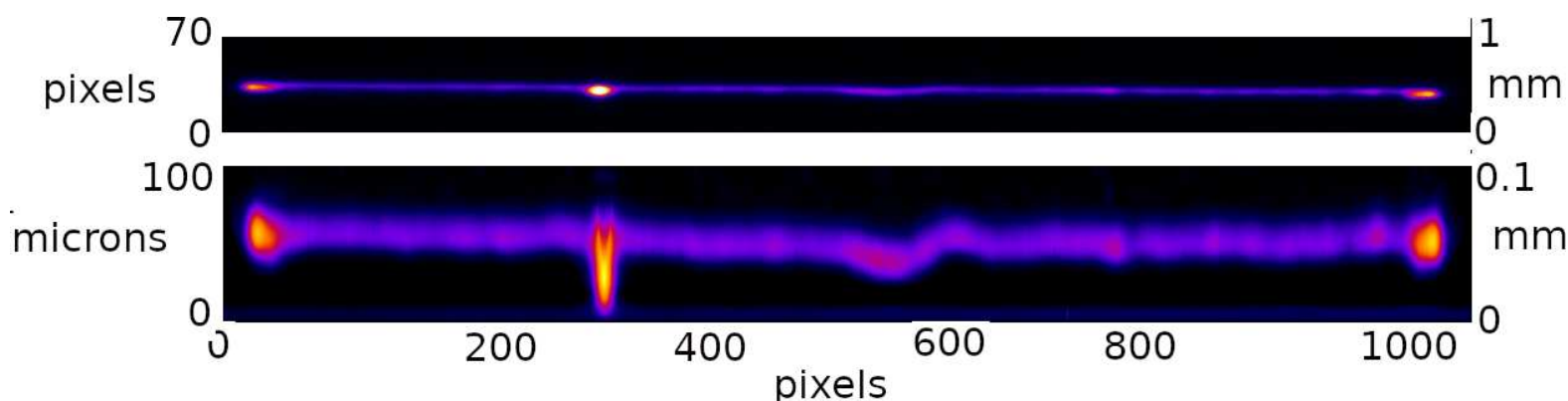# Topography of bent crystals with μrad resolution in one dimension

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[1]Ecopulse, Inc, Springfield, VA 22152, USA; ninorpereira-at-gmail.com

[2]Advanced Photon Source, Argonne, IL 60439, USA

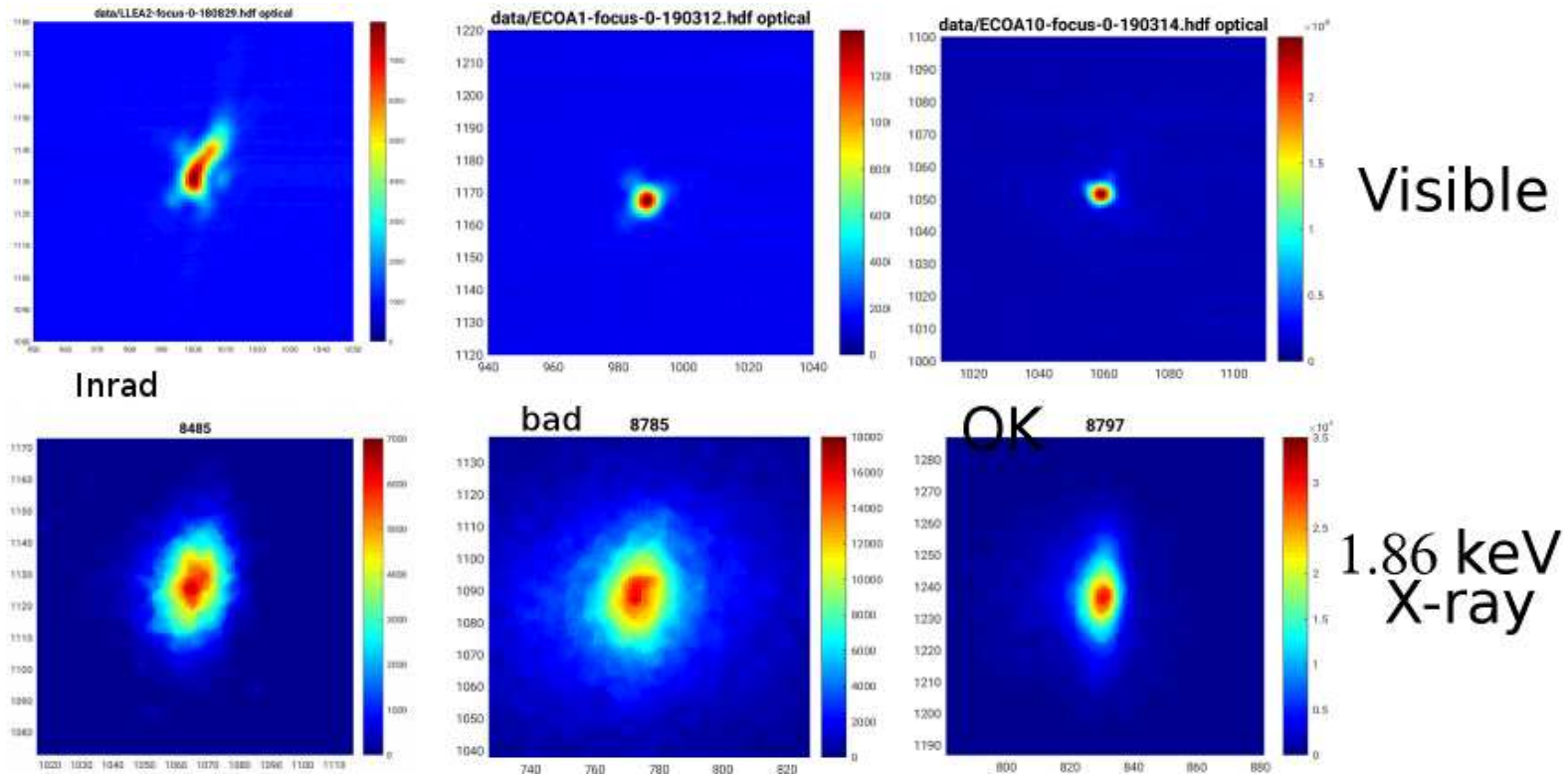[3] Sandia National Laboratory, Albuquerque, NM 87185 USA

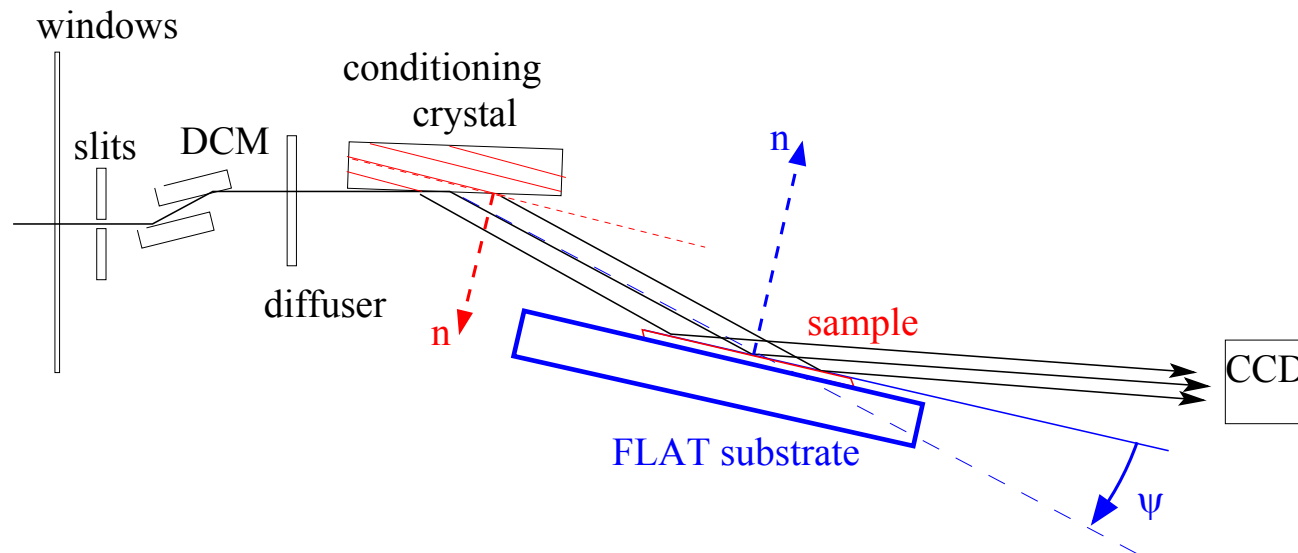(virtual & in-person) HTPD2022, 15-19 May 2022

Groping toward better x-ray crystals

- Many (most?) bent crystals "good enough"; what causes problems?

- Here: look at local x-ray reflection carefully
  - from thin, flat crystals (2-D, across surface)
    * remedy may be deeper polishing
  - from bent crystal (1-D, along line, sub-mm)
  - across line: (many) μm, μrad

- rocking curve compatible w/ theory

- wiggles broaden (slightly) and may cause halo

e.g., images of He-like Si
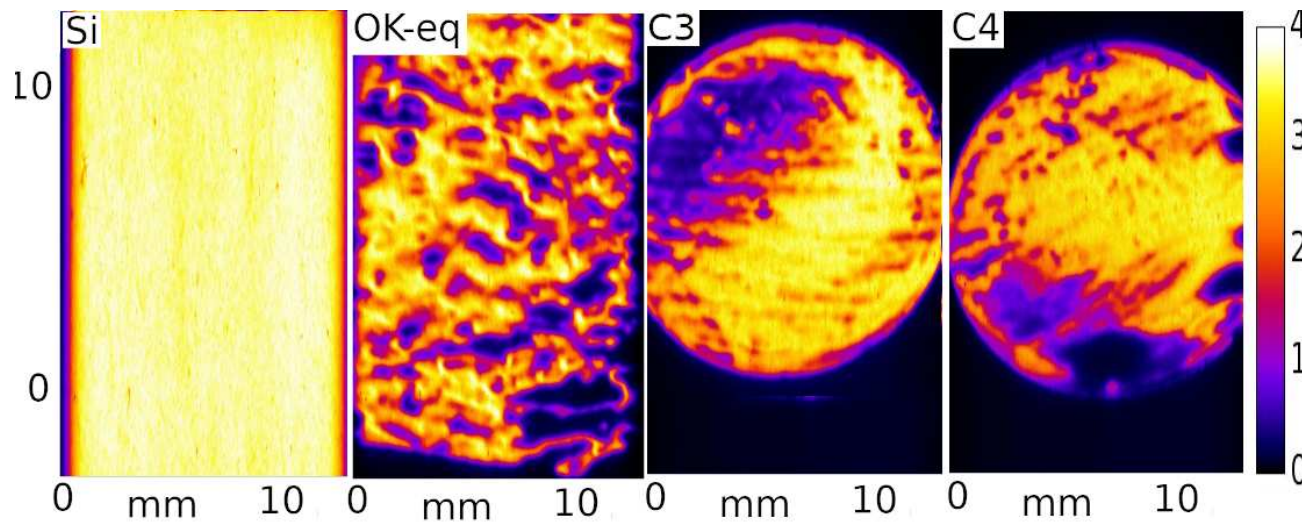

Visible

Inrad

bad

OK

1.86 keV
X-ray

- Question: why different,sloppy x-ray images? (unlike visible)
  - (from Stoeckl, LLE: asphere, Qz $(10\bar{1}1)$, ROC $\sim$ 500 mm
  - what causes scatter? find where reflection has problems.

Use topography at 1BM-B, APS

windows

conditioning
crystal

slits DCM n

diffuser

n sample

CCD

FLAT substrate

ψ

- (almost) ideal irradiation (but: image at angle w/camera)
  - uniform, monoenergetic (~ 8 keV), unidirectional (μrad) $\cdots$
  - $\delta\psi \simeq \mu$rad resolution from flat crystal's angle $\psi + \mathrm{n}\delta\psi$
  - single image (for flat crystal; n=1) already shows $\exists$ problem

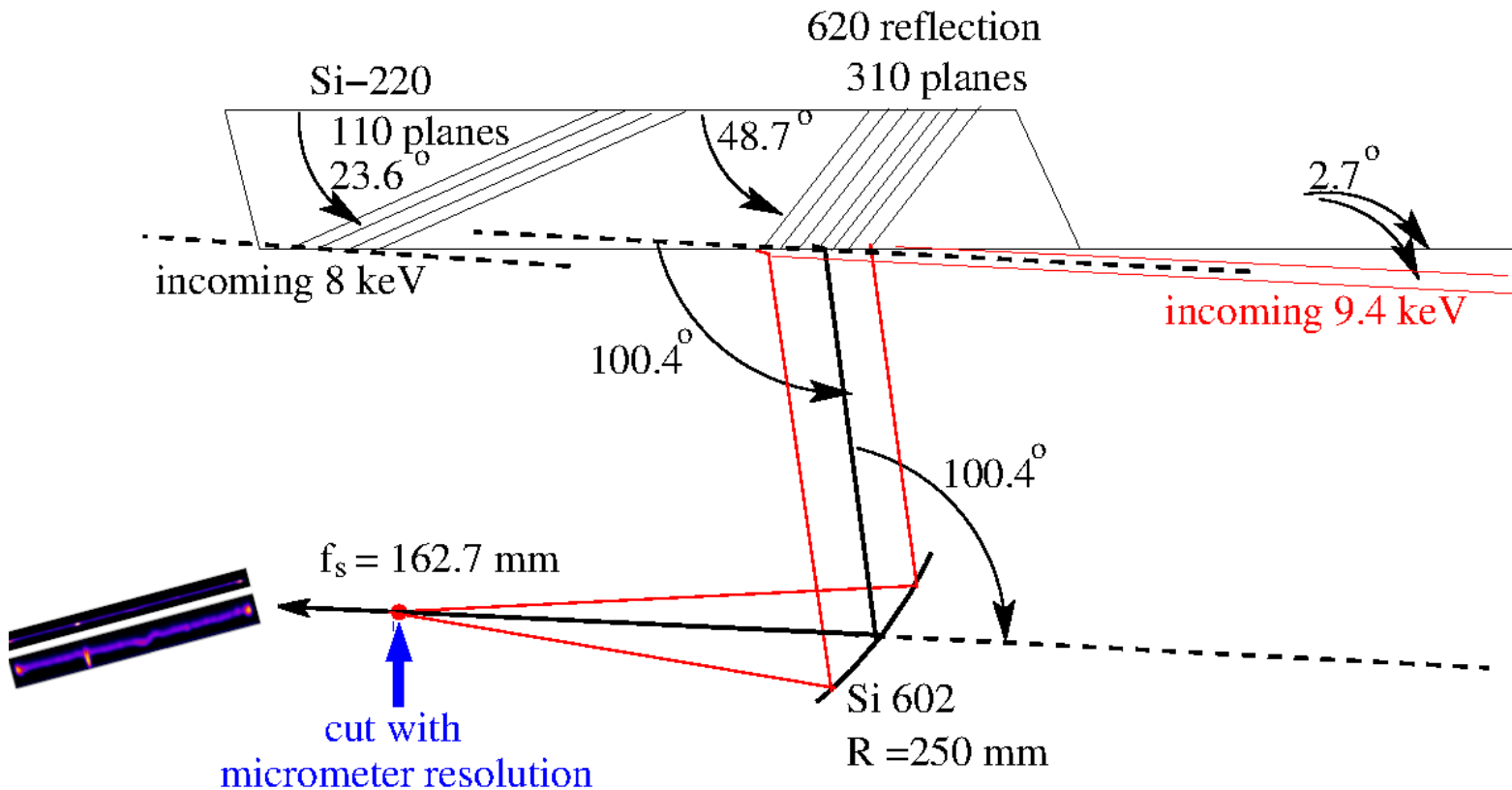# Deeper polishing (may) help(s)

- 2nd panel: thick Si crystal, perfect reflection

- OK, 3 & 4: all quartz ($10\bar{1}1$), ~ 0.1 mm (from 3 mm).
  - Left: original, standard polishing (final 10 h, 0.5 μm CeO_2)
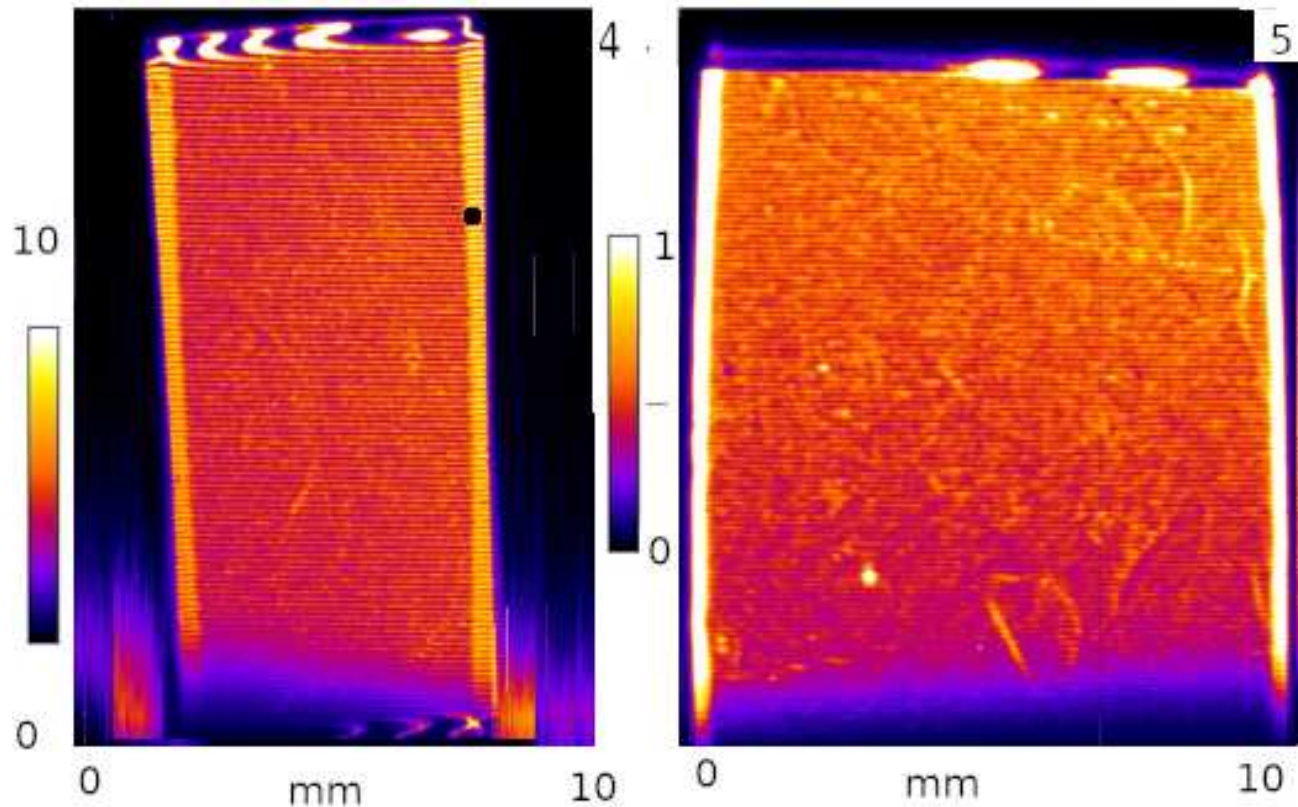 - Right (C3 and C4): polished 2 h longer

(strongly) bent crystals

- continue using perfect, unidirectional, monochromatic x-rays
  - reflect only from arc (at θ_B) on crystal
  - gives arc (1-D, zebra stripe) on 2-D camera
- (sub-)mm scale in 1D along zebra stripe
- $\sim \mu$m scale across zebra stripe
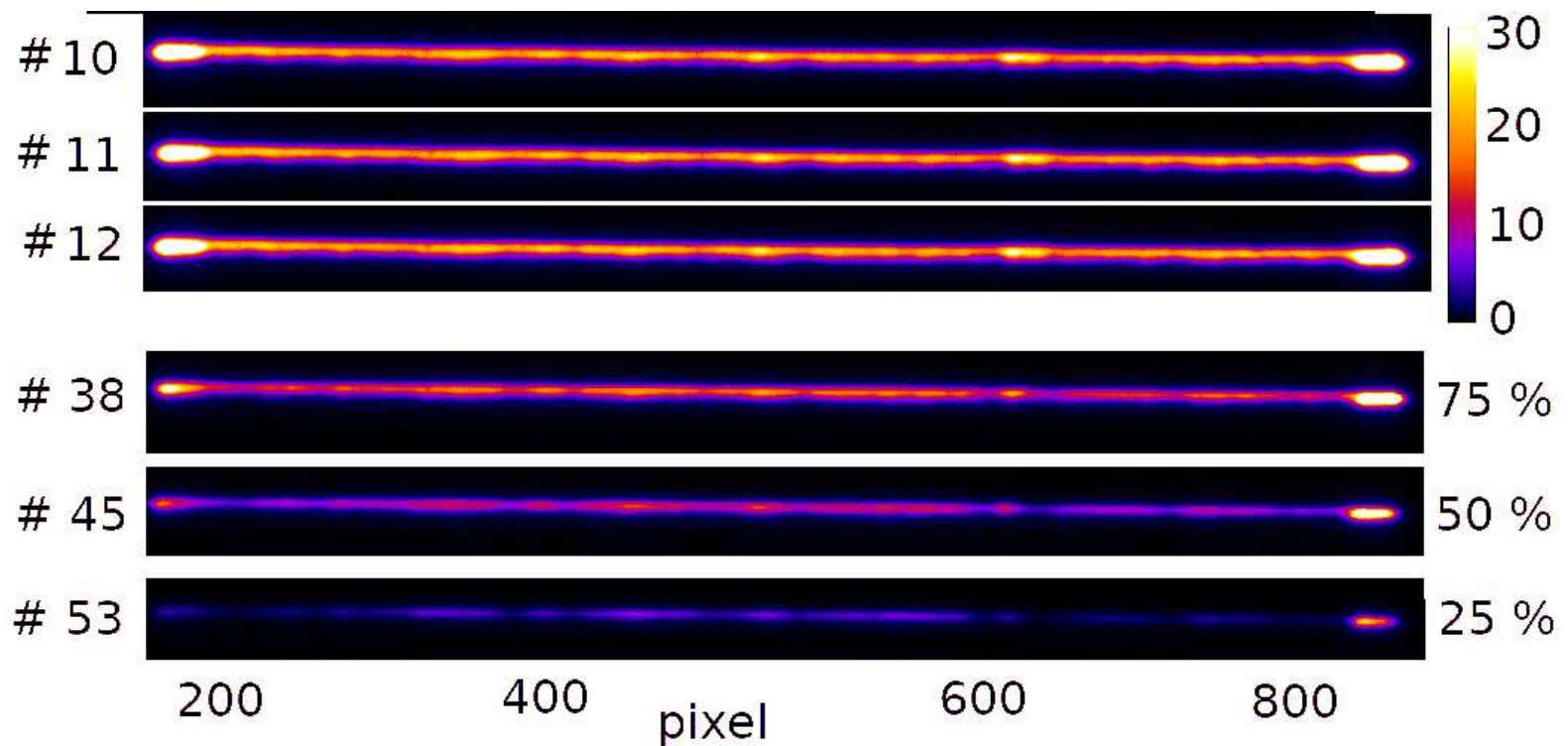
absorber: μm across 1-D zebra

- μm resolution: individual zebra stripe, cumbersome

- 1-D variable is integrated intensity across
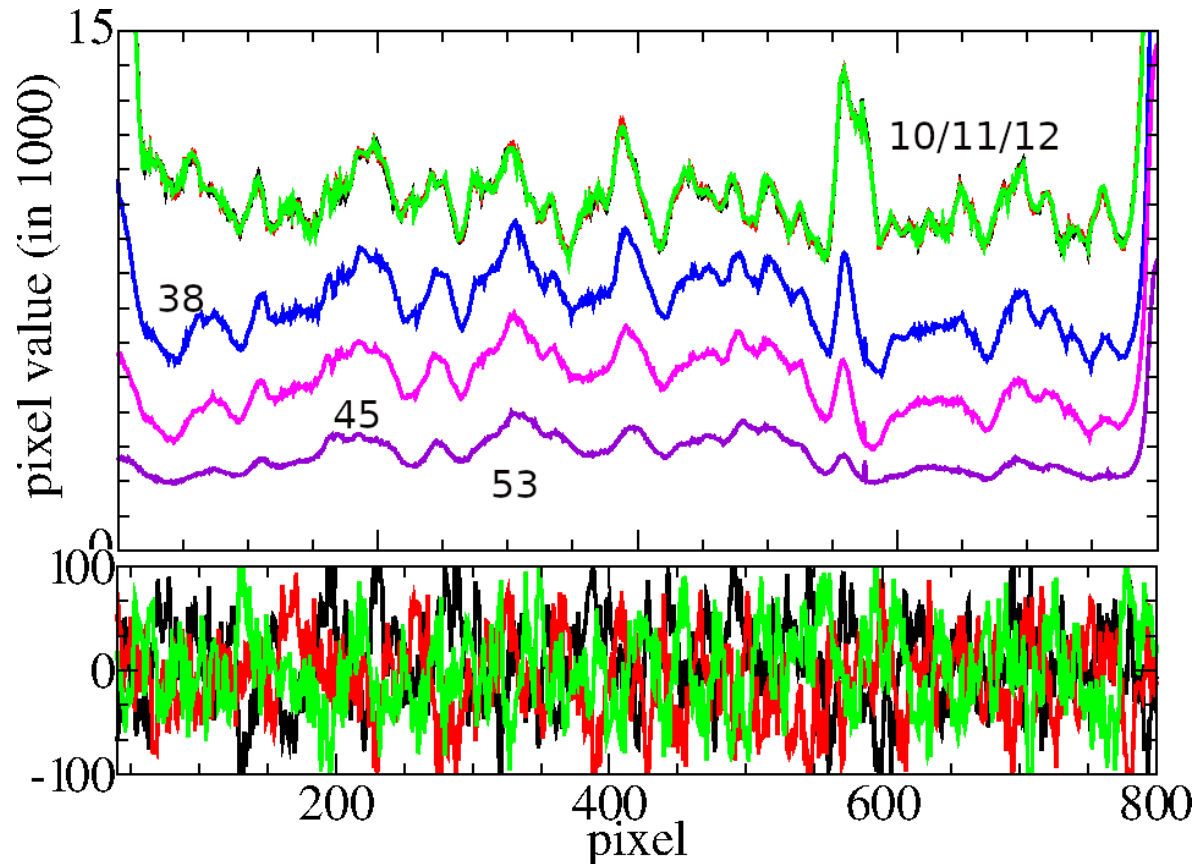
2-D area needs many 1-D stripes

- 2 identical Si crystals, R= 250 mm, 602 reflection, ~ 0.07 mm, $\cdots$

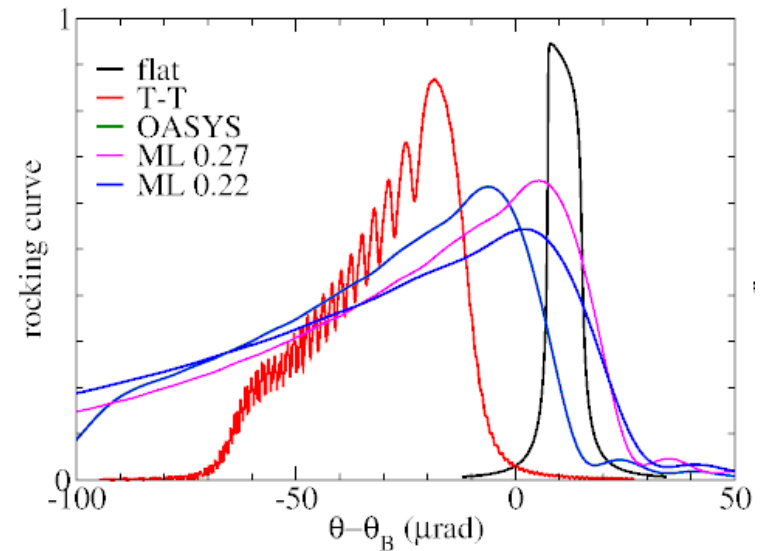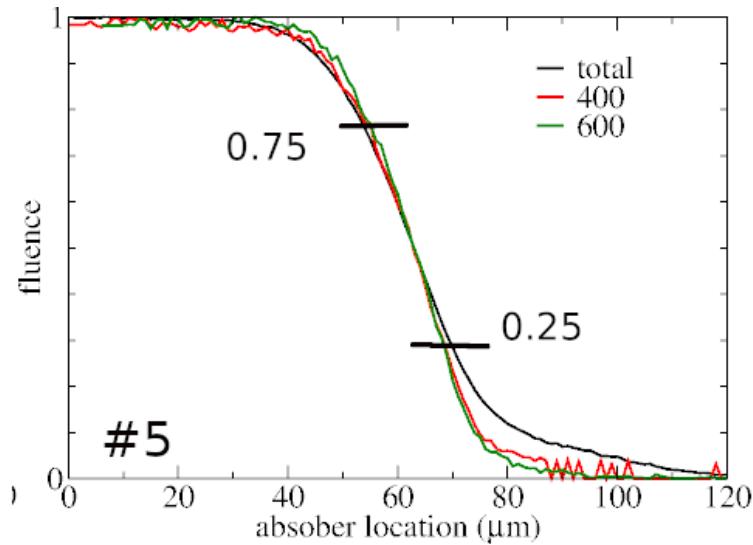- edges, small features may affect images

zebra stripes (C4,#46 @ ·)

- 3 samples reproducible (before blockage starts)

- essential to get $\sim \mu$m resolution from absorber motion
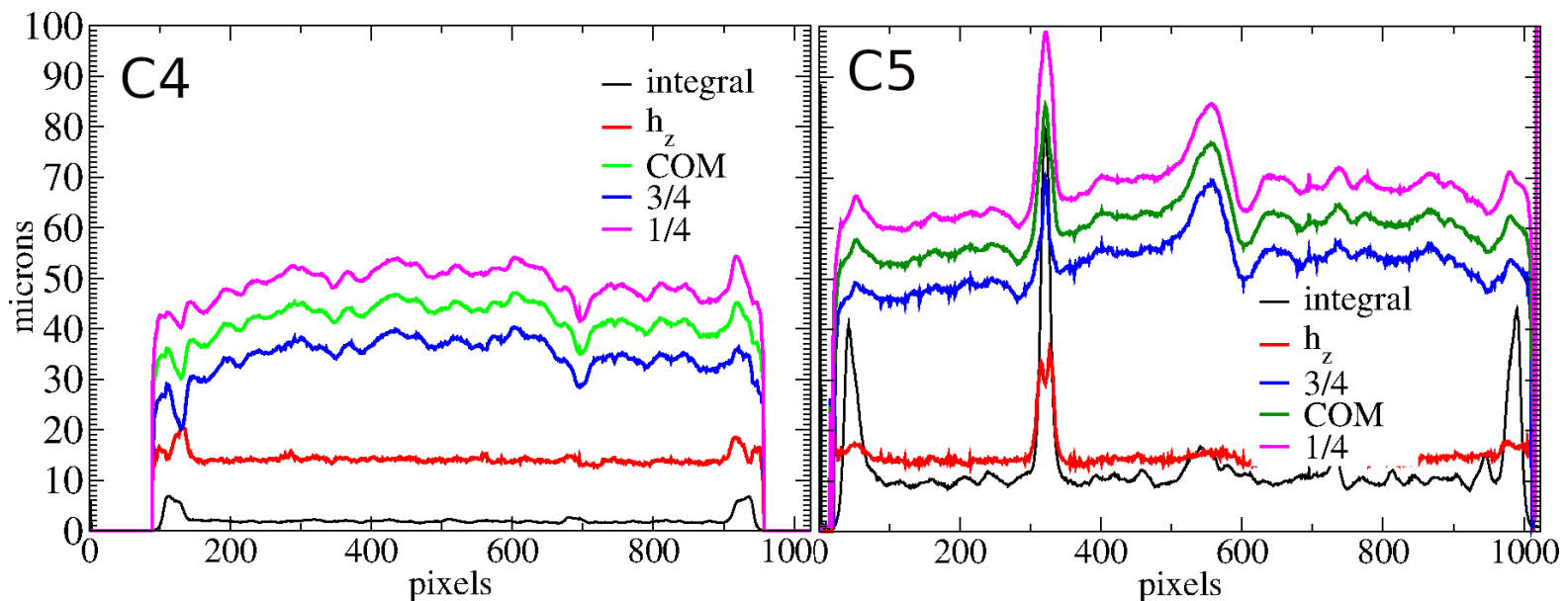
integrated intensity: 100:1 scales

- $\sim$ sub-mm scale along, $\sim \mu$m scale across zebra stripe
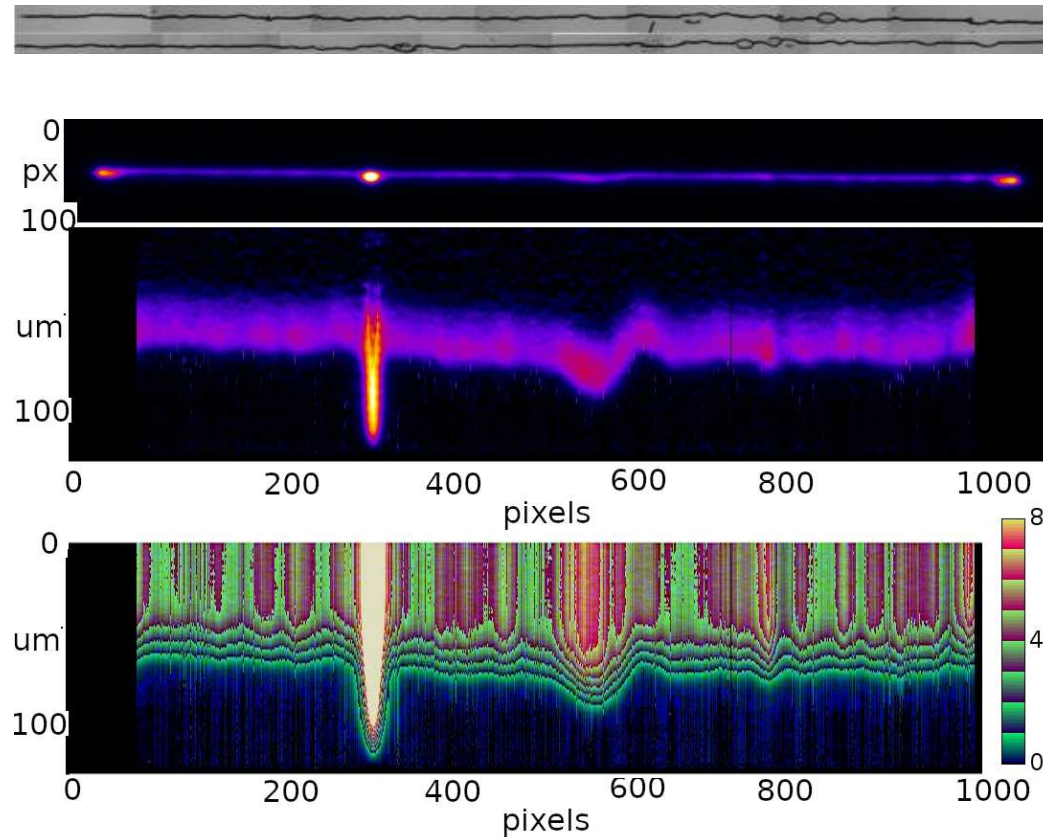- statistics $\sim 1/\sqrt{N} \sim 1$ %

height measure & RC estimates

- 0.25-0.75 h_z height estimate $\sim 15\mu$m

- focal line $F_s \sim 30$ μm high

- at $\sim 1/6$ m, corresponds to ~ 75 μrad
  - OASYS modeling TBD

$\sim \mu$m data across zebra stripe

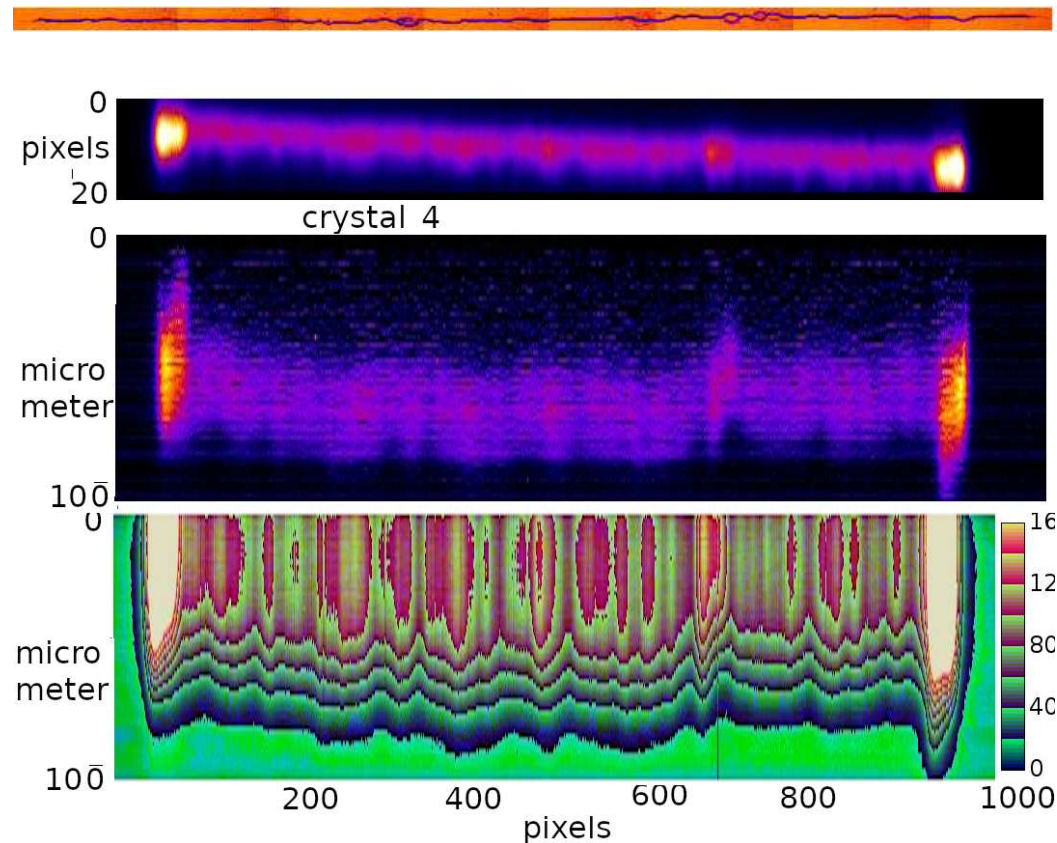- $\sim 15~\mu$m high at $f_s = (R/2)\sin\theta_B \simeq 164$ mm

- well within camera's PSF ($\sim 50~\mu$m, 4 pixels)

more quantitative than film

- now: better irradiation, possible comparison with computed RCs
  - do you NEED this for your application?

more quantitative than film

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