A SUPERSONIC GAS JET-BASED BEAM PROFILE MONITOR USING FLUORESCENCE FOR HL-LHC

H. D. Zhang[1], M. Ady[2], A. S. Alexandrova[1], N. S. Chritin[2], E. B. Diaz[2], T. Marriott-Dodington[2], P. Forck[3], O. R. Jones[2], R. Kersevan[2], S. Mazzoni[2], A. Salehilashkajani[1], A. Rossi[2], G. Schneider[2], R. Schnuerer[1], S. Udrea[3], R. Veness[2], C. P. Welsch[1],

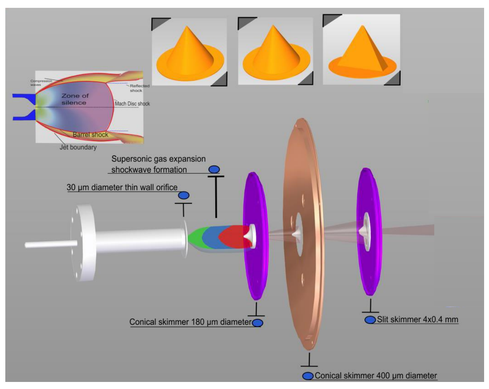
[1] Cockcroft Institute and The University of Liverpool, UK [2] CERN, Geneva Switzerland [3] GSI, Darmstadt, Germany

Abstract

The High-Luminosity Large Hadron Collider (HL-LHC) project aims to increase the machine luminosity by a factor of 10 as compared to the LHC's design value. To achieve this goal, a special type of electron lens is being developed. It uses a hollow electron beam which co-propagates with the hadron beam to act on any halo particles without perturbing the core of the beam. The overlapping of both beams should be carefully monitored. This contribution presents the design principle and detailed characteristics of a new supersonic gas jet-based beam profile monitor. In contrast to earlier monitors, it relies on fluorescence light emitted by the gas molecules in the jet following interaction with the primary hadron beams. A dedicated prototype has been designed and built at the Cockcroft Institute and is being commissioned. Details about monitor integration, achievable resolution and dynamic range will be given.

Principle

1. Supersonic gas jet shaped as 45 degree screen

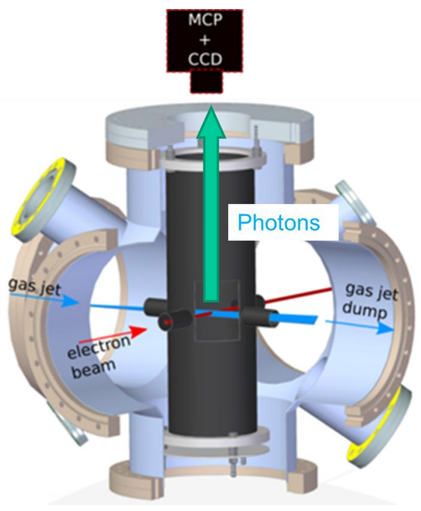


- Differential pumping
- Free expansion through 30 μm nozzle
- 2 stage of skimming with conical skimmer 180 μm and 400 μm
- Curtain shaping 8.2*1.8 mm^2 pyramid skimmer

2. Beam induced fluorescence

The fluorescence is a result of following process: (1) The electronic transition of the excited molecular ion has a certain characteristic wavelength; (2) The electronic transition of the neutral molecule results in photons with a certain characteristic wavelength.

Potential gases will be nitrogen, neon or argon.

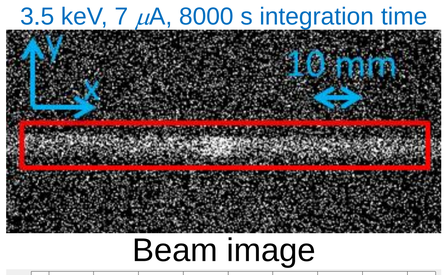


Update on the current monitor

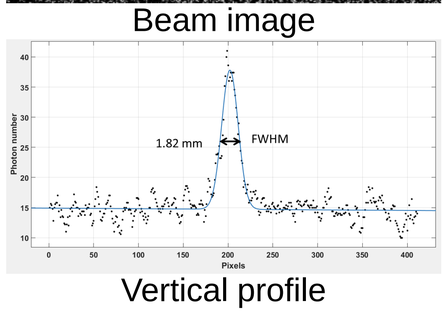
1. Single photon counting

- 2 s picture to show individual photons
- Set the threshold level and find the local maximum to identify the location of the photons
- Integrate many pictures to increase the signal to noise ratio

3.5 keV, 7 μA, 8000 s integration time

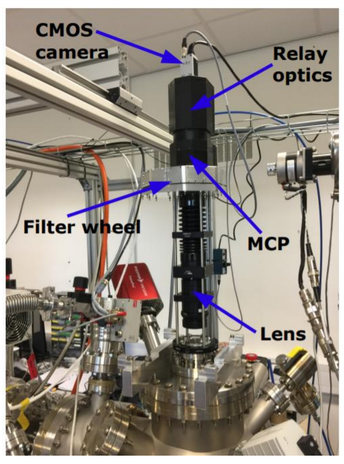


Beam image



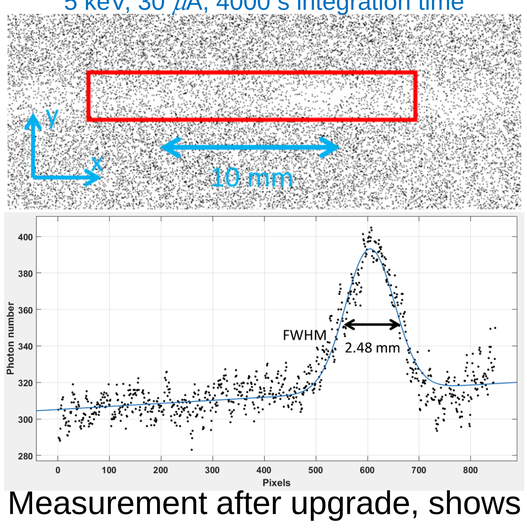
Vertical profile

2. New optics and gun upgrade



Updated imaging system

5 keV, 30 μA, 4000 s integration time



Measurement after upgrade, shows more photons are detected.

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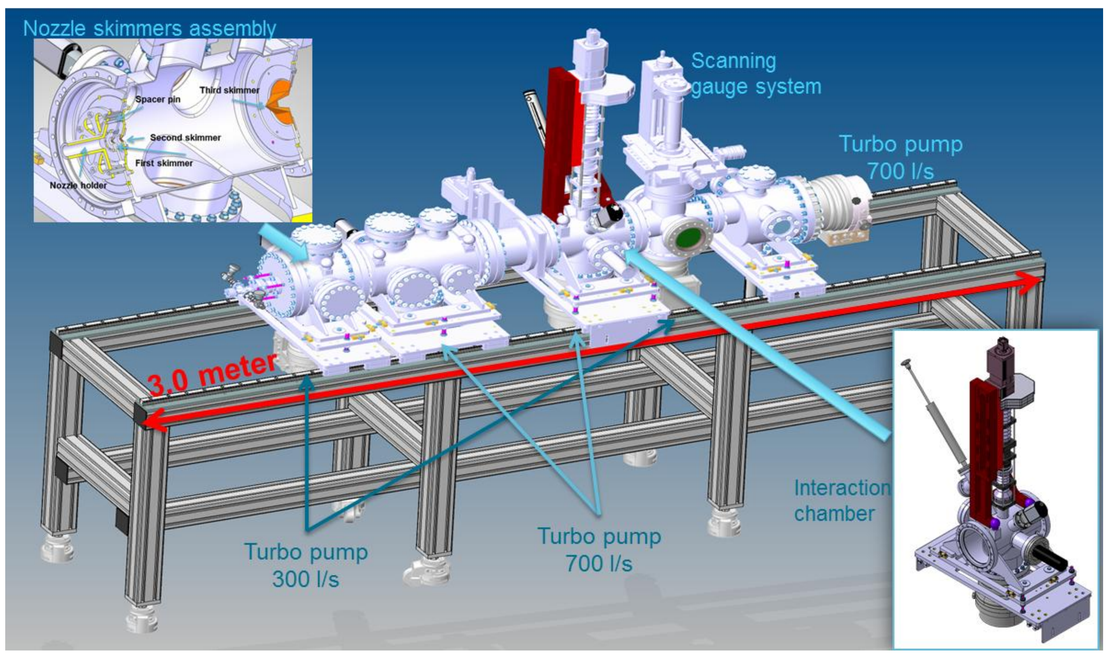
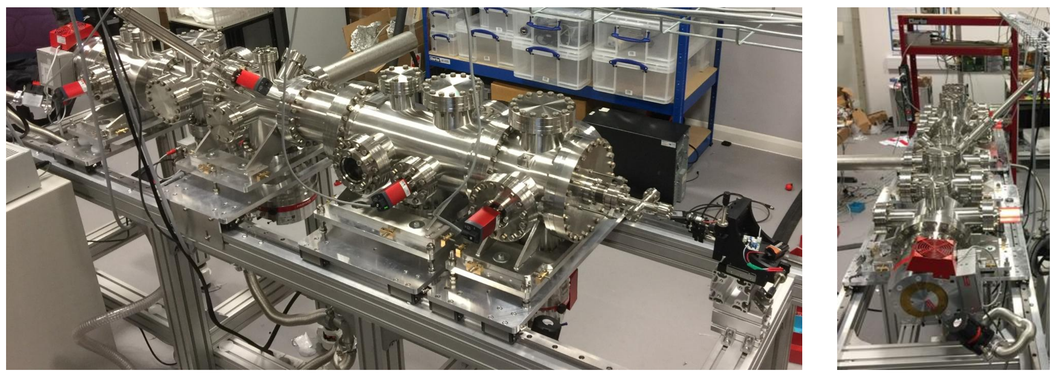
Prototype for HL-LHC



Schematic drawing of the dedicated prototype gas jet monitor using fluorescent mode.

Key Features:

- Mounted in a rail system for easy accessing.
- Increased pumping speed for LHC vacuum requirement.
- Flexible in changing nozzle and skimmers for gas dynamics study.
- Fixed nozzle tube transversely to allow better alignment and increase the stability of gas jet.
- 10 mA electron source to further reduce the testing time.



Photos of the dedicated prototype of the gas jet monitor system in build.

Conclusion

In this contribution, we have discussed the recent progress of the supersonic gas jet-based beam induced fluorescence profile monitor. A 100 s integration time was demonstrated with a 30 mA electron beam and upgraded optical system, which is equivalent to a millisecond integration time for the e-lens project and HL-LHC proton beam. A dedicated prototype has been designed and is currently under commissioning in the laboratory. In this setup, gas jet dynamics will be studied with different nozzles, skimmers and intervening distances, to optimize gas jet density and distribution for the HL-LHC application. Gas species such as neon and argon will be tested, since they are better working gases for the NEG coated pipe in the LHC. These studies will help us in the final design of a monitor suitable for HL-LHC installation.