LIGO-India

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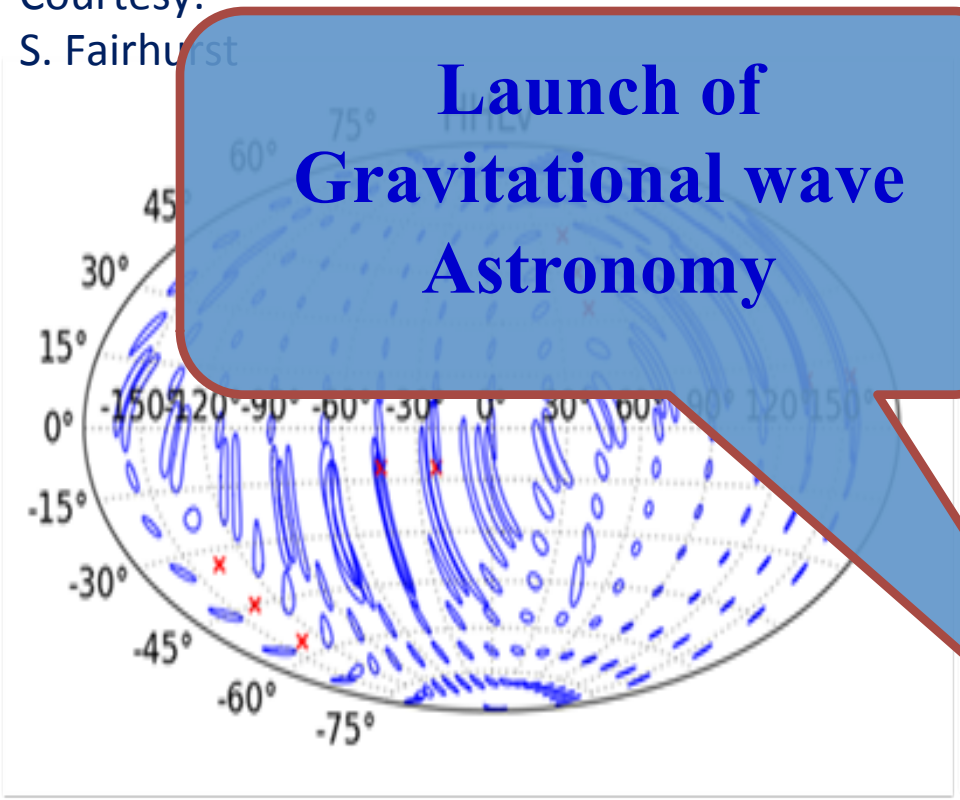
Future of LIGO
Workshop, Siver Springs, MD
May 7-8, 2015

Science Gain from Strategic Geographical Relocation

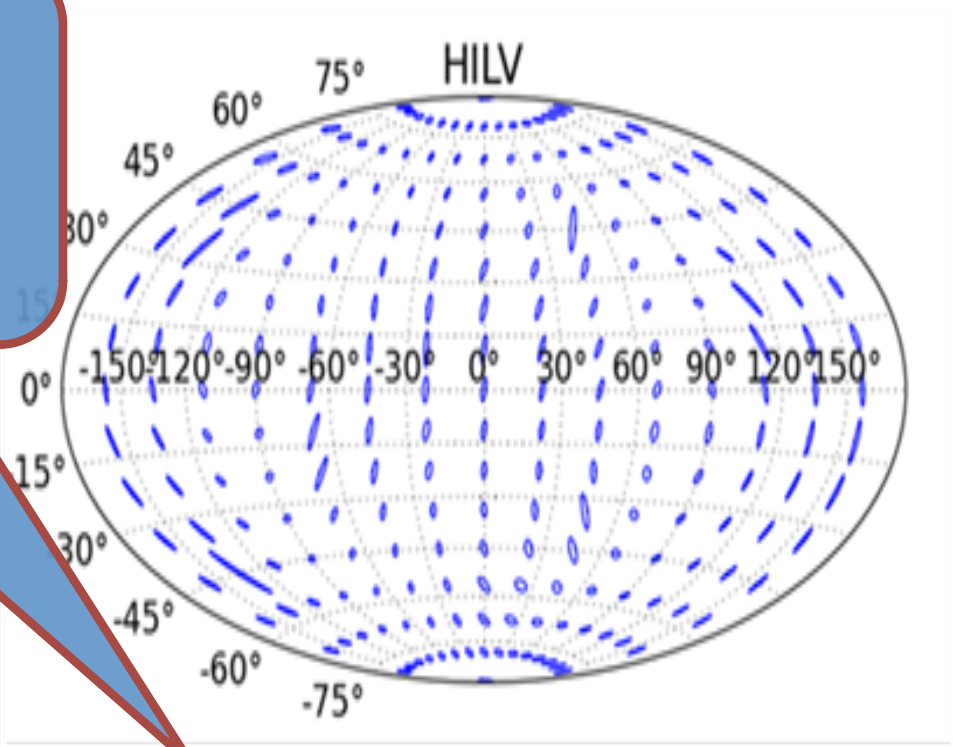
Source localization error

Courtesy:
S. Fairhurst

Launch of Gravitational wave Astronomy



Original plan
2 +1 LIGO USA+ Virgo



LIGO-India plan
1+1 LIGO USA+ Virgo+ LIGO India

LIGO-India Proposal

Indo-US collaboration

Funding agencies: NSF (USA) and jointly **DAE**(India) & **DST**(India)

Institutions: LIGO Laboratories, **Caltech** & **MIT** (USA), **IPR**, **IUCAA** & **RRCAT** (India)

Proposed Indian commitment

- **Construction and Operation of a Advanced LIGO Detector (*Displacement Sensitivity: $4x10^{-20}$ m/√Hz)* on Indian soil in collaboration with the LIGO Laboratory**.

- Set up the Indian node of the three node global Advanced LIGO detector network by end of 2022 and operate it for 10 years.

- The entire infrastructure including the 8 km UHV system, Corner and End stations, Related Labs and clean rooms as well as the team to build and operate the Observatory will be the Indian responsibility ($250 M, 15 yrs)

Contribution from LIGO Labs

The entire hardware components of the aLIGO detector along with designs and software to be provided by LIGO-USA and its UK, German and Australian partners ($120 M including R&D).

Optic Suspensions: All components and needed spares will be supplied.

Seismic Isolation: All components and needed spares will be supplied. (The piping and hydraulic pump stations for the pre-isolator will not be supplied.)

Interferometer Sensing and Control: All components and needed spares will be supplied.

Data Acquisition: All hardware, software, and needed spares will be supplied. (Copper and fiber-optic cabling will not be provided)

~~**Data Computing and Archiving:**~~ This will not be supplied~~.~~

Installation equipment: Specially designed installation hardware will be supplied, with the exception of a fiber pulling machine and a fiber-welding machine

MOU (NSF-DAE & DST)

- NSF, through the LIGO US Institutions, intends to be responsible for providing the Advanced LIGO detector previously intended for installation in Hanford, Washington, associated documentation and drawings, consultation on site requirements, and necessary training of Indian personnel.
- DAE and DST, through the LIGO India Institutions, intend to provide the India site infrastructure and all associated resources necessary to install and operate the detector for a period of ten years.
- **The shipment of the advanced detector to India will be contingent on successful reviews by the Participants, as represented by the JOG, and on the completion of a suitable site and functioning infrastructure in India as described in the agreement among the Collaborating Institutions.**

LIGO-India: Proposed Project Work Breakdown

Recommended by Planning Comm. of India: Mega-Science project in 13th -15th plan
Jointly funded by Dept. Atomic Energy (DAE) & Dept. of Science & Tech. (DST)

AWAITING FINAL CABINET APPROVAL !!!

To be executed by three lead institutes:

1. Inter-University for Centre for Astronomy & Astrophysics (IUCAA)
2. Institute of Plasma Research (IPR)
3. Raja Ramana Centre for Advanced Technology (RRCAT)

The Project Work is sub-divided into broad activity-wise categories

IUCAA	IPR	RRCAT
Site selection and survey	Civil Infrastructure and facilities	Detector Hardware Documentation & Pre-installation
Data analysis & Computing facility	Vacuum System & Mechanical Engineering	Optics & 3rd generation R&D
Science & Human Resource Development	Implementation of CDS system	Detector integration, installation and commissioning

These activities will be under the MOU among them.

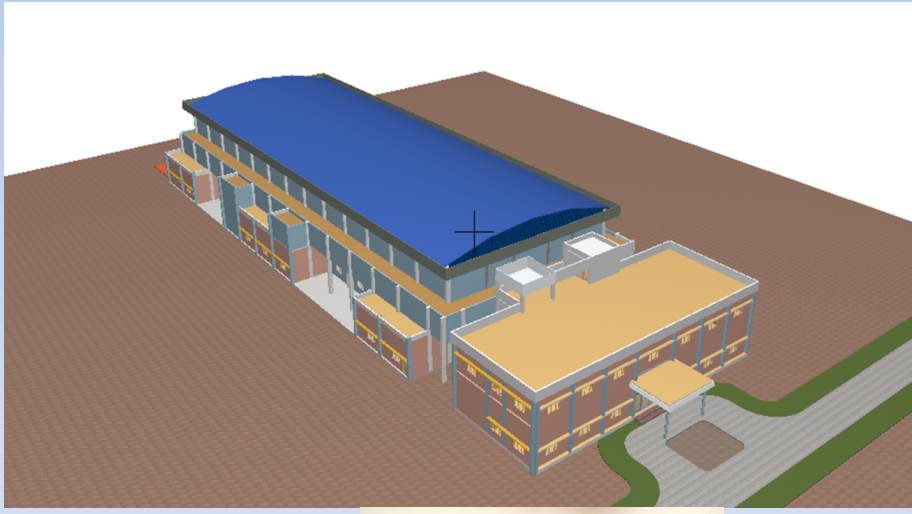
Meanwhile in the
Pre-approval phase ...

notable progress at the three
lead institutes
(stretching institutional resources)

RRCAT LIGO India Off-site Lab

1. Detector Testing and validation lab--Area 2650 Sq.m. *Large span hall as enclosure for clean room and supporting facility for seismic isolation assembly & testing, composite structure (RCC & steel) with 10. MT gantry*

2. Development lab block - Area of 1260 Sq. m. *Two storied RCC structure to house optics, laser, instrumentation and coating lab*



Suspension Fiber Drawing System

A fiber drawing system has been designed and developed for drawing fused silica suspension fibers.

IPR update

- System Requirement Document for civil infrastructure discussed with LIGO-USA and inputs incorporated. Conceptual design of Civil infrastructure has been completed.

- Conceptual drawing of vacuum system has been completed and under discussion with LIGO-USA for dimension verification.

- Meeting with Infrastructure companies, UHV & Steel manufacturing industries.

- Out-gassing measurement of SS sample is under progress as per LIGO-USA design report.

- Z. Khan and M.K. Gupta visited KAGRA during Nov 2014 during the beam tube installation and visited Hanford and Livingston for 2 weeks in April

Site Search & Selection IUCAA

- **Sites narrowed down from ~ 20 leads to a shortlist of 3**
  - ✓ Finalization of site selection requires two professional studies
    - **Land acquisition cost and time estimate for each shortlisted site**
    - **Constructability at site: Engg. feasibility, cost and time assessment**

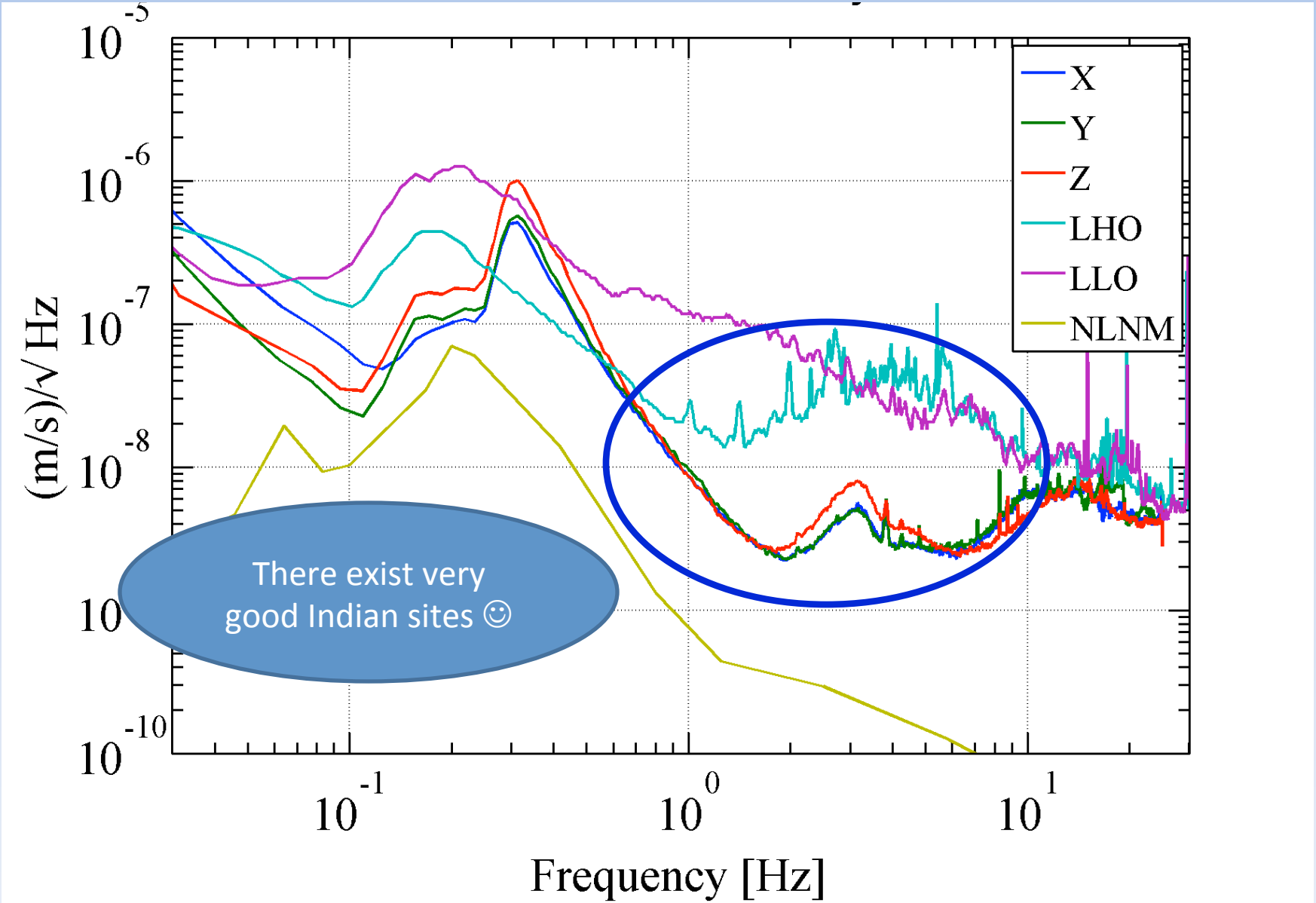
  LIGO India site selection Committee (LI-SSC) will seek inputs from LIGO Lab and then arrive at a final choice of LI primary and backup sites.

(Remote Sensing data from Space Application centre ISRO made especially available to LIGO-India site survey)

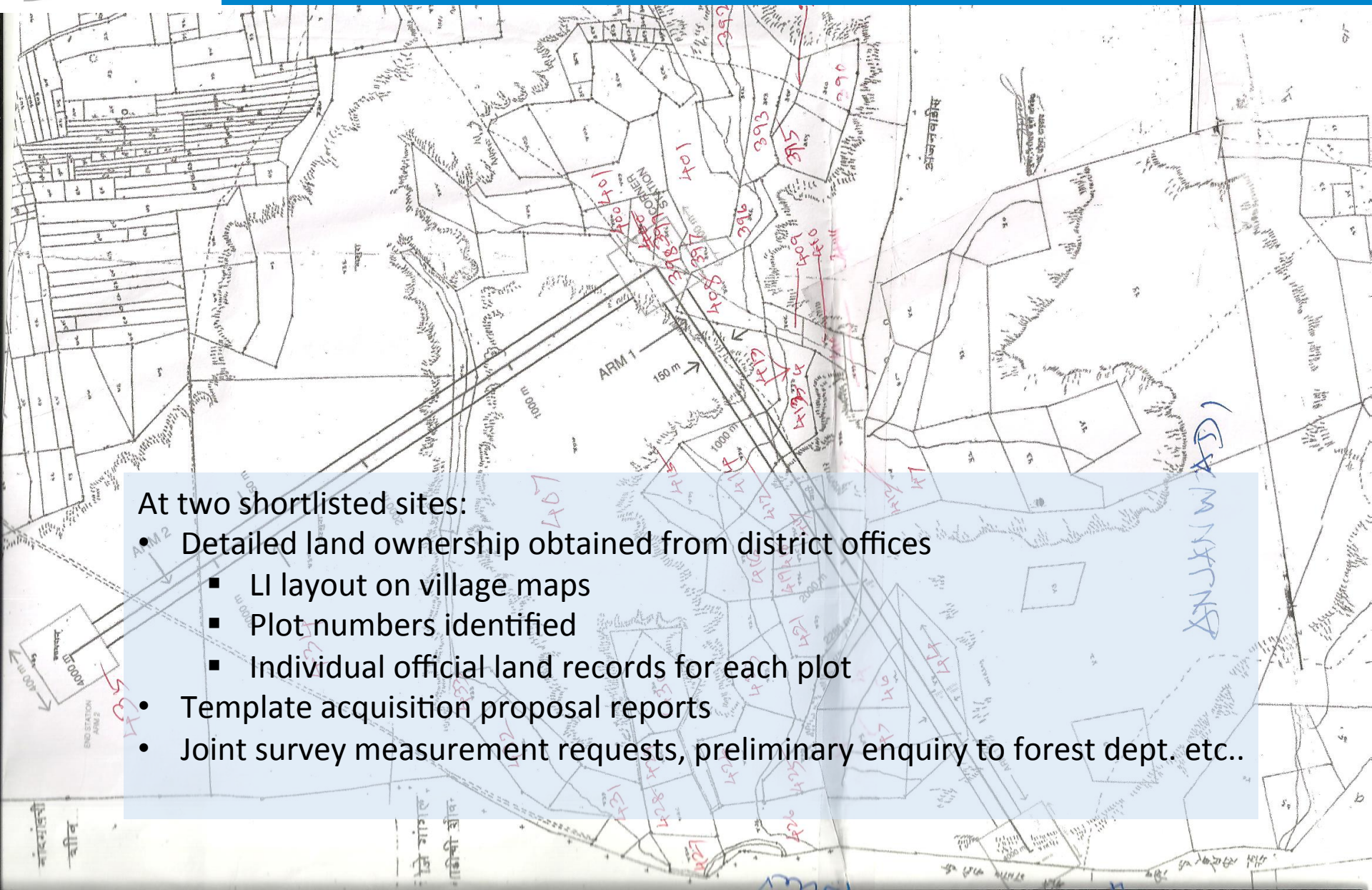
- **Appointment of a top-notch consulting firm for engineering feasibility study at shortlisted sites.**
  (6 week study funded by IUCAA). Started March 25th

- **Appointment of Land acquisition expert as IUCAA LIGO-India consultant**
  - Site visits, land acquisition procedures, estimate of time at various steps, Land records available, Regional development plans, Formal requests to District officials for permission to carry out Joint Survey measurement
  - Template reports for succesful Land acquisition bid in hand

Preliminary Seismic Survey



Site acquisition preparedness



At two shortlisted sites:

- Detailed land ownership obtained from district offices
  - LI layout on village maps
  - Plot numbers identified
  - Individual official land records for each plot
- Template acquisition proposal reports
- Joint survey measurement requests, preliminary enquiry to forest dept. etc..

1st Engineering study

GW Data Centre @ IUCAA

- **Current IUCAA data centre: (oper. Jan 2013) 30Tf , 600 Tb [10Tf for GW]**
- **Planned GWDA centre: ~100Tf, 2400 cores (LSC Tier2) [~ fall 2015]:**
- **All** infrastructure (for expansion to ~300 Tf) in place
- **Future Tier-1 LIGO data centre post LIGO-India operations**

A Tier-3 level facility being also set up ICTS-TIFR, Bangalore
500 cores, 100Tb [Jun 2015]

Status of Cabinet-note

- Request re-submitted to present government during the week of June 9th 2014
- Queries from ministries received, Clarifications drafted and Consolidated Response by DAE included in Cabinet Note. Submitted end Jan 2015
- Cabinet approval awaited …

LIGO-India Schedule (as of Feb 6, 2015)

Mar 2015	**Start LIGO-India Project (??)**
May 2016	Site Acquisition
Dec 2016	Site Construction-Ready
Mar 2017	*Beam-Tube Foundation Complete*
June 2017	*Prototype Vacuum Chambers Acceptance*
Jan 2018	NSF Approval to Ship
Jan 2018	Beam-Tube Prototype Test Complete
Apr 2018	Cooling & Staging Bldg
July 2018	RRCAT LIGO-India Laboratory Complete
June 2018	End-Stations Hand-over

July 2018	Detector components received at site
Aug 2018	Corner station handover
Feb 2019	Begin Detector Installation
April 2020	Beam Tube Installation complete
March 2021	Beam Tube Bakeout complete
May 2021	Detector Installation complete
Nov 2021	Achieve 2 hr lock
Nov 2022	Ready for observing

Accommodate Further Delay !☹!

Ameliorating project Approval Delay

- Parallelize, where possible, LIGO-India activities to optimise the timeline.
- Complete the development of laser fiber drawing and welding systems and carry out training on the fabrication of a "dummy" quad suspension. Build some of the laser sub-systems at RRCAT to serve as installation training hardware.
- **Early Shipment from LIGO USA**
  - **Jan 2016: Shipping certain items (PSL, 1 suspension, 1 seismic iso.) to India which can serve as training hardware for the installation & commissioning team.**
  - **Jan 2018: The full detector based on the meeting an agreed projected progress made on the vacuum and civil infrastructure**
- Match on Indian side by *prioritizing RRCAT off site laboratory* to install early 2016 shipped detector components.

Amend NSF-DAE/DST MoU

Schedule Gain by early Shipping

- **The Project timeline (slide 13) already assumes that the Detector components can be shipped before completion of the vacuum and civil infrastructure to meet the 2022 target** for the LIGO-India to be on the network.
- **If the Detector components are shipped strictly as per the NSF-DAE & DST MOU:** "… on the completion of a suitable site and functioning infrastructure…" **then the approval to ship will be in April 2020 which pushes the end date to 2024.**
- Even if the approval to ship is received only after acceptance of the prototype vacuum chambers & beamtube and the Corner & End station handover the Detector components will ship in Aug 2018, pushing out the end date by six months.
- **IF the detector components ship by Jan 2018 based on the reasonable progress made on the vacuum and civil infrastructure the projected deadline of Nov 2022 can be met.**

Early Shipment in Jan 2016

- **PSL components. (Dr. Jogy George has spent time at AEI training on the PSL) The laser system could be setup at RRCAT and run to avoid last minute surprise of missing components and would also serve as training hardware for the Installation & commissioning team.**
- **One set of seismic isolation system to train the installation and commissioning team on the isolator testing and tuning.**
- **One set of triple suspension to learn testing, characterisation and tuning of the suspensions.**
- Old or rejected ETM/ITM substrates to be used for optics handling, cleaning, inspection, first contact application and end tab assembly training.
- Two sets of control racks (one for IPR and one for RRCAT) for training on the controls hardware.

Shipping of the PSL in early 2016

- The PSL can be installed and tested in a cleanroom made available in existing laboratory building at RRCAT by Aug 2016.
- The PSL can be shifted and reinstalled in a cleanroom in the LIGO-India Lab building at RRCAT by Aug 2018.
- **This provides the laser team hands-on experience on installation and operation of the PSL from Aug 2016 to Feb 2019 when it has be installed at the site.**
- This two half years of working on the PSL coupled with the time spent at the two observatories and AEI should make for a very robust laser team minimising any contingencies during the PSL installation and operation at site.
- The pump diodes of the PSL and and any other components if required will be replaced with new ones before installation of the PSL at site. Funds for these spares in provided for in the project proposal.

Seismic Isolation & Suspensions

- **The Seismic isolation system and suspensions are unique to the Advanced LIGO project.**
- The experience of installing and tuning them can only be achieved by participation of the team during installation/commissioning at the two existing observatories.
- The delay in approvals has not only resulted in the missing out on installation experience even the opportunity to participate in commission is lost.
- With the two observatories poised for observation runs the installation & commissioning team has hardly any place (except for some measure at LASTI for the SEI) to train on these systems.
- **Similar to the PSL installing one set of seismic isolation and suspension systems at the offsite lab at RRCAT should provide valuable working experience for the installation & commissioning team minimising contingency during installation/commissioning at site.**

Summary

- LIGO-India promises exciting indo-US collaboration at an exciting frontier of Science
- Awaiting approval from Union cabinet ! Delayed relative to recent scheduling exercise in Feb 2015 (with minimal contingency)
- Significant pre-approval work ongoing at lead institutes (but now at limits stretched resources)

Thank you !!!

- To make LIGO-India happen and to stay on course for realizing its full potential

  Need effective strategy now to minimize the effect on the date of operation of LIGO-India &

  Early shipment of LIGO hardware could be vital in ameliorating delay in project schedule due to awaited cabinet approval