

Proposal for HSF-India Research Software Collaborations

Strengthening the LIGO Inventory Control System through a Research Software Engineering Collaboration between LIGO Livingston Observatory and IUCAA

Background

The Inventory Control System (ICS) is a critical software platform that supports the construction, installation, commissioning, and long-term operation of the LIGO detectors. It provides complete traceability for detector components by managing inventory, engineering workflows, inspections, testing, logistics, and documentation throughout the lifecycle of every part.

Over the past two decades, the ICS has evolved alongside the Advanced LIGO detectors and has become an essential tool for engineering and operations at LIGO Livingston Observatory (LLO). The system is currently maintained by Dwayne Giardina the LIGO Laboratory General Computing Manager, whose extensive experience with both the software and detector construction activities has been central to its continued success.

As LIGO-India moves into detector construction, IUCAA plans to adopt the same ICS framework to support its engineering and logistics activities. Using a common software platform across both observatories will simplify collaboration, encourage sharing of software improvements, and help maintain consistent engineering workflows throughout the LIGO collaboration.

Motivation

The IUCAA Computing Team will begin building expertise by forming a small development team consisting of undergraduate students working under the guidance of experienced computing staff. This will allow software development to begin immediately while creating a pathway for training future Research Software Engineers. LIGO India is in the process of recruiting a dedicated software engineer to support the long-term development and maintenance of ICS. Once the software engineer is appointed, they will join an already active and well-organized development effort. It is our intention to apply for funding in the future for the software engineer to visit LIGO Livingston and work with Dwayne Giardina on ICS development.

The ICS system deployed at LLO has reached a stage where reviewing the software stack and planning for modernization would be beneficial. Although the system continues to serve its purpose, it is based on outdated versions of several software components, most notably JIRA 3.13.2. Upgrading to currently supported versions would improve long-term maintainability, strengthen security, reduce technical debt, and provide access to new capabilities offered by recent releases.

This presents an excellent opportunity for a collaborative effort. Rather than IUCAA simply learning how to use the existing system, members of the IUCAA Computing Team can work together with the LLO software team to understand the current implementation, review the existing architecture, evaluate upgrade paths, and contribute to planning the modernization of the software.

As part of this collaboration, a **test instance of the Inventory Control System (ICS)** could be stood up on a dedicated **Proxmox-based virtualisation server** at IUCAA. This environment would provide IUCAA staff with a controlled platform to gain hands-on experience with the software, evaluate proposed changes, test upgrades, and develop new features without affecting any production system. Depending on the licensing and access requirements, the test environment could be made available either **locally within the IUCAA network or through secure remote access** to authorized team members. This would establish a practical development and testing environment that can support continued collaboration between IUCAA and LLO beyond the initial visit.

Their participation will not only accelerate the development of expertise within LIGO-India but also provide additional software engineering effort that benefits the LLO team.

A shared modernization effort will help ensure that both LIGO and LIGO-India continue to use a common Inventory Control System, making future software development, maintenance, bug fixes, and feature enhancements easier to share across the collaboration

Proposed Collaboration

The proposed visit will provide dedicated time for the LLO and IUCAA teams to work together to understand and improve the Inventory Control System. We propose a two-week visit to LIGO Livingston by Dr. Deepak Bankar and Harshad Sawant, both members of the IUCAA computing team. Deepak manages the High Throughput Computing (HTC) infrastructure at IUCAA. Harshad is a Scientific & Technical Officer in the computing group. The visit will be hosted by Dwayne Giardina. The HSF-India funding also provides for a reciprocal visit by Dwayne Giardina to IUCAA, without the need for a separate proposal, enabling the collaboration to continue through direct technical engagement between the two teams.

Activities during the visit will include:

- Reviewing the current ICS software architecture and deployment.
- Understanding engineering workflows and JIRA customizations used during detector construction.
- Reviewing the existing software stack and identifying opportunities for modernization.
- Evaluating migration to supported software versions while preserving existing functionality and workflows.
- Discussing software engineering practices, including version control, testing, documentation, deployment, and maintenance.
- Developing a roadmap for future software development that can be shared between LLO and LIGO-India.
- Identifying development tasks the IUCAA software team can undertake following the visit.

Expected Outcomes

The collaboration will produce benefits for both institutions.

For LLO, the visit provides an opportunity to review and plan modernization of an important operational software system with additional software engineering support from collaborators who will continue contributing to the project over the long term.

For IUCAA, the visit will establish the technical foundation needed to begin local development of the Inventory Control System. The knowledge gained will enable the IUCAA team to mentor undergraduate developers, establish software engineering best practices, and build long-term local expertise.

More broadly, the collaboration will establish a common development model for the Inventory Control System. By maintaining a shared software platform, future improvements developed by either laboratory can be more easily adopted by the other, reducing duplicated effort while improving software quality, maintainability, and long-term sustainability.

Alignment with the HSF-India Research Software Collaborations Programme

This collaboration embodies the goals of the HSF-India Research Software Collaborations programme by promoting international collaboration in scientific software development, strengthening Research Software Engineering expertise, and encouraging sustainable software practices.

Rather than developing independent software solutions, the project focuses on maintaining and evolving a shared scientific software platform. The collaboration will encourage knowledge exchange between the software teams at LLO and IUCAA, promote reproducible software engineering practices, strengthen documentation, improve long-term maintainability, and help build Research Software Engineering capacity within the LIGO-India project.

The involvement of undergraduate students, supervised by experienced researchers, also provides an opportunity to train future Research Software Engineers while contributing directly to a production software system used by a major international scientific collaboration.

Long-Term Impact

This proposal aims to establish a long-term collaboration between the LIGO and LIGO-India teams, rather than being limited to a single training or knowledge-exchange visit. The initial visit will provide an opportunity for the teams to work closely together, understand the existing Inventory Control System (ICS), and identify areas for improvement. Following the visit, the collaboration will continue through regular technical discussions, code reviews, software planning meetings, and joint development activities.

ICS is an important part of LIGO's operations, supporting parts tracking, inventory management, logistics, and processing across LIGO sites. It helps manage part inventories, track the location and status of components, support clean and bake workflows, facilitate inter-site transfers, and maintain records related to defects, inspections, testing, and modifications.

The long-term goal is to maintain a modern, secure, and sustainable ICS that can effectively serve both LIGO and LIGO-India. A shared software platform will make future upgrades easier,

encourage the development and sharing of common features, and reduce duplicated maintenance efforts across the collaboration. By investing in the sustainability of ICS today, both laboratories can build a more reliable and resilient software platform that will continue to support detector construction, commissioning, and future operations.

Summary of local support infrastructure

A workspace will be provided along with any needed computing support. The visit is of short enough duration that a Caltech visitor appointment is not needed.

In addition to working with Dwayne Giardina, Deepak and Harshad will have the opportunity to meet and collaborate with the on-site scientific and engineering staff.

Estimated budget

Category	Cost (USD)
Airfare x 2	4500
Ground transport	150
Rental Car	600
Hotel Accommodation	3080
Meals	1400
Total	9980

Table 1. Estimated budget for a 2-week visit from India (XXXX - YYYY 2026). Ground transport covers transfers to and from the arrival airport and the hotel, and any expenses incurred to get to and from the airport in India. Meals are calculated at \$50/day/person for 14 days; accommodation covers 2 hotel rooms at the local per diem rate of \$110 for 14 nights.

Category	Cost (USD)
Airfare	2000
Ground transport	200
Hotel Accommodation	1700
Meals (\$50 X 9)	450
Total	4350

Table 2. Approximate budget for an ~1-week reciprocal visit to India by Dwayne Giardina. Ground transport covers transfers to and from the arrival airport and the hotel, and any expenses incurred to get to and from the airport in India. Hotel rates are calculated assuming 2 nights in Mumbai and 6 in Pune at the US State department rate.