



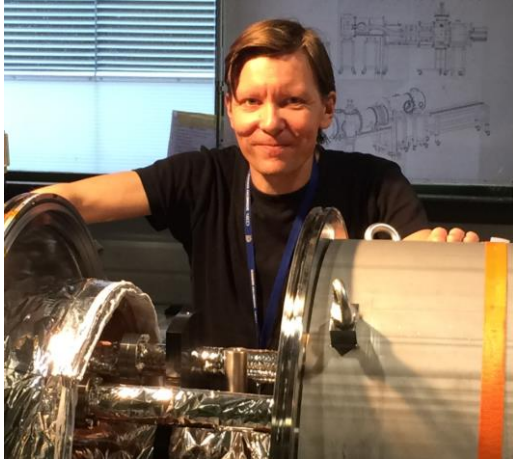
# Mechanical engineering of accelerator and detector components

Antti Kolehmainen EN-MME  
Mikko Barinoff EP-CMX  
Taneli Mutanen TE-MS

Finnish High-School Students visits program

# WHO WE ARE

**Antti**



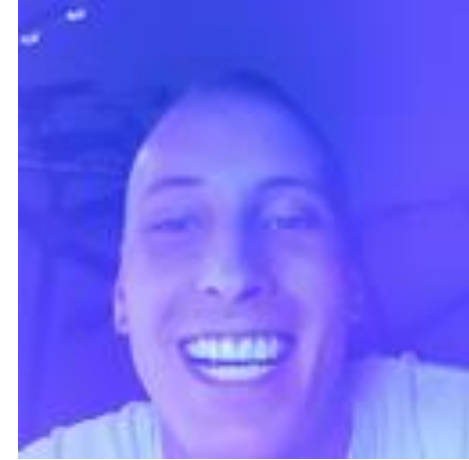
- Mechanical designer in Engineering Department
- BSc in engineering 2004, Jyväskylä
- CERN since 2012
- 10 years in industry prior to CERN

**Mikko**



- Mechanical engineer in the Experimental Physics department
- MSc in mechanical engineering 2021, Aalto university
- At CERN since 2019

**Taneli**



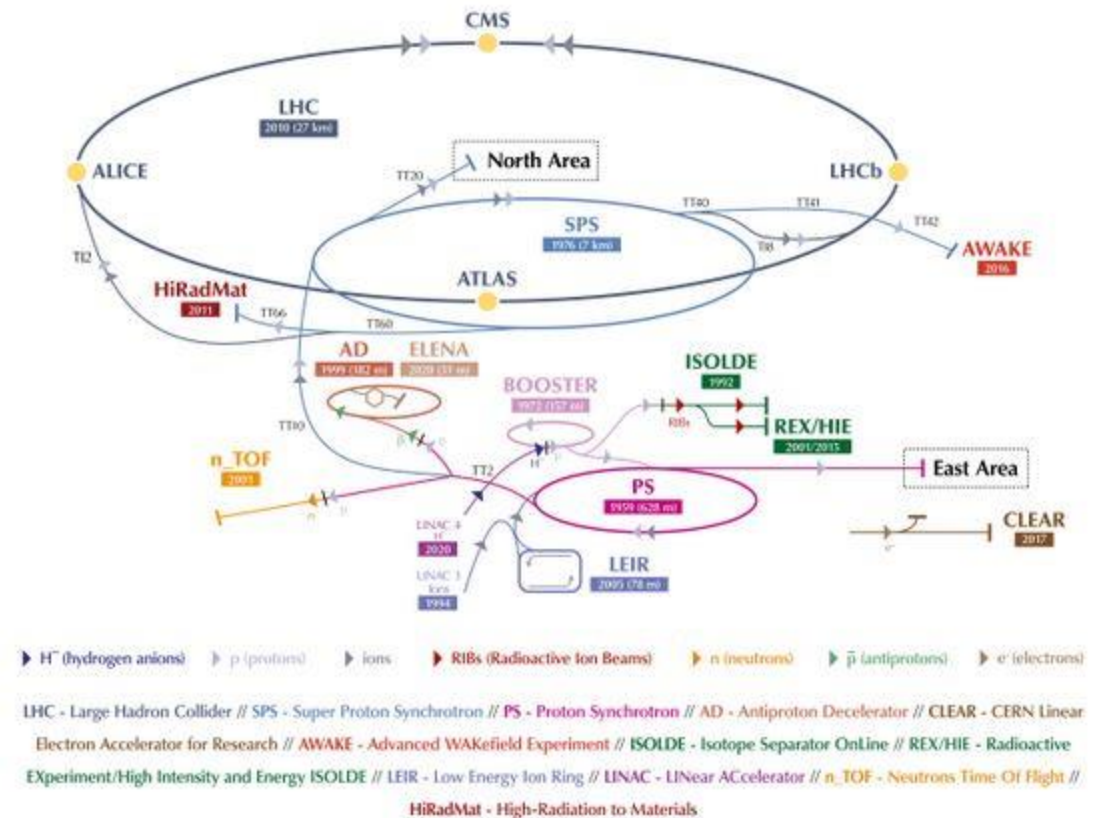
- Micromechanic in the Technology Department
- Micromechanics 2021, Finnish School Of Watchmaking
- At CERN since 2022

# WHAT WE DO?

## Antti

- Mechanical design of components for the accelerator complex
- Small tasks
- Larger design projects
- 3D & 2D
- Calculations
- Fabrication follow-up
- Installation

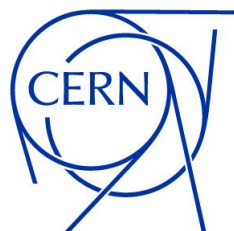
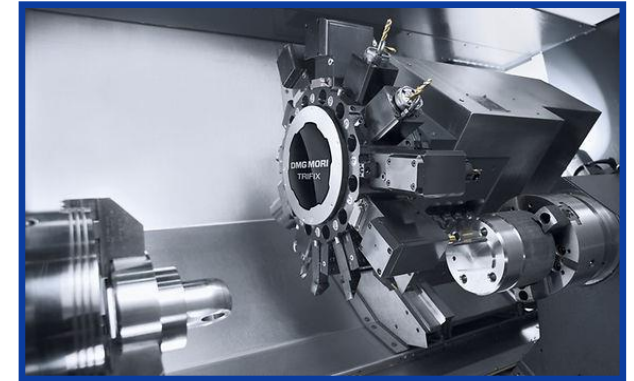
The CERN accelerator complex  
*Complexe des accélérateurs du CERN*



# WHAT WE DO?

## Taneli

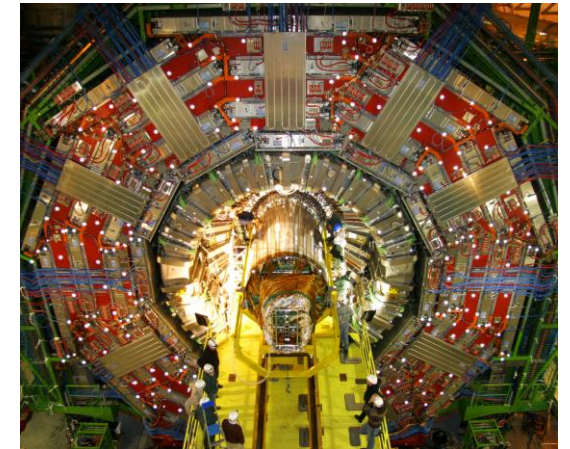
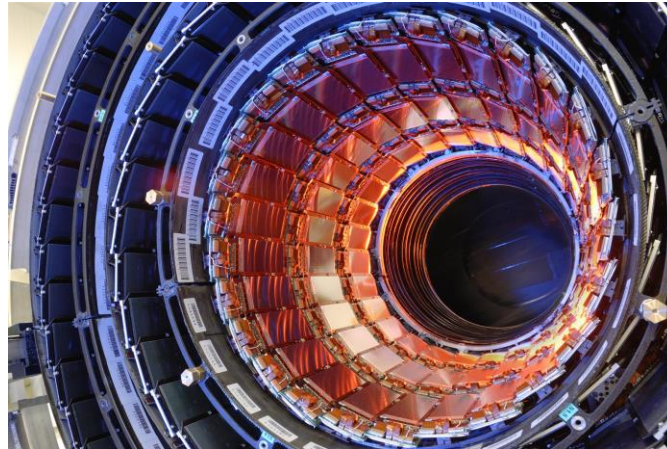
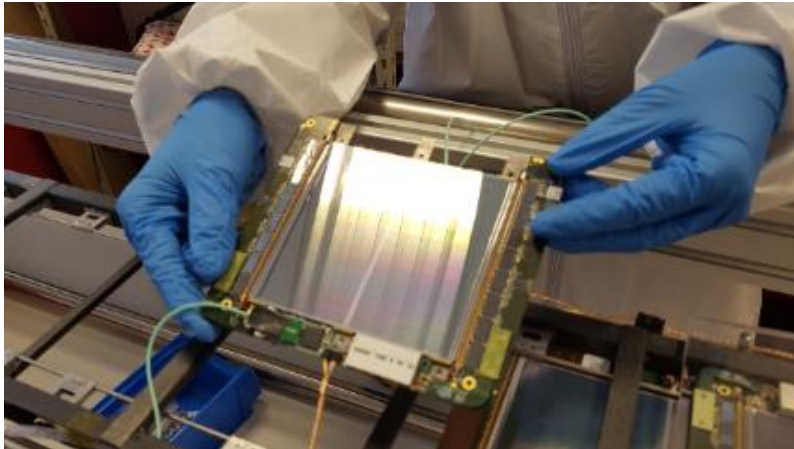
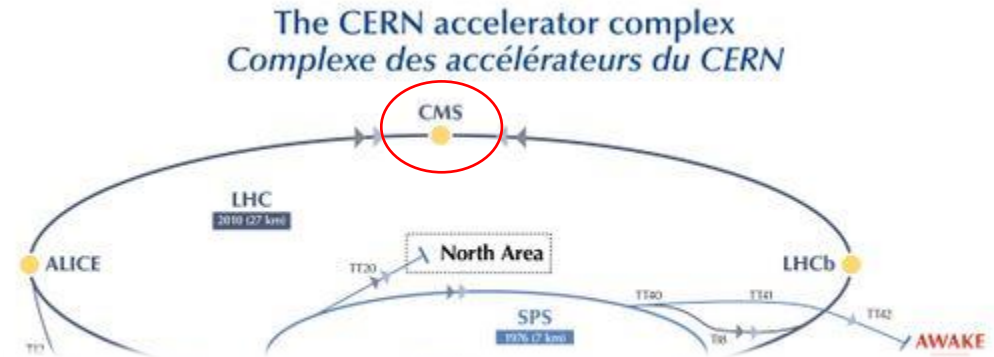
- Manufacturing of prototype components for superconductive accelerator magnets and other projects
- TE-MS-C-specialist in machining
- Programming and operating computer programmable manufacturing robots
- Manufacturing related consultation to help engineers and designers
- 2D&3D Mechanical design of components



# WHAT WE DO?

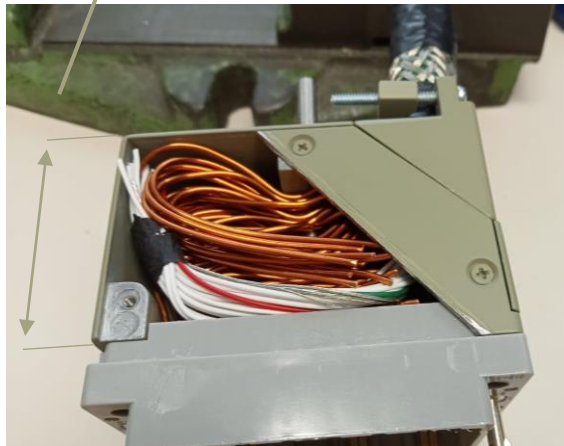
## Mikko

- Mechanical design & construction work for the Phase-2 upgrade of the CMS Tracker
- Tasks vary from high precision micromechanics to heavy handling equipment



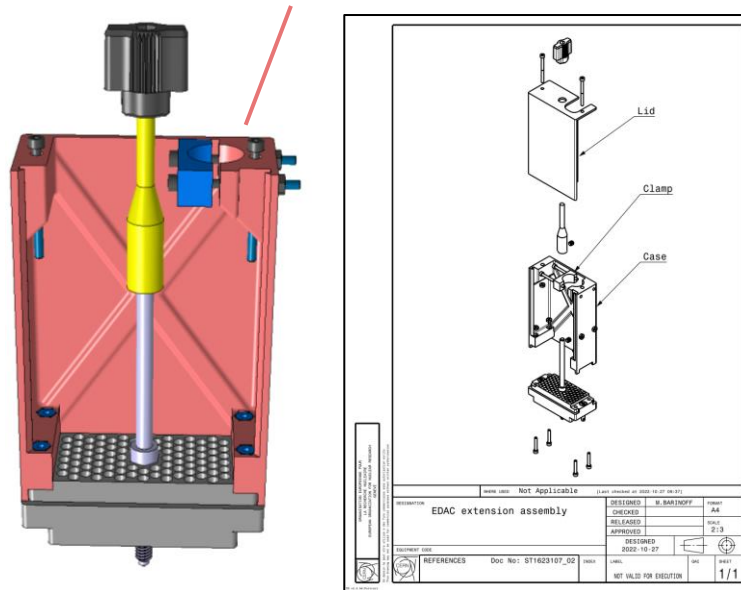
# DESIGN ENGINEERING – daily tasks

Not enough space to terminate the wires in the stock connector shell



**Day 1:** Understanding the problem

Custom design extended shell



**Day 2:** Doing the 3D-design and drawings

3D-printed protos



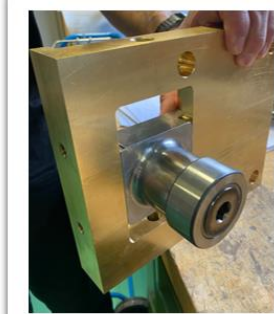
**Day 3:** Prototypes on the desk ready to be tested

# DESIGN ENGINEERING – large projects

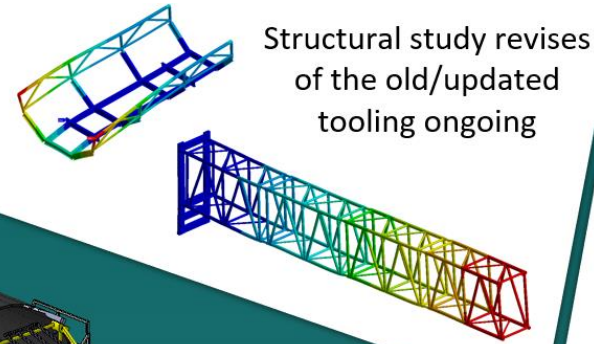
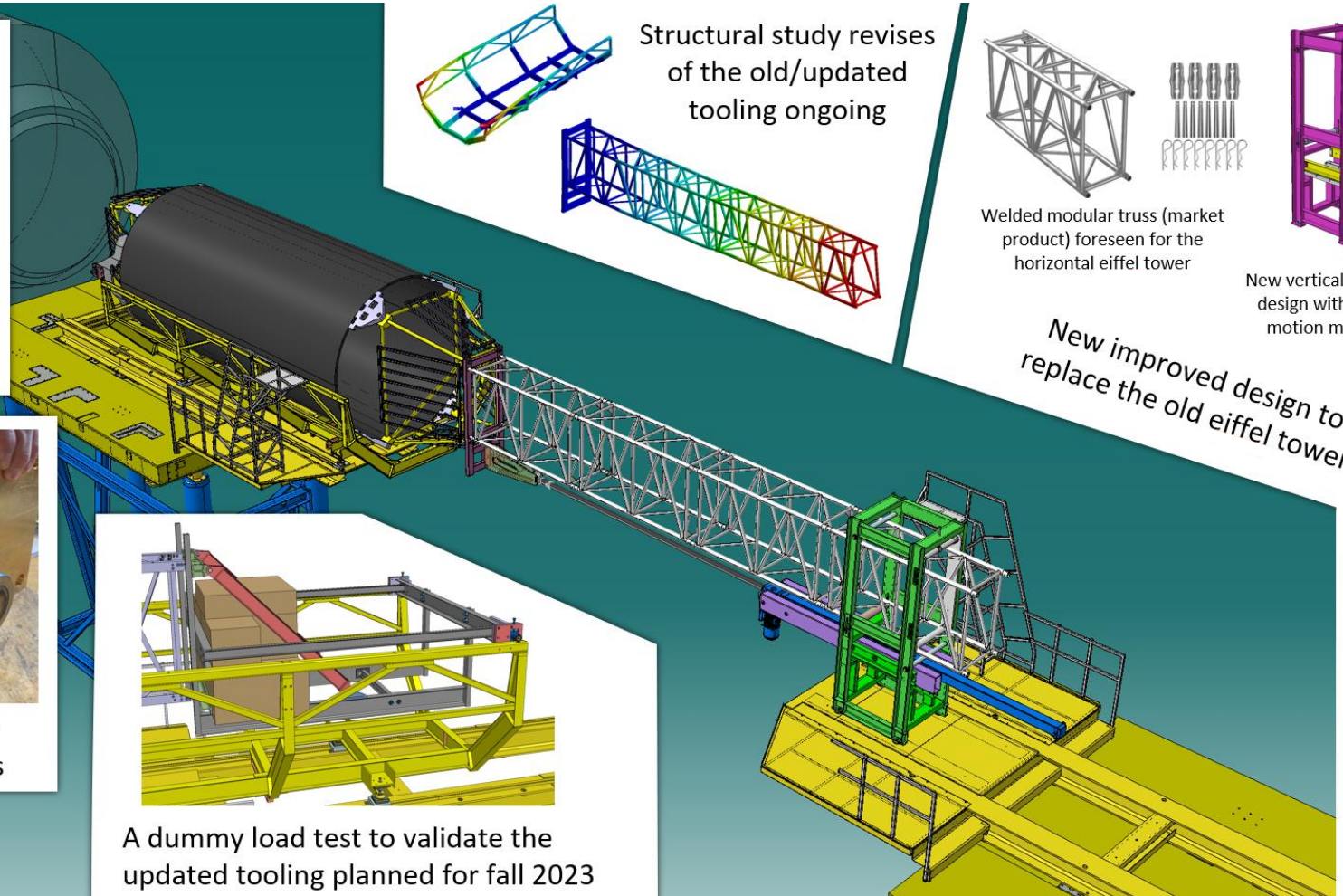
- 2021-2024:  
Re-engineering  
of CMS Tracker  
installation  
tooling
- Manipulation of  
heavy objects  
(6.5t) in mm-  
scale precision



New small ears



New big ear  
mechanisms



Structural study revises  
of the old/updated  
tooling ongoing

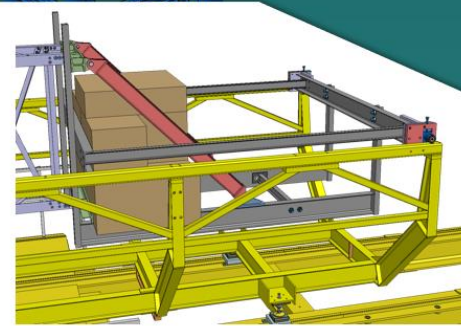


Welded modular truss (market  
product) foreseen for the  
horizontal eiffel tower



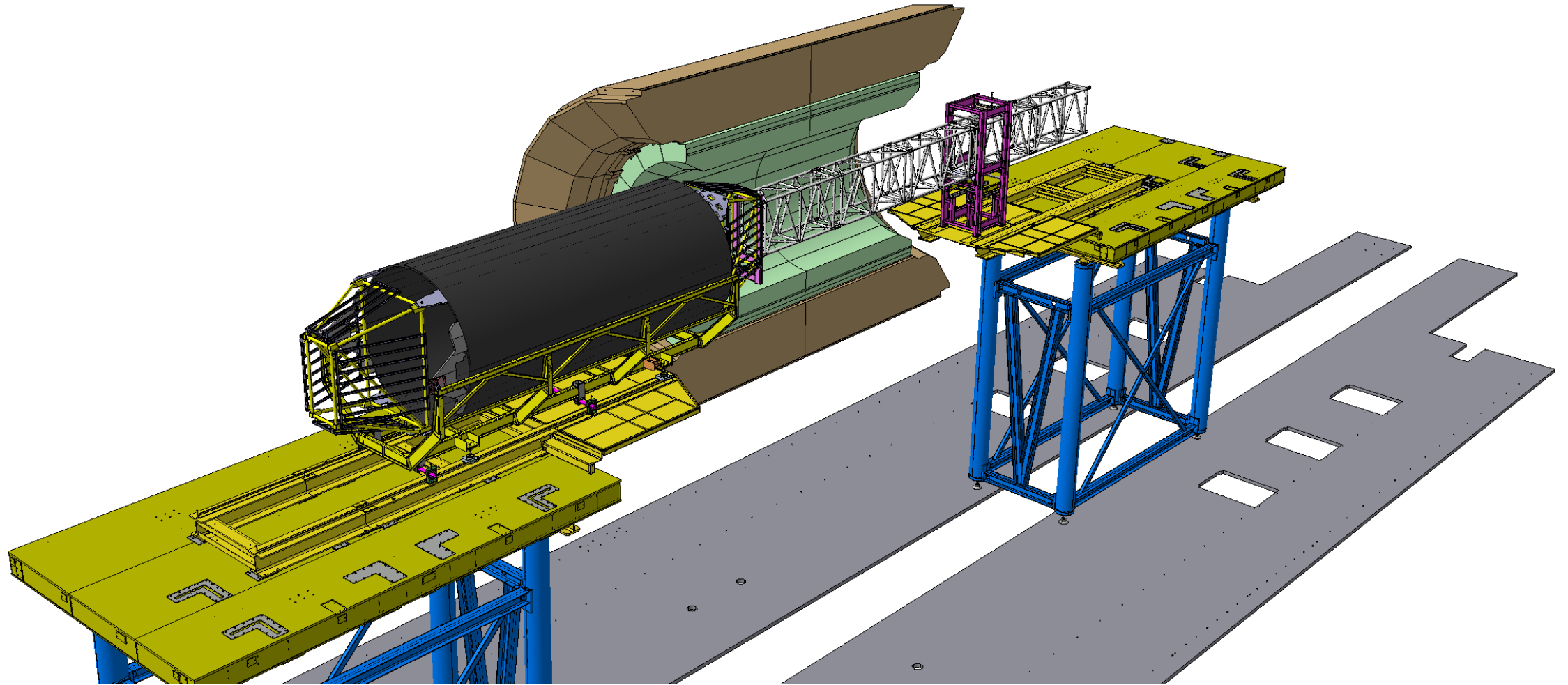
New vertical Eiffel tower  
design with improved  
motion mechanism

*New improved design to  
replace the old eiffel tower*



A dummy load test to validate the  
updated tooling planned for fall 2023

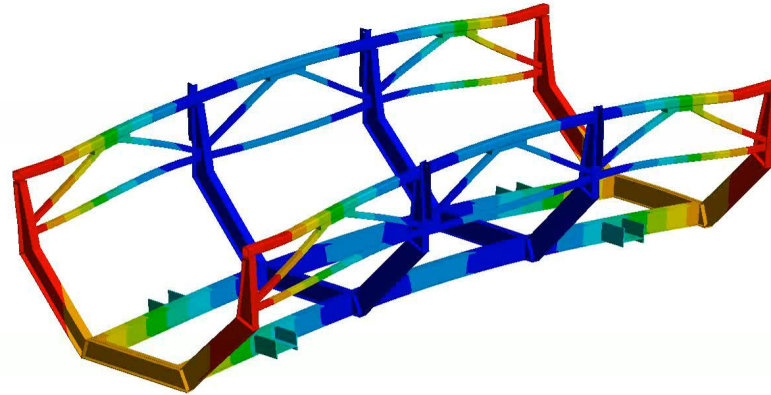
# DESIGN ENGINEERING – large projects



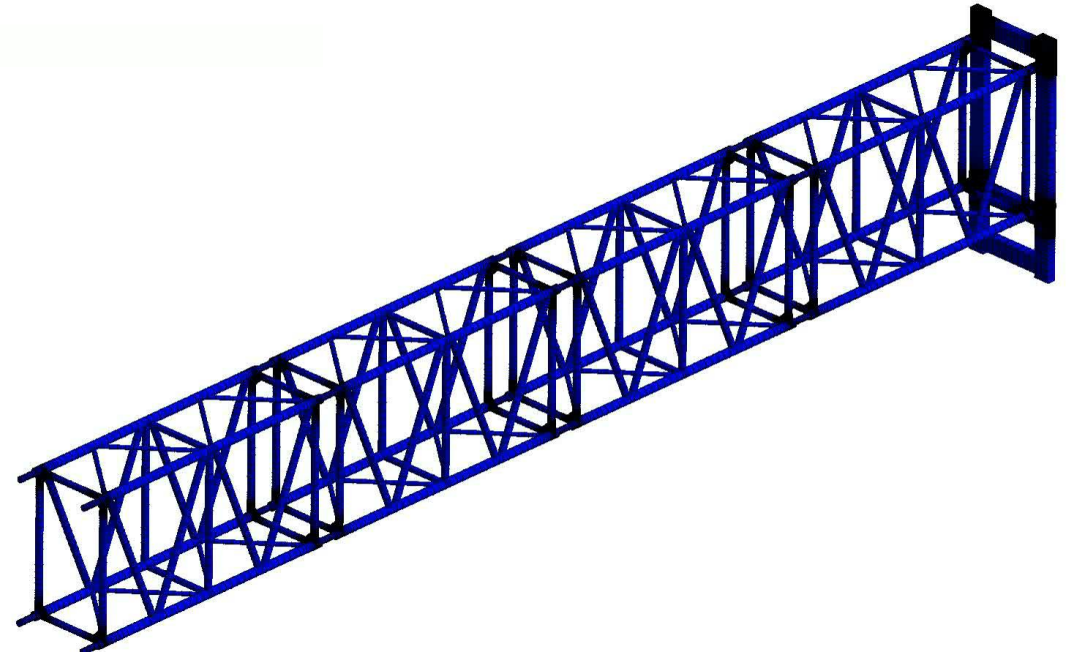


# DESIGN ENGINEERING – large projects

- 2021-2024:  
Re-engineering  
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installation  
tooling
- Manipulation of  
heavy objects  
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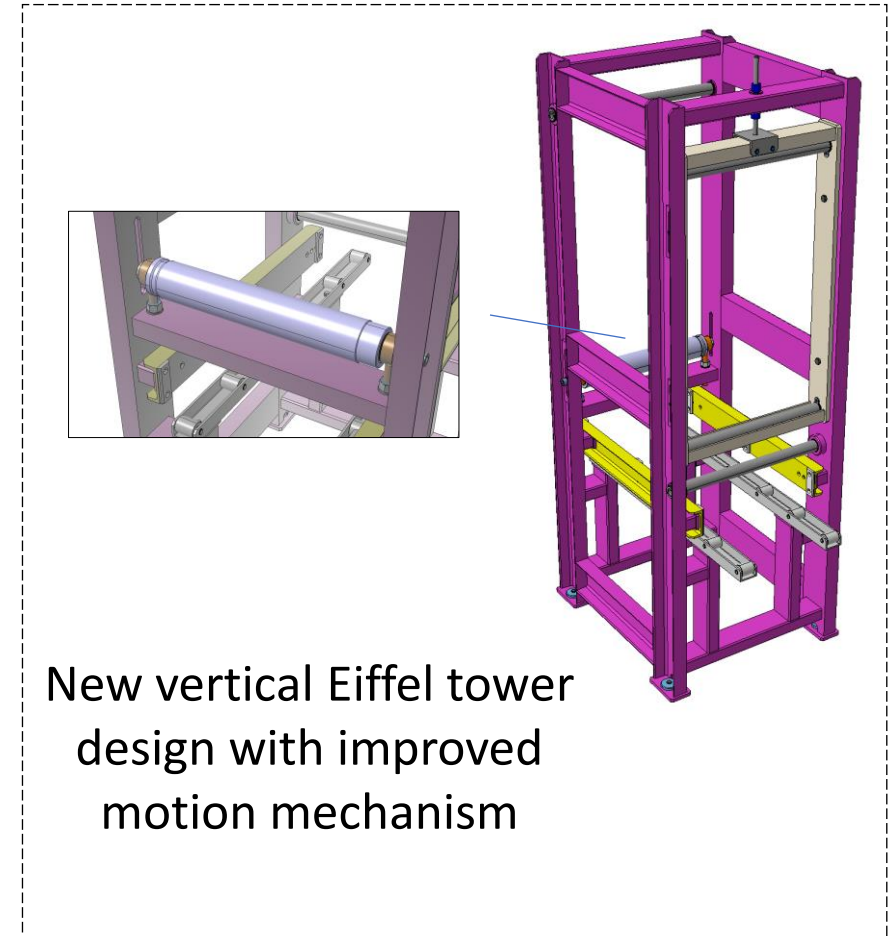
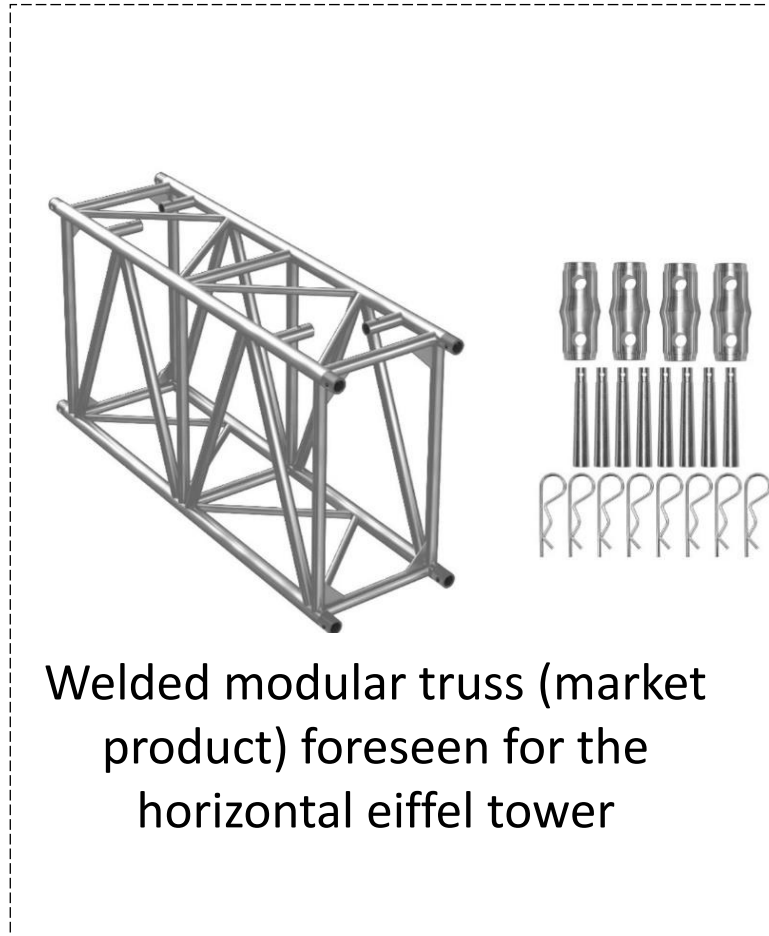


Structural study revises of the  
old/updated tooling



# DESIGN ENGINEERING – large projects

- 2021-2024:  
Re-engineering  
of CMS Tracker  
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- Manipulation of  
heavy objects  
(6.5t) in mm-  
scale precision



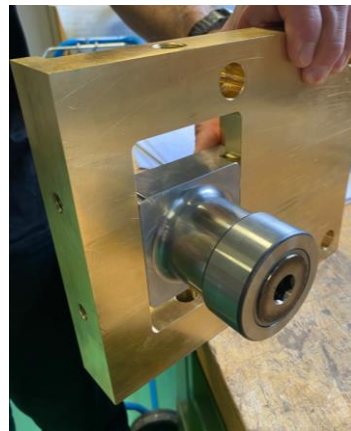
New improved design to replace the old eiffel tower

# DESIGN ENGINEERING – large projects

- 2021-2024:  
Re-engineering  
of CMS Tracker  
installation  
tooling
- Manipulation of  
heavy objects  
(6.5t) in mm-  
scale precision



New  
small ears



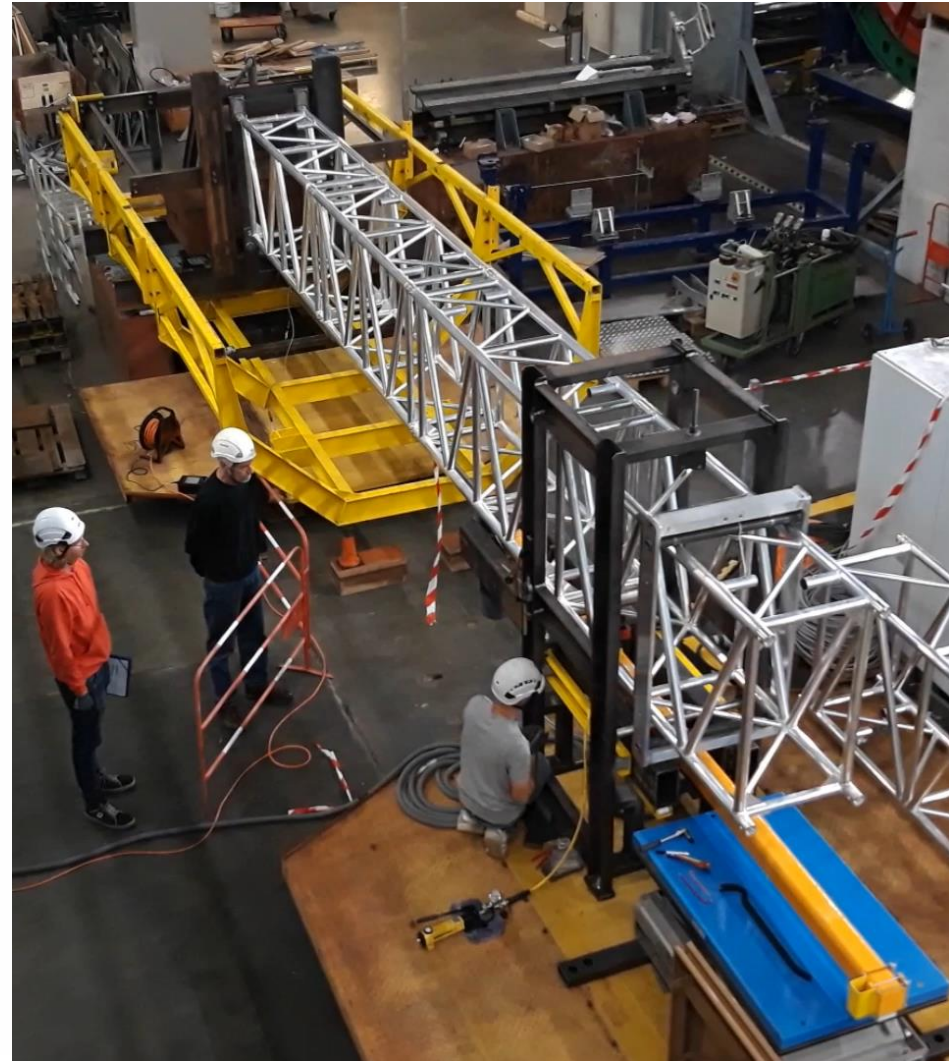
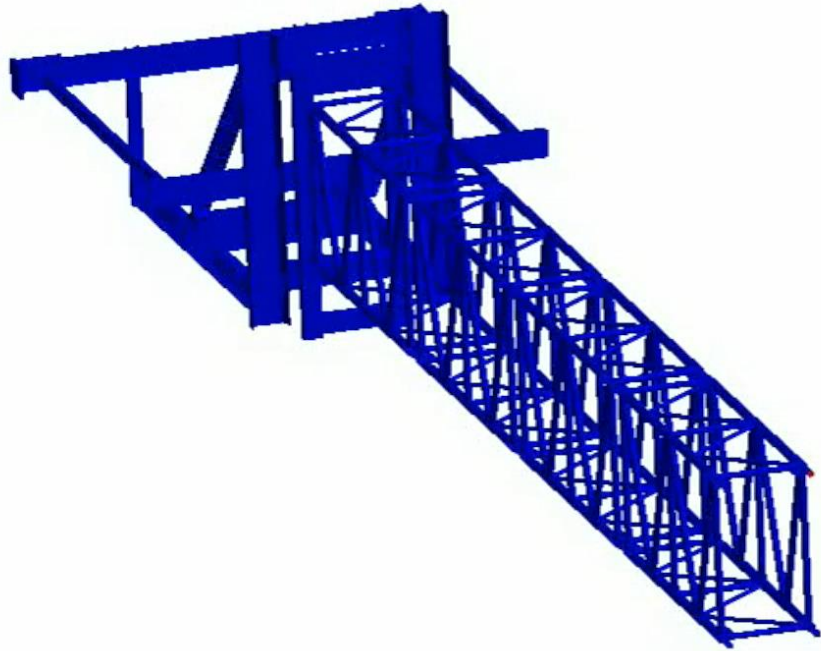
New big ear  
mechanisms



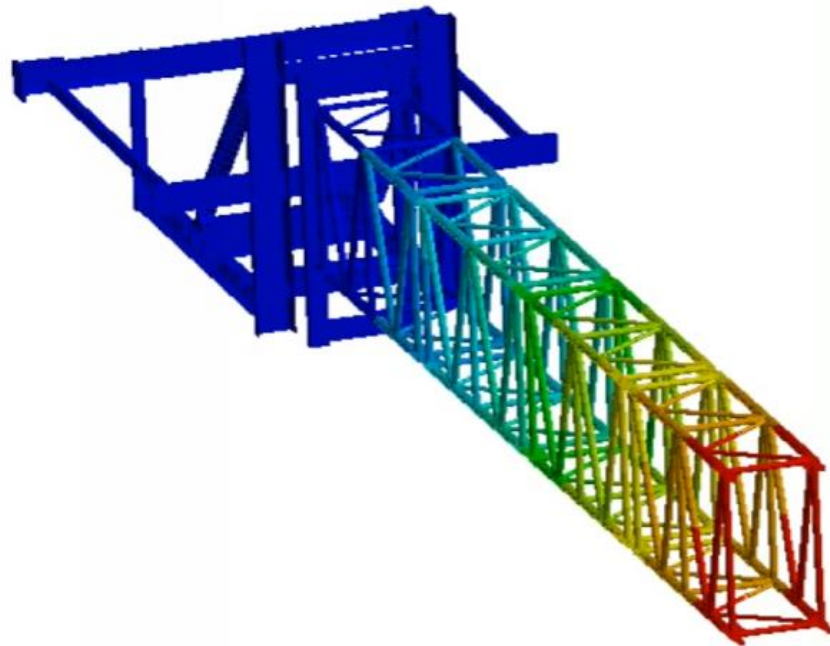
# DESIGN ENGINEERING – large projects



# DESIGN ENGINEERING – large projects



# DESIGN ENGINEERING – large projects



Total deflection: 68.0mm

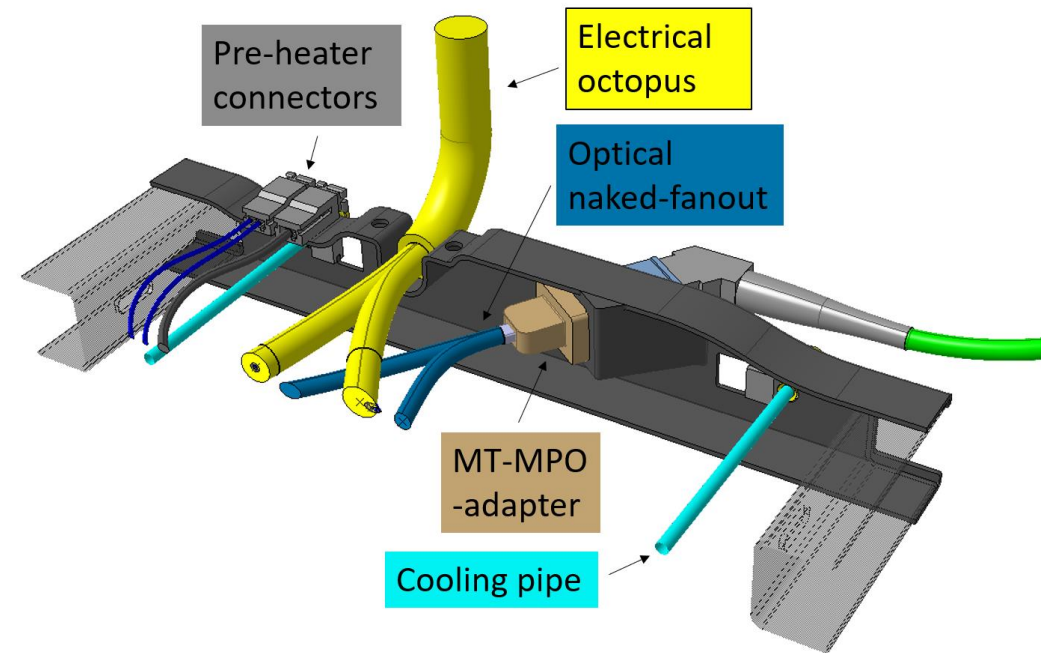
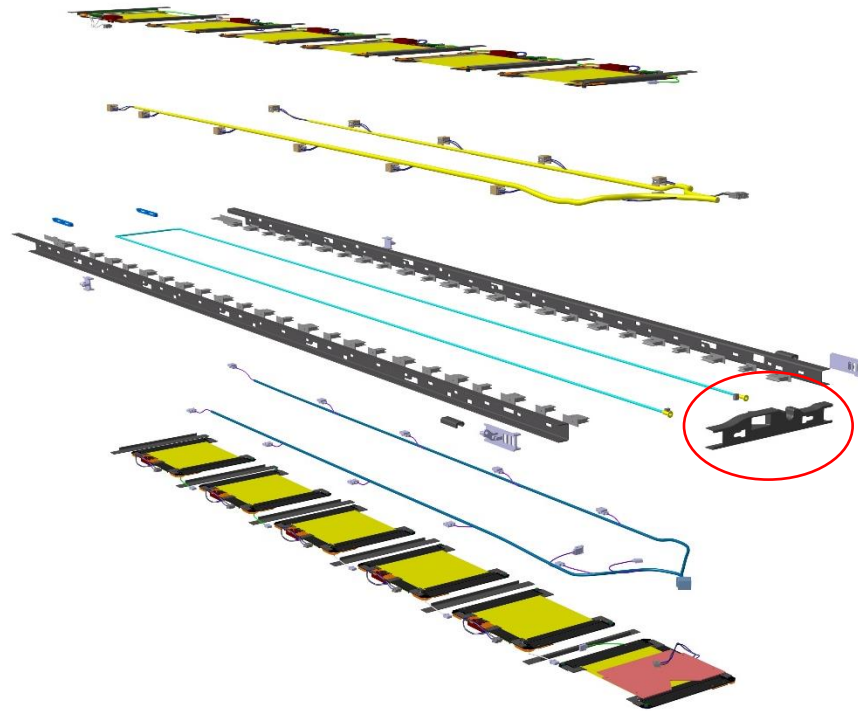
-7%



Total deflection: 72.8mm

# PRODUCTION

- A patch panel of a detector element designed to support different service elements (electrical wiring, optical fibers and cooling pipes)
  - Needs to be made preferably from carbon fiber composite with a production efficient method (400pcs needed)



# PRODUCTION



Raw material:  
Fiber reinforced  
thermosetting  
resin moulded in  
a heated mould



Found an attractive method, BMC/SMC-moulding



Designed and fabricated a mould that when closed, forms a cavity of “negative shape” of the part



# PRODUCTION



Hot-press SMC -machine



After a lot of trial-and-error, adjustments and design changes the pre-production quantity was successfully produced at EP-DT's composite laboratory

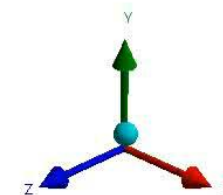
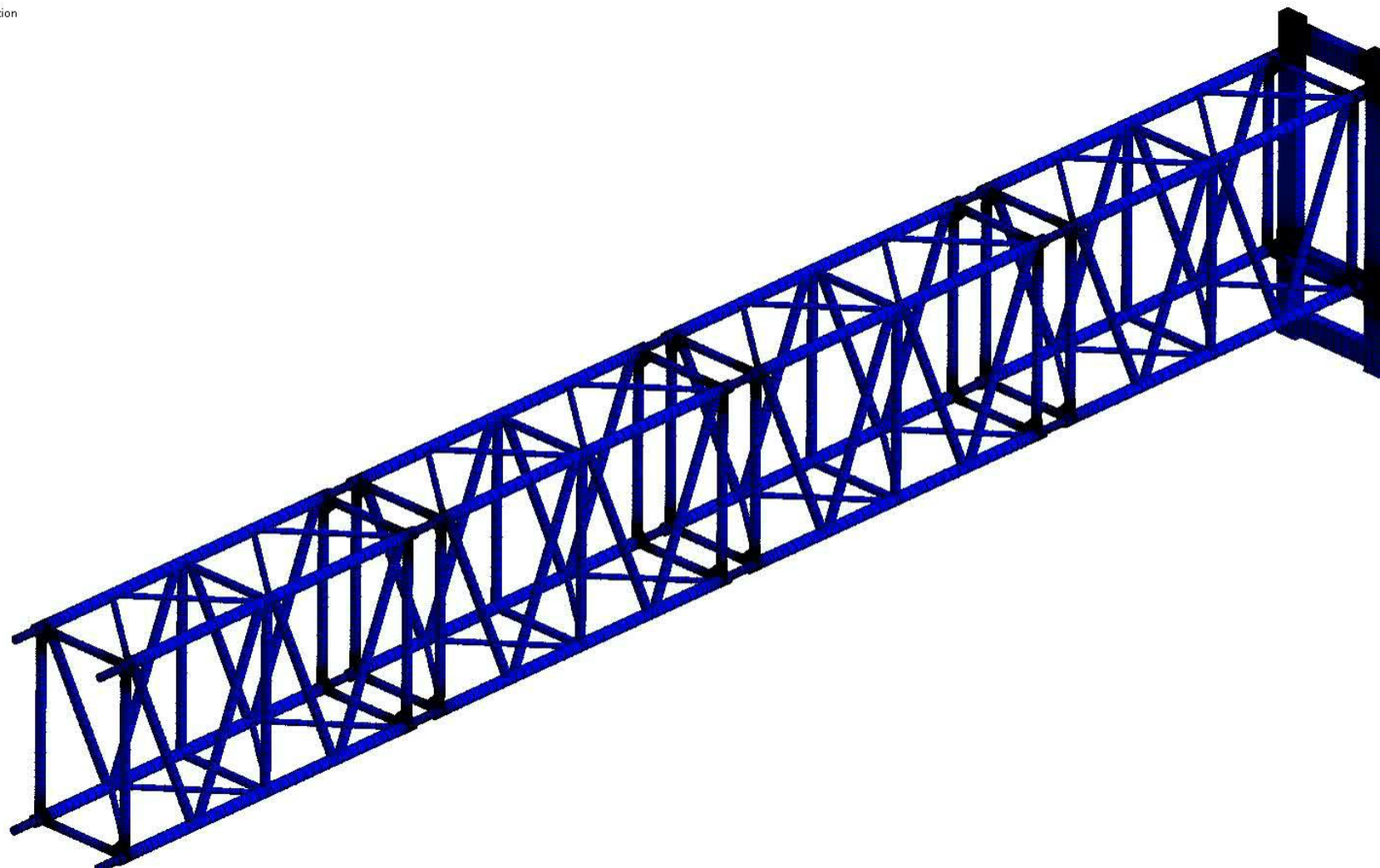
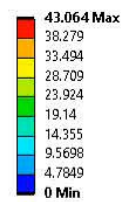
# CHALLENGES...



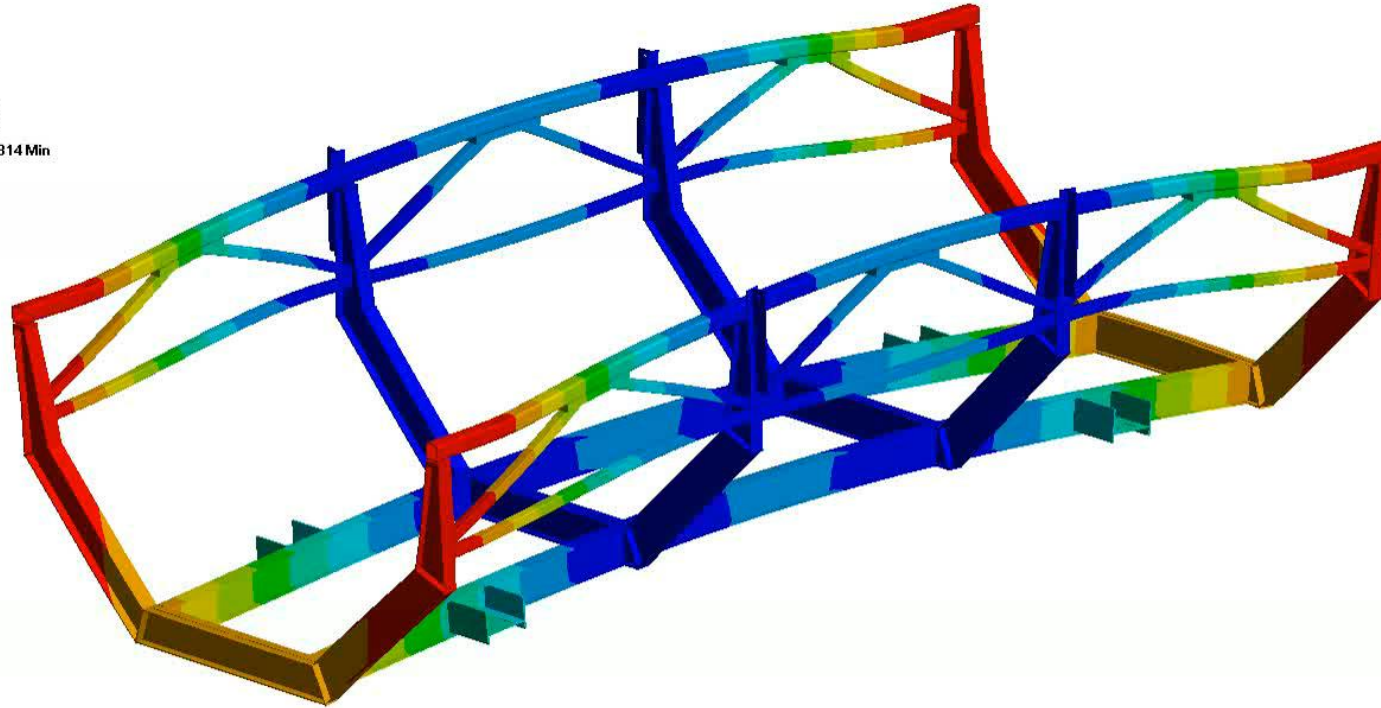
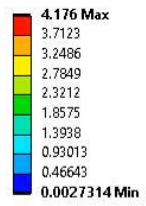
# Spares

BP: Horizontal eiffel tower (Duratruss), solid pins, Nose cone adapter, Flipped truss, corrected cross-section

Total Deformation  
Type: Total Deformation  
Unit: mm  
Time: 0

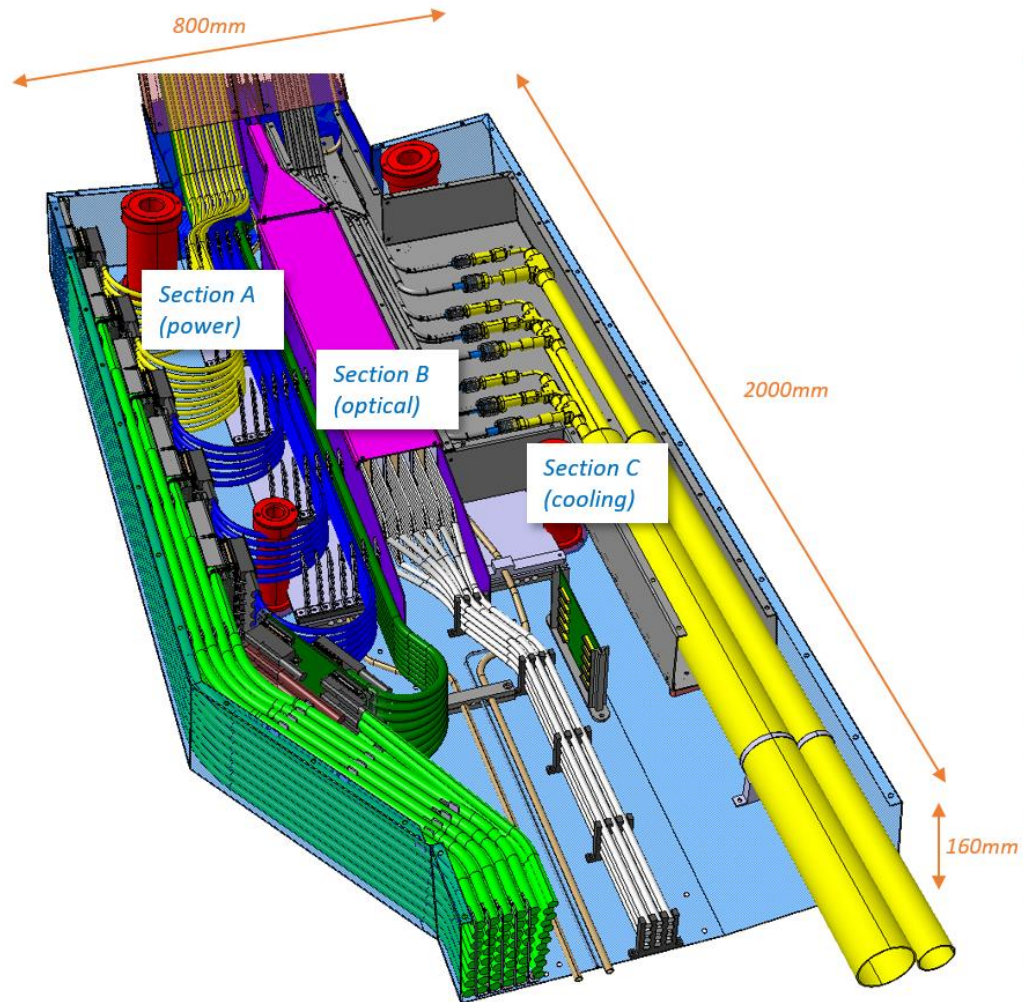


T: Static Structural  
Total Deformation  
Type: Total Deformation  
Unit: mm  
Time: 1 s

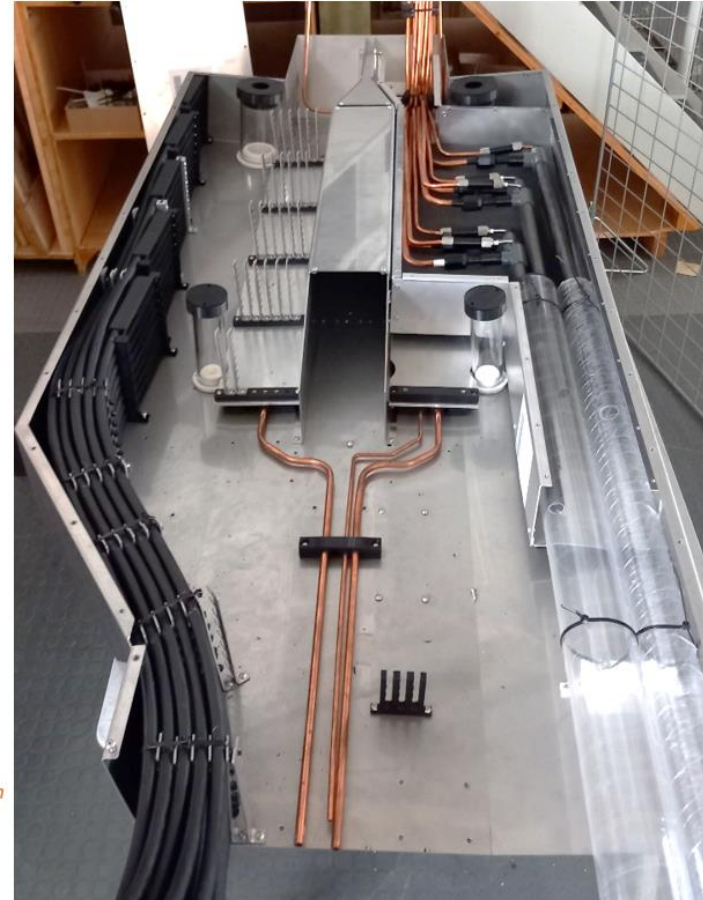




## Design



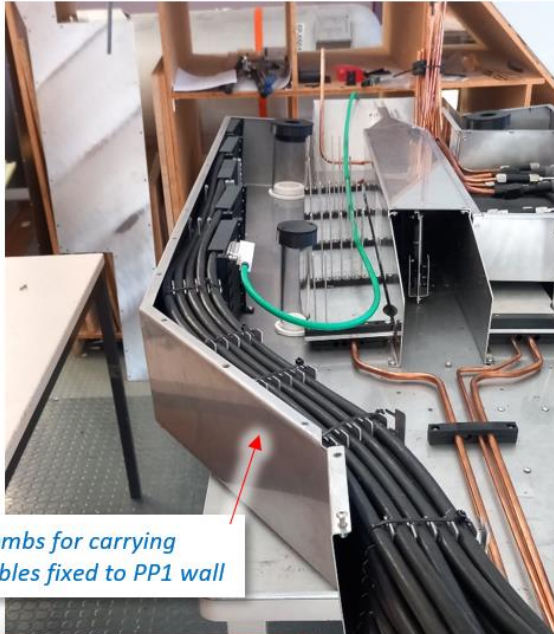
## Mock-up



Mock-up in bldg. 155



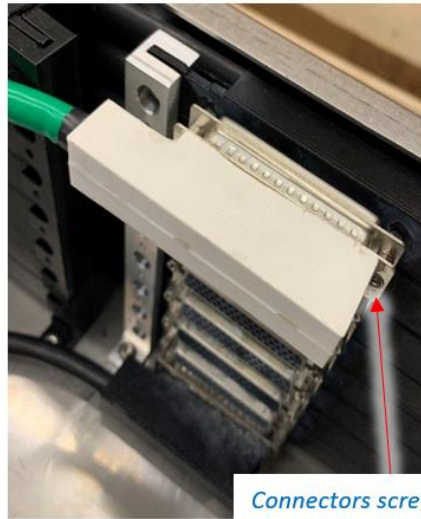
# Power section (A)



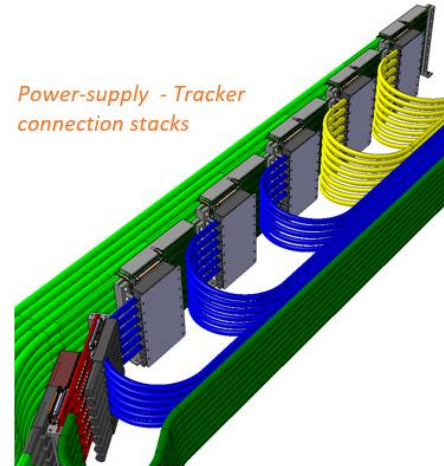
Combs for carrying cables fixed to PP1 wall



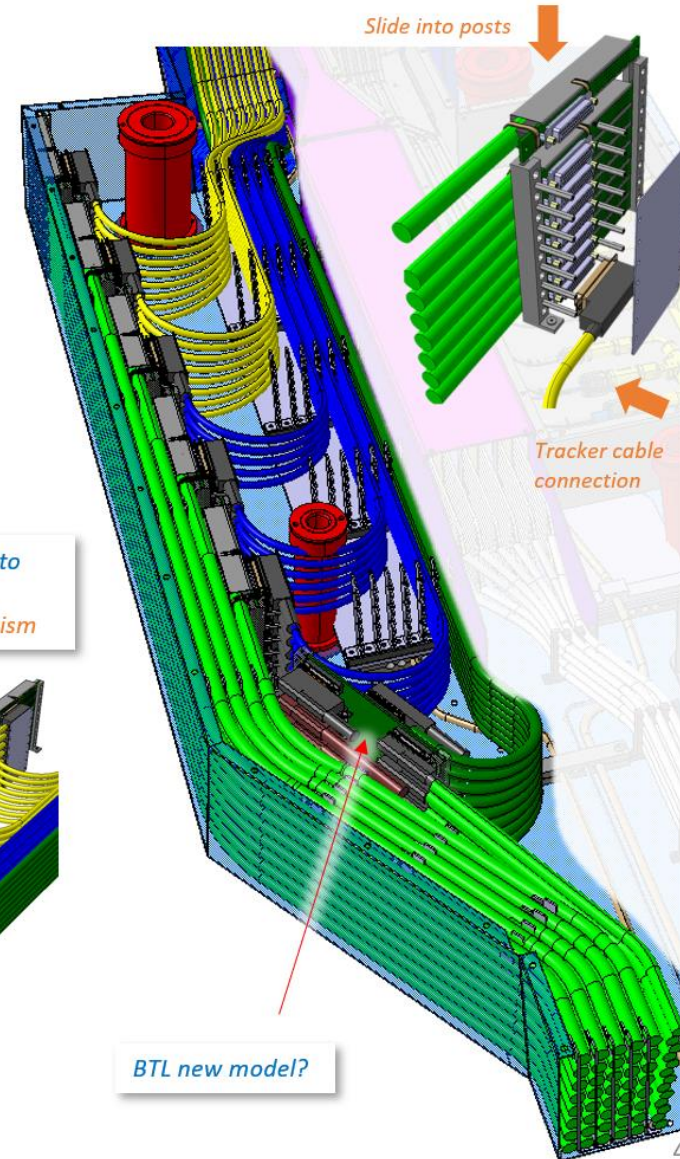
Not real rigidity of cables - spring back effect



Connectors screwed to board, separately?  
Sliding latch mechanism



Power-supply - Tracker connection stacks



Slide into posts

Tracker cable connection

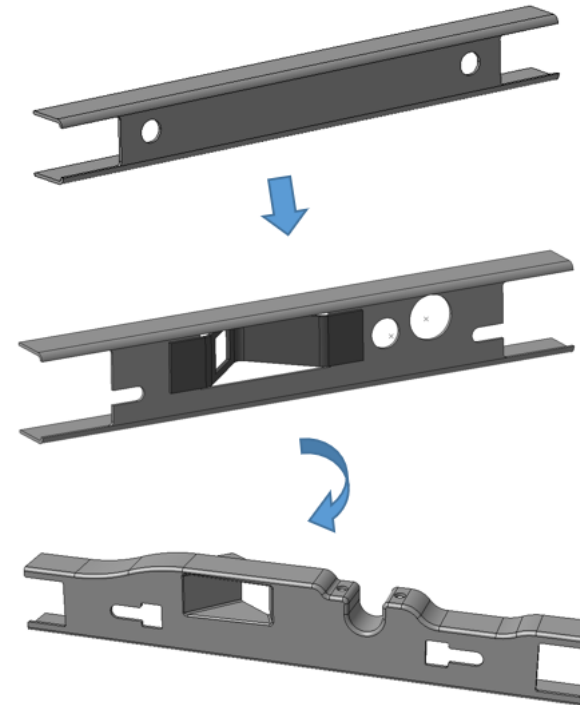
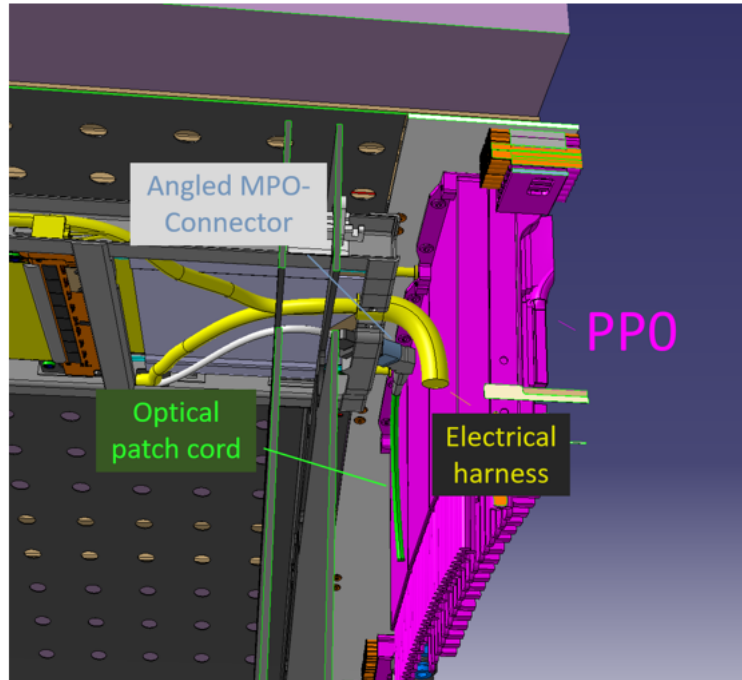
BTL new model?

PP1 design and mock-up, Bartlomiej Markiel



## Front panel design

- The carbon-fibre C-profile used elsewhere in the Ladder needed to be replaced by a more complex part due constraints set by the connections and the very limited space available

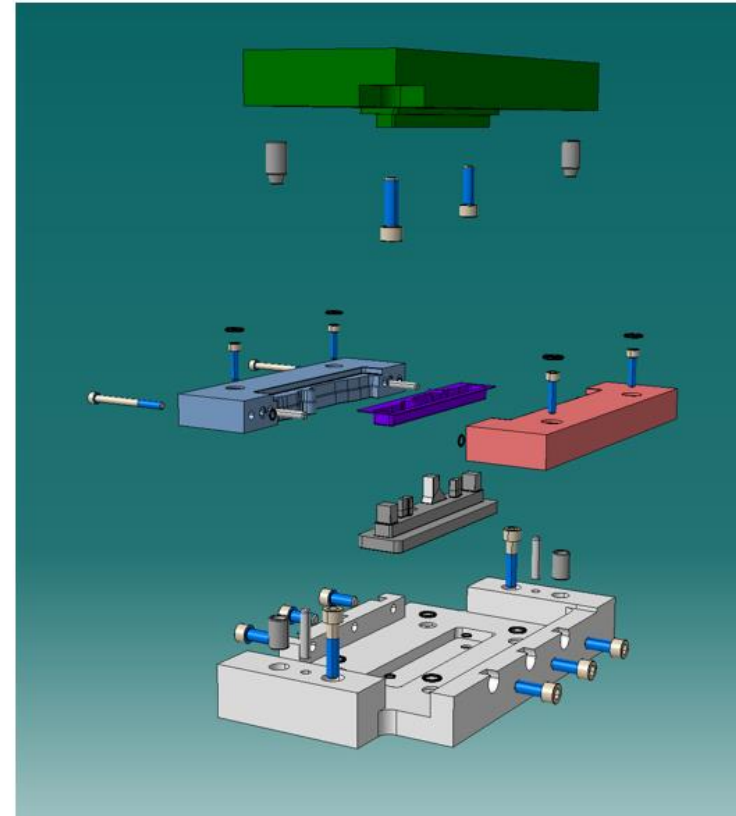






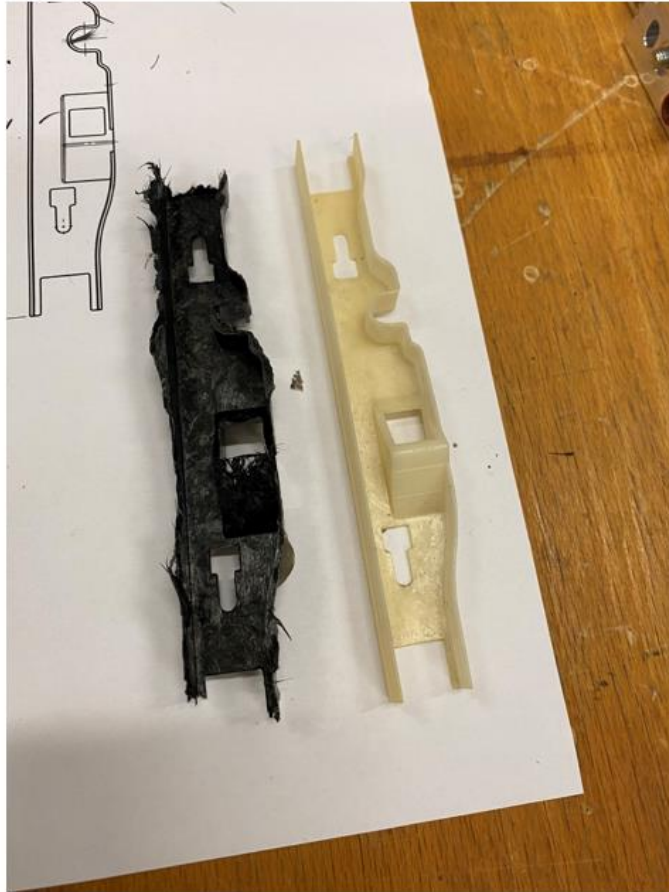
## The compression mould

- Designed a compression mould, that forms a volumetric cavity giving the shape for the final piece (purple)
  - A lot of effort put already in the design phase for mould usability and de-moulding





## Iterations



1<sup>st</sup> trial: too little material



2<sup>nd</sup> trial: too much material & improper closing