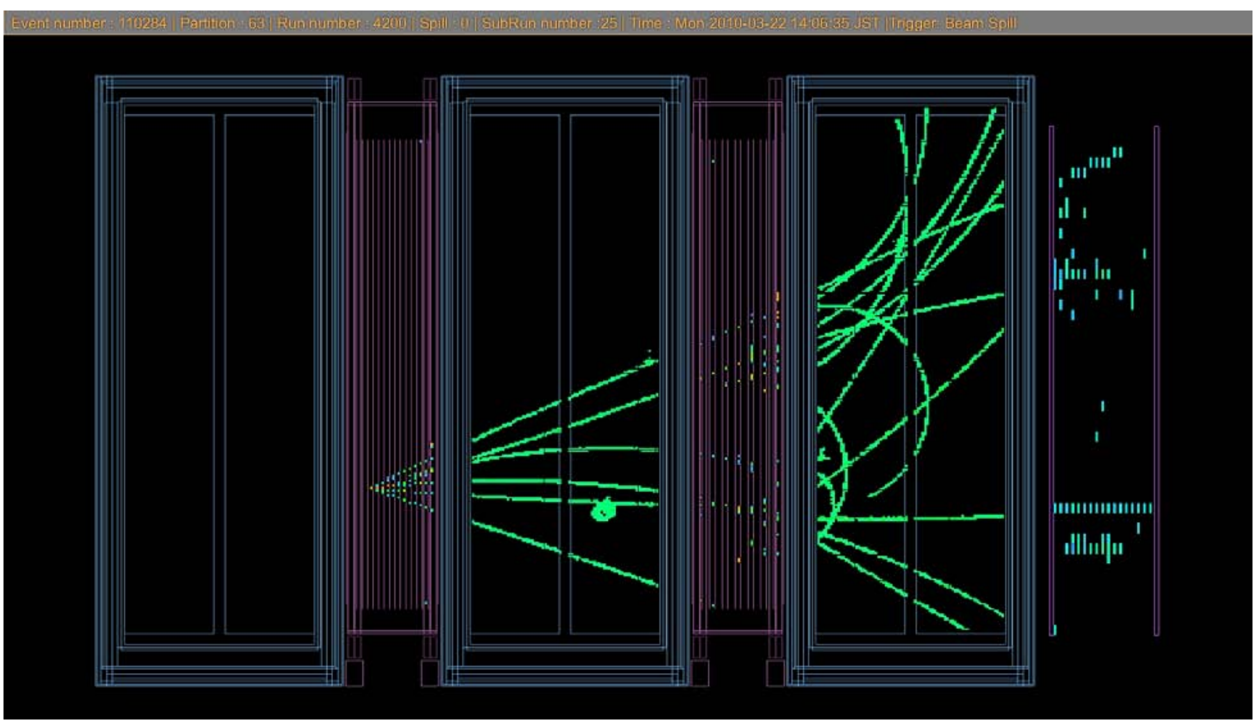
THE INTERNATIONAL ADVISORY COMMITTEE ON THE J-PARC PROJECT

Final REPORT

Meeting held Feb 21-22 2011

Tokai, Japan



Complex T2K event in the near detector tracker circa March 23rd 2010

8 April 2011

Contents

EXECUTIVE SUMMARY:

The tragic events in Japan on March 11th rendered the relevance of this report secondary to the recovery efforts needed to care for survivors and displaced people, to rebuild the country `s infrastructure and to restart the J-PARC complex. The IAC was relieved to learn that no losses of lives were reported at the J-PARC site and that the present J-PARC team is poised to take on the extra challenge of rebuilding the accelerators and experimental facilities. The recommendations of the IAC are to be taken as reflecting the situation before the earthquake and should be viewed as a record of the meeting`s discussions. The IAC hopes that the content of this report will be useful in time when the reconstruction is complete. The IAC would like to express its sympathy for the trauma that our colleagues are experiencing and offers to be of assistance in the recovery effort as may be required.

J-PARC as an International science laboratory

The International Advisory Committee (IAC) for the J-PARC project met on February 21st and 22nd 2011 at the J-PARC centre, Tokai and toured the main J-PARC experimental facilities. The IAC thanks the Director of KEK- Dr. A. Suzuki, the Associate Director of JAEA- Dr. H. Yokomizo, and Dr. T. Fujiyoshi Director of the Office for Quantum Radiation Research at the MEXT ministry for addressing the IAC and presenting the view of the partners in the project. The IAC thanks the J-PARC director Dr. S. Nagamiya for providing a comprehensive view of the laboratory through detailed presentations from his staff as well as from users representatives and advisory committee chairs. Hence the IAC received a very global view of the project on which to formulate its recommendations.

The IAC is pleased to witness the tremendous strides forward that have taken place in the last year and the emergence of world class science on all fronts. The facility has moved rapidly from the construction phase to the exploitation phase and is delivering a user program that is attracting a large community as measured by the increasing number of proposals being submitted and by the user presence on site. The IAC was also pleased to hear some of the early results in the presentations by several young and active participants in the program.

This comes at the right time; the Japanese government is implementing its S&T strategy which places Research, Development, and Innovation as the cornerstone of its policies. IAC thanks Fujiyoshi-san, Director of the Office for Quantum Radiation Research with MEXT for clearly establishing the goals of the program and its vision for J-PARC's role in this strategy. KEK and JAEA have built J-PARC into their respective road map for the future and are committing to the success of the program even though faced with budget and personnel limitations. The latter are creating non-negligible tensions in the system which is being controlled with better communication tools at the management level.

One of the measures of the quality of the infrastructure which has been developed at J-PARC is the beam availability achieved during the past year user time; this reached 90-95%, an efficiency rarely obtained at this stage of a new accelerator complex's life. This achievement is the result of dedicated work by a talented team at J-PARC and has now raised the expectations of the user community (nationally and internationally) which is pushing for more and more beam time and increased beam intensities.

The challenge then is to accommodate the understanding and the development of the accelerator complex while delivering stable and reliable user beam time. Many of the concerns, which now occupy management, are those associated with excellent operation of the multiple components of the J-PARC complex, and raising the performance towards the design goals. The achievement of these goals can be facilitated or hampered by the management structure and performance.

Recommendation*: IAC recognizes that both KEK and JAEA have placed J-PARC on their respective roadmaps for their future. J-PARC has succeeded to function remarkably well despite the complex and different relationships between the two partners, KEK and JAEA, and J-PARC. Some enhancements in the relationships between the J-PARC Directorate and the KEK Directorate have occurred over the past two years. While these changes undoubtedly point in the right direction, more should be done to ensure that the available resources are optimally deployed to achieve the overall scientific goals of J-PARC.*

The role of the J-PARC centre Director is key in the development of J-PARC and its positioning on the world scene. IAC recommends that both host institutions strive to maintain the international calibre of the position.

On the technical side, the IAC endorses the recommendations of the A-TAC committee (see Appendix III for the full ATAC report) that global strategies for both the energy upgrade and for the intensity development be established and monitored in concert with the user community which has to buy into the process. A-TAC was satisfied that a credible plan has been developed for the energy upgrade. However the intensity upgrade is still in the design phase. It is significantly behind the energy upgrade.

Recommendation: ***The operations plan should be augmented by a J-PARC-wide technical upgrade plan that describes the configuration of the complex, associated performance goals throug*h the upgrade period, and ensures that the necessary resources are available.**

The IAC recognizes the budgetary pressures faced by KEK and JAEA in supporting a strong user program while updating/improving the technical capabilities of the accelerator complex. The IAC is concerned by the imbalance of support from the two partners which has now developed and, in particular, the absence of the needed level of support to the Main Ring operations and improvements critical to ensure international leadership in long baseline neutrino, hadron science, and rare kaon decay programs.

Recommendation: ***All of the participants, J-PARC, KEK, and JAEA must continue and redouble their efforts to secure the appropriate levels of funding for all aspects of the J-PARC program*.**

INTERNATIONALIZATION OF J-PARC

J-PARC is already attracting a large non-Japanese community mainly in its flagship neutrino program and some of the hadron experiments. Commitment to future particle physics experiments with muons are also being pledged and the quality of the neutron beams is being noticed by external users. The IAC is pleased with the considerable support by both the J-PARC centre and by local authorities to improve access and environment for users with a particular attention to foreign users.

J-PARC is developing and implementing a strategy to aim at increasing the participation of Asian communities. The first join meeting with Korean researchers took place last August and will lead to new involvements for example in material science. Similar efforts are being made towards China and Taiwan. A neutron scattering association has been formed regrouping Asian and Oceania countries to promote this science, with J-PARC MLF being one of the foci.

The IAC very supportive of these efforts and considers that a large potential exists for making J-PARC a truly international facility.

GENERAL STATUS OF THE PROJECT

The International Advisory Committee (IAC) for the J-PARC project met on February 21st and 22nd 2011 at the J-PARC centre, Tokai and toured the main J-PARC experimental facilities. The IAC thanks the director of KEK- Dr. A. Suzuki, the Associate Director of JAEA- Dr. H. Yokomizo, and Dr. T. Fujiyoshi, Director of the Office for Quantum Radiation Research at the MEXT ministry for addressing the IAC and presenting the view of the partners in the project. The IAC acknowledges the second participation of the Mayor of Tokaimura to the reception on Monday which demonstrates the commitment of his administration to making J-PARC an attractive international destination.

The IAC heard reports from the Accelerator Technical Advisory Committee (A-TAC), from the Muon Science Advisory Committee (MUSAC), from the chairs of the Nuclear and Particle physics, and Neutron Program Advisory Committees, from the representatives of the neutron users, muon science users and hadron users. Presentations on the status of the laboratory by the Director- Dr. S. Nagamiya and on the status of the technical facilities were supplemented by science presentations highlighting the recent scientific achievements. Hence the IAC had a very global view of the project on which to formulate its recommendations.

The IAC is pleased to witness the tremendous strides forward that have taken place in the last year and the emergence of world class science from all fronts. The facility has moved rapidly from the construction phase to the exploitation phase and is delivering a user program that is attracting a large community as measured by the increasing number of proposals being submitted and by the user presence on site. The IAC was also pleased to hear some of the early results in the presentations by several young and active participants in the program.

MANAGEMENT: J-PARC, KEK, AND JAEA

As was discussed a year ago, the construction phase of J-PARC is complete; some aspects of supplementary construction are complete; and many of the concerns, which now occupy management, are those associated with excellent operation of the multiple components of the J-PARC complex, and raising the performance towards the design goals. The achievement of these goals can be facilitated or hampered by the management structure and performance. The recommendations of 2010 were targeted at balancing and mirroring the management structures espoused by the two partners JAEA and KEK in which J-PARC is embedded. Some progress was made, albeit at the level of standing meetings and communication. At the practical level of resource management the effects of the changes were limited. In the past there was a clear difference in the relationship enjoyed by the J-PARC center with the two parent organizations, JAEA and KEK. In particular there was little control, by the J-PARC director, of the resources coming from KEK.

More recently, the organizational situation between J-PARC and KEK has been somewhat clarified. There are now regular meetings, between Yokomizo (JAEA), Kamiya (KEK) and Nagamiya (J-PARC Director) in the first instance, and between J-PARC Director (Nagamiya) and the KEK Directors in the second instance. These initiatives have improved coordination. The J-PARC Director can influence the situation but this does not completely mitigate the absence of control of the KEK resources by the J-PARC management. The government has provided some operations support directly to J-PARC. This has permitted the access to the facilities to be broader than under the direct JAEA organization. This was a very good development. This so called “third party” construct is intended to be independent of KEK and independent of JAEA. It comes as a result of a specific law promoting the provision of user facilities. Funding has also been provided through a “new organization” to support extended activity in neutron sciences.

Again, the motivation by the government (MEXT) to provide for user access to neutron facilities is the driver.

As a result of these observations, we can comment:

- It is important that further efforts to balance the mode of participation between JAEA and KEK be aggressively pursued.
- The funding scheme used for the neutron science initiative appears to have many advantages for the management of J-PARC and it is a construct which might be used in other areas of the program.
- The need for some degree of independence of the J-PARC management has been recognized by MEXT.

Recommendation***: J-PARC has succeeded to function remarkably well despite the complex relationships between the two partners, KEK and JAEA, with the J-PARC centre. Some enhancements in the relationships between the J-PARC Directorate and the KEK Directorate have occurred over the past two years. While these changes undoubtedly point in the right direction, more should be done to ensure that the available resources are optimally deployed to achieve the overall scientific goals of J-PARC.***

BUDGET

The budgetary outlook has evolved both in the level of support and in its structure. In order to achieve the science goals for J-PARC strong support was sought in several areas:

On the operation side, increasing the number of user beam cycles from 6 currently to the optimum goal of 9 cycles per year is a priority (one cycle is approximately 22 days of user time). The proposed budget for JFY2011 can support 8 cycles for the 3GeV operation from a combination of funds from a New Scheme by the government and JAEA. Unfortunately, the level of operating support provided from KEK allows only 6 cycles of user time. J-PARC plans to use what limited flexibility it enjoys to provide the marginal cost of operating the MR of the extra two cycles. The IAC supports the effort by the Director to try and identify extra support for running 8 cycles for the whole complex. On the construction budget, aside from regular maintenance and minor upgrades, several major projects are either underway or awaiting decisions.

Recently**,** important components of the development program have been funded: the energy upgrade (LINAC to 400MeV and upgrades to the beam transport to the RCS has been funded over 3 years by a special budget allocation over three years (48 OkuYen) while new funds are made available for completing and supporting more neutron beam lines in the MLF.

For the intensity upgrades projects, several key decisions must be taken soon to develop a credible plan, as noted in the report of A-TAC (see Appendix III), and seek the necessary capital funding. In particular, the remaining R & D uncertainties still present in the upgrade plans for increasing the beam intensity in the Main Ring (Power supplies upgrade and high gradient RF) prevent the elaboration of specific capital requests for funding to KEK management require strong support in personnel and resources from J-PARC/KEK's accelerator group for the R&D studies . There are similar uncertainties on the 50 mA ion source and new RFQ needed to reach full design power in the RCS, which are under the funding responsibility of JAEA. In addition, there are several experimental facilities projects of high priority to J-PARC and to its users which are thus far not funded, they include:

- Substantial improvements to the muon facilities and most urgently installation of the front end components in the target tunnel.
- High Momentum proton beam line in the present hadron hall.
- Phase 2 Hadron Hall extension (under consideration by RIKEN)

On this later point, it is important to negotiate with RIKEN how they could contribute and participate in the hadron program. The IAC encourages a speedy negotiation between the partners KEK, J-PARC and RIKEN.

Overall, the relative level of support for J-PARC in 2011 from JAEA (including a substantial fraction of operation and capital funding from the new scheme) and that from KEK approaches a factor 2.

Recommendation*: The imbalance of support from the two partners and, in particular, the absence of the needed level of support to the Main Ring 8 cycles operation and to its improvements necessary to ensure international leadership in long baseline neutrino and rare kaon decay programs, is regrettable. All of the participants, J-PARC, KEK, and JAEA must continue and redouble their efforts to secure the appropriate levels of funding for all aspects of the J-PARC program.*

STATUS OF THE ACCELERATOR SYSTEMS

Routine operation of the RCS at 200 kW, of the MR fast extraction at 135 kW and MR slow extraction at 3.6 kW have been achieved with good beam delivery efficiencies which has led to an active science program.

During the beam development time, careful beam studies and simulations identified all the major loss mechanisms related to space charge and foil scattering.

The Linac energy upgrade to 400 MeV is proceeding well, with many components already delivered and being tested. Efforts are being made to reduce the downtime period for installation during the summer 2012 from 8 to 6 months. The schedule for final installation during the summer of 2012 is reasonable. The IAC endorses the A-TAC conclusion that the energy upgrade is in good shape.

For the intensity upgrade, the front-end (new ion source, new RFQ...) upgrades are in an early stage of design and will be completed after energy upgrade. The overall plan for 1 MW beam power from RCS after the energy and intensity upgrade of the front end is realistic. This is not the case for the MR intensity upgrades. The plan for 750 kW beam power for MR fast extraction will require the cycle time to be reduced from 3.2 s to 1.2 s. This will need new MR main power supplies.

Although slow extraction from MR has made good progress with excellent extraction efficiency and up to 30% duty factor, a 100 kW slow extracted beam power with good efficiency and duty factor will require significant improvements and likely the development of new power supplies for the main ring with very low ripples. Several options should be investigated as recommended by A-TAC. The most aggressive support possible for the J-PARC Main Ring modifications leading to increased power and enhanced duty factor is mandatory if J-PARC is to confirm its leadership in long baseline neutrino physics and to take a leadership role in the field of rare kaon decays.

The ATAC believes that the development of strategies for reducing the MR cycle time is a necessary investment to reach 750 kW of fast extracted beams and should be continued. However, the MR plan presented is not sufficiently developed to be deemed “credible”.

Recommendation: ***Schedule sufficient machine study periods for both RCS and MR to support machine performance improvements and the ambitious upgrade program.***

Recommendation: ***Develop a strategy for achieving slow extracted beam power approaching 100 kW that is supported by simulations. The strategy should take into account all known intensity dependent effects, incorporate comparison with beam experiments, as possible, and accommodate losses up to a few kW in the extraction region.***

SCIENTIFIC PROGRAMS

PARTICLE AND NUCLEAR/HADRON PHYSICS

The J-PARC program of particle and nuclear physics is supported primarily by the operation of the 30 GeV Main Ring (MR). The hadron program uses slow extraction to a number of beam lines in the hadron hall. The neutrino beam uses fast extraction and sends an off-axis neutrino beam in the direction of the underground water Cerenkov detector Super-Kamiokande at Kamioka nearly 300 kilometers from Tokai. For the hadron experiments the quality and duty factor of the beams are important. For both hadron and neutrino experiments, beam power is important.

The IAC was very impressed with the improvements both in fast and slow extracted beam. Long term operation above 100 kW for the neutrino experiment and the achievement of 99.5% slow extraction efficiency are great steps toward the higher power operation. J-PARC completed the first experiment in the hadron hall (E19). The IAC congratulates the J-PARC management and accelerator team for these achievements.

HADRON EXPERIMENTS

Currently there are two charged particle beams K1.8 and K1.8BR, which will support a number of experiments using charged pion and kaon beams to search for and examine nuclear structure and nuclear matter to study QCD under some specific and extreme conditions. Some are hypernuclear experiments which provide information on the forces inside the nucleus. Another searches for an exotic bound state called a pentaquark. The IAC congratulates J-PARC accelerator and beam line team and experimental groups for many accomplishments made during fall 2010 running. The power and the duty factor of the slow extraction beams have been greatly improved. Hadron experiments in the secondary beam lines (K1.8BR and K1.8) have observed charged kaons well separated from charged pions. The E19 (pentaquark search) in the K1.8 area took the first physics data successfully with 1.92 GeV/c pion beam, establishing a upper limit on the production cross section of the Θ^+ via ($\pi^- p \rightarrow K^- \Theta^+$) at the 0.3 μb/str level.

The IAC acknowledges that slow-extraction users and accelerator division met to improve communication. Short and long term plans for the slow-extraction beam improvement have been discussed. We encourage users and accelerator division to continue their good communication. Also being developed is a rare kaon decay installation, which will search for the decay of the K^0_L into a π^0 and neutrino-anti neutrino pair. The current state of the art suggests that this mode offers a window on new physics. Development of the beam line, which is being operated in test mode, and the experiment, will take place over the next couple of years. Progress has been made on each. The IAC is pleased to hear that the K^0_L beam line has observed neutral kaons ($K^0_L \rightarrow \pi^+\pi^-\pi^0$) and had a successful engineering run with the CsI calorimeter originally used in the KTeV experiment at

Fermilab. This experiment will require the utmost performance of the accelerator in terms of power and duty cycle. Other facilities include another low energy beam, K1.1BR and an extracted high momentum, primary, proton beam. The new K1.1BR beam line was successfully commissioned and is open for test-beam users. J-PARC is congratulated for this accomplishment.

E16 in the high momentum beam line (E16) is to measure the mass modification of vector meson in nucleus using $\Phi \rightarrow e^+e^-$. High intensity beam and a large acceptance spectrometer are needed for this experiment. Funding for the high p beam line has been requested in the FY2010 budget. This would complete the complement of beam lines intended for the first phase of hadron experimentation. In this context and expecting that there will be little conflict with the program to improve the existing slow extraction performance, the IAC supports this initiative.

Eventually to fully exploit the capabilities of the machine it is expected that the large hadron hall be extended. At present the funding for the extension is not in the planning although we heard an intriguing thought that the RIKEN organization might take on this task. The IAC encourages the J-PARC management to explore further this possibility.

Planning for operation for the next year reflects the tensions in play. Given the priority of the neutrino beam, it is likely that 60 days or less of hadron beam operation will be available in this coming year. In this context, the PAC has offered a set of priorities. However, the IAC would not like to see the laboratory sacrifice its longer-term needs for the beam duty factor and power to improve to an extended run of experiments for which the beam conditions fall short.

NEUTRINO EXPERIMENTS

The T2K collaboration with about 500 members from 62 institutions in 12 countries is a strong international collaboration. The T2K experiment, directing a muon neutrino beam from the Main Ring toward the Super-Kamiokande detector, is the centerpiece of the particle and nuclear physics program at J-PARC. There has been impressive progress in the past few years: Beam line completion in 2008; the first beam to neutrino beam line and beam commissioning in April-May 2009; the installation of the second and third horns and the completion and commissioning of the on-axis near detector (INGRID) in June-October 2009; the completion of the off-axis near detector and the first neutrino event in both near detectors in November-December 2009; the start of physics data taking in January 2010; and the first J-PARC neutrino event in the Super-Kamiokande detector on February 2010. T2K now has 48 neutrino events and the collaboration plans to release the first oscillation results soon. The IAC congratulates the J-PARC/KEK team and the T2K collaboration for this incredible progress and success.

The T2K has strong international competitors from other reactor- and accelerator-based neutrino oscillation experiments with a similar goal of improving sensitivity to the unknown mixing angle $\sin^2(2\theta_{13})$ to a level of 0.01 or beyond. In order for T2K to remain competitive or to observe electron neutrino appearance implying, a finite $\sin^2(2\theta_{13})$ first, J-PARC will have to improve beam power rapidly. The IAC was presented with a viable 5-year Main-Ring beam plan. The long shutdown planned in 2012 for the installation of the 400MeV linac will have a large impact on the physics output from T2K. Given the competitive situation with the reactor experiments and the NOvA experiment, the IAC recommends that every effort to minimize the no-beam period.

Recommendation: ***The IAC urges that a clear strategy for maximizing the impact of T2K be a critical component of an overall J-PARC strategic plan in the face of strong international competition.***

Recommendation: ***The T2K neutrino experimental program is well advanced. On the other hand the hadron program is still in its infancy. Nevertheless, we already see the competition between the two, and within the hadron program for both beam time and for construction resources. Several experiments seek 100% of the full power beam with excellent duty cycle. It is imperative that the user community see a path to the completion of their experiments. We recommend that J-PARC develop, in conjunction with its users, a flexible plan for seeking funding, for construction, and for operation over a five year period which is tenable.***

Hadron User Association

The IAC heard a report from the Hadron Users Association (HUA) which represents more than 160 Institutes, 25% of them being foreign. It has organized successful Activities: workshops, meetings, student awards and is articulating the needs of users to J-PARC management.

The scientific operation of the Hadron Hall has started successfully. However slow extracted beam time given to Hadron users has been moderate (20%), with intensities too low for several of the approved experiments requiring high statistics. For those, only commissioning of equipment or beam lines can be done under such conditions. This is valuable in the short term but would lead to too long data taking time (>6 years) for some experiments. Also the limited quality of the beam (poor duty cycle) precludes coincidence experiments.

It is critical to provide a realistic plan for increasing the beam intensity and improving the duty factor of beam spill to enable the proposed vigorous scientific user program. The range of competitive and rich hadron and nuclear science can be greatly expanded by providing additional beam lines and advanced instrumentation.

The IAC heard from the IPNS PAC chair how the PAC is approving experiments, monitoring their progress and prioritizing the program in particular recommending the distribution of slow versus fast extraction time. The IAC is satisfied that the process is fair and in accord with international standard.

Recommendations:

J-PARC in conjunction with HUA should develop a mid- term strategy for implementing prioritized experiments as beam intensity increases are realized. It recommends that the IPNS PAC be the arbitrator of the beam time assignment within that strategy.

The IAC noted the request for more space in the experimental area and was given a short briefing on the possibility that RIKEN would be prepared to seek funding for the extension of the hall and providing an additional production target. The IAC welcomes this initiative and encourages speedy negotiation between the partners J-PARC, KEK and RIKEN to establish the conditions of such a participation The committee notes that RIKEN has established successfully similar joint centres with foreign institutions (BNL-RHIC, RAL-ISIS, MIT…).

Material and Life Sciences

MLF Accomplishments and Status

The IAC was pleased to hear about recent successes in the initial user's operation at 200 kW beam power. The reliable operation of the neutron source is critical for the large community of users who are ready to perform experiments at the MLF. Some of the highlights of the last year's beam delivery are:

- Recent, sustained increase in beam power to MLF exceeding 200 kW is enabling a vigorous scientific user program. The range of science will expand as beam power is increased to match the quality of the advanced instrumentation
- Beam availability to MLF has been very high (>90%), apart from failure of the hydrogen accumulator.
- The hydrogen accumulator was successfully replaced and high power high-availability operation resumed.
- Good progress was made in developing mitigation of the pitting damage to Hg target using micro-bubbles. This work is important for making full use of the beam power available now and in the future from the RCS.
- A spare target incorporating the bubbler system will be produced by this summer

Comments:

The RCS is capable of delivering more beam power than can be handled by the current MLF mercury target system. Mitigation of mercury target damage caused by pitting is vital for realizing the full beam power capability of the RCS. The development activities related to mitigation of pitting damage by introducing micro-bubbles into the helium flow show good progress. Development of another spare target with the capability of introducing bubbles, now on-track for delivery in summer 2011, should receive high priority. In addition, it is necessary to build up an inventory of spare target assemblies so that the beam power is no longer limited by lack of spare components.

Recommendation:

1. ***Proceed with the plans to deploy the next generation target incorporating cavitation mitigation as soon as possible.***
2. ***Incorporate plans for target development and spares acquisition into the overall plan for beam power scheduling for the MLF.***

MLF Instruments

The number beam lines and instruments currently running, being installed or being commissioned is quite impressive with only 5 ports out 26 still to be allocated. The 21 allocated instruments are distributed as follows:

- 9 operating instruments
- 3 undergoing commissioning
- 6 under construction
- 3 at the planning stage

The IAC congratulates the team for building up the experimental capabilities very quickly and initiating an experimental program on 10 instruments. A notable success is the early engagement of Industry for the construction and use of the instruments – as witnessed by the support of Ibaraki Prefecture and the establishment of Industrial networks, such as Neutron Industrial Users Society, to promote the use of neutron beam research in industry.

The committee was pleased to hear that management has secured the establishment of financial resources for user support at the level of 6 FTE's per instrument, which is recognized internationally as the base requirement for a highly successful user program. It is essential however that these resources are used coherently across all instruments at the facility – this can only be achieved if such resources are managed at facility level. Furthermore, as the IAC has noted in the past, standardization is essential in order to maximize the utilization of available resources.

The committee noted that many activities are taking place in the MLF facility: instrument construction, installation, and commissioning must coexist with the establishment of a full user program. Experience at other facilities shows that it is essential that all participants remain aware of the safety risks involved with the associated changing conditions and that good coordination of all activities in the experimental hall, with a keen eye on the safety aspects, must be high on managements radar screen. In particular, the committee noted the need for storage space, and associated support manpower to accommodate the large number of samples being generated by the facility – a coherent structure and policy for dealing with user sample must be put into place.

Along the same lines, it is also essential that the MLF share best practices and capabilities internationally, in particular in the areas of sample environment, detectors and software - there is great deal to do with few resources. Internal efforts to develop analysis software did not seem well coordinated. The committee heard about the efforts to develop the STARGazer and Z-Rietveld analysis packages; while these are both clearly worthwhile projects they did not seem to fit into any overall facility scheme. Given the rather scarce resources for software development worldwide, we would recommend a more strategic view to software development.

The IAC would like to re-iterate its recommendation from last year as it was misinterpreted and is still relevant now:

Recommendation:

The IAC recommends that J-PARC adopts a coordinated and coherent approach to the operations and future development of the MLF, embraced by all partners. This will require an organizational structure that enables both the scientific and technical development to be owned equally by all partners and a process which ensures that the evolution of the instrument suite delivers world leading instruments fitting into a coherent strategy agreed upon by all stakeholders. The IAC recommends that great care be exercised in allocating the remaining 5 beam lines as they represent an extremely valuable resource.

MLF - achieving maximum science impact

It was a pleasure to hear brief summaries of recent scientific achievements at the MLF, both from facility staff, and from members of the external user community. A growing and diverse portfolio of science is now being addressed at levels of sophistication that approach the best in the world. Attracting international users – at a modest level – will help benchmark current MLF capabilities and provide impetus for future developments. All the hallmarks to create and operate a world-ranking facility are now in place, with a high potential to generate high impact science.

To consolidate this potential, it is essential to achieve a balance between in-house and user science programs in such a way that each enhances the other. The facility will be eventually judged by the impact of the scientific output and the range of scientific disciplines that make use of the neutron capability. This necessarily requires the implementation of a coherent strategy to achieve this impact which intertwines the internal and user science programs across all instruments at the facility. Hence, the selection process for all experiments at the facility must be carried out in a uniform way that allows MLF management to gain full understanding and oversight of the direction of the science program.

The IAC heard from the chair of the program advisory committee for neutron research and from the user's group representative. The procedures adopted to date, while adequate at this stage in the development of the facility, are fragmented; different experiment categories (Public, IP, S type etc.) are treated differently; this is inhibiting the facility from getting an overall view and direction of the science.

Furthermore the processes invoked will not stand up to expansion to the expected scale of the user program over the next few years. Other leading international facilities have been through similar expansion and consolidation exercises and best practices (transparency, inclusivity and robustness including the engagement of international referees) for the selection of the scientific program is already established at other. Experience at other facilities shows that having large panels of reviewers coming to the facility is an excellent way of engaging the community and providing valuable feedback to the facility on the level and direction of science that can, and is being, carried out.

The facility is concerned about high level scientific productivity - the above mentioned panel meetings can help the facility obtain input for science directions that will drive hiring and instrument development. Furthermore it is essential to solicit feedback from users and reviewers and panel members as part of the process. A broad based internal scientific culture within JPARC needs to be established as a focus to attract and serve a sophisticated user community. This can be accomplished in many ways but should not compete with the external user community – rather an atmosphere of collaboration and partnership should be developed. Users have to feel that they own the facility. The committee strongly recommends that a series of focused workshops/retreats be established with the dual purpose of defining a science direction/strategy and engaging a broader scientific community with the facility. On a similar note the IAC recommends that a good cooperation between Quantum Beam activities/facilities be nurtured. It could start internally by embracing the potential of the JRR3M neutron program to complement activities at JPARC MLF as well as those of the MUSE facility.

Recommendation:

In order to ensure the quality of outcomes in the MLF area it is essential to provide independent assessment of all research proposals by a single transparent process. This is to assure contestability in the science. To achieve this even the work from within J-PARC and the "partner" must be submitted as proposals and judged. This is the practice at all of the major international institutes such as ILL (France), ISIS (UK), SNS (USA), OPAL (Australia).

Muon Science and the MUSE facility

Construction of the front end of the U channel (high intensity surface muons) has continued while the MUSE facility has been able to deliver muon to the D1 line. This has generated several publications already. The IAC heard of several results both fundamental studies (F-electron heavy compounds) or applied studies (structure of Finemet material). The scientific program is limited by the lack of beams and spectrometers. IAC notes the budgetary effort by KEK to provide the slow muon channel front end components up to the muon moderator. A community driven proposal to fund the Ultra slow muon experimental part of the facility has received stage 1 approval and is in front of the government for funding approval. KEK has made a commitment to identify further resources to build and install the front end components of the S and H channels while the activation levels are still tolerable.

The IAC noted also that a road map was developed by the muon user community with a focus on the use of ultra slow muon beams and that significant outreach activities occurred in the past year to nurture the muon user community.

Recommendation:

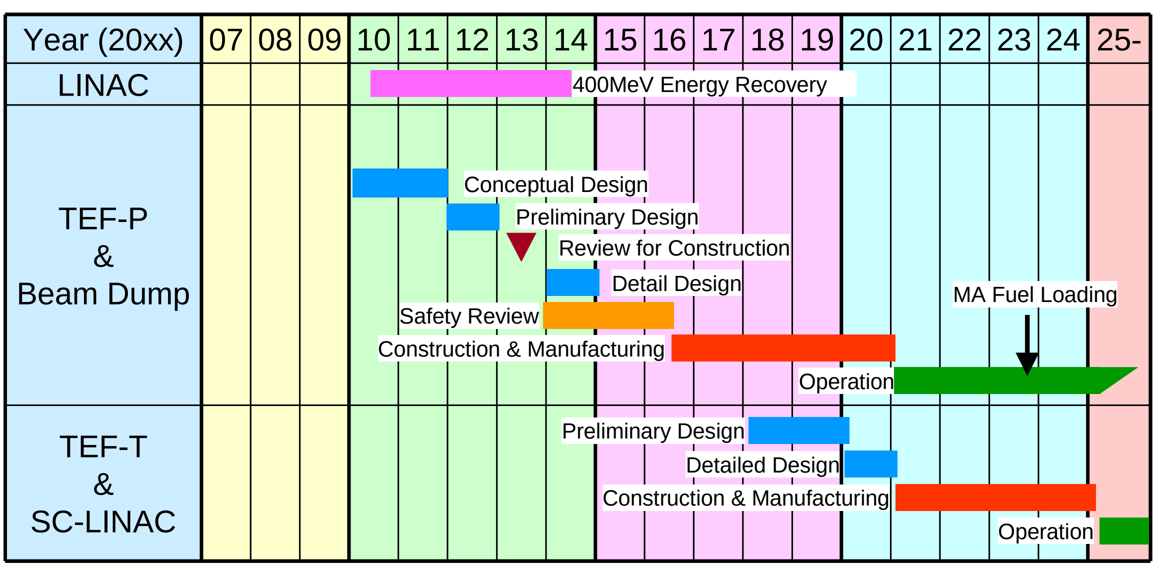
IAC repeats the recommendation that the design, construction the remaining front end elements of the S and H channels be funded soon so they can be installed in the proton tunnel in the upcoming shutdown needed for the Linac energy upgrade in the summer of 2012 before significant radiation levels are generated in the muon production target area.

NUCLEAR TRANSMUTATION

Dr. Oigawa's presentation briefly described the many areas in which the group is involved group in the framework of JAEA's 5-year plan (FY 2010-2014) of JAEA. The committee was pleased to hear that the group follows the recommendations of The AEC of Japan and participates in the integration of Partition and Transmutation in the Fast Breeder Reactor (FBR) cycle. One of the new results presented by Dr. Oigawa was the benchmark of calculations of reactor physics parameters using various nuclear data. A report from the AEC concludes that the uncertainties on an ADS design, revealed by these calculations, justify the importance of minor actinides (MA) experiments using the TEF facility proposed at J-PARC; the R&D program of the TEF facility includes the spallation target design, beam trip effects, material corrosion, and thermal hydraulics of the spallation target.

In the original JAERI-KEK joint project of high intensity proton accelerator, the Transmutation Physics Experiment Facility (TEF) was proposed to study nuclear transmutation technology using an accelerator driven subcritical system (ADS). This project was based on a 600 MeV high power accelerator. The present development of J-PARC has not yet allowed reaching the original design parameters of the accelerator. Thus, the project has received a low priority and has not been funded. Today, the Transmutation group proposes to adapt the TEF project to the actual situation of J-PARC and prepares a new project that will include experiments on subcritical and critical experiments for both ADS and FBR using kg-order of minor actinides fuel. A tentative timeline of the project is presented on the figure below. The OECD Nuclear Energy Agency report "Research and Test facilities required in Nuclear Science Technology" believes that the TEF project may play an important role if it is adapted into an international framework.

Recommendation*: The IAC supports the revised project of TEF. J-PARC should build the TEF proposal in a new way related to the linac upgrade and toward the development of an international activity at J-PARC. The committee requests a detailed presentation next year of the new project including budget, manpower and collaborations involved in the project...*



IAC appreciates the efforts of the J-PARC team to build a strong R&D community bridging academic and industry technology research, in particular the collaboration with Kyoto University on subcritical experiments using KUCA with DT neutron source. The group has joined the Central Design Team (CDT) of the European 7th Framework Program (FP7). The IAC is pleased by this active participation of the J-PARC group in EU major collaborative experimental programs, in particular in the EUROTRANS collaboration and the MYRRHA project (an 85 MW prototype ADS in Belgium).

The state-of-the-art in Accelerator Driven Transmutation and Energy production was recently reviewed by an international group, appointed by DOE, chaired by S. Henderson and E. Pitcher. The report "Accelerator and Target Technology for Accelerator Driven Transmutation and Energy Production" describes the considerable progress accomplished in the field. The report notes that active ADS R&D programs exist in China, Europe, India, Japan, Russia, South Korea. ADS sub-critical systems are recognized to "offer the potential for safely burning fuels which are difficult to incorporate in critical systems, for example fuel without Uranium or Thorium". Two of their findings are of particular interest:

- "Technology is sufficiently well developed to meet the requirements of an ADS demonstration facility; some development is required for demonstrating and increasing overall system reliability.
- For Industrial-Scale Transmutation requiring tens of MW of beam power many of the key technologies have been demonstrated, including front-end systems and accelerating systems, but demonstration of other components, improved beam quality and halo control, and demonstration of highly reliable sub-systems is required"

In this context, the Committee is concerned by the relatively small size of the group (10 members). Although it does contribute to collaborations in the world effort, the Committee believes that a major increase in the support of the group is needed to have a major impact in this domain. The work of the Transmutation group should be integrated in a clear and ambitious strategy of J-PARC with the full support of JAEA. The IAC reiterates that confidence of the public needs coherent information from universities, public organisations and industry research on the future of Nuclear power. This is one of the essential keys for continuing to use nuclear power in Japan in the long term. Difficulties observed in recovering from the sodium leak that occurred in the Monju FBR, and in Rokkasho's reprocessing plant have had a negative impact on the public perception of nuclear power. R&D at J-PARC is a great opportunity for JAEA to demonstrate the progress achieved in the safe use of nuclear power.

Recommendation: ***The IAC recommends that the Transmutation group builds, with the full support of JAEA, a strong community around the TEF proposal.***

The IAC reiterates that the considerable knowledge of Japan in accelerator development, design and safety studies in ADS, fuel studies, materials science, and nuclear data is fundamental to expand the frontier of knowledge in safe and reliable nuclear waste management.

USER SUPPORT AT J-PARC

IAC heard about the extensive cryogenics support provided by the J-PARC expert group to facilities and several experiments. J-PARC is also providing liquid helium and nitrogen to the users free of charge. For this they maintain a refrigeration plant soon to be augmented and a site wide recovery system. A method for planning Helium deliveries on demand is being established. This support is meeting the expectation of users.

The J-PARC centre computing group is supporting network access to the J-PARC data acquisition systems on site and to the KEK main central computer system for processing and storage. They provide an open system of communication independent of JAEA and KEK.

This has allowed for a more flexible access by J-PARC users while respecting the security concerns of JAEA. The demands from the J-PARC experiments for storage and processing are growing but are being met by the existing KEK system. Upgrades to the links speed are planned in 2012 to support the growing scientific effort.

USER OFFICE SUPPORT

There have been significant improvements in lodging, transportation, office, restaurant, shop, and other support functions for users. Users are pleased with the friendly and efficient support provided by the User’s Office. A new dormitory has been opened which can accommodate 49 users and there is plan for possibly doubling that.

The IAC supports J-PARC’s plan on adding to the new dormitory near the user’s office.

The IAC supports the J-PARC management team efforts towards a simpler gate access control dedicated to J-PARC user’s and staff, a more convenient access by a new road, and adding more cafeterias. The IAC thanks the Tokaimura government for their cooperation in solving these issues.

CONCLUSIONS

As this report was prepared, Japan suffered a tragedy of monumental consequences in lives lost and material damages. The IAC offers its most sincere condolences and formulates the wish that, within the priorities of the country, the rebuilding effort will allow J-PARC to continue its scientific goals. The IAC is confident that the J-PARC team under the leadership of Professor S.Nagamiya will be able to restore the capabilities of J-PARC to deliver first rate science. The IAC and the international scientific community will welcome any request for help to restore this international laboratory to its full potential.

Appendix I

Agenda for the International Advisory Committee Meeting of J-PARC in 2011

Date: February 21 (Mon) and February 22 (Tue), 2011

Place: Conference room at the Ibaraki Quantum Beam Research Center (IQBRC)
[http://www.pref.ibaraki.jp/kikaku/kagaku/kenkyu_kaihatsu/ryoshi_beam.html]

February 21 (Mon)

8:50 – 9:30	Report from the Director	S. Nagamiya (Doc.1)
9:30 – 10:10	**Accelerators**	
(9:30 – 10:10)	Progress and Prospects	A. Ando (Doc.2)
10:10 – 10:30	-- Coffee Break --	
(10:30 – 11:00)	A-TAC Views	T. Roser
11:00 – 12:20	**Neutron Science**	
(11:00 – 11:20)	Overview of MLF	M. Arai (Doc.3)
(11:20 – 12:00)	Science Highlights	Y. Idemoto (Tokyo U.Sci.) (Doc.4)
		N. Yamada (Doc.5)
		R. Kajimoto (Doc.6)
		S. Harjo (Doc.7)
(12:00 – 12:20)	Neutron User's Views	M. Hayashi (Ibaraki Pref.)(Doc.8)
12:20 – 13:20	-- Lunch -- @Akogigaura Club	
13:20- 14:20	**Muon Science**	
(13:20 – 13:35)	Facility Report	Y. Miyake (Doc.9)
(13:35 – 13:55)	Science Highlights	A. Koda (Doc.10)
		T. Ito (Doc.11)
(13:55 – 14:10)	MUSAC Report	O. Shimomura (KEK)
(14:10 – 14:20)	Muon User's Views	E. Torikai (Yamanashi U) (Doc.12)
14:20 –14:35	Cryogenics System at J-PARC	T. Ogitsu (Doc.13)
14:35– 14:50	Network and Computing at J-PARC	A. Manabe (Doc.14)
14:50 – 15:20	Accelerator Driven Fission Research	H. Oigawa (Doc.15)
15:20 – 15:45	Coffee Break	
15:45 – 16:00	User's Office	M. Ieiri (Doc.16)
	J-PARC as an International User Facility	
16:00- 16:20	Neutron PAC	M. Shibayama (U. of Tokyo) (Doc.17)
16:20 – 17:20	**Institutional Views**	
(16:20 – 16:40)	KEK and J-PARC	A. Suzuki (Doc.18)
(16:40 – 17:00)	JAEA and J-PARC	H. Yokomizo (Doc.19)

(17:00 – 17:20)	MEXT and J-PARC	T. Fujiyoshi (Doc.20)
17:20 – 18:20	Closed Session	
18:30 -	Reception at Tokai Plaza Café, IQBRC	

<u>February 22 (Tue)</u>

8:50 - 9:10	Executive Session (Closed)	
9:10 – 11:20	**Particle and Nuclear Physics at J-PARC MR** including Coffee	
(9:10 – 9:25)	Hadron Hall Progress and Prospect	Y. Sato (Doc.21)
(9:25 – 9:40)	Nuclear Physics at J-PARC	M. Naruki (Doc.22)
(9:40 – 10:10)	Particle Physics at J-PARC	T. Kobayashi (Doc.23)
(10:10 – 10:25)	Future Neutrino Physics	T. Hasegawa (Doc.24)
10:25- 10:55	-- Coffee Break –	
(10:55 – 11:10)	Hadron User's Views	H. Tamura (Tohoku U.) (Doc.25)
(11:10 – 11:30)	PAC Report	K. Tokushuku (KEK) (Doc.26)
11:30 – 12:30	Closed Session & Working	
12:30 – 13:30	-- Lunch – @ Akogigaura Club	
13:30 – 13:50	**Summary Session**	
13:50 – 15:50	-- Site Tour –	

Adjourn

Appendix II: IAC Committee membership

Jean-Michel A Poutissou	TRIUMF	Associate Director Emeritus. Head of Nuclear Medicine	jmp@triumf.ca
John William White	Australian National University	Professor	jww@rsc.anu.edu.au
Andrew Dawson Taylor	ISIS, Rutherford Appleton Laboratory, STFC	Director Facility Development and Operations; Head of ISIS	andrew.taylor@stfc.ac.uk
Bernard Frois	CEA	Director	bernard.frois@cea.fr
Stuart Douglas Henderson	FNAL	Associate director/accelerator	stuarth@fnal.gov
Satoru Tanaka	University of Tokyo	Professor	s-tanaka@n.t.u-tokyo.ac.jp
Hidetoshi Fukuyama	Tokyo University of Science	Vice President and Professor	fukuyama@rs.kagu.tus.ac.jp
Ian Anderson	NScD/ORNL	Associate Laboratory Director for NScD	andersonian@ornl.gov
Sergio Bertolucci	CERN	Director for Research and Computing	sergio.bertolucci@cern.ch
Young-Kee Kim	FNAL	Deputy Director/Professor of Physics	ykkim@fnal.gov
Hugh Montgomery	Thomas Jefferson National Accelerator Laboratory	Laboratory Director	mont@jlab.org
Thomas Roser	Brookhaven National Laboratory	Accelerator Division Head, Collider-Accelerator Dept.	roser@bnl.gov
Hoerst Stoecker	GSI Helmholtzzentrum fuer Schwerionenforschung	Scientific Director and CEO	H.Stoecker@gsi.de
Eiko Torikai	University of Yamanashi	Professor	et@yamanashi.ac.jp
Tsumoru Shintake	SPring-8, RIKEN	Principal Researcher	shintake@spring8.or.jp

Shoji Nagamiya	J-PARC Center	Director	shoji.nagamiya@j-parc.jp
Yujiro Ikeda	J-PARC Center	Deputy Director	ikeda.yujiro@jaea.go.jp
Hitoshi Kobayashi	J-PARC Center	Deputy Director	hitoshi.kobayashi@kek.jp

Appendix III: Accelerator Technical Advisory Committee (ATAC) report from the Chair,Thomas Roser.

Report from the

10th Meeting of the Accelerator Technical Advisory Committee for the Japan Proton Accelerator Research Complex (J-PARC)

February 17 - 19, 2011

J-PARC Center

Tokai, Japan

Table of Contents

Introduction

The Accelerator Technical Advisory Committee (ATAC) for the J-PARC Project held its tenth meeting February 17 - 19, 2011, at the J-PARC Center in Tokai, Japan. This report of ATAC was presented to the Meeting of the International Advisory Committee (IAC) on February 21, 2011.

ATAC members in attendance at this meeting included: D. Findlay (RAL), J. Galambos (SNS, ORNL), R. Garoby (CERN), S. Holmes (FNAL), A. Noda (Kyoto U.), P. Ostroumov (ANL), U. Ratzinger (U. Frankfurt), T. Roser (BNL, chair), and J. Wei (MSU).

The ATAC wish to express its appreciation to JAEA and KEK management and support staff for their hospitality during this meeting, and to the J-PARC staff for their excellent and comprehensive presentations. The ATAC also congratulates the J-PARC team for a spectacular first year of operation, reaching or exceeding the performance goals for 2010. The Committee also greatly appreciates that the J-PARC team has carefully addressed all recommendations from the last review.

Overview of J-PARC operations and power projections

The J-PARC complex has now been fully operational, supporting experimental research programs both at the Materials and Life Sciences Facility and the Main Ring slow and fast extraction facilities, over the last year. The RCS is routinely providing 200 kW to the neutron target, and the Main Ring is providing 135 kW of fast extracted beam to the neutrino target and 3.6 kW of slow extracted beam with 99.5% efficiency to the Hadron Facility. Facility reliability is approaching 95%. These performance levels are both significantly improved from a year ago and consistent with goals outlined at that time. The 400 MeV linac upgrade is progressing very well and is on schedule for installation in 2012. Planning is well advanced for the next four years of operations, including the period of installation and commissioning of the 400 MeV linac upgrade.

Primary Achievements

- 200 kW of beam to the MLF on a routine basis
  - 10 neutron and 1 muon beamline in operation
  - 2 neutron beamlines in commissioning and 6 under construction
  - RCS capable of 300 kW; currently limited to 200 kW by neutron target
  - 420 kW of equivalent beam power from the RCS demonstrated on single shots
- 135 kW of beam at 30 GeV to the neutrino target on a routine basis
  - Several dozen events observed in T2K detector
  - Currently limited by losses/activation in injection/extraction areas

- 3.6 kW to the 30 GeV slow extraction program
    - First experiment completed (penta-quark search)
    - Significant improvement in extraction efficiency (now 99.5%) and duty factor (now 30%) over last year
    - 10 kW equivalent power demonstrated
    - Currently limited by extraction efficiency as beam intensity increases
- Successful summer 2010 shutdown strongly tied to MR performance improvements
    - 3-50 BT collimator shielding
    - New (fast) MR extraction kicker (8 bunch operations)
    - 6th rf station
    - Transverse bunch-by-bunch damper
    - Improvements to power supplies to decrease cycle time (3.6 to 3.2 sec)
    - Dynamic bump system
    - Transverse noise kicker
- Funding secured to support 200 days of facility operations for users
- Funding secured to complete linac upgrade
- Multi-year plan established through JFY2014
    - Goals unchanged from a year ago
    - Incorporates and depends upon the 400 MeV linac upgrade
    - 1 MW from RCS
    - 430-750 kW from Main Ring (fast extraction)
    - 100 kW from Main Ring (slow extraction)

Comments and Recommendations

- Goals established for JFY2011
    - 200 days operations for users at MLF and MR (FX/SX ~2/1)
    - 300 kW from RCS
    - 150 kW from MR (fast extraction)
    - 30 kW from MR (slow extraction)
- Residual activation is being monitored throughout the facility
    - High activation in RCS injection region (>500 μSv/hr @ 30 cm) and MR injection region (>5000 μSv/hr @ 30 cm) need to be addressed in moving to higher beam power.
    - Possible sources have been identified (multiple foil strikes in RCS; ringing of injection kicker in MR)

      Continue the activation-monitoring program as intensities are raised in the RCS and MR. Utilize the information for benchmarking of simulation codes and developing mitigation strategies as power levels rise.

- Spares queues are being built up per prior ATAC recommendations
- Better understanding of beam loss mechanisms as compared to a year ago
    - Effective program marrying beam studies to simulations (RCS)
    - Simulations could benefit from increased study time to provide benchmarking in MR

Continue studies aimed at characterizing and understanding losses observed in the RCS and MR at the highest beam intensities possible.

- Plan established for improvement of RCS to 1 MW by 2014
    - Reliant on completion of 400 MeV linac upgrade
    - Requires 50 mA x 0.5 msec from linac at 400 MeV
    - New ion source
    - New RFQ
    - Upgrade to RCS injection/painting bump magnet power supplies
    - Improved painting schemes
    - New injection collimation systems
    - New diagnostics and corrector magnets
    - 12 rf stations
    - Plan supported by extensive studies and simulations
    - The ATAC finds the presented plan credible

- Plan under development for improvement of MR fast extraction to 750 kW
    - Reliant on RCS operations at 600 kW
    - Requires upgrade of collimator capacity in 3-50 BT (done) and MR (450 -> 2000 W)
    - New scenario based on decreased cycle time (1.2 sec)
    - Higher gradient rf cavities
    - New dipole/quadrupole power supply systems
    - Anticipated performance in 2014 is 430 kW, based on 2.2 sec cycle time (requires partial replacement with new power supplies)
    - The required power supply upgrade to support 750 kW operations may not be available for several years later
    - The ATAC notes inconsistency in presentation of future projections, some of which display 750 kW by the end of 2014, and current planning which provides 430 kW in 2014
    - The ATAC believes that the development of strategies for reducing the MR cycle time is a necessary investment to reach 750 kW and should be continued.
    - However, the MR plan presented is not sufficiently developed to be deemed "credible".

R1: The plan for achieving MR operations at 750 kW should be further developed. While decreased cycle times should be part of the plan, other options or additions, for example operations at energies higher than 30 GeV or stacking of more than four RCS pulses in the MR should also be explored.

- Concepts have been identified for improvement of MR slow extraction to 100 kW by 2014
    - Ti chamber to reduce residual activation
    - Improved power supply regulation (<2×10-6 ripple)
    - New SX collimators
    - Transverse (noise) kicker
    - The ATAC does not feel a self-consistent plan, supported by simulations and beam experiments, exists for slow extraction of 100 kW beams

R2: Develop a strategy for achieving slow extracted beam powers approaching 100 kW that is supported by simulations. The strategy should take into account all known intensity dependent

effects, incorporate comparison with beam experiments, as possible, and accommodate losses up to a few kW in the extraction region.

- An operations plan for the period through 2014 has been developed that contains:
    - Estimates of peak performance in the RCS and MR by year
    - Estimates of the integrated beam power delivered from the RCS and MR by year
    - Estimates of the integrated hours of beam on target for users and accelerator studies by year.
    - Estimates of commissioning time required following the linac upgrade.
    - Estimates of the expected availability by year.
    - The plan includes input from the user community

    Update the existing operations plan as new information becomes available

- Significant progress has been made at defining the basic configuration and operational parameters for the period through 2014.
    - Parameter tables need to be updated as operational or development activities indicate the need for changes.
    - Extrapolation from current conditions should be guided by simulations and machine experiments.

R3: The operations plan should be augmented by a J-PARC-wide technical upgrade plan that describes the configuration of the complex, associated performance goals through the upgrade period, and ensures that the necessary resources are available.

Linac status

Primary achievements

- Overall there is a marked transition from beam commissioning to beam operations. The linac routinely provides ≥200-kW operation of the RCS and it is adequate to support RCS operation at 420 kW.
- Significant increase of the linac availability compared to the previous years. The RFQ conditioning is no longer the major driver for maintenance stoppage and the ion source replacement time has been reduced from 3 to 2 days.
- Development and test of the new scintillator-based BLM, which is not sensitive to X-rays.
- Fabrication of the spare RFQ is complete.
- Continued beam studies to provide high-quality, high-power beams for injection into the RCS.

Comments and recommendations

- Ion source can support extended runs up to 2 months; the maintenance time has been reduced to 2 days. Possibilities for further reduction of the maintenance time are being investigated.

- The Linac team consistently records downtimes and analyzes possible causes. Troubleshooting of the HVDC power supplies resulted in the development of technical modifications of the HVDC system, which are being implemented.
- There is a substantial improvement in the availability of the RFQ but the RFQ discharge problem is a relatively large contributor to beam downtime. So far the RFQ discharge rate does not appear to be increasing, despite an increase in operational vacuum levels. However, it is unclear how the discharge problem will scale with higher beam currents and full duty cycle.

R4: Consider testing RFQ operation at higher currents approaching the design values as soon as possible (e.g. in beam study time if feasible), to identify any potential discharge issues early.

R5: Continue thorough investigation of the Linac trips related to SDTL and BLM. It is likely that these trips can be eliminated without significant investment of resources.

- The status of the klystrons approaching their design lifetime is being constantly monitored. The klystron efficiency has been observed to be decreasing, but there are no failures yet. There are spares available for about half the klystrons. The procurement of 4 klystrons per year is foreseen.

R6: Consider alternate klystron replacement options such as partial rebuilds of failed units.

- Work on redundancy of the Front End systems is being pursued. The copper parts of the spare RFQ have been successfully brazed and low-level RF measurements of the RFQ assembly are being performed. Main electrodynamics parameters of the RFQ (resonant frequency, field flatness, frequency separation of dipole modes) have been measured. To have a confidence in correctness of the dipole mode tuning, it would be useful to measure frequencies of all modes as a function of the end-tuner penetration and to apply bead-pull measurements for dipole modes. Consider how the spare RFQ will be used after the high power RF tests.

R7: Build a test stand with ion source, LEBT and RFQ capability as soon as possible that would allow developing the required confidence before installing the spare RFQ in the operational machine. Such off-line beam tests of the spare RFQ can be combined with the development and tests of a high-intensity ion source and high intensity RFQ for the future upgrade.

- Despite of limited time for the machine study the Linac team has performed several useful beam studies. Quantitative beam loss measurements in the ACS upgrade area of the linac as a function of the vacuum pressure in the upstream sections have been performed. These experiments clearly demonstrate that an appreciable beam loss increase in the ACS area is caused by the stripping of H-minus beam on residual gas. Important information on linac parameters and the bunch longitudinal profile has been obtained by phase acceptance scan of the SDTL.
- There is still an unexplained beam halo observed at the high-energy end of the linac. Beam studies on the effectiveness of L3BT collimation should be done. Additional collimation is being considered in the MEBT2 section of the linac.

R8: Consider implementation of scraping in the low energy region (MEBT-1).

- The residual activation levels built up while supporting 200 kW operations are quite modest, and not a concern at present. They do not appear to be a limitation for the immediate power ramp-up plans.

<u>3 GeV RCS, including operations after Linac upgrade</u>

Primary achievements

- Routine operation of the Rapid Cycling Synchrotron (RCS) at 200 kW.
- Establishing a good understanding of beam loss issues at injection, including optimisation of foil geometries.
- Making important beam dynamics measurements at the equivalent of 400 kW with 180 MeV injection.
- Resolving problems with the connectors for the fast extraction kickers.
- Demonstrating that except at the injection and collimation regions of the RCS induced radioactivity in the machine structure is markedly low.
- Demonstrating that after resolution of the extraction kicker connector problem the reliability of the RCS has proved to be markedly good.

Comments, suggestions and recommendations

- Since November 2010 the RCS has run routinely at a beam power of 200 kW (with 17 mA in the linac and a pulse length of 0.38 ms). It is likely that the RCS would have run at higher powers except for worries over risks to the target (for which there is no spare) and over less than optimal behaviour of the liquid hydrogen moderator due to the presence of trace amounts of frozen water and hydrocarbons.

  It would obviously be good to remove any perceived barrier to operation at increased powers due to target and moderator worries — as funds, opportunities and user schedules permit.

- It is noticeable again from the absence of any mention of them that most of the RCS systems must have run well, e.g. the main magnet power supplies and the high-power RF drivers, and these successes again deserve to be noted.
- A good set of investigations of beam dynamics issues at injection has been made — involving measurement, simulation, and foil configuration changes. These have resulted in the establishment of a notably improved understanding of the behaviour of the beam at injection, and have pointed the way towards installation of an improved collimation system to further reduce localised beam losses.

  R9: Machine schedules should be arranged so that sufficient time is made available for a sustainable machine development and study program.

  Measurements of beam profiles and time dependences of foil losses could usefully be compared with simulations.

- Linac beam halo may be contributing to beam losses at RCS injection. However, in practice there may be a reluctance to use the L3BT collimation system for fear of activation caused by overly thick stripper foils.

  R10: Study the optimum operational balance between scraping off beam in the L3BT collimators versus the collimators in the RCS. The exercise could include varying the thicknesses of the collimation foils.

- Measurements have been made, at higher beam power, of the beam transmission through the RCS for different painting configurations. For the equivalent of 400 kW with 180 MeV injection it has been shown that the powers deposited in the RCS collimators are well within their ratings.

  R11: Similar measurements should be made with as high a repetition rate as possible.

  As powers deposited in collimators increase, it would make sense to consider procuring entire replacement collimator assemblies so that in the event of failure a whole assembly could be replaced without incurring a significant radiation dose to personnel.

- Simulations for 1 MW with 400 MeV injection have been carried out (50 mA, 0.50 ms, 0.56 beam chopper duty factor). These suggest that beam losses on the RCS collimator could be increased in order to reduce more troublesome beam losses between the RCS and the main ring (MR) with its 54π-mm-mrad acceptance (lower than the acceptance of the RCS by a factor 6), although it is recognised that extensive further work on injection into the MR is necessary.

  Continue work on reducing beam halo to facilitate sustainable injection into the MR.

- Substantial work has been carried out on schemes for upgrading RCS hardware to accommodate injection at 400 MeV. On the basis of the beam dynamics and particle tracking studies carried out so far, the schemes look good. The resources required to carry out the schemes are considerable, however, and efforts should be made to ensure that the resources required would indeed be available.
- It is noted that in moving towards operation of the RCS at 1 MW it is likely that a method for reducing kicker impedances will have to be developed, and that a bunch-by-bunch feedback system for the RCS will become necessary. It is also noted that in moving towards 1 MW attention is likely to have to be paid by accelerator staff to the problem of optimising beam spot sizes and shapes on the neutron-producing target.
- The RCS team should be congratulated on a successful programme to resolve problems with the connectors for the fast extraction kickers.
- The levels of induced radioactivity in the RCS away from the injection and collimation regions are sufficiently low that they will not prevent operation of the RCS at higher beam power.

Main Ring, including operations after Linac upgrade

General

Rapid start of user experiments after establishing of stable LINAC operation was achieved, although some key equipment required modifications and improvements to increase the performance of the facility. Up to now the neutrino experiment using fast extraction with a maximum beam power of 135 kW and the hadron experiments using slow extraction with a beam power up to 3kW have run for 6 and 2 months, respectively.

J-PARC is to be congratulated that the MR is already providing physics output from both the neutrino experiment and the hadron experiments. It is also noteworthy that more than half of the users come from outside Japan, demonstrating that J-PARC is a truly international research facility.

Scheme to Realize Proposed Power at MR

A possible scenario to provide 0.75 MW beam power from the MR was proposed requiring an increased MR repetition rate of 0.8 Hz. The increase of the MR repetition rate is required by the lower than expected limit for the MR circulating beam intensity. 8 bunches out of 60 bunches from the RCS are transferred to the MR with a total beam power of 75 kW taking into account the 3.5 % beam loss of at the 3-50 BT collimator. Accelerating to 30 GeV then realizes the beam power of 0.75 MW for fast extraction to the neutrino experiment. The planned RCS simulation studies including space charge effects to evaluate the beam loss for the case of dynamic collimation with the use of local bump should be pursued.

Slow Beam Extraction

Slow extracted beam has been provided to experimenters with a beam power of up to 3 kW although demonstration up to 10kW was made. The extraction efficiency for the 3 kW operation is a world record 99.5 %. The duty factor of the beam, however, was 3.6 % reflecting the big ripple in the excitation currents of the magnets. The duty factor has been improved to 17 % by additionally short-circuiting trim coils and to 30% with further additional application of transverse 20 MHz RF to increase the beam emittance. Application of transverse RF, however, is suffering from multipacting, which will be mitigated with a solenoid field. To reach a high duty factor for slow extraction the current ripple of the main power supplies has to be reduced by orders of magnitude. This is unlikely to occur by 2014.

The position of collimators may need to be adjusted to avoid beam loss during the last three turns before extraction.

R12: Schedule sufficient beam time for machine studies in the MR.

Linac energy upgrade

Primary achievements

- The series production of the ACS modules has been started, 4 units have been finished already. The fabrication capacity is one module per month. The klystron production is on schedule.
- One out of these four modules was successfully power tested; shunt impedance is above design.
- Installations for linac upgrade have started in 2010 summer shutdown and will be continued during summer shutdown of 2011 (3 months). It was deduced from simulations, that no cavities can be installed in advance, as they would increase the energy spread above RCS injection needs.
- Beam simulations along the linac from RFQ exit to RCS injection were done, including alignment and setting errors.
- For the intensity upgrade a SNS type rf driven source plasma generator will be tested at JPARC, involving cesium. A RFQ3 design for 60 mA (50 mA) beam current is underway.

Comments and recommendations

- The linac energy upgrade is progressing very well. No showstoppers have been seen so far. The planning and time schedules are convincing.
- Recommendation R30i from ATAC10 should be included during the power testing of ACS modules, to assure that neighboring modes will not be a danger at all power levels.
- Detailed beam simulations including alignment and setting errors were presented. In future the RFQ should also be included.
- The intensity upgrade is still in the design phase. It is quite behind of the energy upgrade.
- The choice of using the SNS source plasma generator will not necessarily lead to a 60 mA H^- source. Cesium will be needed now and vacuum conditions down along the LEBT have to be checked to get no cesium contamination of the RFQ.
- The physics design of the high-current RFQ3 is not yet finalized. The proposed design may require additional studies. The design shows a pronounced voltage ramping by more then a factor of two. It is not clear why such a novel design is needed for the still modest design current of 50 mA. Of particular concern is the reduction of the focusing strength at the end of the RFQ, which may result in excessive tune depression and emittance growth due to the space charge of the bunched beam. In addition, a longer RFQ resonator should be considered to reduce peak surface field. A longer RFQ will require appropriate techniques to control the dipole modes.

  R13: Consider decoupling the energy upgrade from the intensity upgrade. The front end might still need more R&D than is presently scheduled before construction of components should start.

  Beam studies from source *to RCS injection including all upgrades should be continued.*

Ring RF, including high gradient cavity

Findings

General:

Eleven cavities are operational in the RCS (12 after the Summer 2012 shutdown) and 6 in the MR (8 after the Summer 2011 shutdown). The RF systems give satisfaction in both rings and do not detrimentally impact on accelerators' performance. The number of major faults during the last 12 months was limited (9 in the RCS and 7 in the MR) and they mostly concerned the electronics. The cavities did not contribute to the down time of the accelerators, although (because?) they remain under close monitoring.

RCS cavities

Buckling is a pending issue for the RCS cavities equipped with uncut cores. "Type C" coating has been identified as a solution, and systematic replacement of the cores of all RCS cavities is in progress at the rate of approximately 2 cavities per year, finishing during the summer 2013. The non-modified cavities equipped with other types of cores still suffer from this phenomenon (e.g. cavity # 1 operating now with 2 gaps whose cores will be replaced during the summer 2011).

MR cavities

A 6th RF station has been installed as foreseen during the summer 2010.

The latent problem is corrosion at the cut. (e.g. cavity # 5 is operating with 2 gaps because of impedance reduction: cores will be replaced during the Summer 2011).

As a remedy, Silica coating has been applied to cavities # 3, 4 and 6 in November 2010. In the case of cavity # 2, treated also in November 2010, this has been combined with the installation of an RTV rubber shield to avoid circulation of water in the cut.

All cavities will be Silica coated after the summer 2011, with RTV in cavities # 1, 2 and 5.

The impedances of cavities # 6 and 3 show a slight decrease. No conclusive explanation exists. It is tentatively attributed to the fact that these cavities have already suffered from some damage, which was recovered by polishing.

As a matter of precaution, the cooling circuit of the cavities will be isolated from the magnets during the summer 2011.

Beam commissioning

A second harmonic RF voltage is used for longitudinal painting at injection in the RCS since 2009. In 2010 it has been successfully applied before ejection in the RCS and at injection in the MR to improve the bunching factor.

Feed forward beam loading compensation on harmonics 2 and 4 has been successfully implemented on the 11 RCS cavities, reducing by more than an order of magnitude the equivalent impedance of the cavity for the beam. This technique will be extended to the MR during the JFY2011.

R & D for future cavities

The R & D for future cavities progresses on two fronts:

- A core module made up of three concentric rings (to remove thermal stress and eliminate buckling) in a chemically inert cooling fluid (to get rid of corrosion in water) has been tested at high continuous RF power (up to 10 kW). RF and thermal measurements fit very satisfyingly with computations, leading to the need of 83 l/min of "Fluorinert" for a heat transfer coefficient of 750 $W/m^2/K$. The next step is to construct a one gap resonator equipped with 6 core modules and to test it with a 60 kW RF amplifier.

- A new technique of production of the MA core is being developed to reduce heat dissipation and increase impedance. Based on the use of a thinner ribbon annealed in the presence of an axial magnetic field, a prototype of such an "FT3L" core has been measured as having twice the impedance of a classical "FT3M" core of the same size. Using the same RF power, a 2 m long cavity with 4 gaps and 6 FT3L cores/gap, would provide 60 kV instead of 40 kV in the present FT3M equipped cavities. Cooling could be done by water, air or Fluorinert. A set-up is being assembled in the J-PARC Hadron Hall for producing 20 MR-type cores and 2 RCS-type cores before the summer 2011. A single gap cavity could be installed in the MR during the summer 2011.

Comments & recommendations

Present RF systems

Important efforts continue to be made for addressing the remaining imperfection of the MA-loaded cavities. The satisfying operational result of the accelerator complex shows that it is worthwhile. Moreover, there are reasons to believe that long-term solutions have now been found. It will unfortunately take a few years to get a convincing proof.

The Committee is concerned about the persistent reduction of impedance of certain MR cavities. This confirms the need to continue the systematic monitoring of the cavities characteristics.

The excellent performance of the feed forward beam loading compensation on the RCS cavities and the observed beneficial effect of a second harmonic RF in the RCS and in the MR to increase the bunching factor are very encouraging for the future operation at much higher beam power.

The Committee congratulates the RF team for these remarkable results and encourages their publication.

R & D for future cavities

FT3L based cavities are a potential solution for getting, within the available straight sections, the RF voltage required by the MR for delivering a beam power of 0.75 MW.

The Committee is impressed by the progress of this development and fully supports its continuation.

Concerning the cooling fluid, a lot of experience has been gained with water, which is used in all installed RF systems at JPARC. It is possible that long-term solutions have now been found, but the demonstration will take many years. The investigation of other cooling fluids is therefore worth continuing, as a back-up solution for future cavities. Similarly, multi ring cores could become an attractive option if experience shows that “Type C” coating does not fully avoid buckling.

The Committee acknowledges the quality of the work accomplished and supports the continuation of the development of the single gap cavity equipped with multi ring core modules and using Fluorinert cooling. This development is performed by a group separate from the J-PARC rf group. The Committee acknowledges the existence of regular communication between the two rf development teams and encourages its enhancement, which could develop into a joint proposal for a future prototype.

(R14 was converted to a comment)

R15: Before starting to build a multi-gap cavity using air or Fluorinert cooling, a complete engineering design should be made describing, in detail, cost, the infrastructure needs (space, electricity, water, air…), the maintenance requirements and the compatibility with safety rules in confined areas.

MR power supply upgrade

Primary Achievements

The present MR magnet power supplies operates with cycle periods of ~ 3.2 sec and ripple amplitudes of ~ 10^{-4}. These pose limitations on the available power for FX and SX. The nominal 750 kW FX scenario requires ~ 1.2 sec cycle time and ripple magnitudes ~10^{-6} for SX operation

Investigations of the present MR power supply system show only marginal possible reductions of the cycle time from 3.2 to 2.6 sec, without sacrificing control further. Ripple reduction prospects of the present system power supply include:

- Shorted trim coils, which are effective in the flattop region, but only provide about 10 times reduction, whereas the SX requirements are ~ 100
- Feedback cancelation, which are effective throughout the cycle (appropriate for FX), but only provide ~ 1/3 ripple reduction, as compared to a factor of 30 needed.

These improvements are not sufficient for a long-term solution.

A new MR PS system is proposed that would:

1. Reduce the number of magnets per power supply to reduce the inductive load
2. Use an IGBT technology
3. Use a capacitor based energy storage scheme

Simulations of the system look promising to meet the requirements, but the design is only conceptual.

Comments and Recommendations

The power supply ripple and cycle time requirements should be clearly specified for the designers, based on beam and overall operational power scenario considerations.

While promising, the new proposed IGBT power supply with capacitive energy storage is quite conceptual at present. There are possible issues with increased space requirements, additional cabling requirements, uncertain component lifetimes, and overall development time. It is not obvious that this proposal is the best solution, as it was the only one presented to the committee. Before initiating such a major upgrade a comparison should be done with the more conventional option of flywheel energy storage and separate high voltage ramp and low voltage flattop power supplies. The proposed solutions should be reviewed by an appropriate panel of experts.

While detailed planning has not yet evolved for the deployment of the new power supply, the prototype testing and initial installation should protect the reliability of operations. Limited testing time of a single prototype may not provide adequate reliability data.

> *Consider initial deployment of this technology in a manner that would allow "roll-back" to the old power supply if there were unforeseen issues. This could be accomplished with an individual quadrupole family power supply, which would not need re-cabling.*

Impedance, instabilities and controls

Primary Achievements

- A single-shot beam with intensity corresponding to 420kW beam power if the repetition rate were 25Hz was achieved in the RCS. In this mode, measured beam intensity reduction is 0.5%, and no beam instability was observed.
- At the 420kW-equivalent intensity, instabilities were observed in the horizontal direction at times more than 10ms after the injection if the chromaticities were corrected.
- An operational scenario was proposed simultaneously meeting power requirements on the RCS and MR without exceeding RCS and 3-50BT collimator limit of 4 kW. This scenario required tune manipulation in the RCS with quadrupole correctors and effective reduction of RCS collimator acceptance with a dynamic bump.
- The horizontal damper reduced the beam loss at injection energy in the MR when 8 bunches were injected at the intensity corresponding to 135 kW at 30 GeV.
- Transverse broad-band beam break-up instabilities were observed with the 135kW-equivalent beam in the MR. The instability frequency extended up to 40 – 70 MHz.

Comments and recommendations:

- The committee commends the efforts in pursuing 420kW-equivalent beam study in the RCS, and beam studies to define the path towards 1 MW beam power in the RCS and 0.75 MW beam power in the MR under realistic operational conditions and collimation constraints. The plan to increase the time of machine studies from the present 20 days to 50 days per year can significantly enhance the understanding of the beam dynamics and accelerator systems performance. Present beam loss studies and computer simulation comparisons indicate that beam dynamics of space charge and phase space painting is relatively well understood. More systematic studies are needed in understanding the nature of collective instabilities and impedance sources including possible electron cloud effects.

  R16: Perform more systematic studies in understanding the nature of collective instabilities and impedance sources, and develop mitigation plans accordingly.

- The committee commends the efforts in significantly enhancing beam diagnostics including fast beam loss measurements, high-frequency beam position measurements, fast transverse beam profile measurements, and longitudinal wall-current-monitor measurements. Understanding and control of transverse beam profile in the RCS is crucial in optimizing beam phase-space manipulation to meet various design requirements under operational conditions and constraints.

  R17: Further enhance beam diagnostics and analysis capabilities, in particular beam profile measurements in the RCS and 3-50BT.

- Kickers are identified as major sources of beam coupling impedance. Test stands are available for off-line R&D. We encourage the project teams to pursue more systematic measurements and analysis including both longitudinal and transverse impedance measurements, and kicker performance calibration including rise time and flattop flatness under various kicker and power supply network design optimization scenarios. Similar efforts on the SNS ring extraction and injection kickers may be referenced.

  R18: Pursue more systematic measurements and analysis including both longitudinal and transverse impedance measurements, and kicker performance calibration including rise time and flattop flatness under various kicker and power supply network design optimization scenarios.

- Instabilities were observed in the MR at relatively low beam intensities. Instability behaviors were similar to those at many other high intensity accelerators. Chromaticity maneuver and bunch-to-bunch dampers may not be adequate to mitigate the effects.

  R19: Consider more instability damping measures including using octupole magnets and momentum broadening rf cavities in the MR.

- Maneuver of the transverse tunes along the ramping cycle of the RCS was identified as one of the key procedures to meet design requirements. We encourage actual implementation of ramping quadrupole correctors both to manipulate the tunes and to correct the β-function beating. We also encourage resonance correction with nonlinear correctors.

  R20: Consider implementation of ramping quadrupole correctors in the RCS for tune maneuver and β-beating correction. Evaluate benefits of nonlinear correctors.

Appendix: Meeting Agenda

Thursday 17 February 2011

09:20	Project Status	NAGAMIYA, Shoji
10:00	Accelerator Overview	ANDO, Ainosuke

Status & Commissioning (Linac)

11:30	Linac Status (00h30')	HASEGAWA, K.
12:00	Beam Study Results of Linac (00h30')	IKEGAMI, M.

Status & Commissioning (RCS)

13:30	RCS Status (00h30')	M. KINSHO
14:00	High Power Study of RCS (00h30')	H. HOTCHI
14:30	Beam Loss in RCS (00h30')	K. YAMAMOTO

Status & Commissioning (MR)

15:20	MR Status and Beam Study Results (00h40')	KOSEKI, Tadashi
16:00	MR Slow Extraction (00h30')	M. TOMIZAWA

Friday 18 February 2011

Status & Commissioning (MR)(contd.)

08:40	Instability: Observation and Study Results of MR (00h30')	TOYAMA, Takeshi

Ring RF

09:10	Ring RF Status (00h40')	YOSHII, Masahito
09:50	Alternative Solution (00h30')	MORITA, Y

Towards 1MW RCS and 0.75MW MR-FX with Linac Energy Upgrade

10:40	Schedule & Commissioning of Linac Upgrade (00h30')	N. OUCHI
11:10	RCS with 400MeV Injection (00h30')	N. HAYASHI
11:40	MR-FX 0.75MW Scenario (00h20')	IGARASHI, Susumu

Towards 1MW RCS and 0.75MW MR-FX with Linac Energy Upgrade

13:00	MR Power Supply at Present (00h30')	S. NAKAMURA
13:30	MR Power Supply in the Next Step (00h30')	Y. KURIMOTO
14:00	High Gradient RF Cavity (00h30')	C. OHMORI
14:30	Instability: Dynamics of High Intensity Beam (00h30')	Y. SHOBUDA

Saturday 19 February 2011

11:00	Report to project team	T. ROSER