# Large area CMOS monolithic active pixel sensors for future colliders

Martin Breidenbach, Angelo Dragone, Norman Graf, Tim K. Nelson, Lorenzo Rota, Julie Segal, Chris Kenney, Ryan Herbst, G. Haller, Thomas Markiewicz, Caterina Vernieri, Charles Young
SLAC National Accelerator Laboratory

James Brau, Nikolai Sinev, David Strom
University of Oregon, Eugene

Marcel Demarteau
Oak Ridge National Laboratory

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Contact Information:
Martin Breidenbach (mib@slac.stanford.edu)

Collider detectors have taken advantage of the resolution and accuracy of silicon detectors for at least four decades [1]. Future colliders will need large areas of silicon (Si) sensors, several hundred $m^2$, for low mass trackers and sampling calorimetry [2]. Trackers will require multiple layers, large radii, and micron scale resolution. Sampling calorimeters will also have very large areas and are improved by very thin overall packages which reduces the Moliere radius. A promising technique is CMOS Monolithic Active Pixels (MAPs), in which Si diodes and their readout are combined in the same pixels, and fabricated in a standard CMOS process [3, 4]. CMOS MAPs sensors have several advantages over traditional hybrid technologies with sensors bonded to readout ASICs. Integrating sensors and front-end electronics on the same die removes the need of interconnections, thus reducing complexity and mass. The close connection of sensor and front-end amplifier reduces input capacitance which reduces the achievable noise floor and thus for the same S/N ratio allows for a reduction in signal and therefore sensor thickness, which also reduces mass. CMOS devices are made in standard commercial technologies with small feature size allowing fine readout pitch. Furthermore designs in standard commercial technologies can be produced quickly and inexpensively, because of an active industrial market, potentially enabling large area detectors.

Nevertheless challenges are present. Full depletion of the device is required for the charge to be collected by drift and not by diffusion, allowing a fast time response and radiation hardness. This adds design complexity and might require access to process customization. CMOS chip dimensions are typically limited to a reticle of about 2 cm by 2 cm. This scale is difficult unless they can be stitched together on large area wafers, and their digital readout area limited to one or two edges.

MAPs are being used in the STAR Heavy Flavor Tracker at BNL RHIC [5] and will be deployed in the ALICE ITS system for heavy ions at the LHC [6]. ALICE will have ~10 $m^2$ of sensor with about 24,000 MAPs chips. We want to go to the next generation of MAPs, emphasizing both the pixel development for speed and resolution, and the system approaches needed for large scale use at reasonable cost.

We propose to develop two types of fully depleted MAP sensors with characteristics suitable for Trackers and Electromagnetic Calorimeters. With an outlook to a broader range of future applications we will use the requirements of the SiD detector for ILC [7].

This work will directly address the issues of making large surfaces by developing the intermediate stage of tens of $m^2$, including powering and readout of large numbers of MAP sensors. It will enable detectors with far more pixels per unit area, and thus higher resolution, with substantially lower mass budget and significantly lower cost.

**References**

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