Focusing SANS using advanced reflective optics

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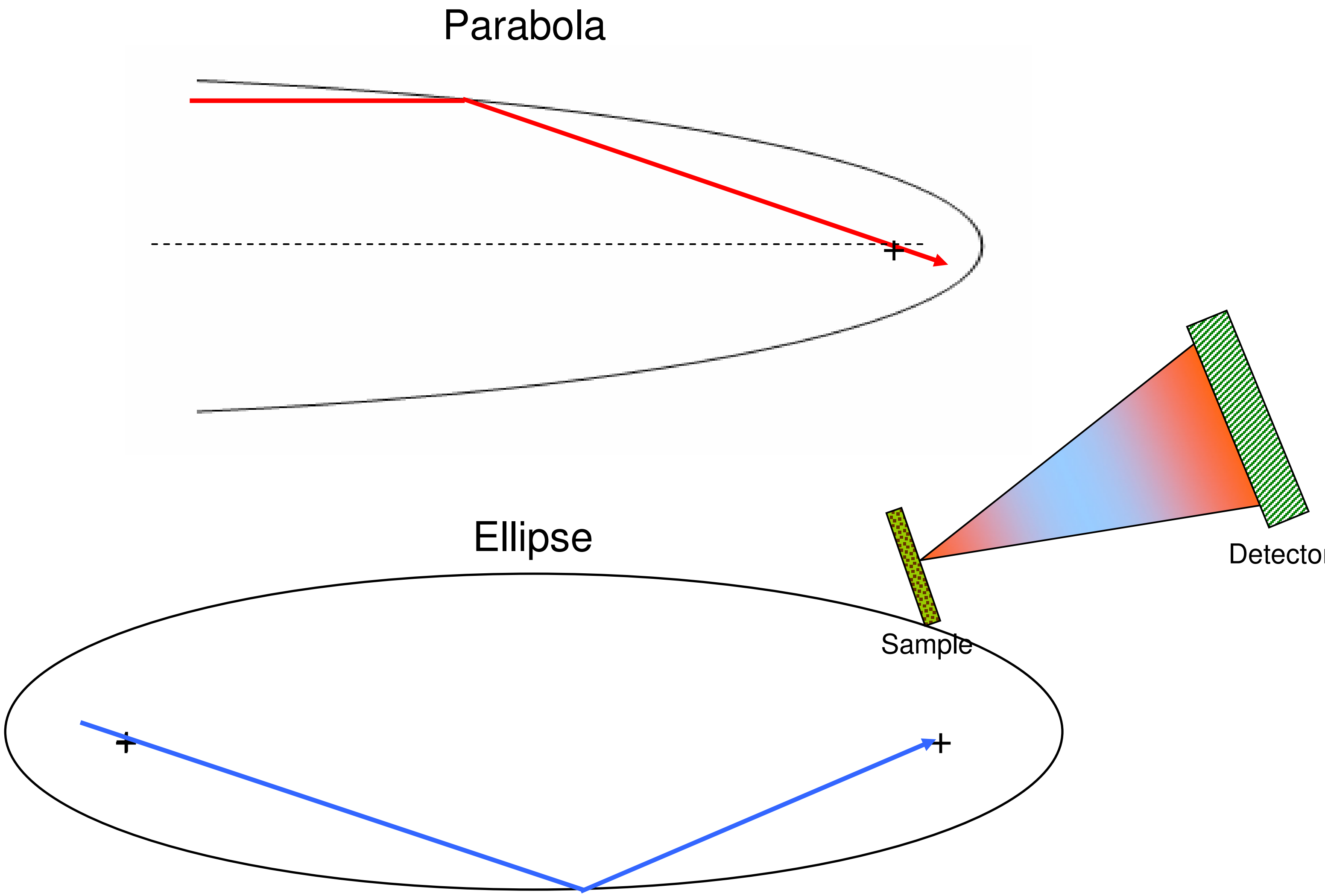
Issues

- Intensity enhancement
  - use of the whole guide surface
  - increased usefull divergence
- No wavelength dependance
  - focusing by reflection
- Design flexibility

Principle

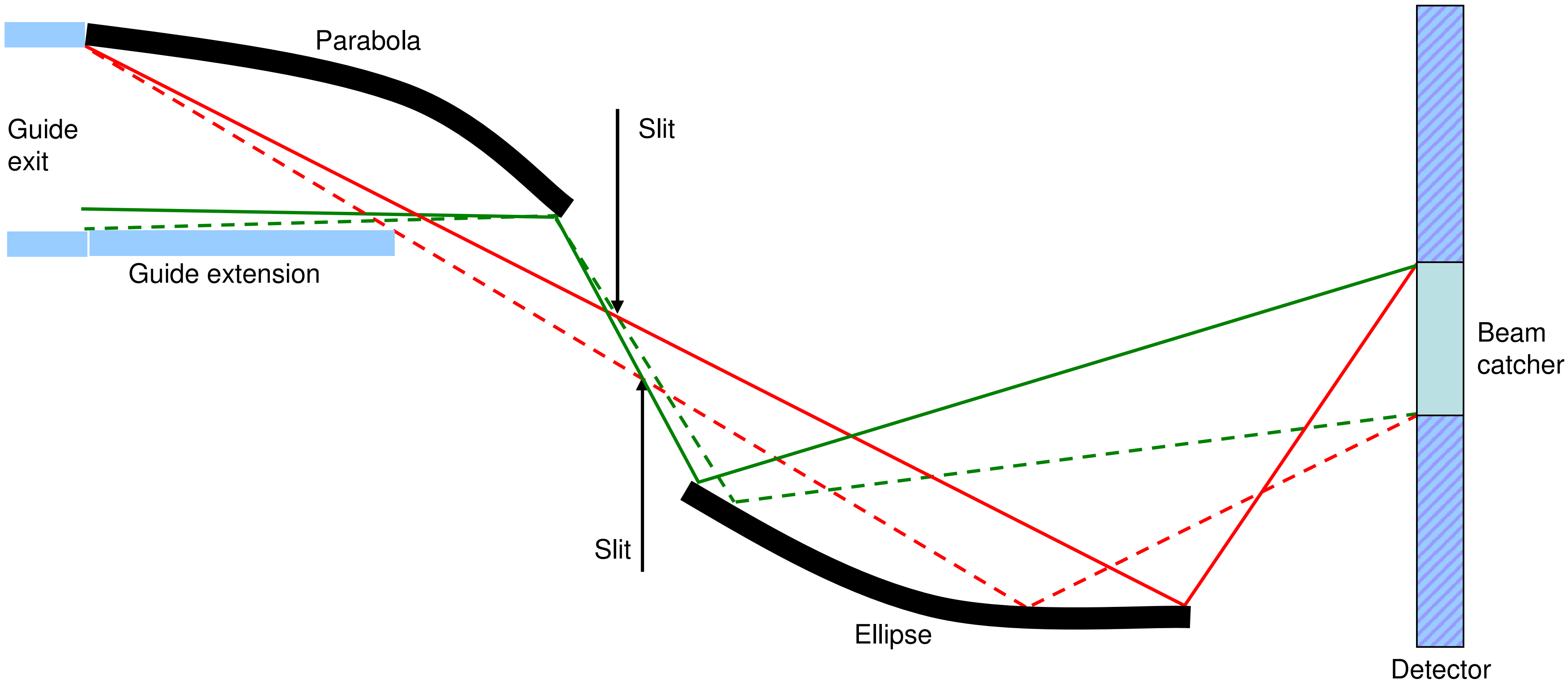


Parameters

- Overall spectrometer length
- Dimension of guide exit
- Minimum λ to handle
  determines critical angle of the parabolic SM
  (high λ ➔ compact spectrometer)
- m of the SM
  determines critical angle
  reflection coefficient
- Q_{min}

Collimation

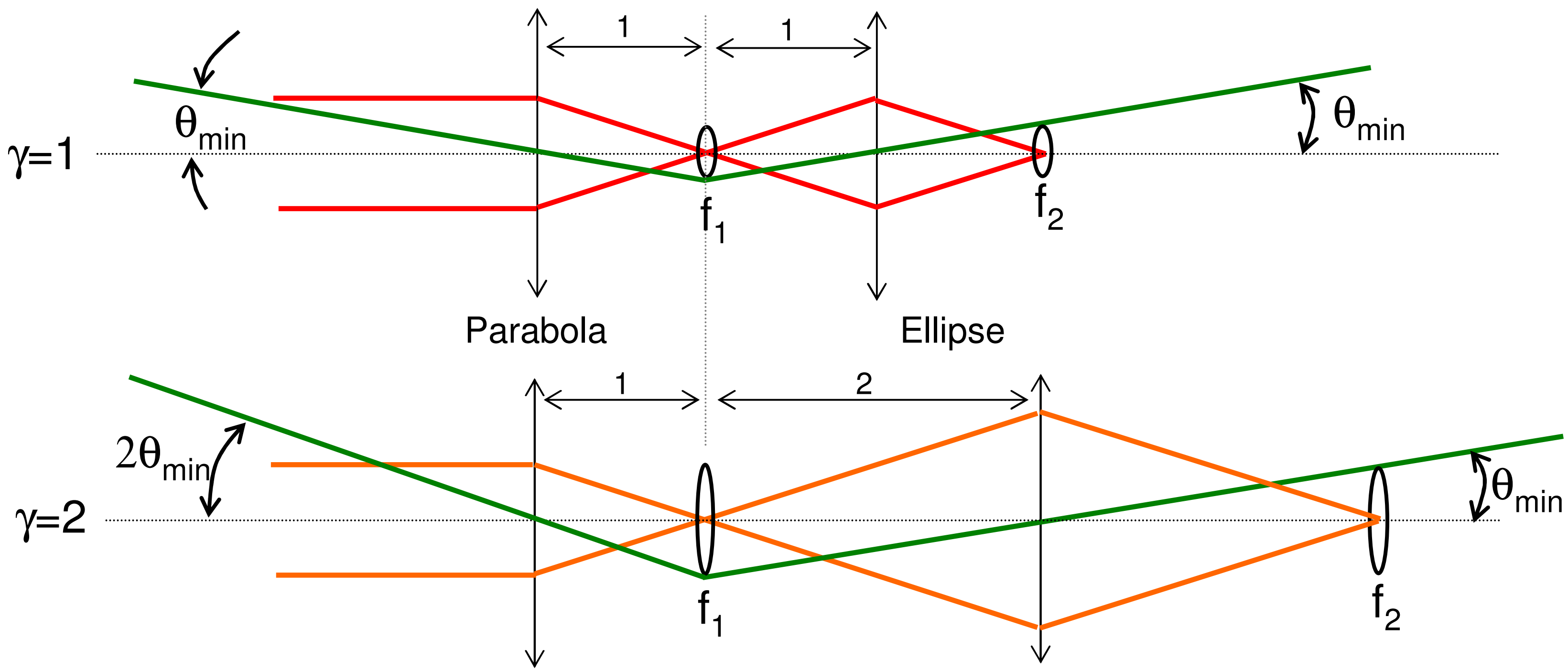
• Collimation made by slits located at the common focal point:



• Slit dimension determines the beam stop size ➔ θ_{min} ➔ Q_{min}

Design parameters

- Gain factor (γ) : ratio of elliptic and parabolic focal lengthes



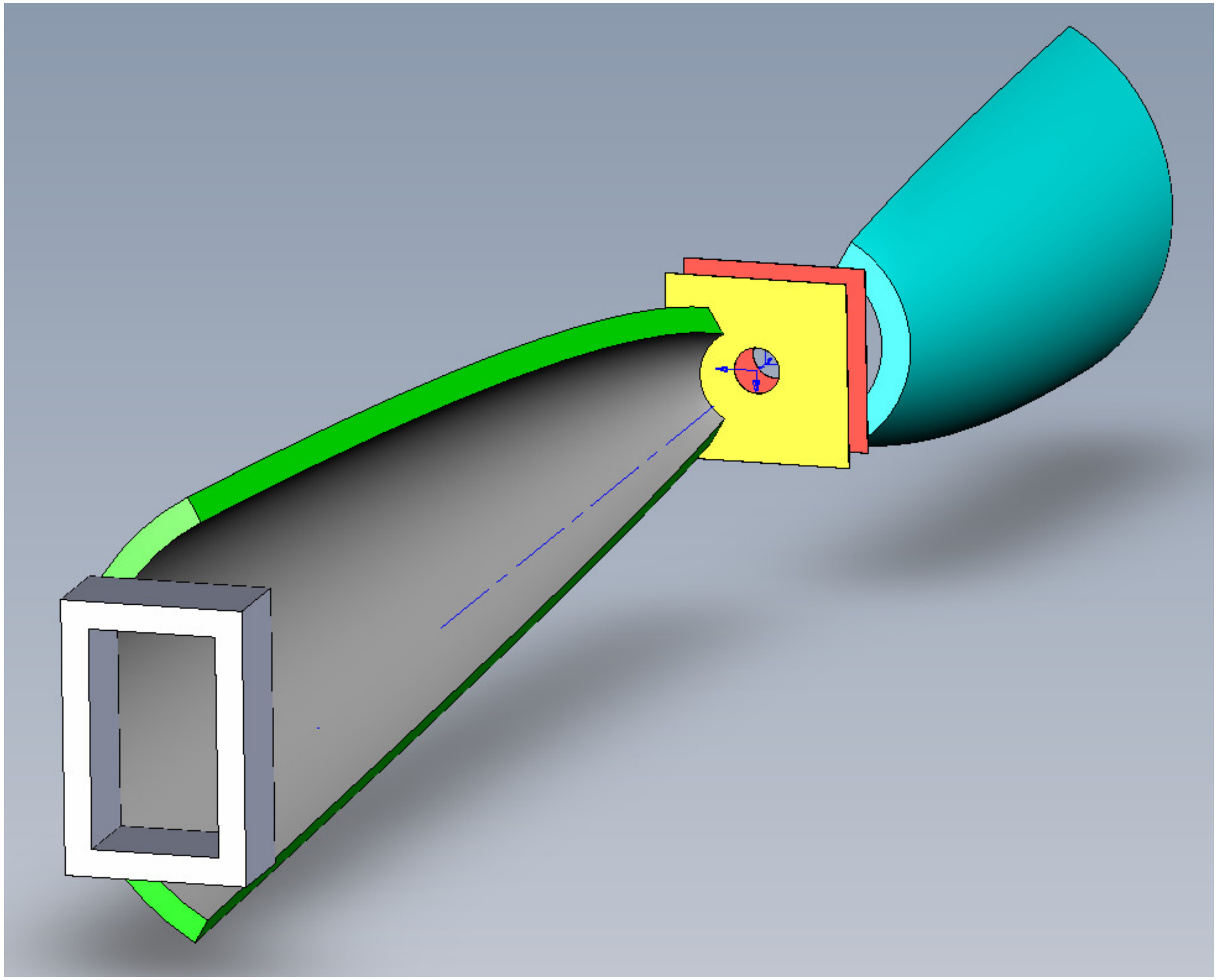
- When γ increases, the usefull divergence at the guide exit increases:

Intensity increases

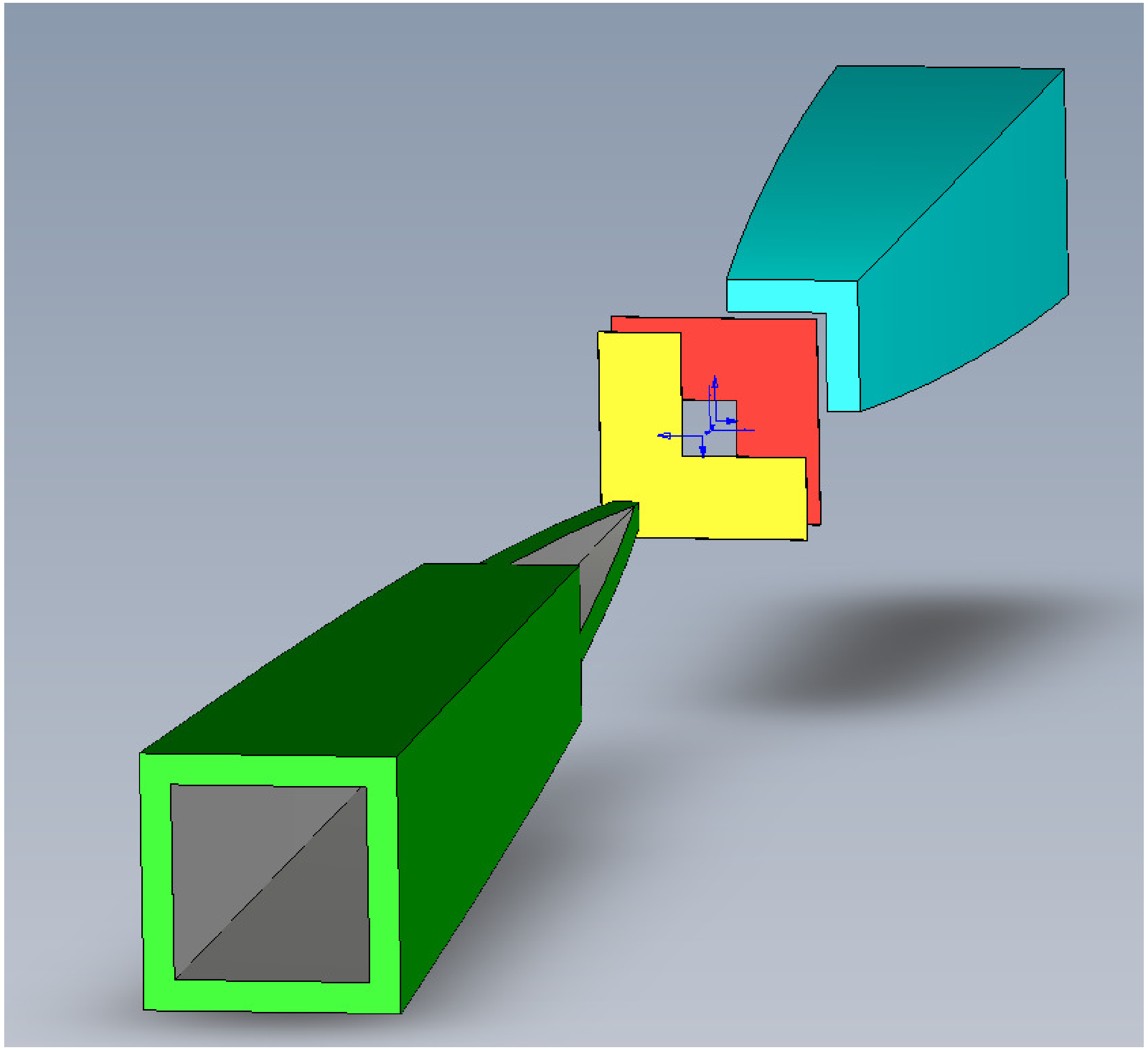
Sample size increases

➔ Flux = Constant

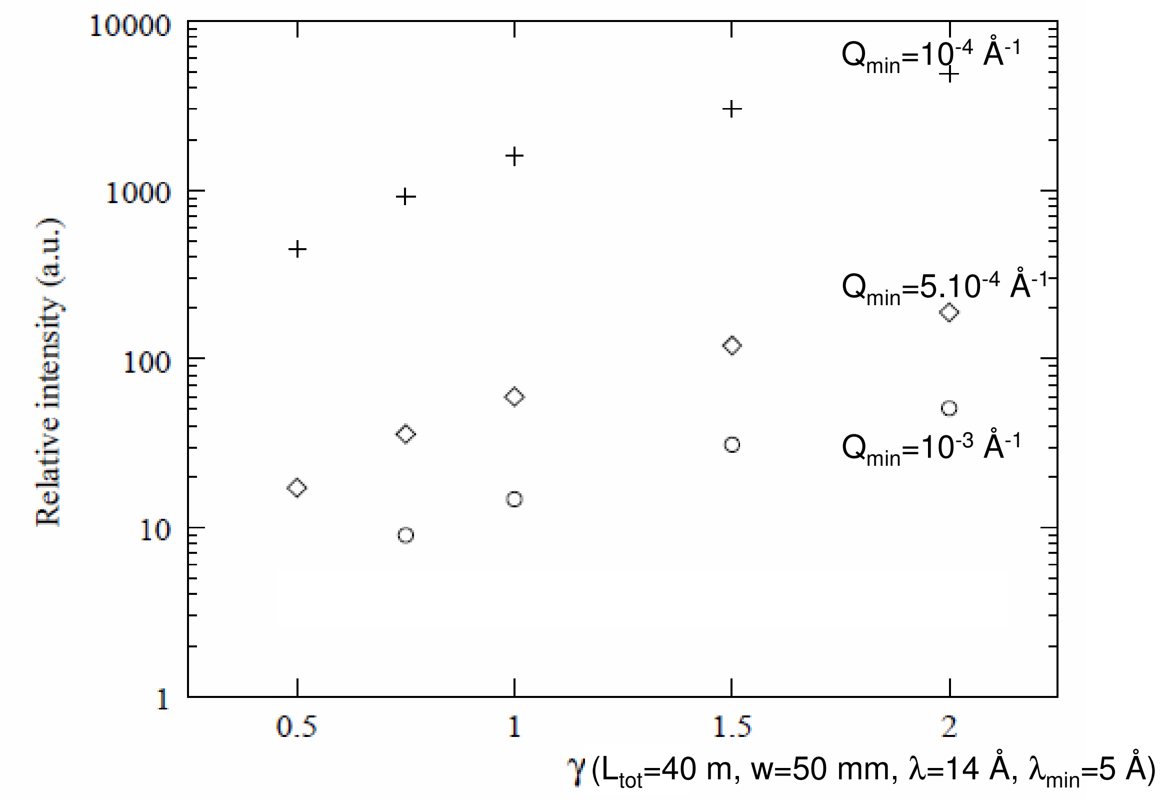
3D View (2 reflections)



3D View (4 reflections)



Comparison with pinhole SANS



- Gain (towards pinhole SANS) increases when Q_{min} decreases (gain ~ Q_{min}^2)
- Gain much larger than multibeam technique
- Flux gain = constant (4 here) in case the sample size is imposed

Summary

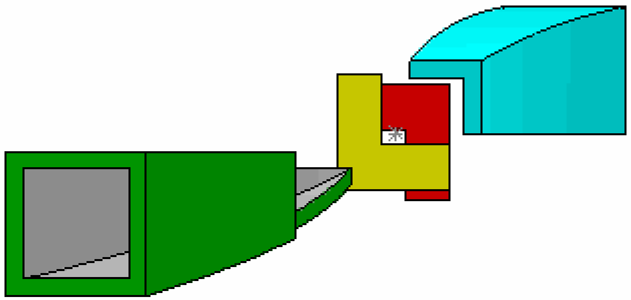
New device for focusing neutrons - Application to SANS

- Achromatic
- Flexible design to optimize constraints
  (guide exit, overall length, …)
- Large intensity gain
  (reflection efficiency 90% @ m=3)
  2 reflections, T=80%
  4 reflections, T=65%
- Increased background - diffuse scattering from SM
  To be studied

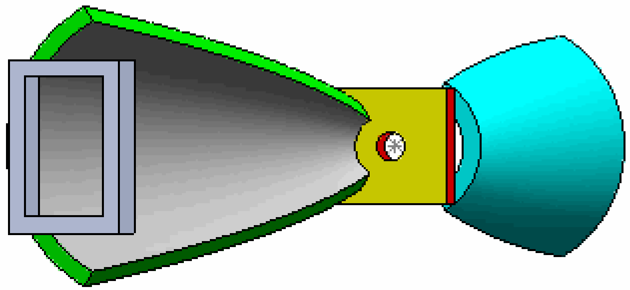
1st year project

- Find parameters
  - ➔ λ_{min}, largest γ, f, spatial filters
- Follow SM quality for noise reduction
  - ➔ Manufacturers
  - ➔ McStas ?
- Build a reduced scale prototype
  - ➔ along 1D
  - ➔ 4 reflections principle
- Test prototype
  - ➔ Signal/Noise ratio

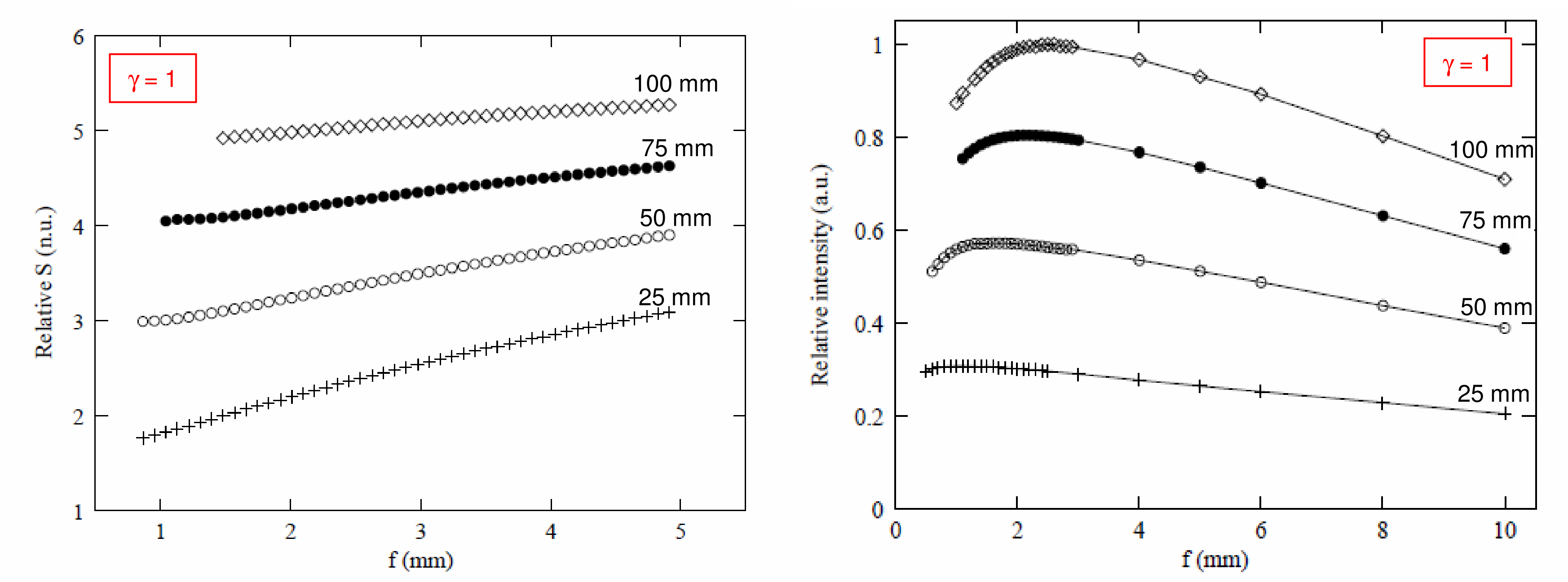
3D View (4 reflections)



3D View (2 reflections)



Some results

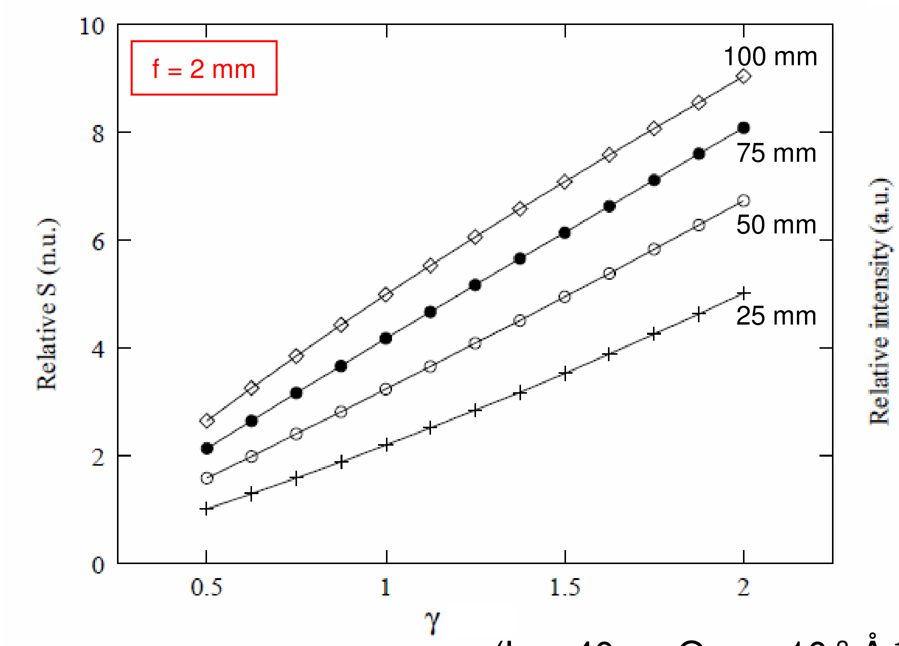


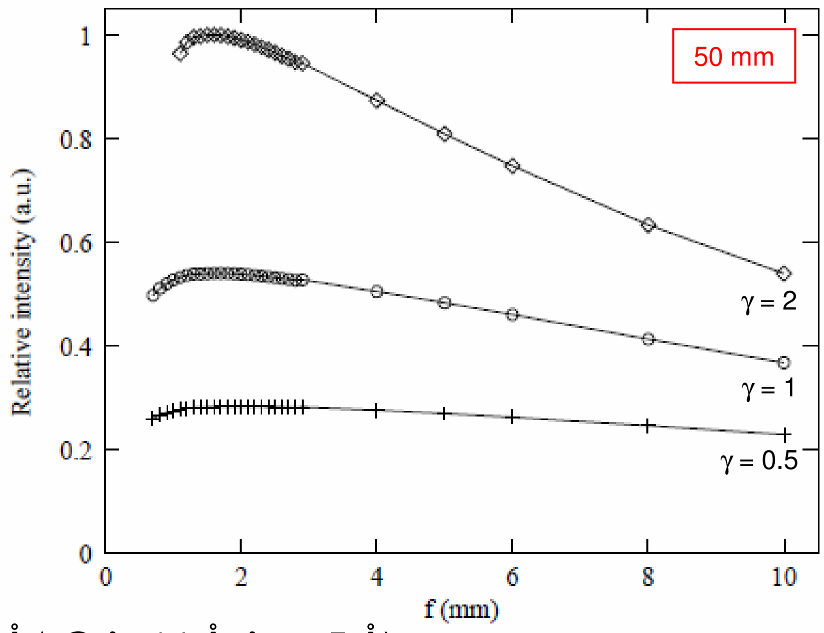
(L$_{tot}$=40 m, Q_{min} = 10^{-3} Å^{-1} @ λ=14 Å, λ_{min}=5 Å)

- Sample size increases with the focal length (and guide dimension)

- There is an optimum focal length for the intensity

Some results





(L_{tot}=40 m, Q_{min} = 10^{-3} Å^{-1} @ λ=14 Å, λ_{min}=5 Å)

- Sample size increases ~ linearily with γ
- Intensity (around f_{opt}) increases ~ linearily with γ

➔ Flux is constant

Equations

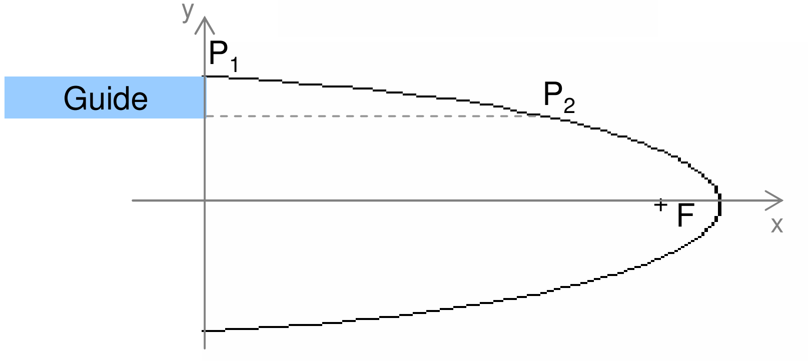
Parabolic SM

$$\tan 2\theta_0 = \frac{y_{P2}}{x_{P2} - x_F}$$

$$y_{P2}^2 = 4f(x_F + f - x_{P2})$$

$$x_F = \frac{(y_{P1}^2 - 4f^2)}{4f}$$

$$y_{P1}^2 = (y_{P2} + w)^2$$



Elliptic SM

$$x_D - x_F = (a^2 - b^2)^{\frac{1}{2}}$$

$$\frac{(x-a)^2}{a^2} + \frac{y^2}{b^2} - 1 = 0$$

$$a = \frac{x_D - x_F}{2} + \gamma f$$