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High Energy Beam Line Based on Bent Crystal

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Abstract

Biryukov V.M. et al. High energy beam line based on bent crystal: IHEP Preprint 95-14. – Protvino, 1995. – p. 3, figs. 2, refs.: 2.

A peculiarity of the beam bent with crystals is the independence of the crystal deflector strength $\Theta = L_D/R_c \sim 0.5$ rad of the particle energy (L_D is the dechanneling length, R_c is the critical radius). The possibility of abrupt bending with crystal of a beam fraction at a large angle allows one to make over a short base a non-traditional beam line to carry out physical experiments. At IHEP, a 150 mrad bent crystal was used to create a test area, to work in parallel with other set-ups consuming practically no power. A 100 mm long Si crystal, placed in the halo of the intense extracted 70 GeV/c beam, extracts along the ~20 m base 10^6 protons/sec beyond the 2-meter iron-concrete shield. The beam high quality (low emittance and high stability) allows one to carry out the program of the studies of channeling and testing the microstrip detectors.

Аннотация

Бирюков В.М. и др. Канал транспортировки частиц высоких энергий, основанный на применении изогнутого монокристалла: Препринт ИФВЭ 95-14. – Протвино, 1995. – 3 с., 2 рис., библиогр.: 2.

Особенность отклонения пучка частиц изогнутым монокристаллом заключается в том, что сила кристаллического дефлектора $\Theta = L_D/R_c \sim 0.5$ rad не зависит от энергии частиц (L_D – длина деканалирования, R_c – критический радиус изгиба). Эта возможность отклонения части пучка на большой угол позволяет на очень короткой базе организовать нетрадиционный канал частиц для проведения физических экспериментов. В ИФВЭ кристалл кремния, изогнутый на угол 150 мрад, был использован для создания тестовой зоны, которая может работать параллельно с другими установками, практически не потребляя энергии. 100-мм кремниевый кристалл, размещаемый в гало интенсивного пучка протонов с энергией 70 ГэВ, на базе всего ~20 м выводит 10^6 протонов в секунду за двухметровую железобетонную защиту. Высокое качество пучка (малый эмиттанс и пространственная стабильность) позволяют выполнять программу исследований по каналированию и тестированию микростриповых детекторов.

Nowadays bent single crystals of silicon are applied to operate high-energy particle beams. As is noted in [1] the peculiarity of the beam bending with crystals is the independence of the crystal deflector strength $\Theta = L_D/R_c \sim 0.5$ rad of the particle energy (L_D is the dechanneling length, R_c is the critical radius).

The possibility of abrupt bending with crystal of a beam fraction at a large angle allows one to arrange over a short base a non-traditional beam line for carrying out physical experiments both with any available accelerators and those under construction.

At IHEP a 150 mrad bent crystal was used this way to create a new test area. The scheme of the crystal beam line and experimental setup is shown in Fig.1. A 100 mm long Si (110) crystal, placed on the beam line № 8 and inserted into the halo of the intense extracted 70 GeV/c beam, has extracted 10^6 protons/sec beyond the 2-meter iron-concrete shield along the ~20 m base. Background particles emerging in the direction of a bending angle of the crystal are some tens of times lower in energy ($P_s \sim 3\ GeV/c$) than primary protons. It is not difficult to subtract these secondary particles and it is realized with two small corrector magnets M1 and M2, the collimator K and a narrow collimation hole in the iron-concrete shield of the beam line. Hereat the beam high quality, low emittance and good stability, are achieved on the plane of the deflection ("band" beam).

The beam diagnostic apparatus involves two undersystems: the undersystem measure beam profile and that for measuring beam intensity. The former uses two double coordinate proportional chambers with 5 mm step. Chambers volume is filled with CO_2. The crates of preliminary electronics placed near the chambers, and those of recording electronics made in SUMMA standard, are analogous to those used in the system for beam diagnostics of IHEP accelerator beam lines [2]. The latter is based on the use of some scintillator counters operating in the coincidence mode.

For channeling experiments aimed at the more detailed study of the structure of beams produced with crystal, two microstrip detector stations are intended to be installed in the experimental area (C_1 and C_2 in Fig.1).

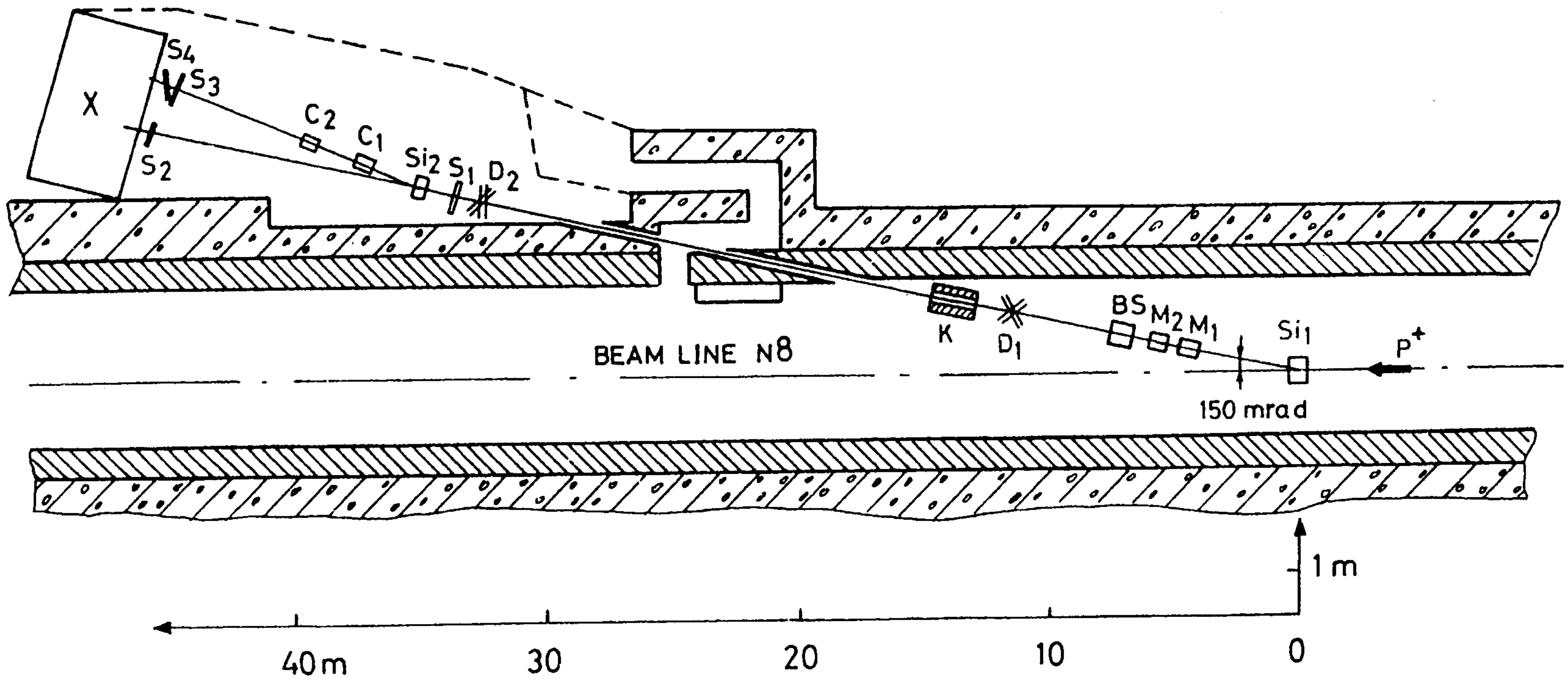

Fig. 1. The scheme of crystal beam line and experimental setup: Si_1, Si_2 – deflecting and testing crystals, M_1, M_2 – corrector magnets, BS – beam stopperp, D_1, D_2 – proportional chambers, K – a collimator, $S_1 - S_4$ – scintillator countes, C1, C2 – microstrip detector stations, X – a beam absorber.

In the first run of the new test area, the intensity of incident protons in beam line № 8 was $2 \cdot 10^{11} p/c$. About 10^{10} particles hit the crystal. In these conditions the number of particles bent with crystal and measured with the scintillator counters was $\sim 5 \cdot 10^5 p/c$. That is in accordance with the calculational data. The orientation-independent component of the signal (background particles) from 10×10 cm^2 size counters did not exceed 3 % of the channeled beam. The profiles of the deflected beam measured with the chamber D_2 are shown in Fig.2.

The constructed test area will allow one to continue the channeling experiments. In particular, it may be used for carrying out the programs to study the channeling properties of the crystals, to increase the efficiency of beam deflection and focusing, and to teste the microstrip detectors. Note that channeled beams are very suitable for a microstrip detector calibration due to their low emittance and high stability.

The new test area consumes practically no power. It allows one to work in parallel with other beam lines without affecting other physical set-ups operation.

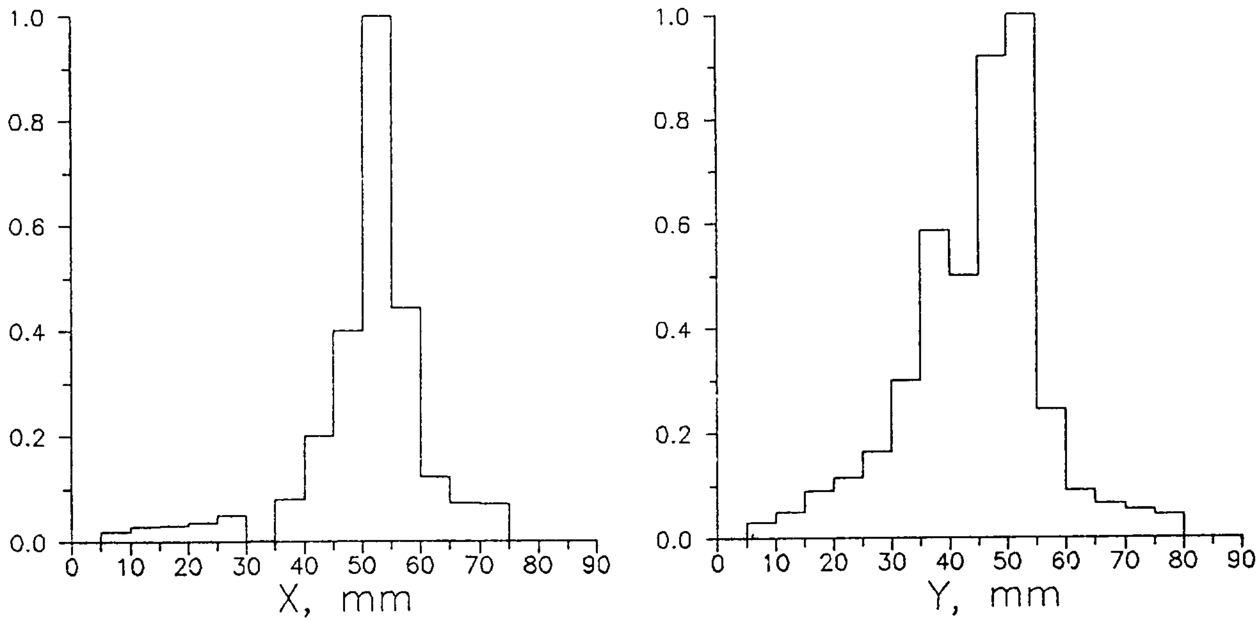

Fig. 2. Profiles of beam in horizontal (x) and vertical (y) planes.

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