Crystals for applications in a muon collider

Istituto Nazionale di Fisica Nucleare

A. Mazzolari on behalf of Eliot experiment

Outlook

- Brief introduction
- Tungsten crystals for coherent pair production
- Innovative sources of hard radiation
- Conclusions

Crystals technology at INFN

Collimation
Beam steering
Innovative radiation sources
Pair production studies
Innovative detectors

Beam steering
Innovative radiation sources
Pair production studies

Beam steering
Innovative radiation sources
Pair production studies

CRYSBEAM
SELDOM

INFN Competencies

INFN has competencies related to

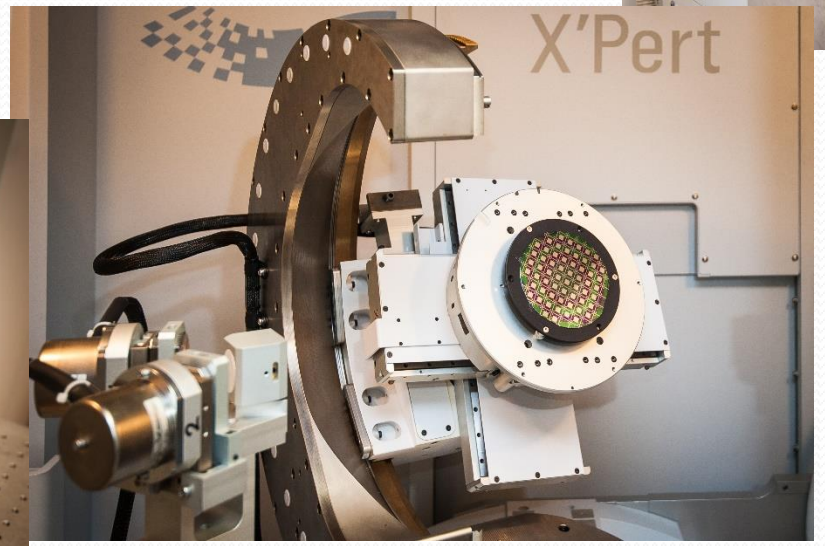
- Development of innovative ideas and research activities (connected to channeling and related effects)
- Crystals manufacturing and characterization
- Holders manufacturing and characterization
- Goniometry
- Trackers and detectors
- Data analysis
- Design of setups for channeling experiments

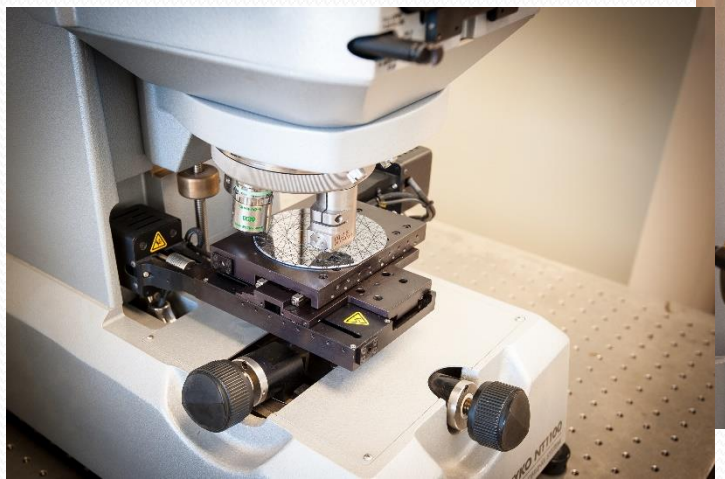
→ INFN is a scientific agency encompassing a full set of competencies related to studies of coherent effects between charged particle beams and crystals.

INFN infrastructure

Laboratory fully equipped for silicon micro and nanomachining
ISO4 certified clean room (130 m²)

High-resolution x-ray diffraction
Dicing and polishing equipment
White light and Fizeau inteferferometers

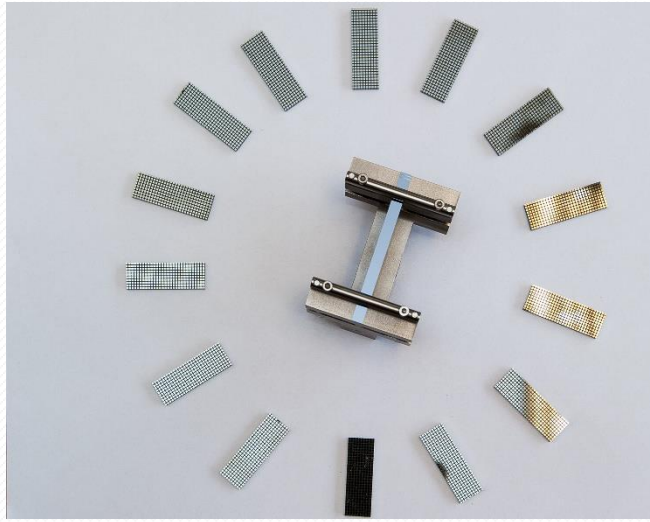


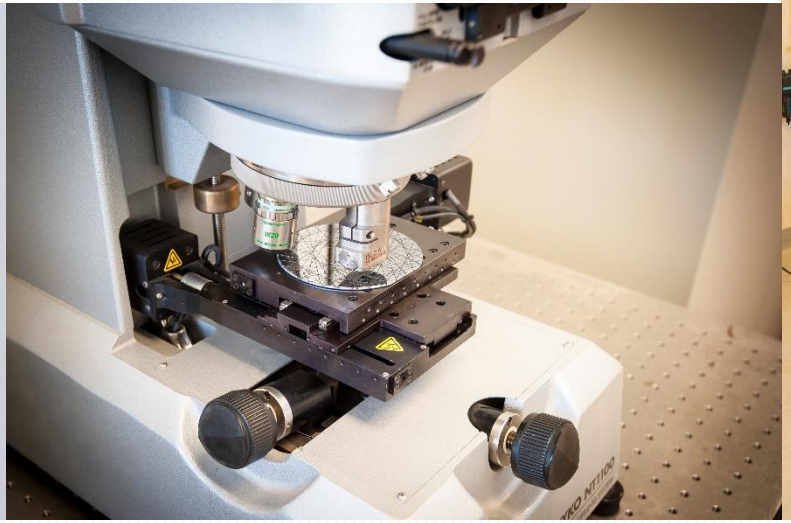


INFN infrastructure

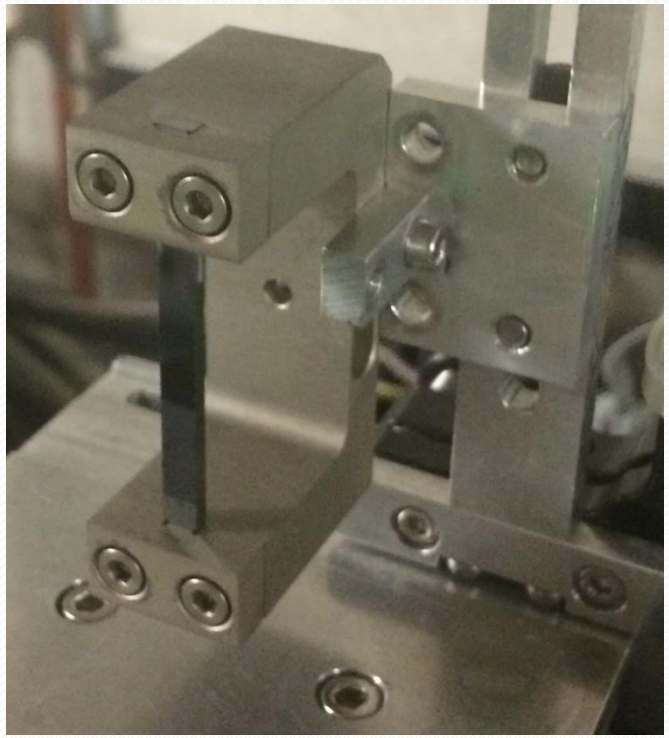
Laboratory fully equipped for silicon micro and nanomachining

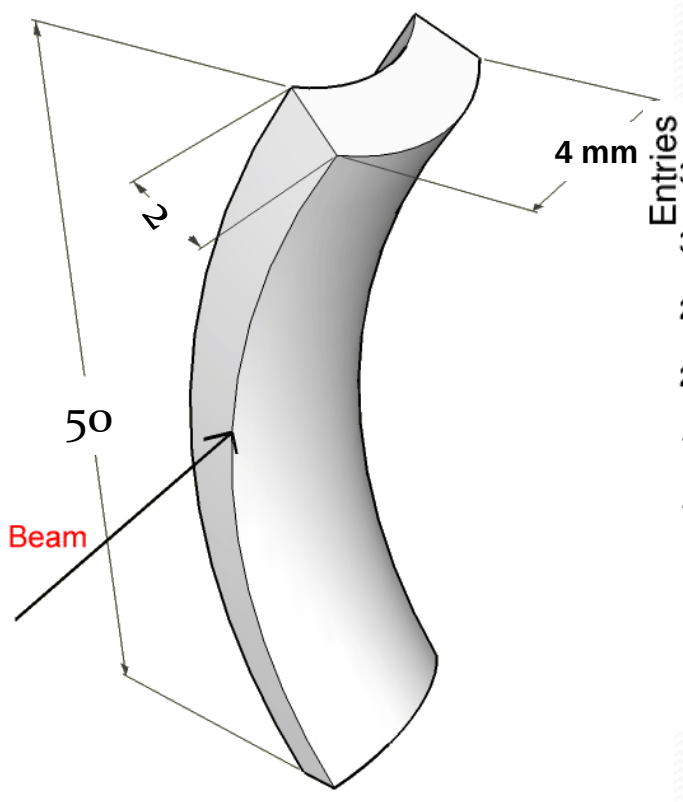
Fotolitography
Equipment for silicon chemical etching
Nanoimpringing

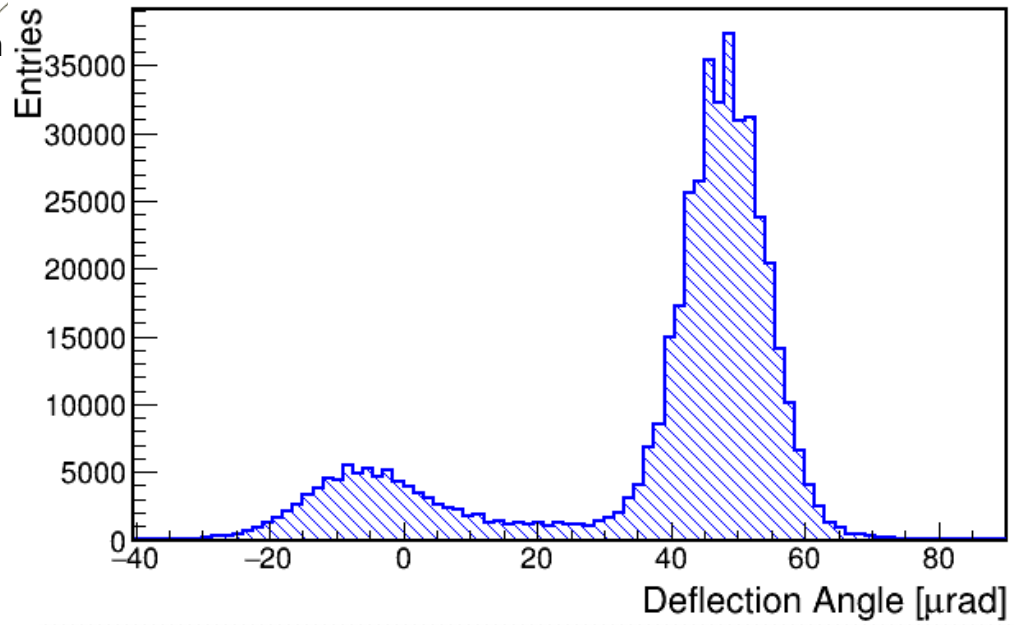




Strip crystals for the LHC





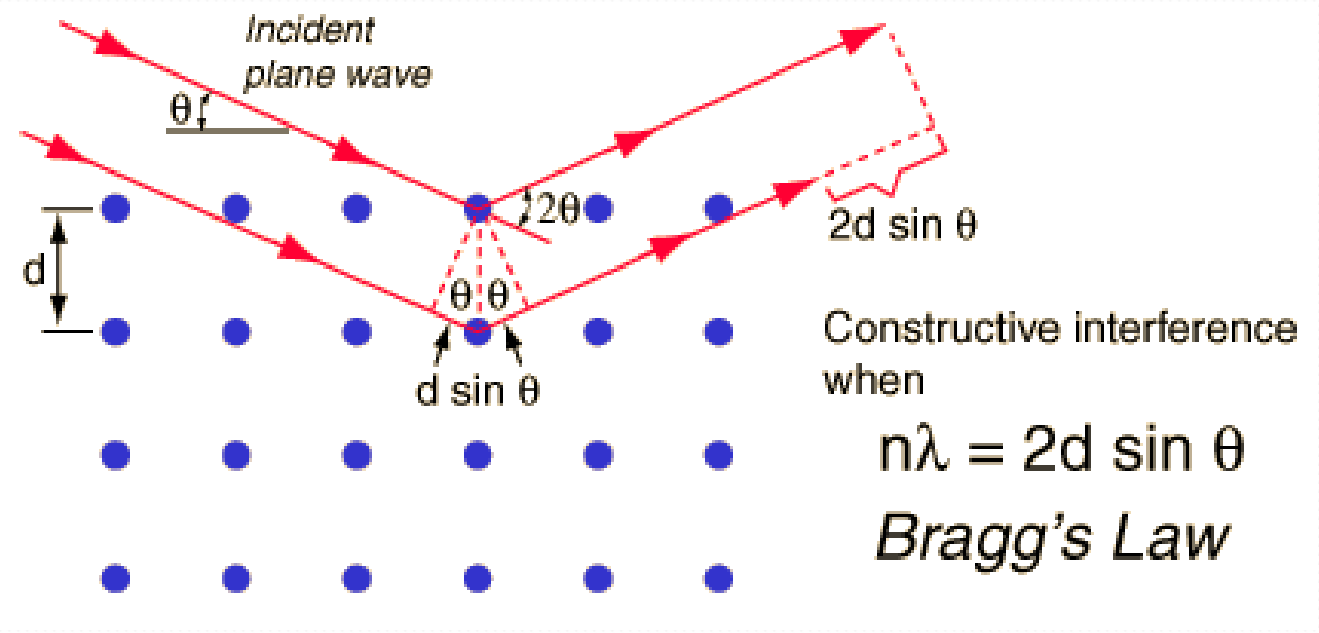


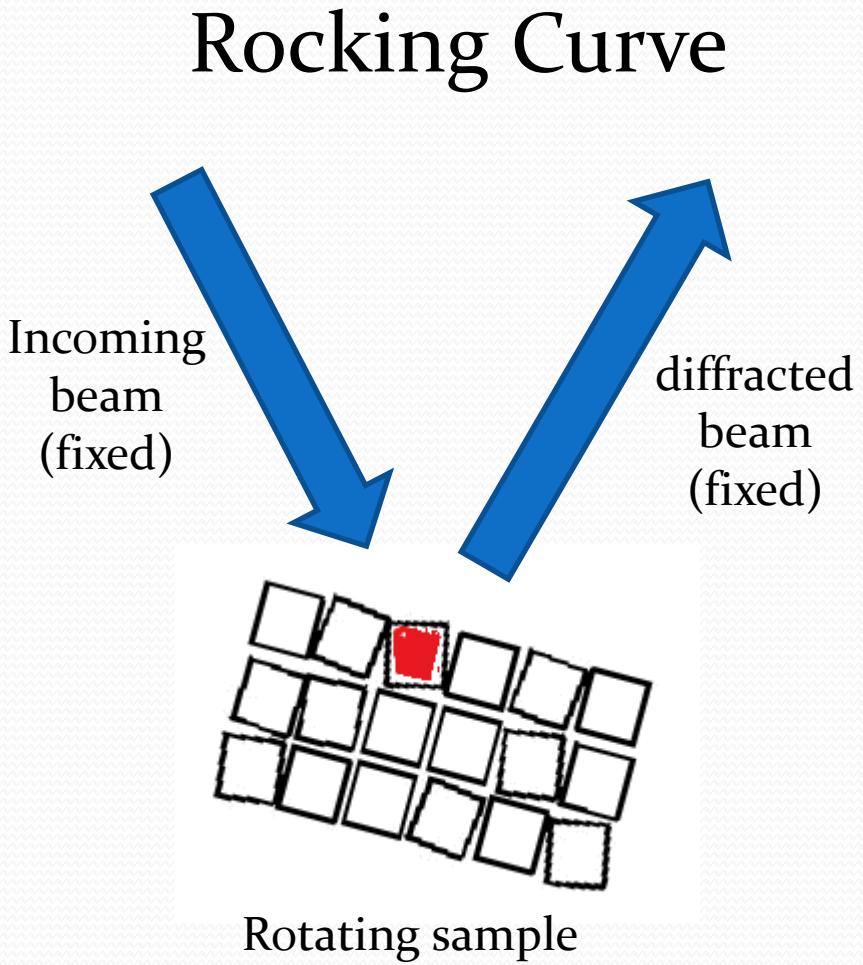
A primary bending is mechanically imposed along the 50 mm size.
As a result, «anticlastic bending» manifests along the 4 mm size.

Tungsten crystals for coherent pair production

- Tungsten crystals for intense radiation generation for hybrid positron source and pair production (KLEVER)
- Innovative sources of hard radiation
- Conclusions

Tungsten crystals for coherent pair production X-rays diffraction





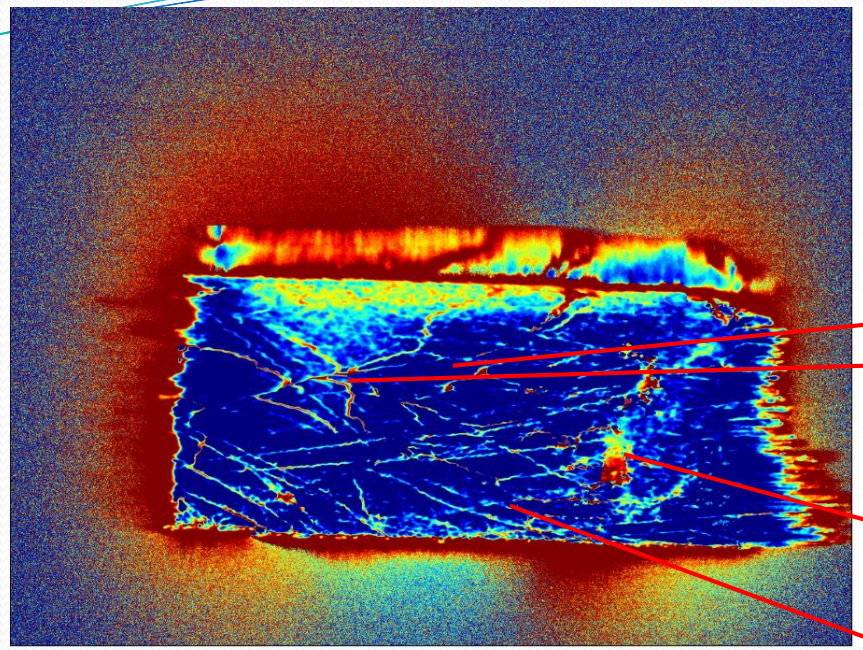
Tungsten crystals for coherent pair production
Instrument set-up

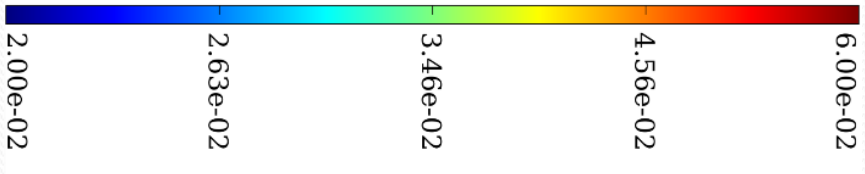
- Synchrotron Beamline B05 @ ESRF in Grenoble
  - 6→60 KeV x-rays
  - High intensity and quality of beam **(only 4 other synchrotrons worldwide with similar features in term of design and power)!!**
  - High resolution imaging detectors (~5 μm vertical, 5 μm/$\sin\theta_B$ horizontal)

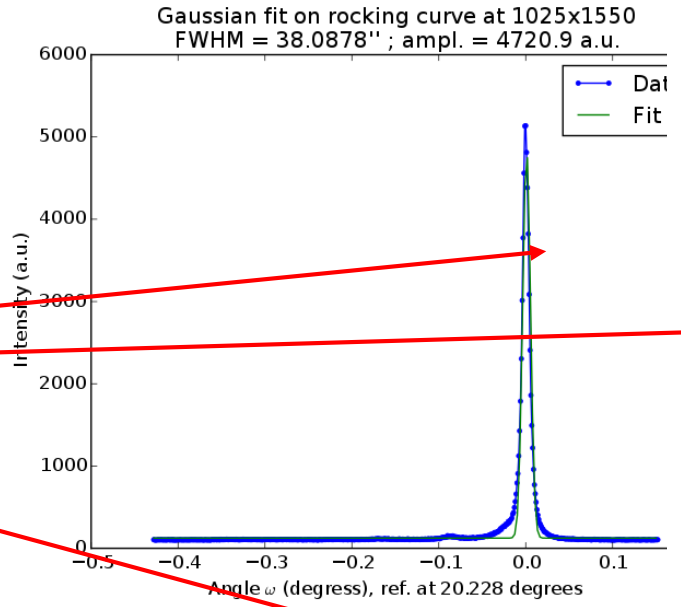
- High resolution X-rays diffractometer (HRXRD) @ INFN-Ferrara
  - 8.14 KeV x-rays (Cu $K\alpha_1$)
  - Analysis of diffracted beam angular divergence (triple-axis configuration)
  - Mapping of total angular distribution of domains in different part of the sample

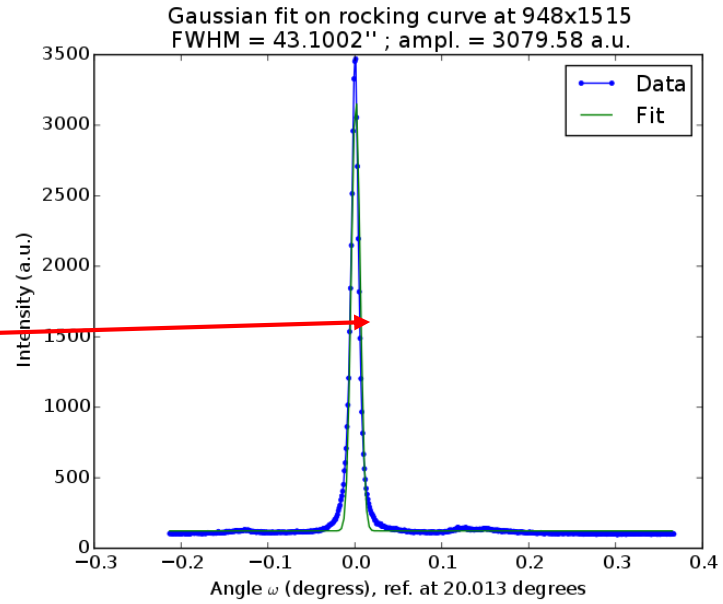
Sample W_ID12 surface (111) → diffract (222), Bragg angle 19.3 degree at 20keV

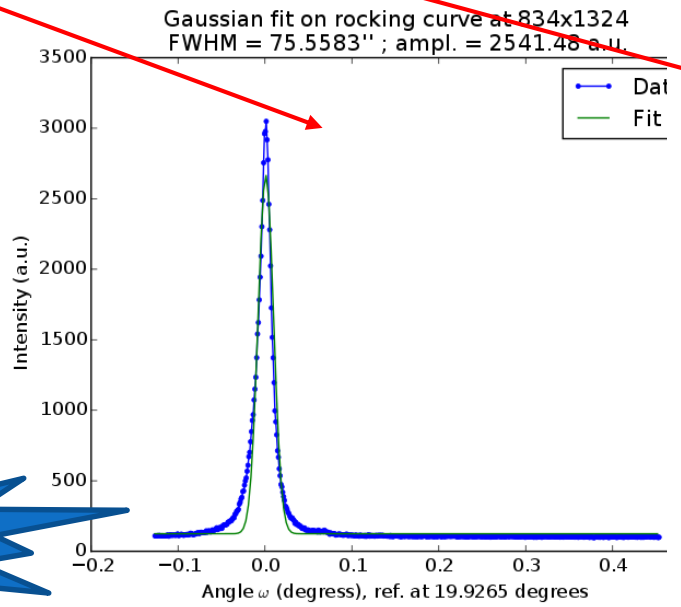
FWHM map (in degree)

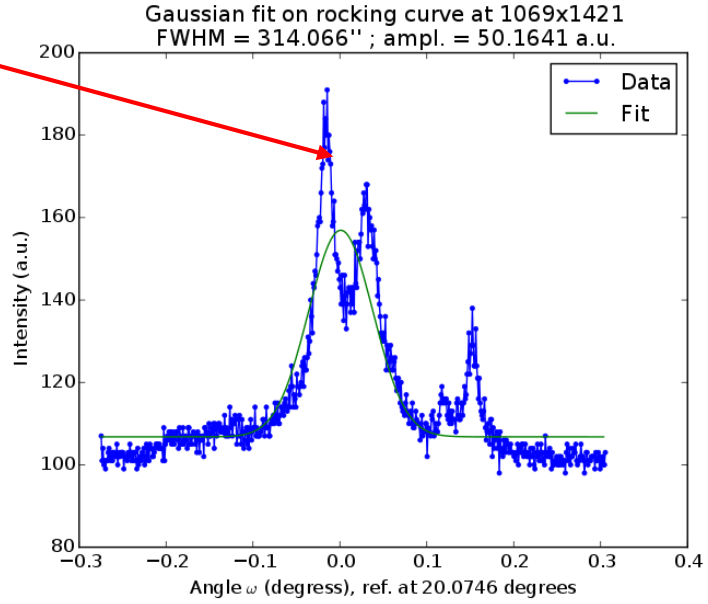












Blue good	Blue	Yellow	Red
185 µrad	209 µrad	366.5 µrad	1522.5 µrad

Courtesy of R. Camattari

Perfect
~10 µrad

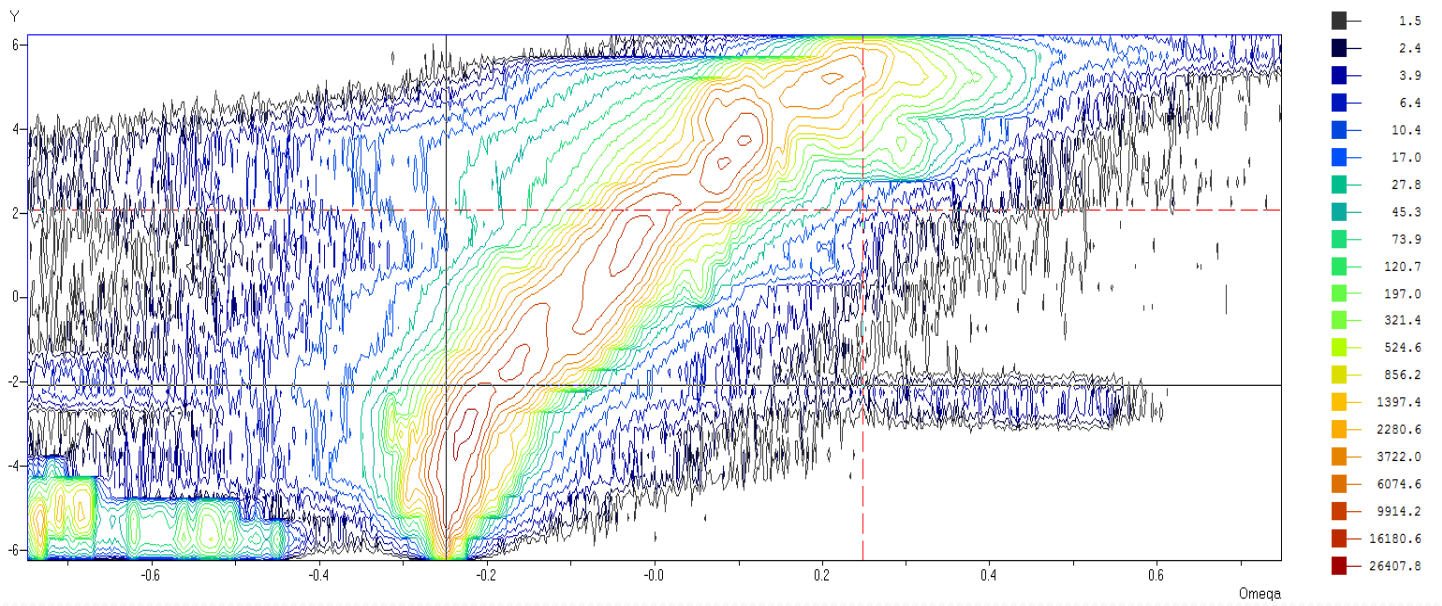
Tungsten crystals for test beam @ DESY

Reflection is observed at all points of the sample

The total angular distribution of all the crystals domains on all the crystal surface is roughly within 0.4° (7 mrad)

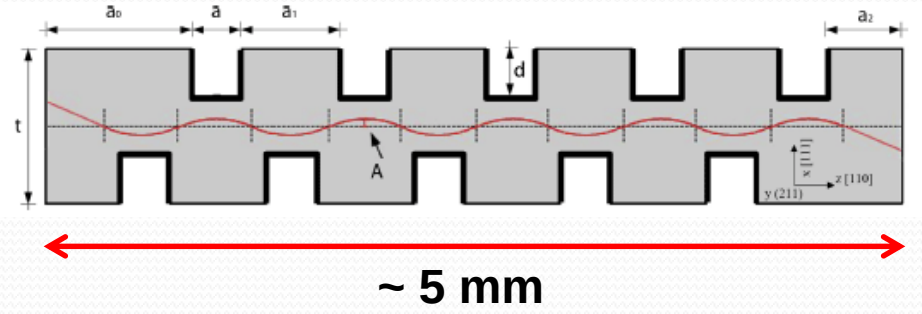
The angular spread of such domain is of the order of 1.5 mrad

The angular position of the diffracted beam and its divergence is close to nominal, possible stress of the order of tens of Mpa.



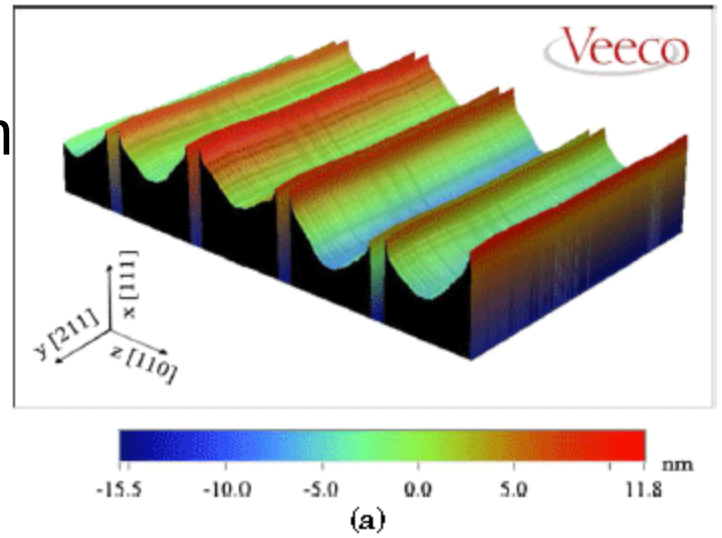
CRYSTALLINE UNDULATOR – MANUFACTURING AND CHARACTERIZATIONS –

Crystalline undulator manufactured grooving a silicon substrate by means of a high precision dicing machine.

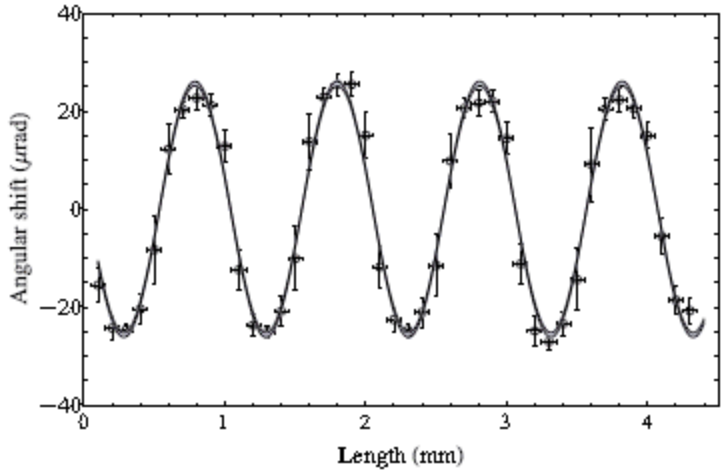


A periodical deformation is Imparted to the crystal

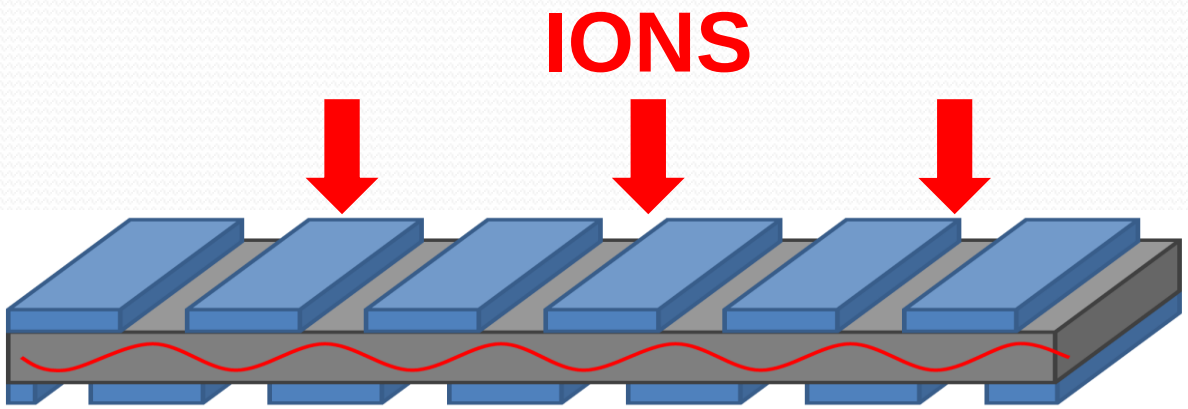
Interferometric characterization (Veeco)



Characterization @ ESRF (BM-05)

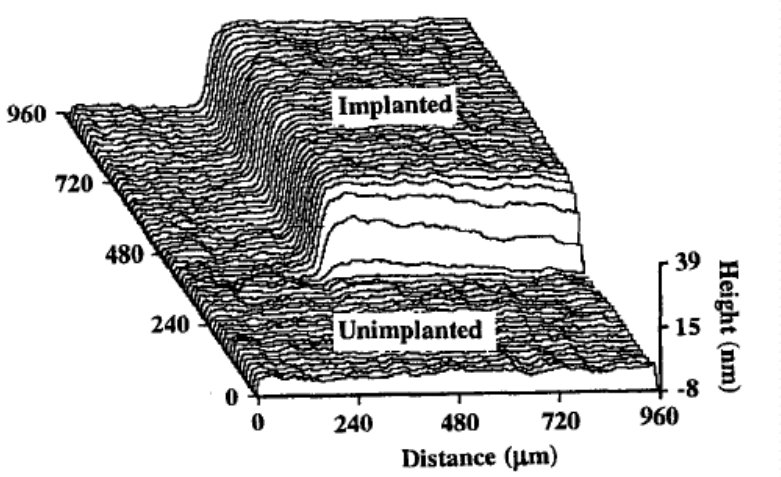


CRYSTALLINE UNIDIMENSIONAL ION IMPLANTATION



Omogeneus flux of Ions (He, Ar) impinges on the free surface of the wafer creating damages and so an amorphization of the crystalline structure.

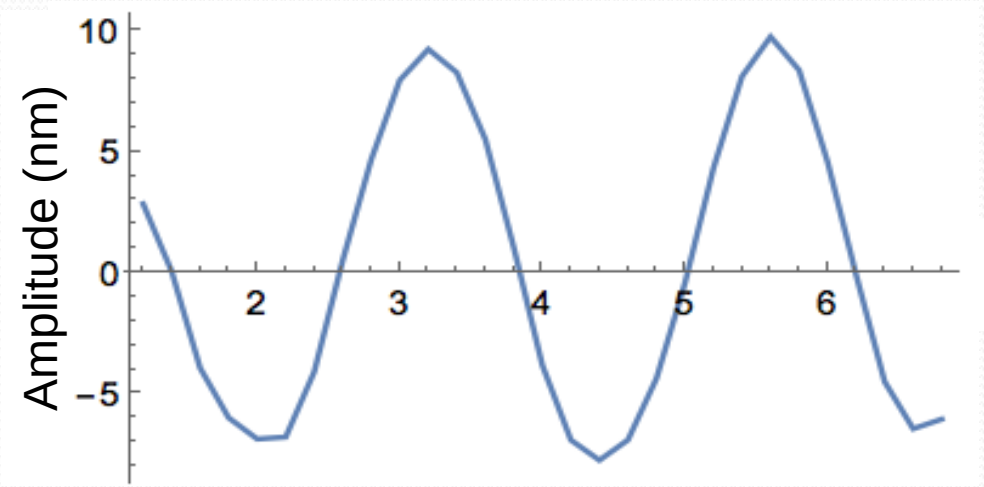
From swelling studies, a density reduction of 3.1% for the pure amorphous Si with respect to crystalline Si was found [1].
The grow of volume of the amorphized region transfers coactive forces to the crystal bulk, thus producing an elastic strain field within the crystal, which results in a net curvature within the crystal bulk.



advantages: no delamination or crack propagation

[1] P. K. Giri at al., Phis. Rev. B 65, 012110 (2001)

CRYSTALLINE UNDULATOR – MANUFACTURING AND CHARACTERIZATIONS



- Implanted ions: 15 KeV He^{++}
- Crystal deformation characterized at DIGRA (ILL) by means of highly energetic gamma-rays
- 181 KeV photons
- Crystal exhibit a clear periodical deformation

Conclusions

- INFN is a scientific agency with a full set of capabilities and an international network of partners capable to perfom experiments aimed to study coherent interactions between charged particle beams and crystals
- R&D on tungsten crystals already started, in collaboration with ELIOT and KLEVER experiments
- Prototypes of crystalline undulators ready