Overview of the LhARA Facility

Review of the LhARA pre-CDR

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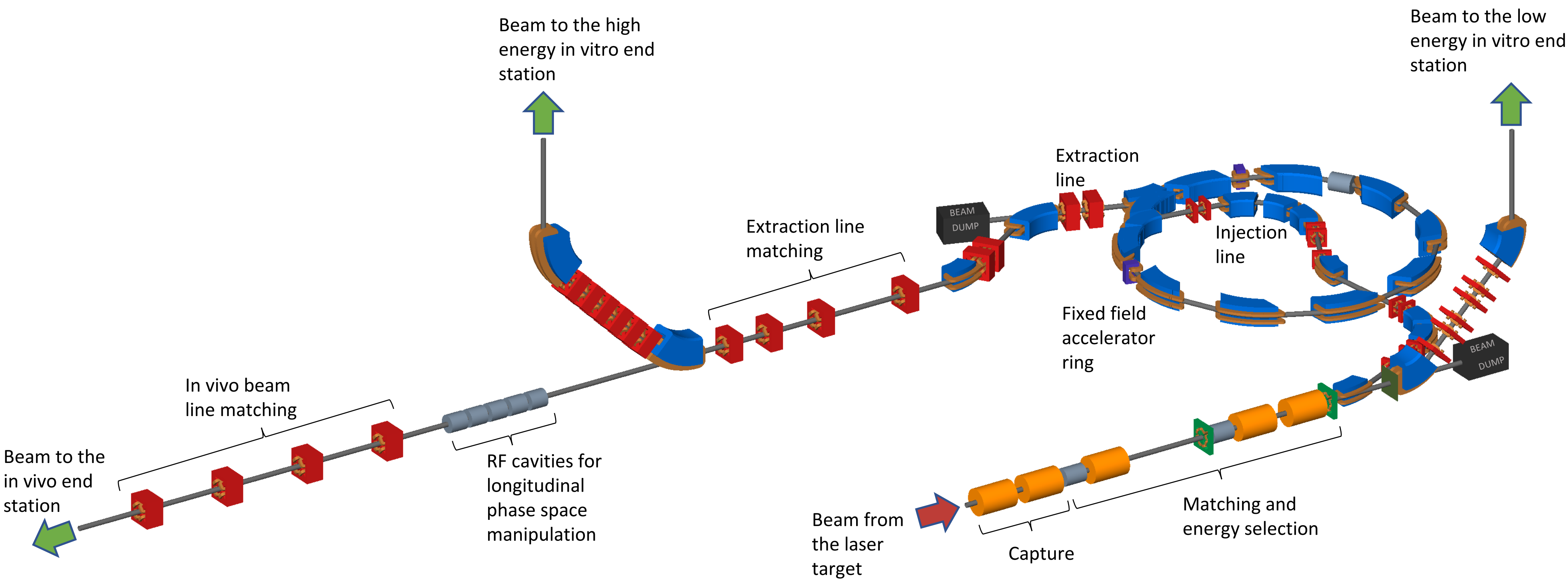
Introduction

- Overview of the design of the facility.
- Design parameters.
- Staging.
- Accelerator.
- Instrumentation.
- Project schedule and R&D plan.

Accelerator



Design parameters

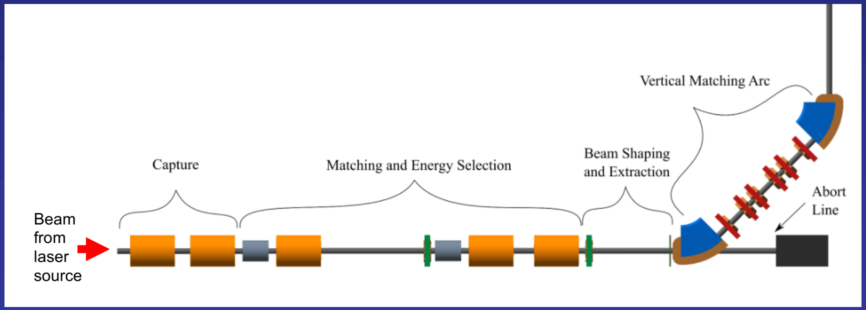
Parameter	Value or range	Unit
Laser driven proton and ion source		
Laser power	100	TW
Laser Energy	2.5	J
Laser pulse length	25	fs
Laser rep. rate	10	Hz
Proton energy	15	MeV
Proton and ion capture		
Beam divergence to be captured	50	mrad
Gabor lens effective length	0.857	m
Gabor lens length (end-flange to end-flange)	1.157	m
Gabor lens cathode radius	0.0365	m
Gabor lens maximum voltage	65	kV
Number of Gabor lenses	2	
Alternative technology: solenoid length	1.157	m
Alternative technology: solenoid max field strength	1.3	T
Stage 1 beam transport: matching & energy selection, beam delivery to low energy end station		
Number of Gabor lenses	3	
Number of re–bunching cavities	2	
Number of collimators for energy selection	1	
Arc bending angle	90	Degrees
Number of bending magnets	2	
Number of quadrupoles in the arc	6	
Alternative technology: solenoid length	1.157	m
Alternative technology: solenoid max field strength (to serve the injection line to the Stage 2)	0.8 (1.4)	T

Design parameters

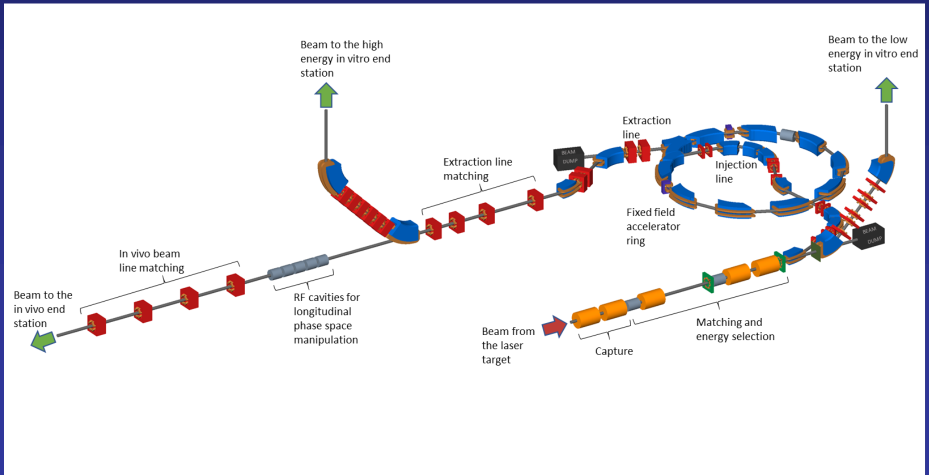
Parameter	Value or range	Unit
Stage 2 beam transport: FFA, transfer line, beam delivery to high-energy endstations		
Number of bending magnets in the injection line	7	
Number of quadrupoles in the injection line	10	
FFA: Machine type	single spiral scaling FFA	
FFA: Extraction energy	20-127	MeV
FFA: Number of cells	10	
FFA: Orbit R_{min}	2.92	m
FFA: Orbit R_{max}	3.48	m
FFA: External R	4	m
FFA: Number of RF cavities	2	
FFA: RF frequency	1.46-6.48	MHz
FFA: spiral angle	48.7	Degrees
FFA: Max B field	1.4	T
FFA: k	5.33	
FFA: Magnet packing factor	0.34	
FFA: Magnet gap	0.047	m
FFA: Number of kickers	2	
FFA: Number of septa	2	
Number of bending magnets in the extraction line	2	
Number of quadrupoles in the extraction line	8	
Arc bending angle	90	Degrees
Number of bending magnets in the vertical arc	2	
Number of quadrupoles in the vertical arc	6	
Number of cavities for longitudinal phase space manipulation	5	
Number of quadrupoles in the in vivo beam line	4	
In vitro biological end stations		
Maximum input beam diameter	1-3	cm
Input beam energy spread	< 2	%
Input beam uniformity	< 5	%
Scintillating fibre layer thickness	0.25	mm
Air gap length	5	mm
Cell culture plate thickness	1.15	mm
Cell layer thickness	0.03	mm
Cell nutrient solution	15	mm
Number of end stations	2	
In vivo biological end station		
Maximum input beam diameter	1-3	cm
Input beam energy spread	< 2	%
Input beam uniformity	< 5	%
Beam options	Spot-scanning, passive scattering, micro-beam	

Staging

- Construction will be done in two stages.



Stage 1



Stage 2

- The goal is maximise scientific output.
  - Generate scientific output during construction of Stage 1.
  - Radiobiology programme using Stage 1 whilst constructing Stage 2.

Schedule

- 10 year programme.
  - Radiobiology.
    - At other facilities.
    - Experiments whilst Stage 2 is being constructed.
  - System/near clinical aspects and outreach.
    - Spin offs.
    - PPI.
    - Outreach.

- 5 year R&D plan.

- Construction.
  - 2 years for Stage 1.
  - 5 years for Stage 2.

Five year R&D plan

- Aims to address the technical challenges highlighted in the pre-CDR and deliver technical designs for the LhARA facility.

- Facility design.
  - Development of conceptual design.
  - Development of technical design.
  - CDR (detailed for Stage 1).
  - TDR Stage 1.
  - TDR Stage 2.

- End stations.
  - Automation, sample handling, imaging.
  - Simulation of the end stations.

Five year R&D plan

- Gabor lens.
  - First generation prototype.
  - Second generation prototype.
  - Theoretical studies.
  - Electron density measurements.
  - Alpha source and detector tests.
- Laser-driven source.
- Laser-capture interface.
- Investigation of space charge algorithms.
- Stage 1 beam line performance evaluation.
- Vertical bend.
- Capture technology milestone.

Five year R&D plan

- FFA.
  - Design and simulation.
  - Detailed magnet design.
  - Magnet prototype.
  - RF cavity design and performance evaluation.
  - Injection and extraction design.
- Stage 2 performance evaluation.
- Longitudinal phase space manipulation design, simulation and prototyping.
- Final beam preparation for in vivo end station.
- Instrumentation.
  - Low-energy beam diagnostics.
  - Online dosimetry and dose profile.
  - Absolute dosimetry at ultra-high dose rates.
  - Fast feedback and control.
  - High-energy beam diagnostics.
- Software and Computing.
  - Development of a global data acquisition and processing system.
  - Development of the controls and monitoring system.

Summary

- LhARA has the capability to provide unique beams for the study of radiobiology.
- Two stage approach will aim to maximise scientific output whilst optimising the machine performance.
  - Stage 1: protons up to 15 MeV.
  - Stage 2: protons up to 127 MeV and C^{6+} ions up to 33MeV/u.
- Conceptual design and initial simulations show the required performance can be achieved in principle.
- Technical challenges will be addressed by the R&D plan.