ATLAS Pixel Subsystem and Simulation

Charles Young
On behalf of the SLAC ATLAS Team

Annual DOE HEP Program Review
(June 2007)

The Pixel Subsystem

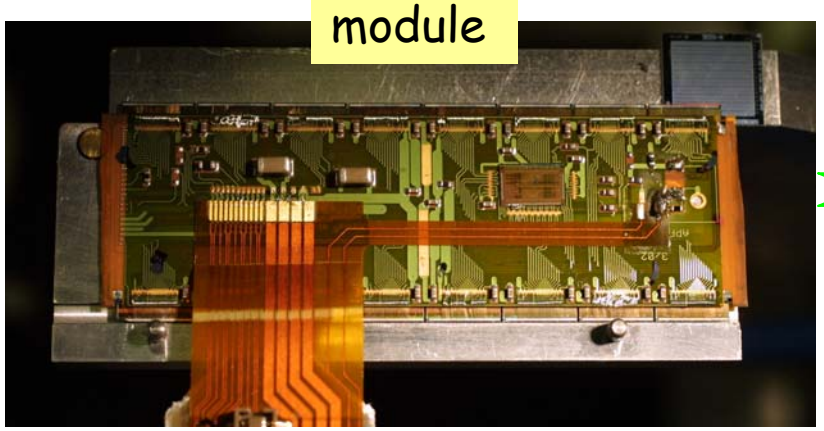
- Basic unit is the module.
  - Approximately 16 mm x 61 mm.
  - 46080 50 μm x 400 μm pixels.
  - Extensive testing: noise, gain, etc. (CY)
- Barrel made of 13-module staves.

Layer	# staves	Radius
0	22	51 mm
1	38	89 mm
2	52	123 mm

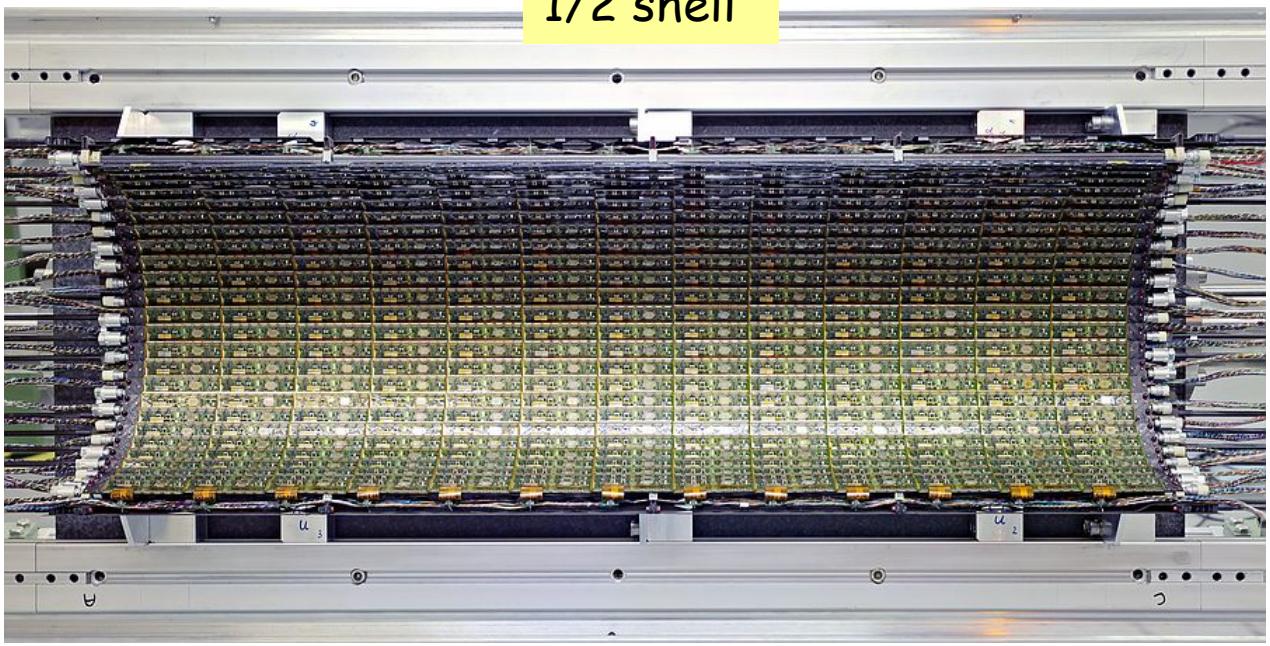
- Three 48-module endcap disks each end.

Stave= 13 modules

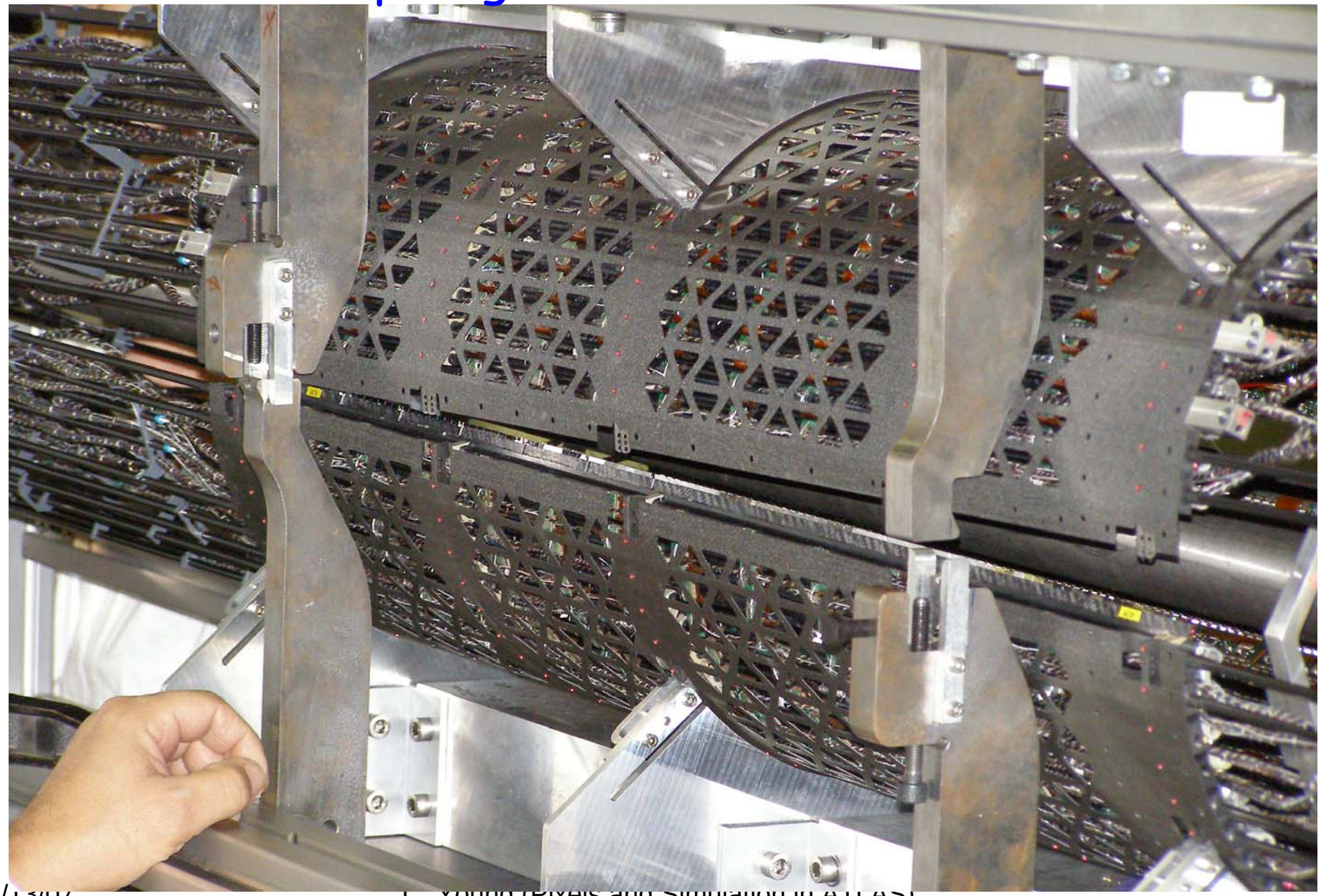
module



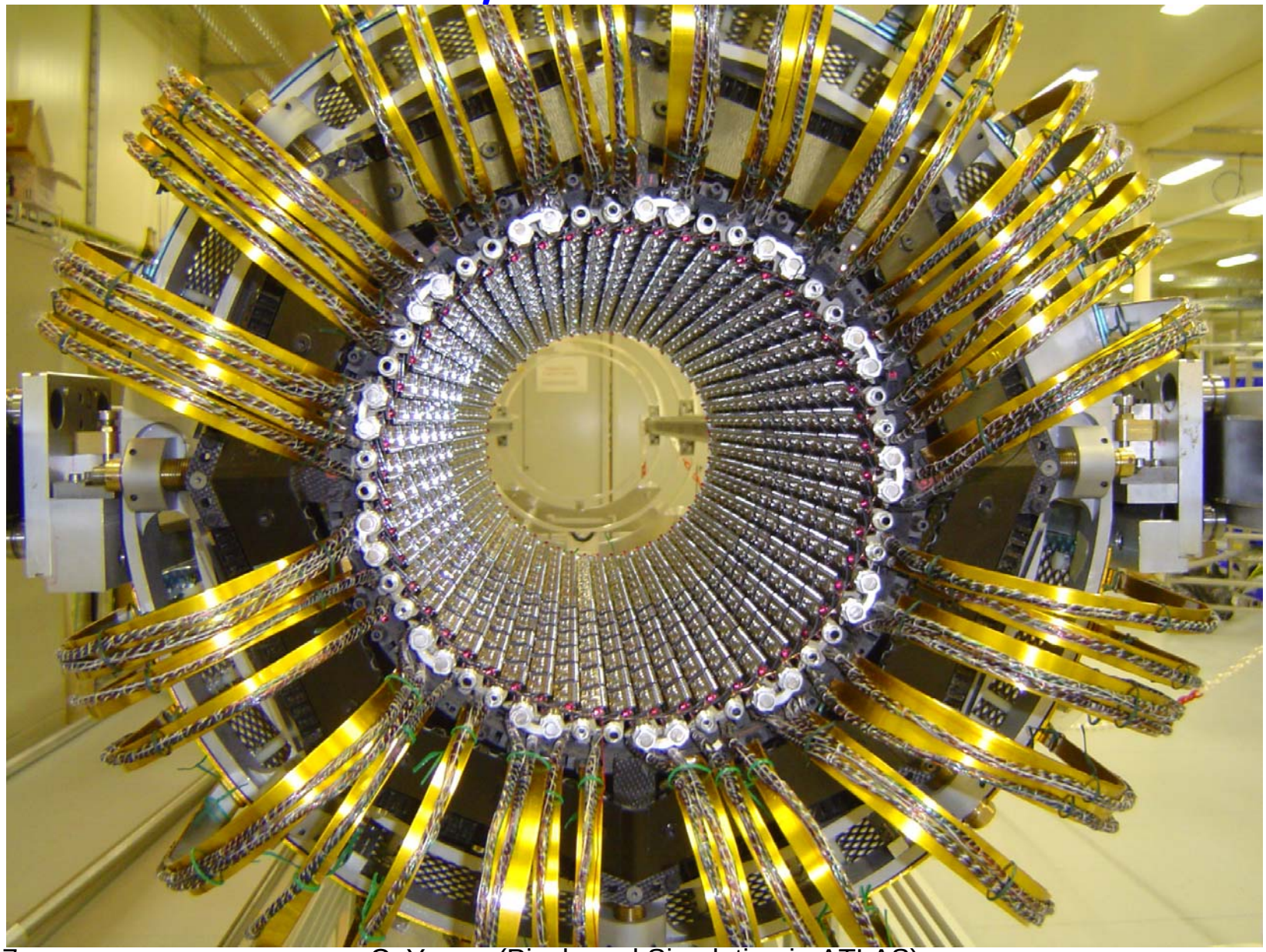
1/2 shell



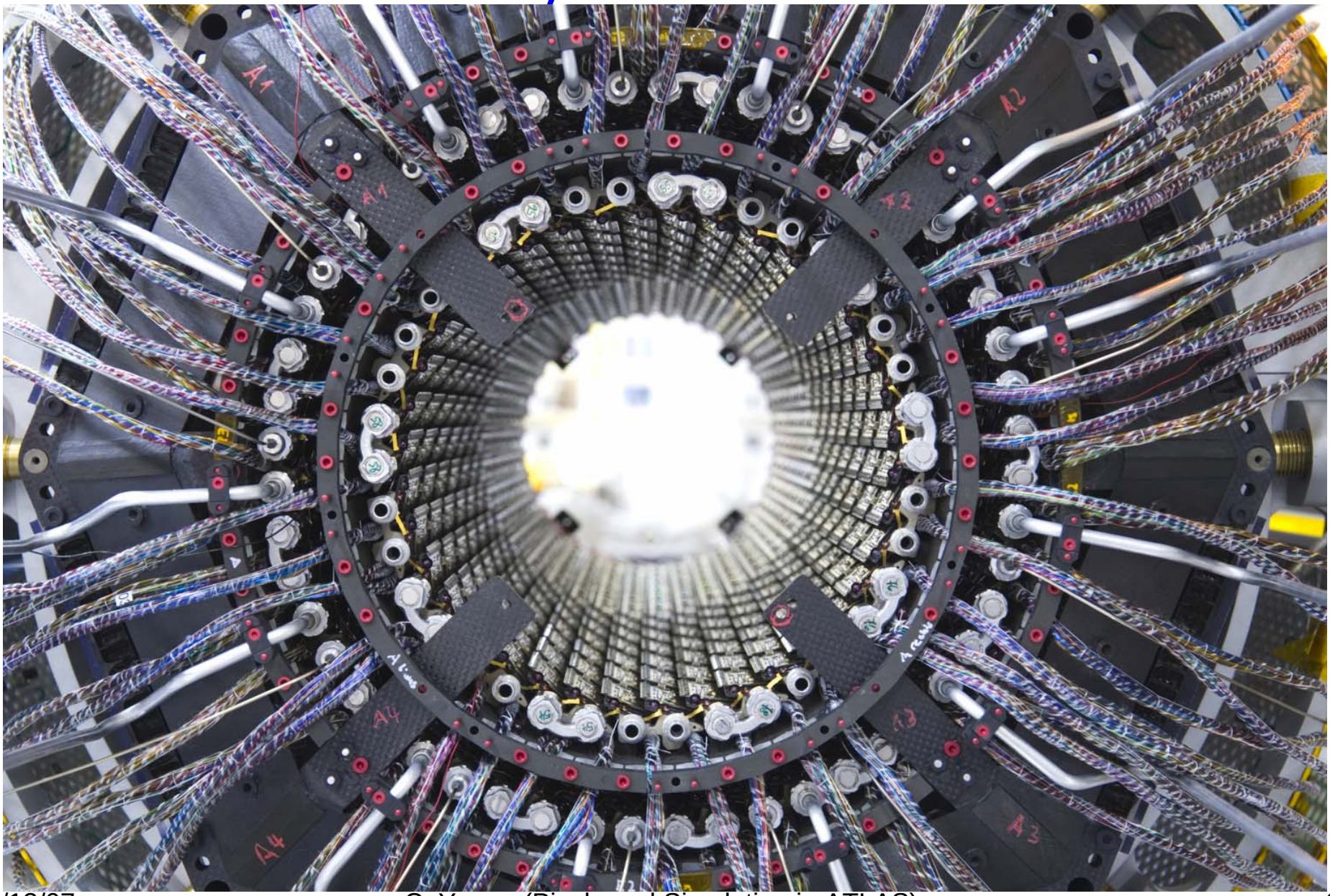
Clamp Together Two Half Shells



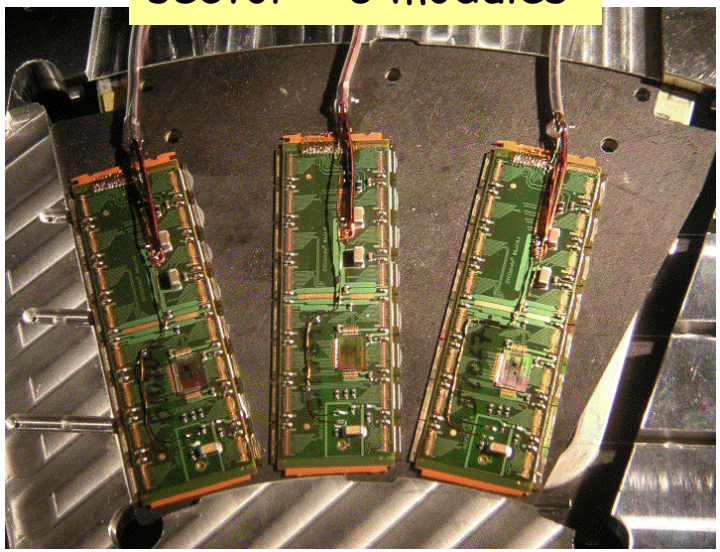
Layer 2 End View



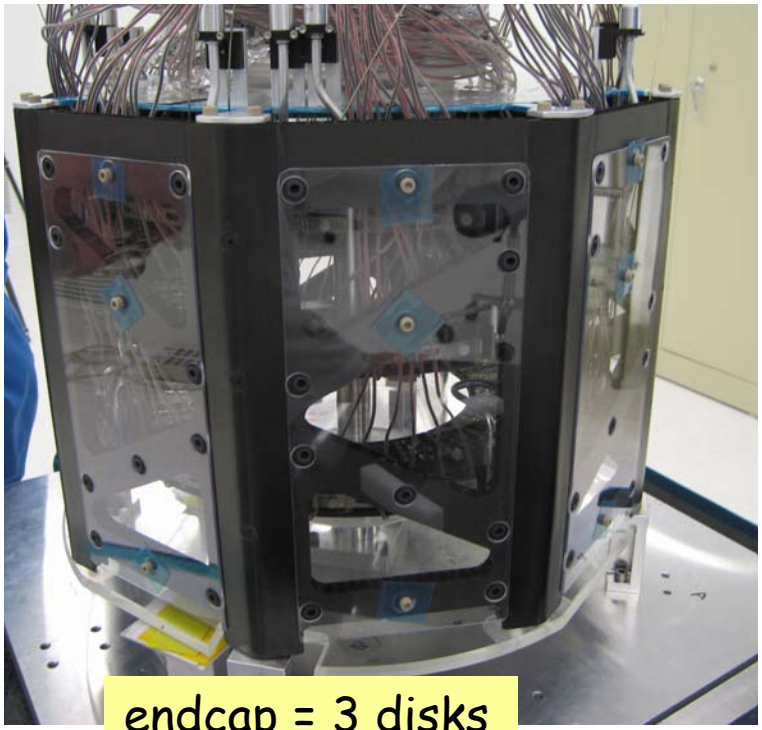
Layers 1 and 2



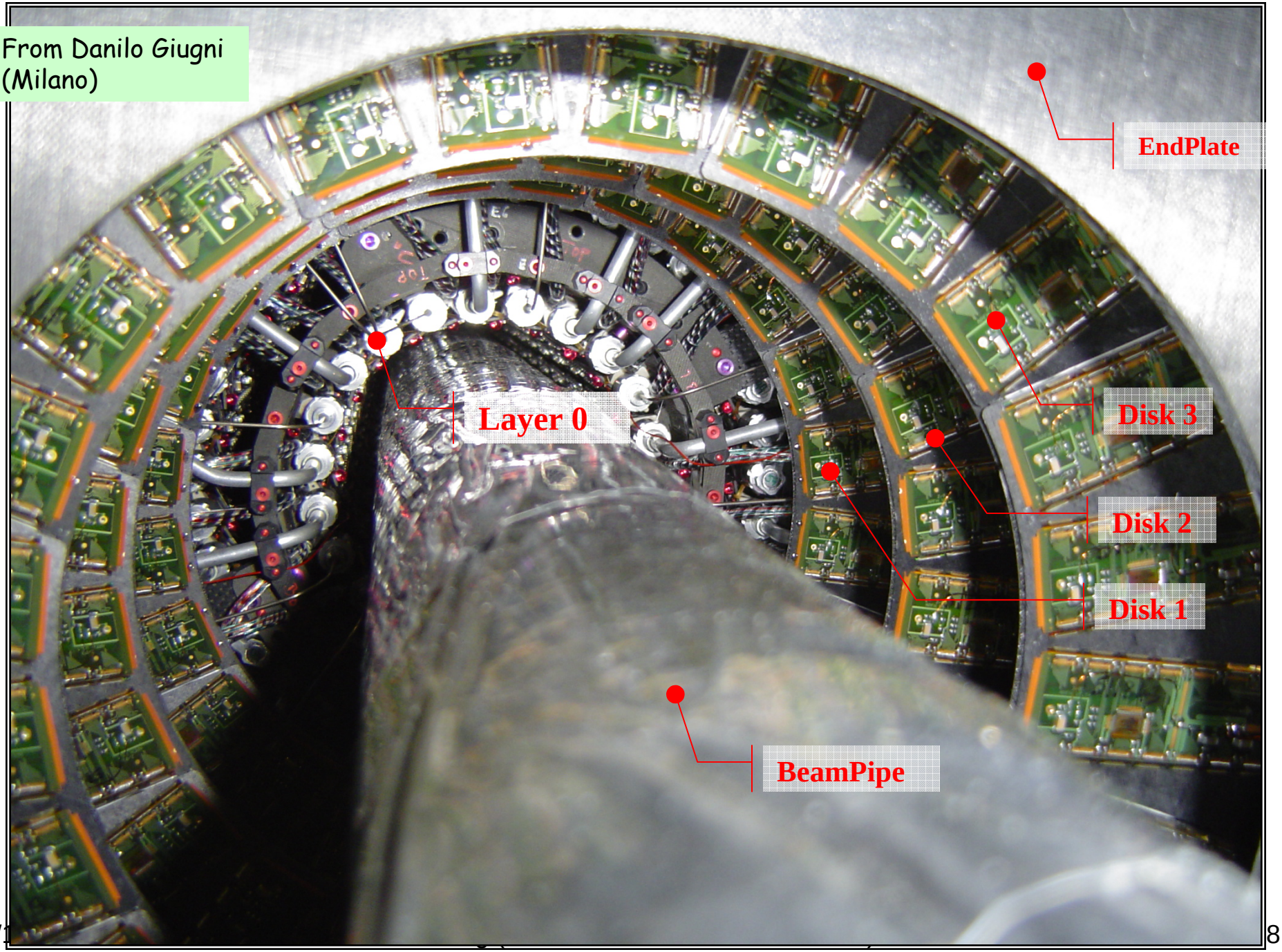
sector = 6 modules



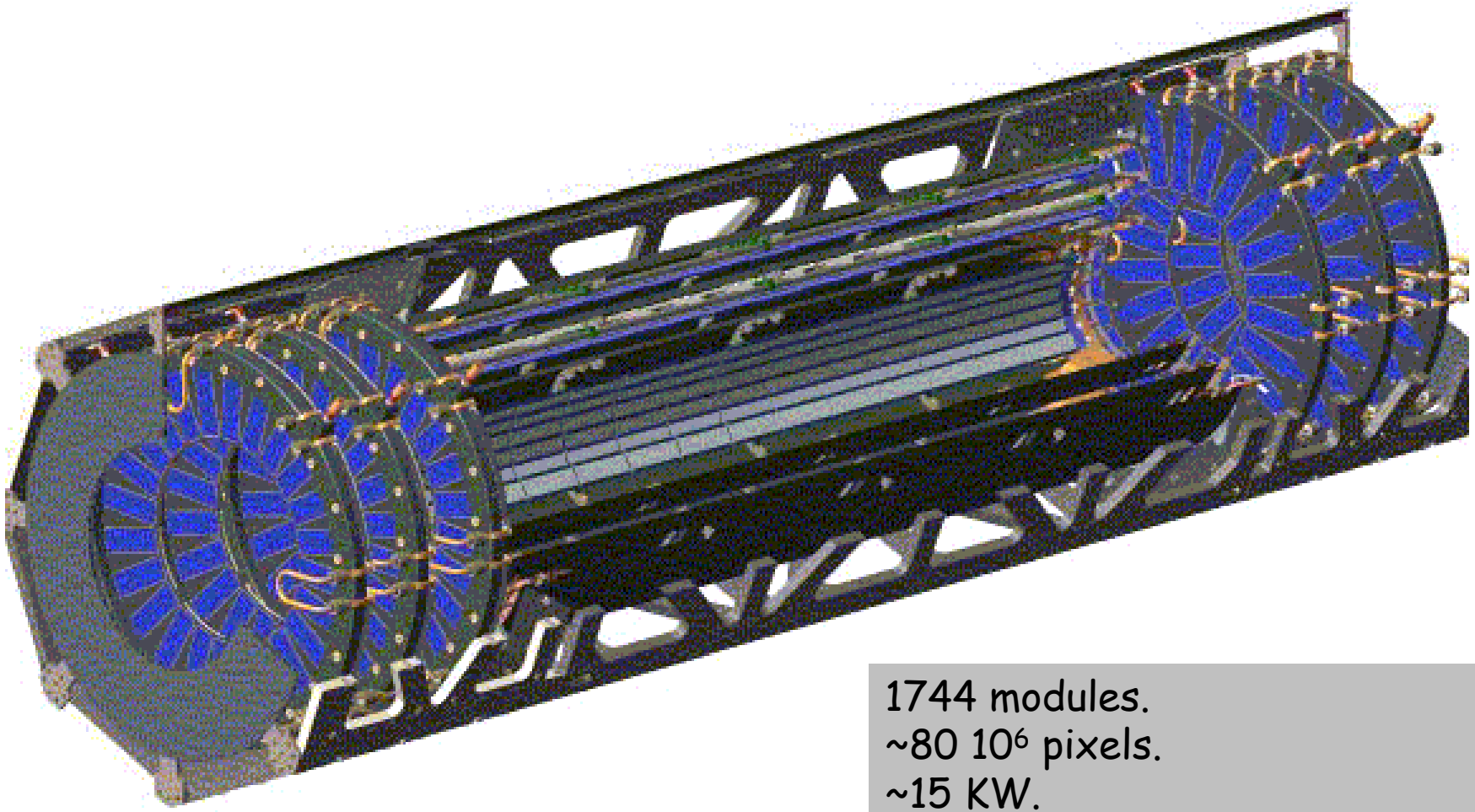
disk = 8 sectors



endcap = 3 disks


From Danilo Giugni
(Milano)
EndPlate
Layer 0
Disk 3
Disk 2
Disk 1
BeamPipe

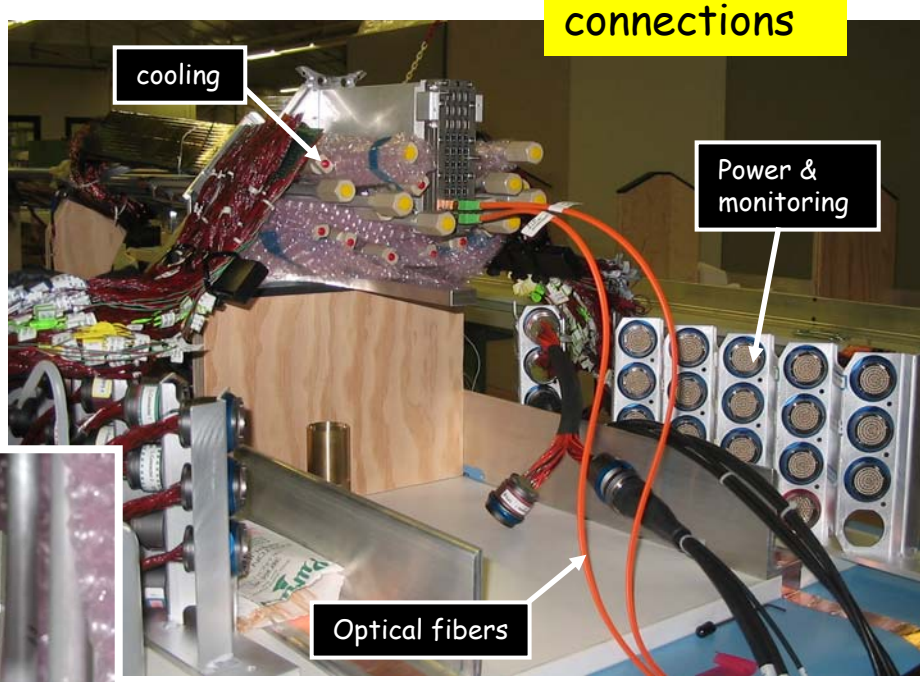
Pixel Detector



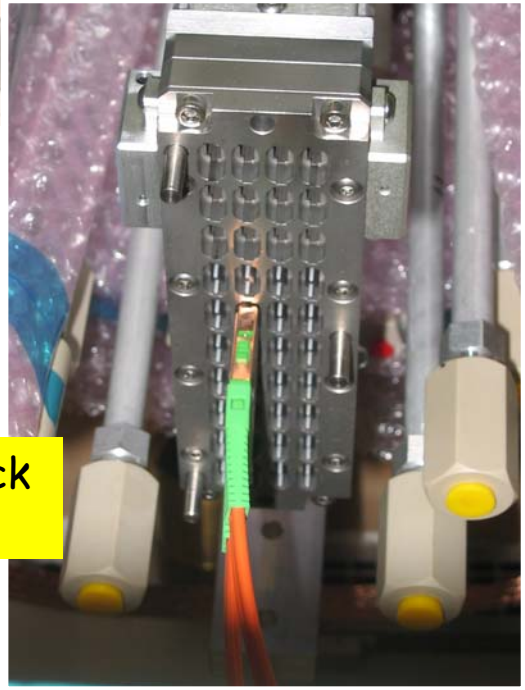
1744 modules.
~80 10^6 pixels.
~15 KW.
Evaporative cooling with C_3F_8.

Service Quarter Panels

PP0: modules connect here



PP1: external connections



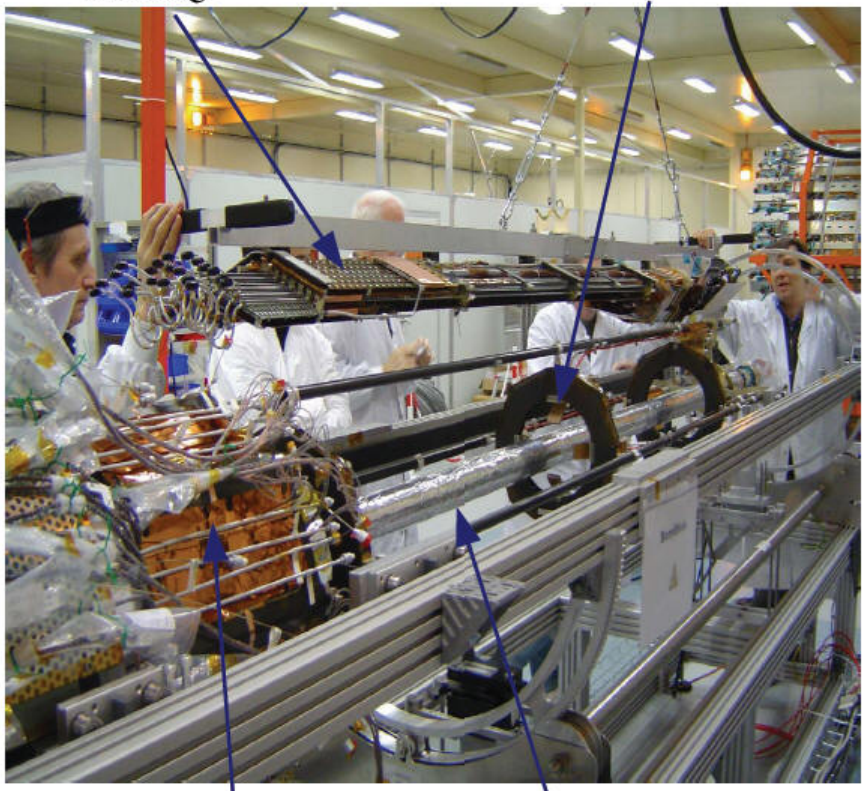
4x10 connector block
16 fibers per cable

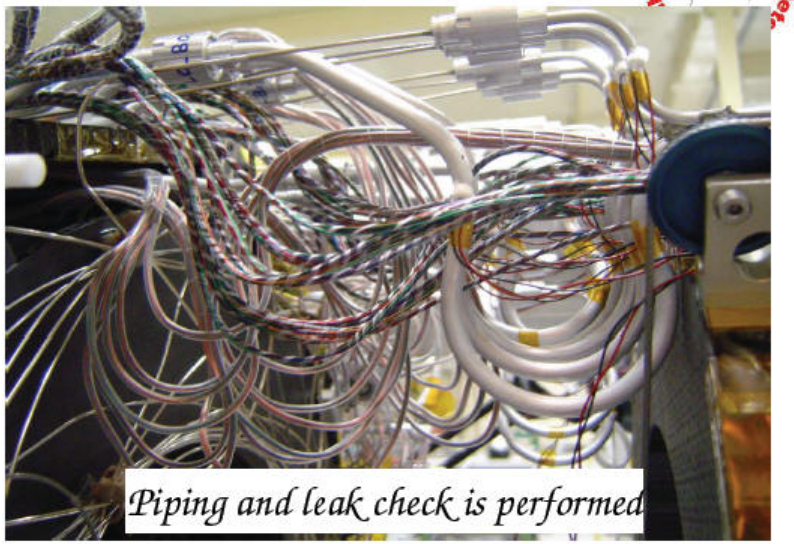
Service Quarter Panels

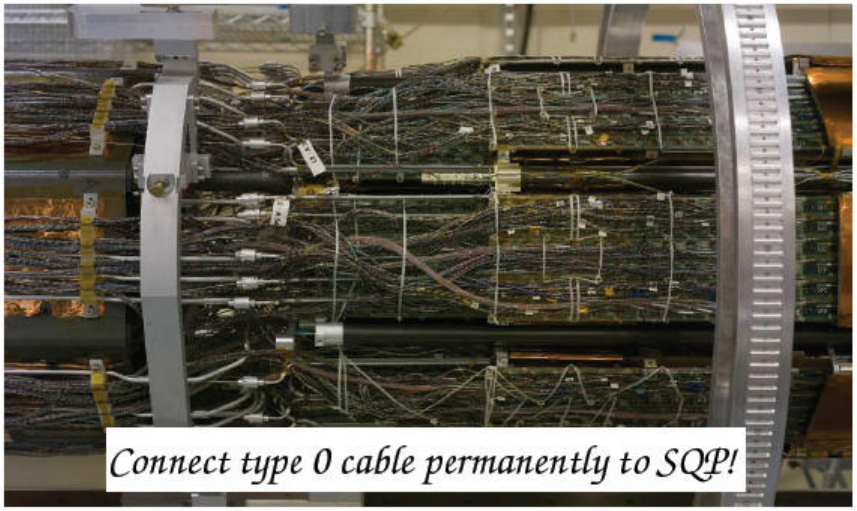
- Initial fabrication at LBNL.
  - Wiring bundles, connectors, etc.
- Final assembly at CERN.
  - Install opto boards, environmental sensors, etc.
- Delicate rework by SLAC electronics technicians.
  - Opto board heaters.
  - SQP internal wiring.
  - Type-0 cable repair.
- Extensive testing throughout the process.
- Coordinated by J. Alonso, M. Gilchriese, R. Madaras (LBNL) and CY.

Integration of the Pixel Package

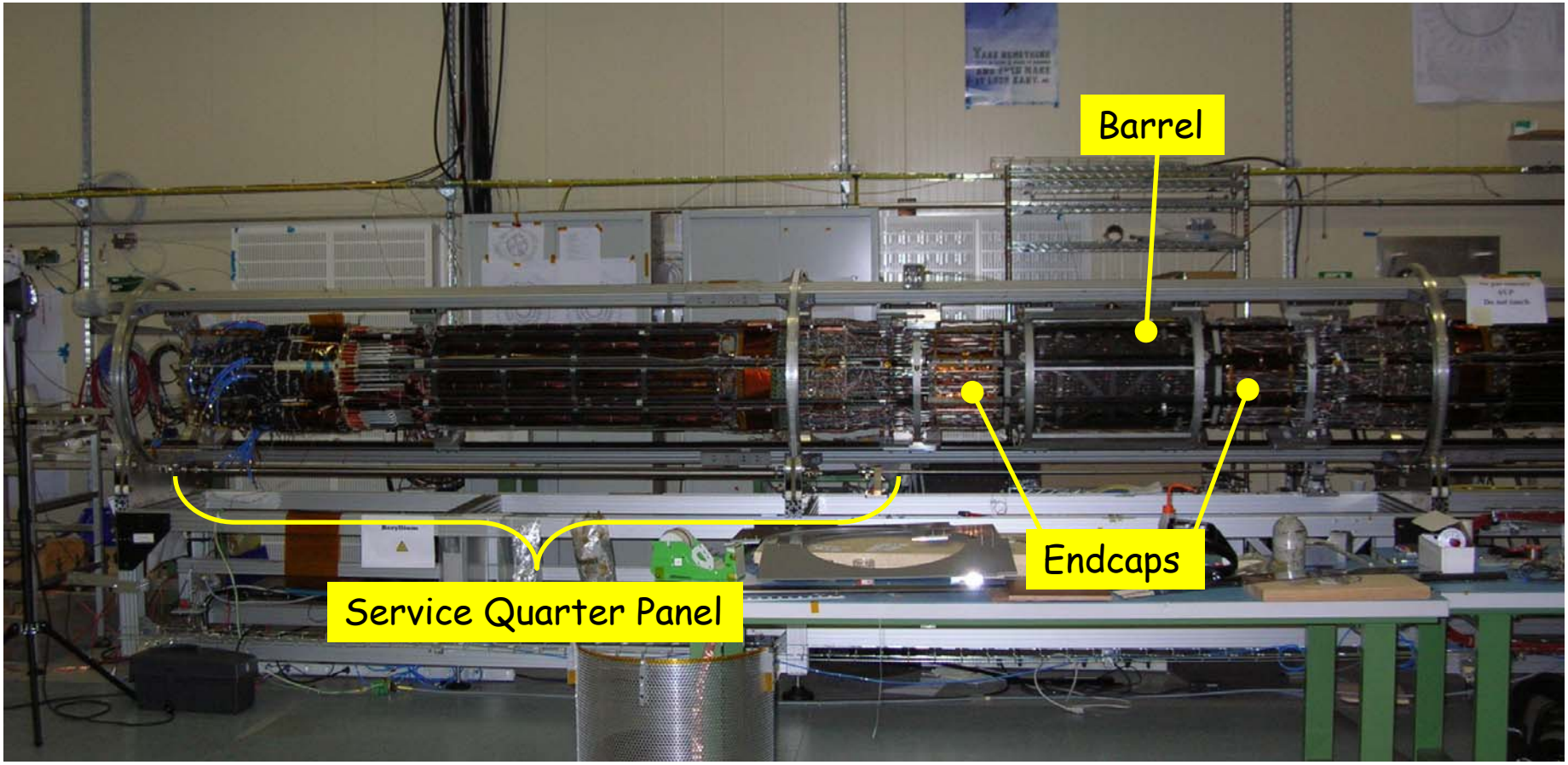
From Jean-Francois Arguin (LBNL)



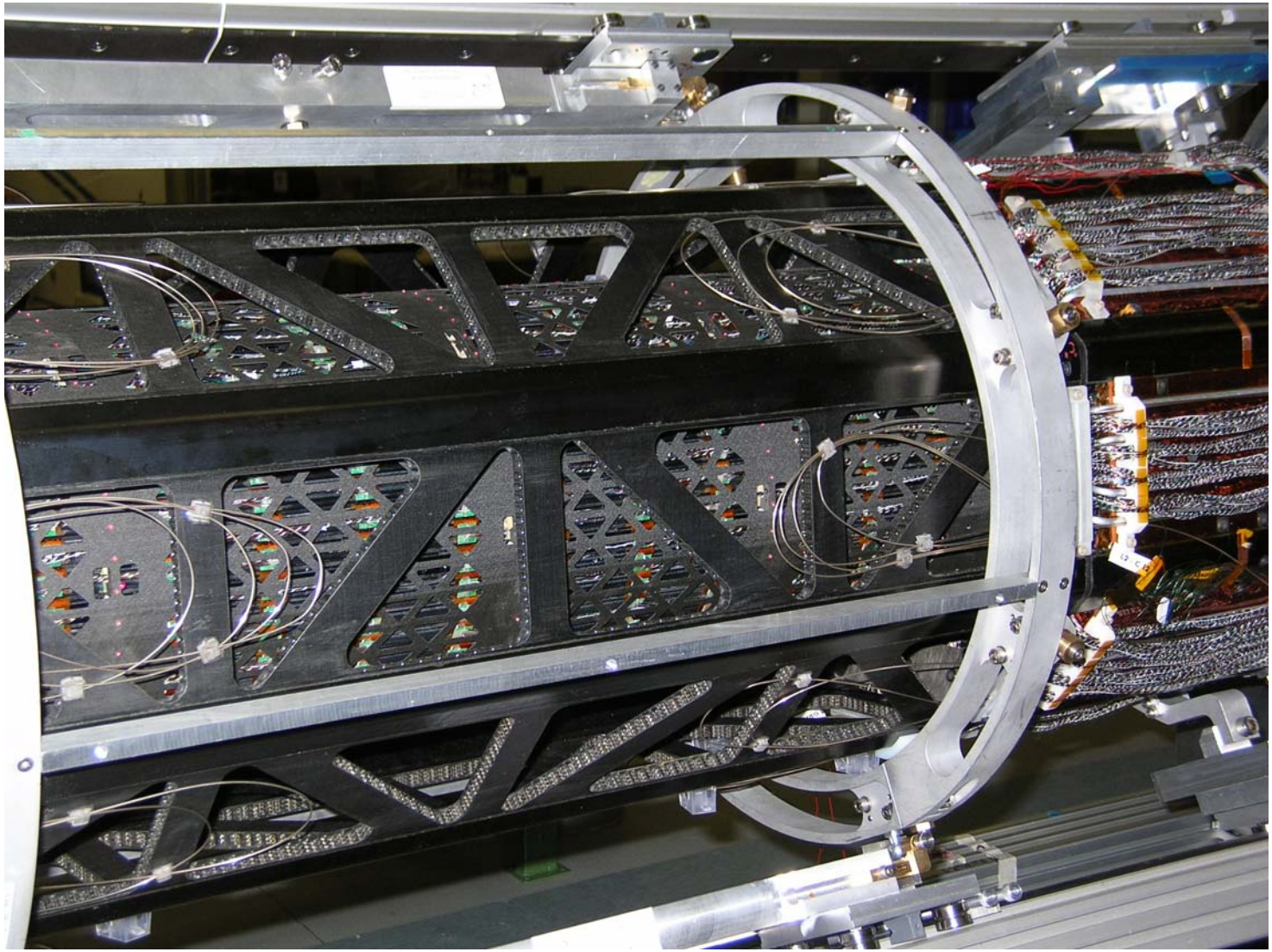




(Half of) Real Pixel Package



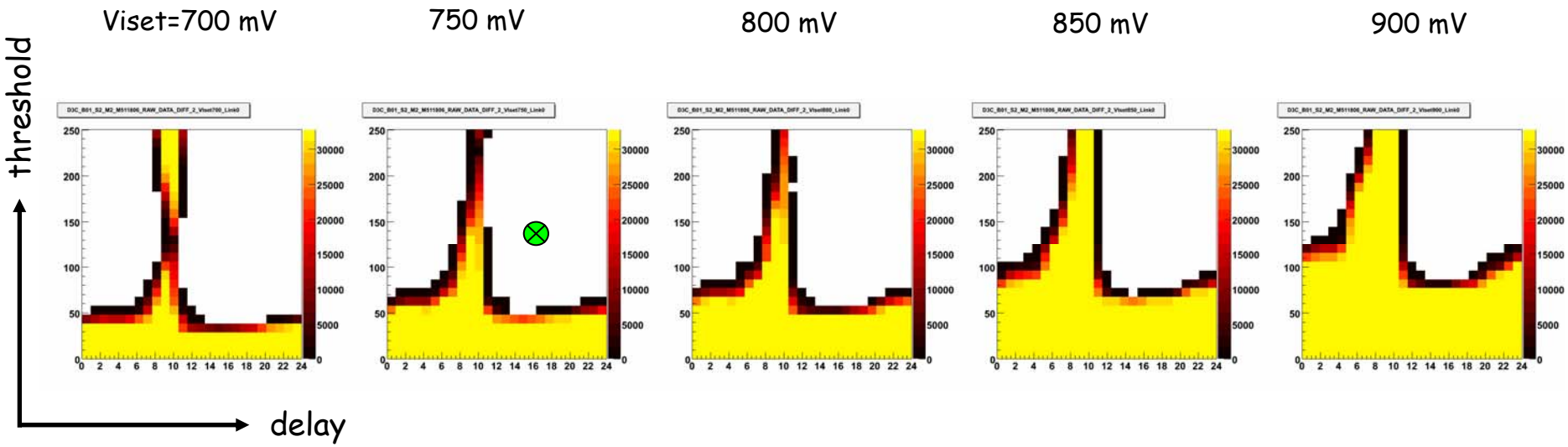
Close-Up of Barrel



Connectivity Test

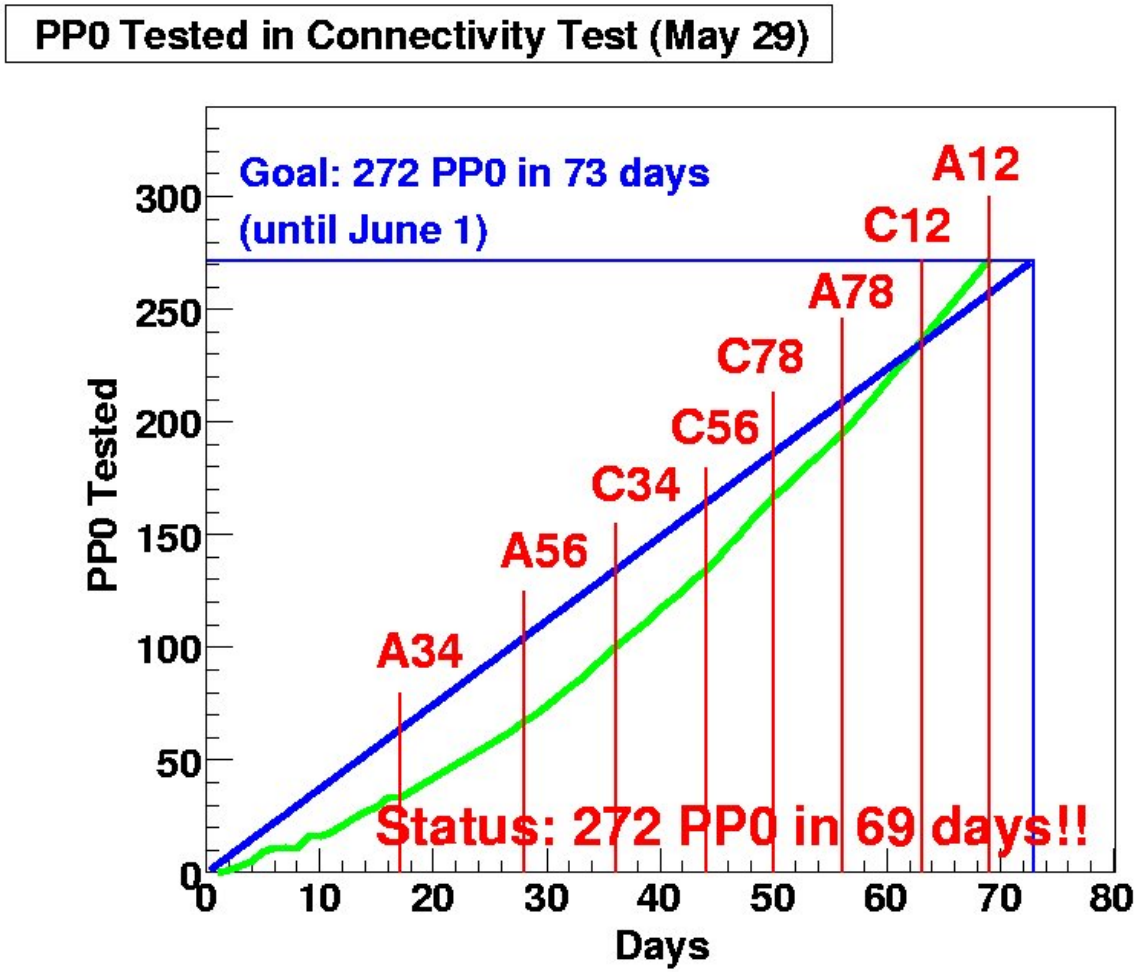
- Connect pixel modules at PP0.
- Connect services at PP1.
  - Power, environmental monitoring, optical, cooling.
- Verify connections.
  - Some mapping errors discovered and corrected.
- Establish optimal operating point for each module in 3-parameter space.
  - BOC delay, threshold and Viset.
- Effort includes:
  - DAQ/Connectivity Test code development.
  - ~2.5 months of testing.
- Claus Horn & Ariel Schwartzman heavily involved in both phases.

Optimal Operating Point



- Find best operating point in white error free region.
- Constraints, e.g.
  - One common Viset for an opto-board serving 6 or 7 modules.
  - Pulse height instability at or below Viset = 700 mV (not obvious from these plots).
- Analysis by Ariel Schwartzman and others.

Connectivity Test Progress



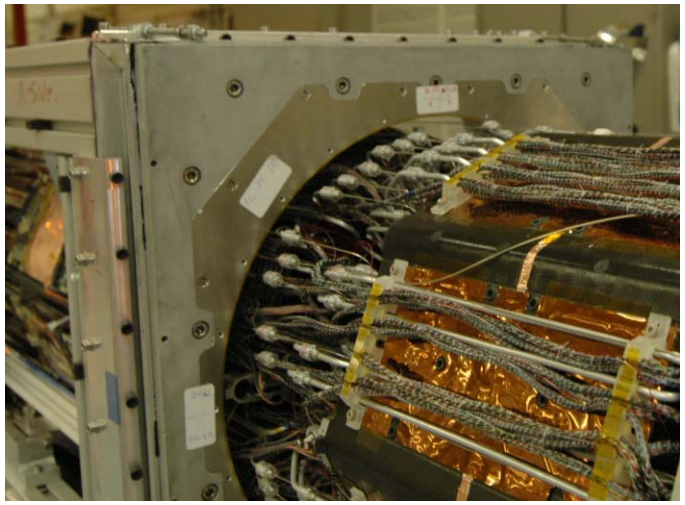
Pixel Status After Connectivity Test

- Three dead modules.
  - Two in barrel.
    - One in layer 2 (may be recoverable) and one in layer 1.
    - Layer 0 OK.
  - One in endcap (may be recoverable).
- Three dead chips in endcap.
  - One chip = 1/16 of a module.
- Dead pixels distributed on many modules.
- Over 99.8% channels working.
- Installation starts on 6/25.
- Commissioning will be focus of activities from now on.
  - Connectivity test inside ATLAS.
  - Calibration and alignment.
  - Monitoring.

Opportunity for hands-on detector experience.

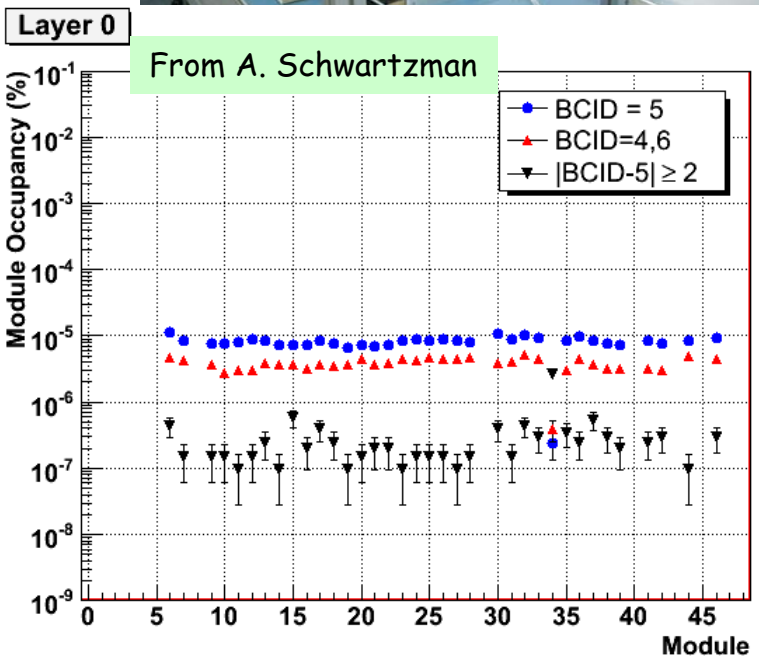
Pixel Package Fits in Dummy Support Tube (6/12/07)

With a little clearance…



System Test with Cosmic Rays in Endcap

- Realistic environment.
  - Production electronics.
  - Production cables and fibers.
  - Cooling system.
- Asynchronous scintillator trigger.
- Demonstrated system operations.
- No surprises in performance.
- Write-up in preparation.
- SLAC people involved include Tim Barklow, Norman Graf, Ariel Schwartzman, Su Dong & CY, and Heather Gray, David Lopez & Kerstin Perez (Columbia).



Data Acquisition – DSP

- Five DSP's in each Read Out Driver (ROD).
  - Send commands to modules.
  - Receive event data.
  - Low level error monitoring.
  - Calibration.
  - Histogramming, e.g. occupancy.
- Crucial to a number of data flow and DAQ functions.
- Very inconvenient code development environment.
  - Windows based cross compiler.
  - Download to DSP to test.
  - No operating system or debugging tools on DSP.
  - Poor code management.

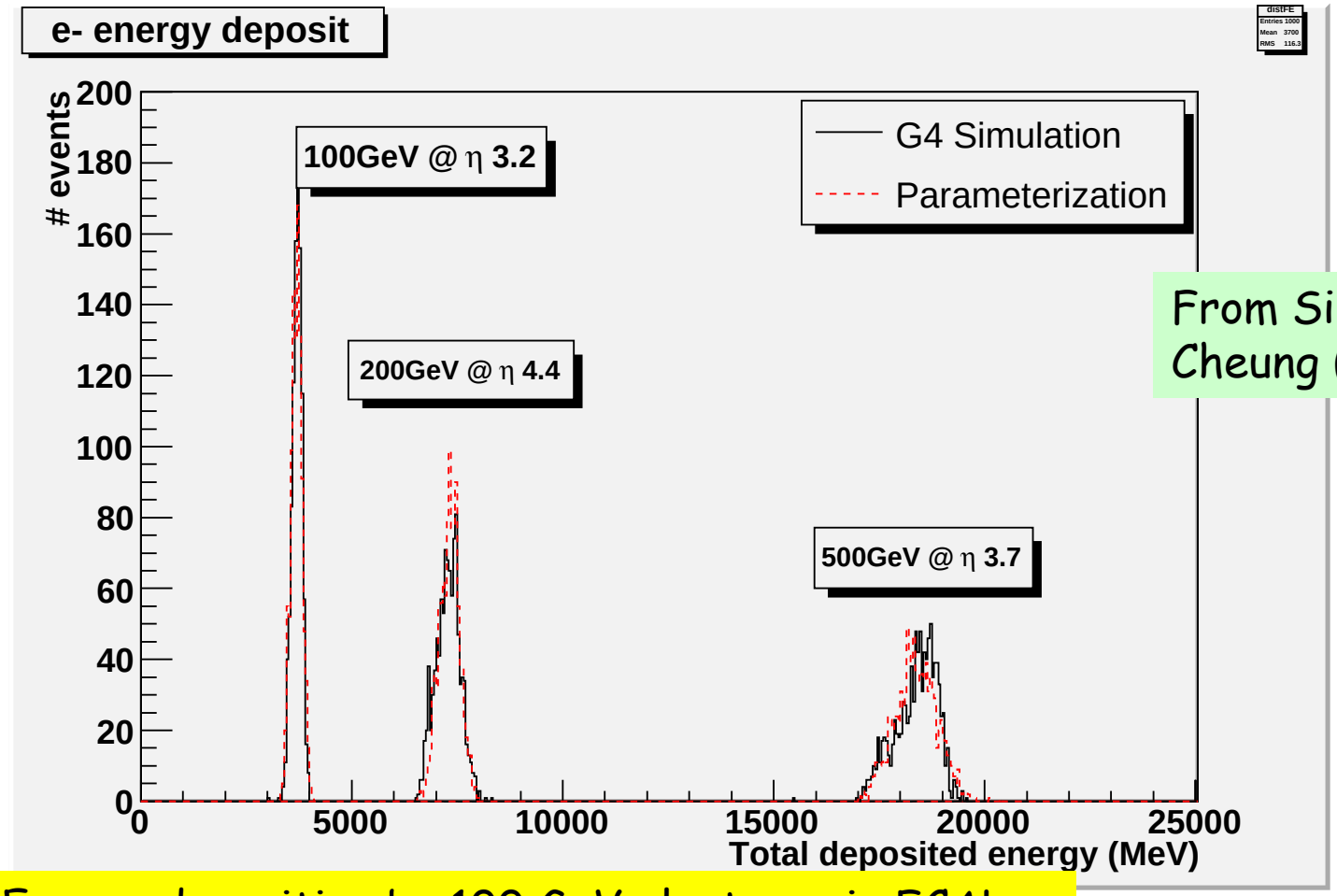
DSP

- Some of these difficulties addressed by Matthias Wittgen.
  - WINE on Linux + gmake.
- Small group of developers.
  - Andreas Korn (LBNL).
  - Matthias Wittgen, Heather Gray (Columbia) and Alex Schreiner (Iowa).

Simulation

- Full simulation using Geant4 is too slow!
  - About 20 CPU minutes per event.
- Several efforts underway to speed up.
  - Speed up full simulation.
  - Parameterized EM shower & shower library.
  - Sophisticated four-vector smearing.
- People involved:
  - At SLAC are Yan Jiang, Bart Butler, CY and Zach Marshall (Columbia).
  - DESY, Melbourne, Pittsburg, Toronto.

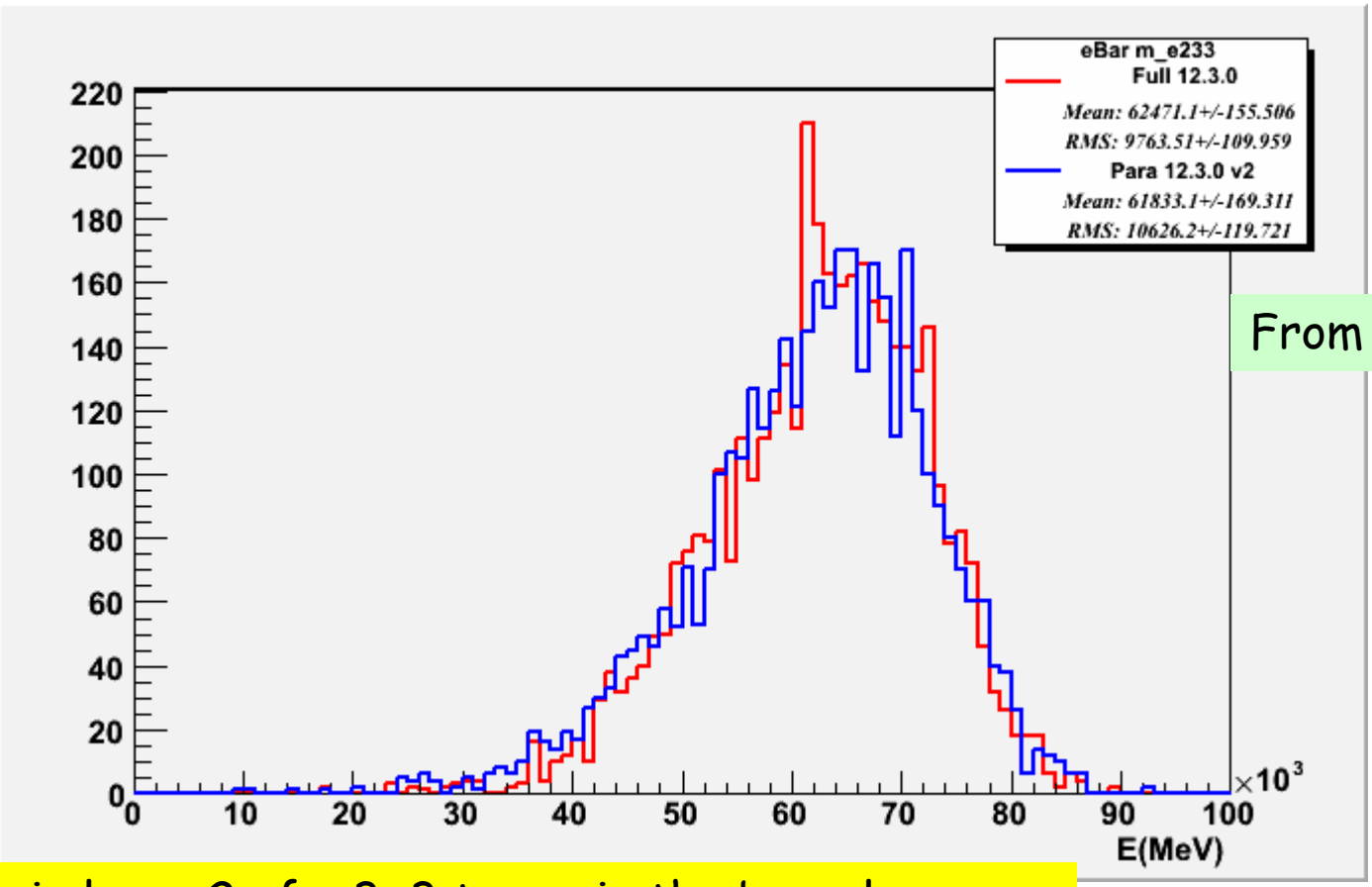
Validation at Simulation Step



From Sing Cheung (Toronto)

Energy deposition by 100 GeV electrons in FCAL.
Black = full simulation
Red = fast shower simulation

Validation at Reconstruction Step



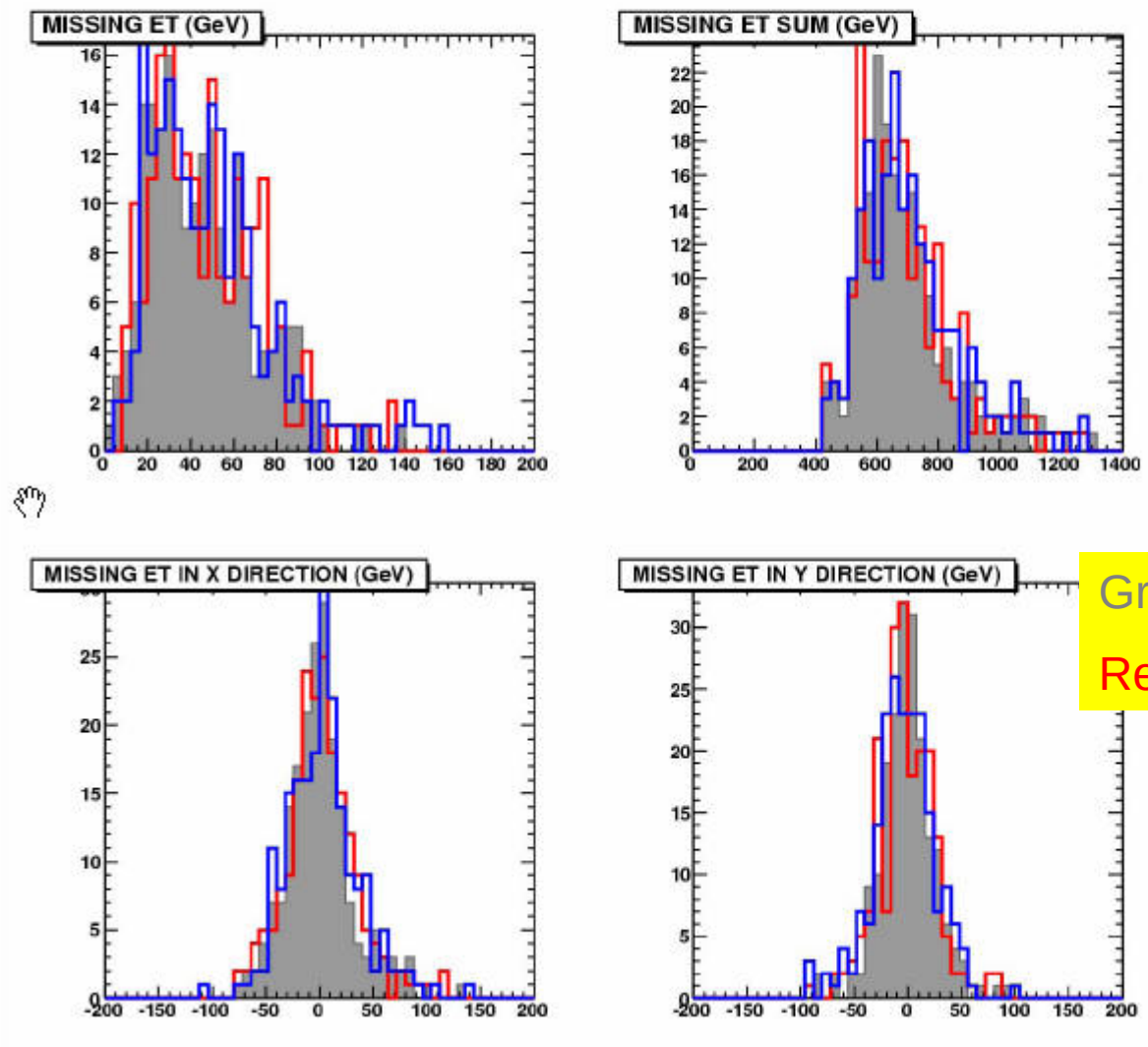
From B. Butler

Energy in layer 2 of a 3x3 tower in the barrel electromagnetic calorimeter from 100 GeV electron.
Red = full simulation
Blue = fast shower simulation

Validation at Analysis Stage – Missing ET

Missing Et: 12.5.0 vs 12.0.6 LAr para

F. Legger (EPFL) at meeting on QCD Background (5/2/07)



Full sim 12.5.0
NTS + LAr 12.5.0
NTS + LAr 12.0.6

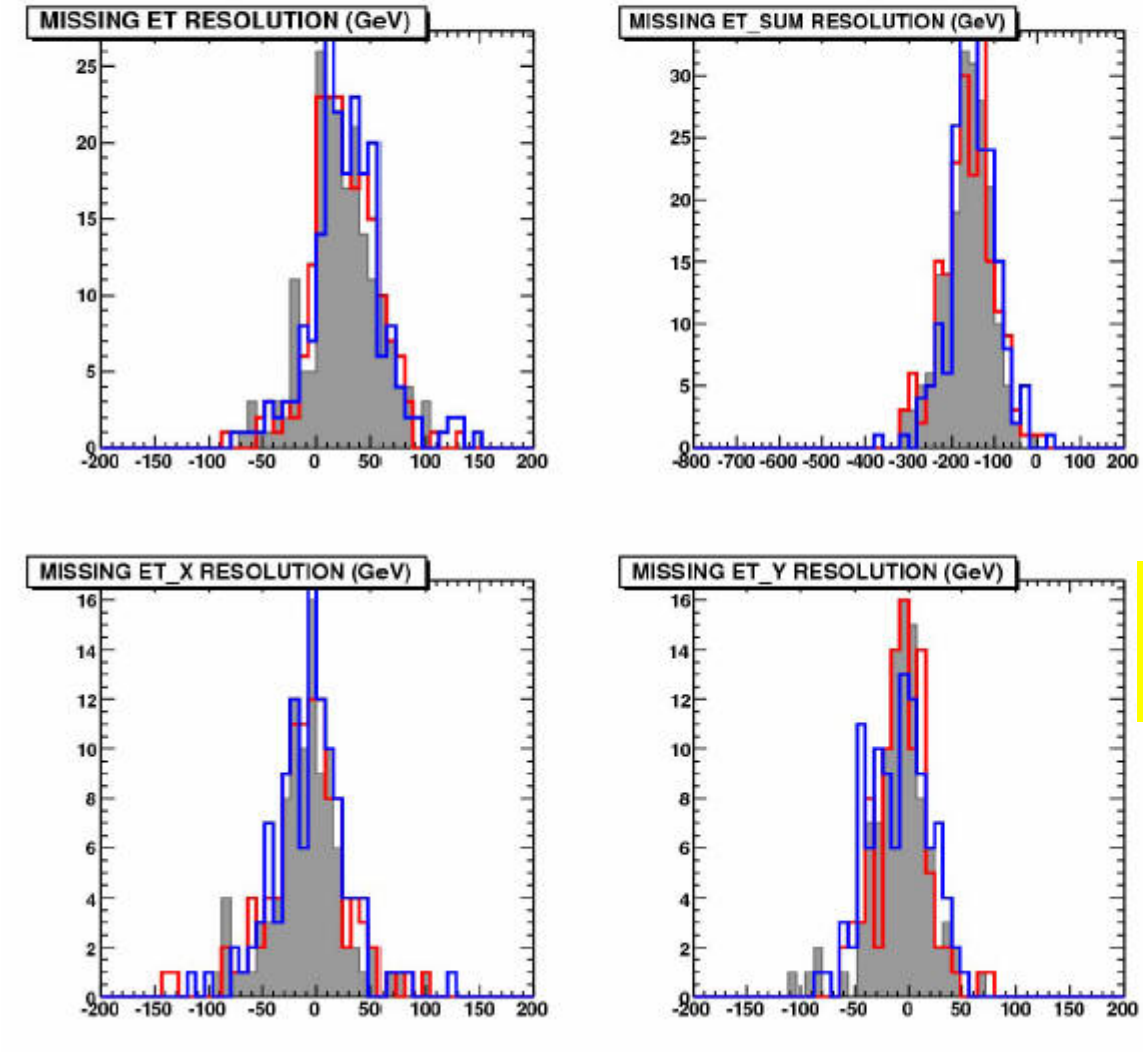
Gray = full simulation

Red = fast shower simulation

Validation at Analysis Stage – Missing ET Resolution

Missing Et resolution: 12.5.0 vs 12.0.6 LAr para

F. Legger (EPFL) at meeting on QCD Background (5/2/07)



Full sim 12.5.0
NTS + LAr 12.5.0
NTS + LAr 12.0.6

Gray = full simulation

Red = fast shower simulation

Fast Shower Simulation Timing Improvement

From Z. Marshall (Columbia)

Subsystem	Full Sim Time (sec)	Fast Sim Time (sec)
Tracker	50	49
EM Barrel	135	41
EM Endcap	552	115
Forward Cal	163	30
Hadronic Barrel	53	37
Hadronic Endcap	50	41
Muon System	71	50
Others	164	111
Total	1238	~2.5X → 473

Simulation Optimization Group

- Mandate: "Optimize the G4-based simulation in terms of physics content and technical performance, recommend baseline releases and parameters, address long-term validation and strategy issues."
- Milestones.
  - Phase 1 (June 15).
    - Define baseline (G4 release, parameters, cuts).
    - Address urgent technical issues.
    - Collect requirements from detectors for optimization beyond [current release].
    - Define validation strategy.
  - Phase 2 (October).
- Members: A. Dell'Acqua, T. Carli, D. Froidevaux, C. Guyot. K. Jakobs, Z. Marshall, A. Nisati, A. Rimoldi, G. Unal and C. Young.

Summary

Pixels:

- Overcame a series of technical difficulties.
- Detector package is now ready for installation.
- Attention turns to commissioning and related activities such as alignment, calibration & monitoring.
- Aligned with SLAC's other projects and physics interests.

Simulation:

- Fostered effort in fast shower simulation.
- Improved program speed by ~2.5X.
- Actively involved in strategy going forward.

Actively supporting our users.