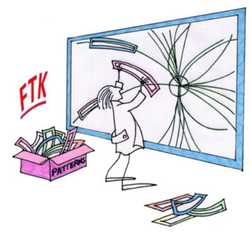
Integration and Commissioning of the Fast TracKer system



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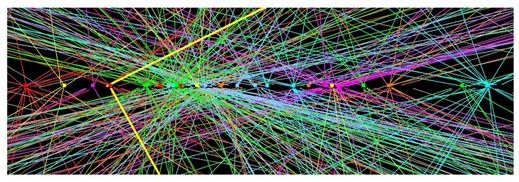
The Fast TracKer system (FTK)

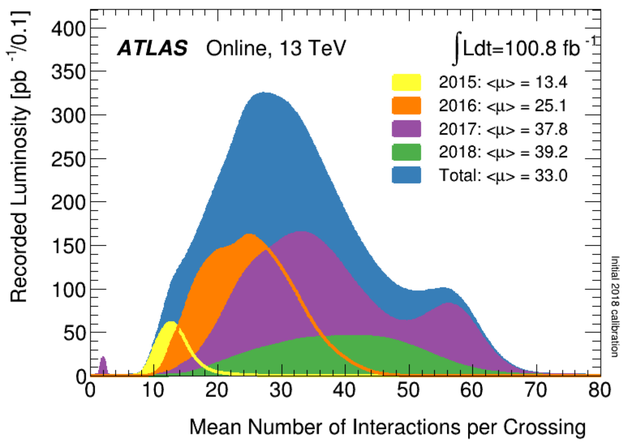
LHC bunch crossing rate: 40 MHz ⟶ ATLAS storage rate ~ 1 kHz

As the LHC luminosity and pileup increase, the fine resolution and granularity of **tracking** makes it critical for selecting events with good purity.

The LHC will deliver more and more challenging conditions:
- **pile-up** (peak mean number of interactions per bunch crossing) above **50** in recent data taking;
- higher pile-up expected in Run 3!
  - **Major combinatorial challenge to tracking!**

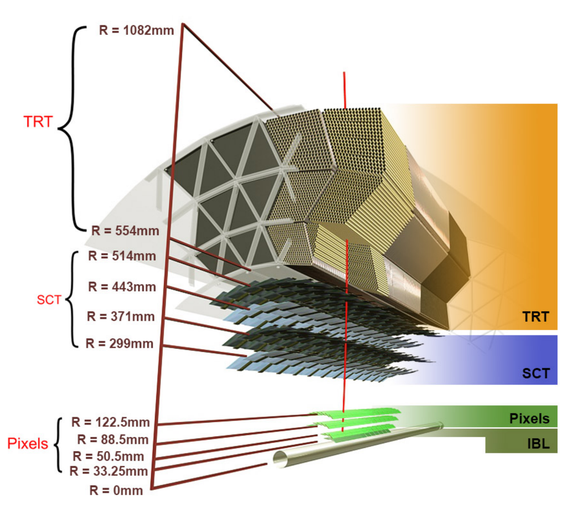


25 reconstructed vertexes, L~2.5 cm

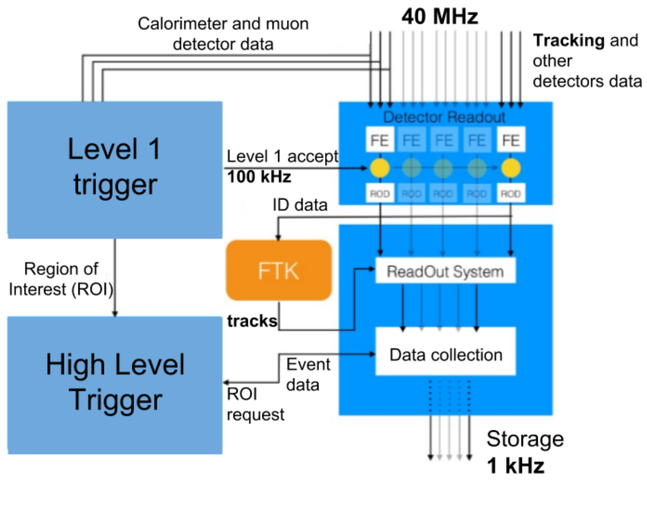


The **Fast TracKer system** (**FTK**) is a track reconstruction processor. It receives data from the Inner Detector (ID) for all events accepted by the ATLAS Level 1 trigger and it performs full event tracking at the Level 1 trigger acceptance rate (100 kHz).

- **Idea**: all possible tracks are simulated before an ATLAS data taking run. During the data-taking, the ID hits are compared with the hits expected from the simulated tracks as they are read out.
- **Hardware needed**: the comparison is implemented using dedicated ASIC hardware based on **associative memories** and high performance Field Programmable Gate Arrays to provide the needed computing power.



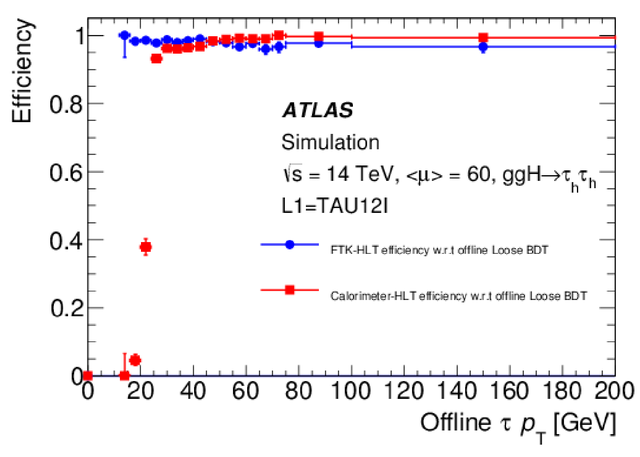
ATLAS Inner Detector



Trigger levels and FTK in ATLAS data taking

The system will deliver full-event reconstruction of all tracks with pT >1 GeV at a much larger rate than is otherwise possible in the High Level Trigger (HLT), allowing for:

- better identification of physics objects such as b-jets and taus;
- improve displaced tracks and secondary vertexes identification;
- refine missing transverse momentum reconstruction;
- help mitigating the effects of pileup;
- use looser HLT jet thresholds.



τ identification efficiency as a function of the offline τ p_T when applying the FTK selection (blue) and calorimeter clusters selection (red) at HLT.

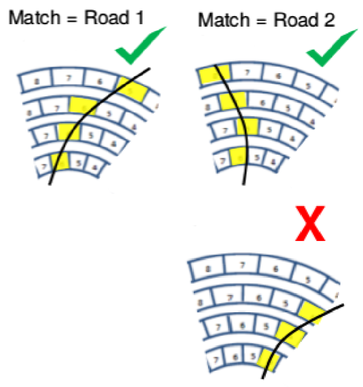
References

[1] Annovi, A. and others, "Design of a hardware track finder (Fast TracKer) for the ATLAS trigger" JINST (2014) no. 9, C01045
[2] FTK public results https://twiki.cern.ch/twiki/bin/view/AtlasPublic/FTKPublicResults
[3] Event display: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/EventDisplayStandAlone

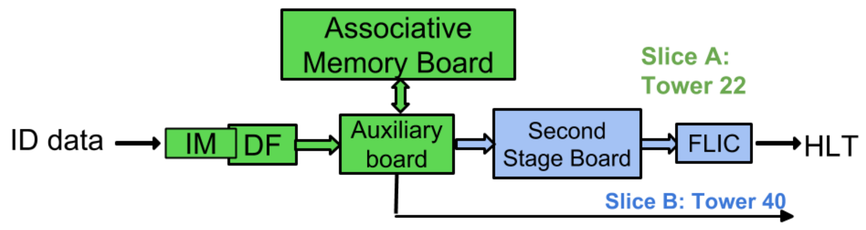
Hardware for the FTK System

The FTK system is highly parallelized: the detector is divided in 64 η x φ slices processed in parallel by **custom electronics boards** (FTK slice):

- **Input Mezzanine (IM)**
  - handles input from the ID and performs clustering.
- **Data Formatter (DF)**
  - distributes clusters to the FTK towers.
- **Auxiliary card (AUX) and Associative Memory Board:**
  - group hits into coarse resolution hits;
  - all possible track patterns have been determined from simulation and stored into **associative memory** (AM) chips;
  - AM chips compare hits to O(10^9) patterns simultaneously;
  - perform first-stage 8-layer track fit.
- **Second stage board**
  - receives data from the AUX and further hits from the DF and performs a 12-layers fit
- **FTK to Level-2 Interface Card (FLIC)**
  - converts data into the ATLAS format and send them to the HLT.



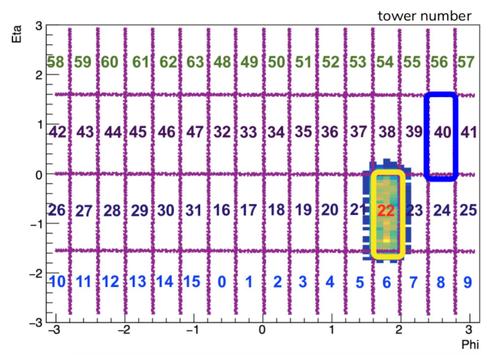
The full system is constituted by ~ 450 boards, 8k AM chips, 2k FPGAs.

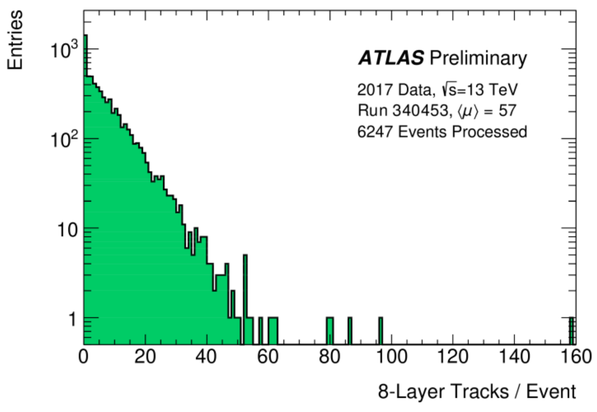


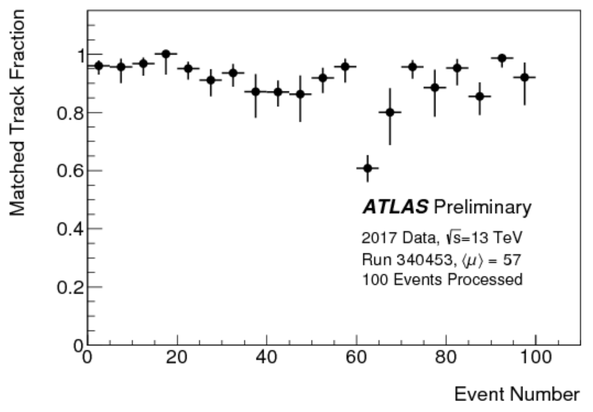
First data with FTK

The FTK system is under installation and commissioning.
Two test configurations available:
- **Slice A**: full FTK slice (tower 22) saving 12-layer tracks
- **Slice B**: AUX to HLT (tower 40): saving 8-layer tracks

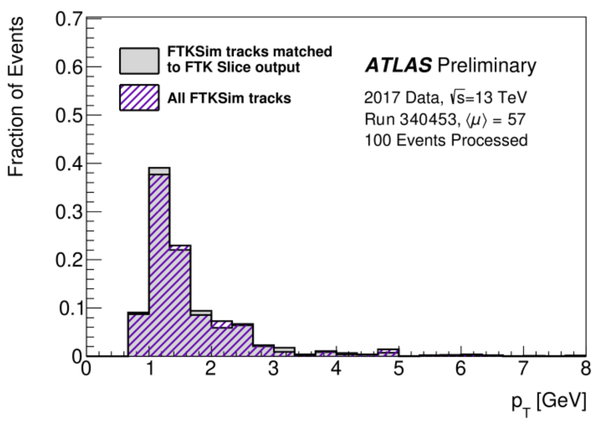
For commissioning FTK slices are prescaling on FTK trigger type

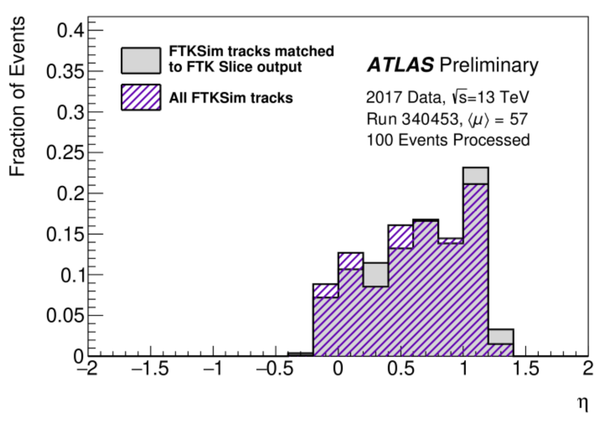






First look at 8L tracks produced with Slice B in 2017:
- the distribution of 8L tracks/event shows that FTK can handle high multiplicity events;
- 100 events have been compared to FTK simulation.





Plans for the future

Validate FTK so that HLT can trigger on its output in Run 3 (planned for 2021):

- evaluation of the performance of FTK with FTK data when available and use collected problematic events to debug the system(2018);
- deploy the "hemisphere" with half FTK coverage (2018);
- further validation and optimization with simulated data (2018-2020);
- validation of patterns by running with FTK simulation on data (2018-2020);
- install more FTK boards for Run 3 (2019-2020).