Pixel detectors for laser accelerated proton beams

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One of the main goals of the Munich Centre for Advanced Photonics (MAP) is the use of laser driven accelerated (LDA) particle beams for radiation therapy.
Laser accelerated particle beams have due to the unique acceleration process very special properties. In particular, they are created in ultra-short particle pulses of high intensity (> 10^7 particles/cm^2/ns), which makes online detection an ambitious task.
Therefore, especially non-electronic detectors such as radio-chromic films (RCF), imaging plates (IP) or nuclear track detectors (e.g. CR39) are broadly used at present. As minutes to hours of processing time are required after exposure of these kind of detectors, there is only offline information on the particle pulse intensity and position available. With increasing pulse repetition rate of the laser system, there is a growing need for online detection of laser accelerated particles. For a future application in radiation therap, quantitative real time monitoring of the beam is even mandatory.

Therefore, we are investigating pixel detectors for real time detection of LDA proton pulses. As each pixel represents a small detector unit in itself, only a small fraction of the whole LDA beam will be detected by each pixel. Hence, problems due to detector saturation might be overcome by this approach. Due to excellent spatial resolution of pixel detectors, additional information about the spatial fluence distribution is obtained.

Test of different types of pixel detectors have been performed at the Munich 14 MV Tandem accelerator in a 8–20 MeV proton beam in dc and pulsed irradiation mode, the latter providing comparable particle flux as under LDA conditions.
For detection tests we chose a commercial system, the RadEye 1 detector, based on a CMOS photodiode array, as well as the Timepix read-out chip, developed in the framework of the Medipix collaboration. The RadEye 1 sensor features a matrix of 512 x 1024 pixels with 48 μm pixel pitch and a depletion depth of approximately 2 μm, thus optimized for optical applications. The Timepix read-out chip contains 256 x 256 pixels with a pitch of 55 micron, bump-bonded to a 300 μm Si-sensor.
Both systems are able to resolve single particles of a low flux beam with high spatial (μm)- and energy-resolution (tens of keV), respectively. In this mode, the Timepix system offers the greatest potential in analysis of the beam parameters due to different available read-out modes. However, the RadEye system shows a higher saturation level in pulsed beam irradiation. The large sensitive area of 25 x 50 mm^2 which can be easily enlarged by tiling of additional sensor modules, is another major advantage of this system. Therefore, it is integrated in a first pixel detector based LDA particle detection system at the MPQ Atlas Laser in Garching.

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