CLIC Workshop 2016 – CERN, Switzerland

CLICdp: Detector Optimisation + New Detector Meeting

Tracker layout options

Szymon Sroka, Wolfgang Klempt

Presentation Layout

- **Introduction:**

  - CLICdp: Status of design & simulation - half a year ago

  - Detector's Sub-systems: Inner & Outer region, Support Tube

- **Barrel Layers:**

  – First concept of cylinders made of sandwich structure

  - Analytical calculation

  - Validation of results: Analytical Calculations vs FEA model

- **Modules conception**

  - Modules distribution: Meander vs Windmill design

  - Modules Conception

- **Alternative support structure:**

  - Looking for inspiration

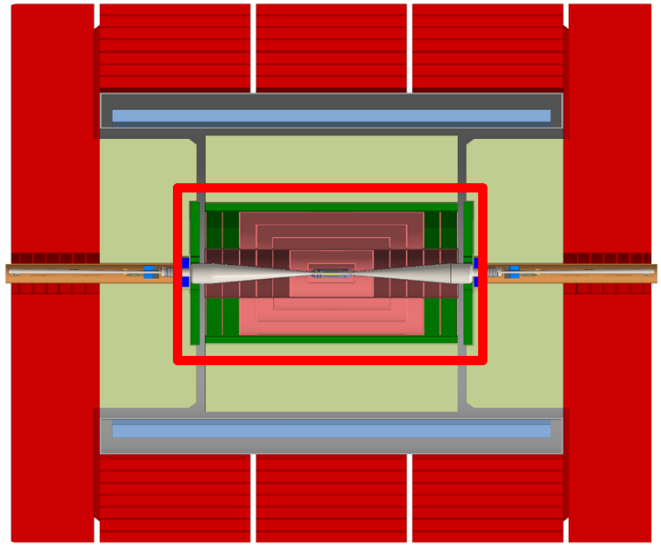
  - New concept of 3D Space Frame

  - Conception of 3D Space Frame: Preliminary FEA calculations

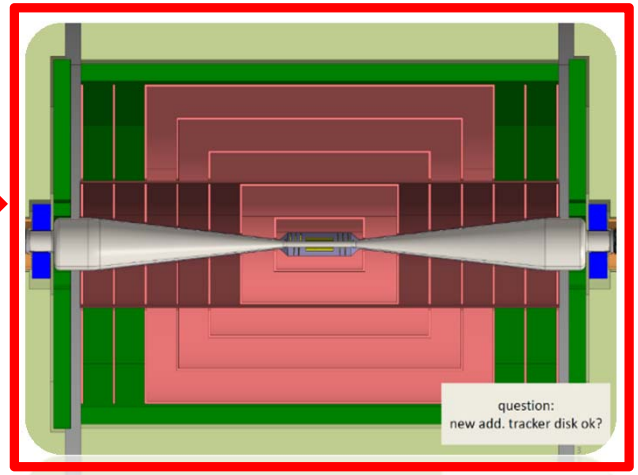
- **Tracker Layouts:** Two different scenarios

CLICdp

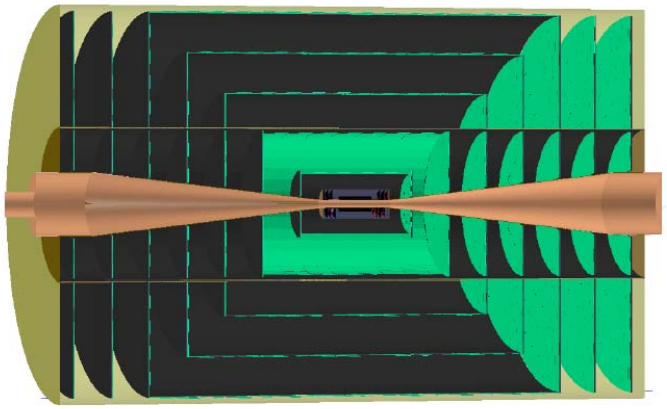
Status of design & simulation - half a year ago



Tracker System - Zoom In



- No support?
- No services?
- Floating in the air ?
- Etc…

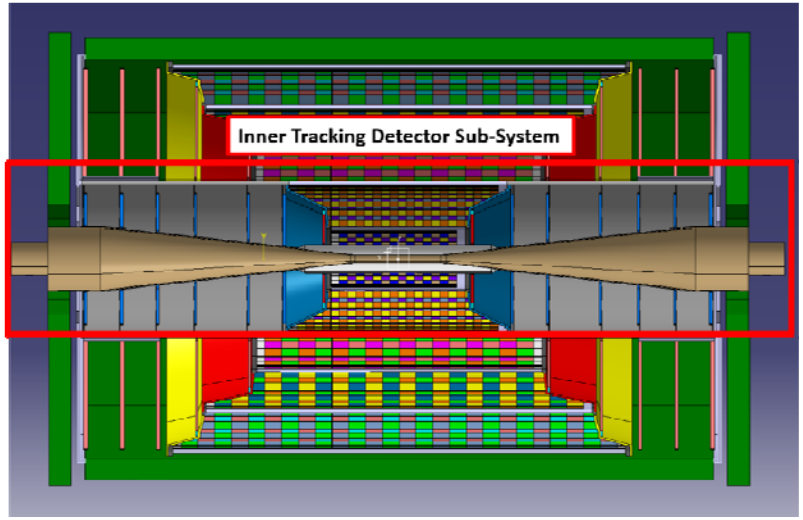


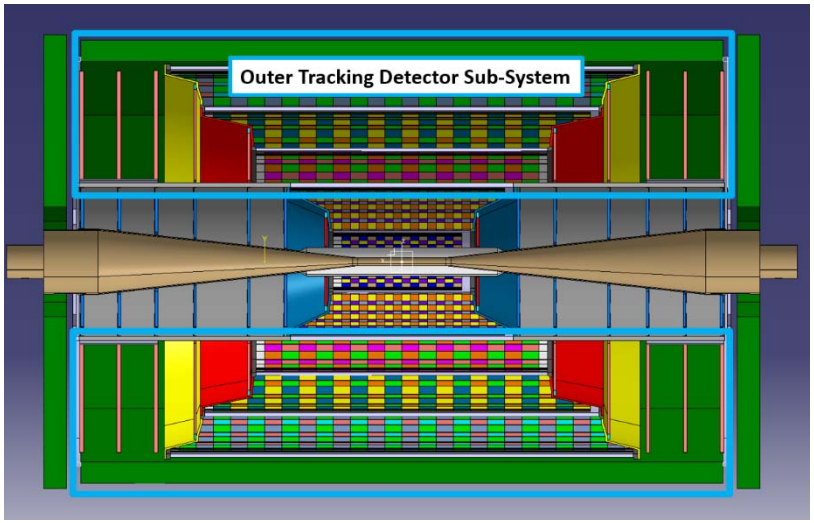
Questions:

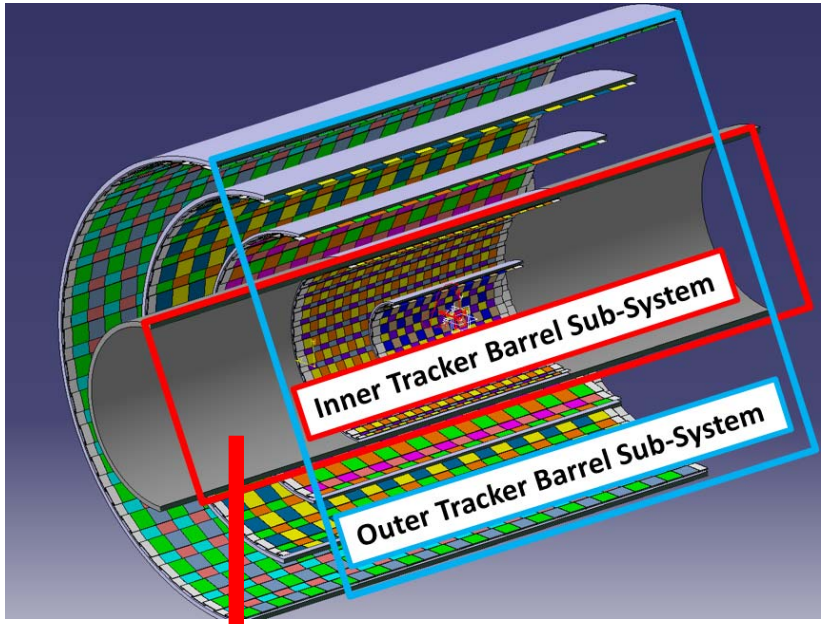
- How to make support ladders?
- How to perform an overlap in z and φ?
- How to cool the system?

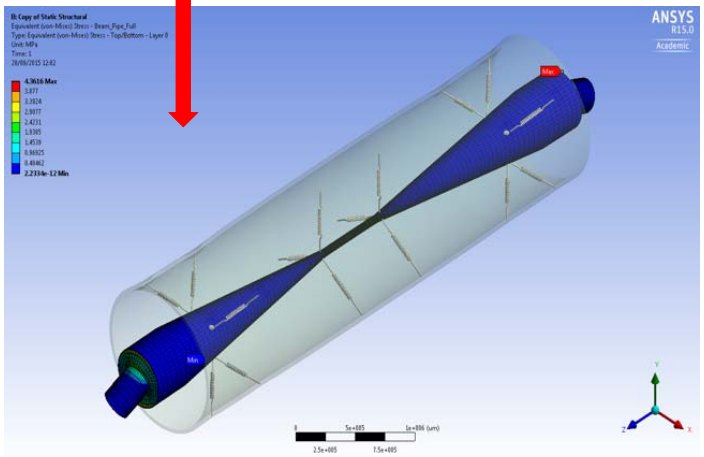
Detector's Sub-systems

Inner & Outer region, Support Tube



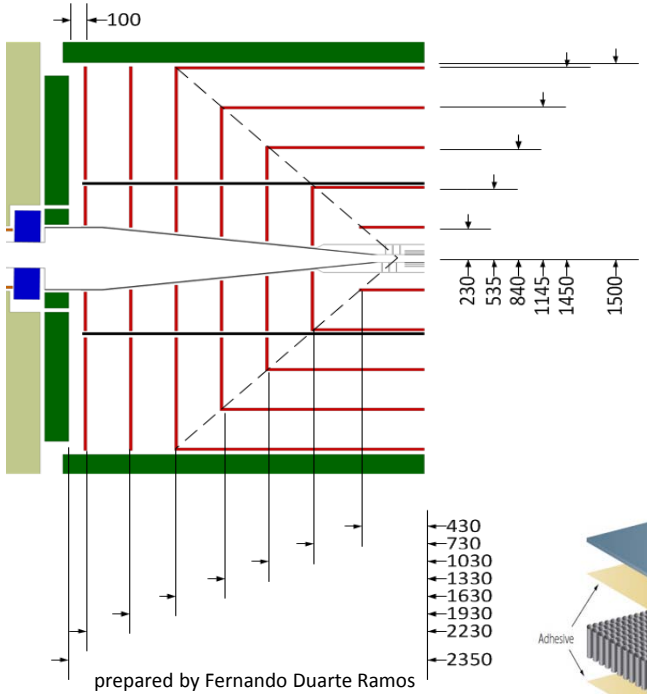




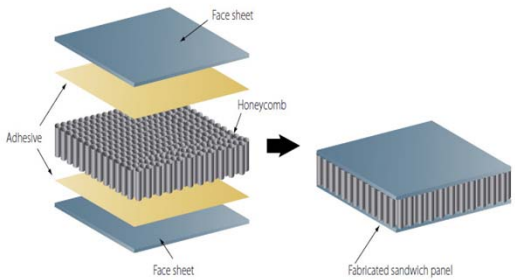


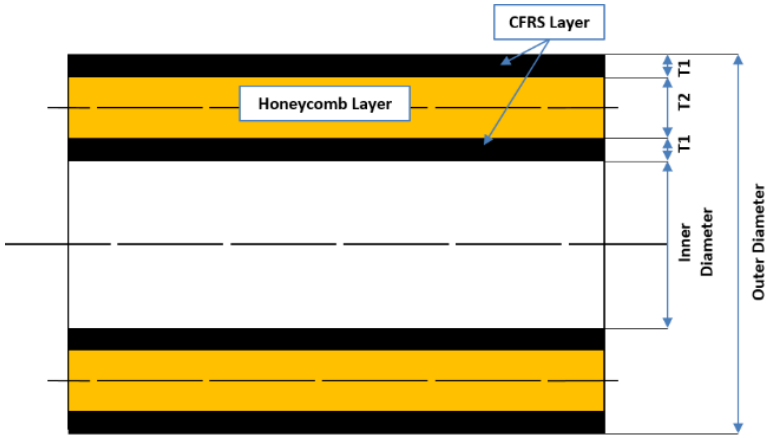
Barrel Layers

First concept of cylinders made of sandwich structure



Tracker Barrel Layers – Dimensions					
Number of Barrels	Radii of Barrels [mm]	Length of Barrels [mm]	Thickness of Honeycomb Core [mm]	Thickness of CF Skins [mm]	Mass of each Barrel [kg]
1	230	860	10	0.6	2.85
3	840	2060	15	1.2	48.1
4	1145	2660	25	1.2	90.1
5	1450	3260	25	1.2	140





Basic Requirements:

- Lightweight structure
- Minimizing the radiation length
- Maximum deflection in the range of **100 [µm]**

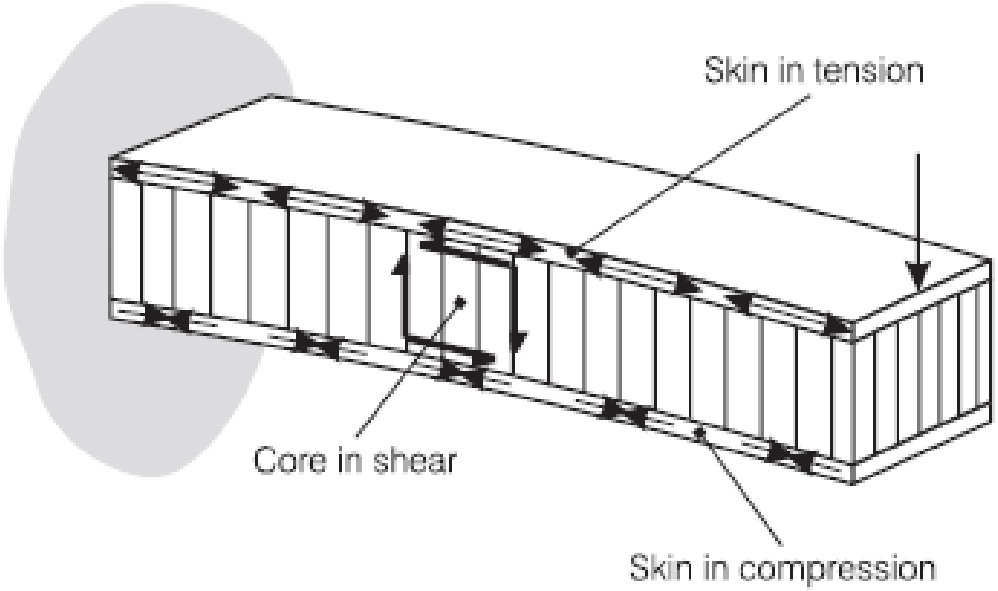
Materials - choices (as an example):

- CF Skins: Toray M55J + Cycom 950-1
- Honeycomb Core: XRH-10/OX-3/16-1.8

Barrel layers

Analytical calculation

Total Deflection = Bending Deflection + Shear Deflection



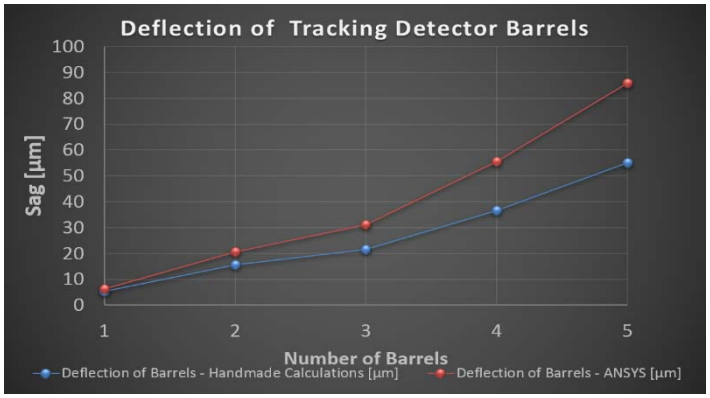
Validation of results

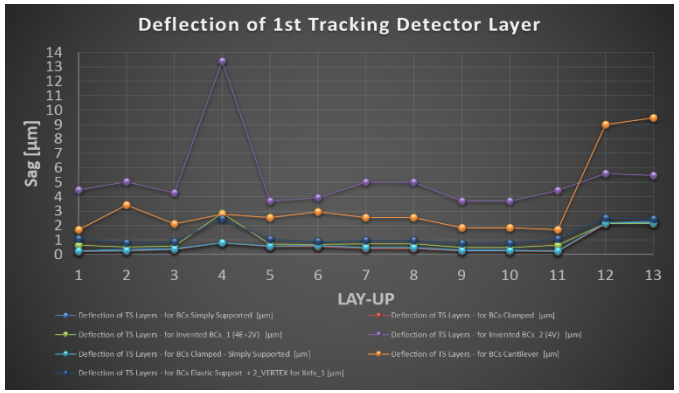
Analytical Calculations vs FEA model

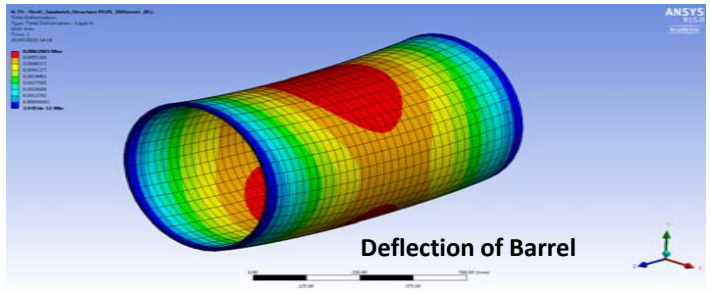
Deflection of Barrels made of Sandwich Structure (CF SKINS PLUS HONEYCOMB CORE)

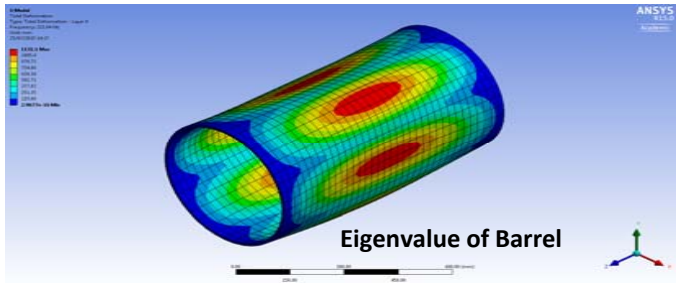
Number Of Cylinders	Mass of Modules [kg]	Deflection of Barrels - Handmade Calculations [µm]	Deflection of Barrels - ANSYS [µm]	Eigenvalue - Natural frequency of Cylinders [Hz]	Difference between Handmade Calculations and Ansys Simulations [%]	% Of Radiation Length - Mechanics [%]	% Of Radiation Length - SEN+COOLING [%]	% Of Radiation Length - TOTAL [%]	% Of Radiation Length of Barrels - TOTAL SUM [%]
1	3.9	**5.4**	**6.2**	224	13	**0.54**	**1.012**	**1.55**	
2	15.16	**15.5**	**20.6**	108	24	**0.572**	**1.00**	**1.57**	
3	33.4	**21.5**	**31.0**	67	30	**1.04**	**1**	**2.04**	**9.387**
4	59.1	**36.7**	**55.6**	58	34	**1.10**	**1.00**	**2.12**	
5	91.5	**55.0**	**85.7**	40	36	**1.11**	**1.00**	**2.11**	

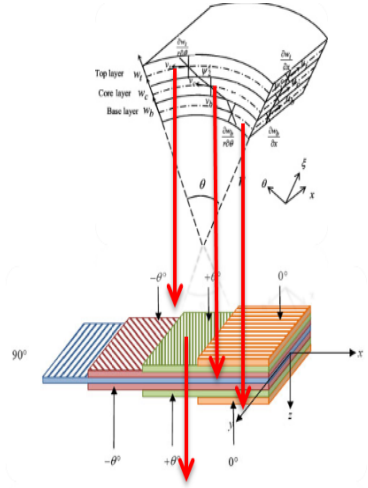
Good agreement between the analytical and numerical calculation!





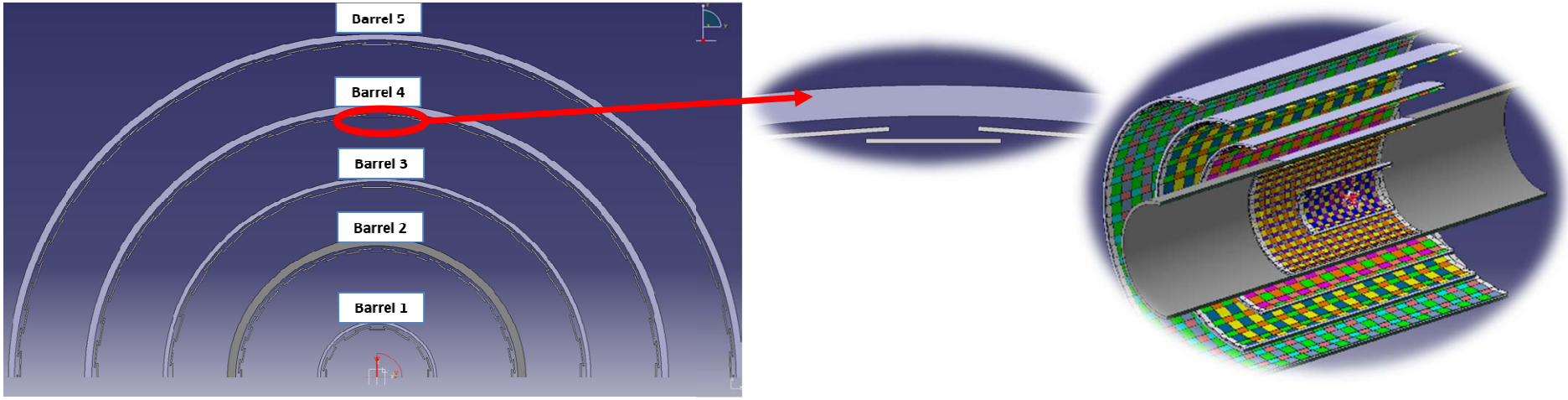


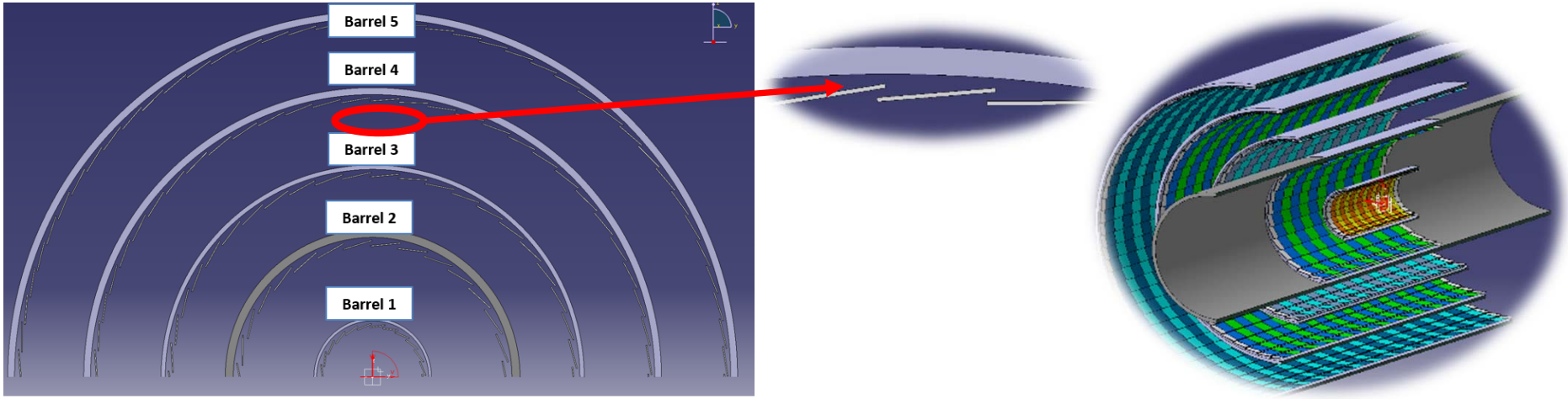




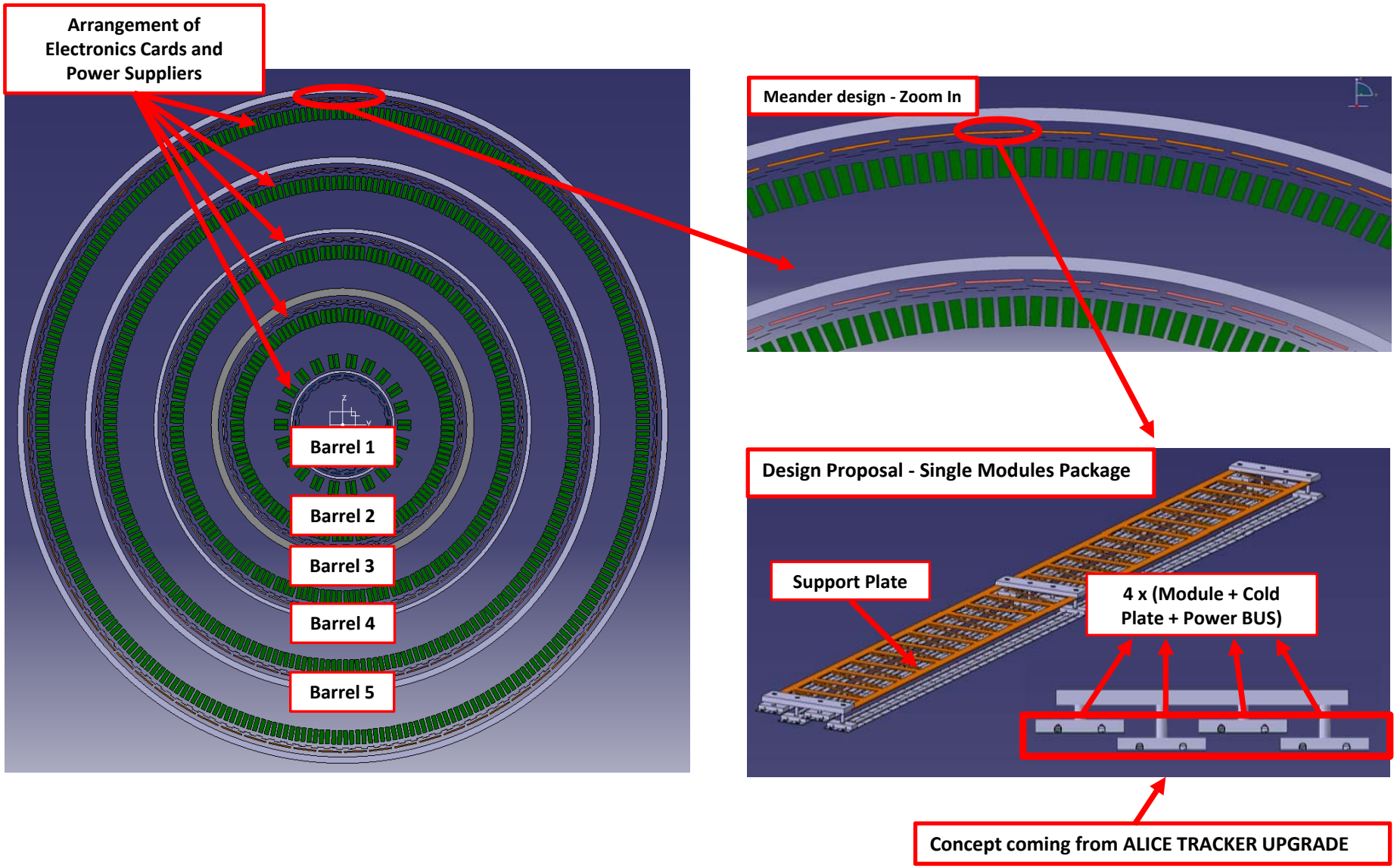
Modules distribution

Meander vs Windmill design





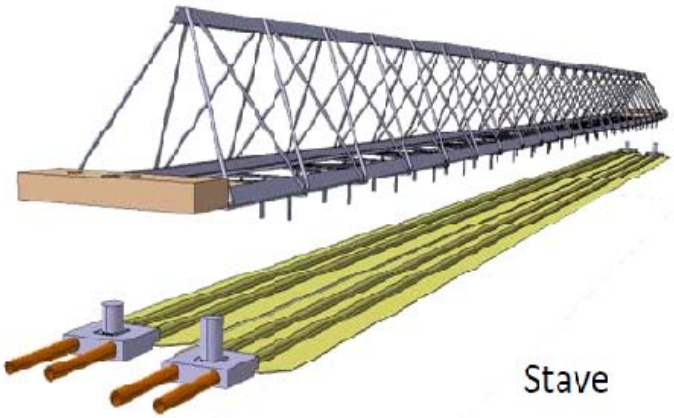
Modules Conception

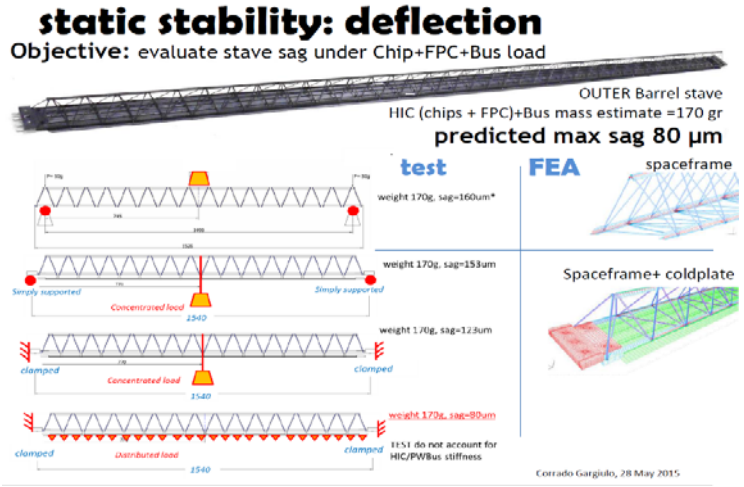


Alternative support structure

Looking for inspiration

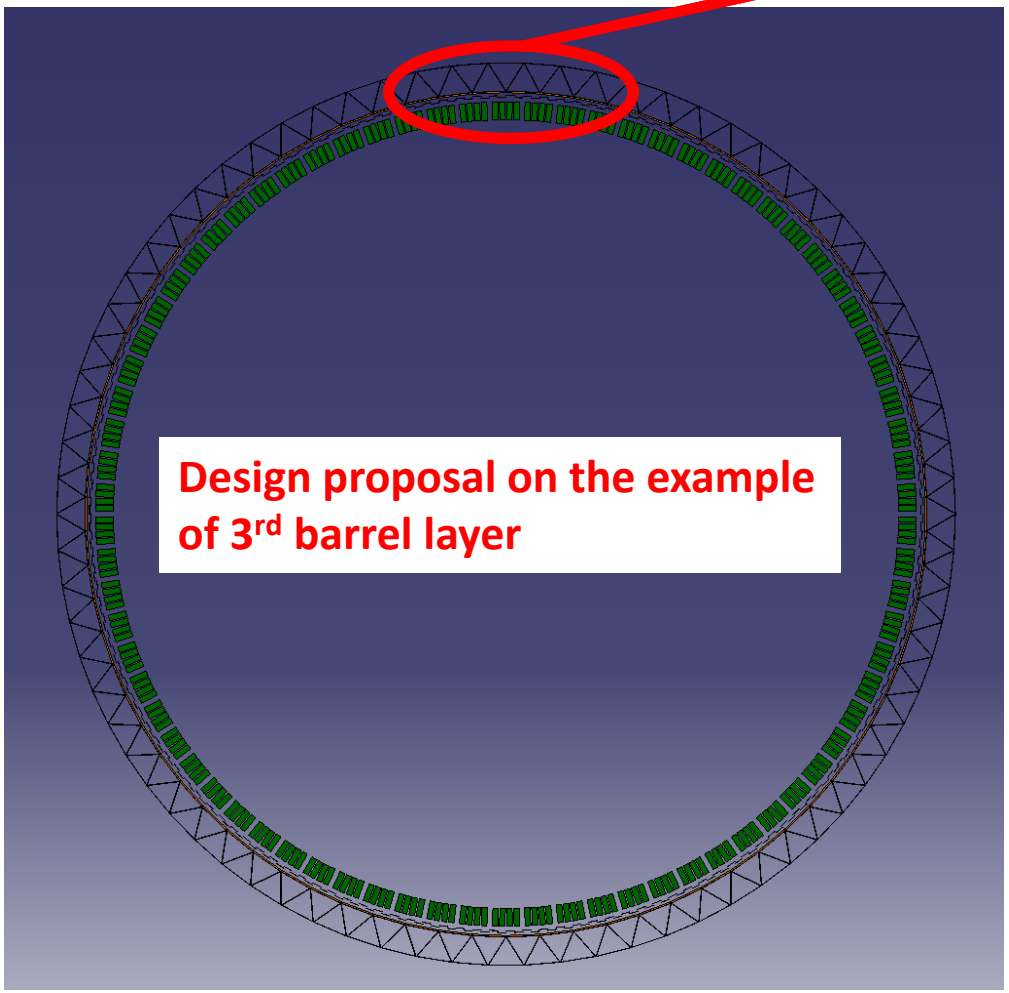
One way of minimizing the radiation length?

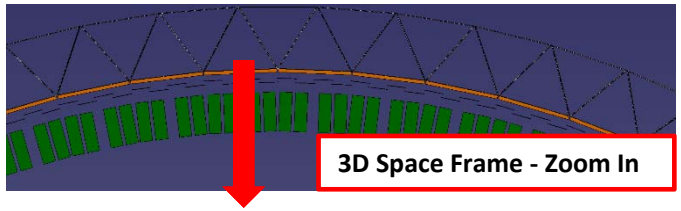


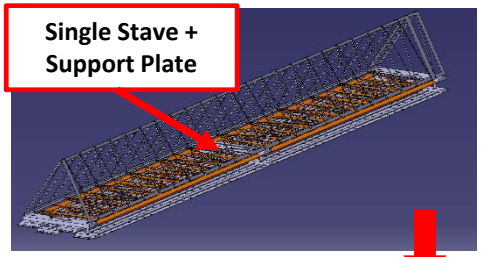


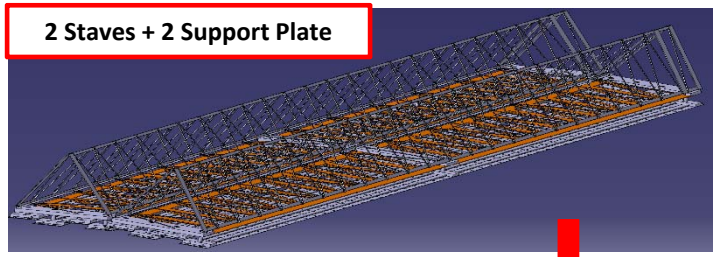
Alternative support structure

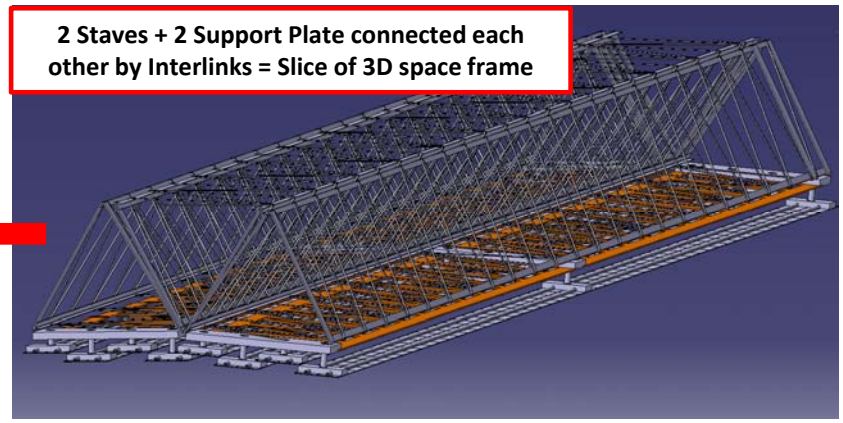
New concept of 3D Space Frame











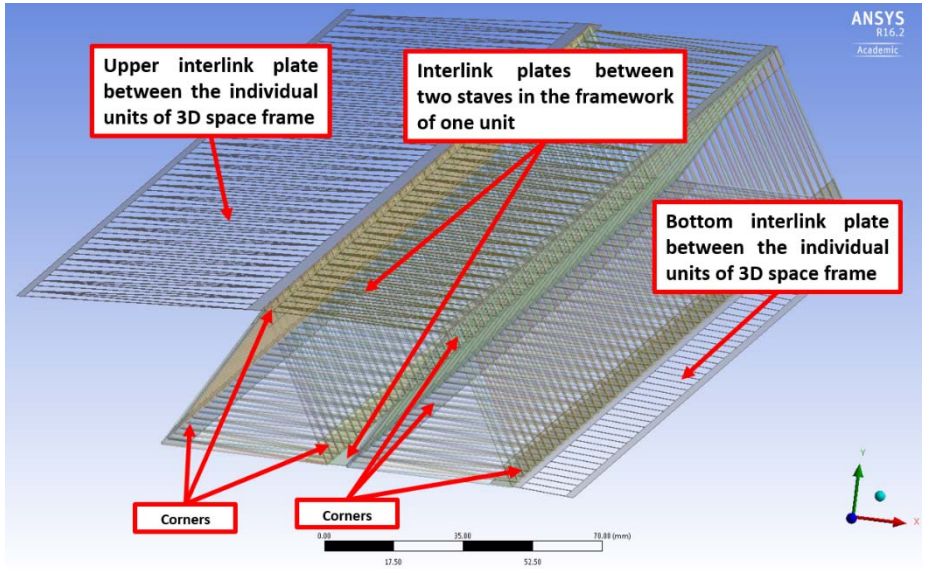
Conception of 3D Space Frame

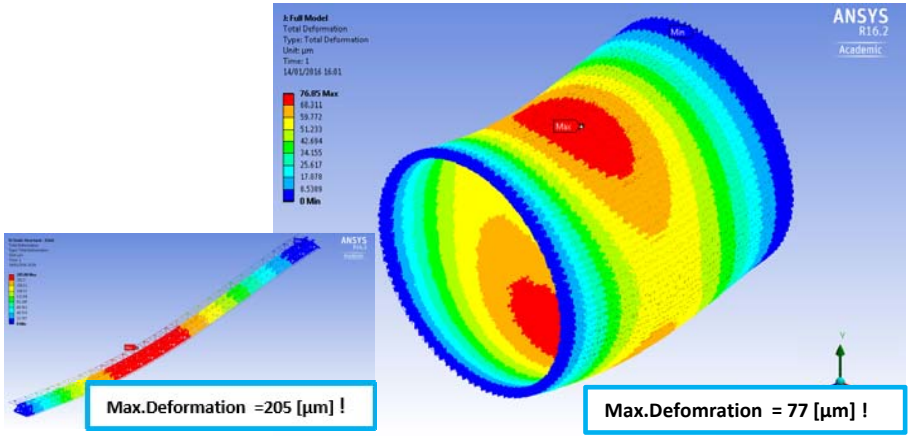
Preliminary FEA calculations

Assumptions:

- Above example refers to 3rd layers of the Tracking System
- Whole 3d space frame consists of 50 individual Units
- Boundary Conditions: for the time being, the Simply supported case is taken under the consideration
- Applied Load is bigger than the nominal one by a factor of ~1.35

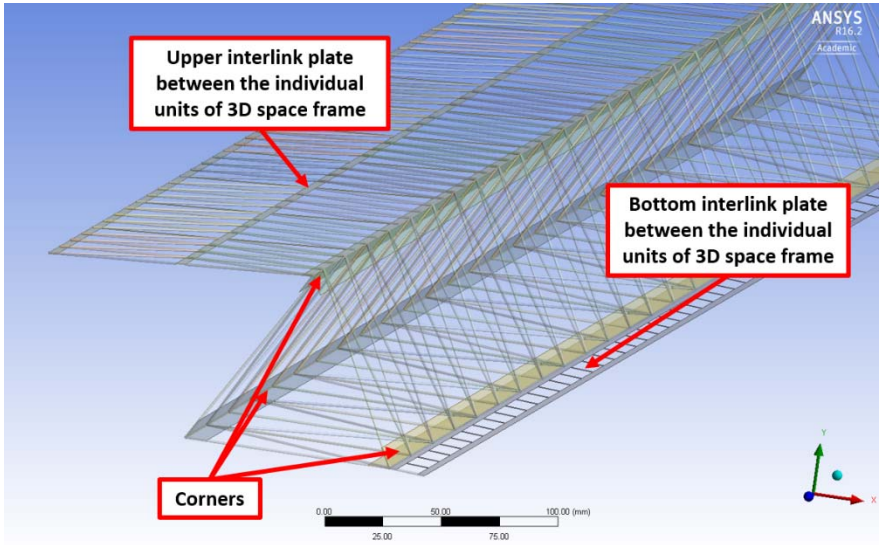
Layup		
	Nb. of Layers and Material	Thickness of one layer [mm]
Upper interlink plate	4 Layers: Toray M55J + Cycom 950-1	0.18
Interlink plates between two staves	4 Layers: Toray M55J + Cycom 950-1	0.18
Bottom Interlink plate	4 Layers: Toray M55J + Cycom 950-1	0.18
Corners	4 Layers: Toray M55J + Cycom 950-1	0.09
Member beams	M55J DATA SHEET TORAYCA - FIBER PROPERTIES * 0.7	R= 0.4 [mm]
Reinforcement fibers along the corners	M55J DATA SHEET TORAYCA - FIBER PROPERTIES * 0.7	R= 0.35 [mm]





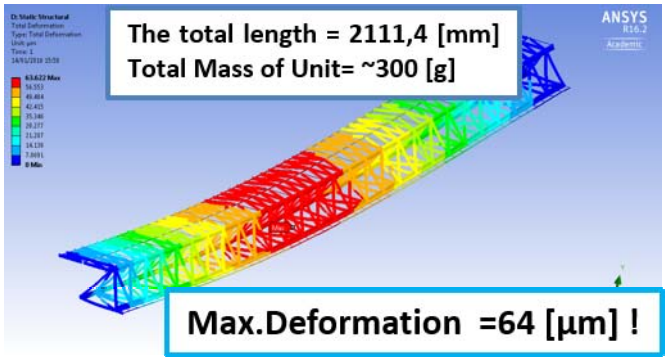
Conception of 3D Space Frame

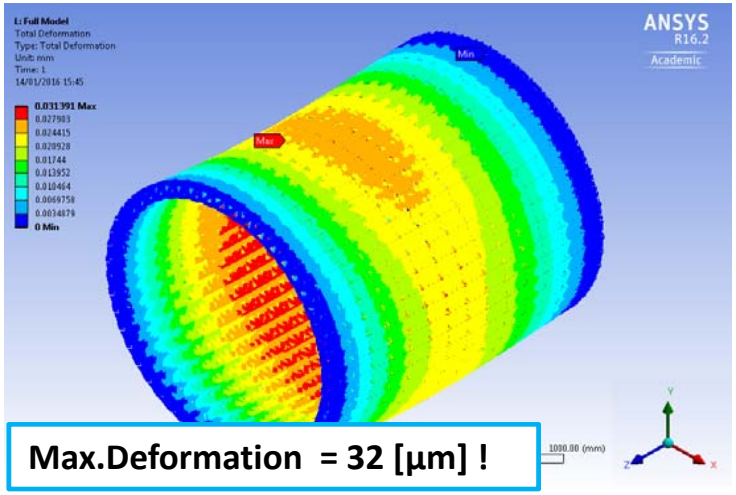
Preliminary FEA calculations



Layup		
	Nb. of Layers and Material	Thickness of one layer [mm]
Upper interlink plate	4 Layers: Toray M55J + Cycom 950-1	0.2
Bottom interlink plate	4 Layers: Toray M55J + Cycom 950-1	0.2
Corners	4 Layers: Toray M55J + Cycom 950-1	0.15
Member beams	M55J DATA SHEET TORAYCA - FIBER PROPERTIES * 0.7	R= 0.6 [mm]
Reinforcement fibers along the corners	M55J DATA SHEET TORAYCA - FIBER PROPERTIES * 0.7	R= 0.35 [mm]

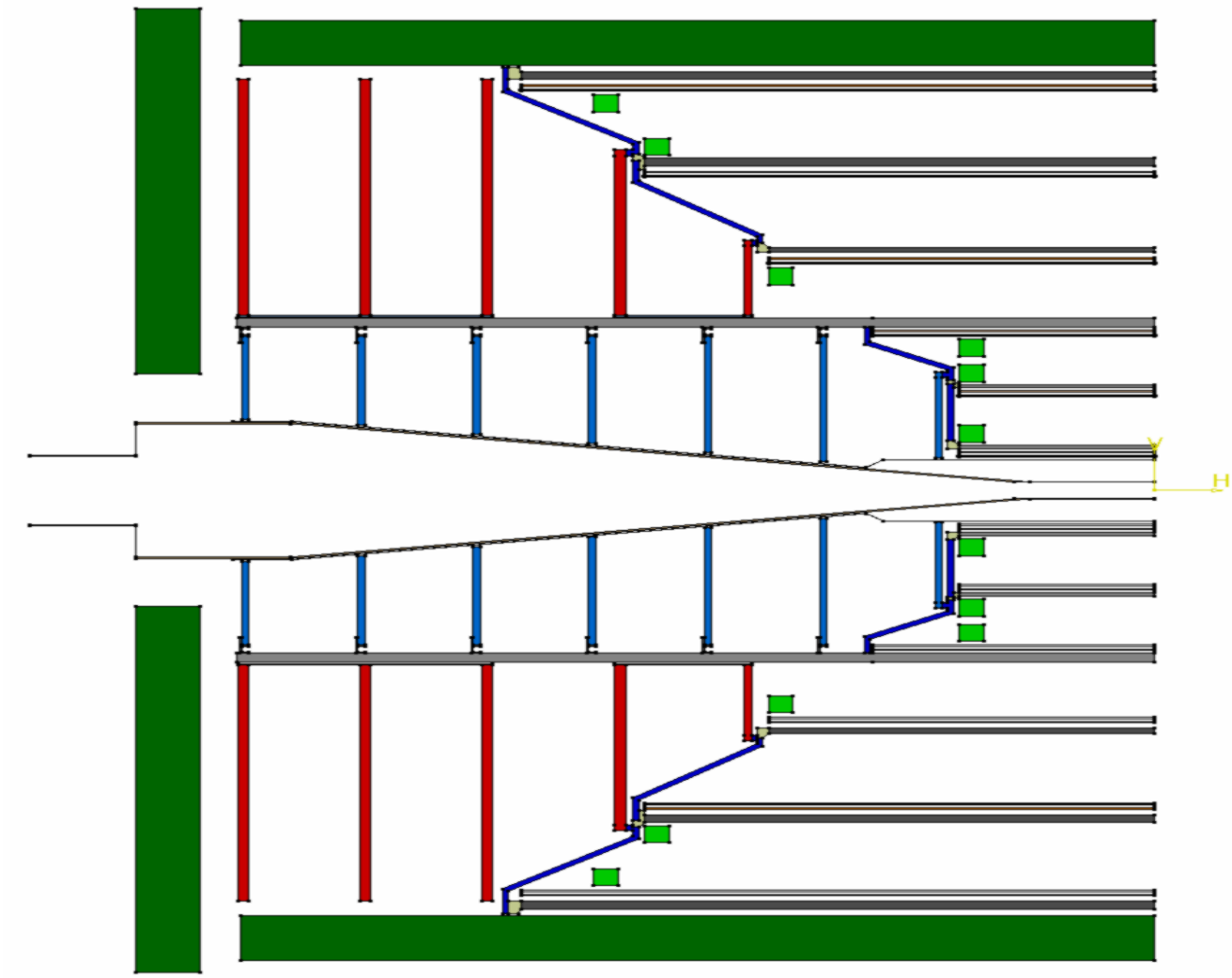
Total deformation of the 3D space frame due to the Standard gravity force and the weight of the packages of modules





Tracker Layouts

Status of the current layout



Outer Sub-system:

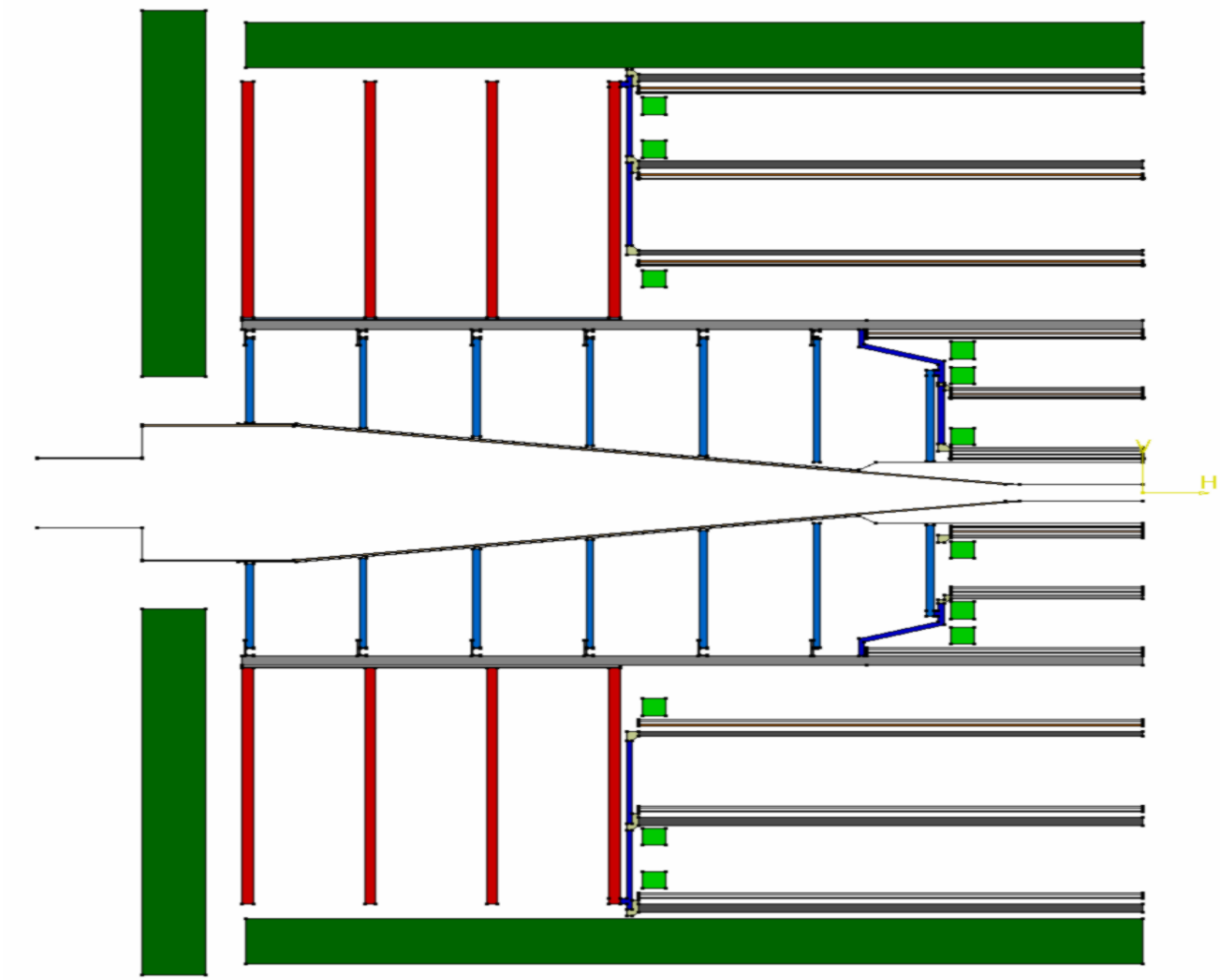
- 5 End-Caps
- 3 Barrel Layers

Inner Sub-system:

- 7 End-Caps
- 3 Barrel Layers

Tracker Layouts

Alternative proposition - equal length of the Tracker's layers in the outer sub-system



Outer Sub-system:

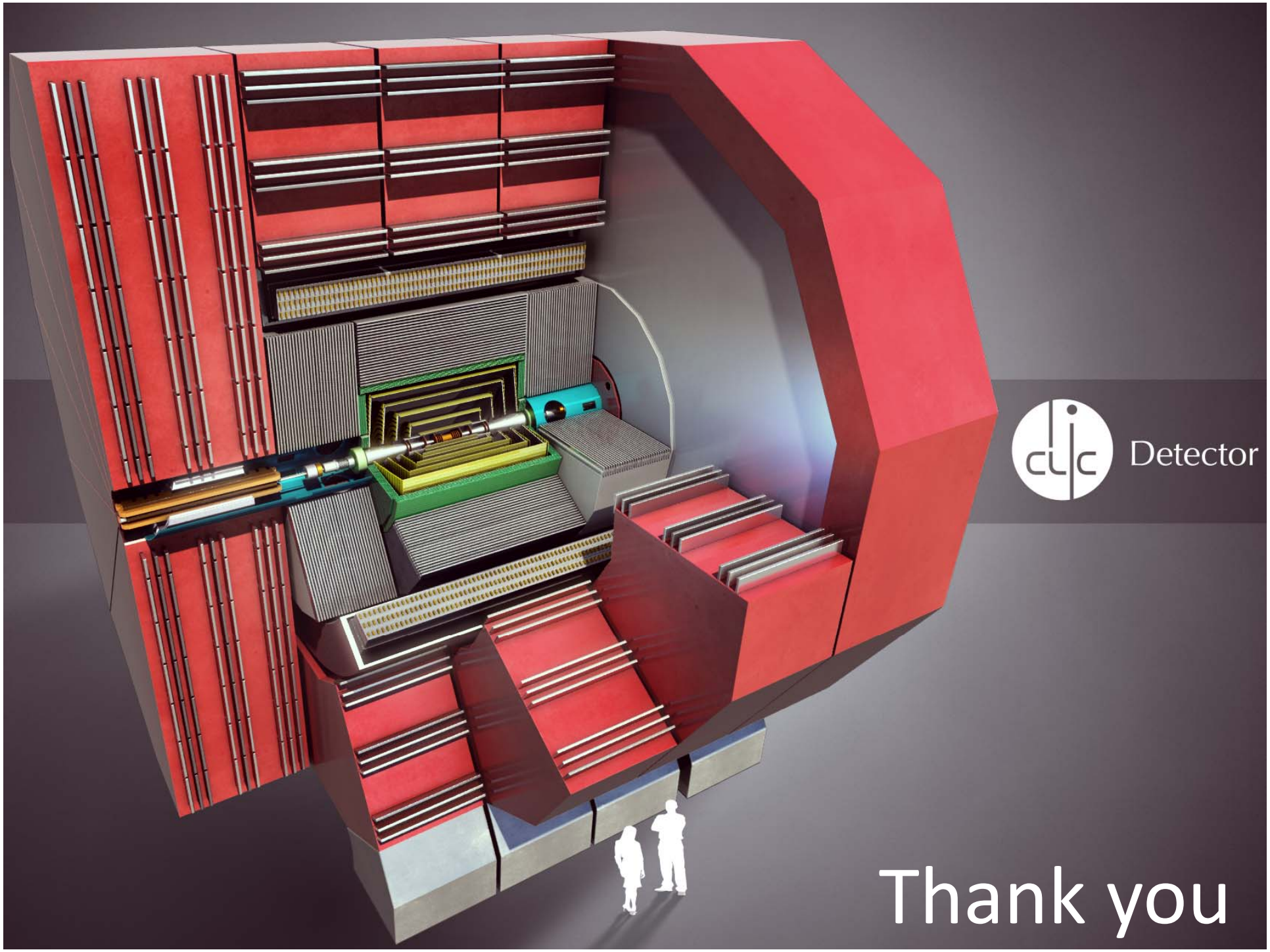
- 4 End-Caps
- 3 Barrel Layers

Inner Sub-system:

- 7 End-Caps
- 3 Barrel Layers

Summary:

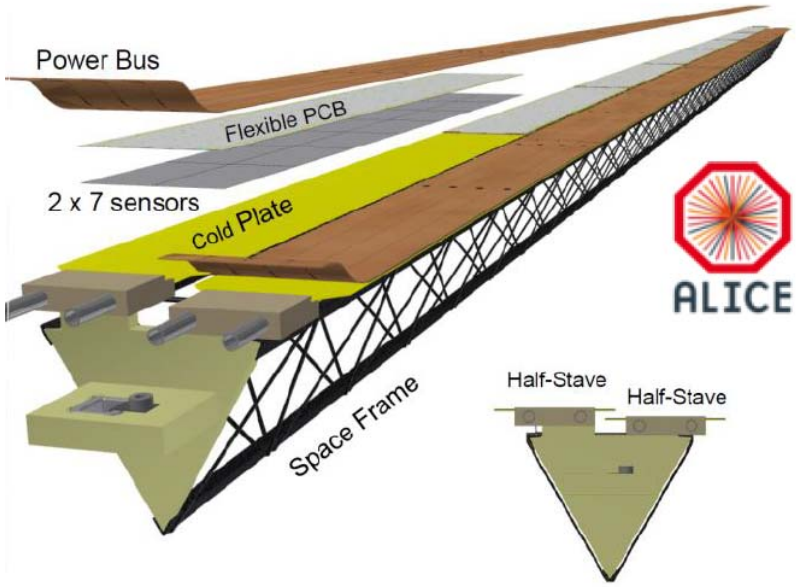
- First preliminary design for the barrel layers.
- First idea in relation to the arrangement of modules
- We are looking for the alternative concept with respect to the barrel support structure in order to minimize the radiation length
- We are considering two different layouts for the Tracker system

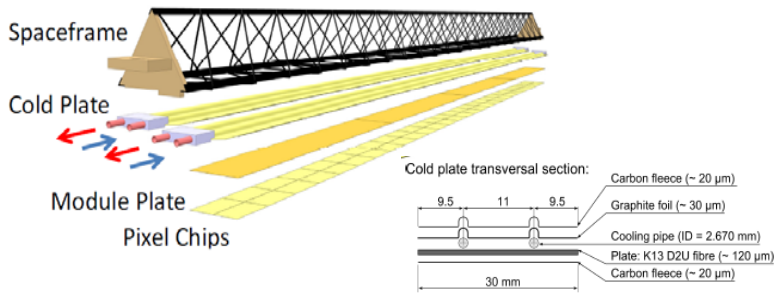

Detector
Thank you

Backup slides

Modules Conception

Estimated contributions of the Outer Layer Stave to the material budget			
	Component	**Material**	**Thickness [µm]**
Module	FPC Metal Layer	Aluminium	**50**
	FPC Insulating Layers	Polyimide	**100**
	Module Plate	Carbon Fibre	**120**
	Pixel Chip	Silicon	**300**
	Glue	Eccobond 54	**100**
Cold Plate		Carbon fleece	**40**
		Graphite foil	**30**
	Cooling pipe	Polyimide	**64**
	Cooling fluid	Water	**-**
	Carbon Plate	Carbon Fibre	**120**
	Glue	Eccobond 54	**100**
Power Bus	Metal Layer	Aluminium	**200**
	Insulating layers	Polyimide	**200**
	Glue	Eccobond 54	**100**





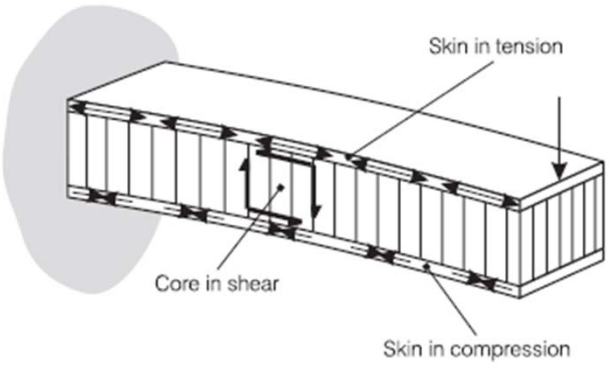
Barrel layers

Analytical calculation

Total Deflection = Bending Deflection + Shear Deflection

Flexural Stiffness: $D := E \cdot I$

Shear Stiffness: $S := A \cdot G$



A- Cross Section Area:

$$A_{Core} := 2 \cdot \pi \cdot \left(R + \frac{T_{Core}}{2}\right) \cdot T_{Core}$$

$$A_{Layer} := \pi \cdot \left(\left(R + \frac{T_{total}}{2}\right)^2 - \left(R - \frac{T_{total}}{2}\right)^2\right) - A_{Core}$$

I - inertia moment

$$I_{Layers} := \pi \cdot \left(R + \frac{T_{total}}{2}\right)^3 \cdot T_{total} - \pi \cdot \left(R + \frac{T_{Core}}{2}\right)^3 \cdot (T_{Core})$$

a - inner radius of Barrel [mm]
b - outer radius of Barrel [mm]

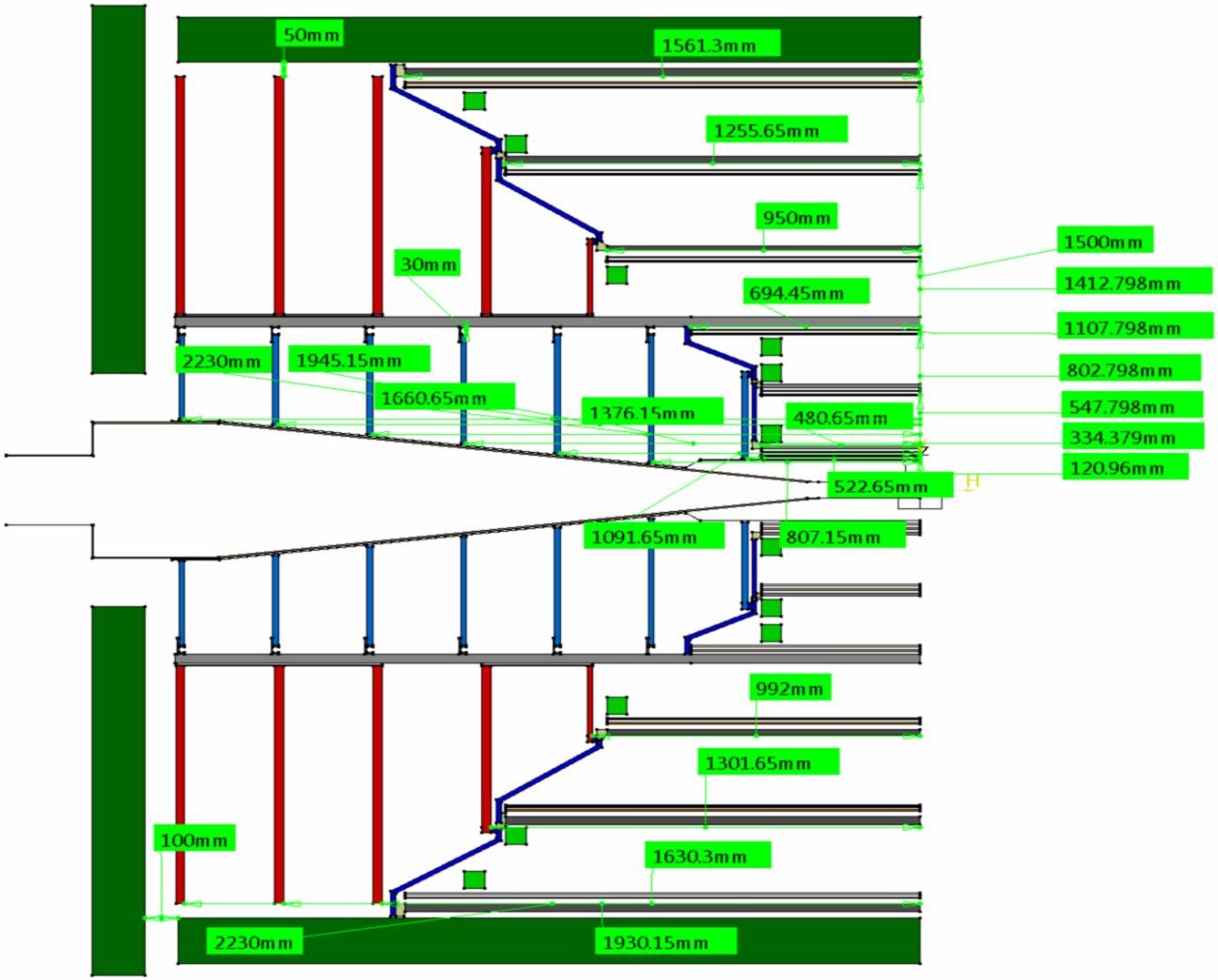
k - the Timoshenko shear coefficient, depends on the geometry

$$w_{total} := Q \cdot \frac{L^4}{24 \cdot D} \cdot \left(\frac{X}{L} - \frac{2 \cdot X^3}{L^3} + \frac{X^4}{L^4}\right) + Q \cdot \frac{L^2}{2 \cdot k \cdot S} \cdot \left(\frac{X}{L} - \frac{X^3}{L^3}\right)$$

$$k := \frac{6 \cdot \left(a^2 + b^2\right)^2 \cdot (1 + \nu)^2}{7 \cdot a^4 + 34 \cdot a^2 \cdot b^2 + 7 \cdot b^4 + \nu^2 \cdot \left(12 \cdot a^4 + 48 \cdot a^2 \cdot b^2 + 12 \cdot b^4\right) + \nu^2 \cdot \left(4 \cdot a^4 + 16\, a^2 \cdot b^2 + 4 \cdot b^4\right)}$$

Tracker Layouts

Status of the current layout



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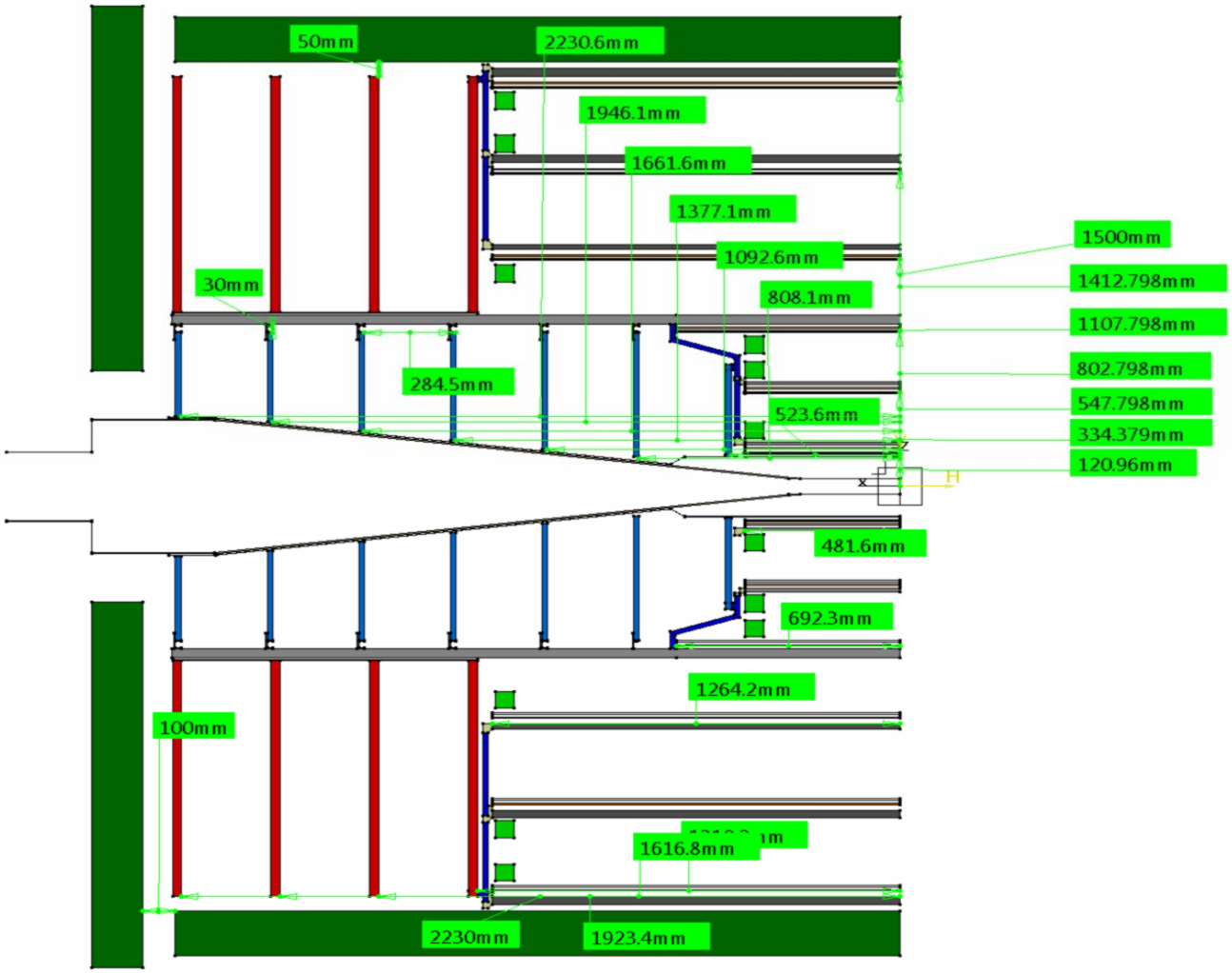

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