ADVANCES IN SECONDARY BEAMS AT THE 70 GeV IHEP PROTON SYNCHROTRON

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(presented by E. A. Myae)

The report on the first secondary beams constructed at the IHEP accelerator was presented at the VII International Conference on High Energy Accelerators [1]. Further development of the experimental programme made it necessary to widen the beam channel system.

Fig. 1 presents the general layout of the beams in the experimental area. Negative beams with P up to 60 GeV/c (beam 2) and P up to 40 GeV/c (beam 4)[1, 3) neutral beam 1 and beam 6 for adjusting the physical apparatus continue to operate and are modified. Beam 9 [4] that is to shape a separated beam with P = (10 - 25) GeV/c for a 2 m liquid hydrogen bubble chamber of Dubna (JINR) is in the course of construction. Muon beam channel 11 [5] is designed to transport a beam of μ-mesons with P up to 35 GeV/c to a beam stop. Magnetized iron is used as lenses and magnets in this beam channel. Description of the beam is given in a separate report [5].

Below we will deal with a number of new beam channels constructed at the IHEP accelerator during the last 2 years.

Beam 10 [6]

Some experiments, in particular, investigations with antiprotons and antideuterons required a certain beam channel and such a beam forms negative pion beams at high intensity with the momentum range (10 - 16) GeV/c with a relatively big content of negative kaons, antiprotons, antideuterons. The targets made of Al and Be of 2 mm diameter and 20 mm length were introduced in the middle of the SS between accelerator units 24 and 25. For the particles with momenta (10 - 16) GeV/c the production angles at the target were (25 - 55) mrad respectively. The optical scheme of the beam channel (Fig. 2a) is not an achromatic one. Due to this fact a thorough choice of location and operational mode of the beam optical scheme was necessary to reduce the influence of dispersions on the beam dimensions in the point of location of the experimental installation.

The maximum solid angle for capturing particles into the beam is 75 μster and the highest acceptable momentum spread is $\frac{\Delta P}{P} = 3\ \%$. The beam is mainly operated at P = 10 and 13.3 GeV/c. In this the apertures of the collimators C1 and C2 reduce the solid angle to 45 μster to match the aperture of the detecting devices. The parameters of the formed beam are given in Table 1.

Table 1

Main characteristics of the negative beams with P = 10 and 13.3 GeV/c in Beam Channel 10 (the energy of the accelerated proton beam is 70 GeV, the solid angle of capturing particles into the beam is 45 μster, the target is made of Al).

Momentum of secondaries, GeV/c	10	13.3
Particle production angle on the target (mrad)	25	47.5
Intensity of the secondaries per operational cycle of the accelerator	$5\cdot10^{6}$	$1.5\cdot10^{6}$
Relative content of negative pions in the beam *	$8.5\cdot10^{-2}$	$9.4\cdot10^{-2}$
Relative content of antiprotons in the beam *	$2.1\cdot10^{-2}$	$3.4\cdot10^{-2}$
Relative content of antideuterons in the beam *	$1.6\cdot10^{-6}$	$3.9\cdot10^{-6}$
Beam dimensions at the experimental installation, (vertically x horizontally)	4.2 x 7.0	

* The data from [7] on the target, decay and absorption taken into account.

Beam Channels 12 and 14

Both beams were created in the area of the former beam 10. The first beam was designed to perform the experiment on scattering on the negative pion beam with P = 50 GeV/c and the second one was for investigations using a polarised target on the beam with P = 40 and 50 GeV/c. Both beams together with beam 2 have a common initial part, target station (see Fig. 1) included.

Particle production angles on the targets equalled 0° for the operational values of the momenta, and the solid angles of capturing particles into the beam channel were 30 μster.

As follows from Fig. 2b and c the beam optical schemes differ in the structure of the second ob-

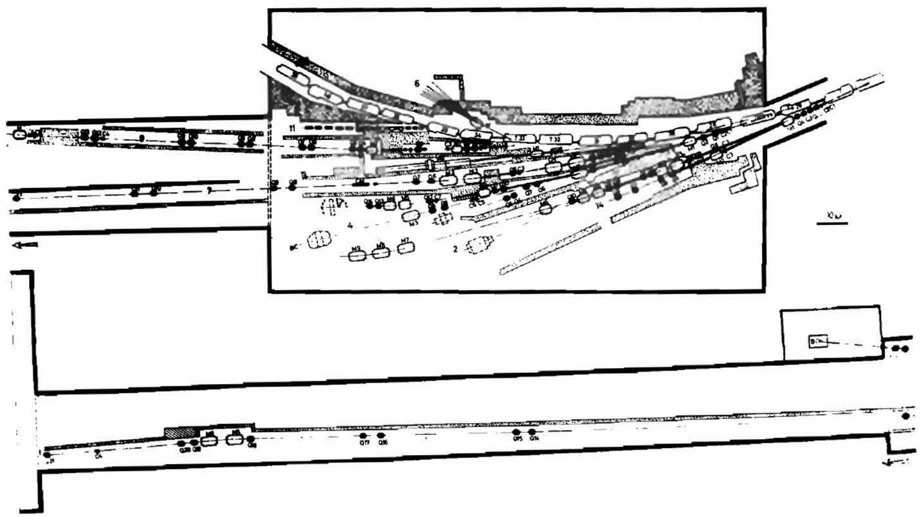

Fig. 1 - General layout of beams in experimental hall (August, 1971), M - defl. magnets, Q - quadr., C - collimators, T - targets, BC - bubble chambers.

jectives of the lenses that focus the beam on to the targets of the experimental set ups. In beam 12 the objective Q5 - Q6 shapes the beam over the distance of 38 m and its dimensions are 5.5 x 4 cm^2. (horizontally and vertically) for the value $\frac{\Delta p}{p}$ ± 1 %. In beam 14 the last objective consists of 4 lenses, Q5 - Q8, which operate as a triplet. In this the beam focused on to the polarised target is of the following dimensions : 1.9 x 1.8 cm^2 for $\frac{\Delta p}{p}$ = ± 2 %. The value of dispersion on the momentum slit C3 is 4.4 mm for $\frac{\Delta p}{p}$ = 1 % which is enough for reliable extraction of the momentum band $\frac{\Delta p}{p} \geq \pm 1$ % with an image dimension of 0.9 mm. Particle intensity of the beam at P = 40 GeV/c for $\frac{\Delta p}{p}$ = ± 1 % is $3\cdot10^6$ per cycle and at P = 50 GeV/c it is $4\cdot10^5$, (energy of accelerated protons 70 GeV and intensity 10^{12} protons/cycle).

Positive Secondary Beam[8)]

Ejection of positive particles, produced at the target at small angles is difficult due to reverse action of the fringing fields of the accelerator especially when one tends to shape the beams in the same direction in a wide momentum range. At the IHEP accelerator the application of magnetic screens and the system of three targets provides positive beams (protons, pions, kaons and deuterons) in one beam channel with the momentum range (25 - 70) GeV/c with a fixed energy of the accelerated protons of 70 GeV.

The screens made of soft steel (see Fig. 3) decrease the magnetic field 50 times (screen N 1) and 5 times (screen N2). At the first screen geometry chosen there are no considerable distorsions of the magnetic field in the neighbourhood of the accelerator equilibrium orbit. On the other hand

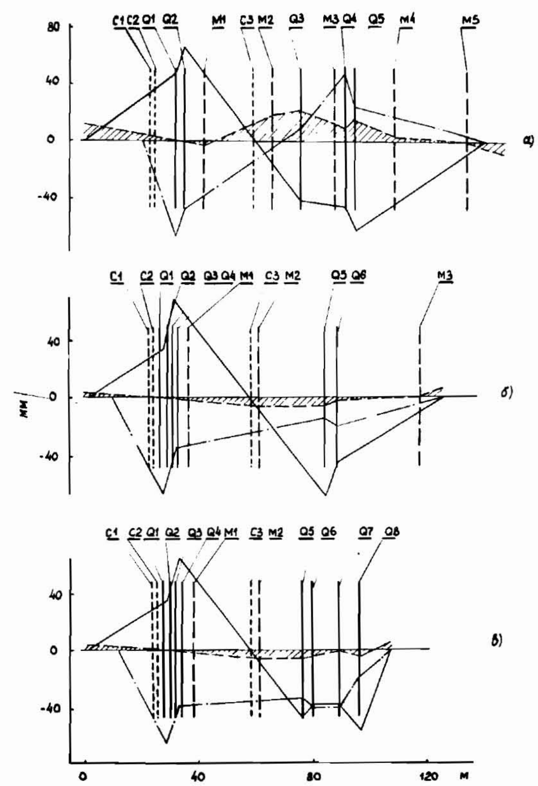

Fig. 2 - Optical schemes of secondary beams a) - N10, b) - N12 and c) - N14. Horizontal (——), vertical (— · —) plane, dispersion (- - -) for Δp/p = 1%.

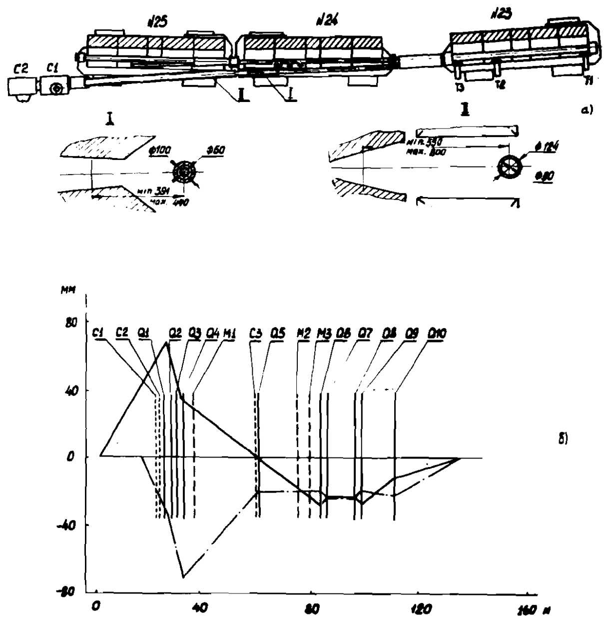

Fig. 3 - Layout of target locations (T1, T2, T3) and ejection section with magnetic screens I and II for pos. secondary beams (a) and optical scheme (b).

we can direct the ejection of positive particles closely to the one of negative particles in beam 2, (Fig. 1). Due to this reason we can use beam 2 to shape positive beams without any considerable modifications. The angles of positive particle production on the targets, situated in magnetic unit 23 vary within 48 ÷ 6 mrad and the solid angles of capturing particles into the beam are (11 ÷ 0.5) μster

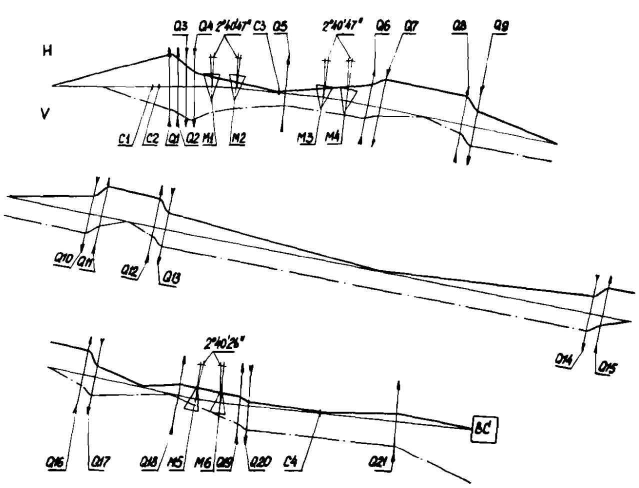

Fig. 4 - Optical scheme of beam 7 for shaping a beam of protons scattered elastically at the target.

for momentum range (25 ÷ 70)GeV/c respectively. The optical scheme of the beam operating with positive particles is given in Fig. 3b. In such a system the values of dispersion at the momentum slit C3 are equal to 8.2 mm for $\frac{\Delta p}{p}$ = 1 % and image dimensions (horizontally) at these points of (1 - 1.5) mm. Angular divergence of the beam in the area of Cerenkov counters (between objectives of lenses Q6, Q7 and Q8, Q) is not more than ± 0.5 mrad. Beam dimensions on the target of the experimental installation are 1.5 x 1.2 cm^2 horizontally and vertically, respectively.

Beam Channel 7

This beam is designed to shape separated secondary beams for the liquid hydrogen bubble chamber "Mirabell" (France) [10]. Its optics were designed so as to give a possibility of shaping beams of protons elastically scattered on the internal target with P up to 70 GeV/c. At the present moment such an operational mode of the beam has been realised using the scheme presented in Fig. 4A proton beam scattered at the angle of 12 mrad on the target situated in magnetic unit 24, is ejected into the beam channel and transported over a distance of 550 m. The solid angle for capturing particles into the beam is about 4 μster. The beam channel provides a reliable shaping of the particle beam with momentum spread of $\frac{\Delta p}{p}$ = ± 0.25 %. The dimensions of the beam in the chamber depend on the operational mode of the last lens Q21 and may reach the values (10 x 50) cm^2 (horizontally and vertically) with slow steering of the beam (up to 1 sec) on to the target [11] the intensity of the particles in the beam channel is 10^6 per cycle when the intensity of the accelerated proton beam is 10^{12} per cycle.

A system of fast steering of the beam on to the target is employed in the work with the chamber. Its duration is 0.5 sec [12]. This system together with a KM situated in the beam channel, provides control of the number of particles passing through the bubble chamber.

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