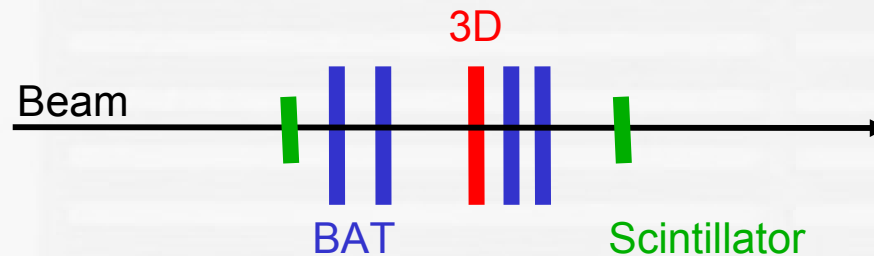# Test beam results with 3E-FEI3
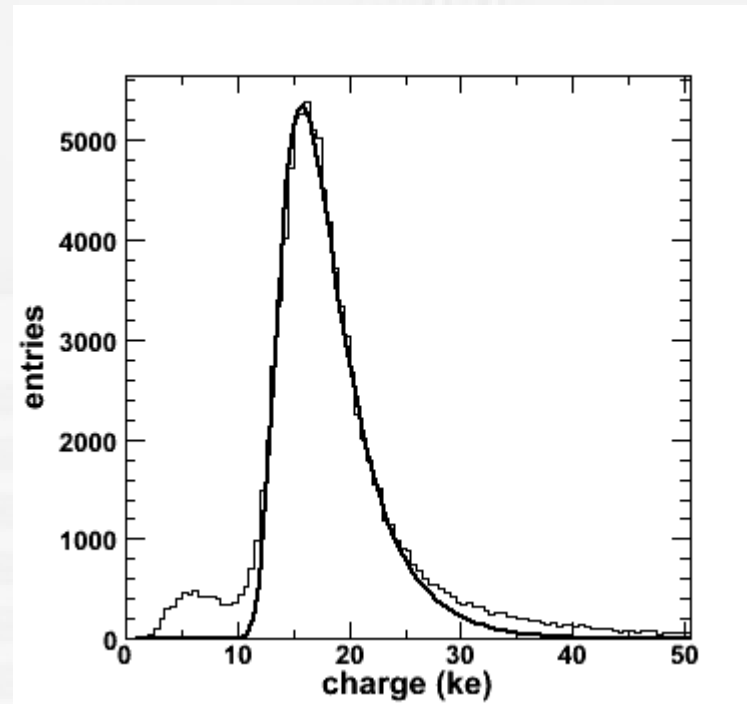
Markus Mathes,

M. Cristinziani, Lars Reuen, Norbert Wermes

Bonn University, Germany

- Final analysis of the data taken end of October 2006
  - 3D-3E (~3.2M raw events)
    - Tuning: Threshold 3000e, 30TOT@10ke
    - Angular scan (0°, 15°)
    - Bias scan (5V to 25V)
 - Reference System
    - BAT-Telescope

  - Beam divergence <2mrad
  - Beam incidence angle known within ±1°
  - Hit prediction precision in the DUT 4-5µm

10V

- charge distribution for predicted hits found in the 3D device
- measured: MPV 15800e, FWHM 6800e
- expected (208µm): MPV 16000e, FWHM 6200e
- Agrees perfectly within the ToT calibration uncertainty of 5-9%
- Population of entries at small charges indicate charge losses
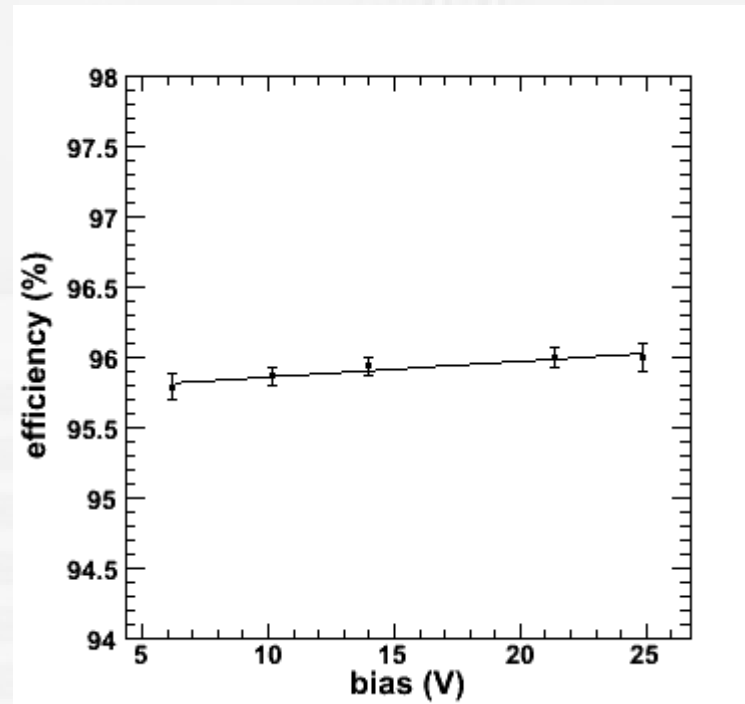
- Efficiency measured at 0° and 10V bias to 95.9%±0.1%
- Basically unchanged for biasing down to ~6V
- slight decrease to low bias voltages
  - maybe undepleted zone around pixel electrodes
  - maybe higher fields influence region inside column

Column Efficiency
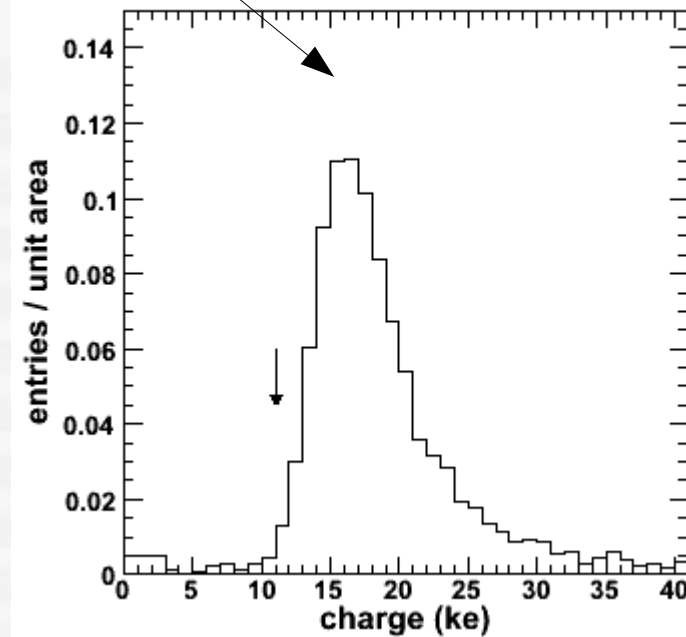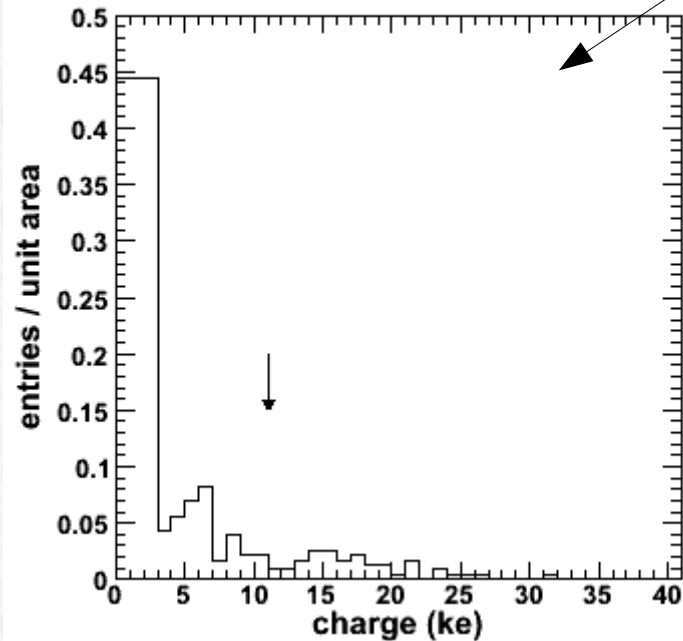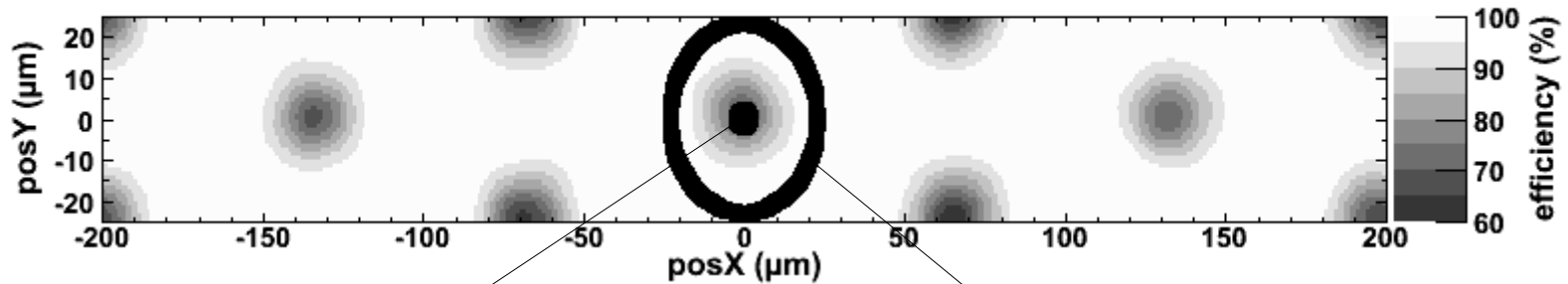

- Low charge entries originate from column centers
- Mean of charge entries: center ~5ke, outside 20-25ke
- Charge collection inside column at most 25%
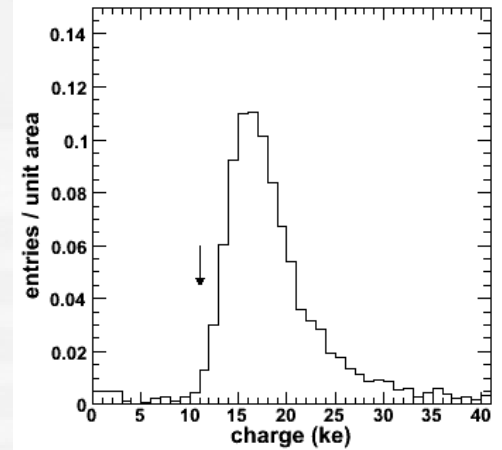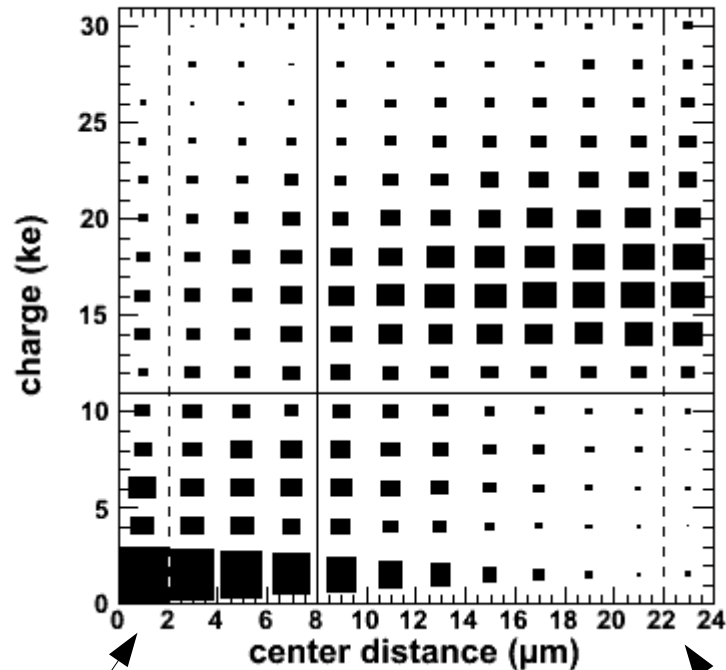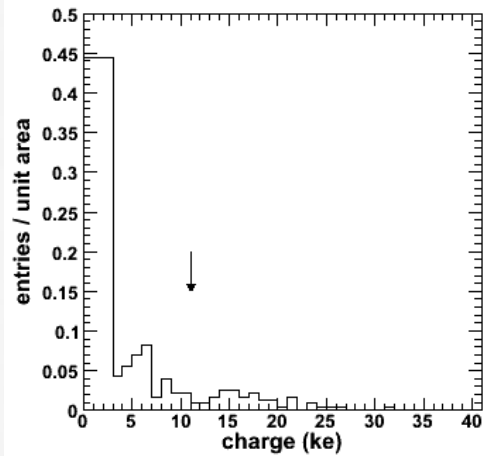
- Distribution of the charge entries vs. distance from column center is shown
- The horizontal line marks 11ke, below no charge entries from the Landau distribution are expected
- The vertical line marks the nominal column radius of 8µm
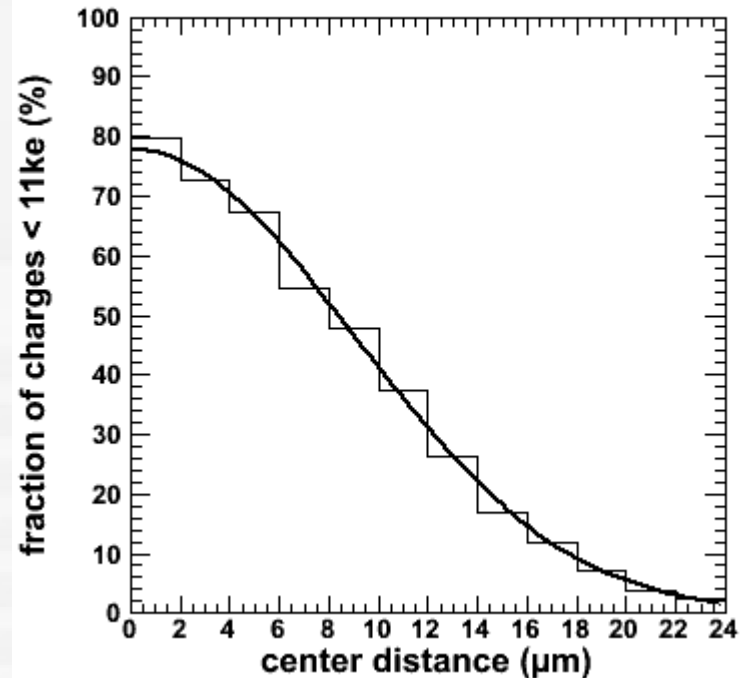
- Plot shows fraction of hits below 11ke vs. distance to column center
- Assuming a step function convoluted by a Gaussian one obtains a column radius of 8.5µm±0.3µm and a sigma of 7.2µm±0.2µm
- Sigma wider than expected from telescope resolution and beam inclination
- Indication for efficiency inside the column being not a step function
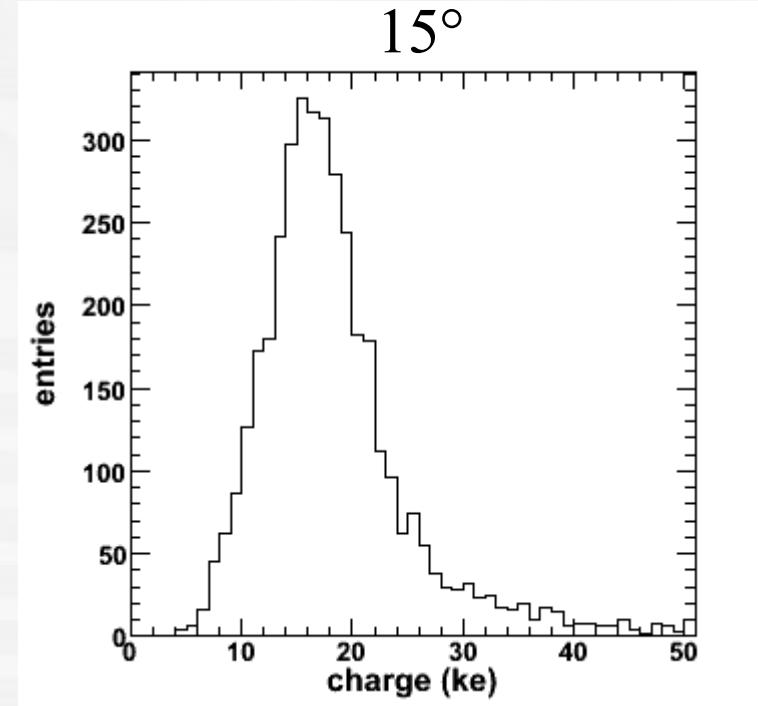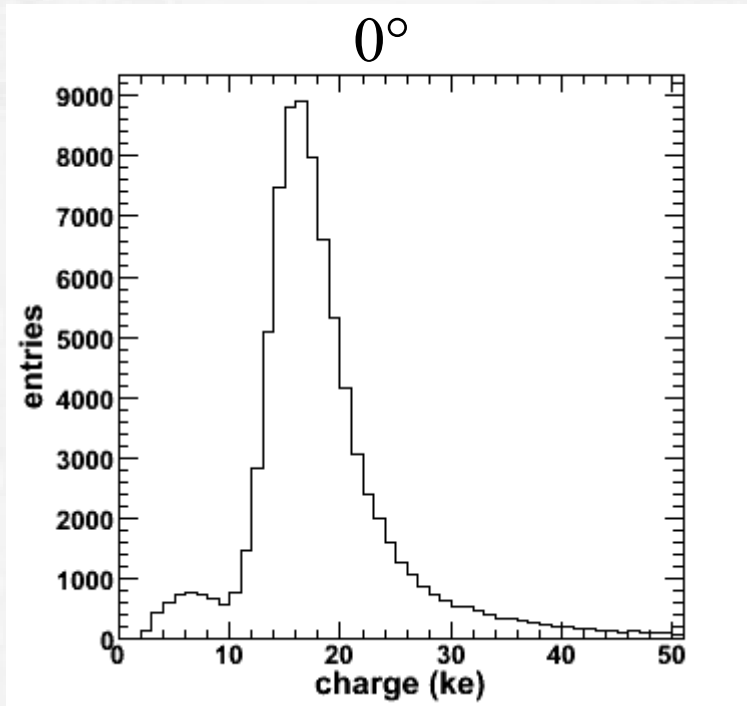
Inclined Tracks

- Efficiency for inclined track of 15° 99.9%±0.1%
- Lowest detected charge for 15° is 5000e
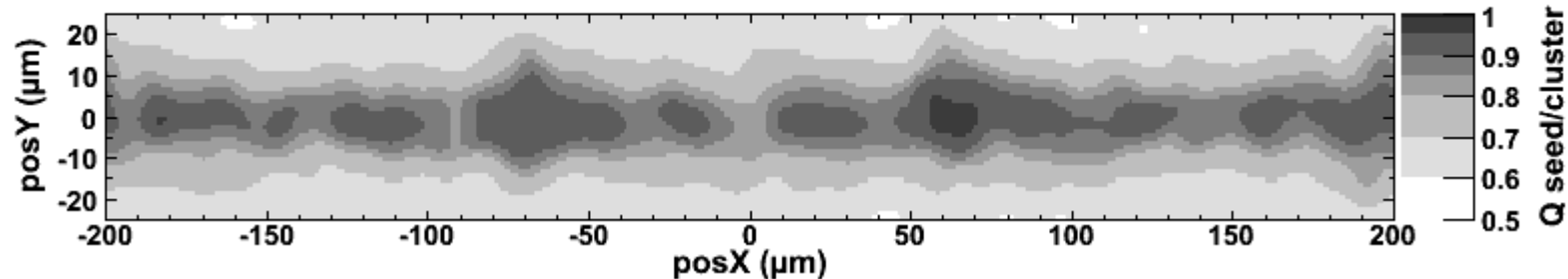- No comfortable distance to threshold of 3000e

50µm direction — 400µm direction
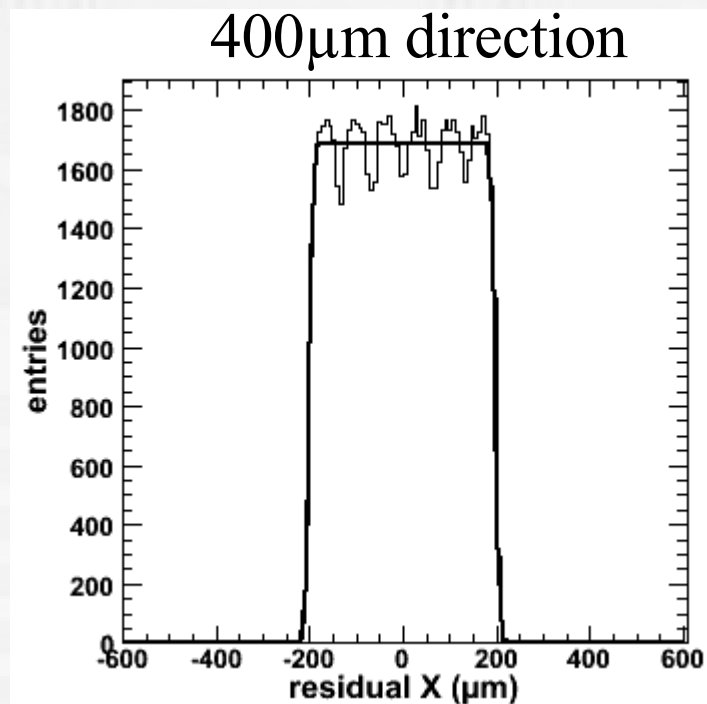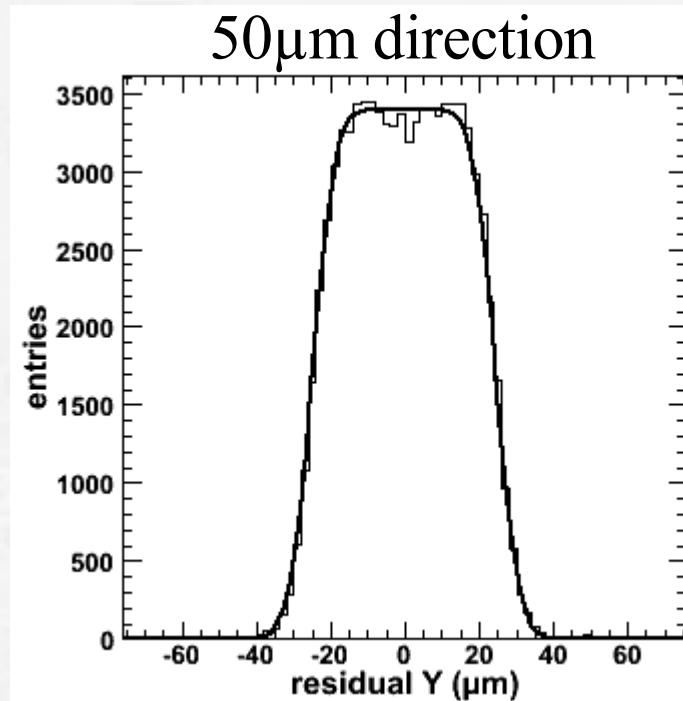
- Center of pixel with highest charge entry taken as reconstructed position
- Fit (rectangular function convoluted with Gaussian)
  - 50µm direction: width (49.4±0.1)µm, sigma (4.8±0.1)µm
  - 400µm direction: width (398.0±0.3)µm, sigma (6.4±0.2)µm
- Structure visible results from position depended efficiency
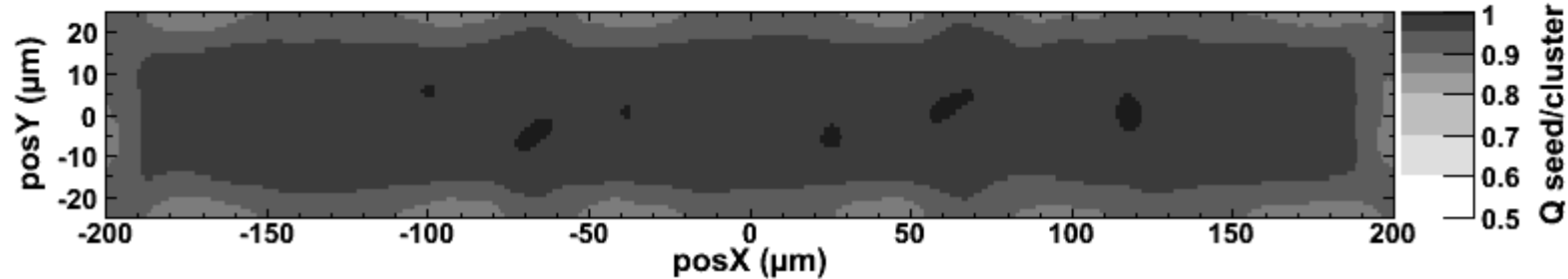
- Fraction of charge found in the seed pixel
- Charge sharing at 0° limited to narrow region at the edges
- Charge sharing ratio is modulated by the column structure (effects hit reconstruction using the analog information)
- Finer structures visible in the 15° plot are due to limited statistics

Conclusion

- 3D-3E silicon sensor, assembled as pixel device has been tested and characterized
- hit efficiencies of 95.9% at 0° and 99.9% at 15° have been obtained
- Inefficiencies identified as being due to the 3D electrodes
- Paper just accepted by IEEE TNS for publication
  - Testbeam Characterization of 3D Silicon Detectors
  - preprint at arXiv:0806.3337