Novel Si-Sensor technology for high resolution and high repetition-rate experiments at accelerator facilities

M. M. Patil[1], M. Caselle[1], L. Rota[1], A. Dierlamm[1], M. Baselga[1], G. Borghi[2], M. Boscardin[3], G. Niehues[1], E. Bründermann[1], M. Weber[1], A-S Müller[1]

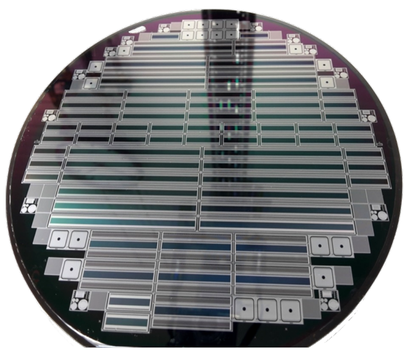
[1]Karlsruhe Institute of Technology, Germany
[2]TERA foundation, Italy
[3]Fondazione Bruno Kessler, Italy

Motivation

To improve the time and spatial resolutions of modern beam diagnostics systems at several European accelerator facilities [1] and overcome the technological limitations of existing systems.

Challenges

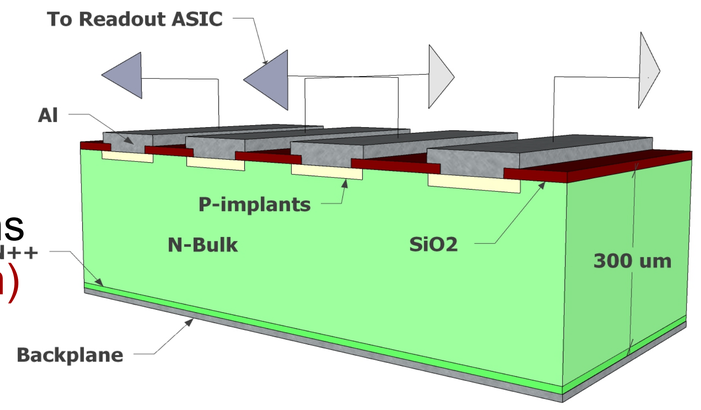
- Very fast charge collection (< 2ns) and moderate gain within the sensor
- High resolution sensor
- Low noise & high dynamics
- Continuous data acquisition

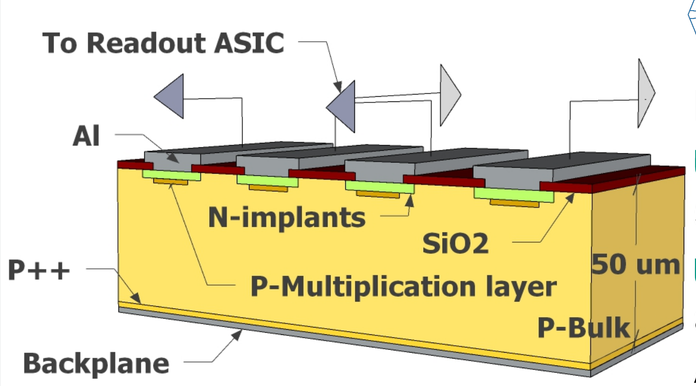


Silicon sensor technologies

Fine-pitch Si microstrip sensors: FONDAZIONE BRUNO KESSLER

- Different options: 512/1024/2048 channels, 25/45 µm pitch
- Anti-reflective coatings (ARC) optimized for different applications
  near-UV (350 nm) - visible (400-850 nm) - near-IR (1050 nm)

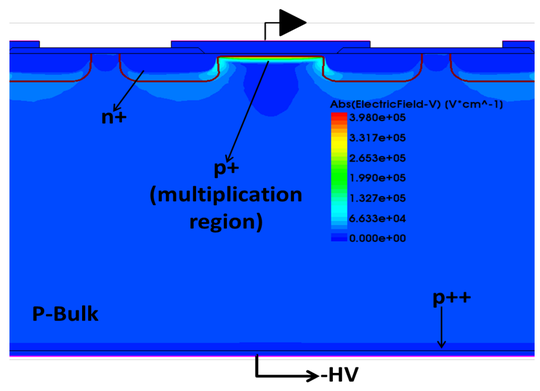




RD50

Low Gain Avalanche Detectors [2]:

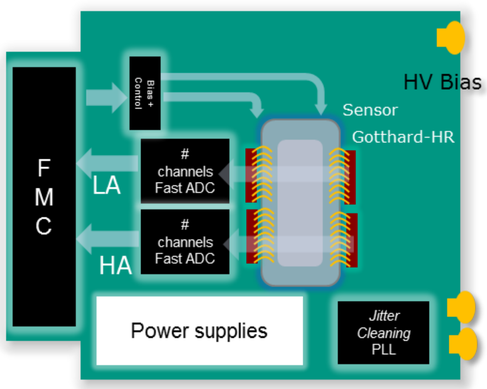
- Charge collection time < 2 ns → repetition rates over 500 MHz
- Internal gain ~ 20 → improve SNR, larger signals avoiding at the same time the additional noise affecting standard APDs
- LGADs designed for imaging applications with 45 µm pitch



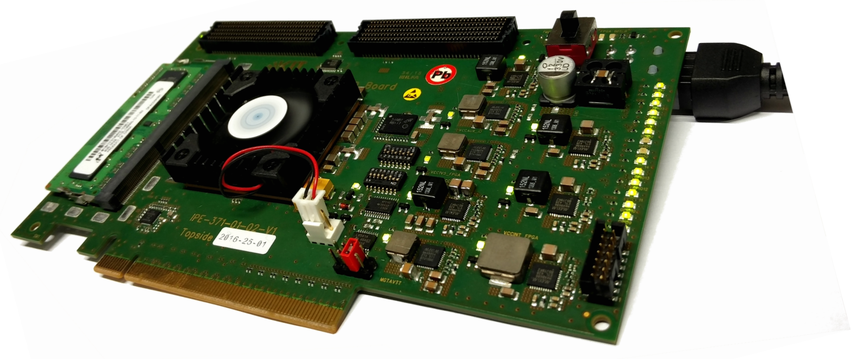
Electric field simulation of an LGAD using TCAD

Detector readout electronics

Kalypso 2.5 - Detector board



FPGA Readout card

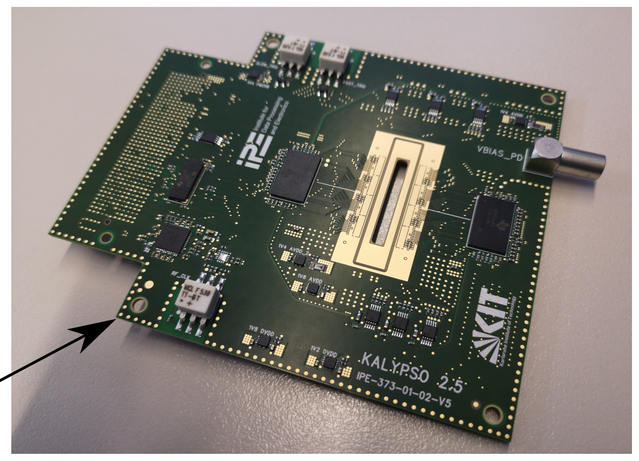


Graphics Processing Unit (GPU)
for real-time data processing based on:
OpenCL, CUDA, machine learning

FMC Vita Connector

PCI Express 3.0

- Modular detector design →extendability from 512 pixels to 1024 pixels
- Heterogenous FPGA-GPU data acquisition system
- Novel Direct Memory Access architecture working close to the theoretical limit of data link and data latency five times better than other DMA architectures



Kalypso 2.5 under development

[1] L. Rota *et al.*, IBIC 2014 **[2]** G. Paternoster *et al.*, C02077, JINST 2017

Contact Author: meghana.patil@kit.edu