# Low energy channeling and x-ray diffraction for crystals characterization

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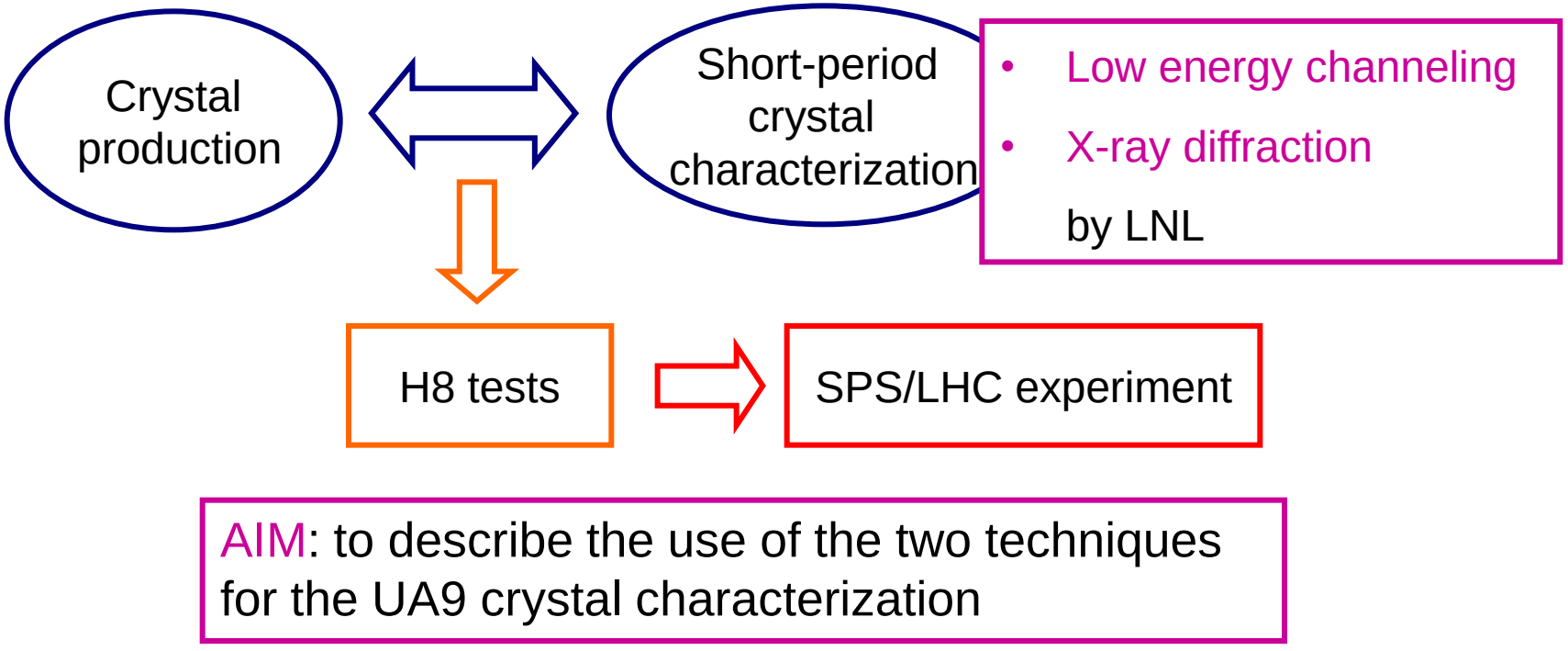
# Introduction

- **Different kinds of crystals for collimation applications have been produced by Ferrara group.**
- **The fundamental tests on such crystals have been performed in H8 experimental area.**
- **Crystal production optimization need a short period feedback basically provided by LNL group.**

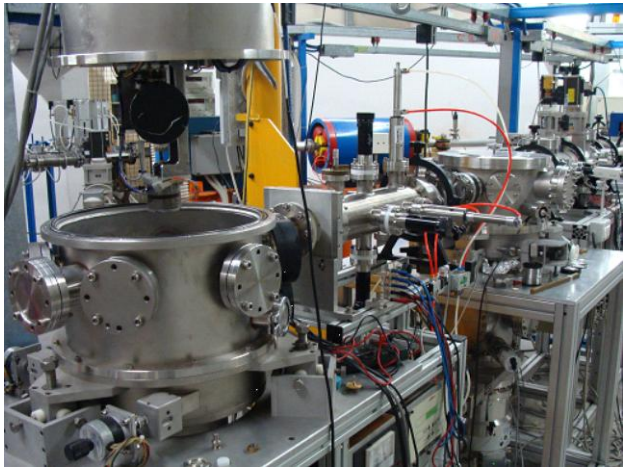


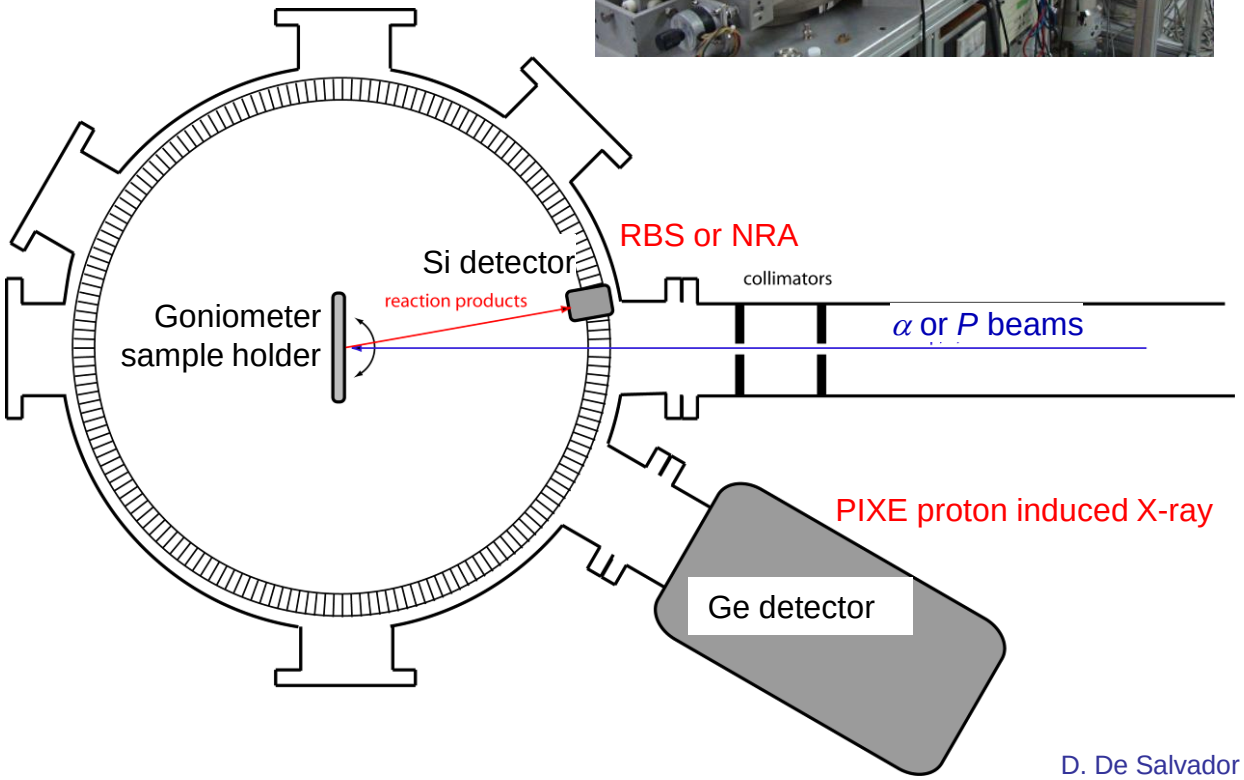

AIM: to describe the use of the two techniques for the UA9 crystal characterization

# Low energy channeling apparatus

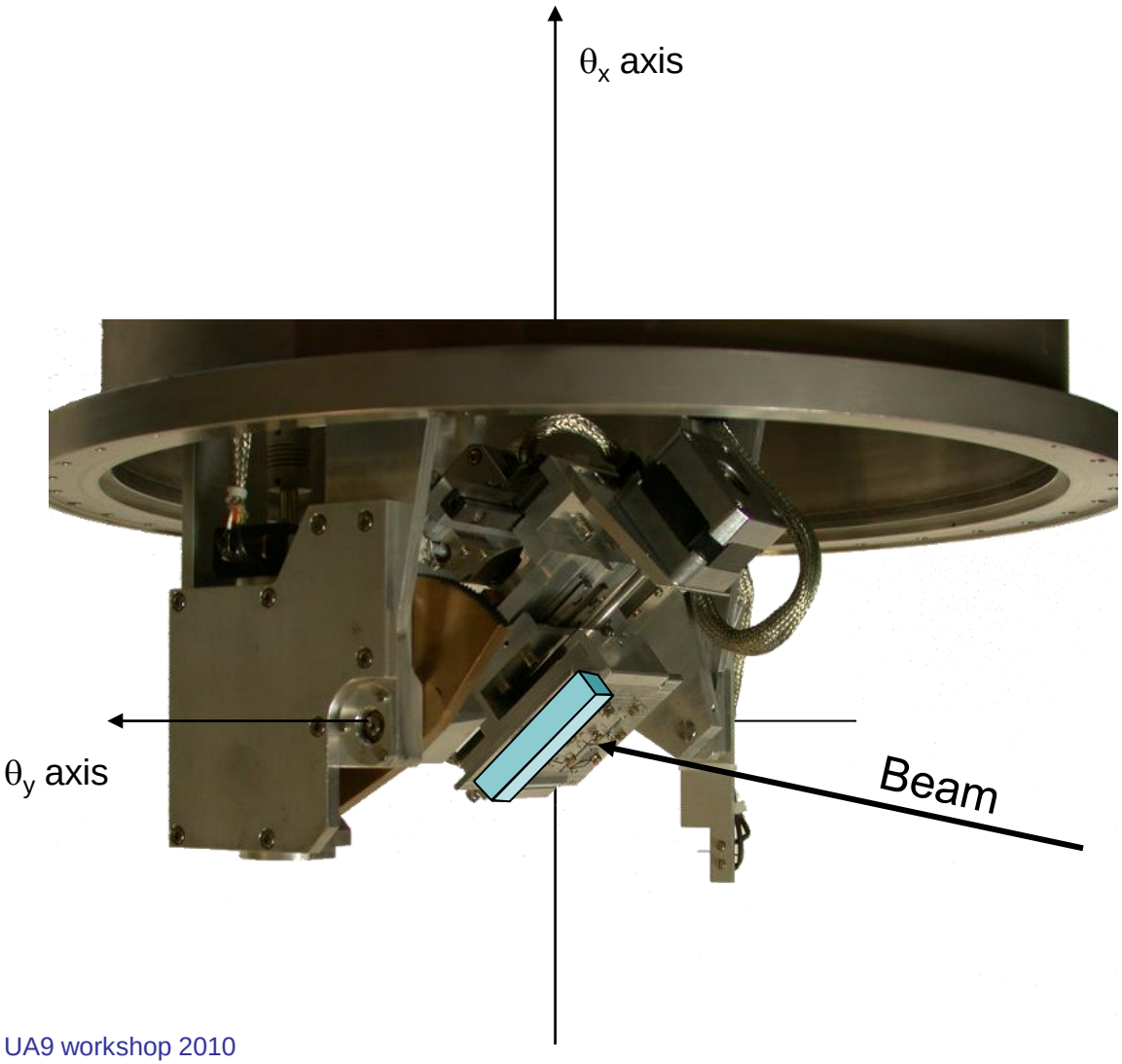
LNL open facility - about monthly available by application

- $\alpha$ or *P* beams
- Energies : 2 to 7 MeV
- Investigated depth in Si: 0.5 to 60 $\mu$m





# The goniometer for low energy channeling studies




Ang. Resolution = 0.2 mrad
Beam divergence < 0.3 mrad

but

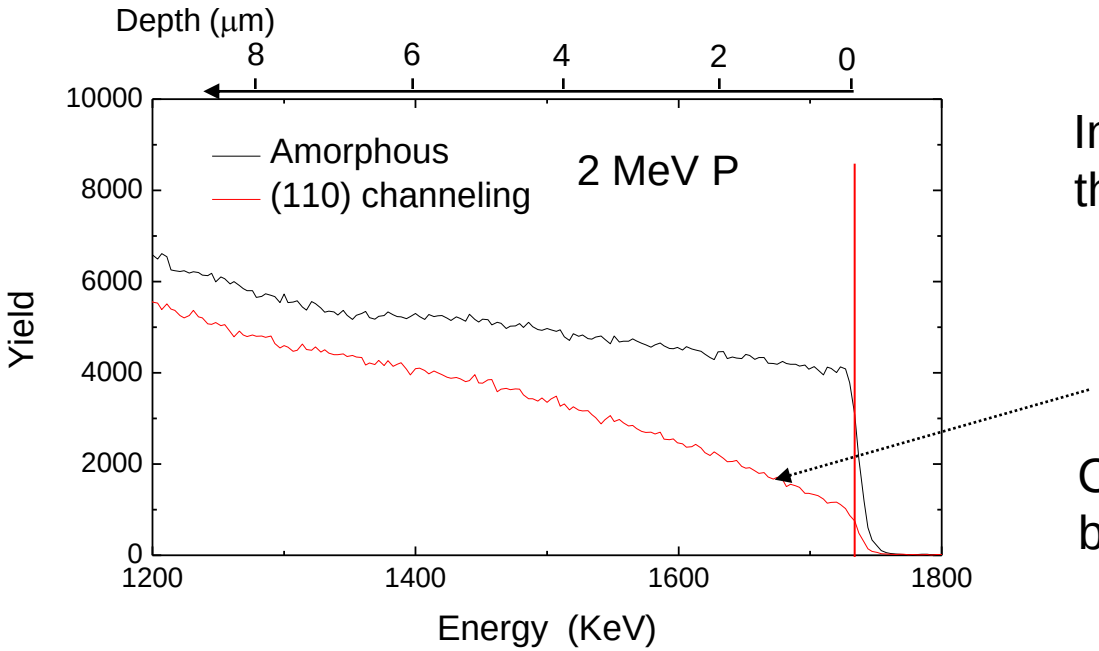
Typical critical angle 2 mrad

Translation resolution 0.01 mm
Beam size down to 0.2 mm

suited

for analysis on the strip border where channelling beam impinges

# What can we learn ?




In channeling condition only the non-channeled particles undergo backscattering

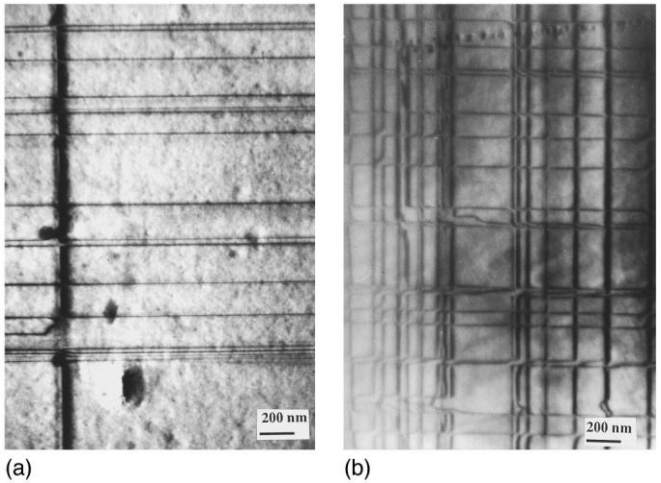
Channeling inefficiency can be measured in the surface region

Low energy efficiency is related to nuclear and electronic dechanneling and, if present, by defect-related dechanneling.

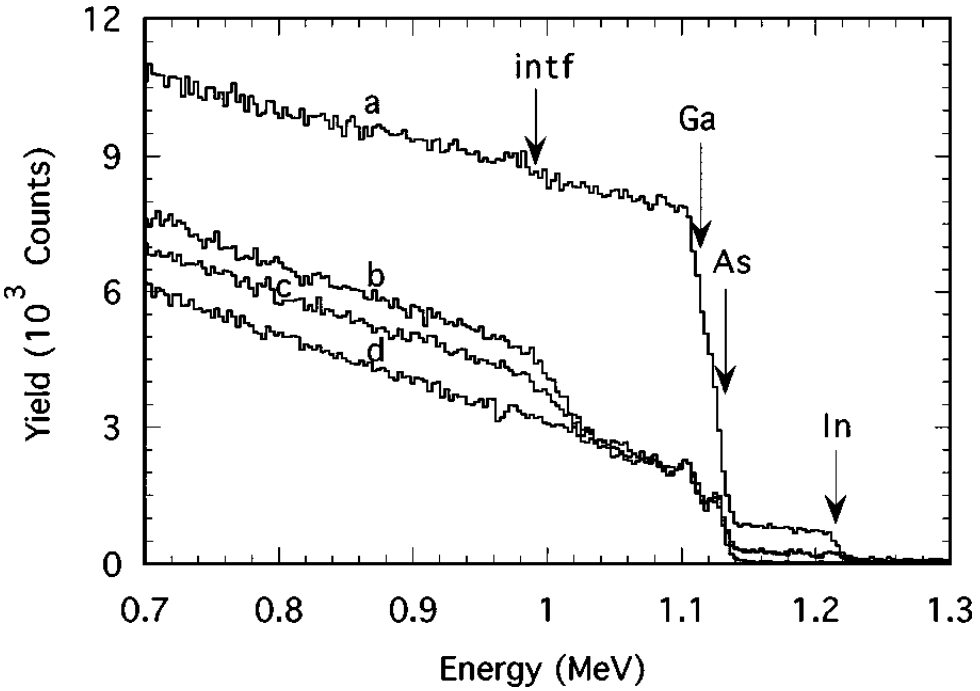
good test for sample preparation quality

# Dechanneling by dislocations

**Single layer InxGa$_{1-x}$As/GaAs strained structure TEM images**



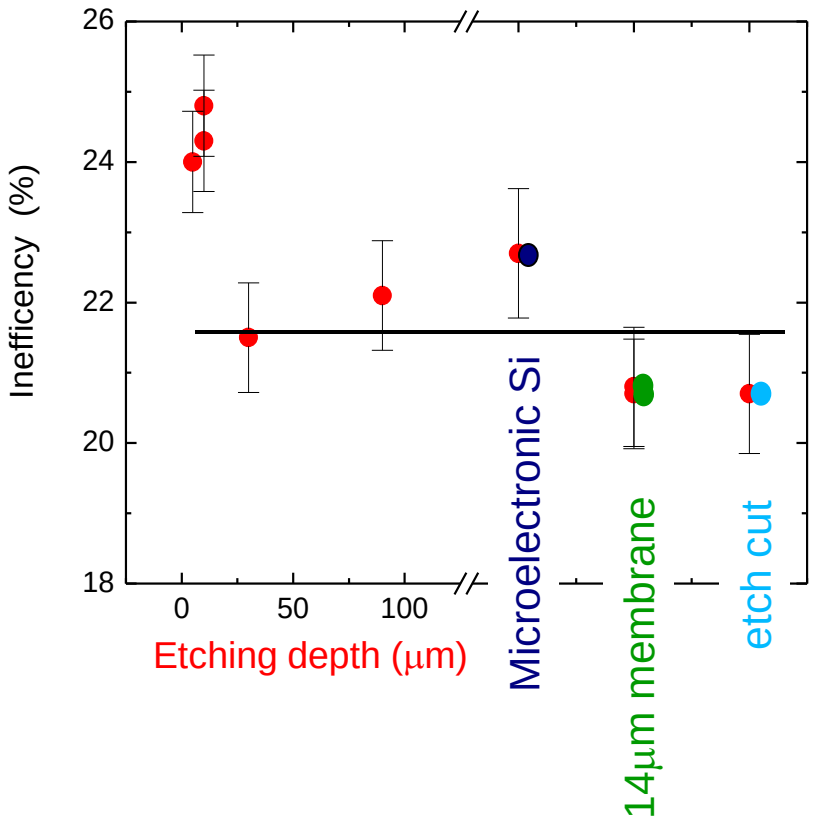

**Single layer InxGa$_{1-x}$As/GaAs strained structure (110) and (1-10) planar channeling**




Mazzer, Drigo, Romanato, Salviati and Lazzarini PRB 56, 6895,1997

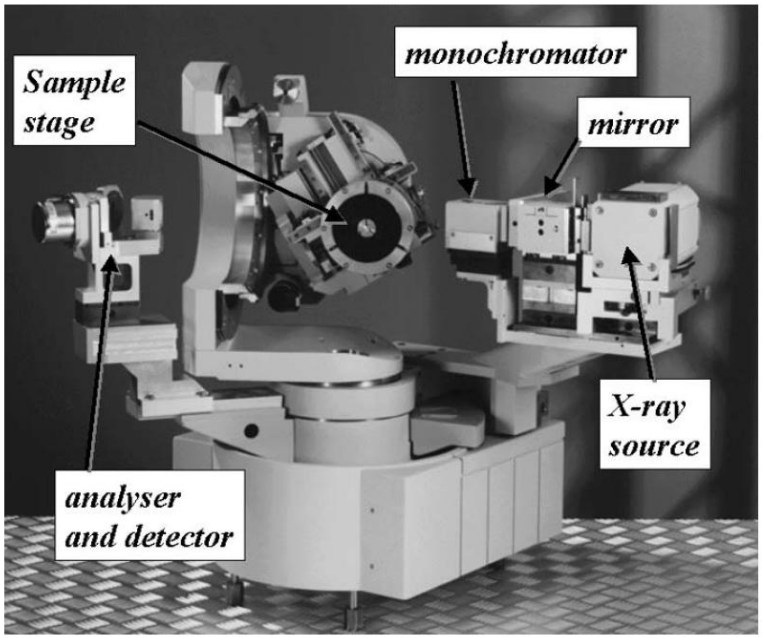
# (110) 2 MeV P in-efficency

- Strips crystal mechanical dicing + isotropic etching (as ST21, ST38A & ST40A); etching depth was optimized
- Anisotropic etch cut strips (as ST45A )
- Thin membrane for H8 focusing experiment



# High Resolution X-ray Diffraction

Internal facilities @ University of Padova physics department (about weekly available)



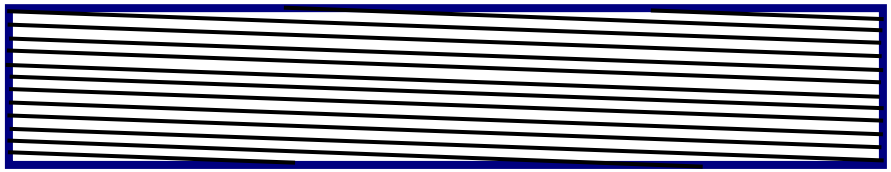

Accurate analysis of Bragg reflection from crystalline planes:

- 5 angular axis (4 for the sample 1 for detector)
- Finest movement resolution: 2 μrad
- 3 translations (1 to 10 μm resolution)
- 8 KeV X-rays with 30 μrad divergence and 30 μrad acceptance.
- Investigated depth in Si about 50 μm

# What can we learn from HRXRD ?

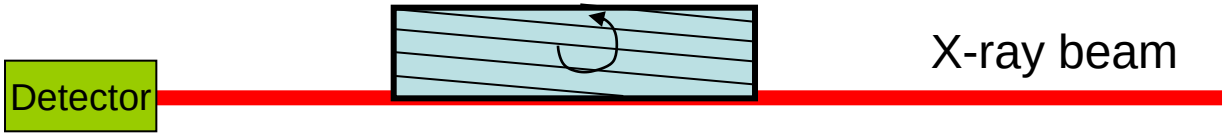
- Orientation of lattice planes
- Deformation of lattice planes

The sign and the amount of the miscut are important for channeling performances.



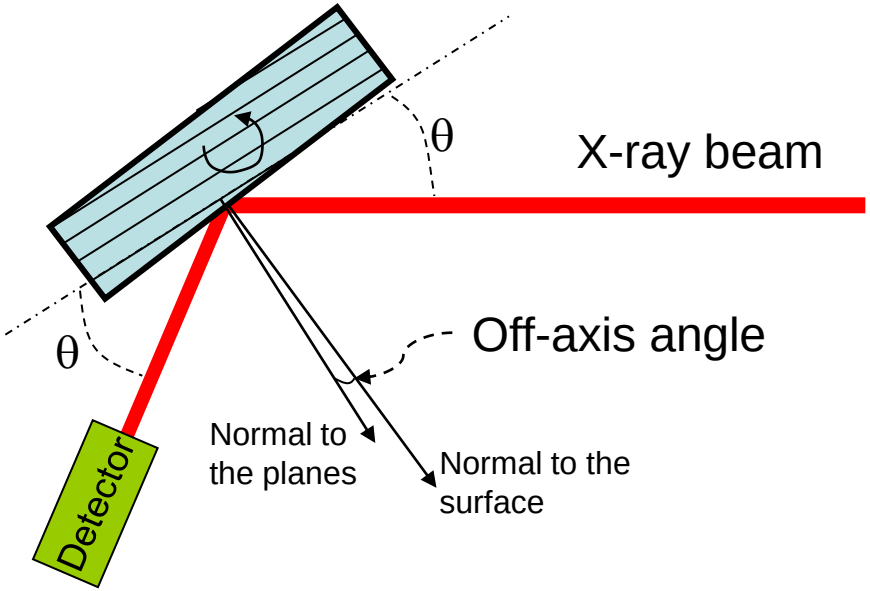
# Off-axis measurement - 1

**Direct beam**: characterization of the surface orientation



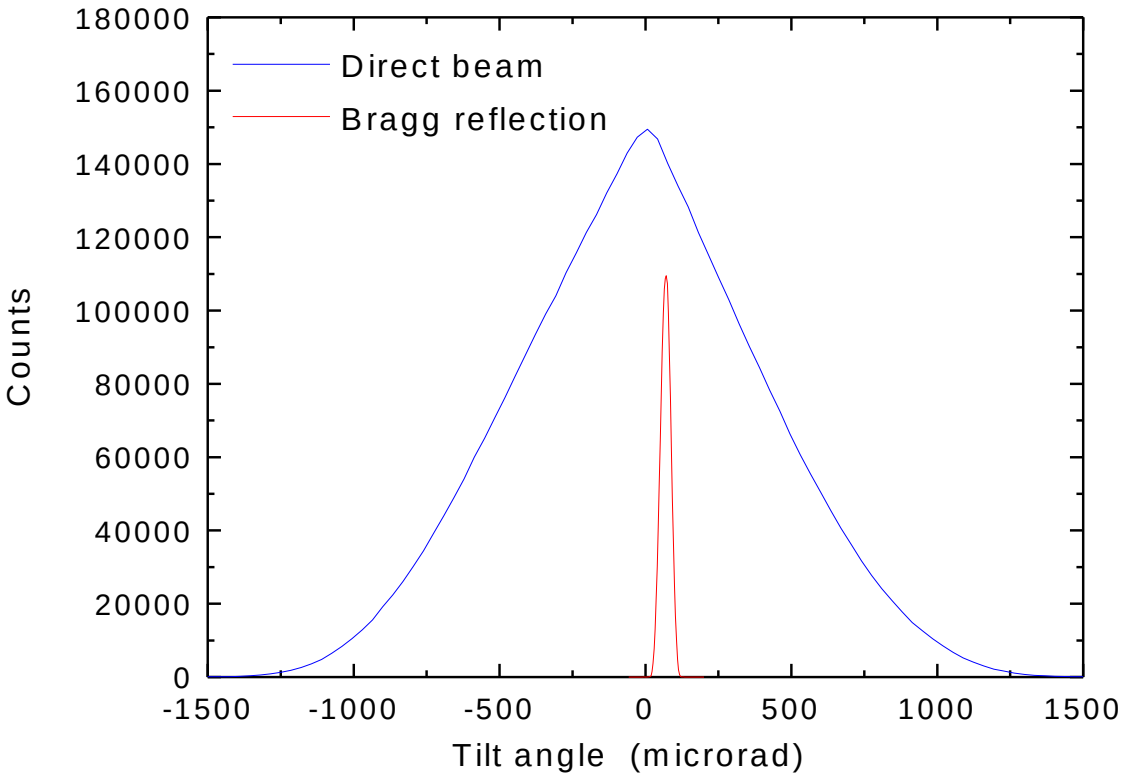

Maximum signal when the surface is parallel to the beam (zero correction)

**Bragg reflection**: Signal from a bragg plane reflection occurs only when the sample is rotated by the miscut angle



# Off-axis measurement example

Off-axis : 70 ± 30 μrad



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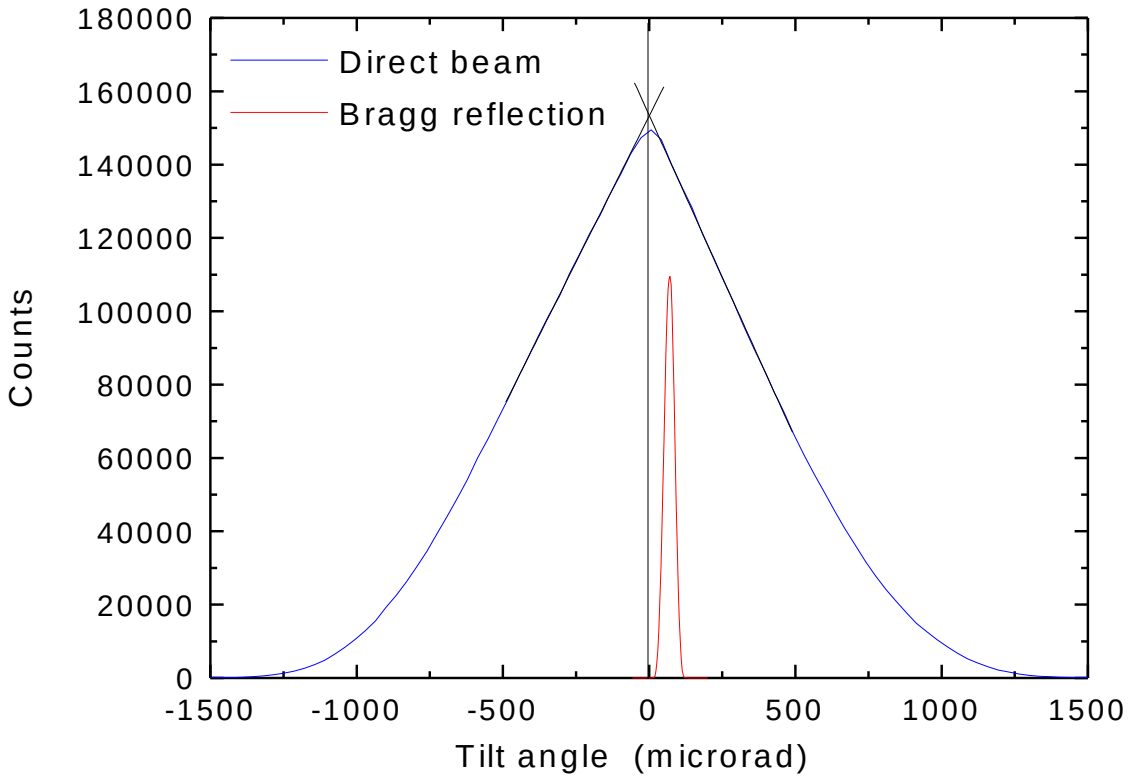
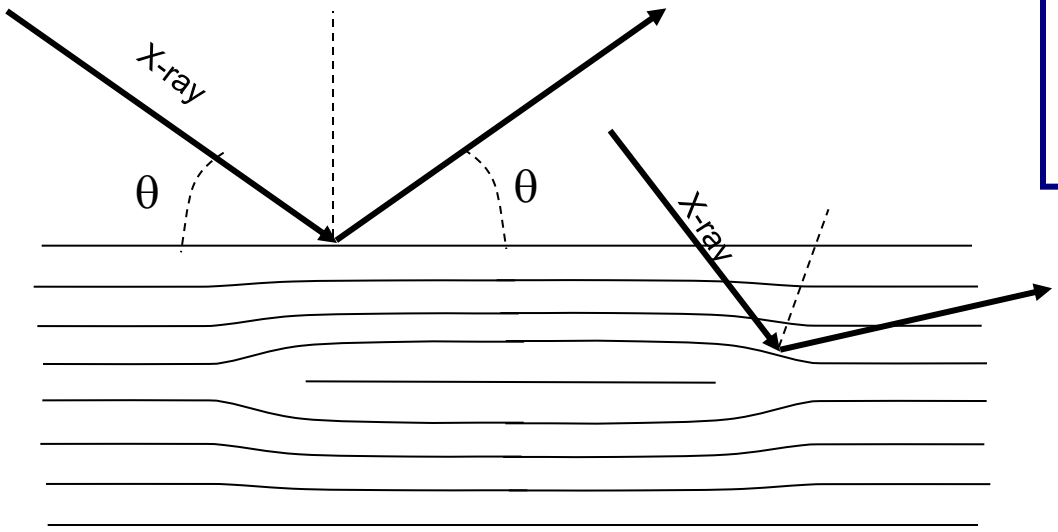


# What can we learn from HRXRD ?

- Orientation of lattice planes
- Deformation of lattice planes

Crystal defects (dislocations, cracks etc.) cause strong lattice deformation in a confined zone of the crystal



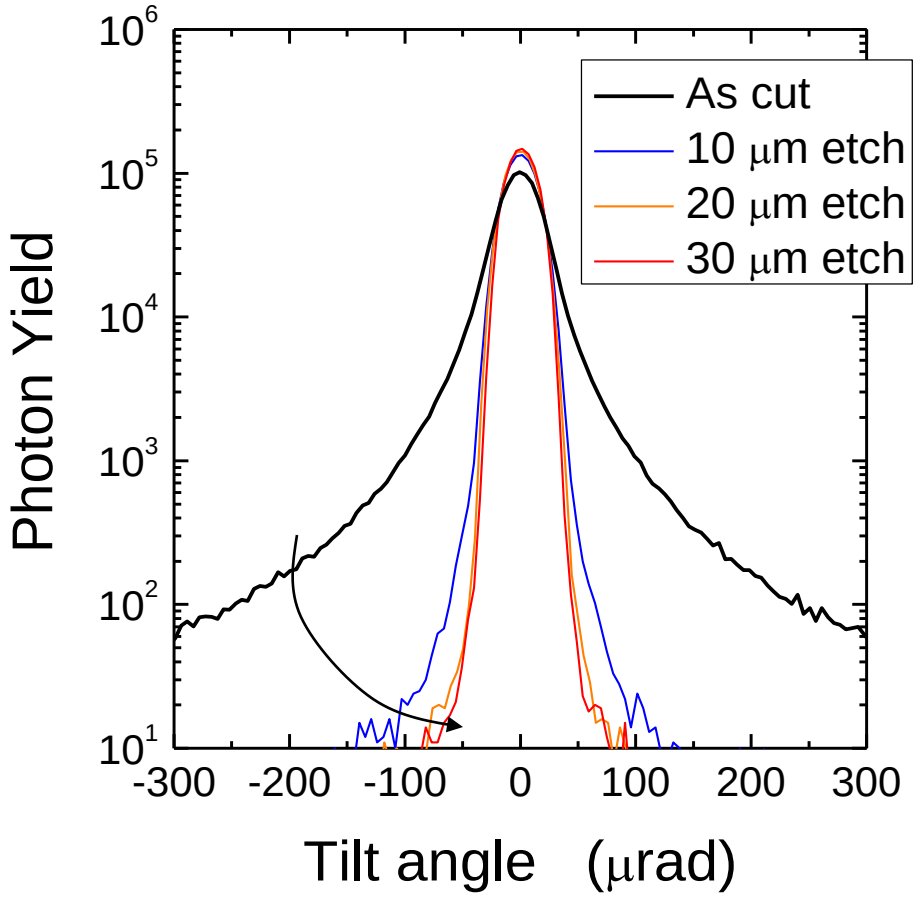

A small part of the scattered X-rays occurs at a different incidence angle

Diffuse scattering tails

# Dicing & isotropic etching

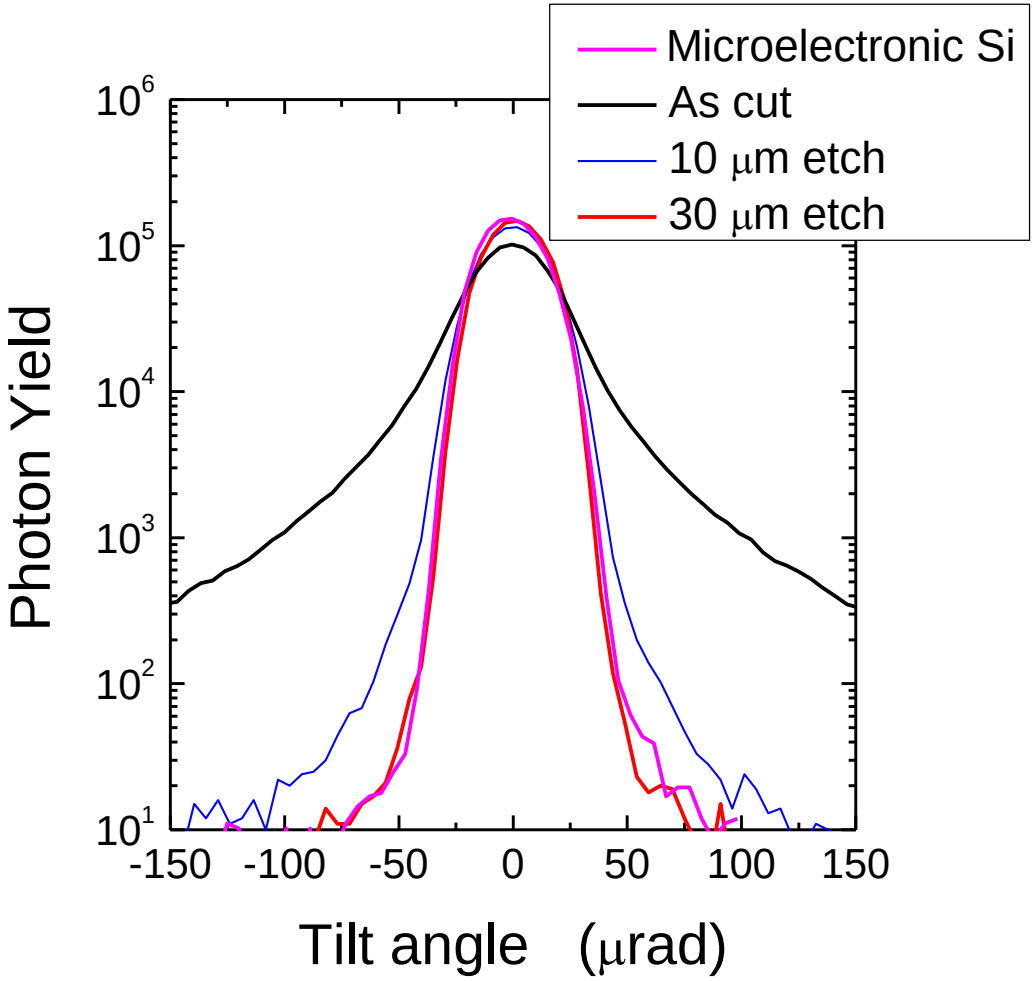
Crystals with mechanical dicing + isotropic etching

Diffuse scattering reduces of order of magnitudes with etching

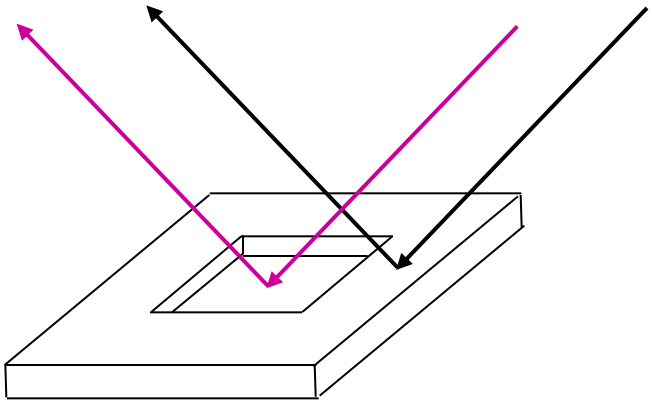


# Measurements on recent process

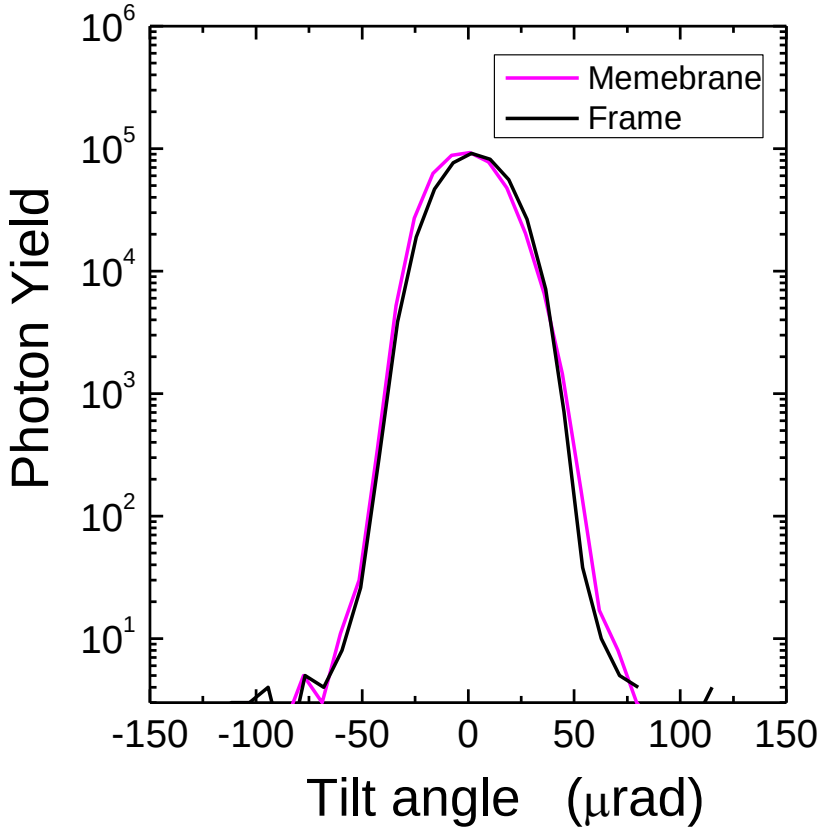
Scattering fingerprint is the same as for a microelectronic grade Si.



# Membrane sample



The frame (that is a microelectronic grade Si surface) and the membrane have the same crystalline quality



# Conclusions

- Low energy channeling is an effective test frame for optimizing sample preparation
- High resolution X-ray diffraction gives access to off-axis evaluation and confirms in more detail the crystalline quality
- Very high standard of preparation for the recent samples is demonstrated

# Channeling comparison