Looking into dynamical diffraction: Using the sensor crystal of the Medipix2 for both diffraction and observation of X-rays

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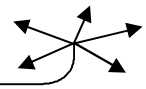
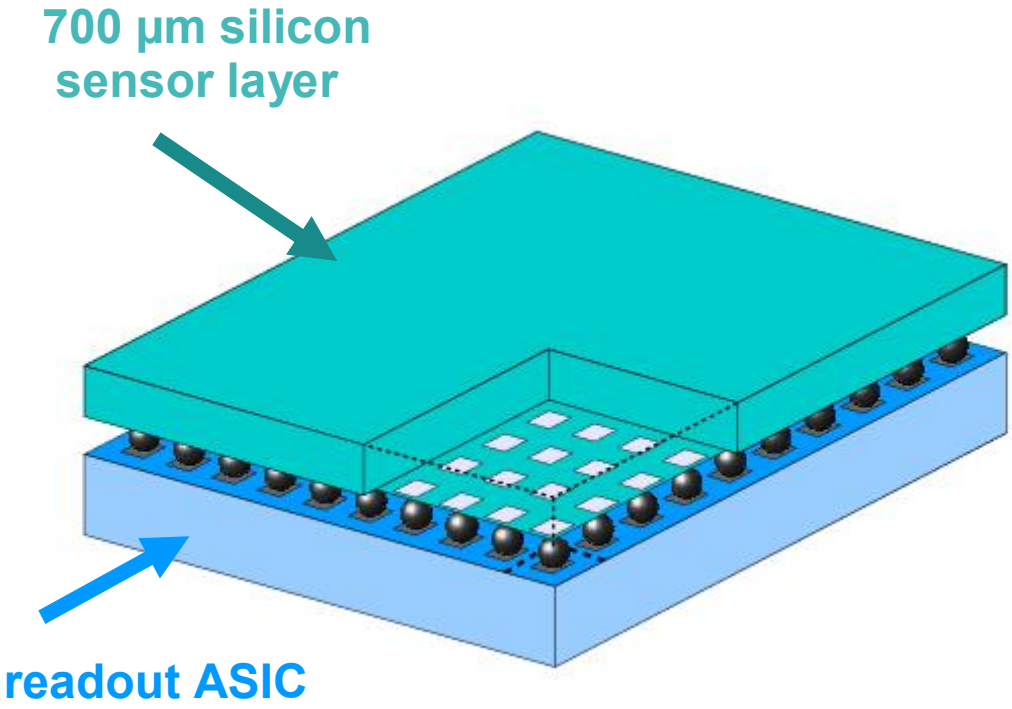
Overview

- **Introduction**
  - **Medipix**
  - **Crystallography**
- **Setup & Measurements**
- **Results**
- **Conclusions**



The Medipix2 Detector

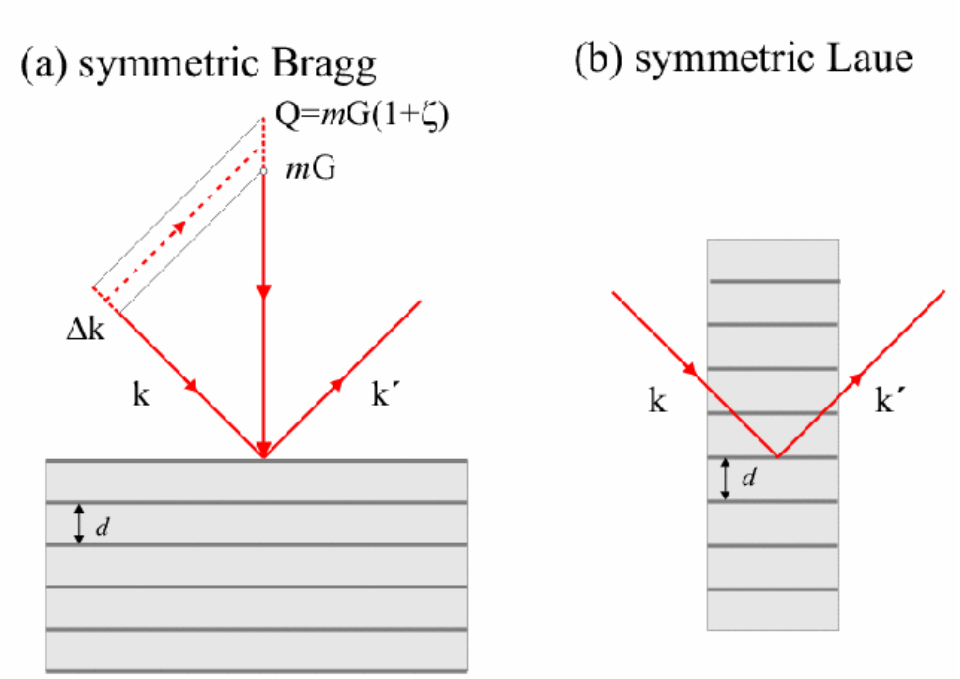


hybrid design

- pixel size: $(55\ \mu m)^2$
- direct X-ray conversion in a semiconductor sensor minimises image blurring and avoids an extra conversion stage from X-rays into visible light.
- single photon counting technique: each pixel cell has a low and high discriminator (threshold) and a 13-bit counter.
- The photon counting principle in contrast to systems based on charge integration suppresses noise and leads to superior SNR properties.

http://medipix.web.cern.ch/MEDIPIX/

Basic Crystallography



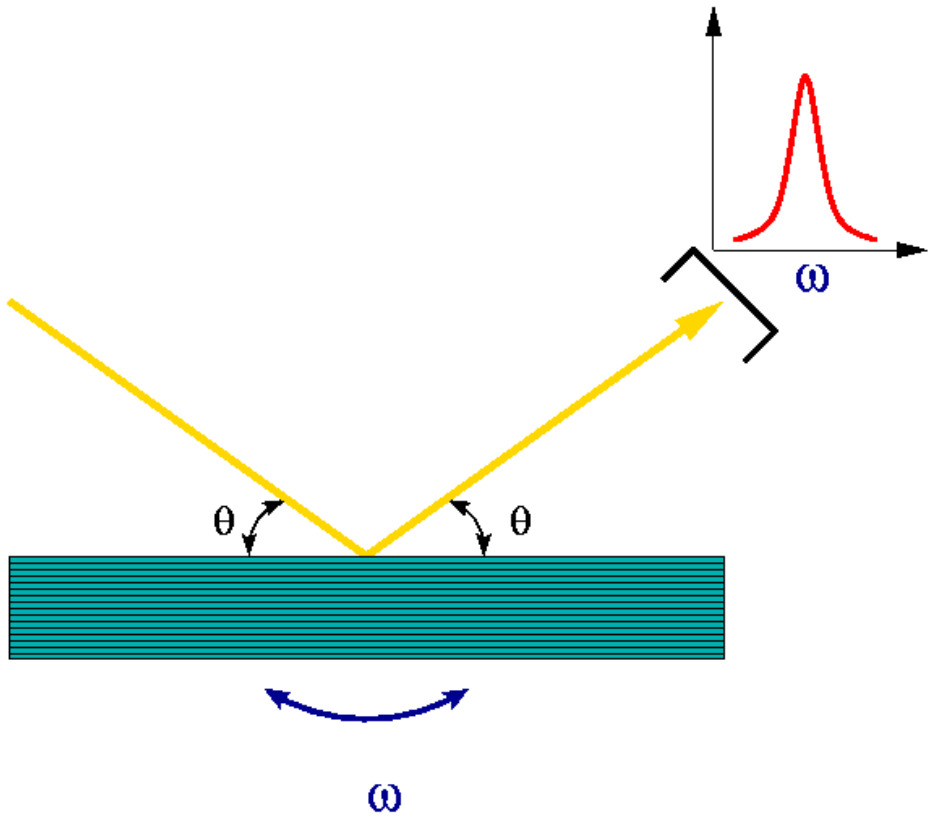
- Bragg's law: $n \cdot \lambda = 2d \cdot \sin\theta$
- Rocking the crystal through the angle ω results in a diffraction curve.

Bragg geometry: incidence and exit on the same side

Laue geometry: incidence and exit on different sides

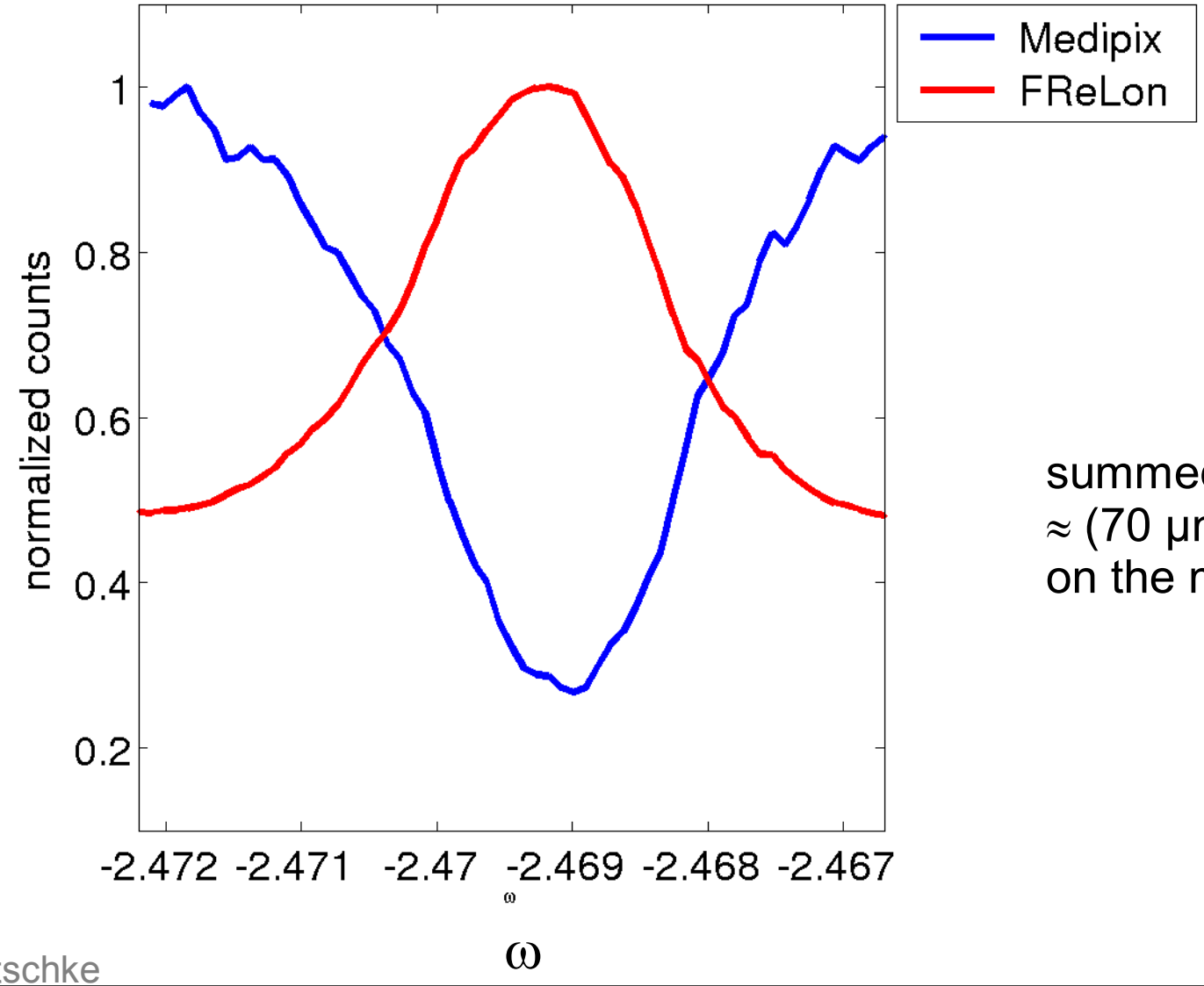
figures: J. Als-Nielsen, D. McMorrow, 2001

Backward scattered Beam (Bragg)



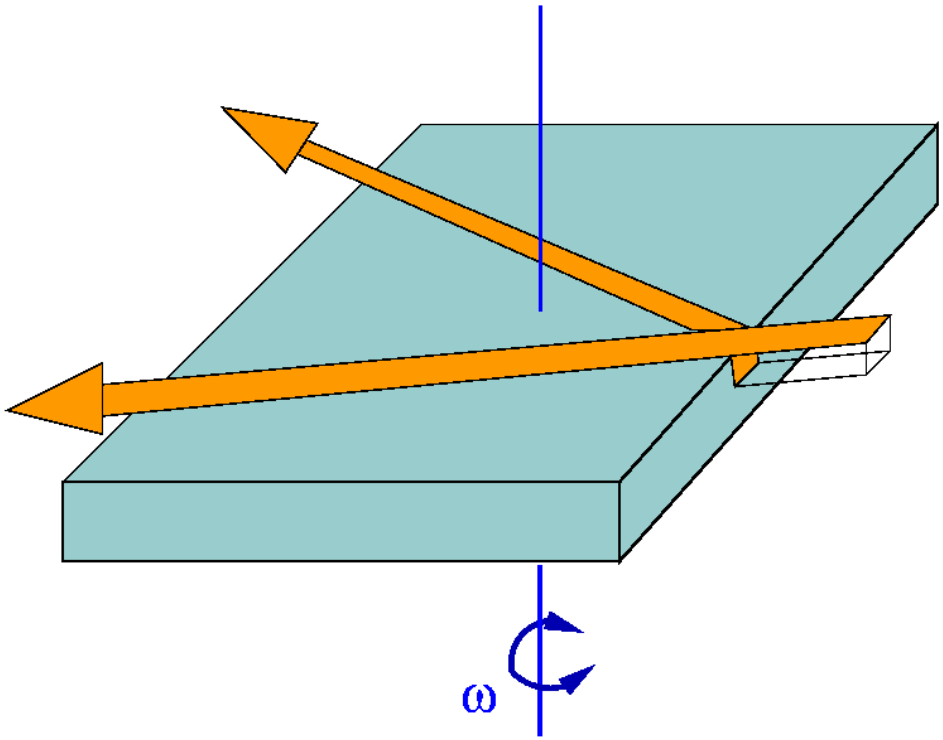
- Simultaneous observation of transmitted (Medipix) and scattered (FReLoN Camera)
- Si (111) reflection
  q_B = 10.8 deg
- very flat incidence to avoid radiation damage to the electronic ASIC

Measurement



summed signal of
≈ (70 µm)^2 beam diffracted
on the medipix

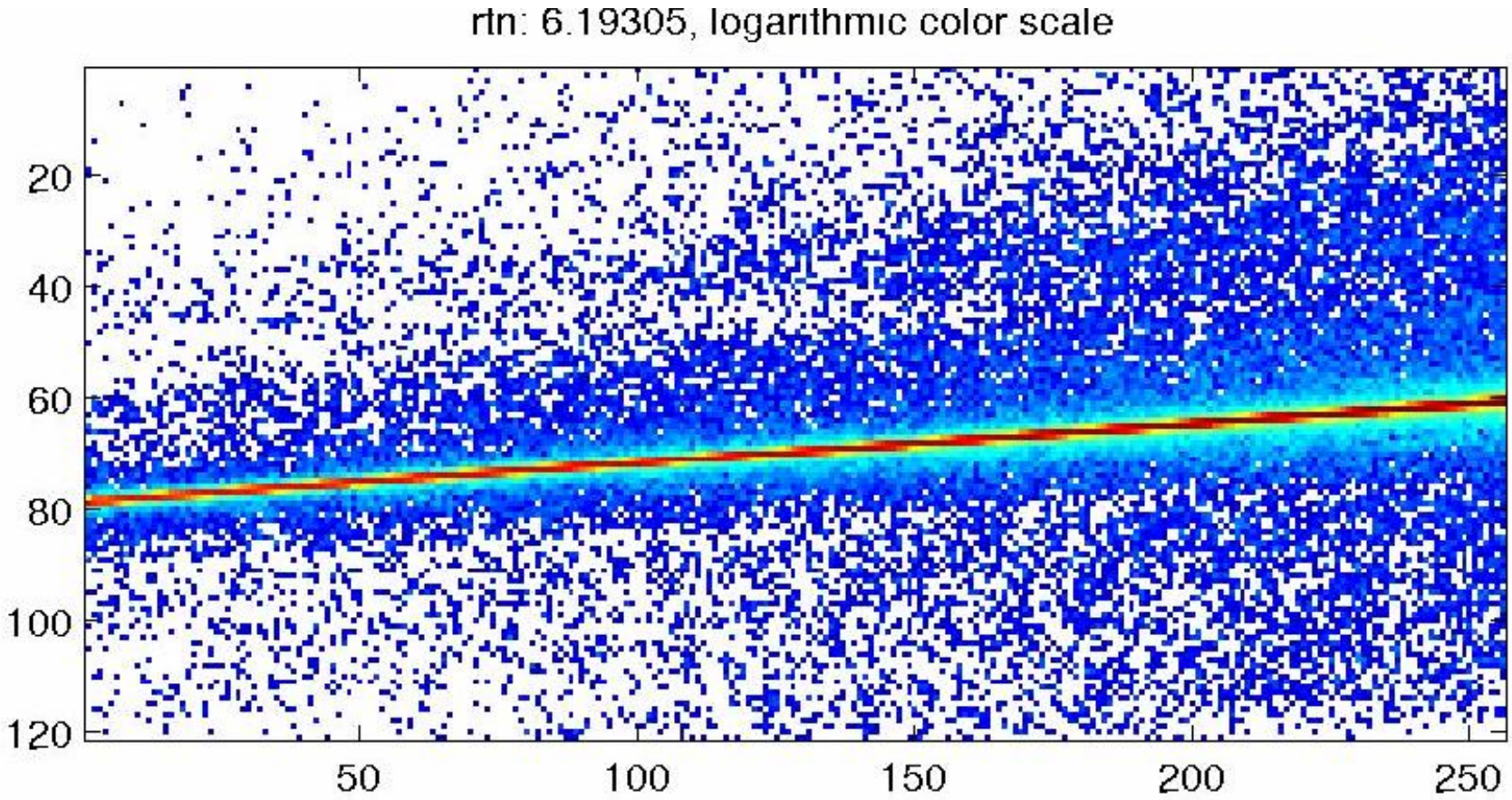
Forward scattering Setup



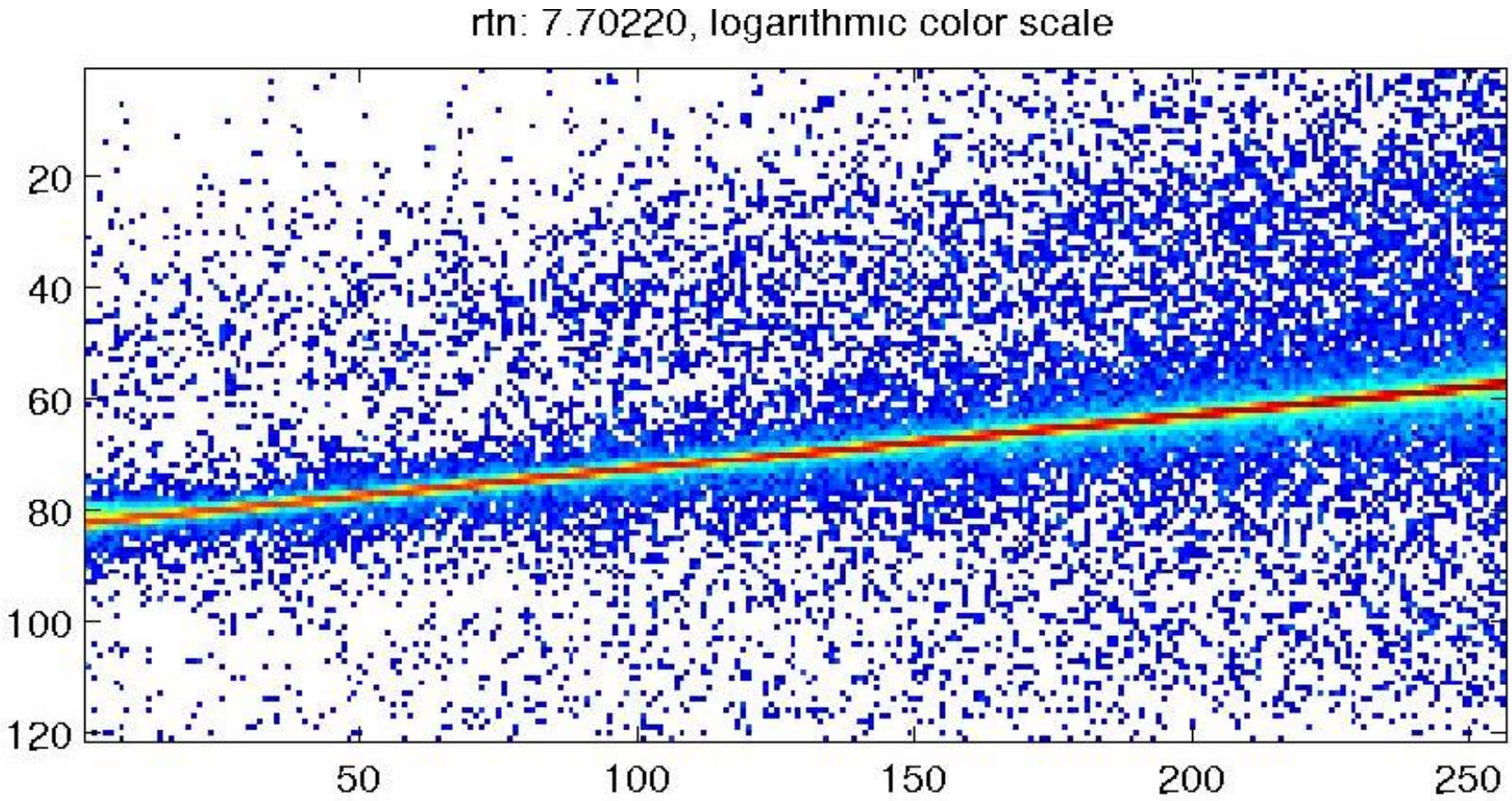
- beams enters horizontically from the side
  ► no radiation damage to ASIC
- E = 50.5 keV ,
  absorption length = 17.613 mm
  reflection **(2 -2 2)**: $2\theta_B$ = 7.3 deg
- the low absorption allows a penetration of the whole sensor
- simultaneous observation of incident and forward diffracted beam

Medipix 700 µm Si sensor,
14 mm diameter

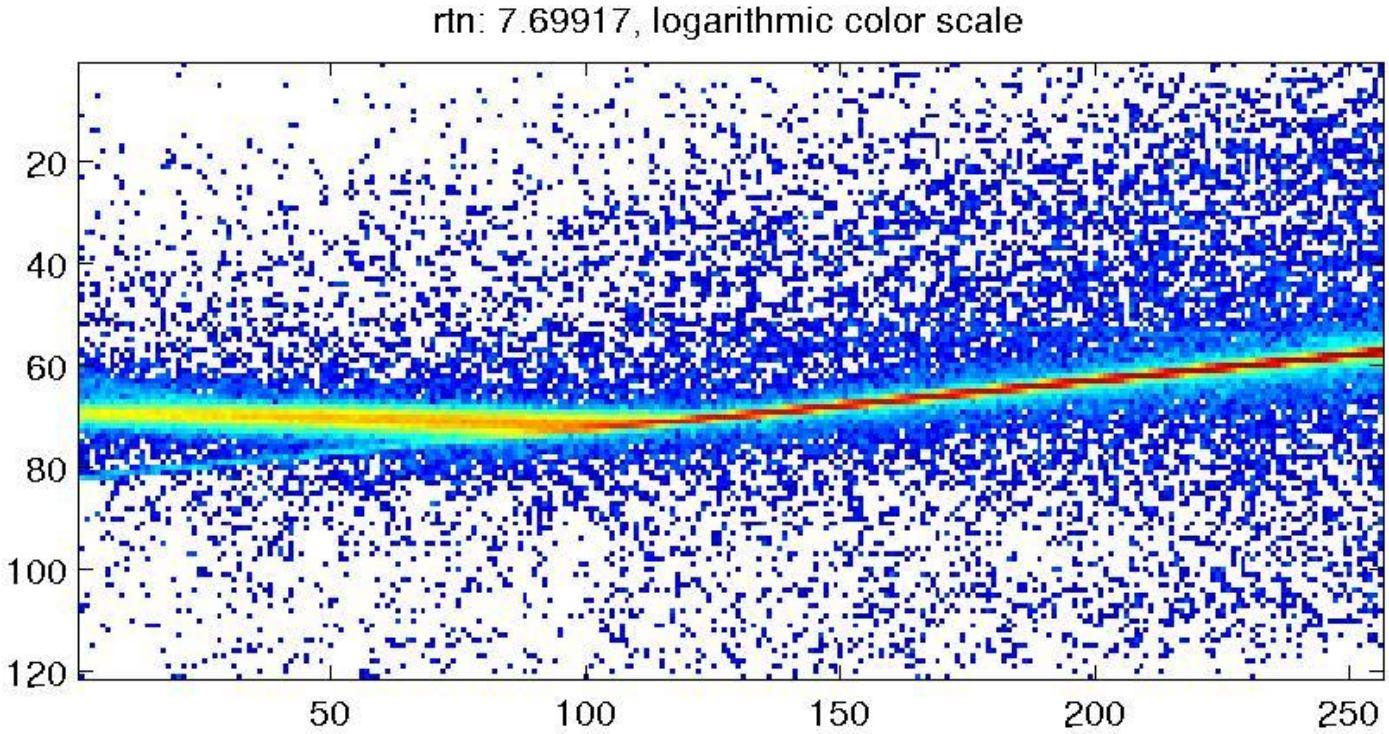
Angle ω Scan (2 -2 0), (5 -5 1)



Angle ω Scan (-3 1 1)

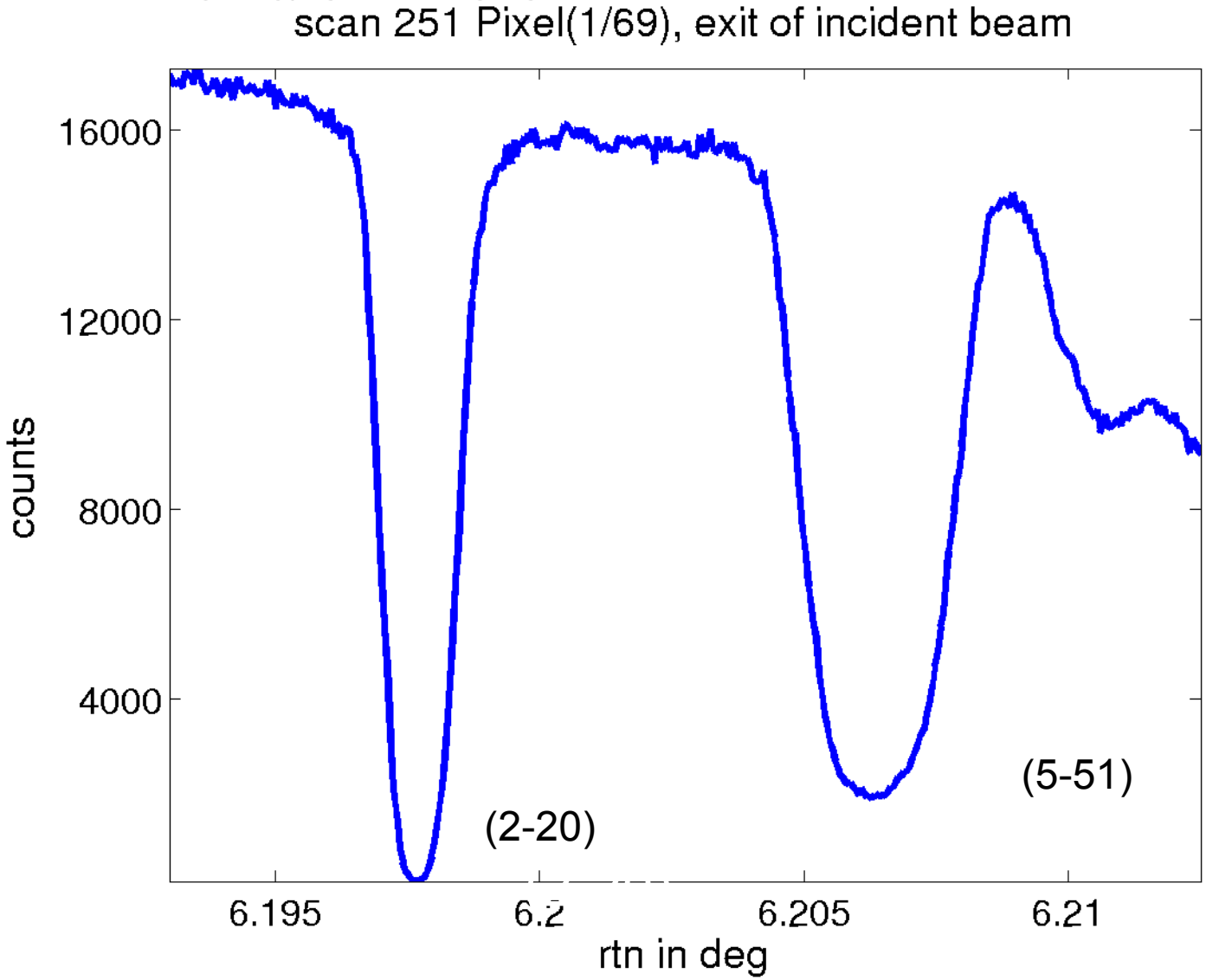


Strain (-3 3 1)

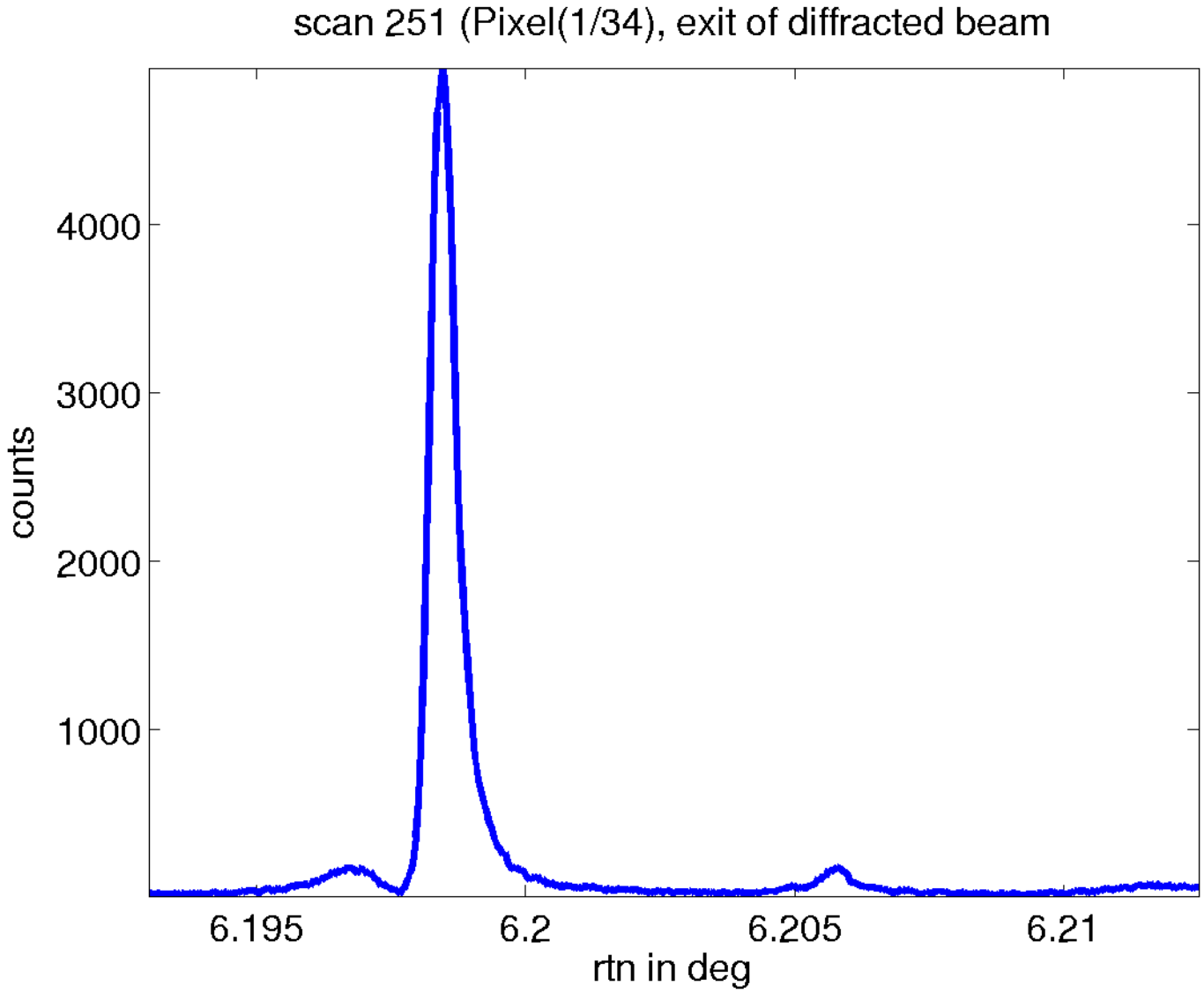


Due to strain inside the crystal, the Bragg condition is only met in one place.

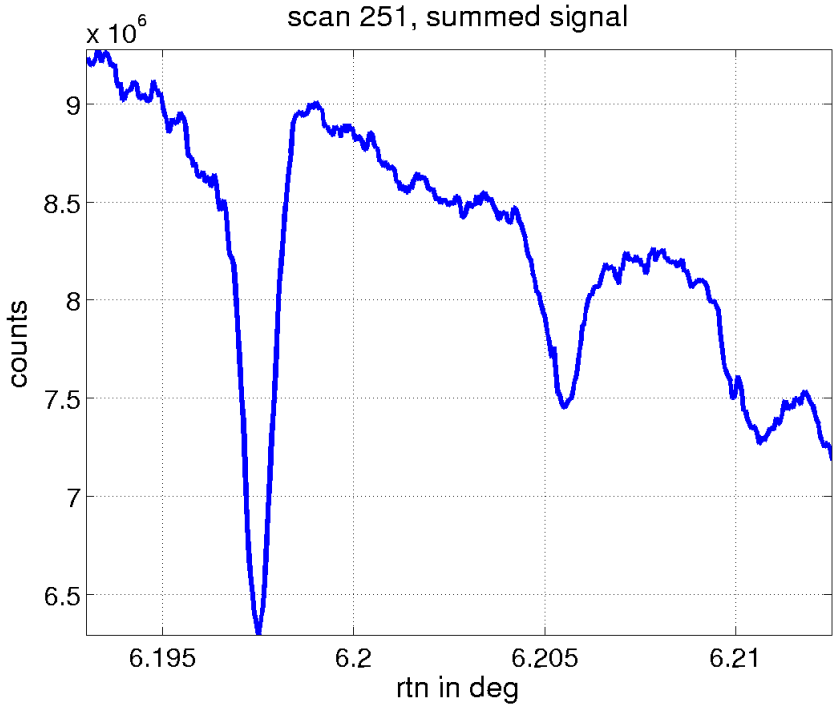
Exit incident beam

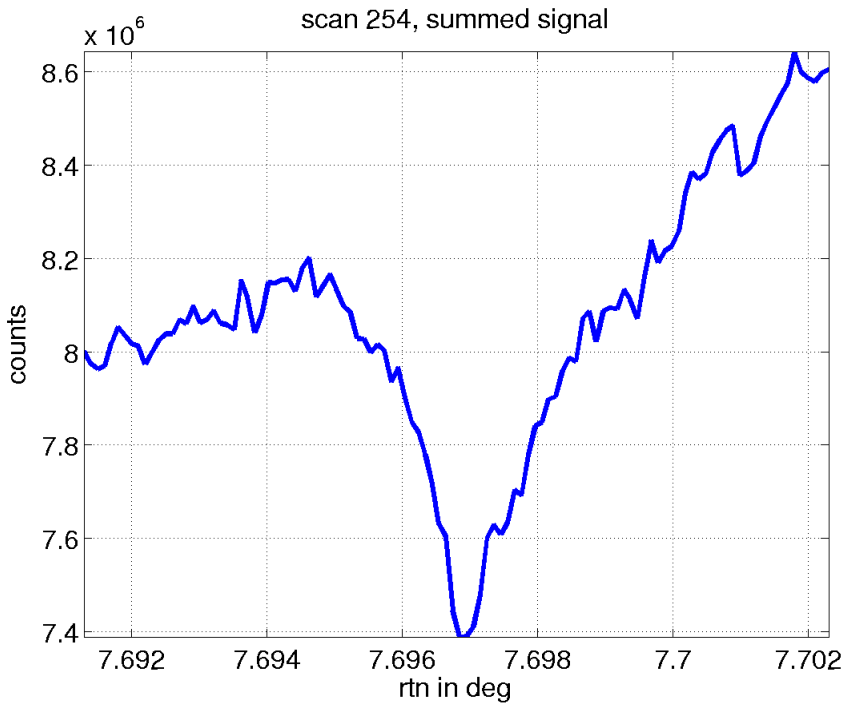


Exit refracted beam



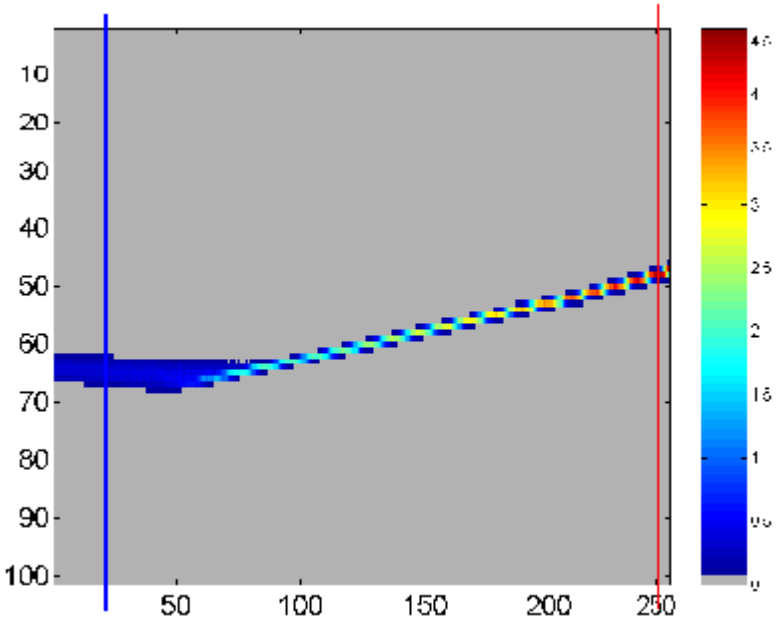
Absorption inside the Medipix

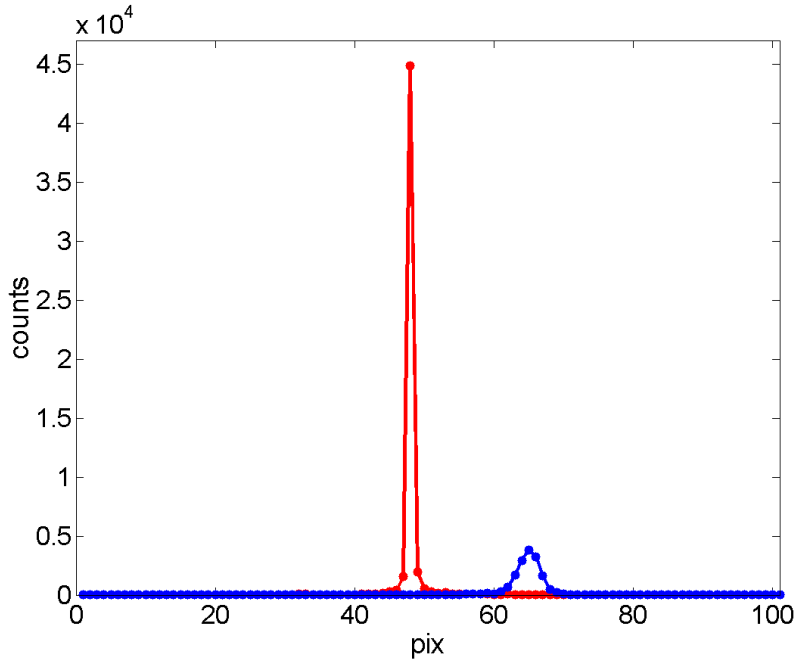




- significant drop in absorbed photons when a reflection is excited.
- due to reflections diffracted outside of the sensor layer.

Dynamic Range



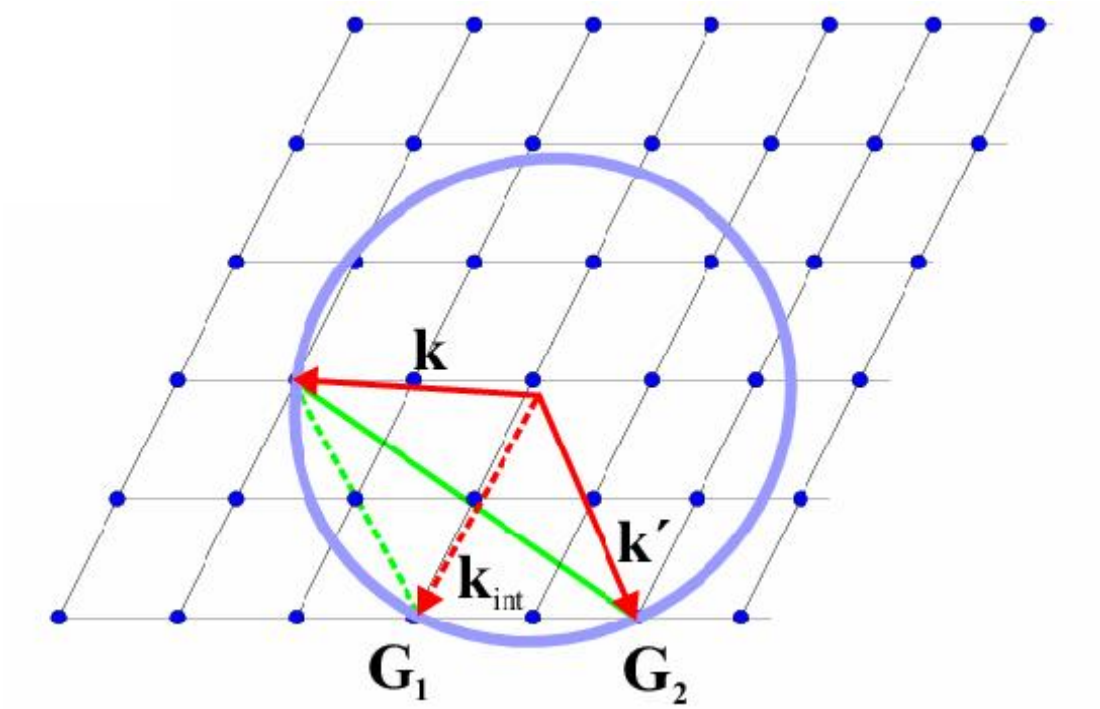


Two line cuts showing difference in countrate. (10 acq were taken)

Conclusions

- Bragg & Laue diffraction has been oberved on the Medipix2 Sensor layer
- high dynamic range of the medipix2 allows observation of incident beam and diffracted beam without deadtime effects
- observation of Laue diffracted beams is a quick and non-damaging way to check for strain in the sensor

Multiple Reflections



ore than one reciprocal lattice point
n be excited on the Ewald sphere.

ıe intensity in the multiple
ˈlections is missing in the primary
ˈlection

figure: J. Als-Nielsen, D. McMorrow, 2001

Anomalous Transmission

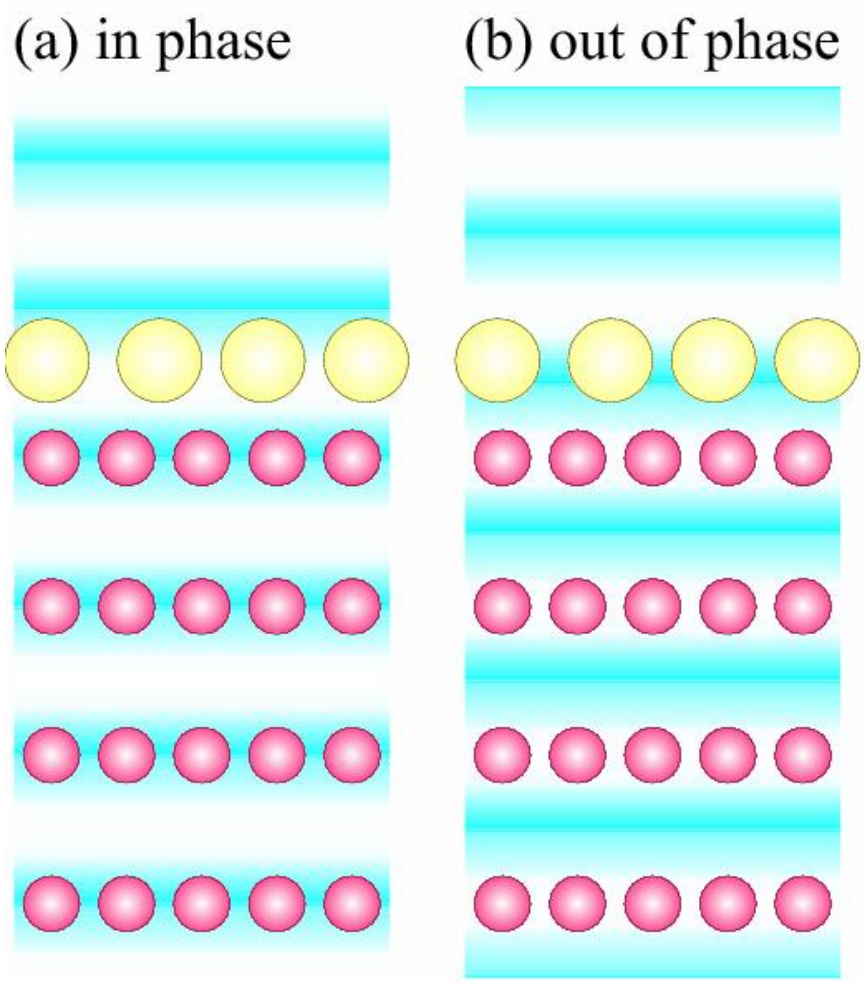


figure: J. Als-Nielsen, D. McMorrow, 2001

- A standing wave field is present inside the crystal, the the wave nodes are at the places of the crystal planes (i.e. atoms).
- Excitation of a forward diffracted beam leads to a higher intensity of the transmitted beam:
  Bormann effect