Commissioning of the ATLAS offline software with cosmic rays

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on behalf of the ATLAS offline commissioning group:
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Introduction

The ATLAS detector

Inner detector

Transition Radiation Tracker (TRT)

Straw tubes
 $\sim 3.5 \cdot 10^5$ channels

Pixels

Si Pixel Detectors
 $\sim 0.8 \cdot 10^8$ channels

SemiConductor Tracker (SCT)
Si Strip Detectors
 $\sim 6 \cdot 10^6$ channels

■ Related talks

- M. Keil, J. Weingarten (N26), S. Mima (N30), J.R. Schieck (N56)

Calorimeters

▪ Lead-Liquid argon calorimeters

- Accordion shape electrodes collect ionization charge
- Barrel in same cryostat as solenoid
- $\sim 2 \times 10^5$ channels

▪ Hadronic Tile calorimeter

- Iron-scintillating tiles
- WLS fibres-PMTs readout
- $\sim 10^4$ channels

Related talk yesterday by D. Rousseau

Muon spectrometer

Trigger chambers, fast timing

Resistive Plate Chambers in barrel

Thin Gap Chambers in endcap

Momentum measurement chambers

Monitored Drift Tubes in most of the solid angle

Cathode Strip Chambers in endcap

$\sim 1 \times 10^6$ channels

■ Related talks

- C. Ferretti (N28), J. Guimarães, J. von Loeben(N30).
S.M.Goldfarb, M. Cirilli (N56)

Cosmic ray data

■ Cosmic muon trigger

- TileCal custom board, top-bottom coincidence since 2005
- Muon spectrometer RPC since summer 2007

■ Detector integration

- 2005: TileCal standalone
- 2006: combined calo, muon standalone
- 2007: calo+ID+muon
- Organized in "Milestone weeks"- M5 ongoing as we speak!

ATLAS software

ATLAS offline framework

Athena (adapted from LHCb's Gaudi) is the ATLAS software framework

- **Used for**

- High-level trigger
- Simulation
- Reconstruction
- Analysis and monitoring

- **Flexible structure**

- Algorithms and tools
- Event data
- Common services
 - DB access, interval of validity
 - Transient (Store Gate) and persistent (POOL) data store
 - Histogram service,...

Detector geometry

■ Common detector description for:

- GEANT4 simulation
- Digitization
- Reconstruction

■ Stored in OracleDB

■ Many different configurations

- Test-beam
- Full ATLAS
- Misaligned ATLAS
- With/without magnetic field
- Commissioning setups

Commissioning setup
3 m gap between barrel and endcap

Cosmics generation/simulation

- Filters applied to generated cosmic rays
 - Origin and initial direction
 - Simulated tracks must pass in given volume (pixel, TRT, muon volume,...)
- Different handling of time info:
 - Hits asynchronous with LHC...

Muon position at surface

- Low energy muons make it through large shaft
 - Rate through TRT: ~ 3 Hz
 - Tile: 0.1-0.3 Hz (higher threshold)

Cosmics reconstruction

Reconstruction by standard and dedicated algorithms. Some adaptations needed:

■ Inner Detector and Muon Spectrometer

- Track not pointing to vertex
- More degrees of freedom in fit

■ Calorimeters

- Event not synchronized with beam clock
- Phase for optimal filter energy reconstruction not known
- Solution: iterate LAr reco, or get phase from TileCal 3-parameter signal fit

$$E_{cell} \propto \sum a_i \cdot (s_i - p)$$

Optimal filter coefficients a_i

pedestal p

Pulse samples s_i

Online Monitoring

- Partial reconstruction running in online DAQ environment
- Monitoring histograms
- Event display shows the reconstructed objects
 - Calorimeter: LAr, Tile cells
 - ID: TRT hits and tracks, SCT hits
 - Muons: MDT, RPC hits and segments
- Updated every ~ 5 s

Computing commissioning

■ Processing model

- GRID Tier-0 (CERN)
 - Prompt first pass processing
 - Calibration
- Tier-1's (10 worldwide)
 - Process 1-2 months later with better calibrations
- Tier-2's (30+ worldwide)
 - Analysis, simulation

■ Event data model

- Raw Data Object (1.6 MB/ev)
- Event Summary Data (0.5 MB/ev)
 - Reco output, calibration
- Analysis Object Data (0.1 MB/ev)
 - Physics-oriented objects

■ Commissioning in M4 week (Aug)

- Nightly bug-fix patching
- Tier-0 running on 24 TB of RDO
- Write calo ntuples, ESD (~0.3 MB/ev)
- Transfer to Tier-1's
- Reprocessed after ~1 month
 - Less than 1 per mille crashes
- Stressing system by using 25 (instead of 5) LAr samples

Examples of muon reconstruction

TileMuonFitter

- **TileCal tool to fit cosmic muon tracks**
 - Just for commissioning, while muon spect. coverage is partial
 - Fits straight line to TileCal cell hits, requires top/bottom, threshold
 - Doesn't require projectivity- good for encap as well
- **Used to**
 - Identify "region-of-interest" in LAr and Tile calorimeters
 - Provide LAr calorimeter with time phase for optimal filter reconstruction
 - Provide muon path length
 - **Monitoring**

Calorimeter cluster matching

2006-10-12 10:50:35 CEST Event: JiveXML_8077_00540 Run: 8077 Event: 540 2006-10-12 10:50:35 CEST Event: JiveXML_8077_00540 Run: 8077 Event:

LAr time (ns)

Time resolution(ns)

Combined track in real data

■ ID-MUON track

- Combine straight line from MDT segments and TRT tracks
- Another algorithm fits directly from sub-detector hits

■ Main problem:

- Difficult to include energy loss and multiple scattering effects without magnetic field (no momentum measurement)

Summary

- The ATLAS offline software is being commissioned with cosmic rays
 - Subdetector commissioning (studies on alignment, uniformity, etc...)
 - Ironing out bugs, exercising subsystem integration
- Commissioning will continue
 - Integrate more subsystems
 - Pixels sub-detector
 - L2 trigger
 - Magnetic field
 - Develop/debug combined algorithms
 - Looking forward to LHC collisions!

Extra slides

Data analysis

Example of TRT analysis

- TRT noise occupancy as expected ($< 1\%$)
- The number of tracks recorded (~ 900) will not be enough to get a good calibration (track occupancy < 0.03 tracks/event)

Data analysis

Example of Muon analysis

- MDT data (at PRD level) is being studied and compared with previous runs.
- First results with RPC show good data quality.

Offline running

Ex: Extrapolating a track into the calo using CaloTrkMuid

- CaloTrkMuid tags a muon by matching tracks with cells in the HCal. Plot shows the efficiency using simulated data.

real data

HEC pulse shape in Atlantis

Before fix Tile cell energy calibration

ATLAS Atlantis 2007-06-04 19:33:13 CEST Event name: JiveXML_10825_00022 Run: 10825 Event: 22

LVL1 Calo decoders