Testbeam simulation with Allpix and testbeam analysis results

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Pixel mini workshop, Bergen 2017

UNIVERSITY OF BERGEN

Overview

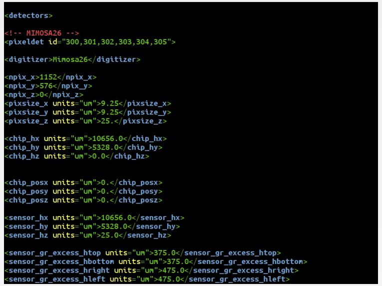
- Motivation
- The Allpix Framework
- Simulation
- Results
- Comparison to Testbeam data
- Active edge studies
- Analysis results
- outlook

Motivation

- We are currently testing pixel sensor for the ATLAS Itk
- This simulation can give insights to the analysis we are currently doing
  - resolution
  - material effects
    - fake hits, multiple scattering etc.
- Justification of cuts in the analysis e.g windows and thresholds
- Allpix seems to also offer detailed simulation of the sensor response

The Allpix Framework

- Generic pixel simulation framework based on Geant4
- Easy to use:
  - xml file to setup sensor
  - macro file for setting up the models used for the simulation
- Difficulties for the local installation
- Choose between .root and ASCII output files
- problems converting ASCII output into .lcio format for the EUTelescope software



```xml
<detectors>

<!-- MIMOSA26 -->
<pixeldet id="300,301,302,303,304,305">

<digitizer>Mimosa26</digitizer>

<npix_x>1152</npix_x>
<npix_y>576</npix_y>
<npix_z>0</npix_z>
<pixsize_x units="um">9.25</pixsize_x>
<pixsize_y units="um">9.25</pixsize_y>
<pixsize_z units="um">25.</pixsize_z>

<chip_hx units="um">10656.0</chip_hx>
<chip_hy units="um">5328.0</chip_hy>
<chip_hz units="um">0.0</chip_hz>


<chip_posx units="um">0.</chip_posx>
<chip_posy units="um">0.</chip_posy>
<chip_posz units="um">0.</chip_posz>

<sensor_hx units="um">10656.0</sensor_hx>
<sensor_hy units="um">5328.0</sensor_hy>
<sensor_hz units="um">25.0</sensor_hz>

<sensor_gr_excess_htop units="um">375.0</sensor_gr_excess_htop>
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<sensor_gr_excess_hright units="um">475.0</sensor_gr_excess_hright>
<sensor_gr_excess_hleft units="um">475.0</sensor_gr_excess_hleft>
```
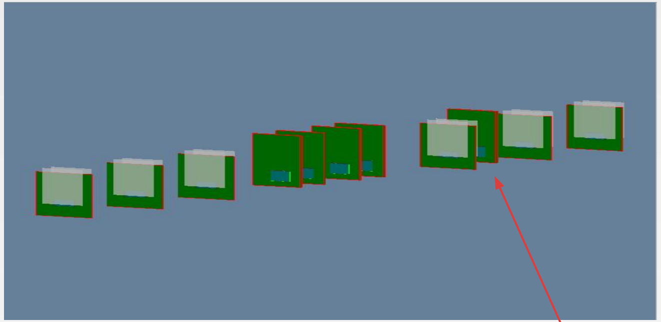

Simulation



Setup:

- FE-I4 SINTEF sensors
  - 80x336 pixels
  - 250x50 μm pixel size
  - Simulated as planar sensors allthough they are 3D
- EUTelescope
  - 18,5 μm pitch Mimosa26 sensors

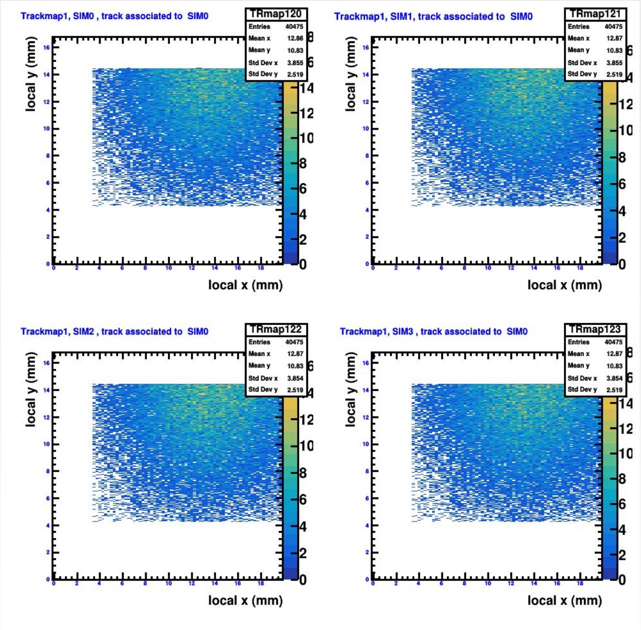
Simulation ‘equivalent’ of SINTEF 12 sensor

Simulation

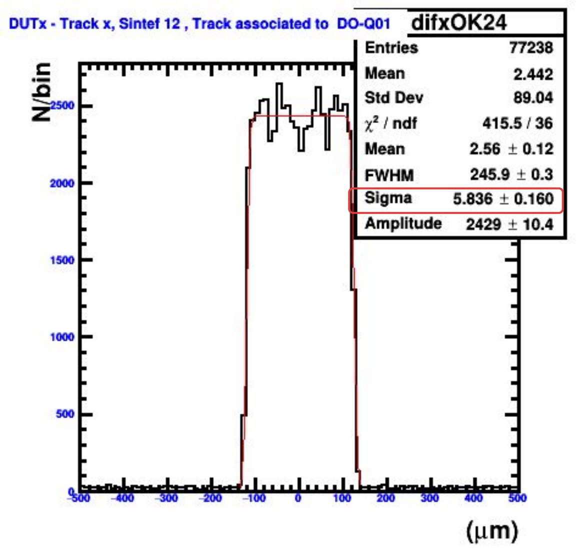
- pi⁻ beam @ 120GeV
- 100k events
- 1 part./event
- ouput as ASCII files

➡ reconstruction software

➡ impact points and reconstructed tracks



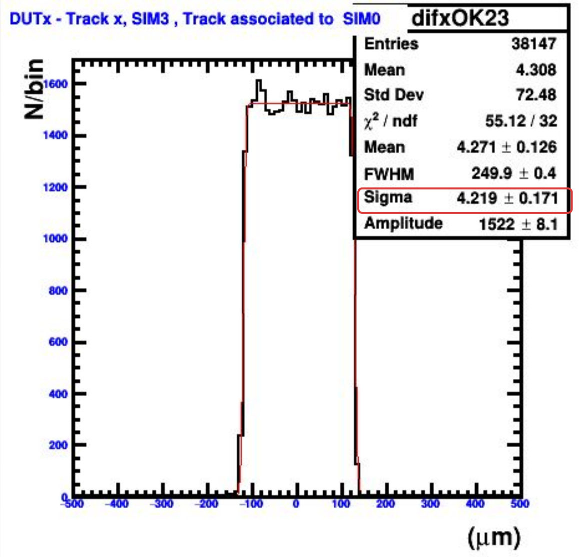
Results



Testbeam data
σ = 5.836 ± 0.16 µm

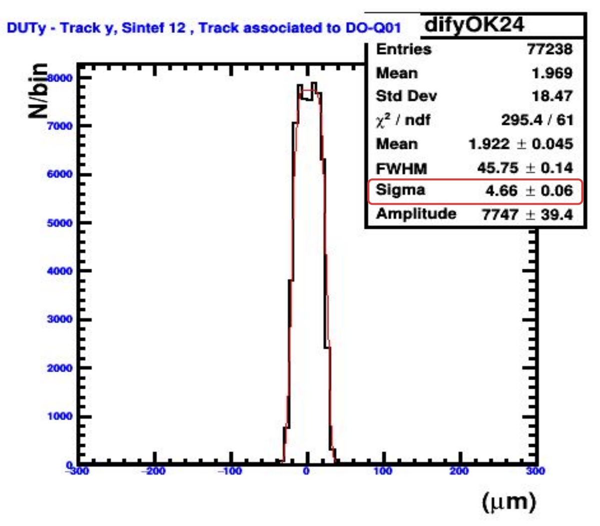
Residuals in x-direction

- comparable spatial resolution!

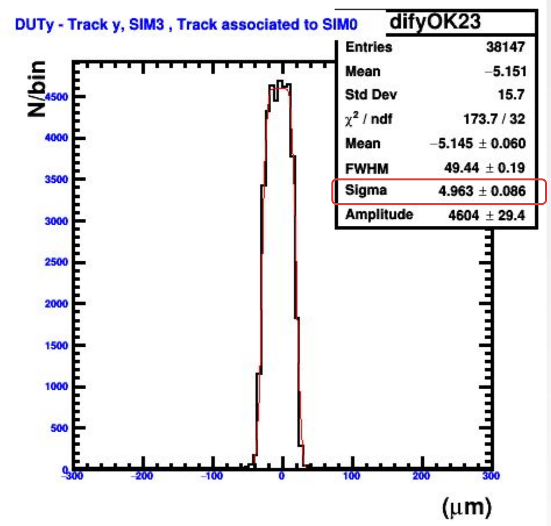


Simulated data
σ = 4.219 ± 0.171 µm

Results



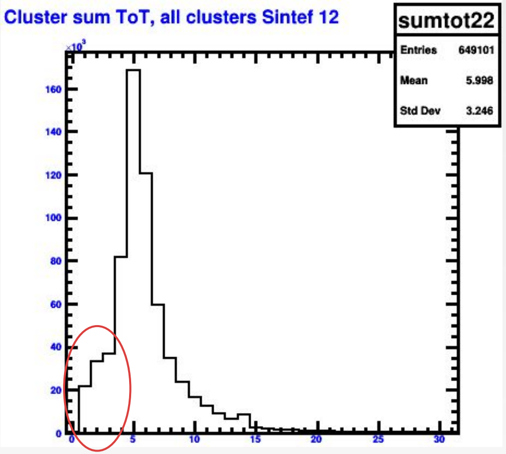
Residuals in y-direction



Testbeam data:
$\sigma = 4.66 \pm 0.06$ µm

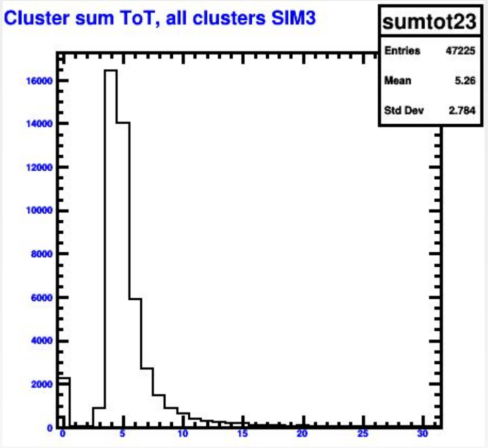
Simulated data:
$\sigma = 4.963 \pm 0.086$ µm

Results



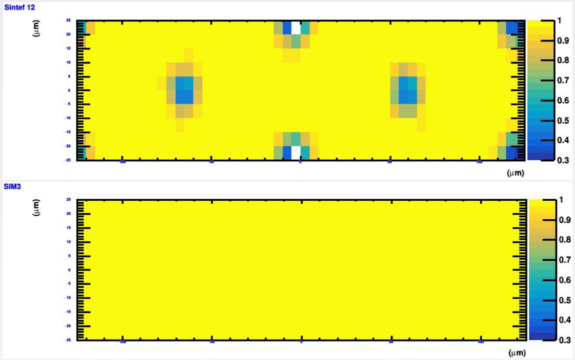
Testbeam data:

- tail due to holes



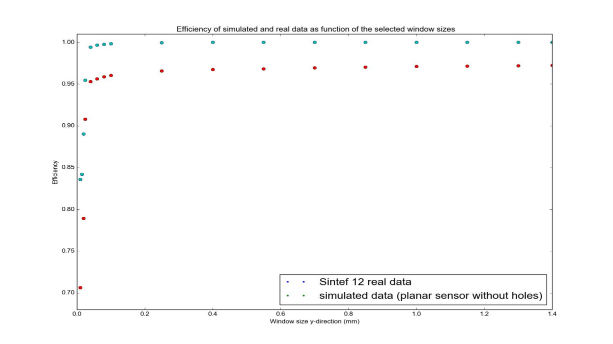
Simulated data:

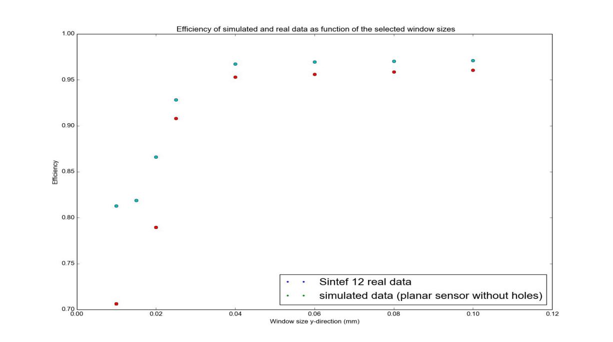
- no tail
- Some hits got 0 ToT



efficiency maps for the real 3D SINTEF sensor and for the simulated planar one

Comparison to testbeam data



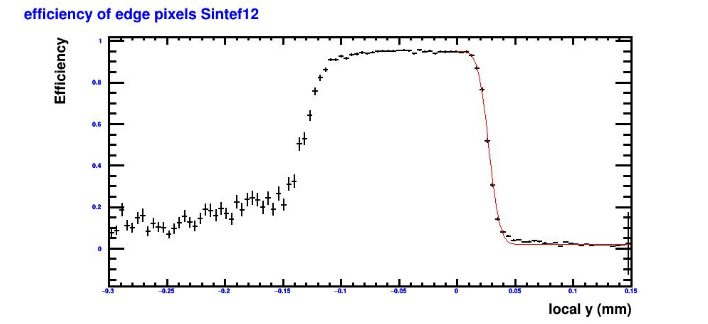


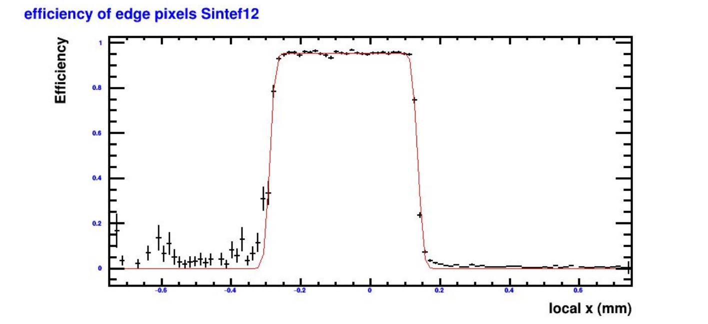
plots shows efficiency as function of window size (Δy) for track-hit association

Zoomed view

- Simulated efficiency higher, no holes
- normalized to the SINTEF12 highest efficiency
- SINTEF12 shows a slope in the platou - could be due to systematics
- shows a somewhat similar response to the cuts, difference at low cuts not yet completely understood

Edge efficiency

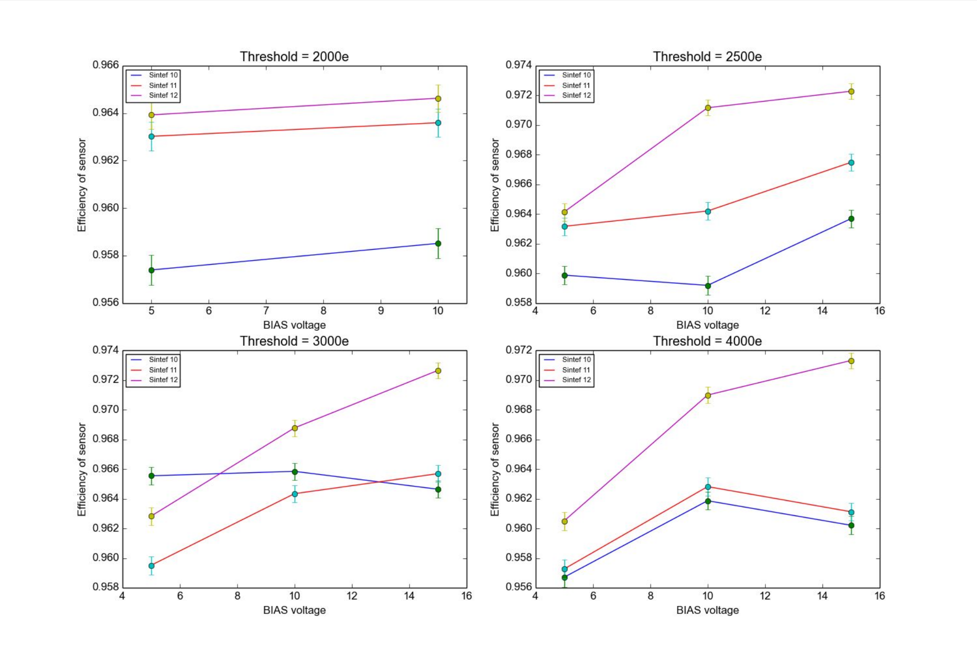




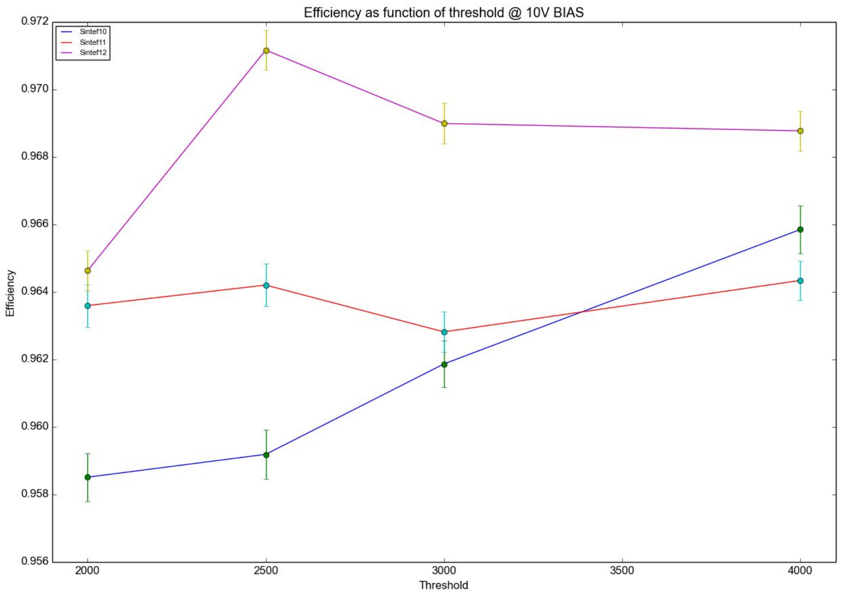
- Data taken at testbeam 2016
- Origo is at the sensor edge, active edge reaches out further
- FWHM gives the pixel width
- Efficiency ‘beyond’ the edge probably due to active material between edge and BIAS pad
- Better cutoff for the long dimension of the pixels -> shorter distance to bias rail

Systematic studies

- Efficiency as function of BIAS voltage @ 4 different thresholds
- see expected trend for Sintef 11 and Sintef 12
- Sintef 10 deviates a bit, possibly due to high leakage current



Systematic studies



- Expected to decrease with increasing threshold
- Sintef10 deviates -> leakage current

Summary

- we have a running simulation that can be used for comparison to testbeam data
- Some features are still not implemented
  - In particular we would benefit from a 3D simulation
  - more material around the telescope

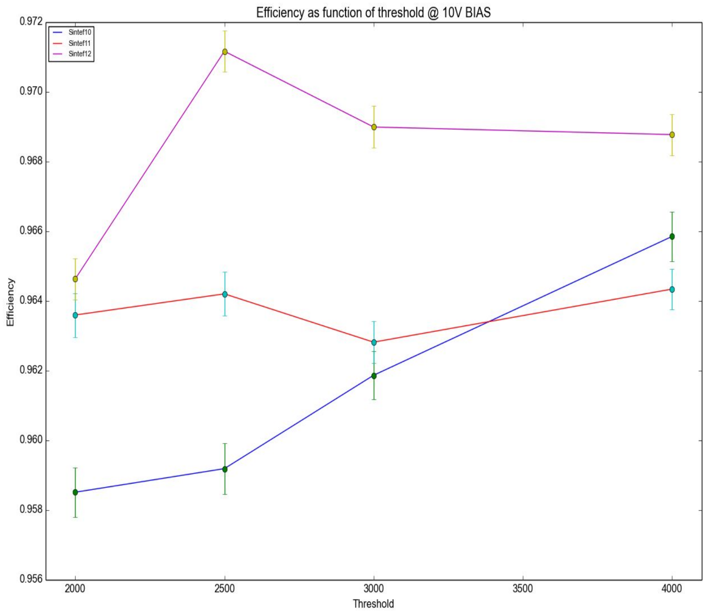
- Edge efficiencies of ~95%
- expected behaviour of the efficiency wrt BIAS and threshold

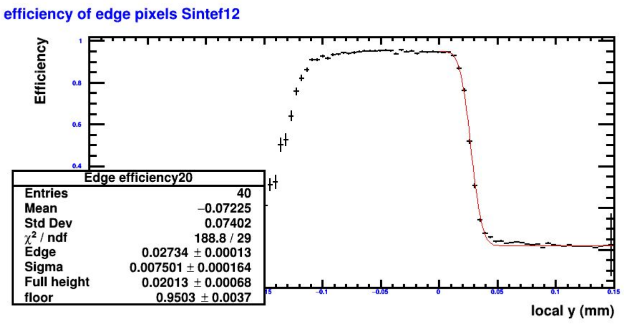
Outlook

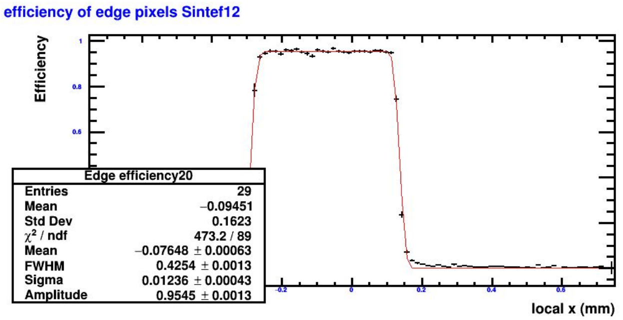
- Compare detailed studies of efficencies for different thresholds and biases
- (hopefully) set up a running 3D sensor simulation with the help from Mathieu Benoit
- Implement more materials around the telescope, particularily the Aluminium cooling box around the DUTs

THANK YOU!

Backup slides







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