The potential of timing as a jet-substructure variable in future collider detectors

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With the next-generation pp colliders such as the FCC-hh [1] and SppC [2] at $\sqrt{s}$ =100 TeV, measurements of high-momentum bosons (W, Z, H) and top quarks could be achieved using the boosted jets produced from their hadronic decays. The challenge is to distinguish the different number of subjets within a large-radius jet. In order to investigate the issue, a full GEANT4 simulation of a future collider detector called SiFCC is implemented [3].

Our studies have been inspired by [4] where the viability of exploiting timing information on the particles in a jet was investigated. The truth-level particle velocities were used to explore the theoretical potential of timing information. In addition, time-of-flight (ToF) measurements in the electromagnetic calorimeter are investigated to see if they would be useful jet-substructure variables, along the lines published in Ref. [5].

In this study, a hypothetical heavy Z' gauge boson, postulated in extensions of the standard model, is simulated with the boson masses of 5, 10, 20 and 40 TeV. The bosons are forced to decay to two light-flavor jets ($q\bar{q}$) [6] to model the background and to WW pairs [7] where the W bosons decay hadronically ($W \to q\bar{q}$) to model the boosted W boson signal. We explore how background rejection can be achieved by including the timing information in addition to the measurement of particle momenta.

We rank order the particles in a jet by their transverse momenta p_T and by their velocities (both truth and measured) and consider the trailing particles by these criteria. We compare the signal to background separation with (i) exploiting only the p_T of trailing-p_T particles, (ii) adding the velocities of the slowest particles at truth-level, and (iii) adding the measured velocities of the slowest particles.

References

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