Science and Technology Facilities Council
Daresbury Laboratory

60 years 1962–2022

ITRF: WP3

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*Accelerator Science and Technology Centre

Emily Barrett PhD student starts Sept 2023

21st March 2023


SCIENCE+
INDUSTRY
MUSEUM
22 OCT 2021 –
MAR 2022
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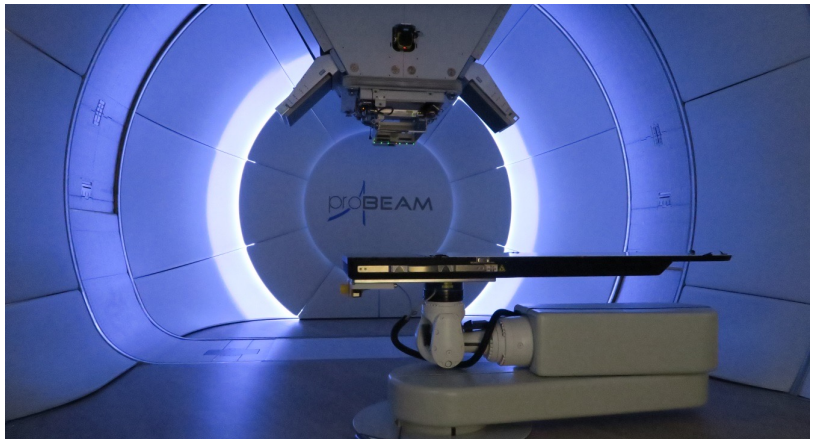
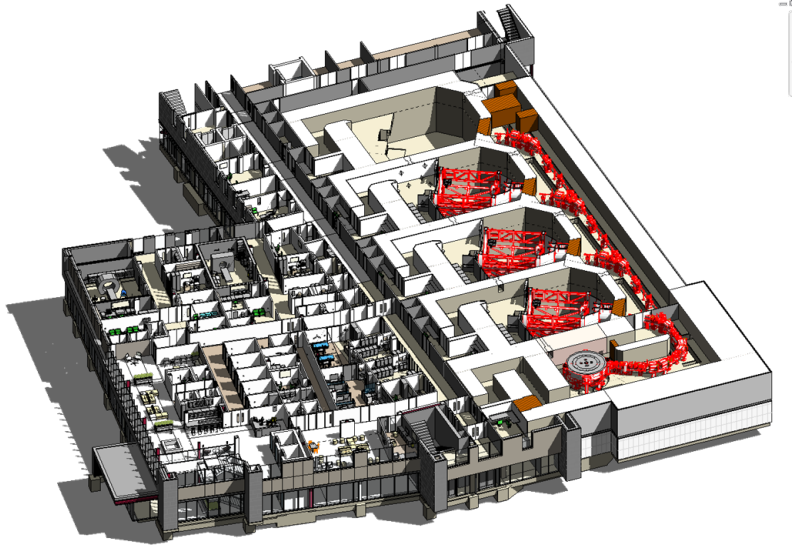
CANCER
REVOLUTION
SCIENCE, INNOVATION AND HOPE


proBEAM




PHILIPS


FRPT
FLASH
RADIOTHERAPY
& PARTICLE
THERAPY
2022


2021
SAVE THE DATE


FRPT
FLASH
RADIOTHERAPY
& PARTICLE
THERAPY
2023
TORONTO

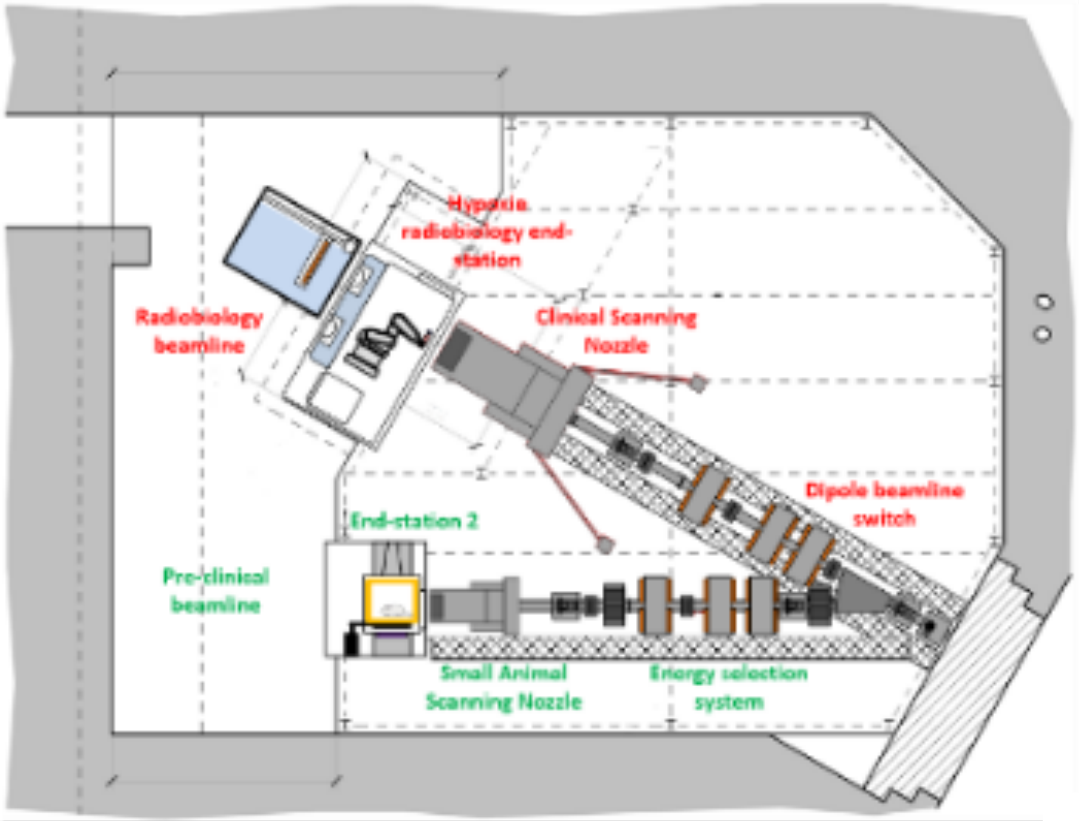
Facility requirements

- Establishing a community and finding out what they would use.
- Will need strong letters of support from the biology and clinical communities
- Develop a community who want to use ITRF and be prepared to travel to use it.
- Funding model, a facility would need to attract people in to use it to defray its running costs.
- It would need biology and animal house facilities nearby
- If you build it will they come?

Draft Requirements for a facility

- *In vitro*, high throughput 2D, 3D, range of plates that are commercially available (largely plastic) from 6 well- 340 wells for drug screening, range of Flask sizes…
- *In vivo* (mice, rats) high throughput, with imaging and able to mimic gantry movement
- Larger animals, companion animals?
- H, He, Li?, B?, C, O, Ne? (He really needs to be available, as there are clinical trials going on in this area)
- Spot scanning (3 cm x 3cm) *in vivo*, ideally 20 x 20 cm *in vitro*
- also single spots
- Able to penetrate 5-15 cm in tissue
- FLASH (> 40Gy/s using Folkert's definition with spot scanning / volume effect)
- Bragg peak FLASH
- Spatially fractionated, could use collimator but ideally using focussed spots to deliver

Research room: design



Mike Merchant

Mike Taylor

Hywel Owen

- Flexible design
- air changes
- cooling
- cooling water
- water wall
- gases
- Floor
- Water
- Electricity
- Earthing
- Radiation protection
- Infrastructure
- connections
- Beam lines
- End Stations
- crane
- Clinical nozzle

The Cockcroft Institute of Accelerator Science and Technology

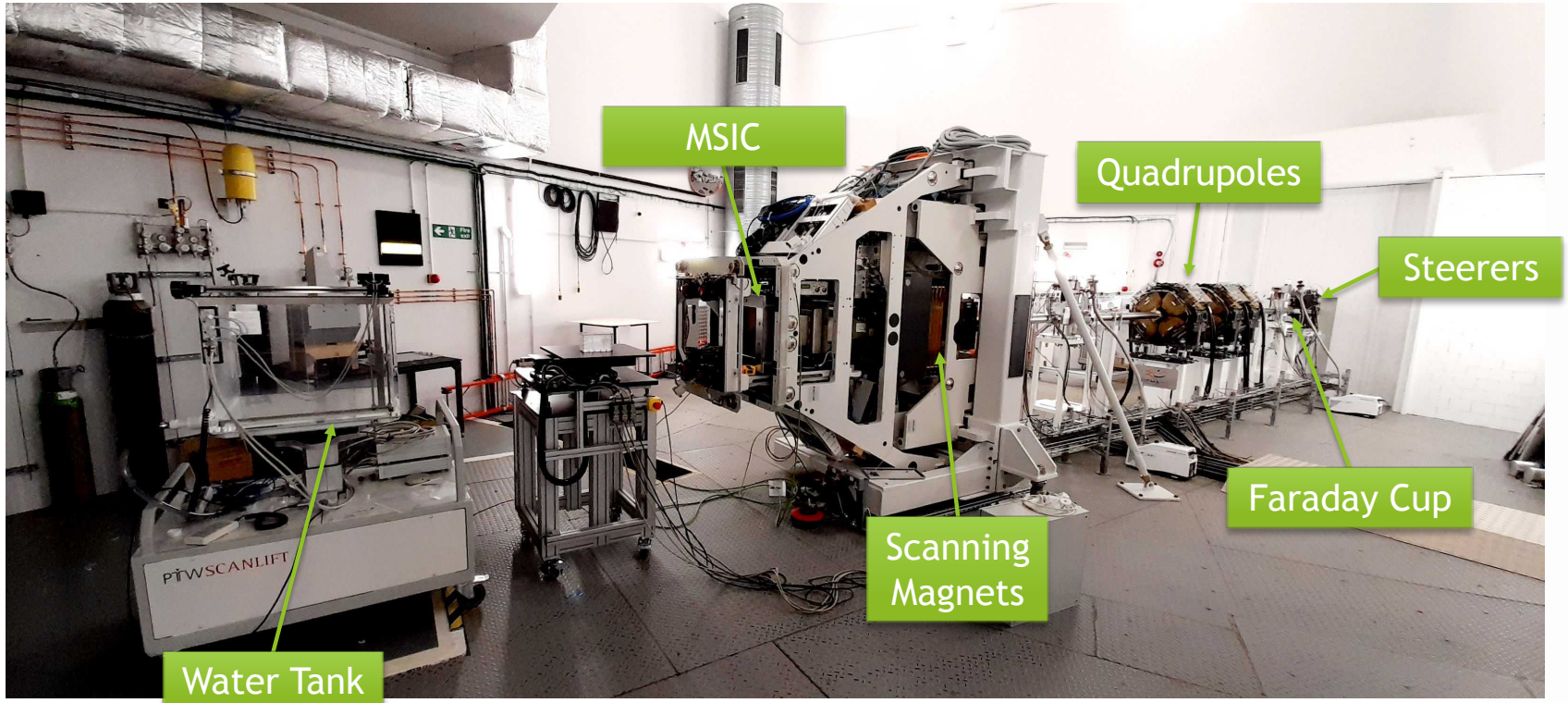
Science and Technology Facilities Council

Research room

https://www.youtube.com/watch?v=j2QR4PQvaeI

Building beamlines

Surrey

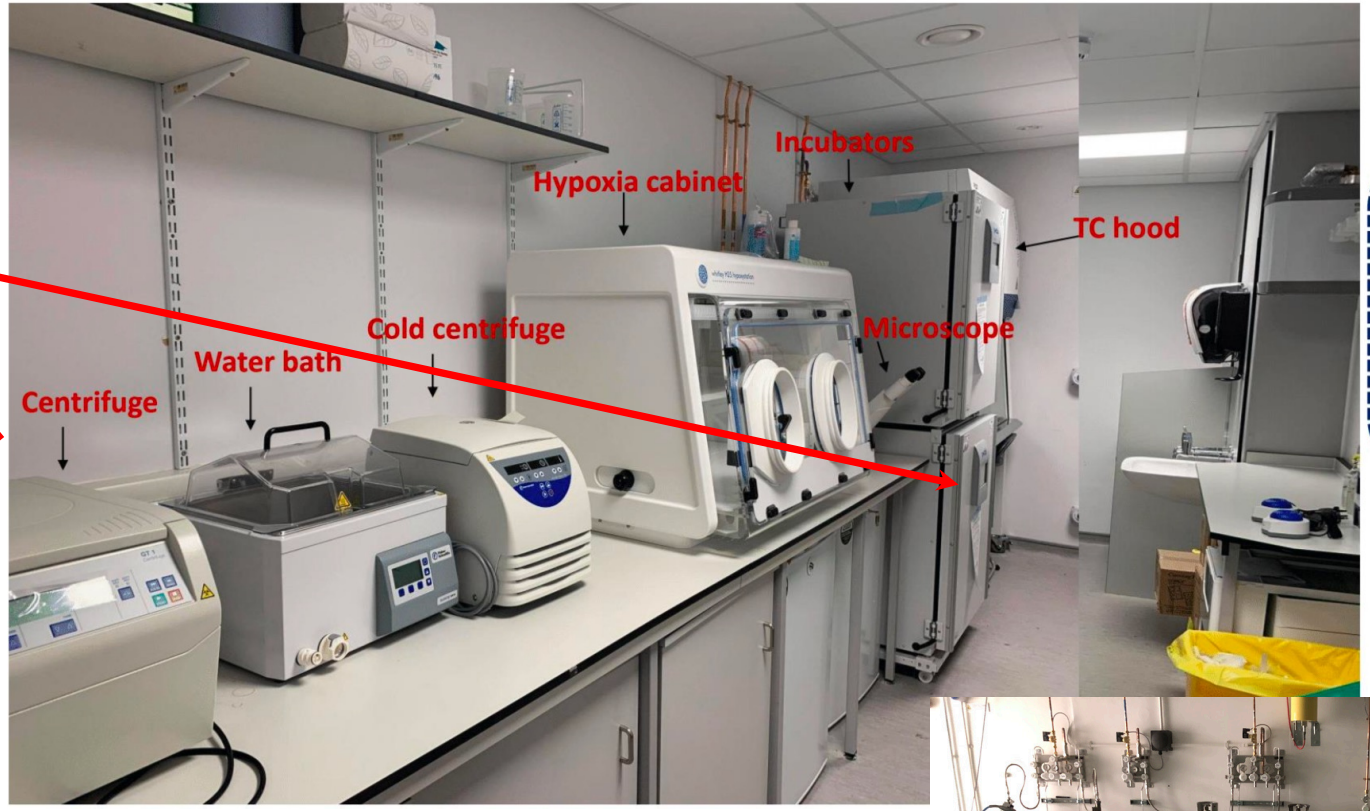


Manchester

PBT Research room: Bio Prep room & control room

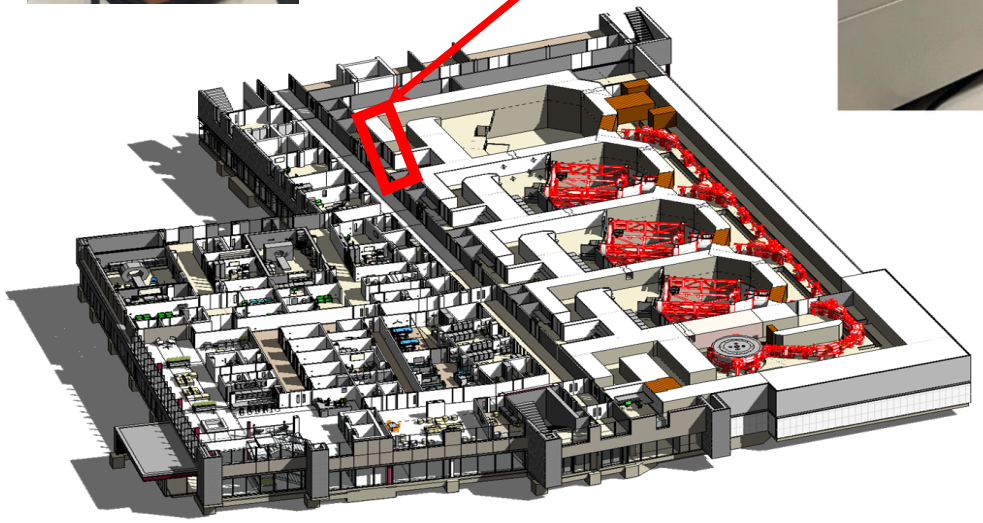
The Christie
Charitable Fund

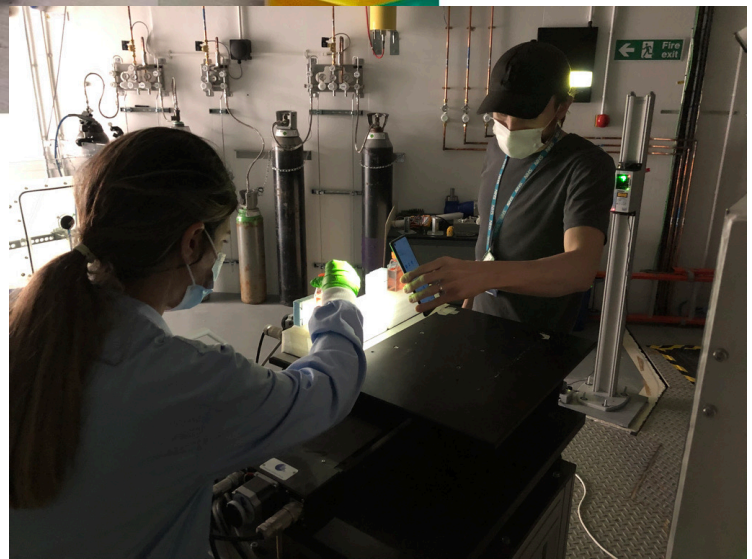
incucyte live cell analysis



Live cell imaging system

EVOS m7000

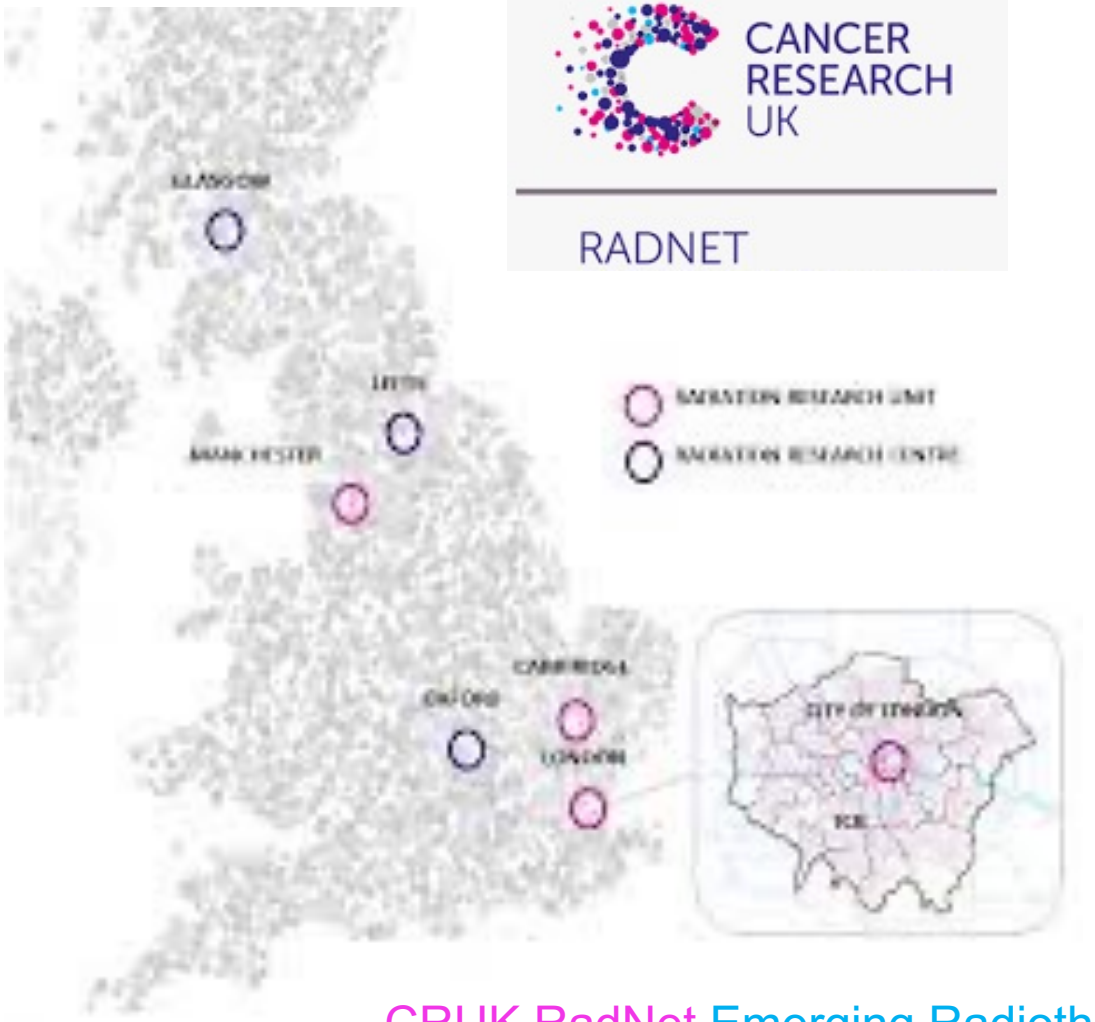




Close access to state of the art facilities

High throughput and high-resolution imaging
Genomics, proteomics, metalabomics
molecular biology facilities, FACS…
Animal house
Engineering space

Engaging with stakeholders



CANCER RESEARCH UK

RADNET

CTRad

NCRI Radiotherapy Research Group

ARR

LhARA

Laser-hybrid Accelerator for Radiobiological Applications

CRUK RadNet Emerging Radiotherapy Technologies Working Group

Emerging Radiotherapy Technologies

CTRad

NCRI Radiotherapy Research Group

CRUK-ARR RADIATION RESEARCH CONFERENCE

4-6 JUNE 2023
UNIVERSITY OF GLASGOW

Submit your abstract by 31 March

UKRI Science and Technology Facilities Council

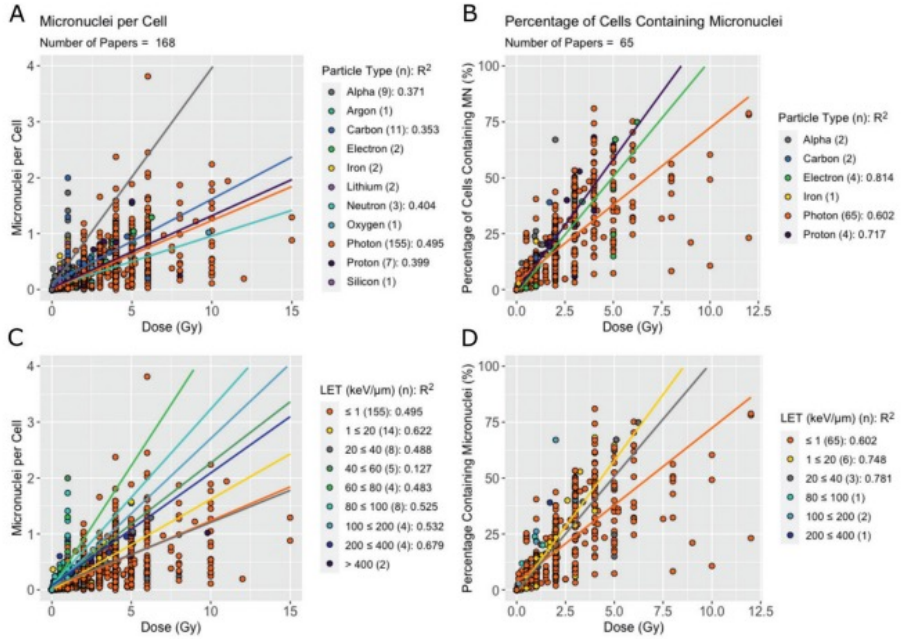
CANCER RESEARCH UK

In partnership with THE ARR The Association for Radiation Research

Designing end-stations: for the user community

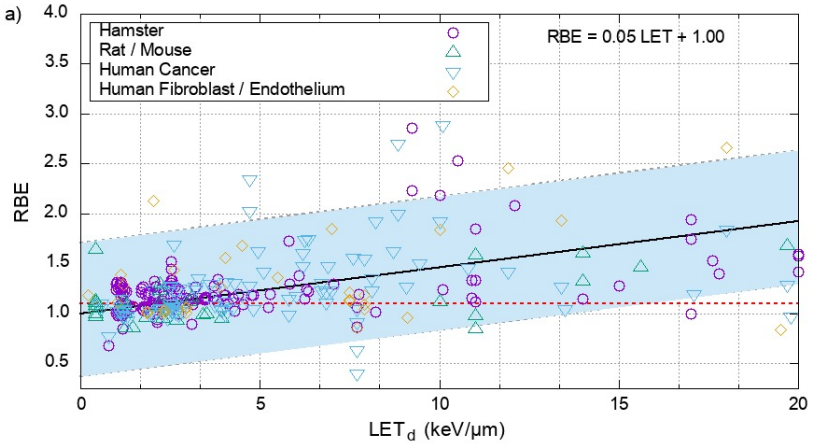
Reduce biological uncertainties
Accurate Dosimetry (1-15 Gy) conventional (3%) and FLASH (5%)
Reproducibility
range of sample sizes compatible with analysis equipment
Controlled environment
infection control

High precision control
single beam
spot scanning
emulate clinical delivery fractionation
Ultra high dose rate (FLASH) transmission
Bragg peak
Spatially fractionated
reduced beam spot 2.4mm

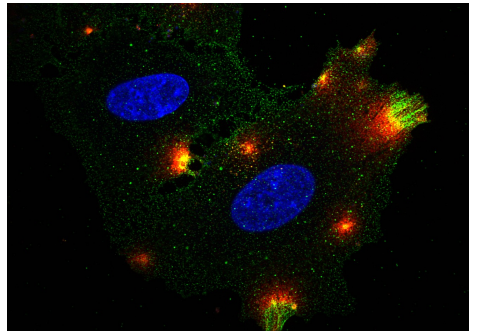


Heaven et al.2022 10.1093/mutage/geac001

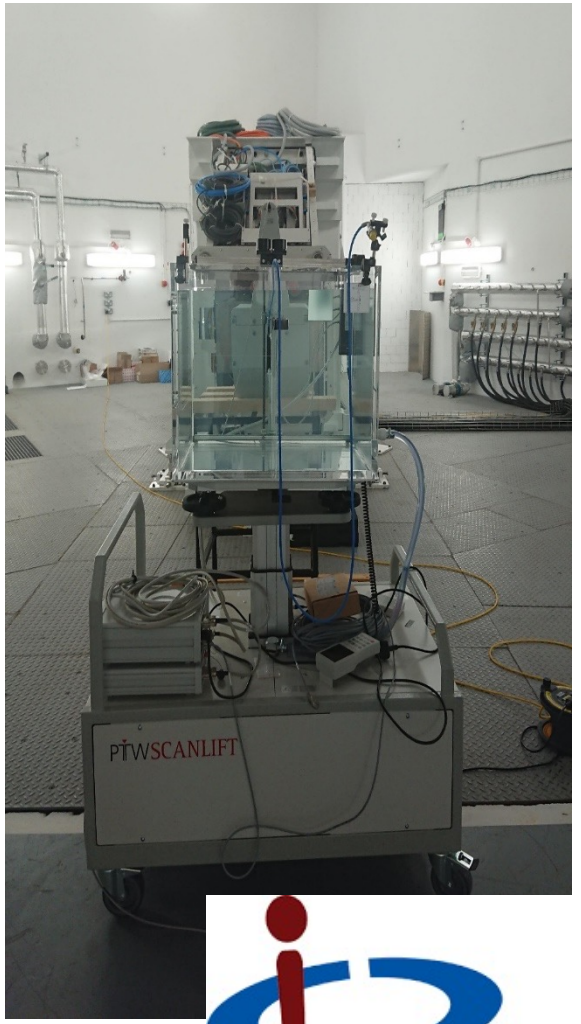
Paganetti 2014 DOI: 10.1088/0031-9155/59/22/R419



in vitro
high throughput
2D, 3D, tissue
in vivo
range of models



PBT research room: beamline A



The Christie
Charitable Fund

The Cockcroft Institute
of Accelerator Science and Technology

End Stations: Hypoxia; high throughput end station

Working with Don Whitley Scientific

Environmental Control

- **O_2:** 0.1% - ambient
- **CO_2:** 0% - 20%
- **Temperature:** ambient +4°C - 45°C
- **Humidity:** ambient – 100%

Irradiation:

- 20 x 20 cm scanning area
- 6-axis robot: 30s between sample
- 36 sample hotel
- Automated liquid handling for 96-well plates
- Scattered dose to hotel at worst 1.27 mGy/Gy
- Conventional; FLASH

Example experiment:

- 56x Samples, 300 Gy delivered, 2 hours

But now they want more: low temperatures, on-line imaging, more samples

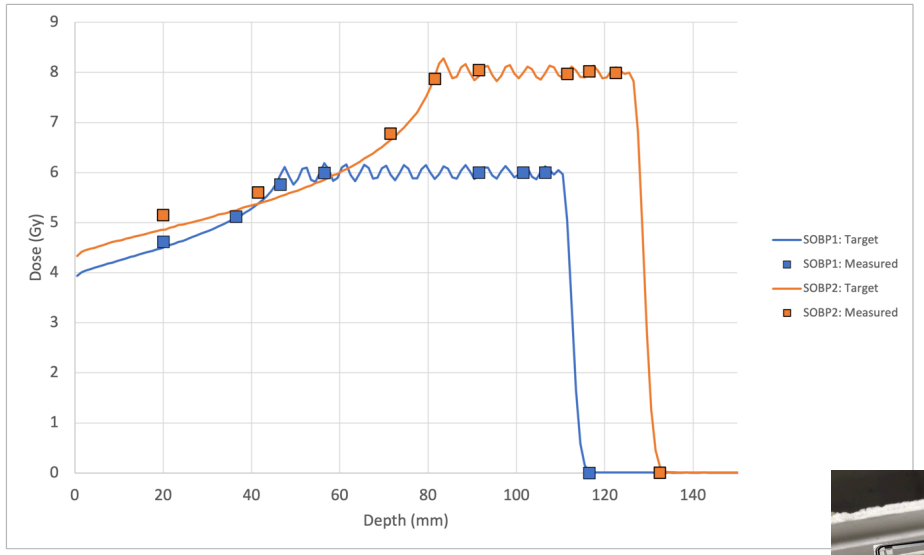
New end-station adaptation

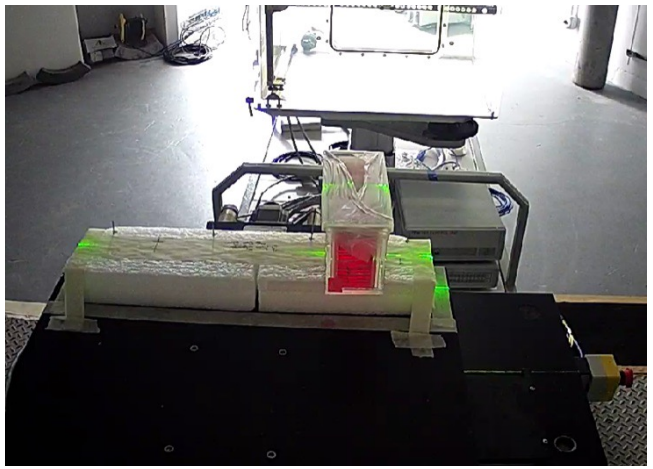
2nd hotel of samples to increase throughput
Cooled stage
- DNA repair
- FLASH studies

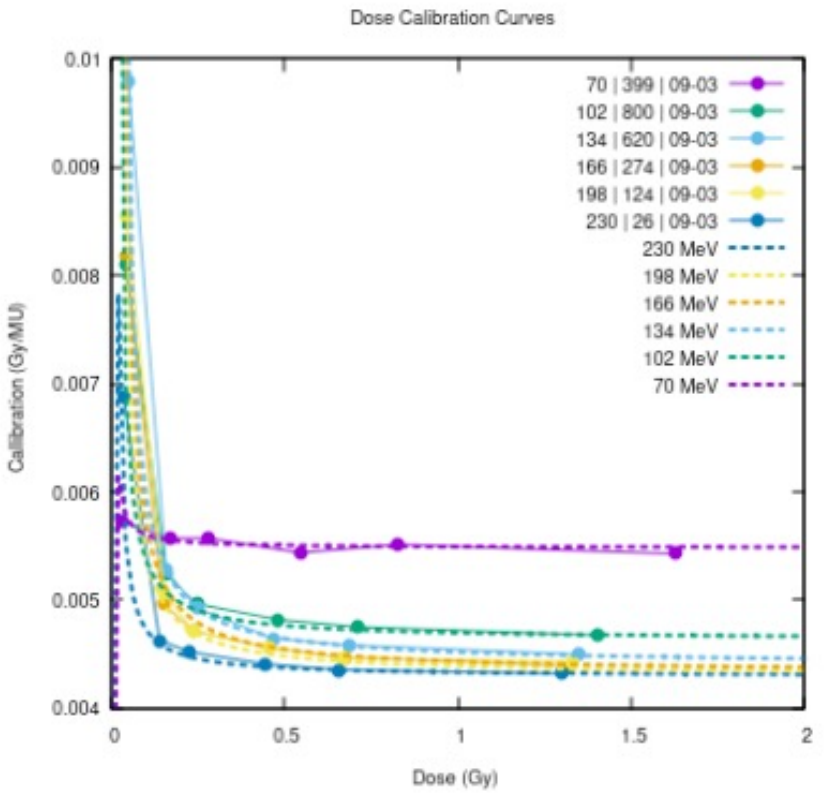
On line microscopy
Utilise same robot
and much much more

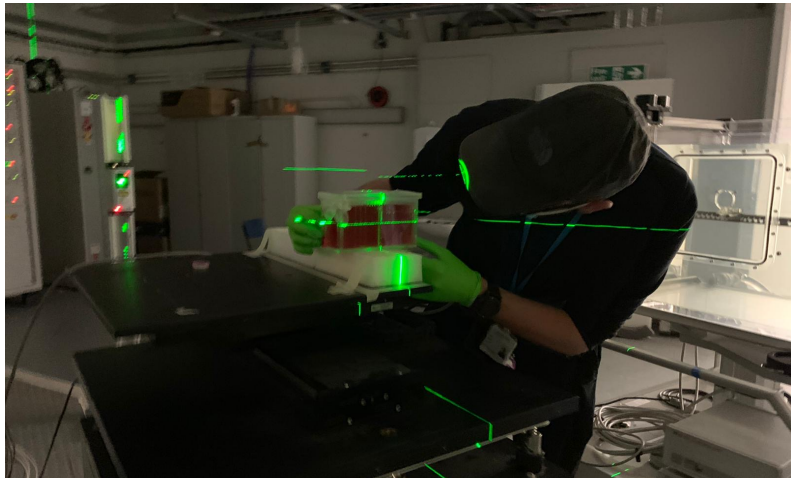
QA and dosimetry

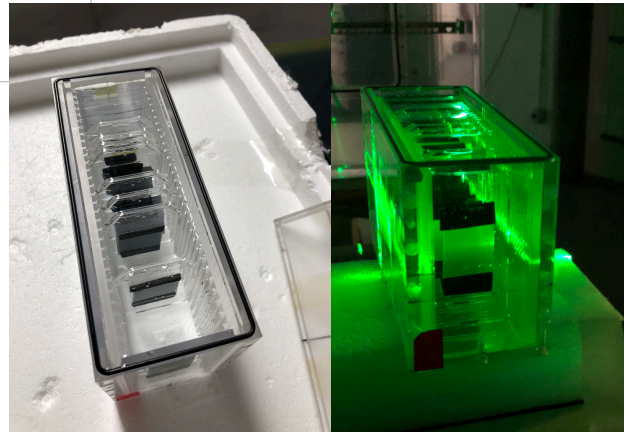
- Accurate, reproducible Dosimetry: GSI Phantom











120 MeV | 800 nA

Target Dose (Gy)	Measured Dose (Gy)	StDev (Gy)
2.00	2.0074	0.0006
4.00	4.022	0.005
6.00	6.00	0.03
10.00	10.03	0.01

InspireProject

Ultra high dose rate FLASH

MANCHESTER CANCER RESEARCH CENTRE

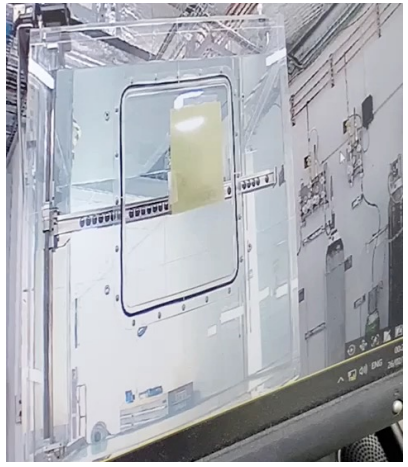
CANCER RESEARCH UK | MANCHESTER CENTRE

A DAY IN THE LIFE....

"On the night of 25th February 2021 members of the University of Manchester PRECISE group and The Christie Medical Physics and Engineering set out to deliver the first Ultra-High Dose Rate (UHDR) proton beams into the Stoller Research Room of the Proton Beam Therapy Centre....."

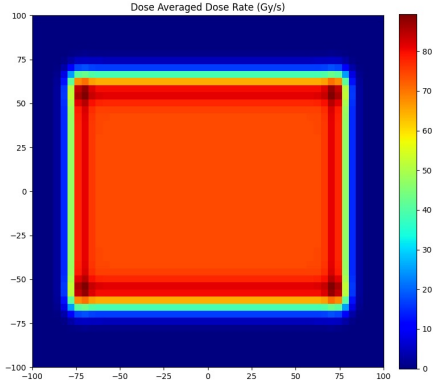
Jack Aylward,
Postgraduate Researcher
Research Group: PRECISE

Training and Education Newsletter
Autumn/Winter 2021



varian
A Siemens Healthineers Company

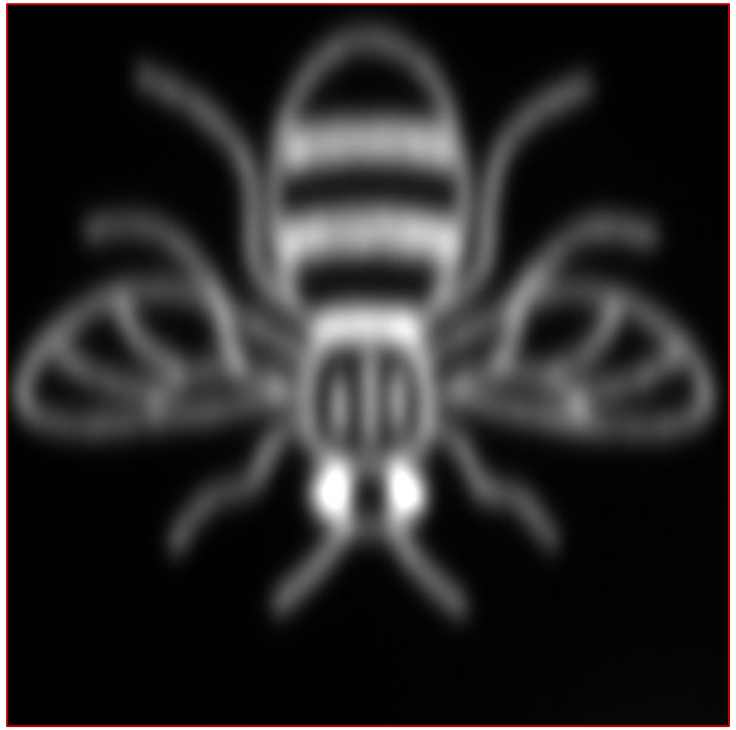
FlashForward™ Consortium



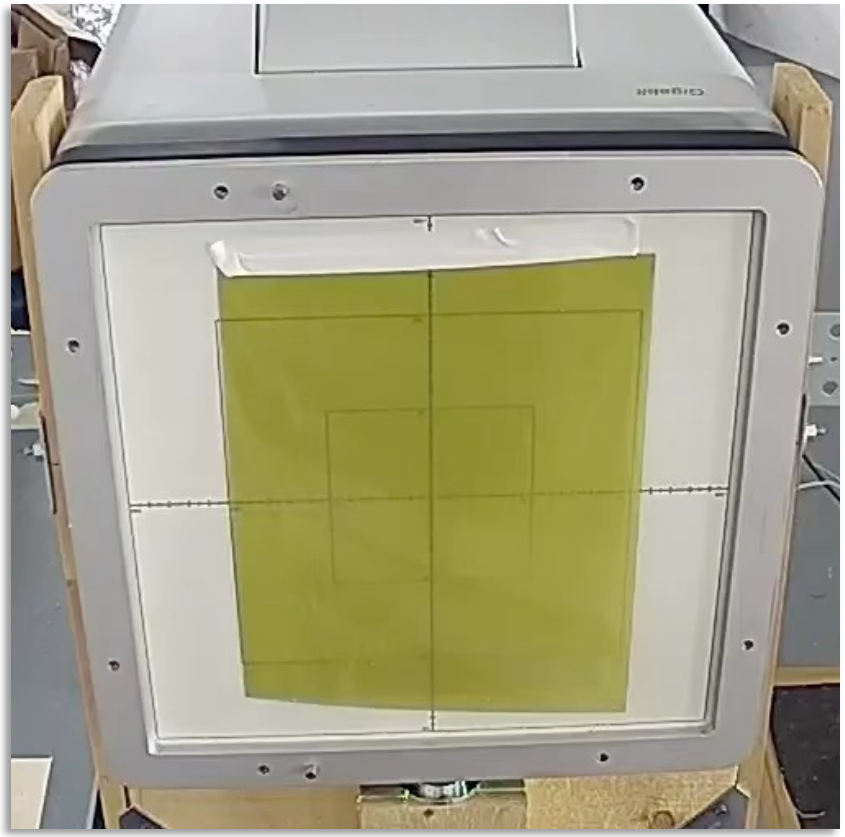
Standard Operation (<=2 nA at nozzle)		
Energy (MeV)	Minimum Nozzle Current (nA)	Maximum Nozzle Current (nA)
70	0.0025	0.41
244	0.52	2.0
FLASH Operation		
Energy (MeV)	Maximum Nozzle Current (nA)	Dose Rate (Gy/s)
244	88	175

FLASH:
Scanning Test

Conventional



FLASH



Research Room/Experiments/2021-04-28_Bee

Pre-clinical Beamline End-station

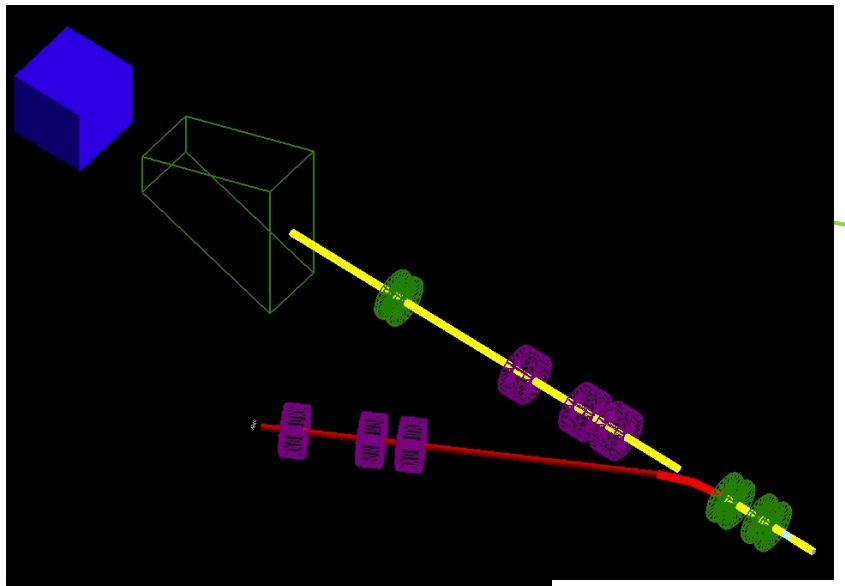
Pre-clinical Beamline

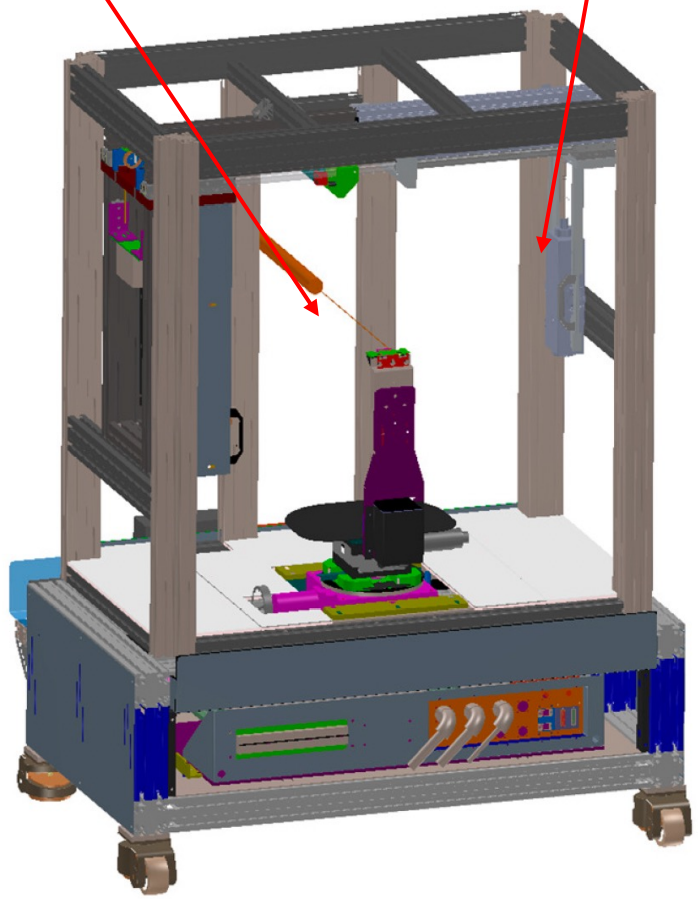
- 1 mm σ spot, 3 cm x 3 cm scanning area
- Flash capable (Bragg peak) [1 MeV – 65 MeV]
- Working with Cockcroft Institute (Prof R Appleby)

Investigating automation solutions.

High throughput and high repeatability are central to design philosophy.

Working with XStrahl





Medical Research Council

NC3Rs National Centre for the Replacement Refinement & Reduction of Animals in Research

The University of Manchester

Science and Technology Facilities Council

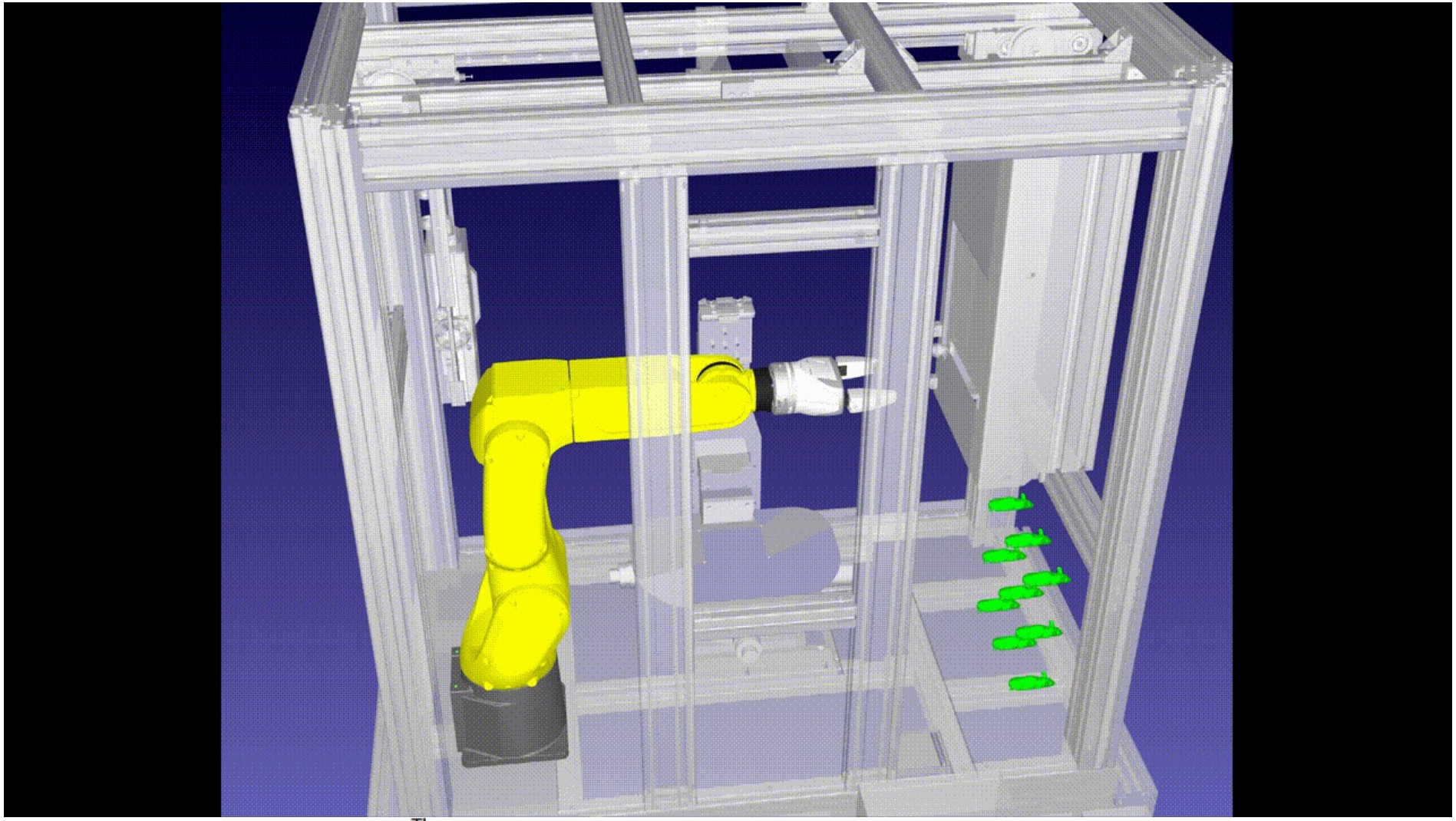
The Cockcroft Institute of Accelerator Science and Technology

The Precise Group

XStrahl SARRP Proton Platform

The Christie NHS Foundation Trust

Pre-clinical Beamline End-station



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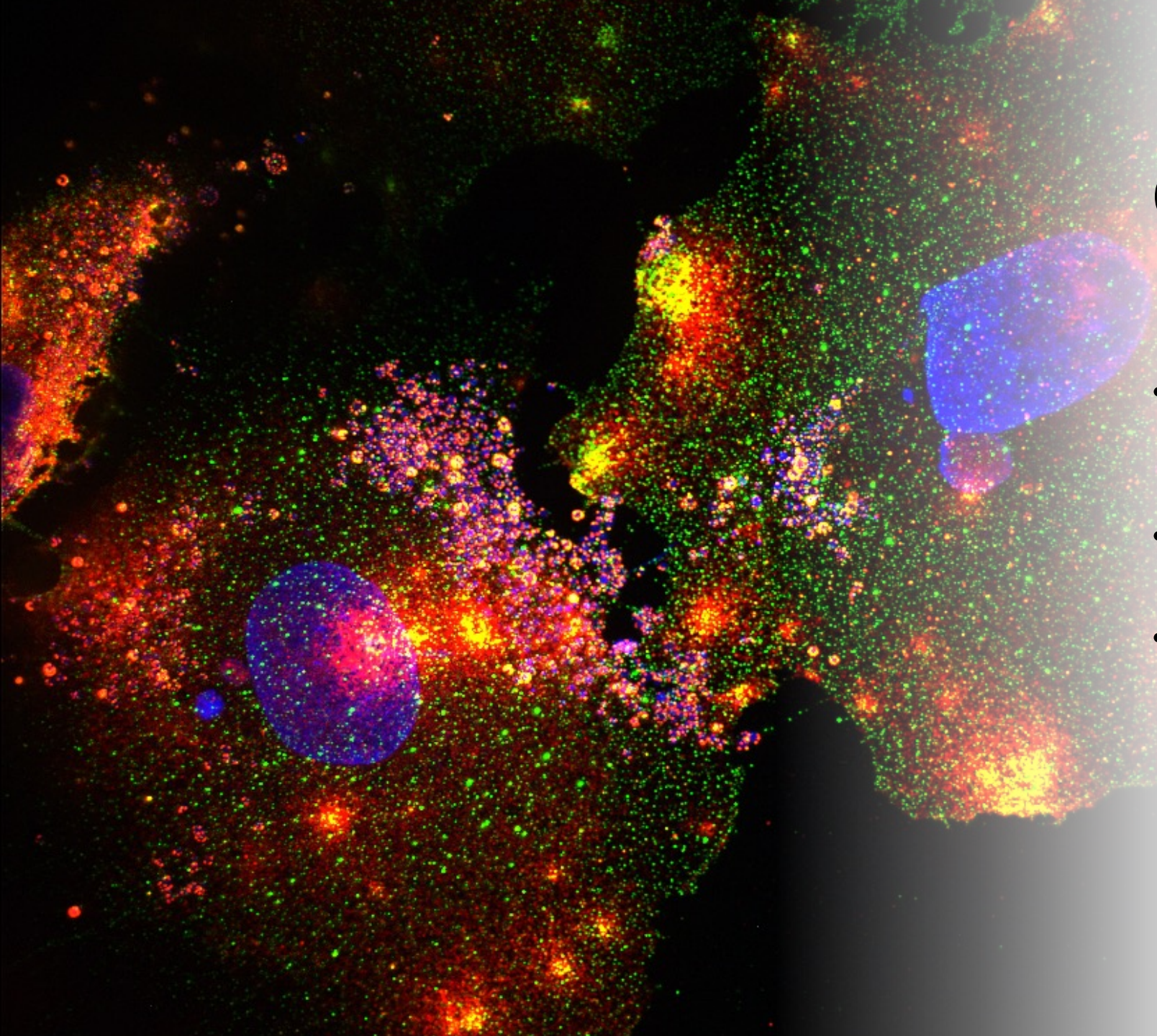

Conclusions

- Need to work with biology and clinical communities on design requirements for ITRF
- WP3 works with STFC and CERN to use this expertise in ITRF
- Using expertise gained on actually designing and building a research room in a clinical facility