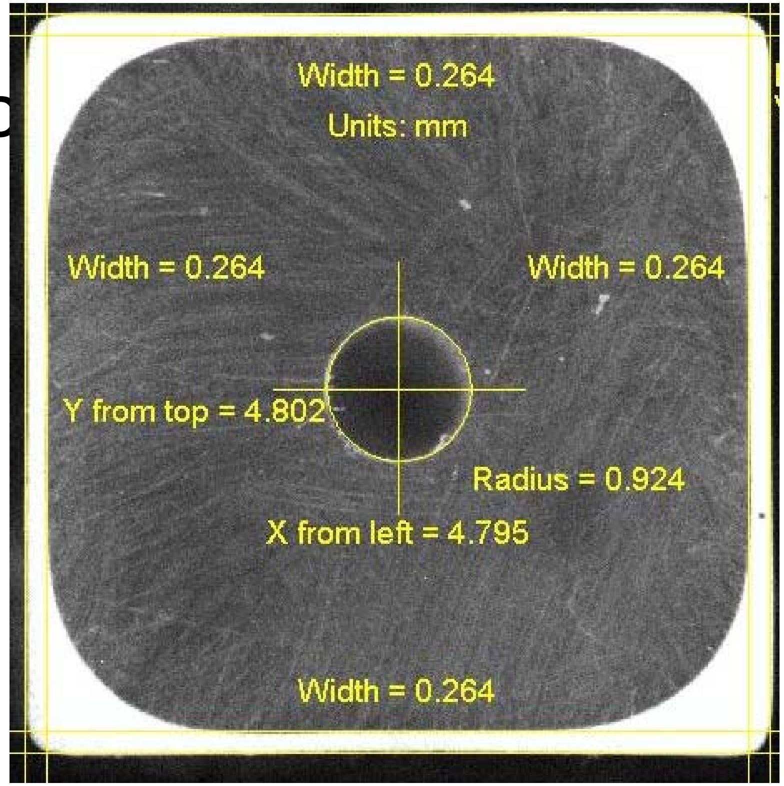
FGD Detector II

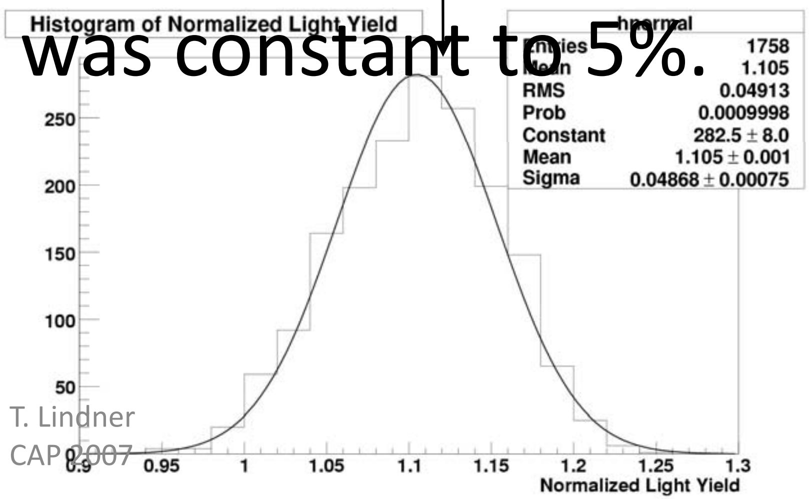
- Light produced in scintillator bar is readout using a WaveLength Shifting (WLS) fibre coupled to a pixellated APD (ie “SiPM”).
- FGD consists of 8448 channels.



Scintillator Quality Control

- Periodically checked Ti02 coating width and size/position of WLS fibre hole.
- Used automated scanner check light output from bars using Ru-106 source; found that bar-to-bar light yield was constant to 5%.





XY Module Construction

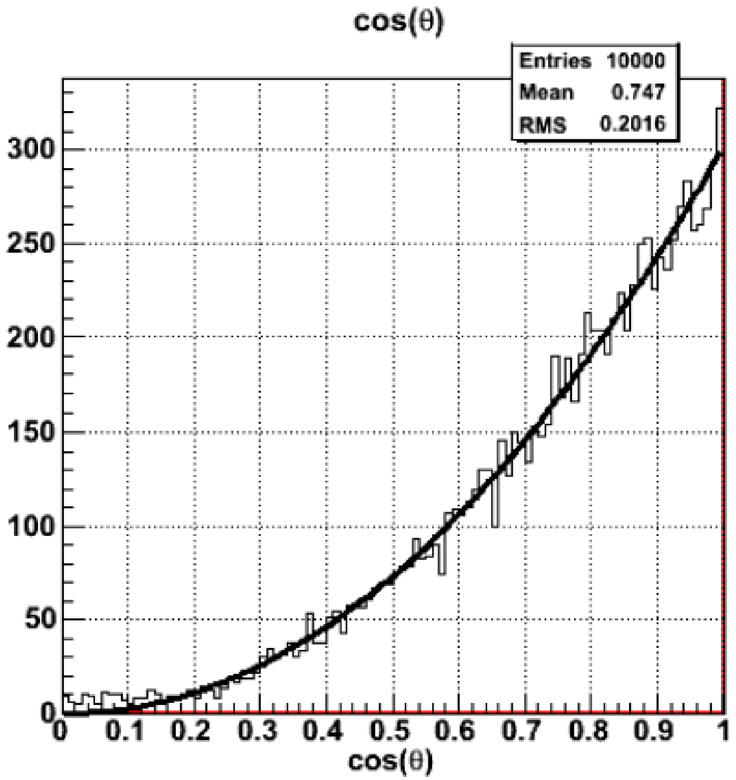
- Each module consists of an X layer, a Y layer and two G10 skins.
- Considerable R/D was done for module glueing procedure.
- Metal jig was constructed to ensure that X and Y layers were aligned and perpendicular.

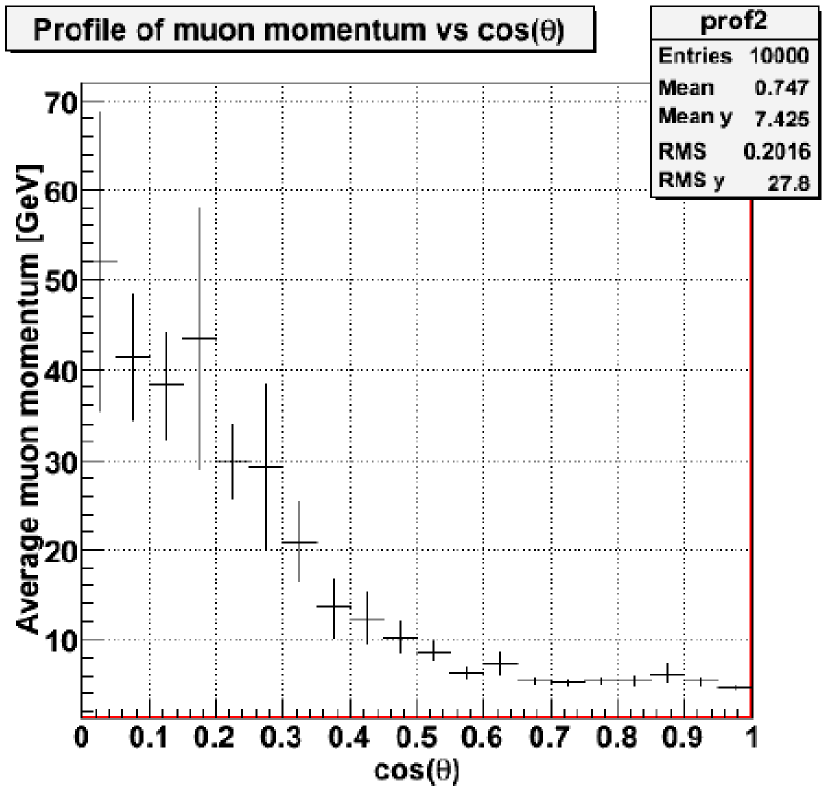
SMRD

SMRD as Cosmic Ray Trigger

Rate estimation of vertical and inclined muons

Muon flux: official K2K data file – Oyama spectrum
fit for cosθ; isotropic in ϕ

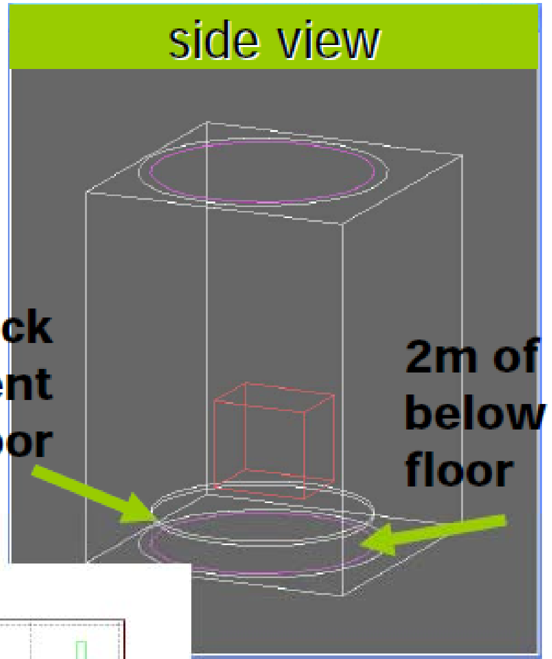




normalization: 70 $\mu/(m^2 s)$ > 1 GeV at surface (PDG)

G4 simulation results

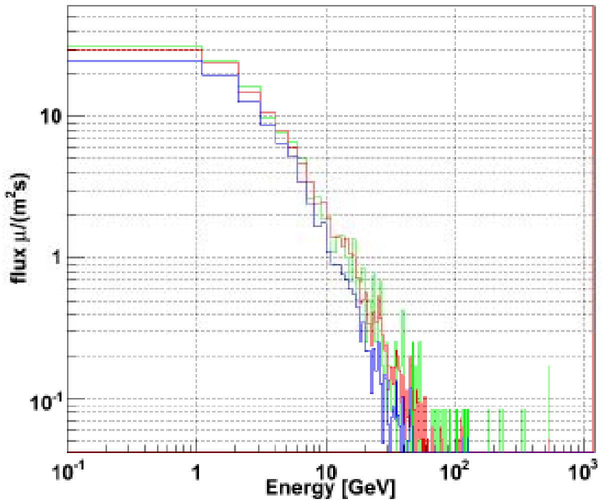
green – 400m x 400m, 0.27 s
red – 200m x 200m, 2.2 s
blue – 22m x 22m, 36 s



30cm thick cement floor

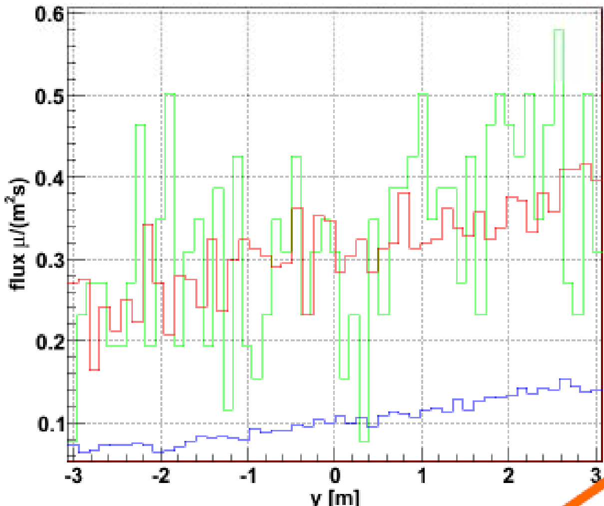
2m of air below floor

top surface



entries	1517	11993	152221
tot. flux [$\mu/(m^2s)$]	128±4	126±1.5	96.9±0.3
mean [GeV]	7.62	8.56	5.29

Two side walls



entries	458	3231	17566
tot. flux [$\mu/(m^2s)$]	17.7±0.8	15.6±0.3	5.12±0.04
mean [m]	0.30	0.27	0.43

height distribution of muons entering the detector box from the sides

Horizontal flux information!

files can be downloaded from:
http://neutrino.fuw.edu.pl/public/samples/t2k/nd280_atm_muons/

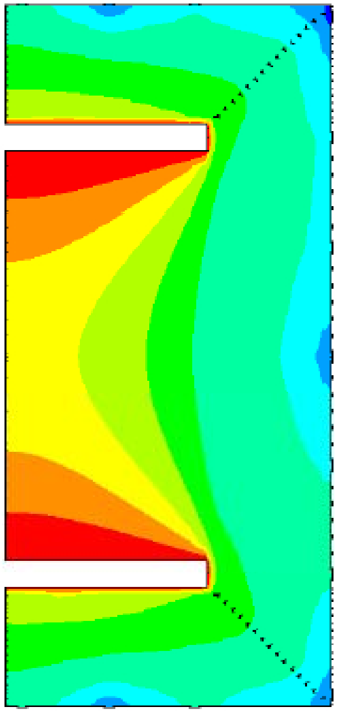
We have tested SMRD counters of different thickness and different scintillator quality. Fiber configuration, counter width and length were the same for all prototypes.

Comparative table of light yields from cosmic MIPs:

Counters (manufacturing date)	Left end: MRS 1710-001	Right end: MRS 1710-047	Σ
10 mm thick (Aug. 2006)	**11.0 p.e.**	**9.9 p.e.**	**20.9 ±0.6 p.e.**
7.9 mm thick (Dec. 2006)	**10.9 p.e.**	**9.7 p.e.**	**20.6 ±0.6 p.e.**
7.0 mm thick (Mar. 2007) with machinend groove	**10.1 p.e.**	**9.5 p.e.**	**19.6 ±0.6 p.e.**

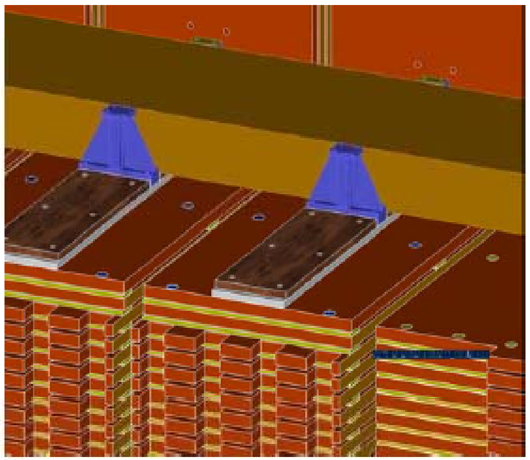
Light yield data are corrected to temperature 22°C

Temperature distribution in yokes

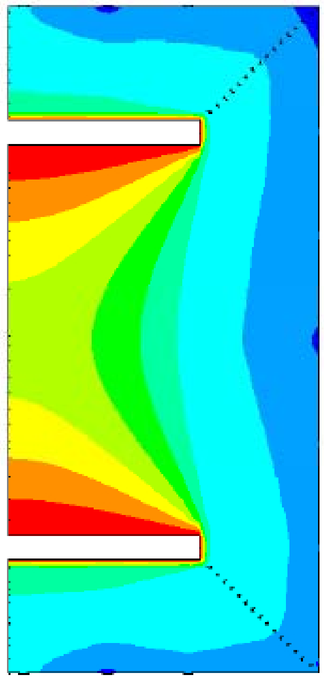


Assumptions:
5 cooling plates for each C,
1 (top) + 3 (side) + 1 (bottom)
plate surface:(400x700) mm²

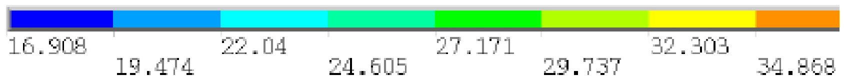
Heat to be removed from yokes = 13.5 kW



Increase timber content in coil support



Heat to be removed from yokes = 8.1 kW



Electronics

TFB Prototype (Mark Raymond)

miniature coax connectors for photo-sensors

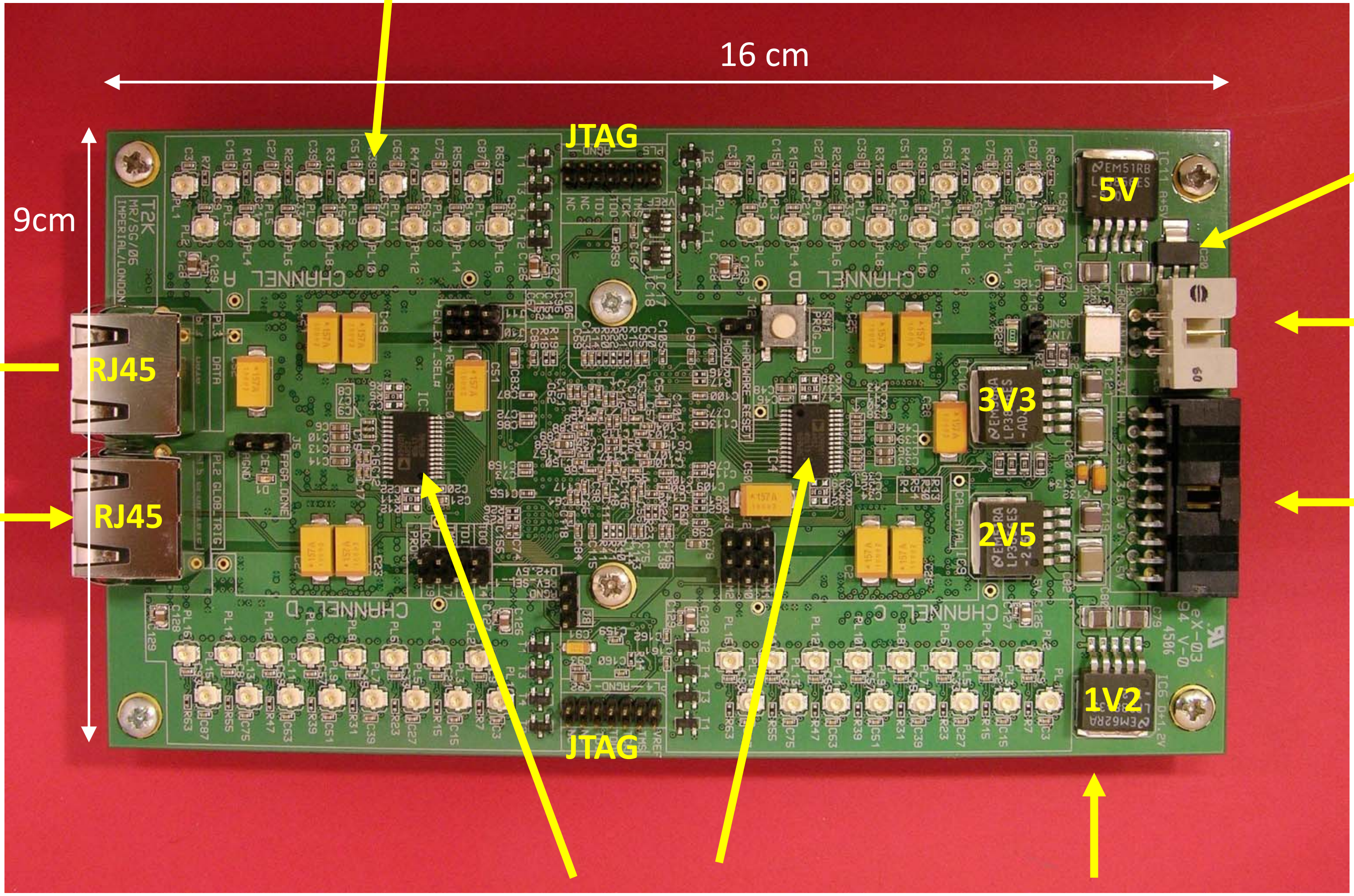
12 layers – 6 routing, 6 power/GND

HV switch

I^{2}C for ext. temp. sensors

trigger out

data in
data out
100 MHz
trigger in



power
5V5,3V8
3V,1V5
HV, GND

2 x dual channel 10 bit ADCs

power regulators

Firmware Status (Matt Noy)