

Memorandum of Understanding
between
Harvard University - LPPC
and
Fermi National Accelerator Laboratory
for
NOvA Experiment R&D
and Construction Work

Aug 20, 2008

I. Preamble

This Memorandum of Understanding is made between Harvard University Laboratory for Particle Physics and Cosmology (LPPC) and the Fermi National Accelerator Laboratory Particle Physics Division (Fermilab). This document represents an understanding between LPPC and Fermilab in connection with NOvA detector electrical and mechanical engineering and development work. This document does not constitute a legal contractual obligation on the part of either of the parties. It reflects an arrangement that is currently satisfactory to the parties involved.

II. Responsibilities

1. Activities

Harvard LPPC will perform engineering and prototype electronics development, construction and testing for the NOvA experiment. This MOU covers work on the NOvA front end electronics, which includes, but is not limited to, the following tasks:

- a) Design, produce, and test a series of prototype Front End Boards (FEBs) for the NOvA Far Detector and a special version for the NOvA Near Detector.
- b) Firmware development
 - Digital functionality, including DSP filters, data I/O and control, is handled by programmable logic (FPGA) on the FEBs. Firmware development for the FPGAs including design, simulation, and implementation is performed in an incremental manner from the earliest prototypes through final production. It will continue for some period during detector commissioning and operation as detector functionality is upgraded. The Harvard group will be responsible for firmware development as required for the duration of the program.
- c) Construct test stands as required for operating prototype FEBs.
- d) Develop software for operating test stands and prototype FEBs. Develop software for data analysis and display for integration and other tests
- e) Provide design services as needed for the APD module substrate.
- f) Perform and document integration tests with FEBs and APD modules to insure that noise and other performance specifications are met.
- g) Perform integration tests with FEBs and Data Collection Modules (DCMs) to insure error free data and control signal transmission.
- h) Produce and test an engineering run of FEBs for the IPND. Support installation and integration of these FEBs on location at the IPND.
- i) Organize and oversee the production and testing of FEBs for the NOvA detector. It is anticipated that approximately 12,000 units will be required.
- j) Travel.
 - Participate in Collaboration meetings
 - Provide on-site engineering support at IPND and NOvA detector as necessary
- k) John Oliver will serve as NOvA Electronics/DAQ Project Engineer.
- l) John Oliver will serve as Level 3 Manager for the Front End Board (FEB)

Harvard LPPC will also provide structural engineering consulting services of Professor John Hutchinson.

2. Personnel

The LPPC NOvA Group Leader is Prof. Gary Feldman, and the contact person for electronics design activities at LPPC is Dr. John Oliver. The work will be carried out by members of LPPC under the direct supervision of the Level-3 manager, Dr. John Oliver. These include electrical engineer, Nathan Felt, and designer/technician, Sarah Harder. Software development will be done by graduate students Josh Boehm and Steven Cavanaugh.

3. Deliverables

Harvard LPPC will deliver

1. Physical copies of prototype 2.0 FEBs for detector testing & readout.
2. Physical copies of prototype 3.0 for NOvA evaluation.
3. FEBs specific to the Near Detector. This will sample the detector signals at up to 4x the speed of FEBs for the Far Detector.
4. Fully tested FEBs in quantity appropriate for the IPND
5. Fully tested FEBs for the NOvA experiment
6. Test software as needed
7. Firmware support through detector installation and commissioning.
8. Test reports and documentation to be placed on the NOvA docdb

4. Institutional Contribution of Services and Equipment

- 1) Facilities and Equipment
 - a) Lab and workshop areas
 - b) Computers and CAD tools
 - c) Normal test equipment

- 2) Operating Costs

Harvard LPPC, subject to adequate funding from the DOE, will support the normal research operating expenses (such as physicists' salaries; physicist travel expenses, miscellaneous supplies, administrative support, etc.) of the Harvard group working on the NOvA experiment.

5. Fermilab Resources Required

In addition to the costs listed in annual Statements of Work, Fermilab will provide funds for Harvard-LPPC technician and engineer travel and for materials and equipment purchases necessary to perform this work. Large purchases will usually be made through the Fermilab Procurement department but some purchases may be made through Harvard procurement, as specified in annual Statements of Work.

Fermilab will provide custom CMOS ASICs developed specifically for NOvA. Fermilab will also purchase and supply custom "Quad ADC" integrated circuits manufactured by ChipIdeas as required as components to be integrated onto the FEBs.

III. Reporting, Costs and Schedule

1. Technical Reporting

Harvard-LPPC will document the procedures, analyses and results obtained in the NOvA document database after the completion of this work.

During this period of performance, the NOvA group at Harvard will monitor the costs and progress of this work regularly, with a view to providing ample notice if the cost of the effort is projected to exceed the estimate described in this document or subsequent amendments. If it is determined that additional costs for effort will be required, the Fermilab NOvA Project Manager will evaluate available options and, in consultation with Prof. Feldman at Harvard to determine the best means of supplying the additional effort.

2. Cost & Progress Reporting

Harvard will invoice Fermilab for all NOvA-related expenditures and labor charges monthly and will report associated technical progress in each item of work by Work Breakdown Structure (WBS) category on a monthly basis through the appropriate NOvA Level 2 Manager to the NOvA Project Manager. Monthly progress reports to NOvA management should include details of work carried out, and current status as required for the NOvA Monthly Report.

3. Schedule

This work will be carried out during the R&D and production phases of the NOvA experiment.

IV. Other Considerations

1. Safety and Engineering Practices

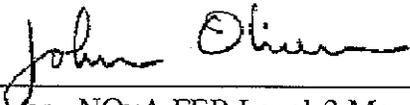
All detector components will be constructed in conformity with Harvard – LPPC safety policies and practices, normal engineering standards. All detector components which will reside at Ash River or Fermilab must conform to Fermilab ES&H policies and practices.

2. Equipment Ownership

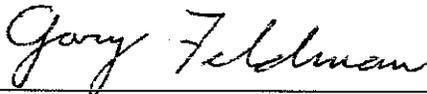
All items purchased or fabricated wholly with funds supplied by Fermilab will remain the property of Fermilab. Such items will be properly identified with Fermilab property tags as required by Fermilab policy. All items purchased with LPPC funds will be tagged as required by Harvard-LPPC policy.

V. Approval

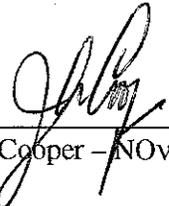
The following concur in the terms of this Memorandum of Understanding.
These terms will be updated as appropriate in Amendments to this Memorandum.



J. Oliver - NOVA FEB Level-3 Manager, Harvard LPPC



G. Feldman - NOVA Group Leader, Harvard LPPC

 8/22/08

J. Cooper - NOVA Project Manager, Fermilab

 8/27/08

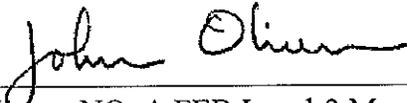
G. Bock - Acting Head, Fermilab Particle Physics Division

 9/2/08

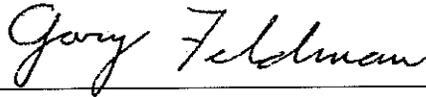
P. Garbincius - Fermilab Associate Director for Research for Project Oversight

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J. Oliver - NOvA FEB Level-3 Manager, Harvard LPPC

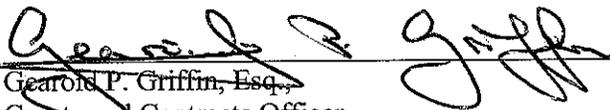


G. Feldman - NOvA Group Leader, Harvard LPPC

~~J. Cooper - NOvA Project Manager, Fermilab~~

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Gerard P. Griffin, Esq.,
Grants and Contracts Officer
Harvard University Office for Sponsored Programs