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# Timing performance of the Timepix3 telescope

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A beam telescope based on the Timepix3 ASIC was built in order to perform detailed studies of VELO Upgrade prototypes using charged particle beams. The telescope consists of 8 planes of hybrid pixel detectors with 300  $\mu\text{m}$  p-on-n silicon sensors, designed to cope with high particle rates using a DAQ system based on Xilinx Virtex 7 FPGA development boards. Tracks measured with the telescope have excellent spatial resolution, reaching under 2  $\mu\text{m}$  due to the small ( $55 \times 55 \mu\text{m}^2$ ) pitch, per-pixel measurements of the deposited charge, and the orientation of the detector planes in order to maximally profit from charge sharing.

In addition to precise spatial measurements, the Timepix3 ASIC operates with a 640 MHz oscillator that allows hit time-stamping in steps of 1.56 ns, giving a potential time-measurement resolution of 450 ps per plane. It is of great interest for future pixel trackers to investigate how precise time measurements can be combined to give optimal track time precision. Detailed studies have been performed to investigate the temporal resolution of individual telescope planes and the track timestamp obtained through the combination of the 8 planes.

In order to control systematic effects and provide an independent time measurement, two plastic scintillators mounted on fast PMTs were placed at opposing ends of the telescope. Their signals are treated by constant fraction discriminators to minimise timing jitter. The combination of this setup and the track timestamps results in a temporal resolution of approximately 200 ps, which has allowed the assessment of new prototypes with more promising technologies for precise timing. The sub-nanosecond precision of the track time allows the study of timing structures within the pixel chip, along with measurements of other potential systematic effects. Complementary studies are being performed in the lab with a laser setup and preliminary results will be presented.

In this presentation the most recent results on the temporal resolution of the Timepix3 telescope will be presented, together with the timing performance of new sensor prototypes.

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