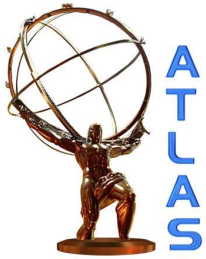
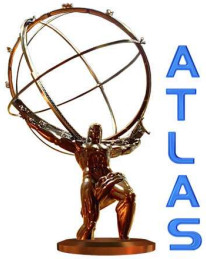


Heavy-Flavor Tagging w/FTK

John Alison

University of Chicago

on behalf of the FTK working group



Outline

- FTK Reminder.
  - Basic Performance
  - Re-fitted Tracks

- FTK in the b-jet trigger.
  - Performance wrt Offline.
  - b-tagging more jets
  - Track b-jet finding/tagging

- Conclusions

Reminder

Fast TracKer:

Hardware system to perform global tracking in IBL + Pixel + SCT.

Done using:

- Highly parallel processing system, cope w/large data volume.
- Custom Associative Memory chips for pattern matching.
- FPGAs: Track fitting / Data Preparation / Ambiguity Resolution /...

FTK in HLT:

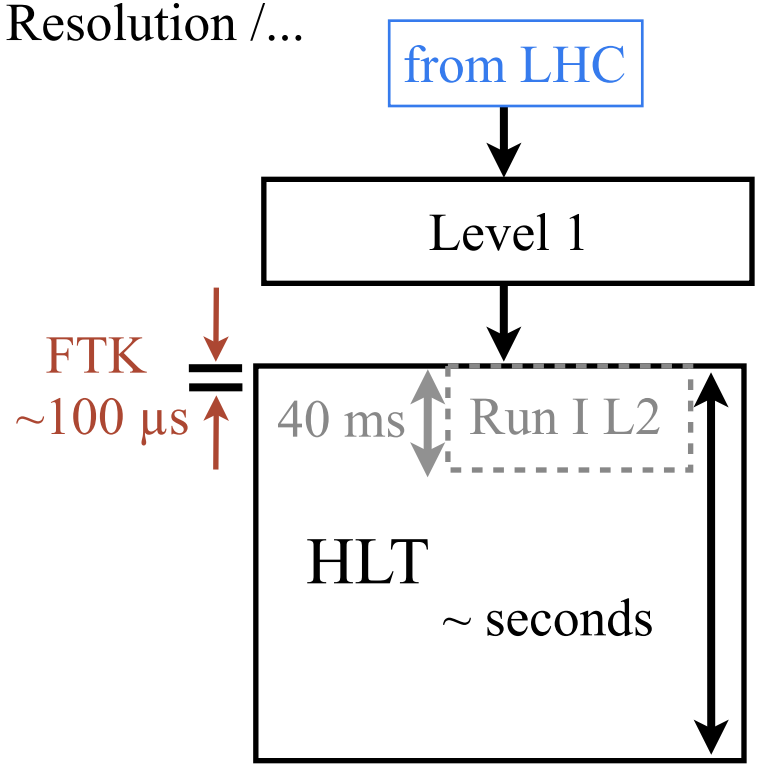
Operates at the full (100 kHz) L1 output rate.

Provides Full Scan Tracking w/ O(100 μs) latency

FTK Tracks input to HLT

Track finding:

- P_T > ~1 GeV / |d0| < 2 mm / |z0| < 110 mm
- 5 track parameter / list of hits / $\chi 2$ estimate
- ~90 % efficient wrt full offline tracking



Track Parameters

In FTK, track parameters estimated by linear approximation.

Re-fit tracks found by FTK system w/offline-like track fitter.

- Feasible: Most time of track reco. is in pattern rec. step.
- Better Estimation of track parameters.
- Refined $\chi 2$ allows reduction of fakes.

FTK in b-Jet chains

Foresee three main areas where FTK can enhance b-jet trigger slice

-) Improve B-tag Performance in ROIs. ("Type-I")

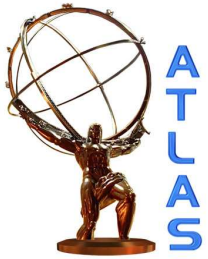
- Baseline FTK / Refitted tracks. *(See below)*
- Fast tracking buys time for more advanced time consuming taggers.
  (eg: ~MV1 at L2-like latencies) *(not yet investigated)*

-) Tag ROIs before L2 Pt Cut ("Type-II")

- Current system reduces rate with pT cut first step, then do L2 tracking/tagging
- Tagging full L1 output rate first allow keep acceptance at low Pt (Low: <50 GeV!)

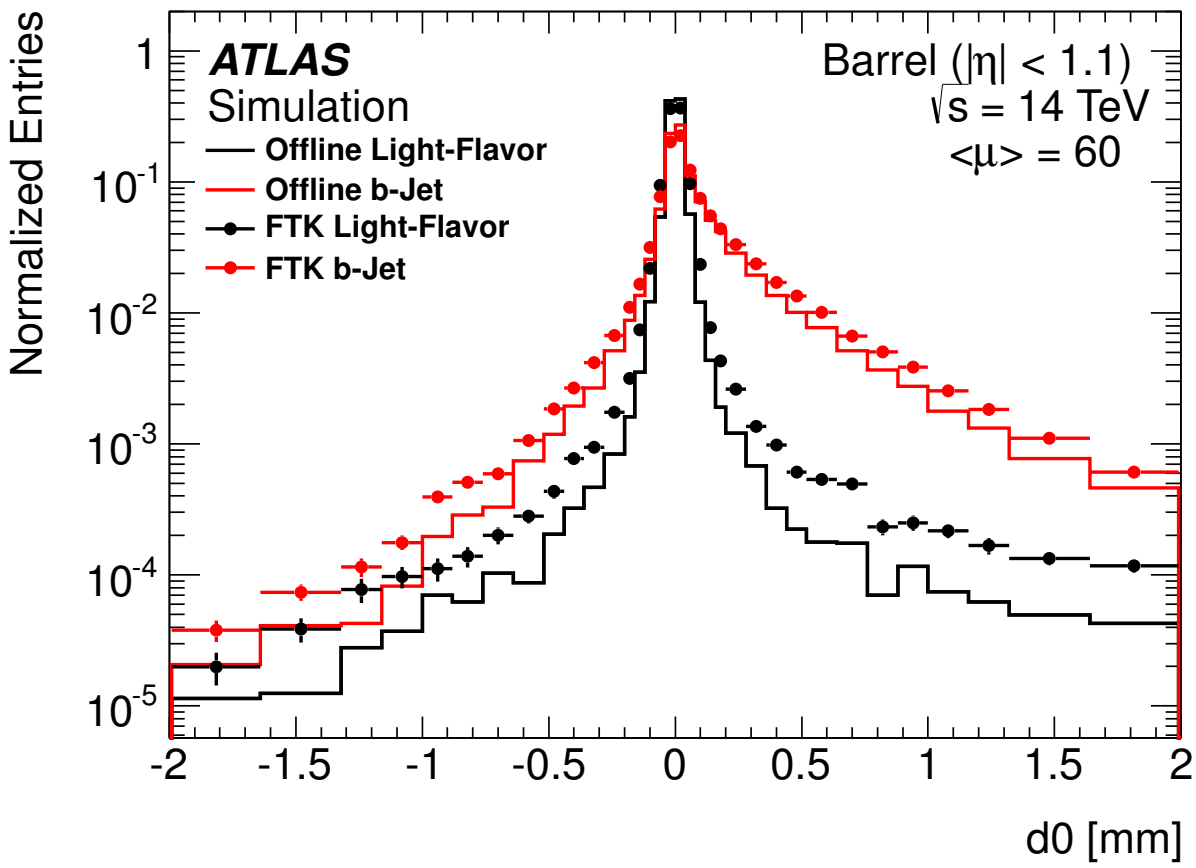
-) Full scan b-tagging / independent of L1_ROIs : ("Type-3")

- Allow to run b-jet finding / b-tag in unseeded
- Run in high rate L1 items: L1_MU_xx / L1_EM_xx / L1_VBF / L1_HT

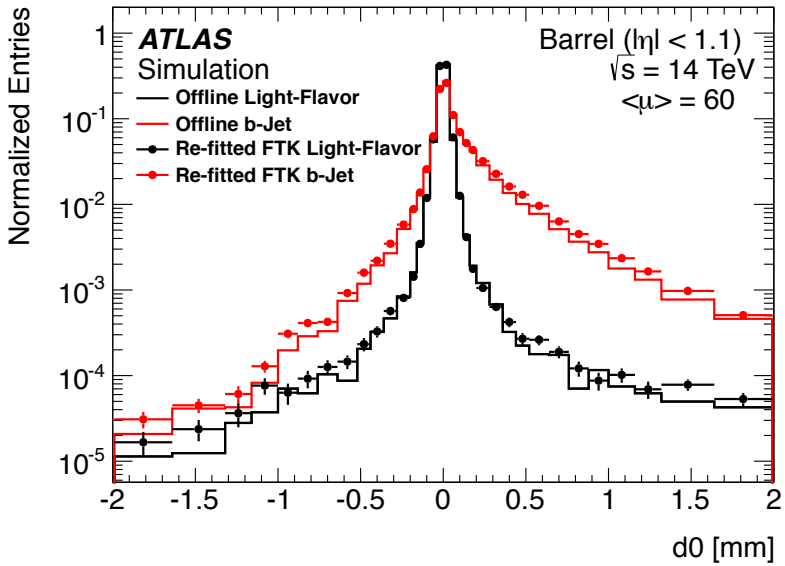


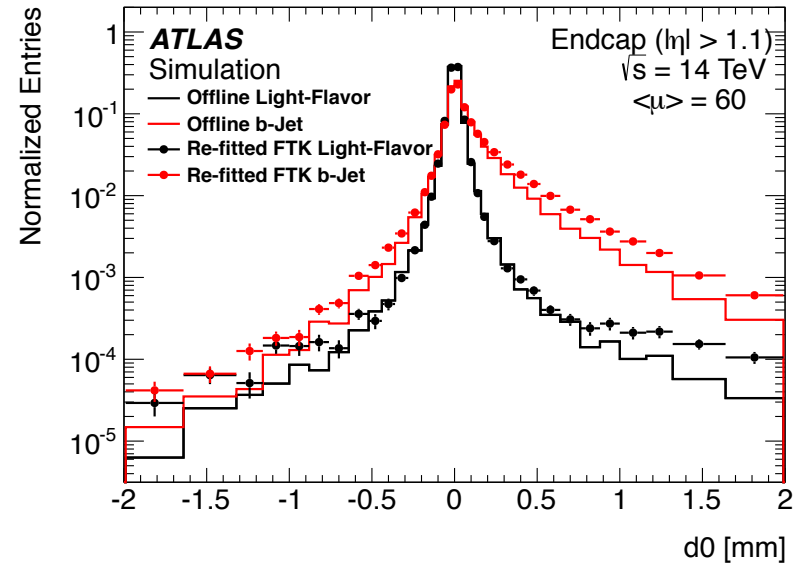
“Type-I” Improvements

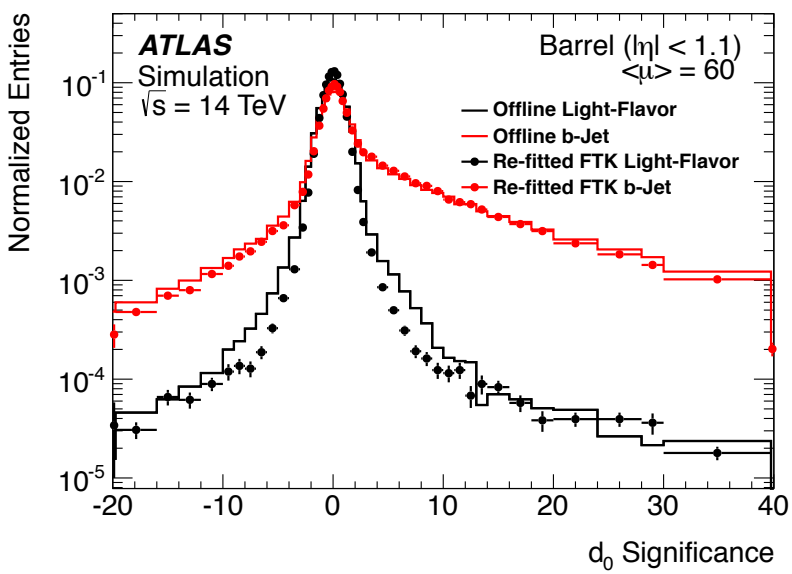
Nominal FTK Impact Parameter

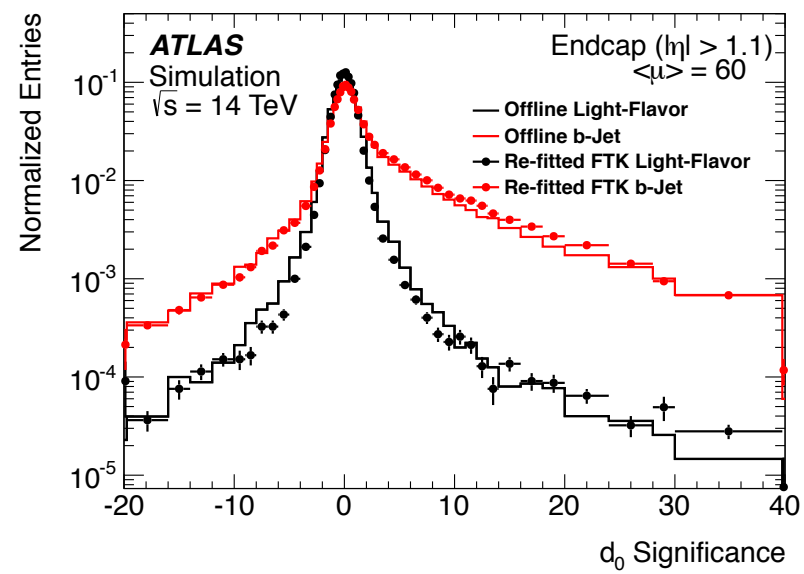


Re-fitted FTK Impact Parameter







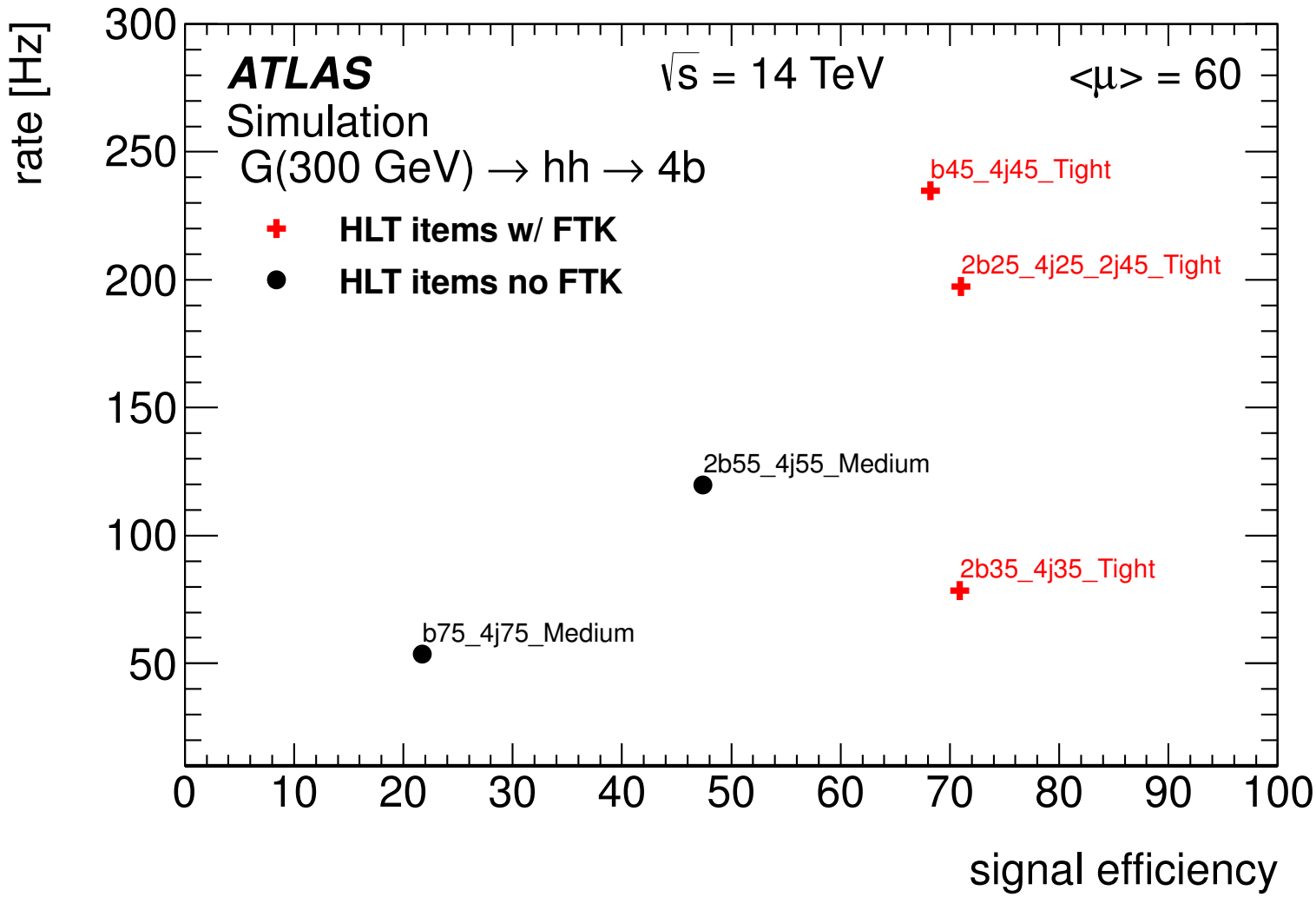


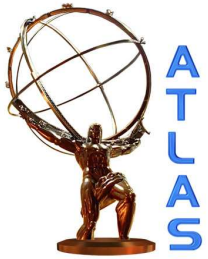
“Type-II” Improvements

X(300)→hh→4b

Similar kinematics as non-resonant di-higgs

Performance with FTK refits





“Type-3” Improvements

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- Trigger at L1 independently of b-jet requirement
- Reduce rate in HLT by adding FTK b-tag track jet
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Example: L1 VBF

- Trigger on the VBF jets at L1.
  - Use "J-J" / "J-FJ" / "FJ-FJ"
  - Mjj from L1 Topo to reduce rate
- Add b-tags in HLT to reduce rates

	J20_J30 Mjj 350	J20_FJ30 Mjj 400	J30_FJ20 Mjj 400	2FJ20 Mjj 50	VBF L1	StrawMan	StrawMan + VBF L1
Efficiency (%) (VBF inclusive)	16.9	15.4	18.0	9.2	31.6	28.3 →	41.0
Efficiency (%) (VBFHbb Mjj>800)	28.6	29.2	37.1	11.6	59.8	37.6 →	64.7

Current L1 Strawman:

VBF inclusive and VBF + jet:

400INVM-AJ30s6-AJ20s6
350INVM-AJ30s6-AJ20s6_3J20

“Type-3” Improvements

- Trigger at L1 independently of b-jet requirement
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FTK Track Jets

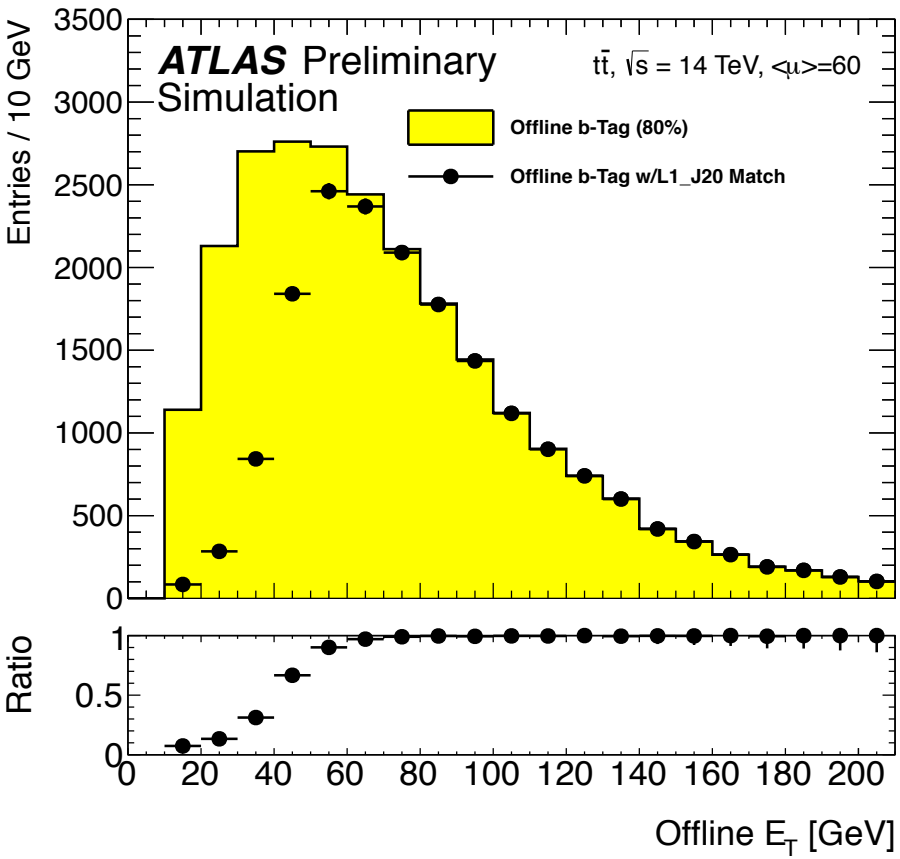
In following, study efficiency of track jet finding w.r.t. offline.

- Using μ=60 ttbar sample.
- Run fastjet (anti-kt 0.4) on passing tracks.
- Apply standard FTK Track selection:

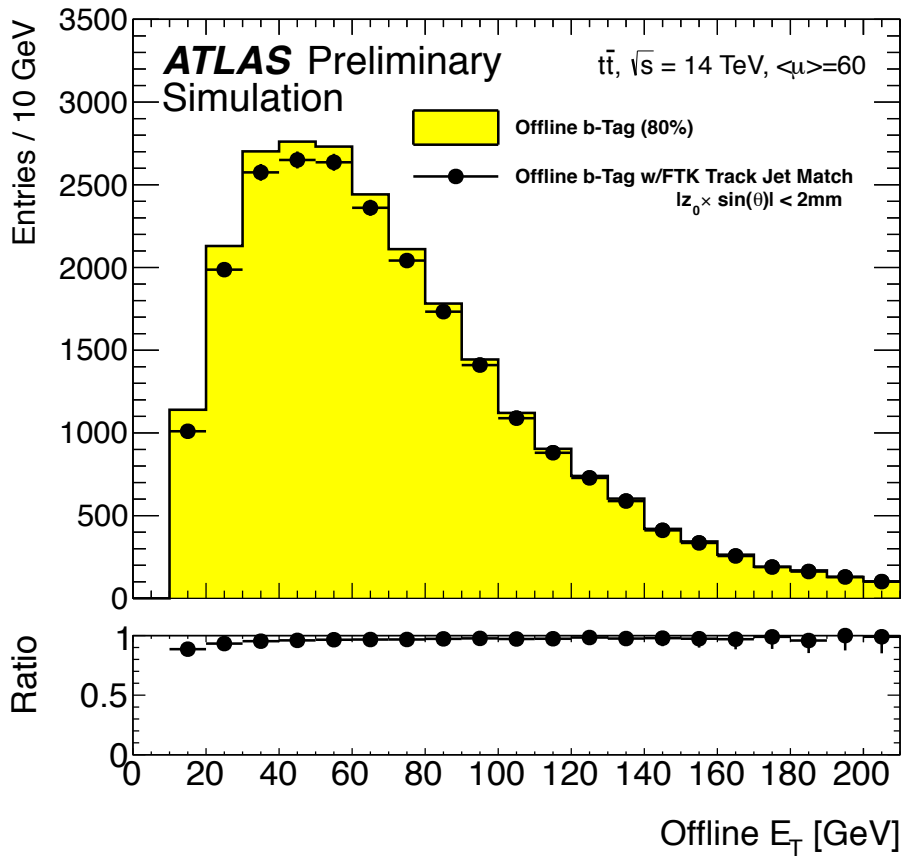
  $pT > 1$ / $d0 < 2$ / $|z0 \times \sin\theta| < 2$ mm / nSi
- Require Jets to have: $Pt > 5$ GeV / $nTrks > 2$.

Turn-on w.r.t. BTagged Jets

L1_J20 turn on



FTK Track Jet turn on



Look at sub-set of offline jets that pass 80% b-Tagging (IP2D)

Taus

Taus are limited at L2.

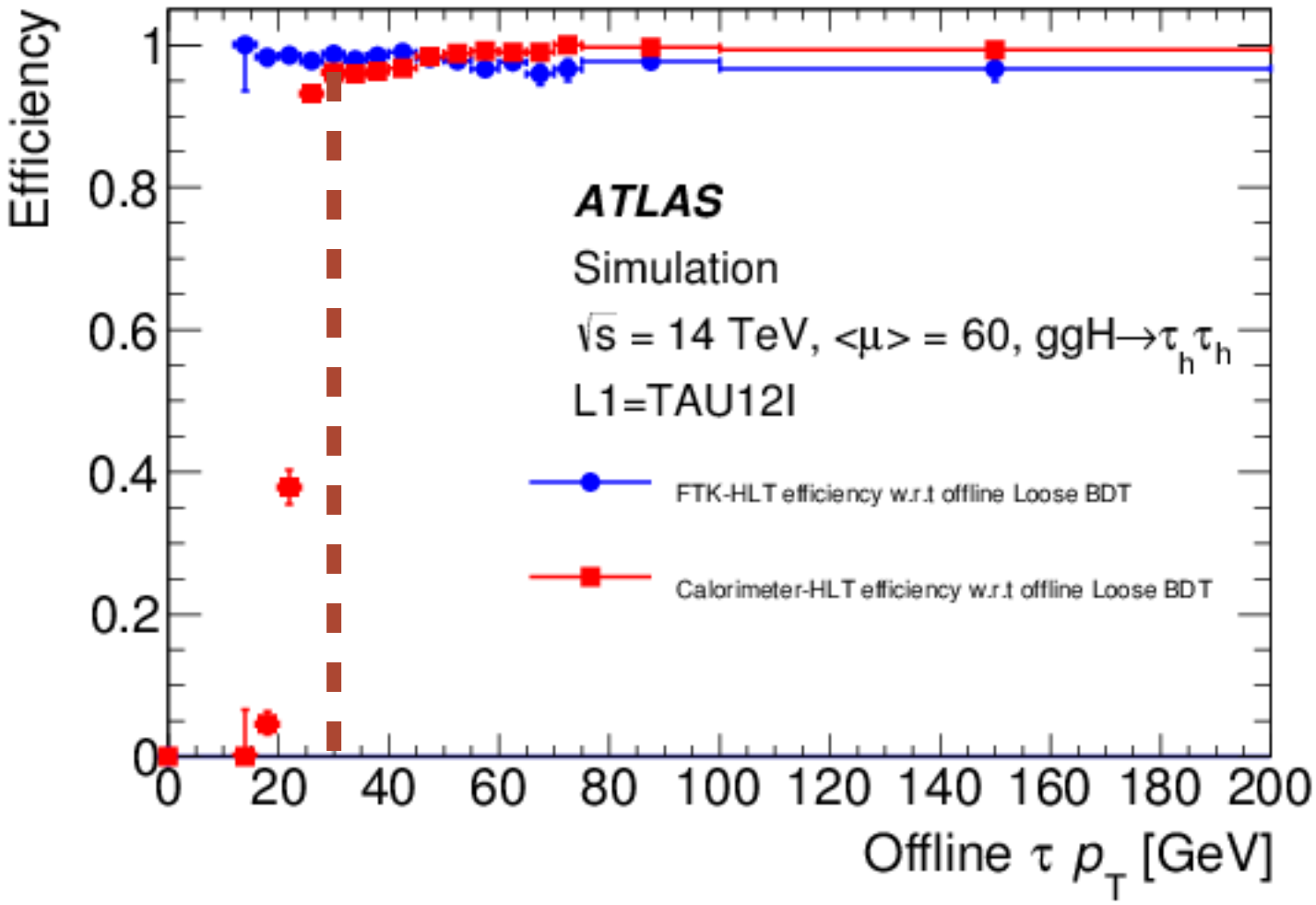
1st) Pt-cut

then) Calo-based ID

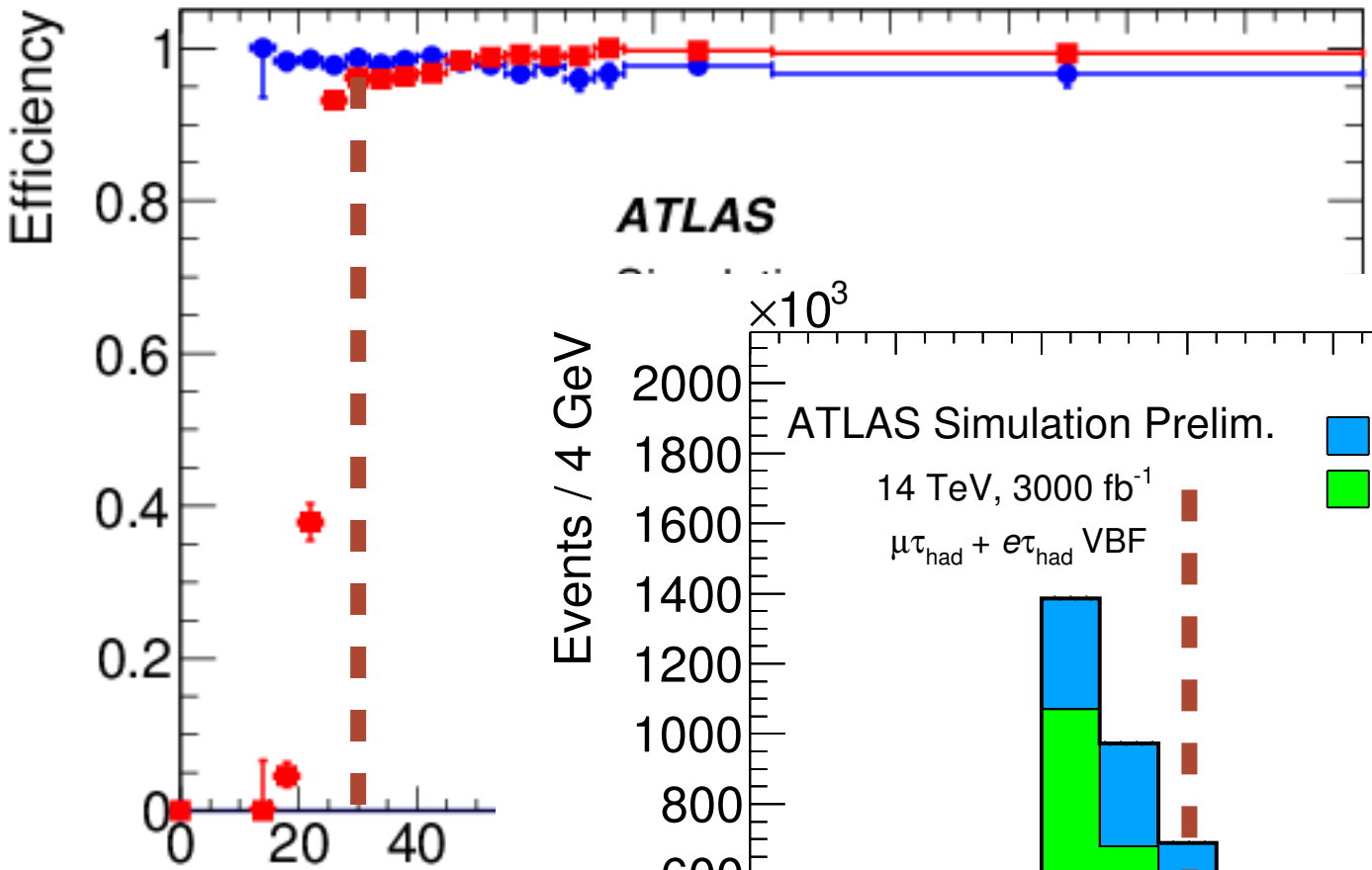
then) Run Tracking

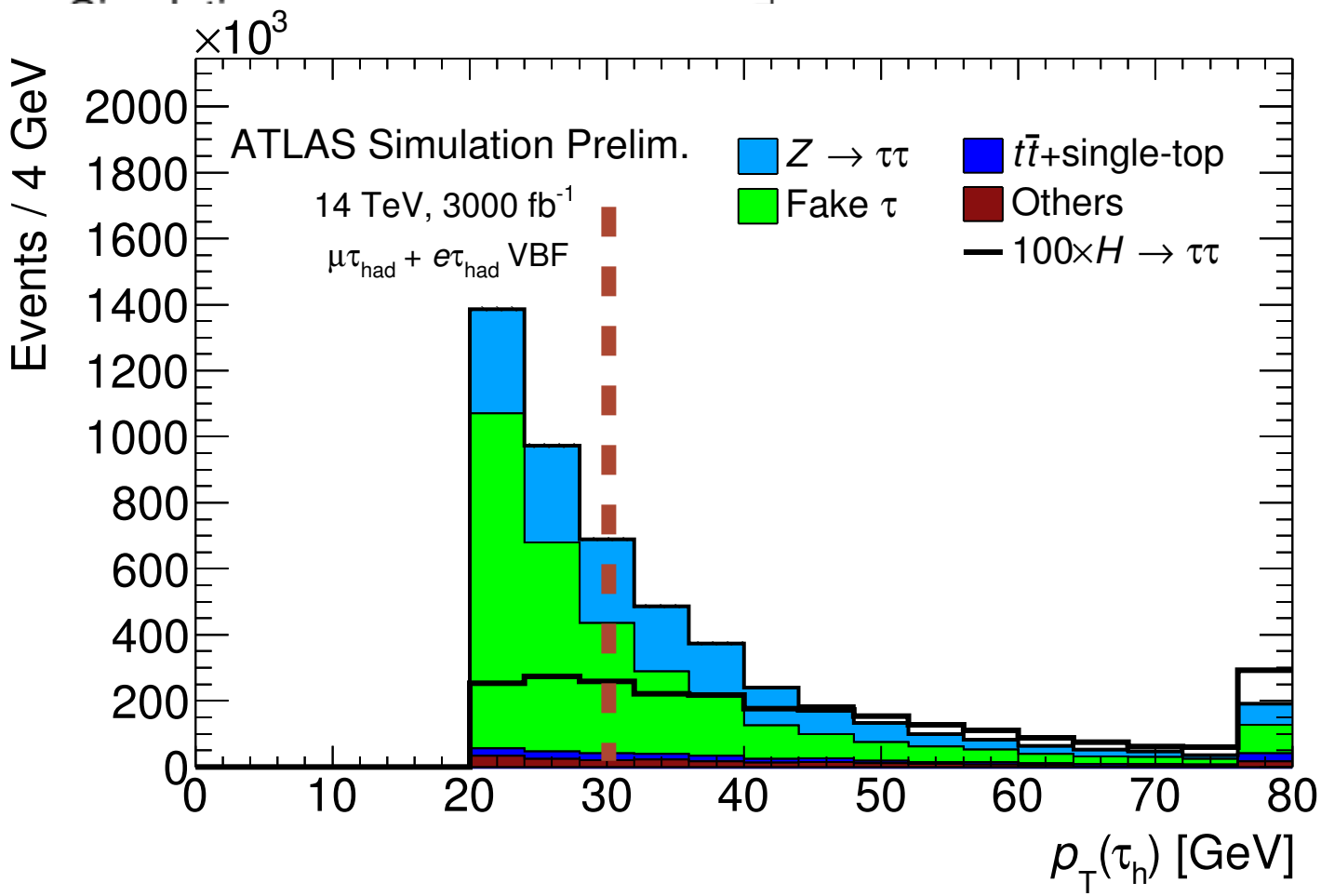
FTK you can reduce the rate using tracks right away.

Taus


Efficiency
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
180
200
Offline τ p_T [GeV]
ATLAS
Simulation
√s = 14 TeV, <μ> = 60, ggH→τ$_h$τ$_h$
L1=TAU12I
FTK-HLT efficiency w.r.t offline Loose BDT
Calorimeter-HLT efficiency w.r.t offline Loose BDT

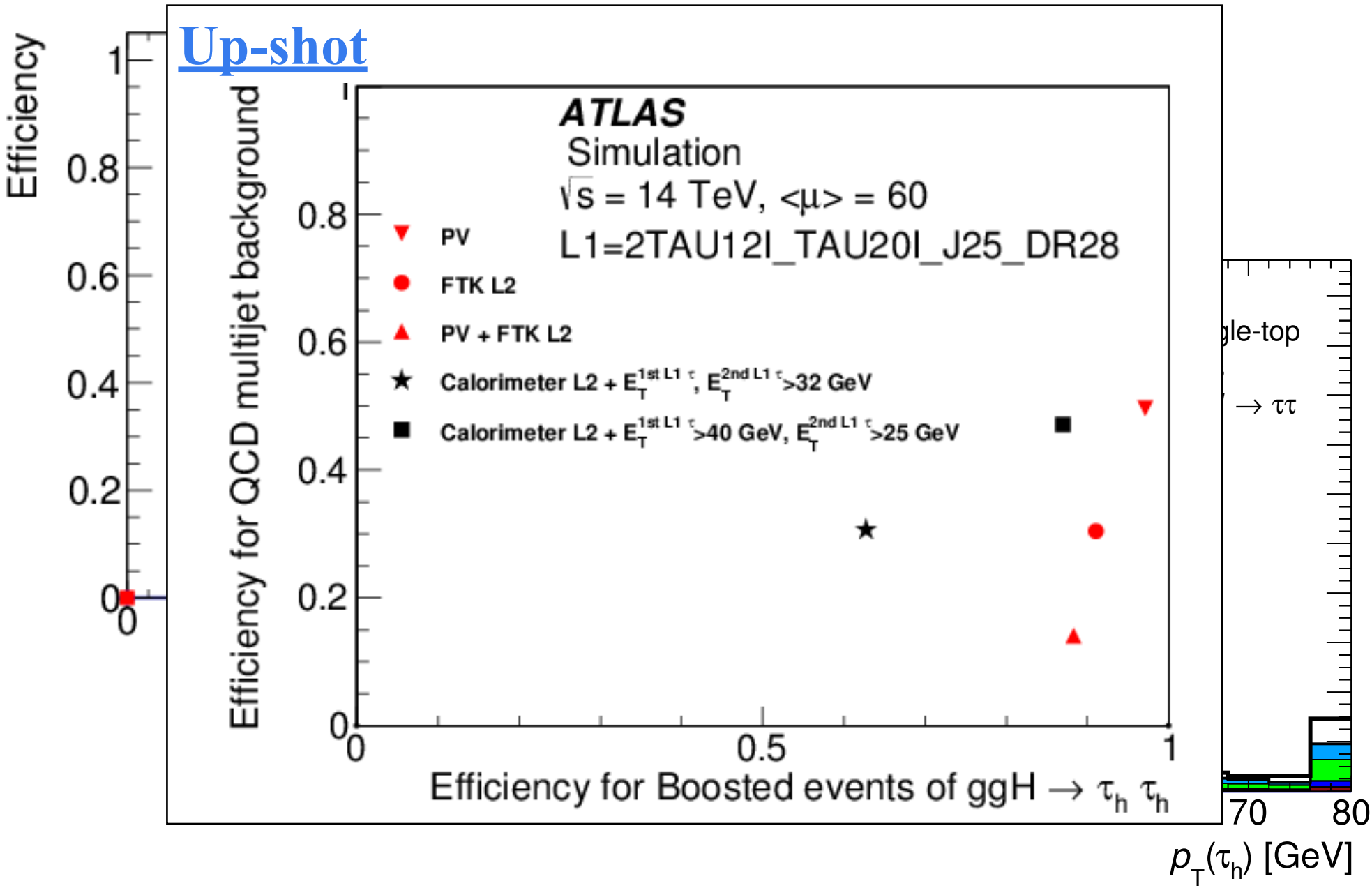
Taus


Efficiency
1
0.8
0.6
0.4
0.2
0
0
20
40
ATLAS


×10³
Events / 4 GeV
2000
1800
1600
1400
1200
1000
800
600
400
200
0
ATLAS Simulation Prelim.
14 TeV, 3000 fb⁻¹
μτhad + eτhad VBF
Z → ττ
Fake τ
tt̄+single-top
Others
100×H → ττ
0
10
20
30
40
50
60
70
80
pT(τh) [GeV]

Taus

Up-shot


ATLAS
Simulation
√s = 14 TeV, <μ> = 60
L1=2TAU12I_TAU20I_J25_DR28
PV
FTK L2
PV + FTK L2
Calorimeter L2 + E_T^1st L1 τ, E_T^2nd L1 τ >32 GeV
Calorimeter L2 + E_T^1st L1 τ >40 GeV, E_T^2nd L1 τ >25 GeV
Efficiency for QCD multijet background
Efficiency for Boosted events of ggH → τ_h τ_h
Efficiency
gle-top
→ ττ
70
80
p_T(τ_h) [GeV]

Physics in the Pile-up

FTK will be reconstructing ~ 10 MHz of *unbiased* pp-collisions

(~μ100 @ 100kHz)

Another way of putting it:

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

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-) have distinctive tracker activity.

Rules of thumb:

If competing with:

LHC searches/measurements: win if $\varepsilon_{L1} < 1/400.$

LHCb searches/measurements: win if $\varepsilon_{L1} < 1/8.$

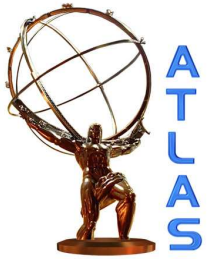
Conclusions

Excited about the possibilities of using FTK in the b-jet trigger slice!

Opportunities for improvements along three fronts.

- Refitted FTK Tracks improve performance/overlap w/offline
- Significant gains by lowering pt thresholds
- First FTK Track Jet finding results look promising.

Work currently being documented in FTK Performance note.



Backup