

# Silicon n-in-p Pixel Sensors for future ATLAS Upgrades

A. La Rosa<sup>1</sup>, Ch. Gallrapp<sup>2</sup>, A. Macchiolo<sup>3</sup>, R. Nisius<sup>3</sup>, H. Pernegger<sup>2</sup>, R.H. Richter<sup>4</sup>, P. Weigell<sup>3</sup>

<sup>1</sup> U. Genève, <sup>2</sup> CERN, <sup>3</sup> MPI für Physik, <sup>4</sup> MPI Halbleiterlabor

## Introduction

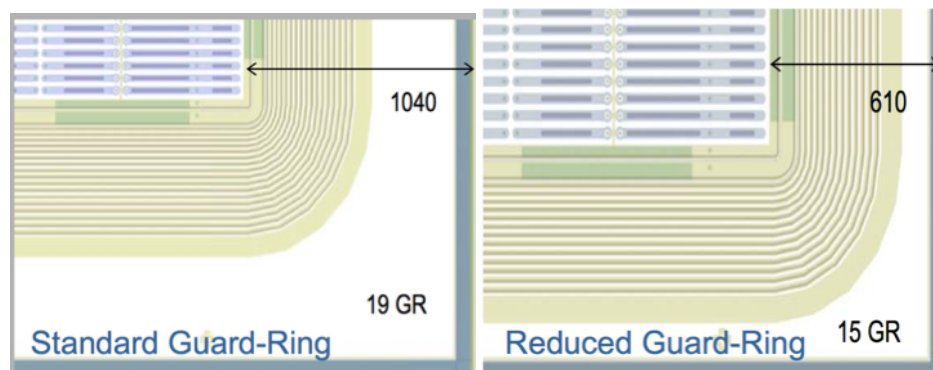
### ATLAS Pixel Detector Upgrade:

- **2022 (Phase 2):** Inner detector Tracker
  - Complete new ATLAS tracker (Pixel and Strip detectors)
  - Much larger Pixel surface w.r.t. current Pixel Detector: ~7-10 m<sup>2</sup>
  - Luminosity:  $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
  - Radiation dose (inner. layer):  $2 \times 10^{16} \text{ 1-MeV } n_{\text{eq}} \text{ cm}^{-2}$

- **Planar n-in-p as future sensor tech.:**
  - Excellent candidate for large volume
  - Single side processing → reduced cost
  - Radiation hardness comparable to n-in-n

## Sensor description

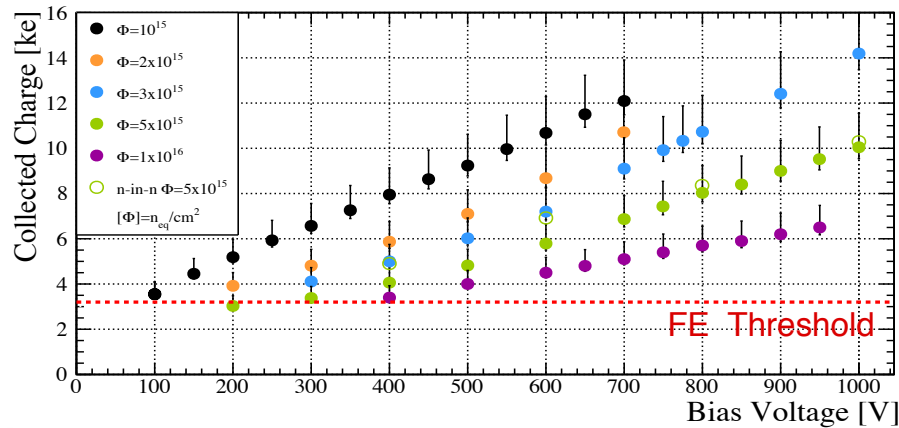
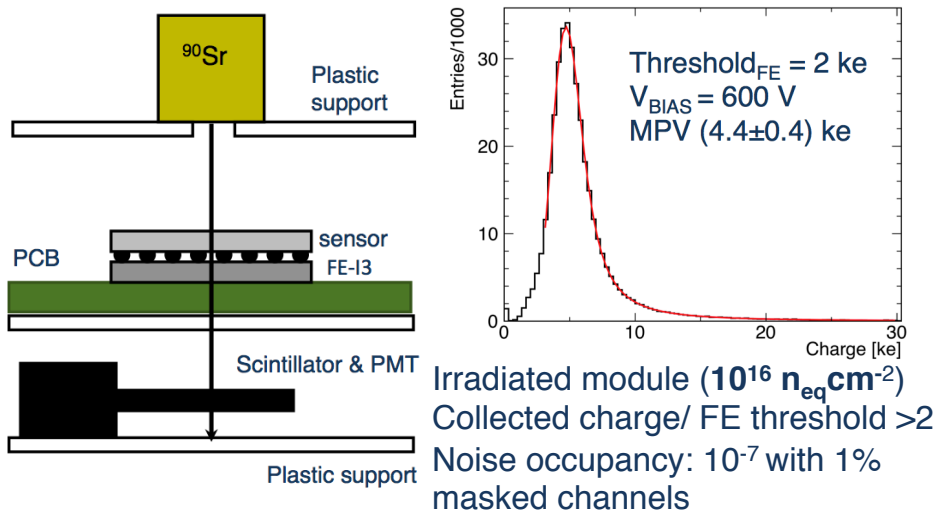
### First CiS n-in-p Pixel production



- Production on 4" Fz p-type wafer, 285 um thick
- Inter-pixel isolation:
  - Moderated p-spray
  - Homogeneous p-spray
- Bump bonding to ATLAS FE-I3 chip by IZM
- BCB layer deposited on the sensor front-end side as isolation to prevent sparks between sensor and FE chip

# Test Results

## External-trigger operation with $^{90}\text{Sr}$ source

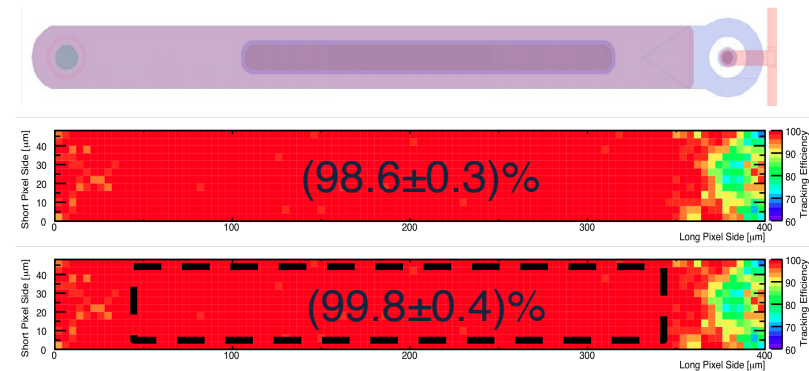


## Beam test at the CERN SPS

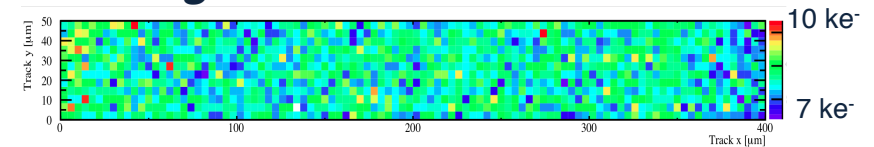
Beam test with a 120 GeV/c pion beam

Mean **tracking efficiency** and **charge collection** as a function of the track impact point for a module irradiated up to  $5 \times 10^{15} \text{ n}_{\text{eq}} \text{ cm}^{-2}$  and biased at 600V.

### Tracking Efficiency



### Mean Charge Collection



## Summary and future plans

- Excellent performance of CiS n-in-p modules irradiated up to  $10^{16} \text{ 1-MeV n}_{\text{eq}} \text{ cm}^{-2}$ .
- New production on 4" Fz p-type wafer of 200μm and 300μm thickness compatible with ATLAS IBL front-end chip (FE-I4) processed. Source-, beam-tests and irradiation up to HL-LHC fluences planned.
- First production of 6" wafers on high resistivity Fz p-type material, with 4-chip and 1-chip modules is foreseen.