DESCRIPTION OF THE PROJECT: VEER

Deflection of sub – GeV energy beam by channeling and reflection in very short crystals.

This project is based on application of channeling and reflection of charged particles in short crystals. The phenomenon of deflection of a charged particle beam in a bent crystal is well investigated and successfully applied for beam extraction in high-energy accelerators, at energies of about 10 GeV and higher (see for example Ref. [1]).

However, the task of bending and extraction of charged particles with energies below 1 GeV presents a big practical interest, for example for the production of ultra stable beams of low emittance for medical and biological applications. In particular, the innovation due to this new technique in accelerators like TERA can essentially (by a few times) reduce expanses for realizing a beam of medical interest.

This project is directed on the investigation of the deflection of a positron beam with available energy 500-700 MeV by bent silicon crystals in the DAPHNE BTF.

There exists a big experimental problem in steering such energy beams, which is connected with the small size of the bent crystal samples. The efficiency of particles deflection is determined by the ratio of the critical channeling angle θ to the beam divergence φ and drops exponentially with the crystal length L:

$$Eff = (\theta / \varphi) \times \exp(-L / Ld),$$

where the characteristic parameter Ld, called dechanneling length, is relatively small for low energy. In our case, for E = 500 MeV, we have $\theta = 0.24$ mrad and Ld = 0.4 mm.

With usual channeling bent crystals (about 1 mm in length) only 20% efficiency was achieved for the deflection of sub – GeV energy particles [2].

In this project we propose a new crystal technique (fig.1):

-- the first option is based on a bent channeling crystal (Fig.1a) with 0.5 mm length (special thin silicon wafers about 100 micron thickness will be used for the production of such samples).

-- the second option is based on the reflection of particles on very thin straight crystal plates with thickness, which is equal to an odd number of half-lengths of oscillation waves (it means the optimal crystal length should be about 10 microns). The reflection angle in one silicon plate should be equal to twice the critical angle 0.48 mrad. For the enhancement of the deflection angle, a few aligned plates placed like a veer are foreseen. The details of the realization of such a type of crystal technique are described in [3].

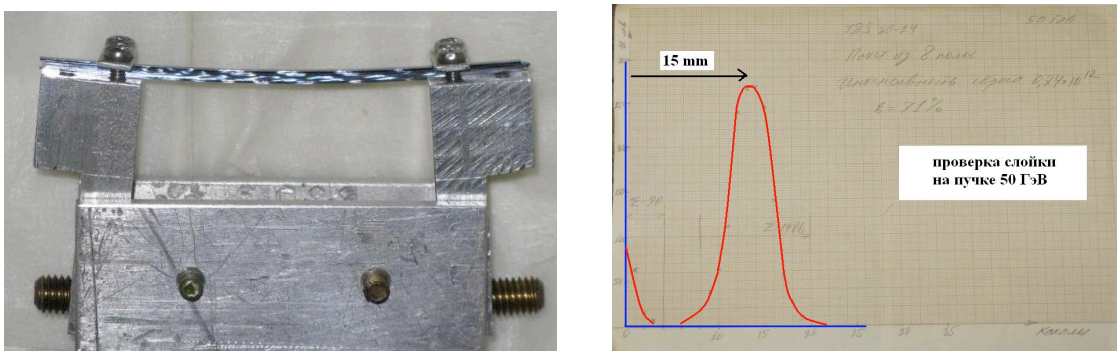

Fig.1 a- array of short bent crystals (strip crystals). b- results of 50 GeV testing

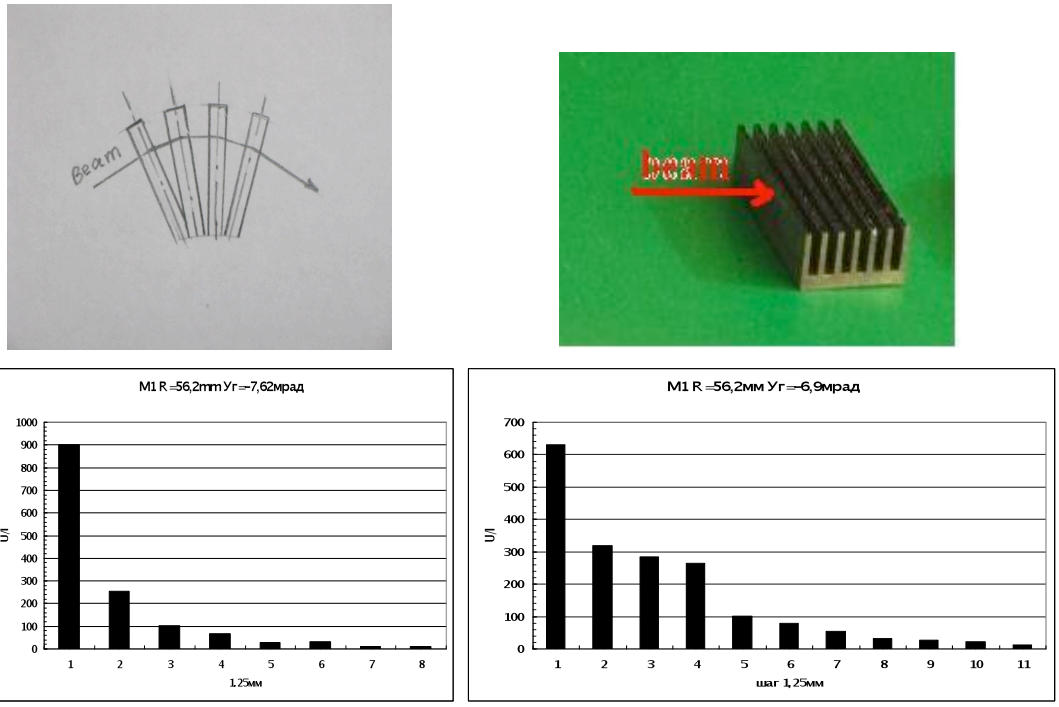

Fig.1 c – Principle of veer deflector, d – realized device, e,f – testing in a 50 GeV beam (disoriented and oriented crystal – notice the difference!).

The scheme of the experimental setup is shown in fig.2

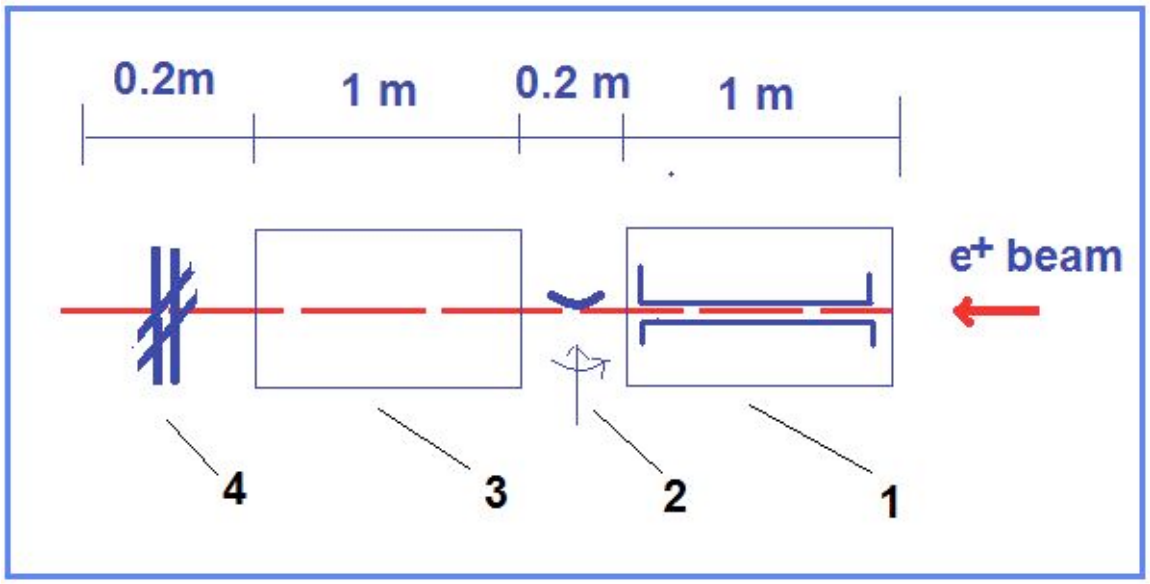

Fig.2 / 1- steel collimator in a vacuum pipe, 2 – crystal sample in a goniometer, 3 - drift space in vacuum about 1 meter long, 4 – microstrip detector with 50 micron resolution.

A low emittance e+ beam is obtained using a special steel collimator. Thus we can achieve the horizontal emittance of the beam $\varepsilon \approx 0.5$ mm× 0.5 mrad and $\varphi \approx +- 0.25$ mrad.
So, in our case the ratio $(\theta / \varphi) \approx 1$ is achieved, which is appropriate for efficient particle deflection observation.

A further step in this approach assumes that aligned arrays of nanopores and nanotubes trap and channel part of the incident beam. By giving to nanotubes a controlled bending of a few milliradian, we can deflect the channeled particles out of the incident beam. The creation of such nanodeflectors is in progress (Ref. [4]).

References:
[1] V.M. Biryukov, Yu.A. Chesnokov, and V.I. Kotov, Crystal Channeling and Its Application at High-Energy Accelerators (Springer: Berlin, 1997). See also http://crystalbeam.narod.ru/.

[2] S. Bellucci, S. Balasubramanian, A. Grilli, F. Micciulla, A. Raco, (Frascati) , A. Popov, (Latvia U., ISSP) , V. Baranov, V. Biryukov, Y. Chesnokov, V. Maisheev, (Serpukhov, IHEP) **.** Using a deformed crystal for bending a sub-GeV positron beam, Nucl.Instrum.Meth.B252:3-6,2006.

[3] A.G.Afonin et al, Deflection of high energy particles using veer – type crystal reflectors, JETP LETTERS, in press.

[4]. S. Bellucci et al. Phys. Rev. ST Accel. Beams 6, 033502 (2003)
"Making microbeams and nanobeams by channeling in microstructures and nanostructures".

Goals of the project

The goal of the project is to carry out an experiment on the efficient deflection of a low energy beam by special crystals.

Schedule of the work.

Only one visit with the duration of three weeks to LNF is planned: one week for general approach, beam arrangement, support and alignment for the samples, positron diagnostics; data taking (14 days).
The most appropriate period is July.

Beam requirements.

The beam required for the experiment is positrons of highest energy, about 500 - 700 MeV, with low intensity.

Support needed.

For a successful start of the project, a microstrip detector is needed.

Also some part of the vacuum setup should be prepared in the LNF workshop (under S. Bellucci guidance): steel collimator in vacuum pipe, drift vacuum tube, supports.
We welcome the participation of interested BTF personnel to the experimental activity and the discussion of the research results.