



# **LhARA End-Station Development WP1.5**

T Price, R McLauchlan, C Welsch, N  
Kumar

# Recap of proposal

The principal objective (**O5.n**) for *Work package 5: Novel end-station development* is:

**O5.1:** Through peer-group consultation, produce detailed specifications and designs for the *in-vitro* and *in-vivo* end stations, the associated dosimetry and the beam diagnostics necessary to characterise the beam delivered to the end stations.

- **M5.1** (month 6): Initial report on the user requirements for the *in-vitro* and *in-vivo* end stations. An initial parameter list and end-station specification will be given;
- **M5.2** (month 12): Report on the beam-monitoring technology for LhARA. The report will include an options analysis and discussion of cost and R&D requirements.
- **M5.3** (month 18): Second report on the user requirements for the *in-vitro* and *in-vivo* end stations. The report will contain detailed specifications, analysis of layout options, and initial designs for key components.

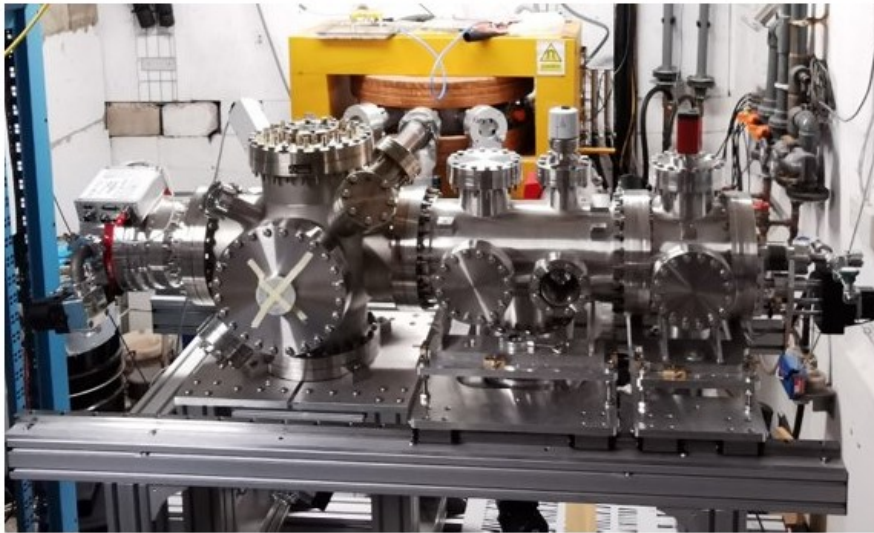
# Staffing update from Liverpool / Cockcroft

- Proposal funds 0.5FTE PDRA matched from UoL
- Currently N Kumar is in post but PDRA will be hired in near future to work 0.5FTE in addition to his efforts
- New PHD project: within EuPRAXIA-DN, new PHD student will be hire in near future working on diagnostic challenges directly related to LhARA
- Successful application for Faculty Impact Fund (UoL) to perform PoC measurements with Gas Profiler at DCF, Whitehaven with proton and carbon beams. Received ~£15k for the beam time. Experiments will be scheduled starting from June 2023. Experimental planning is in progress.

# Beam Diagnostics

- N Kumar has begun conducting the literature review
- Dosimetry for in-vivo has been studied
- Literature on the Graphite NPL calorimeters being digested in terms of dose rate independence
- Measurements at UoB using 28 MeV beam @ UoB of NPL Secondary Standard Calorimeters

# Measurements at DCF, Whitehaven



## **Beam Parameters**

Beam Species:	<b>Protons, Carbon Ions</b>
Beam Energy:	<b>Max 10 MeV for Proton Beam 20-30 MeV for Carbon Beam</b>
Beam Current:	<b>100pA-100nA</b>
Beam Size:	<b>Up to 2 mm</b>

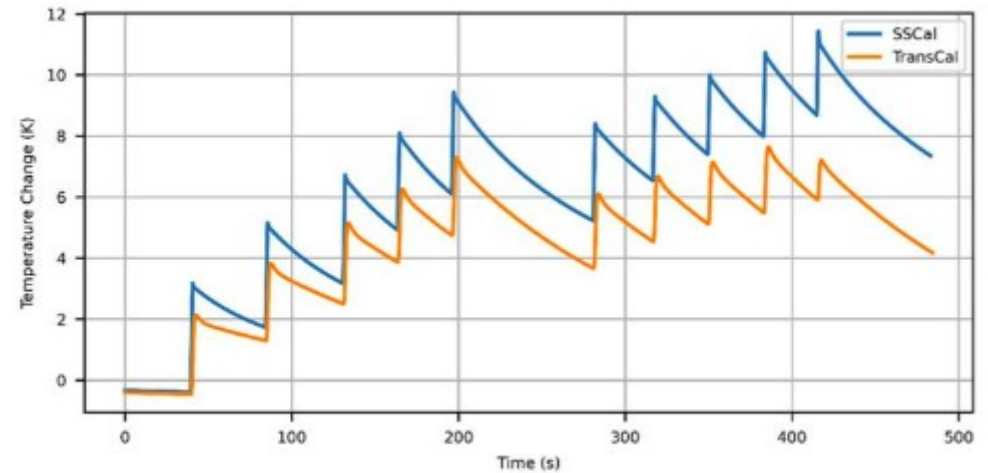
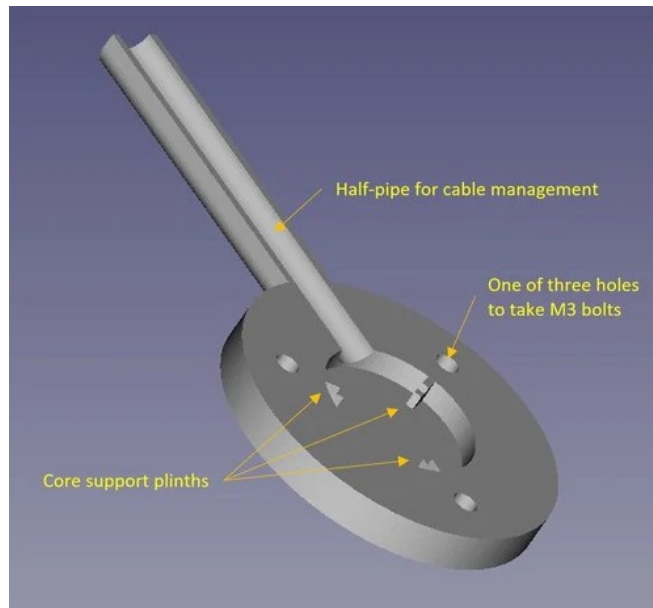
- *Minor modification will be made in the gas jet setup to match the space requirement at DCF.*
- *System will be couple directly to their beam line; means beam will be travelling through vacuum.*
- *30 hours of beam time is in plan with various beam parameters such as beam energy, beam current, beam size for two different species: Protons and Carbon Ions*
- *Two different gas jet will be used during the measurements: Nitrogen and Argon*

# High dose rate test bed @ UoB

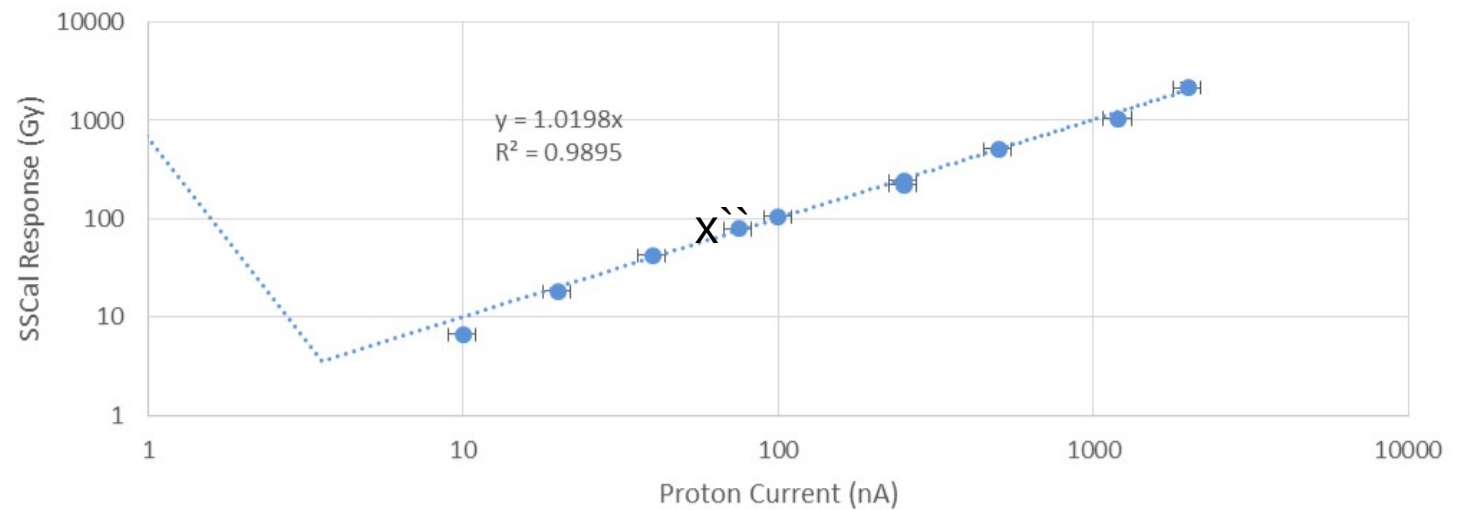
- Monte Carlo simulations setup in Geant4 to assess the beam line impact on low energy (15 MeV) beam
- Can extract properties such as dose uniformity, LET spectra, energy spectra
- FLASH shutter based on Oxford design under testing to control the dose. Open close times of  $\sim 10$ ms possible
- Markus Chamber tested up to  $\sim 100$  Gy/s in line with literature.
- FC measurements extrapolated to dose



# Secondary Standard Calorimeter

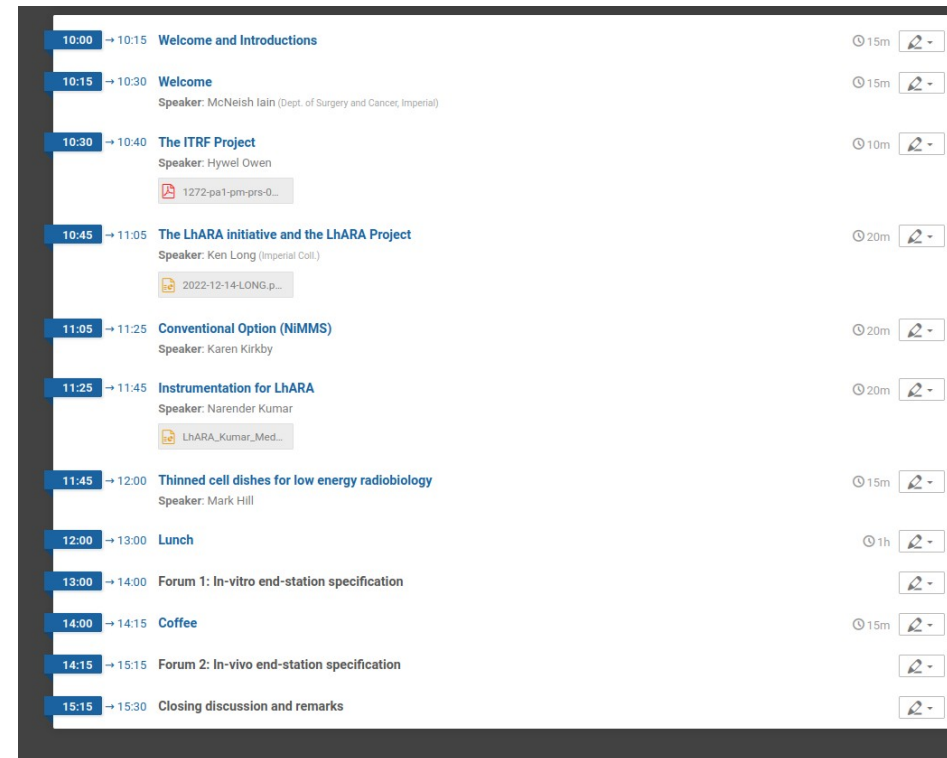


SSCal Beam Current Linearity



# First user consultation meeting

- Organised in collaboration between WP1.5 and WP3
- Originally to be in person at Charing Cross with mixed mode possible
- Train strikes meant we went fully online
- Extended invitations wider across Europe and ended up with 50+ registrations
- Morning session attended by >35 attendees
- Discussion sessions ~15 people but discussions were very good
- Write up underway but delayed due to Spring term restrictions of T. Price
- Progress made by N Kumar and R McLaughlan to be finalised by T Price



The screenshot shows a meeting agenda with the following items:

Time	Topic	Speaker	Duration
10:00	Welcome and Introductions		15m
10:15	Welcome	McNeish Iain (Dept. of Surgery and Cancer, Imperial)	15m
10:30	The ITRF Project	Hywel Owen	10m
10:45	The LhARA initiative and the LhARA Project	Ken Long (Imperial Coll.)	20m
11:05	Conventional Option (NiMMS)	Karen Kirkby	20m
11:25	Instrumentation for LhARA	Narender Kumar	20m
11:45	Thinned cell dishes for low energy radiobiology	Mark Hill	15m
12:00	Lunch		1h
13:00	Forum 1: In-vitro end-station specification		
14:00	Coffee		15m
14:15	Forum 2: In-vivo end-station specification		
15:15	Closing discussion and remarks		



# First User Consultation Meeting – Low Energy In vitro

- Proton beam energy of 15 MeV +/- 2% is useable but some users concerned over range so cell dish choice important.
- Interest in heavier particles but the range will be insufficient
- 35 mm diameter beam would allow studies but interest also in smaller beams. Study ongoing
- Dose uniformity of 35 mm beam also questioned
- Dosimetry requirements ~5% is sufficient
- Reproducibility of beam spots <5% preferred but with dosimetry on a shot by shot basis this can be accounted for (with Film, WP4, or other)
- Interest from users in what studies can be performed with unique temporal structure and dose rates



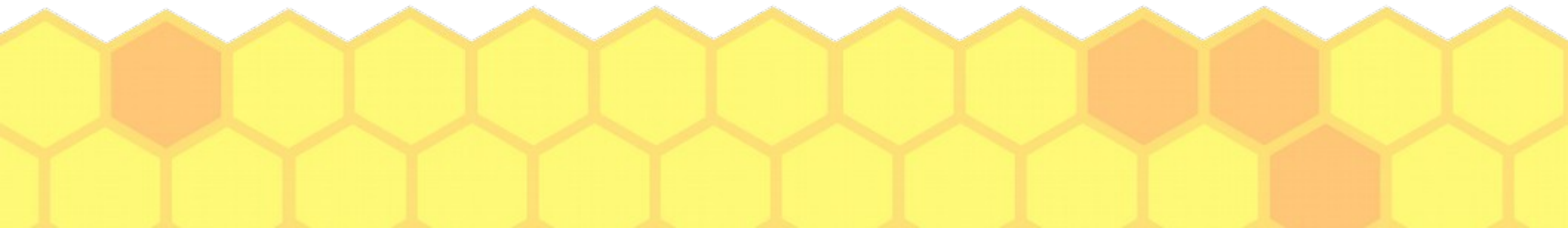
# First User Consultation Meeting – Low Energy In vitro

- Facilities required by users to culture cells mentioned but not discussed in details.
- The model of LhARA irradiations discussed with multiple users, 18 hour up time, and shared (?) facilities requires more input from the user community
- Automation to match the proposed model such as sample handling, reloading, processing of interest to users but again needs more input



# First User Consultation Meeting – In vivo

- Discussion on animal species was interesting
- Mice and rodents allow lots of work
- People around the world are using canines, felines, and peoples pets for treatment.
- Location of facility should have input from things such as
  - Animal house locations and regulations
  - Vet Schools and research
- Will form the basis of next consultation



# Second consultation

- In ITRF proposal we proposed three consultation meetings. In this model we should be organising next meeting now
- However, K Kirkby offered funding from STFC for a fourth meeting as we are running joint between WP1.5 and WP3
- In this model we are behind in planning
- Price's Paradox: Simultaneously not being late whilst always being late
- Currently I feel very late....
- Discussions to hold next meeting in Oxford ongoing, but date TBC
- Term finishes this week, catch up from next week onwards.



# Summary

- M5.1 initial report ongoing, Tony to finish ASAP
  - M5.2 Narender performing review of literature and modifying Gas Profiler
  - M5.3 Next consultation to be organised
  - High dose rates achieved at the MC40 cyclotron
- 
- **M5.1 (month 6):** Initial report on the user requirements for the *in-vitro* and *in-vivo* end stations. An initial parameter list and end-station specification will be given;
  - **M5.2 (month 12):** Report on the beam-monitoring technology for LhARA. The report will include an options analysis and discussion of cost and R&D requirements.
  - **M5.3 (month 18):** Second report on the user requirements for the *in-vitro* and *in-vivo* end stations. The report will contain detailed specifications, analysis of layout options, and initial designs for key components.

