# DESCRIPTION OF THE PROJECT: BENCE

## BENt Crystal Extraction of low energy beam

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

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

This project is directed on investigation of deflection of e+ beam with available energy 500-700 MeV by bent silicon crystals in BTF.

There exist a big experimental problem in steering of such energy beams which is connected with small sizes of bent crystal samples. Efficiency of deflection of particles is determined by the ratio of critical channeling angle $\theta$ to beam divergence $\varphi$ and dropped exponentially with the crystal length L:

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

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

Necessary experimental conditions for channeling investigation in BTF area of LNF were created in the framework of TARI projects 23,35.

Low emittance e+ beam was obtained using special iron collimator. The horizontal emittance of the beam $\varepsilon \approx 1$ mm×1 mrad and $\varphi \approx 1$ mrad were achieved. The image of collimated positron beam in 0.5 m downstream of collimator is shown in Fig. 1, registered with high resolution photoemulsion detector. Effect of beam collimation was also registered by scintillation hodoscope detector, placed at the end of vacuum system in 4 meters behind the collimator.

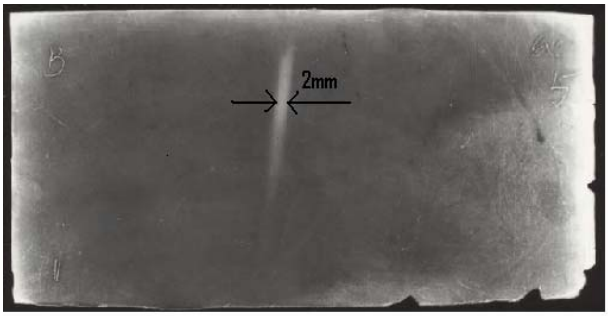


**Figure 1: The image of collimated positron beam. The beam borders in horizontal plane are rather sharp for good separation of deflected and incident beam in case of sufficient bend angle.**

So, in our case the ratio $(\theta / \varphi) \approx 0.2$ was achieved, which is appropriate for the effect of particle deflection observation.

However crystals applied in TARI 23,35 were not optimal for such small energy. They have small temp of bending: 1mrad per 1mm length. It was still not sufficient for separation in space of deflected and incident beams.

Radical improvement of situation is possible with using new recently invented technique of crystal bending! This technique is based on method, described in Ref.[2], which was successfully applied for crystal undulator production. Microscratches on crystal surface allow to reach high temp of crystal bend: up to 10 mrad at 0.3mm length. In these condition pure separation of channeled 500 MeV beam with the efficiency of few tens of percentages is possible.

This experiment is proposed in new TARI call, using new bent samples, more high resolution detectors (straw tubes), and up grate BTF beam.

Accept of straw tubes we are going to try nuclear emulsion layers as a detector of beam, which capabilities are demonstrated on Fig. 1.

The further approach assumes that oriented massives of 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.[3]).

After installation in BTF area additional cleaning magnet also investigation of radiation in different type of crystals and nanosamples would be possible, which is the subject of next TARI proposal.

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 et al., Phys. Rev. ST AB **7** (2004) 023501.
“Cryatal Undulator as a novel radiation source”.

[3]. 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 first in the world experiment on efficient deflection of low energy beam by special bent crystal.

## Schedule of the work.

Only one visit to LNF is planned: one week for general approach, beam arrangement, support and alignment for the samples, positron diagnostics. Data taking (10-20 days).

## Beam requirements.

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

## Support neede.

For successful start of the project only straw tube detector is needed.