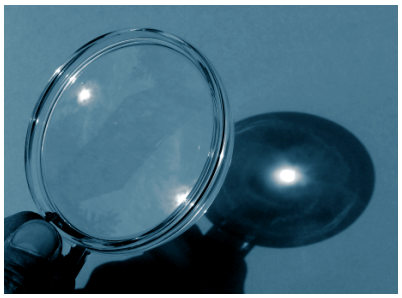
PAUL SCHERRER INSTITUT

Jochen Stahn



benefits, prospects and limitations of a truly focusing neutron guide

ESS seminar, 01. 10. 2013
Lund, Sweden

people involved

experiments

Ursula Bengaard Hansen
Birgit Wiedemann
Anette Vickery

McStas simulations

Emanouela Rantsiou
Tobias Panzner
Panos Korelis
Uwe Filges

ideas / discussions

Björgvin Hjörvarsson
Marité Cardenas
Beate Klösgen
Rob Dalgliesh
Frédéric Ott
Phil Bentley
Bob Cubitt
Peter Böni
Uwe Stuhr
. . .

PSI infrastructure

Vincent Thominet
Sibylle Spielmann
Roman Bürge
Marcel Schild
Dieter Graf
Jan Krebs

inspiration

Selene

Selene picture: ceiling painting in the Ny Carlsberg Glyptotek, København

outline

basics on focusing

example: Selene guide

optics

performance & limitations

discussion

people.web.psi.ch/stahn/publications.html#oral

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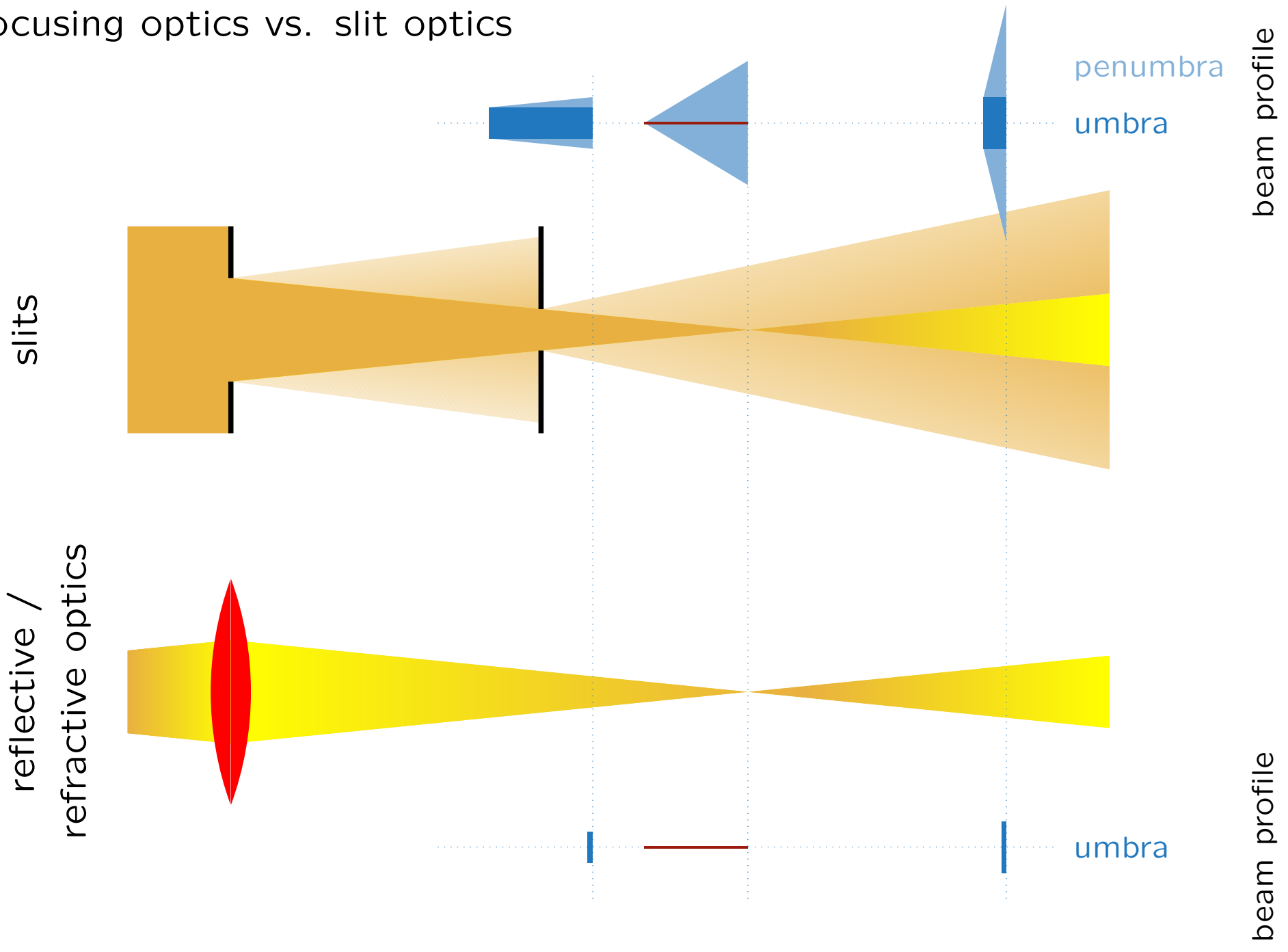
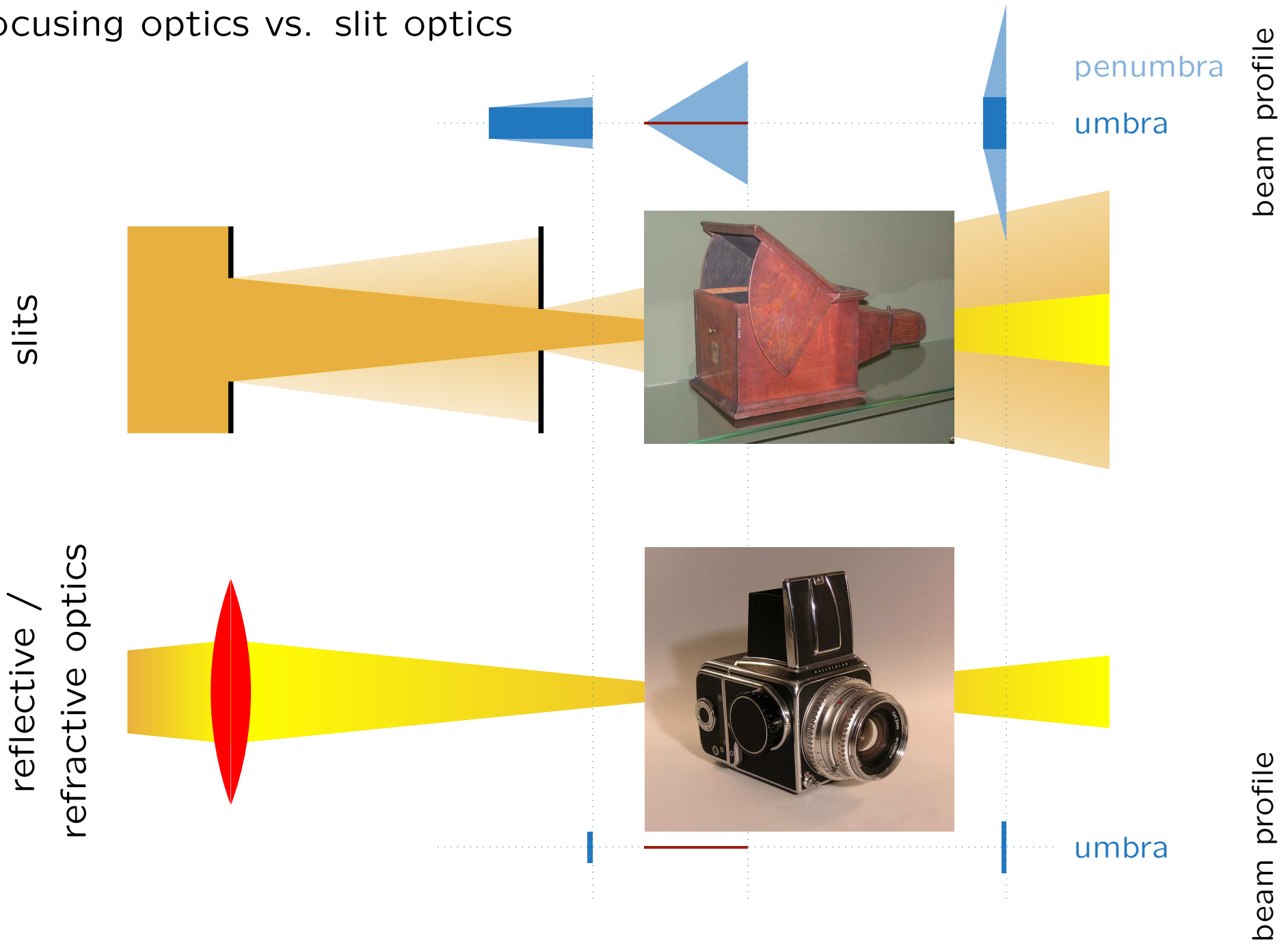
basics

focusing optics vs. slit optics



basics

focusing optics vs. slit optics



basics

focusing optics vs. slit optics

simple mechanics, error tolerant

$\Delta\theta$ and Δy coupled

coated area Εστία: $20 \ldots 40\,\mathrm{m}^2$

unimodal beam characteristics

low background

$\Delta\theta$ and Δy decoupled

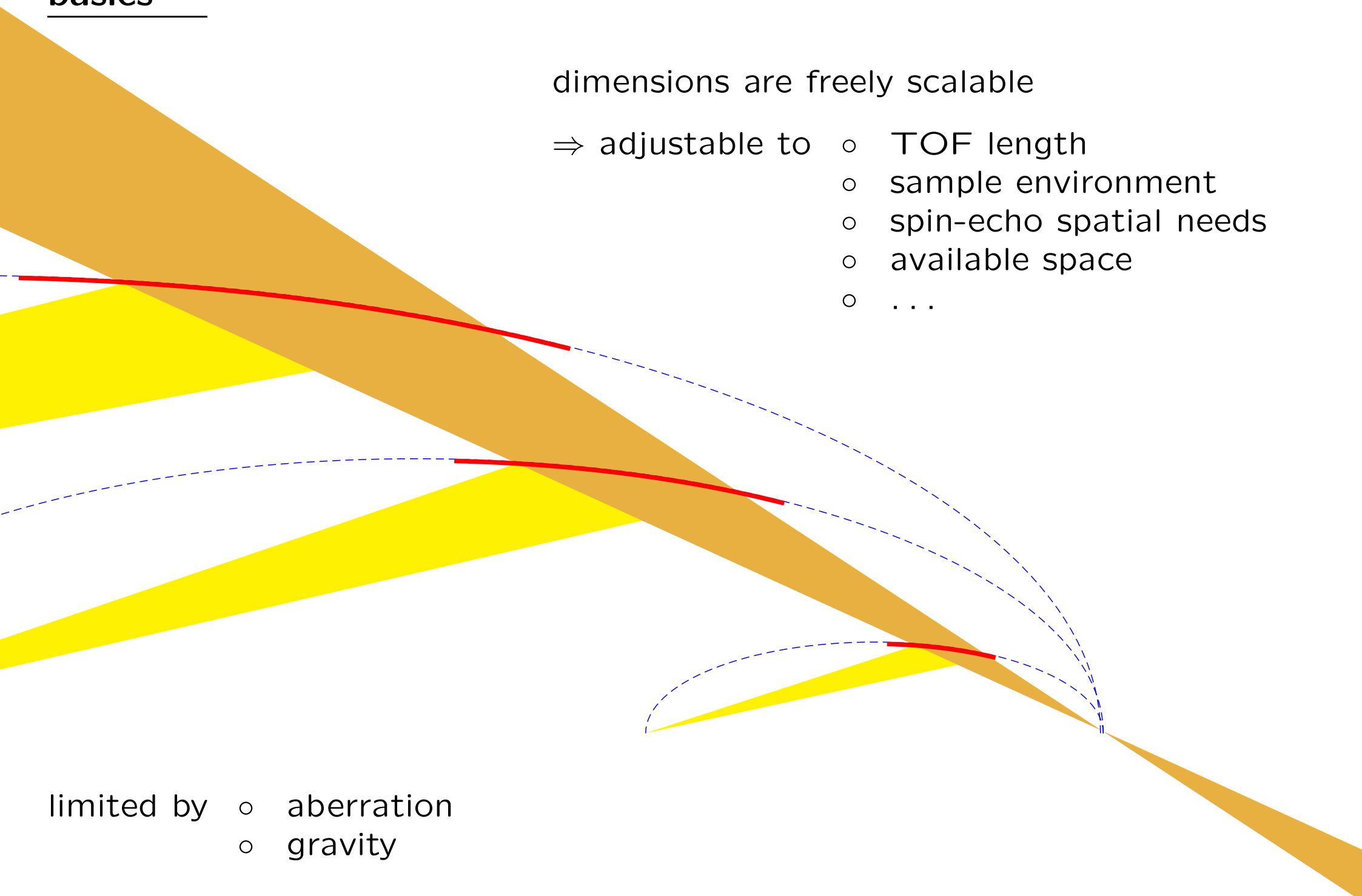
high precision device, lower transmission

coated area Εστία: $4\,\mathrm{m}^2$

basics

dimensions are freely scalable

⇒ adjustable to
- TOF length
- sample environment
- spin-echo spatial needs
- available space
- . . .



limited by
- aberration
- gravity

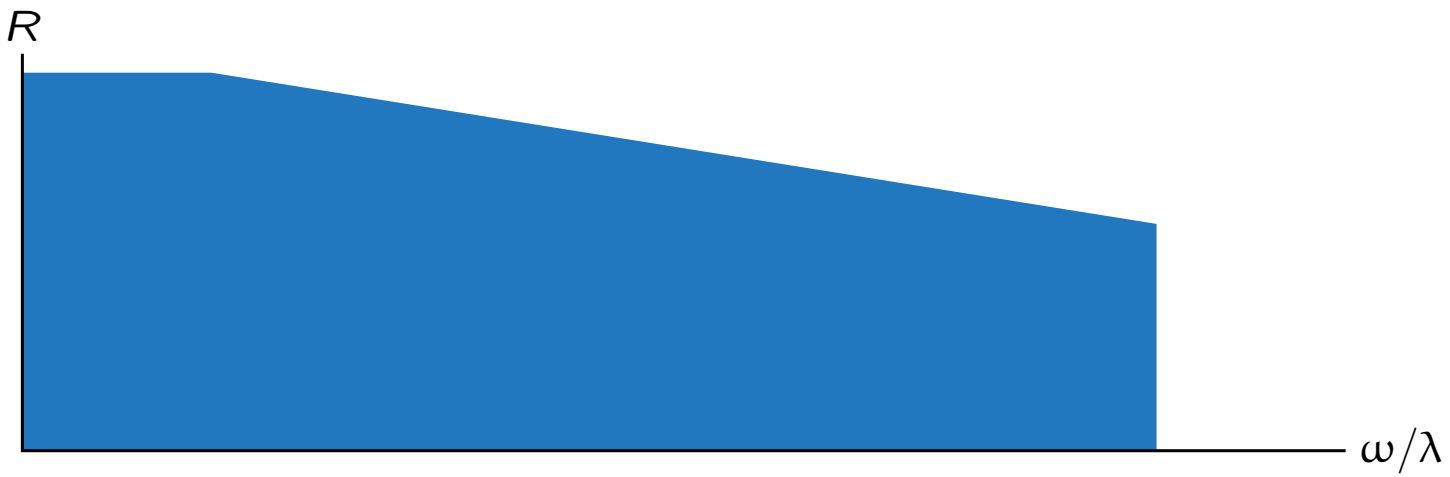
aberration

chromatic:

- not intrinsic to reflective optics!
- due to gravity

  $\Delta z \propto x^2 \lambda^2$

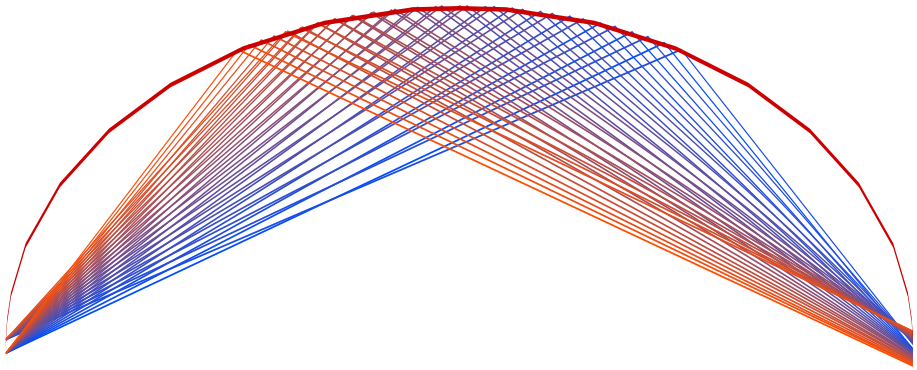
- due to λ-dependent reflectivity



aberration

coma:

- for finite sources / non-parallel beams



- can be partially corrected for
  $\Rightarrow$ 2nd reflection!

aberration

due to geometric imperfections

- finite width / coating
- alignment
- waviness

outline

basics on focusing

example: Selene guide

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Selene guide system

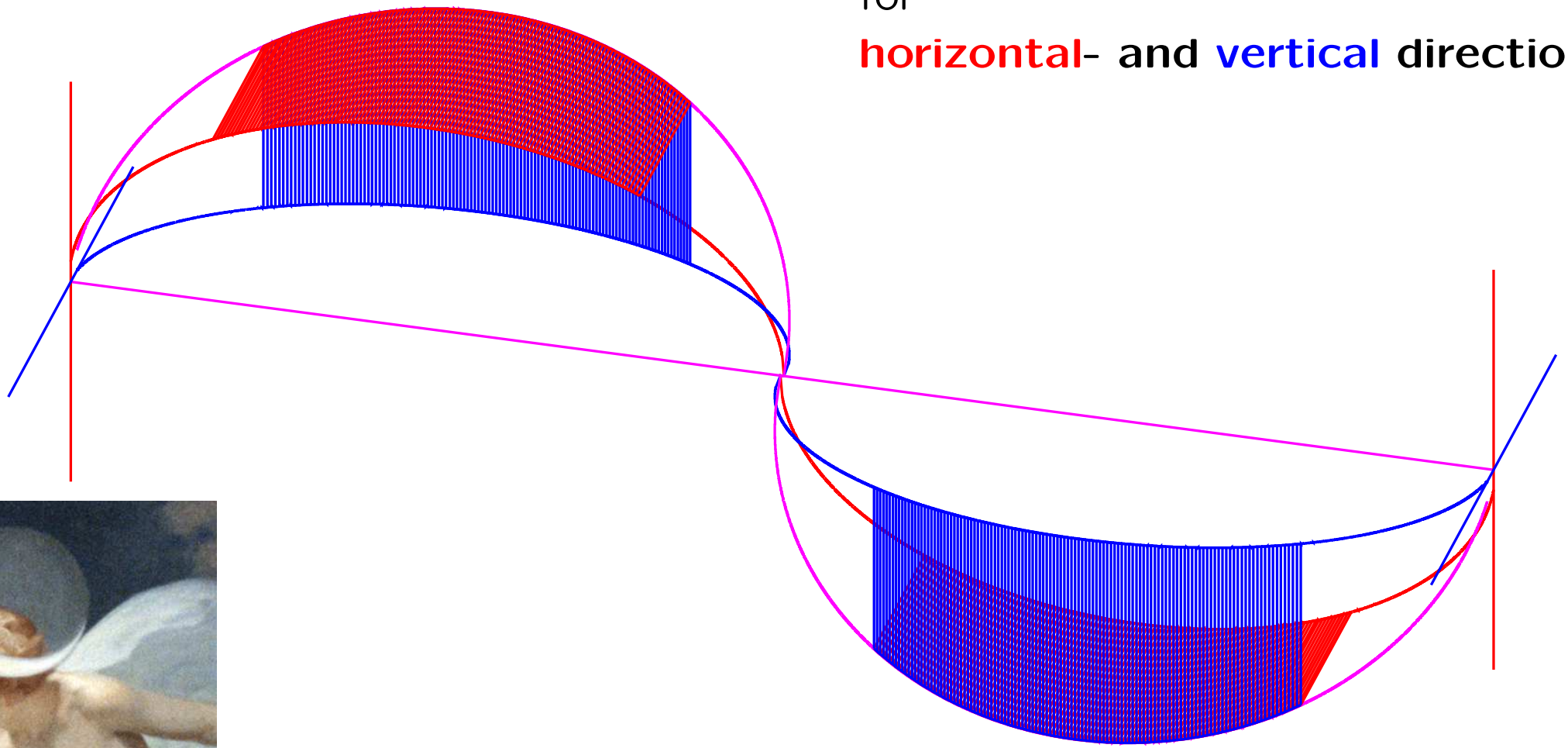
point-to-point focusing

with

2 subsequent elliptical reflectors

for

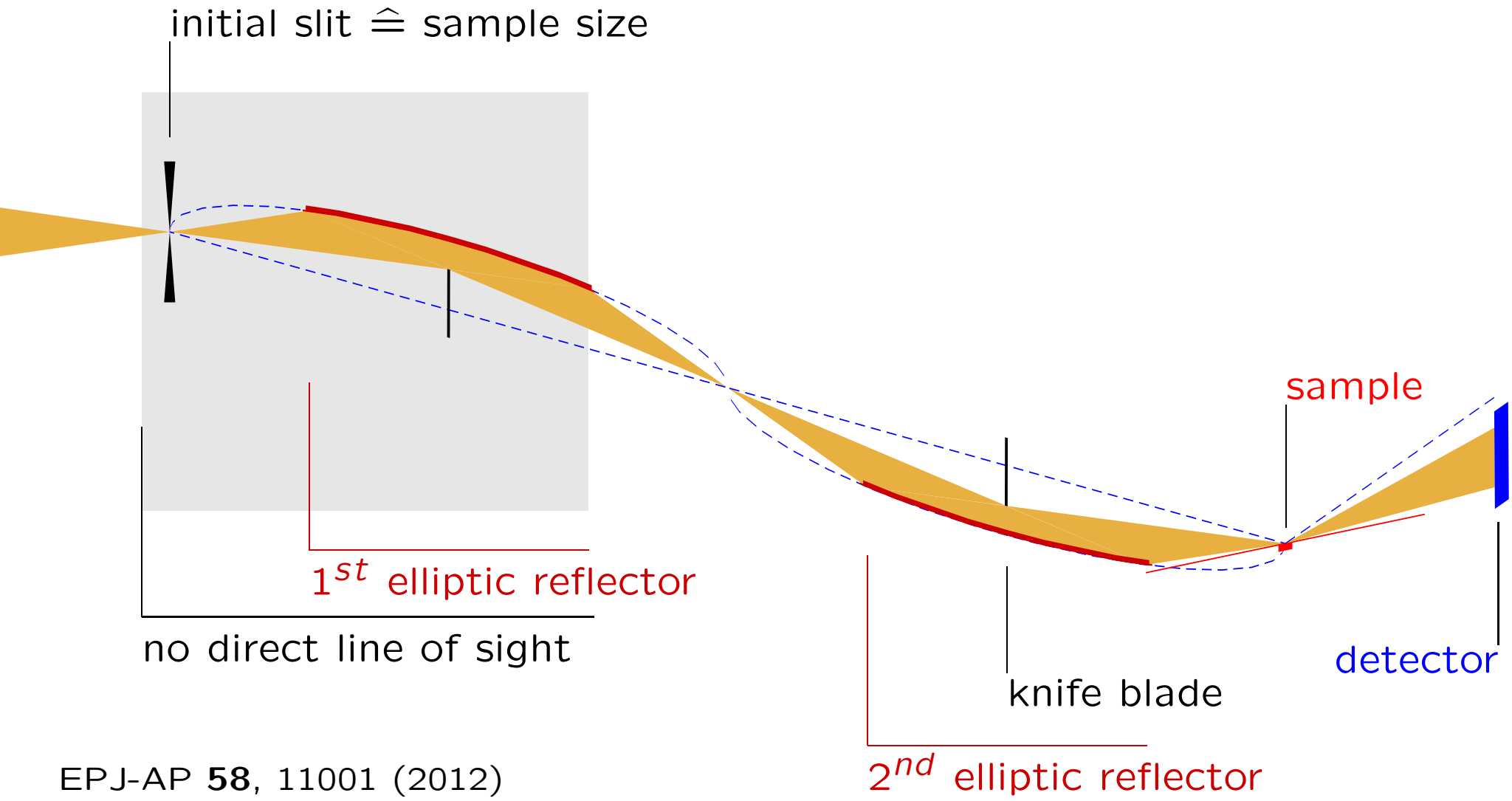
horizontal- and vertical direction



Selene guide system

generic lay-out

cut in the scattering plane stretched by 10 normal to incident beam

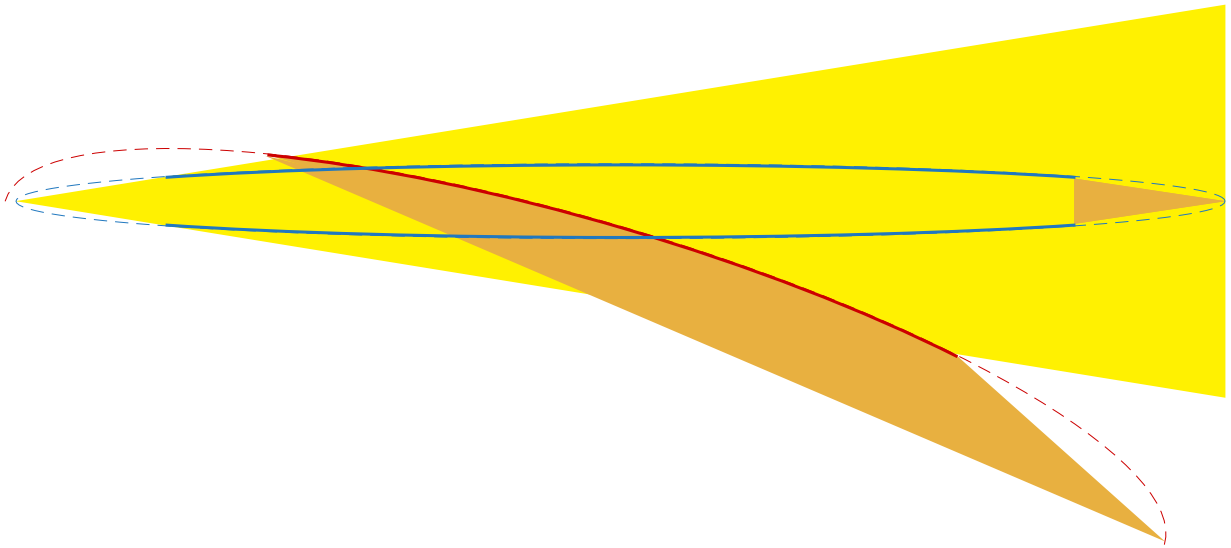


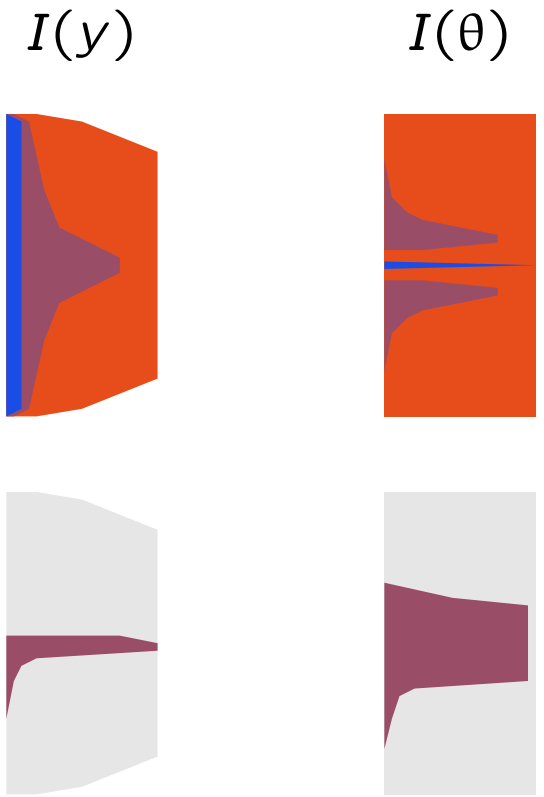
EPJ-AP **58**, 11001 (2012)

Selene vs. full elliptic guide

Selene:

- exactly 1 reflection!
- no line of sight

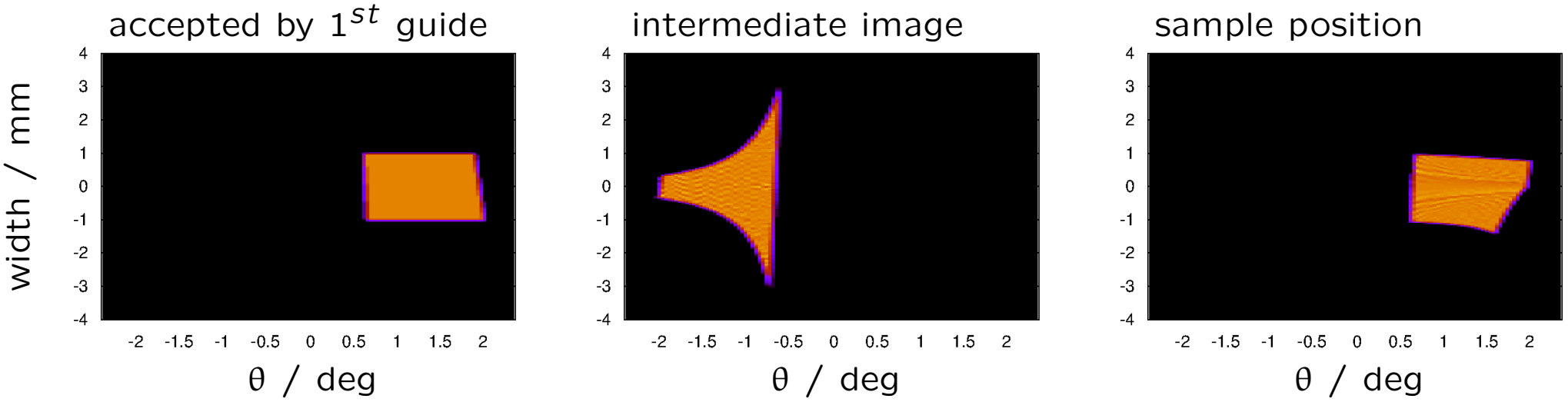




coma aberration & correction

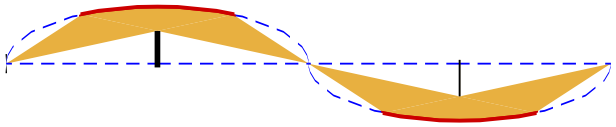
$$z' \approx z \frac{1+\xi}{1-\xi}$$

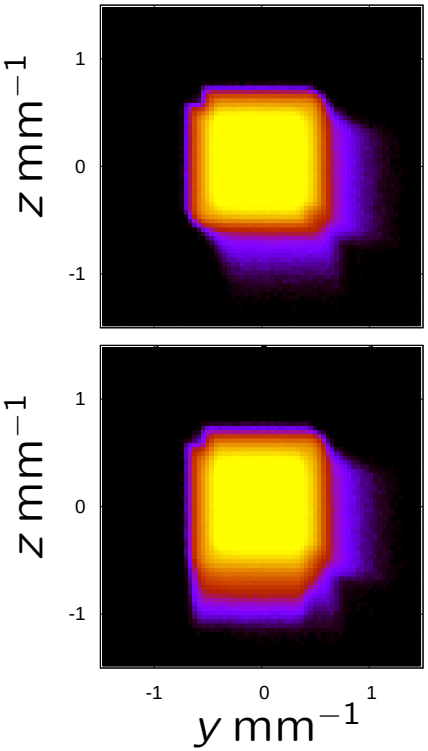
$a = 2000$ mm
$b = 40$ mm

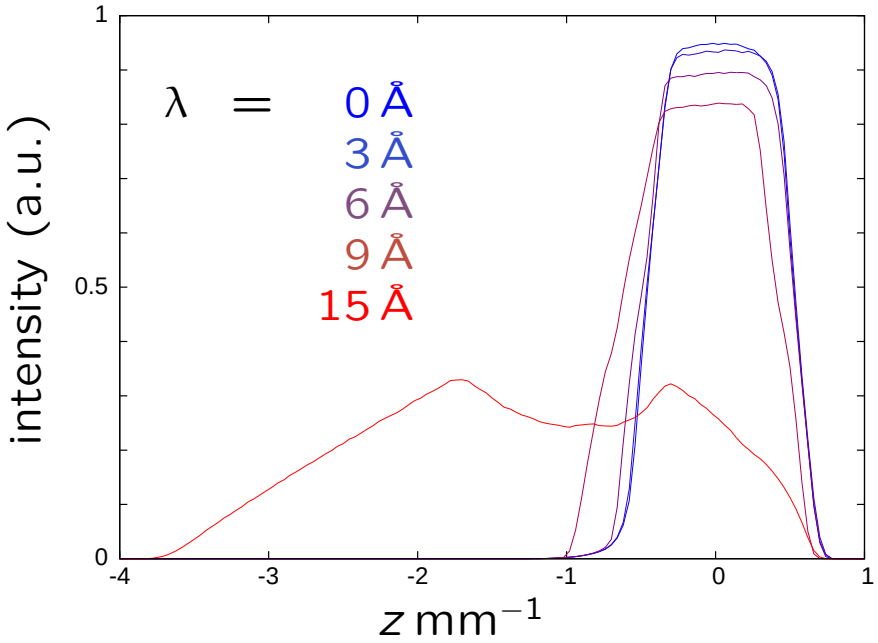


chromatic aberration due to gravity

McStas simulation on a 40 m guide



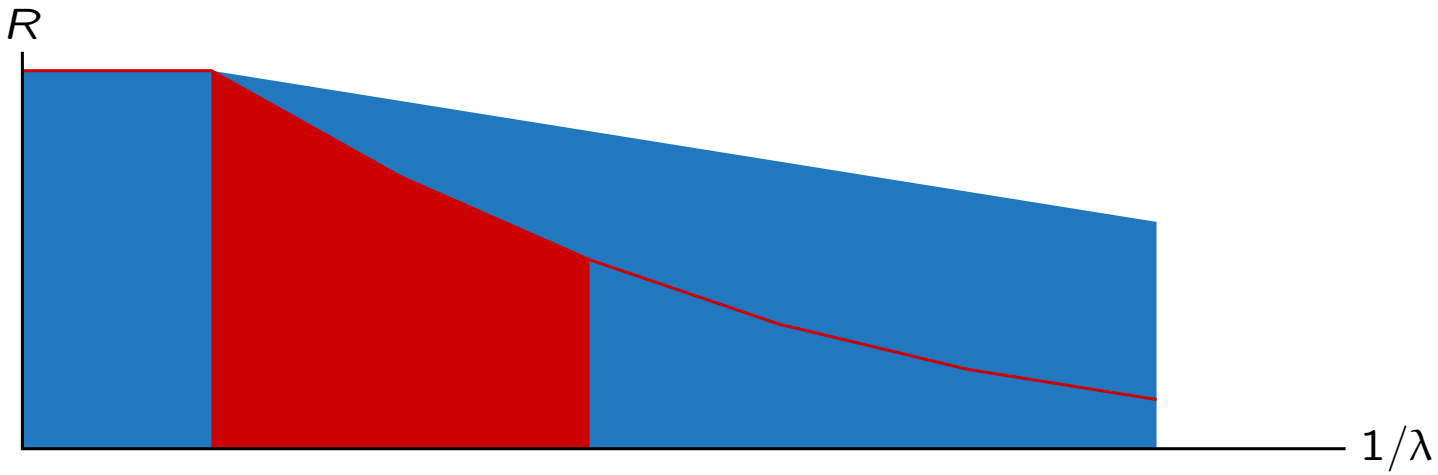




Selene transmission

$\omega \approx$ constant!

$\Rightarrow I \propto I_0 \, R(\lambda)^4$



strongly favours small-m coating!

outline

basics on focusing

example: Selene guide

optics

performance & limitations

discussion

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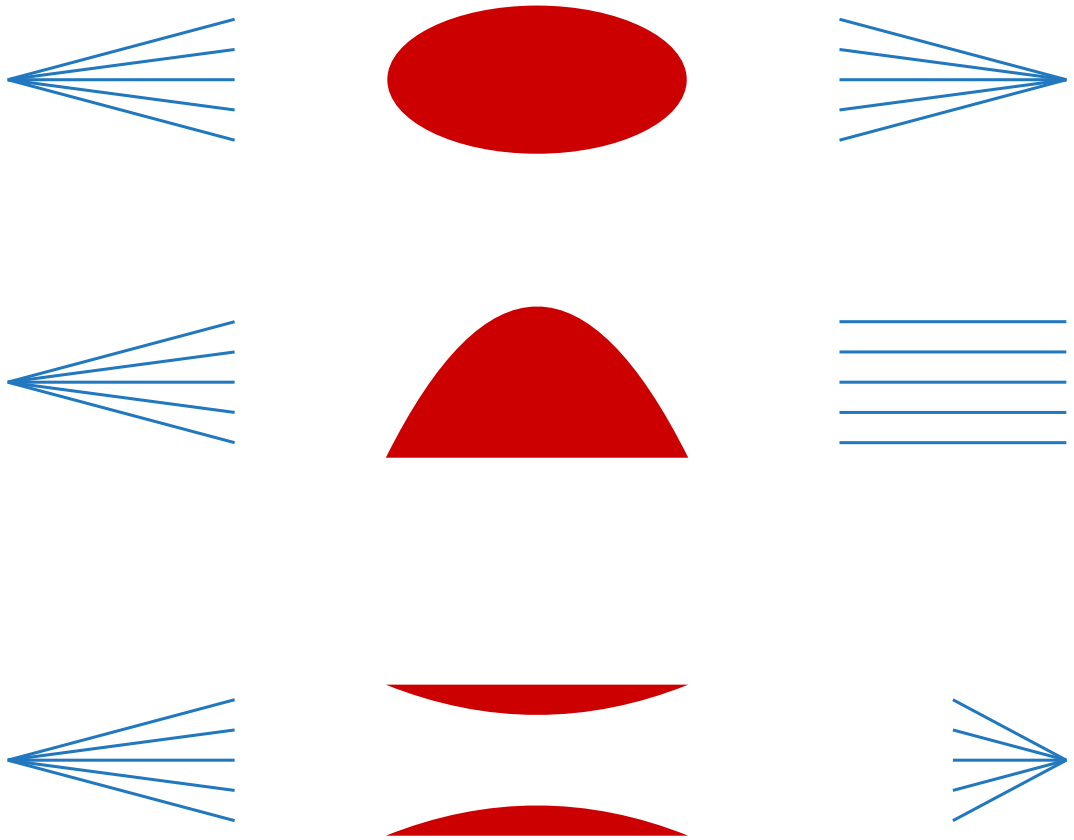
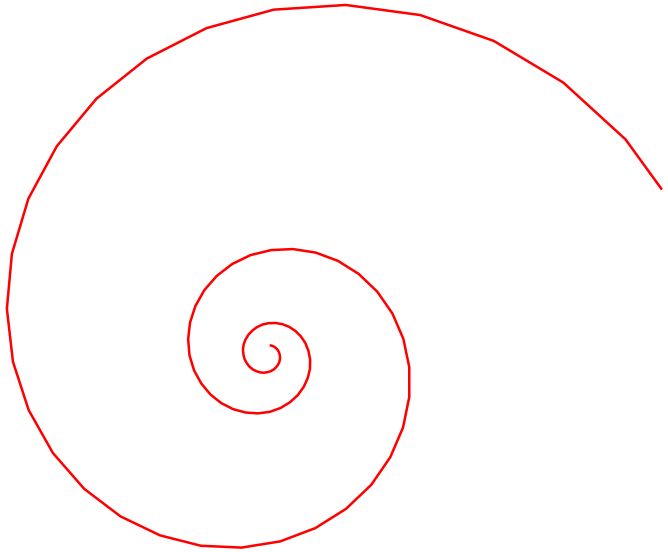
optics & options

basic operation rules for reflective optics



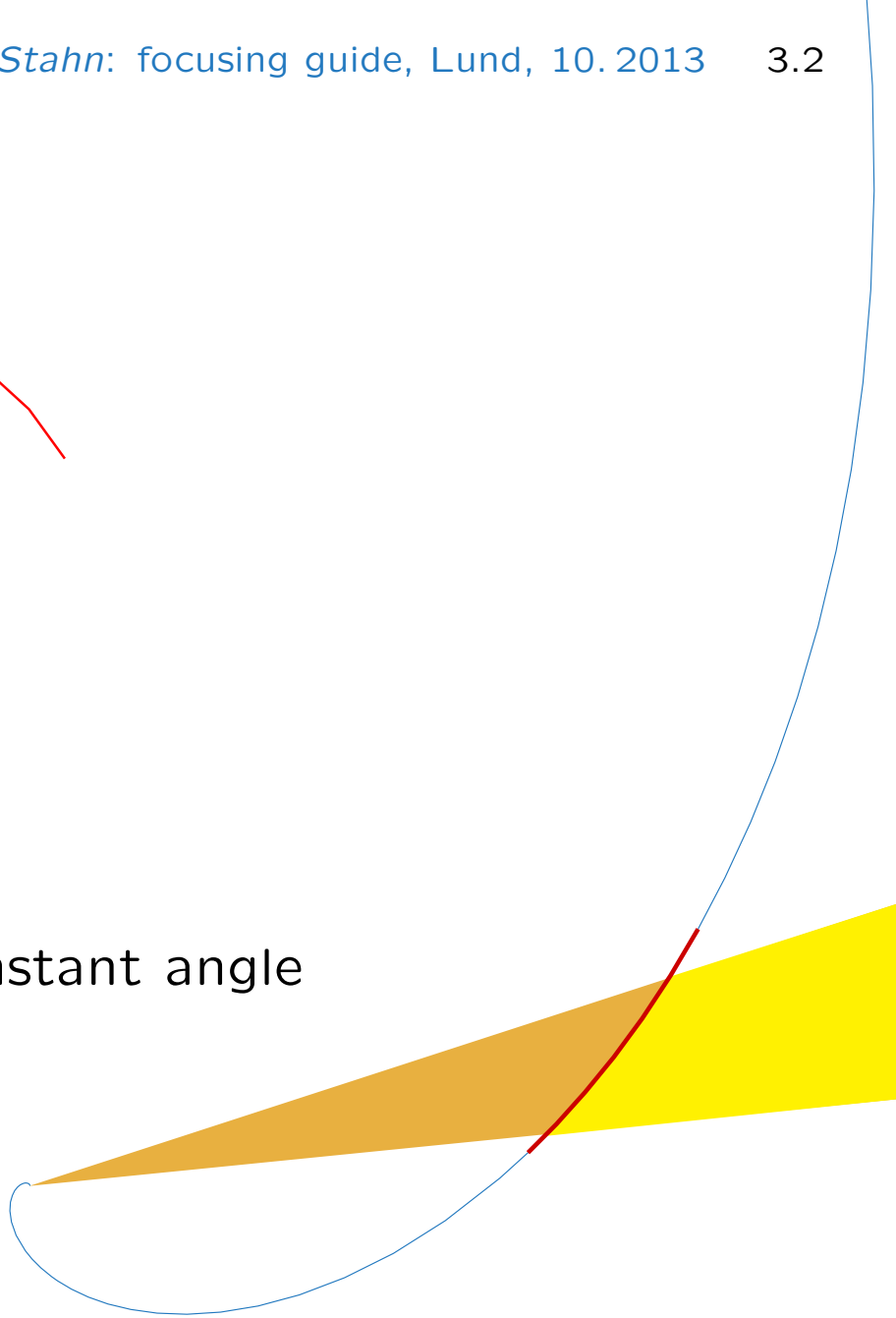
optics & options

polariser



a log-spiral intersects a divergent beam at constant angle

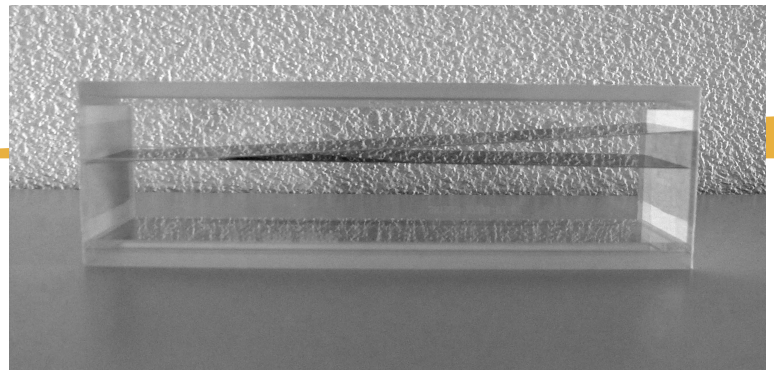
$\Rightarrow$ low-m coating, high performance



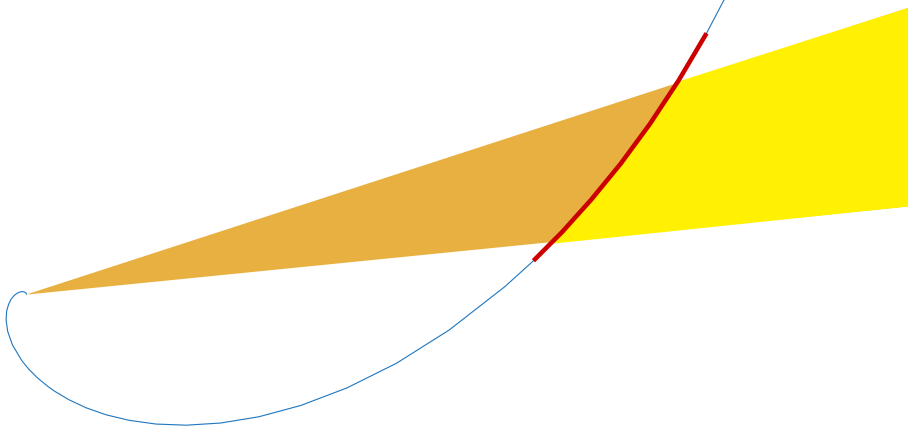
optics & options

polariser: logarithmic spiral

polariser
215 mm long, 1.8° acceptance

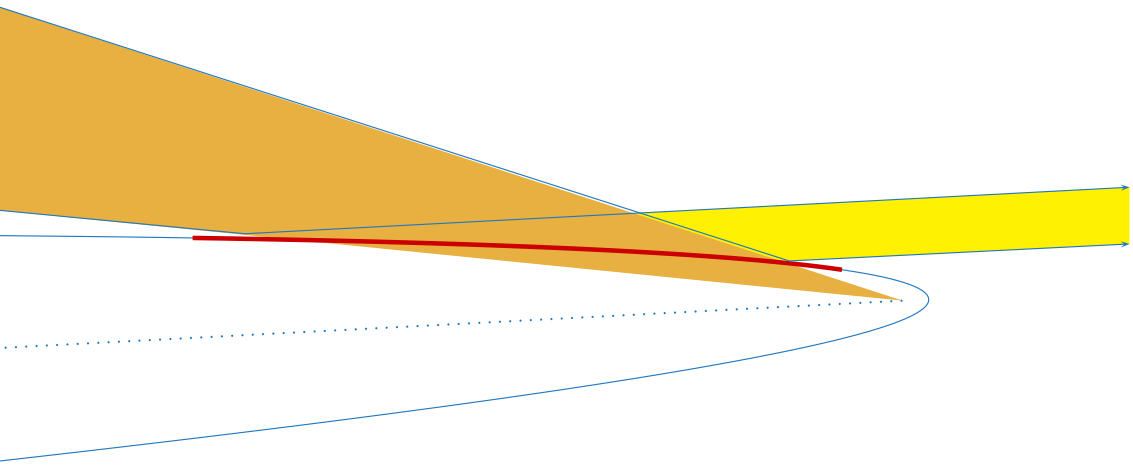


(by SwissNeutronics)



optics & options

condenser: parabolic deflector to generate a parallel beam



parabola axis ⇒ beam direction

focal length ⇒ beam width

beam width & spot size ⇒ divergence

no collimator needed

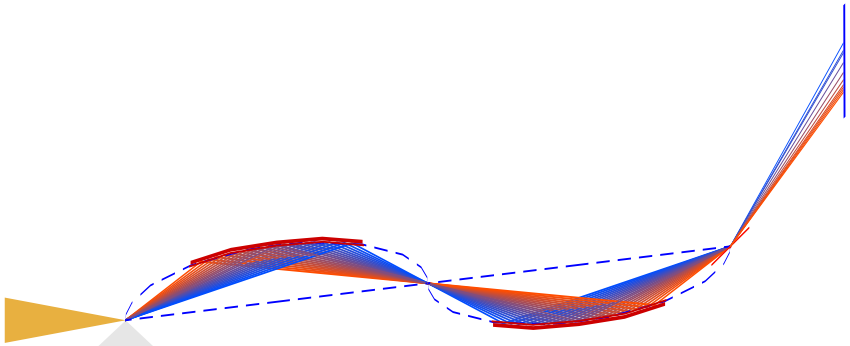
tunable

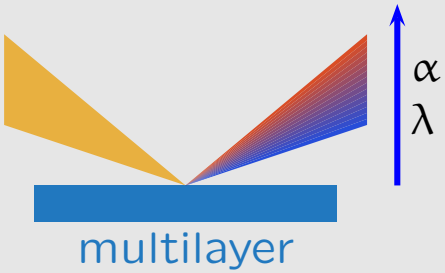
(not yet realised)

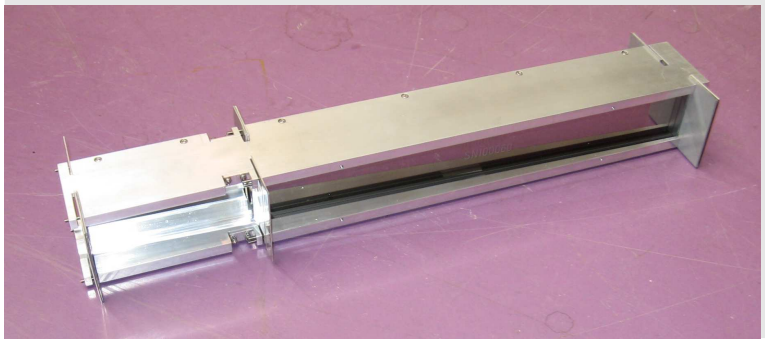
optics & options

spectral analysis

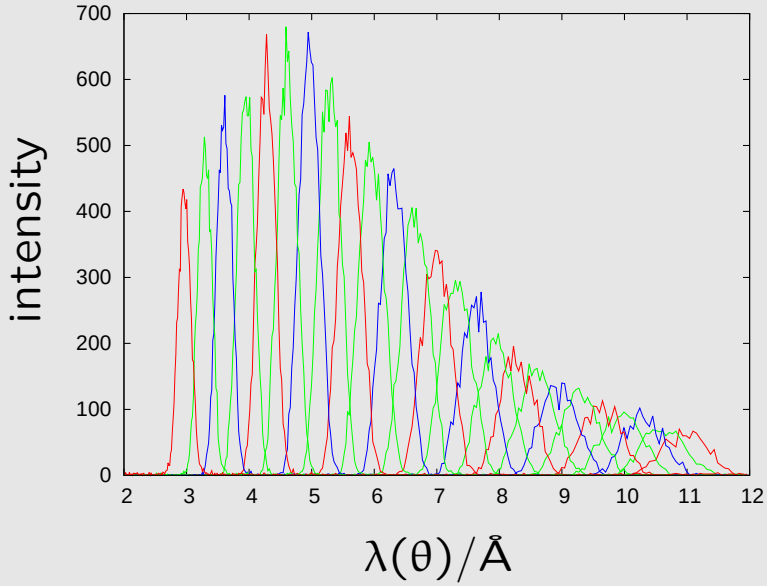
using a multilayer monochromator



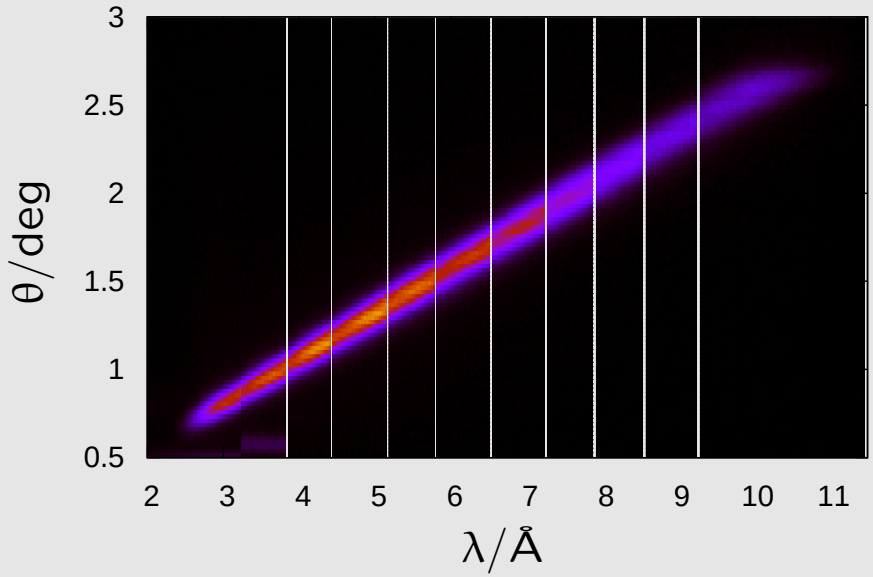




double ML monochromator



$I(\lambda, \theta)$ measured on Amor



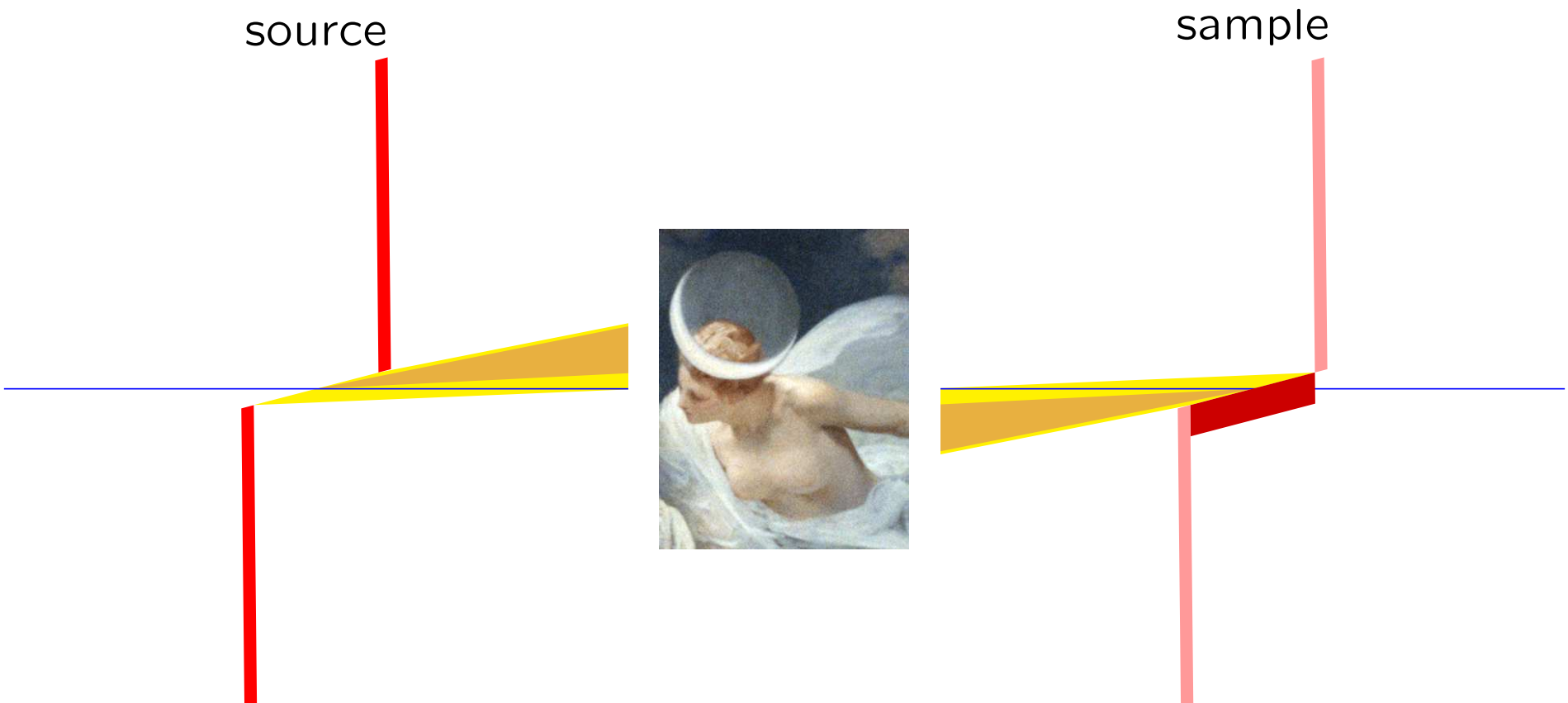
optics & options

3D footprint definition using the imaging property of the *Selene* guide

point source ⇒ illuminates sample centre

finite sample ⇒ needs finite source

source shape & orientation = image of footprint



optics & options

3D footprint definition using the imaging property of the *Selene* guide

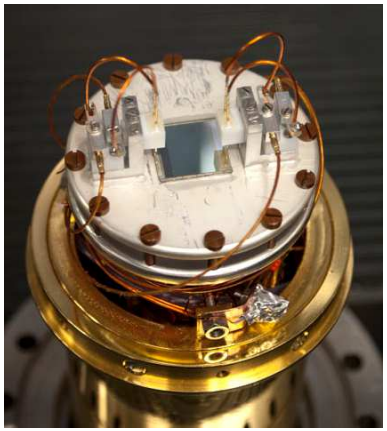
applications:

- exclude sample holder, etc.
- concentrate on one crystallite

reflectometry

- inner region within a trough
- inner region of a solid-liquid cell:

- samples with electrical contacts:



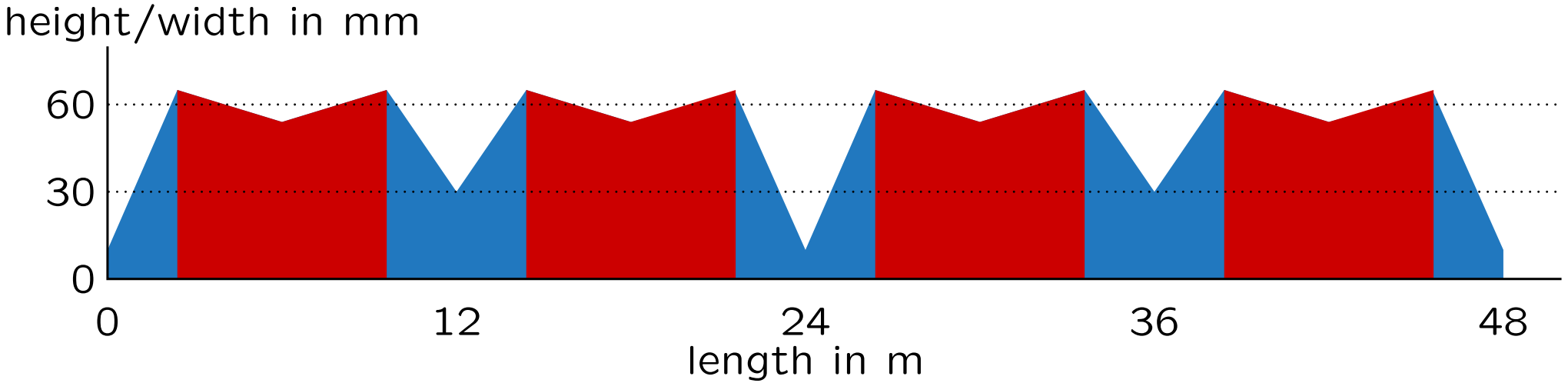
- partially coated substrates
- bent substrates

optics & options

choppers

- the *Selene* guide is compatible with all chopper set-ups
- 3/5 wide *natural* gaps
- moderate beam width

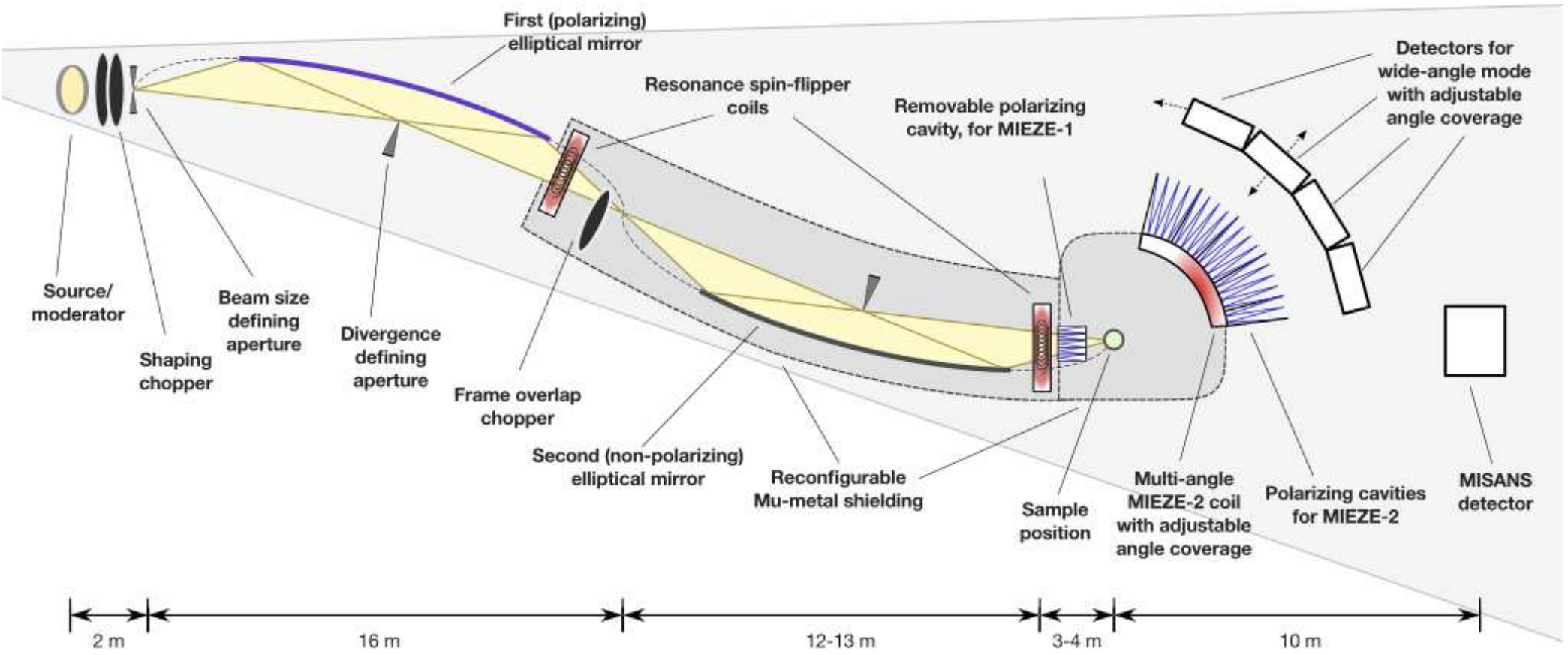
e.g. Εστία guide:



optics & options

MIEZE (NRSE) compatibility with *Selene* guide under investigation

all trajectories have the same length



G. Brandl, A. Chacón, R. Georgii, W. Häußler, *et al.* FRM II & TU Munich

outline

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reflectometer Εστία

key parameters

sample size $1 \times 1\,\mathrm{mm}^2$
to $10 \times 50\,\mathrm{mm}^2$

horizontal scattering plane

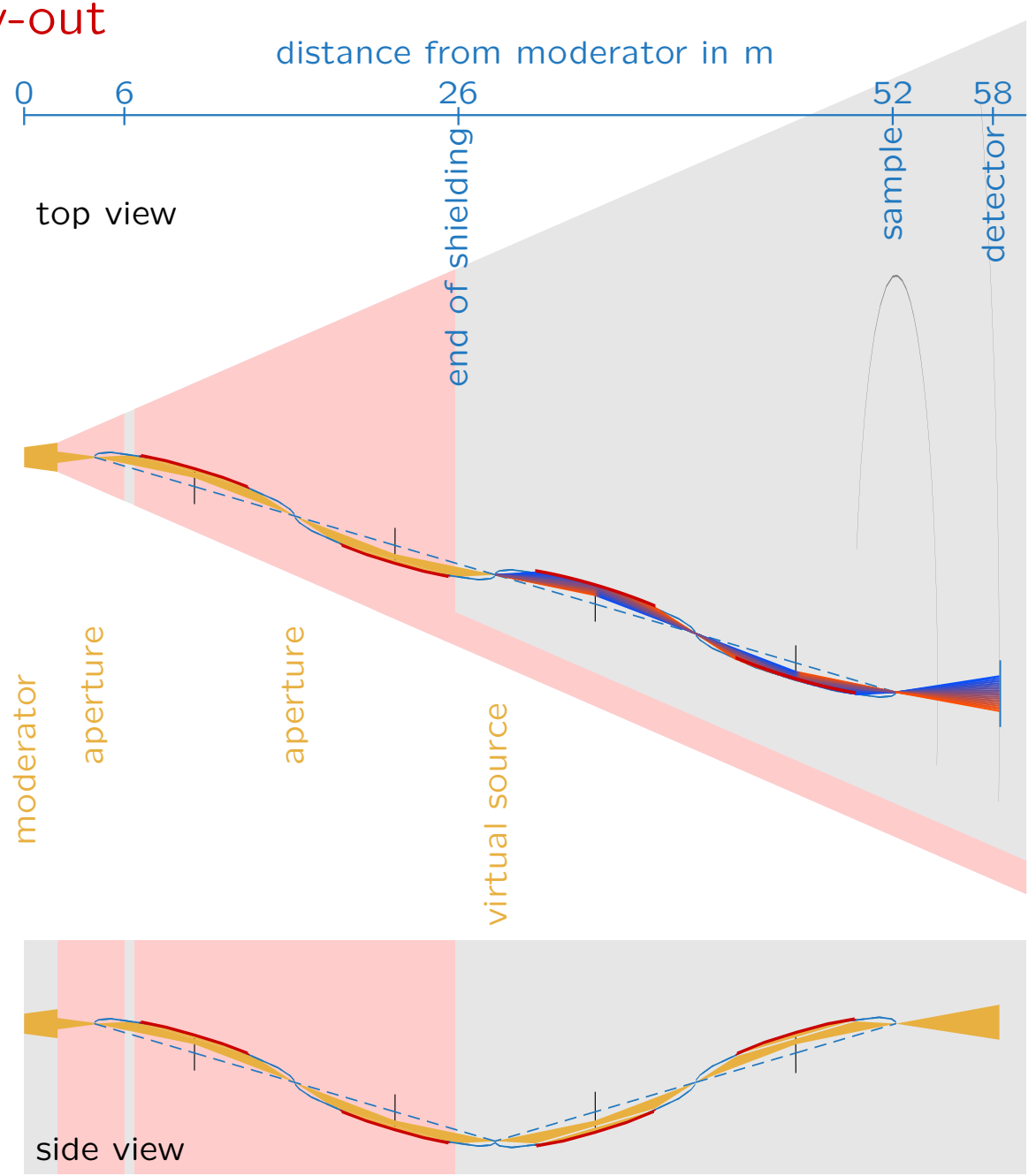
intrinsic resolution 2 to 4%

polarisation option

truly focusing

low background

lay-out

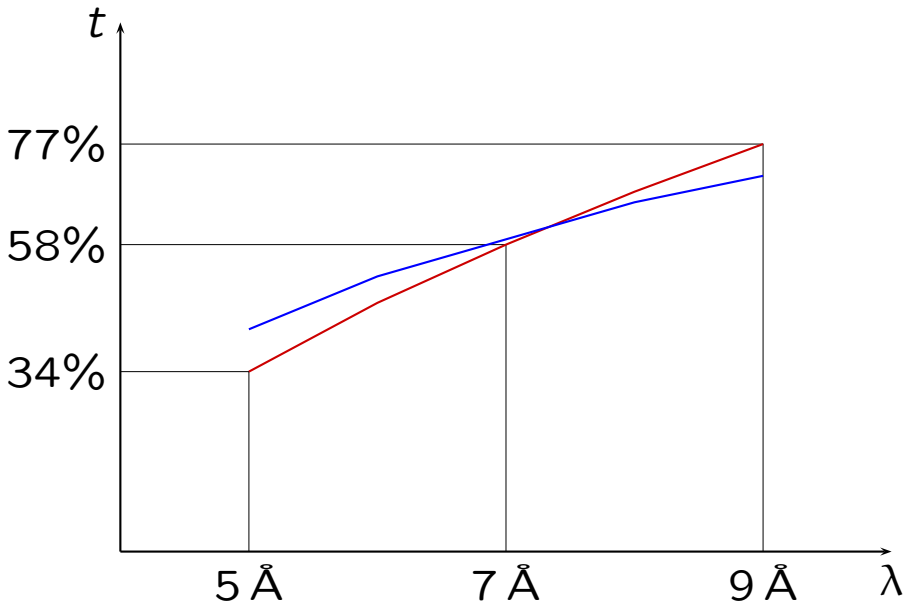


transmission

- is a function of $\Delta\theta/\lambda_{min}$
- $\omega \approx$ const. $\Rightarrow$ high angle of incidence for all trajectories!

e.g. Εστία guide: $\Delta\theta = 15.^\circ$, $\lambda_{min} = 5\,\text{Å}$, 8 reflections

(not optimised for brilliance transfer, but for t, Δq_z and low background)

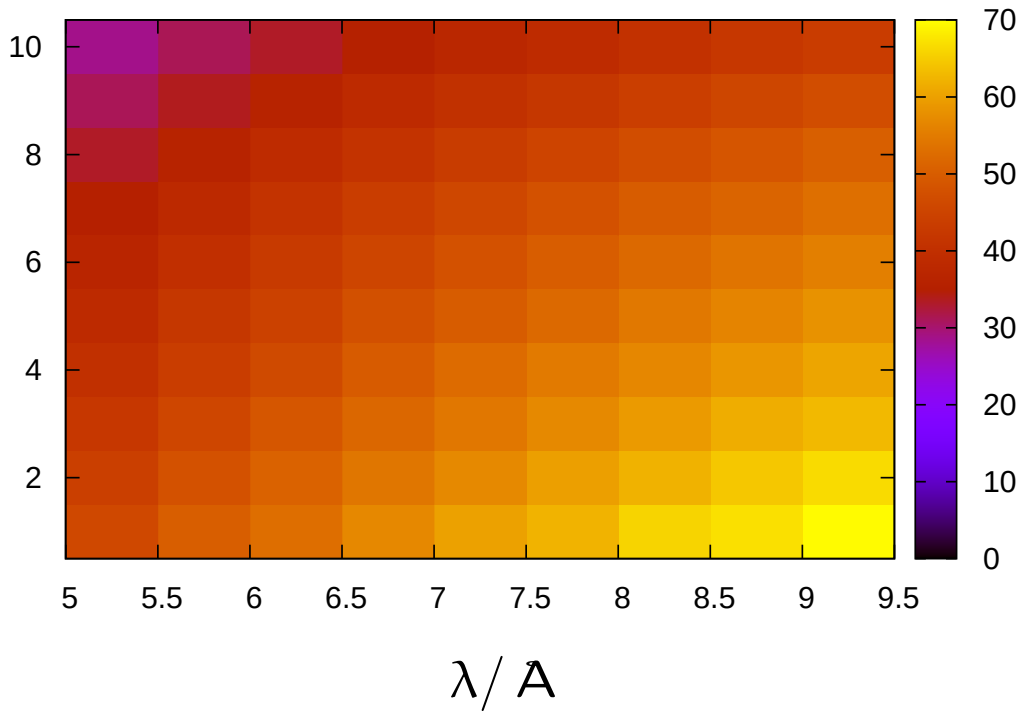


spot size

- guide performance depends strongly on the sample size!

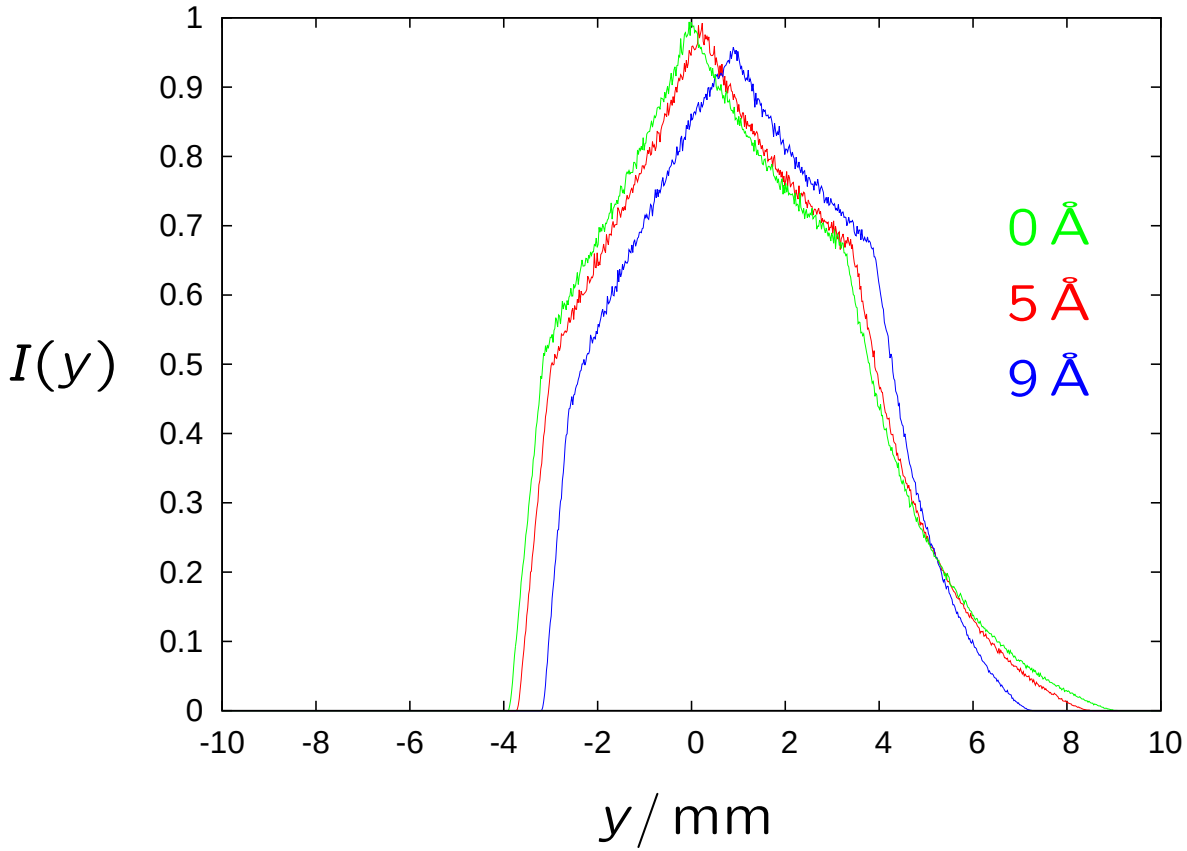
e.g. Εστία (8 reflections) spot width 10 mm and

spot height



gravity

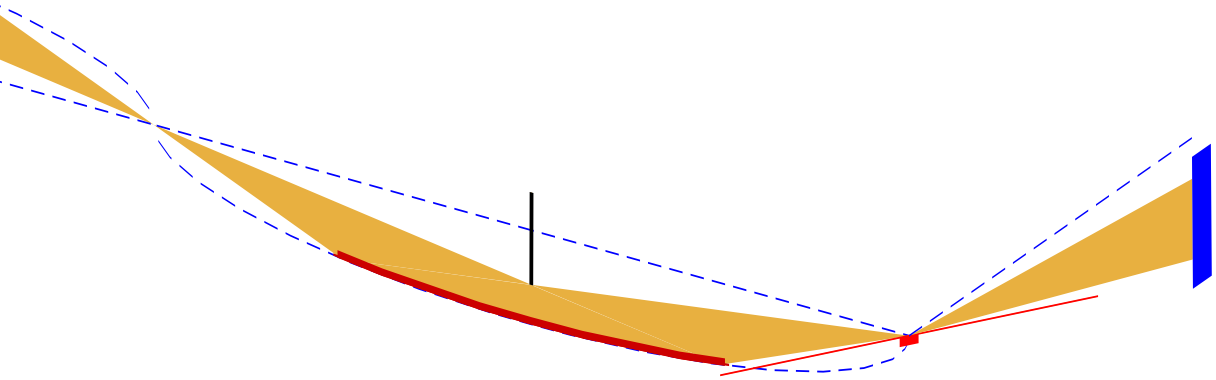
Εστία: vertical intensity distribution on the sample

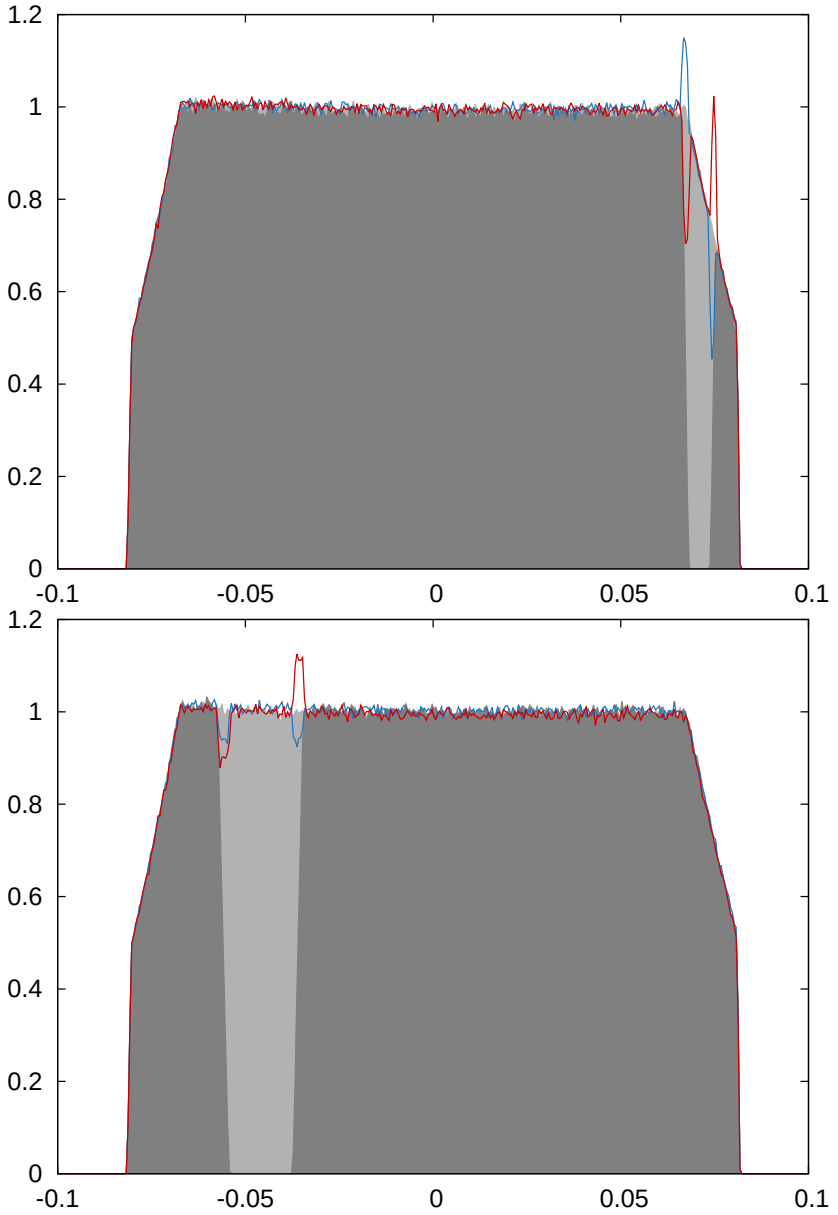


accuracy of alignment

- displacement of 0.1 mm
- tilt by 0.001°

of 0.5 m elements of the last section:



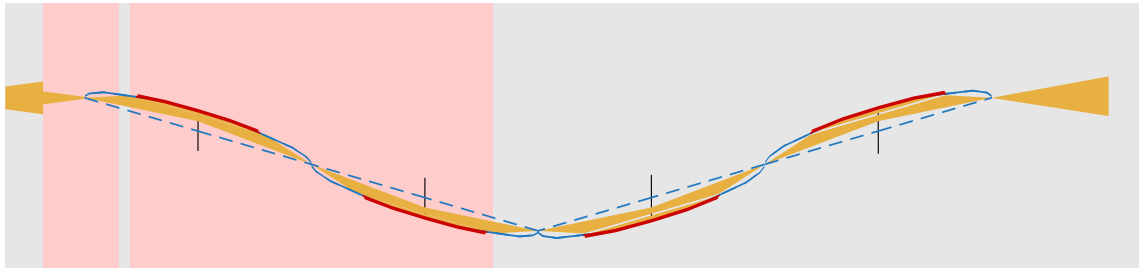


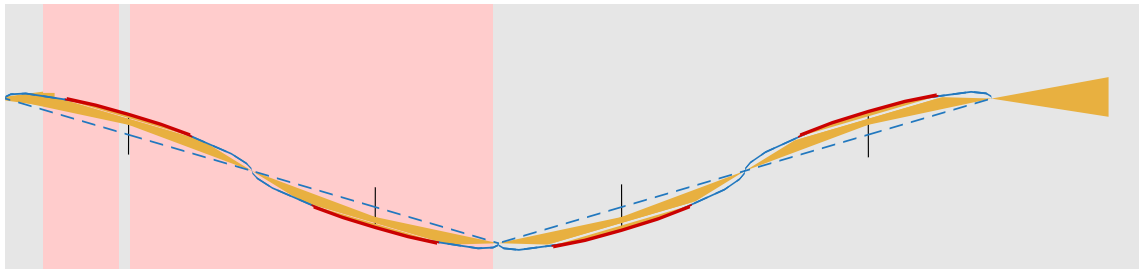
adaption to small moderator

- *tiny* shift of guide geometry
- pinhole replaced by moderator
- free space is sufficiently large

$\Rightarrow$ reduced shielding

$\Rightarrow$ source size not adjustable





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discussion

truly focusing guides are good for

- low divergence / high wavelength (transmission)
- short guide / short wavelength (gravity)
- small samples ($\approx 1\,\mathrm{cm}^2$)