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TUPI (Timepix-based Ultra-fast Photon Imaging) Detector

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The Brazilian Synchrotron Light Laboratory (LNLS), in Campinas, Brazil, part of the Brazilian Center for Research in Energy and Materials (CNPEM), operates the 4th-generation synchrotron light source SIRIUS. CNPEM is currently running the ORION Project, Latin America's first Biosafety Level 4 (BSL-4) laboratory that will be coupled to SIRIUS by three new beamlines, each of them specialized in different bioimaging techniques, such as soft X-rays single-cell imaging, insects and small tissues using tender X-rays and in vivo small animals hard X-rays biological imaging.

To reach ORION tender and hard X-rays beamlines specifications, a hybrid pixel photon-counting detectors family named TUPI (Timepix-based Ultra-fast Photon Imaging) is proposed. TUPI detectors will be based on an elementary module of 3x1 Timepix4 ASICs (Application Specific Integrated Circuit) that can be tiled to assemble larger active areas. Each module has 1344 x 512 pixels (55 µm pixel size), reaching more than 688 kpixels on approximately 75 mm x 28 mm area. It can achieve imaging acquisition rates up to 11 kHz in the called "Data Driven"mode, or 44 kHz in continuous readout photon counting mode with 16-bit dynamic count range. The detector will be able to discriminate high photon flux up to 5 x 109 ph/s/mm2 or 3 x 106 ph/s/mm2 if reading the deposited energy information in the pixels.

The detector hardware concept is composed of two main parts:

- The detection head with ASICs that can be bump-bonded to selected materials depending on X-ray beam energies of each ORION beamline (expected range of approximately 10 keV to 100 keV), a customized hardware for ASICs settings and control, optical transmission channels for readout imaging data. The TUPI hardware must meet the demands of the BSL-4 ORION laboratory environment, including 10-3 mBar in-vacuum applications and decontamination protocols. The modular mechanics will allow precise assembly and alignment. The cooling system for the detector's head and electronic boards will be needed to achieve high thermal stability, especially in long data acquisitions.
- The DAQ system makes use of FPGA boards on a local server for collecting, organizing packages, images formatting and sending for data processing in the SIRIUS HPC (High Performance Computing) infrastructure where the samples data are processed.

Authors: POLLI, Jean Marie (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); ARAUJO, Luana Santos (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); CAMPANELLI, Raul Back (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY)

Co-authors: PEREIRA, Alan Douglas (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); BORGATO, Allan (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); GIACHERO, Augusto Fraga (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); TAVARES, Daniel de Oliveira (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); ANTONIO, Erick Battiston (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); CARDOSO, Fernando Henrique (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); LENA, Francesco Rossi (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); GOMES, Gustavo Siqueira (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); SIMÕES, Henrique F. (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); FERNANDES, Matheus Gimenez (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); VINCOLETTO, Pedro Leonardo (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); GERALDES, Renan Ramalho (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); SPIRIN, Roman (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY); ROLIM, Érico Nogueira (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY)

Presenter: POLLI, Jean Marie (LNLS - BRAZILIAN SYNCHROTRON LIGHT LABORATORY)

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