INFLUENCE OF THIN INTERNAL TARGET ON THE BENT CRYSTAL EXTRACTION EFFICIENCY

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Abstract

An attempt to explain the effect of extraction efficiency increase due to thin internal target during extraction of proton beam by a bent crystal was made, and results of computer simulation of the thin target influence on the beam parameters in our experiment are given.

1 INTRODUCTION

Using the thin internal target (TIT) of a carbonic cloth ~ 50 mg/cm^2 thick [1] allowed one to significantly increase the extraction efficiency of a Si bent crystal installed into the IHEP accelerator vacuum chamber [2,3,4]. Due to scattering some part of the primary beam on the internal target, the intensity of protons transported to the experimental setup was increased 2 times. Preliminary estimates of the extraction efficiency, which were made with account of conditions of the experiment, showed that the extraction efficiency could reach $\sim 0.5 - 0.7\%$ [5]. In the work on computer simulation of multi-turn accelerated proton dynamics during interaction of the beam with TIT installed before the crystal is reported. It is shown that in case of positive working coordinates of TIT one can get higher bent crystal extraction efficiency as compared to the case of direct steering of the accelerated beam onto the crystal.

2 RESULTS OF COMPUTER SIMULATION

The following main processes are taken into account in the program simulating accelerated proton beam interaction with TIT:

- decrease of a proton beam intensity due to nuclear interaction of particles with the target,
- increase of betatron amplitudes due to multiple Coulomb scattering of particles into the target material,
- decrease of the particle momentum due to ionization beam losses, and the closed orbit shift toward the accelerator center.

Two cases of placing the target relatively to the central orbit were considered: on positive and on negative coordinates, as dynamics of beam-target interaction in both cases is different [6]. Simulation of the above mentioned processes was made by Monte-Carlo method, taking into account concrete conditions existing in the IHEP accelerator. Initial distribution of the beam particles over the amplitudes of betatron oscillations was given by Reley law, and $\Delta p/p_o$ distribution was governed by the normal law. The time of beam-target interaction during which one should keep constant spill, was taken equal to 1s.

The calculation results are presented in figs.1 and 2. Fig.1 shows transformation of the beam particles distribution function for different variants of TIT placing. Here the dependencies of $F(x)$-particle distribution function versus their maximum coordinates are given. As a maximum coordinate of particle relatively to the equilibrium orbit was taken the value:

$$x = A_r + \psi \cdot \frac{\Delta p}{p_o}, \qquad (1)$$

where A_r - a horizontal betatron amplitude, ψ is a dispersion function, $\Delta p/p_o$ - momentum deviation. Curve 1 of this figure corresponds to the initial beam of the accelerator, curve 2 - to the case of TIT on negative coordinates, curve 3 - to the positive coordinates of TIT. One can see a substantial difference of the distribution functions that is determined by influence of the TIT.

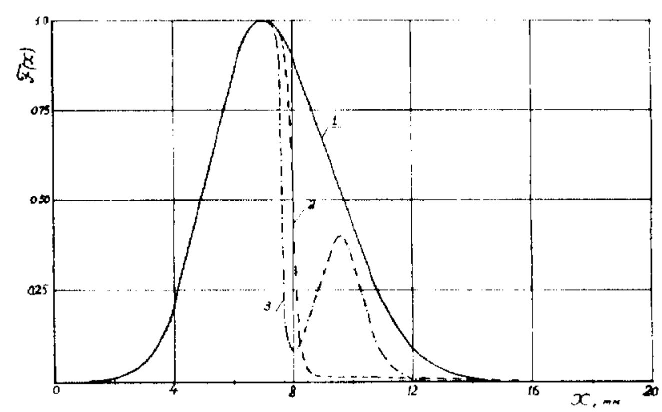

Figure 1: Particle distribution function on maximum coordinate under steering beam onto the thin target. Curve 1 - initial beam into accelerator, 2 - target on negative coordinates, 3 - thin target on positive coordinates.

One should point out that initial distribution function (curve 1 of fig.1) is normalized to the intensity 10^{12} ppc[1], and on large coordinates ($x > 16$ mm) there are so many particles (by our estimates $\geq 10^9$ protons [5,7]) that after

[1]ppc – protons per cycle.

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channeling and extraction one still has enough of them, even taking into account the attained efficiency, to guarantee interesting physical experiments.

Further, on receiving the shown dependencies, the width of the angular distribution for the particles having coordinates more than the given one was calculated. Such distributions are shown in fig.2. Curve 1 corresponds to the initial beam, curves 2 and 3 - to the cases of TIT placing on negative and positive coordinates, respectively. It should be noted that curves 2 and 3 on both figs.1 and 2 refer to the time instant of 300 ms from the beginning of steering the beam onto the target, i.e. when equilization of the particles asimuthal density into the accelerator due to TIT is occured [6].

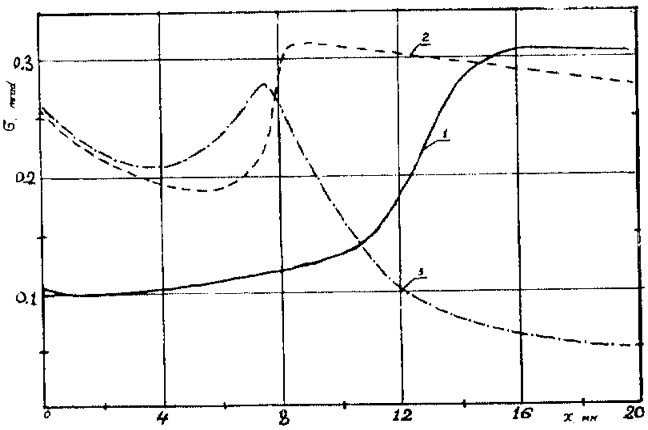

Figure 2: Dependence of the particles anglardistribution width on coordinate at steering of the beam onto the thin target. Curves 1,2,3 - as on fig.1.

One can see from fig.2 that the most favourable for particle capturing into channeling is the case of TIT placing on positive coordinates, as the angular divergence of the beam particles having large amplitudes significantly decreases, approaching the critical crystal channeling angle value at 70 GeV $\psi_c \sim \pm 25$ μrad.

So, two functions exert influence on the bent crystal extraction efficiency:

- distribution of proton beam intensity over coordinates, and

- character of the angular distribution of this particles over different coordinates.

Analysis of figs.1 and 2, and comparison of the given dependencies with experimental results [5] confirm the TIT influence on increase the bent crystal extraction efficiency. Using this method of beam blowing up at the IHEP accelerator allowed one to get the efficiency during extraction of particles by a bent crystal $\sim 1\%$ as well as to transport $\geq 10^7$ of protons to experimental setup.

The merit of the given method of beam diffusing is that the core of the beam is not touched, a target slowly goes into beam, interacting with it during the time defined by the steering rate.

3 REFERENCES

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