



# Real-time b jet identification in ATLAS

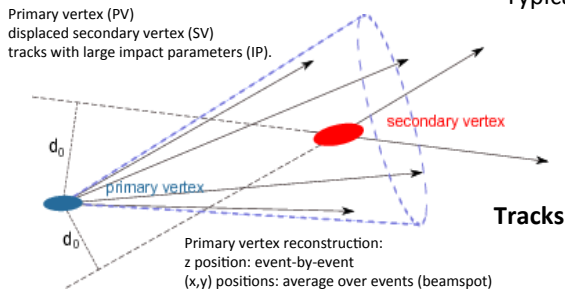
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**Motivation:** There are interesting physics processes studied at the ATLAS detector at the LHC, whose signatures contain jets originating from quarks (at least one of which originates from a bottom quark), but no charged lepton: top quark pair production where both quarks decay hadronically, Higgs boson produced in vector boson fusion and decaying to a bottom quark pair, or supersymmetric signatures with no charged lepton. Data for these processes can only be collected using jet-based triggers. As LHC instantaneous luminosity increases and ATLAS trigger bandwidths are constant, jet energy thresholds need to be raised, which decreases offline analysis sensitivity due to a lower signal acceptance. However, the need to raise jet thresholds can be made less pressing if jets originating from bottom quarks are identified as such (b tagging) already at the trigger stage.

About one in ten data events ATLAS gathered in the LHC Run I was collected using b-jet triggers.

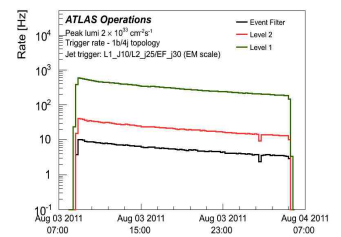
Jet b tagging relies only on identifying tracks



Typical 2012 running ATLAS trigger rates (Hz)

Trigger Level	Total b jets	Total all
L1	5,000	70,000
L2	900	5,000
EF	45	700

b-jet triggers:  
 1b/4j, 2b/4j, 2b/2j

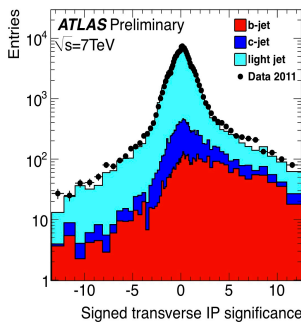


b-tagging algorithms were simplified versions of their offline peers and evolved during the data taking. For the LHC Run II, ATLAS is investigating the opportunity to make the most complex offline algorithms available at the trigger level.

## 2011 (7 TeV)

Signed transverse IP distribution (symmetric for non-b jets, while b jets tend to positive values), computing a chi square probability of all tracks originating from the primary vertex (JetProb), which is flat for jets from light quarks and gluons and peaks at zero for b jets.

In 2010 running online for testing, and monitoring tracking reconstruction, but not for data taking.



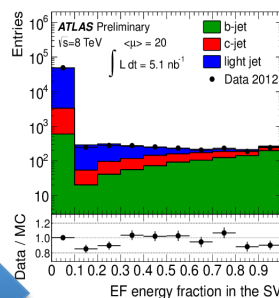
## 2012 (8 TeV)

Both the transverse and longitudinal IP distributions, as well as the prior knowledge from simulated top quark events of how these distributions look like for b jets and non-b jets (Log likelihood method).

$$\mathcal{L} = \prod_{\text{tracks}} \mathcal{L}_i$$

In addition, a likelihood of secondary vertex reconstruction was used, based on mass, number of two-track vertices and the fraction of energy in the SV.

No samples in data pure in b, c, light jets, so we use simulations to separate samples based on generated flavor.



4-5 times better non-b jet rejection  
 Pileup robust primary vertex determination

## 2015 (14 TeV)

Better tracking thanks to adding an extra silicon detector layer at 3.2 cm from beam line (now closest at 5 cm).

Improve timing performance for High-Level-Trigger tracking to allow operation at very high pile-up regimes.

Investigating an event-by-event 3D primary vertex reconstruction.

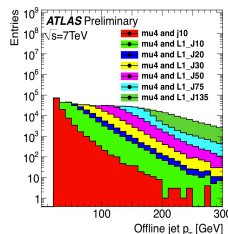
Ability to use same programming objects and any complex b-tagging algorithm adopted for offline b-jet identification.

b-jet identification at the HLT will become crucial to efficiently trigger topologies with charged leptons in the final state. While purely leptonic items were mostly used in 2012, charged lepton + b-jet items could be adopted in 2015, to avoid increasing the leptonic energy thresholds.

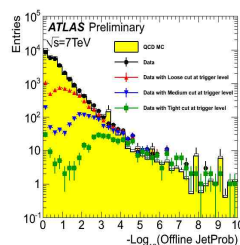
Multivariate decision based on the previous information, plus extra track info, such as the reconstruction of a third vertex from the decay of a c quark produced in the decay of the b quark.

Data-driven techniques for calibration of online and offline b-jet identification are key for offline analysis of many physics channels.

Triggers on b jets using a muon inside the jet used for calibrating b jets.



Data to simulation comparison in 2011 running  
 For the JetProb output at offline and after applying  
 EF cuts at three operating points 90%, 70%, 50% efficiency.



**Conclusion:** b-jet triggers are crucial for physics searches without a charged lepton. ATLAS used ever-improving b-tagging algorithms at the trigger level in the data taking in 2011 and 2012 and calibrates these triggers for data analysis. For the LHC Run II data, more advanced b-jet triggers will be used thanks to the merged HLT trigger, improved tracking and the ability to use the complex offline b-tagging algorithms directly at the new HLT level.