The ATLAS Run 3 High Level B-Jet Trigger

152nd LHCC meeting, November 29th, 2022

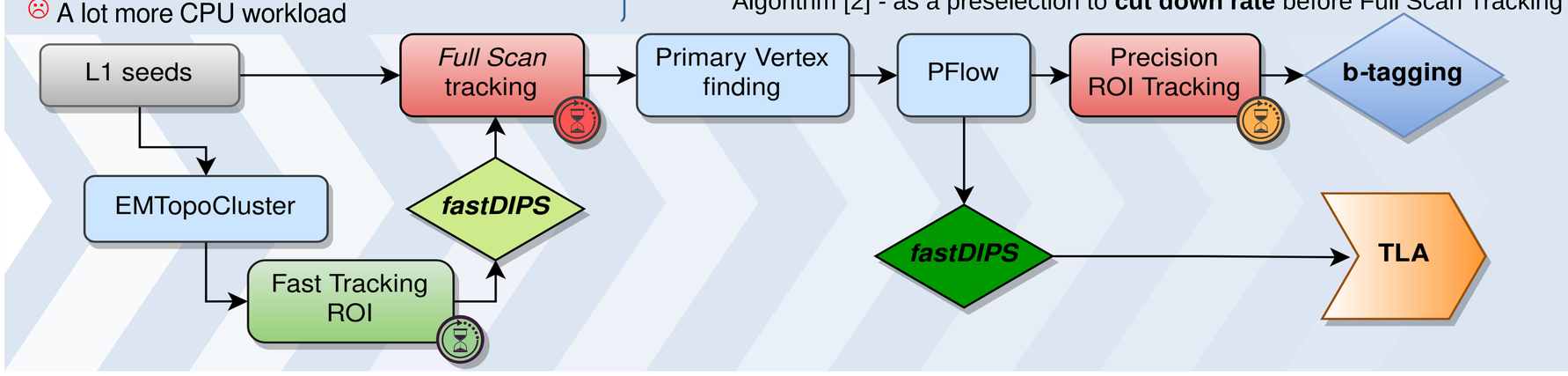
Introduction

- Trigger selections including **b-jets** are amongst the most **CPU intensive** ones, due to the requirement of track reconstruction at the High Level trigger (HLT) in order to perform b-tagging.
- To cope with the real-time constraints and enhance the physics reach for key analyses (e.g. non resonant HH → 4b), **new trigger strategies** were developed for the start of Run 3.

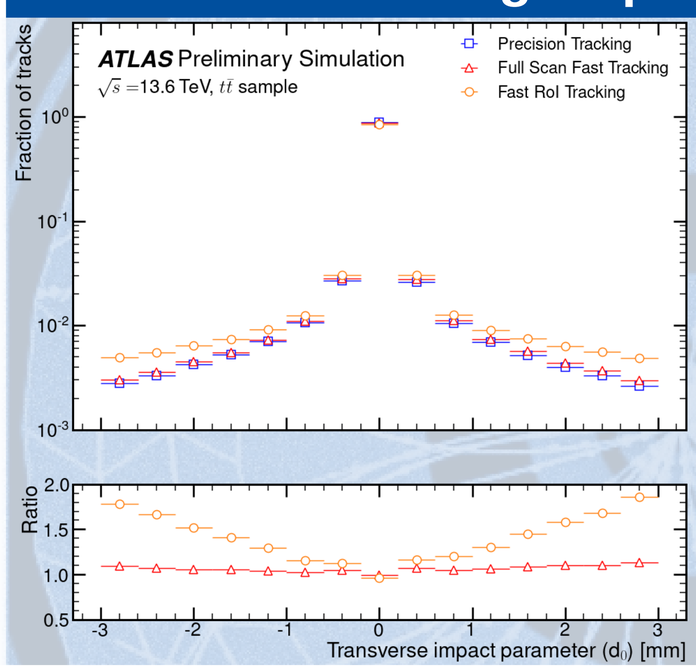
The High Level B-Jet Trigger chains scheme

- Main difference w.r.t. Run 2 is the use of full detector acceptance tracking (Full Scan Tracking) for reconstruction of PFlow objects
  - ☺ More tracking information (better reconstruction)
  - ☹ A lot more CPU workload

→ **Fast b-tagging** - *fastDIPS*, a dedicated Deep Sets neural network Algorithm [2] - as a preselection to **cut down rate** before Full Scan Tracking



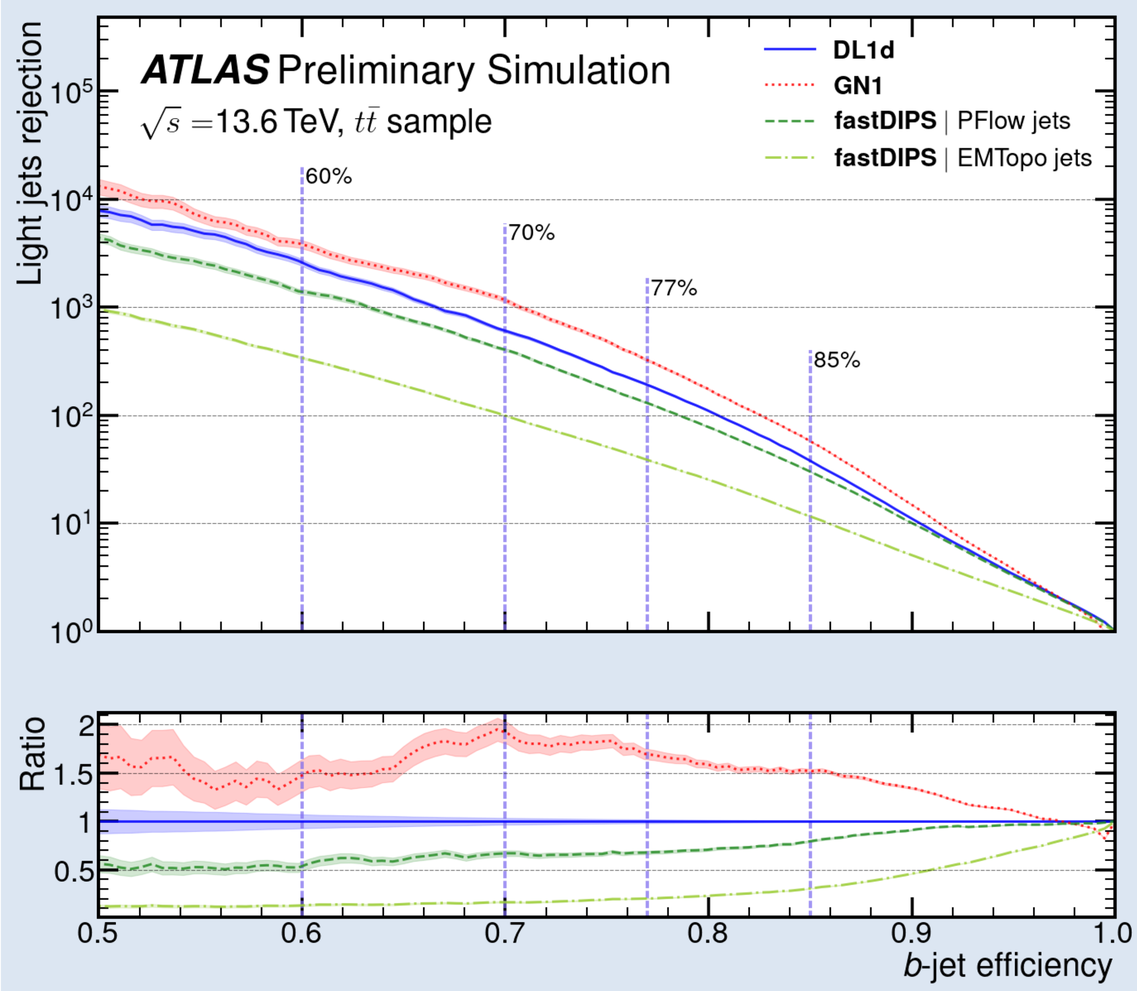
Tracking steps in b-jet chains



- Three different steps of tracking [1] in b-jet chains:
  1) ***Fast* RoI tracking**
     - Earliest tracking steps seeded by calibrated calorimeter jets (EMTopo jets)
     - No primary vertex (PV) information available, impact parameter reconstructed w.r.t. "online" beam-spot
  2) ***Fast* Full Scan tracking**
     - Full inner detector acceptance tracking, for PV and particle flow (PFlow) jets reconstruction
  3) ***Precision* RoI tracking**
     - Tracking for final b-tagging selection step

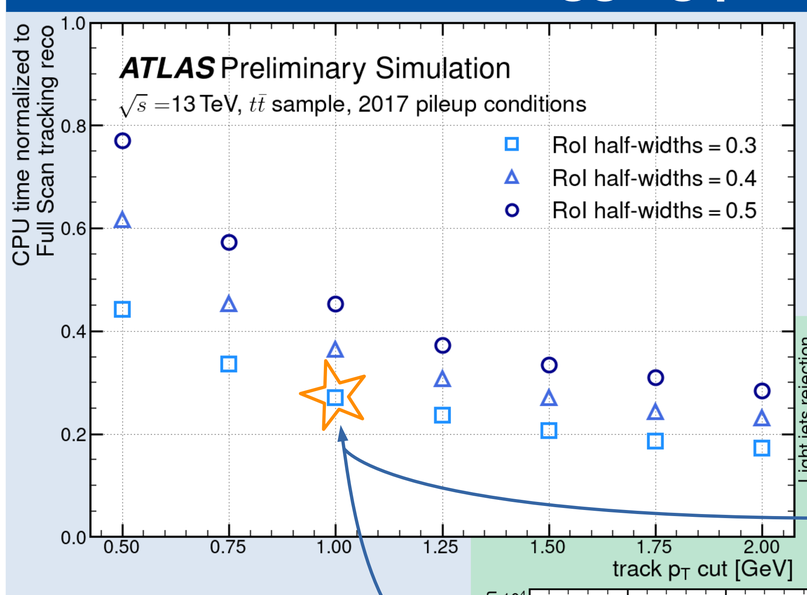
RoI = region of interest
Fast = trigger dedicated algorithm
Precision = offline-like refinement

Trigger b-taggers performance

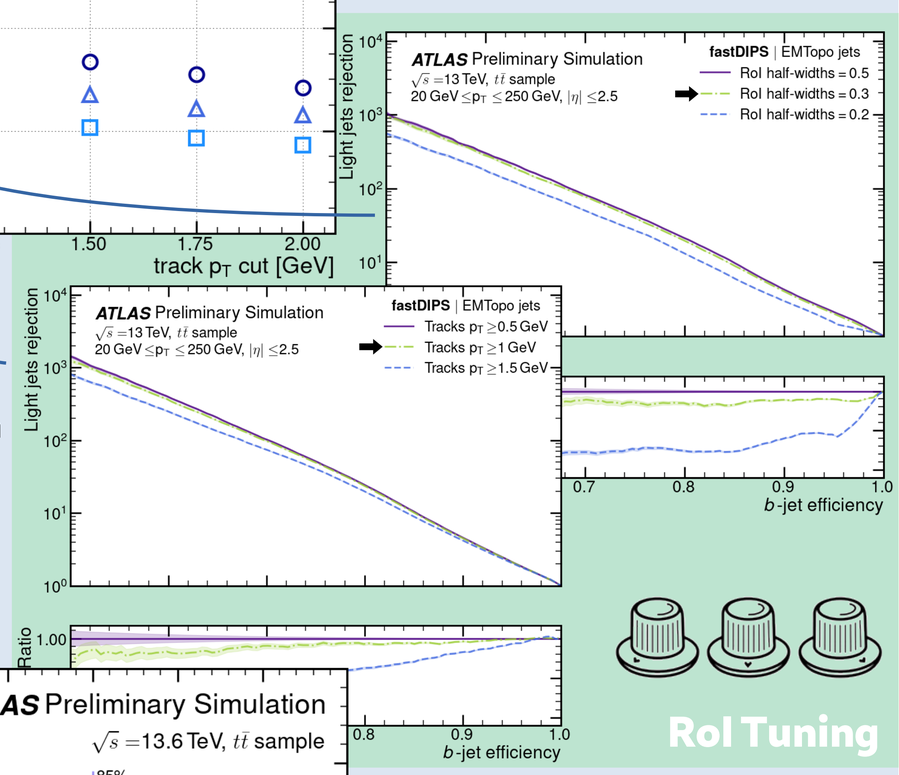


- Run-3 HLT b-jet chains are currently running 3 different b-tagging steps
  1) **FastDIPS** (EMTopo jets), fast b-tagging preselection on fast RoI tracks
  2) **FastDIPS** (PFlow jets), fast b-tagging for trigger level analysis (TLA) with fast Full Scan tracks
  3) **DL1d**, precision b-tagger on which the HLT decision is taken [3]
  4) **GN1**, upgrade of DL1d based on a graph neural network [4]

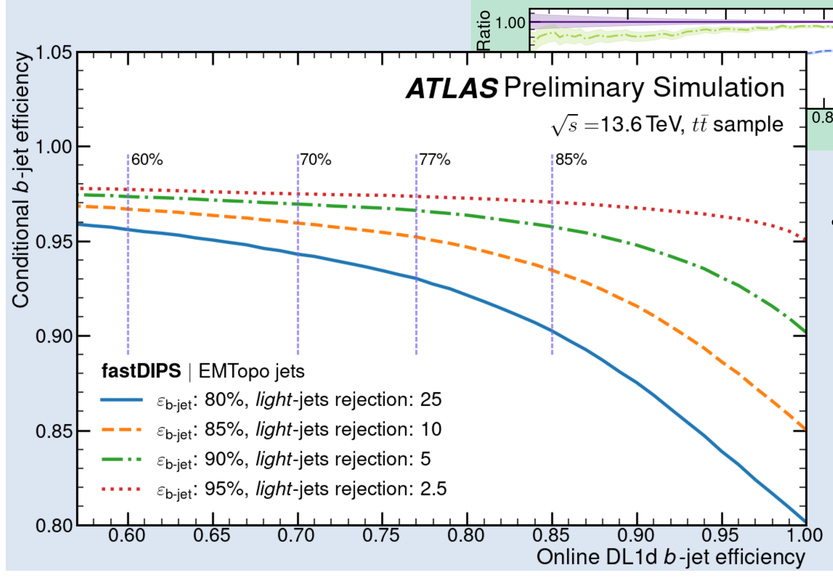
Fast b-tagging preselection



- The fast b-tagging preselection relies on an additional tracking step, but RoI reconstruction is much *cheaper* in terms of CPU requirements
  - Tighter size of tracking volume
  - Higher thresholds on transverse momenta



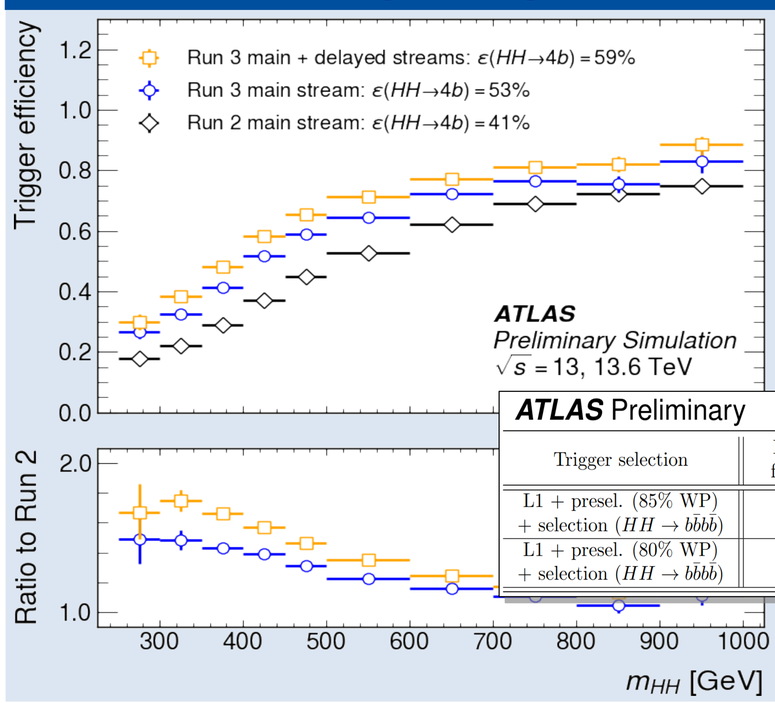
- Important CPU impact reduction
- **Negligible degradation** of light-jets rejection power for the selected working point



RoI Tuning

- Testing the preselection tagger conditional probability w.r.t. the full HLT b-tagger (DL1d)
  - → **good overlap** at object level
  - → High light-jets rejection (important rate reduction)
  - → Minimal signal inefficiency with event level selections

Physics performance



- Preselection **reduces drastically** the **rate** on which high-level algorithms are running
- Large **improvements in acceptance**, such as low-mass multi-b-jet resonances or **HH → 4b** production

ATLAS Preliminary

Trigger selection	Presel. rejection factor on top of L1	$HH \to b\bar{b}b\bar{b}$ relative trigger acceptance
L1 + presel. (85% WP) + selection ($HH \to b\bar{b}b\bar{b}$)	5	0.98
L1 + presel. (80% WP) + selection ($HH \to b\bar{b}b\bar{b}$)	10	0.96

References

[1] "*The ATLAS inner detector trigger performance in pp collisions at 13 TeV during LHC Run 2*", Eur. Phys. J. C 82 (2022) 206

[2] "*Deep Sets based Neural Networks for Impact Parameter Flavour Tagging in ATLAS*", ATL-PHYS-PUB-2020-014

[3] "*ATLAS b-jet identification performance and efficiency measurement with tt̄ events in pp collisions at √s =13 TeV*", Eur. Phys. J. C 79 (2019) 970

[4] "*Graph Neural Network Jet Flavour Tagging with the ATLAS Detector*", ATL-PHYS-PUB-2022-027

*** Plots taken from the ATLAS public Twiki: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/BJetTriggerPublicResults

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