



Inner triplet BPM manufacturing

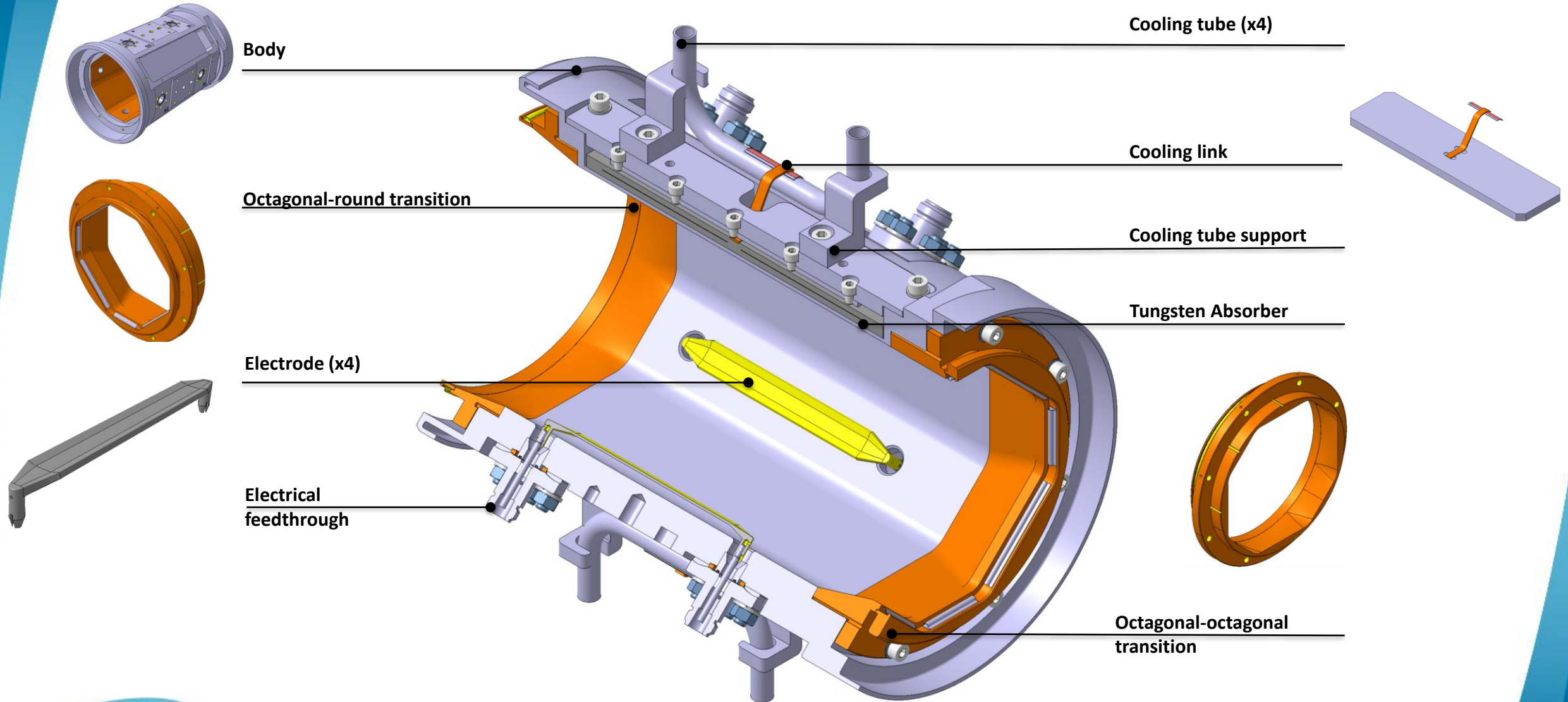
Dmitry Gudkov SY-BI-ML

11th HL-LHC Collaboration Meeting - WP13 Beam Instrumentation – 21.10.2021

Content

- BPM Components Manufacturing
 - BPM Body
 - Transitions
 - Cooling links
 - Electrodes
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- Quality Assurance
- Tooling
- Status of CERN Pre-series
- Conclusions

Inner Triplet BPM Design Overview



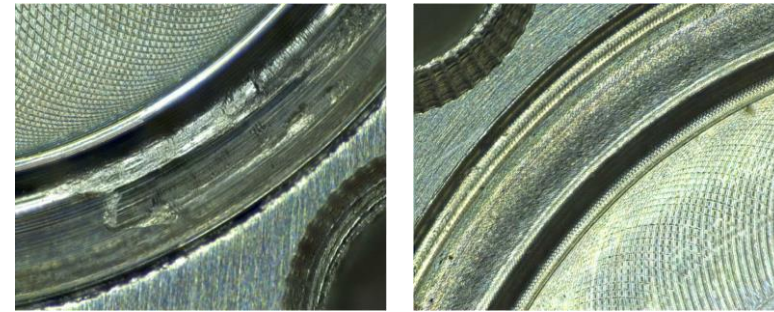
BPM Body Manufacturing



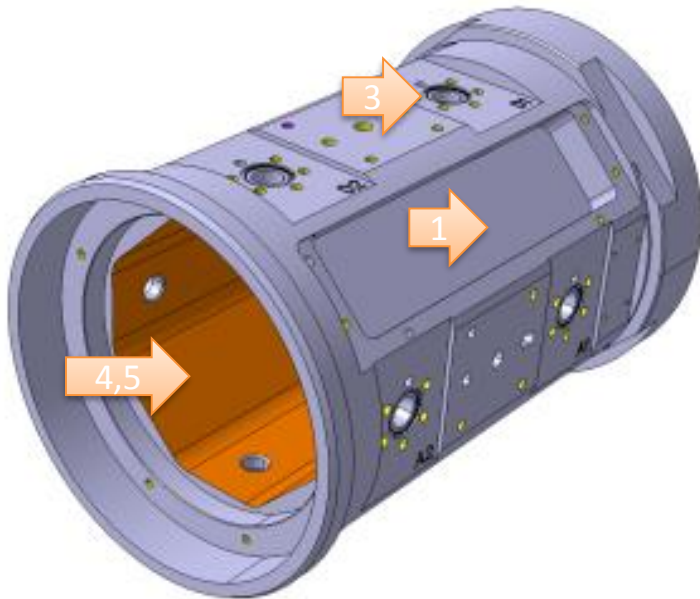
1. Material: CERN material spec. 1001 for 1.4429 round, forged blanks
2. Strict tolerances
3. Machined ConFlat interfaces
4. Octagonal shape (electroerosion wire cutting)
5. Copper electroplating 0.1 mm (with gold flash for adhesion)



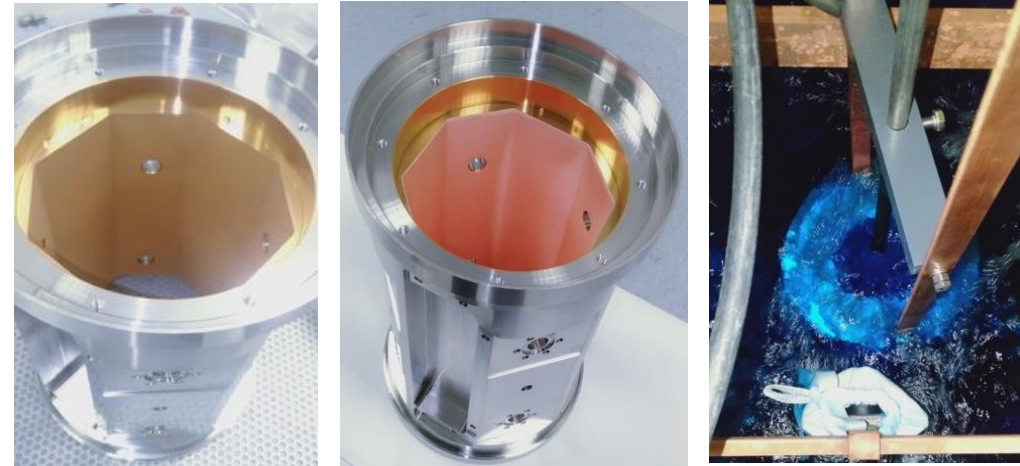
CF – machining results (best – ball mill 0.6 mm)



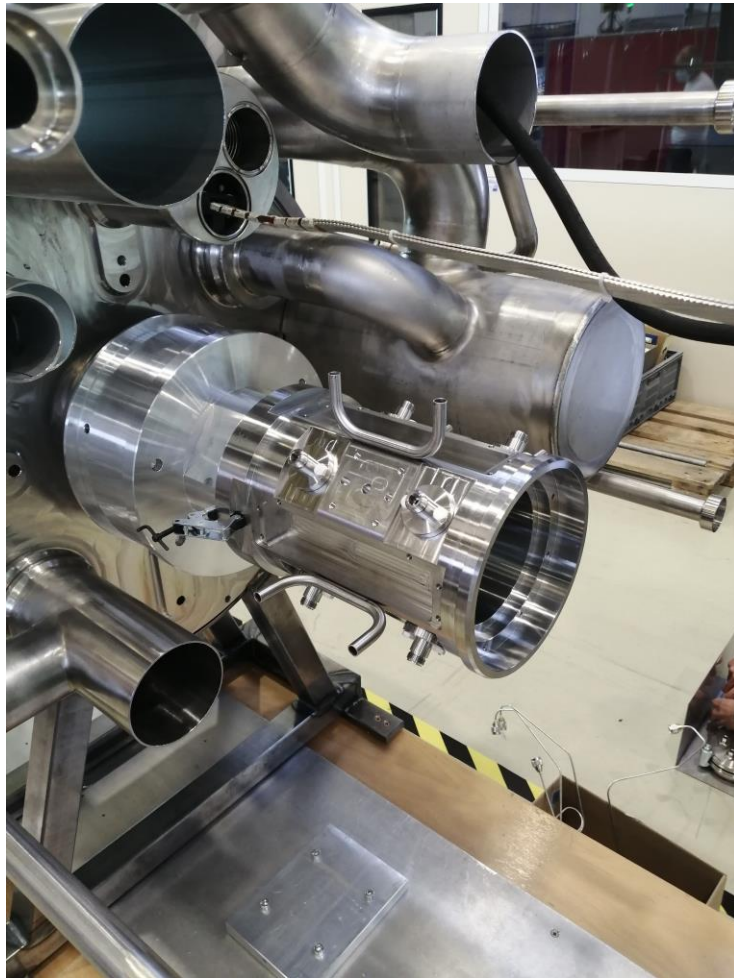
EE-wire cut, Ra3.2



Gold strike and Copper plating



BPM Body Manufacturing – mock-up in 180



BPM Cooling Link Manufacturing

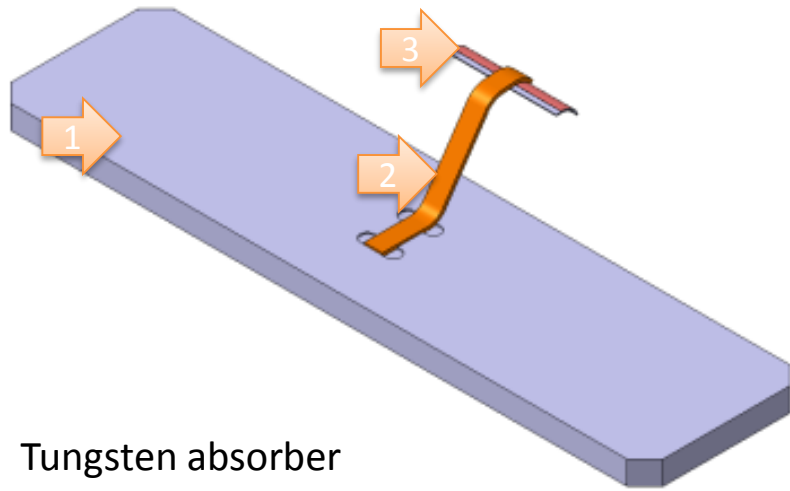
Weld interface plate and cooling strip

Braze interface plate-cooling strip subassembly to the tungsten absorber

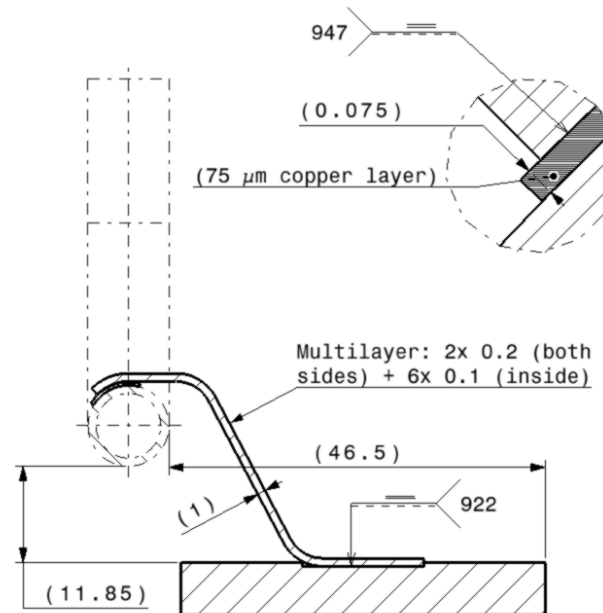
Quality control

Packaging

1. Tungsten absorbers will be supplied by the TE-VSC (40 received)
2. Copper strip and interface plate are welded (ultrasound welding)
3. 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)



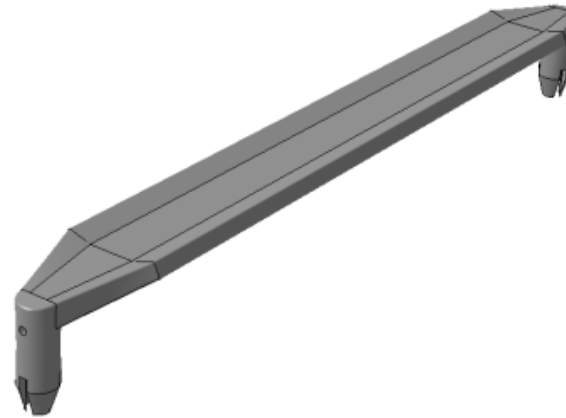
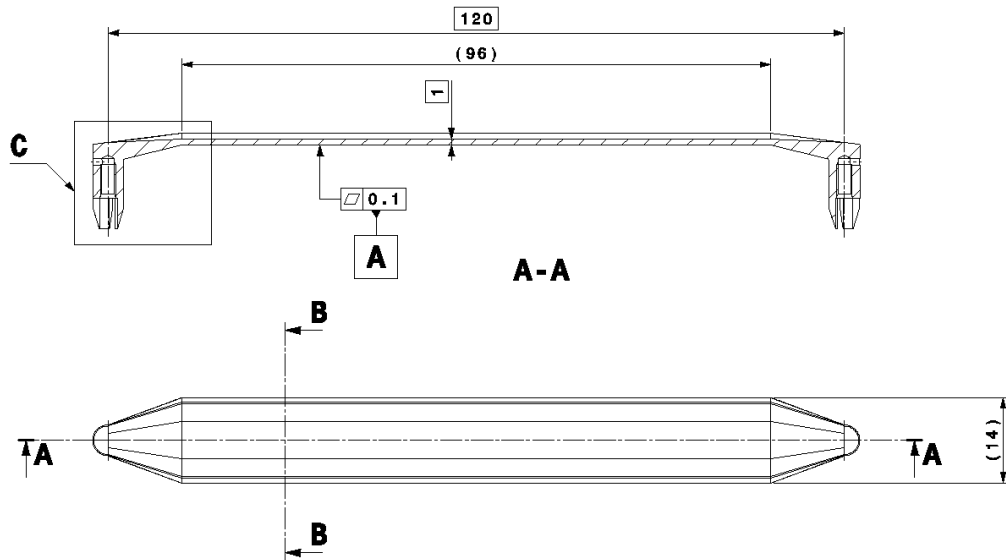
The subassemblies are then welded to the cooling tubes of the BPM body

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

BPM Electrodes Manufacturing



- Iterative design, several prototypes have been manufactured
- Strict tolerances
- Material: CERN material spec. 1000 for 1.4429 round, forged round bars



Scope of work at CERN and BINP

Scope of work is covered by two engineering specifications:

- **Scope of work by BINP**
- **Scope of work by CERN** (including MME workshop, commercial components procurement, operations done at CERN, assembly and testing)



Scope of work (BINP)

<https://edms.cern.ch/document/2387693/1.6>



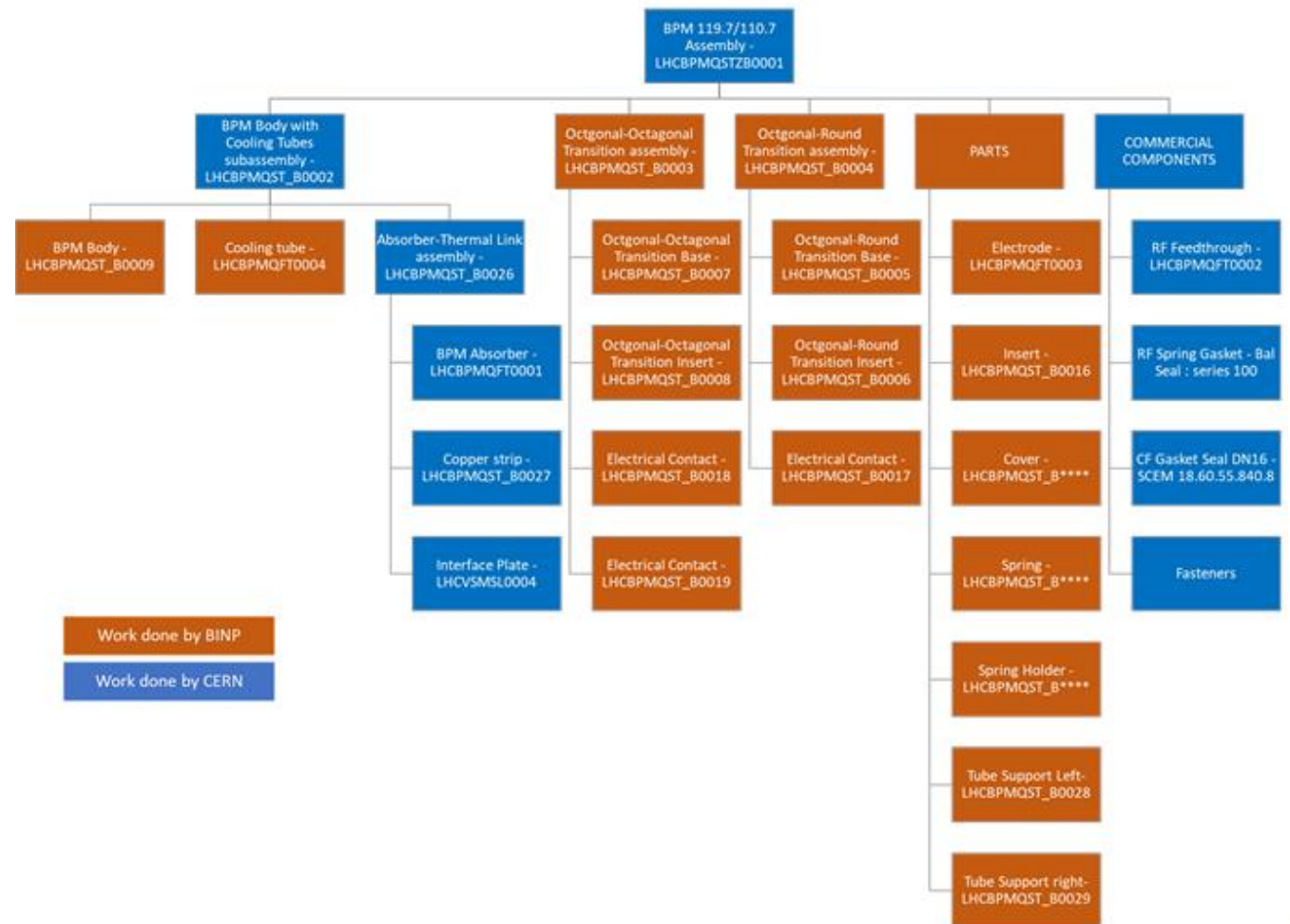
Scope of work (CERN)

<https://edms.cern.ch/document/2338015/1.2>

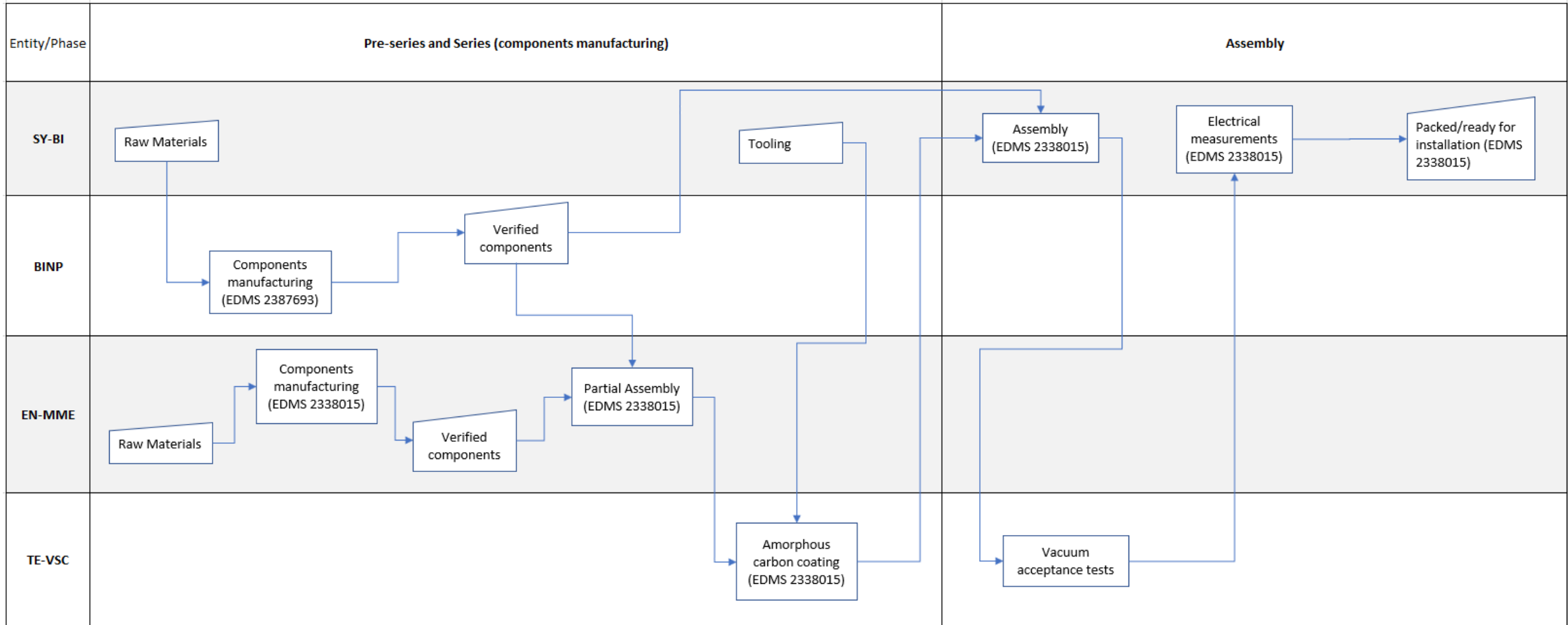
Scope of work at CERN and BINP

BPMQSTZB - LHC BPMQSTZB0001 x22

- Assembly of the BPMs will be performed at CERN
- 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 100 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



Scope of work at CERN and BINP



Quality Assurance

- CERN drawings are released (control 2)
- Three drawing folders with final drawings are in “HL Engineering Check” Status

<https://edms.cern.ch/document/2005150/2.5> - LHC BPMQSTZB0001 - BPM INNER TRIPLET Type B

<https://edms.cern.ch/document/2370344/1.5> - LHC BPMQSTZA0001 - BPM INNER TRIPLET Type A

<https://edms.cern.ch/document/2370347/1.5> - LHC BPMQBCZA0001 + LHC BPMQBCZB0001 = BPM INNER TRIPLET D2

- The quality management is performed in collaboration with HL Quality Team (Hector)
- The BPM items have been created and stored under the EDMS node:
<https://edms.cern.ch/project/CERN-0000175704>
- MIPs are created for all types of components with control points identified
- There are MIPs for BINP which are linked to higher-level MIPs as per scope distribution between CERN and BINP
 - BINP also verified the drawings and provided feedback. No major comments submitted
 - BINP will produce their drawings based on CERN drawings, and CERN will approve them before starting the production
- **CERN procedures exist (or in preparation) for:** Welding, Cleaning, Copper and gold coating, Leak tests, Amorphous carbon coating

- ▶ HCBPMQSTZB001 (v.0) ASSEMBLY OCTAGONAL 119.7/110.7 STRIPLINE
- ▶ HCBPMQST_B002 (v.0) SUBASSEMBLY BPM BODY WITH COOLING
 - ▶ HCBPMQST_B009 (v.0) OCTOGONAL 119.7/123.7 BPM BODY
 - ▶ LHC BPMQST_B0009 (v.0) OCTAGONAL BODY
 - ▶ 2365075 (v.1) MIP_HCBPMQST_B009_Body
 - ▶ LHC BPMQST_B0002 (v.0) BODY WITH COOLING PIPES AND ABS
 - ▶ 2488263 (v.1) MIP_HCBPMQST_B002
 - ▶ HCBPMQST_B004 (v.0) ASSEMBLY OCTAGONAL-ROUND TRANSITION
 - ▶ 2480159 (v.1) MIP_HCBPMQST_B004_ASSEMBLY_OCTAGONAL-
 - ▶ HCBPMQST_B003 (v.0) ASSEMBLY OCTAGONAL TRANSITION 119.7/
 - ▶ 2480151 (v.1) MIP_HCBPMQST_B003_Assembly_Octagonal-Octag
 - ▶ HCBPMQFT002 (v.0) HL-LHC IT STRIPLINE BPM RF FEEDTHROUGH
 - ▶ LHC BPMQFT0002 (v.AA) HL-LHC IT STRIPLINE BPM RF FEEDTH
 - ▶ HCBPMQFT003 (v.0) HL-LHC IT STRIPLINE BPM ELECTRODE
 - ▶ 2488296 (v.1) MIP_HCBPMQFT003
 - ▶ LHC BPMQSTZB0001 (v.0) OCTAGONAL STRIPLINE BPM ASSEMBLY
 - ▶ 2338015 (v.1.2) Engineering Specification for the supply of the Mechanic
 - ▶ 2385616 (v.1) IR1&IR5 heat loads in the IT BPMs due to collision debris
 - ▶ LHC-BPMQ-ES-0004 (v.0.5) Functional Specification - CRYOGENIC DIE
 - ▶ LHC-BPMQ-ER-0001 (v.1.2) RAW MATERIAL BLANKS DIMENSIONS F
 - ▶ 2387693 (v.1.6) Engineering Specification for the supply of the Mechanic
 - ▶ 2005150 (v.2.5) LHC BPMQSTZB0001 - BPM INNER TRIPLET Type B
 - ▶ HCBPMQSTZA001 (v.0) ASSEMBLY OCTAGONAL 99.7/99.7 STRIPLINE H
 - ▶ HCBPMQBCZA001 (v.0) D2 BPM 1 ASSEMBLY

Quality Assurance

HL-LHC: Quality Manufacturing and Inspection Plan													
Prepared by: D. Gudkov Date: 06/02/2021			Project: HL-LHC			Supplier: BINP			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 (SY-BI-ML)			Item description: BPM BODY		EDMS Report No:		
Approved by: N. Surname Date: DD/MM/20YY													
No	ACTIVITY / OPÉRATION	APPL. STANDARDS / 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	Receive and verify raw materials		EDMS 2387693 (for blanks dimensions)				W				Raw Materials acceptance report in MTF	Raw materials are procured by CERN and shipped to BINP	
2	Machining		LHC BPMQST_B0009										
2.1.	BPM body degreasing												
2.2	Dimensional control		LHC BPMQST_B0009				R				Dimensional control report		
3	Electroplating		LHC BPMQST_B0009										
3.1	Gold strike electroplating		EDMS 2387693										
3.2	Visual control		EDMS 2387693										
3.3	Copper coating (0.1 mm thick)		EDMS 2387693										
3.4	Dimensional control		LHC BPMQST_B0009				R				Dimensional control report		
5	Packaging/storage		EDMS 2387693				N				Photograph		

Quality Assurance

HL-LHC: Quality Manufacturing and Inspection Plan													
Prepared by: D. Gudkov Date: 06/02/2021			Project: HL-LHC		Supplier: CERN (EN-MME)		Item Eq. Code: LHC BPM		Asset Code (LHC Part Identifier): HCBPMQST_B002				
Verified by: N. Surname Date: DD/MM/20YY			Work Package: WP13		Client: CERN (SY-BI-ML)		Item description: BODY WITH COOLING PIPES AND ABSORBERS		EDMS Report No:				
Approved by: N. Surname Date: DD/MM/20YY													
No	ACTIVITY / OPÉRATION	APPL. STANDARDS / NORMES APPL.	APPLICABLE DOCUMENTS / DOCUMENTS APPLICABLES	REV. DOC.	INSPECTION / CONTRÔLE						REV. DOC.	NOTES / COMMENTAIRES	
					SUPPLIER / CONTRÔLE		CLIENT / VÉRIFICATION		3 RD PARTY / SURVEILLANCE				INSPECTION REPORT / RAPPORT D'INSPECTION
					Code	Signature/Date	Code	Signature/Date	Code	Signature/Date			
1	RECEIVE AND VERIFY COMPONENTS						R				Inlet inspection report	By CERN (SY-BI-ML)	
1.1	BPM Body		LHC BPMQST_B0009 MTF records									Manufactured by the BINP (MIP EDMS 2365075)	
1.2	Cooling tube		LHC BPMQFT0004									Manufactured by the BINP	
1.3	HL-LHC IT STRIPLINE BPM ABSORBER		LHC BPMQFT0001									Procured by TE-VSC	
2	WELDING OF 4 COOLING TUBES LHC BPMQFT0004 ON THE BPM BODY		LHC BPMQST_B0002										
2.1	Welding												
2.2	Dimensional control		LHC BPMQST_B0002				R				Dimensional control report		
3	ABSORBER WITH THERMAL BRIDGE		LHC BPMQST_B0026										
3.1	Thermal links		LHC BPMQST_B0027										

Quality Assurance

Qualification tests planned in BINP:

- ConFlat Geometry Machining + Quality Control + Leak Test
- Gold and Copper coating quality with use of witness piece (tube)

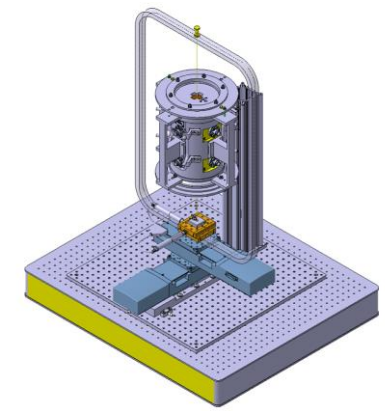
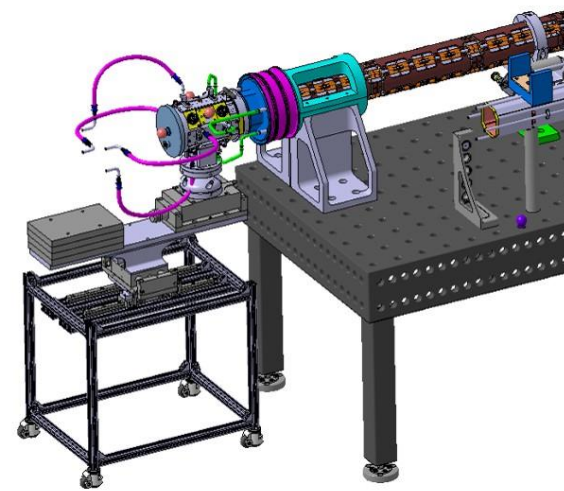
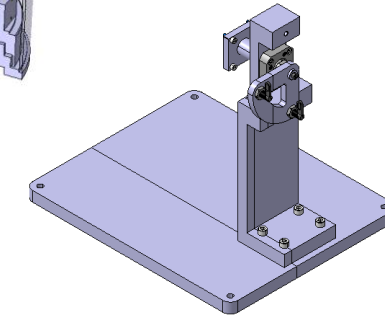
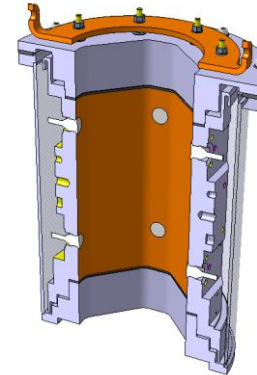
CERN raw materials tracking in BINP:

- BINP shall define a stock control program for all materials.
- All materials shall be kept locked in a particular room exclusively devoted to this aim.
- Access shall be limited to a named QA officer.
- All materials entering or leaving this stock shall be permanently marked and logged by the QA officer and recorded in the corresponding certificates such that full traceability from CERN to each finished component is ensured.
- Tracking with CERN asset management.



Tooling

#	Tooling	Complexity (1-10)	Design	Manufacturing
1	Gold Electroplating Tooling for BPM type A	6	COMPLETE	IN PROGRESS
2	Gold Electroplating Tooling for BPM type B	6	COMPLETE	IN PROGRESS
3	Gold Electroplating Tooling for BPM type D2	6	COMPLETE	IN PROGRESS
4	Copper Electroplating Tooling for BPM type A	6	COMPLETE	IN PROGRESS
5	Copper Electroplating Tooling for BPM type B	6	COMPLETE	IN PROGRESS
6	Copper Electroplating Tooling for BPM type D2	6	COMPLETE	IN PROGRESS
7	Amorphous carbon coating tooling for BPM type A/B	8	NOT STARTED	NOT STARTED
8	Amorphous carbon coating tooling for BPM type D2	8	NOT STARTED	NOT STARTED
9	Assembly tooling (tilting mechanism)	2	COMPLETE	COMPLETE
10	Leak test flanges (quality control)	2	IN PROGRESS	NOT STARTED
11	Alignment and leak test flange for BPM type A/B (installation)	4	IN PROGRESS	NOT STARTED
12	Alignment and leak test flange for BPM type D2 (installation)	4	IN PROGRESS	NOT STARTED
13	Positioning tooling for BPM type A/B (installation)	4	NOT STARTED	NOT STARTED
14	Positioning tooling for BPM type D2 (installation)	4	NOT STARTED	NOT STARTED
15	Tooling for BPM alignment and installation on the beam screen (type A/B)	10	IN PROGRESS	NOT STARTED
16	Tooling for BPM alignment and installation on the beam screen (type D2)	10	IN PROGRESS	NOT STARTED
17	Electrical measurements bench	10	IN PROGRESS	NOT STARTED
18	Electrodes verification bench	6	NOT STARTED	NOT STARTED
19	Buttons verification bench	6	NOT STARTED	NOT STARTED
20	Feedthroughs verification bench	6	NOT STARTED	NOT STARTED



Status of CERN Pre-series

- Machining is in progress.
- Ready for next operations as per production plan – Q1 2022.



Conclusions

- SY-BI is working closely with HL-LHC Project office to refine processes and documentation for CERN-BINP collaboration in alignment with HL-LHC Quality Plan
- SY-BI together with CERN EN-MME Workshop elaborated an optimized manufacturing processes to achieve the best quality of BPM components
- SY-BI have re-started the technical discussions with the BINP on planned manufacturing of the BPM components – catch-up every 3 weeks (E. Pyata, A. Krasnov, T. Bedareva)
- The CERN Pre-series is well advanced. The work will be continued in 2022 by EN-MME, SY-BI and TE-VSC
- Many tools to be designed and manufactured. The design for most of them is in progress
- Overall, the manufacturing process of all the components and assemblies is well understood due to manufacturing studies and prototypes

Thank you for your attention!

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