November 30, 2015

Report
IceCube Science Advisory Committee Meeting
Oct 19-20, 2015

Introduction

The IceCube Science Advisory Committee met at the Wisconsin IceCube Particle Astrophysics Center on October 19-20, 2015. The members in attendance were Roger Blandford, Edward (Rocky) Kolb, Steven Ritz, Jennifer Thomas and Barry Barish (Chair). The agenda and a set of questions posed to the committee are in Attachment A & B. A special focus of this meeting was the NSF solicitation for the Management and Operation of the IceCube Neutrino Observatory. The WIPAC proposal has been submitted and the committee was asked to review the written proposal and presentations to the SAC, in anticipation of a review meeting of the proposal that is expected in the coming months.

Below we summarize the main conclusions and recommendations from the SAC committee.

General Remarks

Neutrino physics and astrophysics continues to be a very rewarding scientific endeavor, in spite of the enormous experimental challenges. The field has recently received a lot of attention, especially with the Nobel Prize to Art McDonald and Takaaki Kajita for neutrino oscillations, the award of the Breakthrough Prize to Yifang Wang, Kam-Bui Luk, Art MacDonald, Koichuro Nishikawa, Takaaki Kajita, Atsuto Suzuki, Yoichuri Suzuki, the commitment by DoE to the field at Fermilab, and the observation of cosmic neutrinos by IceCube. Much discovery space is still available for future neutrino research, especially at high energies. IceCube has published information on more than 50 cosmic events and this provides strong motivation for the future program on high energy neutrino astrophysics.

There are several neutrino project underway or planned, and they promise to address many of the main questions and uncertainties in our present knowledge, including obtaining better oscillation parameters, addressing the hierarchy problem and observing CP violation for neutrinos. In the longer term, ambitious projects, like DUNE, will continue to pursue these central questions. All of this suggests that initiatives at the South Pole to elucidate low energy neutrino physics need to be opportunistic and flexible to complement and react to what is learned in other experiments. How to maintain this flexibility in developing major new facilities at the South Pole (e.g. Gen-2, PINGU and a surface array) will be a major challenge.

WIPAC appears well positioned to be awarded the renewal M&O cooperative agreement. The solicitation is a continuation of the present program with similar scope, but a constant budget. The written proposal was recently submitted and is well written. The combination of an effective M&O organization, a strong international collaboration and an outstanding scientific track record make it hard to imagine there will be another more attractive proposer. Nevertheless, the review will be focused on the effectiveness of the M&O operation and, especially, focused on standard management issues (cost effectiveness, management strengths and weaknesses, etc.) The reviewers will need to become convinced of the ways IceCube is organized and run.

Regarding a possible future MREFC for pursuing a new generation of IceCube science, our view is that the broad program provided by the combination of all the sub-parts of Gen-2 upgrade, surface array and PINGU will give the best and most compelling physics case. However, we are concerned that the cost for the whole package may become prohibitive. It will be important to develop a coherent set of science arguments for developing such a neutrino facility having many exciting goals. As there are likely to be many developments in neutrino physics over the next few years it will be important to include some contingency in the science rationale. A concerning sociological issue is the time scale to fund and develop such a new facilities and how best to incorporate the international collaboration. This is a challenge since the logistics are maintained by the U.S., and especially access to the pole.

M & O Proposal Document and Presentations

The M&O written proposal generally reads well. We have a few suggestions to clarify or emphasize orally when the proposal is reviewed.

- Although cost sharing is prohibited for NSF proposals, it will be important to explain the role of UW and highlight contributions that demonstrate the strong commitment of the University to the project.

- Highlight the improvements over the past 1-2 years and the plans for further improvements/enhancements in performance (particularly for science productivity).

- Show that the science analysis and M&O go hand-in-glove, which enables the overall productivity of the facility, and enumerate how the M&O pieces are distinct.

- Ensure the proposal is compliant with the solicitation. Consider developing a table showing a compliance matrix.

- It would be helpful to develop a more informative organization chart that shows the parts funded by M&O, clearly separate and accountable, and the close connection with the scientific collaboration.

- Where possible, make statements more quantitative than in the written proposal. For example, in 3.2.1.2, what is the satellite allowance? Also, quantify the improvement in supernova trigger efficiency (now 85%, p16). Related, the data volume descriptions on p20 and p27 could be clearer (raw data vs data + MC). Also, justify the large data volume requirements (otherwise it may appear you avoid making decisions)

- In the budget discussions, summarize the savings in the future proposed budgets relative to the current operation. This is both the reduction from $38.1M to $35M and the erosion of effort due to escalation.

- Regarding public data, show the costs and the goals of this part of the program.

- It would be useful to point out the relevant connections to other NSF projects, e.g., HAWC and LIGO, both current and planned.

- Show tracked information on the career trajectories of junior collaborators? also highlight the coding courses.

At the SAC meeting, we heard a series of oral presentations on the M&O proposal subparts and we selectively comment on some of those in anticipation of the anticipated M&O renewal review.

Francis Halzen gave us an impressive presentation of IceCube science. This was stimulating and enjoyable for the SAC committee, but is not what will be needed for the M&O review competition. The review committee will be much less familiar with the science, but nevertheless, this is a science project and presenting the science and the science vision for the future is central to the success of the M&O contractor. We suggest that the science should be presented in a way to motivate the renewal and to convince the reviewers that the present "scientist" management of IceCube is key to its success. The past accomplishments both technically and scientifically make a strong case for the present management arrangements. The ability to extract a cosmic neutrino signal required strong scientific leadership and management. The science of the future will require similar strong scientific leadership and management to fully exploit the science. That is the message that needs to be made in the science talk at the management review.

Olga Botner, Spokesperson for the IceCube Collaboration, gave us a report from the collaboration. The collaboration is broad and strong, consisting of 315 persons from 44 institutions in 12 countries. The international nature of the collaboration brings special strength. Olga characterized the original goal of the collaboration was to "design and build the IceCube Neutrino Observatory," while the present goal is to "exploit it for science, primarily study of high-energy n's from cosmic sources." The data analysis effort of the collaboration on IceCube data is very strong and the publication record is good. Earlier, there were criticisms of slowness in getting results to publication, but that seems to have improved. The collaboration shares the responsibility for detector

operations, and participate in all the main functions: detector M&O, computing and data management, triggering and filtering, data quality, simulation and reconstruction tools. The physics analysis is coordinated through a formal set of working groups. A strategy is in place for public sharing of IceCube data, making the data from the detector usable for general scientists.

The SAC committee is impressed with the viability of the collaboration and suggest for the M&O review the collaboration role should be more evident in the M&O organization, including the organization charts. A side benefit, is that this could help PI grant proposals, as well as the M&O renewal. We also believe that more generally the collaboration represents the community and could play a more pro-active role with funding agencies, especially the NSF regarding the ambitions and science opportunities of a future MREFC.

The detector operations and data acquisition and data flow systems are mature and working well. The data analysis pipelines and tools are evolving. The huge task of generating sensible background simulations is being attached in two ways:

- Robotic Generation of many datasets
- Short-cuts using muon gun + sampling from CORSICA.

Although, people don't like short cuts, we encourage efforts to generate background in the edges of the distributions.

The SAC was part particularly impressed with the innovative idea to training postdocs and students in software engineering called the "Strike Team." This has the potential of greatly reducing the large time and effort fixing bugs in badly written code and is a very good training platform for young people,

Future MREFC Initiatives for IceCube

Since the main focus of this SAC meeting was the M&O renewal, the committee spent little time discussing the future options and possible MREFC initiatives. We expect to focus more on these possibilities in future meetings.

The most obvious new initiative will be to extend the capability of IceCube for cosmic neutrinos. So far, 50+ events have been registered and that will increase in the coming years. However, to gain enough statistics to explore the characteristics and origin of these very high energy neutrinos will require a more powerful detector. We heard the concept for Gen-2. It appears feasible to increase the size of IceCube in clear ice with less granularity such that an order of magnitude increase in event rate can be achieved for a similar cost as the original IceCube MREFC. We also briefly heard of other possibilities, including radio detection and a surface array. Especially with the discovery of cosmic neutrinos, it is clear that developing the possibilities for such an enhanced facility to broadly exploit this exciting new science is well-motivated. The search for positional, statistical and temporal associations with gamma ray bursts, gravitational radiation signals, fast radio bursts and a variety of optical transients including supernovae

etc., has already begun with interesting limits announced. This collaboration is well worth pursuing without preconceptions as to likely physical connections.

We discussed briefly strategies for how to educate and engage NSF on the value and opportunities of a new MREFC proposal. The committee felt the collaboration should play a more active role in this process. They have a dual role of being collaborators, but also in representing the physics community interested in very high energy neutrino astrophysics.

The other future direction (perhaps combined into one project) is to build up the future capability in IceCube to pursue the important questions in low energy neutrino physics, especially neutrino oscillations. We were presented with such an enhancement to IceCube, PINGU and Deepcore, involving a close packed array that might be part of a combined MREFC proposal. There is a large spectrum of oscillation physics to be done with the PINGU part of a new facility. The unique ability of IceCube-Deepcore-PINGU to span decades in energy and distance provide a very useful cross check to the other experiments along with some potentially very accurate parameter measurements. Systematics in DEEPCORE are being better understood and will obviously feed-down into eventual PINGU reach. The mass hierarchy reach is still not yet fully understood but conservative estimates gives about 3 sigma after 4 years of running. The other mixing parameters provide another area where PINGU would contribute to the world knowledge significantly. Dark matter searches and also sterile neutrino limits could be very competitive or world leading.

In general, the case for PINGU, as stated, is certainly weakened because it will take a long time to fund and build this capability. However, the point is not to beat the world to the mass hierarchy, but rather to contribute to neutrino oscillation knowledge. PINGU has a broad spectrum of world leading measurements it could deliver. New collaborators are showing interest, but there is a concern that they may not stay with this project due to the uncertainties and potential long time scale.

We look forward to more in depth discussions of the future MREFC possibilities at our next meeting.

Education and Outreach

We heard an impressive talk on the Education and Outreach program, however it was foreshortened and on the second day. We had no time to discuss this program, so again we look forward to a discussion at our next meeting.

The Questions

A set of seven questions were posed to the SAC committee (see Attachment B). These are a good set of questions to focus our discussions at future meetings, however we only were able to discuss them briefly this time due to the focus on the M & O proposal. We suggest returning to these questions at the next meeting of the SAC.

Final Remarks

We congratulate WIPAC and the collaboration for the exciting science results that portend well for the future of IceCube. The WIPAC renewal proposal is strong, the international collaboration is growing and working well, and there are rich options for exploiting the science through new expanded facilities. We suggest that the focus of the next or a future meeting be on the options and strategies for proposing new IceCube facilities.

In considering the renewal proposal review and the longer range future, it is important to develop a robust long-term management plan. This includes developing succession planning for the leadership and mitigation plans for areas where an individual has crucial responsibilities, representing potential 'single-point' failures in the organization.

ATTACHMENT A

ICECUBE SCIENCE ADVISORY COMMITTEE MEETING AGENDA

October 19 & 20, 2015

Wisconsin IceCube Particle Astrophysics Center
222 West Washington Ave, Suite 500
Madison, WI 53703

AGENDA

FORMAT OF TALKS

To encourage a dialogue, talks have for the most part been padded with discussion time following each talk.

MONDAY 19 OCTOBER

8.45 – 9.15	SAC Closed Session	SAC
9.15 – 9.30	Introductory remarks	Kael Hanson
9.30 – 9.50	IceCube collaboration report	Olga Botner
10.00 – 10.45	IceCube / Gen2 Science	Francis Halzen
11.00 – 11.15	**Pause**	
11.15 – 11.45	M&O, solicitation & proposal status	Kael Hanson
12.00 – 12.30	IceCube detector operations	John Kelley
12.45 – 13.45	**Lunch**	
13.45 – 14.05	Simulations	Alex Olivas
14.15 – 14.45	Raw data to analysis; IceCube data sharing	Erik Blaufuss
15.00 – 15.15	**Pause**	
15.15 – 15.45	PINGU	Ty de Young
16.00 – 16.30	Gen2 HEA	Claudio Kopper
16.45 – 17.15	Gen2 surface array and radio extensions	Albrecht Karle
17.30 – 18.30	Executive session or open discussion as per SAC	
19.30	**Dinner at Resto 43 North**	

TUESDAY 20 OCTOBER

8.45 – 9.30	SAC closed session	
9.30 – 10.15	Education and outreach	Jim Madsen
10.15 – 11.30	Open discussion	
11.30 – 14.00	SAC report writing and working lunch	
14.00	Closeout	

Version 13.10.15.c

ATTACHMENT B

QUESTIONS

1. The Management and Operations proposal being in response to an open bid, its content and the requested budget should be subject to additional scrutiny. Are the proposed activities sufficiently innovative and forward looking? Is the budget justified?
2. Interest is high from groups wishing to join IceCube while funding support for existing groups dwindles or is cut completely. How do we get stronger support in US for analysis grants?
3. Are we making good progress in reducing time to analysis?
4. At the last SAC meeting the answer to the question of whether the collaboration policies on data sharing are adequate indicated a desire to see improvements in this area. Has this changed? Do recent data releases and data sharing agreements demonstrate progress in this area? How should the M&O program support an expanded program in view of lack of support from NSF?
5. Are our plans for proposing the future facility optimized for success?
6. While funding opportunities for Gen2 outside the US exist, US support does not exist at present and the future is unclear. There is a sense of urgency due to competing experiments and due to potential loss of interest. How do we build momentum?
7. What are your thoughts on our response to National Academies report *A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research*?