Performance and operation experience of the Atlas Semiconductor Tracker

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ATLAS Detector
- ATLAS is one of multi-purpose detector in LHC.
- The ATLAS inner detector (ID) is composed of three sub-detectors.
  - Pixel detector
  - Semiconductor Tracker (SCT)
  - Transition Radiation Tracker (TRT)
- Inner detector provides
  - Precision tracking at LHC luminosity
  - Primary/secondary vertex reconstruction

Detector Operation
- Detector Control System (DCS)
  - Implemented automatic turn-on (HV from 50 V to 150 V) after Stable beams
  - Typical time ~1 minute to ready for data-taking
- Data Acquisition (DAQ)
  - Automatic reconfiguration of modules with links errors (<0.2%)
  - Stopless’ removal and recovery of busy RODs (Read-Out Driver Board)
  - Possibility to reconfigure whole SCT without stopping ATLAS data-taking
  - Failing off-detector optical transmitters
  - Significant improvement achieved through a replacement program
  - A reduction of the humidity in the environment

Tracking Performance in High pileup
- Small drop in primary track reconstruction efficiency in high pileup condition
  - ~2-5% loss, depending on track eta
  - 10-20% drop of primary vertex efficiency
  - μ: the average number of interactions in minimum bias Monte Carlo simulation.

SCT module Hit Efficiency
- Hit efficiency: (number of hits) / (number of possible hits on tracks)
  - Hit efficiency >99.5% over all layers
  - Fraction of bad strips <0.6%
- By studying in time hit efficiency a function of readout delay time
  - Synchronize the readout timing of 4088 modules to 2ns precision

SCT Design
- 4 barrel cylinders and 18 end-cap disks, 9 on each side
  - 4088 modules
  - 6.3M channels (61 m²)
  - Back-to-back planar sensors with 40 mrad angle
  - Resolution: r = 16um, z = 58um
  - 12 read-out chips ASIC (ABCD3TA) per module
    - Binary readout with optical data transfer
    - Up to 500 V bias voltage (usual 150V), 5.6 W/module

Radiation Damage
- The radiation effect is monitored via the module leakage currents.
- The predictions of radiation damage are based on
  - The Hamburg/Dortmund model
  - Simulations of minimum bias events using FLUKA
- Excellent agreement was found between data and model

Lorentz Angle
- The lorentz angle is defined as the angle of deflection of the charge carriers in an electrical field due to the influence of a magnetic field.
- It is derived by minimum cluster width as a function of incident track angle
- It is sensitive to the changes in sensor properties
  - Due to radiation and detector conditions

Data Taking
- More than 99% of SCT strips are fully operational during all periods
  - Disabled strips are due to low/high voltage or cooling problem
  - ~30 disabled modules in total (< 1%).

Noise and Gains
- After receiving 30 fb⁻¹ of delivered luminosity
  - Noise increased about 15% in the end-cap middle modules with CiS sensors
  - Increased about 5% in inner modules both with Hamamatsu and CiS sensors
  - Gains: gradual and universal changes of a few % in mid 2011 and early 2012

Noise and Gains
- Alignment can be done run by run to improve the momentum resolution
- Detector is stable up to 1-2 um during normal data taking runs
- Found 5-10um detector movement during technical stop
- Due to cooling failure, power cut, and magnetic field

Laser Alignment
- Frequency Scanning Interferometry (FSI) technique is developed for SCT detector
  - Monitor the relative position of detector components
  - Angular grid of length measurements between nodes attached to the SCT support structures
  - All 64 grids lengths are measured simultaneously using FSI to a precision of < 1µm
- FSI laser alignment provide:
  - Very time resolution (a few second)
  - Continuous measurements: running during ATLAS stop
  - Cross check of Level 1 track based alignment results
- Example: FSI monitor SCT Barrel movement during
  - Solenoid cycle event (left plot) and cooling stopped and re-started (right plot)