LCTPC Collaboration Meeting – DESY

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# First mechanical FEM studies on the advanced ILD-TPC

# outline

1) Introduction
2) Proceeding and mechanical parameters
3) Three different „models“
4) Mechanical support of the ILD-TPC
5) Simulations
6) Summary and outlook

# 1 Introduction

The goal is, to gather some information about

- the mechanical stability of the ILD-TPC model
- The stress in the used material
- The strain energy
- The distortion of the fieldcage / endplate

…simulated with FEM

# 2 Proceeding and mechanical parameters

- three different models → progressive enhancements

- Different mechanical support of the ILD-TPC → suspended and supported system

- Different mechanical attachment on the fieldcage or endplate respectively

- Simple design!
    - » use of well known materials only
    - » all calculations base on an isotropic behavior of the used material (honeycomb shows in fact orthotropic behavior!)
    - » no further mass of cables, electronics, gas etc. included

# Parameters of the endplate / fieldcage

*Endplate*

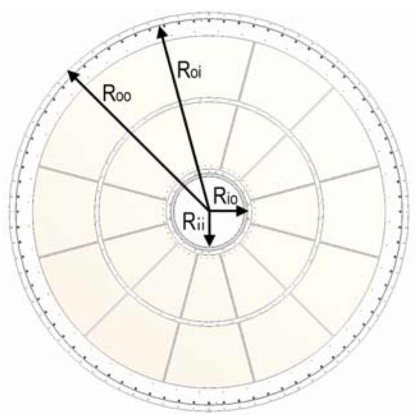
- Material: Epoxy glass fiber (*I-DEAS* Desy data base material)
- Radius
  - $R_{oo}$: 1808 mm
  - $R_{oi}$: 1743 mm
  - $R_{io}$: 395 mm
  - $R_{ii}$: 330 mm
- Thickness: 100 mm

*Fieldcage*

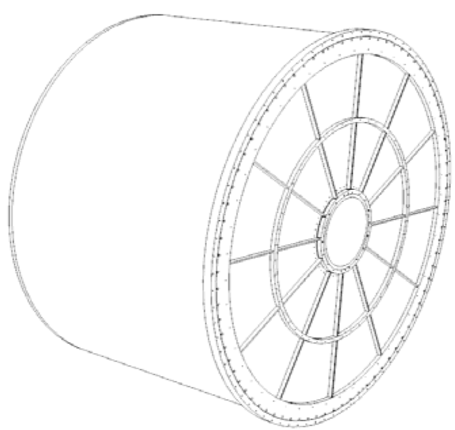
- Material: different ply materials…
  → Creating of a test-laminate for the TPC casing…
- Total length: 4695 mm
- Thickness: up to 44mm (regarding to the model)

ILD-TPC design by Saclay

**Front view**



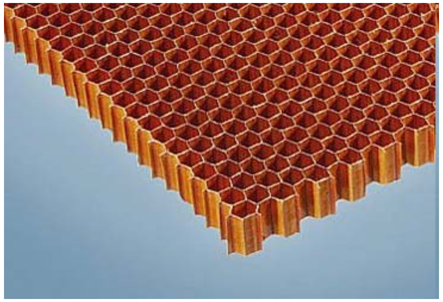

**isometric view**



**side view**

# Parameter of the used material

- The nomex honeycomb used in the current LCTPC is a very complex material (orthotropic behavior and not all mechanical values available yet)

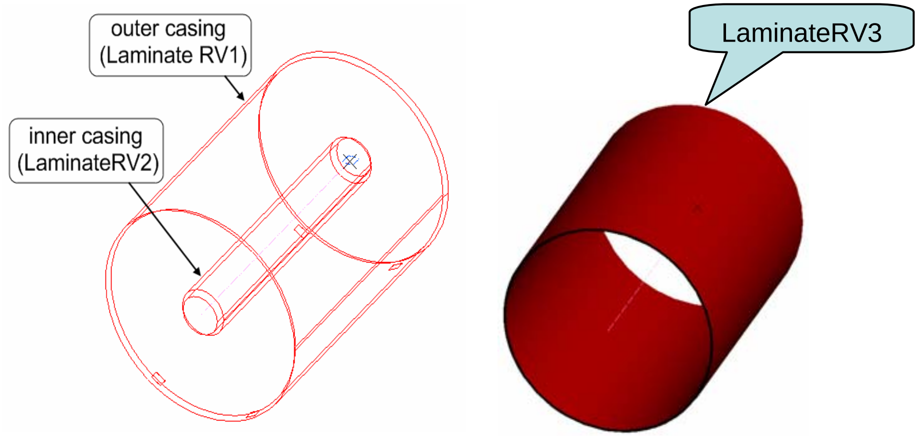


➢ Definition of different ply materials:

LaminateRV1
0.5mm GraphiteSemiconductor
5mm epoxy glass fiber
0.5mm GraphiteSemiconductor

LaminateRV2
2mm epoxy glass fiber
30mm GraphiteSemiconductor
2mm epoxy glass fiber

LaminateRV3
2mm epoxy glass fiber
40mm honeycomb similar structure
2mm epoxy glass fiber



# 3 Three different ILD-TPC models

*1st model*

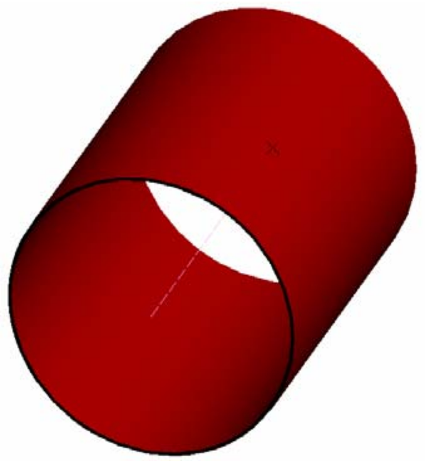
- Simple hollow cylinder without endplates

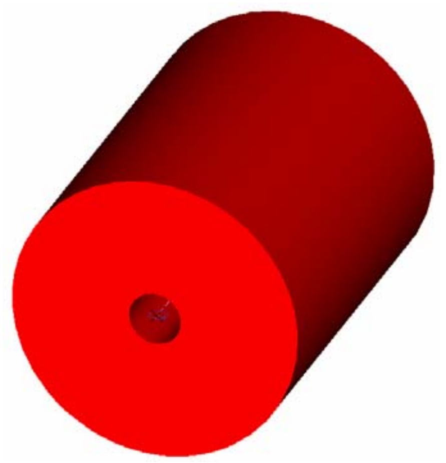
*2nd model*

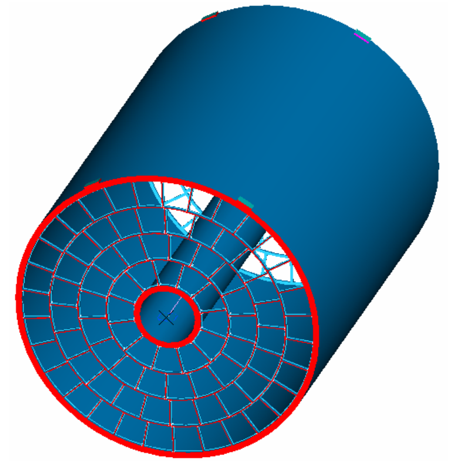
- Inner and outer cylinder with solid endplates

*3rd model*

- Inner and outer cylinder with advanced endplates





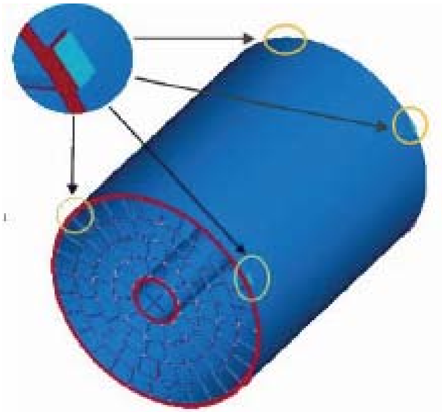


# 4 Mechanical support of the ILD-TPC

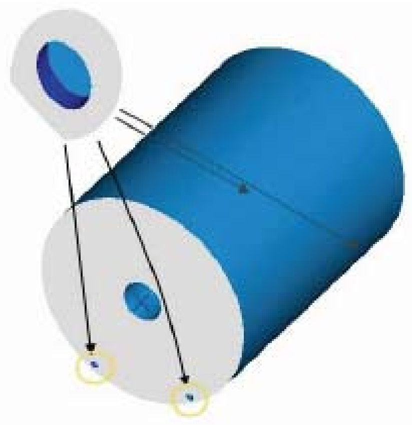
- Either a <u>supported</u> or a <u>suspended</u> system attached on the endplates or at the fieldcage

- No well-thought-out solution yet of the attachment to the TPC, so …

➢ Simulation of a “virtual” attachment to the endplates or the fieldcage



a „virtual“ suspended attachment on the fieldcage



a „virtual“ supported attachment on the endplates

# 5 Simulations

- 1st model: suspended (“hanging”) fieldcage

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- 2nd model:
  1) suspended
     i) on the fieldcage
     ii) on the endplate
  2) supported on the endplates

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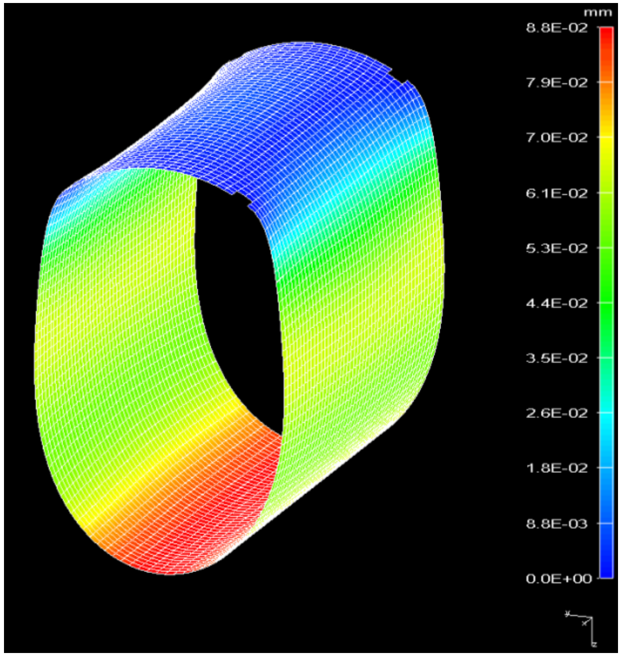
- 3rd model:
  1) suspended
     i) on the fieldcage
     ii) on the endplates
  2) supported
     i) on the fieldcage
     ii) on the endplates

# 1st model




*tensile stress*

Boundary Conditions

bilateral hanging on two rectangular surfaces (150x200)mm on each side of the fieldcage, within 30° of axis each. surfaces constrained in all 6 DOF

gravity in +z

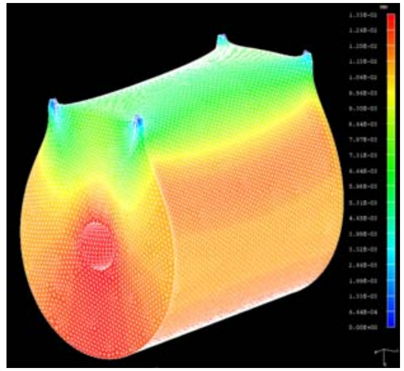
Meshing

| entity | material | mesh type | element length/type |
|---|---|---|---|
| outer casing | LaminatRV3 | thin shell | 100 / rectangle (4 nodes) |

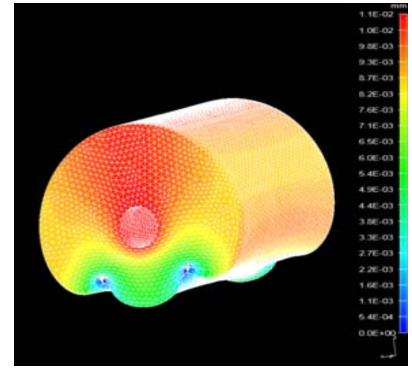
Results Solver

| | |
|---|---|
| max. strain energy | 1.0 N mm |
| max. displacement | 88 µm |

# 2nd model



*tensile stress*



*compressive stress*

## Boundary Conditions

| | tensile stress | compressive stress |
|---|---|---|
| Boundary Conditions | bilateral hanging on two circular surfaces (R=30mm) on the endplates within 30° of axis each. | bilateral supported on two circular surfaces (R=30mm) on the endplates within 30° of axis each |
| | circumference constrained in 6 DOF<br>gravity in +z | circumference constrained in 6 DOF<br>gravity in –z |

## Meshing

| entity | material | mesh type | element length/type |
|---|---|---|---|
| outer casing | LaminatRV1 | thin shell | 50 / triangle std |
| inner casing | LaminatRV2 | thin shell | 50 / triangle std |
| endplates | Epoxy glass fiber | thin shell | 50 / triangle std |

## Results Solver

| | tensile stress | compressive stress |
|---|---|---|
| max. stress (von Mises) | 21.3 N/mm² | 31 N/mm² |
| max. strain energy | 0.56 N mm | 0.57 N mm |
| max. displacement | 13 µm | 11 µm |

# …2nd model

*tensile stress*

Boundary Conditions

bilateral hanging on two rectangular surfaces (150x200)mm on each side of the fieldcage, within 30° of axis each.

surfaces constrained in all 6 DOF
gravity in +z

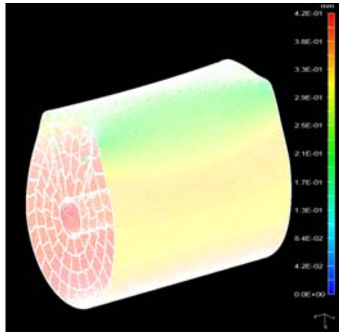
Meshing

| entity | material | mesh type | element length/type |
|---|---|---|---|
| outer casing | LaminatRV1 | thin shell | 50 / triangle std |
| inner casing | LaminatRV2 | thin shell | 50 / triangle std |
| endplates | Epoxy glass fiber | thin shell | 50 / triangle std |

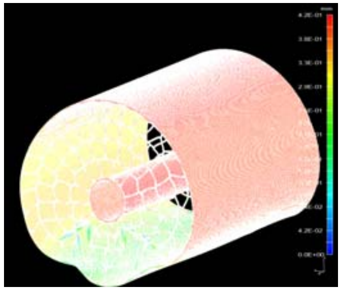
Results Solver

| | |
|---|---|
| max. stress (von Mises) | 2.5 N/mm² |
| max. strain energy | 1.0 N mm |
| max. displacement | 3 µm |

# 3rd model



*tensile stress*



*compressive stress*

| | tensile stress | | compressive stress | |
|---|---|---|---|---|
| Boundary Conditions | bilateral hanging on two circular surfaces (R=30mm) on the endplate within 30° of axis each. | | bilateral supported on two circular surfaces (R=30mm) on the endplate within 30° of axis each | |
| | circumference constrained in 6 DOF<br>gravity in +z | | circumference constrained in 6 DOF<br>gravity in –z | |
| Meshing | **entity** | **material** | **mesh type** | **element length/type** |
| | outer casing | LaminatRV1 | thin shell | 50 / triangle std |
| | inner casing | LaminatRV2 | thin shell | 50 / triangle std |
| | endplates | Epoxy glass fiber | thin shell | 50 / triangle std |

Results Solver

| | tensile stress | compressive stress |
|---|---|---|
| max. stress (von Mises) | 280 N/mm² | 280 N/mm² |
| max. strain energy | 350 N mm | 350 N mm |
| max. displacement | 420 µm | 420 µm |

# …3rd model

| | *tensile stress* | | *compressive stress* | |
|---|---|---|---|---|
| Boundary Conditions | bilateral <u>hanging on</u> two rectangular surfaces (100x200)mm on each side of <u>the fieldcage</u>,<br>within 30° of axis each.<br>surfaces constrained in all 6 DOF<br>gravity in +z | | bilateral <u>supported on</u> two rectangular surfaces (100x200)mm on each side of <u>the fieldcage</u>,<br>within 30° of axis each.<br>surfaces constrained in all 6 DOF<br>gravity in –z | |
| Meshing | **entity** | **material** | **mesh type** | **element length/type** |
| | outer casing | LaminatRV1 | thin shell | 50 / rectangle (8nodes) |
| | inner casing | LaminatRV2 | thin shell | 50 / rectangle (8nodes) |
| | endplates | Epoxy glass fiber | thin shell | 10 and 20 / rectangle (8nodes) |
| Results Solver | | | | |
| max. stress (von Mises) | 770 N/mm² | | 770N/mm² | |
| max. displacement | 300 µm | | 300 µm | |

# 6 summary and outlook

- The FEM-simulations were made as a first rough idea!
  - Results are very preliminary and base onto the specific models though

- first results:
  - max. mechanical distortion of a suspended or supported ILD-TPC < 0.5 mm
  - Max. strain energies 350 N mm
  - Max. stress 770 N/mm²
  - A suspended or supported ILD-TPC system shows similar mechanical stability

- further simulations need more details:
  - Advanced ideas about the supported/suspended ILD-TPC system
  - A bigger *know-how* about composite materials (laminate with nomex honeycomb)
  - New (updated) ILD-TPC model?