



EDMS 2378515v1
raymond.veness@cern.ch

Notes from the BGC Collaboration Meeting of 31/3/20

Raymond VENESS, CERN, Geneva, Switzerland.

Abstract

These are my notes taken during the BGC Collaboration meeting held by VIDYO on the 31st March 2020.

Geneva, Switzerland
May 25, 2020



Contents

1	Introduction	2
1.1	Aims of the meeting	3
2	Notes for each presentation	3
2.1	Welcome to CERN (R.Jones)	3
2.2	Review of actions from last meeting and objectives of the workshop (R.Veness)	3
2.3	Cockroft collaboration (C.Welsch)	3
2.4	Experimental results in 2019 from Cockcroft (N.Kumar, A.Salehilashkajani, H.Zhang)	4
2.4.1	Amir	4
2.4.2	Narender	5
2.4.3	Hao	5
2.5	Experimental results in 2019 from LHC fluorescence measurements (S.Mazzoni)	6
2.6	Developments by GSI (S.Udrea)	6
2.7	BGC and HEL: status of tunnel and lab activities (E.Page)	6
2.8	HEL test stand update (S.Sadovich)	7
2.8.1	HEL beam for HL	7
2.8.2	E-lens test stand	7
2.9	LS2 BGC Installation Integration (Stage 1 and 2) (I.Papazoglou)	8
2.10	Optimisation for V3 (M.Ady)	8
2.11	Acceptance criteria for the final instrument discussion (R.Veness)	9
2.12	Planning (G.Schneider)	9
2.13	Alternative Gas Jet creation (R.Kersavan)	10
2.14	BGV Status (J.Storey)	10
2.15	Wrap-Up discussion	10

1 Introduction

A meeting of the BGC collaboration was held by videoconference on the 31st March 2020. This document summarises the notes taken during the meeting. The aim is principally to capture the discussions and questions. The agenda and presentations can be found on INDICO at the following URL.

<https://indico.cern.ch/event/879781/>

1.1 Aims of the meeting

- For the V2 instrument in Cockcroft: Summarise the measurements of 2019 and define the measurement priorities for 2020
- For the V3 instrument LHC tunnel installation: Give the status on the tunnel installation and V3 instrument design
- For the HEL test stand with V3 design: Define the objectives of the tests, what can be the expected performance, define work share on the HEL test stand with BGC V3 and planning
- HLLHC instrument: Identify design limits with integration constraints, optimise gas jet creation and choice of gas, expected performance, view of schedule and tasks
- Review status of the collaboration, publications, manpower and budget planning
- Fluorescence tests in LHC with distributed gas: Review results and expectations with run 3.
- Discuss alternative gas jet generation

2 Notes for each presentation

2.1 Welcome to CERN (R.Jones)

Rhodri welcomes to meeting and gives status of HL.

Project implementation delayed one year mainly at request of experiments.

2.2 Review of actions from last meeting and objectives of the workshop (R.Veness)

Ray reviews the progress since the last Collaboration meeting in June 2019. He presents a plan for the experimental and decision paths for the coming years. He also reviews the objectives for this meeting.

Comments from Peter: No more possibility for tests at Munchen

Peter asks about PhD for LHC data analysis; Stefano M. replies that yes there is a candidate in mind.

2.3 Cockroft collaboration (C.Welsch)

Carsten gives verbal report on the collaboration.

Not yet received the award letter. Should arrive soon. Should be back-dated to 1st April 2020.

Manpower and milestones. 3 people full-time at the moment and will continue for at least one year. New PhD at CI starting in 2021. Possible new PhD at CERN (as mentioned). Many interesting applications and research interests. More expected from phase 2.

Project has 1.5 MCHF budget envelope, including deliverables, manpower, travel etc.

Delays for the v3 production due to COVID-19 to be evaluated. Funding model from HL-UK1 was rather complex. HL-UK2 is more streamlined with schedule following STFC model.

Design effort is available for UK2 deliverables.

Lots of material available that has not yet been published. CI team were kept busy with experimental work. Should be a number of journal articles in 2020, including some high-impact. Had planned a poster for IPAC, but this is cancelled.

Collaboration worked well and looking good for the future.

2.4 Experimental results in 2019 from Cockcroft (N.Kumar, A.Salehilashkajani, H.Zhang)

2.4.1 AMIR

New model presented for the gas jet formation from the nozzle. Model curve is good, but absolute distances are not comparing well. Ray asks if he knows the parameters for the collisional model? Amir replies they are generally understood.

Measurements and simulations of pressure in the nozzle chamber. Variations tested. Little gain in photon number shown with increase in pumping speed.

Gas mixing tests (N₂ and He): Little increase at the optimum distance. Serban questions validity of keeping constant flow but varying the N₂ content. Amir replies that other measurements could be done.

Recently added a flow-rate meter in front of the nozzle. 0.01-0.03 bar.l.min⁻¹ at 1x10⁻³ bar inlet pressure. Use this to calculate effective pumping speed. Can then use this to calculate the required pumping speeds.

Present the results of tests with CI nozzles. 20,30,50 um. Flat-divergent nozzle from CERN gives optimum with 0.5 bar and 7mm nozzle-S1 distance, but 3x lower densities than the 30 um nozzle (at 5 bar).

Laser interferometry. Fringe patterns observed. Reflections from non-coated surfaces are causing issues. Data analysis shown using Fourier transform methods.

Tests with replacing the 2nd skimmer with the moveable gauge gives 1.6e17 density for Ne. Extrapolate to LHC conditions. Some differences.

2.4.2 NARENDER

Gas jet size experiments. Remove second skimmer and see maximum jet size achievable. Interpolate to new design distances.

Can we reach 40mm at new nominal beam position? We can reach 50 to 59mm with a larger second skimmer. 2nd skimmer of 1.25 mm would give 45mm jet size.

Peter asks about the thickness of the jet. Reply that with these tests they are considering only 2 skimmers so gives a round jet.

Peter asks about relative maximum values of the densities on slide 30. Narendar can make a plot that shows the actual values for each value, not normalised to a maximum.

Peter, slide 24. Can we use the interferometry at lower (10-6mbar) pressures - ie a factor of 100 lower. Narinder: Not yet tried, but will be done.

Serban, slide 14. Would you expect the optimum distance to change.

Adriana. Nozzle optimised for N₂ or Ne? Reply that both have been done

Adriana. slide 30. Can we increase density with different size skimmers?

2.4.3 HAO

Estimates are based on Serban's model of image collection to give the times for images for the LHC and HEL test stand. "Signal to noise ratio". 0.1 to 0.2 in the CI experiments (see later discussion). Estimation of the error on the signal depending on number of photons collected. 200 photons enough to give 0.1mm precision for centroid and 800 to give a beam size. Simulations of how noise affects measurement. Binning works for small photon numbers but not large. Increasing the photon number increase the resolution upto a limit.

Following a question, Hao confirms that the Signal/Noise numbers given did not consider a 'region of interest' but rather the whole image. Rhodri: Need to consider a region of interest to calculate S/N. This would give a value of 2.2 S/N rather than 0.1. Compare a region of interest with the equivalent region outside the signal area.

Serban: Slide 38. Does this 14'000 photons include dark count? Could be improved by cooling the intensifier? How large is the dark count?

CERN CD nozzle - where are we? This should be delivered for test - see later talk.

v3 design. Manufacture of chambers are in progress. Components are on the way. Gerhard confirms pumps are being ordered. Pumps and pumping speeds need to be discussed with CI and VSC.

2.5 Experimental results in 2019 from LHC fluorescence measurements (S.Mazzoni)

Stefano reports on the tests made in the LHC with background gas and plans for tests in Run 3.

Measurement of beam size as a function of time (through the cycle). Compares with the BSRT signal at flat-top. Also good agreement between the light signal intensity and the beam intensity from the BCTDC.

Run 3 measurements. Do we install the CI optical instrument on this?

Peter: Are there new findings for protons? Stefano: Not really, insufficient S/N. Could perhaps gain factor of 1000 with noise? Rhodri says we may need more. Ray says we need to go through these numbers as he feels there is more gained with v3 design.

Stefano will look at S/N for the LHC tests made to-date. Rhodri: Can compare losses between ions and protons to estimate noise.

Rhodri: Fibres requested for the Run 3 tests? Stefano: Yes, was requested at same time as cables.

2.6 Developments by GSI (S.Udrea)

Serban talks about the inherent limitations with optics for a larger e-beam and the optimum gas jet thickness.

Increasing the field of view decreases the depth of field, so perhaps less is in focus. The viewport also limits the solid angle and the size of the object. Gerhard comments that this is critical for the machine impedance. Serban has uploaded an excel sheet with parametrised calculations sheet for the integration times.

Influence of the curtain thickness. It would be good to stay below 2 sigma of beam size to have the best direct image. This would be 0.6mm for the LHC proton beam. A thicker sheet gives more protons, but not exactly in the right location. Normalised analysis shows diminishing returns. Thickness should be less than 5 sigma otherwise no gain in signal.

Made an estimate of the profiles with 5 sigma thick curtain. Signals are good, but profiles are spread-out (compared with a step-function curtain).

Rhodri: Gas jet thickness? Should be 1-2 sigma? Thinner gives better precision, but thicker is more signal. There is a gain of 2.5x signal going from Sigma = 1 to 5. Ray asks about depth of field from a thicker curtain. Serban replies that the issue of depth of field is less important than the 45 degree slant for the optics.

Hao - if we want to image 40mm beam, need to re-design the optical system. Easy to re-design the 3rd skimmer to adjust as necessary.

2.7 BGC and HEL: status of tunnel and lab activities (E.Page)

Eric talks about the work in progress in the VSC group.

2 new sectors made in the LHC (division of one old sector). Differential layouts shown. Status of work given. The sector valves are now installed.

Outgassing of v3 chamber is 2×10^{-8} mbar.l.s⁻¹ with no specific or high mass peaks.

Vantablack tests. 7.8×10^{-7} mbar.l.s⁻¹ outgassing before bakeout. Looks OK so far.

YAG screen acceptance (for HEL test stand). 1.4×10^{-9} mbar.l.s⁻¹, after 48h pumping.

Adriana - some parts still to test? Chiara - yes.

2.8 HEL test stand update (S.Sadovich)

2.8.1 HEL BEAM FOR HL

Injection mode and flat-top modes of operation. Injection mainly used for set-up and MD. 36mm OD for beam at injection and 9mm at top.

Possible shift of proton beam by 2mm (closed orbit variations) and alignment by 2mm, so 40mm region of interest in worst case (for injection).

Possible stochastic mode with variable currents. Average is 3A in this mode.

2.8.2 E-LENS TEST STAND

2 stages, stage 1 for e-gun tests and stage 2 for instrumentation (BPM, BGC). Added sector valve to speed-up interventions.

Test stand beam size is >16mm. 10 keV. 5A peak, with 5mA average. Cooling the collector could help increase this average current.

Working gun arrived from Fermilab. Will check to reduce light by using orifices. Other solenoids will arrive in 7 months.

Peter - supports need for extensive tests of BGC on the HEL test stand. Concerns about space charge, trapped ions etc. that need to be investigated.

Adriana - Is there an additional optical system that can be used in the HEL test stand? Ray answers that we need to make a plan for all available optical systems. Hao - there will be 2 further optical systems for the final instruments and plans to buy another with an improved intensifier.

Rhodri - the expensive part is the camera system. Not logical to buy final systems now. Will find a solution for the test stand.

Stefano Redaelli - Do we have other guns that we can use to make tests earlier? Sergey says they have the Fermi gun. Adriana says no delay as such for the ARIES gun. Perhaps some delay to ARIES arrival, but will then be urgently tested.

Stefano Mazzoni - LHC camera was borrowed from other instrument and used with another cathode with a more yellow filter, but not worked so well as it is noisier.

Peter - what about beam steering? How much affect on beam profile? Sergey replies that small steering is OK, but more deforms the hollow beam. This would be interesting to measure with the BGC. Ray says that the baseline specification is to provide a centroid for the p+ but a 2D profile for the e- beam. How do we define this profile? This needs to go in the specification.

Rhodri - Can we directly compare a YAG screen with a BGC image? Sergey, yes, this can be done.

2.9 LS2 BGC Installation Integration (Stage 1 and 2) (I.Papazoglou)

Ioannis reports on status of all parts and design for v3. Design is much more compact, allowing for a safe clearance to the LHC passage.

Shows design of the proposed alignment diagnostic system.

Eric page: is the high pressure gauge a pirani?. Yes. Eric reminds not to forget to include the connectors, cables and hoses in the integration as they take significant space.

Eric: How long between now and the final acceptance test? Gerhard replies will be shortly after CERN re-start.

Hao - timescale for the CERN nozzle? Ioannis - few weeks after re-start. Will make 5 or 6 pieces.

2.10 Optimisation for V3 (M.Ady)

Explains the vacuum layout and limitation on a larger field of view from the gas jet.

Use of 'Spaceclaim' app in ANSYS allows for simplified shape generation.

Currently skimmer 2 is too small for a 40mm aperture. Suggests to increase to 1.5mm diameter. Suggest to use a larger opening with the same shape. However, this increases the pressures, also in the LHC.

Marton has produced a Demonstrator tool that allows for re-design of vacuum system with on-line re-calculation of pressures.

Possible solutions: add a particle trap on the dump? Increase S/N by 2.5. This appears to be an easy win. Ioannis will add a holder to place mechanically in the v3 design.

Larger skimmer 2 will increase the pressure everywhere. Too high for LHC operations.

Perhaps use a rectangular skimmer 2 that would reduce gas volume? Can go back to the original skimmer volume, but non-circular. This would solve the problem. Could we apply this to the current design? Would gain order of magnitude pressure on the existing design! Can we make a 3mm x 100 um skimmer 2 and align it correctly?? This could also be an easy win.

Rhodri: This shows it will be difficult to get a 40mm high density jet. Do we really need to measure the full e- beam at injection? Carsten - larger skimmers also pose problems for the jet homogeneity across the whole beam. What more do we gain by seeing the whole e-beam? Ray says that we will only be looking at the small proton beam in the LHC for now, so we have some time to solve this problem.

Hao thinks that it will be possible to make such a rectangular 2nd skimmer. Also could imagine just to use a flat plate 2nd skimmer quite easily. Marton comments that at UHV (ie, from skimmer 2 onwards) they think that a plate does the same as the conical skimmer shapes currently used.

Marton asks for gas jet thickness. Rhodri comments that 5 sigma for LHC protons is 1.5mm. Serban says that there is no gain going above this. Hao said that CI currently use 0.5mm for the last skimmer, so we could increase. Peter said that the resolution could suffer.

Serban says that if we want to look for instabilities, then a thinner curtain is better, but should also also look to maximise the e-beam current on the test stand to facilitate measurements.

Rhodri -we can also gate the intensifier to only look at high current part of the HEL test stand e-beam. This should be technically feasible, even for the slow-gating camera.

2.11 Acceptance criteria for the final instrument discussion (R.Veness)

Ray explains we need rapidly finalise the acceptance criteria for the HL-UK2 collaboration. This should only be parameters that can be measured at the time of acceptance. He shows some proposed parameters with some questions.

How can we write '50% variation of the gas jet density across the aperture' more clearly? This is really a FWHM value.

How to define the profile for the hollow e-beam? Rhodri: Number of photons per unit area or other?

How long can we wait for an image? Rhodri says that we can wait longer than 1 second.

Stefano asks about the definition of a profile? Rhodri: We need to define only what we can measure.

2.12 Planning (G.Schneider)

Remaining things for phase 1 - blackening of vacuum chamber.

The hard deadline for installation was 25/4/20 (this will now move due to CERN closure).

HEL stand - all components ready to order by end April.

2.13 Alternative Gas Jet creation (R.Kersavan)

alternative gas jets based on micro-channel gas jets.

Shows and optimised design using one long collimation stage after the aperture. Considered a sticking factor of 50% to simulate pump in this area.

Large scale simulation is not correct due to mesh size.

3 orders of magnitude (10^{18} to 10^{15}) of signal to background. Assumed 0.5 sticking factor, cf 0.1 sticking factor for a turbo pump.

Inlet pressure was a large buffer volume of 10^{-2} mbar with multiple 50um nozzles.

No-one working on production of silicon arrays now at CERN. Adriana says they are working on this at GSI. Peter says diameter is smaller (10 nm).

Stefano M comments that a CERN-EPFL collaboration can make these things, they have a machine that we can use, but no manpower. Someone from CERN would need to go and learn how to do this.

2.14 BGV Status (J.Storey)

James presents the BGV experiment and the interest of using a gas jet instead of a buffer gas volume. Constraining beam gas interactions along the beam axis will be beneficial and could be a necessary condition to meet HL-LHC requirements. We need to discuss and implement experiments at CI to test-out the parameter space needed for the BGV, as this is also a priority instrument for HL-LHC.

2.15 Wrap-Up discussion

Ray reviewed the action list from the meeting. This is published in a separate document. It will be regularly reviewed in the bi-weekly video calls.

Should we push the delivery schedule (due to the extra year) to allow for more time for data to be collected from HEL test stand and LHC? We could push the ECR and FDR dates later assuming some extension at the end of the contract

Could we use N₂ on the HEL test stand? Adriana says this is possible, but will depend on time available in the experimental programme.