# Simulation of XFEL pulse propagation through double crystal Laue monochromator


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# Motivation




Web cams, September 2010

# Motivation

Crystal monochromator for synchrotron radiation:

- For most cases Bragg geometry
- Si perfect crystals
- Band pass ($\Delta E/E$) defined by beam divergence
- Non- or partially coherent source

Crystal monochromator for European XFEL:

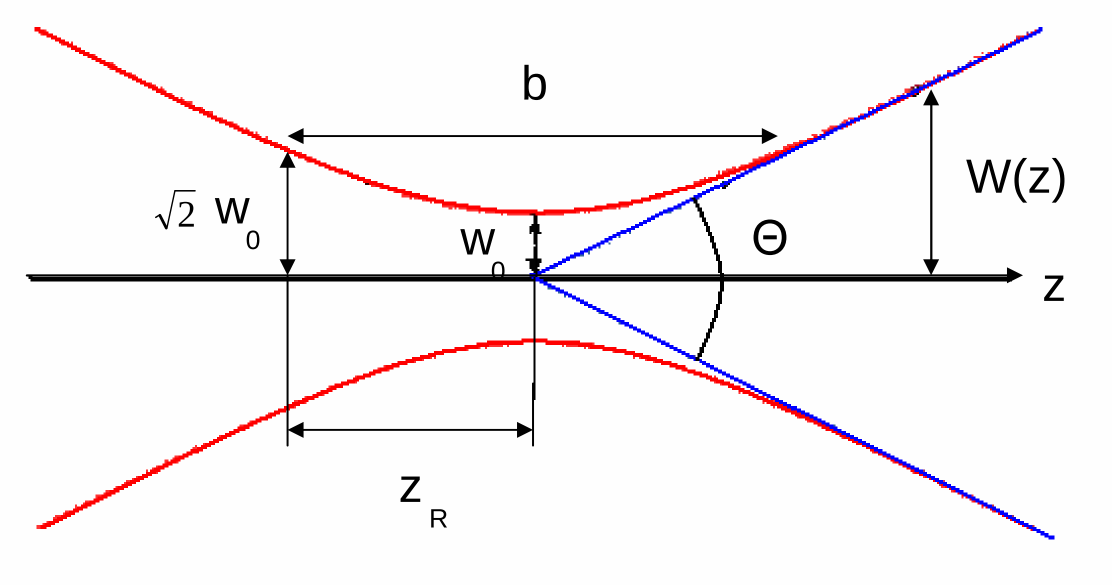
- Laue geometry
- Diamond crystals

} to survive in extremely high peak heat loads

- Angular divergence ~ 1 µrad << $\Delta\theta_{crystal}$
- Almost fully transverse coherent source

} approximated by Gaussian beam

# Gaussian beam



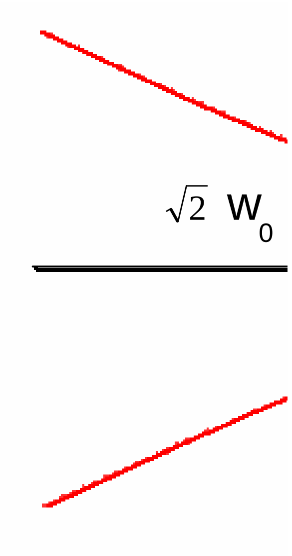

$$\theta \cong \frac{\lambda}{\pi w_0}$$

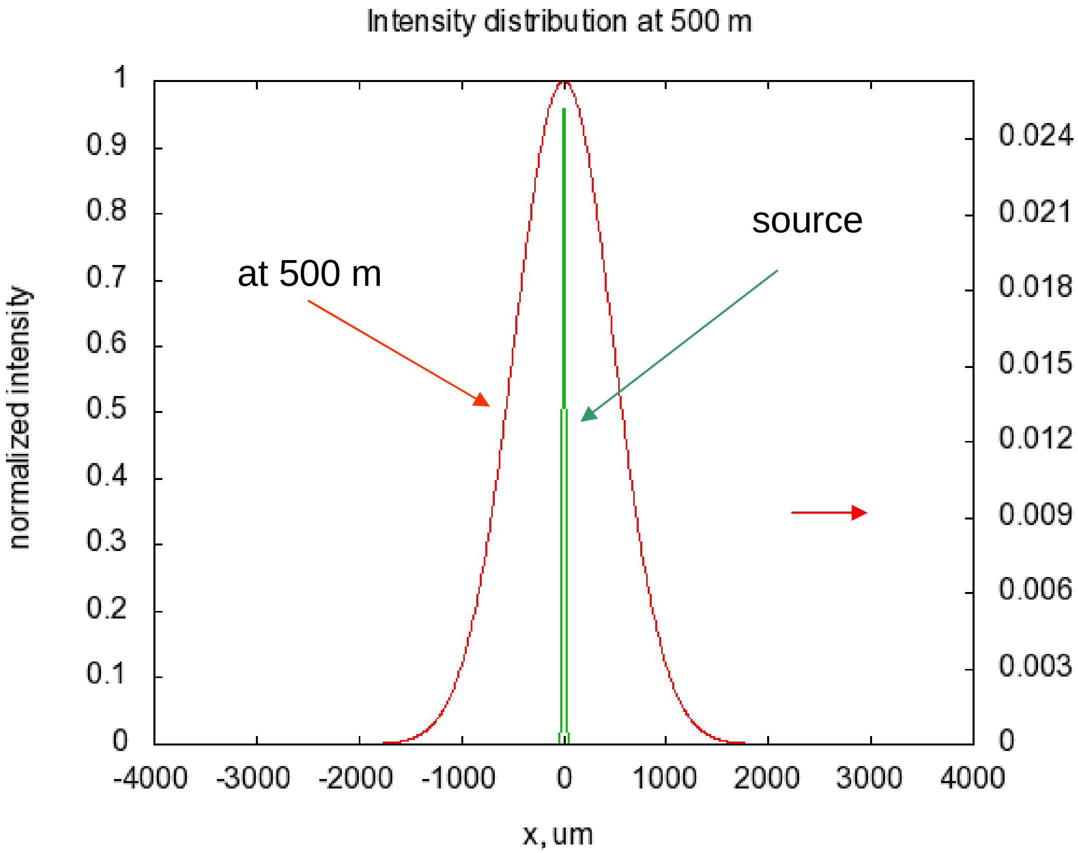
θ - angular divergence

λ - wavelength

$w_0$ - beam waist width

# Gaussian beam



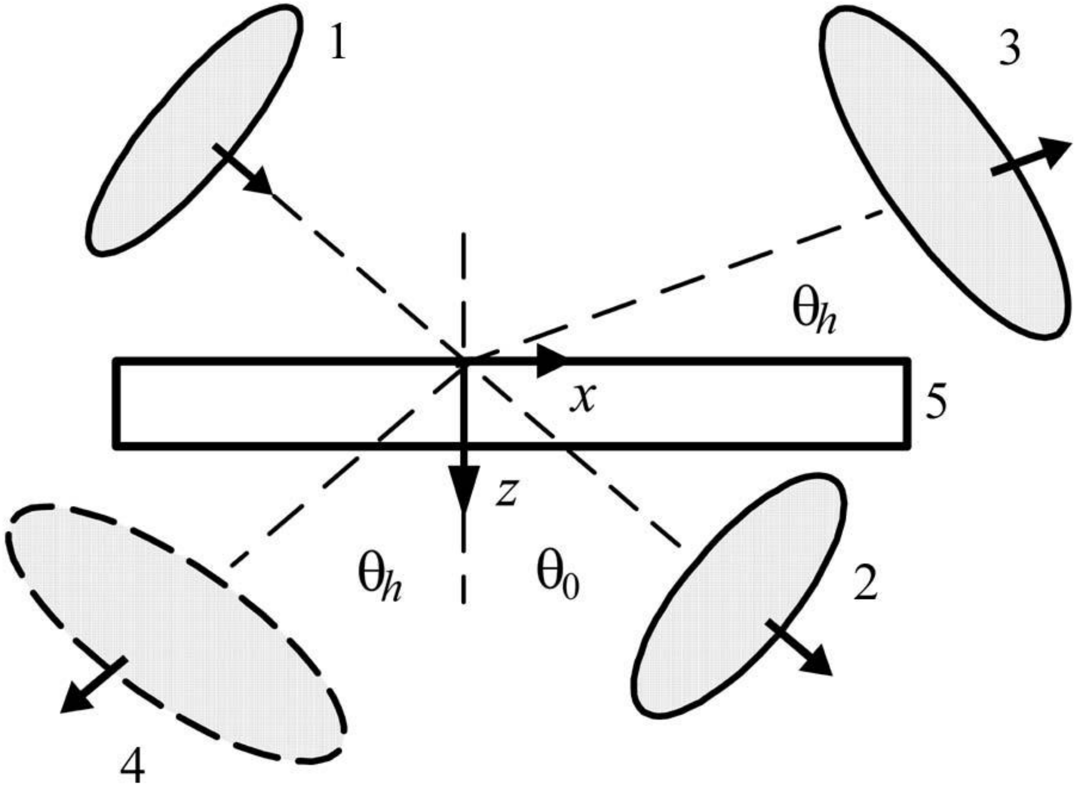

$$\frac{\lambda}{w_0}$$

divergence

ıgth

ize

# Dynamical diffraction theory




$$R(y) = \left|\frac{\chi_h}{\chi_{\bar{h}}}\right| \frac{\sin^2(A\sqrt{1+y^2})}{1+y^2},$$

$$A = \pi \frac{t}{L_{ext}},$$

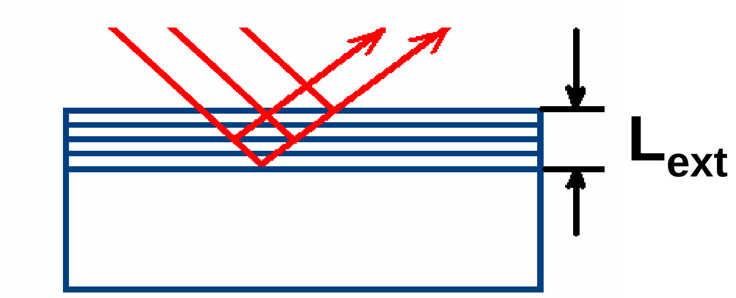
V.A. Bushuev, JSR, 2008, p.495-505

# Dynamical diffraction theory: extinction length

Bragg case

thick crystal

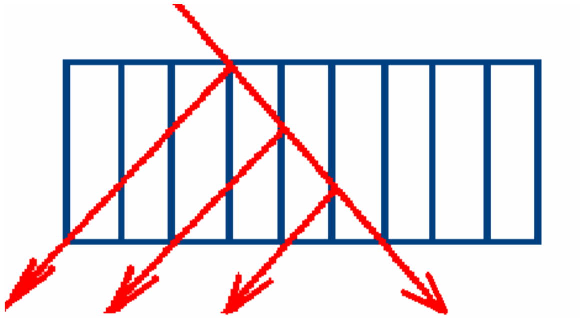
*Extinction*




Laue case

non-absorbing crystal

*Pendellösung*



$$L_{ext} = \lambda \frac{\sqrt{|\gamma_0 \gamma_h|}}{\pi |\mathrm{Re}(\chi_h)|},$$

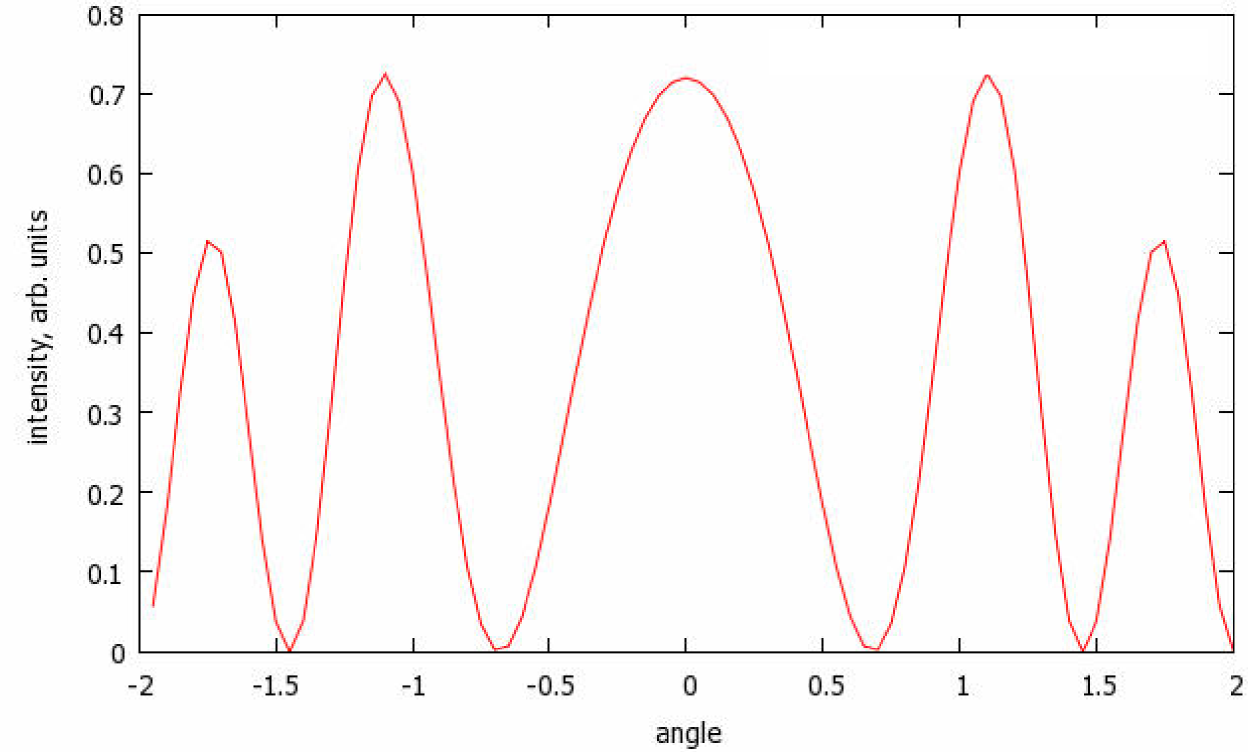
$$\gamma_h = \cos(\Theta_h),$$

$$\gamma_0 = \cos(\Theta_0),$$

$$R(y) = \left|\frac{\chi_h}{\chi_{\bar{h}}}\right| \frac{\sin^2(A\sqrt{1+y^2})}{1+y^2}, \qquad A = \pi \frac{t}{L_{ext}},$$

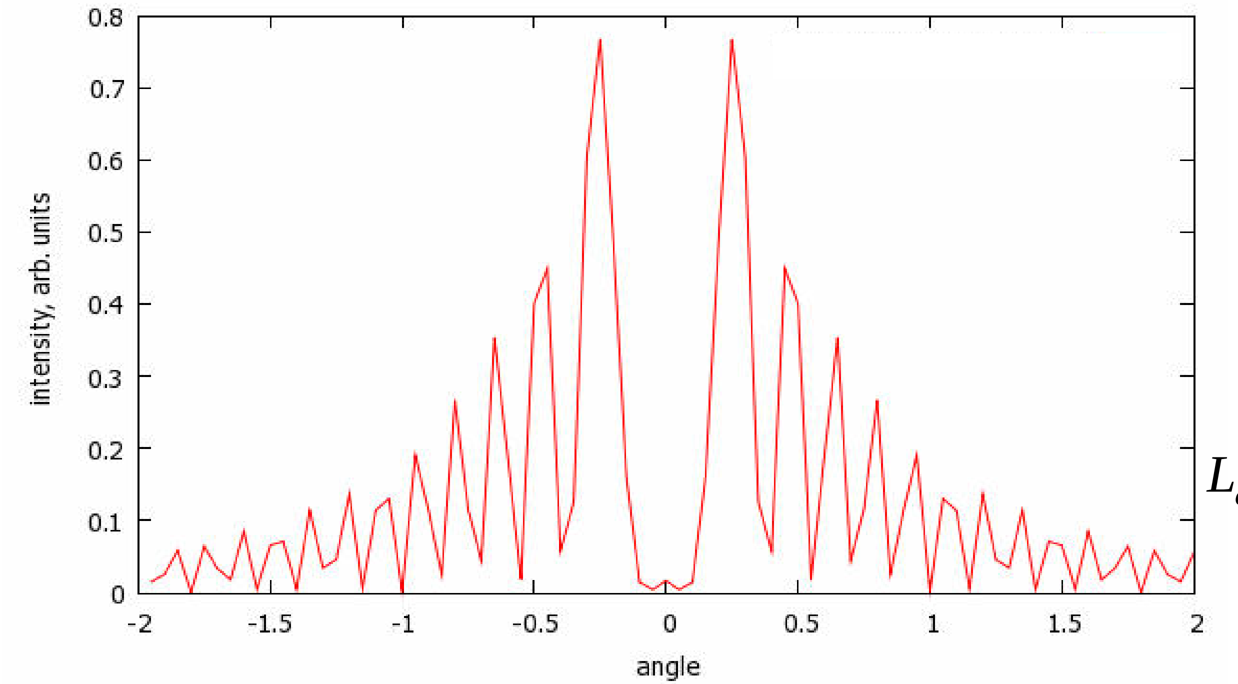
# Pendellösung solution

$$t = \frac{\pi}{2} L_{ext}(2n+1),$$ where n=0,1,2,… is an integer



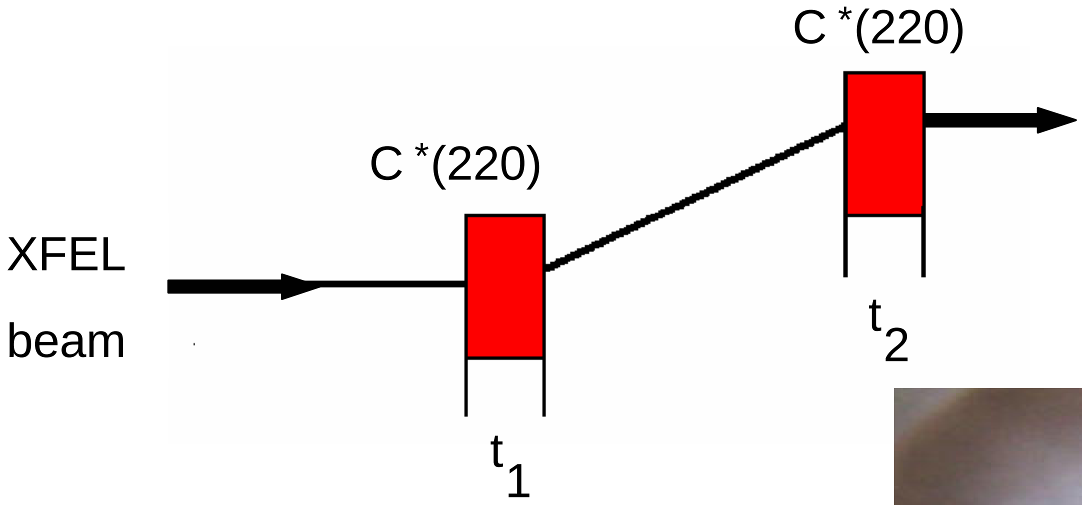
# Pendell*ö*sung solution

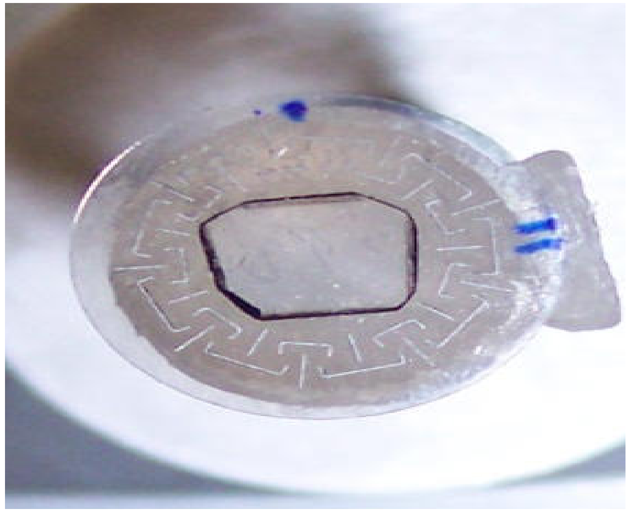
$$t = \frac{\pi}{2} L_{ext}(2n),$$ where n=0,1,2,… is an integer




$$L_{ext} = \lambda \frac{\sqrt{|\gamma_0 \gamma_h|}}{\pi |\mathrm{Re}(\chi_h)|},$$

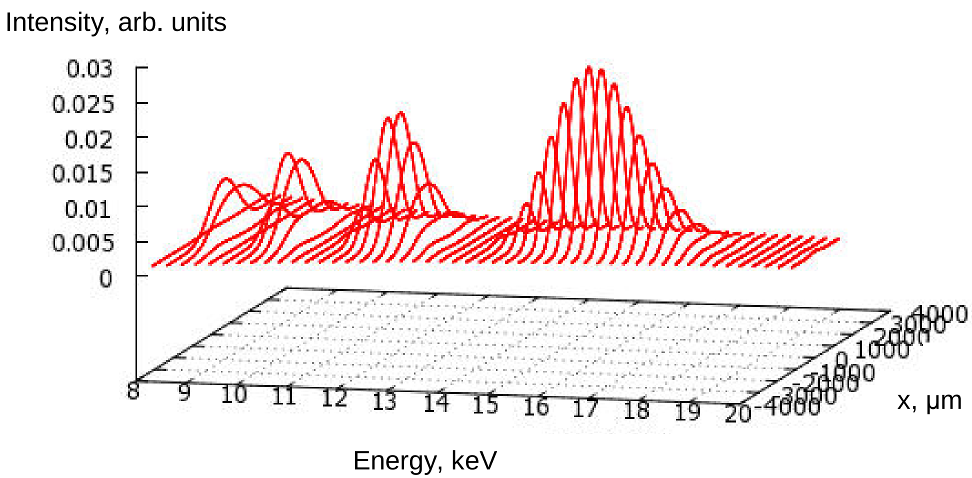
# Double crystal monochromator (DCM)



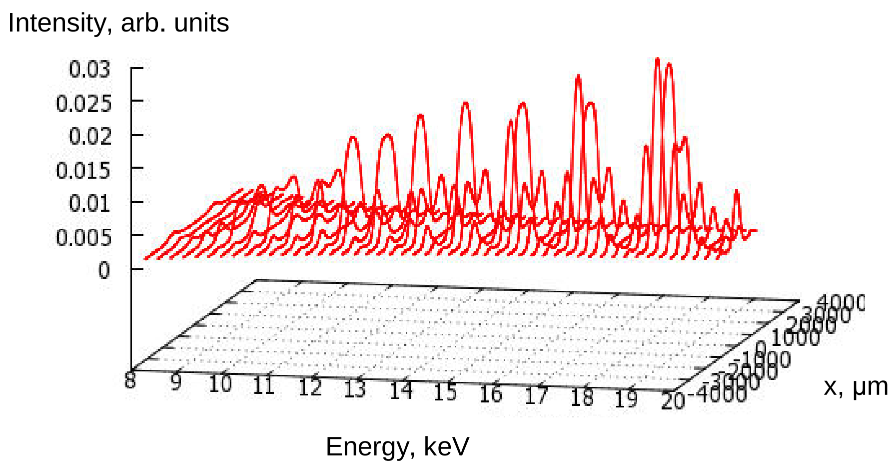



Diamond (100)

# Results

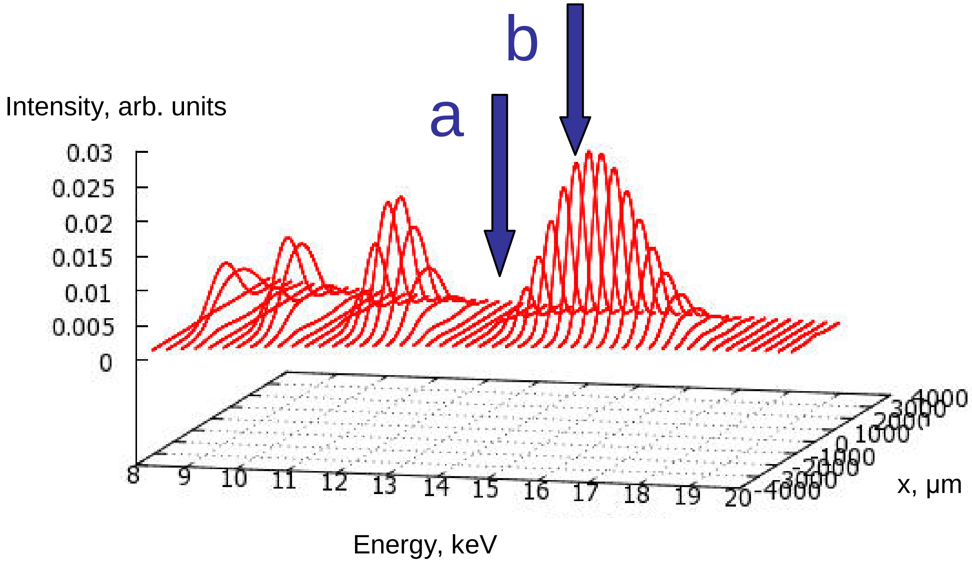



Crystals thicknesses 98 µm

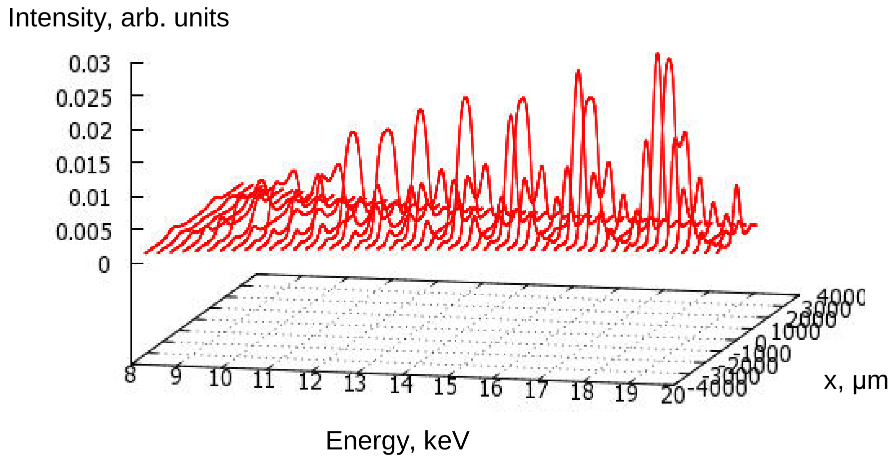



Crystals thicknesses 400 µm

# Results



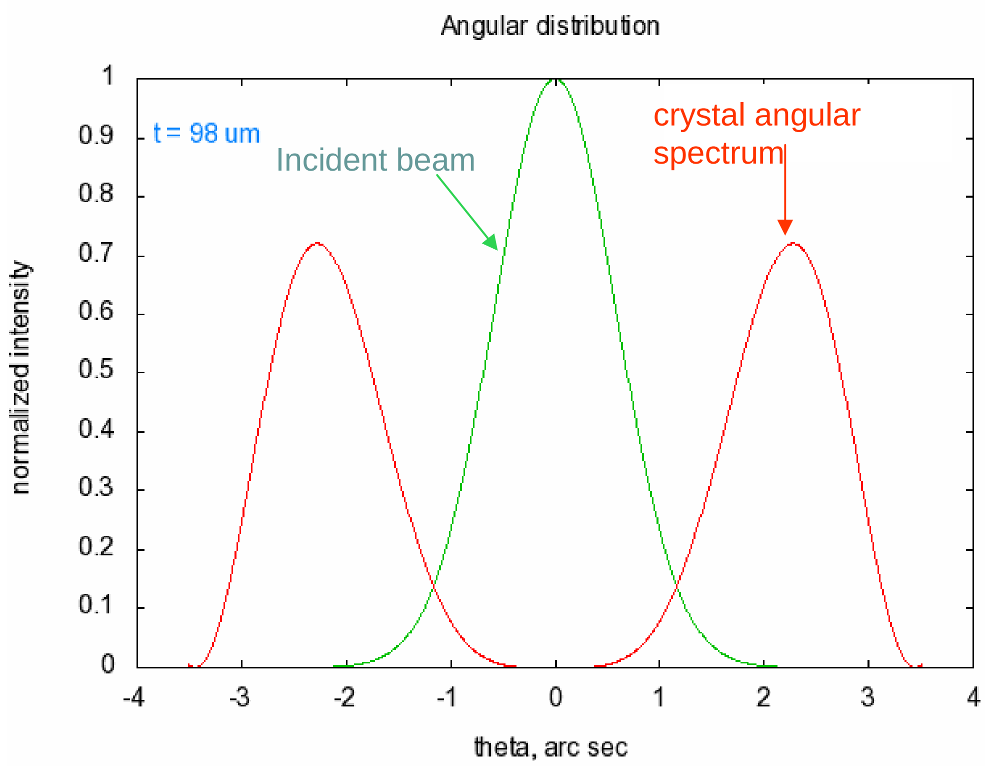

Crystals thicknesses 98 µm



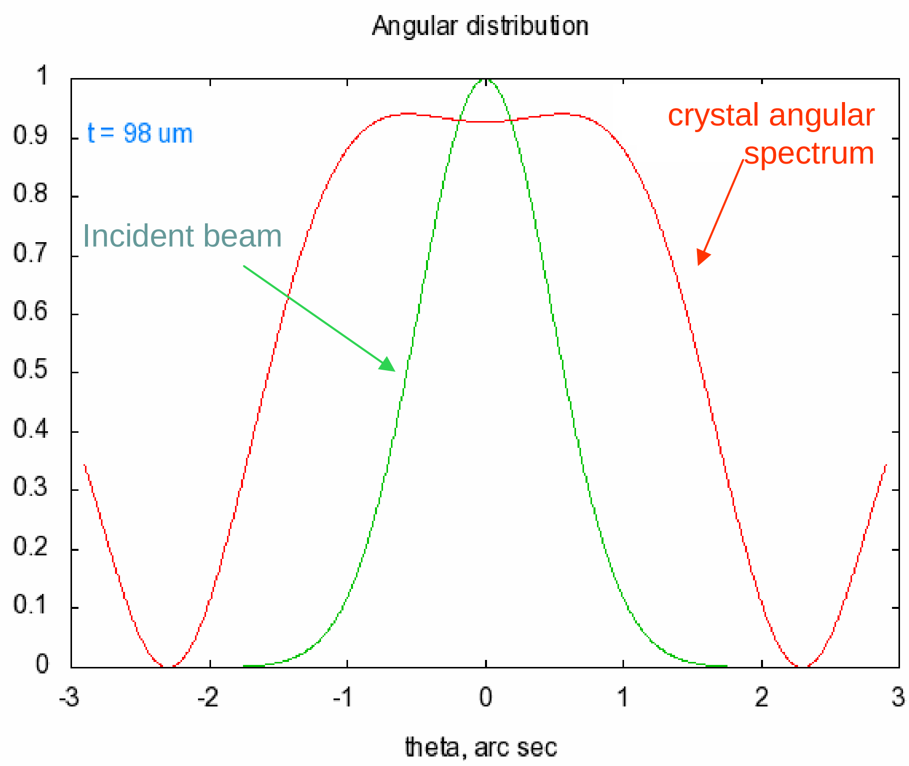

Crystals thicknesses 400 µm

# Reflection curves and beam position

a, E=13 keV

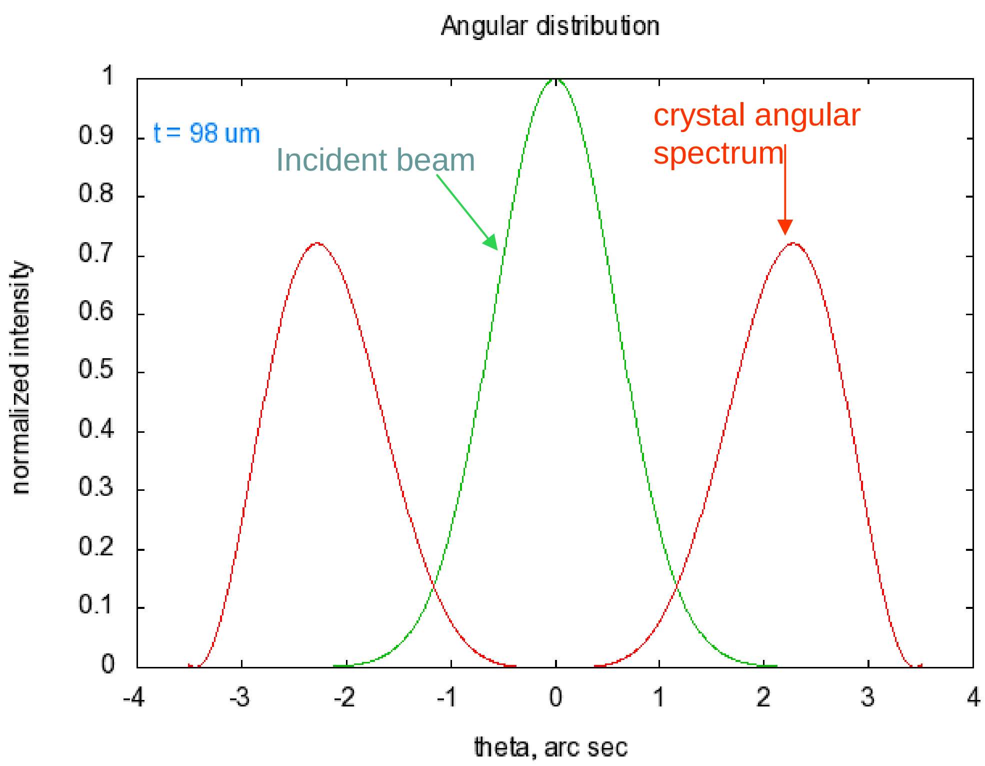



b, E=16 keV

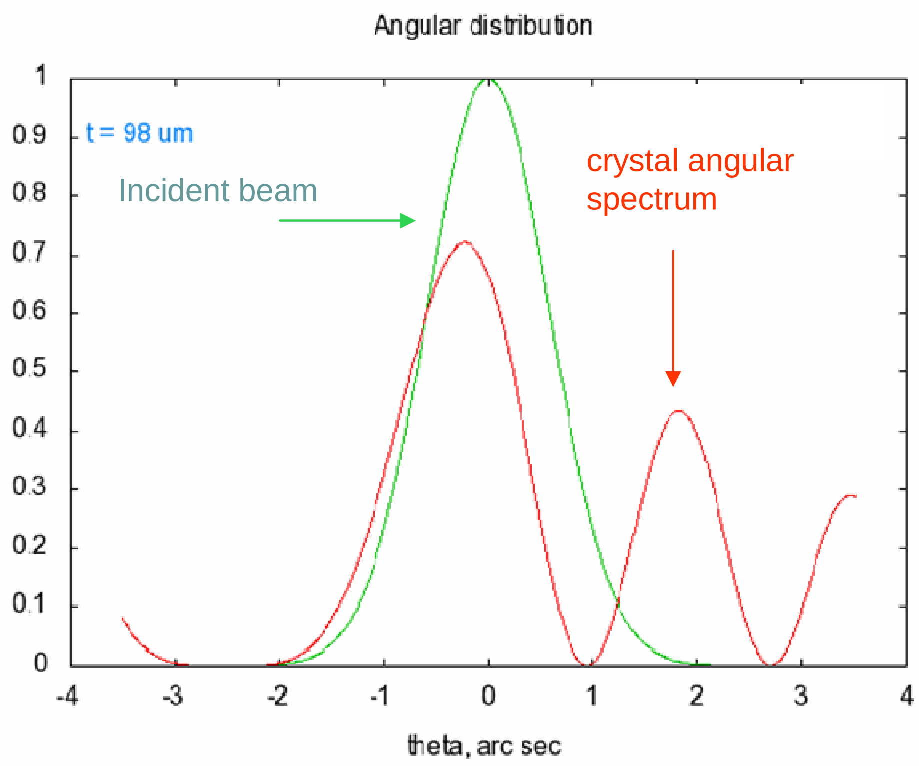


# Reflection curves and beam position

a, E=13 keV

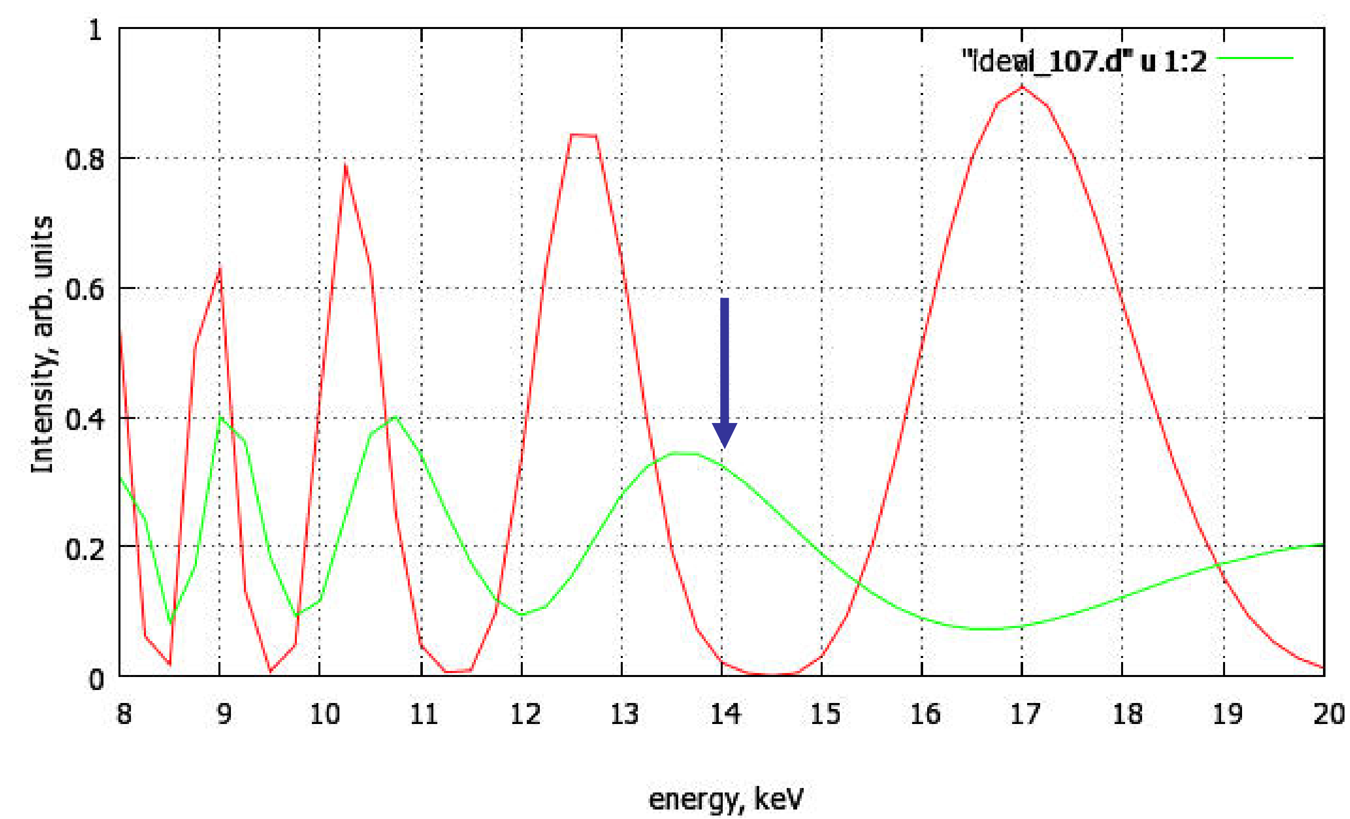



a, **Δθ** = 2.5 arc. sec.



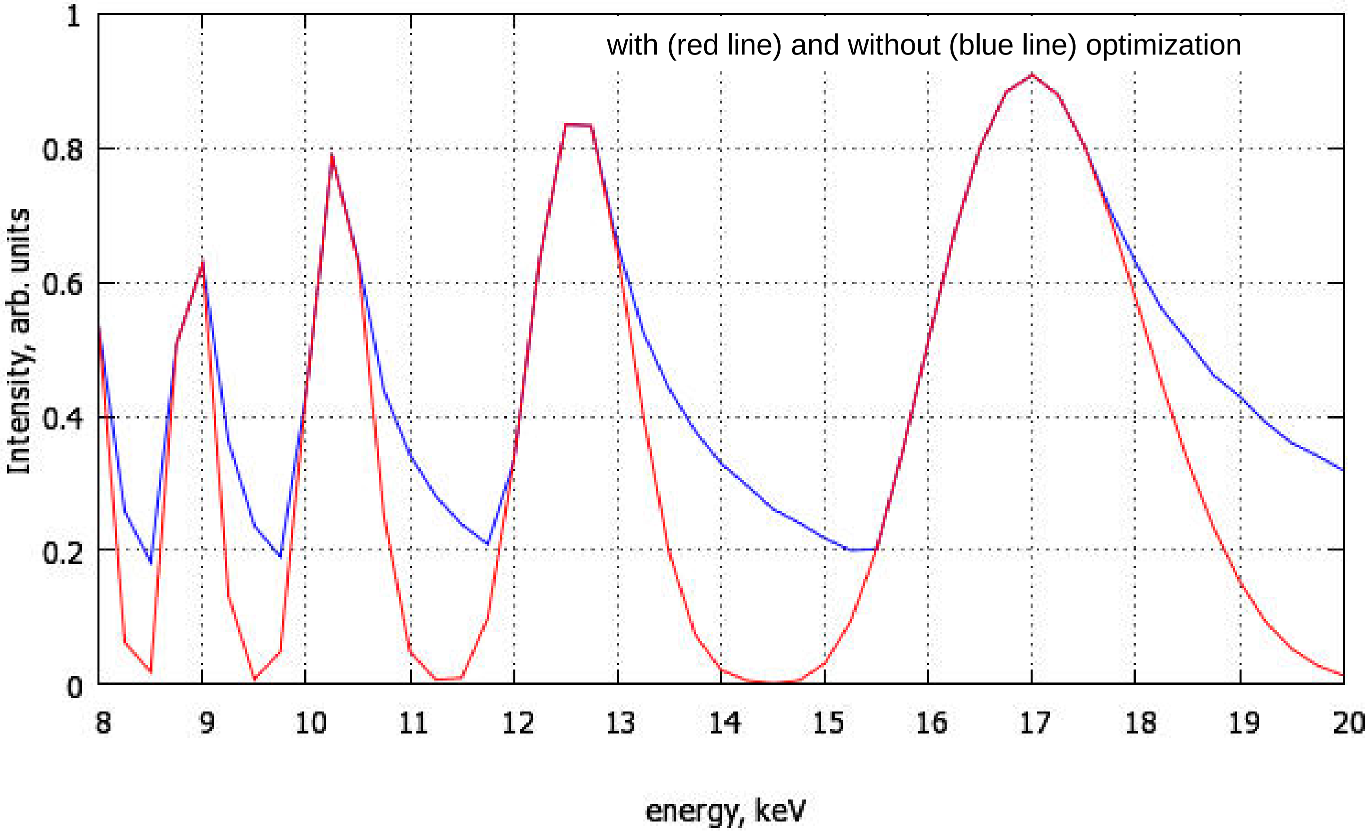
# Integral intensity

crystal thickness 107 µm, angle deviation (green line) 2.5 arc. sec.



# Optimized integral intensity

crystal thickness 107 µm, angle deviation for red line was optimized for each step



# Conclusions and outlook

- Slight asymmetry (~ 1 deg)
- Small deviations from exact Bragg angle (< 1μrad)
- Crystals thickness variation within few microns

} are not critical

➢Small thickness crystals (about 100 μm) seems to be more suitable.

➢Crystal thickness can't be optimized for entire energy range (8-20 keV).

➢Environment for Laue DCM optimization was developed and can be used for further simulations.

<u>Next step:</u>

➢Simulations, taking into account time dependence. For instance, two short pulses separate in time.

# Acknowledgments

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*and all DESY personnel, who made this program available*

## Thank You for attention