The testing of Timepix detectors for position-sensitive detection of charged-particles

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The use of position-sensitive detectors for charged particles from radioactive decay is a crucial task for many applications at radioactive ion beam facilities, e.g. for emission channeling lattice location experiments in solid state physics, or for angular correlations or the search for rare decays in nuclear physics. The development of new detectors for such purposes, however, is generally a complicated process, which often is performed in collaboration with commercial companies and at considerable cost. On the other hand, very advanced detection principles are already applied in many cases for photon and X-ray imaging applications. Often the corresponding detectors are also suitable for the detection of charged particles.
We report here on the testing of Timepix position-sensitive Si pixel detectors with respect to their response to electrons, protons, and alpha particles. The Timepix detectors are produced by the international Medipix Collaboration, hosted by CERN, and typically have a size of 1.5x1.5 cm2, consisting of 256x256 pixels of size 59 micrometer. The detectors were tested with low-energy conversion electrons (40-50 keV) from a radioactive source of 73As, high-energy beta particles from 89Sr (endpoint energy 1.5 MeV), 5-6 MeV alphas from a triple alpha source of ^{240}Pu+^{241}Am+^{244}Cm, as well as 2 MeV 4He and protons from a Van de Graaff accelerator beam that were backscattered from a thin Au layer.
The achieved energy resolution was 6-7 keV FWHM for 40-50 keV conversion electrons, showing that noise levels per pixel are quite low. Since the pixel preamplifiers saturate around 1 MeV, higher particle energies can only be measured if the detector bias is lowered, thus allowing the created charge to spread over a larger number of pixels. Using this method energy resolutions around 46 keV for ~1.8 MeV alphas and protons and 87 for 5.5 MeV alphas were achieved. While the detection system can process higher count rates, pile-up became noticable in the energy spectra above ~1000 events/s.
The position resolution for electrons is limited by the scattering of electrons in the detector, while for alphas and protons it can in principle be even smaller than the pixel size if Gaussian fitting to the charge cloud is applied.