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Selene

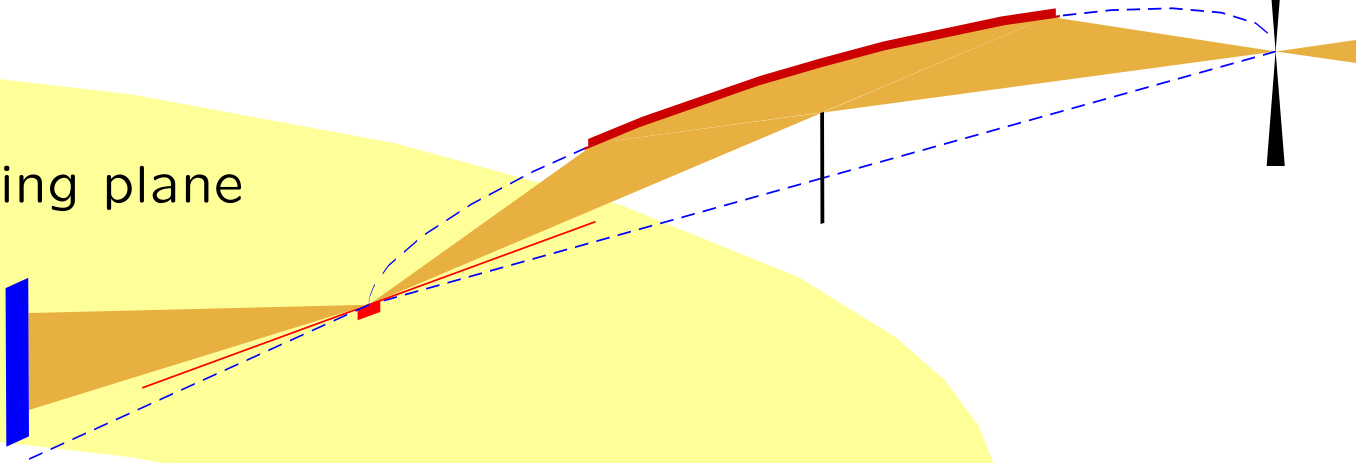
high-intensity specular reflectometry

5th European Conference on Neutron Scattering
17.–22. 07. 2011, Prague, Czech Republic

ECNS 2011

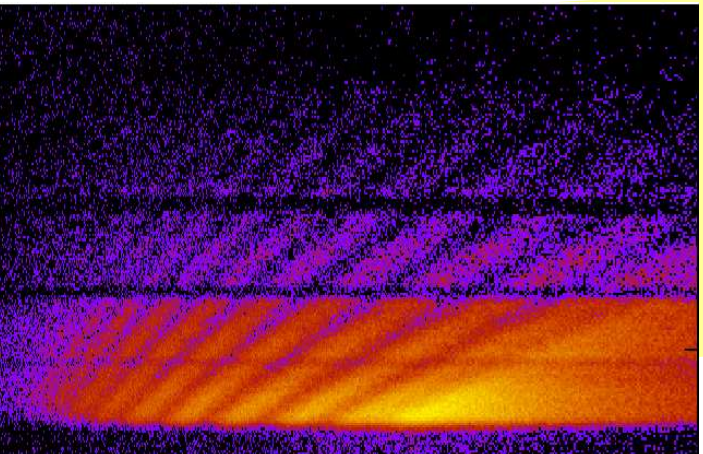
principle:

- focusing in the scattering plane
- aberration
- instrument lay-out



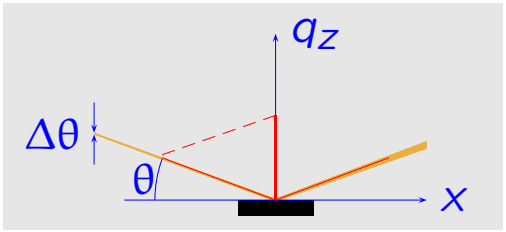
operation modes:

- monochromatic
- λ - θ encoding
- TOF
- conventional



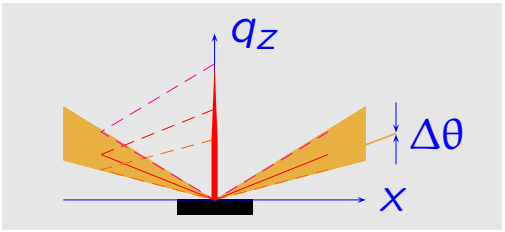
experience so far:

- TOF
- guide quality
- λ - θ encoding



slit-defined beam:

- ω-dispersive, **or**
- λ-dispersive,
- resolution given by $\Delta\lambda$ and $\Delta\omega$

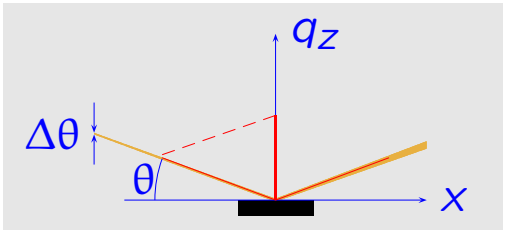


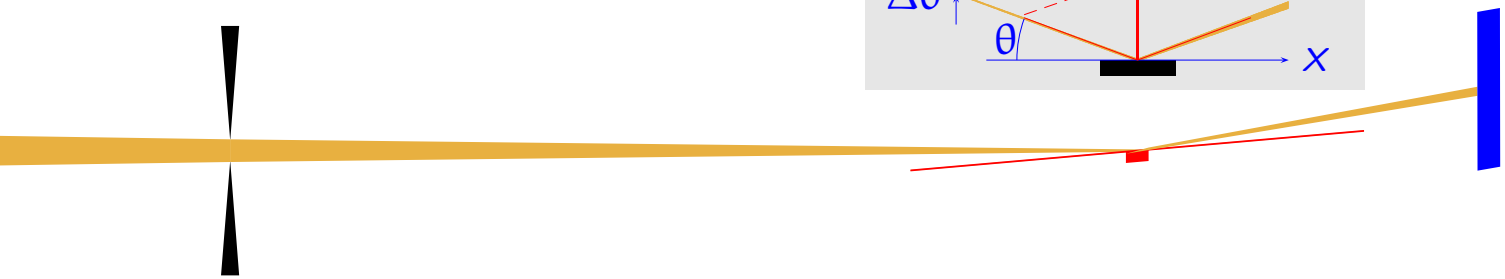
convergent beam:

- ω-dispersive **and**
- λ-dispersive,
- resolution given by $\Delta\lambda$ and detector

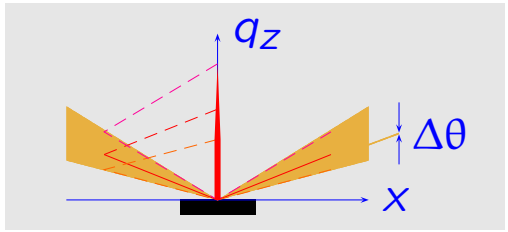
focusing in the scattering plane

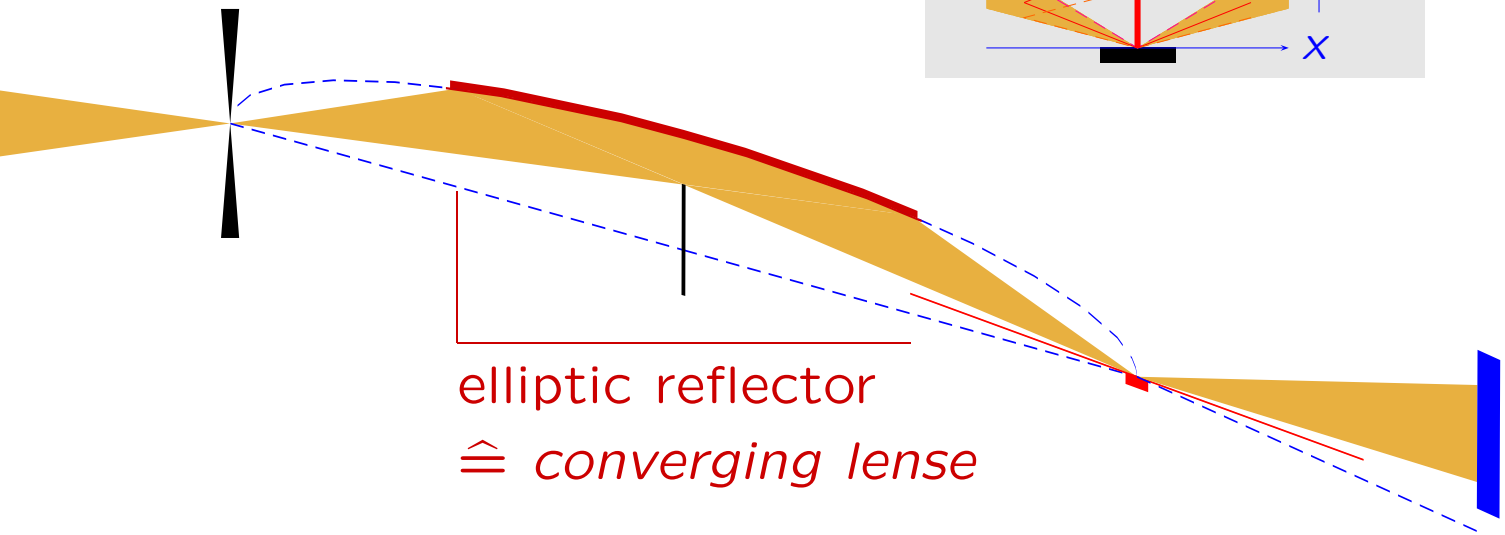
slit-defined beam:





convergent beam:





elliptic reflector

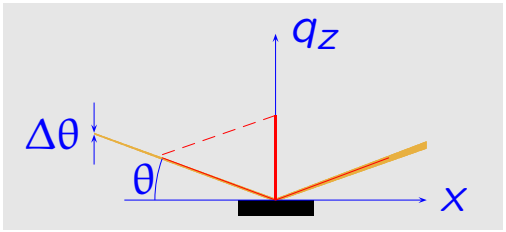
$\widehat{=}$ *converging lense*

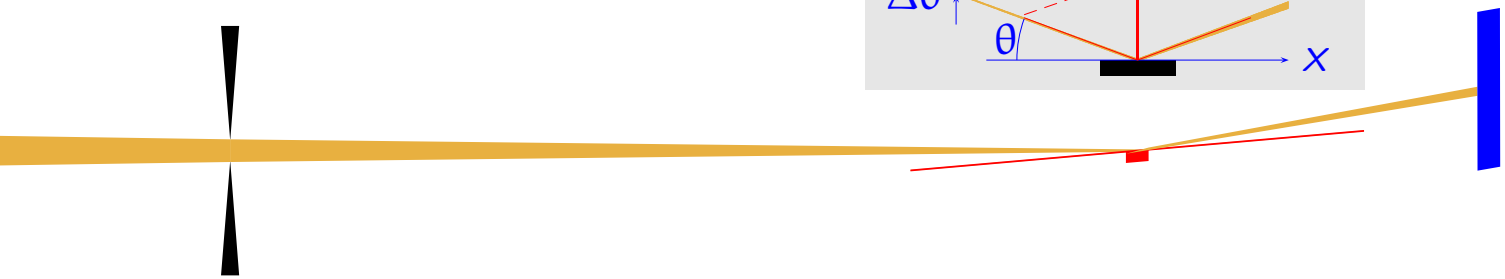
J. Stahn, et al. *N.I.M A* **634**, S12 (2011)

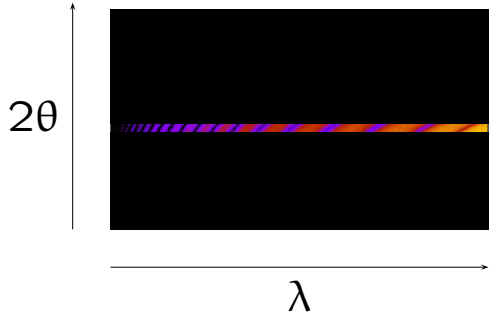
focusing in the scattering plane

TOF operartion

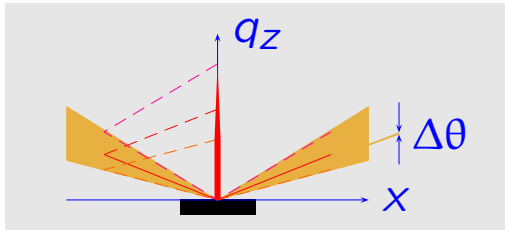
slit-defined beam:

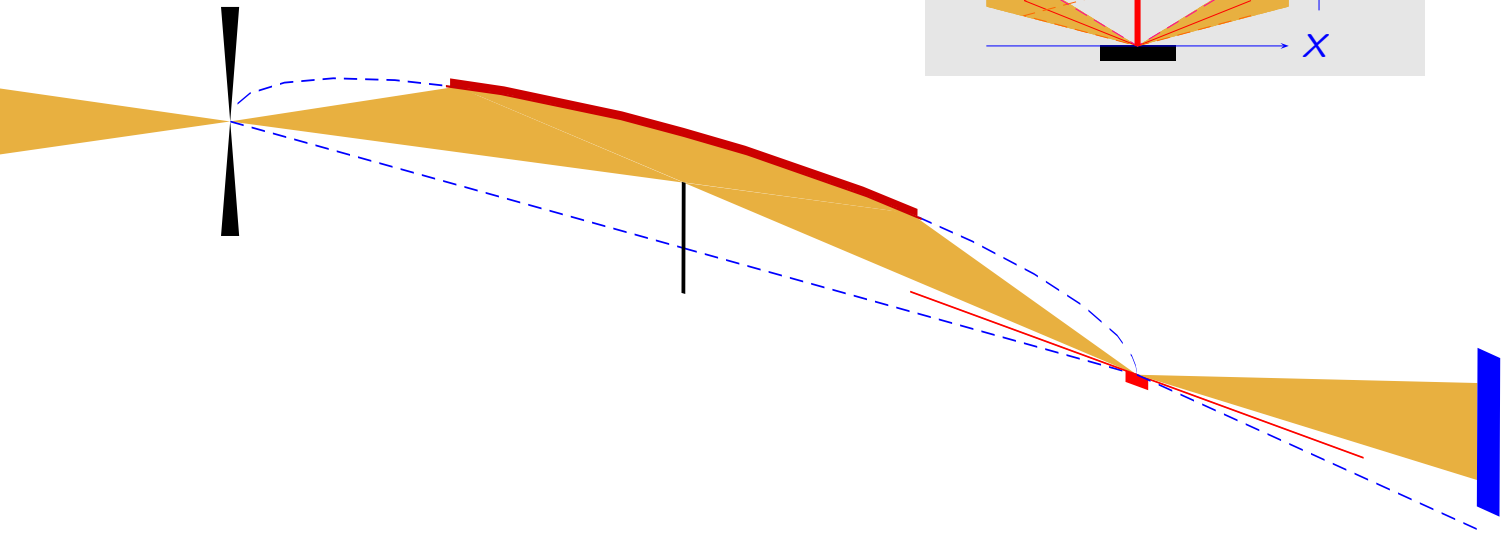


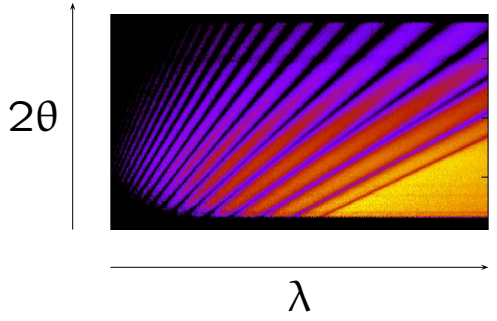




convergent beam:



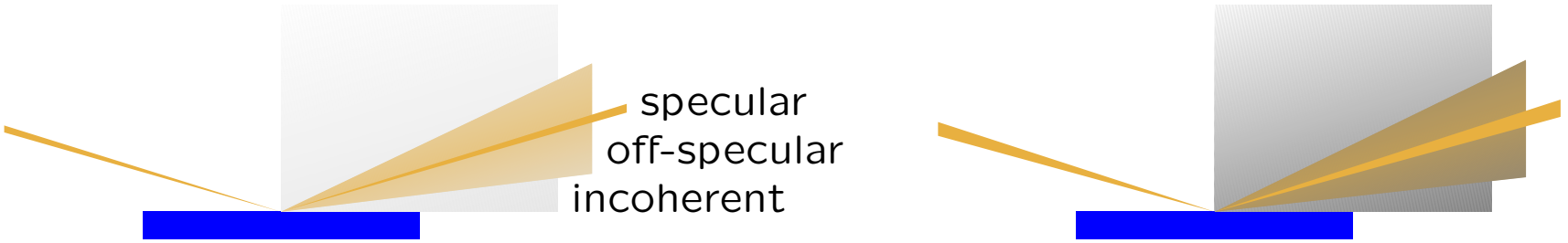




discussion:

– Δq_z varies with θ (finite detector resolution)

– off-specular and incoherent scattering cause background



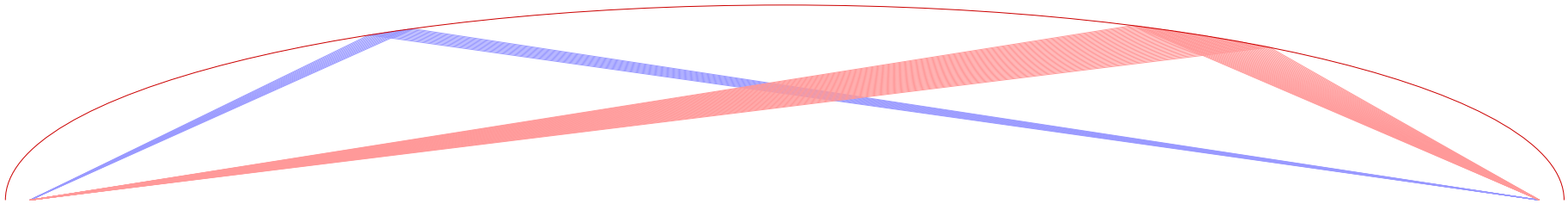
\+ flux gain > 10

\+ fast screening of parameter space (T, $\mathbf{H}$, $\mathbf{E}$, ...)

still possible for high background (*finger print*)

point source at focal point:

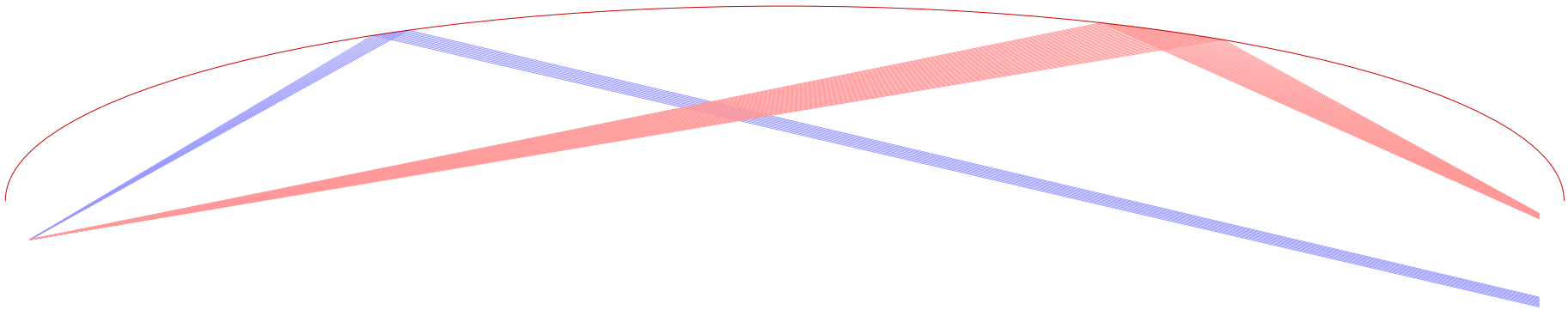
◦ intensity is a function of θ



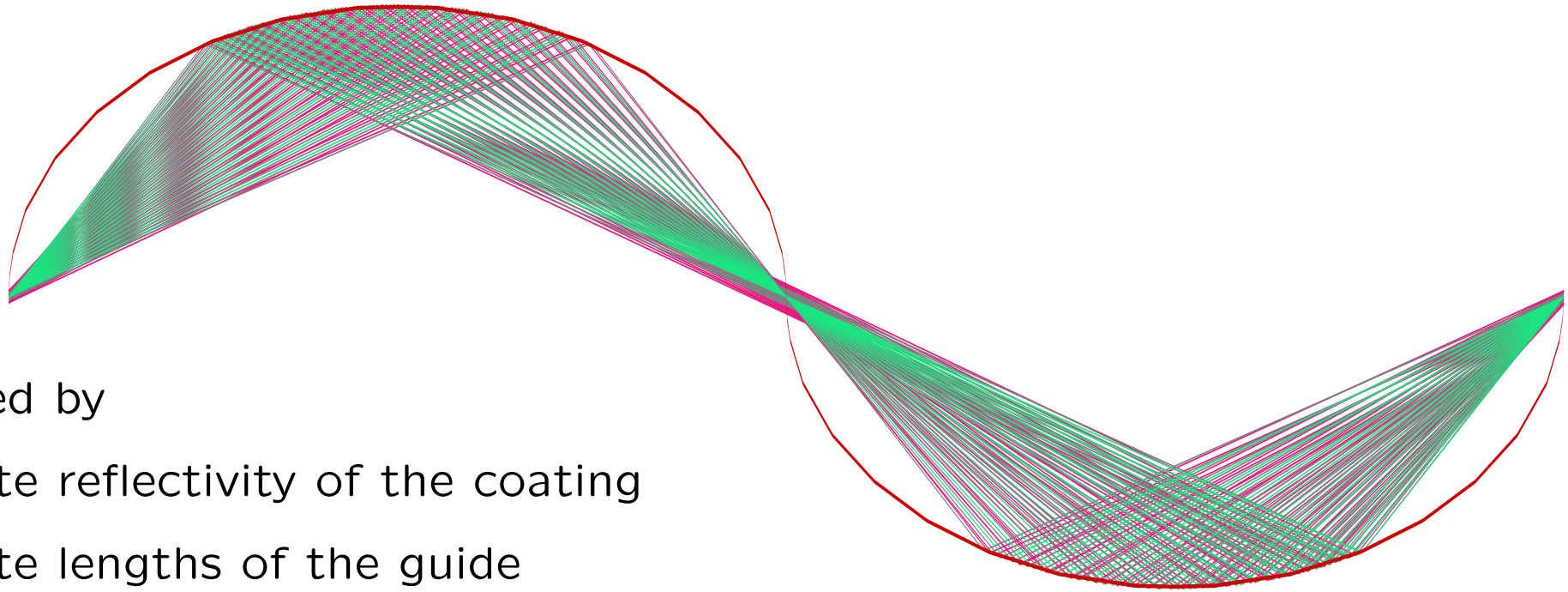
point source off focal point:

◦ coma effect: image is blurred

◦ defocusing / focusing in the early / late part of the ellipse



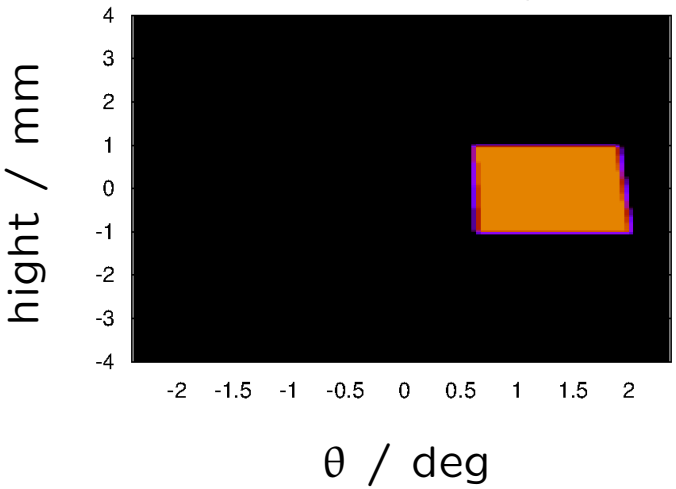
correction for coma aberration:



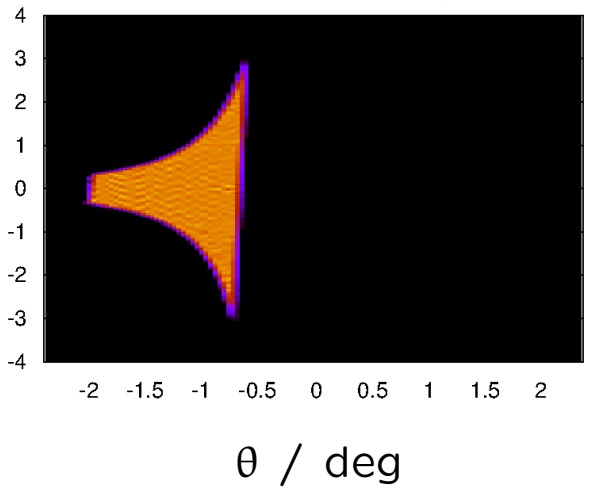
limited by

- finite reflectivity of the coating
- finite lengths of the guide

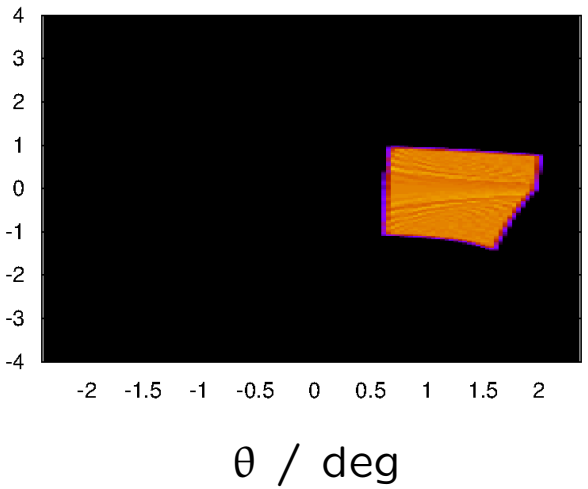
accepted by 1^{st} guide



intermediate image



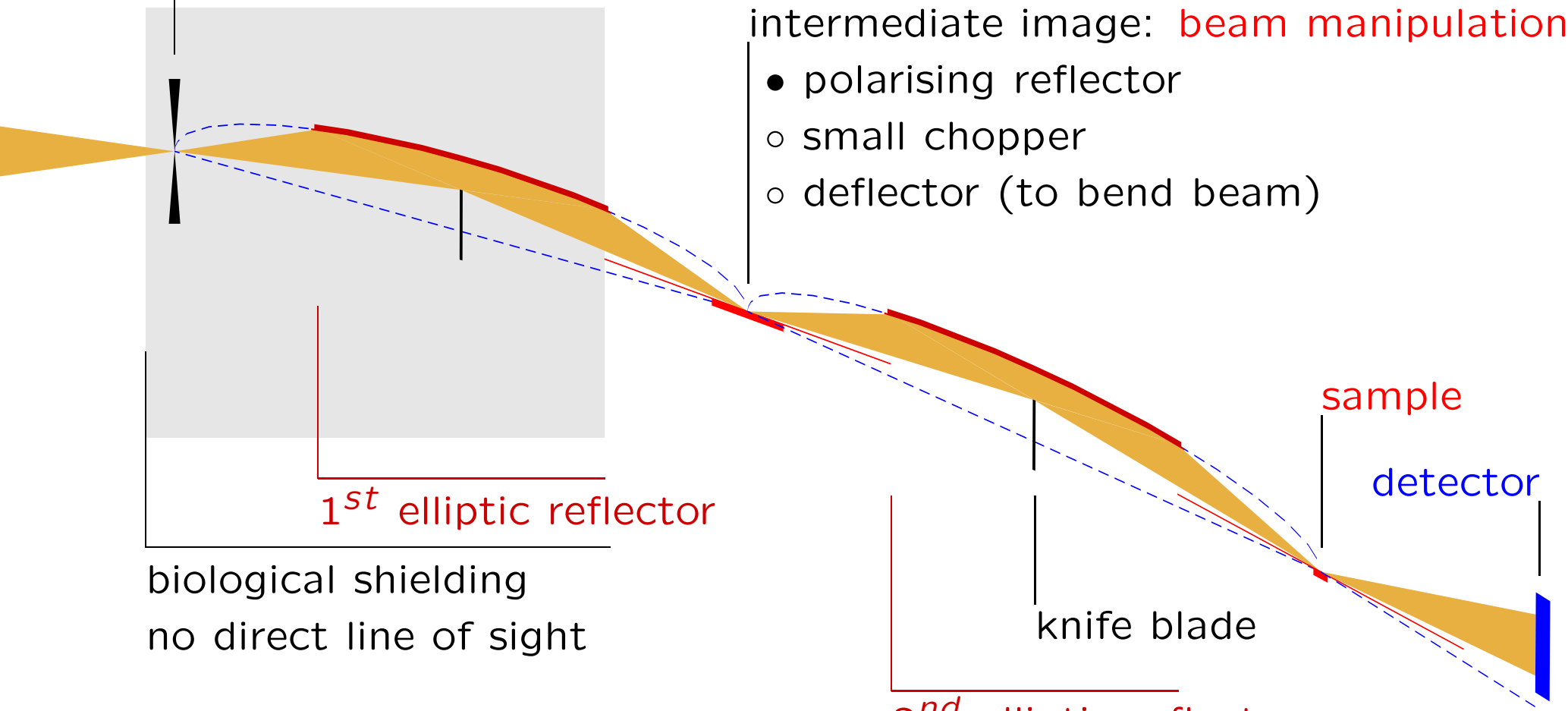
sample position



cut in the scattering plane

stretched by 10 normal to incident beam

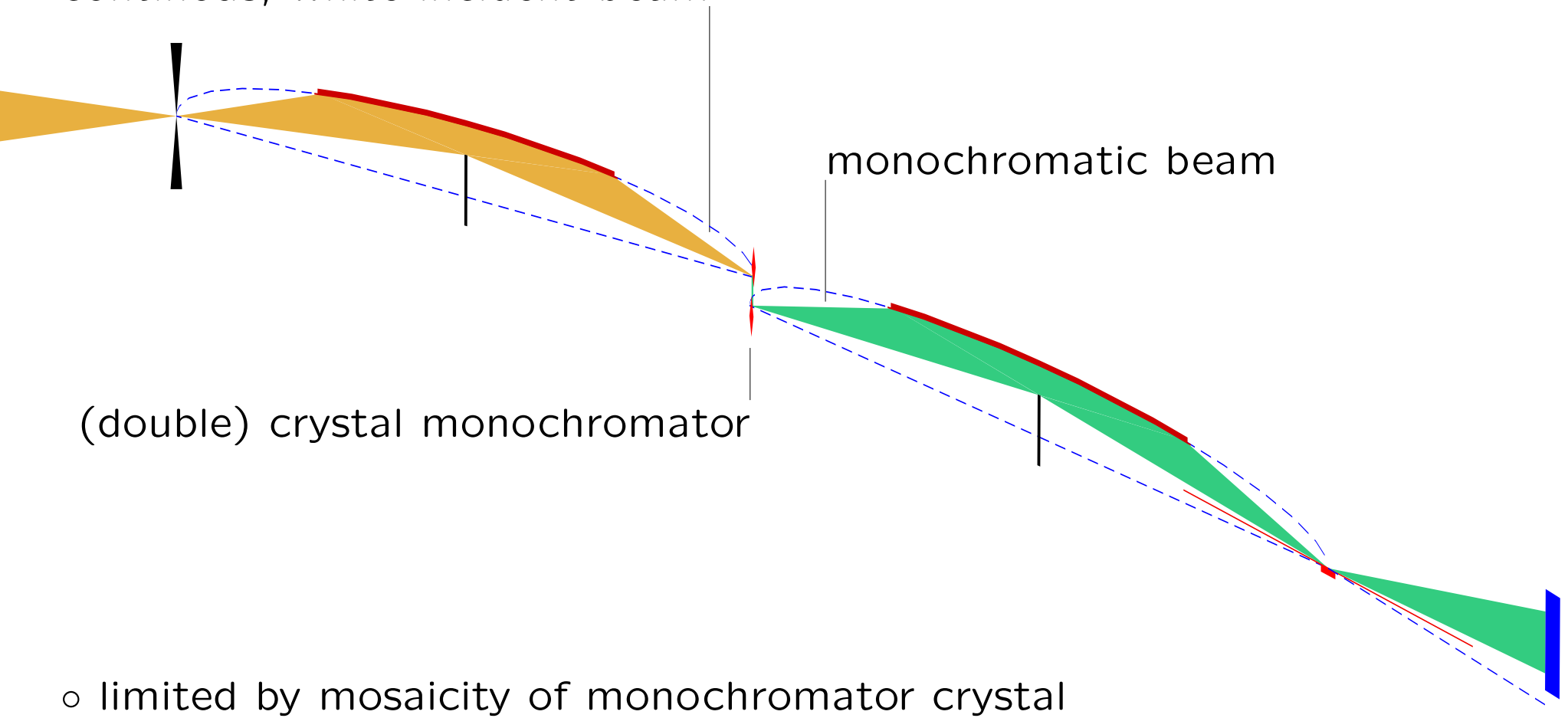
initial slit $\widehat{=}$ projected sample size (e.g. $5 \times 1\,\mathrm{mm}^2$)



- monochromatic

for each 2θ one q_z is probed

continous, white incident beam



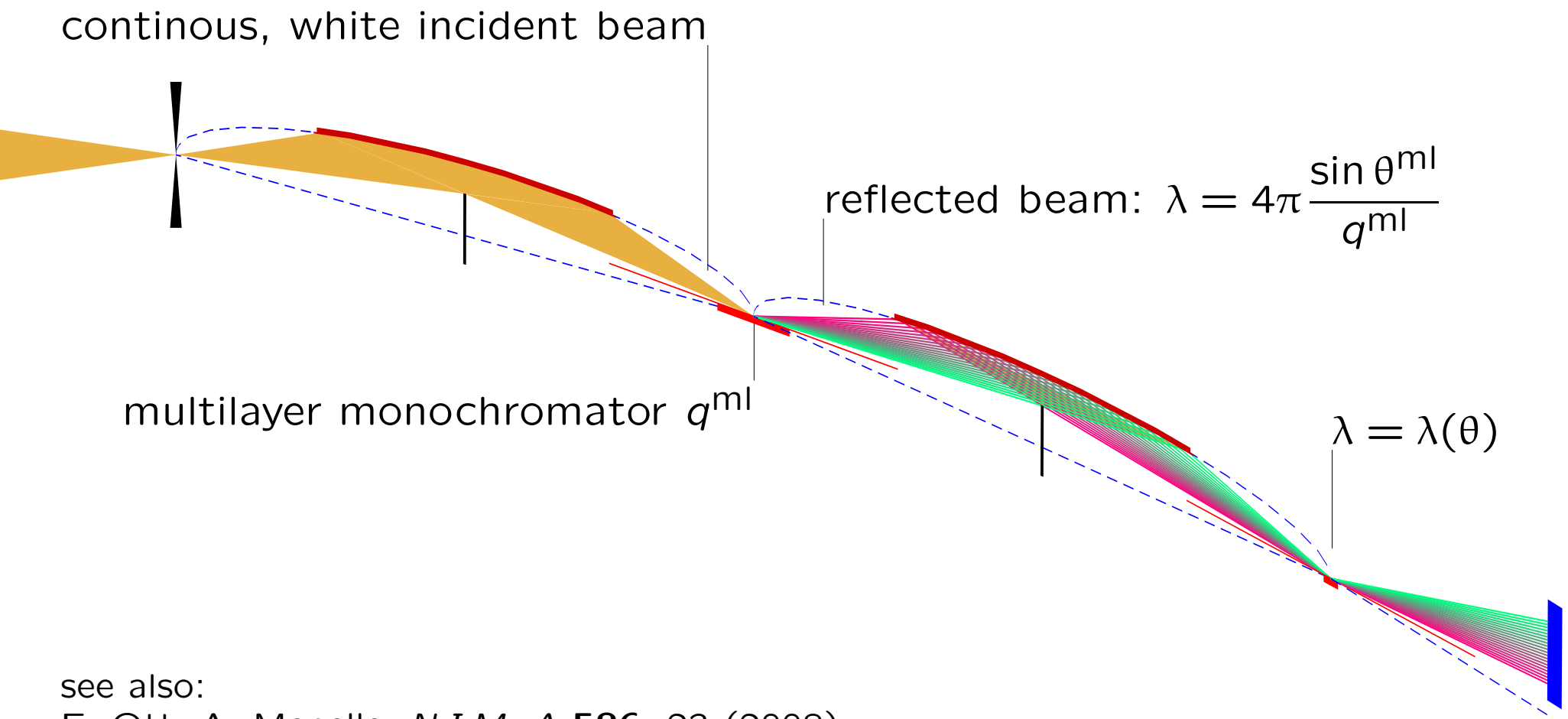
- limited by mosaicity of monochromator crystal

$q_z = q_z(\theta)$

operation modes

- λ - θ encryprion

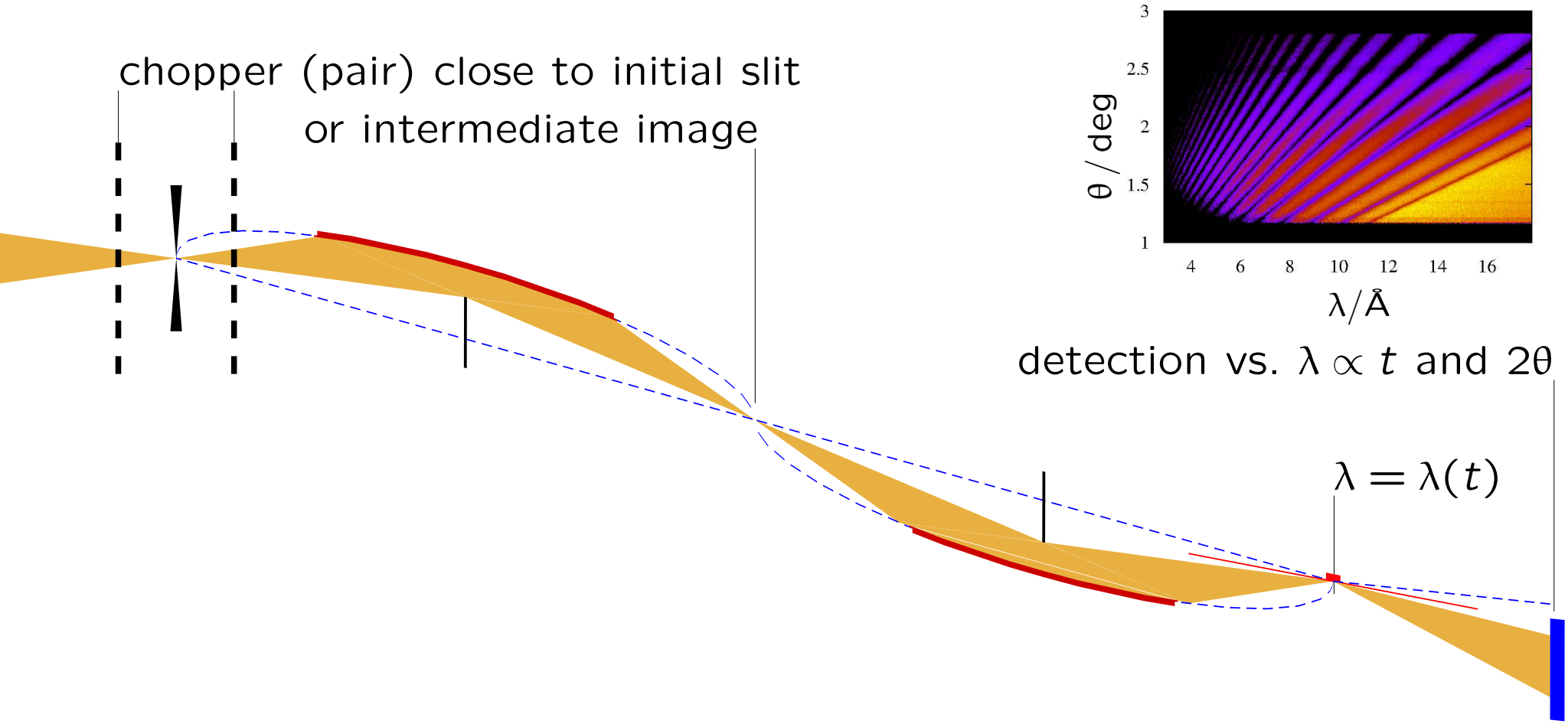
for each 2θ one q_z is probed



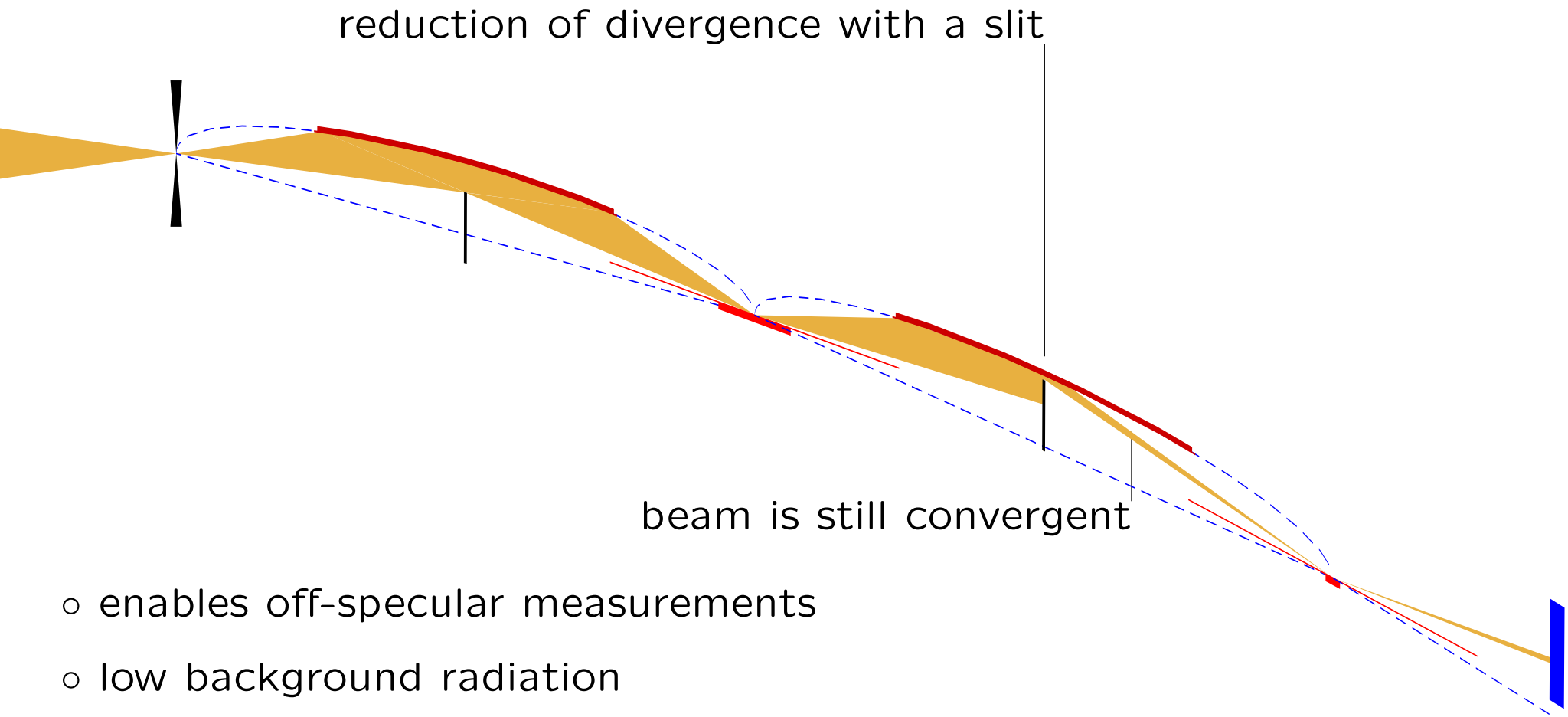
see also:
F. Ott, A. Menelle, *N.I.M. A* **586**, 23 (2008)
F. Ott, A. Menelle, *Euro. Phys. J.* **167**, 93 (2009)

- TOF mode

for each 2θ a $R(q_z)$ curve is measured

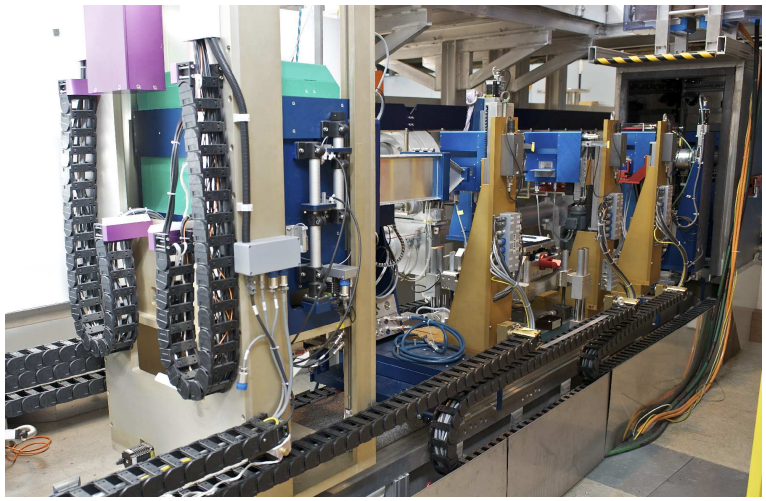


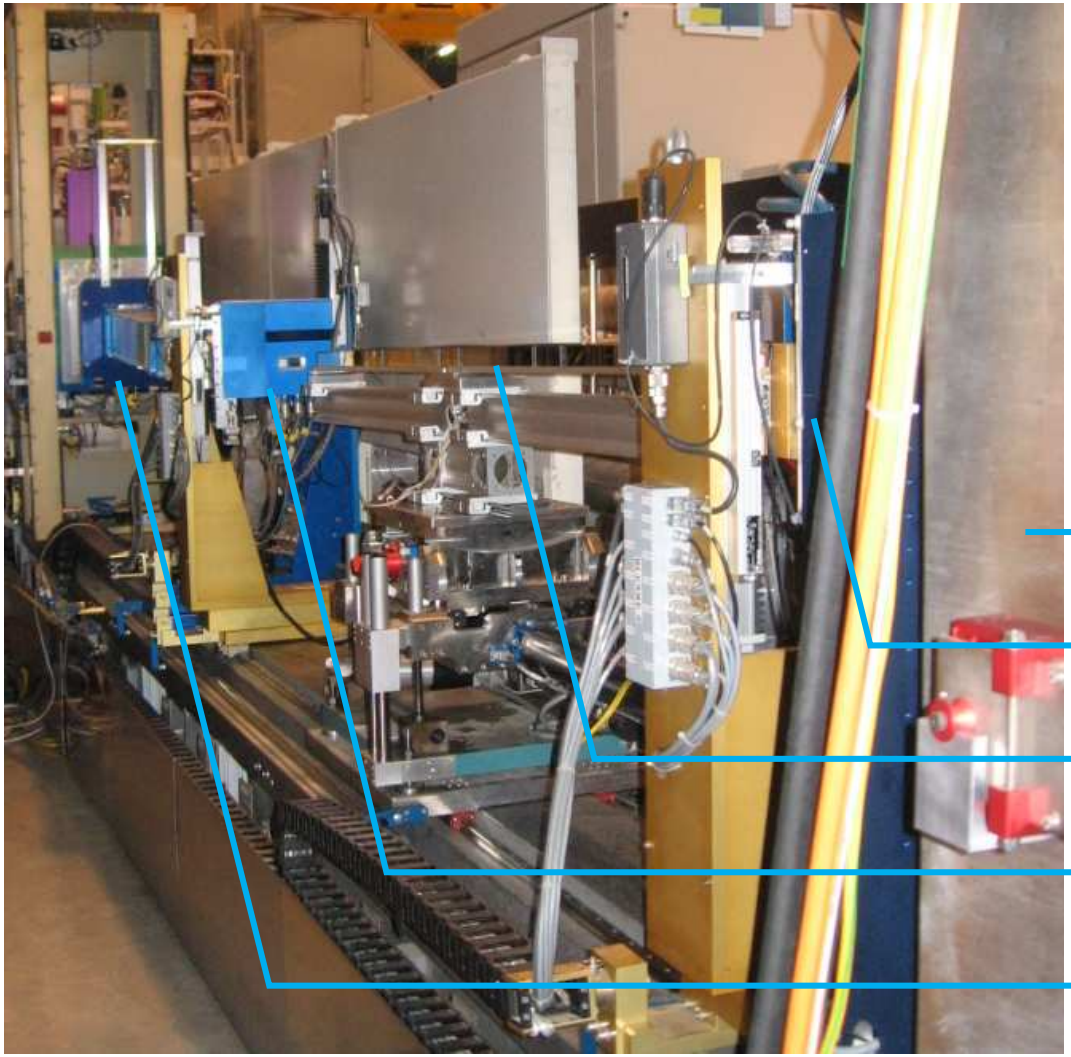
- conventional (*allmost* slit-defined)



- ◦ enables off-specular measurements
- ◦ low background radiation
- ◦ compatibel with all beam manipulations

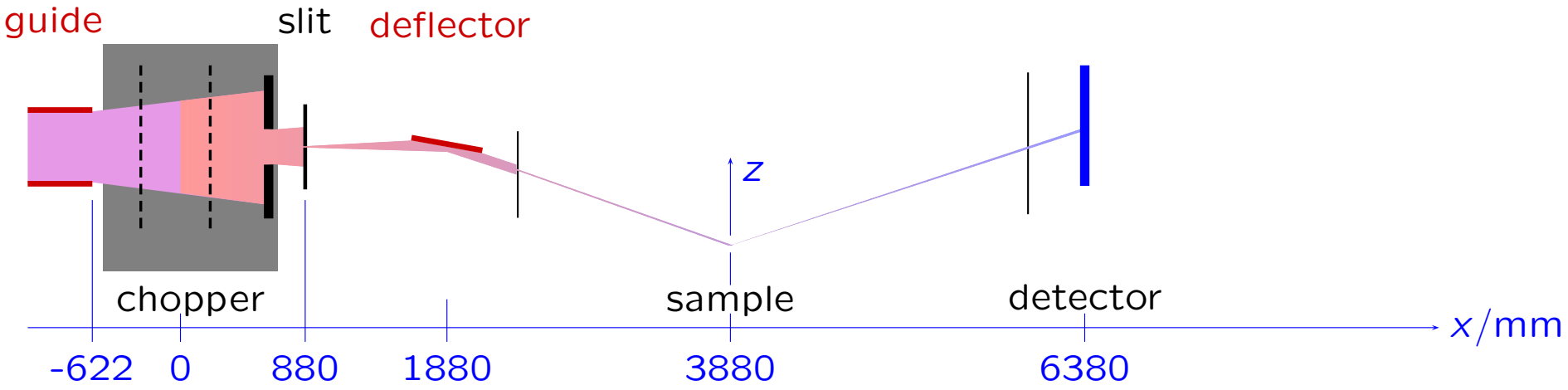
- vertical reflectometer on an optical bench
- set-up with *Selene* reflector:



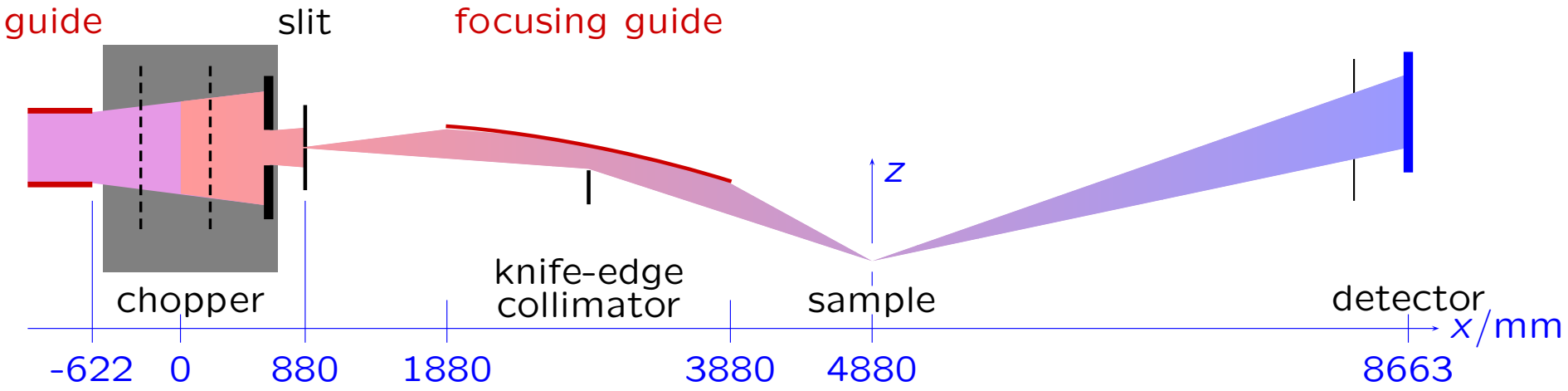


TOF mode:

conventional set-up

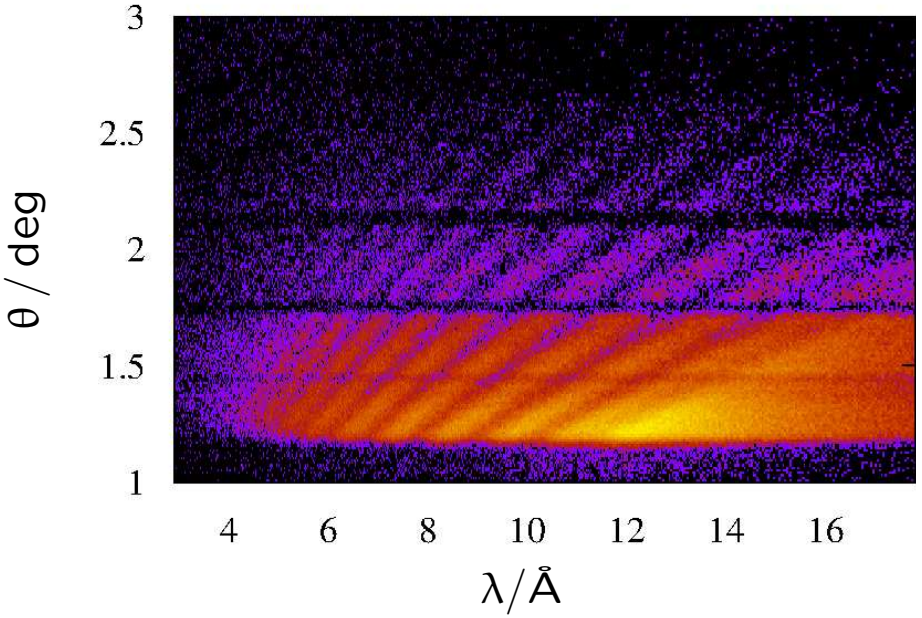


Selne set-up

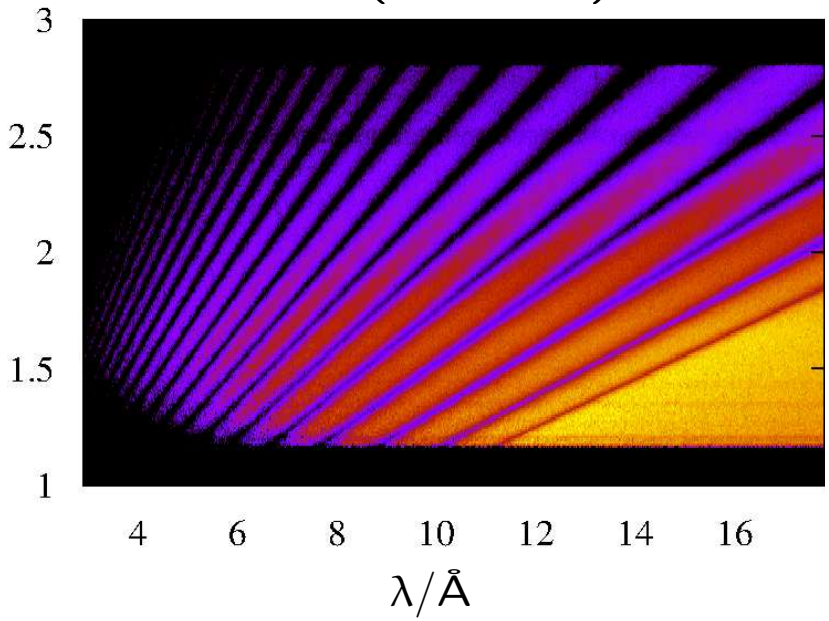


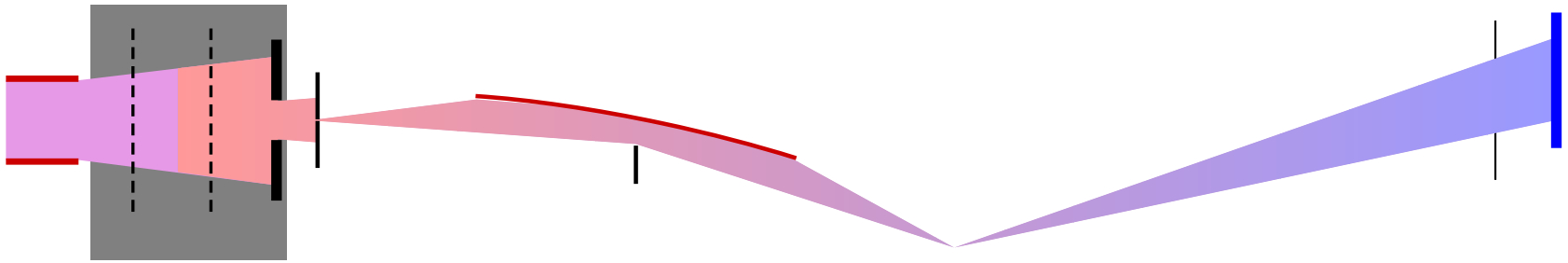
TOF mode sample: 1000 Å Ni on glass

measured



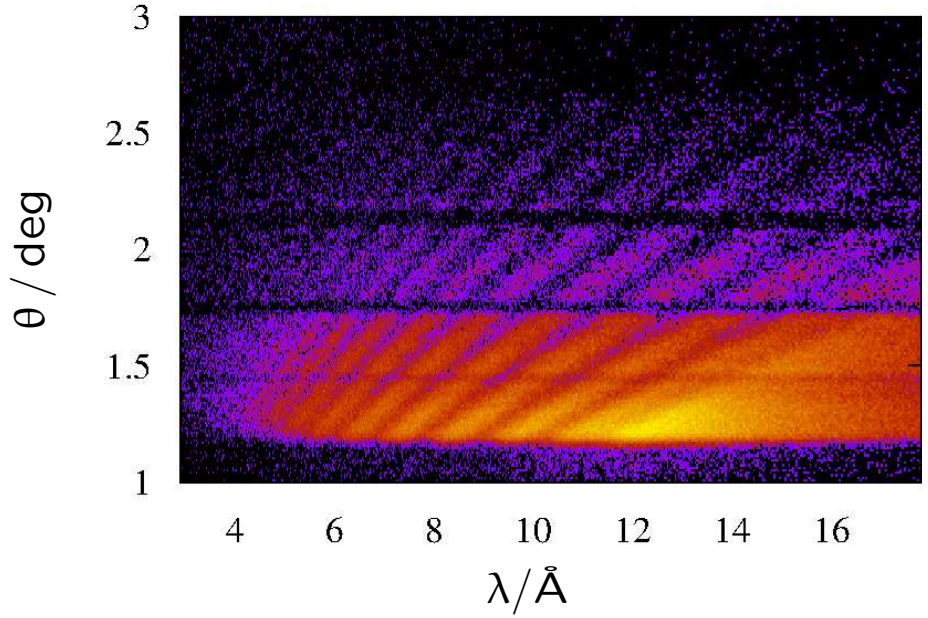
simulated (McStas)



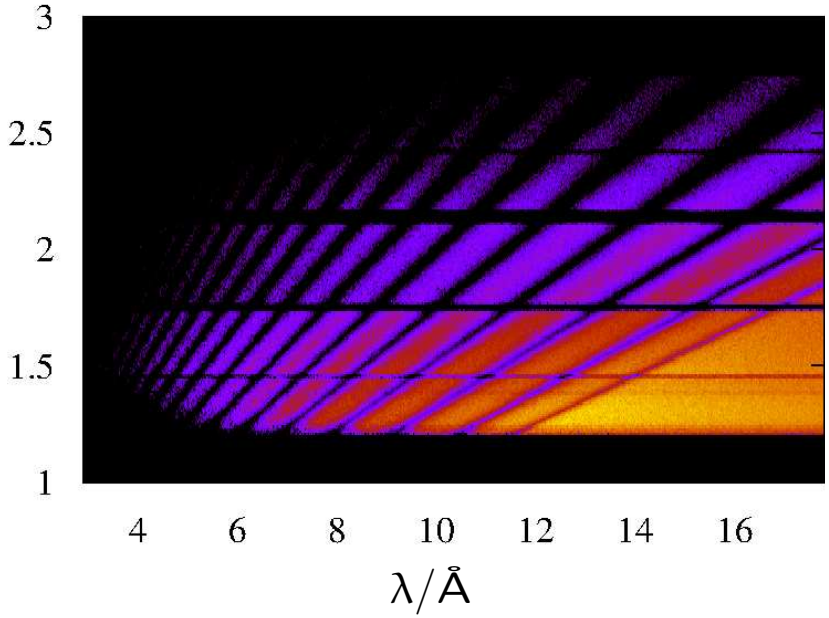


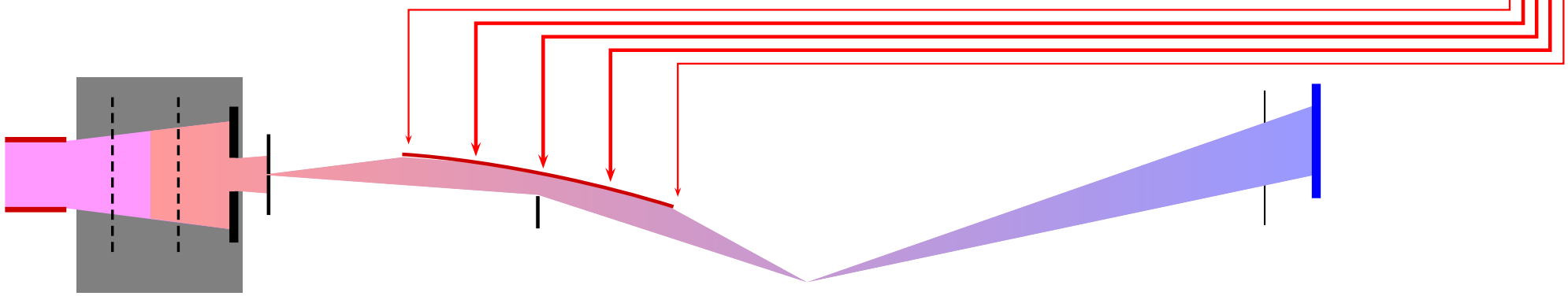
TOF mode sample: 1000 Å Ni on glass

measured



simulated with geometrical errors

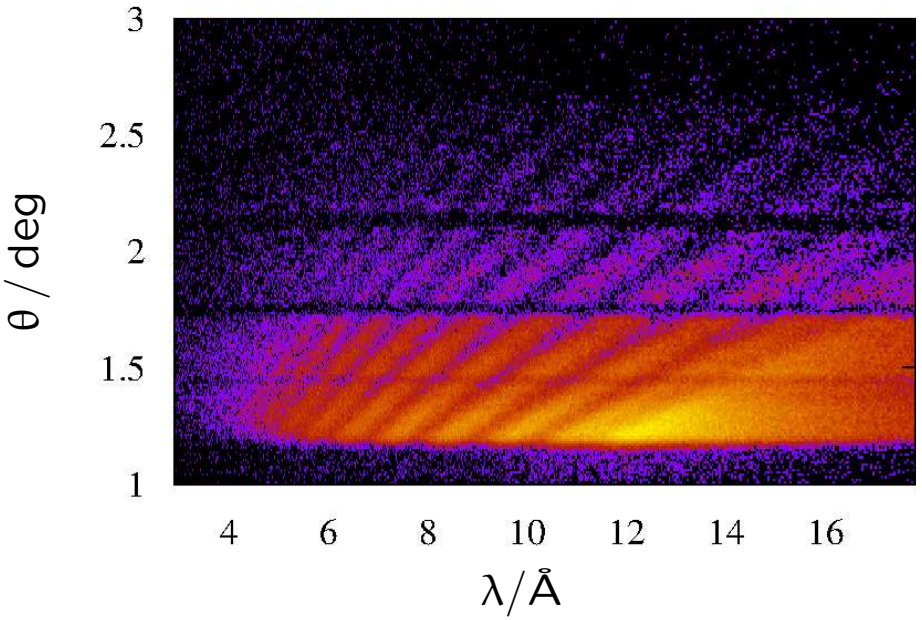


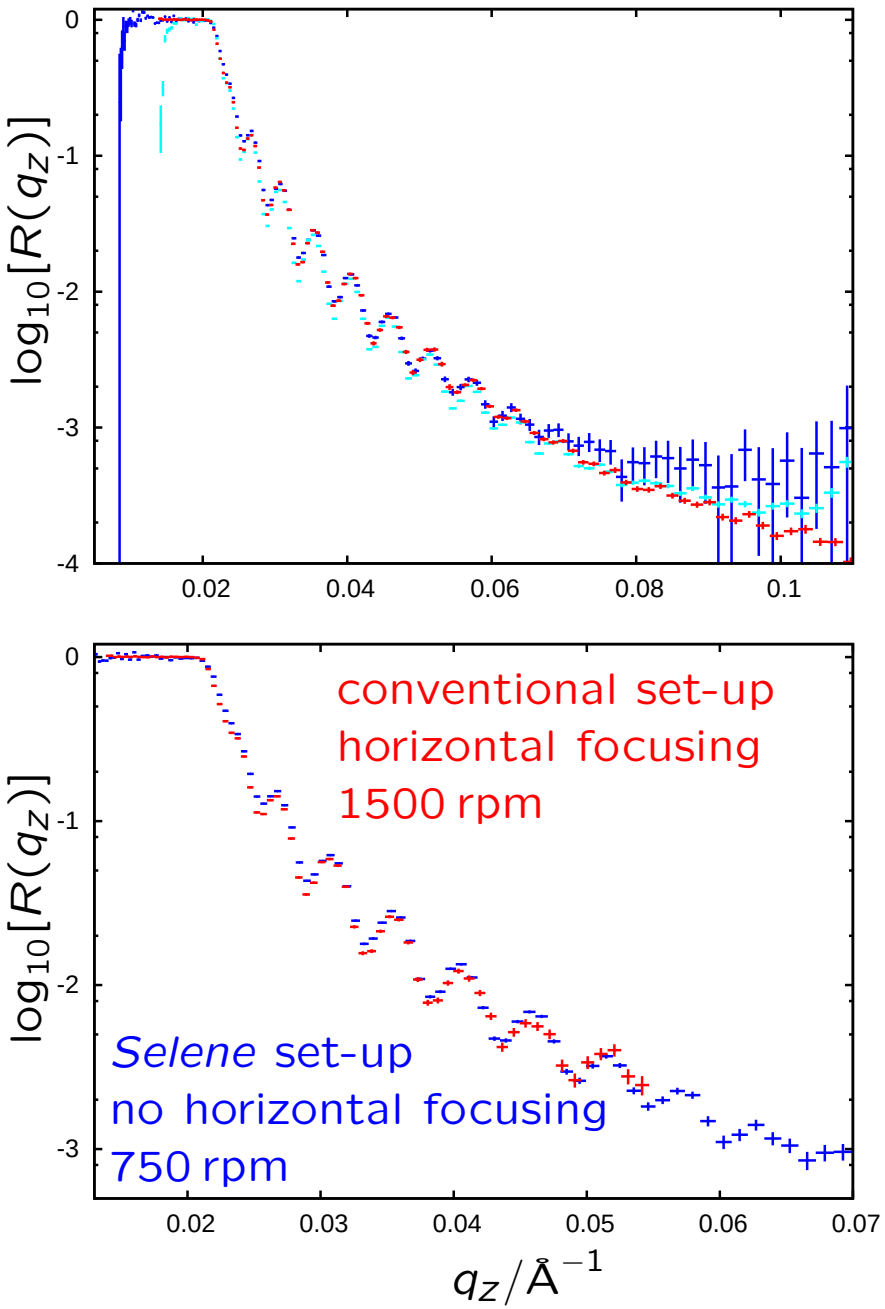


4 guide elements à 500 mm

TOF mode sample: 1000 Å Ni on glass

measured





measurement time:

conventional	5 h
Selene	45 min
gain-factor	6.7

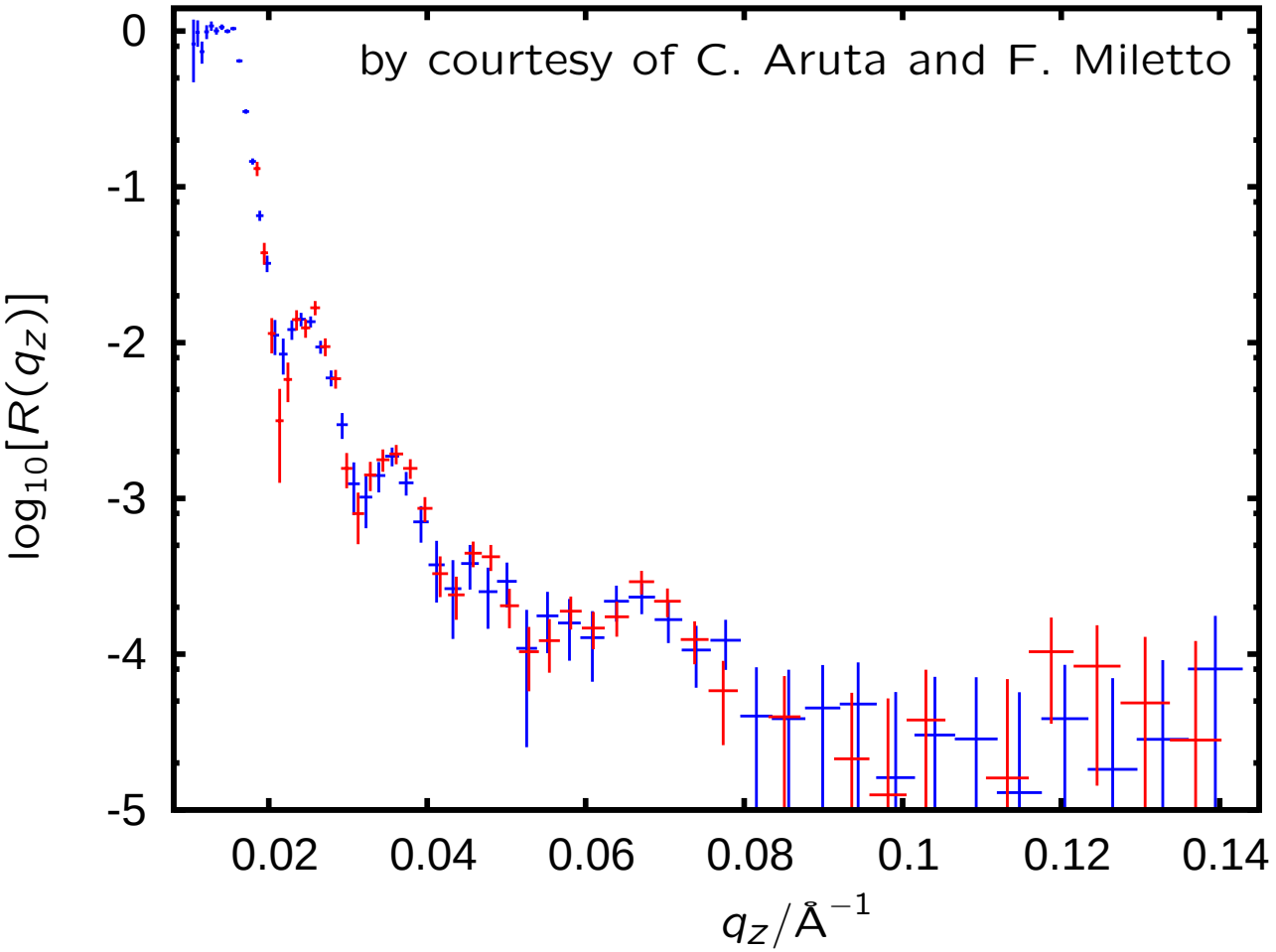
TOF mode

sample: $[La_{2/3}Sr_{1/3}MnO_3 / SrTiO_3]_4 / NGO$
sample-size: $4 \times 5\,mm^2$

no focusing in sample plane
TOF mode, $\lambda \in [2 \ldots 18\,Å]$

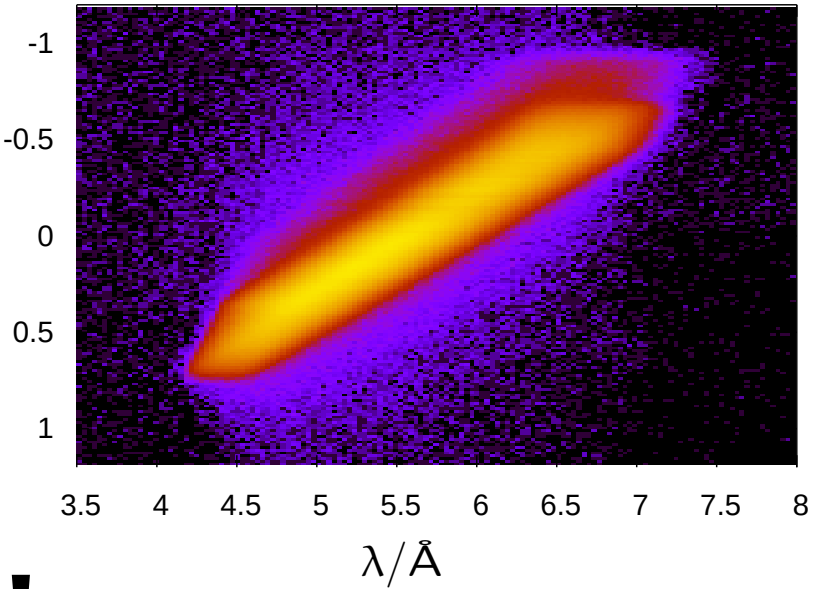
measurement time:

conventional	6.5 h
Selene	45 min
gain-factor	8.3

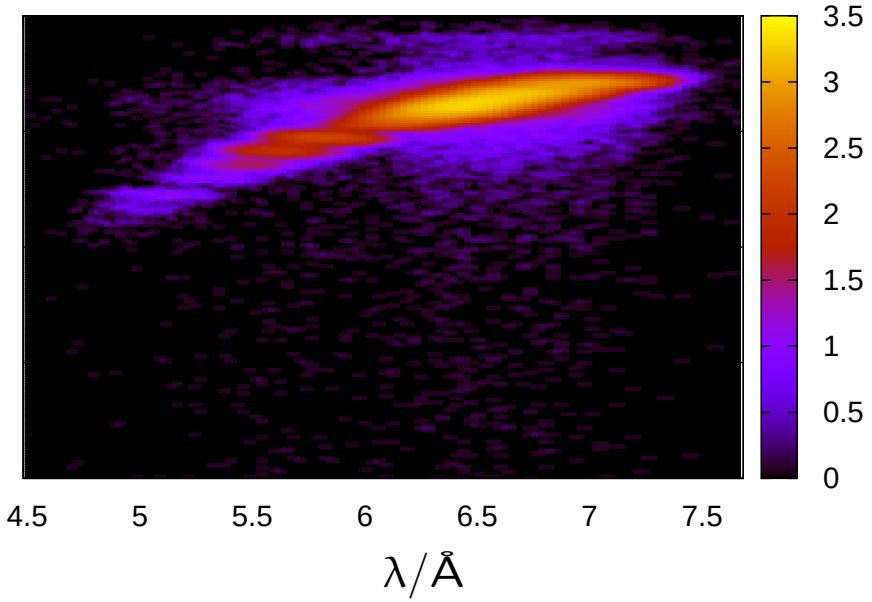


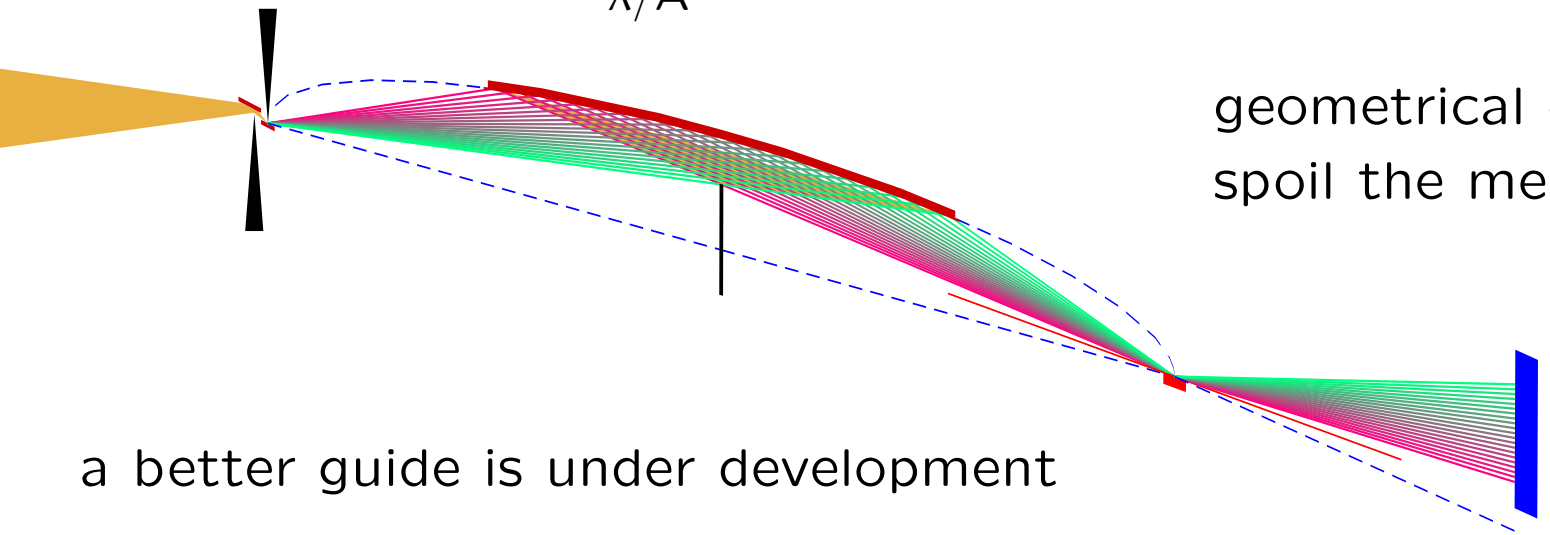
λ - θ encoding:

θ(λ) after the double-bounce ml monochromator



after reflection off a 1000 Å Ni film on glass





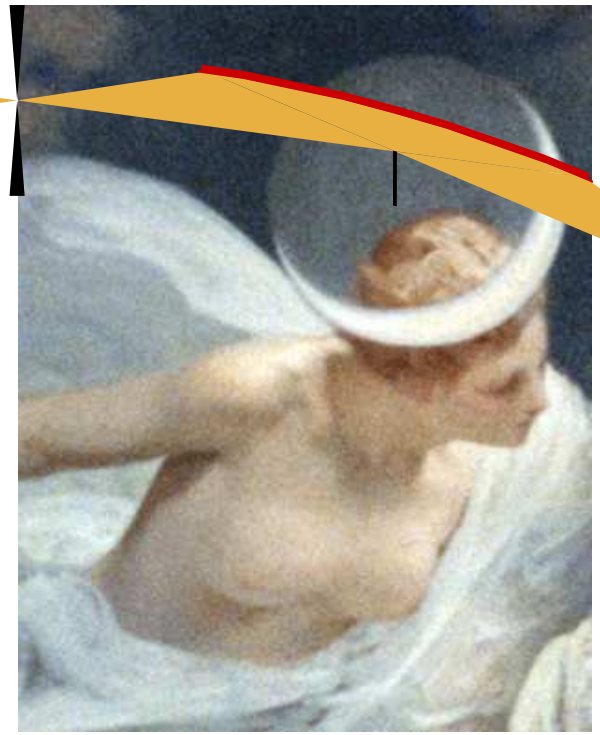
geometrical errors of the guide spoil the measurement

a better guide is under development

Selene is a guide concept which

- prevents direct line of sight
  - reduces radiation in the guide
    - allows for convenient beam manipulation
      - reduces illumination of the sample environment
        - allows for a convergent beam set-up

$\Rightarrow$ flux gain > 10



combination with focusing in the sample plane

- beam spot of the order of $2 \times 0.5\,\mathrm{mm}^2$ within reach
- flux gain > 100 for high-intensity specular reflectometry