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Development of a Standardized Readout System for Active Pixel Sensors in HV/HR-CMOS Technologies for ATLAS Inner Detector Upgrades

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The LHC Phase-II Upgrade results in new challenges for tracking detectors in terms of cost effectiveness, resolution, etc. Active Pixel Sensors in HV/HR - CMOS technologies show promising results coping with these challenges. In order to demonstrate the feasibility of the hybrid modules of active CMOS sensor and readout chip for the future ATLAS Inner Tracker, an ATLAS R&D project has started.

After introducing the basic concepts and the demonstrator program, the development of an ATLAS compatible readout system will be presented as well as tuning procedures and measurements with demonstrator modules to test the system.

Summary

After the Phase-II Upgrade of the Large Hadron Collider, the peak luminosity will increase to $5 \cdot 10^{35}$ cm^{-2} s^{-1}. Thus, there are more interactions per bunch crossing and due to the high particle rates, very high particle fluences are expected in the tracking detectors in ATLAS. To cope with the challenges arising from this, the current ATLAS Inner Detector will be replaced. The active area of the new tracking detector will be about ten times larger than the present area, so more cost-effective detectors are needed.

Several industrial CMOS foundries offer High Voltage (HV) and High Resistivity (HR) design options featuring high breakdown voltages, allowing the creation of a deep depletion zone, suitable for particle detection with active pixel detectors. These HV/HR-CMOS detectors offer new in-pixel signal processing solutions. Sensor productions on larger wafers are possible, which potentially reduces the cost compared to passive hybrid detectors. Together with more cost effective interconnections, like wafer to wafer bonding or gluing techniques, active CMOS pixel sensors are a promising candidate for future use. Due to small pixel sizes the two-track separation is improved and the small active sensor thickness will reduce the cluster size.

The ATLAS R&D project has started a program to demonstrate the feasibility of commercial HV/HR-CMOS technologies for Pixel Detectors for the future ATLAS Inner Tracker. Prototypes and demonstrators from several vendors have been produced and are being characterized. Operation in ATLAS requires simultaneous remote setting of the parameters of both the active sensor and the readout chips. Therefore, intricate tuning procedures are implemented in a standardized test system based on the ATLAS Pixel readout software. This allows the development of optimization algorithms which can be used in the final detector.

The latest results from characterization measurements in the lab, using the newly developed tuning procedures, and in beam tests will be presented.

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