



CLIC Workshop 2016

# Towards a Lightweight Outer Tracker Support Structure

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January 20, 2016

# Outline

- Tracker size/material budget comparison
- Lightweight support structure concept
- Layout optimization
- Deformation estimates
  - Stiffness optimization
- Material budget estimates
- Tooling

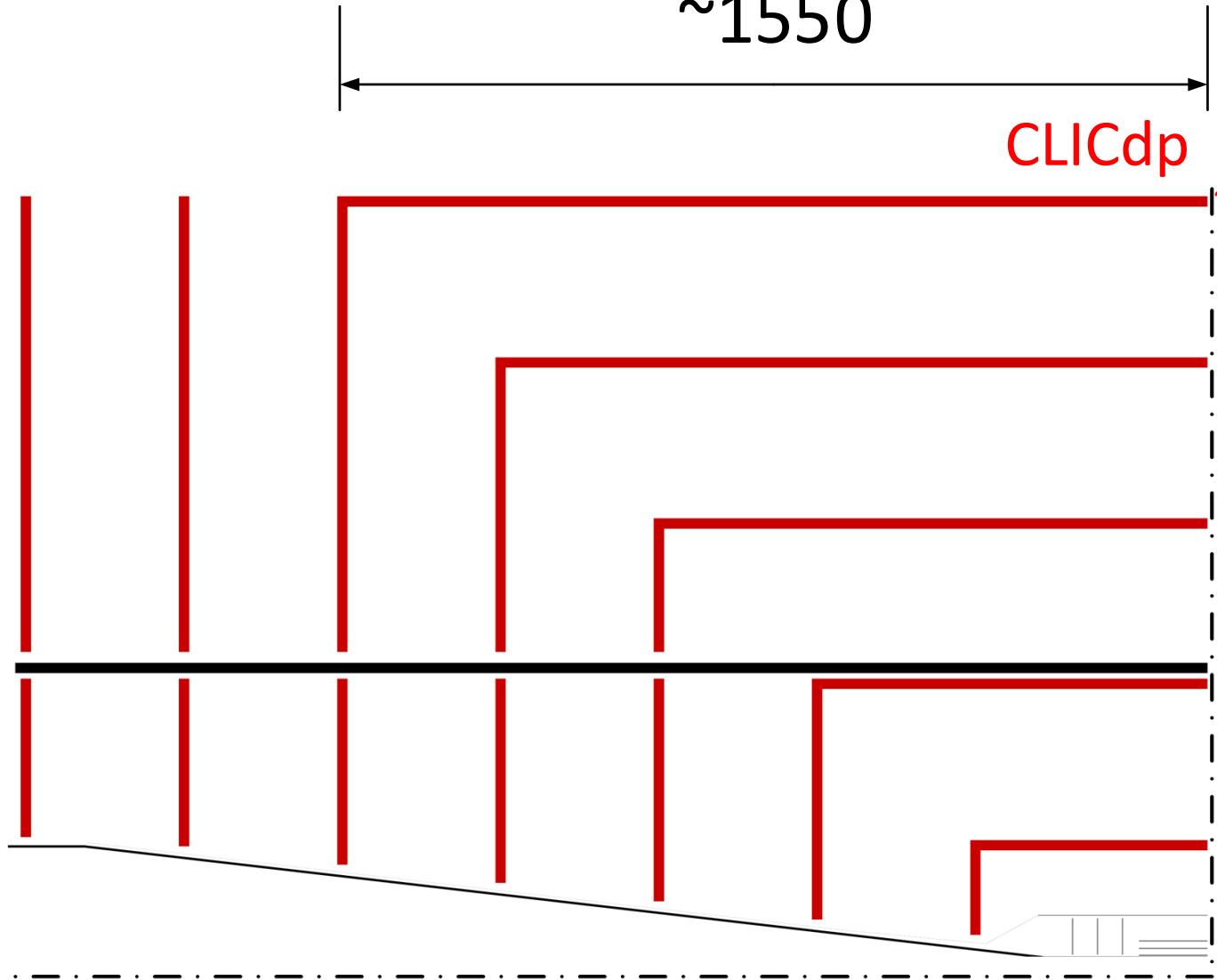
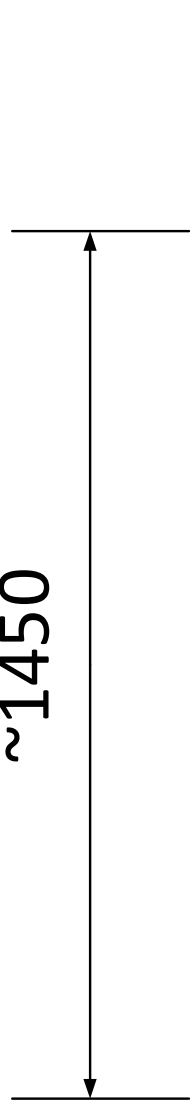
# Tracker size comparison

~1550

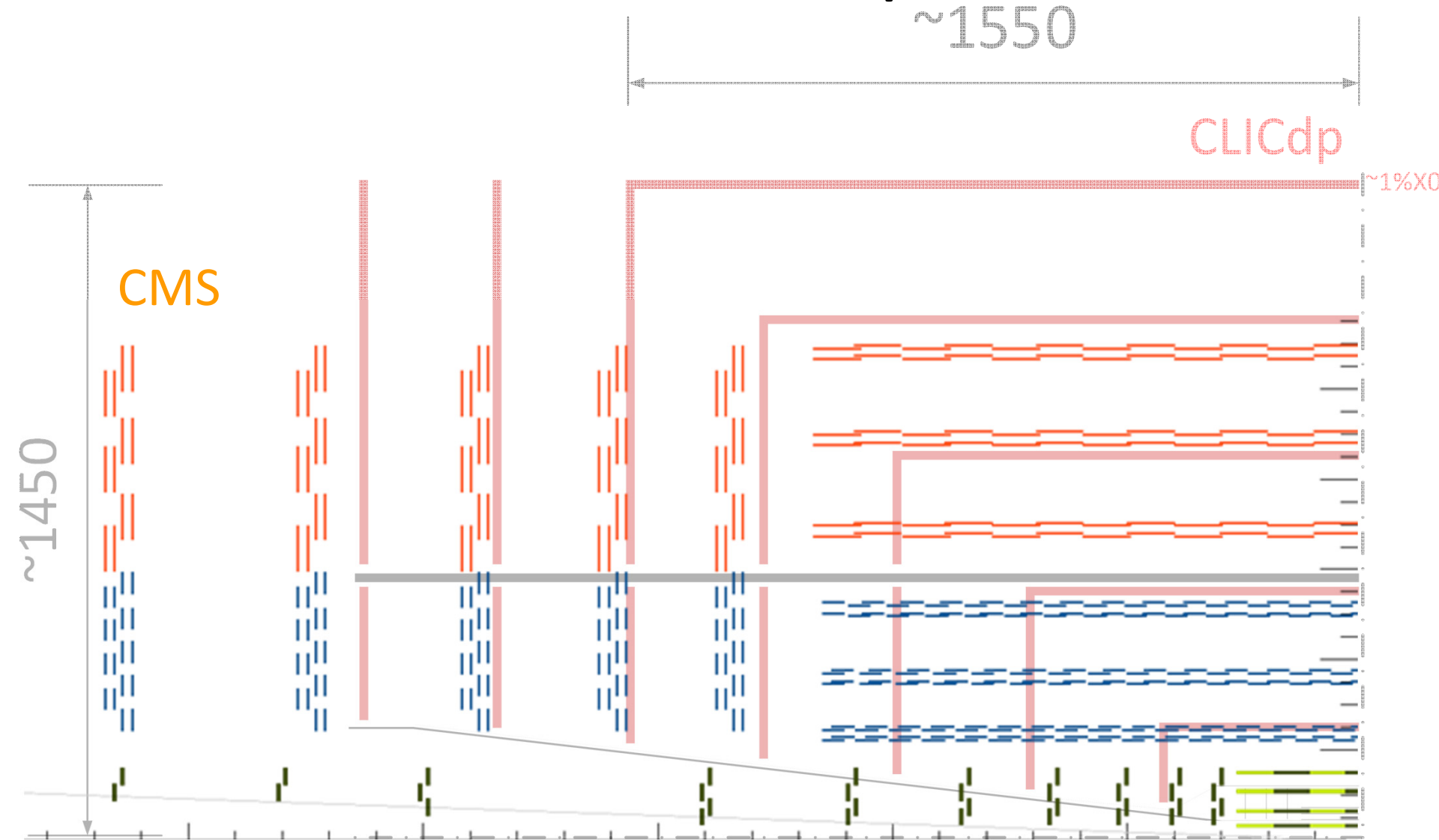
CLICdp

~1% $\times$ 0

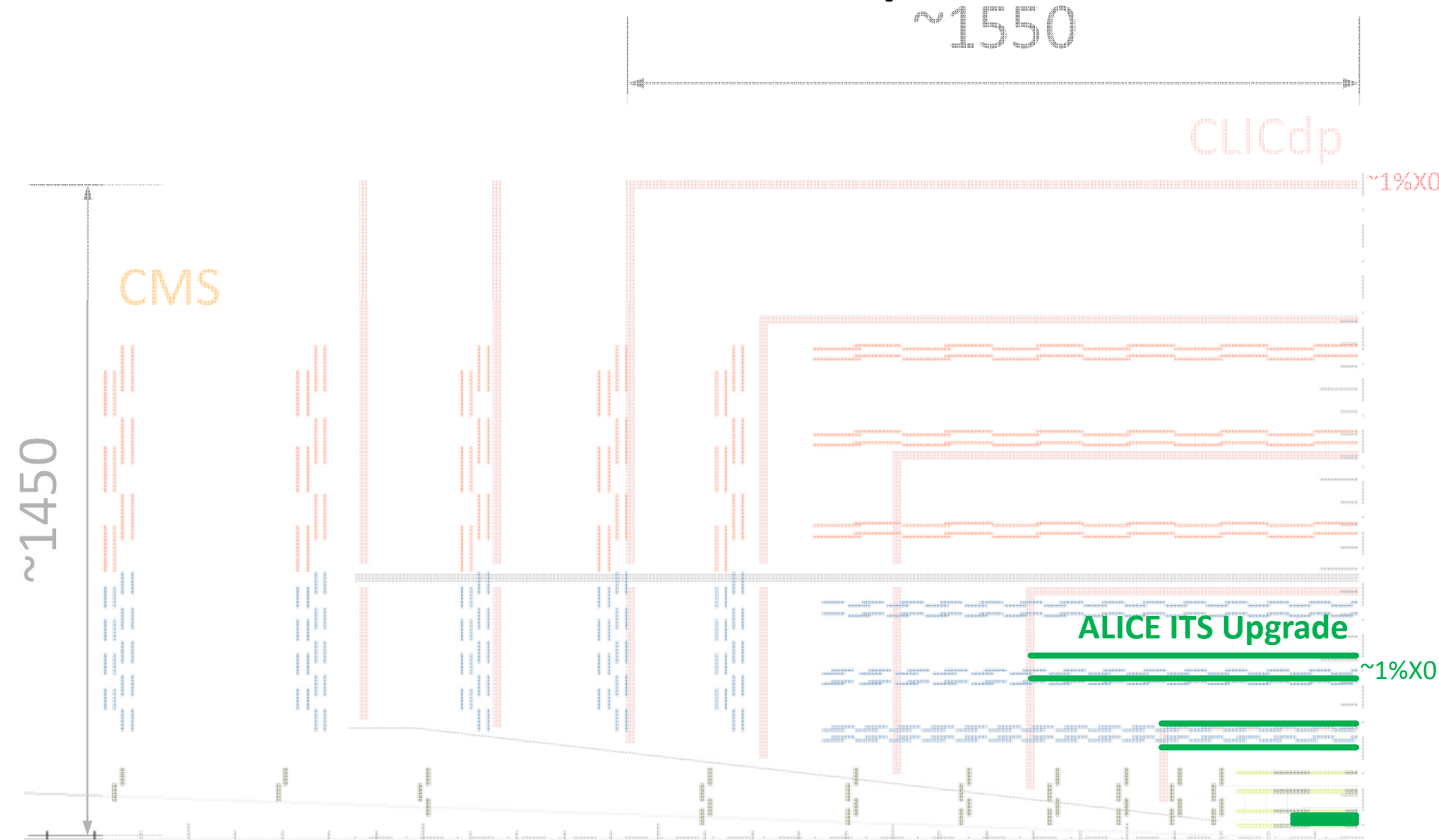
~1450



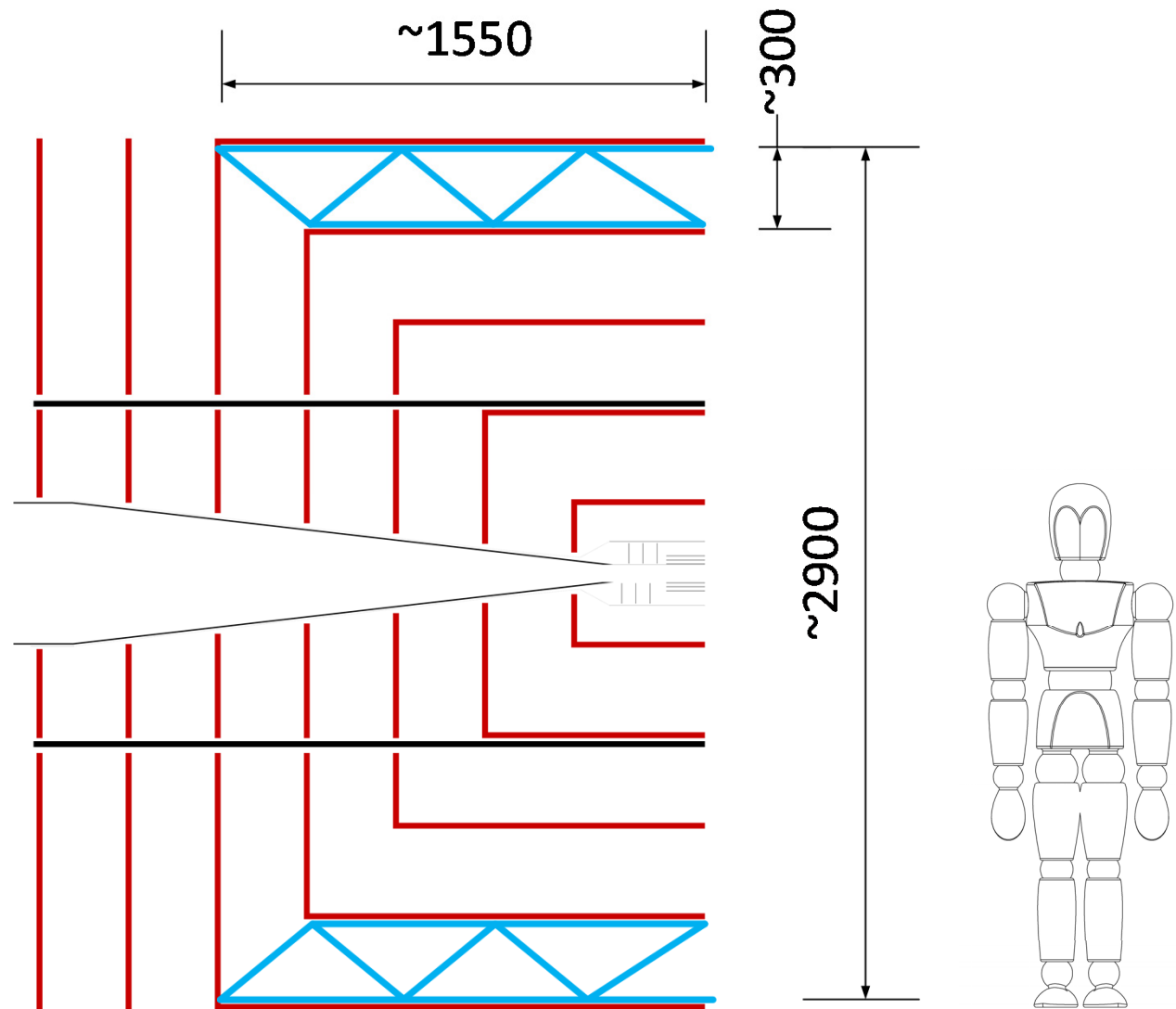
# Tracker size comparison



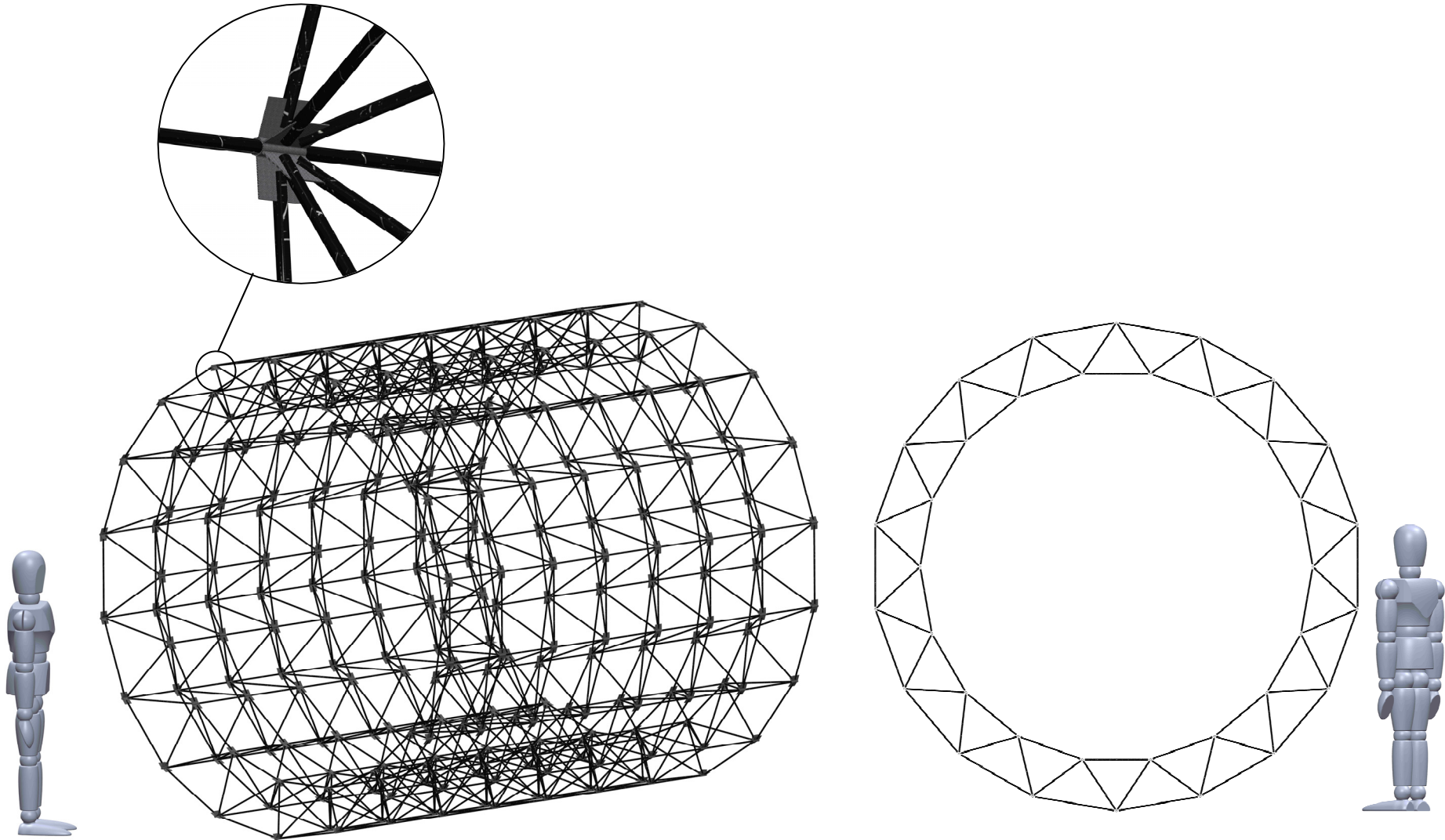
# Tracker size comparison



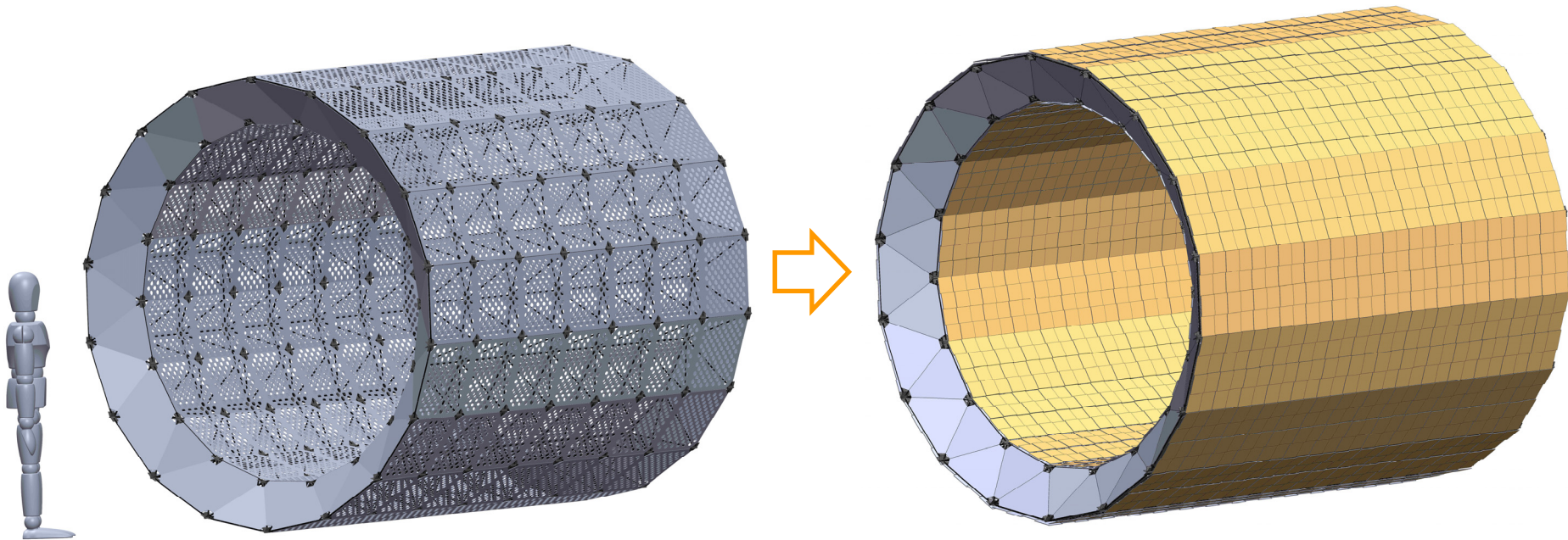
# Concept



# Lightweight tracker support

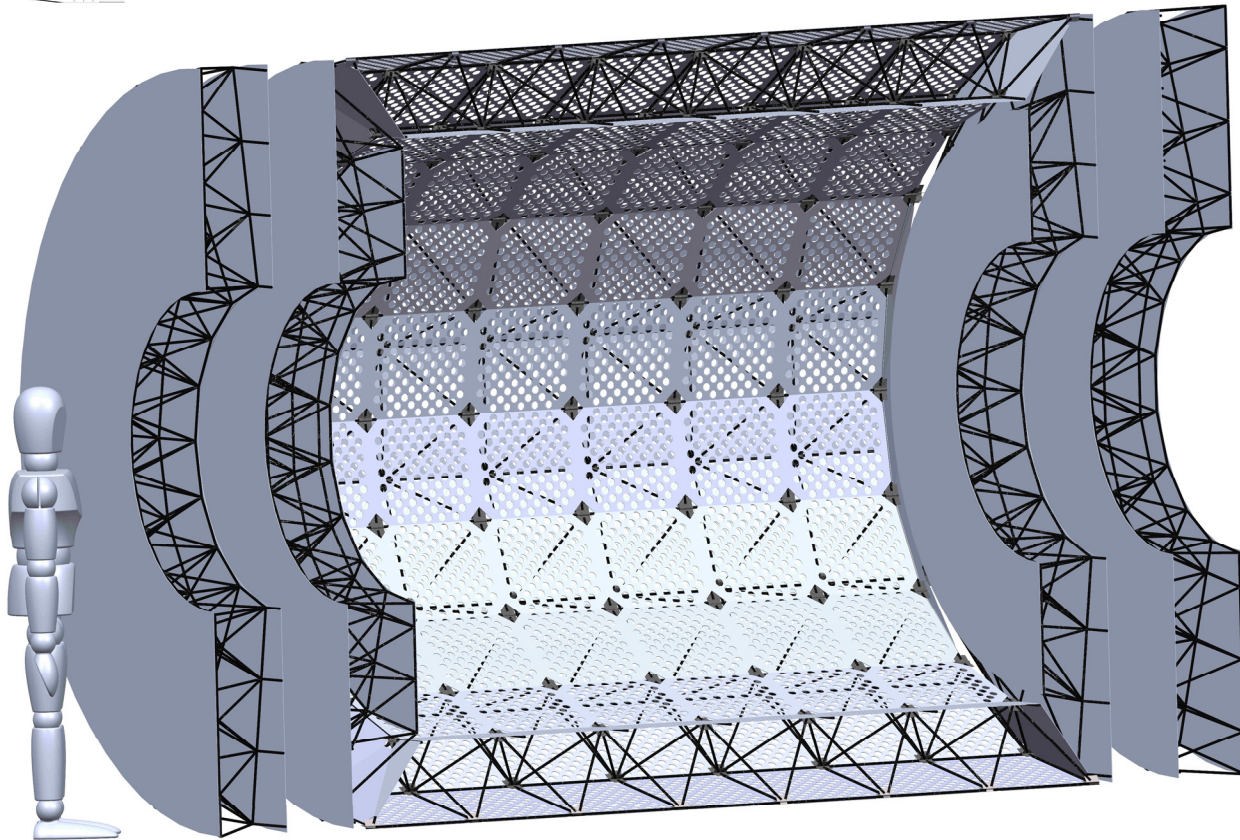
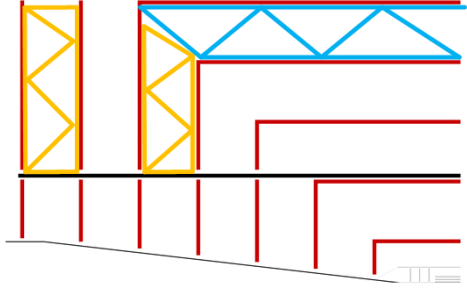


# Lightweight tracker support





# Lightweight tracker support



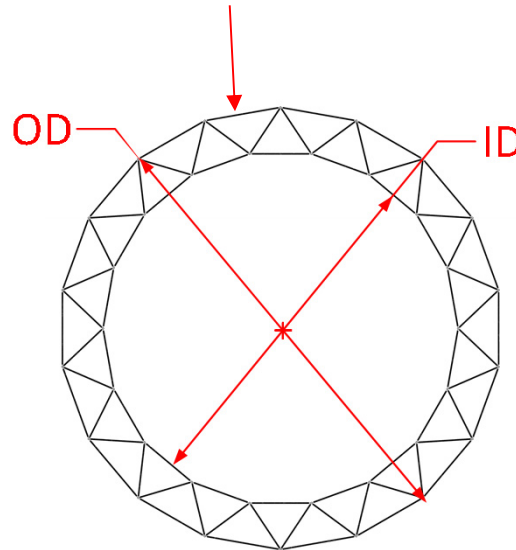
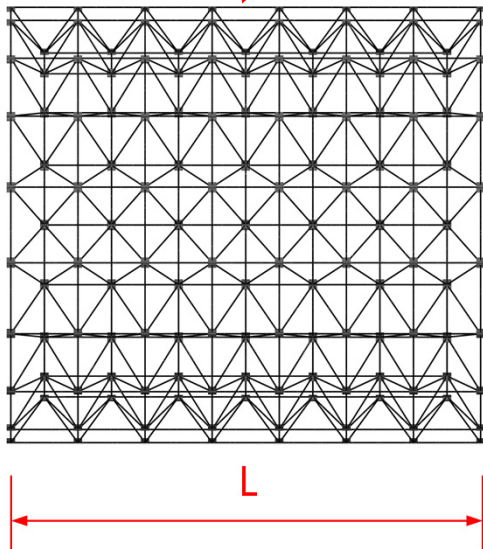
# Layout optimization

## Parameters

# elements along length

# elements along circumference

CFRP tube thickness



## Constants

$ID_{truss} = 2290\text{mm}$ ;  $OD_{truss} = 2900\text{mm}$ ;  $L_{truss} = 3122\text{mm}$

Outer diameter of tube – 10mm

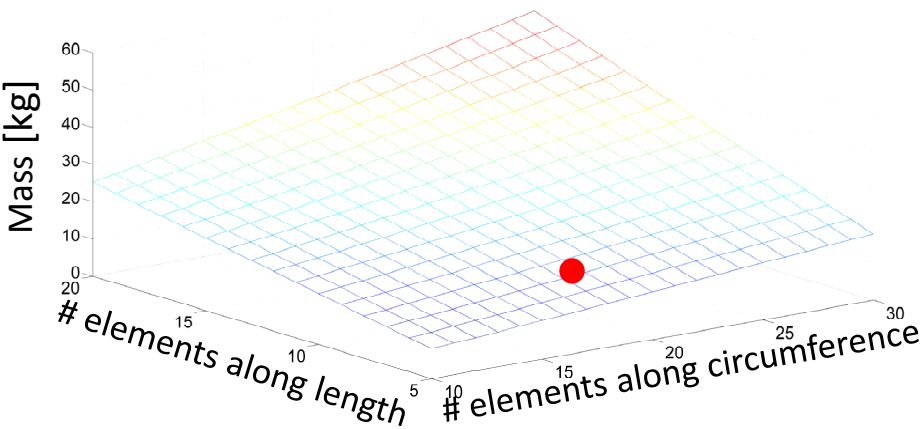
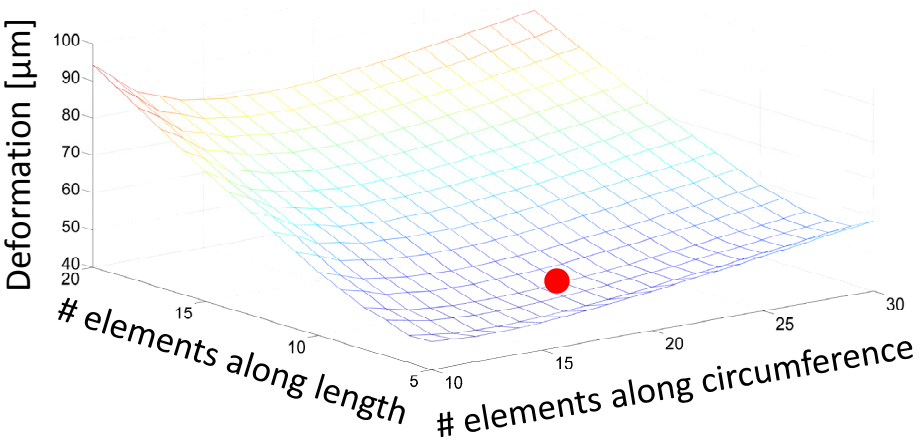
Node mass – 14gm

Mass of outer radius modules – 92kg

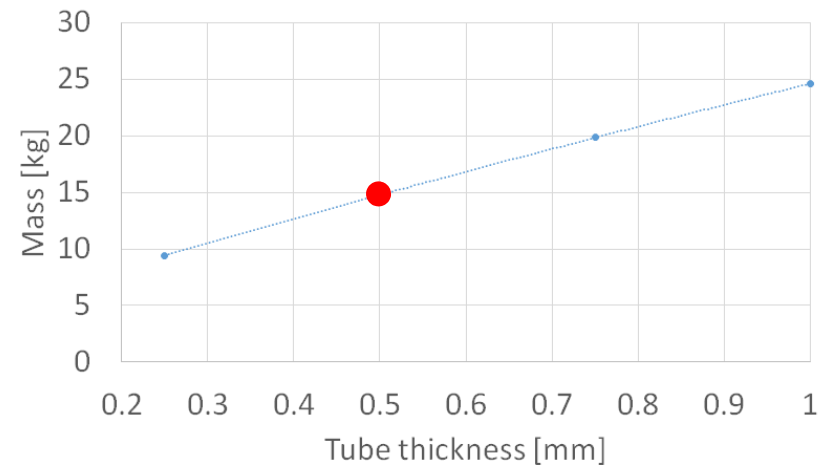
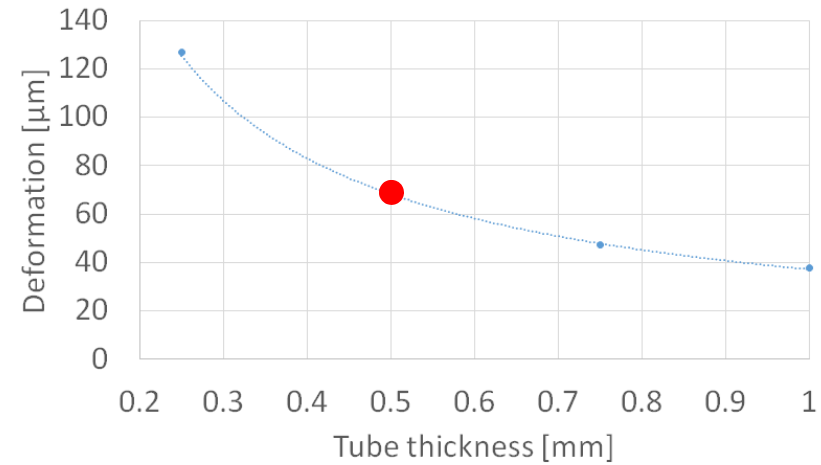
Mass of inner radius modules – 60kg

# Layout optimization

For a tube thickness of 0.5mm

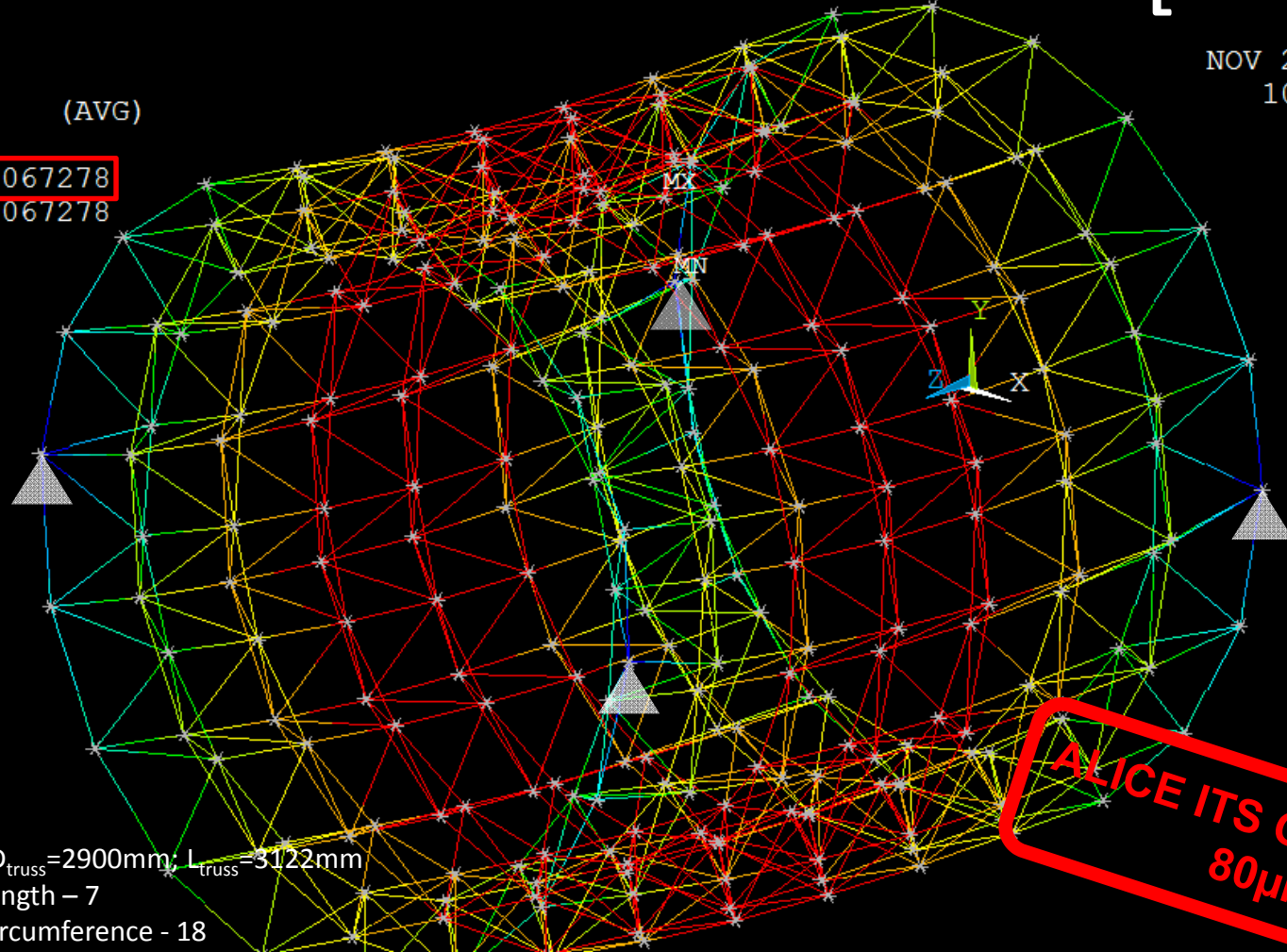


For 7 elements along the length and 18 elements along the circumference



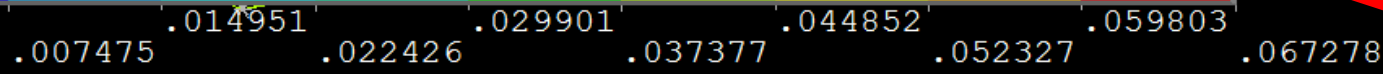
# 1 First deformation estimate [mm]

NORMAL SOLUTION  
STEP=1  
SUB =1  
TIME=1  
USUM (AVG)  
RSYS=0  
DMX = .067278  
SMX = .067278



**ALICE ITS OB upgrade  
80µm**

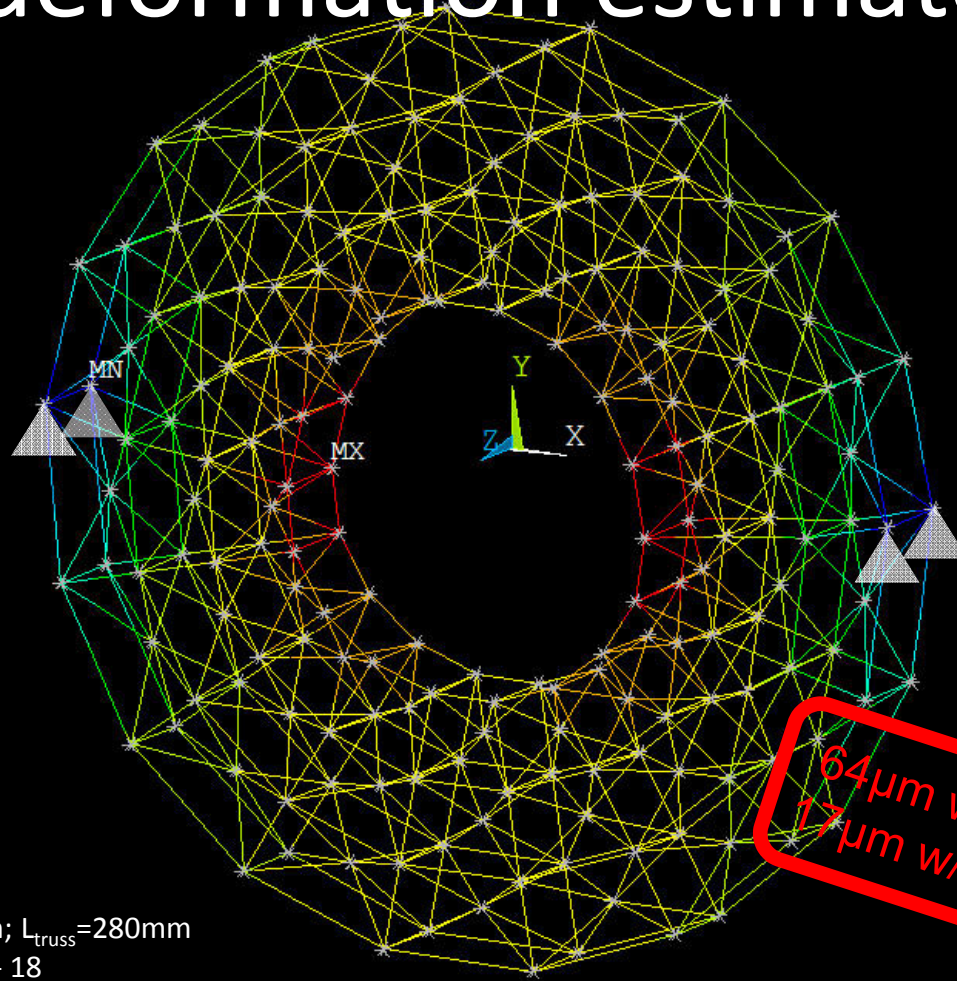
ID<sub>truss</sub> = 2290mm; OD<sub>truss</sub> = 2900mm; L<sub>truss</sub> = 3122mm  
# elements along length - 7  
# elements along circumference - 18  
Outer diameter of tube - 10mm  
Thickness of tube - 0.5mm  
Node mass - 14gm  
Mass of outer radius modules - 92kg  
Mass of inner radius modules - 60kg



Truss Panel - Static Structural 3 (G5)

# 1 First deformation estimate [mm]

NOTAL SOLUTION  
STEP=1  
SUB =1  
TIME=1  
USUM (AVG)  
RSYS=0  
**DMX = .064297**  
SMX = .064297



64µm w/ mass of inner region  
17µm w/o mass of inner region

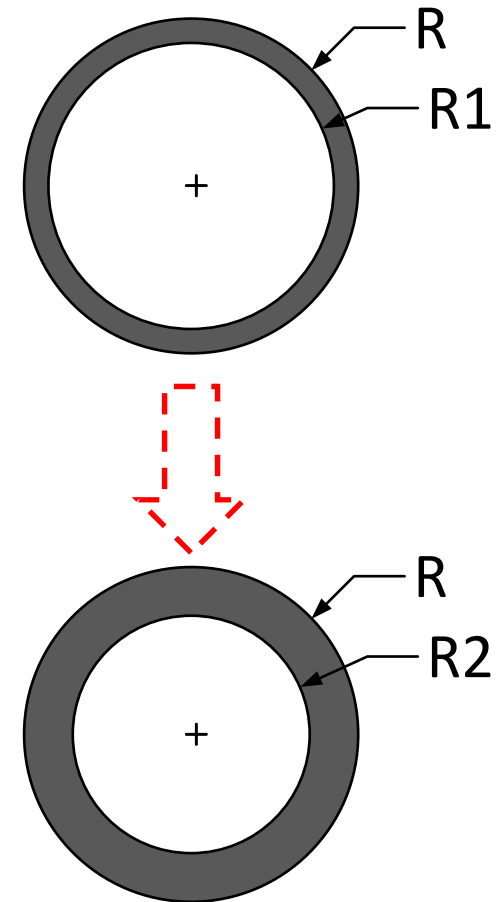
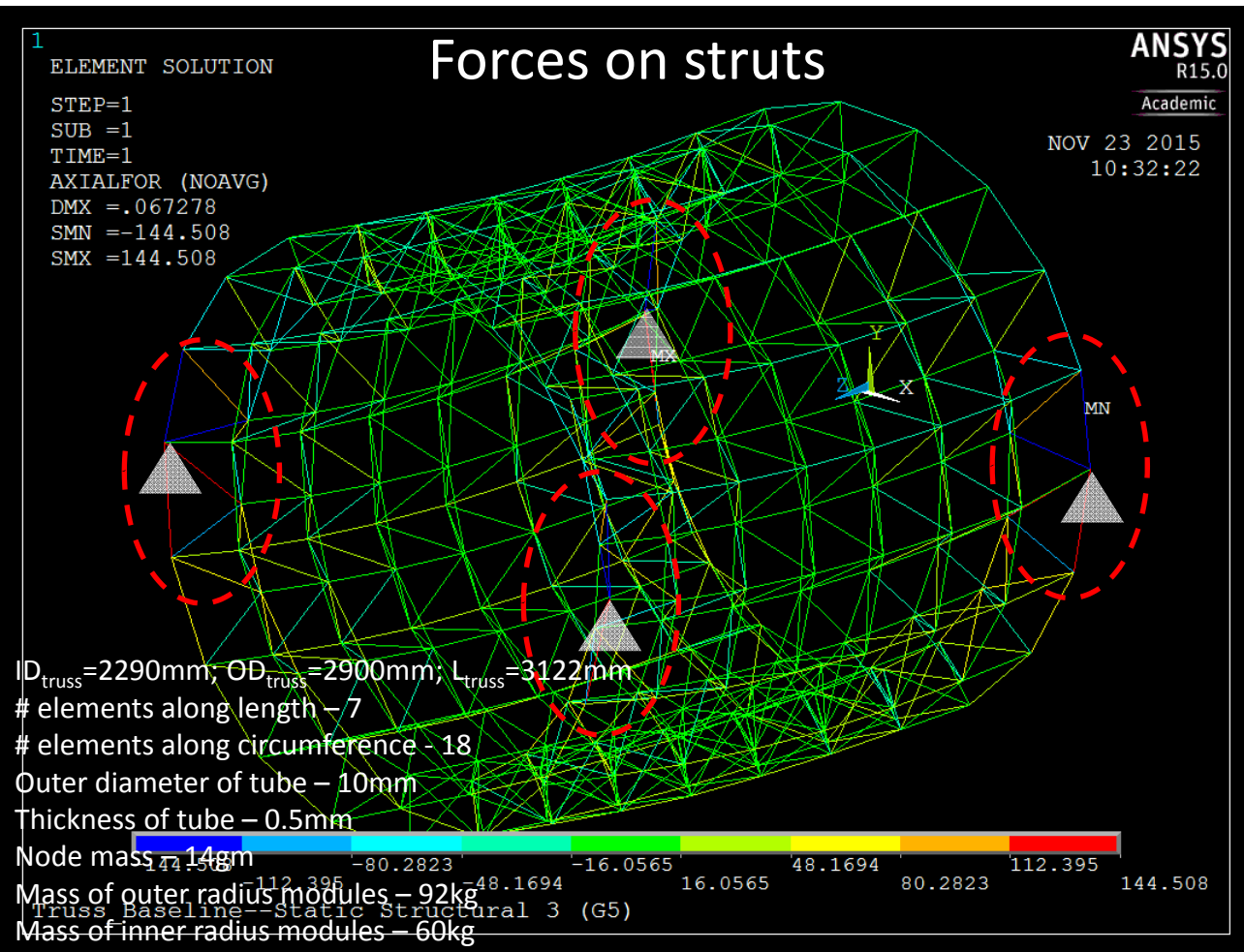
ID<sub>truss</sub> = 1210mm; OD<sub>truss</sub> = 2900mm; L<sub>truss</sub> = 280mm  
# elements along circumference - 18  
Outer diameter of tube - 10mm  
Thickness of tube - 0.5mm  
Node mass - 14gm  
Mass of modules - 70kg  
Mass of inner region - 300kg/2

Endcap Baseline--Static Structural (D5)

# Stiffness optimization

$$\delta_{truss} \propto k_{tube} = \frac{E_{CFRP} \times (A)}{L}$$

Rin=4.5mm / Rout=5mm  
everywhere in this model



# Stiffness optimization

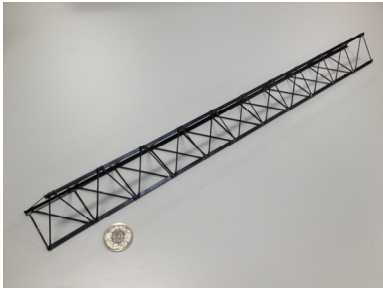
$$\delta_{truss} \propto k_{tube} = \frac{E_{CFRP} \times A}{L}$$



Fiber	Tensile modulus – E <sub>f</sub> [GPa]
T300	230
M55J	540
K13D-2U	935

Used for the previous simulation

# Material budget per layer



## Reference

Component	Material budget
ALICE ITS upgrade OB stave	<b>0.123%</b>



## Option #1

Component	Material budget
Sandwich cylinder	<b>1.11%</b>

## Option #2

Component	Material budget
Nodes	0.019%
CFRP Tubes	0.063%
Sandwich panels	0.043%
<b>TOTAL</b>	<b>0.125%</b>

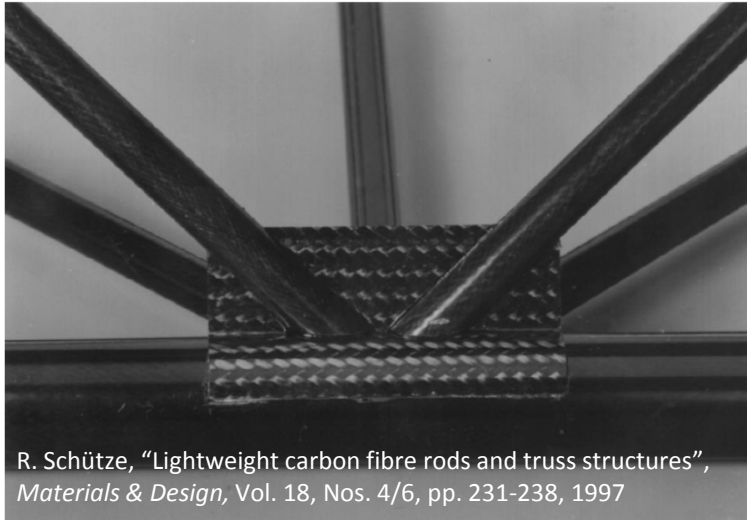
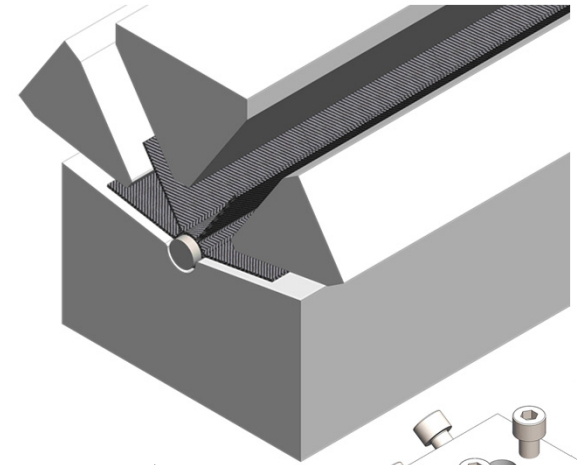
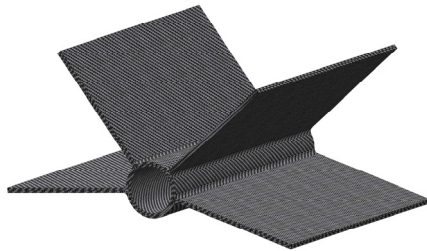
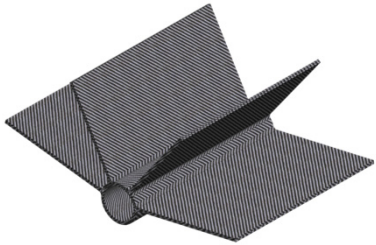




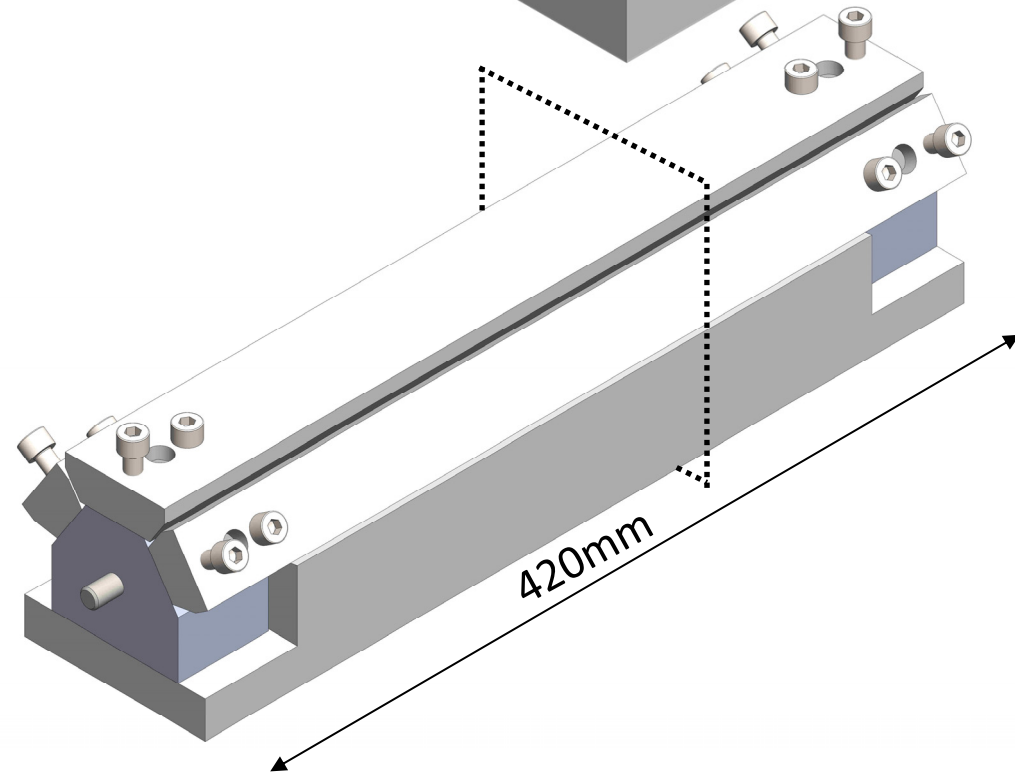
# Tooling – CFRP barrel nodes

Outer Radius Node

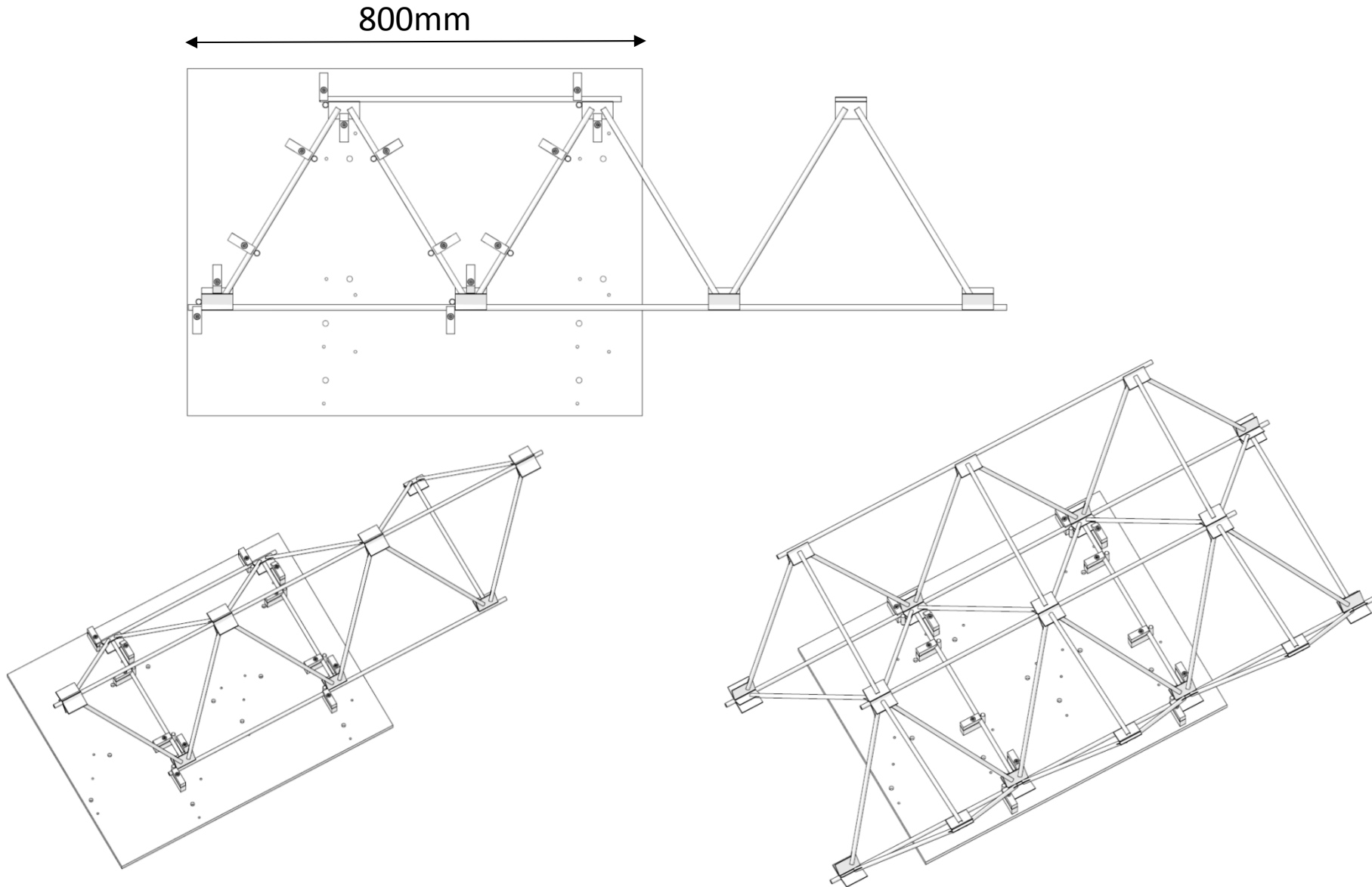
Inner Radius Node



R. Schütze, "Lightweight carbon fibre rods and truss structures",  
*Materials & Design*, Vol. 18, Nos. 4/6, pp. 231-238, 1997

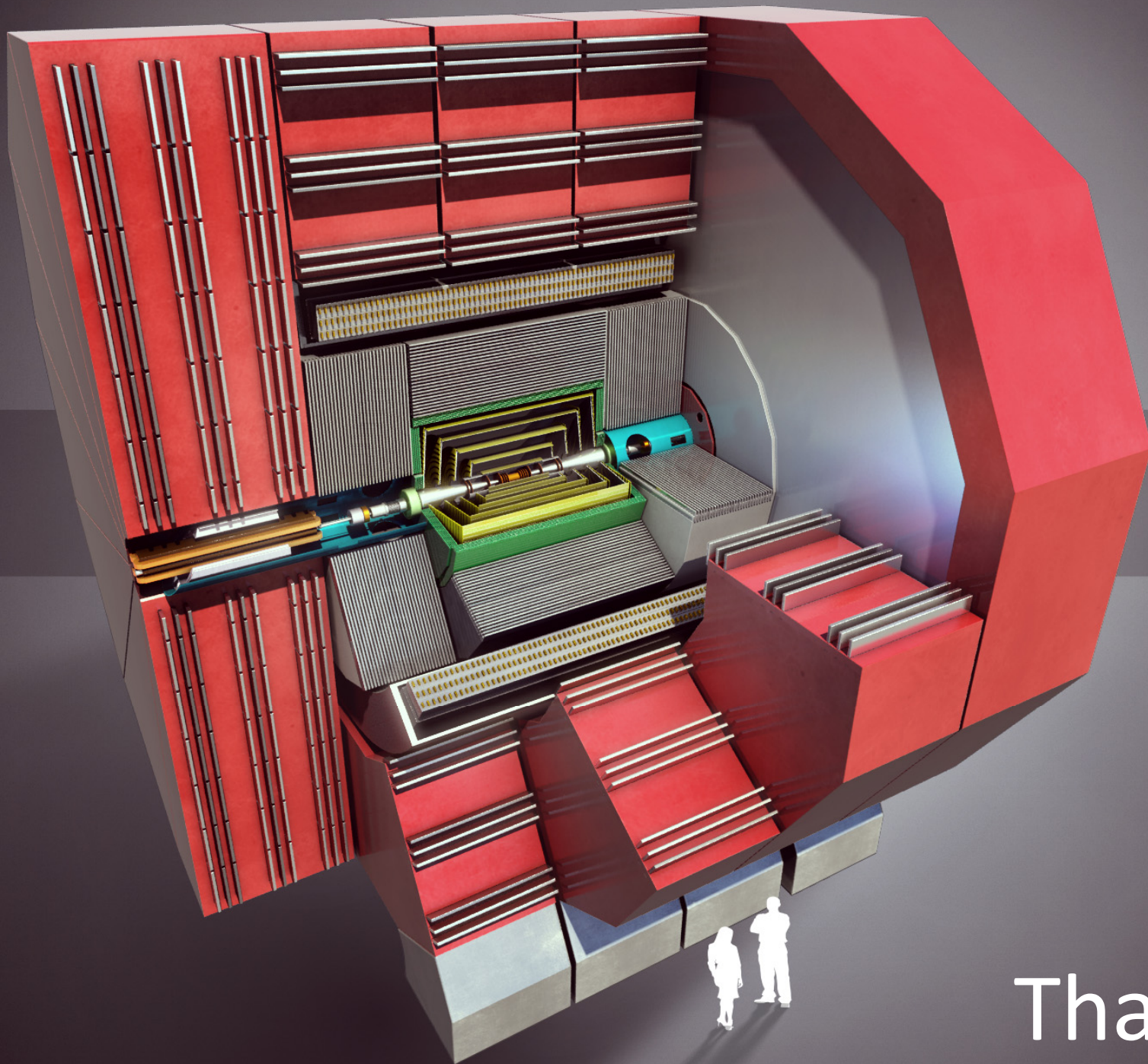


# Tooling – barrel space frame



# Summary

- A lightweight support structure concept for the outer tracker layers (barrel & endcaps) has been shown;
- First estimations of stiffness/material budget are comparable with ALICE ITS OB upgrade;
- Work is ongoing towards the prototyping of nodes and assembly of a portion of the barrel space frame.

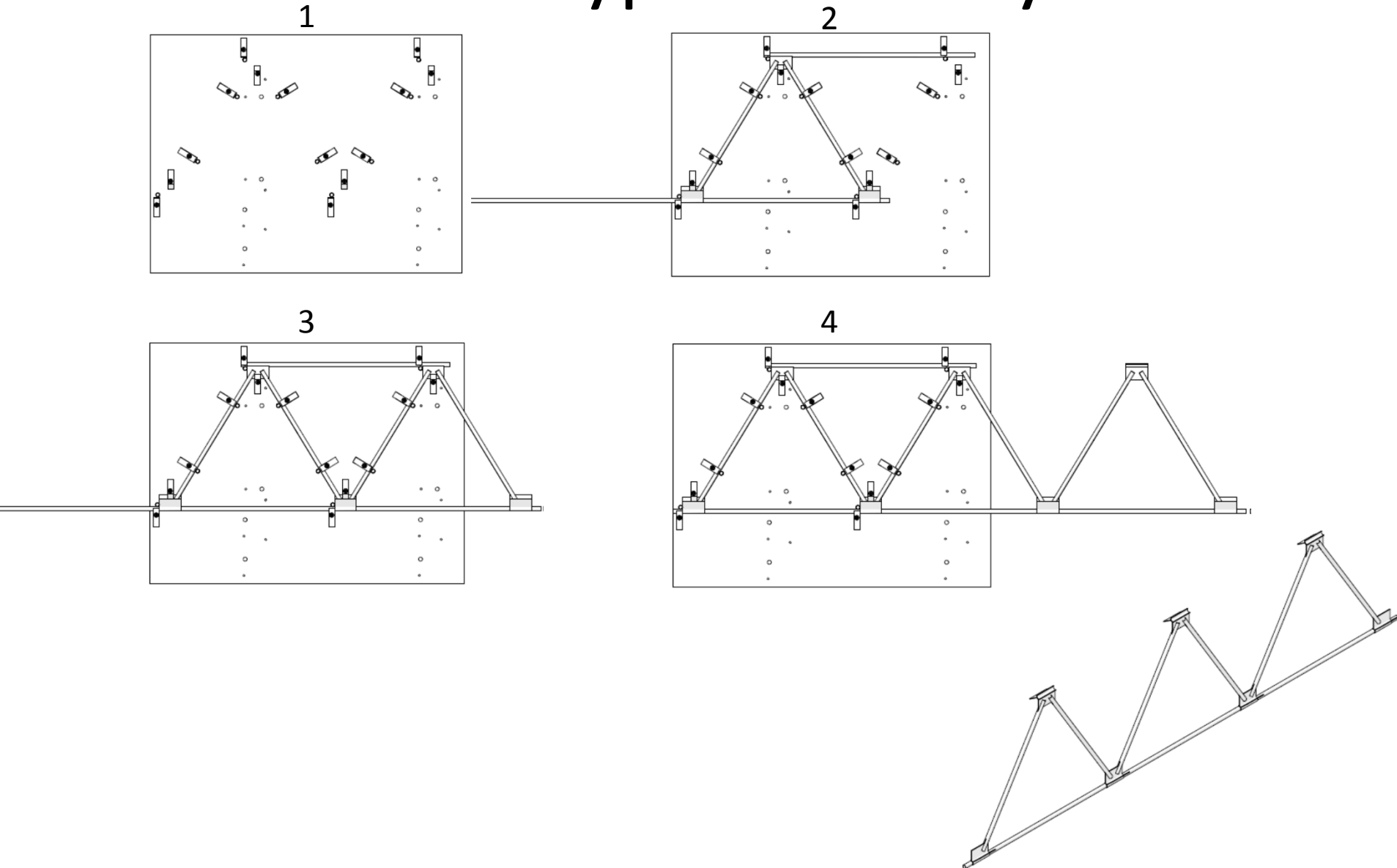


Detector

Thank you

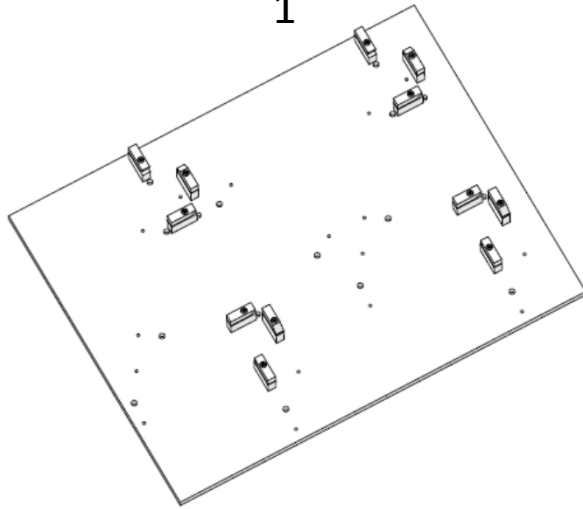
Spare slides

# Prototype assembly

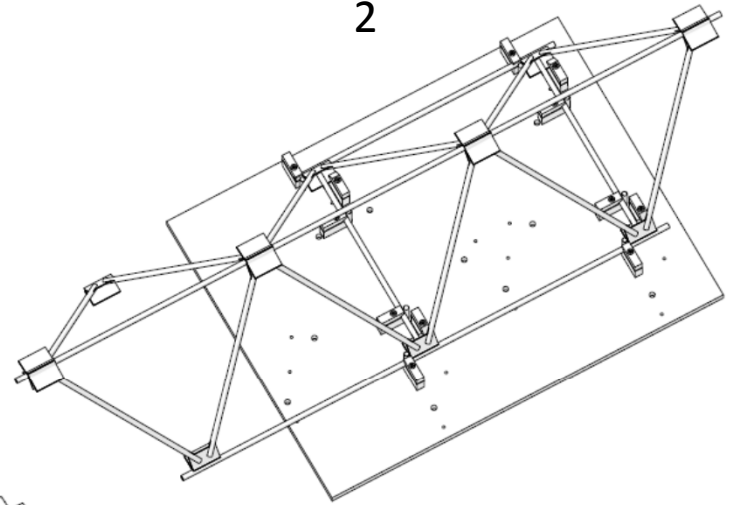


# Prototype assembly

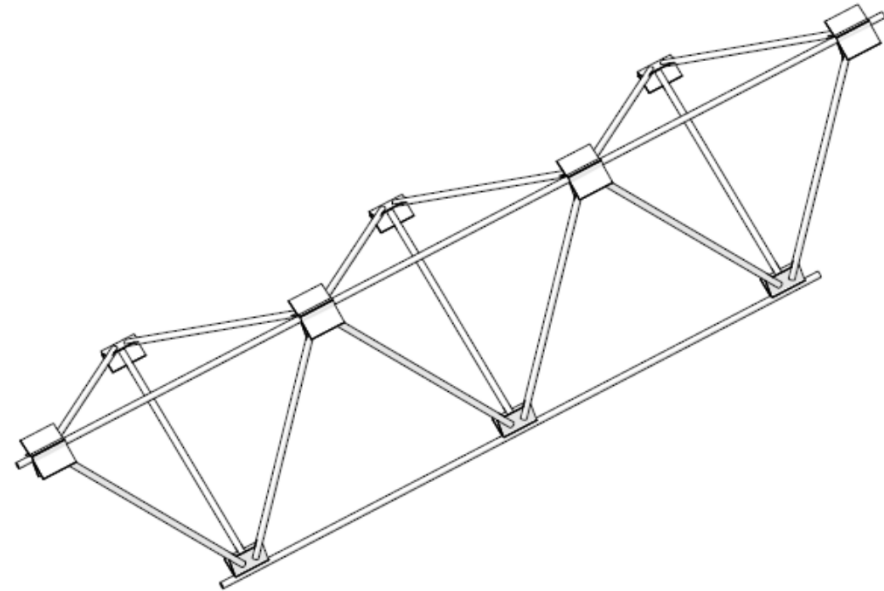
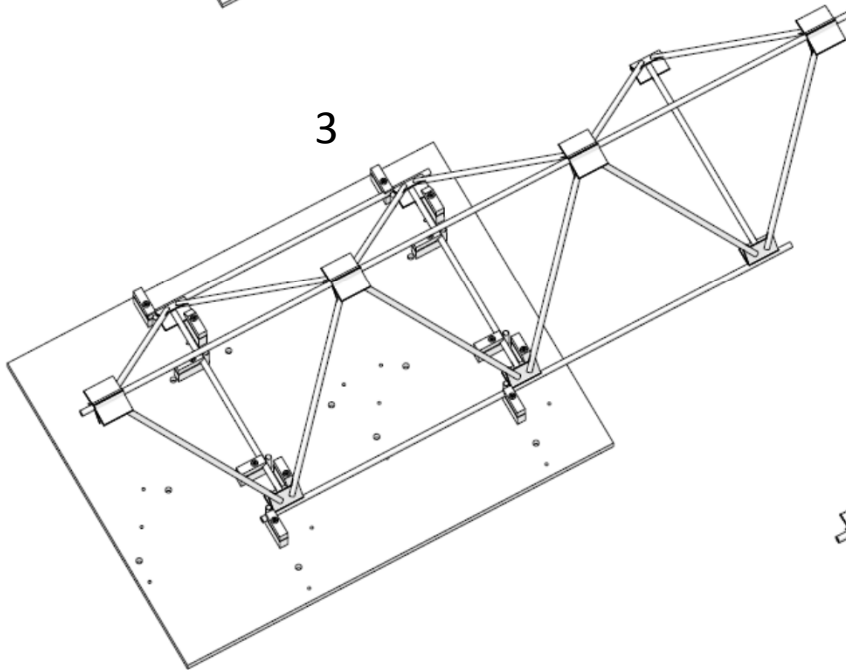
1



2



3



# Prototype assembly

