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LOW ENERGY KAON BEAM LINES AT KEK

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ABSTRACT

The results of the measurements of the characteristics of two low energy separated beams, K2 and K3, are reported. The performances of the electrostatic separators used in those beams are also presented.

INTRODUCTION

In 1976, it was decided to construct two low energy separated beams for counter experiments as the first secondary beams produced by the primary protons extracted slowly from KEK 12 GeV Proton Synchrotron.[1] One of them (K2) was designed to transport secondary particles in the momentum range of 1 - 2 GeV/c, while the other (K3) was for the particles with the maximum momentum of 1 GeV/c. A 6 meter and a 2 meter long separators are used for the mass separation in the beam K2 and K3, respectively. These beams had been completed last autumn and the measurements of the beam characteristics were made in November and December 1978. In the following, the outline of the beams and the results of the measurements are presented as well as the performances of the separators installed in the beams.

BEAM K2

The beam K2 was designed to transport well separated kaons and antiprotons to a experimental target at the momentum range of 1 - 2 GeV/c.[2] The central production angle of 0° was chosen. The solid angle momentum acceptance was calculated to be 6.25 msr%Δp/p. The wanted particles are separated from the other particles using the electrostatic separator and are transported to the final focus where the experimental target is located. At the final focus, the dispersion and the angular dispersion are made to vanish. The fluxes of 5×10^5 K^+, 2.7×10^5 K^- and 7×10^4 $\bar{p}$ were expected at 2 GeV/c for 10^{12} 13 GeV/c incident protons into the 3 mm diam and 60 mm long Ir target with the target efficiency of 0.5. The layout of the beam is shown in Fig. 1 and the designed beam characteristics are shown in Table 1.

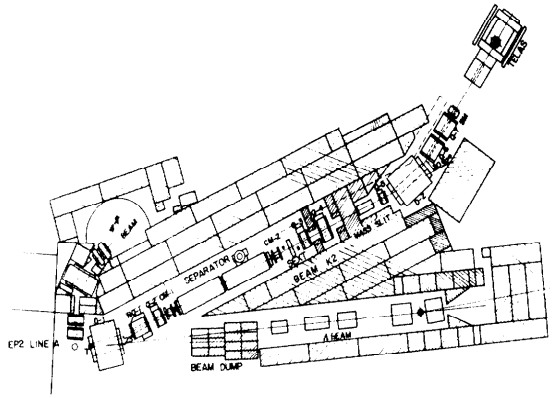

Fig. 1. Layout of the Beam K2.

Table 1
Characteristics of Beam K2

Momentum range	1 - 2 GeV/c
Target	3 mm diam × 60 mm Ir
Central production angle	0°
Beam length	27.9 m
Solid angle acceptance	1.02 msr
Horizontal acceptance	±50 mr
Vertical acceptance	±6.5 mr
Momentum bite	±3%Δp/p
Solid angle momentum acceptance	6.25 msr%Δp/p
Separator voltage	750 kV
Separator gap	10 cm
Separator length	6 m
Beam end characteristics	
Horizontal magnification	2.13
Dispersion	0
Angular dispersion	0
Vertical magnification	2.12
Horizontal image size(σ)	±0.95 cm
Vertical image size(σ)	±0.51 cm
Horizontal divergence	±27 mr
Vertical divergence	±3.6 mr
Yields expected for 10^{12} 13 GeV/c ppp	
2.0 GeV/c K^+	5.0×10^5
K^-	2.7×10^5
$\bar{p}$	5.6×10^4

The tuning and the survey of the beam K2 were performed. The beam optics, the mass separation quality and the particle yields were measured with a counter telescope, Čerenkov counters and multiwire proportional chambers. The data taking was performed by a microcomputer system[3] with one CAMAC crate. The measured horizontal and vertical beam sizes at the experimental tartet were 25 mm and 20 mm (FWHM), respectively. The π^+/K^+ ratio of 5/3 was achieved at the momentum of 1.5 GeV/c with the separator voltage of 700 kV. The secondary particle yields produced from the 3mm diam and 6 mm long Ir target were measured for the $e^\pm$, $\pi^\pm + \mu^\pm$, $K^\pm$, p, $\bar{p}$ and d at the momentum range of 0.5 - 2 GeV/c. The results are shown in Fig. 2. The normarized positive kaon yield at the momentum 1.5 GeV/c was 2×10^5 K^+ per 10^{12} ppp.

The results of the tuning and the survey well agree with the calculated value of the beam optics, the mass separation and the particle yields.

BEAM K3

The beam K3 is a general purpose low energy kaon and antiproton beam. It can transport secondary particles with a maximum momentum of 1.0 GeV/c.[4] Mass separation between wanted and unwanted particles are done by the 2 meter electrostatic separator. The beam is designed to be operated in the two modes: the high intensity mode, K3-S, and the high momentum resolution mode, K3-L. In the former case, the production target is placed 30 cm upstream to the first quadrupole magnet to make horizontal acceptance of the beam as large as ±220 mr owing to the short distance between the target and the first quadrupole magnet. In the latter case, the production target is moved

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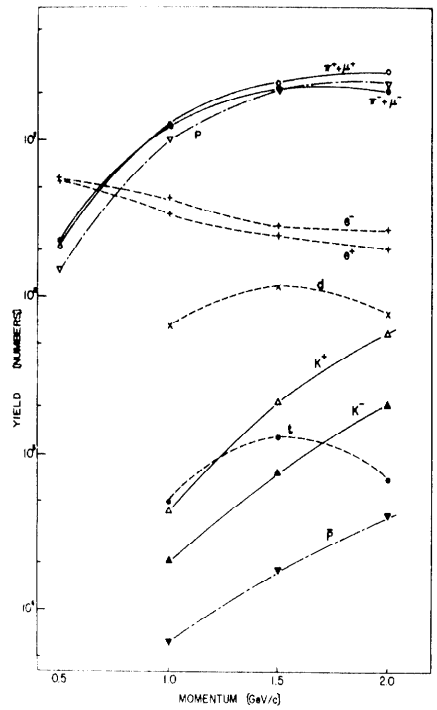

Fig. 2. Particle yields at the final focus of the Beam K2. All curves are for 10^{12} incident primary protons with the momentum of 13 GeV/c into a 3 mm diam and 60 mm long Ir target. The momentum bite is ±3%Δp/p.

further upstream to the position 1.3 meter from the first quadrupole magnet. The momentum resolution at the mass slit is improved to ±0.15%Δp/p at the expence of the reduction of the horizontal acceptance to ±75 mr. The schematic layout of the beam is shown in Fig. 3, and the parameters of the beam are listed in Table 2.

The characteristics of the beam in the K3-S mode for positive particles were measured. The measured momentum range was between 500 MeV/c and 600 MeV/c. Throughout the measurement two multiwire proportional chambers, a water Čerenkov counter, a set of scintillation counter hodoscopes, a range counter telescope, and some trigerring scintillation counters were used. Kaons were identified by a time of flight and pulse

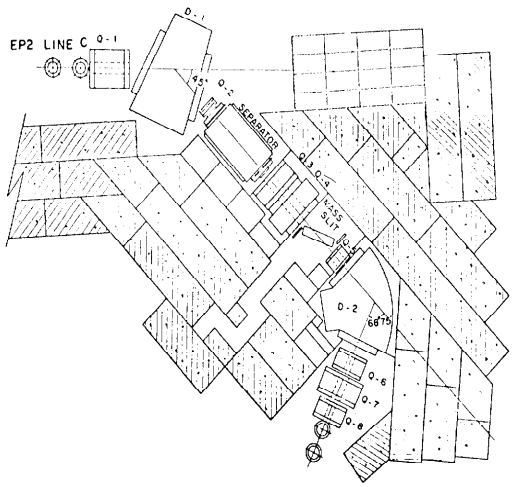

Fig. 3. Layout of the Beam K3.

Table 2
Characteristics of Beam K3

Mode	K3-S	K3-L
Momentum range	0.5-1.0 GeV/c	
Target	3mm diam 60 mm Pt	3mm diam 40mm Pt
Production angle	0°	0°
Beam length	14.45m	16.3m
Solid angle acceptance	7.3mstr	3.0mstr
Horizontal acceptance	±200 mr	±90mr
Vertical acceptance	±11.5mr	±10.5mr
Momentum bite	±3.0%	±1.8%
Solid angle momentum acceptance	48.4msr%Δp/p	13.3msr%Δp/p
Separator voltage	750kV	
Separator gap	15cm	
Separator length	1.9m	
Beam end characteristics		
Horizontal magnification	2.06	2.00
Dispersion	-0.17cm/%	0.0cm/%
Vertical magnification	0.85	0.50
Horizontal image size	1.06cm	0.86cm
Vertical image size	1.50cm	0.76cm
Horizontal divergence	±100mr	±52mr
Vertical divergence	±17.8mr	±24.5mr
Yields expected for 10^{12} ppp		
0.6 GeV/c K^+/K^-	1.1E5/2.2E4	
0.8 GeV/c K^+/K^-	3.3E5/5.5E4	7.2E4/1.2E4
0.8 GeV/c p	1.1E4	

height of the water Čerenkov counter. The data taking and handling were carried out using a micro computor system[3] with one CAMAC crate. The programs were written in CASIC language.[5]

In Table 3 measured intensity and π^+/K^+ ratio are summarized.[3] The target was 3 mm diam and 40 mm long Pt. Momentum slit was opened to transmit ±2%Δp/p particles. The data are normalized to the primary proton intensity of 10^{12} ppp.

The results of the measurements are consistent with the design values.

Table 3
Measured Yields and π/K ratio

Momentum	K^+ flux	π^+/K^+ ratio
500 MeV/c	1.4×10^4	9.5
550 MeV/c	2.4×10^4	8.0
600 MeV/c	4.2×10^4	7.4

ELECTROSTATIC SEPARATORS

The electrostatic separators used in the beam K2, K3 and other beams have been developed at KEK.[6] Feeding the high voltage from the external high voltage generators through the cables is not necessary for these separators, because the built-in high voltage generators were mounted on the separator directly. The many problems caused by the high voltage cables have been eliminated completely. The positive and negative electrodes made of stainless steel and anodised aluminum, respectively, are assembled in the cylindrical vacuum chamber and supported by the corrugated ceramic

insulators. The high voltages are fed through the ceramic bushing from the vuilt-in high voltage generators. Three types of the electrostatic separators, Mark I, II and III, have been developed. The Mark II and the Mark III are used in the beam K2 and K3, respectively. The mark II is a 6 m long separator and the Mark III is a 2 m short separator with crossed magnetic field. The cross section of the Mark II is shown in Fig. 4 and the photograph of the Mark III

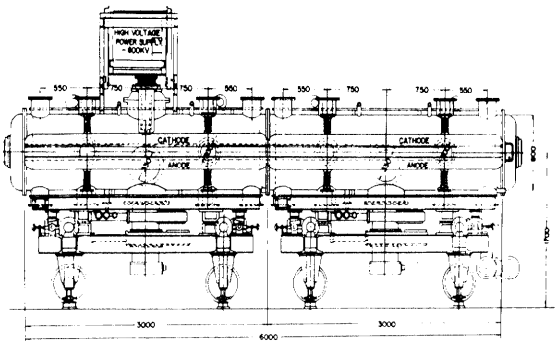

Fig. 4. Cross section of the Separator Mark II.

Fig. 5. Photograph of the Separator Mark III.

is shown in Fig. 5. The achieved maximum high voltages were 850 kV for the Mark II and 870 kV for the Mark III without crossed magnetic field.

Since last October, both separators have been operated in the beam K2 and K3. The normal operation voltage of the Mark II has been 500 - 700 kV to separate kaons at the momentum range of 1 - 2 GeV/c, while that of the Mark III has been 600 kV with the crossed magnetic field to separate kaons at the momentum range of 0.5 - 0.6 GeV/c.

A new separator (Mark II-2) has been constructed and tested last year.[7] The achieved maximum high

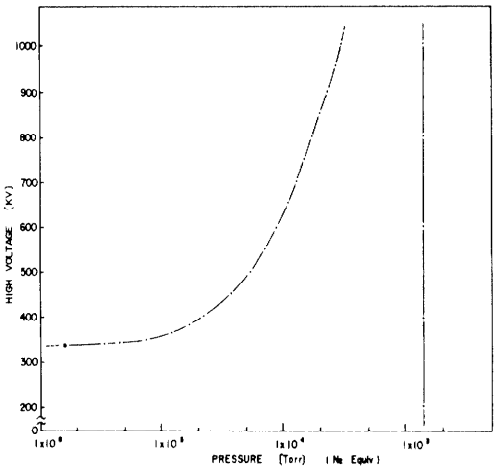

Fig. 6 Voltage-Pressure curve of the separator Mark. The electrode gap was 10 cm and Ne-He (65% - 35%) gas mixture was flowed to adjust the pressure. The spark rate was ∿2 sparks/10 min at 1,005 kV and ∿2 spark/h at 920 kV.

voltage was 1,005 kV across 10 cm spacing between electrodes with the spark rate of ∿2 sparks/10 min. The stable opration were performed at 920 kV with the spark rate of ∿2 spark/hour for 1 week without any problem. The voltage-pressure curve is shown in Fig. 6. This high performance separator was installed in other kaon beam in January 1979.

CONCLUSION

Two low energy kaon beams, K2 and K3, had been constructed in these two years and was completed successfully in December 1979. Various properties of the beams were measured. Typical yield of the beam K2 was 1.5×10^5 K^+ at 1.5 GeV/c with the π/K ratio of 3 and that of K3 was 4.2×10^4 K^+ at 0.6 GeV/c with the π/K ratio of 7.4 for the 10^{12} primary protons.

Since January 1979, the stable operation for the first physics experiments have been performed in both beams.

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