Potential Trigger Improvements with FTK at ATLAS

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Overview

- Thank you to Tova for nice overview of FTK!
- This talk will:
  - Give an overview of the baseline improvements to searches with FTK
  - Present some ideas about how to improve triggers used for LLP searches using FTK
  - Start a discussion about how we can expand the use of track triggers to tailor to LLP searches

The Fast TracKer (FTK)

- FTK is an upgrade to the trigger system that will reconstruct all tracks in all events passing the L1 trigger before the High Level Trigger
- Tracking in the trigger has two broad advantages:
  - Mitigate of the effects of pileup
    - Helps reconstruct **MET**, improves jet resolution, etc
  - Identify particles with track based signatures
    - Notably, **b-jets** and **taus**.
- The above are arguably the most limited in ATLAS' current trigger system and are central to many searches for new physics

Sampling of Current Trigger Limitations

- Combinatoric challenge of tracking means it is CPU intensive and can only be done in Regions of Interest (ROIs) seeded by the L1 trigger
- Limitations:
  - Size of ROI
    - e.g. for taus, HLT performs track reconstruction in ROI $\Delta\eta \times \Delta\varphi = 0.4 \times 0.4$

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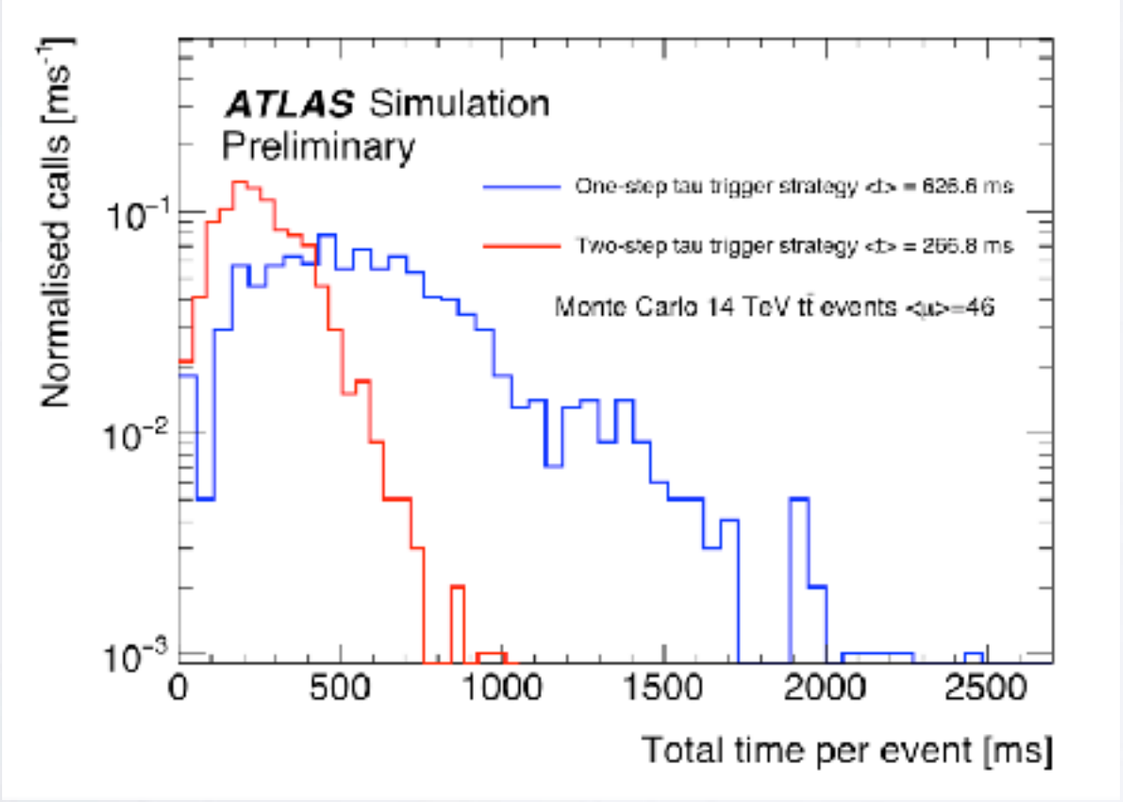
  - Number of tracks that can be reconstructed (speed of track reconstruction algorithm)



88 % of time used for tau trigger in HLT spent on tracking!

lots of potential for time saved with free tracks!!!

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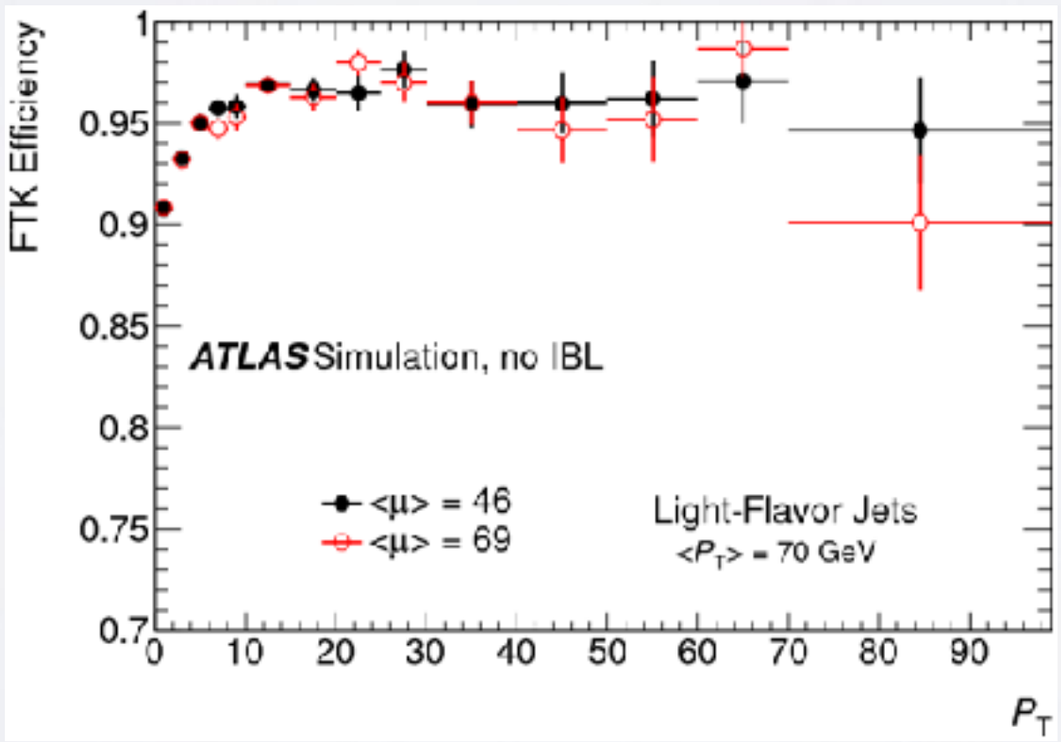
Tracking uses a lot of the CPU of the HLT.

Having all tracks at the start of the HLT gives us more freedom in our event selection

Baseline FTK Improvement

FTK reconstructs all tracks in all events passing L1 trigger in ~.1 ms

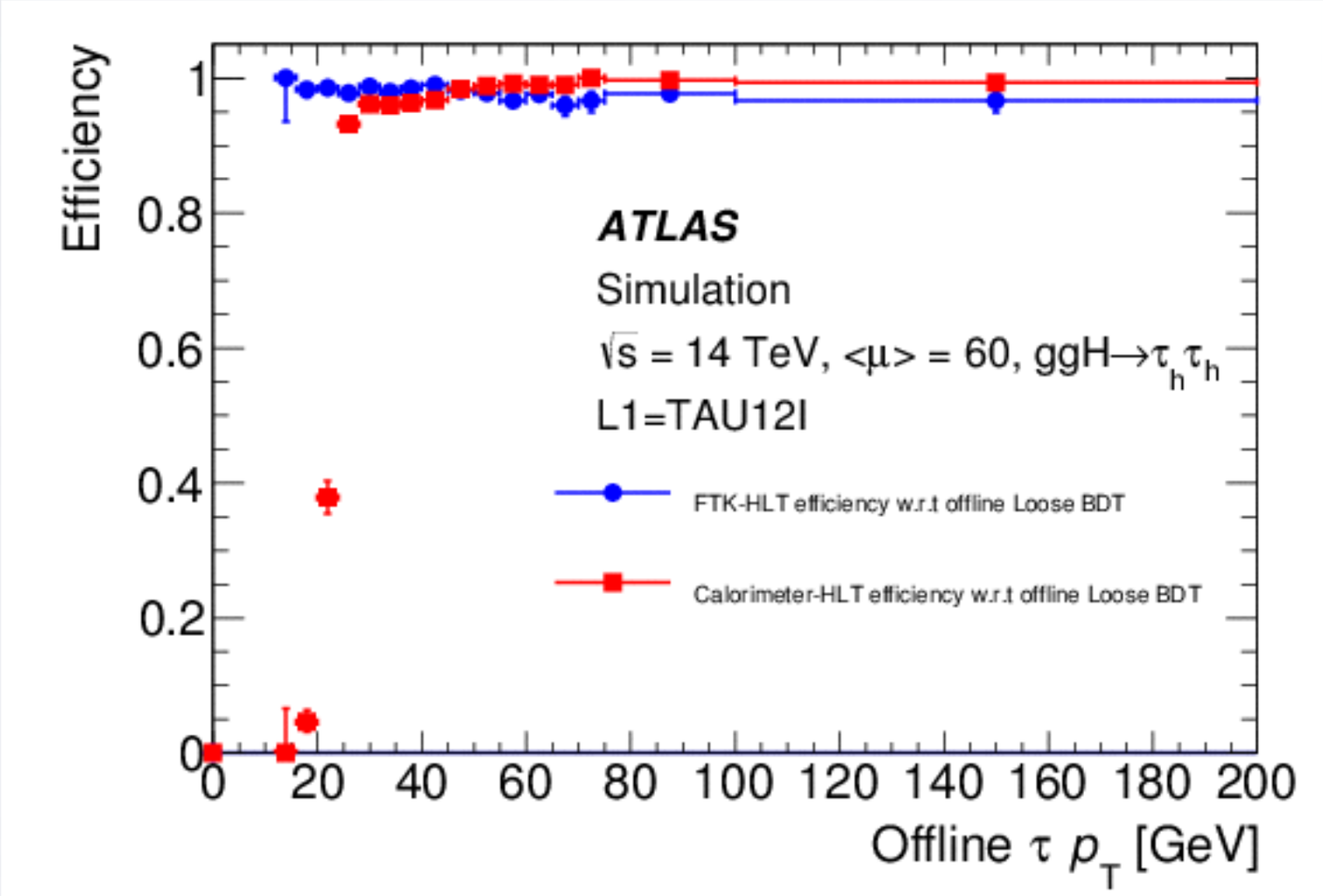
- What do we get for free from FTK?
  - Tracking information for **lower p_T** objects down to track p_T > 1 GeV
    - Allows us to make better decisions within HLT rate constraints
  - More detailed **structure** information to use during object energy calibrations
  - Free up **CPU** for other calculations, not necessarily related to tracking



Good efficiency even at low p_T!

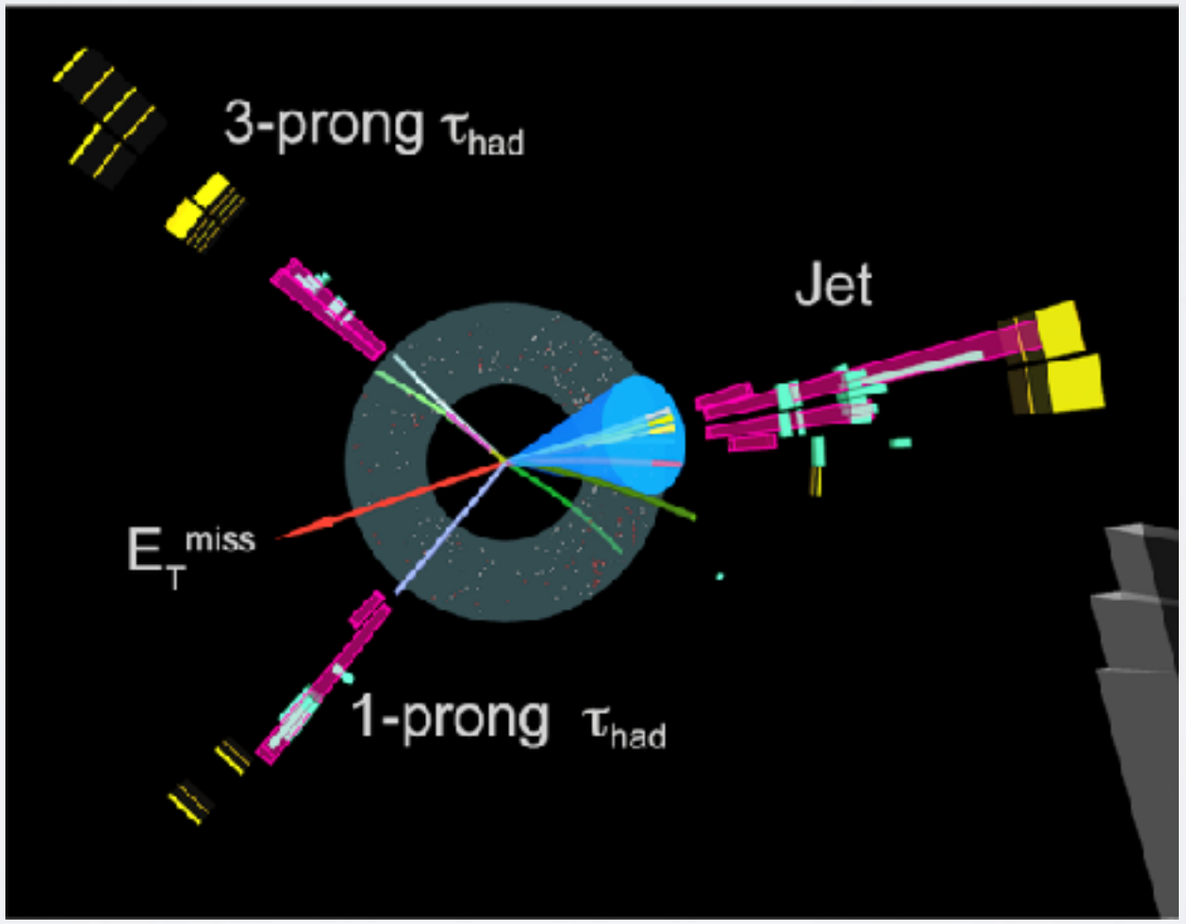
Example: Tau Triggers

- Blue shows improvement to tau turn on curve with FTK
- Primarily limited by L1



Baseline FTK Improvement

- Use tracks to identify specific topologies in HLT
  - FTK gives us the ability to easily identify to the primary vertex and associate objects to it
  - For example, devise a ditau selection based only on track signature
  - Only limited by L1 efficiency

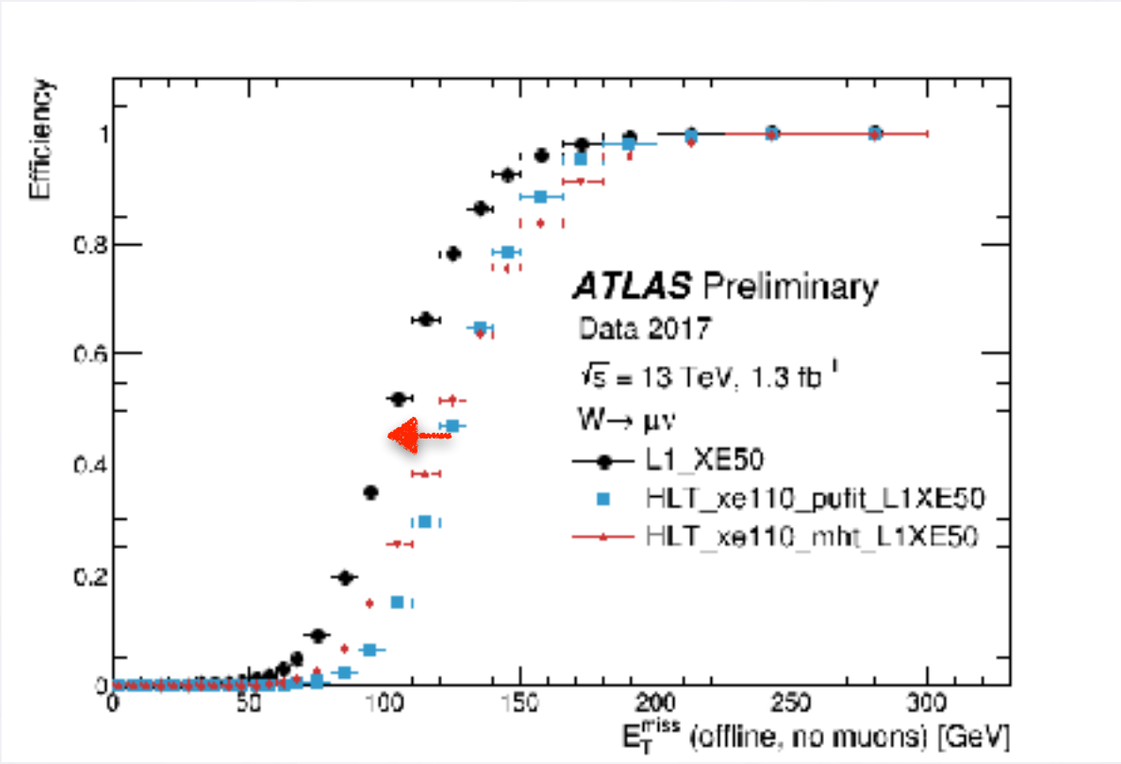


currently no simple ditau trigger!

require ditau+jets

Using Other L1 Seeds

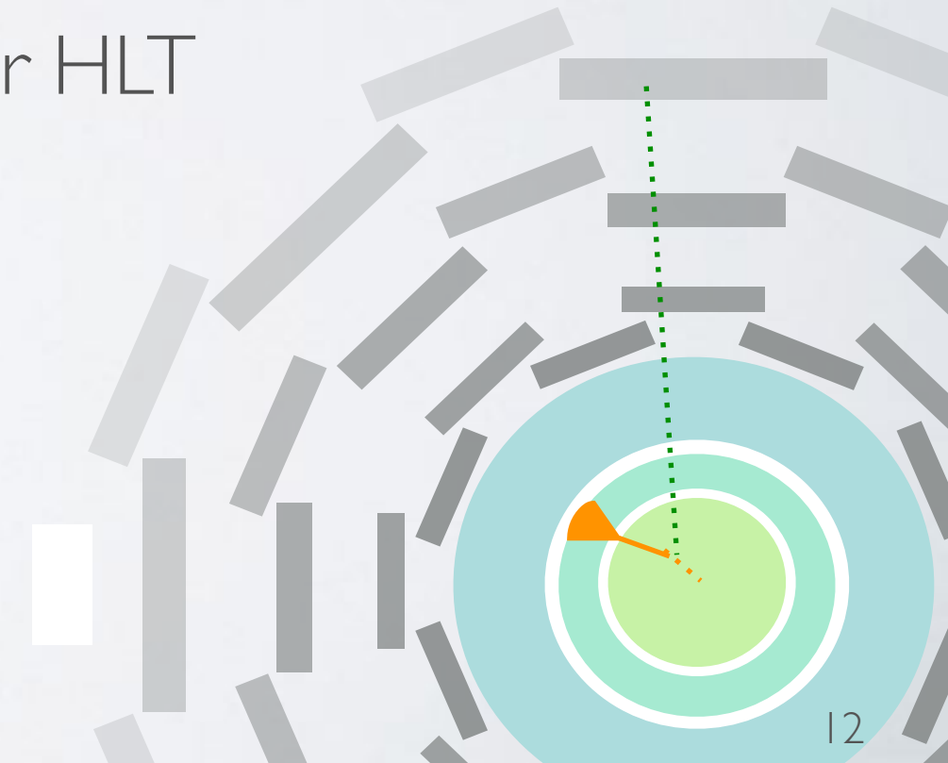
- Can use a different L1 trigger in an analysis to gain sensitivity where we previously had none
- Example:
  - 30-ns R-hadron search where signature is MET + high p_T isolated track
    - L1 MET trigger, HLT track trigger
  - Trigger on track, MET calculation will be uncorrelated with track
  - Get free (limited) sensitivity in region between L1 and HLT



What if the FTK pattern bank includes displaced particles?

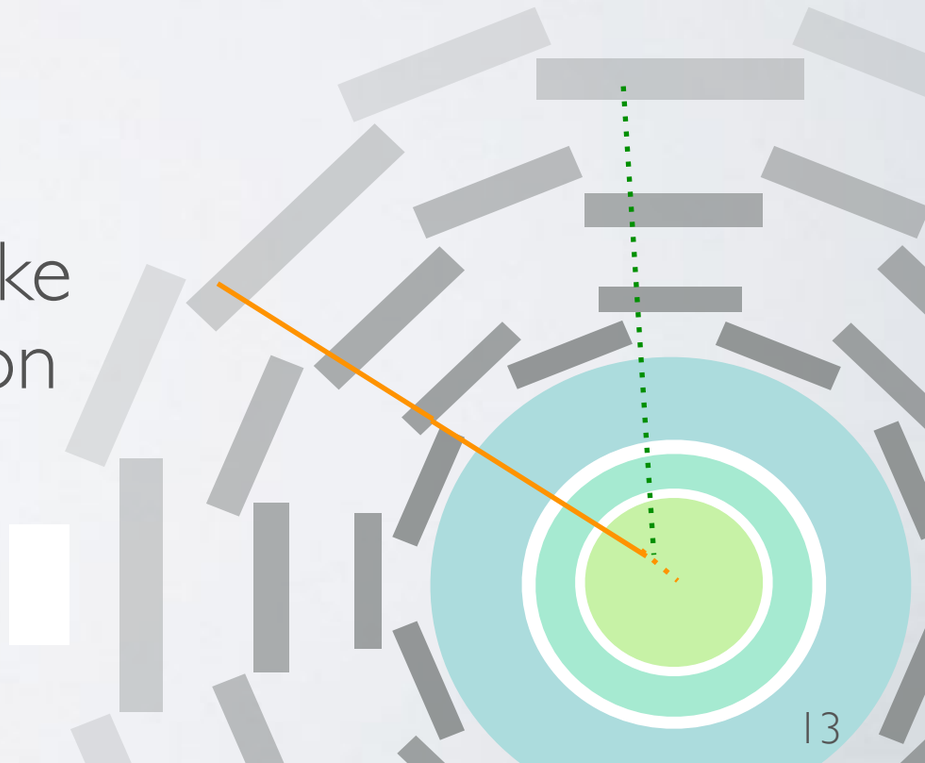
Displaced + Electrons

- Current prompt single electron selections:
  - Level 1: p_T > 22 GeV
  - HLT: p_T > 60 GeV
- For LLP searches, use photon trigger
  - Level 1: p_T > 22 GeV (same as electron)
  - HLT: p_T > 140 GeV
  - More fakes in photon trigger → increased rate → higher p_T threshold
- Use FTK to identify displaced track, no longer HLT rate limited
  - Get down to prompt electron p_T threshold!



Displaced + Muons

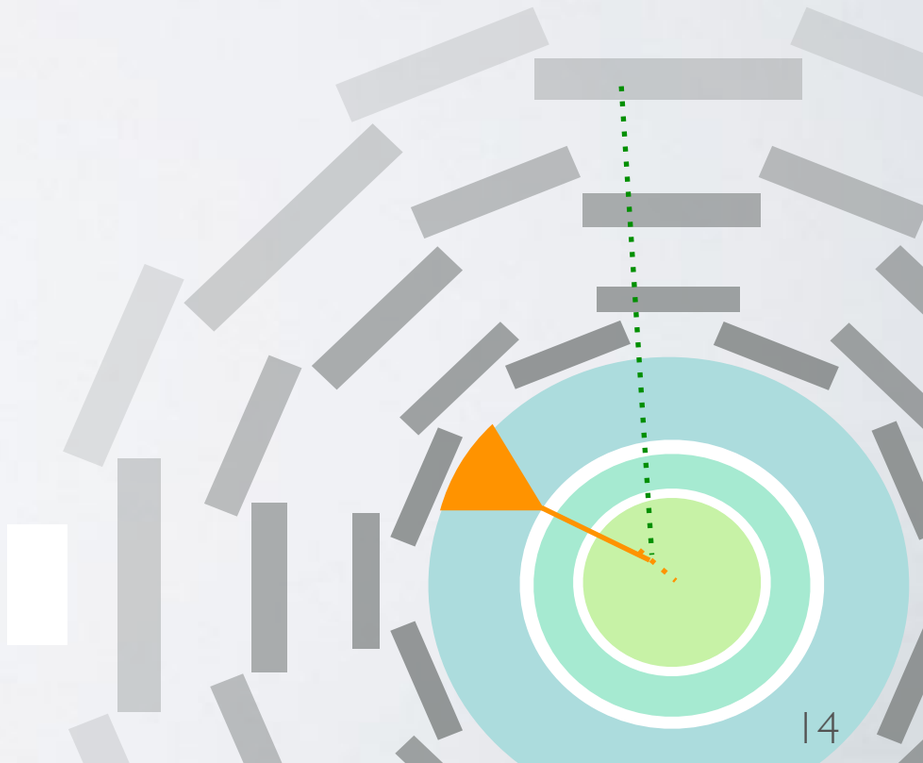
- Current prompt dimuon selections:
  - Level 1: 2 objects p_T > 15 GeV
  - HLT: 2 objects with p_T > 14 GeV
- For LLP searches, use "muon spectrometer only" trigger
  - No dimuon trigger!
  - Single muon spectrometer only
    - L1: p_T > 20 GeV
    - HLT: p_T > 60 GeV (vs p_T > 26 GeV with track)
    - Only in barrel region
- Use FTK to identify displaced track, reduce fake rate and create a more robust trigger selection



Displaced + Jets

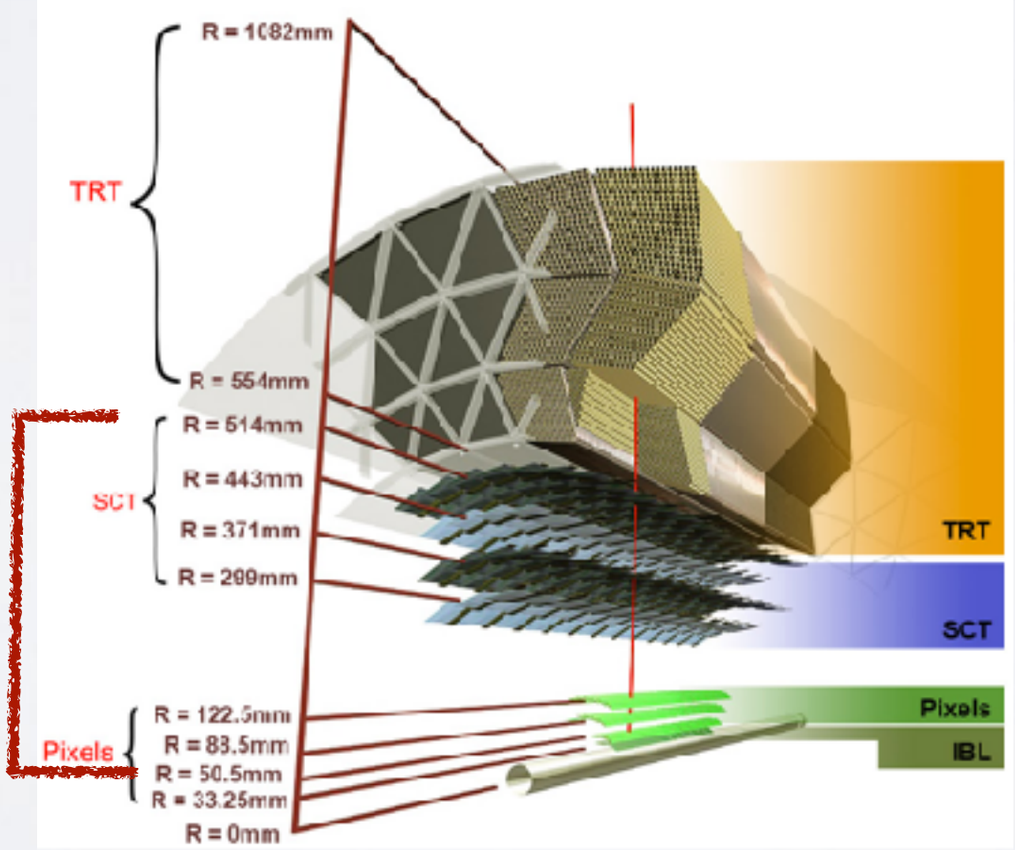
- Currently just use multijet triggers
- No displaced specification possible

- Easy to imagine trigger with displaced identification from FTK tracks which uses same L1 multijet seed to dramatically decrease rate!



Limitations

- Final track fit of FTK requires 10/12 Pixel+SCT layers to have a hit
- So sensitivity limited to particles which decay within roughly 44 cm (~1.5 ns)
- More detailed studies would have to be done to understand real gains and new regimes for LLP searches
- See Tova's talk for more details on this



Conclusion

- FTK has the ability to improve searches broadly, so of course this propagates through to LLP searches
- Many more refined possibilities to be explored
  - Adding displaced vertex/displaced track signatures into FTK pattern banks
  - Using FTK tracks to improve current HLT triggers or devise new ones
  - Be creative with trigger requirements in analyses to gain new sensitivity with access to global track reconstruction

Let's brainstorm how we can use FTK and the trigger to improve LLP searches!

Backup

Sampling of Current Trigger Limitations

	Level 1 Selection	HLT Selection	Offline Selection
Single tau	60 GeV	160 GeV	170 GeV
Single b	100 GeV	225 GeV	235 GeV
Two b	100 GeV	150, 50 GeV	160, 60 GeV
MET	50 GeV	110 GeV	200 GeV

High HLT selections vs L1 selection