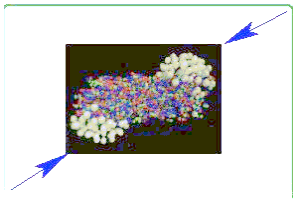


H8-RD22 Experiment to test Crystal Collimation for the LHC

Walter Scandale *CERN*

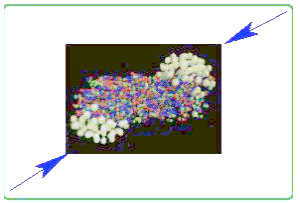
For the H8-RD22 collaboration

(CERN, FNAL, INFN, IHEP, JINR, PNPI)

Highlight talk of HHH network at CARE 06

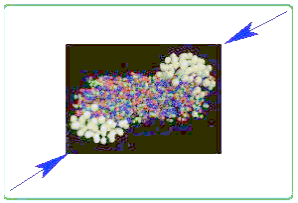
Frascati, 16 November 2006

Outlook

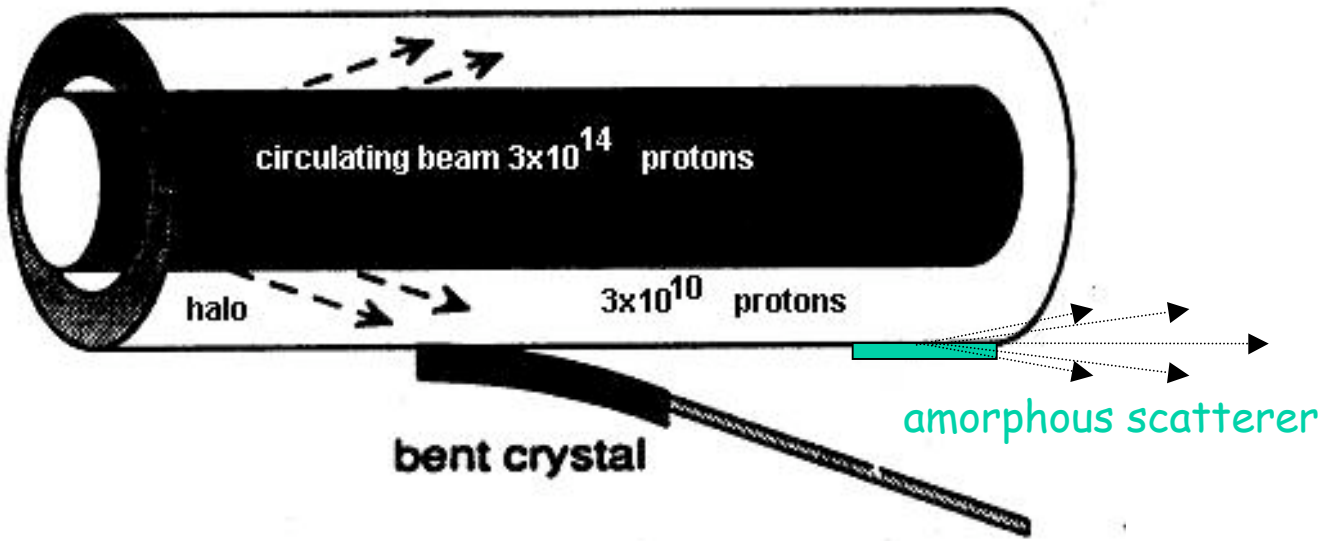


- The concept of crystal collimation
- The role of HHH
- The experiment in the H8 beam line of the SPS north area
  - Silicon crystals
  - Experimental layout
  - High precision goniometric system
  - Tracking detectors
  - Crystal Angular Scans (Strip and Quasi-Mosaic Crystals)
  - Double Reflection Effect
- Concluding remarks

Crystal collimation: a smart approach for primary collimation



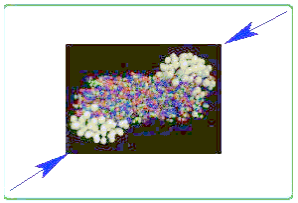
- A bent crystal deflects halo particles toward a downstream absorber:
  - the selective and coherent scattering on atomic planes of an aligned Si-crystal may replace more efficiently
  - the random scattering process on single atoms of an amorphous scatterer.



☺ Larger collimation efficiency

☺ Larger gap of the secondary collimator --> reduced impedance

The role of HHH



1st mini-workshops organized within the HHH-ADP work-package:

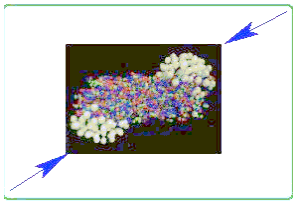
- CC-05: Crystal channeling and collimations in hadron storage rings, CERN, 7-8 Mar. 2005

organization	scientific themes
♦ 42 participants	♦ Historical perspectives of crystal collimation
♦ 9 institutions	♦ Review of the state-of the-art
♦ 18 talks	♦ LHC experimentalists' mini-session (crystals for TOTEM)
♦ one round table	♦ Discussion of a crystal experiment at the CERN-SPS

Main outcomes:

- Negative results at RHIC may depend on crystal quality.
- Meanwhile positive results on crystal collimation have been observed at the Tevatron.
- New SPS experiment (with circulating beams) has been proposed.
- 2nd CARE-HHH-APD mini-workshop on *Crystal Channeling* planned for December 2005.

The role of HHH



2nd mini-workshops organized within the HHH-ADP work-package:

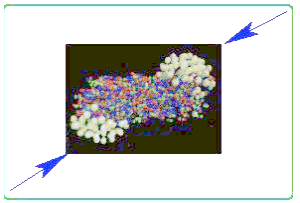
- 2nd CC: Crystal channeling and collimations in hadron storage rings, CERN, 8-9 Dec. 2005

organization	**scientific themes**
♦ 10 participants ♦ 6 institutions ♦ 6 talks	♦ Crystal collimation at the Tevatron ♦ Crystal collimation at the IHEP ♦ First observation of crystal reflection ♦ Crystal experiment in the external line H8 of the CERN-SPS

Main outcomes:

- Review of
  - crystal collimation data, including recent data from the Tevatron,
  - new materials and techniques for channeling of relativistic particles.
  - INTAS experimental program (first observation of beam reflection from bent atomic planes).
- Proposal to study proton small-angle scattering by oriented crystals on a CERN SPS extracted beam.
- Possible follow-up at a co-organized International Conference on Charger and Neutral Particle Channeling Phenomena at Frascati July 2006.

The role of HHH



3rd mini-workshops organized within the HHH-ADP work-package:

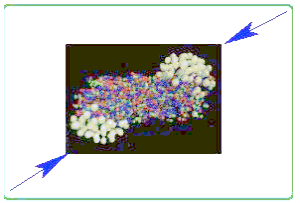
- 3rt CC: Crystal channeling workshop, CERN, 9-10 Mar. 2006

organization	**scientific themes**
♦ 20 participants ♦ 5 institutions ♦ 23 talks	♦ Result on channeling af IHEP and PNPI ♦ Layout and detector of the SPS crystal experiment in the H8 line ♦ Simulation of the expected results in H8

Main outcomes:

- Launcing of the *collaboration H8-RD22 (CERN-INFN-FNAL-IHEP-JINR-PNPI)*, for the SPS experiment on channeling in the H8 beam.
- Definition of the beam parameters and the experimental layout for H8-RD22.
- Cooperative effort of HHH with EU-INTAS-CERN programme to support the networking need of H8-RD22.
- Crystals as possible tools to enlarge the physics potential of TOTEM.

The role of HHH



International Conference on Charger and Neutral Particle Channeling Phenomena co-organized in Frascati 3-7 July 2006

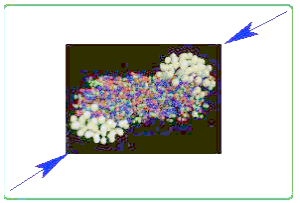
- Channeling 2006:

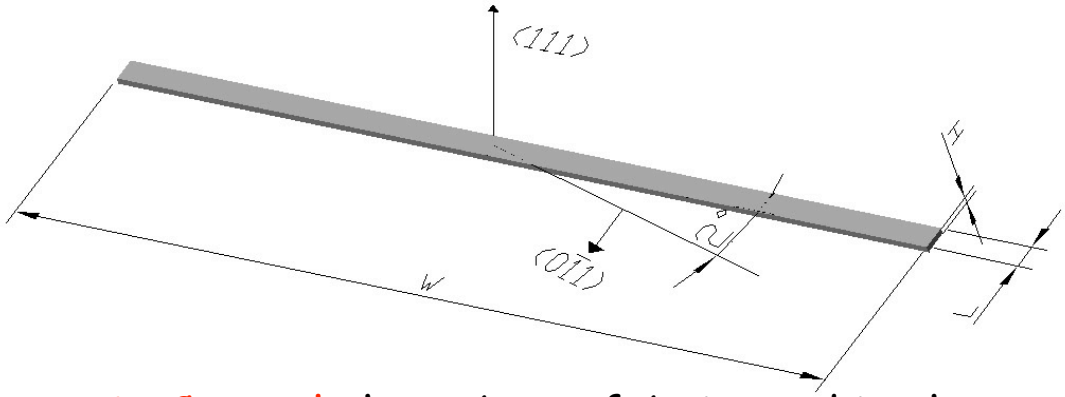
organization	**scientific themes**
♦ 77 participants ♦ 40 institutions ♦ 10 sessions	♦ Coherent and incoherent scattering of hadrons and leptons in matter of various periodicity structure. ♦ Electromagnetic radiation by relativistic electrons and positrons traversing periodic targets, such as coherent bremsstrahlung, channeling radiation, transition radiation, parametric X-radiation ♦ Channeling of charged particles in periodic crystals (monocrystals, complex crystals, nanostructures, etc.)

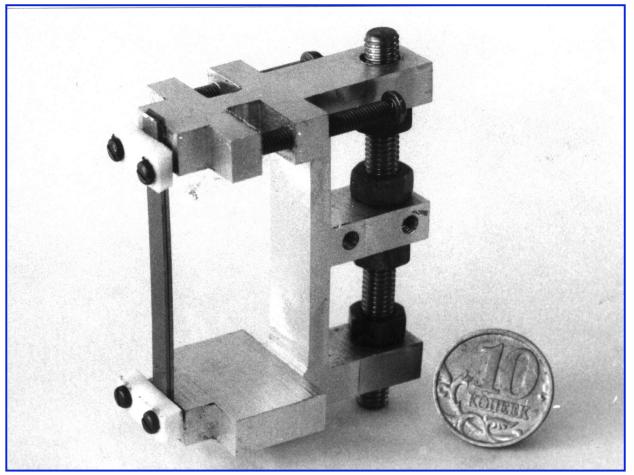
Main outcomes:

- Presentation of the H8-RD22 experiment planned in the H8 beam of the SPS north area.
- Presentations of the recent results on channeling at IHEP and PNPI

Silicon crystals

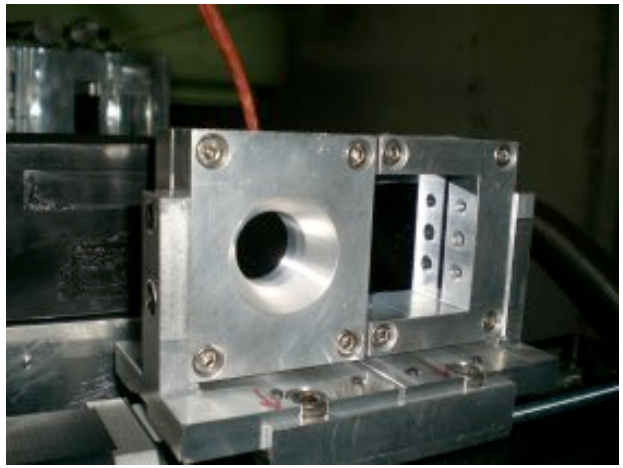






Strip Crystals have been fabricated in the Sensors and Semiconductor Laboratory (Ferrara, Italy)

Crystal sizes: ~ 0.9 x 70 x 3 mm^3

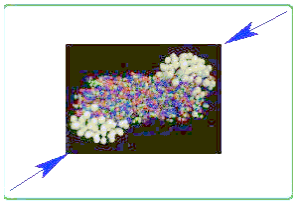


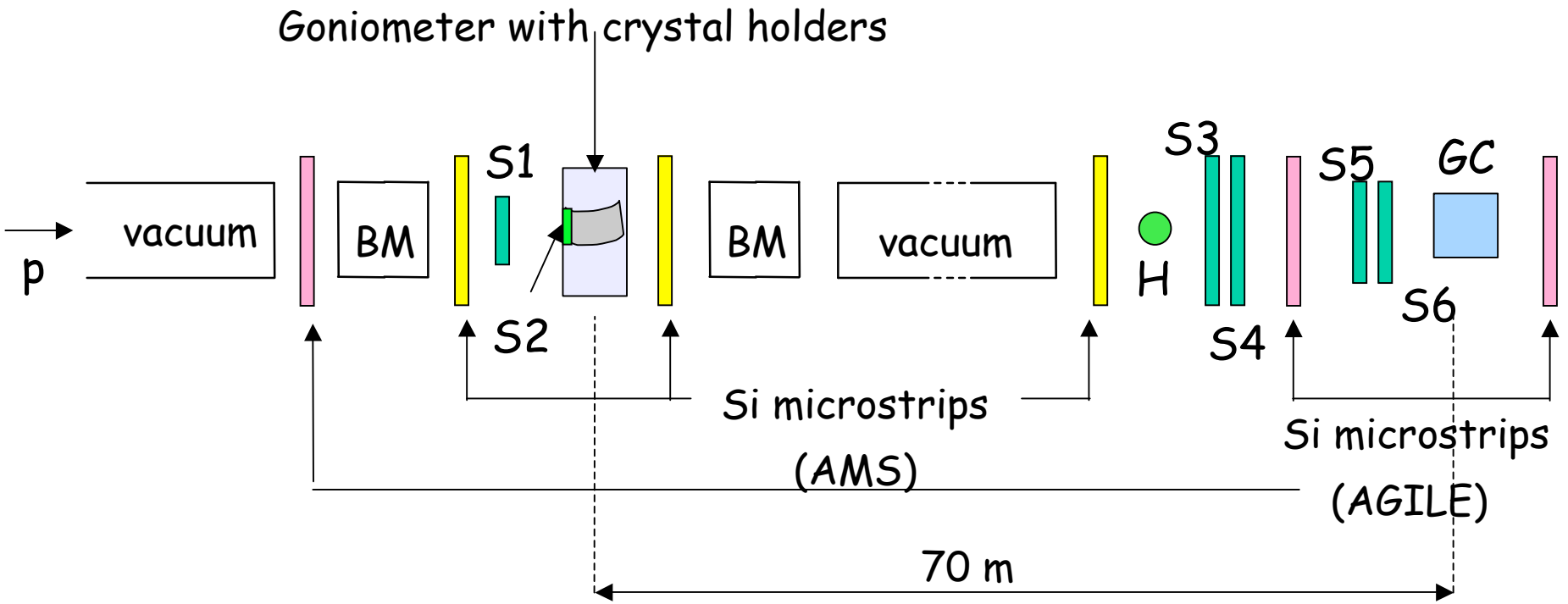
Quasi-Mosaic Crystals have been fabricated in PNPI (Gatchina, Russia)

Crystal plate sizes: ~ 1 x 30 x 55 mm^3

critical angle for 400 GeV/c protons
$\theta_c \approx$ 10 μrad

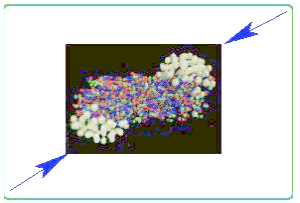
Layout (not to scale)

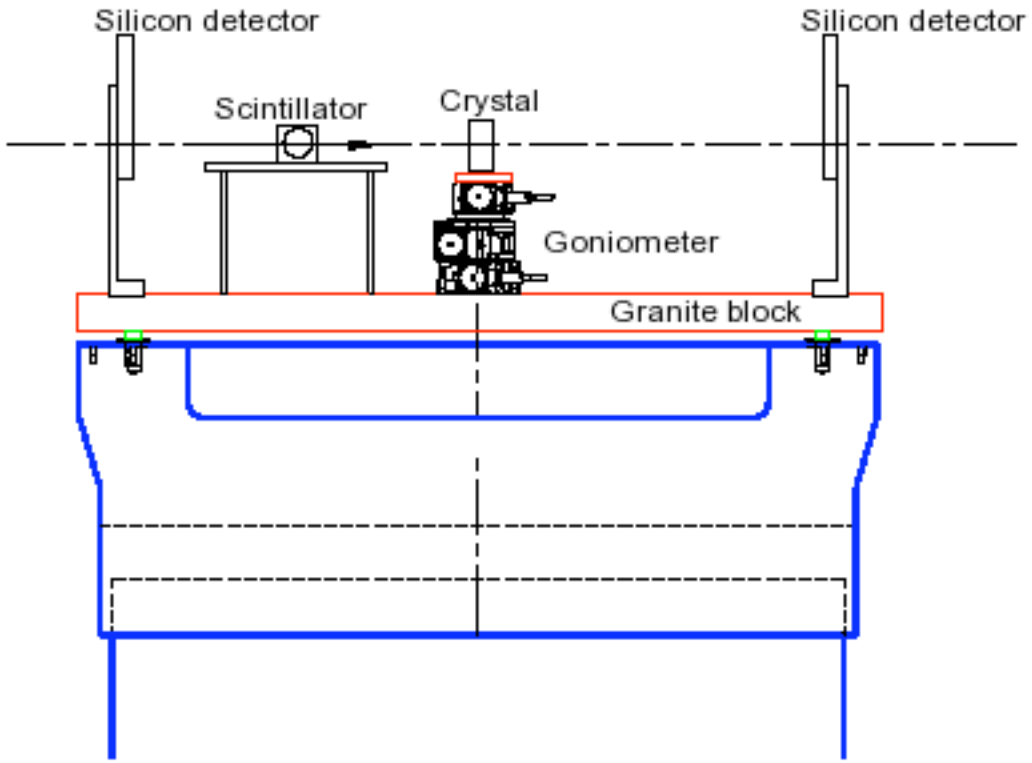


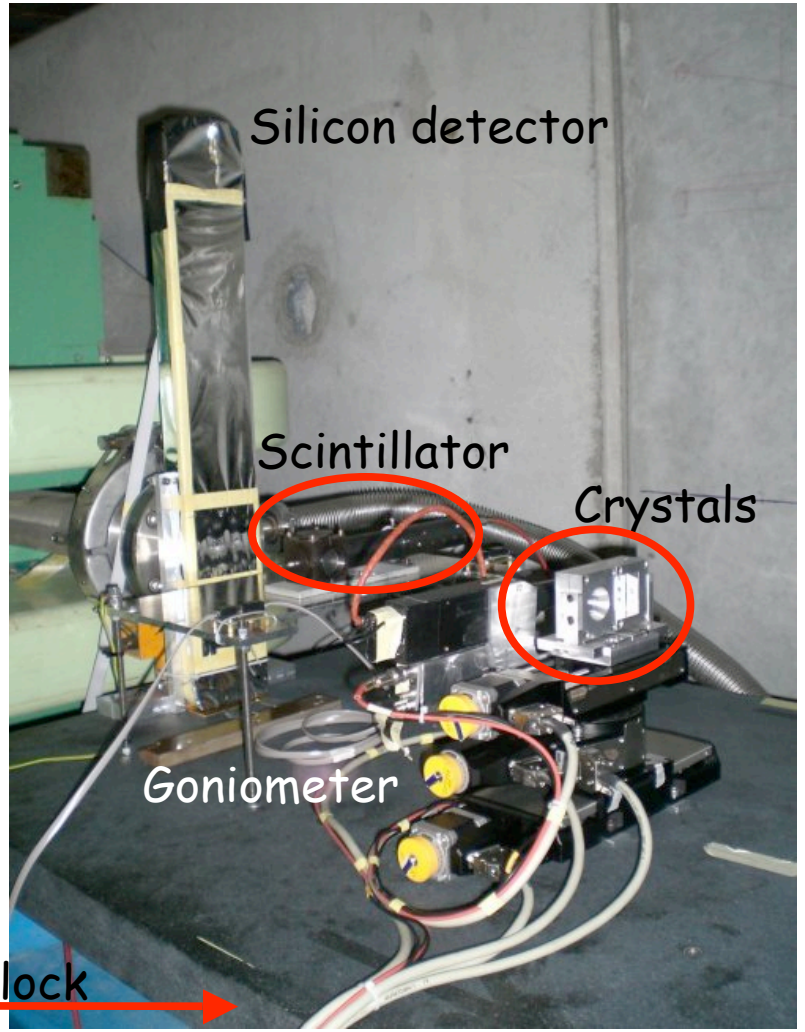


- Scintillators (S1-S6)
- Scintillating Hodoscope (H)
- Gas Chamber (GC)
- Bending Magnet (BM)

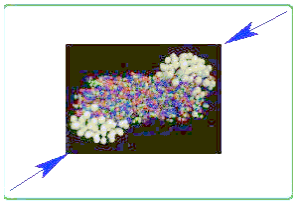
High precision goniometer

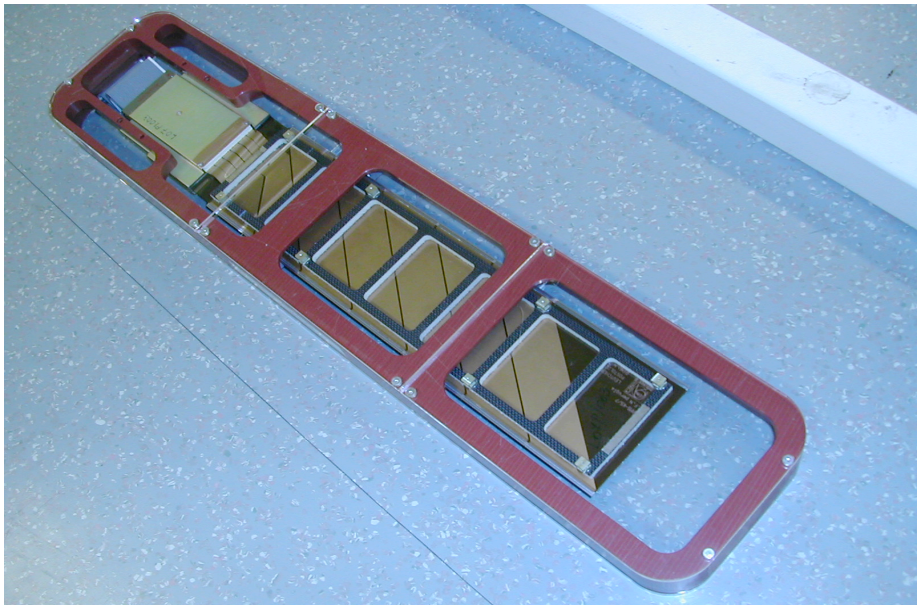






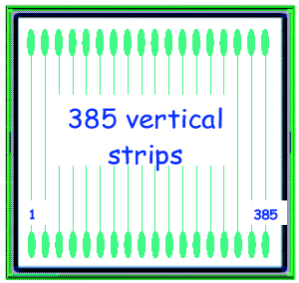
AMS Silicon Detectors





Silicon thickness:

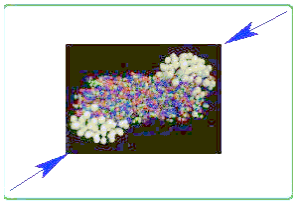
300 μm



- double-sided silicon micro-strip detectors:
  - Resolution ~ 10 μm in bending direction (X coordinate)
  - Resolution ~ 30 μm in non-bending direction (Y coordinate)
  - Active area of the 3 layers installed

  ~ 7.0 x 2.8 cm^2, ~ 1.9 x 1.9 cm^2, ~ 4 x 7 cm^2

AGILE Silicon Detectors

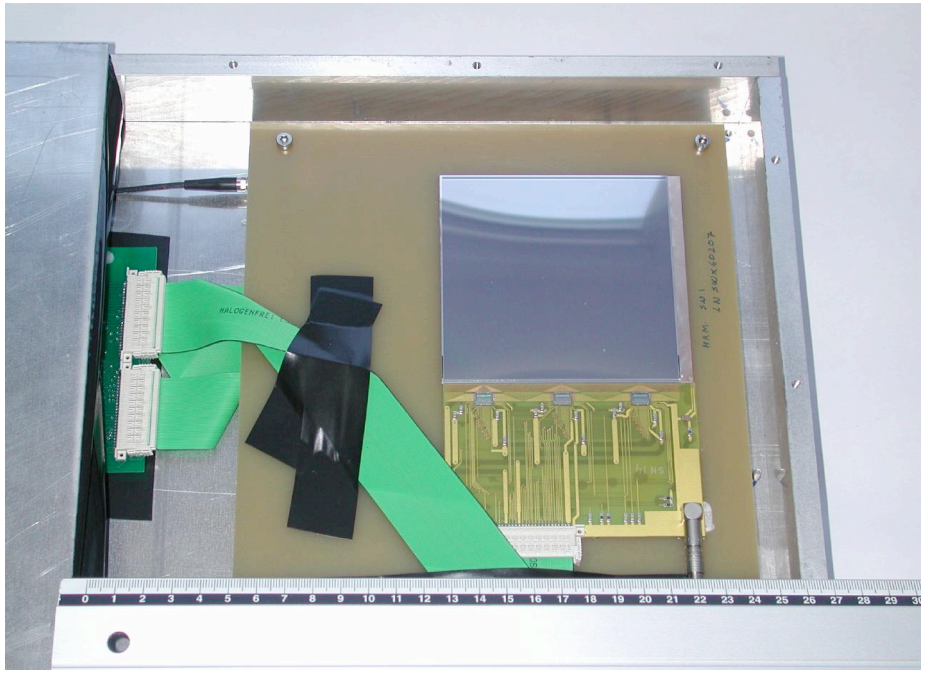


- Single-sided silicon strip detectors
- Built by Agile (INFN/TC-01/006)
- active area 9.5 x 9.5 cm^2
- Spatial resolution: ~ 40 μm at normal incidence (~ 30 μm for tracks at 11°)
- Silicon thickness: 410 μm

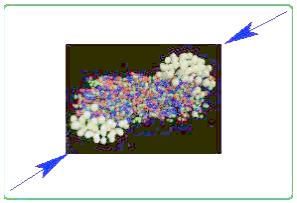
- Upstream detector (before goniometer):
  - 2 silicon detectors at 90° (corresponds to 1 X-Y plane)

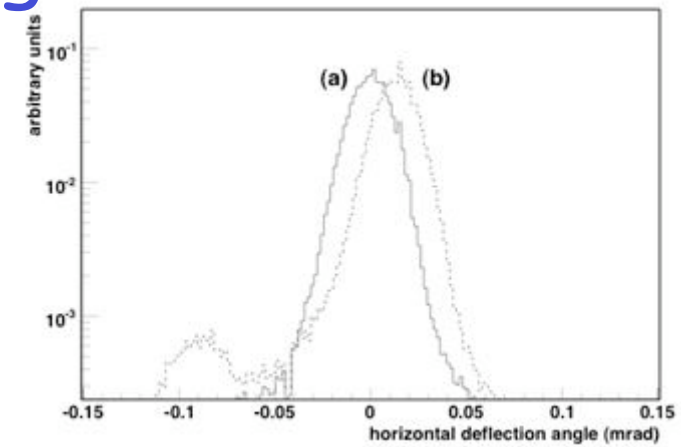
- Downstream detector 1 (at 65 m from crystal location):
  - 4 X-Y silicon planes

- Downstream detector 2 (at 65 m from crystal location):
  - 6 X-Y silicon planes interleaved with 300 μm tungsten planes

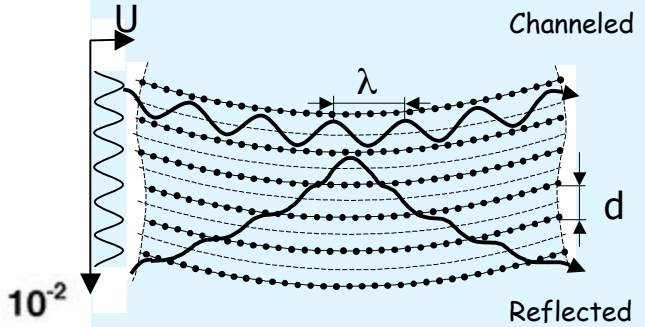


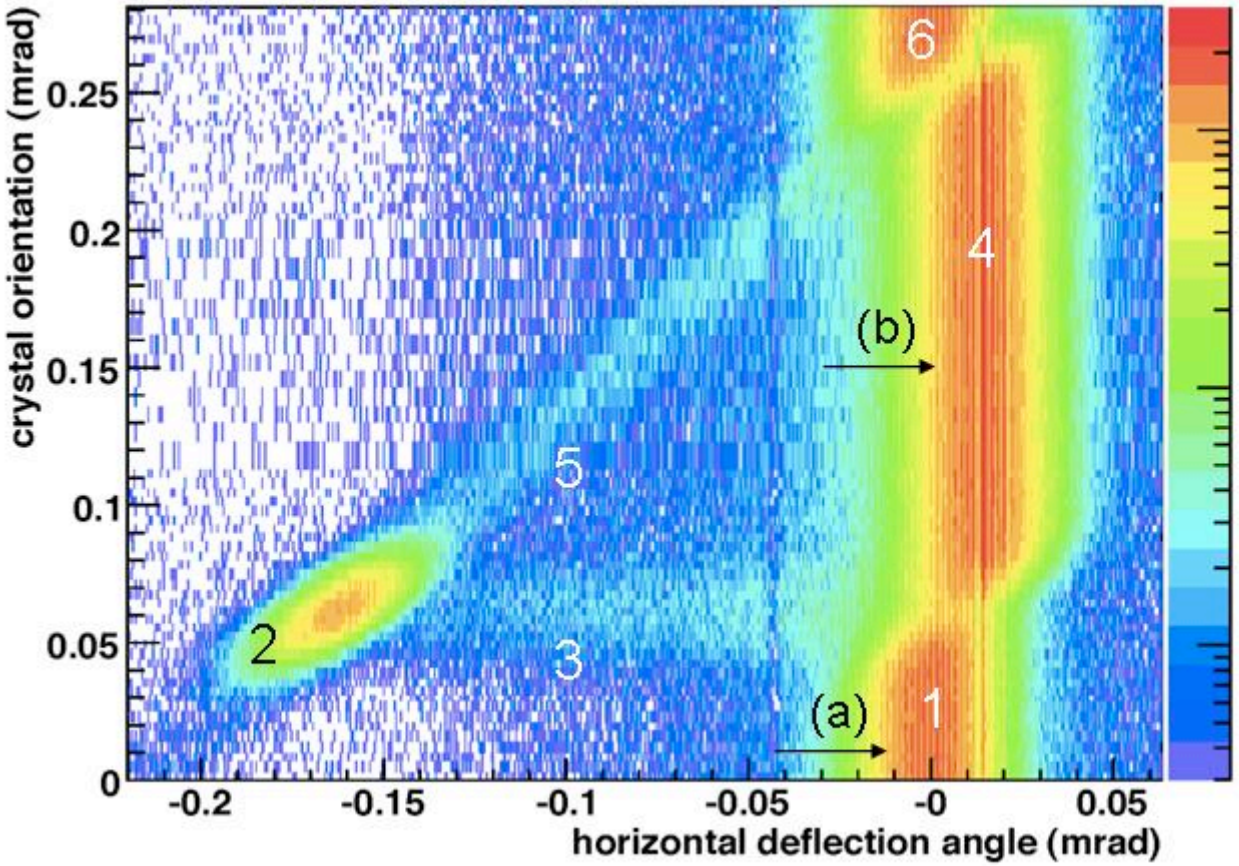
Angular scan of a crystal

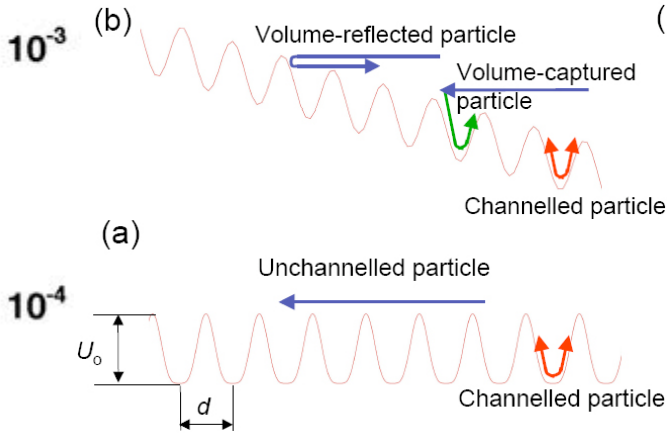




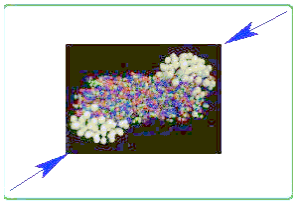
Predictions in 1985-'87 by
A.M.Taratin and S.A.Vorobiev,
and O.I. Sumbaev

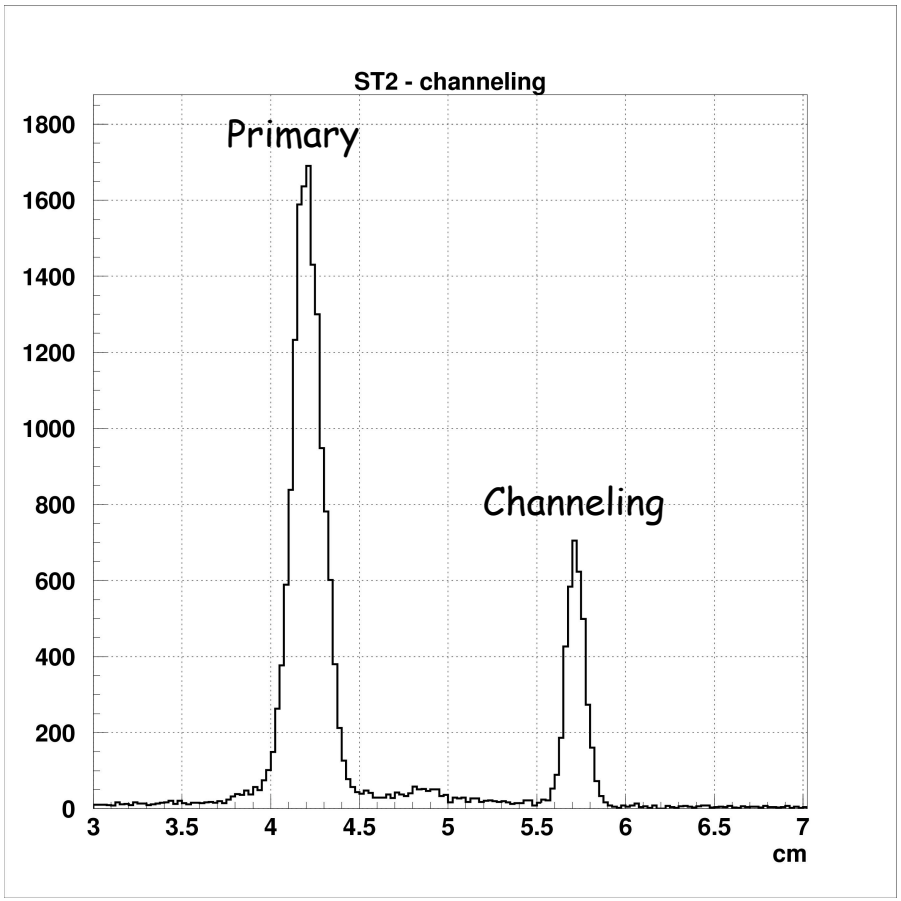


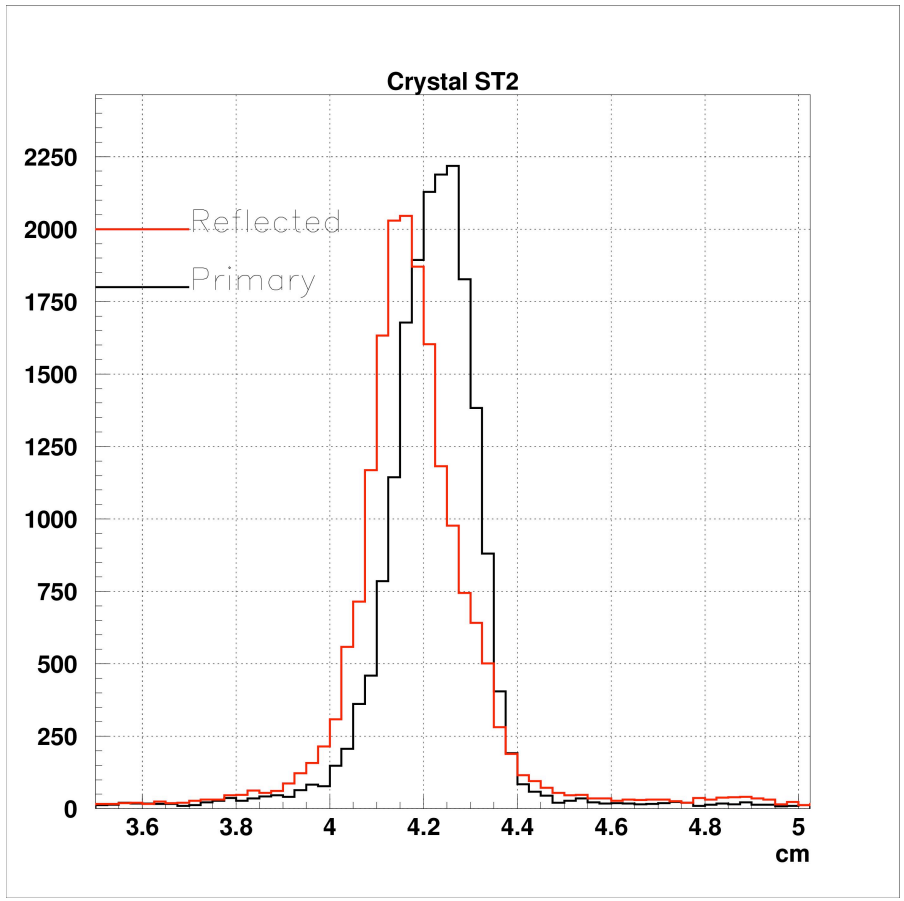




Angular scan of a crystal

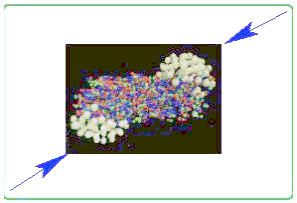




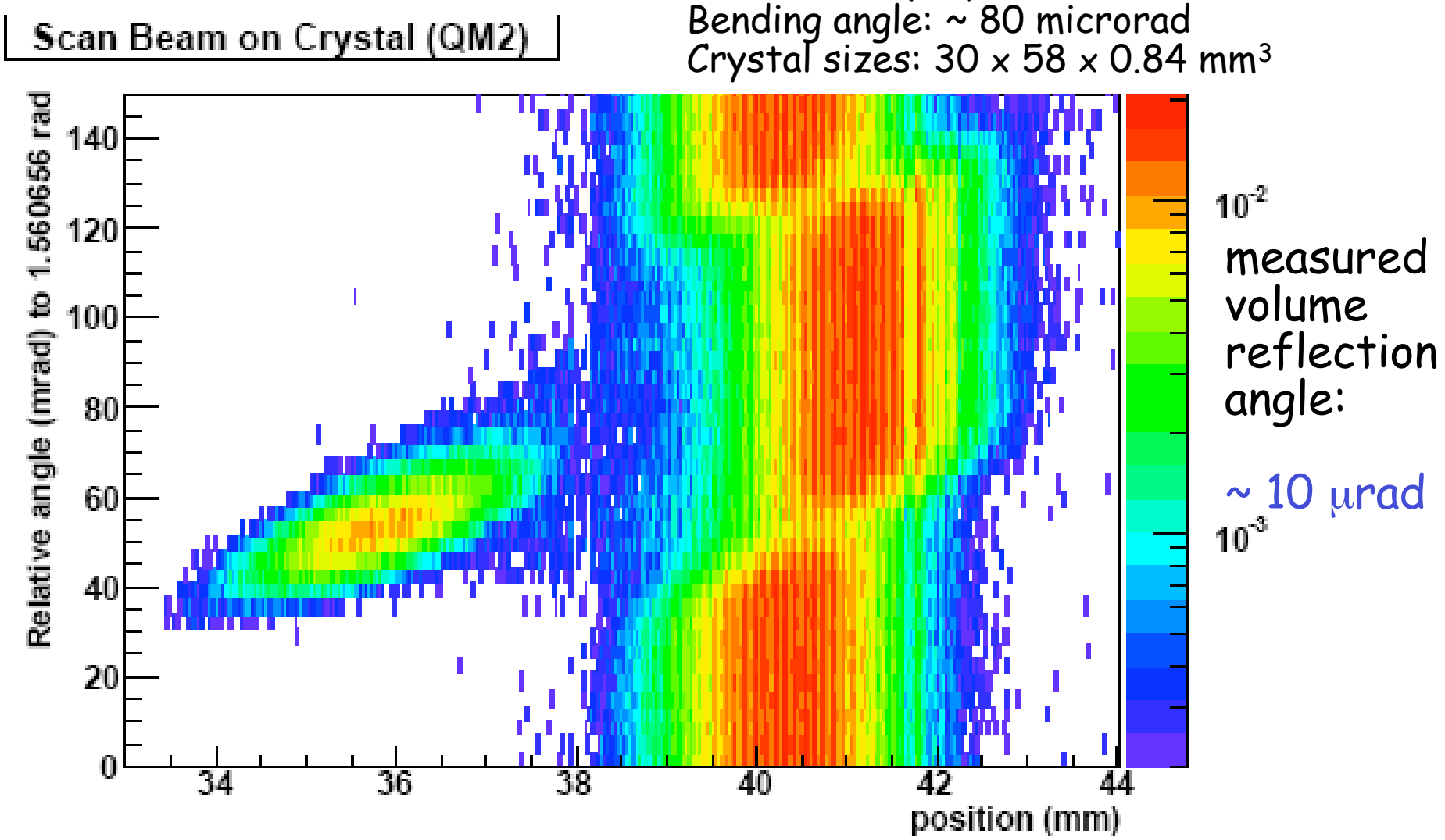


measured volume reflection angle: ~ 10 μrad

Scan of Quasi-Mosaic Crystal



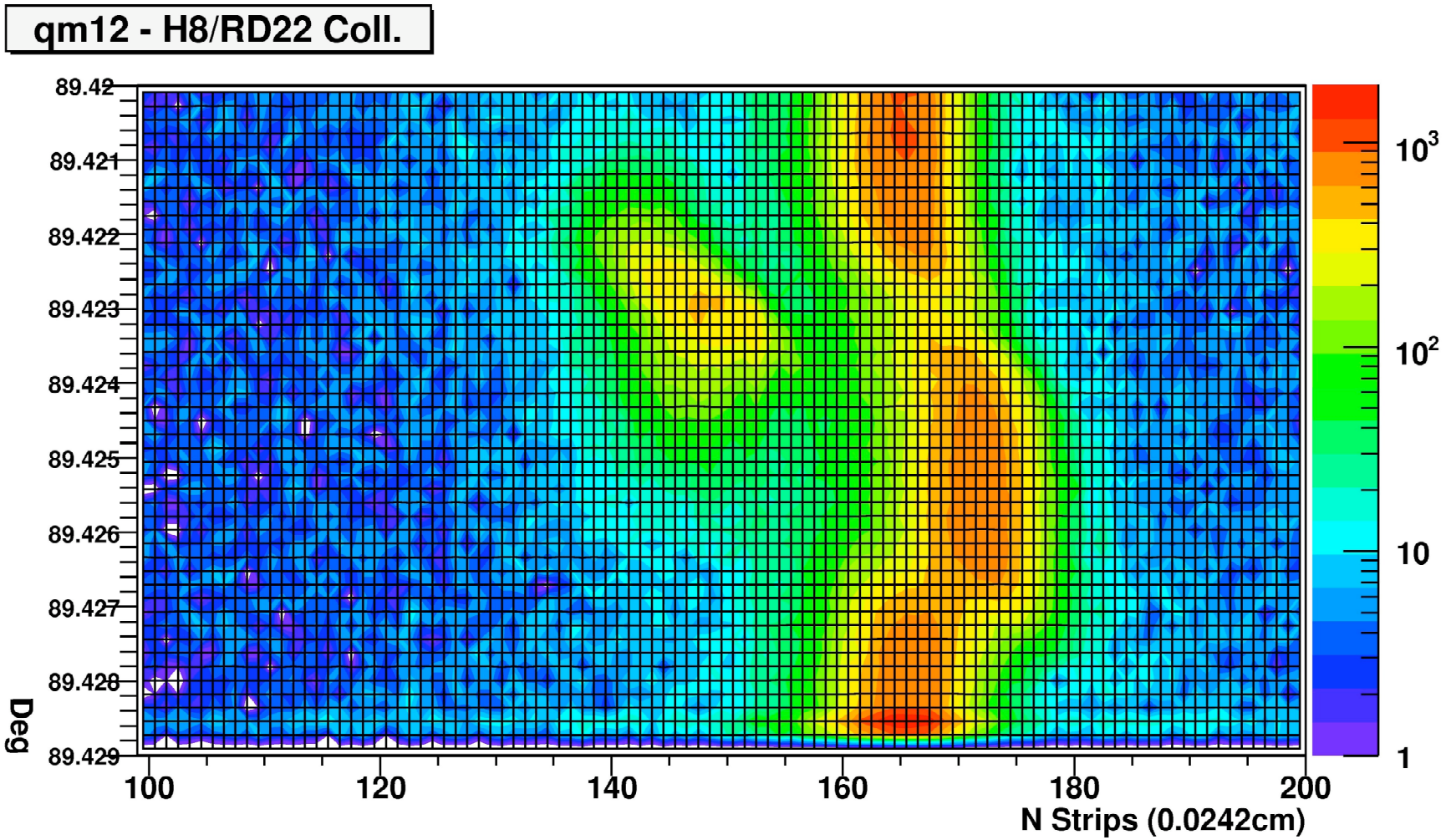
Orientation (111)
Bending angle: ~ 80 microrad
Crystal sizes: 30 x 58 x 0.84 mm^3



measured volume reflection angle:

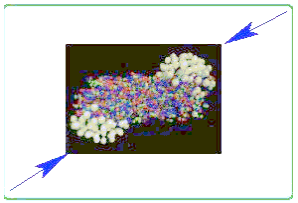
~ 10 μrad

Double Reflection on Quasi-Mosaic Crystals



double reflection angle: ~ 20 μrad

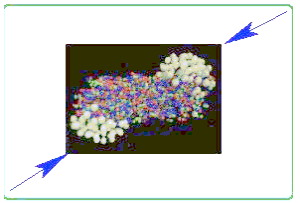
Conclusive remarks



- First observation of Volume Reflection Effect in bent silicon crystals with 400 GeV/c protons with efficiency close to unity
- Measurement of volume reflection angle: ~ 10 μrad
- First observation of Double Reflection using two crystals in series: combined reflection angle is ~ 20 μrad and efficiency close to 1
- Channeling and Volume Reflection phenomena studied with Strip and Quasi-Mosaic Silicon Crystals (different fabrication techniques)
- Measurement of crystals with different crystalline planes orientations: (111) and (110)

Networking support from CARE-HHH and from INTAS-CERN programmes

Forward looking plans



- Precise measurement of the probability of Volume Reflection Effect
- Multi-reflection effect (3 to 5 proton reflections)
- Edge effects
- Use e^- e^+ ions
- Use new crystals (Ge, C, W) and zeolytes

… with the continuing support of CARE-HHH and INTAS-CERN programmes