ATLAS Pixel Subsystem and Simulation

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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.

<table>
<thead>
<tr>
<th>Layer</th>
<th># staves</th>
<th>Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>22</td>
<td>51 mm</td>
</tr>
<tr>
<td>1</td>
<td>38</td>
<td>89 mm</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>123 mm</td>
</tr>
</tbody>
</table>

- Three 48-module endcap disks each end.
Stave = 13 modules

module

1/2 shell
Clamp Together Two Half Shells
Layer 2 End View
sector = 6 modules

disk = 8 sectors

endcap = 3 disks
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

cooling

Power & monitoring

Optical fibers

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)

Beam Counter Monitor (BCM)

Piping and leak check is performed

Connect type 0 cable permanently to SQP!

Pixel End-Cap

ATLAS Beam Pipe
(Half of) Real Pixel Package

- Barrel
- Endcaps
- Service Quarter Panel
Close-Up of Barrel
Connectivity Test

- Connect pixel modules at PPO.
- 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

Goal: 272 PP0 in 73 days (until June 1)

Status: 272 PP0 in 69 days!!
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

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

From Sing Cheung (Toronto)
Validation at Reconstruction Step

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

From B. Butler
Validation at Analysis Stage - Missing ET

**Missing Et: 12.5.0 vs 12.0.6 LAr para**

- Gray = full simulation
- Red = fast shower simulation

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

Gray = full simulation
Red = fast shower simulation

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
# Fast Shower Simulation Timing Improvement

![Table showing simulation times](image)

- **Tracker**: Full Sim Time: 50 sec, Fast Sim Time: 49 sec
- **EM Barrel**: Full Sim Time: 135 sec, Fast Sim Time: 41 sec
- **EM Endcap**: Full Sim Time: 552 sec, Fast Sim Time: 115 sec
- **Forward Cal**: Full Sim Time: 163 sec, Fast Sim Time: 30 sec
- **Hadronic Barrel**: Full Sim Time: 53 sec, Fast Sim Time: 37 sec
- **Hadronic Endcap**: Full Sim Time: 50 sec, Fast Sim Time: 41 sec
- **Muon System**: Full Sim Time: 71 sec, Fast Sim Time: 50 sec
- **Others**: Full Sim Time: 164 sec, Fast Sim Time: 111 sec

**Total**: Full Sim Time: 1238 sec, Fast Sim Time: 473 sec

*From Z. Marshall (Columbia)*
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).
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.