Fast b-tagging at the high-level trigger of the ATLAS experiment

Fast Machine Learning for Science

https://indico.cern.ch/event/1283970/

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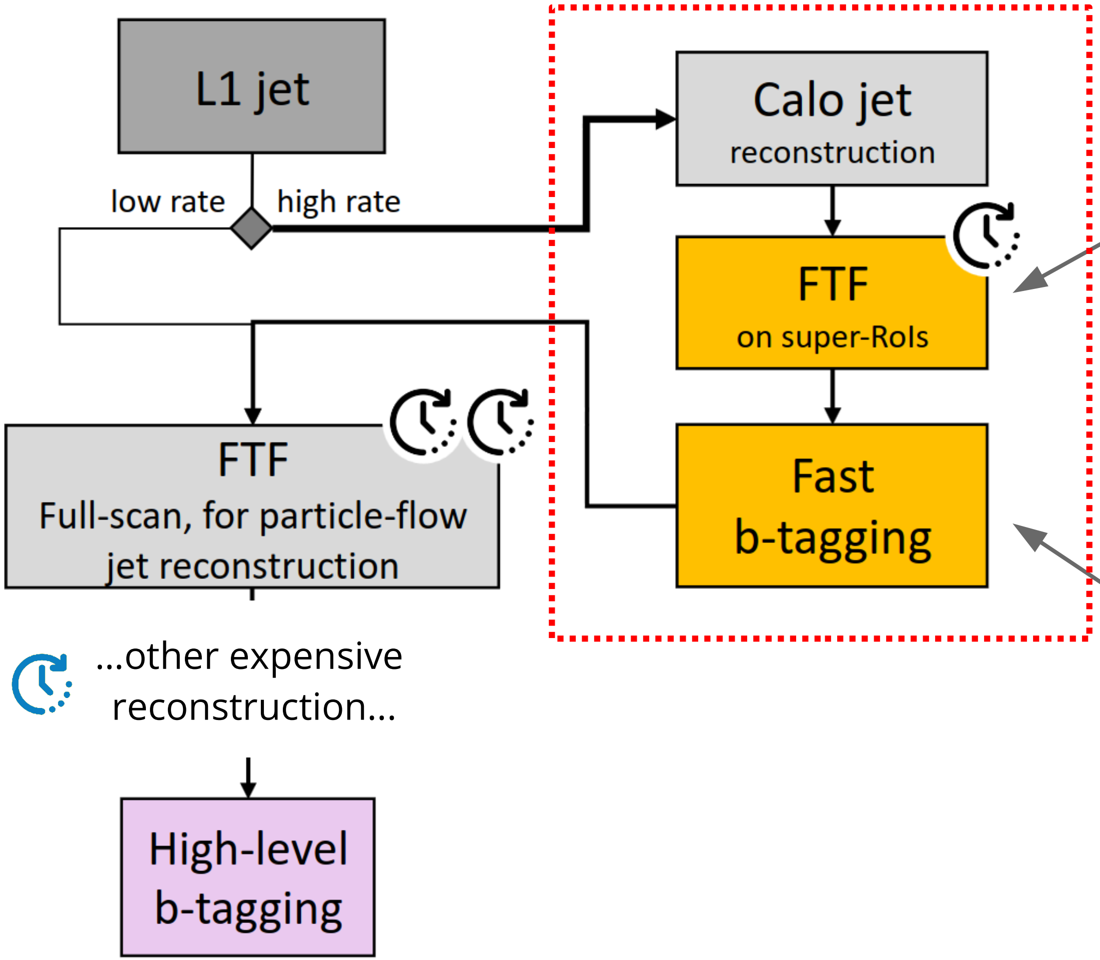
Motivation for "*fast b*-tagging"

- The identification of b-jets is necessary to trigger many interesting signatures
  - **Essential** for fully-hadronic final states of major interest ($\boldsymbol{H \rightarrow 2b}$, $\boldsymbol{HH \rightarrow 4b}$, *new* physics…)

- For the start of LHC Run 3, many novelties implemented in the high-level trigger (HLT)
  - Full detector acceptance (*Full scan*) tracking was a major upgrade for b-jet selections
    - Particle Flow (*PFlow*) reconstruction ⇒ stronger performances
    - CPU intensive ⇒ limited rate

- To fit b-jet selections in the trigger menu, within the CPU constraints, needed to reduce the input rate to *Full scan* tracking
  - **Fast $\boldsymbol{b}$-tagging** ⇒ machine learning (ML) based low precision filter for jet tagging (*much faster* than tracking)

The *preselection* strategy



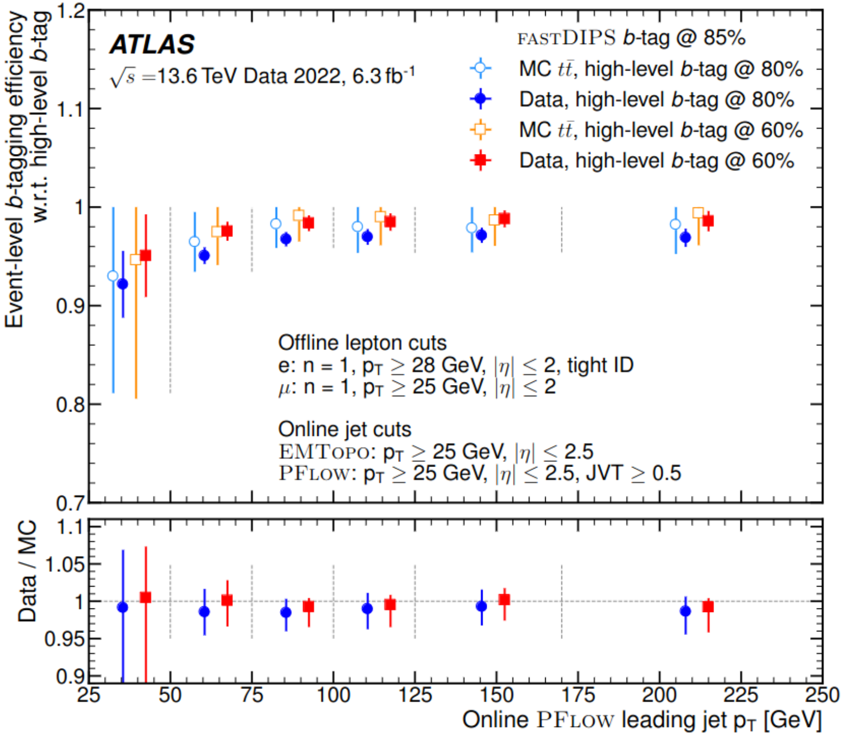
fast track finder (FTF) algorithm in limited regions of interest (RoI), without any further reconstruction *e.g.* no Primary Vertex (PV) information

ML based algorithm, using a *Deep Sets* architecture (DIPS), to filter events containing b-jets

Preselection performance

- The preselection performances have been studied in Monte Carlo (MC) simulations, and then validated with Data
  - High efficiency w.r.t. full-trigger decision
  - Excellent agreement between data and MC

- The impact on physics of interest (*e.g.* $HH \rightarrow 4b$) is negligible while strongly downsizing background rates



Trigger selection	Preselection rejection factor on top of L1	$HH \rightarrow b\bar{b}b\bar{b}$ relative trigger acceptance
L1 + HLT preselection (85% WP) + HLT selection ($HH \rightarrow b\bar{b}b\bar{b}$)	~ 5	0.98
L1 + HLT preselection (80% WP) + HLT selection ($HH \rightarrow b\bar{b}b\bar{b}$)	~ 10	0.96

Summary and outlook

- A fast b-tagging preselection in the ATLAS high-level trigger was implemented for the start of LHC Run 3 (arXiv:2306.09738)

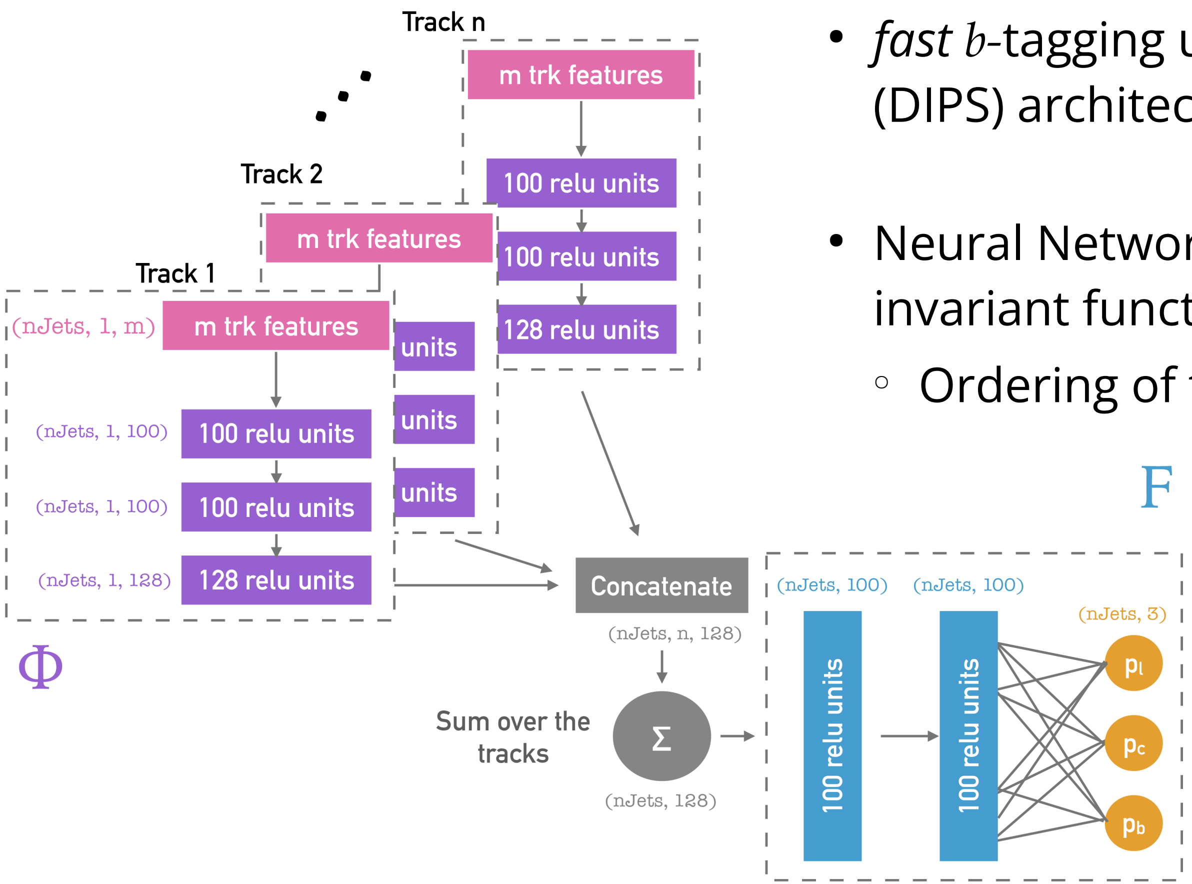
- This method proved to be highly signal efficient, while being able to substantially decrease background rates

- This approach has high potential for application at the High Luminosity LHC

- Interesting times ahead!

Thank you for your attention!

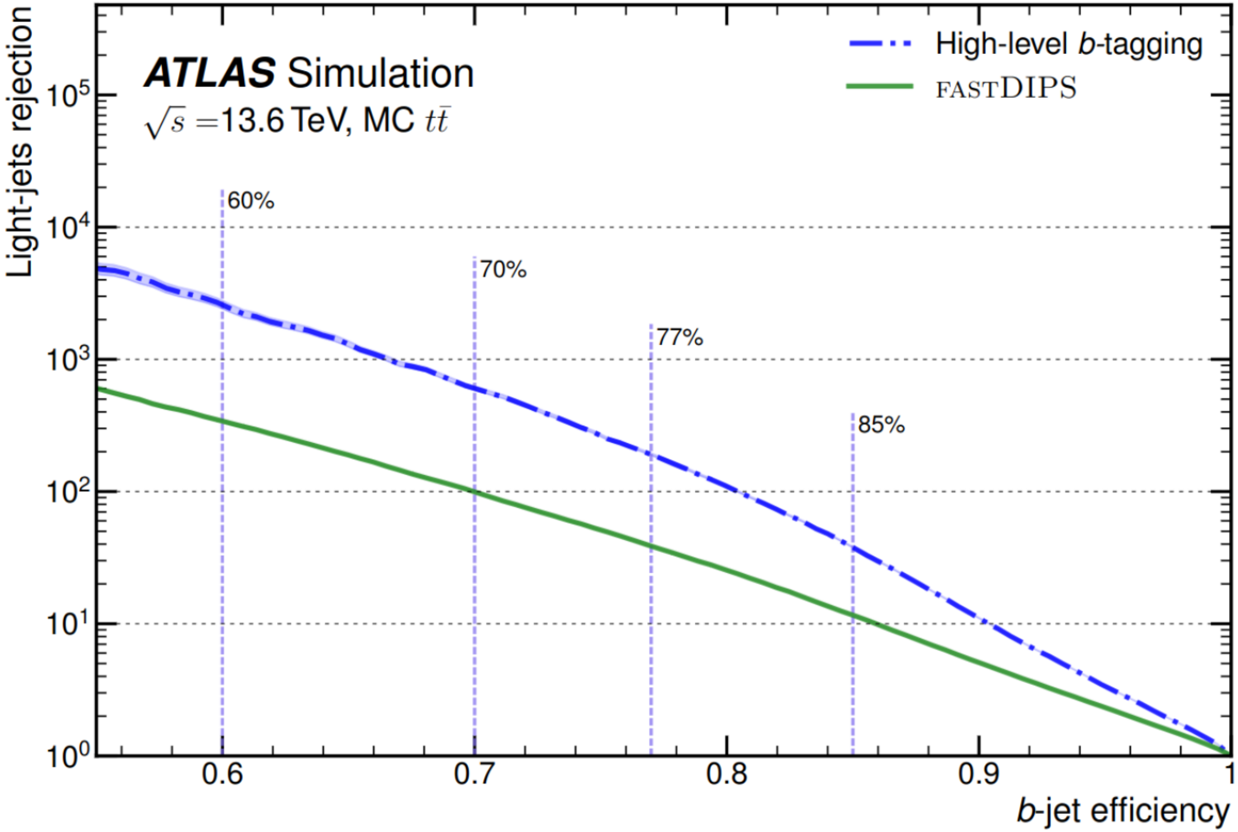
DIPS architecture



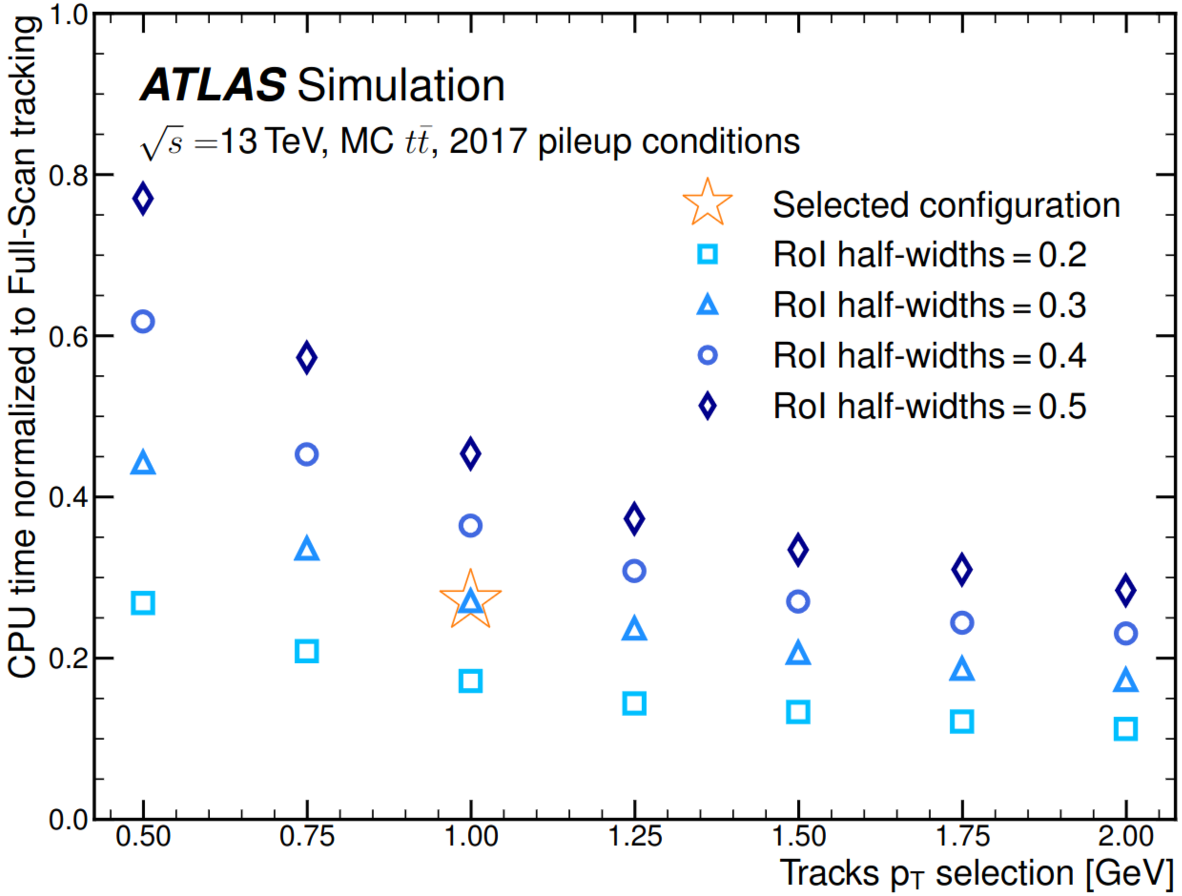
- *fast b*-tagging uses **D**eep **I**mpact **P**arameter **S**ets (DIPS) architecture (ATL-PHYS-PUB-2020-014)
- Neural Network (NN) that learns permutation invariant functions
  - Ordering of the inputs not relevant
- This type network features important advantages:
  - High flexibility, variable input size
  - Very quick to train and very fast inference

Preselection performance (ROC)

- Performances at jet-level of fast b-tagging (FASTDIPS) vs high-level tagger



CPU costs



- Track reconstruction in narrow regions of interest (RoI) for the preselection is ~ 4 times cheaper in terms of CPU time w.r.t. *Full Scan* tracking
- The working point was selected such that there is negligible impact on b-tagging performances