ATLAS Inner Detector Results from the 2004 Combined Test Beam Data

W. Liebig and T. Cornelissen — ATLAS Collaboration

1 The 2004 Combined Test Beam

Layout of ATLAS sub-detectors in CERN SPS beam to resemble the barrel slice (η = 0) of ATLAS

3 months of data-taking with controlled beams:
- e^+e^- at 1...250 GeV
- μ^+, π^+, p up to 350 GeV
- γ at ~ 20...100 GeV
- Inner Detector (ID) collected 22 M “good” events

The test beam has been a considerable effort parallel to the ATLAS construction. The motivations are:

- Hardware and software integration test
- Performance of sub-systems and entire ID
- Tuning of Geant4 simulation and digitisation
- First grip on combined performance ID-Calo-Muon for e, μ, hadrons and photons

Inner Detector offline reconstruction software:

Real Data

Bethe-Stuempfer Converter

RawDataObjects

Detector Description

Pixel/SCT clusters

Track Drift Circles

Conditions Database

Ntuple analysis

Event summary files

Event display

2 Data Quality and Alignment

All corrections for bad channels, calibration & alignment vary between different time intervals or runs. To handle this efficiently, a conditions database is used to store / retrieve the associated numbers.

2.1 Dead and Noisy Channels

- The dead maps show noisy channels (here for SCT, green) which are masked offline (red histogram) at the level of clusterisation and drift circle formation.
- This is performed for all three ID technologies. The map of channels from the DB is also used in MC digitisation.
- Further calibration studies are going on, covering e.g. the measured vs. simulated cluster width and the high-level signal probability providing e^+e^- identification in the TRT.
- They complete results from earlier stand-alone tests.

2.2 Silicon Alignment

A simple alignment algorithm (tracks vs. residuals) has been used to provide the initial alignment. It uses straight line tracks (running with δ = 0) and keeps the position along the beam line (v-axis) fixed.

- The momentum reconstruction yields similar results using all the different alignment algorithms.
- Systematic shifts of several microns can be seen in some pixel modules.
- This is a very important test since ATLAS will finally need to understand the alignment to better than 1 μm.

2.3 TRT Calibration and Alignment

- Fit to e^+e^- relation provides wire positions and calibration (l0, v0)
- l0 vs track depth (right): need individual l0 constants, large variations for different strips
- Very uniform v0
- TRT internal alignment yields residuals with σ = 131 μm (data, right)
- Intrinsic resolution (MC) + wire placement = 30 μm

3 Particle Reconstruction

3.1 Momentum Measurement

- Good agreement on momentum resolution from Pixel+SCT in data and simulation, especially at high energy
- Full measurement including TRT improves resolution but simulation and data disagree at several energies (The TRT is outside of the field)
- Alignment still under revision

3.2 Material in the Inner Detector

Probed using offset between Silicon and TRT track segments parameterised as function of energy:

\[
\text{RES} = \frac{1}{\sqrt{E}} + \text{(offset)}
\]

- The resolution achieved on real data after alignment is 16 μm for Pixel and 22 μm for SCT. It is reproduced by simulation (17 and 23 μm).
- The alignment strategies foreseen for ATLAS were also exercised on test-beam data.

3.3 Particle Identification with the TRT

- The transition radiation from electron tracks in the TRT produces TR-hits which are used to distinguish electrons from pions.
- This pion rejection curve is obtained from an algorithm using the fraction of TR-hits on the TRT track.
- The good data-sim agreement at low E (2 GeV) is an important achievement.
- Studies ongoing with different energies and field on/off
- Fine-tune TR-hit threshold in the simulation
- Studies underway to improve particle separation using time-over-threshold information

4 Measurements with Calorimeters and Muon Chambers

- Match electron track φ (vertical) to LAr calorimeter cluster φ (horizontal)
- Contains several matching corrections
- Important for analysing photon runs and reconstructing γ → e^+e^- in the ID

Combined track fit ID-Muon:

5 Towards ATLAS Data-Taking

- ATLAS has learnt a lot from the hardware & software integration work and data quality analysis at the CTB
- Combined performance studied well before real ATLAS
- The CTB becomes a well-understood environment to develop and test new algorithms
- In the future the CTB data with single particle events will be available to help understanding performance issues from the real ATLAS detector.