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Real-time selection using flavour-tagging algorithms in ATLAS

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Summary. — The physics program covered by the ATLAS Collaboration is broad and also includes final states characterized by the presence of b-hadrons in their final states. Specialized triggers that exploit flavour tagging techniques, the b-jet triggers, have been developed for targeting these topologies. In this contribution the use of flavour tagging algorithms at online level and techniques to improve their performance will be presented.

1. – Flavour tagging

Flavour tagging aims at identifying jets that are likely to be produced by heavy flavour quarks using techniques of machine learning. The differences between b- and *light*-jets is reflected in several physical quantities of b-hadrons (such as long lifetime, secondary vertex position, mass, shower shape, etc.), bringing different and complementary —albeit partially correlated— information that must be combined together.

A first level of combination is performed with likelihood-based taggers, while Multivariate Techniques (MVA) take care of the final combination in order to produce the discriminating variable. As such, an impressive suite of algorithms have been developed that differ from one another via: the use of different multivariate techniques; the information used; and the different levels of complexity of the algorithms.

The training phase of these algorithms is performed on simulated samples of b-jets (signal hypothesis) and *light*- and c-jets (background hypothesis) obtained from simulated $t\bar{t}$ events.

2. – b-jet triggers

To identify and select interesting events amidst the huge amount of proton-proton collisions occurring at LHC, the ATLAS experiment uses a complex trigger system [1, 2].

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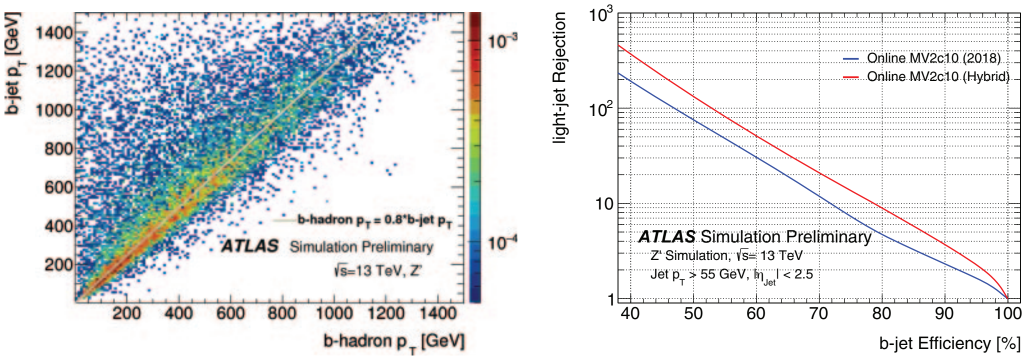

(a) **(b)**

Fig. 1. – (a) Two-dimensional correlations between the b-hadron and the b-jet transverse momenta for $Z' \to t\bar{t}$ simulated events. (b) Online *light*-jet rejection as a function of b-jet efficiency when comparing the nominal $t\bar{t}$ training (blue line) with a training using the hybrid configuration (red line), determined using $Z' \to t\bar{t}$ simulated samples.

This is structured as a two-layer system: a first hardware-based Level-1 trigger (L1), that reduces the trigger rate from 40 MHz to 100 kHz; followed by a software-based High Level trigger (HLT), that further reduces the trigger rate to 1 kHz. Flavour-tagging techniques can be exploited at HLT level. These are the b-jet triggers, which are widely used in ATLAS, both for Standard Model measurements and for searches of new phenomena.

The aim of b-jet triggers is to assure the ability to run the jet flavour-tagging algorithms in the online environment. The performance of b-tagging algorithms with respect to the true flavour of jets is shown in terms of *light*-jet and c-jet rejection as a function of b-jet efficiency. As a function of p_T these performance figures decrease, a symptom that the MVA algorithms are less and less capable of discriminating *light*-and c-jets from b-jets. The training and testing samples, based on $t\bar{t}$ simulated samples, of the flavour tagging algorithms are limited in statistics at high p_T. As a consequence, the b-tagging algorithm does not efficiently learn to discriminate b-jets from *light*- or c-jets. Thus, the use of a $t\bar{t}$ only training sample is not optimal if the targeted phase space comprises high-p_T jets. The introduction of a new MVA training on a mixed sample of $t\bar{t}$ and $Z' \to t\bar{t}$ simulated events —the so-called Hybrid tuning— should result in enhanced performance of b-jet triggers at high p_T [3].

As shown in fig. 1, the new training sample will provide a high p_T-enriched sample to the MVA, and is expected to improve performance at high p_T, while remaining almost unchaged at lower p_T, where the training sample is dominated by the $t\bar{t}$ sample.

REFERENCES

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