Novel end-station development

Diagnostics for LhARA

Milaan Patel

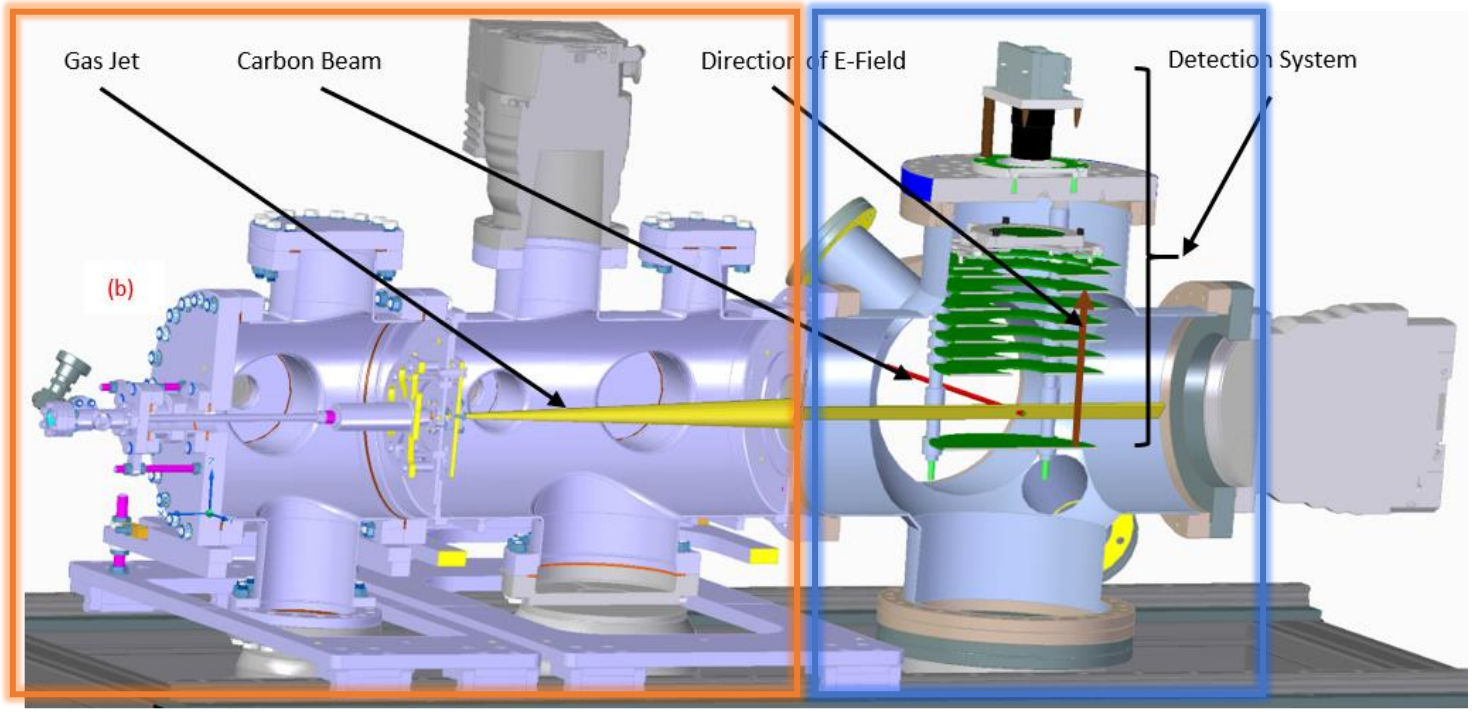
Research Associate

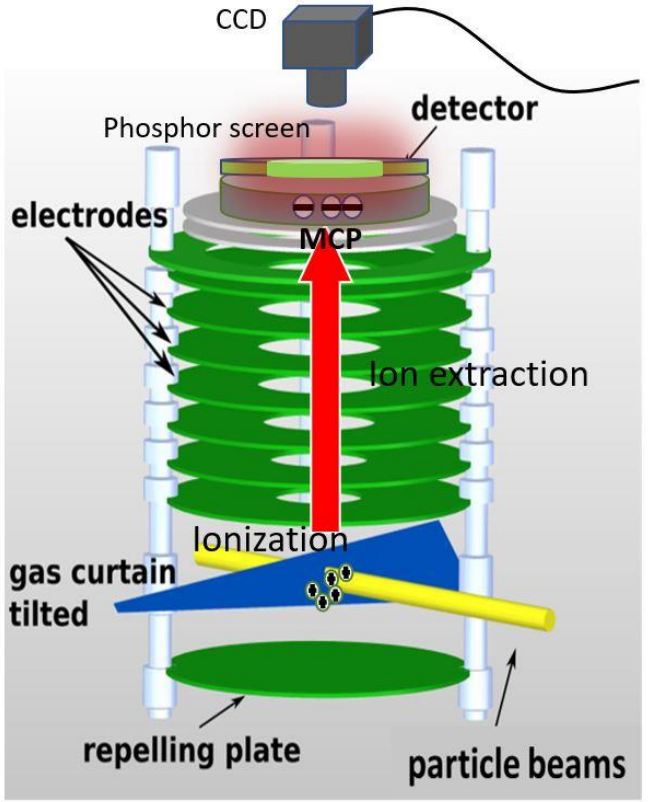
University of Liverpool

Supersonic gas curtain - Ionization profile monitor

SGC
(gas dynamics)

IPM
(beam physics)





Summary of upgrades

Sensitivity: DCF experiments (Aug 2023)		
Curtain	**28MeV C5+**	
Argon	~ 5.0 x 10^7	ions/ sq.mm
Nitrogen	~ 1 x 10^8	

🡐Additional gain by a factor of ~500 is required for single bunch detection

	Gain improvement	
	pessimistic	**optimistic**
QE P43	1.2	1.4
MCP Double chevron	100	1000
Effective ions extraction	1	1-4
curtain thickness	2	5
curtain density	2	5
	480	49700

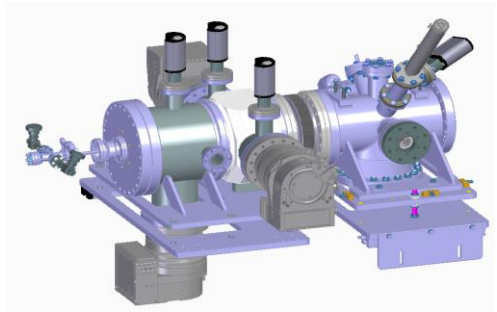
🡐 Installed

Tested at UOB experiment
Aug 2024

🡐 extraction system design (in progress)

🡐 Gas jet section (factor of 7.5 achieved)

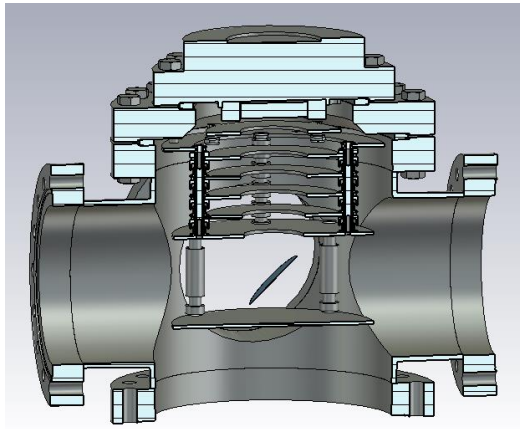
Simulation studies
(25-50% size reduction)
[M. Patel et al, in Proc. IPAC'24 WEPG097]

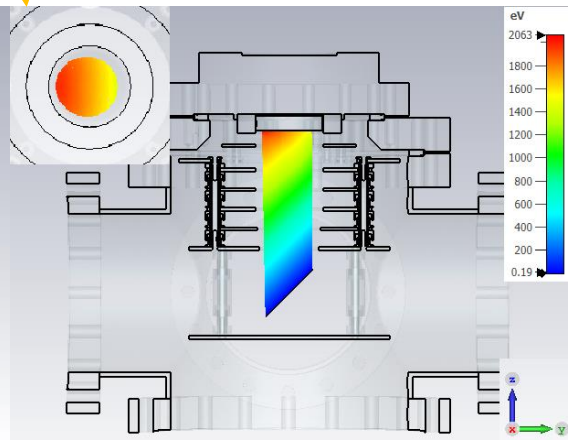


New design
(funded by BGC project)

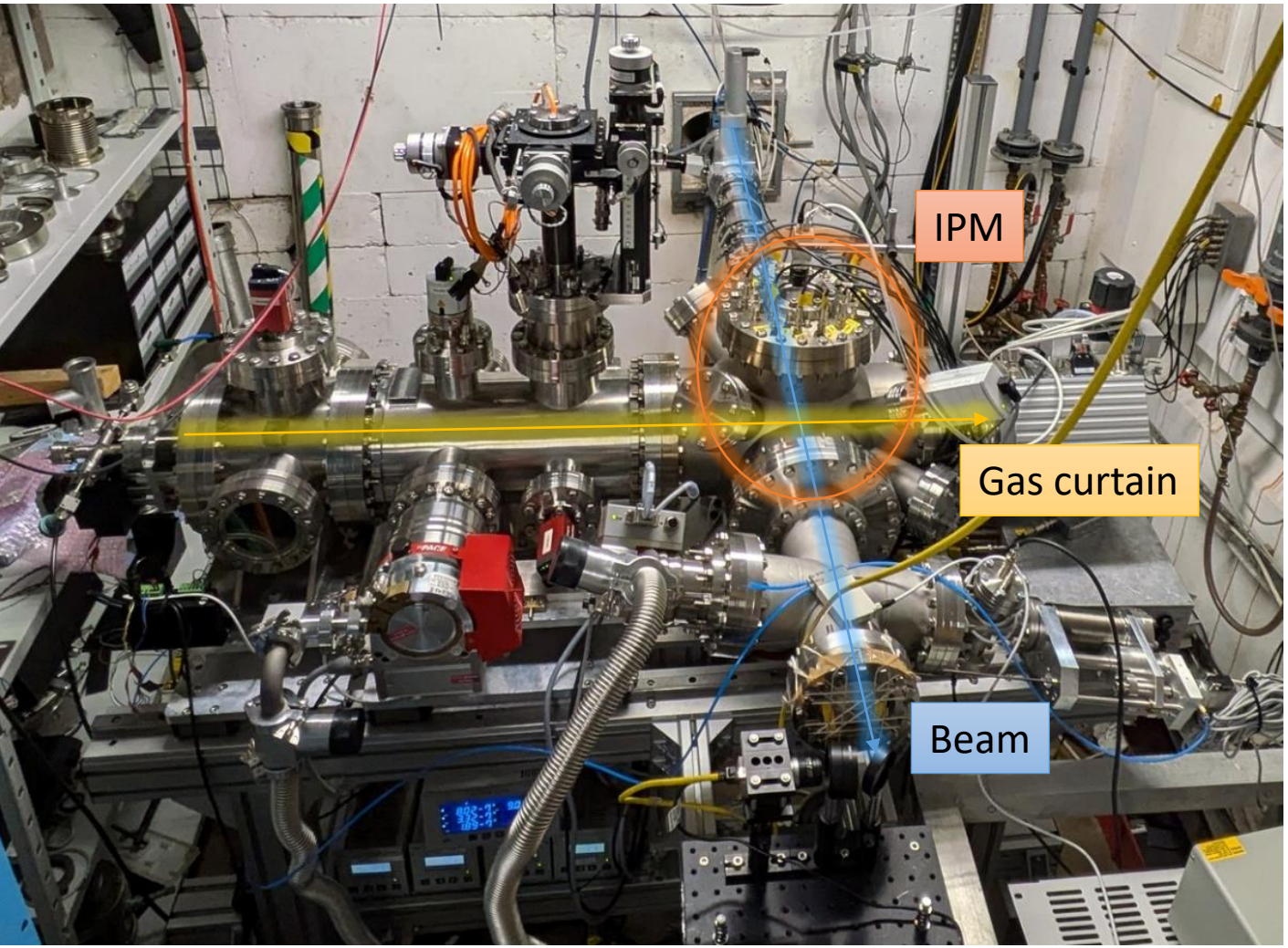
Decides Size

End station requirement





Proton beam profile measurements, UoB

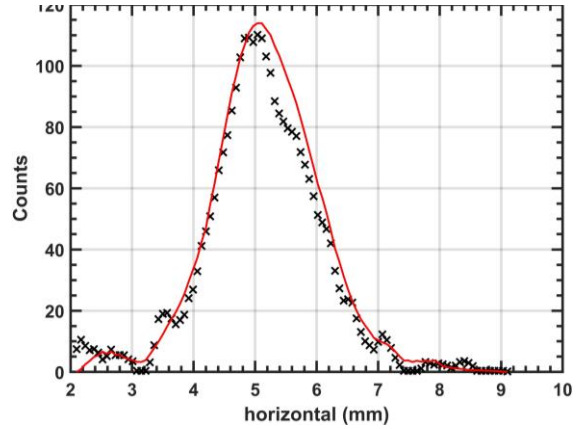


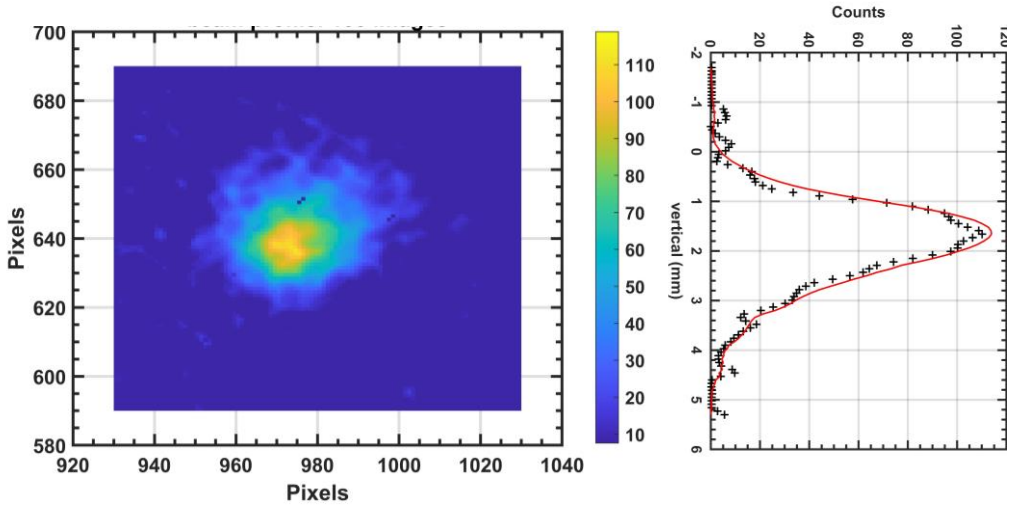
	beam current (nA)							
	~2	~7	~12	~18	~20	~25	~30	
28 MeV	500 750 990	250 500 750	250 500 750	250 500 750	100 250 500			Nitrogen
28 MeV	750	500 750 990	250 500 750	250 500 750	200 500			Argon
20 MeV	500 750 990	500 750 990	250 500 750 990	250 500 750 990		100 250 500	200 500	Argon
16 MEV	500 750 990	250 500 750 990	250 500 750 990	250 500 750		100 250 500		Argon
10.8 MeV	750 990	500 750 990	750 990					Argon

Integration time (ms)

Profile measurements (gain improvements)

UOB: 28MeV, 12nA, 500ms, FWHM-2mm

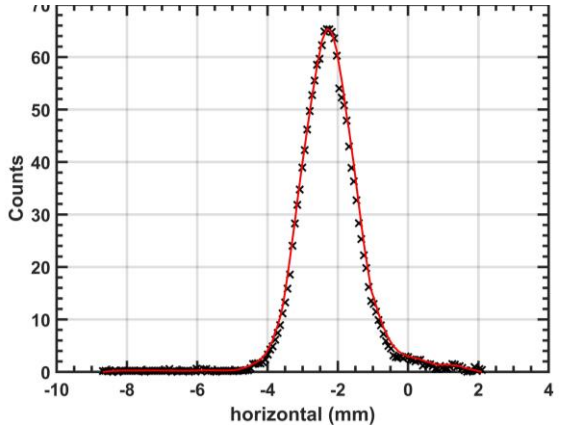


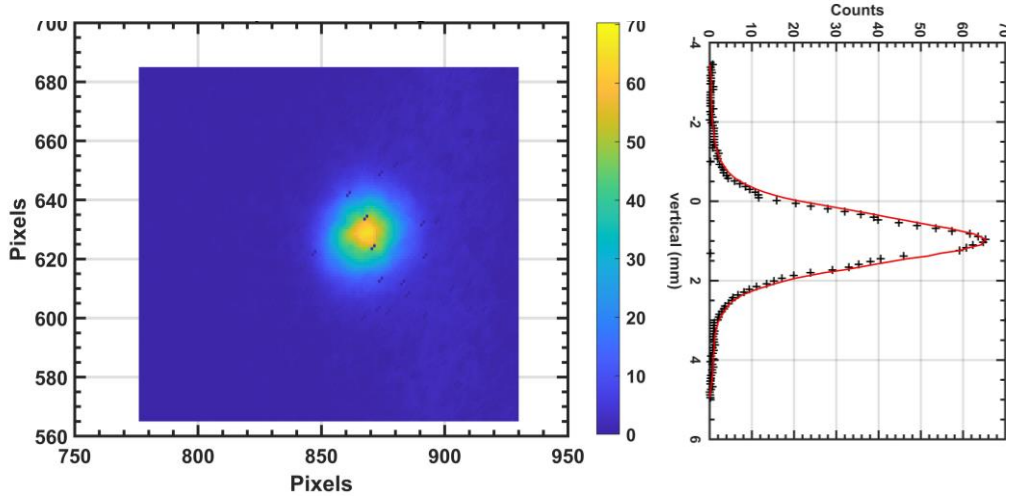


2x counts with ½ the integration, for 1/10th of beam current and ½ current density.

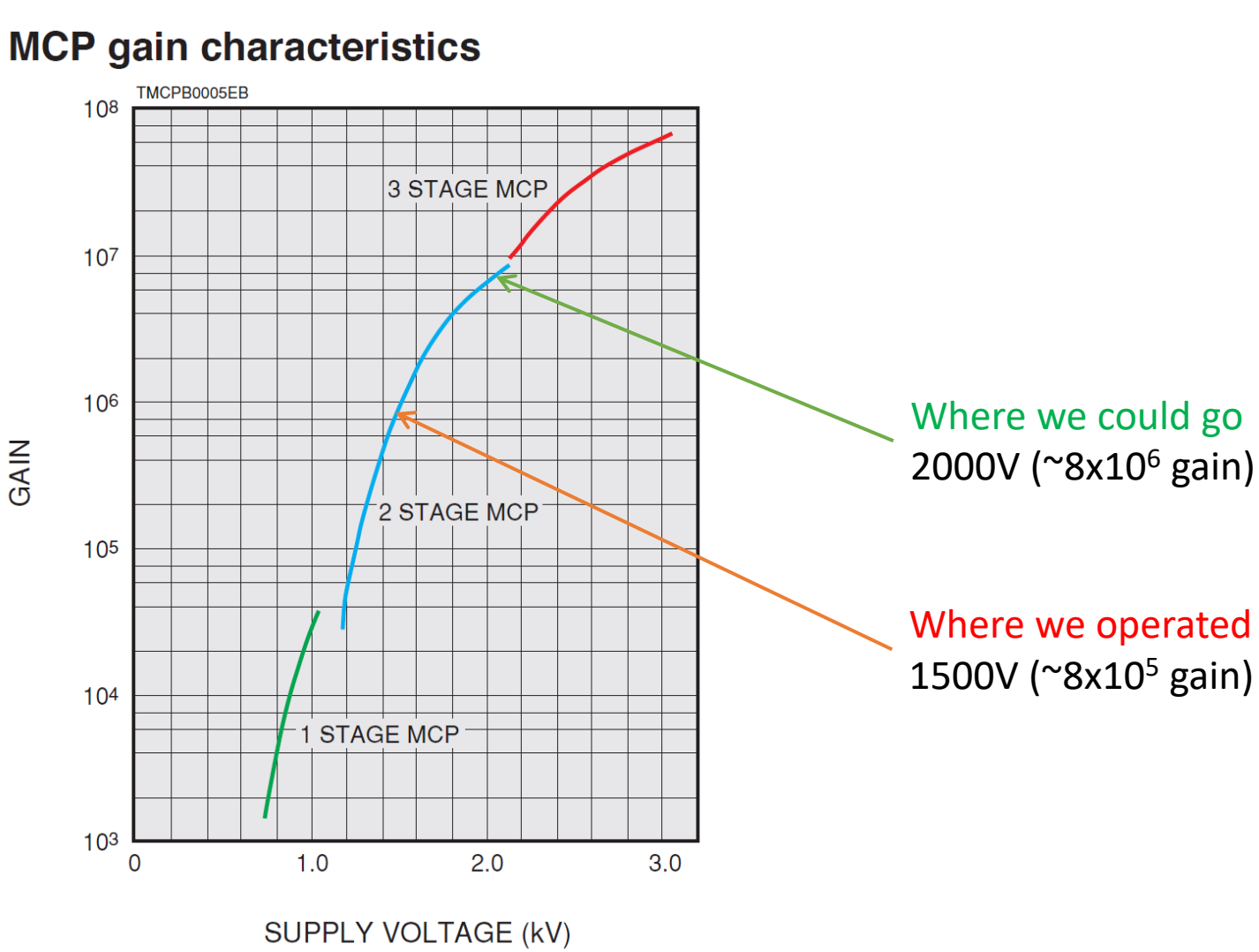
Improvements factor of ~80

DCF: 4MeV, 123nA, 1s, FWHM 1.5mm



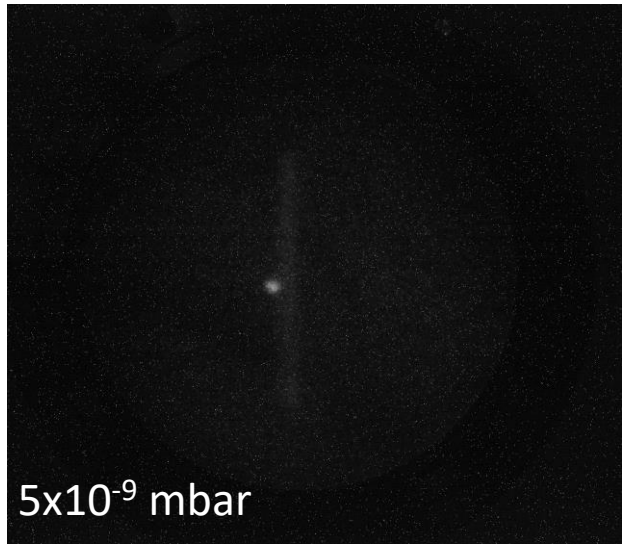


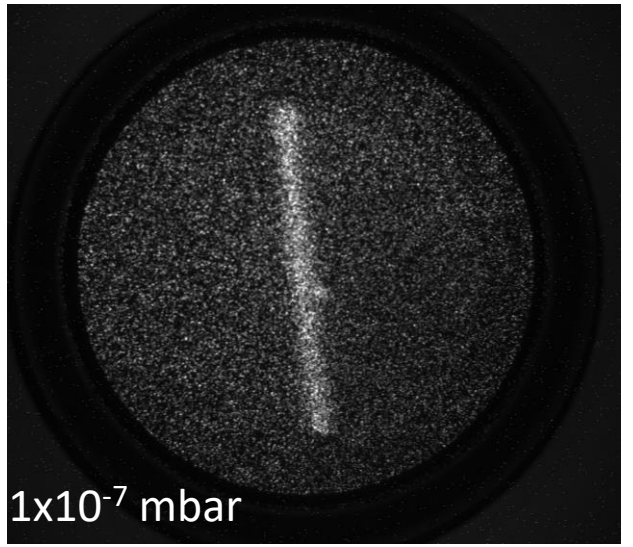
Vacuum level matters



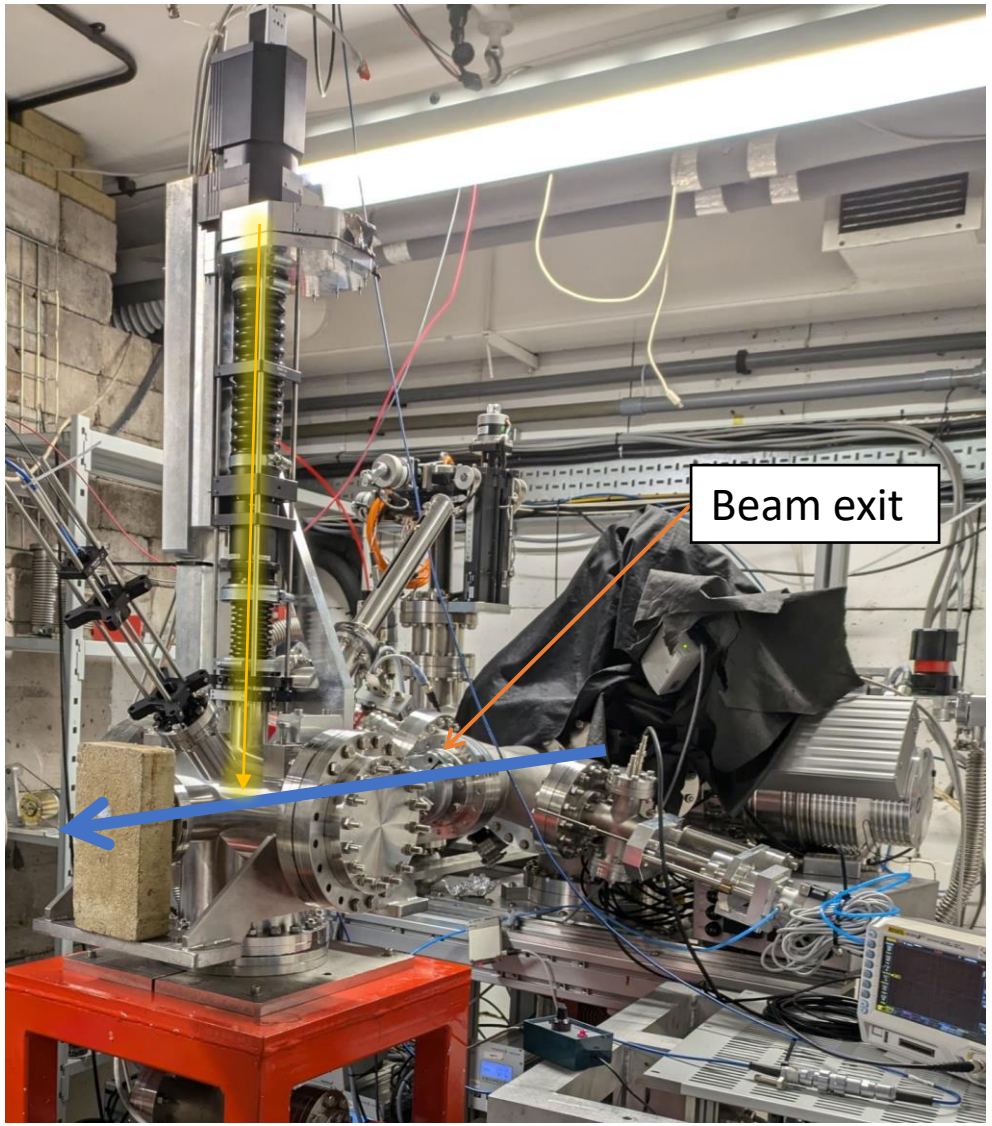
Where we could go
2000V (~$8x10^6$ gain)

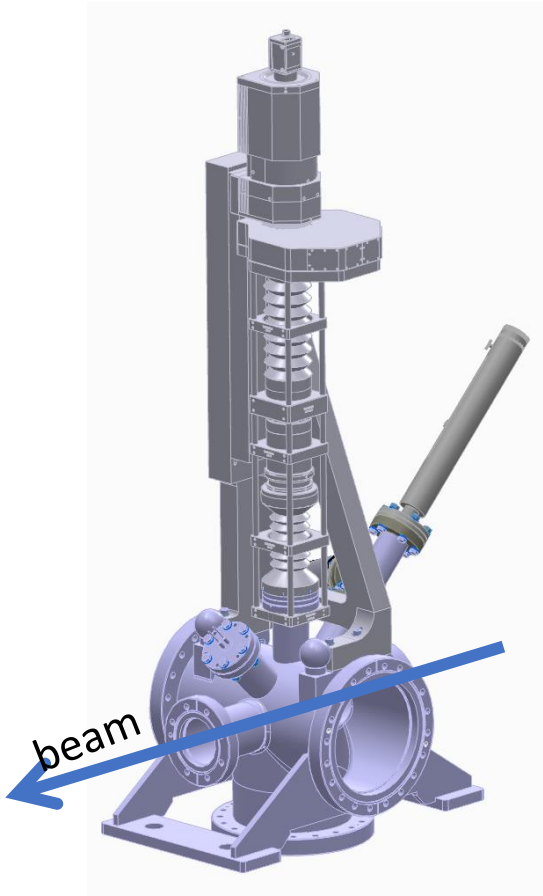
Where we operated
1500V (~$8x10^5$ gain)



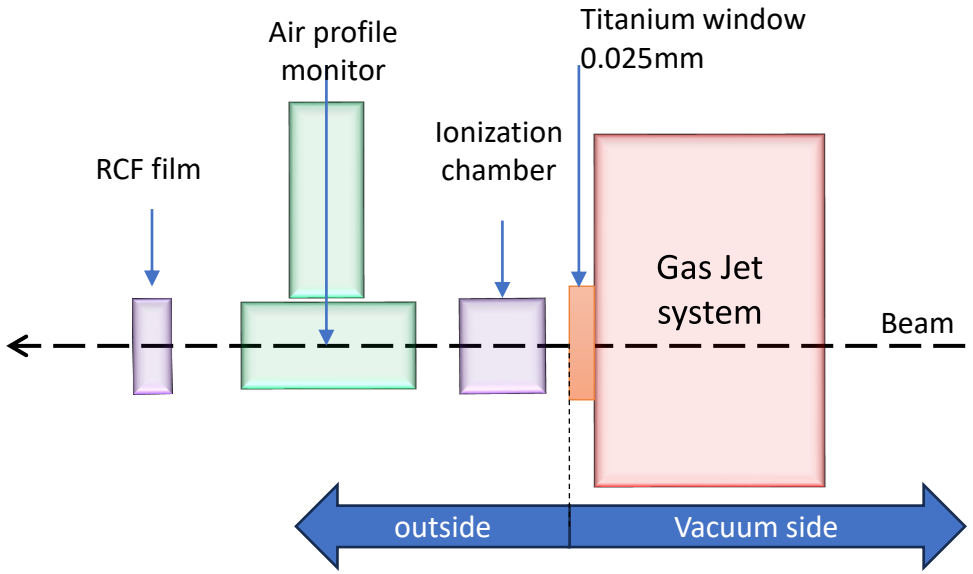


Measuring the beam profile outside beam window

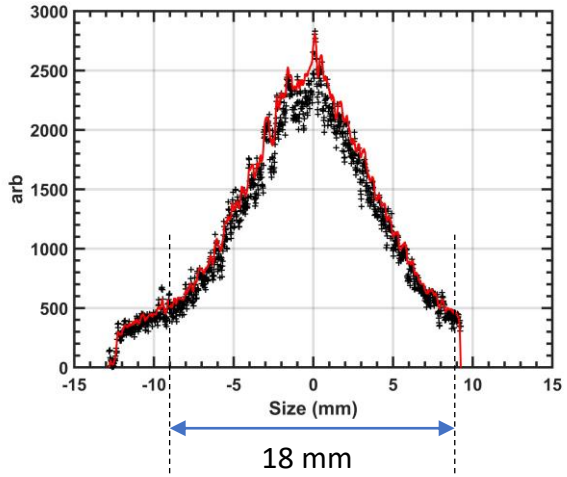




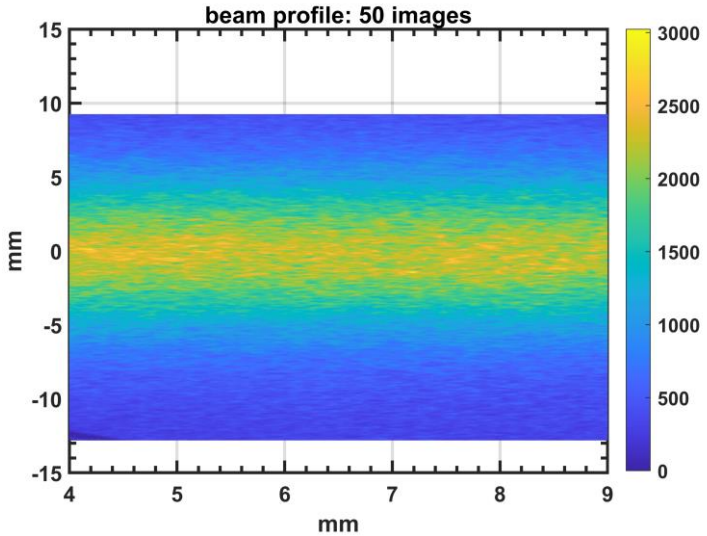
Beam profile measurement and size comparison

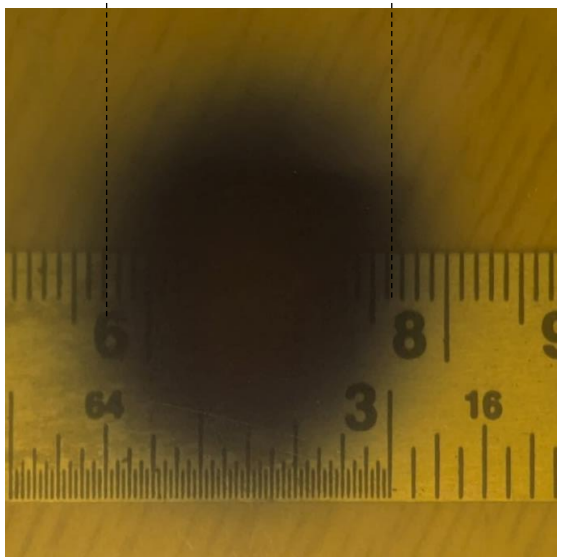


20MeV, 12nA, proton beam
100 ms integration
(*All images have same scale*)



18 mm





RCF film

Summary

Ionization Profile Monitor:

- Measurements taken at UOB for proton beams (10.8, 16, 20, 28 MeV) with beam currents of 2-30 nA.
- Increase in the gain by a factor of 80 (10 bunches of LhARA beam).
- Additional gain of factor 10 through the detector, and a factor of 7.5 through gas jet is possible.
- Detailed analysis of additional data is being carried out.

Air Profile Monitor (tentative name):

- New device tested to measure beam profile outside the vacuum and compared with RCF films.
- Beam profile measured at 10Hz (100ms) for ~12 nA @28 MeV in first POC measurements.
- Currently 1D, with potential scaling to 2D.
- Detailed analysis of the data is underway.

Thank you

Thanks to Narender Kumar, Farahana Thesni, William Butcher, Hao Zhang and Carsten Welsch for their contribution and support during preparation and experiments.
Tony and the MC 40 operation team for the support during experimental campaign.