A Proposal to the
National Science Foundation

From the
University of Wisconsin – Madison
Antarctic Astronomy and Astrophysics Research Institute
(A^3RI)
1225 West Dayton Street
Madison, WI
53706

for

Year 2 of the IceCube Project

March 2003

Amount Requested:

$24,700,000

Francis Halzen
Principal Investigator
University of Wisconsin – Madison
Department of Physics
Phone: 608-262-2667
Email: halzen @pheno.physics.wisc.edu

Charles L. Hoffman
Administrative Officer
University of Wisconsin - Madison
Research and Sponsored Programs
Phone: 608-262-0253
Email: choffman@rsp.wisc.edu

Executive Summary

This proposal is for Year 2 of the IceCube project, and covers effort to be performed during the period from April 1, 2003 through March 31, 2004. The Year 2 effort builds upon the success to date, and will largely complete the transition from engineering development to manufacturing and deployment activities. In addition to preparing the project for production of hardware to be deployed in the 04/05 season, Year 2 will also include delivery of the Enhanced Hot Water Drill system to the Antarctic.

The European members of the IceCube collaboration will participate in all detector system tasks, including fabrication of Digital Optical Modules and Simulation. This effort reduces the total cost to the NSF, and will be funded by European agencies in Sweden, Belgium and Germany. The details of these arrangements are currently under negotiation and levels of financial commitment are summarized by letter attachment. The European effort complements the tasks shown in the Statement of Work, and, in several cases, our European collaborators serve in key roles as Level 3 leads.

The cost of USAP/RPSC support in FY03 is included in this proposal. Funds for this activity are requested as part of this proposal, however these funds are not controlled by the IceCube project office, therefore the University of Wisconsin – Madison (UW) does not take direct responsibility for management of RPSC activity or the distribution of funds for this effort.

The scope of Project Year 2 is defined by five broad areas of work that will be carried out by the IceCube Collaboration: 1) Project Support, 2) Implementation, 3) Instrumentation, 4) Data Systems, and 5) Detector Commissioning and Verification.

Key effort within each of these five main areas has been summarized below, whereas more detailed descriptions of tasking, schedule, and budget are provided in the main body of this proposal.

1.0 Project Support

Project Management tasks during Year 2 include generation of the integrated budget and schedule for the project, planning and budgeting near-term work in detail, preparation and submission of the Year 2 Project Execution Plan, implemention of a project-wide Earned Value reporting system, and conducting formal reviews of engineering requirements, work progress, and quality assurance. Other administrative tasks include preparation / maintenance of collaborative agreements, funds management documents, project documentation, and progress reports.

Systems Engineering effort during Project Year 2 will concentrate on the formalization of engineering practices, full definition of system and subsystem requirements, review of the emerging design baseline, and verification of performance prior to the start of full scale manufacturing.

2.0 Implementation

The primary Implementation focus for Project Year 2 consists of completing the Enhanced Hot Water Drill system to support deployment operations, providing the necessary spares, transporting the EHWD to the South Pole, and building up the key EHWD components at the South Pole. In addition, logistics planning for the FY04 and FY05 seasons will be completed including planning and preparation for the start of deployment in FY04.

3.0 Instrumentation

Instrumentation effort during Project Year 2 completes the detector engineering development cycle and initiates production of the components required to deploy complete strings of detectors (Digital Optical Modules) and IceTop Stations at the South Pole during the FY04-FY05 season. In addition, the networks and computer systems required to host the Data Acquisition software will be developed. Software that makes up the Data Acquisition subsystem, i.e., the Digital Optical Modules (DOMs), DOM Hubs, String Processors, Trigger Processors and Event Builder will also be developed.

4.0 Data Systems

Project Year 2 effort will be directed toward the creation of the systems required to locally archive raw and filtered data, the development of the filter and reconstruction software to be used at the South Pole, and the establishment of the satellite transfer of filtered data from the South Pole to the Northern Hemisphere. Development of simulation software to support the commissioning, verification, and subsequent analysis will first extend the AMANDA simulation software to better meet the needs of IceCube and then develop a fully functional simulation for IceCube/IceTop.

5.0 Detector Commissioning and Verification

Detector Commissioning and Verification effort in Year 2 will create detailed plans for: establishing and measuring physics benchmarks with IceCube data; design and implementation of reconstruction algorithms for use in the Level One and Level Two filters at the South Pole and in the northern hemisphere; design and implementation of detector calibration algorithms, software and hardware; design and implementation of a detector monitoring system; and the integration of the AMANDA and IceCube detectors. Interfaces between these areas and others in the IceCube system will be delineated in these plans. Finally, initial designs of the Level One filter, lower level calibration algorithms, and calibration hardware will be delivered.

Schedule

The top-level schedule for IceCube Project Year 2 is included here for reference. The detailed schedule will be expanded to the appropriate WBS level (typically level 5/6) and presented in the Year 2 Project Execution Plan (PEP).

[Insert schedule and, if needed, related explanatory text here.]

Statement of Work

This section presents Project Year 2 activities to be performed, as well as a list of key milestones and deliverables, for each Level 3 Work Breakdown Structure (WBS) element.

WBS 1.0 Project Support

WBS 1.1 Management

Project Planning includes the generation of the Year 2 Project Execution Plan reflecting an integrated schedule and budget for the project. Additional planning tasks include configuration management for design and manufacturing processes and document control. Subsystem Management is performed to ensure that all IceCube subsystems are adequately managed. Progress Reports will be generated monthly and quarterly to satisfy established internal and external reporting requirements. Risk Management responds to all risks identified by members of the collaboration and determines when risks have been adequately addressed. Project Tracking analyzes information gathered from all institutions regarding the status of current activities.

Financial Management gathers information about planned costs, actual costs, and earned value and organizes the information at various levels. Cost and schedule variances are prepared for review by work package managers, the P.M., and the Deputy P.M. Schedules and budgets are updated as needed, and monthly reports are generated for internal and external reviewers. Cost accounts are established and managed to ensure that all expenses are controlled and properly logged.

Subcontracts Management focuses on work being performed by subawardees to ensure adequate levels of performance and reporting to the Project Office. Project-wide reviews include status reviews, external advisory committees, major design reviews, and collaborative meetings are included.

The main goal of the Quality activities in Year 2 will be to finalize the quality system processes that will be used for IceCube. These processes include design, manufacturing, configuration management (including document management) and corrective/preventive action. Other Quality tasks for Year 2 include developing operations process flows for drilling and string deployment, and inspecting the MDS's as they are received from SeaBox. Although most of these tasks are to be completed before Summer 2003, implementation and maintenance of the Quality System will be an ongoing task throughout the life of IceCube.

The goal of the Year 2 Safety tasks will be to ensure that safety mitigations and considerations have been implemented into the design of the Enhanced Hot Water Drill (EHWD) prior to it being shipped to the South Pole. These activities include completion of Safety Design Reviews, training staff on safety-related issues with the EHWD,

purchase/installation of safety equipment and inspection of the EHWD during IV&T. In addition, the remaining two Hazard Analyses for Drilling and Deployment Operations are to be completed (the completion of these HA's is not expected to impact the delivery of the EHWD to the South Pole). All tasks are to be completed by 8/31/03, except for safety training of the South Pole staff that is planned for October.

The goal of the Production Engineering tasks for Year 2 will be to establish the processes that will be used in manufacturing to purchase parts, build and test DOM's, ensure that all sites are using the same equipment/processes and coordinating design changes throughout the manufacturing plants. A prerequisite to competing these tasks is hiring a Production Engineer that has a background in establishing manufacturing operations of this type. The hiring of a Production Engineer is planned in the first or second quarter of Year 2. The ramp up of manufacturing processes will be started Year 2 with continued surveillance and maintenance throughout the production life of IceCube.

Deliverables:

- Year 2 Project Execution Plan
- Year 3 Project Proposal
- Hazard Analyses
- Quarterly Status Reports
- **[Other?]**

Key Milestones:

8/15/03	System Level PDR
6/05/03	Collaboration Meeting
6/25/03	Year 2 Project Execution Plan (PEP)
8/05/03	1st Quarterly Report [30 days after period close?]
10/05/03	Collaboration Meeting
11/05/03	2nd Quarterly Report [30 days after period close?]
11/15/03	Hartill 3 Review
2/05/04	3rd Quarterly Report [30 days after period close?]
3/15/04	Year 3 Project Proposal
5/05/04	4th Quarterly Report [30 days after period close?]
TBD?	[Safety Design Review(s)?]
October?	[Training of South Pole Personnel]

WBS 1.2 System Engineering

Systems Engineering effort during Project Year 2 will concentrate on the formalization of engineering practices, full definition of system and subsystem requirements, review of the emerging design baseline, and verification of performance prior to the start of full scale manufacturing. These activities include planning and conducting the overall engineering activities of the IceCube project. Major managerial efforts will include updating and maintaining the System Engineering Management Plan (SEMP), conducting Preliminary and Critical Design Reviews for each Configuration Item (CI) identified in

the project, and supporting NSF Reviews, Technical Board meetings, Collaboration meetings and site visits as required.

Systems Engineering will also plan and conduct the overall software coordination effort, (exclusive of EHWD related tasking), for the IceCube project. Software Coordination activities include maintaining and updating the Software Development Plan, conducting Preliminary and Critical Design Reviews of each Computer Software Configuration Item (CSCI), and maintaining oversight of the collaboration-wide software development so that effective software development methodologies and tools are employed by all of the participants in the software development effort. Software coordination will support Technical Board, Collaboration Board, NSF Project Reviews and site visits as required.

System Engineering will continue to identify and refine key system level interfaces, review and approve interface documentation and products including Interface Control Documents (ICD's). Since the architecture of IceCube allows for the efficient division of work among several different institutions, the appropriate definition of interfaces is critical to the successful integration of the system. As a result, Systems Engineering will insure that Interface Control Documents are properly defined, finalized, updated and maintained on an ongoing basis.

Another fundamental task of Systems Engineering is the maintenance of the Engineering Requirements Document so that all subordinate subsystem requirements can be traced back to their source and ultimately to the Science Requirements. In addition, all project requirements and specifications will be reviewed and approved.

Systems Engineering will also provide for the establishment, management, and conduct of integration tests of the IceCube system. A Test Manager will be responsible for test planning, coordination, review of procedures, and test conduct in conjunction with Quality and the Systems Engineering Manager.

A System Modeling and Simulation effort will provide for establishment of a Monte Carlo simulation modeling tool set that can be used for verification of system timing, error budget, reliability, and other aspects that must be confirmed by analysis prior to system deployment.

The Risk Management program will continue to identify, assess and mitigate project risks. A list of identified risks, their severity level, the approach to mitigating the risk and final disposition will be maintained and tracked on a routine basis.

Electrical, Mechanical, and Software Engineering support for systems engineering related tasks will be provided (or subcontracted) when adequate resources are not otherwise available within the collaboration.

Deliverables

- Conduct CI Level Preliminary Design Reviews (PDRs)
- Conduct System Level Preliminary Design Review

- Conduct CI Level Critical Design Reviews (CDRs)
- Conduct System Level Critical Design Review (04/05 deployed elements)
- Conduct Production Readiness Review (04/05 deployed elements)
- Implement System Modeling & Simulation Analysis Tool
- Update System Engineering Management Plan (SEMP)
- Update Engineering Requirements Document (ERD)
- Update Software Development Plan (SDP)
- Ongoing coordination and document review, approval, and updates.

Key Milestones

4/15/03 -7 /31/03	Conduct CI Level PDRs
8/15/03	System Level PDR
6/1/03 - 3/31/04	Conduct CI Level CDRs
10/15/03	System Level CDR (04/05 deployed elements)
1/15/04	Production Readiness Review (04/05 deployed elements)
4/15/03	System Analysis Tool Development Start
6/15/03	System Analysis Tool Validation
7/15/03	System Modeling & Simulation Analysis Tool Operational
(Quarterly)	Updates to SEMP, ERD, SDP

WBS 2.0 Implementation

WBS 2.1 Logistics

The main activities in Logistics in Project Year 2 include identifying and hiring a Logistics Manager by 31 May 2003 who can oversee the complex tasks of coordinating, planning, and scheduling the transportation of material, personnel, and supplies to the South Pole. This individual will provide logistics support so that the construction of IceCube is completed in a timely manner. During Project Year 2, the Enhanced Hot Water Drill will be shipped to McMurdo and key components transported to the South Pole so that drilling at the South Pole can be started in the FY04-FY05 season. Logistics planning for FY04, including the SIP, will be completed and approved by 30 June 2003. The logistics planning and SIP preparation for FY05 will be started.

Deliverables:

- EHWD Shipment
- Final FY04 SIP

Milestones:

5/31/03	Logistics Manager In Place
6/30/03	FY04 Logistics Plan Approved

WBS 2.2 Drilling

Drilling activities for Project Year 2 continue to focus on the successful shipping, deployment, and preparations for drilling, plus enhancements to the EHWD. The most critical task is to ship the primary components of the drill system to Port Hueneme before 1 Sept 2003. After successfully transporting these drill components to the South Pole, the Assembly Supply Hose Reel and the first Tower Operations Structure (TOS) will be assembled and the Drill supply hose will be loaded onto the Supply Hose Reel. These tasks are necessary so that the entire EHWD system can be assembled early in the FY04-FY05 summer season and drilling and deployment of detector strings can begin on schedule.

Spare parts will be ordered and prepared for shipment. Two additional drill heads will also be fabricated

Development of software for the drill automation and optimization will continue. A system simulator will also be developed that can be used to test software and sensor testing will continue.

A Drilling Manager will be hired to be responsible for the successful setup, operation and storage of the EHWD. This individual will be responsible for the hiring and training of the drill crews as well as for preparing the drilling portion of the FY05 SIP.

Deliverables:

- (2) Drill Heads
- (2) Tail Loggers
- System Spares **[ship in Nov '03?]**
- System at South Pole: Supply Hose Reel and Tower-1 assembled.
- Control System Software updates

Milestones:

8/31/03	Key EWHD system assemblies at Port Huenme
10/31/03	Remaining EWHD systems assemblies at Port Hueneme
1/31/04	Preliminary staging work complete for FY05 Season

WBS 2.3 Deployment:

Deployment activities will revolve around two primary functions during Project Year 2, completing plans for deployment in FY05, completion of the deployment operations buildings, and completion of the design and plans for communications systems (data, voice, and video) for the South Pole.

The Schedule for Deployment and the Deployment Operations Plan will be finalized and the final Counting House design will be completed in conjunction with RPSC. In preparation for the FY05 season, a deployment lead will be hired to develop deployment

plans and procedures and train additional deployers. The SIP for FY05 will be prepared and submitted.

Modular Deployment Structures (MDS's) for the second Tower Operations Structure (TOS-2) and second tower (Tower-2) plus the Optical Module Lab (OML) and the Tower Operations Workshop (TOW) will be ordered from SeaBox, the vendor for the rest of the Drill System MDS's. After receipt of the MDS's from SeaBox, they will be outfitted and TOS-2 MDS will be integrated with Tower-2.

Two deployment cable winches will be purchased. The architectural design of the deployment electronics and control systems will be finalized. Control systems will be completed to 65%.

[This list of deliverables / milestones looks more EHWD related- does it really belong here?]

Deliverables:

- TOS-2 MDS
- OML MDS
- TOW MDS
- Tower-2
- Two deployment cable winches

Milestones:

6/1/03	Place MDS order with Sea Box
8/31/03	Receive TOS-2 MDS from Sea Box
10/15/03	Receive TOW MDS from Sea Box
12/31/03	Receive OML MDS from Sea Box
10/31/03	TOS-2 Outfitted
11/30/03	TOW Outfitted
2/28/03	OML Outfitted
11/30/03	Tower-2 Built
3/31/03	TOS-2 MDS / Tower Integration Complete
3/31/03	Approved Deployment Operations Plan
10/1/03	Deployment Lead In Place
10/31/03 [?]	Place orders for two deployment cable winches

WBS 3.0 Instrumentation

WBS 3.1 In-Ice Devices

IceCube continues to pursue an aggressive schedule that culminates in the delivery of seven strings of optical modules in the 04/05 drilling season. The deployment will

include IceTop modules, surface cables, and the data-handling equipment required to operate the strings immediately after the strings are frozen in after deployment.

A new set of 20 engineering prototypes DOMs will be completed and extensively tested to verify recent design changes. A pre-production batch of about 150 DOMs will be manufactured to verify and refine planned methods of production and quality control. The production of about 500 DOMs will begin toward the end of the Project Year 2.

To support the stated goals, major activities include the following:

Complete the design of all DOM components that complement the DOM Main Board. Components include in the In-Ice Device budget include flasher boards, photo-multiplier tubes (PMTs), PMT high-voltage bases, delay lines, pressure vessels, connectors, magnetic shields, mechanical harnesses, and cables.

Operate 20 prototype DOMs individually to test basic electrical functions including photon detection efficiency, DOM noise rates, calibration accuracy, power consumption, and temperature effects.

Operate 20 prototype DOMs as a system on a prototype cable to establish the effects of various cable characteristics. Key characteristics include bandwidth, impedance, signal attenuation, power loss, crosstalk, dark noise levels, time resolution, dynamic range, and noise immunity.

Establish needed design changes and conduct a Design Review to ensure compliance with Systems Engineering and Quality Assurance criteria.

Revise designs as needed and produce 150 pre-production DOMs to verify and refine manufacturing and testing methods.

Conduct a Production Readiness Review to verify and refine the schedule and budget for producing 500 DOMs.

Begin production of 500 DOMs.

Deliverables:

- 20 prototype Digital Optical Modules
- Test Report on prototype DOMs
- 150 Production Cycle DOMs
- Parts List for procurement of materials for production DOMs
- Production Readiness Review

Milestones:

6/30/03	Complete test and calibration of Year 1 prototype DOMs

07/31/03	Instrumentation Design Review
08/31/03	Complete tests of engineering prototype DOMs
10/31/03	Complete 150 production cycle DOMs
11/30/03	Purchase Orders for production DOMs
1/31/04	Production Readiness Review
3/31/04	Start production of 500 DOMs

WBS 3.2 IceTop

The following major IceTop tasks will be performed during Project Year 2:

Two test tanks will be deployed at the South Pole during the 03/04 season. One tank will be instrumented with PMTs to assess signal quality and with thermal sensors to monitor environmental effects throughout the following winter. The other will be used to test deployment techniques and to determine the optimum freeze rate. In order to reduce the complexity and schedule risk of this effort, analog readout of the PMTs will be used.

Software that is unique to the IceTop DAQ and firmware that is unique to the IceTop DOM's will be developed. It is planned that IceTop can use the majority of InIce DAQ software and DOM firmware.

To prepare for tank deployment, studies of water quality and tank calibration will be made. Other preliminary studies, such as a small-scale freezing test at altitude, may be needed.

A "production and deployment readiness review" will be conducted in February 04. Operation of the tanks during 2004 is expected to provide useful experience in their operation, including offline cross-calibration with AMANDA and SPASE coincidences.

Full-scale simulations of air showers and of system response will be conducted. Response to horizontal as well as nearly vertical showers will be studied.

Deliverables:

- Two tanks with related hardware and cables.
- A working DAQ system for an IceTop station that allows study of coincidences between DOMs and recording of time-stamped events.
- DAQ and DOM software and firmware specific to IceTop
- A written report of the simulation studies that will include: a) refined estimates of trigger rates and coincidence rates, b) expectations for response of tanks to muons and to showers for comparison with data taken during 2004, c) assessment of IceTop as a veto shield for IceCube, and d) evaluation of sensitivity to primary composition.

Milestones:

[need list of milestones and dates]

WBS 3.3 Data Acquisition Hardware

Data Acquisition activities for Project Year 2 include both hardware and software tasks for the development, testing and production of the components and subsystems necessary to create InIce Strings and the software to read the data from the Strings.

The hardware tasks involve the completion of engineering development of the DOM Main Boards (DOMMB) and the DOM Hubs, fabrication and evaluation of engineering prototypes of the DOM MBs and DOM Hubs, production and testing of 150 DOM MBs and 9 DOM Hubs for production process development, and procurement of materials and long lead items for construction of 500 DOMs in Project Year 3.

As part of the integration of hardware and software, it will be necessary to verify proper system performance through testing and evaluation. This activity will be supported by physicists through the development of test procedures and analysis of the test results.

DOMMB production engineering will emphasize reliability in the selection of parts and the development of processes that will be used for fabrication of first deployed DOMMBs. Production engineering will also provide support for all of the production efforts.

The prototype DOMMBs, developed in Project Year 1, will be analyzed to determine how they may be simplified and improved prior to release for production.

In order to insure that the proper manufacturing, quality and testing processes are in place prior to committing to full scale production at three "factories" and that there are enough DOMs available to perform integration testing on at least two strings, a model production cycle will be instituted. These 150 pre-production DOMMBs will have the modifications based on test results of the prototype DOMMB included, as well as the production engineering improvements. In order to adequately test these DOMMBs, a Test Stand and Test Software will be developed.

Parts for the fabrication of 500 DOMMBs, adequate for the deployment of 7 Strings in Project Year 3, will be purchased after modifications from testing the 150 DOMMBs are incorporated into the design.

DOM Hub development will follow a similar path as the DOMMBs. Four engineering prototypes will be built that will be used to simplify the Project Year 1 prototypes and incorporate improvements to the original design. The engineering prototypes will form the basis of the production DOM Hubs. These DOM Hubs consist of Commercial Off the Shelf (COTS) rack-mounted PC's that are populated with custom PCI bus cards that communicate with the DOMs over a serial cable.

Following testing and evaluation of the four engineering prototypes, nine production DOM Hubs will be fabricated for support of the deployment of strings in FY04-FY05.

Deliverables:

- Engineering design package including parts list for DOMMB
- Four DOMMB Engineering prototypes
- 150 pre-production DOMMBs for model production cycle
- Four DOM Hub Engineering prototypes
- Nine DOM Hubs for first year deployment
- Test stands for production testing
- Materials for fabricating 500 production DOMMBs

Milestones:

9/31/03	Delivery of 150 pre-production DOMMBs
8/31/03	Test Stand
[?]	Purchase parts for 500 DOMMBs
7/15/03	Delivery of 4 Engineering prototype DOM Hubs
3/31/04	Delivery of 9 Production DOM Hubs

WBS 3.4 Data Acquisition Software

Data Acquisition activities for Project Year 2 include both hardware and software tasks for the development, testing and production of the components and subsystems necessary to create InIce Strings and the software to read the data from the Strings.

Software efforts are divided into two main areas, support for the DOM Main Board and DOM Hub hardware and development of DAQ system software. Software needed for hardware support includes adding necessary features to the DOM Main Board and DOM Hub plus enhancements to their existing applications and creating software for production testing of DOM Main Boards. DAQ system software includes development of String Processor, Trigger Processor, and Event Builder applications; integration and testing of the DAQ InIce software components; and integration and testing of the IceTop DAQ software with the InIce DAQ software.

In order to support the production testing of DOMMBs, software will be developed that will facilitate testing. This software will build on the Simple Test Framework (STF) that was developed in Project Year 1. The STF software allows for standalone and integrated DOMMB subsystem tests with the results being stored in an IceCube Instrumentation database. This database will retain information about the Instrumentation components and assemblies so that information and characteristics about individual components can be retained for future analysis and also for IceCube system initialization and calibration. Detailed test procedures will be documented and converted into software test procedures that are resident in the DOM STF software and in the client host software.

DOMMB software will implement new features required for data compression software, integrate the flasher board operations with DOM data taking application, and update the DOM MB hardware access library as testing dictates.

DOM Hub software improvements will be provided as required for both the PCI driver and DOM Hub readout software. Software capable of providing configuration information about the DOM Hub and its attached DOMs will be created

The initial version of the DAQ configuration test program will be designed and implemented so that the current configuration of the DAQ can be determined and the performance of DAQ processor platforms and the networks can be evaluated. Knowing the exact hardware and software configurations of the DAQ components is important because of the distributed architecture of the DAQ.

The design and initial implementation of the string processor, trigger and event builder for the first deployment will be completed. It will also be necessary to design and implement the first version of the DAQ control program. The DAQ control program is required to provide a mechanism to monitor and control the operation of the DAQ and the associated strings and DOMs.

IceTop will require some unique DAQ software to take into account the different requirements of the IceTop detector array. When these programs are completed, it will be necessary to integrate the IceTop DOMs into existing DOM Hub and string processor portions of DAQ system and verify their proper operation.

Deliverables:

- Additional DOM resident STF software and Java client programs for test host.
- Documentation describing detailed operations of additional STF tests and results.
- Revised versions of DOM MB application and updated documentation.
- Revised versions of DOM Hub Java application, Linux DOM Readout (DoR) card driver and accompanying documentation.
- Additional implementation documentation added to appropriate DOM Hub design document.
- Design documentation and stand alone Java test suite.
- First release IceCube string processor program, control program, trigger program, and event builder program.
- Additional implementation documentation added to appropriate DAQ component design documents.
- Modified DOM Hub and string processor programs.
- Additional implementation documentation added to appropriate DAQ component design documents.

Milestones:

7/31/03	Design documentation and stand alone Java test suite software.
8/31/03	Additional STF code and Java client software for DOM testing.
8/31/03	Revised versions of DOM MB application and updated documentation.
9/30/03	Revised versions of DOM Hub software
3/31/04	First release of IceCube DAQ string processor program, control program, trigger program, and event builder program.

WBS 4.0 Data Systems

WBS 4.1 Data Handling

The emphasis of the Data Handling activities for Project Year 2 will be establishing requirements and baseline capabilities for all aspects of archiving and transferring data from the South Pole to the Northern Hemisphere and storing it in a data warehouse. Candidate hardware for installation at the South Pole will be procured and tested at the South Pole. Initial versions of software for storing, transferring, and satellite transmission of data will be developed.

The following Data Handling tasks will be done during Project Year 2:

In order to support the testing and characterization of PMT and DOMs, a Test Data database will be created and made available in April 2003.

SuperNova detection requires that IceCube have 24/7 communications from the South Pole to be able to participate in the SNEWS network. A connection will be established using the Iridium satellite system. Testing will include gathering data for statistical analysis of the link. After successful testing, the Iridium link will be made available to the IceCube collaboration.

Software will be developed so that simulation and test data can be stored and retrieved by physicists. This will include the development and testing of Data Management software capable of using metadata for easier searching and retrieval.

An initial evaluation version of the computer hardware and network equipment to be used for South Pole data handling will be designed and purchased. Following testing in the Northern Hemisphere, this equipment will be made ready for shipping to the South Pole in September 2003. After installation in December 2003, further testing and evaluation will be performed in this environment to insure proper operation before final purchases are made for the IceCube computer and network system components.

The first release of software for movement, archiving and satellite transfer of data at the South Pole will be designed, implemented, and tested.

Deliverables:

- Iridium 24/7 network connection to South Pole.
- Data Management, and Metadata software for simulation, and test data.
- Design and procure South Pole data handling test equipment for 2004 winter.
- Version of software ready for system integration of South Pole data
- movement, archiving, and satellite transfer programs.

Milestones:

6/30/03	Iridium network connection available
8/31/03	Data Management software Version 1 release
12/31/03	Data Handling Test Equipment installation at South Pole
03/31/04	Data movement, archiving, and satellite transfer Version 1 release

WBS 4.2 Data Filtering and Software

The development of software that will be used as a framework to house and control online filtering reconstruction algorithms at the South Pole, for online filtering and reconstruction at the South Pole, processing and analysis in the Northern Hemisphere, storage of configuration data in a database, and the visualization tools used to display results will begin in Project Year 2. This software forms the basic infrastructure for the algorithms that will be developed and used by all IceCube physicists. The objective of this year's effort is to create the first release of this software. Additional features will be added in future releases.

Prototype South Pole online processing control software will be designed, implemented, and tested for the purpose of processing IceCube event data. Events will be received from the DAQ Event Builder, reconstructed and otherwise processed, written to disk, and delivered to Data Handling for archiving. The main tasks for Project Year 2 are to define the interfaces with: 1) the DAQ data builder, 2) DAQ slow control software, 3) Event reconstruction and processing software, 4) Database, 5) IceCube data format, and 6) the IceCube data handling system. An event processing test stand will be built that simulates data flow from DAQ to Archiving so that testing and evaluation can be performed.

Prototype Production processing control software will be designed, implemented, and tested. Although similar to the Online Processing Control Software this control software will be developed with greater versatility so that different methods can be evaluated and used in processing of IceCube data offline in the Northern Hemisphere.

A prototype Configuration Database will be designed and implemented for tracking critical "non-data" based information about the IceCube detector.

Visualization Tools will be required for displaying IceCube events and analysis results. Existing commercially available and other High Energy Physics graphics display

packages will be investigated and evaluated for suitability for use with IceCube data. After identifying the advantages and disadvantages of each package, a display package will be selected. A prototype event visualization tool for use with simulated data will be designed and developed.

An important aspect of software development and maintenance for IceCube involves Software Management. Continuing the effort began in Project Year 1 on the Software Development Environment, a framework for architecture, design, testing and documentation will be provided for IceCube software. This framework will include system software revision control, update builds and distribution of software releases. As part of this effort, overall software design documents defining the general architecture, design, interfaces and documentation for IceCube software will be created and maintained. A Software Development Environment will be maintained that provides software releases and development tools for software production.

Deliverables:

- Data Pipeline design document
- Prototype online data pipeline and filtering control system
- Prototype data processing control tools
- Configuration database design document
- Prototype database with tools
- Prototype visualization software
- Updated Software system design description document
- Software development and release system

Milestones:

10/31/03	Data Pipeline design document
3/31/04	Prototype online data pipeline and filtering control software
3/31/04	Prototype data processing control tools
3/31/04	Prototype visualization software
3/31/04	Prototype configuration database
5/31/03	Updated Software system design description document

WBS 4.3 Simulation

In the near term, IceCube simulation activities will employ the software that has been developed for AMANDA to simulate certain aspects of IceCube. In parallel, IceCube specific simulations will be developed to more closely represent IceCube physics. In order to conduct these numerous activities in parallel, a large number of collaboration members from Europe and the US will be involved.

AMANDA simulation software can provide an initial implementation of the following processes : 1) response to downgoing atmospheric Muons, 2) response to atmospheric neutrinos, 3) response to diffuse neutrinos sources, 4) response to neutrino point sources,

and 5) response to GRBs. In adapting this code for use in IceCube, the first step will be to coordinate with the AMANDA developers to make sure the capabilities of the AMANDA simulations are discussed and understood.

In addition, the following extensions will be made to existing AMANDA simulation software: 1) Photonics integration, 2) Nusim extension to UHE/EHE, 3) Electron-+Tau neutrino generator, 4) adding DOM emulation, and 5) Longitudinal secondary energy loss distribution. In order to take advantage of previous work, it will be necessary to carefully plan and coordinate activities among the participating collaborators prior to implementing the new extensions.

New IceCube simulation software will be developed to provide a better simulation of IceCube physics. Some of the new software simulations will include: 1) an Air shower generator and integration with Corsika, 2) Neutrino generator for all flavors, 3) Lepton propagation, and 4) a photon field and detector simulation. An overall simulation architecture will be developed and interfaces among the simulation components will be defined so that several participants can work in parallel on the different parts of the simulation system. Since the simulation system will also be a provider of events for IceCube analysis, it will be necessary to coordinate with the Production Processing software and the data warehouse software efforts.

Deliverables:

- IceCube simulations using AMANDA software
- IceCube extensions to AMANDA software
- New IceCube simulations

Milestones:

6/30/03	AMANDA software setup for IceCube simulation
12/31/03	Release 1 of IceCube Extensions to AMANDA simulation software
3/31/04	Release 1 of new IceCube simulation software

WBS 5.0 Detector Commissioning and Verification

WBS Element 5.1: Detector Verification and Physics Benchmarks

The primary effort in Detector Verification and Physics benchmarks during Project Year 2 will be the planning involved for evaluation of the IceCube detector in Project Year 4 and beyond. This data verification plan will include:

Description of use of Monte Carlo to verify data integrity and establish physics benchmarks,
Description of use of data itself for same,
Definition of responsibilities of Working Groups (WGs)

Analysis topics WGs
Underlying theory WG,
Definition of role of Verification Coordinator (VC) (as distinct from L3 lead),
Description of procedure for selecting VC and WG leads,
Plan for "data challenge" for shakedown of full verification chain, and
Initial assignment of WG leads.

Deliverables:

- Draft Data Verification Plan
- Collaboration approved Data Verification Plan

Milestones:

10/31/03	Final Data Verification Plan
11/30/03	Collaboration approved Data Verification Plan

WBS Element 5.2: Reconstruction

Reconstruction activities consist of two physically divided but related tasks, online filtering at the South Pole and a more computationally intense reconstruction in the Northern Hemisphere. Tasks associated with the online reconstruction filter include:

- List of physics and computational requirements for online filter
- Definition of online filter interfaces to DAQ and Data Handling
- Testing plan for online filter
- Initial design of online filter

Similar tasks are associated with the Level 2 reconstruction filter in the Northern Hemisphere. These include:

- List of physics and computational requirements for Level 2 (a.k.a. Northern Hemisphere) filter
- Definition of Level 2 filter interfaces to Data Handling and Data Warehouse
- Testing plan for Level 2 filter

Deliverables:

- Online filter requirements document
- Online filter Interface Control Document (ICD)
- Test Plan for online filter
- Level 2 filter requirements document
- Level 2 filter Interface Control Document (ICD)
- Test Plan for Level 2 filter

Milestones:

10/31/03	Online filter requirements document and ICD complete

1/31/04	Level 2 filter requirements document and ICD complete
9/31/03	Online filter test plan complete
3/31/04	Level 2 filter test plan complete

WBS Element 5.3: Detector Characterization

There are five major tasks associated with Detector Characterization in Project Year 2: 1) creation of a plan for calibration, 2) definition of the calibration database, 3) development of low-level algorithms, 4) creation of a monitoring interface for the TestDAQ, and 5) creation of a method for monitoring detector performance and data quality. These tasks are described below.

The first task is to create a plan for calibrating the detector. This plan will include a) discussion of the use of various possible calibration sources, such as in-situ light sources, surface light sources, InIce/IceTop coincidences, and downward-going muons, and b) the various quantities which require calibration, from low-level quantities such as PMT gain to high-level quantities such as energy and pointing resolution. The plan will incoporate knowledge of possible constraints on parameters such as data rates imposed on calibration by DOM hardware, DOM Hub, and DAQ.

The second task is to define the contents of the calibration database.

The third task is to define, implement and test the lower-level calibration algorithms: Knowledge gained from AMANDA experience will be extrapolated to IceCube to produce a document providing a high-level description of lower-level calibration algorithms, e.g., for gain, geometry, timing, and ice properties. Next a more detailed description of it will be produced, followed by implementation and testing of these algorithms in software. Test results of lower-level calibration algorithms using some combinations of AMANDA data, simulated IceCube data, and IceCube test-stand data will be documented in a test report.

The fourth task is to create a Monitoring Interface for TestDAQ system that can be used to study the characteristics of the first pre-production DOMs. The TestDAQ is special test software used to collect data from DOMs through a DOM Hub without having the rest of the DAQ available. This simple monitoring package will provide a method view the test conditions and the long-term performance of DOMs.

The fifth task is to create a plan for monitoring detector performance and data quality. This plan will include the definition of interfaces to systems to be monitored, such as DAQ, online filter, etc.).

Deliverables:

- Calibration plan
- Calibration database data dictionary
- High-level description of lower-level calibration algorithms
- Detailed description of lower-level calibration algorithms
- Lower level calibration algorithms

- Documented results of tests of lower-level calibration algorithms using some combinations of AMANDA data, simulated IceCube data, and IceCube test-stand data
- TestDAQ monitor software
- Data Quality plan

Milestones:

8/31/03	Calibration plan complete
3/31/04	Tested lower level calibration algorithms
4/30/03	TestDAQ monitor software available
3/31/04	Data Quality plan approved by Technical Board

WBS Element 5.4: AMANDA/IceCube Integration

Project Year 2 will be used to develop a plan for the integration of AMANDA into the IceCube system. This plan will include: AMANDA/IceCube coincidence triggering, AMANDA/IceCube analysis software interfaces, AMANDA/IceCube simulation software interfaces, a maintenance plan for AMANDA hardware, and a proposal for availability of data for AMANDA and IceCube to members of each collaboration.

Deliverables:

- Draft integration plan
- Final integration plan
- Collaboration approved integration plan

Milestones:

9/30/03	Draft integration plan
11/30/03	Final integration plan
1/31/04	Collaboration approved integration plan

IceCube Project Year 2 U.S. Collaboration Budget

Budget description goes here

Budget Detail

Labor: FY03 labor rates were used to calculate the labor estimates. The collaboration institutions set the labor rates used in the estimation of the activities at their institution. The monthly basis is 150 hours or 1800 per year.

Materials & Supplies: The estimate includes materials and supplies necessary to support office activities, engineering design, and system fabrication and testing. It includes purchases of less than $5,000.

Travel: Travel expenses are estimated to support collaboration participation at design, internal, yearly, and external advisory committee reviews. In addition, travel expenses are estimated for project management, finance and subcontract management, quality assurance, and systems engineering**.**

While the collaboration is located throughout the U.S. and Europe, to simplify the estimating process, the travel is modeled to occur between Berlin, Germany; Brussels, Belgium; Madison, WI; San Francisco, CA; Stockholm, Sweden; and Washington D.C. Each cost element is estimated as follows:

Airfare***:*** The airfare rates are based on non-refundable coach seats purchased at least 4 weeks in advance of the anticipated travel dates. The fare used is an average of rates for flights on various airlines with multiple arrival and departure times.

Lodging: The lodging rates are based on the University of Wisconsin System maximums for the given locations. To assure that guideline rates are reasonable they were compared against two hotels at each location.

Vehicle Rental: The domestic car rental rates are based on the University of Wisconsin System vendor contracts. The contracts stipulate percent discounts on foreign car rental. Car rental rates were obtained at each foreign location and the discount applied to arrive at a rental rate.

Per Diem: The per diem rates are based on the University of Wisconsin System rate for each location.

Capital Equipment: Capital equipment includes any purchase in excess of $5,000.

Subcontracts: The estimate includes funding any activity that a given collaboration institute is responsible for completing and hires a group outside their institute to aid in or complete the task.

Overhead: The institution that is responsible for a labor expense, the purchase of material & supplies, or travel sets the applied overhead rate. Overhead is applied to labor, materials & supplies, travel, and the first $25,000 of subcontract expense. Rarely is it applied to capital equipment, and then at a very reduced rate.

Budget table showing budget versus Level 3 WBS goes here

Budget table showing budget versus Collaboration members goes here