



# Laser-driven Proton Beam Therapy (WP4)

Carsten P Welsch

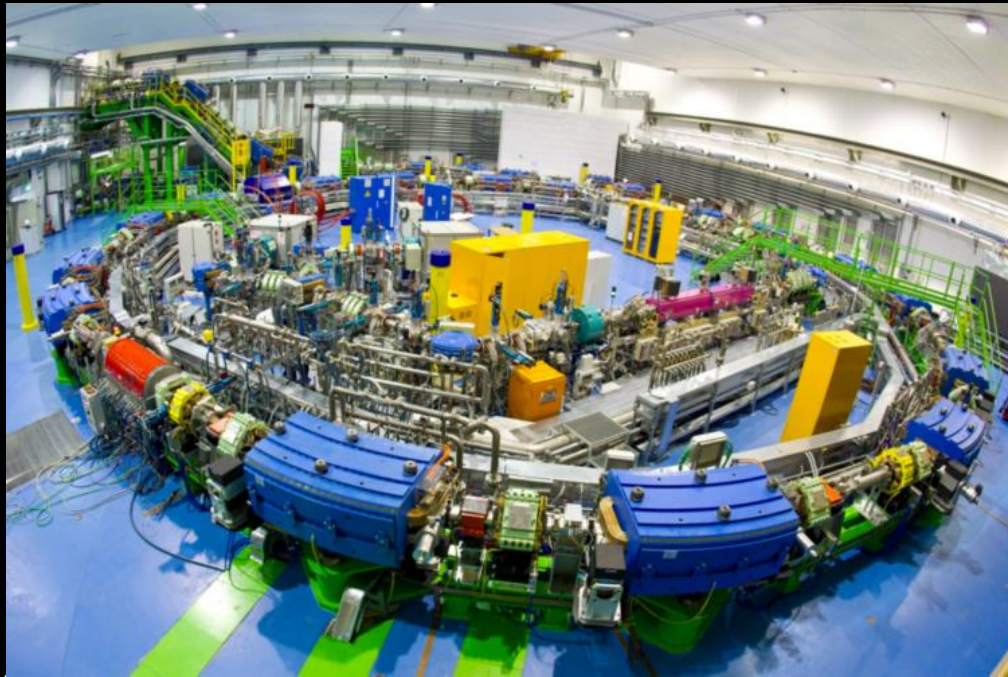
*University of Liverpool*

*The Cockcroft Institute*



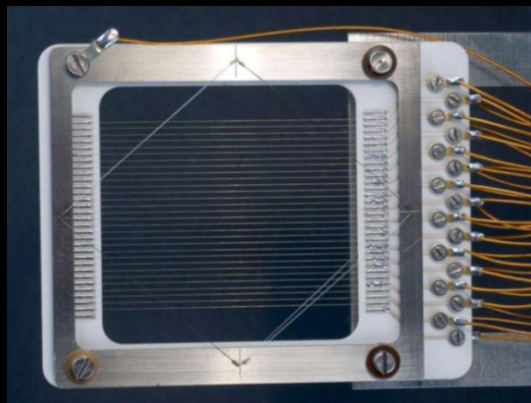
UK Research  
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# Hadron beam therapy

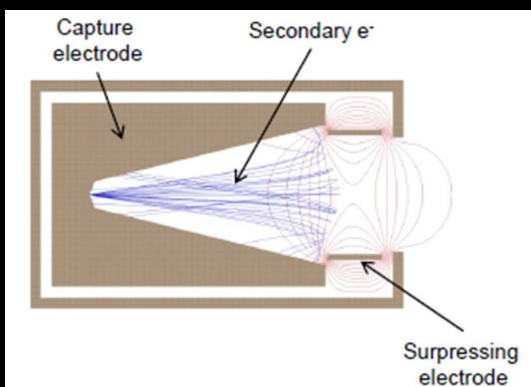


- **Clear healthcare benefits** for certain cancer types;
- **Significant investment** through NHS and private facilities in the UK;
- Optimization of Medical Accelerators (OMA) network **identified key R&D challenges:**
  - Significant time goes into Q&A
  - New technology solutions needed for novel treatment modalities such as FLASH, LhARA
  - Desirable machine operation modes not currently possible due to lack of non-invasive (online) diagnostics

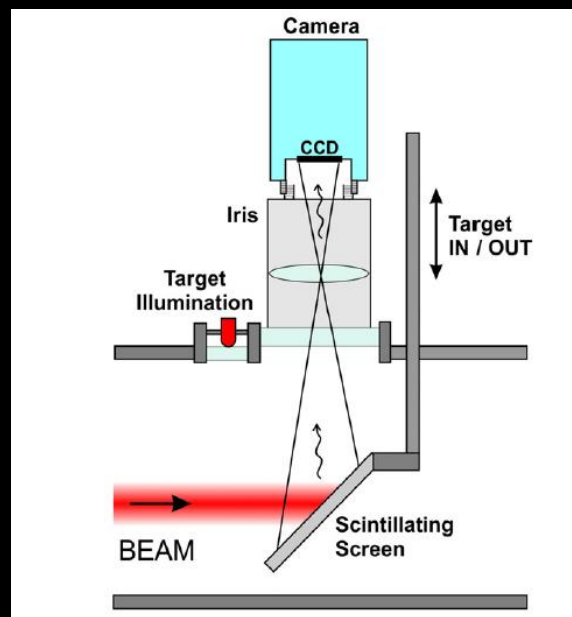
# Proton Beam Diagnostics - Overview



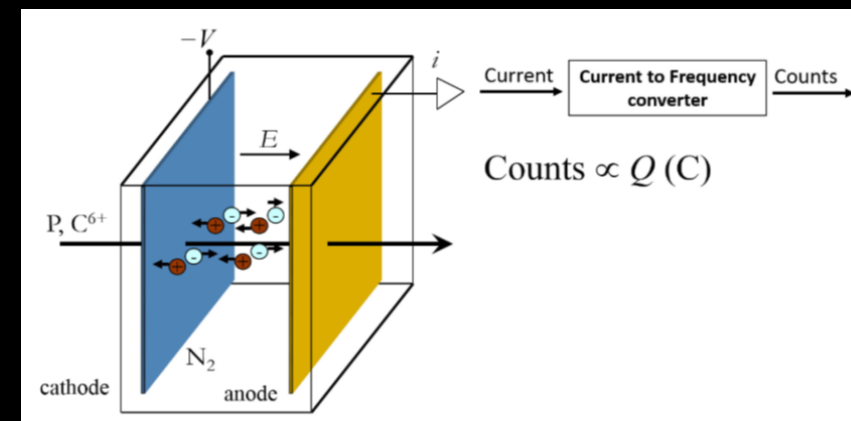
*SEM Grid*



*Faraday cup*



*Scintillating screen*



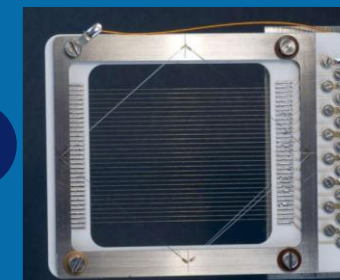
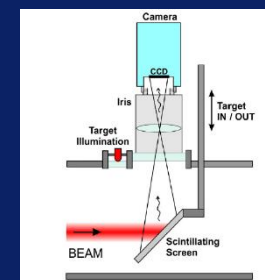
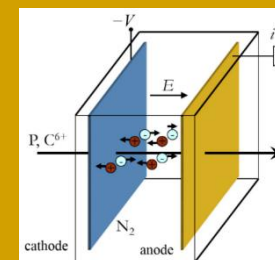
*Ionization chambers*

What, if we could simplify this a lot?

*Credit: B. Walasek-Höhne, GSI and G. Kube, DESY*

# Existing Diagnostics

- + High resolution
- + Reliability
- + Validity
- Interceptive
- Ongoing calibration
- Beam perturbation
- Limited live feedback



# Gas Jet Monitor – Innovative Solution

1

## Minimally invasive

- ✓ No beam perturbation
- ✓ Online monitoring
- ✓ Superior error detection

3

## Novel treatments and improved operation

- ✓ Enabling technology for FLASH and Mini-Beam treatments
- ✓ Active machine regulation based on live feedback becomes feasible



2

## Significantly reduced calibration time

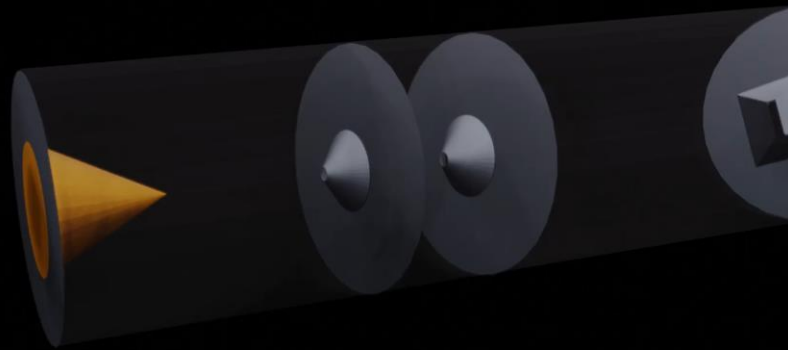
- ✓ No mechanical parts interact with the beam
- ✓ All key parameters monitored remotely
- ✓ Significantly reduced maintenance

N. Kumar, C.P. Welsch, et. al, *Physica Medica* 73, p 173-178 (2020).

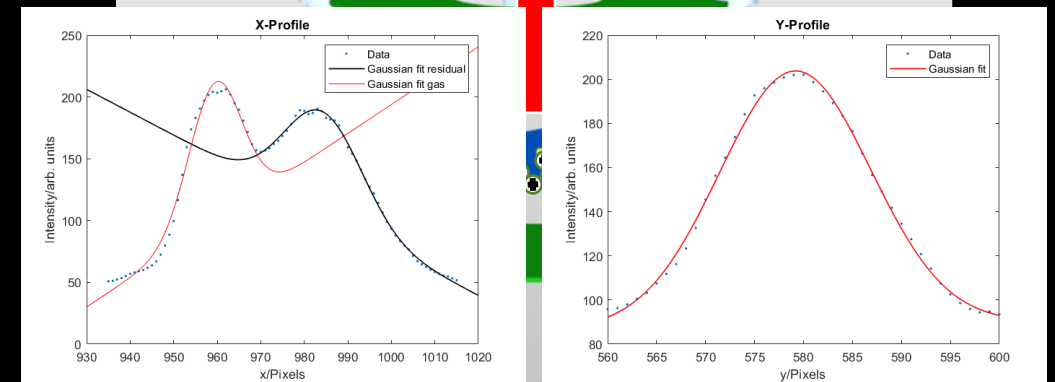
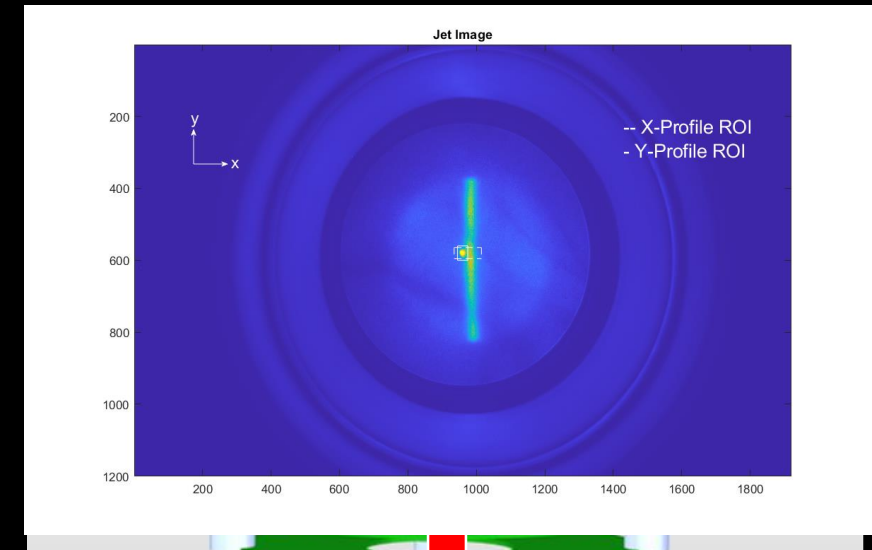
S. Jolly, C.P. Welsch, et al., “*Technical challenges for FLASH proton therapy*”, *Phys Med* 2020 – Galileo Galilei Award, best paper in 2020

“*Non-Invasive Gas Jet In-Vivo Dosimetry for Particle Beam Therapy*”, contributed talk at IPAC21

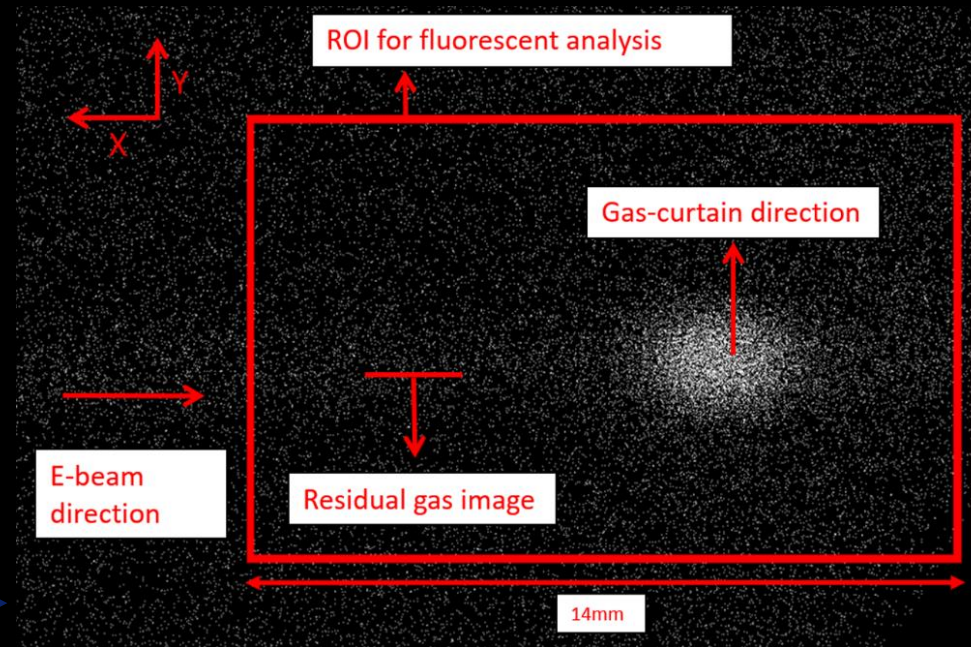
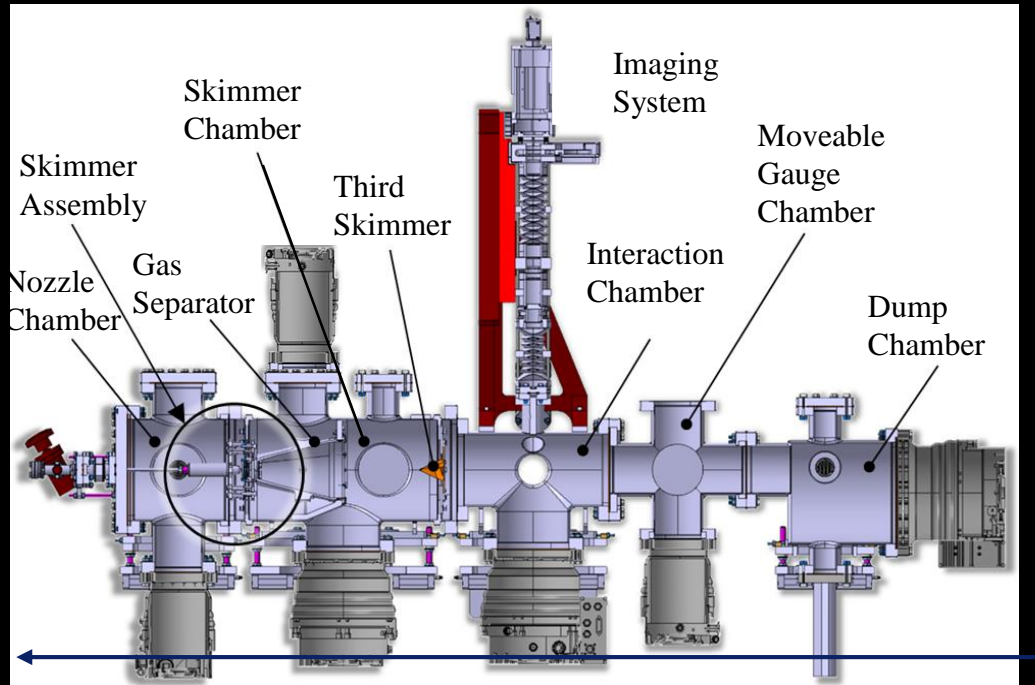
# Building up on previous R&D



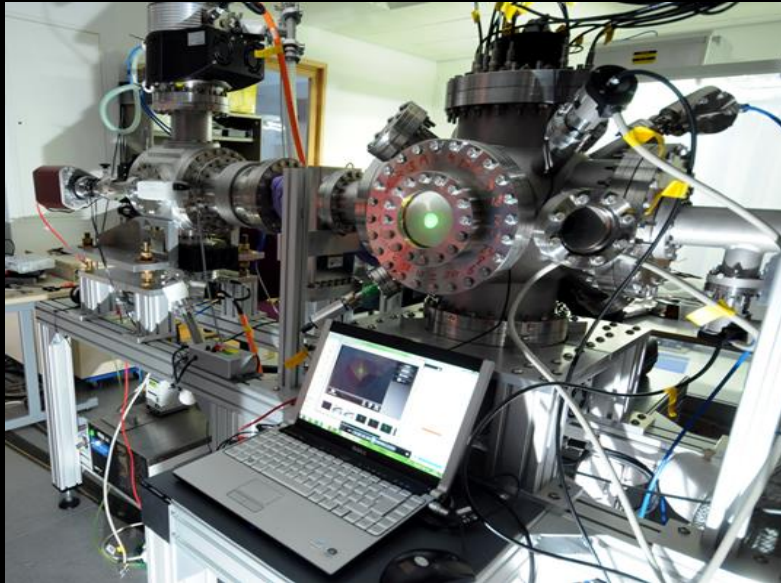
Gas jet shaping



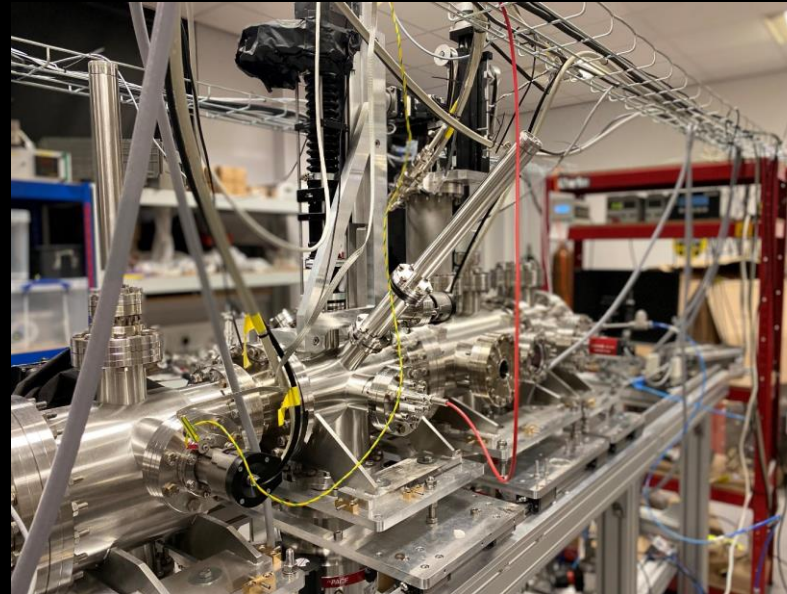
# Capitalizing on Pioneering Technology



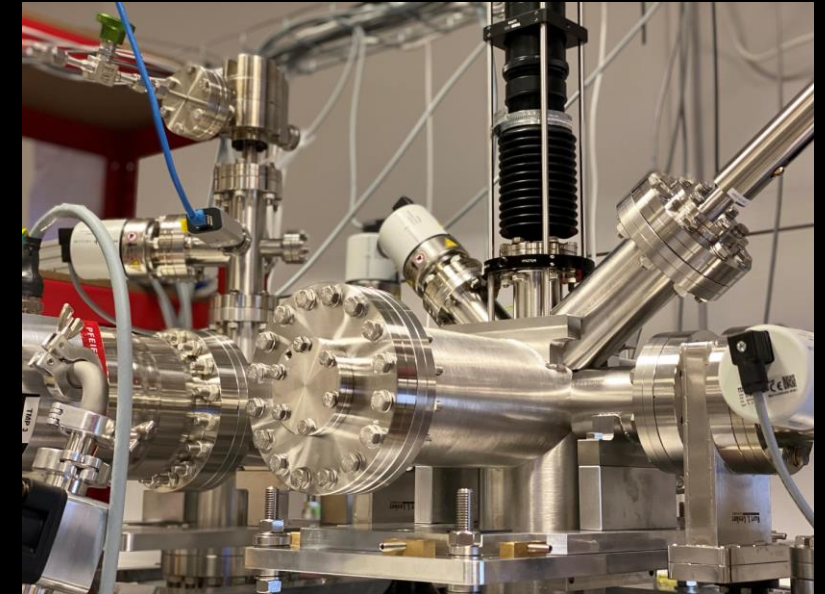
# Different Setups at CI



Monitor for keV beams



HLLHC prototype



HLLHC working instrument



# Optimized Design

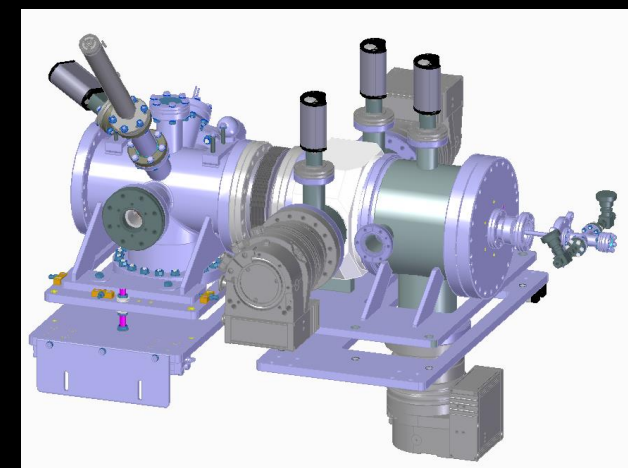
- More flexible design for nozzle skimmer assembly and tuning
- Compact system: total length  $\approx 1\text{m}$

- Postdoc recruited who will work closely with the Fellow
- Closely connected with LhARA targets and consortium
- Significant hardware funding available



N. Jumar, QUASAR Group

Prof Carsten P Welsch, EuPRAXIA Doctoral Network Kick-off Meeting, Brussels, 16/17 January 2023



# Project Overview

Fellow	Host institution	PhD enrolment	Start date		
DC7	ULIV	ULIV	6		
Project Title and WP(s) to which it is related: Laser-driven Proton Beam Therapy (WP4)					
Objectives: Study concepts for using a laser to drive creation of a large flux of protons or light ions; carry out beam physics and plasma simulation studies that target minimizing the beam's divergence, energy spread, and provide stable intensity pulse-to-pulse; adapt gas jet-based monitor design for the challenges found in laser-driven ion beam cancer therapy; develop design for online, shot-by-shot measurement of beam position, profile and intensity (M7, m36).					
Expected Results: Paper on layout of user beamline in EuPRAXIA for proton/ion beam treatment (D18, PDE, m30); Prototype monitor suitable for integration in beam line (D19, PDE, m42).					
Secondment(s): DBEAM <sub>12</sub> (monitor development and optimization, various), INFN <sub>4</sub> (beamline design, m18).					



# EuPRA~~X~~IA

## Doctoral Network



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101073480.



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