Report of the 24th Meeting of the Accelerator Technical Advisory Committee for the Japan Proton Accelerator Research Complex (J-PARC)

February 5 – 7, 2025

The Accelerator Technical Advisory Committee (A-TAC) for the J-PARC Project held its twenty-fourth meeting from February 5 to 7, 2025, at the J-PARC Research Building in Tokai, Japan. The A-TAC members participating were: Alexander Aleksandrov (ORNL), Håkan Danared (ESS), Wolfram Fischer (BNL, remote), Simone Gilardoni (CERN), Toshiyuki Shirai (QST), Sheng Wang (IHEP), Alexander Valishev (FNAL) and Jie Wei (MSU, chair) (Appendix 1). John Thomason (STFC) was unable to attend. We pay tribute to Mats Lindroos (ESS) who passed away in May 2024, and welcome new committee member Håkan Danared (ESS).

The A-TAC thanks the J-PARC management and staff for their thoughtful arrangement of this in-person / remote hybrid meeting, and all the presenters for their excellent and comprehensive talks. In addition, the accelerator team responded appropriately, arranging specific talks to the requests made at the last A-TAC Review and to the questions and homework requests from the committee at this review.

Executive Summary

The J-PARC accelerator team reached a major milestone achieving a beam power of 1 MW during stable MLF operations, 16 years after the completion of the J-PARC construction project. With the successful construction and commissioning of the new MR main PS, the beam power for MR operation is also steadily increasing, exceeding 800 kW in the MR-FX to the neutrino experimental facility and exceeding 80 kW in the MR-SX to the hadron experimental facility. The J-PARC team is commended for their persistent pursuit towards this achievement.

During the past year, the J-PARC accelerator complex operated without reportable personnel safety or beam-induced machine protection incidents. Significant efforts have been made to address issues of aging and obsolescent equipment, and progress has been made, for example in updating Linac (LI) and Rapid Cycling Synchrotron (RCS) water utilities.

The trend of declining number of operation user cycles since 2017 and the level of overall facility availability is concerning. Contributing factors include a declining inflation-adjusted operations funding and a slow response resolving conventional issues during accelerator operations. Appropriate response protocols corresponding to different level-of-care categories are important, allowing expedited recovery and minimizing overall impact to accelerator availability and user programs without compromising safety.

The annual J-PARC operations budget has largely remained flat during the past decade. Budgetary pressure is high as the accelerator facility continues to age and post-pandemic conditions are challenging with increased inflation, an unfavorable currency exchange rate, and a changing supplier base. Supplemental funds so far have been essential to ensure implementation of strategically important programs and to address urgent facility aging and obsolescence issues. To reduce the downtime risk from growing obsolescence a program of sustained upgrades is needed over the lifetime of the J-PARC facility and should be integrated in multi-year planning and funding requests including for an adequate workforce.

Several accelerator development initiatives aligned with J-PARC's long-term missions have been presented at this review. The J-PARC Proton Beam Irradiation Facility (PBIF) is newly proposed and will take advantage of a doubling of the Linac repetition rate to 50 Hz. Such an initiative can be significant, opening J-PARC to industrial users with societal impact and expanded funding sources. It is noted that irradiation facilities with heavy ion beams can create even more on demand.

Dr. Michikazu Kinsho was promoted to be the deputy director of J-PARC in April 2024. Since then, Dr. Hidetomo Oguri has been heading the J-PARC Accelerator Division.

The J-PARC accelerator team has addressed most, though not all, of the 6 A-TAC 2024 recommendations. Presentations were given at this review covering the 2 topics requested by A-TAC at the 2024 Review. Responses to the 4 homework assignments at the 2025 Review were timely. The committee commends the J-PARC team on their dedication and vigor addressing pressing issues.

In the following, we summarize the main recommendations of the A-TAC 2025. Each of the recommendations (**R1 – R7**) will be elaborated multiple times across the main body of this report following committee findings and comments. The order of the main body of this report follows the thirteen talks (Appendix 2) and four homework assignments presented at this review.

The level of overall facility availability is concerning. Contributing factors include a declining inflation-adjusted operations funding and a slow response resolving conventional issues during accelerator operations. A detailed analysis is needed on the facility downtime hours by system (e.g. safety/personnel protection, machine protection/interlocking/diagnostics, equipment protection, controls, magnets, RF, PS, vacuum, collimation, source, cryogenics, utility, handling …) category for the past years of user operations. Given limited funding and other resources, each category should be designated with appropriate levels of care for efficient and effective mitigation.

R1: Identify the root causes of leading contributors to the J-PARC facility downtime, and develop mitigation plans accordingly.

Accelerator incidents fall into various categories in accordance with their impact to (a) personnel and environmental protection, (b) beam-induced machine protection, and (c) equipment protection. Appropriate response protocols corresponding to different categories are important, allowing expedited recovery and minimizing overall impact to accelerator availability and user programs without compromising safety. For example, device overheating without subsequent safety threat should belong to the equipment protection category that would result in straightforward lessons learned to the engineering without prolonged delay to operations.

R2: Work with regulators to develop appropriate response protocols in accordance with the category and severity of incidents to ensure that impact on facility availability is minimized.

Budgetary pressure is high as the accelerator facility continues to age and the post-pandemic conditions are challenging with increased inflation, an unfavorable currency exchange rate, and a changing supplier base. To reduce the downtime risk from growing obsolescence a program of sustained upgrades is needed over the lifetime of the J-PARC facility and should be integrated in multi-year planning and funding requests including for an adequate workforce.

R3: Develop a program of sustained upgrades over the lifetime of the J-PARC facility and integrate it in multi-year work and workforce planning, and funding requests.

The MR team has acquired a special budget and is steadily working on dealing with aging utilities. J-PARC should consider an appropriate yearly budget and extra budget to deal with routine maintenance and aging issues. In addition, the aging issues are not only for the utilities but also all other devices. It is necessary to consider the overall balance in the J-PARC system.

R4: Continue to identify the list of mission-critical aging items, not limited to utilities, whose replacement or preventive maintenance cannot be funded internally by J-PARC and would require additional external funding.

The new MR beam abort dump is important to make a more efficient use of the tuning beam time available, which is so precious considering the balance between time for user operation and for machine studies necessary to reach and, in the future, maintain the 1.3 MW beam. The timeline proposed with the final construction seems to be challenging, considering that the design is still in the early stages.

R5: Develop a comprehensive design, construction and installation plan of the new beam abort dump and present it at the next ATAC.

The setup of the collimation systems seems to be rather complicated, time consuming, and based on empirical observation without the guidance that simulations could offer. It is not clear if the current setting is really optimal, and if the presently used procedure could be applied at a higher beam power, even if the system looks sufficiently effective for 800 kW operation. Simulations could provide valuable help to identify the optimal initial settings and a better understanding of the collimation process, the loss mechanisms and for the characterization of the particles leaking from the collimation section.

R6: Study via simulations the collimation system efficiency and settings once the Xsuite MR model will be ready, and make use of these results to guide the machine development tests and optimize the loss localization at the collimation insertion during operation.

Some of the critical MR elements do not have a spare, or the spare is not ready for installation. Existing spares for the accelerator complex should be maintained and ready to be deployed on a short notice, or spare components should be available depending on the system criticality.

R7: Elaborate a plan to optimize the availability of spare elements and their readiness for installation within the existing budget constraints. The plan should include an assessment of additional procurements for missing spares or parts for critical elements.

Items for the Next Meeting (A-TAC 2026)

The committee would like to hear from the J-PARC accelerator team in particular:

1. Present J-PARC facility availability data using conventionally adopted method of:
   Availability = (Scheduled hours - Unscheduled off hours) / (Scheduled hours)
   (over every annual time periods of pre-approved cycles).
2. Present a comprehensive design, construction, installation and commissioning plan for the remaining elements of the MR 1.3 MW operation.

02 J-PARC Accelerator Overview (WF, AV)

Findings

- The SX beam power to the HD facility increased from 65 to 80 kW in 2024 through a reduction of MR repetition rate from 5.20 to 4.24 sec.
- The FX beam power to the NU facility increased from 760 to 800 kW in 2024, 900 kW were demonstrated in Nov-Dec 2024.
- The MR availability was high in the Jan-Mar and Nov-Dec period, but only 66% in the Apr-Jun period due to a MR bending magnet failure and a cooling water issue.
- The RCS reached a beam power of 1 MW for MLF user operation in Apr 2024 with an availability of 88-90% in the Jan-Jun period. Operations for the Nov-Dec period was canceled due to a problem with the MLF target.
- 5 larger events caused down time between 4.5 days and 2 weeks. A scorched component was observed in the PS terminal box in one of the 12 Linac chillers. The latter event was categorized as a fire incident by the public fire department.
- The scorched component was a power connection box, and the scorching was created through an arc after surface oxidation over several years, the arc and subsequent glow heated the terminal to nearly 1000 C and the power block melted.
- The chiller connection was changed after a 2018 upgrade, and the terminal box was not included in inspections since 2018. The inspection manual has now been revised.
- Item 1 response (initiatives aligned with long-term mission): the organization was presented showing reporting structure from individual thrusts to funding agencies and lab management, and a tentative roadmap aiming at achieving the performance goals.
- Accelerator development initiatives include a beam power upgrade of the RCS from 1.0 to 1.5 MW, and a Linac upgrade of the repetition rate from 25 to 50 Hz.
- 2028 will mark an important milestone in the history of J-PARC with end of the JAEA Mid & Long-Term Plan (2022-2028), a planned trial of 1.5 MW beam acceleration in the RCS, and 1.3 MW operation of the MR.
- The operations schedule for FY2025 assumes 6.4 cycles (141 days) of beam to users, additional budget will be necessary for the standard 7.2 cycles in 2026.

Comments

- The committee congratulates the J-PARC team on achieving the beam power increases in the RCS and MR FX and SX operations. The MR beam power increase follows closely the multi-year plan that ends with 1.3 MW in 2028, and the benefits of the MR main PS upgrade are now visible in both the FX and SX programs.
- The RCS availability with close to 90%, excluding the period with target issues, is notable.
- The MR availability was significantly affected by 2 larger failures. Such large failures could become more common in the future without a systematic program of detecting and mitigating weaknesses in components and infrastructure.

- The event of the scorched connection box at a Linac chiller was investigated, and corrective actions have been implemented.
- The terminal block overheating is a common type of incident, such connections should be serviced periodically sitewide. The evaluation of the extent of condition and implementation of a sitewide plan for inspections is an appropriate step.
- The more granular analysis of downtime by system/component was presented in response to a homework question and benefited the discussion.
- Based on the scorched event and the knowledge gained through continued operation, design specifications should include functions for higher power accelerators and equipment protection.
- The J-PARC facility has entered a phase that needs a continuous program of more intense maintenance and upgrades, presently not matched by funding.

Recommendations

R3: Develop a program of sustained upgrades over the lifetime of the J-PARC facility and integrate it in multi-year work and workforce planning, and funding requests.

03 Status of MR (AV, WF)

Findings

- 800 kW operation mode was established in the MR via a 1.36 s cycle.
- Continuous efforts to reduce beam loss resulted in <1% loss in 800 kW operations, further progress is necessary to establish 900 kW operations as the current losses are at the level of 1.9% (1.7 kW)
- Failure of BM116 bending magnet occurred on May 5, 2024, during SX beam operations. Impedance measurement on the coils revealed a layer-to-layer short. A spare was available, and replacement took two weeks. The failed magnet was repaired with a spare coil.
- The magnet failure due to a shorted layer is a second recurrence since 2016. In the previous case water leakage was suspected as the cause, in the 2024 case no abnormality was observed. A plan is being developed to perform non-destructive surveys.
- IGBT failures in the SX bump magnet caused additional downtime. Several possible causes have been proposed, continuous monitoring of the power supplies is in place to further diagnose. The J-PARC team is also mitigating risk by procuring spare parts.
- Failure of the cooling tower in the M2 outer yard was another source of downtime due to the reduction of the number of operating units below the necessary to maintain cooling capacity. The root cause was bearing wear in the fan motors.
- Phased hardware upgrades are planned to achieve the 1.3 MW MR capability by upgrading the acceleration cycle to 1.28 s (summer shutdown of 2025) and further to 1.16 s, and by increasing beam intensity to 3.3×10^{14} protons per pulse.
- Significant progress was made on the bending magnet power supply, transformers were replaced.
- Along the RF system upgrade, one cavity was installed, and one further will become available in 2025. The power supplies can support 900 kW operations.
- The additional collimator installed in 2024 enables 3.5 kW capability.
- Focus of work modernizing aging systems in 2024 was on the infrastructure such as water cooling, chiller, and power supplies. The execution of the formulated plan will continue in 2025.
- Work is in progress to reduce losses in SX mode to achieve 100 kW in 2026.
- The plan is to achieve stable 900 kW operations in FX mode by reducing losses to below 1% (by implementing new optics and the elimination of resonances).
- 1 MW should be achievable in 2026, which is consistent with the original upgrade plan.
- Response to R5: 40 days are usually allocated in the 159 days of operations for beam tuning and studies, including periods of 1-2 weeks before and after the summer shutdown.
- Longer summer shutdowns are requested in 2026-2028 to accommodate maintenance, upgrades and tuning needed for the high-power operations.

Comments

- Beam power increase in FX and SX mode followed closely the multi-year upgrade plan.
- The execution of beam power upgrades, loss reduction measures and the modernization work are highly commendable.
- The reduced machine availability in 2024 run is a concern, attention needs to be paid to monitoring the sources of downtime and revising modernization priorities in line with the most significantly contributing systems.
- The magnet replacement time of two weeks is rather long and was dominated by the need to move heavy magnets requiring contracting external resources.
- The inventory of spares does not show ready-to-go magnets of 4 types, which is a concern for long-term reliability. Plans should be made to have at least one spare of each type in stock.

Recommendations

All Recommendations apply to MR.

04 Beam study results of the MR (SG, ST)

Findings

- The beam power increases steadily according to the initial plan, with the goal of reaching 1.3 MW by JPFY2028 for continued and stable operation and with limited beam losses, of the order of 1%.
- Stable operation at 800 kW was realized with losses of the order of 0.8 % thanks to improved optics correction, better tune tracking during acceleration, different collimator settings and new optics at flat top. In fact, studies in JPFY2024 were concentrated on the use and optimization of the different new hardware and beam tuning strategies identified already during the JPFY2023, and on their deployment for 800 kW stable operation. In particular, the improvement of the new main power supply noise, the quadrupole circuits balance and the implementation of a new optics, together with the previously mentioned new collimation configuration with two new units, reduced significantly the losses at low energy. Further loss reduction was possible also thanks to an horizontally narrower beam from the RCS. The improved optics at extraction also contributed to the loss reduction, thanks to a smaller vertical beta function for the off-axis extracted beam trajectory.
- The upgrade of the collimation system has been finalized. All the new modules, now 7, are installed and operational, offering an improved coverage of the entire phase space in both planes. The system can now cope with losses up to 3.5 kW. The proposed changes in optics at injection have a little effect on the phase space coverage by the collimators. The collimation system is set up to localize the losses in particular during the injection process until the end of the flat bottom, with some losses at the beginning of the acceleration. The system is acting as a single-stage, single-passage.
- 900 kW beam acceleration was successfully realized in Dec. 2024, however the observed large beam losses, of the order of 2%, are incompatible with stable beam operation. Beam loss reduction is expected thanks to further beam tuning, by the optimization of the working point, in particular at low energy, an improved adjustment of the collimator settings and the deployment of the new optics.
- The new optics proposed during the ATAC2024 to reduce losses at injection will be deployed also on the faster cycle. The goal is to show that the new optics weaken the space charge induced resonances and to explore new working points.
- Two 3rd order resonances can be corrected by 4 trim coils on sextuples magnets and tracking simulations suggest that the proposed upgrade to 24 trim coils could significantly suppress the resonance induced losses affecting off-momentum particles. The upgrade of trim coils on the sextuple magnets is deployed in stages, with 24 units available by the end of JFY2025.
- The exploration of new working points to cope with the larger Laslett tune shift continues, in particular studies with a different vertical integer working point are planned. Simulation studies will be carried out in collaboration with RAL & U. of Oxford. An Xsuite model of the MR for beam dynamics and optics studies is being developed.

Comments

- The committee congratulates the teams operating the machine at 800 kW with stable losses below 1%.
- The committee recognizes the importance of the large number of ongoing studies to reduce beam losses to a minimum for the increased beam power. These studies are complex and time consuming, and they require both beam tuning periods as time to finalise the simulation work. Their importance and success is shown by the low loss operation at 800 kW reached thanks to the implementation of some of the results of these studies.
- The committee takes note of the concerns expressed by the MR study team related to the limited amount of time available for the beam tuning. The committee strongly encourages the team to continue negotiating the allocation of the necessary beam time, compatible with the needs of the physics program.
- Simulation studies as machine tuning results show that every beam power increase towards 1.3 MW stable operation requires the re-optimization of the corrections and machine setting up done for the lower beam power.
- The setting up of the collimation system seems to be rather complicated and based on empirical observations without the guidance that simulation studies offer. It is not clear, in fact, if the current settings are really the optimal ones, and if the same procedure could be applied for higher beam power, even if the system looks sufficiently effective for the 800 kW operation. Simulations could provide valuable help to identify the optimal initial settings, considering the large number of collimators and thus of free parameters (jaws positions, jaw angles, etc…), and to reduce the leaking losses from the collimation region. It could be difficult and time consuming to set up and operate the system based exclusively on machine observations.
- The collimation system is located in a zero-dispersion region, so the losses intercepted during the start of the accelerating ramp seems not related to uncaptured beam. The source of them should be clarified, if for example they are generated by an orbit perturbation due to the start of the acceleration process, or a radial position displacement due to a mis-match between the magnetic field and the beam energy that could cause a transverse halo formation, or else.

Recommendations

R6: Study via simulations the collimation system efficiency and settings once the Xsuite MR model will be ready, and make use of these results to guide the machine development tests and optimize the loss localization at the collimation section during operation.

05 Slow extraction status and plan (WF, SG)

Findings

Beam power:

- In 2021, before the MR upgrade, the SX beam power was 64 kW with 99.5% efficiency, and 75% duty factor.
- The MR upgrade shortened the energy ramp from 1.4 sec to 0.65 sec, and the SX repetition rate from 5.2 sec to 4.24 sec while keeping the flattop length of 2.61 sec. This yielded an extracted beam power increase from 65 kW to 80 kW.
- There is ongoing work on loss reduction in the extraction region (ESS, SMS1/2/3).
- The main loss is upstream of ESS, and losses are reduced or planned to be reduced with 2 diffusers, and possibly a crystal.
- One diffuser is made of high-Z material (tantalum), 100-200 mum thick, and 1-2 mm long. The optimum location has been determined with FLUKA.
- The diffuser reduced losses by ~30% at the highest loss locations.
- After the MR upgrade 83 kW with 4.24 sec repetition rate, 99.6% efficiency and 83% duty factor were reached.
- For further loss reduction with crystals in the beam extraction simulations have been performed.
- Since the number of protons accelerated and slowly extracted has not yet changed, no new beam instability observations were made.

Spill structure:

- In 2020, with all spill regulation systems turned off, large spikes were observed in beam spill caused by ripples in main magnet current.
- Before the upgrade a 78% duty factor was achieved, which dropped to initially 61% after the upgrade and could be increased to 83% with various measures.
- The 150 Hz ripple was enhanced after upgrade due to the load mismatched quadrupole QFRPS PS. To reduce the 150 Hz a new PS is needed long-term, which would cost several oku-yen. and take a few years. In addition, filters were installed to reduce the ripple.
- An active feedback (“ripple canceller”) is planned for the future.

Comments

- The increase of the SX beam power over the last year was facilitated entirely by the increased ramp rate of the new MR main PS.
- A further increase of the SX beam power requires an increase in the number of protons accelerated and could be limited by beam instabilities after debunching.
- While the duty factor decreased from 78% to initially 61% after the power upgrade, it could be increased to 83% with the higher power through several measures.

- The eventual upgrade of the reused QFR PS that is not load matched to the new magnet configuration is uncertain due to the high cost and extended upgrade schedule.
- While the target group is building a new target for 150 kW, no plan with milestones of intermediate steps was presented on how to increase the SX beam power from the present 80 kW to that value. It is expected that this would take several years.

Recommendations

None.

06 MR towards 1.3 MW (SG, WF)

Findings

- During a single shot test, 903 kW have been reached with a 1.36 s cycle. Beam losses were 1.7 kW, which is considered too large for regular operation but still compatible with the new collimation system that can cope with 3.5 kW.
- To reach 1.3 MW in JFY2028, the beam intensity should increase by 30%, from 2.5×10^{14} ppp to 3.3×10^{14} ppp, and the repetition rate reduced by 17%, shortening the cycle from 1.36 s to 1.16 s. These changes will be possible mainly thanks to the upgrade of the MPS and the RF systems.
- Simulations are ongoing to decide the best strategy to modify the MPS and reduce the magnetic cycle for FX to 1.16 s. There is going to be an intermediate step to have a shorter magnetic cycle with a duration of 1.28 s starting from JPFY2025. This should bring another step in beam power increase. Between the few choices available to modify the MPS, the preferred one foresees the increase of each capacitor bank capacity from 480 mF to 540 mF.
- The optimization of the quadrupole power converters is progressing, with the goal of being compatible first with 1.28 s operation.
- The upgrade of the corrector magnet systems is ongoing. These are mainly used for resonance compensation or to compensate for the eddy current effects of the large vacuum chambers of the FX section. Beam dynamics simulations including the compensation of these effects are promising, in particular for the loss reduction.
- The aperture limitation causing losses at extraction should have been addressed by installing new quadrupole magnets with larger aperture in the extraction region. Considering the cost increase for their production, the construction was put on hold after the first one was built. Losses have been reduced by an improved optics with a better ratio of beta functions with respect to the extraction trajectories and the available mechanical aperture. Further loss reductions are expected by the predicted decrease of the beam halo population thanks to the resonance compensation.
- Simulations of the longitudinal beam dynamics with the BLonD code shows that 1.3 MW can be achieved with 10 cavities with a voltage of 510 kV for the 1.16 s cycle. Still, more stable operation could be achieved with 11 cavities.
- The RF anode power supplies are used for the compensation of the beam loading and they have to be upgraded to cope with the higher beam intensity. While the inverter units of each anode power supply have been increased from 16 to 19, the 11 fundamental cavities and 2 second harmonic cavities will be fully operational in 2027. The total voltage available will increase from 462 kV to 574 kV, compatible with the voltage needs determined by BLonD simulations plus some margin. The installation plans and the space are available for both the anode power supplies and the transformer-rectifiers.
- The FX extraction elements were upgraded for final operation at about 1 Hz, however the high field septa coils showed some fragilities, with some water leaks developing in the recent past. The coil replacements with an improved design of the water-cooled connectors will be concluded in summer 2025.

- The beam abort dump upgrade is done in collaboration with RAL (UK). The existing beam dump can receive only 19 high intensity extractions per hour, with the beam power limited to 7.5 kW. A new beam abort dump compatible with 30 kW is proposed. The new system should be available by fall 2026.
- The new BPM Signal Processing System is in production, and it should be installed by the end of JPFY2025.
- Amongst other beam studies concerning optics change to reduce losses, or the optimization of the collimation system, it is proposed to change in the future the vertical integer tune to avoid the overlap between the larger Laslett tune shift at injection and some structure resonances.

Comments

- The timeline presented to reach the 1.3 MW operation in JPFY2028 looks credible, and the progress in the beam power increase matches extremely well the plans developed a few years ago. The activities presented are well on track and budget and workforce available, however without contingency.
- The committee congratulates all the teams for the 900 kW test and the operation at 800 kW.
- There are still concerns with the noise generated by the new power converters affecting the slow extraction spill quality. The impact of the proposed MPS modifications for the FX faster cycles on the current noise that could affect SX should be carefully considered, at least at a second stage of the studies.
- The new beam abort dump is important to make a more efficient use of the tuning beam time available, so precious considering the balance between time for user operation and for machine studies necessary to reach and, in the future, maintain the 1.3 MW beam. The timeline proposed with the final construction seems to be challenging, considering that the design seems to be still at its infancy. In the meantime, it would be useful to reconsider the maximum power that the existing dump could receive.
- Beam coupling impedance should be maintained well under control during the installation of new elements to avoid any new beam instability development with the increased beam power.

Recommendations

R5: Develop a comprehensive design, construction and installation plan of the new beam abort dump and present it at the next ATAC.

07 LI 50 Hz operations (AA, HD)

Findings

J-PARC is considering development of a proton beam irradiation facility (PBIF). This will require additional 250 kW of beam power from the linac independently of the RCS operation. The proposed scheme is to increase the linac pulse repetition rate from 25 Hz to 50 Hz with every second pulse diverted to the PBIF. It is believed that the existing electrical and RF infrastructure is capable of supporting the required doubling of the average RF power. Several systems with insufficient cooling are identified. The J-PARC team has initiated a feasibility study of 50 Hz linac operation. The first test is scheduled for summer 2025. The test goal is to demonstrate operation of the timing and RF systems at 50 Hz without a beam. The test will be conducted with 50 Hz / 300 us RF duty factor. The ion source is already capable of running at 50 Hz. The long-term plan includes design of a separation magnet and a temporary beam dump to demonstrate 50 Hz beam operation. There is no established timeline or secured funding yet for this part.

Comments

- The committee fully supports the effort of exploring feasibility of the linac 50 Hz operation.
- The short-term plan of testing all linac cavities operation at reduced duty factor in 2025 makes sense. The expected main outcome is demonstration of proper operation of the timing and LLRF systems at 50 Hz. However, it should be clearly understood that this test does not demonstrate feasibility of the linac operation at the duty factor required for the PBIF.
- A plan for demonstrating operation at the required duty factor should be developed, starting from the cavities which, presumably, already have sufficient cooling capacity.
- The required peak current of 50 mA unchopped is significantly higher than the current operational current of 50 mA chopped. The available peak RF power can be insufficient for some cavities. This can and should be investigated with the existing 25 Hz linac configuration by running an unchopped beam pulse.
- It would be beneficial to design the 50 Hz Linac operation with independent intensities for RCS and PBIF over a wide range. Otherwise, one user can impose restrictions on the other user. For example, a certain PBIF target may limit the delivered intensity, which would then also affect the MLF.

Recommendations

None.

08 RCS over 1 MW operation (AA, SW)

Findings

Stable RCS operation with 1 MW beam power has been achieved. These improvements open up the possibility for higher beam power in the RCS. Feasibility of achieving 1.5 MW by raising the beam current to 60 mA and pulse length to 600 μs is being explored by the J-PARC team with potential utilization to drive the second neutron production target. The ion source is capable of producing the required beam parameters. Acceleration of single pulse with 1.5 MW equivalent charge has been demonstrated through the linac and up to 0.8 GeV in the RCS. According to the computer simulation, the foil temperature is below the sublimation point at 1.5 MW.

Comments

- Stable operation of the RCS with 1 MW beam is a significant achievement and is a stepping stone to explore higher power limits. We fully endorse this exploration.
- Congratulations on the progress made in the research toward achieving 1.5 MW and even higher 2 MW beam power. The injection and low-energy stages are critical phases for beam loss control. It is recommended to leverage the current machine conditions, along with simulation studies, to conduct further machine studies and verify the potential of the existing accelerator complex. Parameters should remain flexible; for example, achieving higher power using 60 mA x 700 μs is a possibility.
- No showstopper is identified in beam dynamics for RCS operation up to at least 1.5 MW. The beam loss demonstrated with single pulse charge equivalent to 1.5 MW appears manageable and beam instability is under control.
- Available peak RF power for some linac cavities can be a limiting factor for the maximum charge delivered to the RCS for beam power >1.5 MW.
- The foil deformation under high power is a concern and hard to predict
- Performance of the new RF cavities with 1.5 MW equivalent beam is not fully known until all 12 cavities are installed in 2028 and acceleration of single pulse to 3 GeV demonstrated
- Though it was pointed out in the presentation, we want to emphasize once more that there is a significant difference between demonstrating single pulse capability and actual operation at 1.5 MW. It took the J-PARC team several years to achieve stable 1 MW operation. An additional step of 50% is quite significant and should not be considered an easy task.

Recommendations

None.

09 Maintenance plan of utilities III (TS, SG)

Findings

- In the summer of 2024, the heat exchange efficiency between the intermediate cooling water and the open cooling water at M2 was decreased. The beam operation for the neutrino experiment was aborted at noon of 28th June and the beam time before summer shutdown was terminated 5 days earlier than scheduled. The heat exchanger was maintained during the summer shutdown.
- With this incident as one of triggers, a task force for aging equipment in the utilities, MR, and experimental facilities had been established to make a list and prioritize them. Although the budget was limited, the aging utilities picked-up in the previous ATAC such as a high-power pure water pump have been solved or are undergoing.
- Utilities replacement is also progressing at LINAC and RCS. LINAC replaced all water pumps, cooling towers, and compressors of refrigerators of the cooling water system, due to the severe damage to the equipment by the mega-earthquake in 2011. RCS also replaced all water pumps and cooling towers. LINAC replaced all air compressors for air conditioners in 2020.

Comments

- The J-PARC teams are working on many aging issues of utilities with limited resources. Over the last few years, a more systematic approach has been developed, and used to analyze and mitigate specific areas of concern. The MR team has acquired a special budget and is steadily working on dealing with aging utilities. However, they are still insufficient, and it is necessary to continue them to improve the machine availability.
- J-PARC should consider an appropriate yearly budget and extra budget to deal with routine maintenance and aging issues.
- In addition, the aging issues are not only for the utilities but also all other devices. It is necessary to consider the overall balance in the J-PARC system.

Recommendations

R4: Continue to identify the list of mission-critical aging items, not limited to utilities, whose replacement or preventive maintenance cannot be funded internally by J-PARC and would require additional external funding.

10 Status of LINAC (HD, AA)

Findings

- The trend with continued improvement of linac reliability continues.
- The ion source was running successfully for the entire runs #90 and #91 without the need for replacement.
- Studies of source operation for increased current and pulse length are pursued in preparation for 1.3 and 1.5 MW beam power.
- RFQ trips have been reduced thanks to an automatic restart procedure. Only about one trip in ten, occurring within one minute of a previous trip, now requires operator intervention.
- The majority of RF coupler windows are still in use since the start of J-PARC operation. However, arcing has been observed in SDTL14A and SDTL15A couplers after only one year of operation.
- The ACS is running reliably.
- The lifetime of the 324-MHz klystrons reaches up to 96,000 hours, and most of the 972-MHz klystrons have been in operation for 65,000 hours.
- A replacement of capacitor banks that contain PCB is in progress, as required by legislation.
- The settling of the linac floor is surveyed regularly and realignment of the linac is performed as needed.

Comments

- The committee is happy to see the stable operation of the linac.
- The linac team is commended for taking possession of the RF internal antenna technology and for initiating local production of the antennas to avoid dependence on a single provider.
- Studies for increased beam current, pulse length and pulse repetition rate, including endurance tests of the ion source, are in progress well in advance of planned facility upgrades.
- It is satisfactory to see that time lost due to RFQ trips has been reduced through an automatic restart procedure.
- Three RF coupler windows of the SDTL have shown arcing during the past few years, which in itself is not a very significant issue. What makes it worrisome is that these windows were replacements that had been in operation for only 1–2 years. Thus, it is important to analyse the windows and try to find the reason for the arcing.
- Although klystrons are being replaced or repaired on a regular basis, the overall klystron lifetime is very good.
- It should be ensured that there is an adequate stock of spare klystrons as replacements are continuing, considering in particular that most klystrons have been in operation for more than 50,000 hours. The purchase of additional spare 324-MHz klystrons should proceed.

Recommendations

None.

11 Beam study results of the LINAC (HD, AA)

Findings

- Objectives of linac beam studies are to reduce the level of radiation close to linac components and to reduce beam losses in the RCS which also lead to activation.
- The main cause of beam loss in the linac is intra-beam stripping.
- The linac beam quality affects losses in the RCS. Chopper leakage is contributing to RCS losses.
- Weaker transverse focusing reduces intra-beam stripping, as expected. In addition, it was found that beam mismatch inside the ACS is a cause of beam loss, and fine-tuning of quadrupoles in the ACS reduced those losses.
- Further studies at 60 mA will follow.
- The feasibility of beam-loading compensation for thinning operation was shown using new digitisers at 324 MHz. A similar improvement should be achieved also at 972 MHz with new digitisers.
- Congratulations on the progress made in beam commissioning over the past year. By optimizing the lattice, beam losses in the ACS section have been further reduced. The sources of beam loss can be more precisely identified by simulating and comparing beam losses and emittance growth under different lattice configurations, excluding the effects of IBSt. Although the simulations indicate no beam loss, the emittance growth could potentially lead to additional beam losses during beam commissioning.

Comments

- The committee supports continued beam studies with the goal to further decrease beam losses.
- Although losses in the linac currently are not problematic, intra-beam stripping and losses of H0 will increase with future increases in beam current.
- There should be room to improve chopper efficiency with current hardware, reducing chopper leakage, again in preparation for increased beam current.

Recommendations

None.

12 Status of RCS (SW, ST)

Findings

The output beam power of the RCS has steadily increased, achieving stable operation at 1 MW-equivalent for the MLF. During two neutron user operation runs, beam power of 950 kW and 970 kW was delivered to the MLF in the periods from February to March and in May. Additionally, beams were provided to ensure the MR SX/FX operated at 80/800 kW during the periods from January to March, April to June, and November to December. The RCS itself maintained a high availability rate of 95.1%. However, after the summer shutdown, the RCS was unable to deliver a high-intensity beam to the MLF due to target issues.

Over the past year, numerous hardware malfunctions encountered during operations have been successfully resolved. The transformer-rectifier for RF #10, which had been out of service since 2022 due to a lack of spare parts, has now been fabricated and installed by the end of March 2024. As a result, the RCS has resumed operation with 12 MA cavities. Three of these cavities have been replaced with new single-ended models, which consume 40% less power compared to the conventional push-pull type. To date, 6 out of the 12 cavities have been upgraded. The issue of power supply stoppage was traced to a failure of a reference signal in the DC power supply after extensive experiments and tests; consequently, the DAC at the reference signal has been replaced. Additionally, a damaged pump was replaced with a spare, allowing operations to restart, with a recovery time of 4.5 days. Funding has been secured to manufacture the necessary replacement capacitors, and all capacitors are scheduled to be replaced by the end of March 2026.

Significant efforts have been made to achieve 2 MW beam acceleration. Four of the eight kicker magnets have been upgraded with an instability damper, and results from beam commissioning indicate that this measure is sufficient to depress transverse tunability up to 2 MW. Since the start of the Japanese Fiscal Year 2023, J-PARC has transitioned to using pure carbon foil instead of HBC foil. Although the tip of the pure carbon foil exhibits slight deformation, it retains its original shape better than the HBC foil. Successful operations using the pure carbon foil have been conducted, achieving 1 MW for MLF and 800 kW for NU.

Comments

- Congratulations to the RCS team for maintaining stable operations over the past year and making significant progress in beam commissioning, successfully achieving stable 1 MW user operations and resolving several equipment failures due to aging.
- As equipment continues to age, more failures and replacements can be anticipated in the future. It is recommended to prepare contingency plans and ensure both equipment and personnel are ready to minimize the impact of replacements on user operations. For example, with proper preparation, the time required to replace a pump could be significantly reduced.
- The hardware upgrades essential for future power enhancements have been identified and validated. For instance, the MA-loaded cavity not only meets higher power demands but also reduces electricity costs and decreases the need for water cooling system capacity. Therefore, it is advisable to implement these upgrades as soon as possible.

Recommendations

None.

13 Beam study results of RCS (AV, SW)

Findings

- Major hardware updates were implemented in the RCS in 2024, including the replacement of 3 RF cavities to the new single-ended (SE) style for a total of 6 SE cavities out of 12 and the installation of two additional diodes on extraction kicker magnets (4 total now).
- At the power up to 1 MW, the beam loss remained largely unchanged from the previous run (less than 0.1%), however there was a slightly larger emittance growth.
- The installation of additional diodes on extraction kicker magnets resulted in more than a factor of two reduction of the machine impedance. This improvement opens the space for sextupole and tune optimization and creates a path to power exceeding 1 MW. The machine performance is consistent with 2018 simulations.
- Further reduction of the beam loss is pursued through i) transverse beam phase space painting; ii) further increase of momentum spread of the injected beam; iii) correction of the half-integer stop band.
- The transverse painting to 250 pi (vs. the design of 200 pi) in the MLF mode shows the reduction of losses in the injection area due to the smaller foil scattering loss. The horizontal emittance of extracted beam increases from 15 to 18.7 mm mrad.
- A test of the stronger beam debunching to reduce the space-charge tune shift indicates a positive effect on the space-charge induced emittance growth (roughly 10% for the FX mode).
- The correction of 2Qx=13 half-integer resonance caused by the field leakage from the extraction septum using two trim quadrupoles shows promising results at the low energy in low intensity beam studies, allowing to set the bare lattice tune close to half-integer at Qx=6.49.
- Beam studies were performed in preparation for 1.5 MW operation with peak current of 62 mA. Beam loss was mostly localized in the collimator area and is estimated to be approximately 0.1% at 1.5 MW, which corresponds to 0.2 kW and is much less than the collimator capacity of 4 kW.
- Simulations indicated that 2 MW operation could be possible with predicted beam loss of 0.4% (1 kW) and no beam instabilities.

Comments

- The effort to reduce losses in high-power operation of the RCS is highly commendable and demonstrates a high level of understanding of the beam dynamics in the machine and the quality of models.
- It is unclear what are the specific goals of the beam studies with regards to the beam loss, it would be useful to highlight the specific areas for improvement.
- Beam-intensity loss plots may be misleading because the deposited energy is proportional to the beam energy. It would be useful to show instead the power loss.

- It appears that the machine aperture allows for considerable flexibility in the parameters of the injected beam. Any negative downstream effects caused by the larger extracted beam emittance need to be evaluated.
- Correction of half-integer resonance will be dependent on beam intensity and phase space. A self-consistent model is necessary for the accurate prediction of this correction.
- Correction of the second-order chromatic effect (half-integer correction for off-momentum particles) could be effective to further reduce loss in high intensity operation.
- Increasing the beam momentum spread is one approach to enhancing the bunch factor. This can be optimized alongside momentum offset and RF phase sweep to achieve a more optimal solution for improving the bunch factor.
- To enhance beam loss control, adjusting the painting emittance should be paired with optimizing the collimator settings. By increasing the painting emittance to 250π, optimizing the collimators can help minimize beam losses throughout the ring. In general, at higher intensities, employing a larger painting emittance is more advantageous for controlling beam loss. However, this approach is inconsistent with current simulation results, so further studies through beam commissioning are recommended.

Recommendations

None.

Homework 1: Present J-PARC facility downtime hours by machine (e.g. LN, RCS, MR, Targets …) and system (e.g. safety/personnel protection, machine protection/interlocking/diagnostics, equipment protection, controls, magnets, RF, PS, vacuum, collimation, source, cryogenics, utility, handling …) category during the past year of user operations. (TS)

Findings

- Number and duration of beam stops for each device in Linac, RCS, MR, Exp. and others in 2024 are presented.
- Major events to decrease the beam availability in 2024 are the cooling water pump failure in RCS, BM PS trouble in RCS, BM #116 failure in MR, and SX Bump #2 failures in MR.
- During the review presentation, the number and duration of beam stops, and the causes and countermeasures for major events in LINAC and RCS have been reported. Such data were also presented for MR during Homework 1 presentation.

Comments

None.

Recommendations

None.

Homework 2: Present trends of J-PARC facility availability preferably over at least the past three years. (AV)

Findings

- The downtime data for J-PARC accelerators is logged by the operators during scheduled machine operations. The statistics lacks data in case the run is stopped or cancelled.
- The data from past years is of different quality, for example between 2007 and 2010 specific downtime logging was not implemented. Data from 2010 to 2019 was summarized in proceedings of the 2019 J-PARC Symposium.
- In that statistics, the uptime is presented as a function of run number.
- The availability data from 2019 to 2024 was shown by user area.

Comments

- Clear performance metrics flowing down from the user beam delivery requirements for each program (MLF, HD, NU) should be developed and consistently tracked in future operations.

Recommendations

Presentation request No. 1 for A-TAC 2026.

Homework 3: Present examples of existing procedures for installation and/or replacing of main MR accelerator components (e.g. main magnets, RF cavities, septa, etc…) (SG)

Findings

- The timeline for the replacement of the MR main bend MR116 has been presented. The magnet exchange took 15 days, a duration comparable with a similar intervention occurred in 2016.
- The intervention involved personnel from J-PARC and external companies.
- The infrastructure, e.g. cranes and trucks, needed for the magnet, and presumably other elements, replacement is made available and maintained by external companies.
- A spare magnet was available, and it was made ready for installation in three days, during the work for the administrative procedures.
- The MR116 vacuum pipe was reinstalled in the spare magnet to profit from the chamber beam conditioning.

Comments

- A noticeable fraction of the downtime necessary for the element replacements is required by the administrative work to organise the support from external companies and the preparation of the intervention by the companies. It could be interesting to investigate if this time could be reduced from the present three days.
- The committee notes the comment that advanced planning is not possible due to the lack of specific funding and workforce.
- Spare element storage seems not optimized with respect to the accelerator locations. Spare elements have to be transported either within the J-PARC campus or from the Tsukuba campus, with the associated risk for the transport over long distances.
- The location of the spares might be optimized with respect to the criticality of the device or the failure probability during machine operation.
- Some of the critical MR elements do not have a spare, or the spare is not ready for installation. Existing spares for the accelerator complex should be maintained and ready to be deployed on a short notice, or spare components should be available depending on the system criticality.
- Written procedure for element exchanges should exist and a REX document should be prepared after each intervention.

Recommendations

R7: Elaborate a plan to optimize the availability of spare elements and their readiness for installation within the existing budget constraints. The plan should include an assessment of additional procurements for missing spares or parts for critical elements.

Homework 4: Present details on the plan to conduct a test of the linac RF cavity operation at 50 Hz in 2025 (RF test only, no beam). Which cavities do you plan to test? Is the main timing system going to be used? If yes, how significant are the required modifications and do you have a concrete plan how to implement it. (AA)

Findings

- No significant modification of the timing system is required beyond replacing the trigger module.
- All cavities will be tested at a duty factor nominal for 25 Hz operation.
- Time for the test is allocated in summer 2025.

Comments

- The presented material answers our question. We ask for the results to be reported at the next meeting.

Recommendations

None.

Appendix 1 – 2024 A-TAC Committee

Below is the list of those attending the 2024 A-TAC:

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Appendix 2 – Agenda

Agenda for A-TAC2025 (Q&A included for each report) 2/7/2025

February 5, Wednesday **Venue: a conference room on the 2nd floor of theJ-PARC Research Building and Remort**

Time(JPN.ST)		Period	Category	Title	Speaker	
8:00		*Departing the hotel, "Terrace Inn Katsuta"*				
8:40	9:00	0:20	Time for LAN Connection			
9:00	9:15	0:15	**Executive Session**	*Closed*		
9:15	9:55	0:40	**Project Status**		T. Kobayashi	
9:55	10:25	0:30	**Accelerator Overview**	J-PARC accelerator overview	H. Oguri	R1, R3, R4, Item#1
10:25	10:45	0:20	**Group Photo and coffee break**			
10:45	11:15	0:30	**MR**	Status of MR	H. Hotchi	R5
11:15	11:55	0:40		Beam study results of the MR	Y. Sato	
11:55	13:00	1:05	***Lunch***			
13:00	13:30	0:30	**MR**	Slow extraction status and plan	R. Muto	R6
13:30	14:00	0:30		MR towards 1.3 MW	S. Igarashi	R4, Item#1
14:00	14:30	0:30		LI 50Hz operation	K. Okabe	R4, Item#1
14:30	14:50	0:20	**coffee break**			
14:50	15:20	0:30		RCS over 1MW operation	I. Yamada	R4, Item#1
15:20	15:50	0:30		Maintenance plan of utilities III	M. Shirakata	R2, Item#2
15:50	17:00	1:10	**Executive Session**	*Closed*		
<<Reception>> 17:30 - 19:00 at the KEK 1-gou kan						

February 6, Thursday **Venue: a conference room on the 2nd floor of theJ-PARC Research Building and Remort**

Time(JPN.ST)		Period	Category	Title	Speaker	
8:00		*Departing the hotel, "Terrace Inn Katsuta"*				
9:00	9:10	0:10	Time for LAN Connection			
9:10	9:25	0:15	**Executive Session**	*Closed*		
9:25	9:55	0:30	**LINAC**	Status of LINAC	T. Morishita	
9:55	10:35	0:40		Beam study results of the LINAC	Y. Liu	
10:35	10:55	0:20	**coffee break**			
10:55	11:25	0:30	**RCS**	Status of RCS	M. Yamamoto	
11:25	12:05	0:40		Beam study results of RCS	P. Saha	
12:05	13:00	0:55	***Lunch***			
13:00	14:00	1:00		Homework		
14:00	16:25	2:25	**Executive Session**	*Closed*		
<< dinner >> 19:00 - 20:30 at the restaurant in Katsuta						

February 7, Friday **Venue: a conference room on the 2nd floor of theJ-PARC Research Building and Remort**

8:00		*Departing the hotel, "Terrace Inn Katsuta"*				
8:40	10:30	1:50	**Executive Session**	*Closed*		
10:30	11:30	1:00	**Recommendations to J-PARC**		J. Wei	
11:30	12:30	1:00	***Lunch***			
adjourn						