133rd LHCC MEETING POSTER SESSION – CERN, FEBRUARY 28, 2018

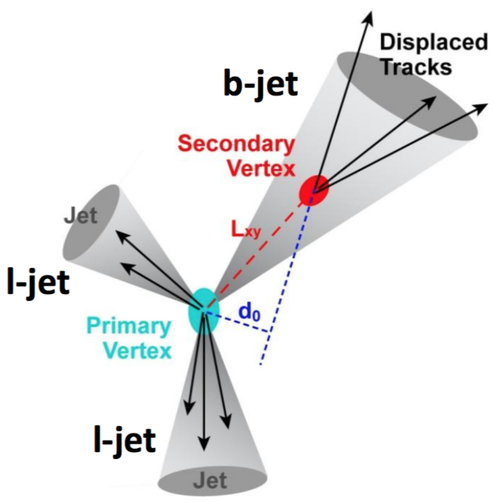
PERFORMANCE OF REAL-TIME FLAVOUR TAGGING IN ATLAS DURING RUN-II

(ATL-COM-PHYS-2018-098)

Flavour Tagging

The goal of flavour tagging is to correctly identify and discriminate between jets originating from light quarks or gluons (light-jets), *c*-quarks (*c*-jets), and *b*-quarks (*b*-jets)

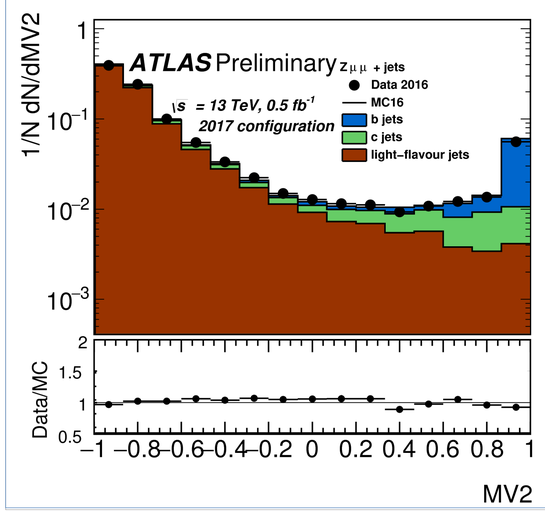
Properties of *b*-hadrons:
- High mass (~5 GeV)
- Relatively long lifetime (~1.5 ps)



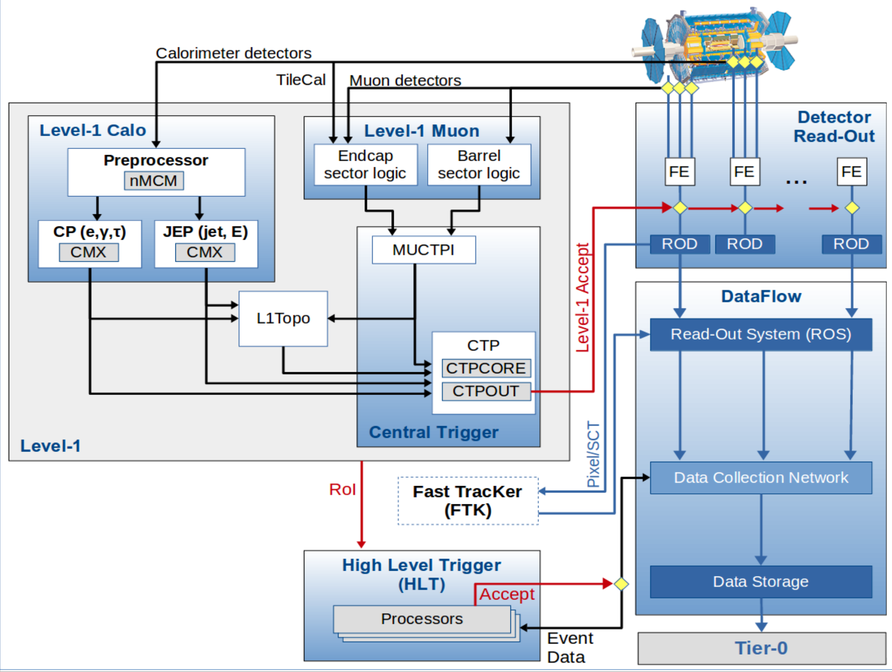
b-tagging Algorithms [4]

The ATLAS *b*-jet trigger uses the same tools as the offline reconstruction:
- Less code maintenance
- Larger online/offline correlation

The MV2c10 flavour tagging algorithm implements a Boosted Decision Tree (BDT) to discriminate *b*-jets from light-jets and *c*-jets



The ATLAS Trigger System [1, 2, 3]



ATLAS uses a two-level trigger: the hardware-based Level 1 Trigger (L1) and the software-based High Level Trigger (HLT)

1. L1 uses Trigger Objects from the calorimeter systems and muon detectors with a reduced granularity
   - Identifies Regions of Interests (RoI)
   - Fast electronics (~2.5 μs)
   - **Reduces trigger rate from 40 MHz to 100 kHz**
2. HLT uses L1 information and Trigger Objects from all the detectors with full granularity
   - Analyzes the L1-RoIs
   - L1Topo: Use L1 Trigger Objects to provide topological selections
   - Latency on Order(ms)
   - **Further reduces rate from 100 kHz to 1 kHz**

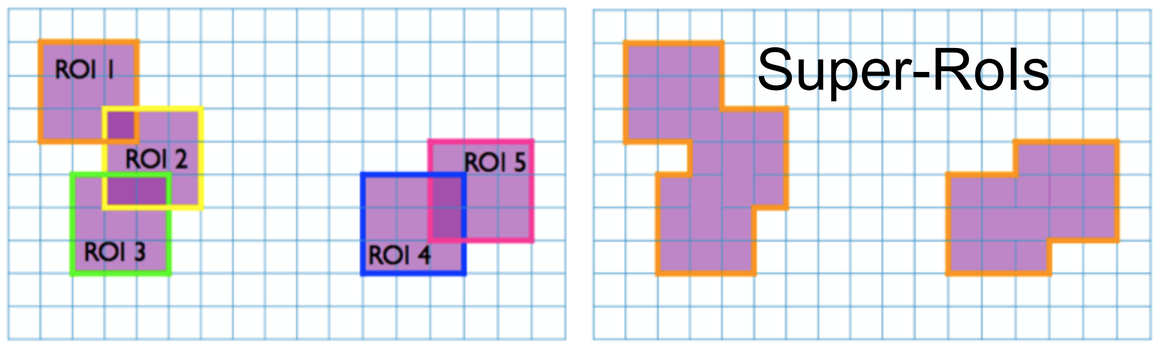
Upcoming improvements:
- Fast Tracker (FTK): provides global ID track reconstruction using associative memories

b-jet Trigger Configuration and Trigger Menu [5]

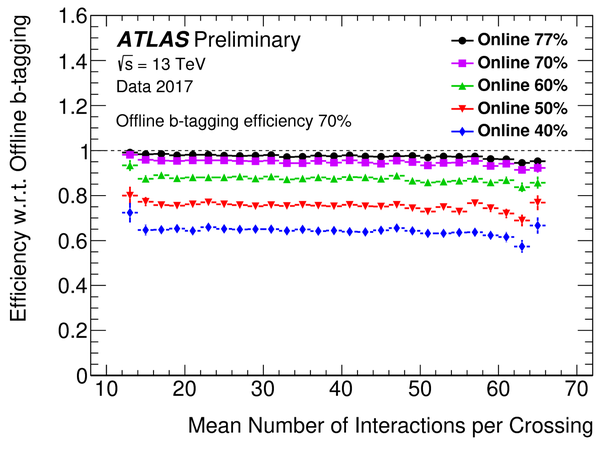
In high pile-up environments with many tracks there is high CPU cost and time loss in running track reconstruction
- As pile-up increases it becomes imperative to be as judicial and efficient as possible
- CPU optimization studies were conducted in 2017 allowing for critical savings

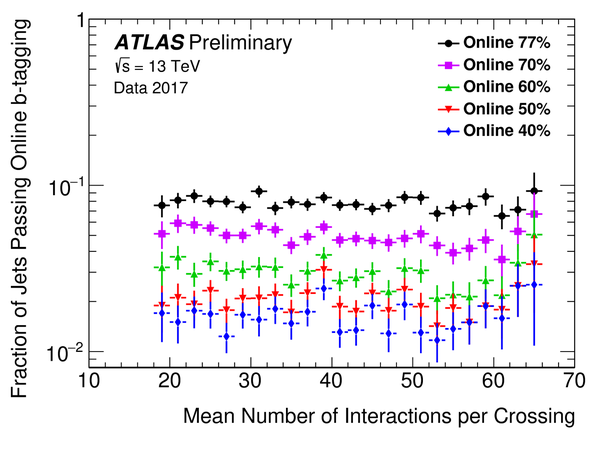
2017 *b*-jet trigger menu changes:
- Global Sequential Calibration (GSC) corrections added to trigger chains
- Expansion of physics centered menus: $X \rightarrow b\bar{b}$, VBF, and use of L1Topo

Run-2 Track Reconstruction Procedure (implemented in 2016):
1. Merge the L1-RoIs into topologically unique “Super-RoIs”
2. Perform fast track reconstruction and primary vertex finding on the Super-RoIs
3. Split the Super-RoIs into the original L1-RoIs
4. Perform a precision track reconstruction on the original L1-RoIs with a constraint on the Primary Vertex



Performance in 2017 Data at High Pile-Up [6, 7]

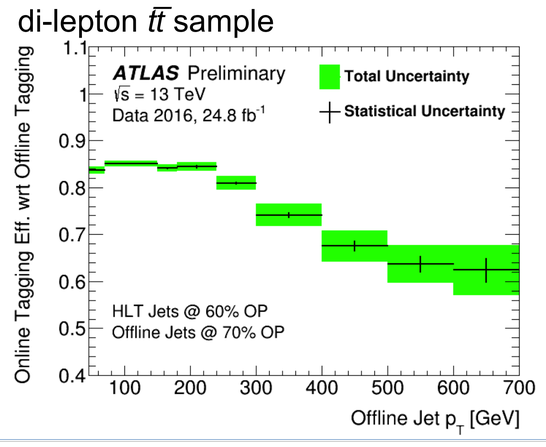




In Run-2 high pile-up conditions in excess of 60 interactions per bunch crossing have been reached
- *b*-jet trigger online efficiency is consistently high and has low pile-up dependency
- Likewise, fraction of jets in data that pass the online *b*-tagging is also robust to pile-up
- Demonstrates robustness of the *b*-jet trigger at multiple *b*-tagging efficiency operating points

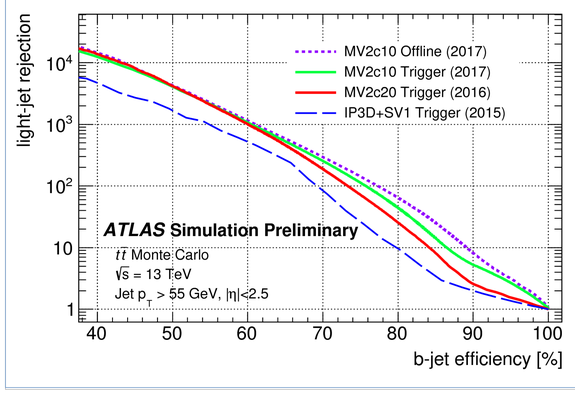
Trigger Efficiency [7, 8]

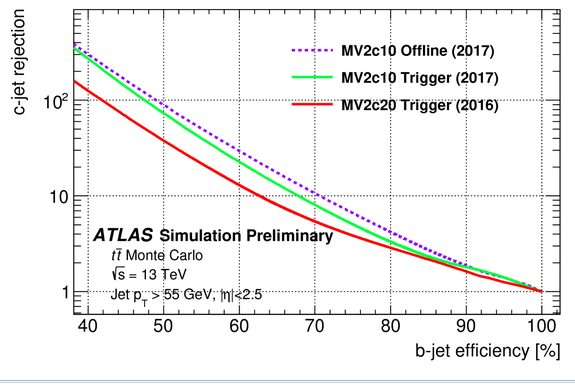
The *b*-jet trigger efficiency is derived using a data driven technique:
- Efficiency for $p_T < 240$ GeV is measured in data
- Efficiency is extrapolated to higher p_T using high *b*-purity Monte Carlo di-lepton $t\bar{t}$ sample



Tuning of the MV2c10 BDT Algorithm and Hybrid Tuning [7, 9]

The BDT algorithm used in the ATLAS *b*-jet trigger requires tuning to be maximally efficient at separating *b*-jets from light and *c*-jet backgrounds.
- The BDT is tuned by retraining with the 2017 configuration on $t\bar{t}$ Monte Carlo samples
- Tuning shows an expected performance increase with MV2c10 for *b*-jet triggers in 2017 data-taking compared to previous algorithms
- Performance increase is seen both in light-jet rejection and in *c*-jet rejection





Hybrid Tuning is implemented to provide a trigger well trained with high p_T jets:
- A mixture of both high *b*-purity $t\bar{t}$ and Z' Monte Carlo samples is used for the training
- Mixture is based on the jet p_T for light-jets and *c*-jets and the *b*-hadron p_T for *b*-jets
- Addition of the Z' samples offers increased statistics of jets across the whole p_T spectrum
- Architecture of the BDT used in the hybrid tuning is the same as the standard tuning
- Already implemented in the offline tagger, and being prepared for the trigger level in 2018

References: [1] CERN-EP-2016-241 [2] ATL-COM-DAQ-2014-019 [3] CERN-LHCC-2013-007 ; ATLAS-TDR-021 [4] ATL-PHYS-PUB-2017-013
[5] ATLAS-CONF-2015-002 [6] ATL-COM-DAQ-2017-182 [7] ATLAS Public b-Jet Trigger Plots for Collision Data TWiki
[8] ATL-COM-DAQ-2017-009 [9] ATL-COM-DAQ-2017-062

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