Detector Design & Mechanics
Time Projection Chamber

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Outline

- Brief references
- TPC detector design
- TPC detector mechanic

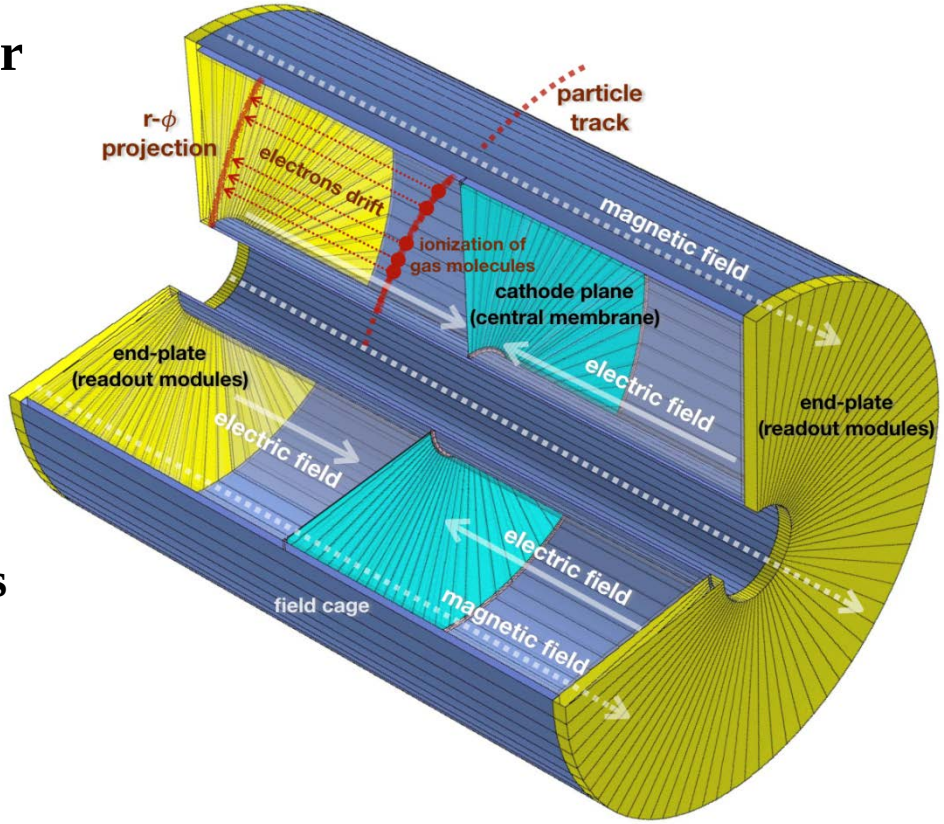
- **Brief references**

TPC detector at CEPC

TPC could directly provides three-dimensional space points; the gaseous detector volume gives a low material budget; and the high density of such space points enables excellent pattern recognition capability.

Why use TPC detector as the tracker detector?

- **Motivated by the H tagging and Z**
- **TPC is the perfect detector for HI collisions …(ALICE TPC…)**
- **Almost the whole volume is active**
- **Minimal radiation length (field cage, gas)**
- **Easy pattern recognition (continuous tracks)**
- **PID information from ionization measurements (dE/dx)**
- **Operating under high magnetic field**
- **MPGD as the readout**

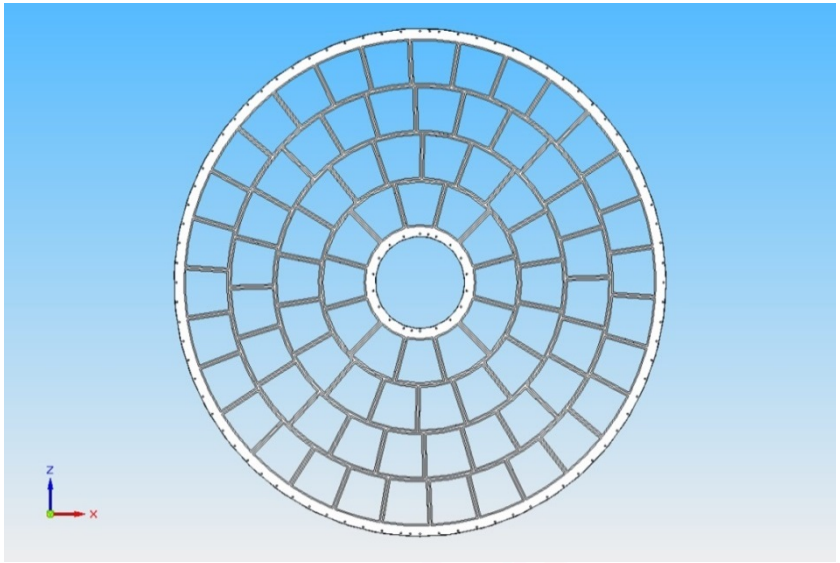


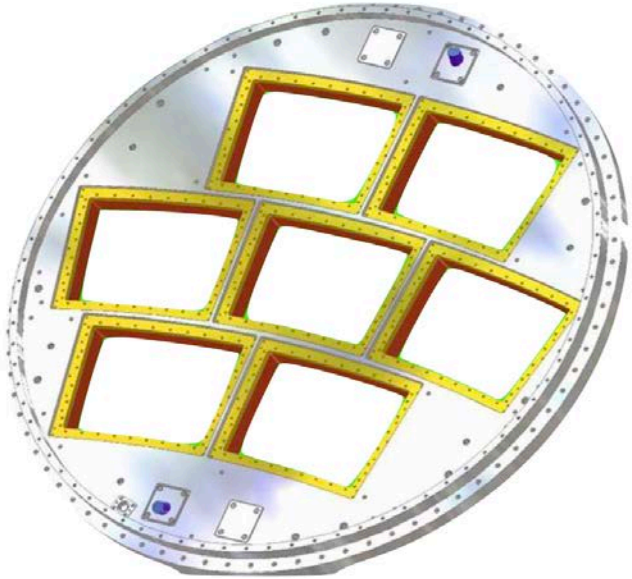
Overview of TPC detector concept

TPC requirements for CEPC

TPC detector concept:

- **Under 3 Tesla magnetic field (Momentum resolution: ~10^{-4}/GeV/c with TPC standalone)**
- **Large number of 3D space points(~220 along the diameter)**
- **dE/dx resolution: <5%**
- **~100 μm position resolution in rφ**
  - **~60μm for zero drift, <100μm overall**
  - **Systematics precision (<20μm internal)**
- **TPC material budget**
  - **<1X_0 including outer field cage**
- **Tracker efficiency: >97% for pT>1GeV**
- **2-hit resolution in rφ : ~2mm**
- **Module design: ~200mm×170mm**
- **Minimizes dead space between the modules: 1-2mm**





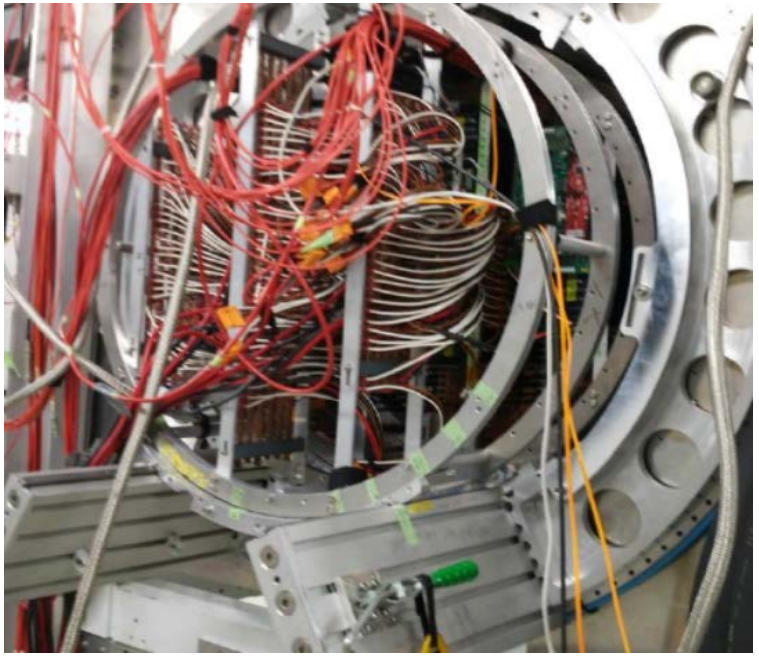
TPC detector endplate concept

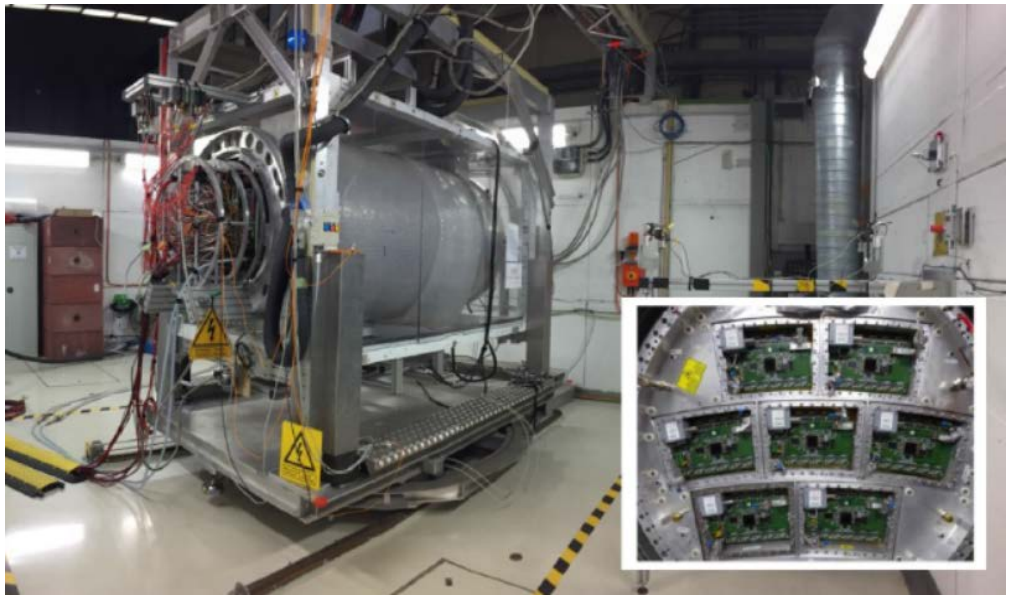
Brief references

ALICE TPC

LCTPC collaboration R&D:

- As the key detector reference
- Phase#0: Small prototype
- Phase#1: Large prototype I
- Phase#2: Large prototype II
- Phase#3: Full size detector
- ……
- Technology collaboration
  - High voltage
  - Low voltage
  - Support layout
  - Gas system
  - Cooling system
  - Electronic system
  - ……

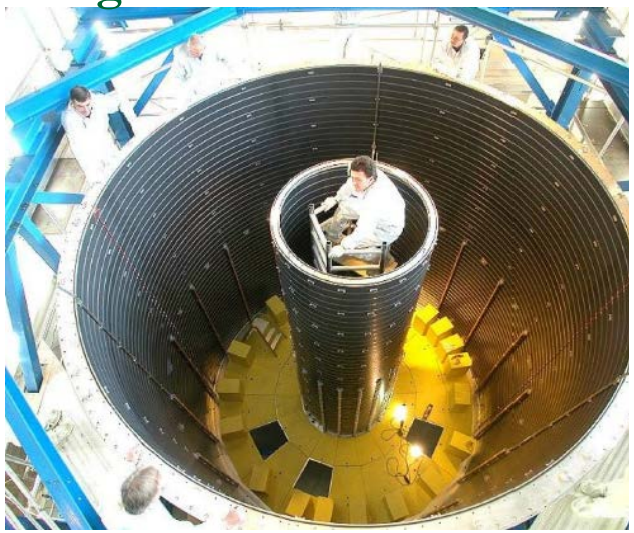


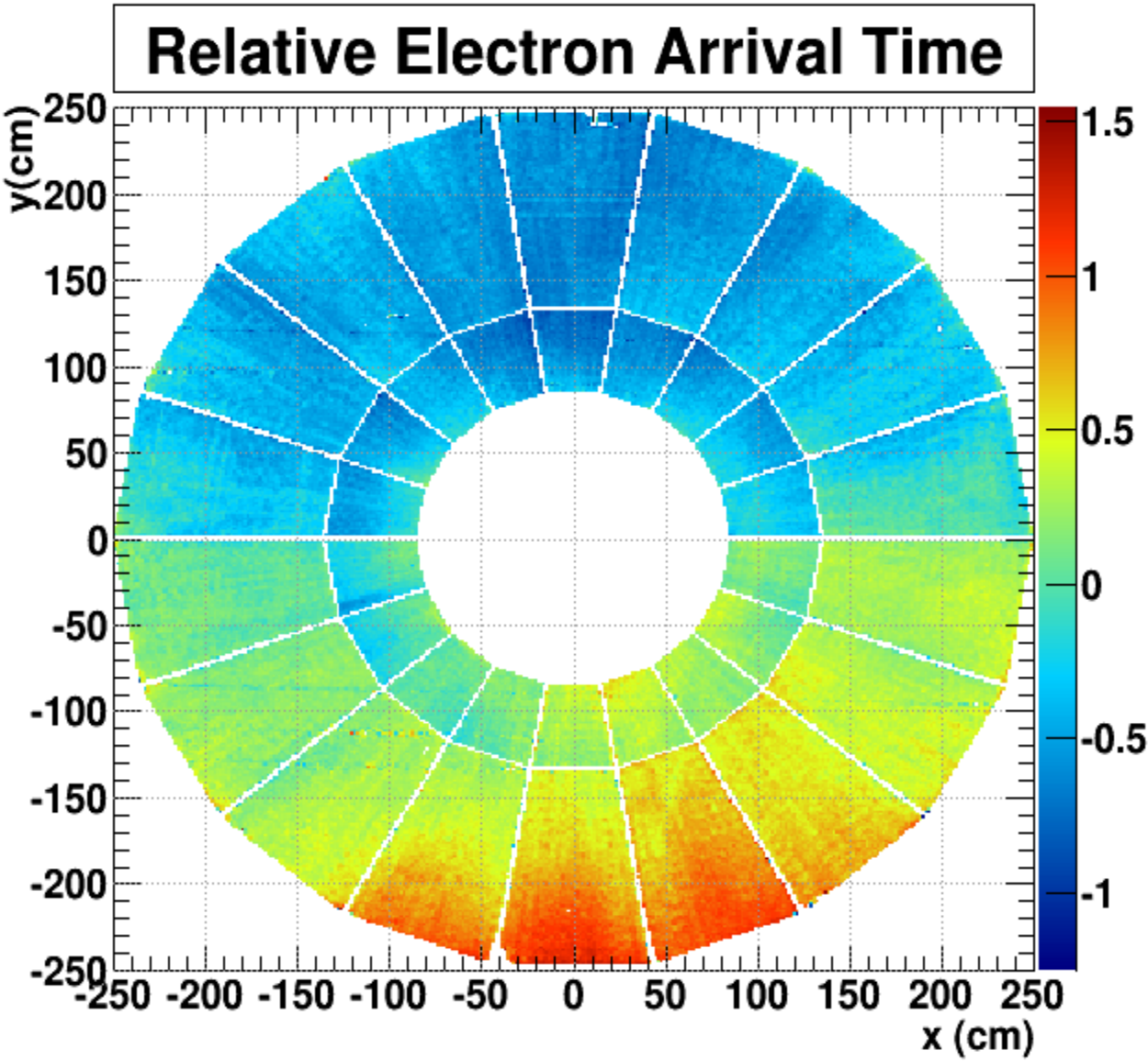


ALICE TPC photos

Gas gravity effect @ALICE TPC

- The drift velocity is measured with precision via the signal produced by stray laser light on the aluminised central electrode
- The drift time gradient due to the pressure gradient is observed

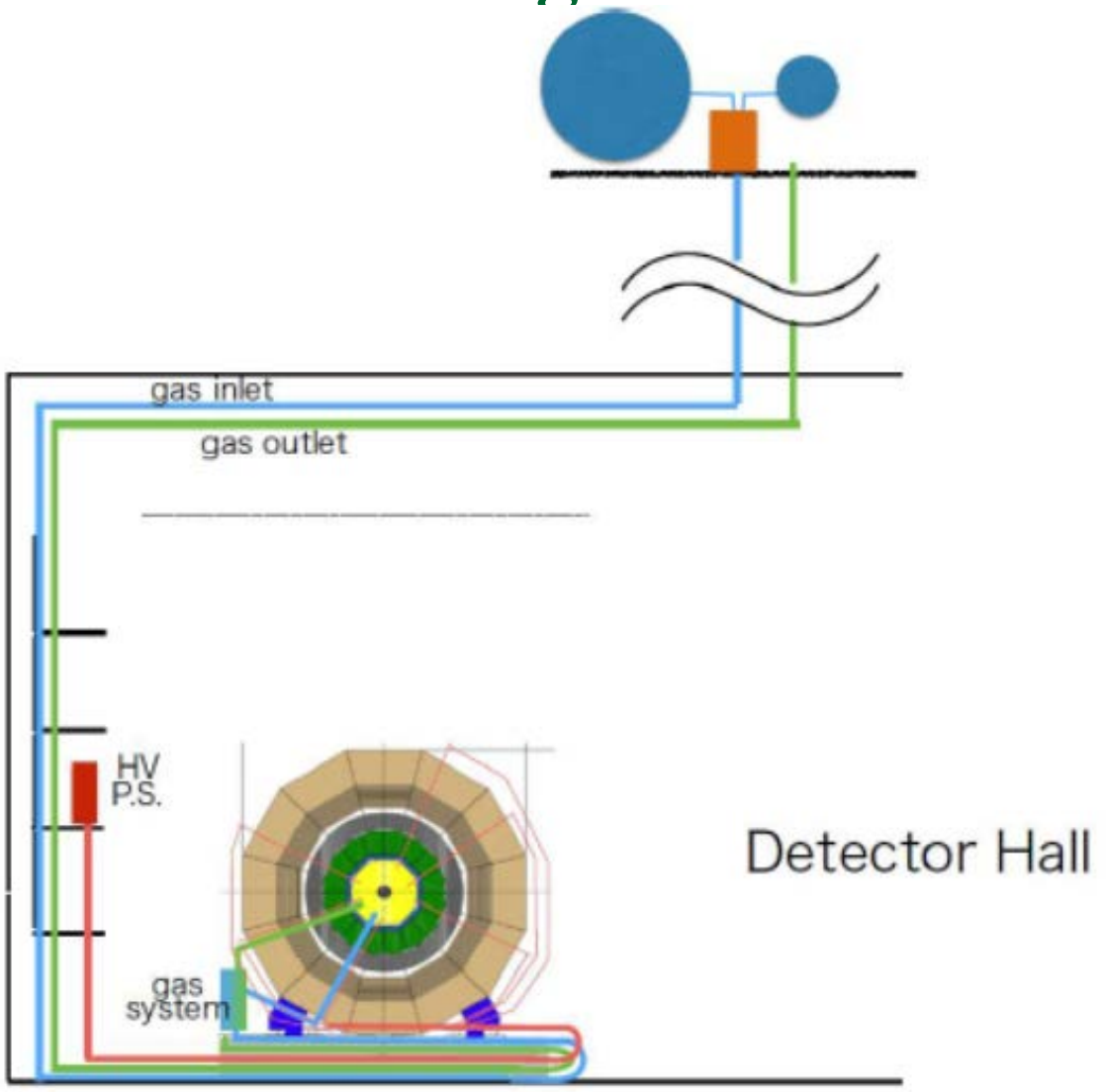




- **TPC detector design**

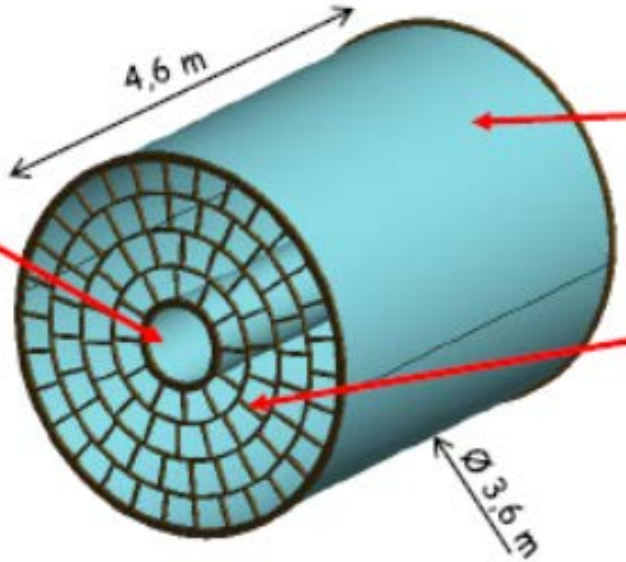
Overview of TPC detector design

- TPC detector system
  - High voltage
  - Low voltage
  - Support layout
  - Gas system
  - Cooling system
  - Electronic system
  - ……



Overview of TPC detector design

INNER CAGE
- MATERIAL : Composite
- FEA ELEMENTS : shell
- THICKNESS : 25 mm



OUTER CAGE
- MATERIAL : Composite
- FEA ELEMENTS : shell
- THICKNESS : 60 mm

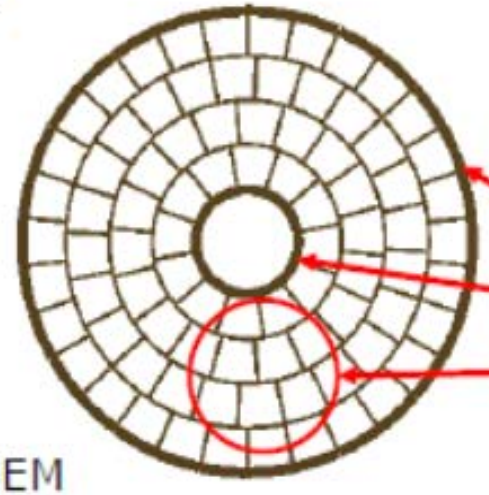
ENDPLATE
- MATERIAL : aluminum alloy
- FEA ELEMENTS : beam

Number of modules mounted on the 2 endplates (2 x 84 PCB) :

- PCB1 : 2 x 12
- PCB2 : 2 x 18
- PCB3 : 2 x 24
- PCB4 : 2 x 30

→ Size of the modules
≈ 300 x 330 mm

1 module = 1 MicroMegas or 4 GEM



Cross sections of the endplate components :

85 x 50 mm (outer ring)

82 x 50 mm (inner ring)

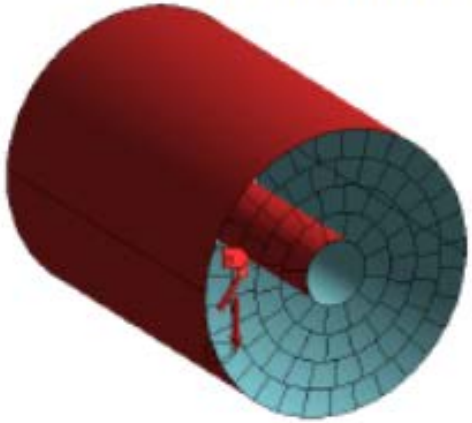
32 x 50 mm (intermediate rings and spokes)

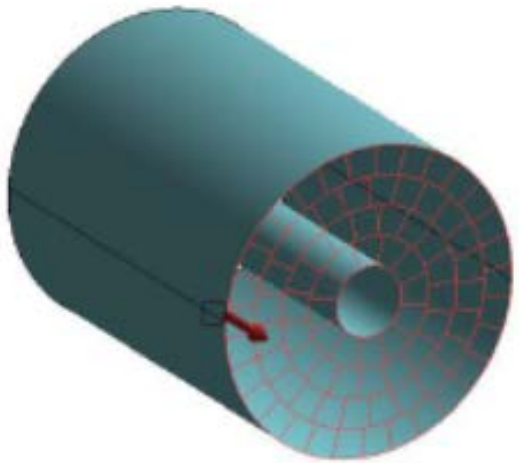
TPC Loads

- Gravitational loads
  - Self-weight of structure : 895 kg
  - Weight of the modules : 1176 kg (84 modules / endplate and 7 kg / modules)

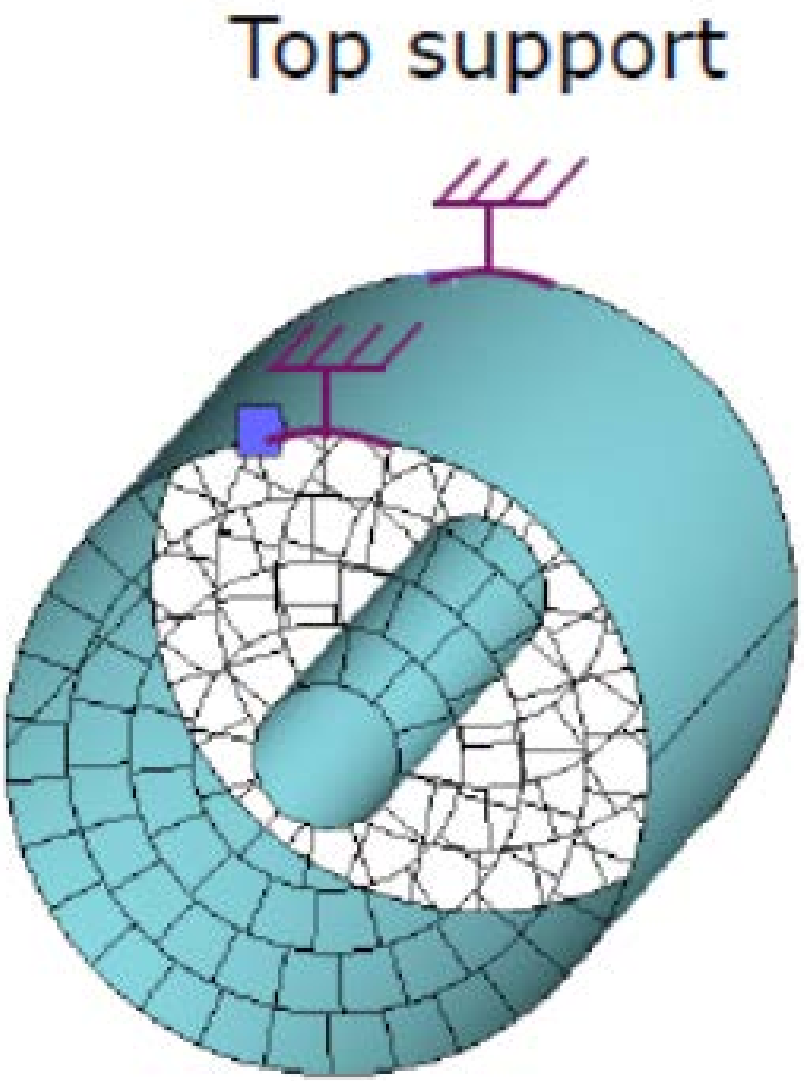
→ Total weight of 2 000 kg

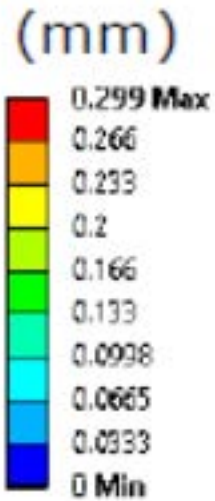
- Overpressure of 3 mbar
  - Pressure applied on the cages
  - Forces applied on each endplate by taking into account the pressure on modules

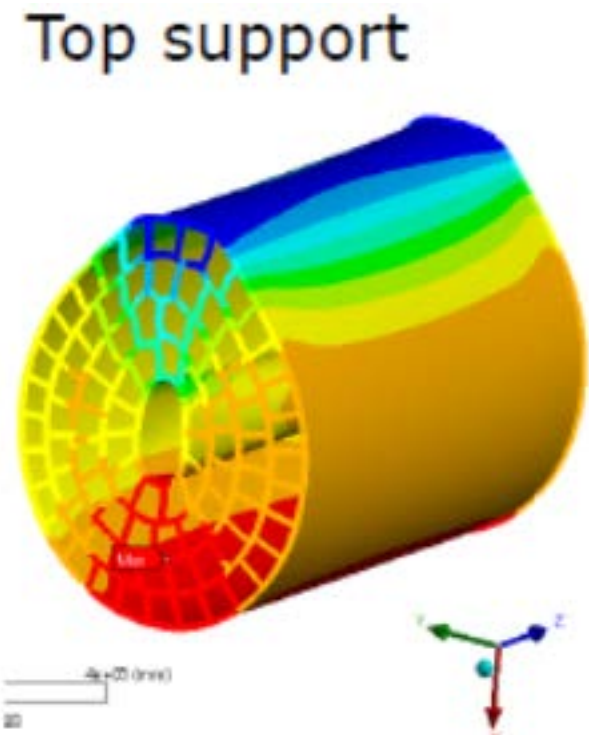




Support of TPC- Top support



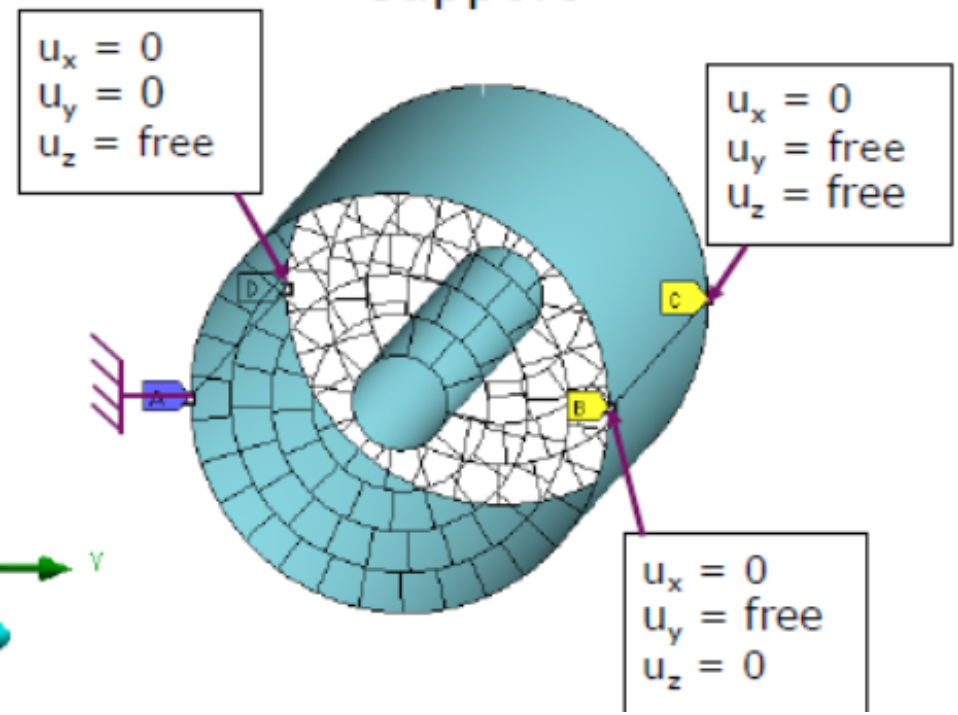




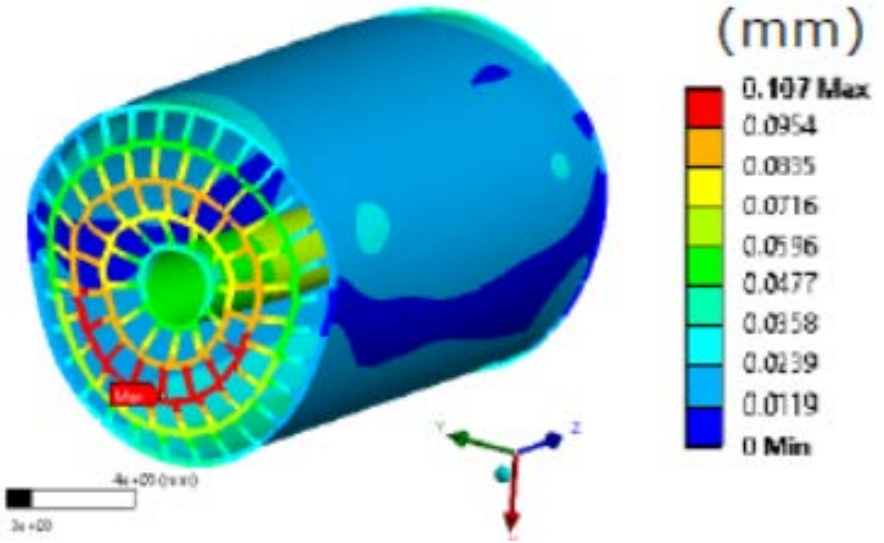
Support of TPC- Isostatic median support

Maximum deformation (µm)		Top support	Median support
Inner cage		234	68
Outer cage		298	39
Endplate displacements (µm)	X	290	44
	Y	110 / -99	23 / -21
	Z	91	93 / -98

Isostatic median support

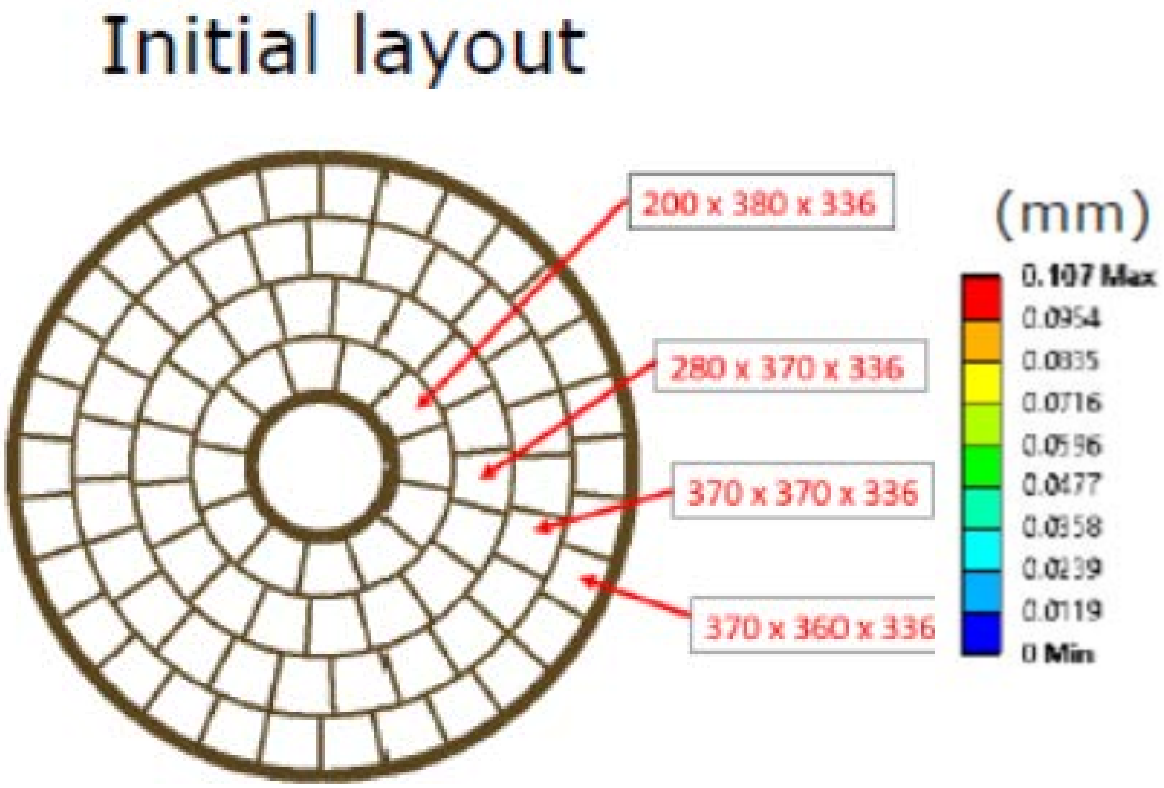


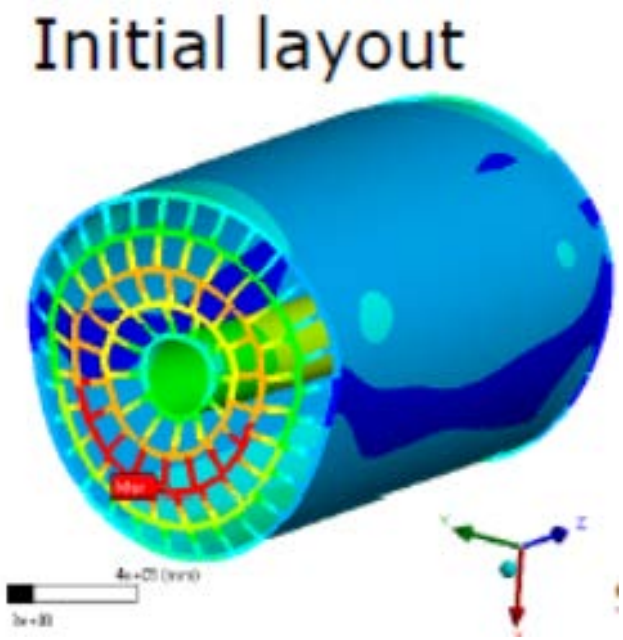
Isostatic median support



→ The displacements have much lower values and are more homogeneous with the median support

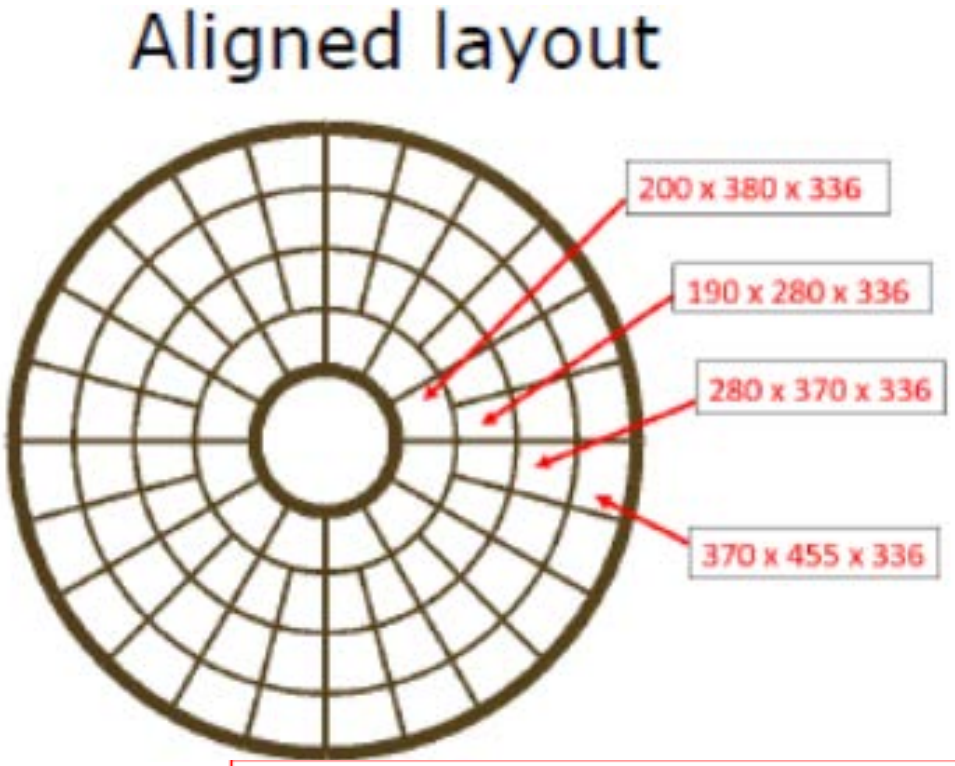
Support of TPC- Layout of the endplates

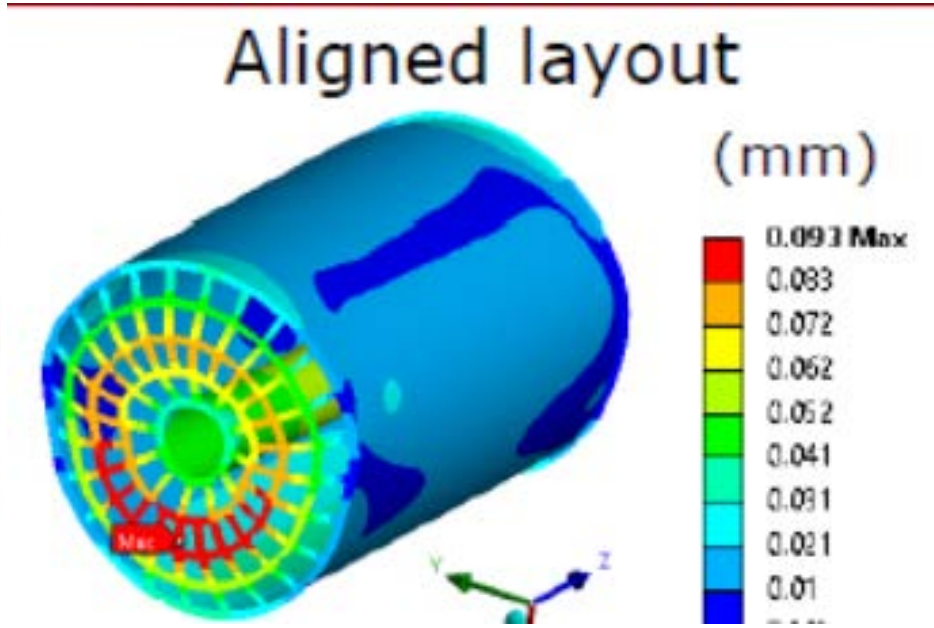




Support of TPC- Layout of the endplates

Maximum deformation (µm)		Initial layout	Aligned layout
Inner cage		68	58
Outer cage		39	33
Endplate displacements (µm)	X	44	35
	Y	23 / -21	17 / -16
	Z	93 / -98	80 / -87





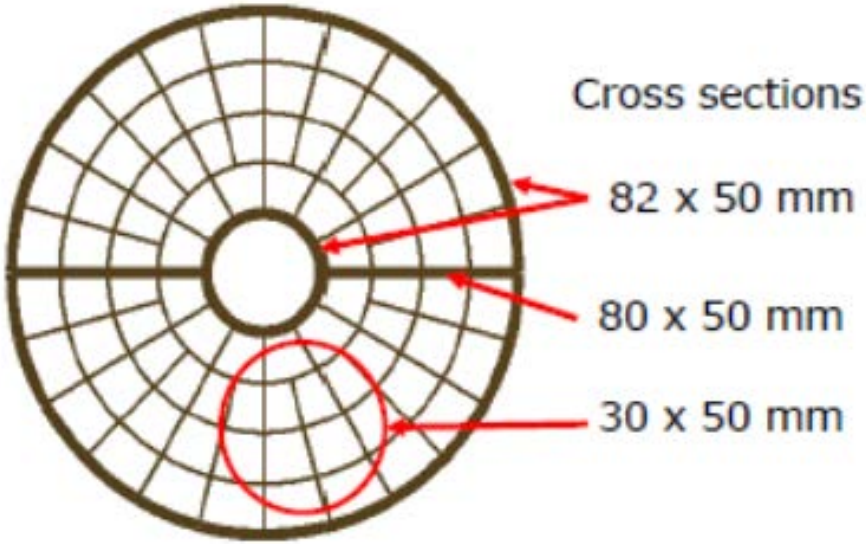
→ Decrease of 10 µm of the maximum deformation on all components

→ Much easier to produce, to assemble and to control on the geometry

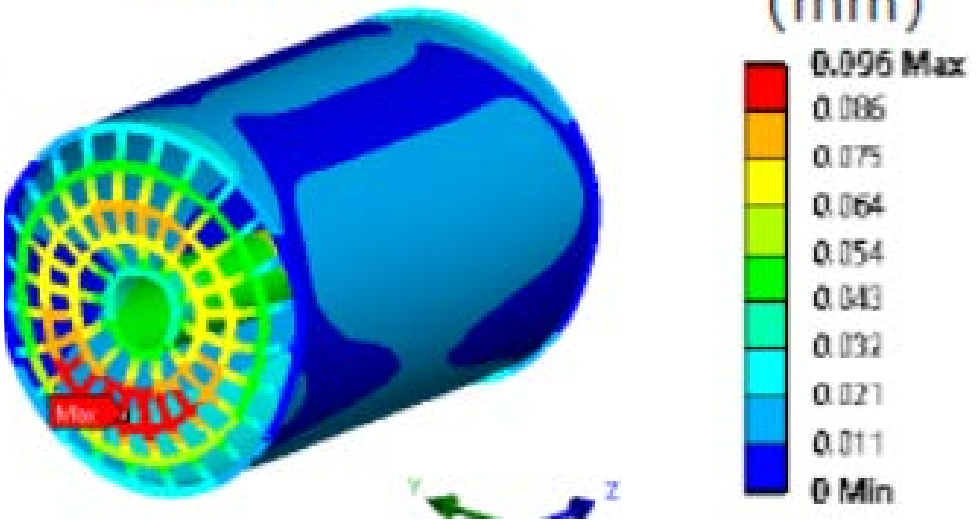
Support of TPC- Layout of the endplates

Maximum displacements (µm)		Initial	Alternative
Endplate	X	35	32
	Y	17 / -16	12 / -11
	Z	80 / -87	81 / -91

Alternative



Alternative

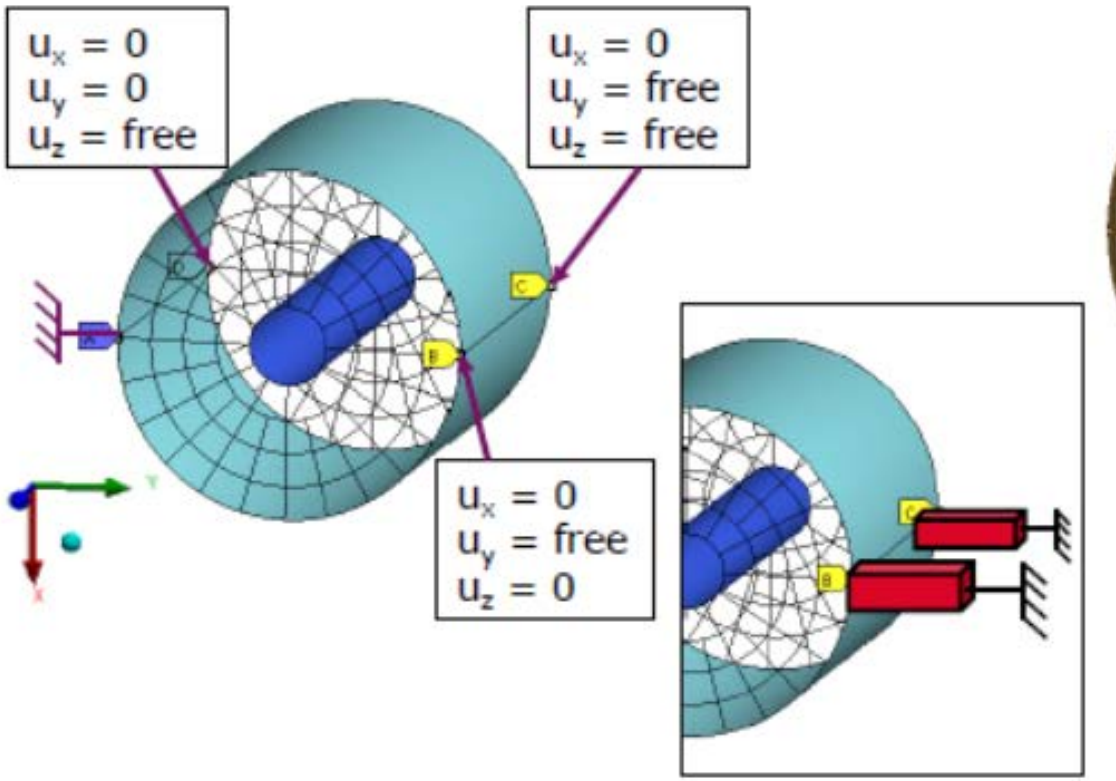


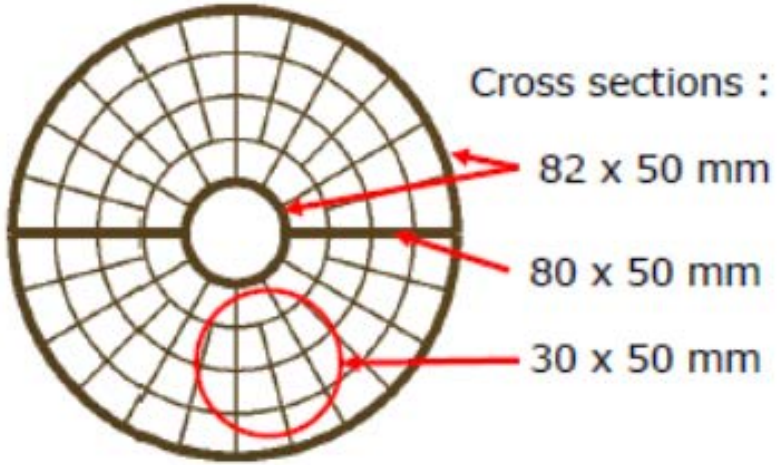
→ Decrease of 10 µm of the maximum deformation on all components

→ Much easier to produce, to assemble and to control on the geometry

Preliminary: best structure

- The best structure found so far has this characteristics :
  - Support in the median plane
  - Aligned spokes for an easier production and for lower deformation
  - Horizontal spokes reinforced for a gain of deformation, especially in the endplate planes





Open questions:

- On the X-Y plan precision and stability, somewhat less than 50/20/10um(?)? Displacement absolute or relative? Each direction or in total? (对于技术上实现的性能需求？)
- What are the physics requirements or technical performance?（对于物理上的性能需求？）

Thanks!