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Imaging Based on Tracking of Individual Particles with the Timepix Pixel Detector

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In radiation imaging applications the pixel detectors are so far mostly operated in single particle counting mode. In this mode the signal generated by the particle is compared with a certain preselected energy threshold to remove noise and, if higher, it is counted in a digital counter. Such approach provides low noise, energy discrimination and absolutely linear image accumulation. Resulting images have extremely high dynamic range and virtually unlimited contrast which play an essential role in imaging of low contrast objects such as soft tissue structures.
Pixel detectors operated in tracking mode with reduced exposure time having only few particle traces in each frame can offer even more complete information about each detected quantum. The pixels can be then operated in Time-over-Threshold mode providing information about energy deposited in each pixel. The shapes of recorded traces are often characteristic for different particle types. Analyzing these shapes it is possible for instance to suppress undesired background, to improve spatial and energy resolution, to estimate particle type and its mass. Using coincident techniques based on time stamping in each pixel it is possible to derive also other radiation properties such as polarization for X-rays, identification of secondary particles of nuclear reactions or decay products.
Radiation imaging methods can be significantly enhanced by particle tracking principles. A few examples will be given such as fully spectroscopic X-ray transmission imaging, neutron and proton radiography with very high spatial resolution and imaging based on ion scattering.
A brief glance into the future of pixel detectors and their applications including spectroscopy, tracking and dosimetry will be given too. Special attention will be paid to the problem of detector segmentation in context of the charge sharing effect.
This work is carried out in frame of the Medipix Collaboration.

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