KEK/J-PARC-PAC 2011-28
March 17, 2012

J-PARC Program Advisory Committee

for the

Nuclear and Particle Physics Experiments at the J-PARC 50 GeV Proton Synchrotron

Minutes of the 14th meeting held on
Friday and Saturday, 16-17 March 2012

OPEN SESSION (16-March-2012):

1. Welcome, Mandate of this meeting:	K. Nishikawa (KEK)
2. J-PARC accelerator status and plan:	T. Koseki (KEK)
3. T2K status and plan:	T. Kobayashi (KEK)
4. K1.8/K1.8BR status and plan:	T. Takahashi (KEK)
5. KOTO status and plan:	T. Nomura (KEK)
6. Physics with the high-p beam line	K. Ozawa (KEK)
7. Physics with the COMET staging plan	S. Mihara (KEK)
8. Physics with the K1.1BR beam line	J. Imazato (KEK)
9. Hadron Hall status and plan	K.H. Tanaka (KEK)
10. Muon Physics at MLF	N. Saito (KEK)

CLOSED SESSION(16,17-March-2012):

Present: A. Dote, A. Gal, J.Haba (remote),
T. Haruyama (incoming IPNS deputy director), M. Ieiri(Secretary),
K.Imai*, S. Nagamiya(J-PARC Director)*, K. Kleinknecht,
T. Kishimoto, T. Kobayashi (Secretary),

T. Komatsubara (Secretary), S. Kumano, T. Mori, T. Nagae,
Y. Nagai, S. N. Nakamura, K.Nishikawa (IPNS Director),
N.Saito (Secretary), M. Shaevitz, S. Shimoura,
K. H. Tanaka(incoming IPNS deputy director),
R.Tschirhart , K.Tokushuku (Chairperson), H.Yamamoto,
M. Yamauchi (incoming IPNS director)

*) Part of the time

1. PROCEDURE

The minutes of the thirteenth J-PARC-PAC meeting (KEK/J-PARC-PAC 2011-21) were approved.

The PAC chairperson introduced the incoming PAC members who were able to attend this meeting as observers. They will become official members of the PAC in April. The incoming PAC chairperson will be Prof. Junji Haba (KEK-IPNS) who remotely joined this meeting from the US.

2. REPORT FROM THE IPNS DIRECTOR

The INPS Director K. Nishikawa welcomed the PAC members and observers. He introduced Prof. Masanori Yamauchi, who will become the director of the IPNS in April.

This March meeting was set up as a special meeting to assess the research plan for the five year period starting JFY2013 being put forward by the Institute of Particle and Nuclear Studies (IPNS) for the J-PARC facilities. The plan and its background motivation was presented during the meeting. The main content presented included: 1) the accelerator improvements and upgrades plans aiming to achieve the full design power for the accelerator complex, 2) the plan to simultaneously construct the high-momentum (high-p) beam line and a muon beam line which could be used for the upstream part of the COMET muon beam line, and 3) R&D for future experiments such as the g-2 (E34) and the neutron electric-dipole-moment (edm) measurement (P33) as well as other neutrino detector development. The plan for experiments with the SKS and other magnetic spectrometers will be presented at the next PAC meeting.

The plan has been discussed by the nuclear and particle physics communities and the proponents of the various experiments at J-PARC. The plan was also shown at the J-PARC International Advisory Committee (IAC) meeting held on February 27-28. After the PAC's assessment, the plan will be formulated to the final proposal and then budget negotiations with KEK and then with MEXT will start.

The accelerator upgrade plan will be discussed in detail later in this report but a summary of key points is given here. The expected beam power after the summer 2014 shutdown is to be greater than 300kW for the fast extraction (FX) and 50kW for the slow extraction (SX). In order to reach the design value of 750kW for FX further improvements will be necessary and higher repetition operation appears to be a realistic approach. This higher repetition rate will require new power supplies for the main ring (MR) magnets and a new RF system. R&D on these devices will be pursued.

The high-p line has been in the hadron hall plan since the beginning but not yet funded. One experiment (E16) on the measurement of the electron-positron decay channel of vector mesons in the nuclear medium was proposed at the first PAC meeting in 2006 and was granted stage-1 approval. There are other proposals and letters of intent to use the beam line. The construction of the beam line has been ranked as the top priority by the Japanese nuclear physics community. Recently, the Research Center of Nuclear Physics (RCNP) at Osaka University has expressed its interest to co-host the design and construction of the beam line to improve the momentum resolution. A memorandum of understanding has been set up among RCNP, IPNS and J-PARC groups for general cooperation associated with nuclear and particle physics studies. Since the construction of the beam line and its operation will be a long time project, cooperation based on MOU will ensure the firm base for the development of the research.

Reflecting the PAC's high evaluation of the physics associated with the COMET experiment and the positive results in the report recently published by a sub-committee of Japanese Association on High Energy Physics (JAHEP) on the future high energy physics projects, the COMET experiment is a high priority component for the J-PARC program. Considering that this high-priority experiment needs a large investment in infrastructure and hence a long time to realize, it is important to start the construction of the COMET beam line in the next 5 years.

The IPNS proposes, as the first priority item in the next five-year plan, that the upstream part of the high-p beam line be constructed and co-used by the COMET experiment and that the first half of the muon capture solenoid be constructed simultaneously.

A consequence of this plan is that the K1.1BR beam line will not be usable after the installation of the production target of COMET. This conflict, as was pointed out by

the PAC in the last meeting, will have a serious impact on the TREK experiments (E06 and P36). The PAC is requested to consider and comment on this in its evaluation during the meeting.

There are various other proposals, which are as yet not submitted or at pre-conceptual stages. Such proposals include the g-2, the neutron edm measurements and R&D programs for large-scale neutrino detectors. It is expected that the R&D for these experiments will also be supported as part of this five-year plan.

Another mandate request for this meeting was to provide advice on the beam time assignment for the current April-June running period. It was tentatively assigned at the previous PAC that the MR FX runs would be during April and May followed by SX operation in June. The recent news that the non-zero θ_{13} value, first reported by T2K in 2011, has been confirmed by the Daya Bay reactor experiment, gives more importance for an early re-confirmation by the T2K experiment. The T2K group has requested continuous data taking now until the end of June. The IPNS plans to re-evaluate the beam-time allocation for this period and seeks input and recommendations from the PAC.

The PAC took note of the Director's mandates for this meeting and developed a discussion plan to address all the issues.

3. REPORT ON THE J-PARC ACCELERATORS

T. Koseki reported the status of the accelerators and the beam and intensity prospects for the near term running. The long term plan will be described in section 5.

After a successful recovery from the earthquake, three runs were performed from December till March 2nd. The current run (Run 42) started on March 4th and will continue till March 31st in the FX mode.

In the last three runs, the total assigned user run time was 610 hours and the actual delivered beam time was 566 hours yielding 93% operation efficiency. The total beam time for the neutrino beam line and hadron hall was 12 and 392 hours, respectively. The main cause for the down time was trips of the RFQ, which happened 50-60 times a day. Based on past experience, the situation is expected to become better after conditioning. The second major beam loss was for trips in the SDT-LINAC. Here conditionings with higher voltage should lead to improvements.

The beam was delivered to the hadron hall from January 28th to February 21st . The installed solenoids around the RF excitors were proven to suppress the multipactoring

effects. The full transverse RF field was able to be applied and the spill duty factor was greatly improved to ~30%. The spill structure will be further improved with the feedback to the new RQ power supply. A prototype test showed that a 41% duty factor is achievable. The new power supply will be ready for the operation in June.

During the physics run, the SX operated stably with 3.3kW of beam power at a 6 second cycle time. The beam extraction efficiency was 99.6%. A collimator located after the electro-static separator (ESS) reduced the activation of the downstream accelerator components.

In order to investigate radiation in the hadron hall, a short two-hour 5kW run was performed. The duty factor was improved to 41% but the beam extraction efficiency was reduced to 97.7%. Two other, even-shorter, higher-power runs showed efficiencies of 98.6% (95.9%) at 6.5kW (10kW). These runs were too short to allow tuning of the extraction. All of these tests showed that significant improvements in beam quality and intensity are expected in the future.

High power tests for the FX were also performed. The effect of the non-alignment of the Rapidly-Cycling-Synchrotron (RCS) turned out to have a small impact on the injection to the MR. After some tuning including the second harmonics RF in the ramping up of the RCS, the beam loss at the collimator in the transport line from the RCS to MR was measured to be 168W for 210kW MR operation. This is far below the collimator allowance of 2kW. Therefore, the re-alignment of the RCS is unlikely to be urgent and will be scheduled for the 2013 summer shutdown

After the installation of the old power supply for the horn magnet, FX operation was resumed on March 3rd. Since March 7th , the MR cycle time was shortened from 3.2 to 2.92 second and routine operation has started with 128kW and then moving up to 138kW. During the night before the PAC meeting, the FX beam power reached 151kW. The beam power was initially limited by the vacuum quality in the MR but the vacuum is gradually improved with high power operation. A beam power of 151kW is thought to be the maximum that can be achieved with the current ion source. The beam loss in the MR was ~300W at 151kW operation, which is below the present collimator limit of 450W.

The operation schedule for JFY2012 was finalized. The aim is to provide 1.5 month continuous operation followed by 2-3 days of maintenance, which is needed for replacement of the ion source. Total beam time is expected to be 253 days with MR user time at 176 days in 8 cycles. During this JFY2012, further improvements are foreseen. The MR cycle time will be reduced to 2.56 second in April. The installation of extra MR collimators and a 9th RF system is planned to take place in the summer shutdown,

which will enable operation for the T2K experiment with more than 200kW. For the SX, the chambers of the magnetic septums will be replaced with titanium chambers in order to reduce the activation. SX operation at 10kW is expected for the autumn runs and a short 50kW run will be tried. The new RF power supply and new exitor for the transverse RF will be installed, which should further improve the duty factor.
Finally, T. Koseki informed the PAC of the outcome of the accelerator technical advisory committee (ATAC) meeting held on February 23rd -25th . Hardcopies of the minutes were distributed to the PAC members in attendance.
Overall, the PAC was very impressed by the achievements of the accelerator group over the short running period of the last few months and congratulates the J-PARC staff and users on the recovery of user operation of the facility.

4. STATUS OF THE ONGOING EXPERIMENTS

1. **E11:** Tokai-to-Kamioka Long Baseline Neutrino Oscillation Experiment (The T2K experiment)

   The PAC was very pleased that the fast extracted beam started up again in March and that the T2K experiment began data taking at that time. The accelerator group should be commended for reestablishing beam power at the 140 kW level with expectations to go to 150 kW very soon. In April the MR cycle time will be reduced from 2.92 to 2.56 s and the beam power should go up to 180 kW. There were some problems with the new neutrino horn power supply in December as reported at the last PAC meeting and for the run this year, T2K will use a refurbished power supply from previous running. Initial commissioning and physics data now show that the beam and detectors are working well with rates as expected. The horn current has been reduced to 200 kA from the nominal 250 kA due to some issues with the refurbished horn power supply, which will impact the neutrino rates by up to 15%. These issues should be addressed soon and running at 250 kA will commence.

   The plan is to run T2K into June this year ramping up to a beam power of 175 kW. This would lead to a collected data sample of approximately 3.9×10^{20} protons on target (pot) before the summer shutdown in July 2012. This will be followed by six months of running in FY2013 at >200 kW giving around 1×10^{21} total pot before the LINAC upgrade shutdown in summer of 2013. After the shutdown, it is

assumed that there will be six months of fast extracted beam each year starting at 400 kW in FY 2015 and ramping up to 750 kW in FY 2017 after upgrades are made to the MR. With this schedule, the T2K experiment will be able to collect a large data sample of about 4.5×10^{21} pot by FY2017 and have yearly data rates comparable to the Fermilab NOVA experiment.

The near term goal for T2K is to measure $\sin^2 2\theta_{13}$ using the appearance of electron neutrinos with a 3σ significance of about the 0.03 precision by summer 2012 and then move on to a measurement at the 0.01 level by the end of 2015. An appearance measurement holds the promise of exploring not only the value of $\sin^2 2\theta_{13}$ but also CP violation in the neutrino sector and the mass hierarchy. T2K is in a unique position to do this appearance measurement over the next several years before the NOVA experiment starts in 2014. At the same time, T2K can explore the value of $\sin^2 2\theta_{23}$, which, at present, is known to be large but inaccurately determined. In the longer term, the combination of T2K and NOVA will offer enhanced physics reach when the data sets are combined.

The mixing angle θ_{13} can also be measured by reactor experiments using the disappearance of anti electron-neutrinos. Such measurements are complementary to the T2K measurements since they only depend on the value of $\sin^2 2\theta_{13}$. Recently, the Daya Bay reactor experiment has announced a 5σ-significant measurement of $\sin^2 2\theta_{13} = 0.092 \pm 0.017$ which is more accurate but consistent with the earlier published Double Chooz result of $\sin^2 2\theta_{13} = 0.086 \pm 0.05$. In the next several years, Daya Bay might be able to reach a total uncertainty on $\sin^2 2\theta_{13}$ below 0.01 and provide a precise constraint on the size of this mixing angle.

Comparing and combining the T2K data with the reactor measurements (and with future NOVA measurements when available) will allow more precise probes of neutrino oscillation physics. To set the scale of the required precision for these comparisons, one can use the expected variation in the T2K appearance $\sin^2 2\theta_{13}$ of $\pm$ 0.02 due to allowing the CP violation phase to vary over its complete range. Initially, the T2K $\sin^2 2\theta_{13}$ measurement this summer is expected to be at the 0.03 ($\sim 3\sigma$) level and can be compared to the Daya Bay value to see if there is consistency between the appearance and disappearance results. In 2015, the T2K $\sin^2 2\theta_{13}$ uncertainty should be at the $\pm$ 0.01 level and will allow the T2K plus reactor combination to start to be sensitive to CP violation effects. For these combinations, the values of other mixing parameters such as $\sin^2 2\theta_{23}$ are also needed, for which T2K can make improved measurements using studies of the ν_μ disappearance

channel. In later years, combinations of T2K, NOVA, and reactor measurements could possibly have some sensitivity to the mass hierarchy as well as CP violation effects.

The T2K experiment has proposed to run this year through the end of June whereas the previous plan was to have SX running during June. This would allow T2K to collect an increased data sample before the summer conferences and likely reach the 3σ signal level. On the other hand, slow spill running in June will also lead to important physics results from, for example, the E27 experiment. For this reason, the PAC recommends that a compromise plan be developed where extended running be provided in June and be split between SX and FX running.

2. **E14:** Proposal for $K_L \rightarrow \pi^0\nu\nu$ Experiment at J-PARC (The KOTO Experiment)

The proponents have set their first physics benchmark for KOTO to reach the so-called Grossman-Nir limit BR($K_L \rightarrow \pi^0\nu\nu$) < ~$1.4\times10^{-9}$ by the summer shutdown in 2013 for the LINAC upgrade. Effects of new physics could begin to appear below this limit, and the PAC supports this goal in order to maintain the excellent momentum of the collaboration. The experiment intends eventually to probe new physics well beneath the Grossman-Nir limit and to reach a single event sensitivity corresponding to the standard model (3×10^{-11}). However, the allocation of beam time for this high sensitivity goal depends on future improvements of the slow extraction intensity and duty factor, which are both crucial for the eventual success of the E14 experiment.

An intense recovery campaign following the March 2011 earthquake has restored most of the CsI calorimeter functionality. The calorimeter performance has been largely validated with transverse cosmic rays and with beam running in February 2012 that provided a large sample of momentum analyzed Ke3 electrons, photons from $K_L \rightarrow 3\pi^0$ decays, π^0's from an in-beam calibration target, and $K_L \rightarrow \pi^+\pi^-$ decays used to fix the momentum scale. Although not all of the calorimeter channels were instrumented due to problems in the crystal/PMT optical coupling (noted in the 13th PAC meeting) the collaboration has demonstrated, with the February data set, that a robust analysis chain employing $K_L \rightarrow 3\pi^0$ events that can be collected *in-situ* with physics running will adequately calibrate the CsI calorimeter. The collaboration will continue to analyze the February data set to determine if more data is required to further develop and refine the calorimeter calibration technique, and may make a

case to the laboratory in April for more beam-running in June. The charged particle veto system (CV) immediately upstream of the CsI calorimeter will be ready for beam by June, and could be calibrated with beam data in June to demonstrate that the necessary veto efficiency exists.

In parallel with the calorimeter restoration campaign there continues steady progress with the other detector systems. The collaboration plans to remove the calibration spectrometer system in the summer and fall and install the remaining detector systems and be ready for beam commissioning with the full detector in November/December of 2012. The PAC endorses this plan and the goal of reaching the Grossman-Nir sensitivity bound prior to the 2013 shutdown. The PAC congratulates the KOTO collaboration for their intense and well executed efforts to recover the CsI calorimeter and to ready the experiment for fruitful physics running prior to the summer 2013 shutdown. The PAC reiterates the urgency to the laboratory of improving both the slow extracted beam power and duty factor which are critical to realize the full potential of the KOTO experiment.

3. Status of the Experiments at K1.8 and K1.8BR beamlines

The achievements at K1.8 and K1.8BR after the previous PAC meeting were reported to the PAC.

The second run of E19 (pentaquark search) with the beam momentum of 2.0 GeV/c was successfully completed in K1.8. With the improvements in the duty factor of the beam and the optimization of the MWPC setting, more than 50% higher beam intensity (1.7M/spill) was handled without deterioration of the tracking efficiency. The first paper of the E19 experiment, based on the year 2010 data, has just been submitted for publication.

For E27 (K^-pp bound state search by $d(\pi^+,K^+)X$ reaction), the range counter array was installed to the K1.8 area and showed sufficient particle-identification performance. Though an installation of a new beam fiber-tracker is planned in order to improve the high-rate handling capability, it was proven that the existing beamline chambers worked without any problem up to a 3M/spill beam rate.

The E27 collaboration is now ready for the first measurement of the inclusive $d(\pi^+,K^+)X$ spectrum in the 2.2-2.5 GeV/c^2 missing mass region in order to understand the background and to test the feasibility of the proton tagging technique.

In the K1.8BR beam line, the negative kaon beam (1.0GeV/c, 3.3kW) was tuned and achieved a yield consistent with expectation.

The trigger rate for higher beam power (10kW) was estimated by an extrapolation from 3.3kW and is controllable for the E15 experiment (K^-pp bound state search by $^3He(K^-,n)$ reaction). Commissioning of the CDS and liquid helium target was successfully done. The remaining equipment, such as neutron counters and a beam-sweeping magnet, will be installed soon and E15 will be ready for engineering runs before June.

The K1.8 and K1.8BR collaborations are requesting two weeks each of commissioning and pilot runs with 10kW beam power before summer 2012.

After the summer shutdown, E13 (hypernuclear gamma-ray spectroscopy) and E10 ($^6_{\Lambda}H$ study by $^6Li(\pi^-,K^+)$ reaction) are expecting 10kW beam for their initial running.

The PAC was pleased to hear that the beam time in February was successfully spent on completing the second run of the E19 experiment and that the beam tuning of the two other experiments was well advanced. As for the beam request, the PAC's recommendations are shown in the next section.

5. RECOMMENDATIONS FOR BEAM TIME ASSIGNMENT AND PLANNING SINCE JANUARY TILL JUNE 2012

The T2K experiment has requested to run this year through the end of June 2012 with fast extraction (FX) whereas the previous plan was to have slow extraction (SX) running during June. This would allow T2K to collect an increased data sample before the summer conferences and likely reach the 3σ significance level of uniquely establishing θ_{13} through an appearance effect. On the other hand, slow spill running in June could lead to important physics results from, for example, the E27 experiment. Further SX running in June could also benefit the KOTO experiment which is now analyzing calibration data from the February SX run. The KOTO collaboration will make a case to the laboratory in April if further running is motivated following a complete analysis of the data collected in February.

For these reasons the PAC recommends that a compromise plan be developed with the proponents where extended running be provided in June and be split between SX and FX running.

6. DISCUSSIONS ON THE MIDTERM PLAN

The Committee heard a presentation related on the accelerator and 3 talks related to physics plans with the high-p, COMET and K1.1BR beam lines. K. H. Tanaka summarized the hadron hall plan. N. Saito summarized the research plan at the Materials and Life Science Facility (MLF). As written in section 2, the plan for the SKS and other magnetic spectrometer experiments was not discussed in this meeting. R&D plans for the neutron-edm and for the neutrino detector development also were not discussed at this meeting.

- **Accerelator plan**

T. Koseki reported the accelerator upgrade plan.

For FX, the cycle time can be reduced to 2.4 seconds during the winter JFY2012. A full installation of the MR collimators is schedule in summer 2013, when the LINAC will also be upgraded to 400MeV. After these improvements operations with more than 300kW will be able to be achieved.

After this stage, the main limit is from space charge effects in the MR. There are two directions for alleviating these effects: increasing the beam energy and/or further reducing the cycle time.

The magnets of the MR start saturating above 30GeV operation and more electrical power is needed for operation. It is estimated that 50GeV operation requires 4 times more electrical power for the magnets. In addition, field uniformity is degraded after the saturation. The region where the magnetic field is within 0.1% different from the beam center will be reduced from ±65cm to ±45cm.

Therefore, the high repetition scenario with 30 GeV acceleration appears to be the favorable solution. With a 1.28 second cycle, 724kW is achievable with a beam loss in the MR of about 0.9kW. New power supplies for the magnets and RF cavities with higher shunt impedance will be required to cope with the high rate.

R&D has been started aiming to reduce the cycle time to less than 1 second. A small scale prototype of the power supply was manufactured and tested in 2011. A full scale prototype for one of the quadrupole families will be built and tested in the 2012 to 2013 period. A technical review is planned in early FY2012.

As presented several times in the PAC meetings, new magnetic alloy (FT3L) for the RF cavities has been developed. This material gives higher impedance than the currently used cores.

For the SX, continuous work is being done to increase the extraction efficiency. In the summer 2013 shutdown, another titanium chamber will be installed for the ESS and 50kW operation will be planed in 2014. R&D for manufacturing the ESS with low-Z materials has also started. The replacement of the magnet power supply will also solve the low duty-factor problem.

An R&D and installation time line was shown for the 2011-2017 period. Production of the power supplies and RF systems will start in FY2014 and FY2013, respectively, in order to have the design power available in 2017.

The PAC's opinions on the accelerator plan of this section are given in **Recommendation 1** listed below.

- **<u>High momentum beamline</u>**

K. Ozawa reported on the "Physics with the high-p beam line" based on two documents submitted for this PAC meeting. (The documents included: "Collected comments for the high momentum beamline" and an ancillary document on the construction of a high-resolution charmed particle spectrometer using the high-resolution, high-momentum beam line.) These documents cover a variety of physics interests and ideas once such a high-momentum beam line is constructed.

The E16 experiment, "Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD", will investigate the possible mass modification of ϕ meson in nuclear medium in high statistics and is a good example to be conducted in this beam line. After stage-1 approval for E16 was granted, the collaboration began extensive R&D work on the detectors for the experiment. A timely execution of the E16 experiment is important since the competing FAIR facility is now in construction and could start their CBM physics program around

2017. Also presented was an idea to construct a high-resolution, charmed-particle spectrometer that could provide a forefront charm baryon spectroscopy program at J-PARC.

The beam line is designed to deliver a fraction of the 30-GeV primary proton beam with an intensity of 10^{10}-10^{12} protons/spill, and also high-momentum (<15 GeV/c) secondary pion beams (unseparated) with an intensity of ~6×10^{6} pions/spill. There is an option to have an improved momentum resolution of ~0.1% for the secondary beams by adding several magnets in the beam line. RCNP has experience to construct high resolution beam line which could open new opportunity for spectroscopic study of hadrons. The construction period of the beam line is estimated to be 3 years. The detector construction needed for the experiments could be carried out simultaneous with the beam line construction.

With the timely completion of the high-momentum beamline construction, this new facility is expected to attract new users worldwide in the hadron physics communities to the J-PARC. The PAC recommends widely investigating new experimental ideas for the high-p beamline by holding international workshops with the goal to develop a strong physics case for the facility. Further recommendations on the high-p facility are given in **Recommendation 2** below.

- **COMET beamline**

S. Mihara reported the plan by the COMET collaboration described in the Letter of Intent submitted to the PAC for this meeting. ("Letter of Intent for Phase-I of the COMET Experiment at J-PARC")

The COMET experiment aims to improve the experimental sensitivity to detect muon-to-electron conversion by four orders of magnitude below the current experimental limit. Measurements at this sensitivity level would probe the range expected by many well-studied new physics models such as SUSY-GUT in a perspective different from LHC. As such COMET could become a flagship experiment for J-PARC and Japanese physics later in the decade. It was given a high priority in the report recently published by the JAHEP's subcommittee on the future high energy physics projects.

The COMET collaboration proposes a two-staged approach to realize their experiment, which is well aligned with the proposed construction plan by IPNS.

In the first stage of the experiment, COMET Phase-I, only the upstream part of the muon beam line up to the end of the first 90 degree bend will be constructed. The same detector technology as to be used for the final COMET Phase-II, the SC spectrometer solenoid with straw tube tracker and crystal calorimeter, will be used to verify the pion collection and measure the beam extinction and background. Continuous 8 GeV SX beam with power of 0.1kW or lower for a period of a few months may be enough for the measurement, although more precise estimation of the beam requirements may be done in the future.

The COMET collaboration also intends to search for mu-e conversion in the Phase-I experiment. A physics sensitivity of 7.2×10^{-15} (90% C.L.), which is two orders of magnitude better than the current best limit and comparable to the present MEG sensitivity in the photon-coupling limit and far beyond MEG in the contact-term limit, may be achieved with modest beam requirements (12 day physics beam time with 3.2kW 8 GeV proton beam).

The PAC strongly endorses this staging strategy, which enables real measurements of the extinction and backgrounds in the first stage to examine experimentally various technical issues and make realistic evaluation of their final physics sensitivity. The PAC considers COMET Phase-I as a key milestone toward realization of the final goal of the experiment. It may also attract more resources that will be available for the Phase-II experiment. The proposal of the Phase-I experiment needs to be submitted soon.

Further recommendations are given in **Recommendation 2** at the end of this section.

- **K1.1BR beamline**

P36: (Measurement of $\Gamma(K\rightarrow e\nu)/\ \Gamma(K\rightarrow\mu\nu)$ and Search for heavy sterile neutrinos using the TREK detector system)

The collaboration proposes to improve the measurement of the helicity suppressed ratio $R = \Gamma(K\rightarrow e\nu)/\ \Gamma(K\rightarrow\mu\nu)$, which is an excellent probe of physics beyond the Standard Model. Including radiative corrections the theoretical prediction is known within a relative uncertainty of 4×10^{-4} and gives a value of $R=2.477\pm0.001\times10^{-5}$. The most precise measurement to date is by the CERN experiment NA62, which has achieved a relative uncertainty of 4×10^{-3}, equally split between statistical and systematic components, with a measured value of $R_{exp}=$

$2.488 \pm 0.010 \times 10^{-5}$. A deviation of the experimental value from the standard model (SM) prediction would indicate the existence of new physics, e.g., a minimal super-symmetric extension of the SM that could cause lepton flavor violation and change R at the percent level.

The P36 collaboration proposes to improve on the NA62 measurement by almost a factor of two by collecting 250,000 $K \rightarrow e\nu$ (K_{e2}) decays at rest with an optimized evolution of the existing KEK-PS E246 detector. The P36 experiment is further motivated by systematic uncertainties, which are completely different between this stopped kaon experiment and the decay-in-flight NA62 experiment. The P36 experiment also could have interesting sensitivity of heavy sterile neutrinos, which further motivates the physics case.

The PAC's opinions for P36 are presented in **Recommendation 4** at the end of this section.

E06 (TREK): Measurement of T-violating Transverse Muon Polarization in $K^+ \rightarrow \pi^0 \mu^+ \nu$

The TREK initiative is based on an intriguing physics case. Final state interactions can induce a non-zero muon transverse polarization (P_T) at the 10^{-5} level and a genuine CP asymmetry can arise only on the 10^{-6} level, since it requires the interference between helicity conserving and violating amplitudes. On rather general grounds one can argue that P_T cannot exceed the 10^{-3} level no matter what dynamics generates this direct CP violation. New Physics models where CP symmetry is broken by the exchange of scalar fields could produce P_T in the range of 10^{-4} to 10^{-3}, in particular if the coupling to leptons were enhanced. TREK would thus be the first experiment exploring this range, where the unambiguous signature for such physics scenarios could surface.

The PAC's opinions are given in **Recommendation 5** at the end of this section.

- **Priority in the hadron hall**

K.H. Tanaka summarized the construction plan in the hadron hall. The demands for the high-p and COMET beam lines are similar. The high-p line would provide primary 30 GeV protons or secondary hadrons generated at the T0 target, which will be placed 120m upstream of the existing T1 target. The COMET experiment needs

to transfer 8 GeV 50kW primary proton beam with bunched slow extraction. The experiments in the high-p line will face important competition from the FAIR facility in Germany and the COMET experiment is competing with the Mu2E experiments at Fermilab. Beam line designs have been done such that the two lines commonly use the upstream components. The high-p line will be located in the south hall almost identical to the original design. The beam dump for COMET will be located outside (and the underground of) the current hadron hall by constructing an annex building where the beam dump and the COMET curved solenoid plus detectors will also be placed. The total cost is estimated to be about 40 Oku-yen (4 billion yen), including the pion capture solenoid and the first half of the curved solenoid of the COMET beam line.

The construction can be completed in 2015 if it starts in JFY2013. With this time scale, most of the construction work can be done in the summer shutdown periods so that the impact to the other beam lines will be minimal. The exception is the K1.1BR line, which will need to be shut down after March 2015. An extra 2 month shutdown for the hadron hall is foreseen in 2014 for construction work between the hadron hall and the upstream area. During this period, the MR could be operational with FX for the neutrino experiment.

As stated by the IPNS director (section 2), the proposal by the IPNS is for the simultaneous construction of the high-p line and the first half of the COMET beam line to be the first priority item for the next 5 year construction plan of the IPNS-related facility at J-PARC .

The PAC took note on the IPNS proposal and the recommendations are given in **Recommendation 2** at the end of this section.

- **Physics at MLF**

N. Saito reported on two of the projects planned for the H-line at the MLF, namely, the muon g-2/EDM experiment and the DeeMe experiment. In addition, he also reported on the status of the H-line preparation.

The muon g-2/EDM experiment aims to measure a_μ to 0.1ppm, which is 5 times better sensitivity than the previous best measurement by BNL E821, and the muon EDM to 1×10^{-22} e·cm, which is 2 orders of magnitude more sensitive than the

previous experiment. Currently, the measured value of the muon g-2 deviates from the expectation of the standard model by 3.4 sigma, and further explorations are in order. At the proposed sensitivity for muon g-2, it is possible to constrain many new physics models such as MSSM. On the other hand, the study of the muon EDM at the stated sensitivity also probes T-violating interactions at an important level. The experiment plans to utilize the H-line of the MLF where muons are generated as surface muons of protons on a target, turned into cold muonium atoms, which are then ionized by a high-power laser and then re-accelerated up to 300 MeV to enter a detector with a high-precision magnetic storage field. The PAC recognizes the importance of the physics goals pursued by the proponents that are also complementary to possible results from the LHC.

The goal of the DeeMe experiment is to study mu-e conversion with single-event sensitivity of 2×10^{-14} with 2×10^{7} sec of running. It is believed that this can be improved to $0.5\sim0.6\times10^{-14}$ if the running time is increased to 8×10^{7} sec. This is a two-orders-of-magnitude improvement over the past best experiment. The experiment would be installed after the first bend of the H beam line where the muon HFS experiment, which is overseen by the Institute of Materials and Structures Science (IMSS) at KEK and not by the IPNS, would precede this experiment. In DeeMe, muons stopped in the target decay to emit electrons which are captured, transported and momentum analyzed. Even though the stated sensitivity is only at a level comparable to phase I of the COMET experiment, the PAC appreciates the physics goals of DeeMe, which could be accomplished at a small fraction of the cost of COMET and with different systematic and technical uncertainties.

The three experiments of H-line (g-2/EDM, DeeMe, and HFS) form a good combination of programs that are closely-related where the experience gained in one can be applied to the others. The details of the beam line are currently being designed by a group of J-PARC MLF Muon Science (MUSE) facility together with IMSS and J-PARC. The muon g-2/EDM experiment has been given Stage-1 recommendation by PAC while that for the DeeMe experiment is deffered. On the other hand, all three experiments have been given Stage-1 approval by IMSS. The PAC re-iterates the importance of IPNS and IMSS working together to coordinate the efforts leading to the realization of this multi-experiment program, and is pleased to be informed that the proponents have started discussions with directors of both labs.

The summary of the PAC's recommendations is given in **Recommendation 3** at the end of this section.

- **Remarks from the PAC**

Recommendation 1: (Accelerator)

The PAC reiterates the importance of two main themes to maximize the productivity of the J-PARC research program:

1) The timely delivery of neutrino beam with the highest integrated intensity to the T2K experiment, with a goal for 2014 of greater than 300kW for protons on target.

2) Improving the intensity and instantaneous duty factor of slow extracted beam to the hadron hall experiments with a goal for 2014 of 50 kW for protons on target.

Realizing these goals is critical to the scientific success of the J-PARC research program. Looking toward the future, research and development now on new magnet power supplies and RF systems necessary to realize the full intensity potential of J-PARC is strongly encouraged, so that appropriate funds to build these systems can be secured in a timely manner.

Recommendation 2: (Hadron hall)

The PAC endorses the laboratory plan to pursue a joint project to build a new high momentum beam-line to the hadron hall and build the first stage (upstream elements) of the COMET beam-line as the highest priority project for the next 5 years.

1) The high momentum beam-line is a long standing request of the Japanese nuclear physics community, and the associated research program could substantially enhance the physics breadth of J-PARC and further establish J-PARC as a world class facility in the nuclear physics community. The PAC encourages the laboratory to explore the potential of the high momentum beam-line by hosting workshops with international participation to study and identify unique and important research opportunities enabled by the high momentum beam line.

2) The physics potential of the COMET experiment is simultaneously of great interest to the international particle physics community and an important large improvement from current state-of-the-art rare muon decay experiments. The COMET collaboration proposes a staged approach, where the first stage measures key performance parameters (e.g. beam-extinction, backgrounds) of the experiment and affords an opportunity to reach intermediate sensitivity for several rare processes of great interest to the particle physics community. This staged approach also limits risk to the laboratory by establishing a key milestone where the technical strategy and physics reach of the experiment can be assessed before the full scope of the experiment is committed.

International competition in nuclear physics and rare muon decay physics is high, and has motivated the proponents to push for a rapid construction schedule for this joint initiative. The laboratory should work to carefully balance the pressure to construct a new facility (and the inevitable downtimes associated with construction) with a continued stream of research results from the current and near term research program.

Recommendation 3: (Experiments at MLF)

The J-PARC PAC continues to recognize the great particle physics potential of developing the H-line of the MLF. The committee strongly encourages IPNS to continue supporting R&D on the g-2 and DeeMe experiments, and to work closely with the IMSS to explore mechanisms for the timely realization of the H-line.

Recommendation 4: (P36)

The P36 collaboration has persuasively argued that the only appropriate beam-line to mount this experiment is the K1.1BR line, which physically is in conflict with the future footprint of the COMET initiative and the high momentum beam-line initiative. The PAC recognizes the physics potential of P36 but cannot endorse a program that would substantially delay the timely execution of the COMET and high momentum beam-line initiatives. The current schedule does present an opportunity in 2014 to run the P36 experiment. The PAC requests that the P36 collaboration present a clear plan for how the experiment could be run during this restricted window. In order to achieve the goals of the experiment in the framework of this restricted time schedule, it is important that the collaboration can show in the coming PAC meeting in July how the necessary

funds and manpower can be secured. Further the PAC requests the laboratory to investigate whether the cryogenic infrastructure required by P36 can be forward funded from the COMET initiative and later be used by COMET following the timely completion of P36 running. The PAC continues to endorse the physics case and looks forward to hearing a scenario of how the 2014-2015 window can be exploited. In the absence of a credible scenario the PAC cannot endorse continuation of P36 at this time.

Recommendation 5: (E06)

Realizing the goals of the E06 component of the TREK research program requires slow-extracted (SX) beam at very high beam power, in excess of 100 kW, beyond what has been achieved from any previous proton synchrotron of comparable energy to J-PARC. Based on demonstrated progress to date and the projected SX beam power by the laboratory, the PAC does not believe the TREK initiative could receive adequate beam power delivered to the K1.1BR beam-line prior to the timely execution of the COMET and high momentum beam-line initiatives. Further there is no clear path foreseen for this high level of charged kaon flux in other locations in the J-PARC hadron hall. Based on these practical realities, the PAC regrettably cannot endorse mounting the experiment in the existing hadron hall.

7. DATES FOR THE NEXT J-PARC PAC MEETINGS

The date of the 15th meeting is set to 13-15 July in 2012. The meeting will be a joint meeting of the new/continuing PAC members along with past members leaving on March 31 who will be present as observers.

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

- Minutes of the J-PARC PAC meeting held on 13-15, January 2011 (KEK/J-PARC-PAC 2011-21)
- Collected comments for the high momentum beamline (KEK/J-PARC-PAC 2011-22)

- Comments to the Physics Interest on K1.1 beam line: List of Documments to be submitted
  (KEK/J-PARC-PAC 2011-23)

- An Expression of Interest for Phase-I of the COMET Experiment at J-PARC
  (KEK/J-PARC-PAC 2011-24)

- Experiments at K1.1BR in the Hadron Hall
  (KEK/J-PARC-PAC 2011-25)

- An ancillary document to 'collected comments for the high momentum beamline': Construction of a High-resolution Charmed Particle Spectrometer at the High-resolution, High-momentum Beam Line
  (KEK/J-PARC-PAC 2011-26)

- Letter of Intent for Phase-I of the COMET Experiment at J-PARC
  (KEK/J-PARC-PAC 2011-27)