DEVELOPING COSMIC PATTERN BANKS FOR ATLAS FAST TRACKER

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ABSTRACT

In early 2020, ATLAS will take cosmics data which will be used to aid the commissioning of the FTK system. The work focuses on deriving sectors and constants, and developing pattern banks for the FTK to find and reconstruct tracks from cosmic data. The sectors are the sets of consecutive pixel and SCT modules which are hit by valid tracks and the constants are the constants for the linearized track fit. From these two ingredients the pattern banks can be derived. The first step is to simulate and to reconstruct the interactions of proper cosmic muons with the expected parameters. The cosmic muons produce hit patterns which we can incorporate in the pattern bank, we then can produce the sectors and constants and develop the pattern banks for the FTK to find and to reconstruct tracks from cosmic data. This poster shows the first results from the cosmic simulation.

ATLAS TRIGGER[1] AND FTK [2]

- First Level Trigger (L1):

  - Uses custom electronics system to determine regions of interest.
  - Based on the calorimeter and muon chambers.
  - Decision time to accept events is about 2.5 μs.
  - Reduces events rates from 40 MHz to 100 kHz.

- High Level Trigger (HLT):

  - Verify L1 decision in regions of interest.
  - Reduces the rate from the level 1 output to 1 kHz.

- Fast Tracker (FTK) :

  -A fast and efficient hardware tracking processor.
  -Reconstruct tracks with pT > 1 GeV in the pixel and semi-conductor detectors .
  -Finds tracks by matching hits with pre-calculated track trajectories called pattern.
  -Provides high quality track information to HLT processor.

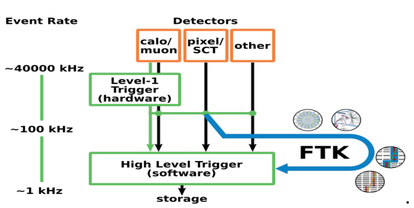

Figure 3: Schema of ATLAS Trigger and FTK.

FTK SYSTEM

- FTK uses 12 layers of ATLAS inner detector: 4 layers of silicon pixel 8 layers of silicon strips (SCT).
- 4 η segmentation : 2 in the barrel, 2 in the endcap.
- Each segmentation is divided into 16 ϕ-slices : 64 (16 x 4) regions (towers).
- Pattern recognition : 8 layers (3 pixel + 5 SCT).
- First stage fit : 8 layers.
- Second stage fit : 12 layers.
- latency is about 100 μs.

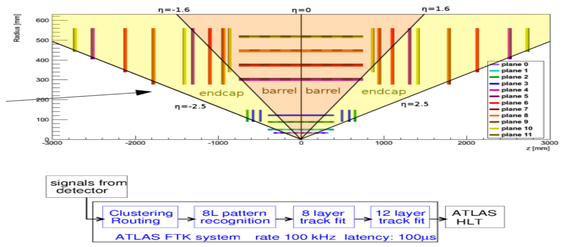

Figure 1: Inner detector seen by FTK [3].

COSMIC SIMULATION

- In order to simulate interactions of proper cosmic muons events, a simulation software called CosmicGun generator based on the GEANT4[4] was used.
- The magnetic field is turned off during the simulation and the reconstruction of the cosmic muons events as the cosmic data taking next year will have the solenoid off.
- The cosmic muons are generated in a given surface representing the inside of ATLAS detector and they are then filtered by the requirement that they initially point to a given distance from the detector centre.
- Only events where the muons interact with the inner detector are saved. The events are then digitized and reconstructed.
- From 1 million initial events generated only 21000 events survived the inner detector filter, and generated 32000 tracks.
- From looking through the events displays a fair amount of cosmic muons that due to bremstrahlung and other effects do not reach the inner detector.
- Many of the tracks with lower SCT/Pixel hit numbers are coming from noise.
- To cut away the tracks coming from noise, only tracks with at least 4 pixel and 8 SCT hits will be used for the pattern bank generation.

FTK KEY FEATURES

- Pattern bank :

  Each track produces a hit pattern. The collection of all these patterns defines both the space of the tracks we are trying to find and how they look in the detector, this collection called pattern bank.

- Pattern bank generation :

  Using single particle or cosmic events with the full detector simulation to derive the list of valid sectors (modules hit by a track) and the fit constants (constants for the linearized track fit, one set of constants per sector) for each sector. Tracks are then generated by generating random track parameters, and looking up which sector matches the parameters. Then using the inverted fit constants for the sector to determine where this track would hit the modules. In this way the enormous amount of tracks needed for the pattern banks can be generated.

- Pattern recognition :

  For real data, detector hits sent to pattern bank in parallel and tracks are recognized.

RESULTS

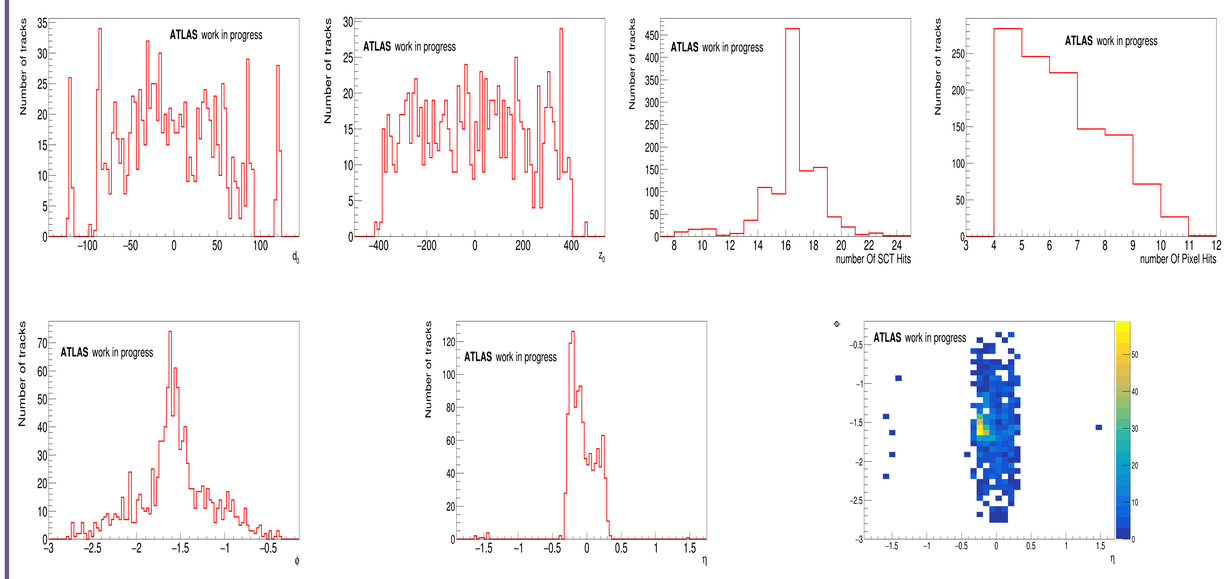

Figure 2: Track parameters with at least 4 pixel and 8 SCT hits.

REFERENCES

[1] The ATLAS TDAQ Collaboration. The ATLAS Data Acquisition and High Level Trigger system. 2016.

[2] ATLAS-TDR-021 Geneva: CERN. 2013. Annovi A et al. ATLAS Fast TracKer (FTK) Technical Design Report, CERN-LHCC-2013-007.

[3] France 2017. Stefan Schmitt. Am chip pattern recognition with optimized ternary bit usage.Connecting the dots, Orsay.

[4] Nucl. Instr. Meth.A vol. 506 no. 3 pp. 250-303 2003. S. Agostinelli et al., GEANT4 a simulation toolkit.

CONCLUSION

After cutting away the tracks coming from noise, the track parameters look as expected. The remaining low-hit tracks can be explained by cosmics not going through the complete Pixel detector.

The work is under developement and we are thinking about the next step to produce the sectors and constants to start the pattern bank production.

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