INSTITUTE OF HIGH ENERGY PHYSICS, SERPUKHOV
Preprint IHEP 70-28

HIGH-INTENSITY (10-16) GeV/c NEGATIVE PARTICLE BEAM

N.I. Golovnya, M.I. Grachev, K.I. Gubrienko, E.V. Eremenko,
V.I. Kotov, V.S. Seleznev, Yu.S. Khodyrev

Serpukhov, 1970

Translated at CERN by R. Luther
and revised by N. Mouravieff
(Original: Russian)

(CERN Trans. 71-16)

Geneva
November 1970

A channel of secondary negative particles with a momentum of (10-16) GeV/c was set up for a series of experiments at the accelerator of the Institute of High Energy Physics. The results obtained from the measurement of the negative secondary particle yields in a momentum range of (25-65) GeV/c [1,2] showed that it was possible to produce a high-intensity beam of π^- mesons which contained a relatively large number of antiprotons, K^- mesons, and antideuterons. Furthermore, the channel provided favourable conditions for the search for hitherto unobserved heavy particles, in particular antihelium-3 [3].

The layout of the channel is shown in Fig. 1; it is 110 m long. A vacuum of $\sim 10^{-2}$ mm of mercury is created throughout the channel, except for the pick-up areas. The channel is fitted with standard equipment developed at the D.V. Yefremov Scientific Research Institute of Electrophysical Apparatus. A paper[4] describes the characteristics of the channel's 20K200 and 20K100 quadrupole lenses and the SP-129 and SP-12A1 bending magnets. Another paper[5] gives basic information on the remote control of the collimators and on the accuracy of the equipment's geodetic levelling.

The secondary particles are produced by the interaction of an accelerated proton beam with an internal target placed at the centre of the straight section between the accelerator's magnet units 24 and 25 (see Fig. 1). By shifting the target along the radius by +4.5 cm to -3 cm with respect to the stable orbit, it is possible to obtain in the channel beams of 10 to 16 GeV/c negative particles when the energy of the accelerated protons is 70 GeV. The particle production angle on the target varies within a range of (25-55) mrad. These production angles were selected mainly because the proportion of heavy particles in the beam rises with the increase in the angles[1,2]. Targets with a diameter of 2 mm and a length of 20 mm, made from Al and Be, were used in the channel. The accelerated beam was guided efficiently on to the target by means of local perturbation of the equilibrium orbit at the flat top of the magnetic cycle[6,7]. Under these conditions the interaction of the proton beam with the target could be made to last for more than 1 sec [7].

The channel optics system is shown in Fig. 2. The secondary particle beam is confined at the entry to the channel by the C1 (vertical) and C2 (horizontal) slit collimators. The Q_1,Q_2 doublet of quadrupole lenses, which feature DF (defocusing-focusing) horizontal focusing, focuses the beam horizontally into the momentum collimator C3. In the vertical plane the beam is focused behind magnet M2. With due allowance for the accelerator's field, the bending magnet sets up in the momentum collimator C3 an 11 mm dispersion for 1% $\Delta p/p$, where p is the momentum of the particle and Δp is its momentum spread. With the aid of bending magnets M2 and M3 the particle beam is extracted on to a set path in the channel. The quadrupole lens triplet Q_3, Q_4, and Q_5 (with FDF horizontal focusing) shapes the beam on to the experimental device. Bending magnets M_4 and M_5 form a part of this device. The maximum solid angle for particle acceptance into the channel is 75 μsr and the maximum $\Delta p/p$ value in the beam may reach ±3%. Another essential condition for the selection of the channel's optic system, besides the area, was the fact that the beam dimensions in the vertical plane should never exceed those of the magnet apertures M1 - M4 which are 80 mm. This criterion was a key factor in the adjustment of the quadrupole lenses' operating conditions. The beam axis was aligned with the channel axis by regulating the field currents of the bending magnets and adjusting the position of the internal target in the vertical and horizontal planes using the method described elsewhere[5,8]. The beam profiles in the experimental device (in front of magnet M4) are measured by finger-action counters and are shown in Fig. 3. The calculated beam profiles are also shown (broken line and broken and dotted line). As can be seen in Fig. 3, the beam dimensions obtained correspond satisfactorily with those calculated.

The channel operated mainly with beams of 10 and 13.3 GeV/c. A 45 μsr solid angle of acceptance was separated out by the slit collimators C1 and C2 in view of the narrow aperture of the pick-up apparatus. The parameters of the beams produced in the channel are shown in the table.

In conclusion, the authors wish to express their deep gratitude to R.M. Sulyaev for his interest in the paper, and to Yu.D. Prokoshkin, L.G. Landsberg, S.P. Denisov and V.M. Kut'in for their useful assessment of channel variants and for the data on 10 and 13.3 GeV/c negative particle yields which they supplied before they had been published. The authors are also grateful to all those divisions of the Institute which operated the accelerator, channel and targets.

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Basic characteristics of 10 and 13.3 GeV/c
negative particle beams

(Accelerated proton beam energy 70 GeV; solid angle for acceptance of particles into the channel, 45 μsr, aluminium target)

Momentum of secondary particles (GeV/c)	10	13.3
Production angle of particles on the target (mrad)	25	47.5
Intensity of secondary particles per accelerator cycle at Δp = ±0.2 GeV/c and accelerated beam intensity of 10^{12} protons per cycle	5×10^6	1.5×10^6
Proportion of K^- mesons in beam *)	8.5×10^{-2}	9.4×10^{-2}
Proportion of antiprotons in beam *)	2.1×10^{-2}	3.4×10^{-2}
Proportion of antideuterons in beam *)	1.6×10^{-6}	3.9×10^{-6}
Beam dimensions in the experimental device (cm) (vertical and horizontal)	4.2×7.0	

*) Allowing for target, particle decay, and absorption

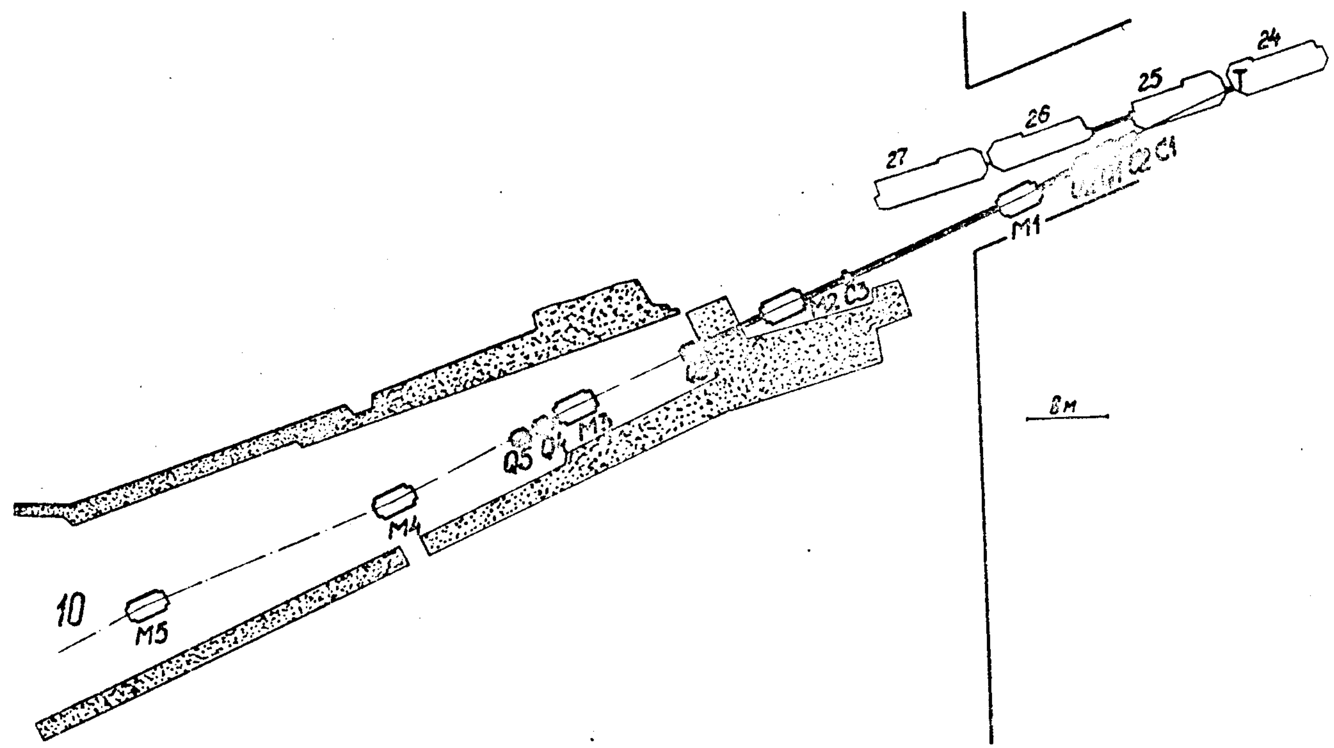

Fig. 1 Layout of the channel in the experimental hall. T - target; C1, C2, C3 - collimators; Q_1, Q_2, Q_3, Q_4, Q_5 - 20K200 quadrupole lenses; Q_3 - 20K100 quadupole lens; M1, M2, M3, M4 - SP129 bending magnets; M5 - SP-12A1 bending magnet.

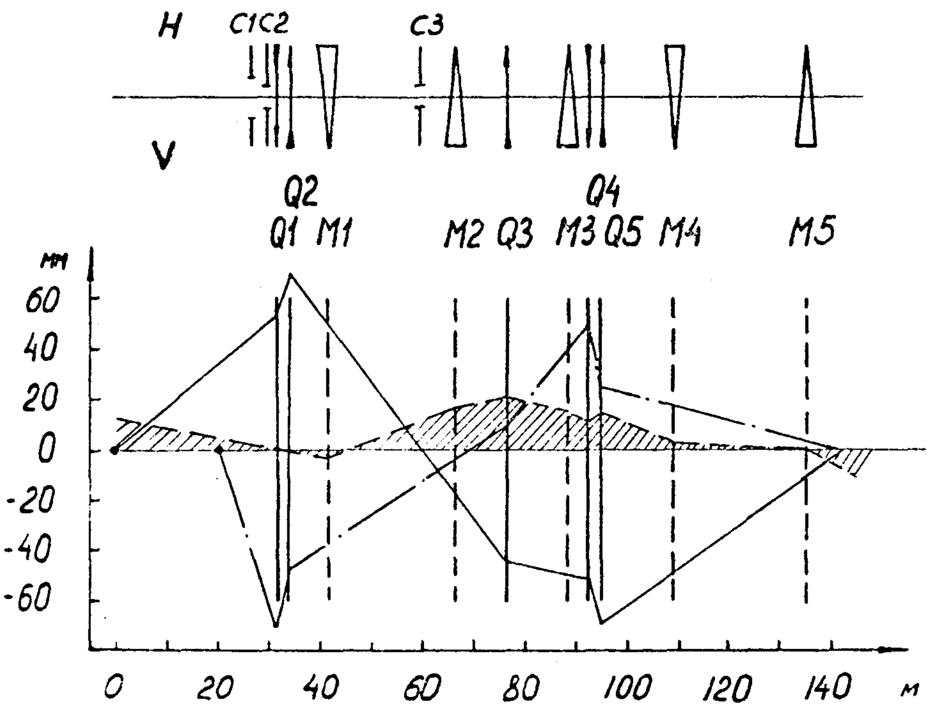

Fig. 2 Optic system of the channel. Continuous curve – path of beams in the horizontal plane; broken and dotted line – in the vertical plane; broken line – dispersion when $\Delta p/p = 1\%$.

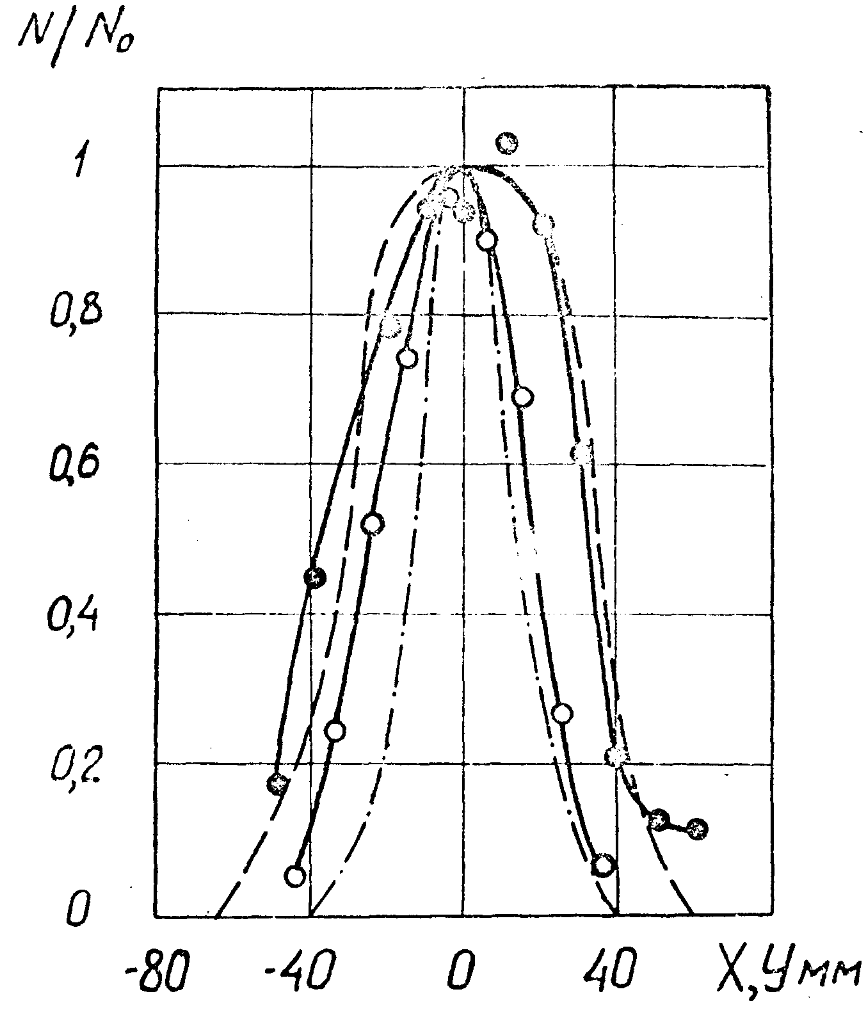

Fig. 3 Beam profiles in front of bending magnet M4: ——●—— horizontal plane; ——○—— vertical plane; broken curves and broken-and-dotted curves - relevant profiles calculated in the horizontal and vertical planes.