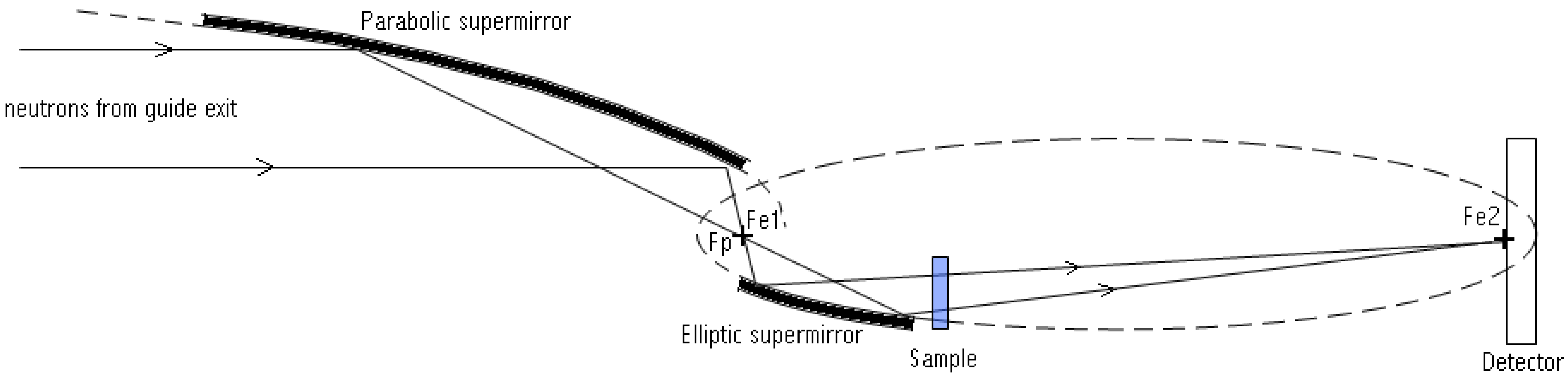
FOCUSSING SANS

Sylvain Désert
P. Permingeat
T. Panzner
J. Stahn

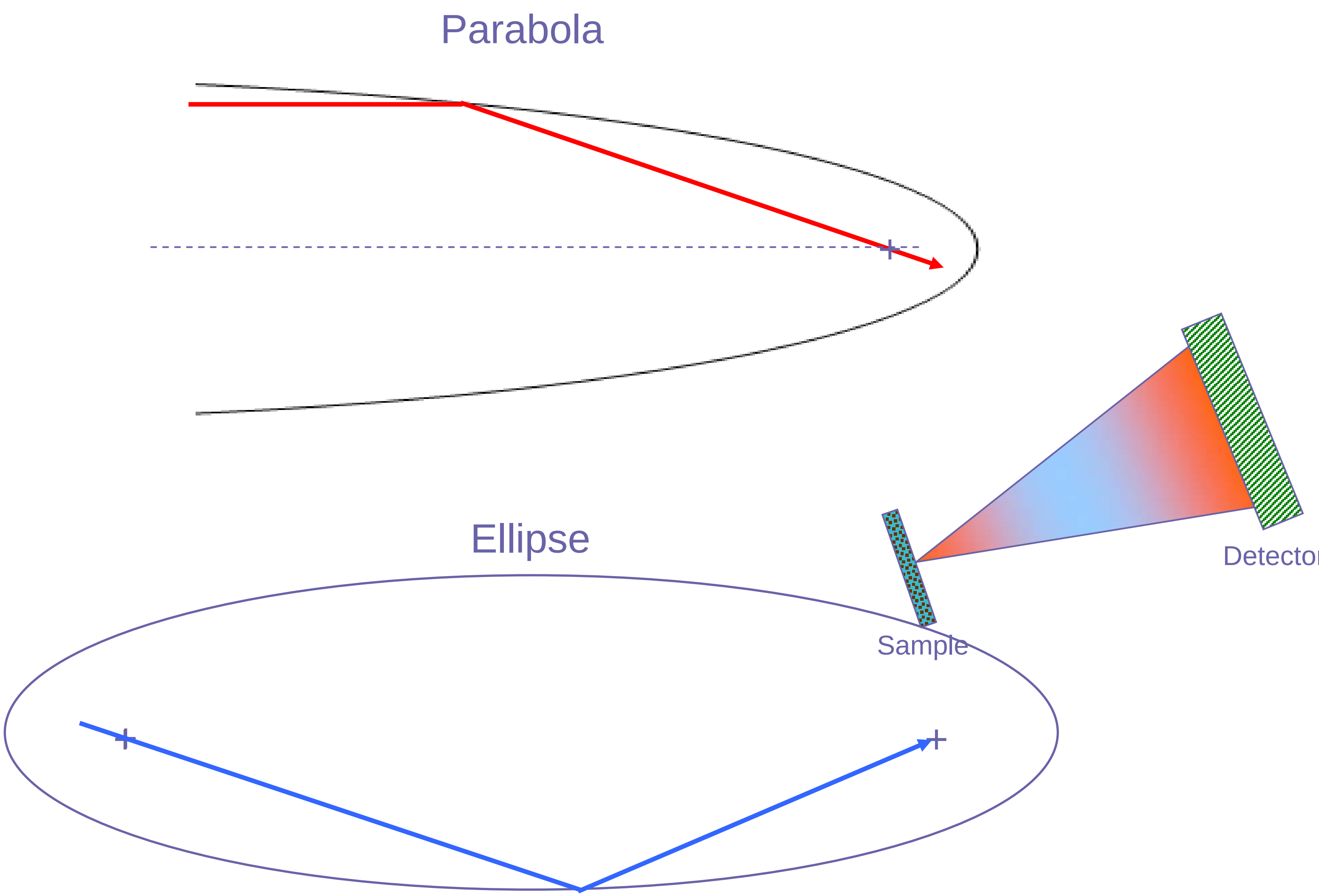
JRA presentation
General Assembly
Rome 2011, Nov. 8th

Task 4: Focussing SANS using reflective optics

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



Principle

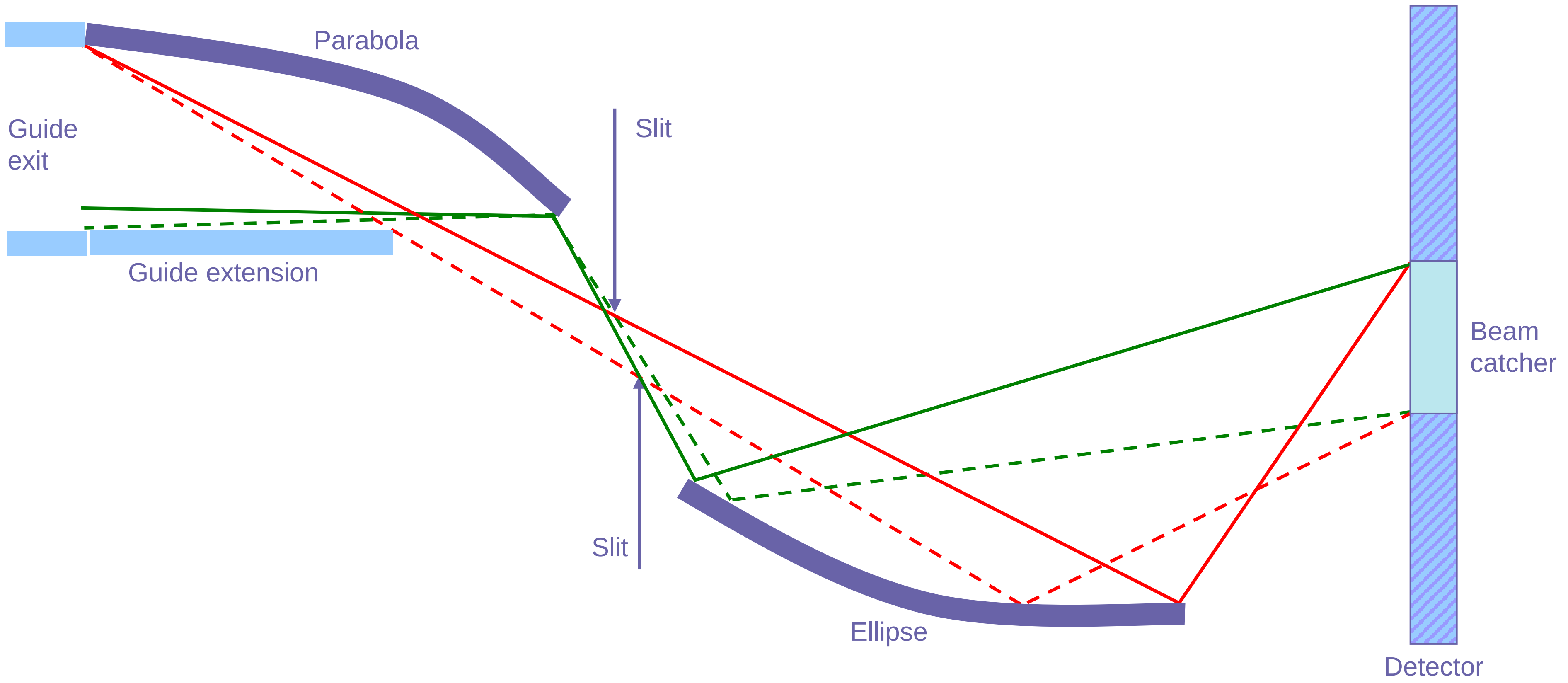


Parameters

- 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
- Qmin

Collimation

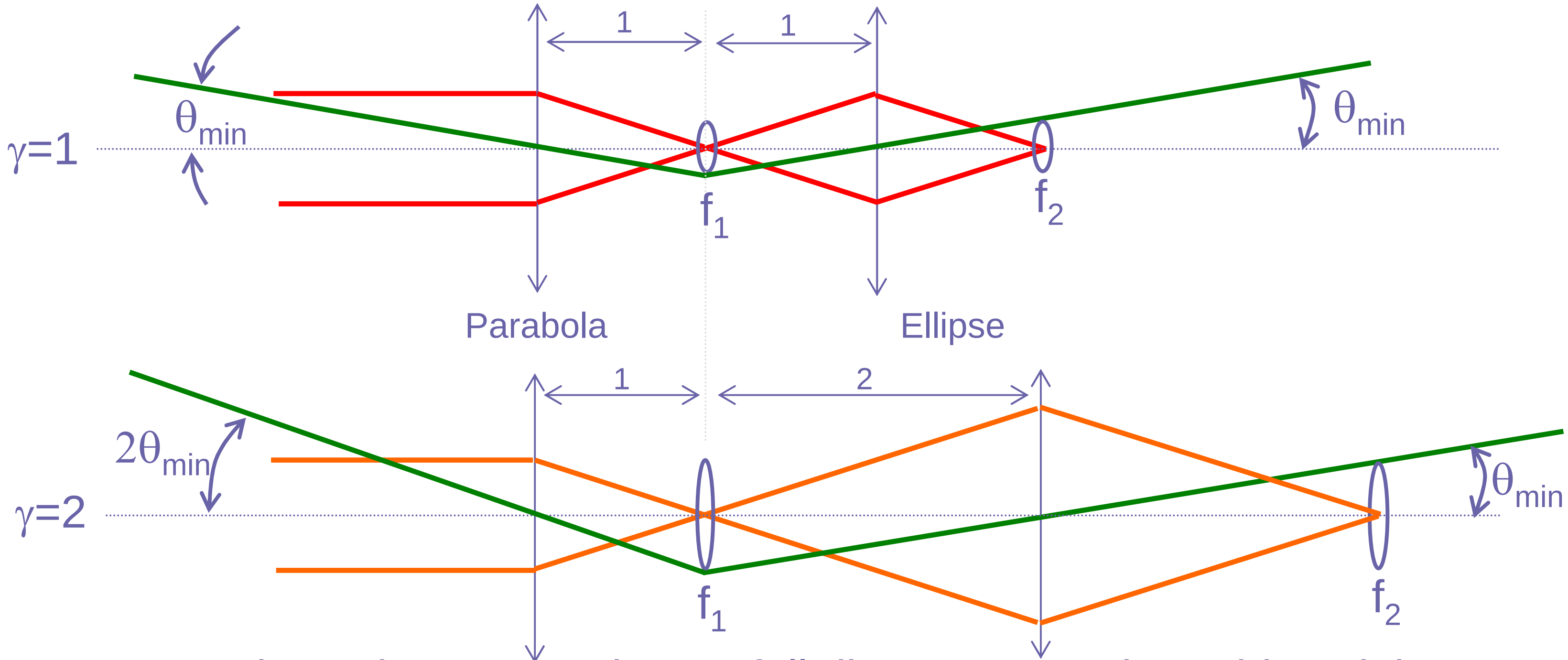
• Collimation made by slits located at the common focal point:



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

Design parameters

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



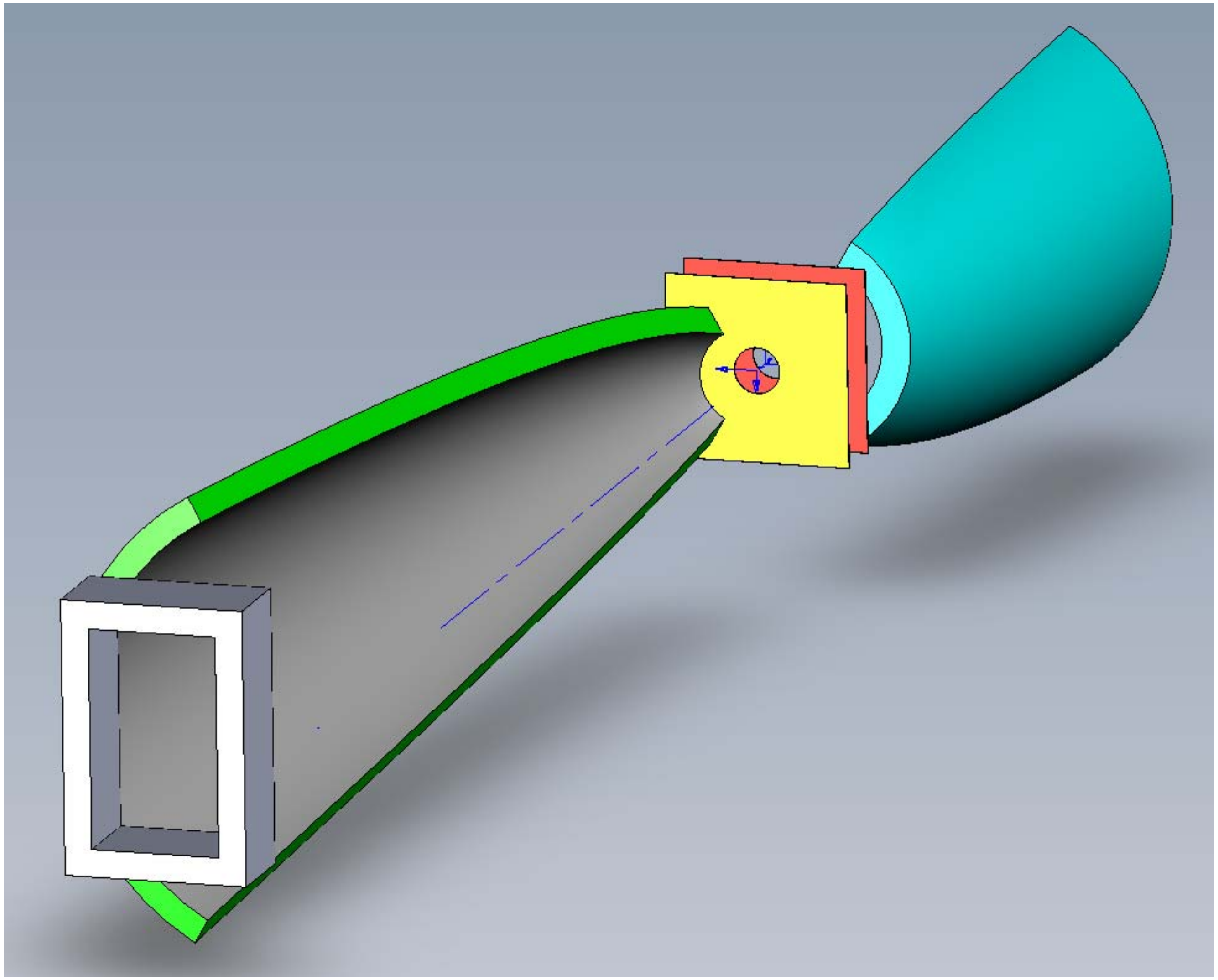
- When γ increases, the usefull divergence at the guide exit increases:

Intensity increases

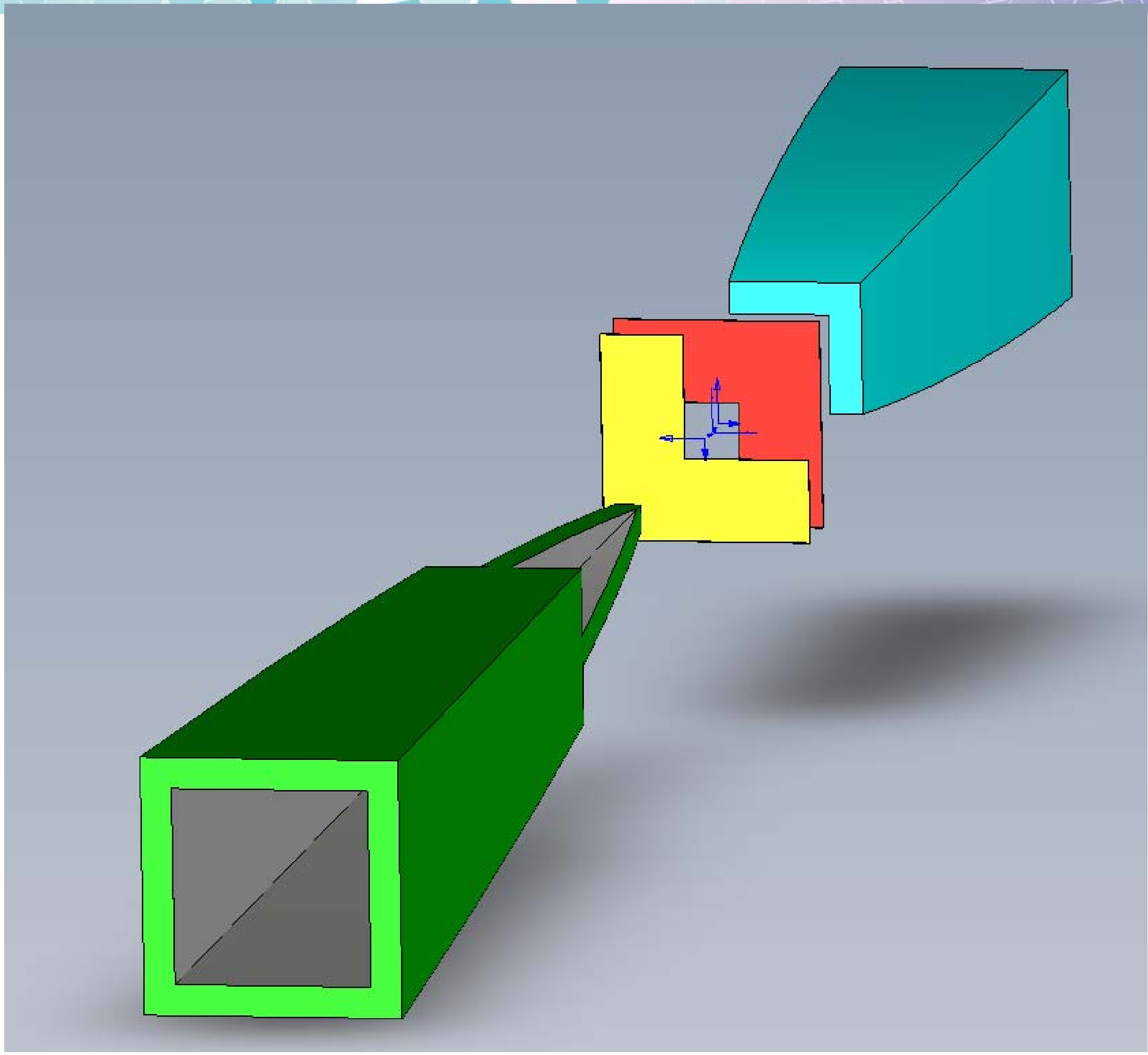
Sample size increases

➔ Flux = Constant

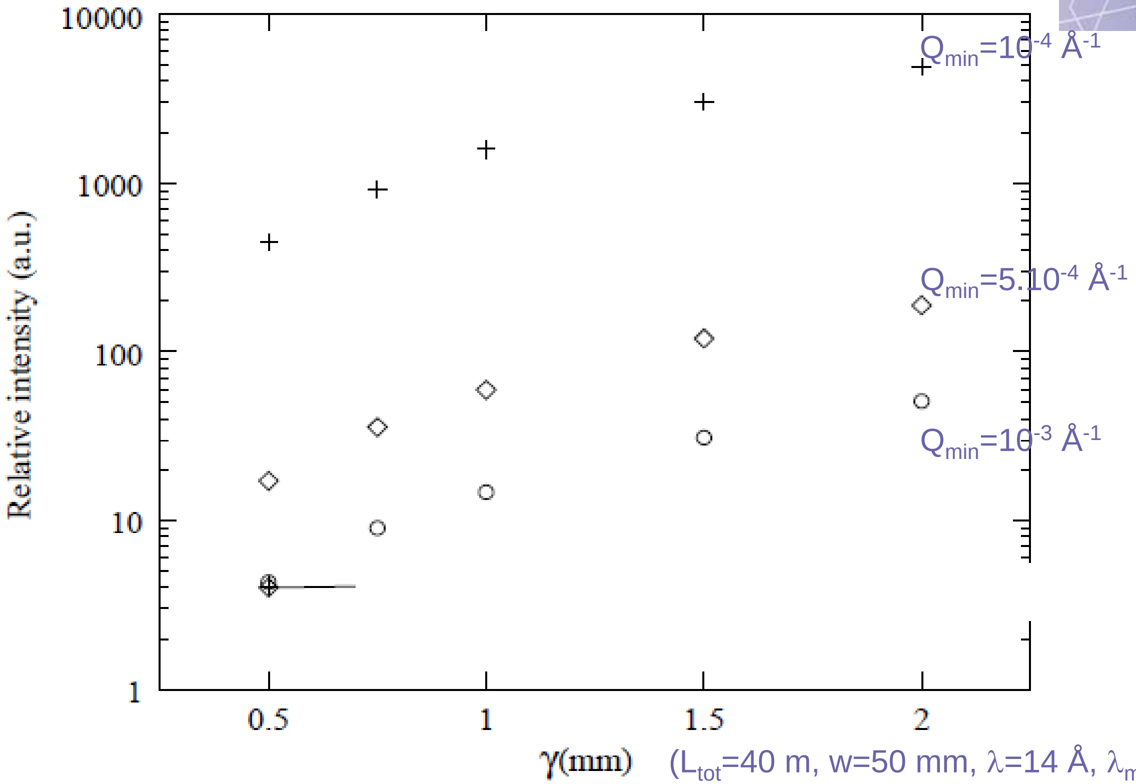
3D View (2 reflections)



3D View (4 reflections)



Comparison with pinhole SANS



(L_{tot}=40 m, w=50 mm, λ=14 Å, λ_{min}=5 Å)

- 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

Achromatic

- Flexible design to optimize constraints
  (guide exit, overall length, …)

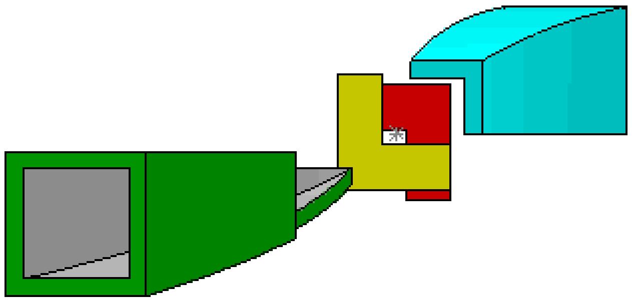
- Large intensity gain
  (reflection efficiency 90% @ m=3)
  2 reflections, T=80%
  4 reflections, T=65%

Increased background - diffuse scattering from SM
To be studied

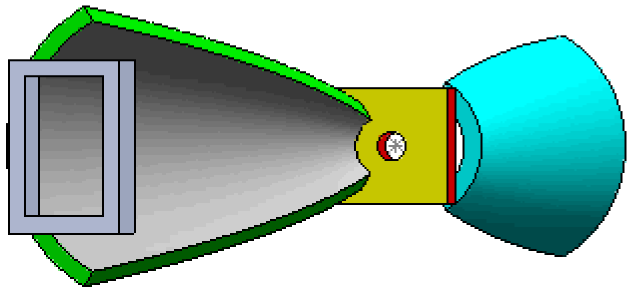
1st year project

- 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

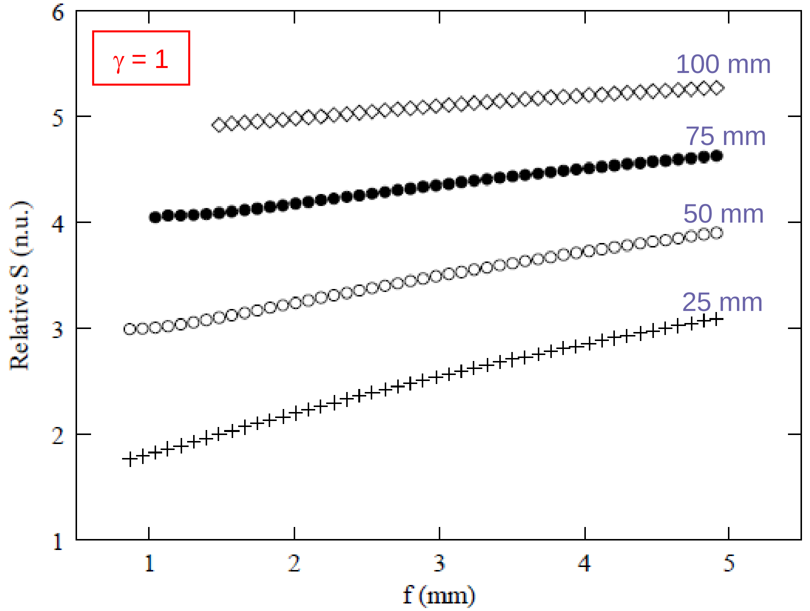
3D View (4 reflections)

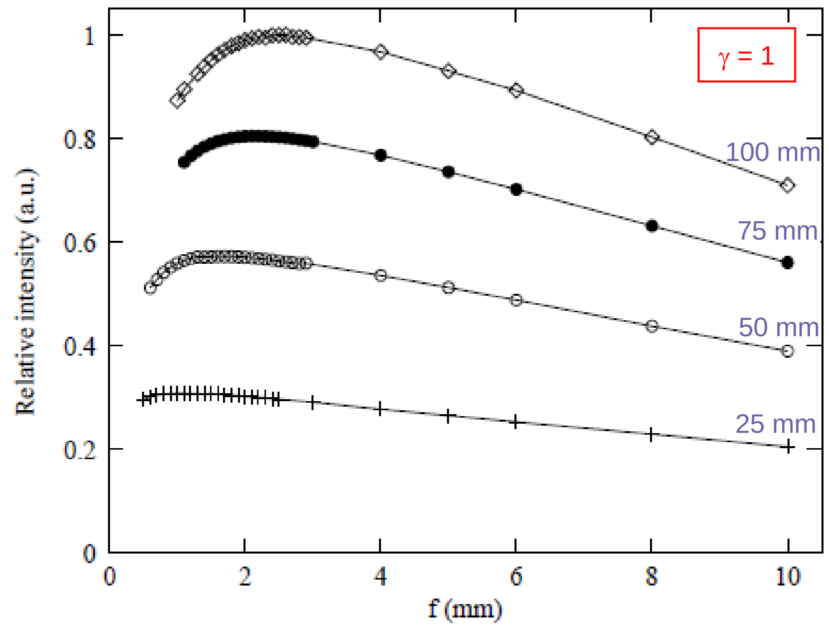


3D View (2 reflections)



Some results

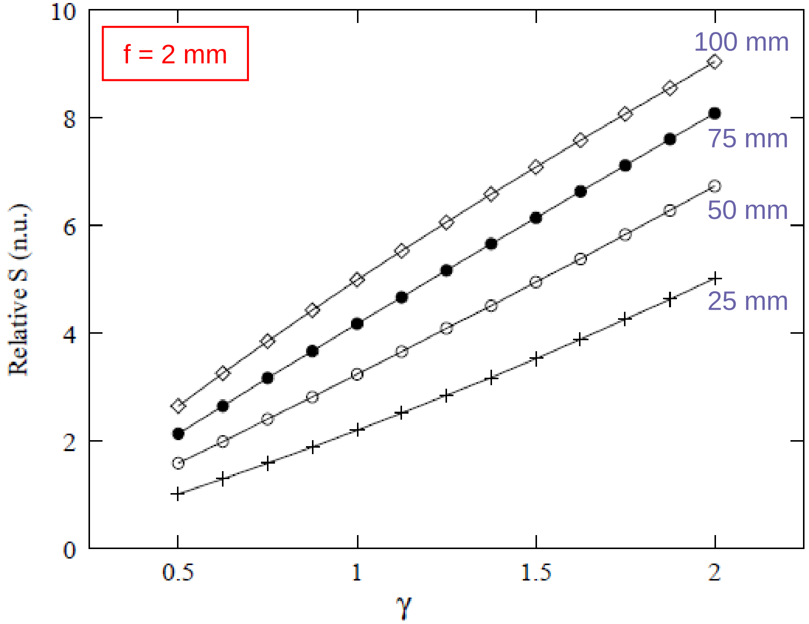


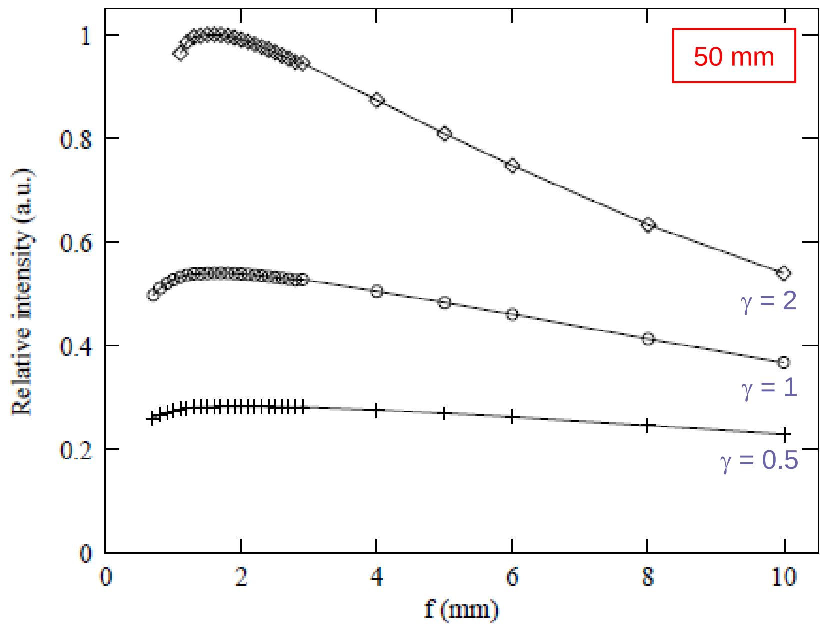


(L_{tot}=40 m, Q_{min} = 10^{-3} Å^{-1} @ λ=14 Å, λ_{min}=5 Å)

- 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

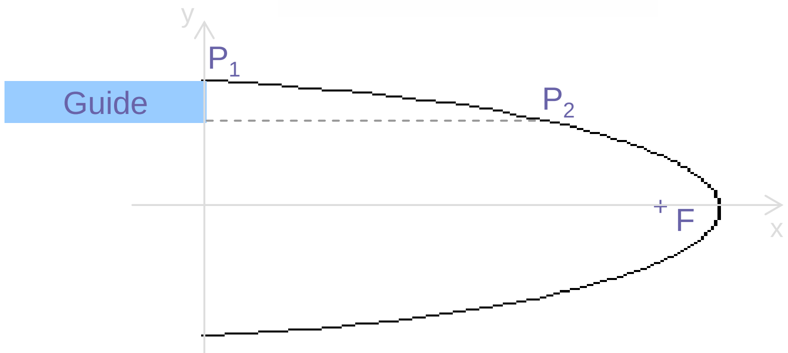
Parabolic SM

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

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

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

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

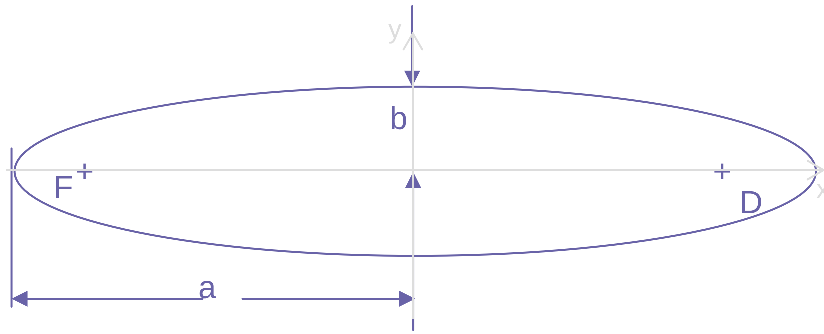


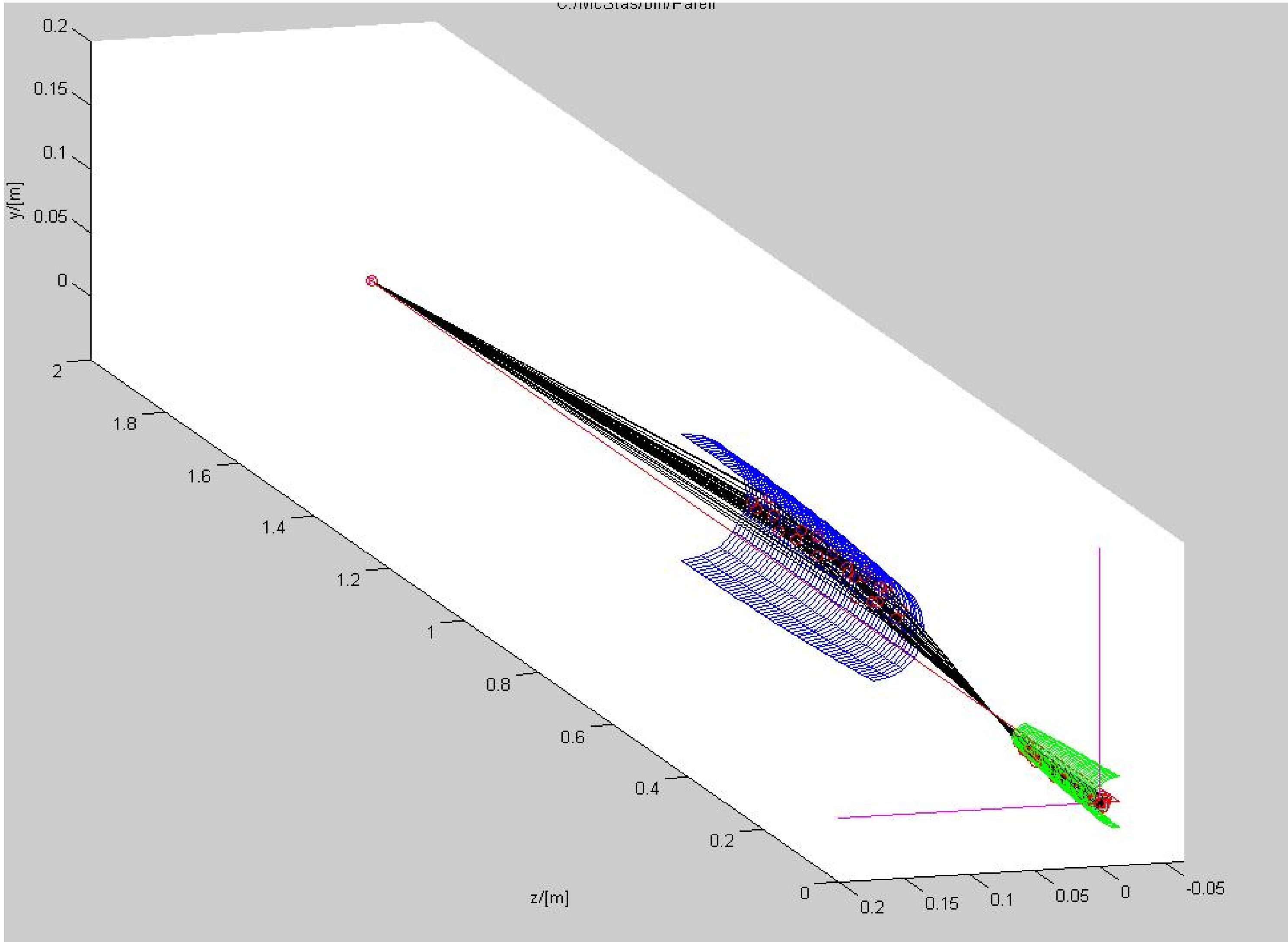
Elliptic SM

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

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

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

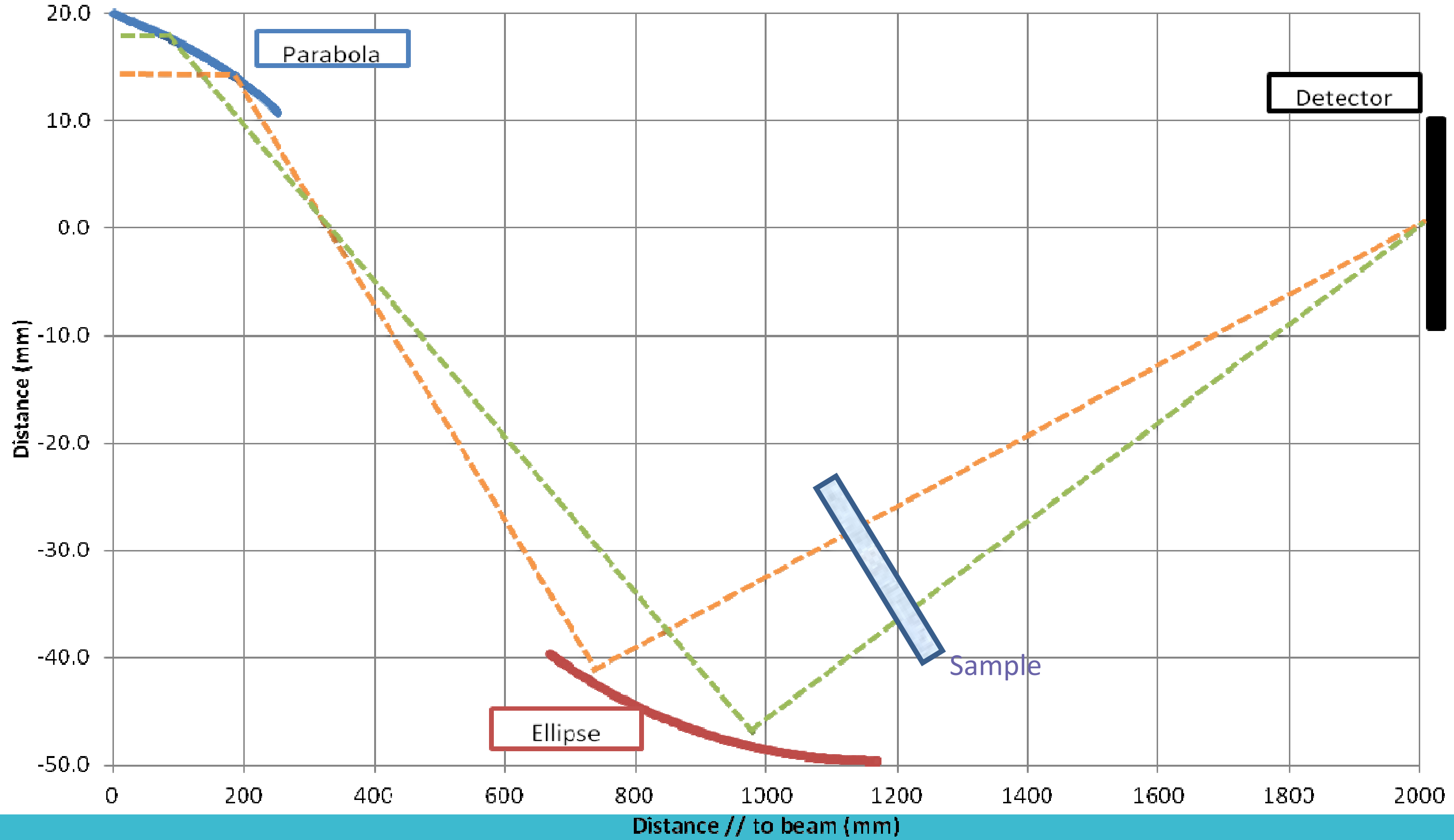



y/[m]
z/[m]
0.2
0.15
0.1
0.05
0
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
-0.05

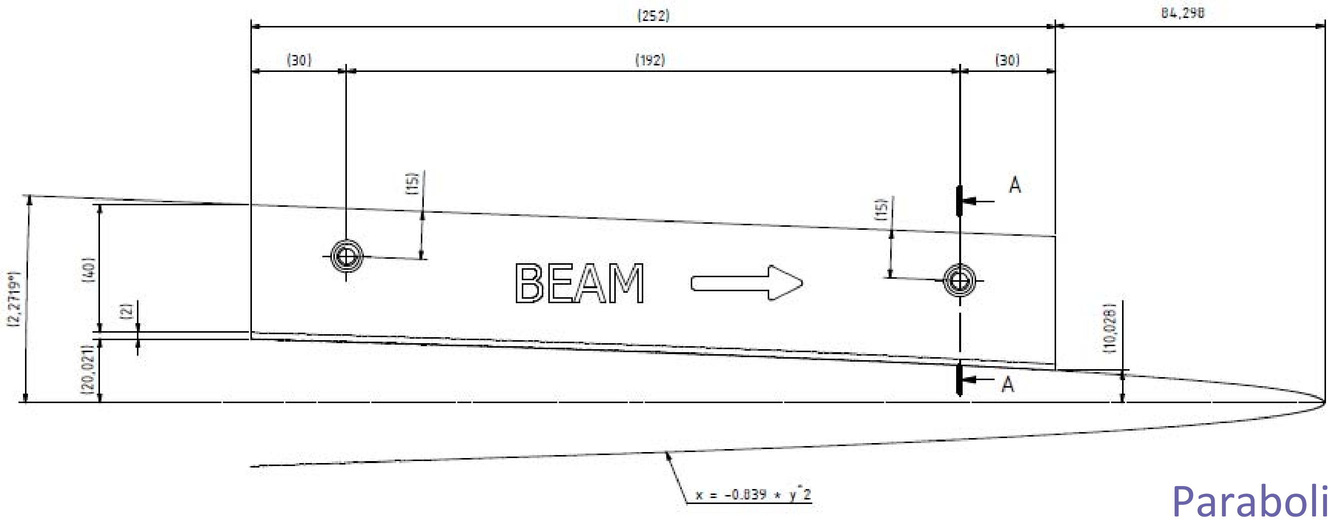
1D prototype

1D prototype specifications:

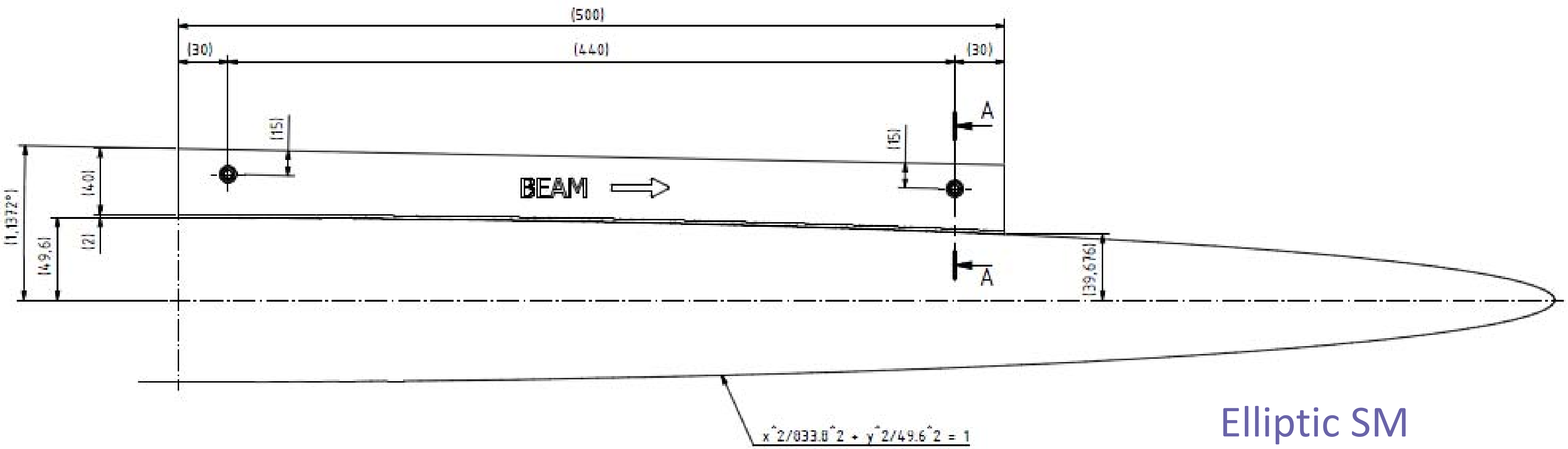
Total instrument length	2 m
Parabolic mirror	length 250 mm, height 30 mm, m=3.4
Elliptic mirror	length 500 mm, height 30 mm, m=3.4
Sample to detector length	833 mm



Manufacture of the mirrors



Parabolic SM

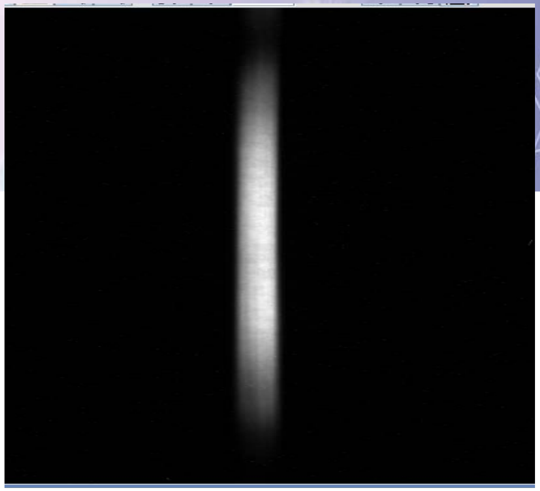


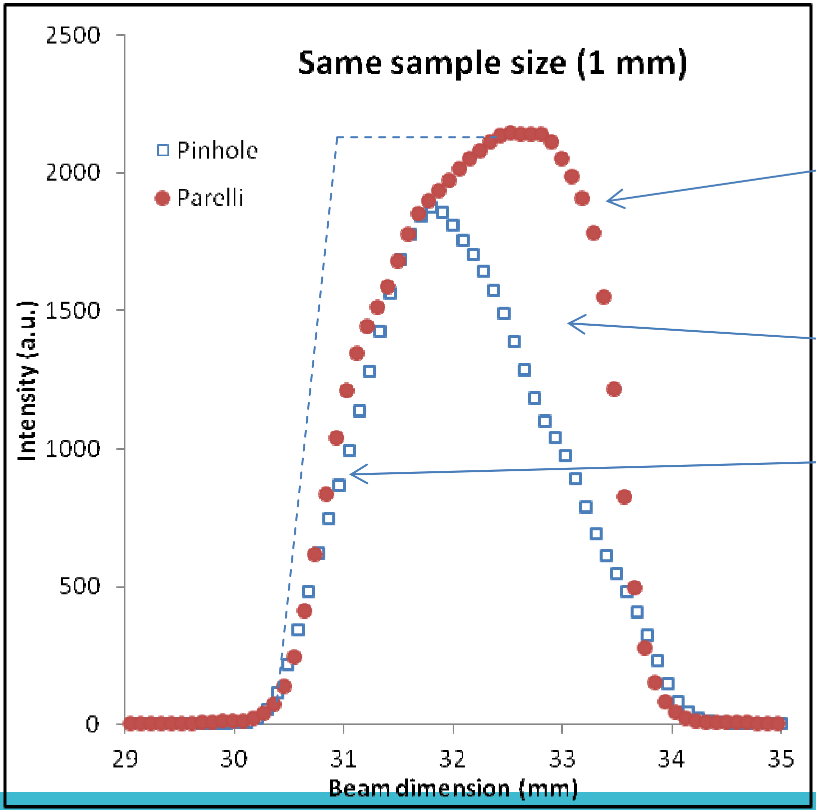
Elliptic SM

Test of prototype on BOA (T. Panzner) @ PSI, 03-06 Oct. 2011

Data treatment:
Integration along slit axis
Plot along perpendicular of slit axis

θmin=0.15°


Beam on the detector



Shape close to step distribution of intensity

Ratio of intensity is 1.25

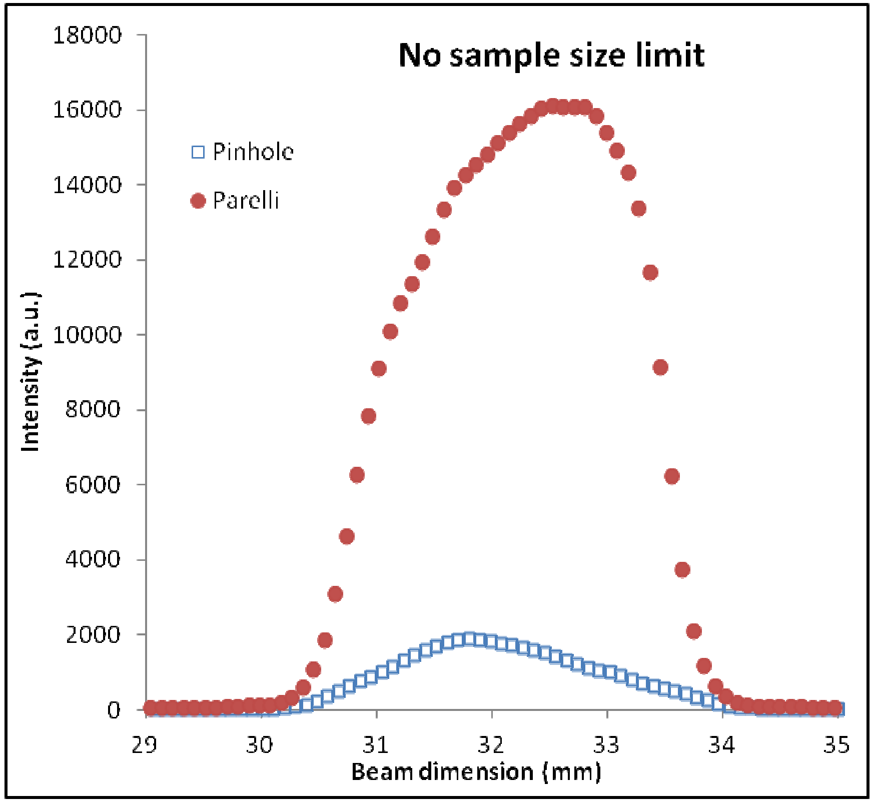
No step distribution for geometrical constraints (can be recovered by adding a SM)

Gain 10 along one axis
➔ 100 with a 3D setup.

Interests of the setup:
-Beam focusing without abberation

-Gain approx. 3 compared to pinhole with same sample size

- The beam size on the detector is independant of the sample size
➔ Large samples can be used for large intensity gain



Next steps

-Finish the data treatment and compare with simulations

-Design a 3D prototype

Aknowledgements to:

- Patrice Permingeat (LLB)
- Jochen Stahn (PSI)
- Tobias Panzner (PSI)