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on behalf of the ATLAS HV/HR-CMOS R&D activities

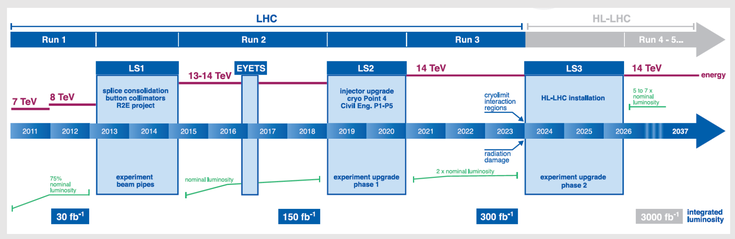
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

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

Introduction

LHC / HL-LHC Plan

- Large peak luminosity $5 - 7 \times 10^{34}$ cm^{-2}s^{-1}
  → Improved triggers
- Multiple interactions per bunch crossing - $<\mu> \approx 200$
  → High occupancy up to 20%
- Huge fluences for innermost layer $2 - 3 \times 10^{16}$ n_{eq}/cm^2
  → Radiation hard detectors
- Large tracking detector area $O(10\ m^2)$
  → Cost effective detectors

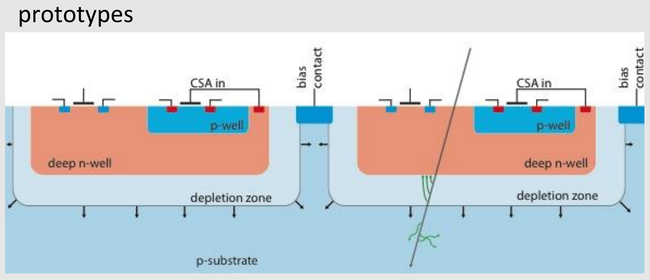


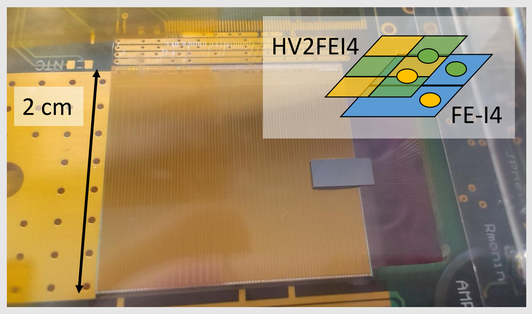
Active Pixel Sensors

CMOS Demonstrator Program

Goal: Investigate possibility of using CMOS sensors for ATLAS Inner Tracker (ITk)

- Many institutes involved in program
- Various layouts and technologies from different foundries to evaluate feasibility
- Lab and test beam characterisation to evaluate detection efficiency and tracking properties of sensors
- Irradiation campaigns conducted to evaluate radiation-hardness of prototypes





HV2FEI4 Sensor

- PMOS and NMOS in active area
- Deep n-well surrounds pixel electronics
- Depletion zone (ca. 10-15 μm) around n-well
- First amplification in sensor
- Glued to FE-I4 readout chip (IBL)
- 3 subpixel (125 x 33 µm²) connected to 1 readout pixel (250 x 50 µm²)

USBpix Readout System

Multi-IO Board

- Versatile digital interface board with FPGA, micro controller and on board memory
- USB 2.0 interface
- Digital communication to chips

CCPD PCB

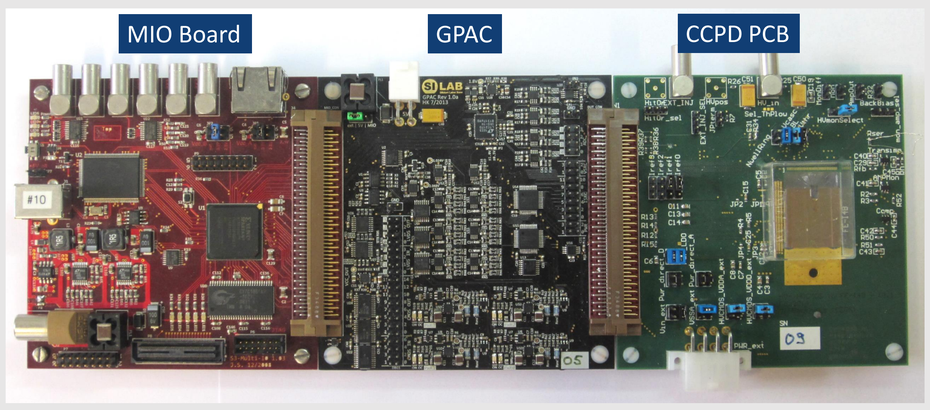
- Routes readout chip supply and numerous sensor bias voltages
- Used for all prototype versions

GPAC (General Purpose Adapter Card)

- Extends digital IO capabilities of MIO
- Provides injection pulse signal and analog signals
- Several voltage and current sources

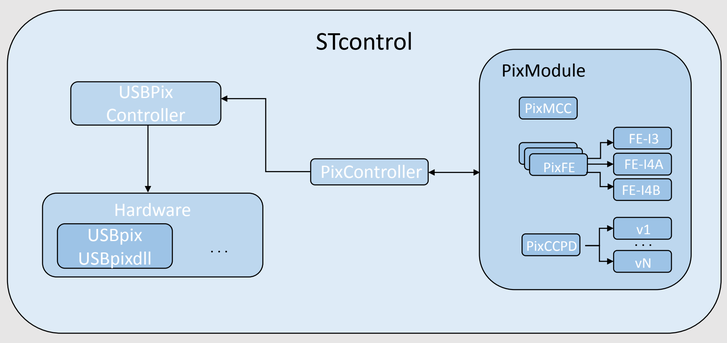
System

- Software: STcontrol (C++)
- Standard system for IBL module tests
- Configuration of active sensor with USBpix
- Completely integrated with AIDA telescope including Trigger Logic Unit (TLU)



STcontrol

Modular software with 3 main components



PixModule
- Module components implemented as abstract classes (e.g. FE, CCPD)
- Defines configuration parameters for components
- Automatic translation into GUI

PixController
- Communication between software and hardware
- Scan control (PixScan)

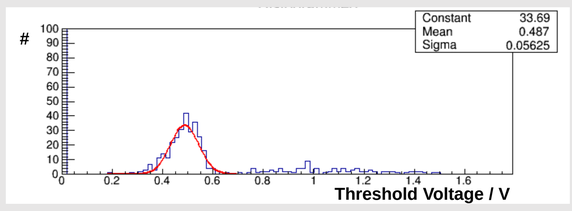
USBpixdll
- Hardware interface

PixScan
- Control of sensor bias voltages and sensor registers implemented as scan parameters

Measurements

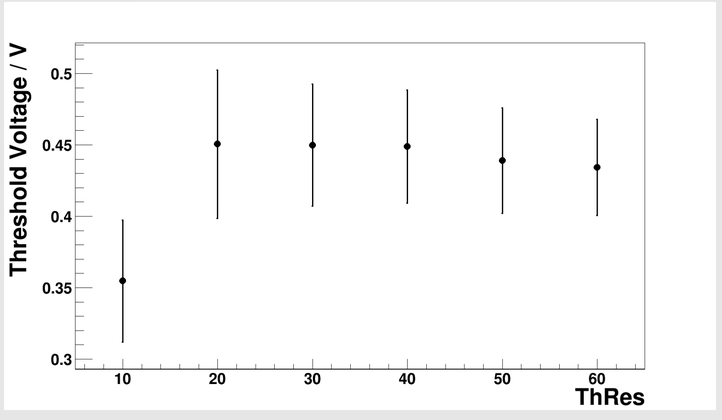
Analog Test of Active Sensor
- Injection into active sensor and readout with FE-I4

Threshold Scan of Active Sensor
- Fit of turn on curves for all pixels -> Threshold
- Histogram of all pixel thresholds

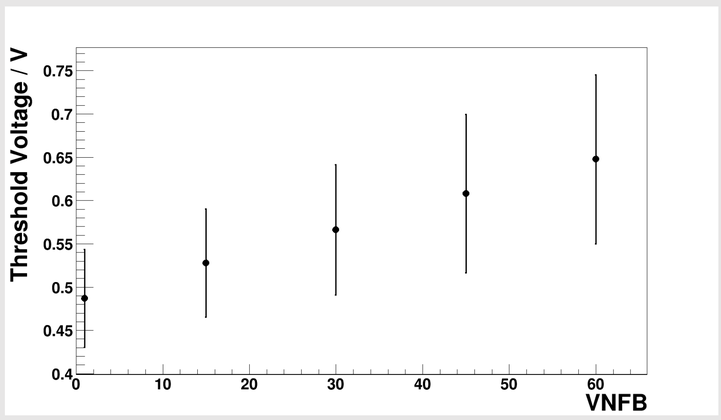


Study of Parameters

ThRes
- Influences threshold step size
- Threshold dispersion decreases with ThRes
- No large influence on threshold



VNFB
- Influences feedback current
- Threshold and its dispersion increases with VNFB



Tuning Algorithms

Threshold Tune
- Many different parameters influence threshold
- STcontrol has access to all parameters
- Combined tuning for sensor and readout chip under development

Subpixel Decoding
- Signal amplitude needs to be tuned to decode subpixel position

Summary & Outlook

- Active CMOS Sensors under investigation for HL-LHC Phase
- Standard scans are implemented for active sensor
- Tuning algorithms under development
- First results with demonstrator modules are produced
- Laboratory and test beam measurements will be performed

ATLAS EXPERIMENT
Bundesministerium für Bildung und Forschung
FSP 101 ATLAS