



- Resources and Project Plan
 - Why Gabor lenses?



Laser/plasma source

- high flux, high energy
- minimise space charge effects

Gabor lens capture system

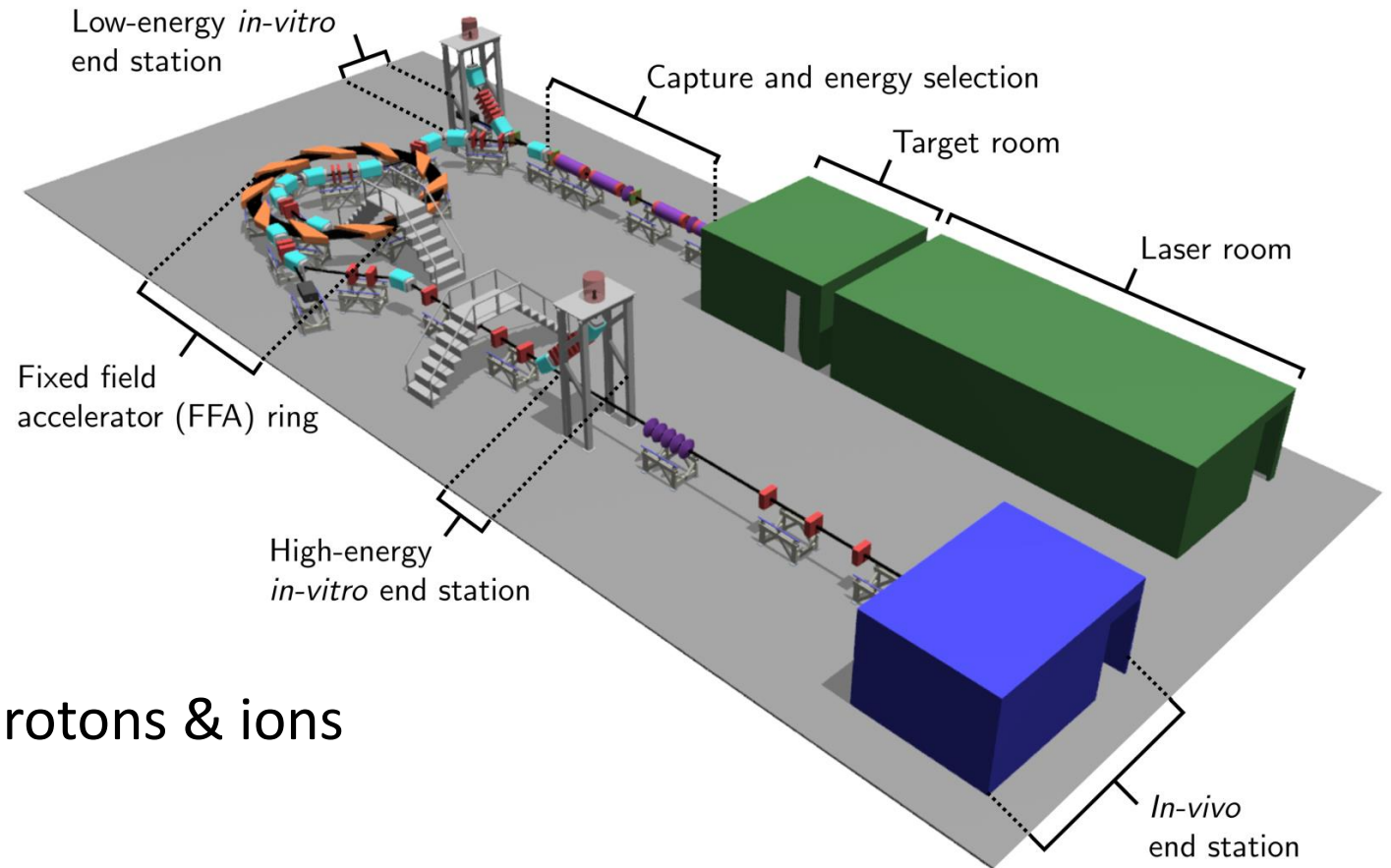
- efficient, low focal length lens. Protons & ions

Ion-Acoustic dose measurement

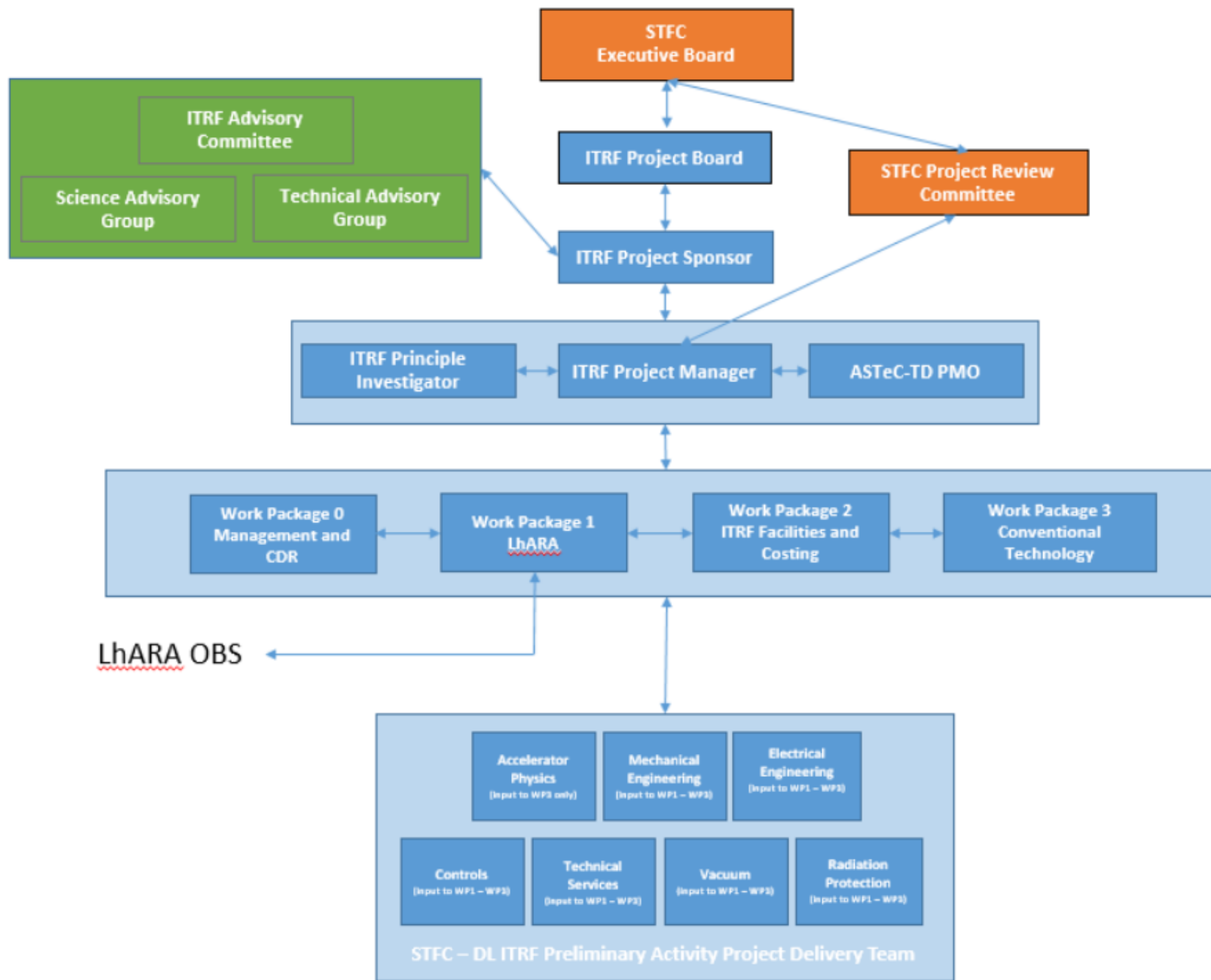
- single shot due to unique beam time structure.

Novel end station design and instrumentation – user consultation.

Beam line, accelerator design and Integration – high fidelity particle selection.

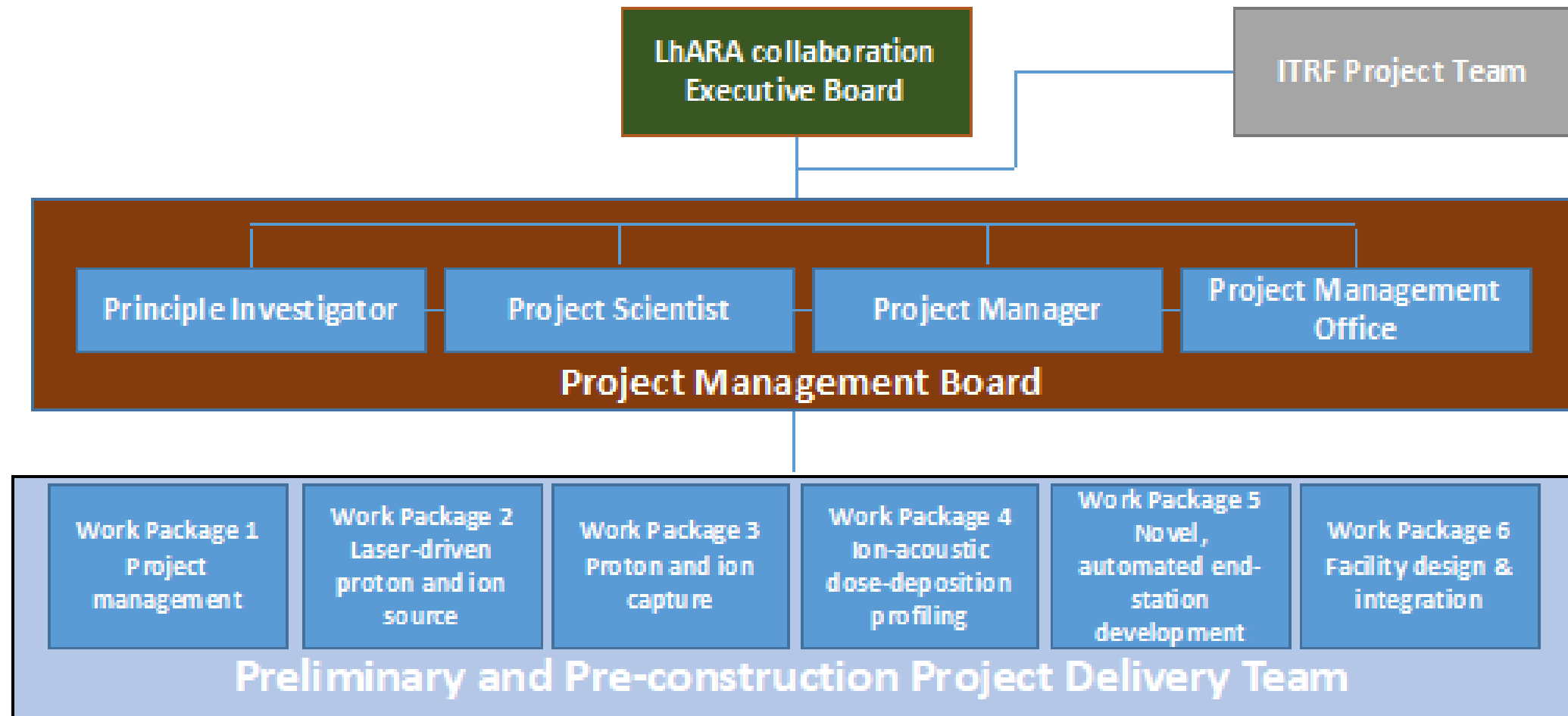


ITRF OBS



LhARA Project

Organisational Breakdown Structure



Timeline & Milestones for the Design

	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7				Year 8															
	FY22-23				FY23-24				FY24-25				FY25-26				FY26-27				FY27-28				FY28-29				FY29-30				FY30-31											
	2022				2023				2024				2025				2026				2027				2028				2029				2030											
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4								
Stage 1 & 2 CDR				█	2 Years																																							
Stage 1 TDR									1 Year																																			
Stage 2 Technical Design													2 Years																															
Construction Project Funded (Assumed)																			◆																									
Building Specification & Architect Design													1.5 Years																															
Building Construction Tender																	█	█																										
Building Construction																					1 Year																							
Radiation Shielding & Technical Services Stage 1																									█	█																		
Radiation Shielding & Technical Services Stage 2																													█	█														
Equipment Install & Testing Stage 1																													█	█														
Stage 1 commissioning with beam																																	█	█										
Start research with low energy beams																																					◆							
Equipment Install & Testing Stage 2																																					█	█						
Stage 2 commissioning with beam																																									█	█		
Start research with high energy beams																																									◆			
					4 Year Pre Construction Project												4 Year Construction Project																											

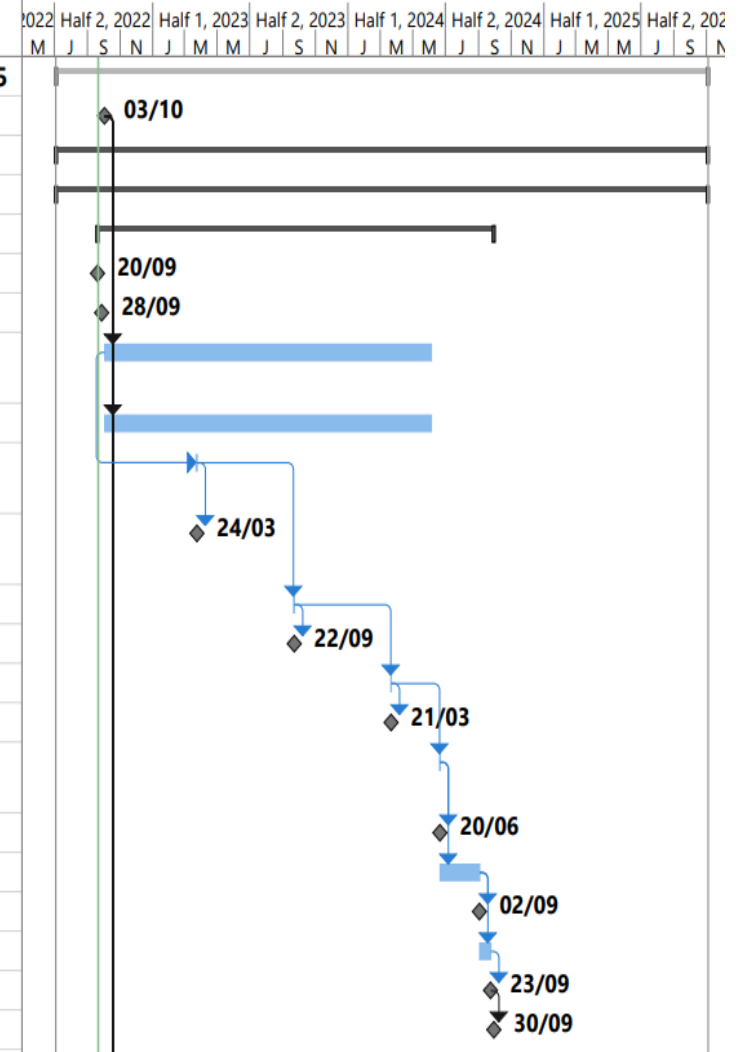
LhARA Project Schedules & Milestones

3 documents:

1. 1272-pa1-pm-ppl-0005-v1.0 - ITRF CDR milestones and deliverables 2022-10-18
2. 1272-pa1-pm-ppl-0004-v0.7 - ITRF CDR schedule 2022-09-20
3. 1272-pa1-pm-ppl-0001-v2.0 - ITRF schedule 2022-07-20 (Covered later in WP6 talk)

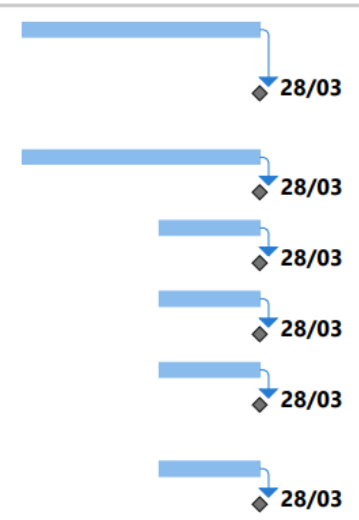
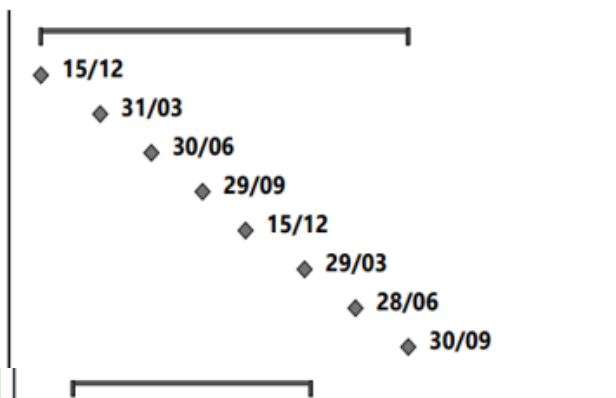
CDR Schedule 1272-pa1-pm-ppl-0004-v0.7 - ITRF CDR schedule 2022-09-20

ID	Task WBS	Task Name	Duration	Start	Finish	
0	0	ITRF CDR schedule	870 days	Mon 04/07/22	Mon 03/11/25	
1	1	Project start	0 days	Mon 03/10/22	Mon 03/10/22	
2	2	WPO ITRF Management & Conceptual Design Review	870 days	Mon 04/07/22	Mon 03/11/25	
3	2.1	UKRI Infrastructure Funding Waves	870 days	Mon 04/07/22	Mon 03/11/25	
15	2.2	ITRF Conceptual Design Report (CDR) - 2 years	529 days	Tue 20/09/22	Mon 30/09/24	
16	2.2.1	ITRF Team Kick-Off meeting at STFC Daresbury Laboratory	0 days	Tue 20/09/22	Tue 20/09/22	
17	2.2.2	ITRF IF monitoring kick off meeting	0 days	Wed 28/09/22	Wed 28/09/22	
18	2.2.3	Project Management Plan; scope, specifications, risk, finance, stakeholders, deliverables	437 days	Mon 03/10/22	Tue 04/06/24	
19	2.2.4	Technical studies	437 days	Mon 03/10/22	Tue 04/06/24	
20	2.2.5	Preliminary Conceptual Design Review (6 months) - refine scope, specifications, define parameters and schematic diagram of facility equipment.	2 days	Thu 23/03/23	Fri 24/03/23	
21	2.2.6	M2: ITRF Refined scope, specifications, defined parameters and schematic diagram of facility equipment complete.	0 days	Fri 24/03/23	Fri 24/03/23	
22	2.2.7	Interim Conceptual Design Review 1 (12 months) - specify baseline design	2 days	Thu 21/09/23	Fri 22/09/23	
23	2.2.8	M4: ITRF Baseline designs complete	0 days	Fri 22/09/23	Fri 22/09/23	
24	2.2.9	Interim Conceptual Design Review 2 (18 months) - refine specifications & designs	1 day	Thu 21/03/24	Thu 21/03/24	
25	2.2.10	M15: Refined ITRF specifications & designs	0 days	Thu 21/03/24	Thu 21/03/24	
26	2.2.11	Final Conceptual Design Meeting (21 months) - final specification & design ready for CDR write up	1 day	Thu 20/06/24	Thu 20/06/24	
27	2.2.12	M16: Start ITRF CDR write up	0 days	Thu 20/06/24	Thu 20/06/24	
28	2.2.13	CDR writing	52 days	Fri 21/06/24	Mon 02/09/24	
29	2.2.14	Chapter authors complete CDR writing	0 days	Mon 02/09/24	Mon 02/09/24	
30	2.2.15	Proof reading and final adjustments to CDR	15 days	Tue 03/09/24	Mon 23/09/24	
31	2.2.16	M18: ITRF CDR Publication	0 days	Mon 23/09/24	Mon 23/09/24	
32	2.2.17	M19: ITRF CDR phase complete	0 days	Mon 30/09/24	Mon 30/09/24	



CDR Schedule 1272-pa1-pm-ppl-0004-v0.7 - ITRF CDR schedule 2022-09-20

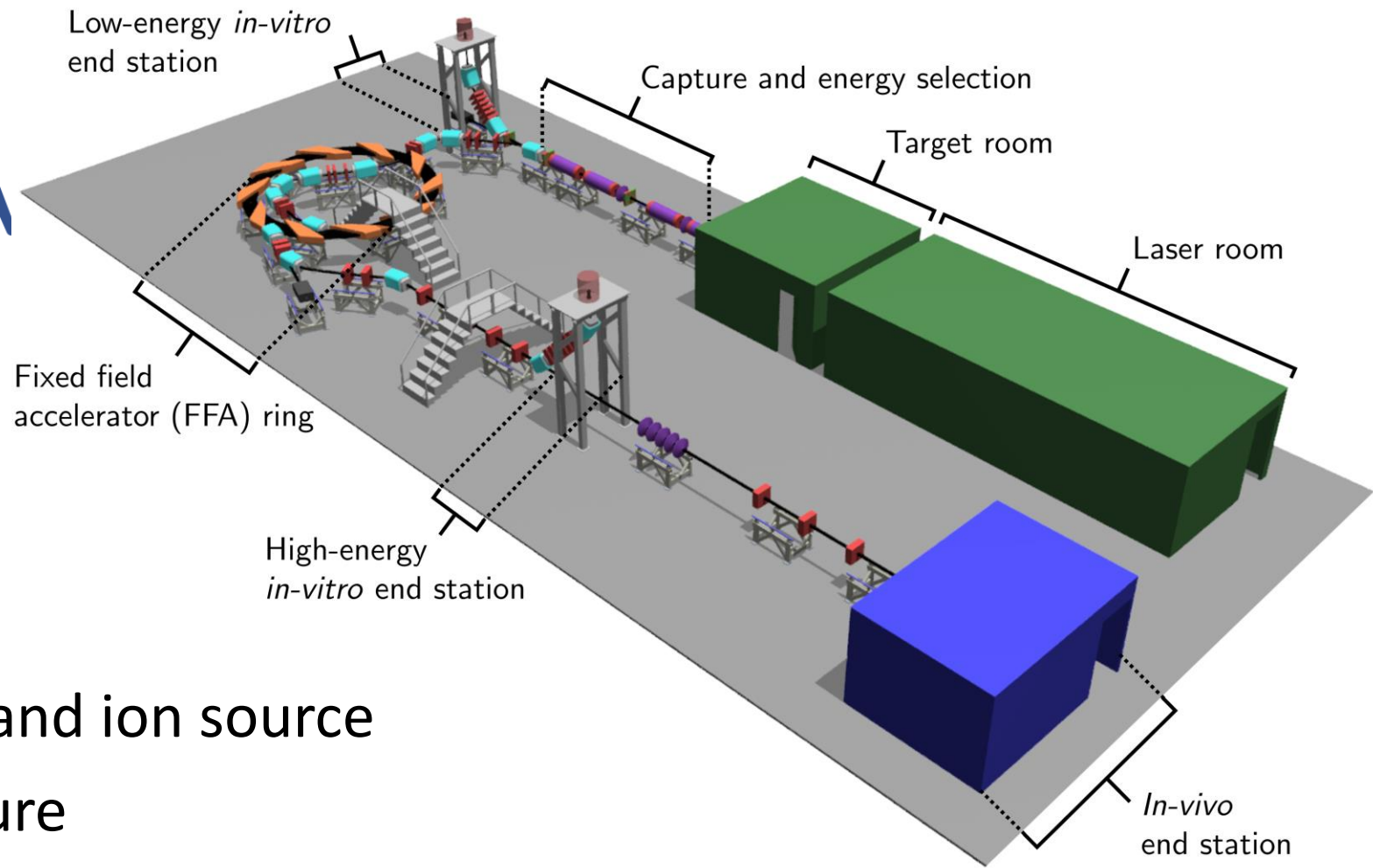
33	3	UKRI Infrastructure Fund (IF) Deliverables	467 days	Thu 15/12/22	Mon 30/09/24
34	3.1	D1: Y1Q1 IF progress report	0 days	Thu 15/12/22	Thu 15/12/22
35	3.2	D2: Y1Q2 IF progress report	0 days	Fri 31/03/23	Fri 31/03/23
36	3.3	D3: Y1Q3 IF progress report	0 days	Fri 30/06/23	Fri 30/06/23
37	3.4	D4: Y1Q4 IF progress report	0 days	Fri 29/09/23	Fri 29/09/23
38	3.5	D5: Y2Q1 IF progress report	0 days	Fri 15/12/23	Fri 15/12/23
39	3.6	D6: Y2Q2 IF progress report	0 days	Fri 29/03/24	Fri 29/03/24
40	3.7	D7: Y2Q3 IF progress report	0 days	Fri 28/06/24	Fri 28/06/24
41	3.8	D8: Y2Q4 IF progress report	0 days	Mon 30/09/24	Mon 30/09/24
81	5	WP2 ITRF Facilities & Costing	302 days	Wed 01/02/23	Thu 28/03/24
82	5.1	Preliminary design study of bulk shielding, beam dump and radioprotection requirements	302 days	Wed 01/02/23	Thu 28/03/24
83	5.2	M7: Preliminary design study of LhARA bulk shielding, beam dump and radioprotection requirements complete	0 days	Thu 28/03/24	Thu 28/03/24
84	5.3	Mechanical design of accelerator systems & integration	302 days	Wed 01/02/23	Thu 28/03/24
85	5.4	M7: Mechanical design of LhARA accelerator systems & integration complete	0 days	Thu 28/03/24	Thu 28/03/24
86	5.5	Preliminary design of the building and infrastructure requirements	129 days	Mon 02/10/23	Thu 28/03/24
87	5.6	M7: Preliminary design of LhARA building and infrastructure requirements complete	0 days	Thu 28/03/24	Thu 28/03/24
88	5.7	LhARA vacuum systems specification	129 days	Mon 02/10/23	Thu 28/03/24
89	5.8	M7: Finalise LhARA vacuum systems specification	0 days	Thu 28/03/24	Thu 28/03/24
90	5.9	Preliminary design of the mechanical supports including the vertical arc	129 days	Mon 02/10/23	Thu 28/03/24
91	5.10	M7: Preliminary design of LhARA mechanical supports including the vertical arc complete	0 days	Thu 28/03/24	Thu 28/03/24
92	5.11	Estimation of LhARA power consumption and cooling requirements	129 days	Mon 02/10/23	Thu 28/03/24
93	5.12	M7: Estimation of LhARA power consumption and cooling requirements complete	0 days	Thu 28/03/24	Thu 28/03/24





LhARA - Project organisation

- WP1 – Project management
- WP2 – Laser Driven proton and ion source
- WP3 – Proton and Ion Capture
- WP4 – Real-time dose-deposition profiling
- WP5 – End station development & Instrumentation
- WP6 – Facility design and integration



Project management

All the essential planning and organisation, but also..

Engagement and outreach:

Stakeholder

Peer group

User community

Public

Patient

Diversification of LhARA funding – alternate funding sources

CDR Milestones 1272-pa1-pm-ppl-0005-v1.0 - ITRF milestones and deliverables 2022-10-18

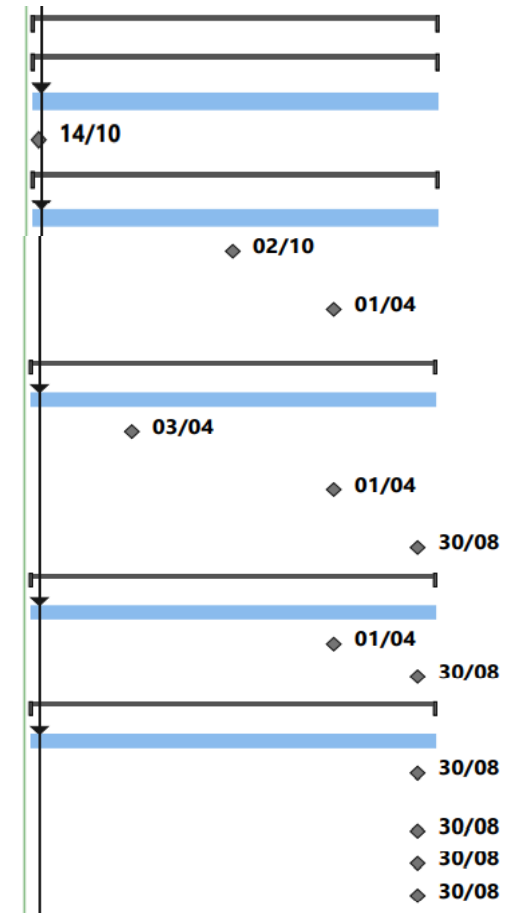
WBS	ITRF No.	High Level Milestones	Date
1		Project start	Mon 03/10/22
2.2.1		ITRF Team Kick-Off meeting at STFC Daresbury Laboratory	Tue 20/09/22
2.2.2		ITRF IF monitoring kick off meeting	Wed 28/09/22
3.1		D1: Y1Q1 IF progress report	Thu 15/12/22
4.6.2	M1	LhARA lattice optimisation, aperture estimation, parameter list and schematic diagram update	Tue 31/01/23
2.2.5	M2	Refined scope, specifications, defined parameters and schematic diagram of facility equipment complete (6 month design review) .	Thu 23/03/23
3.2		D2: Y1Q2 IF progress report	Fri 31/03/23
4.3.2	M3	Validate LhARA plasma simulations with existing Swansea experimental set-up (LhARA M3.1)	Mon 03/04/23
3.3		D3: Y1Q3 IF progress report	Fri 30/06/23
2.2.7	M4	M4: ITRF Baseline designs complete (12 month design review) .	Thu 21/09/23
3.4		D4: Y1Q4 IF progress report	Fri 29/09/23
4.2.2	M5	Prediction of optimised LhARA proton source parameters for 100+ TW laser systems based on hydrodynamic and kinetic simulations complete (LhARA M2.1)	Mon 02/10/23
3.5		D5: Y2Q1 IF progress report	Fri 15/12/23
4.6.4	M6	Preliminary design of LhARA MA RF cavity, FFA magnet, diagnostic system, control & feedback systems complete.	Thu 28/03/24
5.2	M7	Preliminary design study of LhARA Building concept design, bulk shielding assessment, mechanical systems integration support concepts, vacuum concepts, power consumption & cooling requirements complete.	Thu 28/03/24

CDR Milestones 1272-pa1-pm-ppl-0005-v1.0 - ITRF milestones and deliverables 2022-10-18

WBS	ITRF No.	High Level Milestones	Date
4.2.3	M8	First LhARA ion source simulations and experiment on SCAPA completed (LhARA M2.2)	Mon 01/04/24
4.3.3	M9	Progress report of LhARA large diameter plasma experiments and simulations (LhARA M3.2)	Mon 01/04/24
4.3.3	M10	Geant4 simulations of beam energy deposition profile (LhARA M4.1)	Mon 01/04/24
2.2.9	M11	Refined ITRF specifications & designs (18 month design review) .	Thu 21/03/24
3.6		D6: Y2Q2 IF progress report	Fri 29/03/24
2.2.12	M12	Start ITRF CDR write up (21 month design meeting) .	Thu 20/06/24
3.7		D7: Y2Q3 IF progress report	Fri 28/06/30
4.6.14	M13	Finalise Conceptual Design iterations (All LhARA WP6 systems) complete	Wed 24/07/24
4.3.4	M14	Next generation plasma lens test bench design (LhARA M3.3)	Fri 30/08/24
4.4.3	M15	Acoustic sensor array design complete (LhARA M4.2)	Fri 30/08/24
4.5.3	M16	Automated cell dish handling and environmental system design complete (LhARA M5.1), End-station user-community consultation complete (LhARA M5.2), End-station component testing at Birmingham complete (LhARA M5.3), kG,y/s tests at Birmingham complete (LhARA M5.7).	Fri 30/08/24
4.5.6	M17	Specification of LhARA beam monitoring technology complete (LhARA M5.5)	Fri 30/08/24
2.2.16	M18	ITRF CDR Publication	Mon 23/09/24
2.2.17	M19	ITRF CDR phase complete	Mon 30/09/24
3.8		D8: Y2Q4 IF progress report	Mon 30/09/24

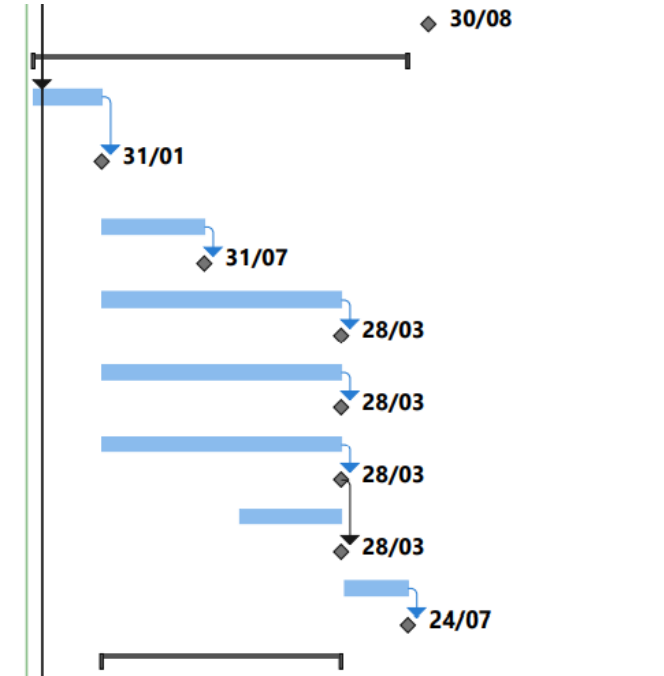
CDR Schedule 1272-pa1-pm-ppl-0004-v0.7 - ITRF CDR schedule 2022-09-20

42	4	WP1 LhARA	521 days	Mon 03/10/22	Mon 30/09/24
43	4.1	WP1.1 Project Management	521 days	Mon 03/10/22	Mon 30/09/24
44	4.1.1	Project management of the LhARA project	521 days	Mon 03/10/22	Mon 30/09/24
45	4.1.2	LhARA Collaboration Meeting	0 days	Fri 14/10/22	Fri 14/10/22
46	4.2	WP1.2 Laser-Driven Proton & Ion Source	521 days	Mon 03/10/22	Mon 30/09/24
47	4.2.1	Sub project management of the WP1.2	521 days	Mon 03/10/22	Mon 30/09/24
48	4.2.2	M5: Prediction of optimised LhARA proton source parameters for 100+ TW laser systems based on hydrodynamic and kinetic simulations complete (LhARA M2.1)	0 days	Mon 02/10/23	Mon 02/10/23
49	4.2.3	M8: First LhARA ion source simulations and experiment on SCAPA completed (LhARA M2.2)	0 days	Mon 01/04/24	Mon 01/04/24
50	4.3	WP1.3 Proton & Ion Capture	521 days	Mon 03/10/22	Mon 30/09/24
51	4.3.1	Sub project management of the WP1.3	521 days	Mon 03/10/22	Mon 30/09/24
52	4.3.2	M3: Validate LhARA plasma simulations with existing Swansea experimental set-up (LhARA M3.1)	0 days	Mon 03/04/23	Mon 03/04/23
53	4.3.3	M9: Progress report of LhARA large diameter plasma experiments and simulations (LhARA M3.2)	0 days	Mon 01/04/24	Mon 01/04/24
54	4.3.4	M14: Next generation plasma lens test bench design (LhARA M3.3)	0 days	Fri 30/08/24	Fri 30/08/24
55	4.4	WP1.4 Ion-acoustic dose - deposition profiling	521 days	Mon 03/10/22	Mon 30/09/24
56	4.4.1	Sub project management of the WP1.4	521 days	Mon 03/10/22	Mon 30/09/24
57	4.4.2	M10: Geant4 simulations of beam energy deposition profile (LhARA M4.1)	0 days	Mon 01/04/24	Mon 01/04/24
58	4.4.3	M15: Acoustic sensor array design complete (LhARA M4.2)	0 days	Fri 30/08/24	Fri 30/08/24
59	4.5	WP1.5 Novel, automated end-station development	521 days	Mon 03/10/22	Mon 30/09/24
60	4.5.1	Sub project management of the WP1.5	521 days	Mon 03/10/22	Mon 30/09/24
61	4.5.2	M16: Automated cell dish handling and environmental system design complete (LhARA M5.1)	0 days	Fri 30/08/24	Fri 30/08/24
62	4.5.3	M16: End-station user-community consultation complete (LhARA M5.2)	0 days	Fri 30/08/24	Fri 30/08/24
63	4.5.4	M16: End-station component testing at Birmingham complete (LhARA M5.3)	0 days	Fri 30/08/24	Fri 30/08/24
64	4.5.5	M16: kG,y/s tests at Birmingham complete (LhARA M5.7)	0 days	Fri 30/08/24	Fri 30/08/24



CDR Schedule 1272-pa1-pm-ppl-0004-v0.7 - ITRF CDR schedule 2022-09-20

65	4.5.6	M17: Specification of LhARA beam monitoring technology complete (LhARA M5.5)	0 days	Fri 30/08/24	Fri 30/08/24
66	4.6	WP1.6 LhARA Facility design & Integration	473 days	Mon 03/10/22	Wed 24/07/24
67	4.6.1	LhARA lattice optimisation, aperture estimation, parameter list and schematic diagram update	87 days	Mon 03/10/22	Tue 31/01/23
68	4.6.2	M1: LhARA lattice optimisation, aperture estimation, parameter list and schematic diagram update	0 days	Tue 31/01/23	Tue 31/01/23
69	4.6.3	Preliminary design of LhARA mitigating solenoid	129 days	Wed 01/02/23	Mon 31/07/23
70	4.6.4	M6: Preliminary design of LhARA mitigating solenoid complete	0 days	Mon 31/07/23	Mon 31/07/23
71	4.6.5	Preliminary design of LhARA MA RF cavity	302 days	Wed 01/02/23	Thu 28/03/24
72	4.6.6	M6: Preliminary design of LhARA MA RF cavity complete	0 days	Thu 28/03/24	Thu 28/03/24
73	4.6.7	Preliminary design of LhARA FFA magnet	302 days	Wed 01/02/23	Thu 28/03/24
74	4.6.8	M6: Preliminary design of LhARA FFA magnet complete	0 days	Thu 28/03/24	Thu 28/03/24
75	4.6.9	Preliminary design of LhARA diagnostic system	302 days	Wed 01/02/23	Thu 28/03/24
76	4.6.10	M6: Preliminary design of LhARA diagnostic system complete	0 days	Thu 28/03/24	Thu 28/03/24
77	4.6.11	Preliminary design of LhARA control and feedback systems	129 days	Mon 02/10/23	Thu 28/03/24
78	4.6.12	M6: Preliminary design of LhARA control and feedback systems complete	0 days	Thu 28/03/24	Thu 28/03/24
79	4.6.13	Finalise Conceptual Design iterations (All LhARA systems)	80 days	Thu 04/04/24	Wed 24/07/24
80	4.6.14	M6: Finalise Conceptual Design iterations (All LhARA systems) complete	0 days	Wed 24/07/24	Wed 24/07/24
81	5	WP2 ITRF Facilities & Costing	302 days	Wed 01/02/23	Thu 28/03/24



Resources

<https://ccap.hep.ph.ic.ac.uk/trac/raw-attachment/wiki/Communication/Notes/CCAP-TN-10.pdf>

Staff		Year 1		Year 2		Total	
		Fraction	£k	Fraction	£k	Fraction	£k
BHM Physics							
	<i>BHM-Phys-NoOH</i>						
	LhARA: Novel end station development	0.20	8.90	0.20	8.90	0.40	17.80
Total		0.20	8.90	0.20	8.90	0.40	17.80
IC NHS HC Trust							
	<i>IC-NHS-HC-Trst</i>						
	LhARA: Novel end station development	0.20	22.00	0.20	22.00	0.40	44.00
Total		0.20	22.00	0.20	22.00	0.40	44.00
ICR, Radiotherapy and Imaging							
	<i>ICR-Stf-1</i>						
	LhARA: ionacoustic Imaging	0.05	11.00	0.05	11.00	0.10	22.00
	<i>ICR-Stf-2</i>						
	LhARA: ionacoustic Imaging	0.05	9.95	0.05	9.95	0.10	19.90
Total		0.10	20.95	0.10	20.95	0.20	41.90
Imperial Physics							
	<i>IC-Phys-PDRA-1</i>						
	LhARA: Design and integration	0.50	86.81	0.50	86.81	1.00	173.62
	<i>IC-Phys-Stf-1</i>						
	LhARA: Laser-driven proton and ion source	0.43	73.17	0.50	85.48	0.93	158.66
Total		0.93	159.98	1.00	172.29	1.93	332.28
Lancaster Physics							
	<i>Lanc-Phys-PDRA-1</i>						
	LhARA: Laser-driven proton and ion source	0.50	60.00	0.50	60.00	1.00	120.00
	<i>Lanc-Phys-Stf-1</i>						
	LhARA: Laser-driven proton and ion source	0.05	7.50	0.05	7.50	0.10	15.00
Total		0.55	67.50	0.55	67.50	1.10	135.00
Liverpool Physics							
	<i>Liv-Phys-PDRA</i>						
	LhARA: Novel end station development	0.50	61.50	0.50	61.50	1.00	123.00
Total		0.50	61.50	0.50	61.50	1.00	123.00
Manchester Physics							
	<i>Man-Phys-Stf-1</i>						
	LhARA: Proton and ion capture	0.10	20.75	0.10	20.75	0.20	41.50
Total		0.10	20.75	0.10	20.75	0.20	41.50
Queen's Physics							
	<i>Qns-Phys-Stf-1</i>						
	LhARA: Laser-driven proton and ion source	0.05	6.50	0.05	6.50	0.10	13.00
Total		0.05	6.50	0.05	6.50	0.10	13.00
RHUL Physics							
	<i>RHUL-PDRA-1</i>						
	LhARA: Design and integration	0.50	87.50	0.50	87.50	1.00	175.00
Total		0.50	87.50	0.50	87.50	1.00	175.00

Resources

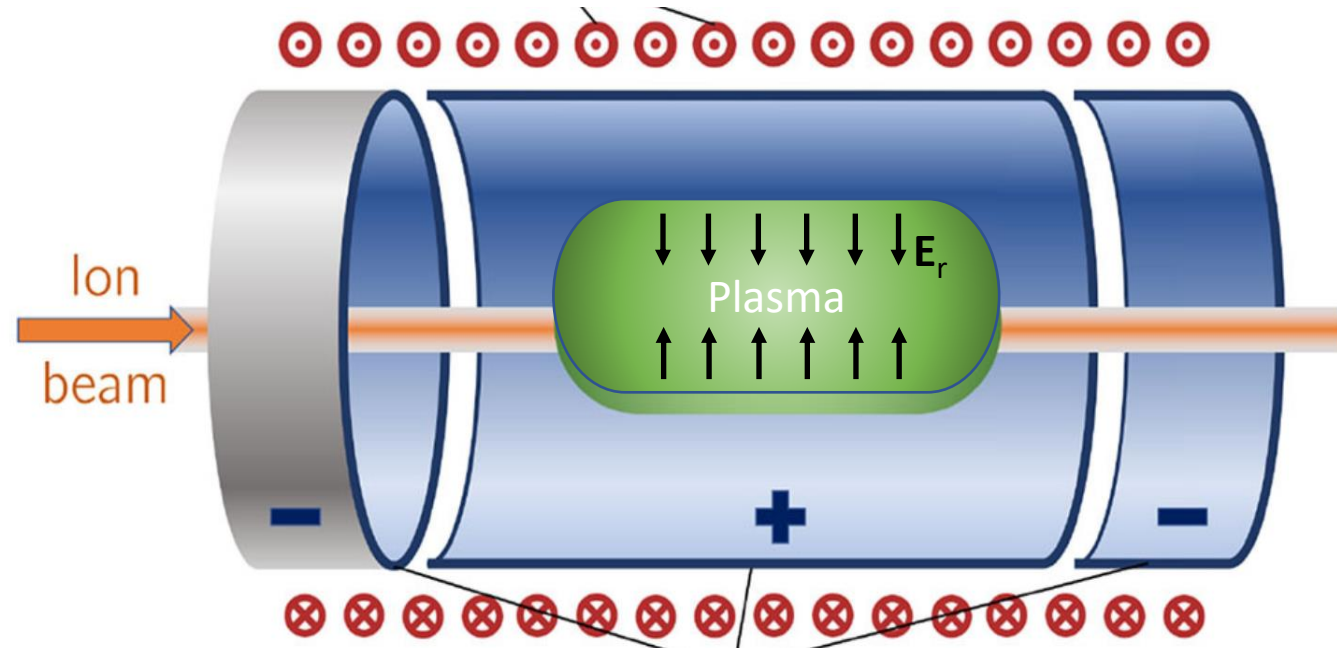
<https://ccap.hep.ph.ic.ac.uk/trac/raw-attachment/wiki/Communication/Notes/CCAP-TN-10.pdf>

STFC Technical							
	<i>Controls specification</i>						
	LhARA: Design and integration	0.05	5.00	0.25	25.00	0.30	30.00
	<i>Electrical engineering design specification</i>						
	LhARA: Design and integration	0.05	5.00	0.55	55.00	0.60	60.00
	<i>Mechanical engineering design specification</i>						
	LhARA: Design and integration	0.50	50.00	0.80	80.00	1.30	130.00
	<i>Radiation Protection Advisor</i>						
	LhARA: Design and integration	0.03	2.50	0.08	7.50	0.10	10.00
	<i>STFC WP management</i>						
	LhARA: Design and integration	0.20	20.00	0.25	25.00	0.45	45.00
	<i>Technical services specification</i>						
	LhARA: Design and integration	0.00	0.00	0.40	40.00	0.40	40.00
	<i>Vacuum specification</i>						
	LhARA: Design and integration	0.00	0.00	0.20	20.00	0.20	20.00
Total		0.83	82.50	2.53	252.50	3.35	335.00
STFC-PPD							
	<i>STFC-PPD-Stf-1</i>						
	LhARA: ionacoustic Imaging	0.04	6.00	0.04	6.00	0.08	12.00
Total		0.04	6.00	0.04	6.00	0.08	12.00
Strathclyde Physics							
	<i>Strathclyde-Phys-PDRA-1</i>						
	LhARA: Laser-driven proton and ion source	0.50	61.50	0.50	61.50	1.00	123.00
	<i>Strathclyde-Phys-Stf-1</i>						
	LhARA: LhARA Project Management	0.50	80.00	0.50	80.00	1.00	160.00
	<i>Strathclyde-Phys-Stf-2</i>						
	LhARA: Laser-driven proton and ion source	0.10	13.50	0.10	13.50	0.20	27.00
Total		1.10	155.00	1.10	155.00	2.20	310.00
Swansea Physics							
	<i>Swans-Phys-PDRA-1</i>						
	LhARA: Proton and ion capture	1.00	107.70	1.00	107.70	2.00	215.40
	<i>Swans-Phys-Stf-1</i>						
	LhARA: Proton and ion capture	0.10	18.89	0.10	18.89	0.20	37.78
Total		1.10	126.59	1.10	126.59	2.20	253.18
UCL, Biomedical Engineering							
	<i>UCL-Stf-1</i>						
	LhARA: ionacoustic Imaging	0.05	8.75	0.05	8.75	0.10	17.50
Total		0.05	8.75	0.05	8.75	0.10	17.50
Grand total		6.24	834.42	8.02	1016.73	14.26	1851.15

Risk Register

	Number	WP Number	Name	Description	Likelihood	Impact	Score	Mitigation	Mitigated Likelihood	Mitigated Impact	Mitigated score
WP1	1	1.5	Resources	Insufficient resources secured to deliver the project.	5	4	20	Pursue additional sources of funds.	4	4	16
WP1	2	1.3	Performance specification parameters	Inadequate ion beam parameters to meet the Physics and Biology requirements.	3	5	15	The project consortium includes the required experts to improve performance and adapt requirements to maximise convergence of capability and need.	2	5	10
All	3	9	Key specialist staff	Availability of key specialist staff critical to project.	4	5	20	Identify potential single point failure risks, apply cover and succession planning where appropriate.	2	5	10
WP2	4	2.7	Source output	Unable to deliver desired beam.	3	4	12	Investigate experimental techniques to increase yield	2	2	4
WP2	5	2.1	Laser Access	Laser schedule does not allow sufficient access.	3	4	12	Apply for access to other, similar, laser systems e.g Gemini	2	3	6
WP3	6		Plasma Density	A low density will result in too long a focal length (& beamline)	4	4	16	Expert experimental design coupled with established and novel mitigation measures	4	3	12
WP4	7	4.1	Low acoustic signal	Insufficient acoustic signal to noise ratio.	3	5	15	Employ range of established techniques. Adaptively trade dose-map resolution for enhanced signal	3	3	9
WP6	8	6.6	Facility Integration	Delayed start/insufficient early resource.	3	5	15	Prioritise integration work package	1	4	4
WP5	9	5.1	End Station Specification	End station specification does not clearly specify requirements.	5	5	25	Early progress review, input from system designers to user consultation exercise	1	5	5

Why Gabor Lenses



- Power consumption
 - B reduced by factor of 5-10.
 - Equivalent first solenoid as focussing element \sim 5T weight, 150-200kW.
- Electrostatic focussing compared to magnetic
 - Force proportional to q compared to $qv \times B$
 - Heavier particles will have lower velocity, require higher solenoid field
 - Gabor lens has orthogonal E and B fields and so acts as a Wien filter
 - select for particle velocity
 - used as part of the transmission line particle selection.
- Achievable – Swansea/Manchester demonstrated capability in ALPHA.









































