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A Reconfigurable CMOS Sensor for Tracking, Pre-Shower and Digital Electromagnetic Calorimetry

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Recent advances in CMOS imaging sensor technology have led to designs able to withstand much higher radiation levels, up to those required at hadron colliders for all but the innermost layers. Also, with stitching, wafer scale devices have been fabricated on the same process as used for the prototypes described in this submission, for applications such as, for example, direct electron detection in transmission electron microscopy.

A small sensor prototype has been designed and fabricated in the TowerJazz 180nm CMOS imaging process. The prototype has a pixel matrix of 64x64 pixels with a pitch of 55x55 μm and reads out using fast logic at 40 MHz. Each pixel contains four collection electrodes, trimming logic, pre-amplifier, shaper, comparator and discriminator with digital output. It can be reconfigured to function as either a binary short strip sensor, for particle tracking including as a pre-shower, or as a pad sensor, counting the number of pixels above threshold for digital calorimetry.

As well as providing a seamless transition from outer tracking to EM calorimetry, for optimal use of particle flow algorithms, digital calorimetry also can give excellent energy resolution. This concept is proposed as a possible option for future digital calorimeters able to read-out at LHC collision rates with good radiation hardness and realisable in low cost commercial technologies for equipping large areas.

The presentation contains both the results on physics performance simulation in a FCC-hh context and the characterisation of the prototype sensor. The summing logic is demonstrated and the analogue pixel performance is validated by illuminating a test pixel within the matrix with a laser of wavelength of 1064 nm. The absolute laser intensity is calibrated such that the injected charge is similar to that expected for a MIP. The measurements of the pre-amplifier and shaper signals are compared to Cadence simulations. Laser illuminations in the digital pixel area and the response measured using a threshold scan confirm successful digital functionality in strip and pad operation modes.

Submission declaration

Original and unpublished

Primary authors: Prof. ALLPORT, Philip Patrick (University of Birmingham (UK)); BOSLEY, Robert Ross (University of Birmingham (GB)); DOPKE, Jens (STFC - Rutherford Appleton Lab. (GB)); FLYNN, Sam (National Physical Laboratory); GALLOP, Bruce (STFC - Rutherford Appleton Lab. (GB)); GONELLA, Laura (University of Birmingham (UK)); KOPSALIS, Ioannis (University of Birmingham (GB)); PHILLIPS, Peter (STFC - Rutherford Appleton Lab. (GB)); PRICE, Tony (University of Birmingham (GB)); SCOTT, Andrew (Science and Technology Facilities Council); SEDGWICK, Iain (STFC); VILLANI, Enrico Giulio (STFC - Science & Technology Facilities Council (GB)); WARREN, Matt (University College London); WATSON, Nigel (University of Birmingham (GB)); WILSON, Fergus (STFC - Rutherford Appleton Lab. (GB)); WORM, Steven (University of Birmingham); ZHANG, Zhige (STFC - Rutherford Appleton Lab. (GB))

Presenter: Prof. ALLPORT, Philip Patrick (University of Birmingham (UK))

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