IceCube Maintenance & Operations
Fiscal Year 2013 Mid-Year Report

October 1, 2012 - March 31, 2013

Submittal Date: March 29, 2013

University of Wisconsin–Madison

This report is submitted in accordance with the reporting requirements set forth in the IceCube Maintenance and Operations Cooperative Agreement, ANT-0937462.

Foreword

This FY2013 Mid-Year Report is submitted as required by the NSF Cooperative Agreement ANT-0937462. This report covers the six-month period beginning October 1, 2012 and concluding March 31, 2013. The status information provided in the report covers actual common fund contributions received through March 31, 2013 and the full 86-string IceCube detector (IC86) performance through March 1, 2013.

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Section I – Maintenance and Operations Status and Performance

Program Management

Management & Administration – The primary management and administration effort is to ensure that tasks are properly defined and assigned and that the resources needed to perform each task are available when needed. Efforts include monitoring resource use and adjusting plans as needed to achieve IceCube's scientific objectives.

- Operations Management and Science Support: The detailed M&O institutional responsibilities and Ph.D. authors head count were revised as part of the institutional Memorandum of Understanding (MoU) Scope of Work (SOW) planning. The MoU-SOW documents were revised in September 2012 for the Fall collaboration meeting in Aachen, Germany. Updates and changes to the personnel plan are made in consultation with the Operations Director and Associate Director for Science & Instrumentation, Collaboration Spokesperson, and the leads at the collaborating institutions to ensure coverage on all critical M&O tasks.
- Computing Infrastructure Management: IceCube continues to manage computing resources to maximize uptime of all computing services and ensure the availability of required distributed services, including storage, processing, database, grid, networking, interactive user access, user support, and quota management.
- Financial Management: NSF released a total of $6,900,000 to UW–Madison to support M&O expenses during FY2013, including a total contribution of $914,550 to the U.S. Common Fund. A total amount of $1,132,022 was committed to the seven U.S. subawardee institutions (details in Section III). Supplemental IceCube M&O Cyberinfrastructure proposal in the amount of $193,749 was approved and awarded in FY2013.

Engineering, Science & Technical Support – Ongoing support for the IceCube detector continues with the maintenance and operation of the SPS, the SPTS, and the Cable Test System. The latter two systems are located at the University of Wisconsin–Madison and enable the development of new detector functionality as well as investigations into various operational issues such as communication disruptions and electromagnetic interference. Technical support provides for coordination, communication, and assessment of impacts of activities carried out by external groups engaged in experiments or potential experiments at the South Pole.

Software Coordination **–** A review panel for permanent code was assembled for the IceTray-based software projects and to address the long-term operational implications of recommendations from the Internal Detector Subsystem Reviews of the online software systems. The permanent code reviewers are working to unify the coding standards and apply these standards in a thorough and timely manner. The internal reviews of the online systems mark an important transition from a development mode into steady-state maintenance and operations. The reviews highlight the many areas of success as well as identify areas in need of additional coordination and improvement.

Work continues on the core analysis and simulation software to rewrite certain legacy projects and improve documentation and unit test coverage. The event handling in IceTray has been successfully modified to solve two related problems: 1) the increasing complexity of the triggered events due to the size of the detector and the sophistication of the online triggers, and 2) the increasing event size due to different optimizations of the hit selections used in different analyses.

Education & Outreach (E&O) – IceCube collaborators continue to engage national and international audiences through a multitude of venues and activities. We provide noteworthy examples below followed by exciting aspects of the growing IceCube E&O program made possible with the development of new activities and partnerships.

Public engagement:
To celebrate innovative science conducted in the state of Wisconsin, IceCube participated in the second annual Wisconsin Science Festival. This multisite event included partners across the state and attracted 18,000 visitors statewide, with several thousand visitors per day at the headquarter location, the Wisconsin Institutes for Discovery, in Madison.

IceCube contributed an eight-foot model showing the scope and scale of the neutrino observatory. The model, which replays data from the South Pole, gave participants a chance to visualize the unseen while learning more about neutrino astronomy. Additional hands-on activities prompted conversations with researchers and technical staff about the construction and operations of IceCube in one of the most remote and extreme environments on Earth.

Live connections with scientists and specialists at the South Pole Amundsen-Scott Station were offered five times during the 2012-13 austral summer. Several hundred participants from K-12 and post-secondary schools along with interested members of the public from 13 states and three countries connected for our first season of open webcasts. South Pole science, daily life, travel, and weather were covered in these webcasts. PolarTREC teacher Liz Ratliff assisted with promotion and presentation, and participated in these events. Ratliff was at the South Pole for about three weeks in December 2012.

The sixth annual UW–Madison Physics Fair provided an opportunity for community members to take lab tours, participate in hands-on demonstrations, and have informal conversations with scientists. IceCube graduate students, postdocs, and staff presented a neutrino event classification quiz for the first time this year. Posters and staff supplied background information about types of neutrino events. Plans are underway to expand the neutrino classification quiz for general use on the IceCube website.

Additional E&O activities:

- Hosted 35 students in the Expanding Your Horizons program. This program encourages girls to pursue STEM careers by exposing them to role models and hands-on activities. Students learned about IceCube science and were introduced to basic computer control of devices through an LED programming activity.
- Presentation and participation at statewide science teacher conferences: Wisconsin Association of Physics Teachers and Wisconsin Society of Science Teachers.

- Brown bag particle physics presentations. Local, internal engagement for students and staff about particle physics research conducted at the Wisconsin IceCube Particle Astrophysics Center.
- Regular small-scale presentations and interviews at schools, rotary clubs, civic groups, alumni associations, and planetarium societies around the U.S. and Europe.

Ongoing projects and partnerships:
IceCube E&O staff continue to build partnerships that will help bring neutrino science to new audiences and engage people in different ways.

New partnerships with the Milwaukee Public Museum and the Bell Museum in Minneapolis have allowed IceCube to tap into another medium for science E&O, the digital dome. The University of Wisconsin at River Falls has upgraded its planetarium with a digital projector, allowing the system to move beyond solely viewing the night sky to enable better visualization of scientific data. Plans are underway to expand the network across the state of Wisconsin, which will allow IceCube to efficiently present scientific data to colleagues and the general public.

The Milwaukee Public Museum is working with IceCube E&O personnel to create a high-quality fulldome video show explaining the construction, operation, and science of the IceCube Neutrino Observatory. The project has the potential to impact hundreds of thousands of people with the extensive planetarium network available for distribution. IceCube personnel used a special camera at the South Pole during the 2012-13 season to shoot video for the show. To build anticipation and excitement for the premiere of the planetarium show, events are being held with the Milwaukee Public Museum this spring and summer. The premiere is scheduled for fall 2013.

A grant from the Ira and Ineva Reilly Baldwin Wisconsin Idea Endowment, received June 2012, has allowed the Wisconsin IceCube Particle Astrophysics Center (WIPAC) the opportunity to share science with the state of Wisconsin. The project, called “Bringing the Universe to Wisconsin,” brings WIPAC personnel to each of the two- and four-year University of Wisconsin system campuses and communities. This partnership allows communities access to researchers, engineers, and computer technicians that have worked on major astrophysics projects—IceCube, the Askaryan Radio Array (ARA), and DM-Ice. Showcasing the Wisconsin connections that have made these projects possible, along with funding from the NSF, has the potential to excite and attract thousands of attendees to these events in two years. Six events have been successfully completed with six additional events scheduled this spring.

IceTop data was presented in a sound-light installation at the Nuit Blanche festival through a partnership with Slap!HQ (http://www.slaphq.com/). There were 350,000 visitors in attendance at the one-night art festival in Toronto. Partners Mark-David Hosale and Jean Michel Crettaz are planning a new installation for the IceCube Collaboration meeting in Madison in May 2013. IceCube looks forward to a continued partnership with Hosale and Crettaz, with the possibility for an installation in association with the fall IceCube Collaboration meeting in Munich in October 2013.

Student experiences:
IceCube is dedicated to providing research experiences for undergraduates, K-12 teachers, and two- and four-year university faculty. Each year, IceCube scientists at UW–Madison sponsor two REU (Research Experience for Undergraduates) students and fund 10 to 15 undergraduate students; additionally, several IceCube Collaboration institutions provide similar research opportunities for undergraduates. Students collaborate on a variety of IceCube research projects, including data analysis, information technology, communications, and outreach. Personnel are currently preparing for summer student experiences like REU, Information Technology Academy (ITA), and Upward Bound. ITA is a four-year, precollege program that provides technology access and training for minority youth. Upward Bound provides support to economically disadvantaged youth to encourage them to their pursue higher education through summer enrichment courses and other activities throughout the year.

IceCube is excited to offer a new internship program for high-school students in the Madison, WI area. Interns participate in real-world science: learning how to write computer programs, contributing to data processing, and forming relationships with professionals in astrophysics. The inaugural class of interns includes seven students from Madison West High School and one student from Mount Horeb High School who serves as the student internship coordinator. Weekly meetings began in February and run through May.

Partnering with the NSF's PolarTREC program, IceCube will send middle school teacher Obed Fulcar to the South Pole for the 2013-14 summer season. Fulcar teaches at MS319 Maria Teresa Mirabal Middle School of Math, Science and Technology in Washington Heights, NY. In addition to interacting with his students and professional network, Fulcar has the potential to reach thousands of other students and hundreds of other teachers through his blog posts and webcasts. Former PolarTREC teachers continue to participate in the UW-River Falls Upward Bound program providing math and science content based on IceCube research.

Detector Operations and Maintenance

Detector Performance – During the period from September 1, 2012 to March 1, 2013, the full 86-string detector configuration (IC86) operated in standard physics mode 96.2% of the time. Figure 1 shows the cumulative detector time usage over the reporting period. Detector maintenance, commissioning, and verification required 1.5% of detector time. Careful planning of the hardware upgrades during the polar season limited the partial configuration uptime to 1.9% of the total. The unexpected downtime due to failures of 0.4% is comparable to previous periods and reflects the stability of the detector operation.

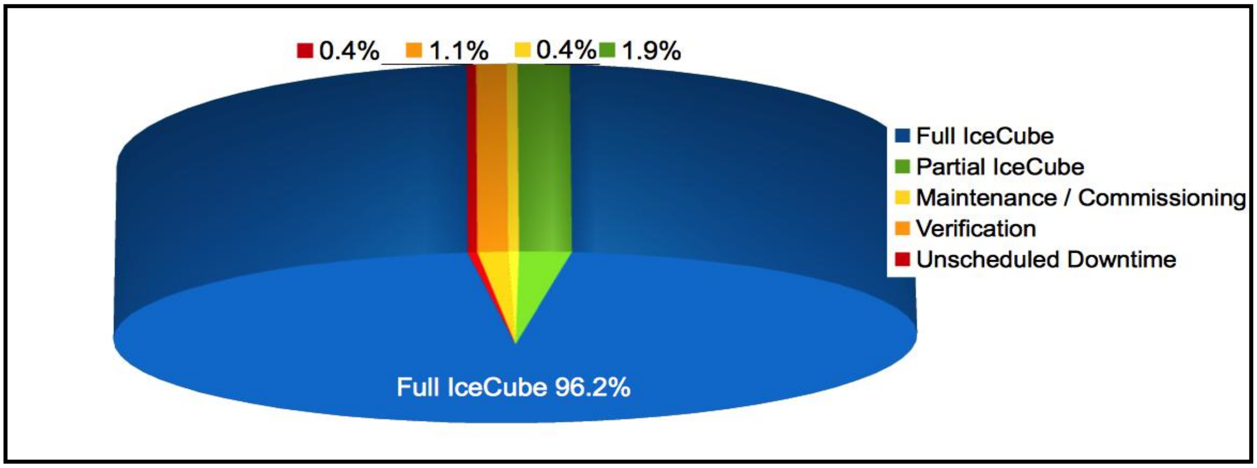

Figure 1: Cumulative IceCube Detector Time Usage, September 1, 2012 – March 1, 2013

Over the reporting period, an average detector uptime of 98.85% was achieved, comparable with previous years, as shown in Figure 2. Of the total uptime, 91.84% was clean, full-detector uptime ready for standard analysis.

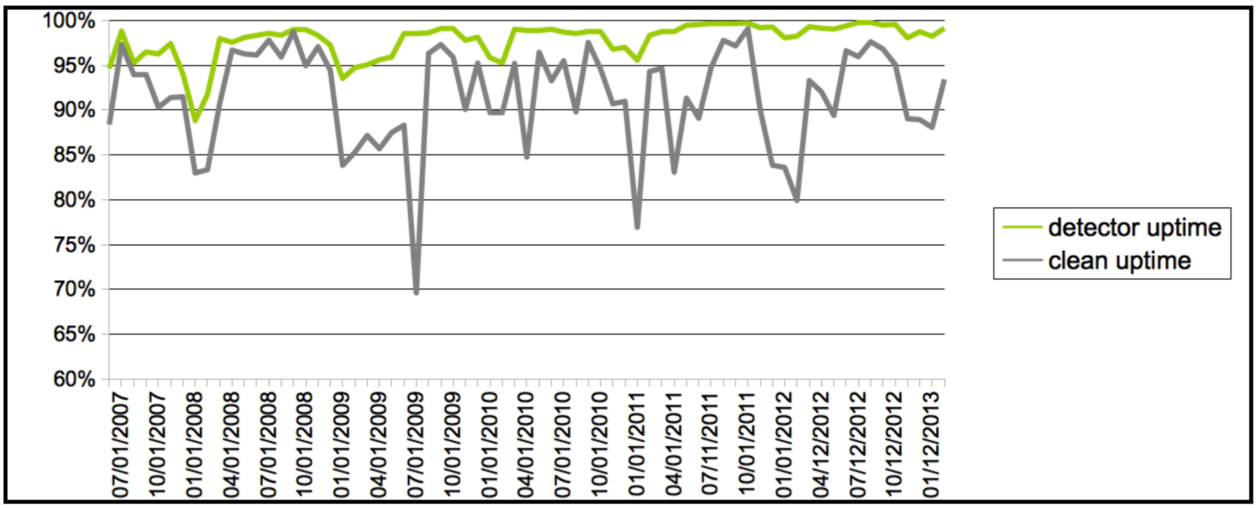

Figure 2: Total IceCube Detector Uptime and Clean Uptime

About 5.0% of the loss in clean uptime is due to runs that fail, from intermittent power, network, software, or hardware instabilities. The implementation of the good run list, which tracks runs good for further offline processing, is improving in several ways in order to address this; in particular, we are now implementing the ability to track portions of runs as good, allowing the recovery of data from all but the last few minutes of multi-hour runs that fail. Additionally, the data quality criteria of the good run list are now integrated into the experiment control system, IceCube Live, and good/bad decisions for each run are easily visible to the collaboration.

The IceCube Run Monitoring system, I3Moni, provides a comprehensive set of tools for assessing and reporting data quality. IceCube collaborators participate in performing daily monitoring shift duties by reviewing information presented on the web pages and evaluating and reporting the data quality for each run. The original monolithic monitoring system processes data from various SPS subsystems, packages them together in ROOT files for transfer to the Northern Hemisphere, and re-processes them in the north for displaying on the monitoring web pages. In a new monitoring system under development (I3Moni 2.0), all detector subsystems will report their data directly to IceCube Live via a ZeroMQ messaging system. Major advantages of this new approach include: higher quality of the monitoring alerts; simplicity and easier maintenance; flexibility, modularity, and scalability; faster data presentation to the end user; and a significant improvement in the overall longevity of the system implementation over the lifetime of the experiment.

During 2012, we have developed and documented in detail the I3Moni 2.0 system requirements, identified disposition of the monitoring quantities, designed standard tests to be run on the data, specified the data flow for an example of monitoring quantity, and developed an implementation schedule and plan. In February 2013, during a weeklong workshop at the University of Alabama, prototypes of all software components were assembled, and the first end-to-end test of monitoring quantities was realized on a test setup. The full implementation is planned for the end of 2013.

IceCube Live v2.1 was released on schedule in December 2012 and installed in early January 2013. This release allows for deadtime-free run transitions (when also deployed in DAQ) as well as automated failover to reduced configurations in case of localized hardware failures. This release also provides an upgraded interface to the winterover paging system, allowing operators with privileges in the north to page winterovers in case of an urgent situation not caught by any of the automated monitoring systems. IceCube Live v2.1 also provides multiple views into the entire set of deployed DOMs, along with more detailed and accurate dropped-DOM information from the DAQ.

In support of the expanded operations-wide upgrades for I3Moni 2.0, a second, highly scalable (NoSQL) database has been added to the SPTS and production web servers in the north. I3Live v2.2, scheduled for release in mid-2013, will begin making use of the new database as the number and complexity of captured quantities increases. A JavaScript library ("i3d3") that allows for more full-featured displays of this information is also in progress. The other major deliverable for this release will be the ability to automatically generate, capture, and display time-dependent lists of runs suitable for further processing and analysis. As part of this work, the ability to set ranges of "good" times for runs which would otherwise have to be rejected for analysis has been added.

The IceCube Data Acquisition system (DAQ) added new features and fixed issues in the “Ale Asylum” and upcoming “Capital” releases, with test runs at SPS of a Capital release candidate starting in October 2012. A principal feature of this release is the support for stopless runs, which allows fast run switching and a reduction of deadtime of about 5 minutes/day from the run transitions every 8 hours. SPS testing of the Capital release, however, exhibited intermittent bottlenecks in the DAQ trigger system, and the release has been delayed until mid-2013.

The IceCube trigger system has long been considered one of the more fragile systems within the IceCube DAQ: it is at this juncture where data from all channels currently under control of the acquisition system must arrive bounded in time and where trigger decisions, the latencies of which are also bounded in time, must be rendered and passed onto the event assembly stage. The trigger system currently implemented uses a single thread of execution to contain all of the trigger algorithms that are run on the data stream. While this model was adequate for the initial IceCube DAQ, which contained only three triggers, the current DAQ employs a dozen separate trigger algorithms. To increase robustness and to better fit the highly parallel computing architecture, the DAQ team has launched a major rewrite of the trigger code to split the execution of the multiple triggers across independent threads. The trigger system rewrite will be merged into the pending Capital release.

The single-board computer (SBC) in the IceCube DOMHubs was also previously identified as a bottleneck in DAQ processing. The CPU is eight years old and running very close to its limit, and software features must be added with great care in order to ensure that they do not overflow the computing budget. Several modern versions of the SBC were tested at SPTS in mid-2012, and ten DOMHubs at SPS were upgraded during the 2012/13 polar season with new Advantech D525 SBCs. Initial performance of the new hubs is excellent, and we plan to upgrade the remaining hubs during the 2013-14 season. Additionally, new SATA disks and high-efficiency ATX power supplies were installed into the 10 upgraded hubs. We continue research and development efforts in a new design of the hub architecture for increased rack density and ease of maintenance.

HitSpooling, a DAQ feature under development since 2011, extends the data collection buffers of the IceCube DOMHubs from O(100) seconds to O(10000) seconds. It uses the DOMHub readout computers' hard disk drives to store the raw data stream from each DOM channel. These streams are written to a set of files organized as a circular buffer at the rate of approximately 2 MB/sec per hub. The current size of the hub hard drives results in approximately 1.5 hr of buffer time.

The primary client for this data is the IceCube supernova online trigger (SNDAQ). The SNDAQ collects scalar counts from each channel and triggers on a statistic derived solely from the scalar data to detect the neutrino burst of a galactic core-collapse supernova. However, this trigger is formed several minutes after the DOM hit data has been collected and consequently the contents of the RAM buffers read out by the mainline DAQ trigger system have long been cleared to make room for new incoming data. The SNDAQ can now request data from the extended hitspool buffers and use this data to remove correlated noise from cosmic ray muons to improve trigger sensitivity, gain additional information on the supernova neutrino shockwave, and partially recover data from a very nearby supernova even in the case of a DAQ crash.

HitSpooling was activated at SPS on January 29, 2013. The infrastructure to handle requests to collect time intervals from the disk buffers is still undergoing development following several successful tests. It is expected that the entire system, including automated requests for data on high-significance SN triggers, will be available for the IC86-2013 run start in May.

The SNDAQ found that 97.8% of the available data from September 6, 2012 through March 11, 2013 met the minimum analysis criteria for run duration and data quality. The trigger downtime was 1.4 days (0.8% of the time interval) from physics runs under 10 minutes in duration. Supernova candidates in these short runs can be recovered offline should the need arise.

A new SNDAQ version ("Morion") was installed on January 24, 2013, and additional fixes improving the communication between the SNDAQ and I3Live were installed one month later. The improvements include the real-time transmission of process latency to I3Live; a backup ring buffer to store 24 hours of raw data files for data checks and transmission of raw data in case of a serious alert; a redesigned logging mechanism; and the identification and removal of three sources of occasional SNDAQ crashes. No SNDAQ crashes were recorded since the Morion release.

The online filtering system performs real-time reconstruction and selection of events collected by pDAQ and sends them for transmission north via the Data Movement system. Version V12-09-00 is currently deployed in support of the IC86-2012 physics run. Development work continues in support of I3Moni 2.0, with several data-quality monitoring values now available for direct reporting to the I3Live system. Future work in support of the online filtering system includes managing the transition to the IC86-2013 physics run in May, with targeted support for updated filter configurations from physics working groups and reduced downtime between DAQ runs. Additionally, work continues to further develop and deploy the I3Moni 2.0 system and plan for upgraded computing infrastructure to be deployed in the austral summer Pole season.

A weekly calibration call keeps collaborators abreast of issues in both in-ice and offline DOM calibration. A major new change in calibration is the refinement of the DOM voltage baseline calculation to eliminate occasional light contamination of the pedestal pattern and to avoid instability in recently rebooted DOMs. The updated code is part of DOM mainboard release 445 and was deployed in March 2013. Additionally, an effort is underway to refine the gain calibration using muon data, which is collected continuously throughout the year; initial results are expected in summer 2013. Online verification software is being merged into the upcoming I3Moni 2.0 framework. Flasher data continues to be analyzed to reduce ice model systematics, with a major recent focus on the hole-ice features and the effect of a scattering column within the hole ice.

A procedure for tracking IceTop snow depths between physical measurements was established last year and is working well. Snow depths are physically measured at the South Pole three times during each season, once soon after station opening, once after grooming, and once soon after station closing. The plan for snow management is reviewed with South Pole station management each season.

***IC86 Physics Run* –** The second season of the 86-string physics run, IC86-2012, began on May 15, 2012. Online improvements included the revised SlowParticle and new FixedRate triggers, the new SuperDST data compression format, and a simplified implementation for filters running on SPS. Preparations for the IC86-2013 physics run are being finalized, with updated filter settings, DOM calibrations, HitSpooling support, and re-commissioned DOMs. DAQ trigger settings are not changing from IC86-2012. As with last year, we are returning recommissioned DOMs to the array at a faster rate than problem DOMs are removed: 2 DOMs (0.04%) failed during IC86-2012, and at least 5 will be returned for IC86-2013.

TFT Board **–** The TFT board is in charge of adjudicating SPS resources according to scientific need, as well as assigning CPU and storage resources at UW for mass offline data processing (a.k.a. Level 2). Working groups within IceCube submitted approximately 20 proposals requesting data processing, satellite bandwidth and data storage, and the use of various IceCube triggers for IC86-2013. Sophisticated online filtering data selection techniques are used on SPS to preserve bandwidth for other science objectives. Over the past two years, new data compression algorithms (SuperDST) have allowed IceCube to send a larger fraction of the triggered events over TDRSS than in previous seasons. The additional data enhances the science of IceCube in the study of cosmic ray anisotropy and the search for neutrino sources toward the Galactic Center.

The average TDRSS data transfer rate during IC86-2012 was 100 GB/day plus an additional 5 GB/day for use by the detector operations group. IceCube is a heavy user of the available bandwidth, and we will continue to moderate our usage without compromising the physics data. During austral summer 2012-2013, the bandwidth usage by IceCube exceeded its allocation by about 5 GB/day (about a 5% overuse). The data rate in IceCube is intrinsically variable with the seasons because the muon rate underground depends on the upper atmospheric temperature. The summer excess bandwidth usage was caused by an inaccurate estimate of the seasonal effects in the new SuperDST data format. NSF temporarily increased IceCube's allocation to 110 GB/day. Filter usage in IC86-2013 has been adjusted accordingly so that IceCube doesn't exceed its bandwidth allocation of 105 GB/day.

The TFT Board assumed responsibility for the offline Level 2 processing in May 2012. For IC86-2012, a speedup of about 6 months in the start of processing was achieved. For IC86-2013, the target is to run Level 2 processing only 2-4 weeks behind data-taking at South Pole. This will result in a speedup of up to a year in data processing, with significant gains passed on higher-level analyses.

SuperDARN **–** The SuperDARN radar at the South Pole went online in January 2013. SuperDARN coordinated its initial activities with IceCube personnel on station at the time and is providing time-stamped logs of its radio transmissions. Several analyses are underway searching for any radio-frequency interference in IceCube; no adverse effects have been observed so far.

Personnel **–** The detector operations manager, Denise Laitsch, retired in October 2012; this position was filled by the deputy operations manager, John Kelley.

Computing and Data Management

Computing Infrastructure **–** IceCube computing infrastructure and storage systems both at the Pole and in the north have performed well over the past year. An expansion of storage space for analysis data is in progress. This expansion will increase capacity by 135 TB, bringing total storage for analysis work to 270 TB. Another 300 TB of disk storage will be added in 2013 to accommodate incoming experimental data. The total disk storage maintained in IceCube's data warehouse is currently at the level of 2.5 PB (petabyte).

The 768-core extension to the cluster computing resources was completed on schedule in November of 2012. In October of 2012, the IceCube Collaboration approved the use of direct photon propagation for the mass production of simulation data. The direct propagation method requires the use of GPGPU hardware to deliver adequate performance. It is estimated that 300 GPUs will be needed to support science goals. A project is underway to deploy an additional 100 GPUs at UW–Madison. Together with the 48 GPUs previously deployed in the GZK-9000 cluster, this delivers half of the GPU capacity required. The other half of the needed GPU capacity will be provided by other institutions in the collaboration. This expansion will be completed by July 2013.

The planned upgrades to the South Pole system were successfully completed during the 2012/13 season. The existing Cisco switches were replaced with Cisco 3750-X switches. This upgrade not only increased redundancy by adding a second switch to each rack, but also upgraded the backbone to 10 GB/s capacity. In addition, a second UPS was added to each rack, adding redundancy to power distribution systems. Finally, numerous enhancements to monitoring systems were completed.

For the 2013/2014 austral summer, lifecycle upgrades of the Dell servers are planned. The current servers are in their third season of use. In addition, the remaining HP UPS systems will be replaced. A prototype system that will write data to disk instead of tape will be deployed in the 2013/14 season. This system will operate in parallel with the existing tape-based system. This will provide direct experience with the handling of disks and the procedures necessary to operate such a system. If the prototype is successful, the tape-based system will be retired in the 2014/2015 season.

The annual test of the fire suppression system in the ICL was completed without incident. Future tests will follow the protocol in which IceCube personnel are present in the ICL during this test to ensure that any outages or side effects of the test are detected and immediately remedied. At the request of ASC, the ambient temperature in the ICL machine room was raised five degrees. This is an effort to reduce power consumption by using the warmer exhaust air to preheat the incoming external air. So far, this change has had no negative impact on the detector support systems, but we continue to monitor this.

Data Movement **–** Data movement has performed nominally over the past six months. Figure 5 shows the daily satellite transfer rates in MB/day through March 2013. The IC86 filtered physics data, in orange, dominates the total bandwidth.

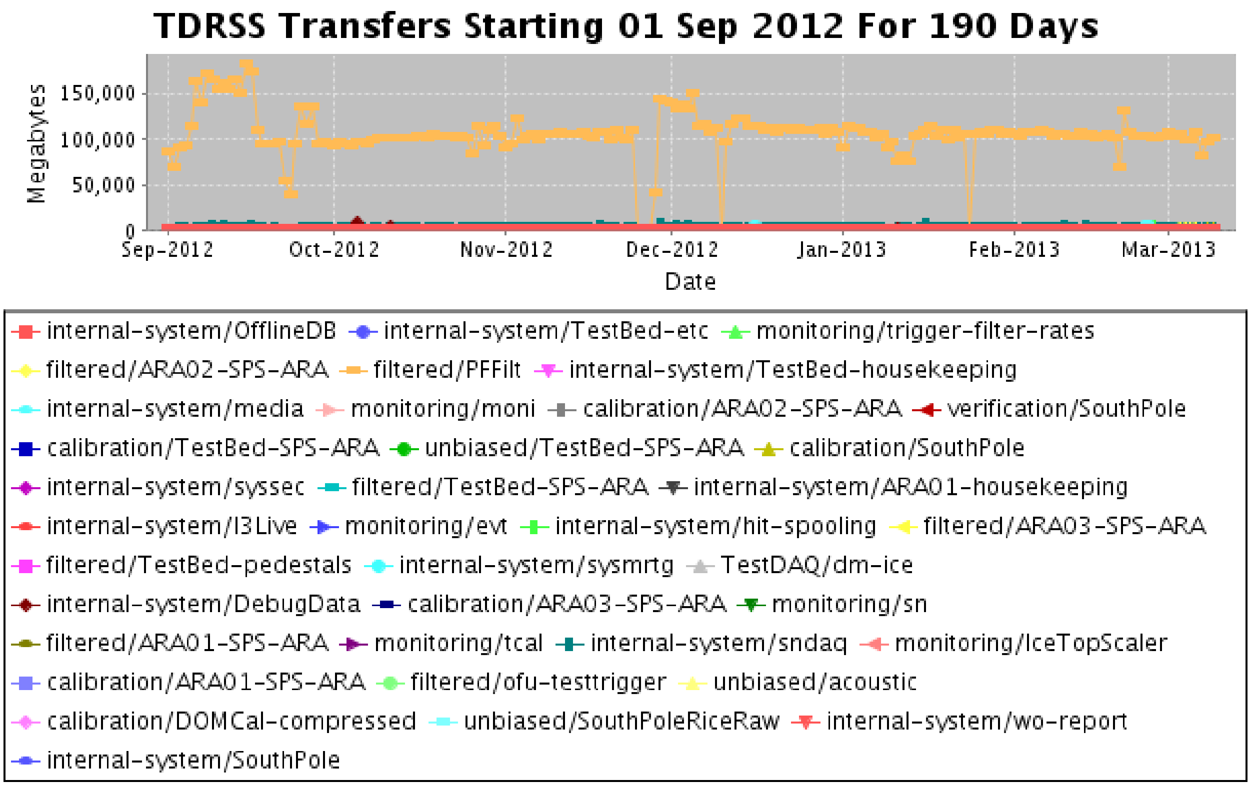

Figure 5: Daily TDRSS Data Transfer Rates

In August, a problem with a Ku-band waveguide at the Pole prevented all science data transfers. After replacement of the defective waveguide, a higher rate in September allowed transfer of the backlogged science data. In late November, network problems prevented science data transfers. After maintenance was performed on the network, a higher rate allowed transfer of the backlogged science data.

Data Archive – The IceCube raw data are archived on two sets of duplicate LTO4 data tapes. Data movement goals were met despite some outages for maintenance. A total of 159.5 TB of data were written to LTO tapes, averaging 859.6 GB/day. A total of 19.6 TB of data were sent over TDRSS, averaging 105.6 GB/day.

Due to the limited lifespan of and difficulty of data migration from the raw data tapes, alternate strategies for long-term data archiving are being explored. A promising approach is to compress the raw data using the new SuperDST format, allowing storage on disk. In this scenario, existing data from the full detector would be read from tapes and converted; later, an additional SuperDST-compressed data stream of all triggered data would be written at SPS for archiving.

Offline Data Filtering – The offline Level 2 filtering of IC86-2011, May 2011 through April 2012, is complete, and final validation has also been completed. Transfer of the IC86-2011 data to Deutsches Elektronen-Synchrotron (DESY) for backup and improved accessibility is proceeding smoothly. UW–Madison and DESY have worked out the few technical problems encountered during initial attempts, improving the efficiency of the data transfer.

Offline Level 2 processing of IC86-2012, data collected from May 2012 to April 2013, started in December 2012. The goal of bringing offline processing as close as possible to data collection has been achieved, with processing currently lagging data collection by a maximum of 2 weeks. A total of 120 TB of data storage and 950,000 CPU hours on the UW–Madison NPX4 computing cluster are the estimated requirement for the IC86-2012 processing.

Scripts for offline processing of IC86-2013 data have been written and are currently being tested. It is planned that the final version of the scripts will be ready by the scheduled transition to the IC86-2013 season in May 2013.

Simulation **–** The current production of IC86-2011 Monte Carlo began in mid-2012, and we are now in the process of incorporating IC86-2012 detector simulation into the current production. We have progressed toward having 100% of all simulations based on direct photon propagation using GPUs or a hybrid of GPU and spline-photonics for high-energy events. Production of IC79 Monte Carlo has concluded, with the exception of a few datasets needed for studies of systematic uncertainties. Producing simulations of direct photon propagation using GPUs began with a dedicated pool of computers built for this purpose in addition to the standard CPU-based production. The simulation production sites are: CHTC – UW campus (including GZK9000 GPU cluster); Dortmund; DESY-Zeuthen; University of Mainz; EGI – German grid; SWEGRID – Swedish grid; PSU – Pennsylvania State University; LONI – Louisiana Optical Network Infrastructure; GLOW – Grid Laboratory of Wisconsin; UMD – University of Maryland; IIHE – Brussels; UGent – Ghent; Ruhr-Uni – Bochum; UC Irvine; PDSF/Carver/Dirac – LBNL; and NPX3 – UW IceCube. There are plans to incorporate additional computing resources in Canada and to expand the pool of GPU resources at several computing centers.

Personnel **–** The search for the computing and data management position was successfully completed with the hire of Gonzalo Merino, who assumed these duties on March 1, 2013. A 1.0 FTE system administrator responsible for cluster computing was vacated, and a search is underway to fill this position.

Section II – Financial/Administrative Performance

The University of Wisconsin–Madison maintains three separate accounts with supporting charge numbers for collecting IceCube M&O funding and reporting related costs: 1) NSF M&O Core Account, 2) U.S. Common Funds Account, and 3) Non-U.S. Common Funds Account.

A total of $6,900,000 was released to UW–Madison to cover the costs of Maintenance and Operations in FY2013. Of this amount, funds totaling $914,550 were directed to the IceCube M&O U.S. Common Fund account and the remaining $5,985,450 were directed to the IceCube M&O Core account.

A total amount of $1,132,022 of the IceCube M&O FY2013 Core funds was committed to seven U.S. subawardee institutions. Figure 6 summarizes M&O responsibilities and funds for the subawardees. Subawardees submit invoices to receive reimbursement for their actual IceCube M&O costs. Deliverable commitments made by each subawardee institution are monitored throughout the year.

Institution	Major Responsibilities	Funds
Lawrence Berkeley National Laboratory	DAQ maintenance, computing infrastructure	$76,631
Pennsylvania State University	Computing and data management, simulation production	$37,029
University of California at Berkeley	Detector calibration, monitoring coordination	$137,300
University of Delaware, Bartol Institute	IceTop calibration, monitoring and maintenance	$195,242
University of Maryland at College Park	IceTray software framework, online filter, simulation software	$578,030
University of Alabama at Tuscaloosa	Detector calibration, reconstruction and analysis tools	$50,000
Georgia Institute of Technology	TFT coordination	$57,791
Total		**$1,132,022**

Figure 6: IceCube M&O Subawardees - FY2013 Major Responsibilities and Funds

IceCube M&O Common Fund Contributions

The IceCube M&O Common Fund was established to enable collaborating institutions to contribute to the costs of maintaining the computing hardware and software required to manage experimental data prior to processing for analysis.

Each institution contributed to the Common Fund based on the total number of the institution's Ph.D. authors at the established rate of $13,650 per Ph.D. author. The collaboration updates the Ph.D. author count twice a year, before each collaboration meeting, in conjunction with the update to the IceCube Memorandum of Understanding for M&O.

The M&O activities identified as appropriate for support from the Common Fund are those core activities that are agreed to be of common necessity for reliable operation of the IceCube detector and computing infrastructure and are listed in the Maintenance & Operations Plan.

The final 2012-2013 non-U.S. contributions are underway, and it is anticipated that all of the planned contributions will be fulfilled.

IceCube NSF M&O Award Budget, Actual Cost and Forecast

The current IceCube NSF M&O 5-year award was established at the beginning of Federal Fiscal Year 2011, on October 1, 2010. The following table presents the financial status five months into FY2013, which is Year 3 of the award, and shows an estimated balance at the end of FY2013.

Total awarded funds to the University of Wisconsin (UW) for supporting FY2011-13 of IceCube M&O are $20,894K. Total actual cost as of February 28, 2013 is $14,897K; open commitments are $3,851K. The current remaining unobligated funds at UW are $2,145K. With a projection of $1,466K for the remaining expenses of the final seven months of FY2013, the estimated unspent funds at the end of FY2013 are $680K, which is 9.6% of the FY2013 budget (Figure 7).

(a)	(b)	(c)	(d)= a - b - c	(e)	(f) = d – e
FY2011-2013 Budget (October 2010-September 2013)	**Actual Cost To Date** through Feb. 28, 2013	**Open Commitments** Feb. 28, 2013	**Current Balance** Feb. 28, 2013	**FY2013 Remaining Expenses Forecast** March 2013-September 2013	**FY2013 Forecast Balance** Sept. 30, 2013
$20,894K	**$14,897K**	**$3,851K**	**$2,145K**	**$1,466K**	**$680K**

Figure 7: IceCube NSF M&O Award Budget, Actual Cost and Forecast

The current forecasted balance at the end of the third year of the 5-year M&O award (FY2013) is expected to be less than the 10% reporting threshold requirement in the M&O Cooperative Agreement.

Section III – Project Governance and Upcoming Events

The detailed M&O institutional responsibilities and Ph.D. authors head count are revised twice a year for the IceCube collaboration meetings as part of the institutional Memorandum of Understanding (MoU) documents. The MoU was last revised in September 2012 for the Fall collaboration meeting in Aachen, Germany and the next revision will be posted in April 2013 before the Spring collaboration meeting in Madison, WI.

IceCube Major Meetings and Events

IceCube Spring Collaboration Meeting – UW–Madison	May 7-11, 2013
IceCube Particle Astrophysics Symposium – UW–Madison	May 13-15, 2013
NSF M&O Review	May 15-17, 2013
IceCube Fall Collaboration Meeting – Munich, Germany	October 7-11, 2013

Acronym List

ARA	Askaryan Radio Array
DAQ	Data Acquisition System
DOM	Digital Optical Module
GPGPU	General purpose graphics processing unit
IceCube Live	The system that integrates control of all of the detector's critical subsystems; also "I3Live"
IceTray	IceCube core analysis software framework, part of the IceCube core software library
ICL	IceCube Laboratory (South Pole)
LED	Light-emitting Diode
MoU	Memorandum of Understanding between UW–Madison and all collaborating institutions
pDAQ	IceCube's Data Acquisition System
REU	Research Experience for Undergraduates
SNDAQ	Supernova Data Acquisition System
SPS	South Pole System
SPTS	South Pole Test System at UW–Madison
SuperDST	Super Data Storage and Transfer, a highly compressed IceCube data format
TDRSS	Tracking and Data Relay Satellite System, a network of communications satellites
TFT Board	Trigger Filter and Transmit Board
UPS	Uninterruptable Power Supply
WIPAC	Wisconsin IceCube Particle Astrophysics Center