Field distortions introduced by the DESY module

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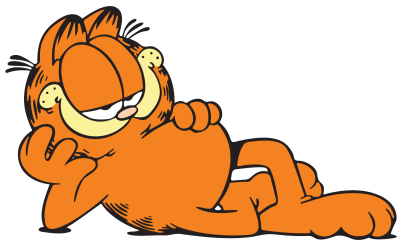


Motivation for the study

Investigate field distortions introduced by the DESY module.

1. Use finite element based software to simulate electrostatic fields (CST™)
2. Use GARFIELD++ to drift electrons in that field and add constant B-field

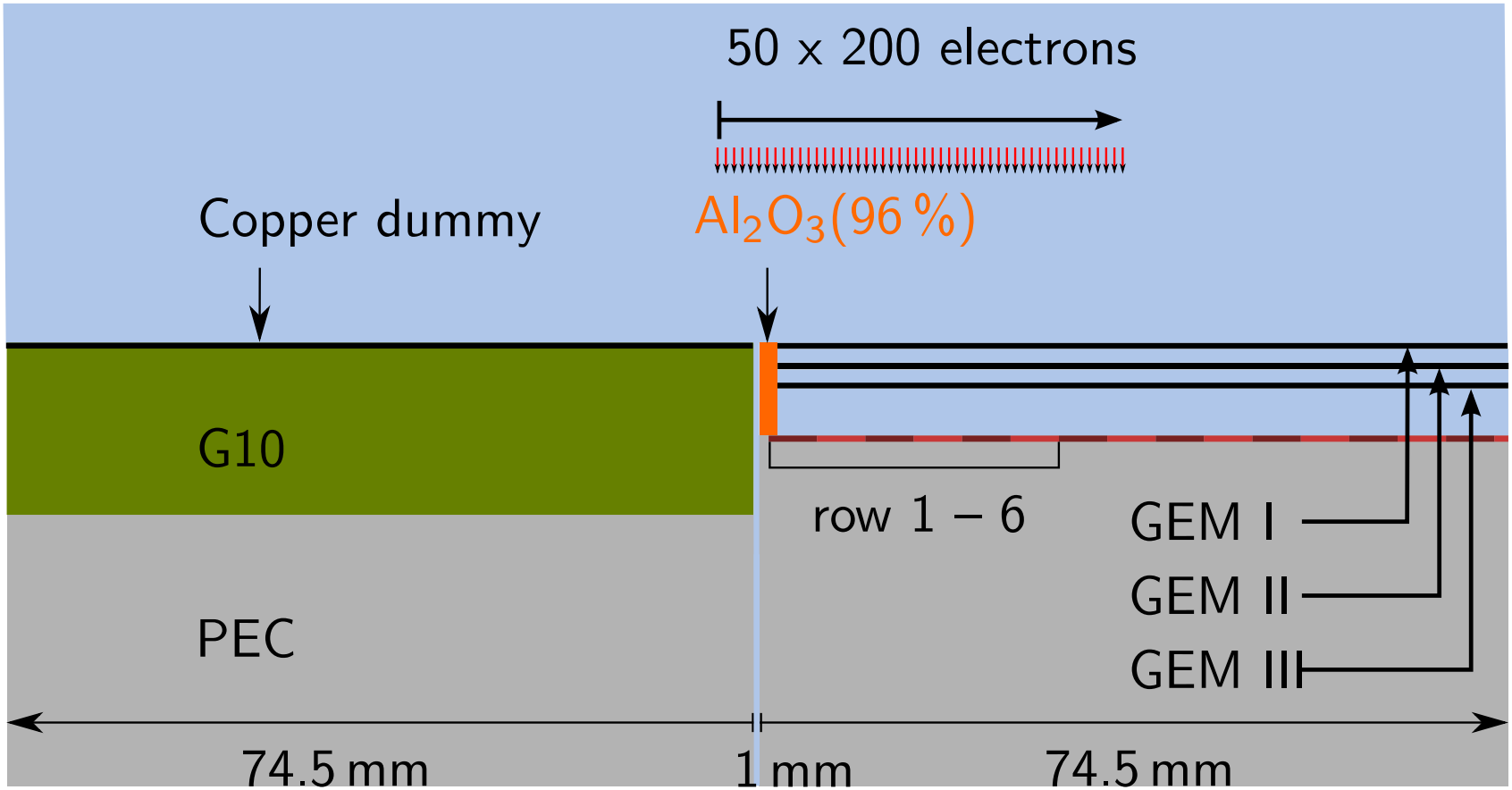


Fig.: Side view of the FEM model.

Settings

Drift field:

- $E_{\mathrm{drift}} = 220\,\mathrm{V/cm}$ in z-direction

Gas:

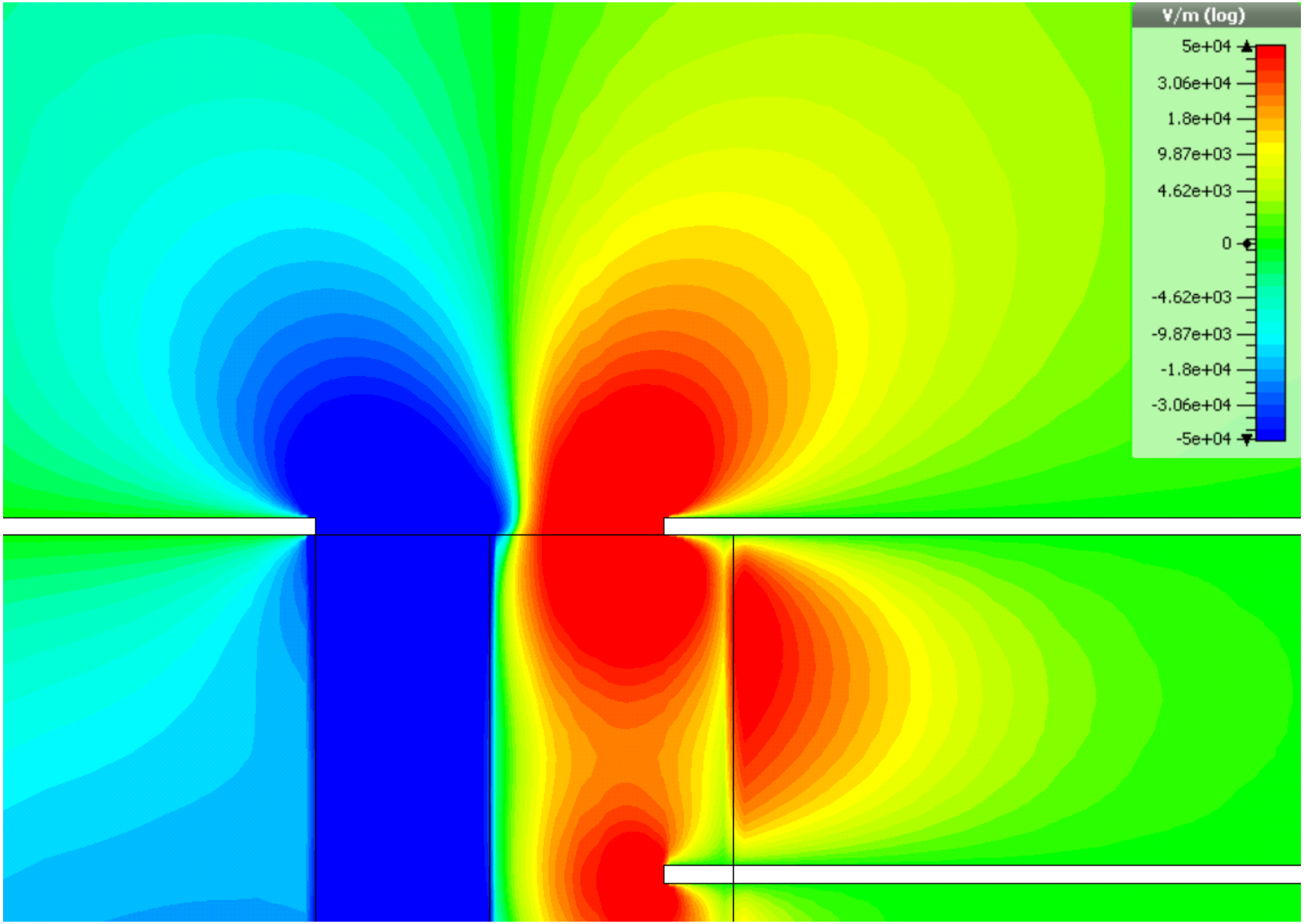
- T2K gas (95 % Ar, 3 % CF_4, 2 % iC_4H_{10})

Drift distance:

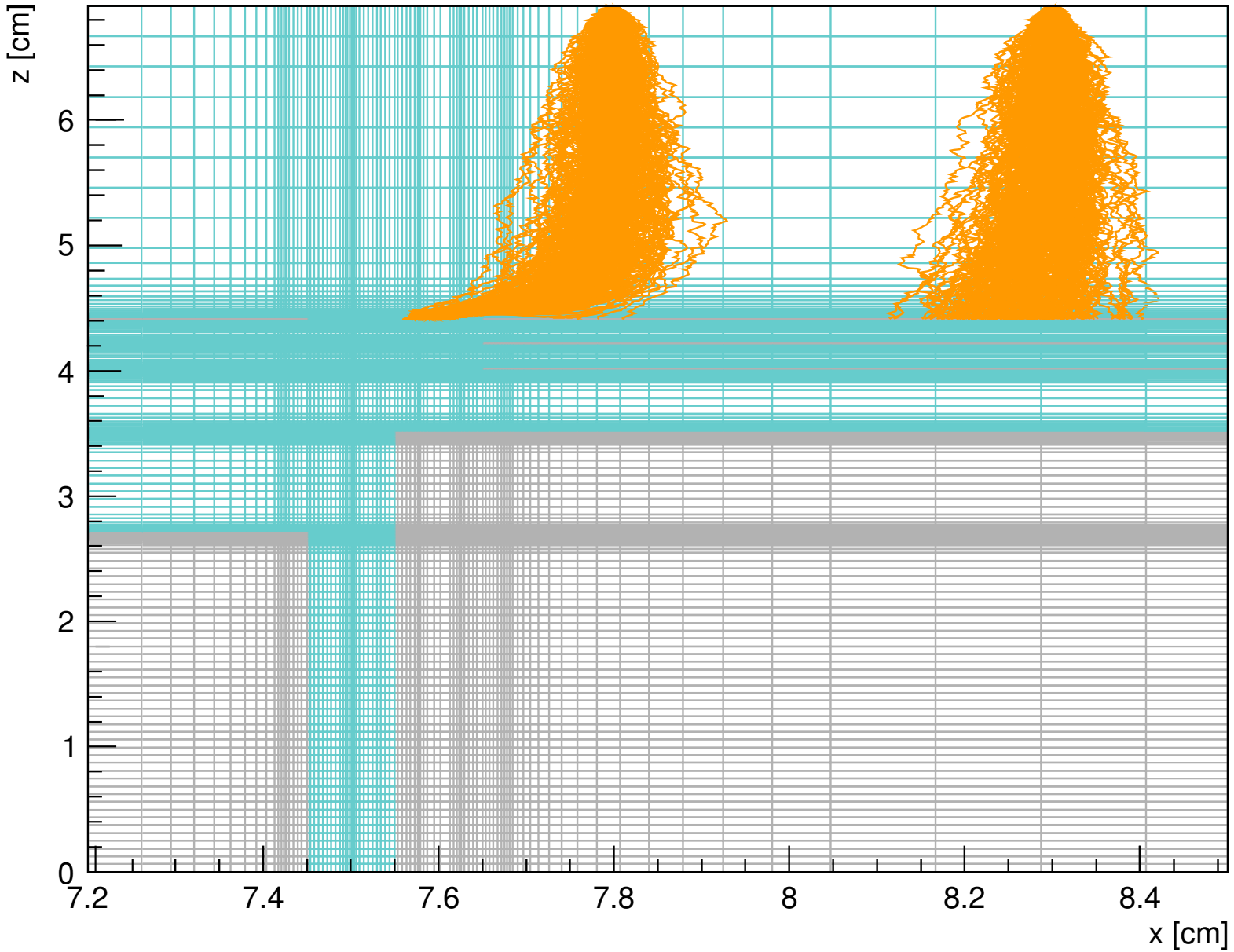
- $d_{\mathrm{drift}} = 25\,\mathrm{mm}$

	potential
PEC	0 V
GEM III	-1200 V
GEM II	-1800 V
GEM I	-2200 V
Copper dummy	-2200 V
boundary (at z_{max})	-2750 V

Electric field transverse to the drift field E_t ($x - z$ plane)



Example of the electron drift (without magnetic field)



Analysis

1. Drift 200 electrons starting from one position in the drift volume towards the module.
2. Stop the drift directly above the module and analyse the end positions.
3. Repeat this for different start positions along a line above the module and transverse to the drift field (here in x-direction)

Assumption: If there are enough start positions and the distance between them is small enough a uniform charge distribution above the module can be assumed.

4. Project the pad rows to the top of the module and count how much electrons end on each.

$\Rightarrow$ A uniform distribution leads to the same number of electrons on each row.

Result of the analysis (without magnetic field)

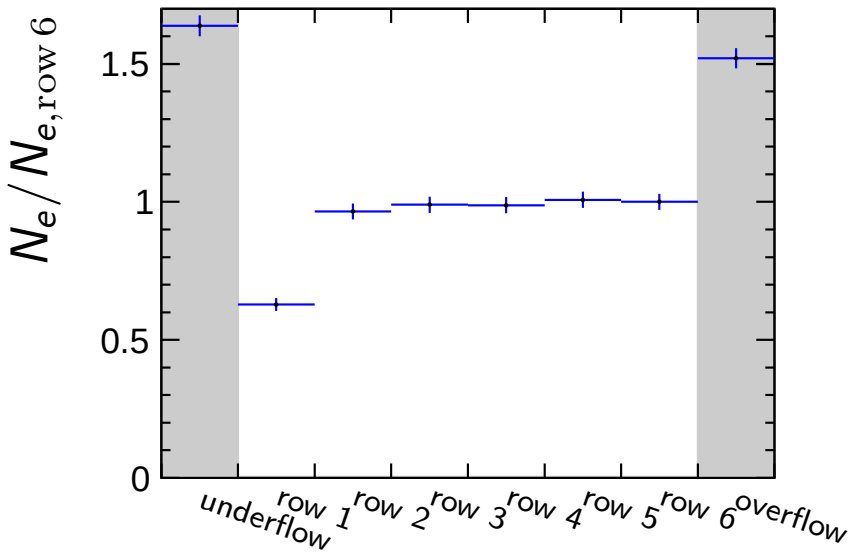


Fig.: Number of electrons on a certain row position normalised to electrons on row 6.

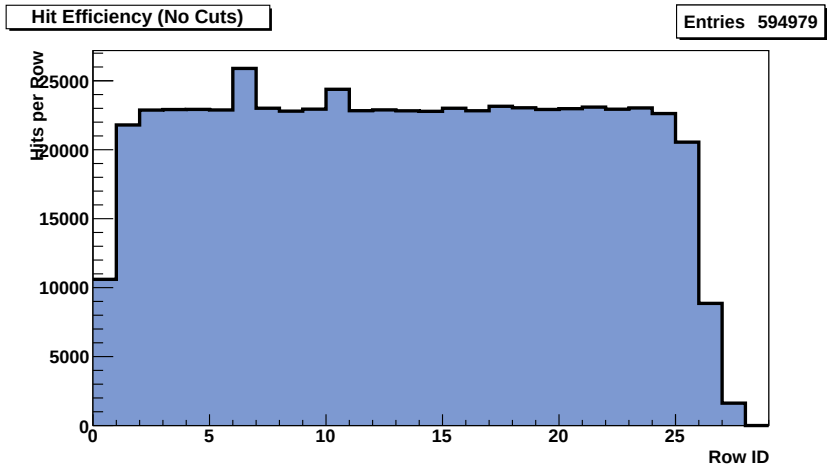


Fig.: Test beam result from July 2011 showing decreased charge collection on rows at the border of a readout module. This measurement was taken without a magnetic field.

Modifications of the module – E_t $(x - z$ plane)

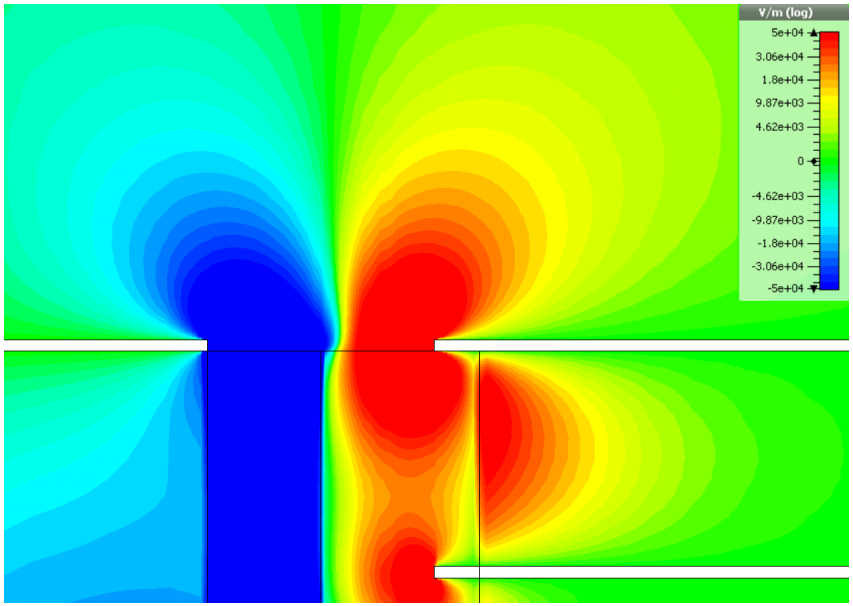


Fig.: Default module.

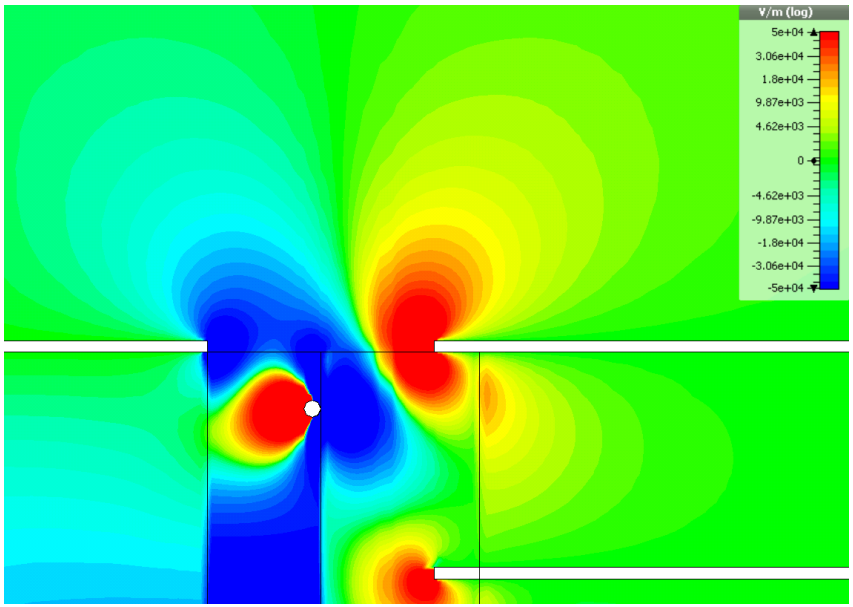


Fig.: One wire. ($\varnothing = 150\,\mu\mathrm{m}$)

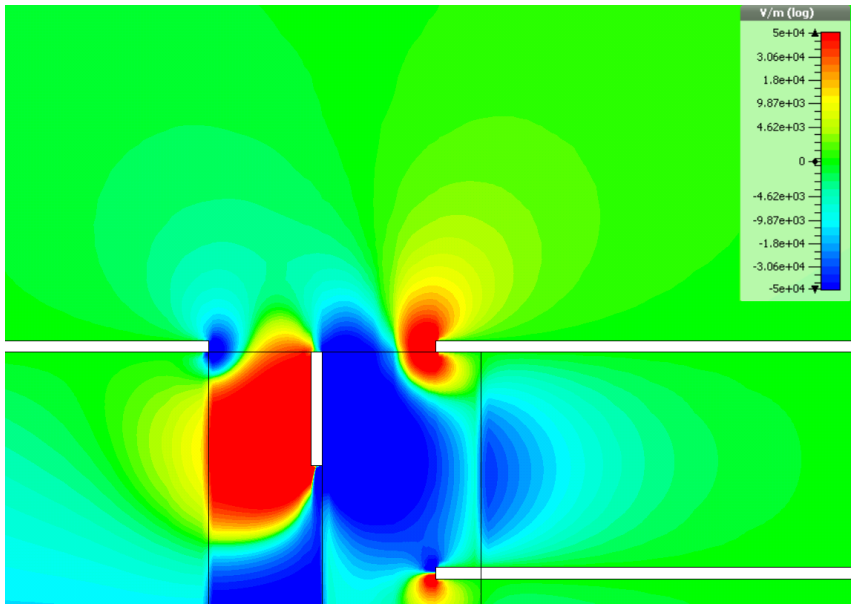


Fig.: One strip.

Results with modifications (no magnetic field)

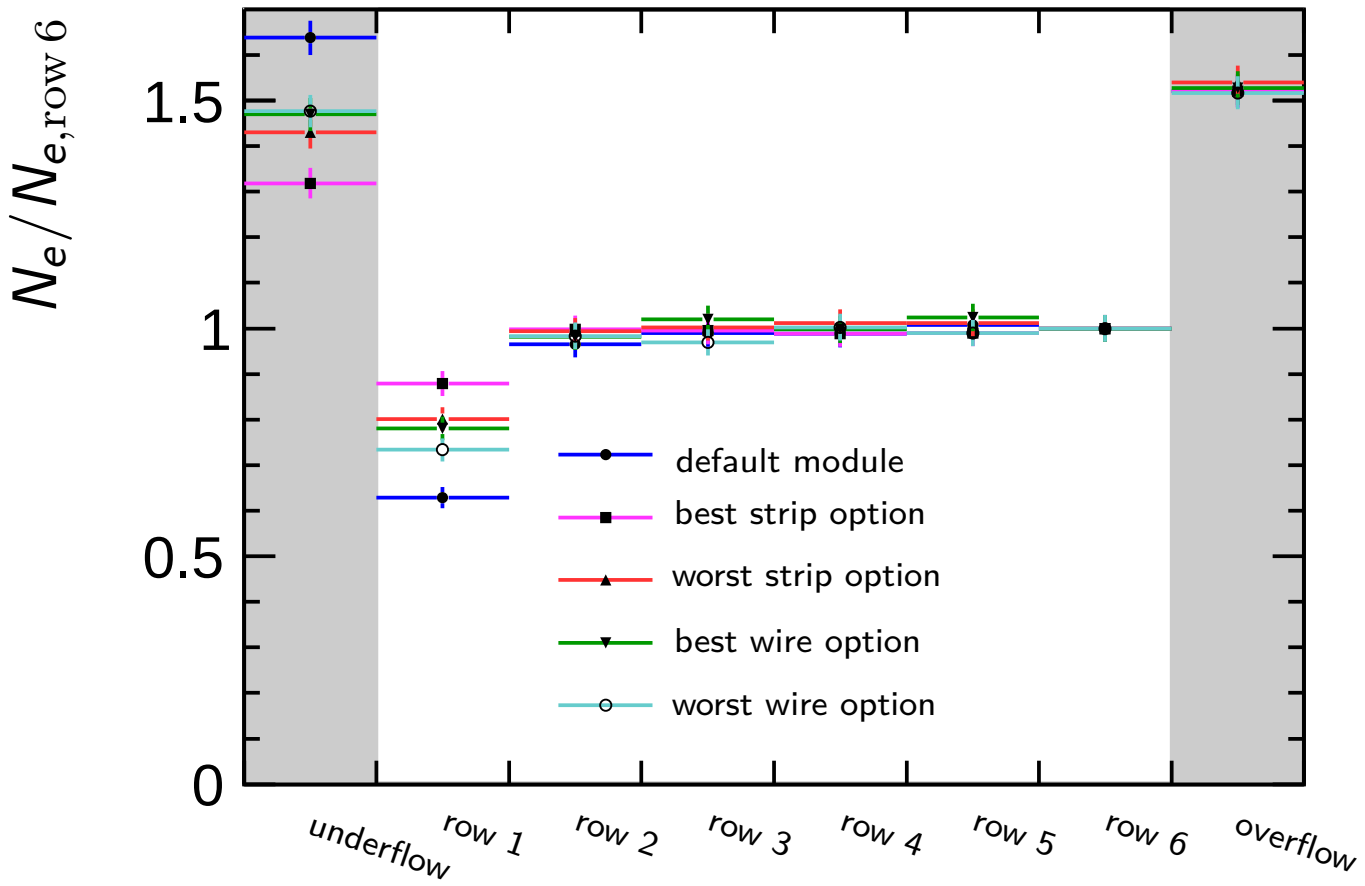


Figure: Number of electrons on a certain row position normalised to electrons on row 6. Results for different possibilities of modifying the readout module are shown.

Results with modifications ($B = 1\,\mathrm{T}$)

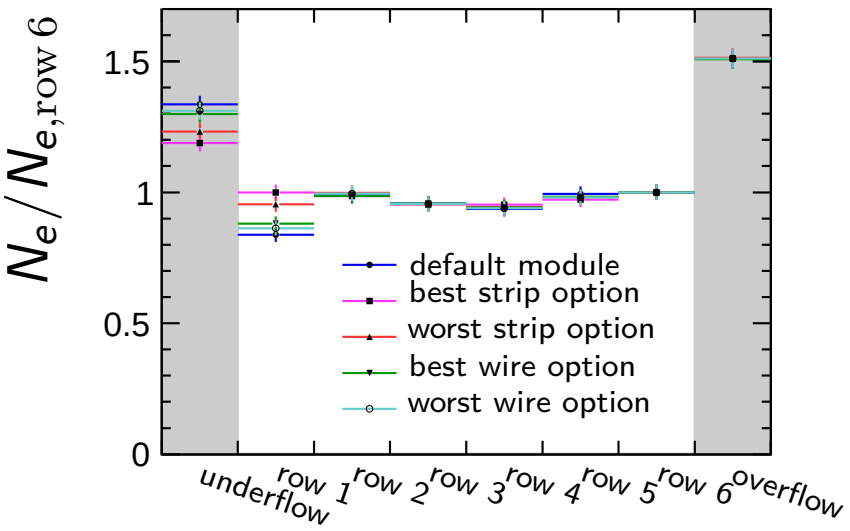


Fig.: Number of electrons on a certain row position normalised to electrons on row 6. Results for different possibilities of modifying the readout module are shown.

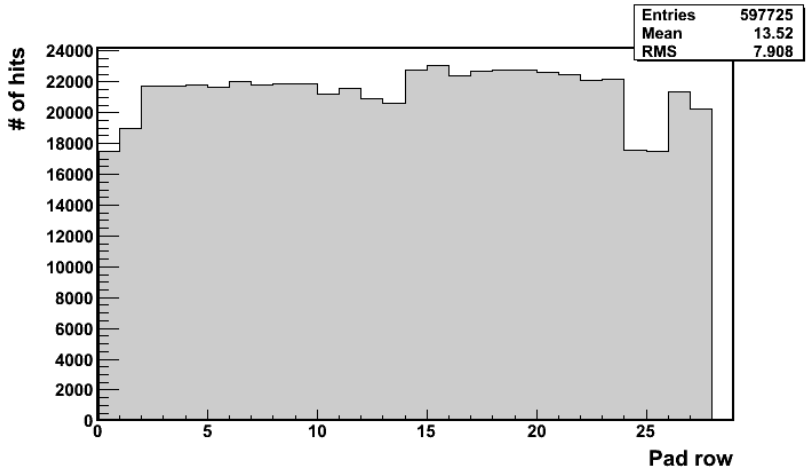
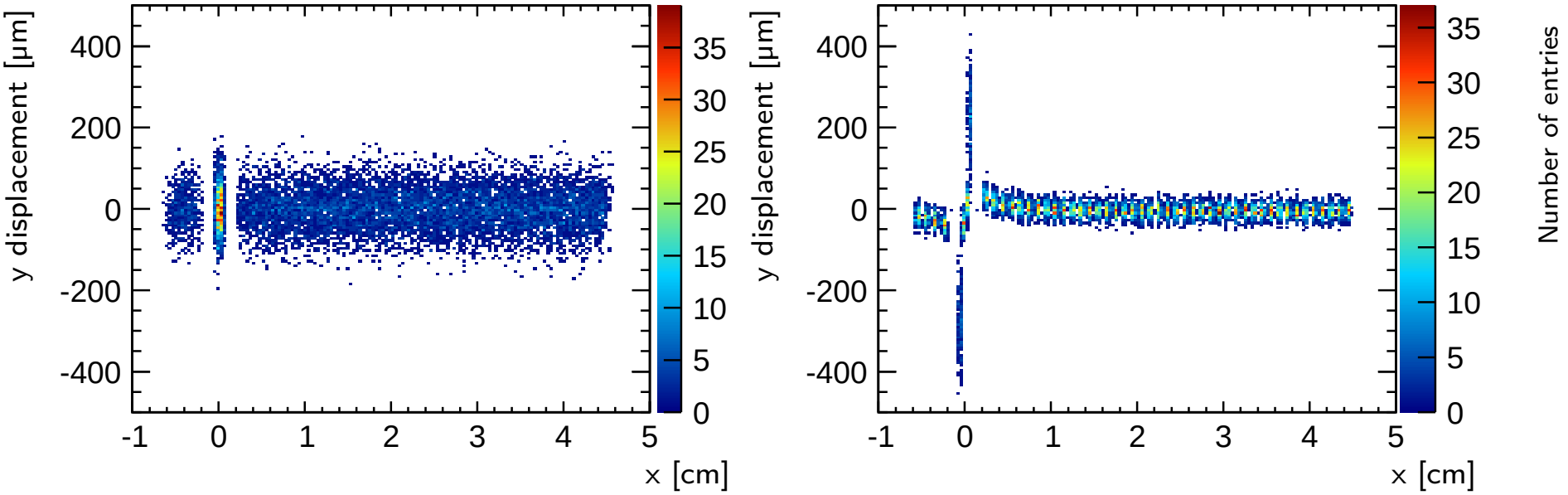


Fig.: Test beam result from July 2012 showing a less decreased charge collection on rows at the border of a readout module compared to the dafault DESY module. The modification used in the experiment corresponds to the best wire option.

Analysis in the module surface ($x - y$ plane)

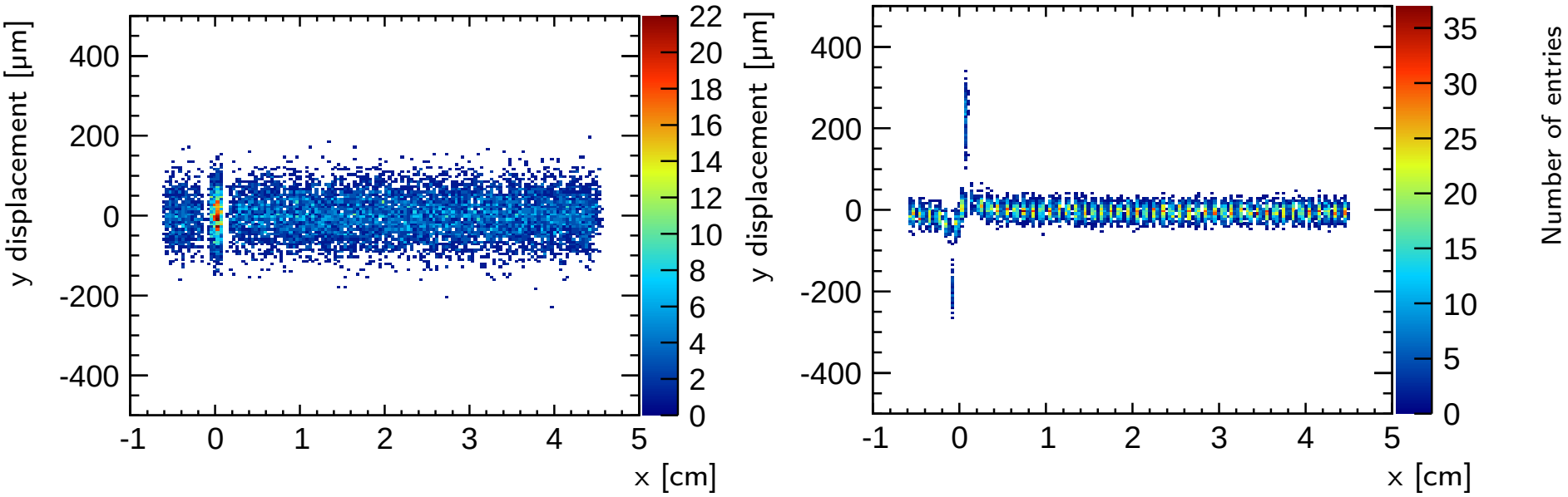


- Transverse diffusion is reduced with magnetic field
- Displacements due to $E \times B$ effects are visible with $B = 1\,\mathrm{T}$
- The first row is at $x = 0.1\,\mathrm{cm}$

$\Rightarrow$ At this position: $\delta y \approx 50\,\mu\mathrm{m}$

- This is close to the value observed and shown by Wenxin Wang in the last analysis meeting

Analysis in the module surface plane ($x - y$)

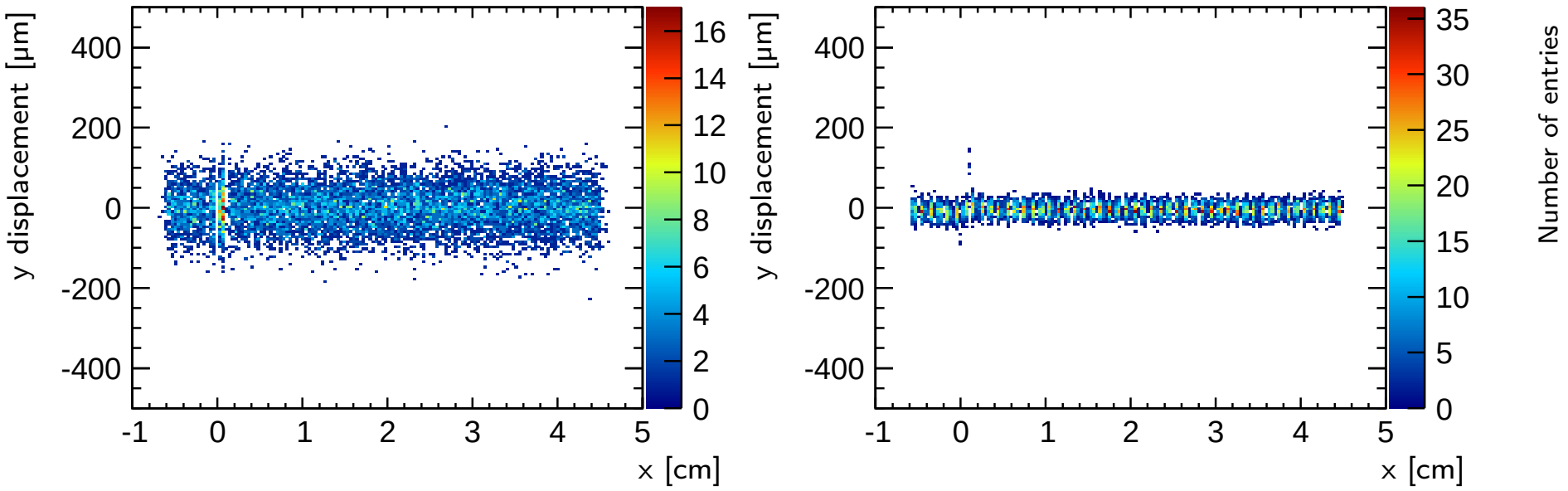


One wire attached to the module:

- Reduced displacements:

$\Rightarrow$ At the first row: $\delta y \approx 25\,\mu\mathrm{m}$

Analysis in the module surface plane ($x - y$)



One strip attached to the module:

- Displacements nearly vanished
- Only diffusion spreads the signal

Conclusions

- Simulation results are in good agreement with measurements
- Optimisation based on the simulation was done in case of the DESY module
- First measurement with a wire attached to the DESY module showed promising results
- A paper summering the results will be available soon