

# EP-DT Group Meeting

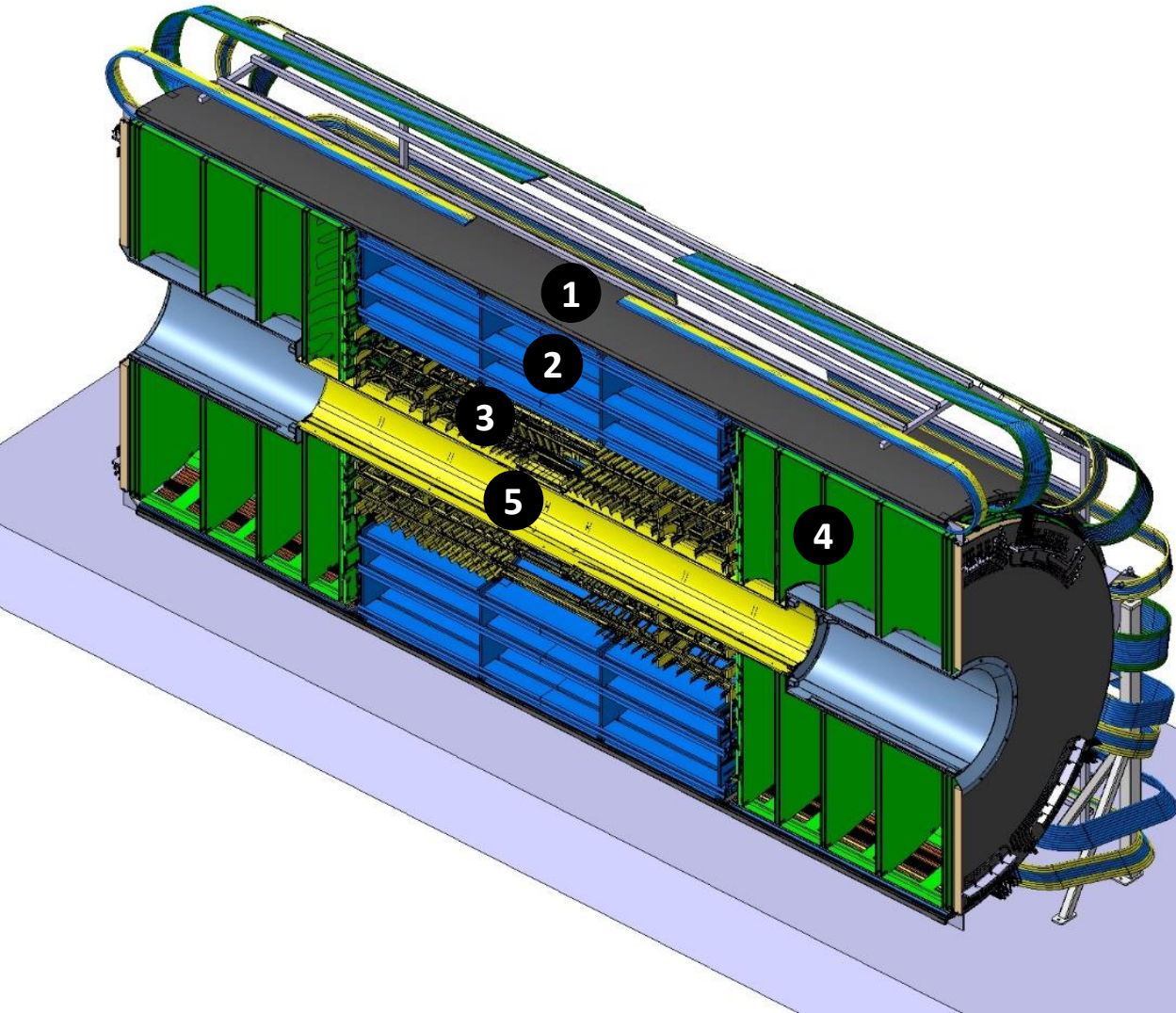
## CMS Outer Tracker

Contributors from EP-DT group: Alexandre Perez, Antti Onnela, Carmine Stile, Luc-Joseph Kottelat, Fernando Perea Albela, Francisco Perez Gomez, Francois Boyer, Joao Batista Lopes, Philippe Lenoir, Quentin Piazza, Remus Vrancianu, Robert Kristic

<https://indico.cern.ch/event/1415265/>

26 June 2024

# Phase-2 Upgrade of the CMS Outer Tracker



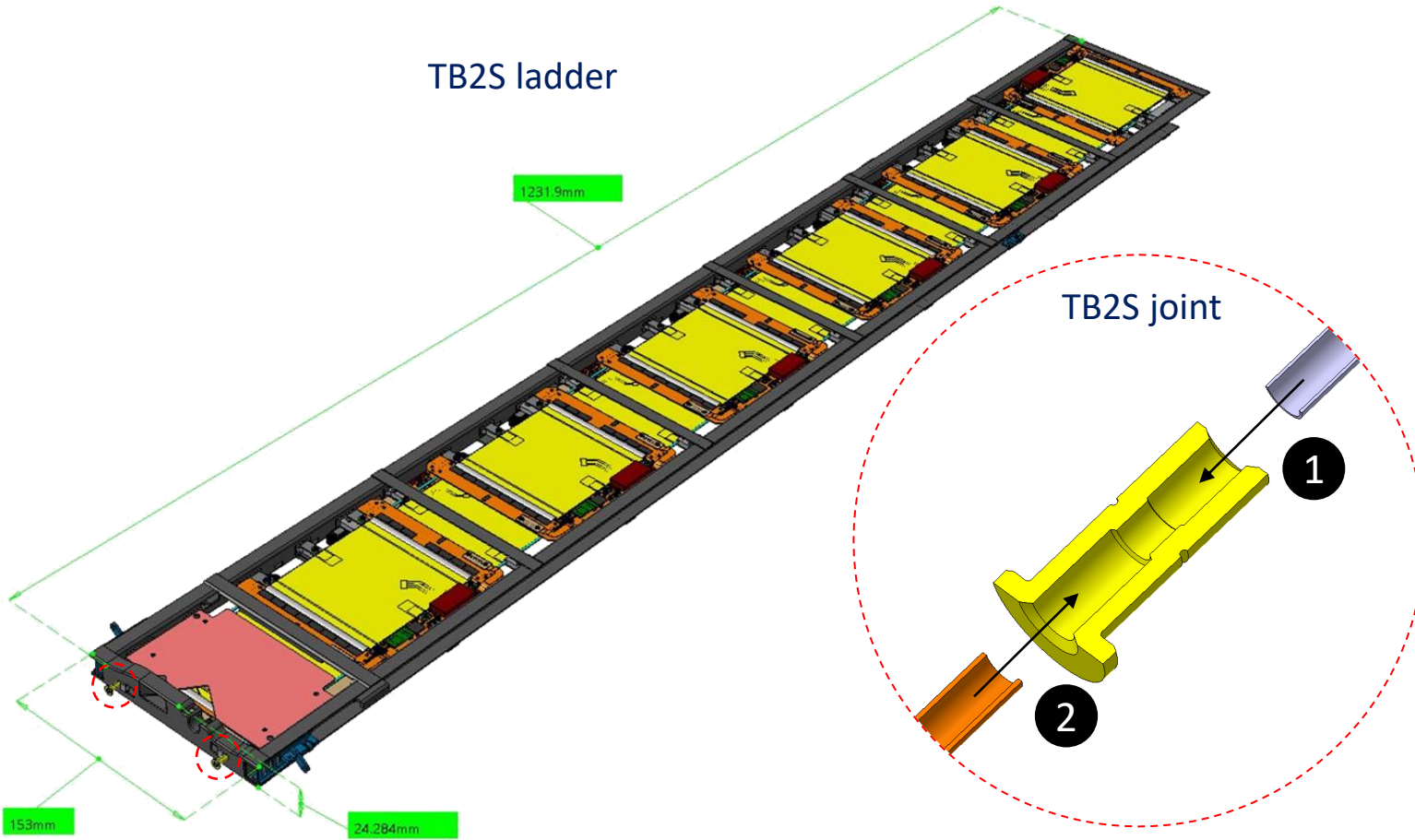
1. BTL Tracker Support Tube (BTST)
2. Tracker Barrel with 2S modules (TB2S)
3. Tracker Barrel with PS modules (TBPS)
4. Tracker Endcap Double-Discs (TEDD)
5. Inner Tracker Supporting Tube (ITST)

EP DT involvement:

- Global integration design
- Design, manufacturing and QC of mechanical parts and assemblies for the TBPS and TB2S sub-detectors. Examples shown in this presentation:
  - TB2S cooling pipes
  - TBPS rings

# TB2S – CO<sub>2</sub> cooling pipes

TB2S ladder



## Overview

- 368 ladders for 3 layers of TB2S
- Cooling pipes assemblies to produce: 420
- Following development at EP-DT the stainless-steel pipe was replaced by Ti

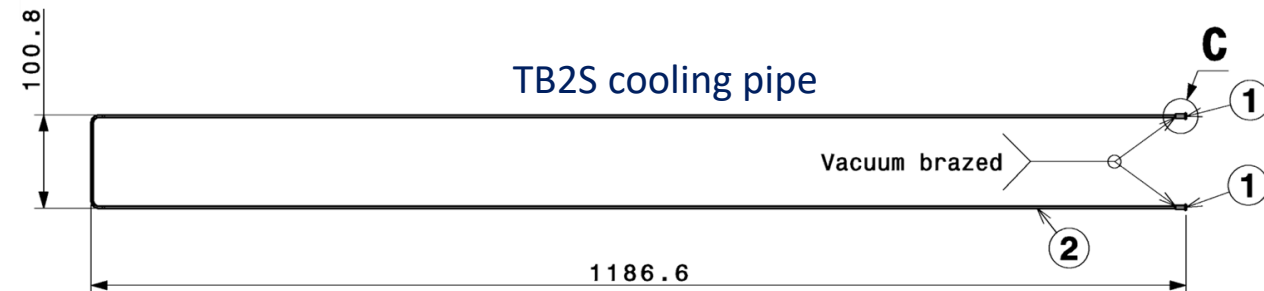
### 1. Furnace vacuum brazing

- Soft annealed Ti grade 2 pipe OD2.3 ID2.0
- CuNi 70-30 sleeve
- Filler: Incusil 15 (61.5% Ag, 23.5% Cu and 15% In)
- Brazing temperature: 730°C

### 2. Soft soldering

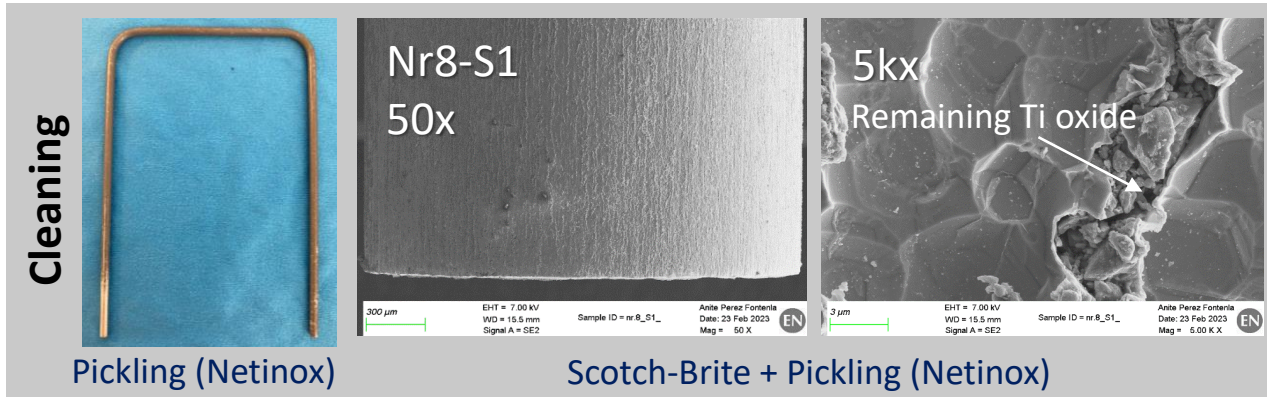
- CuNi 70-30 pipe OD2.5 ID2.0
- Filler: Sn62Pb36Ag2 (RT15 1.5%)
- Melting temperature: 179°C
- Soldering iron temperature: 230°C

TB2S cooling pipe

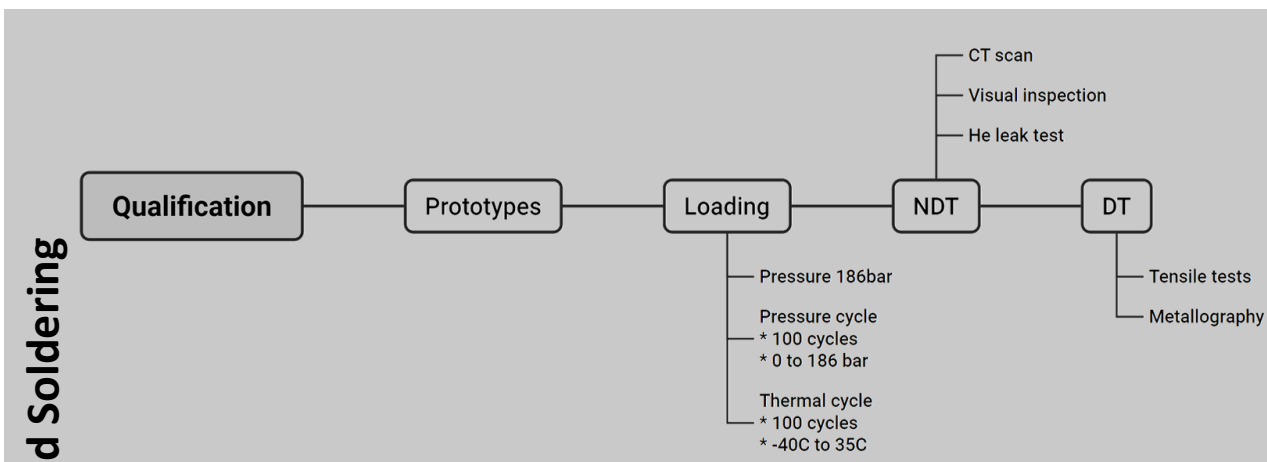
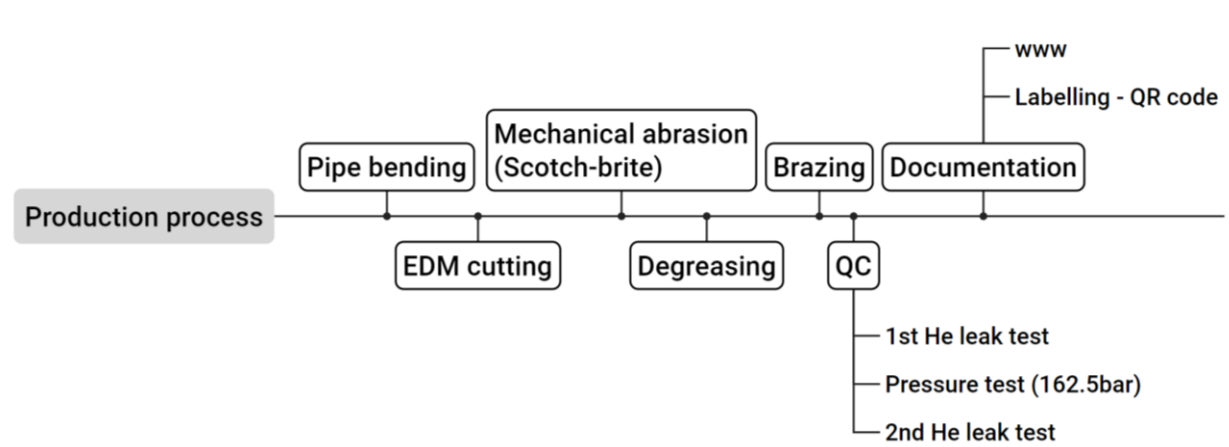




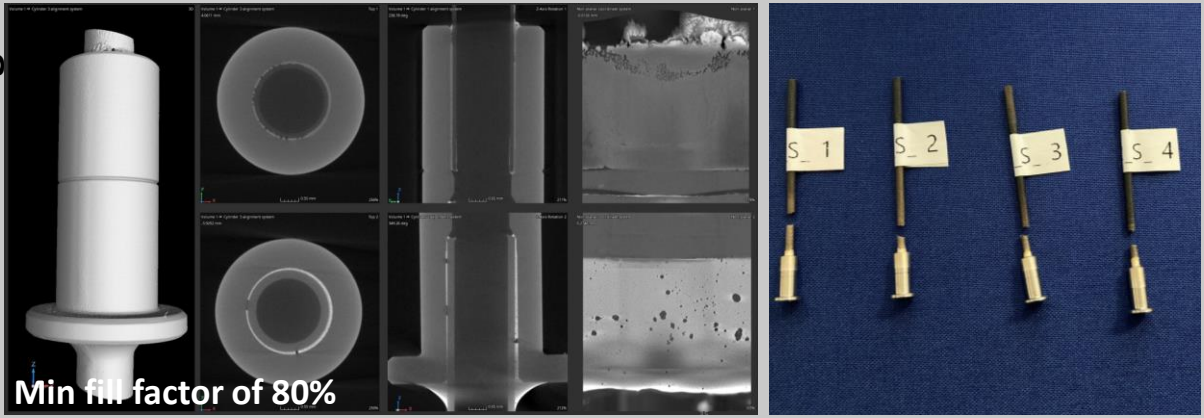
# Qualification testing - Prototyping



# Acceptance testing - Production



# Brazing and Soldering



**Brazing**

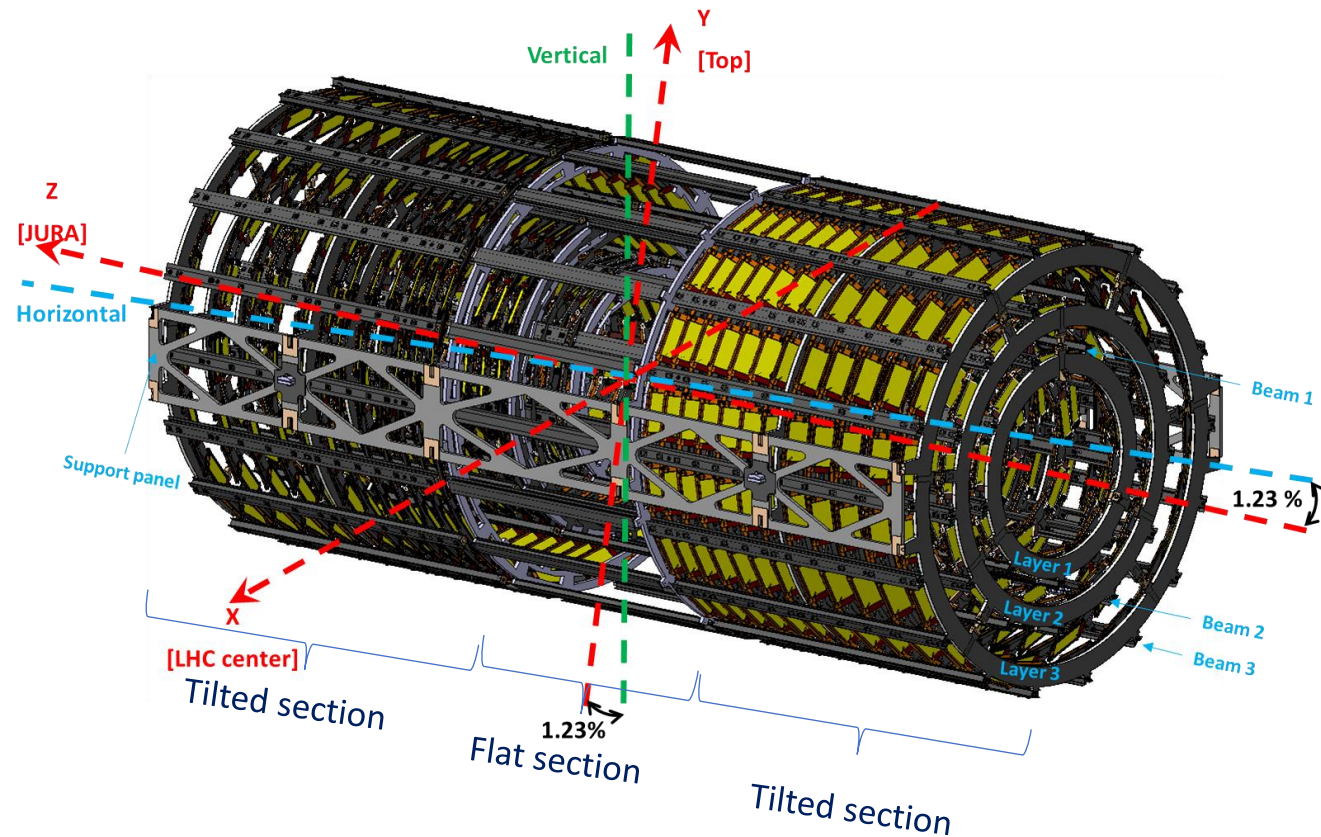
<b>Brazing method</b>	Furnace vacuum brazing
<b>Brazing by</b>	Alexandre Gerardin, Lisa Gall
<b>Brazing date</b>	19 February 2024
<b>Filler material</b>	<ul style="list-style-type: none"> <li>Incusil 15 (61.5% Ag, 23.5% Cu and 15% In)</li> <li>Liquidus temperature: 725°C</li> </ul>
<b>Filler quantity</b>	2 rings of wire (diameter 0.5mm). Approximate mass of 0.04g
<b>Brazing cycle</b>	<ol style="list-style-type: none"> <li>Vacuum RT &lt;math&gt;5 \times 10^{-6}&lt;/math&gt; mbar before cycle</li> <li>Temperature increase up to 730°C</li> <li>Filler fusing for 2-3 minutes at 730°C</li> <li>Natural cooling under vacuum</li> </ol>

Furnace brazing

**Check status:** Validated      **Check date:** 26 February 2024      **Checked by:** Joao Batista Lopes

[JMT](#)  
[JOB](#)  
[Brazing cycle plot](#)

# TBPS



## Tilted section overview

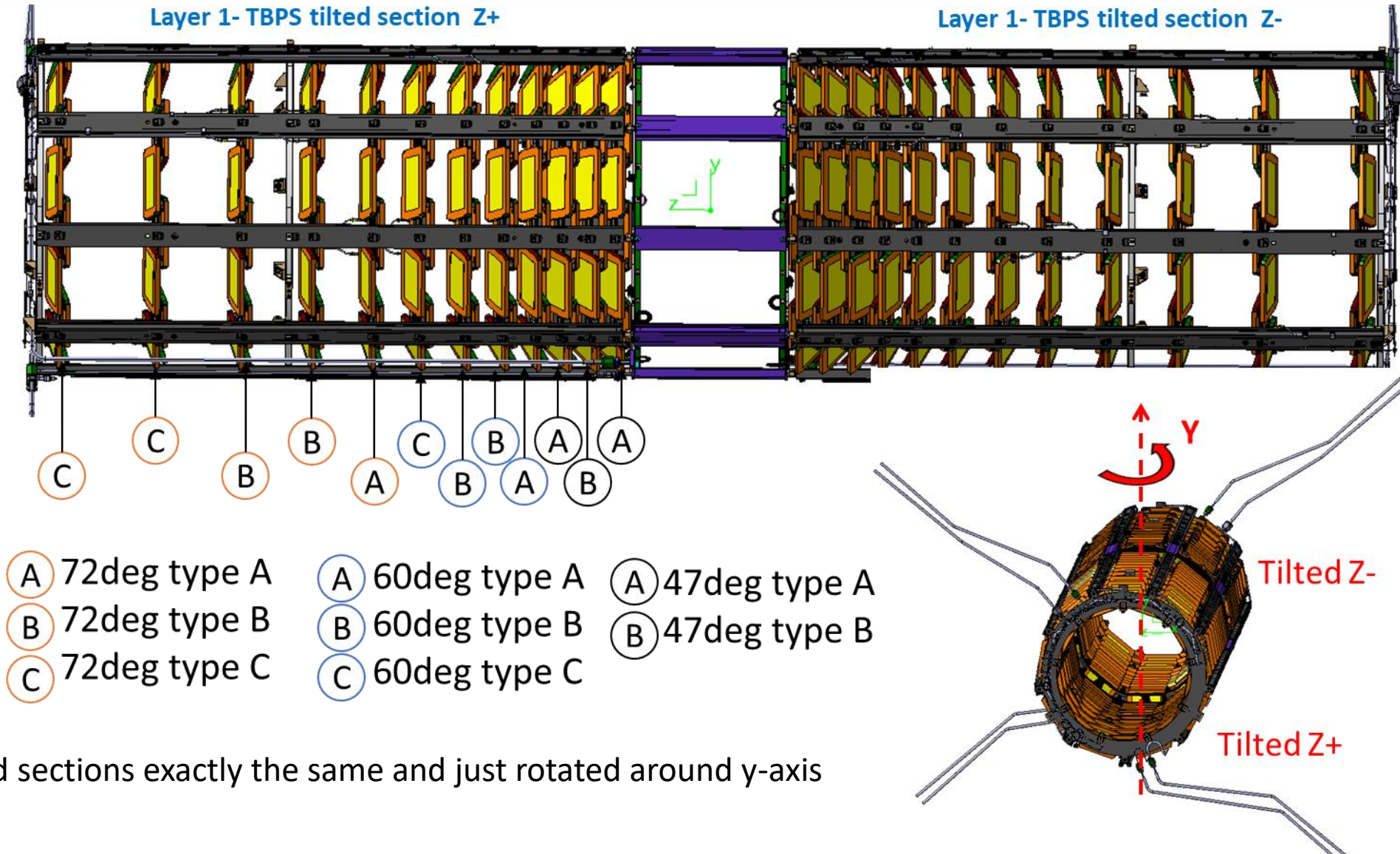
- 3 layers
- 2\*12 tilted rings per layer
- Modules per ring: 18 (L1), 26 (L2), 36 (L3)
- Radius ranging from 215mm to 626mm
- Total length of 2450mm
- Estimated mass of 200kg

## EP DT involvement

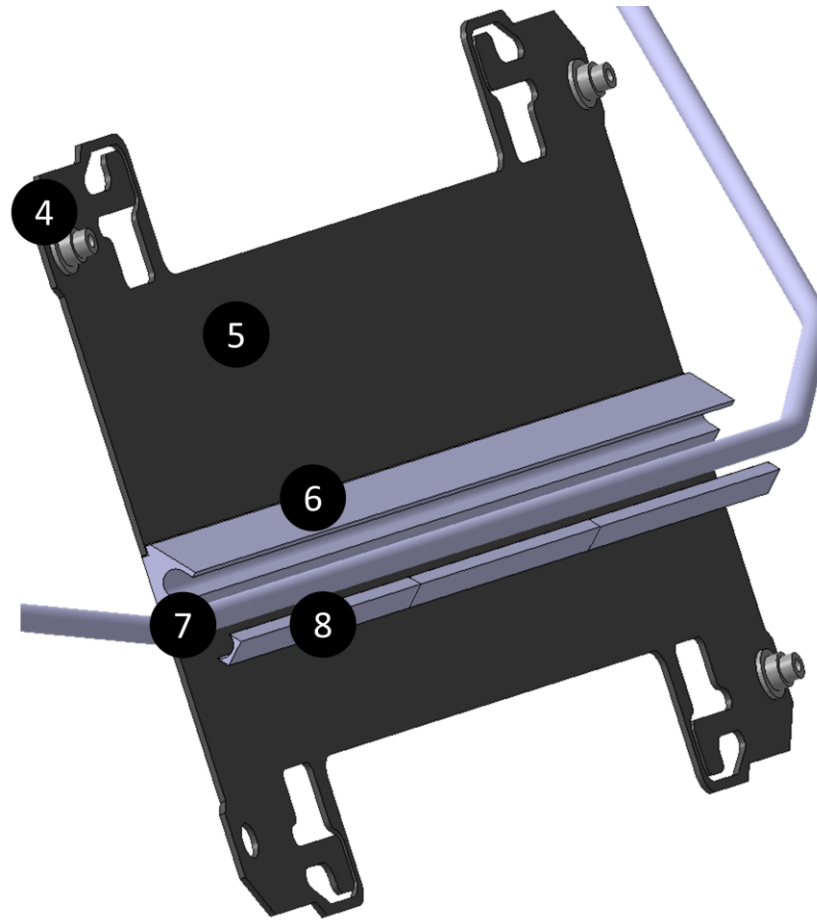
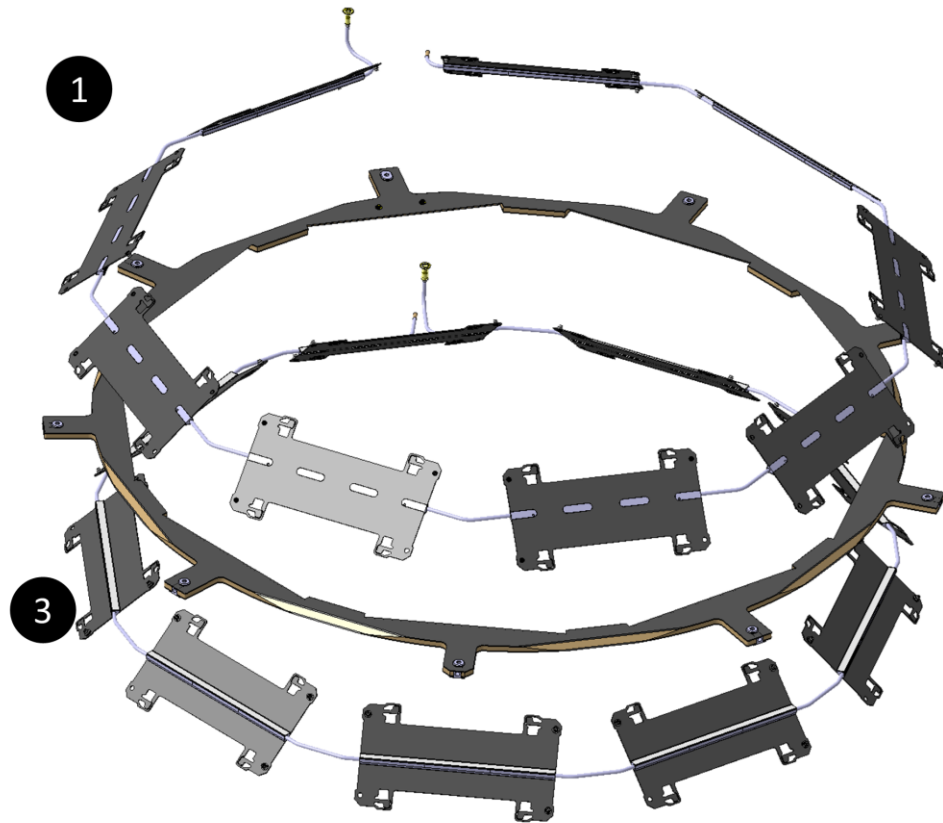
- Design, manufacturing, production and QC of:
  - TBPS global assembly design
  - Design of the tilted section and their services
  - Tilted ring structures
  - Manufacturing jigs
  - Assembly tools
- Assembly of the tilted section (loaded tilted rings)
- Assembly of the complete TBPS, together with Fermilab's flat sections



# Layer 1 structure – As an example

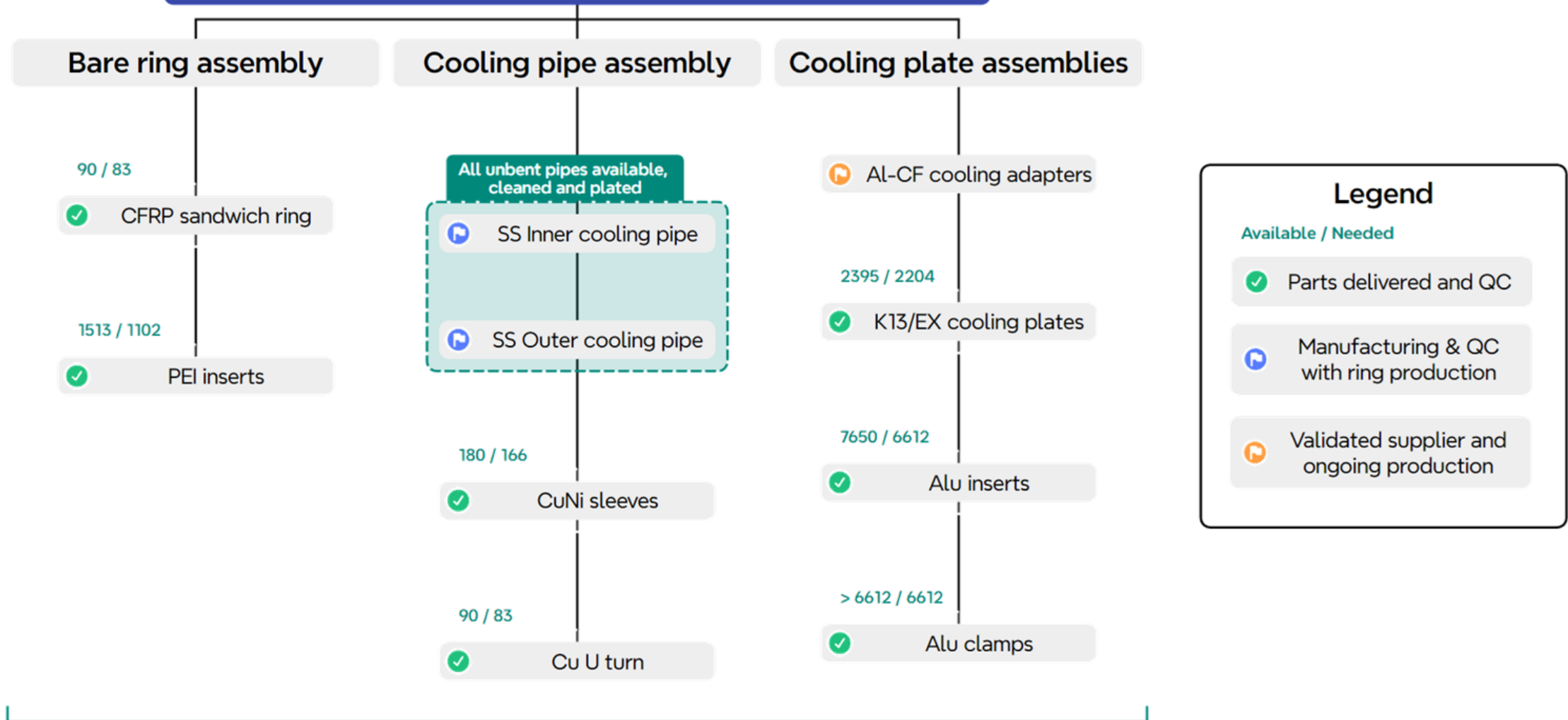


# Tilted ring mechanics



1. Outer cooling plates/pipe
2. Sandwich ring
3. Inner cooling plates/pipe
4. Module positioning inserts
5. Cooling plate
6. Cooling adapter
7. Cooling pipe
8. Cooling pipe clamp

# TBPS tilted ring components - Status



**Tilted rings: produced/(needed+ spares):**

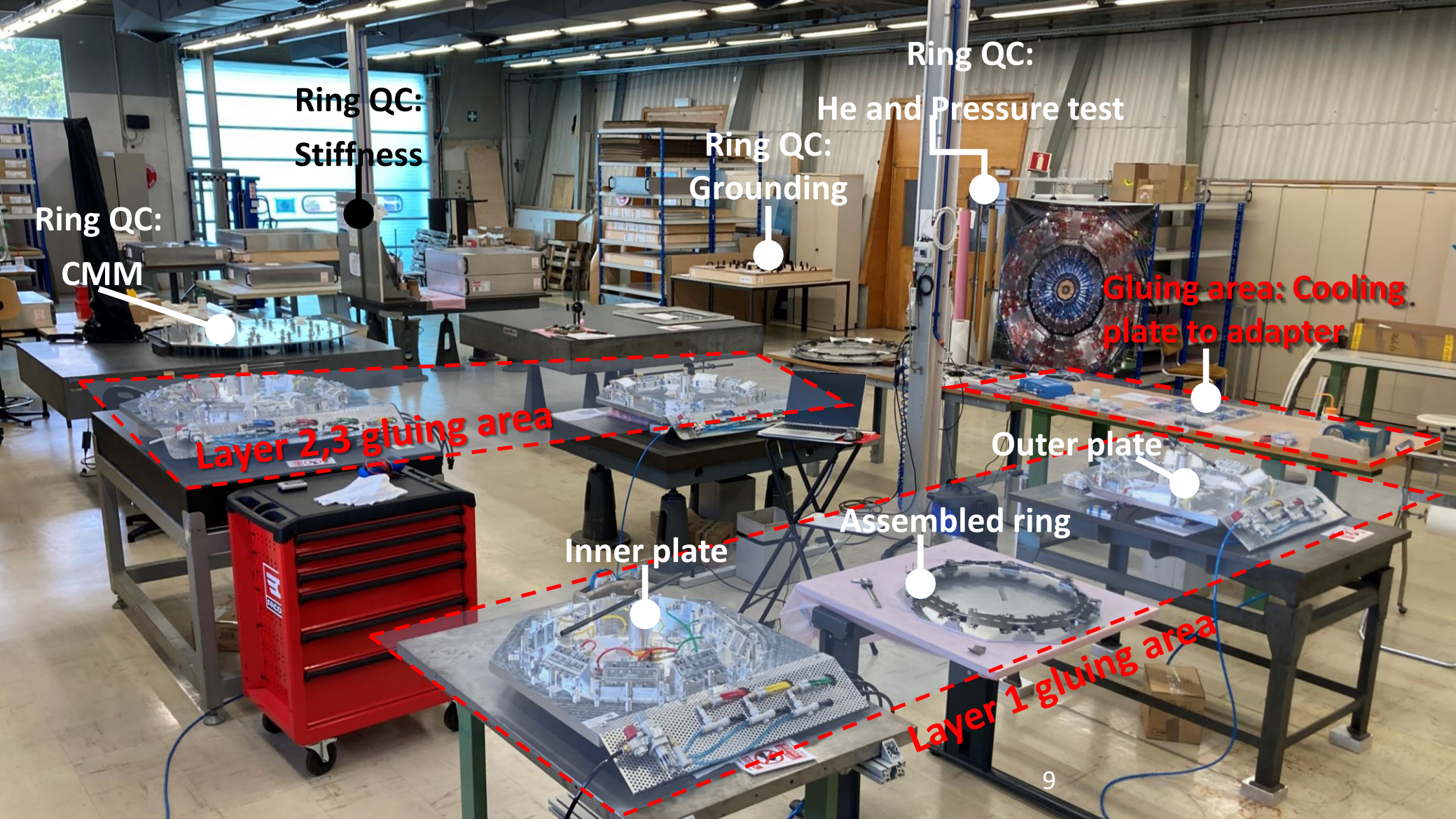
Layer 1: **10** / (24+4)  
 Layer 2: **5** / (24+4)  
 Layer 3: **3** / (24+3)

Total: **18** / 83

**Estimated end  
production: January 2026**

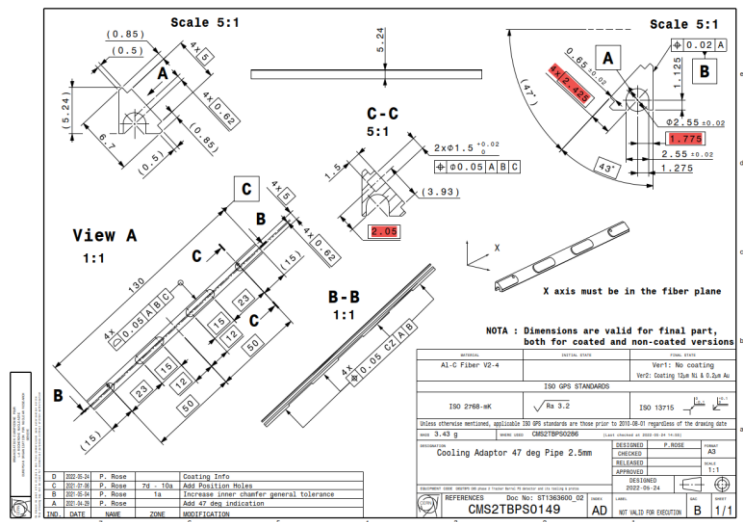
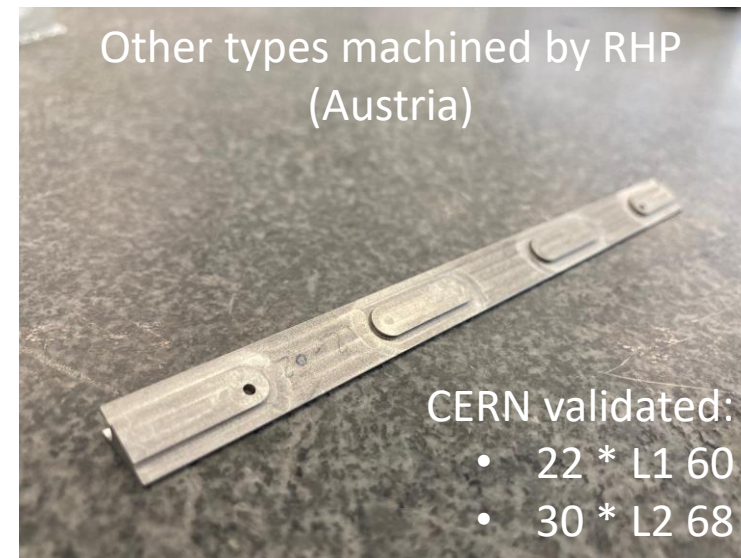
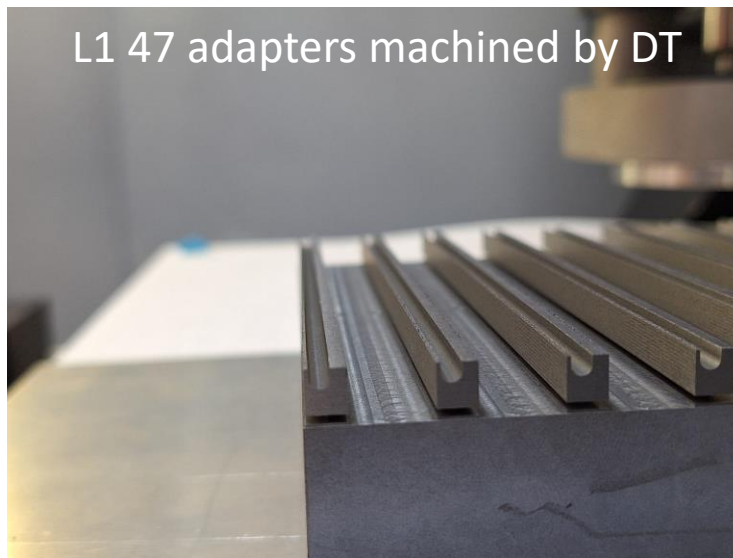


# Ring production in b. 187





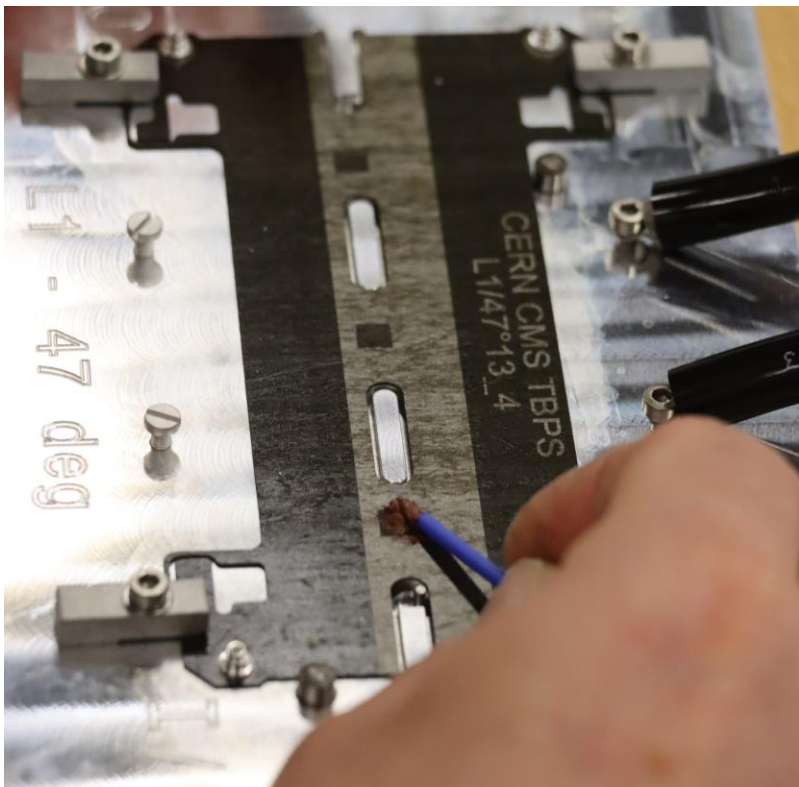
# Critical component: Cooling adapters AICF



Previous machining company went bankrupt in summer 2023.

New production channels implemented:

- EP DT manufacturing L1 47
- RHP validated and ongoing orders: 156\*L1 60, 218\*L1 72, 200\*L2 40, 224\*L2 68



Dispensing conductive glue: EPO-TEK 430



Dispensing glue: Polytec EP 601-Lv

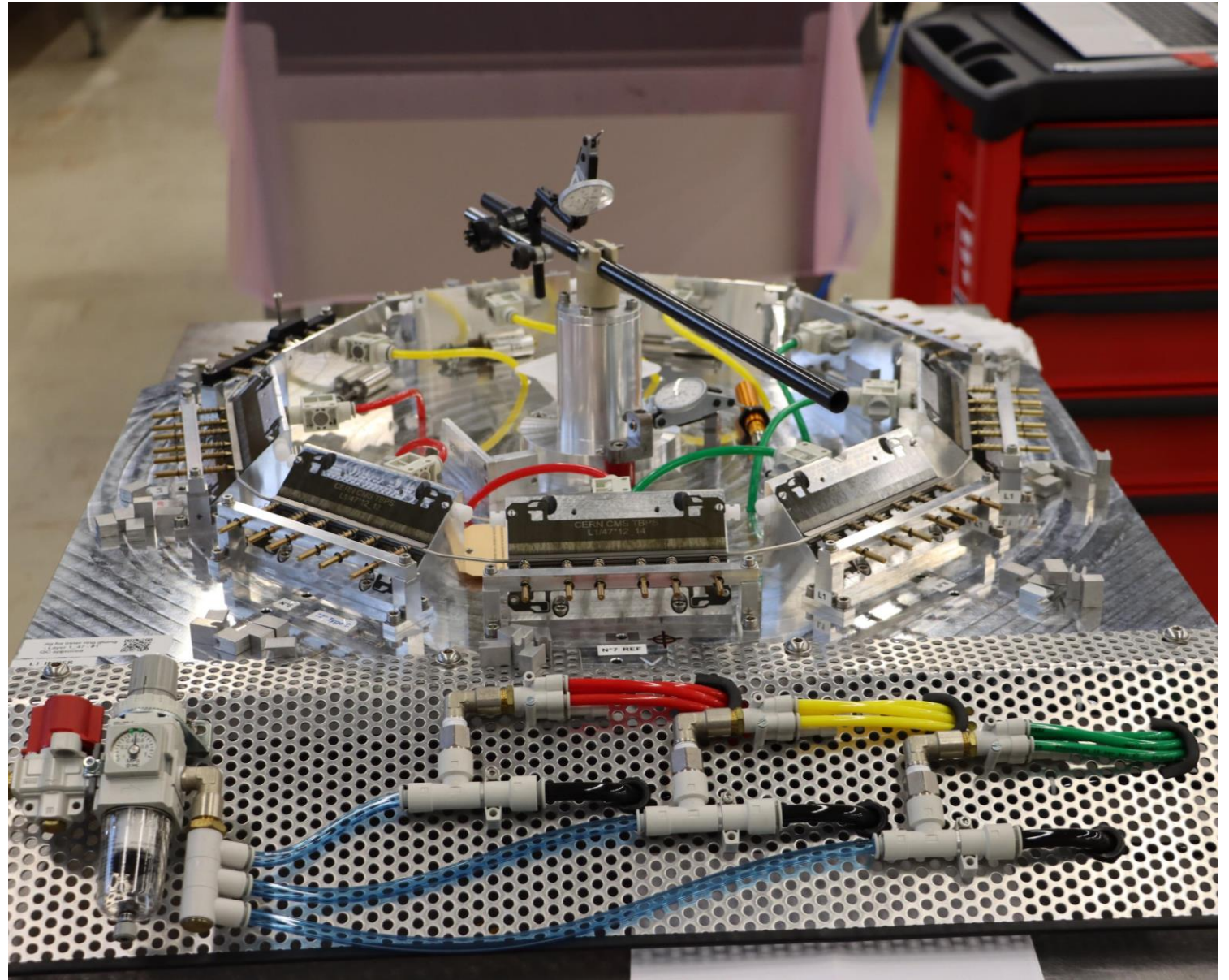
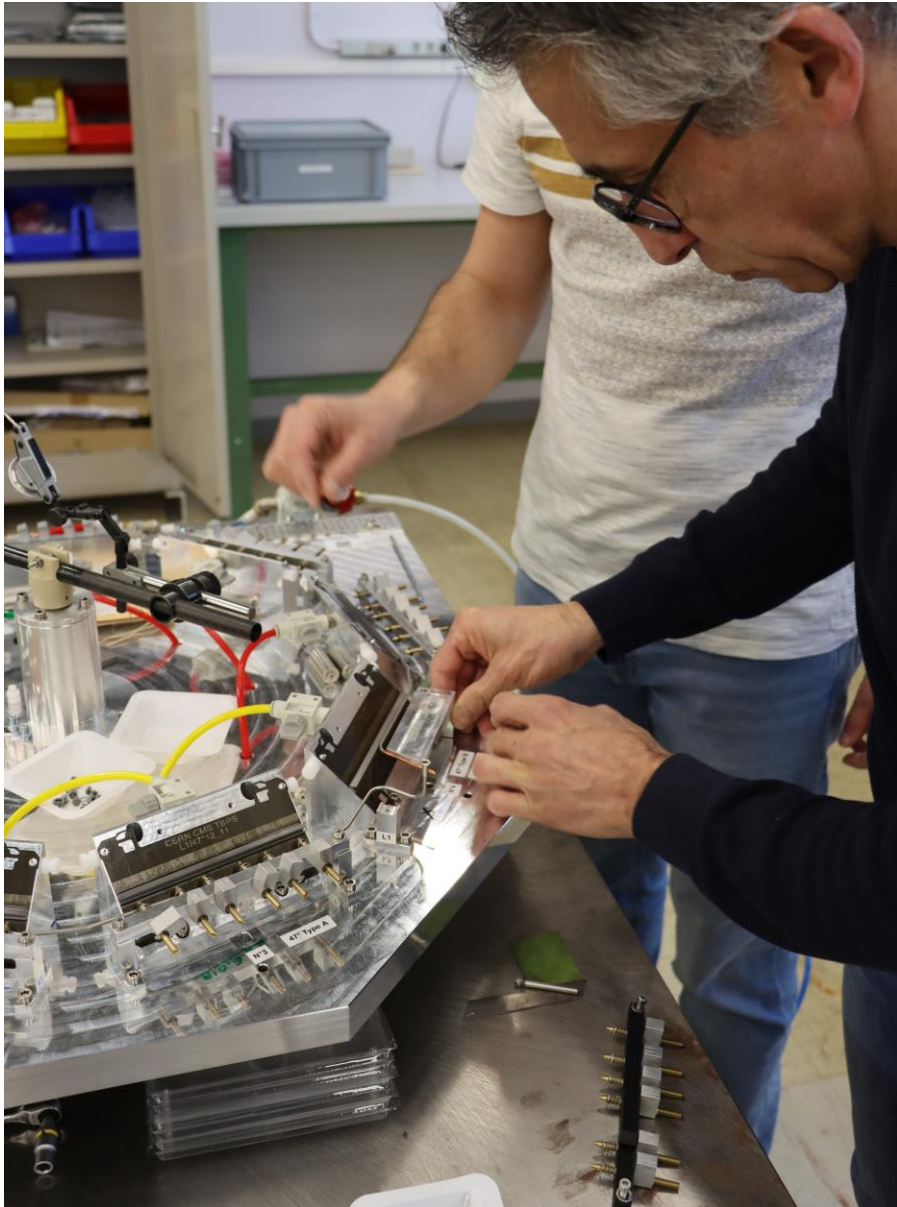


Dispensing glue: Polytec EP 601-Lv

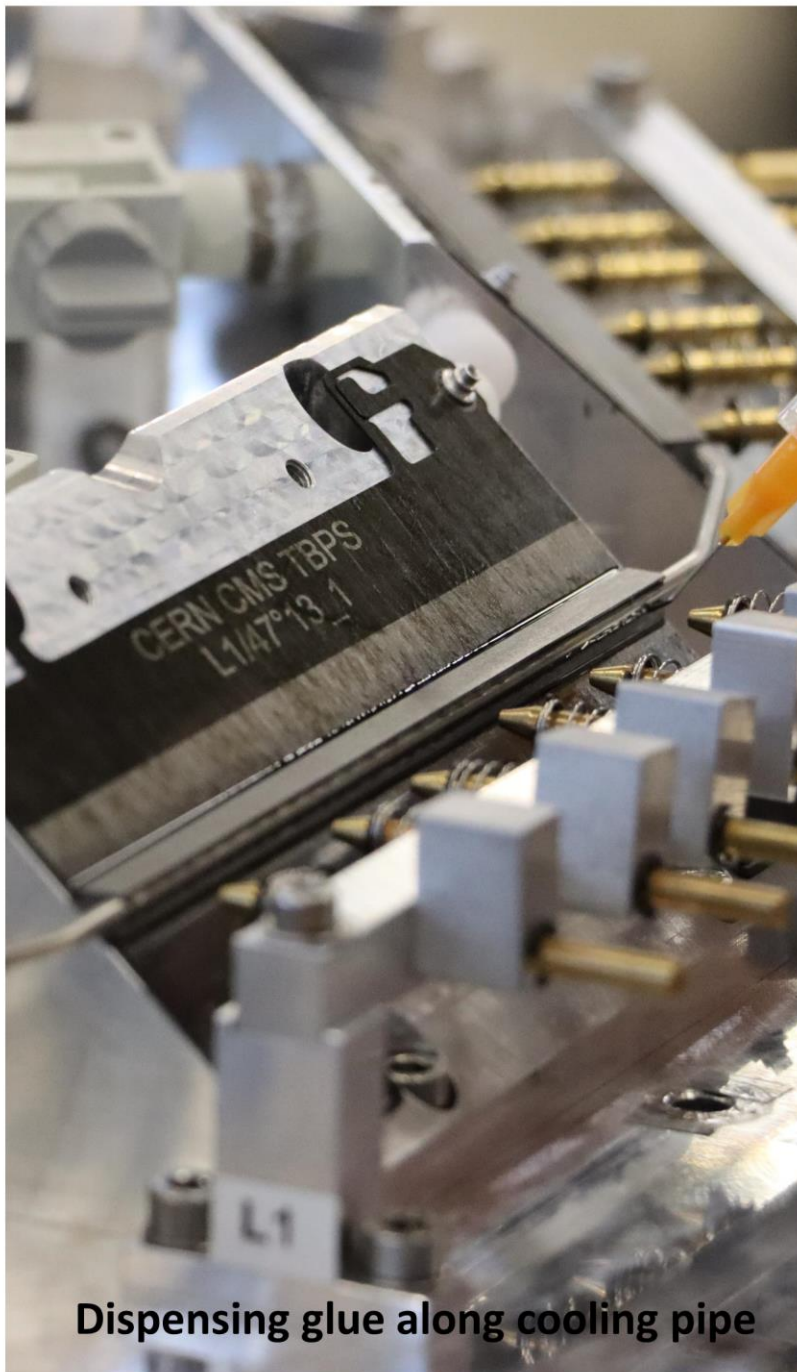
# Gluing of cooling plates to cooling adapters



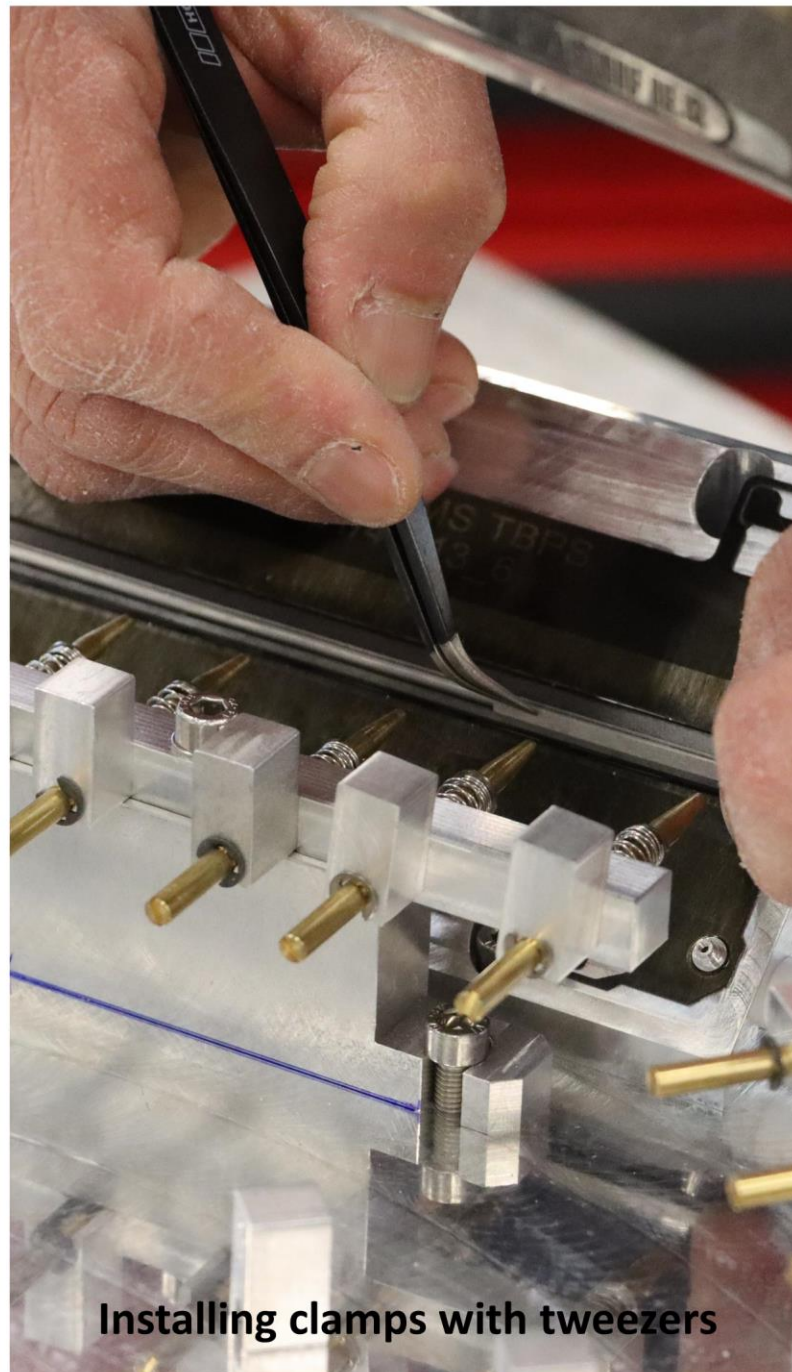
# Tilted ring gluing jig







**Dispensing glue along cooling pipe**



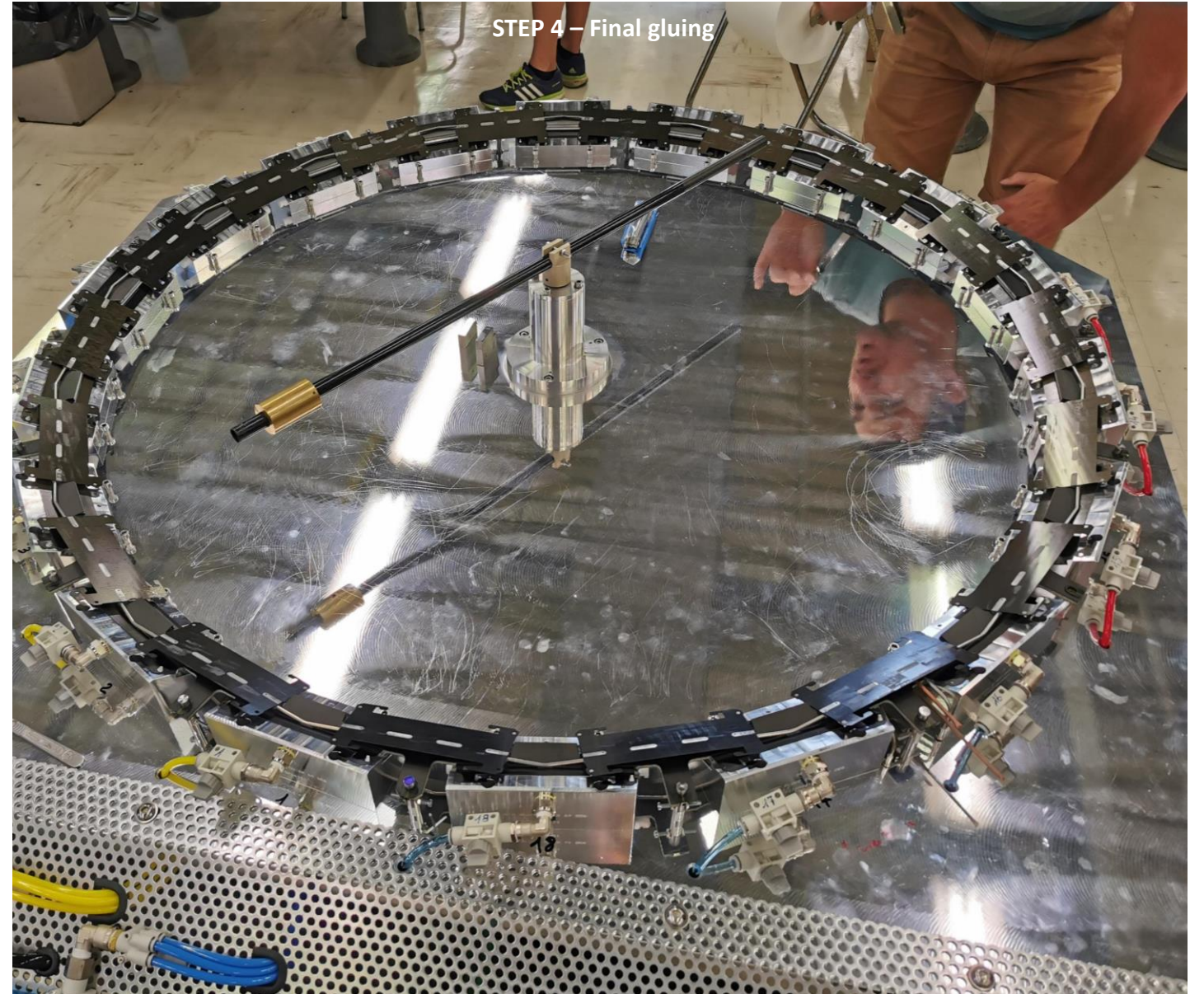
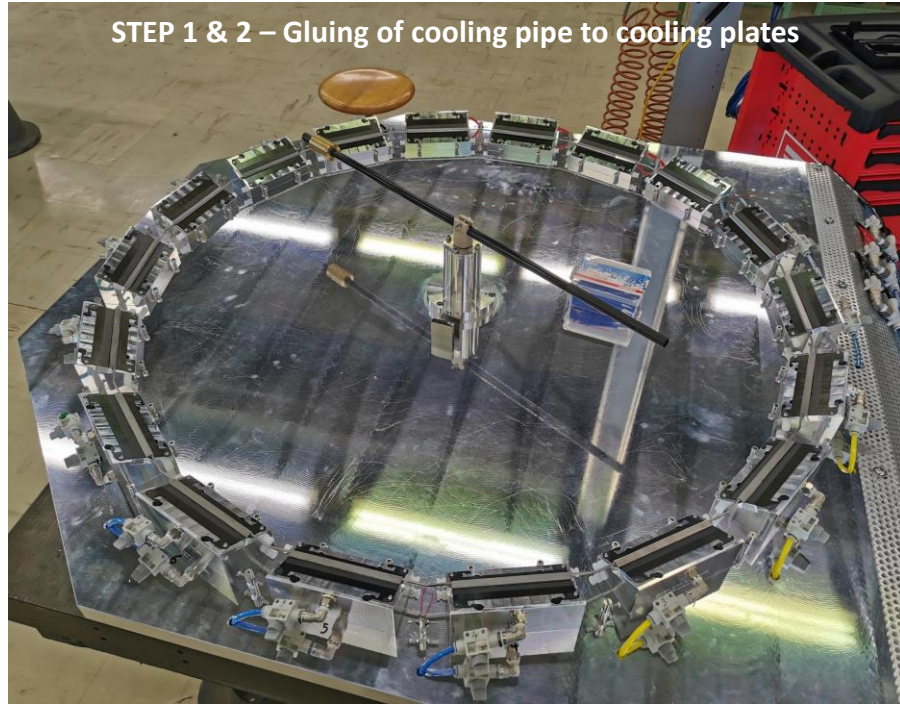
**Installing clamps with tweezers**



**Pressing clamps with push system**



## L3 ring assembly



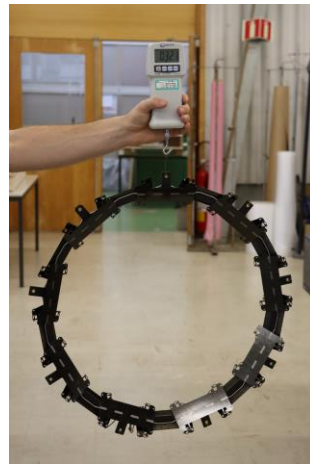
Objective: 100microns precision of module support



# Ring QC



CMM



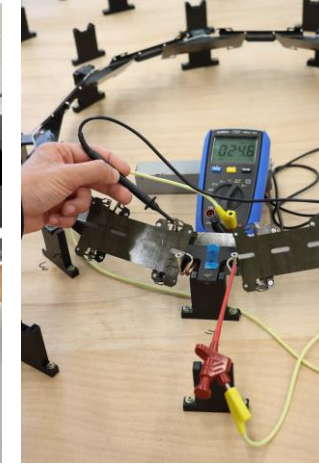
Mass



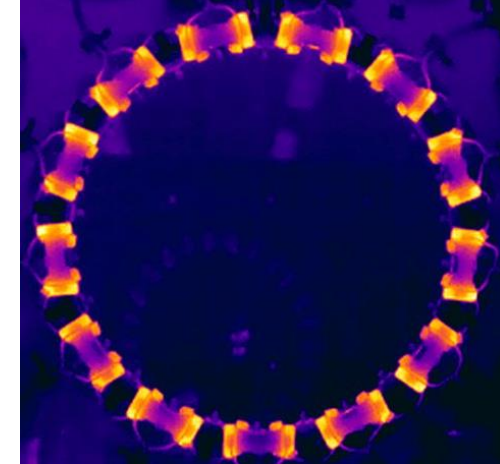
Stiffness




Pressure  
He leak



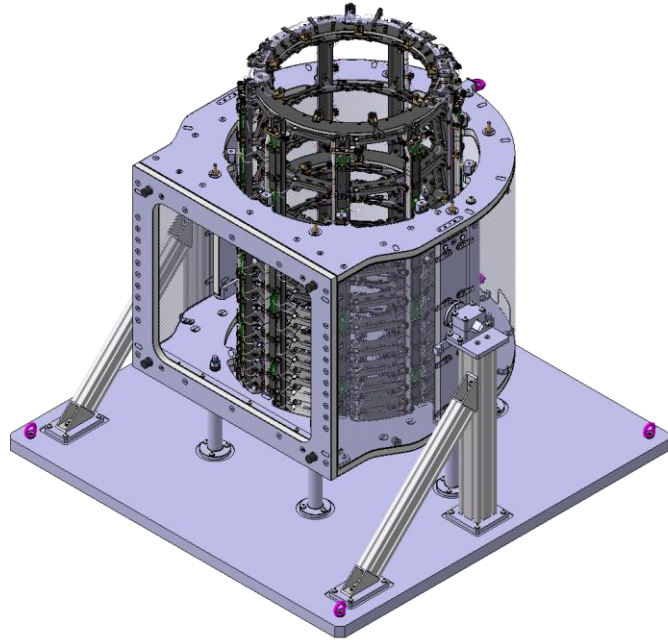
Grounding



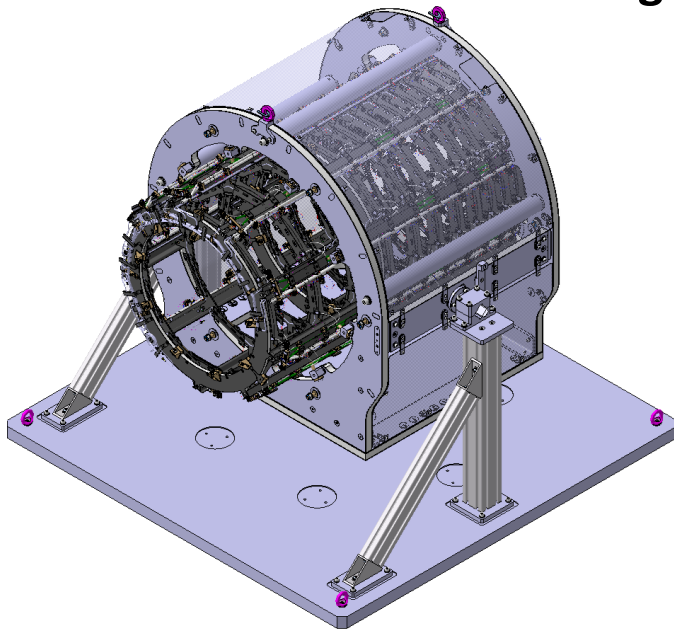
Thermal

↑ THIS SIDE UP ↑	
<b>FRAGILE</b>	
HANDLE WITH CARE	
	
<b>Tilted ring L1_47_A#3</b>	
Mass	<input checked="" type="checkbox"/>
Stiffness	<input checked="" type="checkbox"/>
Leak test	<input checked="" type="checkbox"/>
Pressure test	<input checked="" type="checkbox"/>
Conductivity	<input checked="" type="checkbox"/>
Thermal test	<input checked="" type="checkbox"/>
Notes:	

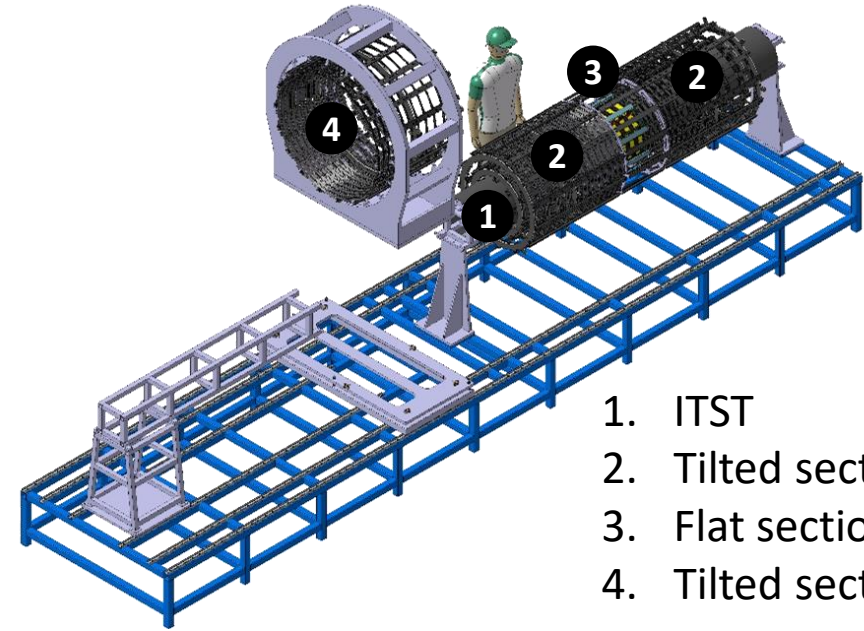
**TBPS tilted section stacking tool**



**TBPS tilted section rotation before integration**

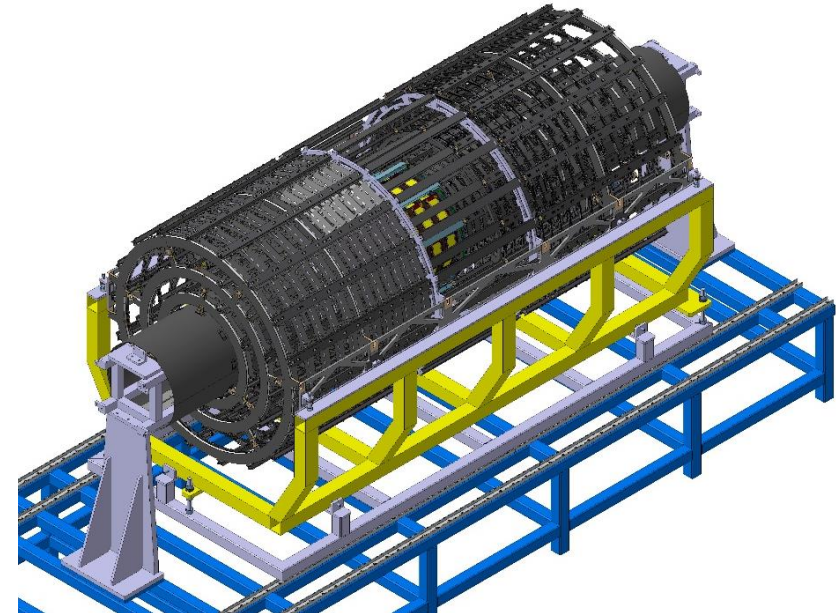


**TBPS Integration**



1. ITST
2. Tilted sections (L1, L2)
3. Flat sections (L1, L2)
4. Tilted section L3

**TBPS support structure for insertion in barrel**



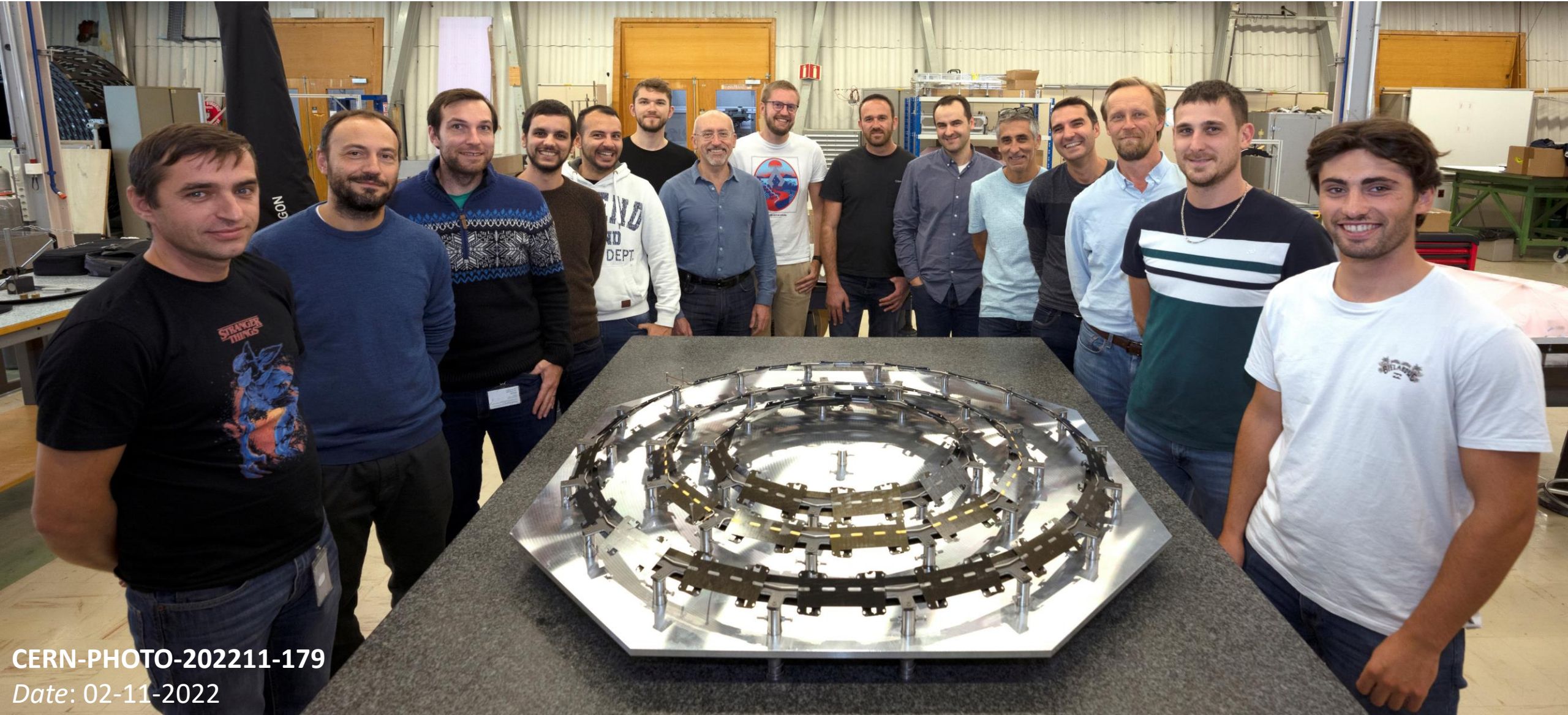
# TBPS schedule – Version of January 2024

ID	Group	Task	Start date	End-date	1-Jan-24	1-Mar-24	1-May-24	1-Jul-24	1-Sep-24	1-Nov-24	1-Jan-25	1-Mar-25	1-May-25	1-Jul-25	1-Sep-25	1-Nov-25	1-Jan-26	1-Mar-26	1-May-26	1-Jul-26	1-Sep-26	1-Nov-26	1-Jan-27	1-Mar-27	1-May-27	1-Jul-27	
1	Tilted ring	Prototype production (1*L1 47, 1* L2 68, 1* L3 40)																									
2		Pre- production (1*L1 47, 1* L2 68, 1* L3 40)																									
3		Production - 5* L1 47	5-Feb-24	29-Mar-24	█																						
4		Production - 10* L1 60	1-Apr-24	1-Jul-24		█																					
5		Production - 12* L1 72	2-Jul-24	21-Oct-24																							
6		Production - 9* L2 68	19-Feb-24	28-Jun-24	█																						
7		Production - 8* L2 40	1-Jul-24	11-Oct-24																							
8		Production - 10* L2 55	14-Oct-24	21-Feb-25																							
9		Production - 15* L3 44	22-Oct-24	3-Mar-25																							
10		Production - 12* L3 60	4-Mar-25	8-Sep-25																							
11	Tilted TBPS mechanics	Production (beams, balconies, interconnection rings, service supports, support panels, rails)	15-Jan-24	30-Jun-25	█	█	█	█	█	█	█	█	█	█	█	█											
12	Stacking tool	Production L1 stacking tool	1-Nov-23	28-Jun-24	█	█	█	█	█	█																	
13		Production L1, 2*L2, 3*L3	1-Nov-24	28-Nov-25							█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
14	Services (cooling, optical, cable)	L1 service production	1-Jul-24	30-Oct-24																							
15		L2, L3 service production	3-Feb-25	1-Oct-25																							
16	Equipped tilted rings arrival at CERN [INFN Pisa]	L1 rings 1-12	2-Dec-24	30-May-25																							
17		L1 rings 13-24	2-Jun-25	31-Oct-25																							
18		L2 rings 1-12	3-Nov-25	15-Jan-26																							
19		L2 rings 13-24	16-Jan-26	31-Mar-26																							
20		L3 rings 1-12	1-Apr-26	30-Jun-26																							
21	L3 rings 13-24	1-Jul-26	30-Sep-26																								
22	Stacking of tilted sections	L1 stack 1	16-Dec-24	11-Jul-25																							
23		L1 stack 2	28-Jul-25	28-Nov-25																							
24		L2 stack 1	10-Oct-25	12-Feb-26																							
25		L2 stack 2	24-Dec-25	28-Apr-26																							
26		L3 stack 1	25-Mar-26	28-Jul-26																							
27	L3 stack 2	25-Jun-26	28-Oct-26																								
28	ITST [Purdue]	Delivery at CERN	1-May-25	1-May-25																							
29	Flat section [Fermilab]	L1 delivery at CERN	21-Apr-26	21-Apr-26																							
30		L2 delivery at CERN	28-Apr-26	28-Apr-26																							
31		L3 delivery at CERN	23-Dec-26	23-Dec-26																							
32	Integration	Central ITST and L1 integration	21-Apr-26	15-Jun-26																							
33		L2 added	16-Dec-19	10-Jan-20																							
34		L3 added	23-Dec-26	16-Feb-27																							
35		TBPS moved to cradle	17-Feb-27	23-Feb-27																							
36	Installation	Installation to TB2S	24-Feb-27	2-Mar-27																							
37		Pipe and cable connections	3-Mar-27	30-Mar-27																							
38		TBPS ready	24-May-27	24-May-27																							

DT responsibility - acquired experience and have 2-3 months delay
DT responsibility
Institute responsibility



Thanks!



CERN-PHOTO-202211-179

Date: 02-11-2022