RIKEN-RIBF IAC Meeting Feb 23-25, 2006

Recommendations and Conclusions of the International Advisory Committee for the Accelerator research program at RIKEN

Following the invitation of the Director of RIKEN Discovery Research institute and of the Director of the Frontier Research Systems the IAC was asked to review:

1- **The activities of the Accelerator Research Program regarding**
   a) **Accelerator development and the on-going progress of the RIBF accelerator**
   b) **Development of experimental equipments:**
      Big RIPS and RIBF "Day One" Experiments.
      Major RIBF experimental installations –Phase II.
   c) **Accelerator-based applications**

2- **Recommendations and suggestions for the new organization "RIKEN NISHINA Center for Accelerator-Based Science**
   a) **operation of the NISHINA Center**
   b) **the Center's role in accelerator-based Science**
      the RIBF, RIKEN BNL, Research Center
      the RIKEN Facility office at RAL, Theory, etc...
   c) **Globalization**

Introduction

The members of IAC express their thanks to Drs. Yano and Motobayashi and to the RIKEN teams for their hospitality during our visit. We have also appreciated the quality and detail of the presentations and the written materials provided during and in advance of the meeting. Open discussions on the new proposed organisation were also appreciated.

We could not review all aspects of what was covered at the review in all its details in our report. In particular the IAC has used the outcome of the recent TAC review to formulate suggestions and recommendations on the items 1) of its terms of references.

Our main conclusions and suggestions are presented in the following:

The rate of progress in the construction of RIBF since the last meeting of the IAC in November 2004 is quite impressive, as was demonstrated in presentations during the meeting and the tour of the facility. The IAC congratulates the accelerator team for achieving a "major milestone"

The successful operation of all 6 magnetic sectors of the world largest cyclotron, the SRC.

The facility has great scientific potential and is well on its way to becoming a world-leading center in the field of RIB science.

-The IAC is pleased to note that the new Centre has been established along the lines that the Committee recommended in its 2004 report.

1- Review of the activities of the Accelerator Research Program

a) Accelerator development: the on-going progress of the RIBF accelerator

The accelerator group lead by Dr. Yano continues to make outstanding progress toward the completion of the RIBF Phase I accelerator complex. The IAC was impressed with the fast pace toward completion and the overall quality of the project. We note with pleasure the exemplary integration of various components and the coordination between industrial partners. The operation of all six sectors of the SRC cyclotron at the full K-value of 2500 is a significant accomplishment. We view this accomplishment in building the world's first superconducting ring cyclotron a milestone in the field of cyclotron design.

The status of the accelerator was reviewed in detail by a technical advisory committee (TAC), which met in November, 2005. We fully support the report of the TAC and will not repeat their finding and recommendations here.

As was also noted by the TAC, we did not have sufficient time to judge whether the ambitious goal of first operation in December 2006 is likely to be feasible, but it seems a reasonable goal. There are a large number of sub-systems yet to be installed, including the RF, injection and extraction systems for the SRC and RI Beam Delivery Line. Efficient coordination of these activities will be important toward reaching this goal.

The loss of helium caused by a failure of one of the ceramic feedthroughs has resulted in a delay in commissioning the SRC. It is believed that differential thermal expansion is responsible for this leak of helium into the insulating vacuum. This type of failure is normal for a project with this degree of complexity and innovation. Failures in other subsystems may well occur. A redesign has been completed and the failed feed through will be replaced by a unit with a smaller cross section that is expected to be less sensitive to differential thermal expansion. The remaining feedthroughs will be replaced as the availability of time and parts allows. Until all are replaced, they represent a potential failure mode that can result in extended down times.

The other cyclotrons the fRC and the IRC are progressing well and commissioning should proceed in a timely manner. Progress in the completions of other components is also proceeding well.

Plans for multi-use operation of the facility were presented. The IAC views such options as important expansions of the scientific potential of the facility and commends the management for giving them high priority. In particular, we are pleased that our previous endorsement for the development of a new injector linac (to allow the parallel operation of the heavy element program) has been followed. We note that this new injector is planned for phase II, but it is of sufficient importance that we recommend that it be implemented as soon as possible.
We also strongly encourage the management to look into the details of switching the beam after the IRC to allow both the present RIPS and super RIPS to run in parallel. Approximately 10 percent of the beam intensity would be available to be sent to RIPS. This will allow a large scientific output of the facility and meet the needs of a certain part of the user community, such as the polarized ion program.

b) The development of experimental equipments: BigRIPS and RIBF "Day-One Experiments, major RIBF experimental installations –Phase II

Status and Development of Big RIPS

Tremendous progress has been made in the implementation of the BigRIPS fragment separator and RI Beam Delivery Line. The system consists of a pre separator, a second stage separator and RI Beam Delivery Line. The pre-separator has been installed and cooled down. Installation of the other components and their testing is underway. Considerable work is necessary before the system will be ready for first experiments. It appears ambitious, but possible that the system will be ready for first beam in December 2006.

BigRIPS will be the world's most advanced fragment separator when it is finished. It includes many innovative features, such as two stages of separation and ion tagging, in its design and is well matched to the needs of the facility.

The Technical Advisory Committee reviewed the status and plans for the separator and spectrometer in their November 2005 meeting and we agree with the findings and conclusions of that report. In particular we agree that a full suite of diagnostics will be critical for the commissioning process.

Day-One Experiments

The facility plan is to commission the accelerator facility with uranium. It is intended that the same uranium beam also be used for the first radioactive beam production and the first experiments. This will make the secondary beam production and the experiments more challenging than the use of a lighter beam such as calcium or krypton, but it will provide a more thorough test of all aspects of the facility. The IAC feels that the use of a lighter beam may be more appropriate for the first demonstration experiments, but also applauds the plan of the management to make a more complete first test.

The commissioning of the facility is only ten months away. We strongly urge that the process of a "**Call for Proposals**" followed by a **Program Advisory Committee meeting start as soon as possible.** We agree that an initial beam list such as ^{238}U, ^{48}Ca, ^{86}Kr, ^{136}Xe, is appropriate.

An important step toward the use of uranium for commissioning of the facility was the acceleration of 10.7 MeV/u uranium in the RRC. The group achieved a uranium intensity of 10 pnA, which will be adequate for the commissioning experiments. We congratulate the facility on this important development.

The IAC notes that

a) The future operation of RIBF at 1 pμA for U beams depends strongly on the successful design and construction of a new ECR ion source beyond the present state of the art.
b) The operation of stripper foils at the full design intensity for very heavy beams needs to be established experimentally, as was also recommended by the TAC report.
c) Radiation hardness of the components remains a concern.

c) PHASE II Instrumentation proposals

Phase I experiments will open a new research frontier worldwide. Initially, BigRIPS with its focal plane detectors and RI Beam Delivery Line are well optimized to efficiently probe the discovery potential of RIBF. However, the utilization of the research capabilities and scientific opportunities will require more substantial investment in Phase II instrumentation. These are not financially supported yet and no priorities have been given. The Day-one experiments should be those that emphasize and demonstrate the power of RIBF. Priorities in the construction of experimental apparatus for phase II should be decided by continuing scientific evaluation, both within the Nishina Center and by the PAC process.

The phase II program includes the RI Spin Laboratory which will be used for spin-polarized RIB studies, material science experiments as well as for R&D studies necessary for the realization of some of the BigRIPS experiments. The major planned facilities employing the BigRIPS are the SHARAQ spectrometer for a variety of studies, including charge exchange reactions of exotic nuclei, SAMURAI for multiparticle spectroscopy, the SLOWRI facilities for stopped beam experiments, the isochronous storage ring for mass measurements and the electron-ion scattering experiment SCRIT. SLOWRI is a very nice and promising universal technique to study stopped RIs with short lifetimes which are difficult for ISOL techniques. Up to now, for the above mentioned instrumentation a lot of related R&D work has already performed. Particularly, one can expect valuable information about exotic neutron-rich nuclei produced by the in-flight fission of U.

Finally, a new linear accelerator is needed to continue the program to synthesize super-heavy elements. It is strongly recommended. In order to make certain of the synthesis of element 113 and to pursue further studies up to 114 and 115, the development of increased beam intensity and that of targets for intense beams will be necessary.

As in its previous report in November 2004, the IAC strongly finds that the timely realization of the Phase II program along the lines proposed, is crucially important to exploit the potential of the forefront accelerator facility.

The total cost of 5.8 BYen for Phase II instrumentation over the period from 2007 to 2010 was given. While the IAC has not been able to consider any details, the importance of the science to be addressed and the complexity and scope of the tasks is such, that the level requested seems reasonable

The successful and timely realization of Phase II will require a detailed plan for the organisation of the collaborations for each proposed facility. It is also likely to be necessary to set priorities.

Due to unique opportunities offered by the facility, the international context should be considered from the beginning.

d) Accelerator-based applications

RI Spin Laboratory

The RI Spin Laboratory is devoted to condensed-matter applications and hyperfine interaction studies with radioactive ions that can be used as nuclear probes in condensed matter to study solid state properties such as atomic site configurations and the hyperfine fields the ions are subjected to in static as well as in dynamic and relaxation conditions. They are particularly attractive to study nano-structured materials when selectively introduced at surfaces, at shallow depths or in multilayer structures, or to study very dilute impurities in semiconductor materials with externally controlled Fermi-level position

In Phase I the applications will be geared towards deep implantations connected with the high beam energies. The low energy beams planned in the Phase II SLOWRI project and the adjoining ISOL facility show promise for developing depth-selective implantations in multilayer systems and shallow semiconductors. In Phase II RIBF offers the prospect of using exotic short-lived isotopes that cannot be used in existing RI facilities. The possibility of developing the capability for multiple use is encouraged. The list of potential users was restricted to Japan; worldwide participation should be encouraged.

Application Research in Biology

Two presentations were made by members of the cyclotron group which impact the biological sciences:

Multitracer Technology. Multitracer technology, a method with carrier-free preparations allows the application of isotopes at non-toxic concentrations. In addition, multitracer mixtures of biologically relevant elements can be produced allowing for an analysis of the interaction between elements in biological systems.

Another method utilizes a Compton camera to localize elements in living tissue, for example ^{59}Fe and ^{65}Zn in animal and plant tissues. Even though the resolution of images from the Compton camera was low, this technique shows promise for the localization of elements in living tissues. The multitracer technology holds great promise for investigations into physiological functions of elements in living tissues and we look forward to seeing refinements in these technologies in the next several years.

Generating Mutations in Plants by Ion Beam Irradiation. Although ionizing radiation has been used for decades to generate mutation in plants, none have shown to be as successful as the application of heavy ion beams for the generation of mutations. Experiments with a range of plant species have now shown that useful mutations can be produced in horticulturally important ornamentals such as petunia, dahlia and begonia as well as in agronomically important species such as rice, barley and wheat. The advantages of this method of generating mutants are clear. They do not pose the environmental risks that are perceived with genetically modified organisms, and because they are not genetically modified, they are much less likely to receive resistance from the public. Evidence of this comes from the fact that ornamentals have been widely and successfully marketed with great success in Japan.

Generating mutants using heavy ion beams shows great potential and is very likely to become increasingly important in agriculture and horticulture. We encourage RIKEN researchers to explore the molecular and genetic basis of these radiation-induced mutations. An understanding of the fundamental mechanisms underlying these mutations is likely to improve the effectiveness of the process of mutant production.

2) Recommendations and suggestions.

2a-b) the operation scheme of the Nishina Center and the Center's role in accelerator-based science and the Center's role in Accelerator Based Science (RIBF, RIKEN BNL, RIKEN @RAL, Theory)

The International Advisory Committee is pleased that the new Center has been established along the lines it discussed in the 2004 IAC report. The Committee has several suggestions regarding the presentations that are listed here.

NAMES

Names do communicate information, and at a Center of international importance the terms used should convey the intended meaning to outsiders correctly. Along these lines the IAC has several suggestions.

a) The term 'Accelerator Physics' is a literal translation from Japanese and has a slightly different meaning in English ('the science of accelerators'). ***The committee suggests that the name of the Centre be changed to "RIKEN Nishina Center for Accelerator-Based Science".***

b) Similarly, we suggest that, in order that the intended meaning be better understood by non-Japanese speakers, ***the name of the 'Public Use Promotion Committee' be changed to 'Scientific Policy Committee',***

c) ***the name of the 'Collaboration Promoting Division' be changed to 'User Liaison and Support Division',*** and

d) ***the name of the 'Steering Committee" be changed either to 'Coordination Committee' or to 'Board of Directors'.***

POLICY

a) The IAC strongly applauds the statement made in the presentation that a guiding principle in the allocation of research time at RIBF will be that no distinctions will be made between inside and outside users. This is an important policy for a major international user facility.

b) The committee was also pleased to hear that the installation of experimental beam lines and of major equipment will become part of the responsibility of the Operations Group.

RESEARCH GROUPS OUTSIDE THE CENTER.

Significant, major components of the research program at RIBF will have to be carried out by groups that are not a part of the Center.

There are some such groups, with substantial involvement, that can be identified now and there will (and must) be others in the future. **It is important that a mechanism be found whereby major outside participants in research at RIBF become an integral part of the process of research planning at RIBF**. (Such groups, at present, are the CNS - University of Tokyo group and the Atomic Physics Laboratory at RIKEN). For the effectiveness of RIBF it is important that mechanisms be established, formal and informal, for a closer consultative and participatory relationship with such outside research groups, especially ones who have a major, longer term stake in research at RIBF with commitments to of their efforts and their intellectual, technical and/or financial resources.

THE COMMITTEE STRUCTURE :

a) **International Advisory Committee** is an outside review committee that is charged with focusing on the optimization of the scientific goals of the Center. Such a process is particularly useful to the effective operation of large facilities.

- But, such a review committee's effectiveness is best if it is focused on one major entity – in the present case the operation and scientific program of RIBF. ***The committee recommends that subcommittees be appointed, of a few people with the required expertise, to review activities at the Center such as the RIKEN BNL Research Center and the RIKEN Facility Office at RAL, and any other activities that are not an integral part of RIBF operations and research programs.*** These committees might perhaps meet less frequently than the IAC, and report through the IAC for overall coordination.
- The IAC is asked to review the research program of the RIBF – and there are major components of this program that are not directly under the Center. While these activities have their own review processes it would be very essential to the IAC's task if some members of such groups could directly tell the committee of their activities and plans (e.g. the Atomic Physics Laboratory of RIKEN, the CNS of the University of Tokyo, and others as it becomes appropriate).
- Possibly the membership of the IAC could be enhanced by adding a member with more direct experience of accelerator-based atomic physics as is now the case for solid state and biological applications.
- It is noted that the IAC reports to the Director of the Discovery Research Institute but the Organization Chart given to the committee does not reflect this. This should be corrected.
- The reports of the other major Advisory Committees, such as the TAC on RIBF construction, and the Program Advisory Committee in the future, should continue to be made available to the IAC before their meetings, together with a summary explanation of actions taken (or not taken) in response to them.
- At future meetings of the IAC it would be appreciated if the Center management could review the previous IAC report and comment on the specific actions that were taken since the previous meeting on the items discussed in that report.

b) The **Program Advisory Committee** considers **all** *Proposal*s for research at the RIBF and makes recommendation for beam time allocations to the Director.

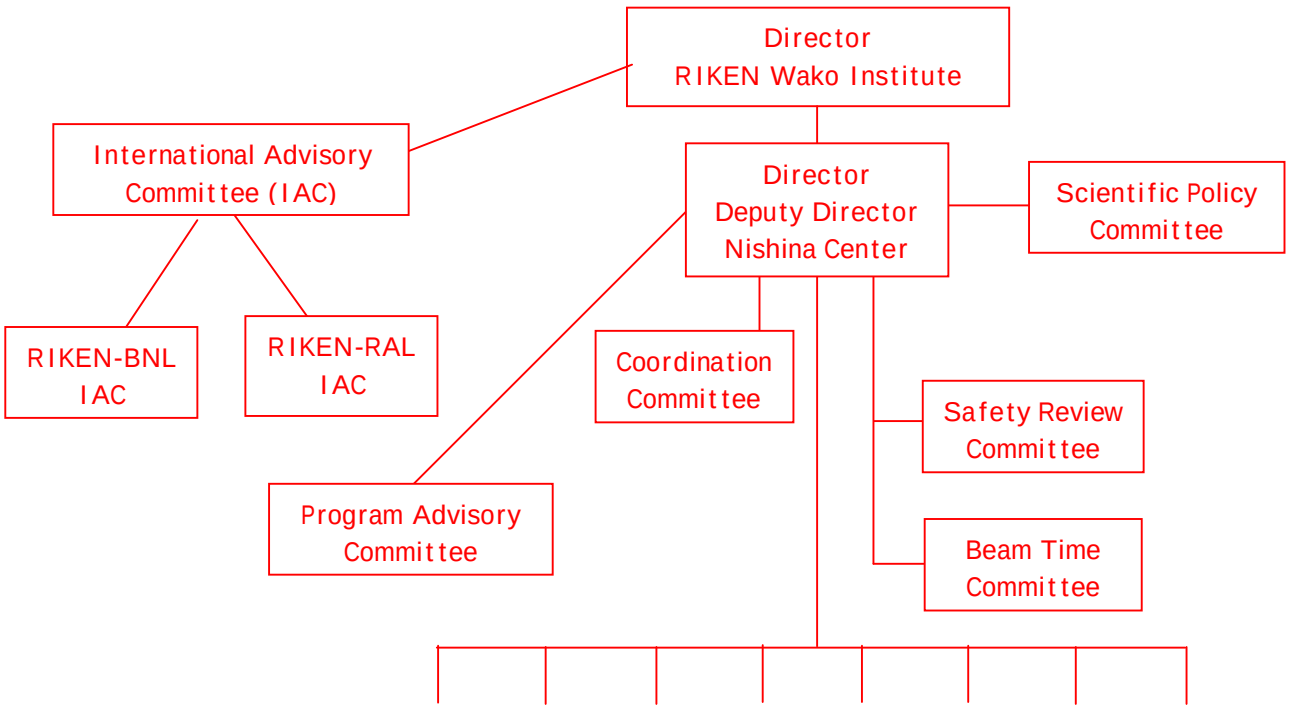
- The PAC also considers *Letters of Intent* on projects involving longer term development of experimental devices in order to examine whether the objectives of the proposed devise are appropriate for the RIBF program. Upon the completion of such a device, allocation of research time for specific measurements must be on the basis of specific further PAC Proposals.

– The PAC may occasionally ask that an appropriate outside expert be consulted or an *ad hoc* Technical Advisory Committees be appointed, when the technical issues for particular experiment or project require deeper or more detailed examination or expertise, beyond that available within the Committee. This requires prior consultation between the Center and the Chair of the PAC

c) The **Scientific Policy Committee** (presently Public Use Promotion Committee) is intended to assist the Director of the Center in decisions regarding major technical, budgetary or organizational alternatives, and in setting overall scientific, technical, and budget priorities between competing needs of different areas of research and different facility capabilities. It is seen as having some senior in-house members, some members of major user groups, and some with a broader perspective of the relevant scientific areas without necessarily having close ties to RIBF. This is seen as a more local group than the IAC or PAC, meeting perhaps twice a year to assist the Director regarding the overall status of the facility as well as to specific requests for advice on major policy issues. The reports and recommendations of this committee are generally internal documents that are transmitted to the IAC only when the Director finds it necessary to do so.

d) The **Coordination Committee** or the **Board of Directors** (presently Steering Committee) is likely to be an internal committee to help the Director of the Center in making day-to-day decisions, setting priorities and carrying out the complex tasks confronting the Center, especially in the operation of RIBF.

The Committee believes that the proposed committee structure would be better represented in the following organization chart



Center's role in accelerator-based Science (RIKEN BNL, RIKEN @RAL, Theory)

RIKEN BNL Center

After the birth of this RIKEN-BNL Center about ten years ago, this Center played an important role in promoting sciences centered at BNL RHIC. Particularly noted are: 1) theoretical contributions to the lattice QCD calculations, 2) muon-arm related sciences, for instance, the detection of heavy mesons with charm flavor such as J/psi's, 3) computing in the data analysis by creating PHENIX Computer Center in Japan (CC-J), and 4) spin physics with polarized protons at RHIC. Among them, it is widely known that the spin physics at RHIC became possible by having RIKEN at BNL. RIKEN constructed snakes and other needed facilities at RHIC. In addition, the intellectual leadership in this area came from Japanese physicists in the RIKEN-BNL Center. The IAC was pleased to listen to broad activities of this group.

The group spends about $7M/year for the activities at BNL. It is advised to form a subcommittee of IAC, which could be the same committee as the Scientific Review Committee of RIKEN-BNL, in order to monitor the role of this RIKEN-BNL Center within the Nishina Center. A regular report of this subcommittee to the Nishina Center IAC is important and useful.

RIKEN RAL Center

This Center's work has been concentrated on muon sciences with muon beams at RAL-ISIS. Quite a few pieces of pioneering work on the use of muons have originated from this group. The group has an intention to continue its activities at ISIS until J-PARC provides muon beam with intensity similar to that available at ISIS. The anticipated date to move from ISIS to J-PARC is around 2010.

Again, since the formation of the present IAC does not have a sufficient number of experts in this field, we advise to form a subcommittee of the IAC for RIKEN-RAL in order to monitor the role of this RIKEN-RAL Center within the Nishina Center.

The group intends to expand into two directions. One is to extend its muon work at 3 GeV at J-PARC and the other to initiate a new nuclear physics activity with kaon beams at 50 GeV at J-PARC, since Dr. Iwasaki's prime interest lies in kaon physics. In both cases, a close discussion between the J-PARC management and RIKEN management is needed, and such meeting(s) must be arranged soon.

Theory

The experimental RIB program is supported by a strong CNS/UT effort in theoretical nuclear structure, led by Prof. Otsuka, a world-renown nuclear theorist. Prof. Otsuka has started initiatives to extend and enlarge these theory efforts, in particular by building up international collaborations. Their initiatives have recently been awarded a grant by the Japanese Science Promotion Society (JSPS), which allows extending the scientific exchange with laboratories in USA and Europe. Furthermore regular theory meetings between RIKEN and GSI have been established and a strong collaboration with the RIA theory community has been initiated.

The IAC welcomes and supports these efforts to increase the national and international nuclear structure theory efforts. For the midterm future it would be highly appropriate to establish a strong theory group in nuclear structure and reactions and in nuclear astrophysics at RIKEN.

2-C Globalization

The RIBF facility is an important and unique international scientific resource. It is important that its use be optimized internationally and especially in Asian countries outside Japan. Countries with large numbers of well trained physicists such as China, India, Korea, etc. can be a major resource for skilled manpower in experiments. Collaborations with scientists in Europe and America are also highly desirable.
Riken is continuing to take steps to establish Nishina Center as a user's facility for both the Japanese and the international science community. (Building on the successful partnership with CNS/UT, Nishina Center proposes to establish and actively promote a 'Partnership Research system' which should facilitate the collaboration with and the involvement of other Japanese institutions in the Nishina Center activities and experiments. In particular, the IAC suggests that permanent equipment being brought-in from outside become part of the Nishina Center facility for common use, open to everyone.
Additional steps have been taken to open the facility to the international communities. In Feb 2006, a meeting to establish the Collaboration Council between Japan and China on nuclear physics has been held at RIKEN.

To further promote international collaborations the IAC suggests the establishment of an *'International Collaboration Program'* within the liaison user office.
Further active encouragement, particular in Asian countries beyond China, is strongly encouraged by the IAC.

On behalf of IAC

Sydney Galès
Chair of IAC–RIKEN RIBF