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Conceptual design of TUPI (Timepix-based Ultra-fast Photon Imaging) detector's front-end electronics

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The TUPI (Timepix-based Ultra-fast Photon Imaging) direct conversion hybrid detector, currently under design at the SIRIUS light source, is a modular photon-counting detector based on the Timepix4 ASIC (Application Specific Integrated Circuit). It targets multiple SIRIUS bioimaging beamlines for ORION, Brazil's first Biosafety Level 4 (BSL4) laboratory under design. Each TUPI base module will be composed of a set of 3x1 ASICs that can be bump-bonded to different sensor materials depending on the beam energies, providing an active area of approximately 75 x 28 mm² (1344 x 512 square pixels of 55 μm pitch). Its modular design approach ensures scalability for larger active areas. With accompanying mechanics, cooling, power supply, digital control, and multigigabit transceivers, each module can stream thousands of frames per second through 48x10.24 Gbps optical links directly connected to a DAQ server. The ASIC's control and configuration are managed by a control board featuring an Ethernet interface for external communication and an FPGA for deterministic tasks. The TUPI's detector head design is extremely compact and specified to be vacuum-compatible. This work will discuss conceptual front-end electronics design, highlighting challenges and future development.

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