Contribution ID: **4** Type: **not specified**

The 100µPET project: a small-animal PET scanner for ultra-high-resolution molecular imaging with monolithic silicon pixel sensors

Sunday, June 5, 2022 9:45 AM (15 minutes)

Recent developments in semiconductor pixel detectors allow for a new generation of positron-emission tomography (PET) scanners that, in combination with advanced image reconstruction algorithms, will allow for a few hundred microns spatial resolutions. Such novel scanners will pioneer ultra-high-resolution molecular imaging, a field that is expected to have an enormous impact in several medical domains, neurology among others. The University of Geneva, the Hôpitaux Universitaires de Genève, and the École Polytechnique Fédérale de Lausanne have launched the 100µPET project that aims to produce a small-animal PET scanner with ultra-high resolution. This prototype, which will use a stack of 60 monolithic silicon pixel sensors as a detection medium, will provide volumetric spatial resolution one order of magnitude better than today's best operating PET scanners. The R&D on the optimisation of the monolithic pixel ASIC, the readout system and the mechanics, as well as the simulation of the scanner performance, will be presented.

In its present planning, the 100µPET project will use monolithic silicon sensors in SiGe BiCMOS technology which have already demonstrated 36 ps time resolution and full efficiency [JINST 17 (2022) P02019] with a PN-junction sensor. Future versions could envisage to use monolithic pixel sensors with internal avalanche gain (the PicoAD sensor, patent EP18207008.6/US-2021-0280734-A1, developed within the ERC Advanced project MONOLITH) which are expected to deliver time resolutions better than 10 ps. In this context, very fast electronics is being developed, among which a novel concept TDC with simple circuitry (patent EP3591477A1) that provided 1.4 ps in its first prototype realization.

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Session Classification: Technologies for ≤100ps TOFPET resolution: Photodetectors

Track Classification: Technologies: Photodetctors