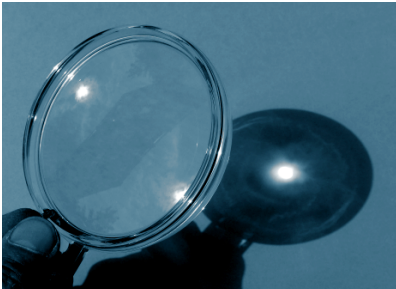


---

# benefits, prospects and limitations of a truly focusing neutron guide



## people involved

McStas simulations

Emanouela Rantsiou  
Tobias Panzner  
Panos Korelis  
Uwe Filges

inspiration

*Selene*

experiments

Ursula Bengaard Hansen  
Birgit Wiedemann  
Anette Vickery

PSI infrastructure

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

ideas / discussions

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

# outline

**basics on focusing**

**example: Selene guide**

**optics**

**performance & limitations**

**discussion**

# outline

**basics on focusing**

example: Selene guide

optics

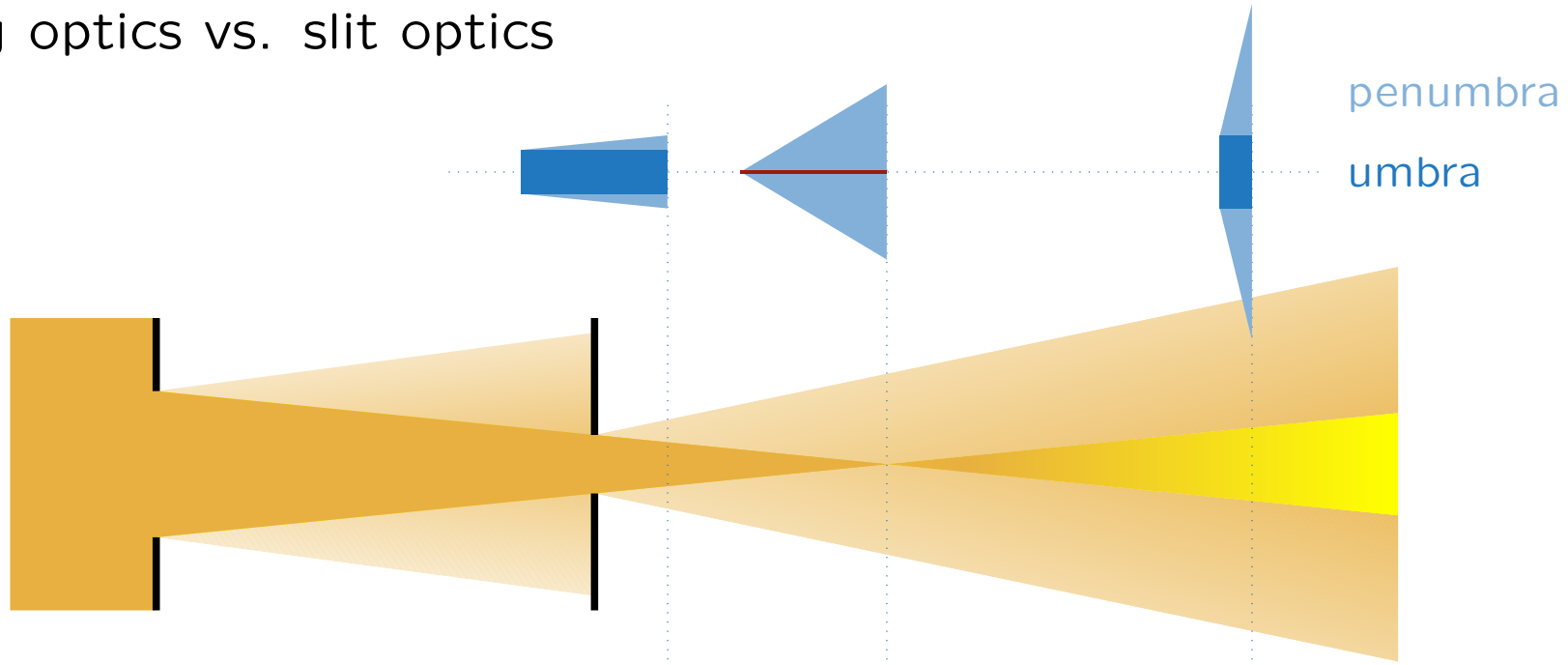
performance & limitations

discussion

# basics

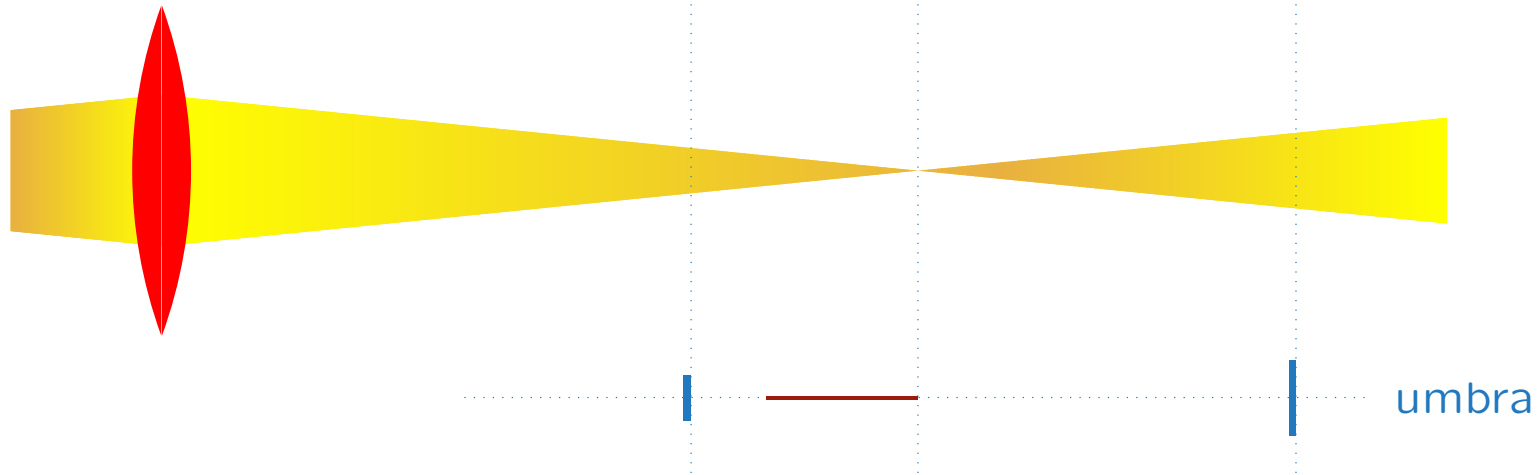
## focusing optics vs. slit optics

slits



beam profile

reflective /  
refractive optics

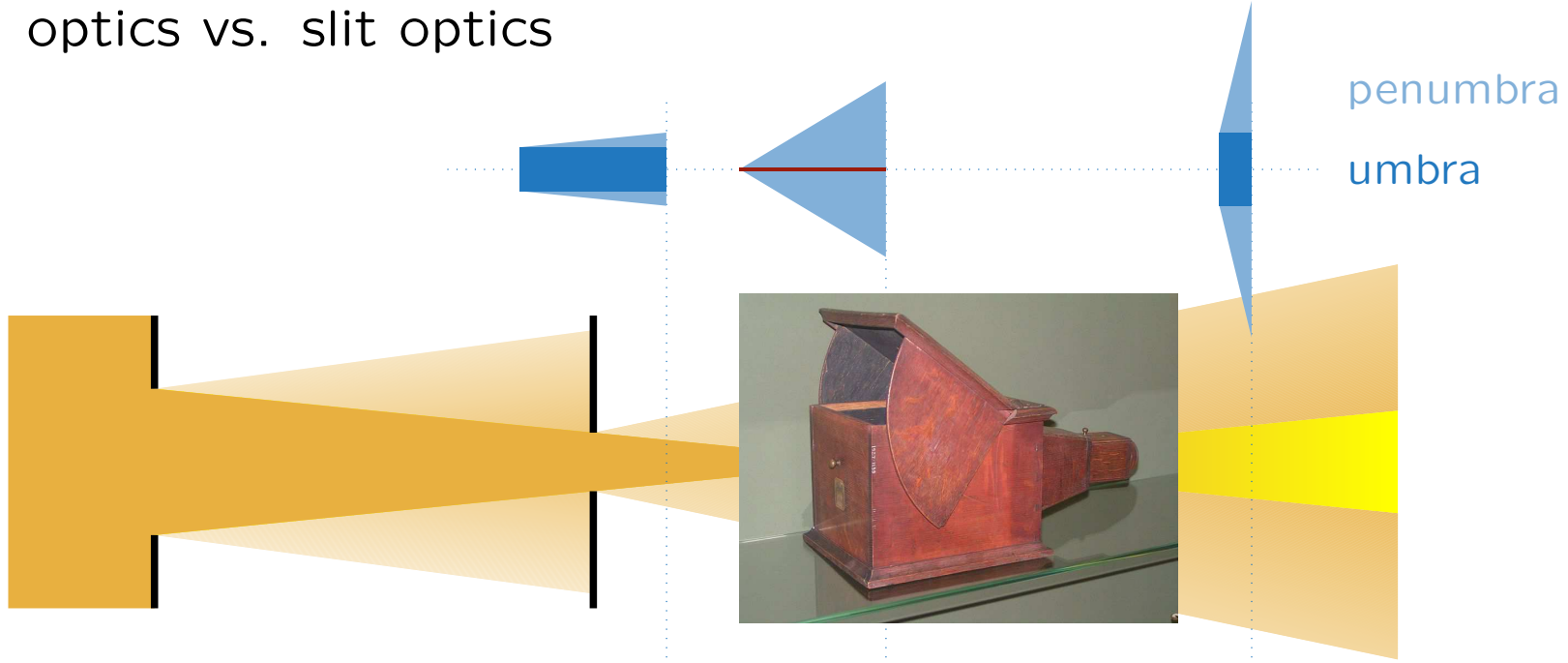


beam profile

# basics

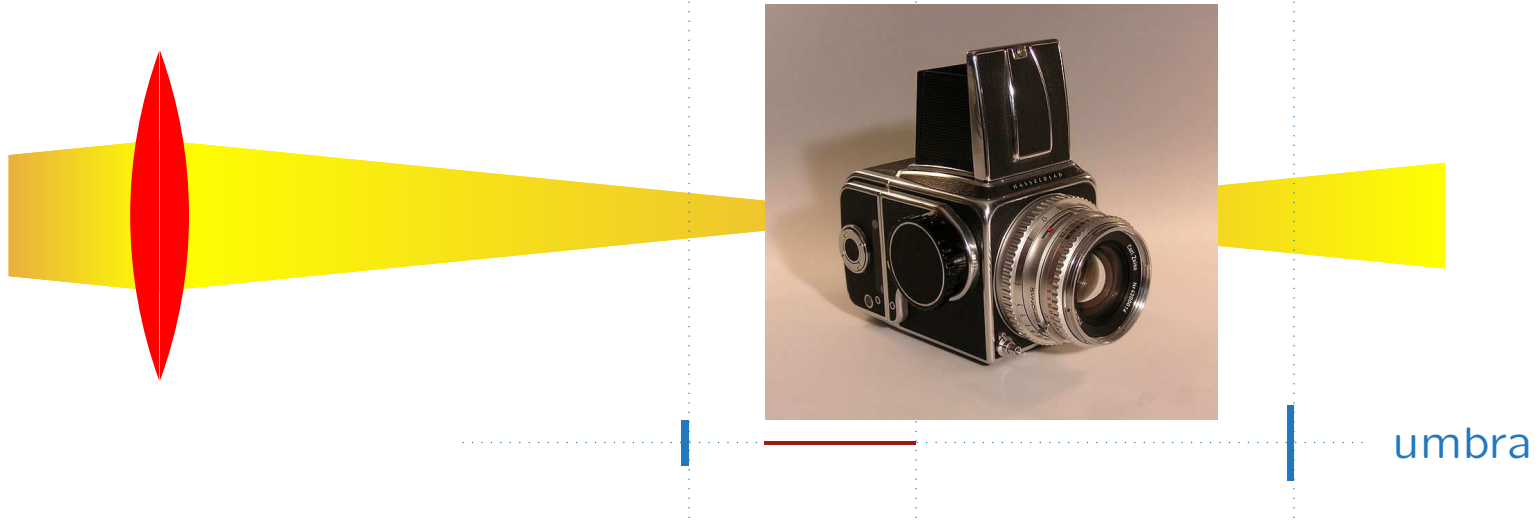
## focusing optics vs. slit optics

slits



beam profile

reflective /  
refractive optics



beam profile

## basics

### focusing optics vs. slit optics



simple mechanics, error tolerant

$\Delta\theta$  and  $\Delta y$  coupled

coated area Εστία: 20...40 m<sup>2</sup>



unimodal beam characteristics

low background

$\Delta\theta$  and  $\Delta y$  decoupled

high precision device, lower transmission

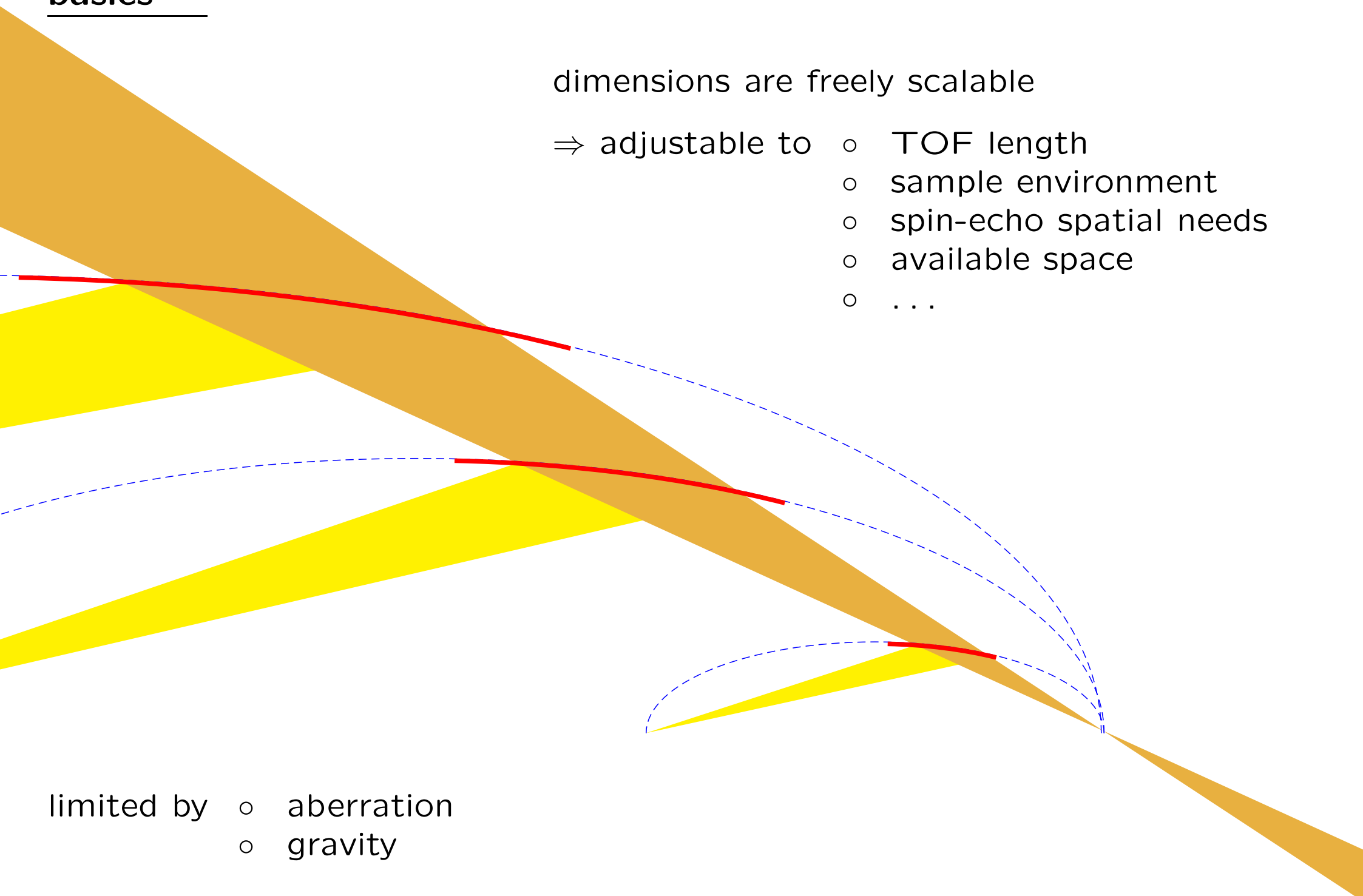
coated area Εστία: 4 m<sup>2</sup>

# basics

dimensions are freely scalable

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

- limited by
- aberration
  - gravity





## aberration

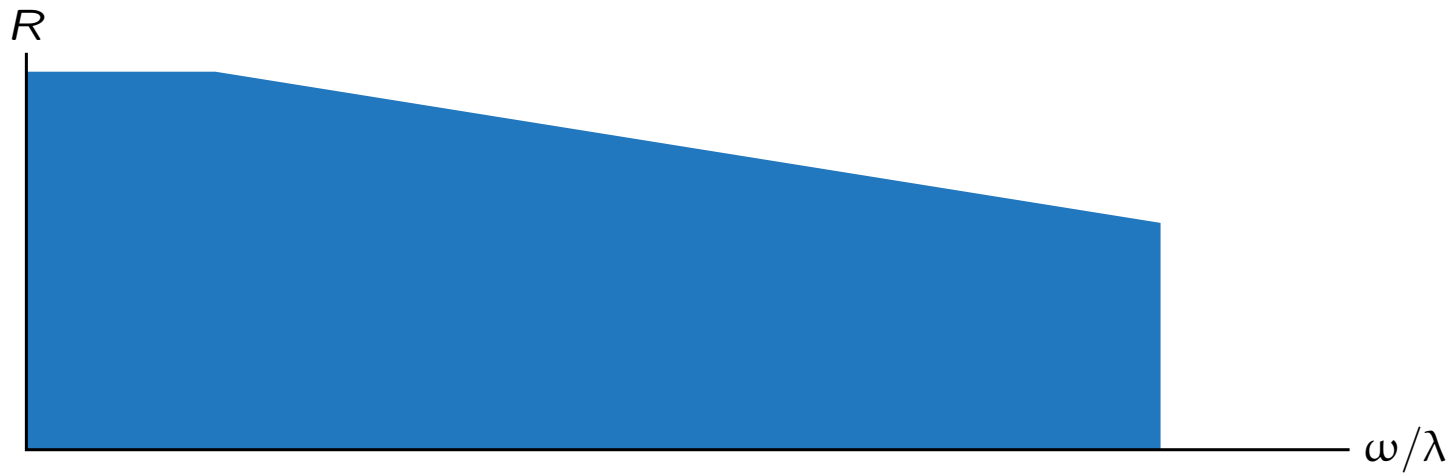
### chromatic:

- not intrinsic to reflective optics!

- due to gravity

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

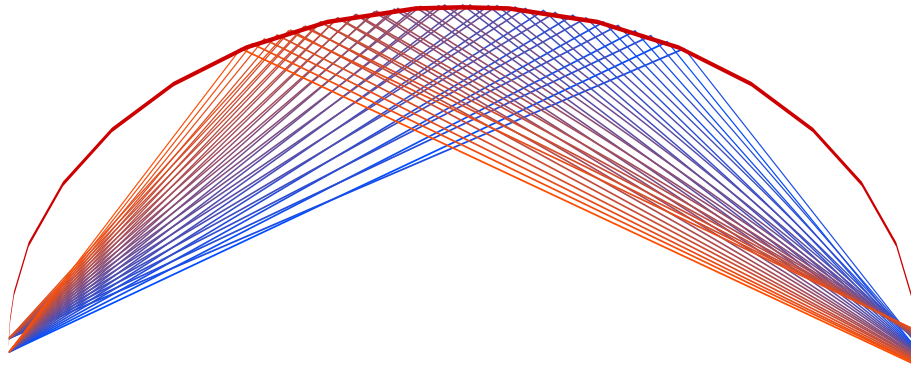
- due to  $\lambda$ -dependent reflectivity



## aberration

### coma:

- for finite sources / non-parallel beams



- can be partially corrected for  
⇒ 2nd reflection!

## aberration

### due to geometric imperfections

- finite width / coating
- alignment
- waviness



# outline

basics on focusing

**example: Selene guide**

optics

performance & limitations

discussion

# Selene guide system

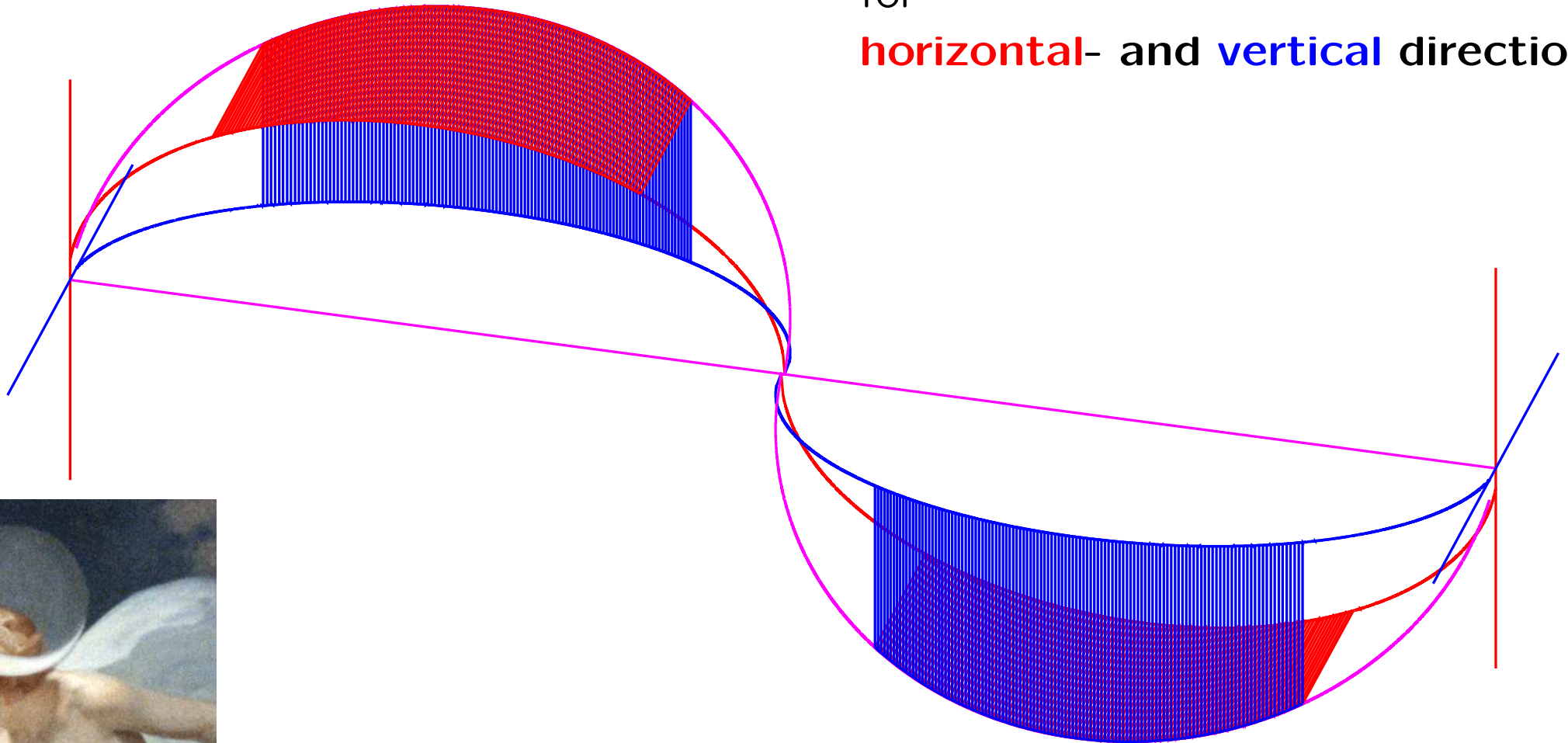
point-to-point focusing

with

2 subsequent elliptical reflectors

for

**horizontal-** and **vertical** direction

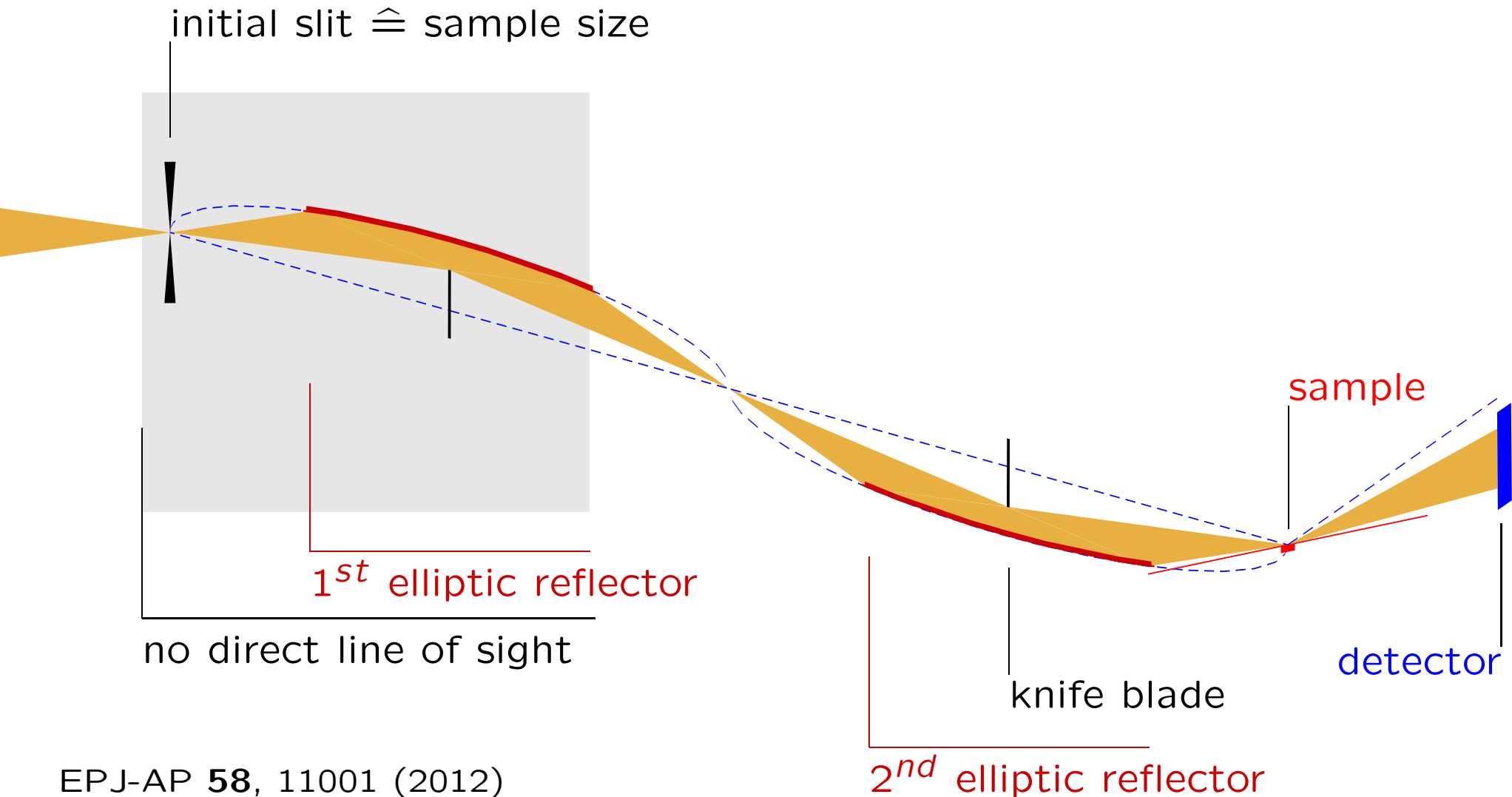


# Selene guide system

## generic lay-out

cut in the scattering plane

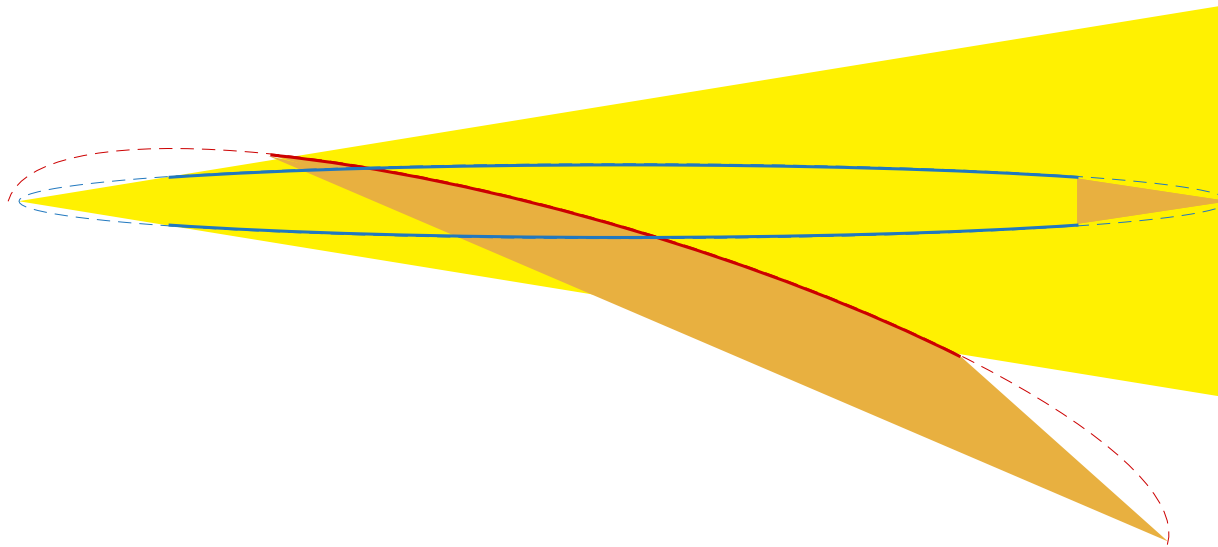
stretched by 10 normal to incident beam



## Selene vs. full elliptic guide

*Selene:*

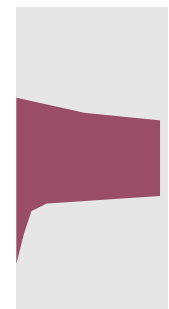
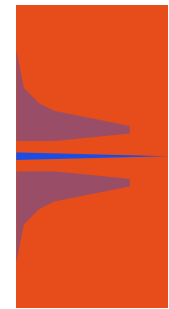
- exactly 1 reflection!
- no line of sight



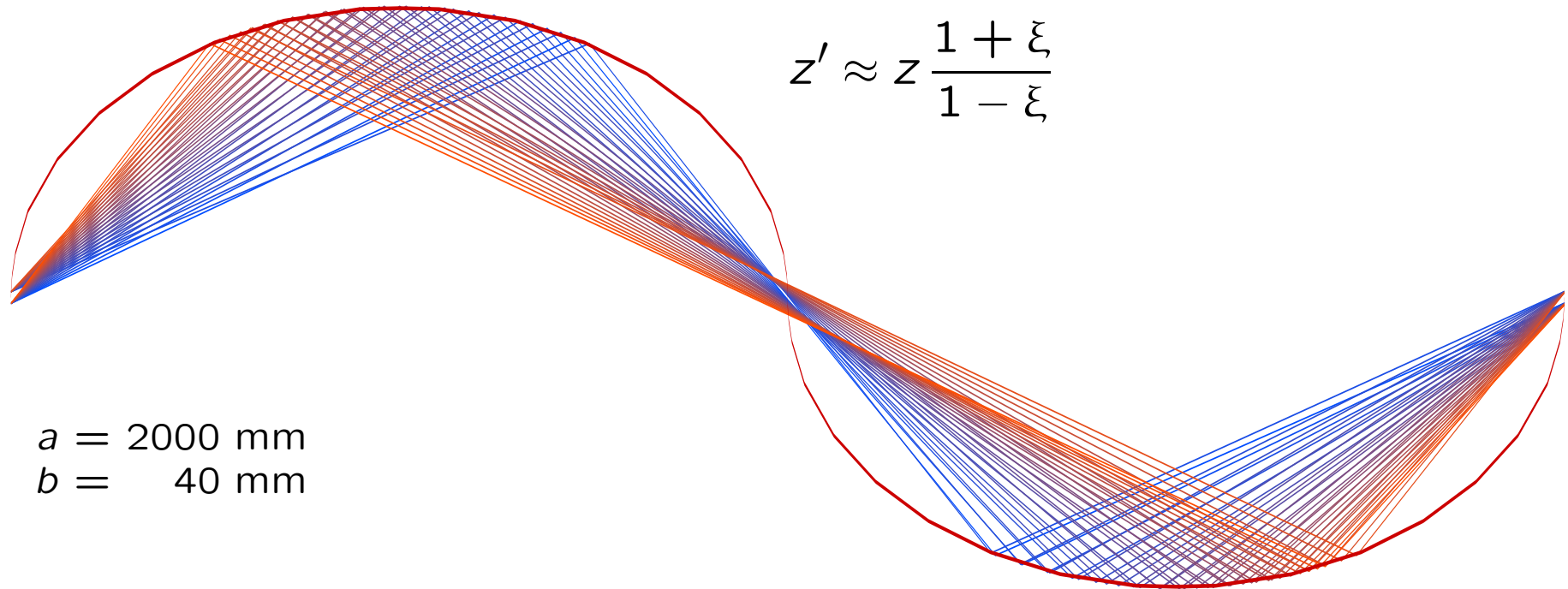
$I(y)$



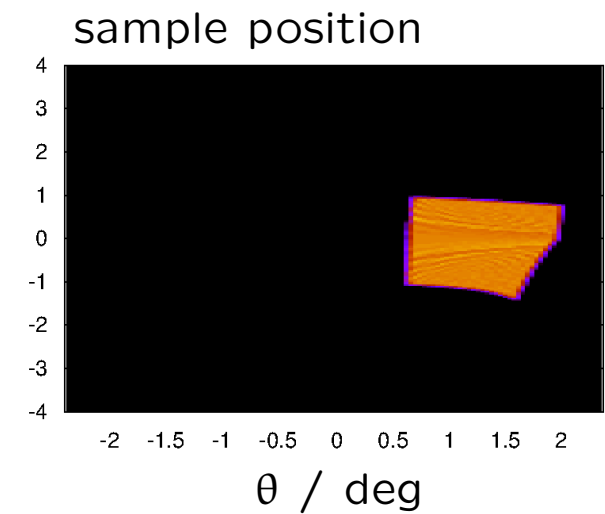
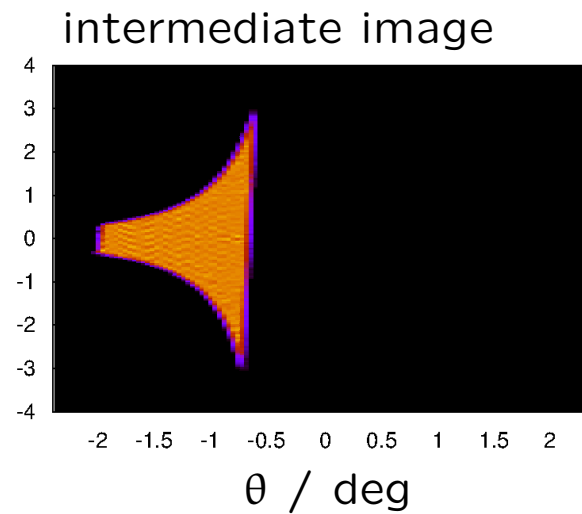
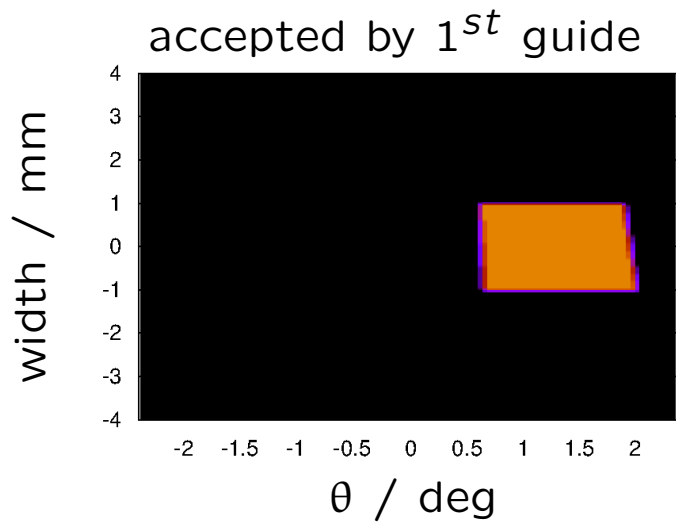
$I(\theta)$



# coma aberration & correction



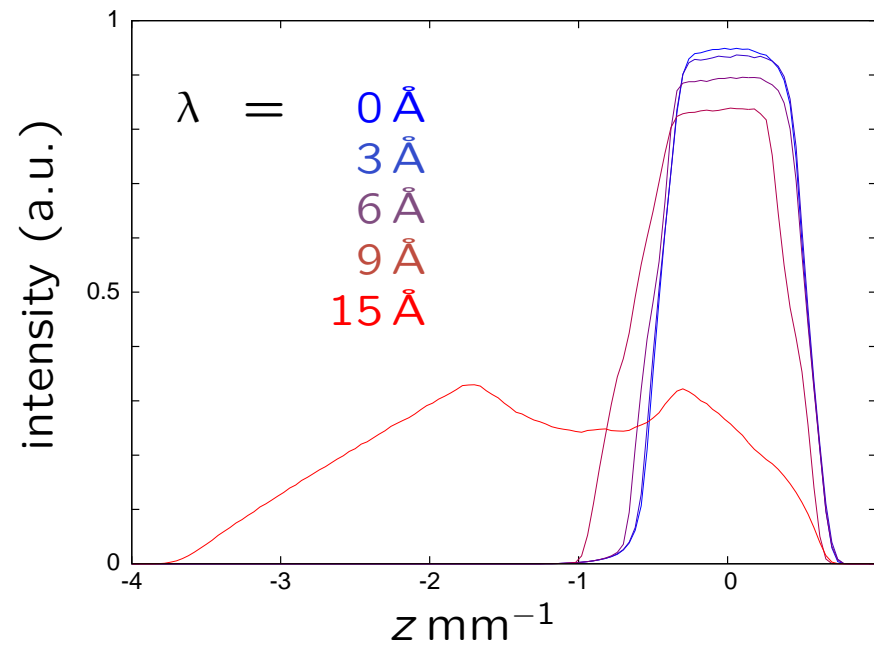
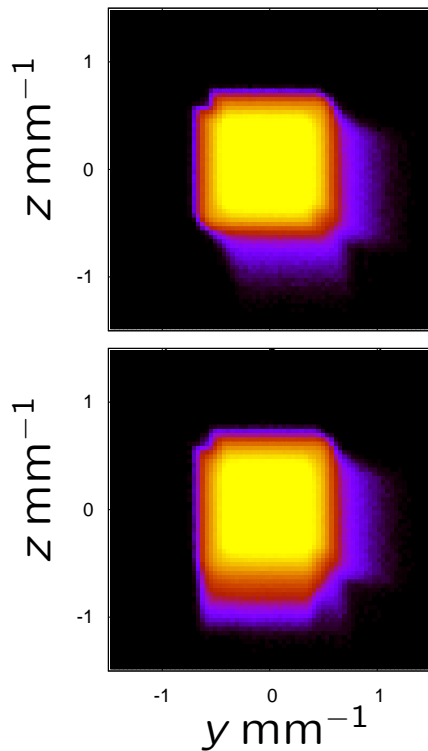
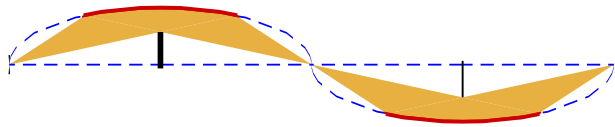
$a = 2000 \text{ mm}$   
 $b = 40 \text{ mm}$





# chromatic aberration due to gravity

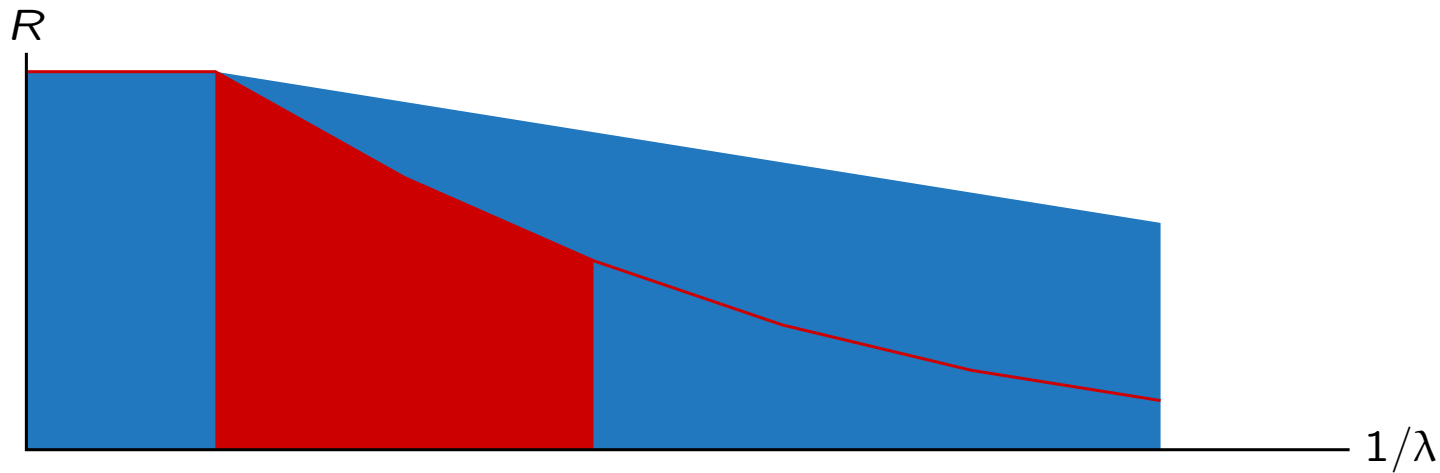
McStas simulation on a 40 m guide



## Selene transmission

$\omega \approx \text{constant!}$

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



strongly favours small- $m$  coating!

# outline

basics on focusing

example: Selene guide

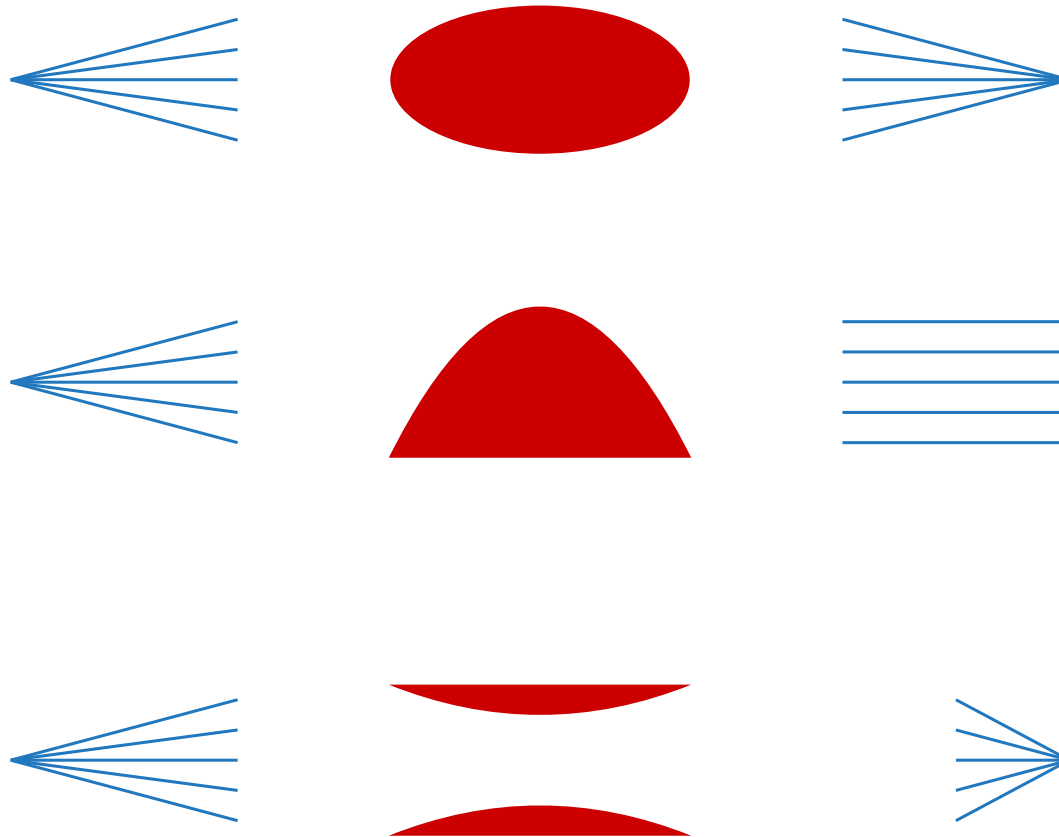
optics

performance & limitations

discussion

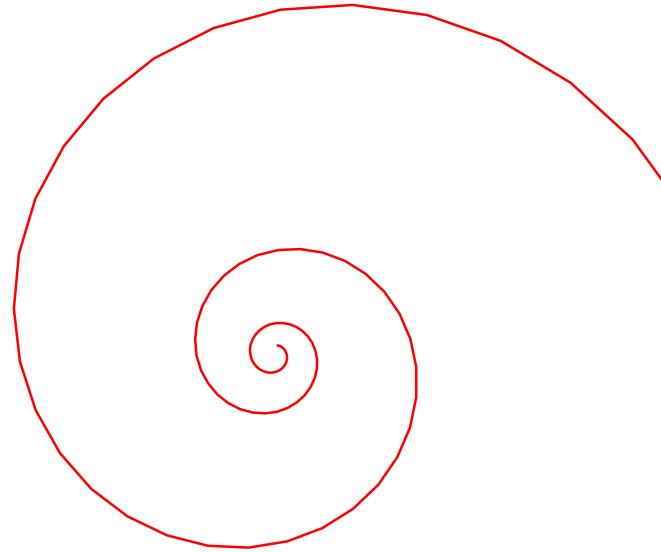
# optics & options

basic operation rules for reflective optics



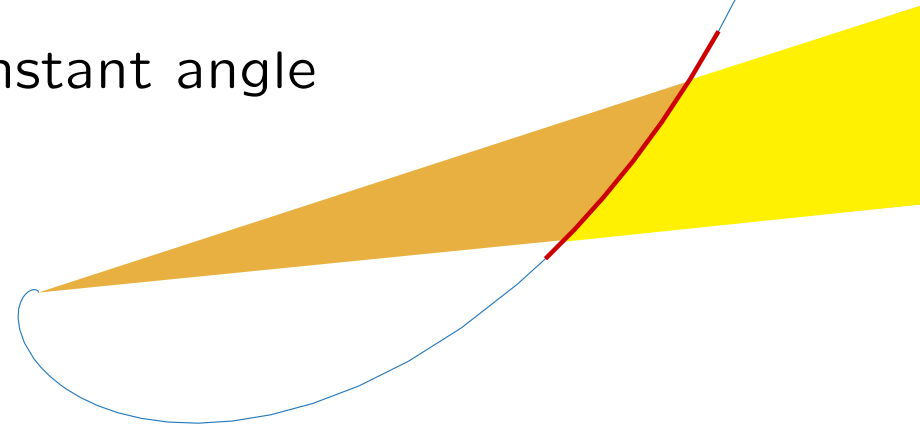
# optics & options

## polariser



a log-spiral intersects a divergent beam at constant angle

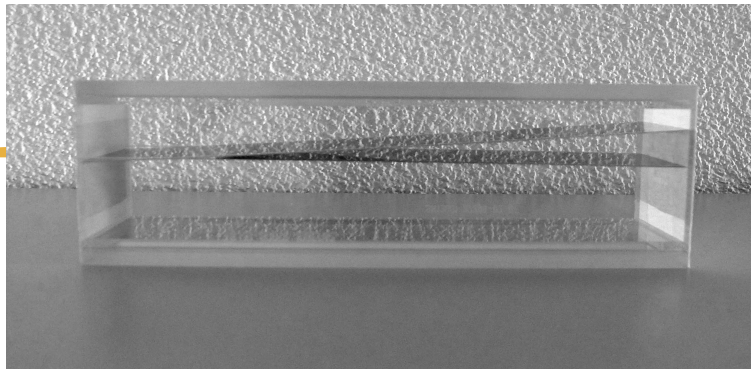
⇒ low- $m$  coating, high performance



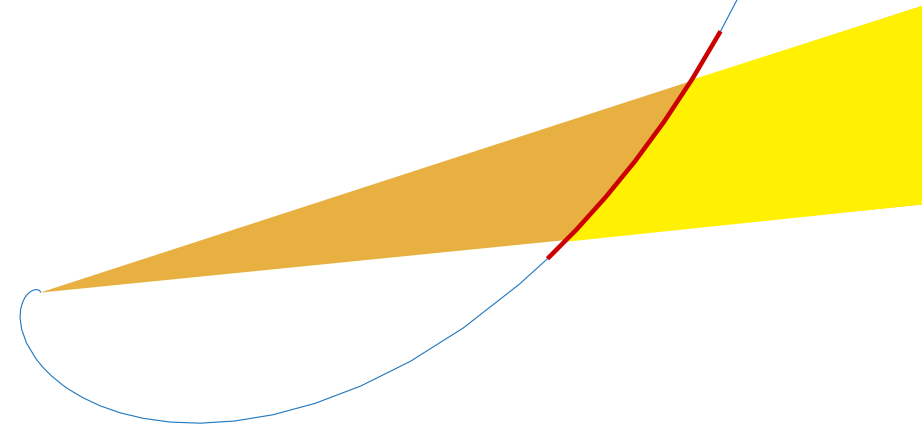
## optics & options

**polariser:** logarithmic spiral

polariser  
215 mm long, 1.8° acceptance

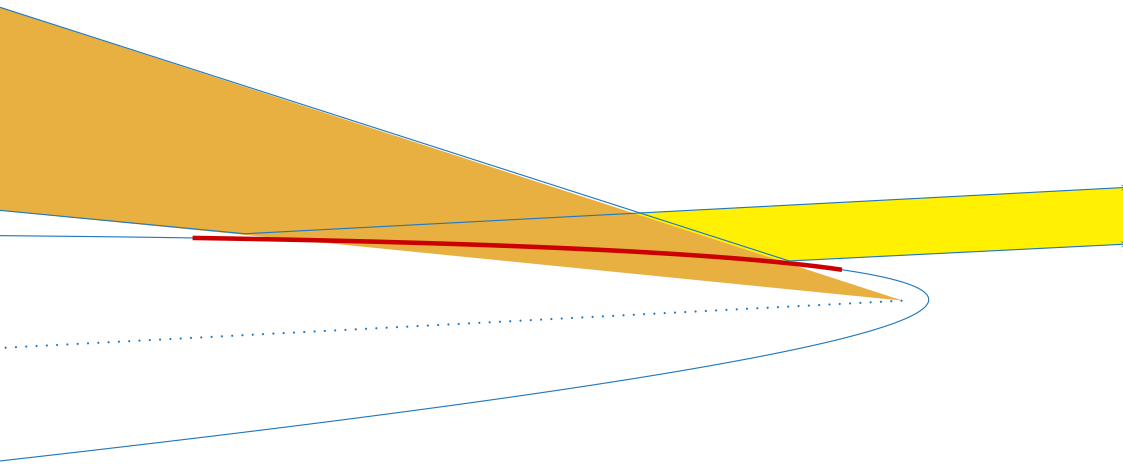


(by SwissNeutronics)



## optics & options

**condenser:** parabolic deflector to generate a parallel beam



parabola axis  $\Rightarrow$  beam direction

focal length  $\Rightarrow$  beam width

beam width  
& spot size  $\Rightarrow$  divergence

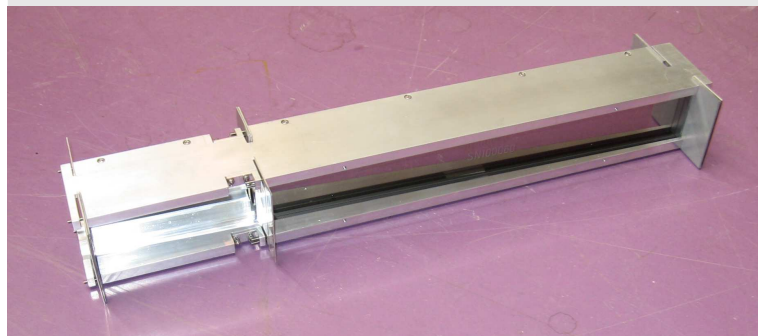
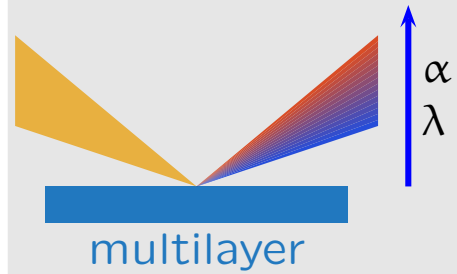
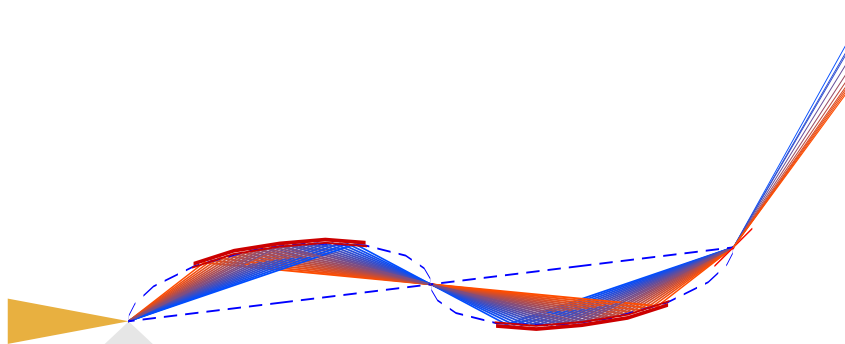
no collimator needed  
tunable

(not yet realised)

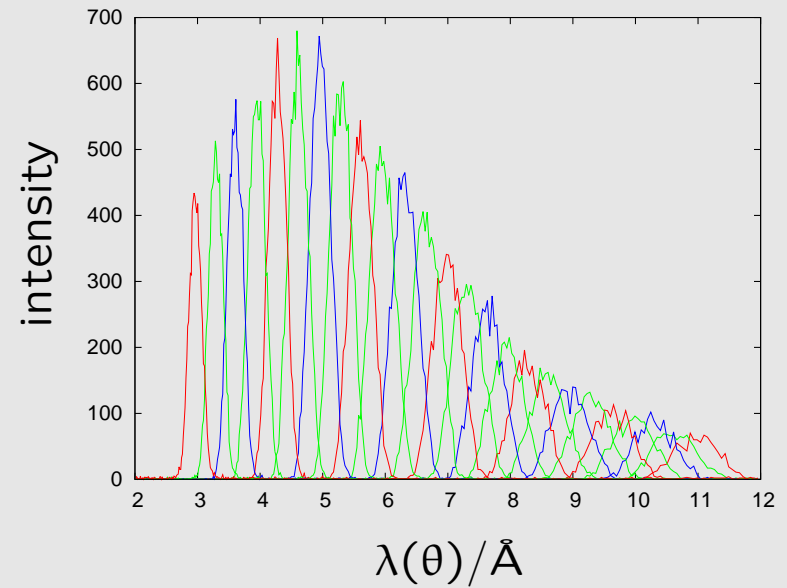
# optics & options

## spectral analysis

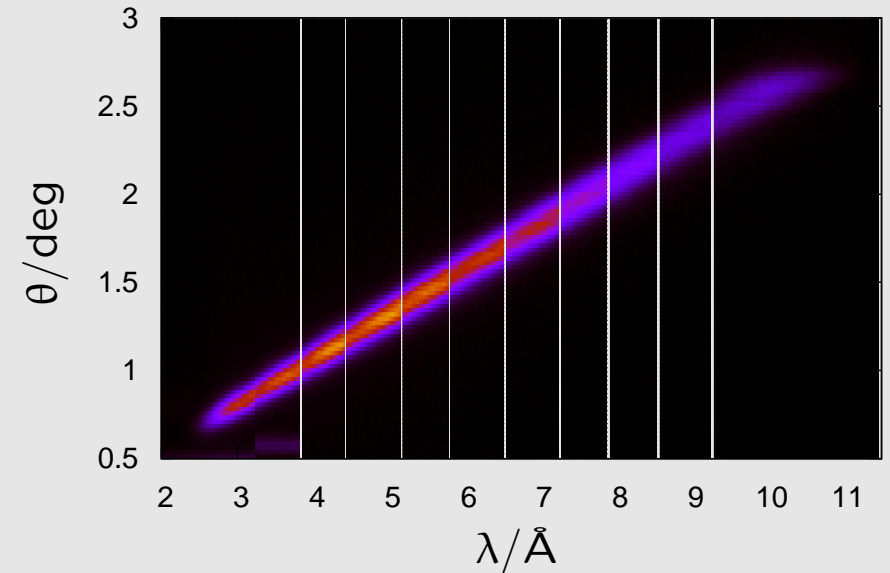
using a multilayer monochromator



double ML monochromator



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





# optics & options

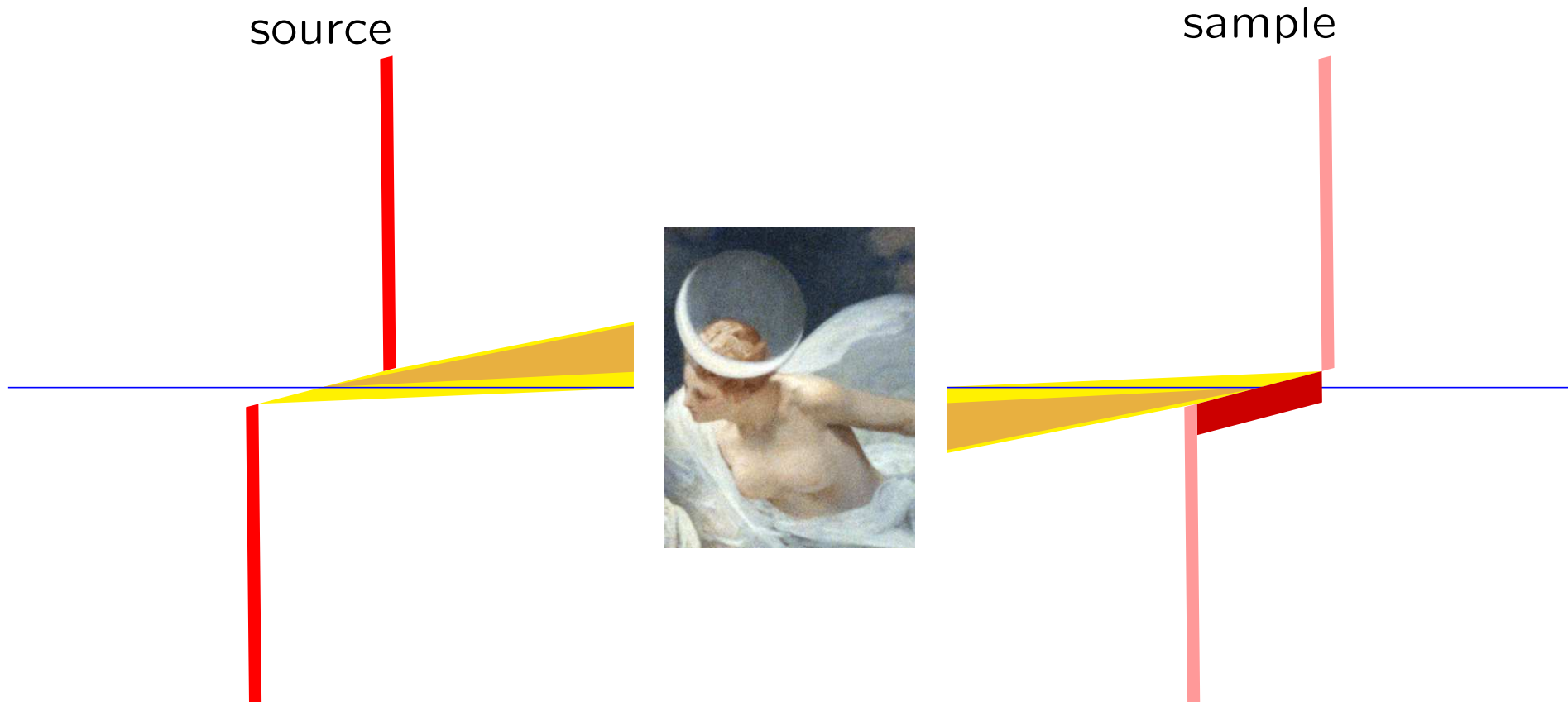
## 3D footprint definition

using the imaging property of the *Selene* guide

point source  $\Rightarrow$  illuminates sample centre

finite sample  $\Rightarrow$  needs finite source

source shape & orientation = image of footprint



## optics & options

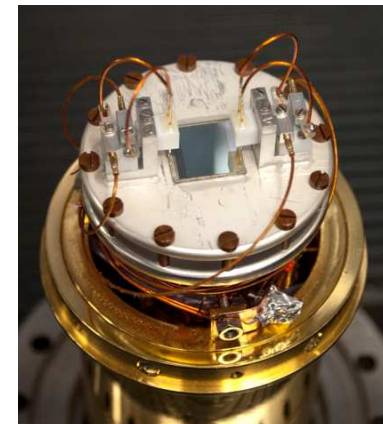
**3D footprint definition** using the imaging property of the *Selene* guide

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

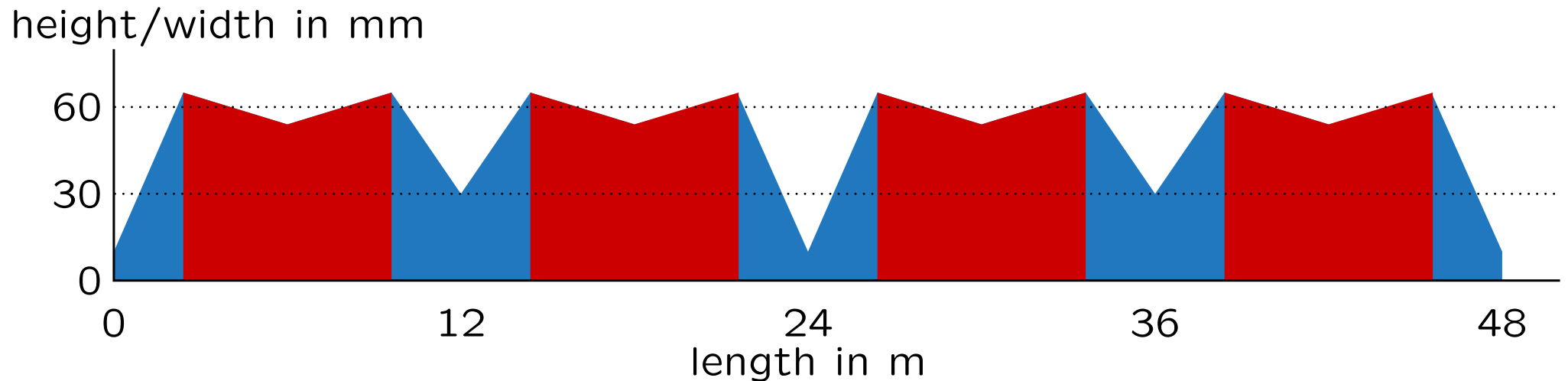


## optics & options

### choppers

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

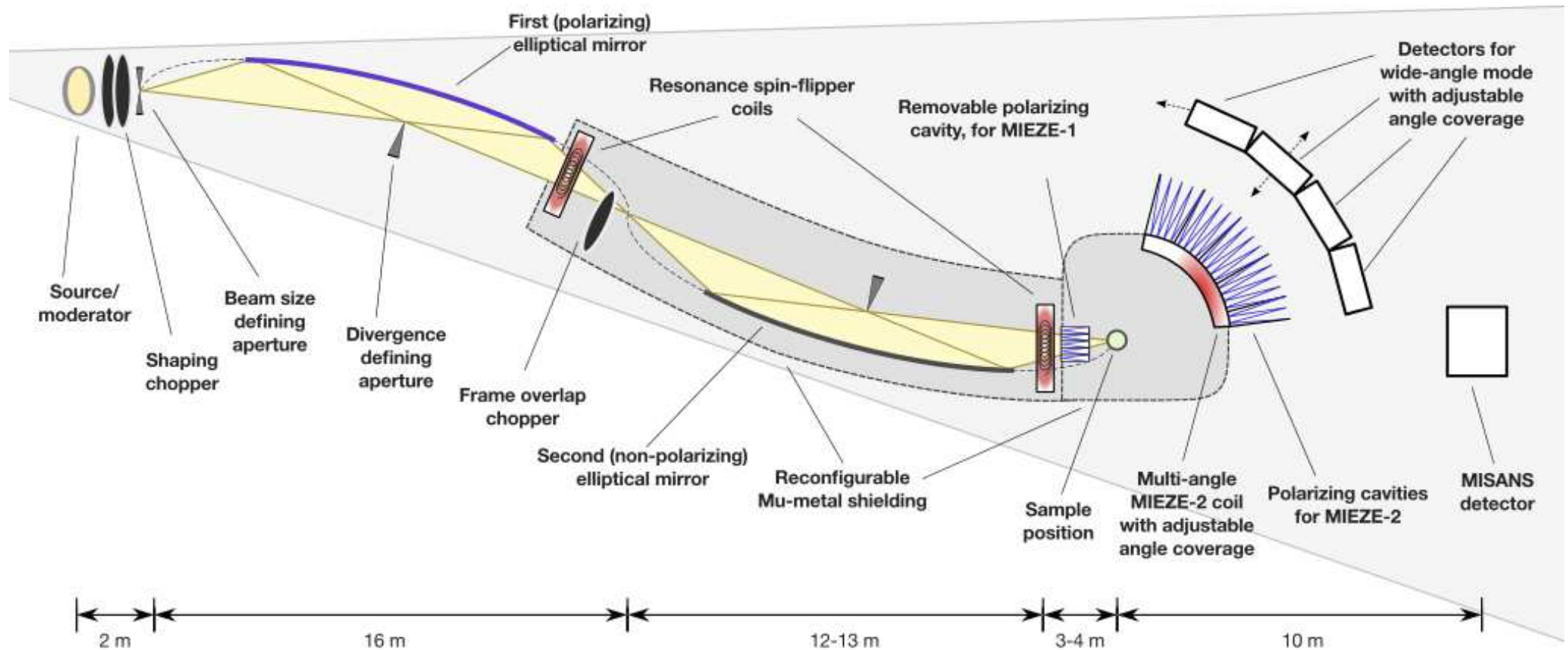
e.g. Εστία guide:



# optics & options

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

all trajectories have the same length



# outline

basics on focusing

example: Selene guide

optics

**performance & limitations**

discussion

# reflectometer Εστία

## key parameters

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

horizontal scattering plane

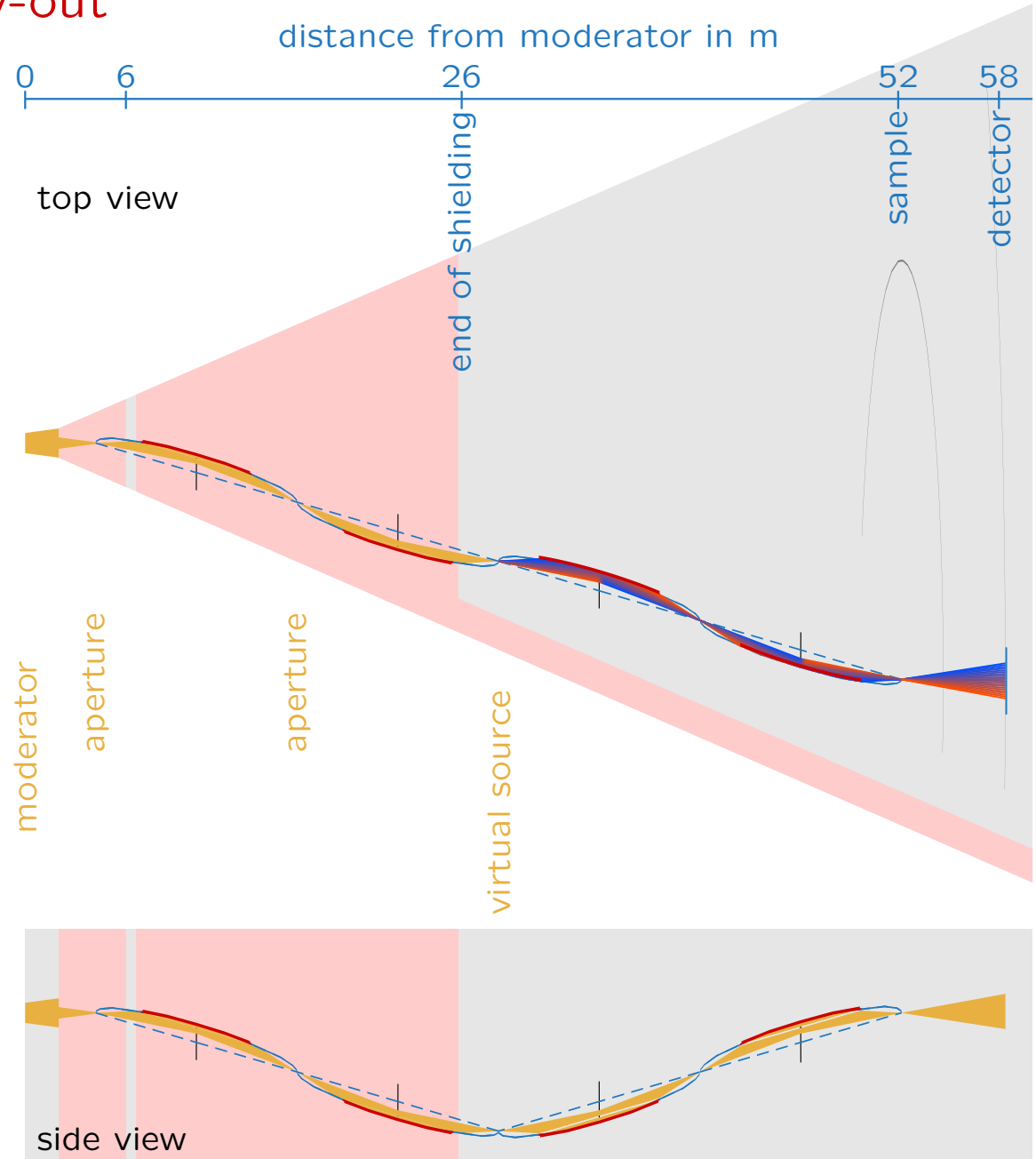
intrinsic resolution 2 to 4%

polarisation option

truly focusing

low background

## lay-out

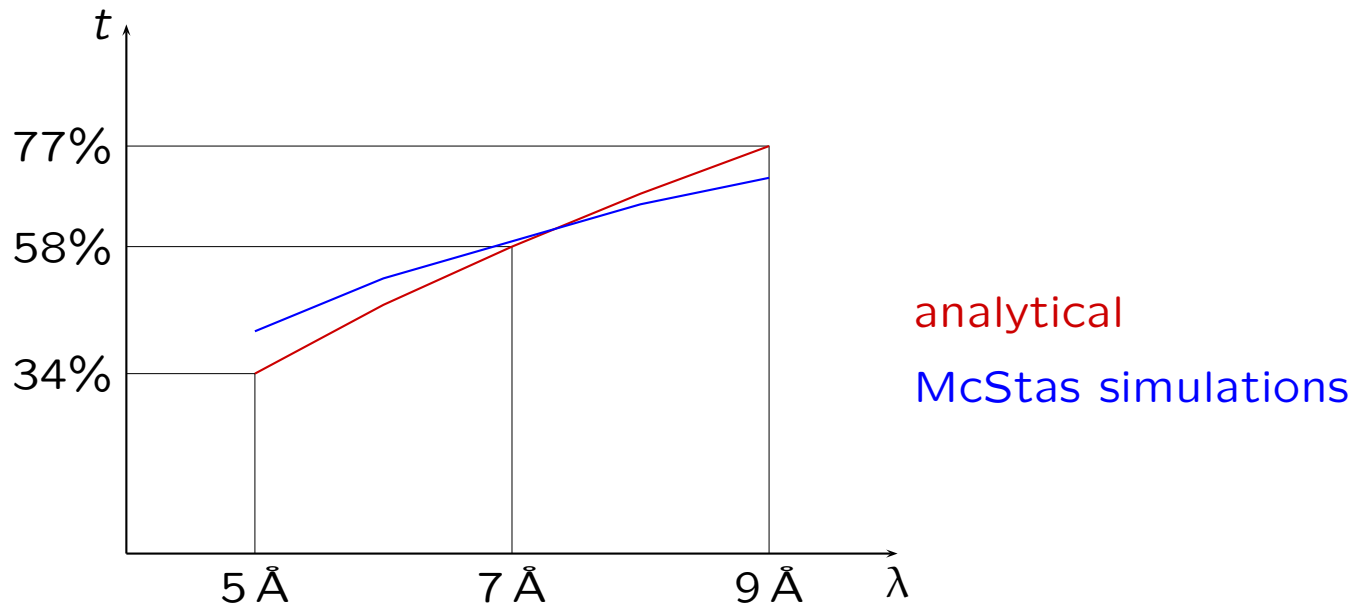


## transmission

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

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

(not optimised for brilliance transfer, but for  $t$ ,  $\Delta q_z$  and low background)

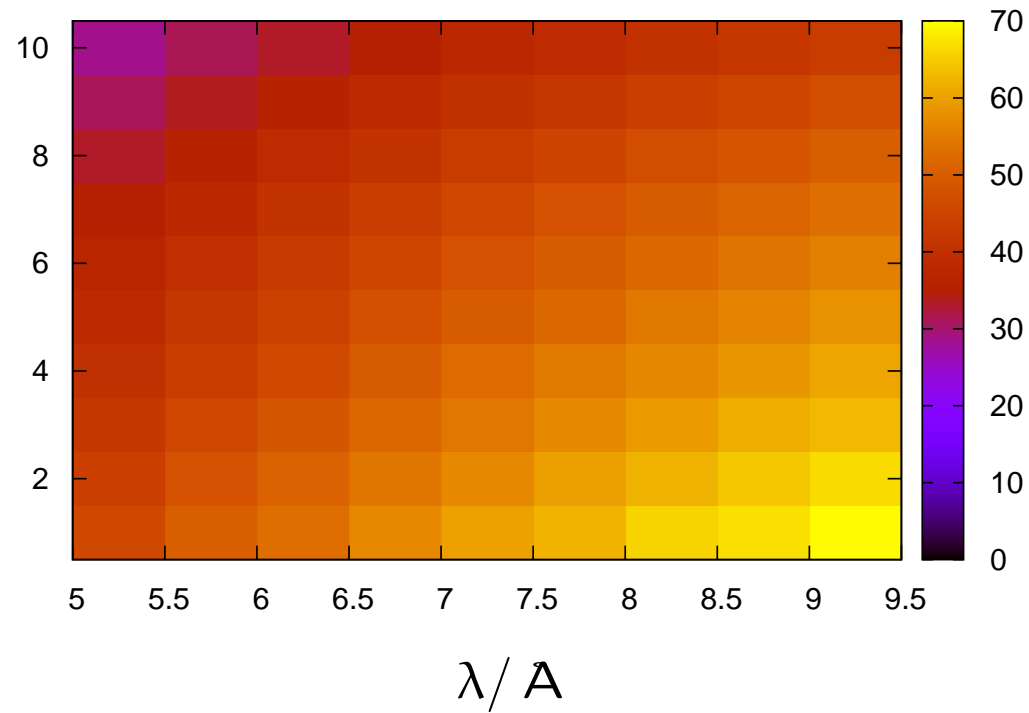


## spot size

- guide performance depends strongly on the sample size!

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

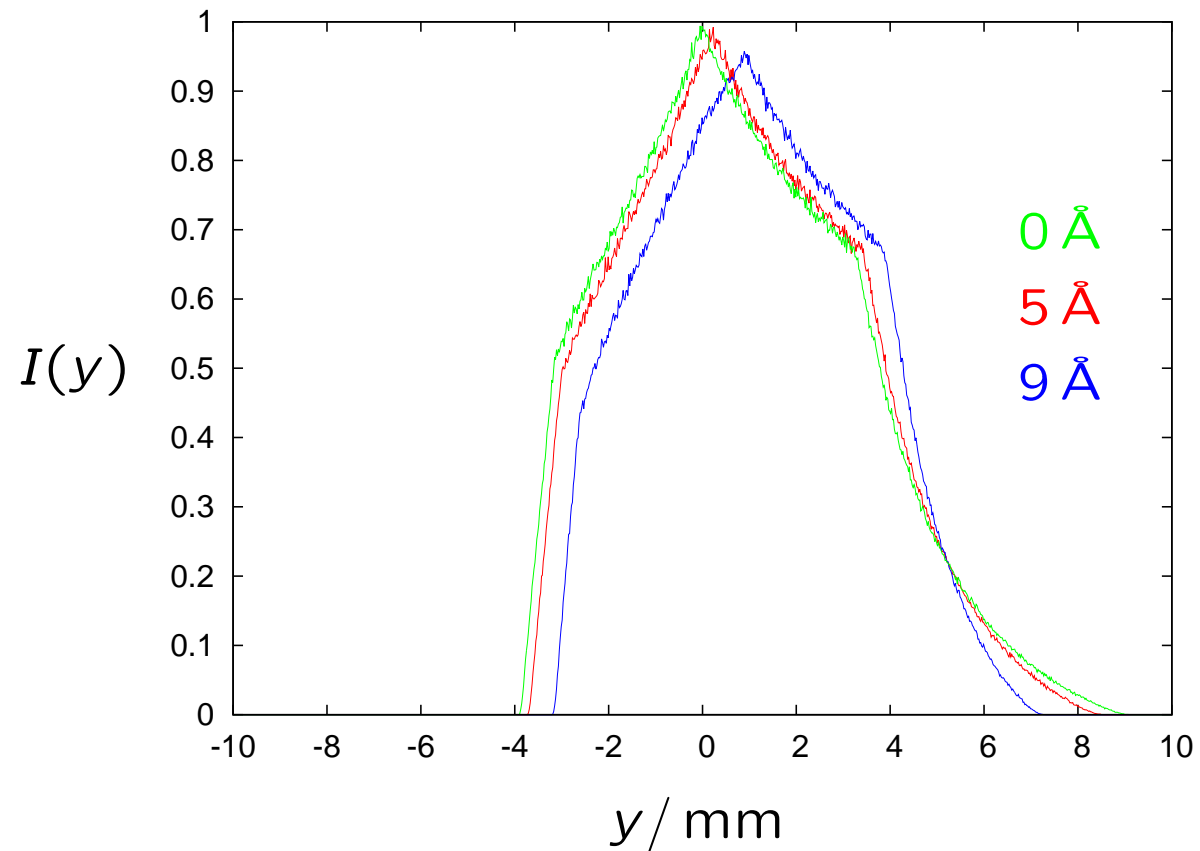
spot height





## gravity

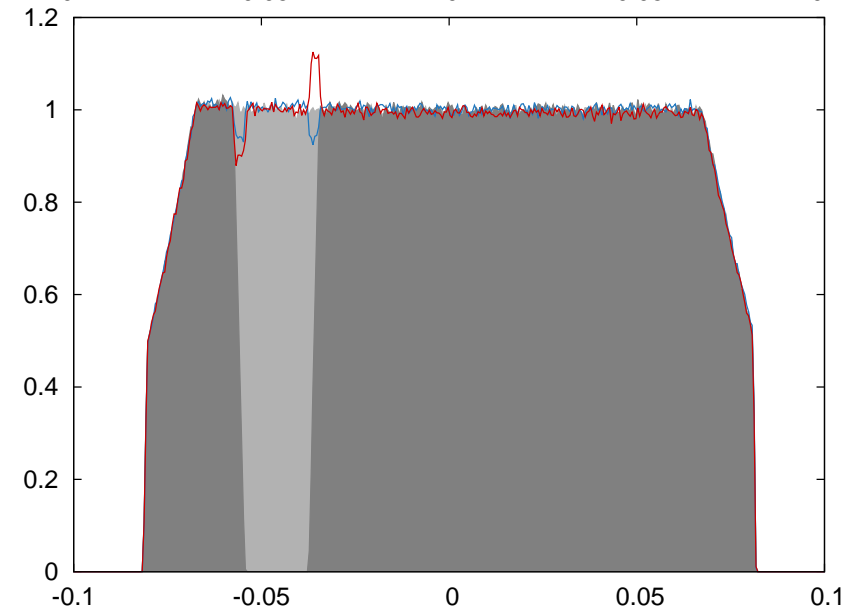
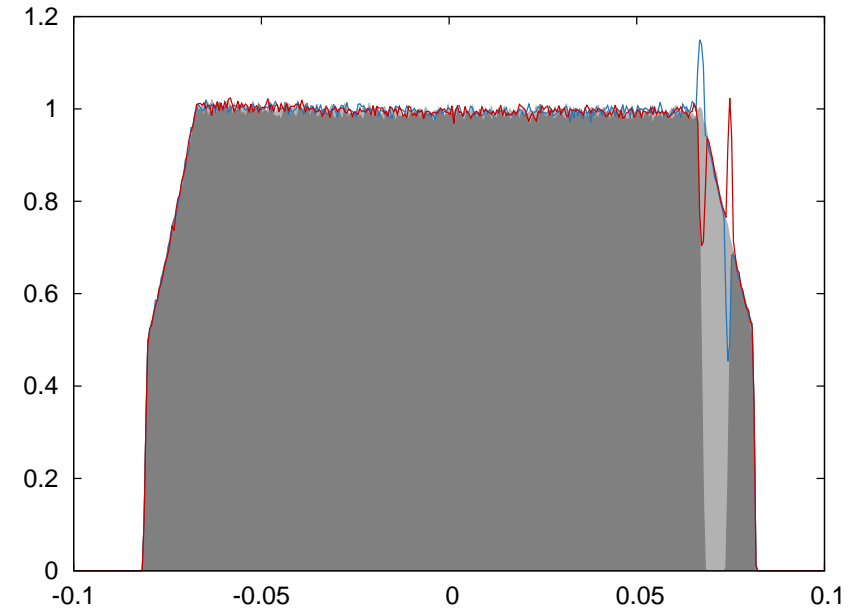
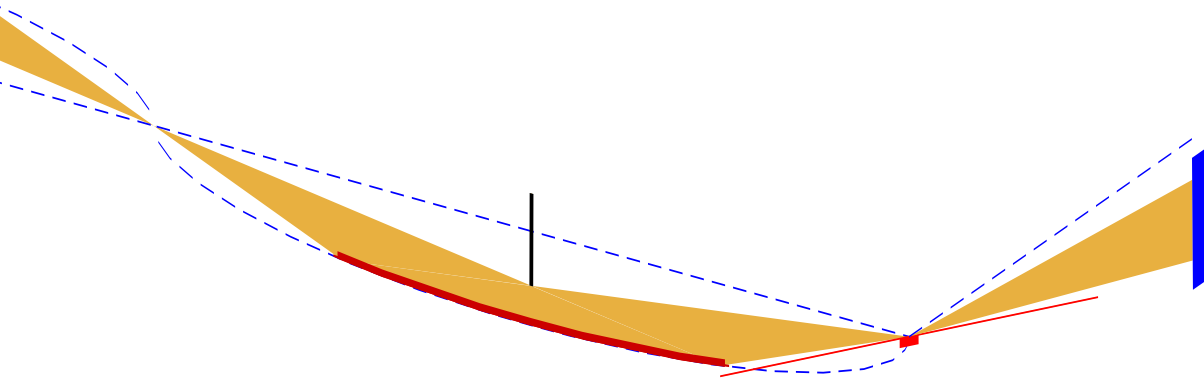
Εστία: vertical intensity distribution on the sample



# accuracy of alignment

- displacement of 0.1 mm
- tilt by  $0.001^\circ$

of 0.5 m elements of the last section:

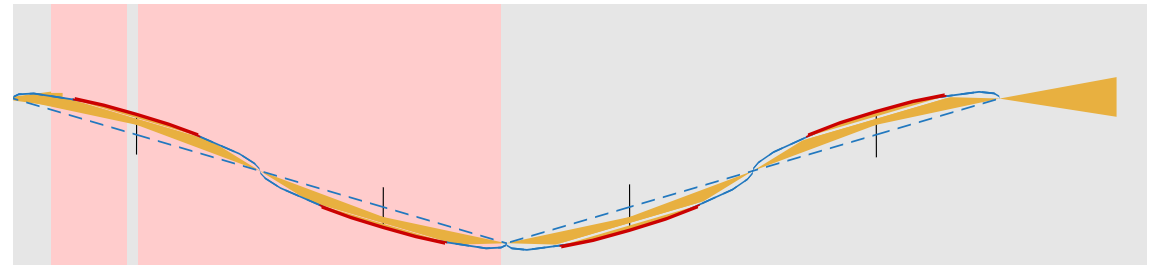
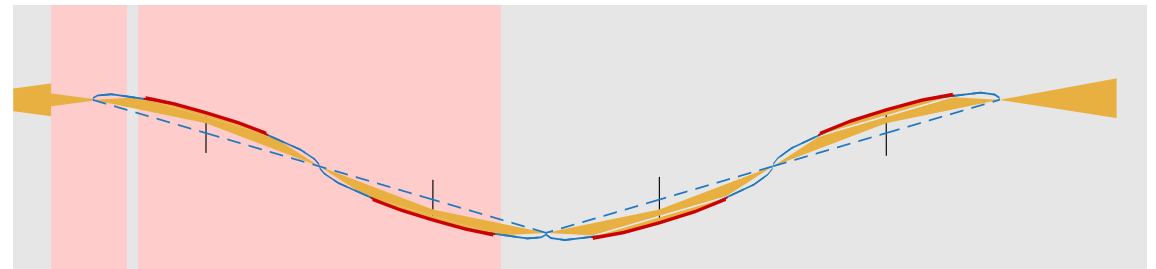


## adaption to small moderator

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

⇒ reduced shielding

⇒ source size not adjustable



# outline

basics on focusing

example: Selene guide

optics

performance & limitations

discussion

# discussion

truly focusing guides are good for

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

