Eleventh International Workshop on Semiconductor Pixel Detectors for Particles and Imaging

ID de Contribution: **51**

Type: **15mOral**

Characterization of large area LGADs for space applications

lundi 18 novembre 2024 15:37 (20 minutes)

Abstract- Experiments that study charged cosmic rays in space combine a tracker and calorimeter to measure the charge magnitude, the energy, and the momentum of the incoming particles. However, secondary particles created in the calorimeter and entering the tracker will degrade the reconstruction capability of the instrument. Most of the tracker systems in these experiments use micro-strip sensors to provide spatial information of the charged particles passing through the tracker. In such sensors, the energy deposited by the primary particles cannot be separated from the energy deposited by the back-scattered secondaries. However, it has been shown that measuring the timing of charged particles crossing the tracker layers with a precision better than 100 ps can help separate the primary from the secondary particles. Low Gain Avalanche Diodes (LGADs) are silicon detectors that use the impact ionization process to achieve gain values of about O(10) and timing resolution of 30 ps for Minimum Ionizing Particles. In High Energy Physics, the state of the art LGADs have an active thickness of 50 µm and a channel size in the order of O(1 mm2). Current experiments like AMS and DAMPE could therefore benefit from a Time of Flight system composed by these sensors. Scaling up the technology to match the typical channel area of the micro-strip sensors used in space-borne experiments deteriorates the timing capabilities of the LGADs due, in first approximation, to the increased capacitance. The devices used in this study consist of pad sensors with thickness 50 µm, 100 µm or 150 µm and presents different gain layer profiles to cope with the capacitance variation. Each thickness presents three active areas (6.25 mm2, 25 mm2 or 100 mm2) and three layout designs for each area to better understand their consequences on the device performance. Different layout designs and gain layers are compared to determine the best time resolution. The timing performance of these devices is evaluated using Transient Current Technique and radioactive sources, to simulate the passage of a Minimum Ionizing Particle, along with Current and Capacitance against Bias Voltage characterisation. By evaluating gain, noise, and jitter, this work demonstrates it is possible to obtain 1 cm2 LGADs with a jitter as low as 40 ps. At the same time, the signal propagation and uniformity are studied since it was observed the channel size makes these features relevant for the timing capabilities.

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Classification de Session: Astrophysics applications

Classification de thématique: Astrophysics applications