PECULIARITIES OF USING THE BENT CRYSTAL FOR THE EXTRACTION OF PROTONS FROM IHEP ACCELERATOR TO THE PROZA FACILITY

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1 INTRODUCTION

In 1987 when the polarization effects on the experimental setup PROZA were investigated, the indication on a possible discovery . of the unkown phenomenon, the scaling asymmetry [1] was received. The interval of the investigated energies was not large: from 13 GeV at BNL [2] to 40 GeV at IHEP. It was very desirable to extend this region to the maximum of the IHEP accelerator energy – 70 GeV by ejecting the accelerated proton beam onto the target of the experimental setup.

The ejection methods used before [3] could not ensure the required beam parameters. It was decided to investigate the possibility of the A-70 primary beam ejection by bent crystal. For the first time the attempt to realize such ejection was made in Dubna (1984) with the 7.5 GeV beam [4].

First results of the 70 GeV proton extraction from IHEP accelerator made in 1989 with the crystal of Si, istalled into the vacuum chamber of magnetic block 25 and bent by 80 mrad, were reported in [5]. In 1990 the physical use of the new method of ejection is started and a few runs of polarization experiments on the PROZA setup were done.

In the article the results of the investigation and optimization of the proton ejection to the PROZA setup during simultaneous extraction of the secondary particles to another beam lines from internal targets (IT) are reported.

2 THE PECULIARITIES OF USING THE CRYSTAL

One of the peculiarities of using the crystal for the beam extraction to experimental setup is the position of it $\sim$ 55 – 60 mm from the central orbit (in the region of the beam envelope), that is more distant than the IT working coordinates ($\pm$40 mm). To steer the A-70 primary beam onto the crystal the local distortion (bump) of the closed orbit was required. The bump is formed with an additional field ΔH generation into the magnetic gaps of the four blocks 20, 22, 26, 28 [5,6]. A such orbit bump gives a required beam deflection on the crystal asimuth and makes no aperture limitations through the accelerator.

Another peculiarity of the new method of ejection was a requirement to save a possibility of the simultaneous work with the PROZA setup of the experimental setups of another beam lines (e.g. 4 and 18) with the secondary beams: on A-70 as a rule 4-5 facilities work simultaneously with the beams from IT [7].

It should be noted, that for the beam steering onto the crystal one can use the bump which is formed with blocks 20, 21, 26, 27. Such a bump in some regimes (e.g. at the simultaneous work with nonresonant slow extraction [8,9] is more preferable.

3 EXPERIMENTAL RESULTS

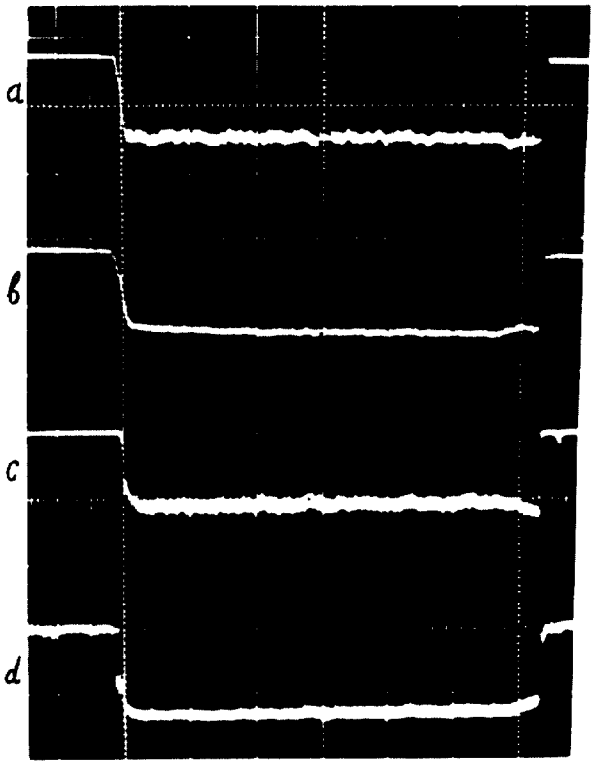

Figure 1: The oscillograms of simultaneous extraction from the accelerator different particles for different experiments. a) and d) – extraction of the 70-GeV protons by bent crystal and nonresonant slow extraction, accordingly; b) and c) – extraction of the 40-GeV secondary beams from IT. Time scale – 200 ms/div.

Fig.1 gives the impression about duration and quality of the beams, when the accelerated protons and secondaries are extracted simultaneously from the accelerator for the different experiments and to the different beam lines. The traces a) and d) of the oscillograms – a 70-GeV proton beam time structure is extracted to the PROZA (beam

line 14) with the bent crystal and FODS-2 (beam line 22) in the nonresonant slow extraction mode [8,9]. The traces b) and c) – a time structure of the 40 GeV secondary particle beams are extracted to the setups GAMS, MIS JINR (beam line 4) and GIPERON (beam line 18) from IT installed accordingly into magnetic blocks 27 and 35 of A-70. Fig.1 confirms an investigated earlier possibility of the protons extraction to the PROZA facility by the bent crystal of block 25 simultaneously with the extraction of particles for different experiments by another methods of extraction in the same accelerator cycle. A high quality of the ejected beams time structure is reached due to use of the thin IT [10], making preliminary scattering the beam before steering it on the crystal.

A proton beam was formed with the existing focusing elements of beam line 14 forming the negative hadron beams (mainly the π^--mesons) with the impulse $\leq$ 40 GeV/c. The efficiency, has been reached at the ejection of protons by the Si crystal, bent along the (111) plane with dimensions 65x15x0.5 mm^3 is $\geq 1.5 \cdot 10^{-4}$ [11], that is in agreement with the results reported in [12].

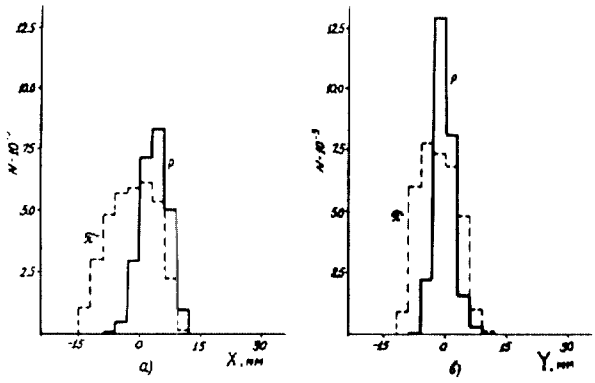

Figure 2: The space distributions of the 70-GeV proton beam and 40-GeV π^--mesons at 3.1 m before the target of experimental setup.

The possibility to compare in the region of the experimental facility PROZA target spatial and angular distributions of the 70-GeV proton beam is extracted by the bent crystal and π^--mesons of the 40 GeV energy from IT of block 24 is presented on fig.2 and fig.3. Fig.2 is a space distribution, fig.3 – an angle distribution in a horizontal and vertical planes (a and b, accordingly). It is seen that the transverse distribution of the proton beam is about 2 times narrower of the pion beam, the proton beam has as well less angle divergency. Fig.4 shows the phase ellipses of the 70-GeV proton beam and the 40-GeV π^--mesons in two planes (a and b accordingly) at about 3.1 m before the experimental facility target. The percentage of the beam, contained into ellipses and the appropriate area in $mm \cdot mrad$ are shown there also. One can see that in this case there is a substantial improvement of the proton beam parameters comparing to the π^--mesons parameters. So, the phase space area of the proton beam is 2 times smaller in XX'-plane and about 4 times – in YY'-plane. Such parameters of the formed beam quite satisfy the requirements of the polarization researches on the experimental setup PROZA.

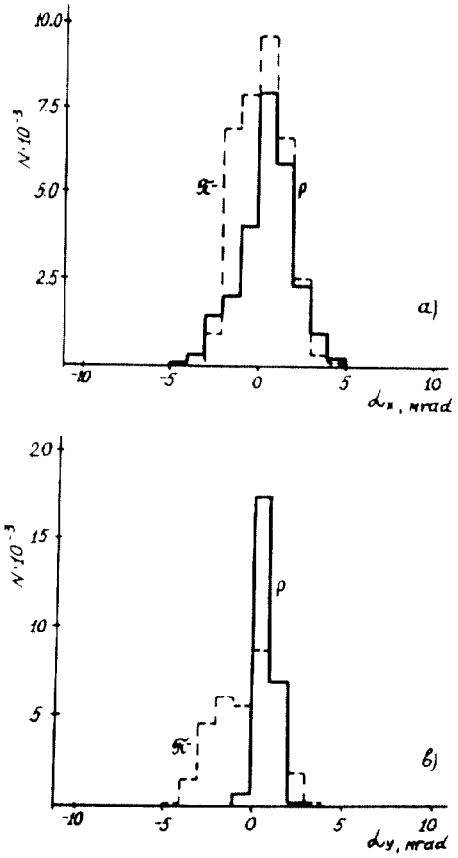

Figure 3: The angle distributions of the proton beam and π^--mesons on the target of experimental setup.

4 CONCLUSION

The experience of the realization during a long time (a few runs in 1990-1991 more than a month each) of the new method of the maximum energy protons extraction by the bent crystal for the physical experiments gained for the first time at the IHEP allows to make conclusion about its reliability, high stability of the beam parameters, compatibility of it with another methods and modes of the particles extraction. The simplicity of using bent crystals, possibility of mounting them on any region of the accelerator vacuum chamber as well as possibility of using existing beam lines suppose the expedience of their wide use for beam extraction both on the IHEP accelerator and on other machines of higher energies.

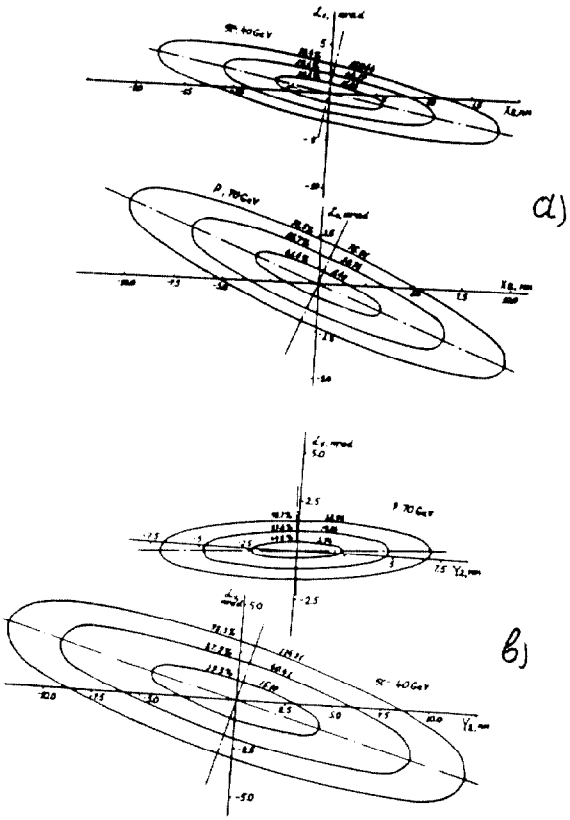

Figure 4: The phase ellipses of the proton and π^--mesons at 3.1 m before the target of experimental setup: a) – in horizontal plane, b) – in vertical plane.

5 REFERENCES

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