INSTITUTE FOR HIGH ENERGY PHYSICS

Barrel EMC Mechanics Components Design Status

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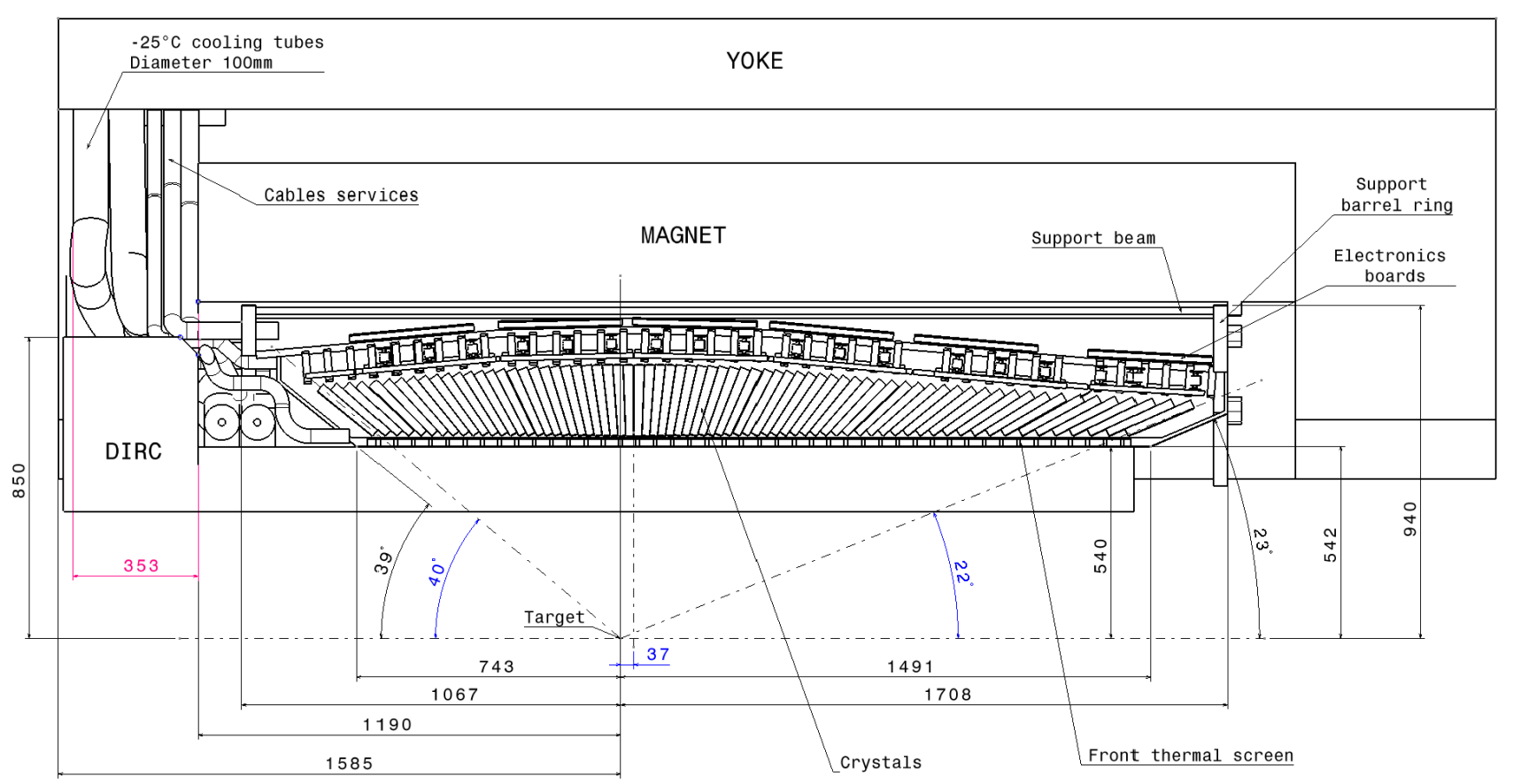
on behalf of the IHEP-Protvino group

IHEP-FAIR
March, 2014

CONTENT OF THE REPORT

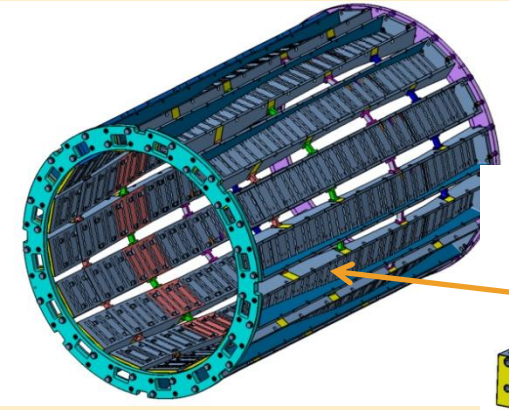
INTRODUCTION

This Design is based on a parameter scheme of the Barrel EMC Calorimeter and on the Technical Specifications for the Mechanical Structure of the Central Electromagnetic Barrel Calorimeter for the PANDA experiment.

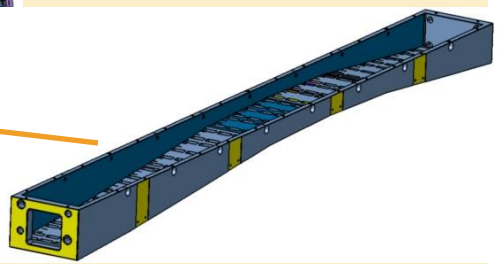


DIMENSIONS OF ONE SLICE (from TS from June 2013)

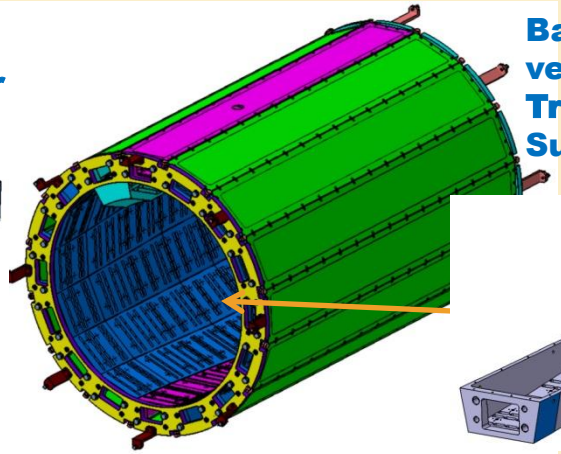
EMC BARREL DESIGN



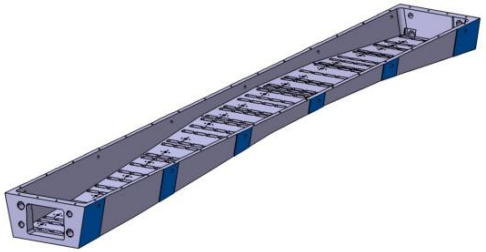
Barrel simplified Model version with Rectangular Support Beams



1. Weight ~58 kg
2. S= 11572 mm2



Barrel simplified Model version with Trapezoidal Support Beams



1. Weight ~65 kg
2. S= 14553 mm2

ADVANTAGES:

1. Weight a little bit less for Support Beam.

DISADVANTAGES:

1. Necessity of additional supporting elements in the Barrel Assembly;
2. Less space for services

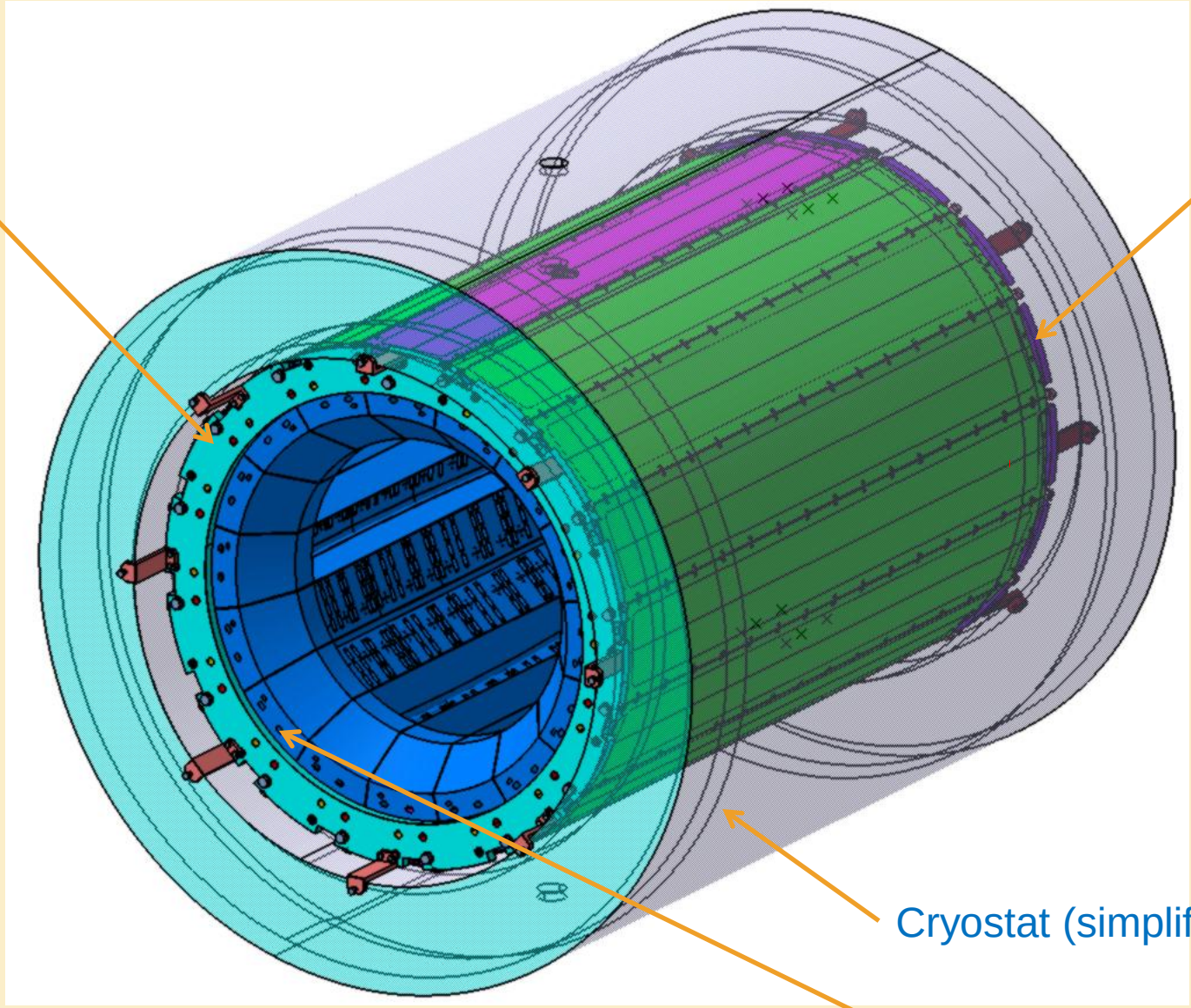
ADVANTAGES:

1. Barrel Support Structure more rigid because Support Beams supported by themselves.
2. Not necessary additional supporting elements in the Barrel Assembly;
3. More space for services

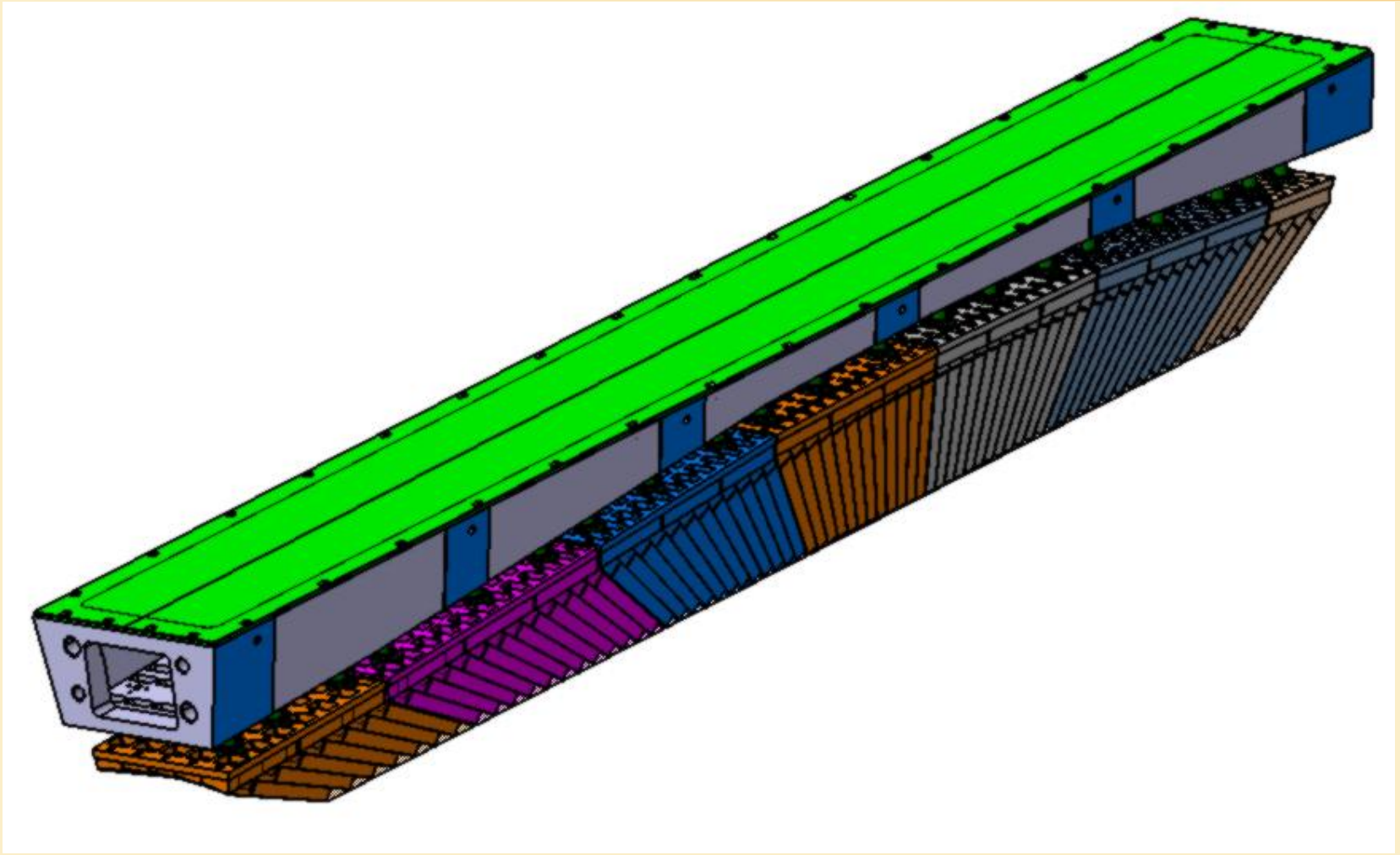
Taking into account all advantages and disadvantages and ANSYS Calculations we suggest Trapezoidal shape of Support Beam for the Barrel.

COMPARATIVE ANALYSIS
RECTANGULAR AND TRAPEZOIDAL VERSIONS OF SUPPORT BEAMS

EMC BARREL DESIGN

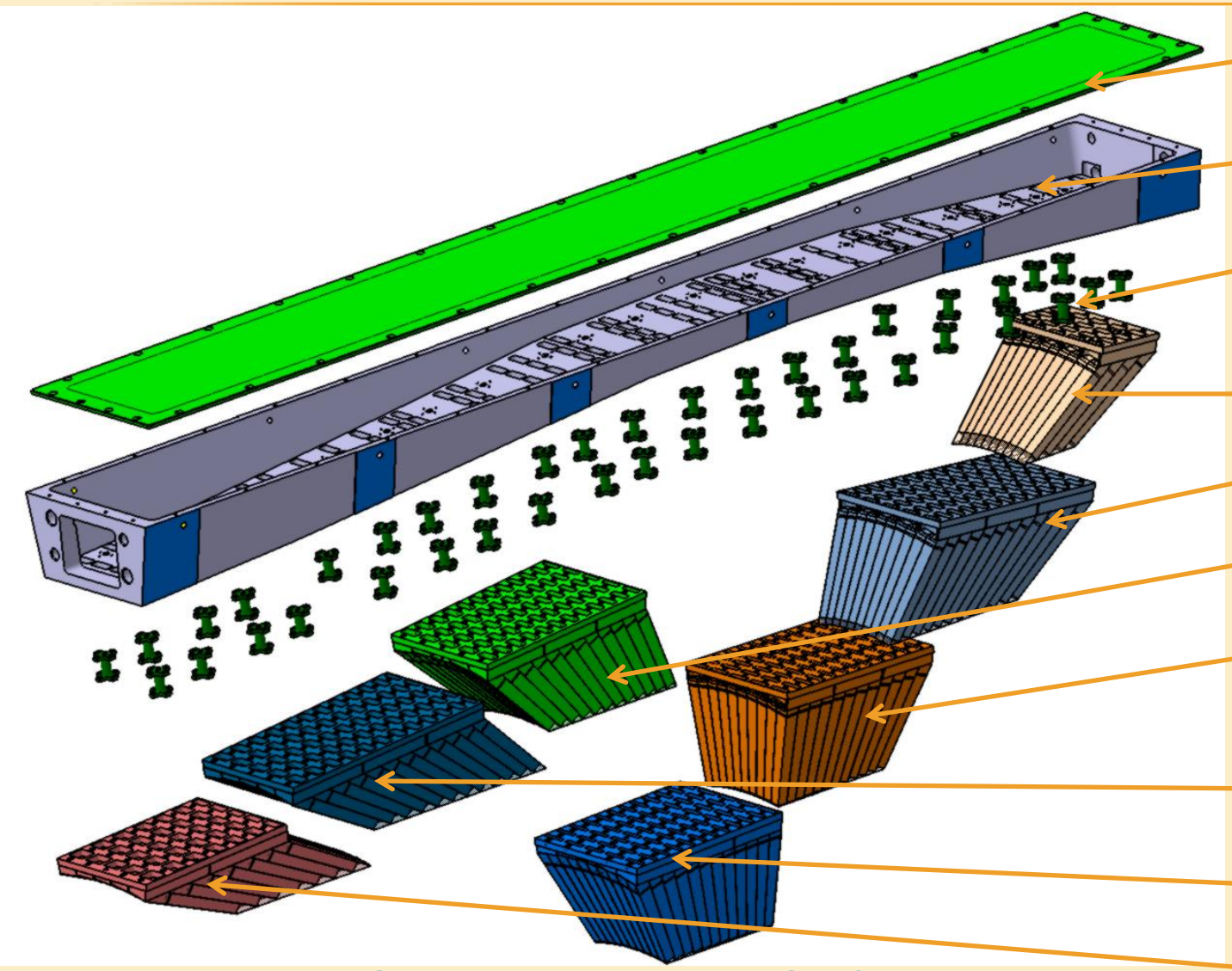


DESIGN OF EMC BARREL SLICE



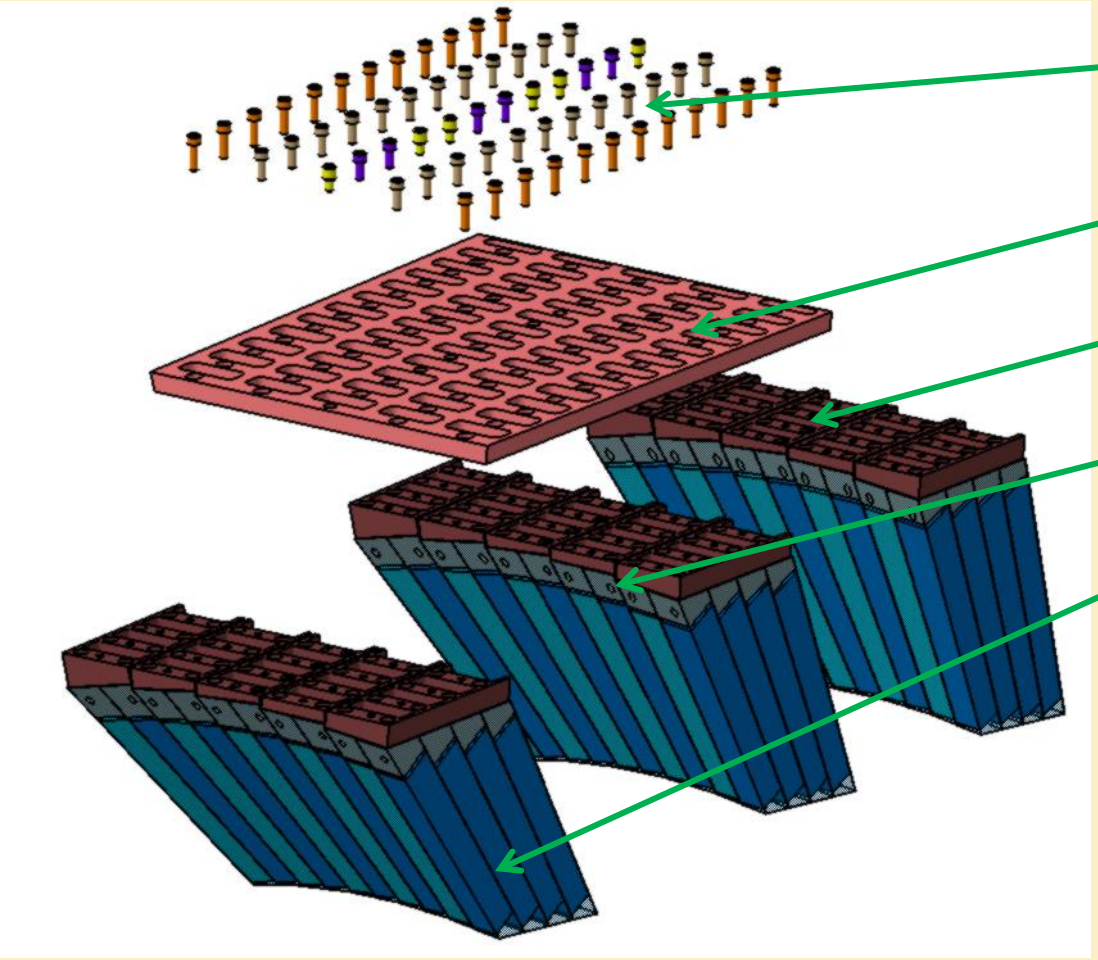
ASSEMBLIED STANDARD SLICE.
THERMAL SCREEN,
SIDE PLATES AND SERVICES ARE NOT SHOWN

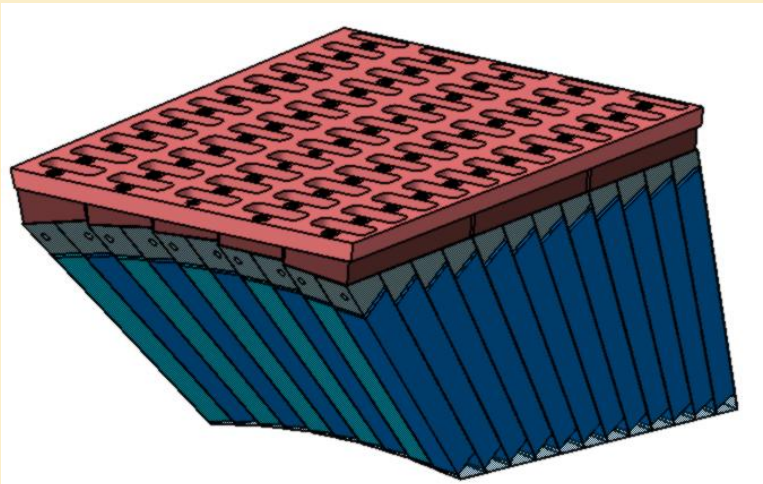
DESIGN OF EMC BARREL SLICE



STANDARD BARREL SLICE (EXPLODED VIEW)

DESIGN OF EMC BARREL SLICE





BEFORE OF SLICE ASSEMBLY 7 SUPER-MODULES ASSEMBLY TO BE PREPARED IN SPECIAL TECHNOLOGICAL DEVICES

SUPER-MODULE #2 - COMPONENTS (EXAMPLE)

DESIGN OF EMC BARREL SLICE

MAJOR REQUIREMENTS TO MATERIAL:

1. It must be nonmagnetic;
2. It must be with high strength;
3. It must be with corrosion resistance;
4. It must has good machinability;
5. Weight;
6. Optimal cost.

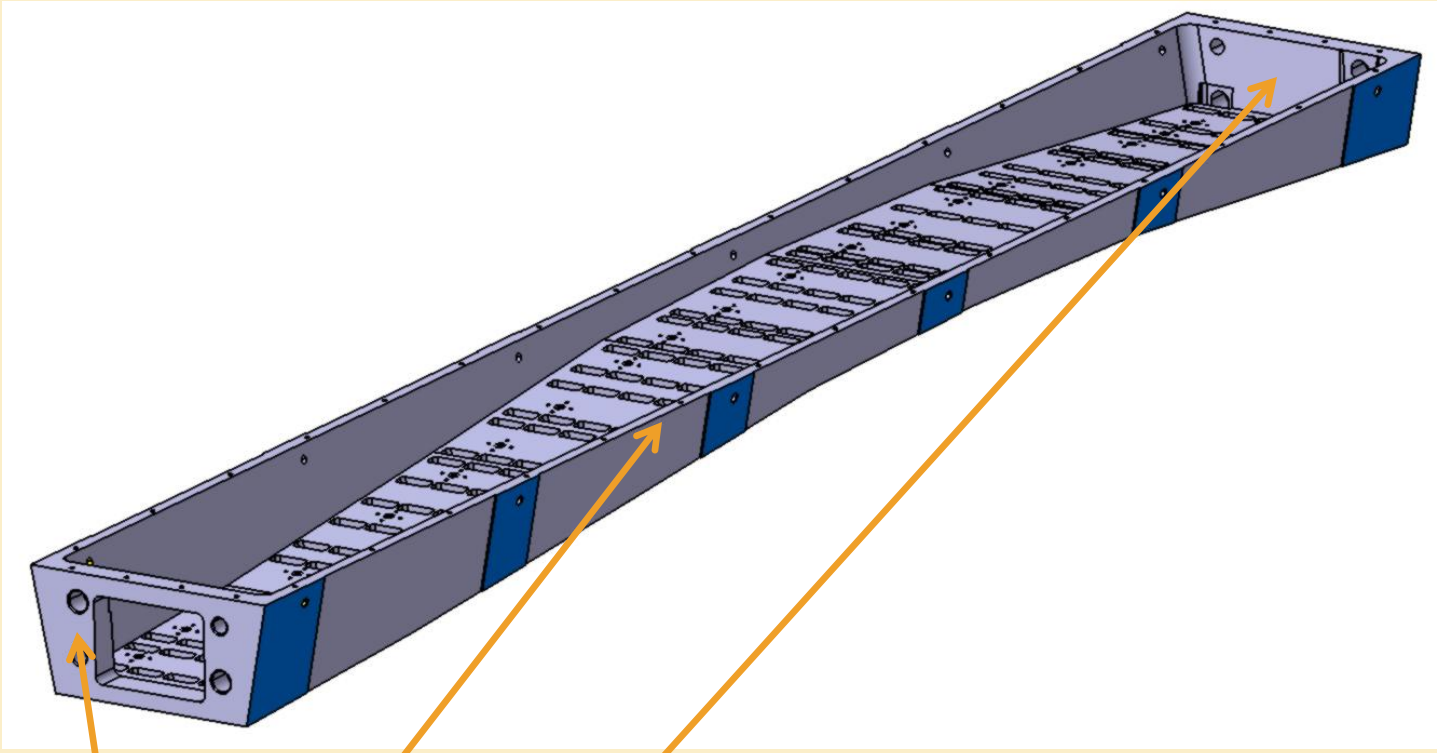
Taking into account all the requirements we have chosen high-strength Aluminum Alloy 7050 HOKOTOL from Aleris Aluminum Koblenz GmbH Carl-Spaeter-Strasse 10, Koblenz , 56070, Germany www.aleris.com
Alloy 7050 is the premier choice for aerospace applications requiring the best combination of strength, stress corrosion cracking (SCC) resistance and toughness. Alloy 7050 exhibits better toughness/corrosion resistance characteristics than other aluminum alloys. Because it is less quench sensitive than most aerospace aluminum alloys, Alloy 7050 retains its strength properties in thicker sections while maintaining good stress corrosion cracking resistance and fracture toughness levels.

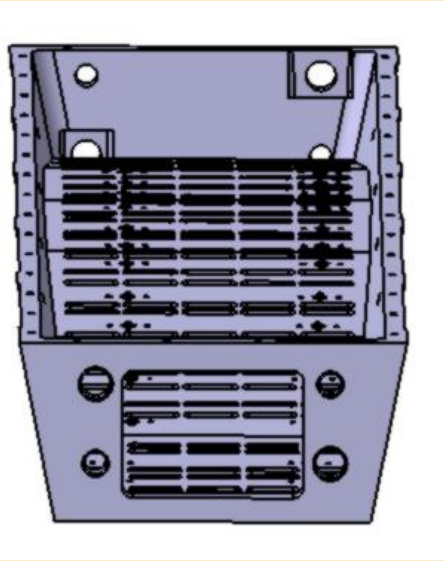
Mechanical Properties

Tensile stregth R_m N/mm²		0.2% proof stress $R_{0.2}$ N/mm²		Elongation $A_{50\,mm}$ A		Brinell hardness HBS
min.	max.	min.	max.	% min.	% max.	
550		500	-	4	-	160-180

CHOICE OF MATERIAL AND SHAPE FOR SUPPORT BEAMS

DESIGN OF EMC BARREL SLICE





DIMENSIONS:

1. **L = 2695 mm**
2. **296.5 x 364 x 169 mm**
3. **314 x 364 x 126 mm**
   Weight ~65 kg.

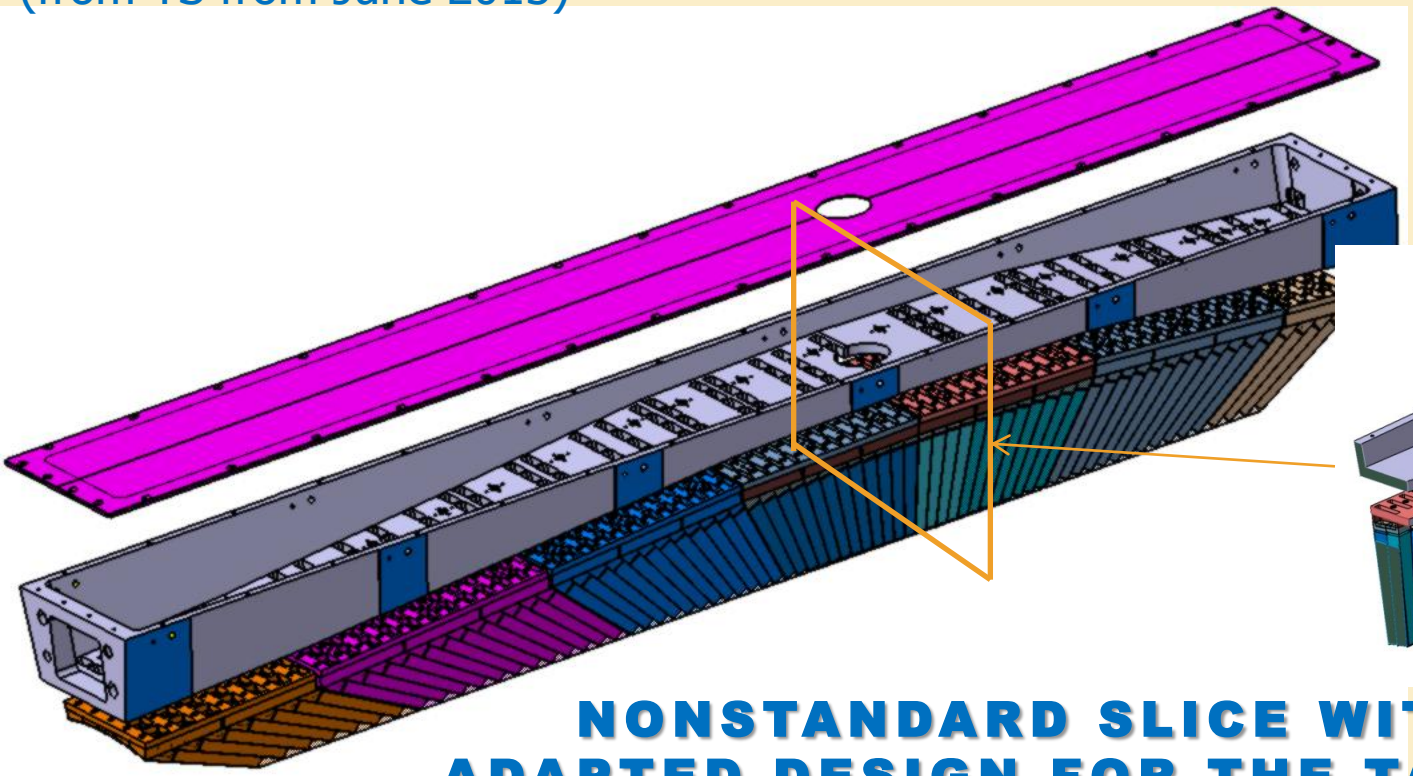
VARIANT N2- TRAPEZOIDAL SHAPE
OF SUPPORT BEAM FROM ALUMINUM

Material– Aluminum Alloy 7050 “HOKOTOL”

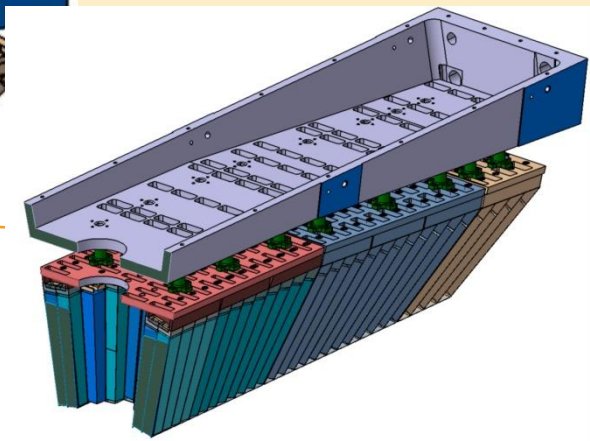
CHOICE OF MATERIAL AND SHAPE FOR SUPPORT BEAM

DESIGN OF EMC BARREL SLICE

The target system has the vertical axis. It is foreseen to place two slices, an upper and a lower one, specially designed with a central hole. 6×8 crystals of type 1 have to be removed on each one of the two vertical slices. No special alveolus but a reduction of the alveoli packs with less gluing is needed. The mechanics and the thermal shields have to be modified to allow a hollow cylinder of insulation pass through. The target tube must not be in contact with the cold area and has to be free to move.
(from TS from June 2013)

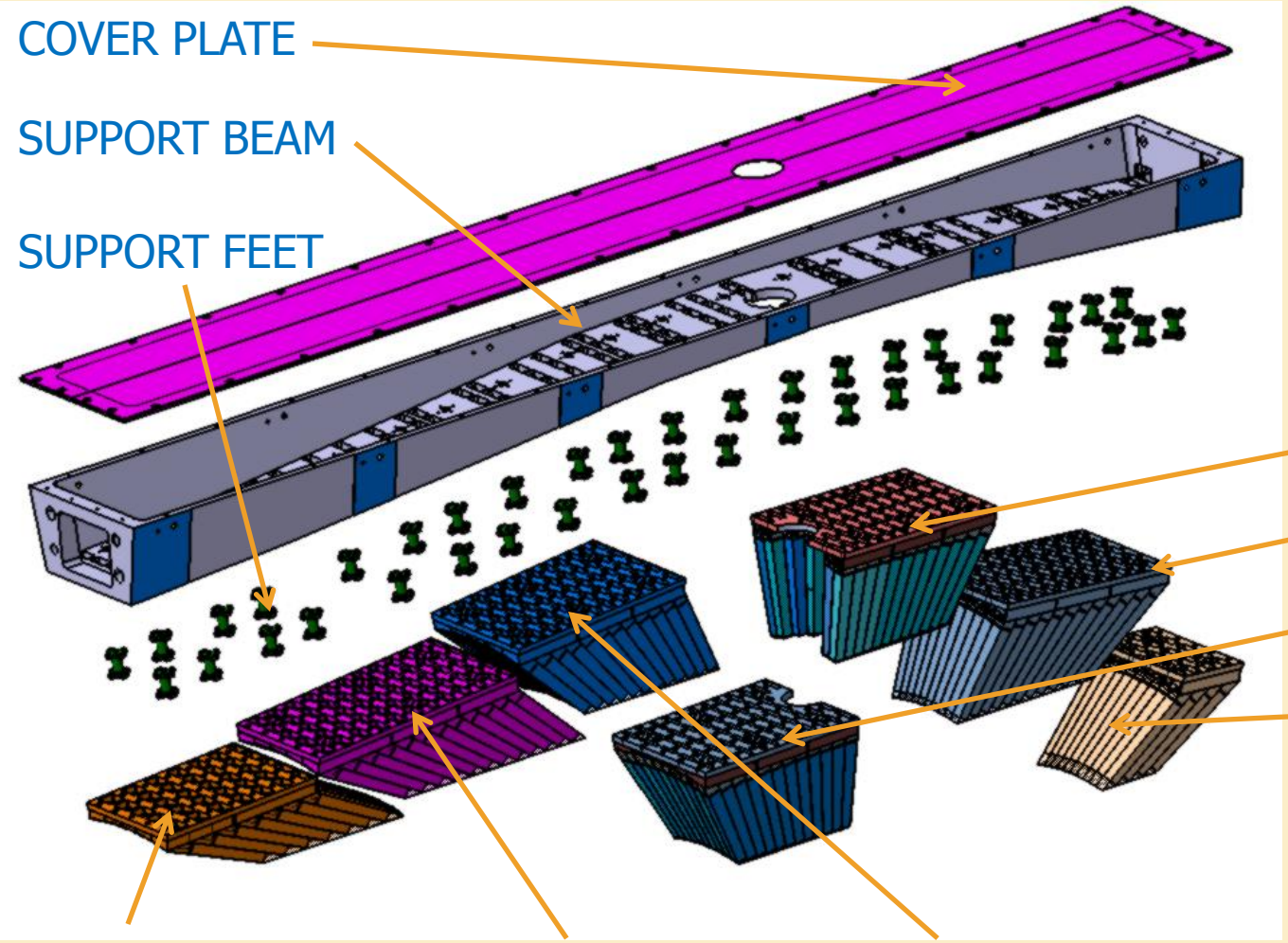


Cross-section of slice



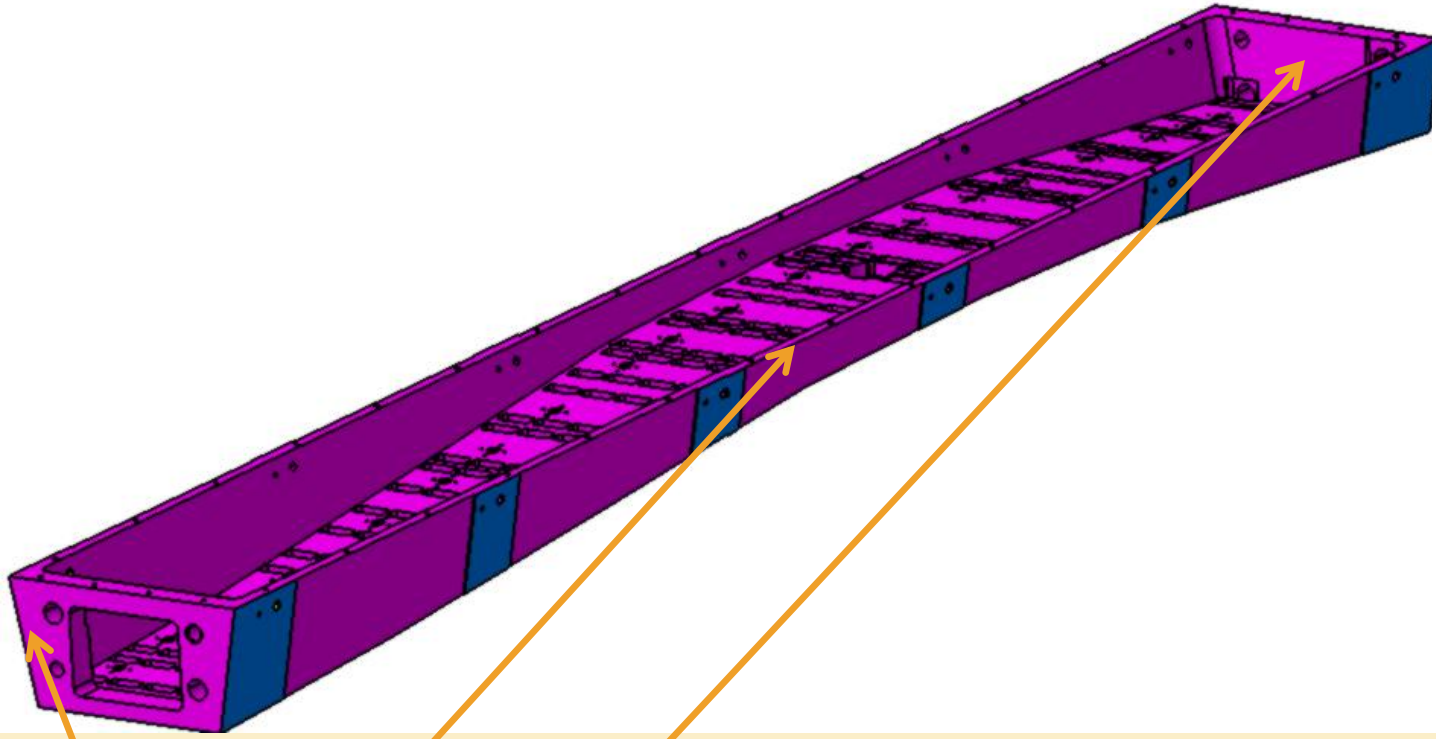
NONSTANDARD SLICE WITH ADAPTED DESIGN FOR THE TARGET

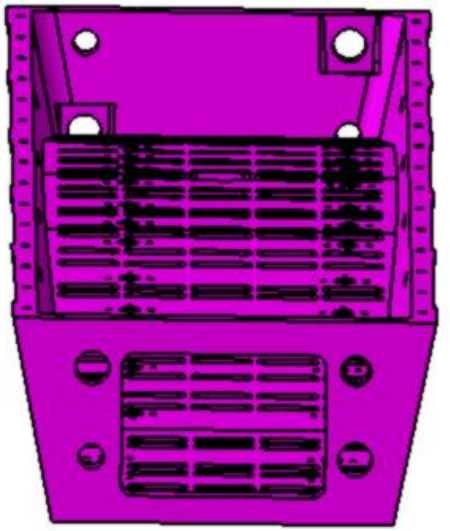
DESIGN OF EMC BARREL SLICE



BARREL NON-STANDARD SLICE ASSEMBLY (EXPLODED VIEW)

DESIGN OF EMC BARREL SLICE





DIMENSIONS:
1. L = 2695 mm
2. 285 x 353 x 172
3. 302 x 353 x 128
   Weight ~63,5 kg.

Material– Aluminum Alloy 7050 “HOKOTOL”

BARREL NON-STANDARD SUPPORT BEAM WITH TRAPEZOIDAL SHAPE (2 PIECES)

BARREL ASSEMBLY

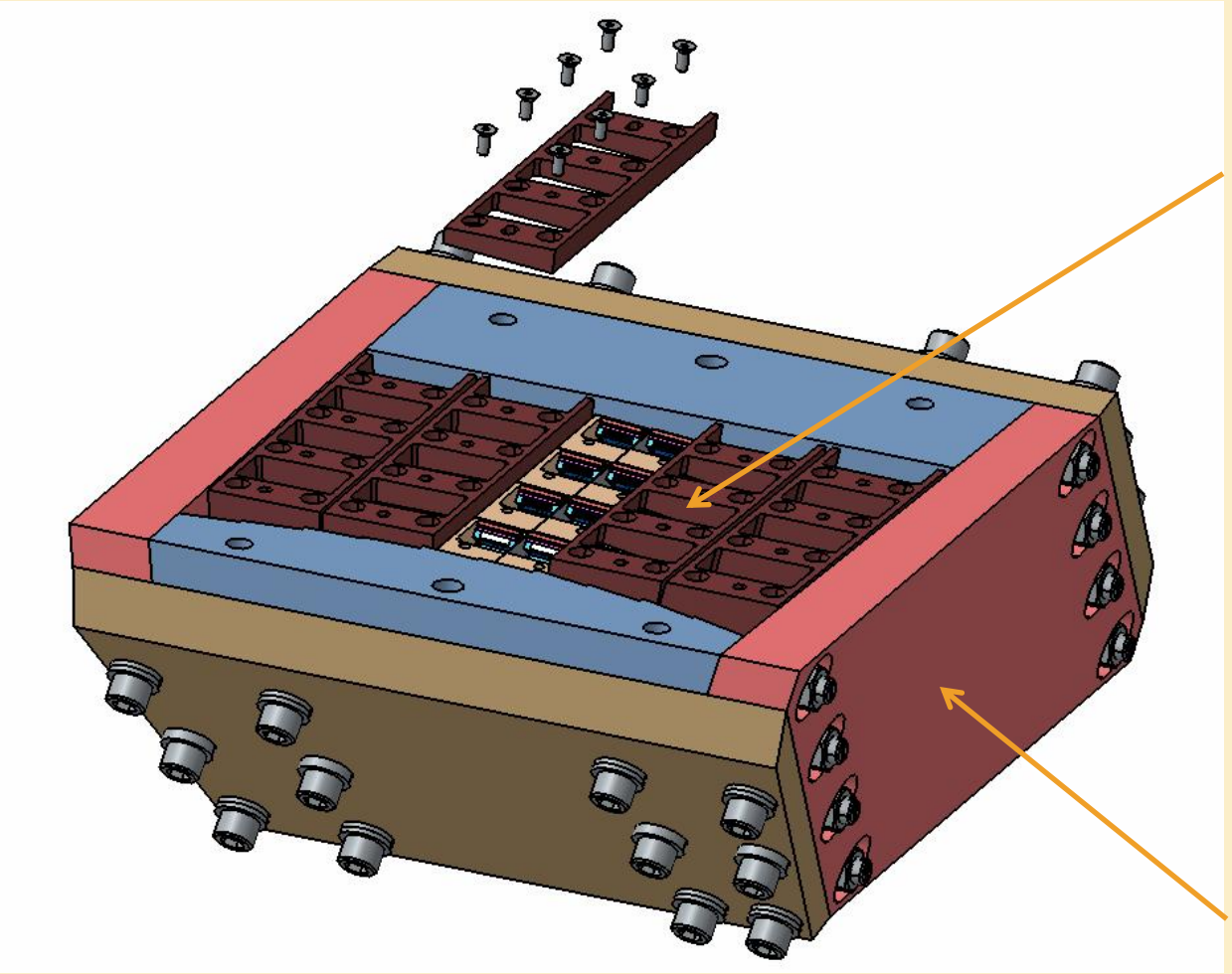
STEP BY STEP PROCEDURE

1. SLICE ASSEMBLY
1.1 MODULES ASSEMBLY;
1.2 SUPER-MODULES ASSEMBLY;
1.3 MOUNTING OF SUPER-MODULES TO THE BARREL SUPPORT BEAM.

2. BARREL ASSEMBLY
2.1 MOUNTING OF SLICES ON A TECHNOLOGICAL DEVICE;
2.2 MOVEMENT OF FRONT AND BACK RINGS ON WORKING POSITION;
2.3 MOUNTING OF SLICES TO FRONT AND BACK RINGS;
2.4 DISASSEMBLY OF TECHNOLOGICAL FLANGES;

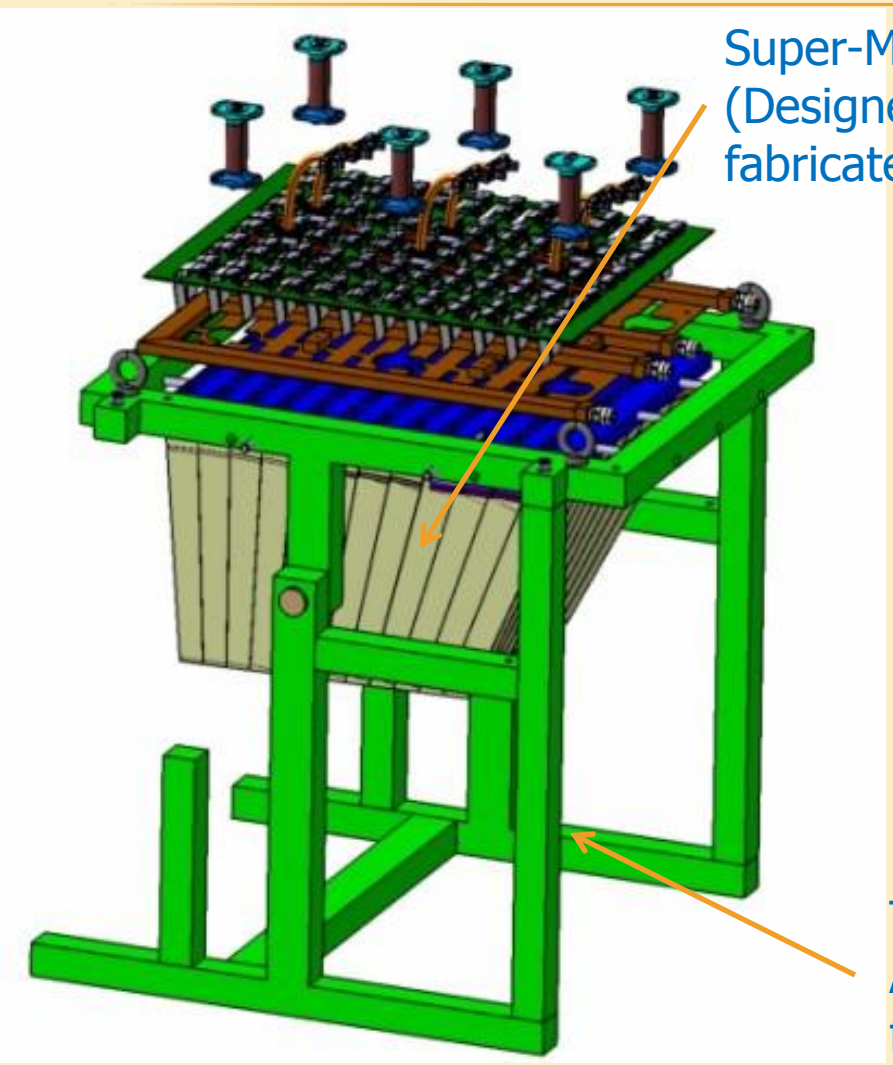
3. BARREL INSTALLATION INTO CRYOSTAT
3.1 MOVEMENT OF BARREL INSIDE OF CRYOSTAT;
3.2 ADJUSTING AND FIXING OF BARREL;
3.3 DISASSEMBLY OF TECHNOLOGICAL DEVICES.

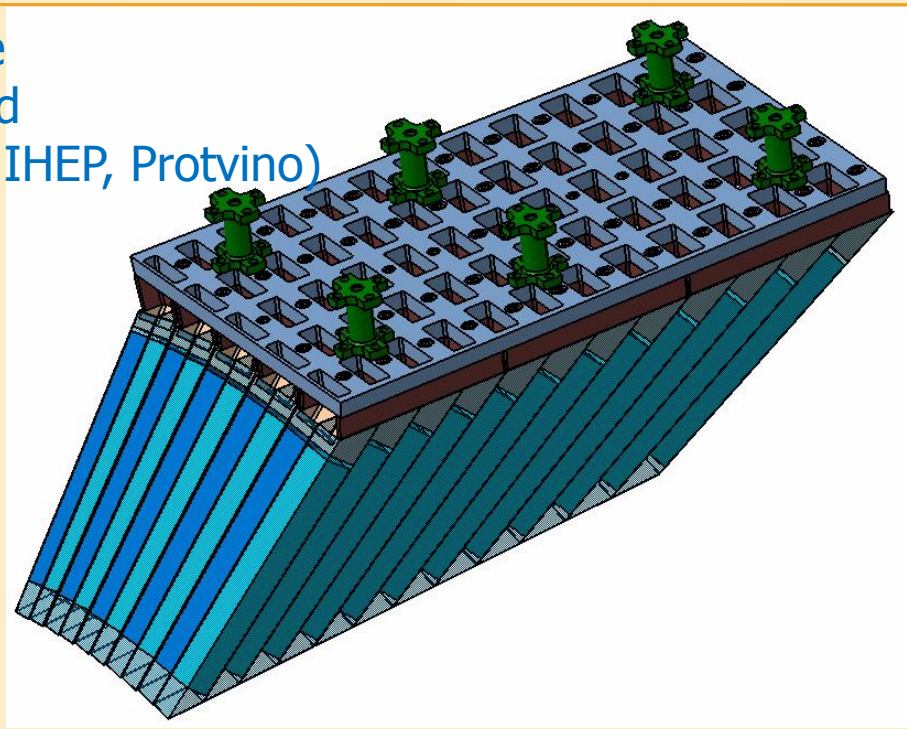
BARREL ASSEMBLY



Assembly of MODULE in Technological Tool

BARREL ASSEMBLY



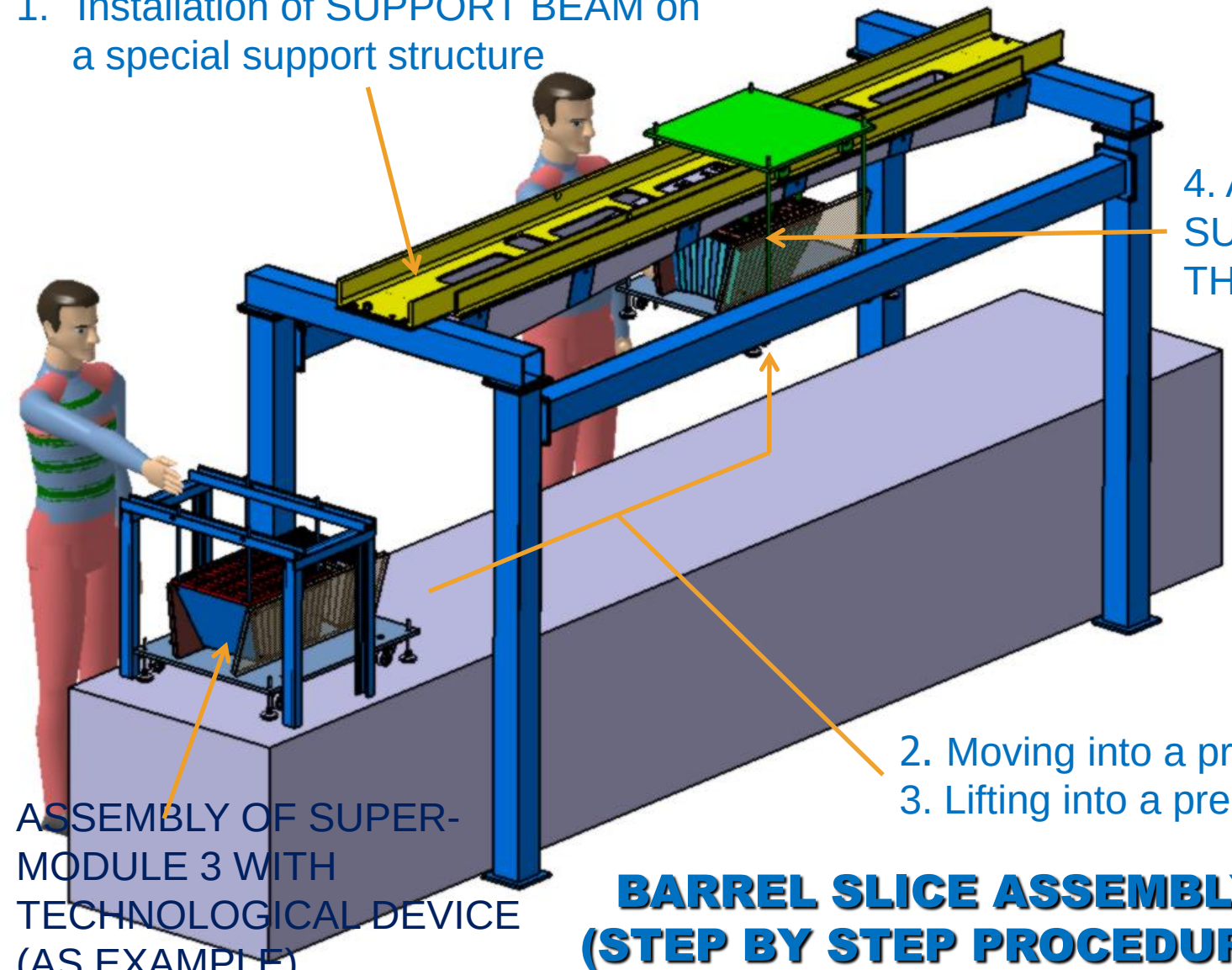


Example of Super-Module

SUPER-MODULE ASSEMBLY

BARREL ASSEMBLY

1. Installation of SUPPORT BEAM on a special support structure



4. Adjusting and fix SUPER-MODULE to THE SUPPORT BEAM

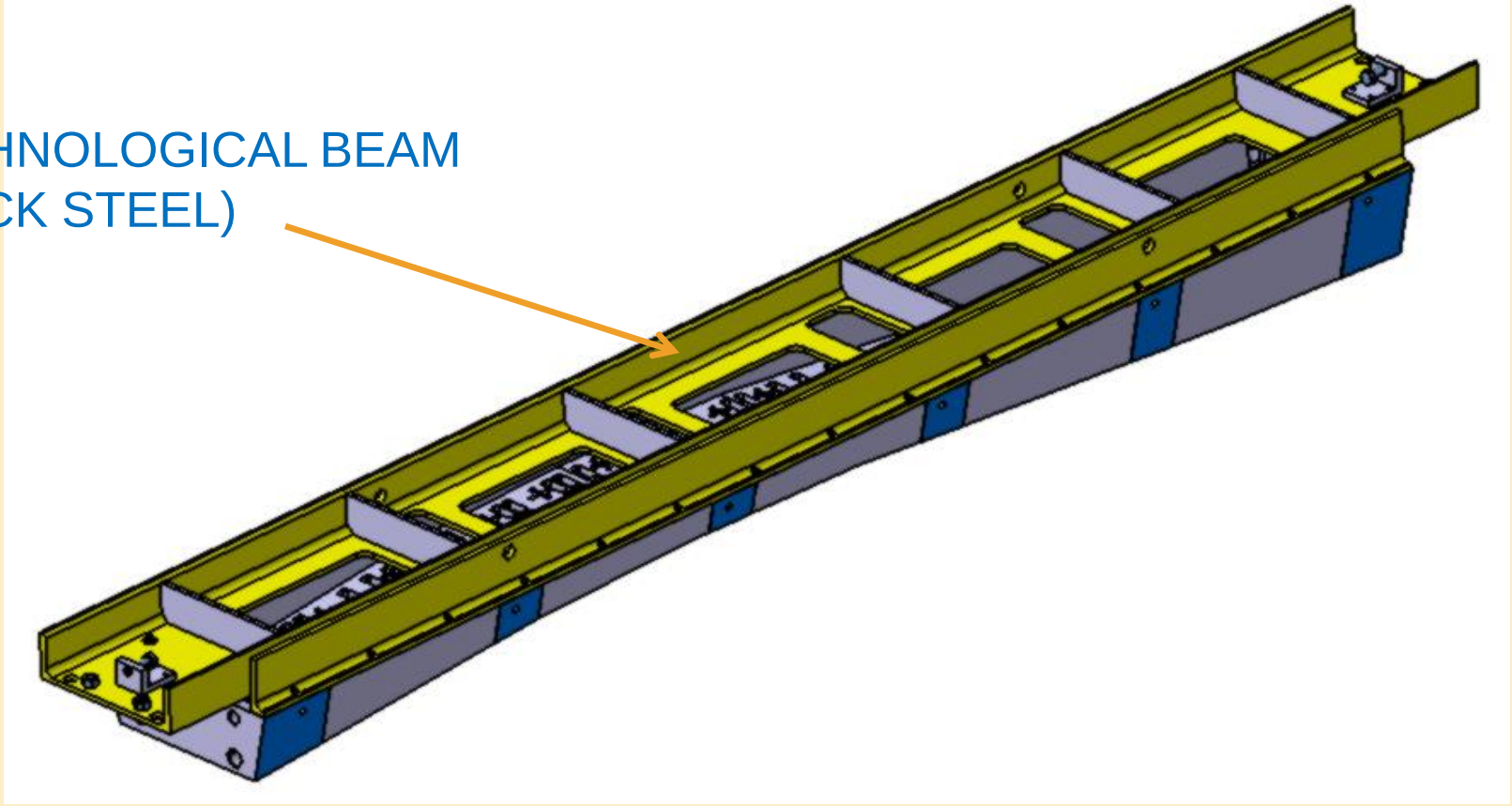
2. Moving into a pre-working position
3. Lifting into a pre-working position

ASSEMBLY OF SUPER-MODULE 3 WITH TECHNOLOGICAL DEVICE (AS EXAMPLE)

BARREL SLICE ASSEMBLY (STEP BY STEP PROCEDURE)

BARREL ASSEMBLY

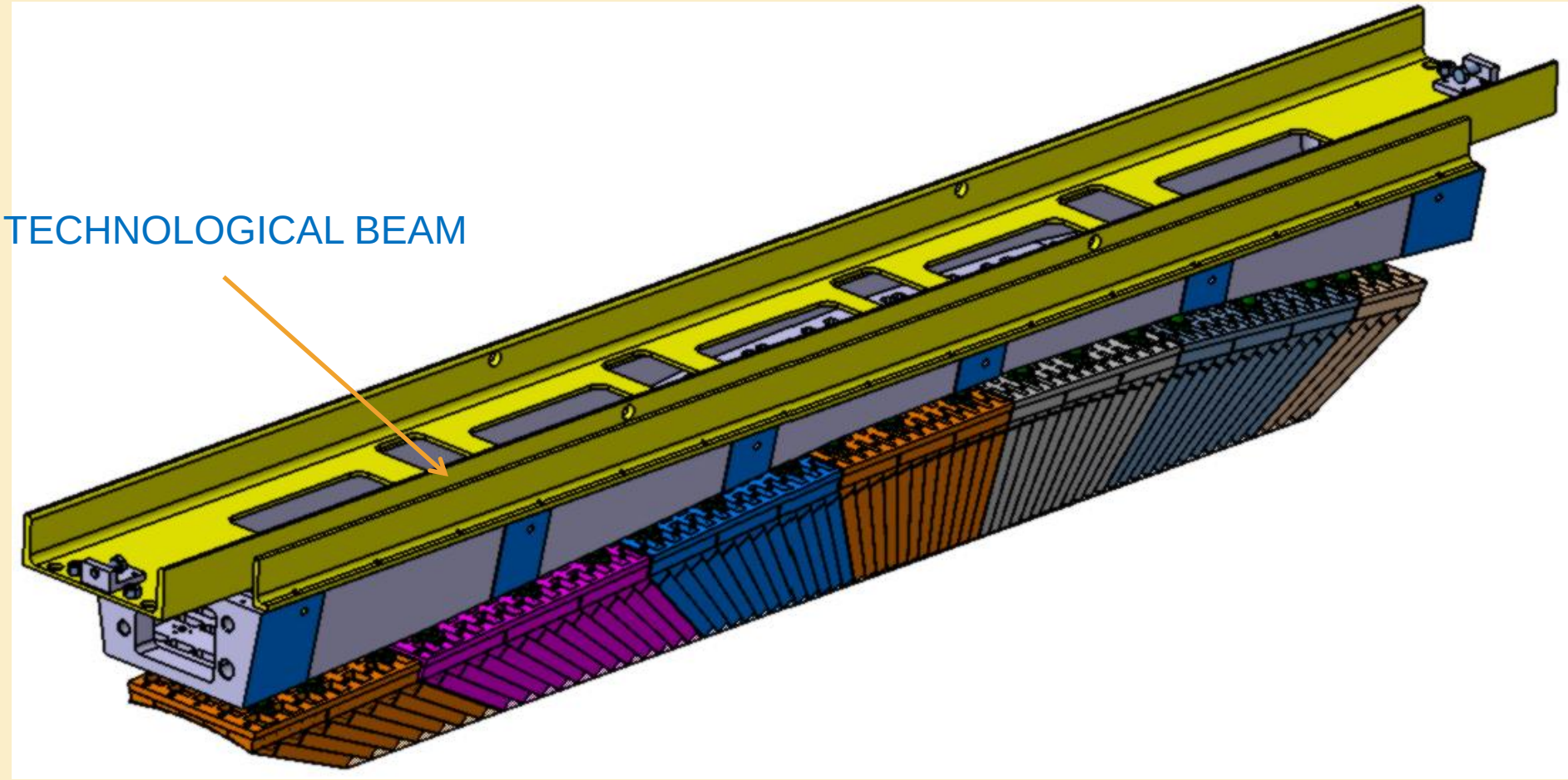
TECHNOLOGICAL BEAM
(BLACK STEEL)



This Technological Beam is used for supporting and adjusting BARREL SUPPORT BEAMS during of Assembly Procedures.
After THE BARREL final assembly procedure to be removed.

SUPPORT BEAM WITH EXTRA TECHNOLOGICAL BEAM

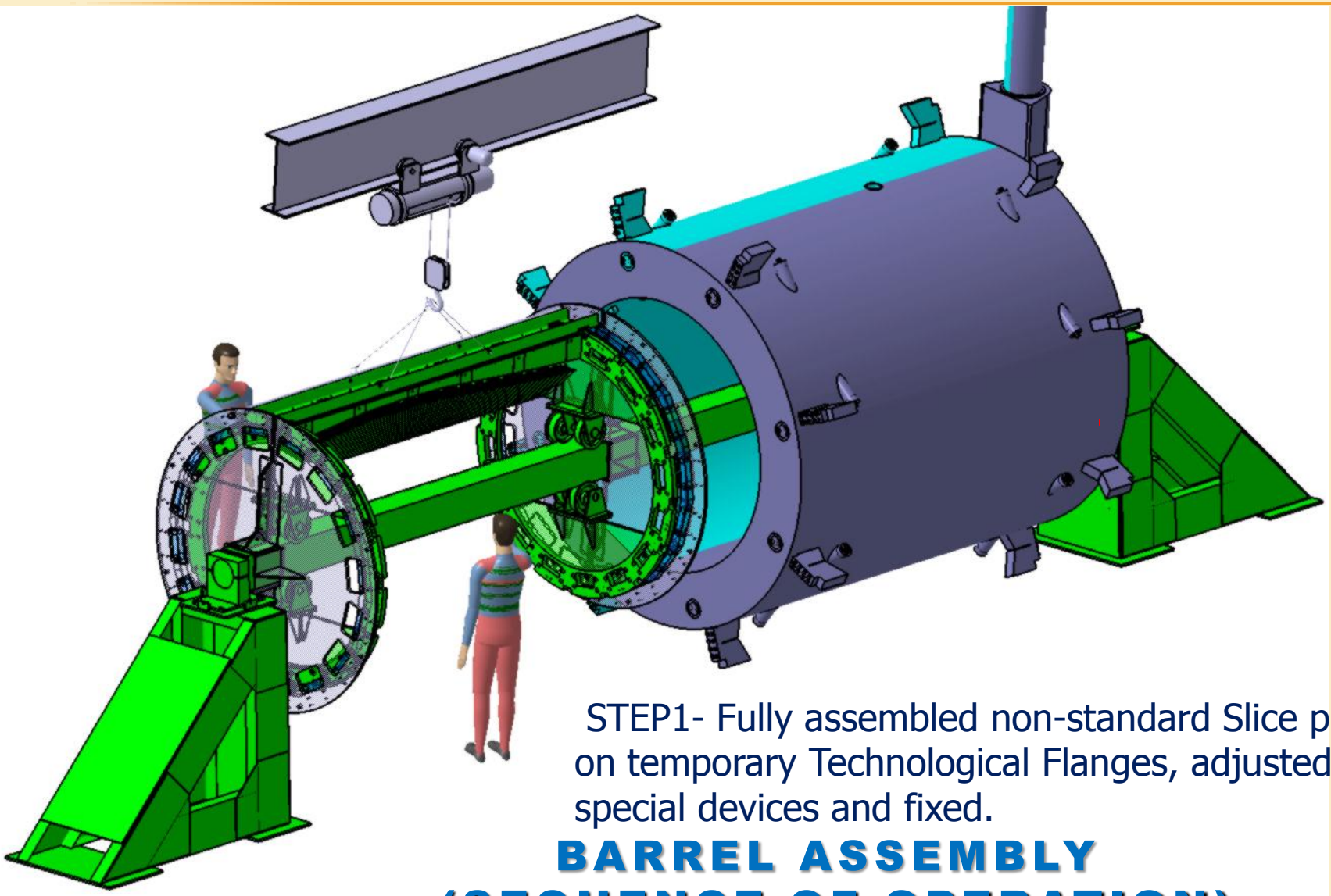
BARREL ASSEMBLY



SLICE ASSEMBLY IS READY FOR INSTALLATION IN TO BARREL
(Thermal Screen, Side Plates and Services are not shown)

FULL ASSEMBLED SLICE WITH TECHNOLOGICAL BEAM

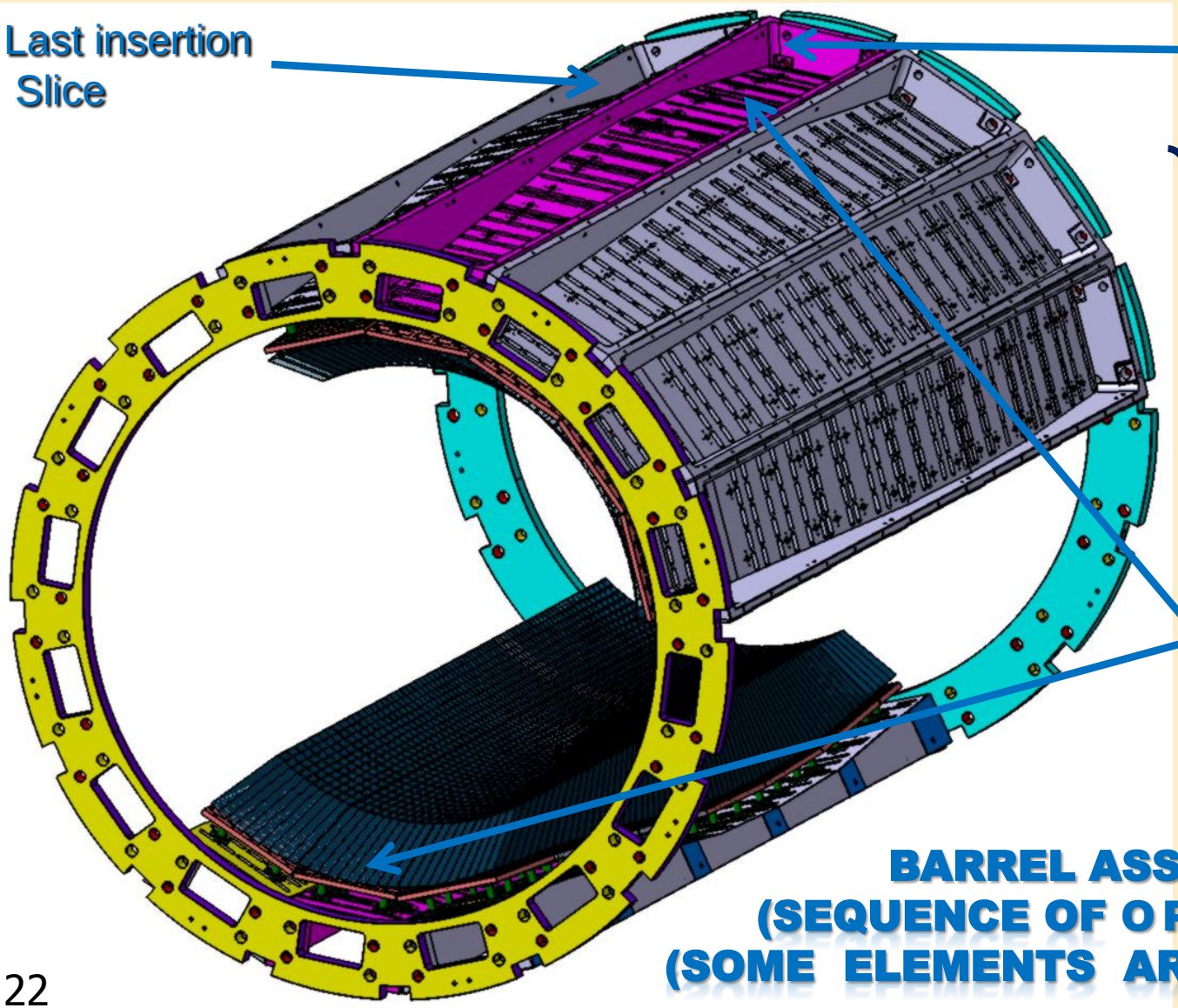
EMC BARREL DESIGN



STEP1- Fully assembled non-standard Slice placed on temporary Technological Flanges, adjusted with special devices and fixed.

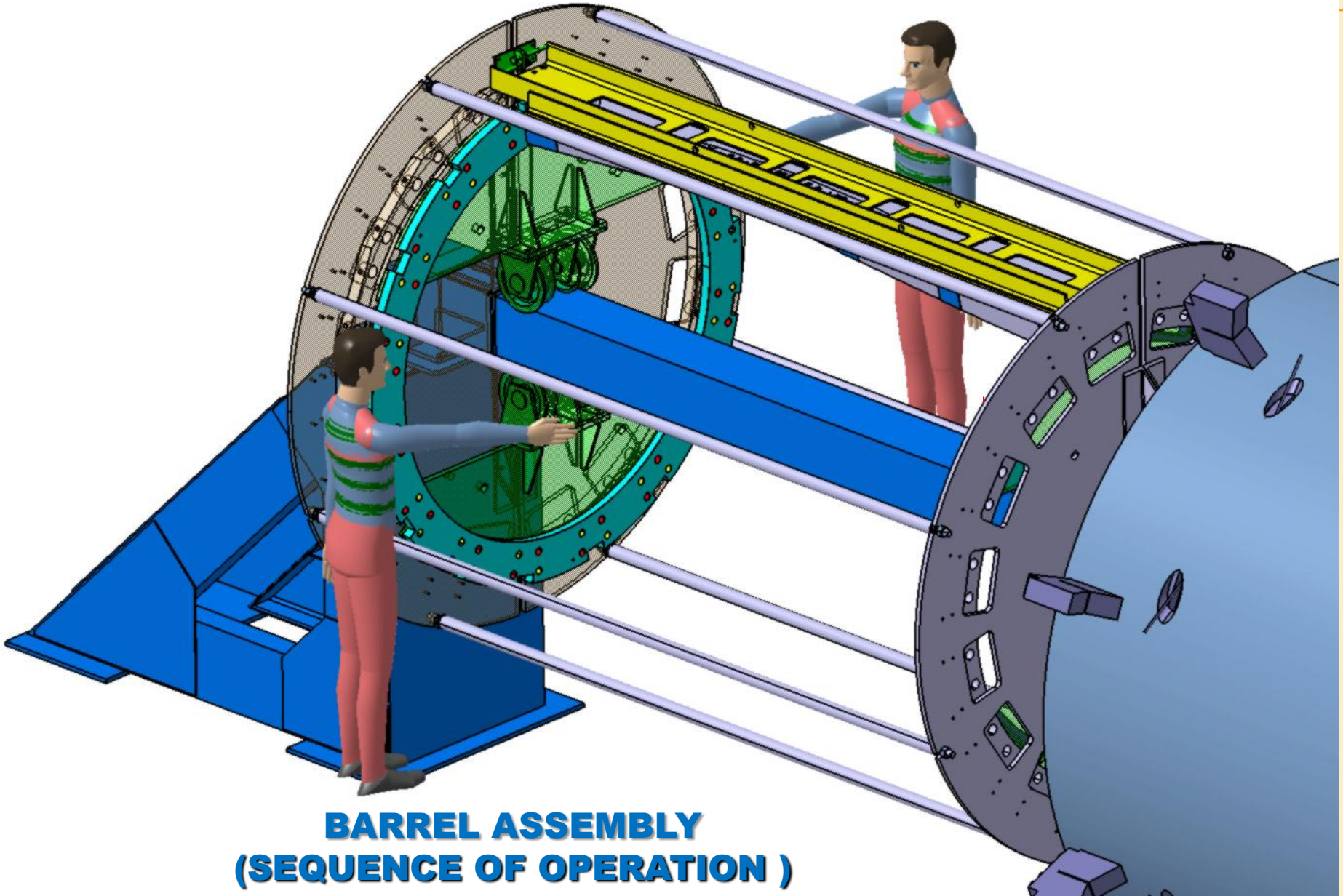
BARREL ASSEMBLY (SEQUENCE OF OPERATION)

EMC BARREL DESIGN



BARREL ASSEMBLY
(SEQUENCE OF OPERATION)
(SOME ELEMENTS ARE NOT SHOWN)

EMC BARREL DESIGN

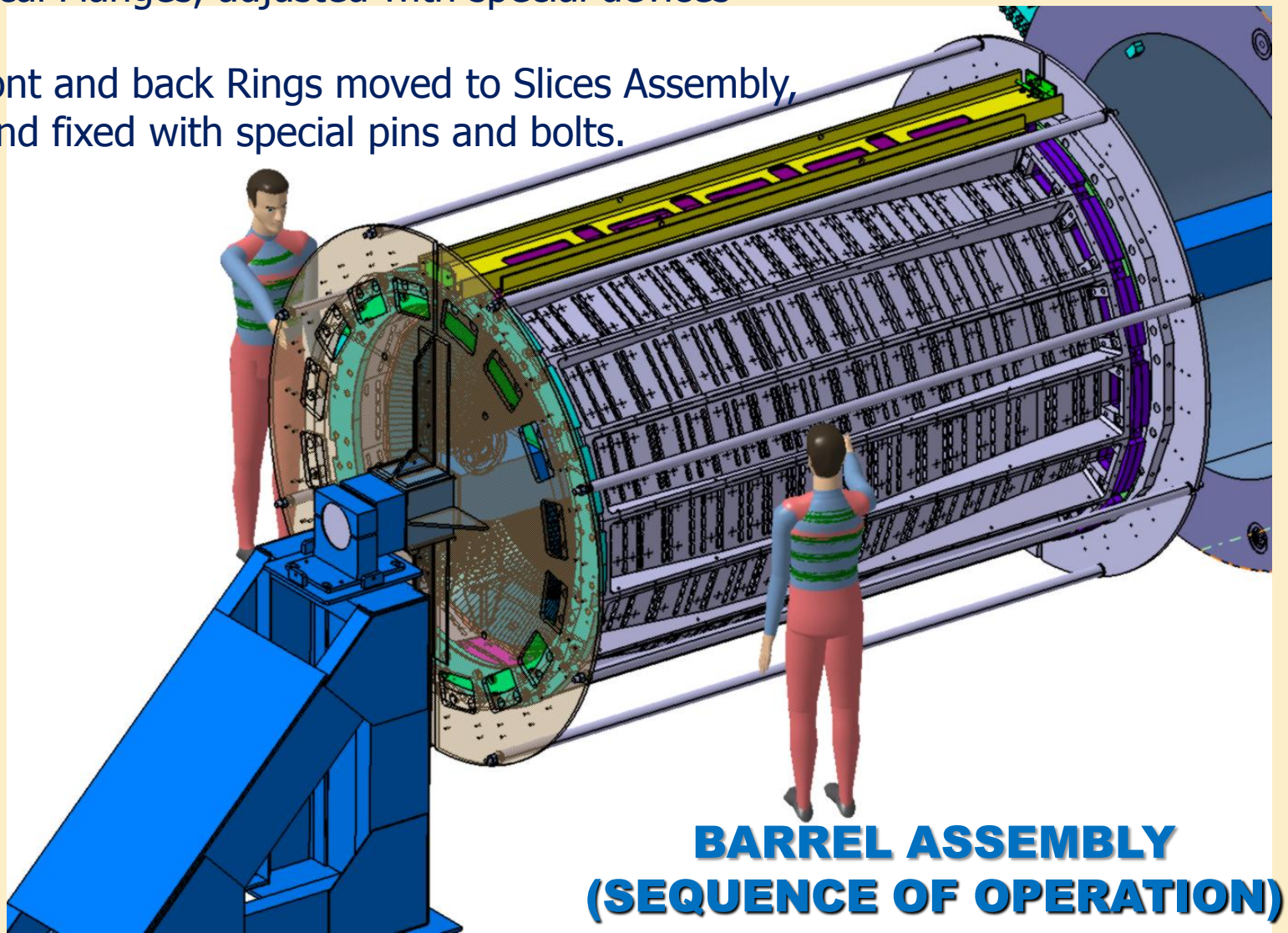


BARREL ASSEMBLY
(SEQUENCE OF OPERATION)

EMC BARREL DESIGN

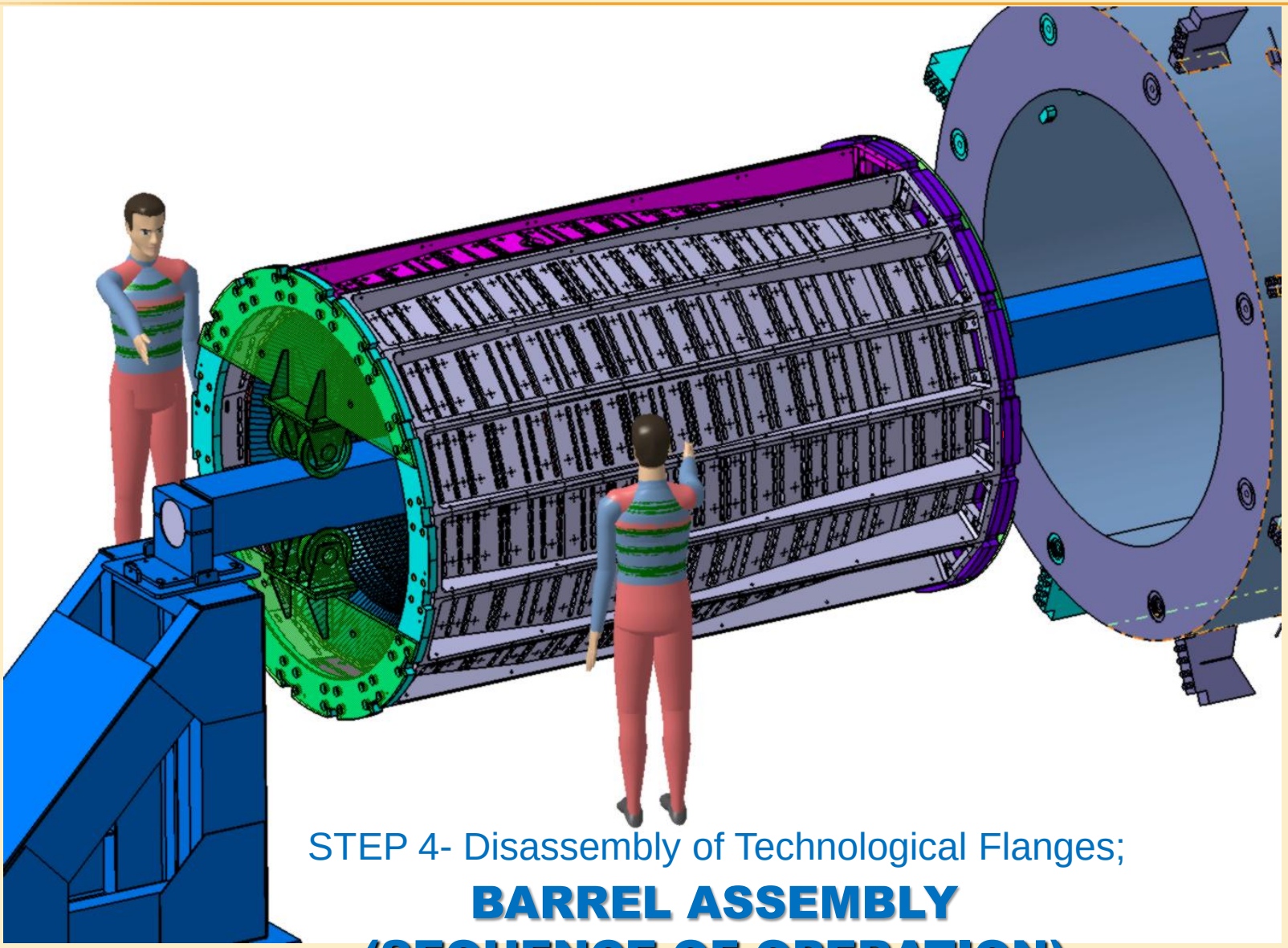
STEP2- Fully assembled Slices placed on temporary Technological Flanges, adjusted with special devices and fixed.

STEP3- Front and back Rings moved to Slices Assembly, adjusted and fixed with special pins and bolts.



BARREL ASSEMBLY (SEQUENCE OF OPERATION)

EMC BARREL DESIGN

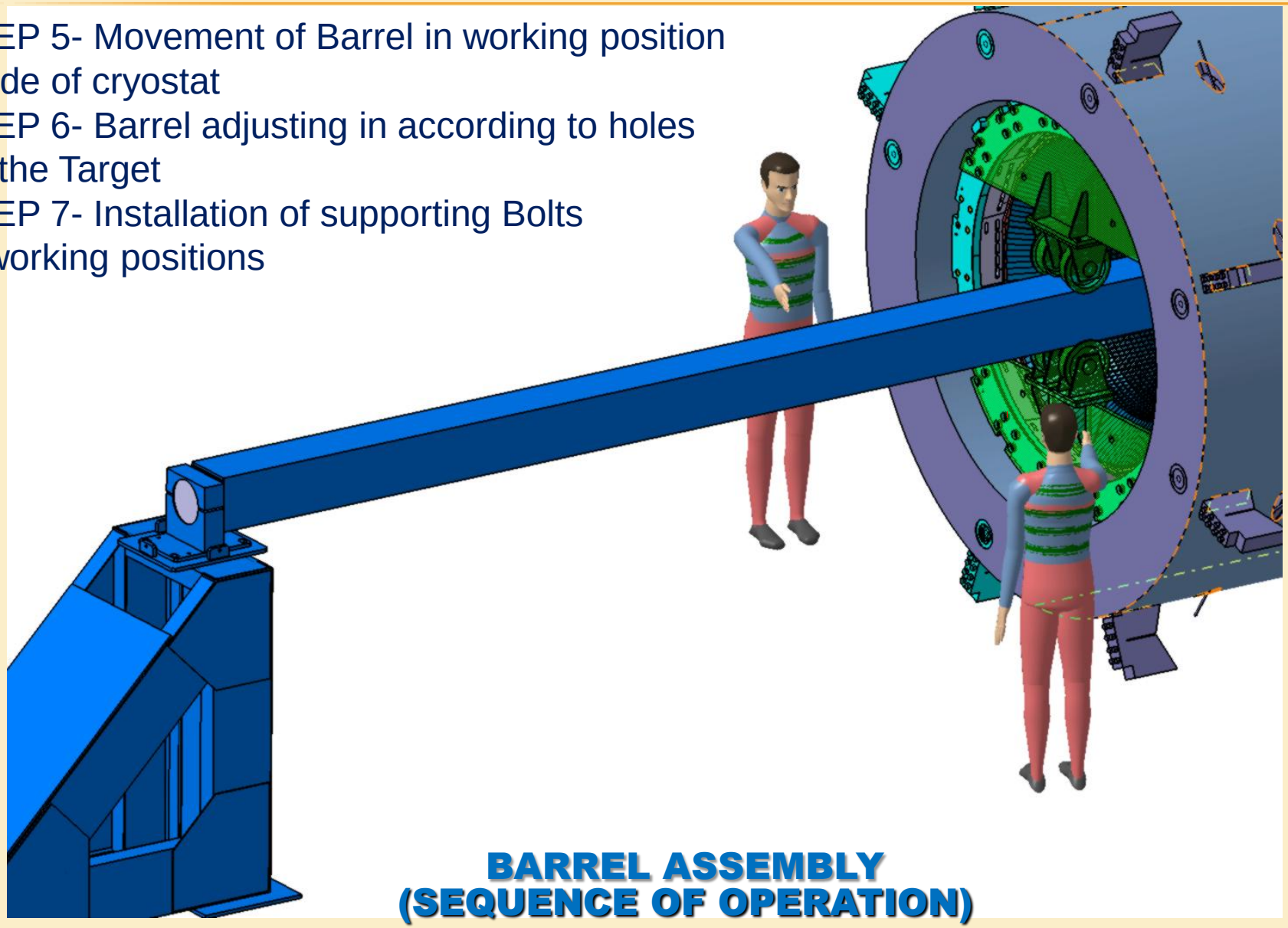


STEP 4- Disassembly of Technological Flanges;

BARREL ASSEMBLY (SEQUENCE OF OPERATION)

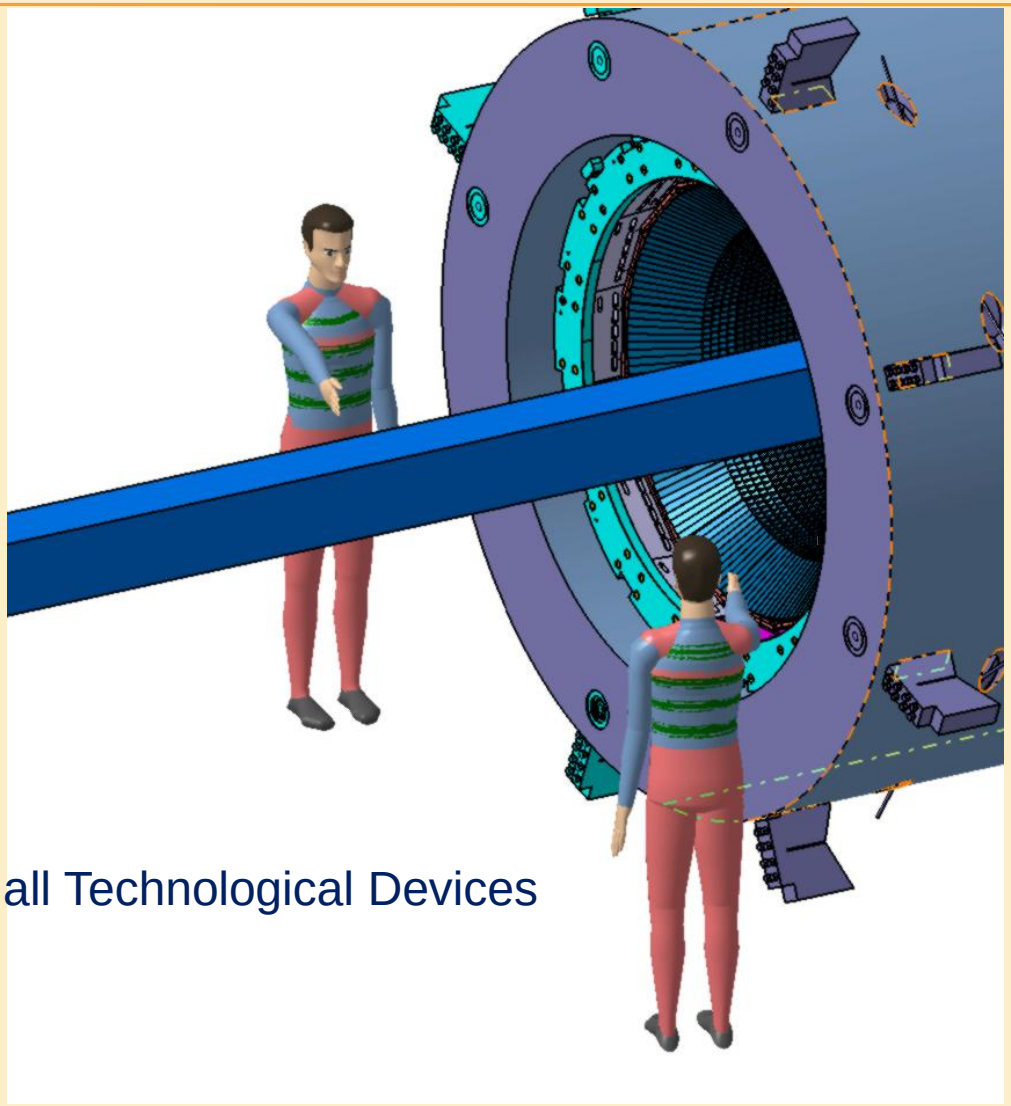
EMC BARREL DESIGN

STEP 5- Movement of Barrel in working position inside of cryostat
STEP 6- Barrel adjusting in according to holes for the Target
STEP 7- Installation of supporting Bolts in working positions



BARREL ASSEMBLY (SEQUENCE OF OPERATION)

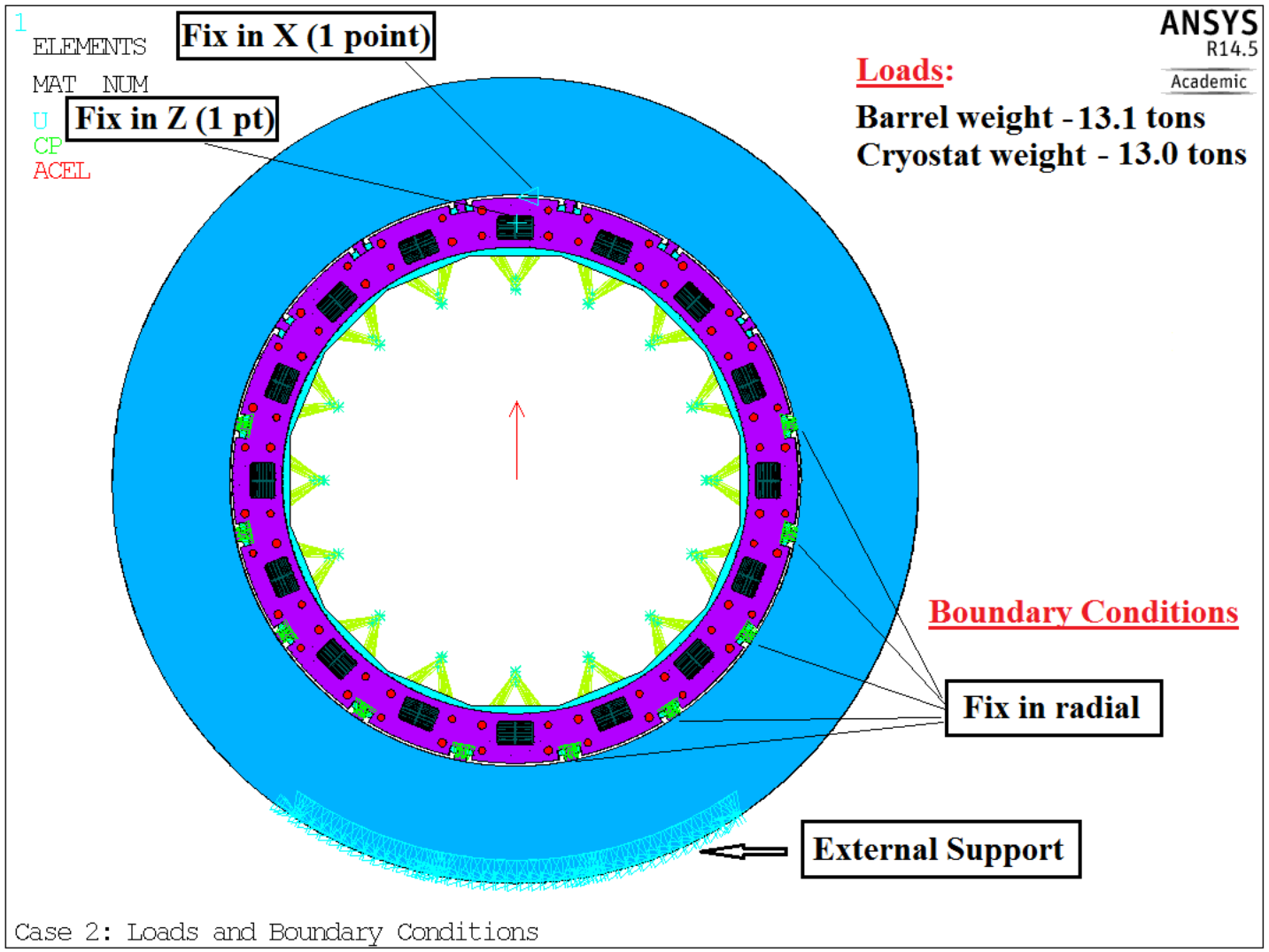
EMC BARREL DESIGN



STEP 8- Disassembly of all Technological Devices and Tools.

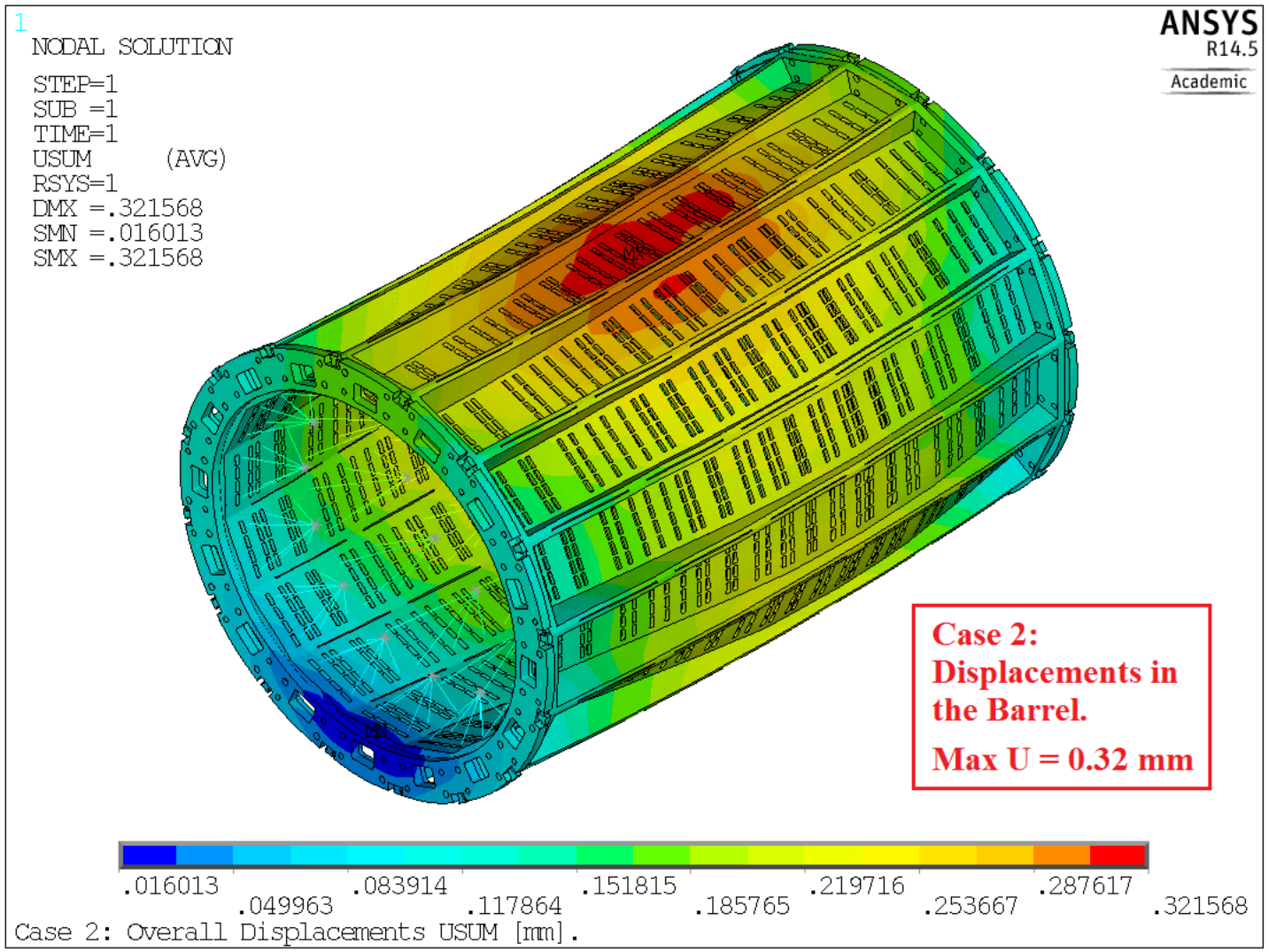
BARREL ASSEMBLY
FINAL INSTALLATION

FINITE ELEMENTS ANALYSIS OF BARREL STRUCTURE (BY A. RYABOV)



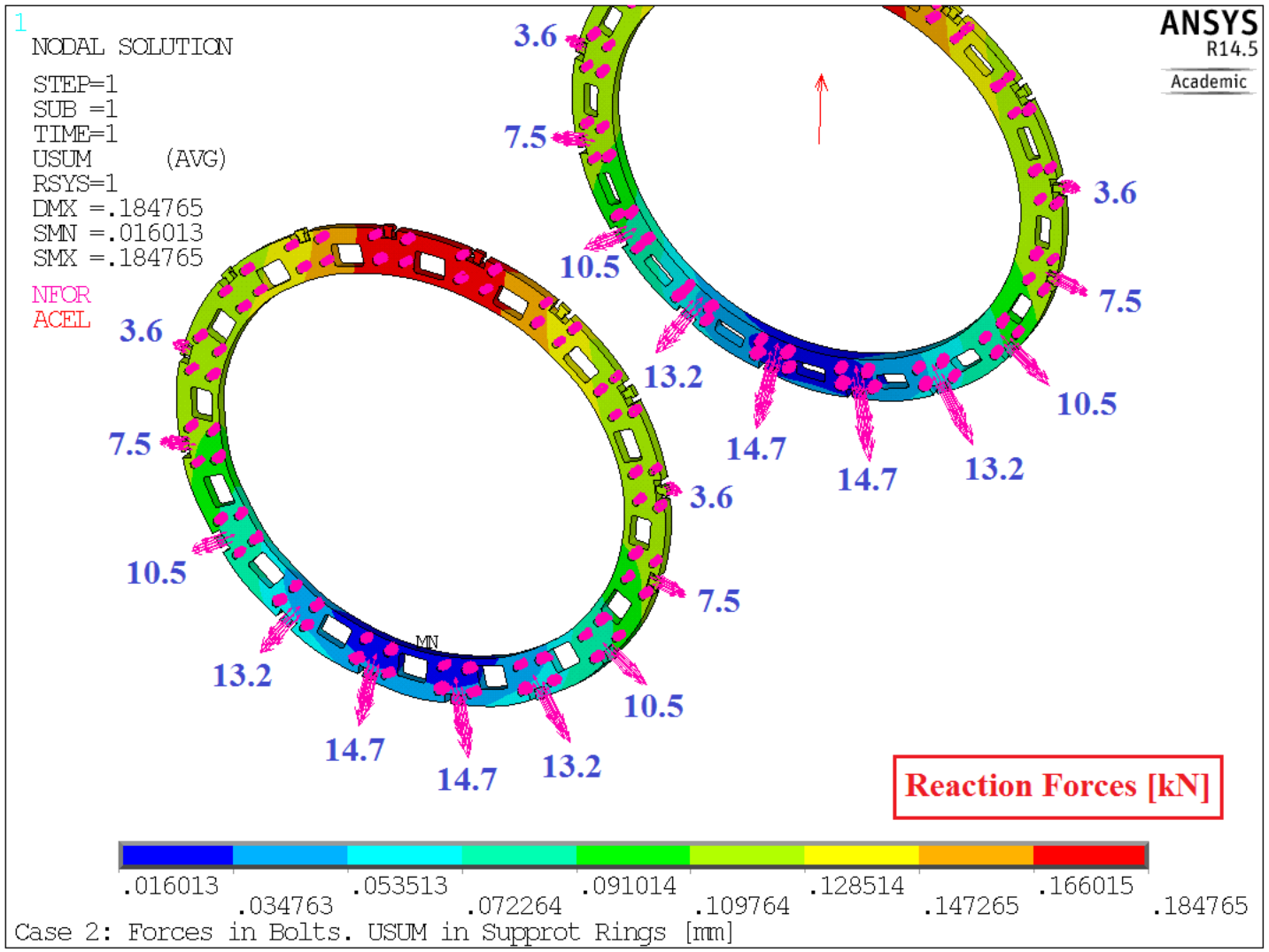
CASE 1: LOADS AND BOUNDARY CONDITIONS

FINITE ELEMENTS ANALYSIS OF BARREL STRUCTURE



CASE 1: OVERALL DISPLACEMENTS

FINITE ELEMENTS ANALYSIS OF BARREL STRUCTURE



CASE 1: REACTION FORCES

CONCLUSION

Actual design of EMC Barrel made by IHEP has preliminary character.
The Support Beams for Barrel Structure can be made with trapezoidal shape from aluminium alloy 7050 HOKOTOL.
The Benefits are:

- Non-magnetic;
- More rigid;
- Lighter than steel:
  total weight of the support structure without crystals with support beams
  - made from aluminium alloy 7050 is ~1.4 tons
  - made from stainless steel is ~3.4 tons;
- Easily machined, also by hand tools during assembly;
  (especially important for the first slice – prototype);
- More useful area for Services

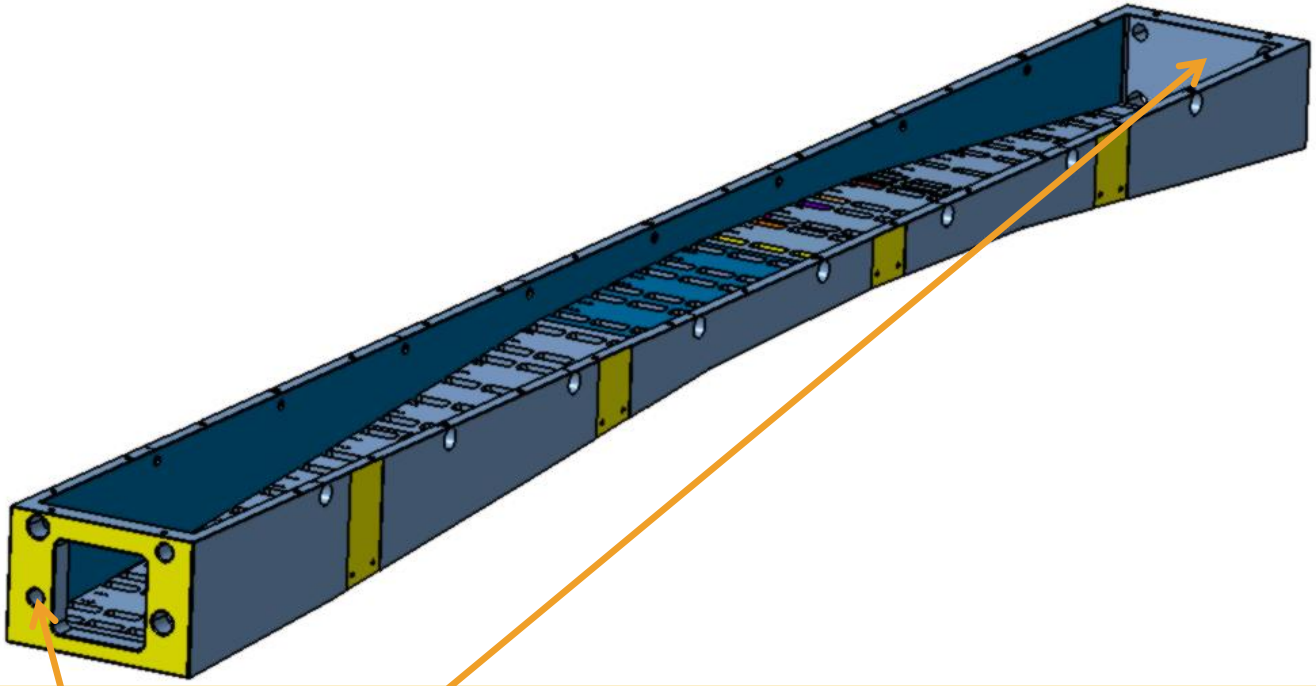
OPEN QUESTIONS

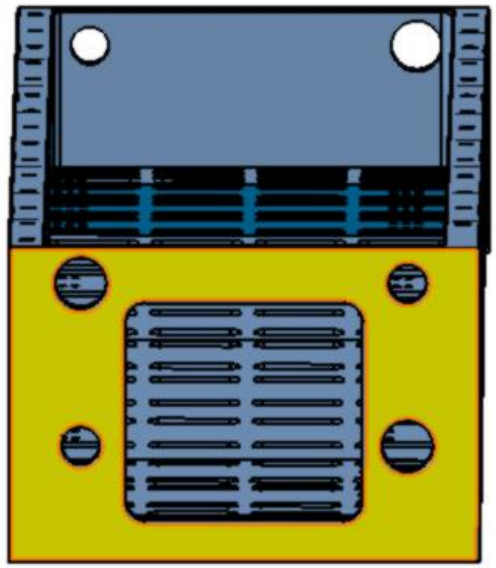
To continue our design we need additional information:

1. Actual simplified Design of Cryostat;
2. Design of Thermal Screen for Slices;
3. Design of Services for Slices;
4. Design of Side Plate for Slices;
5. Design of Tooling for Super-Module Assembly;
6. Surrounding Area by Cryomagnet for optimal scenario of Barrel Main Assembly.

THANK YOU FOR ATTENTION !!!

DESIGN OF EMC BARREL SLICE





DIMENSIONS:
1. L = 2695 mm
2. 260 x 174 mm
3. 260 x 136 mm

Weight ~58 kg (from Aluminum) or ~168 kg (from St. Steel)

VARIANT N1- RECTANGULAR SHAPE OF SUPPORT BEAMS FROM ST. STEEL OR ALUMINUM

CHOICE OF MATERIAL AND SHAPE FOR SUPPORT BEAMS-BARREL STANDARD SUPPORT BEAM WITH RECTANGULAR SHAPE