IceCube Maintenance and Operations
Fiscal Year 2020 / 2021 PY5 Mid-Year Report

April 1, 2020 – September 30, 2020

Submittal Date: September 28, 2020

University of Wisconsin–Madison

This report is submitted in accordance with the reporting requirements set forth in the IceCube Maintenance and Operations Cooperative Agreement, PLR-1600823.

Foreword

This FY2020/2021 (PY5) Mid-Year Report is submitted as required by the NSF Cooperative Agreement PLR-1600823. This report covers the 6-month period beginning March 1, 2020 and concluding August 31, 2020. The status information provided in the report covers actual common fund contributions received through September 30, 2020 and the full 86-string IceCube detector (IC86) performance through August 31, 2020.

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Section I – Financial/Administrative Performance

The University of Wisconsin–Madison is maintaining 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 Fund account, and 3) Non-U.S. Common Fund account.

The first PY5 installment of $5,250,000 was released to UW–Madison to cover the costs of maintenance and operations during the first three quarters of PY5 (FY2020/FY2021): $798,525 was directed to the U.S. Common Fund account based on the number of U.S. Ph.D Authors in the last version of the institutional MoU's, and the remaining $4,451,475 was directed to the IceCube M&O Core account. The second PY5 installment of $1,750,000 is expected to be released to UW–Madison to cover the costs of maintenance and operations during the second half of PY5 (FY2021): $266,175 will be directed to the U.S. Common Fund account, and the remaining $1,483,825 will be directed to the IceCube M&O Core account (Table 1). An additional $291,712 FY2019 funding was awarded to support an IceCube M&O supplemental proposal to further develop talent for STEM research, increase diversity and inclusion in science and related fields, and connect research-based skills and technology to societal challenges.

PY5: FY2020 / FY2021	Funds Awarded to UW for Apr 1, 2020 – March 31, 2021	Funds to Be Awarded to UW for Apr 1, 2020 – March 31, 2021
IceCube M&O Core account	$4,451,475	$1,483,825
U.S. Common Fund account	$798,525	$266,175
TOTAL NSF Funds	**$5,250,000**	**$1,750,000**

Table 1: NSF IceCube M&O Funds – PY5 (FY2020 / FY2021)

Of the IceCube M&O PY5 Core funds, $1,017,057 were committed to the U.S. subawardee institutions based on their statement of work and budget plan. The institutions submit invoices to receive reimbursement against their actual IceCube M&O costs. Table 2 summarizes M&O responsibilities and total PY5 funds for the subawardee institutions.

Institution	Major Responsibilities	Funds
Lawrence Berkeley National Laboratory	DAQ maintenance, computing infrastructure	$88,311
Pennsylvania State University	Computing and data management, simulation production, DAQ maintenance	$72,987
University of Delaware, Bartol Institute	IceTop calibration, monitoring and maintenance	$193,967
University of Maryland at College Park	IceTray software framework, online filter, simulation software	$619,644
University of Alabama at Tuscaloosa	Detector calibration, reconstruction and analysis tools	$12,299
Michigan State University	Simulation software, simulation production	$29,849
South Dakota School of Mines and Technology (added in July 2017)	Simulation production and reconstruction	$00.00
Total		**$1,017,057**

Table 2: IceCube M&O Subawardee Institutions – PY5 (FY2020/2021) Major Responsibilities and Funding

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

The current IceCube NSF M&O 5-year award was established in the middle of Federal Fiscal Year 2016, on April 1, 2016. The following table presents the financial status five months into the Year 5 of the award, and shows an estimated balance at the end of PY5.

Total awarded funds to the University of Wisconsin (UW) for supporting IceCube M&O from the beginning of PY1 through the end of PY5 are $35,360K (including the supplemental funding of $67,999 in PY2 and $291,712 in PY3). Total actual cost as of August 31, 2020 is $30,862 and open commitments against purchase orders and subaward agreements are $621K. The current balance as of August 31, 2020 is $3,877K. With a projection of $3,853K for the remaining expenses during the last seven months of PY5, the estimated negative balance at the end of PY5 is $24K, which is 0.07% of the total PY1-PY5 budget (Table 3).

(a)	**(b)**	**(c)**	**(d)= a - b - c**	**(e)**	**(f) = d – e**
YEARS 1-5 Budget Apr.'16-Mar.'21	**Actual Cost To Date** through Aug. 31, 2020	**Open Commitments** on Aug. 31, 2020	**Current Balance** on Aug. 31, 2020	**Remaining Projected Expenses** through Mar. 2021	**End of PY5 Forecast Balance** on Mar. 31, 2021
$35,360K	**$30,862K**	**$621K**	**$3,877K**	**$3,853K**	**$24K**

Table 3: IceCube NSF M&O Award Budget, Actual Cost and Forecast

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 contributes 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.

Table 4 summarizes the planned and actual Common Fund contributions for the period of April 1, 2019–March 31, 2020, based on v26.0 of the IceCube Institutional Memorandum of Understanding, from May 2019.

	Ph.D. Authors	**Planned Contribution**	**Actual Received**
Total Common Funds	**151**	**$2,047,500**	**$1,876,611**
U.S. Contribution	78	$1,064,700	$1,064,700
Non-U.S. Contribution	73	$982,800	$811,911*

Table 4: Planned and Actual CF Contributions for the period of April 1, 2019–March 31, 2020

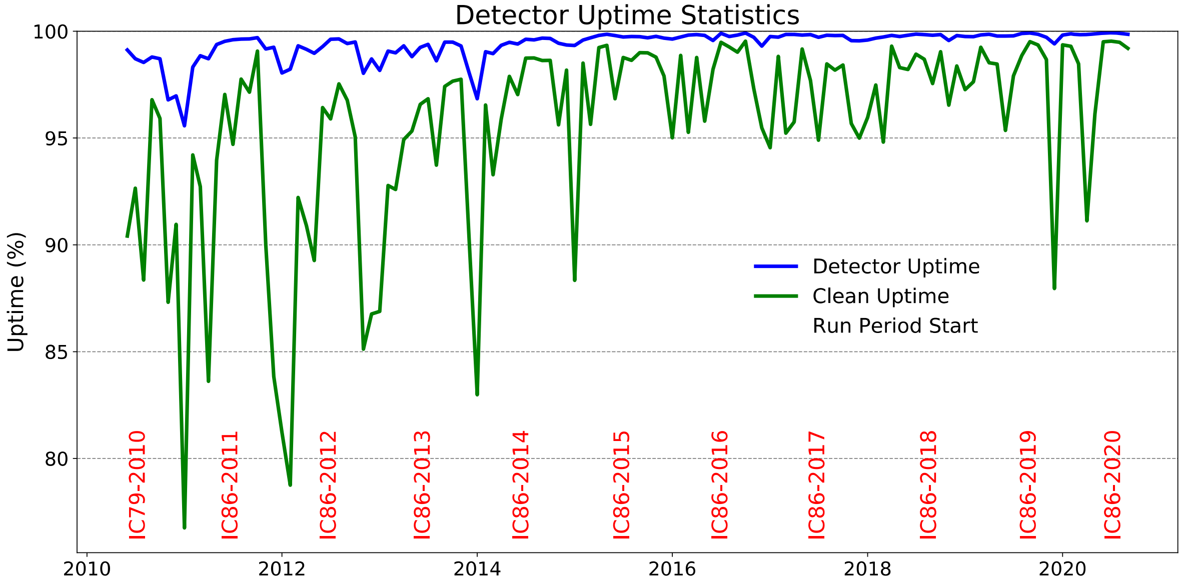
* The non-U.S. invoicing and contributions are still underway, and it is anticipated that most of the planned contributions will be fulfilled.

Section II – Maintenance and Operations Status and Performance

Detector Operations and Maintenance

Detector Performance — During the period from March 1 to August 31, 2020, the detector uptime, defined as the fraction of the total time that some portion of IceCube was taking data, was 99.9%, exceeding our target of 99% and close to the maximum possible, given our current data acquisition system. The clean uptime for this period, indicating full-detector analysis-ready data, was 97.4%, exceeding our target of 95%. Historical total and clean detector uptimes are shown in Figure 1.

Figure 2 shows a breakdown of the detector time usage over the reporting period. The partial-detector good uptime was 1.2% of the total and includes analysis-ready data with fewer than all 86 strings. Excluded uptime includes maintenance, commissioning, and verification data and required 1.3% of detector time; this is higher than usual due to the commissioning runs for the IC86-2020 physics run start. The unexpected detector downtime was limited to 0.1%.



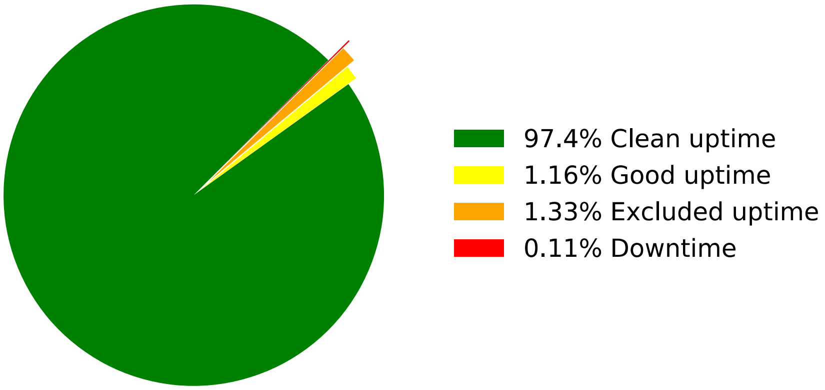


Figure 2: Cumulative IceCube Detector Time Usage, March 1–August 31, 2020

Hardware Stability — The total number of active DOMs in the data stream is currently 5405 (98.5% of deployed DOMs), plus three DOM-mainboard-based scintillator panels. No DOMs failed during this reporting period; the previous DOM failures were in December 2018.

The high failure rate of DOM power supplies and DOMHub ATX computer power supplies appears to have been resolved by the ongoing maintenance over the past three pole seasons. Since January 2020, there have been zero failures in the new Mean Well DOM power supplies, and one failure of an ATX power supply.

IC86 Physics Runs — The tenth season of the 86-string physics run, IC86–2020, began on May 29, 2020. No trigger or filter changes were implemented relative to the IC86-2019 physics run. The annual full-detector calibration was performed in March 2020, and DOM configuration settings were adjusted accordingly. The detector clean uptime since the beginning of the IC86-2020 is 99.42%.

Data Acquisition — The IceCube Data Acquisition System (DAQ) has reached a stable state, and consequently the frequency of software releases has slowed. During the reporting period, the following accomplishments are noted:

- Delivery of the pDAQ:Akupara release in April 2020, a major maintenance upgrade that includes cleanup of Java dependencies and changes to support migration to Python3.
- Work towards the migration of the pDAQ codebase from the SVN version control system to GitHub, the IceCube software revision control standard moving forward.
- Work towards the pDAQ:Basilisk release, which will support changes in the hitspool buffer size without data loss, as well as addressing minor bugs.

Additionally, significant development has taken place to support calibration of the PMT after-pulse calibration of the DOMs. These calibrations require DOM operating modes that have not been supported in the standard DAQ, such as low-deadtime readout modes and the ability to flash the low-intensity mainboard LED in the DOM while operating normally. Preliminary data-taking using these new modes is ongoing at SPTS.

Online Filtering — The online filtering system ("PnF") performs real-time reconstruction and selection of events collected by the DAQ and sends them for transmission north via the data movement system. No filter changes were performed for the IC86–2020 physics run start.

PnF relies on the core reconstruction software used in offline analysis. The increasing divergence between the aging SPS operating system and toolchain and the tools used for IceCube analysis is an issue when upgrades to the online filters are needed. A major overhaul of the online and Level2 filtering systems is under discussion with the TFT board, but this is dependent on the SPS operating system upgrade. Since that upgrade has been postponed by the COVID-19 situation (see below), and the filtering overhaul was not deemed operationally critical, major PnF changes are planned now for the 21–22 pole season and IC86-2022 run start.

Detector Monitoring and Experiment Control — Development of IceCube Live, the experiment control and monitoring system, has transitioned to a maintenance mode. This reporting period has seen the following progress:

- Deployment of Live 4.2.0 ("Cochrane") in April 2020, which factors out some of the common code for monitoring and alerts used by other systems such as PnF and SNDAQ into a new "livecore" project for easier deployment and long-term maintenance. An overhaul of the operator command-line tool syntax was also included.

- Work towards a major late-2020 release, which will include support for migration to Python3.

The uptime of the I3Live experiment control system during the reporting period was greater than 99.999%.

Supernova System — The supernova data acquisition system (SNDAQ) uptime for March 1 to August 31, 2020 was 99.9%. Patch release BT18rev1 of the SNDAQ software was deployed in April 2020 and fixes an alert threshold configuration file and formatting of the internal alert e-mails.

An unidentified memory leak in SNDAQ is requiring regular but infrequent restarts to avoid instability. The memory usage is being monitored automatically while debugging of the issue continues.

Surface Detectors — A plan for the restoration and enhancement of the IceTop surface array has been proposed as part of the next IceCube Management & Operations cycle. The upgraded surface array combines elevated scintillator panels and radio antennas for hybrid cosmic ray air shower detection. Measurement of the radio emission provides shower-by-shower energy and mass composition information, significantly enhancing the capabilities of IceTop.

During the 2019–20 pole season, a prototype scintillator station was upgraded to the production version of the electronics, and all panels and the field-deployed electronics have been elevated above the snow surface. Figure 3 shows the central station area in September 2020, after the polar winter. No significant snow accumulation on the panels or antennas is observed.

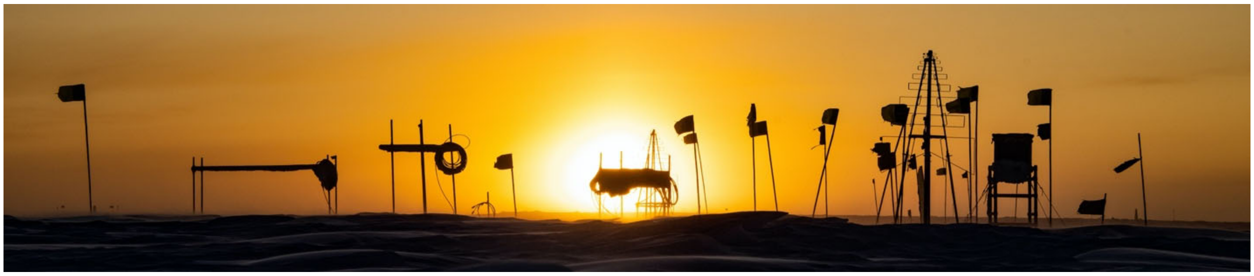


Figure 3: Upgraded scintillator + radio surface array station after the 2020 polar winter.

Development of the firmware and software has supported commissioning data-taking on the scintillator panels as well as detection of radio emission from air showers using the panels as a trigger. Figure 4 shows the measured radio signals from an air shower triggered by the scintillator panels.

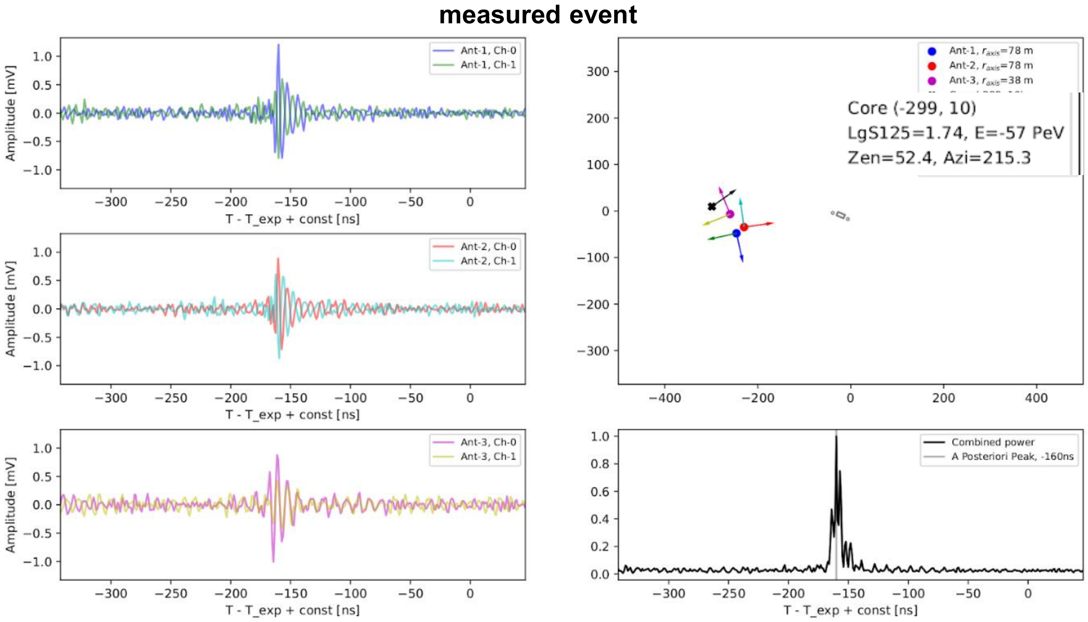


Figure 4: Cosmic ray air shower radio signals (left side) and core reconstruction (upper right panel) from the hybrid surface array station.

In January 2020, the IceAct roof telescope was refurbished with the same DAQ as the field telescope, and the lens heating system has been upgraded on both telescopes. Both telescopes took data during the austral winter night.

South Pole System — Approximately 50% of the South Pole System servers were replaced in the 2018–19 season, and the remaining servers were upgraded during the 2019–20 season. Performance and hardware stability have been excellent.

The South Pole System is currently running a version of Scientific Linux 6 (SL6). We were planning to upgrade all SPS computers to CentOS 8 in the 2020–21 season, in order to support migration to modern versions of compilers, Python, the Linux kernel, and other key software. This has been postponed due to the cancellation of the normal pole season.

Personnel & Management — Two new winterovers (M. Wolf and J. Veitch-Michaelis) have been hired for the 20–21 season. Both winterovers are non-U.S. residents (see below for discussion).

Computing and Data Management Services

Data Transfer – Data transfer has performed nominally over the past ten months. Between March 2020 and August 2020 a total of 39 TiB of data were transferred from the South Pole to UW-Madison via TDRSS, at an average rate of 69 GiB/day. Figure 1 shows the daily satellite transfer rate and weekly average satellite transfer rate in 69 GiB/day through September 2020. The IC86 filtered physics data are responsible for 95% of the bandwidth usage.

Since September 2016 the JADE software handles all the IceCube data flows: disk archive at the South Pole, satellite transfer to UW-Madison and long-term archive to tape libraries at NERSC and DESY. JADE continues to operate smoothly and has been an effective tool for handling a variety of our routine data movement workflows. This has been confirmed over the last year with experience from both the Winterovers and IT staff at UW-Madison.

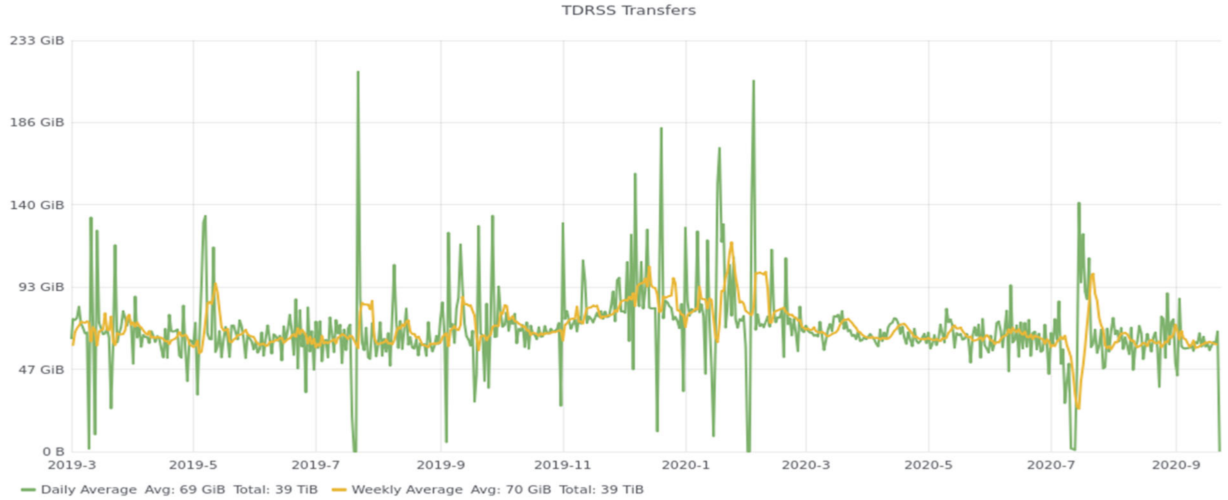


Figure 1: TDRSS Data Transfer Rates, March 1, 2020–September 22, 2020. The daily transferred volumes are shown in green and, superimposed in yellow, the weekly average daily rates are also displayed.

Data Archive **–** The IceCube raw data is archived by writing two copies on independent hard disks. During the reporting period (March 2020 to September 2020) a total of 0.6 PiB of unique data were archived to disk averaging 1.6 TiB/day.

In May 2020, the set of archival disks containing the raw data taken the previous season was received at UW-Madison. These disks are processed using JADE which now indexes the metadata, bundles the data files into chunks suitable for storage in tape libraries, and replicates the data to the long-term archives at DESY and NERSC.

Beginning in September 2016 we have been regularly transferring archival data to NERSC. At this time, the total volume of data archived at NERSC is 3.8 PiB. Figure 2 shows the rate at which data has been archived to NERSC since the start of this service. The plan is to keep this archive stream constantly active while working on further JADE functionality that will allow us to steadily increase the performance and automation of this long-term archive data flow.

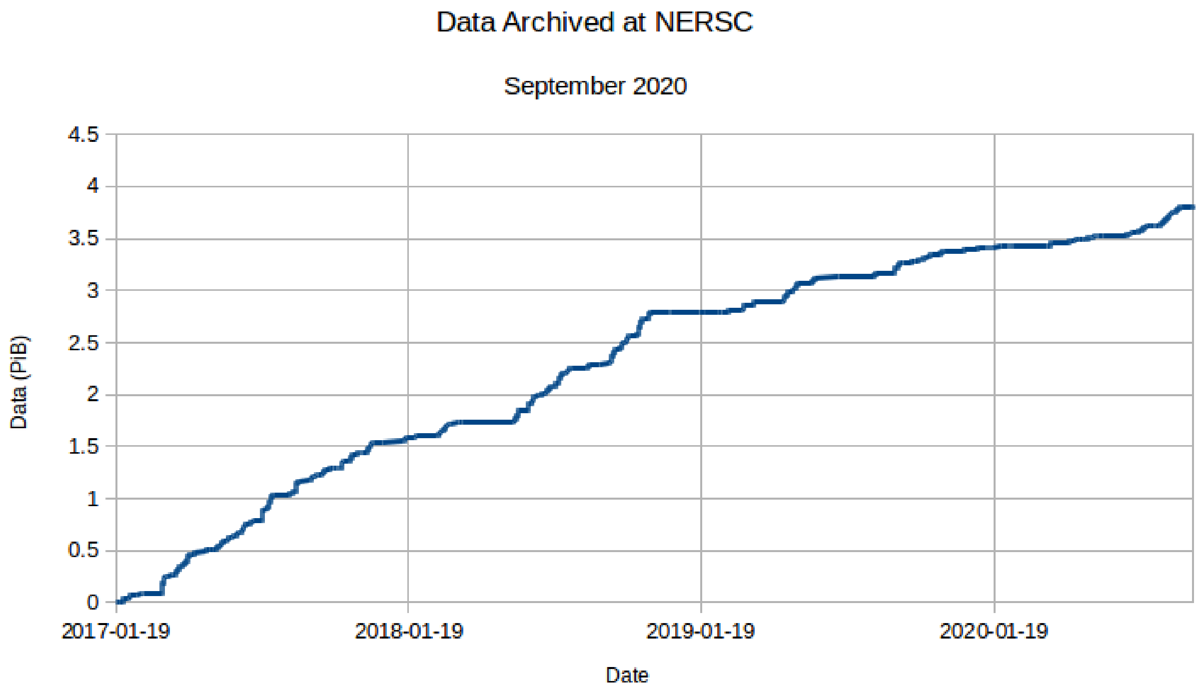


Figure 2: Volume of IceCube data archived at the NERSC tape facility by the JADE Long Term Archive service as a function of time.

Computing Infrastructure at UW-Madison

The IceCube computing cluster at UW-Madison has continued to deliver reliable data processing services. Boosting the GPU computing capacity has been a high priority activity since the Collaboration decided to use GPUs for the photon propagation part of the simulation chain in 2012. Direct photon propagation provides the precision required, and is very well suited to GPU hardware, running about 100 times faster than in CPUs. In addition, we have decommissioned the data center facility at our 222 West Washington Avenue location, and relocating the equipment to a commercial facility leased by UW-Madison.

The facility is located approximately seven miles from our 222 West Washington Avenue location. It is a commercial facility offering redundant battery-backed generator power and biometric physical security. UW-Madison leases space, power, and cooling in this facility to support internal needs as well as project needs for the campus as a whole. As such, they have extended the campus high speed networks to the facility which offers us easier integration with the rest of our campus systems without the higher costs typically associated with commercial rates for network transit. We have a full 200 Gb/s network path between this facility and our other facilities on campus.

The total amount of data stored on disk in the data warehouse at UW-Madison is 9.3 PB: 6.5 PB for experimental data and simulation, 2.7 PB for analysis and user data. An additional 1 PB will deployed later this year.

Storage comprises the largest user-visible infrastructure. A number of other critical systems (access to South Pole, for example) have been migrated to the new facility. The work was completed in early 2020. Only hardware under warranty was migrated to the facility. Older hardware that is still usable but out of support will be re-purposed for testing or moved into the compute cluster in Chamberlin Hall on the UW campus as needed. Any old hardware not needed for these purposes will be disposed of.

Simulated datasets are a key deliverable of the core M&O program, from the software that generates the physical processes of interest and simulates the response of the ice and the optical detection units, to the production scheduling and data provenance software to the hardware running within multiple large distributed computing clusters. Acquisition of the massively parallel GPU clusters is a regular aspect of M&O to meet the expanding needs of the Collaboration reliance on the highest-fidelity simulated dataset that employ direct photon propagation. GPU needs outstrip the capacity of the GPU cluster at UW-Madison, thus, additional GPU resources are deployed throughout the collaborating institutions, most recently at Michigan State University, and M&O computing management continues to aggressively pursue additional allocations on supercomputing clusters worldwide.

IceCube has been awarded or participated in several cyberinfrastructure-related projects. Namely, UW-Madison participated in an EAGER award (NSF OAC 1941481). UW-Madison has been awarded Phase I of Internet2's Exploring Clouds for Acceleration of Science (E-CAS) project for $100,000 in credits with Amazon Web Services and Google Cloud Platform and 0.4 FTE.

Distributed Computing - In March 2016, a new procedure to formally gather computing pledges from collaborating institutions was started. This data is collected twice a year as part of the already existing process by which every IceCube institution updates its MoU before the Collaboration week meeting. Institutions that pledge computing resources for IceCube are asked to provide information on the average number of CPUs and GPUs that they commit to provide for IceCube simulation production during the next period. Table 1 shows the computing pledges per institution as of September 2020:

Institution	CPU	GPU
Aachen	10	0
Alberta	1200	144
Brussels	400	14
DESY	1400	180
Dortmund	400	48
LBNL	114	0
Marquette	96	16
MSU	750	100
NBI	0	10
Queen’s/King’s College	0	55
UMD	350	36
UW-Madison	6000	400
Wuppertal	500	64

**Table 1: Computing pledges from IceCube Collaboration institutions as of September 2018.
* indicates maximum shared resources, not exclusively for IceCube.**

We are implementing a feedback planning process by which the numbers from available resources from computing pledges are regularly compared to the simulation production needs and resources used. The goal is to be able to manage more efficiently the global resource utilization and to be able to react to changes in computing needs required to meet IceCube science goals.

A strong focus has been put in the last years to enlarge the distributed infrastructure and make it more efficient. The main strategy to accomplish this has been to try and simplify the process for sites to join the IceCube distributed infrastructure, and also to reduce the effort needed to keep sites connected to it. To do this, we have progressively implemented an infrastructure based on Pilot Jobs. Pilot Jobs provide a homogeneous interface to heterogeneous computing resources. Also, they enable more efficient scheduling by delaying the decision of matching resources to payload.

In order to implement this Pilot Job paradigm for the distributed infrastructure IceCube makes use of some of the federation technologies within HTCondor[1]. Pilot Jobs in HTCondor are called “glideins” and consist of a specially configured instance of the HTCondor worker node component, which is then submitted as a job to external batch systems.

Several of the sites that provide computing for IceCube are also resource providers for other scientific experiments that make use of distributed computing infrastructures. Thanks to this, they already provide a standard (Grid) interface to their batch systems. In these cases we can leverage the standard GlideinWMS infrastructure operated by the Open Science Grid[2] project for integrating those resources into the central pool at UW-Madison and provide transparent access to them via the standard HTCondor tools. The sites that use this mechanism to integrate with the IceCube global workload system are: Aachen, Canada, Brussels, DESY, Dortmund, Wuppertal and Manchester.

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[1] http://research.cs.wisc.edu/htcondor/

[2] https://www.opensciencegrid.org/

Some of the IceCube collaborating institutions that provide access to local computing resources do not have a Grid interface. Instead, access is only possible by means of a local account. To address those sites we have developed a lightweight version of a glidein Pilot Job factory that can be deployed as a cron job in the user's account. The codename of this software is "pyGlidein" and it allows us to seamlessly integrate these local cluster resources with the IceCube global workload system so that jobs can run anywhere in a way which is completely transparent for users. The sites that currently use this mechanism are: Canada, Brussels, DESY, Dortmund, LBNL, Mainz, Marquette, Munich, NBI, and UMD. There are ongoing efforts at the Delaware, and Chiba sites to deploy the pyGlidein system. We continue observing a growing trend both in the number of sites integrated, as well as the computing time delivered.

Beyond the computing capacity provided by IceCube institutions, and the opportunistic access to Open Science Grid that are open to share their idle capacity, IceCube has received additional computing resources from targeted allocation requests submitted to supercomputing facilities such as the NSF Leadership-Class Facility and Extreme Science and Engineering Discovery Environment (XSEDE). We have been awarded a Large-Scale Community Partnerships for NSF's leadership-class HPC system Frontera with 130,000 SUs per year.

IceCube submitted a first research allocation request to XSEDE in October 2015 (allocation number TG-PHY150040) that was awarded with compute time in two GPU-capable systems: SDSC Comet[3] and PSC Bridges[4]. The latest renewal for this research allocation, in July 2020, was awarded with GPU compute time in two systems: SDSC Comet with 165,000 SUs and PSC Bridges with 440,000 SUs. IceCube stands out as one of the largest GPU users in XSEDE and has been acknowledged in several XSEDE press releases. An additional 10,000 CPU SUs was awarded on Stampede2.

With the aim to continue exploring the possibilities to expand the pool of available computing resources for IceCube, IceCube took part in an experiment at Supercomputing 2019 funded through an EAGER award (NSF OAC 1941481) from the NSF OAC. A UCSD/SDSC and UW-Madison team created one of the largest GPU clusters ever using the resources of commercial cloud providers while using the IceCube photon propagation code as a payload[5].

In order to integrate all these heterogeneous infrastructures, we strongly rely on the HTCondor software and the various services that the Open Science Grid (OSG) project has built and operates around it. We continue being active in the OSG and HTCondor communities by participating in discussions and workshops. During the reporting period, IceCube members made oral contributions to the OSG all hands meeting at Jefferson Lab in Virginia, and the HTCondor workshop in Madison.

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[3] https://portal.xsede.org/sdsc-comet

[4] https://portal.xsede.org/psc-bridges

[5] https://arxiv.org/abs/2002.06667 and https://arxiv.org/abs/2004.09492

Data Release

IceCube is committed to the goal of releasing data to the scientific community. The following links contain data sets produced by AMANDA/IceCube researchers along with a basic description. Due to challenging demands on event reconstruction, background rejection and systematic effects, data is released after the main analyses are completed and results are published by the IceCube Collaboration.

Since summer 2016, thanks to UW-Madison subscribing to the EZID[6] service we have the capability of issuing persistent identifiers for datasets. These are Digital Object Identifiers (DOI) that follow the DataCite metadata standard[7]. We are in the process of rolling out a process for ensuring that all datasets made public by IceCube have a DOI and use the DataCite metadata standard capability to "link" it to the associated publication, whenever this is applicable. The use of DataCite DOIs to identify IceCube public datasets increases their visibility by making them discoverable in the search.datacite.org portal (see https://search.datacite.org/works?resource-type-id=dataset&query=icecube)

Datasets (last release on 12 Jul 2018): http://icecube.wisc.edu/science/data
The pages below contain information about the data that were collected and links to the data files.

1. IceCube data from 2008 to 2017 related to analysis of TXS 0506+056
   - https://doi.org/10.21234/B4QG92
2. IceCube catalog of alert events up through IceCube-170922A
   - https://doi.org/10.21234/B4KS6S
3. Measurement of atmospheric neutrino oscillations with three years of data from the full sky
   - https://doi.org/10.21234/B4105H
4. A combined maximum-likelihood analysis of the astrophysical neutrino flux:
   - https://doi.org/10.21234/B4WC7T
5. Search for point sources with first year of IC86 data:
   - https://doi.org/10.21234/B4159R
6. Search for sterile neutrinos with one year of IceCube data:
   - http://icecube.wisc.edu/science/data/IC86-sterile-neutrino
7. The 79-string IceCube search for dark matter:
   - http://icecube.wisc.edu/science/data/ic79-solar-wimp
8. Observation of Astrophysical Neutrinos in Four Years of IceCube Data:
   - http://icecube.wisc.edu/science/data/HE-nu-2010-2014
9. Astrophysical muon neutrino flux in the northern sky with 2 years of IceCube data:
   - https://icecube.wisc.edu/science/data/HE_NuMu_diffuse
10. IceCube-59: Search for point sources using muon events:
    - https://icecube.wisc.edu/science/data/IC59-point-source
11. Search for contained neutrino events at energies greater than 1 TeV in 2 years of data:

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[6] http://ezid.cdlib.org
[7] http://schema.datacite.org

  - http://icecube.wisc.edu/science/data/HEnu_above1tev
12. IceCube Oscillations: 3 years muon neutrino disappearance data:
    - http://icecube.wisc.edu/science/data/nu_osc
13. Search for contained neutrino events at energies above 30 TeV in 2 years of data:
    - http://icecube.wisc.edu/science/data/HE-nu-2010-2012
14. IceCube String 40 Data:
    - http://icecube.wisc.edu/science/data/ic40
15. IceCube String 22–Solar WIMP Data:
    - http://icecube.wisc.edu/science/data/ic22-solar-wimp
16. AMANDA 7 Year Data:
    - http://icecube.wisc.edu/science/data/amanda

Data Processing and Simulation Services

Data Reprocessing – The data re-processing (pass2) started on June 1st, 2017 and completed in August of 2018 to (a) unify the multi-year data set; (b) profit from improvements in our understanding of low-level DOM calibration parameters. Seven years (2010 - 2016) are currently re-processed. Four years start at sDST level (2011 - 2014) and three years at raw data. Starting at raw data was required for 2010 since sDST data was not available. Since sDST data for 2015 and 2016 has already been SPE corrected, a re-processing of sDST data was required in order to apply the latest SPE fits as we perform for the other seasons.

The reprocessing of pass2 utilized 10,905,951 CPU hours and 520 TB storage for sDST and Level2 data. An additional 2,000,000 CPU hours and 30 TB storage were required process the pass2 Level2 data to Level3.

An additional pass was needed to add some reconstructions that were missing from pass2. This pass2a production was done on existing pass2 data and required little additional CPU. More recent improvements in calibration and feature extraction prompted an evaluation for the need to implement such changes in the online filter and subsequently reprocess previous data a second time. However, after careful studies it was determined that there was not sufficient evidence that a pass3 would result in improved science at this time. The question will be revisited before next season, after we have made more detailed studies on the matter.

Offline Data Filtering – The data collection for the IC86-2020 season started on May 29, 2020. A new compilation of data processing scripts had been previously validated and benchmarked with the data taken during the 24-hour test run using the new configuration. No significant changes have been made relative to the IC86-2019 season scripts.

As of May 29, 2020, all offline processing of data at Level2 and Level3 has migrated to the IceProd 2 framework. The switch to IP was planned to coincide with the run start for the 2020-2021 season. This makes use of the computing grid distributed across IceCube institutions as well as opportunistic computing resources. The processed L2 data are stored in Madison and are typically available 1.5 weeks after data taking. Replication of all the data at the DESY-Zeuthen collaborating institution is being done in a timely manner.

The current utilization of resources required for the offline production is approximately 480,000 CPU-hours on the IceCube cluster at the UW–Madison datacenter. An effort was made in 2019 to clean up filters, reconstructions, and libraries no longer needed in offline reconstruction, resulting in a 36% reduction of CPU utilization and a comparable reduction in memory requirements. We add roughly 100 TB of storage per year for both the Pole-filtered input data and the output data resulting from the offline production. Additional savings in storage resulted from switching to a more efficient compression in the last couple of years.

Simulation – Current production of IC86 Monte Carlo simulations includes the pass2 trigger and filter configurations. This models current data from years 2012, 2013, 2014, 2015 and 2016, as well as current data. As with previous productions, direct generation of Level 2 background simulation data is used to reduce storage space requirements. Current simulations are running on the new Combo meta-project that includes both simulation and reconstruction code. Some new features in the simulation include, individually calibrated PMT waveforms, optimized event resampling for low-energy background simulation as well as new, more detailed ice models along with further improvements in GPU utilization. Direct photon propagation is currently done on dedicated GPU hardware located at several IceCube Collaboration sites and through opportunistic grid computing where the number of such resources continues to grow.

Simulation Production transitioned to the newly redesigned simulation scheduling system IceProd2 during the Spring of 2017. Production throughput on IceProd2 has continually increased due to incorporation of an increasing number of dedicated and opportunistic resources and a number of code optimizations. A new SimProd Dashboard allows users to request new simulations sets and track the progress of such requests. Additional monitoring tools are currently being developed as part of this dashboard in order to keep track of efficiency and further optimizations.

The simulation production team organizes periodic workshops to explore better and more efficient ways of meeting the simulation needs of the analyzers. This includes both software improvements as well as new strategies and providing the tools to generate targeted simulations optimized for individual analyses instead of a one-size-fits-all approach. New strategies are currently under development for simulating and determining the impact of systematic uncertainties in our understanding of ice properties, hole-ice and DOM sensitivity. A new campaign will begin once the necessary tools are in place.

IceCube Software Coordination

The software systems spanning the IceCube Neutrino Observatory, from embedded data acquisition code to high-level scientific data processing, benefit from concerted efforts to manage their complexity. In addition to providing comprehensive guidance for the development and maintenance of the software, the IceCube Software Coordinator, Alex Olivas, works in conjunction with the IceCube Coordination Committee, the IceCube Maintenance and Operations Leads, the Analysis Coordinator, and the Working Group Leads to respond to current operational and analysis needs and to plan for anticipated evolution of the IceCube software systems. In the last year, software working group leads have been appointed to the following groups: core software, simulation, reconstruction, science support, and infra-structure. Continuing efforts are underway to ensure the software group is optimizing in-kind contributions to the development and maintenance of IceCube's physics software stack.

The IceCube collaboration contributes software development labor via the biannual MoU updates. Software code sprints are organized seasonally (i.e. 4 times per year) with the software developers to prepare for software releases. Progress is tracked, among other means, by tracking open software tickets tied to seasonal milestones. The IceCube software group has several major projects, labeled as 'on-going' that are nearing completion:

- One feature release including systematics support and two subsequent patch releases;
- Release candidate is soon to be released;
- Test coverage measurements now included in release notes;
- Reduced memory usage in simulation production;
- New ice model including birefringence is in a release candidate;
- Nightly test system improved with CI/CV support;
- Significant progress towards a new background simulation model is included in a release candidate. This model is designed to achieve more efficient simulations by sampling important parameter space instead of brute force methods to simulate easily identified background cosmic-ray showers. This dynamic-stack CORSIKA framework provides a realistic path to achieve a rate of simulation production comparable to that of data taking.

Calibration

We continue to refine measurements of the optical properties of the South Pole ice that comprises the majority of our detector, as well as the IceCube DOM response to photons. Precise modelling of both is fundamental to converting detector observables into physical measurements such as neutrino direction, energy, and absolute flux.

Ice characterization - These studies are typically subdivided into those that concern the naturally formed bulk ice, and those that concern the refrozen ice in the columns where DOMs were deployed.

The absolute absorption and scattering as well as their depth dependence of the bulk ice have been well established for some time. In addition we observe the photon propagation through the ice at the South Pole to exhibit anisotropic behavior, with light traveling more efficiently along the glacial flow direction and less efficiently in directions perpendicular to the flow. Previous attempts to model this anisotropy have relied on a scaling of the scattering strength according to the direction of propagating photons. This ad-hoc model resulted in an improved description of the total photon count on DOMs, but a poor agreement in the leading edge of the time profile due to the modification of the scattering strength. Over the past year significant efforts have been spent on understanding and modelling photon transport while taking into account the microscopic properties of ice, which is a birefringent polycrystal with an optical axis. This means that the average size and orientation of ice grains influences the light dispersion in a direction dependent way (see Figure 1).

By parameterizing and fitting to a number of idealized cases a new ice model (called SpiceBFRv1) incorporating these effects has recently been developed and released internally. It shows a dramatic improvement in the ice model fit (see Figure 2) as well as an improved data description when applied in event reconstruction. During this reporting period, photon propagation algorithms have been ported from PPC to CLSim, allowing use in simulation production.

Efforts to further improve upon this model are continuing. This in particular entails a detailed, first-principle description of the crystal properties. For this work we are in close communication with the SPICEcore team who can provide inputs to the model such as ice grain size and elongation as a function of depth.

Previously the mis-modeling of the anisotropy introduced a significant bias when trying to fit the position of the central hole ice column with respect to each DOM position. With the new ice model being available, hole ice fits are now being updated. Preliminary results are promising. The previously observed biases are no longer present and several methods yield consistent results.

By request from the glaciology community we have in May also released a dataset comprising depth dependent ice temperature readings (10.21234/sp-ice-temperature) as measured in AMANDA and more recently IceCube. These will be used to model the geothermal heat flux.

DOM characterization – The calibration of each DOM's single photoelectron (SPE) response was finalized last PY, leading to a significant improvement in data/MC agreement of a fundamental observable: charge-per-DOM. The methods and results used in this calibration have now also been published in JINST (DOI: 10.1088/1748-0221/15/06/P06032).

Understanding the delayed pulse characteristics of the PMTs is critical for analyses that rely on delayed light, e.g. searches for signals of neutron capture from extremely high energy hadronic interactions. A previously unanticipated component of after-pulsing was recently discovered on a time-scale of ~100 microseconds and appears to vary by DOM. In order to be able to calibrate the effect in-situ an extended pDAQ mode has recently been implemented which allows for a deadtime-free FADC acquisition of arbitrary duration following a flash from the mainboard LEDs. Testing at the SPTS is currently underway in preparation for dedicated calibration runs.

Upgrade related activities – In preparation for the IceCube Upgrade we are facilitating discussion and simulation for the calibration devices (i.e. Pencil Beam, POCAM, camera systems, LED flashers). Recent simulation of the pencil beam in particular has revealed a nice experimental signature which is unique to the birefringence anisotropy and would give direct evidence for the curved photon trajectories: When trying to target a DOM some distance away, one has to actually aim slightly beside the DOM for it to be directly illuminated. Even without exact knowledge of the DOM positions, the effect becomes apparent as an asymmetry in the received charge as the Pencil Beam sweeps across the DOM.

Regarding the testing of the LED flashers to be integrated into mDOMs and dEggs, we are in particular assuring that the characterization setups employed in the US, Germany and Japan deliver equivalent and comparable results.

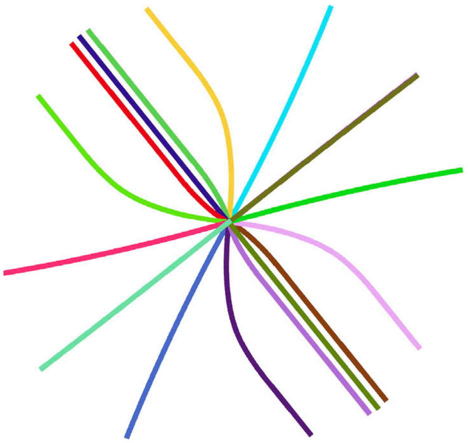

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Figure 1: Conceptual sketch of our understanding of the curved average photon trajectories resulting from the asymmetric light diffusion in the crystal structure of the South Pole ice.

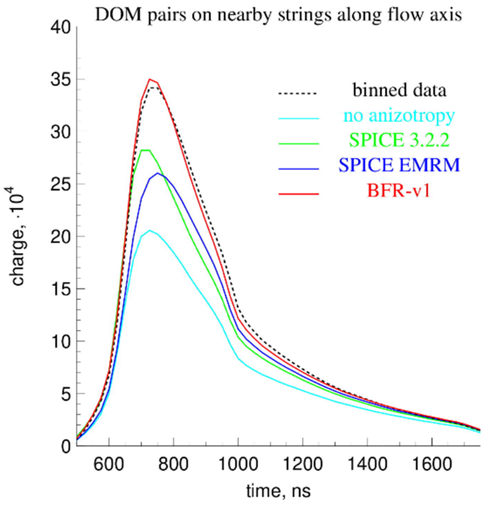


Figure 2: Average light curves (received intensity vs. time) for DOM receiver-emitter pairs aligned along the ice flow axis. The new birefringence based model (BFR-v1) closely matches the data (black) and outperforms all previous models.

Program Management

Management & Administration – The primary management and administration effort is to ensure that tasks are properly defined and assigned, that the resources needed to perform each task are available when needed, and that resource efficiency is tracked to accomplish the task requirements and achieve IceCube's scientific objectives. Efforts include:

- The IceCube Coordination Committee is migrating away from manual process of collection of pledges of labor and computing resources pledge collection by collaboration institutions and allocation of those resources to a prioritized list of tasks of vital importance to the scientific infrastructure needs of the collaboration. It is moving to a web-based application which permits continual updates by institutional PIs of pledged resources as well as updated core tasks.
- A complete re-baseline of the IceCube M&O Work Breakdown Structure was initiated at the beginning of the current M&O cycle that more accurately reflects the structure of the principal resource coordination entity, the IceCube Coordination Committee, and the major supporting infrastructure deliverables of the M&O program. This WBS has remained largely intact, however the SPS and SPTS WBS L3 nodes have been merged due to the symmetry of the deliverables in those areas.
- Since Q2 2020, M&O administration has been collecting costs incurred during facility operation that are unambiguously due to the ongoing COVID-19 pandemic. A new section of the project reports has been added to address COVID-19 issues including costs.
- The PY4 M&O Plan was submitted in March 2020 and PY5 M&O Plan will be submitted before the end of October 2020.

- The detailed M&O Memorandum of Understanding (MoU) addressing responsibilities of each collaborating institution was revised after the Spring Collaboration meeting, June 2020.

IceCube M&O – PY5 (FY2021/2021) Milestones Status:

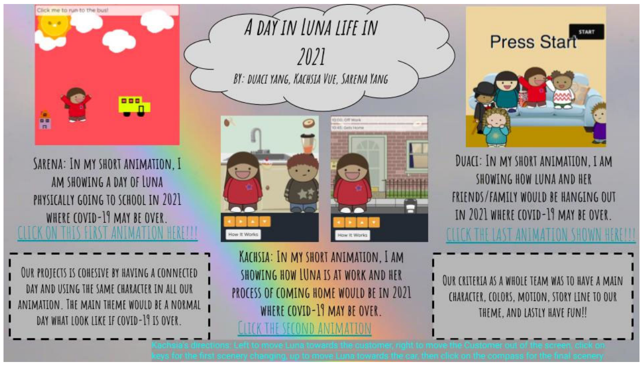
Milestone	Month
Revise the Institutional Memorandum of Understanding (MOU v28.0) - Statement of Work and Ph.D. Authors head count for the spring collaboration Meeting	**June 2020**
Report on Scientific Results at the Spring Collaboration Meeting	**Apr. 28 – May 15, 2020**
Report on Scientific Results at the Fall Collaboration Meeting	**Sept. 14-25, 2020**
Submit for NSF approval a mid-year report which describes progress made and work accomplished based on objectives and milestones in the approved annual M&O Plan.	**September 2020**
Revise the Institutional Memorandum of Understanding (MOU v29.0) - Statement of Work and Ph.D. Authors head count for the fall collaboration meeting	October 2020
Submit for NSF approval, a revised IceCube Maintenance and Operations Plan (M&OP) and send the approved plan to non-U.S. IOFG members.	October 2020
Revise the Institutional Memorandum of Understanding (MOU v30.0) - Statement of Work and Ph.D. Authors head count for the spring collaboration meeting	March 2021

Engineering, Science & Technical Support – Ongoing support for the IceCube detector continues with the maintenance and operation of the South Pole Systems, the South Pole Test System, 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. The IceCube detector performance continues to improve as we restore individual DOMs to the array at a faster rate than problem DOMs are removed during normal operations.

Education & Outreach (E&O)/Communications – The IceCube Collaboration made significant adjustments to many efforts during the reporting period due to constraints from COVID-19. The E&O and Communications activities are organized around four main themes:

1) *Reaching motivated high school students and educators* through internships, IceCube Masterclasses, and the University of Wisconsin-River Falls' (UWRF) and University of Rochester's (UR) Upward Bound programs
2) *Providing intensive research experiences* for educators (in collaboration with PolarTREC) and for undergraduate students (NSF science grants and Research Experiences for Undergraduates (REU) funding) to increase STEM awareness
3) *Engaging the public through various means,* including web and print resources, graphic designs, an IceCube comic, live talks, virtual reality gaming, and displays
4) *Developing and implementing communication skills and diversity workshops*, held semiannually in conjunction with IceCube Collaboration meetings

The UWRF Upward Bound program provides additional mentoring and skill-building activities for low-income/first-generation high school students to help prepare them for post-secondary school success. Former IceCube/PolarTREC educator Katey Shirey worked with current IceCube /PolarTREC educator Jocelyn Argueta. They developed and taught a 10-day computer coding boot camp curriculum, focused on computational thinking basics, and embedded in a personal reflection engineering design challenge. Students produced a video game that reflected what life would be like in the summer of 2021.



A DAY IN LUNA LIFE IN 2021

BY: DUACI YANG, KACHSIA VUE, SARENA YANG

SARENA: IN MY SHORT ANIMATION, I AM SHOWING A DAY OF LUNA PHYSICALLY GOING TO SCHOOL IN 2021 WHERE COVID-19 MAY BE OVER.

CLICK ON THIS FIRST ANIMATION HERE!!!

KACHSIA: IN MY SHORT ANIMATION, I AM SHOWING HOW LUNA IS AT WORK AND HER PROCESS OF COMING HOME WOULD BE IN 2021 WHERE COVID-19 MAY BE OVER.

CLICK THE SECOND ANIMATION

DUACI: IN MY SHORT ANIMATION, I AM SHOWING HOW LUNA AND HER FRIENDS/FAMILY WOULD BE HANGING OUT IN 2021 WHERE COVID-19 MAY BE OVER.

CLICK THE LAST ANIMATION SHOWN HERE!!!

OUR PROJECTS IS COHESIVE BY HAVING A CONNECTED DAY AND USING THE SAME CHARACTER IN ALL OUR ANIMATION. THE MAIN THEME WOULD BE A NORMAL DAY WHAT LOOK LIKE IF COVID-19 IS OVER.

OUR CRITERIA AS A WHOLE TEAM WAS TO HAVE A MAIN CHARACTER, COLORS, MOTION, STORY LINE TO OUR THEME, AND LASTLY HAVE FUN!!

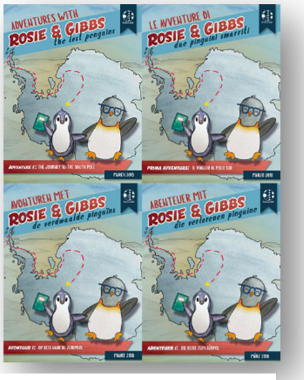
Kachsia's directions: Left to move Luna towards the customer, right to move the Customer out of the screen, click on keys for the first scenery changing, up to move Luna towards the car, then click on the compass for the final scenery

Concept map for Upward Bound student project.

The UWRF REU program was suspended for the summer of 2020 and only a small number of continuing undergraduates at other institutions worked on projects remotely.

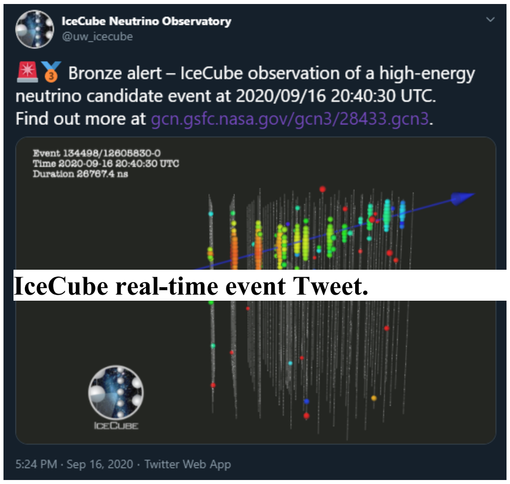
To compensate for cancelled in person education and outreach events, we significantly increased our efforts on-line. We worked with our winterovers John and Yuya, to provide frequent webcasts from the South Pole. They connected through virtual talks, presentations, and print media to promote both IceCube and the Antarctic science mission:

- six public webcasts, a few of which are available on our YouTube channel, including a "Kids' Edition" with Jargie the Science Girl
- Astronomy on Tap for the University of Edinburgh's School of Physics & Astronomy
- a live Q&A with a school group in Tennessee
- a South Pole virtual visit for attendees of the MOBSTER-1 virtual conference
- a shout-out at SciAccess 2020 – the Science Accessibility Conference, organized by The Ohio State University
- two live calls to two schools in Japan
- a "Letter to the Editor" of Physics Magazine for their COVID-19 series by John
- monthly columns to a Japanese newspaper, the Chunichi Shimbun and a cover article for the September issue of the Physical Society of Japan by Yuya.



Multilingual Rosie and Gibbs covers.

The IceCube communication office manages press and other communication activities for both the neutrino observatory and the IceCube Collaboration. All issues of the IceCube comic series "Rosie & Gibbs" are available in English, Spanish and French, and soon Portuguese. Translations are in progress for Italian, Swedish, German, Dutch, Chinese and Korean. We continue to produce multimedia content for social networks, which has increased the reach of IceCube communication from a few thousand to tens of thousands on an average week, with peaks of hundreds of thousands associated with big announcements. Real-time neutrino event alerts have been implemented on Twitter, providing followers with a behind-the-scenes look at our science as it develops. We have been selected to virtually present an extended video talk and South Pole tour at ScienceWriters 2020-"Science Where You Are" in October, 2020.


IceCube Neutrino Observatory
@uw_icecube

🚨🥉 Bronze alert – IceCube observation of a high-energy neutrino candidate event at 2020/09/16 20:40:30 UTC. Find out more at gcn.gsfc.nasa.gov/gcn3/28433.gcn3.

5:24 PM · Sep 16, 2020 · Twitter Web App

IceCube real-time event Tweet.

IceCube Collaboration meetings include professional development opportunities to improve skills and help create a more inclusive environment. The LGBTQ+Allies meetup, the women's meetup, and the social justice workshop held virtually in conjunction with the virtual fall IceCube Collaboration meeting produced productive dialog and ideas to improve equity, diversity and inclusion.

The Multimessenger Diversity Network, funded by the M&O INCLUDES supplemental award, added two more multimessenger collaborations, LISA and Auger to increase to a total of 9 members. The first two equity, diversity and inclusion training awards were made to graduate students Jessie Micallef (Michigan State) and Alex Pizzuto (Wisconsin). Another round of awards will be made in the fall of 2020.

Section III – Project Governance and Upcoming Events

The detailed M&O institutional responsibilities and Ph.D. author head count is revised twice a year at the time of the IceCube Collaboration meetings. This is formally approved as part of the institutional Memorandum of Understanding (MoU) documentation. The MoU was last revised in June 2020 after the Spring collaboration meeting (v28.0), and the next revision (v29.0) will be posted in October 2020 after the Fall collaboration meeting.

IceCube Collaborating Institutions

As of September 2020, the IceCube Collaboration consists of 53 institutions in 12 countries (30 U.S. and Canada, 19 Europe and 4 Asia Pacific).

The list of current IceCube collaborating institutions can be found on:

http://icecube.wisc.edu/collaboration/collaborators

IceCube Major Meetings and Events

ICNO M&O Mid-Term Review (virtual)	March 16, 2020
IceCube Spring Collaboration Meeting (virtual)	April 28 – May 15, 2020
IceCube Fall Collaboration Meeting (virtual)	September 14-25, 2020
International Oversight and Finance Group (virtual)	September 29-30, 2020

Section IV – COVID-19 Impacts to ICNO Management and Operations

Two decades ago, the maintenance and operations aspects of a uniquely remote, large-scale neutrino telescope facility were carefully considered and influenced the all-digital design of IceCube and its online systems. This has resulted in an observatory that, aside from occasional major upgrades every few years, can largely be operated by a field deployed crew of two operators, with the majority of operations carried out by subject matter experts remotely. Moreover the distributed nature of the M&O team that spans institutions in USA, Europe, and Asia forced early adoption of organizational processes suited for management of remote teams. In light of these considerations, it is not surprising that ICNO M&O has continued uninterrupted as the workforce of 2020 necessarily moved to telecommuting. Operational and financial impacts are nonetheless discussed in this section.

Operational Impacts

Detector Operations: Because the travel restrictions due to the COVID-19 pandemic did not start until after South Pole station closure, and the operations team is already accustomed to working while geographically distributed, IceCube detector operations have continued smoothly so far.

Training of the 20–21 winterovers has been significantly impacted, as travel to and in-person training at WIPAC has been impossible. All training has been compressed in schedule and replaced with virtual sessions. The risk to operations in the next season has been mitigated by the following actions:

- One of the new winterovers, M. Wolf, has previously wintered for IceCube and thus has extensive prior operations experience.
- One of the current winterovers, J. Hardin, has been extended through January 2021 to provide on-site, hands-on training to the new winterovers.
- A backup winterover, T. Leps, has been participating in the training in case one of the primary winterovers cannot deploy due to travel or quarantine issues.

The logistics of getting the winterovers to New Zealand has been complicated by the fact that they are non-U.S. residents, and thus did not have permission to enter the U.S. to join an ASC charter deployment flight. While simultaneously working with Immigration New Zealand on a backup plan to fly them directly to Auckland, we were able to expedite visas for them with the help of our congressional representative. As of 9/23/2020, they are quarantined in a hotel at San Francisco airport and are scheduled to join the rest of the USAP South Pole Winterover crew on 10/6 for a charter flight to CHC and subsequent quarantine steps prior to departure for Antarctica late October or early November.

Because significant hardware maintenance was accomplished in the 19–20 pole season, cancellation of the 20–21 pole season does not significantly jeopardize IceCube detector operations, as long we are successful in exchanging our winterovers. However, the situation has resulted in the following operations being postponed, nominally until 20–21:

- The planned SPS operating system upgrade. This may result in an increased online software maintenance burden as we need to support more modern tools on the older OS.
- An upgrade of the system configuration management system to support the SPS operating system upgrade.
- An upgrade of the SPS keyboard/video/monitor (KVM) system.
- The deployment of the first production surface array station (by moving the prototype station). If the surface array deployment proceeds in 21–22, we will attempt to recover the original construction schedule.
- Rack space consolidation in preparation for the IceCube Upgrade.

Population planning for the 21–22 summer season will need to take postponed tasks into account. Additionally, COVID-19 workplace restrictions delayed the copy of the 2019 data returned from Pole at the beginning of the year to online disk. As a result the set of experimental data disks holding that data could not be sent back to Pole this year for reuse in 2021, and a new set of disks had to be purchased and sent to Pole. Costs associated with these operational impacts are detailed in the next subsection.

Computing and Data Management: The M&O core computing and data infrastructure support teams have continued to work effectively throughout shelter in place orders. IceCube HTC and storage cluster remain online with high availability. As detailed in the next subsection on financial impacts, a mechanical lift was purchased as a remediation to workplace population limits that would have otherwise prevented cluster maintenance activities.

Financial Impact

Explicit COVID-19 expenses incurred by ICNO operations are listed in the table below.

WBS	Cost	Description	Justification
2.2 – DetOps	$284.49	Webcam	WO remote training
2.2 – DetOps	$10,771.20	Disks (40)	Replacement disks for 2021 season experimental data storage.
2.2 – DetOps	$28,847.92	Labor – T. Leps	WinterOver backup hired as precaution against failure to insert primary WOs into SP team: 8/24/20 – 10/31/20.
2.2 – DetOps	$8,517	Labor – J. Hardin	Extension of existing WO at Pole through 1/31/21 for on-site training.
2.2 – DetOps	$18,974.39	Travel	WO travel (Wolf, Veitch, Leps) for purpose of obtaining J-1 visa; additional costs due to manadatory 14-day quarantine at Grand Hyatt SFO
2.3 – Computing & Data Mgmt	$13,554.37	Server lift	Motorized lift for racking / de-racking computing and storage server chassis.
Grand Total	**$80,949.36**		

Acronym List

CPU	Central Processing Unit
CVMFS	CernVM-Filesystem
DAQ	Data Acquisition System
DOM	Digital Optical Module
E&O	Education and Outreach
GPU	Graphical Processing Unit
I3Moni	IceCube Run Monitoring system
IC86	The 86-string IceCube Array completed Dec 2010
IceACT	IceCube Air Cherenkov Telescope
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
MoU	Memorandum of Understanding between UW–Madison and all collaborating institutions
PMT	Photomultiplier Tube
PnF	Processing and Filtering
PQ	Physical Qualification
SNDAQ	Supernova Data Acquisition System
SPE	Single photoelectron
SPS	South Pole System
SuperDST/sDST	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
WIPAC	Wisconsin IceCube Particle Astrophysics Center