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Test of different pixel detectors for laser-driven accelerated particle beams

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Laser driven accelerated (LDA) particle beams have due to the unique acceleration process very special properties. In particular they are created in ultra-short bunches of high intensity typically up to 10^9 particles/cm²/ns. Characterization of these beams is very limited with conventional particle detectors especially with non-electronic detectors like radiochromic films, imaging plates or nuclear track detectors which are still broadly used at present. Moreover, all these detectors give only offline information about the particle pulse position and intensity as they require minutes to hours to be processed, calling for a new highly sensitive online device. Therefore, we are using pixel detectors for real time detection of LDA ion pulses. As each pixel represents a small detector unit in itself, only a small fraction of the whole beam will be detected by it and so problems due to detector saturation might be overcome by this new approach. Besides beam flux monitoring with high spatial and temporal resolution, additional knowledge about beam energy is also advantageous.

Tests have been performed at the Munich 14MV Tandem accelerator in an 8-20 MeV proton beam in dc and pulsed irradiation mode, the latter simulating LDA-like ns ion pulses. For detection tests we chose the position-sensitive quantum-counting semiconductor pixel detector Timepix which also provides per-pixel energy- or time-sensitivity. Additionally other types of commercially available pixel detectors are being evaluated such as the RadEye1, a large area (25 x 50 mm²) CMOS image sensor based on a photodiode array in a matrix of 512 x 1024 pixels with 48 micron pixel pitch.

All of these devices are able to resolve individual particles of the beam with high spatial- and energy-resolution down to the level of µm and tens of keV, respectively. Various beam delivering parameters of the accelerator were thus evaluated and verified. The different readout modes of the Timepix detector which is operated with an integrated USB-based readout interface allow online visualization of single and time-integrated events. Therefore Timepix offers the greatest potential in analyzing the beam parameters.

This work is carried out in frame of the Medipix Collaboration and the Munich Centre for Advanced Photonics (MAP).

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