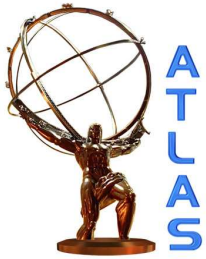


New Trigger Capabilities with FTK

John Alison

University of Chicago

Outline

- Reminder of Current Trigger Scheme
- FTK: Track Trigger Upgrade
- *Physics in the Pile-up*
- Potential applications for exotics Higgs

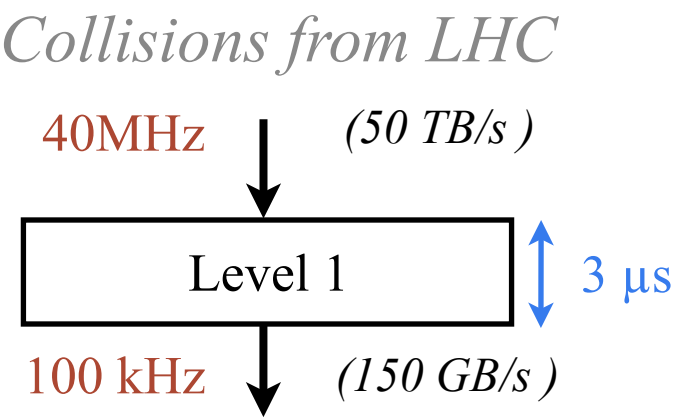
Triggering in ATLAS

- LHC provides orders of magnitude more collisions than can save to disk.
- Interesting physics is incredibly rare: (Higgs ~ 1/billion)

Current ATLAS Trigger system

Level-1

- Keeps 1/400 input events in ~3 μs
- Custom hardware.
- Decisions using Calo/Muon detectors
- Defines *ROI*. Narrow η-φ segments



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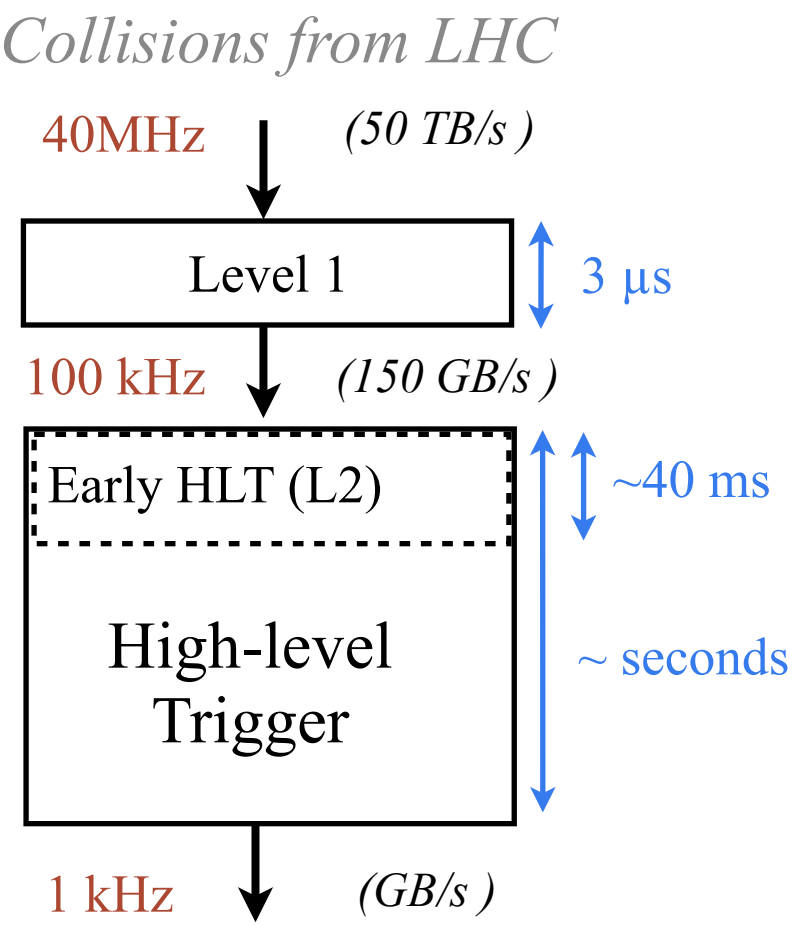
High-Level Trigger

- Keeps 1/100 events which pass L1.
- Adds tracking information
- Processing seeded on L1 *ROIs*
- 2 reconstruction flavors
  Quick and Coarse / Offline-quality



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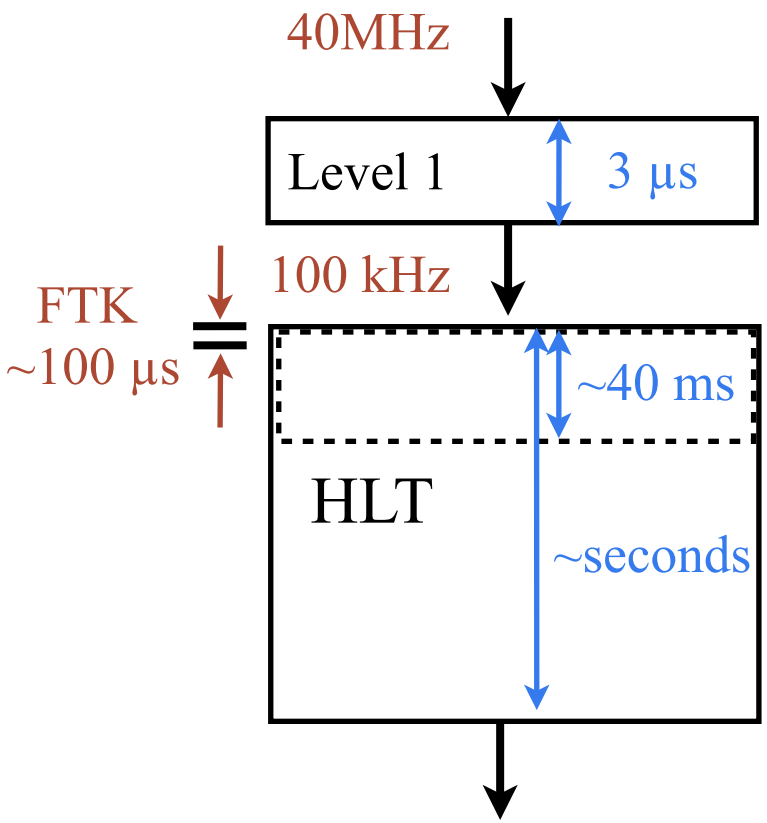

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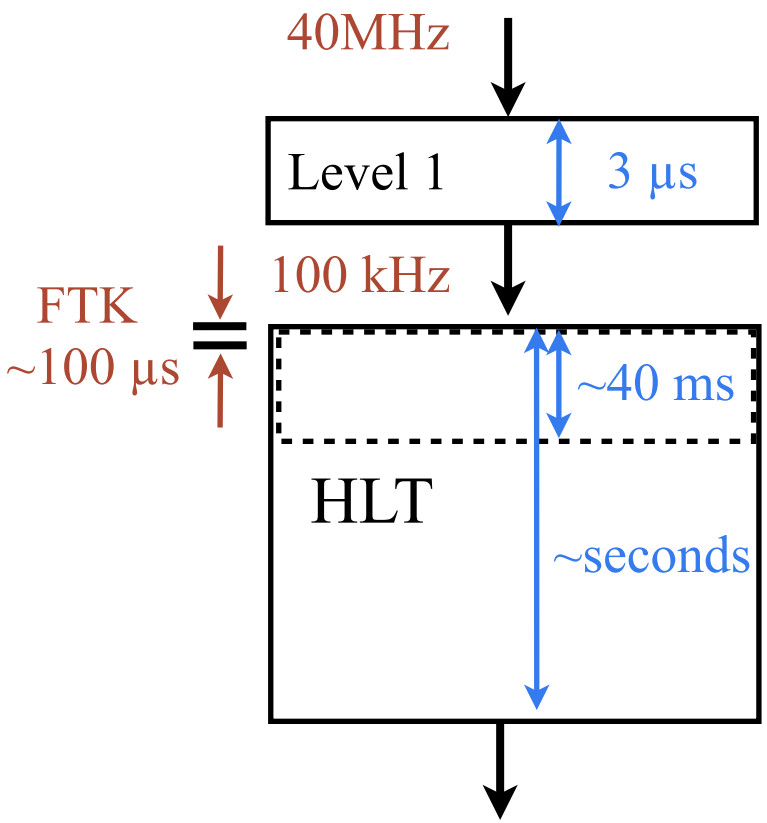

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- Full-scan event tracking w/Si detectors
- No reliance on L1 ROI
- Track finding (*baseline*):
  - P_T > ~1 GeV / |d0| < 2 mm / |z0| < 110 mm
  - 5 track parameter / list of hits / $\chi 2$ estimate
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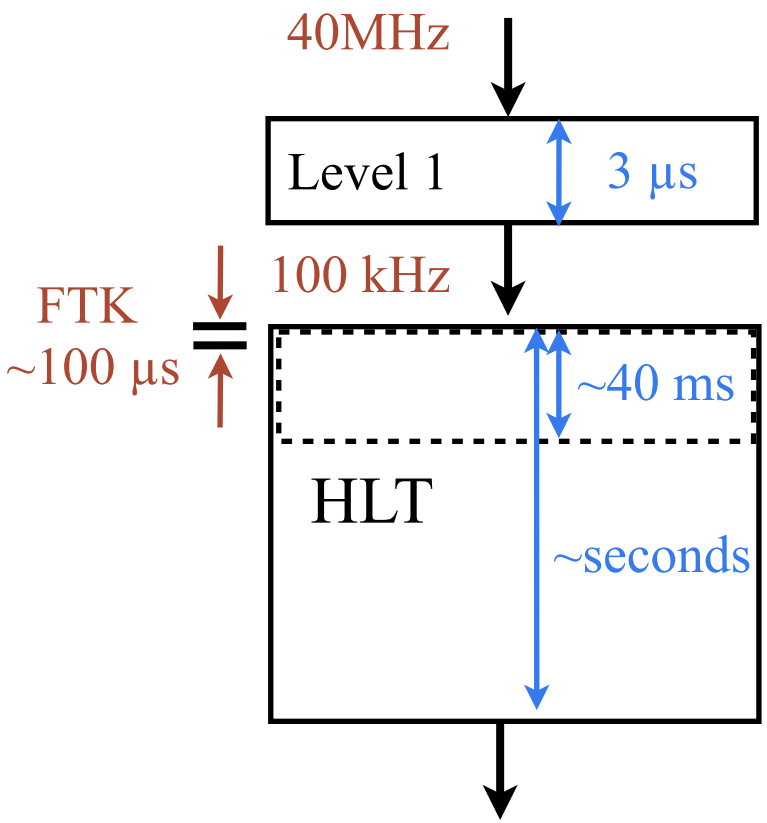

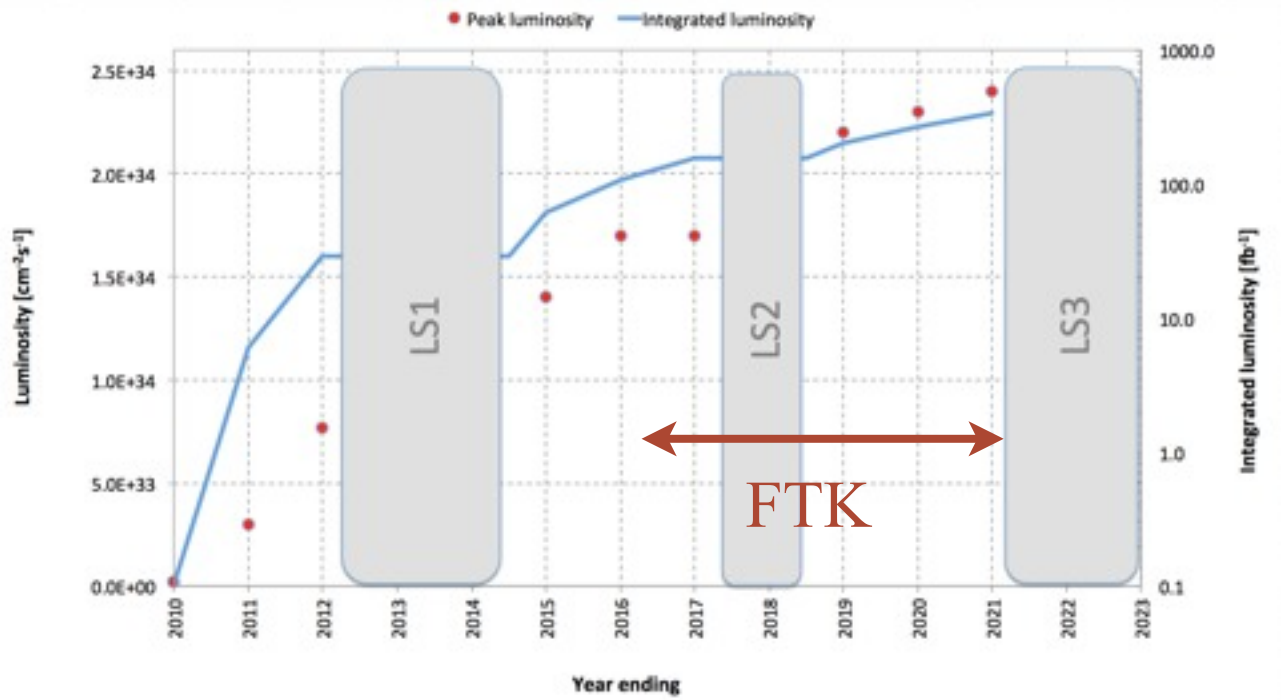

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FTK: Role in ATLAS Trigger.

-) Enhancing Current Trigger:

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Focus of rest of the talk.

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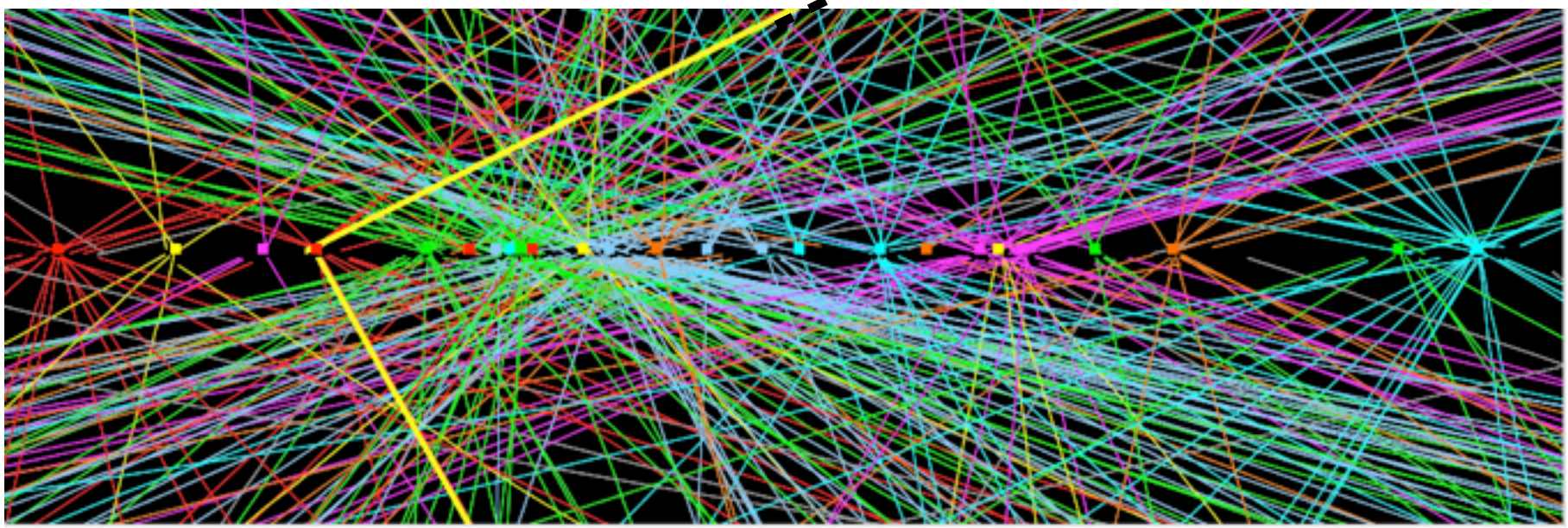

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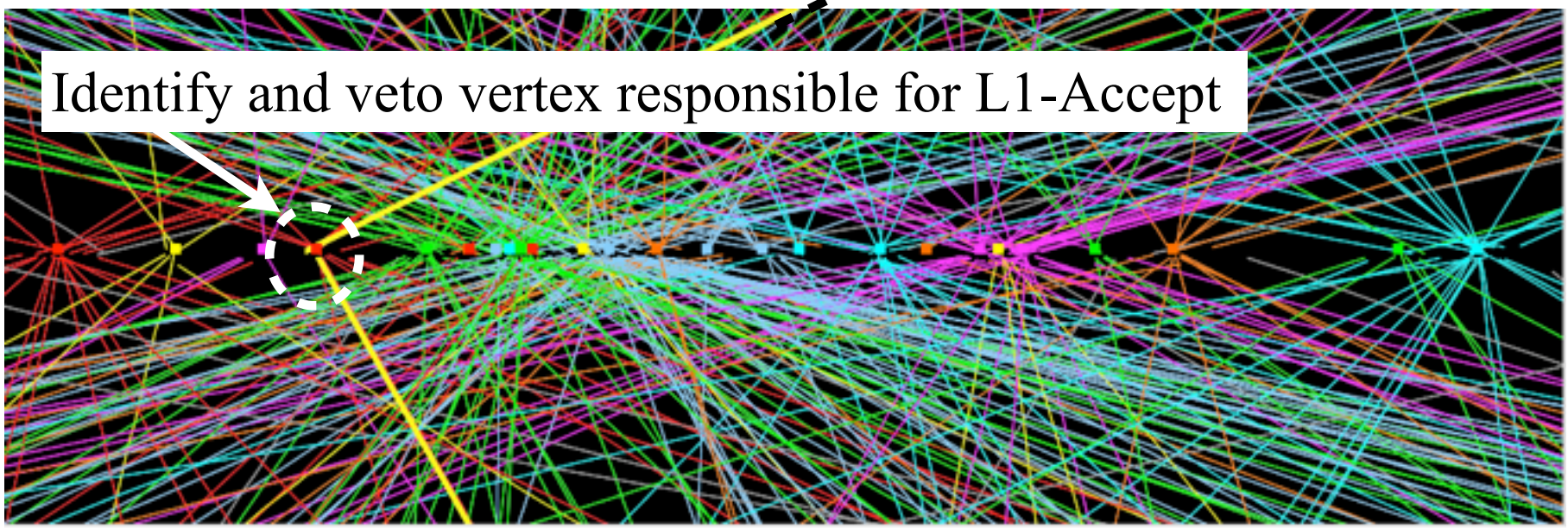

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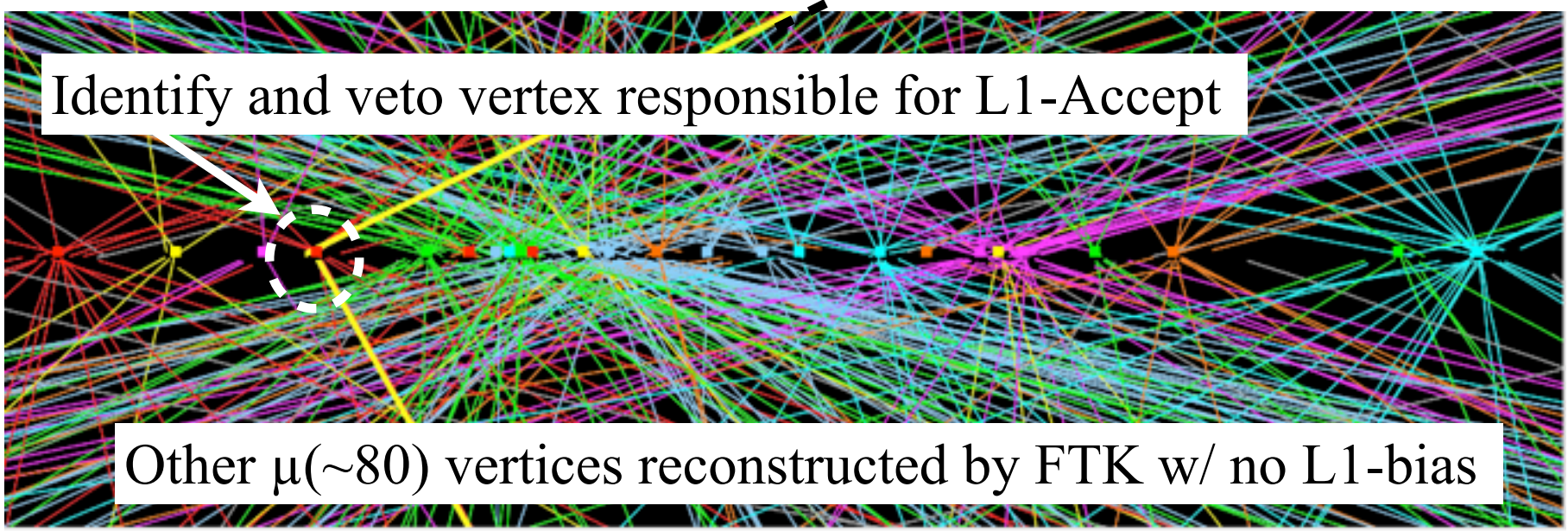

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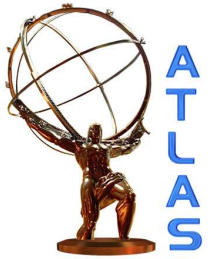

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unbiased pp collisions at $\mathscr{L} \sim (1/400) \times 3 \cdot 10^{34} \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$

Effective pre-scale from L1-accept

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Rules of thumb:

Start winning when competing with:

ATLAS/CMS searches/measurements w/ $\varepsilon_{L1} < 1/400.$

LHCb searches/measurements w/ $\varepsilon_{L1} < 1/8.$

FTK: For Exotic Higgs

- *Physics in pile-up* near-miss for exotic higgs.

- $h \rightarrow$(soft tracker activity) can live off $W(\ell\nu)h$ production

  $\sigma(Wh(\rightarrow l\nu)) \times \text{Acceptance}(50\%) / \sigma(ggF) \sim 1/300$ (> 1/400)

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- For exotic higgs, advantage in paring FTK with L1 items.
  eg: -) L1_VBF jets: VBF + ($h\rightarrow$(soft))
  -) L1_MeT: $Zh\rightarrow(\nu\nu$+soft)
  -) L1_EM: ggF $\rightarrow h\rightarrow \gamma$(soft) *(eg: $h\rightarrow\gamma\varphi$)*
  -) L1_Lepton: $W(\ell\nu)h$ when single ℓ pre-scaled in HLT

Ideas for Tracker Activity

- Track Multiplicities.
  - N(tracks) > XX GeV
  - N(isolated tracks) > Y GeV

- Track jets: (B-Tagging/ 3-prong τ-tagging (?))

- Charged particles resonances

- Displaced vertices ???
  - Baseline Tracking |d0| < 2mm
  - Can potentially extend with limited efficiency.

- Others ???

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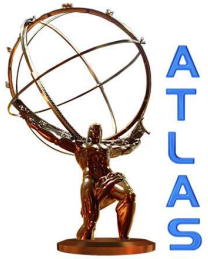
Should Target:
- Output rate O(10 Hz)
- HLT rejections of:
  - 10e4 @ full L1 output rate
  - 10e3 w/L1 item ~10kHz

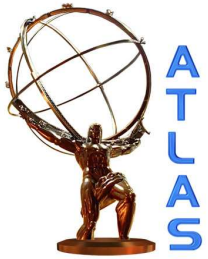


Conclusions

- Adding triggering capabilities,
  changes potential physics reach.

- FTK will reconstruct an enormous **unbiased** *pp* dataset
  - Rate ~3 orders of magnitude larger than Run1.

- Potential opportunity for signals w/little-no L1 signature



Backup

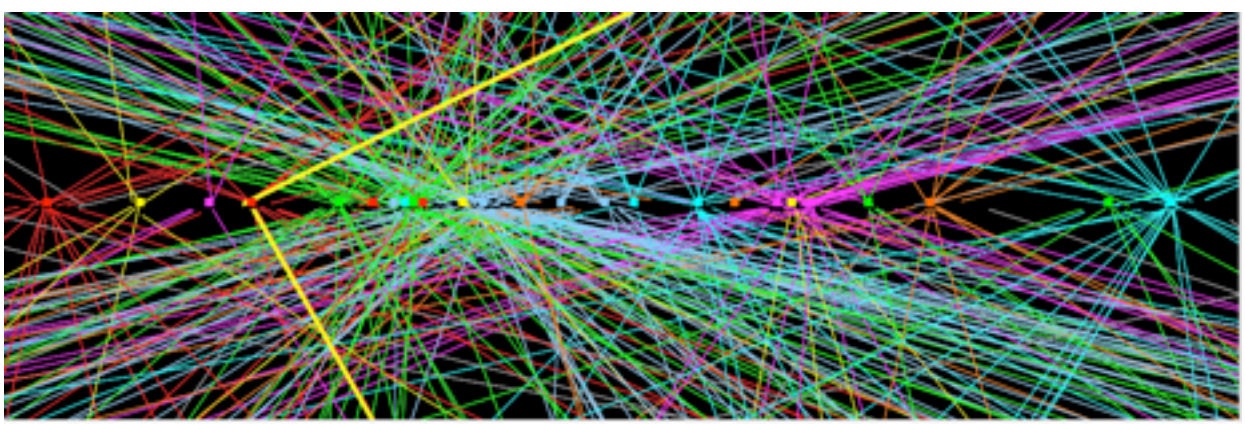
LHC Run 1 Legacy

- Found the Higgs.

- Excluded simplest *expected* SM extensions.

- Excluded even more *unexpected* extensions to the SM.

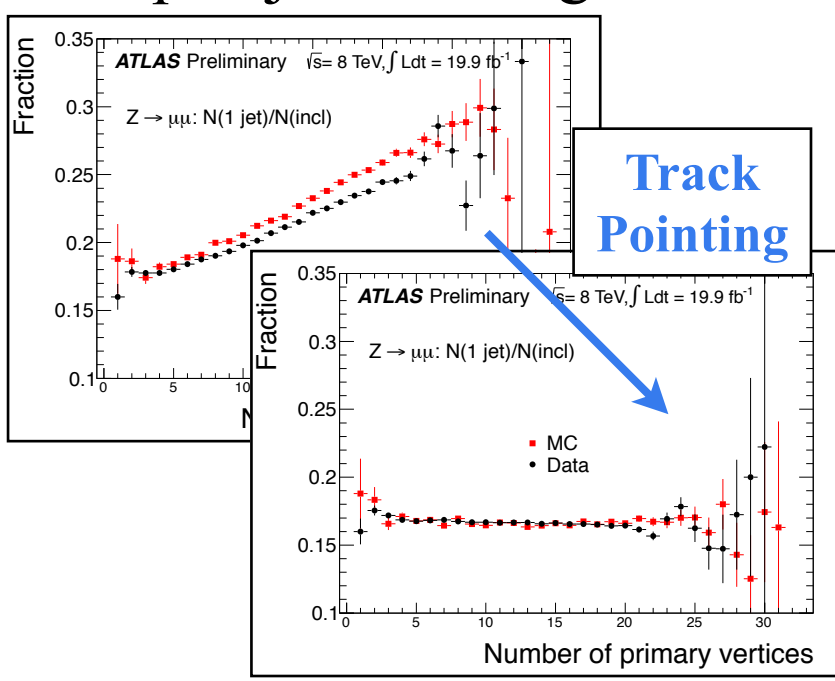
- Learned how to live with pile-up ...



... use the tracker.

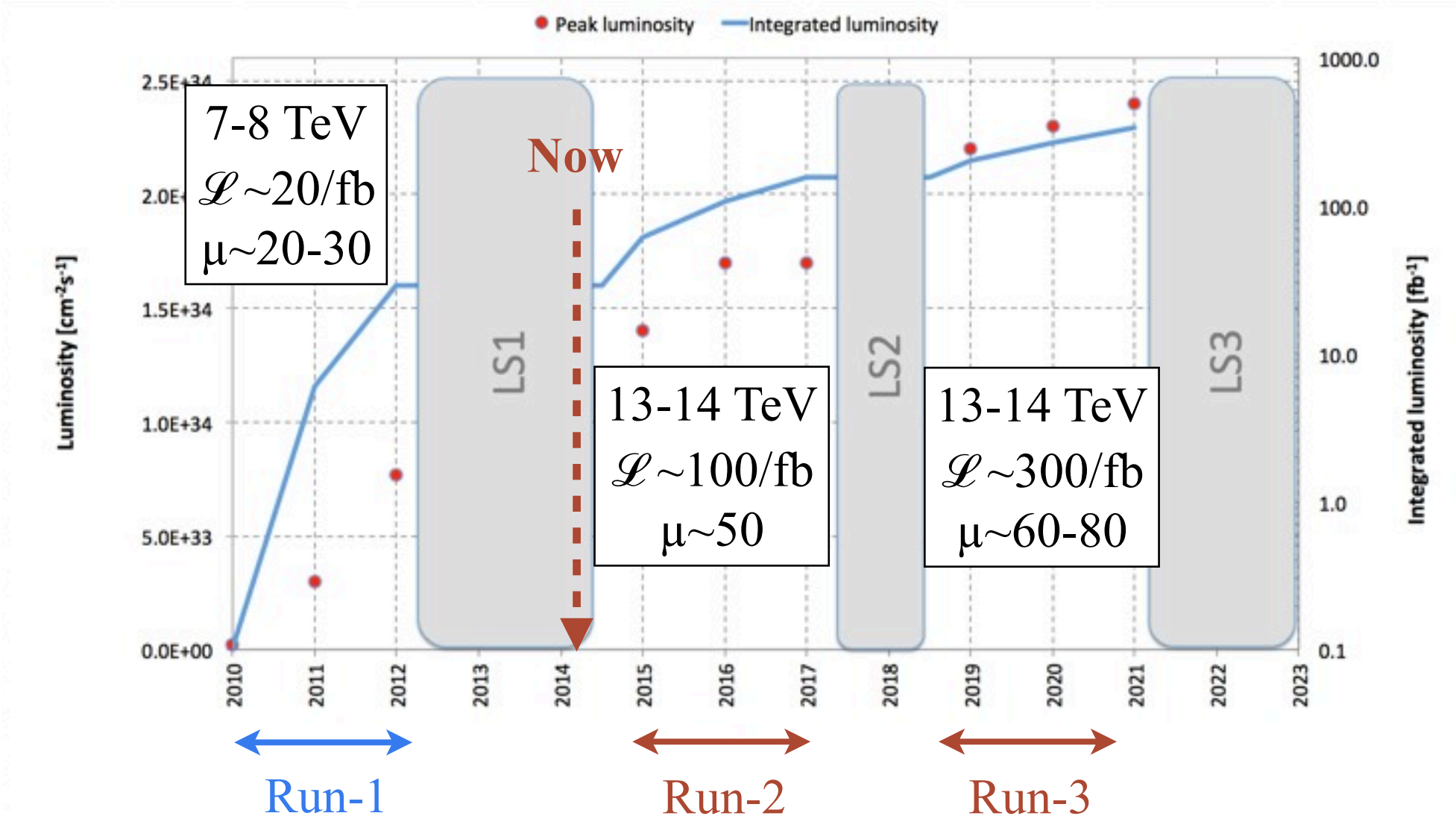
(Its how we're able to color the lines.)

Example: jet-counting.



Where do we go from here?

Planned *and approved* next steps for the LHC



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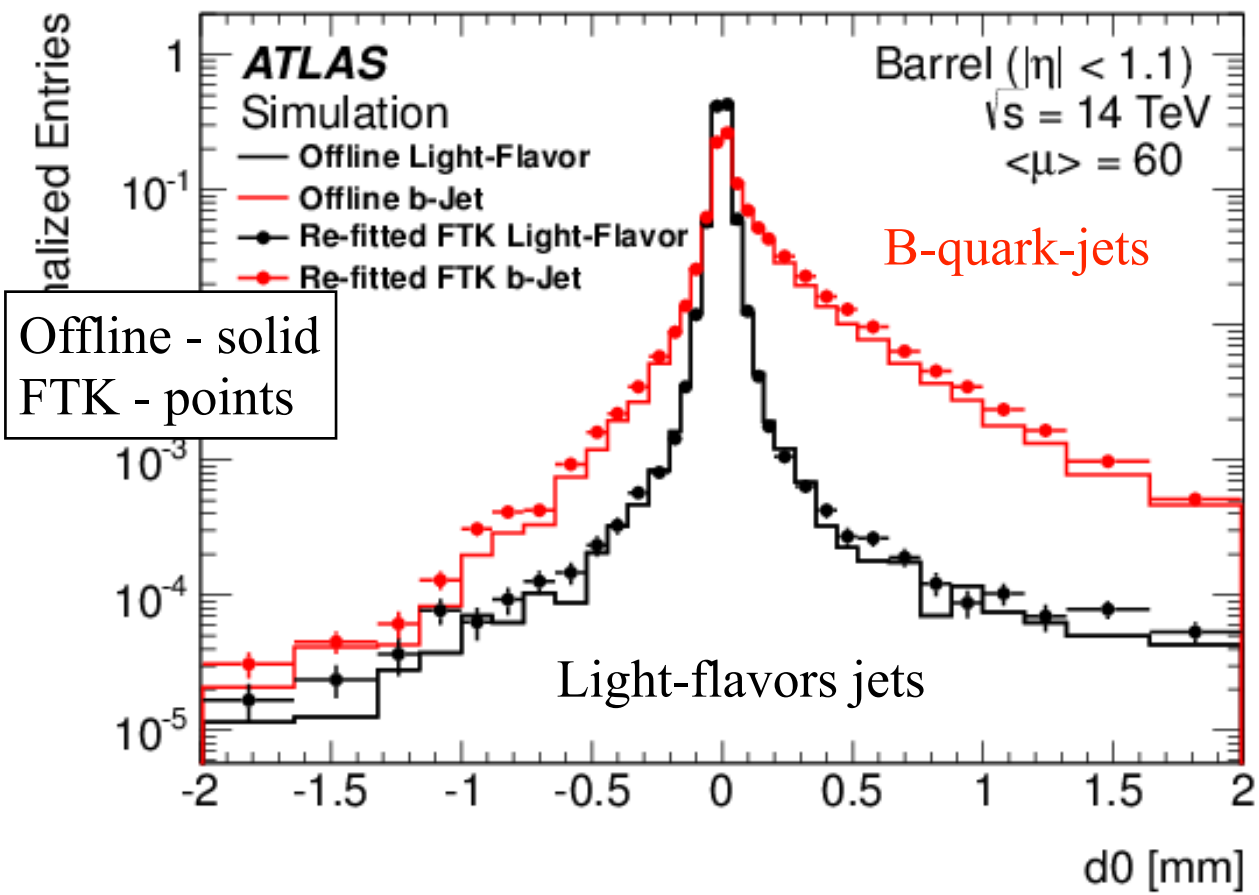

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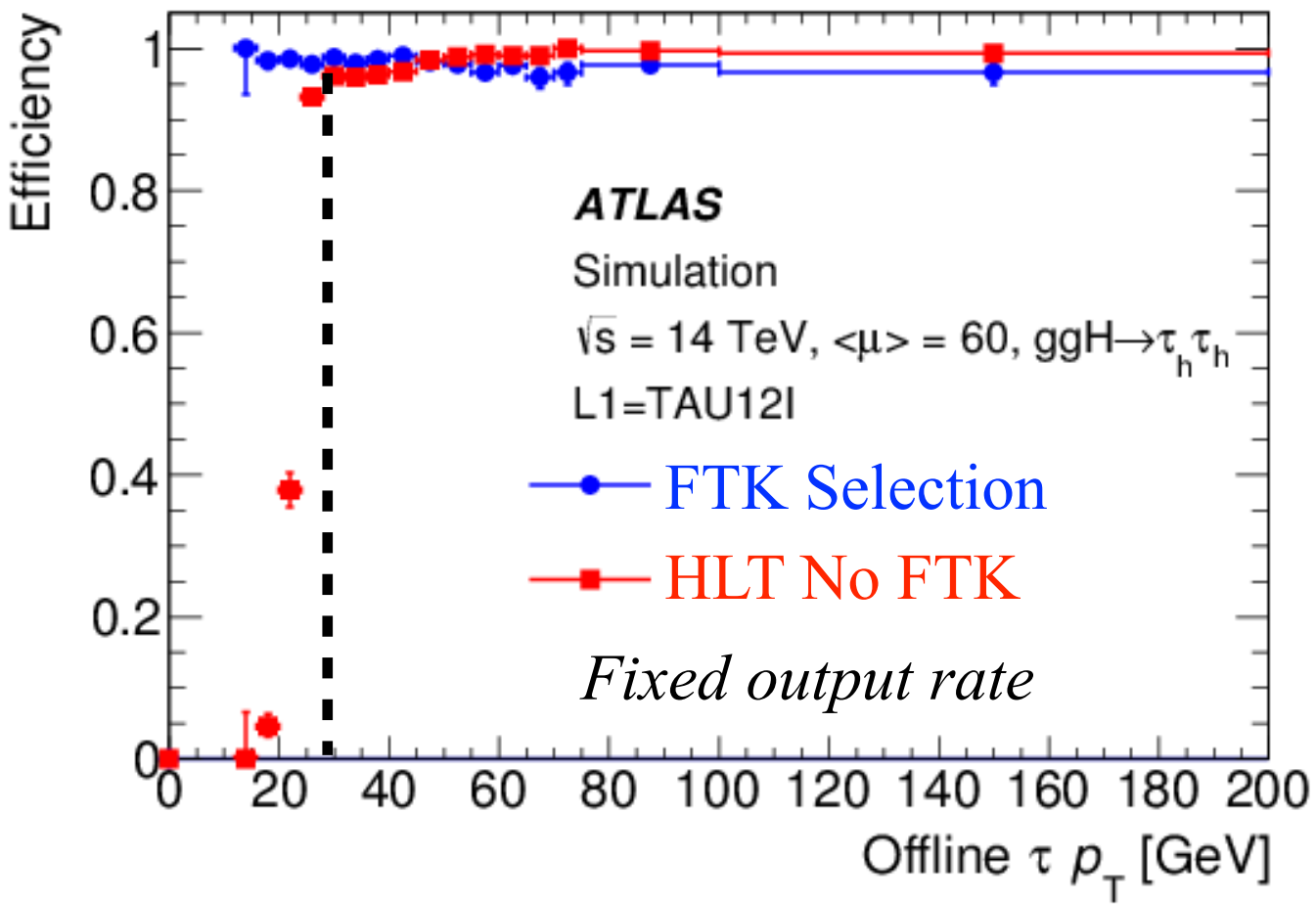

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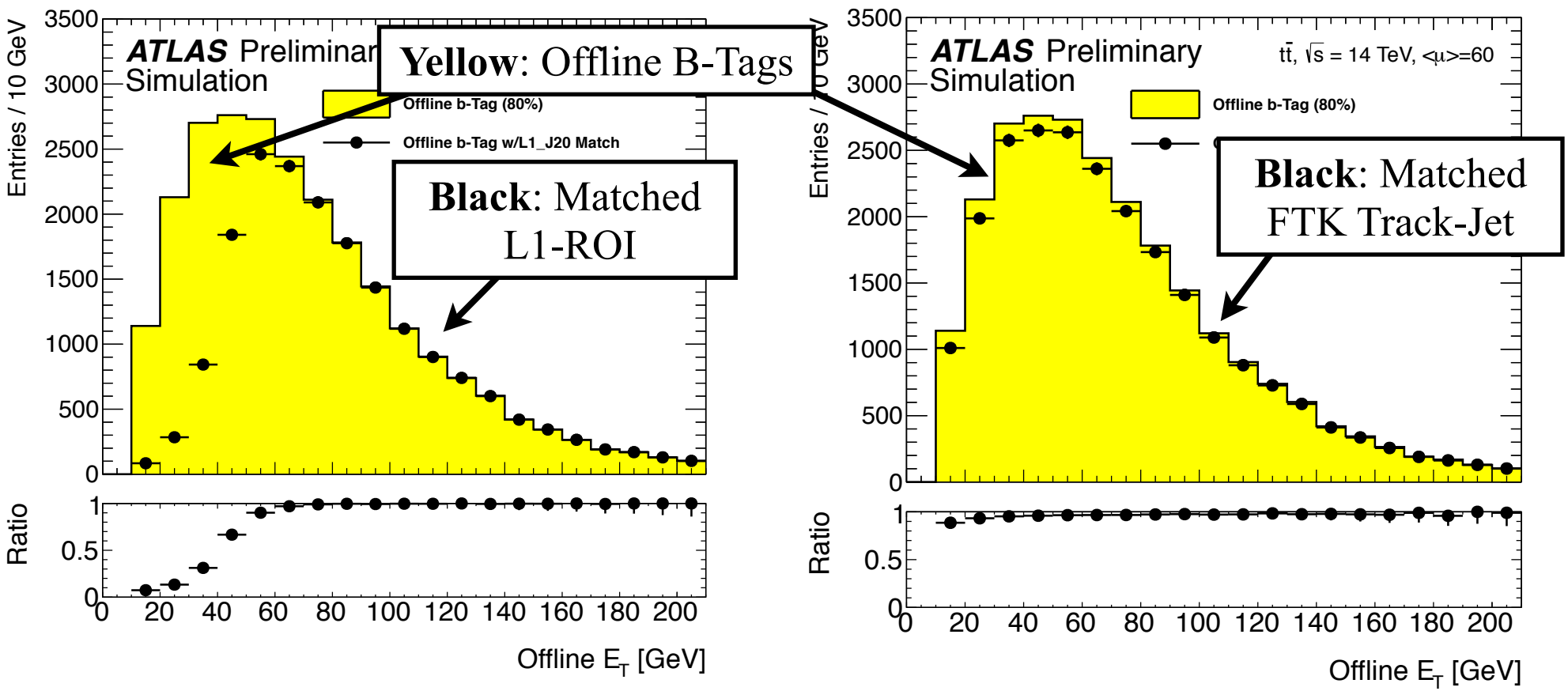

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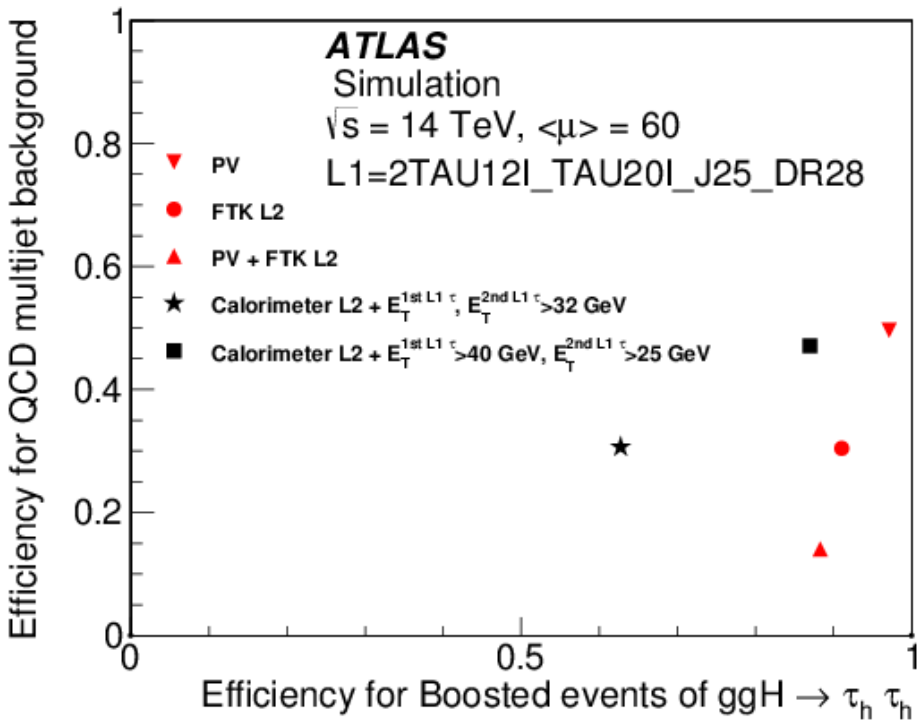
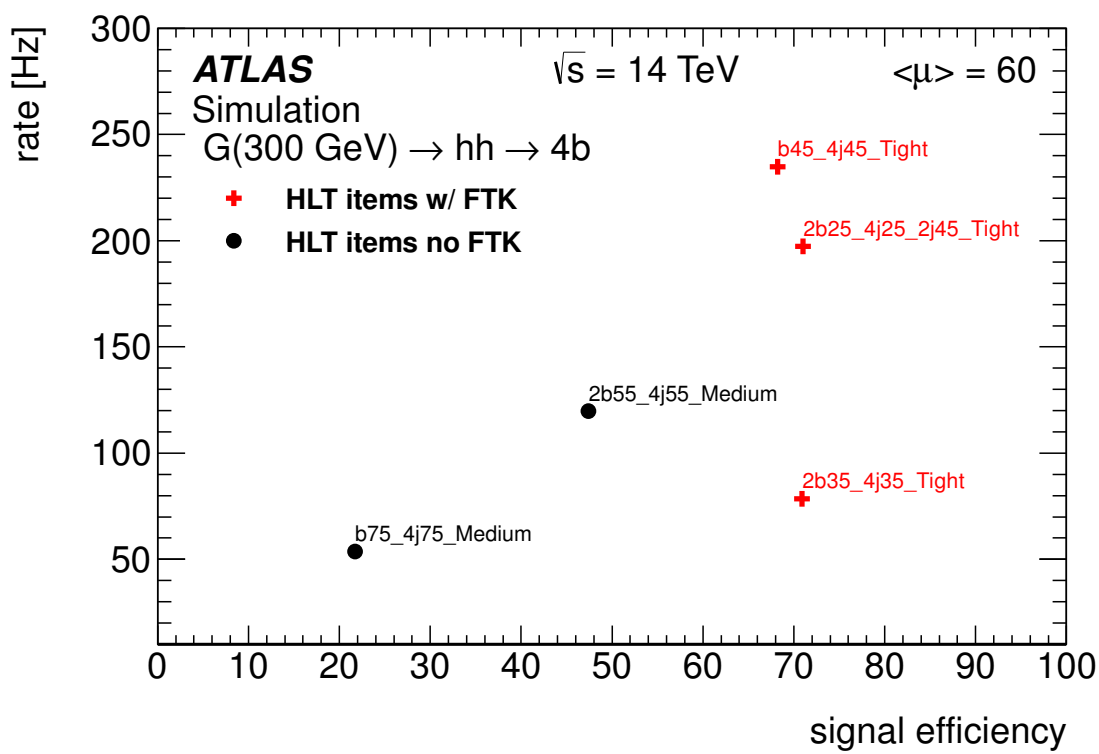
Upshot





SVT → FTK → L1-Track

	SVT	FTK	L1-Track
Event Rate	25 kHz	100 kHz	~500 kHz
#-Patterns	6 M	1,000 M	O(B)
Detector Layers	5 (4-SVX / 1-COT)	12 (8 + 4)	9-13
Track DoF	3	5	5
Input data	1,000 hits/event	>200,000 hits/event	O(M) hits/event
Latency	O(10μs)	O(100 μs)	O(10 μs)