b-jet triggering in ATLAS

Viviana Cavaliere on behalf of the ATLAS Collaboration

University of Illinois (viviana.cavaliere@cern.ch)

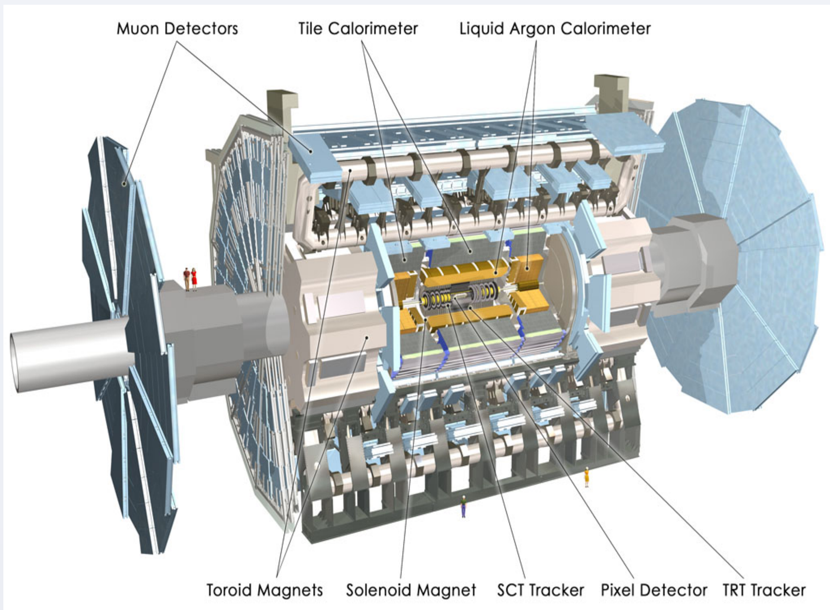
INTRODUCTION AND PHYSICS MOTIVATION

The possibility to identify and tag jets originating from b-quarks in proton-proton collisions is an important aspect for many physics analyses. It can allow the study of otherwise difficult processes, such as all-hadronic decays of top quark pairs through increased background rejection and help probe the flavor structure of new physics.

Due to the large multi-jet production rate at the LHC it is challenging to study signatures without relying on leptons to trigger the event. The b-jet trigger offers an advantage compared to calorimeter-based jet triggers as it additionally exploits track information to identify b-jets.

ATLAS DETECTOR

The ATLAS detector is a multi-purpose particle physics apparatus with a forward-backward symmetric cylindrical geometry, divided in different subsystems.



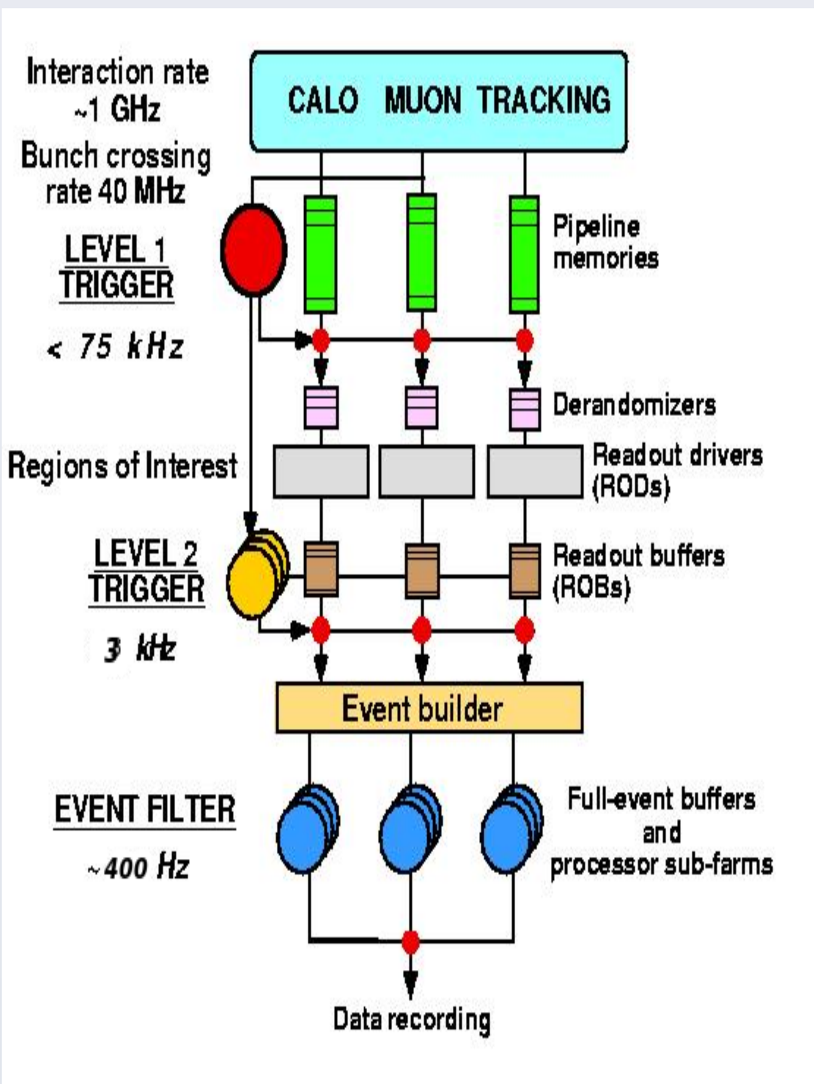
- Inner Detector reconstructs charged particle trajectories and measures their momentum. It has excellent performance in the momemtum resolution and reconstruction efficiency together with capability to identify secondary vertices formed by the hadronization of b-quarks
- Calorimeters: the Electromagnetic calorimetry identifies and measures the electrons and photons. The Hadronic calorimeter identifies jets formed by the hadronization of quarks
- The Muon System consists of a combination of detectors providing precision hit measurements (e.g.drift tubes) and fast trigger information (e.g. resistive plate chambers).

TRIGGER SYSTEM

The ATLAS Trigger is aimed at reducing the initial collision rate of 40MHz to a reliable data rate for permanent storage of around 200-400Hz.

A schematic overview of the ATLAS Trigger System is shown in Figure. It consists of three levels:

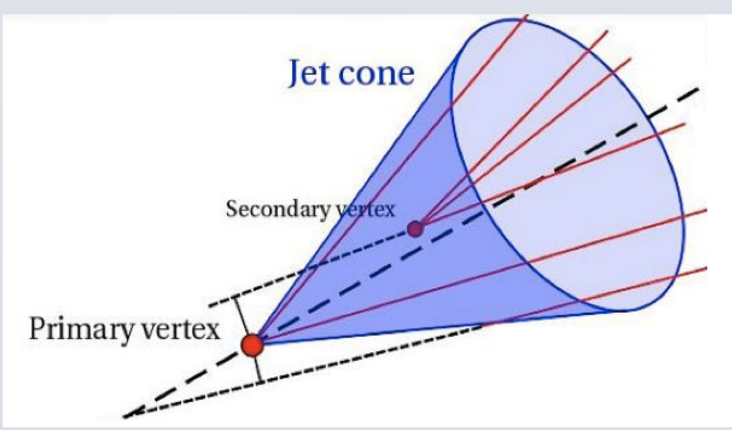
- The Level 1 (L1) is a hardware trigger implemented in custom-built electronics. It uses the calorimeters and muon spectrometer with coarse granularity to select Regions of Interest (RoI), which will be analyzed by the following levels.
- The High Level Trigger (HLT) is a software based trigger, running on large computer clusters. It is subdivided into the Level-2 (L2) trigger and Event Filter (EF), and is used to refine the L1 decision to select interesting events in order to reduce the event rate further.



PROPERTIES OF B-JETS

The identification of jets originating from the hadronization of b-quarks (b-jets) is experimentally possible because of b-quark decay properties like the relatively long lifetime of B-hadrons – of the order of 1.5 ps – that allows them to travel several millimeters before decaying.

The larger impact parameter of the reconstructed tracks and the presence of a secondary vertex and its associated properties are all good discriminators between jets coming from the hadronization of b quarks and jets coming from light quarks or gluons

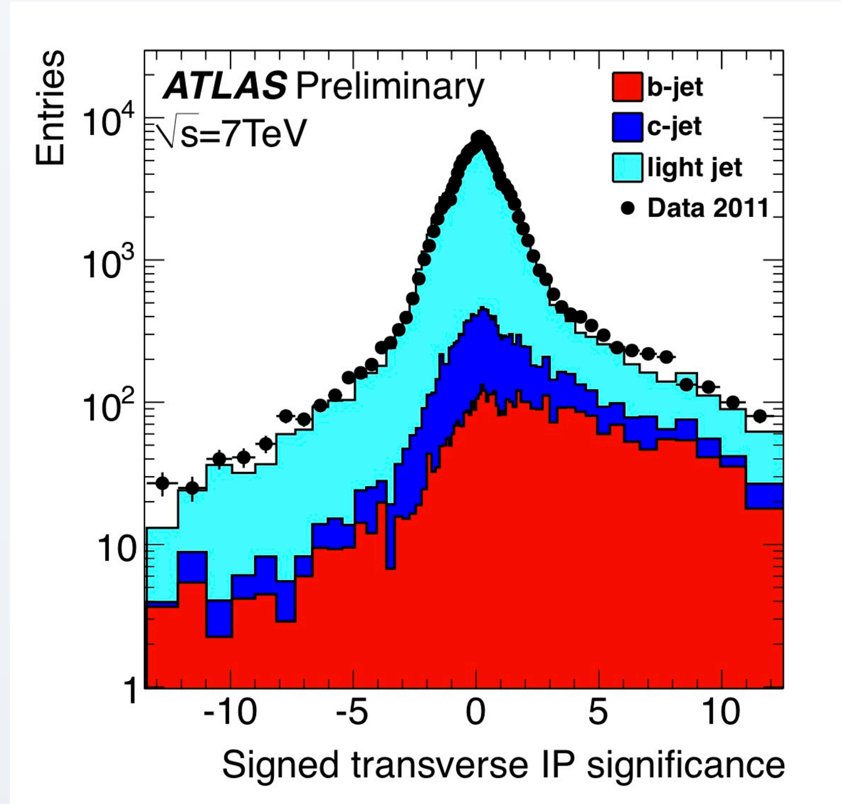


Using the properties of tracks reconstructed in the inner detector we can tag jets which are likely to originate from b quarks.

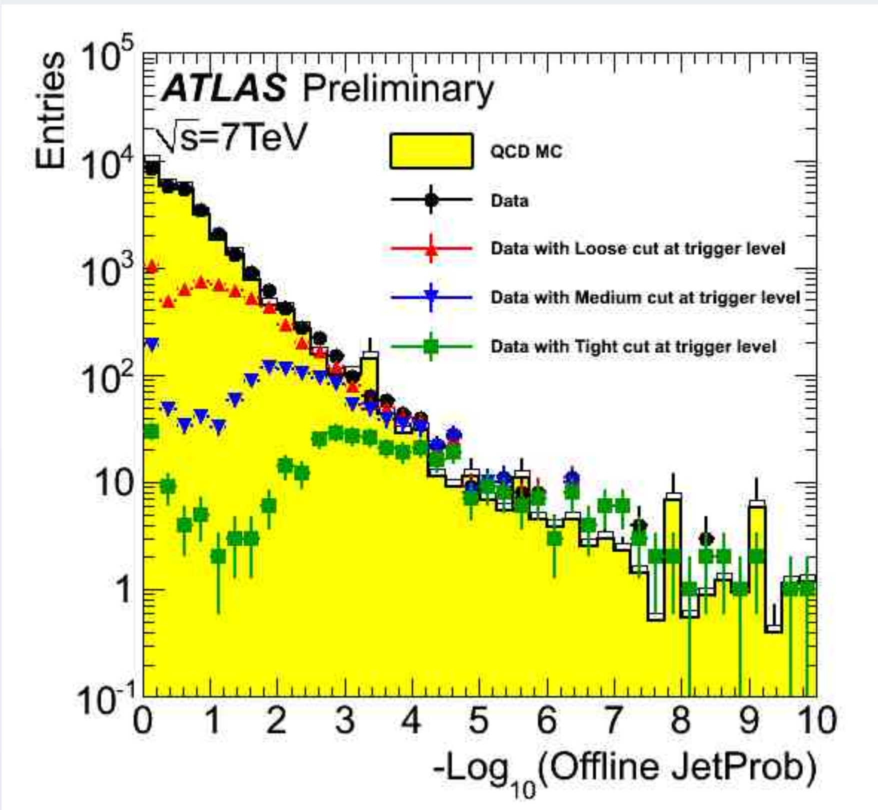
BJET TRIGGERS IN 2011

The b-jet selection is part of the trigger strategy of the ATLAS experiment and a set of dedicated triggers has been in place for the 2011 data-taking period. Online b-jet tagging selection was based on transverse signed impact parameter of reconstructed tracks.

The *JetProb* method computes the probability for a jet to originate from the primary vertex, based on the transverse impact parameter significance of tracks within the jet. The probability is computed comparing the signed impact parameter significance (shown in figure) with a resolution function *R* for prompt tracks, which can be directly measured from experimental data, using the negative side of the signed impact parameter distribution:



$$\mathcal{P}_{\text{track}} = \int_{-\infty}^{-|d_0|/\sigma(d_0)} R(x)dx$$



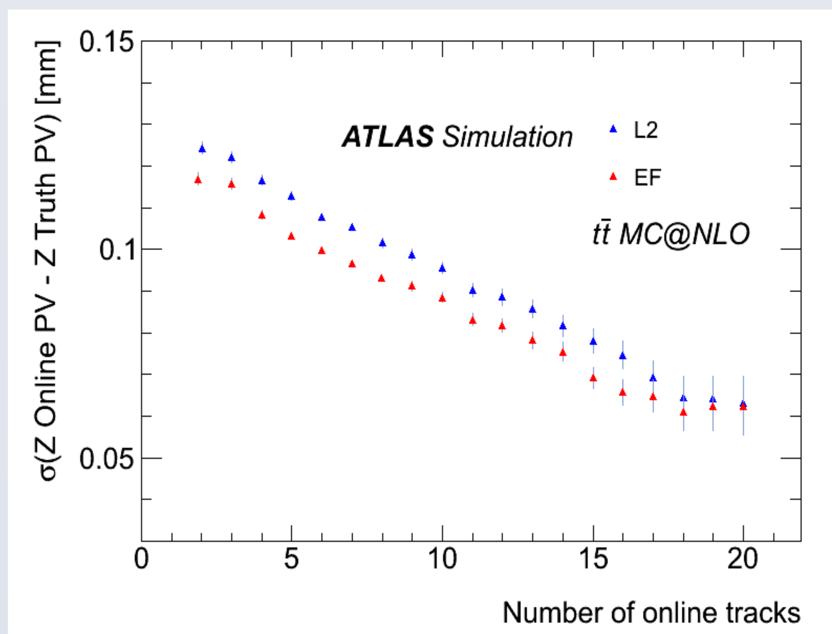
Three working points are considered. They correspond to roughly 70%, 55% and 40% efficiency on a b-tagged jet sample using top simulated events.

Figure shows offline JetProb distribution in data and simulation and the same distribution in data when a b-jet requirement is added at the trigger level, both LVL2 and EF.

b-jet triggers in 2012

For the 2012 run several improvements have been implemented in the set of b-jet triggers for physics analysis:

- The default taggers changed from JetProb to a likelihood ratio approach exploiting information from both track's impact parameters and properties of secondary vertices
- Per-event primary vertex (PV) estimation: in 2011 all of the b-jet triggers relied on multi LVL1 jets as seed. Then for each RoI the standard sequence of algorithm was run. It is possible to obtain a substantial gain when combining the information coming from the various RoIs



Since the z coordinate of the PV is calculated by histogramming the z_0 of all selected tracks in the RoI and using a sliding window algorithm to select the largest local maximum, using all the tracks improves its resolution, robustness and impacts the calculation of the significance of the longitudinal impact parameter. The resolution of the PV estimate as a function of the track multiplicity is shown in Figure, where we can see that there is a ~25% gain in resolution at EF when using more tracks in the event.

CONCLUSION

b-jet triggers have been actively running during the 2011 data-taking operations period. Various triggers have been designed for different event topologies and are now being used for physics purposes. Several improvements have been designed and among those the per event PV estimation has been implemented for the 2012 data-taking period. Future improvements will include exploiting the access to more tracks to estimate the vertex position also in the transverse plane which has a direct impact on the b-tagging performance. Finally, with this technology in place, we can think of studying a per-RoI versus per-event b-tagging weight.