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100 µPET: Multi-layer monolithic silicon pixel scanner for ultra-high-resolution molecular imaging

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The 100 µPET project is developing a novel small-animal PET scanner for ultra-high-resolution molecular imaging. The design consists of four towers surrounding the tissue to be analysed, each containing 60 layers of monolithic pixel sensors and flexible printed circuits.

The monolithic pixel sensor based on SiGe BiCMOS technology with HBTs offers high bandwidth and efficient noise-power trade-off. The 2.3 cm x 3.0 cm ASIC integrates a matrix of 132 x 192 hexagonal pixels with a pixel area of $(150\ \mu m)^2$, which allows for an extremely low volumetric granularity.

The read-out architecture is designed to handle an event rate of 10 kHz/cm², with each event consisting of a single cluster of up to 5x5 pixels. A high efficiency with a low fake hit rate can be achieved with a pixel threshold of 3000 e-, an ENC of 200 e- and a 3-bit DAC for pixel-level threshold tuning. The binary event-driven read-out provides the pixel address encoding on a fast bus, while a fast-or signal is sent to a periphery TDC for time-of-arrival and Time-Over-Threshold measurements. A system-level time resolution of 200 ps is achieved within a power budget of 100 mW/cm². The precise timing information is crucial for selecting true coincidence events and enhancing image quality in single-event imaging applications.

The design of the monolithic pixel sensor and scanner system along with simulation results will be presented.

Autore principale: KUGATHASAN, Thanushan (Université de Genève)

Coautore: BOQUET, Aleix (École Polytechnique Fédérale de Lausanne); PICARDI, Antonio (Université de Genève); FENOGLIO, Carlo Alberto (Université de Genève); FERRERE, Didier (Université de Genève); CADOUX, Franck (Université de Genève); IACOBUCCI, Giuseppe (Université de Genève); SAIDI, Jihad (Université de Genève); PAOLOZZI, Lorenzo (Université de Genève); IODICE, Luca (Université de Genève); WALTER, Martin (Universität Luzern); VICENTE BARRETO PINTO, Mateus (Université de Genève); UNSER, Michael (École Polytechnique Fédérale de Lausanne); JANÉ, Pablo (Hôpitaux universitaires de Genève); CARDELLA, Roberto (Université de Genève)

Relatore: KUGATHASAN, Thanushan (Université de Genève)

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