X-ray Rocking Curve and Topography Study of High Quality Coherent Bremsstrahlung Radiators

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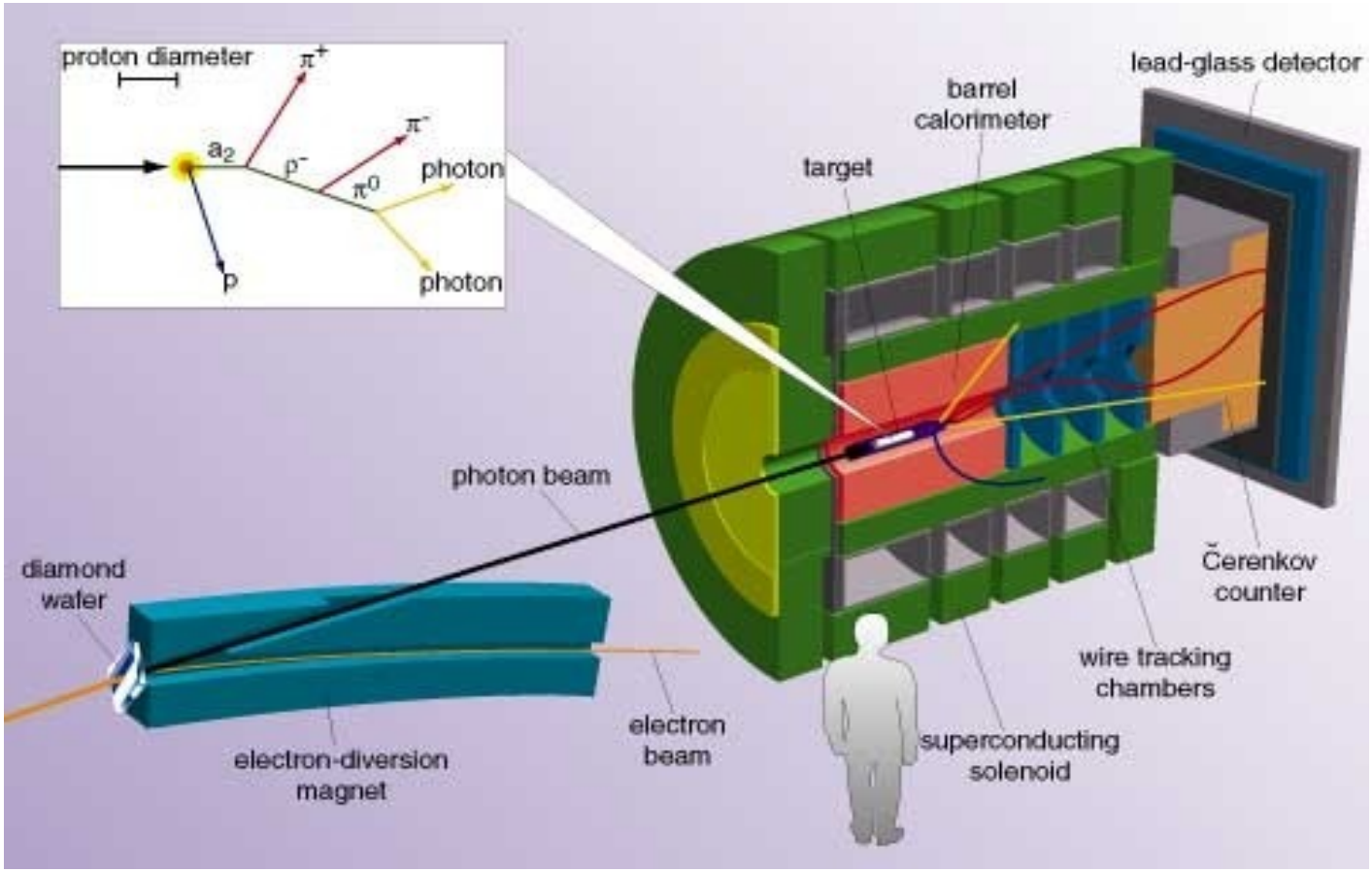

- Diamond radiator is used to produce linearly polarized photon.
- Diamond quality affects the degree of polarization.

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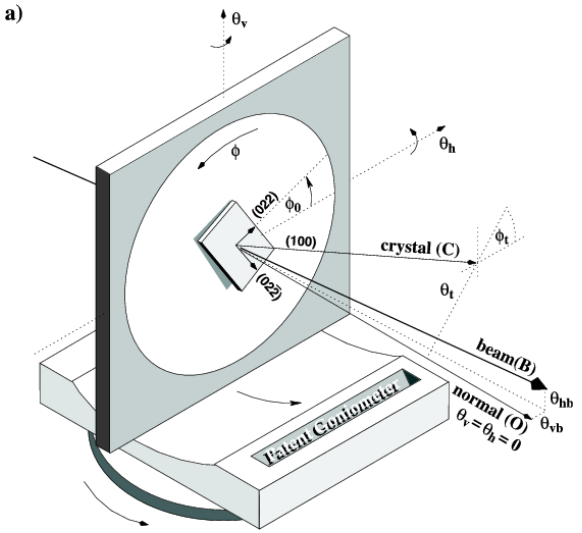
Diamond radiator requirements



- Minimum size: **4 mm x 4 mm**
- Orientation: **[100]**
- Orientation error: **5° maximum**
- Mosaic spread: **20 µr r.m.s. maximum** (integrated over the whole crystal) ← coherent edge definition
- Thickness: **20 to 100 µm** ← multiple scattering

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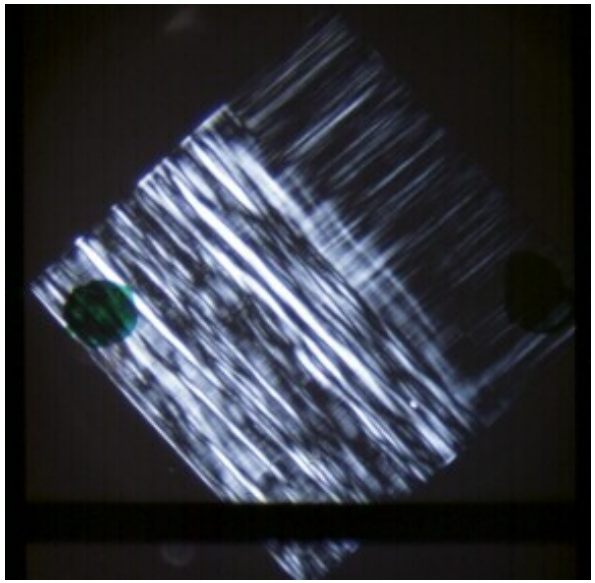
Sources of single crystal diamond radiator

- **natural diamonds**
  - used in the past (eg. SLAC)
  - Obtained from the gem industry
- **synthetic diamonds – CVD**
  - potentially low cost, but large mosaic
- **synthetic diamonds – HPHT**
  - a reliable source of low-mosaic crystals
  - is responding to a growing world-wide demand (eg. X-ray monochromators)



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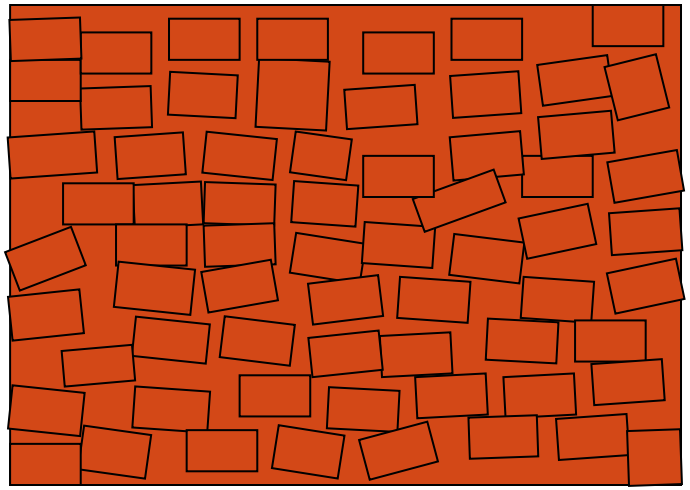
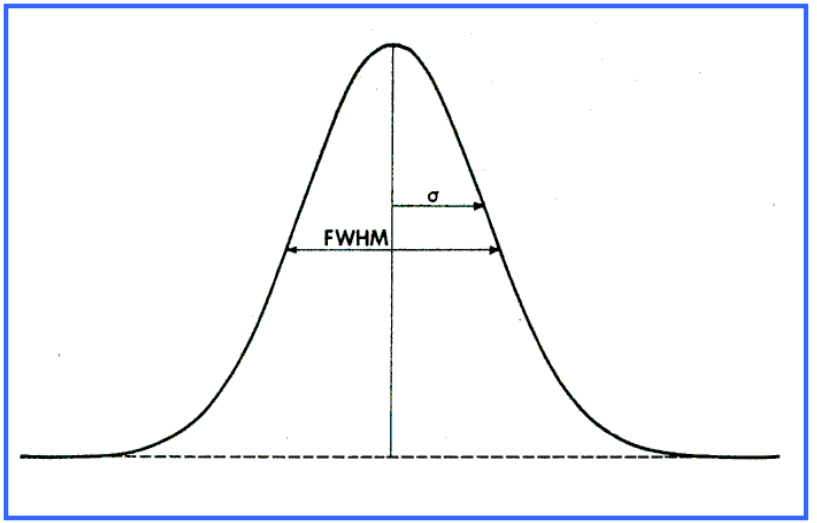
Mosaic spread



- rms angular deviation = "mosaic spread"



- Diamond crystal quality can be described by its mosaic spread.

- Experimentally, we can estimate the value of the mosaic spread from the rocking curve width.

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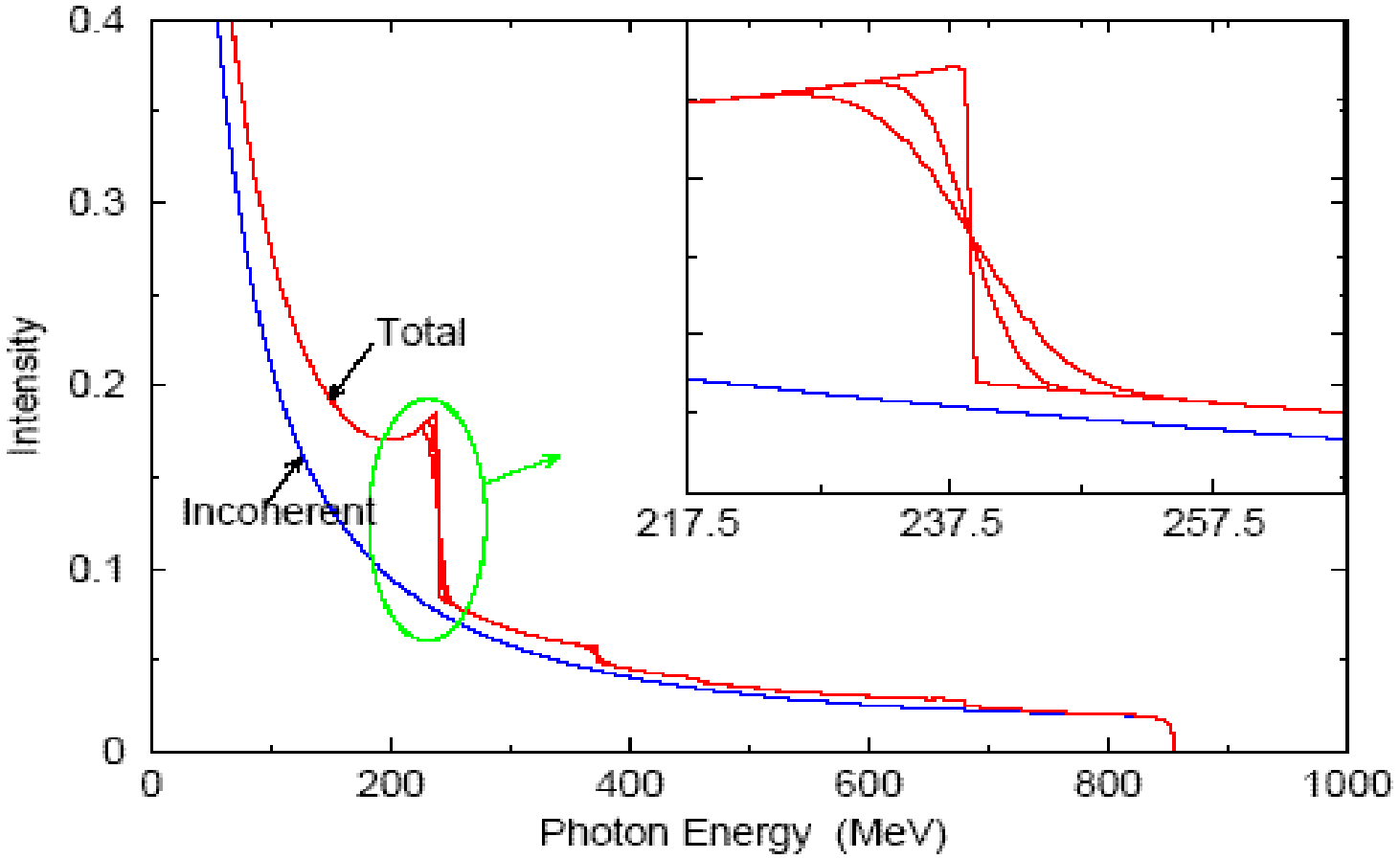
Effects of mosaic spread on coherent bremsstrahlung



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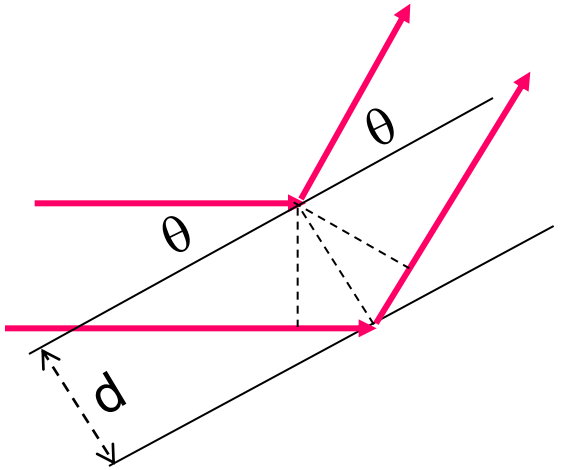
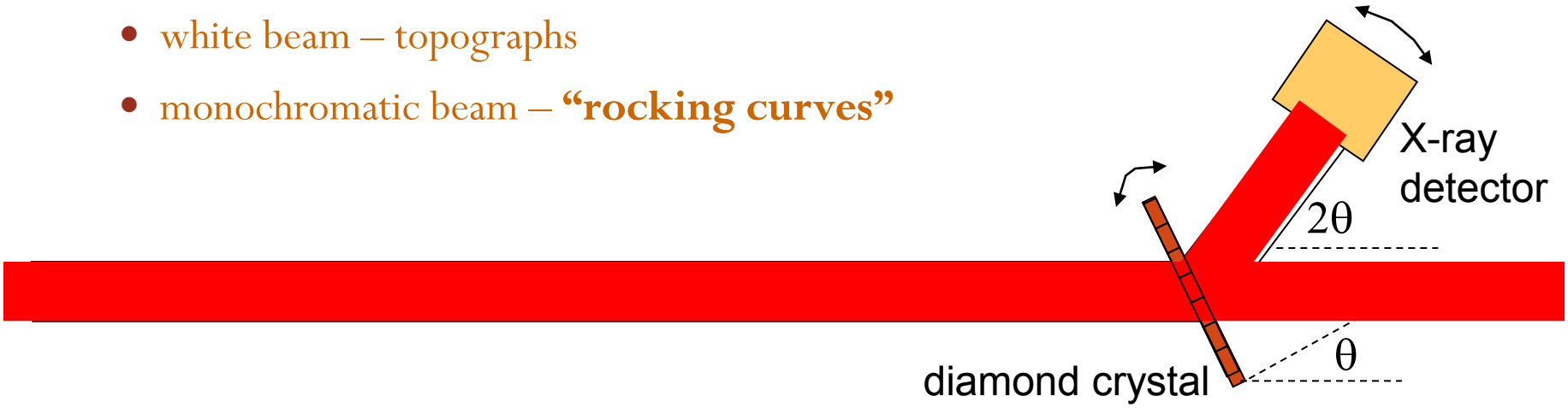
Measuring mosaic: X-ray diffraction

- **X-ray diffraction of crystals**

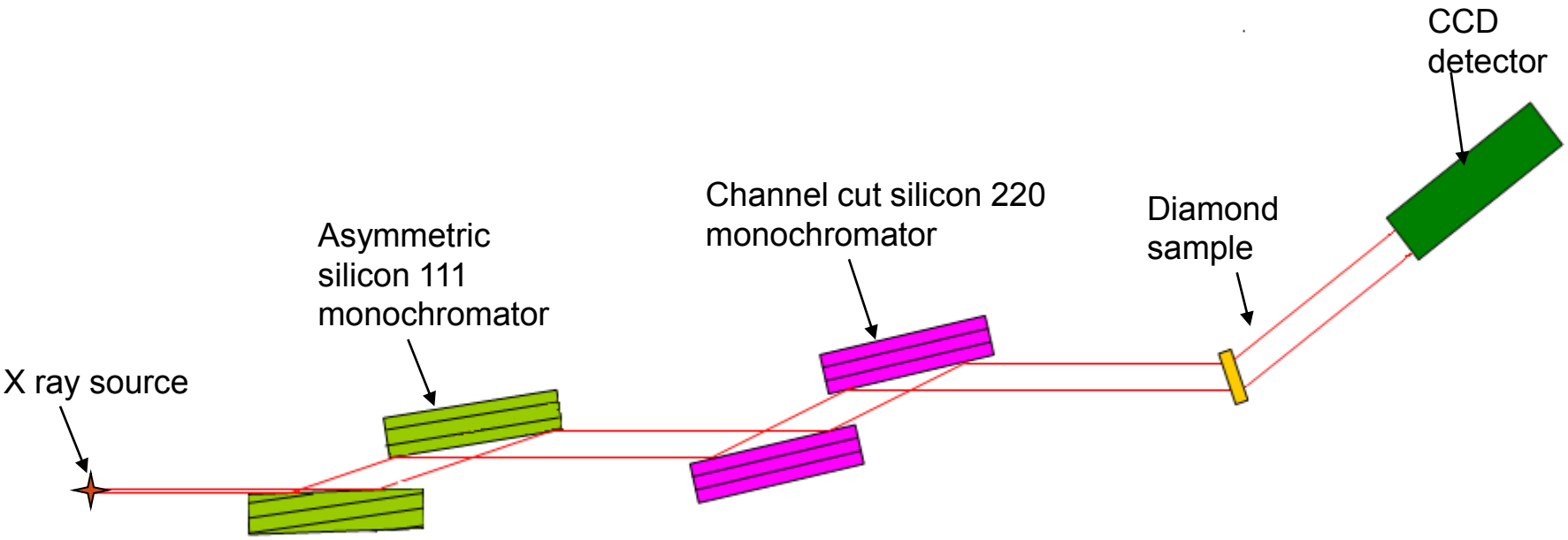
$$\lambda = 2\, d \sin(\theta)$$

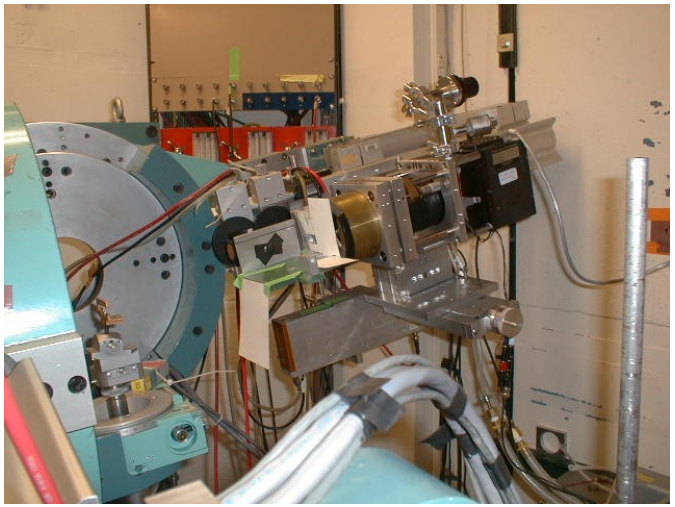


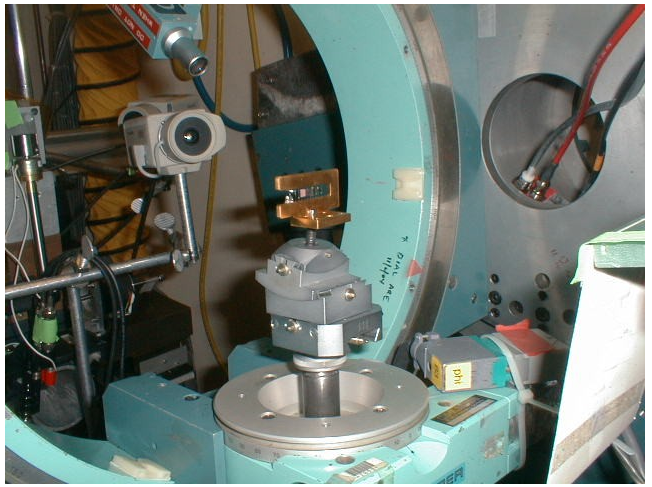
- **transmission-mode diffraction**
  - whole crystal volume is probed (not only the surface)
  - white beam – topographs
  - monochromatic beam – **"rocking curves"**



Experimental set up







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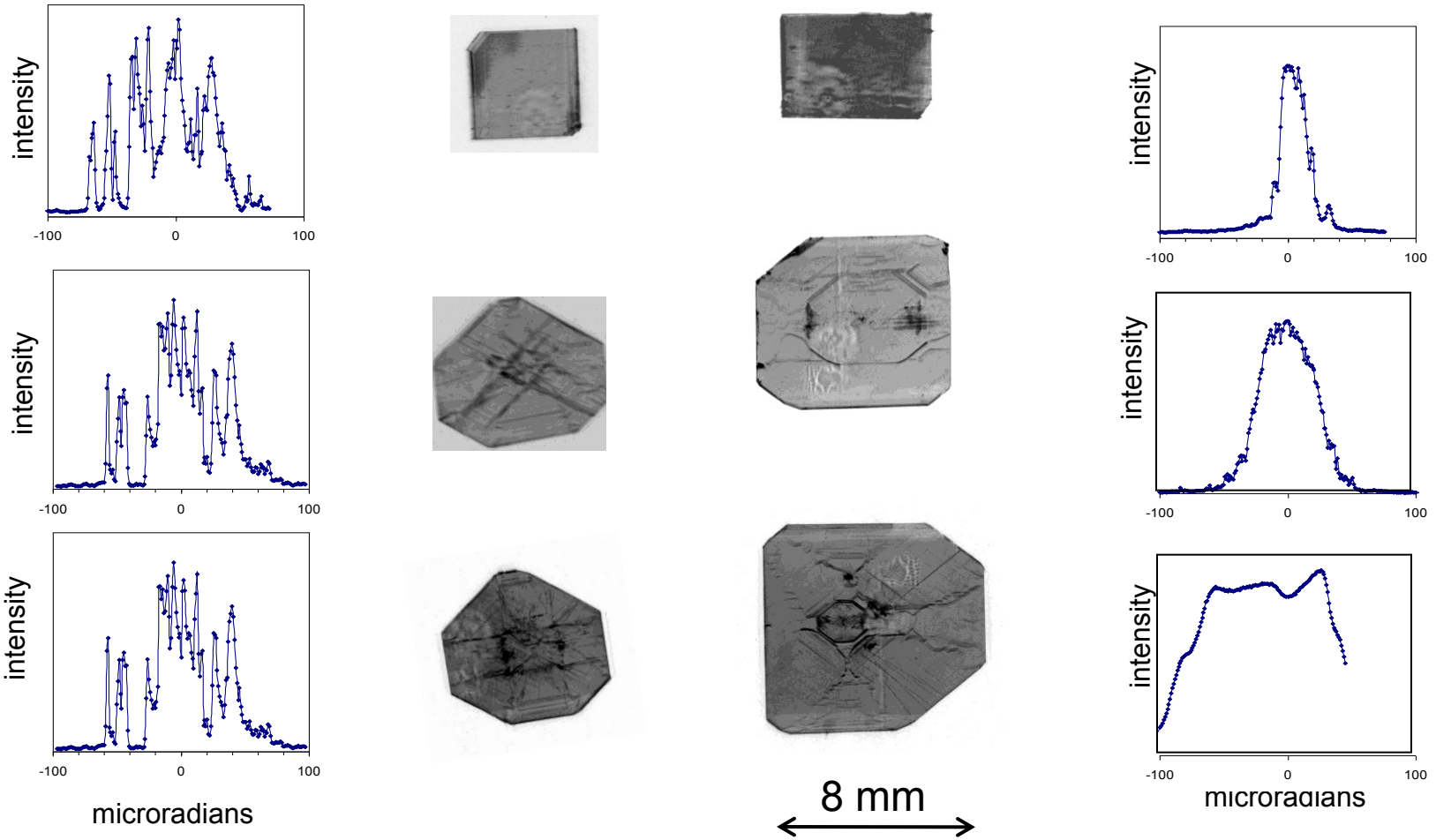
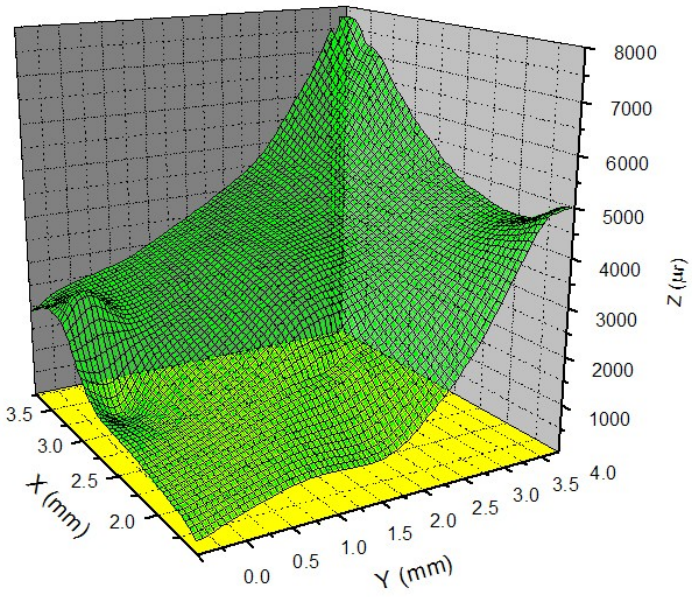
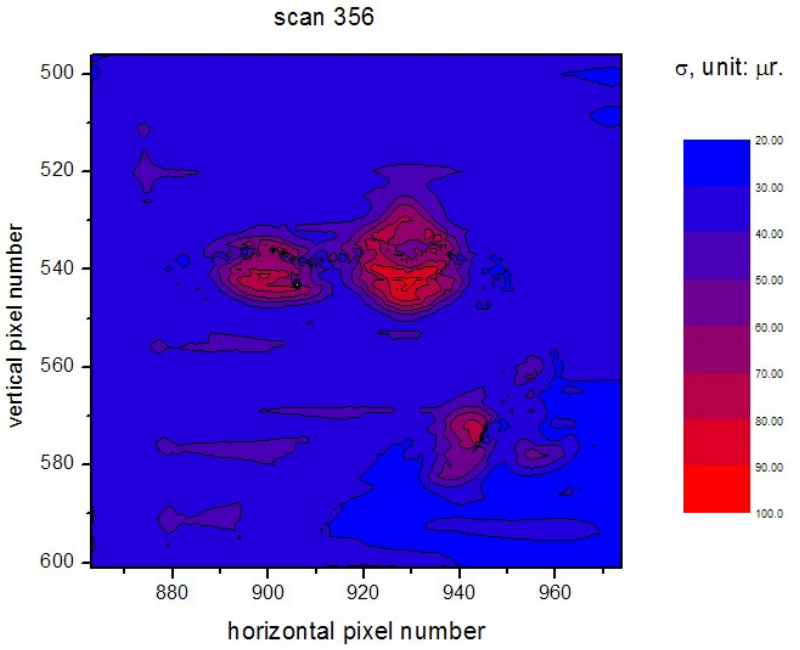
Experimental results from SRS



Experimental results from CHESS



Rocking curve peak position over the measured regions



Contour map of the rocking curve width

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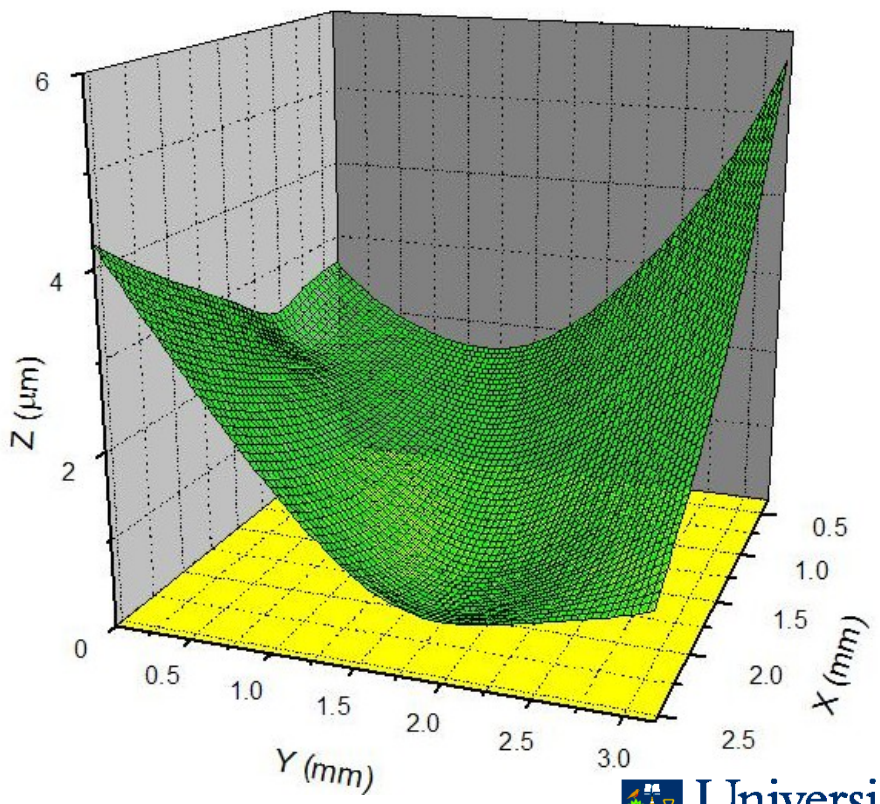
Interpretation of the diffraction data

- **CHESS data analysis results for a 20 microns thick diamond:**

- Hypothesis:
  Diamond is mechanically warped.

- Questions:
  1. **Why?**
  2. **mounting strains?**
  3. **20 microns only?**
  4. **surface damage?**
  5. **What else?**

reconstructed [1 0 0] plane profile



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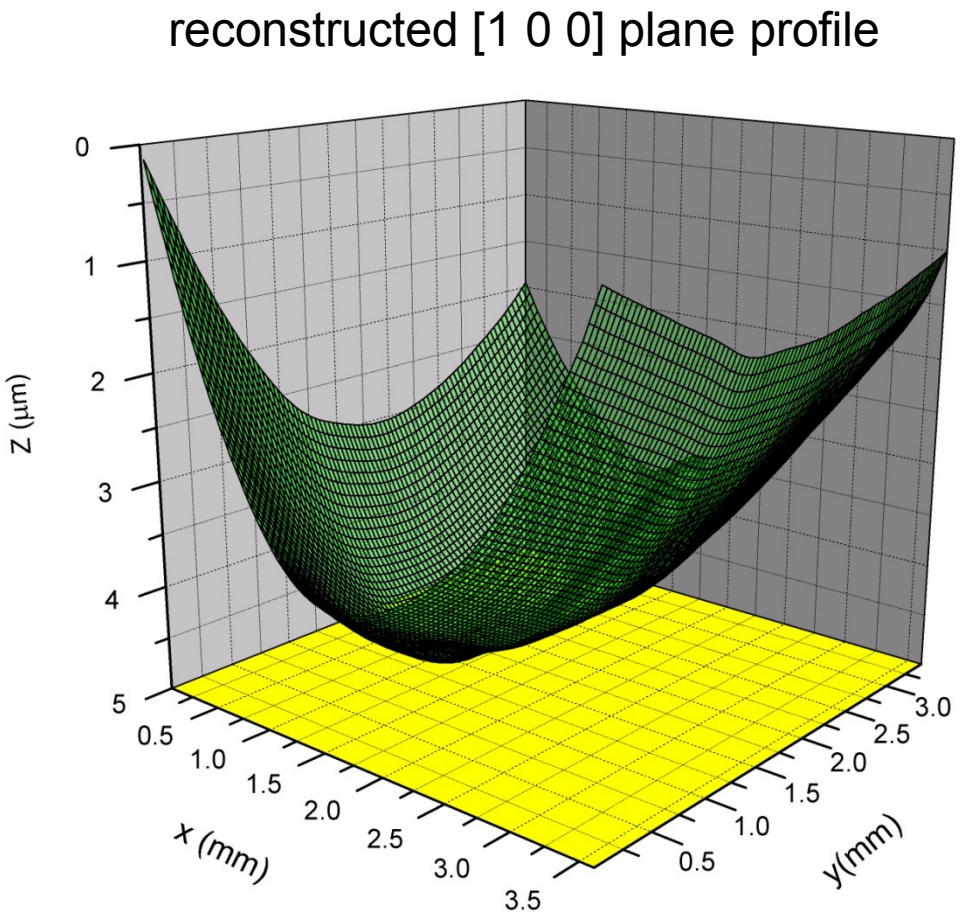
Another sample for mechanical warping

- **stone M100**
  - 100 μm thick
  - **shape is very similar to the 20 micron diamond**
- questions:
  - Is the warping interpretation correct?
  - Did radiation damage cause it?



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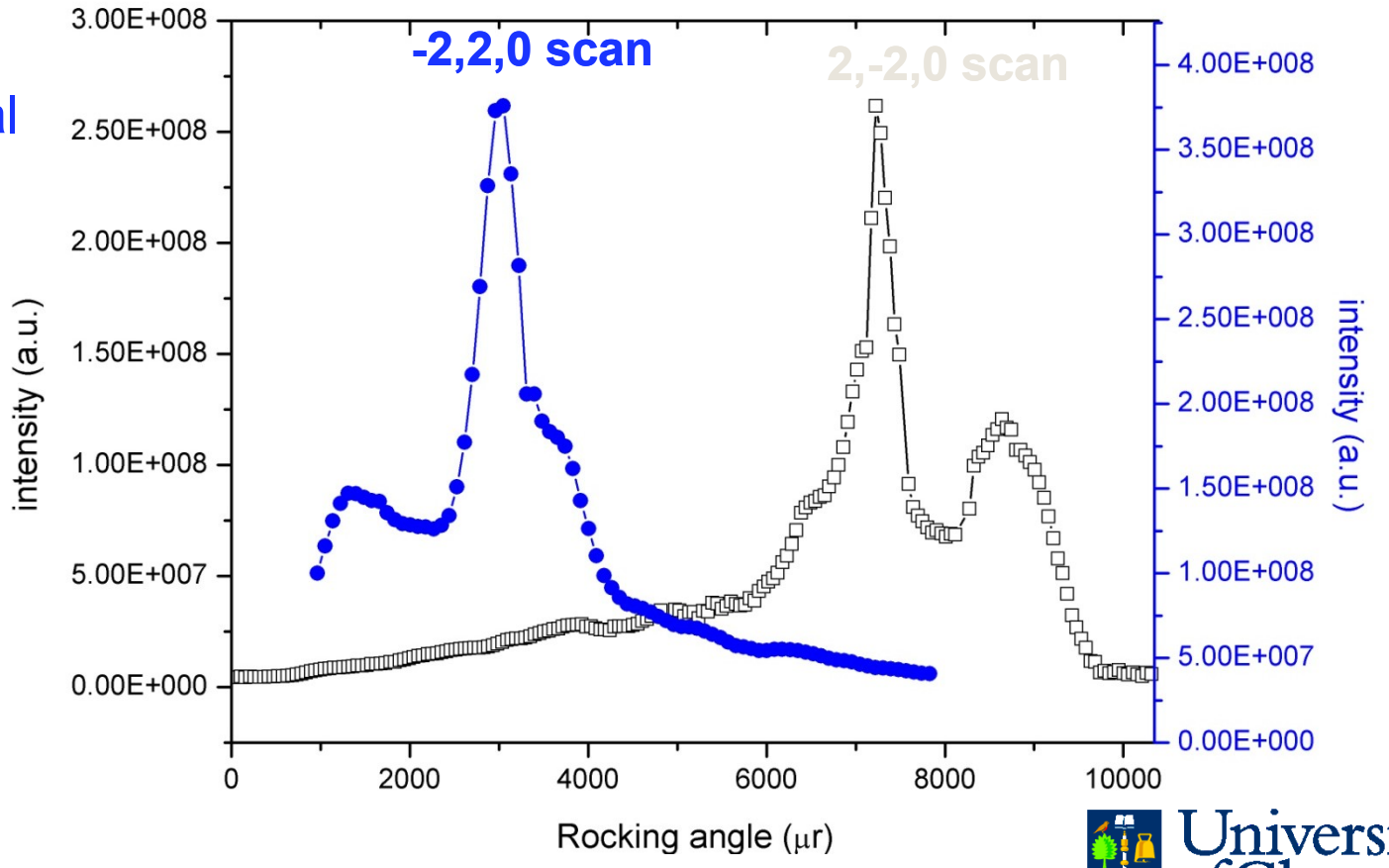
Is the warping interpretation correct?

Test :

Invert crystal



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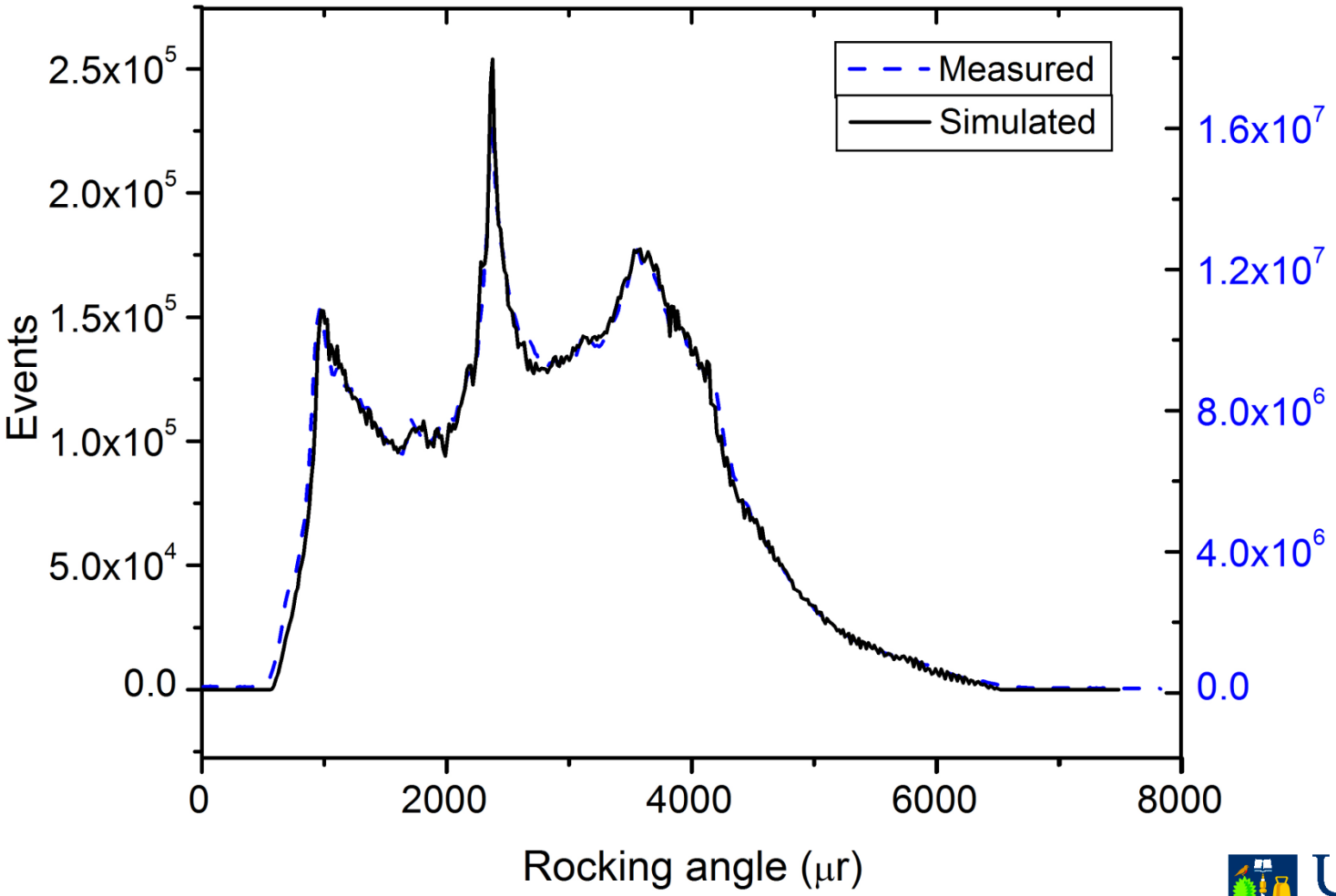
Comparison between simulated and measured rocking



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Conclusions

1. The above results clearly demonstrate that rocking curve imaging is a very powerful method for assessing the suitability of diamond crystals for use as CB radiators
2. The resulted 2D maps of rocking curve width as well as the rocking curve peak position can serve as a monitor of the crystal quality for the whole crystal and for local regions.
3. It was confirmed by the measured variation of rocking curve widths across the samples studied that the defect distribution is non-uniform in these samples.
4. Crystal warping contributes significantly to the rocking curve width for the region to be sampled by the electron beam in the coherent bremsstrahlung process.

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Thank you for your attention!