Part III

General Information on the project status

1. Organisation and formal status of the project

The IceCube collaboration

Present members of the Interim IceCube Collaboration come from the USA, Germany, Sweden and Belgium:

1. USA
   Bartol Research Institute, Newark, DE
   Clark-Atlanta University, Atlanta, GA
   Institute for Advanced Studies, Princeton, NJ
   Southern University, Baton Rouge, LA
   Univ. of California Berkeley, Berkeley, CA
   Univ. of Kansas, Lawrence, KS
   Univ. of Pennsylvania, Philadelphia, PA
   Univ. of Wisconsin, Madison, WI
   Lawrence Berkeley Nat. Lab., Berkeley, CA

2. Germany
   DESY-Zeuthen
   Univ. of Mainz
   Univ. of Wuppertal

3. Sweden
   Univ. of Kalmar
   Univ. of Stockholm
   Univ. of Uppsala

4. Belgium
   Univ. of Brussels
   Univ. of Mons

The group from the University of Irvine will likely participate in the integration of Amanda into the phase-I IceCube strings but decided not to be a formal member of the IceCube collaboration.

Formal status of the IceCube Project in the four countries

1. USA

Most of the US budget for AMANDA has been supplied by the National Science Foundation NSF, Office of Polar Programs OPP and Physics Divisions. The cost of IceCube exclude a budgeting from normal NSF operational funds. Therefore, this project will be classified as a **Major Research Equipment, MRE**, with external additional funding to be approved by Congress.

Typically, the NSF funding of MRE projects is realized via a **host institution** which obtains the grant and distributes it to the other US institutions. The host Institution of IceCube is the University of Wisconsin. A **Principal Investigator (PI)** is responsible to the host institution for scientific and technical direction of the project. The IceCube PI is Francis Halzen (UW). The PI is supported by a project manager (PM) and a project scientist (PS), with the first concentrating on resource management, the second onto physical and technical realization of the project during the construction phase. The PM is Bob Paulos (UW), the position of the project scientist has been announced.

In 1998, a **Letter of Intent** has been sent to NSF. It was followed by a 65-page **Proposal** in November 1999. This proposal was sent to internal referees determined by NSF and was positively assessed. In March 2000, the IceCube project was presented to SAGENAP, the Scientific Assessment Group for Experiments in Non-Accelerator Physics, again followed by a positive recommendation. In June 2000, the project was presented to a review panel led by Donald Hartill ("Hartill committee"). This panel put emphasis not only on the science, but also on technology and management. The Hartill committee strongly endorsed the project's scientific merit but noted a number of deficiencies, most notably the open question of baseline technology and questions of management.

During the period since June 2000, these questions are either solved (as e.g. the decision for a baseline technology), or solutions are being worked out and will be finalized for a next comprehensive **baseline review in June 2001** again led by Donald Hartill. This review will present an opportunity to demonstrate that the project is ready to proceed in all respects: in terms of the science case; the technical feasibility of the project plan; the soundness and completeness of cost estimates; the demonstration of a realistic time schedule; the existence of a strong collaboration; and the implementation of an effective management structure.

The original schedule was based on the expectation that the IceCube project successfully passes the June review, and, after final approval by NSF and official implementation in the list of NSF MRE-projects, would pass Congress and gets first funding in FY02. In the mean time it turned out that the President's budget in FY02 will not include new major construction projects, therefore earliest possibility for MRE funding is in FY03.

For the year 2002, other sources of funding have to be found. We schedule the deployment of the first six strings for the season 2003/2004; therefore heavy equipment like the hot water drill, winches and cables, which will be transported by a vessel, have to be ready for transport in November 2002. This equipment has do be built or purchased. Also, personal costs in 2002 have to be covered. Provided internal approval, NSF might find a minimum funding to proceed from existing internal sources (as it was the case for AMANDA).

2. Sweden

The Swedish Institutions have asked in 2000 for 36 million Skr for the IceCube construction phase (3.7 million US$ at present exchange rate). This is pure investment cost, without salaries. In March 2001, they got an approval under the condition that IceCube gets funding in the USA. The requested funding will come in equal parts from the Swedish National Research Council and the Wallenberg Foundation. The capital contribution from Sweden will be the production of 900 optical modules (OM).

3. Belgium

The Belgian Institutions have asked for 1 million US$ investment cost. They expect a conditional approval in summer 2001.

4. Germany

The DESY group applies with the present proposal for investment cost of about 7 million DM over the IceCube construction phase. Universities in Mainz and Wuppertal will follow with applications to the German Ministry of Research and Education in summer, with a total of about 3.5 million for investment. The main contribution of the German institutions will be production and funding of 1500 optical modules.

Taken alltogether, the European contribution to investment and material cost would be 3.7 M$ from Sweden, 1 M$ from Belgium and about 5 M$ from Germany. This compares to an overall budget of 45-50 M$ for IceCube (see below), i.e. is of the order of 20%. This is lower than for the Amanda phase, but still represents a visible contribution. The man power contribution from the European partners (including workshop capacities) will be higher - between 25 and 30%.

The relation between Collaboration and NSF project

The IceCube project is conducted as an international project. Scientific goals and objectives are established by a Collaboration Board (CB). The CB is shared by a spokesperson. In April 2001, the present Interim CB elected Per-Olof Hulth (Stockholm) as Interim Spokesperson. The IceCube PI acts as co-spokesperson.

The collaboration board formulates science policy and goals and decides on matters of scientific publications, conference attendance, data access policy and the admission of new members. The CB will not manage the day-to-day problems of IceCube construction and data handling but has to approve all scientific and major technical changes.

2. General IceCube Schedule and Cost

The collaboration at present envisages the deployment plan given in Table 1:

Table 1: IceCube deployment schedule

season	number of strings	remarks
03/04	6	arranged around Amanda II
04/05	12	arranged around Amanda II
05/06	16	regular extension of IceCube
06/07	16	"
07/08	16	"
08/09	14	completion of IceCube

The following cost summary reflects the planning status of autumn 2000. It was compiled by the project managment group at the University of Wisconsin. It still assumes that US funding will start in FY02 (which is obsolete in the mean time). It also still assumes analog read-out of the optical modules via fibers. Since the digital read-out does not need fibers, cost for in-ice devices might reduce by 15-20% compared to the tables below. Other categories turned out to be estimated with a too low cost (e.g the drill equipment, for which new estimates end with approximately twice the cost planned 5 months ago). Therefore, actual overall cost will be only slightly lower than given below.

An actual cost and schedule plan based on the DOM technique is presently being worked out by the collaboration for the NSF June review. This plan will be also the basis for an updated plan to the DESY directorate.

Note that the tables below include personal costs, overhead costs, a contingency contribution and (if not mentiond otherwise) a correction for inflation. They do not include cost for flights and for drilling fuel, nor any cost for infrastructure at the South Pole. This significant cost will be covered separately by the South Pole operation budget of the NSF Polar Program Office.

Table 2: Cost Summary

Cost Category	**Cost (in million US$)**
Labor	52.5
Material	4.9
Travel	2.8
Overhead	19.7
Capital Equipment	44.4
Subcontracts	0.5
Total	124.8
Contingency	27.3
Total with contingency	**152.1**
Inflation	15.3
Total with contingency & inflation	**167.5**

The following table gives the time development for one of the categories, capital equipment, and for the overall cost.

Table 3: Cost for capital equipment per year

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09		Total
capital equip.	7.4	12.1	9.5	7.9	6.3	0.5	0.5	0.3		44.4
total cost	25.6	39.4	28.8	24.4	21.0	10.1	10.0	8.0		167.4

Table 4 gives the IceCube cost by subsystems. It includes contingency but not inflation, therefore the sum is 152.1 M$ instead of 167.5 M$. Note also that cost for each category include labor cost. Therefore, e.g. the sum for in-ice devices is larger than the cost for capital equipment in Table 2.

Table 4. IceCube cost summary by subsystems

Category	Cost in million US$
Management	8.5
Systems engineering	3.3
Education and outreach	2.3
Logistics	0.7
Drilling	10.7
Deployment	2.2
In-ice devices	61.3
Data Acquisition	19.3
Data Handling	13.6
Detector operations	8.0
Data Analysis	16.1
Total	**152.1**

Table 5 gives for the two categories of table 4 with the highest cost - in-ice devices and DAQ, a more detailed information. The first 3 categories comprise the in-ice devices, which are optical modules, cables and calibration devices. Although on ice and not in ice, the IceTop array is also listed here in its function as calibration detector for IceCube. The cost for cables will be reduced by about a factor of 2 since no fiber cables are used.

The first 3 columns give cost for capital equipment, material and labor. The final sum in the last column is larger than the sum of the 3 columns since it contains also overhead, subcontract and travel cost.

Table 5: Cost for in-ice devices and DAQ

	capital equipment	material	labor	total cost with contingency
Optical Modules	19.4	1.7	5.5	33.4
Cables (still including fiber cable!)	16.8		2.1	23.8
Calibration devices -light sources -IceTop -pressure & temperature sensors	1.7 0.4 0.25 1.0	0.02	1.1 0.3 0.8 0.06	4.1
DAQ	2.0	1.7	7.7	19.3

This cost is broken down for the optical module in Table 6. Note that these numbers are derived for the analog OM. The DOM will not contain optical components, this reduces cost for fibers and splitters to zero and penetrators by a factor of about 2. Also, the cost for the main PCB can presumably be kept lower, even taking into account that the DOM board is more sophisticated than the board for the analog OM. The total cost per OM from table 5, normalized to 5000 OM, would be 3.9 k$, and with the indicated cost savings **about 3.5 k$.**

Table 6: Cost for Optical Modules

Component	**cost in million US$**
PMT	6.2
Spheres and Gel	3.2
Fibers and splitter	0.5 → 0
Penetrators	1.7 → 0.8
Main PCB	4.7 → 4.0 ?
Base PCB	0.5
Flasher board	1.0
mu metal shield	0.5
mechanical components	1.1
Total	**19.4**

4. Roles and responsibilities

The distribution of roles and responsibilies is given below. For better identification, German institutions are underlined, irrespective whether they play a leading role for that subproject or not.

PMT: UW, **Germany,** Sweden
selection
procurement
coordination of procurement: IceCube project office
testing

PMT Base
Design: **DESY,** with LBL, **Wuppertal**, UW
Testing: **Wuppertal**
Interface to DOM: UW
EMI/EMC testing: **Wuppertal**, LBNL

Pressure Vessel
design and low-radioactivity testing: **DESY,** UW
procurement: **DESY**, Sweden, US

Connector
design: UW
procurement: UW

PMT Magnetic shield
design: **DESY**
procurement: **DESY**

DOM design
Hardware design and oversight: LBNL, **DESY**
Firmware: LBL, Sweden, Penn
DOM-surface Communications: LBNL, **DESY**
Quality Assurance: LBNL
DOM Board Manufacture: LBNL
DOM board burn-in: LBNL
DOM development test stand and manufacture: LBNL
DOM production test stand design and manufacture: LBNL

DOM assembly, burn-in and testing: UW, **DESY**, Sweden
assembly
burn-in
test suite in northern hemisphere
test suite in McMurdo
test suite at Pole
pack and ship

Integration of DOM elements
mechanical: UW
electrical: LBNL

Calibration light sources: UCB, UW, others
source to generate light according to photon table waveforms
various specialized devices

Temperature and Pressure sensors
selection: UCB
procurement: UCB
deployment: UCB
analysis and archive of output data: UCB

Hole Drilling: UW, Sweden

Main electrical cable: UW, with input from LBL and in situ devices groups
design: UW
procurement: UW
coordination: UW

String commissioning
verification: LBNL
testing: LBNL

Deployment
coordination: UW, UCB

IceTop
construction: Bartol, UW
cables: Bartol, UW
interface to DAQ: DAQ group, with Bartol input

Wavelength Shifter: Belgium
design
test

Slow control: Belgium
HV control
DOM program (LBNL)
GUI interface
Low voltage control
monitoring interface

RAP timing & other DOM-related code: LBNL, others

Power supplies: UW
System engineering
determination of power budget
UPS specification
UPS procurement

Racks, Crates, Lab Layout: UW, LBNL

DAQ Online
DOM hub (converts string output to ethernet): LBNL, **DESY**
Trigger processors : Penn, Sweden
Event Builder: **Mainz**

Online filter
Design and implementation: **<u>Mainz</u>**, UW, all
Data handling to disk at Pole: UW, **<u>Mainz</u>**

Database: Belgium

Monitoring: **<u>Mainz,</u>** LBNL

Calibration:
UCB, S, Penn, Bartol

System Integration: UW, LBNL

Interface Management: UW, LBNL

Data Reconstruction: LBNL, UW, **<u>DESY</u>**
software design: LBNL, Belgium, **<u>DESY</u>**
large scale production reconstruction: LBL/NERSC, UW/SSEC, **<u>DESY</u>**

Data simulation:
software design: LBNL, Belgium
detector simulation: UW, UCB, **<u>Wuppertal</u>**

Part IV

Planned contributions of the DESY group

The DESY group plans to participate in the following IceCube activities, with the first 5 items referring to development tasks and the last points to production, maintenance and analysis.

1. Detector optimization (design & physics possibilities)

The present IceCube configuration was optimized with respect to high energy muons by M.Leuthold and H.Wissing (DESY). Simulations for cascade like-events have been performed in Irvine and Wisconsin. Algorithms to use the full waveform instead of the arrival time of the first photon only, are just beginning to be worked out. The effect of using the waveform, and the response of the detector to very high (EeV) and very low (< 500 GeV) energies have to be studied in detail. In addition, it is necessary to simulate the implementation of Amanda into IceCube. The DESY group wants to continue making a strong contribution to simulation and optimization of IceCube.

2. DOM development

2.1. Hardware design
2.2. Communication
2.3. Surface part
2.4. Physicist support

The DOM principle was originally proposed by the LBNL group. Also, the first simple DOM without time synchronization and without fast data transmission was build in LBNL and deployed at Pole in 1998. The DESY group started to test DOM components and demonstrated a time resolution of 2 ns in 1998. In the following year the Amanda collaboration decided to accept the DOM principle as a realistic alternative to the AOM. LBNL and DESY started a common development, with LBNL designing the DOM and DESY the surface DAQ. As a result of these efforts, 41 DOMs have been deployed in January 2000. They are read out in parallel over optical fiber and are therefore included in the standard Amanda DAQ. The main functionality of the DOM has been demonstrated only during the season 200/2001, with a time synchronization of 5 ns**.** Still, fast data tranmsission has to be demonstrated since at present only a small fraction of the data can be transmitted due to the slow transmission protocol.

The DESY group wants to continue to work on DOM development, in particular on the data transmission part, firmware implementation in FPGAs and surface front-end electronics. Also other groups like Stockholm will contribute to DOM development, e.g. by developing fast in-ice software for pulse identification. The support of the full collaboration is essential for a timely and reliable realization of the DOM.

3. Optical Modules: selection, tests

3.1. PMT : tests and selection
3.2. PMT Base: improvements and tests → Wuppertal
3.3. Pressure vessel: tests and selection
3.4. Magnetic shield: tests and modification
3.5. Construction of test facilities

The main contribution of the German groups shell be 1500 OM, with 1000 payed by DESY and 500 by the two Universities (see item 5). DESY has built for Amanda 50 OMs in 1995. The present active PMT base for the latest variant of the analog OM and for the DOM was developed and iteratively improved, following DESY requests, by the ISEG company (Germany), and tested and implemented in DESY. Also, DESY has built prototypes of the mu-metal shield, which is indispensable to operate 10" PMTs. The DESY group, together with the other German groups, has the expertise to play a significant role in selection and test procedures and quality assurance for all components of the OM. This activity will start as soon as possible. The University of Wuppertal will take over further PMT-base developments.

4. Software design

4.1 General software strategy and design
4.2. Simulation
4.3. Reconstruction

The DESY group plans to continue its strong engagement in software development. Actually, most of the present standard Amanda software has been written at DESY, like the detector simulation program *amasim* (by Stephan Hundertmark, now Irvine), the program *pdt* tabulating the photon yield (by Albrecht Karle, now Wisconsin), and the reconstruction package *recoos* (by Christopher Wiebusch, at CERN from May 2001). We note that, if the DESY group wants to continue playing a significant role in software development, we need an experiencend software/analysis physicist starting from next year.

5. Optical Modules: production

5.1. Electronics tests
5.2. Bare PMT tests
5.3. Potting and mounting
5.4. Test and calibration of fully assembled OM

The capital contribution of the German groups will be 1500 OMs, to be build by a common effort (money and personal) in DESY Zeuthen (see below), with 2/3 be funded by DESY and 1/3 by the two participating Universities. The ordering of the various components will be shared in the way that is most efficient for ordering, quality control, assembly and commissioning.

6. Installation and calibration

The group will participate in the installation and calibration of the detector at the South Pole.

7. Maintenance

The group will participate in maintenance and monitoring of the detector which is strongly related to physics analysis.

8. Large scale data processing

One of the two centers for large scale data processing could be in Germany. The present Amanda PC cluster in Zeuthen would be updated as soon as first IceCube data await processing.

9. Analysis

The DESY group will participate in the physics analysis of the data.

The IceCube activities 1-9 have to be conducted in parallel with Amanda-upgrade, maintenance and analysis efforts. In particular for 2001-30, we plan to put signifcant effort into Amanda-II analysis.

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The mentioned activities are along the line of our past activities in Amanda and along the line of our preprational activities for IceCube. This concerns analysis software as well as OM production and development work on the DOM. We note, however, that our present manpower has to be increased in order to continue our visible activities in all of these fields.

Cost

The following table summarizes planned expenses for investment and material over the years 2001-2009.

Table 8: DESY expenses for investment and material in 2001-2009 (thousand DM)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	total
1. simulation		-	-							-
2. DOM developm't	60	50	-	-	-	-	-	-	-	110
3. OM: selection, developm't tests	120	50	-	-	-	-	-	-	-	170
4.Design software	-	-	-	-	-	-	-	-	-	-
5.OM production		700	1100	1000	1000	1000	1000			5800
6.Install & calibr.	-	-	-	-	-	-	-	-	-	-
7.Mainte-nance & monitoring	-	-	-	30	30	30	30	70	100	290
8. Data processing	-	-	-	200	300	-	-	300	-	800
10 Analysis	-	-	-	-	-	-	-	-	-	-
11.Upgrade & Mainten. Amanda	150	100	20							270
Total	330	900	1120	1230	1330	1030	1030	370	100	7440

For table 8, we have assumed that DESY carries the expenses for 1000 optical modules, and also assume a price of 5800 DM per module. This implies a cost sharing for DOM electronics, with the larger part payed by LBNL. Note that the distribution over the years is still subject to change and has to be adjusted according to component production, deployment plan and available funds. The two German Universities are planning to carry the expenses for the additional 500 optical modules (about 3 million DM). All OM will be assembled and tested in DESY.