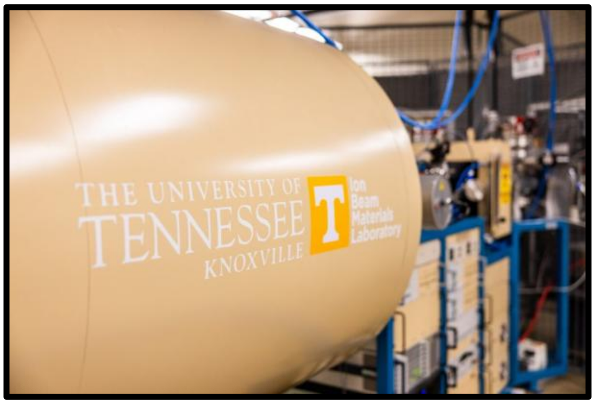
TIBML – Workflow Upgrades



Introduction

The Tennessee Ion Beam Materials Laboratory (TIBML) is a rapidly evolving advanced laboratory with an ever-expanding set of capabilities. Operating since 2014, the lab has conducted thousands of irradiation experiments supporting both internal research programs and external collaborations across a broad range of materials systems, scientific objectives, and irradiation conditions. With the delivery of a 200 kV Transmission Electron Microscope (TEM), a 300 kV National Electrostatics Corp. (NEC) Implanter in late 2025, and the planned delivery of a Scanning Electron Microscope (SEM) in the summer of 2026, the growing list of hazards, experiments, and operating procedures has become complex. With difficult irradiation and testing environments, all lab staff, users, and visitors must completely understand and effectively communicate the range of evolving hazards and projects that are being actively worked. As a nuclear engineering lab, there is inherently dangerous equipment in operation. These Radiation Generating Devices (RGD) are ultra-high vacuum systems and thus present risks associated with high voltage electronics, X-rays, other ionizing particles, class IIIB and IV lasers, and even implosion. These pose risks to users and equipment alike if not operated correctly or not maintained properly.

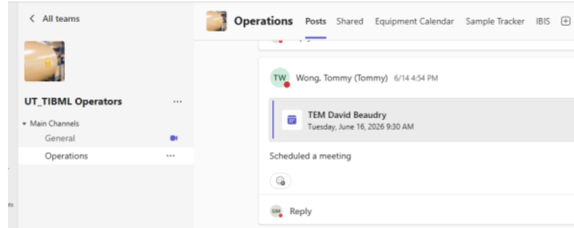
Previously, all experiment planning, equipment tracking, and project management were conducted on handwritten notes, over email, or through verbal conversations. The continued expansion of TIBML's personnel, equipment, and experimental workload has thus established a need for a more standardized, central management system. Information distributed across multiple formats can be difficult to locate, update, and communicate consistently, especially when projects involve several researchers and extended project timescales. A recent vacuum system event during routine chamber maintenance highlighted how headspace factors including competing priorities, time pressure, assumptions about equipment status, and incomplete communication can influence the decision-making process even during familiar, routine tasks.

New Software

Over the past year, our group has developed and implemented in-house project management and equipment tracking software to streamline communication among sub-teams, new lab members, and collaborators. The software also provides clear visibility into equipment status and maintenance needs while allowing any group member to seamlessly take over ongoing tasks as needed.

Group Coordination & Lab Brain

Microsoft Teams has been implemented as our main organizational project management hub, with irradiations planned and booked in our new shared calendar and all project files centralized on OneDrive so that any team member can find the same information. Building on this Teams/OneDrive foundation, TIBML is developing a Lab Brain that makes the hub easily searchable and interactable through a locally hosted model. Qwen3, a 235B parameter model run on-site, indexes calendar entries, meeting notes, and project files kept on Teams/OneDrive so that any team member can ask a plain-language question and get pointed to the relevant experiment, procedure, or conversation instead of digging through folders and channels from memory. Because the model runs locally, researchers can query it under CUI regulations with a human-on-the-loop at every step. The goal is to give people the information they need without asking them to hold it all in their heads, so attention during hands-on work stays on the task and the equipment in front of them. Additional tabs have been added to allow for easy access to several new software tools created by TIBML members. A Kanban board has been created to organize and communicate lab member priorities, goals, and accomplishments. We have also added a weekly meeting outside of group meetings where the sole focus is to discuss, plan, and communicate; safety concerns, equipment maintenance, purchasing needs, and staffing for the large variety of irradiation experiments, including overnight irradiations.



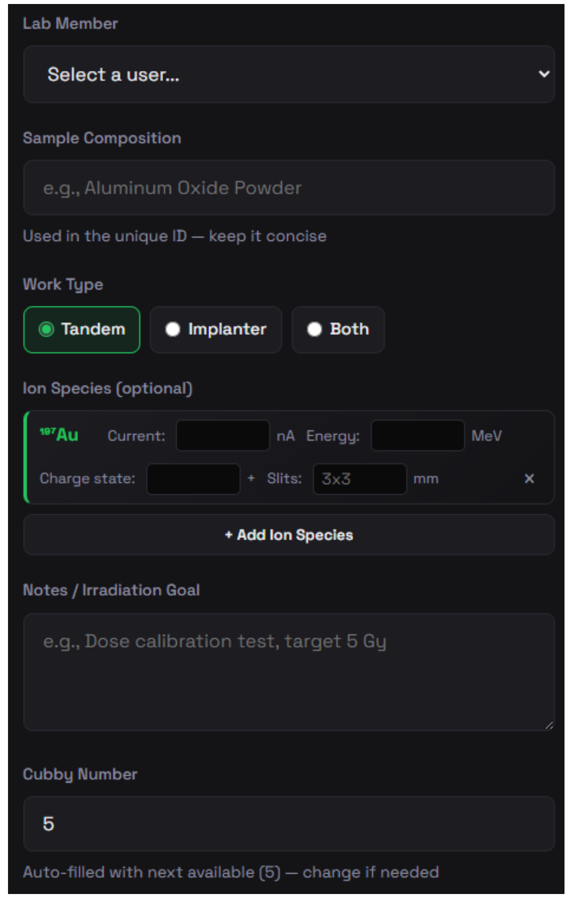
TIBML IMS

TIBML Inventory Management Software (IMS) was created to track all components within the lab. Safety is best achieved when users can locate and use the proper tools and equipment for a given task. In addition, all hand tools have been placed on a single large peg board colored to identify the location of all hand tools. TIBML members have also been testing, repairing, and labeling all vacuum components, pumps, gaskets, electronics, and consumables with codes that allow for easy searching in the future. Eventually, new users or team members will be able to scan components, find out what they are, provenance, and find the proper location of the component. For consumables, automatic alerts are being set up to order more stock, such as the specialized copper gaskets used in ultra-high vacuum systems.

TIBML Sample Tracker

Another new organizational software TIBML has implemented for project management is the Sample Tracker. Utilizing this software, all experiments performed at TIBML get tracked here. Trained staff use a secure login via their UTK email address to add samples to our virtual cubby system, which maps to our real sample storage cabinets. This permits direct connection between the physical sample and the detailed digital experimental plan. This experimental plan includes ion species, ion energy, fluence, irradiation temperature, and any other needed requirements. The software also records the date the sample arrived, and creates a sample queue based on first in, first out principles. When an adequate irradiation plan has been developed and entered in the sample information, it can be marked “In-queue” to communicate readiness. Should equipment critical to an experiment break and require repairs, the experiment can be marked as “stalled” where details on the stall can be entered and communicated with other TIBML team members. Tandem, implanter, TEM, SEM and nanoindentation tabs are used to track and communicate additional capital equipment that is needed to complete characterization of a sample. After a sample has been completed, a log entry is automatically created and archived where it can be included in reports to collaborators or stored to inform future experiments. All data can then be safely stored on the TIBML RAID (Redundant Array of Independent Disks).

The Sample Dashboard was built around FAIR (Findable, Accessible, Interoperable, and Reusable) data principles so that the record for any sample is never more than a search away. Sample IDs and the 1-to-1 cubby-to-cabinet mapping make each experiment *findable*; secure logins give any trained team member *access* to a sample’s status without depending on whoever originally set it up; shared tandem, implanter, TEM, SEM, and nanoindentation tabs keep records *interoperable* across instruments; and the automatic archiving of completed samples keeps every log *reusable* for future planning and collaborator reports.



Equipment Safety

Part of ensuring successful experiments and engineering safety into a transparent and low-stress environment is understanding when and where equipment failure is likely to occur. Since the delivery of the new NEC 300 kV ion implanter earlier this year, multiple mechanical turbopumps (TMP) have failed for, at the time, unknown reasons. This has had a severe impact on the installation and the initial experiment timelines, preventing any implantations. To monitor and troubleshoot this issue, automatic pressure logging has been implemented lab wide to alert operators to unexpected pressure changes, which can be indicative of pump failure. Additional systems, such as the Pico Accelerometers are being integrated for predictive TMP monitoring to help minimize the impact of future pump failures.

Conclusion

With growing TIBML capabilities, and a rapidly expanding team and collaboration set, communication and coordination are becoming increasingly critical to lab safety. Having a well communicated and documented experimental plan helps to ensure safe operation and reduce frustration, unexpected delays, and concerns of altered headspace in equipment operators. A dedicated meeting to discuss experiments and lab status has helped to increase visibility and maintenance needs. Several new software tools are changing the way TIBML functions, increasing visibility in day-to-day operations, which in turn improves the mindset and subsequent safety with which we approach work in the lab.

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