KEK/J-PARC-PAC 2021-17
October 12, 2021

J-PARC Program Advisory Committee

for the Nuclear and Particle Physics Experiments

at the J-PARC Main Ring

Minutes of the 32nd meeting held
14(Wed.)-16(Fri.) July2021

<u>OPEN SESSION</u>:

1. Welcome and J-PARC Center Report: T. Kobayashi (J-PARC/KEK)
2. J-PARC Accelerator Status & Plan: S. Igarashi (J-PARC/KEK)
3. Hadron Facility Status & Plan: H. Takahashi (J-PARC/KEK)
4. Welcome and Mandate to the Committee: N. Saito (KEK)
5. P83 SUB-Millicharge ExperimenT (SUBMET): J. H. Yoo (Korea)
6. P89 Investigation of fundamental properties of the KNN state: T. Yamaga (RIKEN)
7. P88 Study of in-medium modification of ϕ mesons inside the nucleus with $\phi \rightarrow K^+K^-$ measurement with the E16 spectrometer: H. Sako(ASRC-JAEA)
8. P87 Dielectron measurements in heavy-ion collisions at J-PARC with E16 upgrades: T. Gunji (CNS)
9. Overview of Hadron Experimental Facility Extension Plan: F. Sakuma (RIKEN)
10. P84 High precision spectroscopy of Lambda hypernuclei at HIHR: S. N. Nakamura (Tohoku)
11. P86 Measurement of the differential cross section and spin observables of the Λp scattering with a polarized Λ beam: K. Miwa (Tohoku Univ.)

12.	P85 Spectroscopy of Omega Baryons:	K. Shirotori (RCNP-Osaka)
13.	T2K(E11)/T2K-II(E65):	F. Sanchez (Geneva)
		K. Mahn (Michigan)
14.	E14(KOTO):	T. Nomura (J-PARC/KEK)
15.	E21(COMET):	Y. Kuno (Osaka)
16.	E34(g-2/EDM):	T. Mibe (J-PARC/KEK)
17.	E56/E82(JSNS2):	T. Maruyama (J-PARC/KEK)
18.	E36(TREK):	S. Shimizu (Osaka)
19.	E70 Ξ hypernuclear spectroscopy:	T. Gogami (Kyoto)
20.	P73 Lifetime measurement of $^{3}_{\Lambda}H$:	Y. Ma (RIKEN)
21.	E16 Measurement of Spectral Change of Vector Mesons in Nuclei:	
		S. Yokkaichi (RIKEN)
22.	E42 H-dibaryon search:	J.K. Ahn (Korea)
23.	Beam Time Schedule in 2022	T. Kobayashi (J-PARC/KEK)

CLOSED SESSION:

Present: P. Achenbach (Mainz), I. Adachi(KEK), M. Blanke (KIT), M. Endo (KEK), L. Fields (FNAL), Y. Itow (Nagoya), D. Jaffe (BNL), T. Kawabata (Osaka), F. Le Diberder (CNS/IP2N3/LAL), A. Ohnishi (YITP-Kyoto), H. Ohnishi (Tohoku), A. W. Thomas (Adelaide), K. B. Luk (Berkeley), N. Xu (LBNL), 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 31st J-PARC-PAC meeting (KEK/J-PARC-PAC 2021-6) 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, introduced the new J-PARC management which started since 2021 April. He showed the beam power histories of RCS and MR and introduced highlights of the J-PARC activities, namely the elemental analysis of the asteroid RYUGU sample brought back by HAYABUSA2 and awarding of Suwa-Prize for the accelerator group. He outlined the midterm plan of FX and SX powers along with the future prospect of the MR power upgrade which will be realized by increasing the proton intensity per pulse with more rapid operation cycle. The new magnet power supplies equipped with capacitor banks were introduced as a part of the MR power supply upgrade. Recent improvement of the spill structure for SX experiments was also discussed.

Kobayashi presented the J-PARC decadal plan: accelerator upgrade to achieve the MR high-power operation at 1.3MW, neutrino beam line upgrade and continuation of the neutrino program, experiments in the Hadron Hall with its extension as well as the COMET program, MLF neutron and muon beamline upgrade and construction of a new target station, and activities in the ADS R&D. He mentioned the status of the Hyper-Kamiokande; construction is in progress with approved funding in JFY2019. The experiment is expected to start in 2027.

He also introduced recommendations given in the J-PARC international Advisory Committee (IAC) meeting held online on March 4th and 5th 2021, two years after the previous meeting in 2019. They recommended the laboratory to work with funding agencies to identify additional operating resources, and to consider the priority of the scientific program with the SX beam.

Kobayashi finally explained the budget of JFY2021 that includes 1.5 cycles of operation, production of new power supplies for the MR, beam power upgrade to 750 kW and J-PARC upgrade for the Hyper-Kamiokande project. He also explained a budget plan to be requested for JFY2022 that includes 6.5 cycles of operation and accelerator commissioning, beam power upgrade for 750 kW, J-PARC upgrade for the Hyper-Kamiokande project and Muon g-2/EDM facility.

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

Susumu Igarashi reported the status of the J-PARC accelerator. He explained the history of the beam power provided at the RCS and MR in detail. Beam power of 700 kW was successfully delivered to the MLF for the user operation from April 5^{th} although it was reduced to 600 kW on June 24^{th} due to the temperature rise of the cooling water; 64.5 kW and 1.8 kW beams were delivered to the Hadron Experimental Facility in SX mode at the energies of 30 GeV and 8 GeV respectively, and a 510 kW beam was delivered in the FX mode at 30 GeV. Accelerator availability during these periods were 96.0%, 85.4%, and 85.5% at the MLF in the SX mode, and FX mode respectively.

Extraction efficiencies and spill duty factors in the SX mode were 99.5% and 50-55% respectively in the 30 GeV operation, and 99.1% and 55% in the 8 GeV operation. Performance of the 8 GeV operation has been significantly improved compared to that in 2018 where these numbers were 97.3 % and 16 %. They observed beam instability at the de-bunch process after acceleration when the beam power was above 60 kW in the 30 GeV SX mode. This was found to be due to the longitudinal structure of the microwave generated by the impedance effect. They also found that longer longitudinal beam emittance was effective in suppressing this instability. There were several hardware failures during the SX mode operation. Among them a faulty circuit breaker (QS-VCB) for the MR magnet power supplies caused a serious problem on 28^{th} February, resulting in a serious SX ESS damage. The ESS was replaced with a spare for the SX mode user operation in May and June. However, the QS-VCB problem happened again on 29^{th} June; the QS-VCB was accidentally opened for 2 seconds or longer. This could potentially damage the connected transformer, which is difficult to replace. Therefore, they terminated the MR operation on that day.

Igarashi explained the FX power upgrade concept as well as a mid-term plan of the MR operation. At this moment the MR repetition cycle is 2.48 seconds with the number of accelerated protons of 2.6×10^{14} ppp to provide a 500-kW beam. The cycle will be reduced to 1.32 seconds with the number of accelerated protons of 2.1×10^{14} ppp to achieve 750-kW beam power after the long shutdown with magnet power supplies replaced. Then efforts will be continued to reduce the repetition cycle to 1.16 seconds while increasing the number of accelerated protons to 3.3 $\times 10^{14}$ ppp, realizing the 1.3 MW MR operation. This will be accomplished by using newly installed RF cavities with higher voltage and replacing the extraction septum magnets for quicker cycling.

Finally, Igarashi summarized his presentation by showing a schedule in 2021 – 2022. The accelerator shutdown will continue until the end of March 2022. They will spend April and May 2022 to test newly installed power supplies, and June 2022 to check the upgrade system by accelerating protons. No user operation is scheduled in this period. There will be a regular summer shutdown in July – September 2022, followed by MR operation in the FX mode with 1.32-second repetition cycle as well as one month of beam-tuning and operation in the SX mode.

2-3 Hadron Facility Status and Plan (Hitoshi Takahashi, J-PARC/KEK)

Hitoshi Takahashi reported on the status and plan of the Hadron Experimental Facility. He explained the recent beam delivery and planned major works during the long shutdown.

The SX beam operation was carried out from February to June 2021. Although there was interruption due to the trouble of the electrostatic septum in the MR, the integrated beam power of about 2800 kW·days was successfully accumulated, and the maximum beam power of 64.5 kW was achieved. The E03 and E40 experiments at K1.8 finished their data taking in these runs, and the E14 (KL), E16 (high-p), and E73 (K1.8BR) also conducted data acquisition. In addition, the 8-GeV beam commissioning and beam extinction factor measurement of the COMET was performed as the T78 experiment. The accelerator operation efficiencies during the user time in the February run, March-April run, and May-June run were 67%, 85%, and 94%, respectively.

In this beam time period, the Hadron group has succeeded in improving on the beam quality; since the vertical beam width at the splitting magnet located at the A-B line branching point was decreasing gradually during a 2-second spill, the instantaneous beam intensity in the B-line at the beginning of the spill had been higher than at the end. The spill structure was successfully improved by the ramping operation of the vertical steering magnets during a spill. Another improvement was made for the A-line beam. The spill-by-spill fluctuation of the vertical beam position at the production target was significantly reduced by adopting a new beam optics minimizing the vertical dispersion at the target.

Takahashi presented the planned major works during the long shutdown. Construction of the new primary beamline for COMET (C-line) will complete. Preparation for the COMET phase-α in the Hadron south building will also be completed by the end of the long shutdown. In the K1.8 area, the KURAMA spectrometer currently located in the area will be replaced with a new spectrometer S-2S. Hadron facility will be ready for beam by the end of November, 2022.

2-4 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 new organization of the IPNS that started since 2021 April. He reported on the plan of budget requests for Japanese Fiscal Year (JFY) 2022. The operational budget for 6.5 cycles of MR operation, the improvement budget toward 0.75MW and a new construction budget for the muon g-2/EDM facility will be requested. In addition, the Hyper-Kamiokande budget at the J-PARC side including the intermediate detector, the accelerator and the beam facility improvements toward 1.3MW will be requested.

Saito explained the KEK Roadmap 2021 and Project Implementation Plan (PIP) 2022. The KEK Roadmap 2021 is an overall research strategy for a period from JFY2022 to JFY2027. This roadmap was prepared based on the inputs from relevant communities. It has been published on May 31, 2021 and reflected the KEK Scientific Advisory Committee (SAC)'s recommendations. The PIP 2022 will be established as a prioritized list for budget request for the next 5 to 6 years after the SAC's review scheduled in Feb. 2022. A straw-man-proposal on "Outline of PIP 2022" is being circulated within the relevant communities. This was drafted by the KEK Director General. Its outline is (1) priority is placed on beamtime when the budget is allocated, (2) then some hardware improvements will be implemented and (3) thirteen new projects requiring budget request are listed for prioritization. The thirteen new projects include projects relevant for particle and nuclear physics at J-PARC such as the hadron experimental facility extension and the COMET phase-II.

He reported on the progress after the 31th PAC meeting. Following the PAC's recommendation, stage-1 status was given to the P79, P80 and P82 experiments. A focused review committee of the hadron experimental facility extension was setup under the PAC in response to a request by the Hadron User Association. The three-day-long meeting is scheduled on 10th,11th and 17th August 2021. He also reported on the status of facility operation since the last PAC. For the neutrino facility, beam operation was conducted with a stable 510-kW beam power during March 8 to 19 and April 8 to 27. This is the first beam time with Gd-loading in the Super-K detector. Upgrade work of J-PARC for Hyper-K as well as upgrades toward 750kW are ongoing. The Hyper-K groundbreaking ceremony was held on May 28. For the hadron facility, the beam time was interrupted by several failures of the accelerator apparatus. The ESS needed to be fixed. The beam power after the ESS fix was 45kW and gradually improved up to 64kW. In addition to the usual slow extraction (SX) operation, a bunched-SX operation for 8GeV was conducted for T78 and the beam extinction factor was successfully measured. E56(JSNS^2) at MLF successfully accumulated 1.5×10^{22} protons-on-target (POT) which corresponds to 13% of the approved POT.

There are seven new experiment proposals submitted to the PAC32. Saito requested the PAC to evaluate the new proposals to provide recommendations for approval/rejection to the IPNS and J-PARC directors. He also requested to assess the progress of the ongoing experiments as well as any advice on the run plan after the long shutdown.

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

P83 Sub-Millicharge ExperimenT (SUBMET)

P83 is a proposal to search for a fractionally charged (millicharged) particle using neutral meson decays from proton-on-target at the T2K beamline with the detector located behind the INGRID detector in the neutrino monitoring building. This experiment does not require dedicated beam time and data-taking can be done in parallel to the T2K operation. The present detector configuration consists of two sets of arrays of scintillator modules with one PMT readout, and two sets are aligned so that the incoming millicharged particle penetrates through each module in both upstream and downstream sets. One array is composed of 10×10 modules, each of which has 5x5x150 cm^3 dimensions. With this set-up, P83 showed that a sensitivity of $Q < 10^{-4}e$ and $m_x < 1\mathrm{GeV}/c^2$ can be reached with 5×10^{21} pot, where Q and m_x are the charge and mass of the millicharged particle, respectively. This significantly improves on the experimental results obtained so far. The P83 group carried out a similar experiment in the CMS cavern at LHC as a "demonstrator" of the millicharged particle search ("milliQan demonstrator") to examine the basic concept of detector system and detection technique. The P83 detector is based on the experience from this demonstrator. As far as the budgetary situation is concerned, this experiment is fully funded by the Korean National Research Foundation.

The PAC finds the P83 proposal to be unique. It widens the variety of the physics program at J-PARC. The PAC encourages the P83 group to further study signal sensitivities and background rejections. For instance, 100 % efficiency is assumed in each module for tiny light yield less than single photon, which should be checked. The P83 group should consult the T2K group on the background situation, and determine the background rejection under realistic conditions. Such a study may lead to additional optimization of the detector design. The sensitivity should be updated by taking into account beam power improvement to be conducted at the MR in the coming years. The space and resource availability in the neutrino monitoring building could be an issue since the candidate area for the P83 detector may be in conflict with the present experimental apparatus. The P83 group is requested to contact T2K and other relevant groups as well as the Lab management to secure the detector space. The PAC asks the management to help SUBMET to find a feasible solution. Contingent on the space issue being resolved, PAC is ready to recommend stage-1 status.

P89 Investigation of fundamental properties of the $\bar{K}$NN state

The collaboration aims to use the $K^- + {}^3He \rightarrow (\Lambda\ p)\ n$ and $(\Lambda\ n)\ p$ reactions to determine the binding energy of the presumed doublet of deeply bound K^-pp and $\bar{K}^0nn$. This proposal is a natural continuation of an earlier experiment with results now published, which established the existence of a deeply bound K^-pp state. Furthermore, using the correlation between the spin of the Λ and that of the proton as a function of the Λp opening angle it should be possible to measure the spin of the K^-pp state. Progress on the proton polarimeter, which is crucial to the success of the experiment, is closely tied to experiment E80.

The beam request is for 8 weeks in 2025 at 90kW on the K1.8BR beamline.

E80 is at stage-1 status but is not yet stage-2 approved. We await the TDR to be submitted for E80 in due course. Then we would like to see the detailed feasibility of P89.

P88 Study of In-medium modification of ϕ mesons inside the nucleus

The PAC is pleased to see this new proposal where the measurement of ϕ meson via K^+K^- pairs in p+A collisions with the upgraded E16 detector is proposed. As the mass of the ϕ meson is close to the K^+K^- threshold, the branching ratio of the K^+K^- decay channel is sensitive to a possible in-medium change of the ϕ meson mass spectrum. The study of in-medium modifications of ϕ mesons in the E16 experiment will benefit greatly from both e^+e^- and K^+K^- pairs being detected within the same experiment.

The PAC appreciates the presented strategy for operating modular kaon ID and electron ID detectors in combination. The PAC asks the proponents to consider the feasibility of a (even a partial) simultaneous measurement of dilepton and kaon decay channels of the ϕ meson by the evaluation and optimization of the tracking capabilities and maximum beam intensity. Such data taking can test consistency between the different running conditions and to suppress systematic effects such as variations in detector performance, efficiency, and acceptance.

The PAC encourages the proponents to perform a Monte Carlo simulation of the distortion of the invariant mass spectrum in the low-mass tail of the peak by the strong kaon-nuclear interaction. A closer cooperation with theory groups that have developed nuclear transport codes would be beneficial for such a task. The PAC also encourages the consideration of a measurement of the A-dependence of the ϕ meson spectral shape by using p-Cu up to p-Pb collisions.

The PAC defers stage-1 status recommendation and asks that for the next PAC meeting, to be held in January 2022, microscopic simulations with nuclear models to be presented.

P87 Dielectron measurements in heavy-ion collisions at J-PARC with E16 upgrades

P87 is a proposal for a heavy-ion experiment with high intensity nucleus beam provided by the future upgraded J-PARC accelerator complex. The proposed spectrometer will have large acceptance, tracking at low transverse momenta and multi-dimensional event selectivity. This proposal is a beginning part of a big project of heavy ion (HI) physics program at J-PARC and its focus will be on the dileptons measurement with an updated E16 detecting system where hadron ID is enabled.

The proponents presented a plan to upgrade the E16 experiment including adding a forward spectrometer (replace GEM Tracker by SSD and replace PbGl by $PbWO_4$), adding ZCAL and enhance capability of Trigger/DAQ. They expect an Au beam of

10^8/spill and 50kHz. 2029 is the target year of operation, updated after the PAC presentation..

HI program at J-PARC is still to be developed. We encourage further development and discussions in the community and with the Lab management. The development of a comprehensive HI program beyond this proposal is likely necessary to move an HI program at J-PARC forward.

Dielectron pair measurement is important for heavy ion collision physics for understanding medium properties especially in the high baryon density region. Given the timescale, we encourage the proponents to think about more versatile detector enabling (for example) concurrent measurement of leptonic and hadronic measurements.

P84 High precision spectroscopy of Lambda hypernuclei at HIHR

Microscopic interpretation of the neutron star matter and the questions it raises, for example, how more than two times a solar mass neutron star holds its mass together, are recognized as crucial scientific questions. Nowadays, the so-called "hyperon puzzle" is known to be central to these questions.

One of the critical knowledges that need to be gained, in order to solve the puzzle, is to understand the role of three-body interaction (3BF) that include the hyperon. The information can be revealed in the fine structure of the hyper-nucleus spectrum in mid-heavy and heavy nuclei.

The aim of the proposed experiment is to measure the spectrum of hypernucleus with a mass resolution of about 0.4 MeV, which is 3.8 times better than the experiment ever done at KEK, by utilizing a spectrometer design based on dispersion matching technique. The beamline is called High-Intensity High-Resolution beamline (HIHR). The dispersion matching technique is already established at low energies. The spectrometer used for this technique is already in operation at RCNP, Osaka University, and RIKEN. However, use of the HIHR at the Hadron Experimental Facility Extension (HEF-EX) is the first attempt to apply this technique to a hadron beam, and it is evident that some critical issues exist. However, having the HIHR at J-PARC will open a new era for super high-precision spectroscopy at J-PARC. The PAC encourages the collaborations to realize the new spectrometer to shed light on three-body interaction, including hyperon by high-precision hypernuclear spectroscopy at J-PARC.

The connection of 3BF at high density and the EOS inside a neutron star is not a straightforward task that can be accomplished only from super high-precision hypernuclear spectroscopy. A strong international collaboration framework between theorists and experimentalists, especially including young scientists, needs to be formed. The PAC encourages the formation of such a collaboration.

This proposal is a part of the HEF-EX discussion and we await the outcome of the special committee to convene in August for more information.

P86 Measurement of the differential cross section and spin observables of the Λp scattering with a polarized Λ beam

Hyperon-nucleon scattering experiment is a unique way to investigate the hyperon-nucleon interaction directly. Unfortunately, there is not much data available to date and so constraints for the theoretical prediction are limited. Therefore, new experiments to measure the hyperon-nucleon scattering are very welcome.

The proposed experiment is the successor of the Σ baryon and nucleon scattering experiment, the J-PARC E40 experiment. Proponents extend the scope of the measurement to include Λ-p scattering. Moreover, by using Λ's self-polarization, when produced in the (K^-, π^-) reaction at p(K^-)=1.1 GeV, the collaboration proposes and demonstrates the possibility of extracting spin observables in Λ-p scattering. The high statistics Λ-p differential cross-section and spin observable are essential for a theoretical understanding of Λ-p interaction. The information will be crucial in understanding the physics of high-density nuclear matter.

Λ-p scattering information can also be accessible via correlation measurement in high-energy nuclear collisions, such as at ALICE at CERN. However, only s-wave interaction can be accessed and spin-observables cannot be measured in this case. The proposed experiment will provide unique information about Λ-p scattering, i.e. Λ-p scattering information in p-wave and spin observables. Scientific merit for the experiment is high.

The experimental technique and detectors for a proposed experiment are almost identical to the previous J-PARC E40 experiment. Moreover, the proponents showed "proof of principle" using the data taken for the E40 experiment. The Λ identification method is already established. Therefore, the feasibility of the experiment appears to be rather well-established.

One concern is the beamline where the proposed experiment can be performed. The beamline is proposed as one of the beamlines in the HEF-EX. Therefore, realization of the HEF-EX is mandatory for those measurements.

Another concern is connecting scattering information at low energy to interaction in high-density nuclear matter. The PAC recommends considering forming an international theoretical support group to consider physics in high-density nuclear matter.

This proposal is a part of the HEF-EX discussion and we await the outcome of the special committee to convene in August for more information.

P85 Spectroscopy of Omega baryons.

P85 aims at studying Ω baryons at the K10 beamline of the HEF-EX. The Ω baryons consist of three valence strange quarks (sss) and are suited in elucidating the internal quark-gluon dynamics. The K10 beamline is designed to provide a high-intensity high-momentum negative kaon beam with high purity in the momentum region up to 10 GeV/c, where abundant hyperons (S=−1, −2 and −3) and their excited states will be produced.

In order to provide a high-momentum high-purity K^- beam, it is important to develop the technique to separate kaons at very high momentum. The ordinary ES separator will not work with such high momentum particles. Proponents present one possible way by using an RF-separator. Conceptual design on RF-separator exists, but it is evident that there are still many milestones to be met. The PAC recommends close collaboration with the laboratory in order to realize an RF-separator in a reasonable time.

The PAC recognizes that the Ω baryon physics can be an interesting direction to study at J-PARC, but the motivations and goals should be further elaborated. The idea to extract the effects of the instanton induced interaction and the pion cloud is model dependent; it is desirable that the explicit measurements are defined, for example ones that connect directly to some operators that can be measured on the lattice. Comparison with the E50 experiment should be also mentioned, where the charmed baryons will be studied in view of the diquark picture. The PAC asks the proponent to provide an outlook that takes into account the hadron spectroscopic studies at the existing and future J-PARC hadron facilities, as a whole, in a future meeting. The PAC also asks P85 to evaluate the Ω production yield more rigorously and to provide a qualitative estimate of systematic uncertainty. This is necessary in order to estimate the needed beam time.

This proposal is a part of the HEF-EX discussion and we await the outcome of the special committee to convene in August for more information.

E11/65 (T2K/T2K2)

T2K is a flagship long-baseline neutrino experiment. It is highly complementary to the other neutrino oscillation experiments due to the difference in baseline. We have heard with pleasure a report on the recent impressive results based on data collected in Run 1-10 (up to 2020), current activities and the plan of analysis. The T2K collaboration has reported new results in eight publications in 2020-2021. They provide the best measurement of the mixing angle θ_{23} and one of the most precise determination of the mass-squared difference Δm^2_{32} in the world. For unknown reasons, T2K still observes more electron-neutrino events than expectation but less electron-antineutrino events. The current systematic uncertainty is significantly reduced from 5.1% to 3.0%. This is achieved by updating the beam-flux and cross-section models. Further improvements are expected through tagging protons and/or photons in the ND280 data analysis. By implementing multi-ring selection and better neutron tagging with Gd-loading in water, more neutrino events are obtained at the far detector (the Super-K detector) which should also help in reducing systematic uncertainties. Future analyses will utilize data samples with these improvements. The joint analysis with Super-K and NOvA is progressing well even though the pandemic has not allowed desirable face-to-face meetings. The goal is to release the first NOvA-T2K joint result in 2022. We congratulate the T2K collaboration on all these excellent accomplishments.

In the last run (Run 11), only INGRID and the new WAGASCI/BabyMIND were operated smoothly at the near site. The collaboration managed to institute remote shifts. The PAC commends the success of operating WAGASCI/BabyMIND and remote shifts. Data with only 2.65×10^{20} protons on target, as compared with their request of 4×10^{20}, was obtained. Very preliminary analysis indicates that they have observed events with neutron capture in SK-Gd which are in time with the T2K beam, which is encouraging. However, they have not amassed enough NCQE events yet.

The T2K collaboration has carried out an internal review of the subsystems of the existing ND280. They have identified shortcomings that will need to be addressed in order to ensure efficient operation of the near detector. The collaboration advocates for more support of the magnet from J-PARC.

Besides learning about the excellent progress in upgrading the beamline, the PAC was also informed about the status of the upgrade of ND280, which consists of building two high-angle TPCs, 6 planes of time-of-flight detectors and the SuperFGD. The construction of the former two subsystems appears to be on schedule. The SuperFGD is a bit behind. The outstanding issue is the assembly of the detector. To meet the schedule, the collaboration is looking into moving this task from CERN to J-PARC. Although the upgrade is about two months behind, we praise the collaboration for making good progress. The concern is the uncertain development of COVID-19 which may affect the assembly of SuperFGD and the other new subsystems at J-PARC.

The T2K collaboration has presented two potential beam-time requests, each asking for 8 months of beam time in JFY2022 and 2023. These tentative requests are in line with the agreement between the J-PARC administration and the collaboration. One of the requests under consideration is to have two months of running in February and March 2023, and six months in JFY2023. The other possible request is two months of beam in Autumn 2022 without ND280, another two months in February and March 2023, and then four months in JFY2023. We have taken note of their tentative plans and look forward to receiving a detailed request of beam time and progress in the next PAC meeting. The PAC strongly recommends J-PARC to take the T2K's tentative run plans into account when the laboratory finalizes the beam time schedule for the post 2021-2022 shutdown. It is important to note that the T2K results have been statistically limited. It is thus very desirable for T2K to obtain as much data as possible in the future to continue to produce world-leading results. We also strongly encourage the T2K collaboration to look into options for mitigating the impact of COVID-19 on the assembly and installation of the upgraded subsystems of ND280 at J-PARC.

E14 KOTO

The E14 (KOTO) experiment searches for the CP-violating rare decay $K_L \to \pi^0 \nu\bar{\nu}$ at the J-PARC neutral beamline. With small theoretical uncertainties at the 2% level in total, measurement of the branching ratio is a very sensitive probe of physics beyond the Standard Model. The PAC congratulates the KOTO collaboration for the publication of the 2016-2018 results where the upper limit is set to be 4.9×10^{-9} at 90% C.L. with the single-event sensitivity of 7.2×10^{-10}.

At this PAC meeting, KOTO reported the current status and efforts on detector upgrades, and analysis improvements as well as future projection toward the SM branching fraction sensitivity. In the 2016-2018 results the background is found to be dominated by $K^{\pm}\to\pi^0 e^{\pm}\nu$ (0.81 event) and halo $K_L\to\gamma\gamma$ (0.26 event) which should be further suppressed for the next analysis round.

In 2021 KOTO successfully took 3.8×10^{19} POT data in total for a physics run with the upstream charged veto system (Generation-1 UCV) for $K^{\pm}$ rejection. The UCV performance was evaluated by the data taken by turning off the sweeping magnet, confirming the expected 5% inefficiency. The growth of MPPC dark current in the UCV due to beam radiation was observed. For the next runs with higher beam power they are preparing the next generation UCV with a 0.2mm-thick scintillator viewed by PMTs with better radiation tolerance, by which a 99% efficiency is expected. In addition, significant progress is being made to reject the halo $K_L\to\gamma\gamma$ background by using likelihood ratio and kinematic MVA at the analysis level. Given the experience gained in 2016-2018 analysis, it is important to establish a new approach before opening the signal box to confirm known backgrounds near and inside the signal region. Since the computing resources for MC generations will be more important for estimating dominant background and for employing advanced analysis techniques such as Deep Learning, the PAC suggests that KOTO makes continuous efforts to secure sufficient computing resources. The DAQ upgrade is planned for incorporating more-than-16K events/spill (100KW beam power) configuration. Replacement of the L2 board to implement event-building capability with new modules, and construction of the new L3 cluster are expected to be completed by the next run in Autumn in 2022.

In summary, the PAC congratulates the collaboration on the successful modifications to the detector to address backgrounds and acceptance. The PAC is pleased to see steady improvements in data and analysis quality monitoring both online and offline that should ensure robust future search into the BR regime below 10^{-10}. The PAC thank the collaboration for providing their latest projections on background suppression. The PAC encourage the collaboration to provide updates on such projections at future PAC meetings.

E21 COMET

The COMET experiment searches for coherent neutrino-less conversion of muon to electron utilizing the new beamline (C-line) under construction in the Hadron Experimental Hall that will be completed during the long shutdown which started in July 2021.

The COMET collaboration reported the construction status of the C-line, facility, detector components, electronics and software. Once again, the PAC is pleased to learn that steady progress is made at all fronts. The large-scale production of simulated data MC6 is on hold until refined inputs are available. The PAC looks forward to the realization and results of MC6 in the coming PAC meetings.

In May 2021, the T78, an 8-GeV operation test/extinction study, was conducted as planned at the K1.8BR beamline. After having reproduced the results obtained at the MR/Abort in 2018, it confirms the effectiveness of the Forward-SBK (Single Bunch Kick) extinction scheme and establishes the validity of the promising Backward-SBK scheme. The PAC looks forward to hearing the results of the ongoing detailed analysis.

The COMET collaboration intends to carry out the low-intensity beam run (Phase-α) in JFY2022 for proton-beam commissioning and diagnostics (in particular for determining the extinction factor) as well as the backward pion/muon yields. Hardware preparation is proceeding well. After the initial Phase-α Study Note of January 2021, an improved version was released this month, in particular with more detailed simulation.

The PAC congratulates the COMET collaboration on its strong steady progress, and its ability to attract important new funding supports. As of today, COMET is on schedule and should be able to start commissioning with beam early 2024, slightly ahead of Mu2e. The PAC strongly supports COMET be given access to the C-line beam as soon as it is ready.

E34 g-2/EDM

E34 is an experiment to measure the anomalous magnetic moment and electric dipole moment of the muon by using an accelerated surface muon beam and a compact storage magnet.

In the 32nd PAC meeting, the collaboration reported progress of the beamline construction and development of components as milestones in 2021.

The final engineering design of the building and facility is now fixed with 13% reduction of space, compared to the previous design, achieved without major impacts. Preparatory works for the H-line construction and the first ionization test at S2 are ongoing. The qualitative goal of the test is to evaluate thermal muon intensity, an ionization rate (7×10^{-5}) and muon intensity (3 per sec). Mass production of positron trackers is ready. The collaboration also supports various meeting activities such as the muon g-2 theory initiative workshop, and increases workforce with young researchers.

The PAC congratulates the successful progress of the project in various aspects and encourages tight collaborative works with the laboratory to work towards success in obtaining main funding foreseen for JFY 2022. The PAC recognizes that the recent result from the FNAL g-2 experiment strengthens the importance of E34 even further and would like to see an independent g-2 results from the collaboration with the projected performance in a timely manner.

E56/E82 JSNS^2

The PAC heard updates from the JSNS^2 and JSNS^2-II experiments, which seek to confirm or reject the LSND anomaly using the same source and target as the LSND experiment but with lower backgrounds and duty factor. The JSNS^2 experiment took a short 1st run in 2020 and a second run between January and June of this year, collecting 1.45×10^{22} POT (13% of their approved POT). The data collection went smoothly in spite of the ongoing COVID-19 pandemic, which meant all on-site shifts were staffed by Japanese collaborators, with foreign collaborators taking remote shifts.

The collaboration reported on a new high-efficiency trigger that identifies IBD events based on energy and timing of the prompt and delayed IBD signals. Data taken in June 2020 has also been analyzed to understand backgrounds. Observed backgrounds are in good agreement with expectations and are dominated by neutrons generated by cosmic rays. A pulse shape discriminator has been developed that can suppress at least 90% of the neutron background. A blind analysis of the 2021 data is ongoing now, with unblinding of 2021 data and results expected soon.

The JSNS^2-II experiment will use the original JSNS^2 detector plus an additional detector. After the last PAC meeting, JSNS^2-II received official Stage-I status, secured pure and Gd-loaded Liquid Scintillator from Daya Bay, and continued design of the second detector. The collaboration plans to deliver a TDR at the next PAC meeting, and to address concerns from the 31st PAC meeting in it. Data-taking is scheduled to commence in late 2023.

The PAC congratulates the collaboration on the improved trigger, the preliminary analysis results from the June 2020 data, and the successful collection of data in

2021. The amount of progress is particularly impressive in light of the COVID-19 pandemic.

We note the importance of carefully verified and validated early results to establish JSNS^2's crucial impact on the LSND anomaly. To this end, we recommend the following:

- Concerning the unblinding of the analysis of the first 13% of the requested POT (as well as future data, assuming it will also be blinded), the collaboration should create a well-defined, step-wise procedure for making unblinding decisions. This procedure should have specific milestones to ensure robust and convincing first results.
- The collaboration should provide greater quantitative detail in future presentations so that the PAC can clearly understand the progress and potential issues. This should include, for example, more detail on:
    1. Background estimates for the signal and near-signal regions of the blinding procedure
    2. Training, testing and verification of the pulse shape discrimination,
    3. Data being collected in addition to the IBD triggers, and how that data is being used (this includes both beam and non-beam data)

Regarding JSNS^2-II, the PAC looks forward to receiving the TDR by the end of September so that the committee can give timely input on the design. The TDR should address outstanding questions raised by the PAC at the Jan. 2021 meeting, including the recommendation to understand the impact of differences between two detectors, and the potential differences of signal and background characteristics between two locations.

E36 Lepton Universality

E36 is an experiment testing lepton universality in the ratio R_K of K_{l2} decays. The collaboration aims to match the precision of the previous NA62 result (but with different systematics), which shows agreement with the Standard Model prediction at 0.4% level. A timely completion of the analysis is highly motivated in light of the possible deviations from the Standard Model recently indicated in lepton universality violating B decays and in $(g-2)_\mu$.

At the PAC meeting the collaboration presented their result for the structure-dependent $K_{e2\gamma}$ decay, which is a background process to their main analysis. The PAC congratulates the collaboration for submitting this result for publication, and urges the collaboration to complete the R_K analysis in a timely manner.

E70 Ξ hypernuclei spectroscopy

We congratulate the collaboration on the impressive progress in the development of this experiment, including the construction of the S-2S spectrometer.

The study of strangeness minus-2 nuclei is just beginning and J-PARC has unique capabilities to carry out these studies. This experiment aims to determine the binding energies of the levels in the $^{12}{}_{\Xi}Be$ nucleus through the (K^-,K^+) reaction on ^{12}C, with an energy resolution of the order of 2 MeV. This is a very significant improvement over the pioneering work at BNL which had a resolution of the order of 14 MeV.

The collaboration requests 2 weeks commissioning in Nov-Dec 2022 and a production run of 20 days around March 2023.

E73 Lifetime measurement of $^{3}{}_{\Lambda}H$

E73 is a unique experiment to determine the lifetime of the lightest strange nucleus directly via the $^{3}He(K^-,\pi^0)^{3}{}_{\Lambda}H$ reaction. The lifetime is determined event-by-event by the time difference between the starting time and the decay product pion of $^{3}{}_{\Lambda}H$. The experiment has already been granted the stage-1 status.

Previously the proponents successfully carried out a pilot run (E73 Phase0) with the $^{4}He(K^-,\pi^0)^{4}{}_{\Lambda}H$ reaction. The resulting lifetime is about 20 ps lower than the current world average. The systematic uncertainties have not, so far, been evaluated, but the apparent discrepancy is of some concern. Per last PAC recommendation, the production cross section measurement for (E73 Phase1) was carried in May, 2021 where both 2-body and 3-body decays are clearly observed.

The proponents request for stage-2 approval with 25 days beam time at 80kW. About 1000 2-body decay events are expected and will be used for lifetime analysis.

The PAC understands the importance of the measurement as well as the readiness of the experiment. The earliest beam time will be in the fourth quarter of 2022. Before granting the stage-2 status to E73, the PAC suggests to the experiment: (1) complete the analysis of $^{4}He(K^-,\pi^0)^{4}{}_{\Lambda}He$ reaction and determine the systematic uncertainties and (2) Prepare a detailed document on the analysis procedure for the lifetime measurement and submit the material before the next PAC meeting.

E16 Measurement of Spectral change of vector mesons in nuclei

J-PARC E16 aims to measure the spectral change of vector mesons in various nuclei with the e^+e^- decay channel, using 30-GeV primary proton beam to confirm the observation by KEK-PS E325 and obtain more precise information of the spectral change of vector mesons in dense nuclear matter.

E16 has performed the latter half of the commissioning run in two separate beamtimes Run-0b (110 hours) and Run-0c (134 hours) before the long shutdown. The latter benefitted from an additional 64 hours that were allocated for further detector and background studies. The PAC was pleased to see that the detectors worked well and that the time structure of the beam spill has been improved during the commissioning. However, the PAC is concerned about the high single LG background rates (without target) that were observed in the detectors of which 80% could not be identified. Frequent beam tuning was necessary as the rates were different cycle-by-cycle, and even week-by-week. Some data were taken with a di-electron trigger and a high-intensity beam of 1×10^{10} protons/spill to reconstruct ϕ mesons. The PAC encourages E16 to perform the analysis, and requests the first physics results to be shown in the next PAC meeting in January 2022. It is expected that the beam-time for a physics run will be requested at that meeting accompanied by an updated TDR.

The PAC encourages E16 to make every effort to study the beam-related problems and to identify the source of remaining background. The PAC asks for a detailed report in which E16 specifies under which background conditions the physics run could be reasonably performed. In addition, it is important to make clear if the performances of the detectors meet the requirements. For example, if the combination of HBD and LG provides sufficient power for suppressing background.

E42 H-dibaryon search

E42 aims at identifying the H-dibaryon via the $^{12}C(K^-,K^+)$ reaction. In PAC 32, E42 reported the completion of the commissioning and physics runs in May—June 2021. The collaboration switched over the experimental setup from the preceding E03 setup at the K1.8 area just in 4 weeks, which was much shorter than the original allocation, thanks to the extraordinary effort of the team. During the beam time, the accelerator and the detector system were very stable except the two short interruptions due to problems with HypTPC stopping data taking. The collaboration accumulated beam yields of 175G K^-s. It was approximately 60% of the estimation made before the beam time. This is because E42 had to suppress the K^- beam intensity at the beginning and gradually increased it for stable HypTPC operation. Despite some shortage of event yields, the measurement was successful. The collaboration presented a preliminary missing mass spectrum of the $^{12}C(K^-,K^+)$ reaction as well as the good tracking performance of HypTPC. The PAC congratulates the successful completion of the physics run and encourages the collaboration to proceed to the data analysis. The PAC also expects that the experiences of the HypTPC operation in E42 will be helpful in the future experiments because the stable operation of HypTPC with a high intensity beam is crucial for several experiments planned at J-PARC.

4. GERAL REMARKS AND RECOMMENDATIONS

The committee was informed of the assignment of the new IPNS Director Naohito Saito and the new J-PARC Director Takashi Kobayashi, and other changes in the leadership at KEK and J-PARC. The committee warmly congratulates the new leadership and looks forward to constructive partnership in the coming years. We also congratulate KEK on achieving the luminosity world record at SuperKEKB of 3.12×10^{34} cm^{-2}/s.

The committee was happy to hear that the SX and FX running in the last period went mainly smoothly and that the planned experiments completed their data taking before the shutdown. In particular, the high operational efficiency achieved in the last period of SX operation, even as the beam power rose to 64kW, is impressive and the laboratory is to be congratulated. We would like to congratulate the laboratory and the experiments on successful navigation of the COVID situation so far. We note that there are still likely challenges ahead including, for example, the semi-conductor shortage currently observed world-wide, that may affect future plans.

We also heard with pleasure that the facility and accelerator upgrade up to ~>750 kW, is on track to be finished during the shutdown with gradual increase in power up to 1.3 MW to 2028 planned in anticipation of Hyper-K. It is also encouraging that the budget request for FY22 for J-PARC includes, besides that needed for 750 kW operation, muon g-2/EDM facility as well as 6.5 cycles of operation that will allow the maximal use of available time for science in JFY22.

At this meeting, we heard the plans for the Hadron Experimental Facility Extension . These plans are to be reviewed by a special committee to be convened in August that will report back to PAC. Our initial reaction to the plans is that the scientific motivation for the plans is exciting and appears to be well founded; we are enthusiastic. However, given that the current plan calls for a 3-year shutdown of SX operation, the available beamtime before and what portion of the existing program can be completed before the shutdown is a crucial consideration. Also, we encourage all considerations on shortening and/or lessening the impact of the shutdown.

As we are still somewhat far from the next data taking period in JFY22, we do not make beamtime assignments in this PAC. We note that for the longer term, the plans of the HEF-EX calling for an extended shutdown of SX operations may have influence on the allocation of beamtime for SX and FX operations over the next several years.

We note that we heard the first proposal for a HI experiment at J-PARC, which requires an extensive investment which is not yet defined. Obviously, more complete scientific program beyond a single proposal is necessary to move forward on such a program. We look forward to hearing about developments of J-PARC program in this direction. We encourage discussion between the Lab managements and the proponents of the HI program.

Finally, we emphasize, as we have done in the past, that the ability to operate the facility at, or near, the maximum utilization becomes more and more crucial in the coming years as T2K II, the new Hadron Experimental Facility , COMET, and eventually Hyper-K comes on line. In this connection, the committee was glad to hear the management intends to put operations funding as first priority in the coming years.

5. DATES FOR THE NEXT J-PARC PAC MEETING

The next J-PARC PAC meeting will be held January, 2022.

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

- Minutes of the 31st J-PARC PAC meeting held on 16-18 January, 2021 (KEK/J-PARC-PAC 2021-6)
- Proposals:
  - Search for sub-millicharged particles at J-PARC (KEK/J-PARC-PAC 2021-7)
  - High precision spectroscopy of Lambda hypernuclei at HIHR (KEK/J-PARC-PAC 2021-8)
  - Spectroscopy of Omega Baryons (KEK/J-PARC-PAC 2021-10)
  - Measurement of the differential cross section and spin observables of the Λp scattering with a polarized Λ beam (KEK/J-PARC-PAC 2021-14)
  - Proposal for dielectron measurements in heavy-ion collisions at J-PARC with E16 upgrades (KEK/J-PARC-PAC 2021-13)
  - Study of in-medium modification of phi mesons inside the nucleus with $\phi \rightarrow K^+K^-$ mesons (KEK/J-PARC-PAC 2021-12)
  - Investigation of fundamental properties of the $\bar{K}$NN state (KEK/J-PARC-PAC 2021-9)
- Reports:
  - Status of COMET Phase-alpha Study (KEK/J-PARC-PAC 2021-15)
  - ND280 hall B2 space: current status (KEK/J-PARC-PAC 2021-16)
- Letter of Intent
  - Modification of baryon structure in nuclear matter studied from beta-decay rate of a Λ hypernucleus (KEK/J-PARC-PAC 2021-11)