



2019 LArSoft Work Plan

Last updated: December 13, 2019

Introduction

This document records the LArSoft work plan for 2019. Progress on specific items going forward are recorded in redmine issues with updates to this document given quarterly at Steering Group meetings.

Erica and Katherine discussed 2019 priorities with the Offline leads and spokespeople in November of 2018. The experiments detailed their plans for the next year, the implied requirements for LArSoft, and how LArSoft could help, as well as what the experiments might be able to contribute to LArSoft code. Some items were raised by LArSoft, not a particular experiment, and address general problems faced by all LArSoft users.

Based on those discussions, LArSoft proposed a plan of work for 2019 along with the relative priority of the various items. This was discussed and approved at the December 13th LArSoft Steering Group meeting.

The resources responsible for executing parts of the plan is listed in cases where this is known. It should be noted, however, that the LArSoft project team does not have sufficient staff at present to carry out the entire program. Some projects can and should be performed by the experiments. Allowing experiment service credit for contributions to items that benefit an experiment, but that are of a more general nature would help to fill some of this gap in effort. The more this happens, the more all experiments benefit.

Short term priorities for 2019

We define short term priorities as those items that should receive sufficient effort to be completed in CY2019 due to the urgency or timeliness of the need. The meaning of priorities listed is discussed in Appendix A.

1. **Finish investigating a new Event Display framework common to all experiments.**

Priority: high

(Investigation began in 2018.) Some important features:

- a) Provides a simple, intuitive means to navigate through large events and multi-TPC detectors.
- b) Ability to zoom and pan with a data density that matches the screen resolution.
- c) Provides basic interfaces to art for controlling runs and events, the geometry service, run conditions services. Re-running reconstruction workflows and displaying the result should be possible.

This work does not cover development of drawing routines. It is expected that the core event display users within the experiments will provide this code. Investigating is being tracked under <https://cdcvns.fnal.gov/redmine/issues/19034>

Resources: Erica Snider, Paul Russo & waiting on the division after SPPM meeting on 2/21/19.

3/7/19 status: Four potential technical solutions have been identified, along with some of the costs, benefits and trade-offs of each. Significant effort will be required to create prototypes with any substantial functionality. We are weighing how to proceed from here with the evaluation.

5/30/19: In response to input from management, we have pursued an investigation to determine whether BNL can contribute effort and take ownership of the event display, along with other elements of a closer collaboration with BNL. This is in the early stages. No changes in status on this item are expected until the situation with BNL becomes more clear.

9/4/19: no update

11/21/19: no update

2. **Event Display development plan.**

Priority: high

Phase 1: Design and implement an event display framework following the requirements and investigation of tools above. Phase 2: Consult with the experiments as they implement the Event Display in their analysis.

Resources: Waiting on the evaluation and the division after SPPM meeting on 2/21/19.

6/11/19: See item (1).

3. Migrate to GitHub and pull requests. (Started in June 2018)

Priority: high

Investigate moving the LArSoft central repositories from Redmine to GitHub, along with those collaboration services offered by GitHub that make the migration cost effective. There are three phases once a migration decision is made.

- Phase I: Migrate central repositories to GitHub
- Phase II: Develop necessary infrastructure to support pull requests
- Phase III: Transition the current model of merging to develop by developers and the Code Management team to a pull-request system where authorized experiment personnel handle requests after mandatory CI testing prior to merging.

Resources: Patrick Gartung

3/7/19 status: Chris Jones spoke at length with the offline leads on 2/21. He provided details of the roles, workflows and tools CMS uses to support their GitHub / pull request system, and described how the system evolved. An extensive discussion followed on how this might be applied to LArSoft. Deployment options include the bare system offered by GitHub, through a fully developed, multi-role system with well-defined workflows and approvals. Additional work will be required to develop a proposal for LArSoft.

5/30/19 status: Have identified person to work on scripts for LArSoft, and developed a high-level plan to carry out a project that will deploy a system similar (or identical) to what was done in CMS. The plan is in the final stages of approval. Work is expected to start the week of June 3.

Goals

1. Start using GitHub as the reference LArSoft repository/repositories instead of redmine.
2. Move to a system of pull requests which provides a scalable solution for code integration, and allows experiments to better manage and control how code is merged into develop.
3. Move to scheme that allows a more modular checkout of the code, possibly under a smaller set of root directories. Consider within the context of a possible / eventual migration to Spack / SpackDev build system.

6/11/19 status: Held initial discussion of the plan with Patrick Gartung and Kyle Knoepfel. Decided to allow the three point plan to be factorized as needed to allow work to continue, since the repository re-organization requires detailed knowledge of SpackDev implementation. First task is to assess portability of CMS pull-request code, and scope of new coding that will be required to port it to LArSoft context.

9/4/19: Development work for items (1) and (2) has been completed.

- Documentation is currently under development, with draft version for some already posted (e.g., on how an organization could set up their own GitHub and set up web hooks to point the pull request workflow scripts [here](#).).

- There will be a detailed presentation of the supported pull request workflow, and a preliminary transition plan at the Sep. 10 LArSoft Coordination Meeting.
- Item (3) has been deferred until more is known about the new build system

11/21/19 update: Work toward deployment has progressed over the past two months

- Documentation describing the approval workflow, the duties and tasks required of each role in executing the workflow has been written and reviewed.
https://cdcv.sfnal.gov/redmine/projects/larsoft/wiki/Pull_request_testing_and_approval_workflow
- User documentation for using LArSoft with GitHub has been completed,
https://cdcv.sfnal.gov/redmine/projects/larsoft/wiki/Working_with_GitHub
- The new system was opened for testing on Nov 5.
- Initial Level 2 managers for each of the experiments have been identified
- Details of the release build procedures are still under development
- Details of the final migration and deployment are still under development, pending feedback from tests
- The goal is to complete the migration and put the system into production before the end of the calendar year.

12/13/19 update: While work has progressed, completion of this item has moved to the 2020 work plan with the expectation that it will be completed in early 2020.

4. **SPACK - new build system for art and LArSoft** (deferred from 2017, continued from 2018).

Priority: high

Purpose:

- To migrate to a standard set of build tools that have broad community support
- To address portability and configurability issues raised by experiments with the current build system
- To allow continued full support of Mac OSX as a LArSoft development platform within the context of Apple's System Integrity Protection system

<https://cdcv.sfnal.gov/redmine/projects/spack-planning/issues>

Resources: Chris Green

5/3/19 Update: Chris Green had a successful build of all dependencies and a fully-populated LArSoft SpackDev area. Relevant repositories / branches have been updated.

6/11/19 Update: Chris Green presented [FNAL Spack / SpackDev status update](#) at the June 4th LArSoft Coordination meeting. MVP1a (LArSoft edition) is ready but for tweaks for the stack build against art 3.02.05 and updates to the documentation. Will organize the offline leads to test the system, and provide feedback on what still needs to be done to meet needs.

9/4/19 update: The MVP1a has been released, along with a [PDF](#) that explains the MVP in detail, and how to set it up to evaluate the system.

- Offline Leads were asked on 6/20/19 to review it and provide comments by 7/20/19. Only a few comments have been received so far, with none suggesting a detailed evaluation
- The Spack code to support the MVP1a is in the process of being integrated into the main branch of Spack. Chris has been dealing with numerous comments and questions from the Spack librarians in an effort to complete this work.
- The project requires more detailed evaluations and feedback from the experiments in order to proceed.

11/21/19 update: There has been little feedback from the MVP release June. Migration to the new system requires changes to Spack that have not yet been adopted by the Spack librarians. Discussions with the librarians on the underlying issues are on-going. A phased deployment plan has been developed. The first phase will replace the build tools with those in SpackDev, leaving much of the existing ups packaging and configuration systems intact; the second phase will replace the ups packaging system with Spack.

5. NuWro Integration.

Priority: medium

Provide an architecture for integrating NuWro into LArSoft using the direct integration model. NuWro should take configuration data via data conversion from LArSoft, and provide output data to LArSoft. A data conversion layer provides an interface between the two. Input data sources should include FHICL files, LArSoft services, and LArSoft compatible flux files. The results should decouple LArSoft from specific NuWro version so that experiments can select the NuWro version best suited to their needs without changing LArSoft releases.

Resources: Erica Snider, and Genie experts

6/11/19 status: We have begun a reorganization of the nutools that will provide a model for integrating NuWro, and similar products, into LArSoft. The NuWro integration can begin after the nutools refactoring is completed.

9/4/19: The nutools refactoring is still in progress.

11/21/19 update: The basic re-factoring of NuTools has been completed. This work should allow NuWro to be integrated using the same model as the newly re-factored Genie generator. There is, however, one remaining task for the Genie refactoring: to remove the Genie module (which is tied to specific Genie versions) from LArSoft. The original plan of combining the LArSoft and NOvA modules has as yet unsolved technical problems. A decision about addressing those versus implementing a work-around has not yet been made. The Genie problem need to be solved before integrating NuWro. Effort to carry out the NuWro integration has not been identified.

6. **Provide training sessions and/or workshops on using LArSoft.**

Priority: medium

Provide and record a workshop on the architecture, design choices, and why we do the things we do. More advanced topics as well--such as contributing algorithms, multi-threading, code analysis.

- Make a plan for addressing the need for local training sessions in different geographic regions

Resources: Erica Snider, Katherine Lato, & presenters

3/7/19 status: This task will be addressed via a session at the summer LArSoft Workshop. Current planning for this includes a rough outline of a curriculum, and examination of existing materials from DUNE tutorials that could be used in part or in whole.

5/30/19: A half-day session explicitly on learning LArSoft at the LArSoft Workshop has been designed, and speakers arranged. Work is proceeding to refine and produce the content. See <https://indico.fnal.gov/event/20453/other-view?view=standard> for details.

9/4/19: The workshop was held as planned, with three sessions across one and a half days:

- a LArSoft tutorial providing basic knowledge and tools for navigating, using, writing and contributing LArSoft code;
- a session that discussed multi-threading and vectorization targeting CPUs and grid processing, gave people the background and tools needed to approach the code and start thinking about vectorizing and making their code thread safe to address memory issues;
- a session on the long-term vision for LArSoft.

Attendance reached about 20 from outside the SciSoft / SCD for some sessions.

- The multi-threading and long-term vision portions were particularly well attended.
- Comments from attendees included suggestions for more hands-on and detailed coding sessions, particularly with respect to multi-threading.
- The material from the tutorial session has been used to bring the basic training materials up to date.

More information can be found at <https://larsoft.org/larsoft-workshop-june-2019/>

11/21/19: This item is closed. To help with the need for local training sessions in different geographic regions, all sessions from the workshop were recorded and can be found at: <https://vms.fnal.gov/>. The slides from the speakers can be found on [indico](#).

7. **Re-architecture of art services in LArSoft to ensure thread safety.** (from 2018)

Priority: medium

Based on a discussion in December of 2017, a plan was developed to re-architect a certain class of services (such as those that tag event-by-event transients in various electronics channels, and the calculation of event trigger times used in the global clock service) such that they are inherently thread safe, while still providing the capability of on-the-fly, event-by-event updates.

<https://cdcv.sfnal.gov/redmine/issues/19288>

Resources: Mike Wang, Paul Russo

3/7/19 status: Mike has demonstrated both intra-event and inter-event multi-threading and favorable memory scaling using a LArSoft signal processing algorithm in a stand alone environment. The same code has also been used to demonstrate inter-event and intra-event multi-threading within a LArSoft job. The memory scaling properties have not yet been measured in this case. Mike is now focused on identifying targets for further work within production workflow for ICARUS, DUNE and SBND.

5/30/19: Work is proceeding in three areas: (1) porting the code Mike made changes to back into LArSoft; (2) Mike Wang is working on ICARUS signal processing code to ensure thread safety; (3) Saba Sehrish is working on making DUNE “data preparation” workflows thread safe. The latter work is also intended to create a data preparation framework that is suitable for use by all experiments.

9/4/19 update: Work is proceeding in multiple areas:

- Mike Wang continues to make progress on various parts of the ICARUS signal processing code. Recent results showed that in the process of implementing multi-threaded versions of this code, he obtained a factor of two improvement in execution time.
- Saba Sehrish is continuing with work on the DUNE production data preparation code.
- Kyle Knoefel has been working on various production modules across the core LArSoft repositories to address thread safety problems and enforce LArSoft coding guidelines and practices.
- Paul Russo has been deeply involved in various debugging problems related to multi-threaded code, and advising others in proper multi-threading coding techniques and practices.

9/11/19 update: Paul Russo is no longer working on this since he is leaving Fermilab.

11/21/19 update:

- Mike Wang continues working closely with ICARUS on their signal processing workflow, and is preparing to integrate some newly thread-safe code back into the ICARUS development branch.
- Saba Sehrish has reported progress on making the data prep workflow thread safe in meetings with DUNE, and agreed to plans for moving forward. That work will focus on

ensuring thread safety, but will not implement multi-threading until the DUNE processing needs are better understood.

- MicroBooNE is working on running their “reco 1” and “reco 2” workflows on HPC resources at Argonne. LArSoft will assist them in this task by ensuring thread-safety of those workflows.

8. **Pixel-detectors within LArSoft.** (2018)

Priority: medium

Work with experiments to identify and implement common solutions that include LArTPCs with pixel readout in cases where such integration is cost effective. It is possible that no such integration The reconstruction piece has two possible scenarios:

- Pattern recognition algorithms shared between pixel and SP/DP LArTPCs. This requires agreeing on a common data format to represent 3D data, whether obtained directly from a pixel detector, or inferred from 2D views in SP/DP detectors. There will likely be implications for the geometry interface, which will then need to support both conventional and pixel-based detectors. Some study will be needed to determine whether these constraints can be met. If code is shared, then support for the development of those algorithms will also be needed.
- No sharing of pattern recognition algorithms between pixel and conventional SP/DP LArTPCs. The code bases in this case diverge, so no further work is required aside from the normal support for data product, service and algorithm development.

<https://cdcv.sfnal.gov/redmine/issues/19328>

Resources: Erica Snider & ??

3/7/19 status: There has so far been little interest in collaborating or traction for this as a high-priority item, so it may not be pursued this year.

6/11/19 update: no change

9/4/19 update: no change

9/11/19 update: this will go into the 2020 work plan.

11/21/19 update: no change

9. **Optimize LArSoft algorithms for Performance** (Was - Use of SIMD vectorization to optimize LArSoft algorithms (2018).

Priority: medium

Optimize performance of LArSoft algorithms with the goal of significantly improving CPU and memory performance on existing computing resources. This work should include studies and projects to introduce SIMD vectorization in those algorithms that might benefit from

vectorization. The project should proceed by profiling real use cases and reviewing code to identify high-value targets; conducting vectorization studies, such as enabling compiler vectorization on minimally modified code, introducing vectorized data types coupled with re-design of select LArSoft data structures and algorithms; documenting performance comparisons and other studies; and preparing reports and documentation as needed. The work should include an assessment of the potential gains from further vectorization efforts. Resources: ??

3/7/19 status: The project and the LArTPC reconstruction SciDAC project have agreed to coordinate work plans and objectives, and have initiated weekly meetings to work toward this goal. An early goal will be perform tests using HPC resources to run LArSoft algorithms selected from high data density production workflows.

6/11/19: Sophie Berkman is working on introducing vectorization into LArSoft hit-finding code. The changes are being made in art-independent repositories, such that ex post porting of code will be unnecessary. Presenting at the 6/18/19 LArSoft Coordination Meeting.

6/18/19: Sophie Berkman presented [Vectorizing and Parallelizing the Gaus-Hit Finder](#) at the June 18th LArSoft Coordination meeting.

9/4/19: Sophie Berkman presented an [update](#) at the July 18th LArSoft Coordination meeting. New version of the GausHitFinder integrated into LArSoft: – 12 times faster than the current implementation on MicroBooNE overlay events, work ongoing for ICARUS. Work is continuing to implement multi-threaded parallelization in the hit-finder. See the 9/4/19 update of item (7) above for more on optimization work stemming from the multi-threading effort.

11/13/19: Due to changes in the direction in which HPC resources are evolving, the need for vectorization has decreased. So this will not be a specific project priority in 2020.

Long term and continuing priorities for 2019

We define long term priorities as those that we do not anticipate completing within CY2020 due to the nature of the work involved. Unless explicitly indicated, a project defined as a long-term priority should not be construed as implying it is “low priority”. A “continuing priority” is a set of tasks that by construction represent a continual, recurring stream of work that may or may not span more than a calendar year.

1. Places where 2019 support from LArSoft team has been requested

Priority: high as needs arise. Low otherwise

- a. Support for migrating to the refactored LArG4

- b. ~~Provide a work-around for build system issues on OSX prior to Spack/SpackDev deployment—critical for code development at ICARUS, problem with install and cmake stages~~ -- this is now, “provide containerized solutions...”
 - c. Wire-cell integration
 - d. ~~Global wire coordinates at DUNE~~
 - e. ~~Memory and CPU profiling~~
 - f. Geometry (e.g., cases where ICARUS breaks implicit assumptions: non-vertical collection wires, existence of horizontal wires, multiple channels per geometric wire)
 - g. ~~FLUKA integration~~
 - h. ~~Improving code location / browsing tools~~
 - i. ~~Improve the usability of the development environment and reduce the overhead required to maintain a stable and consistent development build~~
 - j. Extend the NuWro direct integration model to include the GiBUU event generator framework and the NEUT event generator.
 - k. ~~A workshop to discuss event overlay requirements, techniques, solutions [Added Dec 20, 2018]~~
 - l. Investigate need for magnetic field map within LAr volume. Design and develop the interface for such a service. -- Make this a named project. Assign architect, etc.
 - m. Coordinate between GArSoft and LArSoft
 - i. Ensure sharing of data products and geometry (and with other detectors)
 - ii. Ensure sharing of any services, should that be needed (eg, for magnetic field)
 - iii. Possible introduction of non-uniform magnetic field to LAr volume
 - n. SBND data reduction strategies
 - o. Participate in the discussion of how the DUNE data streams (SN + possibly others/all) will be handled within *art* / LArSoft. May involve moving away from root-based I/O.
2. Support for running select LArSoft workflows on HPC resources.
 - a. SBND has time allocations on Theta at Argonne, and are looking to run LArSoft there
 - b. LArIAT has requested that they be able to run LArG4 on GPUs.
 3. Architecture work to support common framework for data preparation (??)
 4. Architecture work to provide full integration of DL networks
 5. **Ongoing work on bug fixes, emergency feature requests, building software, helping users.**
Priority: high, or as indicated by the request
 Resources: SciSoft team, primarily Erica Snider, Saba Sehrish
 6. **Making LArSoft thread safe.**
Priority: medium
 After the services are thread safe, LArSoft will determine what else needs to be modified to ensure that LArSoft code is thread safe. As part of this work, documentation should help people in writing thread safe code.

7. **Architecture-dependent libraries (2018).**

Priority: low

Follow-on work to SIMD vectorization or other identified use case. Support is needed to allow coexisting builds that include / exclude, support for different computing backends under a given OS flavor.

- a. An immediate goal will be to allow the standard setup procedure to support a generic library as well as one built with a single SIMD extension set
- b. More generally, there are a number of areas that might benefit from this feature, such as allowing use of GPU backends when available for external libraries, or selecting the optimal SIMD instruction set for a given computing node. The types of backend support required needs to be studied, and appropriate tools adapted or developed to allow the required setup procedures.

Resources: ??

8. **Other topics under consideration to work on include the list of accepted, but not assigned, redmine issues.** These can be found under [accepted redmine issues](#).

Priority: low or as indicated in the respective ticket

Appendix A: Definition of priorities

The priorities listed above have the following meaning. The impacts noted are those negotiated with the experiments.

- High: the most urgent projects that have high impact to the community, and that should be fully staffed at all times until completion
- Medium: a project that has a significant impact to the community, and that should be staffed sufficiently to ensure completion within the calendar year
- Low: a project that does not have immediate impact to the community, could be rolled into the next planning period without imposing undue burdens, and should be staffed after meeting all other obligations.