J-PARC Program Advisory Committee for the Nuclear and Particle Physics Experiments at the J-PARC Main Ring v1.6

[To be approved at the 40th PAC meeting
KEK/J-PARC-PAC 2025-XX
July 16–18, 2025]

Minutes of the 39th meeting held on
January 8th (Wed.) – 10th (Fri.), 2025

Contents

1 Open Session

1.	Welcome and J-PARC Center Report	T. Kobayashi (J-PARC/KEK)
2.	Welcome and Mandate to the Committee	N. Saito (KEK)
3.	Hadron Facility Status & Plan	H. Takahashi (J-PARC/KEK)
4.	FIFC Report on E16	S. Uno (KEK)
5.	E16: Measurements of Spectral Change of Vector Mesons in Nuclei	S. Yokkaichi (RIKEN)
6.	J-PARC Accelerator Status & Plan	Y. Sato (J-PARC/KEK)
7.	P104 Double ϕ Production in $\bar{p}p$ Reactions Near Threshold	J. K. Ahn (Korea University)
8.	P89 Investigation of Fundamental Properties of the $\bar{K}NN$ State	T. Yamaga (J-PARC/KEK)
9.	E21 (COMET)	Y. Fukao (J-PARC/KEK)
10.	E14 (KOTO)	T. Nomura (J-PARC/KEK)
11.	P107 (KOTO II)	H. Nanjo (Osaka Univ.)
12.	Secondary beam at B-Line	K. Shirotori (Osaka Univ. RCNP)
13.	P95: Pion-induced ϕ-meson Production on the Proton	T. Ishikawa (Osaka Univ. RCNP)
14.	E11/E65 (T2K): T2K Analysis Status and Plan	C. Riccio (Stony Brook Univ.)
15.	E11/E65 (T2K): T2K Beamline and Detectors Status	M. Friend (J-PARC/KEK)
16.	Hyper-Kamiokande Status and Plan	M. Shiozawa (Univ. of Tokyo)
17.	E56/E82 (JSNS2, JSNS2-II)	T. Maruyama (J-PARC/KEK)
18.	E71 (NINJA)	T. Fukuda (Nagoya Univ.)
19.	E34 ($g-2$/EDM)	D. Nomura (International Univ. of Health and Welfare), T. Yoshioka (Kyushu Univ.)
20.	Hadron Hall K1.8/K1.8BR Plan and Request Summary	M. Ukai (J-PARC/KEK)
21.	Beam Time Schedule	T. Nakadaira (J-PARC/KEK)

2 Closed Session

Present:

M. Aoki (Kanazawa), V. Cirigliano (Washington), L. Fabbietti (Munich), H. Ishino (Okayama), K. Joo (Connecticut), G. Karagiori (Columbia), C. Lazzeroni (Birmingham), H. Lenske (Giessen), K. Miyabayashi (Nara), M. Oka (JAEA), X. Qian (BNL), K. Sekiguchi (Inst. of Science Tokyo), J. Stroth (Goethe), Y. Yamazaki (Kobe), T. Yamanaka (Chair, KEK),
N. Saito (KEK-IPNS Director), T. Komatsubara (KEK-IPNS Deputy Director) and T. Kobayashi (J-PARC Center Director)

3 Procedural Report

The minutes of the 38th J-PARC-PAC meeting (KEK/J-PARC-PAC 2024-15) were approved.

4 Laboratory Report

4.1 Welcome and J-PARC Center Report (Takashi Kobayashi, J-PARC Center Director)

The J-PARC Director, Takashi Kobayashi, gave a welcome and presented the status and plan of the J-PARC Center.

Kobayashi reported that since the last PAC meeting, stable operations were achieved > 1 MW for MLF, > 800 kW for NU, and > 80 kW for HD. He then explained several incidents that affected the beam operation. On June 24, MLF stopped the user beam operation one week earlier than scheduled, due to the presence of moisture in the helium vessel. The cause was identified, and countermeasures were implemented. On June 27, some of the MR cooling tower motors broke down due to aging, reducing cooling capability. This resulted in the termination of the NU beam nine days earlier than planned. On July 5, a scorched component was found in the J-PARC Linac building. It was caused by an insufficient connection in the power line terminals. Countermeasures were implemented for the affected component and similar ones across the J-PARC site. A final report, required to restart machine operation, was submitted to the local governments and was accepted on Sept. 26. On Sept. 18, the power manipulator for the MLF target maintenance failed; it was then fixed on Oct. 11. This delayed the restart of the user operation for MLF by three weeks, and that of NU/MR by eight days.

Kobayashi also gave a report about the budgetary situation. For JFY2024, JAEA obtained 101.8 Oku-yen[1] for the upstream facilities (Linac, RCS, and MLF), and KEK obtained 53.08 Oku-yen for the downstream facilities (MR, NU, and

[1] Oku-yen = 10^8 Japanese Yen

HD). In addition to these budgets, JAEA obtained a supplementary budget for the operation and KEK allocated an additional operation budget from its own internal budget. As a result, both facilities managed to operate for 7.2 cycles. For JFY2025, JAEA obtained the same 101.8 Oku-yen which allows the upstream facilities to operate for 6.4 cycles only. KEK obtained 50.48 Oku-yen, that is 2.6 Oku-yen less than last year. Thus an additional budget is needed to secure the operation of 6.4 cycles or more for the downstream facilities. KEK is going to discuss their internal budget allocation. Regarding the countermeasures against aging equipments, KEK obtained 6.06 Oku-yen (compared to 3.01 Oku-yen last year), and JAEA obtained 16.2 Oku-yen. Because 6.06 Oku-yen is significantly less than the requested 21 Oku-yen, an effective way to use the limited budget must be considered. Additionally, the budget of 0.46 Oku-yen for constructing the g-2 experimental facility, and the budget of 12.74 Oku-yen for Hyper-Kamiokande were secured.

Kobayashi mentioned that the construction of the SOKENDAI Joint Research Center / J-PARC Experimental Building has started and is expected to be completed by the end of March 2025. To prepare for building a new access road to J-PARC, the relocation of a radiation monitoring post started in JFY2024. The plan is to build the road in JFY2025 and JFY2026. However, the requested budget for JFY2025 was not approved, and J-PARC is working to minimize the delay of the project completion.

Kobayashi also reported that the J-PARC Symposium 2024 was held in Mito in October, with 416 participants from 18 countries. The symposium provided an opportunity to discuss the results and future program of J-PARC.

4.2 Welcome and Mandate to the Committee (Naohito SAITO, KEK IPNS director)

The director of the Institute of Particle and Nuclear Studies (IPNS), Naohito Saito, welcomed the PAC members.

He firstly introduced the physics programs driven by IPNS covering a wide range of scientific research topics, the organization structure of the IPNS, the current status of IPNS projects, and the timeline of various ongoing and future large scale projects. He reported that the long-term timeline table was currently being updated. The status of various task force meetings for those projects was presented. A review committee for COMET Phase-I, chaired by Dr. Augusto Ceccuci (CERN), submitted the final report of the first meeting, held in July 2024, to the IPNS director in September 2024. Post-review activities are in progress by the COMET collaboration, such as an optimization study for the shielding and financial efforts to cover the missing budget.

New documents submitted to this PAC meeting were summarized: one report from T101; one addendum from P95; four new proposals, regarding three test experiments (P106 at B-Line, P108 at K1.8, and P109 at K1.8BR) and an experiment (P107 named KOTO II) at the Hadron Experimental Facility; and one

Letter of Intent regarding experiments at Neutrino Experimental Facility. One Technical Design Report for the Stage-2 request was submitted by E16 and thus a Facilities Impact and Financial Committee (FIFC) meeting was held for this PAC meeting. He also mentioned that a test experiment T105, which measures the yield of secondary particles for a test beamline at the Hadron Hall, will be conducted during the January 2025 beam time.

The Director introduced the PAC members participating in this meeting, as well as FIFC members. He also reported that the FIFC chair, currently Prof. Shoji Uno, will be replaced by Prof. Mikihiko Nakao from the next fiscal year.

Saito requested the PAC to evaluate the new proposals along with requests for the Stage-1 status and the Stage-2 approval, providing recommendations to the IPNS and J-PARC directors. He also requested the PAC to assess the progress in the ongoing experiments as well as to give advice on the beam time allocation plan in upcoming fiscal year. Finally, two status reports of future experiments presented at this meeting, i.e., the Hyper-Kamiokande experiment and the realization of a secondary beam to B-Line (so-called π20), are not under review at this moment but it is worth continuing to track their progress and plans in the PAC meetings.

4.3 J-PARC Accelerator Status (Yoichi SATO, J-PARC/KEK)

Yoichi Sato from the Accelerator Group reported the J-PARC accelerator status and plan. In the summer of 2024, the J-PARC accelerator complex undertook significant hardware upgrades for the Main Ring (MR). The accelerator team reconfigured RF cavities, upgraded anode power supplies, and enhanced the collimator system. They also adjusted the main magnet power supply's current patterns to accommodate new optics and operation cycles. To check the effectiveness of these upgrades, additional beam tuning days were required before the physics run period. By 24 November 2024, MR beam operation was successfully restarted, gradually increasing the beam power to 806 kW by 5 December 2024. The 800-kW beam operation remained stable with acceptable beam loss levels of around 1%.

Looking ahead to the first half of 2025, the team plans to operate the SX/HD beam at 80 kW and the FX/NU beam at over 800 kW. They have a detailed schedule for beam tuning in January 2025, aiming to improve the spill duty factor and to complete all necessary tunings. Their near-future plans include achieving 900-kW beam acceleration while reducing the beam loss to less than 1%. Dedicated beam tuning time is mandatory to reach the goals. They also plan further hardware upgrades of the RF system, power supplies, magnet system, and the beam dump, to reach the final goal of 1.3 MW for FX by JFY2028, by shortening spill cycles and increasing the number of protons per pulse. Four months plus five weeks of maintenance time during every shutdown period in 2026-2028 are needed to achieve the required beam quality and stability.

4.4 Hadron Facility Status and Plan (Hitoshi Takahashi, J-PARC/KEK)

Hitoshi Takahashi presented the status and plans for the Hadron Experimental Facility (HD). He first described the HD beam lines (A-, B-, and C-lines) and their operational patterns. A round of maintenance was completed during the summer shutdown, and the rebuilding of the radiation shields will be completed early in January 2025. The SX beam time is scheduled to begin on 16 January 2025.

Two test experiments, T105 and P106, are planned to prepare for future beam-line constructions: T105 for the test beam line (π1.0), and P106 for the high-momentum secondary beam line (π20). Takahashi also reported that the COMET pion capture solenoid was delivered and installed on the south side of the Hadron Hall.

Takahashi provided further details of the two beam lines under plan. The π1.0 beam line will be built near the K1.8BR area, utilizing the existing pipe that penetrates through the concrete shielding. T105 aims to measure the pion yield; this is important for the detailed planning of this test beam line. The π20 beam line is intended as a part of the upgrade plan for the high-momentum beam line (B-line). Upgrades include replacing the Lambertson and septum magnets, adding a production target capable of handling a 15 kW beam loss, and installing beam swinger magnets. Four quadrupole and three sextupole magnets will also be added. A staging plan is under discussion: in Phase 1, secondary beams will be produced and transported using the current magnet configurations, utilizing the loss at the Lambertson magnet, which is less than 420 W. P106 is designed to measure positively charged secondary particles from the beam loss.

Takahashi also reported on the development efforts for the next-generation production target, designed for the beam power of 150 kW. The target will be a Euro-coin-type structure with several material options, or a whole-tungsten rotating disk. Helium gas will be used for cooling. A key device in this system is the gas bearing. The gas bearing has in principle an unlimited lifetime even in high-radiation environment and enables high rotational speed. A conservative estimate of the temperature rise at 150 kW is 34 K, and a stable operation with a temperature up to 70°C must be confirmed. The performance of the gas bearing depends on the clearance between the shaft and the bearing, which changes due to thermal expansion. To be resilient to hard-landing, the material was reconsidered and bronze CAC603 was selected instead of stainless steel SUS630. However, the coefficient of thermal expansion (CTE) was initially unknown and was subsequently measured. As a result, the load capacity was reduced from 84 kgf to 56 kgf, which is close to the actual disk load of 49 kg (whole tungsten case). A high-temperature rotation test using a tungsten disk heated above 80°C was successfully completed. The HD team now plans a long-term ($\sim$1000 hours) rotation test. Engineering evaluations of a test fabricated, full-size, pure-tungsten disk are also underway. Developments of disk monitoring systems, such as a radiation-hard displacement sensor and an infrared thermometer, are in progress.

Takahashi then introduced the Hadron Experimental Facility Extension project. This project includes a new production target (T2), four new beam lines (HIHR, K1.1/K1.1BR, KL2, K10), and upgrades of two beam lines (π20, Test-BL). The project was selected as the first priority project for the budget request in KEK-PIP 2022. The $g-2$/EDM is currently in the queue and the extension project is the next in line after the $g-2$ experiment. The estimated construction cost increased from 150 Oku-yen as estimated in PIP2022, to 200 Oku-yen. Cost reduction and optimization, and staging plans with smaller steps, are under discussion. Cost reduction measures involve optimization of beam optics to reduce the number of magnets and possible reduction of the Hall surface area. The former option already results in a few Oku-yen saving, but it is deemed insufficient.

5 Evaluations of the Proposals and Status of the Ongoing Experiment

5.1 E16 (Vector meson in nuclei)

Deferred

The experiment E16 aims to measure the in-medium spectral function of the ϕ meson by exploiting a high intensity proton beam (10^{10} particles/s) impinging on low-mass (Carbon) and high-mass (copper) targets, with the ϕ spectral shape reconstructed from its e^+e^- decay. A similar experiment was conducted several years ago by the E325 collaboration; the accumulated statistics was about 1000 ϕ candidates for the heavier target, that allowed to see the first signature of the in-medium melting of the ϕ meson. The E16 experiment includes a tracking system made of one STS silicon layer, three GEM-based (GTR) tracking detectors followed by a hadron-blind (HBD) detector, and a lead glass (LG) calorimeter. The last two detectors are used for triggering on e^+e^- pairs.

The PAC Committee congratulates the E16 collaboration for their significant progresses since the last PAC meeting in the summer 2024, including improvements to the data acquisition system and detector performances, and considers this experiment of capital importance for the field.

The E16 collaboration performed a test run in Apr-Jun 2024 (Run-0e, 237 hours), during which an improved beam optics to mitigate the micro spill structures (5 ms, and 5 μs) and an upgraded DAQ system were tested. The status of the beam optics has slightly improved but the PAC thinks that additional effort should be made by the accelerator team to further reduce the micro spill structure. At the level of rate acceptance, thanks to the DAQ upgrade, the experiment can run with the originally planned maximal beam intensity and a total trigger rate of 2 kHz with an acceptance efficiency of 90%. However, the events present an important background component in the high multiplicity events that jeopardizes the reconstruction efficiency.

The E16 collaboration employed the 2024 data to improve on the electron-pion separation in the trigger detectors. The PAC inquires if the electron-pion separation can be further improved, since the shown distribution seems very broad and the current trigger efficiency (64%) differs from the envisaged one (88%).

The E16 collaboration performed first calibrations of the GTR and tested the full reconstruction chain, obtaining the first significant signal for the ω and ϕ vector meson invariant masses. The current invariant mass resolution is about 23 MeV/c^2 for the ϕ meson against the envisaged 9 MeV/c^2 (the E325 experiment had a resolution of 11 MeV/c^2). The E16 collaboration presents some ideas to improve the GTR tracking efficiency by refining the calibration of the drift velocity and the determination of the Lorentz angle, also including timing information by exploiting the leading edge signal of the GTR hits to disentangle overlapping clusters and so reduce fake contamination which currently hampers the efficiency in high multiplicity events. These strategies are however not demonstrated yet and the current projected total ϕ yield for 120 days of data taking is only 4000 events.

Taking into account the above considerations, the PAC concludes that, despite the tremendous effort already carried out by the collaboration, the Stage-2 Approval can not yet be conferred to the experiment, and suggest the following next steps before the next PAC meeting in summer 2025. The PAC advises to carry out 3D Garfield simulations of the GTR response to obtain the response function for the GTR under different inclination angles, voltage settings and magnetic field values. This should reduce the uncertainties in the fitting procedure and ease the calibration. The 2024 data should be used to fully calibrate the GTR and the results should be shown at the next PAC meeting. The PAC also advises to analyze the same data set with improved timing measurements and cuts to reduce the efficiency losses due to overlapping clusters, and update the signal yield estimate. Results should be shown at the next PAC meeting. The PAC is concerned about the available manpower within the collaboration to carry out the necessary improvements and recommends that additional FTEs become available.

The PAC recommends up to a maximum of 15 days of data-taking in 2025 for E16, that should be exclusively focused on fully calibrating the detector, improving the trigger settings and developing the tracking procedure. The E16 collaboration should decide whether the 2025 15 days data-taking is necessary or if the required performance plots can be produced using only the 2024 data. The improved results are to be presented at the next PAC meeting. The PAC expects a detailed written report before the next meeting.

In conclusion, the PAC recommends not granting yet the Stage-2 Approval status and postpones the decision to the next meeting in summer 2025 after having seen improvements in the calibration and reconstruction.

5.2 P104 (Double ϕ production)

Recommend Stage-1 Status

P104 proposes a cross-section measurement for $\bar{p}p \to \phi\phi$ production at energies near the production threshold. The previous results, reported by the JETSET experiment at LEAR in 1994-1998, showed that the cross sections at around 2.2 GeV

CM energy were about two orders of magnitude higher than that expected from the OZI rule. The experiment eventually aims to pin down the production mechanism that is an alternative to the OZI-suppressed two-gluon emission. The proponents plan an energy scan for CM energies between the threshold and 2.15 GeV to provide the first cross-section measurements and the polarization measurement in the region that has not been explored yet.

The experiment uses the same detector as that for E72 at K1.8BR but with a $\bar{p}$ beam and a different trigger condition. P104 requests 9 days of beam time; no switching time from E72 was requested as it was considered negligible. The PAC noted that the K1.8BR area may be rearranged for the E80 experiment in 4Q JFY 2025 after the E72 experiment, although the plan is subject to the final approval.

The 38th PAC deferred the decision on the proposal, and suggested that the motivation for the proposed measurements should be quantitatively strengthened. However, the PAC noted that the measurements on this channel were unique and that proposals using the $\bar{p}$ beam would extend the physics potential of the facility.

In the 39th PAC, the proponents presented the feasibility of the trigger scheme, showing clear identification of the ϕ-meson productions of interest. They also presented the angular distribution of the ϕ mesons based on theoretical models, and then proposed an energy scan study of the cross-section from the threshold energy to 2.14 GeV with 10 MeV energy bins for the partial wave analysis, along with the polarization measurement at 2.14 GeV. After their presentation, the proponents further demonstrated the expected outcomes, showing that the estimated experimental uncertainties are sufficient to distinguish between different processes of $\bar{p}p \to \phi\phi$ with a partial wave analysis and the cross-section measurements of selected polarization sets of $\phi\phi$.

Based on the P104 updated report and the evidence provided during the PAC meeting, the PAC recommends the Stage-1 Status for P104. The PAC also considers the polarization observable to be a significant outcome and strongly recommends that P104 demonstrates the feasibility of measuring the polarization observable as a function of scattering angles, including the estimated experimental uncertainties, to obtain the Stage-2 Approval.

5.3 P89 ($\bar{K}NN$)

Recommend Stage-1 Status

P89 proposes to measure $K^- + {}^3\mathrm{He} \to \Lambda np$ production cross section at the Λp and Λn two-body resonance states corresponding to K^-pp and $\overline{K}^0nn$ bound states, respectively. The former bound state at 2.3 GeV mass was already observed by the E15 experiment, but its spin and parity have not been determined. The latter is supposed to be the isospin partner ($I_3 = -1/2$) of the former state ($I_3 = +1/2$). The same experimental group is conducting the experiment E80 (with Stage-2 Approval) to observe a heavier bound state with baryon number equal to 3. The first phase of P89 can be carried out with the new cylindrical detector system (CDS) developed for the E80 experiment, while in the second phase of the experiment P89 would be equipped with a polarimeter to measure the proton spin.

The first goal of P89 is to observe the isospin partner $\overline{K}^0 nn$ and confirm the consistency with the K^-pp state for mass and width. The second goal is to determine the spin-parity of K^-pp state by measuring the polarization of the proton. According to the K-exchange picture, the production rate of $\overline{K}^0 nn$ is predicted to differ by a factor 5 or more depending on the spin of the state, and so it gives additional information to determine the spin. From the measured cross section, i.e. 9.3 μb for the K^-pp state, the K-exchange mechanism predicts 1.2 μb ($J^P = 0^-$), or 7.0 μb ($J^P = 1^-$) for the $\overline{K}^0 nn$ production. Based on these numbers, the simulation shows significant peak structures for both cases. The simulation of the polarization measurement also demonstrates a clear difference between the two spin cases.

The proponents request 2 weeks of beam time for the first phase with the same setup as E80 at the K1.8BR beam line. They further require 8 weeks for the full setup to measure the polarization.

The experimental apparatus of E80 aims to extend the E15 apparatus with a novel CDC detector that contains an almost hermetic neutron detector barrel. The resolution of the Λn invariant mass in the $\overline{K}^0 nn$ channel depends on the efficiency and momentum/energy resolutions of the new detector for neutrons. Despite the fact that an efficient neutron detector was already utilized by the E15 experiment and the technology planned for the E80 barrel is the same as that for E15, the PAC considers as mandatory that the P89 collaboration produces performance plots of the planned neutron detectors, and simulated mass distributions before granting the Stage-2 Approval. The PAC also requests that the P89 collaboration prepares a commissioning schedule for the full system before requesting the production beam-time for the first run.

In conclusion, the PAC recommends the Stage-1 Status.

5.4 E21 (COMET)

The COMET experiment is designed to search for a muon converting into an electron without emitting any neutrino inside an aluminium target at a new C-line beam line in the Hadron Experimental Facility. The original strategy involves two phases: Phase-I, targeting a conversion rate of 10^{-14} with beam power of 3.2 kW, and Phase-II, aiming for the rate of less than 10^{-16} with 56 kW. While Phase-I has received the Stage-2 Approval, to ensure collection of some data as soon as possible, a revised schedule has been devised, reducing the initial beam power and using less shielding to reduce cost. Specifically, COMET Phase-1 at low intensity (Phase-1 LI) will run with far less iron ceiling shield. Phase-1 LI would reach a single event sensitivity (SES) comparable to SINDRUM-II in about 1 cycle (provisionally in 2026). Phase-1 would reach a SES comparable to that of the competitor experiment Mu2e at Fermilab taken in its 2027 Run1, in about 150 days of 8-GeV MR from 2028. The COMET data taking is therefore mutually exclusive to both NU and HD operations.

A Review committee for COMET, commissioned by PAC, was held in 2024. The review assessed the scientific significance, the soundness of the technical aspect of the experiment, and the management and leadership aspects of the collaboration, considering the non-negligible funding still required to realize the experiment. The final review Report was produced in September 2024 and preliminary findings presented to the PAC in July 2024. The review puts forward several recommendations; in particular, regarding Phase-1 LI, taking data as soon as possible at low intensity (Phase-1 LI) is judged important, and the collaboration and the laboratory should continue to work together to ensure that the necessary funding is secured for the realization of Phase-1 LI as soon as possible, since the success window is narrow. The COMET Promotion Task Force is closely following the progress of COMET. At the July 2024 meeting, the PAC agreed that taking data at a reduced intensity in Phase-1 LI as early as possible is the correct strategy at this point. Subsequent COMET Phases will be eventually discussed in future.

The COMET collaboration is preparing point-by-point responses to the points raised in the Review Report and the PAC requests that the document, even in a draft form, is submitted to the 2025 July PAC meeting.

Progresses in COMET were reported at this PAC meeting: the completion of the set of needed magnets for the beam line and their installation; the improved structure of the Collaboration and internal communication; the progress with the collimator design, and the detector construction. A cosmic ray veto specific for Phase-1 LI is being investigated using iRPCs. Some progress has been made towards resolving, or at least mitigating, the present significant shortage of funding (due to cost of shielding and operation) via in-kind contributions and a Common Fund structure. A schedule towards completion of COMET Phase-1 LI was presented, with an associated schedule of the required funding. The PAC notes that even half of the missing funding to completion of Phase-1 LI - as stated in January 2024 - is roughly equivalent to the funding of 1 month of J-PARC MR running time and so it is potentially highly significant.

The PAC congratulates the collaboration on the progress made, acknowledging their efforts in overcoming challenges. The PAC encourages COMET to continue their efforts towards the timely realization of Phase-1 LI, which has an increasingly crucial timescale. The PAC stresses that the collaboration and the laboratory should continue to work together to ensure that the necessary funding for Phase-1 LI is secured with the minimum impact on the J-PARC operation costs.

5.5 E14 (KOTO)

The KOTO experiment (E14) searches for the rare CP-violating decays $K_L \to \pi^0 \nu \overline{\nu}$ in the J-PARC neutral beam line. The decay rate is precisely predicted and thus provides an excellent probe for physics beyond the Standard Model. At this meeting, KOTO notified the submission of their final 2021 result to journal publication.

KOTO received the beam in April-June 2024 at > 80 kW intensity, but the period was significantly shorter than planned due to MR down time. About 83% of the beam taken is used for kaon physics, and the rest for neutron data, monitoring and calibration. At this meeting, KOTO presented the status of the analysis of the 2024 dataset: data looks generally of good quality and the first look at the Pt-Z plot (corresponding in terms of statistics to about 45% of 2021 data) shows no surprises. The evaluation of the $K_L \to 2\pi^0$ background via the γ detection inefficiency has been improved significantly thanks to the addition of a dedicated trigger line without prescaling (made possible by the DAQ upgrade in 2021-23). The feasibility of using 1-cluster data for collimator alignment was studied with 2024 data, and will be used in 2025. For the 2025 data taking, an additional disk node will be added to the DAQ to avoid a possible bottleneck at high-level trigger.

Unfortunately, the beam structure in 2024 was not improved with respect to 2021. The beam structure has a direct and significant impact on accidental losses, and in turn on acceptance. Currently, this impact negates any improvements in beam power, and leads to sizeable additional accidental losses. For 2025, a monitor of the accidental hit rate in NCC based on GPUs, which reflects the spill structure, will be introduced. This will allow quick monitoring of the spill structure. KOTO stresses again the necessity of improving the spill quality, and requests >60 days at >80 kW beam power every year for 4 years with a smooth beam spill shape.

The PAC congratulates KOTO for the final result and publication based on 2021 data. The PAC also congratulates KOTO for the good progress made on analysis of recent data sets, in particular for the use of data to devise ways to both reduce the background and improve the accuracy of its evaluation. To this end, the PAC recommends to also investigate further ways to boost and improve the MC production. The PAC commends the introduction of the spill-structure monitor and encourages KOTO to continue its close collaboration with the accelerator division to improve the spill quality. Finally, the PAC acknowledges KOTO beam request and recommends that beam time for KOTO remains a high priority.

5.6 P107 (KOTO II)

Recommend Stage-1 Status

P107 (KOTO II) aims to search for signatures of physics beyond the Standard Model in rare neutral Kaon decays, primarily $K_L \to \pi^0\nu\overline{\nu}$. This experiment plans to prepare a new detector setup, and a new K_L beamline that is a part of the J-PARC Hadron Facility extension.

In order to achieve the desired sensitivity, the K_L beam is extracted at 5° from the primary proton beam axis, while, for comparison, currently running KOTO uses 16° extraction. This change gives higher average K_L momentum (the peak momentum becomes 2.9 GeV/c, increased from the current 1.4 GeV/c) and higher K_L flux per beam power by a factor of 2.6. The main electromagnetic calorimeter will be enlarged to 3 m in diameter, accompanied by an increase in the decay volume length from 2 m in KOTO to 12 m in KOTO II.

The baseline KOTO II detector design is based on the experience already obtained by KOTO, and the anticipated sensitivity to detect $K_L \to \pi^0\nu\overline{\nu}$ is carefully estimated. Details of the sensitivity estimate are well described in the proposal:

KOTO II improvement with respect to KOTO is estimated to be a factor 58 with the baseline detector. The resultant signal yield is expected to be 35 events under the assumption of $\mathcal{B}(K_L \to \pi^0 \nu\overline{\nu}) = 3 \times 10^{-11}$ (i.e. the Standard Model value), while the background is estimated to be 40 events, thus making an observation above 5σ level achievable.

If the branching fraction measurement were to show a 40% deviation from the Standard Model prediction (i.e. a similar deviation to that currently observed by NA62 for the analogous charged channel), it would indicate new physics at the 90% confidence level. By performing the measurement of $\mathcal{B}(K_L \to \pi^0 \nu\overline{\nu})$, physics beyond the SM contributing to flavor-changing-neutral-current-like $s \to d$ transitions can be explored up to energy scales of $\mathcal{O}(1000\ \text{TeV})$, i.e. above the reach of direct detection at colliders. With additional detectors, the experiment can also study other related decay modes, such as $K_L \to \pi^0 e^+ e^-$ and $K_L \to \pi^0 \mu^+ \mu^-$, but detailed background studies are still in progress.

The KOTO II experiment will become the only place in the world to provide the possibility to perform dedicated rare kaon decay studies. PAC is pleased to see that a new international collaboration is being formed to advance and realize this project. Based on the feasibility studies by the proponents, PAC sees appropriate scientific merits and technical soundness in this proposal. PAC therefore recommends to give a Stage-1 Status to P107 (KOTO II). Discussions to grant the Stage-2 Approval will be subject to the approval of the J-PARC Hadron Facility extension.

5.7 P95 (ϕ production)

Recommend Stage-1 Status

P95 proposes to measure the cross-section of the pion-induced ϕ-meson production on the proton, to study the nature of the ϕn interactions and to examine a possible hidden-strangeness pentaquark resonance of mass around 2.1 GeV.

The ϕn interaction is naturally expected to be weak as it is dominated by two or more gluon exchanges. However, recent femtoscopy analysis and lattice calculations suggest a significant attraction but its origin is not clear.

The major goal of P95 is to study the origin of a resonance-like bump and sharp change of the slope parameter observed in the $\gamma p \to \phi p$ cross sections at around 2.1 GeV in the center-of-mass energy. The nature of the bump is still unclear, but the interpretation of hidden-strangeness pentaquark is suggested by the recent observation of the hidden-charm pentaquark resonances, P_c, at LHCb. The ϕn resonance may be an analogous pentaquark state in the strange sector. The pion-induced ϕ production has the advantage to be dominated by the s-channel resonance states, while the photoproduction is expected to be t-channel dominated.

P95 proposes to send 1.6 – 2.4 GeV/c π^- beam from the $\pi 20$ beam line on a liquid hydrogen target and measure K^+K^- pairs to identify ϕs with the modified E16 spectrometer. The collaboration proposes to measure the cross sections using the $\pi 20$ Phase-1 π^- beam,requesting 5 days of commissioning + 15 days of beam time for the measurement at $P_\pi = 1.8, 2.0, 2.2$, and 2.4 GeV/c. They further plan to have a full run with an intense beam of $P_\pi = 1.6, 1.8, 2.0, 2.2$, and 2.4 GeV/c in the π20 Phase-2, with a total of 35 days of beam time.

The previous PAC was concerned with two issues.

The first is the physics merit. Confirmation of a "peak" in ϕn may not itself justify the long beam-time request. Analyses of the charmed analogy, P_c, revealed the importance of the couplings of $D^{(*)}\Lambda_c$ and $D^{(*)}\Sigma_c^{(*)}$ channels. P95 originally focused on the ϕn final states, but the analysis of the production cross sections may require taking into account the couplings to the relevant $K/K^* + \Sigma/\Lambda$ production channels, that are also background sources for the experiment. The PAC recommended simulating these background processes to show the ability to single out and analyze the ϕn interaction/resonance data.

In the presentation at the 39th PAC with an additional document, P95-phi-add4-07, the proponents presented the result of the simulations of $\pi^- p \to K^{*0}\Sigma^0$ and $K^{*0}\Lambda$. They showed that in a 10-day measurement, they expect several thousand K^{*0}s identified and can separate the final Σ and Λ channels. They also analyzed the production of $K^0\Sigma^{*0}(1385)$ and $K^0\Lambda^*(1405)$ and demonstrated the possibility to identify these processes in the detector.

PAC congratulates the proponents for the successful analyses of the possible final states that may couple to the ϕn final state. The missing mass spectrum in which Σ^0 and Λ are clearly separated is impressive. However, the PAC points out that the combinatorial background, for instance from $\Lambda^*(1405)$ decays into charged states, could be significant in the analysis. The PAC thus recommends that the proponents go through all possible production channels and show the results of the combined simulations.

The second concern of the previous PAC was whether P95 is coherently folded in into the planning of the π20 beam line construction. Negatively-charged secondary beam at the π20 beam line requires development of the polarity changer.

At the 39th PAC, Shirotori presented the overall construction plan of the π20 beam line and the planned experiments. P95 is scheduled at the Phase 1 (minimum modification), just after the installation of the polarity changer and commissioning negatively charged beam lines. According to the presented timeline, P95 can run as early as in FY2028. This clarifies the role and status of the P95 experiment within the overall planning of the π20 beam line.

In conclusion, the proponents of P95 have successfully answered the requests of the previous PAC. The PAC thus recommends the Stage-1 Status.

5.8 E11/E65 (T2K)

The T2K experiment is a long-baseline neutrino experiment which utilizes a high-power neutrino beam and a combination of a near detector suite at J-PARC and the Super-Kamiokande (SK) detector in Kamioka in order to overconstrain three-neutrino oscillations and search for CP violation in the neutrino sector.

The committee congratulates the T2K collaboration on the recent publication of the joint T2K and SK analysis, on the great progress with calibrating and understanding the performance of the upgraded ND280 detector, and on the successful completion of the SK geomagnetic field compensating coil repair. The committee also congratulates both the T2K collaboration and the accelerator for achieving stable beam operations at 805 kW at the end of last calendar year (2024). Finally, the committee congratulates Dr. Sara Bolognesi and Professor Masayuki Nakahata on their prestigious awards in recognition of their achievements.

The committee is pleased with the progress on the upgraded ND280 detector calibration and looks forward to first analyses with the upgraded ND280 anticipated in early 2026, as well as the fruition of their planned publications on the latest oscillation analyses, cross-section measurements, flux model, and T2K+NOvA combined analyses. The upgraded detector is performing well despite some (minor) hardware issues, which the collaboration is actively working to address in the coming few months—namely the malfunctioning of the WAGASCI timing module, some ECAL troubles, and a small number of dead channels in the Super-FGD. The committee was also pleased to see that the coil replacement has nearly restored uniformity to the original performance.

The committee encourages T2K to advance efforts on electron neutrino cross-sections, especially given the enhanced capabilities of the upgraded near detector. On the joint efforts with the NOvA collaboration, the committee looks forward to an update on any new joint analysis plans that might be adopted at the upcoming joint T2K-NOvA workshop.

The collaboration anticipates that the beam upgrade to 900 kW will take place within the current fiscal year, and the committee notes that meeting the T2K beam request is crucial, in order for T2K to achieve as close to their original target of 1×10^{22} cumulative POT as possible before HK operations begin. With a beam exposure of 10.5×10^{21} POT, the collaboration projects a 99% exclusion of $\sin \delta_{CP} = 0$, and world-leading resolution of Δm^2_{32} and $\sin^2 \theta_{23}$, assuming maximial CP violation, normal ordering, and inclusion of the reactor constraint. For this POT, a measurement of $\bar{\nu}$ appearance at the $3 - 4\sigma$ level is also projected. With the inclusion of SK data, the collaboration projects $\sqrt{\Delta\chi^2}$ of 3.1 (2.8) for $\delta_{CP} = 0$ (π), and an exclusion of the inverted ordering at the level of 2.25σ – 2.45σ.

5.9 E56/E82 (JSNS2, JSNS2-II)

The JSNS^2/JSNS^2-II experiment searches for sterile neutrino oscillations using the J-PARC MLF as the source of neutrinos. Data-taking runs have been carried out in 2021, 2022 and 2024. Analysis is ongoing regarding the 2022 data as a reference and necessary cares for the difference in 2021 (slightly different liquid scintillator composition) and 2024 (minor change of trigger condition) data are being studied.

Without pulse shape discrimination (PSD) method, data distributions have been examined to see if background estimation is reasonably understood. The collaboration has not yet looked at relevant distributions in one of the sideband regions (B2), but the PAC encourages to visit that region soon to have a comprehensive understanding of the taken data. It was good to hear the path to extract results with the PSD method. Results of 2022 data is to be reported in the next PAC meeting and analysis using entire data is supposed to come in 2026.

Due to several external factors, a part of the electronics and Di-isopropyl-naphthalene (DIN) for the far detector are not in hand. PAC strongly encourages the collaboration to get additional funding to complete the physics run and planned instrumentation of both near and far detectors.

The JSNS^2/JSNS^2-II experiments do not require dedicated beam exposure from the MLF. The PAC recognizes that the collaboration unfortunately did not receive its foreseen beam exposure due to the MLF target problem. The PAC hopes that the problem can be resolved as soon as possible for the benefits of JSNS^2/JSNS^2-II as well as other experiments receiving beam from this facility.

5.10 E71 (NINJA)

The NINJA experiment continues to make good progress in advancing its physics program, which focuses on precise measurements of neutrino-nucleus interactions using nuclear emulsion technology. Its ability to detect low-energy final-state particles with detailed particle identification offers great potential for reducing systematic uncertainties in neutrino oscillation measurements. The collaboration reported notable achievements in Physics Run E71 phase I (E71a), including the detection of low-energy protons, good position resolution achieved with the Emulsion Cloud Chamber, and timing resolution for the scintillation tracker. The PAC remains impressed with NINJA's advancements in developing fully automated high-speed track-reading systems, which have significantly contributed to their physics goals. However, discrepancies between data and Monte Carlo simulations for low-energy muons remain under investigation. The PAC encourages the collaboration to address these issues promptly and proceed with the publication of their first cross-section results from E71a, expected this year, followed by additional publications.

The T2K-NINJA joint working group represents an important development. The PAC highlights several priority areas where NINJA can make potentially significant contributions, including: i) addressing the excess observed in backward pion samples to improve event generators, ii) studying the impact of the axial form factor and the interplay between 1p1h and 2p2h processes to refine neutrino energy reconstruction, and iii) exploring low-energy electron neutrino cross-section measurements using NINJA's fine-grained detector capabilities.

With respect to NINJA's envisioned future program, while the proposed heavy water measurements and sterile neutrino searches are promising, careful consideration is needed for challenges such as in subtraction methods and sensitivity studies. In summary, the PAC commends NINJA's continued progress, emphasizes the importance of regular publications, and encourages the collaboration to maintain a robust publication plan, aiming for multiple outputs within the next few years.

5.11 E34 (g-2/EDM)

E34 aims to measure the anomalous magnetic moment and electric dipole moment of the muon at the J-PARC MLF H-line using a novel technique that employs a cold surface-muon beam, muon acceleration, and injection into a compact storage magnet. This method offers an opportunity to measure the muon g-2 with systematic effects distinct from those using the magic-gamma approach.

The PAC acknowledges the large variance in recent theoretical g-2 calculations within the lattice and dispersive techniques with differing experimental inputs for the hadronic vacuum polarization contributions. The cause of this variance remains unknown at this stage, and the PAC looks forward to hearing updates on any progress.

The PAC recognizes the substantial progress made by the E34 collaboration toward achieving its milestones for FY2024. The installation of the muon focusing magnets has been completed, with commissioning set to begin in February and March. The PAC congratulates the team on successfully demonstrating muon cooling and acceleration, achieving a significant reduction in beam emittance for both axes, and publishing their results on arXiv. The E34 team is making commendable efforts to address comments from the IPNS Progress Review Committee regarding the muon source, LINAC, storage magnet, and positron detector.

The PAC also notes that the unavailability of KEK's requested funding for the H-line extension building in FY2025 causes a delay in the project. The building funding should be secured as soon as possible.

6 Other Reports

6.1 Hyper-Kamiokande

The spokesperson of the Hyper-Kamiokande (HK) experiment, Prof. Masato Shiozawa (Institute for Cosmic Ray Research (ICRR), the University of Tokyo), presented the status and plan of the HK experiment.

The HK experiment includes a long-baseline neutrino oscillation experiment which uses the upgraded J-PARC Main Ring (MR) and a beam line that delivers 1.3 MW neutrino beam, the world-largest neutrino detector called Hyper-Kamiokande detector, and new/upgraded near detectors (NDs). Compared to the existing Super-Kamiokande detector, the Hyper-Kamiokande detector has 8.4 times larger fiducial volume, and is equipped with new photo-sensors with twice higher photon detection efficiency. Its main physics goal is to precisely measure the CP phase δ_{CP} in the lepton sector. Assuming 10 years of 1.3 MW operation, the HK experiment is expected to determine δ_{CP} with precision of $< 20°$.

The HK project is listed in the MEXT's "Large-scale Academic Frontier Promotion Project", and was approved in 2020. The first assessment by MEXT since the start of the project reported that construction (HK far detector, J-PARC upgrade, and ND upgrade) has been progressing steadily and the project should continue to be promoted. The host institutes, the University of Tokyo and KEK, have signed an MoU to promote the HK project and have established a collaborative framework with international partners. The HK collaboration, formed in 2020, has 610 collaborators from 22 countries. The HK Project Advisory Committee has been established under the Directors of ICRR and IPNS, to assess and advise on the scientific merit, technical feasibility and managerial strategy of the project.

Shiozawa also presented the status of the construction project. As parts of the HK project, J-PARC MR and neutrino beamline upgrades towards 1.3 MW are proceeding according to plan. For the intermediate-distance water Cherenkov detector, a new piece of land has been officially secured, the facility design will be completed by March 2025, and the facility construction will begin in April 2025. Excavation of the far detector cavity is progressing steadily, and construction of the water tank (liner installation and PMT support structure) is expected to start in 2025. Many underwater detector components (such as PMTs and electronics) are being manufactured through international collaborations, and their installation will start in 2026.

Shiozawa foresees that a 1.3 MW beam will be delivered to HK for six months each year for 10 years after HK begins operations in FY2027, as proposed by the host institutes and defined in the MEXT's program.

6.2 Secondary Beam at B-Line

Kotaro Shirotori reported the plan for a modified beam line called $\pi20$, to be built by modifying the B-line which currently provides a primary proton beam of 30 GeV to the high-p experimental area. Various experiments are proposed to be conducted using the secondary particles at the B-line to explore the internal structure of baryons. One of the flagship experiments is charmed baryon spectroscopy (J-PARC E50), which requires a 20 GeV/c π^- beam with an intensity of 6×10^7/spill. The B-line can provide such secondary particles by modifying some of the beam line components. Key items for the realization of $\pi20$ include: A) polarity-changing devices for magnet power supplies, B) a production target, C) additional radiation shields, D) beam swinger magnets, and E) additional magnets. Polarity-changing devices are needed to provide negatively charged beams. A production target and additional radiation shields are necessary to allow 15 kW losses compared to the currently permitted 420 W losses. Beam swinger magnets are placed upstream and downstream of the production target, enabling secondary beam extraction at zero-degree. Additional magnets are required to increase the acceptance and momentum resolution.

Shirotori explained a staged plan for the construction of $\pi20$. Phase 1 will provide 10^5 negative pions per spill with a momentum range of 2–20 GeV/c, with minimal modifications to the beam line. A Lambertson magnet is currently placed at the A-B branching point to deliver a small portion of the primary beam to the high-p experimental area. The allowed beam loss at the branching point is 420 W, and the secondary particles produced by this loss can be transported to the experimental area. The only necessary additional components for Phase 1 are the polarity-changing devices for which the budget of 40 MYen has been secured. P106 and P93 are proposed to investigate the quality of the secondary beam in this configuration. P95 aims to study ϕN interaction via the reaction $\pi^- p \to \phi n$ and can be performed in Phase 1. Pilot runs for Λ^*/Σ^* spectroscopy can also be conducted.

Phase 2 will provide high-intensity, high-momentum beams, pions with an intensity of several 10^6/spill in a momentum range of 2–20 GeV/c, as well as K^- and $\bar{p}$ beams with an intensity of 10^5/spill and a momentum range of 5–10 GeV/c. Necessary components include a thin production target that allows several kW of beam loss, and beam swinger magnets. The target and shields are being designed. The estimated cost is 600–1000 MYen. Experiments such as Ξ spectroscopy (E97), non-strange dibaryon D_{30} search (E79), and exclusive Drell-Yan investigations can be conducted in Phase 2.

Phase 3, the final configuration of $\pi20$, will provide 6×10^7/spill pions and several 10^5/spill $K^-/\bar{p}$ with a momentum range of 2–20 GeV/c. Necessary components include a gas-tight production target and additional shields to allow a 15 kW of beam loss. The estimated cost is 800–1000 MYen. Charmed baryon spectroscopy (E50), Ω spectroscopy (P85), and the study of ΩN bound state can be conducted in this configuration.

Shirotori also presented a timeline for the B-line, including on-going, approved, and proposed experiments. If approved, P106 will be conducted as a test experiment to investigate beam property in January 2025. Polarity-changing devices are being produced and will be installed in JFY2025–2026. After completion of E16($\phi \to e^+e^-$), P95 (ϕN) and E88 ($\phi \to K^+K^-$) experiments and $\pi20$ phase 1 experiments can be conducted. E88 ($\phi \to K^+K^-$) and P95 (ϕN) will utilize a modified E16 spectrometer. Experiments in phases 2 and 3 require the MARQ spectrometer and FM magnet reconfiguration. The Hadron Hall extension requires three years of no-beam period. The schedule is still uncertain, however the no-beam period is currently assumed to be JFY2031–2033. The construction of $\pi20$ phases 2 and 3 may proceed in parallel with the Hall extension work. After completion, other experiments using $\pi20$ can be conducted.

7 General Remarks and Recommendations

The PAC congratulates the IPNS and J-PARC on their steady improvements made on the facility. In particular, the efforts on the beam power increase made by the Accelerator Division is highly commended. The PAC also heard that studies to improve the spill structure for the slow extraction are being planned. Because the poor spill quality is severely affecting the sensitivities and performances of the experiments, close collaboration between the Division and experiments is highly recommended. The PAC also recognizes that a financial plan for replacing aging equipment was made: although it is not fully funded at present, the plan should be executed as much as possible. Any disruptions in the beam time due to an equipment failure could delay the execution of experiments by months, due to tight schedules for switching experiments and modifying the beam lines.

The PAC was asked for a guideline in the prioritization of running experiments in case of limited beam time. First of all, every effort should be made to secure the necessary funding to achieve at least the same beam time as last year. If the beam time were shorter than that, the highest priority should be given to T2K, but some adjustments may be necessary to finish E72 so that the spectrometer on the K1.8BR beam line can be replaced for the next set of experiments.

PAC would like to remind experiment groups that, when asking for a Stage-2 Approval, full details are required to demonstrate technical feasibility.

8 Dates for the Next J-PARC PAC Meeting

The next J-PARC PAC meeting being planned to be held in July, 2025.

9 Documents Received

For this meeting, the J-PARC received the following documents.

- Minutes of the 38th J-PARC PAC meeting held on July 30 - August 1, 2024 (KEK/J-PARC-PAC 2024-15)
- Proposals:
  - Proposal for the first stage of the P93 experiment (Evaluation of the performance of the secondary beam at the high-momentum beam line) (KEK/J-PARC-PAC 2025-1)
  - Proposal of the KOTO II experiment (KEK/J-PARC-PAC 2025-4)
  - Test Experiment to Optimize $\bar{d}$ Beam Intensity at the K1.8 Beam Line of the J-PARC Hadron Experimental Facility (KEK/J-PARC-PAC 2025-3)
  - Optimization of Low Momentum K^+ Beam Using a Beam Degrader (KEK/J-PARC-PAC 2025-5)
- Technical Design Report:
  - Addendum-2 to the J-PARC E16 Technical Design Report (KEK/J-PARC-PAC 2025-8)
- Letter of Intent:
  - Precise measurement of neutrino interactions and sterile neutrino search with nuclear emulsion detector at J-PARC (KEK/J-PARC-PAC 2025-2)
- Reports:

- T101 Measurement of neutrino-induced neutron and γ-ray background for BGO-based detectors at J-PARC (KEK/J-PARC-PAC 2025-6)
- P95 Pion-induced phi-meson production on the proton (addendum 4) (KEK/J-PARC-PAC 2025-7)
- E99 Status Report and Schedule (KEK/J-PARC-PAC 2025-9)
- E100 Status Report and Schedule (KEK/J-PARC-PAC 2025-10)
- COMET Phase-I Review (KEK/J-PARC-PAC 2025-11)