

# Status of the development of the pre-CDR

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## LhARA Steering Group Meeting

**Ajit Kurup**

**31<sup>st</sup> January 2020**



**Imperial College  
London**

# Introduction

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- Overview of the preparations for the LhARA pre-CDR.
  - <https://ccap.hep.ph.ic.ac.uk/trac/wiki/Research/DesignStudy/PreCDR>
- Progress on the end-to-end simulation.
- LhARA project schedule and R&D plan.
- Status of the write up.

# Simulations

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- Five codes are used for the simulation.
  - BeamOptics
    - Used to do the beam optics design the accelerator (except the FFA ring).
    - Input parameters taken from the simulation of the laser target interaction.
  - MADX
    - Verify BeamOptics calculations.
    - Match optics to design the vertical bends.
  - BDSIM
    - Geant4 based single particle tracking toolkit.
    - Visualisation.
    - Energy deposition in the end stations.
    - Compare optics parameters.
  - GPT
    - Verify design including space charge effects.
    - Compare optics parameters.
  - pyZygoubi
    - FFA ring design.

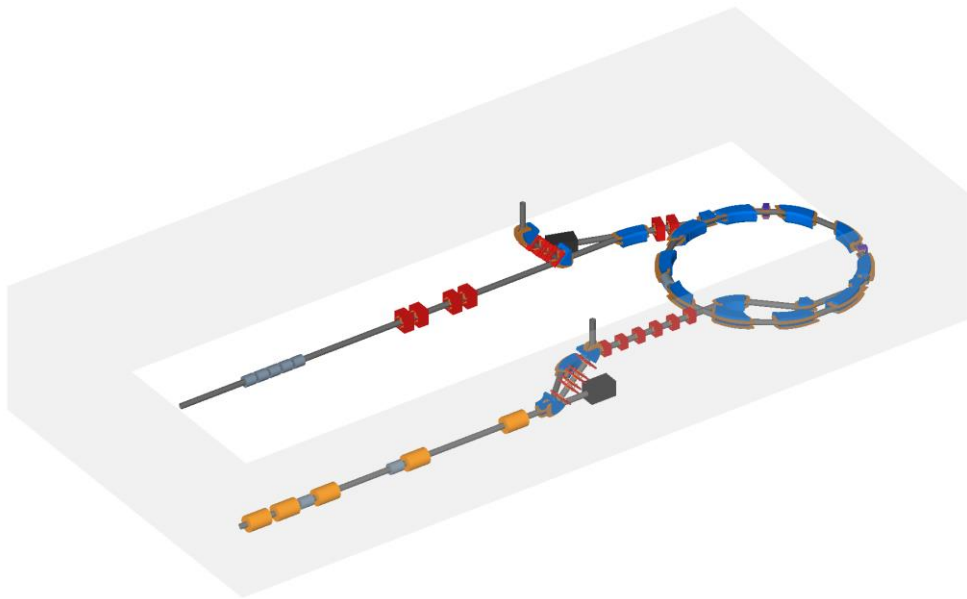
# Simulations

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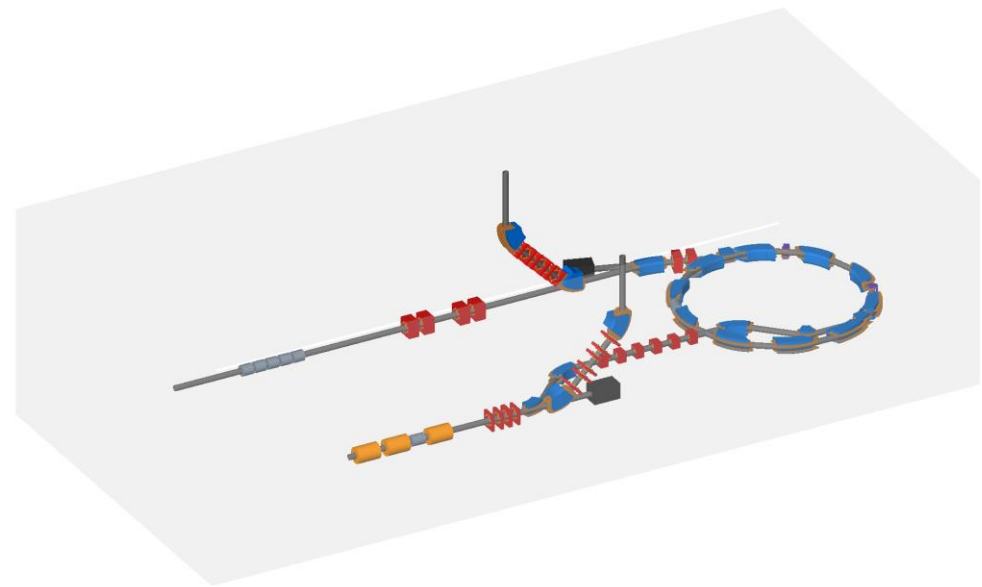
- Input beams
  - An idealised Gaussian beam generated from Twiss parameters.
  - Based on a 2D EPOCH simulation where the results (histogram of energy and theta) have been extrapolated to 3D assuming a Gaussian distribution for phi.
    - Peak of the energy-theta distribution not centred at 0 degrees.
    - Peak of the energy-theta distribution centred at 0 degrees.
  - 3D beam from a Smilei simulation beyond timescale for the pre-CDR.
- Simulation of the 10cm drift before the first Gabor lens.
  - Drift of 5cm where the beam is assumed to be space charge neutralised.
  - Further 5cm drift with space charge (using GPT).
  - Then run parallel simulations in BDSIM and GPT (with and without space charge).
- For comparison with BeamOptics an idealised beam is generated at the target and tracked through.

# Simulations

- Version 4.3 now includes an octupole after the 5<sup>th</sup> lens to improve the uniformity of the beam.
- Version 5 has undergone a few re-optimisations to improve the vertical arc and increase the beam size in the end station.
- Transfer line to the in vivo end station has been implemented.



Version 4.2 of the accelerator



Version 5.0 of the accelerator

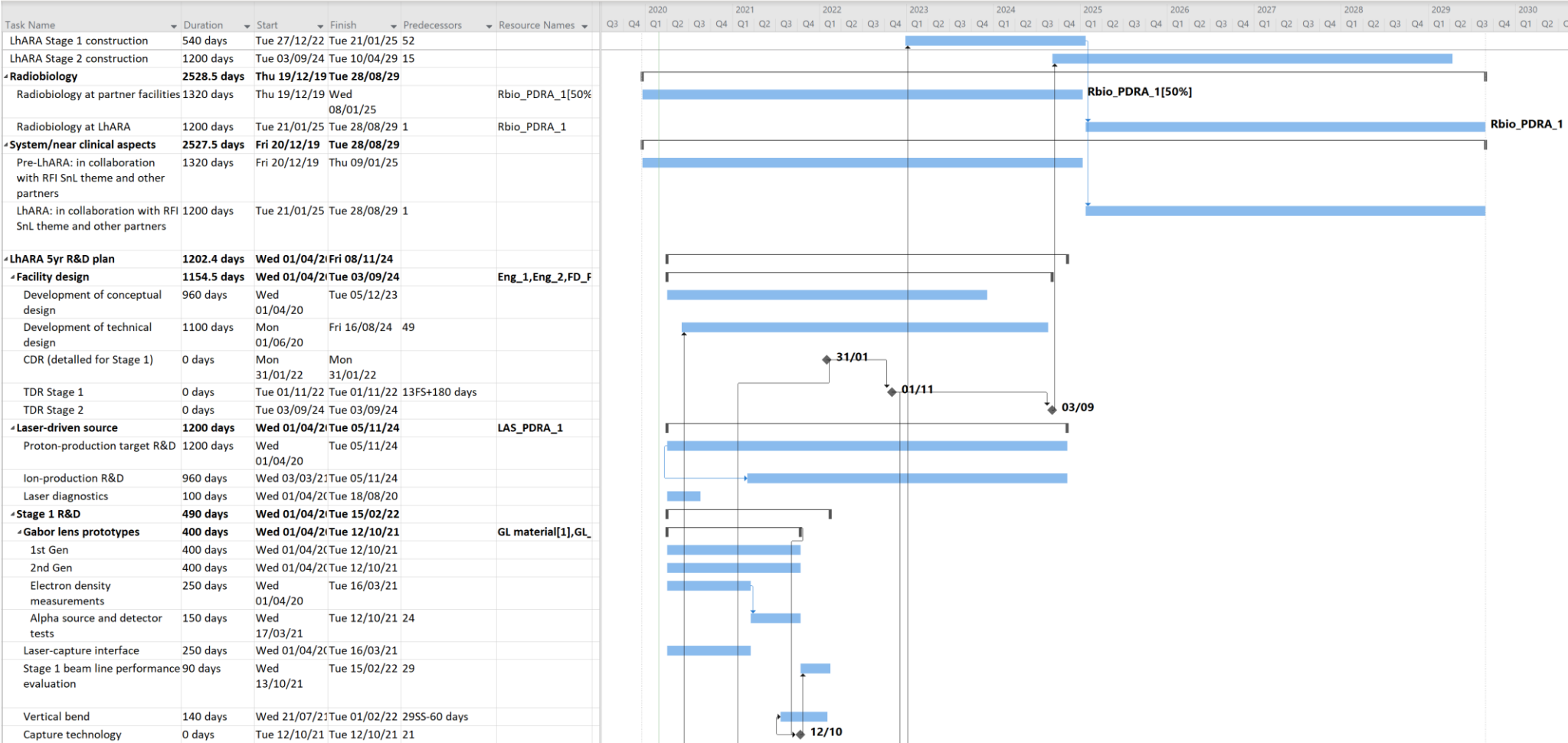
# Simulations – Current status

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- Need to decide which is the preferred lattice for Stage 1.
  - Five Gabor lenses and an octupole.
  - Three Gabor lenses and quadrupoles.
- Design for the transfer line to the in vivo end station complete.
  - Can transport the whole range of energies available with small tweaks to the quads.
  - Matched to RF cavity aperture.
  - Avoids very small beta at low energies.
- Remaining tasks.
  - Injection line into the FFA ring is being designed.
    - The mirror of this will be used for the extraction line.
    - There were a few bugs that were fixed.
  - Design of the FFA ring.

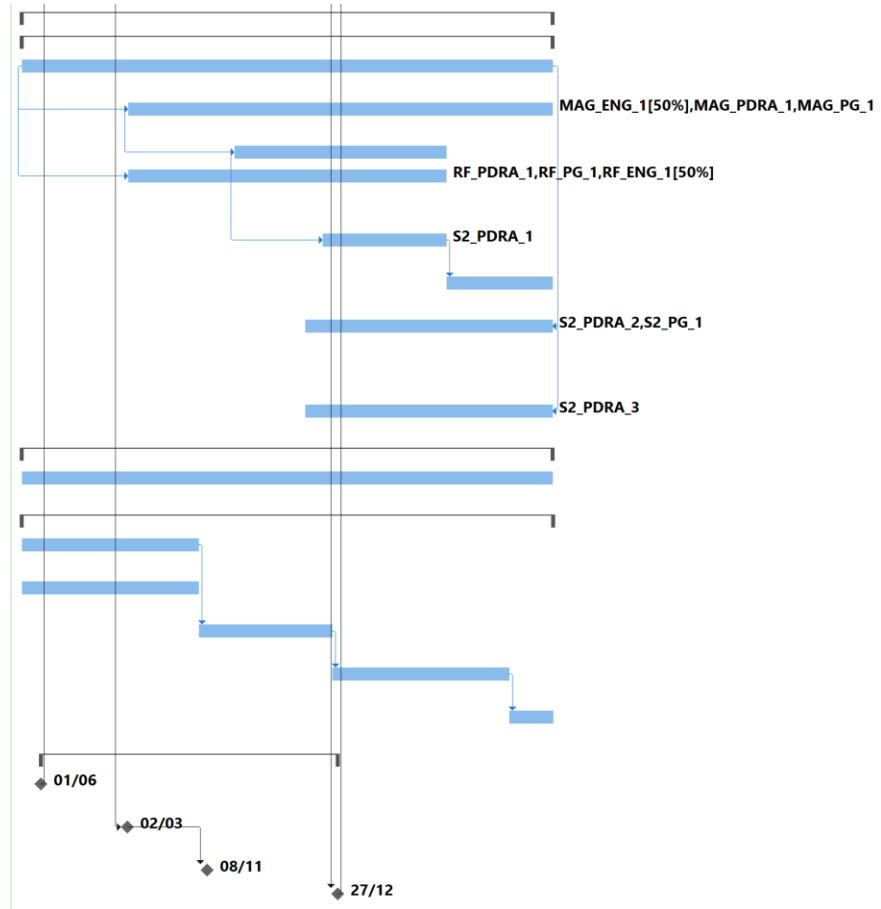
# LhARA project schedule

- Detail added to the project schedule.



# LhARA project schedule

◀ <b>Stage 2 R&amp;D</b>	<b>1200 days</b>	<b>Wed 01/04/21</b>	<b>Tue 05/11/24</b>		
◀ <b>FFA</b>	<b>1200 days</b>	<b>Wed 01/04/21</b>	<b>Tue 05/11/24</b>		
Design and simulation	1200 days	Wed 01/04/20	Tue 05/11/24		
Detailed magnet design	960 days	Wed 03/03/21	Tue 05/11/24	MAG_ENG_1[50%] MAG_PDRA_1,MA	
Magnet prototype	480 days	Wed 02/02/22	Tue 05/12/23		
RF cavity design and performance evaluation	720 days	Wed 03/03/21	Tue 05/12/23	RF_PDRA_1, RF_PG_1, RF_ENG_1[50%]	
Injection and extraction design	280 days	Wed 09/11/22	Tue 05/12/23	34SS+200 days S2_PDRA_1	
Stage 2 performance evaluation	240 days	Wed 06/12/23	Tue 05/11/24	36	
Longitudinal phase space manipulation design, simulation and prototyping	560 days	Wed 14/09/22	Tue 05/11/24	32FF S2_PDRA_2, S2_PG_1	
Final beam preparation for in vivo end station	560 days	Wed 14/09/22	Tue 05/11/24	32FF S2_PDRA_3	
◀ <b>End stations</b>	<b>1200 days</b>	<b>Wed 01/04/21</b>	<b>Tue 05/11/24</b>		<b>Rbio_PDRA_1[50%]</b>
Automation, sample handling, imaging	1200 days	Wed 01/04/20	Tue 05/11/24		
◀ <b>Instrumentation</b>	<b>1202.4 days</b>	<b>Wed 01/04/21</b>	<b>Fri 08/11/24</b>		<b>INST_PDRA_1</b>
Online dosimetry and dose profile	400.8 days	Wed 01/04/20	Wed 13/10/21		
Absolute dosimetry at ultra-high dose rates	400 days	Wed 01/04/20	Tue 12/10/21		
Low-energy beam diagnostics	300.8 days	Wed 13/10/21	Thu 08/12/22	43	
Fast feedback and control	400.8 days	Thu 08/12/22	Fri 21/06/24	45	
High-energy beam diagnostics	100 days	Fri 21/06/24	Fri 08/11/24	46	
◀ <b>Gateway process</b>	<b>671.5 days</b>	<b>Mon 01/06/21</b>	<b>Tue 27/12/22</b>		
GW0 -- Strategic assessment	0 days	Mon 01/06/20	Mon 01/06/20		
GW1 -- Business justification	0 days	Tue 02/03/21	Tue 02/03/21		
GW2 -- Delivery strategy	0 days	Mon 08/11/21	Mon 08/11/21	50FS+9 mons	
GW3 -- Investment decision	0 days	Tue 27/12/22	Tue 27/12/22	14FS+2 mons	





# Preparations for writing up

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- Ken prepared an outline of the pre-CDR.
- Main sections.
  - Executive summary.
  - Lay summary.
  - Introduction.
  - Motivation.
  - LhARA facility.
  - Infrastructure and integration
  - Conclusions.
- Appendices.
  - Timeline.
  - Costs.
  - Risk analysis.

# Status of the write up

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- LhARA facility.
  - Overview.
  - Laser-driven proton and ion source.
    - First draft received.
  - Proton and ion capture.
  - Beam transport and delivery to the in-vitro end station.
  - Post-acceleration and beam delivery to in-vitro and in-vivo end stations.
  - Instrumentation.
    - First draft received.
  - Software and computing.
  - Staging considerations.
    - First draft received.
  - Biological end stations.
    - First draft received.

# Deadlines

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- <https://ccap.hep.ph.ic.ac.uk/trac/wiki/Research/DesignStudy/PreCDR#Keydates>
- ✓ **29 Nov 2019:** First issue of the baseline. This will include lists from the various systems of what needs to be updated on the existing floor layout, WBS, interfaces document and the parameter table.
- ✗ **31 Dec 2019:** First end-to-end simulation.
- ✗ **31 Jan 2020:**
  - Design of the facility will be frozen.
  - First view of the costs.
  - R&D programme needed to realise LhARA and be able to write a technical design report will be defined.
- ✗ **28 Feb 2020:** Complete the write-up of the pre-CDR.
- **Mar 2020:** External review of pre-CDR in advance of publication.