LBNE DOE Review Package (draft 0.0.2)

LBNE Software and Computing Organization

April 2, 2014

Contents

1 Progress Report

1.1 Introduction

Overall Software and Computing effort in LBNE is organized in work areas, which include the Physics Tools Group, Data Acquisition and Online Systems, and the Software and Computing Organization (core computing services). This structure was put into place by the end of FY2013, and efficient interaction and cooperation among these groups has been our focus since that time. For the purposes of this Progress Report, we follow the same classification of deliverables throuout the document, presenting individual sections accordingly.

1.2 FY2012

1.2.1 Physics Tools

The decision to proceed with a Liquid Argon TPC Far Detector (FD) was made in Jan'12. Prior to that decision, the Collaboration investigated the designs for both a liquid argon TPC and a large, underground Water Cherenkov (WC) detector (Fermilab DocDB system references 3600/4342, and the Science Capabilities review). The CDR and the CD-1 review took place mostly in FY2012. Completed items were:

- **Water Cherenkov:** Investigation of WC light collector and different PMT coverage options; development WC event displays; various reconstruction algorithms; software frameworks evaluation, adaptation and deployment, code management; WC DAQ architecture design
- **Liquid Argon Detector:** Assessment of the LArSoft software suite and identification of components that need to be modified for the LBNE Far Detector studies
- **Beam Simulations:** Adaptation of G4NUMI simulation of the beamline, creation of G4LBNE toolkit; computation of the initial flux spectra; development of geometry visualization tools
- **Cosmogenic Backgrounds:** Charged **K** background estimates for **p** decay; backgrounds for supernova burst neutrino measurements; implementation of MUSIC/MUSUN generators the FD simulations; exploration of rates at the 800 ft. and 4850 ft. levels, as well as the surface option
- **Near Detector (ND):** Parameterized studies of ND sensitivities to beam physics and ND-specific measurements; initial systematic uncertainty calculations; muon monitor response predictions
- **Fast Monte Carlo (FastMC):** initial version of FastMC software; integration of the ICARUS particle response parameters; application of GLOBES to compute physics sensitivity; predictions of δ_{CP} and mass hierarchy sensitivity

1.3 FY2013

1.3.1 Physics Tools

The CD-1 process was completed in FY2013 after the CDR finalization at the end of FY2012. Recommendation was made to consider underground placement of the Far Detector. Completed items:

- **Liquid Argon Far Detector (FD):** 10 kt FD and 35t apparatuses – development of prototype geometry for simulation, production of MC samples with single particles and neutrino scattering events; zero-suppression and other data compression algorithms; clustering and pattern recognition algorithms and

study of hit-finding performance; characterization of wire-wrapping ambiguities; studies of the FD fiducial acceptance and event containment; "PANDORA" reconstruction algorithm; inclusion of the NEST model

- **Beam Simulations:** G4LBNE V3 (new geometry); simulations with He and Air in the decay pipe and different target and pipe designs, and alignment tolerances; flux predictions using different models
- **Near Detector:** Muon monitor response predictions; fast Monte Carlo analysis studies
- **Cosmogenic Backgrounds:** Optimization of cosmic-ray rejection requirements; estimates of backgrounds to ν_e appearance on the surface; backgrounds from neutrons, protons, π^0, γ, K_L^0; impact of varying overburden on surface FD, and of the hillside vs flatter FD location
- **Radiological Backgrounds and Cleanliness:** Preliminary inclusion of ^{39}Ar decays in LArSoft; study of cosmogenically-induced radionuclides in the detector materials; dust study at SURF
- **Fast Monte Carlo:** Inclusion of ν_τ interactions; improved particle response functions and uncertainty matrices; study of impact of systematic uncertainties on physics sensitivity; flux driver for FastMC

1.3.2 DAQ and Online Systems

Initial work was started in order to apply the *artDAQ* software as the foundation of the Data Acquisition system for the 35t prototype, based on Reconfigurable Cluster Element (RCE).

1.3.3 Software and Computing Organization

FY2013 saw the beginning of systematic work to create an efficient organizational structure of LBNE software and computing effort as a whole. This structure was defined as conisisting of layers, with the ***Physics Tools Group (PT)*** providing software and components necessary for LBNE research groups, R&D and detector design, while the ***Software and Computing Organization (S&C)*** supplying services such as basic Software Infrastructure (e.g.code revision control, continuous integration and distribution), data storage, distributed data access, databases, collaborative tools etc. ***Online Systems and Data Acquisition Group (DAQ)*** was also formed and worked in close cooperation with their PT and S&C colleagues. By the end of FY2013, the Collaboration has developed a document titled "Physics Tools and Software and Computing Organization of the Long-Baseline Neutrino Experiment: the goals, the structure and the plan", accompagnied by an organizational chart. Based on this plan, a prioritized list of actionable items was created, which guided most of LBNE computing work in FY2013-2014. Certain technical issues, such as building LBNE software on remote sites, were also being considered during this period.

1.4 FY2014

1.4.1 Physics Tools

Highlights of FY2014 include recommendation for He in the decay pipe, and renewed focus on full LBNE configuration with substantial international participation.

- **Liquid Argon Far Detector (FD) and the 35t Prototype:** Migration of LArSoft and components of LBNE code to the *git* repository and *mrb* build tool; raw data display tools, and prototype event display; study of disambiguation using 45° and 36° wrapping angles; reconstruction algorithms for 35t prototype data analysis; estimates of trigger and physics event rates in 35t; NEST model validation in LArSoft

- **Beam Simulations:** G4LBNE V3 geometry validation and updates; systematic study of impacts of alignment tolerances and the cooling water on beam flux; Monte Carlo simulations in support for the recommendation to put Helium in the decay pipe; study of different beam energies and beam/detector placement configurations, and of new target/horn designs to accommodate the 1.2 MW beam
- **Near Detector:** FastMC sensitivity studies; exploration of search for exotic phenomena with the ND
- **Cosmogenic Backgrounds:** Shift to the underground detector configuration – adaptation of simulation sofware, background study for ν_μ analyses, continued work on nucleon decay background characterization
- **Radiological Backgrounds and Cleanliness:** Systematic study of radioisotopes found in construction materials – DocDB 8797
- **Fast Monte Carlo:** Studies of impacts from nuclear modeling systematics; improved treatment of systematic uncertainties in multi-sample fits
- **Cross Sections and Nuclear Models** Three-flavor fit with dissimilar near and far detector framework under development Documentation of current status of cross sections and nuclear models relevant to LBNE's detector configuration initiated

T.Junk (FNAL) was appointed by the Collaboration's Spokespersons to coordinate the Physics Tools Group.

1.4.2 DAQ and Online Systems

LBNE Project appointed Giles Barr (Oxford, UK) to the position of Level 3 Manager for DAQ. LBNE Collaboration appointed Matt Graham (SLAC) the position of the Coordinator of the DAQ Group. Matt also serves as a Deputy Level 3 Manager on the Project. Completed the design of the "vertical slice" of the DAQ chain, based on off-the-shelf components. Performed initial integration test of the artDAQ software on this platform.

1.4.3 Software and Computing Organization

Formation of the S&C Organization continued during this period, with personnel assigned to a few important positions according to the organizational chart, covering Software Infrastructure, Data Handling, Distributed Computing, Databases and Collaborative Tools. Two coordinators (M.Potekhin – BNL and E.Sexton-Kennedy – FNAL) were appointed to lead the S&C Organization. A standing biweekly meeting was estasblished to improve coordination in the computing sector of LBNE.

On the technical front, progress was made in the software infrastructure area. Some of the crucial software components utilized by the PT Group are centrally maintained at Fermilab and did not always come with straightforward procedures and tools for building these components on remote computing sites. This was recognized as a problem early on, and accordingly the top item on priority list was the so-called "portable build" system, with emphasis on completeness, ease of configuration and obviously portability. This work was initiated in FY2013, and continued in FY2014 in close cooperation between FNAL and BNL. The issue of software distribution was addressed by utilizing CVMFS technology with close cooperation with the Open Science Grid Consortium. This work will continue through FY2014 and will enable utilization of remote Grid sites. LBNE S&C also started data storage preparations for the 35t prototype data and Monte Carlo simulations needs, by defining meta-data necessary for storage and retrieval via the SAM and Enstore systems at FNAL.

2 Computing Plan for FY2014 through FY2018

2.1 Introduction

This document is a result of continuous effort by LBNE to plan and coordinate all aspects of its Software and Computing activities, including the Physics Tools, Data Acquisition and Online Systems, and Software and Computing Organization (responsible for core computing services). It is based on the document titled "Physics Tools and Software and Computing Organization of the Long-Baseline Neutrino Experiment: the goals, the structure and the plan", delivered to DOE in September 2013, and on the "Software and Computing Requirements developed in 2014". In addition to the list of deliverables to be met in FY2014-2018, it contains a timeline for achieving these goals.

We follow the same methodology as before, where the primary goal of the Software and Computing work in LBNE is to help the experiment to meet its scientific goals in the most efficient manner. To this end, the activities of Physics Tools are attuned to the needs of LBNE scientists and its ongoing R&D effort, while the Software and Computing (S&C) team is charged with supporting the Physics Tools effort by creating and maintaining a proper software infrastructure, data handling systems, etc. There is also an important interaction of the Online and Data Acquisition work area and both the Physics Tools and S&C.

2.2 Outline of Work Areas

2.2.1 Physics Tools

There are six Physics Tools working groups:

Far Detector Simulation and Reconstruction, Near Detector, Beam Simulations, Cosmogenic Backgrounds, Radiological Cleanliness, Fast Monte Carlo.

The work of each of these groups is needed in order to characterize the experiment design, propose changes, operate and interpret data from prototypes and R&D efforts, and eventually to operate and interpret the data from the full LBNE experiment. The roles of these groups will evolve over the FY2014–2018 time period, e.g. much of the effort in the near term will focus on the 35t prototype, while subsequently the focus will shift to the full experiment. The CD-2 decision process will be supported by the technical design and related documentation supplied by the Physics Tools Group.

2.2.2 DAQ and Online Systems

The effort to develop the main Data Acquisition and other online software for the LBNE Far Detector is well under way. The plan must contend with the (somewhat contradictory) requirements of being (a) future-proof to run on commercial computing hardware to be procured almost a decade from now and (b) available presently to integrate with the designs of the experimental hardware. The 35t prototype is a central component of the current phase of the plan.

Coordination with the Physics Tools Group and the Software and Computing Organization will be necessary throughout this planning period, in order to ensure reliable and efficient data interface between online and offline software components, proper calibration procedures, adequate database support etc.

2.2.3 Software and Computing Organization

The Software and Computing Organization is charged with defining and maintaining the foundation of LBNE computing infrastructure and forming the basis of shared software in support of computing activities across the experiment including the Physics Tools, DAQ and others. The following priority items have been identified:

Software Infrastructure, Data Management, Databases, Distributed Computing, Geometry Management and Visualization, Networks, Collaborative Tools, Security.

Relative importance and resource allocation across these items will change during the period covered by this Plan, reflecting the evolving needs of the Physics Tools and other groups withing LBNE.

2.2.4 Contributions from International Collaborators

Far Detector TPC and Photon Detector simulations and reconstruction provide considerable opportunities for international cooperation. Groups from the UK already contribute to Far Detector reconstruction, and our Brazilian collaborators have expressed interest in the Photon Detector effort. Our Indian colleagues are starting work on Near Detector technology and are getting involved in simulations to help move their design work forward. Expertise from MicroBooNE and LArIAT – many members of these collaborations are also LBNE collaborators – will also speed up the work on the Far Detector design and characterization. We expect to obtain knowledge and technical skills from our international colleagues who are members of the ICARUS collaboration.

Major contributions to online systems and DAQ are already being made by our UK collaborators from Universities of Oxford, Sussex, Warwick and Lancaster, and also Rutherford Appleton Lab (RAL).

2.3 FY2014

2.3.1 Physics Tools

In FY2014, collaborators working on Far Detector simulation and reconstruction will focus their efforts on preparing for 35t data taking and analysis. Deliverables for the 35t test:

- Finalized 35t detector geometry for simulations.
- Response functions from photon detector test apparatus and from cold electronics (to be included in the Monte Carlo and reconstruction algorithms).
- Reconstruction algorithms for the 35t detector, targeted for the measurements envisioned for the run, e.g. response to minimum-ionizing particles, electronics noise, response to cosmic rays passing external scintillator paddle triggers etc.
- Simulated data samples to be used for testing and validation by the DAQ/online group. Data adapter software, conforming to the DAQ data formats, to allow ingestion of the 35t data by the offline software.
- Supporting cosmogenic background calculations (e.g. for decays in stopped muon events)

Near Detector effort:

- Calculation of physics sensitivities of the near detector design
- Estimates of the impact of residual systematic uncertainties on the beam physics

2.3.2 DAQ/Online

In FY2014, the 35t prototype test is a major milestone and focus for the DAQ effort. It allows us to thoroughly test most of the DAQ components in close to real operating conditions before the design is too close to final. This complete end-to-end test enables us to identify any shortcomings in the software and gives us a complete definition of the interface specifications much earlier than is normally the case in an experiment. The primary deliverables of the DAQ group are:

- Data Acquisition and Run Control Software for the 35t detector.
- Once installation of all electronics components is complete, "Outside of Cryostat" integration tests (i.e. systems located outside of the cold volume).
- The Online Monitoring and Software Triggering System.
- Software interface for feeding calibration data back to the boards.
- General design of data structure and organization, such as definition of runs and sub-runs to provide optimal data granularity.
- Demonstration of readout mechanism of the cold electronics, as an important prototype of the cold ADC circuitry.
- Design of data formats (including embedded Metadata) and the Event Builder which is to feed data to LBNE offline software, in order to enable detector and reconstruction performance studies

2.3.3 Software and Computing

General computing items – deliverables:

- Revision control for most important components of the physics applications code
- Creation and management of databases necessary for the 35t prototype test run, such as calibrations database, file catalog etc
- Revision control for geometry parameters and other data necessary to align simulation and reconstruction in the rapidly changing development environment

Preparations for data handling in the 35t prototype test run:

- Configuration of storage interface for the FNAL Enstore system, including dropbox and File Transfer System (FTS), monitoring for the FTS
- Metadata Design for the 35t prototype

Core software management and distribution:

- First release of the "build orchestration system", which provides coherent methods for configuring software components maintained at FNAL (e.g. ART, LArSoft) as well as all software used for the purposes of applications created by the Physics Tools Group.

- Configuration of software for distribution via CVMFS for select use cases utilizing the Open Science Grid OASIS service.

Distributed Computing and Distributed Data Handling:

- Initial configuration of a Xrootd server for distributed data access in LBNE
- "Grid Technology Demonstrator", which will combine mechanisms for software distribution, Grid job submission and distributed data access

Documentation: The LBNE Computing Model will be developed.

2.4 FY2015

2.4.1 Physics Tools

For FY2015, the focus will shift to 35t operations and subsequent data analysis (to be extended through FY2016 and FY2017). Deliverables:

- Evaluation of the basic performance of the 35t detector, quality assessment and validation of its data. Testing of raw data deconvolution and hit-finding algorithms, reconstruction of tracks
- Determination of critical operational characteristics of the TPC (e.g. charge collection, electron lifetime, space charge etc)

Nuclear Modeling, Cross Section, Near Detector and Cosmogenic Background deliverables:

- Three-flavor neutrino oscillation fit analyses with nuclear modeling uncertainties as floating parameters.
- Design of cross section measurement analyses. The physics output of the will inform the technology choice.
- Design, simulation and evaluation of background control methods for nucleon decay search

2.4.2 DAQ/Online

- Operating the 35t detector throughout the planned data-taking period, analysis of its data to refine ideas about triggering, noise, zero suppression and compression.
- Review of timing, trigger requirements and design, as well as the following components: run control, diagnostics, error recovery, triggering performance and the Event Builder.

2.4.3 Software and Computing

- Automated build and basic validation of the principal components of simulation software, and a continuous integration system that runs the build orchestration system, triggered by new tags of that system.
- Enhancments to the software development process, architectural compliance and QA, review of code by librarians
- Development of LBNE-maintained CVMFS repository server, and interface with OSG through OASIS.

- Fully functional Grid submission tools (software configuration and packaging for execution on the Grid), Grid Monitoring and accounting.
- Distributed access to the data for LBNE Grid payload, monitoring and diagnostics of data access
- Documentation: the LBNE Computing Technical Design Report (TDR) will be developed

2.5 FY2016

2.5.1 Physics Tools

In FY2016 and onwards, the work of the FD simulations and reconstruction group will encompass full analyses of neutrino scattering events, though work will continue on improving the detection efficiency, particle ID, and energy resolution for single particles. The performance with single particles as well as full events will be the main deliverable for the CD-2 decision and the technical design report.

Deliverables:

- Software for data collection and data interpretation, to support prototyping and R&D efforts for the photon detection systems.
- Integration of the photon detection components into the full Far Detector simulation and reconstruction software suite.
- Final stage of analysis of systematic uncertainties for the 700kW and 1.2MW versions of the beam, with appropriate changes in software to cover the latter.

2.5.2 DAQ/Online

Deliverables:

- Development of requirements concerning cost and schedule, risk, value engineering.
- Assessment and certification of the zero-suppression and compression technologies to be used in the final detector.
- Design description documentation and interface specification.
- Estimates of performance and limits.

2.5.3 Software and Computing

- Further development of Continuous Integration System with enhanced regression testing of all units and application integration tests
- Expansion of LBNE Grid and data network.
- Implementation of a Workload Management System for LBNE.
- Expansion of the LBNE CVMFS infrastructure to regional centers for increased bandwidth and performance.

2.6 FY2017-2018

2.6.1 Physics Tools

Details of cooling, shielding, and horn design will be included in the simulation as they become finalized. The beam simulations group feeds input back into the design of the beamline components by evaluating the impact of geometry, materials, and electrical changes on figures of merit that are directly related to the physics sensitivity of LBNE. This group will contribute their results for the CD-2 review and the technical design report for LBNE.

The Cross Section and Nuclear Models Group will compute predictions of the total and differential cross sections of the three species of neutrinos and anti-neutrinos on argon, iron, silicon, oxygen, magnesium, aluminum, and other components of the rock surrounding the underground LBNE location. Cosmogenic background calculations, as well as strategies to mitigate them and to measure them *in situ* in the far and near detectors will be part of the LBNE technical design report and the CD-2 materials.

2.6.2 DAQ/Online

- CD-2 documents update based on internal review.
- Final Photon Detector readout implementation.
- Additional testing of APA.
- Upgrades of the "vertical slice" of the DAQ system.
- Final design review to address the following issues: assessment of stability and design of the system, and maintainability of its software; specification of commercial, off-the-shelf components; review of principal risks.

2.6.3 Software and Computing

Software and Computing Organization will continue to manage LBNE code base, provide librarian and Continuous Integration functions to the Collaboration. The state of the software infrastructure will be such that it will shorten learning curves and encourage wide participation of Universities, National Laboratories and our colleagues abroad in the development and application of the Physics Tools and analysis software.

By the end of the time period covered by this plan, LBNE computing infrastructure will include:

- a functional Workload Management System, allowing utilization of widely distributed and/or opportunistic resources in a transparent manner, complete with versatile monitoring capabilities
- a fully distributed and scalable data access system

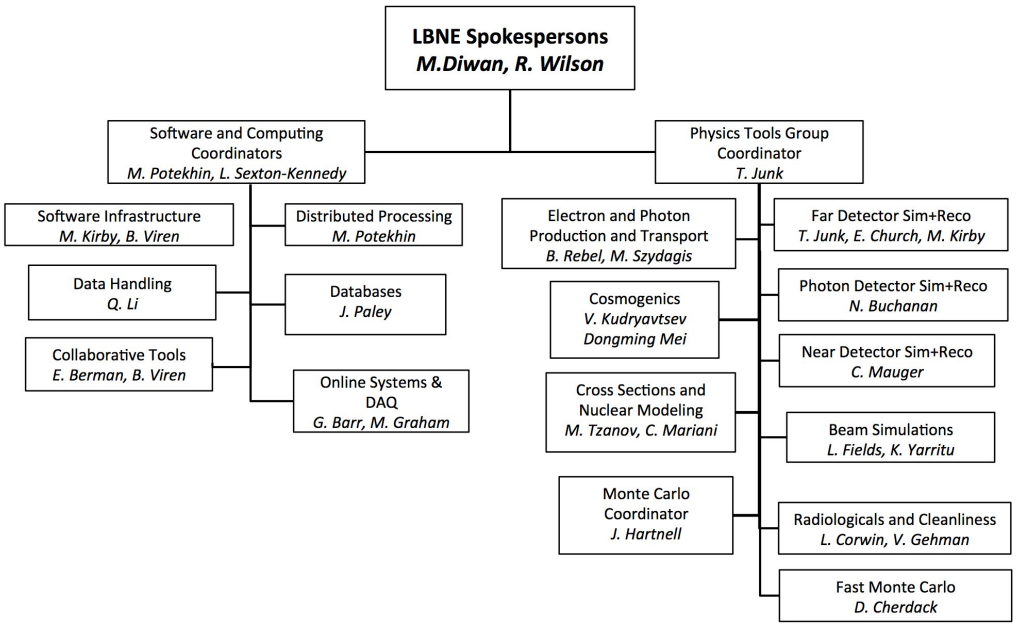

Figure 1: Organization chart for the LBNE collaboration software, computing, and physics tools efforts.

3 Computing Organization

The LBNE Software and Computing organization is divided into two components – the Software and Computing groups, which coordinate the core software and hardware services for the experiment, and the Physics Tools groups, which coordinate the scientific software tools for the collaboration. The organization chart showing these two main branches as well as their subgroups, is shown in Figure 1. This section discusses this organization, and also the coordination between project and off-project tasks. This organization, with collaborator names and responsibilities, is also described in the LBNE Collaboration organization document [**?**].

3.1 Software and Computing

The Software and Computing organization is headed by two co-coordinators, and comprises six subgroups: Software Infrastructure, Distributed Processing, Data Handling, Databases, Collaborative Tools, and Online Systems & DAQ. The Software and Computing coordinators chair the bi-weekly S&C meetings, develop requirements, evaluate technologies, coordinate with the Physics Tools groups in order to provide needed resources,

produce documentation, and report to the spokespersons. The coordinators also assist in aligning the needs of the collaboration with resources provided by the laboratories, universities, and other computing centers.

The Software Infrastructure subgroup manages the code repositories used by the other Software and Computing subgroups and also for the Physics Tools subgroups. In addition, the Software Infrastructure subgroup manages software build tools, distribution, and release management. This subgroup provides documentation on how to use the tools and on best practices. We envisage a future set of software librarians who will perform code review and validation before collaboration approval. The software infrastructure subgroup will also maintain automatic software testing tools, though the individual tests of specific software packages must be designed by the authors and/or maintainers of those packages to the specifications set forth by the Software Infrastructure group.

The Distributed Processing subgroup evaluates processing technologies and makes them available to the LBNE collaboration. This subgroup is charged with interfacing with laboratory, university, and other grid computing providers in order to evaluate the appropriateness of the computing resources for LBNE's needs, and to provide tools for LBNE collaborators to make use of them. A seamless job submission and monitoring system is desired, in which a processing job can be configured on interactive computers easily accessible to LBNE collaborators and submitted to a broad array of available computing resources. The Distributed Processing subgroup interacts with the Data Handling group to ensure that the data required by the jobs are delivered in an efficient manner and in a way that is easy to configure by collaborators, and that job output can be retrieved by collaborators easily as well.

The Data Handling subgroup evaluates and incorporates technologies for data storage, transmission, and retrieval provided by the laboratories, universities, and cooperating institutions, such as Open Science Grid computing centers. The Data Handling group interfaces with providers of storage and networking to identify available data storage facilities of which LBNE can make use, and to make requests on behalf of LBNE for increased storage and/or bandwidth. The Data Handling subgroup designs the scheme for indexing archived data, called metadata, so that collaborators can easily retrieve desired data and simulation samples from mass storage devices. We desire a seamless interface to LBNE data and Monte Carlo samples that interoperates among the distributed computing resources, and the Data Handling subgroup is tasked to provide this interface, coordinating with local resources available at each computing installation. This task is not unique to LBNE and is helped by significant existing data handling infrastructure. The data handling group provides documentation to the collaboration on the subject of data archiving, access, and assists in communicating the specific properties of each dataset.

The databases subgroup designs and maintains the run conditions and calibration databases for the LBNE experiment. The near-term focus will be on the database for the 35t prototype. The database will be served by dedicated hardware, and the database subgroup will interface with the maintainers of these computers. The database group is charged with the design of the content of the database, its updates, versioning, backups, replication, distribution, and use by offline data and simulation analyses, as well as providing documentation.

Online systems and DAQ comprise those software efforts that are needed to acquire useful, valid data from the LBNE experiment and the 35t prototype. The DAQ electronics efforts are supported on the LBNE project and are not included in the May 2014 Software and Computing review, though the online systems subgroup interfaces closely with the DAQ electronics group in order for the data to be delivered, monitored, and logged. The online systems group will provide run control, data quality monitoring, data logging and transfer to permanent storage, and, in the full LBNE configuration, interface with networking between Fermilab and SURF. The online systems and DAQ group also provides slow controls and monitoring of process variables such as those associated with the cryogenics and high voltage, and provides software that writes values into the run conditions database. This subgroup also evaluates and maintains instances of an electronic control-room logbook. This subgroup also is charged with providing detailed documentation of the online systems.

The Collaborative Tools subgroup designs and maintains collaboration web sites, document databases, and collaboration member lists. Useful information for new collaborators to get started is stored on these web sites, and maintenance is provided by the Collaborative Tools subgroup.

3.2 Physics Tools

The Physics Tools organization is headed by a coordinator, and comprises ten subgroups: Electron and Photon Production and Transport, Far Detector Simulations and Reconstruction, Photon Detector Simulations and Reconstruction, Near Detector Simulations and Reconstruction, Beam Simulations, Cosmogenics, Cross Sections and Nuclear Modeling, Radiologicals and Cleanliness, Monte Carlo Production, and the Fast Monte Carlo.

The Electron and Photon Production and Transport and the Far Detector Simulations and Reconstruction subgroups currently share a weekly meeting. This group is responsible for the simulation of particle interactions with the liquid argon TPC (though the hard scattering processes are validated by the cross sections and nuclear models group). This group interfaces to and contributes to the development of LArSoft, which is a code base shared by MicroBooNE, ArgoNeuT, and the LBNE experiments, as well as LArIAT and several prototypes. The reconstruction effort develops algorithms for identifying and measuring tracks, showers, cosmic rays, and performs particle ID and measurements of particle energies, starting positions and energies. Detailed documentation is required.

The Photon Detector simulations and reconstruction subgroup is a new addition to the organization chart, with members drawn from the efforts to prototype possible photon detectors for LBNE. The prototype experiments require all of the services needed for the full LBNE experiment, but in miniature – data acquisition, storage, simulation, reconstruction, and interpretation. This group is currently chaired by the group leader of the Photon Detector systems.

The Near Detector Simulations and Reconstruction subgroup is focused on predicting the sensitivity of the ND to its proposed physics program – the support of the beam oscillation physics program, as well as a comprehensive program of measurement of inclusive and differential cross sections of neutrinos on nuclei. This effort is currently focused on using fast Monte Carlo simulation tools to perform these calculations, and thus works closely with both the ND hardware group and the fast Monte Carlo group. In the future, we expect close collaboration between the near and far detector efforts to determine the exact relationships between the event detection efficiencies for the near and far detectors.

The Cosmogenics subgroup is charged with computing backgrounds to the physics analyses of the LBNE experiment, and to develop strategies for rejecting them and constraining the remaining amounts using samples of data. It has produced background estimates for a surface FD and strategies for reducing these backgrounds. It is charged with predicting the cosmogenic backgrounds and developing these strategies for the underground physics program, as well as the 35t prototype and the ND. This subgroup provides detailed documentation of its predictions and recommendations.

The Cross Sections and Nuclear Modeling subgroup collects results from other experiments to predict interaction rates in the FD, and also the ratio of rates between the ND and the FD, in service of the beam oscillation physics program. Support is also to be provided for the other physics analyses – atmospheric neutrinos and supernova burst neutrino measurements. Members of this group are working on joint fitting techniques for extracting beam oscillation parameters from a dissimilar ND and FD, where the uncertainties that float in the fit are nuclear model uncertainties.

The Fast Monte Carlo subgroup supports the physics analyses of LBNE by calculating sensitivities to oscillation parameters and other physics targets of the experiment using state-of-the-art cross sections and nuclear models, as well as parameterized detector responses to particles. Since the full simulation and reconstruction

of events in the ND and FD are not yet available, and first iterations through will not have the full future resolution and efficiency, the parameterization is a more reliable estimate of LBNE's future sensitivity.

The Beam Simulations subgroup develops and maintains a GEANT4-based simulation of the baffle, the target, the horns, the decay volume, and the hadron absorber, and provides flux predictions for the hadron monitors, the muon monitors, the ND, and the FD. The dependence on alignment parameters of beamline components and parameters such as the horn current. This group provides an important service in the chain between beamline component design and LBNE's physics sensitivity, both from the central values of the flux predictions and their systematic uncertainties. The work of this group helps to optimize the configuration of the beamline components, such as the choice between using helium or air in the decay pipe. Results are compared between the GEANT4 and MARS calculations.

The Radiologicals and Cleanliness subgroup predicts the backgrounds in the FD arising from unstable nuclides, either those that are naturally occurring in the detector materials, or that are produced via cosmogenic activation (the latter is less important underground). It interfaces with the simulation and reconstruction groups to evaluate the impact on the physics sensitivity of LBNE.

A separate subgroup is charged with managing Monte Carlo production. Tools for streamlining this production, monitoring and resubmission of failed jobs, and storage of the results with appropriate cataloging and metadata are within the charge of this group.

3.3 Coordination Between Project and Off-Project Computing Tasks

There is a very clear interface between the on-project DAQ and electronics effort and the off-project offline computing efforts. Active communication between the DAQ, Software and Computing, and Physics Tools groups is ongoing in order for the data produced from the 35t prototype to be easily used and provide the most value to the experiment. The challenge of reading out and storing the data from the FD is addressed in ways that must be agreed upon by the online and offline efforts, which span the project/off-project boundary.

The on-project detector and beam design groups constantly consult the simulation and reconstruction efforts in order to define detector requirements and performance levels as functions of detector design choices. The FD design effort for instance needs to know what the fiducial requirements are on the beam data in order to design the FD to have the appropriate fiducial mass as requested, but the amount of non-fiducial volume depends on the physics and physics tools requirements. The FD simulation and reconstruction group also informs the choice of the induction-plane wire angle due to ambiguities introduced by wrapping.