



Status and Strategy of Beam Loss Monitor Ionisation Chamber (BLM IC) Production

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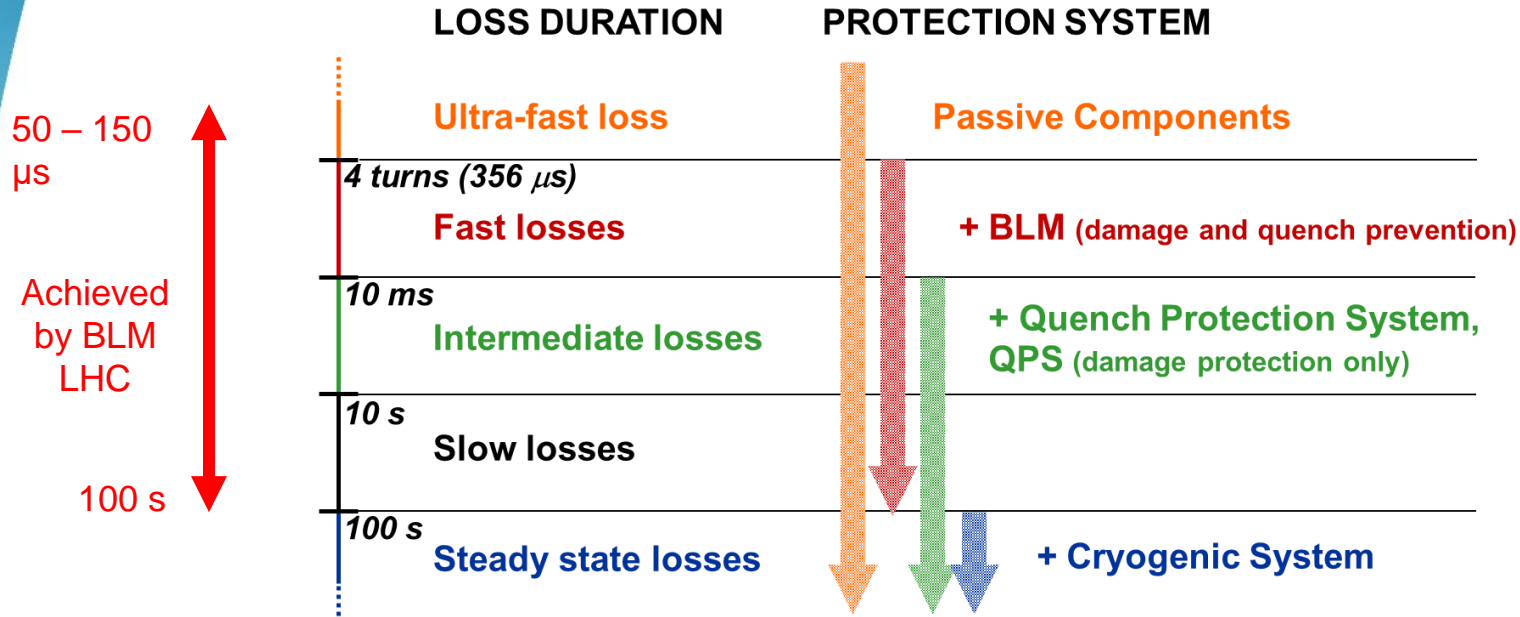
14th HL-LHC Collaboration Meeting, Genoa, 09.10.2024

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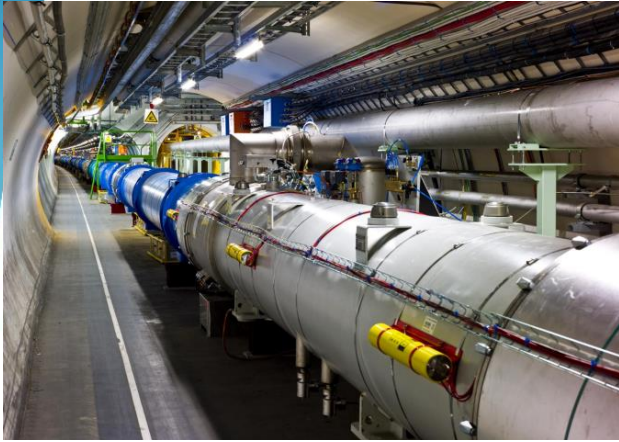


Beam Loss Duration and Protection Systems



- Impossible to have active protection from ultra-fast losses
- No real redundancy for fast losses; later additions of beam and magnet current change monitoring

LHC BLM System Overview



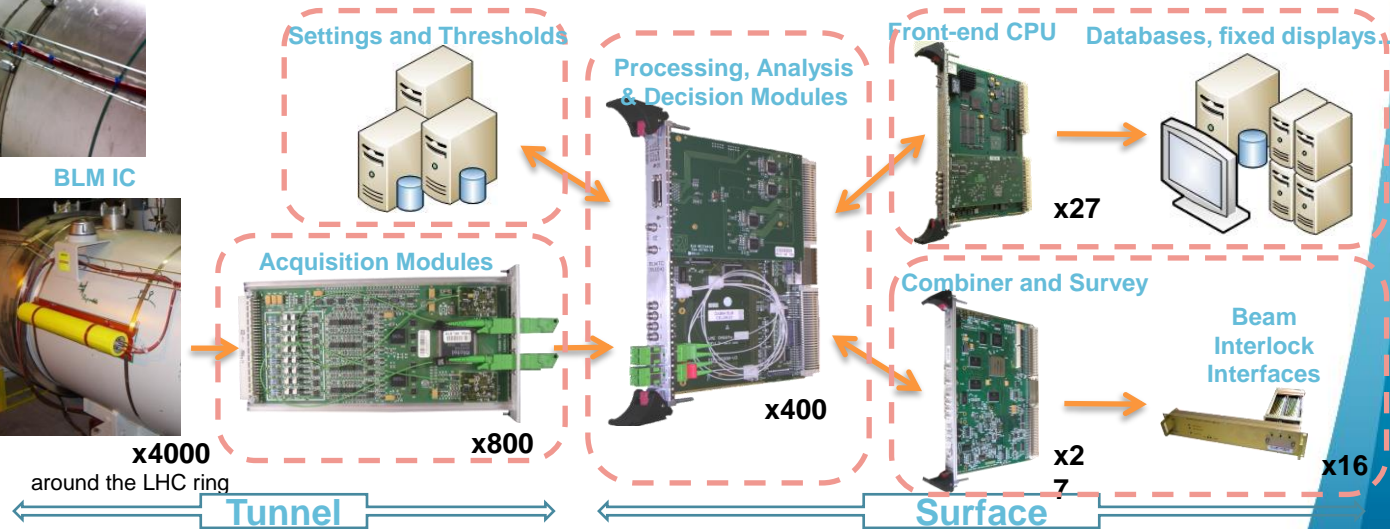
BLM IC



x4000

around the LHC ring

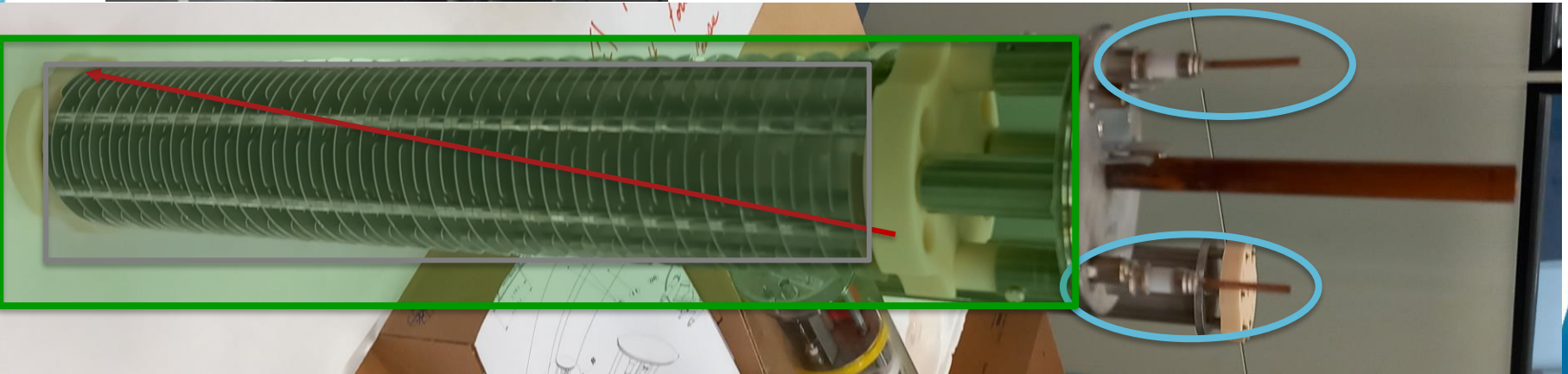
- A highly critical system for the protection of the LHC.
- Deployed throughout the 27 km tunnel.
- Speed, reliability, fail-safety are required.
- A large amount of measurement data is published continuously.



Work Principle of the BLM IC



- Voltage 1500 V
- 1.1 bar Nitrogen Gas
- 61 Electrodes
- Particle Ionising Gas
- Measure Current



BLM IC History at CERN

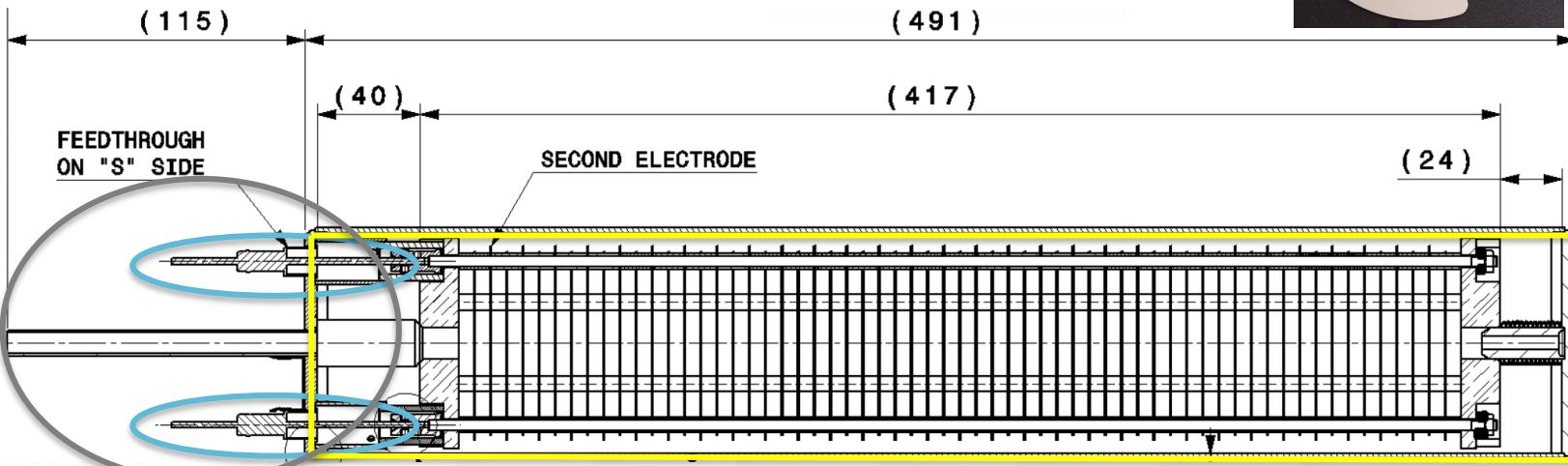
- More than 4,000 BLM ICs are operating at CERN.
- About 93% are installed in the LHC.
- They were previously produced in collaboration with external institutes.
- The end of long-term collaboration with these institutes made re-engineering of the BLM IC necessary.

Production Objectives

- Produce 1000 BLM ICs:
 - 200 for HL-LHC
 - 800 for the renovation in the LHC injector complex
- Timeline:
 - 400 units to be delivered by end 2025
 - >200 units to be delivered by end 2026
 - Remaining units in 2027

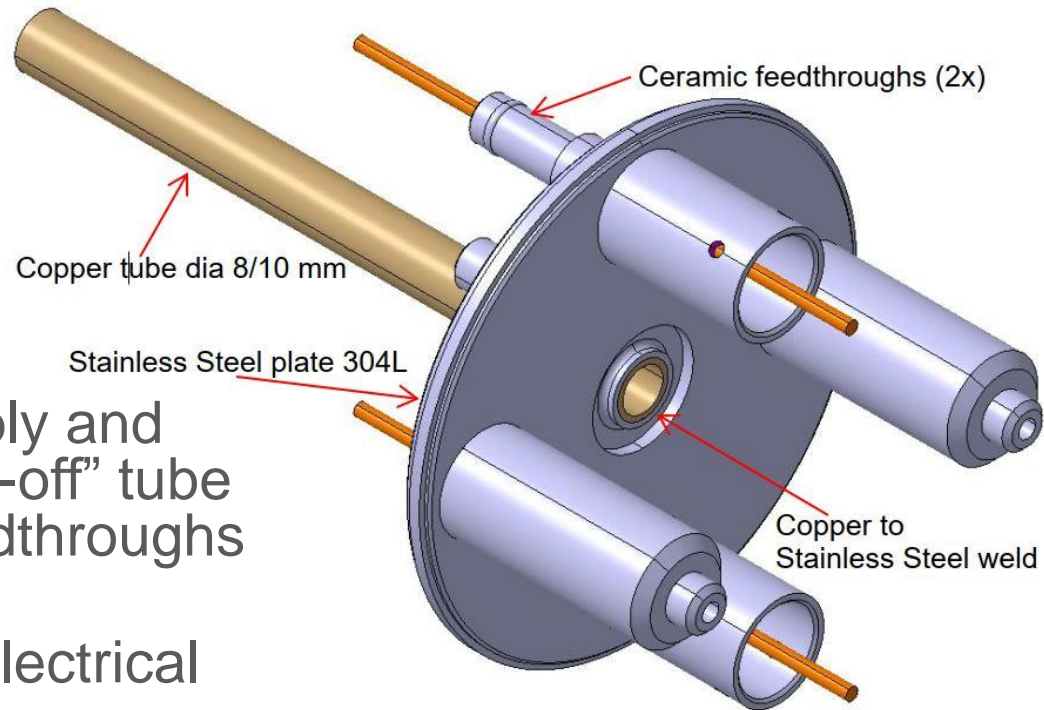
BLM IC Parts Overview

- Ceramics Al_2O_3 with very low conductance (2x)
- Electrodes: Al EN6082 (61x)
- Ceramic Feedthroughs (2x)
- Welded cover with all vacuum welds done by TIG
- Vacuum container
- Many other components, totaling 330 parts



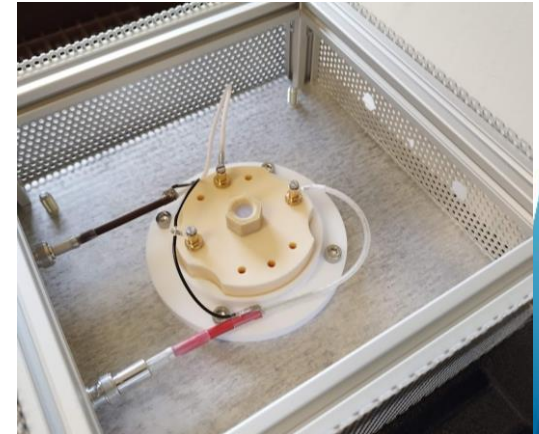
BLM IC Critical Part Endplate

- Endplate Production Competencies (LHCBLM__0002):
 - Precision machining
 - UHV cleaning
 - UHV-compatible assembly and welding of copper “pinch-off” tube (SS/Cu) and electric feedthroughs (SS/SS)
 - Dimensional and basic electrical checks
 - Leak check



BLM IC Critical Part Ceramic Insulator

- Ceramic Insulator Production Competencies (LHCBLM__0005):
 - Precision ceramic Al_2O_3
 - Ultra-high resistance:
 - < 1 pA when 1.5 kV applied
 - Resistivity checks in a controlled environment to guarantee consistent measurements
 - UHV-clean delivery

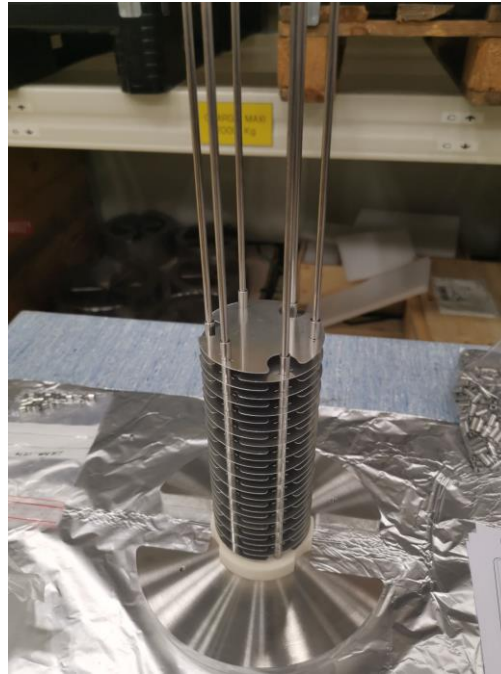


BLM IC Parts Assembly Sequence (1/3) “Stacking”

- Mount the electrodes, spacers and ceramic insulators.

The spacers and electrodes are stacked by arranging the electrodes in an alternating pattern.

- Low dust & hydrocarbon “free” area required → office type cleanliness sufficient.



BLM IC Parts Assembly sequence (2/3) “End Plate”

- The End Plate (LHCBLM__0002), with electrical connections and “Pinch-off”, is installed.



BLM IC Parts Assembly Sequence (3/3) “Finishing”

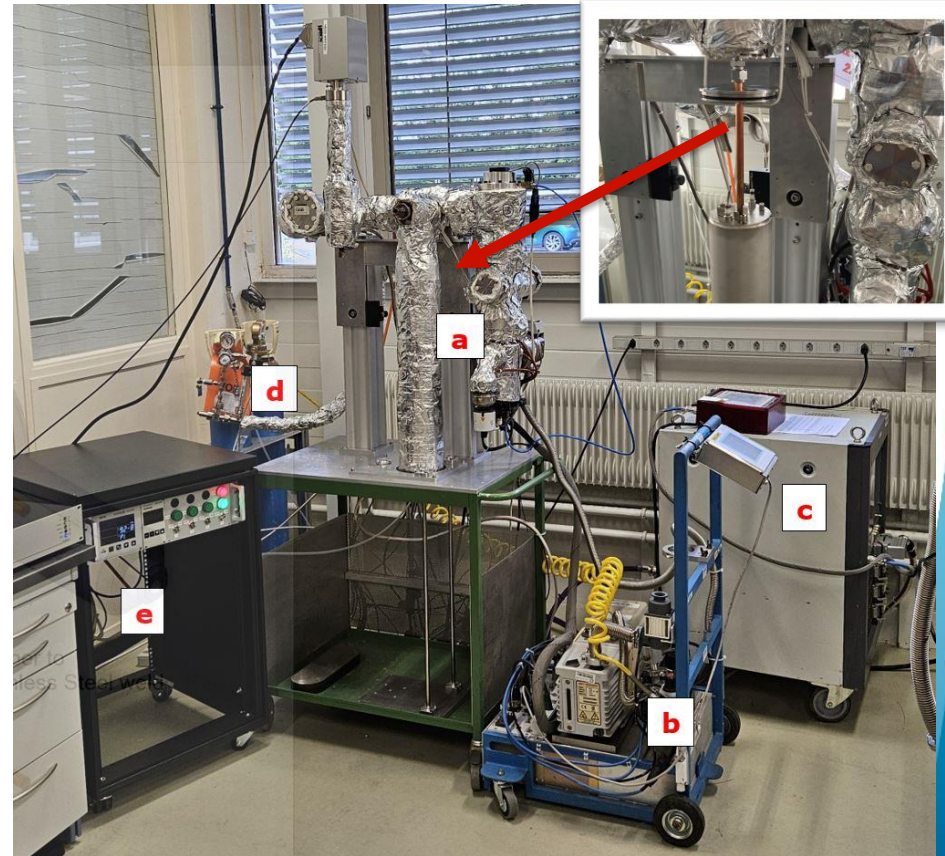
- Insert the stack, including the end-plate, into the vacuum housing.
- Two Leak-tight welds are made on either end of the tube.



BLM IC Conditioning and Finishing on Test Stand

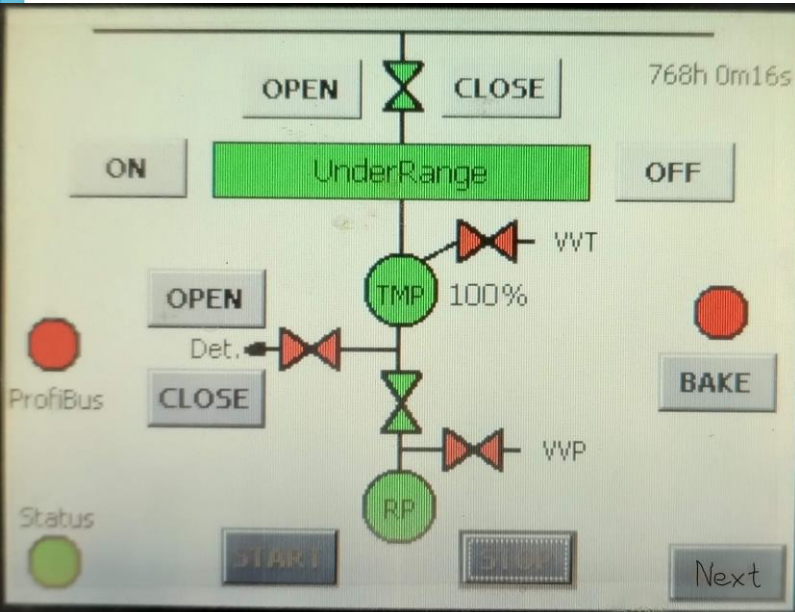
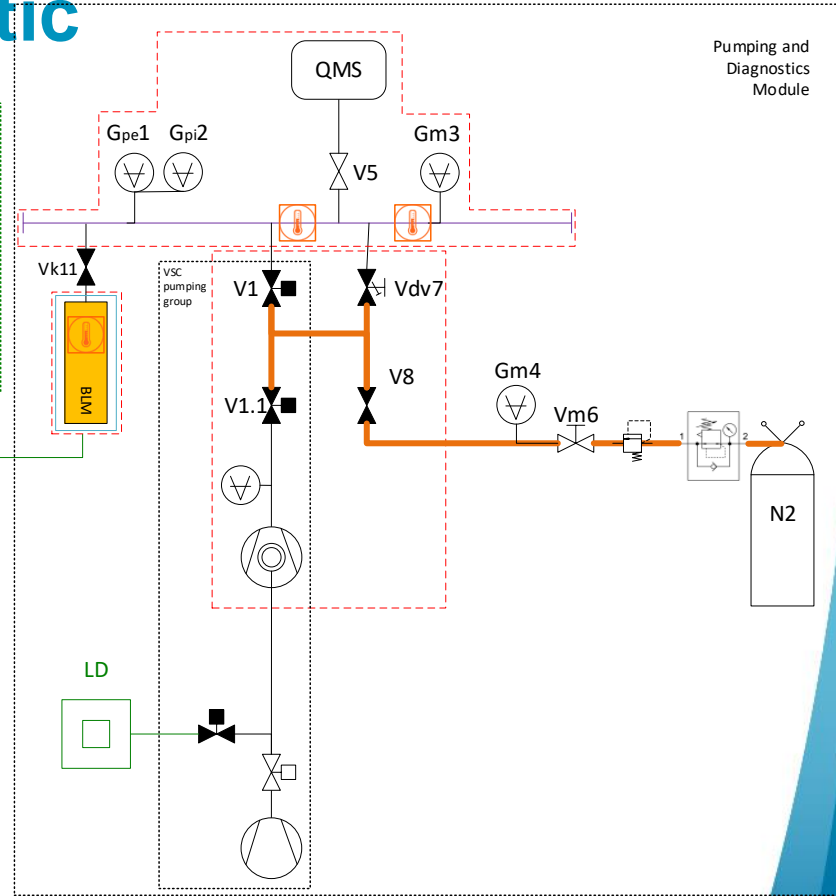
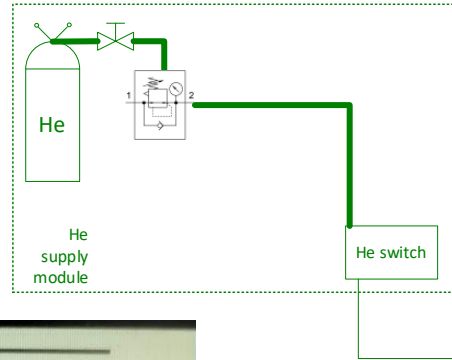
- Leak Check
- Bakeout to 220 °C
- Residual Gas Analysis
- Refill with Nitrogen to 1,100mbar absolute (100 mbar overpressure)
- “Pinch-off”
- Electrical Checks

→ Complex expert procedure



Test Stand Synoptic

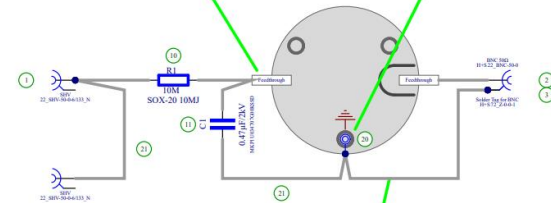
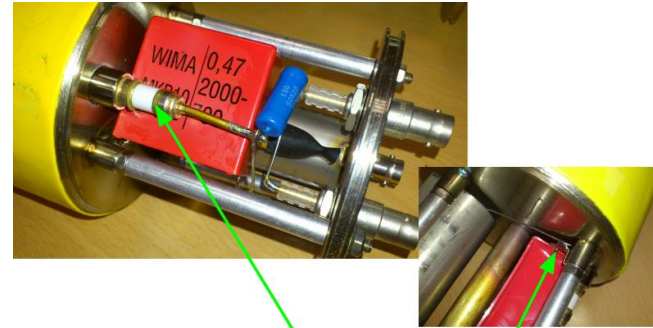
Vacuum controls for pumping system including Turbo Molecular and primary Pumps



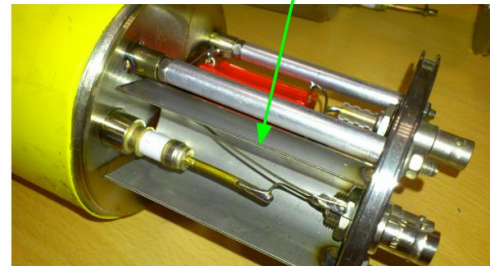
Procedure for BLM IC leak tightness tests, bake-out, N2 filling and RGA with use of vacuum stand EDMS [2916501](#)

Add the electronic components and yellow sleeve

- Add all electrical components to the BLM IC.
- Install the yellow sleeve onto the BLM IC.

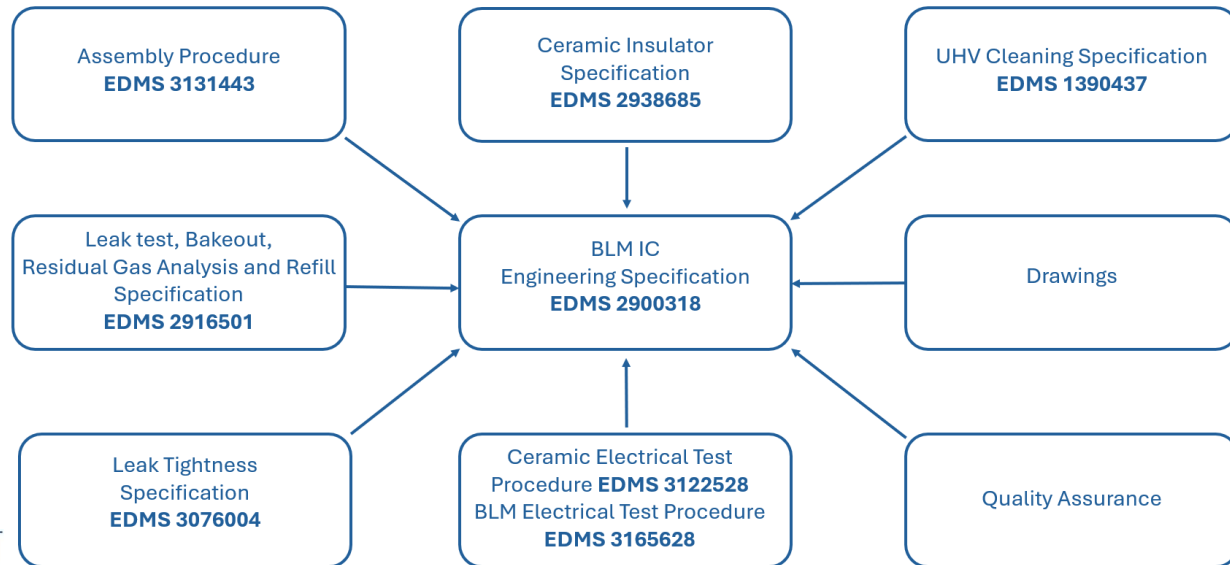


! Check all the electrical contacts after soldering the wires and components !



Status of the Project – Set the scene 23/24

- Following the end of the collaboration, a significant amount of re-engineering was required to ensure the function and quality of the BLM IC production.
- The result of this process has resulted in several drawings and engineering specifications.



Status of the Project – Produce New BLM ICs with the New Procedures 23 and 24 in HiRadMat



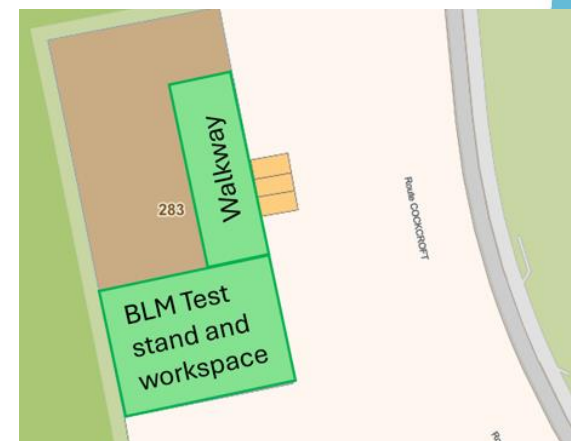
- Done with a beam of 288b (4x42b)
- Similar Trend as previous measurements
- Total 6 BLM tested: Performance as expected

Status of the Project – Procurement

- The raw material orders on-going
 - Not expected to be critical.
 - All relevant raw materials have been ordered by CERN according to CERN specifications.
- Price enquiries for critical items are currently with the bidders:
 - Ceramic insulator as per DO-34404/SY/HL-LHC (DR-10411247).
 - End plate as per DO-34448/SY/HL-LHC (DR-10441935) to be sent out in the days to come.

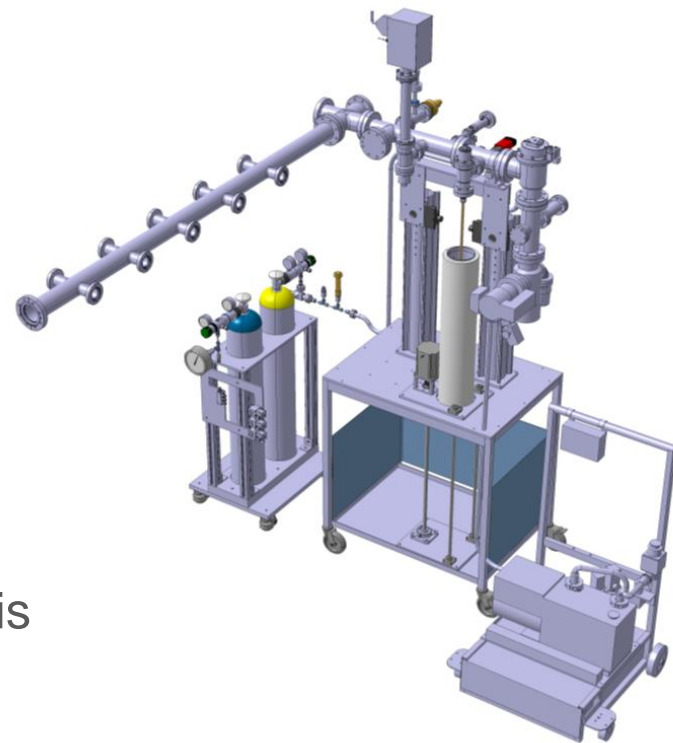
Status of the Project – Go For Series Production: Location @ CERN

- Objective is to have 400 produced by end 2025:
 - CERN's in-house production will fully confirm the processes.
 - “Stacking” will occur in 37-R-15+17, and the lab space is currently being cleared.
 - The BLM IC test stand in building 283 requires significant refurbishment and the installation of safety equipment, including fire detectors.



Status of the Project – Go For Series Production: Missing Apparatuses

- Extension of the Test Stand aims to transition from 1 single item to a batch process of 20 units in one bake-out cycle.
 - Objective is to achieve one (ideally two) bake- out cycles per week.
 - A study for the extension is ongoing.
 - Rotation of personal on this particular job is causing some delays.



Strategy of the Years to Come

- 2024
 - Order all materials.
 - Design the extension of the test stand.
- 2025
 - Make assembly space available for CERN in-house series production (Q1/Q2).
 - Follow-up production of BLM IC components.
 - Procure and assemble the test bench extension.
 - Advance the strategy for assembling the remaining 600 units, either in collaboration with a partner institute (possibly at a lower cost) or within European industry.
- 2026
 - Start series production outside CERN.

Summary

- 1,000 BLM ICs to be produced, including 200 for HL-LHC.
- BLM ICs were re-engineered, design updates were made, and prototypes produced at CERN. A total of 6 BLM ICs were tested in HiRadMat in 2023 and 2024.
- All relevant series raw materials are procured by CERN to guarantee the quality, especially for vacuum-critical material.
- Price inquiries for critical components, such as the ceramic insulator and the end plate, have been sent out or are imminent.
- The test stand extension to accommodate 20 units ongoing.
- Lab space is being prepared to start CERN's in-house production of 400 units as from Q2 2025.
- Efforts to establish contacts with both institutes and industry are ongoing to make the assembly of the remaining 600 units.

A big

“THANK YOU”

to all the many, many colleagues in

**SY-BI, EN-MME, TE-VSC, ATS-DO, IPT-PI,
HSC-OHS,...**