Crystals for experiment on the SPS beam collimation

Deflection angles → for successful collimation and its registration

Collimation → to be sufficiently far from the collimator edge
→ deflection angles are achievable for LHC

Registration → direct particles to the sensitive area of detectors ≈ 20 mm
→ over offset distance and dead area of detectors

With bend angle α positions of channeling pick at RP1 and TAL

100 μrad → 2.4 mm , 2 mm

150 μrad → 4.8 mm , 6.5 mm

200 μrad → 7.3 mm , 11 mm

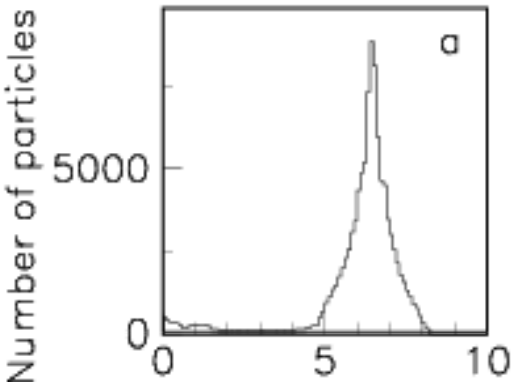
Impact parameters of 2 mm are too small

Optimum value for deflection angles – 150 ÷ 200 μrad

Deflection by channeling – single bent crystal

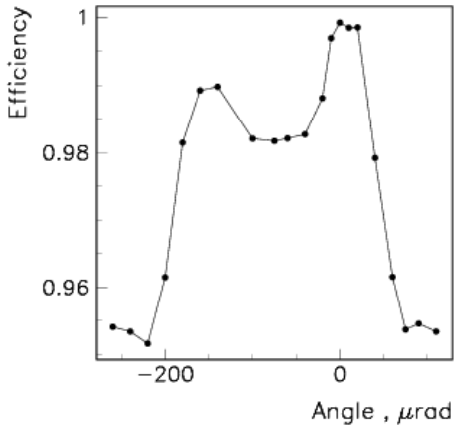
(111) Si, length L=1 mm, bend angle α= 150 μrad

Impact parameters



For protons
120 GeV

Dependences on orientation angle

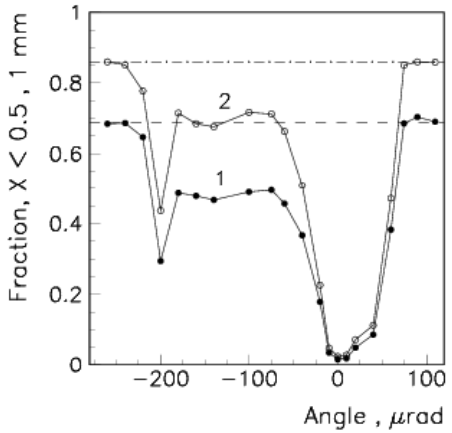


Efficiency

Efficiency at θo=0 – larger 99.9%

For angles ± θc – larger 99%

Edge fraction near θo=0 – smaller 2 and 3%

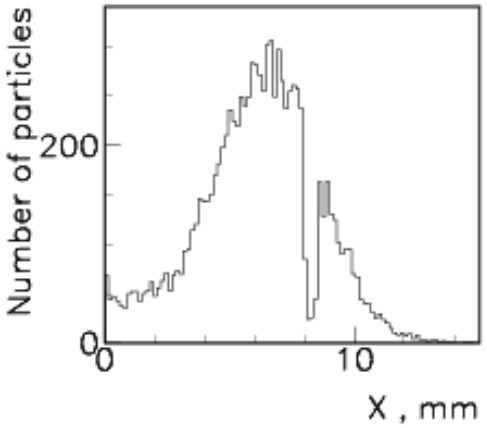


Edge fraction

Deflection by MVR – sequence of bent crystals

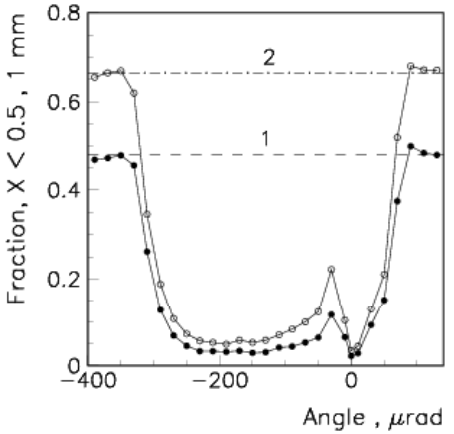
7 crystals (111) Si, L=0.5 mm, α= 250 μrad, $\delta\theta$=-20 μrad

Impact parameters



For protons
120 GeV

Edge fractions as a function of θo

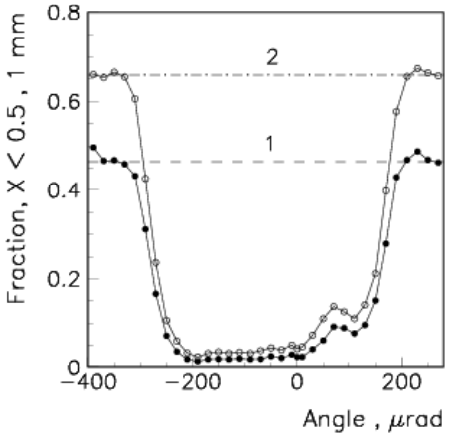


Parallel SVR
with forward BC
5 μm

Efficiency for VR and CH areas – 99%

Edge fractions - parallel SVR with forward crystal – 3% and 6%

Unparallel SVR – 2% and 4% in MVR area
Channeling area - acceptance - increases

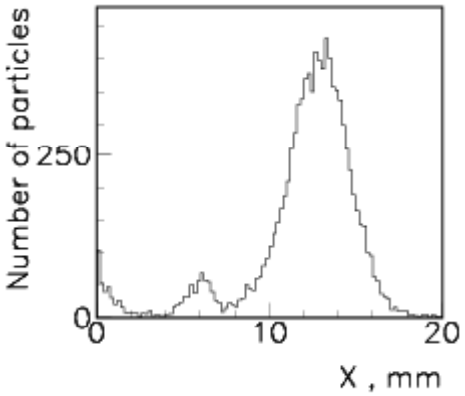


Unparallel SVR
tilt angle
-20 μrad

Deflection by MVR – sequence of bent crystals

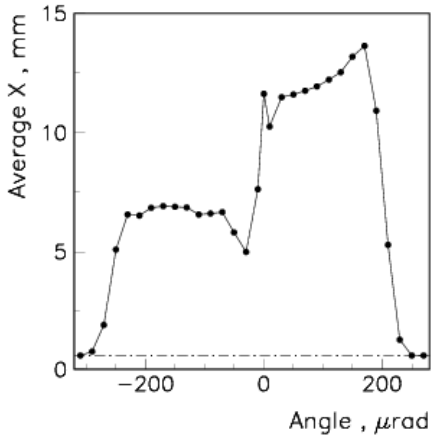
10 crystals (110) Si, L=1 mm, α= 217 μrad, $\delta\theta$=-16 μrad

CH deflection for θ_o=90 μrad



For protons
270 GeV

Dependences on orientation angle

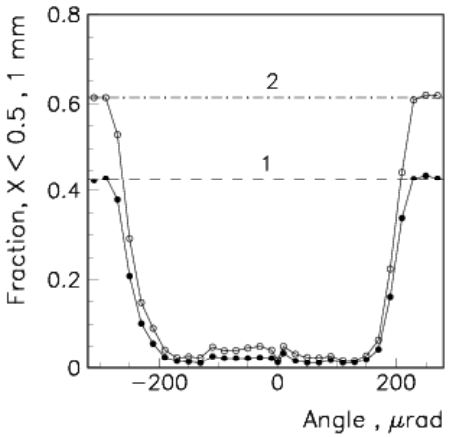


Average impact parameter

Efficiency for VR and CH areas – 97.5%

Acceptance for CH increases
Both VR and CH works

Edge fraction – 2% and 4%



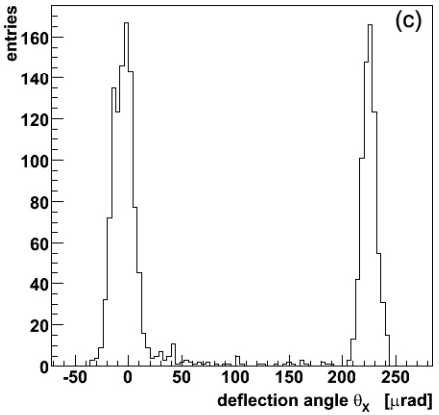
Edge fraction

Single bent crystals for collimation

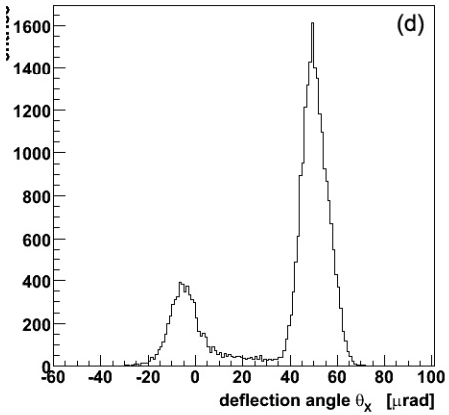
ST9 (Ferrara) - strip of (110) Si crystal, L=2 mm
It was used for R-dependence studies of VR

There are the data for deflection due to channeling for different R

R=8.9 m



R=38 m



There is a good agreement with simulation for R=38 m

And large discrepancy for R=8.9 m

Crystal torsion for small R ?

ST9 should be bent with R=13.3 m to receive α= 150 μrad
and angle should be measured before the installation

Bending without large torsion !

Alternative - use strip with L=3 mm to increase radius → R=20 m
It was a good agreement with simulation for ST4, R=18.5m

(111) Silicon crystal QM, L=2 mm – PNPI
Crystal was bent with α= 150 μrad and studied with 400 GeV protons

Crystal for channeling mode

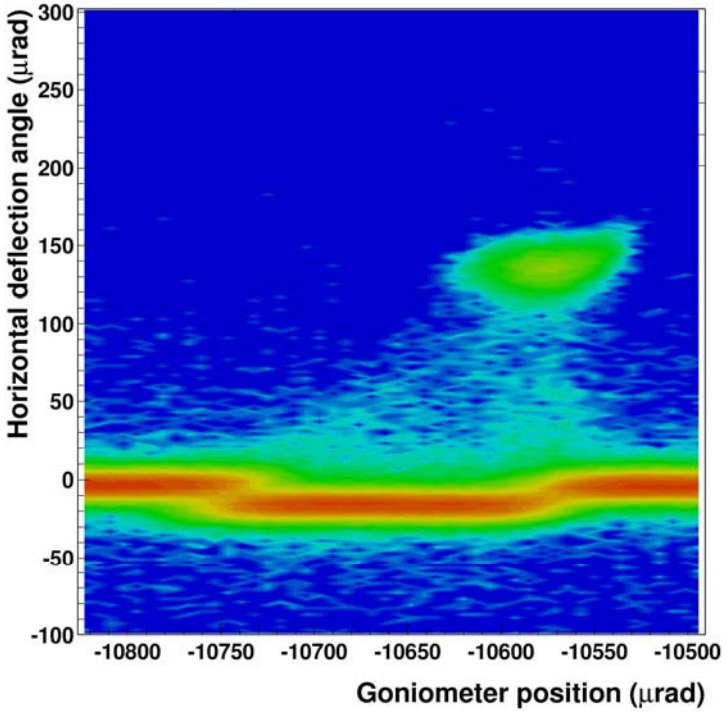
Height 10 mm

Width 2 mm

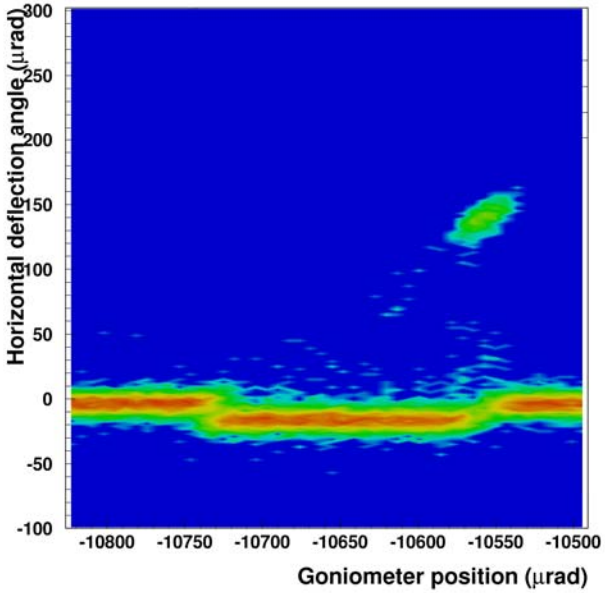
Length 2 mm

Tests with 400 GeV protons

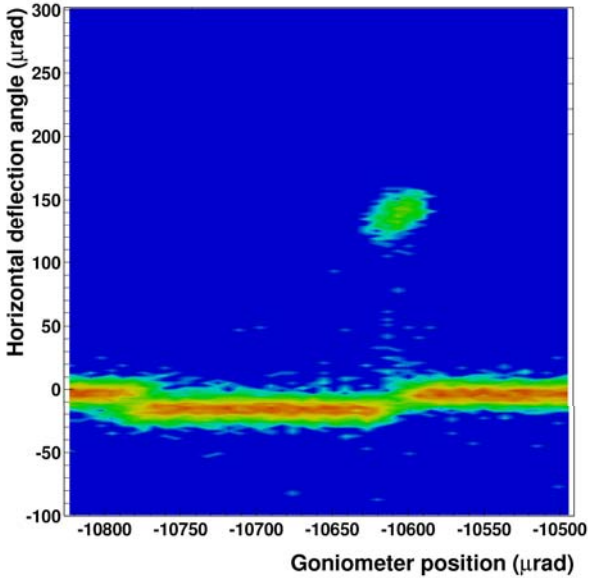
Cut (2.0x4.0mm)
x=10800/11800
y= 5000/ 9000



Cut (0.4x0.4mm)
x=10800/11200
y= 6800/ 7200



Cut (0.4x0.4mm)
x=11800/12200
y= 6800/ 7200



Saddle

~40 mcrad/mm

Sequence of bent crystals for 120-GeV proton beam collimation

PNPI - sequence of seven (111) silicon crystals QM, L=2 mm, $\alpha \approx 250$ μrad
Crystal alignment was partly fulfilled and studied with 400-GeV protons

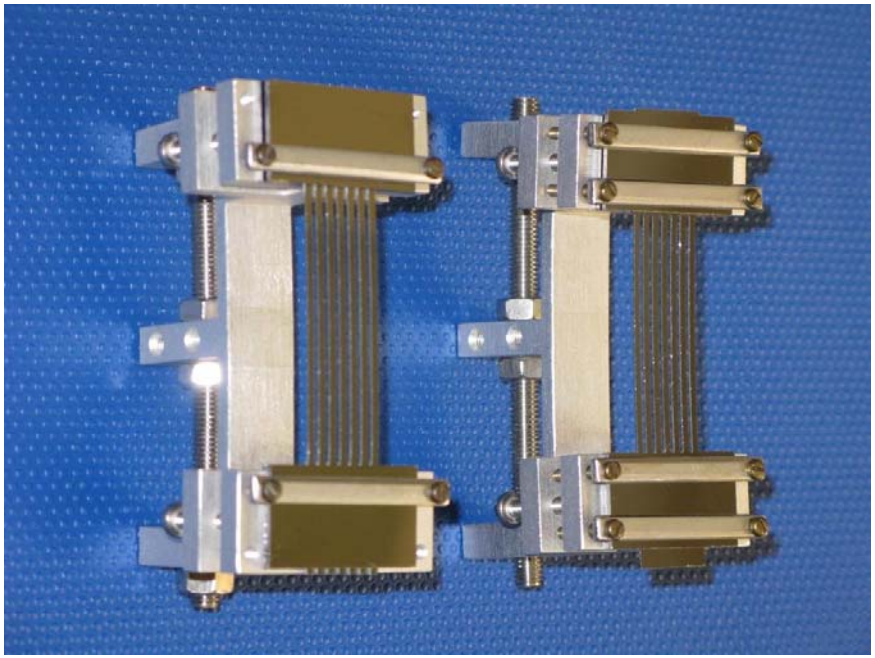
Multi-crystal (7)

Under testing with X-rays.

Next set of 7 bending devices and 7 crystals is under preparation

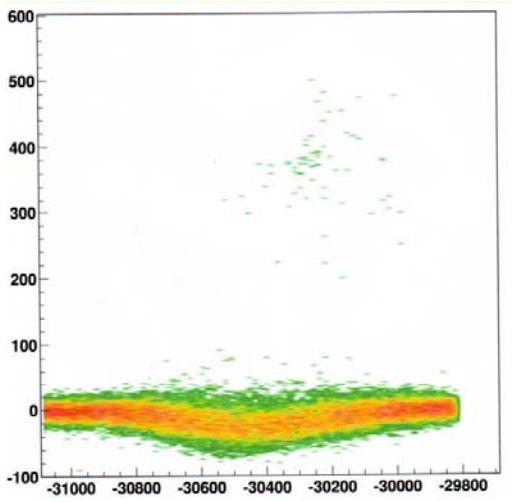
Sequence of bent crystals for 120-GeV proton beam collimation

IHEP – multi-strip (111) Si crystals with 7 strips, L=1 mm, α = 500 μrad with convex and concave bending were studied with 400-GeV protons

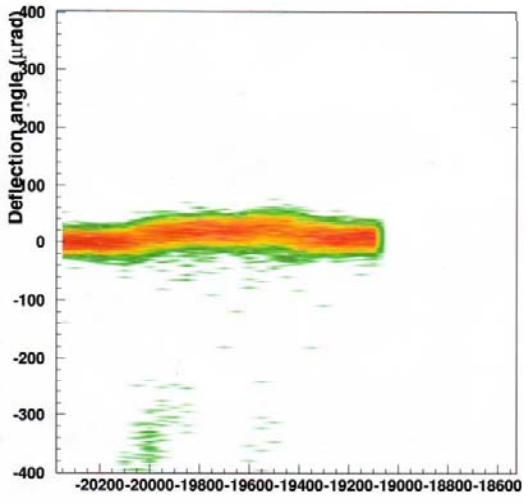


Horisontal angular scan near (110) skew planes

Convex bend



Concave bend



Triangle form of MVR area – acceptance area for 7VR is narrowed up to 0

Convex bend – bad unparallel sequence

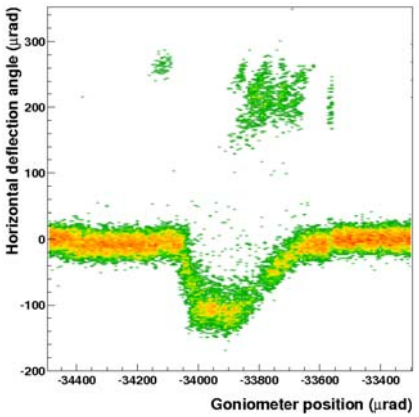
Trapezium form of MVR area – acceptance for 7VR should be sufficiently wide

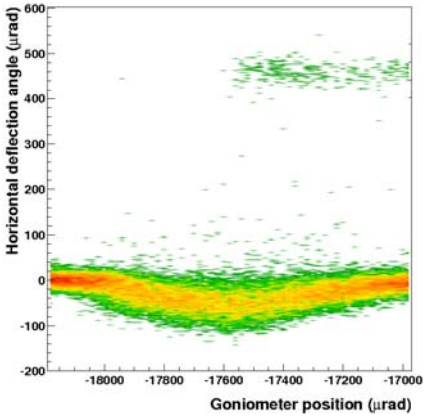
Concave bend – nearly parallel sequence

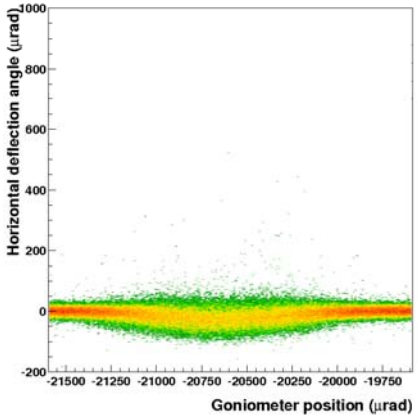
Sequence of bent crystals for 270-GeV proton beam collimation

Ferrara – multi-strip (110) Si crystals with 14 and 15 strips, L=1 mm were studied with 400-GeV protons

Crystal radii R= 4.61 m, 2.14 m and 1.47 m







About 11 strips for R=4.61 m coherently deflect protons, angle 130 μrad

Angular acceptance for MVR was larger than 150 μrad

Strip number is sufficient to receive kick ≈ 150 μrad for 270-GeV protons

Angular acceptance for MVR should decrease by $N\Delta\theta_{vr} \approx 60$ μrad but still be about 100 μrad