KEK/J-PARC-PAC 2008-15
7 March 2009

J-PARC Program Advisory Committee

for the

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

Minutes of the 7th meeting held on
Friday and Saturday, 6-7 March 2009

CLOSED SESSION (6-March-2009):

1. Welcome: F. Takasaki (KEK)

OPEN SESSION (6-March-2009):

2. J-PARC Status: S. Nagamiya (J-PARC)

3. J-PARC Accelerator Status and Commissioning Plan: M. Yoshioka (KEK)

4. Beam Line Status: K. Tanaka (KEK)

5. Planning of the experiments in K1.8 Beam Line: T. Takahashi (KEK)

6. E11 Report : Beam Line and Neutrino Facility: T. Hasegawa (KEK)

7. E11 Report : Near Detector Status: M. Yokoyama(Kyoto)

8. E15/E17 Status Report: H. Outa (Riken)

9. E06 Report: M. Kohl (Hampton)

10. E14 Report: T. Nomura (KEK)

11. Report form Muon Task Force: S. Mihara (KEK)

12. P21 Report (An experimental Search for Lepton Flavour Violating mu-e conversion): A. Sato (Osaka)

OPEN SESSION (7-March-2009):

13. P26 Report (Direct measurements of omega mass modification in A(π^-,n)ω reaction and $\omega \rightarrow \pi^0 \gamma$ decays) : K. Ozawa (Tokyo)

CLOSED SESSION(6,7-March-2009):

Present: A.Ceccucci, H.En'yo, A.Gal, K.Hagiwara, J.Imazato (Secretary), T.Kobayashi (Secretary), S.Kumano, T.Mori, Y.Nagai, S.Nagamiya (J-PARC Center Director)*, S.N.Nakamura, T.Nakano, K.Nishikawa (IPNS), J.C.Peng, N.Saito (Secretary), M.Shaevitz, S.Shimoura, F. Takasaki (IPNS director)*, R.Tschirhart, K.Tokushuku (Chairperson), H.Yamamoto,M.Yoshioka(J-PARC)

*) Part of the time

1. PROCEDURE

The minutes of the sixth J-PARC-PAC meeting (KEK/J-PARC-PAC 2008-11) were approved without correction.

2. DISCUSSION ON THE J-PARC GENERAL STATUS

The J-PARC project leader S. Nagamiya presented the progress since the previous PAC meeting. M. Yoshioka reported the status of the main ring (MR) accelerator.

After the successful commissioning of the neutron and muon beam lines in the Materials and Life science facility, as reported in the previous PAC meeting, the commissioning of the main ring (MR) was resumed in December. The beam was successfully accelerated to 30 GeV on December 23rd and extracted to the fast abort beam line. On January 27th, the beam was extracted to the hadron facility. The commissioning of the neutrino beam line will start in April. The J-PARC construction schedule has stayed consistent with the milestones set up in FY2005.

The PAC is impressed that all important milestones for the initial beam commissioning were met on time and congratulates the J-PARC center for the successful start-up of the facilities.

The operational budget for the FY2009 is 6.5 billion yen for KEK and 5.96 billion yen for JAEA. This amount is about two-third of that required for full operation. In order to increase the operation budget in the future, a new finance scheme is under discussion with the government and JAEA and possibly also with KEK. A supplemental budget is expected for the K1.1BR beam line.

Although the initial commissioning was successful, there are still many issues to be solved for the routine operation of the J-PARC accelerators. M. Yoshioka summarized the problems found during the past six-month period.

- The ripple on the magnet power supply reported in the previous meeting was significantly reduced to the 10^{-4} level by adding extra filters and by rerouting the cables. The acceleration in the MR is now stable for the slow repetition mode but better (10^{-5} – 10^{-6}) stability is needed for stable slow extraction and for an ultimate repetition rate of 0.5Hz.

- During the commissioning frequent discharges were observed in the RFQ, which limited the beam current fed to the linac. Inspection of a prototype indicated that the surface treatment in the fabrication was not sufficient. A back-up RFQ is being designed and will be available in one and a half year. Until then, the current RFQ needs to be kept operational. Several actions are being taken to improve performance but safe operation may require a short RF pulse and hence a lower current.

- The initial commissioning is being performed with the low beam current, where the space charge effect is negligible. Recent detailed simulation studies for running with high current indicate the emittance growth and the current collimator may not be sufficient.

- For the high intensity running of the accelerator, beam losses in the accelerators need to be well controlled. At this initial stage where beam losses are not fully understood, a conservative guideline is being adopted where the losses in the slow extraction area are to be kept less than 25W. For the planned early 10kW operation, this requires that the extraction efficiency be more than 99%, which is at an unprecedented level. The situation will be eased after the better beam control is achieved and the losses can be localized at collimators.

M.Yoshioka showed a roadmap of how the J-PARC group expects to reach high power operation. For the neutrino beam, the 100kW run is achievable if the current RFQ can deliver the corresponding beam current. Slow extraction at this power level will require further development. In order to achieve MW-class operation, a strong team is needed to review and improve the current design.

Although there have been many problems encountered during the commissioning, the PAC was impressed by the quality of the team tackling the problems. The PAC noted that there are still many studies to be performed in order to achieve high power and stresses the importance to achieve design beam figures for the success of both fast and slow extraction physics programs. Future improvements to reach high intensity are crucial and the PAC strongly supports the plans to form working groups to address these issues.

3. STATUS OF THE HADRON FACILITY

K. Tanaka presented the status of the hadron facility. The construction of the slow extraction beamline complex including the T1 target and the beam dump was on time for accepting the first beam on January 27th. The beam diagnostic devices such as beam loss and profile monitors were in place and operational. The beam profiles were measured and found to be well reproduced by simulation. The K1.8BR lines were also ready and secondary proton and pion beams were successfully transported.

The upcoming construction plan for the beamlines was also summarized. By autumn 2009, the K1.8 line will be ready for the experiments using the SKS spectrometer. The KL line will also be ready for the beam survey planned by the KOTO experiment. With help from the supplementary funding mentioned by S. Nagamiya, the completion of the other beamlines will be accelerated. The test beam line discussed in the previous PAC meeting will be ready in FY2009. The major part of K1.1BR line will also be constructed in FY2009.

A study to increase the intensity of the secondary beam has been started. By replacing the T1 target disc made from nickel to a thicker rod made from platinum, the intensity is estimated to be increased by a factor of 2.7. This will help many of the experiments in the initial period when the power of the MR might be low due to the RFQ and other problems.

The PAC congratulates the hadron beamline group for the successful operation with the first beam. The PAC is also pleased to hear the major construction of the K1.1BR and test lines is scheduled in FY2009. The PAC supports the investigations to increase the secondary beam yield by changing the T1 target for the initial run period.

4. PLANNING OF THE EXPERIMENTS IN K1.8 BEAM LINE

T. Takahashi presented the status of the preparation for the experiments with the SKS spectrometer in the K1.8 beam line. The transportation of the SKS magnet with the modified cooling system was finished. After the excitation test of the SKS, the detector installation will be started this summer. Although there are some minor problems to be fixed, the detector system will be ready for the autumn run. The PAC commends the solid progress of the preparation of the beam line and the SKS.

Takahashi also presented a possible run plan for the first beam in 2009. Because the beam intensity is expected to be too low to run experiments which require a kaon beam, it is proposed to carry out the E19 (Pentaquark search) and E10 (Production of neutron-rich hyper nuclei) experiments after the commissioning of the SKS and beam line using the $^{12}C(\pi^+,K^+)^{12}_{\Lambda}C$ reaction. This reaction could provide a confirmation of the expected performance of the detector system, but other processes might be better if detailed calibration of the field map turns out to be necessary. All planned experiments require a pion beam with a beam intensity of ~10kW. The PAC endorses the proposed beam plan. However, the PAC raised a question about what should be the decision making procedure of the run plan of this program. The director will discuss this issue and present an initial run plan at the next PAC meeting.

5. PROPOSAL EVALUATION

1. **P26:** (Direct measurements of omega mass modification in $A(\pi^-,n)\omega$ reaction and $\omega \rightarrow \pi^0 \gamma$ decays)

   The primary goal of the proposed experiment is to measure the mass modification of the ω meson in the nuclear medium via the detection of the $\omega \rightarrow \pi^o\gamma$ decay mode. This decay mode has the advantage of a relatively large branching ratio (8.9%, compared to 0.007% for the $\omega \rightarrow e^+e^-$ decay mode). Furthermore, the background from ρ meson decay is greatly suppressed due to a small $\rho \rightarrow \pi^o\gamma$ branching ratio of 0.06%. Indeed, the CBELSA/TAPS collaboration reported an observation of a 14% decrease of ω mass via a measurement of this decay mode for low-momentum ω mesons produced in the (γ,ω) reaction on the Nb target.

The P26 proponents propose a new experimental approach using the $A(\pi^-,n\ \omega)X$ reaction. By detecting neutrons produced at forward direction in coincidence with the $\omega\rightarrow\pi^o\gamma$ decay, the low momentum ω mesons produced in the recoilless $p(\pi^-,n)\omega$ quasi-free reaction can be tagged, providing additional information on the initial condition of ω production. The experiment requires a 1.8 GeV π^- beam of 10^7/spill at the K1.8 beam line together with the CsI crystals from E06 for $\pi^o\gamma$ detection, and a neutron detector composed of segmented layers of lead plates and scintillation counters.

The proposed experiment addresses the important issue of mass modification of hadrons if spontaneous breaking of chiral symmetry is partially restored in nuclear matter. The CBELSA/TAPS result has provided one of the more convincing pieces of experimental evidence for an ω mass modification. It is very important to confirm or refute the CBELSA/TAPS result using an independent technique as proposed in P26. Furthermore, P26 complements the E16 and KEK E325 experiments which study the $\omega\rightarrow e^+e^-$ decay mode with proton beams.

With respect to the P26 proposal, the following issues have been raised by the PAC:

1) The rate estimate (Table 5 in the proposal) assumes a branching ratio of 8.9% for $\omega\rightarrow\pi^o\gamma$ decay in nuclear matter. However, the width of ω meson in nuclear matter was found in a recent paper by CBELSA/TAPS collaboration (PRL100, 192302(2008)) to be 130-150 MeV, a factor of ~20 larger than in free space. This implies that the branching ratio for $\omega\rightarrow\pi^o\gamma$ in nuclear matter could be reduced by a factor of ~20, lowering the expected count rate significantly.

2) The role of background $\pi^o\gamma$ events stemming from ωN nuclear reactions has to be considered. For example, $\omega N\rightarrow\pi^\circ\pi^\circ N$ reaction can produce $\pi^o\gamma$ background if one of the γ's from π° decay is missed.

3) The proposed measurement is for a carbon target only. To clearly demonstrate the modifications of ω mass in nuclei, it is important to do the measurement in several targets, possibly including hydrogen.

4) The effect of the final-state interactions for the outgoing π^o is important. The simulation presented in the proposal is from a different reaction (γ,ω) on a different nucleus. It is important to carry out realistic calculations for the proposed measurement, since the final-state interactions might alter the mass spectrum in the crucial mass region.

5) One of the proposed physics goals is to search for an ω bound state by searching for peaks in the neutron spectrum using the missing mass technique. However, the proposed trigger requires a coincidence between the neutron detector and two clusters in the CsI counter. This trigger would greatly reduce the signal for ω bound state, since it is unlikely for a bound ω to decay into $\pi^o\gamma$.

6) A transport calculation such as the BUU (Boltzmann-Uehling-Uhlenbeck) by the Giessen group would be very useful for evaluating the expected mass spectra, taking into account the various nuclear medium effects and final state interactions.

7) It would be useful to consider the feasibility of using the K1.8BR beam line, where the flight path would be longer than the K1.8 line and where there is no space constraint from the SKS spectrometer. Further, the optimal beam momentum might be lower than 1.8 GeV/c, which might give a better resolution for the neutron detection.

8) The performance of the CsI detectors, which contains 12 acceptance holes, for detecting the $\pi^o\gamma$ events should be studied in more detail. In particular, the energy leakage due to the presence of the holes might introduce distortion in the reconstructed invariant mass of the $\pi^o\gamma$ events.

The PAC recognizes the importance of the physics goals of the proposed P26 measurements. However, many important issues remain to be addressed by the experimenters. The PAC recommends that this proposal be deferred, and encourages the proponents to submit a revised proposal in which the issues raised by the PAC are fully addressed.

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

There has been very good progress for the T2K program over the past four months. Most of the beamline components and monitoring hardware have been installed and are being tested. The goal is to have a first commissioning run of the beam in April 2009, which will allow a fairly thorough testing of the complete beam system. In response to the October PAC request, T2K has developed an extensive list of goals for this run. The goals include testing the beam quality and parameters at extraction and targeting, a checkout of the horn 1 focusing with the muon monitors,

examining the performance of an INGRID module signals and data acquisition, and completing the government inspection of radiation safety for the neutrino beam in May 2009. Due to some mechanical interferences in the target station, horn 2 and 3 will not be installed until the summer with full commissioning starting after the summer shutdown. In order to limit the irradiation of the target region, the April commissioning will be done with low intensity of $1.0 – 4.0 \times 10^{11}$protons per pulse. A full commissioning of the beam with all three horns, the full INGRID detector, and most of the ND280 detector will take place in fall 2009 leading to a data run starting near the end of the year. During the fall, commissioning work will be done to improve the beam power with multibunch operation and control of losses, to increases the protons per pulse, and to do fine tuning of the beam.

The data run which will start at the end of 2009 is a critical milestone for the T2K program. The goal is to collect data for 10^7 seconds with 100 kW beam by the summer of 2010. During this running period, about 150 muon neutrino events will be observed in the SuperK detector, thus, providing a first accelerator beam data set for commissioning the new electronics and analysis. The data set can also be used to search for electron neutrino appearance and probe for the θ_{13} mixing angle. Since the expected background is small (about 0.5 events), the statistics dominated sensitivity is at the level of $\sin^2 2\theta_{13} > 0.06$, which is competitive with the expectations for the Double Chooz reactor neutrino experiment on the same time scale. To accomplish this data run, stable, high-intensity, fast-extracted beam needs to be established. This will require amelioration of several of the current problems associated with the accelerator complex including the RFQ injector. The PAC encourages the Lab and collaboration in its efforts to accomplish this milestone for the T2K program.

At Super-K, the detector has been fully operational with the new electronics and data acquisition since September 2008. Running has been proceeding and a detailed electronics check with calibration data has been completed indicating performance as expected.

The ND280 detector construction and installation is going well with no major delays with respect to the schedule shown at the last PAC meeting. The PAC appreciated the presentation of a high level milestone schedule showing how the various components and installation are planned for the ND280 detector. The detector building was completed in January 2009 and the near detector assembly building will be available in April 2009. All detector systems except part of the

ECAL are to be delivered to J-PARC by the summer with installation and testing being done over the fall. This installation schedule appears to be very tight and the PAC looks forward to hearing about the progress at the next meeting.

With respect to the problem of the ordered power supplies for the UA1 magnet not being able to reach the 0.2 T magnetic field level, the T2K collaboration has developed a plan where the experiment will do the field map at 0.15 T and do the initial data run with a field somewhere between 0.15 T to 0.18 T. Hysteresis effects are small, so the field map can be extrapolated from the lower 0.15 T up to 0.2 T without much uncertainty. The degradation of the TPC performance due to the lower field will be evaluated from this initial data and a decision will be made as to whether to upgrade the power supply to the full field. The PAC concurs with this plan.

3. **E15/E17:** Search for K^-pp deeply-bound kaonic nuclear state/Precision spectroscopy of K^- ^3He 3d-2p x-rays

The PAC heard that there has been significant progress on the E15 and E17 detector preparation. The cylindrical drift chamber is now being commissioned in the K1.8BR beamline and the solenoid magnet with hodoscopes will be installed soon.

The liquid helium-3 cryogenic system for E17 is now ready and a beryllium target cell will be used instead of MICTRON cell which showed unexpected poor x-ray transmittance. The commissioning of the SDD is in progress at Vienna. The collaboration requests to use a thick platinum target during the E17 production runs in order to compensate for the limited proton intensity.

For E15, several recent theoretical calculations predict a large width, 50-100MeV, for the K^-pp bound state. The unique interpretation of the proposed Λp invariant-mass spectrum may, therefore, be difficult. The collaboration is encouraged to look for other possible final states, $\Sigma^0 p$ and $\Sigma^+ n$, in order to extract as much information on the anticipated K^-pp bound state as possible.

The PAC is pleased to hear that the K1.8BR beamline had its first beam. The successful commissioning of K1.8BR line is essential for these experiments. Close communication with the beam channel and accelerator groups is crucial to improve the beam quality such as a micro-structure in a beam spill. The PAC encourages the E15/17 collaboration to continue detailed discussions with these groups as well as

doing work to provide the necessary detector signals as feedback on the beam quality to the accelerator group.

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

The PAC heard a report on TREK (E06). A lively international collaboration is in place. The collaboration represents a good example of internationalization of the J-PARC physics program. Progress was reported on the tests of the 1/5 polarimeter chambers which showed good performance for the position resolution based on the charge division method. Good results were also reported concerning the radiation hardness of silicon photomultipliers exposed to pion beams. According to beam tests performed in TRIUMF with pion beams, the devices can stand doses equivalent to more than ten TREK years without significant performance loss. This is a good improvement over previous results reported from proton exposure. The PAC was informed that the K1.1BR beam line, where the experiment is supposed to be installed, was funded by a supplementary budget contribution.

Most of the funding for the detector construction has been requested to the Japanese funding agencies, and the PAC looks forward to hearing the status at the next meetings.

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

The PAC received a Technical Design Report on the construction of the KL beam line and heard an oral presentation concerning the preparations for the beam survey and the overall progress on the R&D.

A new design of the collimator has reduced the simulated halo neutron to K_L ratio by more than factor of 3. Good progress on the procurement of the collimator material was reported. The option to employ wire chambers instead of hodoscopes for the beam survey is being considered as a backup solution, and additional hodoscopes with better timing have been proposed to cope with accidental hits.

Accidental pile-up induced by poor spill structure should be manageable for the small intensities foreseen for the beam survey. The PAC was reminded about the aims of the beam survey: beam tuning, study of the core and halo neutrons and

measurement of the K_L flux. The latter is important because a large spread of predictions is available. The halo neutrons depend critically on the position of the proton beam on target.

To mitigate the effects of the reduced extracted beam power at the start-up, the collaboration should investigate the implications of carrying out the beam survey employing both a Pt rod target and a nominal Ni disk as target. This might allow one to increase the effective flux of kaons per primary proton significantly. It is noted that the upstream magnets of the K1.1 beam line will not be present at the time of the beam survey which is scheduled in 2009. According to simulations this should lead to a 60% increase of the halo neutron flux while only marginally affecting the K_L flux.

Even though substantial work has been performed related to the beam survey preparation, the PAC encourages the collaboration to further develop the strategy for this beam survey. In addition to the beam work, good progress was reported also towards the realization of the main E14 detectors.

6. **Muon Task Force Report and P21:** An experimental Search for Lepton Flavour Violating mu-e conversion (The COMET experiment)

Muon Task Force:

The Muon Task Force (MTF) presented an interim progress report on the following topics:

1) Proton beam acceleration: Investigation of the method described in the proposal and other possibilities to produce the required proton beam structure.

2) Beam extinction: Conceptual designs that can achieve the 10^{-9} extinction required to reach 10^{-16} mu-e conversion sensitivity, and techniques to measure and monitor the extinction.

3) Proton beam extraction/transport: Proton beam transport and conditioning to the target, radiation shielding around the target and the beam dump.

4) Experimental space, possible location(s): In the current experimental hall or extensions of the current hall.

The PAC is pleased with progress on (1) and (2), and the plans to begin beam extinction studies with the K1.8BR beam-line and a primary beam abort monitor in

the near future. The PAC is also impressed with the collaborative work on the AC-dipole extinction system (3) and the conceptual location studies for the experiment. All of these studies will be important to establish the feasibility, cost and schedule.

The MTF appears to be working well with the COMET collaboration. The PAC encourages other members of the COMET collaboration formally join the MTF to further facilitate progress on developing a Conceptual Design Report for the COMET.

COMET:

The PAC is pleased with the R&D progress on solenoids, extinction dipole R&D, calorimeter R&D, and growth in the collaboration.

The PAC supports the collaboration's plan to complete the CDR prior to the next PAC meeting in July so that consideration for Stage-1 scientific approval can begin at the July meeting. Stage-1 approval validates that a compelling physics case exists, and that construction and successful execution of the proposed experiment are plausible with reasonably projected resources at J-PARC.

The proponents should explicitly address the following questions and concerns in the CDR:

1) The COMET proponents should present the experiment's sensitivity as a function of time with a total exposure of 8×10^{20} protons on target.

2) The CDR should serve as basis for a plausible cost range and operations schedule. The COMET proponents and the MTF should present a breakdown of the elements of the cost range as well as drivers and milestones for a plausible schedule. The cost and schedule estimate should include the accelerator modifications, required beamlines, detector elements and civil construction.

3) The COMET proponents should present a plausible plan for how collaboration resources, cooperative agreements with the Fermilab mu2e collaboration, KEK resources, J-PARC resources and industry can provide the resources required to meet the schedule and performance goals of the experiment.

4) What are the relative strengths/weaknesses of the proposed COMET and mu2e experiments? What are the strategic advantages and risks of both experiments going forward and making measurements?

The accelerator and beam requirements for COMET running are non-standard, and require dedicated operation of the J-PARC accelerator complex for COMET. The collaboration needs to work with the MTF to assess the feasibility and impact of running the J-PARC accelerator complex for the COMET experiment. In conjunction with the COMET CDR, the PAC requests that the laboratory prepare and present a draft 10-year scenario that could plausibly include running of COMET, T2K, and the slow-extracted beam program.

6. DATES FOR THE NEXT J-PARC PAC MEETINGS

The date for the 8th PAC meeting is 17-19 July 2009. The tentative agenda is;

- Status report on J-PARC
- Report on the beam time assignment in the autumn-winter runs
- Report from the muon task force
- CDR presentation from COMET group
- Status report from the KOTO experiment
- Report from the T2K experiment

The date of the 9th PAC meeting is tentatively set to 15-17 January 2010.

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

- Minutes of the J-PARC PAC meeting held on 16-17, October 2008 (KEK/J-PARC-PAC 2008-11)
- Proposal: Direct measurements of ω mass modification in $A(\pi^-,n)\omega$ reaction and $\omega \rightarrow \pi^0\gamma$ decays(KEK/J-PARC-PAC 2008-12)
- Technical Design Report of KL Beamline at the J-PARC Hadron Hall (KEK/J-PARC-PAC 2008-13)
- COMET Task Force Report I (KEK/J-PARC-PAC 2008-14)