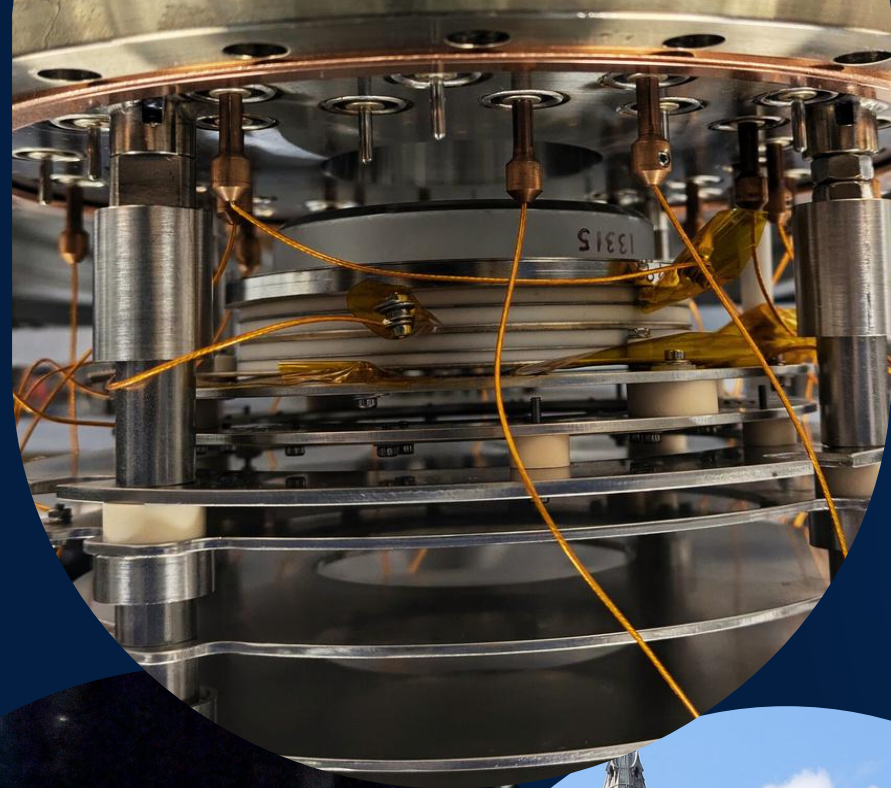


End Station Beam Monitoring: Gas Jet Profile Monitor and Air Fluorescence Monitor

Milaan Patel

LhARA Collaboration meeting #9

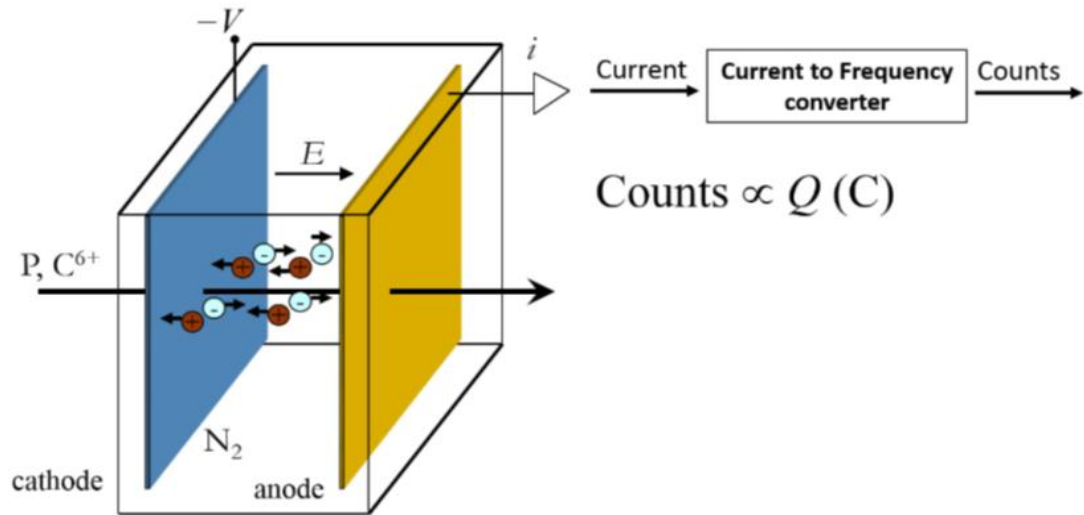
RAL



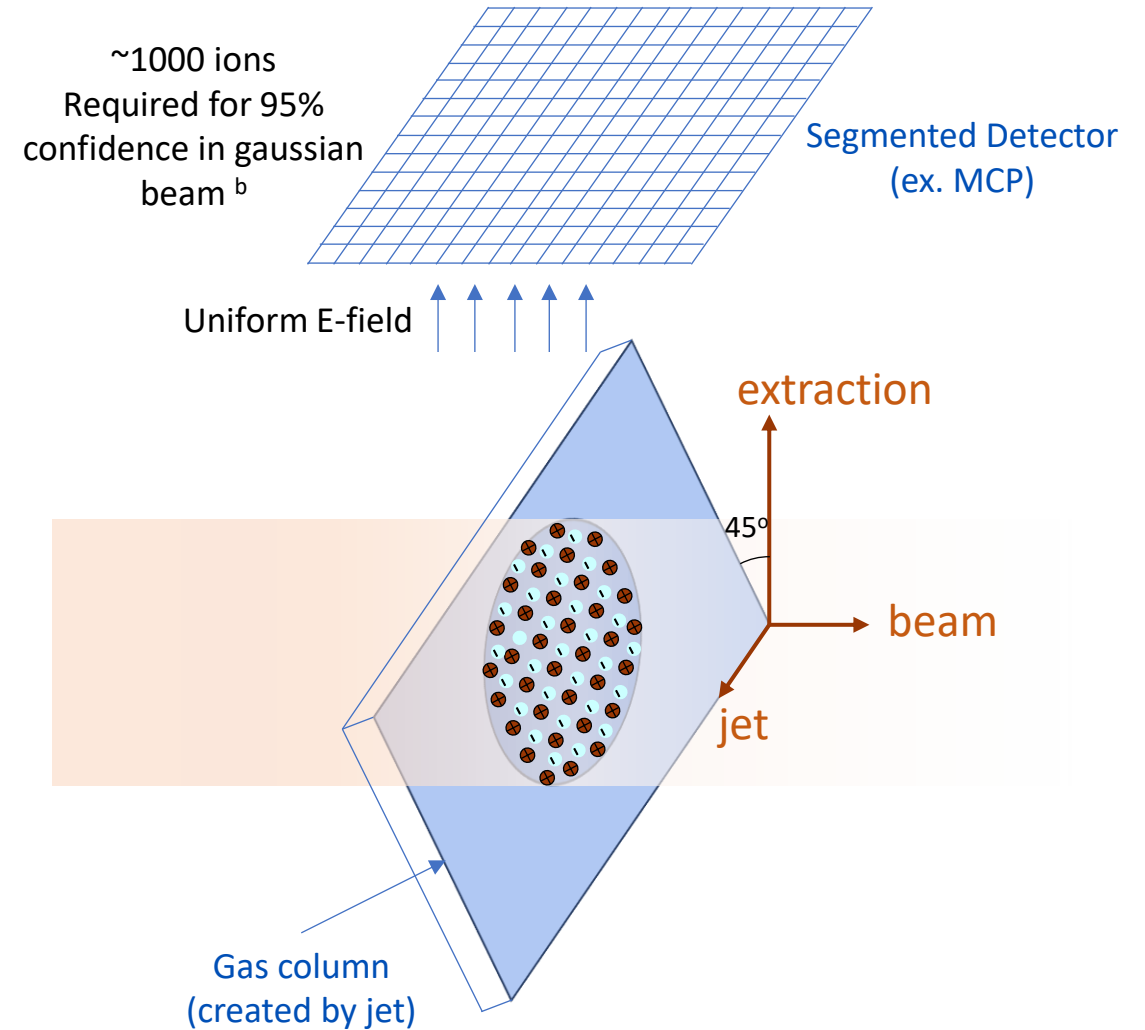
Thanks to

Narender, Tony, Ruth, Farhana, William and
Carsten

Gas jet beam profile monitor: Concept

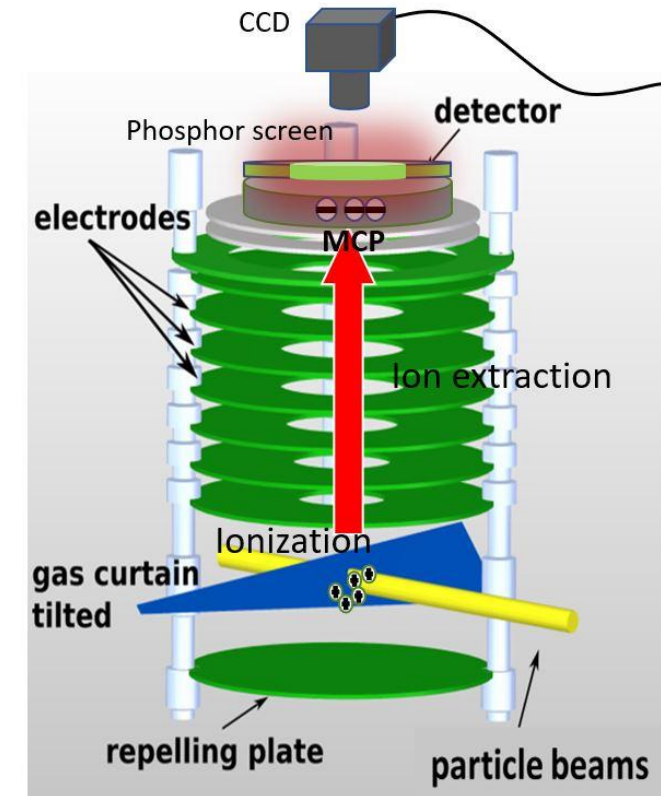
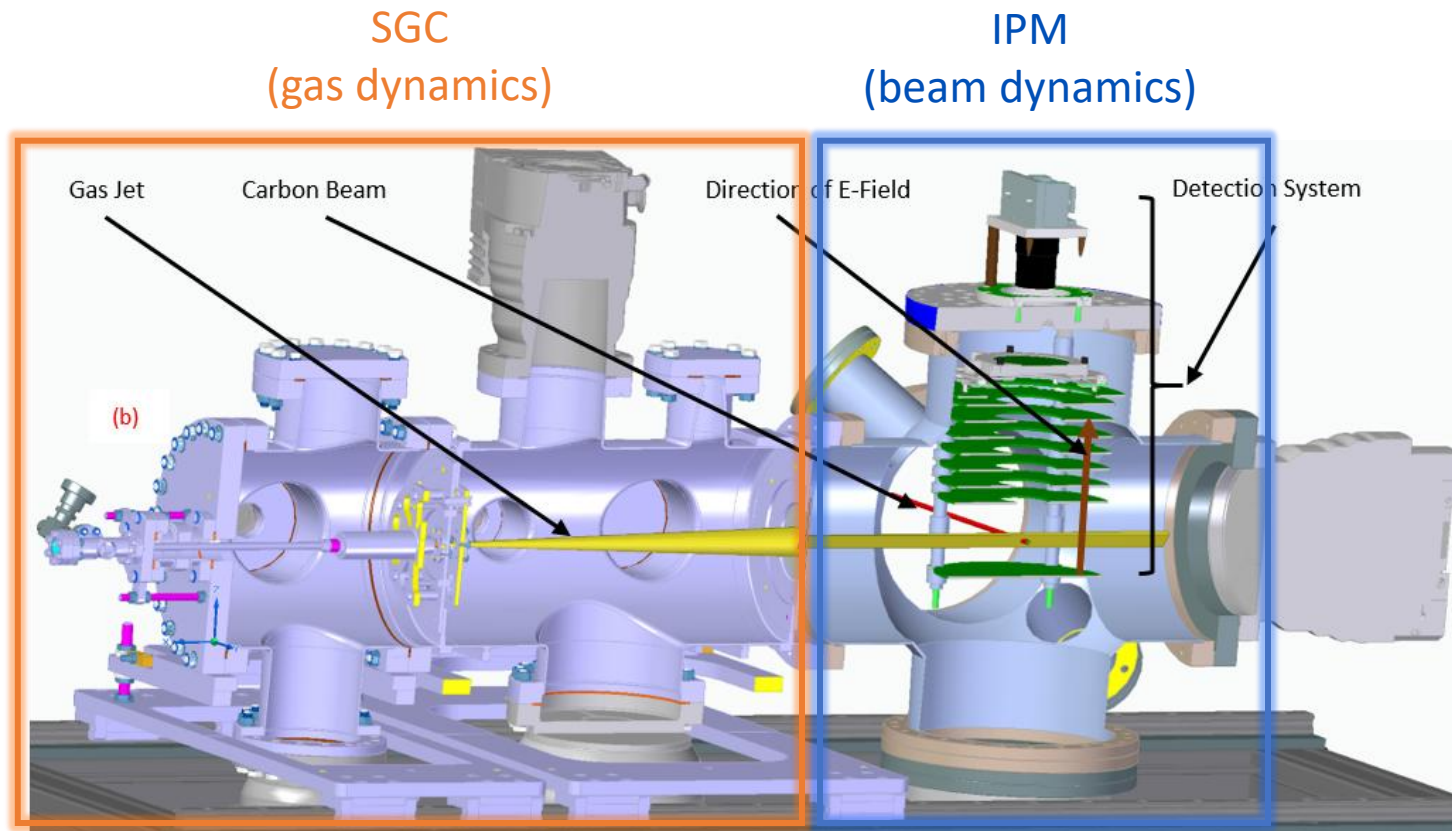


Detection principle of the Ionization chamber ^a

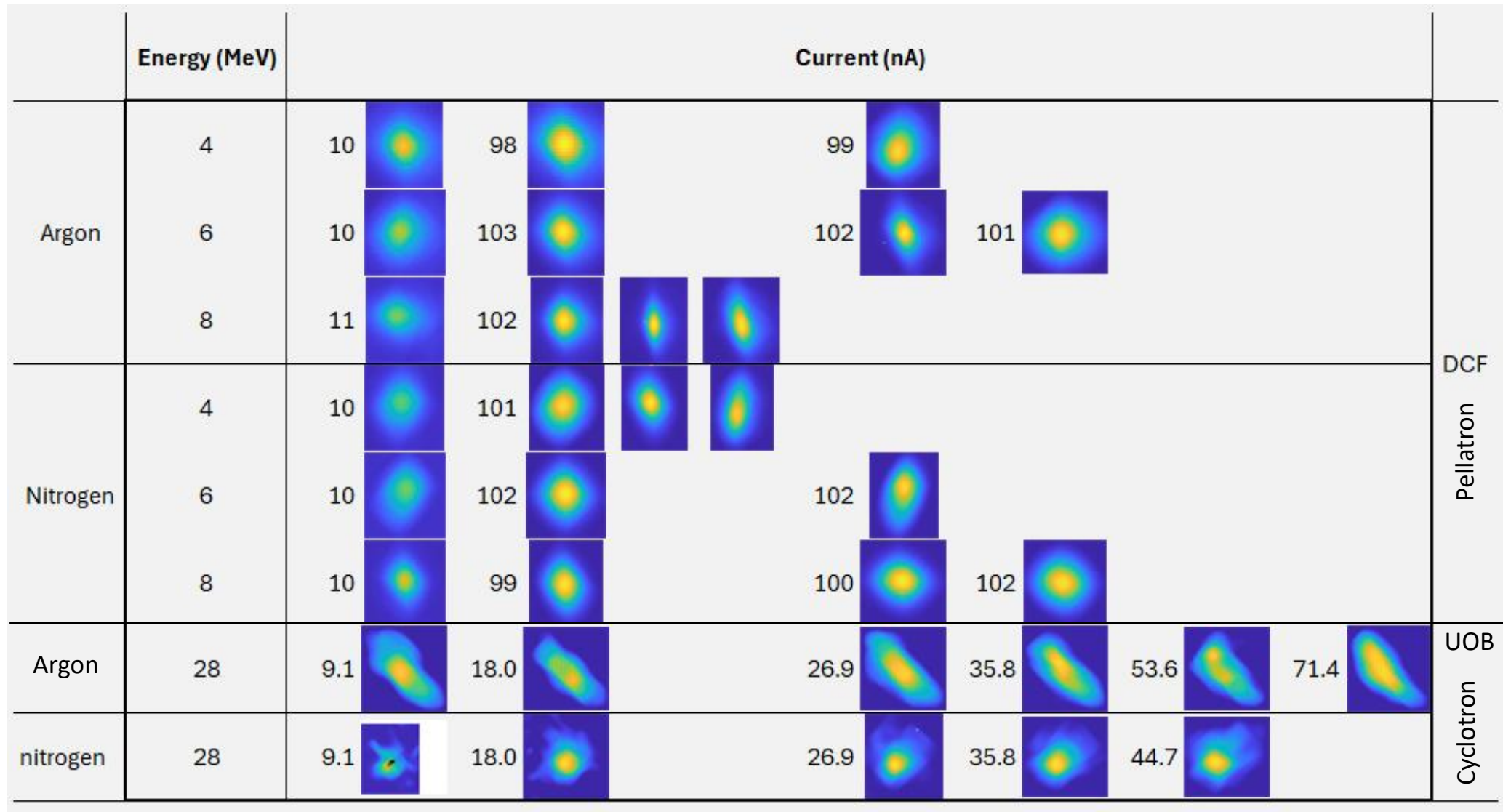


[a] Romano.F, et al., Med Phys. 2022; 49(7): 4912-4932
 [b] N. Kumar et al, Physica Medica 2020; 73:173-178

Gas jet beam profile monitor: Device

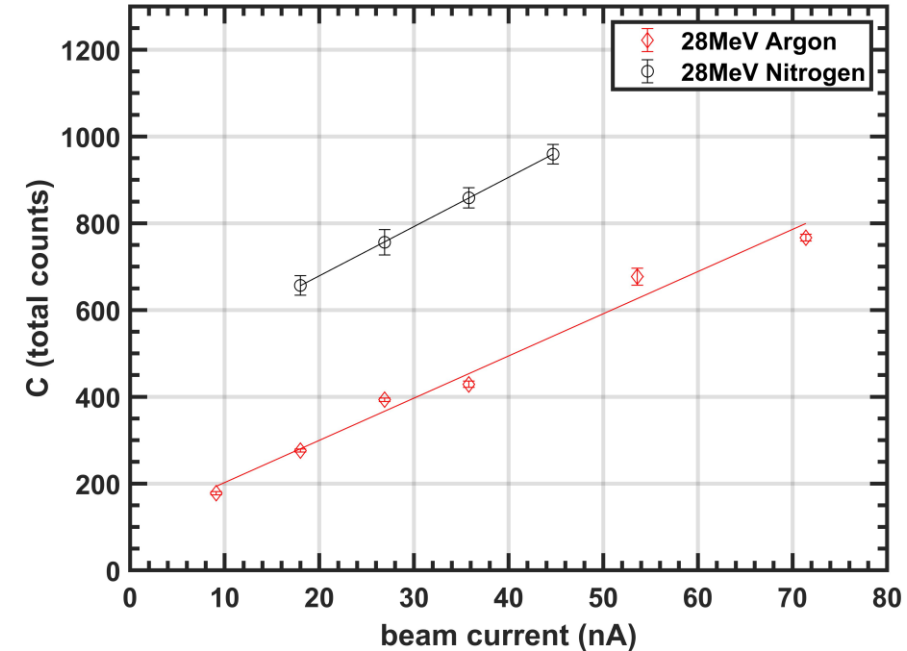


Proton beam profile measurements: DCF and UOB



Linearity with the beam current

- The device shows linearity with the beam current within the test range
- A behaviour typical to Ionization chamber
- Does it maintain that at FLASH dose rates
 - Theoretically, Yes.
 - Experimentally, need to test.



Counts vs Current for 28 MeV P-beam (100 ms)

frontiers | Frontiers in Oncology

TYPE Original Research
PUBLISHED 27 October 2025
DOI:10.3389/fonc.2025.1694310

Check for updates

OPEN ACCESS

EDITED BY
Suzie Sheehy,
The University of Melbourne, Australia

REVIEWED BY
Xinle Lang,
Chinese Academy of Science, China
Lingshu Yin,
University of Pennsylvania, United States

Supersonic gas curtain based ionization beam profile monitor for FLASH proton beam therapy

Milaan Patel^{1,2}, Narender Kumar^{1,2*}, Farhana Thesni^{1,2}, William Butcher^{1,2}, Tony Price³, Ruth McLauchlan⁴ and Carsten P. Welsch^{1,2}

← Experimental

<https://www.frontiersin.org/journals/oncology/articles/10.3389/fonc.2025.1694310/full>

Simulation →

instruments

MDPI

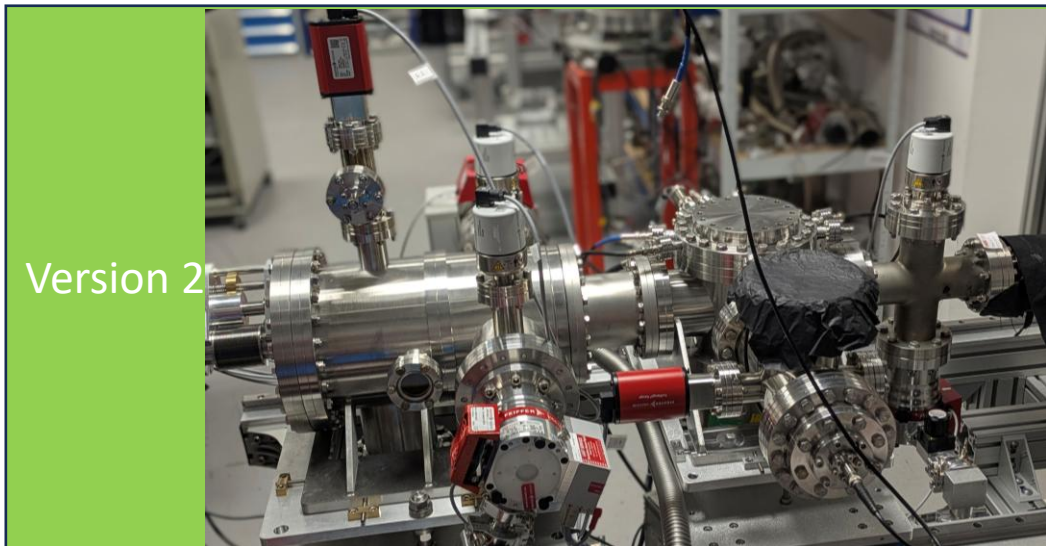
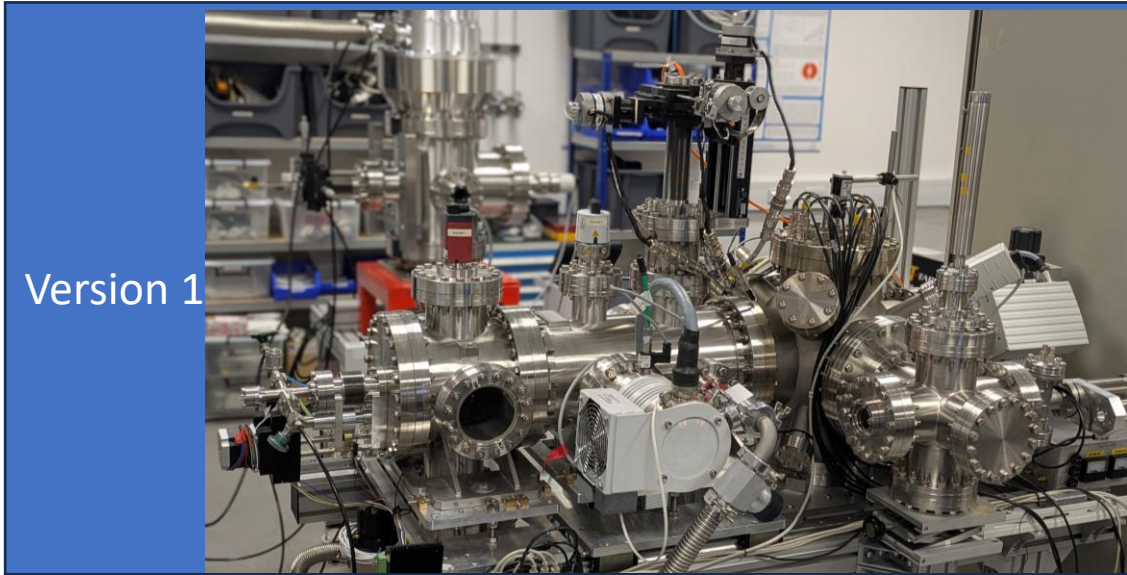
Article

Characterization of the Extraction System of Supersonic Gas Curtain-Based Ionization Profile Monitor for FLASH Proton Therapy

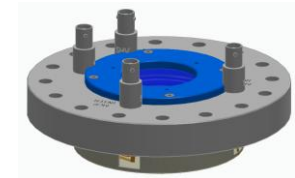
Farhana Thesni Mada Parambil^{1,2}, Milaan Patel^{1,2}, Narender Kumar^{1,2*}, Bharat Singh Rawat^{1,2}, William Butcher^{1,2}, Tony Price³ and Carsten P. Welsch^{1,2}

<https://doi.org/10.3390/instruments10010004>

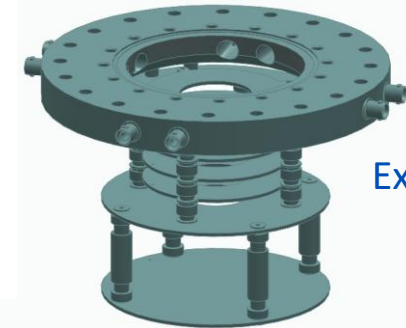
Recent developments: SGC-IPM V2



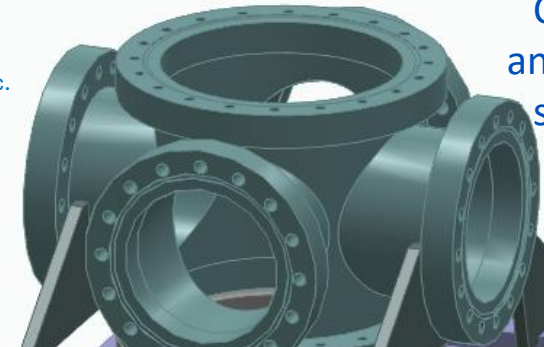
[M. Patel et al, in Proc. IPAC'24 WEPG097]



Detector



Extraction unit

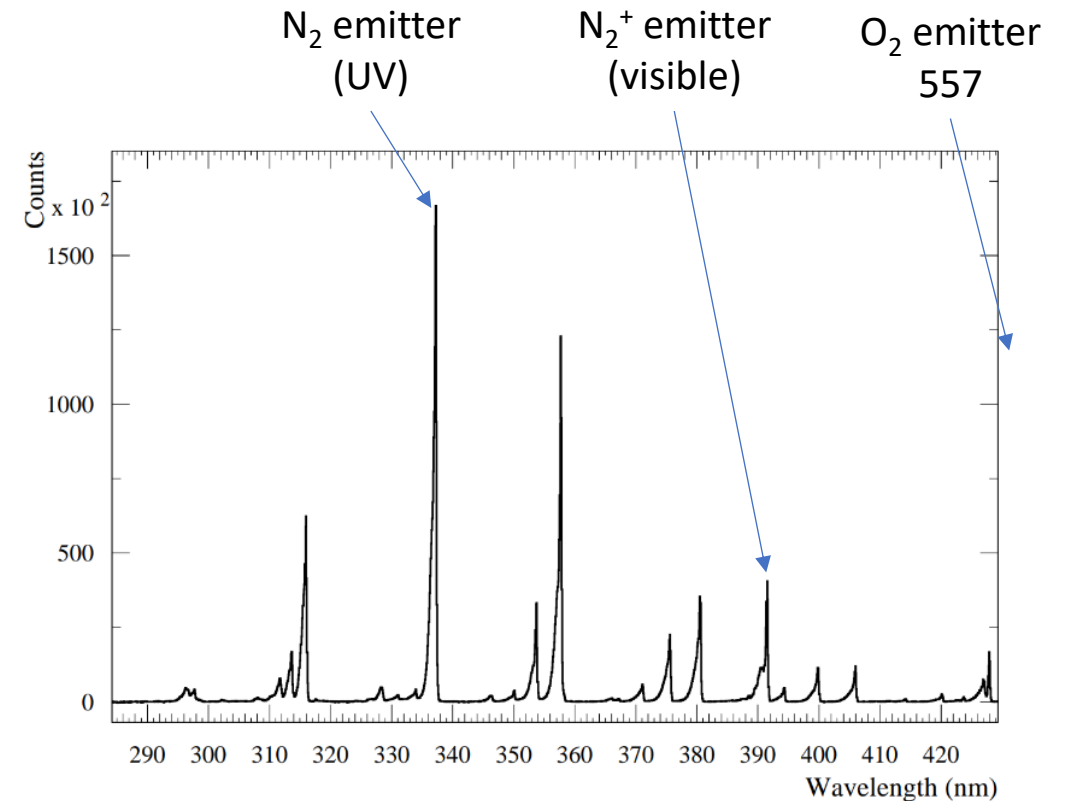


Chamber and support structure



Air fluorescence monitor

- Beam interacting with any gas results in the excitation of gas atoms which yield fluorescence during radiative de-excitation
- Medical beam inherently travel through air yielding fluorescence mainly coming from nitrogen.
- Emitting species can be both
 - N_2^{i+} : prone to space charge spread
 - N_2 : prone to thermal spread
- Line-intensity depends on the exciting species.

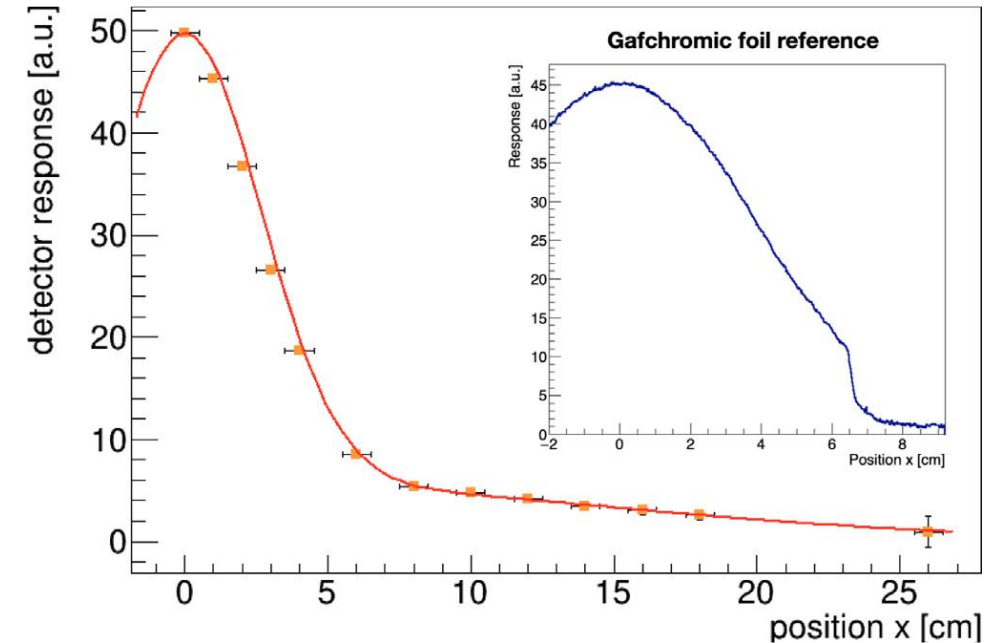
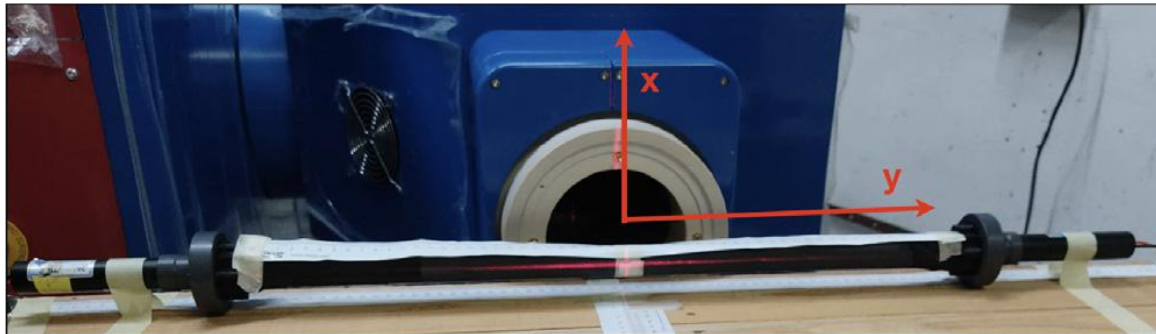


Fluorescence spectrum in Dry Air, (800hPa) from electron beam 200 MeV [a]

[a] M. Ave et al., Astro Particle Physics 28, (2007) 41, 57

Earlier works Antonio T. et al., NIMS PR-A1041 (2022) 167334

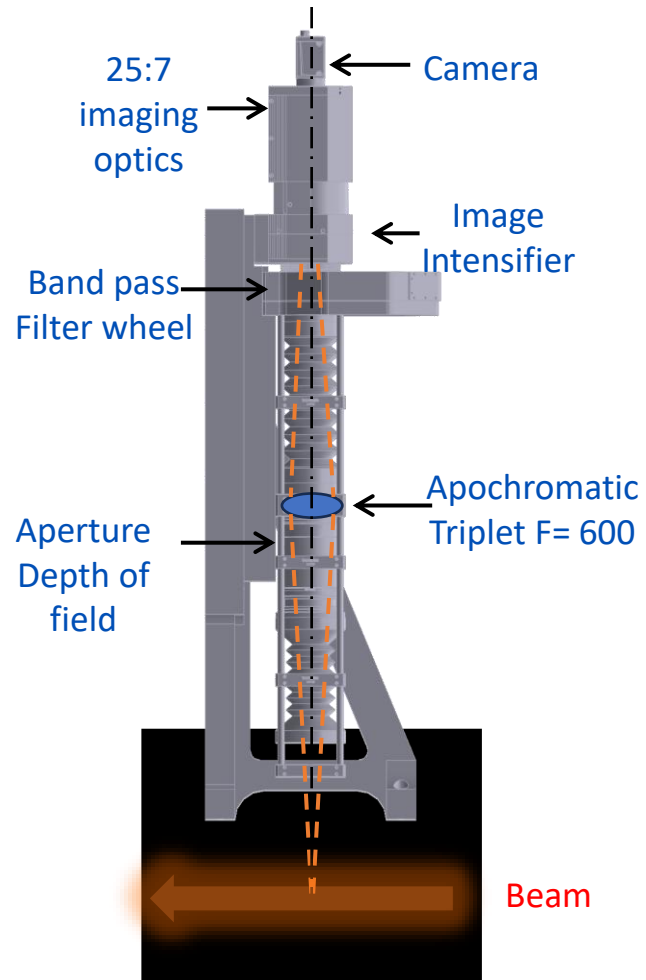
- Tested at FLASH dose rate (e⁻, 6 MeV, 10¹⁰ e/bunch at 10⁶ Gy/s) [a]
- Fluorescence yield from air enclosed in black Tedlar tube measured using APD.
- The tube scanned across the beam to reconstruct profile



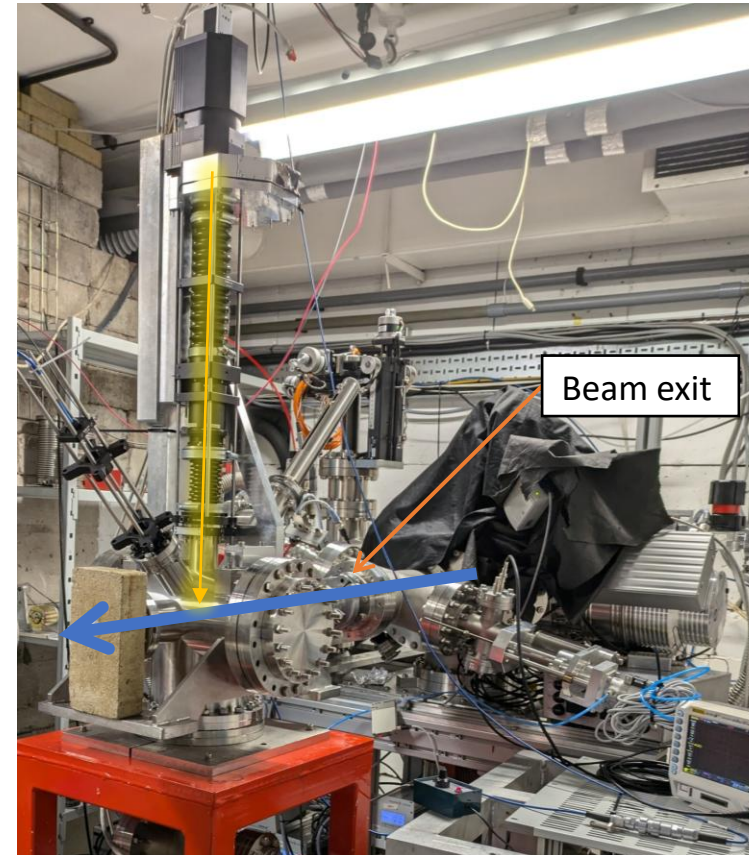
Comparison of the beam profile measured with tube (orange) with Gafchromic film (blue)

Prototype test:

POC measurements were carried out on MC 40 Cyclotron University of Birmingham

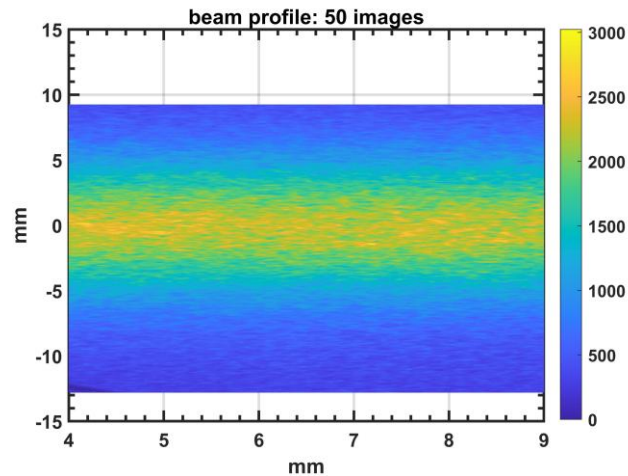
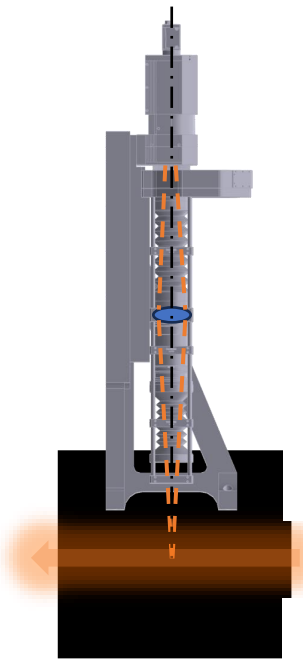


Blackened chamber open to atmosphere

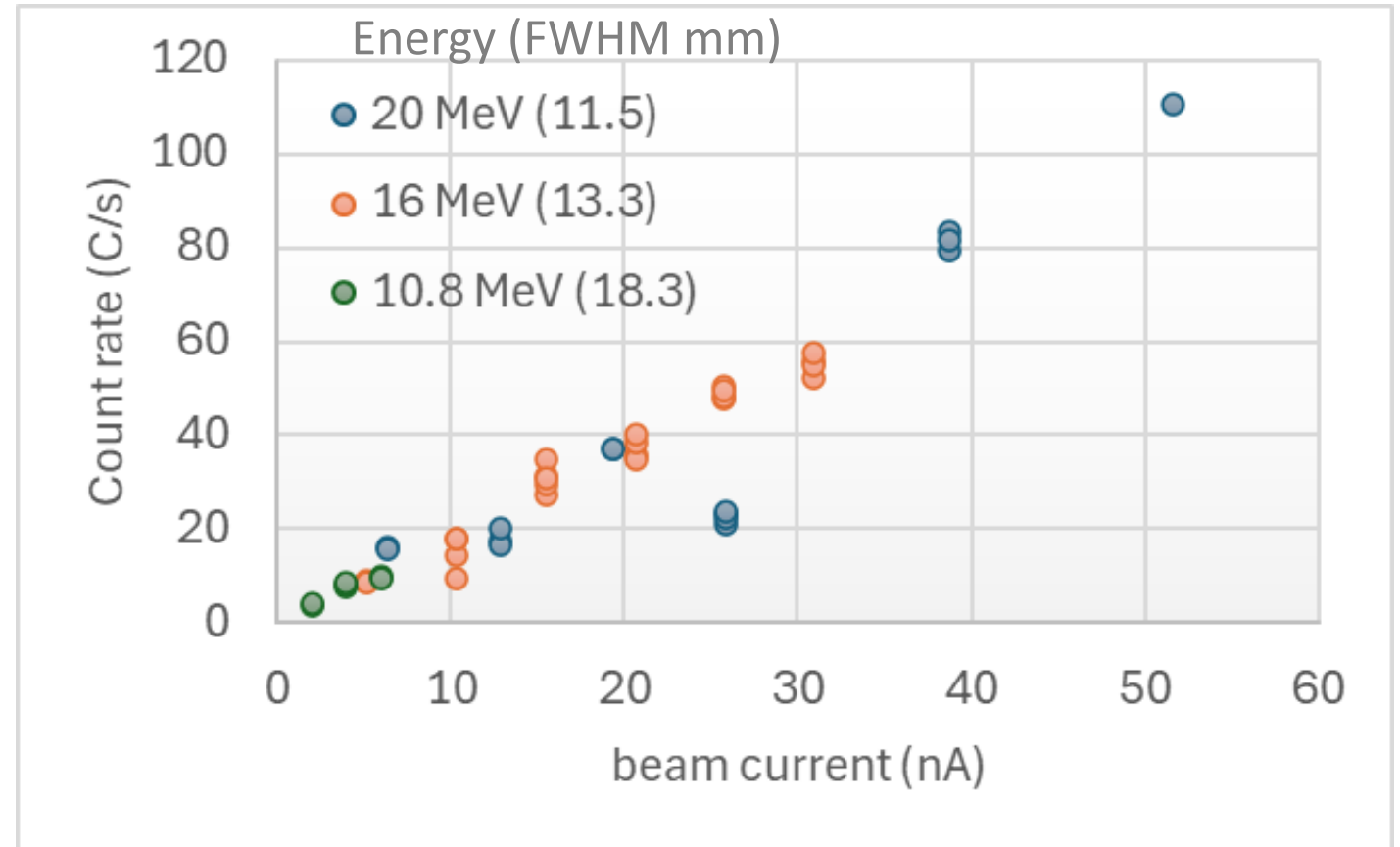
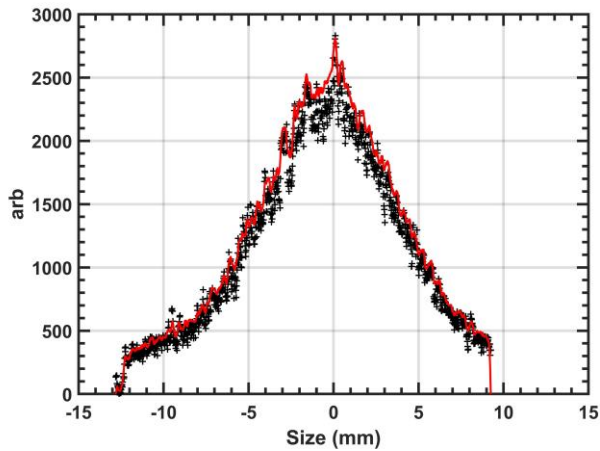


AFM installed at MC40 cyclotron (August 2024)

Test results (we got measurable signal)



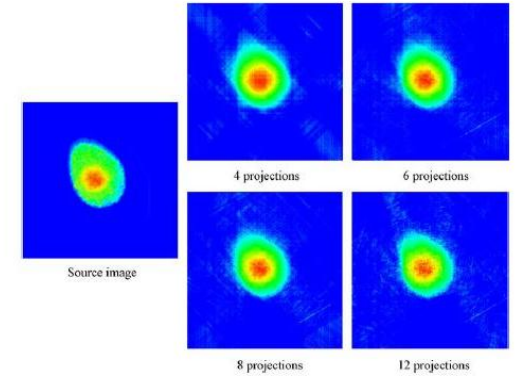
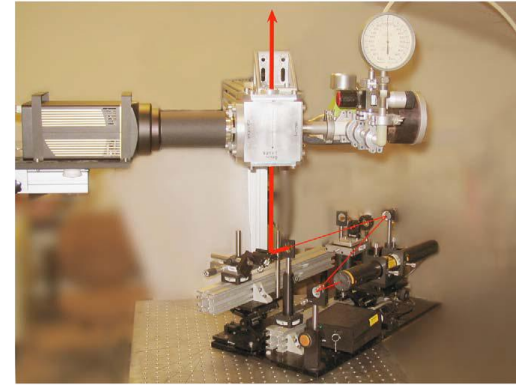
p+ @ 20MeV, 12nA, 100 ms



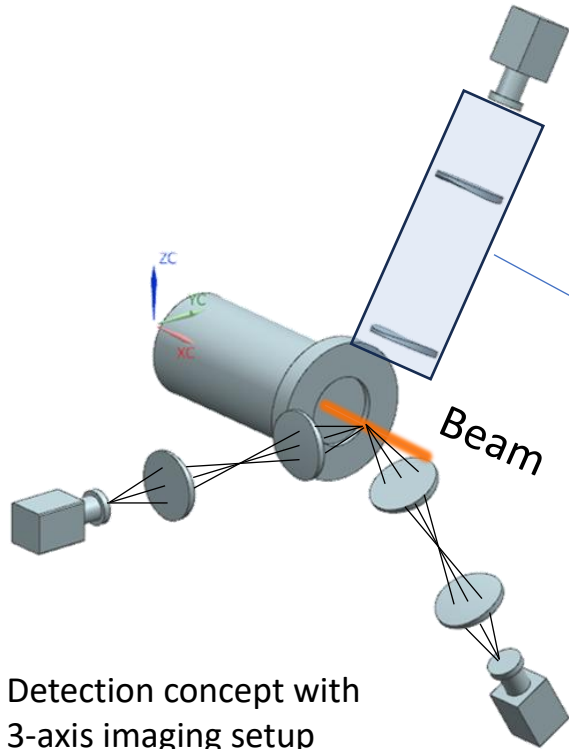
Count rate vs beam current for different energies linear within the measured ranges

Beam profiler concept

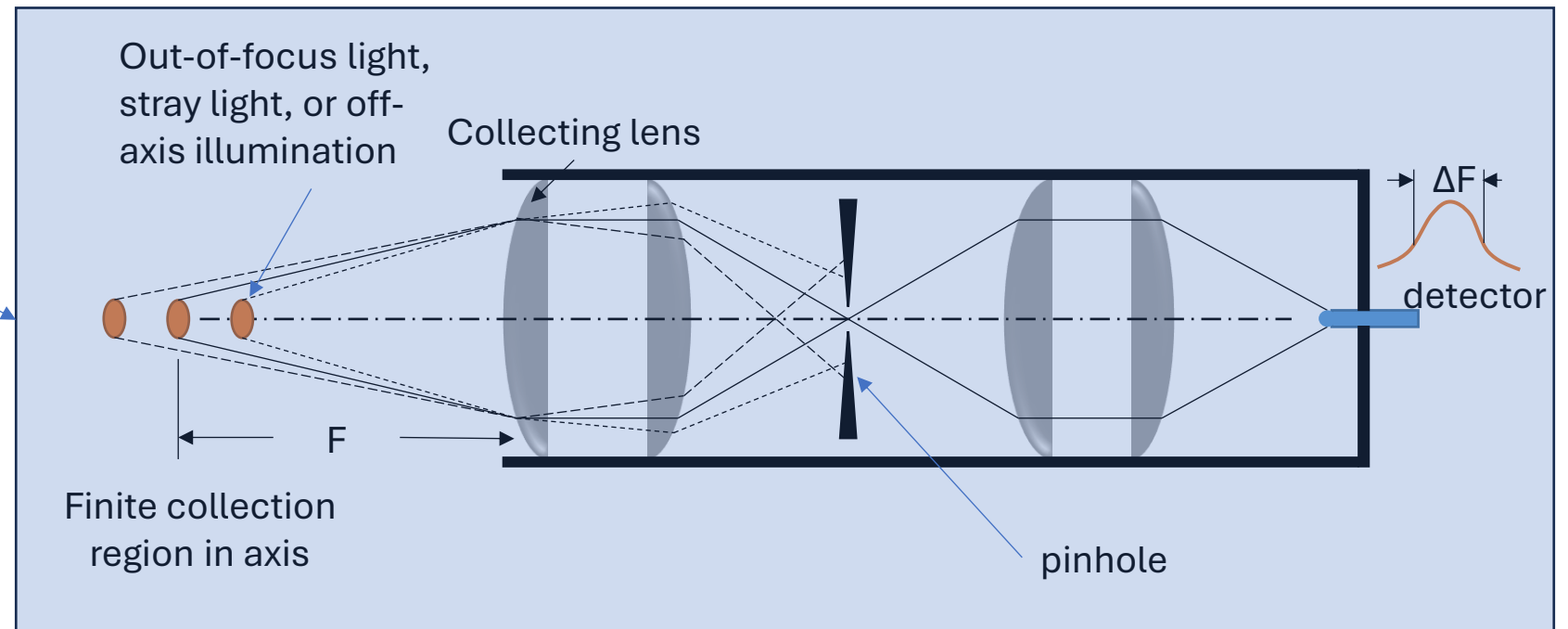
- Reconstruction of 2D profile from multiple 1D profiles
-> Already demonstrated in multiple publications
- Challenge: Remove the background from surrounding light
- Solution -> from **Confocal microscopy**



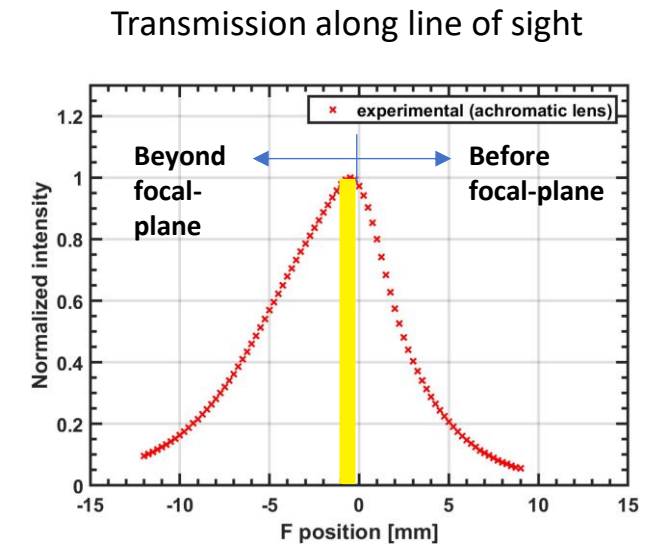
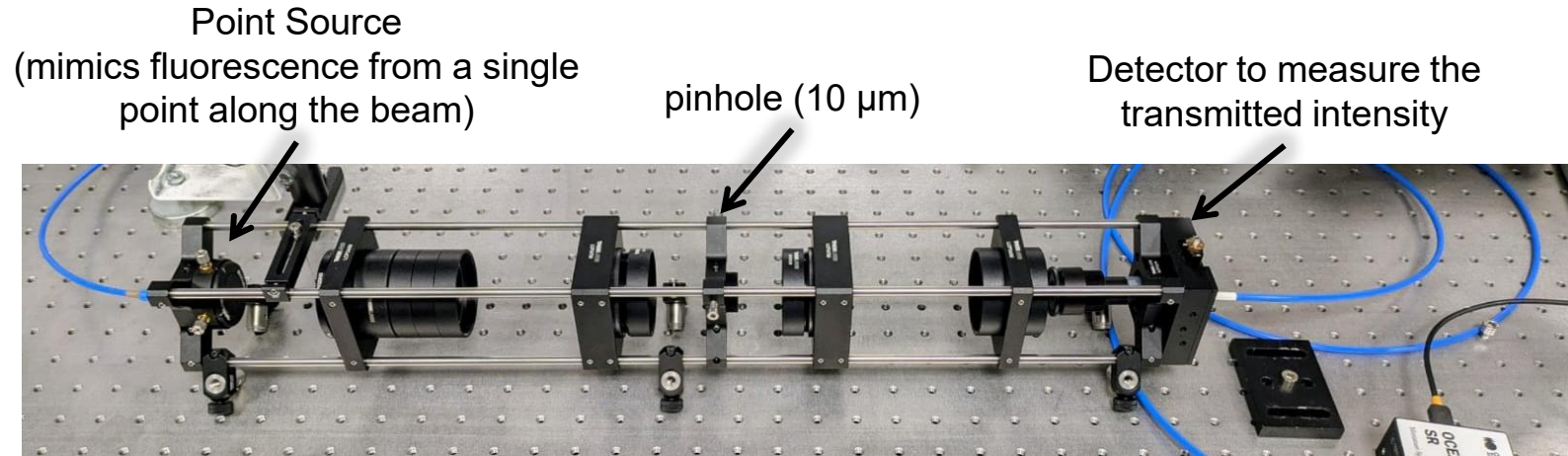
G.E. Belyaev et al. / Nuclear Instruments and Methods in Physics Research A 578 (2007) 47–54



Detection concept with 3-axis imaging setup

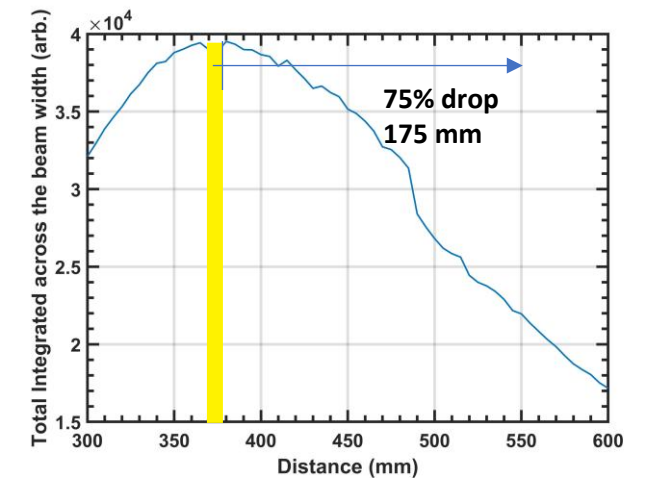
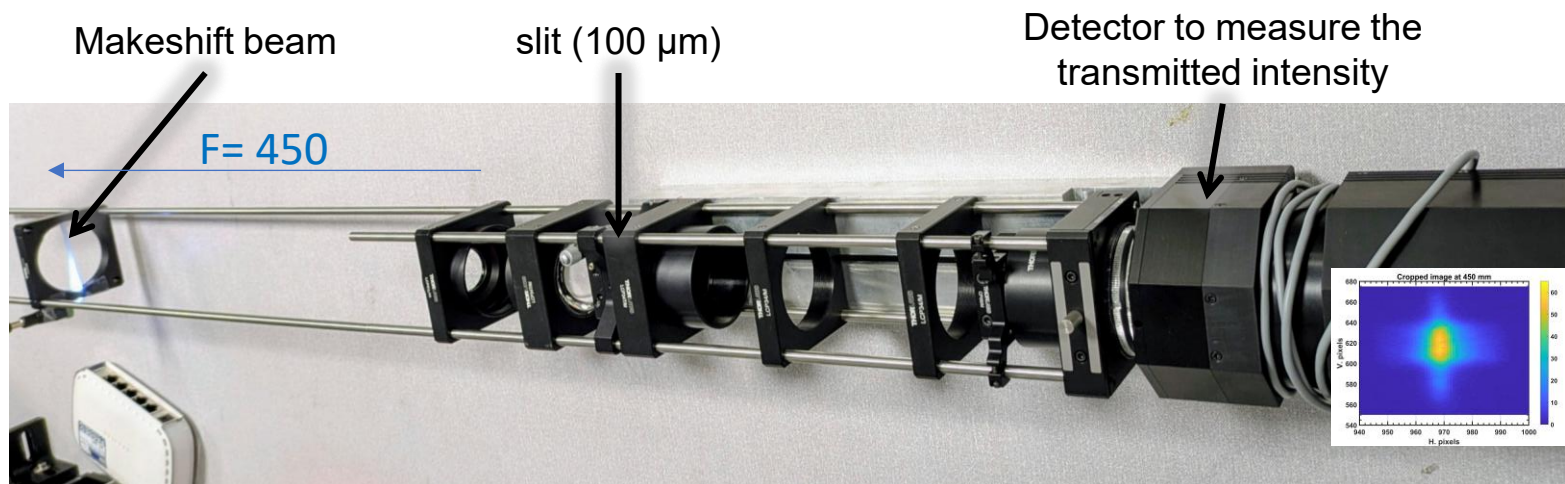


Background light filtering test



Orifice type (captures a single point in the beam path)

Slit Type (captures a line across the beam path)



Summary

Gas-Jet monitor (in-vacuum)

- We could observe a proton beam within the realistic time frame with **non-measurable perturbation***.
- Total Count /100ms (count rate) is linear with the beam current within the measured range of beam current.
- More sensitive to high instantaneous beam current

Air fluorescence monitor (outside the vacuum)

- High quality signal in real time – no hard installation – no perturbation beyond what's already there.
- The counts (count rate) is linear with the beam current within the measured range.
- Our **numbers suggest it can provide shot to shot beam current and profile^x** for SCAPA like beam (**10^9 ions ,1sq.mm**) **but that needs to be tested.**

* W. Butcher et al. (manuscript submitted to instruments)

^x Assuming same SNR as that of the UOB measurement.