

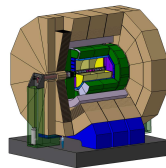
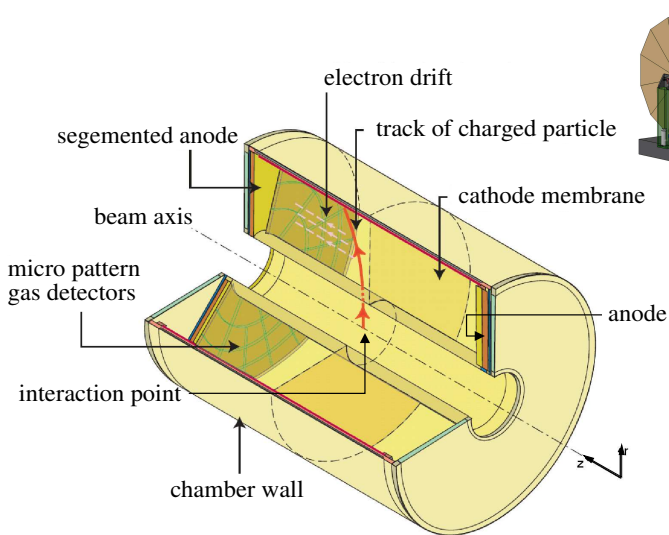
# Field cage (and HV) system

Peter Schade

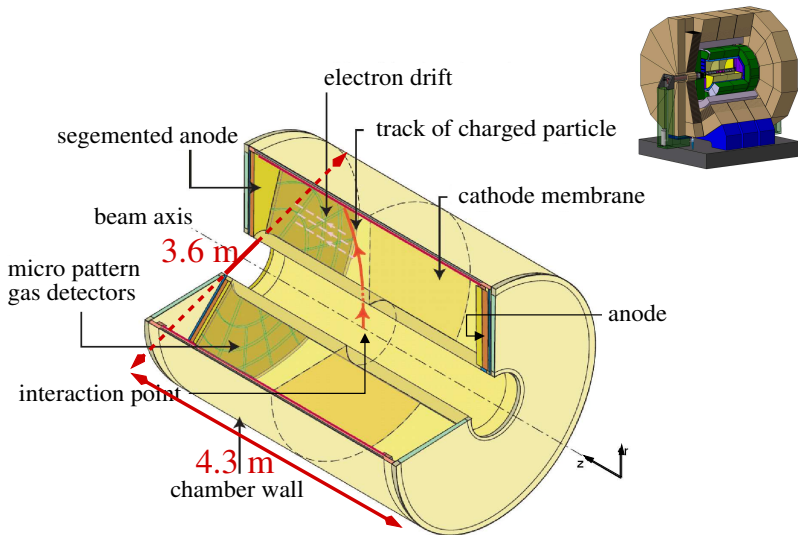
DESY Hamburg

22th September 2009

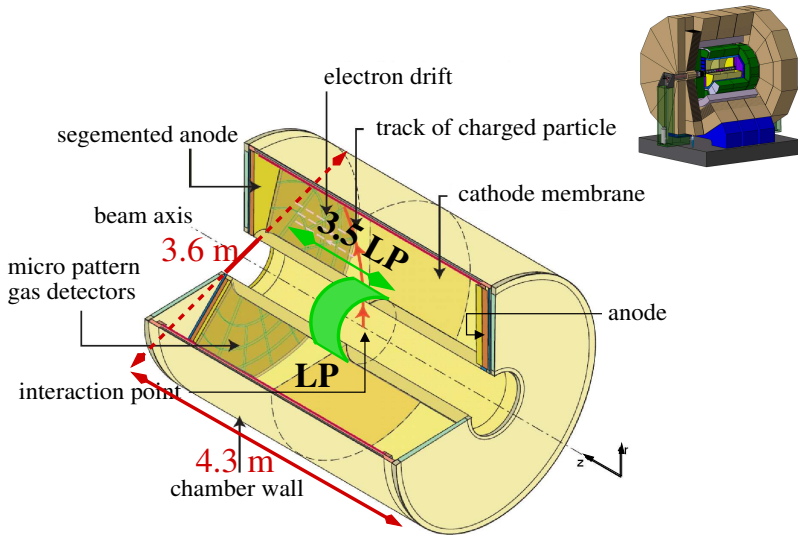
# A TPC for the ILD



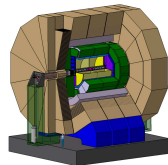
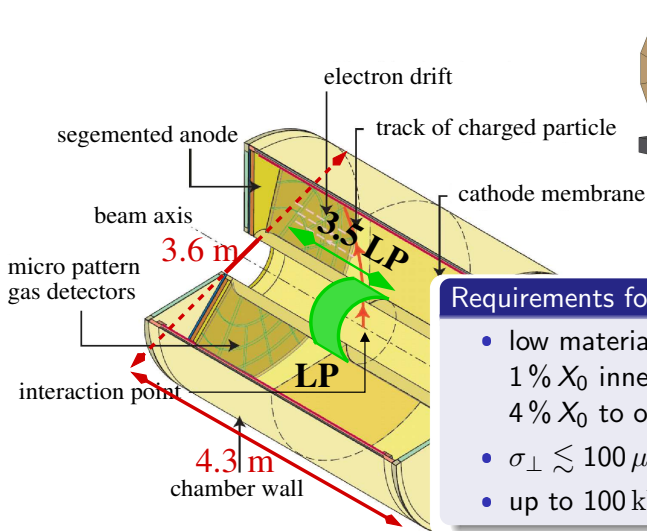
# A TPC for the ILD



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# A TPC for the ILD



## Requirements for the ILD

- low material budget  
1%  $X_0$  inner wall  
4%  $X_0$  to outer wall
- $\sigma_{\perp} \lesssim 100 \mu\text{m}$
- up to 100 kV at cathode

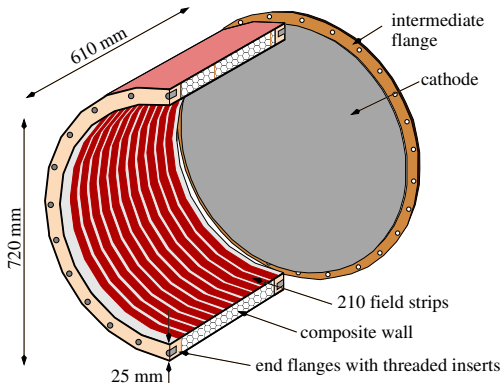
# Development and Construction of the LP

## Requirements

- fit into PCMAG
- material budget: about 1%  $X_0$  per wall
- field homogeneity  $\Delta E/E \lesssim 10^{-4}$

## Development

- electrostatic calculations:
  - optimised field strips
  - mechanical accuracies
- test on sample pieces to optimise the wall

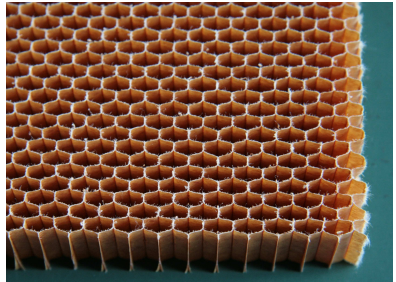


→ LP is a prototype for the inner ILD TPC field cage

# Mechanical Structure of the Field Cage

## Composite wall

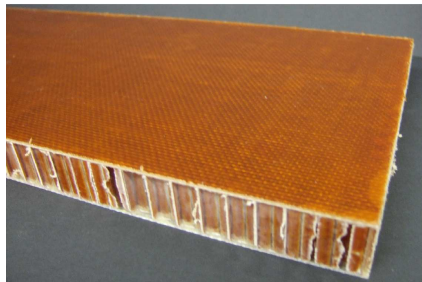
- aramid honeycomb material sandwiched between GRP
- low  $X_0 \leftrightarrow$  thin GRP
  - bending tests
  - high voltage test (30 kV)
- estimated 1.2 %  $X_0$



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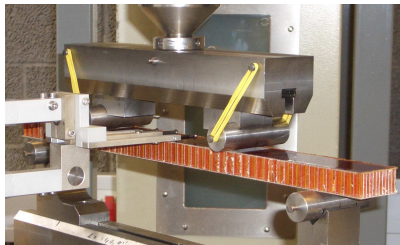




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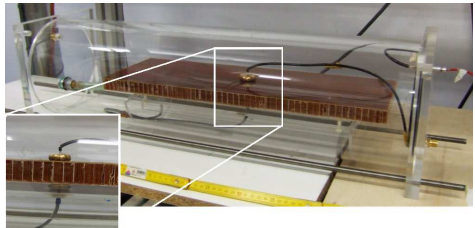
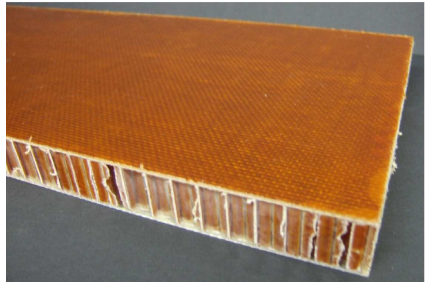
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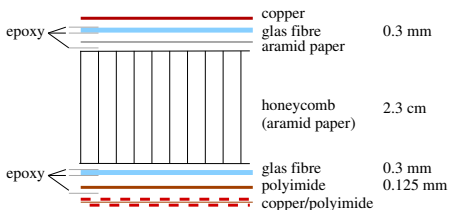
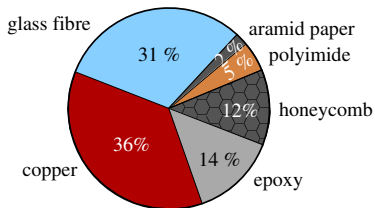
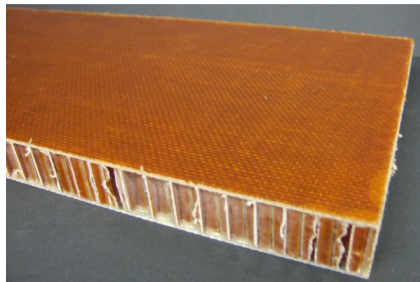
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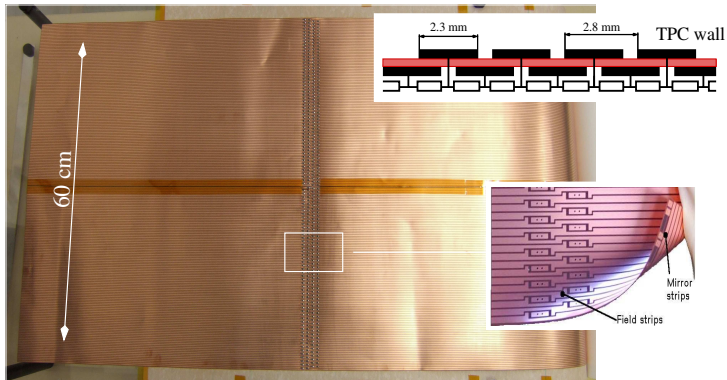
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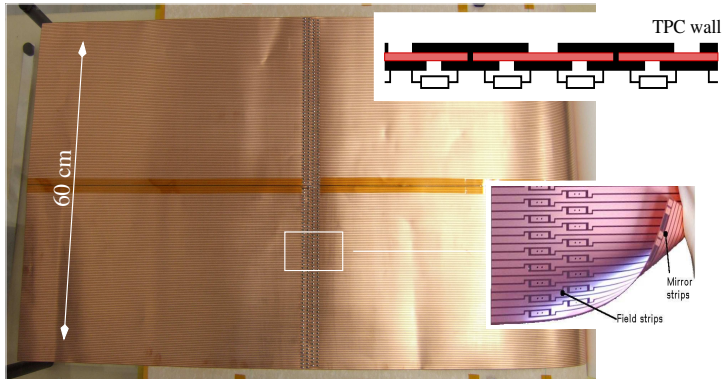
# Realisation of the Field Strips



## Field strip board

- flexible printed circuit board with 210 field and mirror strips
- resistors:  $1 \text{ M}\Omega \pm 100 \Omega \rightarrow \Delta R/R \approx 10^{-4}$

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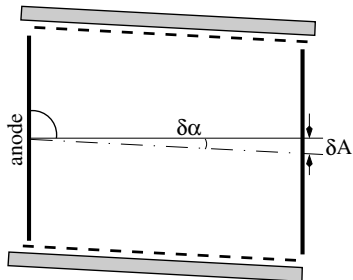
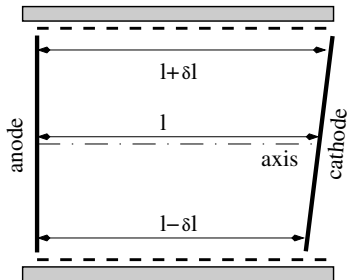
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# Mechanical Accuracy

Imperfect geometry of the field cage  $\rightarrow$  field distortions

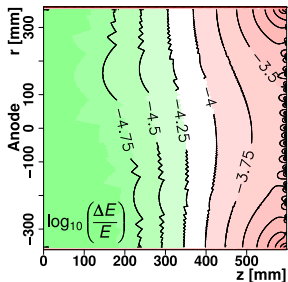
- anode - cathode alignment:  $\delta l \lesssim 100 \mu\text{m}$   
axis alignment:  $\delta A \lesssim 100 \mu\text{m}$



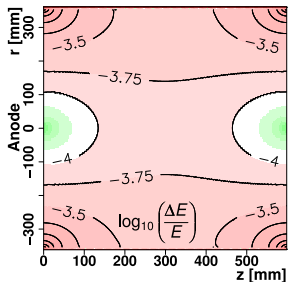
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$\delta l = 100 \mu\text{m}$

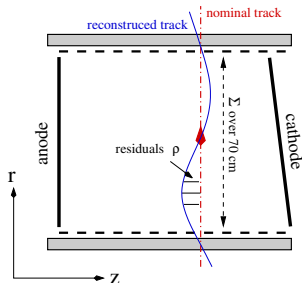
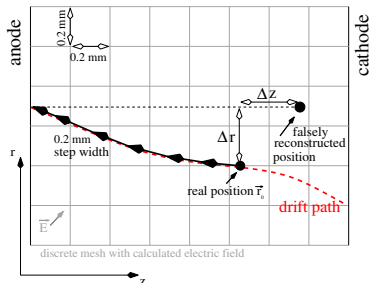


$\delta A = 100 \mu\text{m}$

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- anode - cathode alignment:  $\delta l \lesssim 100 \mu\text{m}$   
axis alignment:  $\delta A \lesssim 100 \mu\text{m}$
- effect of field distortions in 1 T magnet field
- upper estimate  $\Delta\sigma_{\perp} = \sqrt{1/N \sum_1^N \rho_{\perp}^2}$

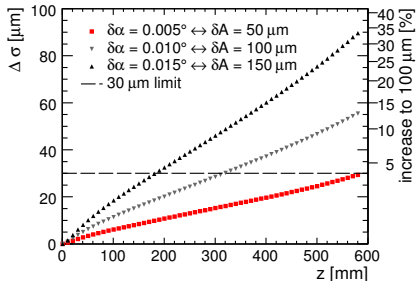
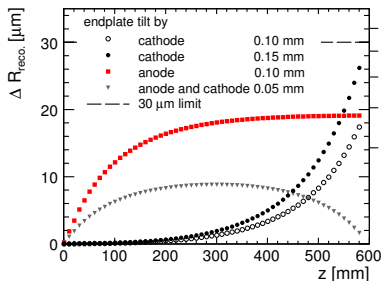




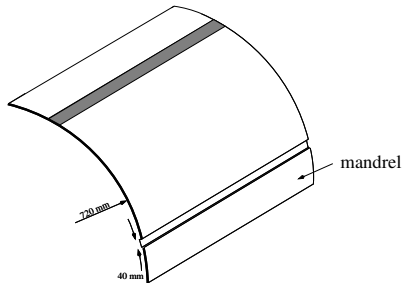
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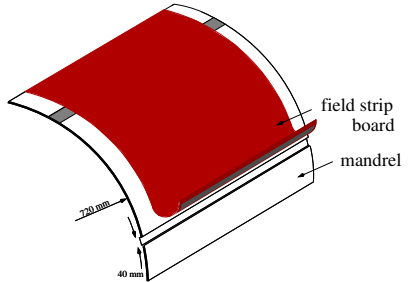
# Construction of the Field Cage



## Construction of the field cage on a forming tool

- in cooperation with a specialised company
- reusable mandrel with a diameter of 72 cm  
→ different layers of the wall laminated onto the mandrel
- extraction of the field cage without damage

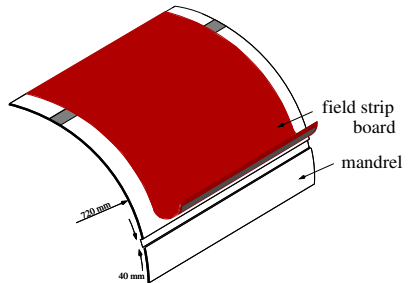
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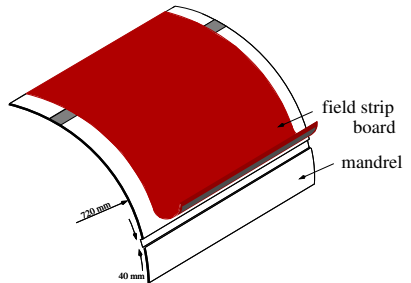
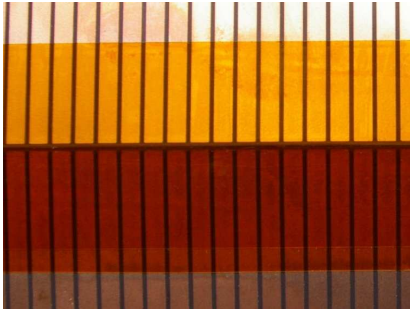
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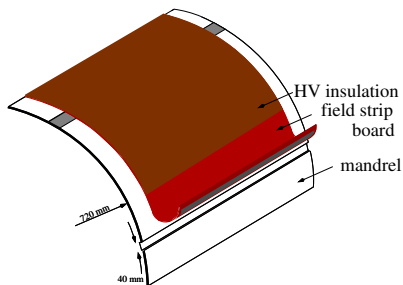
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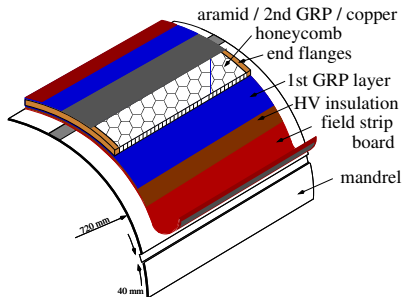
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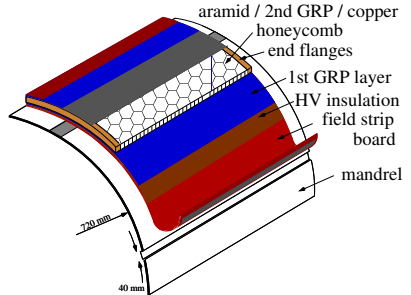
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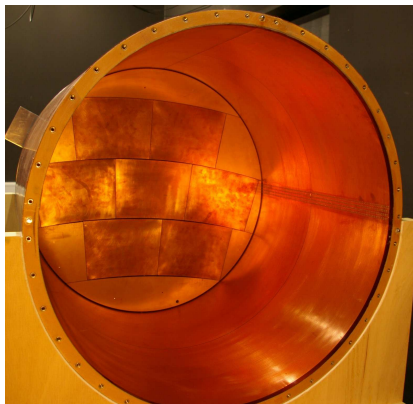


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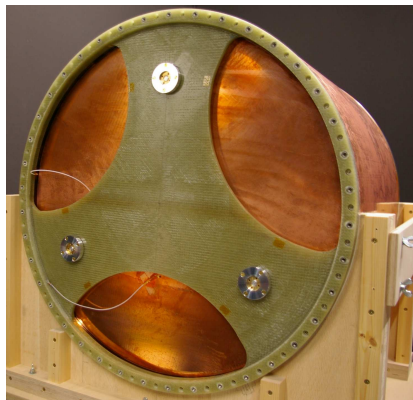
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# The Large TPC Prototype

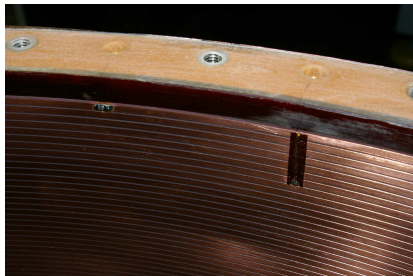


field cage with anode end plate

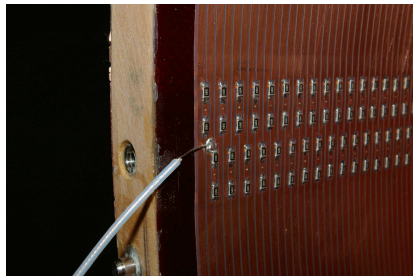


field cage with cathode end plate

# High Voltage Connections

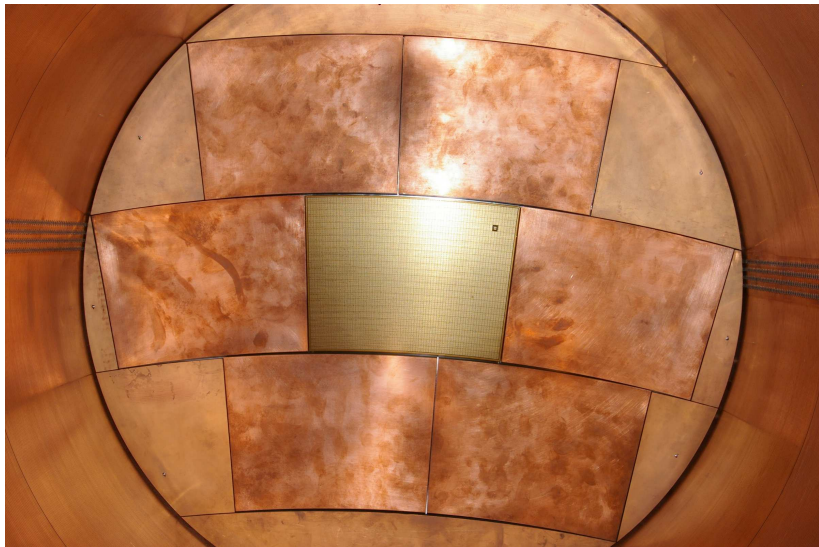


Anode side

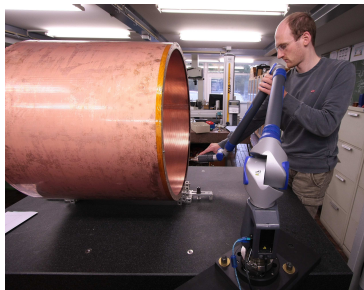
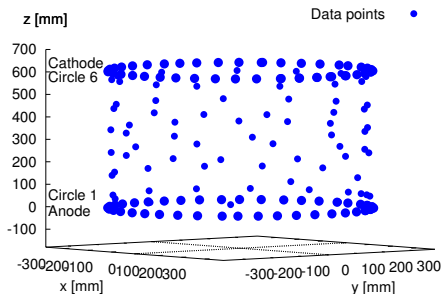


Cathode Side

# MicroMEGAS module



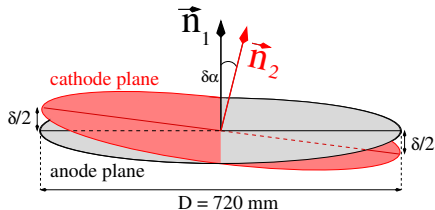
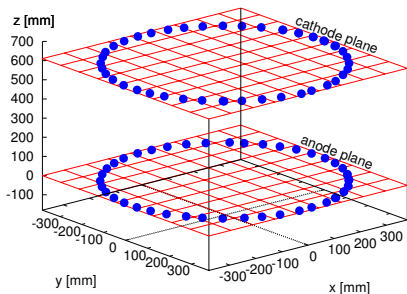
# Quality Assurance Measurements



## Achieved mechanical accuracy

- alignment of the end faces:
- alignment of the field cage axis:
- field quality:

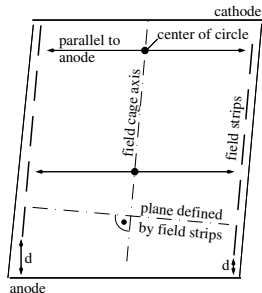
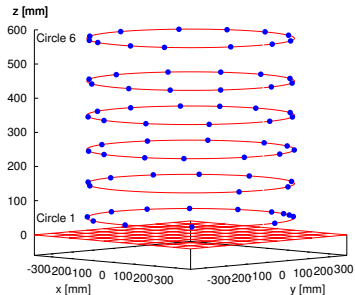
# Quality Assurance Measurements



## Achieved mechanical accuracy

- alignment of the end faces:  $\delta < 40 \mu\text{m}$
- alignment of the field cage axis:
- field quality:

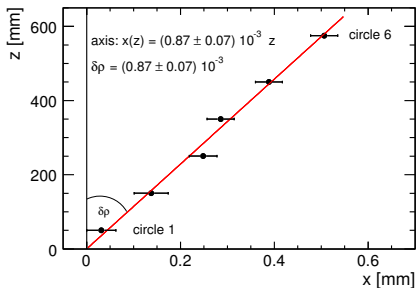
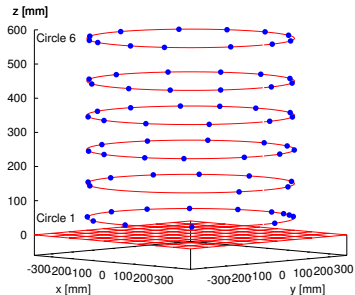
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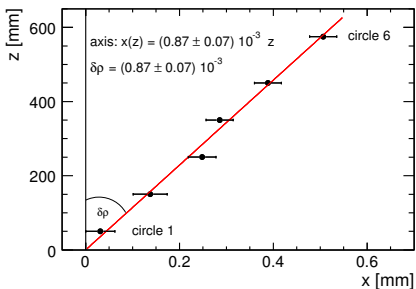
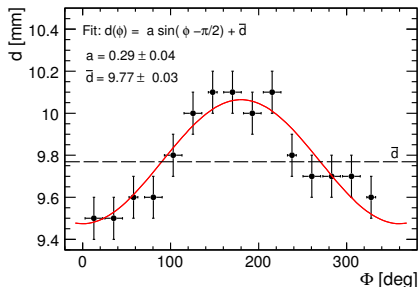
# Quality Assurance Measurements



## Achieved mechanical accuracy

- alignment of the end faces:  $\delta < 40 \mu\text{m}$
- alignment of the field cage axis: offset at cathode  $\sim 500 \mu\text{m}$
- field quality:

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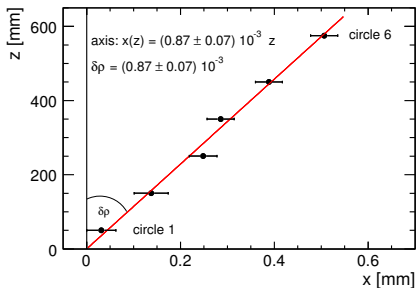
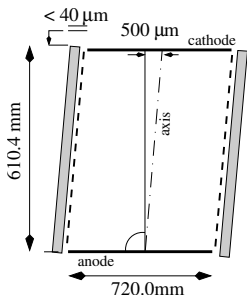


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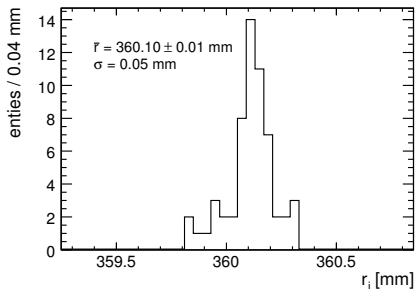
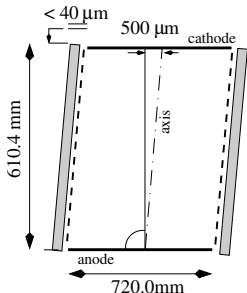
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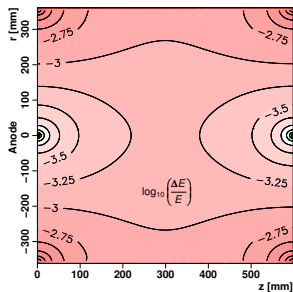
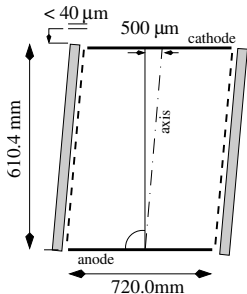
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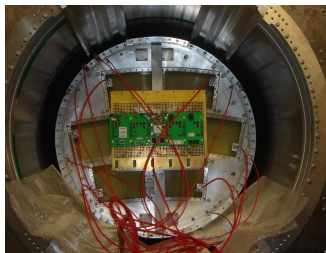
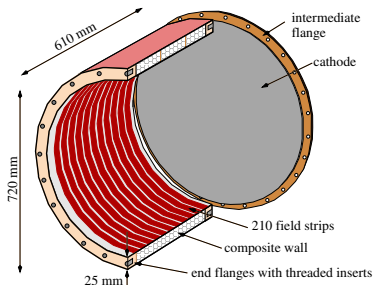
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- alignment of the field cage axis: offset at cathode  $\sim 500 \mu\text{m}$
- field quality:  $10^{-4} \lesssim \Delta E/E \lesssim 10^{-3} \rightarrow$  fails requirement

# Summary Large TPC Prototype

## Construction

- LP as infrastructure for ongoing studies → diameter 72 cm
- lightweight field cage  
→ structure 1.2%  $X_0$  per wall
- production in cooperation with industry (Haindl)  
→ field cage does not meet accuracy requirements
- discussion with Haindl company started → at the moment 'lack of enthusiasm'
- 2<sup>nd</sup>, improved field cage ??
- mandrel is in principle available



# Outlook: LP $\rightarrow$ ILD TPC

## Inner field cage

- LP times 3.5 in length (plus combination of two halves)
- wall structure: (LP  $\rightarrow$  ILD TPC)
  - $\rightarrow$  30 kV  $\rightarrow$  100 kV HV stability
  - $\rightarrow$  1.2 %  $X_0$   $\rightarrow$  1.0 %  $X_0$  material budgeted
- production of a 2.15 m long field cage on a mandrel?

## Outer field cage

- radius: 5 times LP radius  $\rightarrow$  production?
- wall structure less critical than inner field cage (2.0 %  $X_0$ )

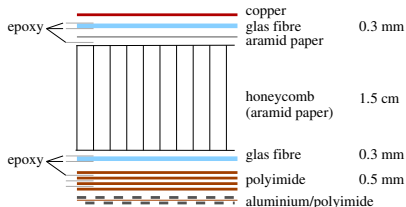
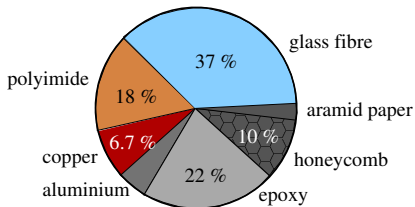
## Mechanical Accuracy

- length / B is the same for ILD TPC and LP estimation
  - $\rightarrow$  mechanical accuracy:  $\Delta l, \Delta A \lesssim 350 \mu\text{m}$

# Inner ILD TPC field cage wall

## Composite wall

- structure similar to LP
  - copper strips to be replaced by aluminium strips
  - HV insulation four times thicker
- stick to 300  $\mu\text{m}$  thick GRP → same as ALICE TPC
- estimated 1.06 %  $X_0$ 
  - include in FEM calculations
  - alternative materials to be discussed



# Conclusions

- LP is first prototype with a size which is relevant for the ILD TPC
- cooperation with industry and specialised institutes (Uni Harburg)
- first LP is available for operational studies
- refined field cage could be built → demonstrate that the mechanical accuracy goals can be met
- production infrastructure (mandrel) will be available for further studies