Letter-of-Intent for Test-beam Facilities at J-PARC

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1 Purpose and Importance of Test-beam Facilities at J-PARC

Detector technologies for high-energy experiments nowadays have become very complicated and of cutting-edge. Those technologies and devices must be tested and verified carefully at every stage: designing the detector system, examination of test module performances, and validation of prototype detector performances. For these purposes, test-beam programs are mandatory.

KEK-PS has been providing precious and unique opportunities of test-beam programs for 25 years. This, however, has been determined to be shut down at the end of JFY 2004 due to the J-PARC construction. At this occasion of the call of LoI for J-PARC experiments, we would like to propose construction of test-beam facilities in the K-hall at the first phase, and in dedicated halls attached to the 50 (30) GeV main-ring beam line and/or to the 3 GeV booster beam line at the second (or could be further later) phase.

KEK-PS has been providing two test-beam lines, T1 and $\pi 2$, over a quarter century. They have been extremely precious for detector development of hundreds of KEK-PS experiments, TRISTAN and KEKB experiments, and many others carried out at FNAL, BNL, SLAC, CERN, DESY etc, as well as experiments currently under construction such as ATLAS. So far, about 18 experiments are carried out every year on average, with total allocated beam time of $\sim$300 shifts/year. We have not had current prosperity of the high-energy physics in Japan without them. They should also have been going to play an essential role in detector development for JLC, SuperB, and many experiments to be proposed at J-PARC such as a long-baseline neutrino oscillation experiment and kaon super-rare-decay experiments, if not terminated. Construction of test-beam facilities which succeed their role is of vital importance.

In addition, test-beam experiments have been very good educational programs for students. Current particle experiments are large-scaled and long time-ranged, and hence one can not participate in all steps and subsystems of experiments. In the test-beam experiments, on the contrary, students can work on designing, construction, set-up, data-taking, analysis, and publication of the results, with actual work on all sub-detectors. This precious experience is something which present particle experiments can not provide.

At the T1 and $\pi 2$ beam lines, unseparated beams of momenta up to 4 GeV/c with momentum bite of 1% and inclusive intensity of several thousands per spill are available. These performances, together with equipments presently provided at the T1 and $\pi 2$ area, are the baseline requirements for the test-beam facilities. Those baseline requirements imposed to the new test-beam facilities are described in the section 2. Other optional, but very important, requests are also described there. A summary is described in section 3.

2 Requirements on the beam and the area of the test-beam facilities

The baseline of the requirements on a new test-beam facility at J-PARC is to be a specification of the $\pi 2$ beam line at KEK-PS. Better beam quality and facilities in the beam area, however, will also be important and desired. In this session, requirements on the beam and the area of the test-beam facilities are described.

2.1 Beam requirements

Major requirements to the beam characteristics are summarized in Table 1. Most of the requirements are similar to the T1/$\pi 2$ properties: one exception is the maximum beam momentum. In order to have complementary features of the test-beam facilities over the world (CERN, FNAL, etc), it is highly required that the beam momentum should range up to 10 GeV/c. Since several users need to stop an incident beam inside their equipments, lowest momentum is to be less than 0.5 GeV/c. Momentum bite of 1 % should be good enough for the most of test experiments. However in case no momentum-analyzing magnet is provided in the beam area, better momentum bite must be available at the sacrifice of the beam intensity.

Variable beam intensity is to be a very crucial issue. Users sometimes need to have an intensity of a few particles per spill to avoid a pile-up effect of their equipments. On the other hand, several users need to have high statistics in their test experiments or to study the response of their equipments under the high intensity condition up to a thousand particles per spill. Thus user-adjustable intensity of the beam is strongly required.

Test-beam should consist of electrons/positrons, kaons, anti-protons and deuterons as well as pions and protons. In a low momentum region below $\sim$2 GeV/c, separated beam by a DC separator will be desired to enhance the population of rare species, as is provided at K2 beam-line at KEK-PS,

Table 1: *Requirements to the beam properties.*

	must/indispensable	should/required	desired	preferred/optional
momentum	0.5$\sim$2 GeV/c easily tunable	up to 10 GeV/c		
momentum bite	less than 1%		analyzing magnet	
intensity [particles/s]	electrons: 1$\sim$10 inclusive: 1$\sim$100 easily tunable		up to $\sim$100 up to $\sim$1000	
particle species[1)]	unseparated $e\mu\pi Kp\overline{p}$		DC separator[2)]	e-enriched tertiary
time structure	flat-top			chopper

1. Polarity of the beam line must be easily switched, including the DC separator, to obtain both positive and negative particles.
2. Existing at K2, and can be transfered to the new facilities.

A beam spill should have flat-top time structure to provide uniform intensity in the spill. As for the time structure, it would be useful, in some special detector-readout schemes, to have a chopper magnet to thin out the bunch population to make inter-pulse time longer.

It is very useful to have an option of the electron/positron-enriched tertiary beam by using a sweep magnet and a removable converter just after the primary target.

Finally the operation of the test-beam should be easy even for a novice. Users do not want to spend their short beam time to study the property of the beam nor to find proper beam parameters. Well-known beam parameters should be provided by the experts and the beam control system should be designed to be convenient to the unexperienced users and to be robust against the human errors.

Table 2: *Requirements to the area utilities.*

	must/indispensable	should/required	desired	preferred/optional
number of lines	1		2 (isolated)	
beam height	$\geq$1.8m			
hoist: lifting height lifting weight	 $\geq$3m $\geq$several hundred kg	 $\geq$5.5m $\geq$30ton		
area sizes		$\sim$10m-long $\sim$6m-wide	$\sim$12m-long $\sim$8m-wide	non-magnetic floor
electricity and infra- structure	stabilized 100V 100A[1]	UPS 100V 30A[1] 3-phase 200V 30A clean ground		homeothermal water
counting room	exist	2-groups capacity		
	network	CATV monitor		
	telephone over Japan			
equipments	moving stage[2] ($\geq$a few hundred kg)		moving stage ($\geq$30ton)	
		large-aperture magnet (2T)[3]		strong magnet ($\geq$3T)
		gas Cerenkov counter[1]	tracking chambers[4]	
			momentum- analyzing magnet[5]	

1. Existing at π2/T1, and can be transfered to the new facilities.
2. Many moving stages up to $\sim$several tons exist at KEK-PS E-hall, which are of user-properties. They may be transfered to the new facilities.
3. Ushiwaka at π2 can be transfered to the new facilities.
4. Readout electronics should also be provided.
5. Former D5 at π2 can be transfered to the new facilities.

2.2 Area requirements

Well-maintained beam areas are inevitable to carry out test experiments efficiently. Users can concentrate on their own equipments during short allocated beam time if utilities such as a moving stage, particle identifiers, a momentum analyzing magnet and beam tracking devices are provided as a common facility. Two or more test-beam areas are desired in the J-PARC, which are completely separated radiation controlled areas, to carry out one test-beam program and preparation for another in parallel.

2.2.1 Size of the beam area

In order to discuss the size of the beam area, we have to assume the size of the equipments to be tested in the area. Here we defined a maximum size and weight of the equipments to be 3.5 m and 27,000 kg, respectively, which correspond to the size (height) and the weight of a burden to be allowed to transport on roads with regular permission.

Beam area should have a depth of 10 m and a width of 6 m, which is needed to carry out position scan of 3.5m-long device from its center to the end. A wider width of 8 m is desired to enable the survey of the position dependence over its full span. In order to illuminate the center of the equipments up to 3.5 m-high, the height of the beam should be higher than 1.8 m from the floor level.

Since some equipments do not accept a residual magnetic field in the beam area, the floor of the beam area is preferred to be non-magnetic, but to be electrically grounded.

2.2.2 Utilities in the beam area

A hoist is mandatory to install user equipments into the beam area. Capacity of the hoist should be more than 30,000 kg, which accepts the maximum weight of the equipments defined above. The head of the hoist should climb up to 5.5 m to handle 3.5 m-high equipments.

Many users are to move or rotate their equipments to survey its position and angle dependence to the incident particles. A moving stage (X, Y and rotation) is strongly required in the beam area. The capacity of the moving stage must be at least a few hundred kg, which most of university laboratories can handle, and is desired to be 30,000 kg, the assumed maximum weight.

Several particle detectors are preferred to be provided as a common facility. A set of gas Cerenkov counters was used as an electron identifier in the $\pi 2$ beam line at the KEK-PS. Again in the J-PARC, a set of gas Cerenkov counters will be required. Drift chambers in the test-beam area have been desired by many users. These chambers are used to track incident particles event by event as well as to study beam profile. Past users in the KEK-PS spent their beam time to set up drift chambers by themselves. The beam-test at the J-PARC will become more efficient if those tracking devices are provided as a common facility together with their read-out electronics. The trackers can also be used as a part of momentum analyzer described below.

Sometimes a user has to know precise momenta of the incident particles just in front of their equipments. A small-gap dipole magnet is desired as a momentum analyzer. In addition to this small-gap magnet, a large-gap magnet providing up to 2 T is strongly required in a beam area to study the response of the equipments in a strong magnetic field.

Good condition of the electricity is also important. Stabilized power supply is strongly required. Uninterrupting power supply should also be provided. 100 V 100 A (stabilized), 100 V 30 A (uninterrupting) and 3-phase 200 V 30 A would be required to the test-beam area and the electronics hut. Clean ground should be defined inside the beam area and in the electronics hut. It would be useful if homeothermal water is provided to keep the temperature of detectors stable: for some devices, it is essentially important.

The electronics hut should have large capacity to accept two or more user groups simultaneously. In the hut, information such as the accelerator status and the beam intensity should be provided. A network service, sufficient IP addresses, and a few PCs which can be used for data taking/monitoring are of essential importance. A telephone line is also indispensable which can be called directly from the outside of the J-PARC to keep communications with user's home institutes.

3 Summary

In principle, LoI for construction of test-beam facilities themselves may deviate from the very purpose of LoI: what must be called for are LoIs for test-beam programs at test-beam facilities rather than LoIs for construction of test-beam facilities. However we dare submit an LoI for construction of test-beam facilities here since there are no plans at present for construction of test-beam facilities.

The most important condition to the test-beam facilities at J-PARC is that at least one channel does exist attached to the currently-postulated extraction lines in the K-hall at the first day of the operation, even though the performances are limited. Test-beam of momentum up to $\sim$2 GeV/c with intensity of $\sim$ten particles/sec will be adequate for many test-beam programs.

Eventually we hope two extraction lines will be constructed in a dedicated test-beam hall. One beam line is for general users with baseline requirements. We prefer to have a switching dipole-magnet at the end of the beam line to feed the beam into two areas separated by a radiation fence, so that one user can carry out a test experiment with the beam while the next user can do a preparation without beams simultaneously. This, however, can be a optional feature to be realized at the later phases.

Another beam line will be to provide beams with the highest momentum. Desired but not mandatory criteria, which require expensive equipments, are to be satisfied in this line. But, if budget situation is tight, this high momentum beam line can be realized after the construction of the low momentum beam line described above.

Another key issue for the test-beam is availability in a year. During the extraction period to the neutrino beam line, the beam may not be delivered to the K-hall. In order to realize full availability of the beam through a year, construction of the test-beam line at 3 GeV booster area, for example, should be seriously thought out. In case an unseparated beam can be extracted with an intensity of one or two particles per spill at the 25-Hz repetition rate, this beam line becomes suitable for test experiments which just need to expose their equipments to the beam. However this request exceeds the LoI on experiments at J-PARC-PS.

Finally, we hope that procedures for test-beam experiments will be fairly simple, quick, and flexible.

As a conclusion, we have to seriously recognize that there are no hadron beams in Japan during the transition stage from KEK-PS to J-PARC-PS. Further unavailable time has to be avoided to keep our activity for detector R&D. We, in the High Energy Community in Japan, shall make every effort to realize an efficient beam-test facility at J-PARC.