Vertex ’09 Workshop – 18/09/09

ATLAS Track Trigger for SLHC – Ideas & Plans

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Outline

- Trigger-DAQ challenges at 1E35cm^{-2}s^{-1}
- ATLAS Trigger-DAQ upgrade plans & ideas
- Motivation for Track Trigger
- Alternative designs and some results
- Conclusions

TDAQ challenges at 1E35$cm^{-2}s^{-1}$

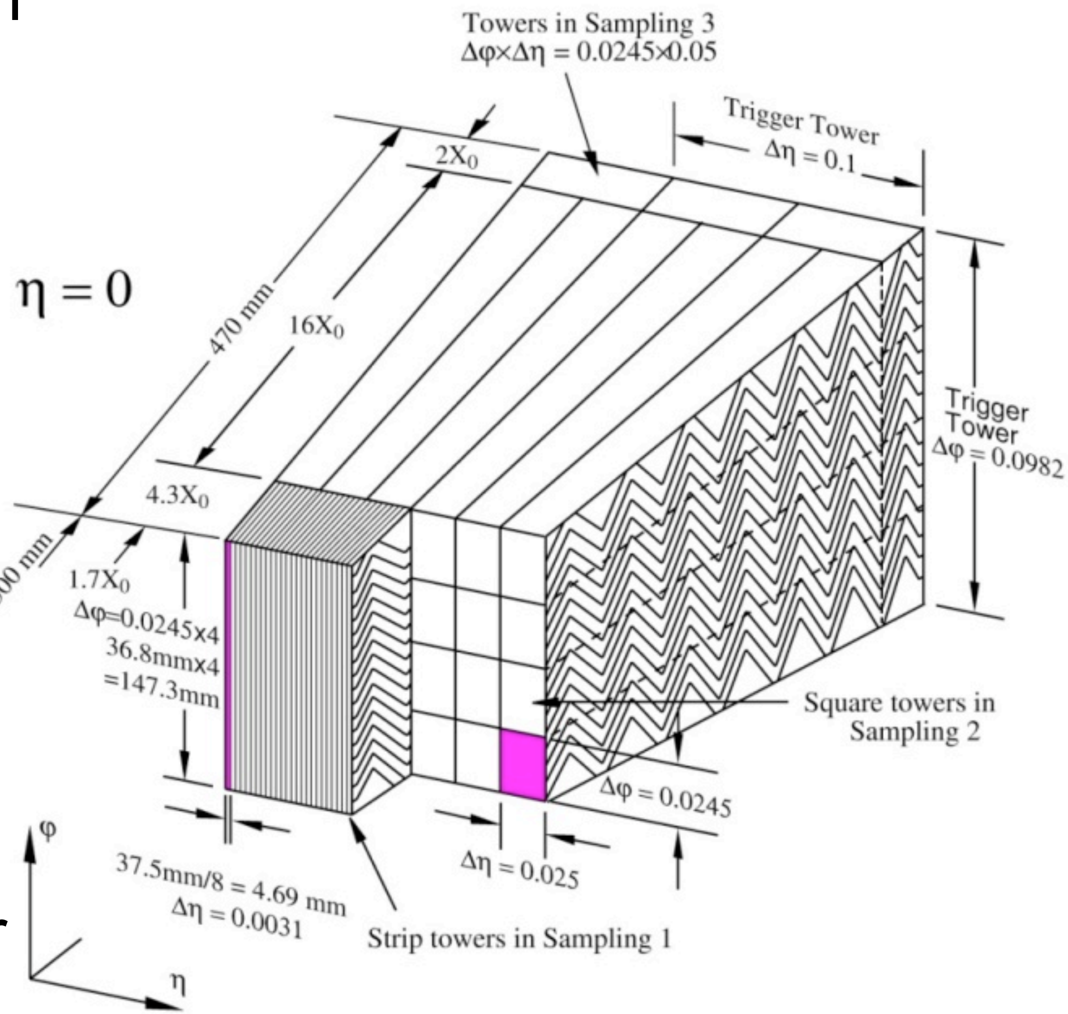
- Much higher occupancies ($hits/cm^2$)
  - Similar L1 rate as for LHC (~100kHz) requires ~10x higher bandwidth, esp. in tracker; (same argument for data transfer to Tier-0)
- 10x higher trigger rates (for same thresholds) and much more complex events
  - Pattern recognition will be a lot harder
  - L1 will have to use ideas from current HLT
  - HLT selections will have to become more exclusive
    - Inclusive $W \rightarrow e/\mu$ rates are a few kHz; cannot record all
  - Focus on reading out from the detector physics events with the highest purity

ATLAS TDAQ upgrade plans

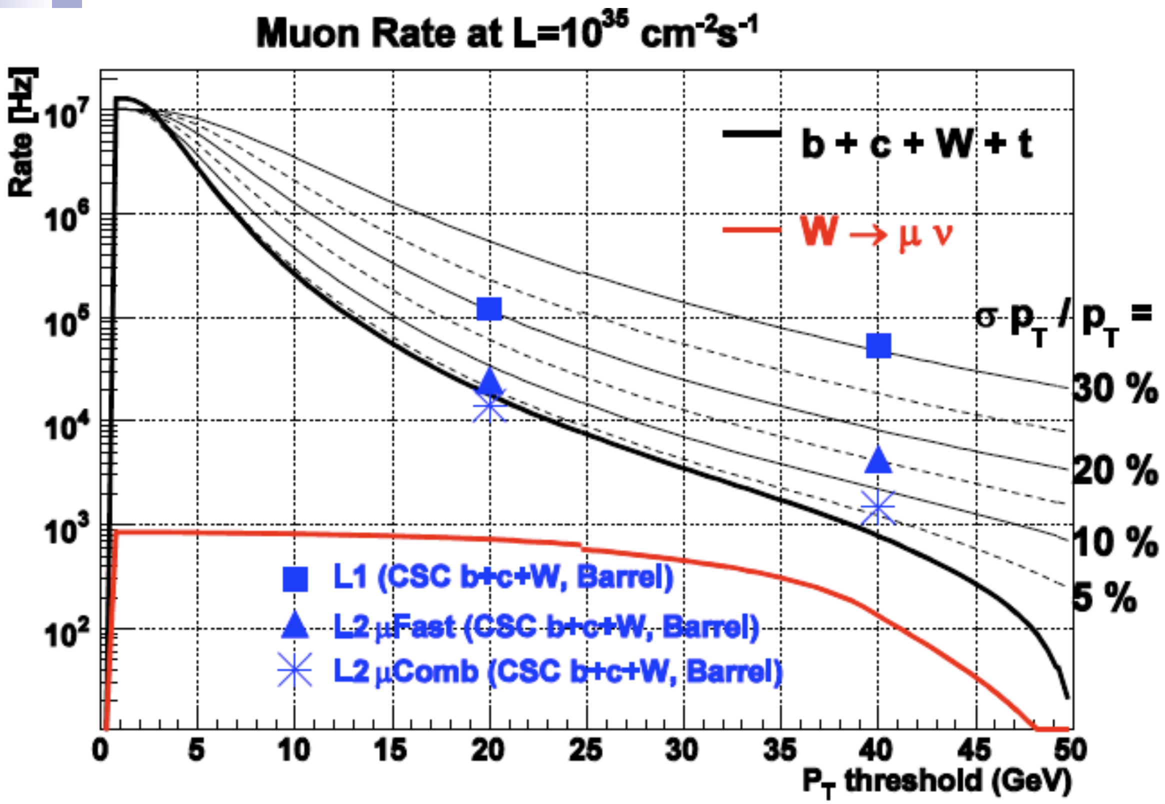
- Plan to completely redesign L1 system
  - L1Calo: will have access to full Calo granularity
    - Calorimeters plan on-det digitization & full readout at 40MHz (rate: 160Tbps!)
  - L1Muon: investigating installation of additional chambers for sharpening muon pT thresholds
  - L1Track: investigating potential benefits and alternative technologies
  - Global Trigger Processor: more than thresholds
    - Features from L1Calo/Muon(/Track) combined for final L1 decision, using similar ideas as in current HLT

L1Calo – Phase II upgrade

- Current L1Calo uses 0.1x0.1 (η,ϕ) trigger towers
- For the upgrade:
  - finer calorimeter resolution (minitowers) for feature identification
  - different handling of em & hadronic towers?
  - EM shower depth profile (LAr samplings)
  - Implement HLT techniques at Level-1
- Strips of $\Delta\eta$=0.003 in 1st LAr sampling essential for rejecting π^0s and photon conversions



L1Muon – Phase-II upgrade



- Curves are physics x-section convoluted with pT resolution
- Blue points are full simulation extrapolations from lower lumi

- L1 rate for MU20 >100kHz, for MU40 >50kHz
  - Estimate does not include cavern background nor charged π/K decays in flight, hence it is a lower bound
  - Driven by pT resolution
- Studies underway to evaluate if new or additional chambers can help sharpen the L1Muon pT resolution
  - Some endcap chambers would have to be replaced anyway (high occupancy)

Motivation for Track Trigger

- L1 MU20 rate >100kHz, L1 E30 rate >200kHz
  - Both lower bounds, since they are extrapolations from lower luminosities
    - Improved L1Calo will have to fight worsening isolation
    - Improved L1Muon will have to fight higher combinatorics
- Tracker is the only other source of info for L1
  - We know from current L2 that track matching to Calo or Muon objects is key for the L2 rate reduction
  - Track Trigger can provide the much needed extra flexibility and redundancy (hence robustness) to L1
    - It will allow z0-matching for multiple trigger signatures
    - Track-based isolation maybe vital for e/μ/τ triggers at 1E35

Comments about TT in ATLAS

- Not necessary to use layers close to beam line
  - Fine η segmentation of 1st Lar sampling effective in rejecting pi0s and photon conversions
- Mainly looking for high pT (>~10GeV) e/μ(/τ)
  - Pattern recognition easier/faster

    (Unless track-based isolation proves to be essential!)
  - Modest track parameter resolutions are sufficient
    - η, ϕ, z0 also useful for matching with Calo/Muon objects
- Increase of material in tracker should be small
  - Benefits from track trigger should be bigger than any loss of Calorimeter and tracking performance

Track Trigger: Alternative designs

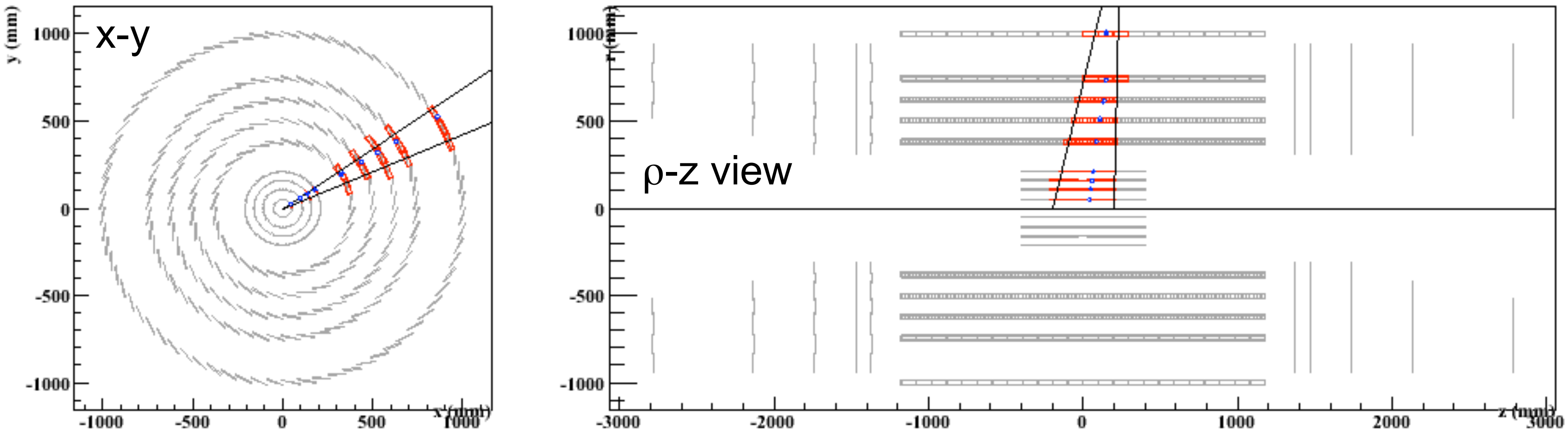
- Not realistic to perform full readout at 40MHz
  - Ideas for minimizing the amount of data needed for the track trigger are being investigated

1. Standalone TT, based on coincidences between closely-spaced pairs of silicon layers
   - Layers are electrically connected
   - Coincidence logic satisfied only by high-pT tracks
   - Coincidences are read out at 40MHz & processed off-detector

2. Regional tracker readout driven by L1Calo/L1Muon
   - L1Calo/Muon reduce the rate from 40MHz to ~400kHz
   - They identify a few (~4) Regions of Interest (RoI) & send readout requests only to tracker modules inside RoIs
   - Only a few % of tracker is targeted (400kHz x 5% = ~20kHz additional equivalent rate)
   - But regional data must come out fast

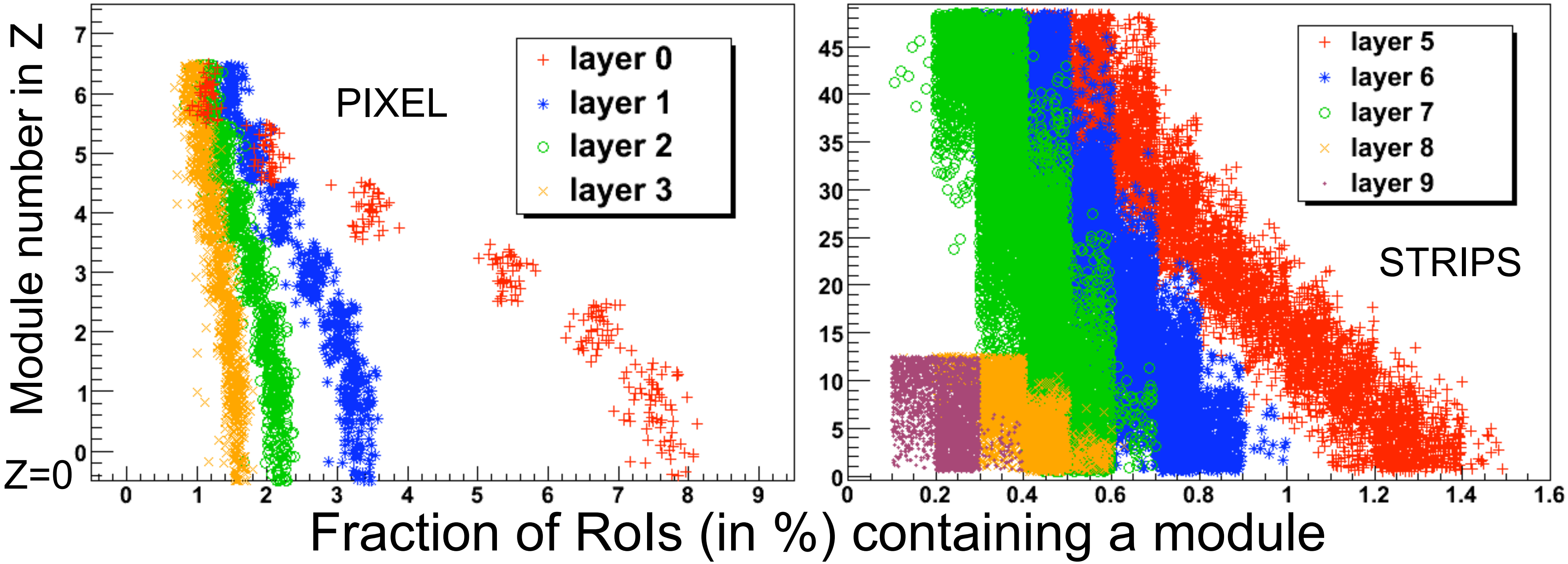
RoI characteristics

RoI: $\Delta\phi$=0.2, $\Delta\eta$=0.2 at Calo Δz=40cm at beam line



- A typical lepton RoI
  - Contains about 1% of the tracker modules
  - Needs to be wider in z near the beam line to allow for the spread of the interaction region

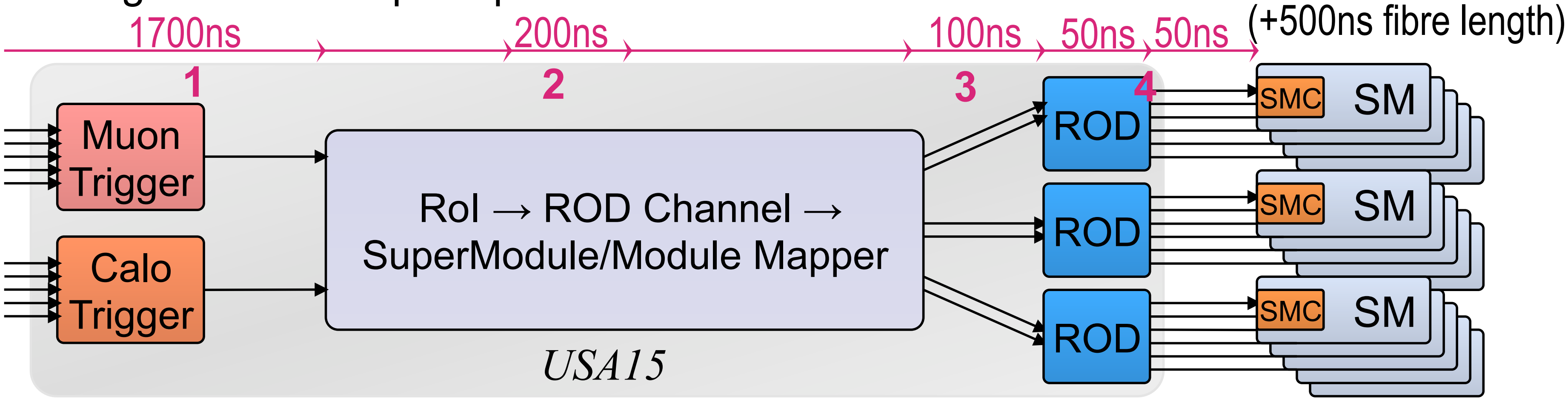
How often a module in an RoI?



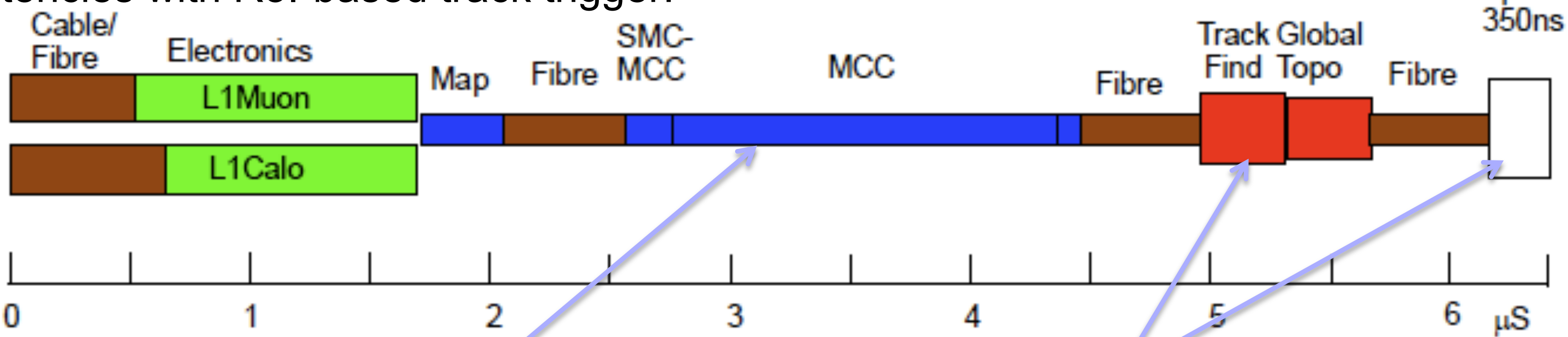
- Central modules in layers near the beam line are more frequently inside an RoI
- Work ongoing to determine how many layers are adequate for pattern recognition

Regional readout hw & latencies

The regional data request path:



Latencies with RoI-based track trigger:



Module readout the slowest part

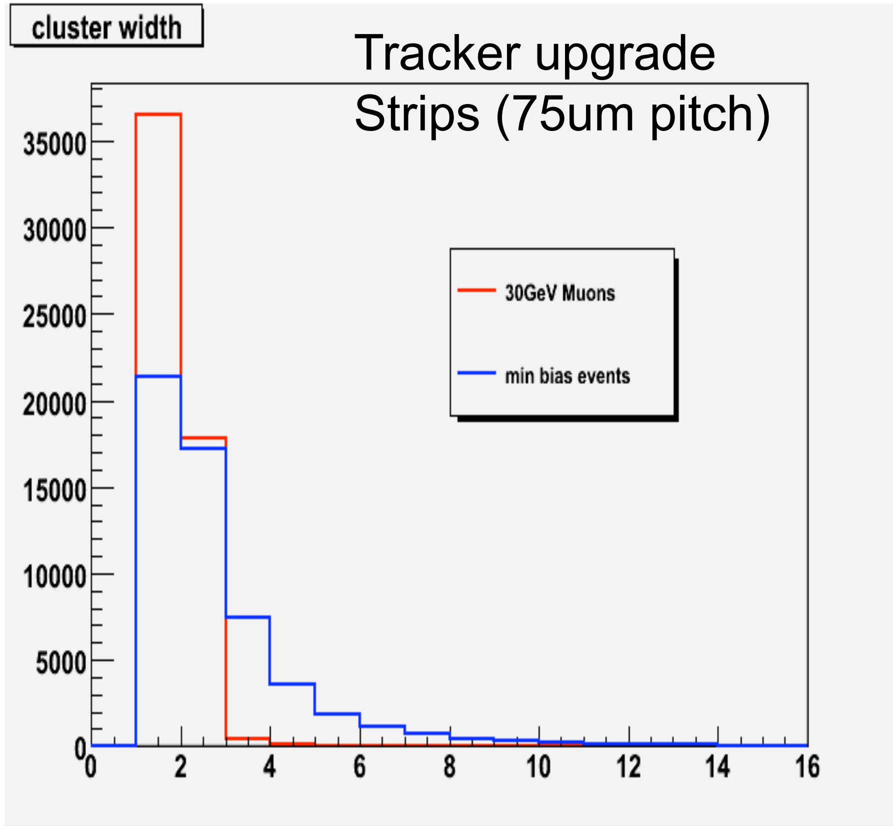
May or many not fit within 6.4us (next slide)

Regional readout alternatives

- Within the L1 latency (L0/L1 approach)
  - Targeted tracker data are taken from the middle of the L1 pipelines at L0, and track trigger processing fits within the remaining L1 latency
- Outside the L1 latency (L1/L1.5 approach)
  - On a L1-Accept, the data move from pipelines to on-detector buffers
  - The L1.5 decision (coming some -10s of?- μs after the L1 latency) determines whether the data are cleared or readout
- Currently investigating the feasibility, robustness and cost-effectiveness of each approach

On-detector data reduction

- Whatever the choice, we want to minimize the bandwidth for track trigger
  - Exploring possibilities for reducing/fixing the bits per chip/module
  - Clustering on the FEs and sending only central strip address
    - Reduction by a factor ~2
  - Reject wide clusters if only looking for high p_T tracks
    - Reduction ~30%



Summary – Outlook

- The ATLAS L1 Trigger will have to be entirely redesigned for 1E35cm^{-2}s^{-1}
- A lightweight hardware Track Trigger could strengthen the triggering capabilities of ATLAS, hence its physics potential, at SLHC
- First feasibility studies underway with positive results; the RoI-based track trigger appears feasible
- We expect a lot more results in terms of the benefits and optimal architecture for the ATLAS track trigger by the ATLAS Upgrade Letter-of-Intend next year