Facility Impact and Funding Committee (FIFC) Report

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J. Haba, M. Ieiri, J. Imazato, R. Itoh, T. Kamitani, M. Kikuchi, H. Kobayashi, T Miura, K. Nishikawa, M. Nozaki, K. Sato, M. Takasaki, M. Tanaka, T. Tauchi and Y. Unno

1. INTRODUCTION

To evaluate validity and feasibility of the experiments planned in the Hadron Experimental Hall of J-PARC, the Facility Impact and Funding Committee (FIFC) of the Institute of Particle and Nuclear Physics (IPNS) was set up in the fall 2006.

Following the charges imposed by the IPNS director to the committee, the review is being made in the viewpoints as follows:

1) Technical validity and feasibility of the experiment and the detector.
2) Validity and feasibility of the requested beam.
3) Safety.
4) Validity of the cost estimate and the budget plan.
5) Validity of the human resource and the group organization.
6) Support requested to IPNS.

Those discussed and evaluated in the two meetings held in May and June 2007 were the four experiments approved for stage-1 (E03, E06, E10 and E14) in the last PAC meeting. The beam lines K1.1BR and K0 were also reviewed as major components of the E06 and E14, respectively. In summary the followings subjects were investigated here.

- E03: "Measurement of X rays from Ξ atom"
- E06 : "Measurement of T-violating Transverse Muon Polarization in $K^+ \rightarrow \pi^0 \mu^+ \nu$ Decays" and its beam line K1.1 BR.
- E10: "Study on Λ-hypernuclei with the Charge-Exchange Reactions"
- E14: "Proposal for $K_L \rightarrow \pi^0 \nu\nu$ Experiment at J-PARC" and its beam line K0.

E03: "Measurement of X rays from Ξ atom"

The E03 experiment is to observe X ray from the Ξ-atom for the first time. It gives the direct information on the Ξ-A optical potential. The experimental setup is shown in Fig. 1. It is planned to be built in the K1.8 beamline with the Kurama spectrometer previously used for the E373 and E522 experiments at KEK-PS. The configuration is mostly common with E07, and the Ge detector array called Hyperball-J, which is developed for the E13 experiment, is placed surrounding the target to detect X-rays.

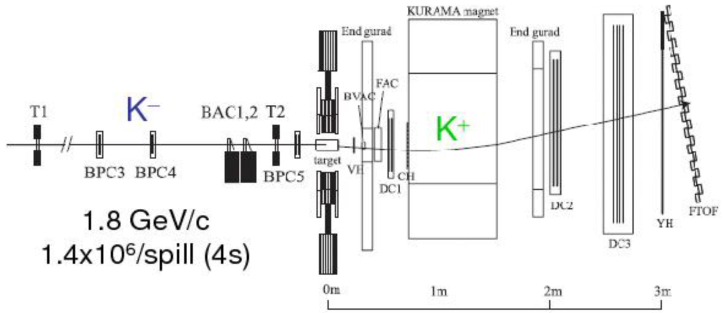


Fig.1 The detector setup for E03

The committee do not see particular problems in the detector system, however, following comments are raised.

1) In the proposed apparatus, the Ge detector arrays are placed in a wall shape around the target which may loose the effective solid angle when compared with the ball configuration. The reason to use the wall configuration is explained that the guard plates of the Kurama magnet conflict with the placement of the refrigerator of the Ge detector. One possible solution to use the ball type configuration is to replace Kurama with SKS, however, the yield of usable kaons become half when compared with original proposal in this case. The committee recommends to estimate the overall efficiency for these two cases quantitatively and to take the better choice.
2) It is reported that the estimated DAQ dead time is 25% in the typical condition and can become up to 50%. The dead time is explained to come from the slow signal response of the Ge detector. However, it is equivalent to loose such a

large amount data of more than 25%, and the experiment group should pay more attention to the reduction of the dead time. The committee suggest to think about the possibility to use the wave form sampling readout which may help to reduce the dead time.

3) Because of the slow signal response of the Ge detector, the peak shift and width broadening depending on the hit rate are crucial problems to obtain the required energy calibration of less than 0.05 keV. The experiment group proposes two different methods for the calibration, one is to have special runs dedicated for the calibration using the strong source, and the other is to use the scintillator embedded source which enables the simultaneous data taking with the real data. The group put the emphasis on the first method, however, it requires dedicated runs frequently in order to keep track the change of the hit rate which may occupy more than 10\% of the beam time. The committee suggest to explore the second method as possible which can truly monitor the rate dependence in the real data without disturbing the data taking.
4) The current estimation of continuous X-ray background is based on the measurements at E419 of the (π^+,K^+) reaction, and it may not describe the real background rate in (K^-,K^+) reaction correctly. It is also pointed out that there may be a dependence on the background shape in the X-ray peak shift and the width. The experiment group is asked to study these issues more in detail by utilizing the existing data.
5) The experiment is assumed to be performed after the E07 experiment. However, the case should be considered that this experiment is scheduled prior to E07.

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

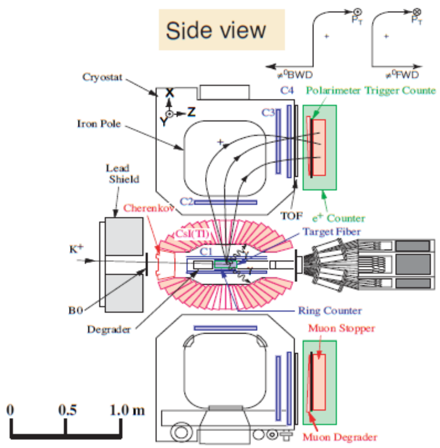
Detector

E06 experiment is to measure the transverse polarization (*Pt*) of the stopping muons from the stopped K^+ decaying into neutral pion, positively charged muon, and muon neutrino. The spurious effects from final state interaction are small, thus non-zero *Pt* is a signature of time-reversal (*T*) violation. Contributions from the Standard Model is < 10^{-7}. E06 utilizes the infrastructure of the predecessor E246 and tries to improve the transverse polarization measurement from 10^{-3} of E246 to 10^{-4} level.

The E246 experiment at KEK-PS utilized super-conducting Toroidal magnets for analyzing momenta of the charged muons and CsI(TI) crystals for measuring photons to reconstruct neutral pions. The polarization of stopping muons was measured with the polarimeter trigger counters in a magnetic field (Muon field). E246 took data in 1999 to 2000 and published the final result [1]. The parameter measured (A_T) was the difference of the asymmetries of the clock-wise (*cw*) and the counter-clock-wise (*ccw*) events of the polarization where the neutral pions decayed into the forward (*fwd*) and the backward (*bwd*) directions. Thus, many systematic errors were cancelled in the *fwd*/*bwd* subtraction. *Pt* was proportional to A_T. The published result is

Pt = - 0.0017 +/- 0.0023 (statistical errors) +/- 0.0011 (systematic errors) (1)

The statistical error will be improved from E246 to E06 by increasing the K^+ beam intensity by 30, the detector acceptance by 10, and the analyzing power by 50%, thus increasing the statistics by about 400 times and reducing the error by about 1/20 of E246.



In order to reduce the systematic errors in E06, the systematic errors of E246 was carefully analyzed and the upgrade plan was laid out. In the E246, the major contributions that were not cancelled out by the *fwd*/*bwd* scheme (and the $\sum^{12}$ scheme) were (a) charge muon multiple scattering, (b) Muon field alignment (*B* rotation (δz)), and

(c) decay plane asymmetry (θz).

The target will be made of the 2.5 mm diameter fibers (E06) from the 5.0 mm (E246), with readout of MPPC (Silicon photomultiplier device), in order to improve the rate performance and achieve a better background rejection, and suppress the systematic errors. In the tracking, a new position measurement device (C0 (Cylindrical GEM) (and C1 (Planer GEM))) will be introduced, in order to improve the rate performance and achieve a better background rejection (C0 near the target). The tracking volume will be filled with He gas in order to reduce the multiple scattering of the muons. The polarimeter will be from passive (E246) to active (E06), in order to improve the acceptance and the analyzing power and to suppress the background and the systematic errors. The Muon field will be provided by dedicated magnets, in order to improve the analyzing power and suppress the systematic errors. The CsI(TI) readout will be replaced from PIN photo diodes to APD (avalanche photo diode) device, in order to improve the rate performance and achieve a better background rejection.

The active muon stopper, a sandwich of plates (Al alloy) and wire-chambers, will identify the stopping points and decay verteces of the muons and measure the positron energy (E_e+) and its angle (θ_e+), thus providing large positron acceptance of nearly 4π. Dedicated magnets will provide a uniform magnetic field of 0.03T to the muon stopper.

Evaluation of the alignment and the systematic errors are carried out rigorously. The alignment of CsI(TI) calorimeter will be controlled by using two-body-decay kinematics of K^+ decaying into π^+ and π^0 where π^0 decays into two photons. The alignment of polarimeter will be controlled by using Kμ3 decays, and then to be confirmed with Kπ2 decay in flight and Kμ2 events. With the precession patterns, the polarimeter chamber rotations (ε_r, ε_z) and the Muon field rotations (δr, δz) will be calibrated. With the time-integrated asymmetry, the μ-spin angle (θ_0) will be calibrated and Pt is shown decoupled from the misalignments. A simulation with Pt=0 and $\delta z=\delta r=5°$ (=85 mrad) gives the determination of $\delta Pt=2+/-7 \times 10^{-4}$ for 10^8 events. In reality, the $\delta z\sim\delta r\sim$ 1 mrad from precision survey, the transverse polarization error should be $<10^{-4}$.

The systematic error due to charged muons decay-in-flight (dif) from charged pions from Kπ2 is $< 10^{-4}$. First of all, the Kπ2-dif background will be 1/10 of E246 by addition of C0 chamber. By integrating muons in the Toroidal gap, the error will be cancelled by 1/10. The error will be cancelled further by 1/100 by subtracting *fwd/bwd* π^0 events.

The systematic error due to the decay plane rotation angle (θr) is canceling with *fwd/bwd* scheme. The error due to the angle (θz) is not canceling and correlated to the π^0 direction determined by the decayed two photons. The final Pt will be corrected for this effect, and the error associated with this correction is only statistical and estimated to be $<10^{-4}$ with an improved statistical error by 20. The systematic errors could be further reduced by symmetrizing the distributions of stopping K^+ and stopping μ^+.

In summary, the experiment is well thought out and analyzed. By upgrading the target with MPPC, the polarimter to be active, and adding C0 chamber with a GEM (Cylindrical) technology, and using APD readout for CsI(TI), the detector will cope with the rate to increase the statistics by about 400 and to achieve the systematic errors to be $\sim 10^{-4}$. There are two new types of detectors: MPPC, GEM (specially of cylindrical shape for C0). If the radiation damage in MPPC turns out non-usable for the experiment, the experiment has an option to use a conventional PMT in a remote location. For the GEM chambers, C0 and C1, if the radiation length of C1 is problematic for the multiple scattering in muons, the experiment will eliminate the chamber with little performance crippling. The C0 chamber is critical for the experiment and its progress should be monitored regularly. If a delay is observed, the experiment should take an action to find a backup option in early stage.

References

[1] M. Abe et al., Phys. Rev. D73, 072005 (2006)

BEAMLINE K0.8 (K1.1BR)

The committee evaluated the designs of the K0.8 beamline for experiments using K^+ beam of 0.8-GeV/*c* momentum with the front end which includes a production target and an initial beam collimator, one stage of electrostatic *K*/π separation and a final focusing section. The primal purpose of the beamline is to supply high-intensity separated K^+ beams with low pion contamination. The structure of the beamline, the beam optics and beam qualities were checked. In particular an external reviewer Dr. P. Pile performed an independent beam simulation calculation and confirmed the validity of beam optics concept and expected performance of the beams basically. His report is attached in the appendix 2.

K0.8 beamline

(1) Front end part

The low momentum beamlines (K0.8 and K1.1) share the same production target with the K1.8 line. The K1.1 beam is extracted in the opposite direction to the K1.8 beam at 6° angle from a straight line to the beam dump. Interference of the magnets for the K1.8

beam and those for K0.8 beam, gives constraints to the position of the first bending magnet of the K0.8 line. It is the main reason of the smaller angle acceptance of this K0.8 beamline, which is only 8% of the similar beamline at the BNL. It was estimated in the external reviewer's report. There is no easy way to overcome this constraint except for an independent target system for the low momentum beam in a future stage. Therefore, the experiment group should be aware that the K0.8 beam intensity will be comparable to BNL when the primary proton intensity of J-parc exceeds more than ten times that of BNL. Hardware issues in the front end parts are assumed to be similar to that for the K1.8 line, thus they are not reviewed here. There is one important notice on the consideration of the construction schedule. In the present plan, the beamlines (K1.8 and K1.8BR) are constructed at first and start their operations and in a year later, the K0.8 lines will be constructed. The production target and its vicinity will be highly activated in one year operation and installation of magnets for K0.8 lines (especially first four magnets) will be practically impossible. It is strongly recommended for these magnets to be installed at the same time of K1.8 beamline construction and the cost for this should be included in the total cost estimation for the experiment.

(2) Beam optics design and K/π separation

While the K1.1 beamline has two stages of electro-separators for K/pi separation, its branch line K0.8 is equipped with only the first stage of the equivalent system to make total beamline length shorter and minimize kaon loss by decays. Details of the electro-separator is not reviewed here and assumed to be similar to that of the K1.8 line. Under the constraint that the magnet layout up to the branching point should be shared between the K1.1 and K0.8 lines, the beam optical design is optimized. The basic optical design was performed with the TRANSPORT code. The beamline has two vertical focal points before and after the electrostatic separator and a horizontal focal point just after the final bending magnet. The horizontal focus is achieved by the wedge bending magnet. The slits at these three points eliminate pions. Two sextupoles and one octupole are used to correct higher order abberation. The optimization of the higher order correction and the K/pi separation was performed with the particle tracking simulation code ZGOUBI including up to fifth order calculation. The effect of particle scattering in the slit with finite length is estimated with the REVMOC including up to second order calculation, since the ZGOUBI simulation treated the slits lengths as zero. Major sources of pion contaminations by (1) the higher order aberrations, (2) the pions scattered at the slits and (3) the cloud pions (Ks decay products) are individually estimated by these simulations. Muon contamination is also estimated.

In conclusion, the higher order abberation correction by the sextupoles and the octupole and the beam collimation at the two vertical focal points and at the horizontal focus are totally effective to eliminate pion and muon contamination and the performance of K0.8 is comparable to that of K1.1 with two stages of the electro-separators. The expected beam intensitiy is 2.1×10^6 K^+/pulse and both of the K/π ratio and the K/μ ratio exceeds unity.

The committee agrees with the presented performance as a whole, although it still have a room for improving K/π ratio by further elaboration of the beam collimation as pointed out by the external reviewer. Cross check of the estimation of the ratio of initial kaon and pion intensities presently based on the BNL experience, will be useful to obtain more precise K/π ratio estimation.

Conclusion

Based on the presented beamline optics design and kaon purity performance study by simulations, the committee found no problem in the prospect that the K0.8 beamline will be operational with sufficient performance for the experiments, in general. It is remarkable that the K/π and K/μ ratio greater than unity is presented in the simulation study of the designer. The beam optical design and the performance study are also supported by the independent check by Dr. Pile.

E10: "Study on Λ-hypernuclei with the Charge-Exchange Reactions"

This experiment (E10) is descendant of E521 at KEK-PS. These two experimental groups are essentially same with new members in E10. The E521 has been positioned as the pilot experiment for high statistics experiments at JPARC in order to study neutron-rich hypernuclei close to neutron-drip line. Both experiments have the same beam energy and the same SKS spectrometer. The group has verified the experimental technique at E521 in principle, while E521 results show that "no significant discrete peaks were observed, which may be due to the limited statistics, the experimental resolution and a possible complicated nuclear structure (P.K.Saha, et al., KEK-PS-E521Collaboration, Phys. Rev. Lett. 94 (2005) 052502)". Especially, the energy resolution of 2.5MeV (FWHM) must be essential even with the high statistics.

Major difference from E521 is the higher beam intensity of three times as well as the target materials for production of more exotic neutron-rich hypernuclei . In order to meet the high intensity beam, the group is upgrading tracking chambers (hodoscope) at beam line and in the SKS spectrometer which are BC4, BH2 and DC1,DC2, respectively. The upgrade of BC4 is one of options, and finer segmentation of BH2 must be straightforward. These chambers are MWPCs with 1mm wire spacing. Since the chambers would have the same structure as BC1 and BC2, the group is watching the progress of R&D on 1mm MWPC for BC1 and BC2 by E05.

The first prototype of 1mm MWPC has a discharge at the chamber edge. E05 group is preparing the second prototype to reduce the edge-discharge with modification of the wire configuration and thinner anode wires as well as better cathode material. This dependence on the other experiment may be a weak point. We encourage the group to collaborate on this R&D with E05 as much as possible.

We understood that the design of beam line was fine for good K/pion ratio and good momentum resolution although the beam distribution has a sharp edge in BC4 from their reply of Q12 (" Can you explain the beam distribution in BC4 , p.11, especially the sharp edge in left ?") which is given in the appendix 2.

Finally, we list four recommendations below for the successful experiments at K.1.8 and SKS-spectrometer.

1. We would like to emphasize coordination between machine and experimental groups for optimization of slow extraction. We would like to ask the machine group to report the status of spill control with baseline design and schedule.

2. We would like to see the commissioning strategy of K1.8 beam line with clarification of responsibilities.

3. We would like to hear the progress report of SKS spectrometer and K1.8 beam line at every FIFC meeting.

4. We would like to hear the status of standardization of readout system among experimental groups, which the FIFC committee has recommended.

We asked 14 questions (Q1-Q14) to the group after the presentation. The questions and their replies are appended in this review.

E14: " Proposal for $K_L \rightarrow \pi^0 \nu\nu$ Experiment at J-PARC"

Detector system

This experiment (E14) is planning to measure the branching ration of the $K_L \rightarrow \pi^0 \nu\nu$ decay and to probe direct CP violation in the quark sector using a neutral kaon beam in the Hadron Hall. This experiment is a sequel to the KEK-PS E391a experiment which was performed as a pilot experiment. The same basic experimental concepts of 1) large detector acceptance, 2) hermetic veto system, 3) double decay chambers, 4) very high vacuum in the decay region, and 5) use of a pencil beam will be employed. In order to suppress the background associated with the halo neutrons in the beam, several parts of the detector must be upgraded. This background has been shown to be the most serious background of E391a from the analysis of the partial data. The detector upgrade is also necessary to meet the high rate conditions at J-PARC.

In the report submitted by the group, details of the upgrades for the CsI calorimeter, the main barrel (MB), the neutron collar counter (NCC2), the downstream veto counters such as the beam-hole charged veto (BHCV) as well as the photon veto (BHPV), and the charged veto (CV) are presented. Although it is not explicitly shown how much quantitative improvement can be anticipated in the suppression of the backgrounds by each separate upgrade, all the planned upgrades are regarded to be reasonable and necessary for E14 to obtain a much higher sensitivity than E391a.

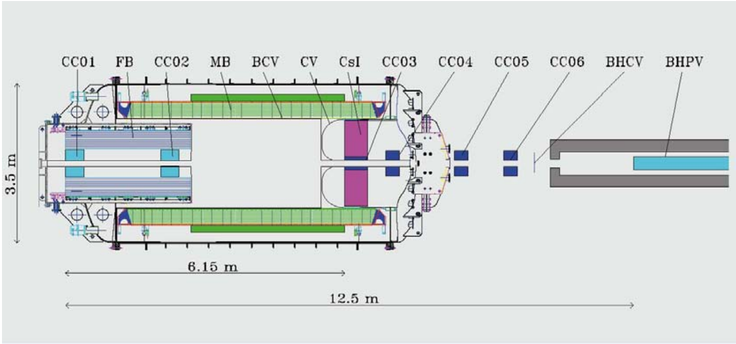
In particular, the introduction of the KTeV CsI crystals will be very important. The use of such longer crystals will be effective in reducing the rear-side energy leakage and thus in improving the decay vertex resolution. It is expected that this will suppress the downstream tail of the vertex distribution and hence prevent the admixture of halo-neutron induced backgrounds into the signal box. The smaller lateral size of the KTeV crystals plays an important role to separate two nearby photons. It is also anticipated that the production of backgrounds due to halo neutron hits can be substantially suppressed with the new NCC2 counter as was demonstrated in a simulation study.

The merits of these upgrades, however, should be evaluated as the improvements from the experimental data of the E391a pilot experiment by taking into account the anticipated beam quality at J-PARC. It is recommended that the group continues to check the validity of the upgrades along with the progress of the E391a analysis and to update the experimental sensitivity estimate of E14.

The basis scheme of the readout electronics by means of FADC's was shown. The introduction of a Gaussian low-pass filter for the CsI enables the application of the 125 MHz FADC and hence contributes to lower the costs substantially. This choice is regarded to be reasonable. The BHPV counter based on the new concept of Cherenkov radiation detection is a very promising device to pick up photons selectively. The prototyping to develop it seems very reasonable.

However, there are some detector elements which do not yet have basic designs fixed such as CC03 and the Charged Veto. It is desired that the group fixes the final design for those components based on R&D as soon as possible, and that the total performance of the detector is checked including those elements.

The detector assembly needs a more rigid system of support with the nearly doubled CsI weight and the thicker main barrel compared to E391a. It is desirable that the group should have an expert for the mechanical design of the detector just as it has engineering experts for the beamline construction.



K0 beam line

The beam line was planned to deliver a well-collimated neutral kaon beam for E14 experiment. The most critical design issue was minimizing halo neutrons which generate disastrous background noises. The technical report describes the beam line layout including mechanical designs of some key components, and demonstrates the validity of its collimation scheme by extensive simulations. The report has already reviewed by an external expert, Dr. Lau Gatignon, and his referee report has returned to the FIFC committee.

The committee agrees that the beam line design is well founded and its expected performance is reasonably demonstrated by simulations. Although the basic design is sound the committee should advise some items. The first is a sizeable amount of unnecessary material upstream of the first collimator, as the external reviewer pointed out. Should this line is to be approved minimization of the material along the line have to be considered in constructing the pentagonal huge vacuum chamber, installed first and hardly modified afterwards. The amount of material there is not negligibly small compared with the vacuum wall in K1.1 D2, which has been mentioned in the report. The second is that some mechanical designs are not fully convincing. The beam line member should consult relevant experts. Among those are the configuration of bellows which should endure the collimator movement, and the vacuum window structure upstream of the first collimator. The third is the alignment scheme, which was not fully explained in the report. Since the beam line will be under a high radiation level and the floor level is foreseen to be unstable, the beam line member should reconfirm schemes of the realignment as well as the initial alignment examining the collimator mover design and the optical alignment method.

The committee members fully support the beam survey plan described in the proposal. It would not only confirm the collimation scheme producing "a pencil kaon beam" together with very scarce halo neutrons, but also consolidate the fine adjustment method of collimators by observing beam distributions.

General Remarks

Man-power, organization and schedule

E03 and E10

Since the collaborations consist of reputable physicists who have performed many experiments at KEK-PS, there seems to be no big problem in group organization and man-power. However, many physicists have signed up for more than one proposal. The Committee feels comfortable if it become clear that the actual commitment of each participant. Please report to the PAC in term of person-year of the each participant.

E06

This group has an experience on the similar setup in old KEK-PS experiment. As long as the main works to be made on the detector, which include construction of new polarimeters with good magnetic field quality, GEM tracking system and other modification to the old equipment, could be handled by adding a small number of collaborators to the existing members.

However, even if some funding may be available from Canada on the beam line components, there is no prospect of the available man-power to construct K1.1 beam line in the near future (at least till the commissioning of K1.8 line to be completed). There is a dilemma here. The commissioning of K1.8 line makes the installation of K1.1 line difficult due to radioactivity around T1 target. The commissioning and construction of beam line must be well organized.

E14

Same problems exist as in E06. As long as the beam line work, only two persons are working on the hardware of beam line elements, mainly on the collimator system. One of the two persons will retire within this fiscal year..

Other two physicists from KEK are working on beam line MonteCarlo aspect. Although the detector modification/construction could be done, the group is definitely short in man-power on beam line construction.

The group is planning to install their collimators and to do beam survey in FY2008, in order to avoid working around T1 target region after the commissioning of K1.8. This requires certain amount of money from KEK, the collimator design must be fixed soon, and material in the upstream of the collimators must be installed, which is K1.1 magnets.

As a conclusion for both E06 and E14, the hardware construction schedule and financial profile and the commissioning of K1.8 line must be well coordinated and examined.

Cost and Funding

E03

The apparatus of E03 is common to the other experiments previously approved. It requires only a few additional detector components dedicated to this experiment. The expenditure for E03 was estimated to be about 10 Myen; detector support, PMTs, consumable and travel expenses. Although the amount of budget needed to carry out E03 is not so large, there is no available fund at this moment. The E03 group is encouraged to continue trying to be funded in a proper time scale.

E06

The experiment group has estimated a cost of the detector and the K1.1BR beam line. The breakdown of the detector components cost presented to the committee covers all the major items and the total amount of 2.8 oku-yen seems reasonable. In addition to the detector construction, the experiment needs to transport the existing spectrometer, a magnet and a cryogenic system, from Tsukuba to Tokai. The cost of transportation amounts to 1.8 oku-yen. The beam line of E06 is divided into two sections: the upstream section sharing the beam line with other K1.1 experiments and the downstream section dedicated to the E06 experiment. The construction cost of the upstream is estimated 7 to 8 oku-yen and the downstream is 0.5 oku-yen. In total, if we include the whole beam line, the project cost is not less than 12 oku-yen. Although the beam line should be constructed and provided to users by the host institute, considering a present tight budget situation of J-PARC, it is difficult to guarantee for KEK to prepare the necessary infrastructure in a timeline desired by the experiment. The E06 group has no foreseeable budget for the time being and expects some resources from US/Canada. Therefore, it is recommended to proceed the project after securing the budget of a main part of the experiment, such as the beam line and the major part of the detector, either by the J-PARC operation budget or a Grant-in-Aid.

E10

This experiment is fully supported by the Grant-in-Aid and the Committee found no financial problems.

E14

The E14 detector is based on an existing apparatus that was used in E391a. The major part of the expenditure is constituted of the beam line, such as collimators and magnet modification, and read-out electronics. In total, the experiment costs 7.2 oku-yen, including 2 oku-yen for the beam line and 1.9 oku-yen for the electronics. About a half of the total cost (3 oku-yen) will be covered by Grant-in-Aid and the most of the other half (3.6 oku-yen) is expected to be funded by KEK. In order to install and align collimators before beam commissioning starts with high intensity beam, which makes difficult the access to the target area, funding to the beam line preparation is urgent. However, budget for the beam line is not allocated in the present budget and the budget plan for the next fiscal year. Therefore, it is recommended to proceed the project after securing the budget of the beam line related components.

Electronics and Data acquisition system

E03

The readout electronics and DAQ system for the E03 experiment is mostly common to those for E05, E07, E13 and E19. In addition the readout electronics for the beamline chambers are also common to the experiments at the K1.8BR (E15 etc). From the view point of an efficient usage of resources, the committee would encourage the K1.8 and K1.8BR users to make an organized effort to construct and maintain several common detectors system to be equipped in the beamline/spectrometers. E03 members should play a major role in it..

One concern in E03 is a dead-time issue. They might loose 50% (a rather conservative estimation) of the events due to the dead-time along with 10% (max) due to the detector inefficiency. The group should make more effort to enhance the bandwidth of their DAQ system.

E06

Though they need detail consideration of trigger rate/efficiency and robustness of the readout system under unexpected environment (i.e. behavior under high trigger rate and large data size), there is no serious technical issue.

E10

The same recommendation regarding the common system to the K1.8 and K1.8BR users is valid for E10. There are no other special concerns for E10 electronics/DAQ.

E14

E14 employs pipeline data acquisition system. The latency of level-1 trigger should be determined as soon as possible in order to construct the readout electronics, because the change of the latency affects not only electronics design (i.e. circuit schematics and its production schedule) for all detectors in E14 but also the robustness of the trigger system and the data acquisition control system. It is preferable that they will study trigger rate/efficiency and robustness of the readout system under high trigger rate and large data size before the experiment.

There is one common concern to all the groups in the manpower devoted to the electronics design/construction. Every experiment is planning to apply new electronics and a new data acquisition system to accommodate with a higher data rate expected in J-PARC. Even though the core parts of them (like a front end ASIC or framework of DAQ) are being developed by the expert team in IPNS, more collaborative efforts of the experimental team are essential to evaluate and apply them successfully to each experiment. It is noted that a good support from IPNS to the developer team is also very important.

Several experiments assume a good availability of the common electronics stocked formerly for the 12GeV-PS experiments. IPNS should find a good way for all the experiments to make the best use of them.

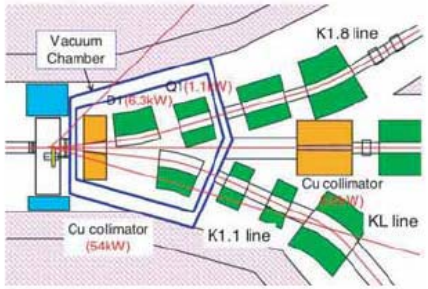
Safety

There are no concerns in the experiments discussed in the present report. Since E14 has several heavy objects with irregular shape, special care should be taken on their transportations and placements.

Beam line commissioning and E06/E14 scheduling

The committee has a big concern about a possible conflict among the schedules of the E06 and E14 constructions and the commissioning of the slow extraction line, the T1 target and its following K1.8 beam line. It is believed that the access to the area and equipments placed around the T1 target would be very hard (if not impossible), once the primary beam is introduced to the area. This will happen some day in later 2008 according to the official schedule.

Both the upstream equipment of K0.8 including the first four magnets and the collimators of E14 should be installed in time by the fall of 2008. Due to some reasons (lack of resources, difficulties in fabrication, longer time to delivery …) , if any of the equipments will not be ready to install before the full commissioning of the slow extraction beam line, the later installation of the missing equipments are very hard to imagine. There might be a chance that the first stage commissioning of the slow extraction made before that of the fast extraction scheduled in the spring 2009 could be rather moderate and the access to the T1 area would still be possible even after it. Since it depends on the strategy and planning in the commissioning of the slow extraction and overall coordination of the 30 GeV PS operation, the committee like to have more information about it from the corresponding commissioning team.



Appendix 1

Q&A among FIFC and E10

Ver. 15 June, 2007

Replies to FIFC questions on E10 experiment

Q1 : Do we need to confirm the E521 result with high statistics by E10, JPARC ?

A1 : No, we believe we don't need reconfirmation. The KEK-PS-E521 experiment was performed to confirm the feasibility of the production of the neutron-rich hypernuclei by using the double charge-exchange (DCX) reaction. The experiment was successful, and we wish to go to the next step at J-PARC. We are proposing to produce the ${}^{9}_{\Lambda}$He and ${}^{6}_{\Lambda}$H hypernuclei. The core nuclei of the ${}^{9}_{\Lambda}$He hypernucleus is a typical halo-nucleus ^{8}He. We are interested in the effect of the addition of a Λ hyperon on the halo structure. The ${}^{6}_{\Lambda}$H hypernucleus is a quite exotic hypernucleus with a large N/Z ratio.

The spectrometer system at J-PARC will be almost same as the old system at KEK-PS, so the reconfirmation just for a system check is not necessary, too. The measurement of the DCX reaction is time consuming, and the reaction is not a suitable reaction for the system check. We can make the system check by the ordinary (π^+, K^+) reaction.

Q2 : If so, why you do not plan the confirmation first ?

A2 : As we answer above, we don't need to confirm the E521 result.

Q3 : What is your relation to the E521 collaboration ?

A3 : Fukuda, Saha and Noumi are co-spokesperson of the KEK-PS-E521 experiment. Kishimoto, Sakaguchi, Ajimura, Takahashi and Bhang are the members of the collaboration.

Q4 : Can you show us the significance of signals as a function of energy resolution in order to verify the 2.5MeV (FWHM) requirement ?

A4 : Figure 1 is a result of the calculation of the S/N ratio in the case of the ${}^{6}_{\Lambda}$H production. In the calculation, the energy threshold of particle decay channels in ${}^{6}_{\Lambda}$H is assumed to be 3 MeV. The ratio of yields between the signal (hypernucleus production) and the background (quasi-free Λ production from 0<-BE<20MeV) is assumed to be 1:10. These parameters are same as that used in the discussion described in the document for FIFC (see Fig.2 in the document). The energy window for signal selection are set to $\pm 2\sigma$ (σ is the energy resolution in rms).

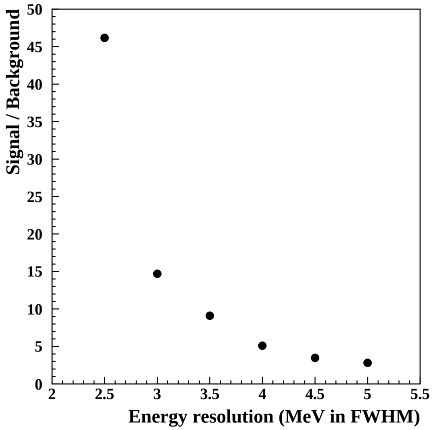


Figure 1: S/N ratio as a function of energy resolution in the case of the ${}^{6}_{\Lambda}$H production. For more details see the text.

The result shows the signal is quite significant in the case of the 2.5 MeV resolution. The S/N ratio drops quite rapidly with the increase of the energy resolution.

Q5 : What is the status of DC1 and DC2 (1mm MWPC) ?

A5 : Currently, we have no practical drawing for the DC1 and DC2 tracking detectors based on the 1 mm wire-spacing MWPC because the 1mm MWPC is still under development at KEK. We are waiting for the completion of the R&D works.

A difference between BC1/BC2 and DC1/DC2 is the size of the detectors. BC1 and BC2 (1 mm MWPC) have the same size of the sensitive area, 256mm(W)×100mm(H). DC1 has a sensitive area, 288mm(W)×150mm(H), and DC2 has a sensitive area, 384mm(W)×250mm(H). The size of DC1 is similar with that of BC1/BC2, so we believe we can fabricate the 1mm MWPC version of DC1 without any difficulties if R&D of BC1 and BC2 will be completed. The fabrication of DC2 may need some development due to the larger size than BC1/BC2, but we believe knowhow to be obtained during the BC1/BC2 R&D works will help us.

Some amount of budget is allocated for the fabrication of DC1 and DC2 and readout electronics as written in the E10 document for FIFC.

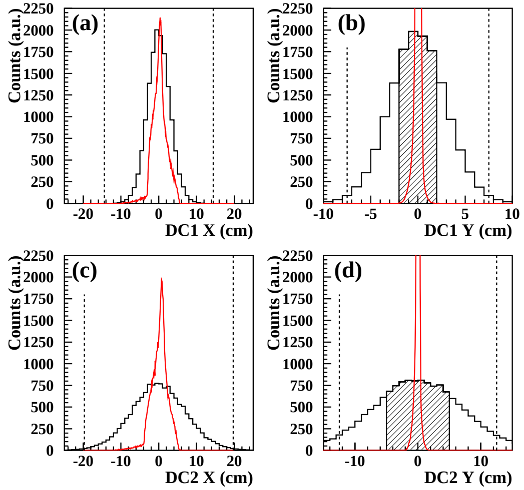


Figure 2: Simulated hit distributions at DC1 and DC2. Black and red colored histograms corresponds to hypernuclear events and beam hits, respectively. See text for more details.

Q6 : What is the DC update in "Time Schedule, p.25 in your presentation" ?

A6 : The 1st version of DC1 and DC2 for SKS will be prepared by the E05 collaboration (practically by KEK and Kyoto University groups). But, the 1st version is the 3 mm wire-spacing drift chamber. So, we wish to update DC1 and DC2 by the 1 mm MWPC version for the E10 experiment (and also for E22). We call it "DC update".

As we mention in A5, we believe the fabrication of the 1 mm MWPC version of DC1/DC2 is rather straightforward if the R&D works will be finished by the E05 collaboration. So, the time allocated for the DC update is essentially the time needed for the chamber fabrication.

Q7 : Can you show us K^+ distribution in DC1, DC2 together with the beam ?

A7 : Figure 2 shows simulated hit distributions at DC1 and DC2. The distribution projected to the x (a) and y (b) axes at DC1, and the x (c) and y (d) distributions at DC2. The black colored histograms correspond to events with the production of hypernuclei, and red colored histograms correspond to beam hit distributions.

For the simulation, the angular dependence of the differential cross section of the production cross section of hypernuclei is included in the black histograms, but he SKS acceptance is not included. The SKS acceptance changes the x distributions, (a) and (c), a little. For the y distributions, (b) and (d), the hatched areas roughly show the SKS acceptance.

The vertical dashed lines indicate the edge of DC1 and DC2.

Q8 : What is the momentum resolution as a function of spatial resolution of DC1 and DC2 in SKS ?

A8 : We don't have result of the simulation study on the effect of the DC1 and DC2 resolution to the momentum resolution for the original SKS setup. We have an example of the simulation for the SksPlus case (see E05 documents to FIFC). The result tells that the momentum resolutions are roughly 10% worse with 500 μm chamber resolutions in comparizon with the 300 μm resolution case. This weak dependence of the momentum resolution on the tracker position resolutions mainly comes from the multiple scattering effects. Further, in the practical offline momentum analyses of the SKS spectrometer, the final resolution does not depend so much on the chamber position resolution but depends largely on how to remove or cancel the systematic correlation in the wide SKS acceptance.

We also wish to mention that the nominal position resolution of the existing SKS tracking chambers (5 mm wire-spacing DCs) is roughly 300 μm and the position resolution of 1 mm MWPC is expected to be $1000/\sqrt{12} \sim 290\mu$m. So, we believe the replacement of the 3 mm DC by the 1 mm MWPC affects not so much to the momentum resolution of the SKS system.

Q9 : What is the status of cryocooler system in SKS ?

A9 : As the SKS user group announced, we will replace the cooling system of the SKS magnet by a system with three modules of GM-JT 4K cryocooler (3.5 W cooling power for each). In FY2006, we made a bench test of a cryocooler which was fabricated in FY2005, and obtained a net cooling power of 3.32 W. Since the heat leak of the SKS cold box is in 5 W level, the performance of the cryocooler is enough good for our purpose.

In FY2007–2008, the fabrication of two other cryocoolers and the modification of the cooling system will be proceeded.

Q10 : What is the status of chambers (BC1-4) and counters(BH1-2) in K1.8 beam line, which will be fabricated in FY2007 ?

A10 : BC1 and BC2 are 1 mm wire-spacing MWPC. The R&D works for the 1 mm MWPC is in progress at KEK (by the E05 collaboration). They designed a prototype MWPC (version 1) with 1 mm wire-spacing, 3 mm anode-cathode gap and 15μmϕ anode wires. During the bench test of the prototype MWPC, we had a problem of a discharge at the chamber edge. The discharge damaged the cathode plane, aluminum coated poly-alamide film. The anode wires had no damage.

E05 is preparing another prototype MWPC (version 2). For the version 2 MWPC, E05 is planning following modifications:

- Modify the wire configuration at the edge of the chamber. Several dummy wires are added to hide the edge wires from the cathode plane.
- Use thiner wire, 12.5 μmϕ, to reduce the operation voltage.
- Look for other martial for the cathode film coating because the thin aluminum layer is fragile for the discharge.

We hope the updated prototype MWPC will have a good performance after the modifications, then we can proceed to the BC1/BC2 productions.

BC3 and BC4 are 3 mm wire-spacing drift chambers. The design of the 3 mm chambers is similar with that of the 5 mm wire-spacing drift chambers used for the beam tracking chambers at KEK-PS K6 beam line. Practical design works will start at Kyoto University, soon.

The beam line hodoscope BH1 was designed and fabricated already by the E05 collaboration at KEK. It will be placed at the upstream end of the beam line momentum analyzer system. This beam line hodoscope BH1 is common for all K1.8 experiments. We need another beam line hodoscope BH2 for E10 to be placed at the downstream end of the beam analyzer. We are planning to design BH2 in FY2007 and fabricate it in FY2008. We have no technical problem for BH2.

Q11 : What is the R&D status of 1mm MWPC for BC4 although it is the second option ?

A11 : If we will fabricate 1 mm MWPC version of BC4, the structure of BC4 may be exactly same as that of BC1/BC2. So, no additional R&D work is necessary. We will just make a copy of BC1/BC2. The concern is only the cost for fabrication.

Q12 : Can you explain the beam distribution in BC4, p.11, especially the sharp edge in left ?

A12 : First of all, let us describe the design principles of the K1.8 beam line optics very briefly (you can find details in the report of the Hadron Beam Line Group to FIFC). The most important design principles are:

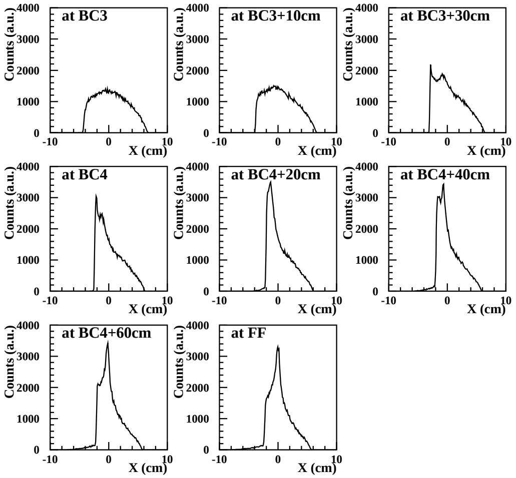


Figure 3: Hit profile change from BC3 to the final focus point (FF) in the x (horizontal) direction.

– Higher order corrections to obtain very small beam size at the mass slits (MS1 and MS2). This is inevitable to realize the good K/π ratio.
– Point to point optics from the BC2 position to the BC3 position. This is inevitable to obtain the excellent momentum resolution by the beam line spectrometer.

The optimization of the beam optics according to the design principles may affect to the beam profiles around BCs and also the final focus point (FF). Especially, the optimization may introduce higher order aberrations in the beam profiles. Other minor issues of the beam line optics are:

– Chromaticity at FF, $(x|\delta)$=0, δ=dp/p.
– Small x and y beam sizes at FF (or no beam divergence toward FF).

We believe these design of the beam optics creates the somewhat "singular" beam profile at BC4.

Figure 3 shows the hit profile change from BC3 to the final focus point (FF) in the x (horizontal) direction. The beam focusing becomes significant around BC4 position. The peak structure at the left end at the BC4 position seems to move toward center (x=0) from BC4 to FF.

To see the profile change more clearly, 2 dimensional profiles are created (see Fig. 4). The left and right sides show the correlations of position-angle (x-x') and position-momentum (x-dp/p), respectively. The monitoring points are 20 cm downstream of BC3, BC4, 30cm downstream of BC4 and final focus point (FF) from top to bottom. The dashed lines are shown to guide the symmetry axis (not perfect symmetry) of the profile distributions. The dashed lines rotate clockwise and anti-clockwise from top to bottom for the left and right plots, respectively, and lines becomes almost parallel to the vertical axises at FF. This means the focusing is realized at FF.

The 2 dimensional profiles have non-uniform distributions and there are 2 clear loci maybe due to the higher order aberrations. At the BC4 position one of the loci accidentally becomes almost parallel to the vertical axis. This is the reason that the BC4 profile has very asymmetric distribution.

We wish to mention that the BC4 x profile is quite asymmetric in shape, but the asymmetric profile causes no technical problems in the E10 experiment.

Q13 : What is background in the chambers from the π^- beam in SKS ? The high intensity beam would hit the SKS magnet.

A13 : In the KEK-PS E521 experiment, the trigger rate of the (π^-, K^+) reaction was typically about 130 per 5×10^6 pions, which was factor five to six smaller than that of the (π^+, K^+) reaction. We learned that scattered particles associated with the pion beam absorption at the SKS return yoke did not contribute to the count rate very much.

Trigger, time-of-flight (TOF), aerogel Čerenkov (AČ) and lucite Čerenkov (LČ) detectors, and tracking chambers were located backward from the beam absorption. Energetic and fast charged particles could not be emitted backward. Low energy and slow charged particles were smeared out by a strong magnetic field of SKS.

A γ-ray could reach the trigger counters to sneak into the kaon time window. The γ-ray could interact with TOF and kick out a fast electron, which could fire both of TOF and lucite. In fact, we experienced an increase of the trigger rate by this effect in the KEK-PS E438 experiment. E438 is an experiment to measure the (π^-, K^+) spectra at a Σ^- production region. The beam momentum was used at 1.2 GeV/c, but SKS excitation was greater than that for E521. The background from the γ-rays was enhanced in E438 since LČ was moved to be located just behind TOF, while LČ was usually located 1 m behind TOF and AČ was placed between them. These γ-ray oriented events could be removed by increasing a threshold of TOF discriminators, since an energy deposit was small.

Q14 : Can you show us a breakup in the 1kHz trigger rate which you mentioned ?

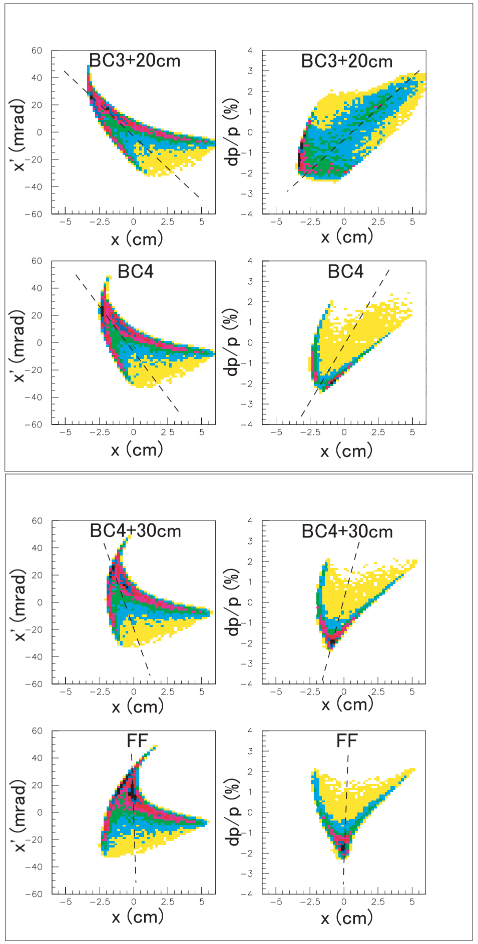


Figure 4: Correlation (left) between position, x, and angle, x', and (right) between position, x, and momentum difference, δ=Δp/p. (From top to bottom) positions are at 20cm downstream from BC3, at BC4, at 30cm downstream from BC4 and at final focus point, FF.

A14 : According to the E521 data analysis, almost all the (π^-, K^+) triggers are the (π^-, p) reactions in the target. A fast proton kicked out at a forward angle has a velocity close to that of the kaon, and thus can sneak into the kaon trigger logic and time window. This is due to a large acceptance of SKS.

As we mention in A13, the trigger rate for the (π^-, K^+) reaction was 130 per 5×10^6 pions in the E521 experiment. This means the trigger rate in the E10 experiment is estimated to be about 400 triggers/spill if we will use the 5×10^6 pions/s beams and employ the 3 s beam spill. So, our estimation of the trigger rate is less than a half of that we mentioned in the FIFC meeting.

Appendix 2

Report from the external referee, Dr. Philip Pile (BNL), on K08 beamline

20 June 2007

I have reviewed the optics design on the K0.8 JAPRC beam line. My assessment is based on the 11 May 2007 report by Jaap Doornbos entitled "An 800 MeV/c separated kaon beam at J-PACR". My comments and recommendations follow:

General Comments:

Overall I believe the optics design is good. The design takes into account the constraints placed on the 800 MeV/b beam by the physical elements in the first half of the K1.1 beam line. This results in rather small angular acceptance for the K0.8 beam as well as a rather short interaction length production target. This would result in an unacceptable stopped K^+ flux if the primary beam intensity was limited to AGS intensities. However, given the higher beam energy and intensity expected at the J-PARC facility the flux should be acceptable. A rough comparison of the K0.8 to the BNL LESBIIII stopped K^+ beam is shown in the below table (Sanford Wang used for energy and production angle scaling):

Parameter	LESBIII	K0.8	K0.8/LESBIII
Primary Proton	25 GeV	30 GeV	1.4
Target	6 cm Pt	5.4 cm Si	0.6
Mean Prod. Angle	5 deg	6 deg	1.1
$\Delta\Omega$dp/p	50 msr%	5 msr%	0.1
Beam Line Length	19.6 m	20.3 m	0.9
Net Loss factor			0.08

So for the same proton intensities the beam line would deliver about 8% of a beam line "optimized" for the task. The JPARC primary proto beam intensity, however, should more than make up for this.

The 9 μA beam current projected for the first phase of JPARC running should be compared to the maximum capability of the AGS 76 TP (achieved in 2002) together with a slow beam spill length limited by target temperature considerations (~20 TP/sec). So with a 3.8 sec spill and a 6 second repetition rate the beam current is 2 μA. – with a more robust target and a 0.7 sec spill (as is the plan for JPARC) the beam current is 4 μA.

The nominal LESBIII K^+ rate into the stopping target was about 5 x 10^6 per 10 TP protons so with 9 μA (54 TP/sec) the K^+ rate should well over 10^7/sec with stopping rates just under 10^7/sec…. assuming the experiment can tolerate instantaneous rates associated with the 0.7 sec spills necessary to achieve 9 μA.

Beam purity is then the issue. The below table compares relevant collimators for LESBIII and K0.8 :

Parameter	LESBIII	K0.8
Theta-Phi Collimator	Yes	No
Separation Stages/Mass Slits	2x 50KV/cm x 2 m	1x 50KV/cm x 2.5m
Vertical Focus/Collimator before Separation	No	Yes
Momentum Collimator	Yes	No
Horizontal Achromatic Focus	Yes	Yes
Sextupoles	3	2
Octupoles	1	1
K^+ Beam Purity at 800 MeV/c	70%	tbd

I'll comment on each of the above differences.

(1) **Theta-Phi collimator**:

In LESBIII this collimator is located upstream of the first separation stage and allows independent variable cuts in the 4 corners of x-y phase space. The collimator is located in a place where x and y at the collimator correlate well with theta and phi at the target, so a x-y cut will reduce the theta-phi phase space allowed into the separation stages. This was important for LESBIII due to the very large theta and phi acceptance (~ +/- 200 and 20 mr full width respectively) of the channel and allowed high order theta-phi aberrations to be controlled. Since the K0.8 beam line acceptance is only about 10% of LESBIII (theta/Phi +/- 35 and 10 mr respectively) it is probably of no consequence that this type of collimation is missing. The only caveat is the high order optics must be right, otherwise theta-phi (and dp/p) aberrations could result in tails that cannot be removed.

An example is shown in Fig. 1 below in a TURTLE simulation with the K0.8 separator at half voltage to allow pions to the end of the beam line. The histogram shows the theta-phi phase space of those pions that are transmitted through a 4 mm IY1, 3 mm MS1 and 1.2 cm HFOC to the end (no slit scattering included). For this simulation the pions were given a positive 1.25 mr phi kick in the separator. The number of pions transmitted to the final focus in this simulation roughly translates to 1:1 π/K. If a suitable location for a phi collimator could be found such as between the first sextupole and the separator (see Fig. 2.) this could provide an additional handle on direct pion contamination.

Recommendation: Investigate the possible addition of a variable vertical collimator upstream of the separator to reduce phi acceptance. Note this collimator need only have one jaw either top or bottom depending on the polarity of the separator.

```
Histogram No  5
 horizontal axis   x' in mrad                         0.000 m    from the target
 vertical axis     y' in mrad                         0.000 m    from the target
 flag at 20.3 m

                  -50.000   -25.000     0.000    25.000    50.000 totals
                     I**---**---**---**---**---**---**---**---**I--------
   15.000 to  13.500 I                                          I      0
   13.500 to  12.000 I                                          I      0
   12.000 to  10.500 I                                          I      0
   10.500 to   9.000 I                      1                   I      1
    9.000 to   7.500 I               1             1            I      2
    7.500 to   6.000 I                  1                       I      1
    6.000 to   4.500 I              11  1   11 2                I      7
    4.500 to   3.000 I                         1                I      1
    3.000 to   1.500 I                      1      1            I      2
    1.500 to   0.000 I                  1 1      1 1            I      4
    0.000 to  -1.500 I               111  1 1   11     1        I      8
   -1.500 to  -3.000 I         111113  1  3221521 1 21          I     29
   -3.000 to  -4.500 I         11 11 3211312222 214 1  1  1     I     33
   -4.500 to  -6.000 I           2  1   12  212 1  22           I     16
   -6.000 to  -7.500 I                   11  11141152 1         I     19
   -7.500 to  -9.000 I       1               32214142 2         I     22
   -9.000 to -10.500 I                1        324233 1         I     19
  -10.500 to -12.000 I                   1  1 12113112          I     14
  -12.000 to -13.500 I                        11 11 1           I      5
  -13.500 to -15.000 I                                          I      0
                     I**---**---**---**---**---**---**---**---**I--------
                     I                                          I
                     I                                          I
                     I                                          I
                     I                                          I
                     I                      1 1111111           I
             totals  I 0000001022322564357741944343843420010000 I    183
```

Fig. 1. Theta-phi histogram of pions at the production target gated by those that reach the final focus.

```
1Histogram No  3                    SEP
 horizontal axis   y' in mrad                         0.000 m    from the target
 vertical axis     y in cm                            9.158 m    from the target
 flag at 20.3 m

                  -12.000    -7.000    -2.000     3.000     8.000         totals
                     I**---**---**---**---**---**---**---**---**---**---I--------
   12.000 to  11.000 I                                                  I      0
   11.000 to  10.000 I                                                  I      0
   10.000 to   9.000 I                                                  I      0
    9.000 to   8.000 I                                                  I      0
    8.000 to   7.000 I                                                  I      0
    7.000 to   6.000 I                                                  I      0
    6.000 to   5.000 I 1                                                I      1
    5.000 to   4.000 I 27 33321                                         I     21
    4.000 to   3.000 I   31979841                                       I     42
    3.000 to   2.000 I     1  27653                                     I     24
    2.000 to   1.000 I           2223342                                I     18
    1.000 to   0.000 I              1248968 11                          I     40
    0.000 to  -1.000 I                   38511 1                        I     19
   -1.000 to  -2.000 I                        2 1 1                     I      4
   -2.000 to  -3.000 I                         1   13                   I      5
   -3.000 to  -4.000 I                                  11   1          I      3
   -4.000 to  -5.000 I                                 11 1  2          I      5
   -5.000 to  -6.000 I                                                  I      0
   -6.000 to  -7.000 I                                                  I      0
   -7.000 to  -8.000 I                                                  I      0
   -8.000 to  -9.000 I                                                  I      0
   -9.000 to -10.000 I                                                  I      0
  -10.000 to -11.000 I                                                  I      0
  -11.000 to -12.000 I                                                  I      0
                     I**---**---**---**---**---**---**---**---**---**---I--------
                     I                                                  I
                     I                                                  I
                     I                                                  I
                     I                                                  I
                     I     11111       1  1                             I
             totals  I 373430111775245809965222210113001211003000000000 I    182
```

Fig. 2. Phi of pions at production target vs y upstream of separator gated by pions that reach the final focus.

(2) **Separation Stages/Mass Slits**:

Doornboos argues that although the K0.8 beam line does not have two separation stages the incorporation of a vertical focus (IFY) upstream of the separation stage that allows the target to be imaged on a collimator therefore providing a cleaned-up object to transport through the single separation stage. This then helps to minimize pions and muons coming from so-called cloud sources. The advantage of two separation stages is the first mass slit not only provides a cleaned-up kaon object but also a pion object that is substantially reduced in number so pion tails at the second mass slit due to optics and/or slit scattering are not so troublesome. I, do however, agree that the inclusion of a variable IFY collimator in K0.8 will help to insure a good π/K ratio although as Doornbos points out slit scattering at IF1 is an issue and could well make pion contamination worse if not for the inclusion of a achromatic horizontal focus/slit downstream of the last bend. This conclusion should be double-checked as I have no evidence of such a problem in either LESBIII or the 2GeV D6 beam line.

Recommendation: Double-check the assertion that slit scattering at IF1 could significantly increase the pion contamination through the mass slit.

(3) Vertical Focus/Collimator before Separation:

See comments in (2) above.

(4) Momentum Collimator:

K0.8 does not presently incorporate a momentum collimator. This could be a worthwhile addition to the beam line should chromatic aberrations be a problem. The Doornbos optics happen to provide from the optics standpoint a good location for such a collimator – just downstream of the first sextupole. Although not a horizontal focus this location is close enough to a focus and has good enough dispersion to allow momentum collimation. Fig. 3 below illustrates this point. This would also allow better optimization of K+ stopping efficiency.

Recommendation: Consider adding a variable (or fixed) horizontal collimator to allow momentum selection.

```
1Histogram No 33                   XFOC
 horizontal axis    x in cm                          9.158 m    from the target
 vertical axis   dp/p in %                           9.158 m    from the target, flag at
20.323 m

                  -10.000    -5.000     0.000     5.000    10.000 totals
                     I**---**---**---**---**---**---**---**---**I--------
    5.000 to   4.500 I                                          I      0
    4.500 to   4.000 I                                          I      0
    4.000 to   3.500 I                                          I      0
    3.500 to   3.000 I                                2341      I     10
    3.000 to   2.500 I                            117AEJ6       I     58
    2.500 to   2.000 I                          23IS$L62        I    119
    2.000 to   1.500 I                      229JW$WWM 1         I    187
    1.500 to   1.000 I                   1129U$$$$M7            I    236
    1.000 to   0.500 I                 17GR$$$$$WD              I    329
    0.500 to   0.000 I               19NYX$$$$U4                I    338
    0.000 to  -0.500 I             36L$$$$$SE4                  I    313
   -0.500 to  -1.000 I            2S$$$$XL71                    I    302
   -1.000 to  -1.500 I           ES$$$M71                       I    225
   -1.500 to  -2.000 I         2K$$VA2                          I    172
   -2.000 to  -2.500 I       16R$P51                            I    120
   -2.500 to  -3.000 I      1HZP8                               I     86
   -3.000 to  -3.500 I     2II7                                 I     45
   -3.500 to  -4.000 I    382                                   I     13
   -4.000 to  -4.500 I    1                                     I      1
   -4.500 to  -5.000 I                                          I      0
                     I**---**---**---**---**---**---**---**---**I--------
                     I                                          I
                     I                                          I
                     I                                          I
                     I             11111111111111               I
                     I     123458981122332322312097663221       I
             totals  I 0000401684365535603221854384388134010000 I   2554
```

Fig. 3. x vs dp/p histogram of kaons at position just upstream of the first separator gated by those that make it to the final focus through nominal K0.8 slits.

(5) Horizontal achromatic focus (HFOC):

This collimator is similarly located in K0.8 as it was in LESBIIII and should provide the final clean-up of cloud pions and slit scattered pions (if indeed an issue). Doornbos pointed out that a one sided vertical aperture(top or bottom depending on the separator polarity) would be helpful to reduce slit scattered pions. Such a slit will also provide a measure of help to reduce direct pions from the target due to optics tails (see Fig. 4 below). This slit is the last defense against cloud pions.

The TURTLE simulation shown in Fig. 5 below is for a cloud of pions at the production target and shows an x-y histogram of those that make it to HFOC gated by a 4 mm IFY and a 3 mm MS1. Note the nominal horizontal opening of the slit is about a cm so most of this cloud will be eliminated by this cut. The remaining cloud pions could eliminated with top and bottom y cuts at some expense to the kaons (see Fig. 6). Note that a single 2-jaw collimator with the proper azimuthal orientation might be worth considering.

Recommendation: Consider using rotated 2-jaw collimator here.

```
1Histogram No 64                   HF
 horizontal axis    x in cm                          17.173 m    from the target
 vertical axis      y in cm                          17.173 m    from the target

                  -5.000    -2.500     0.000     2.500     5.000 totals
                     I**---**---**---**---**---**---**---**---**I--------
    5.000 to   4.500 I                    111                   I      3
    4.500 to   4.000 I                     121                  I      4
    4.000 to   3.500 I                     12                   I      3
    3.500 to   3.000 I                     1                    I      1
    3.000 to   2.500 I                     11                   I      2
    2.500 to   2.000 I                     21                   I      3
    2.000 to   1.500 I                    11                    I      2
    1.500 to   1.000 I                   1 631                  I     11
    1.000 to   0.500 I                    252                   I      9
    0.500 to   0.000 I                   1AB3                   I     25
    0.000 to  -0.500 I                   3961                   I     19
   -0.500 to  -1.000 I                   463                    I     13
   -1.000 to  -1.500 I                   38                     I     11
   -1.500 to  -2.000 I                   43                     I      7
   -2.000 to  -2.500 I                   411                    I      6
   -2.500 to  -3.000 I                   84                     I     12
   -3.000 to  -3.500 I                 2 A4                     I     16
   -3.500 to  -4.000 I                  1761                    I     15
   -4.000 to  -4.500 I                  5A21                    I     18
   -4.500 to  -5.000 I                  161                     I      8
                     I**---**---**---**---**---**---**---**---**I--------
                     I                                          I
                     I                                          I
                     I                                          I
                     I                                          I
                     I                   6541                   I
                totals  I 0000000000000000271826200000000000000000 I    188
```

Fig. 4. x-y histogram of pions at entrance to HFOC with half-field separator, 4 mm IF1 and 3 mm MS1.

```
1Histogram No 50                    HF
 horizontal axis    x in cm                          17.173 m    from the target
 vertical axis      y in cm                          17.173 m    from the target


                  -12.000    -7.000    -2.000     3.000     8.000         totals
                     I**---**---**---**---**---**---**---**---**---**---I--------
    6.500 to   6.000 I                             1 11 1 1             I       5
    6.000 to   5.500 I                        2339IKEB9NF77934          I     157
    5.500 to   5.000 I                         7LT$$$$$$$YPGD7521       I     468
    5.000 to   4.500 I                         AIM$$$$$$$$RQPGC71       I     535
    4.500 to   4.000 I                        119P$$$$$$$$$SMIME73321   I     577
    4.000 to   3.500 I                         3FMS$$$$$$$$$WRMLBA9924  I     667
    3.500 to   3.000 I                         16ADR$$$$$$$U$$STSKEBA75 I     653
    3.000 to   2.500 I                          136NNY$Y$$$$$$$TNRJKHE7 I     645
    2.500 to   2.000 I                            4BEIJVV$$X$ZLTVMMIEGA I     506
    2.000 to   1.500 I                              2229DOOLOMECIELJBBD I     276
    1.500 to   1.000 I                                  41142735B685A14 I      72
    1.000 to   0.500 I                                                  I       0
    0.500 to   0.000 I                                                  I       0
    0.000 to  -0.500 I          2 4                                     I       6
   -0.500 to  -1.000 I        1559DC433                                 I      55
   -1.000 to  -1.500 I         AKS$MMKD73 2                             I     184
   -1.500 to  -2.000 I       138$P$$$SXLJ823                            I     315
   -2.000 to  -2.500 I        18L$$$$$$VUDB821                          I     434
   -2.500 to  -3.000 I        1BLZ$$$$$$$XF45                           I     510
   -3.000 to  -3.500 I       1 4DMT$$$$$$WJB822                         I     511
   -3.500 to  -4.000 I          6JN$$$$$$$X$9442                        I     643
   -4.000 to  -4.500 I           1CJZ$$$$$$WJ921                        I     545
   -4.500 to  -5.000 I            6DS$$$$$$YG872                        I     550
   -5.000 to  -5.500 I            16BZ$$$$$$I9B1 1                      I     469
   -5.500 to  -6.000 I             189GNRP8573111                       I     135
   -6.000 to  -6.500 I                111 2 2                           I       7
                     I**---**---**---**---**---**---**---**---**---**---I--------
                     I                                                  I
                     I                                                  I
                     I                                                  I
                     I          112344554321     12233333332221111      I
                     I         4286125637757833372070004540542643098653 I
             totals  I 000000266609289634627660241210885619230781264539 I    8925
```

Fig. 5. x-y histogram of cloud pions at entrance to HFOC with full field separator, 4 mm IF1 and 3 mm MS1. Cloud pion phase space is x=+/- 20 cm, y=+/-10 cm, theta=+/- 100 mr, hi=+/- 40 mr and dp/p=+/-20% with (?) 10^8 initial rays.

```
1Histogram No 52                    HF
 horizontal axis    x in cm                          17.173 m    from the target
 vertical axis      y in cm                          17.173 m    from the target


                   -1.000    -0.500     0.000     0.500     1.000 totals
                     I**---**---**---**---**---**---**---**---**I--------
    6.500 to   6.000 I                                          I       0
    6.000 to   5.500 I                  1 1    1   2  11    1   I       8
    5.500 to   5.000 I                       1 2 211 1332111342 I      28
    5.000 to   4.500 I                       1   4212 11 323233 I      28
    4.500 to   4.000 I                  1           1 1 11 1221 I      11
    4.000 to   3.500 I                         2  1   221133 21 I      18
    3.500 to   3.000 I                             1    1 112 1 I       7
    3.000 to   2.500 I                                        1 I       1
    2.500 to   2.000 I                                          I       0
    2.000 to   1.500 I                                          I       0
    1.500 to   1.000 I                                          I       0
    1.000 to   0.500 I                                          I       0
    0.500 to   0.000 I                                          I       0
    0.000 to  -0.500 I                                          I       0
   -0.500 to  -1.000 I                                          I       0
   -1.000 to  -1.500 I                                          I       0
   -1.500 to  -2.000 I                                          I       0
   -2.000 to  -2.500 I   1                                      I       1
   -2.500 to  -3.000 I                                          I       0
   -3.000 to  -3.500 I 1  1      1  1                           I       4
   -3.500 to  -4.000 I  1  11  1 1 21             2             I      10
   -4.000 to  -4.500 I 2111 2 1 1 11          1                 I      12
   -4.500 to  -5.000 I 21   2 2 11   1 1211      2              I      17
   -5.000 to  -5.500 I 2211111   31121111  1                    I      21
   -5.500 to  -6.000 I   11     1     1      1       1          I       6
   -6.000 to  -6.500 I                                          I       0
                     I**---**---**---**---**---**---**---**---**I--------
                     I                                          I
                     I                                          I
                     I                                          I
                     I                                          I
                     I                                      11  I
             totals  I 7544261313624422251210315086532875679019 I     172
```

Fig. 6. Same as Fig. 5 above showing only the x = +/- 1 cm.

(6) Sextupoles and Octupoles:

These are used to correct optics to 3^{rd} order as was the case for LESBIII. Even with the reduced phase space of K0.8 the 2^{nd} order corrections are needed as Doornbos pointed out and I agree with. The need for the Octupole, however, was stated but no back-up material provided.

Recommendation: RAYTRACE (or equivalent) simulation that takes into account 3^{rd} and higher order optics should be done. quadrupole fringe fields should consider using rotated 2-jaw collimator here.

(7) Production target issues:

The LESBIII target was designed with respect for the potential for a pion source that originates in material either in the target or its holder. Fig. 7 is an x-y histogram of cloud pions at the production target of K0.8 gated by cloud pions that are transported to the HFOC . The separator is at full field and initial phase space is as was outlined in Fig. 5. As can be noted the x-y area nominally traversed by the beam has no events so the elimination of direct pions is good. The case was similar for the LESBIII beam line and the target and holder were designed so as to not overlap cloud pion events. For the case of a positive phi kick in the separator as in the simulation that was used to generate the histogram in Fig. 7, this would dictate a target holder that extended above the target. As I understand it the K0.8 target is a 28 cm diameter rotating Nickel disc (roughly drawn in Fig. 7) with the protons hitting an edge such that the secondary beam for K0.8 must pass through the full z extent of the target. There are then three issues with the target that I'm aware of:

1) The target could act as a source of pions from points that overlap the K0.8 cloud pion acceptance

2) Kaons will be absorbed and lost (20%?)

3) Multiple scattering of the pions (and kaons) will increase the apparent size of the pions resulting in an increased image size at the mass slit.

These target issues were not accounted for in the Doornbos report. Since the target is only 0.3 interaction length and relatively low Z the two issues 1) and 3) above may be of little consequence but a good target model should be developed.

Recommendation: RAYTRACE (or equivalent) simulation that takes into account 3rd and higher order optics should be

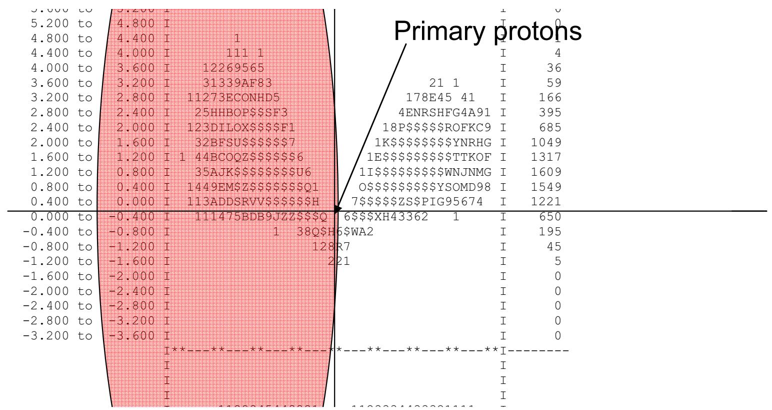


Fig. 7. x-y histogram of cloud pions at production target gated by those that reach HFOC. Initial phase space as in Fig. 5. The ellipse shows the approximate profile of the rotating Nickel target.

(8) General Comments:

I like the Doornbos optics design..I tried others that looked better in first order but couldn't compete with the Doornsbos solution to second order. Below is a second order transport profile for one of the alternate solutions with 0,1,2 and 3% dp/p and your x,theta,y,phi. The problem is I could not rid of enough of the direct pions in the tails. In this design I tried to momentum collimate upstream of IFY so that a cleaner image was presented to IFY and to cleanly transport the beam that emerged from IFY. The profile was generated with the same phase space as the Doornsbos beam line.

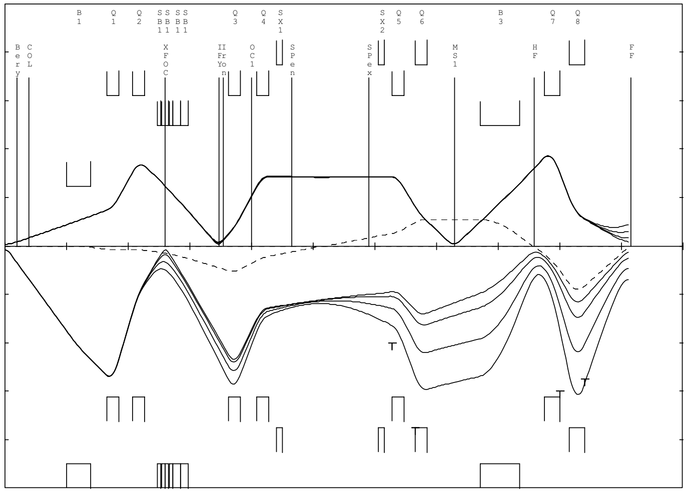
So…all in all I think Jaap has done a superb job with the optics, especially considering he had to work around the already designed K1.1 beam line. I did not get into the muon issues with this review.

A comment on separator length. I do not see that a case has been made for lengthening the separator by 0.5 meters (2 to 2.5 meters) If there's room to do this you may be better served with a shorter separator with the B field separated from the E field.

I'd be happy to answer any question you or the committee may have and will in any case continue to look at the beam optics for K0.8.

Best Regards,
Philip Pile

JD Revised, with PP_tune ver5, dp/p=+/- 0,1,2,3 %



Appendix 3

Report from the external reviewer, Dr. Lau Gatignon (CERN), on K0 beam line

CERN/AB/ATB/LG 2 July 2007

M E M O R A N D U M

To: Professor J.Haba,
Members of the FIFC Committee

From: Lau Gatignon

Subject: Referee Report on the E14 neutral beam line for the FIFC Committee

---

Dear Professor Haba,

Let me start this review for the FIFC of the neutral beam line for the $K_L \rightarrow \pi^o \nu\nu$ experiment at JPARC by saying that I feel very honored by your request to help in this review. It is with great interest that I have looked at this design of this neutral kaon beam line (at CERN we have quite some tradition of kaon beam lines as well and a number of years ago we have looked into the possibilities for a neutral kaon beam for a $K_L \rightarrow \pi^o \nu\nu$ search). Let me also add that highly appreciated the prompt reply to my long list of questions by the proponents.

In fact I realized quite quickly that the arguments and considerations used for the design at JPARC are very similar to the ones we used in our pre-study at CERN. The well collimated pencil beam seemed also to us the correct way to go. Although ideally the whole beam should be in vacuum, the photon absorber is in my view indeed a 'necessary evil' to reduce the rate of the veto counters to an acceptable value and to reduce the rate of photon gas interactions in the vacuum tank. Very good vacuum is essential, also because of neutron interactions in the rest gas, and I understand that the proposed vacuum in the decay volume is indeed at a very good level.

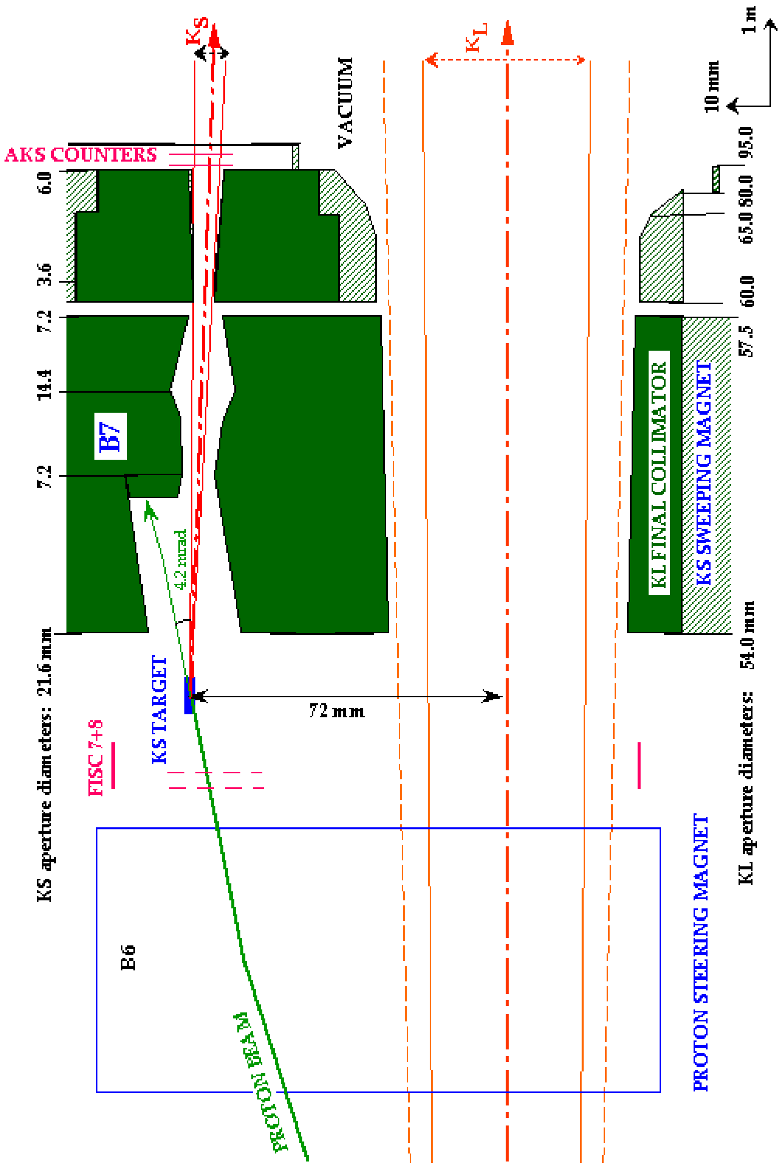
1. Collimation

I am glad to see that the team has paid great attention to the collimation strategy, which is a key factor towards correct beam performance. Unfortunately the collimation design is complicated by the need to cohabitate with other users from the same target. This has three somewhat unfortunate consequences:

1. the target has a large transverse dimension, which together with the 16^o production angle leads to an uncomfortably large source size, making it difficult to completely avoid some parts of the collimator jaws facing at the same time some part of the source and the experiment,
2. the large production angle, which reduces the kaon flux per proton substantially, but on the other hand helps to suppress neutron backgrounds by lowering their rate and softening their spectrum,
3. the presence of a sizeable amount of unnecessary material on the beam upstream of the first collimator. This material adds to the fuzziness of the beam through multiple Coulomb scattering and thus reduces the efficiency of the collimation. It also reduces substantially the kaon flux. In particular the presence of the K1.1 duct is a disadvantage.

However, within these constraints, the team has come up with a reasonable design, validated by their Monte Carlo results. The direct and simultaneous view of collimator planes on both target and detector has been minimized in terms of solid angle whilst keeping sufficient material on the passage of most particles. The first collimator is placed at about 1/3 of the way to the exit of the second collimator, which is the optimum for minimizing scattering effects on the collimator apertures. The collimator faces are oriented correctly. I assume that muons are not a problem, as the typical muon momenta are so low that they are ranged out or swept away.

A small suggestion I could make is to try a configuration similar to Figure 5 in part-1 of the proposal, but with the aperture angle of the last half of Coll 2 slightly increased, so that particles produced on the downstream edge of Coll1 cannot see the material of the second half of Coll2. Also one might consider to have the definition of the aperture cone at the center of Coll1 and the aperture at the entrance of Coll1 so large that the plane of that section has no direct view into the Coll 2 aperture. This is equivalent to lengthening Coll 0, suppressing Coll 1a and shortening Coll 1b correspondingly in Table 1. Simulation will tell whether this is better of not. As an illustration I add on the next page a picture of the design of the collimator of the NA48 K_S beam line, which had similar features incorporated. Independent of these suggestions, the collimator design chosen seems adequate, as confirmed by the simulations.



2. The photon absorber

The photon absorber is located on the neutral beam. However, it also located upstream of the sweeping magnet. If I understand the paper correctly, K1.1.D1 is not used to sweep away charged secondary particles. The absorber will thus not only convert photons into electron positron pairs, but also produce photons from electrons, still present in the beam. In fact the absorber could be seen as part of the target. In case the K1.1.Q1, Q2 and D2 would not yet be installed, it might be helpful to use K1.1.D1 as an initial sweeping magnet, complemented with appropriate dumps. It may also help to remove some background from high momentum muons that would miss the aperture of the sweeping magnet. I have sent a question on this feature to the proponents and I am looking forward to their answer.

The thickness of the photon absorber is substantial, driven by the need to reduce the amount of photons by a large factor. The side effect of this is obviously interactions and scattering of the particles in the beam, thus further reducing the kaon rate and adding to the effective source size as seen by the collimation system. I have seen groups using aligned crystals, made of e.g. Tungsten or Iridium, to enhance the photon conversion efficiency. This would allow to reduce the thickness of the absorber and hence its adverse effects, while maintaining the photon conversion efficiency. However, I must admit that the size of your absorber (both in diameter and thickness) is rather large. I do not know whether mono-crystals of such dimensions can be obtained easily. But maybe it is a suggestion for consideration.

3. Beam performance

I appreciate the huge amount of detailed simulations. The authors have done their best to optimize the target performance, taking into account the constraints from other users on the size and shape of the target. In view of the good level of agreement between the different simulation tools used, the results are reasonable and credible.

I support the authors in underlining the importance of a detailed beam survey as soon as possible. The effect on the halo of small misalignments inside a collimator and between target and both collimators can be large. The multiple scattering of particles on the different collimators are parts of the tails of the distributions, therefore a measurement will be the ultimate validation of the beam line design.

A pre-alignment will be made with a laser system. I understand from the proponents that the final alignment will be verified and if necessary adjusted with the neutral beam itself. The motorizations are of sufficient range and precision to allow such fine adjustments. The proponents confirmed that they have sufficient instrumentation available, using either the calorimeter, using the center of gravity of the 6 photons from $K_L \rightarrow 3\pi^o$ decays in calorimeter, or by minimizing the rates and maximizing the up/down and left/right symmetries in the collar counters.

The duty cycle of the beam is over 20% and there should be no or little remaining RF structure in the extracted beam. This will be helpful to not only for the data collection rate, but also to reduce pile-up effects and the resulting backgrounds.

Conclusion:

I conclude that in spite of some constraints from other beam lines the present design is well thought through and it should in my view work according to what the authors have specified. This is corroborated by the convincing results of the simulations, that reduce neutron backgrounds to the 10^{-4} level.

Nevertheless I underline, like the proponents, that a beam survey beforehand is vital and also that the final alignment of the collimators must (in my view) be done with the neutral beam.

Finally I consider that the Step1 experiment will be a useful and necessary element on the way to the beam for Step 2, for which I hope and assume that the external constraints on the beam design can be mostly avoided. In particular I hope that at that stage a beam without unnecessary material can be provided. This would allow a more optimal collimation scheme and a of course a substantially higher kaon rate.

Let me finish this review by encouraging all the teams involved and by expressing my hope that this beam and experiment will become a success.

Yours sincerely,

Lau Gatignon