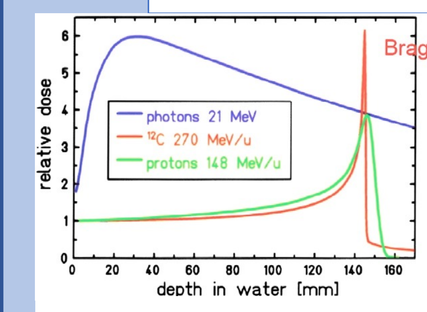
LhARA

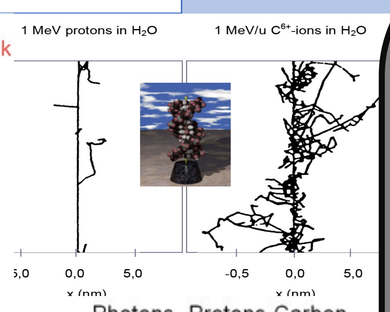
Laser-hybrid Accelerator for Radiobiological Applications

Kenneth Long on behalf of the LhARA Collaboration

Ion Therapy

Therapy	Rationale for clinical benefit
Proton	▪ Deliver a higher, targeted radiation dose with decreased toxicity to surrounding tissue compared with photon therapy, especially near critical structures
Carbon	▪ Further increase target tissue damage with decreased secondary tissue affected compared with proton ▪ Specific potential benefit with intractable radio-resistant tumors

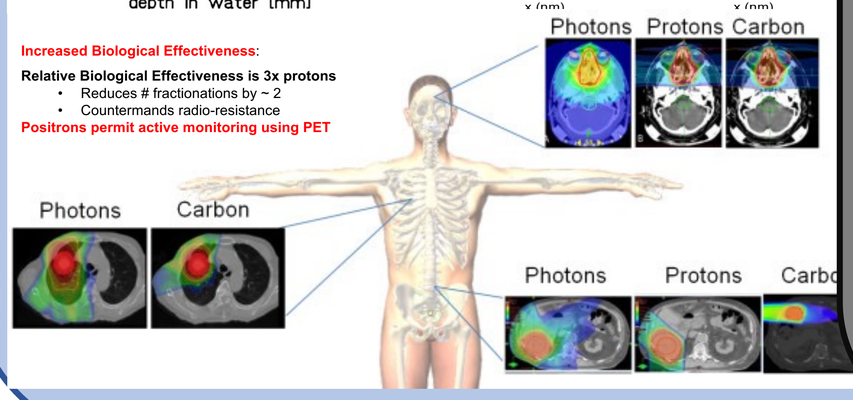




Increased Biological Effectiveness:

Relative Biological Effectiveness is 3x protons
- Reduces # fractionations by ~ 2
- Countermands radio-resistance

Positrons permit active monitoring using PET



Superior Dose Depth Distribution & Physical Beam Characteristics
-Higher LET
-Superior RBE
-Low OER
-Narrow penumbra

Engineering
Gantry
Miniaturisation

Physics
Beam Characteristic
Beam Heterogeneity

Materials Science
Target production
Shielding

Radiobiological Research
-Radiosensitisation
-Carbon ion interactions
-Metabolism
-Microenvironment

Multi-disciplinary LhARA Program

Clinical Biology Research
-Dose limitations, Toxicity
-Which tumor histologies benefit most
-Tumor microenvironment
-Development of new clinical trial design

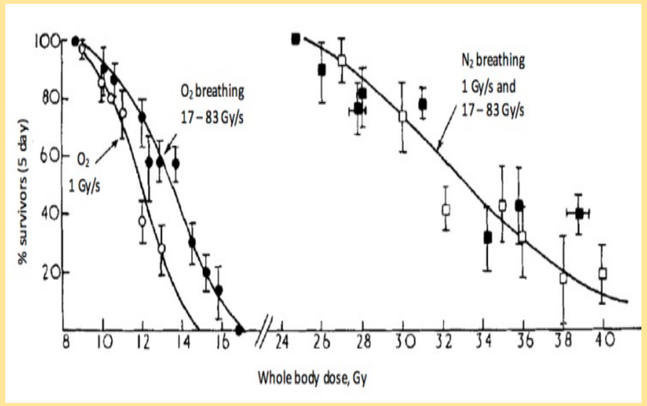
Clinical Physics Research
-Treatment *planning*
-*Develo*pment of IMCT
-Absorbed Dose Calcs
-Modeling RBE

Radiology
-Ionacoustic Imaging
-Positron imaging
-Dose distribution

Patient Experience
-New Lhara Ion therapy
-Less toxicity
-Given in short period of time
-Cost effectiveness research

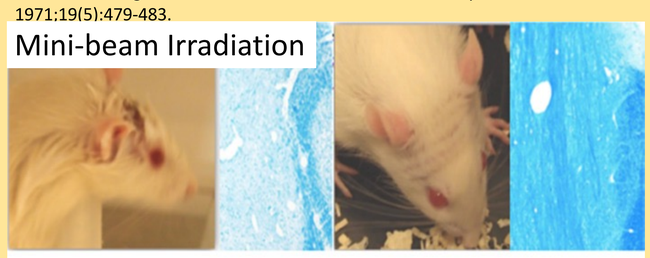
STFC/UKRI/ITRF
-Accelerator miniaturization
-Active and Passive Beam Shaping
-Beam Production
-Beam Delivery

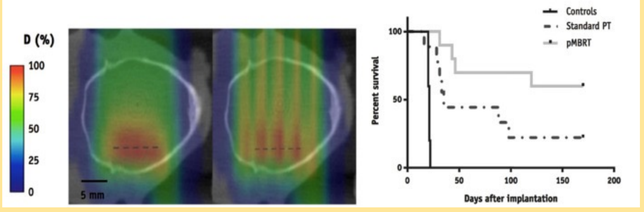
FLASH Radiotherapy



Hornsey S, Bewley DK. Hypoxia in mouse intestine induced by electron irradiation at high dose-rates. *Int J Radiat Biol Relat Stud Phys Chem Med.* 1971;19(5):479-483.

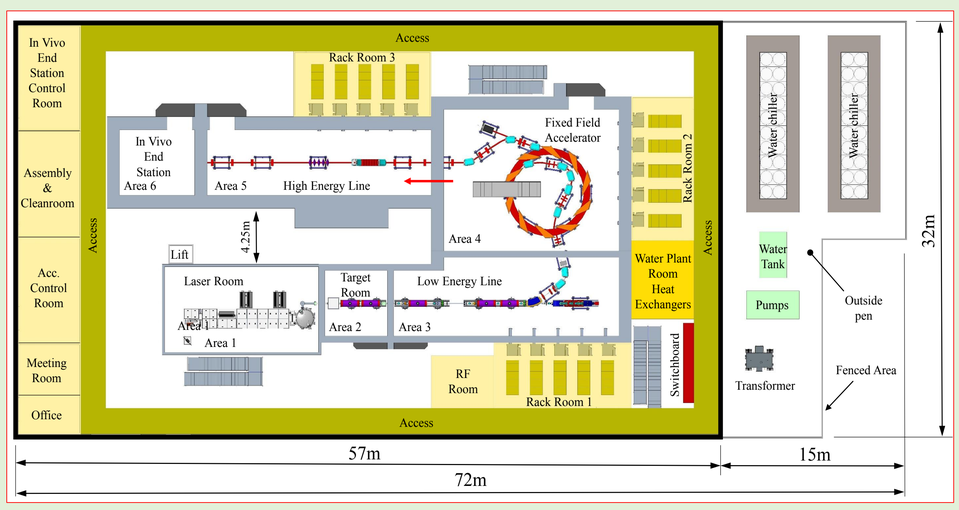
Mini-beam Irradiation





Br J Radiol 2020 Mar;93(1107):20190412. doi:10.1259/bjr.20190412.

LhARA Facility Design and Engineering



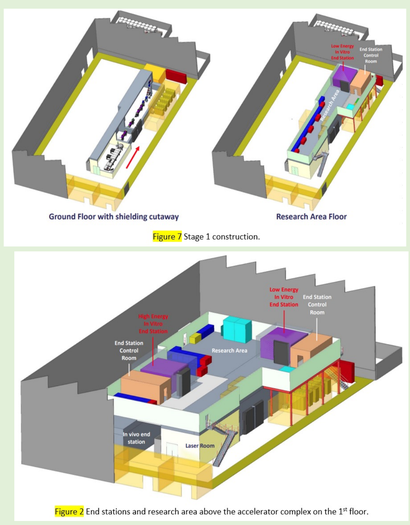
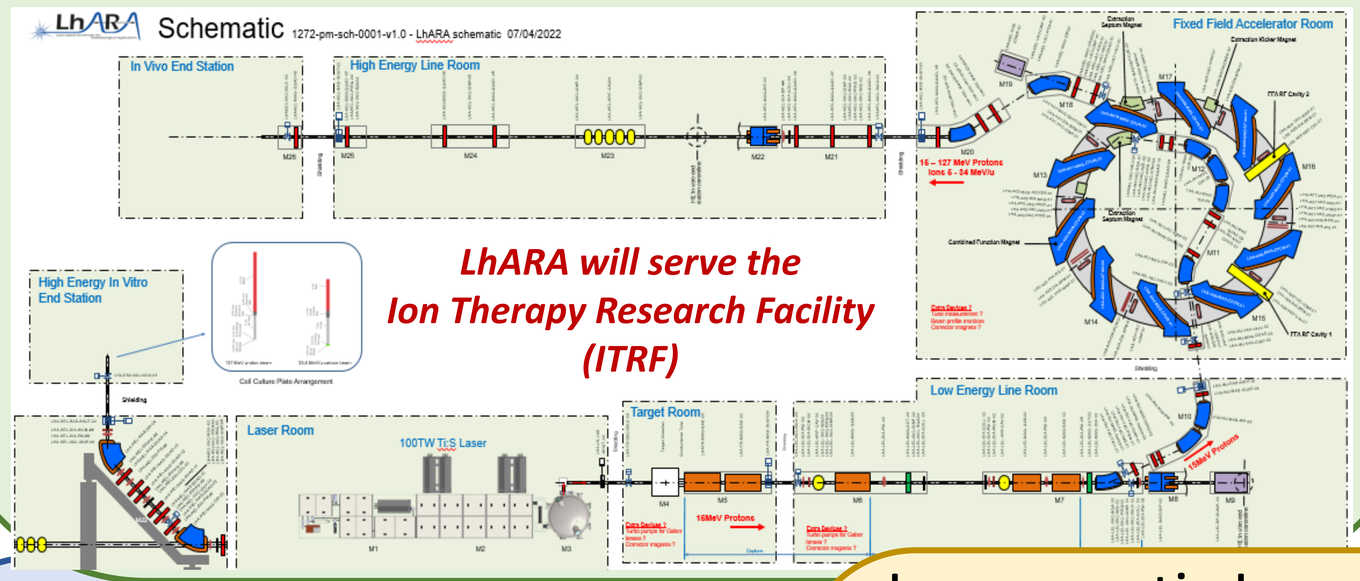


Figure 7 Stage 1 construction.

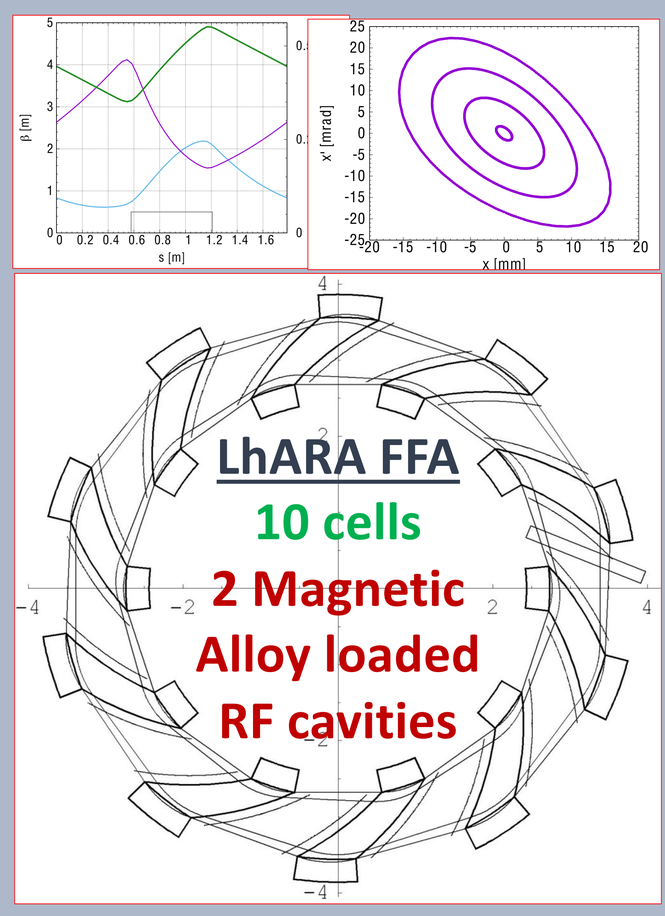
Figure 2 End stations and research area above the accelerator complex on the 1st floor.



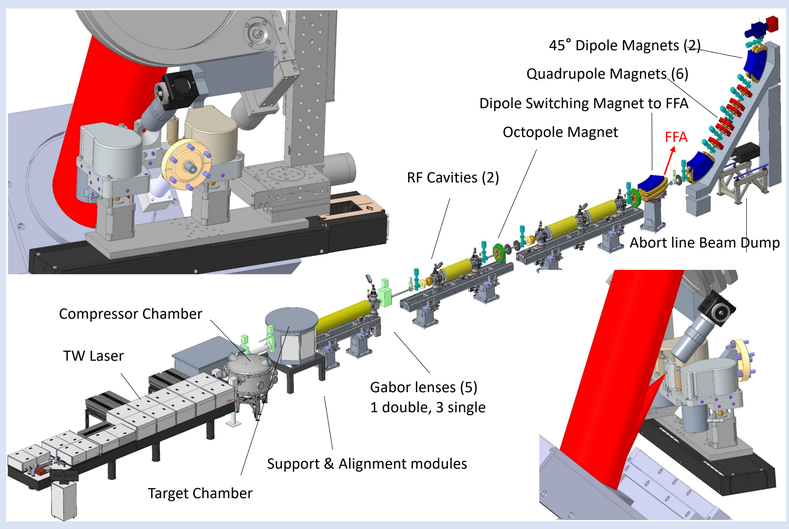
LhARA will serve the Ion Therapy Research Facility (ITRF)

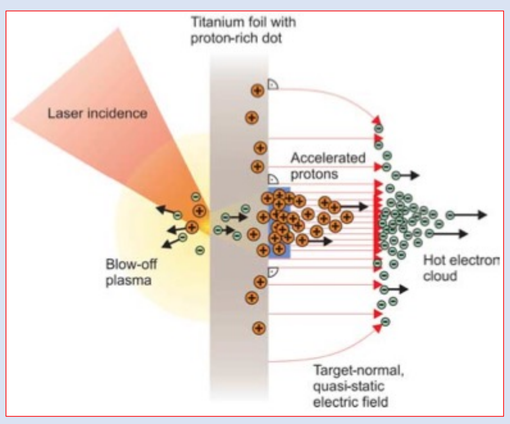
LhARA: Stage 2 FFA

Spiral FFA: accelerate 12-15MeV beam to :
Protons : 127MeV
Carbon : 33.4 MeV/u



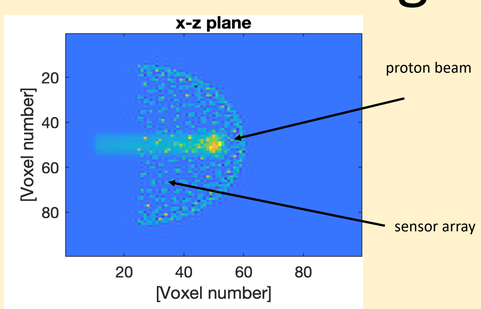
LhARA FFA
10 cells
2 Magnetic Alloy loaded RF cavities

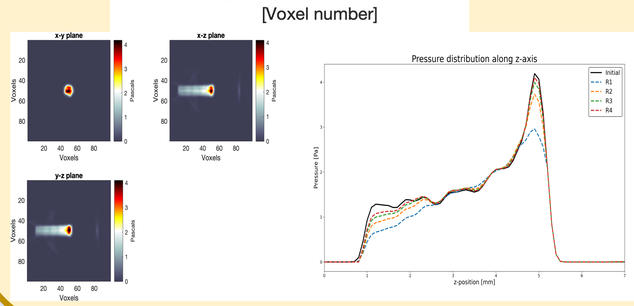




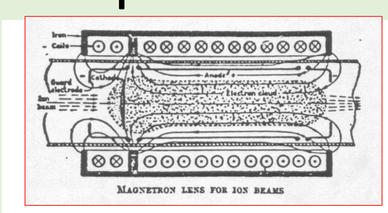
Source
TNSA
12-15 MeV
10 Hz

Ion-acoustic Imaging





Capture – Gabor lens



Large aperture
non-neutral plasma
Low magnetic field req.
Stability, hold time, density

End Station Design

- Vertical beamlines for both low energy in-vitro and high energy in-vitro and in-vivo radiobiology experiments
- Horizontal beamline for high energy only
- 4 consultations.
- High throughput
- Integrated diagnostics

Partners: University, Clinical, Industry, Accelerator, Laboratory