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3-D Pixel Imagers with Exploitation of Delta-rays in Precision Tracking and Identification of Relativistic Particles

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no abstract summary only

Summary

The scenario for long-term development at the Large Hadron Collider LHC is a further increase in luminosity, which might be beyond the current limits of the trigger capabilities of the experiments based primarily on emerging muons and large particle energy deposits in the calorimeters. The community must investigate new approaches for detectors and their signals that would allow recognizing specific features of particles that emerge from a collision with high potential for new physics. When such features could be identified locally within the tracker, or closeby, a more effective trigger could be constructed and higher intensities may become acceptable. One possibility under discussion is the recognition of a “stiff-track”, high momentum particles such as muons, by correlating signals in closely spaced inner pixel detector layers. Here we like to describe an even more ambitious possibility: exploitation of high-frequency delta-ray emission by relativistic charged particles when these traverse a 3-dimensionally arranged layer of pixel cells (see Fig. 1). Such a high-granularity active detector at the same time allows an order-of-magnitude improvement of precision on the spatial position of the particles that traverse this device, comparable to a passive nuclear emulsion. Several experiments have studied ‘glancing-angle’ incidence of minimum-ionizing particles in pixel detectors. In this case, delta-electrons are clearly recognizable via tracks as one or several off-trail pixels, or as a pixel with excess-signal, as visible in Fig. 1. Different generation processes compete, where some may provoke discontinuities. For example interaction of hadrons, emerging from the vertex, with silicon nuclei represents such a track discontinuity. For the tracking a relatively thick silicon layer could bring near real-time information about ‘energy-flow’, and providing a ‘pre-shower’ identification potential.
-> Here is an essential and nice figure; how can I put this in ?????
Fig. 1. Selected tracks produced by energetic particles in the pixel detector Timepix onboard the ESA Proba-V satellite in LEO orbit at 820 km altitude. The particle identification can be done not only based on ionizing losses but also on energy distribution and density of observed delta electrons associated to the track. The track shape is influenced by dE/dx and by charge sharing in the process of charge collection across the silicon sensor depth (z-coordinate). a) High energy transfer heavy particle (high Z and high A), b) High energy transfer heavy particle (high Z and high A) accompanied by energetic light particles, c) high energy transfer light particle, d) MIPs.

Author: ERIK H.M. HEIJNE1,2, CARLOS GRANJA2, STANISLAV POSPISIL2, RAFAEL BALLABRIGA1, MICHAEL CAMPBELL1, JAN JAKUBEK2, CLAUDE LEROY3, XAVIER LLOPART1, KARIM MELLAB4, STEPAN POLANSKY2, ALAN OWENS4, DANIEL TURECEK2, ZDENEK VYKYDAL2, Erik (CERN+IEAP-CTU)