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CMOS pixel sensors optimized for large ionizing dynamic

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Monolithic active pixel sensors (MAPS) are now well established as a technology for tracking charged particles, especially when low material budget is desirable. For such applications, the design of the sensor focus mainly on optimizing the spatial resolution. Small pixels with coarse charge measurement and digital outputs are well suited for this purpose.
Within the European Union's STRONG project that focuses on experiments using hadrons, the TIIMM joint research activity intends to expand granular MAPS capacity to energy-loss (ΔE) measurement. The project targets to develop sensors for a wide input signal range. Covering energies from minimum ionization particles up to heavily ionization ions, such as carbon at few 100s MeV/u. The foreseen MAPS will combine tracking and identification.

The design challenge lies in the implementation of the front-end electronics in a small pixel (about 40 µm x 40 µm) that will be capable of operation with a wide dynamic range of the input signals (of the order of 1:105). .
TIIMM exploits recent advances in CMOS pixel sensors, where the sensitive layer is fully or partially depleted, allowing faster and more efficient charge collection.
in order to explore the tradeoff between fluctuations of the released charge and the minimization of multiple scattering.

The pixel architecture contains a charge sensitive amplifier with a Krummenacher feedback, a comparator and the digital logic performing the time-over-threshold measurements with 6-bit precision. First sensor prototype has been fabricated in the Tower-Jazz 180nm technology in 2020. The second corrected version is foreseen for a submission in Q3 2021. Both sensors feature different analogue front-end designs that affect the extent of the dynamic range (in excess of 105 e- equivalent input charge) and the fluctuation of the time-over-threshold output.
This contribution will detail the result of the analogue design optimization and initial tests of the first prototypes.

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