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Development of Depleted Monolithic Active Pixel Sensors (DMAPS) for Dosimetry in Space

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The ability to protect astronauts from harmful radiation particles is critical for future human exploration missions beyond ISS. Active dosimeters with demanding specifications concerning mass, power consumption and local intelligence are required to support crew autonomy for operational decisions related to radiation hazards. Important progress in the direction of active dosimetry is being made by the EuCPAD detector and by the timepix based dosimeters. We leverage on the research and development made by the high energy physics community on the HVCMOS particle tracking detectors in order to investigate the possibility to use this kind of detectors for measuring the energy deposition in Si and the track of protons and heavy ions which are constituents of the Galactic Cosmic Rays and of the Solar Energetic Particle (SEP) events. Based on this technology we proposed a device whose data can be used for inferring the flux spectra and discriminate between particle species. Consequently the device can determine the dose equivalent, while its data can be used to calculate dosimetric quantities apart from the point where it is placed. DMAPS sensors in high energy physics experiments are measuring energy deposition by minimum ionizing particles impinging on them with high rate. In the space environment outside the geomagnetic field they have to detect energy depositions which vary by many orders of magnitude as they can be caused by minimum ionizing particles or by completely ionized heavy nuclei. The rate is very low except in the cases of SEP events. However mass and power reduction, radiation hardness, simplicity and even cost reduction are common concerns in both applications. We target these specifications by developing a CMOS pixel sensor in the LF15 technology. The first demonstrator chip has been manufactured and characterized. It contains 32 x32 pixels with 105 um pitch. The detecting p-n diode is formed by the fully depleted 2500 Ohm*cm p type substrate and the deep nwell. The deep nwell cathode is connected to an error amplifier. The amplifier through negative feedback maintains the reset voltage at the cathode, when there is no hit. When a hit occurs, the amplifier triggers a comparator which closes a switch connecting the diode to a lateral overflow integration circuit for some tens of nanoseconds. In this way the charge of the pulse is stored. The dynamic range is limited at the low side by the diode capacitance and at the high side by the dimensions of the necessary lateral overflow capacitor. Only hit pixels are readout and the two voltage readings for each pixel are converted to digital words by an embedded successive approximation analog to digital converter.

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