

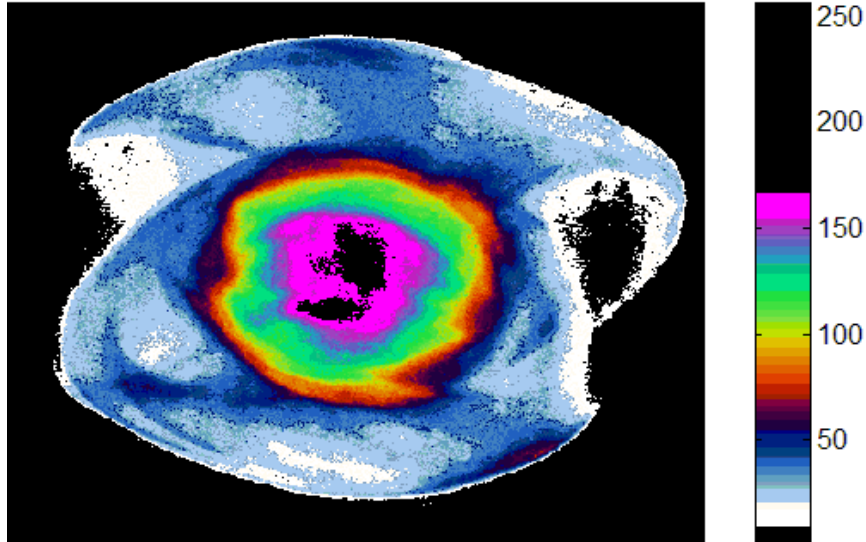
Propose a beam halo monitor for hadron machines based on an ionisation monitor with a supersonic molecular curtain beam

H. D. Zhang*, O. Stringer, N. Kumar, A. Webber-Date, C. Welsch



UNIVERSITY OF
LIVERPOOL

Beam halo



- Beam Halo Description

- Bad Effects

- Nuclear Activation of The Transport Channel
- Emittance Growth
- Emission of Secondary Electrons
- Increasing Noise in The Detectors

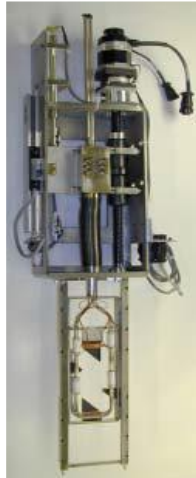
Current measurement methods

Wire Scanner and Scraper Assembly

at LEDA (LANL)

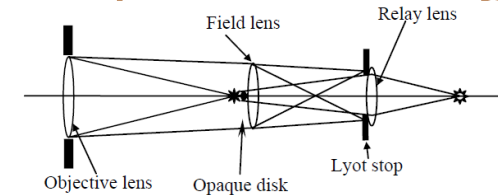
DR: 10^5

Wangler, et. al. PAC01



Achieve high dynamic range (DR) is essential.

Passive Spatial Filtering



solar coronagraph applied to beams

DR: 10^5

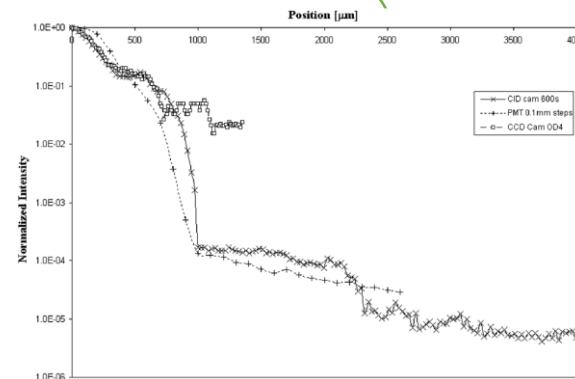
T. Mitsuhashi, EPAC 2004.

High Dynamic Range Camera³

Spectra-Cam CID

DR: 10^6

C P Welsch et al 2006 Meas. Sci. Technol. 17 2035

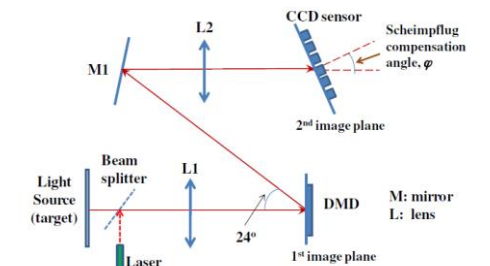


Adaptive Mask

DMD

DR: $>10^5$

H. Zhang, et al. PRAB, 15, 072803(2012)

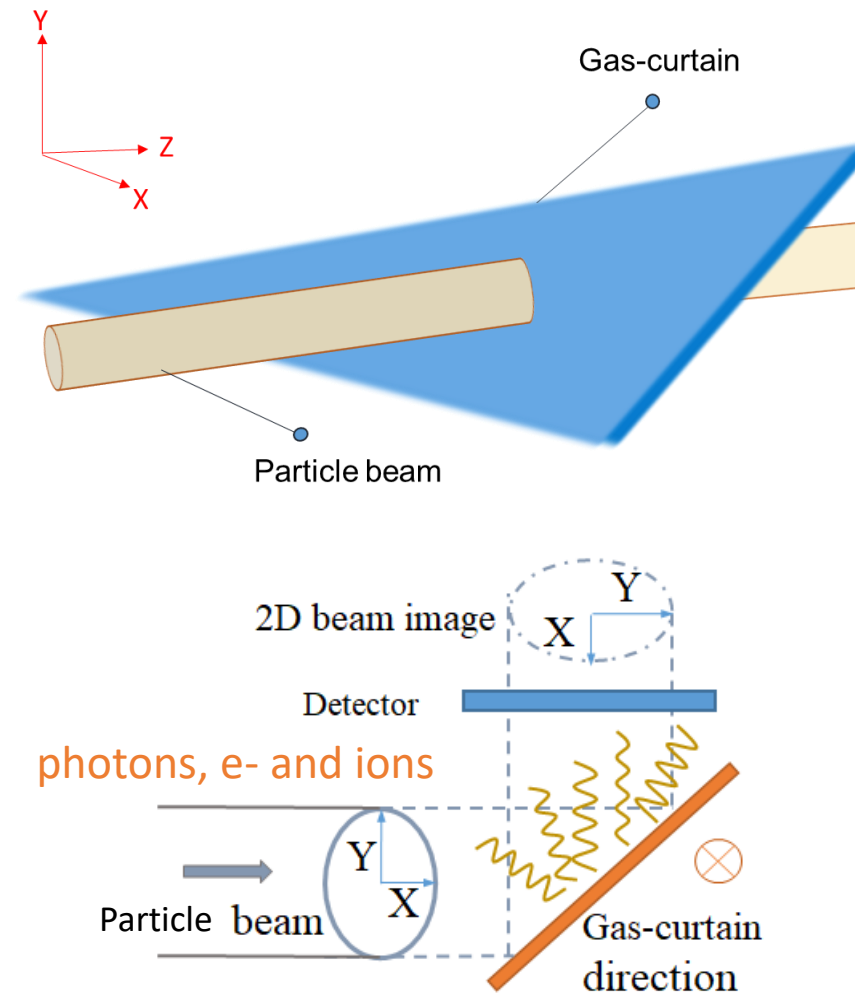


Supersonic molecular curtain-based beam profile monitor

- A projectile beam passing through residual gas present in a vacuum chamber, or a gas curtain, gives rise to two processes:
 - Ionisation, used in Ionisation Profile Monitors (IPMs)
 - Fluorescence, used in Beam Induced Fluorescence Monitors (BIFs)
- BIF method using a gas curtain:
 - Minimally-invasive to the projectile beam and the vacuum level.
 - Can provide a 2D image with one imaging system.
 - Signal intensity/photon number depends on the following parameters:

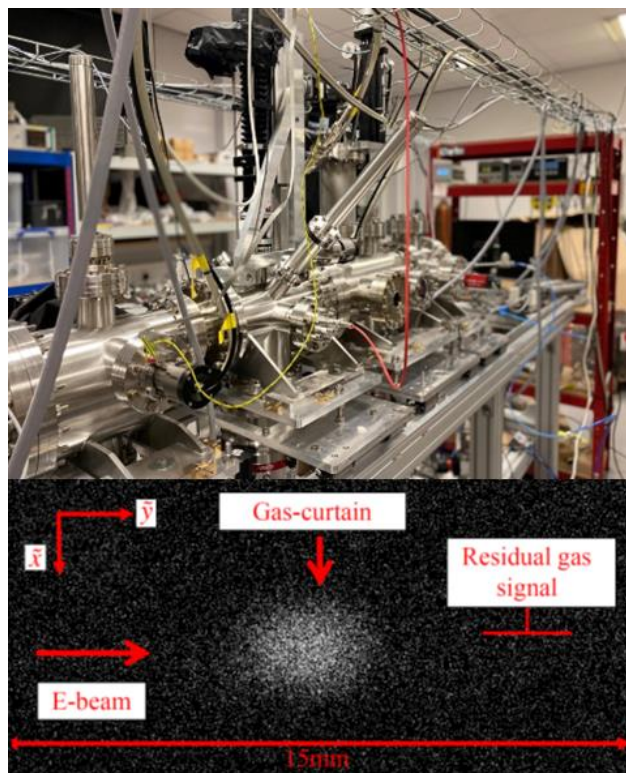
$$\dot{N} \propto \sigma_{fluorescence} \cdot \Omega \cdot T \cdot I \cdot d \cdot n$$

$$\dot{N} \propto \sigma_{ionisation} \cdot T \cdot I \cdot d \cdot n$$

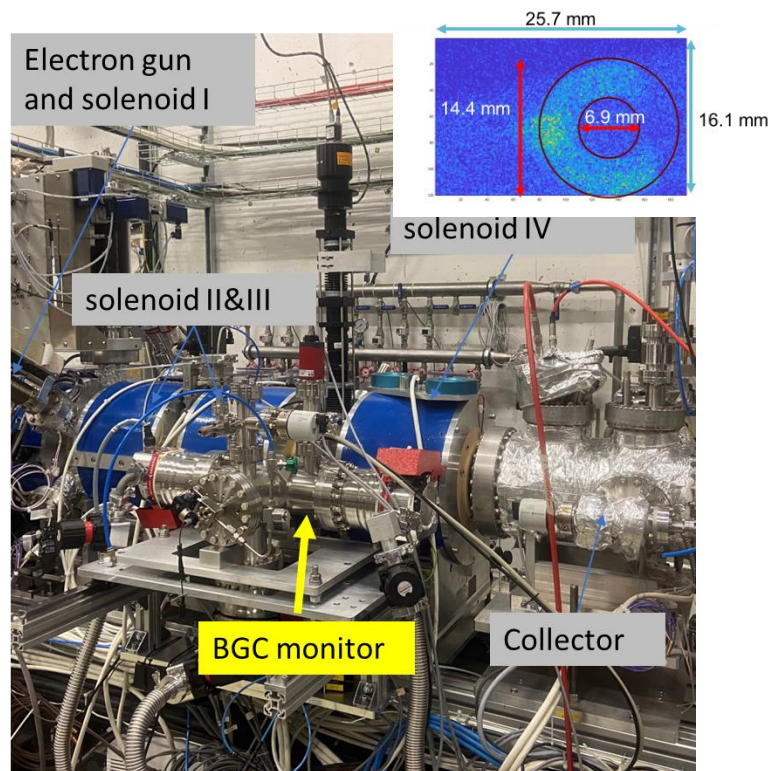


Current status

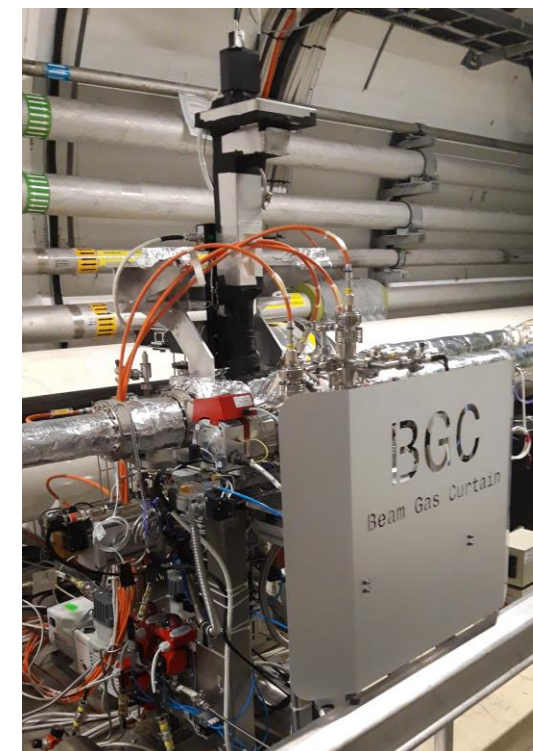
CI experiment



EBTS experiment



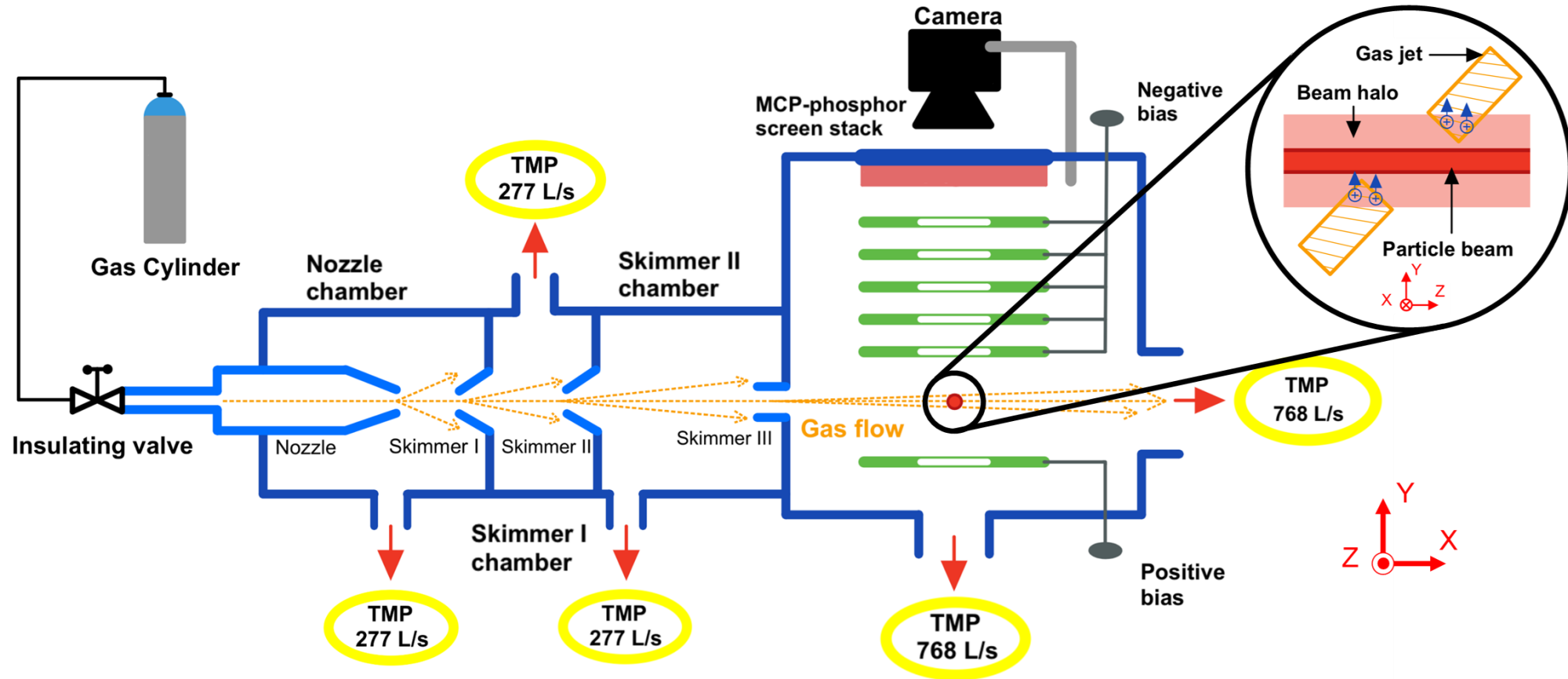
LHC installation



More details about the function in this [Video](#)

Halo monitor using double slit skimmer

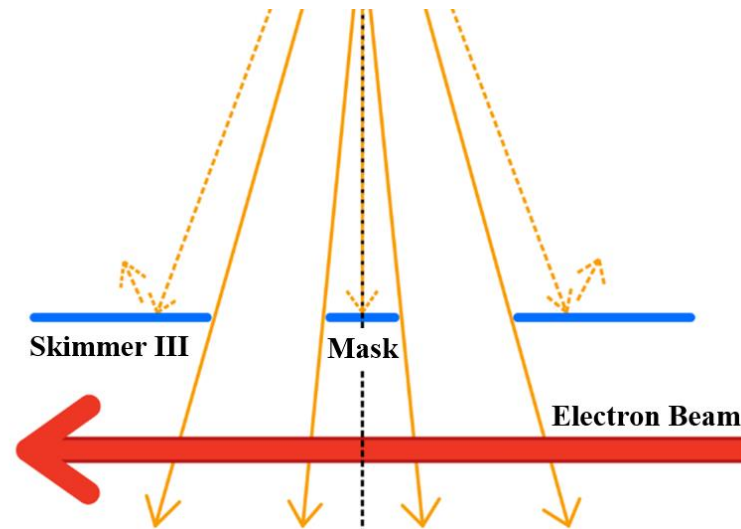
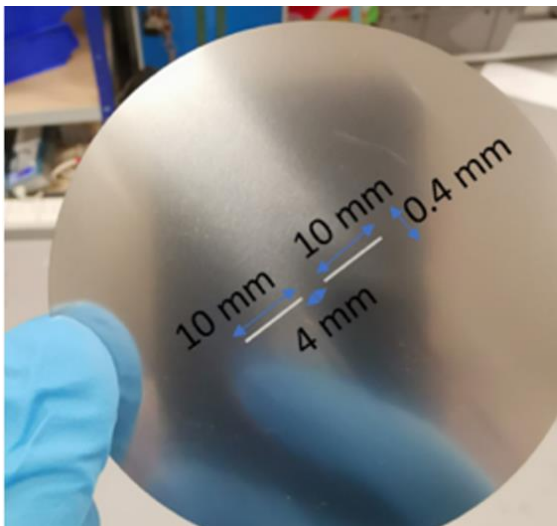
- BGC schematic for the measurement of halo particles



Creedt: O. Stringer, et. al, Linac 2022

BGC Mask for Halo Measurements

- Beam halos could be measured with the BGC using modified 3rd shaping skimmer
- Create a mask for the gas jet to filter out core particles
- Gas curtain only measures the halo particles



Parameter	SPS
Ring circumference (m)	7000
Beam Energy (GeV)	26
Protons per turn	< 6.5E13
BIF Cross section(N ₂ , cm ²)	3.06E-20
BIF Cross section(Ne, cm ²)	4.70E-22
IPM Cross section (N ₂ , cm ²)	1.5E-18
Gas jet density (cm ⁻³)	1.0e11
Gas jet thickness d (mm)	0.1
N_ionisation_core per second	4.17E+09
N_ionisation_halo per second	4.17E+04

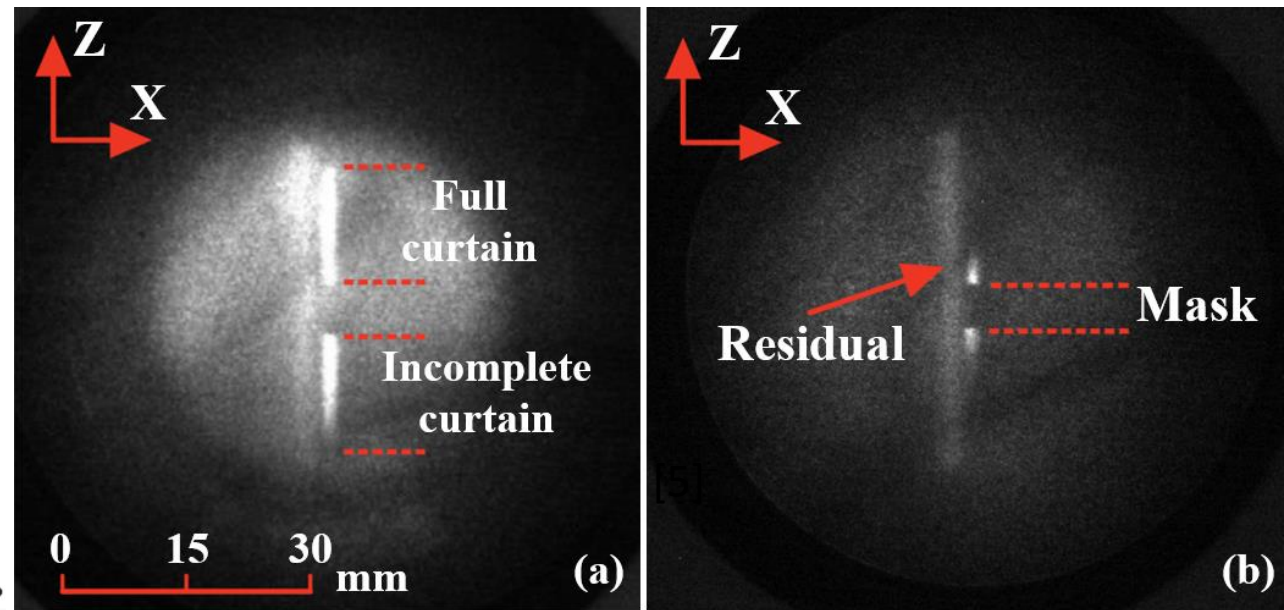
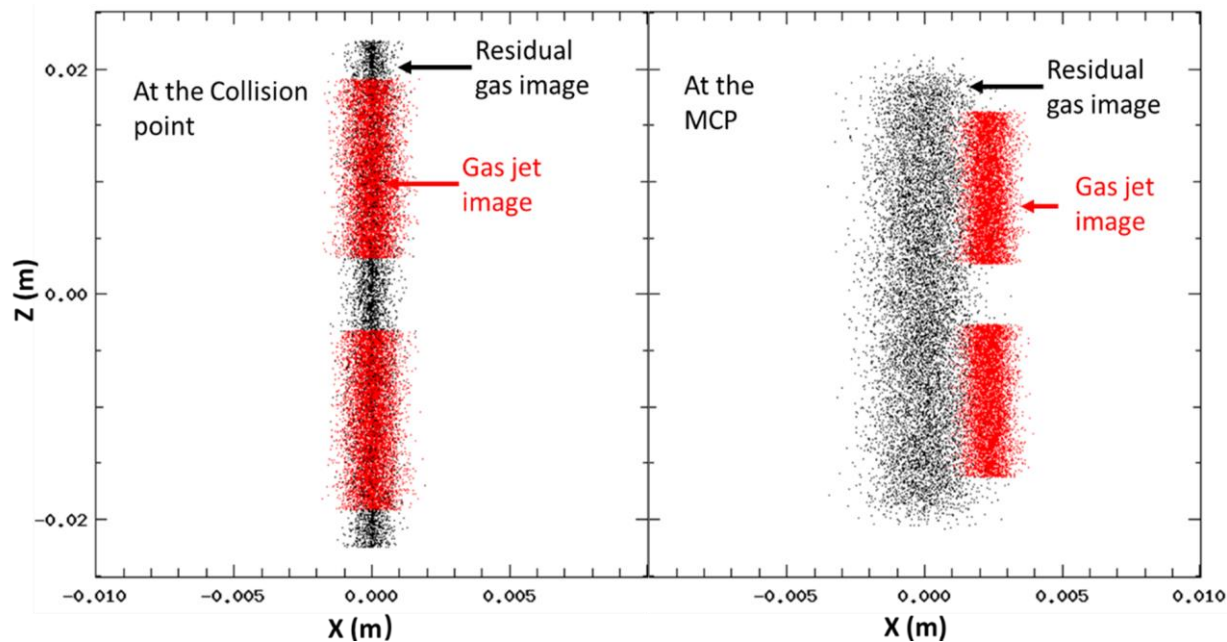
Possible to have a distribution measurement of the halo in seconds !!

$$\dot{N} = \sigma_{fluorescence} \cdot \Omega \cdot T \cdot I/e \cdot d \cdot n$$

$$\dot{N} = \sigma_{ionisation} \cdot T \cdot I/e \cdot d \cdot n$$

Curtain Characterisation and preliminary experiment

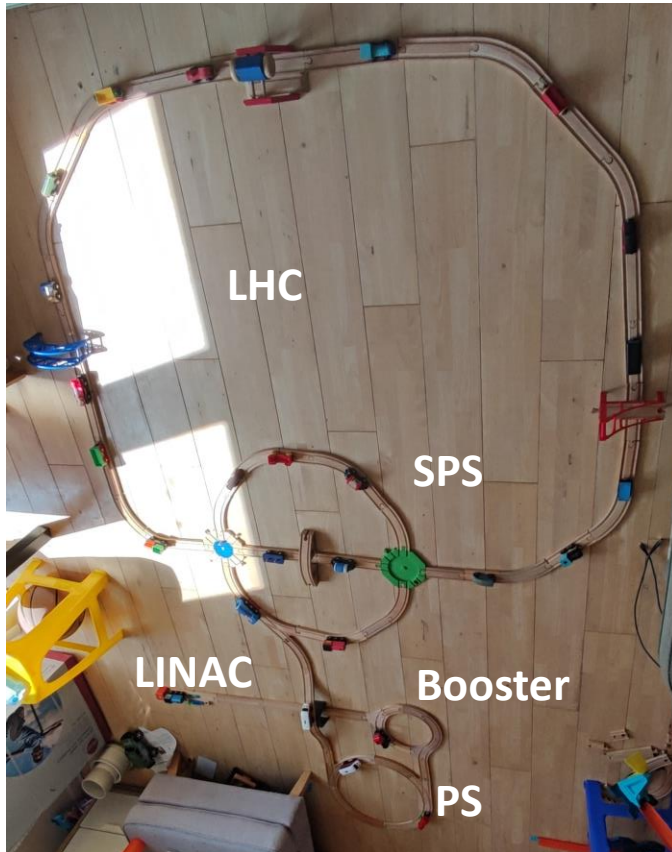
- Gas particles simulated using WARP code [4]
- Gas curtain has been characterised using eGun with 3rd skimmer at 90 degrees
- Experiment test using a E-beam with ~ 5 keV energy and $\sim 1\mu\text{A}$ current.



Summary

- Measuring the beam halo is still a challenge.
- Gas jet based beam profile monitor could be a solution for online halo monitor.
- Preliminary experiments are still on going at Cockcroft Institute.

Acknowledgment



Any Questions?

This work is supported by the HL-LHC-UK phase I & II project funded by STFC under Grant Ref: ST/T001925/1 and the STFC Cockcroft Institute core grant No. ST/G008248/1.