



LIGO-India Project

a brief overview

July 5, 2023
ngGW Subcommittee, NSF MPSAC

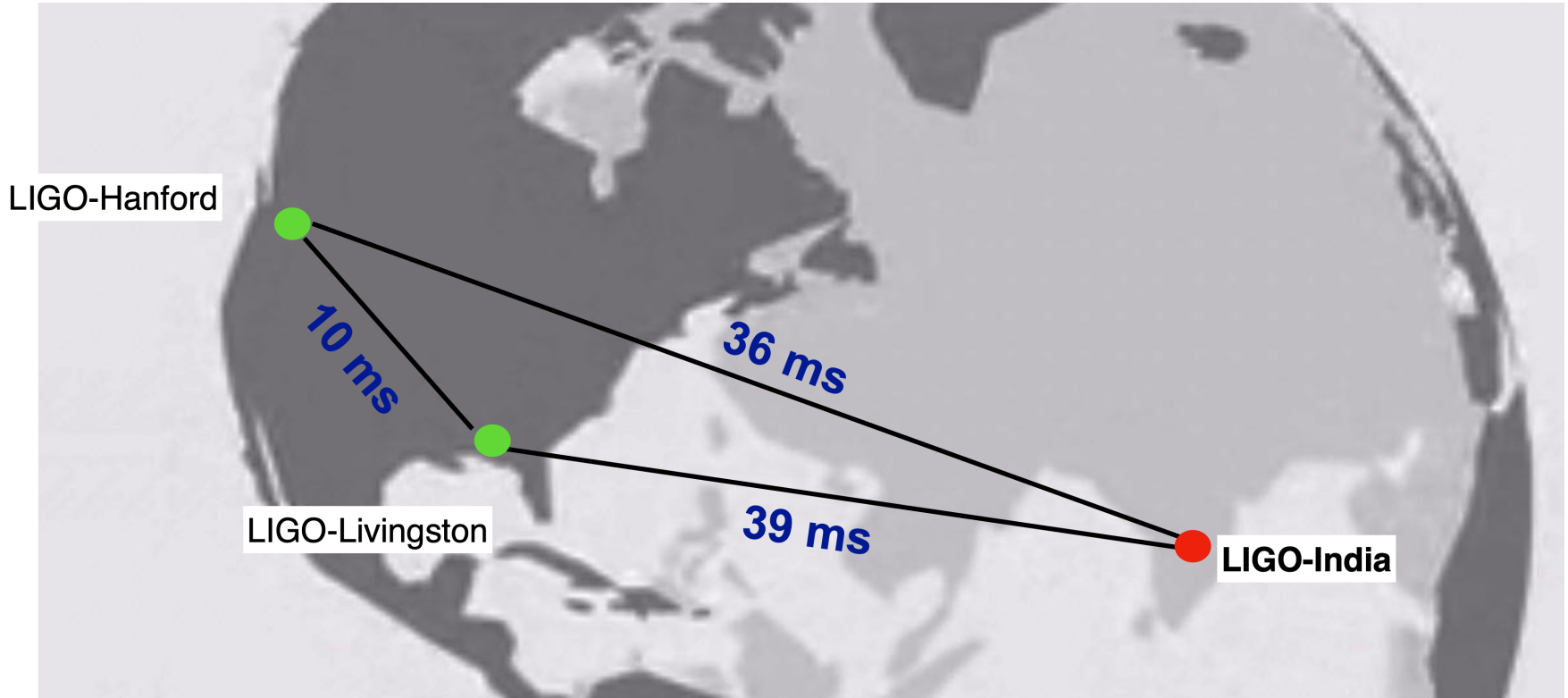


LIGO-India Project

The LIGO-India is a project under the Mega-Science Consortium of Department of Atomic Energy and Department of Science and Technology for the construction of a Laser Interferometer Gravitational-wave Observatory (LIGO) in India under an MoU with NSF, USA.

The LIGO-India Observatory is being set up under an International Collaboration with LIGO Laboratory, Caltech & MIT of the United States of America.

Global Network of LIGO Detectors



The intent is to join the GWN as A+ (preferably A#) by the end of this decade



LIGO-India Project

On the Indian side LIGO-India Project is lead by the DAE Institutions; Raja Ramanna Center for Advanced Technology, Indore, Institute for Plasma Research, Gandhinagar, and the Directorate of Construction Services and Estate Management, Mumbai along with Inter-University Centre for Astronomy and Astrophysics, Pune, a UGC institution.

The Observatory will be setup at Aundha, in Hingoli District of Maharashtra, India (LIGO Aundha Observatory or LAO) which was selected due to it very low micro-seismic noise.

Aundha Site

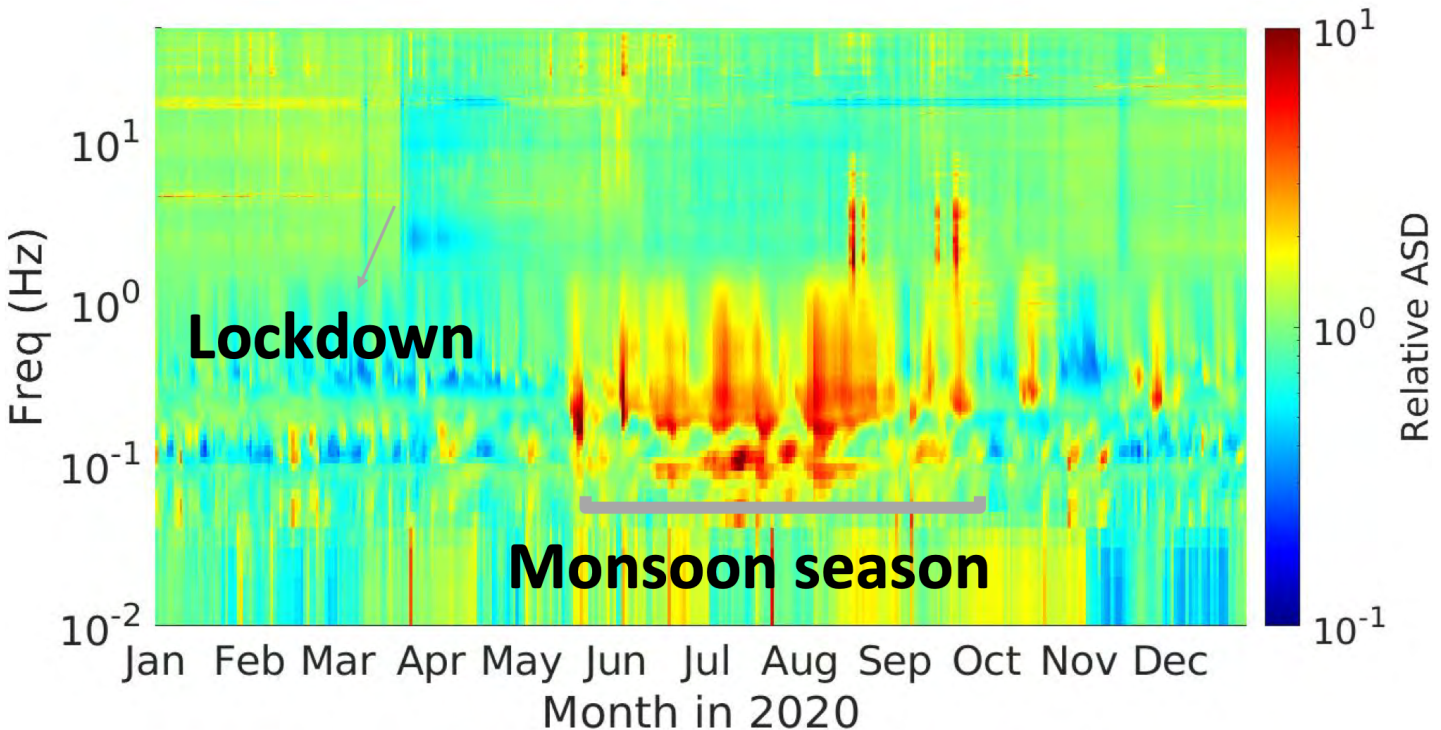


Aundha Site



Aundha Site


Spectrogram LGCS-Z [2020][Daily median]



LIGO-India Primary Site

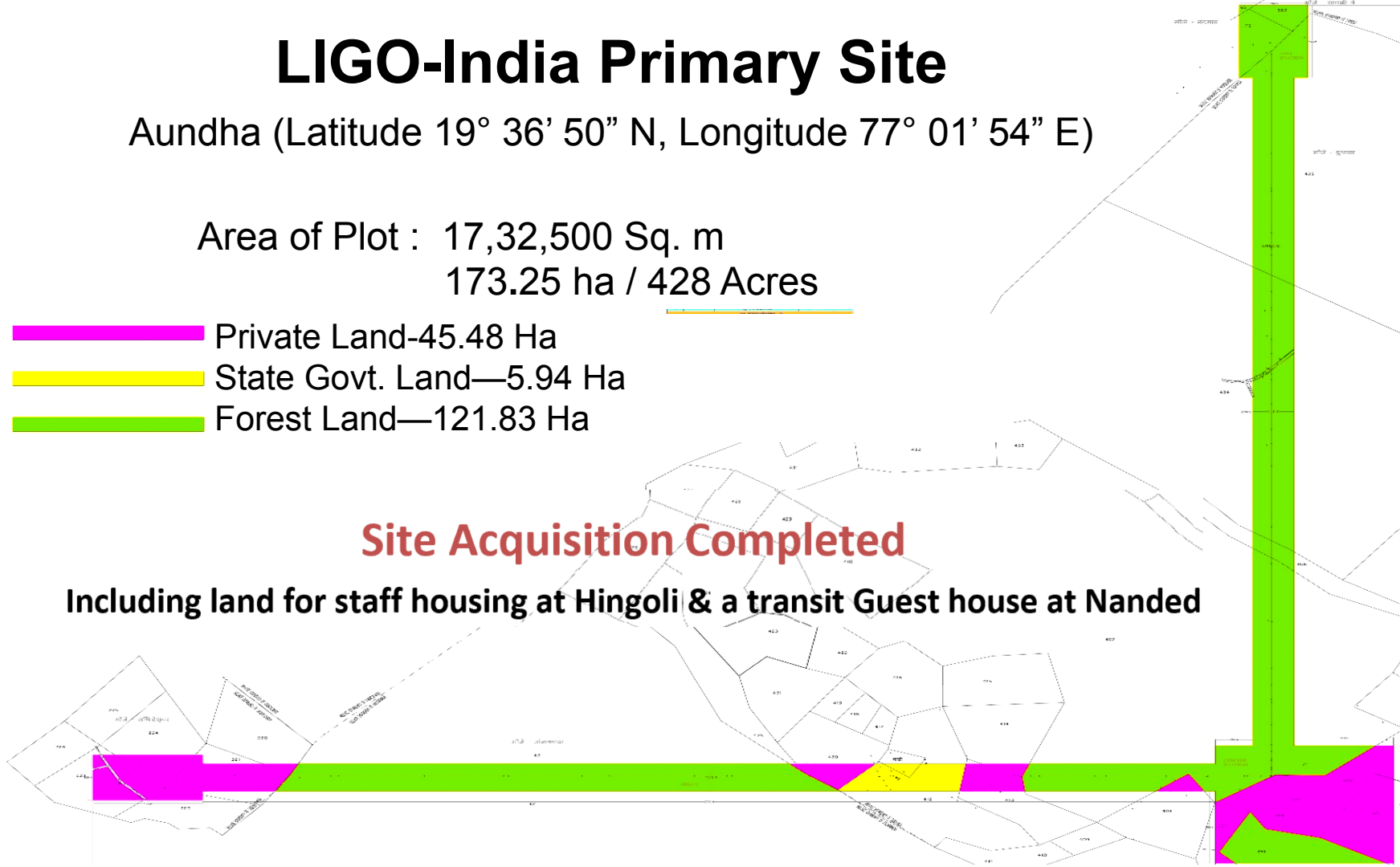
Aundha (Latitude 19° 36' 50" N, Longitude 77° 01' 54" E)

Area of Plot : 17,32,500 Sq. m
173.25 ha / 428 Acres

-  Private Land-45.48 Ha
-  State Govt. Land—5.94 Ha
-  Forest Land—121.83 Ha

Site Acquisition Completed

Including land for staff housing at Hingoli & a transit Guest house at Nanded



Seismic survey, Weather Station, Site office



Site office for LIGO-India Project



Weather station at the LAO site



Site office at the LAO site

Off-site Staging & Training facility



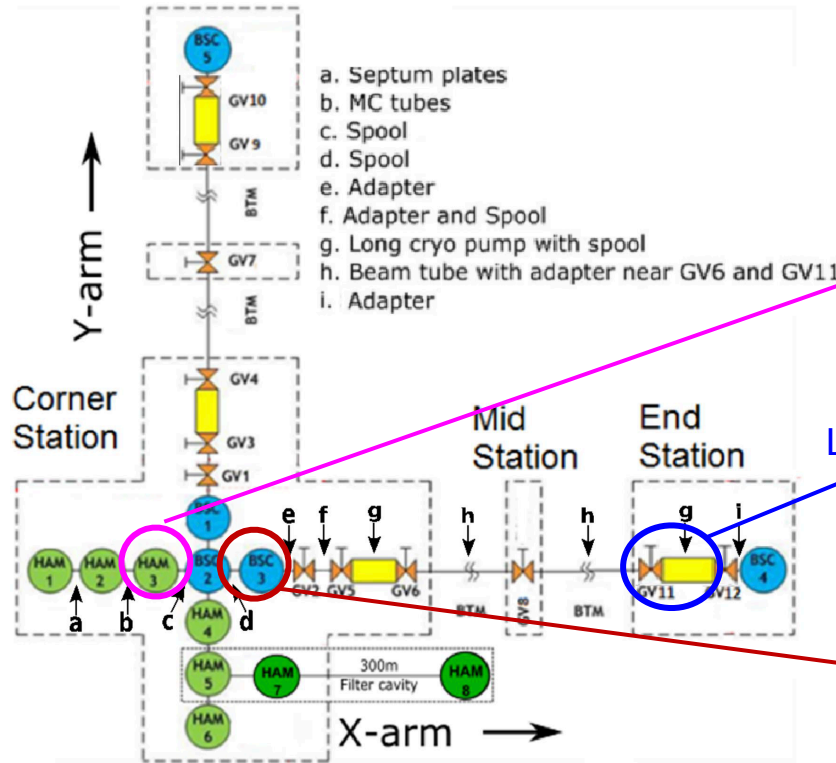
Staging and testing facility & 3G R&D

LIGO-India Training & Testing Laboratory

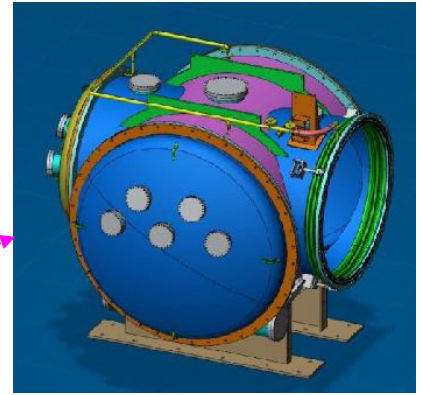


A dedicated laboratory building has been constructed meeting the unique requirements (vibration isolated floor slab, low acoustic noise and dust free clean ambience, etc.,) of LIGO-India Project related activities.

Vacuum system Development



HAM



Long cryo-pump

BSC



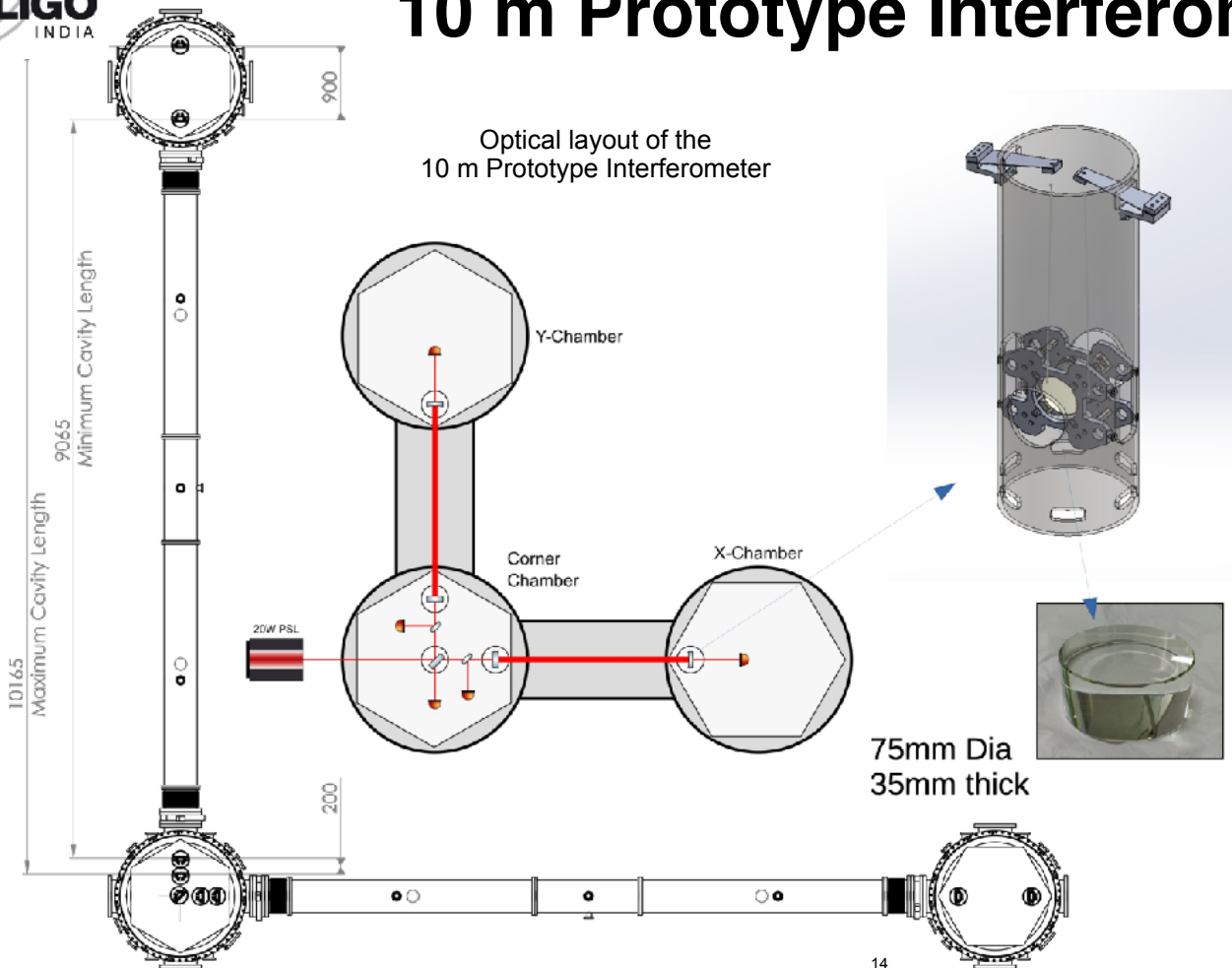
Schematic of LIGO-India Vacuum System Layout

HAM Vacuum Chamber Prototyping



M/S Vacuum Techniques Pvt. Ltd. (Bengaluru), followed the stringent manufacturing guidelines laid down by the Project Team in terms of material, machining to tight tolerances, metrology, vacuum leak testing and vacuum demonstration

10 m Prototype Interferometer



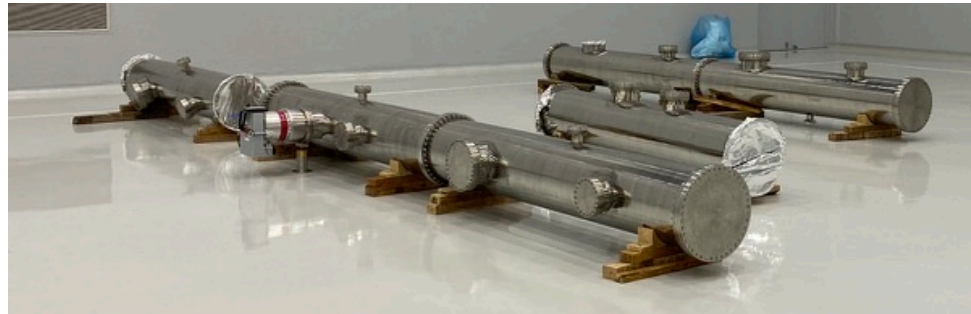
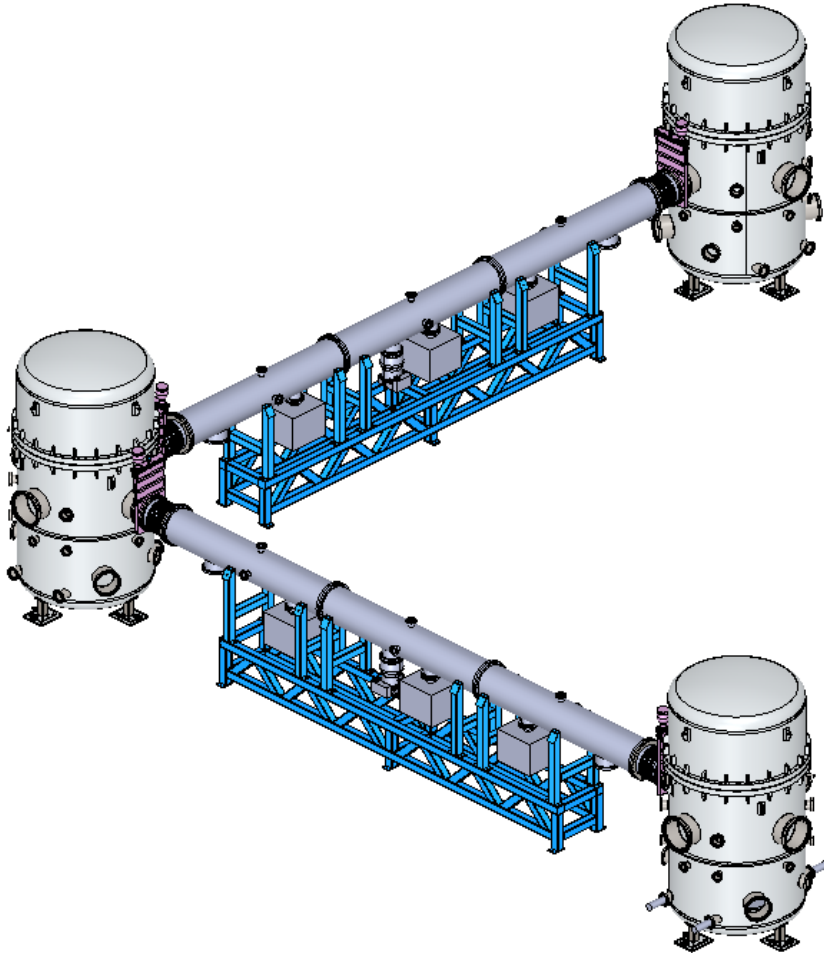
10 M Optical Layout

(C₁: Initial controls training configuration)
Michelson with Fabry-Perot arm, no PRM, no SRM

S.No.	Optic	ROC (m)	S1	S2
1	ITMx	Plano	AR	HR(99.0)
2	ITMy	Plano	AR	HR(99.0)
3	ETMx	34 m	HR(99.8)	UC
4	ETMy	34 m	HR(99.8)	UC

- Lx and Ly = 9.1 m
- FP Arm finesse : ~500 (plane-concave cavity)
- Arm stability g_{arm} : 0.73
- Beam-waist w_0 : 2.26 mm (at ITM S2)
- ITM/ETM size: 75 mm dia/35 mm thick (mass 340 g)

10 m Prototype Interferometer

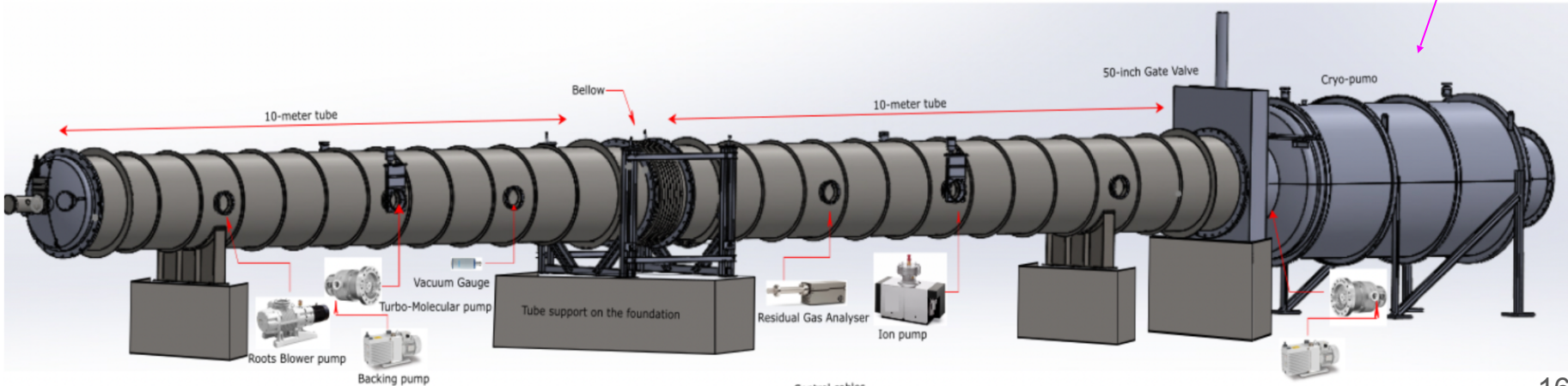
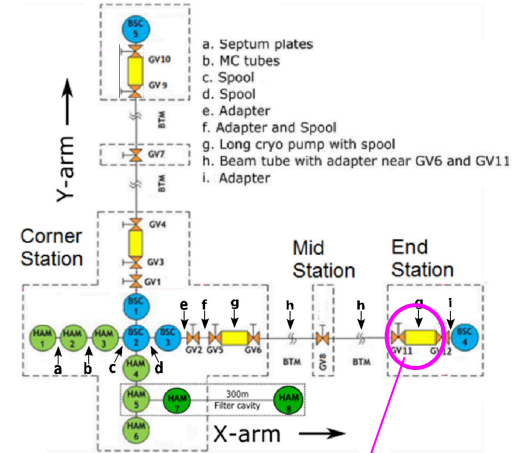


UHV envelope of the 10 m Prototype Interferometer has been designed, fabricated and accepted after leak testing.

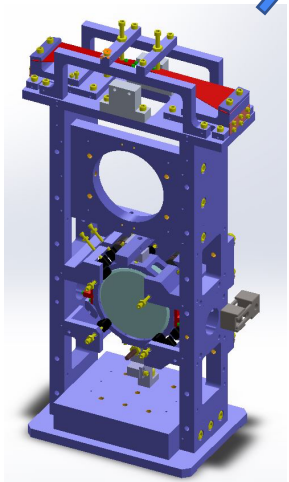
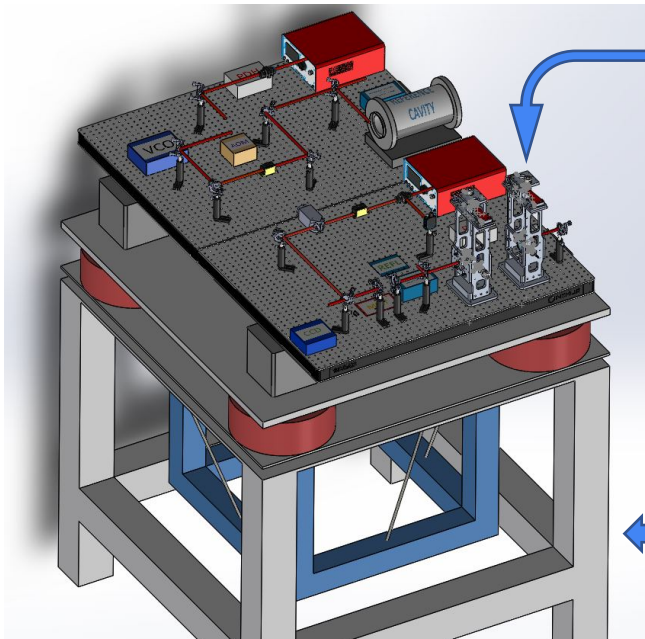
LI-VISTA

LIGO-India Vacuum integrated system test assembly

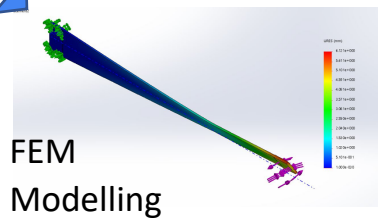
- 80 K Long Cryo-pump
- 2 x 10 m vacuum vessel
- Gate valve



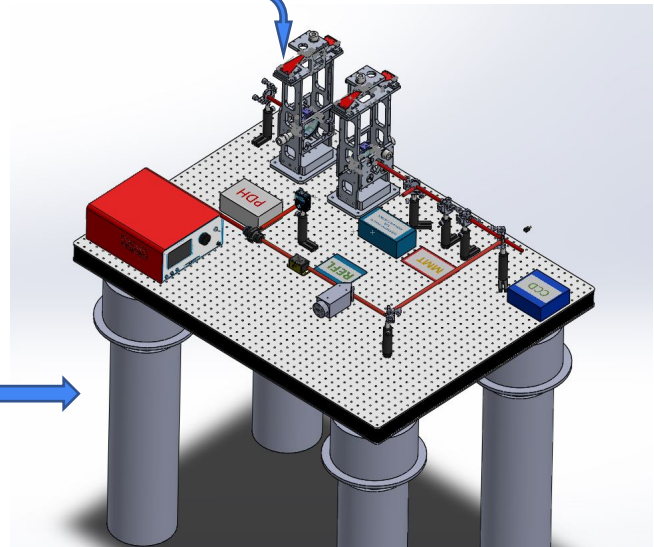
LIGO-India Training Program



Suspension
Design and control



FEM
Modelling



Active
Seismic
Isolation

LIGO India Project

- On May 1, 2023 the Department of Atomic Energy issued the Office Memorandum for the financial sanction for the project.
- On May 17, 2023 the Department of Atomic Energy setup the Empowered Board for the LIGO-India Project.

Project Duration: 7 Years

Schedule: from 1st May 2023 to 30th April 2030

Project Cost: Rs 2600 Cr. (~ \$ 300 million)

LIGO India Project



On May 11, 2023 Hon'ble Prime Minister of India laid the foundation stone for the construction of the Observatory.

LIGO India Project



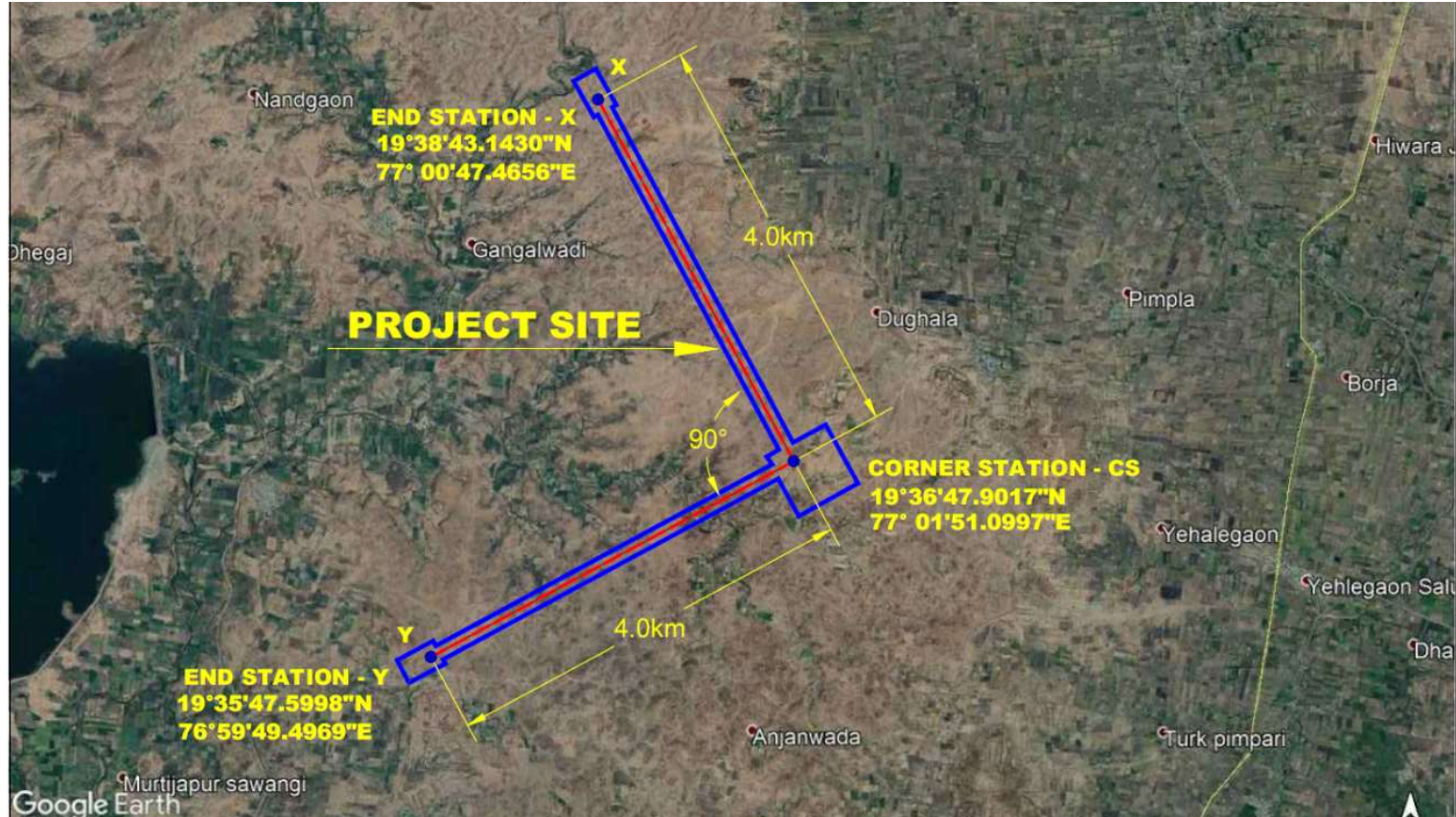
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LIGO Aundha Observatory



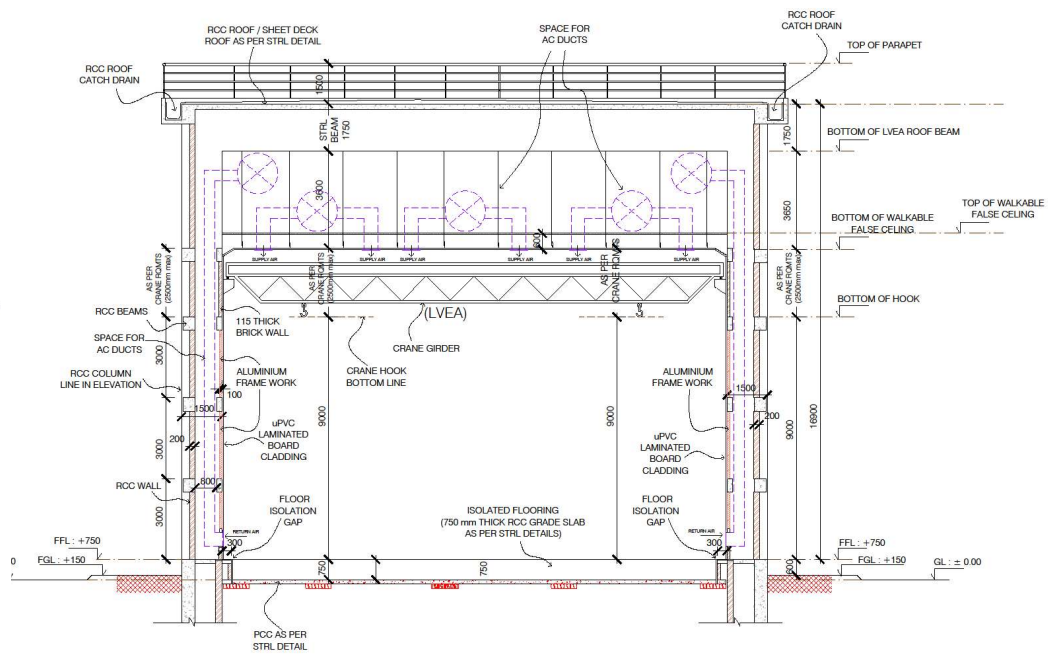
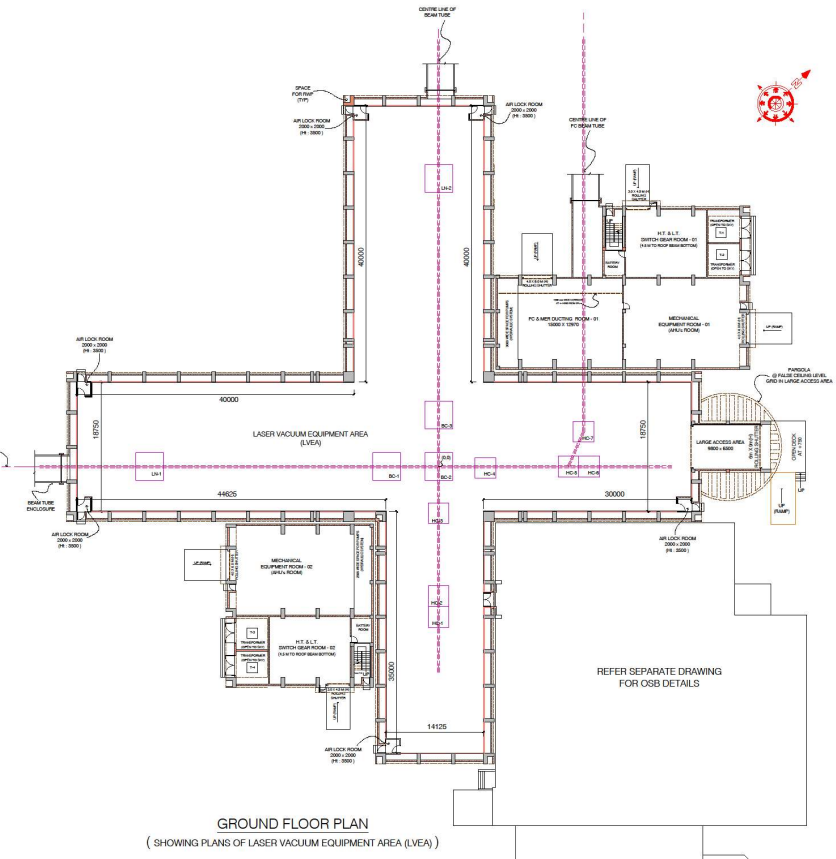
Conceptual Ariel view of LIGO Aundha

Site Preparation



Site Shape & Extents over Google Earth Imagery

Civil Infrastructure



The revised DBR for the Civil Infrastructure has been completed, review by LIGO-US is being taken up.



LIGO-India Schedule

No.	Major Milestones	Year & Quarter
1	Completion of the Design Based Report for the Civil infrastructure and its review by LIGO-India & LIGO-US teams	2023-24 (Apr-Jun 2023)
2	Completion of the Final design report for the Civil infrastructure	2023-24 (Jul-Sep 2023)
3	Preparation of Estimates for Comprehensive tender of the Civil facility at Aundha for the LIGO-India Observatory	2023-24 (Oct-Dec 2023)
4	Issue tender Civil infrastructure Construction & Vacuum system fabrication contract	2023-24 (Jan-Mar 2024)
5	Pack and ship first set of LIGO-India sub-systems from LIGO-Hanford, USA to India	2024-25 (Apr-Jun 2024)
6	Issue contract for the Civil infrastructure Construction & Vacuum system fabrication	2024-25 (Jul-Sep 2024)
7	Site preparation and levelling required for starting construction of Staging Building completed	2024-25 (Oct-Dec 2024)



LIGO-India Schedule

No.	Major Milestones	Year & Quarter
8	Pack and ship the components of the Pre-Stabilised Laser system from LIGO-Hanford, USA to India	2024-25 (Jan-Mar 2025)
9	Complete the installation & testing the Pre-Stabilised Laser system at the off-site facility at RRCAT	2025-26 (Apr-Jun 2025)
10	Completion of the construction of the Storage & Staging building for start of detector component testing	2025-26 (Jul-Sep 2025)
11	Recipe of detector components at the Storage & Staging building	2025-26 (Oct-Dec 2025)
12	Completion of operational verification of BSC and HAM isolation system on test stands	2025-26 (Jan-Mar 2026)
13	Completion of the construction of the Corner-Station building for start of detector vacuum system installation.	2026-27 (Apr-Jun 2026)
14	Begin installation of the the vacuum chambers in the LVEA	2026-27 (Jul-Sep 2026)



LIGO-India Schedule

No.	Major Milestones	Year & Quarter
15	Start of the in-vacuum detector components installation in the Laser and Vacuum Equipment Area of the corner station	2026-27 (Oct-Dec 2026)
16	Installation of the in-vacuum detector components in the Laser and Vacuum Equipment Area of the corner station	2026-27 (Jan-Mar 2027)
17	Installation of the in-vacuum detector components in the Laser and Vacuum Equipment Area of the corner station	2027-28 (Apr-Jun 2027)
18	Installation of the Beam-Tube assembly completed	2027-28 (Jul-Sep 2027)
19	Installation of the in-vacuum detector components in the Vacuum Equipment Area of the End stations	2027-28 (Oct-Dec 2027)
20	Completion of the arm vacuum Beam-Tube bake-out	2027-28 (Jan-Mar 2028)
21	Vacuum pump down of the BSC & Ham chambers in the Laser and Vacuum Equipment Area of the corner station	2028-29 (Apr-Jun 2028)



LIGO-India Schedule

No.	Major Milestones	Year & Quarter
22	Start initial alignment of the interferometer detector	2028-29 (Jul-Sep 2028)
23	Completion of the Detector installation	2028-29 (Oct-Dec 2028)
24	Completion of the Engineering run-achieve 2-hour lock of the LIGO-India Interferometer	2028-29 (Jan-Mar 2029)
25	Commissioning to improve sensitivity required for the first Science run	2029-30 (Apr-Jun 2029)
26	Commissioning to improve sensitivity required for the first Science run	2029-30 (Jul-Sep 2029)
27	Commissioning to improve sensitivity required for the first Science run	2029-30 (Oct-Dec 2029)
28	Carry out Science runs in coordination with LIGO-Laboratory, USA.	2029-30 (Jan-Mar 2030)

Thank You