Status of fluorescence tests with protons in the LHC

Ondrej Sedlacek for BGC Collaboration Team
Ondrej.Sedlacek@cern.ch

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Content

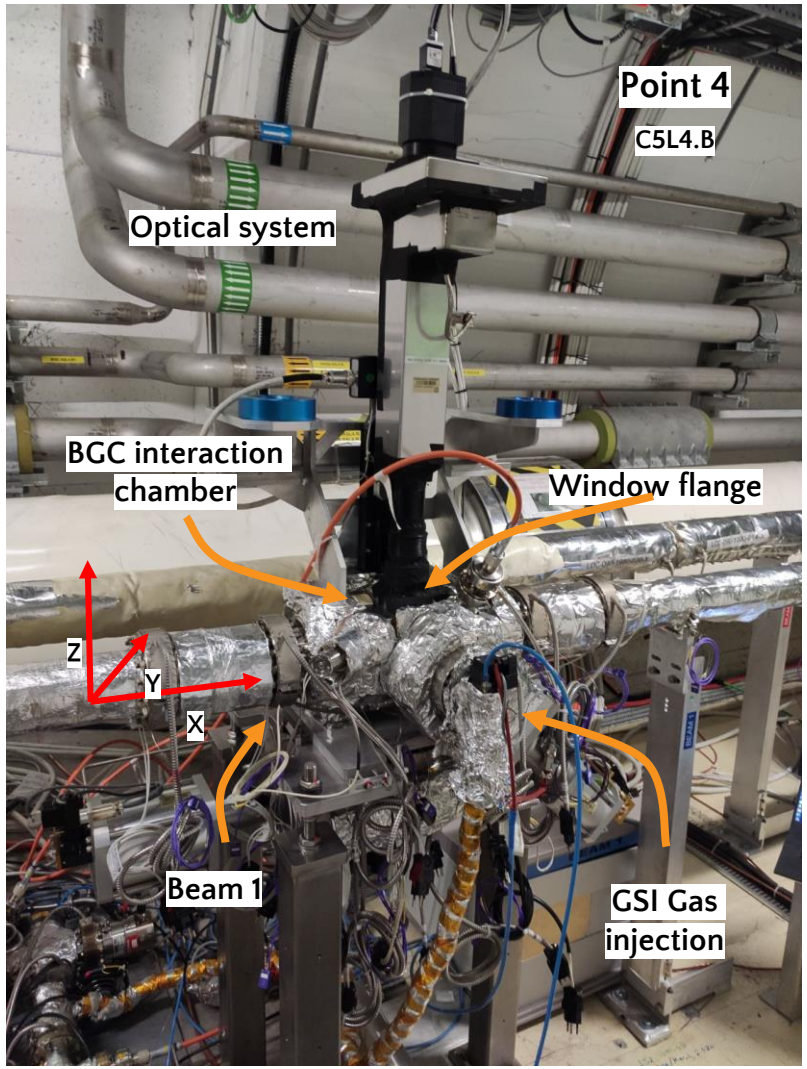
- Motivation
- Experimental setup
- Ne gas effects on LHC beam
- Results
  - Background studies
  - Preliminary fluorescence signal
- Outlook & Summary

Motivation for fluorescence experiments at LHC

- Measure the Neon – proton fluorescence cross-section at 6.8 TeV for first time $2s^2 2p^5\ (2P^0_{1/2}) 3p^2[½]_0 \rightarrow 3s^2\ [½]_1$ transition at 585.4 nm
  - Previously only extrapolated
- Part of a Beam Gas Curtain studies using gas curtain
  - Photon yield – $$N = \sigma \cdot \frac{\Omega}{4\pi} \cdot T \cdot \frac{I}{e} \cdot \eta_{pc} \cdot \eta_{MCP} \cdot d \cdot n$$
- Low levels ($< 5 \cdot 10^{-8}$ mbar) of Ne gas injected locally into LHC pipe at Point 4
- Photon yield measured with intensifier camera
- In 2018 fluorescence experiment – high background
  → Substantially improved now

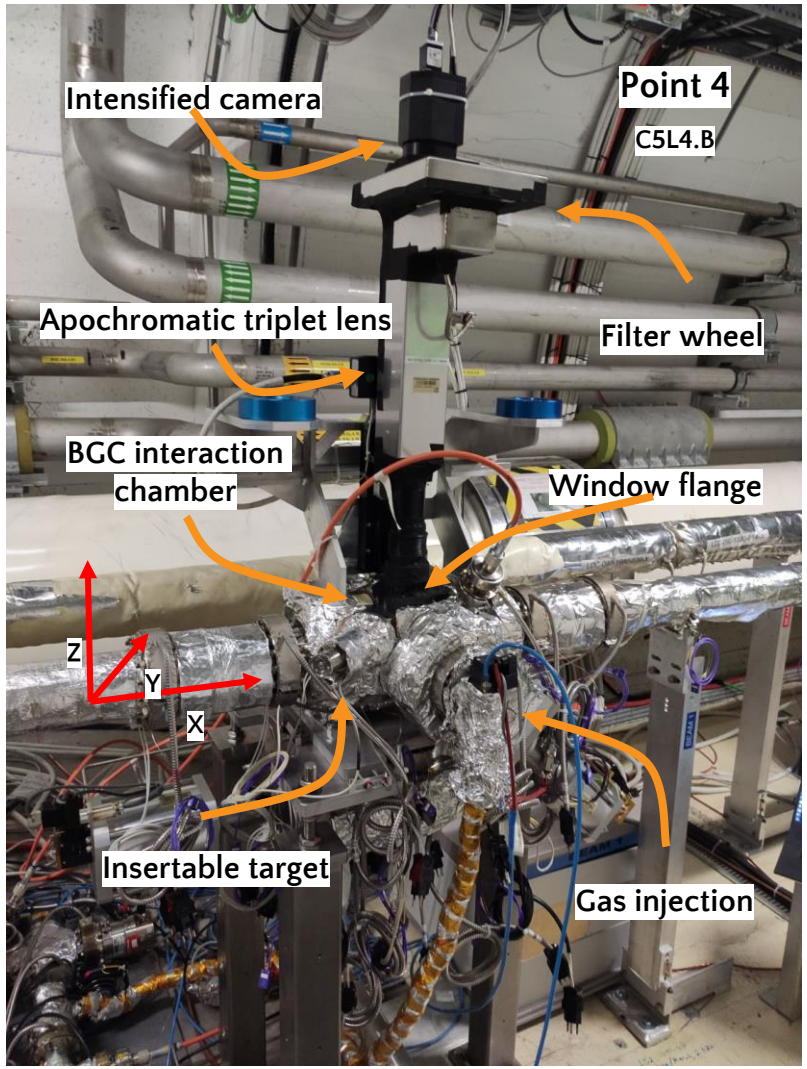
Parameter	Value
σ	Fluorescence cross-section
Ω	Solid angle
T	Transmittance of the imaging system
I	Beam current
$\eta_{pc} \cdot \eta_{mcp}$	Quantum efficiency of photocathode and MCP
d	Gas curtain thickness
n	Gas curtain density

Experimental setup - installed 2022



- Position with expected low synchrotron radiation levels
- Gas Injection system formerly BGI
  - Max pressure $5 \cdot 10^{-8}$ mbar
- Copper liner – blackened amorphous carbon coating
  - Reflectivity ~ 14 %
- Contrast plate – ultra-low reflectivity multi-layered coating
  - Reflectivity ~ 0.25 %

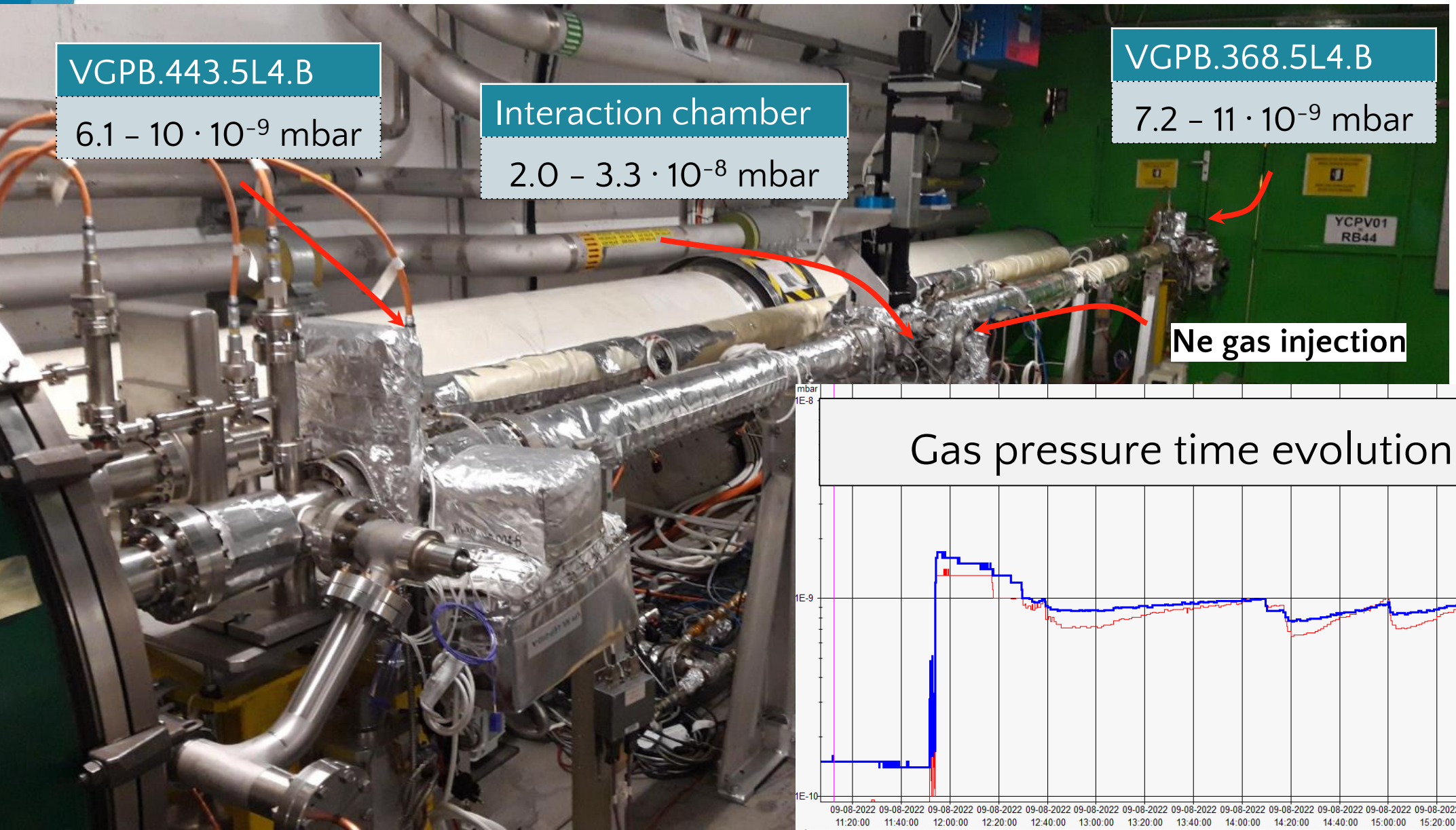
Experimental setup - installed 2022



- Double stage intensified camera
  - Quantum efficiency ~ 6.75 %
- Filter wheel: 585 ∓ 10 nm, Blocking filter, empty filter socket
- Apochromatic triplet lens
  - Transmittance ~ 80 %
- Magnification: 0.205
- Acceptance: $1.4 \cdot 10^{-3}$
- 10.5 pix per 300μm ~ to LHC beam σ

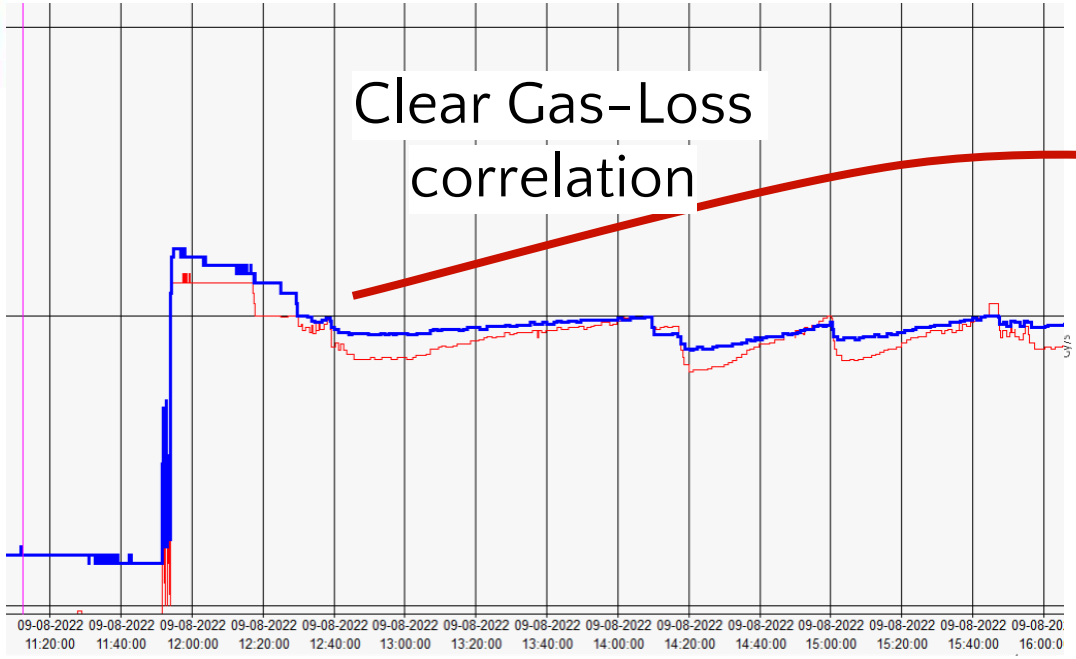
MTF [%]	line/mm
46	1.000
38	0.500
26	0.250
13	0.125

Ne gas injection - typical levels

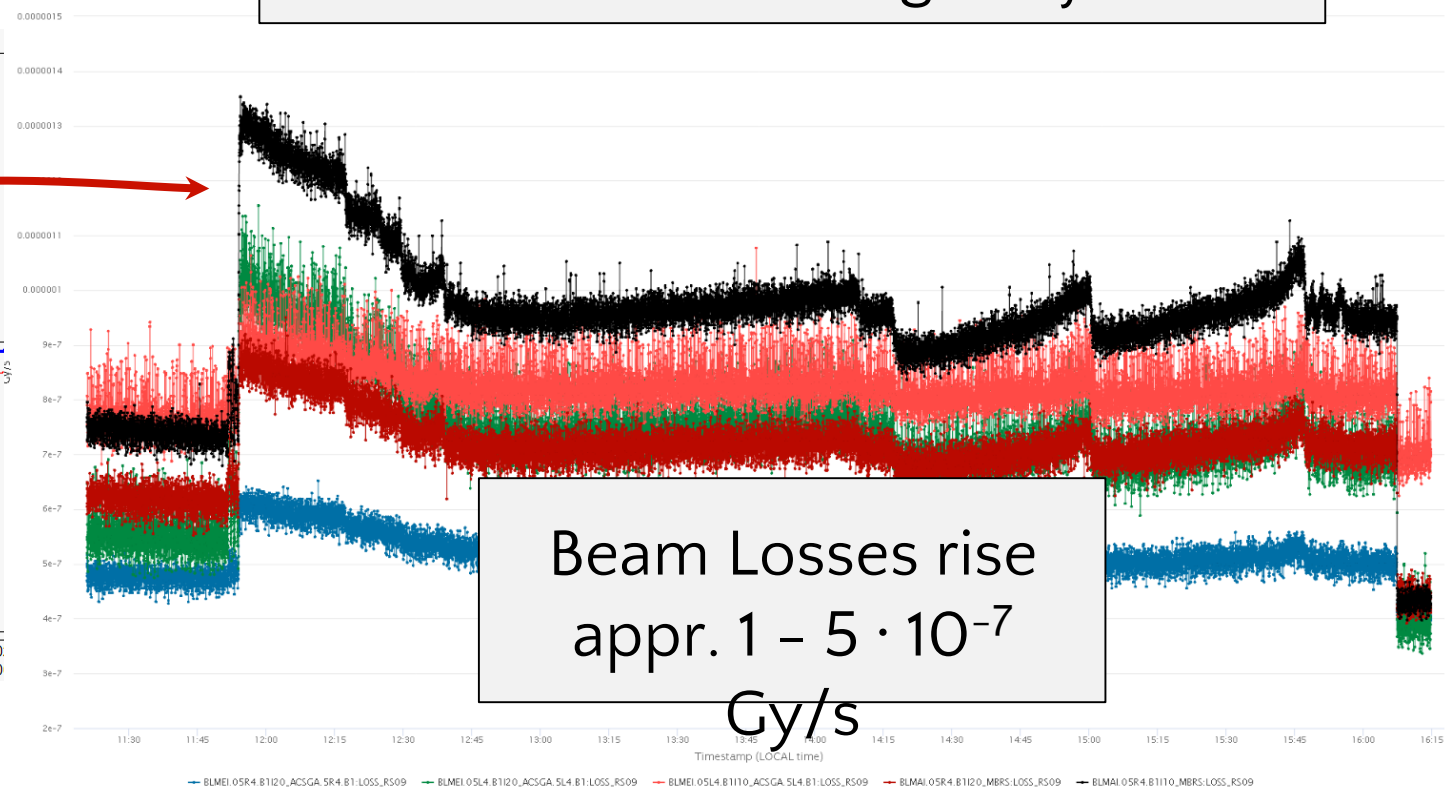


Gas induced beam effect

- No additional losses (< 1%) visible with LHC BLM fixed display
  - Fully transparent for LHC beam at 6.8 TeV with intensities up to 2100 bunches



Losses around BGC gas injection



Beam Losses rise appr. $1 - 5 \cdot 10^{-7}$ Gy/s

Results from LHC

LHC background - contributions

- Dark counts (Photocathode + MCP)
  - ~ 45 cps
- Optical background at 585 ∓ 10 nm
  - ~ 110 cps

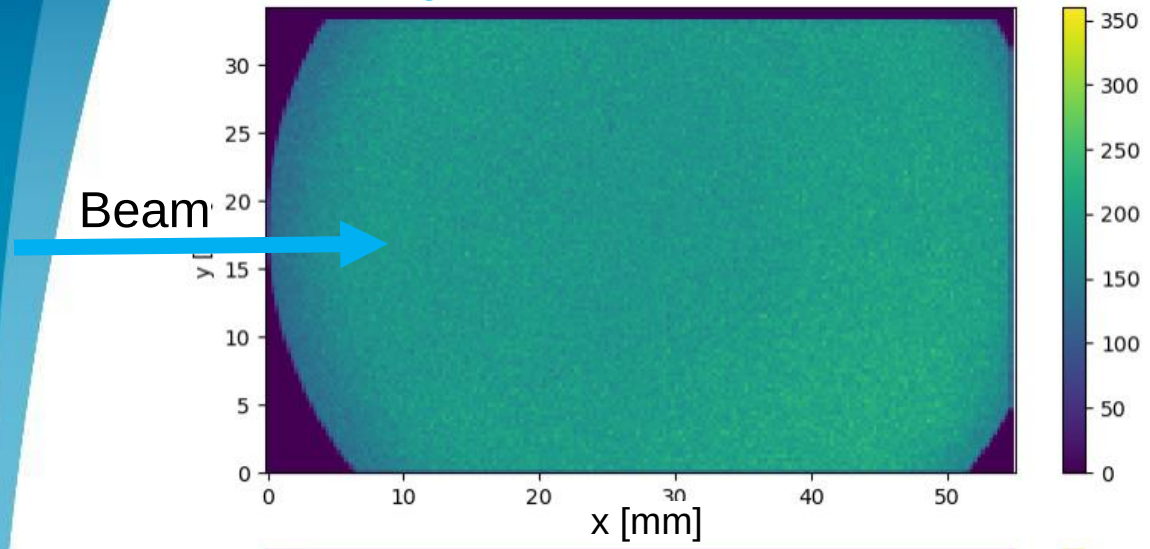
→ – Negligible at 6.8 TeV

- Beam losses (with and without injected gas)
  - Particle showers passing through intensifier can create photon-like signal
- Synchrotron radiation

→ – Dominant at 6.8 TeV

LHC background

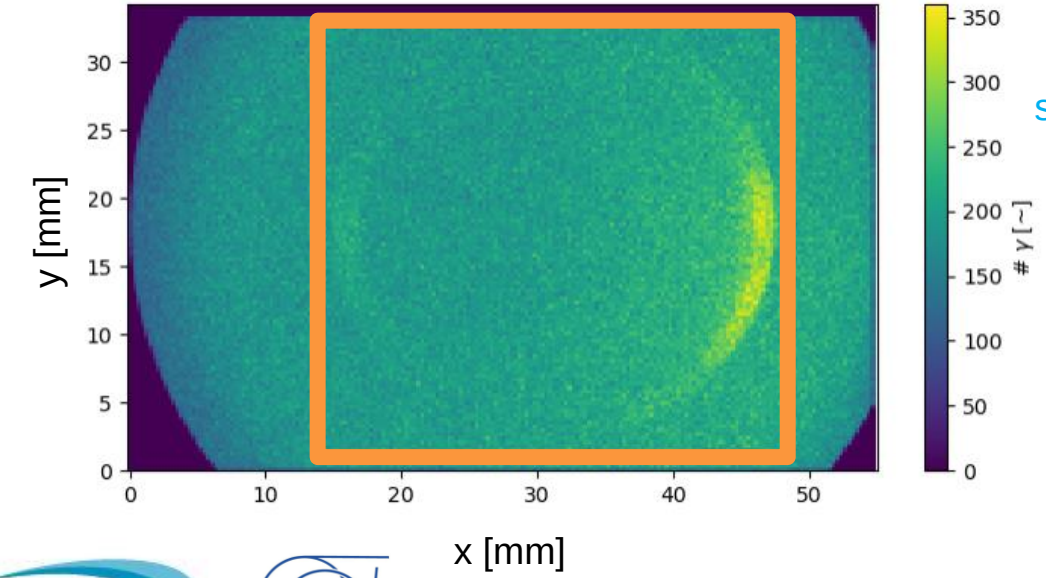
All results used single photon counting method



Blocking filter - Beam loss induced signal

Beam [#bun]	Beam [#p]	Energy [TeV]	Gas [mbar]	Int time [s]
2100	$1.5 \cdot 10^{14}$	6.8	0	80

- Accounts for ~ 96.3 % of all counts

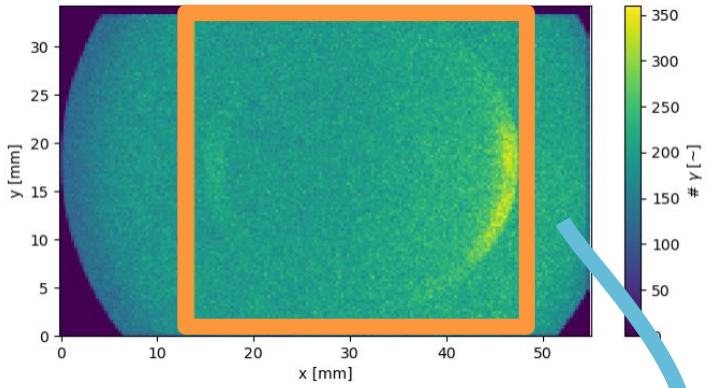


585 ∓ 10 nm filter - Beam loss induced signal + Synchrotron radiation

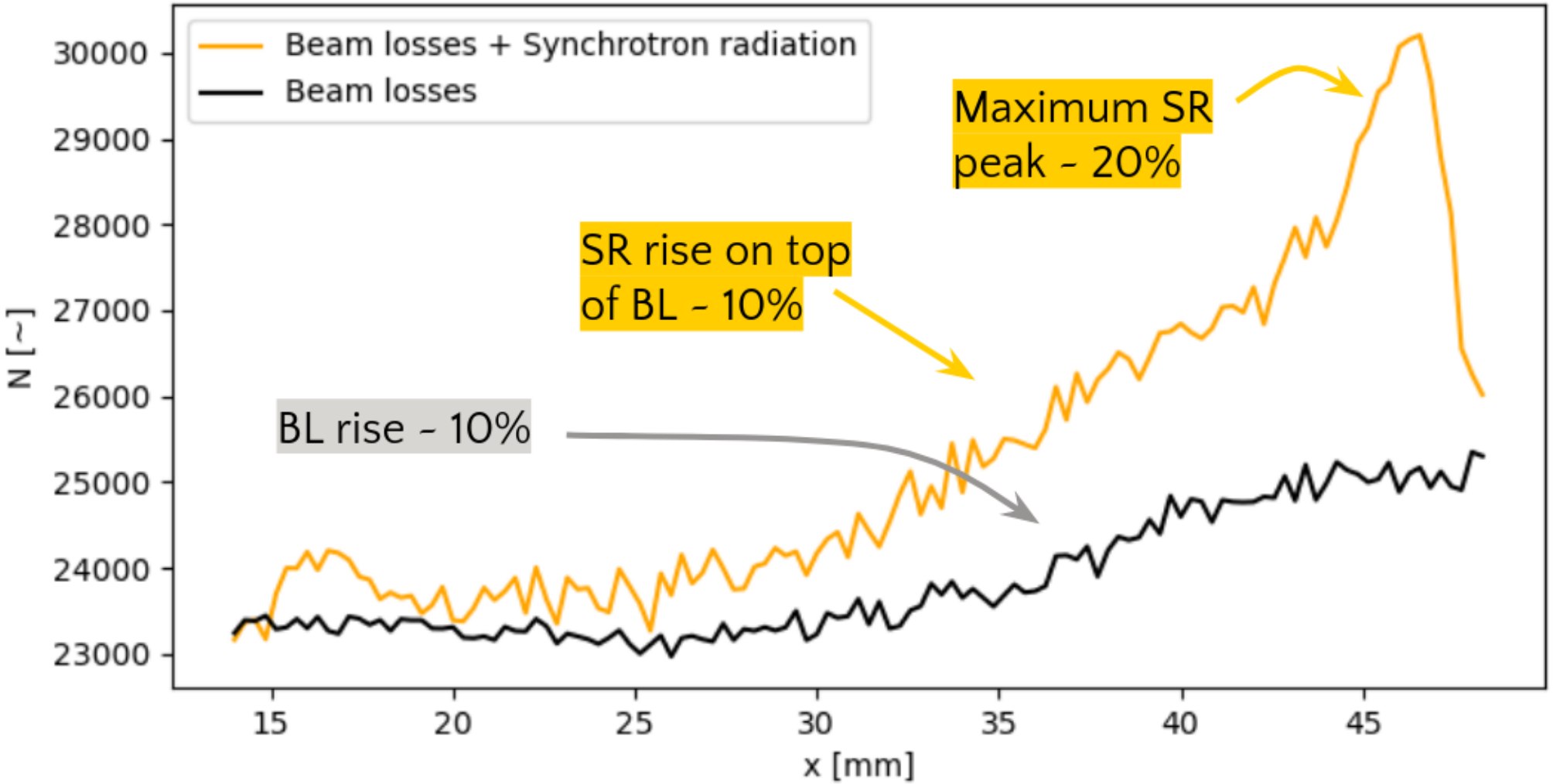
- SR – 3.7 % of all counts
  - 6 % in window flange area
- Lower by factor of ~ 40 in comparison to 2018 experiments

LHC background

- Beam losses not completely homogeneous
- Synchrotron radiation – highly inhomogeneous



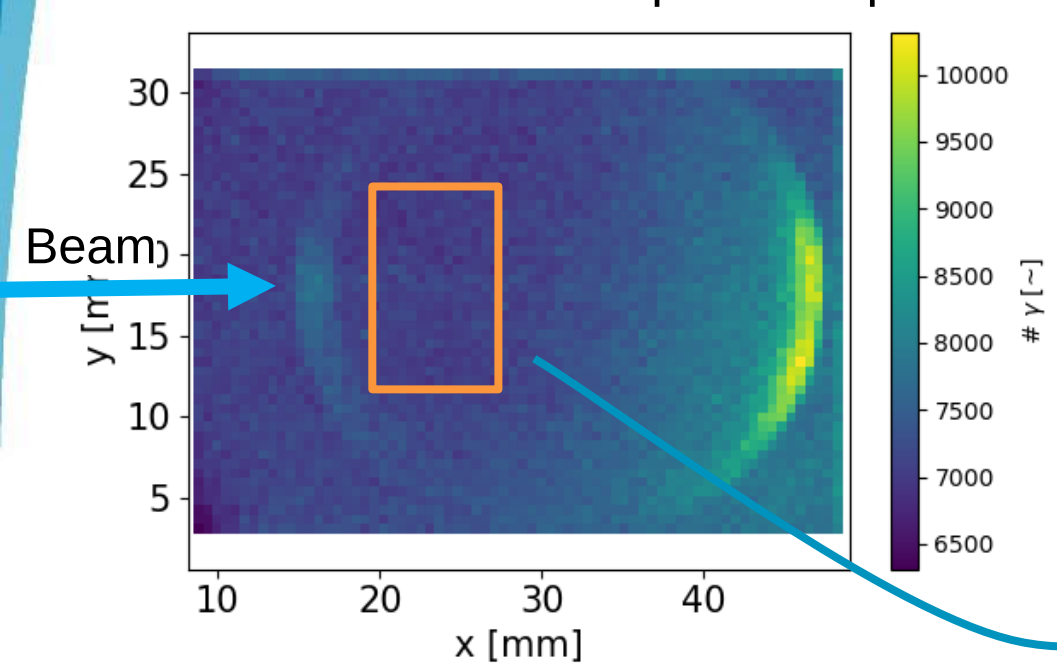
X projection
(Sum across y)

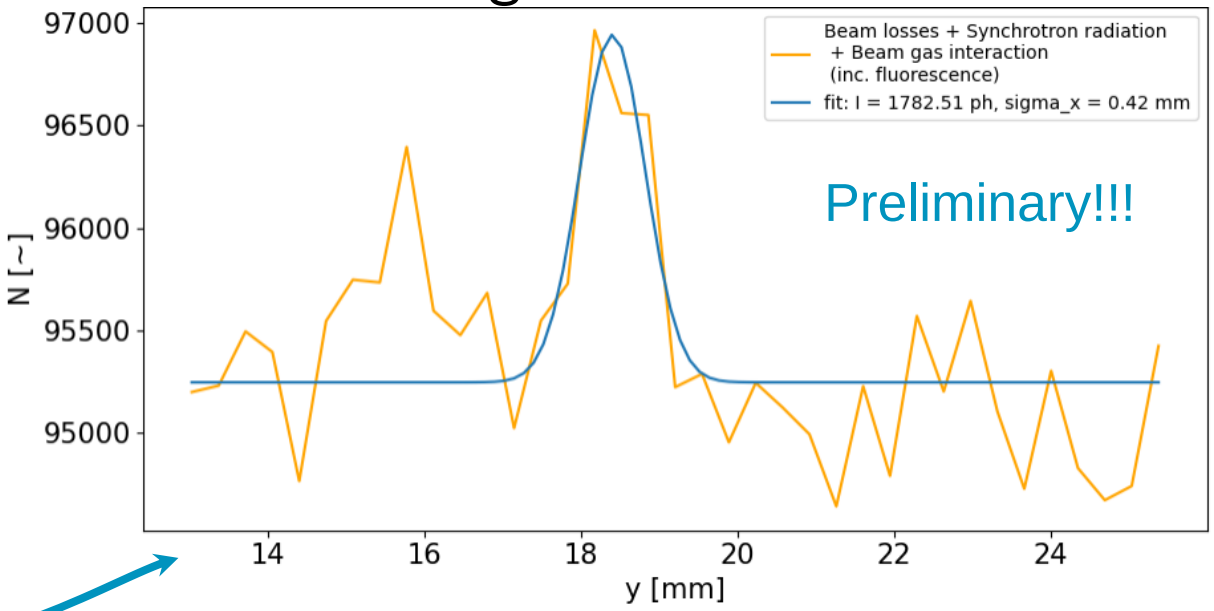


First preliminary fluorescence signal

- High binning (20) & integration time
- Expected position, weak signal – high error
- Fitted beam σ = 0.42 mm
- Lower than expected photon yield – under investigation

Beam [#bun]	Beam [#p]	Energy [TeV]	Gas [mbar]	Int time [s]
2100	~$1.4 \cdot 10^{14}$	6.8	~$2 \cdot 10^{-8}$	430





Y projection
(Sum across x)

Outlook & Summary

- Gas injection experiments at Point 4 to measure fluorescence cross-section installed and on-going
- Gas pressure bump is completely transparent to LHC beam
- First weak preliminar fluorescence signal observed

- Acquiring more data with LHC proton beam at 6.8 TeV
  - Obtain exact photon yield
- Measure protons at 450 GeV and Ion beam
- Install whole BGC - gas curtain system YETS 2022/23

Thank you for your attention!

Questions?

Ondrej.Sedlacek@cern.ch

Work presented on behalf of the BGC collaboration:

O. Sedlacek[12], M. Ady[2], A. R. Churchman[2], P. Forck[3], T. Lefevre[2], S. Mazzoni[2], M. Sameed[2], O. Stringer[1], A. Rossi[2], G. Schneider[2], C. Castro Sequeiro[2], K. Sidorowski[2], S. Udrea[3], R. Veness[2], C. P. Welsch[1], H. D. Zhang[1],

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

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