CERN
CH-1211 Geneva 23
Switzerland

LHC

EDMS NO.	REV.	VALIDITY
2025553?	**0.3**	**DRAFT**

REFERENCE
LHC-BGC-EC-0003

Date: 2020-01-23

ENGINEERING CHANGE REQUEST

Update of the BGC Phase 1 installation and move of the gas injection system.

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

A "Beam Gas Curtain" instrument (BGC) is under development in the framework of HL-LHC WP13 for use in the HL-LHC hollow electron lens. The details of a prototype installation in the LHC are given in the approved ECR EDMS 2025553.

The purpose of this ECR is to clarify aspects of the installed device following developments made in the course of the last 12 months. This includes:

- coatings used in the beam vacuum chamber amorphous carbon and multilayer coating
- up-date on the support structure and clearances
- up-date on the RF-liner
- up-date on the orientation
- request to move and operate the gas injection system used for fluorescence tests in Run 2 to the BGC location.

This activity is within the scope of HL-LHC (WP13).

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
G. Schneider BE-BI S. Mazzoni BE-BI R. Veness BE-BI G. Papazoglou BE-BI Data contributed from E. Page TE-VSC O. Santos TE-VSC P. Santos Diaz TE-VSC G. Mazzacano (BE-ABP) M. Gonzalez De La Aleja Cabana (ATS-DO) J. Oliveira (ATS-DO)	C. Adorisio, V. Baglin, M. Barberan, M. Bernardini, I. Bejar Alonso, C. Bertone, G. Bregliozzi, S. Bustamante, J. –P. Corso, R. de Maria, B. Delille, P. Fessia, R. Folch, J. –F. Fuchs, C. Gaignant, M. Giovannozzi, G. Girardot, E. Jensen, R. Jones, M. Lamont, E. Metral, D. Missiaen, M. Modena, Y. Muttoni, T. Otto, A. Rossi, B. Salvant, J. Sestak, R. Steerenberg, L. Tavian, M. Tavlet, C. Vollinger, J. Wenninger	P. Collier (on behalf of the LMC) L. Rossi (on behalf of the HL-LHC Project)

DOCUMENT SENT FOR INFORMATION TO:

ATS groups leaders

SUMMARY OF THE ACTIONS TO BE UNDERTAKEN:

[List the main actions to be undertaken]

Note: When approved, an Engineering Change Request becomes an Engineering Change Order.

1. INTRODUCTION

The ECR for the staged installation of the BGC was approved on 21.01.2019 [1].

The purpose of this ECR is to clarify the engineering choices taken in 2019 for the final prototype instrument. The position in C5L4.B start DCUM 9954.7272, length 0.5 m, internal diameter 80 mm and function of the BGC have not changed.

The following aspects were defined since the approval of the ECR for which additional approval is now requested:

- the blackening coatings used in the beam vacuum chamber
- up-date on the support structure and clearance
- up-date on the RF-liner used to reduce impedance
- up-date on the measurement orientation
- request to move and operate the gas injection used for fluorescence tests during Run 2 [2] in D5L4.B to the BGC sector C5L4.B.

Under discussion here is only phase 1 of the full BGC prototype installation, as covered by the ECR 2025553. This is schematically shown in ANNEX 1. A new ECR will be provided for any modifications to this layout.

2. REASON FOR THE CHANGE

2.1 Coatings

2.1.1 Amorphous carbon coating

Amorphous carbon coating is chosen both for the internal side of the liner and the inner side of the vacuum chamber due to its low reflectivity for visible light, see Figure 1. There is good in-house knowledge of this technology, proven vacuum and electron cloud compatibility as well as the low reflectivity of about 13% [3].

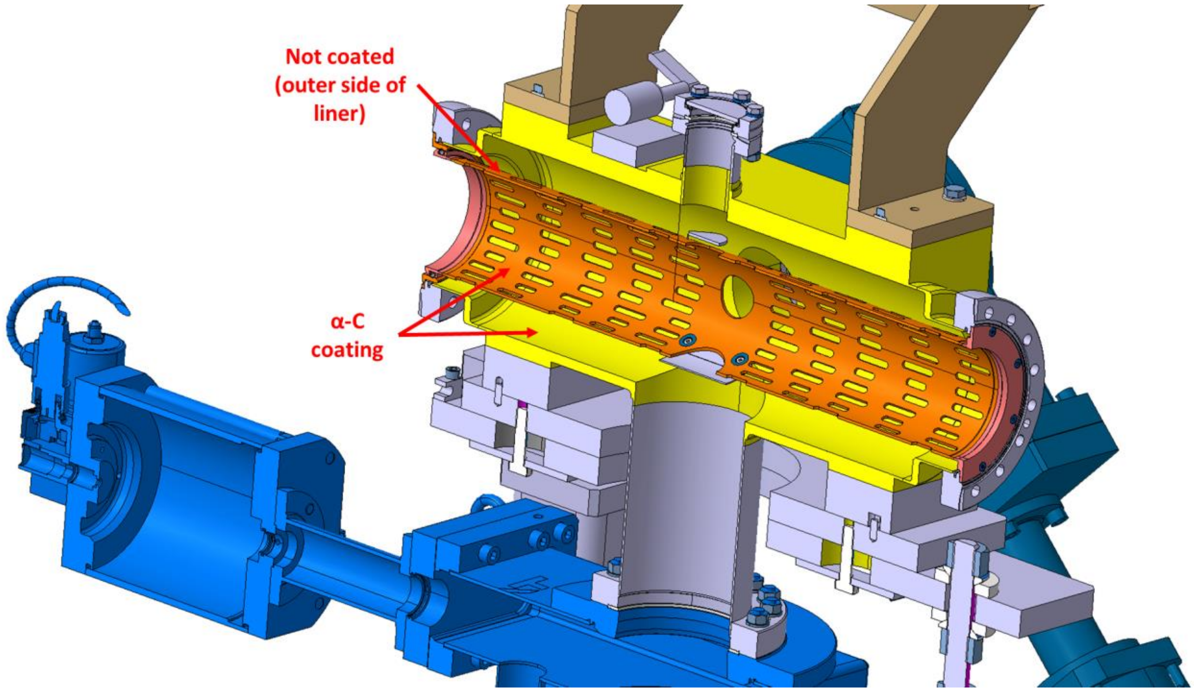

Figure 1: Amorphous carbon coating of the vacuum chamber (LHCBGCAB0013) and copper liner (LHCBGCAB0026).

2.1.2 Mulitlayer coating

The plate which is seen by the camera will have a very low reflectivity multilayer coating made of Ti, Al, Si, O, N, see Figure 2. The outgassing of this coating is LHC UHV compatible [4].

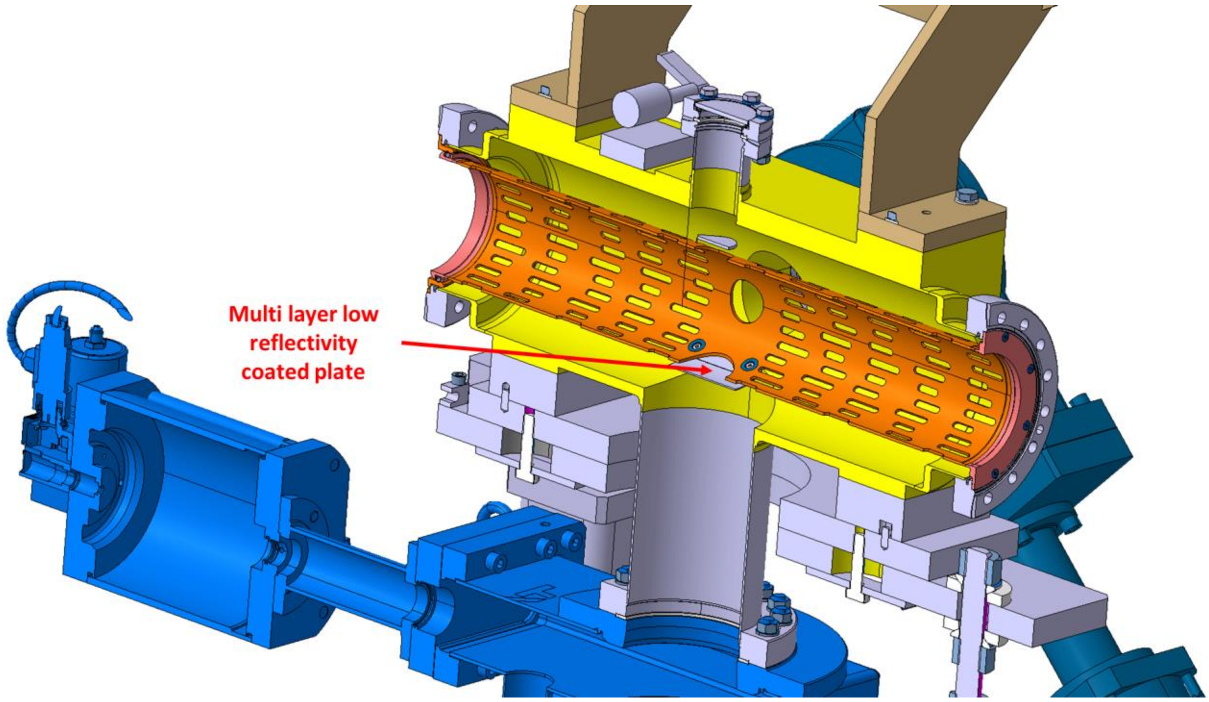

Figure 2: Multi-layer coated low reflectivity plate (LHCBGCAB0006).

The surface of the plate will be coated by magnetron sputtering. The first three layers are coated with a TiAl magnetron-electrode. TiAl is the base layer. Nitrogen is then injected into the chamber and a layer of TiAlN is created. A top layer of TiAlON is then created by adding oxygen to the nitrogen atmosphere in the chamber. A last layer of SiO_2 is added with a second magnetron of silicon. The total thickness of the coating is in the range of 400 nm.

2.2 Support Structure and Clearances

The footprint of the support structure slightly exceeds the 500 mm space allocated for the BGC. The design of the BGC support has to reflect the accessibility to assemble the individual parts, namely the voluminous all metal gate valves. The design of the support is 710 mm long with the footprint and two gate valve entering into the adjoining VSC sectors, see Figure 3 and Figure 4.

In order to have more space between the BGC valve on the left side towards the VSC tube support, we request to move the support by 60 mm to increase the space from 64 mm as seen in Figure 4 to 124 mm.

The optical assembly and the geometer targets as seen Figure 5 can be temporarily demounted if requested.

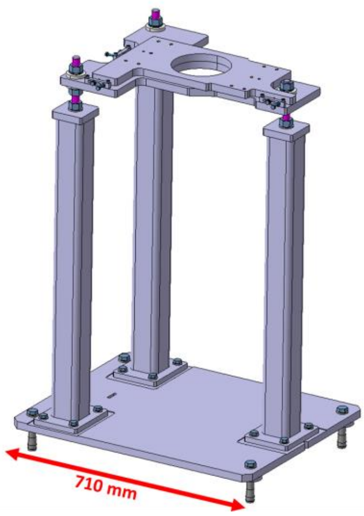

Figure 3: Design of the support structure (LHCBGCAB0014).

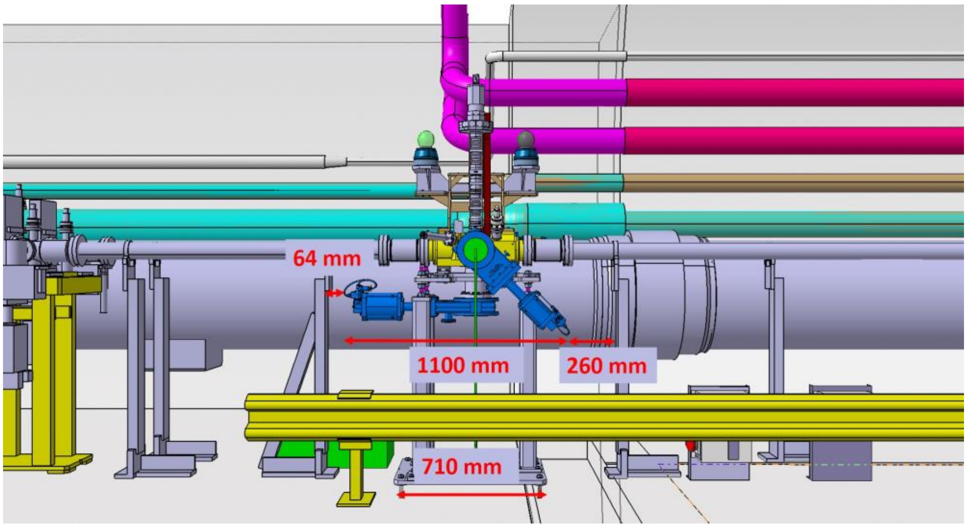

Figure 4: Clearances of the valves to the adjacent vacuum supports

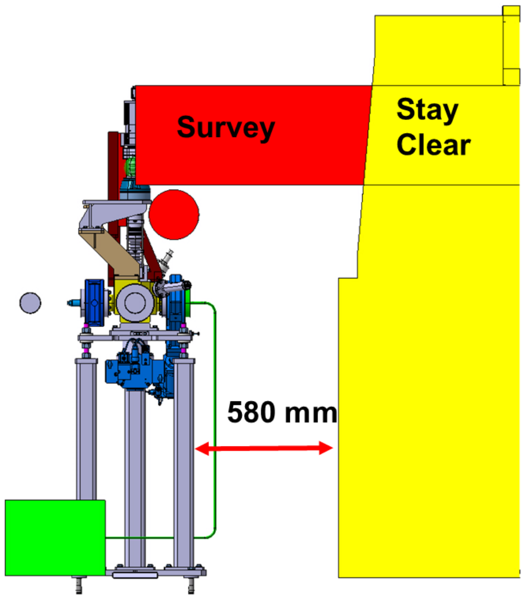

Figure 5: Position with survey (red) and tunnel (yellow) stay clear. The optical target on the BGC is demountable if requested during alignment activities in the tunnel.

2.3 RF-liner

In order to minimise the impedance, a beam screen type slot pattern with randomised slot locations and dimensions was selected, see LHCBGCAB0008 for details. The present design was presented and approved by the Impedance Working Group [5].

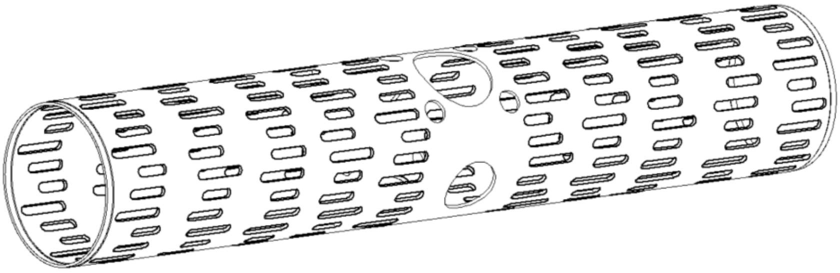

Figure 6: Randomised slot pattern of BGC liner

2.4 Horizontal positioning of the BGC

The final Phase 2 gas jet (not part of this ECR) will be mounted in the horizontal plane [6]. An engineering solution to fulfill this requirement while fitting within the allocated space without entering the tunnel stay clear has been found. The preparation and orientation of the instrument will be already be implemented for in Phase 1, with the Phase 1 layout shown in Fig 7.

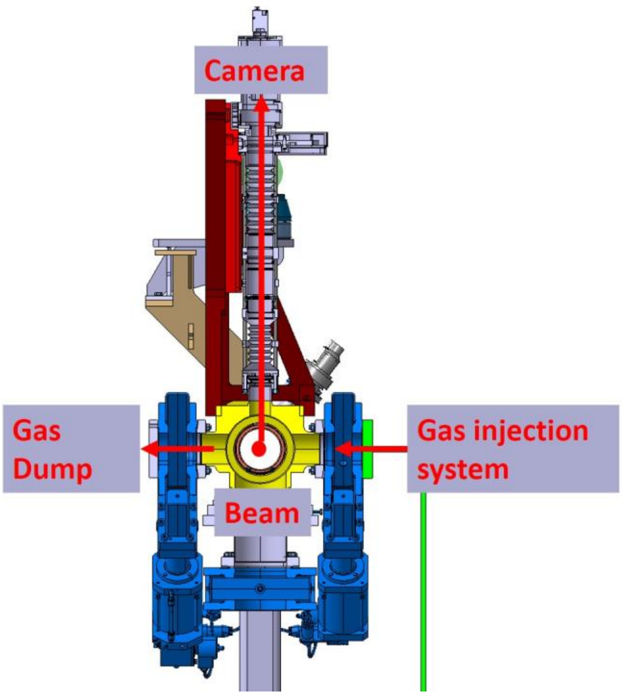

Figure 7: BGC phase 1 installation with the gas jet horizontal position.

2.5 Displacement of the gas injection system

The final Phase 2 BGC will have its own integrated gas curtain generation system. However this system is not available for Phase 1.

In order to continue optimisation of the optical system and understanding of proton beam fluorescence cross sections at 7 Tev without the final gas curtain it is proposed to move the gas injection of the former BGI DCUM 9932 to the BGC Phase 1 location DCUM 9955 during LS2, see Figure 8, Figure 9 and Annex 1.

All functionalities including the maximum gas injection pressure of $5*10^{-8}$ mbar will remain the same as for the present BGI gas injection system. Some of the gas injection control cables might need short extensions. The gases to be tested are neon, argon and nitrogen with a focus on neon. All gas types used will first be approved by TE-VSC.

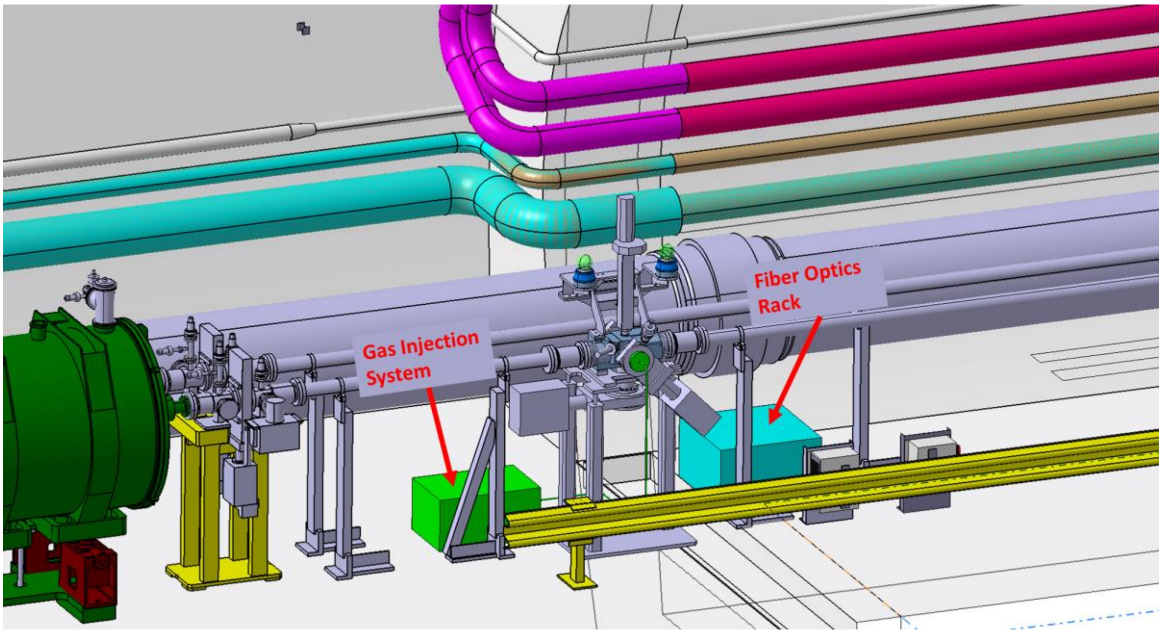

Figure 8: BGC Phase 1 with gas injection position in the tunnel.

Figure 9: - Vacuum sector B5L4 during YETS 2017/18

3. SCHEDULE AND SERVICES REQUIRED

The mechanical installation is foreseen from February 2020 to April 2020.

The bakeout activities should be foreseen from May 2020.

Any cable extensions required for the gas injection system are to be put in place by August 2020.

4. IMPACT ON OTHER ITEMS

4.1 IMPACT ON ITEMS/SYSTEMS

Integration/Layout	The location of the gas injection system needs to be updated. The as-built drawings need to be reflected in the integration drawings. An update of SCADA VSC will be required.

4.2 IMPACT ON UTILITIES AND SERVICES

Raw water:	No
Demineralized water:	No
Compressed air:	No
Electricity, cable pulling (power, signal, optical fibres…):	Some of the signal, power and multi strand cables must be extended by ~23 m for the gas injection system.
DEC/DIC:	To be agreed upon with VSC and then EN-EL for the cable extension.
Racks (name and location):	Not applicable
Vacuum (bake outs, sectorisation…):	Movement of the gas injection system including cables
Special transport/ handling:	
Temporary storage of conventional/radioactive components:	No
Alignment and positioning:	No
Scaffolding:	No
Controls:	Yes, modification of the instrumentation in SCADA VSC application
GSM/WIFI networks:	No
Cryogenics:	No

Contractor(s):	No
Surface building(s):	No
Others:	No

5. IMPACT ON COST, SCHEDULE AND PERFORMANCE

5.1 IMPACT ON COST

Detailed breakdown of the change cost:	For VSC: Under evaluation
Budget code:	64062 (HL-LHC WP13 Gas Jet Profile Monitor)

5.2 IMPACT ON SCHEDULE

Proposed installation schedule:	LS2, February to August 2020
Proposed test schedule (if applicable):	
Estimated duration:	
Urgency:	
Flexibility of scheduling:	

5.3 IMPACT ON PERFORMANCE

Mechanical aperture:	None
Impedance:	The impedance due to the randomised slots is expected to be reduced [4] as compared to the original design
Optics/MADX	None
Electron cloud (NEG coating, solenoid…)	Amorphous carbon coating
Insulation (enamelled flange, grounding…)	None
Vacuum performance:	None
Others:	

6. IMPACT ON OPERATIONAL SAFETY

6.1 ÉLÉMENT(S) IMPORTANT(S) DE SECURITÉ

Requirement	Yes	No	Comments
EIS-Access		x	
EIS-Beam		x	
EIS-Machine		x	

6.2 OTHER OPERATIONAL SAFETY ASPECTS

Have new hazards been created or changed?	No
Could the change affect existing risk control measures?	All risk can be mitigated by standard and proven procedures already in place in BE-BI. Compliance with electrical norms is ensured.
What risk controls have to be put in place?	No extra measures to be taken. Radioactive waste created when dismantling will be disposed of using standard CERN protocols.
Safety documentation to update after the modification	-
Define the need for training or information after the change	

7. WORKSITE SAFETY

7.1 ORGANISATION

Requirement	Yes	No	Comments
IMPACT – VIC:	x		
Operational radiation protection (surveys, DIMR…):		x	
Radioactive storage of material:		x	
Radioactive waste:	x		Screws, gaskets
Non-radioactive waste:		x	
Fire risk/permit (IS41) (welding, grinding…):		x	

Requirement	Yes	No	Comments
Alarms deactivation/activation (IS37):		x	
Others:			

7.2 REGULATORY TESTS

Requirement	Yes	No	Responsible Group	Comments
Pressure/leak tests:	x		TE-VSC	
Electrical tests:				
Others:				

7.3 PARTICULAR RISKS

Requirement	Yes	No	Comments
Hazardous substances (chemicals, gas, asbestos…):		x	
Work at height:		x	
Confined space working:		x	
Noise:		x	
Cryogenic risks:		x	
Industrial X-ray (*tirs radio*):		x	
Ionizing radiation risks (radioactive components):		x	[Traceability by TREC.]
Others:			

8. FOLLOW-UP OF ACTIONS BY THE TECHNICAL COORDINATION

Action	Done	Date	Comments
Carry out site activities:			
Carry out tests:			
Update layout drawings:			

Update equipment drawings:			
Update layout database:			
Update naming database:			
Update optics (MADX)			
Update procedures for maintenance and operations			
Update Safety File according to EDMS document 1177755:			
Others:			

9. REFERENCES

[1] ECR Installation of a Beam Gas Curtain (BGC) Demonstrator Instrument Stage 1, LHC-BGC-EC-0002, G. Schneider, EDMS 2025553

[2] ECR fluorescence measurement test chamber installation, LHC-BGC-EC-0001, G. Schneider, February 2018, EDMS 1869099

[3] Blackening Investigation for the BGC Interaction Chamber, J. Glutting, December 2018, EDMS 2052543

[4] Vacuum acceptance test for multilayer coating for BGC project, G. Bregliozzi, March 2019 EDMS 2134360

[5] Impedance Working Group #36; https://indico.cern.ch/event/860185/

[6] Meeting minutes of the BGC collaboration meeting 27th and 28th November 2018 at CERN, Wrap-up and Action list, Page 12, EDMS 2217335

ANNEX 1: Phase 1 installation (ST1150059)