Beam gas curtain experimental programme

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for the
BGC Collaboration team

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Outline

- **Motivation**
  - Potential diagnostics for e-lens project and HLLHC.
  - Principle of the supersonic gas jet beam profile monitor in beam induced fluorescence (BIF) mode.

- **Building a prototype**
  - Current status
  - Vacuum condition test
  - $N_2$ and neon gas jet test
  - Optimization of gas jet generation

- **Future plan**
Principle of detection

BIF detection using residual gas

Particle Beam propagate to the jet curtain perpendicularly

BIF detection using supersonic gas jet

Gas jet curtain 45 degree tilted


Atomic collisions $N_2^+ \leftrightarrow$ Beam Ions. Exciting vibrational levels, 391 nm, 427 nm, ...


V-stack MCP
$HV \rightarrow$ gain $\sim 10^6$
Single photon detection!
## N₂ V.S. Ne as working gas

<table>
<thead>
<tr>
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<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>N₂</td>
<td>• Higher photon rate, shorter integration time.</td>
<td>• Ion emitter with 60ns lifetime, potential distortion due to space charge and external EM field on the N₂⁺</td>
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<td>N₂⁺ emitter</td>
<td>• lower dark counts rate for the photocathode</td>
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<td>391.4 nm</td>
<td>• Higher quantum efficiency of photocathode</td>
<td>• Vacuum concern</td>
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<td>Ne</td>
<td>• Fluorescence due to neutral Ne (yellow line), not affect by space charge of the primary beam and external EM field</td>
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<tr>
<td>Ne emitter</td>
<td>• LHC vacuum compatible</td>
<td>• Lower photon rate, longer integration time</td>
</tr>
<tr>
<td>585.4 nm</td>
<td>• Higher dark counts rate for the photocathode</td>
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Building a prototype in CI

Larger pumping speed for all the turbo pumps

Ø = 30 μm

Nozzle

Nozzle holder

Nozzle tube

3.0 meter
Vacuum condition test

- Ultimate pressure matches with simulation
- Pressure in the interaction chamber is \( \sim 1.0 \times 10^{-9} \) mbar without bake-out with jet on.
Nozzle and skimmers
Alignment of the nozzle skimmers assembly

1. Only nozzle is mounted → marker on nozzle position
2. 1st 2nd skimmer mounted
3. Adjust nozzle precisely, according to preparation
4. Mount 2nd skimmer and adjust it precisely, according to the preparation
Interaction chamber

- Compact chamber
- New optical system
- New Electron gun
- More diagnostics
Blackening of the interaction chamber
Electron gun

- Energy: 100 eV to 10 keV
- Current: 200uA to 10mA
- Spot size: 1.5mm to 20 mm
Electron beam diagnostics

Phosphor screen

Faraday Cup

20 mm

115 mm
Nitrogen gas jet test

- Electron energy: 5keV
- Beam current: 0.69mA
- Integration time: 2 s
- Gas jet type: N₂
- Inlet pressure: 5bar

2s integration time to give a profile

More time to give a 2D detailed image

200s integration time

Background pressure: 1.56E-08mbar
Preliminary results of Neon gas jet

Electron energy: 3 keV
Beam current: 0.50 mA
Integration time: 200 s for N₂, 4000 s for Neon
Inlet pressure: 5 bar

Image from the phosphor screen
Optimize the gas jet parameter

- Inlet pressure
- Geometry (Nozzle to skimmer1 distance)

![Graph showing photon number vs. inlet pressure for different nozzle to skimmer1 distances.](image-url)
Summary of highlight

- A prototype supersonic gas jet monitor based on BIF mode was designed, built and successfully commissioned;
- N2 and Neon have been successfully tested as working gas using laboratory electron beam source;
- Optimization of key parameters for gas jet generation has been completed.
Future work

- Continue to optimize the design and geometry
  - E.g. new De Laval nozzle
  - Skimmer geometry
- Argon used as a working gas
- Design and building of v3 gas jet system (LHC compatible)
  - Final deliverable for the HL-LHC-UK
Thanks for your attention

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