Lab session on pixel front-end characterization

Valerio Re
(valerio.re@unibg.it)

Università di Bergamo and INFN Pavia, Italy

Lodovico Ratti
(lodovico.ratti@unipv.it)

Università di Pavia and INFN Pavia, Italy

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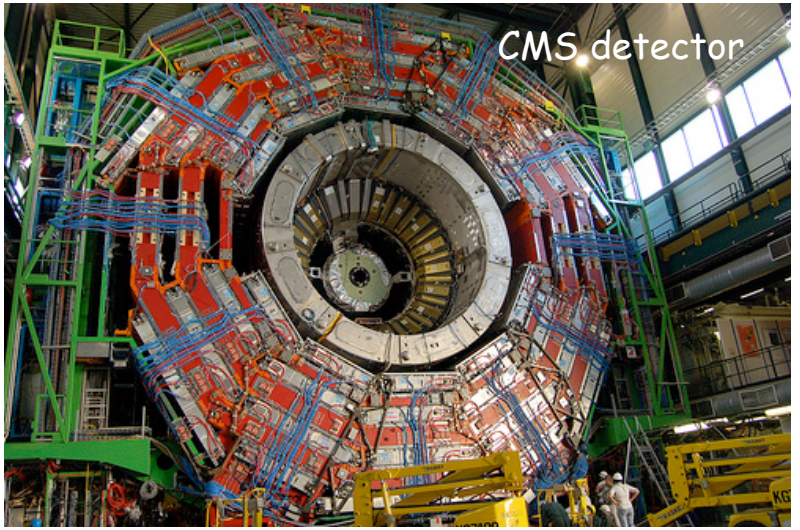
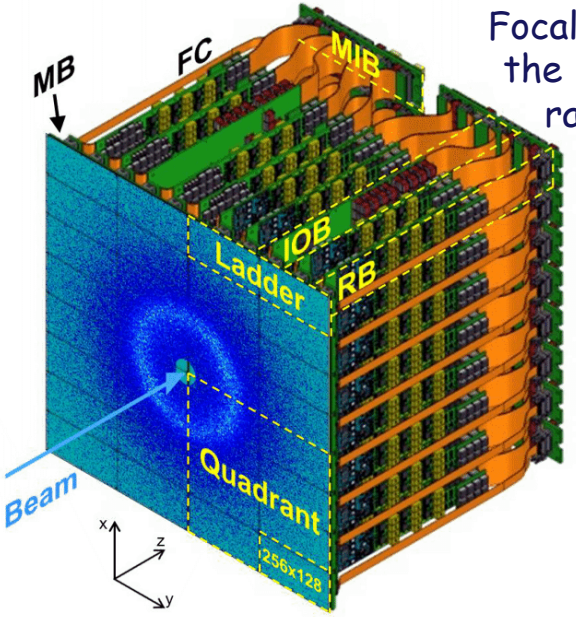
Focus of the lab

- Pixel front-end ASICs are located at the very beginning of the signal processing chain in pixel based detectors used in many fundamental and applied research fields
- Experimental characterization of front-end circuits in advanced microelectronic technologies is an integral part of the implementation of modern radiation detection systems
- The focus of the lab will be the **characterization of a front-end channel for pixel detectors in a 65 nm CMOS technology**
- The circuit under test, a prototype for the CMS phase 2 upgrade, was developed in the framework of the Italian CHIPIX65 and the international RD53 collaborations



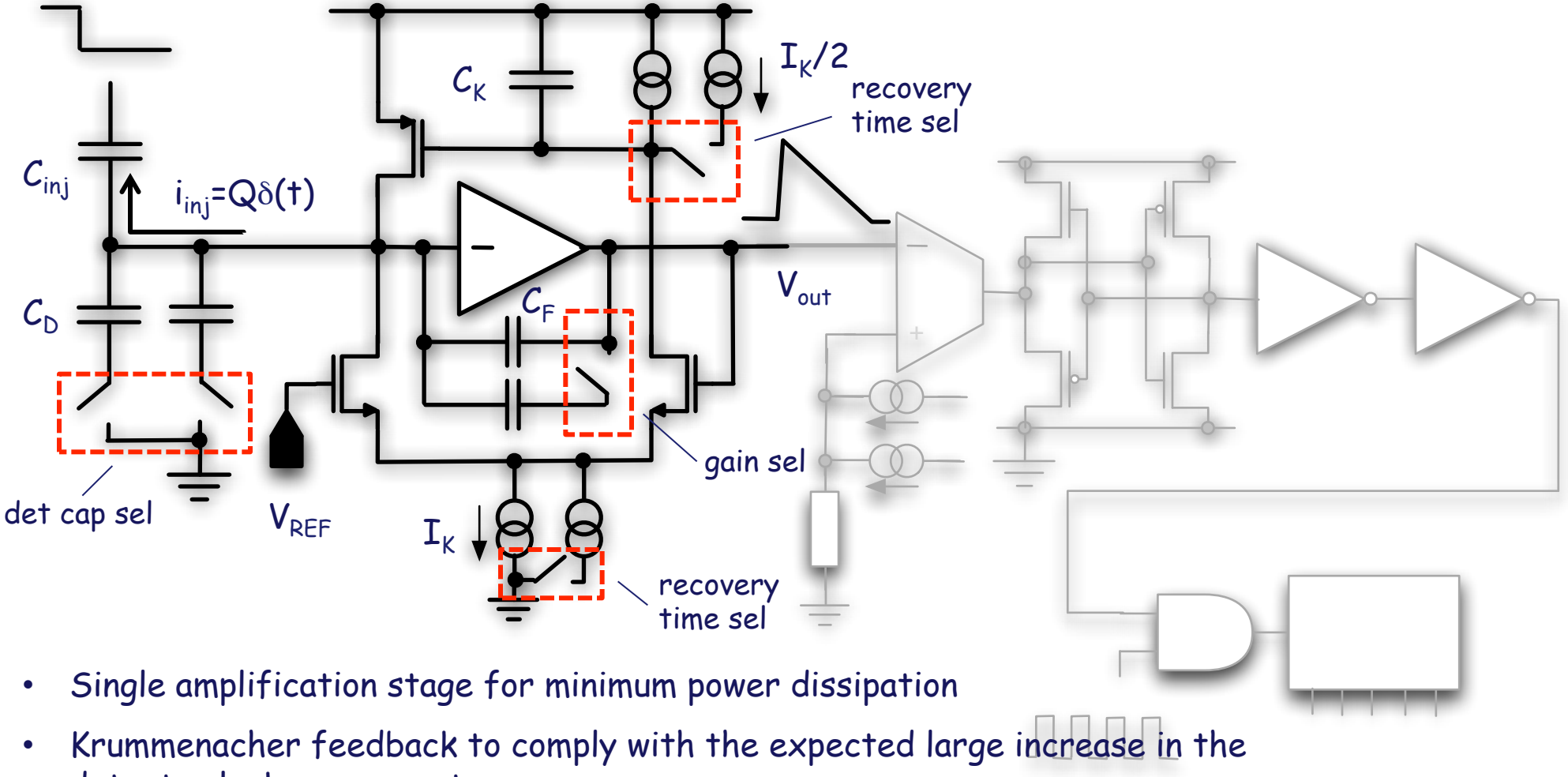


Focal plane of the DSSC X-ray imager

Pixel front-end specs for HL-LHC

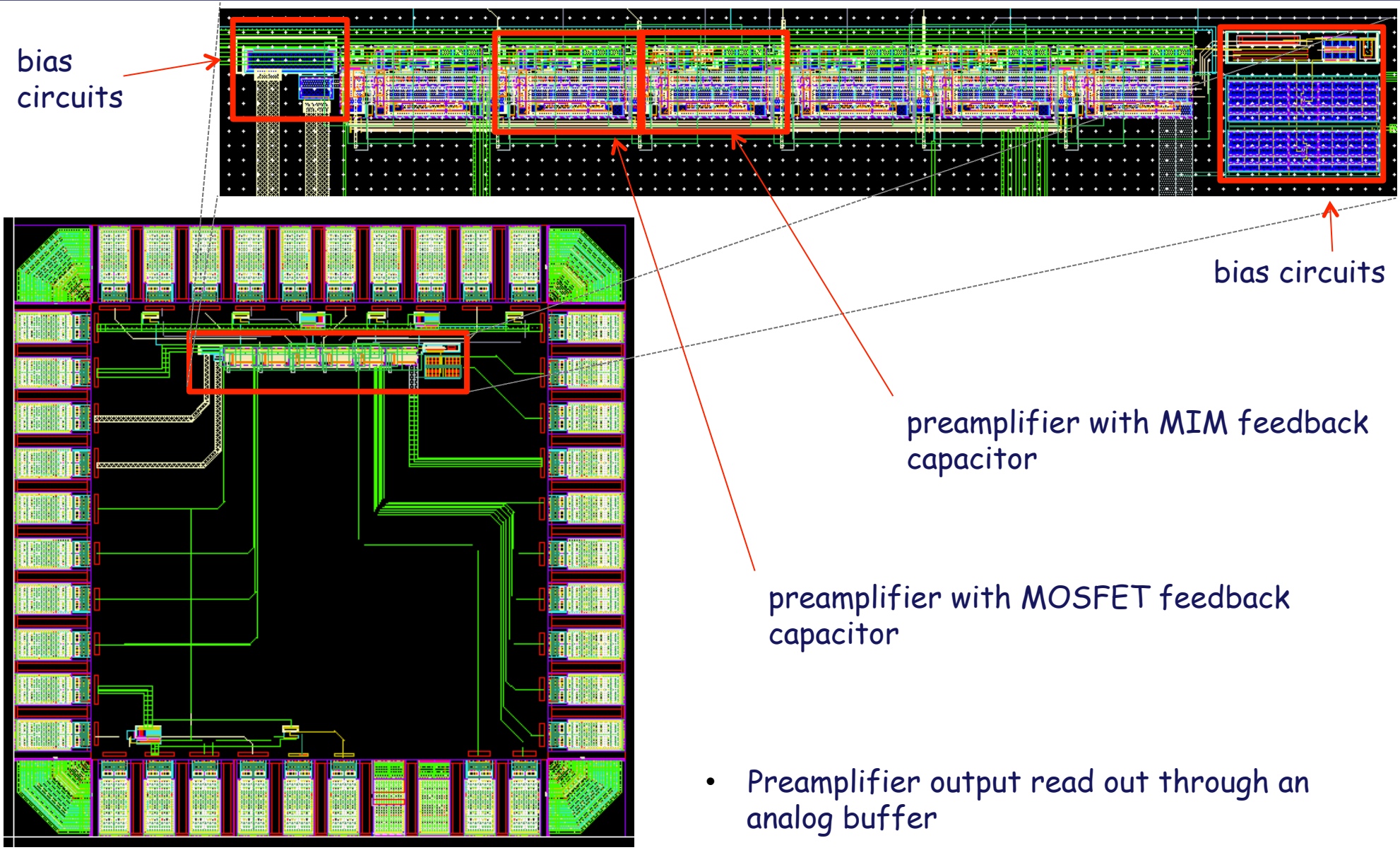
- In the phase 2 upgrade of the ATLAS and CMS experiments at the LHC, the inner layers of the pixel trackers will have to face some serious challenges
  - very high hit rates: 1 – 2 GHz/cm^2 ➔ need of intelligent pixel level data processing
  - very high radiation levels: 1 Grad total ionizing dose, 10^{16} neutrons/cm^2 fluence
  - very high trigger rates: 1 MHz
  - small pixel cells: 50x50 um^2 (or 25x100 um^2) ➔ improve resolution and reduce occupancy
  - small power dissipation: ~10 uW per cell (including analog and digital sections)
- Optimum front-end design requires a trade-off between noise, area, speed, power dissipation, amount of in-pixel functions
- The 65 nm CMOS process in its low power (LP) flavor is optimized for a reduced leakage and a small power consumption (at the price of a lower speed)

Channel schematic



- Single amplification stage for minimum power dissipation
- Krummenacher feedback to comply with the expected large increase in the detector leakage current
- 30000 electron maximum input charge, ~450 mV preampli output dynamic range
- Selectable gain and recovery current

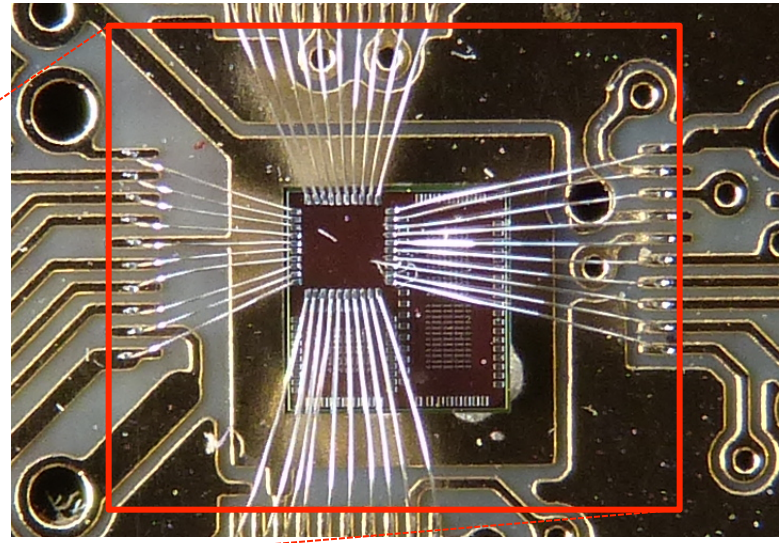
Circuit layout

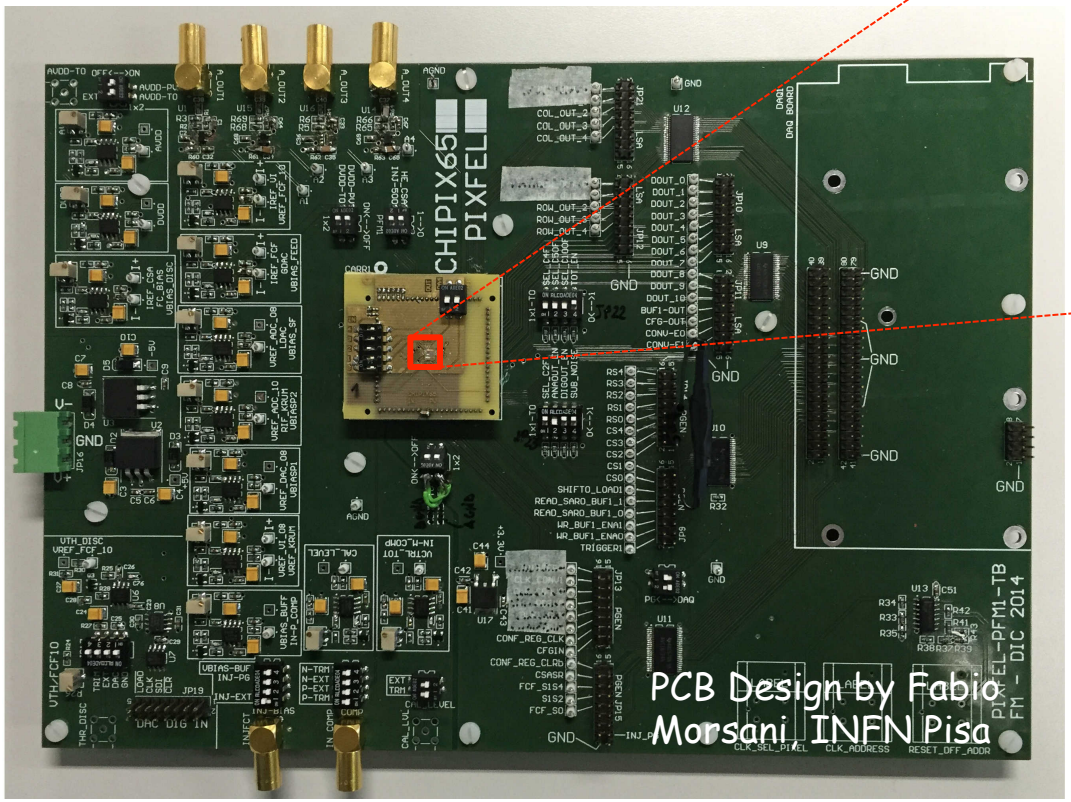


- Preamplifier output read out through an analog buffer

Test setup

- 2 mm x 2 mm chip including two different versions of a charge preamplifier with Krummenacher-style feedback network





- Chip on a small daughter board mounted on a test PCB, including dip switches for channel configuration: gain, time to baseline, input capacitance for detector emulation

Instrumentation and prerequisites

- Simple bench top instrumentation is required for measuring gain, ENC, response of the channel in presence of a leakage current: power supply, digital scope, arbitrary function generator
- No previous experience in pixel front-end characterization is required
- Basic knowledge on electronic circuit operation and standard electronic instrumentation is a prerequisite