PRIMAY AND SECONDARY BEAM LINES AT THE KEK 12GeV PROTON SYNCHROTRON

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Abstract

Performance of primary and secondary beam lines of the KEK 12 GeV Proton Synchrotron (KEK-PS) will be described. -- The KEK-PS is the first accelerator constructed at KEK and is still serving physicists with excellent beams. Now two experimental halls, i.e. the North Hall and the East Hall are ready for counter experiments using proton beams slowly extracted from the KEK-PS. Several target stations are prepared in both halls to produce secondary particles such as pions, kaons and antiprotons by irradiating heavy metal targets. Secondary particles thus produced are collected and momentum analyzed by secondary beam lines and are provided for experimenters. For kaon beam users, well established electrostatic (DC) separators are installed in the secondary beam lines in order to produce well enriched kaon beam and to eliminate unwanted pions and/or protons. For the direct users of primary protons, two especially designed primary beam lines are prepared to provide halo-free clean beams.

1 PRIMARY BEAM LINES

Two primary beam lines are prepared to introduce protons to the north experimental hall (Extracted Proton beam line No.1, EP1) and to the east experimental hall (Extracted Proton beam line No. 2, EP2). The EP1 was initially constructed for the fast extracted protons dedicated to the bubble chamber application in 1977 and was shut down in 1981. The new (and present) EP1 was constructed in 1990 when the new (and present north) counter experimental hall was built in the former bubble chamber site. The EP2 was completed in 1978 as the slow extracted proton line from the beginning and is still active even at present. The reason why the new EP1 and new counter experimental hall (the North Hall, hereafter) were built is to handle intense protons up to 10^{13} pps (protons per second) which is almost 10 times larger than the acceptable intensity of the old experimental hall (the East Hall, hereafter) and EP2, and is expected to be delivered by the upgraded KEK-PS soon.

The maximum intensity of EP2 is now limited by the beam loss along the beam line and by the tightness of the radiation shielding. The EP2 consists of three branch lines EP2-A, B, C and the most upstream matching section, EP2-0. The extracted beam is divided to three parts for A, B, and C, by means of Lambertson type septa placed between 0-line and A-B-C branches. Unfortunately the beam loss at the septa reaches about 20-30% of extracted full beam intensity in the case of two/three way splitting. This is partly because of the mismatching between the emittance of the extracted beam and the acceptance of the Lambertson septa. Relatively week radiation shielding of EP2 consisted of many pieces of concrete blocks also limited the maximum beam intensity of EP2. Only the imperfect radiation shielding could be realized by means of such shield structure as the East Hall. By reviewing these problems experienced at EP2, we have designed and constructed the new EP1 and the North Hall to handle one order of magnitude higher intensity than that of the EP2 and the East Hall. The new cascade targetting method so called the Beam Swinger Optics (BSO)[1] was developed and was employed in order to irradiate two or more thick production targets at the same time instead of the traditional beam splitting scheme. The most parts of the radiation shielding of the new hall consist of bulk concrete. The concrete blocks were used just for the ceiling part of the shielding, which was necessary to remove troubled beam line elements by using an overhead crane. In addition, all the beam line elements are manufactured as radiation-resistant components. Quick disconnect system of cooling water, electric power, monitor signals, and vacuum ducts were newly developed for the construction of the new EP1. Results of such R and D works have already been published elsewhere[2]. The new EP1 has been operated approximately 8 years without any serious failure.

2 SECONDARY BEAM LINES

12GeV protons extracted to the experimental halls generate secondary particles such as pions, kaons and antiprotons by irradiating metal production targets.

Two production targets are under operation in the cascade way at the EP1 line in North Hall. The low momentum separated beam channel, K5, is connected to the upstream target and the medium momentum separated beam channel, K6, is provided secondary particles by the downstream target. The main characters of K5 and K6 are summarized in Table I. The EP1 line has a long branch, EP1-B, which was originally designed for the extraction of low intensity primary protons in the experimental area. This EP1-B can be used high momentum test beam channel by putting a small production target at the branching point from the main stream EP1 line (here after EP1-A).

Table I: Secondary beam channels at the North Hall.

Name	Specification ~Max. mom.	Prod. Angle (degree)	Ref. No.	Status
K5	Separated beam, ~0.65GeV/c	0±3.	1	Active
K6	Separated beam, ~2.0GeV/c	0	1	Active
EP1 -B	Test beam, ~8GeV/c	~3.		Active

In the East Hall, four targets have been operated for a long time. The EP2-A line has one target which provides secondary particles to the medium momentum separated beam channel K2. The low momentum πμ channel is also connected to the same target as K2. The EP2-B line had two targets in the cascade way. The upstream target provided secondary particles to high momentum unseparated beam channel π1, high momentum test beam channel T2. The π1 beam channel had three supeconducting dipoles and the maximum momentum available was 9 GeV/c. After the shut down of the superconducting dipoles, π1 was replaced by high momentum test beam channel T3. The maximum momentum of T3 was 6 GeV/c because of relatively low magnetic field of normal conductor dipoles. The downstream target of the EP2-B was connected to neutral kaon beam channel, K0. This cascade targetting system of the EP2-B was designed and constructed before the development of BSO, the production angle of the secondary particle from the upstream target could not be set at zero degree. The EP2-C line had one target which connected to low momentum separated beam channel, K3. The double stage separated beam channel K4 was the extension of the K3. Now, unfortunately, production targets of EP2-B line has been shut down in order to save magnets and power supplies for the construction of new neutrino beam channel. The EP2-A and C targets are still active even at present. Characteristics of K2, π1, T2, T3, K0, K3 and K4 beam channels are summarized in the Table II.

In order to realize very good "separated" beam channels, new type of DC electrostatic separator with built in high voltage generator was developed. An electric field of 50~100 kV/cm can be achieved by the KEK-type DC separators[8]. The K2 and K6 beam channels employed 6m long 10cm gap separator and the K3 and K5 were built with 2m long 15cm gap separator with crossing magnetic field.

Table II: Secondary beam channels at the East Hall.

Name	Specification ~Max. mom.	Prod. Angle (degree)	Ref. No.	Status
(Beam lines from the external targets)				
K2	Separated beam, ~2GeV/c	0	3	Active
πμ	Unseparated beam ~0.3GeV/c	150.0	4	Active
π1	Unseparated beam, ~9GeV/c	1.5	5	Closed
T2	Test beam, ~6GeV/c	15.0		Closed
T3	Test beam, ~6GeV/c	5.5		Closed
K0	Neutral beam,	0~5.0		Closed
K3	Separated beam, ~1.1GeV/c	0	6	Active
K4	Double Stage Separated beam, ~0.7GeV/c	0	7	Closed
(Beam lines from the internal target)				
π2	Unseparated beam, ~4GeV/c	10.0		Active
T1	Test beam, ~2GeV/c	23.0		Active

3 OTHER BEAM CHANNELS

For primary beam users, two beam channels were prepared. The EP1-B channel is the branch of the main EP1-A line in the North Hall and is the first channel designed and constructed exclusively to the primary beam experiments which require very small beam halo contamination. The P1 channel is prepared at the downstream part of EP2-A line in the East Hall. The P1 channel was initially designed for the production of lambda hyperon beam[9] in 1979 and was modified to the monochromatic neutron beam[10] channel by using the disintegration of high energy deuterons accelerated by the KEK-PS. After the completion of the neutron experiments, the P1 was modified again for the high energy test beam channel using the primary 12GeV protons directly. A series of nuclear multifragmentation experiments[11] were performed at P1. Both beam channels, EP1-B and P1, can handle protons and other particles up to 1 x 10^9 nucleons per second accelerated by the KEK-PS. For the experiments using primary beam directly, the double slow extraction (DSE) from the KEK-PS can be performed. In the DSE mode, 99% of the accelerated beam is extracted to one experimental hall and 1% is for the other hall. Thus the coexistent operation of the secondary beam users and the primary beam users can be achieved.

Two beam channels, T1 and $\pi 2$, connecting to the internal target of the KEK-PS have been active also in the East Hall since 1977. Performances of these two channels can be seen also in the Table II. Now these two channels are used as test channels and are the most busy ones in the East Hall. Detectors developed and prepared for the most KEK-PS experiments usually experience their first beam there. The beam tests and R and D works of components of many "famous" large scale detectors such as ATLAS, BELLE, PHENIX etc. are also very active with beams from T1 and $\pi 2$.

4 SUMMARY

History and present status of the primary and secondary beam lines of the KEK-PS are briefly summarized. Now the East Hall is going to the shut down stage. It is partly because of the effective use of limited resources of magnets, power supplies and engineers/physicists for the design, construction and operation of the new neutrino beam line. The primary EP1-A line is now being extended to the outside of the North Hall and bent approximately 90 degree to west direction in order to generate the neutrino beam and to shoot it to Super Kamiokande Cosmic Neutrino Observatory, which is 250 km far from KEK. Fast extraction system will be installed in the KEK-PS in order to realize the pulsed neutrinos of approximately 1μs beam width. Details of the new neutrino beam line will be covered by Ieiri et al.[12] in this conference. The other reason is the preparation for the Japan Hadron Facility (JHF)[13] which is the main future project of hadron accelerator science in Japan. In the JHF era, the East Hall will be converted to an experimental area of the neutron scattering facility. An intense spallation neutron source will be constructed in the central region of the East Hall. The most secondary beam channels in the both North and East Halls will be moved to the new experimental area of the 50GeV Proton Synchrotron which is the main accelerator of the JHF. The total scheme of the JHF project is available at the JHF promotion office of KEK.

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