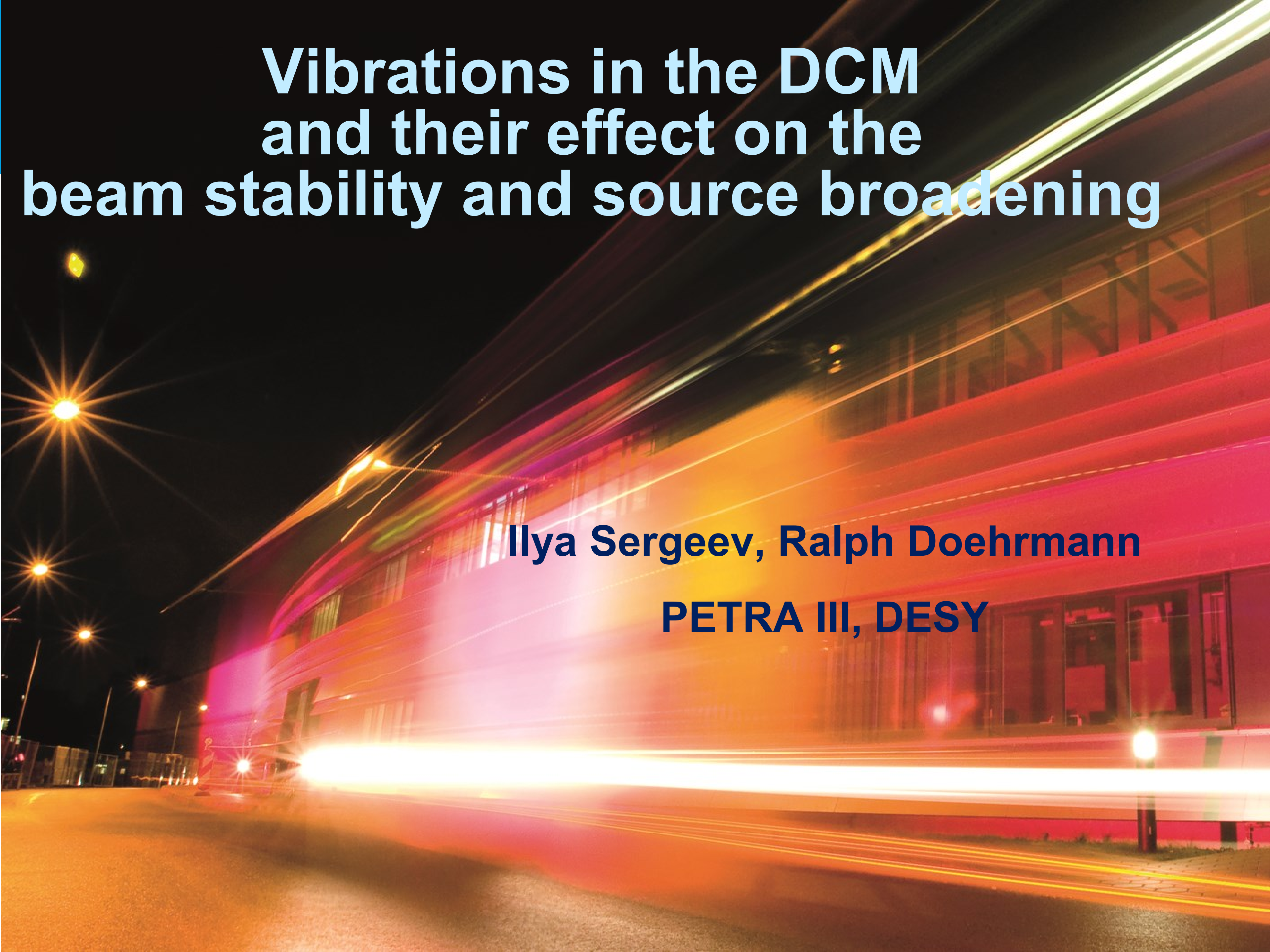
Vibrations in the DCM and their effect on the beam stability and source broadening



Ilya Sergeev, Ralph Doehrmann

PETRA III, DESY

Outlook

- Effect of crystal vibrations on the beam focal position

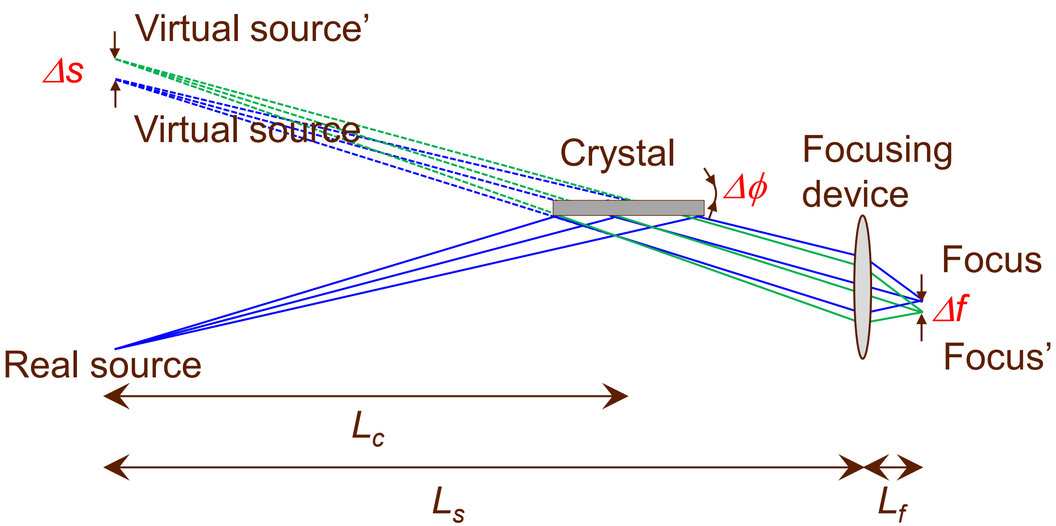
- Beam vibrations measurement procedure
- Overview of the vibrations in DCM at PETRA III and ESRF (ID06, ID18)

- Offline measurements with differential interferometer
- Characteristic features found with offline measurements

- Conclusion

Effect of crystal vibration on the focus position

Idea from *R. Tucoulou et al., J. Synch. Rad (2008)*



Focal size:

$$focus = \frac{L_f}{L_s}\, source$$

Effect of crystal rotation:

Shift of the virtual souce:

$$\Delta s = 2\Delta\phi \cdot L_c$$

Shift of the focal position:

$$\Delta f = \frac{L_f}{L_s}\Delta s = \frac{L_f}{L_s} L_c \cdot 2\,\Delta\phi$$

<u>Example:</u>

$\Delta\phi$ = 0.1 urad
L_c = 50 m

→ Δs = 10 um

Source = 10 um

Shift of the source is comparable with the source size

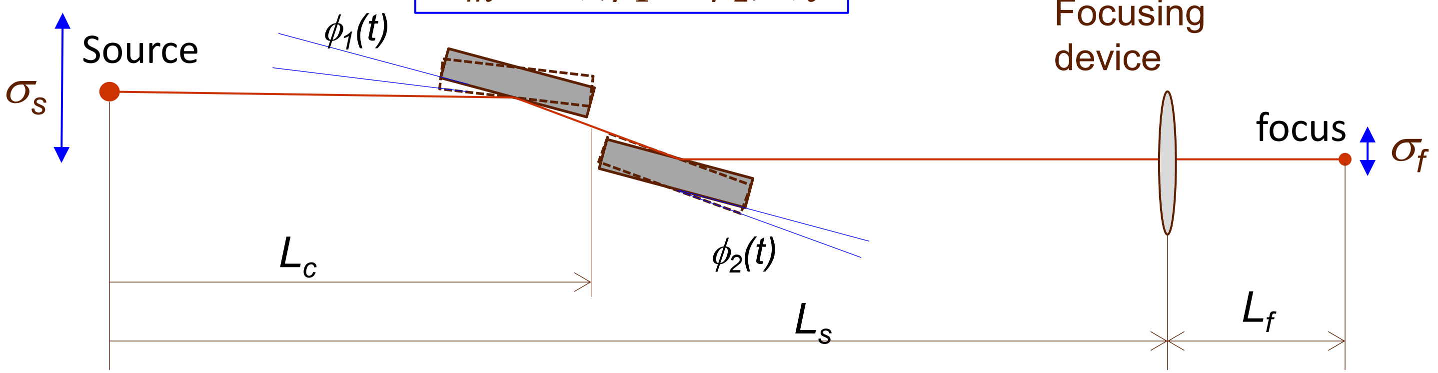
Effect of the optics vibrations on the beam stability

Monochromator

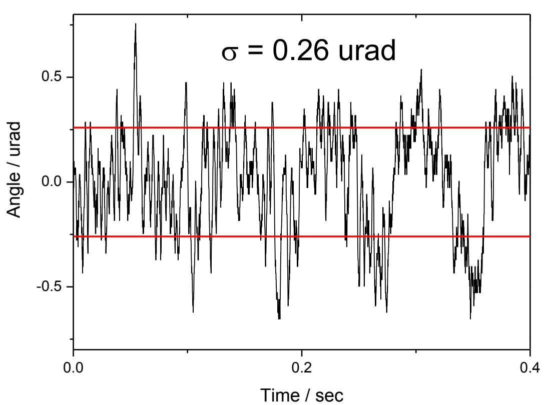
$$\sigma_m{}^2 = \langle(\phi_1 - \phi_2)^2\rangle_t$$

$$\sigma_s = 2\,\sigma_m \cdot L_c$$

$$\sigma_f = \frac{L_f}{L_s}\sigma_s$$

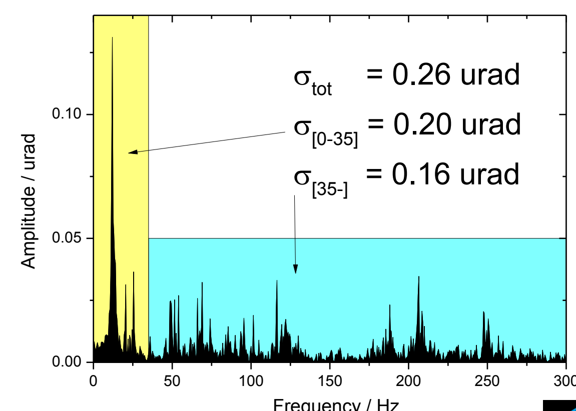


Separation of vibration contributions



Fourier transformation

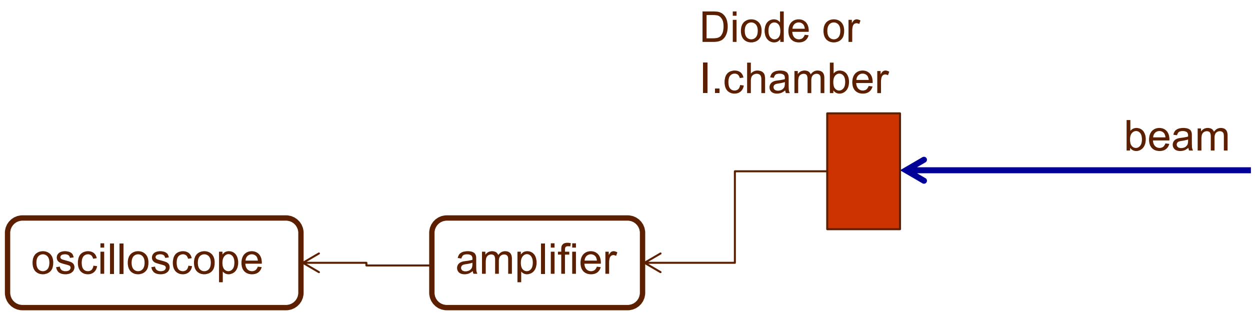
$$\sigma^2 = \sum_{i=1}^{N} c_i{}^2$$



Vibration measurements

- Direct measurement of beam vibrations by fast X-ray camera.
  Restricted frequency range

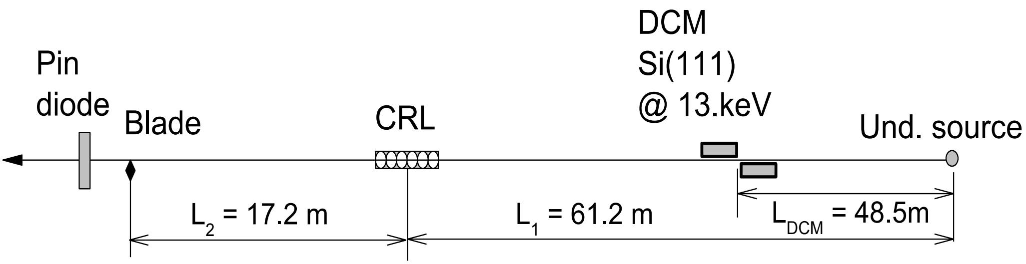
- Measurements of beam intensity fluctuations

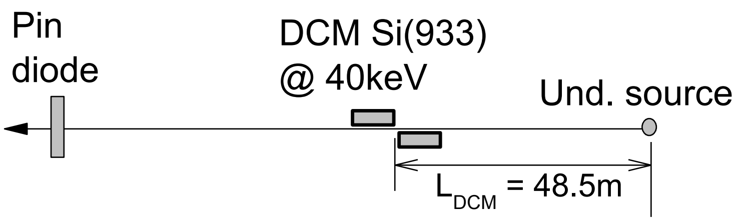


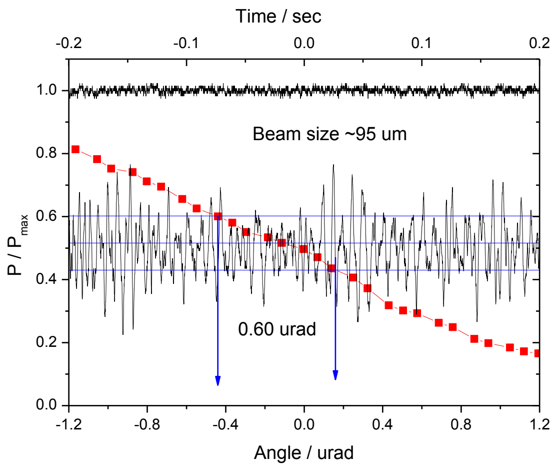
1. Slit at the half beam with/without focusing

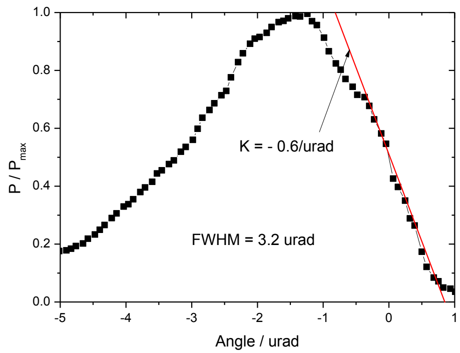
2. Slope of the rocking curve.

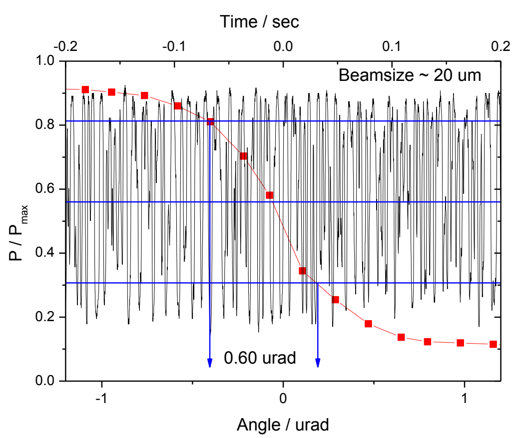
Vibration measurements at P01, PETRA III

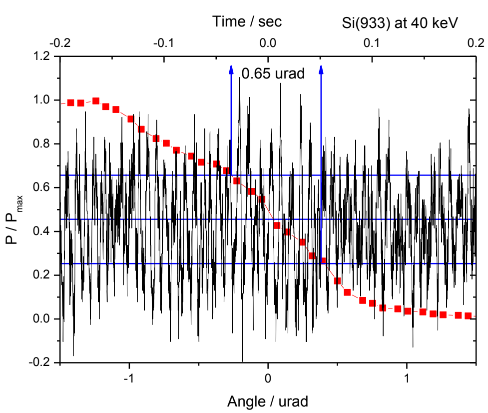




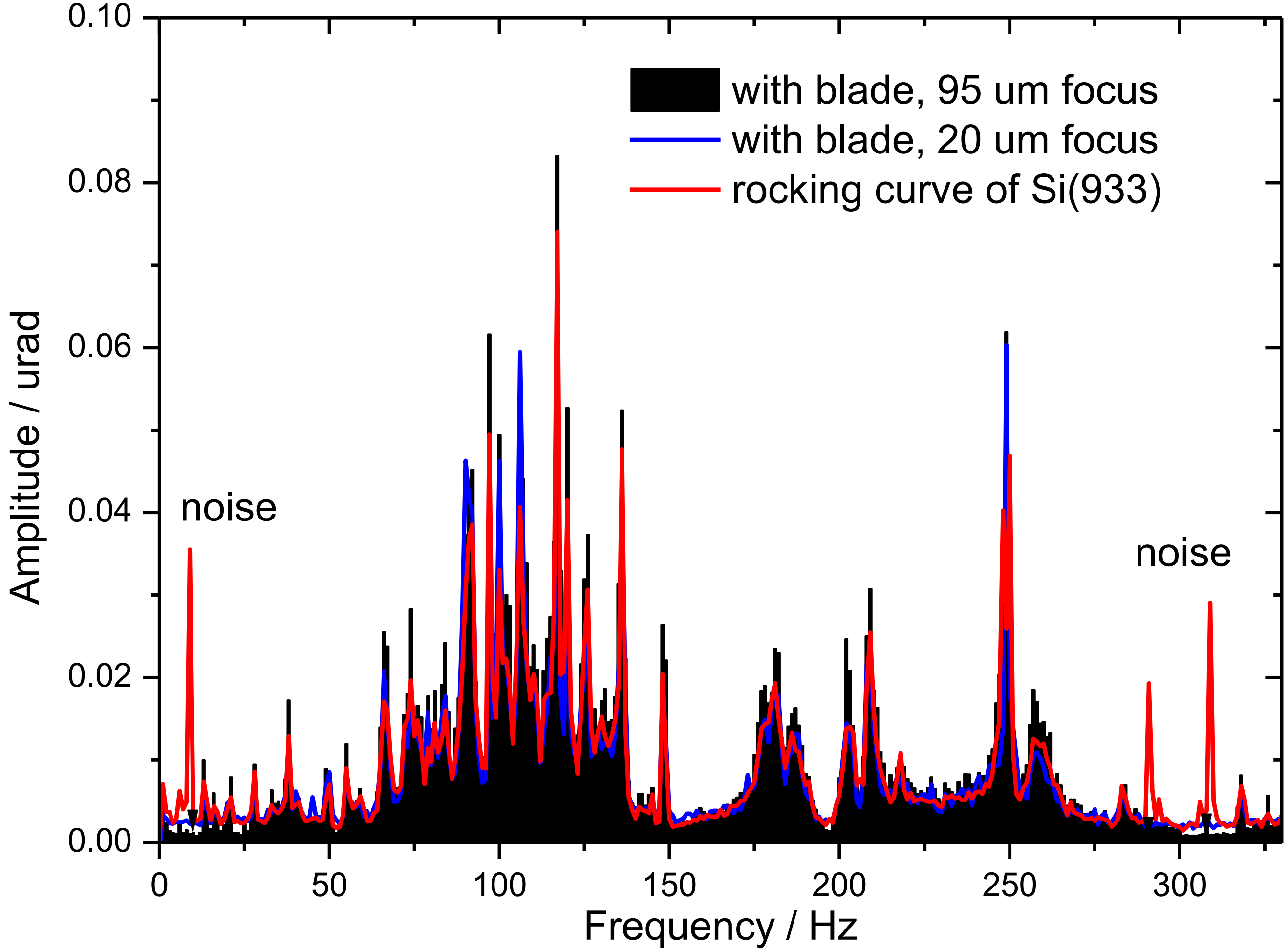




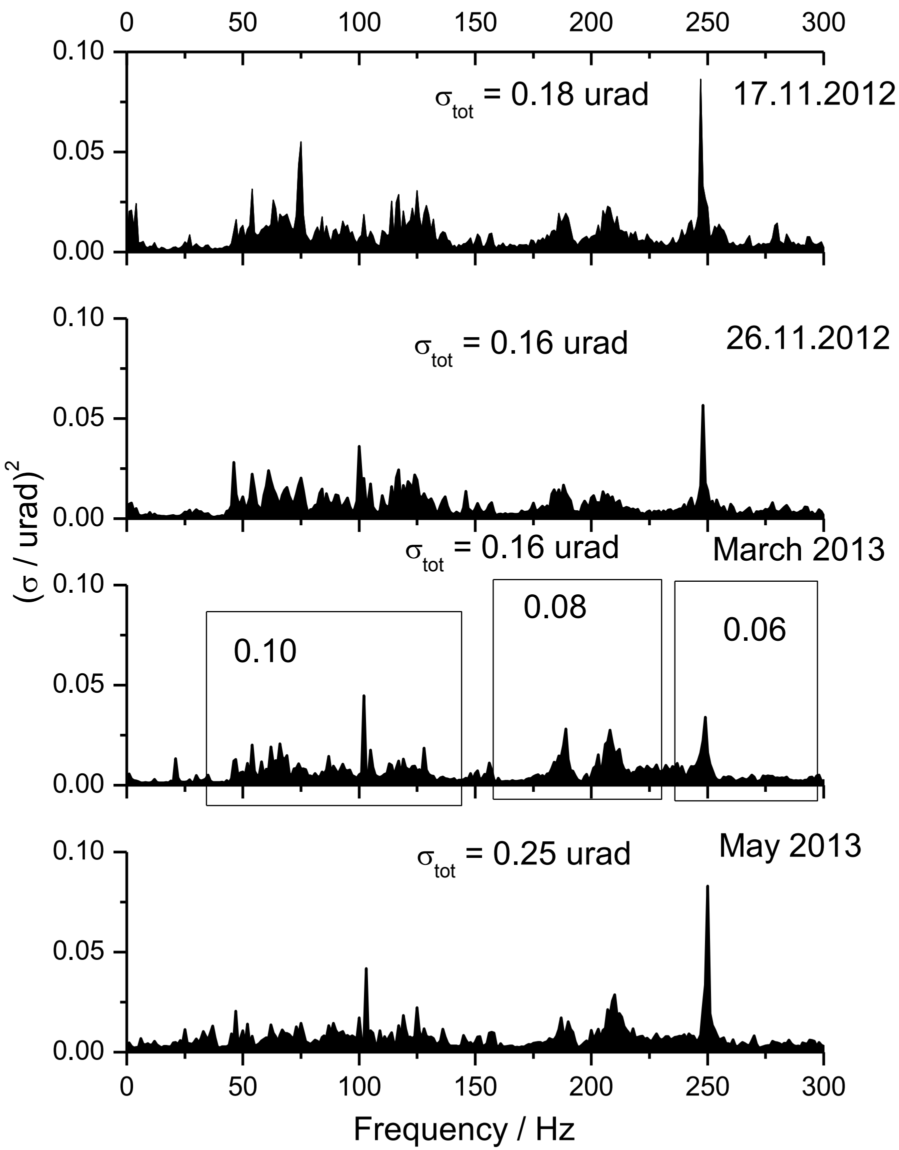




Vibration measurements. Frequency distribution



Evolution of vibrations with time



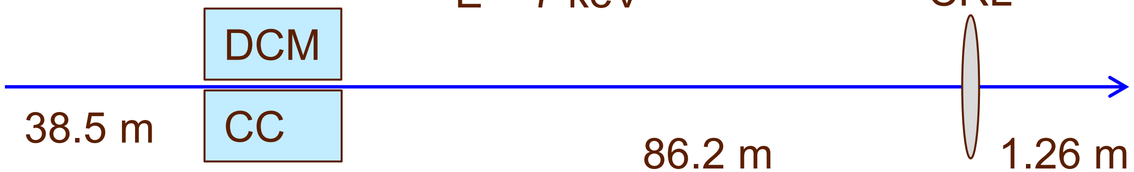
Measurements at P01 PETRA III.

Upgrade of mono –
- beginning of November 2012

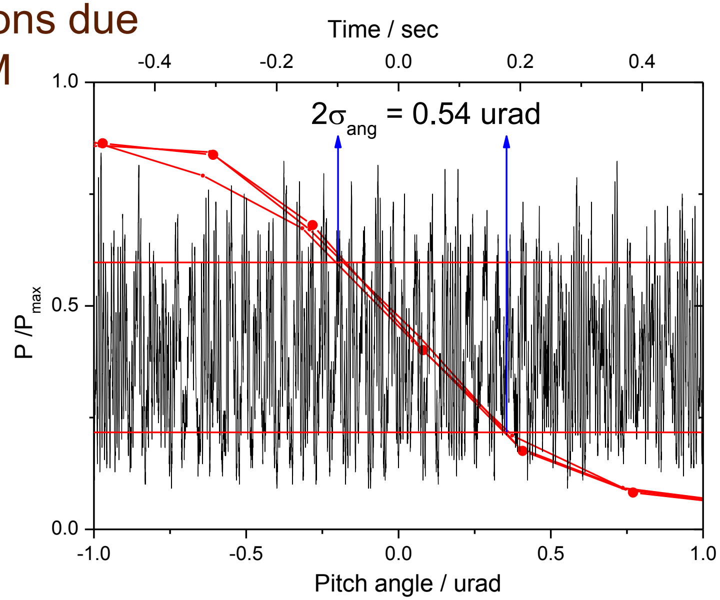
Effect of vibration in Channel-Cut and in DCM

P10, PETRA III

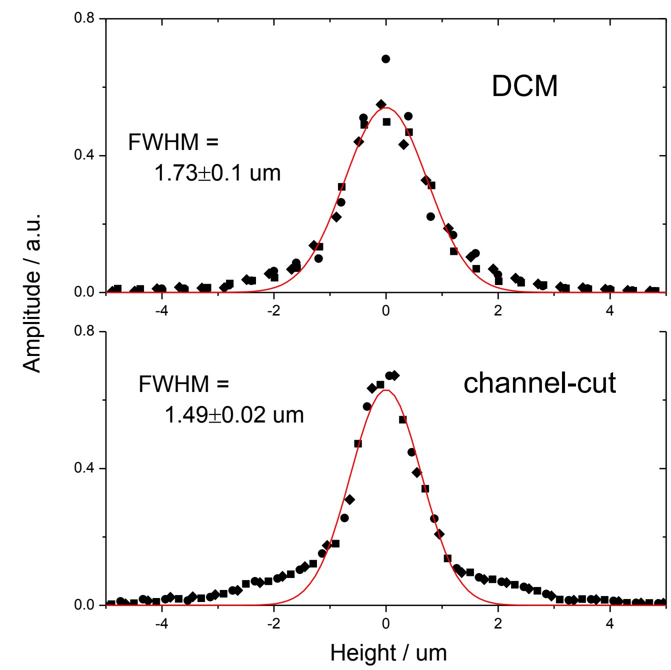
A. Zozulya et al., J. Phys. Conf. Ser. (2014)



Vibrations due to DCM



Focal beam size



Source broadening: σ_{source} = 0.27 urad · 2 · 38.5 m = 21 um

Focal broadening: σ_{foc} = 21 um · 1.26 / 86.2 m = 0.31 um, $FWHM_{foc}$ = 0.73 um

Broadening from beam size: $FWHM_{foc} = \sqrt{1.73^2 - 1.49^2} = 0.88$ um

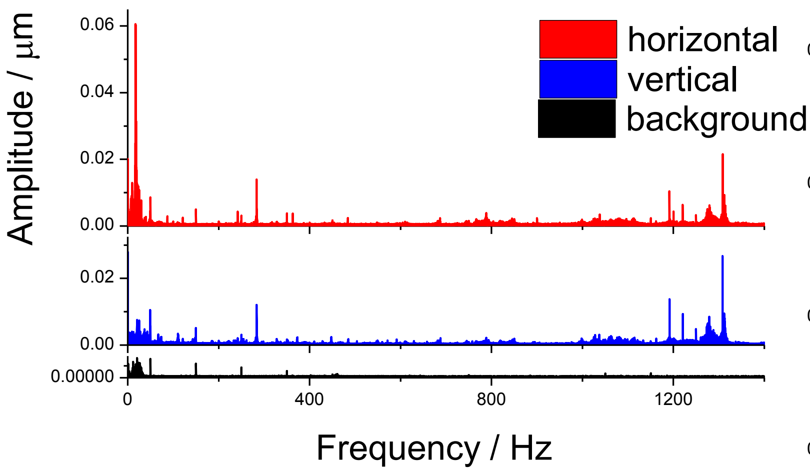
Frequency distribution of vibrations for DCM and CC

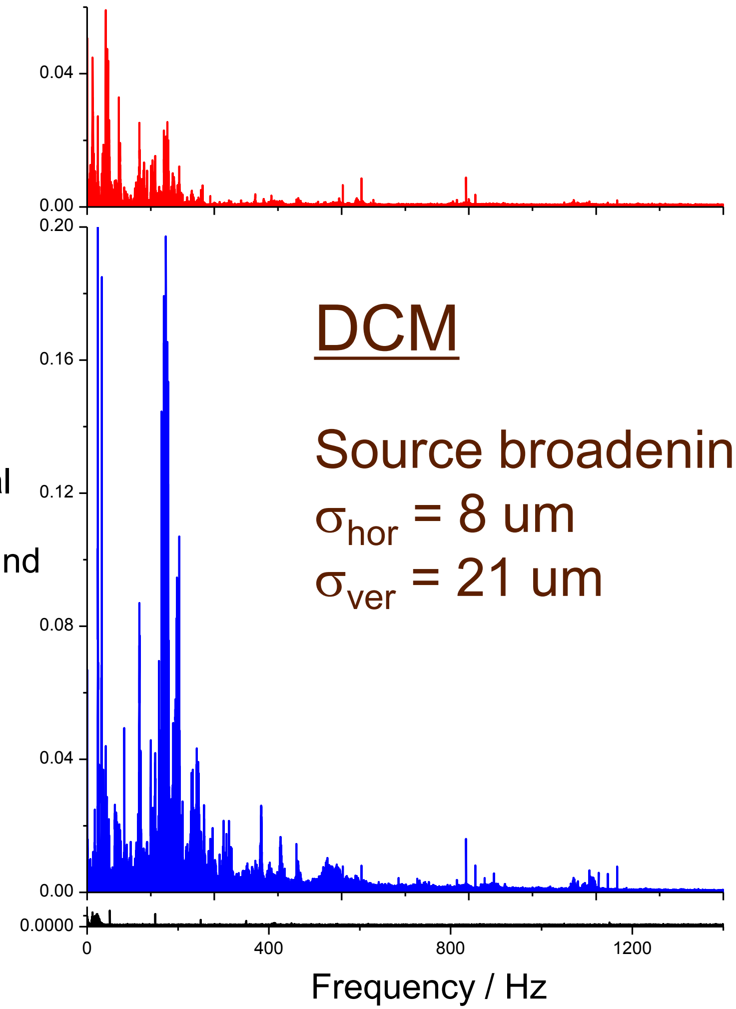
Channel-cut

Source broadening:

σ_{hor} = 5 um

σ_{ver} = 3 um





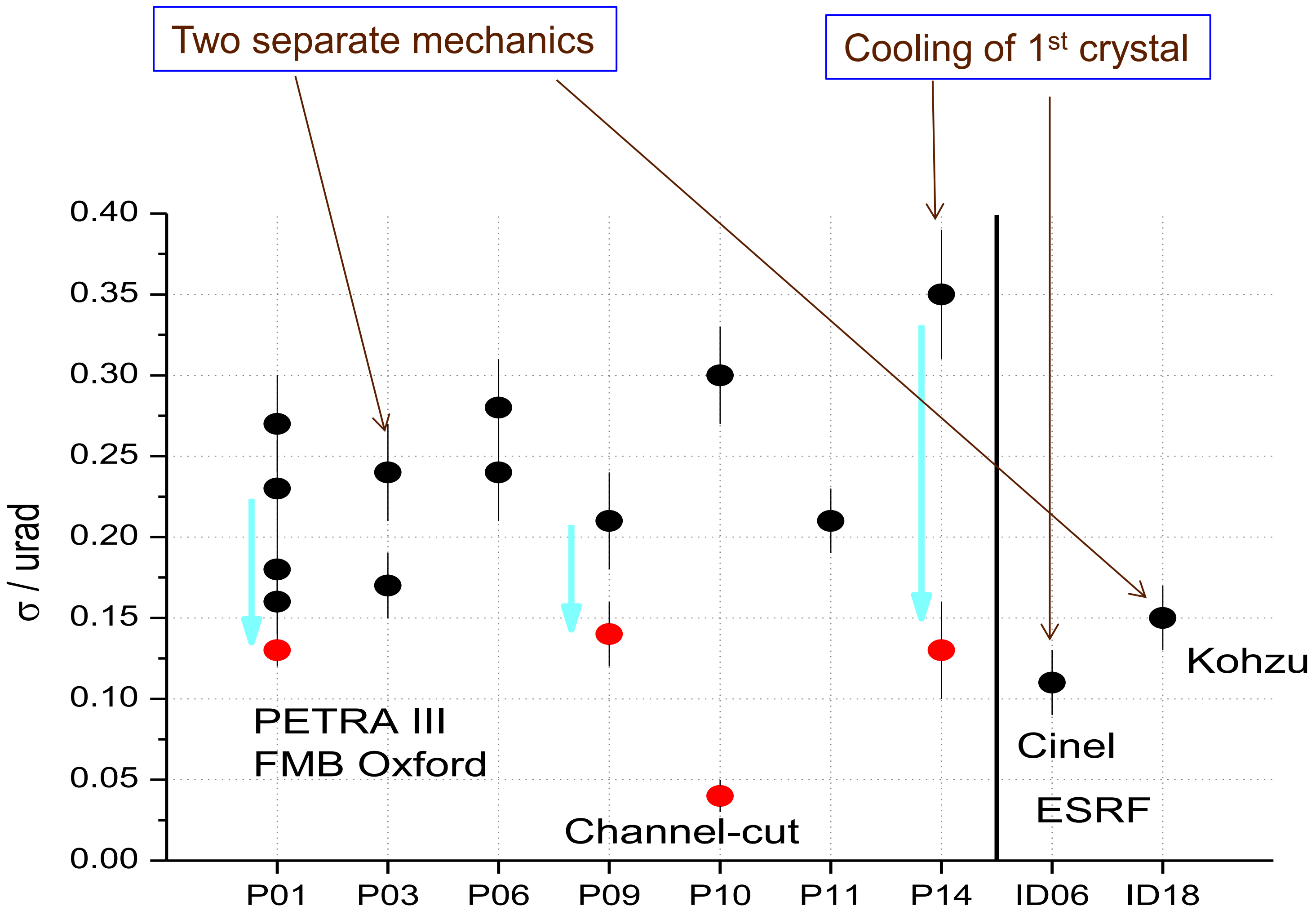
DCM

Source broadening:

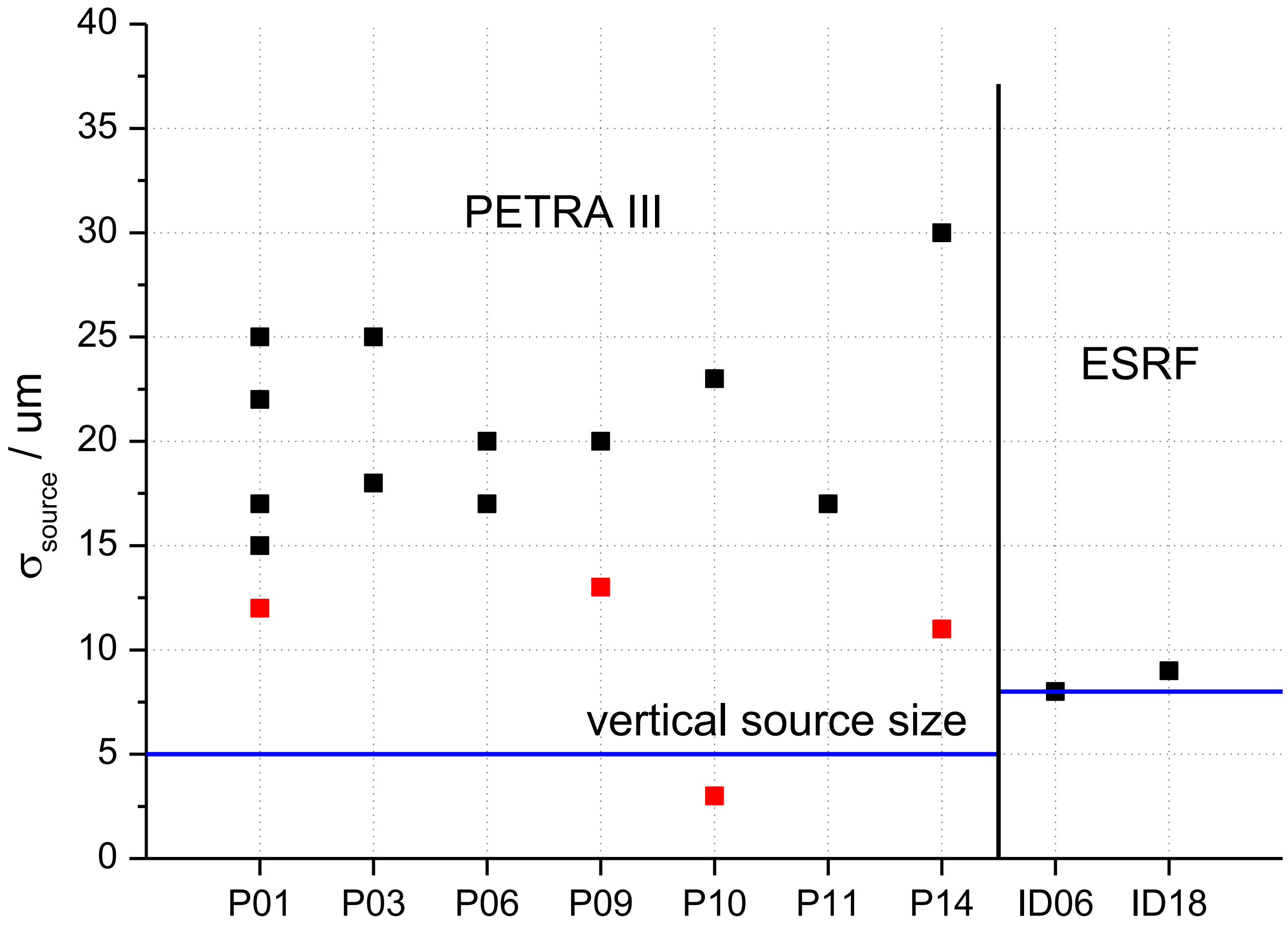
σ_{hor} = 8 um

σ_{ver} = 21 um

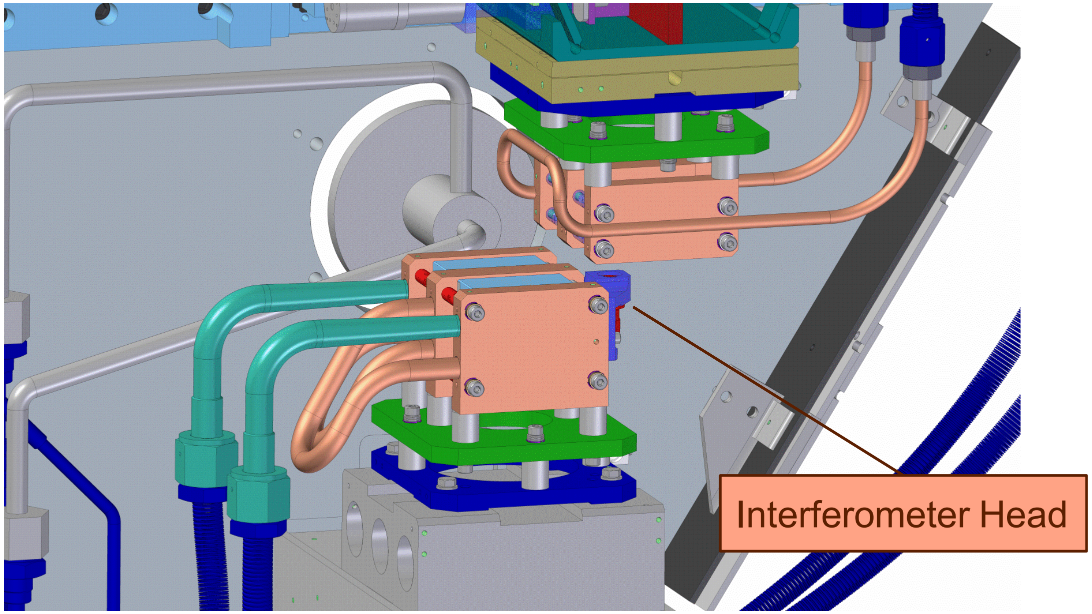
Overview of the vibrations of monochromators



Overview of the vibrations of monochromators

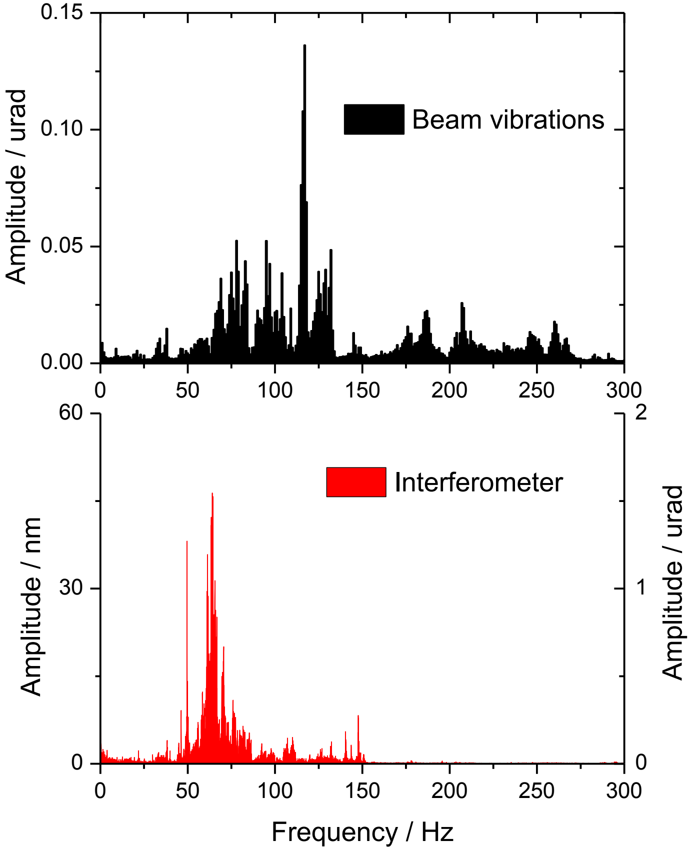


Vibration measurements without beam

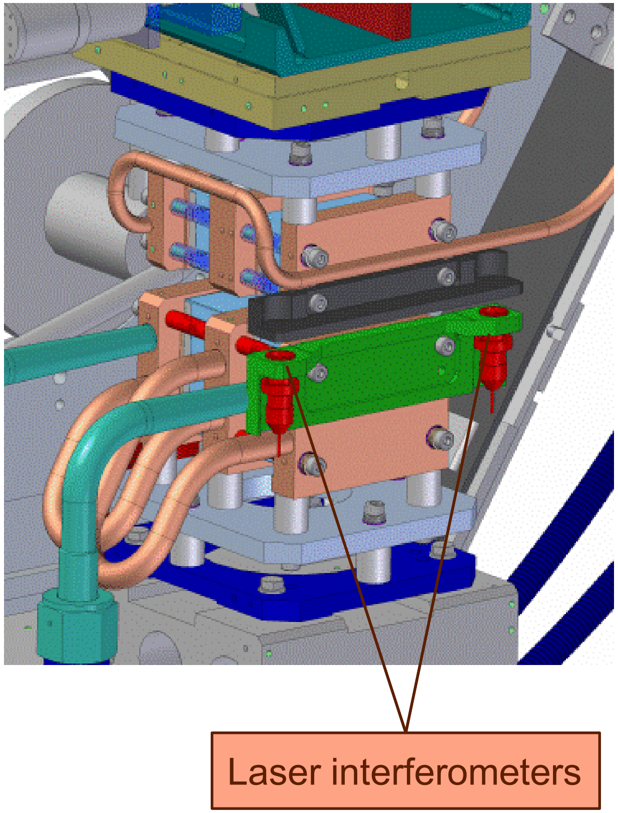


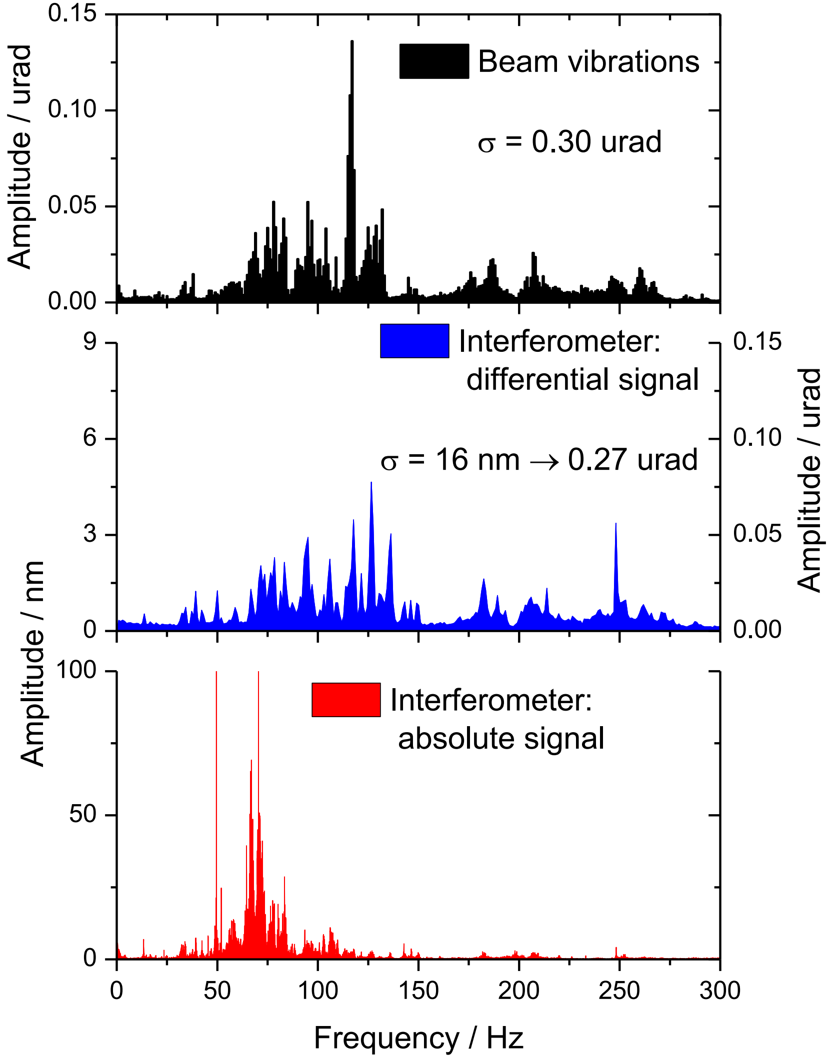
Laser interferometer (FPS

Working distance 0-400 mm
Sensitivity 25 pm
Repeatability 2 nm
Bandwidth 10 MHz

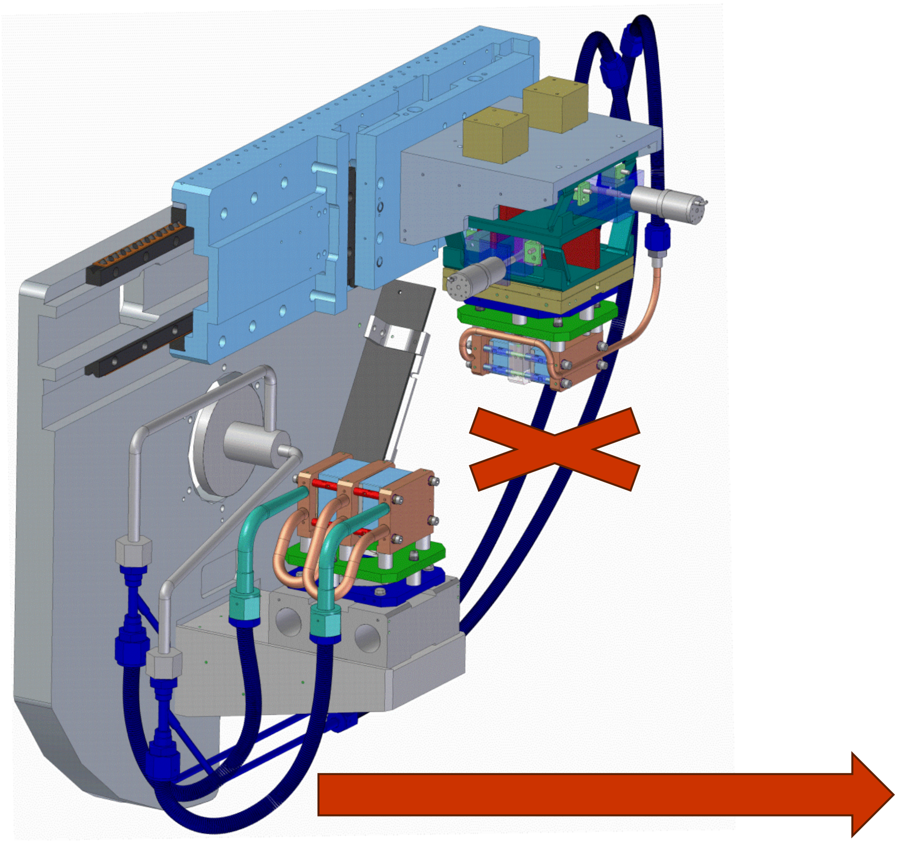


Vibration measurements without beam



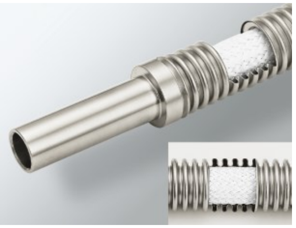


Effect of the tubes on vibrations



Tubes to the 1st crystal holder:

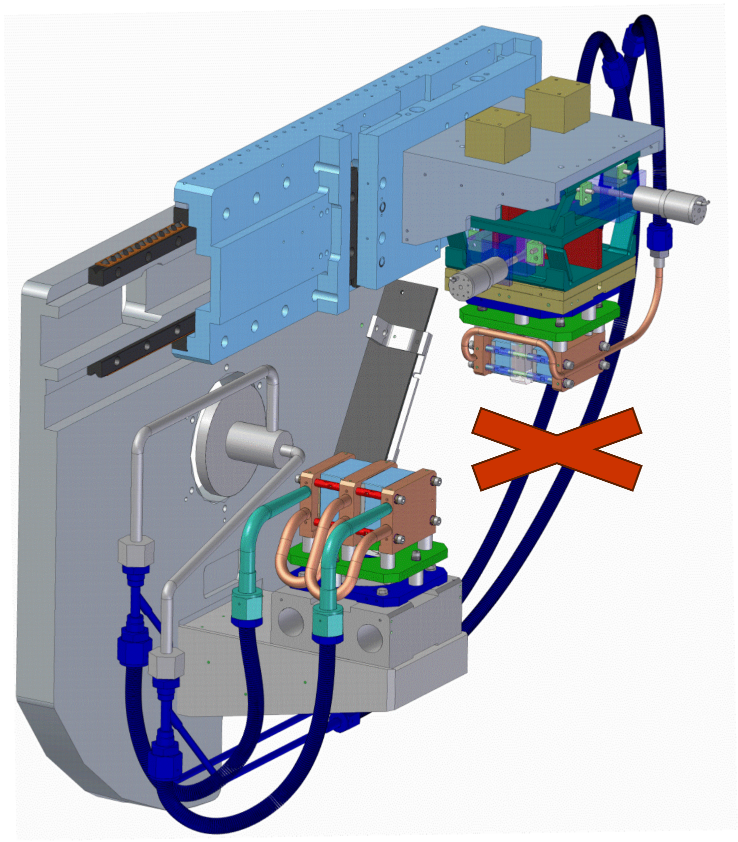
1. No tubes
2. Tubes with flexible sleeve

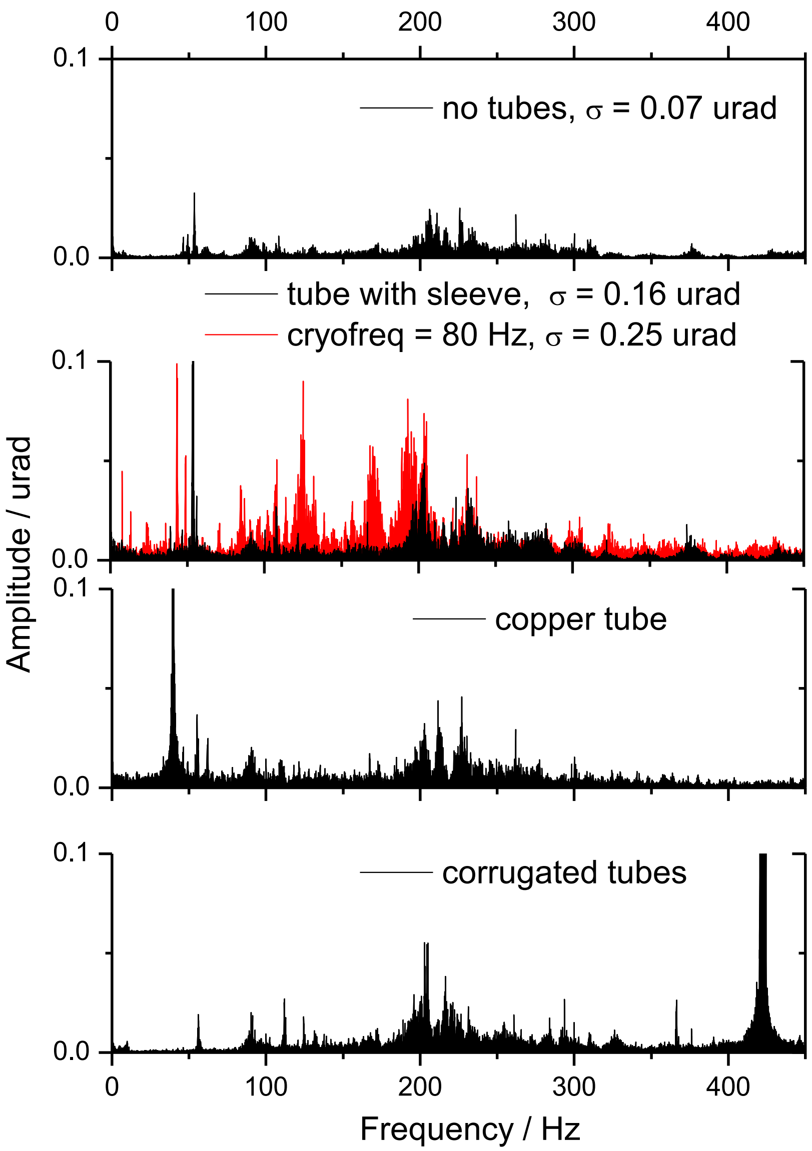


3. Copper tubes

4. Corrugated tubes

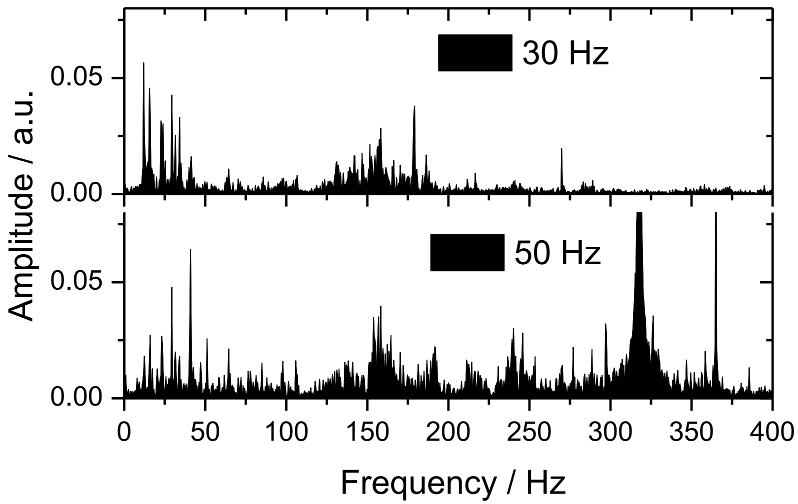
Effect of tubes on vibrations



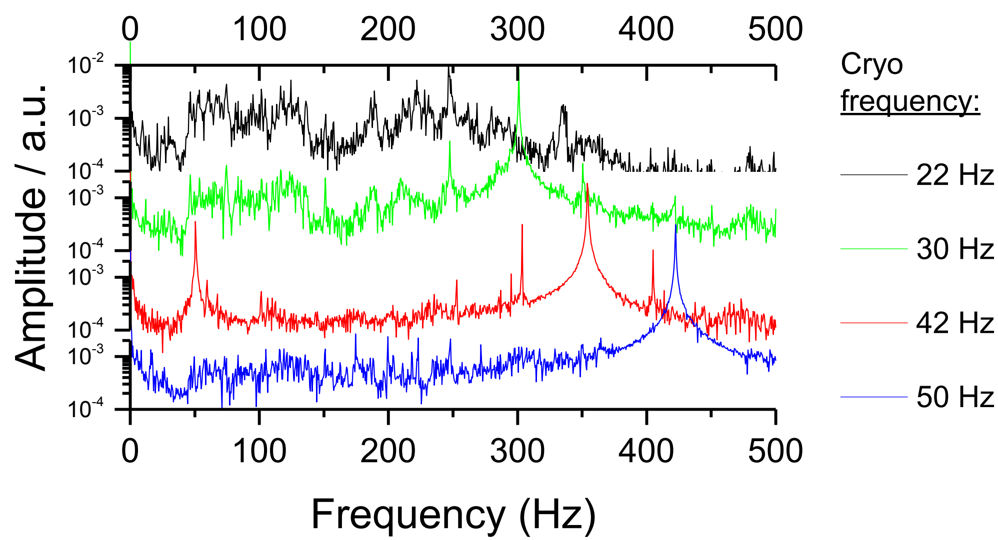


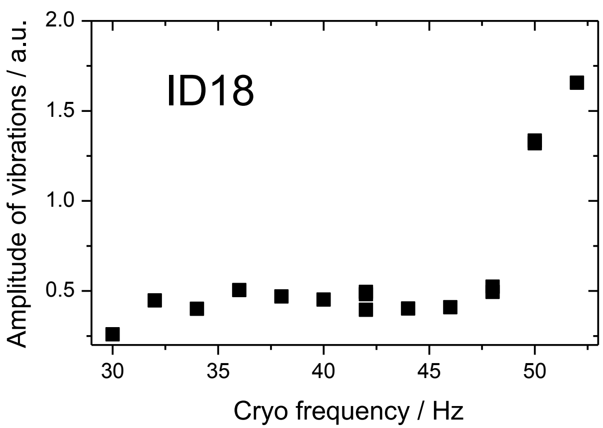
Resonance in corrugated tubes

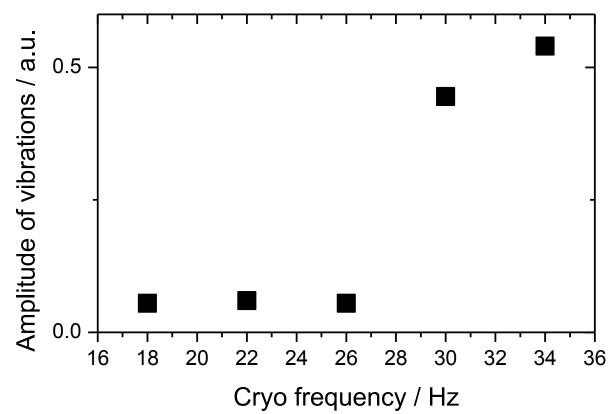
ID18, ESRF



P01, PETRA III







Summary

- DC monochromators produce significant angular vibrations of the crystals in the vertical plane. Characteristic range:

  $\sigma_{ang} = 0.10 \div 0.30$ µrad

  $\sigma_{source} = 8 \div 30$ µm

- The characteristic frequency range of the vibrations is 40-300 Hz.

- The procedures of the vibration measurements is established with beam and offline with differential interferometer

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