The field cage for a Large TPC-Prototype

DESY FLC TPC Group, Peter Schade

The TPC field cage

- Design, develop and build a field cage for a "Large TPC-Prototype" (LP) to be used for studies and development work towards a TPC at the ILC

- Eudet-funded project

  ↪ Field cage will be available as infrastructure for studies with different endplates

- Size and boundary conditions of the field cage are defined through PCMAG

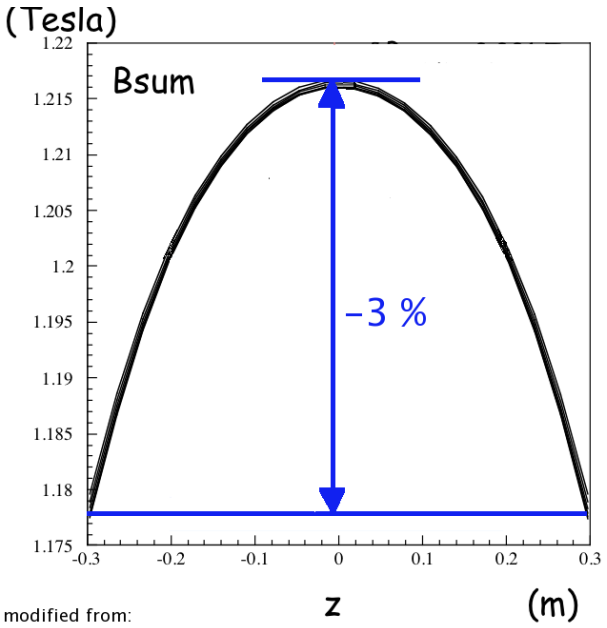
  ↪ Length: $60\,\mathrm{cm}$, outer diameter: $80\,\mathrm{cm}$
  ↪ "Large" diameter allows development of large surface readout structures

- Field cage should be lightweight, stable and flexible
  → structure will be made of composite materials

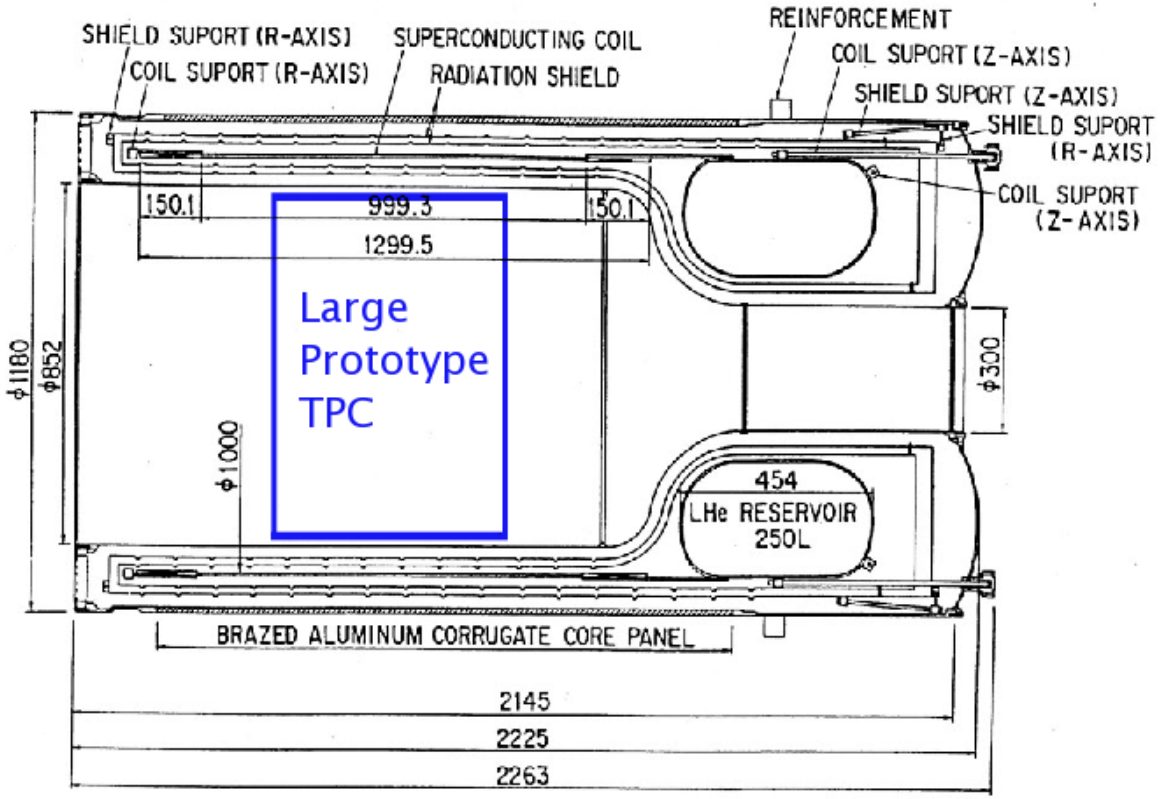
- Field cage available until middle of 2007

Superconducting Magnet PCMAG

- PCMAG will be installed in DESY test beam
- Diameter: 86 cm

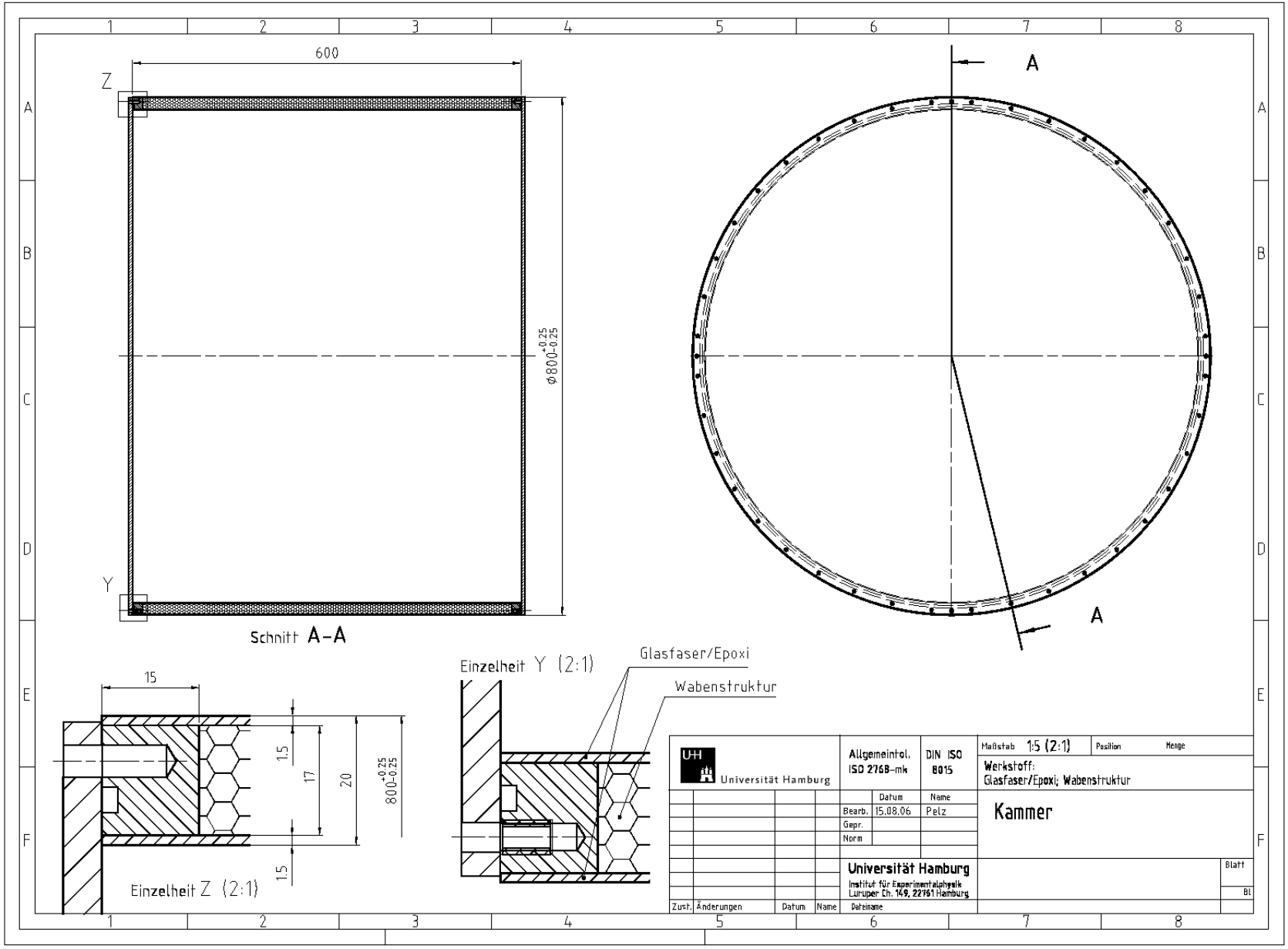


modified from:
B calculation of S_JACEE magnet, Sakamoto/Sugiyama saga univ.



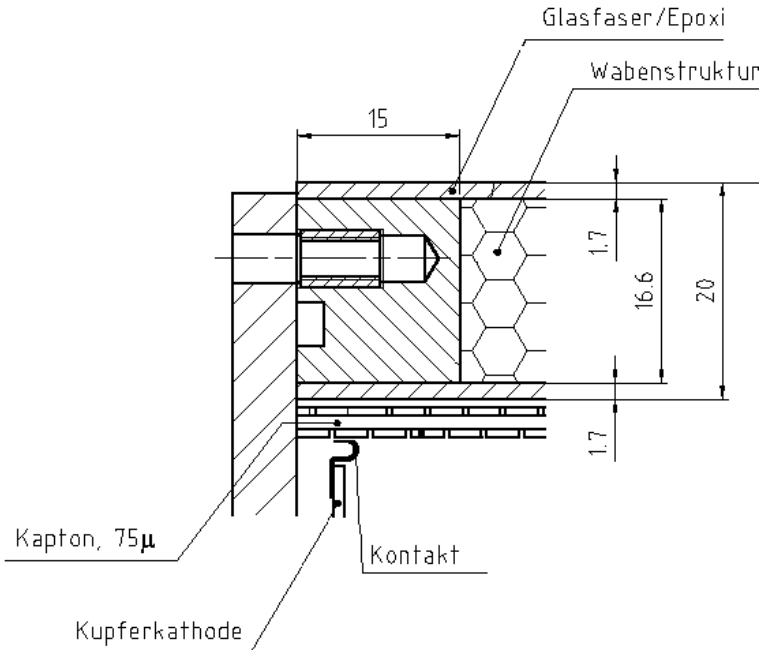
BALLOON-BORNE EXPERIMENT WITH A SUPERCONDUCTION MAGNET SPECTROMETER, Akira Yamamoto, KEK, 01.12.94

Preliminary field cage construction plans



Status field cage mechanics

- Ongoing negotiations with industry concerning construction of the field cage
  - ↪ First acceptable cost offer
  - ↪ Construction details are under discussion (materials, accuracy, ...)

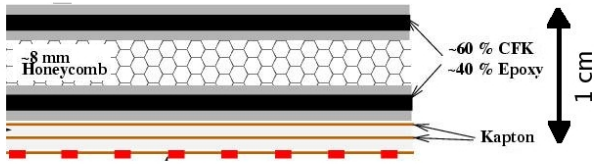


To be optimized:

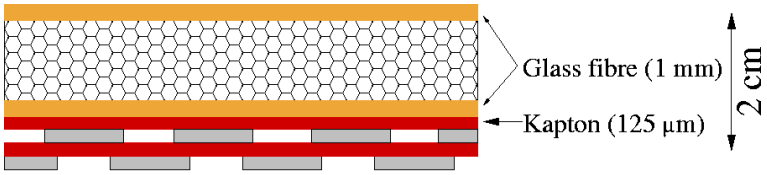
- Thickness of different layers of the wall
  - ↪ Mechanical calculations on the way
- Materials of anode/cathode inlays (G10 at cathode, Aluminum at anode)
- Cathode and anode interfaces have to be defined

- Final design until middle of January 07

Status electrostatic layout



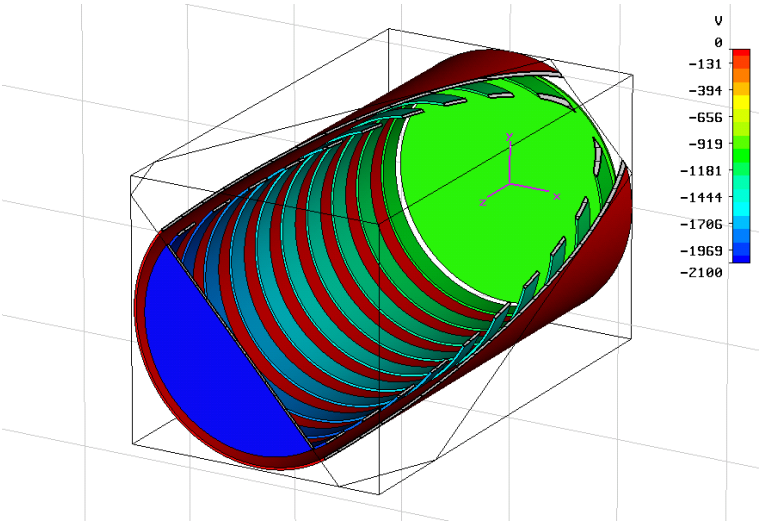
Medi – TPC Wall



LP Wall

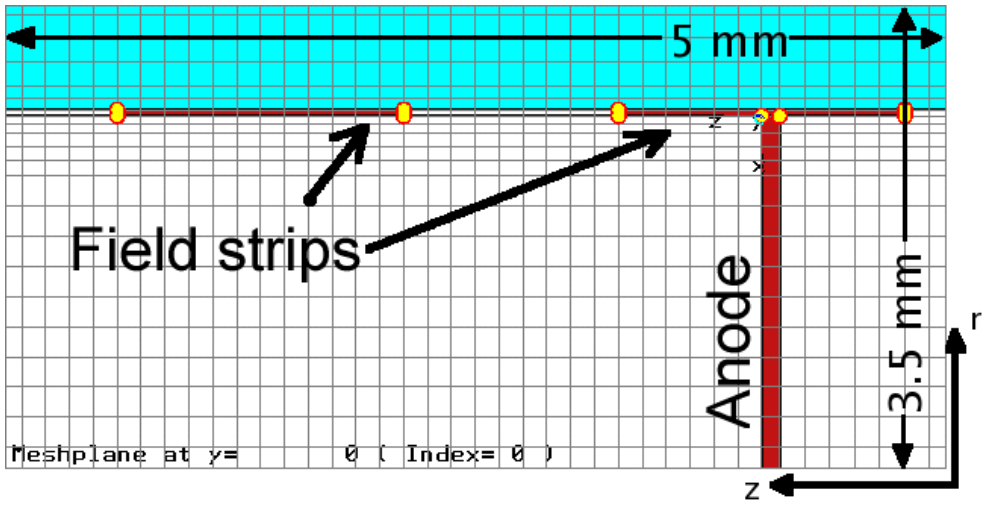
- High voltage:
  - ↪ Drift fields of up to $300\,\mathrm{V/cm} \Rightarrow 21\,\mathrm{kV}$ have to be applied at the cathode
  - ↪ Kapton foil at the inside and glass fibre layers will provide needed dielectric strength
  - ↪ HV stability tests

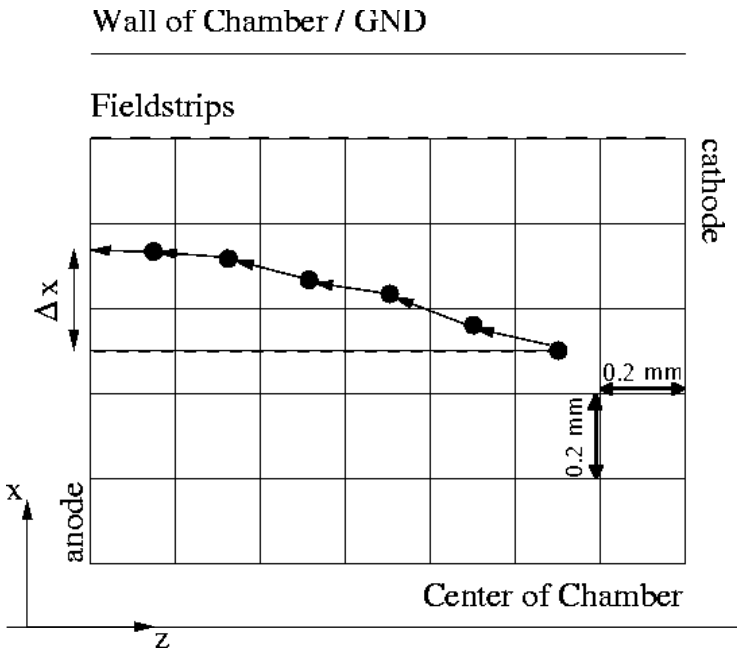
- Drift-field quality:
  - ↪ Electrostatic calculations to find the optimal field strip design
  - ↪ Aim:
    - ⋆ make the intrinsic field deviations as small as possible
    - ⋆ make an estimation of final $\vec{E}$-field quality



Electrostatic field calculations

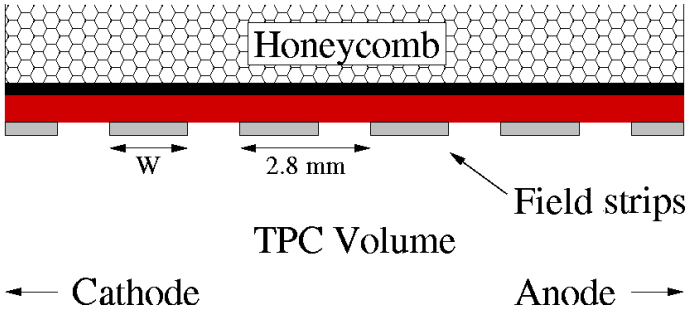
- Model for calculation:
  - ↪ Rotational symmetry
    ⇒ 2-dim model
  - ↪ Size: $40\,\mathrm{cm} \times 60\,\mathrm{cm}$
  - ↪ Fine Mesh: $5 \cdot 10^6$ cells
    10-20 along strip



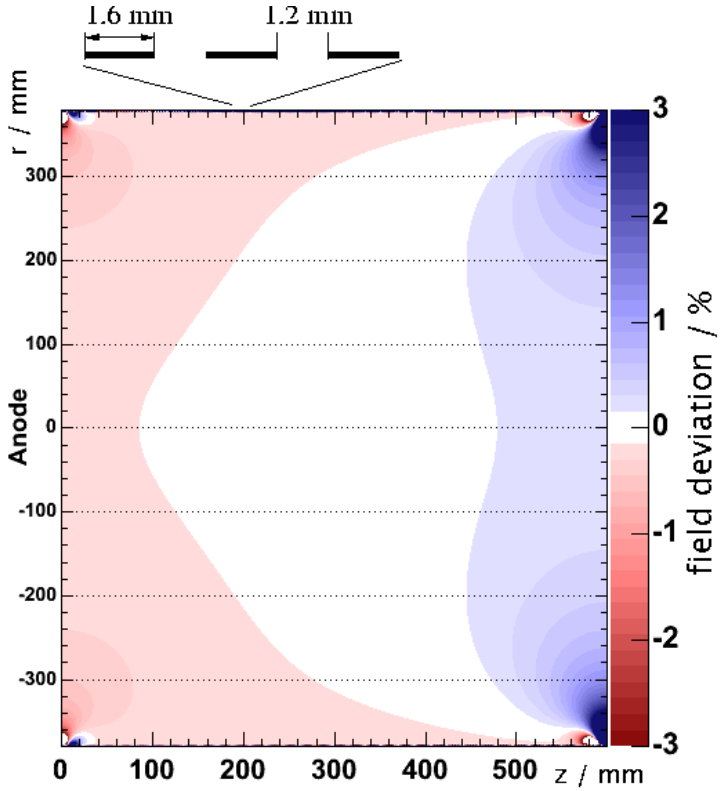


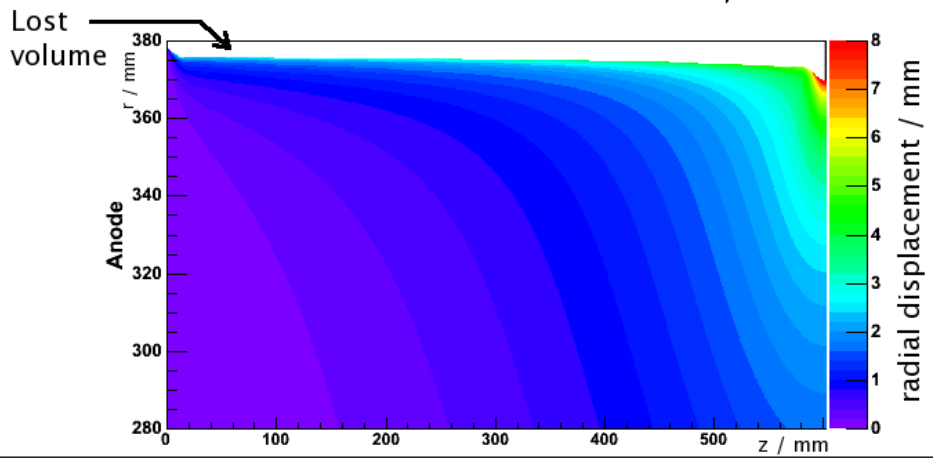
- To estimate the systematics of different strip geometries, electron drift is simulated
  - ↪ Radial displacement
  - ↪ Loss of sensitive volume at the corners

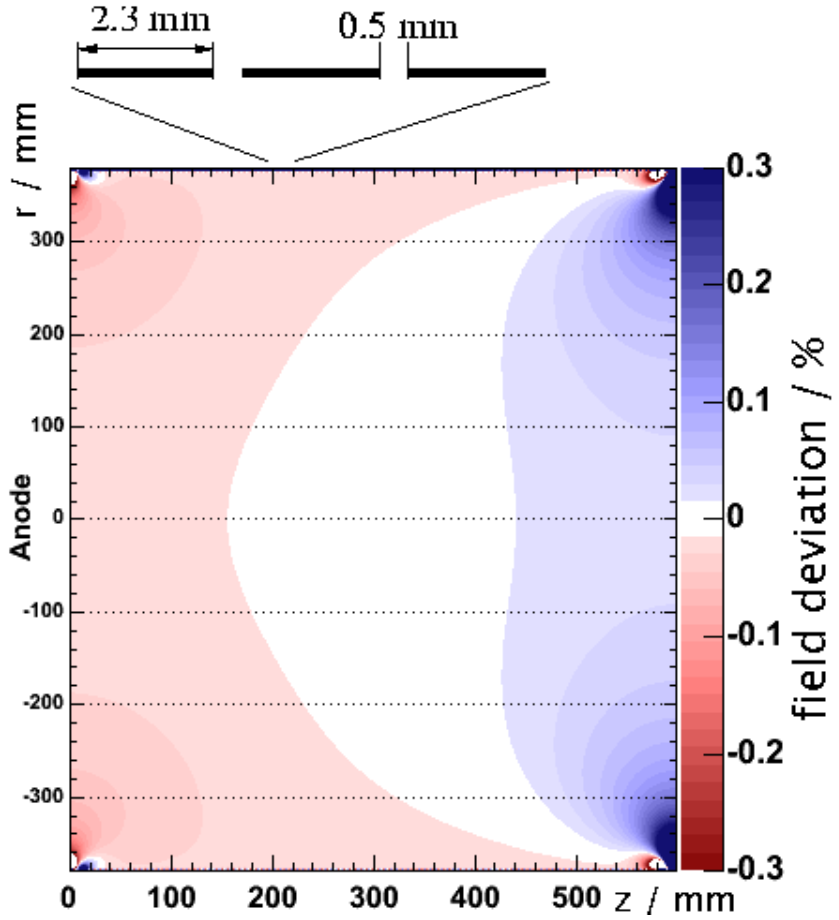
One-sided field strips

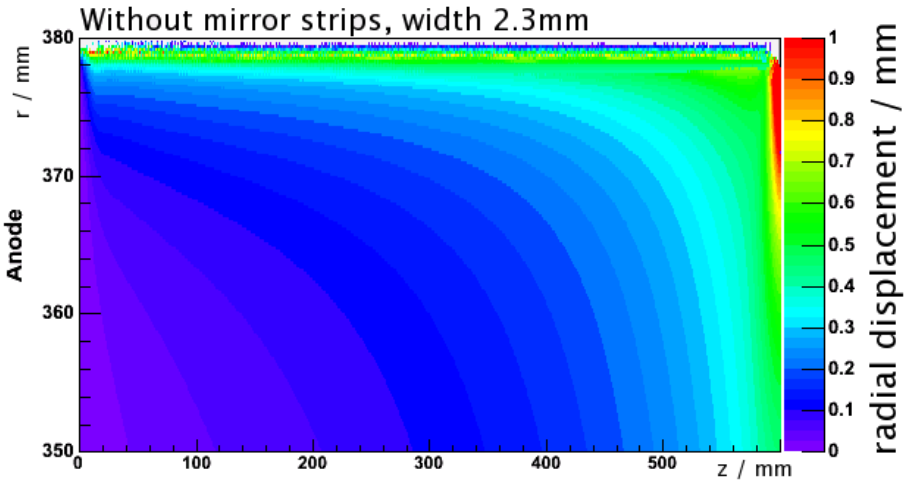


- Design used in Medi-TPC
- $\vec{E}$-field deviations: $\approx 3\,\%$
- Increasing the width of the strips improves field quality



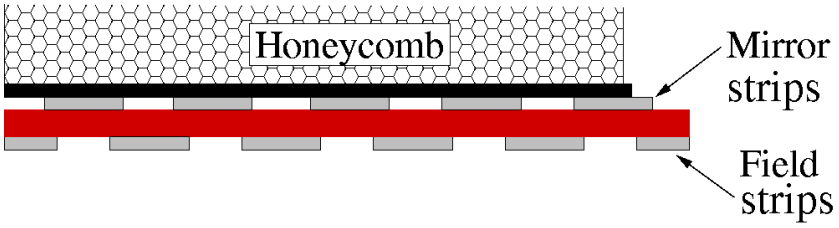




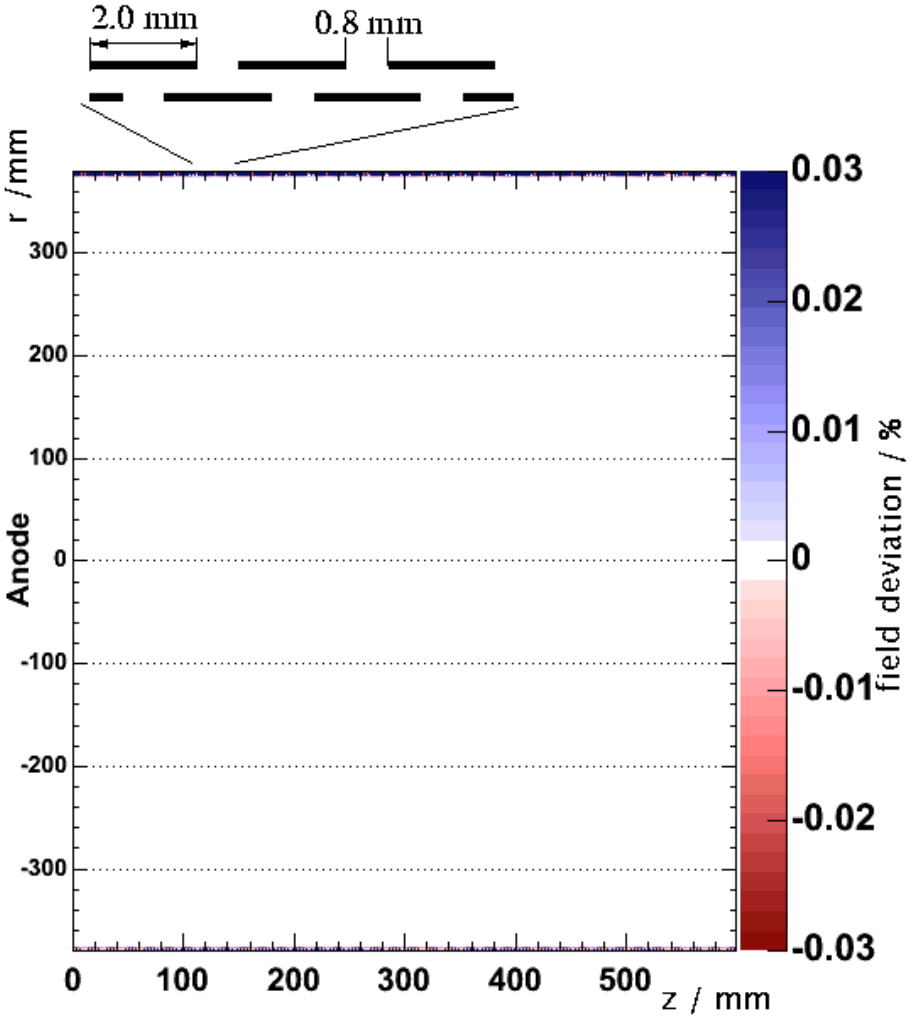


- $2.3\,\mathrm{mm}$ wide strips with $0.5\,\mathrm{mm}$ gaps (smallest possible gap size)
- Deviations: $\approx 0.3\,\%$
- Radial displacement up to $1\,\mathrm{mm}$ in the drift volume
- Field quality not sufficient

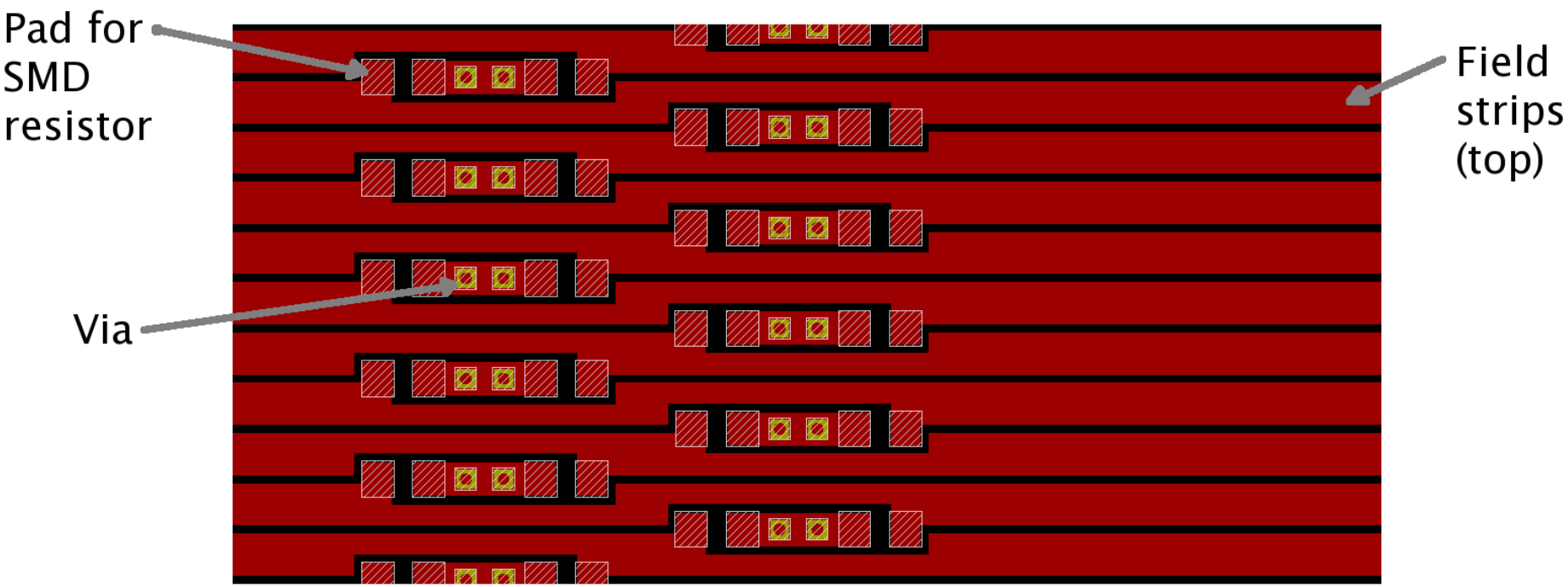
Optimized design with mirror strips



- Mirror strips are placed behind the field strips
- Each mirror strip has the intermediate potential of two strips in front
- Result: No $\vec{E}$-field deviations
- Foil will have a thickness of $75 - 100\,\mu\mathrm{m}$

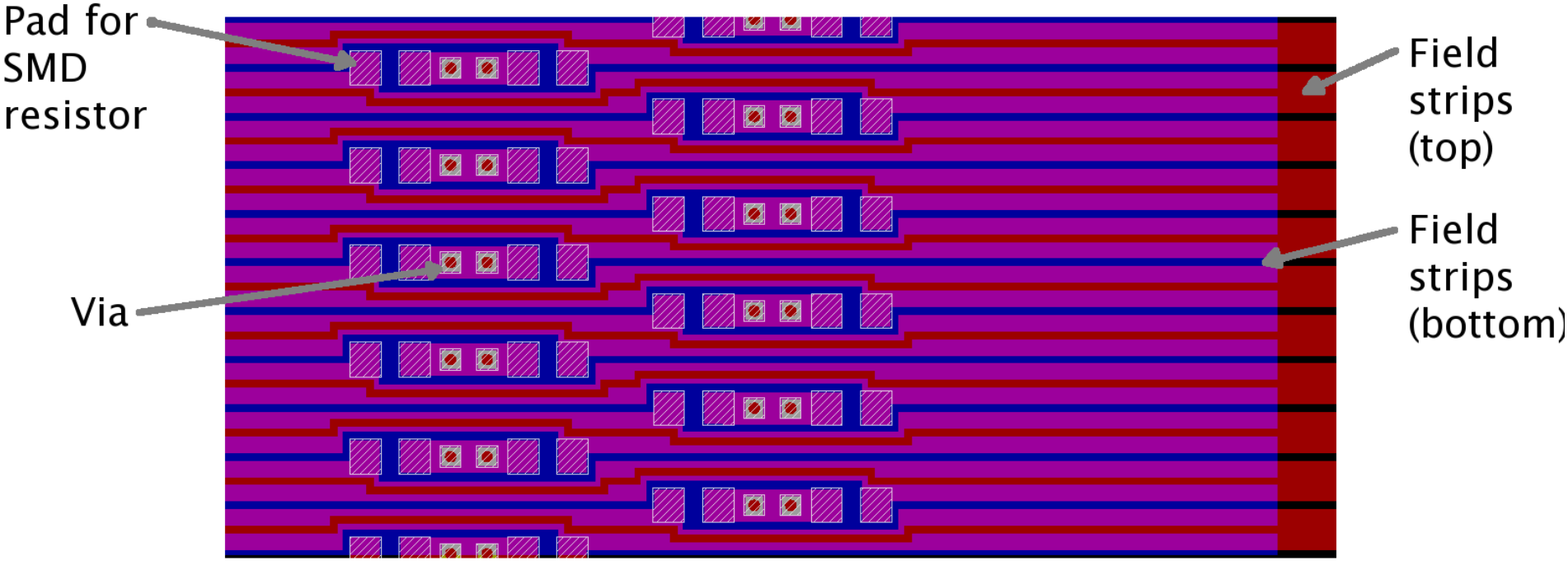


Layout of the field strips



- $2.4\,\mathrm{m} \times 0.6\,\mathrm{m}$ flexible circuit board with field strips needed
- SMD-Resistor chain to devide the potential inside the chamber connections through the foil by vias
- Negotiations with industry are ongoing $\rightarrow$ test foils are ordered

Layout of the field strips



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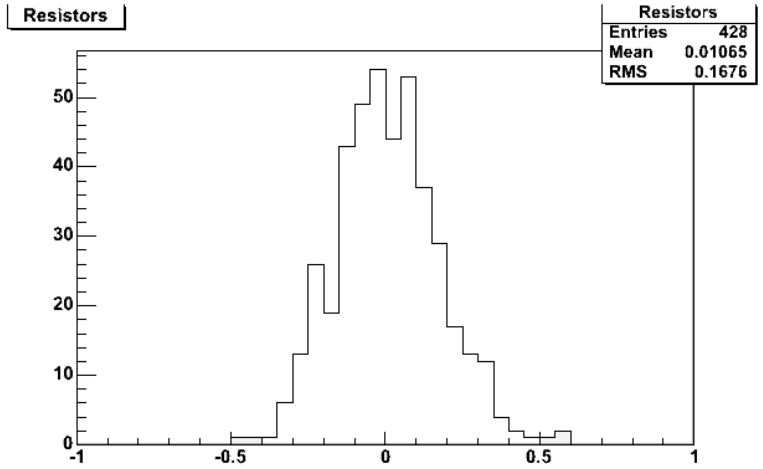
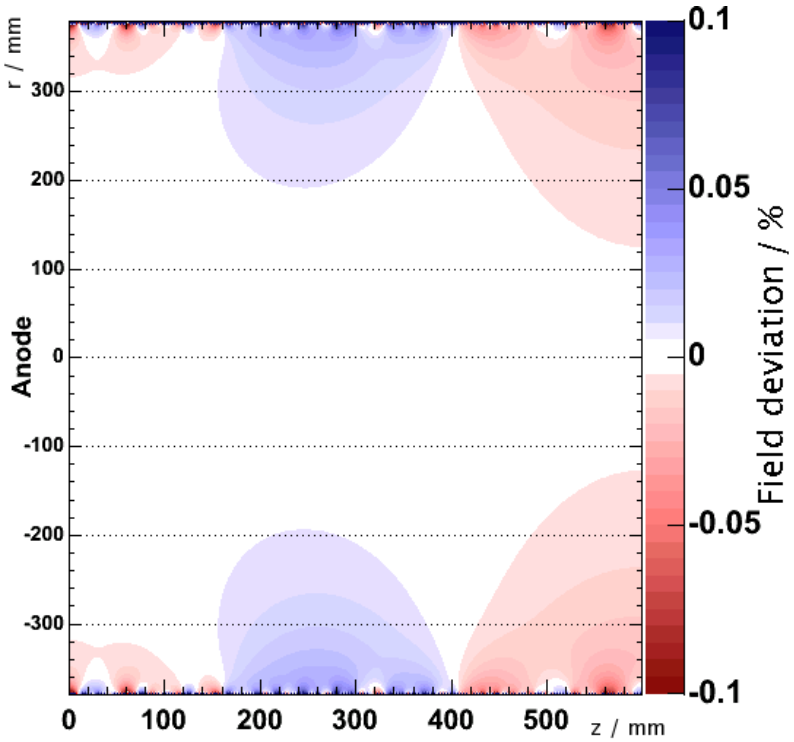
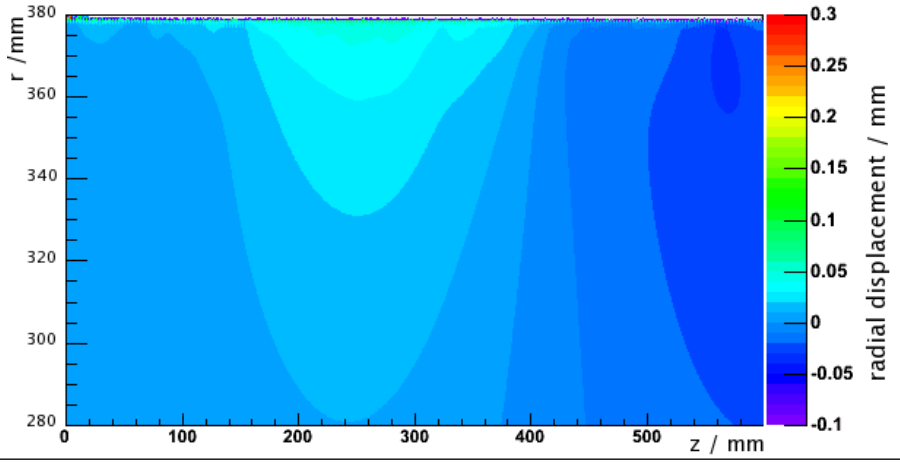
Non-perfect resistors





- SMD-Resistors between neighbouring strips will have MΩ resitivity
- Tolerance in resitivity: $\pm 0.5\,\%$
- Modified potentials on the field strips calculated for randomly generated resistivities
- Deviations of order $\pm 0.1\,\%$



Outlook

- Final design of field cage in January 07, construction until June 07
- Field cage available at DESY in August 2007 seems feasible
- Mechanics:
  - ↪ Construction of field cage in collaboration with industry
  - ↪ Lightweight barrel made of composite materials
  - ↪ Readout surface up to $0.44\,\mathrm{m}^2$ at $60\,\mathrm{cm}$ drift length
- Electrostatics:
  - ↪ Field strips and mirror strips with $2.8\,\mathrm{mm}$ pitch ($2.3\,\mathrm{mm}$ strips, $0.5\,\mathrm{mm}$ gaps)
  - ↪ Two parallel SMD-resistor chains inside the chamber
  - ↪ $\vec{E}$-field inhomogeneities $\leq 1\,\%$ within few cm distance to the walls
  - ↪ Drift fields up to $300\,\mathrm{V/cm}$ in the chamber