



Manufacturing Study, Pre-production and Quality

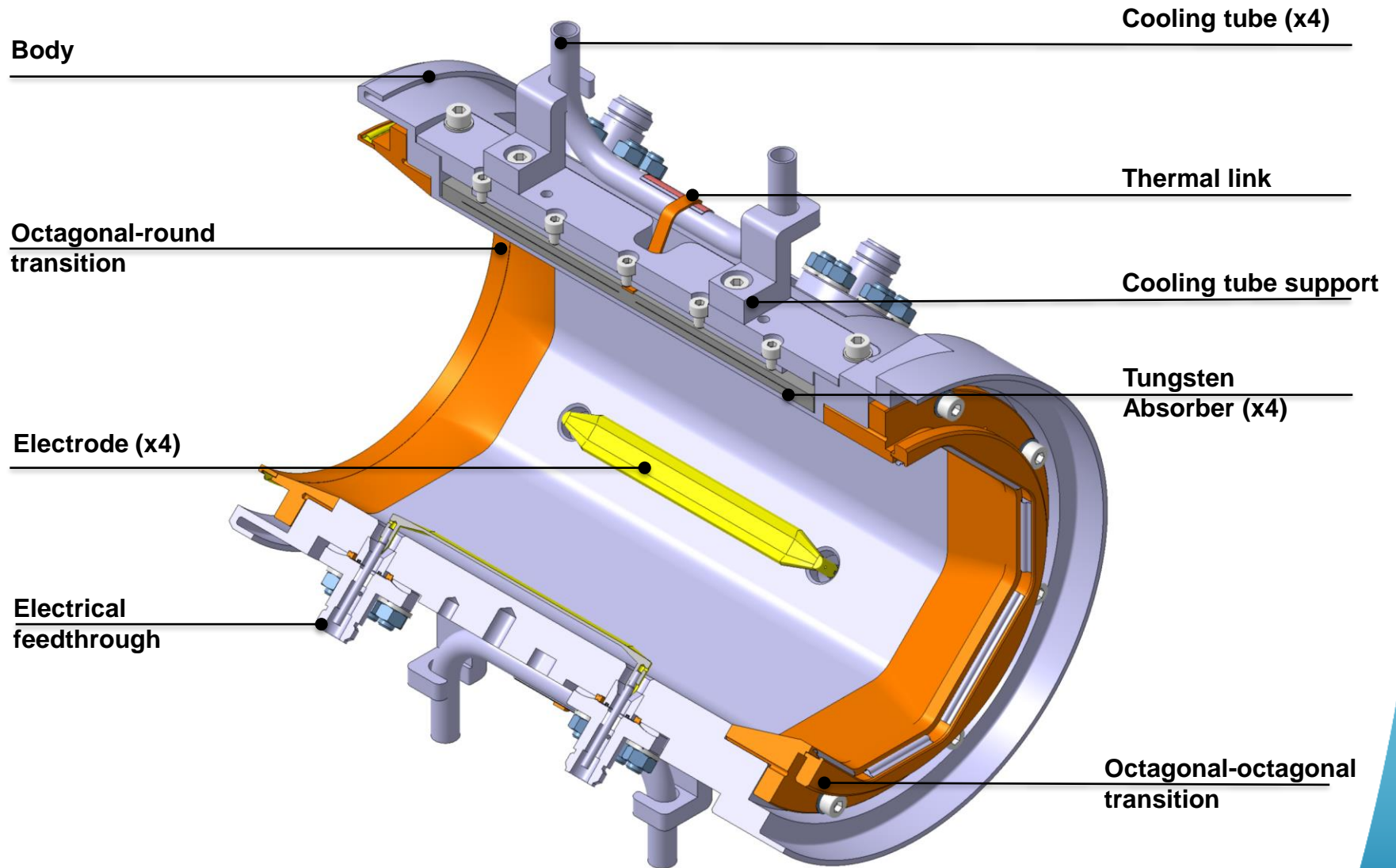
**HL-LHC WP13
Beam Instrumentation**

D. Gudkov, G. Schneider, M. Krupa

Content

- Details of components manufacturing
 - BPM Body
 - Machining
 - Coatings
 - Welding
 - Relevant tooling
 - Prototypes and tests at CERN
 - Transitions
 - Electrodes
 - Cooling links
 - Assembly
 - Amorphous carbon coating
- Identification of work for BINP and CERN
- Quality assurance

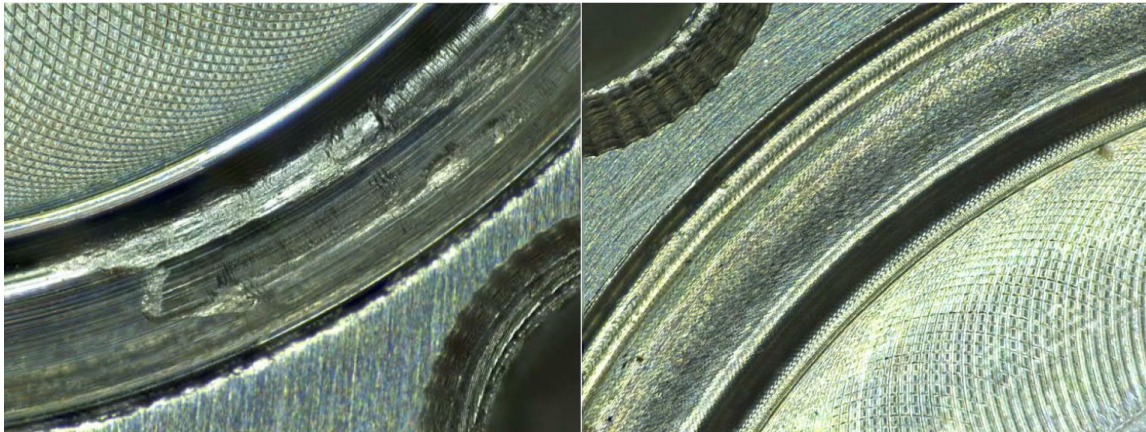
Most representative cases (B-type)



Body (Vacuum Chamber, [LHCBPMQST_B0009](#))

2. Machined ConFlat interfaces: Trial of machining by different methods have been performed (Report in EDMS [2302967](#)):

- Form tool
- Ball Mill



Form tool

0.6 mm ball mill

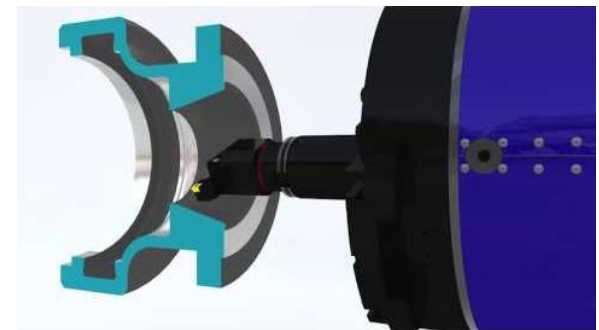


Pre-

Fin-

- Machining time is identical
- Both methods provide leak tightness
- Ball mill: better surface finish

+ 3rd method, use of boring head with automatic transversal feed (proposed by BINP): [here](#) and [here](#)



Body (Vacuum Chamber, [LHCBPMQST_B0009](#))

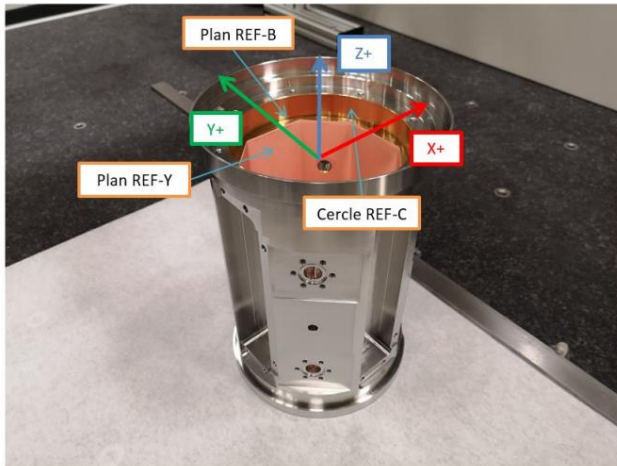
3. Octagonal shape (electroerosion wire cutting)



EDMS [2254544](#)

Surface dimensions:
Length 190 mm
Octagonal 119.7 x 125.1
Obtained roughness Ra3.2

4. Copper electroplating 0.1 mm (with gold flash for adhesion)



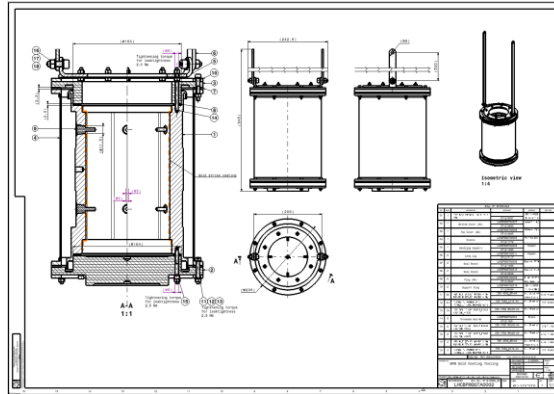
Obtained roughness <Ra3.2

Body (Vacuum Chamber, LHCBPMQST_B0009)

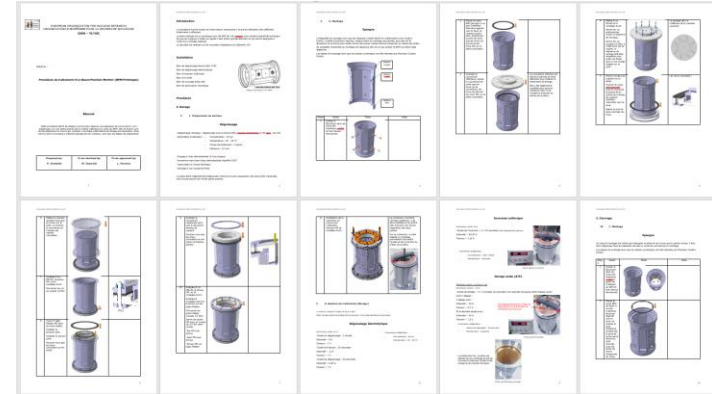
4. Copper electroplating 0.1 mm (with gold flash for adhesion)

2 tools were designed and built at CERN for electroplating tests (1 setup per coating, 2 setups in total):

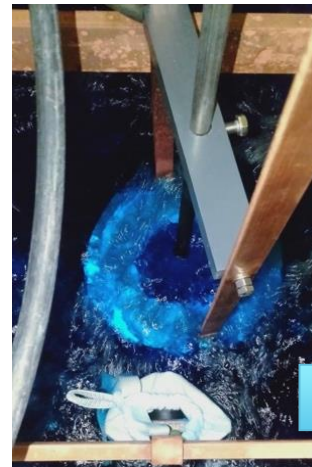
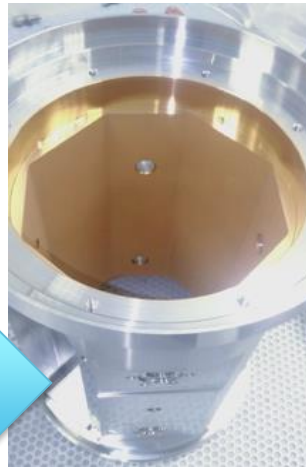
- gold flash
- Copper 0.1 mm



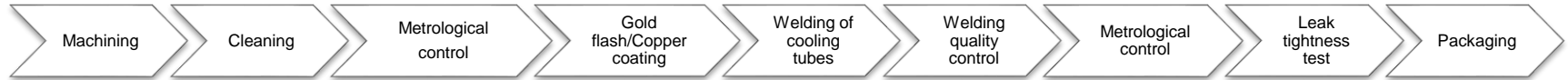
Drawings



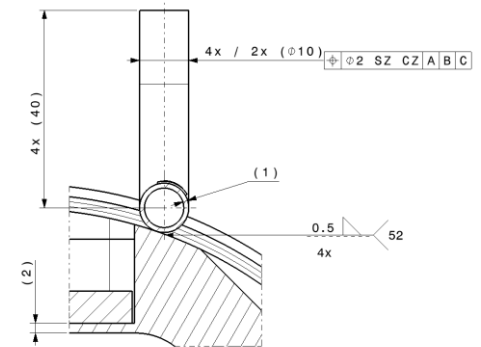
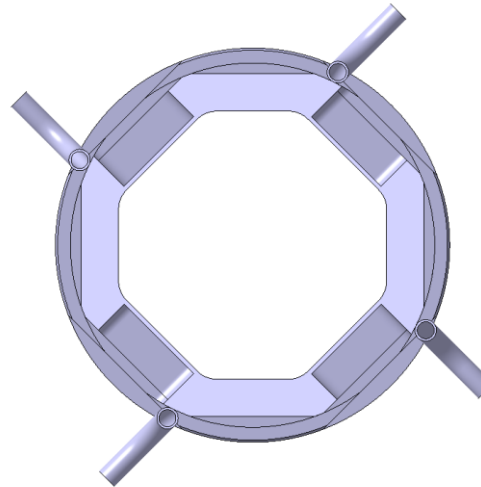
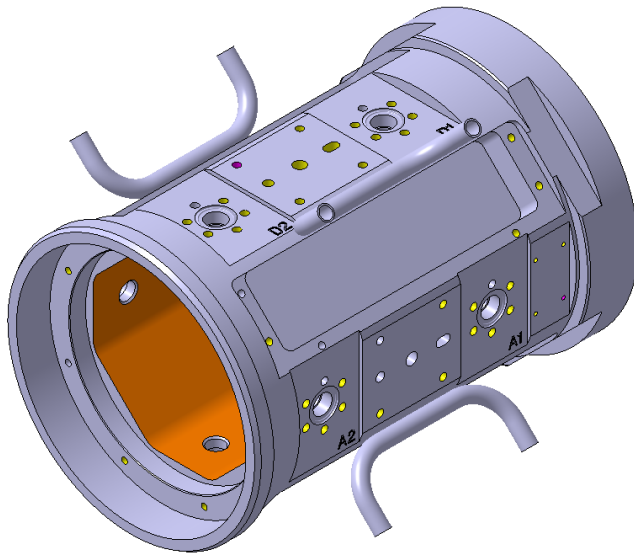
Procedure and work instruction



Body, welding of cooling tubes (LHCBPMQST_B0002)

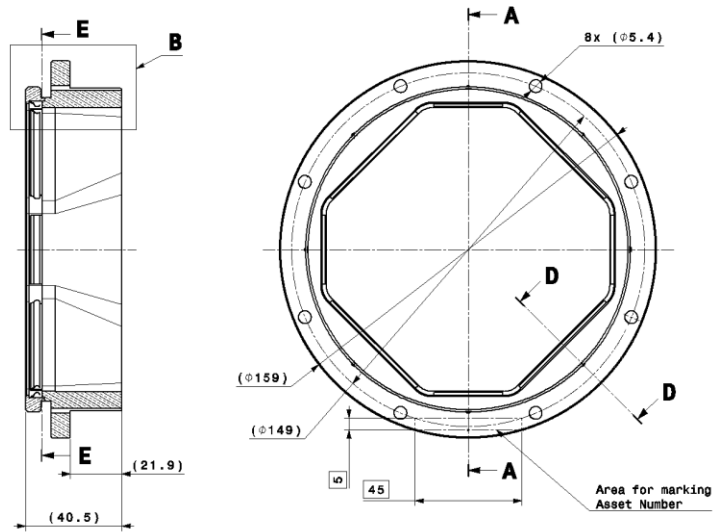


- Laser welding of cooling tubes, 0.5 mm penetration, 55 mm long seam

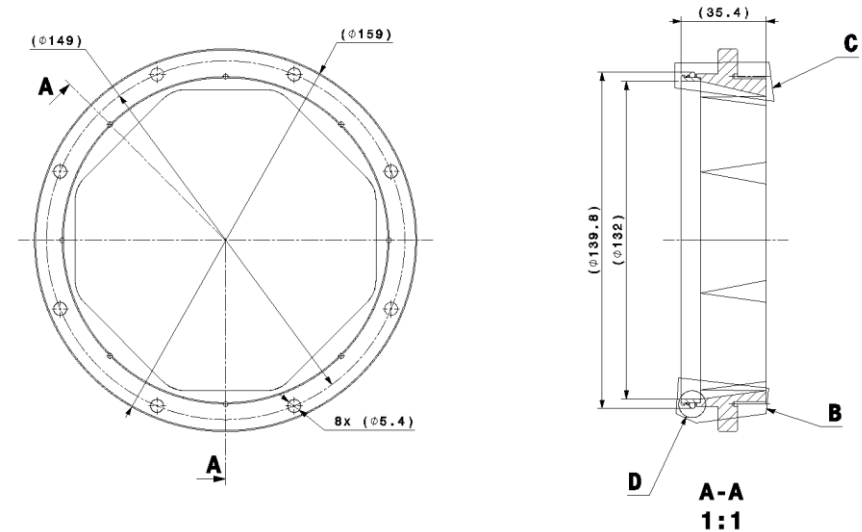


Transitions (LHCBPMQST B0003 and LHCBPMQST B0004)

LHCBPMQST B0003



LHCBPMQST B0004

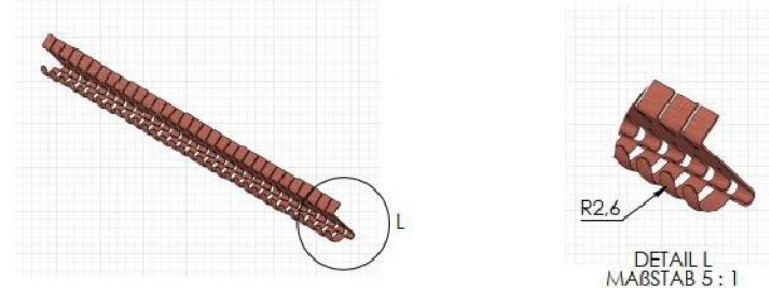
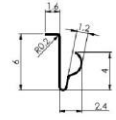
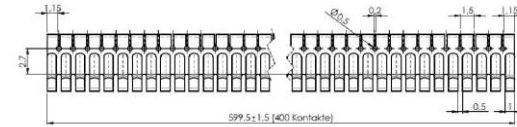
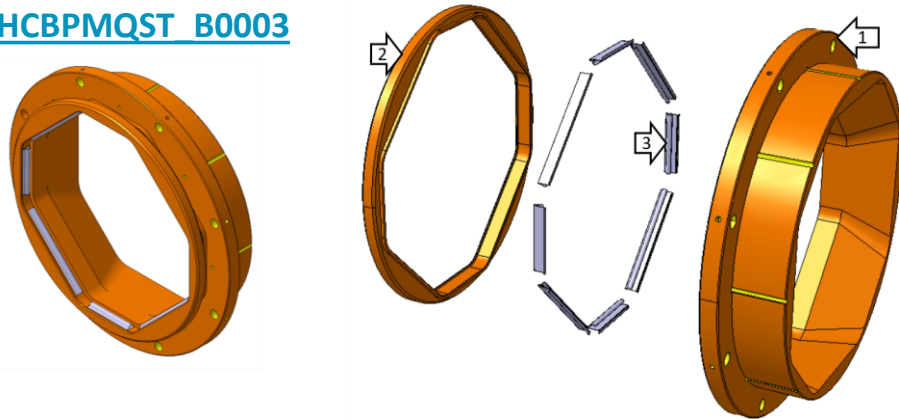


- CERN material spec. 2000 for Oxygen-Free Electronic copper sheets – transition parts
- CuBe 17410 – electric contacts
- Electrical contacts are supplied in form of 600 mm strips

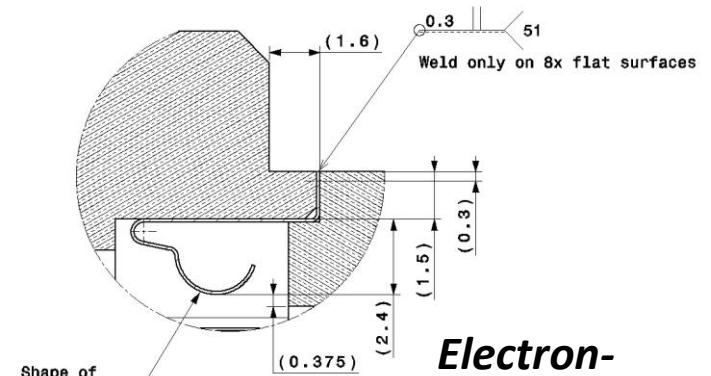
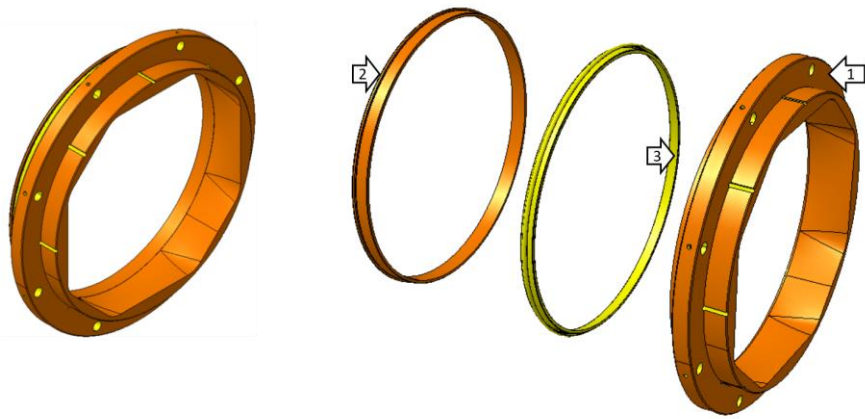
Transitions (LHC BPMQST B0003 and LHC BPMQST B0004)



LHC BPMQST B0003



LHC BPMQST B0004



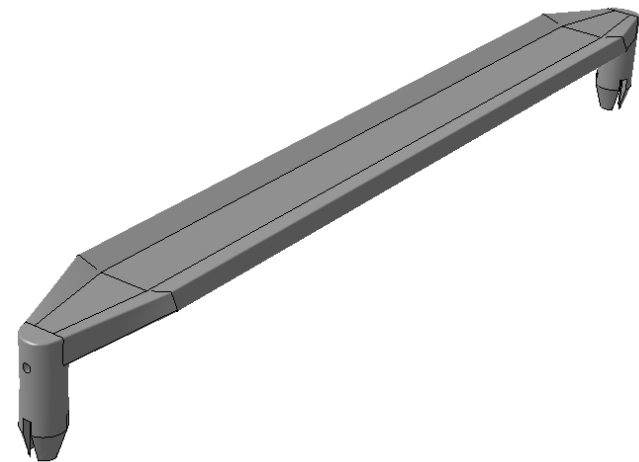
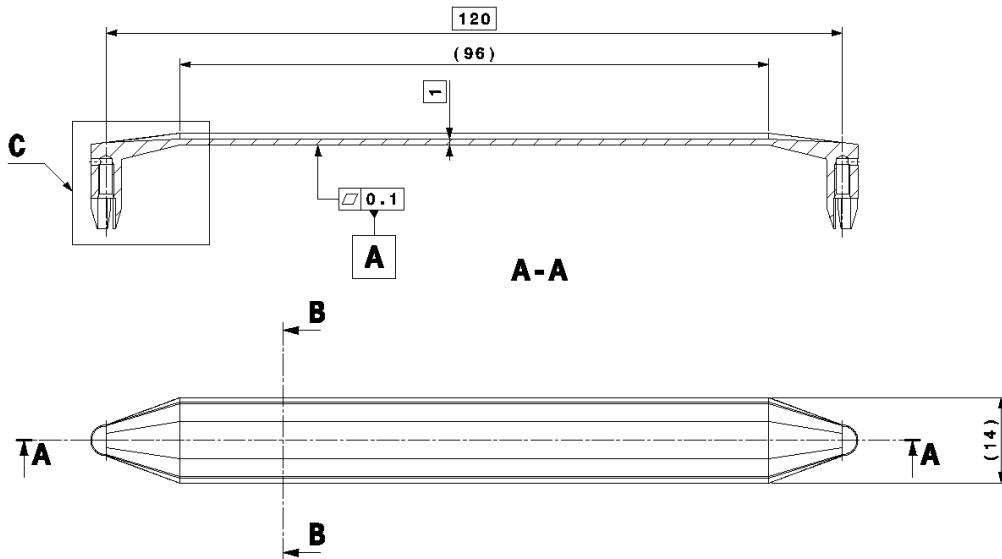
C
10:1
8x

Electron-beam welding

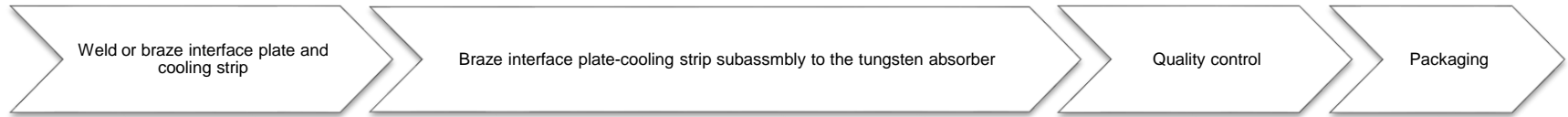
Electrodes (LHC BPMQFT0003)



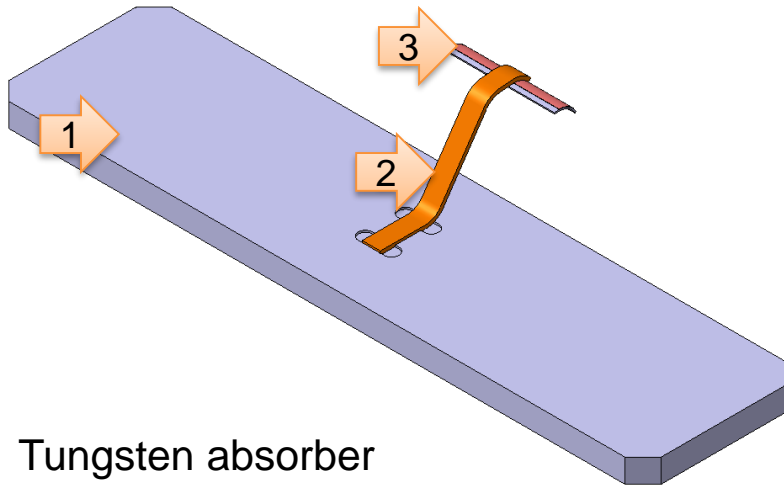
- Iterative design, several prototypes have been manufactured
- Design optimization completed, documentation is being prepared
- Material: CERN material spec. 1000 for 1.4429 round, forged round bars



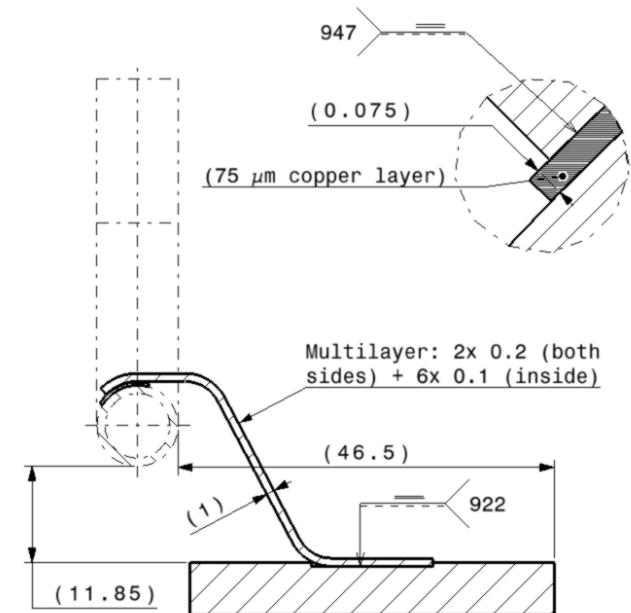
Tungsten absorber – Copper strip – Interface plate assembly (LHC BPMQST B0026)



- Tungsten absorbers will be supplied by the TE-VSC
- Copper strip and interface plate are welded (ultrasound welding)
- Then the strip-interface plate subassembly is brazed to tungsten block



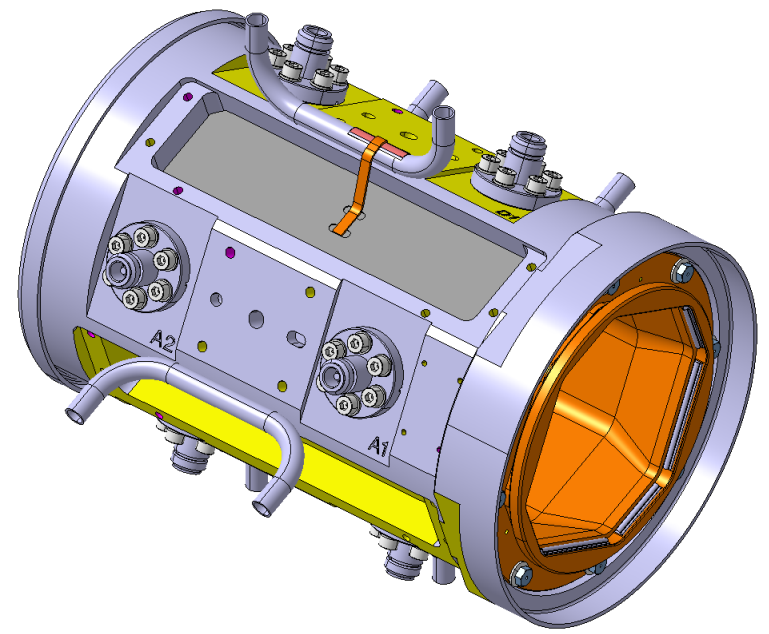
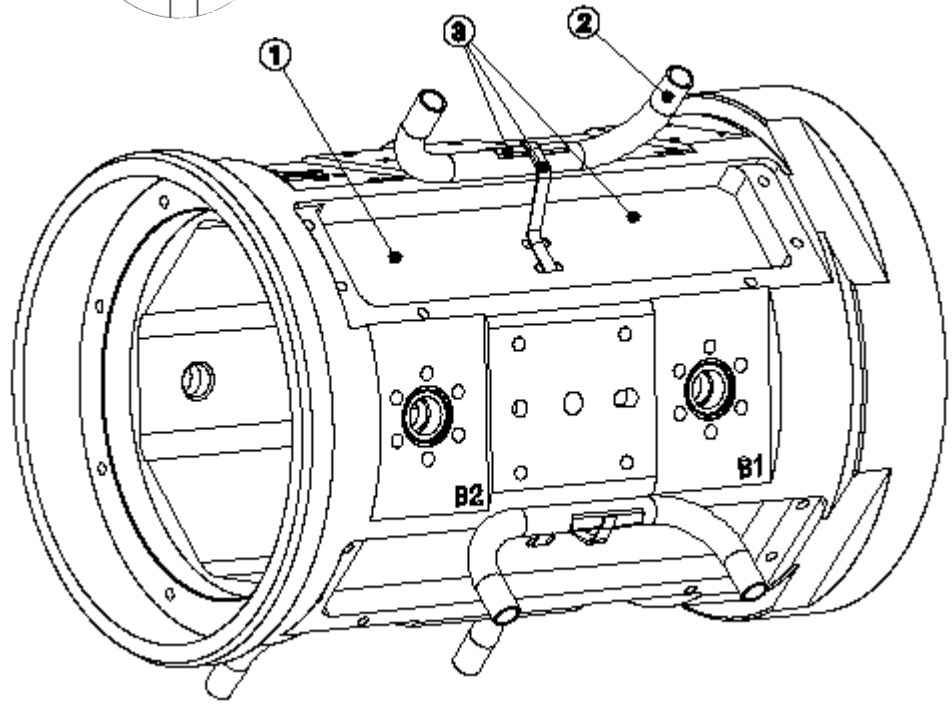
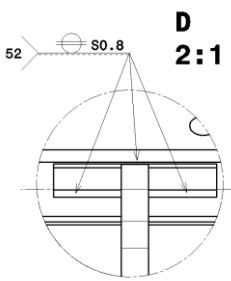
- (1) Tungsten absorber
- (2) Copper strip
- (3) Interface plate (is laser-welded to the cooling tube)



CERN Workshop has developed the manufacturing process which will be used to produce 100 pcs. subassemblies

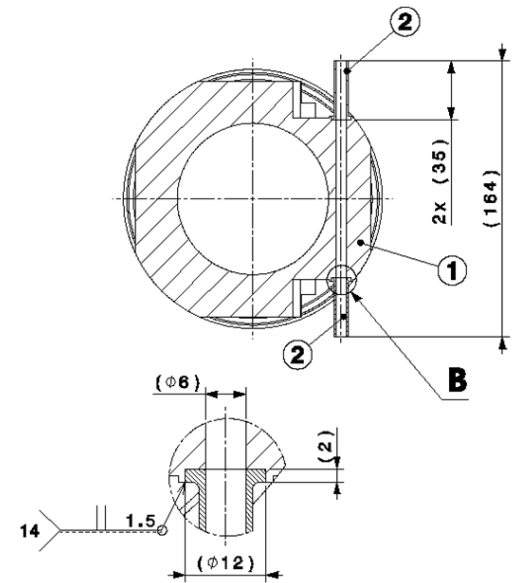
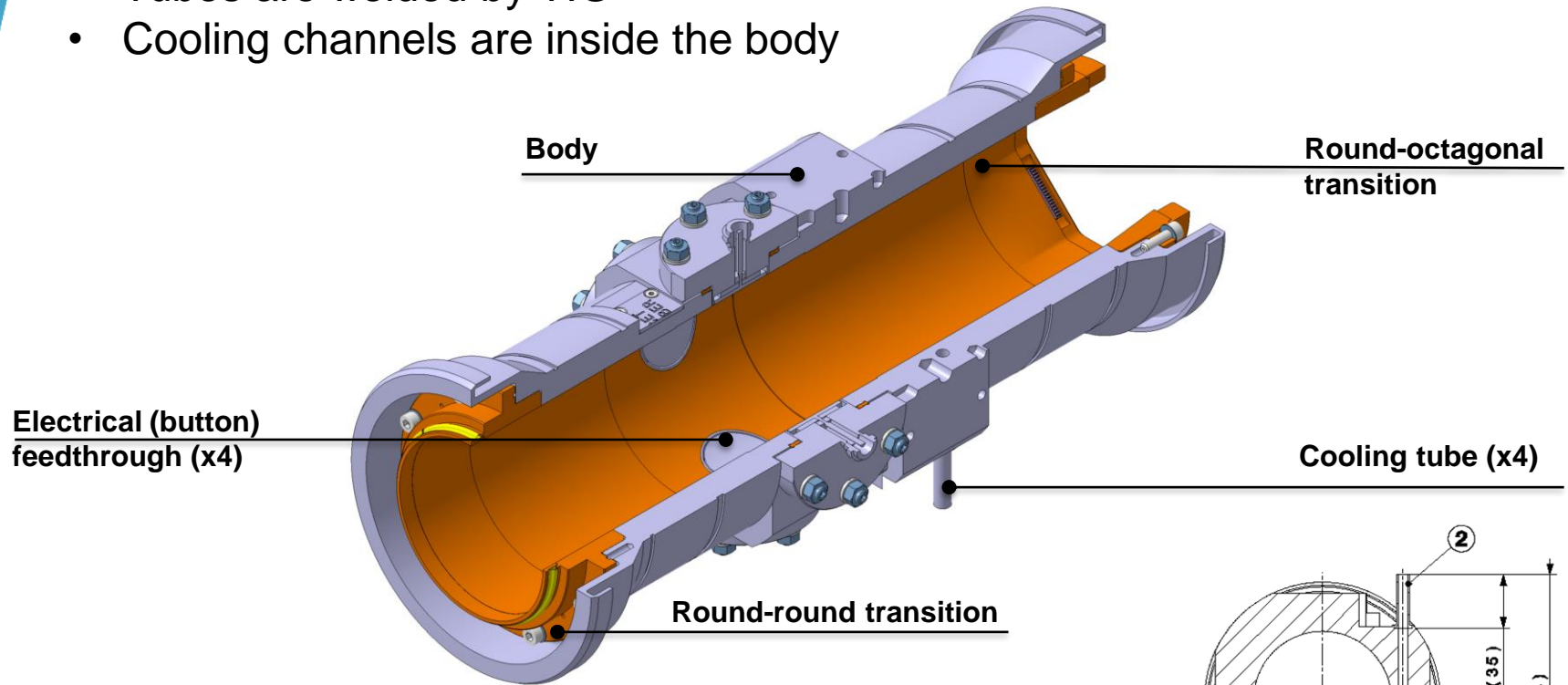
Body, welding tungsten – cooling subassembly (LHC BPMQST_B0002)

- Last welding step
- The tungsten blocks are put into the pockets on the body
- The interface plate is welded (laser) to the cooling tubes



D2 Body assembly with cooling tubes (LHCBPMQBC_A0010)

- Tubes are welded by TIG
- Cooling channels are inside the body

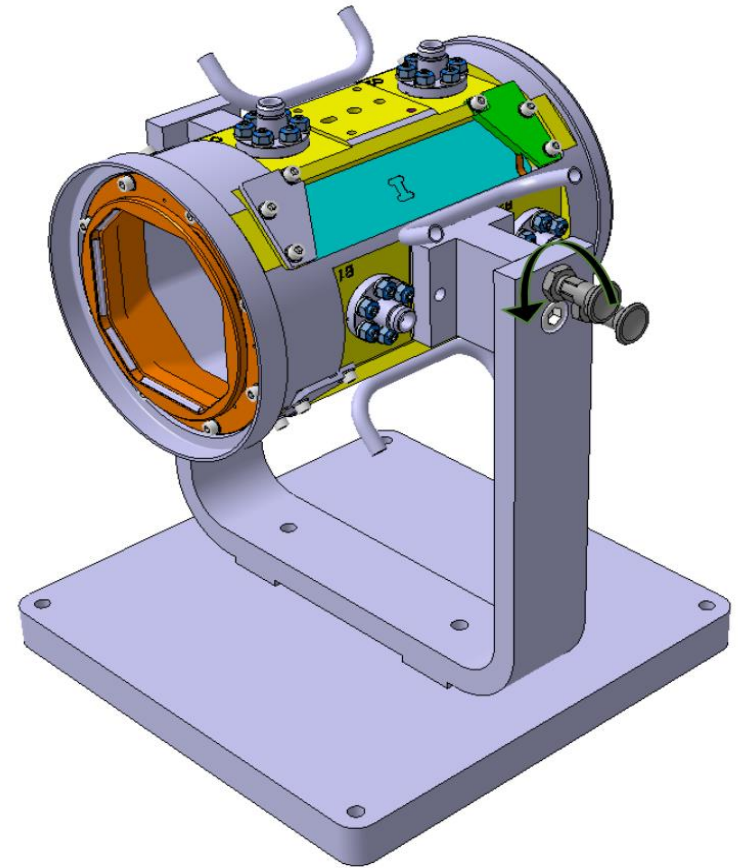


Description

- Tooling to provide 4 different orientation of the BPM for access
- Simplified assembly and visual control
- Compatible with all the BPM types
- Tooling parts are interchangeable with the components of other tools
- Bottom magnetic plate can be used for installation of control instrumentation
- Easy to manufacture and not expensive equipment
- Commercial mechanical components

Status

- 3D design 50%
- 2D not started



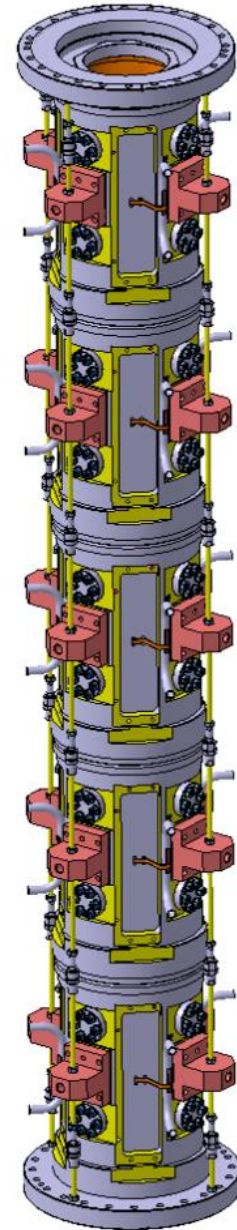
Amorphous Carbon Coating

Description

- Tooling for performing the amorphous carbon coating on 4 BPMs in one setup
- Sealed structure (O-rings and CF flanges)
- Threaded rods and swivel joints to create axial force
- 2 designs are required: 1 –type A and type B; 2 – type D2

Status

- 3D design 50%
- Integration with VSC setup to be done
- 2D 25%
- Tooling to be manufactured by Q4 2021



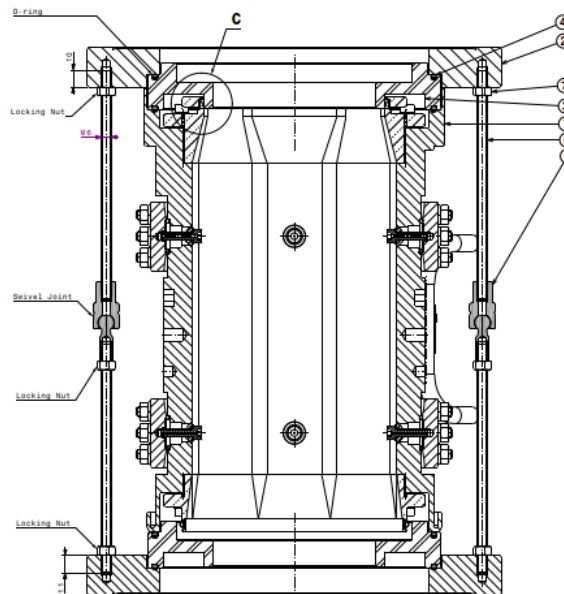
Amorphous Carbon Coating. Test

Description

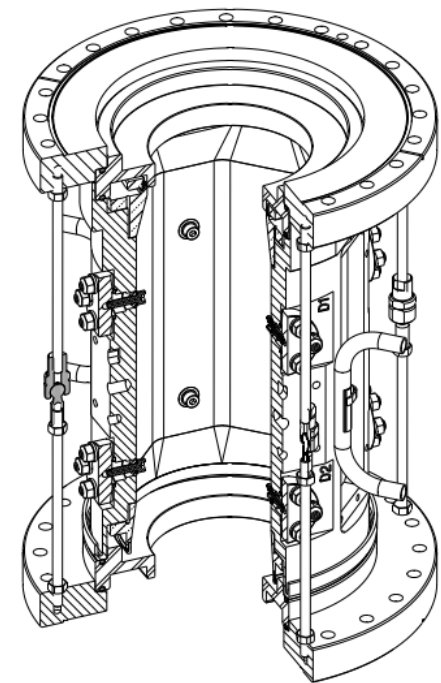
- Tooling for performing the amorphous carbon coating on 1 BPMs
- Sealed structure (O-rings and CF flanges)
- Threaded rods and swivel joints to create axial force

Status

- 3D design 100%
- Integration with VSC setup to be done
- 2D 75%
- Tooling to be manufactured by end of Q1 2021



A-A
1:1



Isometric view
1:1

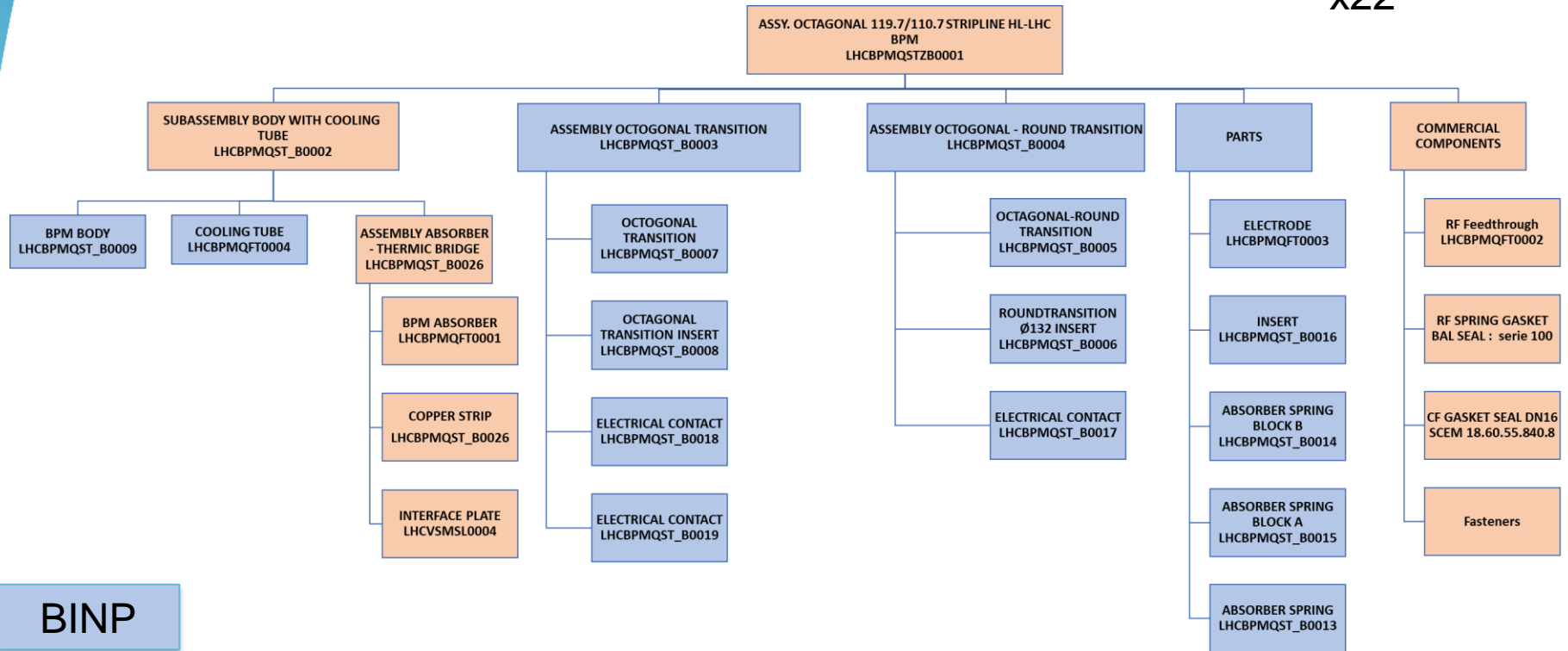
Identification of work for BINP and CERN

- Assembly of the BPMs will be performed at CERN
- Manufacturing of tungsten absorbers is a part of large order placed by TE-VSC
- Assembly of tungsten absorbers with cooling links and interface plates will be done at CERN (MME has a process used for Beam Screen, they can do 120 pcs. for us)
- **All the raw materials will be purchased by CERN and shipped to BINP**
- All fasteners will be purchased by CERN (no need to have them in BINP as assembly will be done here)
- Commercial components (electrical feedthroughs, CF gaskets, RF springs, electrical contacts) will be purchased by CERN
- **All machining work will be done by BINP**
- **Electron-beam welding of transitions will be done by BINP**
- **Copper coating of bodies will be done by BINP**
- **Preassembly of bodies and transitions - BINP**
- Amorphous carbon coating → at CERN

Identification of work for BINP and CERN

BPMQSTZB - LHC BPMQSTZB0001

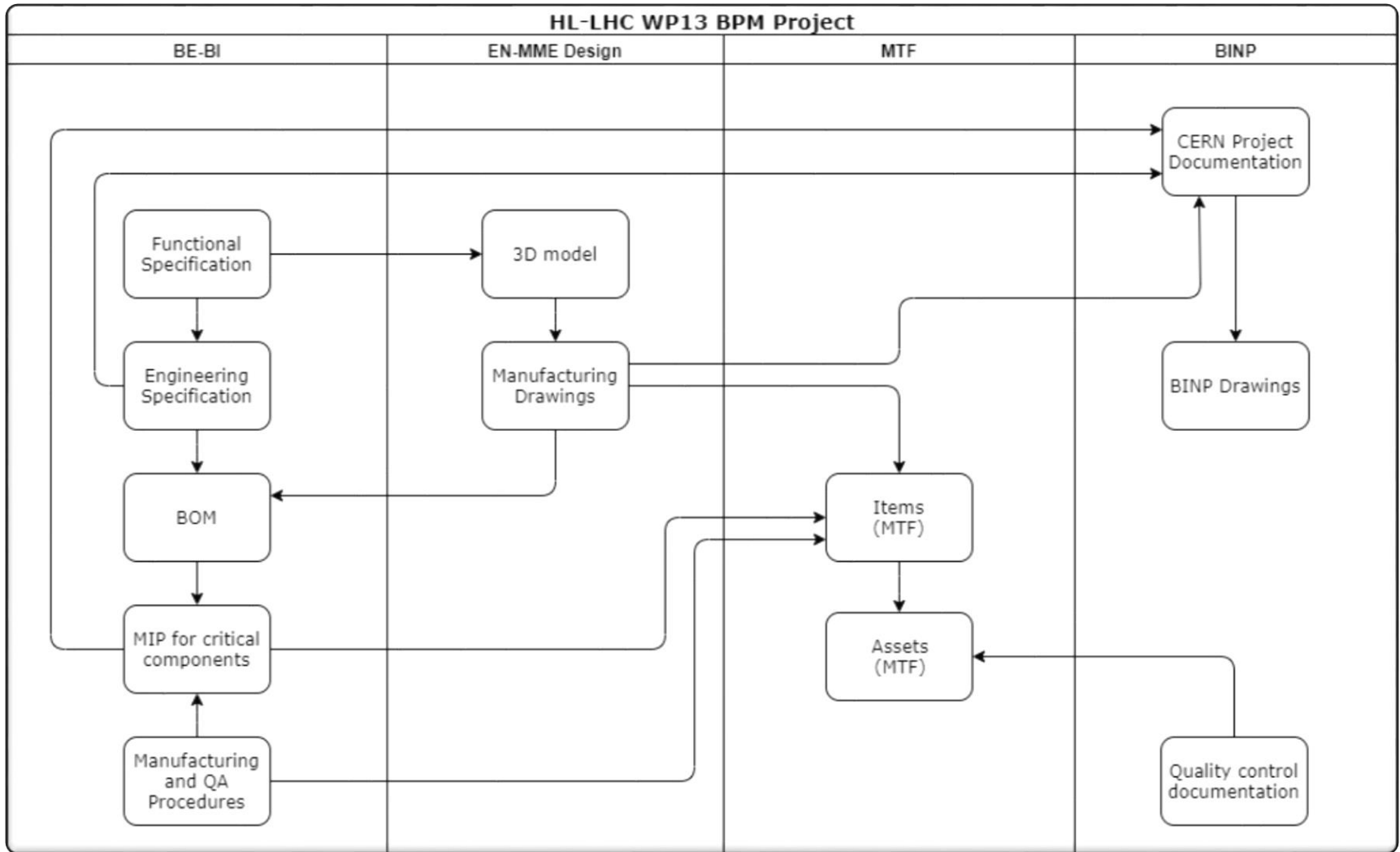
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BINP

CERN

Quality assurance. Documentation



Quality assurance. MIP



EDMS NO. 2365075	REV. 0.0	VALIDITY DRAFT
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REFERENCE: LHC-EQCOD-FP-XXXX

HL-LHC: Quality Manufacturing and Inspection Plan

Prepared by: D. Gudkov Date: 06/03/2020		Project: HL-LHC		Supplier:		Item Eq. Code: LHC BPM		Asset Code (LHC Part Identifier): HCBPMQST_B009					
Verified by: N. Surname Date: DD/MM/20YY		Work Package: WP13		Client: CERN (BE-BI-ML)		Item description: OCTOGONAL BPM BODY		EDMS Report No:					
Approved by: N. Surname Date: DD/MM/20YY													
No	ACTIVITY / OPÉRATION	APPL STANDAR DS / NORMES APPL.	APPLICABLE DOCUMENTS / DOCUMENTS APPLICABLES	REV. DOC.	INSPECTION / CONTRÔLE						NOTES / COMMENTAIRES		
					SUPPLIER / CONTRÔLE		CLIENT / VÉRIFICATION		3 RD PARTY / SURVEILLANCE			INSPECTION REPORT / RAPPORT D'INSPECTION	REV. DOC.
					Code	Signature/Date	Code	Signature/Date	Code	Signature/Date			
1	Procurement of raw materials (Cu-OFE)		LHC BPMQST_B0009 BOM EDMS 2314930 (for blanks dimensions)							Material certificates if applicable			
2	Machining		LHC BPMQST_B0009										
2.1	Rough machining												
2.2	Stress relieve heat treatment												
2.3	Electroerosion of octagonal shape												
2.4	Intermediate dimensional control		LHC BPMQST_B0009	N						Dimensional control report			
2.5	Fine machining		EDMS 2338015 LHC BPMQST_B0009	N									
2.6	BPM body degreasing												
2.7	Dimensional control		LHC BPMQST_B0009	H / R		R				Dimensional control report			
3	Electroplating		LHC BPMQST_B0009										

Quality Assurance. Future actions

- BINP should have access to MTF (1 person should be managing BINP quality documentation) → someone from BINP workshop?
- This person should be trained on using MTF: HL-LHC P.O. provides such a training
- MIP, Spec. and drawings will be sent to BINP for the manufacturing processes validation. In case BINP wants to change MIP or drawings, these changes should be validated by CERN before manufacturing can start
- BINP can create their own drawings based on CERN drawings, however the quality control will be performed based on CERN drawings



Thank you for your attention!

Special thanks for the input and discussions: N. Chritin, A. Demougeot, N. Kos, G. Favres, E. Rigutto, L. Prever-Loiri, R. Veness, K. Scibor, P. Bestmann, P. Costa Pinto, W. Vollenberg, P. Garritty, C. Garion, F. Santangelo, H. Garcia Gavela, M. Thiebert



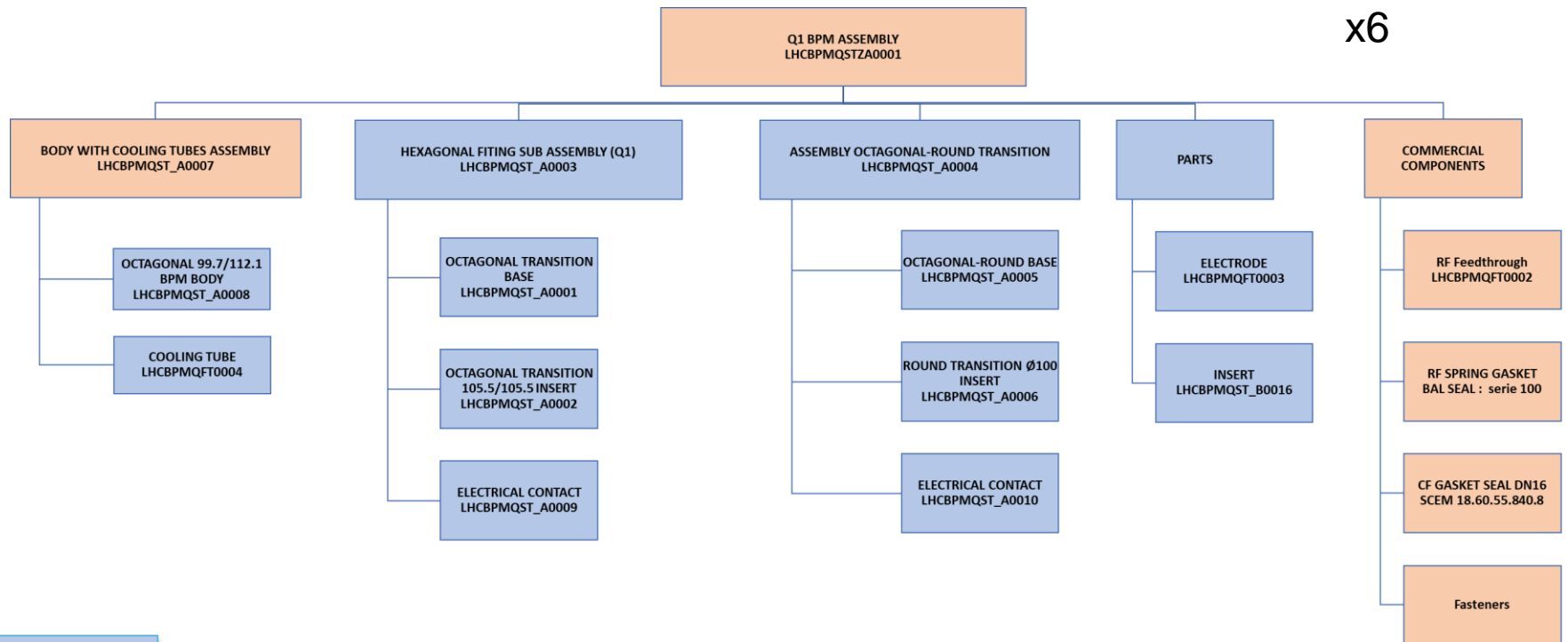
backup

Core competencies needed to produce the BPMs for HL-LHC

- High precision machining (BINP)
- Electro-erosion machining (BINP)
- UHV cleaning (BINP)
- Gold and Copper Electroplating (BINP)
- Electron beam welding (BINP)
- Laser welding (CERN)
- TIG welding (BINP)
- Ultrasound welding (CERN)
- Vacuum brazing (CERN)

Identification of work for BINP and CERN

BPMQSTZA - LHC BPMQSTZA0001

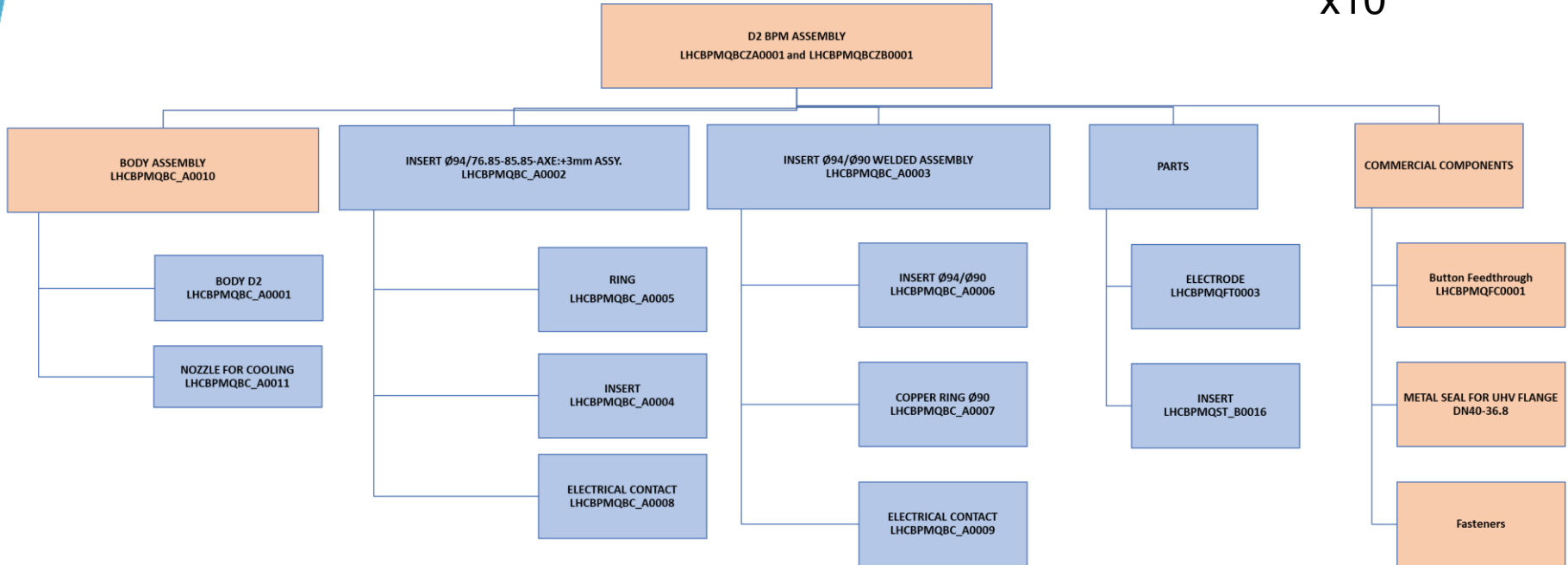


BINP

CERN

Identification of work for BINP and CERN BPMQBCZA/B LHCBPMQBCZA0001 and LHCBPMQBCZB0001

x10



BINP

CERN

Design and pre-production

- BE-BI is working closely with HL-LHC Project office to identify necessary processes and documentation for CERN-BINP collaboration in alignment with HL-LHC Quality Plan
- BE-BI is working closely with EN-MME, TE-MSD, EN-SMM and TE-VSC to finalize design of interfaces and integration
- BE-BI is working together with CERN Main Workshop to elaborate optimized manufacturing processes to achieve the best quality of BPM components
- By doing so, we are striving to simplify as much as possible the manufacturing of parts and assembly processes
- As the BPM design is completed, we have started communications with BINP on planned manufacturing of the BPM components