Beam-Gas Curtain (BGC) profile monitor: Progress with gas jet testing

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With thanks to:
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7th HL-LHC Collaboration meeting, 15th November 2017

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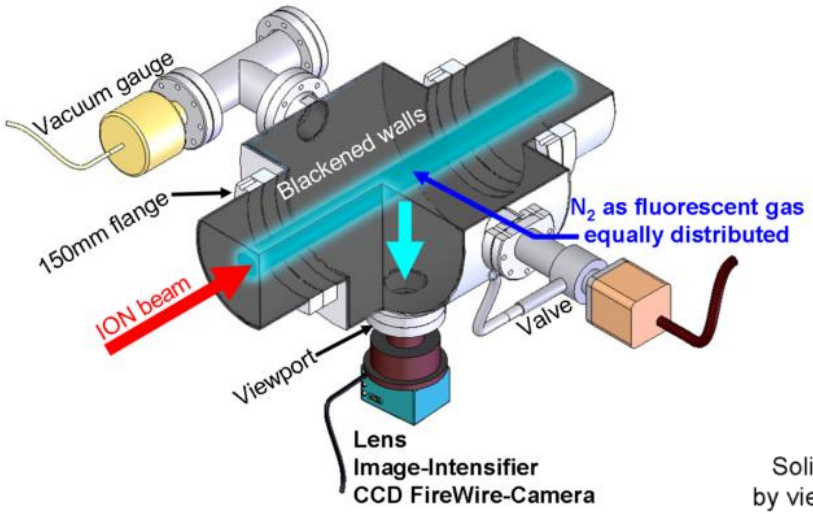
Outline

- Motivation
  - Potential diagnostics for e-lens project and HLLHC
  - Principle of beam induced fluorescence (BIF) detection with supersonic gas jet
- Progress with gas jet testing
  - Experimental setup
  - Supersonic gas jet generation and gas dynamic simulation
  - Characterization of the jet density
  - First measurement using BIF with gas jet
- Development of second gas jet prototype (version 2)
  - Improvement
  - Progress of the production

Principle of detection

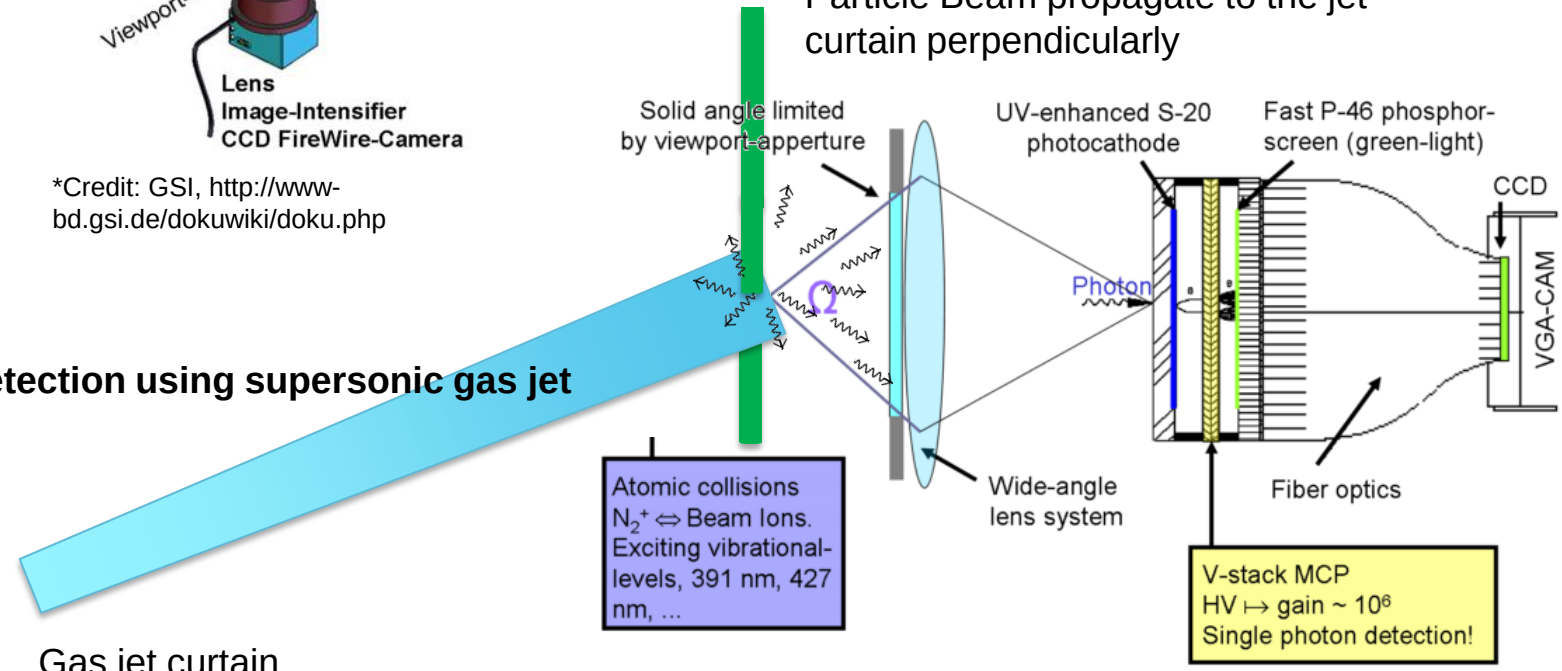


*Credit: GSI, http://www-bd.gsi.de/dokuwiki/doku.php

BIF detection using residual gas

Particle Beam propagate to the jet curtain perpendicularly

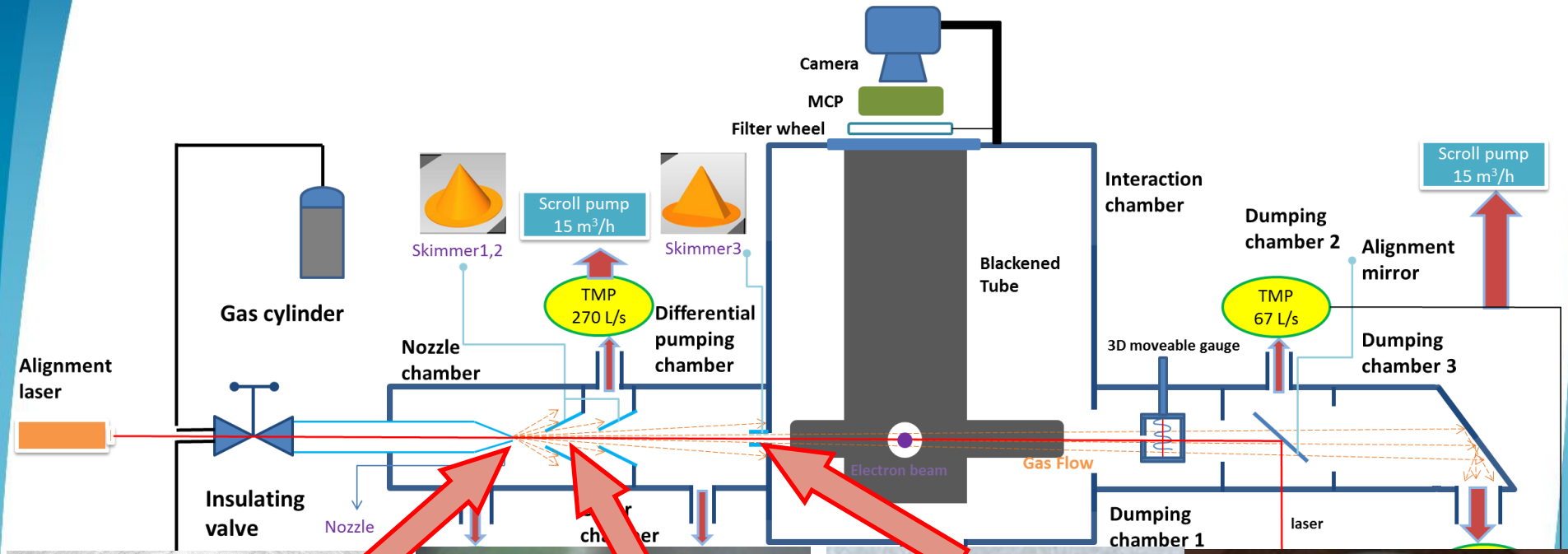
BIF detection using supersonic gas jet

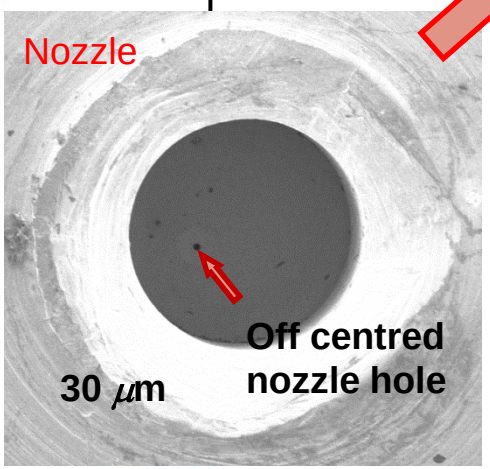


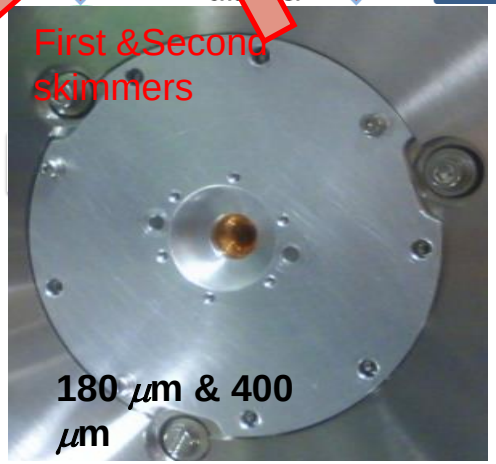
Gas jet curtain
45 degree tilted

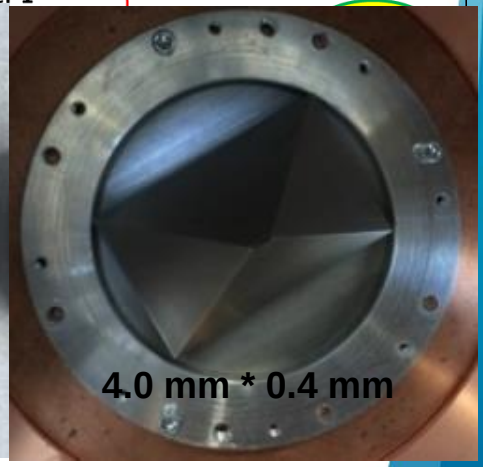
*Credit: GSI, http://www-bd.gsi.de/dokuwiki/doku.php

Modified monitor (version1) for beam induced fluorescence test

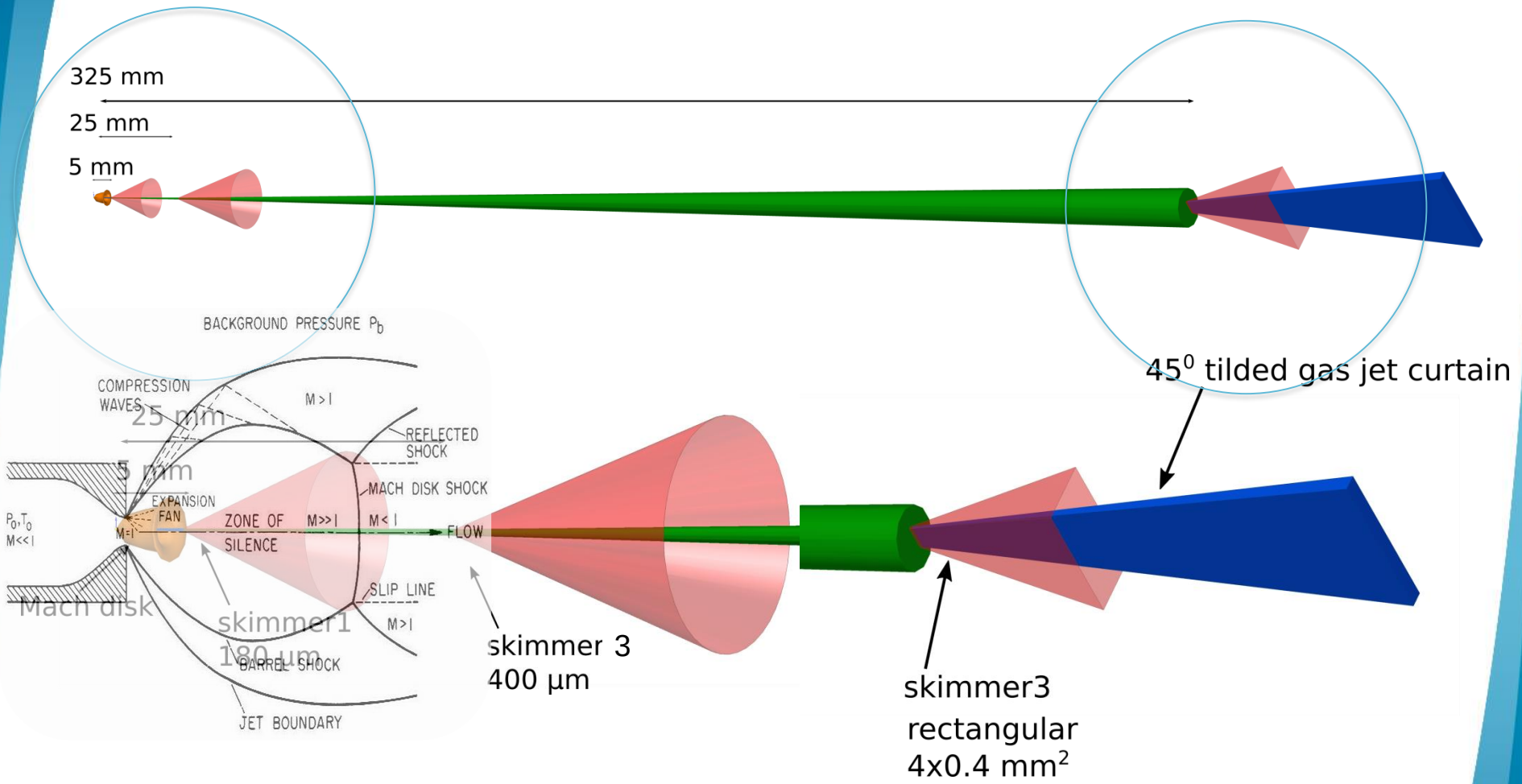






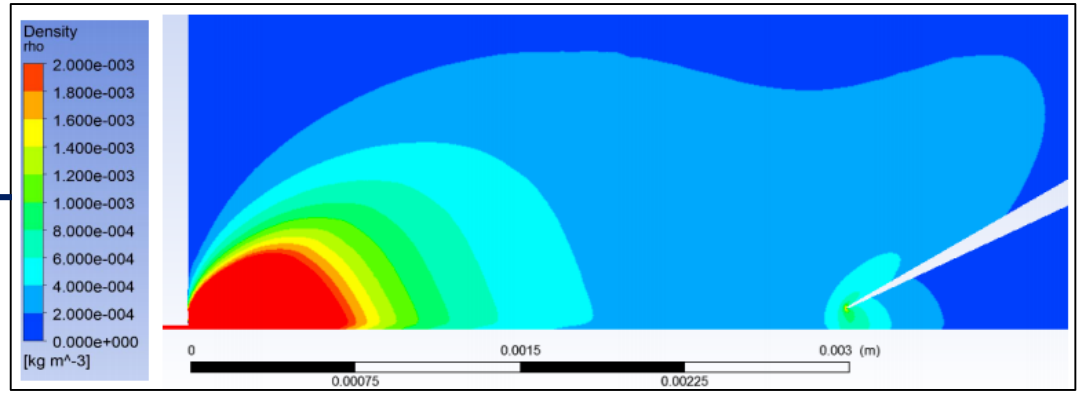


Generation of supersonic gas jet



Progress of the gas dynamics simulation

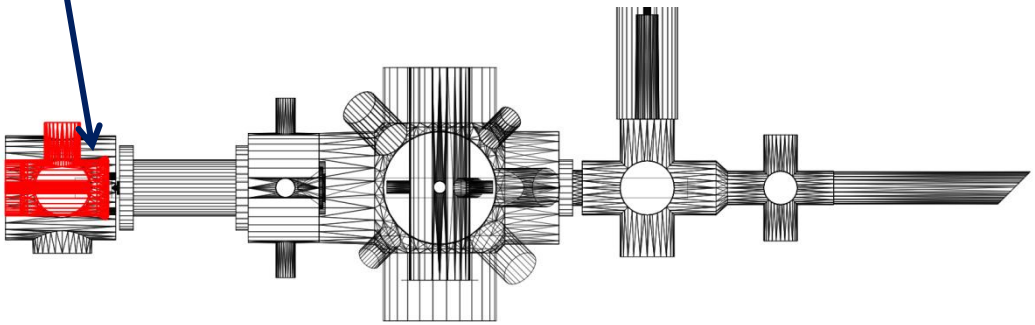
Viscous-flow regime before 1st skimmer (ANSYS CFX)

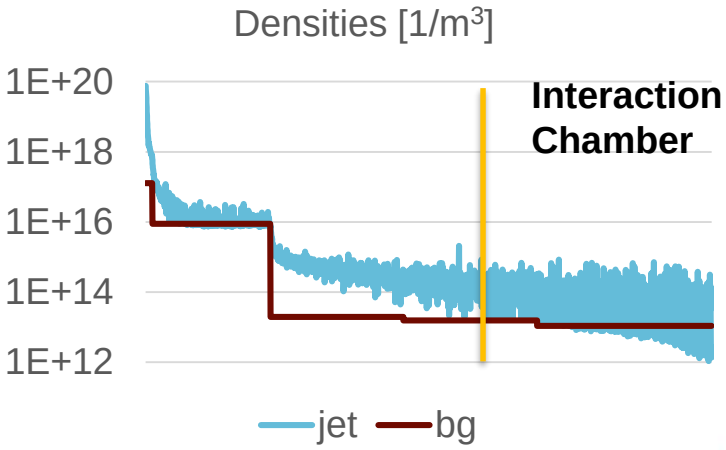


Credit: P. Magrgnin

The model is basic and have a converging issue when the chamber pressure is lower than 10^{-3} mbar, thus the divergence calculated from CFX is not accurate.

Molecular flow after 1st skimmer (Monte Carlo simulation)



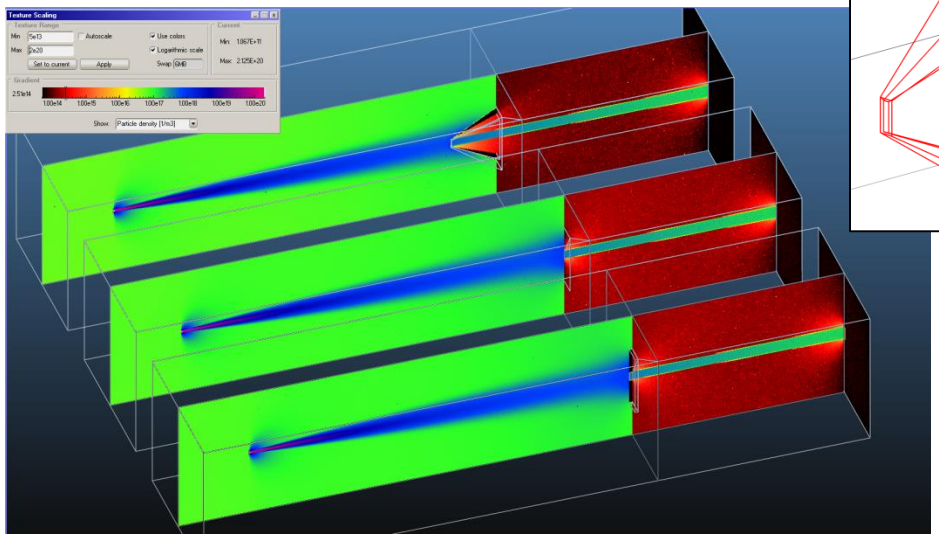


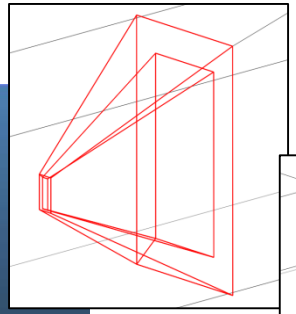
Molflow model：simulated from the 1st skimmer and input from the viscous-flow simulated in ANSYS CFX

Credit: M. Ady

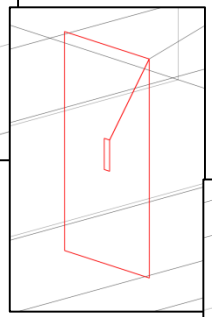
Study of skimmer shape and pumping efficiency

3rd skimmer shape VS density

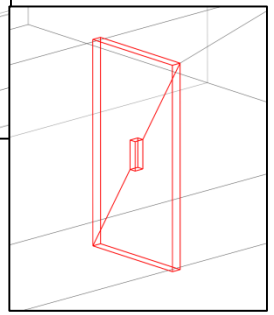




Original 'pyramid' skimmer
78x18mm

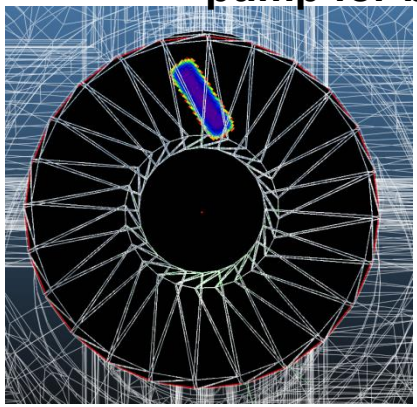


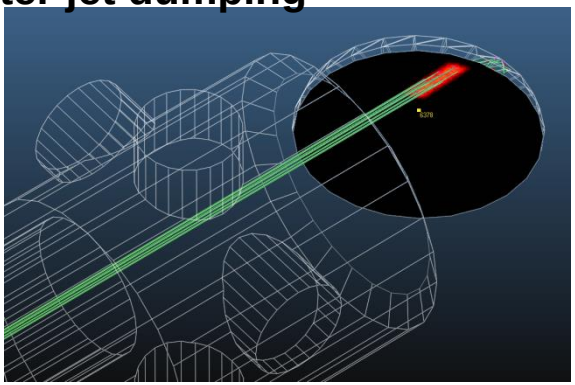
Thin plate with hole
(theoretical)

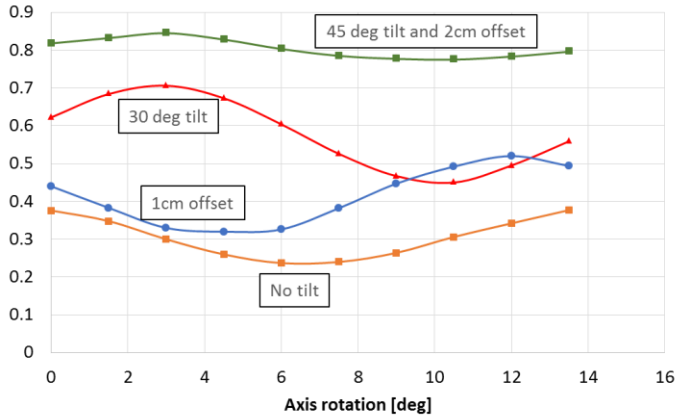


Thick plate with hole
(3mm thickness)

Offset the turbo pump and Tilt the turbo pump for better jet dumping







Credit: M. Ady

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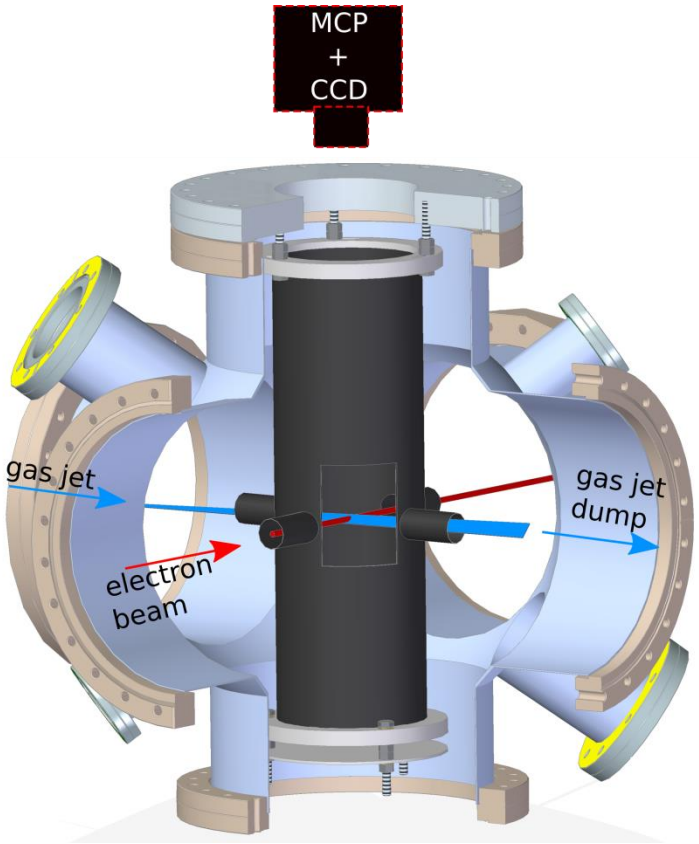
Details on the interaction chamber



$$N_\gamma = \sigma \cdot \frac{I \cdot \Delta t}{e} \cdot n \cdot d \cdot \frac{\Omega}{4\pi} \cdot T \cdot T_f \cdot \eta_{pc} \cdot \eta_{MCP}$$

σ (cross section, N_2, 391 nm)	$9.2*10^{-19}$ cm^2
I (electron current)	~10 uA
n (gas jet density)	(~10^{-6} mbar)
d (jet thickness)	2.8 mm
Ω (acceptance solid angle)	$4\pi \cdot 10^{-5}$ sr
T (Transmittance of optics)	0.65
T_f (Transmittance of band pass filter)	0.3
η_{pc} (MCP photocathode efficiency)	0.2
η_{MCP} (MCP detection efficiency)	0.5

N_γ [photon number] ~ 0.08*Δt [t]

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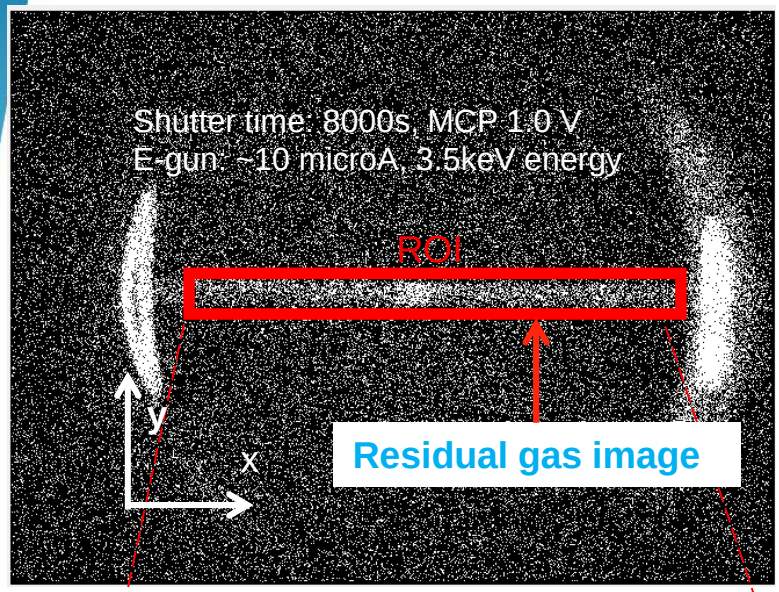
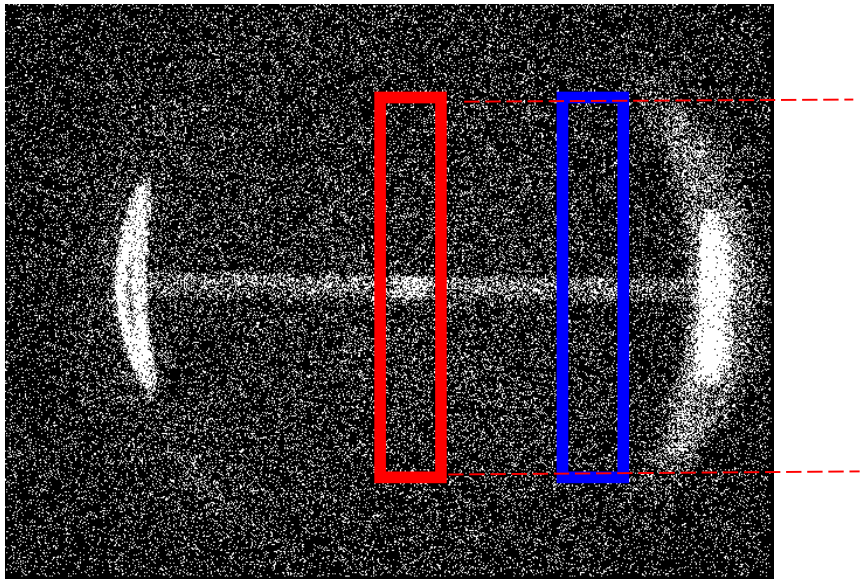
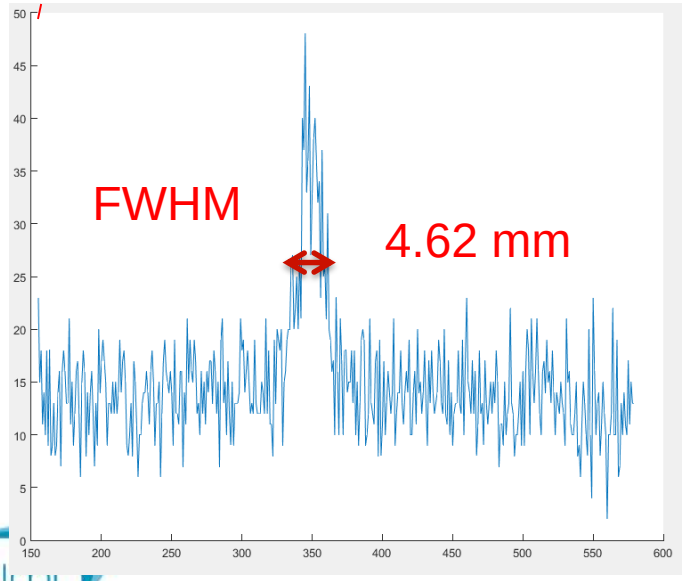
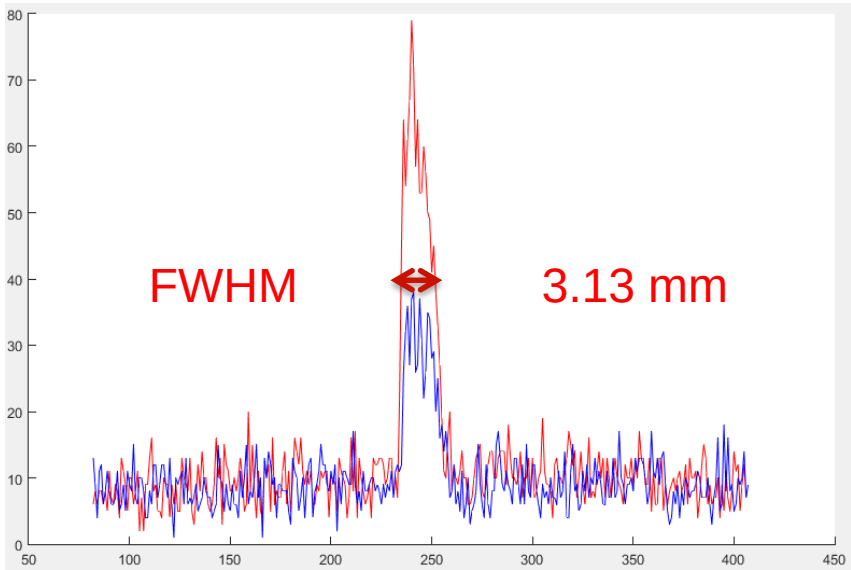
Gas jet image from fluorescence









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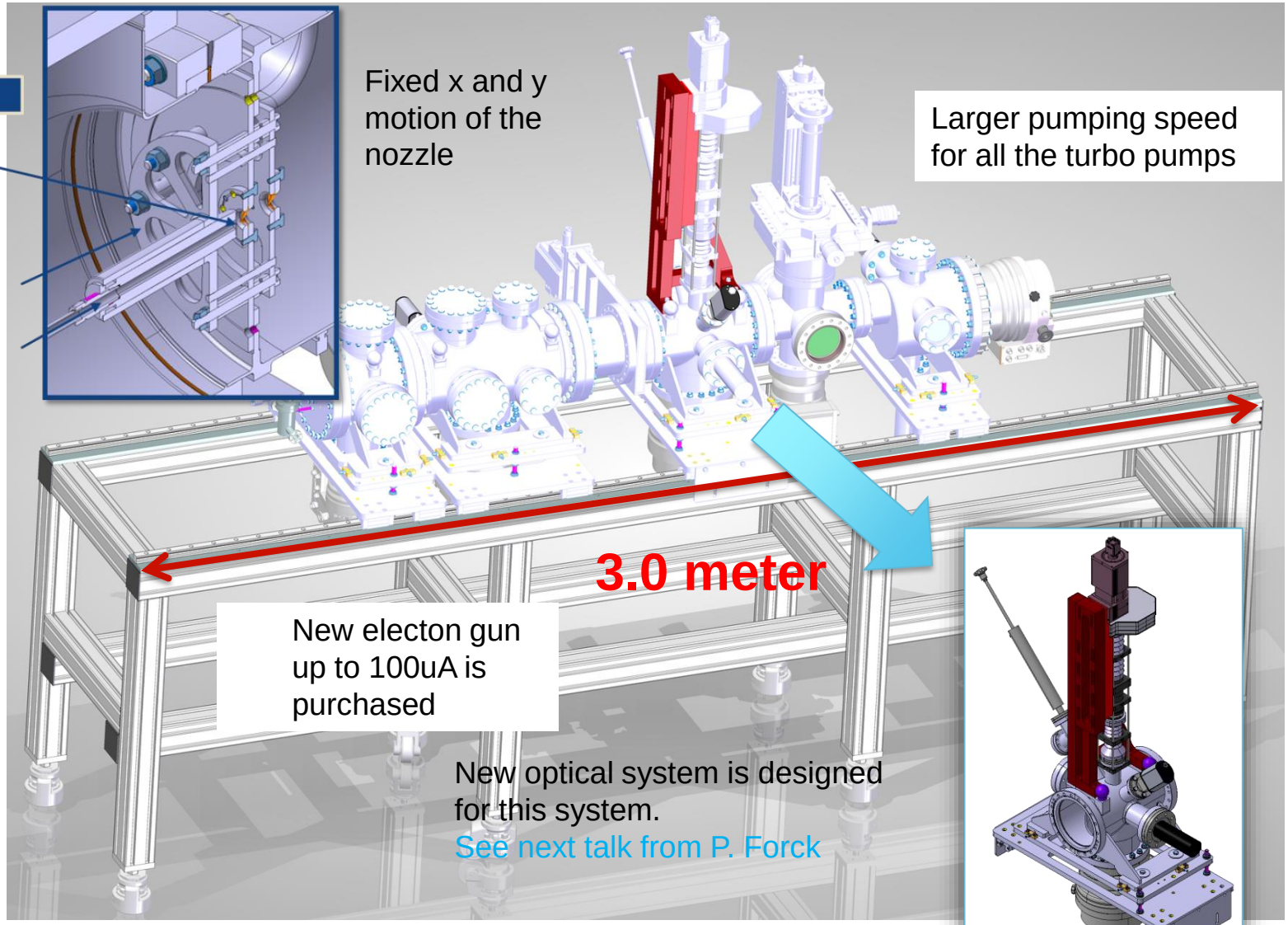
Progress of the new gas jet



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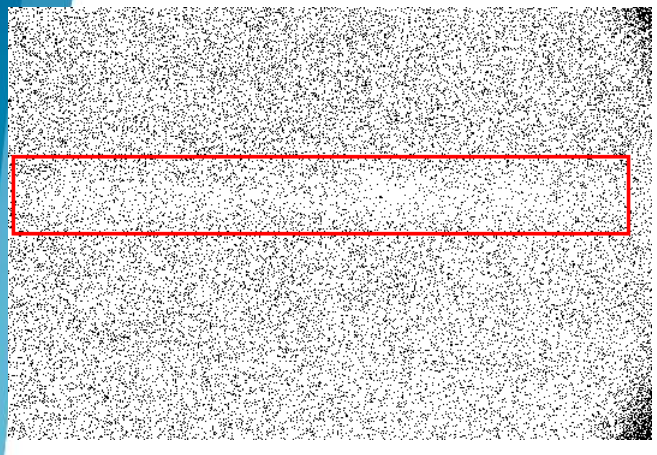
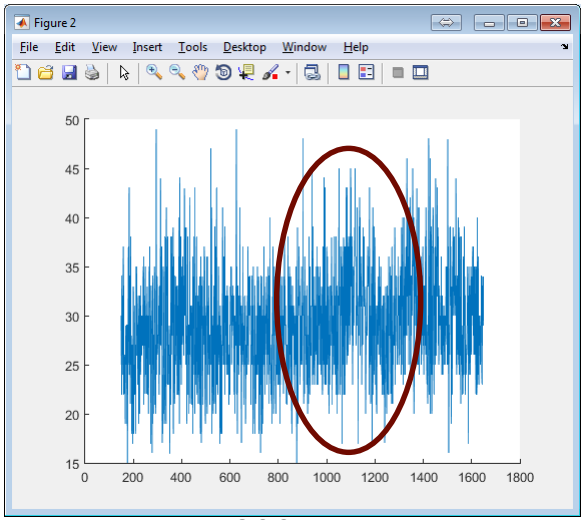
Open issues

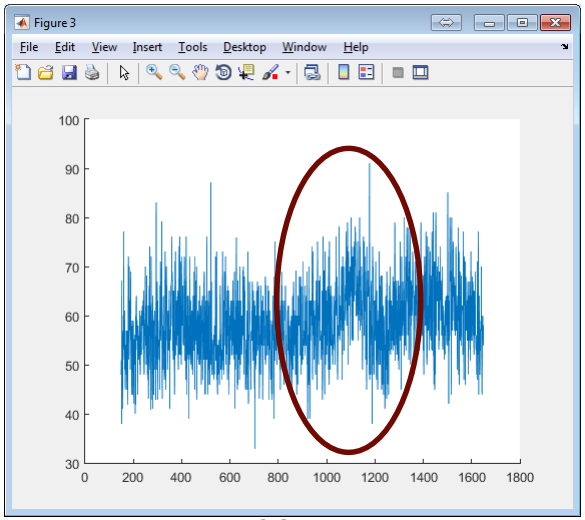
- The gas density
  - Better nozzle-skimmer alignment
  - Combinations of sizes, distances of nozzle and skimmer
  - Higher stagnation pressure
- The E-gun
  - Not reached the maximum current
  - Test with other higher current electron source
- Gas species
  - Nitrogen is tested currently
  - Candidates could be Neon, Argon.

Upgrade the electron gun and optical system

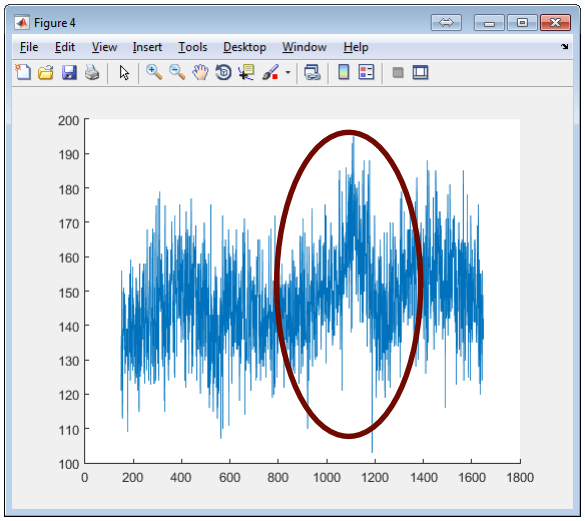




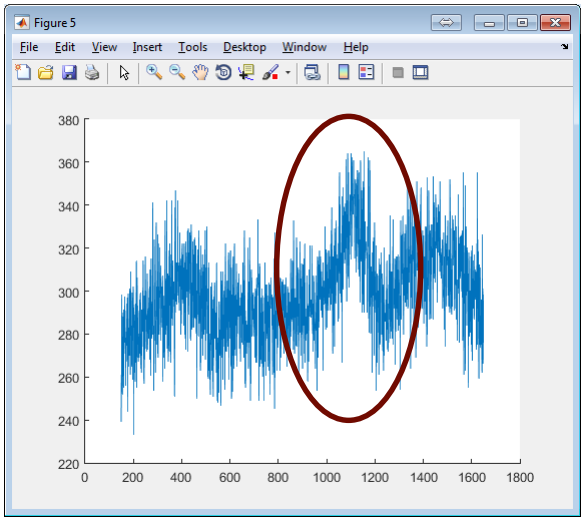
200 s



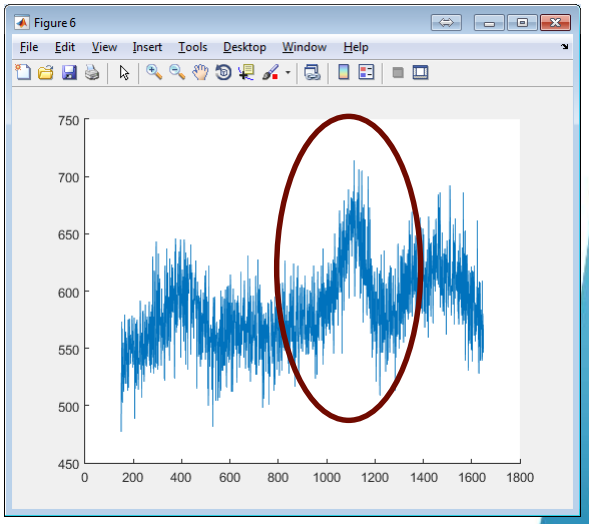
400 s



1000 s



2000 s



4000 s

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Summary

- A prototype beam profile monitor using supersonic gas jet have been built to detect the beam induced fluorescence.
  - The setup is modified from the previous beam jet ionization monitor.
  - Simulations have been set up for the gas jet generation
  - First measurement of a 2D beam image with gas jet using BIF mode.
- A second prototype monitor has been designed and in process of production
  - The new setup will be ready for testing earlier next year.

Thanks for your attention

Thanks to the BGC collaboration:

V.Tsoganis, C.Welsch(Cockcroft Institute)

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