Report from the
12th Meeting of the Accelerator Technical Advisory Committee for the Japan Proton Accelerator Research Complex (J-PARC)

February 21 - 23, 2013
J-PARC Center
Tokai, Japan

Table of Contents

Introduction

The Accelerator Technical Advisory Committee (ATAC) for the J-PARC Project held its twelfth meeting February 21 - 23, 2013, 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 25, 2013.

ATAC members are: Alberto Facco (INFN), David Findlay (STFC), Roland Garoby (CERN), Subrata Nath (LANL), Akira Noda (Kyoto U.), Michael Plum (ORNL), Thomas Roser (BNL, Chair), Jie Wei (MSU), Robert Zwaska (FNAL).

The ATAC thanks the J-PARC management and staff for their hospitality during this meeting, and all the presenters for their excellent and comprehensive talks. The Committee also greatly appreciates that the J-PARC team has carefully addressed all recommendations from the last review.

Accelerator Overview and Projections

Two years after the earthquake and tsunami disaster of March 11, 2011, nearly the entire infrastructure has been restored and the beam powers to the MLF and MR have increased beyond their pre-disaster levels. Furthermore, J-PARC operated for 5096 hours in JFY12 with greater than 90% availability. The ATAC applauds the continued dedication of the J-PARC staff to achieve ever-higher levels of performance in the wake of such adversity.

JFY12 has been dominated by user operations with record performance and intense preparation for the major machine upgrades planned for installation during the 6-month shutdown in JFY13.

These upgrades to the accelerator are anticipated to eventually lead to 1 MW beam power for the MLF and, with further upgrades to the MR magnet power supplies, to 750 kW beam power for neutrino production.

Primary Achievements

- 2012 was a year of record operation for J-PARC:
    - The fiscal year includes 9 months of user operation with a 3-month maintenance period
    - An excellent year of operation makes the basis for significantly improved performance after further upgrades in JFY13

- Present operations of the accelerators well exceed pre-earthquake levels
    - 300 kW RCS (+50%), 225 kW MR-FX (+55%), 15 kW MR-SX (+350%)
    - RCS has demonstrated 540 kW operation for 35 s, but is presently limited to ~ 300kW put on the target
    - MR intensity has improved with improved collimator loss capacity
    - Slow extraction provides a “duty factor” of 43% at 15 kW and 99.5% extraction efficiency

        - A study at 20 kW showed similar performance
    - The higher performance was made possible by incremental upgrades in the 2012 shutdown and continued study of the machines and their optimization

- Operations provided excellent up-time, in addition to record intensities
    - 3586 hours for MLF, 2512 hours for MR-FX, 795 hours for MR-SX through February 7, 2013
    - Accelerator availability was greater than 90% in each run period

- Preparations have been made for a substantial upgrade program in the 6-month 2013 shutdown
    - The most significant item is the installation of the ACS portion of the Linac bringing the beam energy to 400 MeV
    - Replacement of the ion source and RFQ to allow the Linac to produce a 50 mA current (roughly 3x present performance)
    - The RCS shutdown plan is dominated by a comprehensive, precise realignment to fully account for distortions from the earthquake
        - Additional modifications to injection and the RF will be implemented to accommodate the 400 MeV beam from the Linac
    - The MR upgrade plan includes collimator and beam pipe upgrades to allow higher beam intensities for both slow and fast extraction
        - In the long-term, a major power supply upgrade is planned to reduce the cycle time to 1.3 s, ultimately allowing 750 kW FX production

- The JFY13 operations schedule maintains 6 months of user operations in addition to the shutdown
    - Previous to the shutdown, power levels are anticipated to be similar to those achieved in JFY12
    - A key goal is to provide adequate protons for the T2K experiment to achieve a 5σ sensitivity to ν_e appearance
    - High-intensity studies of the RCS are planned to help establish future operational limits
    - User operation after the shutdown will restart end of January, 2014 in parallel with efforts to exploit the many upgrades performed during the shutdown

Comments and Recommendations

- Nearly all of the earthquake effects have been mitigated, including the building infrastructure. The primary outstanding issue is the comprehensive realignment of the accelerator components.
    - The committee was presented with a plan to comprehensively realign the RCS during the JFY13 shutdown. This is a large job, but achievable within that time period. The committee commends the decision to redefine the coordinate system so that realignment in the injection region would be minimal, also minimizing the radiation dose to workers on this job.

    - Further alignment of the Linac and MR will also be performed, but a 1 mrad "kink" in the Linac will be maintained. The committee finds that this kink is likely acceptable within the mitigations already performed.

- The committee was presented with a comprehensive schedule for the shut-down
- The committee is still concerned with the very large work load during the shut-down and difficulty of the ambitious and compressed recommissioning schedule
- Since the projected power requirement in early JFY14 does not require the 50 mA current at end of Linac the installation of the new ion source and RFQ III could be delayed to the summer 2014.

  R1: Consider delaying the installation of the 60 mA ion source and RFQ III by one year. This would allow for thorough testing of RFQ III with the 60 mA ion source in the test area.

- The remaining major upgrade is the installation of improved power supplies in the MR to allow a lesser cycle time, along with numerous incremental upgrades throughout the complex.
    - The MR power supply upgrade is still in the development stage. The recent prototype for the bend magnet power supply has only 5% the capacity of the ultimate supplies. Further development will be time-consuming and the implementation timeline for mass production in JFY15 is aggressive. Effort towards accelerating the process must be maintained.

Beam power projections:

RCS for MLF:

- Substantially the same as at the previous ATAC: 300 kW before JFY13 shutdown, ~ 500 kW by JFY14, 1000 kW by middle of JFY15
- Last goal is dependent upon the successful installation of the 60 mA ion source, RFQ upgrade, the 400 MeV linac upgrade, and achieving 1MW capability of the neutron production target.
- A high-power study was performed to demonstrate the ability of the RCS to operate at higher powers (presently limited by the target)
    - This study established 534 kW operation for 35 s with 1.5-2.0% beam loss, which is deemed acceptable by present collimators.
    - This study can be extrapolated to first order to higher injection energy by requiring the equivalent tune shift. At 400 MeV, with the same physical emittance injected, the equivalent beam power would be 1.56 MW. With the same normalized emittance injected, the equivalent beam power would be 1.00 MW.
    - The committee is concerned whether a substantially larger emittance could be accommodated. Particularly, experiments found that larger painted emittance

severely affected efficiency and that the complex is nearing limitations from lost beam in the extraction, transport, and injection of beam from the RCS.

- In addition to the beam study, detailed simulations of 1 MW beam power operation and potential improvements support being able to produce 1 MW with the Linac upgrade.
- Significant commissioning and operations time will be required to achieve these beam power levels on this ambitious schedule. The RCS will need to not only deal with its own realignment and improvements, but also with the increase in injection energy and new painting schemes.

R2: Develop an emittance budget from the source to the users that includes all sources of growth indicated by experiment and simulation. Establish limits on the maximum physical and normalized emittance at each step, with a particular emphasis towards the painted emittance for RCS injection.

MR with fast extraction:

- Substantially the same as at the previous ATAC, except with the longer implementation time of the MR magnet power supplies: 225 kW before JFY13 shutdown, 300 kW by JFY14, 750 kW by late JFY17
- Latter goals dependent upon the successful installation of the 60 mA ion source, RFQ upgrade, the 400 MeV linac upgrade, MR collimator upgrades, and the MR magnet power supplies.
- Near-term goals are achievable
- J-PARC has adopted a plan to reduce the cycle time to 1.3 sec as its primary path achieving 750 kW in the MR. As a result the MR magnet power supply needs to be upgraded and the RF voltage needs to be increased.
- Other improvements in the MR could also contribute to higher FX intensities (2nd harmonic RF, increased collimator capacity)
- The budget for the MR magnet power supplies has not yet been secured and the development process must occur immediately to meet the production timeline

MR with slow extraction:

- 15 kW before JFY13 shutdown, 50 kW by end of JFY14, 100 kW by middle of JFY17
- The committee expects that the slow extraction goals will be very challenging to achieve
- The limitations on slow extraction intensity were presented as being primarily due to residual activation. Titanium beam ducts are to replace stainless steel ducts with a 3x lower residual activation. This improvement is likely only to allow 3x greater integrated beam over a long period.
- However, it is not clear what the required duty factor is for SX operation. The experiments will likely require an improved duty factor at high beam intensity to limit the number of accidental coincidences.

R3: Determine the required duty factor for high intensity SX operation and develop a plan to achieve it.

Linac status and studies

Primary achievements

Recovery from earthquake:

The beam availability continues to be excellent, greater than 94%. User operation beam power has been increased from pre-earthquake level of 13.3 kW to 20 kW. It is a testament to the dedication and hard work of the linac team.

Comments and Recommendations

With the new results from the Bunch Shape Monitors (BSM), one can have some confidence that the linac beam emittance is suitable for injection into the new ACS portion of the linac. BSM measurements should be continued to ensure that beam is in fact suitable for he ACS.

SDTL-5 continues to experience problems when its gradient is set to the design value. It must be operated substantially above (109 to 116 percent) the design gradient for stable operation, with a corresponding decrease in the SDTL-4 gradient. No problems encountered so far under such operating conditions since summer of 2012. Discolored bands are apparently not unique to SDTL-5, and may not necessarily be related to the problems with the gradient. For example, it was mentioned by a review committee member that similar bands are seen at ISIS. Also it is not clear that changing the direction of the RF loop was helpful.

R4: Continue to investigate why SDTL-5 must be operated above its design gradient in order to achieve stable operation.

SDTL5 has to be repaired in view of re-establishing a correct operation at the nominal field level.

Beam loss in the linac appears to be dominated by residual gas stripping of H^-. Residual hydrocarbons from vacuum pumps appear to be the chief contributors to the residual gas load. However, intra-beam stripping (IBSt) could become an important mechanism for beam loss at higher beam currents, since the amount of IBSt is proportional to the beam density squared.

The J-PARC personnel should make a rough estimate of the expected magnitude of IBSt losses.

The ion source routinely operates at 17 mA. The highest sustained current attained so far is 34 mA for 100 hours. For comparison, the design current for 1 MW RCS operation is 60 mA. A new volume ion source that utilizes cesium is being developed and the plan is to install it if it meets the required beam currents, with expected lifetimes of over a month as is the case for LANSCE and SNS.

Following the earthquake the RFQ trip rate was high, but it eventually reduced on its own to levels comparable to other areas of the facility, corresponding to about 30 hours per year. In any case, a new RFQ (RFQ III) has been designed and is being built for the 400 MeV upgrade to accommodate up to 60 mA peak current. The planned 60 cm LEBT space between the injector and the RFQ III should also help alleviate the undesirable gas-load at the entrance to the RFQ.

Following the earthquake the activation levels at DTL-1 were unusually high. This was successfully addressed by changing the trajectory of the beam entering the DTL. The beam loss levels are substantially reduced, not to the pre-earthquake level, but still low enough for safe and sustainable operation. The beam loss at the location of the future ACS sections was also successfully mitigated by realignment of beam ducts.

The linac klystrons appear to be suffering from a discharge problem at an increasing rate. Attempts to address this issue by increasing the distance between the Teflon pipes and ground did not help. It is now suspected that the problem lies with the electron guns. One klystron will be replaced before RUN #47 (on DTL-2) to check this idea. No klystron has failed during operation.

3 GeV RCS, including injection bump upgrade

Primary achievements

- Making significant increases to the beam power from the RCS since the previous ATAC meeting in February 2012 and increasing the beam power to 300 kW from 200 kW before the 2011 earthquake — a notable achievement on which the whole RCS team must be congratulated.
- Reaching 95% availability for the RCS for FY2012 to mid-February — a very fine performance.
- Investigating and making important improvements to several component systems of the RCS — including reducing beam losses by a factor of ~6 at injection by improving the vacuum pressure locally, installing a new L3BT collimation system based on thinner scraper foils, demonstrating successful switching between the distinct painting configurations required for MLF and MR, using two pulsed magnets and reducing beam losses at the 3-50BT collimator, and mitigating effects of stray magnetic fields at extraction by installing a vacuum chamber made from high-permeability alloy.
- Improving computer simulations of physically important effects — including re-optimising the operating point (expected to be confirmed by measurement in April 2013), improving agreement with measurement of calculated beam-loss distributions by including effects of previously unsuspected significance (1 kHz ripple on the main bending magnets and a ~100 kHz resonance induced in the ceramic vacuum vessel screening strips by the shift-bump magnet), investigating strategies for mitigating the build-up of halo/tail formations, and updating 1 MW beam simulations for 400 MeV injection. Of course, the success of the RCS team in simulating detailed beam dynamics will be enhanced when effects predicted by the simulations appear in practice (*e.g.* predictions of beam dynamics at 1 MW could be checked by making suitable series of single-shot measurements).
- Running at >500 kW beam power for a short time, thereby allowing key measurements to be made that pave the way for performance improvements aimed ultimately at reaching 1 MW beam power.
- Preparing for injection at 400 MeV, including demonstrating routine operation of four of the five new power supplies required for injection at 400 MeV. The preparations are progressing well, and no obvious reason has yet become apparent why arrangements for injection at 400 MeV should not be successful, although success here does depend

absolutely on the success of the installation and operation of the new shift-bump power supply.

- Through the fact that there were essentially no operational issues worthy of mention, implicitly demonstrating once again the very good standard of performance of the RCS RF systems.

Comments and recommendations

- While it is admirable that the RCS now routinely delivers 300 kW of beam, the rate of increase in beam power of the factor of ~2 per year achieved over the past twelve months is not likely to be maintainable indefinitely. While many characteristics of the RCS have been measured at 530 kW during a 35-second run, very much longer runs will be necessary before the behaviour of the machine at these significantly higher powers can be assumed to be fully understood. Beam losses for 530 kW running were ~2% (mostly in the collimator region), but they are likely to become lower once the RCS is re-aligned and operating parameters are optimised.

  R5: Carry out trials, each lasting at least several hours, at increasing beam powers above 300 kW in increments of ~5–10% to capture effects with relatively long time constants.

  Conclusions based on relatively simple comparisons of space charge effects may not always be borne out in practice.

- The measured radiation dose rates from induced radioactivity in the machine structures after 20–30 days of running at 300 kW appear to be encouragingly low.

- The RCS team has found that formation of beam halo can be substantially reduced by combining several measures — tune manipulation, application of extended-duration second harmonic RF, and removal of the shift-bump-induced ripple. Extension of the second harmonic RF to the estimated 8 ms required for full effect will need cavities incorporating the new FT3L magnetic material, which may be installed from 2014 onwards.

- Initial results from the new L3BT collimator look encouraging. It may be possible to reduce the vertical size of the primary stripper foil and thus reduce the beam loss in the RCS injection area. This work should continue.

- Painting into the full aperture of the RCS at 400 MeV to minimise beam loss may result in a larger emittance of the extracted beam, which could cause increased beam losses — both at extraction and on downstream collimators.

- The allocation of 18 days for commissioning the synchrotron with beam for 400 MeV injection may well prove challenging if anything unexpected comes to light during the commissioning work.

- There is clearly a great deal of work to be carried out on the RCS during the 2013 shutdown — including a demanding programme of realigning magnets and ceramic vacuum chambers. Is it certain that there is sufficient time available?

- The capability of the mercury neutron-producing target to accommodate ever higher beam powers and the expectations of the users of the neutron beam line instruments need to be fully integrated into the time scales for the strong push towards 1 MW.

Main Ring, including MR PS upgrade

Findings

- J-PARC aims at intensity frontier through MW-class proton accelerator already realizing 225kW for neutrino physics (fast extraction) and 15kW for hadron physics (slow extraction).
- 11 candidate events for electron neutrino appearance have been recorded with 3e20 protons on target. 5.3e20 pot has been realized up to now and 7e20 protons on target will be attained in August this year. The goal is a 5 sigma electron neutrino appearance measurement.
- Slow Extraction with the Third Order Resonance applying spill feedback and transverse RF System has reached extracted power of 15kW with extraction efficiency of 99.5 % and duty factor of 45%.
- Feed forward has been applied to MR main magnet power supplies, which reduced the tracking error somewhat while creating other new deviation from the designed pattern. This needs further studies.
- Repetition time of the MR power supplies has been reduced from 2.56s to 2.48s up to now, which is to be further reduced to 2.32s at the next shutdown.
- Review committee was organized to review the MR power supply upgrade. It recommended that (1) cost and performance balance, (2) long life and safety of the capacitor bank, (3) the effect of the eddy current on the magnet and beam pipe, (4) stabilization of the power line including the possibility of flywheel and (5) test of medium-sized power supply for the quadrupole magnets should be considered.

Comments and Recommendations

- Slow beam extraction has attained remarkable advance since the last ATAC even though the current ripple is still pretty large. This should be improved with the new magnet power supplies.
- The performance of the power supplies for the MR magnets in large part determines the scientific capabilities of the MR. Therefore the MR power supply upgrade, the mass production of which is scheduled to start in 2014, is critical to the success of J-PARC.
- A dedicated low voltage supply for flat top operation would significantly reduce current ripple.

Instabilities and Diagnostics

Findings

- In the RCS, it is claimed experimentally confirmed that the dominant impedance source is the extraction kicker impedance. It is 10 times larger than that of SNS kickers, since no impedance reduction cure has been made. Space charge effect is believed to suppress the beam instability. However, the effect of suppression is believed to be marginal in RCS with present kickers for the success of 1 MW operation.

- In the MR, the present narrow-band feedback system is effective to control the beam instabilities during the injection and at the onset of acceleration on both planes at the beam power level of 230kW. An analytical model demonstrates that the observed intra--bunch oscillations during the injection can be explained by a simple dipole mode with the oscillating betatron phase difference between the head and tail phase of a bunch. It is not clear how these intra-bunch oscillations will play a role in limiting the beam power in future. As a precaution the development of a intra-bunch feedback system is underway.

- Beam power on target during slow extracted beam operation increased significantly to 15 kW with a 6 second cycle period. Extraction efficiency was about 99.5% and the duty factor was about 45%. During a study 20 kW extracted beam power was reached with about the same efficiency and duty factor. Since activation due to the beam losses during SX operation limit the extracted beam power vacuum chambers of high loss devices will be replaced with chambers made from Ti to reduce activation.

Comments and recommendations

- In similar accelerators like the original ESS ring (as designed by G. Rees and his colleagues) and the SNS accumulator, significant efforts were made to minimize the beam coupling impedance of the extraction kickers at an affordable cost including the amount of increased power needed to accommodate a low terminating resistance for the pulse-forming network (PFN). As similar optimization has not yet been performed on the RCS extraction system, instabilities driven by the kicker impedance can limit the performance as the beam intensity is raised to meet the design goal of beam power of 1 MW and beyond. We recommend a detailed comparison and, if necessary, alternative design of the RCS extraction kicker system

  An implementable design alternative of the RCS extraction kicker and its PFN system reducing the beam coupling impedance closely referencing the experience of the original ESS design (Rutherford) and the operating SNS accumulator could be considered.

- Significant amount of benchmarking efforts were made with ORBIT codes on the SNS accumulator obtaining quantitative agreements between experimental measurements and simulations on the onset and growth of various instabilities. Collaboration is underway between J-PARC and SNS to adapt the ORBIT codes to the RCS incorporating the varying revolution frequency as the beam is accelerated. We encourage such codes adaptation and developments along with a thorough benchmarking of the existing machine under various conditions (like chromaticity, tune working point, beam and bunch configurations etc.) so as to predict the performance obstacles towards 1 MW and beyond beam power.

Continue the adaptation and development of the ORBIT codes and perform thorough beam studies to benchmark the RCS instabilities under various machine conditions.

- Vacuum chambers and bellows made with permeability alloy (permalloy) were newly introduced to the RCS. Such material changes the optical properties of the machine and introduces new impedance sources. A more careful analysis is needed to understand the implication of such objects. In general for both RCS and MR, impedance budgets need to be monitored tracking the change of ring elements.

  R6: Monitor impedance budgets for both RCS and MR and develop mitigation scenarios on leading impedance sources.

- Efforts were made in understanding the onset and feedback suppression of coupled-bunch and intra-bunch oscillations at MR injection including establishment of analytical models. However, intensity dependence of such phenomena is not obvious. We urge dedicated intensity-dependence studies including measurements of both the transverse and longitudinal impedances

- Beam diagnostics can play an important role in the power ramp up of both RCS and MR addressing instabilities and collective effects. For example, Schottky detectors can be useful in providing frequency domain information of the MR beam at flattop and the high intensity debunched beam in the MR can easily develop longitudinal microwave instabilities or getting neutralized by electron clouds. A broadband wall current monitor and electron detectors can be used to identify this situation.

Linac energy upgrade

Main achievements

- Significant progress has been made in the linac energy and current upgrade program.

- The new RF ion source has exceeded the specifications both in current and emittance, and has been operated for several days above 60 mA at specified frequency and pulse length. Although the commissioning is not yet concluded and the operation procedures have not yet been optimized, the results are very encouraging.

- The RFQ-II has been successfully tested up to 118% of nominal power and would be ready to be tested with beam; although limited to 24 hours, this result represents an encouraging confirmation of this RFQ cavity design, the same as RFQ-III which includes, in addition, 60 mA capability.

- The RFQ-III construction is nearing completion; all the mechanical and low power RF measurements and checks have been done, showing that the alignment precision, the field distribution and the vacuum characteristics are within the design specifications.

- All ACS cavities have been fabricated, and five of them will be tested at high power before July. Preliminary testing was reported not to show any problem or difficulty in conditioning, giving hope for a fast commissioning.

- Most critical components for the linac upgrade, including RF system, are either ready for installation or close to completion and no showstoppers appeared to date. There are still open problems, which are being properly tackled by the group.

- The ATAC Committee 2012 recommendations have been properly addressed.

- A detailed plan for the linac upgrade has been presented. The plan foresees the completion of the linac installation within November 2013 and completion of its commissioning with beam in December 2013. The plan is very ambitious and does not include any significant time contingency.

- Regarding installation and commissioning of the ion sources and RFQ-III, an alternative plan to the two plans considered before has been proposed by the group. This "plan C" foresees the commissioning of both the old filament source and the new RF source with RFQ-III on the test stand, leaving on line RFQ-I and a spare filament source (with maximum current capability of 30 mA). In October 2013 RFQ-III would be put on line either with the RF source (if ready) or with the old source (if necessary).

Comments and recommendations:

- The work performed in the last year on the linac upgrade front by the J-PARC accelerator group is remarkable, and was presented very clearly and in an informative way during the ATAC meeting by the J-PARC accelerator group.

- Since the maximum delivered current in the source-RFQ system depends on the least performing component, the high-current RFQ III should be used only in connection with the high-current RF source. R&D and pre-commissioning of this system on the test stand should continue until it can deliver the specified high intensity beam and is ready for installation in the upgraded linac. This time might be prolonged beyond October 2013 if necessary, leaving the old source-RFQ system in place for beam commissioning of the linac with 30 mA.

  R7: The RFQ III should be fully tested with beam on the test stand using mainly the new, high current RF source, and installed in the linac when ready to operate with the 60 mA source current.

- Some issues were reported with the ion source development. The presently installed filament ion source (Cs free) shows rather short filament lifetime when powered for beam intensity of 30 mA or more. Although filament replacement and beam recovery could be obtained in 1-2 days, that source seems not to be suitable for 60 mA operation. On the contrary, the new RF source with Cs could fulfill the beam specifications, with limited requirement of Cs deposition for about 4 minute per day. Operation with constant optimum Cs pressure, as done in most operating sources that make use of Cs, would reduce the beam current fluctuations and probably minimize the amount of Cs required in the source.

- The risk of contamination of the RFQ with Cs from the source is always present, but the RF source is at present the only possible choice for high current operation at J-PARC. A cold diaphragm (water-cooled or even liquid N cooled) for Cs gas condensation installed inside the 600 mm long LEBT would prevent, or at least limit, Cs spill into the RFQ.

  R8: Consider installing a cold diaphragm in the LEBT to collect Cs particles preventing them from reaching the RFQ vacuum.

- The installed RF chopper was operating well with the I<30 mA beam; a similar cavity with larger aperture and higher voltage, needed for efficient chopping of the 50 mA beam as demonstrated with calculations, is planned to be constructed and installed in the linac in 2014. A tungsten beam scraper has been proposed in place of the existing C/C one, which showed to be damaged by the beam in a few years of operation. This plan of chopper upgrade appears feasible and credible, and should guarantee suppression of bunch tails at high beam current. The reduced bunch length necessary in the MEBT for the chopper to operate satisfactorily increases the space charge induced blow-up.

- Generation of protons in the front end could become a serious issue again when reaching 400 MeV.

- The planned time period for installation and commissioning is claimed to be feasible, but without margin and quite ambitious. The limited amount of ACS structures tested at high power before installation is, for example, worrisome. Some time-contingency in the schedule would improve the reliability of the delivery time. However, it must be recognized that the accelerator group has demonstrated capability of working with very tight schedules as evidenced by the very fast recovery of the J-PARC accelerators after the earthquake.

Ring RF, including high gradient cavity

Findings

General

The long shutdown resulting from the 2011 earthquake was used to improve the RF systems in both RCS and MR, and further upgrades were implemented during the summer shutdown in 2012. RF systems performed remarkably well in both rings during the last 12 months, and no new issue has been found.

As recommended by ATAC in 2012, the repair of the RF test place in the Hendel building in Tokai is in progress and will soon be finished.

RCS cavities

Eleven cavities are installed in the ring. Seven of them are presently equipped with new "buckling-free" cores using type-C coating. These cavities show consistently good performance, with no measurable reduction of impedance.

Two more cavities will be upgraded during the summer shutdown in 2013, and a 12th cavity will be installed. The last two unmodified cavities will be upgraded in 2014.

At a later stage, if experimental observations after this summer upgrades confirm that more voltage is necessary on the 2nd harmonic of the RF to reduce halo formation, the replacement of all cavities with high gradient units using FT3L cores will be requested.

MR cavities

Since the summer shutdown in 2012, the MR is equipped with 9 cavities using diamond polishing, Silica coating and RTV rubber shielding. The cavities are cooled by a separate water-cooling circuit independent from other equipment.

The development of FT3L cores has continued to progress during the past 12 months. A mass-production set-up is being prepared for industry to manufacture the 280 cores required by the new cavities, which will replace all the present ones during JFY2015. At the same time, a low duty factor/air-cooled second harmonic system will be installed in another straight section. After this upgrade, the accelerating RF voltage will reach 450 kV, as required for cycling the MR to 30 GeV in one second and potentially reaching 750 kW with fast extracted beam.

Feed forward

Feed forward on multiple harmonics has been implemented in the MR, reducing drastically longitudinal oscillations during the cycle and decreasing by an order of magnitude the variation of energy during debunching.

R § D on alternative solution

A half-gap structure loaded with three sets of multi-ring cores and Fluorinert coolant has been built. The 60 kW power amplifier necessary to fully characterize it is presently in construction. This R&D will be concluded after high power tests within the next fiscal year.

Comments and recommendations

Present RF systems

The excellent performance of the RCS and MR RF systems during the last 12 months is an obvious consequence of the tenacious efforts of the RF team members since the beginning of the J-PARC project, with the determined support of the project management. The Committee congratulates the members of the RF team for this excellent result, which shows that this technology is mature for use in other accelerator projects.

The committee encourages continuing the systematic and regular monitoring of the Finemet cavities characteristics.

The Committee acknowledges that the RF test place in Tokai will resume operating soon.

RCS cavities
The Committee approves the strategy to wait for quantified experimental evidence demonstrating the need for more 2nd harmonic RF voltage before starting the production of high gradient units using FT3L cores to replace the existing cavities.

MR cavities
The Committee congratulates the team developing the FT3L cores and encourages further investigations (e.g. reducing the thickness of the ribbon in view of reducing Eddy current losses).
The use of air instead of water-cooling is a worthwhile choice whenever feasible. The Committee therefore approves the choice of air-cooling for the future low duty factor second harmonic system.
The Committee agrees with the decision to start immediately constructing new high gradient cavities using the present technology for FT3L cores as a necessary means to permit ramping the MR to 30 GeV in about one second before the end of 2016 and potentially delivering 750 kW of beam power.

Feed forward
The benefits expected from feed forward on the MR cavities are indeed observed at the present beam intensity and beam power.

R9: Continue to develop the MR feed-forward system to accommodate the increased impedance of the future FT3L-equipped cavities and the higher intensity foreseen for the slow extracted beam.

R&D for future cavities
The Committee agrees with the termination of the development of multi-core/Fluorinert cooled cavities after the high power test of the existing half gap prototype.

Appendix: Meeting Agenda

Thursday 21 February 2013

09:00	Project Status	Y. Ikeda
09:30	Accelerator Overview	K. Hasegawa

Status & Commissioning (Linac)

10:50	Linac Status	H. Oguri
11:20	Linac Beam Study Results	M. Ikegami

Status & Commissioning (RCS)

12:50	RCS Status	M. Kinsho
13:15	Beam Study Results of RCS	H. Hotchi
13:50	Realignment Plan of the RCS	M. Yamamoto

Status & Commissioning (MR)

14:10	MR Status and Plan	T. Koseki
14:45	MR Beam Study Results	S. Igarashi
15:45	MR Slow Extraction	M. Tomizawa
16:15	Instabilities	Y. Shoubuda, Y. Chin

Friday 22 February 2013

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

09:10	Linac Upgrade Plan	N. Ouchi
09:40	Linac Front End Upgrade	T. Morishita
10:40	Power Supplies of RCS Injection Bump Magnets	T. Takayanagi, N. Hayashi
11:10	MR Power Supplies 1	F. Naito
13:00	MR Power Supplies 2	Y. Kurimoto
13:30	High Gradient RF Cavity	C. Ohmori

Saturday 23 February 2013

10:30	Recommendations to J-PARC	T. Roser