KEK/J-PARC-PAC 2023-7
July 19, 2023

J-PARC Program Advisory Committee

for the Nuclear and Particle Physics Experiments

at the J-PARC Main Ring

Minutes of the 35th meeting held
23(Mon.)-25(Wed.) January 2023

OPEN SESSION:

1. Welcome and J-PARC Center Report: T. Kobayashi (J-PARC/KEK)
2. J-PARC Accelerator Status & Plan: S. Igarashi (J-PARC/KEK)
3. Mandate to the Committee: N. Saito (KEK)
4. P97 Cascade baryon spectroscopy at J-PARC high-momentum beam line: M. Naruki (Kyoto Univ.)
5. P98 Measurement of Anti-Matter Reaction in Liquid Argon Time Projection Chamber (LArTPC): M. Tanaka (Waseda Univ.)
6. P95 Pion-induced ϕ-meson production on the proton: T. Ishikawa (RCNP)
7. Hadron Facility Status & Plan: H. Takahashi (J-PARC/KEK)
8. E21(COMET): Y. Uchida (ICL)
9. E34(g-2/EDM): T. Mibe (J-PARC/KEK)
10. E42 Search for H dibaryon with a large acceptance Hyperon Spectrometer: J. K.Ahn (Korea Univ.)
11. E72 Search for a Narrow Λ^* Resonance using the $p(K^-, \Lambda)\eta$ Reaction with the HypTPC: S. Hayakawa (Tohoku Univ.)
12. E07 Double Strangeness System with a Hybrid Emulsion Method:

K. Nakazawa (Gifu Univ.)

13. E70 Ξ hypernuclear spectroscopy: T. Gogami (Kyoto Univ.)

14. E75 Measurement of the formation cross section ${}^{7}_{\Xi}He$ in the ${}^{7}Li(K^{-}, K^{+})$ reaction:
H. Fujioka (Titech)

15. E73 Lifetime measurement of ${}^{3}_{\Lambda}H$: Y. Ma (RIKEN)

16. E11/E65(T2K) Beamline and SK Status and Plan:
M. Friend (KEK/J-PARC)

17. E11/E65(T2K) Analysis and ND upgrade status and plan:
F. Sanches (Univ. of Geneva)

18. E56/E82(JSNS^2, JSNS^2-II): T. Maruyama (J-PARC/KEK)

19. E71(NINJA) : T. Fukuda(Nagoya Univ.)

20. E14(KOTO): T. Nomura (J-PARC/KEK)

21. E16 Measurement of Spectral Change of Vector Mesons in Nuclei:
S. Yokkaichi (RIKEN)

22. FIFC report: S. Uno (KEK)

23. E83(SUBMET): J. H. Yoo (Korea Univ.)

24. E94 New generation Λ hypernuclear spectroscopy with the (π^{+}, K^{+}) reaction by S-2S: T. Gogami (Kyoto Univ.)

25. E96 Measurement of X rays from Ξ-C atom with an active fiber target system:
T. Yamamoto (JAEA ASRC)

26. Hadron Hall K1.8/K1.8BR plan and request summary:
M. Ukai (J-PARC/KEK)

27. Beam Time Schedule in 2022 T. Komatsubara (J-PARC/KEK)

CLOSED SESSION:

Present: P. Achenbach (Mainz), V. Cirigliano (Washington), M. Endo (KEK),
L. Fields (FNAL), H. Ishino (Okayama), D. Jaffe (BNL),
K. Joo (Connecticut), T. Kawabata (Osaka), C. Lazzeroni (Birmingham),
K. Luk (Berkeley), K. Miyabayashi (Nara), H. Ohnishi (Tohoku),
M. Oka (JAEA), K. Yorita (Waseda), R. Yoshida (Chair, Argonne),
N. Saito (KEK-IPNS Director),
T. Komatsubara (KEK-IPNS Deputy Director) and
T. Kobayashi (J-PARC Director)

1. PROCEDURAL REPORT

The minutes of the 34th J-PARC-PAC meeting (KEK/J-PARC-PAC 2022-23) were approved.

2. LABORATORY REPORT

2-1 Welcome and J-PARC Center Report (Takashi Kobayashi, J-PARC Center Director)

The J-PARC Director, Takashi Kobayashi reported the beam power history at MLF and showed that the 730 kW-800 kW stable operation at 96% availability was maintained. In addition, he showed that the beam study at the LINAC and RCS for beam loss mitigation, low emittance, and higher power feasibility have been performed. He also reported the power history and Mid-term plan of MR.

Kobayashi informed the PAC that the MR study at 30 GeV had been scheduled from Nov. 19 until Dec., but it was changed to restart on Jan. 23 due to accelerator failures, the MR BM4 PS converter failure, and the water leak from the MR septum magnet. Then he showed the possible operation plan in FY2022 until March to be performed; MR/FX/SX study at 8 GeV, and COMET study and COMET Phase-α at 8 GeV. He showed that LI/RCS/MLF and KEK side can operate until March 14 with a supplemental budget in JFY2022. He showed the operation prospect for MR/NU/HD in FY2023 in which 3-cycles operation before summer is aimed at and more operation time in the latter half of 2023 is planned to be secured.

Kobayashi mentioned that in recent years the approval process for Radio Isotope facility modification by NRA (Nuclear Regulation Authority of Japan) takes longer (> 6 months) than in previous cases of nominal 3 months. The current application to NRA submitted in Feb. was finally acquired on Nov. 4.

Kobayashi discussed the MEXT review of the KEK-side of J-PARC published in 2022 July and proposed plans for the next 10 years including accelerator power upgrade to 1.3MW, hadron/muon experiments in HEF and HEF extension, T2K and upgrade for HK, neutron/muon experiments in MLF, and muon g-2/EDM in MLF.

Kobayashi showed the construction plan and the progress of the J-PARC access road. Direct access to the J-PARC site is a long-standing request from user communities.

Before summarizing his presentation, Kobayashi showed that the number of users visiting J- PARC from abroad gradually reviving from around 2022 summer after 2.5 years of travel restrictions to Japan becoming less restrictive.

2-2 J-PARC Accelerator Status (Susumu Igarashi, J-PARC/KEK)

Susumu Igarashi gave a report on the status of J-PARC accelerator. Beam operation of the Main Ring (MR) completed in June 2021 and then the MR went into a long shutdown for the purpose of upgrade work. This upgrade aims to achieve a shorter beam cycle operation in FX as well as a steady operation with an increased stability in SX. The main work of this upgrade is replacement of magnet power supplies in 6 bending magnet families in JFY 2020 and QDN, QFN and QDR magnets in JFY 2021. The power supplies used for these magnets are recycled to excite other Q magnet families.

They spent April-June 2022 testing newly installed magnet power supplies, followed by a preliminary beam acceleration test in June-July. The MR operation was then suspended again for conducting further upgrade work. They faced some problems in these periods; a coil of BM6 contractor was found to be misaligned, which was replaced promptly. Hardware failures such as Q magnet fuses blowing and IGBT unit breakdown also happened. However, all issues were solved before resuming beam operation on Jan. 23rd, 2023.

In addition to magnet power supply upgrade, they performed RF system modification by installing two 2nd harmonic RF cavities and power amplifiers as well as power supplies. These will be available by Fall 2023. The kicker system was also upgraded for high

intensity operation with 1 Hz repetition cycle. Septum magnets (SM30, SM31, and SM32) in the extraction section were replaced by new ones. However, they found water leak in SM32 in August of 2021 and in SM31 in December of 2022. These were found to be caused by wrong coil assembly soldering. They decided to install reinforcement on-site to prevent further coil damage and water leak. More sophisticated work is planned in future. Beam collimators in MR are also upgraded. This will localize beam loss, enabling them higher intensity beam operation.

Even in this situation they succeeded in carrying out beam test in Jun. 27th – Jul. 7th. In this test, they confirmed the improved stability of magnetic field, resulting in reduction of beam ripples. Newly installed FX septum magnets with new shielding helped to reduce quadrupole field leakage. They conducted high-intensity beam study with new configuration where they succeeded in accumulating 740 kW equivalent protons with well-controlled beam loss.

Igarashi concluded his presentation by showing a beam operation plan in 2023. They plan to start tuning the beam on Jan. 23rd at a proton acceleration energy of 8GeV and continue beam tuning and user operation at a beam energy of 30GeV in April – June. Igarashi addressed an issue of the short pulse beam extraction in SX. This must be prevented by equipping fast interlock in recycled magnet power supplies, which is anticipated in May 2022.

2-3 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 first introduced the organization structure of the IPNS which covers a wide range of science research. He also introduced recent activities of Instrumentation Technology Development Center (ITDC) which was just launched last April. The IPNS has been setting up task-force meetings to promote each project of the IPNS such as Hadron hall extension, COMET and Neutrino experiments as well as SuperKEKB/Belle II, Energy Frontier experiments and LiteBIRD. There is also a task force meeting for P93 in which the beamline modification is discussed. A review meeting for the muon g-2/EDM was also launched to assess the progress towards a timely realization of the experiment. Another review meeting for KOTO is being formed under the J-PARC PAC to assess a reach of the experiment in coming years.

He explained the government budget for Japanese Fiscal Year (JFY) 2023. The preparation budget for the H-line in MLF construction is also being allocated. Hyper-

Kamiokande budget at the J-PARC side including the intermediate detector construction cost, the accelerator and the beam facility improvements toward 1.3MW will be allocated based on the budget plan. However, severe situation of operation cost persists due to a soaring electricity price. KEK is aware that this is not a normal situation, and KEK is continuing discussions on what can be done to enable operation for as long a period as possible. KEK aims for 3-cycles operation before this summer and will make every effort to secure more operation time in the latter half of JFY2023. Based on this situation, he requested the PAC to review operation plan for the 3 cycles before summer and consider a possible priority if we can secure budget for additional 3 cycles, which needs to be revisited in the next PAC meeting.

Technical design reports from E83(SUBMET), E94 and E96 were submitted to the PAC35. FIFC meeting was held at the end of December and its report was also submitted. There are also two new proposals in this PAC meeting. One of them is a new experiment at Hadron hall B-line, and another is one at Hadron hall K1.8BR. Addendum of the proposal for P95 was also submitted.

Saito requested the PAC to evaluate the new proposals along with requests for Stage-1 status and Stage-2 approval to provide recommendations to the IPNS and J-PARC directors. He also requested to assess the progress in the ongoing experiments as well as any advice on the run plan after the long shutdown.

2-4 Hadron Facility Status and Plan (Hitoshi Takahashi, J-PARC/KEK)

Hitoshi Takahashi reported on the status of the Hadron Experimental Facility. The report included the status of construction and maintenance work during the long shutdown, and the development of the new production target.

Several maintenance works were performed in the experimental hall during the long shutdown. The upstream slit in the K1.8 beam line was replaced due to the end of the lifetime of the potentiometer. The upstream slit and magnets in the K1.1 beam line were uninstalled for their maintenance. Many old power supplies were replaced to remove PCB-contaminated materials and to better match the operating current and voltage of the magnets.

In parallel with the maintenance work in the hall, preparations of the COMET phase-α were pursued in the Hadron south building. The construction of the primary beam line including the installation of the production target was completed, as well as the radiation

shielding and air sealing of the beam line room. The first beam to the COMET is scheduled at the beginning of February 2023.

The R&D status of the new production target was also presented. The current target is a fixed gold target indirectly cooled by water. It is capable of the beam power up to 95 kW for a 5.2-s spill cycle. To increase the beam power over 100 kW, a He-gas cooled rotating target is now under development. The cooling efficiency with the rotation speed up to 1000 rpm has been measured using a new rotation system. The preliminary result showed that the cooling efficiency at the speed of 500 rpm is sufficient for the 150 kW beam operation. As for the gas drive, the realistic rotation test was performed by using a dummy target disk with a real size and shape. A sonic nozzle with a restriction diameter of 1.5 mm was found to be suitable for achieving the rotation speed of over 500 rpm. The radiation-hard capacitance-type displacement sensor is being developed in order to monitor the eccentricity, thermal expansion, and rotation speed of the target disk. The first version of the radiation-hard sensor was prepared, and the position resolution was measured to be better than the requirement (2 μm).

3. EVALUATIONS OF THE PROPOSALS AND STATUS OF THE ONGOING EXPERIMENT

E97

P97 proposes to perform the spectroscopy of cascade baryons with intense, separated kaons at the secondary beam line to investigate the diquark correlation in the strangeness sector, and to explore an unknown field of excited cascade baryons. The physics goal is to determine Ξ^{*0} states up to 2.3 GeV/c with 7 sigma significance for the first time. The proposed experiment probes Ξ^{*0} from its ground states up to highly excited states systematically, since they can be identified in the missing mass spectra, and will obtain their production cross sections of $K^- p \rightarrow K^{*0}\ \Xi^{*0}$ at the beam momentum of 8 GeV/c. The J-PARC E50 spectrometer is used to measure scattered K^{*0} together with decay products of Ξ^{*0}. The expected results will shed light on an effective degree of freedom of baryon, and especially on the role of (sq) diquarks. Based on the status of the proposal together with the importance of its proposed physics measurement, PAC recommends Stage-1 status for the P97.

P98

P98 proposes to utilize the K1.8BR beam to determine the discriminating power of a liquid argon TPC (LArTPC) for identifying anti-deuterons against anti-protons. Phase-1 of P98 will use the existing time-of-flight counters in the K1.8BR area to determine the yield of 1.1 GeV/c anti-deuterons in the K1.8BR beam at a proton beam power of greater than 10 kW for 8 hours. Once the rate of anti-deuteron is known, an existing LArTPC will be installed in the K1.8BR area in Phase-2 of this experiment to study anti-particle capture on argon with 1.1 GeV/c anti-deuterons, and anti-protons with momentum of 600 MeV/c and 700 MeV/c for one day.

We appreciate the value of P98 for the GRAMS project which uses a balloon-launched LArTPC for investigating cosmic anti-matter. Besides observing actual anti-deuteron and anti-proton interactions in the LArTPC, P98 will provide valuable inputs for tuning simulation for GRAMS at a reasonably low cost. The PAC thus recommends approval of P98 as a test-experiment so that data can be collected before the summer of 2023. We look forward to hearing the findings on the anti-deuteron rate and anti-proton contamination in the beam from Phase 1 in the next PAC meeting before decisions on beam time allocation for Phase 2.

P95

P95 proposes to measure the cross-section of the pion-induced ϕ-meson production on the proton and to examine a possible ϕ-N resonance around 2.2 GeV in the center-of-mass energy. P95 is motivated by a speculation that this resonance might be an exotic pentaquark state. P95 submitted the addendum in response to the concerns raised in PAC34.

PAC appreciated that P95 invited theorists to the collaboration, but their strategy to clarify the internal structure of the possible resonance is still unclear. The addendum proposes that the ϕ-momentum distributions of cross sections could be a clue to examine the internal structure. However, the discussion is still immature. PAC encourages P95 to continue further discussion with the theoretical collaborators.

P95 proposes dividing their requested beam time into two parts and focus on the existence of the bump at W = 2.2 GeV in the first phase. PAC is concerned whether P95 can draw a conclusion on a possible narrow resonance with a width of several tens of MeV from the proposed measurement at a momentum interval of 0.2 GeV/c.

PAC also considers that the existence of a suitably high-intensity negative pion beam is one critical component of the proposed measurements. Not only P95 but also several proposals and LOIs requiring a high-intensity secondary beam have been submitted to PAC. In order to reach a general understanding of the scientific importance of a high-intensity secondary beam development, the PAC would like to see these activities considered as a group. INPS has already started the discussion on the secondary beam line in context of the P93 taskforce. PAC encourages the Lab/facility management continues the discussion on the development of the secondary-beam line with users.

E21(COMET)

COMET is an under-construction experiment with the goal of searching for a muon converting into an electron without emitting any neutrino after stopping inside an aluminium target.

The PAC has heard a detailed report on the completion of the beamline for Phase-α. We congratulate the Beam Group on the job well done. In addition, we were informed that preparation of the detectors to be used in Phase-α is progressing well. All except four out of the 30 ROESTI front-end boards of the straw-tube tracker will be installed imminently. The software packages related to the data-acquisition system and offline data processing are mostly developed. By adding titanium alloy support rods between the radiation shield and the vacuum vessel of the superconducting transport solenoid magnet, the stress problem in the shield induced by a quench at full current of 210A is now mitigated. Tests of the superconducting magnets at 3T will be performed in the future. COMET will be ready to carry out Phase-α in March. The PAC congratulates the COMET collaboration on their impressive accomplishments and looks forward to hearing the outcomes from the Phase-α run.

Preparation towards Phases I and II was also reported. Development of ICEDUST, the offline software framework for simulation and offline analysis, continued to make good progress. Degradation of coil insulation was found during production of the Pion Capture Solenoid (PCS) magnet. We await the solution to resolve this problem in the future. While most of the hardware tasks are proceeding well, we noted that geopolitical issues are continuing to negatively impact the delivery of some detector subsystems, especially the cosmic-ray veto system. We acknowledge COMET's effort in striving forward despite experiencing some challenges.

E34

E34 is an experiment to measure the anomalous magnetic moment and electric dipole moment of the muon using novel techniques including a cold surface-muon beam, muon acceleration and injection into a compact storage magnet.

In the meeting, PAC heard that the progress review by IPNS will take place soon after this meeting, and the review report and responses will be presented in the next 36th meeting. PAC congratulates the team for securing a budget for the initial construction from KEK, a preparatory funding for JFY2023 from MEXT, and multiple grant-in-aids. PAC also congratulates E34 for achieving two publications and two Ph. D. theses, and the awards to young researchers in the team. PAC acknowledges the update of the project schedule based on the current situation. The PAC encourages E34 to work with the laboratory towards success in obtaining construction funding foreseen for JFY2024 to avoid further delay.

PAC acknowledges many progresses since the last meeting. The extension of the H-line is in progress. The building extension is under preparation with the proposed organization structure. The beam time is approved for 10 days in February 2023 at S2 area for a test of muon cooling and acceleration up to 80 keV with the test assembly prepared already. PAC is looking forward to hearing the result which is one of the important milestones. PAC congratulates the first demonstration of a 297 keV/c electron beam injection and storage in the storage magnet. As for the muon source, E34 team has already shown the first demonstration of muon ionization in the previous meeting. Further refinement is in progress for an achievement of the required muon beam intensity. The team also shows the status of the mass production of the tracking detector. They plan is to fabricate a quarter vane prototype (1/4 of the tracking plane) by the end of JFY2022.

E42

E42 aims to search for the H-dibaryon via $C(K^-, K^+)$ reaction. In PAC 35, E42 presented the data analysis progress of the KURAMA spectrometer for scattered particles and the HypeTPC for decayed particles. The analysis work is still in progress, i.e., calibration of the detector for the HypTPC still needs to be done with better precision; however, E42 showed a clear reconstructed peak structure for Λ and Ξ baryons from the HypTPC analysis. Moreover, E42 showed the clear peak structure of K^* reconstructed by the HypTPC from the Carbon target. The results may open new analysis topics in the E42

program, i.e., K^* in nuclear matter. The PAC recognizes their achievements and encourages further efforts for the first results of the H-dibaryon analysis.

E72

E72 experiment is proposed to establish a narrow Λ^* resonance with J=3/2 and to determine its parity. The resonance is not well-understood mainly because of the lack of precise data for states with strangeness. In E72, angular distributions and Λ polarizations in the $Kp \rightarrow \Lambda\eta$ reaction will be measured by using the HypTPC detector at the K1.8BR beamline.

At this meeting, E72 reported on the status and progress. New LH_2 target system and HypTPC target holder/gas vessel are being made ready. Prototypes of the trigger counters were tested at ELPH. Also, all R&D will be completed in the early JFY 2023. E72 requests the same beamtime as before: 80 kW × 8 days for physics and 6 days for commissioning/calibration, aiming for 100 times statistics than Crystal Ball to achieve $\delta P_\Lambda \sim 0.05$ for each momentum/angle bin. They expect to take 6 months to switch from CDS to HypTPC and need 4 hours to re-check the beam profile/intensity before E72.

The PAC congratulates E72 on their steady progress. The PAC is looking forward to hearing updates at the next PAC meeting.

E07

E07 is the most ambitious and complex emulsion experiment to date investigating double hypernuclei with Hybrid emulsion method. The physics run at the K1.8 beam line at the J-PARC hadron experimental facility were completed in 2017. At this meeting, E07 presented the current status of analysis work and future prospects of S = -2 physics. The collaboration has produced 15 PhDs and 15 journal publications so far. At PAC35, E07 presented the progress in scanning methodology, specifically: (1) Overall speed up of scanning of E07 emulsion by Gifu U., (2) Effective search using machine learning by RIKEN. These scanning methods may open a new era on S = -2 hypernuclear physics. The PAC congratulates their achievements and encourages the collaboration to push their work on the overall scanning method and looks forward to seeing the new results.

E70

The E70 experiment will perform the spectroscopy of ${}^{12}_{\Xi}Be$ hypernuclei via the ${}^{12}C(K^-, K^+)$ reaction. In comparison to the earlier experiments, BNL AGS-E886 and J-PARC E05,

E70 has a much better missing-mass resolution, 2 MeV, expected to be achieved by the installation of the S-2S spectrometer. With this better resolution, they expect ~100 counts for a few bound-state peaks of $^{12}_{\Xi}Be$ hypernuclei in 20 days of data taking with an 80 kW beam.

The PAC congratulates the collaboration on the progress in setup of the S-2S spectrometer, including the water Cherenkov counter and the active fiber target. The PAC is happy to see that the collaboration is ready for the commissioning run.

The collaboration requests, at minimum, 11 days of 40 kW beam for commissioning the S-2S spectrometer before summer. The PAC recommends the E70 run as the highest priority for the SX operation before the summer shutdown. The PAC looks forward to seeing the commissioning data analysis results and the strategy to achieve the final target resolution in the next PAC meeting.

E75

The final goal of E75 is performing decay pion spectroscopy of $\Lambda\Lambda H$ produced by Ξ^--hypernuclear decay. In the PAC 35th meeting, the progress on the design consideration for the Phase-1 experiment, i.e., measurement of the formation cross-section of $^{7}_{\Xi}H$ in the $^{7}Li(K^-, K^+)$ reaction, has been presented. Proponents satisfactorily answered questions raised in the last PAC meeting. These questions were mainly related to estimation of systematic error in the formation cross section for the Phase-1 measurement.

In addition, E75 formed a collaboration with theorists to gain more reliable estimation for their measurement, and the preliminary results of the effort were presented. The PAC congratulates E75 on their achievements.

Moreover, to overcome the soaring price of the enriched ^{7}Li target, the proponent presented an alternative approach of using a natural Li target and a ^{6}Li target sequentially to do the experiment. The plan is to extract the formation cross section for ^{7}Li by subtracting the result obtained with the ^{6}Li target from that of the natural Li target. In the discussion, a question on the difference in the thickness of the ^{6}Li and natural Li targets was raised. We learned that the thickness of the natural Li target is dictated by the final statistics that they need for the measurement whereas the ^{6}Li target already exists. Different thicknesses of the targets may induce additional systematic error when subtracting the ^{6}Li contamination from the natural Li target data, even though the main effect is due to well-known Coulomb multiple scattering.

The PAC has concerns about the systematic uncertainty due to different target thickness between the two targets. We ask the E75 collaboration to properly assess the target size effect in the subtraction method. In addition, the PAC recognizes that the resolution of the S-2S spectrometer is a key to the measurement. Therefore, we request the proponent to evaluate the systematic uncertainty in the measurement, including the S-2S spectrometer resolution when the E70 data for determining the S-2S resolution is available.

E73

The PAC recommended allocating a 25-days 80 kW beam for E73 in JFY2023 if the schedule and the budget permits in the 34th meeting. The PAC congratulates that the team has obtained the result of the measurement of the lifetime of ${}^{4}_{\Lambda}H$ in the pilot experiment to demonstrate the feasibility of the experimental setup and is preparing its publication. The PAC recognizes that the ratio of the production cross sections of ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ provides the binding energy, giving a better understanding of the structure of ${}^{3}_{\Lambda}H$. We note that the length of the run will need be determined according to the JFY2023 budget, schedule, and the availability of the intense beam requested by E73.

E11/E65(T2K)

The T2K experiment uses an off-axis neutrino beam produced at J-PARC to precisely measure neutrino oscillation parameters and seeks to make the first measurement of leptonic CP violation. The near detector ND280 is used to constrain the neutrino flux before oscillation. SK, located 295 km away, observes electron (muon) neutrino (dis)appearance. Two presentations by T2K were made to the 35th PAC meeting.

We learned that Sakashita will replace Ichikawa in May 2023 as T2K Spokesperson. We thank Ichikawa for the past achievements and wish future success to Sakashita. We congratulate the T2K collaboration for the progress in detector upgrades and data analysis presented.

The neutrino beamline has been extensively upgraded since the last T2K beamtime. The changes include the MR upgrade, a new downstream bending magnet and realignment of the magnets, a new target and horns, higher maximum horn current of 320 kA and improvements to beamline monitoring. At least 2 weeks of beam commissioning before summer 2023 are requested so that any issues can be resolved during the summer shutdown.

SK has now been upgraded to include 0.03% Gd to add detection capability for supernova relic neutrinos and aid in neutrino/antineutrino separation. Cosmic and calibration data shows that SK-Gd is functioning as expected and ready for beam.

The ND280 upgrade comprises the sFGD (super fine-grained detector), two HA(High Angle)-TPCs and a TOF system. sFGD has been assembled at J-PARC save for the insertion of the WLS fibers. The sFGD electronics have been delayed but should be ready for deployment by June 2023. The HA-TPC field cage was delayed due to improper material use during assembly by the vendor. After months of investigation, the issues were resolved, and field cage production is in progress. The bottom HA-TPC, sFGD and TOF modules will be ready for installation in October 2023. The top HA-TPC should be ready for data-taking in December 2023.

Three oscillation analysis papers by T2K are expected to be submitted to journals soon. The first two (one for standard PMNS oscillation and the second measuring oscillation in neutrino and anti-neutrino separately) utilizes a spectral function model for the neutrino-nucleus cross-section to minimize previously dominant systematics of binding energy and include 30% more data in neutrino mode. The third paper improves control of systematics using new NA61/Shine constraints for improved flux modeling and new ND samples with proton and photon tagging and, for the first time, multi-ring events at the far detector. The joint T2K-NOvA analysis was slowed by the lack of in-person communication due to COVID-19 and is expected to have results by the end of 2023. Besides the increased statistical precision, the combination should break degeneracies. The joint T2K-SK analysis is also underway and quite promising, as the common fit will allow to lift the degeneracy between the CP-violating phase and mass ordering. Preliminary sensitivity studies were presented, and results are expected on a time scale of a few months.

The long shutdown and delays due to COVID-19 have significantly influenced young scientists on T2K regarding their research or thesis plan and have had a potentially detrimental effect on them. In addition, NOvA has nearly doubled their integrated POT since 2018 to have a comparable POT to T2K. T2K requests 44 days (2 cycles) of beam before summer 2023 and a total of 88 days (4 cycles) during JFY2023. The PAC acknowledges these requests, but note that the current situation precludes their fulfillment (see management comments below).

E56/E82(JSNS^2, JSNS^2-II)

E56/JSNS^2 is a sterile neutrino search experiment at the MLF aiming to test the LSND anomaly with a single detector. Since JSNS^2(-II) uses the same neutrino source, target, and detection principle as LSND, it provides a direct test of the excess. 2.96×10^{22} POT were collected in 2021-2022 (that is 27% of the approved POT for JSNS^2 on the near detector). The last data taking was in January-May 2022. A blinded search for sterile neutrinos is underway. Four sidebands and a signal region have been identified in the two-dimensional space of prompt IBD candidate energy and delayed IBD candidate energy. The sidebands are enriched in accidental and neutron backgrounds. The signal region will be unblinded once good agreement between data and simulation has been achieved in all four sidebands.

New for this 35th PAC meeting is the evaluation of the accidental delayed rate, which turns out to be substantially higher (about 4 times) than the predicted value in the TDR. The prompt candidate rate was presented at the 34th PAC meeting and compares well with the TDR value within a factor of 2, which is not entirely surprising given that the current detector is bigger than what was foreseen in the TDR. The remaining events of the accidental delayed rate after selection are due to gammas created by beam and cosmic rays (about half of them) and beam neutrons but thermalized outside the GdLS region (about half). The spatial correlation efficiency and the Likelihood efficiency are still under investigation, and a reduction of the accidental delayed rate must be achieved before opening the blinded sidebands. Further work to identify the source of the residual accidental delayed rate is ongoing.

Measurements of neutrinos from K^+ decay at rest (KDAR), with the initial goal of providing feedback on charged-current quasi-elastic scattering models, are also foreseen. A KDAR analysis strategy is being formed (as requested in the 34th PAC meeting). At present the peak of the neutrino prompt energy is seen, but no energy scales or resolution systematic effects are yet applied, and the work is ongoing to understand the detector effects and MC/data difference. The K^+ production rate in the target at 3 GeV is difficult to understand and this hampers a possible cross section measurement.

E82/JSNS^2-II extends E56/JSNS^2 by adding a second detector 48 m from the Hg target.

The experiment received Stage-2 approval in April 2022. Construction is ongoing. The first approval to construct the detector was given by the fire department in Oct 2022. Safety evaluation at J-PARC is near completion. The acrylic tank production progresses

well and will be delivered by March 2023. An LED calibration system was delivered in 2022. 223 PMTs are donated by Double Chooz, and additional 33 PMTs will be delivered from France. Overall, the installation is slightly delayed from the end of 2022 to the beginning of April 2023.

An upgrade of the near detector electronics is ongoing. The new system has been developed at the University of Michigan and was tested at J-PARC in December 2022 with the real detector (but no LS) and the LED system and it clearly sees the 1 p.e. signal and the saturation point. This upgrade will extend the dynamic range while maintaining good energy resolution and more trigger flexibility. The new readout system will be installed for the next physics run. The experiment aims at the next data taking from Jan 2024.

On seismic safety, resonance mode measurements have been made but only in the HENDEL building which has quite a different setup; they will be repeated in April on MLF 3rd floor with a real configuration containing liquid scintillator.

The PAC acknowledges the progress made since the last meeting and congratulates E56/E82 especially on the construction of the far detector and the near-detector electronics upgrade. The PAC is looking forward to hearing further progress in the data analysis toward the opening of the sidebands at the next meeting.

E71(NINJA)

NINJA measures charged-current neutrino-nucleus interactions in a water target with layers of emulsion and iron immersed in water. NINJA's scintillation tracker and emulsion shifter provide precision time and position information to timestamp emulsion tracks and link them with muons detected in BabyMIND. NINJA has good efficiency for low momentum tracks in the 100-400 MeV/c region inaccessible to other neutrino experiments.

NINJA reported new results on antineutrino-Fe interactions in October 2022 at NuInt based on a 3.5×10^{20} POT 'Detector' run with a 65 kg iron target. Proton angle and momentum distributions agree with MC predictions, but excesses are observed in backward and low momentum pion production. These discrepancies were the topic of a recent meeting between NINJA and T2K and a workshop with an invited theorist.

Emulsion scanning of physics run E71a (4.8×10^{20} POT neutrino beam on 75 kg water/130 kg iron) was completed in March 2022. E71a has 30 times the statistics of the detector run. Preliminary results on muon and proton production in neutrino-water interactions from 10% of the E71a data were presented and indicate that forward proton production is less than the MC prediction. The PAC congratulates the collaboration on timely production of these results and looks forward to a presentation with the full E71a statistics at the next PAC meeting.

NINJA and T2K have been cooperating for quite some time to consider two approaches to use NINJA's unique low momentum hadron information to reduce systematic uncertainties in the analysis of neutrino oscillations. The PAC commends the collaborations for this cooperative study and awaits a quantitative demonstration of the reduction in systematics.

NINJA is preparing for run E71b, nominally in fall 2023, to acquire 5.2×10^{20} POT with a 1.7 times larger target mass that can be quickly scanned thanks to the 5-times improvement in emulsion scanning speed. The PAC encourages all parties to decide on the position of NINJA for the upcoming run.

The PAC appreciates the initial studies performed by NINJA to assess the impact of a heavy water target in a future run. The studies show that a run with at least four times the scale of E71a is needed to make a statistically significant neutrino-neutron cross-section measurement from the difference of neutrino-H_2O and -D_2O data. Current knowledge of neutrino-neutron interactions relies on relatively small hydrogen and deuterium bubble chamber data samples from the 1980s that lack key analysis details. Since neutrino-H_2 and -D_2 measurements will be scarce in the near future, the PAC encourages the collaboration to continue their investigations to determine how these difficult measurements can quantitatively improve the knowledge of neutrino-nucleon interactions that are crucial for future neutrino oscillation analyses.

E14(KOTO)

The KOTO (E14) experiment searches for the highly suppressed $K_L\rightarrow\pi^0\nu\bar{\nu}$ decay that is very sensitive to physics beyond the Standard Model. They showed the status of the analysis for their data taken 2019-2021 at 35th PAC meeting. Compared to the analysis based on the data taken 2016-2018, K^+-background is highly suppressed, while the $K_L\rightarrow\pi^0\pi^0$ (Kp2) background is estimated to be significantly larger, 0.14±0.06 events compared to a previous estimate of less than 0.08 events at 90% C.L. upper limit. These

estimates are based on simulation using GEANT4 v9.5.2 for the 2016-2018 data analysis, and GEANT4 v10.6.2 for the 2019-2021 data analysis. Between 9.5.2 and 10.6.2, the GEANT4 photon-nuclear interaction model was switched from the Chiral Invariant Phase Space (CHIPS) model to the Bertini-Cascade (BERT) model because of poor technical support of CHIPS.

The activity to perform this study is facing a practical computing resource limitation in terms of amount of storage and CPU. They are attempting to solve this problem by introducing the usage of Open Science Grid (OSG). Some demonstrations to show the capability to carry out mass production of the Kp2 MC background sample has been done; the PAC encourages the work toward this direction.

E14 colleagues attempted to validate the simulation results by selecting putative $K_L \rightarrow 3\pi^0$ decays with 5 reconstructed photons and using the sixth photon to probe the photon veto inefficiency. The validation was statistically limited because the trigger for the 5 gamma events had a 30-times pre-scale. This resulted in the assignment of a 100% systematic uncertainty and a 25% increase of the central value of the Kp2 background. The planned DAQ upgrade should allow 5 gamma data to be acquired without pre-scaling in the future.

Furthermore, the inverse cut studies have been updated, yielding an improved understanding of the contribution of halo $K_L \rightarrow \pi^+ \pi^- \pi^0$ events. KOTO reported that they are currently investigating minor data/MC discrepancies found in inverted cut studies, but that they generally found good data/MC agreement.

The PAC commends E14 for their careful and diligent efforts to understand backgrounds. The PAC recognizes that the E14 collaboration has responded to the recommendation given at the 34th PAC meeting to exercise great care with the analysis. We look forward to continued care and diligence prior to the box opening in the next few months.

In this PAC meeting, progress in the DAQ upgrade to expand the bandwidth from 10k to 30k events/spill was presented. Full integration of the new DAQ system is planned to be tested in 2023 March. It will enable higher statistics control samples to understand backgrounds and is regarded as the right way to go. A new, thinner UCV with ~10 times lower inefficiency is also ready for installation once a vacuum feedthrough arrives.

Since KL beam can co-exist with the K1.8 or K1.8BR beamline operation, the PAC recommends approval of their beam request of 1.5 days startup and at least 10 days at 65

kW. This will allow understanding of the beam properties with the upgraded MR and acquisition of physics data before summer 2023.

E16

E16 is the experiment to carry out measurement of mass modification in matter using $\phi \rightarrow e^+e^-$ decay at J-PARC high-p beamline. It is an attempt to see partial restoration of broken chiral symmetry, is thus important in understanding the mass generation mechanism.

Three pilot runs, Run0 a, b, c were performed in 2020 and 2021, corresponding to the total 403 hours operation time. Analysis results of these pilot runs are described in the Technical Design Report (TDR) submitted 2022 May and review has been done. Track reconstruction efficiency is almost as designed, while improving calibration is expected to take care of worse-than-expected position resolution. The electron identification performance is found to be achieving the design value except for the Hadron Blind Detector (HBD), for which improvements on the low voltage power supplies and wiring are planned. There is a beam microstructure causing the instantaneous high interaction rate and DAQ live-time deterioration. Countermeasures for this issue are also described in the TDR.

Toward Run1, the full 8-module detector configuration will be ready by the end of 2023 April. The PAC appreciates all the E16 colleagues' effort and progress mentioned above. Since it is important to understand the beam condition and to find out proper trigger setting, the PAC recommends the approval of their beam request of 53 hours shot operation with B-line only and 180 hours continuous A+B lines operation before 2023 summer.

E83

The E83 experiment is designed to search for low mass milli-charged particles that are predicted in dark-sector models beyond the SM and can be produced simultaneously with the neutrinos for T2K(E11, E65) at the J-PARC neutrino facility. The E83 detector will be installed on the B2 floor of the NM building. The milli-charged particles will go through the beam dump and following soil because of their feebly-interacting nature before reaching the detector. The detector configuration consists of two sets of arrays of

scintillator modules with one PMT readout: the two sets are aligned so that incoming particles penetrate through each module in both upstream and downstream sets. The milli-charged particle causes correlated single photon signals at the beam bunch timing. The aluminum frame that holds the detector is tilted by 1 degree such that the detector axis points to the J-PARC neutrino production target. The detector is covered by VETO panels to help with rejection of external radiation and cosmic muons. Half detector (that is half of the front array plus half of the back array) will be constructed in spring 2023, and the other half will be added in Autumn 2023. The whole construction budget is covered by the National Research Foundation of Korea.

Based on a PYTHIA8 simulation (for the production rate of mesons, and assuming only EM-interacting milli-charged particles) and assuming 5×10^{21} POT data, E83 has a sensitivity for mass below 0.2-0.3 GeV and charge down to 10^{-4} that improves on previous constraints. E83 offers a complimentary coverage of the phase space investigated by Millikan that is sensitive to higher masses. Considered background sources are accidental coincidence of PMT dark current and/or external radiation, beam-induced backgrounds such as the secondary particles from neutrino-beam interaction in the surrounding materials, and cosmic-ray backgrounds. The dominant background sources are PMT dark rate (about 11 events/year assuming PMT dark noise of 500 Hz) and external radiation (about 30 events/year based on a measurement at MN-B2). The background from cosmic rays has been evaluated using simulation and is found to be negligible. The beam-induced background is also negligible. The background from neutrino-scintillator interaction has been evaluated using INGRID data and double-checked with Neutral-Current data from existing measurements and is also negligible. The background from muons from neutrino-material interactions has also been checked using INGRID data and will be checked with data and Geant4 simulation and will result in an inefficiency of 5% at maximum. The effect of detector misalignment has also been evaluated and corresponds to a reduction in acceptance.

The E83 Collaboration obtained Stage-1 status in April 2022 and now requests Stage-2 approval recommendation at the 35th PAC meeting. E83 requests the 4 m^2 space for the detector, 1,500 W of electricity, and the network connection from J-PARC to data storage at Korea University. The E83 experiment does not request dedicated beam time and plans to use the beam time for T2K.

The J-PARC FIFC has examined the E83 TDR, has concluded that E83 setup is feasible enough because it is based on well-established technologies, and made a number of

recommendations. The main points are that to improve the detector and mechanics description in the TDR, that a full system test is performed in Korea before shipping to J-PARC, and that the beam-induced background event rate is estimated by scaling the event rate of T2K on-axis detector. FIFC asks IPNS/J-PARC to appoint a liaison at NM-B2, to assist in managing resources available at the experimental site.

The PAC is satisfied that the main FIFC comments have been or will be addressed and will be described in an updated version of the TDR. The effect of the acceptance degradation due to random veto effects of the Veto Counter (especially if high-dark-rate PMTs are used in the VC) should be evaluated and added to the TDR. The sensitivity curve for the combined effect of a reduced acceptance and increased background should also be added to the TDR.

The PAC congratulates the E83 collaboration for the work done. Conditional to the satisfactory update of the TDR, the PAC recommends Stage-2 approval.

E94

E94 has submitted a TDR on determining the binding energy of the Lambda hyperon in the hypernuclei produced by the (π^+, K^+) reaction with nat-*Li*, ^{10}B, and nat-*C* targets. The binding energy will be measured to an accuracy of 100 keV and with excellent energy resolution of 1 MeV at FWHM.

It was pointed out that the binding energy of the Lambda hyperon derived from the (π^+, K^+) reaction measured at KEK might be systematically shifted by about 0.5 MeV. If the KEK data are re-normalized by the binding energy of $^{7}_{\Lambda}Li$, they come close to the result obtained from the emulsion and FINUDA data. However, the proposed measurement is still important to precisely establish the Lambda binding energy in $^{12}_{\Lambda}C$, which has been widely used as a calibration reference in many counter experiments.

From a technical point of view, FIFC has requested E94 to revise the TDR for Stage-2 approval. The PAC agrees with FIFC that detailed simulations on the signal and background rates are mandatory. The beam stop in the S-2S spectrometer could cause serious background because it is much closer to the detectors than the target. The proper encapsulation of the metal *Li* target is also an issue. Although E94 has briefly explained their experimental considerations in the PAC presentation, it is necessary for them to re-submit an updated TDR to FIFC in preparation for the upcoming PAC meeting for the Stage-2 approval.

E96

E96 is a proposal to measure X rays from transitions in exotic Ξ^--*C* atoms. Stage-1 status was given to the proposal in the 34th PAC meeting in August 2022.

The Ge γ/X-ray detector array (Hyperball-X') will be placed around the Active Fiber Target (AFT) in the E70 setup that makes use of the S-2S spectrometer. With such a configuration the experiment will detect X rays in coincidence with (K^-, K^+) events identified by S-2S and AFT.

The S-2S spectrometer construction at the K1.8 beam line started in January 2022 and progressed very well. The proponents of the S-2S experiments have demonstrated that all detectors have been installed and most of the system is ready for taking beams. The PAC congratulates the collaborations for these achievements.

It was shown that E96 could overcome the shortcomings of experiments E07 and E03, where no X-ray peaks from Ξ^- atoms have been found. The AFT in E96 will allow for a 95% background reduction with 70% survival ratio for Ξ stopping events, greatly improving the signal-to-noise ratio. The X-ray yield was simulated and is expected to be large enough to generate observable peaks in the spectrum assuming 20 days of 80 kW MR power beam common with E70.

The E96 Collaboration has submitted a Technical Design Report (TDR) that was reviewed by the FIFC. The TDR outlines the experimental setup, possible interferences between E96 and E70 detectors, the modified Hyperball X', the trigger and DAQ system, and the overall readiness. Few items noted by the FIFC have been addressed by the collaboration in the meantime and the TDR was updated accordingly.

The PAC recommends the Stage-2 approval for E96 and to run in parallel with E70.

4. GENERAL REMARKS AND RECOMMENDATIONS

The PAC was happy to learn that J-PARC has been evaluated highly by MEXT in a recent review and recommended for prioritized execution of its plans. As we heard already last time, KEK roadmap 2021 and Project Improvement Plan (PIP) 2022 have been published and reviewed and endorsed by the Scientific Advisory Committee. It is good to see the emphasis there for many J-PARC priorities including the Hadron Hall Extension.

It is a relief to hear that the necessary permissions for Radio Isotope Facility from the Nuclear Regulatory Authority of Japan have been granted after much delay, removing the roadblocks for the extension of the H-line, improvement for the neutrino beam for operation at up to 1300 kW proton beam, and the construction of the beam line for COMET phase-α. We also welcome the establishment of the IPNS task forces to review P93, KOTO and g-2/EDM and look forward to their reports.

J-PARC is to be congratulated on the progress they have made with the new MR supplies and associated upgrades so far. Unfortunately, the MR BM4 PS converter failure and the water leak from the MR septum magnet have delayed the restart of the beam considerably. While both problems have now been addressed, the planned November start of the 30 GeV MR study has had to be pushed back to January. This puts a severe constraint to the physics program that could be accomplished before the summer shutdown in June.

The other major concern is the soaring electricity costs already evident at the last PAC meeting. It appears there will be enough operation funds for ~3 cycles of beam operation in JFY2023 up to the summer shutdown which includes the remaining accelerator commissioning needs. The intention is to secure 3 more cycles of beam operation after the summer shutdown; however, the outcome of this effort remains uncertain.

The priority for operation before the summer shutdown is first to establish the SX and FX operations after this major shutdown, and second to carry out those activities that could lead to work that need to be carried out during the summer shutdown. The latter includes the neutrino beam commissioning, COMET phase-α, S-2S spectrometer commissioning (E70), and high momentum beam tests for E16.

The PAC recommends proceeding with the current plan to the end of JFY22 with initial FX and SX tuning and the completion of COMET phase-α. Towards the 3rd week of April, final FX tuning followed by baking can start. During the beam baking, neutrino beam commissioning can occur. The duration of the period of beam baking/neutrino beam commissioning is not certain, but this is currently planned for about 13 days. After this period, there should be about 15 days for beams to hadron hall for experiments before the summer shutdown (not counting the reestablishment of SX operation after FX operation). A part of this period should be taken up by ~2.5 days of exclusive line-B operation needed for establishing the high momentum beam (E16) with the rest of the time providing beam for both A and B lines. The priority should be S2-S commissioning (E70) and the remaining 'A+B' commissioning for E16. Some other experiments such

as KOTO can run concurrently during this time. Small requests such as 8 hours for P98 could be accommodated also. The exact balance of SX and FX operations need to be adjusted as the run proceeds.

It is not possible to give recommendations in any details for the running after the summer shutdown, given the current uncertainties. While it's unlikely that the long-term outlook will be clearer by the time of the next PAC meeting, we hope that at least the total allocation of beam operation during FY23 will be known by then. The PAC plans to make detailed recommendations on beam allocations at that time

In general, there are two main drivers for the running strategy for J-PARC; one is the need of T2K to accumulate sufficient data in the next few years, and the other is the need to clear the large backlog of Hadron Hall experiments prior to the start of the long shutdown associated with the Hadron Hall extension. Therefore, the general priority for the running after the shutdown should be the establishment of the 750 kW running for FX and improving the beam intensity for SX operations. The latter has the possibility of cutting down the running time required by large factors for many experiments and should be vigorously pursued.

Finally, the PAC notes that there was remarkable progress in the reported experiments. It is also gratifying to see the gradual return of foreign researchers to J-PARC.

5. DATES FOR THE NEXT J-PARC PAC MEETING

The next J-PARC PAC meeting will be held around the middle of July, 2023.

6. FOR THIS MEETING, THE J-PARC PAC RECEIVED THE FOLLOWING DOCUMENTS:

- Minutes of the 34th J-PARC PAC meeting held on 3-5 Aug, 2022 (KEK/J-PARC-PAC 2022-23)
- Proposals:
    - Cascade baryon spectroscopy at J-PARC high-momentum beamline (KEK/J-PARC-PAC 2023-4)

- Proposal for Measurement of Anti-Matter Reaction in Liquid Argon Time Projection Chamber (LArTPC) (KEK/J-PARC-PAC 2023-5)

- Technical Design Report:
  - Technical Design Report E83: Search for sub-millicharged particles at J-PAC SUB-Millicharge ExperimenT (SUBMET) (KEK/J-PARC-PAC 2023-1)
  - E94: Technical Design Report, New generation Λ hypernuclear spectroscopy with the (p+, K+) reaction by S-2S (KEK/J-PARC-PAC 2023-2)
  - Technical Design Report for J-PARC E96 experiment Measurement of X rays from X-C atom with an active fiber target system (KEK/J-PARC-PAC 2023-3)

- Reports:
  - Pion-induced phi-meson production on the proton (Addendum) (KEK/J-PARC-PAC 2023-6)