Report of the IceCube Science Advisory Committee's May 20-21, 2009 Meeting

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(Not attending: Howard Gordon, Karol Lang, and Jay Marx)

Introduction

A meeting of the IceCube Science Advisory Committee (SAC) was held at Madison, Wisconsin on May 20-21, 2009. The Committee heard a number of presentations (see attached agenda) related to the status of the construction project, the operations and data collection for the experiment, and plans and results for data analysis and physics measurements with the IceCube detector.

Construction during the past year has gone better than expected with 19 strings deployed including one "Deep Core" string. This brings the total installed string count to 59 which is ~70% of the final 80 plus 6 "Deep Core" strings planned for the project. In addition, 19 IceTop stations were set up making a total of 59 units out of a final goal of 80 stations. The project has two more seasons of installation and is planned to be completed in 2nd quarter of 2011. The majority of the technical risk has now been retired. As throughout the project, there also continues to be close attention to safety and quality assurance. The Committee commends the IceCube collaboration for this impressive progress and looks forward to a timely completion of the construction project over the next two years.

The Committee was also impressed with the transition of the collaboration from being mainly a detector construction organization to focusing more on exploiting the science of the detector. The results from the IC22 data set have highlighted the capabilities of IceCube and given enticing results associated with possible point sources and limits on WIMPs. The Deep Core extension also should provide additional physics reach and new possibilities. The Committee eagerly awaits the IC40 results that are about to be unblinded. The IC40 detector is moving into the sensitivity region that will give the first view of the possible IceCube physics signals. The broad spectrum of physics places a challenge to the finite sized collaboration in organizing and accomplishing the required analyses.

As for our previous meeting, the Committee was charged by IceCube management by being given a list of questions to be addressed in our deliberations and in our report. The report is organized around these questions in the sections below.

Construction Endgame

Question 1: Should the deployment of the final nine strings be optimized to enhance the energy reach of the detector as currently proposed i.e., HEE86, and what should be the criteria?

Findings

Now that IceCube is approaching completion it is appropriate for the collaboration to consider ways to optimize the science by a judicious reconfiguration of the remaining strings based on what has been learned since the project was first conceived.

The Deep Core, now being installed, holds the promise of detecting downward going neutrinos while rejecting the background using the surrounding IceCube array as a veto shield. The Deep Core enhancement would, however, benefit from a better understanding of its performance.

The IceCube collaboration has also proposed that seven (or possibly nine) strings, originally intended for the IceCube array, be deployed in an extended, sparser array thereby increasing the final aperture by about 20% for events between 10^{13} to 10^{18} eV while decreasing the active area below 1 TeV by less than 10%. IceTop coincidences above 10^{17}eV would increase by more than 50%. The total project cost would remain nominally the same. The configuration of the high energy extension is designed so that the drilling camp, centered in this new array could service the drilling operation for holes reaching to the perimeter. The cable hardware and readout would be the same as it is for the strings in regular IceCube configuration. The angular resolution for events in the sparse array would be about 10 degrees.

The science objective is to increase sensitivity to higher energy neutrino flux. The expected rate for GZK events is about 0.5 events per year.

The only technical risk seems to be the attenuation in the longer, 3.8 km signal cables. This concern has yet to be resolved.

The installation of the high energy extension in the last drilling season is incompatible with the proposed installation of the two high density strings in the Deep Core. The work-around would be to fly the two strings down for the 2009-2010 season at significant cost (~$100K).

Comment

The IceCube collaboration should develop and clarify the science motivation for the high energy extension.

Recommendations

1) The SAC is of the opinion that strings 79 and 80 could improve the performance of the Deep Core at modest cost. We recommend, however, that the performance of both the original Deep Core and the augmented Deep Core be better understood using suitable simulations. Should these studies confirm the value of an augmented Deep Core, the

SAC recommends that the extra strings be prepared and included in the Deep Core if the necessary funds can be found.

2) Although the high energy extension adds only a 20% increase to the sensitive area of the array at high energy, the SAC supports this change with its increased physics reach and minimal impact on the IceCube project.

3) Should the IceCube collaboration decide to install the high energy extension, we recommend that it meet the following criteria:

- The installation of the seven (or nine) strings is approximately cost neutral relative to including these strings in the IceCube array.
- The cables to the strings in the sparse array are demonstrated to be sufficiently low loss that exceptional measures are not required to move the signals to the counting house.

M&O Plans

Question 2: What general improvements should be made to the current M&O plans as described in the 5-year M&O proposal and the institutional MOUs?

The IceCube project is now moving from being a construction project to a running experiment with the main funding for operations to be provided through an M&O funding from NSF as well as support from European agencies. A 5yr M&O proposal has been submitted to start in April 2010 which lays out a detailed plan to operate the experiment and provide maintenance of equipment and upgrades of the computing infrastructure. The M&O program has significant contributions from the collaborating groups and the planning has been organized through MOU's with the various institutions. While the Committee did not look at the M&O proposal in detail, it appears that this phase of the experiment appears well planned.

Question 3: Is the IceCube response to the SAC and the Software and Computing Advisory Panel recommendations on software and computing appropriate, in particular, the plans for addressing the increasing data rates?

We commend IceCube for creating the Software and Computing Advisory Panel (SCAP). The report has a long list of findings and recommendations: seven executive summary recommendations and ten more detailed recommendations. We heard that IceCube is working towards meeting the intent of each one.

The committee considers the response of IceCube appropriate. The experiment has identified as an overarching theme the issues of Formal Requirements Process, Distributed Collaboration Model, Computing Facilities Manager, and Costs of Computing.

We heard about the Distributed Collaboration Model as outlined in the M&O proposal

which is being put into place now, and about the search for a Computing Facilities Manager. These are good steps to make the software and computing efforts in IceCube more coherent. It will be important to form a coherent offline software and computing organization across the different boxes in the org chart. Such an organization should be able to work with and respond to needs of the physics organization on the one side and also ensure that the IT facilities and infrastructure operations on the other side are delivering on the computing needs. Other responsibilities include software release planning, setting priorities for software development to follow the needs of data taking, trigger, and analysis, making sure that calibration constants get delivered timely, and that reprocessed data is made available to the collaboration. The offline software and computing organization should also assess, document and address any risks involved in the data and workflows in the experiments, like the need for redundant data storage, and critical path items like the satellite link.

We commend the collaboration for taking steps towards these issues. It will be important to identify the right level of leadership, which should be provided by physicist(s) well connected in the experiment and technically capable to work with the IT organization at UW and other computing provider sites. This experiment-wide function should most likely be separate from finding a new leader for the IT line organization at the UW data center, a function that should be mainly concerned with the local IT and operational issues.

Work is proceeding to address the increasing data rates. We were presented with requirements that are predicted to scale at a level of 50% increases per year. Scaling from this level will require the IT group to be proactive and follow technology developments to ensure that systems don't develop throughput bottlenecks and instabilities. Planning needs to be timely and the upgrade of computing systems and storage will require enough lead time between procurement, commissioning, and integration to allow release of resources to experiment users, to ensure that systems remains robust and that the user community develops trust and confidence in the computing providers.

Another theme is the area of the “Formal Requirements Process”. We heard that steps are underway to produce white papers to define the UW data center requirements, the plans for distributed simulation production, and the plans for distributed data processing. These should be produced promptly and discussed in the collaboration. For the distributed computing resources used for MC production, it will be important to make sure those resources get delivered, that adequate sites are robustly available to the data processing group, and that workflows get executed in a timely fashion.

The collaboration is also addressing the issue of “Costs of Computing”, both by thinking about improvements of the procurement process to obtain prices that are more in line of what other experiments achieve and also in developing a new data life cycle model with potentially lower storage costs. We have not heard yet details about this, and recommend that the SCAP reviews these plans.

Question 4: Comment on ongoing use of data challenges.

The SAC considers data challenges to be an important component to verify the analysis chain and to establish that IceCube would indeed identify a potential signal in the data. We understand that last year a data challenge was used to assess a new neutrino point source method (FDR). We hope that these efforts will continue and that we will hear more about subsequent data challenges next year.

Analysis Plans

Question 5: What general improvements should be made to our organization and manpower for data and physics analysis as described by the analysis coordinator and others?

We commend the analysis coordinator and the collaboration for identifying and addressing the issue of broader analysis organization. The newly established coordination board has been presented as an escalation route for resource conflicts in general, and the weekly Tuesday and Thursday phone meetings have been presented to us as the main forums for collaboration-wide discussions. We see good signs that a feedback of problem discovery from analysis efforts to low-level processing and/or detector issues is beginning. We were told of the large attendance at the Thursday phone call – this is a good sign. We assume this is the meeting in which the systematic issues and problem discoveries are pursued. We did not see agendas for the Thursday meetings, but suggest that there should be regular reports from the low-level analysis groups at this meeting to involve those working on high-level science analyses in the instrumental issues and *vice versa*, a concern identified by the analysis coordinator.

What is not so clear from the information given is the level of formality attached to making sure that all the necessary verifications are finished in a timely manner and that problems are pursued with appropriate priority. The collaboration should consider whether the meetings as described are working sufficiently well or whether a bigger effort at central coordination is needed (for example, one could imagine a regular meeting chaired by the analysis coordinator of the physics working group leaders, the channel group leaders, and the computing coordinator, targeted at setting priorities for attacking common problems).

Another issue is the large number of physics groups, with a small amount of FTE effort in each group. The coordination board, when it deals with allocation of analysis resources, may be in need of guidance in the form of the designation of 'key projects' to make collaboration priorities clear. We strongly recommend that each physics group maintain a *prioritized* list of expected analyses, and resulting papers, with a schedule for each. The priorities should be presented to and agreed by the larger collaboration. The collaboration should also consider combining some of the science groups as well as some of the separate channel and issue working groups.

We note that the physics groups should have a clear route to participation in the development and updating of computing requirements. As the March 2009 SCAP report

noted, a firm version of these requirements is urgently needed. We were told that white papers are in preparation, but were not given a timeline or an indication of how the physics groups will participate in their preparation. We strongly recommend that the collaboration make a timeline and a plan for physics group participation.

Question 6: Comment on our plan for obtaining and presenting physics results and publications as summarized in the presentations.

There is a reasonable framework in place for obtaining physics results using blinded analyses and for obtaining collaboration approval. We are pleased to see the timely arrival of results from IC22 and imminently from IC40. We commend the collaboration for its visible presence with results at major meetings and particularly for the large number of presentations at ICRC. We hope that the overall grant support afforded to the collaboration from the various funding agencies, over the next few years as the construction project ramps down, continues to be sufficient to provide the scientific effort necessary to keep the flow of results timely.

Question 7: Comment on our new multi-wavelength efforts.

Multi-wavelength efforts are often absolutely necessary, but they can also be a significant distraction for minimal payoff. At this stage, we recommend that IceCube multi-wavelength efforts be focused on leveraging information from other observatories to enhance the significance of the IceCube data. For example, the Milagro collaboration greatly increased the value of their marginal detections by correlating them with the Fermi LAT Bright Source List, particularly the pulsar systems.

Future Plans - R&D & Post MREFC Improvements

Question 8: Should IceCube prepare detailed plans and proposals for a high energy extension, i.e., HEE110?

The SAC took note of this interesting idea to extend the IceCube array although no in depth details were presented. It was felt that it is still too early to assess this possibility and develop a proposal. The discussion might be revived after the analysis of the IC40 and IC 59 data have been completed and either evidence for source candidates (or other positive physics observations) shows up or not. Therefore decisions based on these findings should only be started then. Initially, a first but simple study of potential gains has to be made and a coarse evaluation of the pros and cons should be made before a major extension could be proposed.

Question 9: Is the progress and plans on radio likely to converge on an appropriate technology and deployment plan?

a) The SAC was impressed by the progress made in the radio detector studies. The presented ideas are very encouraging. It seems that it might be possible to build a detector for GZK neutrinos that is far cheapest in cost per km^2 than other techniques and

that has the potential to reach a detector with greater than a 1000 km^2 area. Such a detector would require ice as absorbing medium and the only suitable site is probably at the South Pole.
b) The detector development is still in its early phase. The proof of the technique awaits convincing calibration and background rejection methods because the expected real rates are extremely small.
c) With a radio detector, there will be no redundant information available for a detected signal. For this reason, it may be very difficult to substantiate if some low number of signal events are from real events or rare exotic background effects. R&D studies will need to address this issue.
d) It is felt that a multistep approach is necessary, such as first building a small array in connection with IceCube to use for UHE cosmic showers > 10^{17} eV that are tagged by Icetop and IceCube. These events can be used to validate the radio detector concept as well as to address the calibration, background rejection, and lack of redundant information. In general terms, there is practically no other site suitable for these very important initial studies. A natural follow-up project would then be to design for a ~100 km^2 array and eventually a really large array to record significant statistics of GZK neutrinos.

Question 10: What are the appropriate next steps for acoustic R&D?

The SAC was impressed with the progress of the acoustic R&D during the last year. The group has made remarkable progress in clarifying some most important issues and uncertainties associated with the technique. The studies showed that there exist some basic limitations in the signal attenuation length being considerably shorter than initially anticipated. Signal detection would therefore require a very high energy threshold to allow a significant target mass. In view of this expected high energy threshold and rather short attenuation length, the SAC feels that using such a detector for GZK neutrinos would be very costly since it would require a dense sensor matrix extending deep into the ice. It is therefore suggested that the R&D program should be shelved at this time but with encouragement to publish soon the very interesting and clarifying technical results that have been obtained. The group is advised to minimize any further studies and effectively bring these studies to an end at this time. This might allow reorienting the research potential to the presently more promising radio development where nevertheless many problems, quite similar to the initial acoustics detector problems, await solutions.

Question 11: How should the R&D program be structured to allow maximum exploitation of the IceCube facility now and into the future?

The next two seasons of IceCube deployment will provide the unique opportunity to install antenna arrays parasitically in the holes drilled for the optical sensors and to use the IceCube power and communications infrastructure. In addition, the IceCube detector will provide test and calibration information that can be used in studying the radio detector capabilities. For these reasons, the IceCube collaboration in cooperation with relevant external collaborations should plan and execute a R&D program for radio

detection that maximizes these opportunities to resolve some fundamental issues in the radio technique.

As reported by Klaus Helbing, presently the R&D Working Group has six major tasks:

1) Working out task distribution amongst participating institutions
2) Establishing a letter of intent
3) Defining interfaces and common infrastructure for different sensors
4) Establishing milestones for an intermediate scale detector
5) Establishing a roadmap towards a full scale detector
6) Coordinating planning of funding proposals

While these tasks will be important in the long run, it is most important that the R&D working group develop a program to maximize the opportunities of the next two seasons and address the many uncertainties associated with very large radio array. These include calibration, lack of redundancy, and unexpected backgrounds associated with rare events as outlined in Question 9. The upcoming June R&D Workshop should focus on the structure of this important near-term R&D program. The SAC also notes that that radio detection R&D and establishing a radio detector for high energy neutrinos is beyond the scope of IceCube and will most likely be accomplished by a new group composed of physicists and groups both within and outside of IceCube.

Agenda
IceCube Science Advisory Committee
May 20-21, 2009

Wednesday

08:30 – 09:00 SAC Closed Session - Mike Shaevitz
09:00 – 09:30 Overview & Response to SAC Report 2008 - Tom Gaisser
0:930 – 10:00 Construction Endgame Plan and M&O Program Overview- Jim Yeck
10:00 – 10:20 Deep Core Update- Francis Halzen

Break

Progress on Data Analysis – T. Gaisser
10:40 – 11:05 Data Analysis and Simulations and organization - Elisa Resconi (dial-in)
11:05 – 11:30 Point Source/GRB Reports - Teresa Montaruli
11:30 – 11:55 WIMPS/Low Energy Reports - Doug Cowen
11:55 – 12:20 CR/Atmospheric ν/Diffuse/EHE Reports - Paolo Desiati

Working Lunch

13:30 – 14:00 Open Discussion/Executive Session
Detector & Simulation Data Production – J. Yeck
14:00 – 14:20 Detector Data Rates - E. Blaufuss/Kael Hanson
14:20 – 14:40 Data Management Challenges - Martin Merck
14:40 – 15:00 Data Challenge Update - Jim Braun

Break

Future Plans – A. Karle
15:15 – 15:45 Strategies on the energy frontier - Albrecht Karle
15:45 – 16:05 R&D working group report - Klaus Helbing (dial-in)
16:10 – 16:35 R&D results radio and future options - Hagar Landsman
16:45 – 18:00 Open Discussion/Executive Session

Thursday Final Discussions, Writing, & Closeout

08:30 – 10:00 Open Discussion
10:00 – 12:00 Report Writing/Working Lunch
13:00 Closeout Mike Shaevitz