Project Statement

1. Introduction

The Laser Interferometer Gravitational Wave Observatory (LIGO), comprising two operational detectors, at the LIGO-Hanford Observatory (LHO) and LIGO-Livingston Observatory (LLO), has revolutionized the field of Gravitational Waves (GW) observational science. LIGO-India will be the third and upcoming detector within LIGO, located in Aundha, Maharashtra, India. It is expected to be ready for operations around 2030. Commissioning of LIGO-India is a critical milestone to be achieved and significant effort is needed for it to become operational. This requires development of a strong and knowledgeable team which can perform Detector Characterisation: this makes it imperative that regular communication and deeper collaborative interactions occur between scientists in LIGO-India and the LIGO Scientific collaboration (LSC).

2. Detector Characterisation

Detector Characterization is a large working group in the LSC that monitors the detector operation to improve its astrophysical sensitivity. Specifically, it looks for instrumental or environmental artifacts that affect the searches for astrophysical sources introducing a non-astrophysical background with short transients, sinusoidal interference, or periods of excess noise ("glitches"). The DetChar working group has strong connection and frequent communication with the staff working on-site to implement mitigation for the noise sources that are identified, and to use software tools on short notice to help problems that appear while taking data.

3. Science Goals

The work of the Detector Characterization group relies on many software tools, with results summarized daily in "Summary pages". Some of the results shown in the summary pages are outdated or not used often anymore. Also, some of the results are only useful when analysed statistically over a long period, not on a day-by-day basis. This could be accomplished by a meta-tool that collects results and, using machine learning, recognizes patterns.

One of more sophisticated tools is h-veto [1]. This tool finds a ranked list of auxiliary channels where short transients are found to be correlated with (non-astrophysical) transients (glitches) in the GW science channel. The results are used in vetoing false alarms in searches for unmodelled transients, but they have not been used for identifying the sources of the transients. We will develop software to collect the results of h-veto and identify common patterns in the first Intermediate Run (IR1) starting in the fall of 2026. In consultation with detector experts on-site, we will use the patterns to find clues for sources of the transients. We will also develop a user-friendly fast version of h-veto to refine the searches for the sources, by using different times than a single whole UTC day, and concentrating on specific channels.

The Detector Characterization group produces "summary pages" consisting of hundreds of web pages, each with plots monitoring the status of the data quality of the gravitational wave strain, as well as of the many detector subsystems and environmental channels. This system has grown substantially over the years of Advanced LIGO, and it has become difficult to maintain. However, it is a critical tool used by instrumental and data quality scientists, so it must be created for LIGO-India. During this project, we will collect statistics of the usage of individual pages and study a common architecture for different detector subsystems. With this information in hand, we will

consult experts on site and in the Detector Characterization group to propose a phased creation of the pages for LIGO-India. We expect that this will also inform a possible optimization of the current LIGO summary pages [2, 3]. These improvements will have an impact on the efficiency of searches for GW events and the science enabled by the enhanced sample.

4. Prospects for long-term collaboration

DetChar software tools continue to evolve rapidly and there is a strong need for increased accuracy and automation. Many of these tools rely on machine learning algorithms underneath. By the time LIGO-India is operational much of the vetting currently being performed by humans is expected to be automated. It is critical for LIGO-India members to participate in the development, testing and deployment of this infrastructure so that it will be locally available when observations begin. In alignment with the goals of HSF-India, further development and maintenance of existing tools as well as development of new tools motivate the need of long-term collaboration and personnel exchange, especially, those require performing tests directly at the detector.

5. Specific objectives and tentative timelines:

Following are the specific objectives of the activities during the visit -
Obj 1: Identify the sources of transients in IR-1 using the h-veto code
Obj 2: Analyse GW Summary pages to create a plan for LIGO-India summary pages

Tentative Monthly Timeline:

1. Month 1:

   - Write and document code to collect cumulative statistics of daily h-veto results, test it on last month of O4 and the first month of IR-1 for the LIGO Livingston detector.

   - Write and document code to run h-veto on custom time periods with custom lists of channels.

   - Write code to collect usage of LIGO summary pages at both detectors, rank the pages by most frequent use. Identify differences in structure for pages of different subsystems.

2. Month 2:

   - Use results from LLO daily IR1 h-veto runs to create a list of channels with the largest significance of transients correlated with the gravitational wave strain.

   - Run h-veto on longer time periods with the list of channels with largest significance, share the results with staff at the LLO site.

   - Share lists of most- and least-used summary pages with detector and data quality scientists and collect feedback from them on the importance of the pages for their work.

3. Month 3:

   - In collaboration with LLO and Louisiana State University scientists, use h-veto results to identify plausible sources for the correlations. Ideally, run tests to confirm or rule out these sources.

   - Draft a multi-phase plan to create LIGO-India summary pages to be implemented as various systems in LIGO-India are installed. Document and share results with the LIGO Scientific Collaboration.

Summary of local support infrastructure

I will receive a visitor's appointment at Caltech which will allow me to work at the observatory. A workspace will be provided along with any needed computing support. During my visit to LLO, I will be provided with shared accommodation and access to a shared rental car. These are furnished as part of the LSC Fellows program.

I will collaborate with the on-site scientific and engineering staff and also with the LSC group at Louisiana State University, which is led by Professor Gabriela Gonzalez. The visit will occur during LIGO's IR1 observing run, which will offer excellent opportunities to perform detector characterization on real data.

Estimated budget

Category	Cost (USD)
Airfare	2000
Taxi	250
Living Expenses	5250
Total	7500

Table 1: Estimated budget. Living expenses are calculated at $350/week for 15 weeks. Taxi costs are for travel from the arrival airport in New Orleans to the apartment in Baton Rouge.

References

[1] Joshua R Smith, Thomas Abbott, Eiichi Hirose, Nicolas Leroy, Duncan MacLeod, Jessica McIver, Peter Saulson, and Peter Shawhan. A hierarchical method for vetoing noise transients in gravitational-wave detectors. *Classical and Quantum Gravity*, 28(23):235005, nov 2011.

[2] Soni et al. Ligo detector characterization in the first half of the fourth observing run. *Class. Quantum Grav.*, 42:085016, 2025.

[3] Duncan Macleod et al. gwpy/gwsumm: 2.3.2. `https://zenodo.org/records/15420335`, 2025. Accessed: 2026-06-23.