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A modular software framework for test-beam data analysis. The TbGaudi package

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A dedicated irradiation programme followed by detailed studies with particle beam are essential for proper evaluation of detector prototypes and predict their performance after accumulating the design fluence.

In order to perform precise measuremens with the LHCb VELO detector prototypes a dedicated high resolution pixel beam telescope was developed based on 8 Timepix3 detector planes. This telescope has been taking data at CERN in the PS and SPS facilities since 2014. The Timepix3 can readout on data driven mode with very precise timestamps which makes triggering unnecessary.

At the centre of the telescope a Device Under Test (DUT) can be installed on a motion stage allowing angular rotations about the y axis, and x and y translations, where the z coordinate is the beam direction. The telescope provides precise measurements of particle trajectories with a pointing resolution of ~2 µm and a time resolution of ~1 ns allowing in-depth analysis of the DUT performance.

The data produced by the telescope can easily incorporate the signals from the DUT and in particular for Timepix3 devices the analysis is straight forward. The LHCb software embeded in the so-called Kepler project performs the decoding of raw data and produces track objects inside the official LHCb's Gaudi framework. In this way it is simple to produce histograms and ntuples with track and cluster data information.

Subsequently, the offline analysis compares the performance after irradiation with several fluences of protons or neutrons from 2 to $8{\times}10^{15}$ 1 MeV neq/cm^2; different silicon substrates (n-on-p or n-on-n), distances from last pixel to the edge, guard rings designs and different vendors. Charge collection efficiencies (CCE), track resolution (TR), Eta correction are of particular interest as function of fluence.

For purposes described above, a modular software framework has been developed. It allows to handle the test beam data for a set of runs, as well as the set of different DUTs in one-go, and obtain an integrated workflow to present the results.

All code is written in C++, which is a general-purpose objective programming language. A class based design makes it flexible to add any new features of the device under investigation following a plug-in scheme. Currently, the toolkit handles different types of analysis such as CCE, TR and Eta correction, implemented for non-uniform irradiated sensors.

The presentation will describe the implemented analysis framework as a proposal of the prototype of a general design framework for test beam campaigns, that could be followed to obtain a quick ROOT based application for complex test beam data analyses being performed in different facilities and different irradiation sources or profiles. The interface is implemented for a series of algorithms in a user-friendly way. We believe it is a valuable complement to used by different groups performing detector R&D programs.

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