Karlsruhe Institute of Technology

Institut für Experimentelle Teilchenphysik (ETP)

Optimization of bias rail implementations for segmented silicon sensors

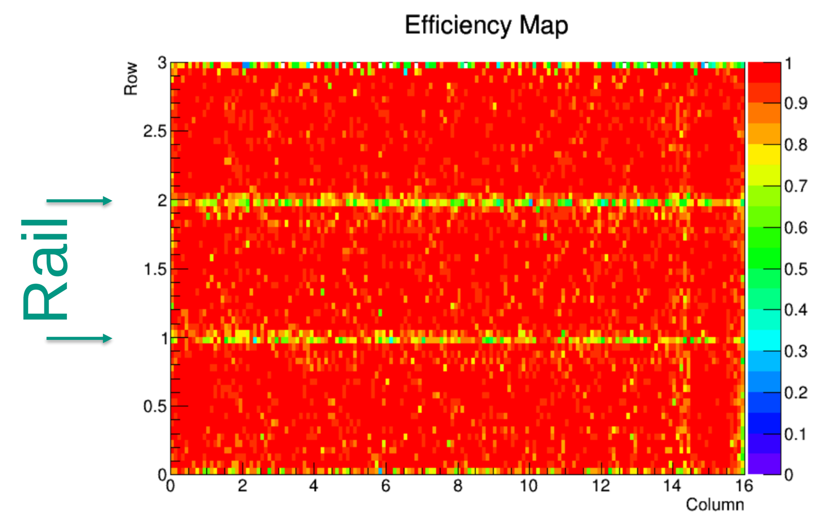
Alexander Dierlamm, Daniel Schell

AIDA 2020

KSETA

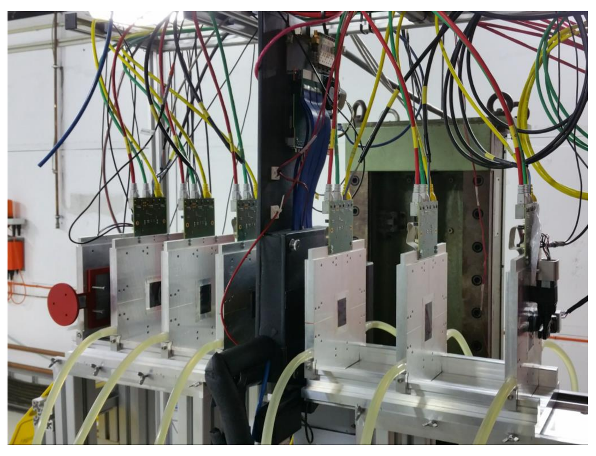
Motivation

- Aluminum bias rails necessary to test segmented silicon sensors
- Testing segmented AC coupled sensors simplified by introducing additional bias rails
- However, depending on the geometry, rails also lead to a certain amount of inefficiency



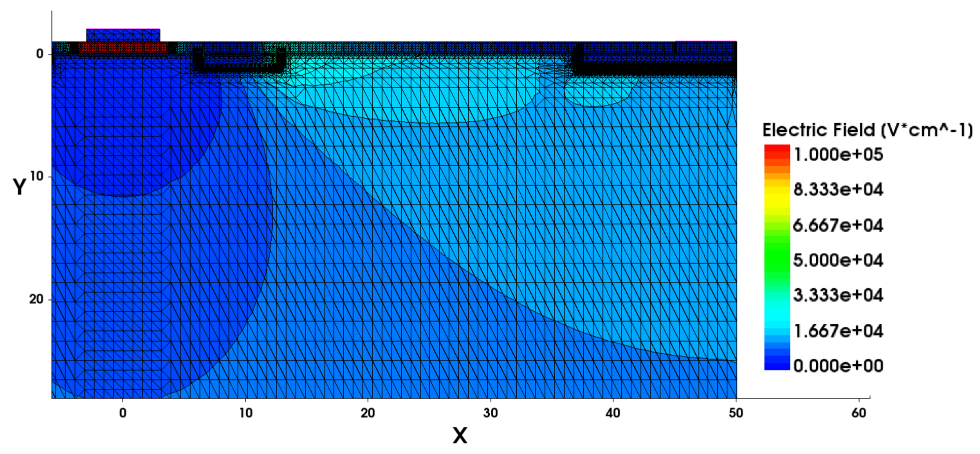
Efficiency measurement at test beam

- Macropixel sensor ($100 \times 1446\ \mu m^2$) with aluminum bias rail bump bonded to binary readout chip
- 5.6 GeV positron beam at DESY, Germany
- EUDET-type beam telescope for track reconstruction



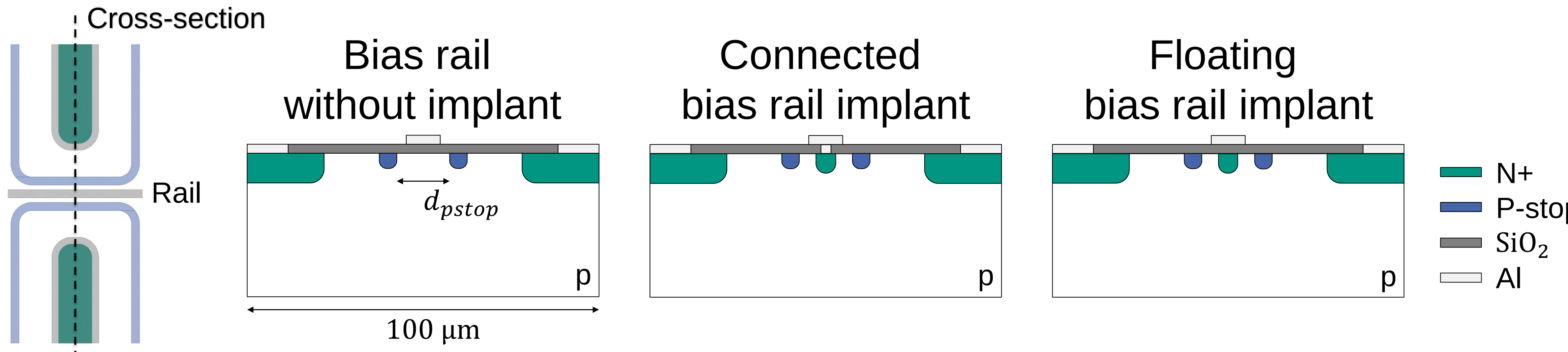
Device simulation

- TCAD simulations offer deeper understanding of possible reasons for efficiency loss
- Electric field distribution and charge collection efficiency used to determine and optimize critical parts of the sensor
- Tool: Sentaurus TCAD (Synopsys)



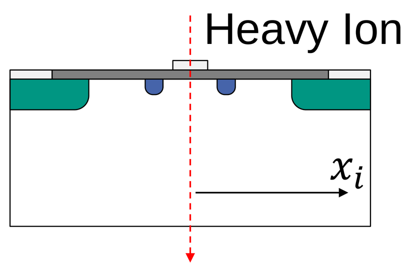
Layout

- Design study based on macropixel layout with $75\ \mu m$ spacing between opposing pixels
- Investigation of three bias rail implementations

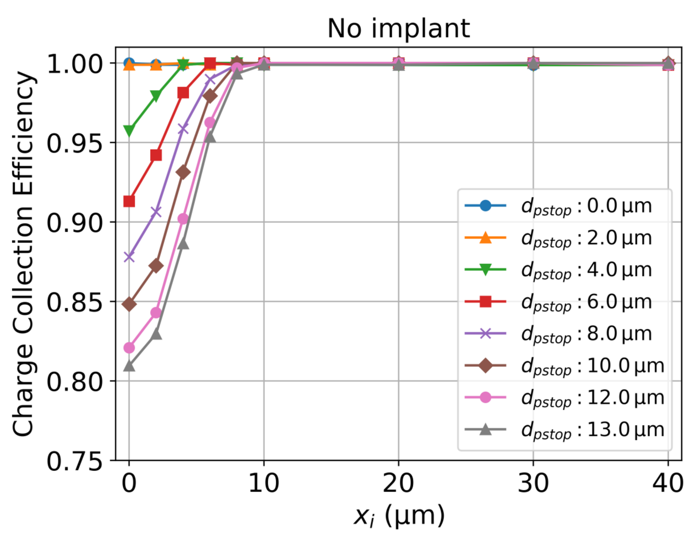


Efficiency analysis

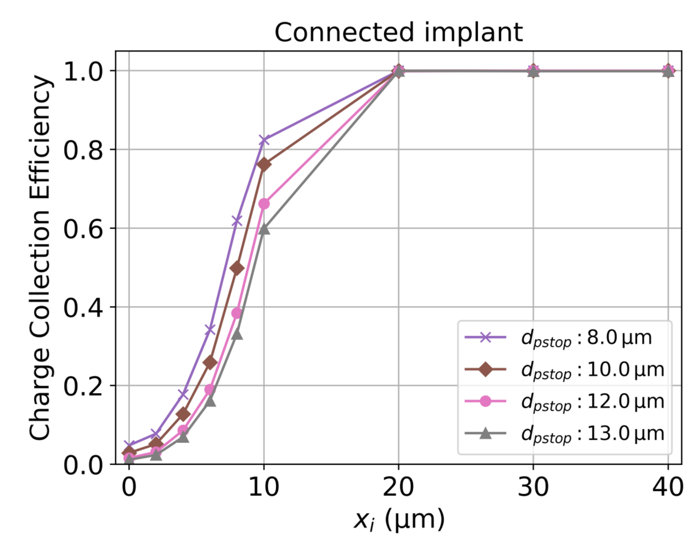
- P-stop implant necessary to isolate single pixels in *n*-in-*p* sensors



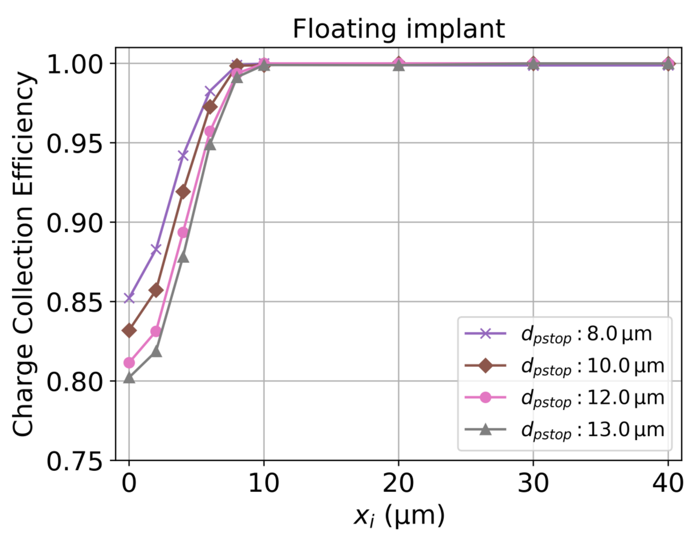
- The closer the p-stops the higher the efficiency below the rail
- Common p-stop approach ($d = 0\ \mu m$) shows highest efficiency between opposing pixels



- Additional implant below bias rail helps to set up uniform electric field between pixels (bias ring extension)
- Connected implant acts as additional strip which collects charge that is not available for further processing

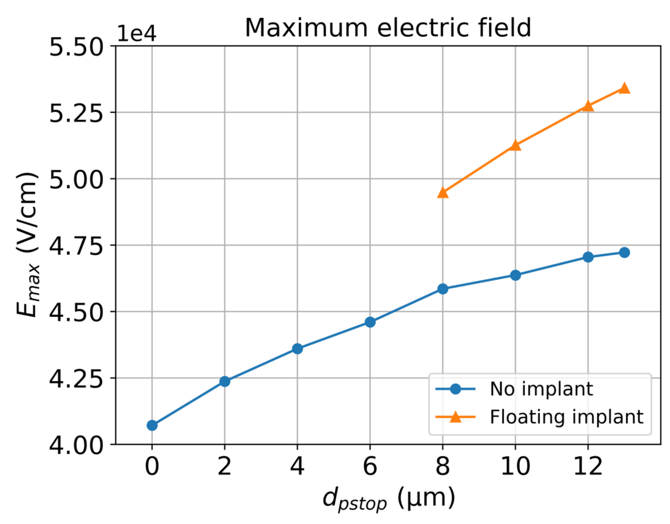


- Design with floating implant reduces inefficiency below the rail
  - Similar performance as geometry without additional implantation



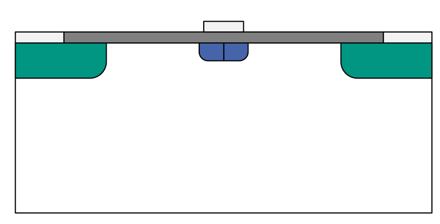
Maximum electric field in the bulk

- Sensor with floating implant shows an increased maximum electric field
- Maximum is always located at the interface between p-stop and silicon dioxide
- Closer p-stop rings lead to reduced field strength

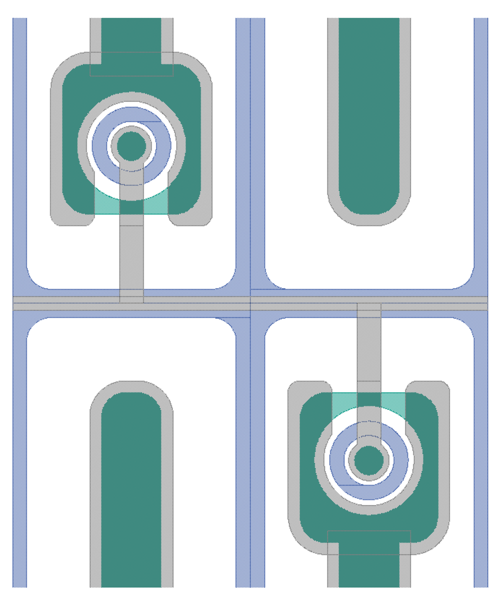


Conclusion and outlook

- Bias rails with connected implant act as additional strips that collect almost all charge generated below them



- **Common p-stop** between opposing pixels preferable considering charge collection and maximum electric field
- Prototypes for further test beam studies expected in February 2018



Common p-stop prototype