June 6, 2007

Report of the 2006 External Review Committee for the Institute for Cosmic Ray Research

Committee members:
B. Barish, J. Cronin, W. Hofmann, K. Kodaira, K. Nakai,
H. Sugawara (chairman), A. Suzuki, Y. Tanaka

The committee reviewed the scientific activities of the Institute for Cosmic Ray Research (ICRR). The hearing session was held on October 19 and 20 of 2006 at the Kashiwa campus with all the committee members attending. The schedule of the hearing session is listed in appendix B. The committee evaluated some of the completed, on-going and future projects. It also makes some comments on ICRR organizational issues.

1. Summary

A. General research environment to which ICRR is currently exposed

The committee understands that the current emphasis of scientific research in general is towards its applications, not only in Japan, but worldwide. Cosmic ray physics and astro-particle physics are among the least interesting fields for those who are exclusively interested in the industrial applications of science and technology. The main problem for basic research is the generally negative attitude towards fundamental science. The huge Japanese national budget deficit also is affecting the minds of government officials who hesitate to invest in basic science.

The lack of appropriate funding for rather expensive scientific projects is often attributed to organizational or structural problems in the university system. This structural issue is important, but it could be corrected if the interested parties can reach an agreement. This will be discussed in section 3 of this report.

Another point the committee wants to make is that many of the ICRR projects should be international collaborations. In order to facilitate international collaborations ICRR needs to nourish an environment in which varieties of ideas and approaches can be incorporated. The committee, therefore, recommends that ICRR hire more Japanese women researchers, as well as more women and men foreign researchers.

B. Summary of review of individual projects

The committee highly appreciates the contributions to the scientific community over the last several years of Super-Kamiokande and K2K. The properties of neutrinos have been much clarified, although there still remain some important parameters to be fixed in future experiments, such as θ_{13} or the CP parameter "δ".

Super-Kamiokande must be ready to observe the next nearby supernova explosion by making it more sensitive to neutrons and it should also be prepared for the next generation of long baseline neutrino experiments (T2K). The committee is happy to learn that ICRR is working hard towards this goal.

Understanding the properties of dark matter, or just finding what it is, profoundly affects particle physics and cosmology. In principle we should be free of any prejudice about what it could be, but in practice the design of the detector needs some guidelines and it is probably acceptable to follow the currently popular idea of dark matter being the neutralino. The XMASS project, which is being designed along this line, is a fine one. The committee acknowledges the R&D activities of this project and it appreciates that the plan of splitting the project into two stages is a reasonable procedure.

AGASA has provided the community a controversial, but potentially exciting set of data on the highest end of the cosmic ray spectrum. Currently, the most sensitive detector is the Auger South; it is five times more sensitive than the Telescope Array (TA). The committee understands that the two detectors are complementary in that they use different methods of spectrum measurements: the TA uses a scintillator that is sensitive to the electromagnetic component and Auger uses a water tank that primarily is more sensitive to the muon component. The committee recommends that the TA group should not exclude the possibility of joining international collaboration at certain stage unless some phenomenon which is unique to the northern hemisphere permits them to stay independent.

The committee is not unanimous in judging the rather ambitious Ashra detector (described in the next section). It is certainly tantalizing to have an all-sky detector, but sensitivity is an important element too. The Ashra may be restricted to observe gamma rays from AGN, but not much else. The committee was impressed, however, by the ongoing R&D which is going rather well.

CANGAROO I and II provided rather controversial data and it was worth the effort in provoking the community. CANGAROO III could still contribute to this field, but it needs further improvement of the mirrors. The committee recommends strengthening the group by internationalizing the project further.

The committee acknowledges the air shower array in Tibet would, after its upgrading, contribute significantly to the observation of gamma ray with the energies of 100 TeV or higher. This effort is in contrast to the other gamma ray detectors, which emphasize the importance of reducing the threshold value. The committee recommends that the Tibet Array should also emphasize research determining the primary cosmic ray components. This is a classic problem, but it still is an unsolved important issue.

The committee appreciates highly the extremely productive activities of Sloan Digital Sky Survey (SDSS). This is one of the most successful international and interdisciplinary projects. The committee also appreciates the Japanese contribution led by Fukugita. Among many important scientific achievements it is gratifying that the determination of cosmological parameters, especially of the value of the cosmological constant, has been given an independent check on the WMAP results.

The last frontier of astronomical observations is that of gravitational waves. The committee appreciates the R&D effort of the Japanese group led by ICRR, especially on the cryogenic system. Although the committee's role is not to survey the ICRR future plans, it strongly recommends that ICRR seriously consider working with other institutes and possibly with international participation on the construction of interferometer system with cryogenics.

２. Evaluation of Individual Projects

A. Super-Kamiokande, K2K and T2K

Super-Kamiokande

From 2000 to 2006 Super-Kamiokande (SK) had two shutdowns due to a November 2001 chain implosion accident: one in 2001-2002 (1 year) and the other in 2005-2006 (~10 months). SK was reconstructed first to half the original PMT density and then to the full level. The committee congratulates ICRR on the full recovery of SK in such a short time, made possible by the excellent, hard work of the ICRR group.

After the discovery of neutrino oscillations in 1998, the study of atmospheric neutrinos from 2000 to 2006 with larger statistics has produced further results on neutrino oscillations, specifically the precise determination of oscillation parameters, the discrimination between ν_μ to ν_τ and ν_μ to $\nu_{sterile}$ oscillations, the L/E dependence of oscillations, and the appearance of ν_τ.

As for the study of solar neutrinos, the comparison of solar neutrino fluxes between SK and SNO charged-current measurements, which was done in 2001, gave direct evidence for solar neutrino oscillations. This has solved the long-standing mystery of the “solar neutrino problem”. In 2002 global analysis, combining the precise measurements of SK with other solar neutrino experiments, showed that the LMA (Large Mixing Angle) solution is the most favorable one with 99% C.L.

The committee finds that Super-Kamiokande made critical contributions in understanding the nature of neutrinos and continues to produce essential physics. The committee expects further outcomes in the next decade by (1) searching for the finite θ_{13} in atmospheric neutrino measurements; (2) measuring the spectrum distortion of solar neutrinos, precisely to pin down oscillation parameters; (3) improving the proton decay life time for various decay modes; (4) watching supernova explosions; and (5) searching for supernova relic neutrinos with a thermal neutron tagging by loading 0.2% $GdCl_3$ into the detector water.

We also recommend studying mega-ton detectors, not only for future underground experiments, but also for neutrino-beam experiments.

K2K

K2K was the first accelerator-based long baseline neutrino oscillation experiment, launched in 1999 and finished in 2004. The ICRR group, as one of the host institutes for K2K, was responsible for the operation and the analysis of the K2K main detector, Super-Kamiokande, and for the construction, operation and analysis of the 1k ton water Cherenkov near detector (1KT).

K2K confirmed the neutrino oscillation in the ν_μ disappearance mode with 4.3 σ significance. In the analysis 1KT played an essential role in achieving that significance by providing precise measurements of neutrino flux normalization and energy spectrum especially in the low energy region (<1 GeV).

K2K also set the first upper bound on the mixing relevant to the ν_e appearance with an accelerator-based experiment. The dominant contributions from background events are π^0's produced in ν_μ neutral current interactions (NC). 1KT measured the cross section ratio of $\sigma(\nu_\mu \text{ NC}1\pi^0)/\sigma(\nu_\mu \text{ CC})$ with ~10% precision. This ratio was indispensable for evaluating the expected background rate.

In summary, the committee emphasizes that K2K successfully finished and achieved its physics goal. It provided universal knowledge on the nature of neutrinos, such as the definite confirmation of finite neutrino masses. On top of that it should be noted that K2K established the experimental procedure for long base-line neutrino oscillations based on accelerators.

T2K

The T2K project is the second generation long base-line experiment in which very high-intensity neutrino beams are produced using high intensity proton beams from J-PARC. The primary physics goals are to observe the ν_e appearance and to measure the ν_μ disappearance precisely. The neutrino beamline is under construction and aiming to start the experiment in April 2009.

Since the T2K beam is more than 50 times more intense than the K2K beam, θ_{13} can be searched down to 20 times smaller than the CHOOZ limit, and the oscillation parameters of θ_{23} and Δm_{23}^2 will be precisely measured. If the evidence of finite θ_{13} value is obtained, it will open further studies of the neutrino mass matrix and the CP phase in the lepton sector. The committee recommends that T2K should be promoted to one of the highest priority projects in ICRR.

The ICRR group is responsible for maintaining and producing data from the main detector, Super-Kamiokande. The development of new electronics is in progress and will be replaced in 2008. This is to ensure the long-term stability of detector operation, which is required by T2K. The committee endorses this decision and recommends completion of the development on schedule so that there will be enough commissioning time.

It is also recommended that ICRR take a leading role in the calibration and data analysis of Super-Kamiokande. The analysis of ν_e appearance requires background rejection far beyond the well-established e-like event selections, which have been used in the standard atmospheric neutrino analysis. This imposes much better understanding and more precise calibrations of the SK detector performance. Studies to establish the analysis procedure for the systematic error estimation, such as those of fiducial mass, particle identification and so on, should be initiated as soon as possible in order to obtain physics results in a timely manner.

B. XMASS

The XMASS experimental search for the dark-matter candidate is the most interesting challenge in solving the fundamental puzzle in cosmology, astrophysics and particle physics. It is also aiming at the detection of double beta decays and low energy solar neutrinos. With the 100 kg liquid-Xenon fiducial mass and 5 year exposure, XMASS has a sensitivity of about 10^{-45} cm^2 for spin independent interactions.

For the dark matter search this improves the current best limit of CDMS-II by 2 orders of magnitude. In case the upper limit is obtained, it will constrain SUSY models and will extend our understanding of the nature of dark matter, combined with astrophysics observations and accelerator search for SUSY particles.

The experiment will detect recoils from interactions of neutralino (a WIMP candidate) with nuclei in a liquid-Xe detector. The ingenious idea of using the liquid-Xe detector for detection of low-energy recoils (<500 keV) in extremely rare events has been tested successfully with a prototype small detector (3 kg fiducial volume). The committee understands that the physics target of XMASS with the 800 kg liquid-Xenon is strong, and endorses it as one of major projects of ICRR.

One of the key technical issues is to construct and operate the detector in a cryogenic environment. The XMASS group demonstrated this capability in the prototype detector. Another key issue in achieving this goal is to reduce background events. The XMASS group addresses this issue by:

(1) developing low background photomultiplier tubes,

(2) self-shielding property of liquid-Xenon detector is realized by giving capability of resolving vertex position,

(3) purification of liquid-Xenon, especially removing krypton by distillation. The photomultiplier tubes have almost reached the required quality level of low radioactivity.

The ‘self-shielding’ technology was developed and was shown to be effective in reducing low-energy background in the energy region less than 500 keV in the central fiducial region.

In the last several years R&D studies with the 3 kg prototype detector demonstrated that the vertex resolution was well reproduced by simulation, and that the Kr contamination was reduced by a factor of ~1000 with distillation. Other background activities from U and Th are still higher than the required level by a factor of 10~30. The committee urges the XMASS group to prove the possibility of reducing U and Th contaminations inside liquid Xenon. Much experience suppressing background from outside has accumulated at the Kamioka mine through the Kamiokande, the Super-Kamiokande and the KamLAND experiments. For the possible sources of background such as the ^{85}Kr contamination in Xe liquid and internal radioactivities in the photomultipliers, R&D studies have been done on greatly reducing the background during the process of system construction.

The committee judged that the feasibility to enter the construction stage of the 800 kg liquid-Xe detector (100 kg fiducial volume) has been well demonstrated; consequently, the committee recommends that XMASS proceed to the first stage of XMASS experiment at the earliest opportunity. Although the XMASS project is planned in two stages, the first-stage detector would already reach the world's best sensitivity with improvement of two orders of magnitudes from the present limit. The XMASS at Kamioka is competing with the SuperCDMS at SNOLAB and WARP at Gran Sasso. Early start of the first stage is very important.

The goal of the experiment to observe the neutralino as the most probable candidate; this is solely based on a theoretical prediction of super-symmetry. Consequently, the neutralino dark-matter search is a highly risky mission. Nevertheless, the fundamental importance compensates the risk, and the experimental effort has to be highly encouraged. The committee recommends concentration of efforts on the dark matter search, leaving other experiments (double beta decay and solar neutrino studies) for the second stage.

C. Telescope Array (including AGASA) and Ashra

Telescope Array (TA)

The Telescope Array (TA) project was proposed to confirm the data obtained by AGASA and to study the origin of the ultrahigh-energy cosmic rays. It was unfortunate, however, that the TA proposal took a long time before approval of its funding. Auger project started much earlier with a larger scale. For reexamination of such a crucial data it is certainly important to have two or more independent experiments. Extensive efforts by Auger and TA would be required for detailed studies of the events, probably under international cooperation.

Committee understands that Telescope Array is a hybrid detector in the Northern Hemisphere with an acceptance of the surface array of 1200 km^2sr. This is to be compared to the acceptance of the Auger Observatory in the Southern Hemisphere of 7000 km^2sr.

The TA is not yet operating, but from a technical point of view, there is no reason to doubt that after the usual initial problems with any large system, the TA will work very well. The sensitivity of the TA is about one fifth of Auger South.
The northern region has a more uniform magnetic field because it does not include the center of the galaxy and the flux from the northern sky is significantly different from that in the south. This will make a northern detector more insensitive to the magnetic disturbances from which southern detectors would suffer.

We note that in the next two years Auger South also will be reporting an elongation rate from 10^{17} to ~ 10^{20} eV. The Auger collaboration will be submitting a proposal for an array covering 10000 km^2 with an acceptance of about 23000 km^2sr. It is not clear that this proposal will be accepted. Data from Auger South may strengthen the case for a large northern array. It would seem that the ICRR should consider joining a collaborative effort to develop a very large northern array concentrating on the very highest energies. And, for the participation in international activities, the most important question from scientific viewpoint is 'what are original and unique Japanese contributions?' ICRR is considering the possibility of a major international collaboration in the northern detector after careful examination of the results from TA and Auger.

AGASA

There have been many discussions of the apparently different results between AGASA and the HiRes experiments. The first difference is that the reported flux of AGASA is larger than that of HiRes in the energy region where there are good statistics. The second is that AGASA with its published calibration has about 11 events above 10^{20} eV, indicating the lack of a GZK cutoff. The first difference is most easily accounted for by a shift in energy scale of either AGASA or HiRes by about 30% or a shift of either by 15%. AGASA certainly measures well the parameter S(600) (density of particles in the shower plane 600 meters from the axis).

The methodology for the measurement of S(600) is sound. However, the conversion from S(600) to energy involves simulations using hadronic interaction models in a domain of unknown physics, which might be in error by some 30%. However, it is important to note that the absolute fluorescence efficiency has a systematic error of at least 16%. Also, the published spectrum from HiRes uses mono data, which are prone to significant errors in the geometrical reconstruction. The exact difference between AGASA and HiRes awaits the completion of the HiRes stereo data, which has not been published. Also there are a number of experiments that are measuring the absolute fluorescence efficiency with much greater precision. This could lead to a significant shift in energy scale of fluorescence experiments. It is entirely possible that the differences between AGASA and HiRes will be greatly reduced. If the energy scales of AGASA and HiRes are brought into agreement, the excess of events beyond the GZK cutoff is not statistically different for the two experiments. The ICRR should take pride in the AGASA experiment, which has been well executed.

Ashra

Despite of the fact that the project is 'not authorized' as an ICRR project, the group has made innovative developments for a new step of gamma-ray astronomy by a personal effort being supported by the JST fund. Ashra is a unique detector covering a broad field of view (80 % of full sky) with fine directional resolution (of about 1 arc-minutes), which allows simultaneous monitor and observation of transient phenomena by high-energy gamma-rays as well as optical light. The group emphasizes observation of the gamma-ray burst (GRB) to start with, and various possibilities are discussed. It is also notable that the all-sky long-term observation enables Ashra to detect very rare events, such as those at ultra-high energy. The possibility to find high-energy tau-neutrino coming out from the earth after lepton flavor oscillation of cosmic neutrino is interesting, though it would appear only once a year or so.

The main question on this project may be, while it claims to do everything, does it do any thing better than existing experiments? It seems to the committee that to make a success more human resources and funds may be required to finish it.

As an all-sky optical burst monitor, it is to our knowledge unique and the chance of capturing GRB light curves during the full burst is exciting. Sensitivity is a bit on the edge, so it is open how many bursts this detector will see. As an all-sky VHE gamma ray detector, its sensitivity - especially for bursts - is better than Milagro or Tibet. A lot of people would be very happy to have an all-sky TeV burst monitor. The relatively high threshold will, however, limit this detector to nearby AGNs. For DC sources we believe most of the work will be done by H.E.S.S., MAGIC and VERITAS, but Ashra may still add a handful of sources, in particular off the by then well-studied Galactic plane.

As a UHE cosmic ray observatory, this detector will see a few events with very high angular resolution. The committee would be surprised if this produces new physics.

The committee is most uncertain, but Ashra, as a UHE neutrino monitor, may be in a regime where it is competitive but not leading. Overall, the committee is sure Ashra would produce some nice physics, and there is some potential for surprises. The unique features of Ashra as a survey/monitoring telescope would provide prompt information of any flushing event useful for detailed analyses with other telescopes. Collaboration of Ashra with telescopes such as Subaru, H.E.S.S. as well as other detectors should be encouraged.

D. CANGAROO

High-energy gamma-ray astronomy is a rapidly developing field and the ICRR group was among its pioneers. CANGAROO was the first modern Cherenkov telescope operating in the southern hemisphere and its initial results – such as the discovery of high-energy gamma-ray emission from the supernova remnant RX J1713-3946 – have contributed much to stimulate the field and motivated the construction of the CANGAROO III telescope system, as well as other instruments, such as H.E.S.S. Some of the spectacular claims by CANGAROO I and II have since been retracted, with the apparent gamma-ray signals being traced to poorly understood features of the image analysis. The improved analysis techniques developed for CANGAROO III are, however, paving the way to reestablish confidence in CANGAROO analysis and their results. Compared to other instruments, such as H.E.S.S. in the southern hemisphere (which started operation shortly after CANGAROO III) or VERITAS in the north (which was completed in Fall 2006), CANGAROO III provides reduced sensitivity by a factor of about 3. This can be traced to the fact that the first of its four telescopes has an inferior camera and is not operated anymore, and that the mirrors of all telescopes have undergone severe degradation, both concerning their reflectivity and spot characteristics. In addition, the smaller dish area (compared to other telescope systems) and the location at sea level result in an increased energy threshold. CANGAROO human resources, both at ICRR and in the collaboration as a whole, appear marginal.

Without question, it is highly desirable to operate, besides H.E.S.S. in Namibia, another gamma-ray instrument in the southern hemisphere, providing redundancy and cross checks and allowing the recording of transient gamma-ray emission from variable sources such as AGN without long observation gaps. For CANGAROO to play this role in the longer term, resources need to be invested in the replacement of mirrors and the upgrade of the camera and electronics of the first telescope. Concerning the mirror replacement, some additional R&D is required, since no straight-forward technical solution is at hand. The collaboration should be strengthened, in particular seeking international partners; the committee realizes, however, that this may prove difficult at the current time. The committee supports and encourages attempts to seek funding for the upgrade of CANGAROO. In the medium to long-term future participation in the developing multinational efforts towards development of a next-generation instrument is recommended, as compared to smaller-scale national activities.

E. Tibet

The Tibet AS-gamma Experiment, in collaboration with Chinese scientists, is the only operating air shower array at high altitude. They have a beautiful apparatus: they can measure asymmetries at the fraction of a percent level. The current emphasis is on the detection of high-energy gamma rays in the range 3-100 TeV and decomposition of primary particles around the "knee region". The committee has reviewed the results obtained so far, as well as the potential of the experiment.

Regarding 100 TeV or higher gamma-ray astronomy, the committee takes the point of view that it would be very important for the Tibet array to continue this effort since other detectors, such as air Cerenkov telescopes, emphasize the lower energy region and try to lower the threshold energy. The currently planned upgrade of gamma-ray identification is very important.

The high-altitude array has an advantage in disentangling the classic problem of primary composition. The recent advancement of model simulations is noticed. The key issue is the systematic uncertainties, which would be difficult to squeeze. The committee, therefore, suggests that they have a workshop to discuss whether the proposed upgrading is indeed sufficient. It is also recommended that the workshop will also discuss what the future of this project should be.

F. SDSS

The Sloan Digital Sky Survey (SDSS) is a project to undertake a photometric survey of about a half of the northern sky and a follow-up spectroscopic survey of over one million astronomical objects, complete within precisely defined criteria. The production observation started in early 2000, and SDSS-I ended in June 2005. This survey extended the volume of the well-studied universe by a factor of more than 100. The accumulated comprehensive data were made public as DR5 in July 2006. The SDSS data were and are being used for a wide variety of studies in astronomy and astrophysics. The representative issues are the large-scale structure of galaxy distribution over a very large volume of the universe, detailed characteristics of properties of galaxies and quasars, gravitational-lens phenomena, Galaxy structure, and lowest-mass main-sequence stars.

The contribution of the 6-member Japanese Promotion Group (JPG) was mostly to photometric instrumentation, which included (1) the design, construction, and verification of the mosaic CCD camera with its readout electronics and pipeline, and optical filters, and (2) the initial design of the target selection for spectroscopy. The general success of SDSS should be attributed largely to the solid achievement of the 3 ICRR members in JPG, in addition to the strong initiative and commitment of the JPG leader, Prof. Fukugita, who promoted the total SDSS Project throughout all the phases. Over one hundred SDSS papers carrying the names of the ICRR members were published in international refereed journals. The most valuable contribution of the SDSS group was the confirmation of the validity of the ΛCDM cosmology model with high-quality quantitative data for the middle z-range with the discovery of the acoustic peak in the point correlation function. In summary, the SDSS activities by ICRR members in last years were well rewarded and are highly evaluated.

Now that the initial mission by ICRR members was realized, the SDSS-II program for the remaining spectroscopic targets shall be pursued with much less commitment of ICRR, and science results shall be harvested from SDSS database by the larger community. The huge SDSS database is now mirrored at the NAOJ (National Astronomical Observatory of Japan) Data Center (according to previous recommendation of this Review Committee), and is open to Asian researchers. It is recommended that ICRR, jointly with NAOJ, actively advertise the availability of the SDSS database to a wide range of researches in astronomy and astrophysics. The Japanese science community may make better use of the SDSS data in combination with observation programs of the Subaru Telescope and the IR/X-ray Satellites.

G. **Gravitational waves and the proposed LCGT project**

Direct detection of gravitational waves is a major goal in physics and astronomy worldwide.

Albert Einstein predicted gravitational waves in 1916. Strong evidence for their existence was provided in the binary pulsar timing experiment (PSR 1913+16) of Hulse and Taylor, and we expect direct detection will follow within the next decade. Large investments have been and are being made worldwide toward detection with large scale interferometers in Japan, Germany, Italy and the U.S. The TAMA interferometer was the first large scale interferometer to become operational for science and did several initial measurements. It has been surpassed by the LIGO interferometers and others which are much larger and more ambitious.

LIGO is in the midst of a major data run at design sensitivity for the initial interferometers and could possibly detect gravitational waves in the near term, but most expectations are that it will require a major upgrade, called Advanced LIGO, to make actual detections. That upgrade has been approved and proposed for funding by the NSF; it is included in the President's FY08 budget and likely will be approved for funding by Congress this year. If so, the time-scale to reach design sensitivity for an operational Advanced LIGO is about 2013 (or somewhat later).

It should be stressed that observations of gravitational waves is the beginning, not the end of this topic. Such observations will open two important subjects: testing general relativity, even in the strong field limit, and opening a new astronomical window, gravitational wave astronomy. Therefore, the strategy in Japan is probably best served if a sensitive instrument can be built and made operational on the time scale of entering into these new scientific fields.

The Large-scale Cryogenic Gravitational-wave Telescope, LCGT, is a proposed next generation interferometer that will have sensitivity comparable to the Advanced LIGO design (expected to be operational in seven years). The LCGT interferometer configuration is similar to that of the Advanced LIGO, having arms 3 km long, but with some features that could give improved performance: 1) the facility will be built about 200 m underground, significantly reducing seismic and perhaps environmental noise; 2) the test masses in the two arms will incorporate sapphire cryogenic mirrors operating at 20 degrees Kelvin.

The unique feature of the LCGT design is its use of a cryogenic system to suppress thermal noise. Sapphire was chosen for the substrate material because of its optical thermal conductivity and measured high Q values at low temperatures. A test interferometer, the Cryogenic Laser Interferometer Observatory (CLIO), has100 m arms and sapphire test masses.

The CLIO project has operated with all mirrors cooled down to 20 K degrees, but there were heat flow issues; These have been fixed and the heat flow has been reduced. CLIO is being tested to improve the performance of the interferometer. Due to the reduced seismic backgrounds underground, the 100 m CLIO interferometer promises to exceed LIGO and Virgo sensitivities at very low frequencies.

The LCGT was proposed to cost $130 million, but funding proposals in both FY2006 and FY2007 were not approved. The reorganization of funding in Japan for large projects for fundamental research was an important contributing factor. The LCGT group remains committed and the members are actively pursuing their goals. LCGT has sought and received strong support from the international GW detector community, anticipating that LCGT will become an important part of a global network doing gravitational wave astronomy.

A new proposal is being submitted for FY2008, stressing international collaboration. The Japanese efforts in this area are unique (cryogenic). They also are important members of the larger international community and collaboration. The potential science in the field of gravitational waves is truly exciting and ground breaking, including both profound tests of general relativity and a new way to observe the universe.

Our committee could not perform a technical review of LCGT in the limited time available, but we can confirm that the goal of developing a cryogenic detector is unique and that this project could enable Japan to play a very important role in the evolution of an exciting new field of physics and astronomy.

H. Theory

The tiny theory group at ICRR is not only contributing to the experimental activities of the institute, but it also is contributing much to the understanding of particle physics and astrophysics, working with the researchers outside the institute. The theoretical framework which is popular at the present stage of physics (the so-called standard model or supersymmetric version of it with gravity) is not so powerful in predicting what to expect in certain experiments, due mostly to the appearance of too many parameters. This largely results from the lack of understanding of flavor physics. It is, therefore, hard to design a detector for finding something with some certainty. However, the group is making much effort to contribute towards this goal. The time may be coming that theorists should reconsider the validity of standard cosmology (due to the discovery of dark energy and dark matter) and/or the standard particle theory (due to LHC or ILC results which may be coming soon). Critical review of the existing theoretical scheme may be necessary at this stage. The committee strongly encourages the theoretical effort leading to suggestions for future experimental developments."

３． Comments on the organization of ICRR

In the review, some of the organizational difficulties of ICRR as an inter-university institute have become evident.

Typical examples are the CANGAROO and AGASA-TA projects. In these cases Japanese teams pioneered new fields through very interesting discoveries and kept leading positions for a while, but when other foreign groups joined the research field, the Japanese teams were not able to compete with them. This could be attributed to weak funding. Even so, the internationalization of the projects could have been more robustly pushed forward.

The main financial difficulty (which did not exist before 2005) is that all the university-affiliated research laboratories must submit their budget proposals through the university management. Before 2005 they were able to submit their budget more or less directly to the ministry. The purpose of the change was to increase the autonomy of each university. However, the result is that institutes such as ICRR must compete with other institutes within the university. In addition, ICRR is open to all users, not just those within the university. ICRR interests could be in conflict with the interests of the university.

There is another governmental funding system called “Kakenhi” whereby individual researchers can submit a proposal. Some of the ICRR projects depend on this kind of funding. This system can support a unique and original project with short-term funding (say, $1-10mil for 3-6 years) to build a facility. Unfortunately, after several years of construction there is no guarantee that the operation and management of the facility can be funded when the experiment or observation starts. Because cosmological and astrophysical research is inherently global international cooperation is an important element of the ICRR programs. In the case of international programs, the expenditures for the operation of facilities (telescopes) and for traveling abroad need to be much more than the case of domestic programs. A more important fact is that any international cooperative research will typically last longer than the 3 to 6 year period of “Kakenhi”.

Before 2005 ICRR had long been successful as an inter-university research organization with many research programs, in spite of having only a small number of staffs. Human resources for research activities in every program were supported by outside universities, and research funds for inter-university activities came directly from Monbusho at the request of the institute. However, in the new system ICRR has to ask the University of Tokyo to support inter-university expenditures.

KEK was founded as the first inter-university research organization, which is not affiliated with any university. KEK built KEK-PS, TRISTAN, and KEKB. Recently, INS, which used to belong to the University of Tokyo, moved to KEK to build J-PARC. National Astronomical Observatory of Japan (NAOJ) also separated from the University of Tokyo to build Subaru. Similarly, ICRR could move out of the university to build the MEGATON-class water Cherenkov Detector. Certainly, there is a merit to remaining with a university and the decision must be made with caution.

We know that Monkasho recently established a committee to discuss funding for research institutes, especially the ones affiliated with universities. ICRR management should follow the committee’s activity closely.

Appendix

A. Affiliation of Members of the 2006 ICRR External Review Committee

Name	Affiliation
Barry C. Barish	California Institute of Technology
James W. Cronin	Depts. of Physics and Astronomy & Astrophysics University of Chicago
Werner Hofmann	Max-Planck-Institut für Kernphysik
Keiichi Kodaira	The Graduate University for Advanced Studies
Kozi Nakai	Tokyo University of Science
Hirotaka Sugawara	Hayama Center for Advanced Studies, The Graduate University for Advanced Studies
Atsuto Suzuki	High Energy Accelerator Research Organization (KEK)
Yasuo Tanaka	Max-Planck-Institut für Extraterrestrische Physik

B. Program for the ICRR External Review meeting

Oct. 19th, 2006

9:00-9:30	Overview	Y.Suzuki
9:30-10:00	Closed session	
10:00-10:40	Super-Kamiokande	M.Nakahata
10:40-10:50	(Questions & Answers)	
10:50-11:20	K2K & T2K	M.Shiozawa
11:20-11:30	(Questions & Answers)	
11:30-12:00	Closed session	
12:00-13:00	Working lunch (at the Cafeteria)	
13:00-13:20	XMASS	S.Moriyama
13:20-13:30	(Questions & Answers)	
13:30-14:15	CANGAROO	M.Mori
14:15-14:30	(Questions & Answers)	
14:30-15:00	Closed session (coffee)	
15:00-15:45	Tibet	M.Takita
15:45-16:00	(Questions & Answers)	
16:00-16:45	TA (including AGASA)	M.Fukushima
16:45-17:00	(Questions & Answers)	
17:00-18:00	Closed session	
19:00-	Dinner (at Crest Hotel Kashiwa)	

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9:00-9:20	Ashra	M.Sasaki
9:20-9:30	(Questions & Answers)	
9:30-10:05	SDSS	M.Fukugita (presented by N.Yasuda)
10:05-10:15	(Questions & Answers)	
10:15-10:45	Closed session (coffee)	
10:45-11:20	Theory	M.Kawasaki
11:20-11:30	(Questions & Answers)	
11:30-12:15	Gravitational Wave	K.Kuroda
12:15-12:30	(Questions & Answers)	

12:30-13:00	Closed session
13:00-14:00	Working lunch (at the Cafeteria)
14:00-	Closed session