Physics potential of timing layers in future collider detectors

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1. Introduction

Future particle colliders such as CLIC [1], the International Linear Collider (ILC) [2], the high-energy LHC (HE-LHC), and *pp* colliders of the European initiative, FCC-hh [3] and the Chinese initiative, SppC [4] will motivate high-precision measurements of particles and jets at large transverse momenta. Timing information in these experiments can be used to improve particle and jet reconstruction and to suppress backgrounds. For example, high-precision timing will be beneficial for *b*-tagging for post-LHC experiments. At CLIC and FCC, high-precision time stamping of calorimeter energy deposits will be essential for background rejection (i.e. fake energy deposits) and pile-up mitigation. Precise timing information improves the reconstruction of particle-flow objects by reducing overlap of out-of-time energy showers in highly-granular calorimeters.

In this contribution we investigate the benefits of timing layers with resolution in the range 10 ps – 1 ns. The resolution of 1 ns is standard for existing and planned calorimeters [1, 2, 3, 4], and is used as a benchmark for comparisons with the more challenging 10 – 20 ps resolution devices. In addition, we investigate the capabilities of timing layers for identification of heavy stable particles which may be produced due to physics beyond the standard model (BSM). These studies can help shape the requirements for future calorimeters, which were already outlined in the CPAD report [5] that emphasized the need to develop fast calorimetric readouts.

We explore this idea by using a semi-analytical approach and Monte Carlo simulations. The semi-analytical approach will be used for BSM models. It does not involve the knowlege on the detector design, thus it can be used for any detector and collision types. The studies that require full GEANT4 [6] simulation will use the SiFCC detector [7] geometry for 100 TeV *pp* collisions. Such simulations will allow the use of the ECAL hit information. Recently this detector was used [8] to establish the optimal cell granularity of hadronic calorimeters for TeV-scale jets.

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