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progress report of the Swiss-Danish instrument initiative for the ESS WP2

focusing reflectometer

Selene

IKON 2
09.–10. 02. 2012, Malmø, Sweden

aims

development and proof of concepts for two reflectometers for the ESS, optimized for:

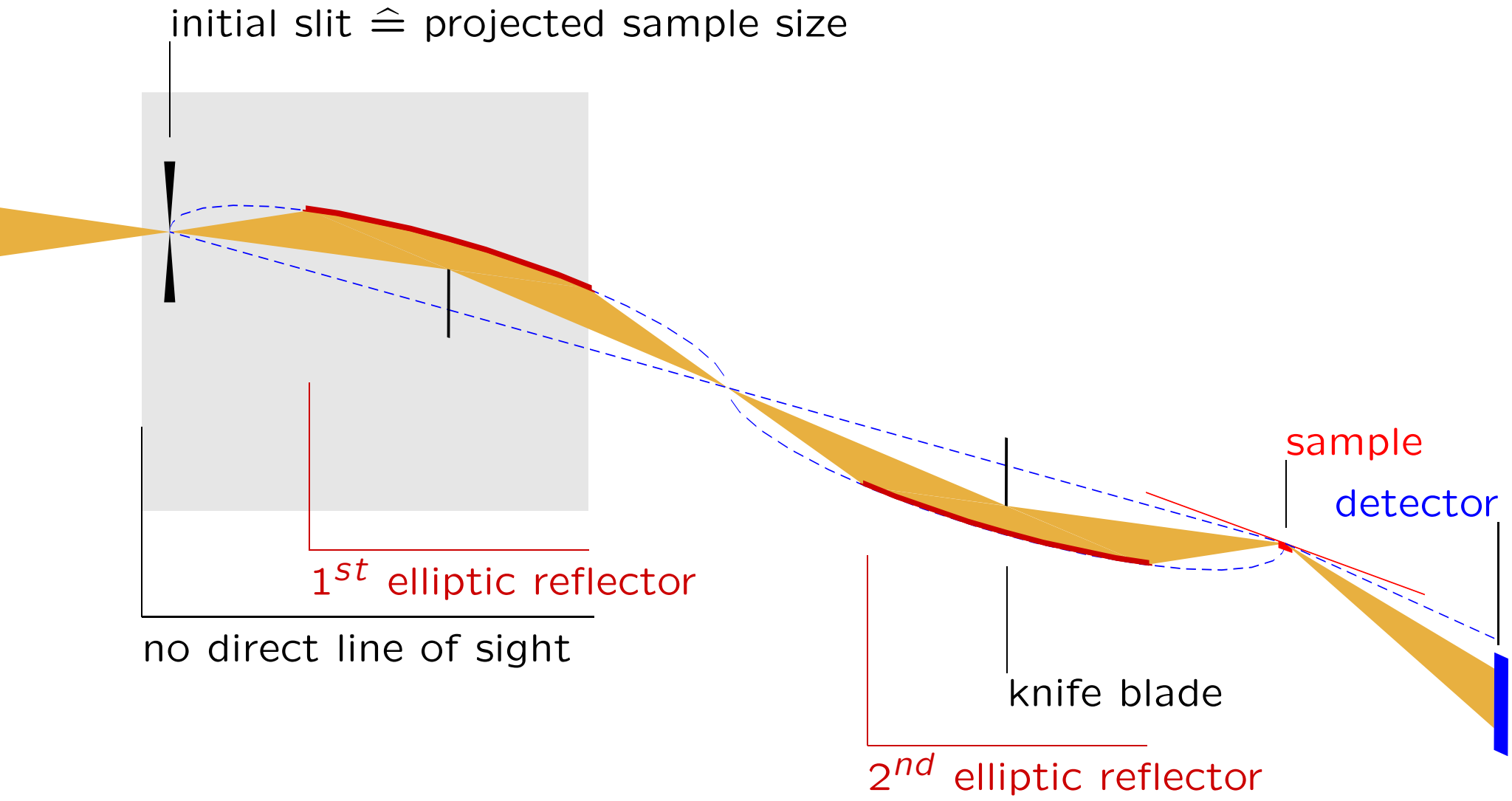
- **small samples** ($< 1\,\mathrm{mm}^2$)
  - horizontal scattering geometry
  - polarization & ∼analysis
  - voluminous sample environment
  - moderate to low resolution
  - . . .

- **liquid surfaces**
  - vertical scattering geometry
  - time-resolved studies ($\Delta t < 1\,\mathrm{s}$)
  - wide q_z-range with one (few) angular setting(s)
  - high to low resolution
  - . . .

generic instrument layout

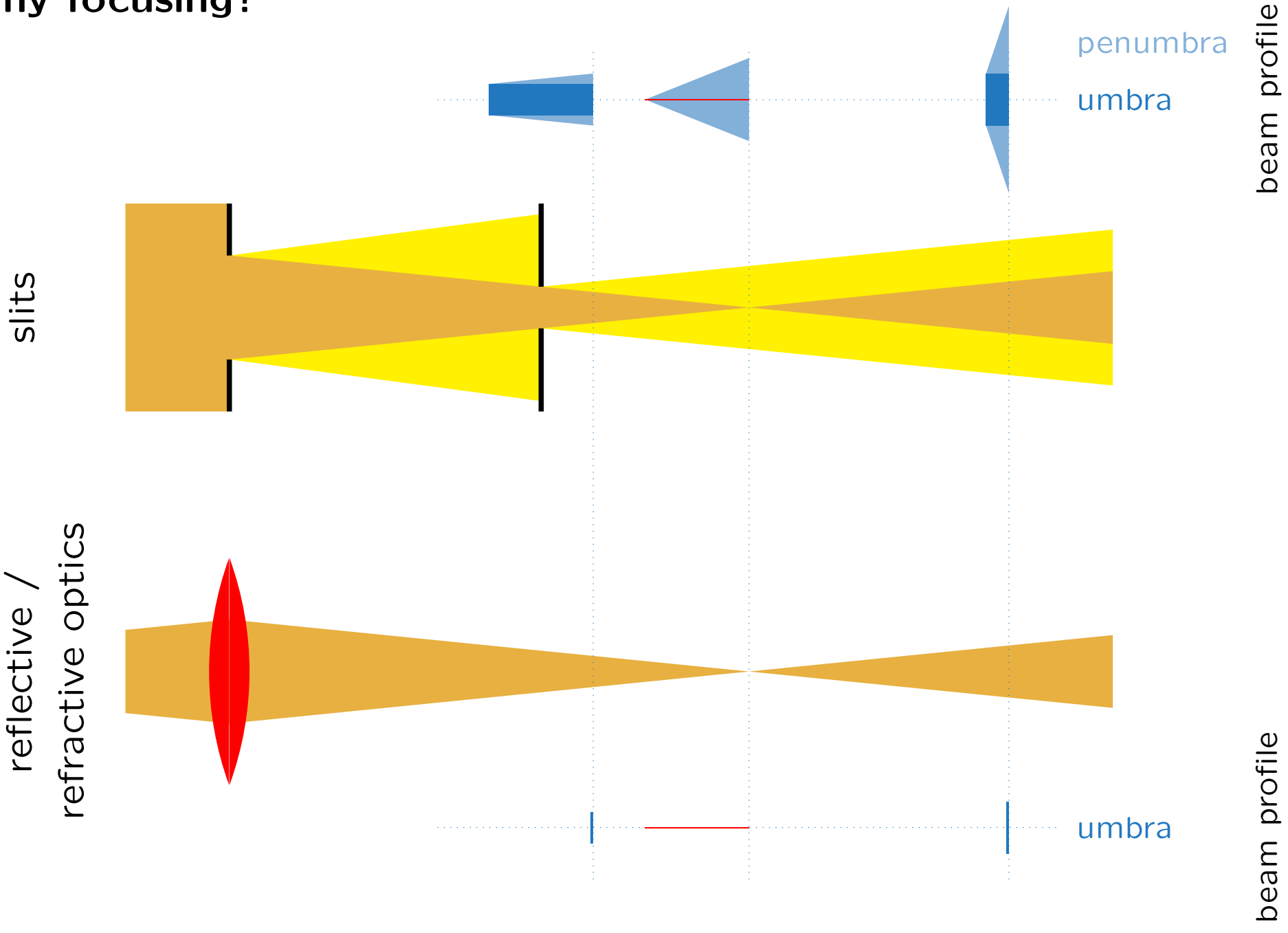
cut in the scattering plane

stretched by 10 normal to incident beam



generic instrument

why focusing?



generic instrument

why an elliptic reflector?

an **elliptic** reflector allows for

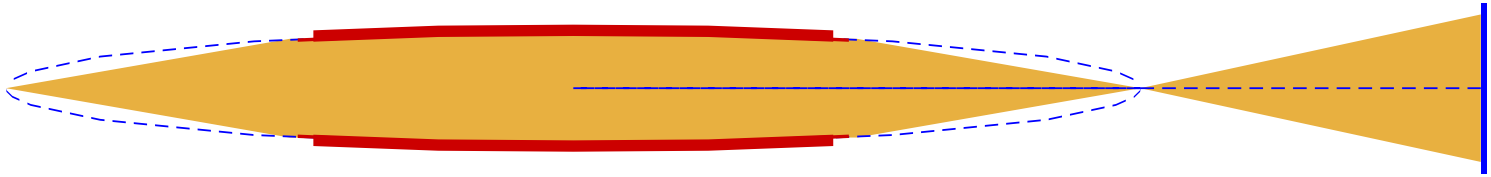
- point-to-point focusing
  - small source point
    - convenient beam manipulation (chopper, filtering)
    - early beam definition
      - low background
      - low radiation
  - disentangling of spot size and divergence
  - λ/θ encoding

a **parabolic** reflector turns beam size into divergence and *vice versa*

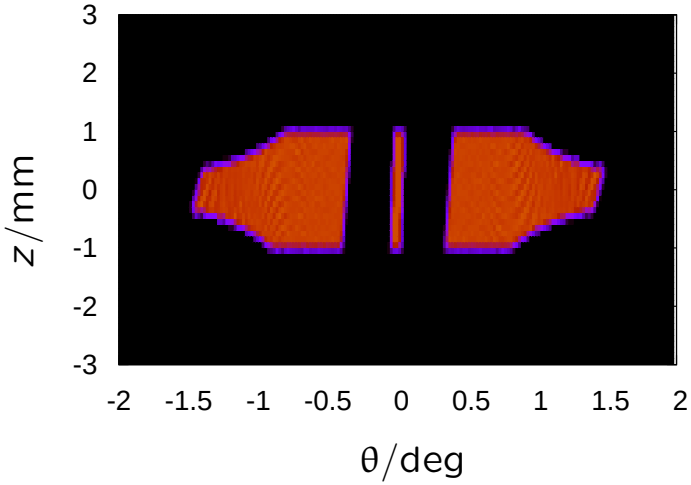
generic instrument

why only one branch of an ellipse?

- no structured $I(\theta, z)$



$I(\theta, z)$ map

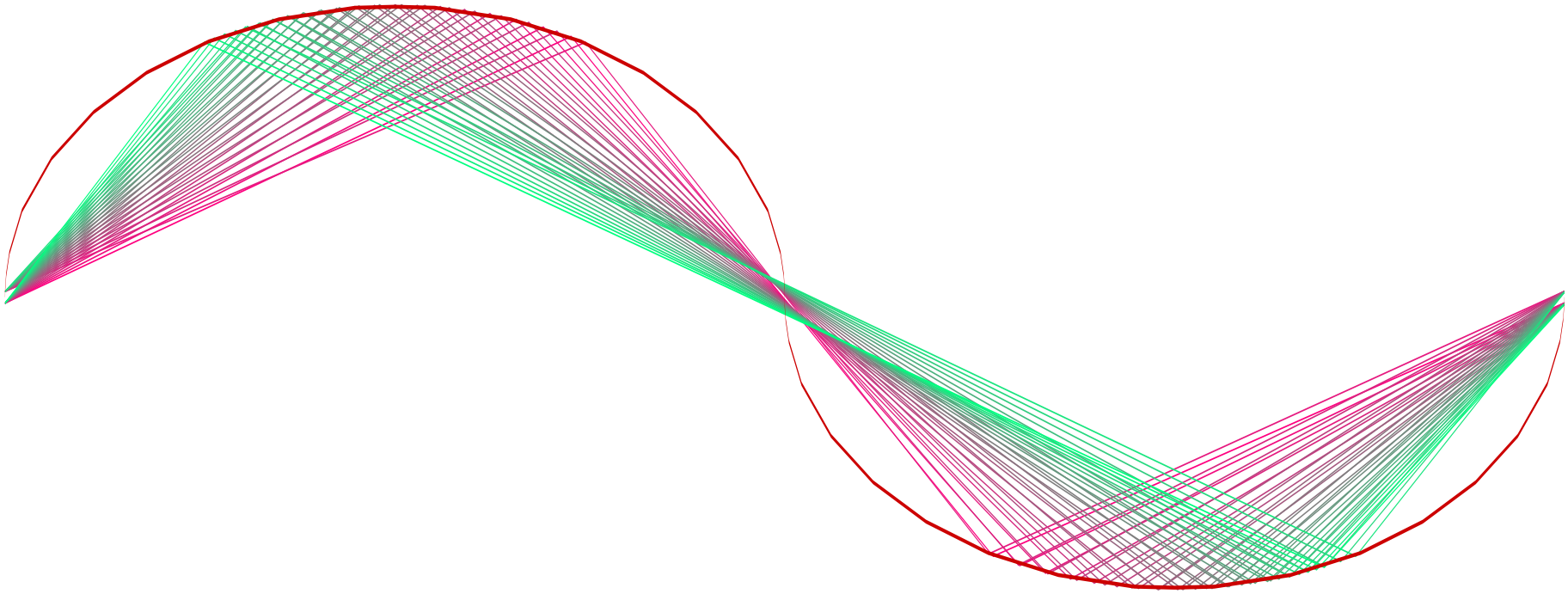


- in most cases one branch can cover $\Delta\theta$

generic layout

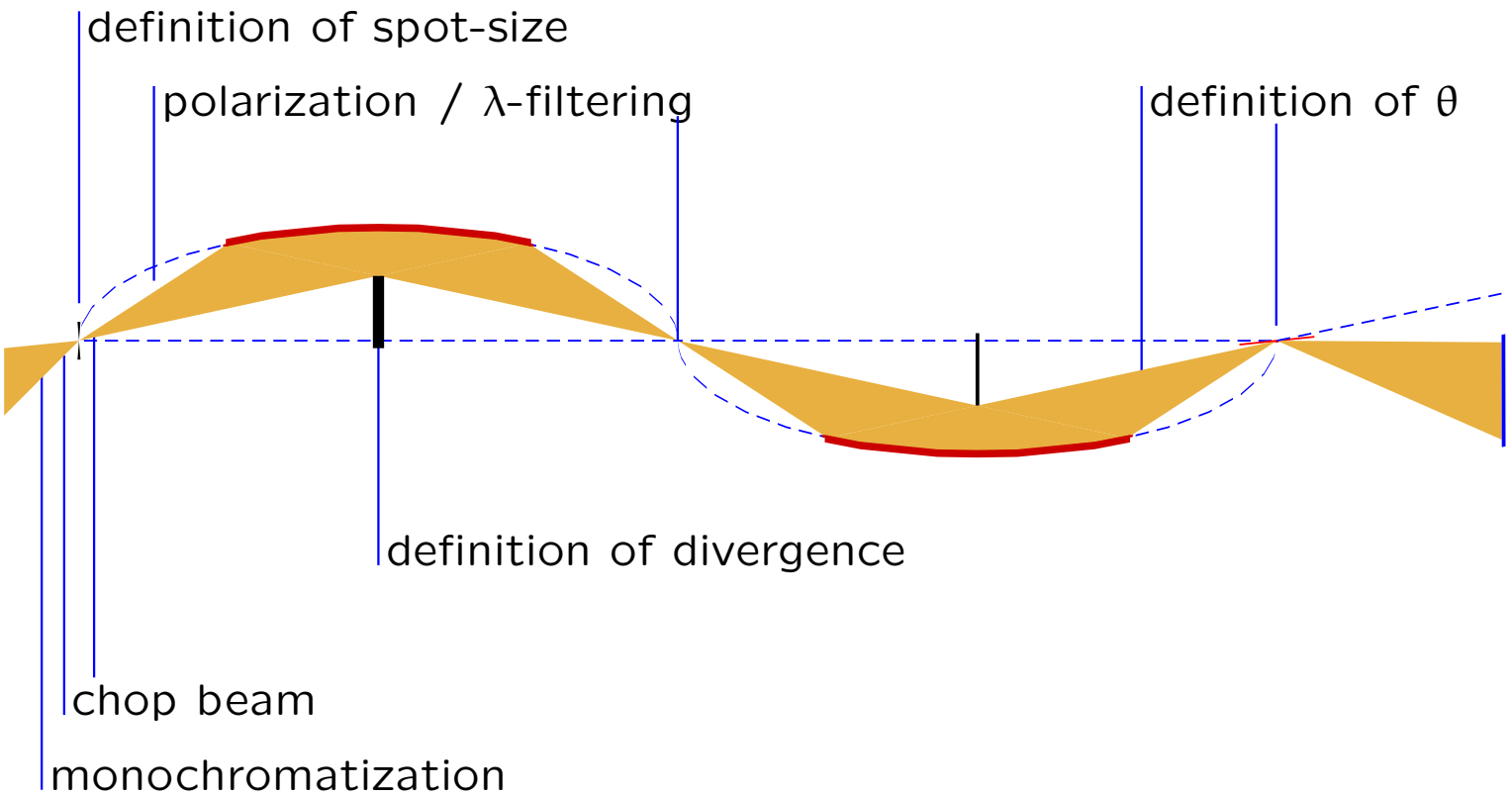
why two subsequent elliptic guides?

- convenient beam manipulation
- guide dimensions not too large
- correction for coma aberration!



operation modes:

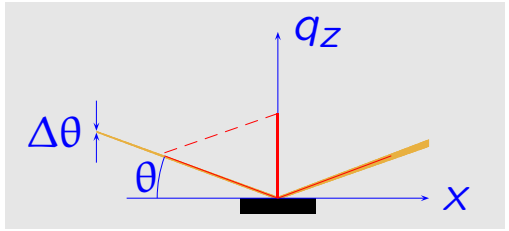
for TOF (non-TOF operation is also possible!)

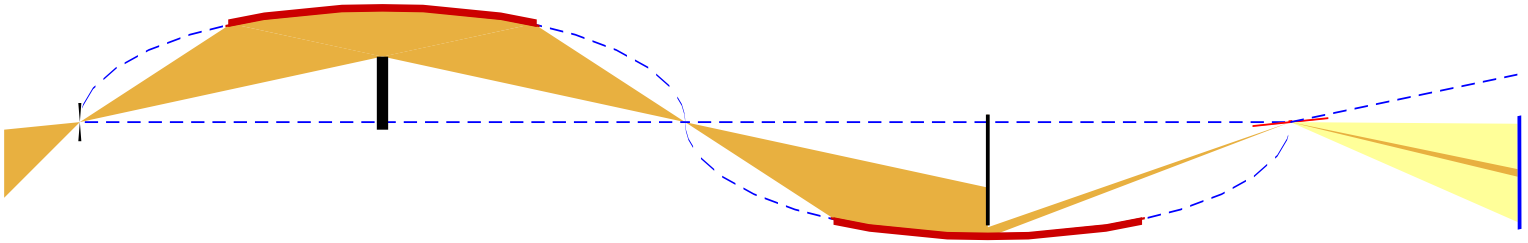


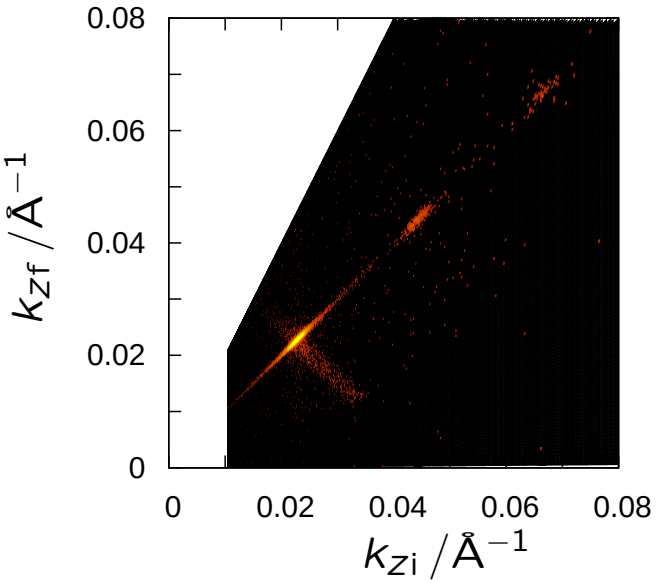
operation modes:

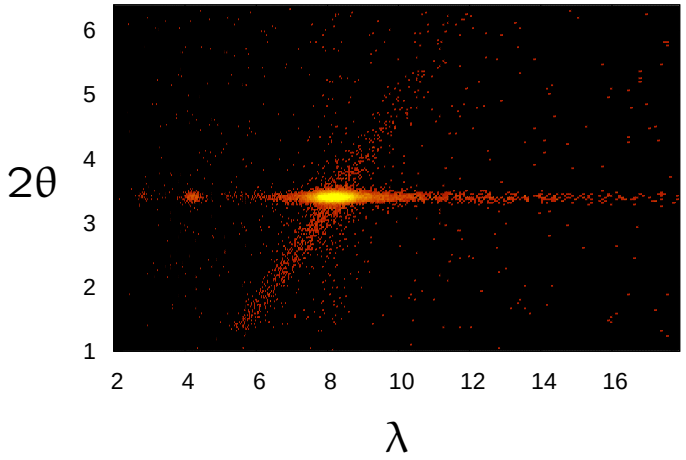
almost conventional

- beam is still convergent
- off-specular measurements are feasible





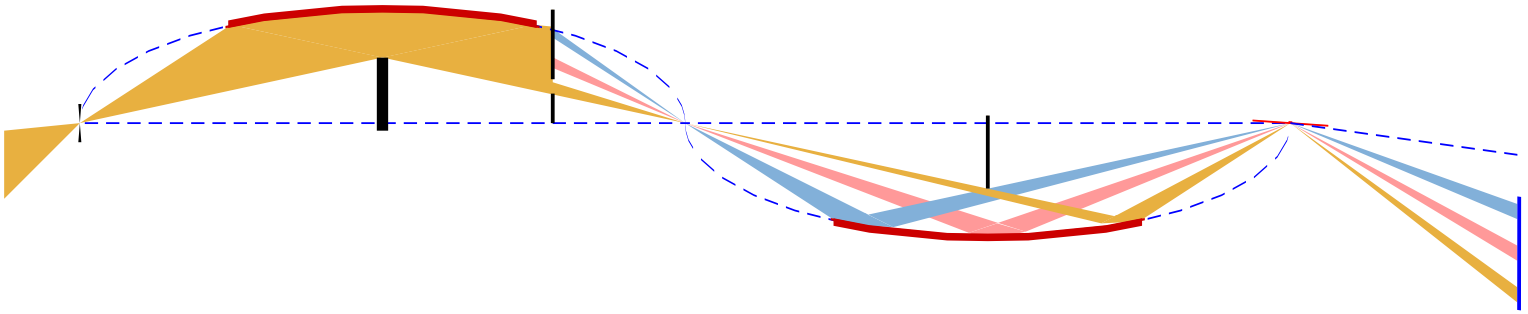




operation modes:

wide q-range

- vary θ with fixed sample position
- shift diaphragm (chopper) between pulses



- suited for liquid surfaces

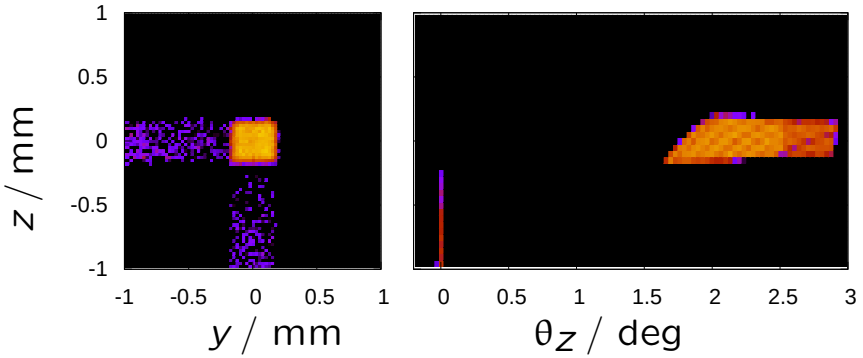
operation modes:

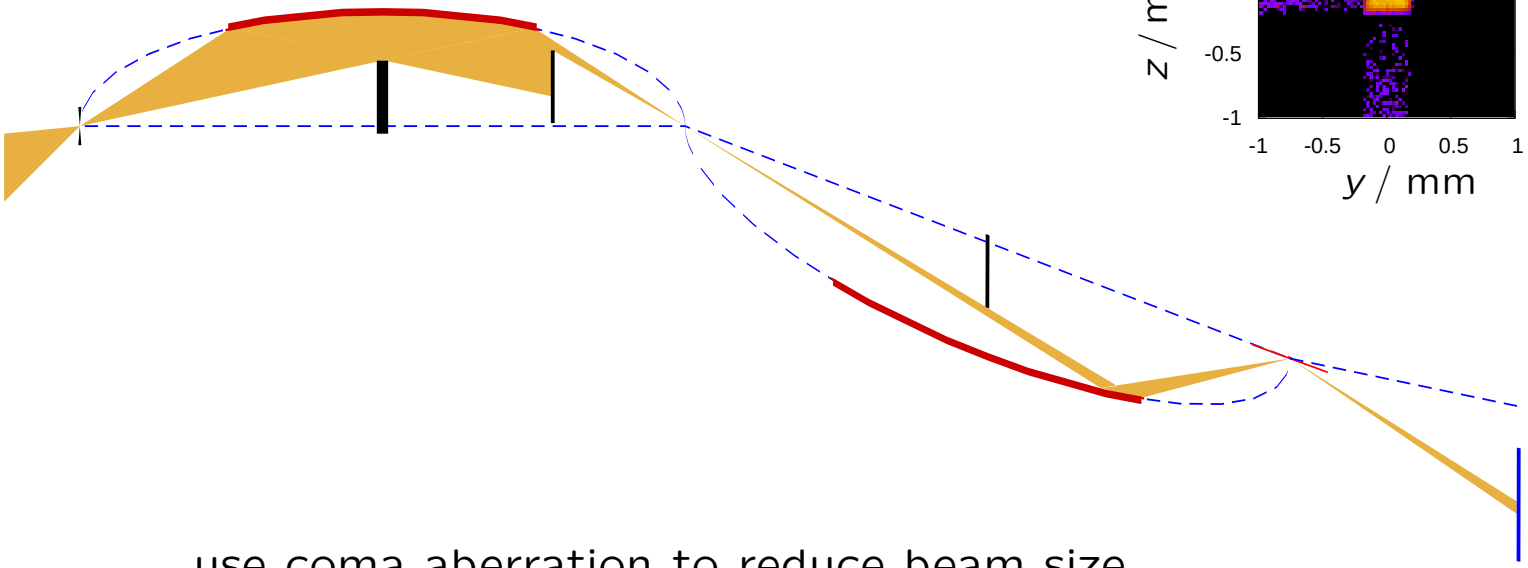
small spot size

- uses focusing due to coma aberration
- scanning mode possible

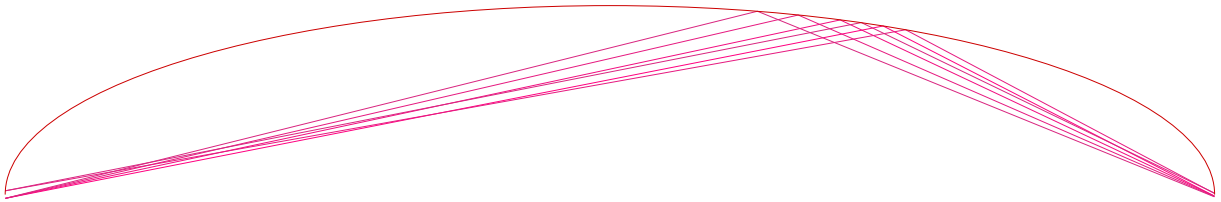
$I(y, z)$ and $I(z, \theta_z)$ at the sample

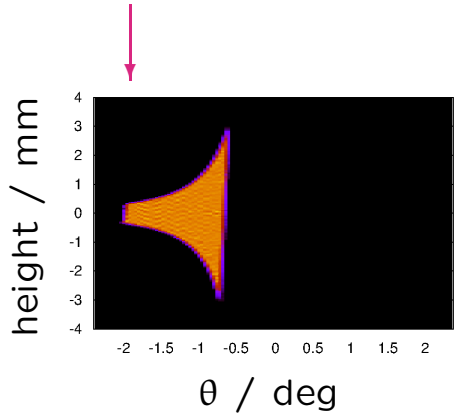
for a $1 \times 1\,\mathrm{mm}^2$ entrance slit





use coma aberration to reduce beam size

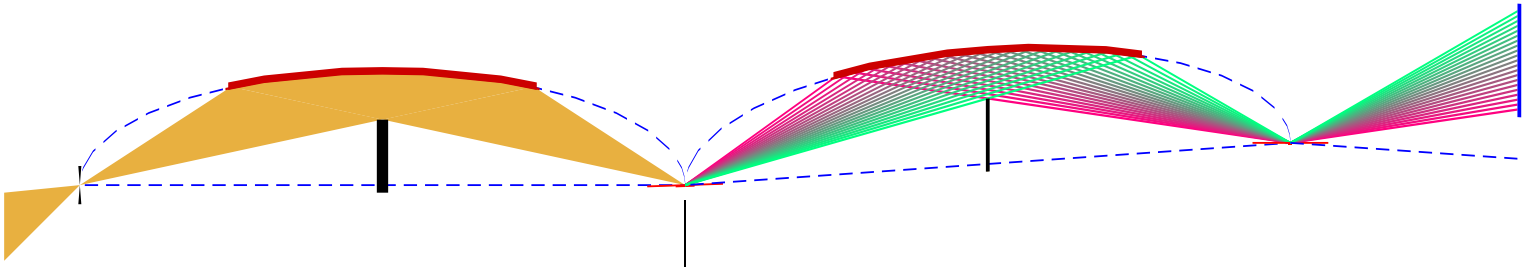




operation modes:

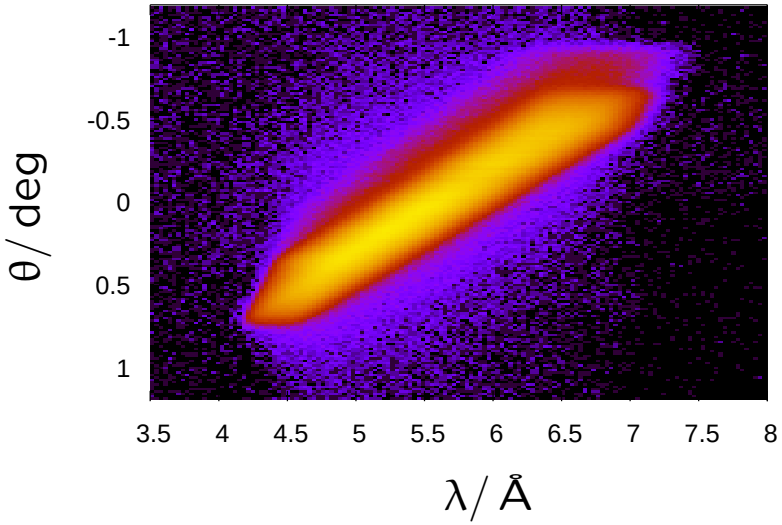
angle/energy encoding

- uses a ml-monochromator at the intermediate image
- spectral analysis of the beam: λ / θ encoding



- large λ on small θ
  ⇒ wide q_z-range

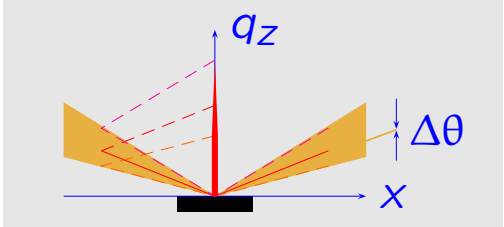
$I(\lambda, \theta)$ after ml monochromator

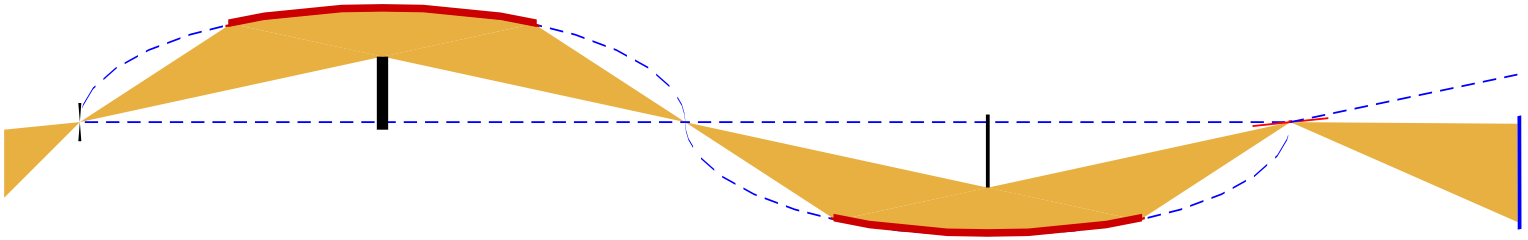


operation modes:

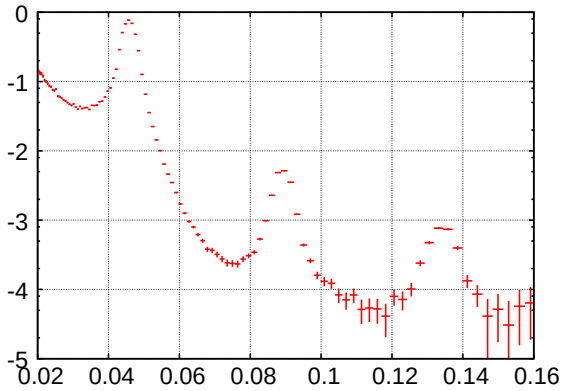
high-intensity specular reflectivity

- energy- and angle-dispersive ⇒ gain > 10
- for fast scanning ($T, \mathbf{H}, \mathbf{E} \ldots$)
- or if off-specular scattering is no *problem*

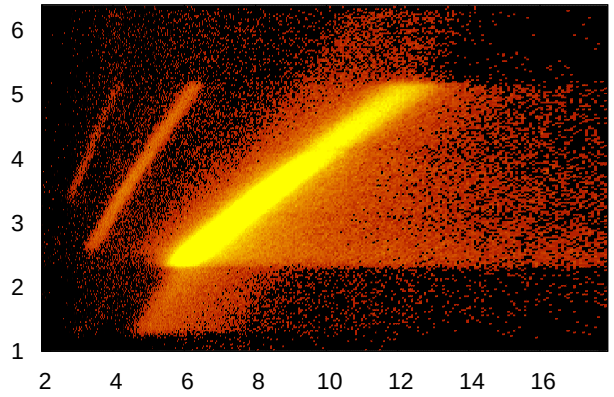




$\log_{10}[R(q_z)]$

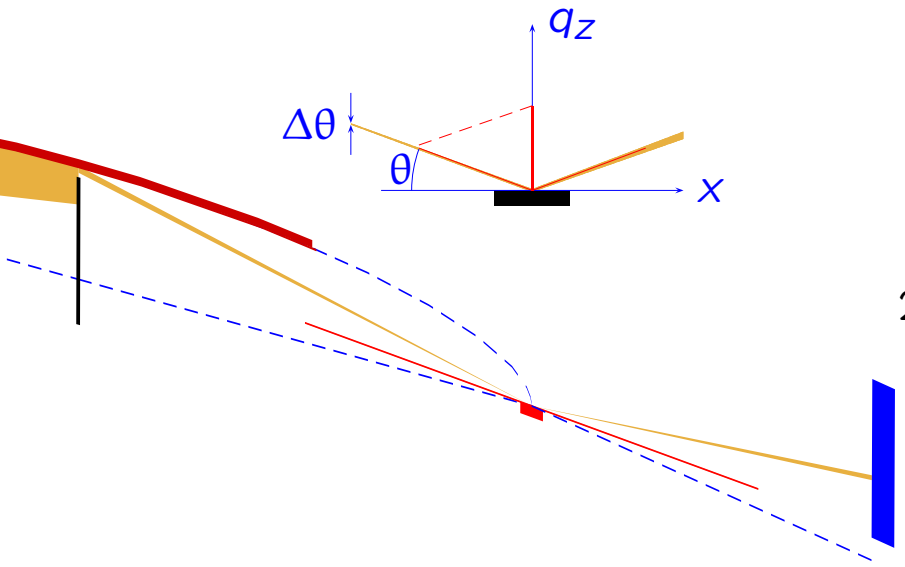


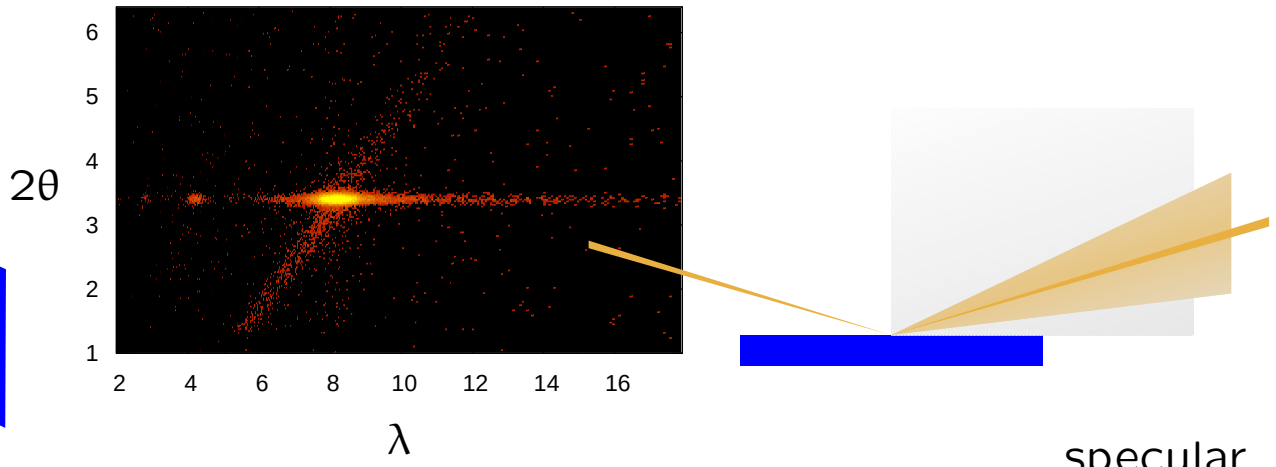
2θ

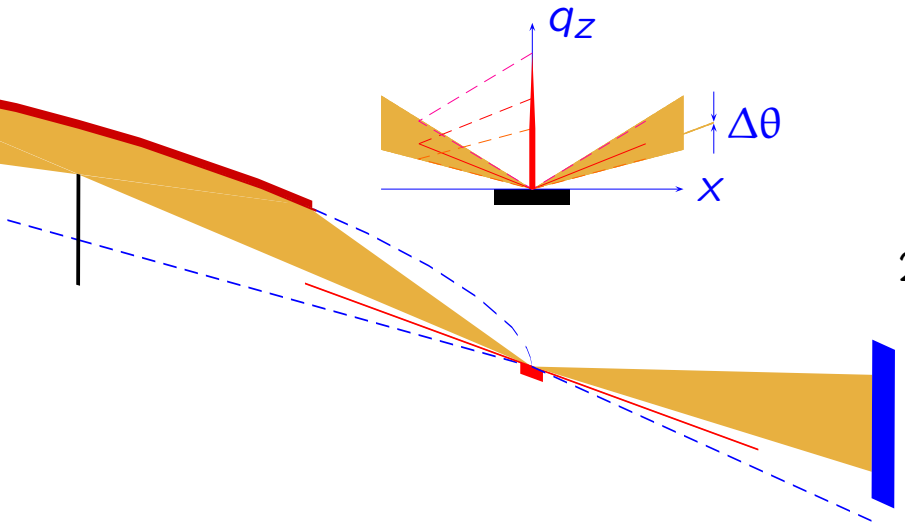


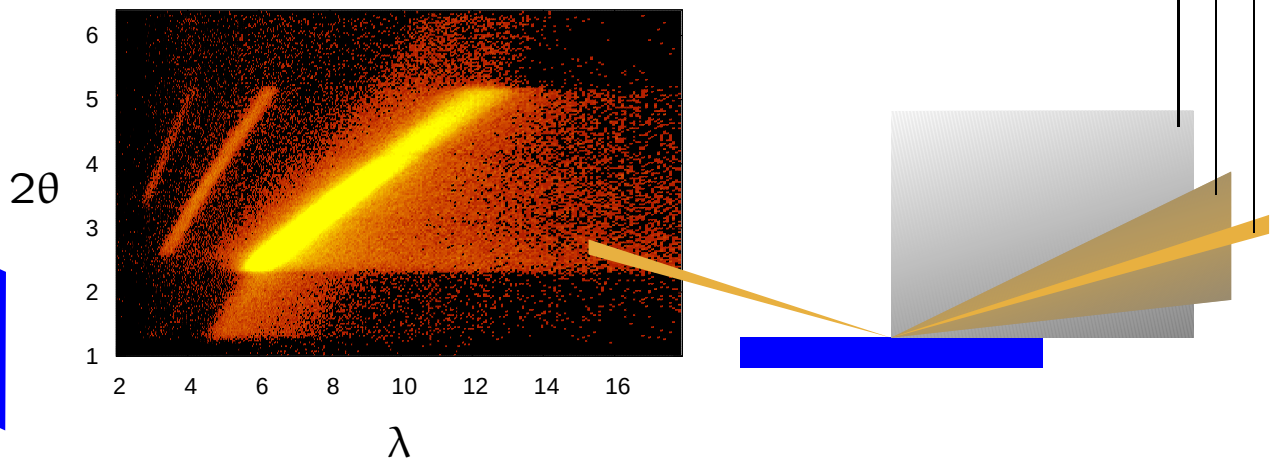
operation modes:

high-intensity specular reflectivity vs. almost conventional









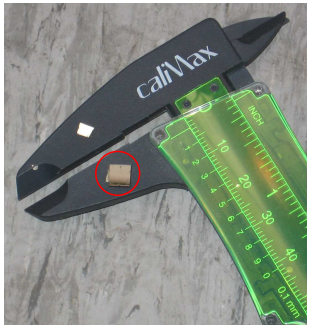
operation modes:

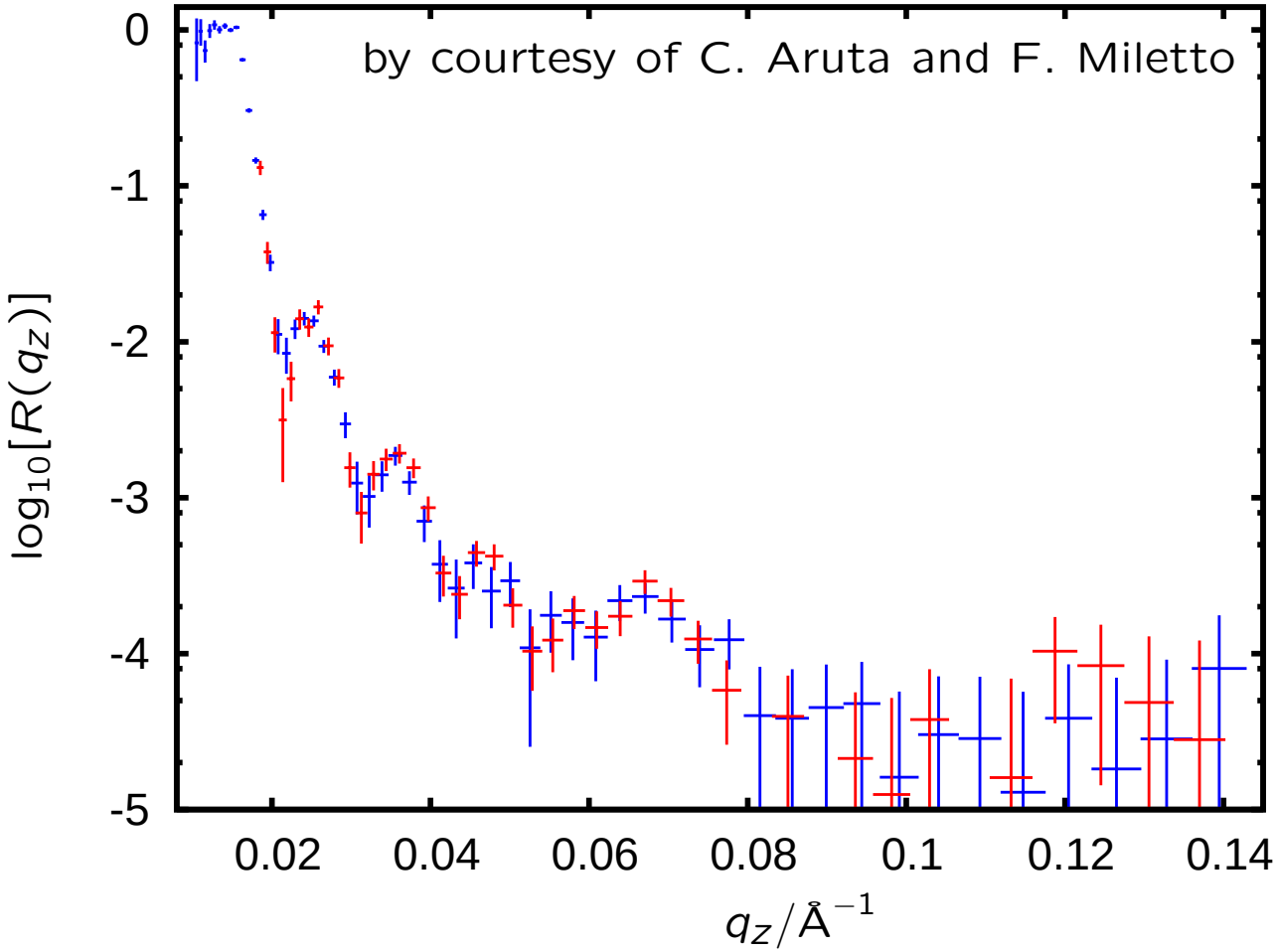
high-intensity specular reflectivity vs. almost conventional

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

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

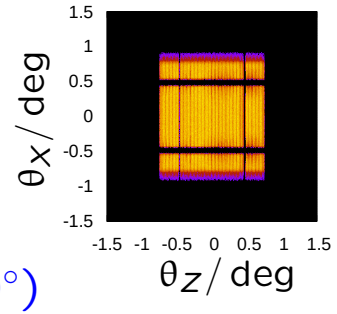
conventional	6.5 h
Selene	45 min
gain-factor	8.3





prototype on BOA

Boa is a test beam line at SINQ, PSI

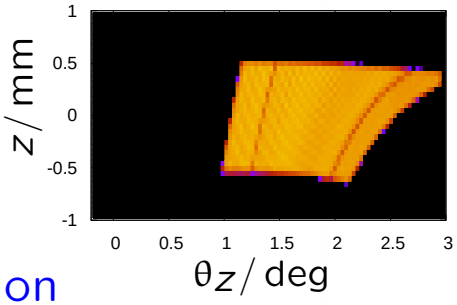


guide-end ($40 \times 150\,\mathrm{mm}^2$, $\Delta\theta_y = 1.4°$, $\Delta\theta_z = 2.0°$)

chopper ($\varnothing = 150\,\mathrm{mm}$)

slit

elliptic guides



sample position

area detector

total length $\approx 8.6\,\mathrm{m}$

$\lambda \in [1.5, 12]\,\text{Å}$

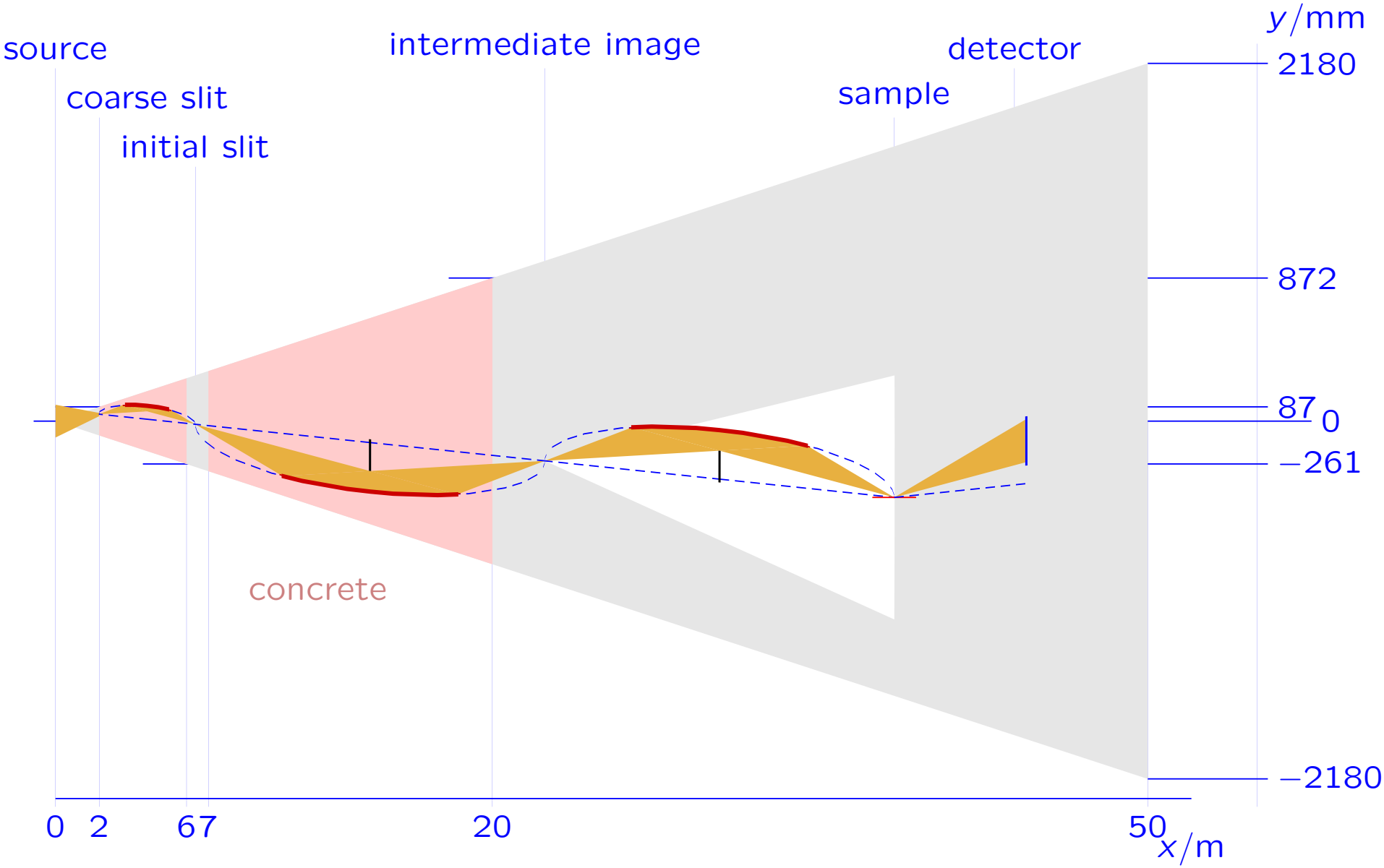
polarized beam

setup operational 8. 2012

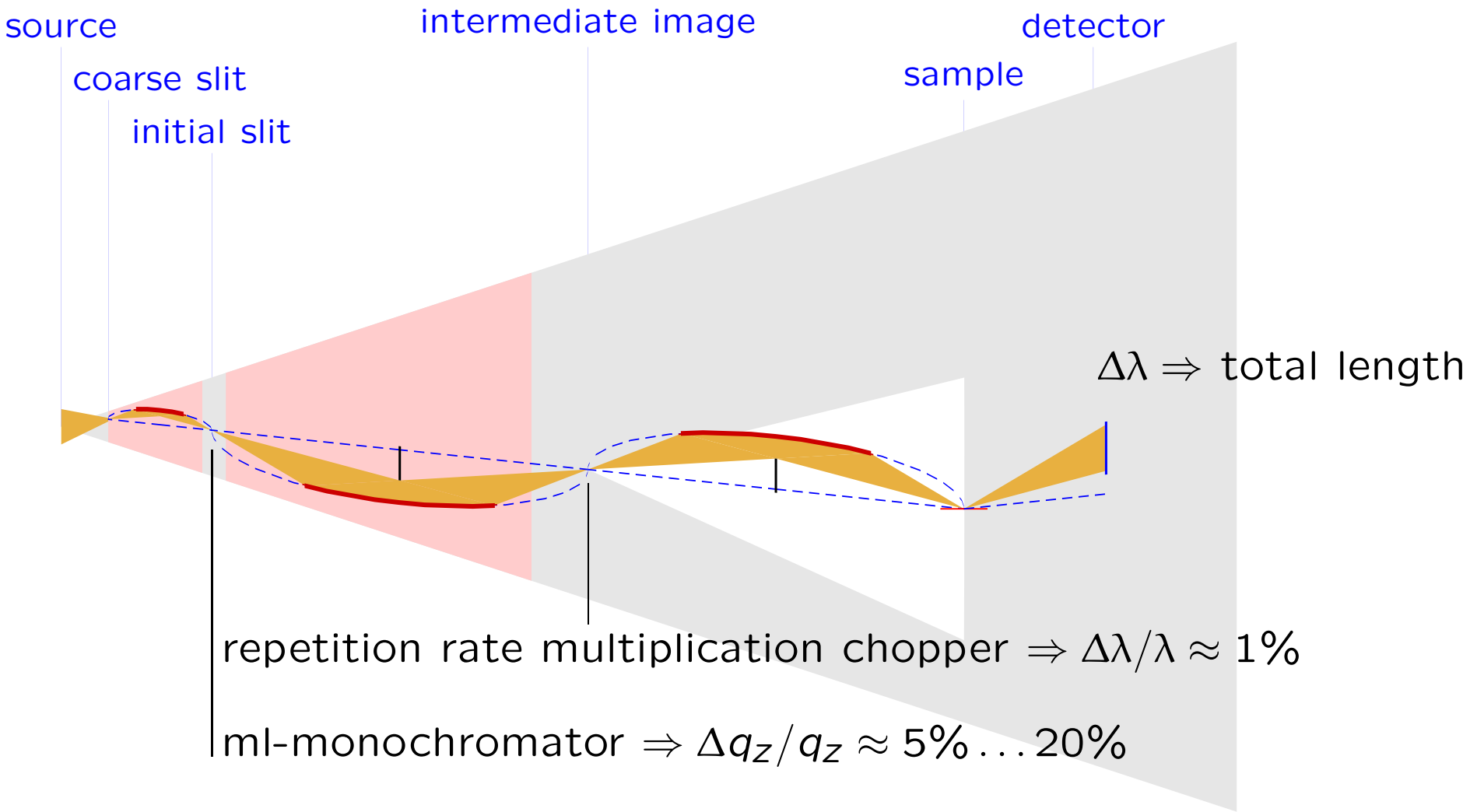
x/y translation, $2\theta/\omega$ rotation stages

concept for the ESS

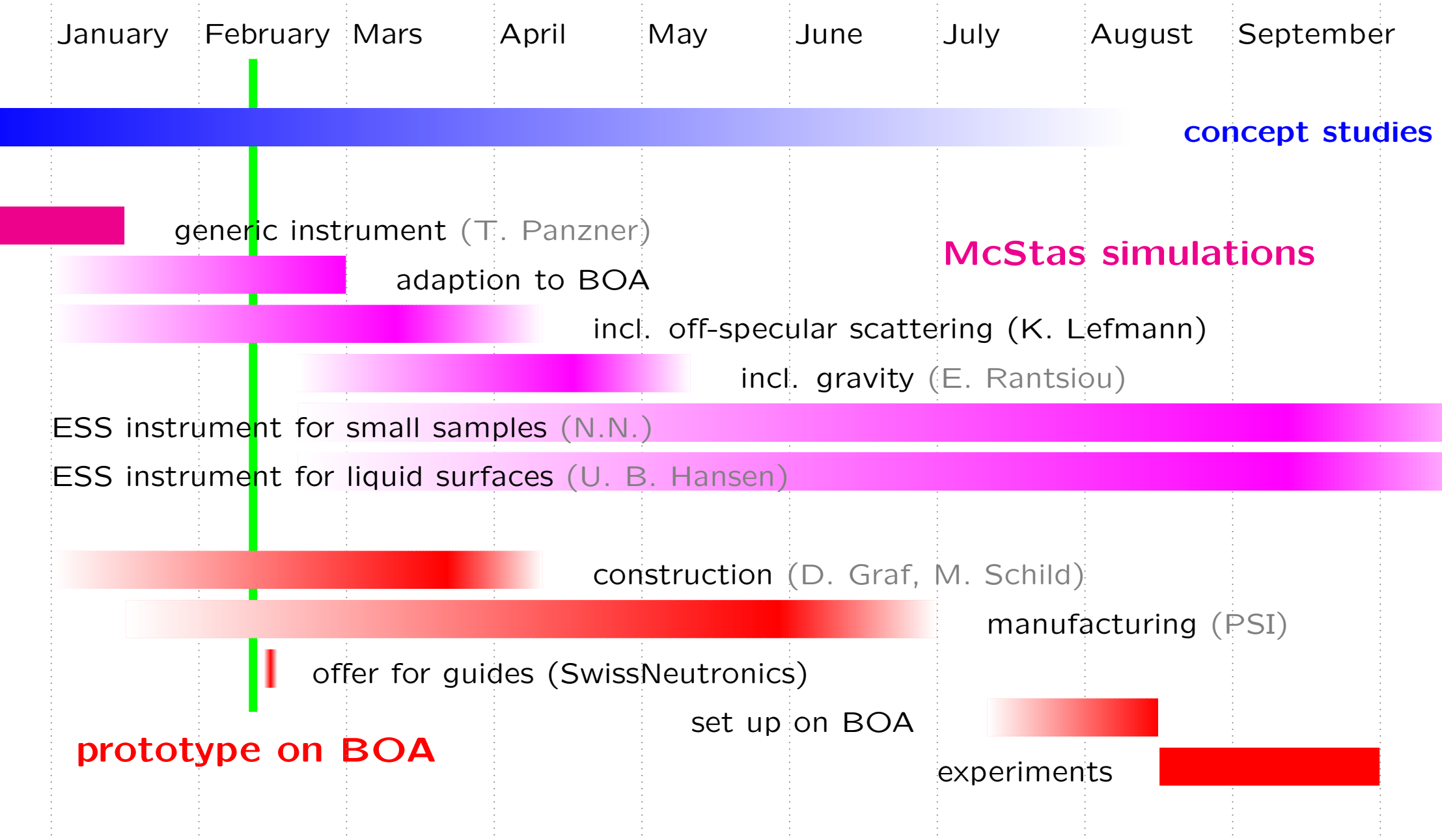
schematic lay-out of the reflectometer for tiny samples



concept for the ESS



schedule


January
February
Mars
April
May
June
July
August
September
concept studies
generic instrument (T. Panzner)
McStas simulations
adaption to BOA
incl. off-specular scattering (K. Lefmann)
incl. gravity (E. Rantsiou)
ESS instrument for small samples (N.N.)
ESS instrument for liquid surfaces (U. B. Hansen)
construction (D. Graf, M. Schild)
manufacturing (PSI)
offer for guides (SwissNeutronics)
set up on BOA
prototype on BOA
experiments

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