KEK/J-PARC-PAC 2013-16
September 27, 2013

J-PARC Program Advisory Committee

for the Nuclear and Particle Physics Experiments

at the J-PARC Main Ring

Minutes of the 17th meeting held
September 25-27, 2013

<u>OPEN SESSION (September 25-26, 2013)</u>:

1. Welcome and Mandate to the committee: M. Yamauchi (KEK)
2. J-PARC status: Y. Ikeda (J-PARC)
3. Accident at the Hadron Experimental Facility: N. Saito (J-PARC)
4. Plan for repairs and safety improvements: S. Sawada (KEK)
5. J-PARC accelerator status: T. Koseki (KEK)
6. E27 status report (Search for a nuclear Kbar bound state K^-pp in the $d(\pi^+,K^+)$ reaction): T. Nagae (Kyoto)
7. E10 status report (Study of neutron rich hypernuclei by double charge-exchange reactions): A. Sakaguchi (Osaka)
8. E13 status report (light hypernuclei): H. Tamura (Tohoku)
9. E07 status report(double strangeness system with an emulsion-counter hybrid method): K. Nakazawa (Gifu)
10. E15 status report (deeply-bound kaonic nuclear states): M. Iwasaki (RIKEN)
11. E14 status report (KOTO): T. Nomura (KEK)
12. E36 presentation (Measurement of $\Gamma(K\rightarrow e\nu)/\ \Gamma(K\rightarrow\mu\nu)$ and Search for heavy sterile neutrinos using the TREK detector system): M. Kohl (Hampton)

13. E34 status report (A New Measurement of the Muon Anomalous Magnetic Moment *g*-2 and Electric Dipole Moment at J-PARC): T. Mibe (KEK)

14. E11 (T2K) Status and Future Plans: C. K. Jung (Stonybrook)
M. Friend (KEK)
T. Kobayashi (KEK)

15. High-p and COMET beamline: K. Ozawa (KEK)

16. E16 status (electron pair spectrometer): S. Yokkaichi (RIKEN)

17. P50 presentation (Charmed Baryon Spectroscopy via the (π^- D^{*-}) reaction in the high-p beam line H. Noumi (Osaka)

18. E21 status report (COMET): Y. Kuno (Osaka)

19. P56 - A Search for Sterile Neutrino at J-PARC Materials and Life Science Experimental Facility: T. Maruyama (KEK)

CLOSED SESSION (September 25-27, 2013):

Present: E. Blucher, T. Browder, A. Dote, J. Haba (Chairperson), M. Ieiri (Secretary), K. Imai, G. Isidori, K. Kleinknecht, T. Kishimoto, W. Louis III, T. Nagae, H. Shimizu, K. H. Tanaka, (IPNS Deputy Director), K. Tokushuku (IPNS Deputy Director), M. Yamauchi (IPNS Director), W. Weise

1. APPROVAL OF MINUTES

The minutes of the 16th J-PARC-PAC meeting (KEK/J-PARC-PAC 2012-23) were approved.

2. REPORT FROM THE IPNS DIRECTOR

The IPNS director M. Yamauchi welcomed the PAC members.

First he summarized the developments since the last PAC.

- An accident in the hadron hall occurred on May 23rd. Operation of the entire J-PARC facilities was halted and the previously scheduled beam time for SX and FX until the summer shutdown was canceled.
- Three proposals were submitted to “Master plan of large scale research projects” by the Science Council of Japan. These are (1) The future plan for the J-PARC facility, which includes extension of the Hadron hall, the 2nd phase of COMET and g_μ-2/EDM at the MLF, (2) Continuation of T2K with a MR upgrade to 750kW, and (3) The future neutrino program with Hyper-Kamiokande.

He reported that five proposals were evaluated and approved by the sub-committee for test experiments. Two of these test experiments, T47 and T48 have been completed..

He gave the following mandate to PAC in this meeting.

1) To review the following issues:

- Schedule : Difficult planning decisions on activities in the hadron hall are necessary due to the unexpected shutdown from the accident. He asked the PAC to provide opinions on a possible scenario to be presented by Prof. Ieiri in the closed session.
- Renovation plan of the hadron hall:
- Experiments performed or being prepared before the accident: E11 (T2K), E19 (Pentaquark), E27 (Kaonic bound states), E10 (Neutron-rich hyper nuclei), E13 (Gannma ray spectroscopy), E14 (KOTO), E15 (Kaonic nuclear states).
- Physics program for the near future: E11 (T2K) will investigate the challenging issue of CPV in the lepton sector, the experiments in the high-p beamline such as E16, P50 including beamline construction and E21 (COMET), E34 (g-2/EDM), E36 (Ke2/Kμ2):

2) To evaluate a new proposal (P56) for a sterile neutrino search at the MLF.

IPNS and IMSS agree that the proposals for particle or nuclear physics experiments in the MLF are primarily evaluated by the MLF-PAC. The MLF-PAC may request suggestions on the physics case and the technical feasibility of proposals from the IPNS-PAC. The IMSS/MLF may also make inquiries to IPNS on resource allocation before full approval. P56 will be evaluated at the next MLF-PAC in January 2014, at which time information on the physics case and technical feasibility of the experiment will be requested from IPNS. In order to avoid unnecessary delay, Director Yamauchi asked the PAC to evaluate the P56 proposal at this meeting.

Finally, he discussed the schedule for recovery of the beam. Although it is not yet decided, it is likely that there will be no MR beam delivered before April 2014. The plan for JFY2014 is subject to final approvals by the Japanese Government and the prefectural government. Careful negotiation is in progress with these parties.

3. REPORT FROM THE J-PARC DIRECTOR

The J-PARC Director Y. Ikeda presented the general status of the facility. He expressed his deepest regrets for losing about two months of beam time because of the accident in the Hadron hall. The staff is struggling to reduce the radioactivity level in the target area. Both the Nuclear Regulation Authority (NRA) and the MEXT have requested that J-PARC reform its organization of safety assurance after taking into account the opinions from specialists in various social sectors. A new organizational structure of J-PARC has been developed, which will be reported to the MEXT and the NRA. The objectives of J-PARC as a user facility are reaffirmed and remain unchanged. Restarting operation of the MLF and the neutrino beam-line are the most urgent and critical goals for which the greatest care at each step is necessary. Important milestones for the revitalization of J-PARC are the restarting of beam to the MLF from Jan. 2014, to the neutrino facility from April 2014 and to the Hadron hall from Oct. 2014, provided that all relevant authorities, including local and national governments give their approval. In JFY2014, 9 cycle operation and beam power higher than 500kW in the RCS and 300kW in the MR are expected. Director Ikeda promised that J-PARC will return to operation as a more vital and a safer facility.

4. REPORT ON THE ACCIDENT IN J-PARC ON 23-MAY

At around 11:55 a.m. on May 23, 2013 due to a malfunction of magnets of the MR for slow beam extraction, a proton beam with an intensity far beyond the design value was delivered to a gold target in the Hadron experimental hall (HD hall). Part of the gold target was damaged (possibly melted and evaporated) and radioactive material, which dispersed from the gold target, leaked into the environment outside of the radiation controlled area of the HD facility. This accident occurred due to a series of extremely unexpected incidents and a failure to assess the ongoing situation properly. An external experts panel (EEP) was set-up by the two parent organizations of J-PARC, the JAEA and KEK in response to a request by the Minister of Education, Culture, Sports, Science and Technology. A working-group (WG) within the EEP investigated and analyzed causes of the accident and matters related to the safety management system. The EEP considered preventive measures to avoid the recurrence of similar accidents and examined the soundness of the facilities other than the HD facility inside J-PARC.

The radioactive material leakage accident can be divided into the following five stages.

1) Due to a malfunction of electromagnets, a proton beam with an intensity far exceeding the design value was delivered to a gold target.

2) The target was instantaneously heated to a very high temperature and was partially damaged, causing vaporization of gold and dispersion of radioactive material from the gold.

3) The radioactive material leaked into the primary beam-line because the target container was not hermetically sealed.

4) Since the primary beamline area in which the gold target was placed was not sufficiently airtight, radioactive material leaked into the HD hall and workers inside were exposed to radiation.

5) Due to operation of the ventilation fans in the HD hall, radioactive material was then released into the environment outside of the radiation-controlled area of the HD facility.

Thirty-four of the 102 persons who were inside the HD hall at the time of the accident, were externally and/or internally exposed to radiation. Each person had a whole-body-counter measurement; the total (internal and external) radiation dose was at most 1.7 mSv. Medical examinations confirmed the absence of any adverse effects due to radiation exposure. The total amount of radioactive material released into the HD hall was estimated with a simulation based on data obtained from airborne samples collected at the HD hall and readings of area monitors in the HD hall, to be ~20 billion Bq (2×10^{10} Bq). The radiation dose on the site boundary at the location closest to the HD facility was estimated to be below 0.29 μSv as reported in the first statutory report; this dose had little effect on the environment.

5. RENOVATION PLAN OF THE HADRON HALL

S. Sawada presented the plan for the restoration of the Hadron hall after the accident. The plan is designed to improve the following items, which were highlighted by the EEP.

A robust target system that is capable of handling a high intensity beam even under unexpected conditions,

An air-tight enclosure of the target system, which can confine possible radioactive material released from the target. Good hazard monitors inside the enclosure should be equipped properly.

Better shielding of the primary beam area from radiation and radioactive material,

Integrated radiation monitor information and alarms.

For point 1, various target materials such as platinum, gold or tungsten with shapes similar to the previous target were investigated. The target is attached to a water-cooled block ("indirect water cooling") to handle beam power up to 50 kW, which is expected by 2016. The system will be enclosed in a gas tight volume filled with helium, which will circulate in a closed system to allow radioactivity to be monitored externally.

The primary beam area will be mostly enclosed with special polymer sheets to seal the gap between shielding blocks better, the cabling/piping paths will be blocked by a caulking compound and the exit of the secondary beam lines will be blocked by dual layer partition panels.

In the Hadron hall, the air exhaust will be controlled and filtered to prevent leakage of contaminated air outside. A contamination inspection system will also be installed at the gates of the hall. An integrated radiation monitor/alarm system will be constructed to inform users about any accident without delay.

By the end of 2013, all the design work and necessary administrative procedures should be completed; this should enable the immediate start of renovation work from 2014. The hall is expected to be ready for beam in the fall of 2014.

The committee was impressed by the heroic work of the J-PARC staff after the incident and their rapid action on the renovation. While technical details and the validity of the renovation plan will be extensively reviewed by other committees of experts, the PAC hopes that the new target system and facilities will be able to accept the highest beam power that will be delivered to the SX line in the coming year.

6. REPORT ON THE J-PARC ACCELERATORS

T. Koseki reported on the status of the accelerators.

Operations before the accident were summarized. In JFY2012, the availability was 89.3% for the T2K experiment and 90.2% for the Hadron users. T2K was provided with a 240kW beam. Slow extraction (SX) beam operation in March stopped due to a problem with the low-field septum magnet, which was repaired and reinstalled by April 27th. The Main Ring (MR) had a problem with a injection septum magnet on May 8th; beam operation resumed on May 13th. Hadron users were provided with a 24.5kW SX beam whose extraction efficiency, spill length and duty factor were 99.51%, 1.95 sec and 43%, respectively, on the day of the accident (May 23). All facilities have suspended operations since the accident.

The cause of the malfunction of the Extraction Quadrupole magnet (EQ) power supply (PS), which triggered the accident, and the preventive measures were explained. A spill feedback system with fast response quadrupoles was adopted in the MR to improve the duty factor of the SX. For the beam shot of the accident, the EQ-PS system malfunctioned and 20 Tera protons were extracted for a period of 5 msec. The cause of the malfunction was a fault in the transmission system of a control signal.

Koseki reviewed the plans for the accelerators during the shutdown period, including the Linac beam energy upgrade (from 181 MeV to 400 MeV to deliver a smaller emittance beam for RCS injection) and the peak current upgrade (from 30 mA to 50 mA), magnet re-alignment after the earthquake in 2011 and other improvements of the RCS, and the improvements of the MR (additional shields and absorbers for ring collimators, electrostatic septums made of Titanium, replacement of a part of beam ducts etc.). A plan for operation from November 2013 to March

2014 was shown: this plan would be followed if beam operation is approved by the Japanese and local governments in time. The mid-term plans in JFY 2013-2017, which were endorsed by the MEXT review committee of the J-PARC project in March-May 2012, were also presented.

EVALUATIONS OF THE PROPOSALS AND STATUS OF THE ONGOING EXPERIMENTS

1. E27 status report (Search for a nuclear Kbar bound state K^-pp in the $d(\pi^+,K^+)$ reaction):

   The PAC heard a progress report on the analysis of data that resulted from the E27 p(π+,K+) and d(π+,K+) pilot runs in June 2012. An ultimate goal of the experiment is to clarify the issue of a possible “K- pp” quasi-bound system. The aim of the pilot run was to produce an inclusive d(π+,K+) spectrum in the missing mass range 2.1 – 2.5 GeV/c^2 , and to study the feasibility of coincidence measurements.

   Spectrometer performance including energy calibration and cross section normalization was successfully tested in the process p(π+,K+) to Σ+ and Σ*+ . A mass resolution of 2.4 MeV was obtained. The differential cross section and missing mass spectrum for d(π+,K+) shows two significant features: a pronounced cusp effect at 2.13 GeV from Σ+n – Λp coupled channels, and a downward shift of the Y* production maximum by about 30 MeV as compared to a simulation using free Y*´s. The Σ(1385) appears not to be shifted in d(π+,K+), therefore indicating a possible spectral shift of the Λ(1405). This is of interest for understanding the interaction of the Λ(1405) with the residual nucleon.

   The original proposal involved the tagging of two protons with a range counter array system in order suppress the quasi-free background from Yp intermediate states, with the second proton coming from hyperon decay. However, with the present setup of the range counter (RC) array, it turned out that tagging of a single proton quite effectively suppresses quasi-free hyperon production backgrounds. Thus, coincidences with a proton or a pion have been investigated. With a proton detected in the RC the emergent spectrum displays, apart from the enhanced Σ+n – Λp cusp, a broad maximum at 2.285 GeV/c2 with a width of about 95 MeV. It is tempting to associate this signal with the “K- pp” quasi-bound system that is often discussed. Its position appears, however, slightly displaced in comparison with the previous DISTO or FINUDA results, indicating that this structure may reflect reaction dynamics. The statistics of the two-proton tagged spectrum is still prohibitively low with the present limited data; this may reflect the suppression of the decay mode of the quasi-bound system.

Further assessment requires detailed studies of detector efficiencies. The PAC is pleased with the progress of the ongoing analysis. Further data taking in order to improve statistics should be carried out as soon as possible.

2. <u>E10 status report (Study of neutron rich hypernuclei by double charge-exchange reactions):</u>

The E10 collaboration has successfully carried out their first phase of data taking in December 2012 and January 2013. The ^{6}Li(π-,K+) reaction at 1.2 GeV/c was studied to produce the neutron-rich hypernucleus $^{6}_{\Lambda}$H with a total pion beam exposure of 1.65 T pions. Great efforts were made to accept more than 10 M pions/spill by installing fiber trackers and silicon strip detectors along the beam line.

The observation of $^{6}_{\Lambda}$H was reported by the FINUDA collaboration in 2012 based on three candidate events. The E10 experiment aims to confirm the existence of this exotic neutron-rich hypernucleus with better statistics and to measure the binding energy with high precision. On the theoretical side, the Σ N- Λ N coupling is expected to introduce extra binding in such a neutron-rich systems.

Results of a preliminary analysis were presented at the PAC meeting. Good energy resolution and missing mass measurements were reported for the p(π+,K+) Σ^{+} and p(π-,K+) Σ^{-} reactions. In addition, the ^{12}C(π+,K+)$_{\Lambda}{}^{12}$C spectrum was presented as an example of normal hyper-nucleus production with a good energy resolution of 3MeV(FWHM).

Even at this preliminary stage, a high level of background suppression has already been reached. The estimated signal sensitivity is about 0.1 nb/sr. At this moment there is no peak structure in the bound region suggesting that the production cross section would be less than 1 nb/sr, one order of magnitude less than expected. The PAC encourages the collaboration to further investigate improvement of the sensitivity and obtain the final results soon.

3. <u>E13 status report (light hypernuclei):</u>

The E13 experiment was previously approved as one of the top priority experiments. The experimental group split the beam time into two parts to accommodate the arrangement plan of beam lines. The first part was scheduled to take place from May to July in 2013 on the K1.8 beam line equipped with the SKS spectrometer to study ${}^{4}_{\Lambda}He$ and ${}^{19}_{\Lambda}F$ hypernuclear physics. However, due to the accident that took place on May 23 at the hadron hall, only a fraction of the assigned beam time was available; the limited beam time only allowed tuning up the K^- beam, the SKS spectrometer, and the Hyperball-J system. The second part of E13 was planned for the K1.1 beam line after the SKS spectrometer moved in from the K1.8 beam line. The PAC understands that the E13 group has been preparing for the first part of the experiment at the K1.8 beam line and is now ready for a physics run on that beam line. The beam time schedule and arrangement of beam lines should be decided at the next PAC meeting.

4. <u>E07 status report (double strangeness system with an emulsion-counter hybrid method):</u>

The E07 experiment plans to study double strangeness (S=-2) systems with an emulsion technique, which has the best position resolution among all detectors, supplemented by information from counters. So far this experimental group has provided 8 of the world’s 9 double hypernuclear events. Only one of them has been uniquely identified. Their final goal is to detect ~102 double hypernuclei and to uniquely identify ~10 of them. These measurements can provide the ΛΛ binding energy, which is in turn of vital importance to constraints on the ΛΛ interaction. Currently, the E07 experiment is the only experiment that could obtain such information. The measurement of the Ξ-N interaction through twin hypernuclear events and X-rays from Ξ-atoms is the first project of this kind in the world.

The PAC understands that the experiment will be ready even if the beam exposure starts only in autumn 2014. Beam intensity and quality have been well studied in order to start data-taking as proposed. The beam line and the KURAMA spectrometer will also be ready. The key component of the experiment is an array of nuclear emulsion plates, which will be ready by March 2014 and which are being stored in Kamioka to avoid background exposure until the experiment can take place. Other detectors will also be ready although minor problems might be present.

The PAC appreciates the fact that the preparation of the experiment has made good progress and will remain on the same pace until beam time becomes available.

5. E15 status report (deeply-bound kaonic nuclear states):

PAC members heard a report on the status of the E15 experiment, which searches for the simplest kaonic nucleus K^-pp using the ^{3}He (inflight K^-, n) reaction at K1.8BR. In the experiment done in March and May before the accident at the Hadron Hall, they accumulated ~1% of the data in the original proposal with 0.9 x 10^9 and 4.0 x 10^9 kaons on target, respectively. The CDS performance was checked from the p π^- and π^+ π^- invariant mass spectra, in which Λ and K^0s were observed with good mass resolution, respectively. The performance of the forward neutron counter was confirmed and found to have a high S/N ratio (~100).

Preliminary results from semi-inclusive and exclusive data analyses were shown. The inclusive neutron missing-mass spectrum has a smooth distribution between the π Σ N and $\bar{K}$NN thresholds where the K^-pp state is searched for. E15 performed an exclusive analysis with a Lambda and a proton observed in the CDS. They confirmed that the missing mass spectrum of ^{3}He (inflight K^-, Λ p) X has a peaking structure at the neutron mass. With the neutron tagged, the Lambda proton invariant mass spectrum was examined, although the statistics are too poor to draw any conclusions at this stage. Preliminary analyses of the data showed that the performance of the detector system is satisfactory.

Further analyses are now in progress including: ^{3}He (in flight K^-, p) to investigate isospin dependence and ^{3}He (inflight K^-, n) $\Sigma^{\pm}\pi^{\mp}p$ to investigate the mesonic decay mode. We look forward to presentation of the results of these analyses and expect that in the next run E15 will accumulate sufficient data to give definitive conclusions. The scheduling of their beam time should be decided at the next PAC meeting.

6. E14 status report (KOTO):

The committee congratulates the KOTO collaboration on the successful completion of detector installation, commissioning, and the start of their first physics run in May 2013. Unfortunately, the accident ended this run after only 5 days of data taking. During these 5 days, the experiment accumulated data from 1.6 × 10^{18}

protons-on-target, 1/5 of the exposure planned with a goal of reaching the Grossman-Nir limit. The collaboration is analyzing these data, and hopes to improve on the E391a bound. The PAC looks forward to seeing the results of this analysis at our next meeting. The PAC recommends further running time for the E14 experiment, as approved. The beam time schedule and arrangement of beam lines should be decided at the next PAC meeting.

7. <u>E36 presentation (Measurement of $\Gamma(K\rightarrow e\nu)/\Gamma(K\rightarrow\mu\nu)$ and Search for heavy sterile neutrinos using the TREK detector system);</u>

   The E36 experiment plans to measure the ratio $\Gamma(K\rightarrow e\nu)/\Gamma(K\rightarrow\mu\nu)$ to a precision of 0.25% (0.2%(statistical) and 0.15%(systematic)). Parasitically, a search for a new neutral gauge boson particle, which couples to $e+e^-$, can be carried out. A search for a heavy neutrino can be carried out after the lepton universality data taking is completed. There is a high level of physics interest in these future results.

   We recognize the effort in optimizing the detector and testing its components. We now recommend stage II approval for E36.

   Since there is currently a funding shortfall for the GEMs, which may be late, a Sci-Fi tracker can be used.

   Since the precision requirements are severe and the detector is somewhat different from KEK PS experiment E246, we recommend cosmic ray data taking as early as possible and reiterate our earlier recommendation for an engineering run with beam as early as possible e.g. in December 2014.

   The cryogenics needed for E36 could start commissioning by November 2014, and then be available by December 2014. When the toroid is in place, the detector could start taking cosmic rays and begin final testing in autumn 2014. This would prepare the group for an engineering run with beam and magnet and then a four-month physics data run in 2015. This would allow enough time for calibration and the lepton universality physics run. However, carrying out the heavy neutrino search may require an extension of the run by a month or more. If extra funding for the cryogenics can be found, the PAC recommends earlier detector commissioning and engineering running.

8. <u>E34 status report (A New Measurement of the Muon Anomalous Magnetic Moment g-2 and Electric Dipole Moment at J-PARC):</u>

The 3σ g-2 anomaly reported by BNL E821 remains a mystery. There are 664 SPIRES citations of the BNL result since 2006, including 109 in 2013. This motivates the transport of the BNL ring to Fermilab for an improved measurement using the same technique with a precision goal of 0.1ppm and the innovative JPARC program with a goal of 0.1ppm. The BNL experiment uses a magic momentum of 3 GeV (γ=30) to eliminate some terms in the precession frequency while, in contrast, the JPARC experiment uses E=0 to simplify the precession frequency and avoid systematics.

The R&D activities for E34 are continuing at a high level. The H line is being designed and the front-end magnets were installed. The Lyman-alpha laser is in operation and will be tested at JPARC. The linac design and injection system design are being worked out in detail. Engineering design of the analysis magnet is in progress. The specifications of the silicon detector system are being finalized. A first prototype of the FE ASIC was evaluated. The importance of detector rotational alignment was emphasized.

One of the critical R&D items for E34 is the muonium production yield. Two production targets have been examined: heated tungsten with SiC (traditional choice) and silica aerogel (novel). For the tungsten target, the expected yield at the H-line is 0.24 x 10^6/sec while the first sample of aerogel gave a yield of 0.04 x 10^6/sec. A new sample of aerogel will be tested in October 2013 and is expected to give a yield of 0.28 x 10^6/sec. To put this in perspective, a muonium yield of 0.1 x 10^6/sec would give a precision of 0.3 ppm for g-2. This would be somewhat better than the precision of the BNL g-2 experiment, which had an error of 0.54 ppm. The goal of E34 is a precision of 0.1 ppm, which would require a muonium yield of 1 x 10^6/sec, beam power of 1MW and a run-time of 1 x 10^7 sec.

Another issue is the uniformity of the B field in the analysis magnet. Examination of a non-optimized MRI magnet with an NMR probe was shown. The requirement is 0.1 ppm over the muon trajectory. This requirement is satisfied for the magnet. The contribution of electric noise was at 0.15 ppm level. The magnetic moments of detector components such as DC-DC converters and optical modules would give a contribution of 10ppm to the B field at 100mm. To reach the required level of uniformity, the detector design must be optimized and these components should be moved further away.

The reacceleration of positive muons is another issue. Tests show a product of 2.9mu m rad at the RFQ output; this is acceptable. The RFQ power is 4.5 kW.

The PAC recommends continuation of these R&D activities and finalization of the beam line design.

9. E11 (T2K) Status and future plan

The T2K experiment has reached a major milestone by observing ν_μ to ν_e appearance with high significance (7.5 σ). This opens up the possibility, with future data taking, of measuring CP violation in the lepton sector, as well as the neutrino mass hierarchy and the θ_{23} octant. In addition to collecting more statistics, the T2K collaboration was able to reduce systematic errors by improving the SuperK event reconstruction and lowering π^0 background with the fiTQun program and by making use of the ND280 near detector measurements. The ND280 detector has begun to make neutrino cross-section measurements, which are important both for their intrinsic interest and for improving the measurement of oscillation parameters. In particular, ND280 has the potential of measuring nuclear effects (e.g. meson exchange currents (MEC) and final state interactions (FSI)) that can affect neutrino and antineutrino interactions differently and, thereby, affect the CP violation measurement.

For the future, T2K will collect more data in neutrino mode and begin to take data in antineutrino mode. An early run of 1×10^{20} protons on target (POT) in antineutrino mode is quite advantageous because it will allow the collaboration to begin to develop their antineutrino analyses and to begin antineutrino cross section measurements. Due to CPT conservation, ν_μ disappearance and $\overline{\nu_\mu}$ disappearance should be identical, so that a comparison of the corresponding oscillation parameters provides a useful check of systematic errors. A difference between the ν_μ and $\overline{\nu_\mu}$ disappearance parameters may indicate, for example, that nuclear effects are not being properly accounted for. If the ν_μ and $\overline{\nu_\mu}$ oscillation parameters are found to be consistent, then this will provide confidence in the search for CP violation by looking for a difference between ν_e and $\overline{\nu_e}$ appearance. The total amount and sharing of neutrino plus antineutrino running will depend, in part, on the level of systematic error that is achieved. If, for example, the systematic error remains at 8.8%, then the experiment becomes systematics limited in some important measurements prior to the stated goal of 7.8×10^{21} POT; however, if a systematic error of 5% or below is achieved, then the experiment would remain statistics limited at 7.8×10^{21} POT.

In addition to the oscillation analyses, various neutrino cross section measurements can be made in both neutrino mode and antineutrino mode, including ν_μ CC inclusive, ν_μ CCQE, ν_e CC, ν_e CCQE, NC elastic, and NC π^0 scattering. These cross section measurements should further reduce the background systematic uncertainty. Finally, exotic physics analyses can also be pursued, including searches for sterile neutrinos, CPT and Lorentz violation, and non-standard interactions (NSI). In order to fully carry out this rich physics program, T2K will need to collect substantially more data, with a significant fraction (up to half the POT) in antineutrino mode, with a detailed sharing between the neutrino and the antineutrino modes to be decided after collecting some data in antineutrino mode. Also, T2K may want to make improvements to ND280 by adding, for example, low-noise MPPCs or by employing D2O and H2O targets or building a high-pressure TPC (HPTPC) for measuring nuclear effects.

In order to make the best oscillation measurements, T2K will perform a global fit that includes data from reactor neutrino experiments, NOvA, SuperK, and T2K. Such a global analysis takes advantage of the fact that the different experiments have different responses to the various oscillation parameters. For example, the reactor neutrino experiments are insensitive to CP violation, while NOvA is more sensitive to matter effects and the mass hierarchy. In performing these global fits, however, it must be realized that the different experiments also have different responses to nuclear effects, which may increase the systematic uncertainty.

The PAC strongly supports the continuation of the T2K experiment with high-priority and encourages the scheduling of a first run in antineutrino mode as early as possible.

10. High-p and COMET beamline

K. Ozawa reported on the design of the high-p and COMET beam lines. The high-p beam line delivers 10^{10} protons per spill (a portion of 10^{-4} of 30 GeV primary protons), which will be extracted from the primary beam by the septum magnet. The optics design of the high-p/COMET beam line has almost been completed, however, there were several concerns raised about beam loss in the septum magnet, stability of beam separation, possible failure in beam transport operation, and so on, in the PAC discussion. Since it is very important to evaluate the technical feasibility of the high-p and COMET beam lines with care, the PAC recommends that an ad-hoc committee with experts be formed to examine the technical details. The

PAC would like to receive the report of this review and be informed of the operational safety measures that are required.

11. E16 status report (electron pair spectrometer)

The collaboration has been working intensively on the R&D of GEM trackers and hadron blind detectors. After confirming their performance in several beam tests, some parts of the detectors and electronics are now in the mass-production stage. As suggested by the collaboration, the PAC encourages E16 to submit a TDR for the next meeting, including clarification of the budget situation, before obtaining Stage-2 approval.

In their next presentation, the E16 collaboration should update and focus their physics motivation, avoiding statements that cannot realistically be supported by their experiment. The principal idea of measuring modifications of the phi meson spectral function in a nuclear many-body system is already a good motivation in itself. The measurements will not only verify and improve the results of the previous KEK-PS E325 experiment, but also provide new insights concerning the systematic momentum dependence of the in-medium phi meson spectral distribution.

12. P50 (Charmed Baryon Spectroscopy via the (π– D*-) reaction in the high-p beam line

An updated discussion of the P50 proposal was presented by H. Noumi in the open session, with further details discussed in the closed session on Friday. Following the recommendations of the previous PAC report, the collaboration has performed more detailed studies about: i) the overall level of the signal and ii) the reliability of the background estimate. The PAC recognizes the significant progress and work by the collaboration in both these directions.

As far as point i) is concerned, more detailed studies of the $\pi N \rightarrow D^*Y_c$ cross section, documented in the written note presented to the PAC, seems to confirm that the reference value of 1 nb is a reasonable estimate, at least for the Λ_c ground state and its radial excitations. On the other hand, the family of Σ_c baryons is likely to have a significantly smaller cross section.

As far as point ii) is concerned, the P50 proponents have performed refined simulations of the background using both PYTHIA and JAM. The background simulations using these two codes have been tested against the available πp data of the BNL and CERN experiments, showing that the JAM code provides a good description of the data of both these old experiments. Using these simulations, the P50 proponents have been able to refine their analysis strategy further reducing the background estimate in the high-mass region.

The proponents have also slightly modified the internal detection system to increase the detection efficiency for decay products of the charmed baryons, reaching an efficiency of 85% for the reference decay $\Lambda_c(2940)+ \rightarrow \Sigma_c(2455)++ \pi-$.

Despite these significant steps forward since the first presentation, some doubts remain within the PAC about the physics goal of P50. The main concern is the following:

In the most optimistic case, after a 1 year run, the statistics collected by P50 −for the currently known baryon states− would be marginally competitive with the statistics already collected by Belle (actually it would be comparable only for the family of Λ_c states). In the meantime a significant very high statistics sample of charmed baryons is also likely to be collected by the LHCb experiment at CERN. As far as charm-baryon spectroscopy is concerned, the only possibility for P50 to add significant knowledge to the field would be the observation of higher exited Λ_c states, assuming these states exist, are not too broad, and have a production cross section within the estimated range.

Given this situation, the PAC concludes that additional work is required to reinforce the physics case for this experiment. On the one hand, the PAC invites the proponents to further clarify the physics goals of the experiment in the charm-baryon sector beside the spectroscopy study. This requires, in particular, a detailed analysis of the possible implications of the relative $\sigma(\pi N \rightarrow D^*Y_c)$ measurements (for the different Y_c states) in comparison with reliable theoretical predictions. On the other hand, the PAC invites P50 to enlarge the physics scope of the experiment beyond charm baryons, including for instance a detailed discussion of the physics reach for K(*) N resonances. This could bring some added value to the experiment in case the observation of the higher Λ_c states turned out to be impossible or is superseded by the results of other experiments.

13. E21status report (COMET):

The COMET experiment has chosen a two-stage approach for the search for muon to electron conversion. For the first stage it appears reasonable to use graphite with radiative cooling for the proton target, while for the second stage a tungsten target with active helium cooling would increase the low-energy pion yield by a factor of 2.5. Bids for the procurement of the superconducting solenoids have been made, the prototype straw tracker has been designed, and tests of the electron calorimeter are planned. The design of the cylindrical drift chamber was presented, and simulations indicate a momentum resolution of 400 keV/c for 100 MeV electrons. Designs were also shown for the detector solenoid, cosmic-ray veto, and the online and offline software. For a beam current of 0.4 μA and a run of 7.5x 10^6 s, a branching ratio sensitivity of 7 x 10^{-15} is estimated for muon to electron conversion. The actual beam current will be optimized once the stopped muon per proton ratio is measured. The background estimate is approximately 0.03 events. The schedule shows that the experiment should be ready to accept an 8 GeV beam starting in 2016.

The PAC endorses an early test of 8 GeV proton operation, extraction, and transport to the Hadron Hall dump in order to understand potential issues and problems. In addition, the PAC supports a technical review of the Phase 1 experimental design in the next few months, organized by IPNS, so that the construction schedule is not delayed. For this review, it will be helpful if the COMET TDR is consolidated into a single coherent document.

14. P56 Sterile ν search

The committee heard a presentation of a new proposal for a sterile neutrino search to be performed at the J-PARC MLF. Several experiments during the last 15 years have shown hints of oscillations with corresponding Δm^2 significantly larger than those allowed by the standard 3-neutring mixing scheme. These oscillations could be an indication of sterile neutrino states. The proposed experiment would be sensitive to such oscillations, in the $\bar{\nu}_\mu - \bar{\nu}_e$ channel and in the mass range $\Delta m^2 \gtrapprox eV^2$.

The experiment will use μ decay at rest to search for $\bar{\nu}_\mu - \bar{\nu}_e$ oscillations. The detector is a Gadolinium-loaded liquid scintillator detector very similar to those used for recent reactor neutrino experiments. Anti-electron neutrinos will be detected via inverse beta decay, $\bar{\nu}_e + p \rightarrow e^+ + n$, followed by neutron capture on Gd. With 4 years of data taking at 1 MW, the 50-ton fiducial mass experiment should be able to exclude at a 5 sigma level oscillations with $\Delta m^2 > 2\ eV^2$ and $\sin^2 (2\theta)$ around or above 10^{-3}, or eventually to find evidence for a positive oscillation signal in this Δm^2-$\sin^2 (2\theta)$ range. Such a measurement would cover a region of the parameter space not excluded yet by other experiments and is therefore of great interest. Indeed other experiments sensitive to this mass range are being proposed elsewhere in the world. These include OscSNS at SNS in the US, STEREO at ILL in Europe, NEUTRINO-4 in Gatchina, Russia, and others. However, none of these other experiments have been approved yet. The PAC invites the proponents of P56 to address the relative time scales and sensitivities of their proposal compared to these potential competitors.

The most critical technical issue is a detailed estimate of the actual background rate at the 3rd floor of the MLF. The PAC recommends a direct measurement of this background with a small-scale prototype detector. If the background levels are as predicted (based on an extrapolation from rates measured at BL13 using a simulation), the experiment would be technically feasible and could receive stage-I approval.

15. <u>Hall planning after renovation</u>

The PAC heard a presentation on the work plan for renovation of the hadron hall. Before the accident, the high-p and the COMET beam lines planned to start construction and the SKS spectrometer was scheduled to move from the K1.8 experimental area to the K1.1 experimental area in FY2013. However, the PAC understands that this scheduled work has to be rearranged. The PAC endorses the decision that the renovation work of the hadron hall has to be started first and has higher priority than high-p/COMET construction and moving the SKS.

In the Hadron hall in May, experiments with secondary kaon beams at 25kW primary proton intensity, E15 at the K1.8BR beam line, and E14 at the KL beam line, were acquiring data, and E13 at the K1.8 beam line and E31 at the K1.8BR beam line were preparing for the beam time in June. The PAC understands that the beam time for these experiments will be fully re-allocated when the Hadron hall beam restarts. The beam time schedule after the renovation should be discussed at the next PAC meeting.

The PAC also endorses the timely restart of the construction of the high-p/COMET beam lines and K1.1beam line with the SKS spectrometer after the renovation of the Hadron hall.

7. EVALUATION OF TEST BEAM EXPERIMENT

The PAC heard the results of the evaluation of new test beam proposals by the sub-committee as described in the director’s report and acknowledged them. However, two test experiments had to be stopped and four have not yet been performed due to the accident. The PAC understands that beam time requests from these teams after restoration of the Hadron hall will be considered under the laboratory’s coordination.

8. RECOMMENDATIONS FOR BEAM TIME ASSIGNMENT AND PLANNING AFTER RENOVATION

T. Koseki explained the plan for MR accelerator studies in March 2013 and FX operation for the T2K experiment in the beginning of the next fiscal year. The PAC endorses this schedule for restarting. The beam time assignment after the Hadron hall renovation will be discussed at the next PAC meeting.

9. DATES FOR THE NEXT J-PARC PAC MEETINGS

The next PAC meeting will be held May 14-16, 2014 at the Tokai site.

The PAC would like presentations on the status of the facilities and the experiments. The plan for beam time and reconfiguration of the equipment in the Hadron hall will be reviewed.

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

- Minutes of the 16th J-PARC PAC meeting held on 9-11 January 2013 (KEK/J-PARC-PAC 2012-23)
- Research Proposal For COMET(E21) Calorimeter Prototype Beam Test (KEK/J-PARC-PAC 2013-1)

- Test of fine pixel CCDs for ILC vertex detector (KEK/J-PARC-PAC 2013-2)
- Test of GEM Tracker, Hadron Blind Detector and Lead-glass EMC for the J-PARC E16 experiment (KEK/J-PARC-PAC 2013-3)
- Test experiment for a performance evaluation of a scattered proton detector system for the Sigma-p scattering experiment E40 (KEK/J-PARC-PAC 2013-4)
- Second Test of Aerogel Cherenkov counter for the J-PARC E36 experiment (KEK/J-PARC-PAC 2013-5)
- Proposal: A search for Sterile Neutrino at J-PARC Materials and Life Science Experimental Facility (KEK/J-PARC-PAC 2013-6)
- Letter of Intent for J-PARC: Measurement of the strong interaction induced shift and width of the 1st state of kaonic deuterium (KEK/J-PARC-PAC 2013-7)
- Report to J-PARC PAC: Physics Potential and Sensitivities of T2K (KEK/J-PARC-PAC 2013-8)
- Status report from E40 to the 17th J-PARC PAC (KEK/J-PARC-PAC 2013-9)
- Summary of the P50 status report (KEK/J-PARC-PAC 2013-10)
- Estimation of the Production Cross Section for P50 (KEK/J-PARC-PAC 2013-11)
- Background Studies and Detection of the Y_c Decay Products for P50 (KEK/J-PARC-PAC 2013-12)
- COMET Phase-I Technical Design Report - the summary document (KEK/J-PARC-PAC 2013-13)
- Status and plan of the J-PARC E16 experiment as of August 2013 (KEK/J-PARC-PAC 2013-14)
- Status report on the E07 experiment (KEK/J-PARC-PAC 2013-15)