Characterization before and after irradiation of slim edge and active edge sensors

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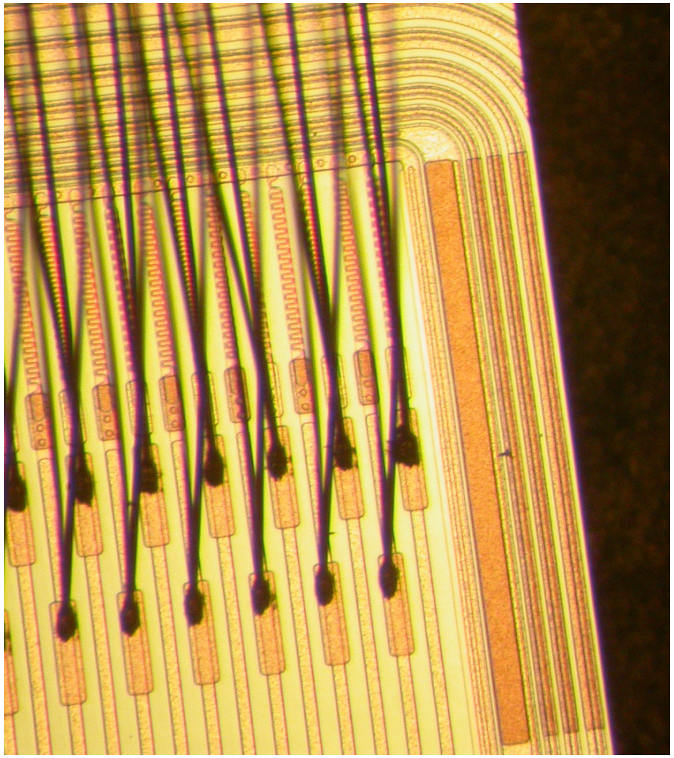
Outline

- Analysis of the charge collection properties at the edge strips in strip sensors treated with Scribe Cleave Passivate method

- Measurements with active edge pixel sensors produced at VTT before and after irradiation:
  - Charge collection properties at the edge investigated with radioactive sources
  - Hit efficiency studied in beam test at CERN-SPS and DESY

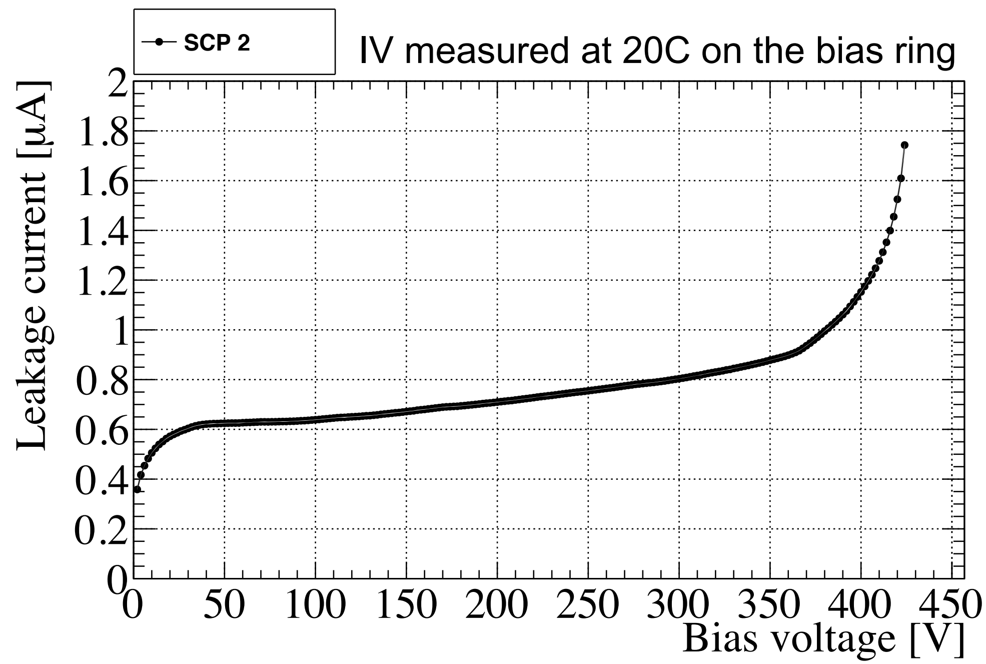
- Status of the RD50 common project 2012-01: diode production on p-type material for defect characterization

Measurements on CIS strip sensors treated with SCP



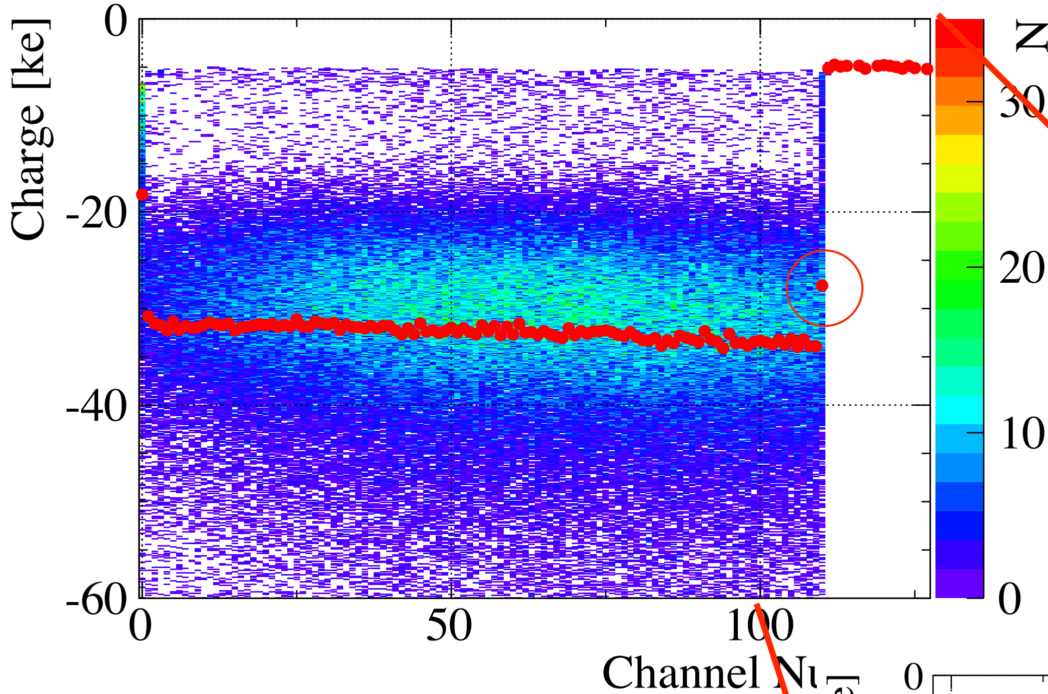
- n-in-p strip sensor CIS production, 285 μm thick, AC-coupled, not irradiated
- Treated with Scribe Cleave Passivate method at NRL/UCSC
- 3 guard rings remaining → 320 μm inactive edge

IV measured at 20C on the bias ring

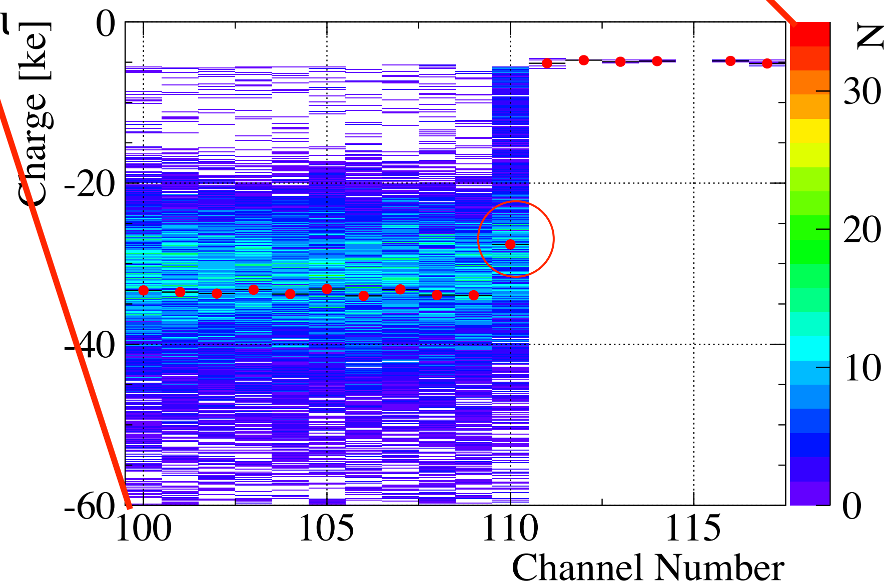


- High breakdown voltage of the sensor after SCP treatment
- Vbreak before treatment <310 V
- Improvement probably due to annealing effect during Al_2O_3 deposition

Charge collection with ALIBAVA

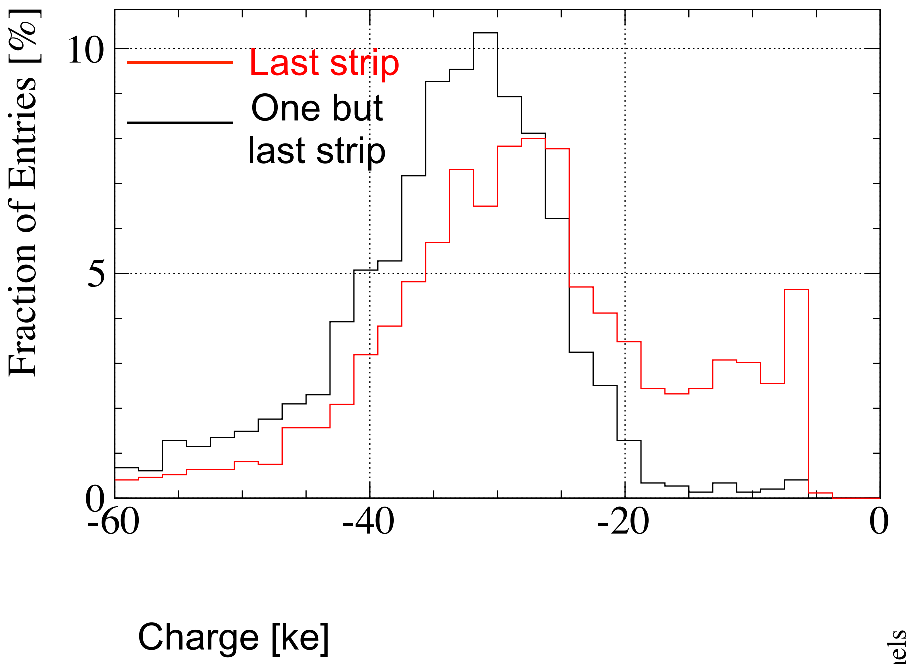


- ^{90}Sr scans with the ALIBAVA read-out system
- Clusters of any sizes: one or more hit strips



- The red markers show the average collected charge for that channel
- Edge strip corresponds to channel 110

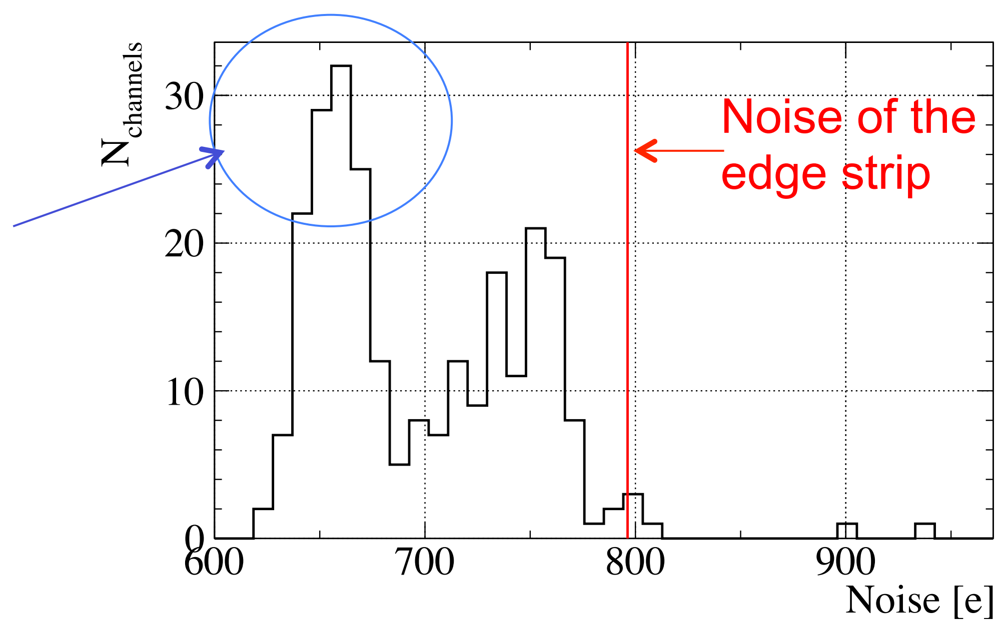
Charge collection with ALIBAVA



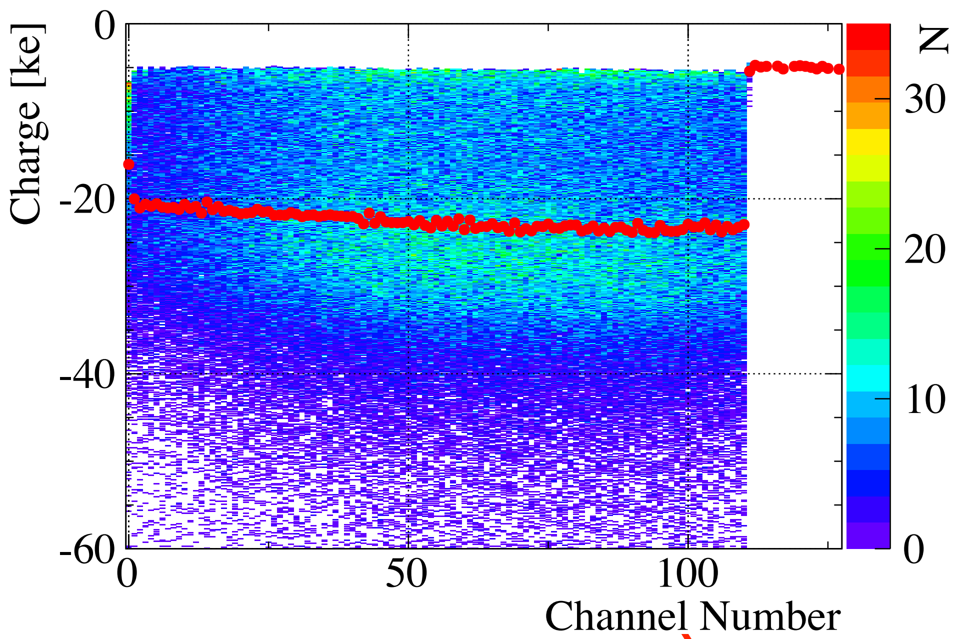
Cluster size ≥1:

Landau distributions for the last two strips close to the edge

Noise distribution for all the channels in the chip



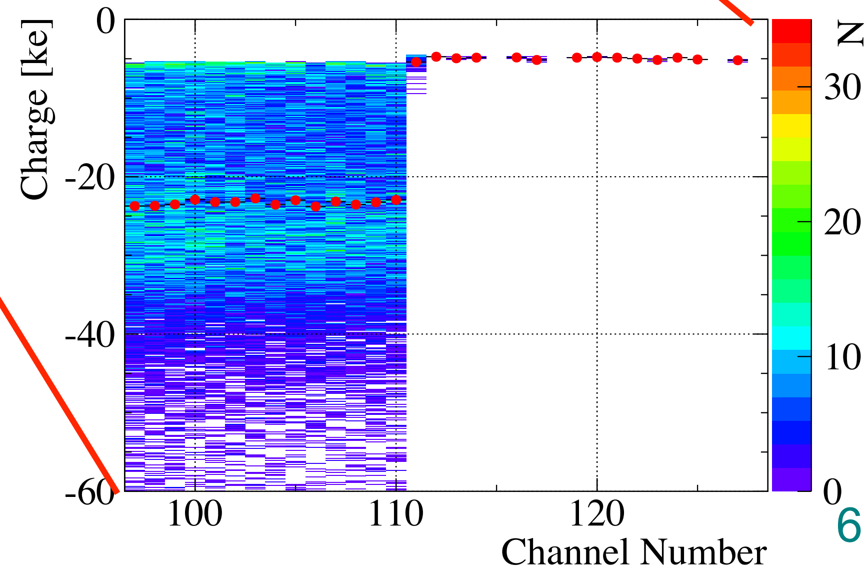
Charge collection with ALIBAVA



- Charge collected with clusters of size=1 only → edge strip has exactly the same collected charge as internal strips

- The slightly lower charge in the edge strip for cluster size ≥1 is due to the missing neighbour on one side

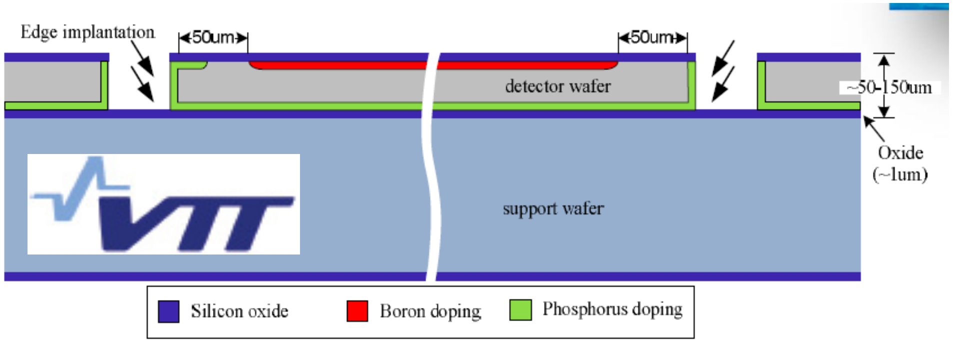
- Outlook: send the two strip sensors treated with SCP to Ljubljana to be irradiated at 5e15 and 1e16 n_{eq} cm^{-2}

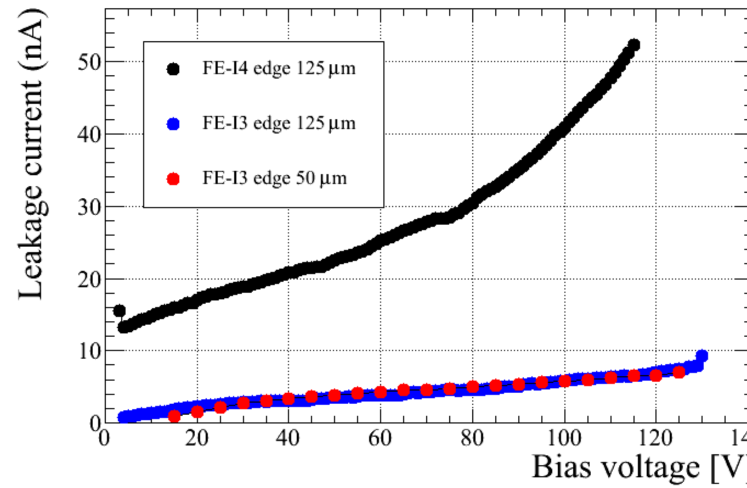


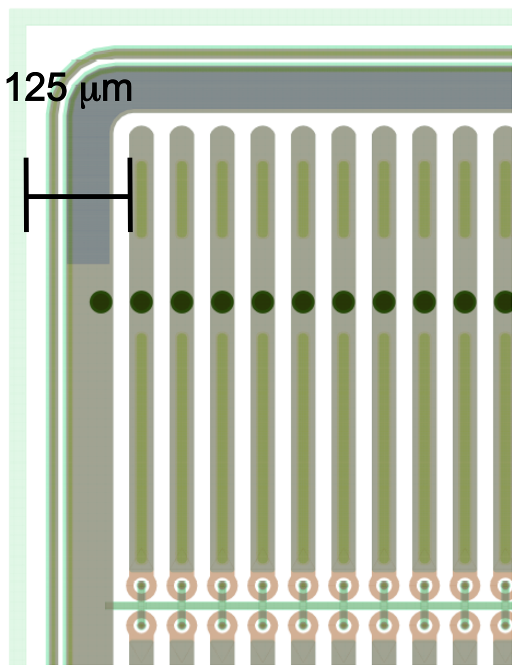
VTT active edge pixel sensors

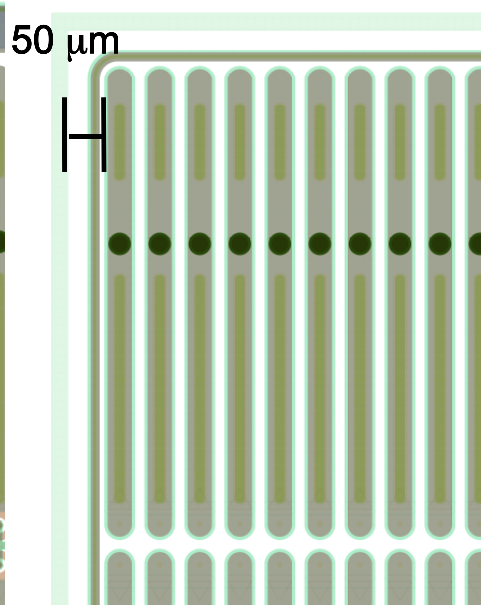
VTT n-in-p active edge pixel sensors

- Trench doped by four-quadrant implantation
- Sensor thickness 100-200 μm



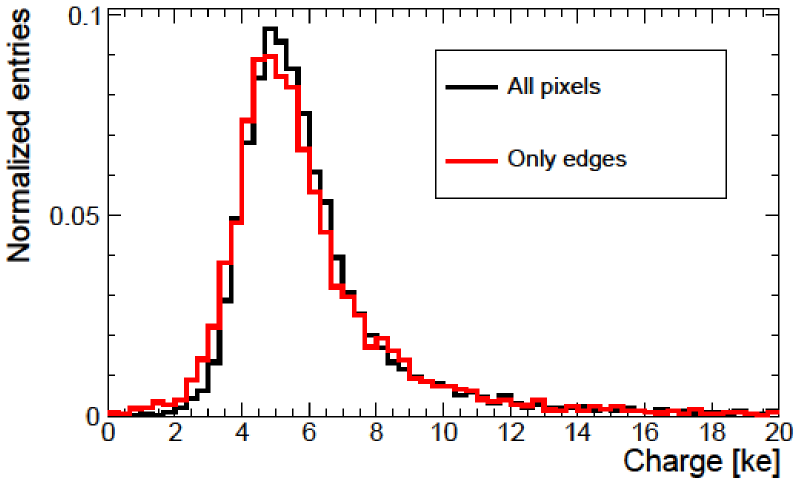


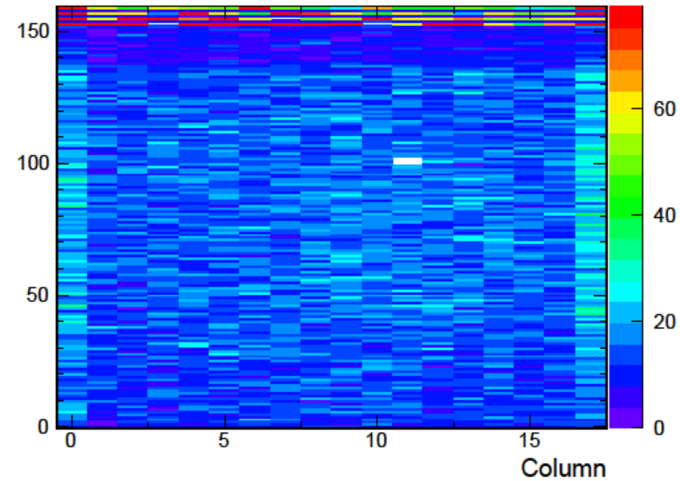




- 125 μm edge implemented In FE-I3 and FE-I4 sensors
- 50 μm implemented only in FE-I3 sensors

Active edges with planar n-in-p sensors

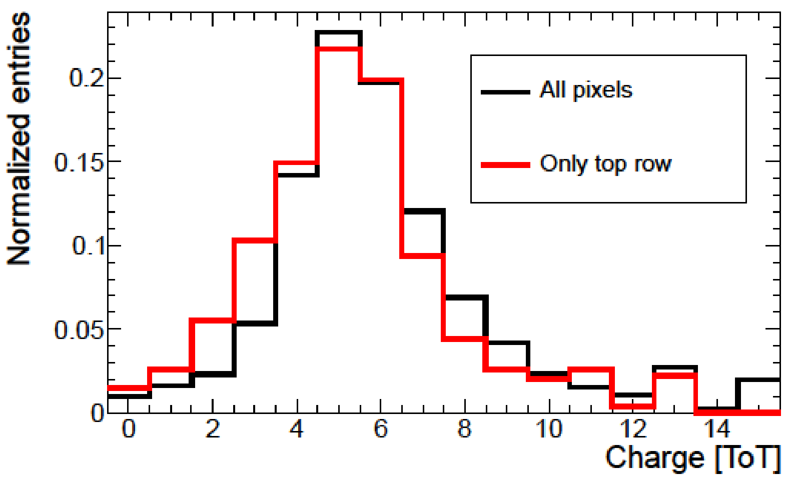


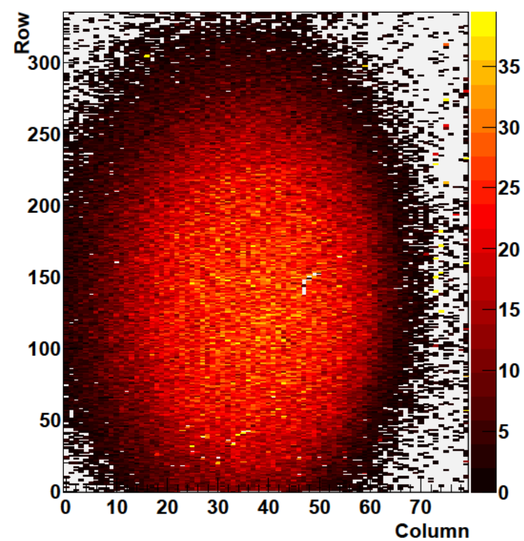


FE-I3

50 μm edge

V_{bias}=15 V





FE-I4

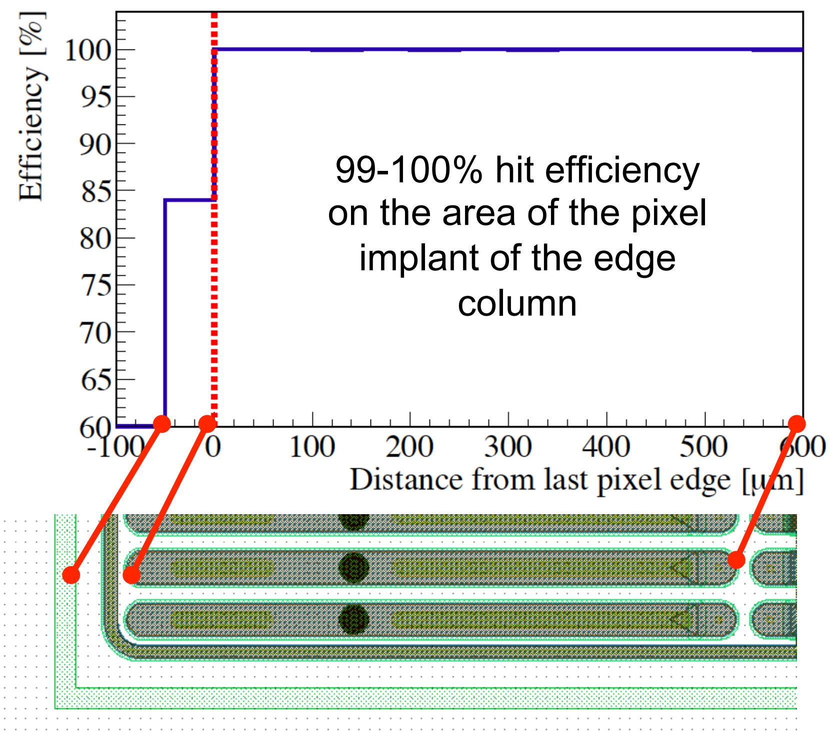
125 μm edge

V_{bias}=15 V

- Edge pixels show the same charge collection properties as the central ones

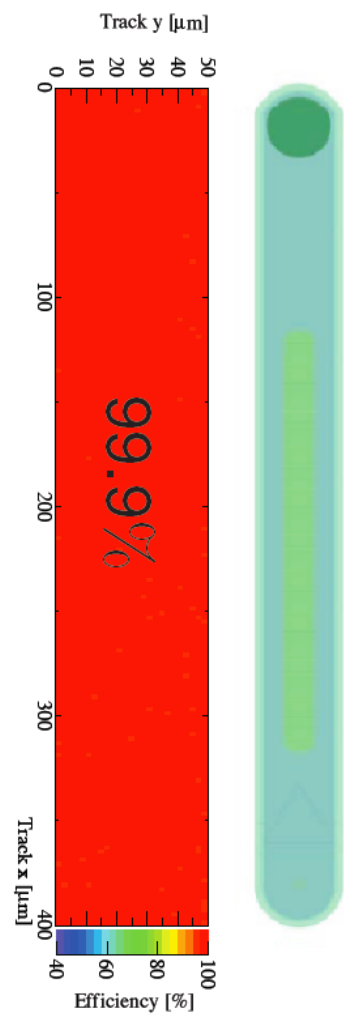
Active edges with planar n-in-p sensors - 100 μm thick

Edge Tracking Efficiency in Beam Tests at SPS

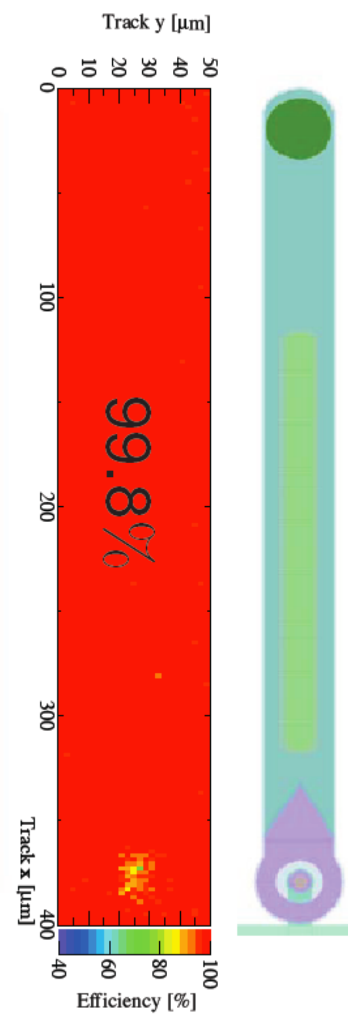


- 84^{+9}_{-14} % efficiency in the last 50 μm of the sensor edge, beyond last pixel implant

Global Efficiency in beam test



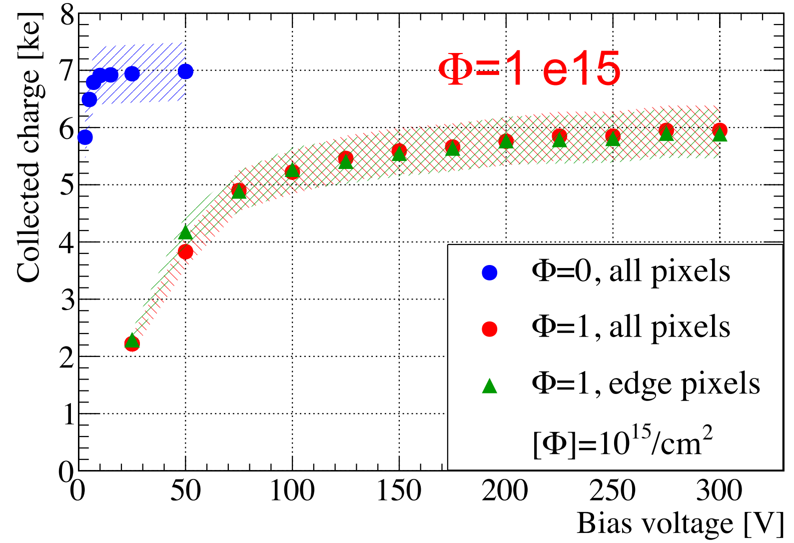
FE-I3, 50 μm edge, Vbias=20V



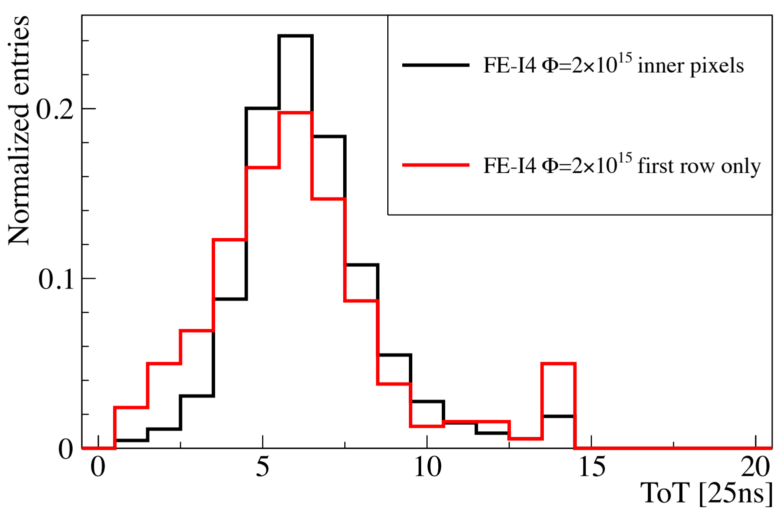
FE-I3, 125 μm edge, Vbias=20V

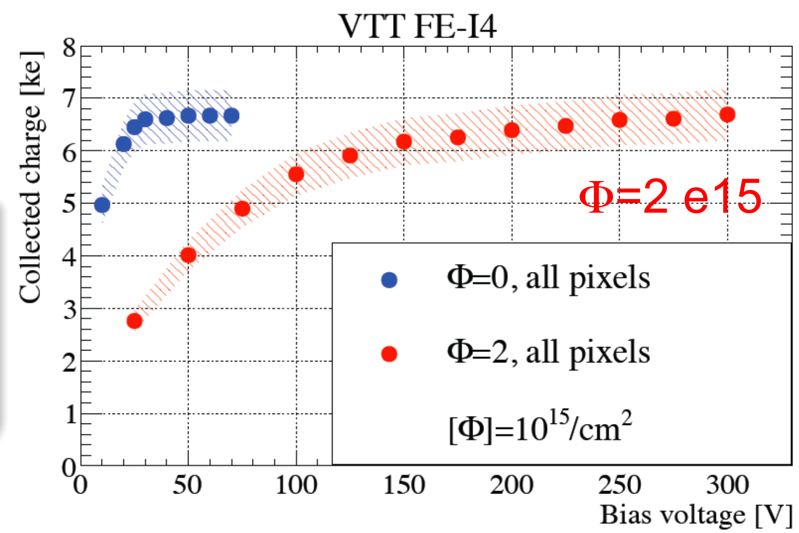
Active edge: charge collection efficiency after irradiation

- FE-I3 100 μm thick sensor with 125 μm slim edge, threshold 1500 e- → 87% CCE at 300 V for both all and edge pixels after irradiation at KIT



- p-type MCZ FE-I4, 100 μm thick sensor, with 125 μm slim edge, threshold 1100 e- → compatible charge collection properties between edge and internal pixels



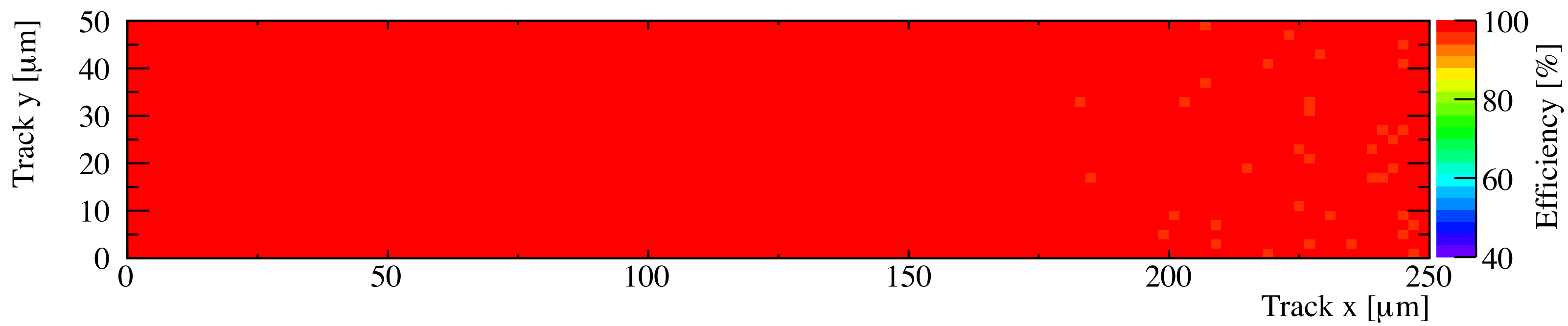


DESY test-beam – 100 μm thick sensors

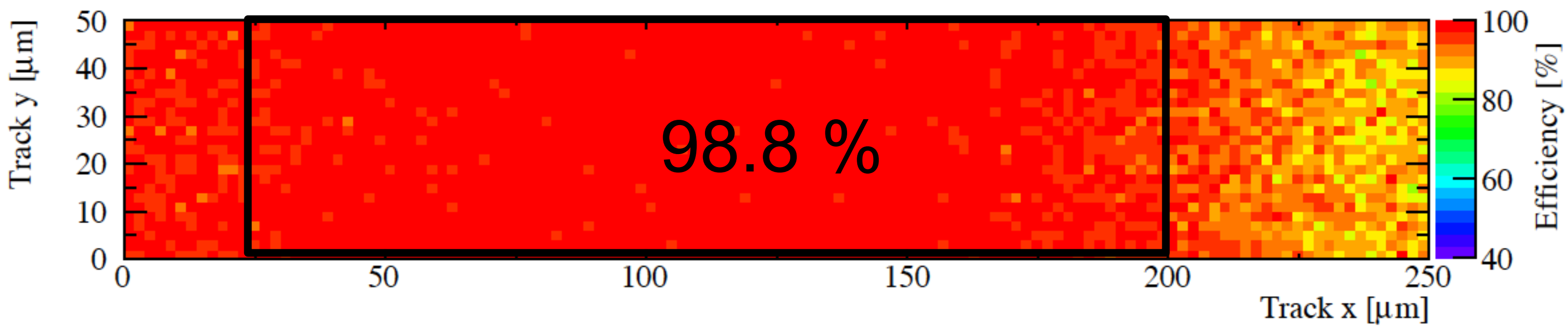
- Test-beam results from DESY test-beam 6 GeV electrons, EUDET telescope
  → due to multiple scattering the analysis of the edge efficiency is not possible

- Tuning Threshold=1600 e, 6 ToT@6ke, beam at perpendicular incidence

- VTT FZ, 100 μm thick, not irradiated → total efficiency 99.7% at 40 V

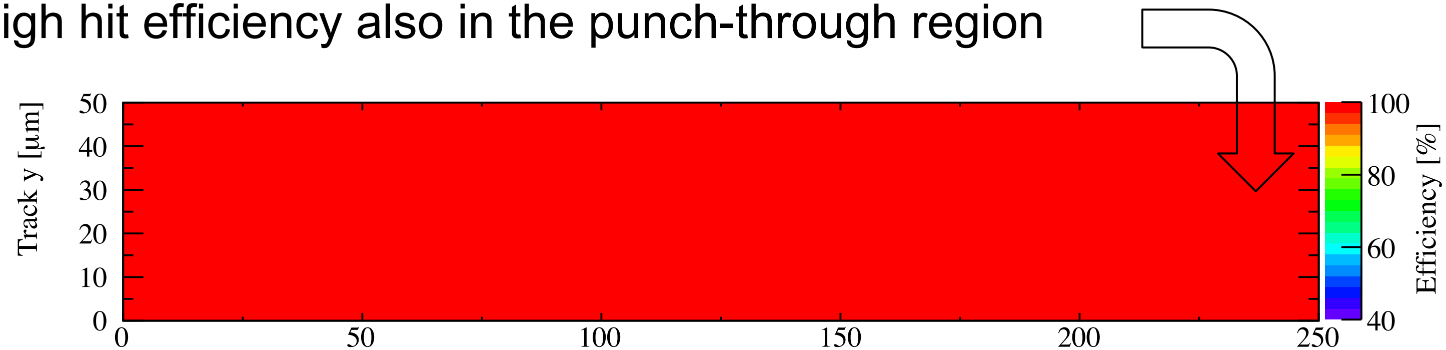


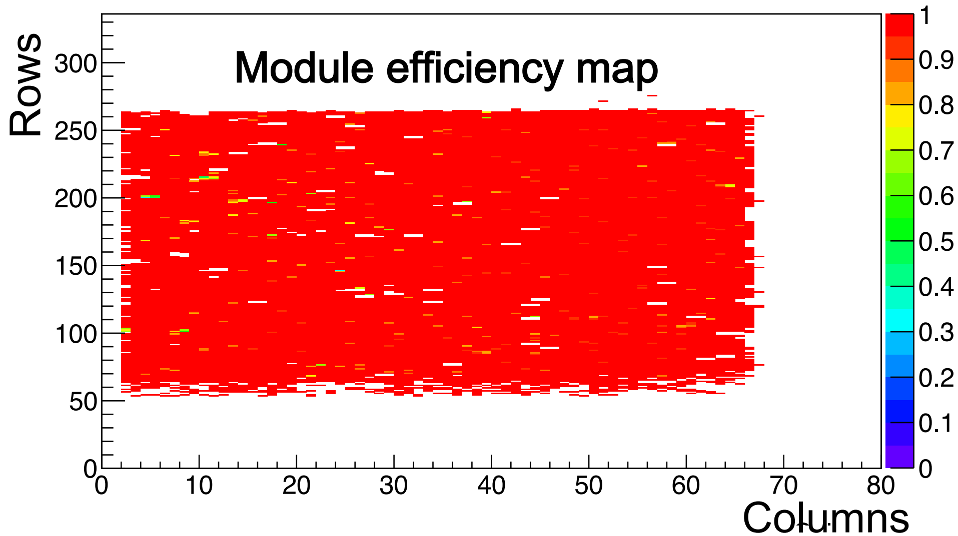
- VTT MCZ, 100 μm thick, Φ=2e15 → total efficiency **97.3%** at 350 V

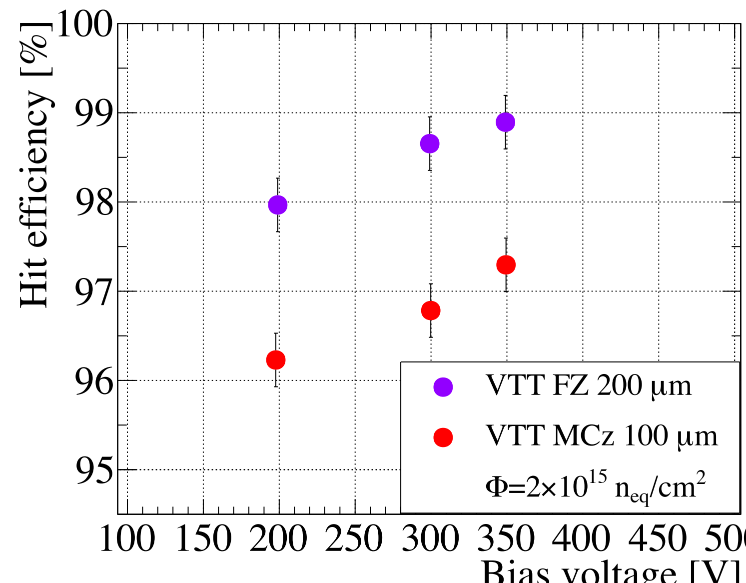


DESY test-beam – 200 μm thick sensors

- VTT FZ, standard GR, 200 μm thick, Φ=2e15 → total efficiency **98.9%** at 350 V
- Tuning Threshold=1100 e, 6 ToT@ 6 ke
- Perpendicular incidence
- High hit efficiency also in the punch-through region







Summary and plans for the future with the VTT modules

- Planar pixels with active edges, 100 and 200 μm thick, show a good performance in terms of charge collection and hit efficiency before and after irradiation up to a fluence of Φ=2e15 n_{eq} cm^{-2}

- Further irradiations of the FE-I4 modules with active edges:
  - KIT up to 5e15 n_{eq} cm^{-2}
  - Los Alamos up to 5e15 n_{eq} cm^{-2}

…. to be then tested in the upcoming test-beam at DESY

- Plans for a second FE-I4 production at VTT with smaller inactive edge :

  from 150 μm to 50 μm (as for the FE-I3 in this first production)

Status of the RD50 project 2012-01

CIS3: n-in-p FE-I4 sensors at CiS – 6” wafers

- First production on 6” wafers at CIS → to be regarded as a test production
- On-going production in collaboration between CiS and MPI Halle.
- 12 wafers on p-type FZ material with resistivity ~ 15 kOhm cm
- RD50 project for the production of p-type diodes for defect characterization:
  - 80 diodes 2.5 x 2.5 mm^2
  - 45 diodes 5.0x5.0 mm^2
- Completion expected in September 2013.