BGC Collaboration Meeting at GSI

Hotel Krone, Hirschberg, Germany

Date: ***2018-03-19/20***	***Project/Activity: WP13***

Attendees:

GSI:

Peter Forck (PF), Serban Udrea (SU), Jochen Wieser (JW).

The Cockcroft Institute:

Carsten Welsch (CW), Hao Zhang (HZ)

CERN:

Rhodri Jones (RJ), Ray Veness (RV), Gerhard Schneider (GS), Adriana Rossi (AR), Stefano Mazzoni (SM), Johanna Glutting (JG), Marton Ady (MA), Tom Dodington (TD)

Agenda:

The aims of the meeting are to:

- Review the objectives for the LHC fluorescence tests in 2018
- Agree on an experimental programme for the Cockcroft 1 test bench (v1)
- Agree on an experimental programme for the Cockcroft 2 test bench (v2)
- Prepare for an demonstrator instrument installation during LS2 at CERN (v3)
- Review the status and compatibility with the HEL of the LS3 BGC (v4)
- Define the strategy to agree on a gas type
- Evaluate realistic goals for the performance concerning precision and resolution

Full agenda and presentations on https://indico.cern.ch/event/712498/

Prepared by :	***Checked by :***	***Approved by :***
T. Dodington *G. Schneider* *R. Veness*		

1.

a. Introduction to the Workshop, P. Forck

PF introduced GSI and went through administration.

Johanna Glutting and Jochen Wieser introduced and welcomed.

GSI has special expertise in heavy ion production, Ion treatment of tumors were studied as from 1975. FAIR Project will be the next big project in GSI using low charged ions.

b. Review of actions from the last collaboration meeting, R. Veness

RV confirmed the next goal will be to develop LHC compatible BGC v3 using experience and knowledge from the BGC v2 instrument set-up at Cockcroft Institute.

He said that the main goals for the coming period are to evaluate realistic values for the performance in terms of precision and integration time and to decide on the baseline gas species. As these will require further experiment and/or simulation, we should agree the programme for these activities.

2. Cockcroft Collaboration, C. Welsch

CW proposes that results should be published in relevant journals. One relevant topic is the findings regarding fluorescence cross sections. A plan should be made including topics, who will write the paper. Open questions include: which journals to publish in and the time allocation for writing submissions. From Cockcroft the Hao and Amir will take responsibility, with Hao as main contact.

Rhodri states that in all publications the new development should be emphasised, so as to avoid repeating posters.

Hao is producing a draft for an IPAC poster for the collaboration.

Serban is planning to publish in IBIC.

CW confirms the electron gun will come at the end of March.

Project costing set at 90K GBP per monitor, components could be reused for a 3rd setup. 90K GBP has been spent on the second set-up.

3. Status of Hollow Electron Lens, A. Rossi

AR outlined the new parameters for the e-beam 5A/15kV, 5 T main solenoid, 60mm diameter vacuum chamber. The new design will allow for one BGC in the centre between 2 solenoids. 200mm allowed space for the instrument.

The size of the e-beam will be larger in the gap between the two solenoid magnets. The expansion should be predictable.

AR explains that in the presence of diocotron instability in the hollow e-beam, the uniformity of the electron tube will likely be compromised due to the electron motion. It would be good if the BGC could be used to detect this instability. PF asks how reliably the instabilities can be estimated. Discussion of the timescale of the instability, would it be noticable or detectable with the integration times the BGC will use?

Will the HEL need clearing electrodes? They were not used in the Tevatron or CERN's e-coolers, and the residual pressure in the LHC is very low. PF says the pressure is not important as it is an accumulated effect. It would be important to determine how quickly 'parasitic' electrons build up.

AR explains that the ON/OFF modulation (randomly on a turn-by-turn base) will be done during the proton beam abort gap. The modulation needed to the BPM to see the e-beam should be between 40 and 400MHz, modulating only few % of the e-beam current.

4. Limitations and Performance of the BGC, S. Udrea

SU gave an introduction to the principles of beam induced fluorescence (BIF). Overview of the advantages and disadvantages for the different gases – N2, N2 and Ar. The results presented are from a specific photocathode with a response which is not sensitive at high wavelengths.

It's important to differentiate between emission and excitation cross sections – only emission cross sections are relevant for BIF diagnostics.

N2 has one small transition, only excited by the e-beam. Ne has one line at 585nm, others below 1%. Ar has no data for protons.

RJ points out the gate intensifier could be installed so as to only see the proton beam, allowing to see both signals more equally.

SU shows calculations of photon detection rates, time required to observe a photon.

Neutral Ne is an ideal working gas' giving no distortion, but low signal.

Different thicknesses of the gas curtain discussed, a thickness of 2 sigma gives 20% distortion of signal. SU reccomends the curtain is less than 2 sigma, so ~0.8mm thick.

The code can be used to simulate non-axisymmetric situations, so simulation of the electron beam instabilities shown by Adriana would be possible.

Conclusion is that Ne is best, ideally a better camera should be found.

RJ asks about the angle of the gas jet and the camera. SU says to a first order, perhaps not significant.

AR asks about effect of synchotron radiation on the signal - will see in LHC fluorescence measurements.

5. BGC Experimental Programme, H. Zhang

HZ shows the work made in 2017 and 2018 up until March. Presents the integration times of the v1 BGC set-up. Shows an image from 7uA electron gun taken in late 2016. The 2nd electron gun (10keV and 80uA) has not been successful so far.

Single photon counting mode was used with 2s integratoin times. PF suggested combining 5 or 10 pixels to make each point, improving the overall signal. Currently about 9um for a pixel. It is suggested that the photon count should be cross calibrated with the pressure. For this, the jet pressure would need to be known accurately relative to the background pressure.

The moveable gauge is giving good results for the gas jet shape, but larger errors on the absolute density. HZ presents measurements with Ne on the v1 set-up. The e-beam was at 7 keV with ~80 uA current.

Jochen says that the gas could be in the form of clusters rather than a monatomic molecule. This could form clusters which changes significantly the signal from the gas jet.

A leak has been found on a weld of the new v2 set-up. HZ will investigate and fix this.

The new e-gun should arrive in March, earlier than expected! It is expected to gain a factor of 10 or more in integration time.

PF notes that there is still trouble with the absolute gas jet density, proposed that it could be considered to also use the first v1 set-up? This was agreed.

Diagnostics for the e-beam: Cockcroft have bought an insertable scintillator. It was queried whether this will withstand the required beam intensity. This will not measure the full beam current.

Electron beam current and size should be measured on the new set-up. Faraday cup and scintillator should be added.

6. LHC Fluorescence Measurement, S. Mazzoni

Stefano restates and agrees that it would be good to publish the results.

A primary goal is to measure the transverse profile of the LHC beam using the fluorescence monitor.

Current setup is using an MCP photomultiplier that was available at CERN. Fluorescence photons cross a limited number of surfaces to minimise absorption

SM presents a description of experimental procedure with the filters.

When to do photon counting test ? It is proposed to ask for an MD on 13/6, 23/7 and 12/9. RJ suggests to perform the measurement outside of MDs as the beam requirements are rather different from typical MD beams (eg a physics beam is needed). This will be discussed with OP.

The second installation will us optical camera. Camera should arrive end of March. Some components are already installed. GaAsP selected as photocathode. Expected to have 40% efficiency at 585nm.

Magnification of 0.15 is rather small. Perhaps we should try to aim for 0.3 or even 1.

RJ points out there will be a large effect because the chamber is not blackened. Synchotron radiation should be a single line, but will observe multiple reflections from the walls of the chamber.

JW asks if the the photocathode calibrated? SM responds it is not, but would appreciate advice on how to do this. Efficiency is also somehow variable across the photocathode.

PF comments on the range of the photographic lens acceptance. JW says that this will probably not work for N2.

PF asks whether we can we use N2? RV says we did not request this. AR suggests we do this at the end of the run.

7. Objectives for an LHC compatible BGC, G. Schneider

GS presents project framework and the performance objectives for the v3 LHC integration of a BGC.

With respect to gas injection, how long will we use the HEL for in a given year? Is there an operational scenario?

There is no time pressure to decide on the optics, priority is the the interface.

The various coating options should be considered, optics and vacuum impact.

8. Gas curtain generation, Gas expansion, P. Smakulski

PS shows that the formation of a stable jet gas flow is less than a micro second.

The de Laval nozzle has factor of around 2 times higher density profile than a simple nozzle geometry.

Neon will not reach the liquefaction temperature under considered initial pressure range, which protects against clustering formation in low pressure side.

Presents modelling of the modified de Laval nozzle geometry- those made at CERN metrology/ machine workshop. These can give almost factor 10 higher in density and velocity.

Equations of state: Ideal gas - should not be interactions between molecules.

CW states that the velocities should be much higher than sonic and the temperatures should be below 20 K.

To find the optimum solution for the BGC, should be set up some requirements of minimum velocity and minimum density before the first skimmer.

9. Gas curtain generation, density and pumping optimisation, M. Ady

MA provided an update on the simulations done on the low pressure side (after 1st skimmer). This is simulating different input conditions to PS.

Different have been simulated models to optimise the signal/noise.

Increasing the pumping speed is beneficial – it has been shown to scale linearly.

The angle of the exhaust pump is important - sticking factor of 0.3 for normal incidence.

Putting a 'jet-catcher' barrier after the interaction chamber can allow up to a factor of 7 improvement. MA will further investigate this and report back in an upcoming meeting.

Tilting the pump is beneficial both with and without the 'jet-catcher'.

Discussion about putting the pump a reasonable distance from the interaction to minimise the interference with HEL.

10. Optical Beam Diagnostics, J. Wieser

Experience using neon-hydrogen mixtures excited by electron beams.

Using ceramic entrance foils, etched from a silicon wafer foil.

Demonstrating optical beam profile determination.

Presented spectral results for 300 mbar of Ne, N, Ar, Kr, Xe.

Ne 585 line seems to give linear results at all high pressures down to 0.1 mbar - so probably lower as well.

Beam time next week at Munich Tandem accelerator with proton beam - will take more data and will distribute and share with the project.

PF asks for lower pressure data. However, low pressures mean long integration times so this becomes impractical. Also limited in the background of the other gases.

11. Optical System, S. Udrea

The quantum efficiency of the proposed photocathode is less than 20%, perhaps down to 7%. The size of the filter wheel will be reduced final BGC versions. The depth of field of 4.5mm is a bit too low.

SU presents images taken from experiments with N2 and Ne.

Estimates from SU's first talk - quite a good comparison considering the number of assumptions. In addition, large variations on the pressure between the two gases.

Adjustment target has been produced and installed. The LED is still not ready due to missing manpower.

Blackening - INOX-COLOR on stainless steel. Transparent Chromium oxide coating, still transparent. Samples have been sent to Tom. Bakeable to 200 C. Adriana says that oxides sometimes have a high secondary emission. The reflectivity has not been formally measured, so currently there is no data on this. Peter asks where we can measure a reflectivity. Stefano says that this exists at CERN in the glass/optical fibre lab in EP (Thomas Schneider).

With respect to the radiation resistance, SM says that radiation is not too high in IR4 and that lenses are generally OK. It may be neccesary to power cycle cameras following Single Event upsets.

It may be better to use a different geometry for an improved depth of field. One solution could be to use a better adapted lens without chromatic correction. For electron multiplication an eCCD camera system could be used.

Queries included importance of magnetic shielding for the camera, what is the magnetic field mapping?

12. Nozzle, Skimmer and v3 design update, T. Dodington

Progress of nozzle manufacture, mechanical drilling achieved near perfect 30um hole.

Considerations of convergent-divergent manufacture nozzle and procurement.

Try not to use a mirror underneath

Summary of spacial limitations for the BGCv3 LHC integration. Significant reductions in lenth necessary, both gas generation and gas capture sides.

RJ says we should try to avoid the camera / window flange pointing downwards to avoid falling debris.

JW suggests investigating increased background due to LHC operation.

PF suggests it would be interesting to try to make profile in horizontal or vertical, not at an angle, avoiding conversion calculations. This could potentially be done using a 'gas mirror' on gas collection side.

13. Discussion and Wrap-Up

RV returned to the main questions for the meeting, ie, selection of working gas and realistic values for resolution and integration time.

For the selection of a working gas, it was clear that there are a number of advantages in terms of precision of using neon, with the Ne 585 spectral line. However, the cross-section for both protons and electrons is much lower than for N2, so signal integration time is an issue.

The excitation time of Argon remains unknown. The 750 nm line is in the IR so noise would be a problem.

N_2 has a relatively long decay time so drift is important and should be accounted for. The spectral line also corresponds to an ionized state, so sensitive to fields.

Regarding integration time, very conservative photon collection values from Serban were 2/sec for protons and 300/s for electrons. There was a discussion as to whether these values are acceptable. The conclusion was that they are realistic for an instrument. We therefore move towards taking Neon as a baseline working gas, considering that are that the area of proton beam is smaller and generally very stable with time in the LHC. It is considered more important to image the electron beam. The numbers presented by SU are for a given gas density - 0.5mm thick curtain with about 10^6 mbar in the jet.

The optics calculations for the light emitted or detected were quite conservative. Possible factors of improvement in the photon collection rate included the integration of the wavelength (factor of 2), the efficiency of the photomultiplier (factor of 10), the optics aperture/ acceptance (factor of 2) and the filter transmission, estimated at 30% (SM suggested factor of 3 possible). These will be quantified by SU. Is the proton beam doing something to a charged decay time?

JW pointed out that with respect to cluster jets, the light emitted will be significantly less if the gas is as droplets rather than atoms (as would be the case in a cluster jet target). We should be sure this is not the case. This would probably only be an issue for argon and nitrogen as the condensation temperature for neon is low.

It would be beneficial to organise future travel arrangements. Serban and Hao could come to CERN for the MD test. Serban, Tom and/or Johanna could be useful at Cockcroft for commissioning.

It is important that Cockcroft calibrate the absolute gas jet signals using background measurements. They should also prioritise taking more measurements with Serban. It should be agreed whether Serban will go back to Cockcroft when the new e-gun arrives.

ACTIONS

Publications - Organise and prepare for peer-review journals.	General	
Look at optimistic proton count rate and limiting factors.	Serban	
Investigate adding up several pixels to produce a significantly smoother image.	Hao	
Would the BGC be able to measure the HEL diocotron instabilities?	TBC	
Experiments		
Check extrapolations of the cross-sections with the new e-gun	Cockcroft	
Which nozzle will be used, how to align on the available equipment?	Hao, Cockcroft	
Redo the tests to calibrate the gas jet vs the residual gas pressure	Hao, Cockcroft	
Confirm the Faraday Cup will be used as a dump for the e-gun on v2 set-up	Hao, Cockcroft	
Investigate adding a 4th exhaust skimmer / barrier for the v2 set-up	Cockcroft	
Make a detailed comparison between Ne, N2 and Ar. Ensure measurement of the e-gun with a Faraday Cup to verify intensity.	Serban & Cockcroft	
Restart tests on different blackening coatings, vacuum and reflectivity.	Gerhard	
Measure the surface finish of the CERN nozzle	Tom	
Investigate moving the exhaust pump further away. If successful, could this be done experimentally on the v2 set-up?	Marton	
Measure the reflectivity of all surface coatings that are UHV compatible	Serban / CERN	
Consider using Argon with 476nm line in the LHC	Stefano	
Simulations		
Should we consider using gas jet clusters?	Hao	
Provide Przemek with publications on analysis of the gas nozzle.	Carsten, CI	
Investigate the difference between a perfect gas model with no interaction between molecules and a viscous model from a FE simulation.	Przemek	26.04.18 / end 05.18
Further investigate exhaust skimmer / barrier on gas exit side.	Marton	
Look at tilting the exhaust pump, feasibility of gas mirror for end pumping at an angle.	Marton	
Use the code from GSI for IPMs to see the effect on beams.	Amir? CI	
Further optimisation of the skimmers and the nozzle set-up		
Accumulation of electrons from the gas jet. Adding low energy electrons.	Russian team?	
Investigate the accumulation of electrons and ions in the interaction chamber from the e-lens.	Adriana	

Design		
Search for most suitable intensifier/camera with about 20% efficiency for Ne	Serban	
Which decisions must be taken by October 2018. Make a timeline.	Gerhard	
Investigate rotation of v3 design to avoid optical system at the bottom.	Tom	
Interfaces		
Investigate the magnetic fields from the SC magnet at the position of camera	Adriana	
200mm allocated for BGC between cryostats. Optimise this with Anttii, including bellows and fixed points.	Adriana	
Write down operational scenarios for feedback into vacuum design.	Gerhard	
Define the parameters of the e-lens test stand, which the BGC should test.	General	
Send Serban a radiation map for the region of the e-lens	Adriana	