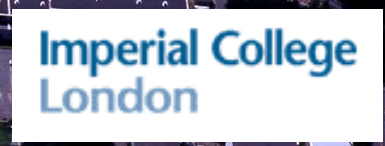
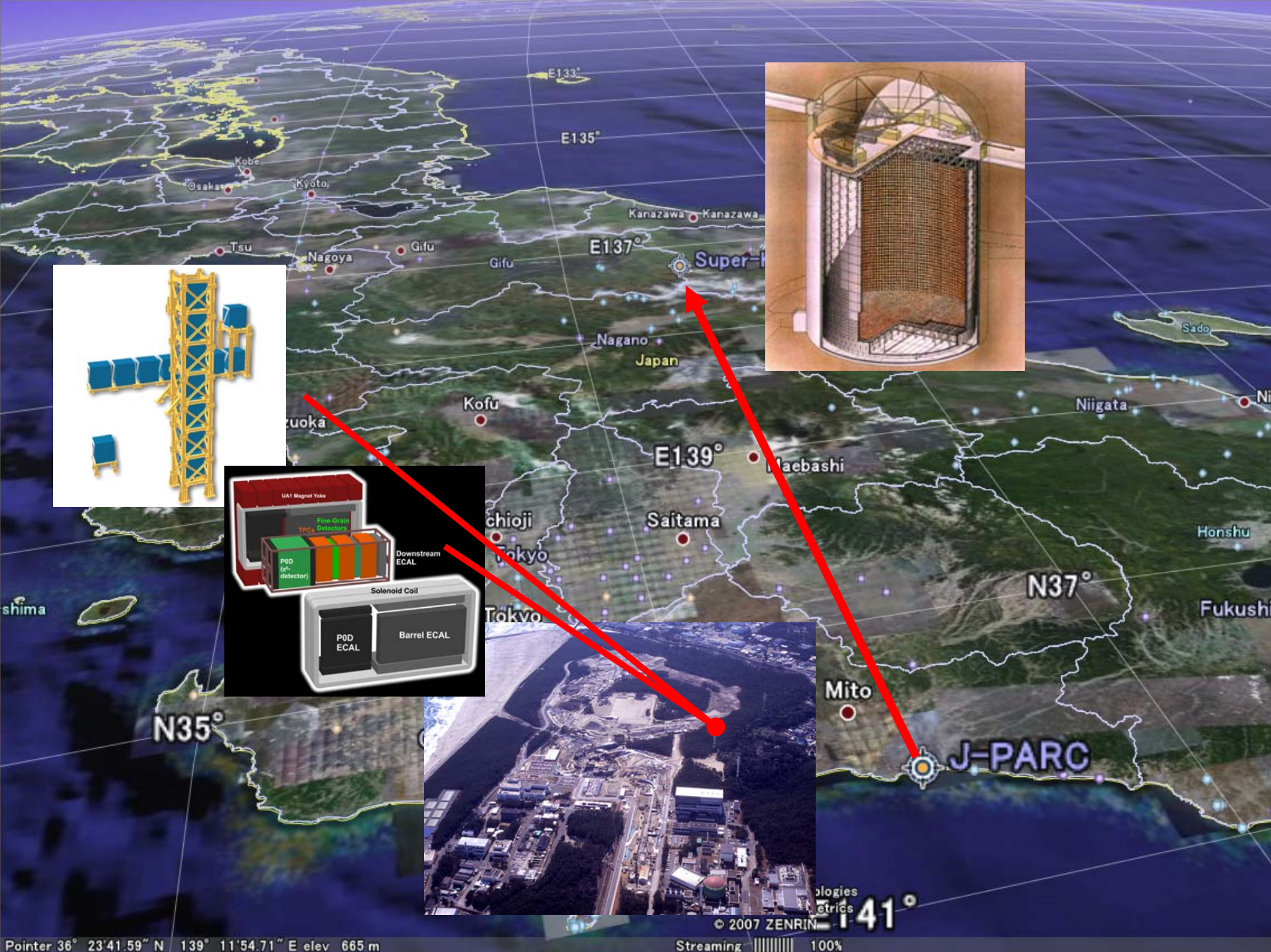
Status of the T2K Detectors

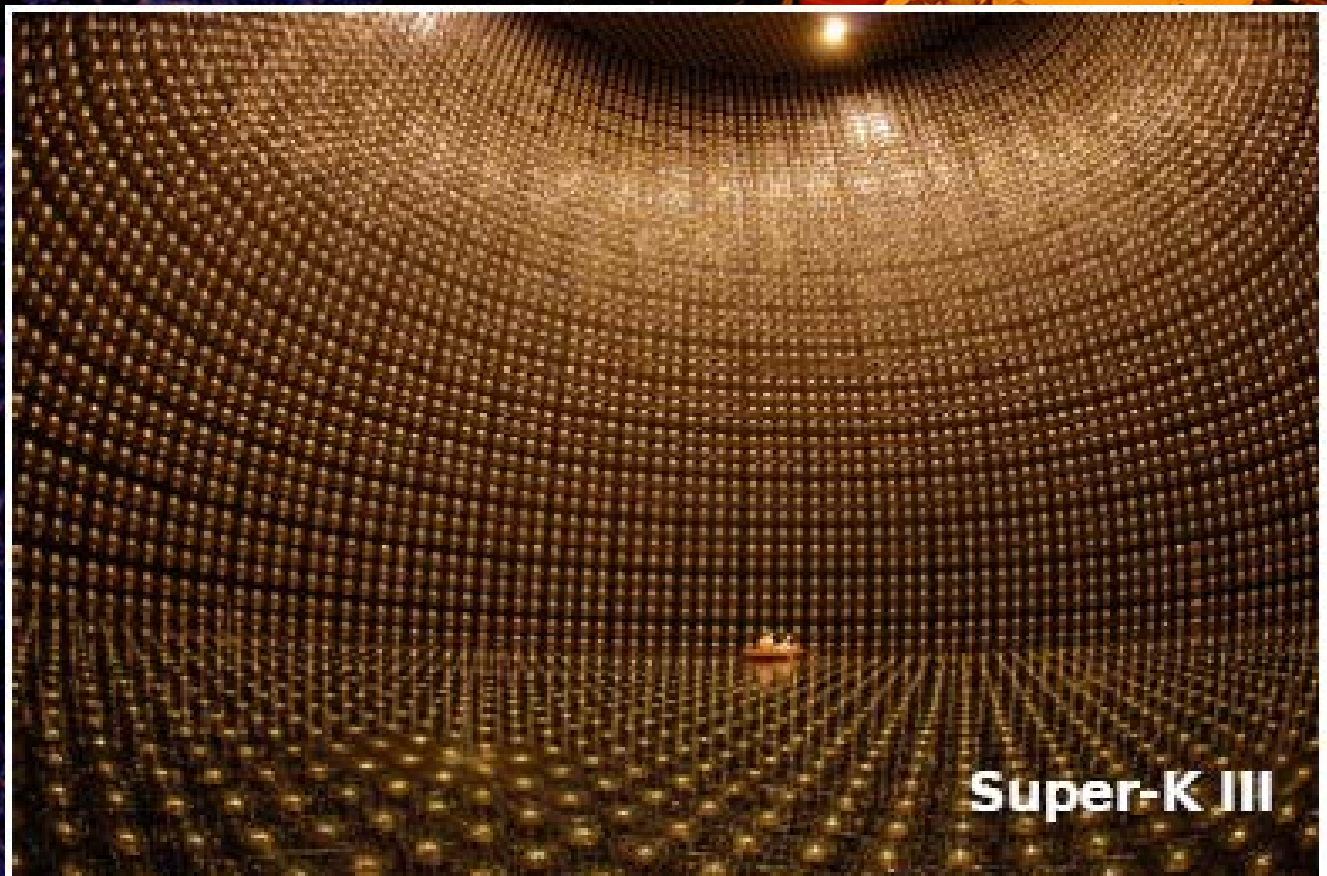
J-PARC PAC
KEK
January 8, 2008

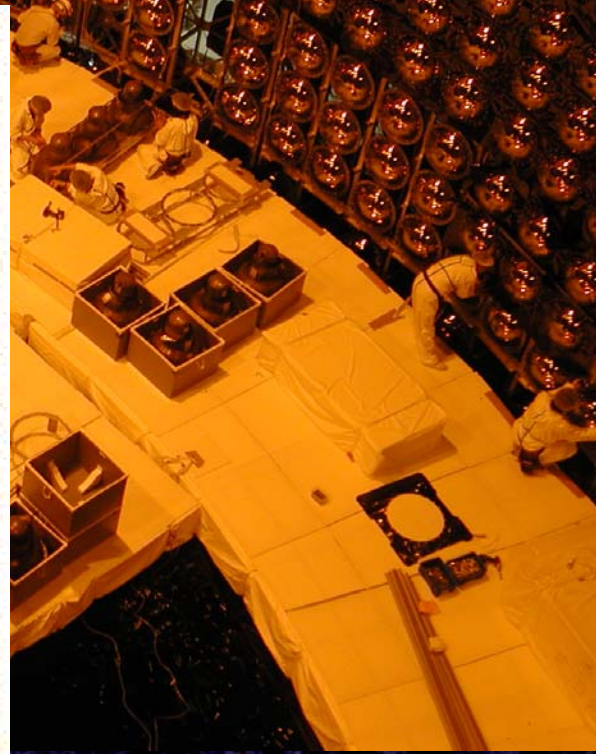
Dave Wark
Imperial/RAL




E133°
E135°
E137°
E139°
E141°
N35°
N37°
Kobe
Osaka
Kyoto
Kanazawa
Kanazawa
Tsu
Nagoya
Gifu
Gifu
Super-K
Nagano
Japan
Sado
Kofu
Niigata
Maebashi
Saitama
Honshu
Tokyo
Tokyo
Mito
J-PARC
Fukushi
UA1 Magnet Yoke
Fine-Grain TPCs Detectors
P0D (π0-detector)
Downstream ECAL
Solenoid Coil
P0D ECAL
Barrel ECAL
© 2007 ZENRIN
Pointer 36° 23'41.59" N 139° 11'54.71" E elev 665 m
Streaming
100%

Super Kamiokande Rebuilt





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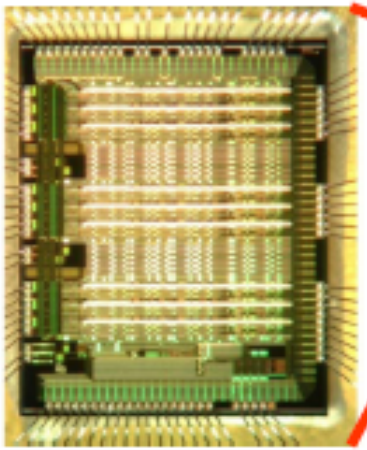
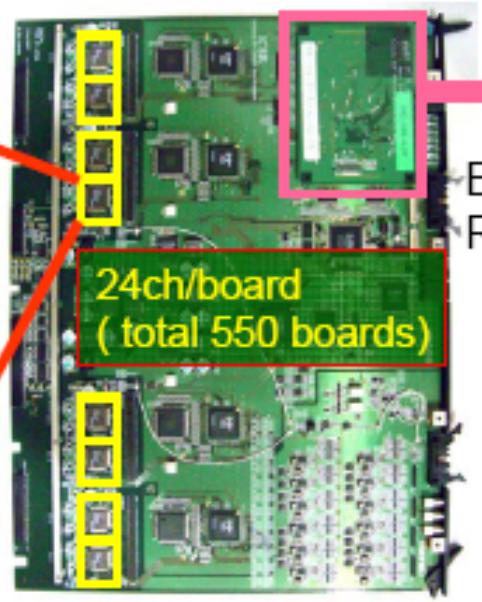
New electronics and DAQ system for the SK detector





Ethernet Readout

Front End computers

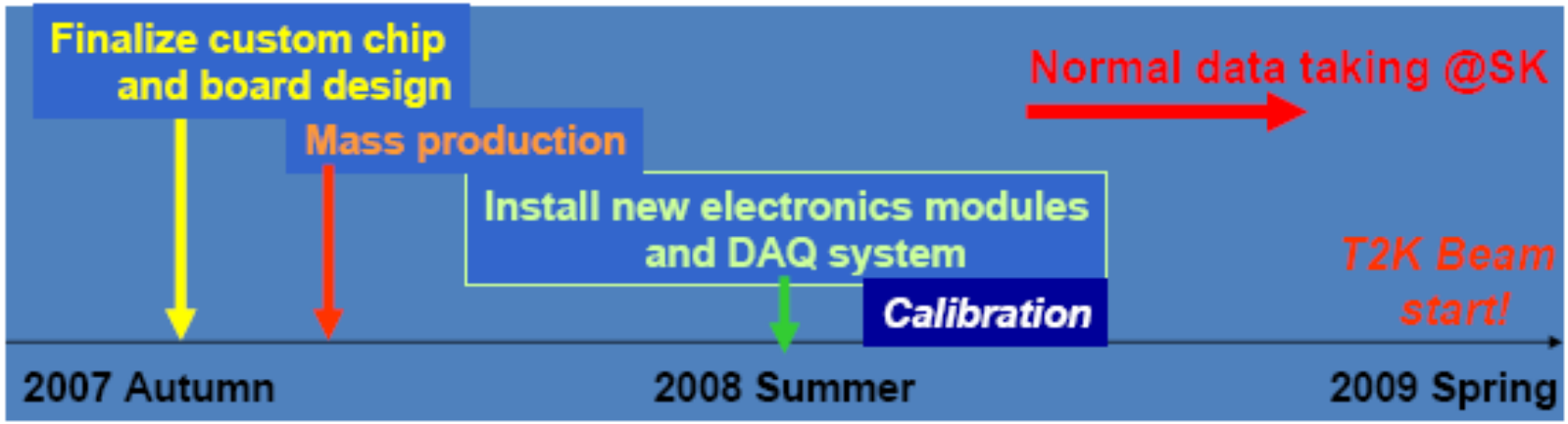
~850MB/sec

Software Trigger farm

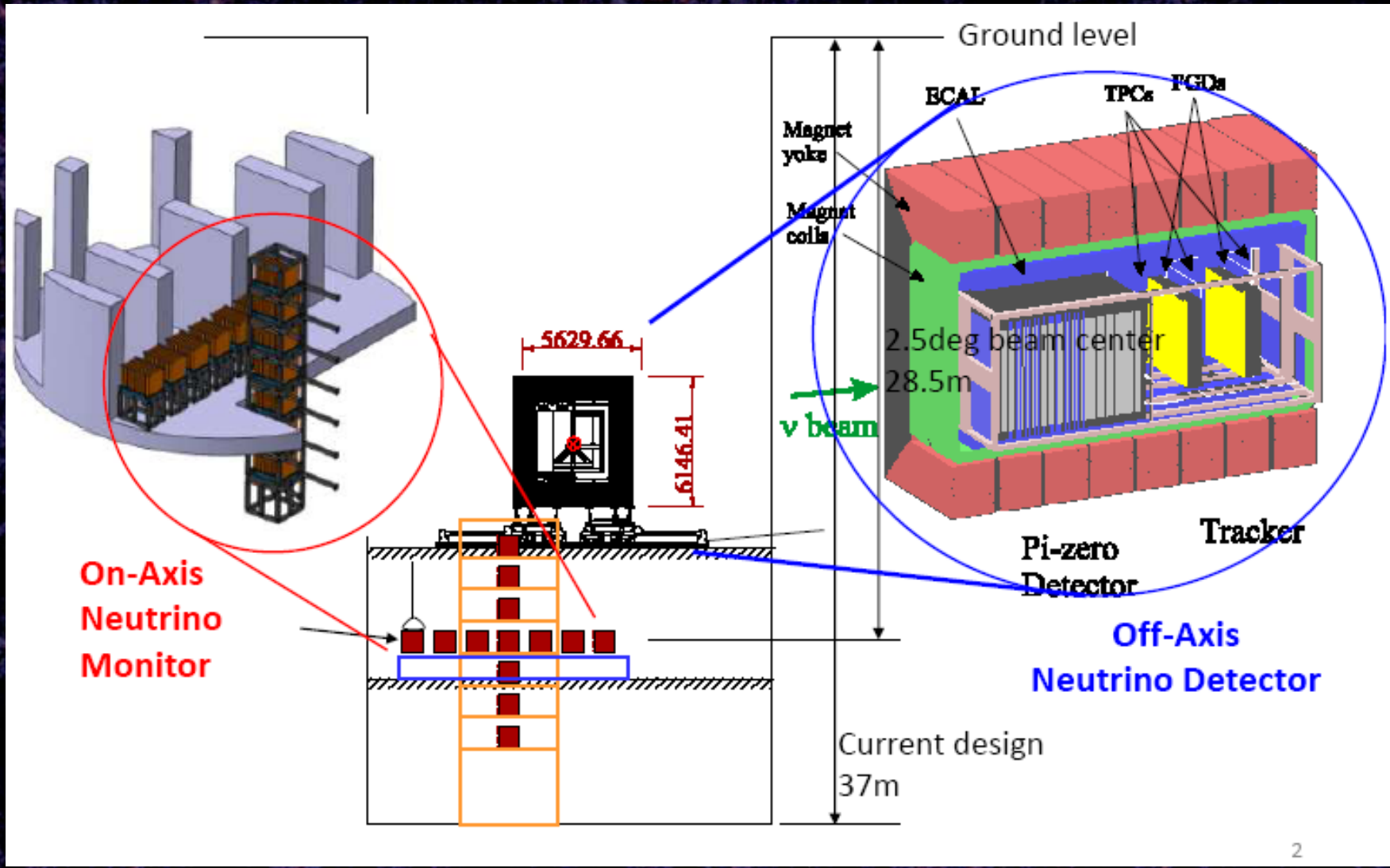
50~100MB/sec

Offline / Storage

Preparation of the new system is on schedule!

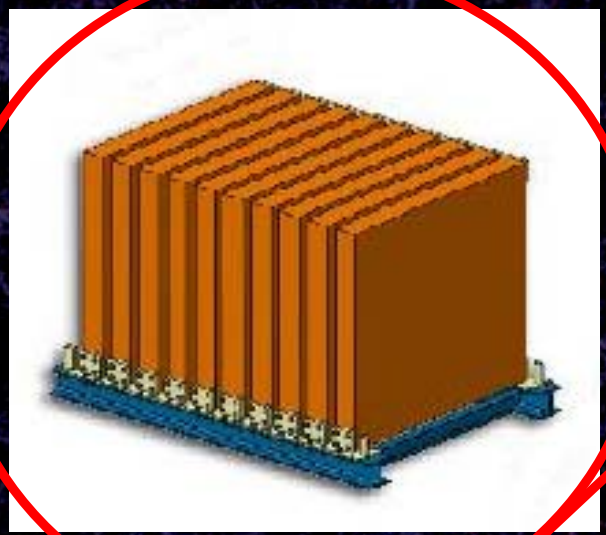


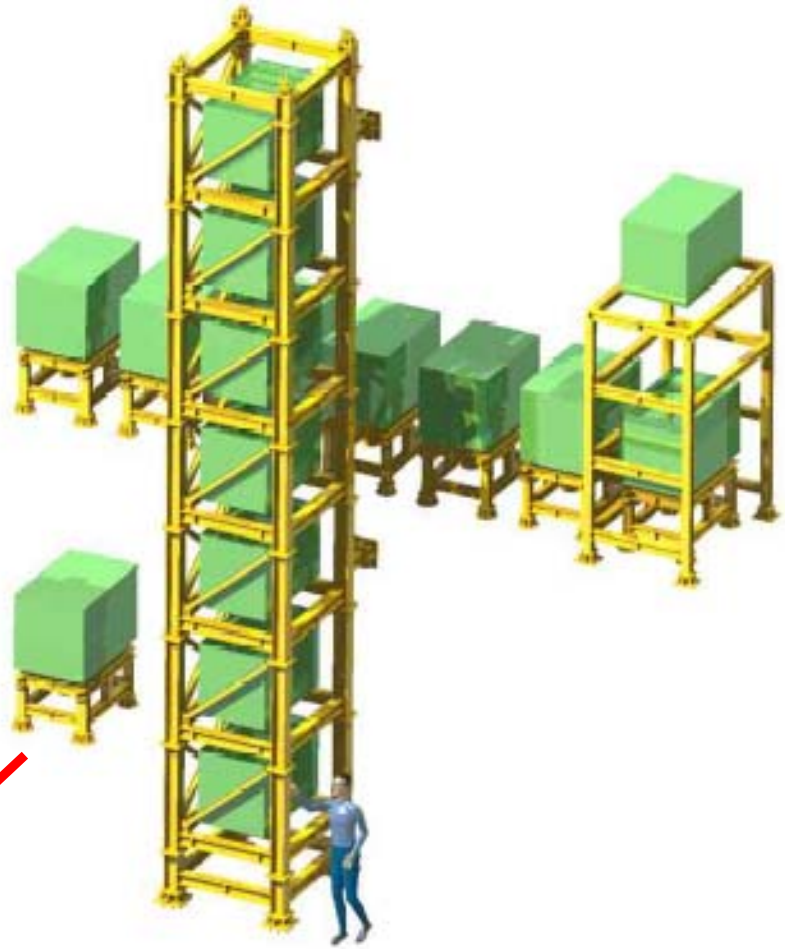
280m Near Detectors



Progress on 280m Hall

INGRID On-Axis Detector





- Japan/France/UK effort
- Must be operating April 1, 2009 for first beam.

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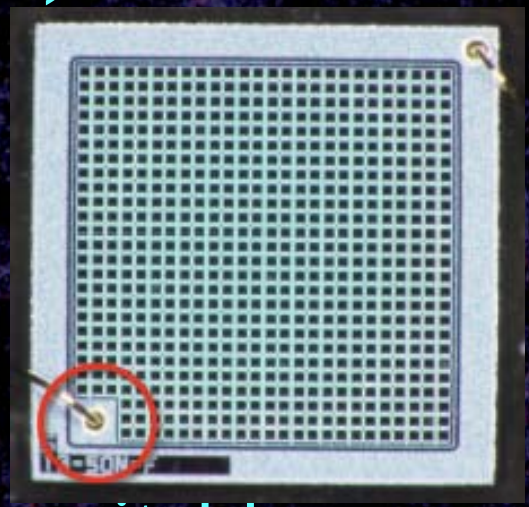
MPPC (aka SiPMs) Status



- 280m detectors require readout of ~10^5 fibers in a 0.2T magnetic field.
- Conventional photodetectors were unsuitable, so we decided to use SiPMs (or MPPCs) despite lack of commercial availability when adopted.
- Hamamatsu have now produced a version with agreed T2K specifications, will deliver 5k/month starting in early 2008 at 1,900 ¥ (plus 5% tax) when purchased within Japan.

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MPPC Stability Test

- 20 MPPCs (400 pixs, 1.1mm^2) underwent 31-day heating test at 80°C, U_{BIAS}=71.6 V: **ALL SURVIVED**
- No visible changes on the surfaces (microscope)
- **Gain** is stable within 2-3%
- **Signal** (sensitivity to light) is stable within 4-5% for "heated" MPPCs, *but it looks like there is a tendency to decreasing* (if to compare with the reference "not heated" MPPCs)
- **Cross-talk** is stable within 10% (for both "heated" and "not heated" groups), probably better for "heated"

6 December, 2007 M Khabibullin Heating test results of 20 MPPCs at INR 11

Aging test at LSU (3 sensors, 80° for 120 days, no sign of changes in gain or dark rate at few % level

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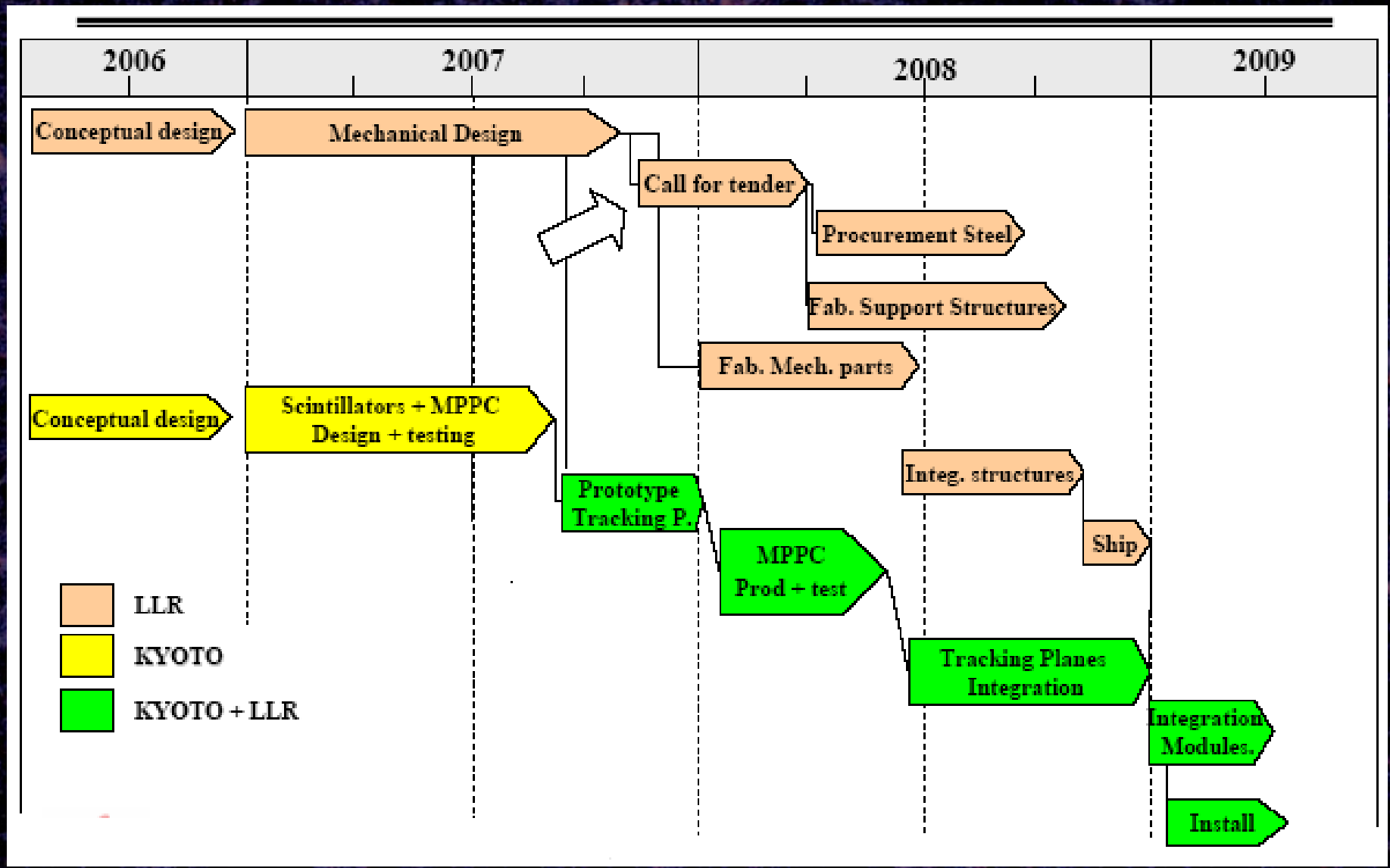
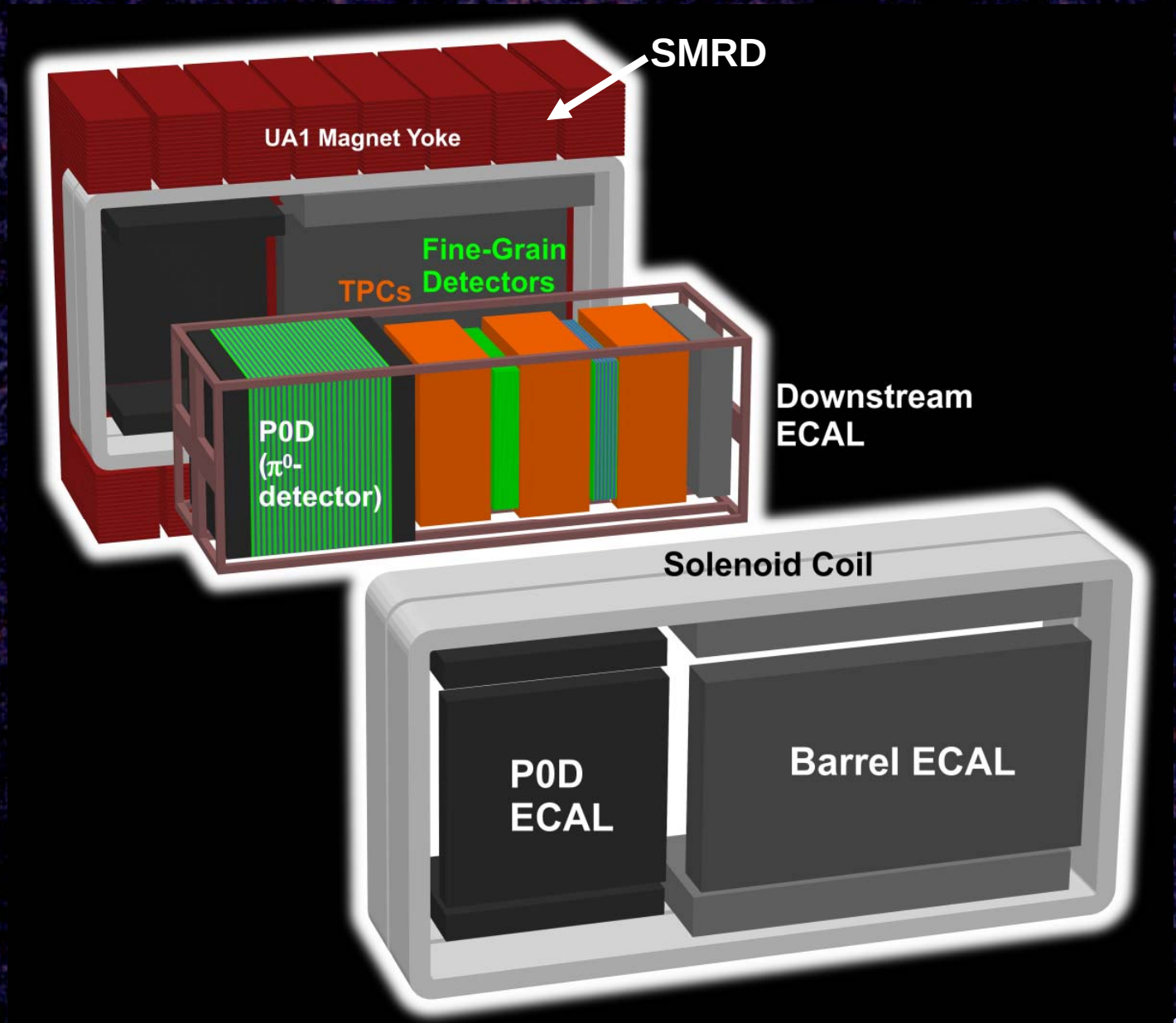
INGRID Schedule

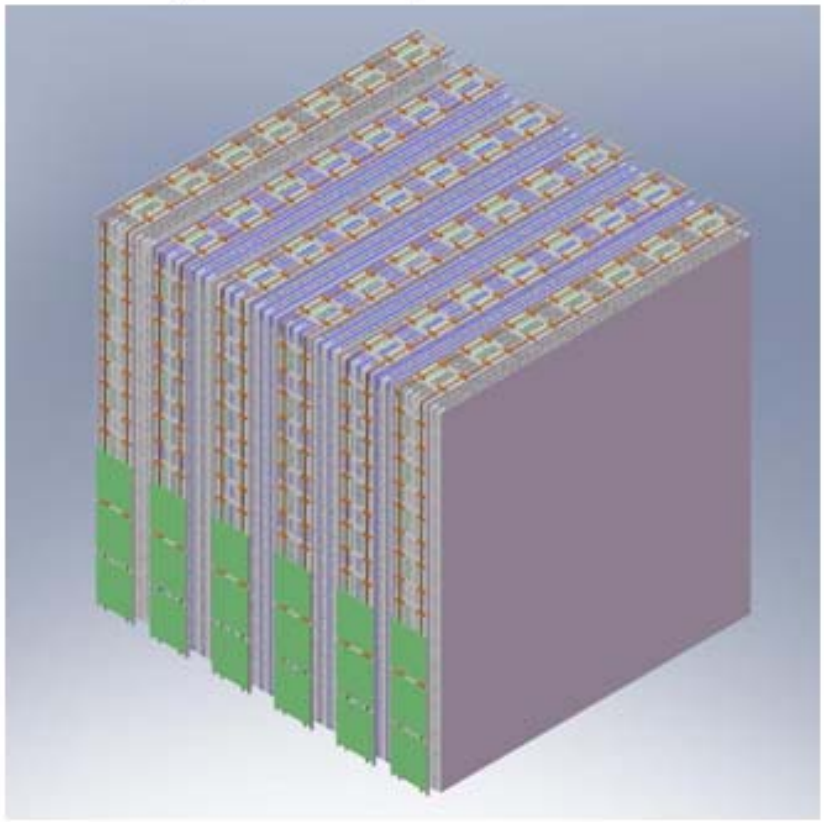


280m Off-Axis Detector



The PØD Design

A Thing of Beauty…(D. Warner)

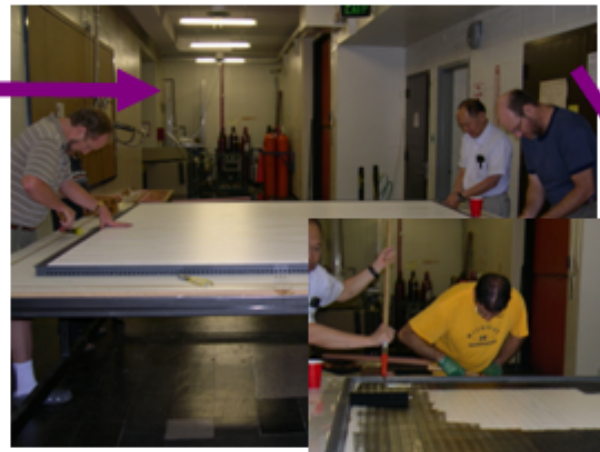


Solidworks design assembly

- 3 Super-PØDules
  - Upstream ECAL (3200 kg)
    - 7 PØDules
    - 7 4mm-thick lead radiators
  - Target (11000 kg)
    - 2857.3 kg water
    - 26 PØDules
    - 25 1.6mm brass radiators
    - 25 Water target layers
    - Split into 2 sub-units for pre-installation handling
  - Central ECAL (3200 kg)
    - 7 PØDules
    - 7 4mm-thick lead radiators
- Total Mass is 17600 kg

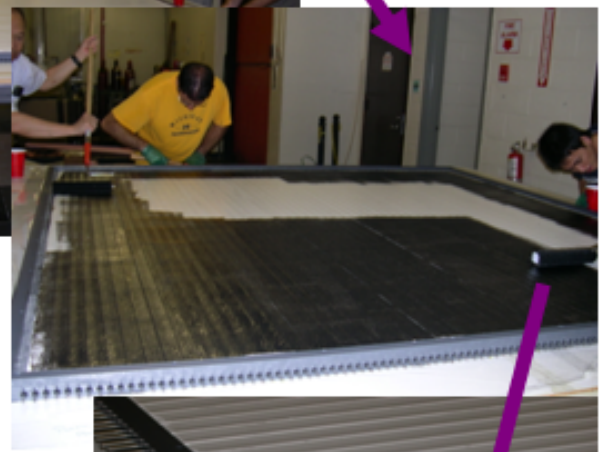
PØDule Prototype

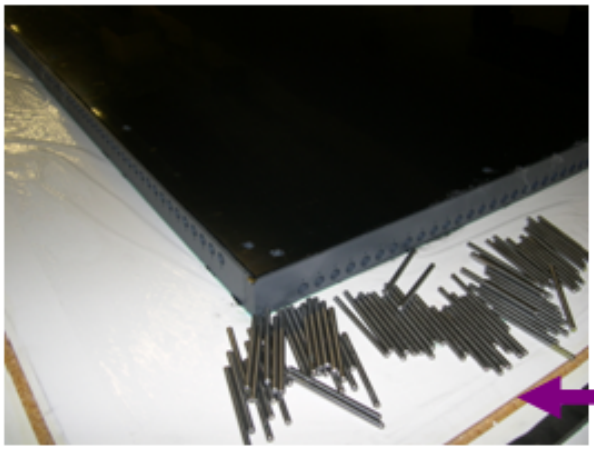
Assembly Table



Dry Assembly

Gluing





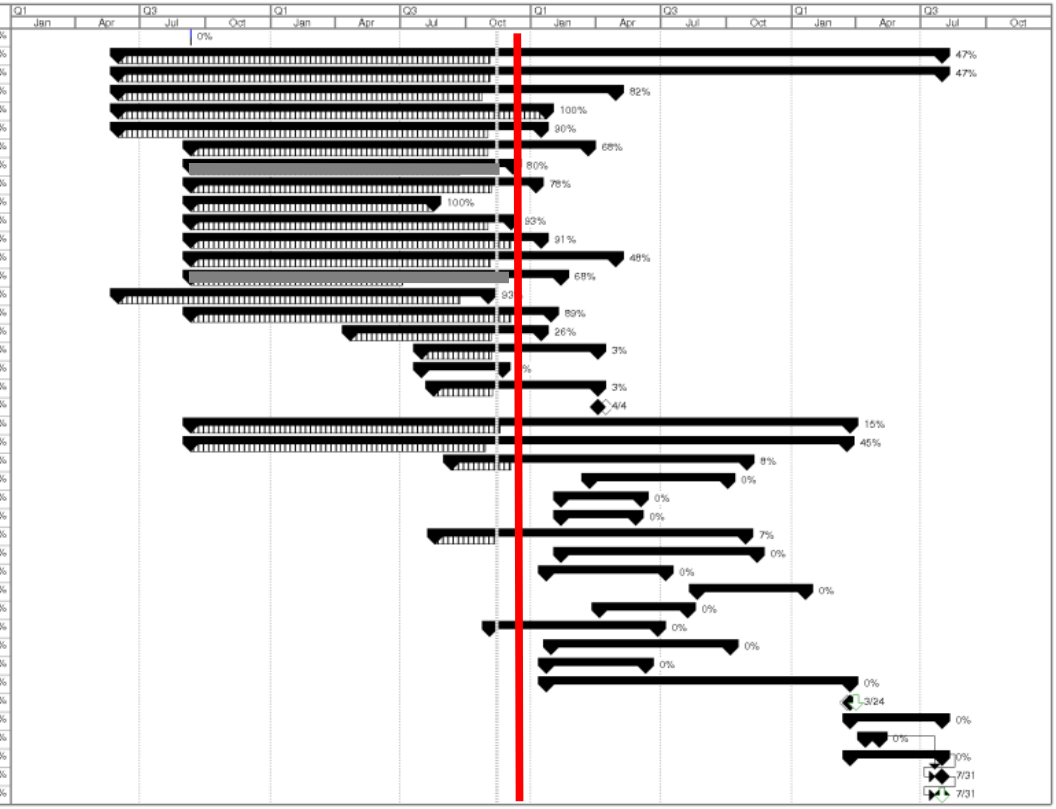
Glued PØDule
next step, insert fibers

Sept 28, 2007 *POD Status -- McGrew* *5*

Measurements of light yield exceed specification

P0D Schedule

ID	WBS	Task Name	% Complete
1	1	Beam Line	0%
2	2	US-B280 Near Detector (ND-280)	47%
3	2.1	Pi-Zero Detector (P0D)	47%
4	2.1.1	P0D Prototype, Design and Development	82%
5	2.1.1.1	Initial P0D Design	100%
16	2.1.1.2	P0Dule Prototypes	90%
114	2.1.1.3	Water Target Prototypes	68%
131	2.1.1.4	Electronics Mounting and Cooling Prototypes	80%
149	2.1.1.5	Light Injection (Optical Calibration) System Prototypes	78%
177	2.1.1.6	Prototype Photosensor Testing	100%
191	2.1.1.7	Super-P0Dule Assembly Plan	93%
198	2.1.1.8	P0D Mounting and Installation	91%
205	2.1.1.9	P0D Production, QC, and QA Planning	48%
223	2.1.1.10	Slow Control Electronics	68%
233	2.1.1.11	P0D Utilities in ND-280 Design and Testing	93%
251	2.1.1.12	P0D Front-End Electronics Design and Prototypes	89%
259	2.1.1.13	Radiator Design and Prototypes	26%
269	2.1.2	Testing & Pre-Production Reviews	3%
270	2.1.2.1	Mechanical Design and Production Review	0%
278	2.1.2.2	Prototyping Results	3%
303	2.1.2.3	Testing & Pre-Production Reviews Complete	0%
304	2.1.3	Production	15%
305	2.1.3.1	Project Engineering	45%
310	2.1.3.2	P0Dule Production	8%
435	2.1.3.3	Water Target Production	0%
443	2.1.3.4	Electronics Mounting and Cooling	0%
465	2.1.3.5	Light Injection System	0%
473	2.1.3.6	Photosensors	7%
489	2.1.3.7	Super-P0Dule Assembly	0%
495	2.1.3.8	Super-P0Dule Mounting and Installation Hardware	0%
506	2.1.3.9	P0D Integration and Checkout	0%
534	2.1.3.10	Slow Control Monitoring and Electronics	0%
543	2.1.3.11	P0D Utilities	0%
565	2.1.3.12	Front-End Electronics	0%
574	2.1.3.13	P0D ECal Radiator	0%
582	2.1.3.14	Shipping to Japan	0%
586	2.1.3.15	Production Complete	0%
587	2.1.4	Installation	0%
588	2.1.4.1	P0D Utility Installation	0%
605	2.1.4.2	P0D Detector Installation	0%
617	2.1.4.3	P0D Installation Complete	0%
618	2.1.5	Pi-Zero Detector (P0D) Complete	0%

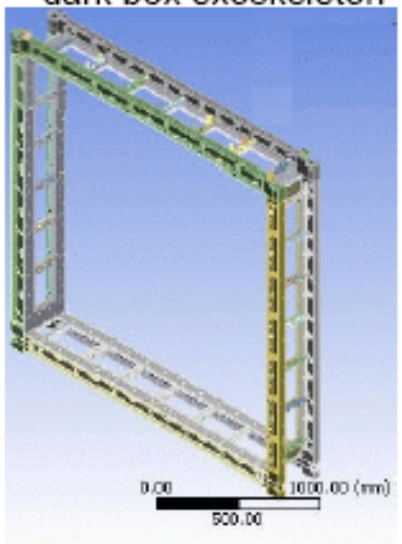


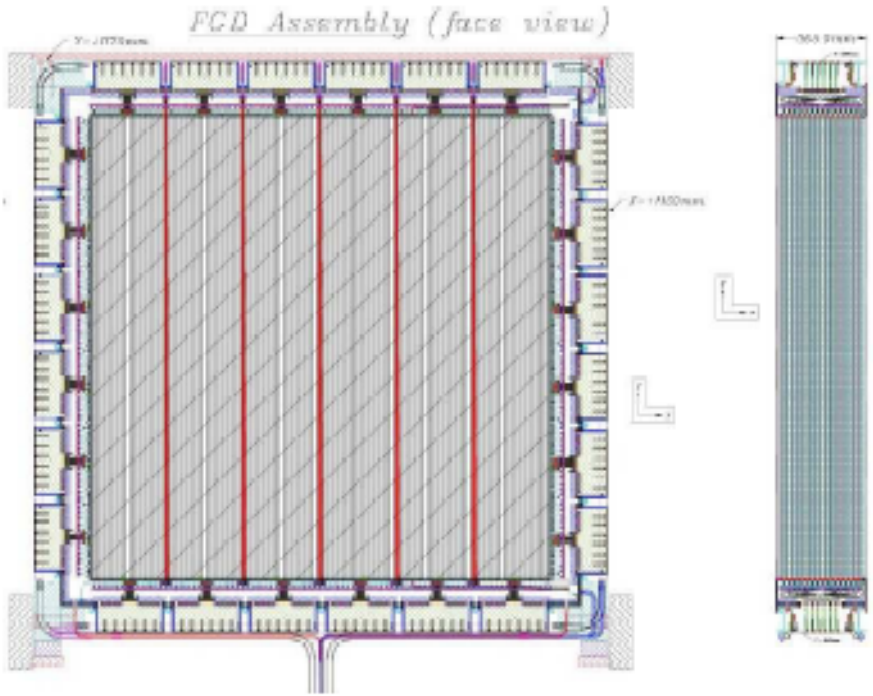
Dave Wark
Imperial College/RAL

FGD Progress

Dark Box/Mechanical Design

dark box exoskeleton





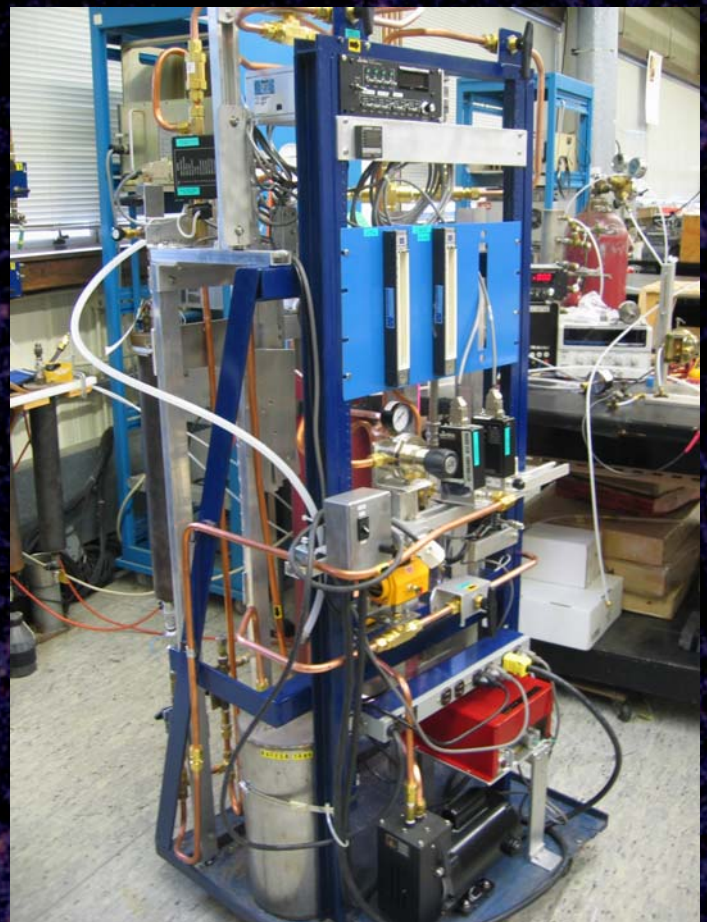
ANSYS calculations complete. TRIUMF design review in April 2007. First dark box now under construction.

FGD Progress

XY Module Construction

- Each module consists of an X layer, a Y layer and two G10 skins.
- Considerable R/D was done for module gluing procedure.
- Metal jig was constructed to ensure that X and Y layers were aligned and perpendicular.
- currently 20 of 24 modules glued

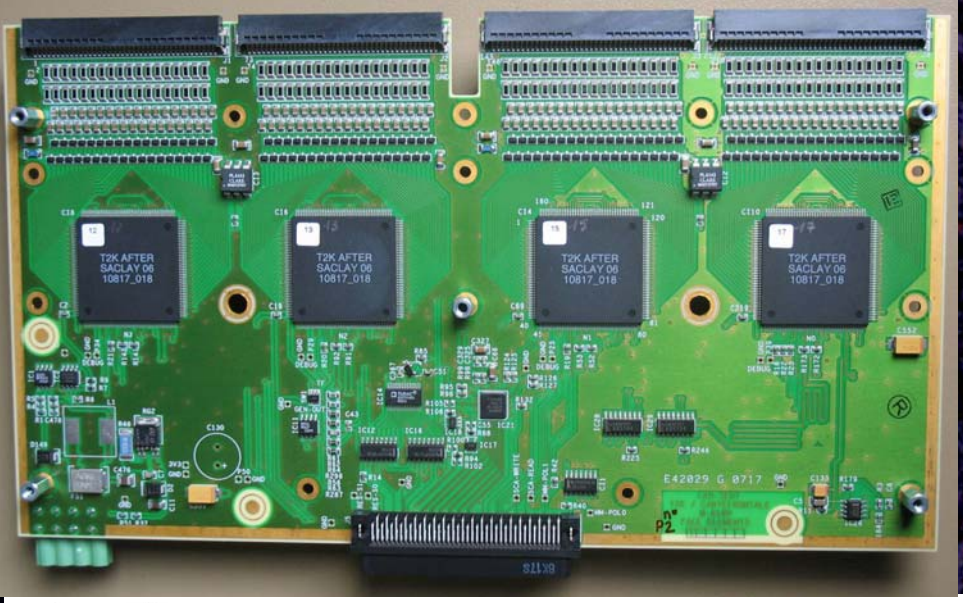
TPC Progress

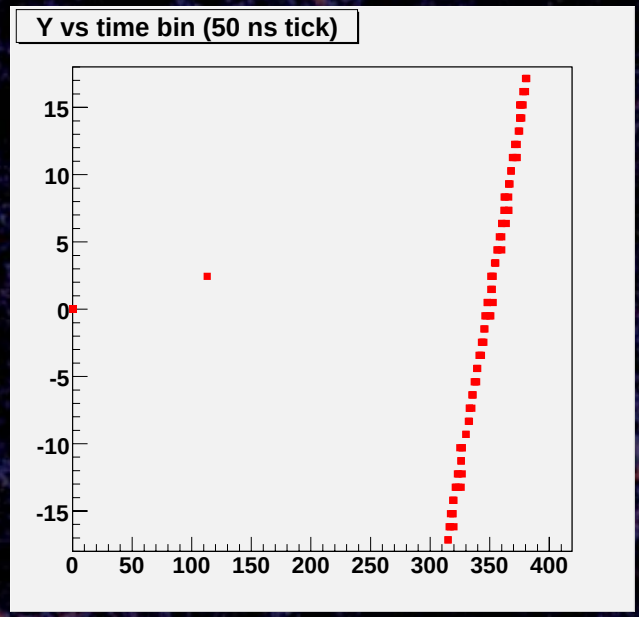


ALUMINUM OUTER STRUCTURE

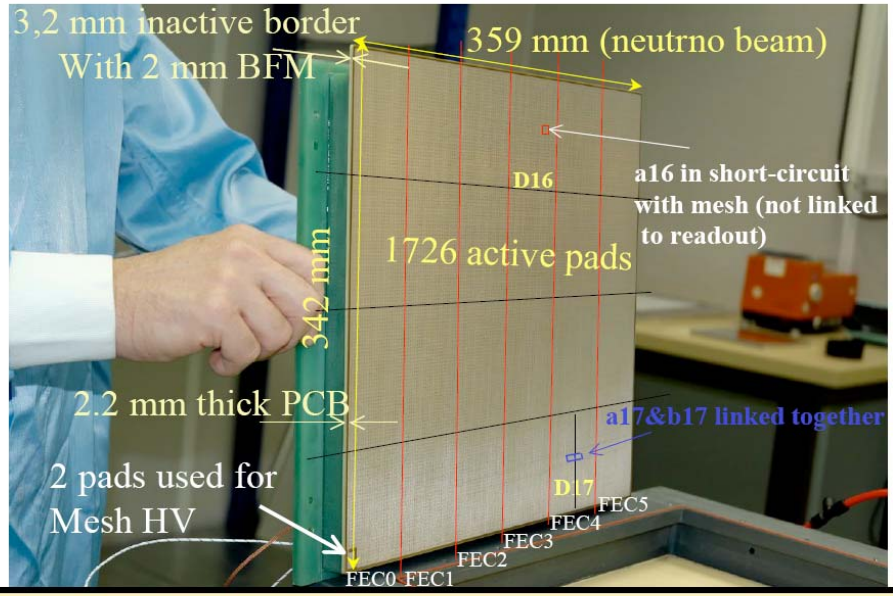
ELECTRONICS COVER

TPC Progress

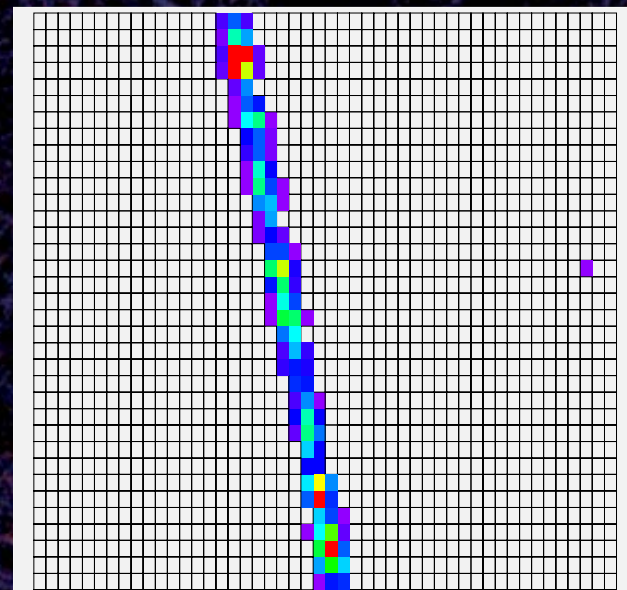




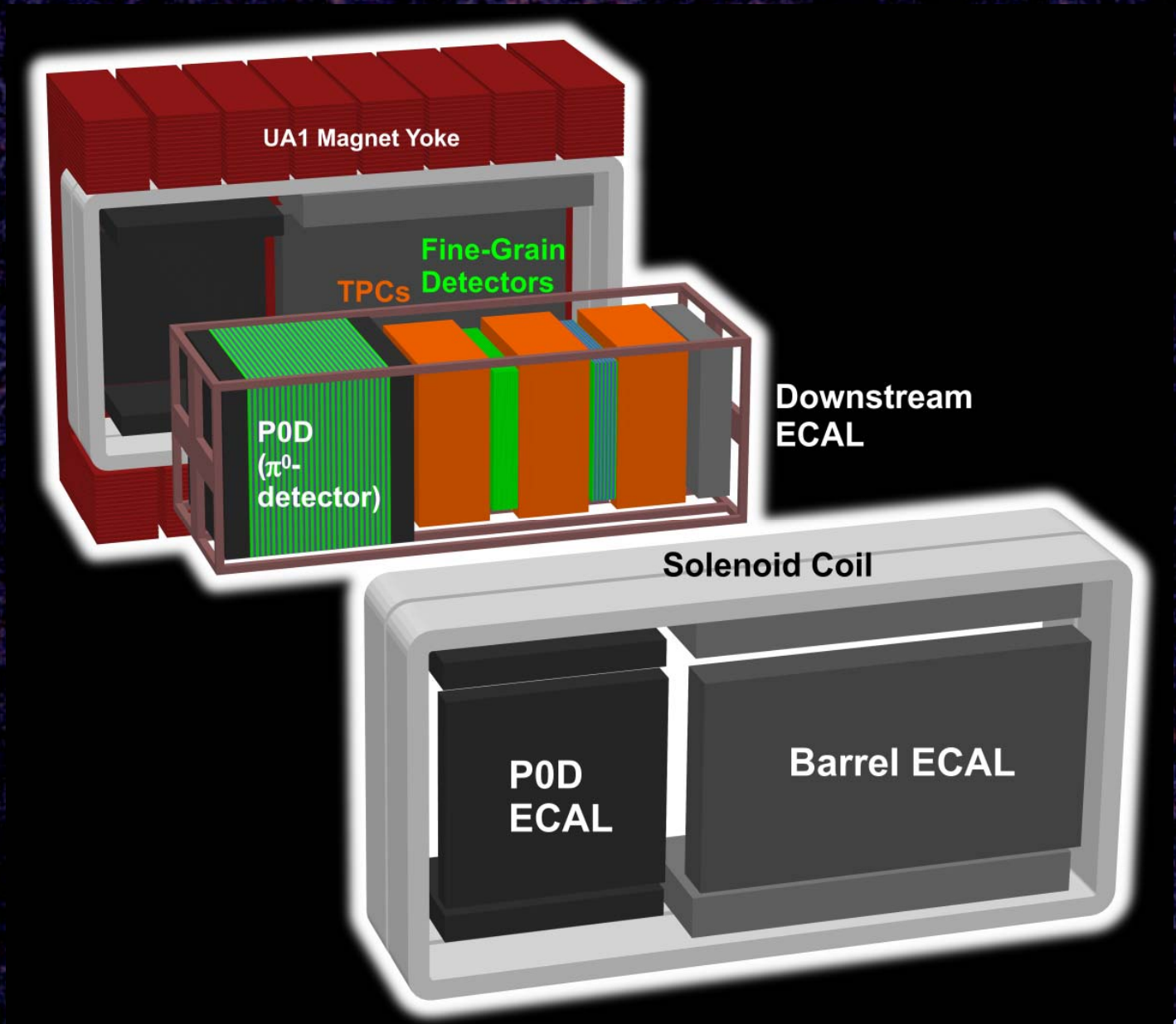
MM1_001 (stiffener V2) (HARp tests 09/19/2007)



- a 30 μm thick 440 Lpi woven micromesh is embedded between 2 layers of pyralux
- 4 layers PCB with internal shielding layer & 6,9x9,7 mm pads with 7x9,8 mm pitch
- 128 μm amp. gap / 12 x ϕ0,5 mm pillars per pad / « stretched » mesh procedure
- 93% of PCB surface is active area / less than 2 faulty pads per module

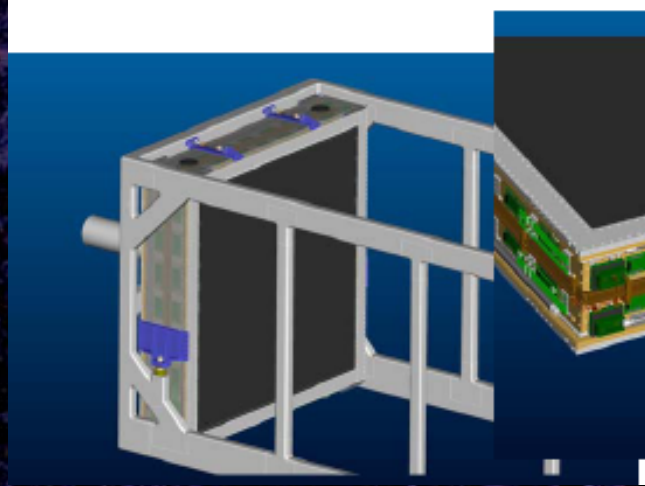


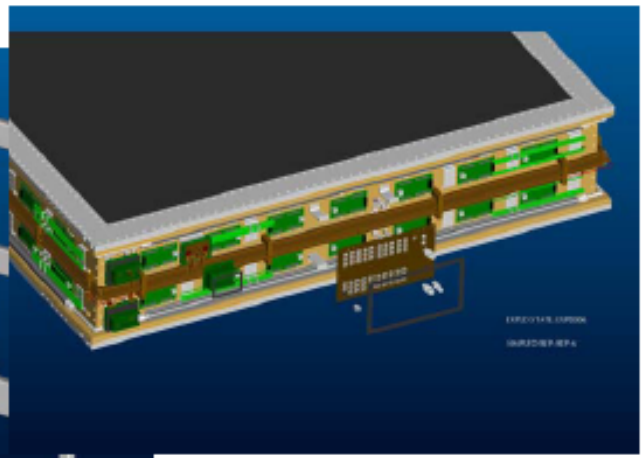
ECAL Progress

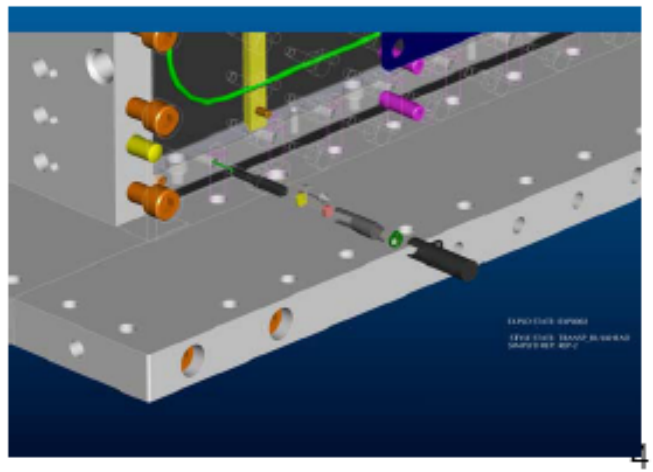


ECAL Progress

- DS ECAL module is now fully specified and designed
- Detailed drawings for components orders are done
- Final Design Review: 12 July @ Daresbury
  - Thanks to C. Hearty, W. Toki, R. Langstaff, D. Warner
- Barrel ECAL modules use same design up to dimensions and fixing points (to the magnet)

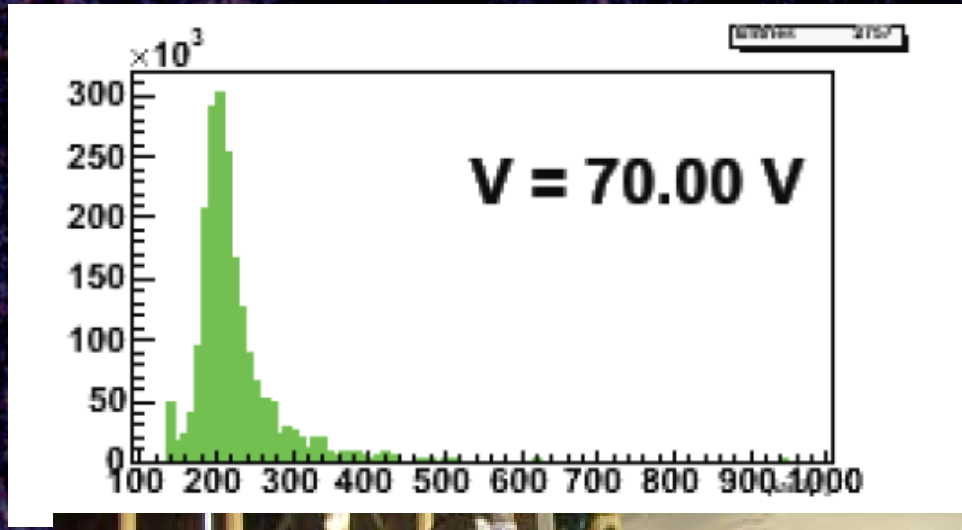


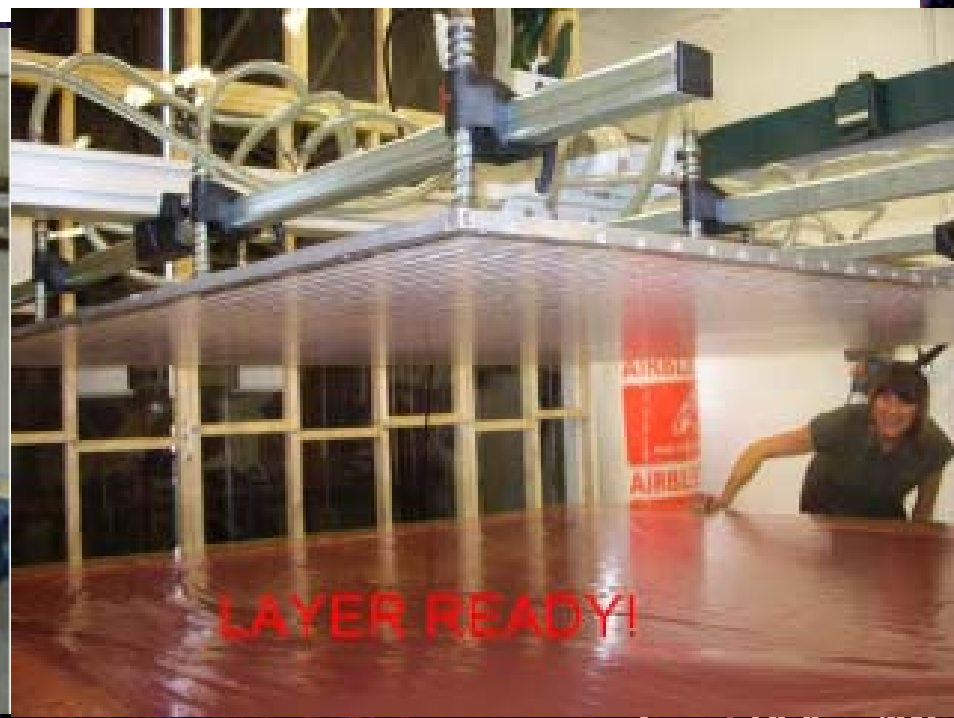




Dave Wark
Imperial College/RAL

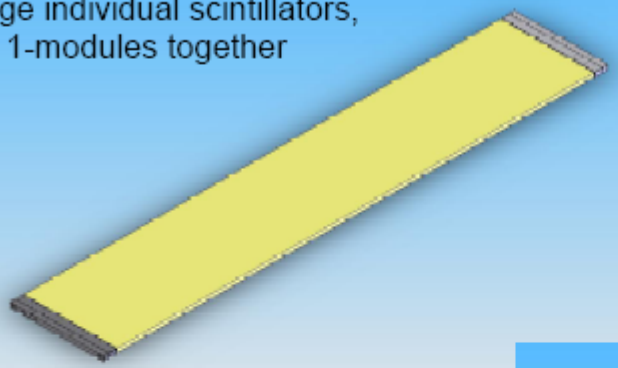
ECAL Progress





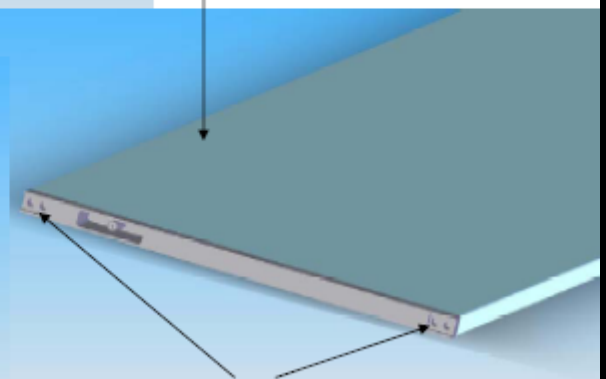
SMRD Progress

Modification:
Package individual scintillators,
attach 1-modules together

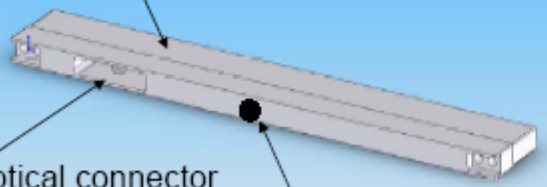


~ 2000 scintillator slabs

250μm stainless steel sheet



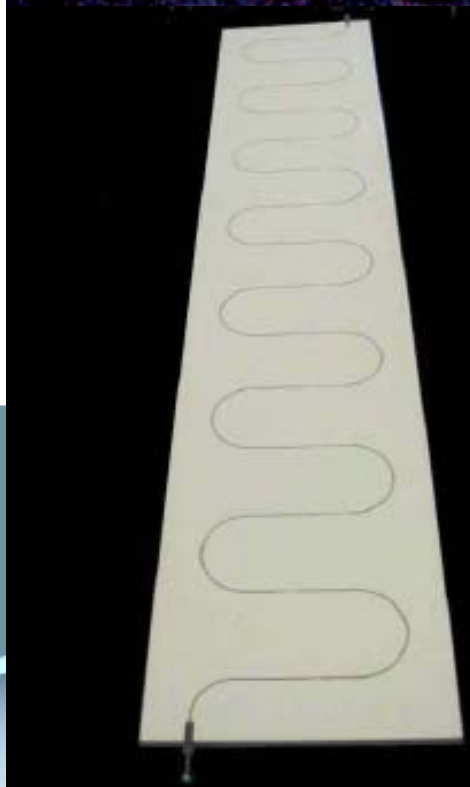
Recess to attach stainless steel tube



Optical connector

Cavity for temperature sensor

widget to attach
modules together



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SMRD production status

- first batch of ~1000 scintillators has been extruded
- first (relative) light yield measurements indicate good quality (as expected)
- S-groove has been machined for large fraction of first batch of scintillators
- WLS fiber segments have been tested (and QA continues)
- first batch of ~1000 endcaps have been produced

- next step:
- Assembly of modules (scintillator, WLS fiber, endcap, stainless steel enclosure) is ready to start now
- Slippages within contingency, delivery of modules by summer 2008 still on schedule

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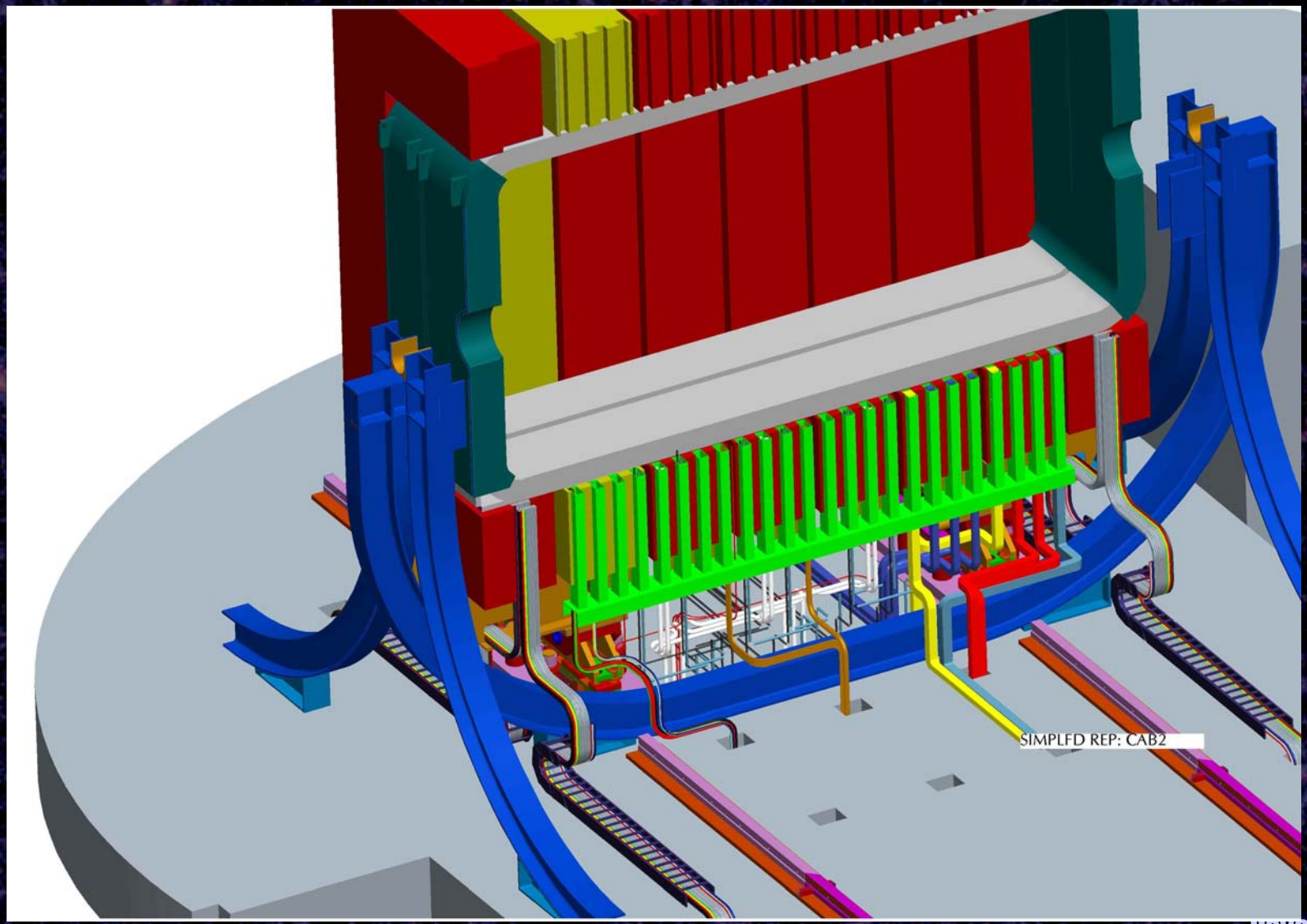
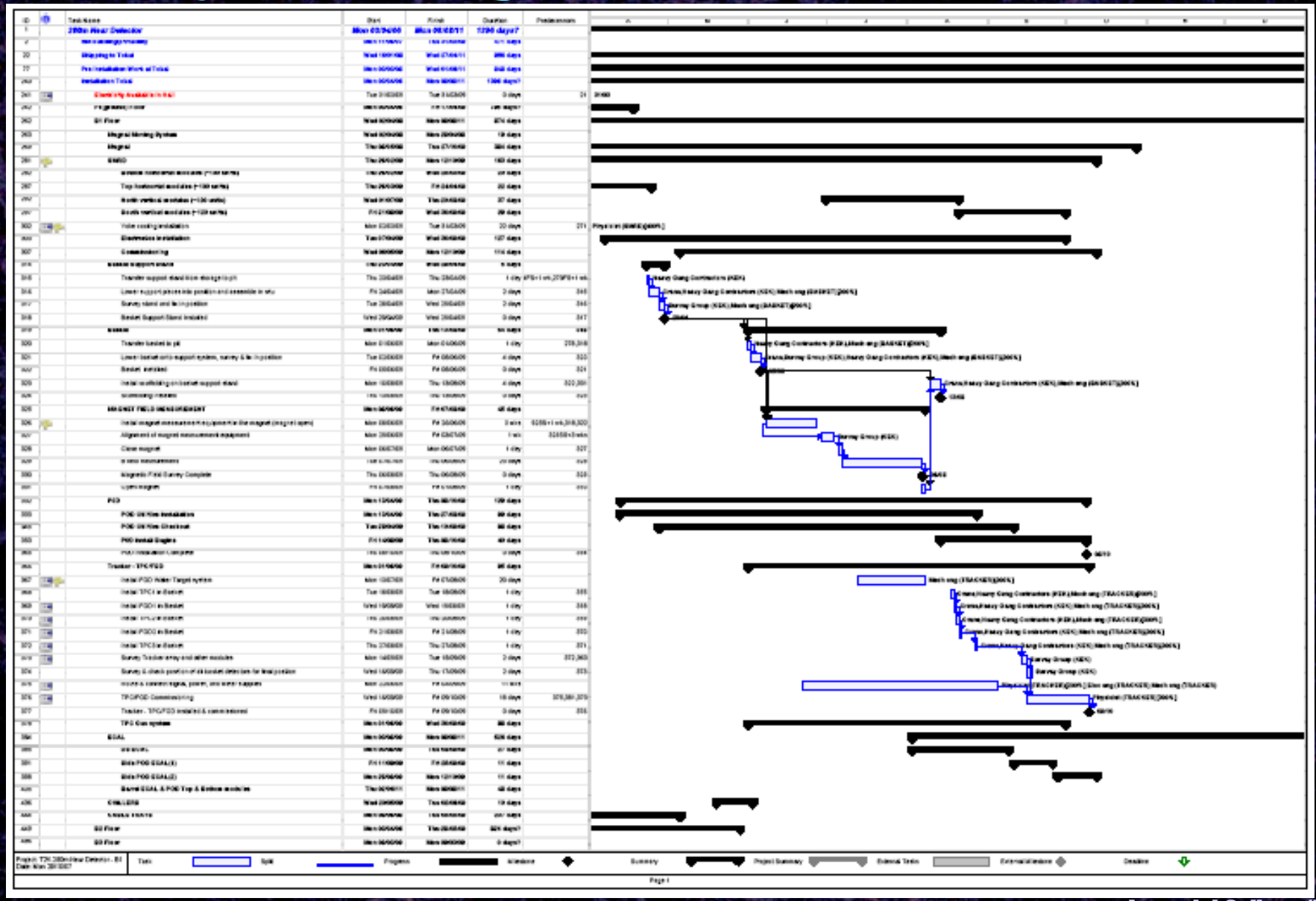
Project Integration and Schedule



Project Integration and Schedule



Overall Technical Situation

- All sub-detectors progressing, some delays here and there:
  - MPPC delivery has slipped a month,
  - TPC boxes taking longer than expected to manufacture
  - Prototype FGD water layers showing some cracking, changing the glue seems to have fixed it, no delay anticipated.
  - Some delays in BE electronics firmware
- Overall the progress is on track for on-time installation with two exceptions
  - Barrel ECAL will not be available for first run.
  - If TPC box production cannot be sped up we may not have the furthest upstream TPC in time for first run.
- Major technical risks are being retired and milestones reached.
- The installation and commissioning schedule for the 280m detectors is aggressive, in particular for the magnet/SMRD, but large amounts of effort are going into planning and no show-stoppers are known.

Contributions and Funding by Country

- Canada
  - Contributions:
    - All the FGD except photosensors
    - TPC mechanical and field cage, integration, gas system
    - Slow Controls and Monitoring
    - Cont. to Beamline: OTR Monitor, Remote handling for hot cell, beam position/profile monitors and vessel
    - nd280m offline software
  - Funding situation: secured with yearly review
- France
  - Contributions:
    - INGRID detector (LLR)
    - TPC Micromegas and FE electronics (Dapnia)
    - TPC BE electronics (LPNHE)
    - Beamline quench detection system
    - Power supply for the UA1 magnet
  - Funding situation: secured.

Contributions and Funding by Country

- Germany
  - Contributions:
    - UA1 Magnet moving system
    - TPC gas monitoring
  - Funding situation: request submitted, decision on Jan. 10
- Italy
  - Contributions:
    - UA1 Magnet preparation
    - TPC calibration
  - Funding Situation: secured
- Japan
  - Contributions:
    - J-PARC
    - Most of SK, and the SK rebuild and upgrades
    - Most of the T2K beamline, target, and beam dump including beamline monitors and muon monitor
    - Infrastructure for the 280m facility
    - INGRID detector
    - FGD photosensors
    - SMRD FEE
    - Cont. to NA61
  - Funding situation: secured, with additional funding from MEXT in form of competitive grants.

Contributions and Funding by Country

- Poland
  - Contributions:
    - Cont. to SMRD
    - Cont. to NA61
    - nd280m offline software
  - Funding situation: secured
- Russia
  - Contributions:
    - Cont. to SMRD
  - Funding situation: secured
- South Korea
  - Contributions:
    - Beamline proton monitor electronics
  - Funding situation: secured
- Spain
  - Contributions:
    - TPC testing, calibration, and gas monitoring
    - Cont. to UA1 magnet
    - nd280m offline software
  - Funding situation: secured
- Switzerland
  - Contributions:
    - Cont. to TPC mechanics, testing, and assembly
    - Major contributions to NA61
    - Major Cont. to UA1 magnet
    - nd280m offline software
  - Funding situation: secured subject to annual review

Contributions and Funding by Country

- United Kingdom
  - Contributions:
    - BEE for ECAL/P0D /SMRD/INGRID
    - Cont. to beamline - beam window, baffle, and engineering for target and dump design, target remote handling
    - Basket/basket stand
    - ECAL (all)
    - FEE design for P0D/SMRD/INGRID
    - DAQ for 280m
    - Cont. to UA1 magnet
    - nd280m offline software
  - Funding situation: ~60% secured, funding for the Barrel and P0D ECALs deferred for decision this year – budget problems in the UK make this potentially problematic.
- United States
  - Contributions:
    - Cont. to SK, including upgrades, rebuild, and new SK electronics
    - P0D (all)
    - Beamline - SC corrector magnets, 2nd horn, monitor electronics and GPS
    - Cont. to SMRD (photosensors, cont. to scintillators, mechanical, slow control)
    - nd280m offline software
  - Funding situation: secured, helped by forward cash flow from institutions. (US budget contained large cut for HEP, however this was targeted on other programmes and we are hopeful that T2K will not be effected).

Dave Wark
Imperial College/RAL

Overall funding situation…

- Mostly good. The only major uncertainty for committed items is the UK funding for the ECAL, which hopefully we should find out soon.
- However, as you know, there is no overall cash reserve or contingency for the project.
- This produced a potential problem for items which are not clearly any one group's responsibility, in particular, the installation of the magnet and the detector cooling system.
- An additional major financial risk was the uncertainty in the costs of shipping and installing the magnet.

T2K IFOP

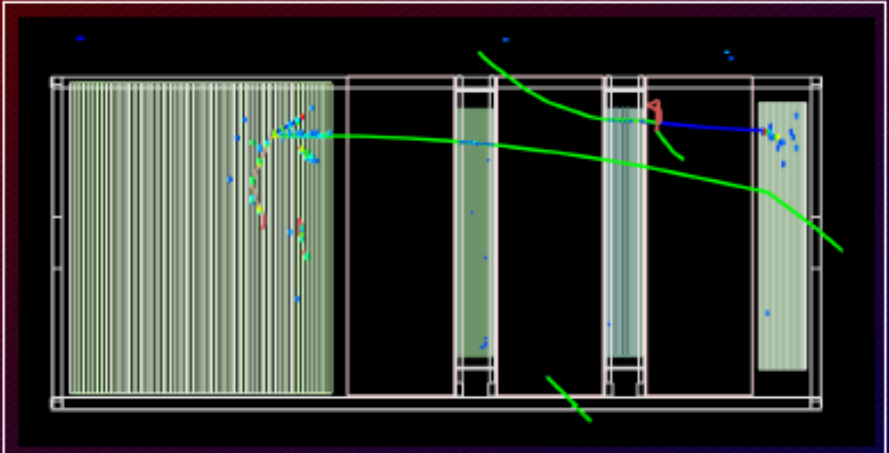
- The T2K IFOP has now been convened to allow discussion of common issues with and amongst the funding bodies.
- First meeting held Nov. 16th by telecon.
- Representatives from Japan, Canada, US, UK, France, and Switzerland.
- Agreed to T2K collaboration proposal for common costs to completion.
- Next meeting will be face-to-face at Tokai on February 26th.
- Bids now available for magnet shipment and installation, both within allowed financial envelope.

Dave Wark
Imperial College/RAL

ND280 Offline Software Status

- Software suite complete with set of packages for simulation-reconstruction-analysis chain
- Modular reconstruction and analysis frameworks, with fully object-oriented design
- Based on C++, Geant4, and ROOT
- Software framework stable, but algorithms undergoing rapid development – algorithm performance shown here is a **snapshot** of the current state!
- **"User Release"** imminent, with consistent user interface and documentation and user support mechanism

Simulation

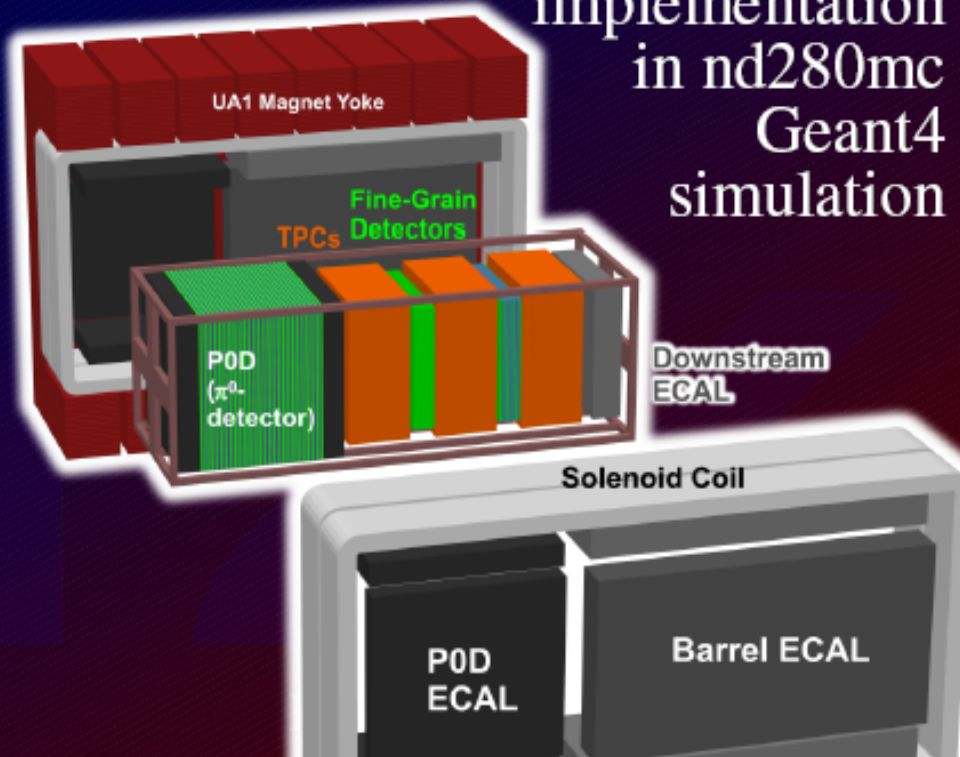


A CC1π interaction in the P0D, with full-bunch background

- Interfaces with all widely-used neutrino interaction generators
- Custom detector response (Scintillator detectors and TPC) and electronics (Trip-t and AFTER) simulations

- Geant4-based simulation
- Simulates full-spill interactions, and additional planted interactions for signal studies

Exploded view of ND280 Geometry implementation in nd280mc Geant4 simulation

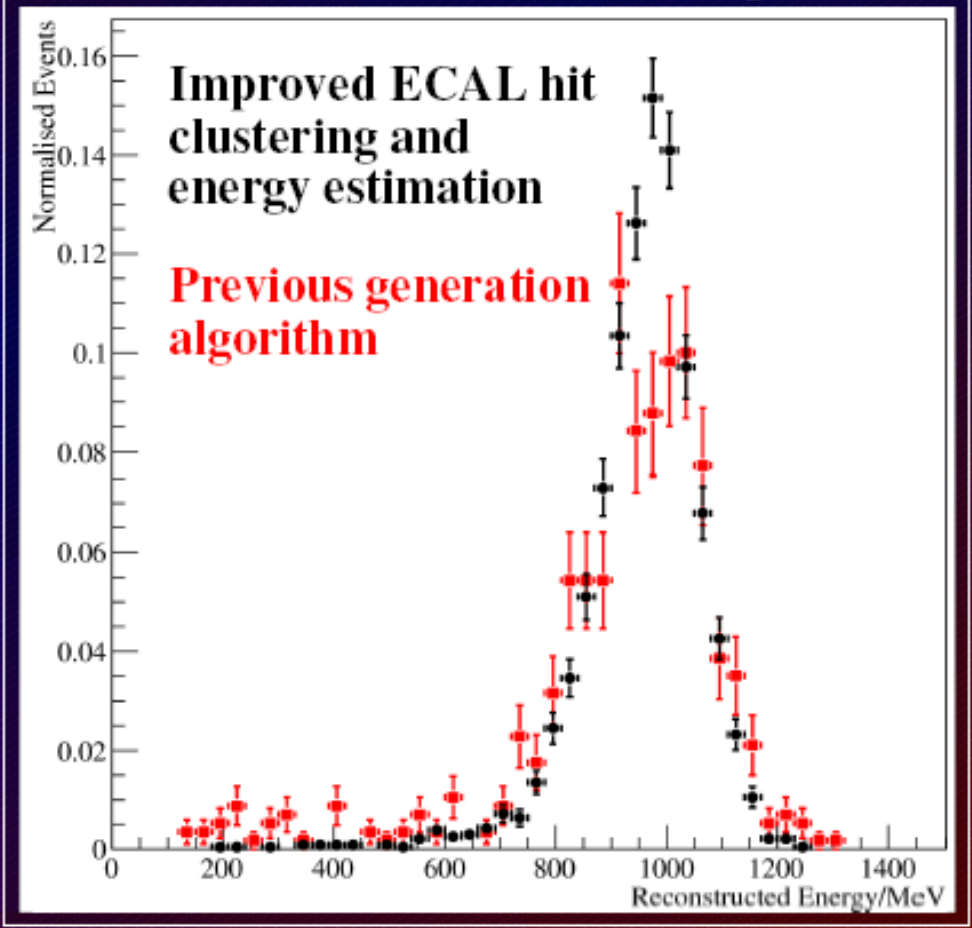


T2K ND280 Offline Software Group

Reconstruction

- P0D, TPC, FGD & ECAL have full "MC truth-free" reconstruction algorithms
- Many algorithms in 2nd and 3rd generation
- SMRD reconstruction being developed, dependent on inner subdetector progress
- Subdetector-level and cross-detector reconstruction assisted by an external event reconstruction toolkit (RecPack) and flexible reconstruction I/O classes

Response of ECAL Energy Estimator to 1 GeV photons



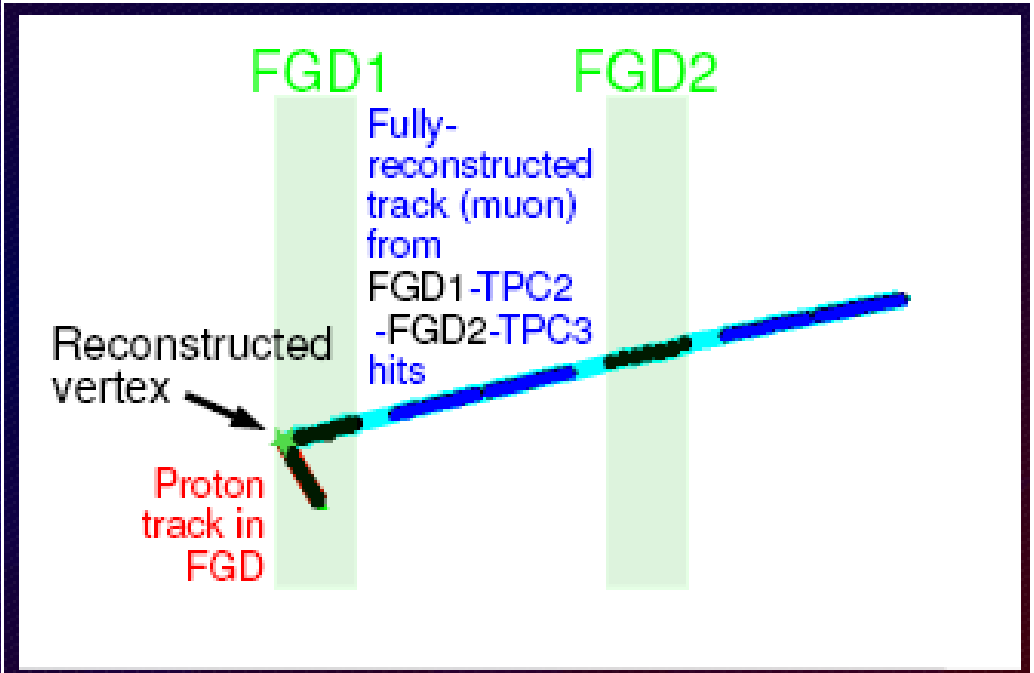
Tracker CCQE Selection

- Vertex in FGD fiducial volume
- A single negative TPC track
- No π^+ decay in FGD at vertex

- Iterative reconstruction between FGDs and TPCs with RecPack

Undergoing tuning:

- Barrel & Downstream ECAL π^0 reconstruction for CC1π^0 rejection
- TPC dE/dx PID
- Full-spill background rejection

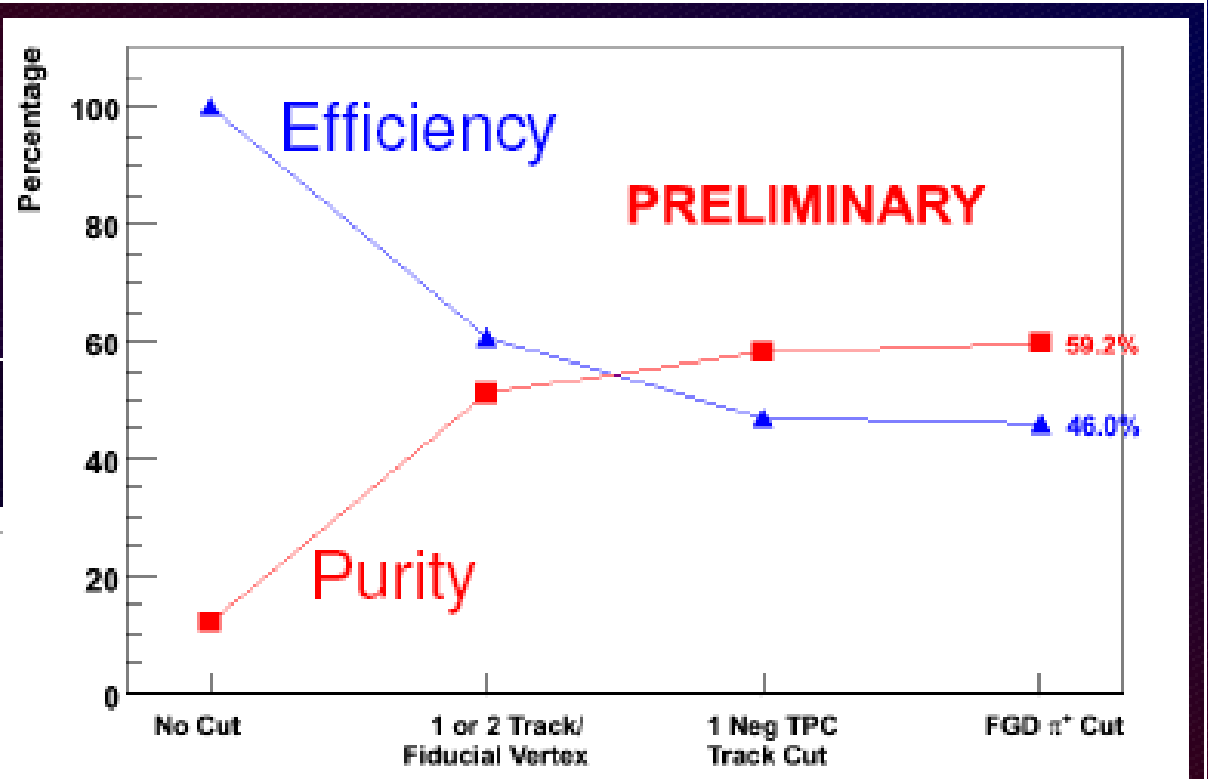


An example of a successfully reconstructed CCQE interaction

Tracker CCQE Selection

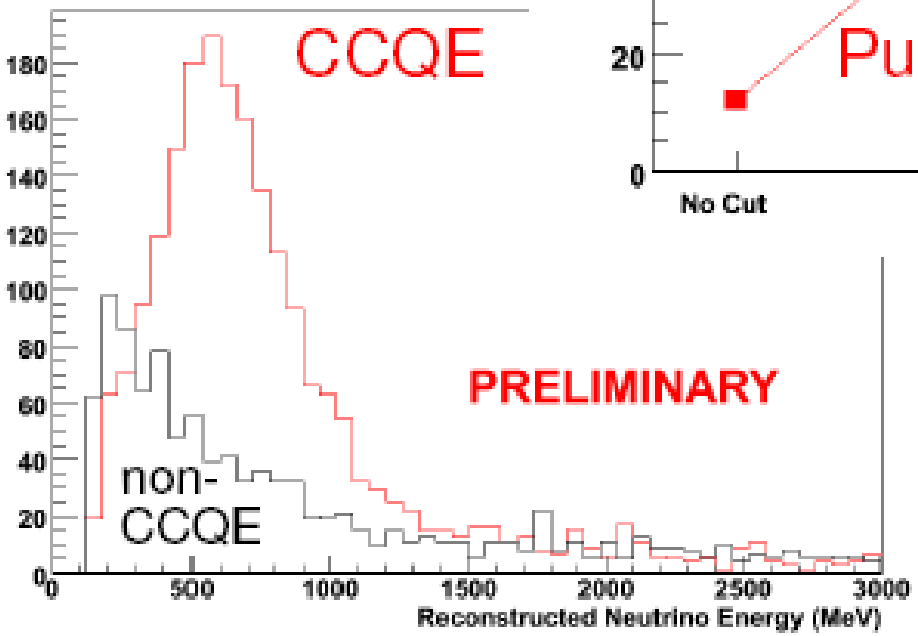
Preliminary Reconstruction Software Demonstration

Reconstruction approaching predictions from earlier studies



Efficiency and Purity versus Cuts

Reconstructed Neutrino Spectrum



(does not include energy losses before entering TPCs)

T2K ND280 Offline Software Group

Report for PAC January 2008

PØD π^0 Selection

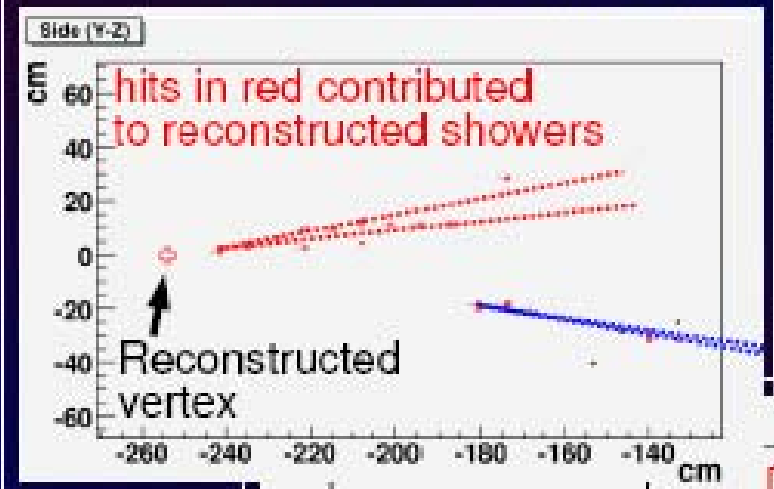
Preliminary Reconstruction Software Demonstration

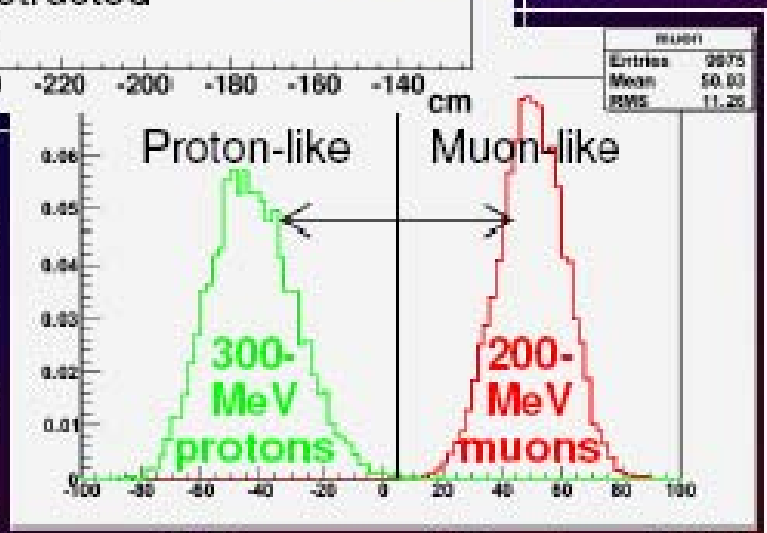
- Reconstructed vertex in fiducial volume
- No μ-like tracks
- 2 or 3 candidate showers
- At least one shower > 10 cm from vertex
- No μ decay candidates
- Event topology consistent with π^0

Ongoing Work

- Charged track and shower selection
- Shower vertex reconstruction
- 3D shower matching

A successfully reconstructed π^0 in the P0D





Muon and Proton PID likelihood distributions

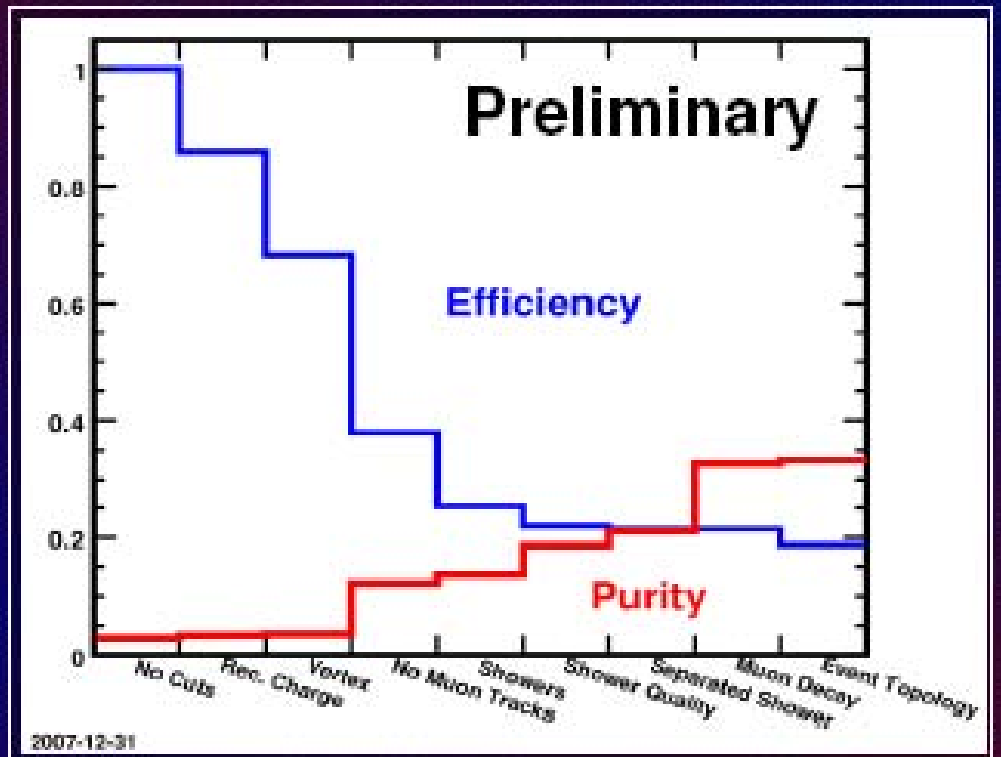
T2K ND280 Offline Software Group

Report for PAC January 2008

PØD π^0 Selection

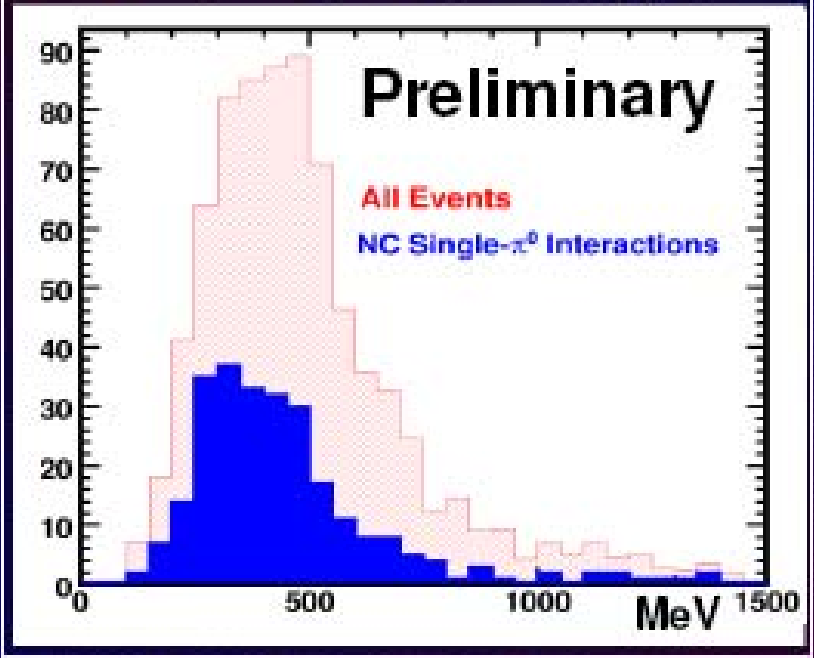
Preliminary Reconstruction Software Demonstration

- Expected performance based on generator information
- Efficiency: 33 % (this study: 19%)
- Purity: 50 % (this study: 34%)



Efficiency and Purity versus Cuts

Reconstructed π^0 Energy



Ongoing work to meet expected efficiencies

Summary

- T2K is making excellent progress.
- We still believe we can meet our ambitious schedule, and should have all major components operational (with the exception of the Barrel ECAL) by the end of 2009.
- On April 1st, 2009 the INGRID will be ready to take neutrino data for commissioning the beamline.
- A significant physics run in early 2010 should therefore allow us to achieve the world's best sensitivity to θ_{13} and begin the era when T2K leads to world's neutrino oscillation experiments.
- In order to actually analyze this data we will need significant computing resources (~400 cores, ~50 TB) onsite, which should be provided by the host. This request has been made to KEK, and is critical to obtaining early physics results.