Channeling effects observed in flat silicon crystal for 1 Gev proton beam.

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Inroduction

Channaling effects are many time observed in flat crystal [1]. Flat crystal test run was been carried out in November 2007 at 1Gev proton accelerator in PNPI. The goal of this experiment is any approach of optimization crystals. Flat crystals are suitable objects for optimization. It is natural that has been used silicon crystal as the first step.

Motivation

Optimization of crystals as device for high energy beams steering is the actual task especially now[2,3]. For serious application is necessary to carried out the preliminary work. Practically, only silicon crystal is using to day, but the choose is to a degree historical. Optimization is the choose a few out of a many in our case.

Heavy atoms crystals according to calculation are promising objects as instrument of manipulation with high energy proton beams . It is reasonable to start an selection with investigation of flat crystals. In this case is absent the problems connected with crystal bending that is the special rather complicated problem.

Benefit for Interpretation and analysis: It can avoid complications connected with the crystal bending. Flat crystal is the important particular case bent crystal Rb=∞ . Main orientation effects for bending crystal being important in application channeling in bending crystal such as volume capture, volume reflection, channaling has a analogy in flat crystal case. In limit Rb=∞ : channeling goes over in channeling; volume reflection goes over in element of channeling process (Volume reflection is single collision with potential wall under angle ~ lindhard angle and channeling is a lot of collisions with it). Volume capture effect will take place during all passing of particle through crystal near aligned condition. So, the measurement with flat and bent crystal must be self-consistent .

Candidates

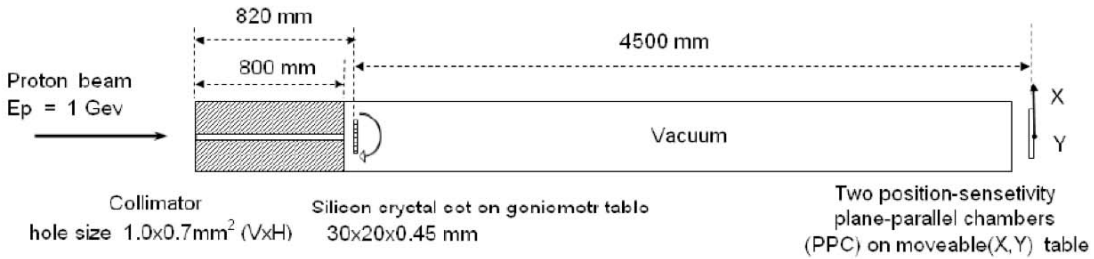
Crystals for investigation
Possible candidates of crystal including heavy atoms:
Ge - Z= 32; available
CsJ – Z= 53,55; available
BGO($Bi_4Ge_3O_{12}$) - Z=83,32,8; available
$PbWO_4$– Z=82,74,8; available
…….
W - don’t available needed size and quality ?
Pb - don’t available needed size and quality ?

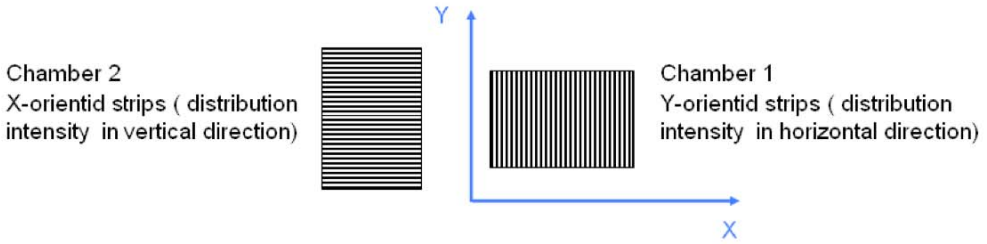
Test run

Test run at 1Gev proton accelerator.
It has been carried out test run in November 2007 on 1Gev proton accelerator in PNPI.
It is natural that has been used silicon crystal as first step

Setup

Setup (top view)





Items of setup

Proton beam:

- Ep = 1Gev
- Size on crystal = 1.0x0.7 mm2(vxh)
- Angle divergence on crystal = 190 microradian
- Intensity = 2×10^5 protons/sec

Si crystal:

- Working plane (1 1 0)
- Size across beam = 30x20 mm2
- In the line of beam = 0.45 mm
- Lindhard angle for 1Gev protons = 170 microradian

Items of setup(continue)

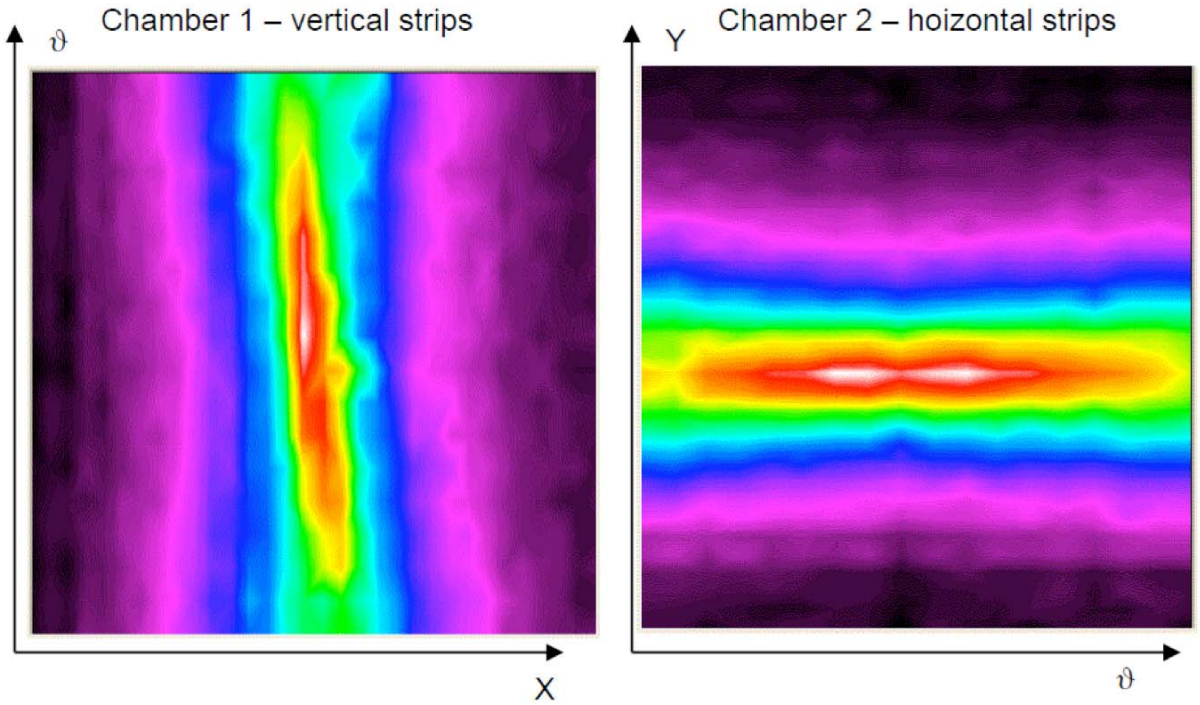
PPC (for both chambers) :

- Strips length = 10 mm
- Strips pitch = 0.5 mm
- Strips number = 32
- Gas gap = 0.6 mm
- HV = 1600 V
- Gas Ar(70%)+CO2(30%)
- Efficiency for MIP ~ 3% (electronics was not optimal)
- ~60%(for optimal electronics)
- Occupancy limit < 10^8 MIP/mm2sec

Goniometer:

- One vertical axis
- Step = 31.2 microradian

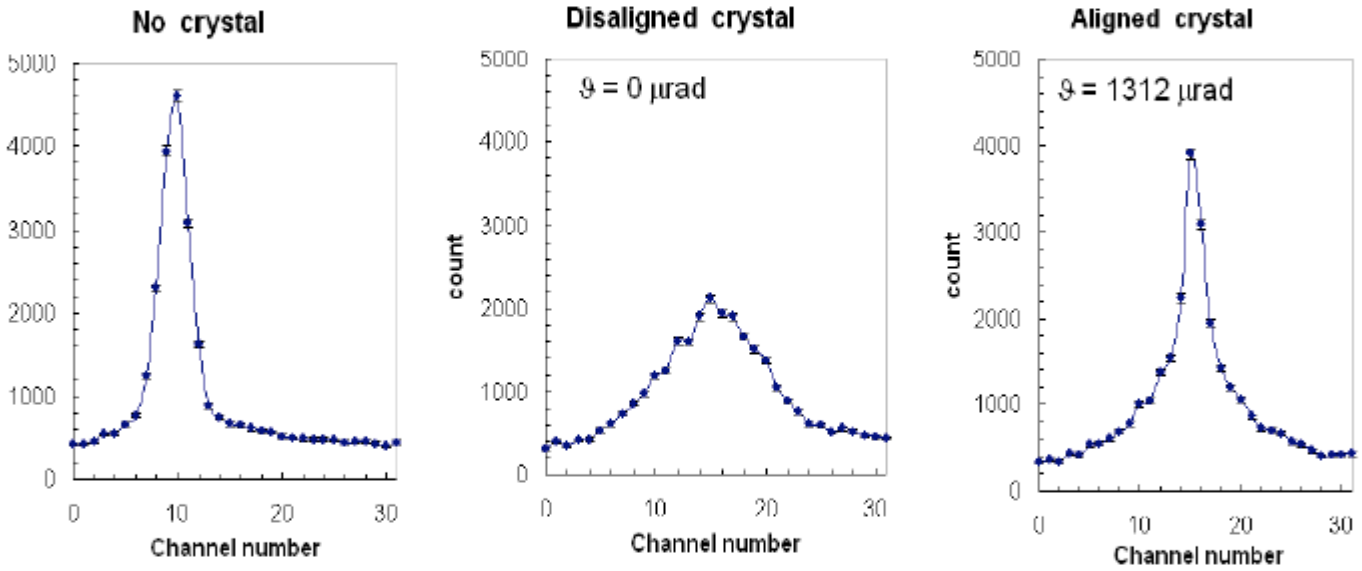
2D Picture



Crystal turn angle on the vertical axis, chamber1 strip number on horizontal axes (left); Crystal turn angle on the horizontal axes, chamber2 strip number on horizontal axes (right) .

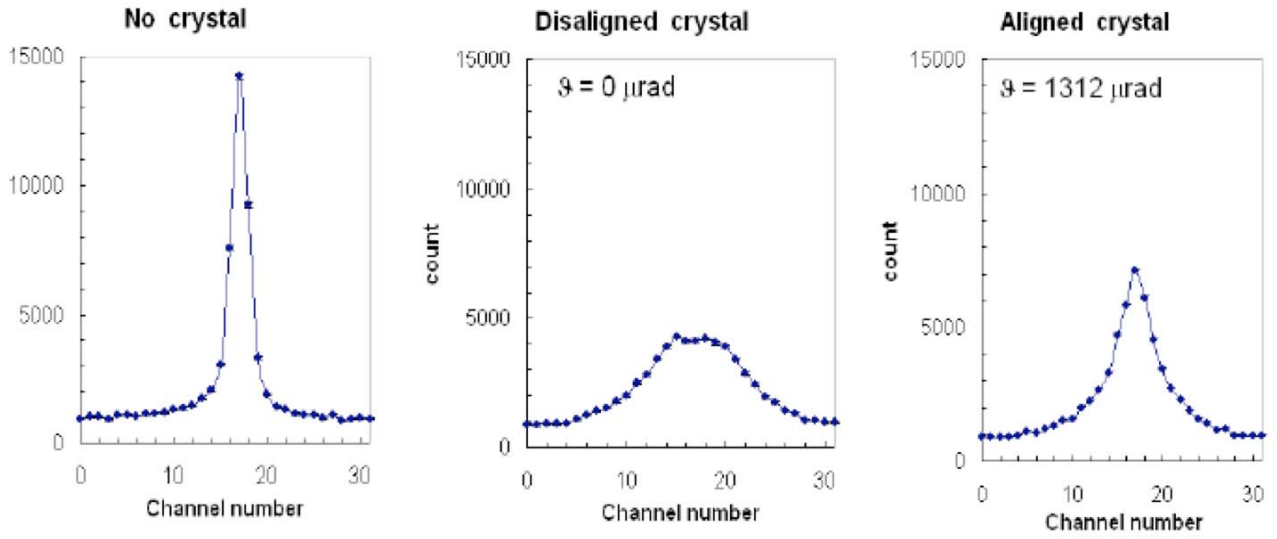
X-profile

X-profiles of the beam intensity distribution

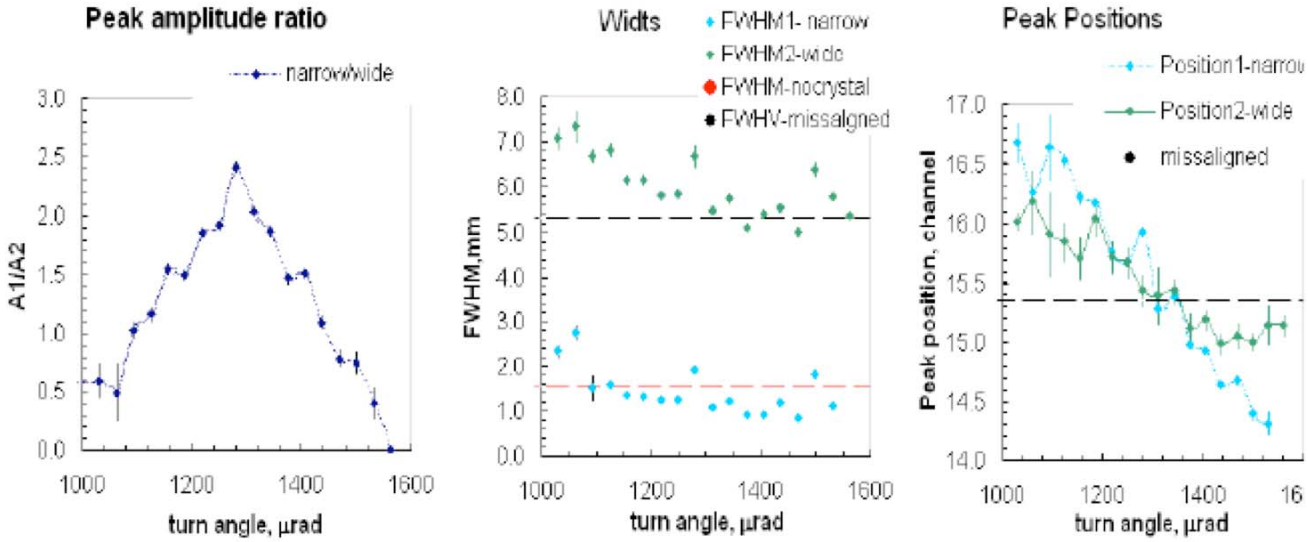


Y-profiles

Y-profiles of the beam intensity distribution

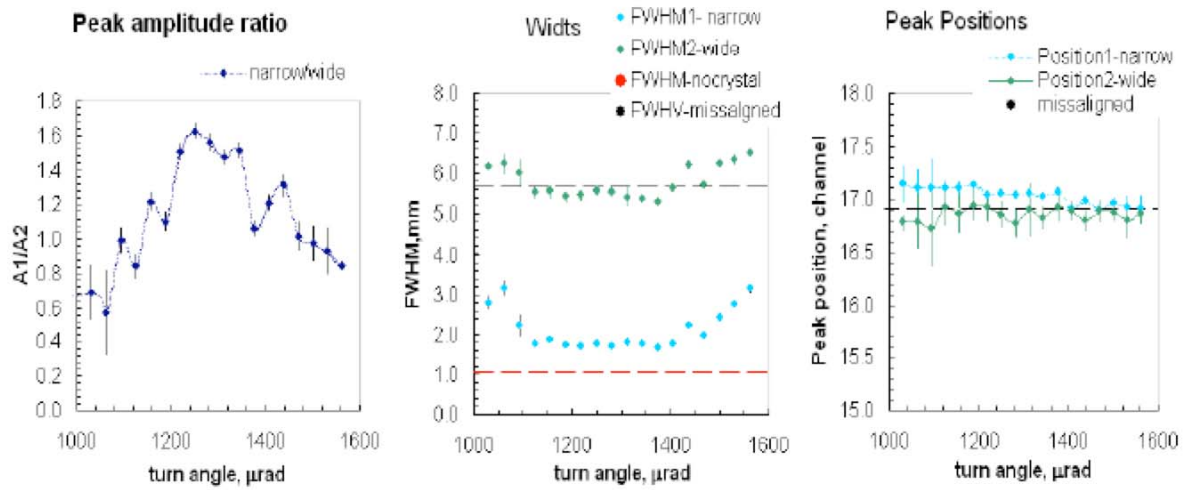


X-profiles parameters versus crystal turn angle



Y-parameters

Y-profiles parameters versus crystal turn angle



Summary

Experimental results:

Narrow peaks FWHM ~ $1\vartheta_L$ X-profiles intensity

Narrow peaks FWHM ~ $1.5\vartheta_L$ Y-profiles intensity

Wide peaks FWHM ~ 1mrad agreement with multiscattering formula in Si

Angle range of channeling effects ~ $2\vartheta_L$

It is observed the shift of peaks position for X-distribution both the narrow component and wide one too (??)

For following runs are prepared:

Si plates - 0.3, 0.5 mm thickness (110)

Ge plates – 1.1, 2.9 mm thickness (110).

It has checked by X-ray

Si, Ge plates of other thickness and heavier crystals is in progress

Conclusion

Test run at 1Gev proton accelerator in PNPI has shown:
Observation of channeling effects are rather easy available even with simple apparatus.
Measurement values can serve criterion as first step selection crystal for high energy beam manipulation.

Referenes

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2. Scandale W., Still D.A. , Carnera A., Della Mea G., De Salvador D., Milan R., Vomiero A., Baricordi S., Dalpiaz P., Fiorini M., Guidi V., G.Martinelli G., Mazzolari A., Milan E., Ambrosi G., Azzarello P., Battiston R., Bertucci B., Burger W.J., M.Ionica M., Zuccon P., Cavoto G., Santacesaria R., Valente P., Vallazza E., Afonin A.G., V.T.Baranov V.T., Y.A.Chesnokov Y.A., Kotov V.I., V.A.Maisheev V.A., Yaznin I.A., Afansiev S.V., Kovalenko A.D., Taratin A.M., A.S.Denisov, Y.A.Gavrikov, Y.M.Ivanov, Ivochkin V.G., Kosyanenko S.V., Petrunin A.A., Skorobogatov V.V., Suvorov V.M., Bolognini D., Foggetta L., Hasan S., Prest M *High-Efficiency Volume Reflection of an Ultrarelativistic Proton Beam with a Bent Silicon Crystal*, Phys.Rev.Lett. 98, 154801 (2007)
3. .

Thank You for Attention