Gigasensors for an Attoscope

Erik H.M. Heijne, CERN, erik.heijne@cern.ch

Executive Summary

When elementary particles cross silicon, they leave a small signal which can be used to trace them. Sophisticated silicon trackers with close to 10^9 sensor cells of 40 -100 µm dimensions are now installed in the experiments at CERN, the accelerator laboratory in Geneva, Switzerland. These systems take snapshots at 40 MHz rate, and allow to record every 25 ns the coordinates of hundreds of particles, that emerge from violent interactions between colliding beams. The purpose is to study the properties of matter in the TeV energy range, where energetic quanta interact on the 'atto' (10^{-18} m) length-scale.

The gigasensor system has to operate at high speed and in a small volume, with signal processing, temporary data storage and logic operations all integrated in chips that are a part of the detectors. It has been essential to employ low-power CMOS circuits, and these, moreover, have to withstand the ionizing radiation inherent to this application.

Around 1987, Eric Vittoz studied the basic parameters for the development of the 'pixel' particle tracking detectors, in collaboration with our team at CERN. His collaborators Christian Enz and François Krummenacher then designed the very first prototype implementation with a low noise input amplifier in each pixel, operating at low power. Subsequently, Krummenacher also implemented a clever scheme for coping with the dark current of the sensor cell, which allows DC connections at very high density: typically > 10^4 per cm^2 .

The evolution of these particle imagers now results in matrices of 256x256 pixels with >1000 transistors per pixel, as illustrated in the Fig. 1.

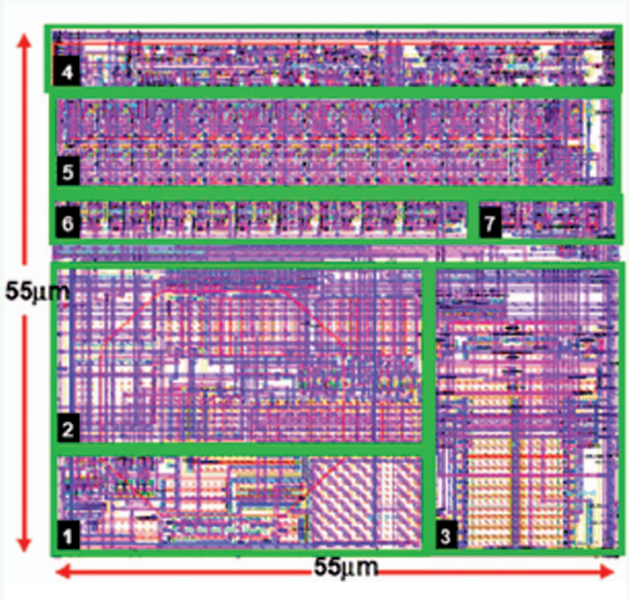

Fig. 1 Layout for the Medipix3 chip of a 55µm pixel cell in a 130 nm CMOS technology by Campbell and his team at CERN. Preamplifier, shaper and comparators, resp. 1, 2 and 3 form the analog part, while 4-7 are the control logic, counters, configuration and arbitration circuits. This pixel has more than 1080 transistors.

Such pixels can process single quanta and are designed to have connections with their neighboring cells, which allows analog and logic operations at ns time-scale for distributed events, where a single incoming X-ray quantum touches several cells simultaneously.

This Executive Summary is a preview of full coverage coming in the fall SSCS News.

