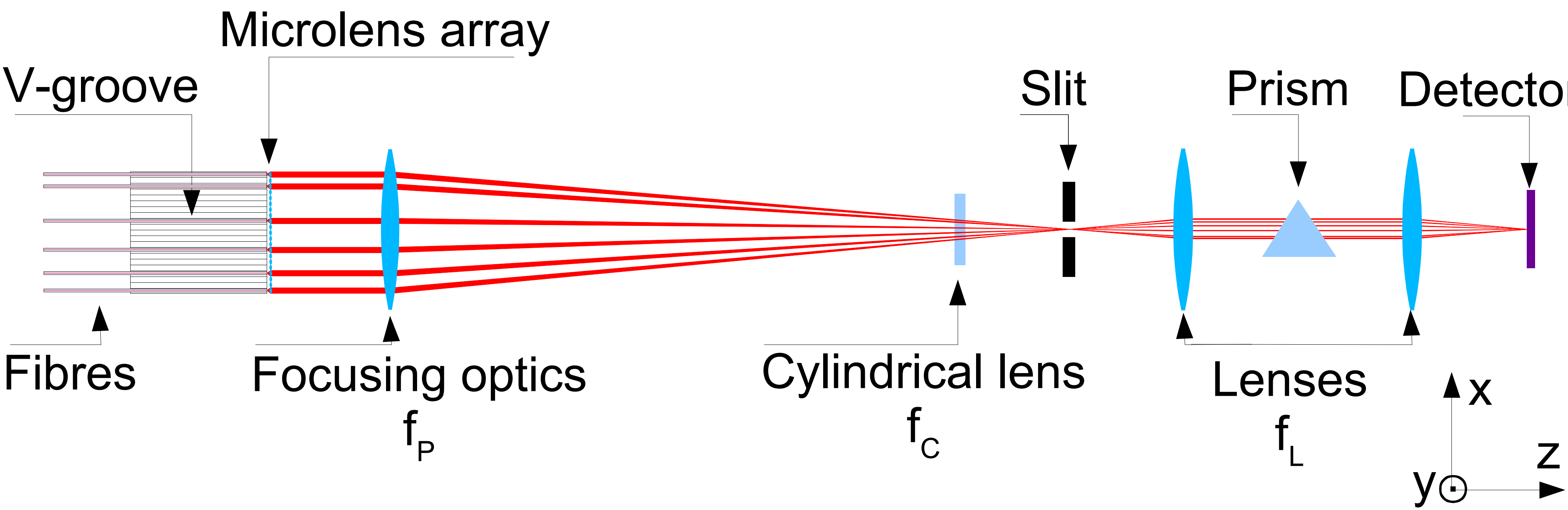
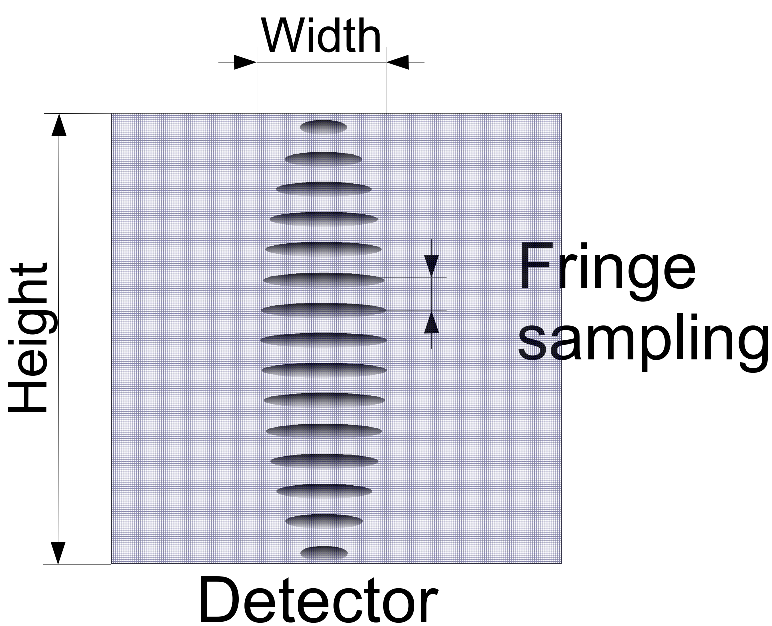
Overview of MIRC spectrograph





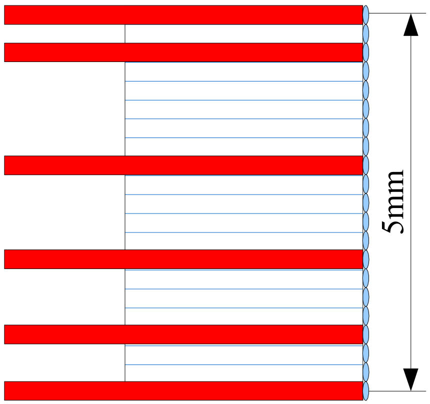
- Fringe sampling:
  - fibers spacing
  - pixel size
  - f_P
- Image Width/Height ratio:
  - f_C

Fringe sampling - 1

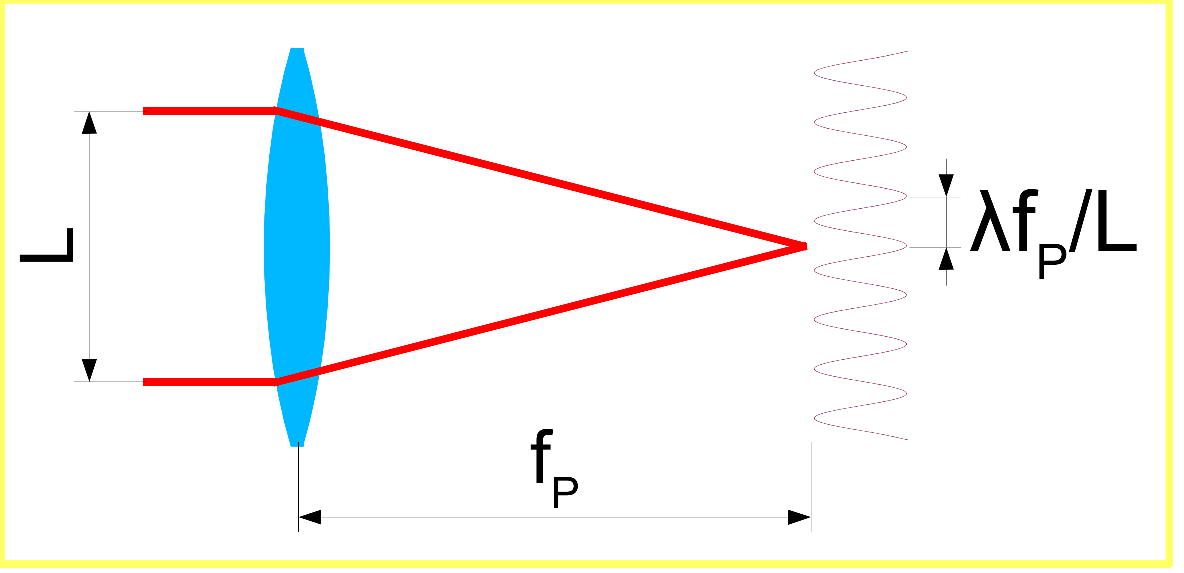
- Minimum requirement (Nyquist): 2px/fringe
- Chosen sampling: 2.5px/fringe @1.5µm

- Detector = PICNIC chip
- Pixel size = 40µm x 40µm

- Fibers spacing: two main configurations:
  - 6 telescopes: 2-6-5-4-3
  - 4 telescopes: 2-6-4



Fringe sampling - 2



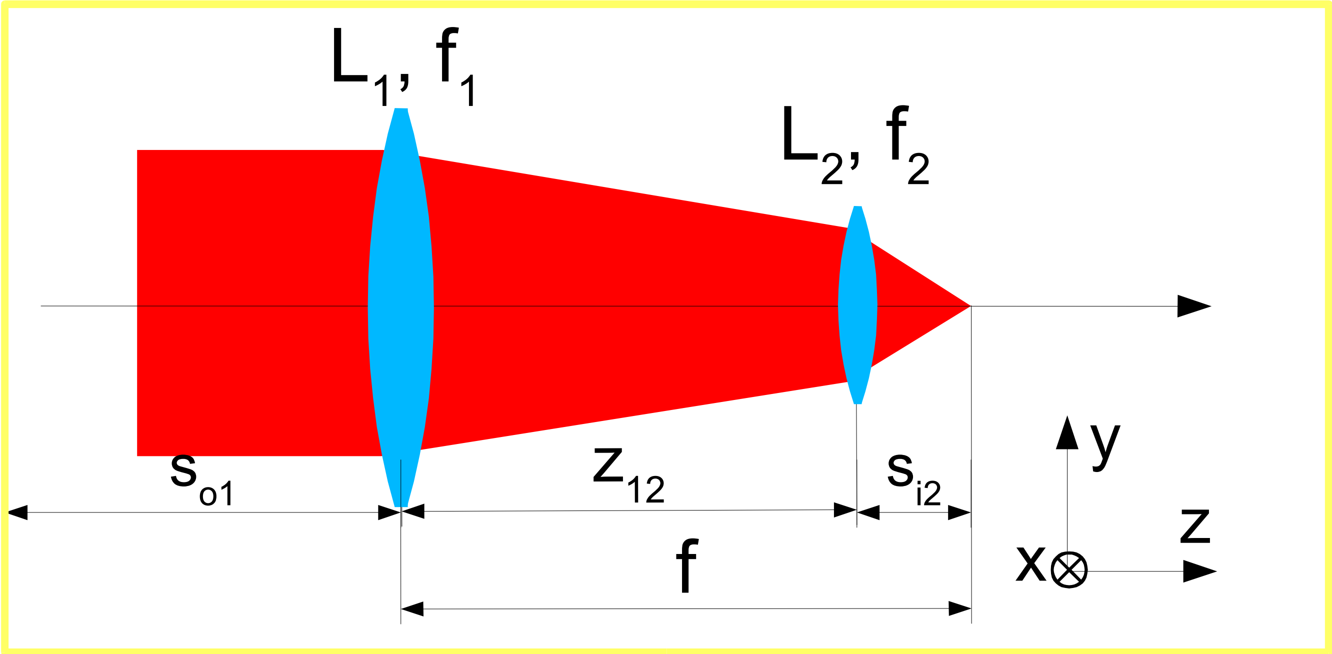
2.5px/fringe @ 1.5µm

→ $\lambda f_p/L = 2.5 \times p$

→ $f_P = 2.5 \times p \times L / \lambda$

- 6 telescopes:
  - f_P= 2.5 x 40e-3 x 5 / 1.5e-3 =333mm
- 4 telescopes:
  - f_P= 2.5 x 40e-3 x 3 / 1.5e-3 =200mm

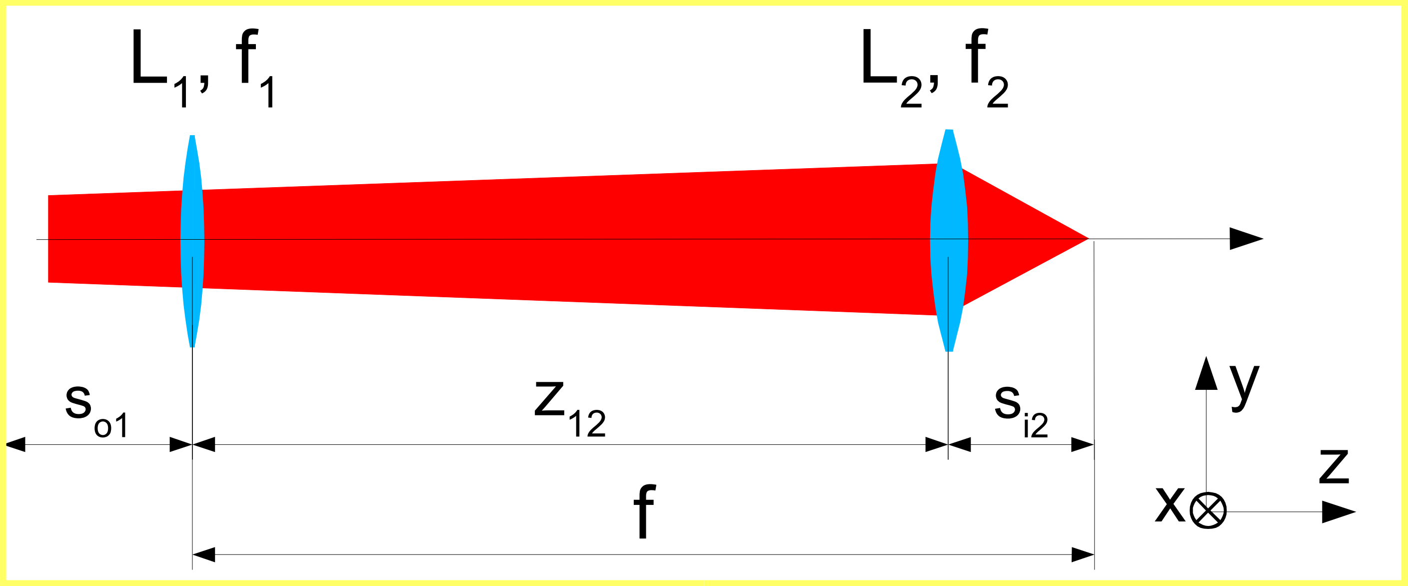
Lens combination – Geometrical Optics



$$s_{i2} = \frac{(z_{12} - f_1) f_2}{z_{12} - f_1 - f_2}$$

f1=333mm, f2=20mm, z12=312mm
=> si2 =10.2mm

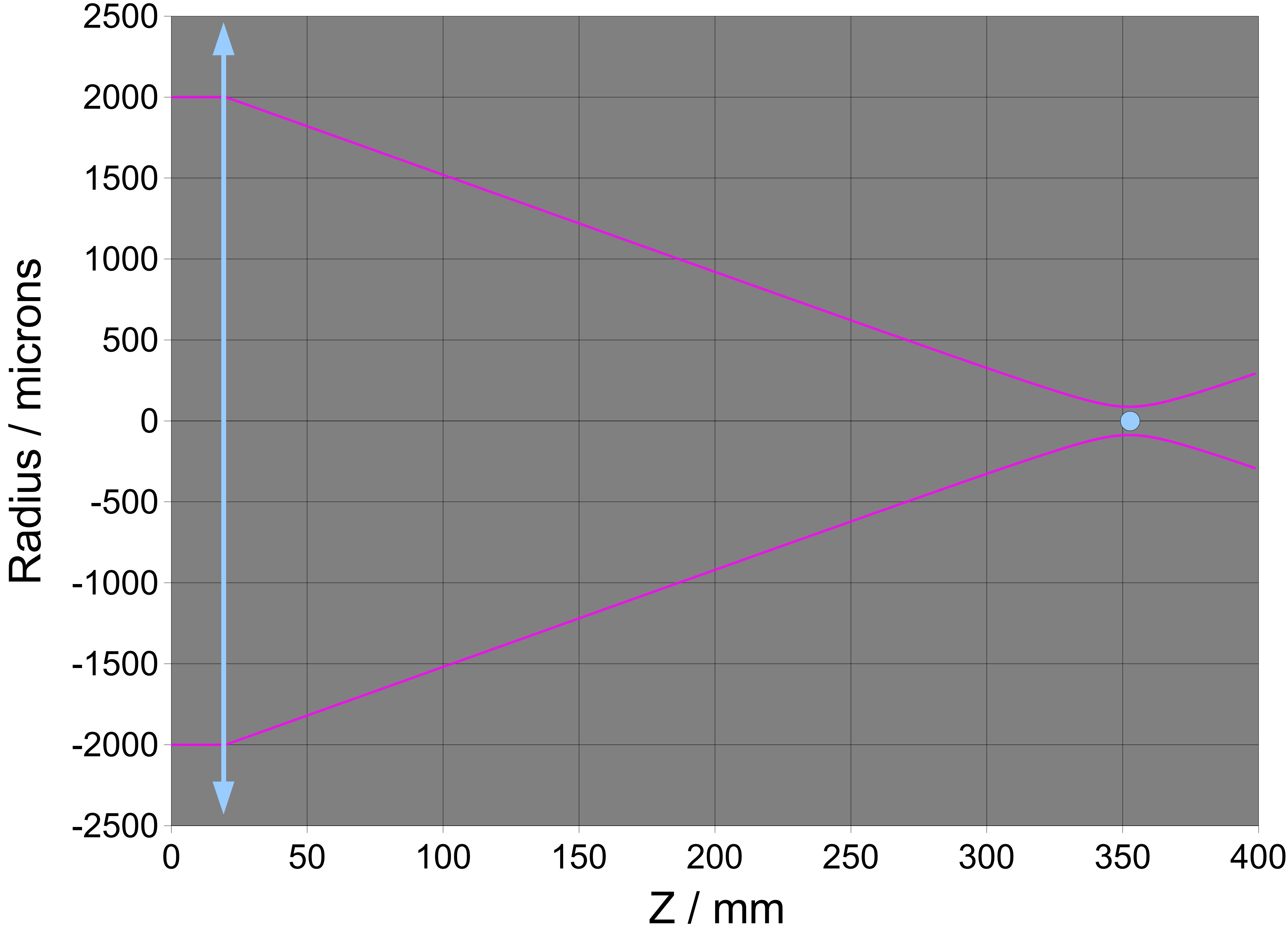
Lens combination and Fresnel diffraction



- Beam diameter << s_{o1}, f_1, z_{12}
- f_1 long focal length == low power
- Fresnel diffraction >> f1 power

$$s_{i2} = \frac{(z_{12} \cdot f_2)}{z_{12} - f_2}$$ = thin lens equation with $s_o = z_{12}$

f2=20mm, z12=312mm
=> si2 =21.4mm



2500
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-2500
Radius / microns
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50
100
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200
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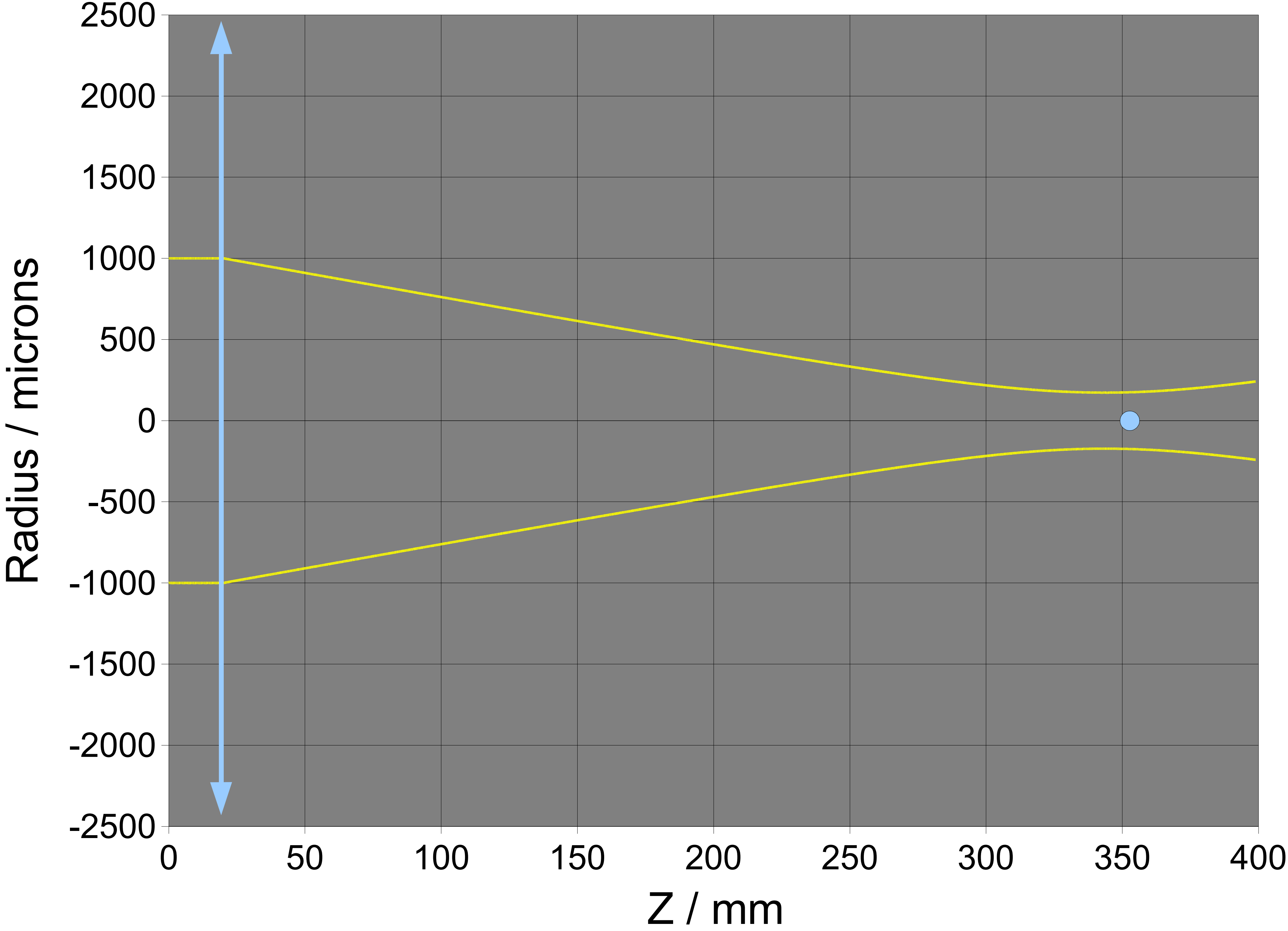
Z / mm



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Radius / microns
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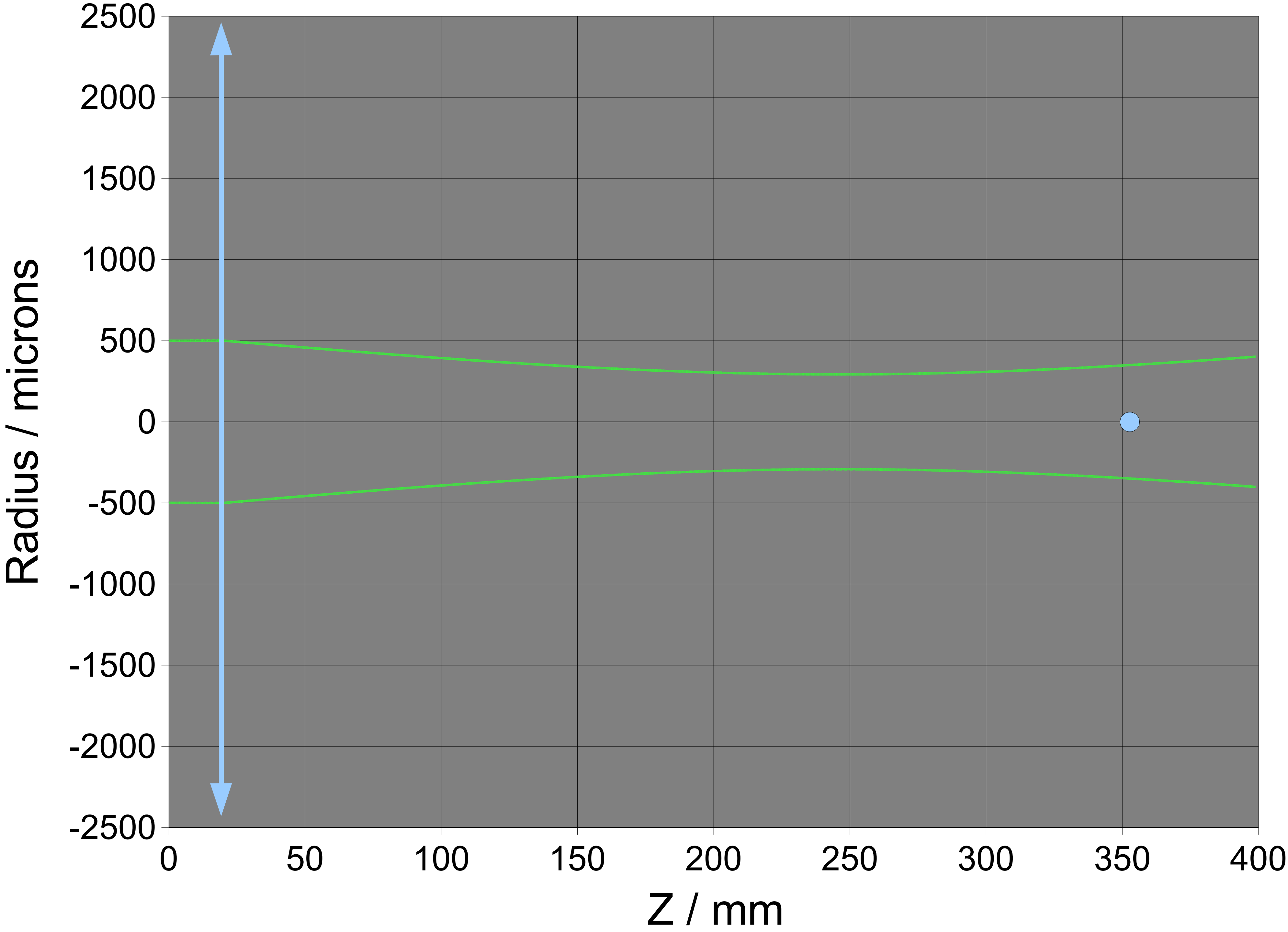
Z / mm



Radius / microns
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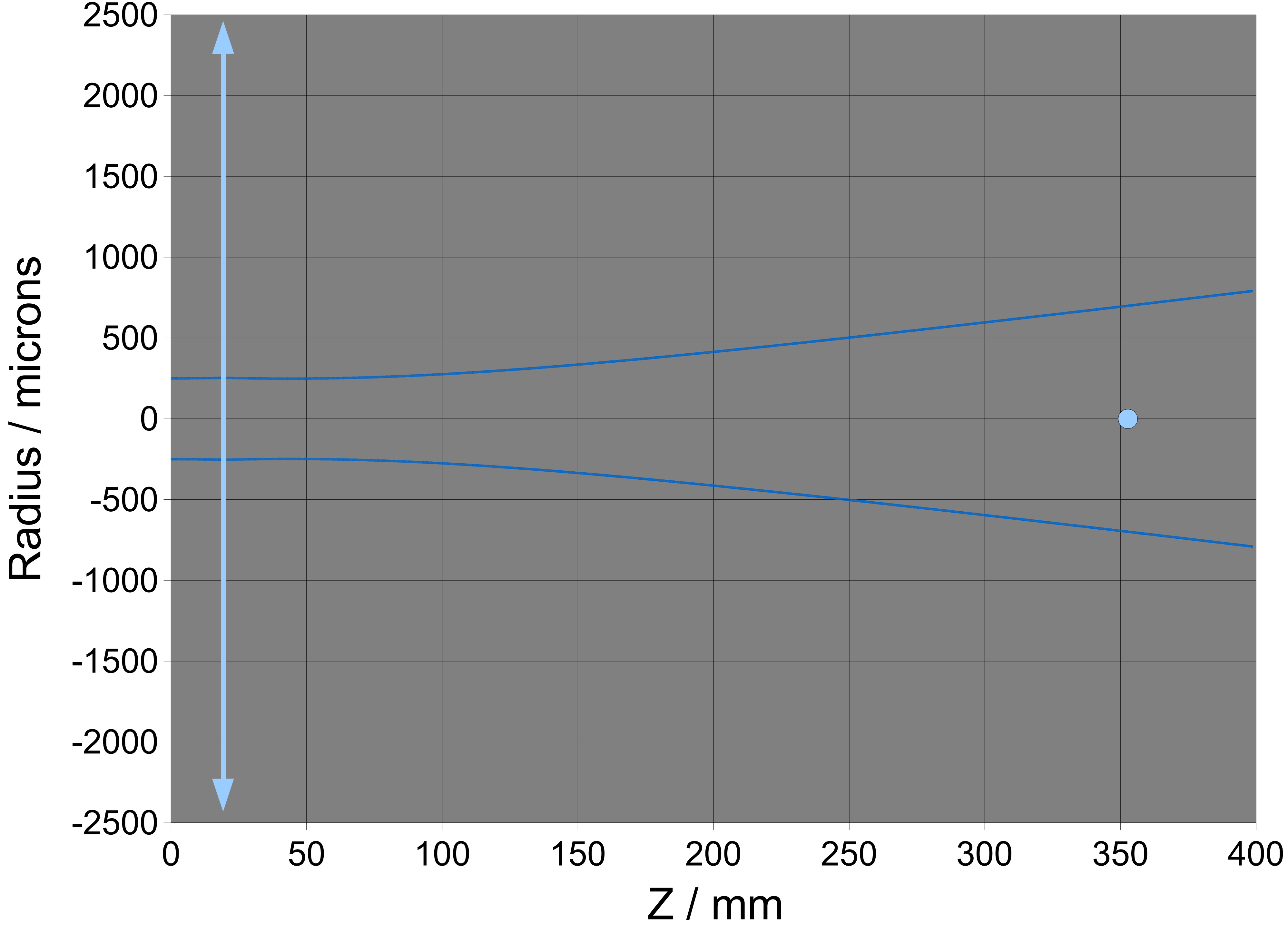
Z / mm



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Radius / microns
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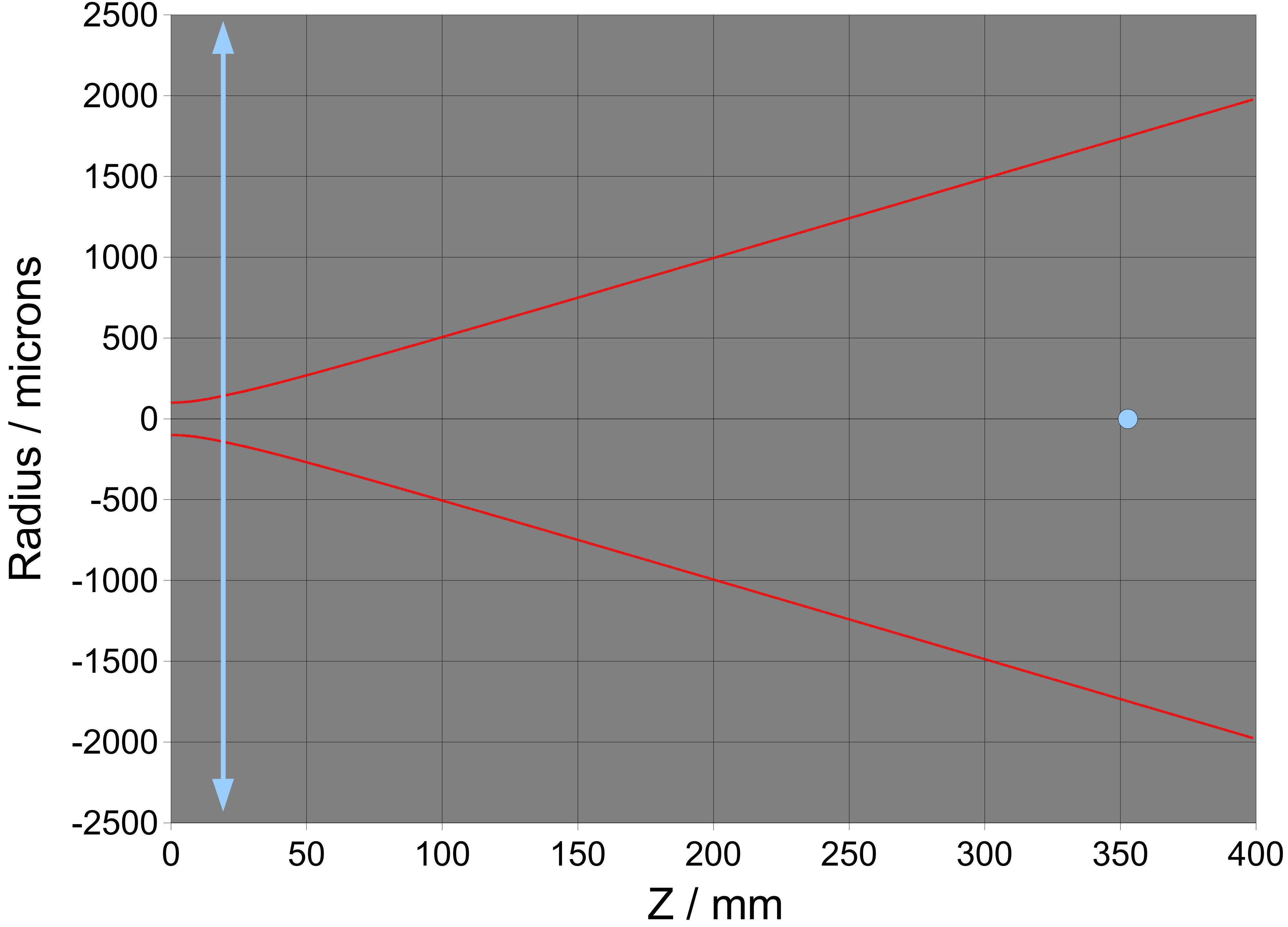
Z / mm



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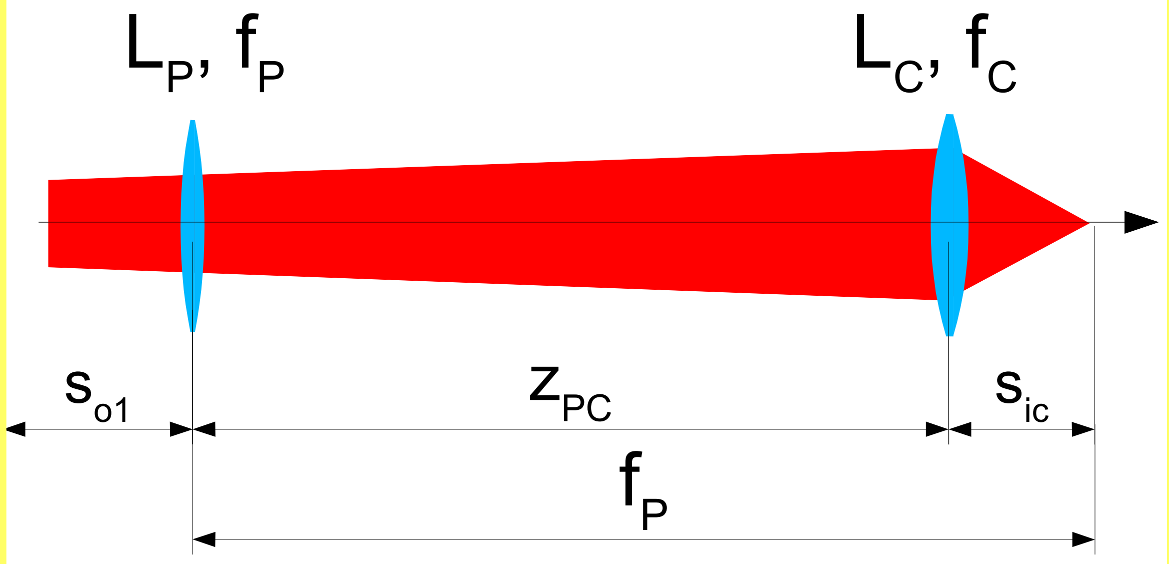
-2000
-2500
Radius / microns
0
50
100
150
200
250
300
350
400
Z / mm

The Cylindrical Lens



$$S_{iC} \approx \frac{z_{PC} \cdot f_C}{z_{PC} - f_C}$$

with $z_{PC} + S_{iC} = f_P$

$$\Rightarrow z_{PC}^2 - f_P z_{PC} + f_P f_C = 0$$

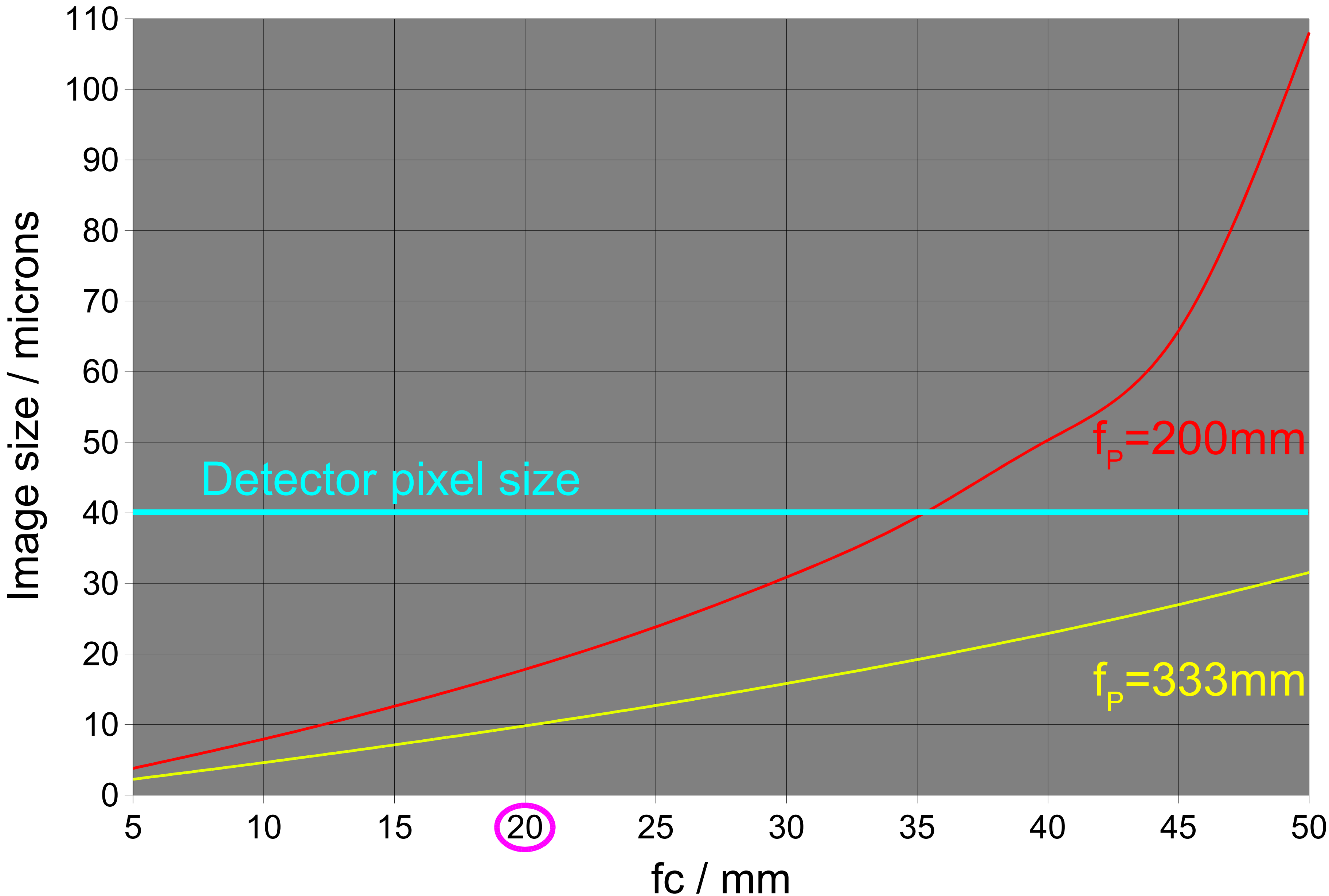
$$f_C \leqslant \frac{f_P}{4}$$

$$z_{PC} = \frac{f_P + \sqrt{f_P^2 - 4 f_P f_C}}{2}$$

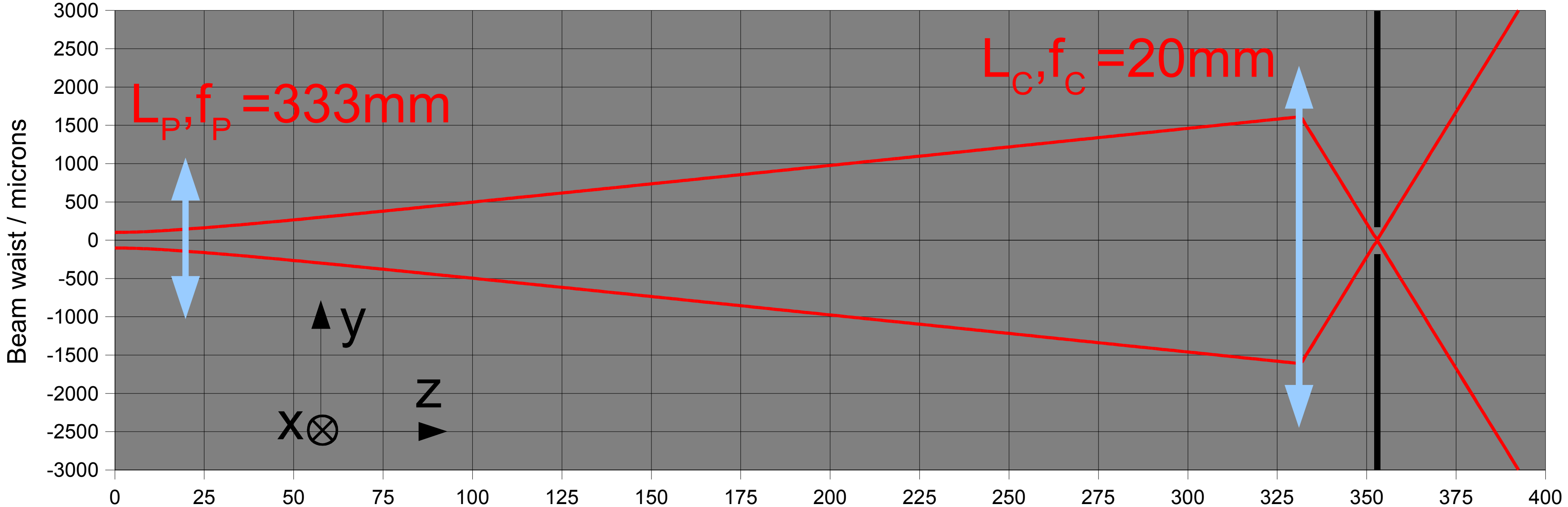
$$f_P = 200\,\text{mm} \rightarrow f_C \leqslant 50\,\text{mm}$$

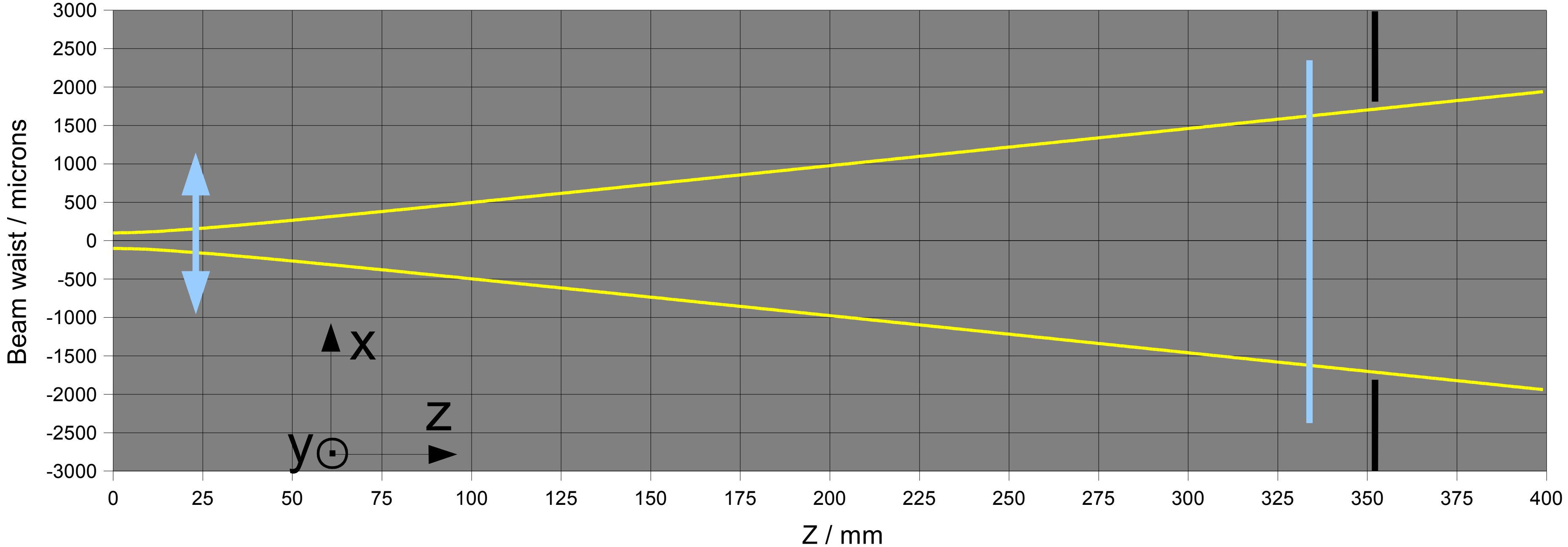
$$f_P = 333\,\text{mm} \rightarrow f_C \leqslant 83\,\text{mm}$$

The Cylindrical Lens

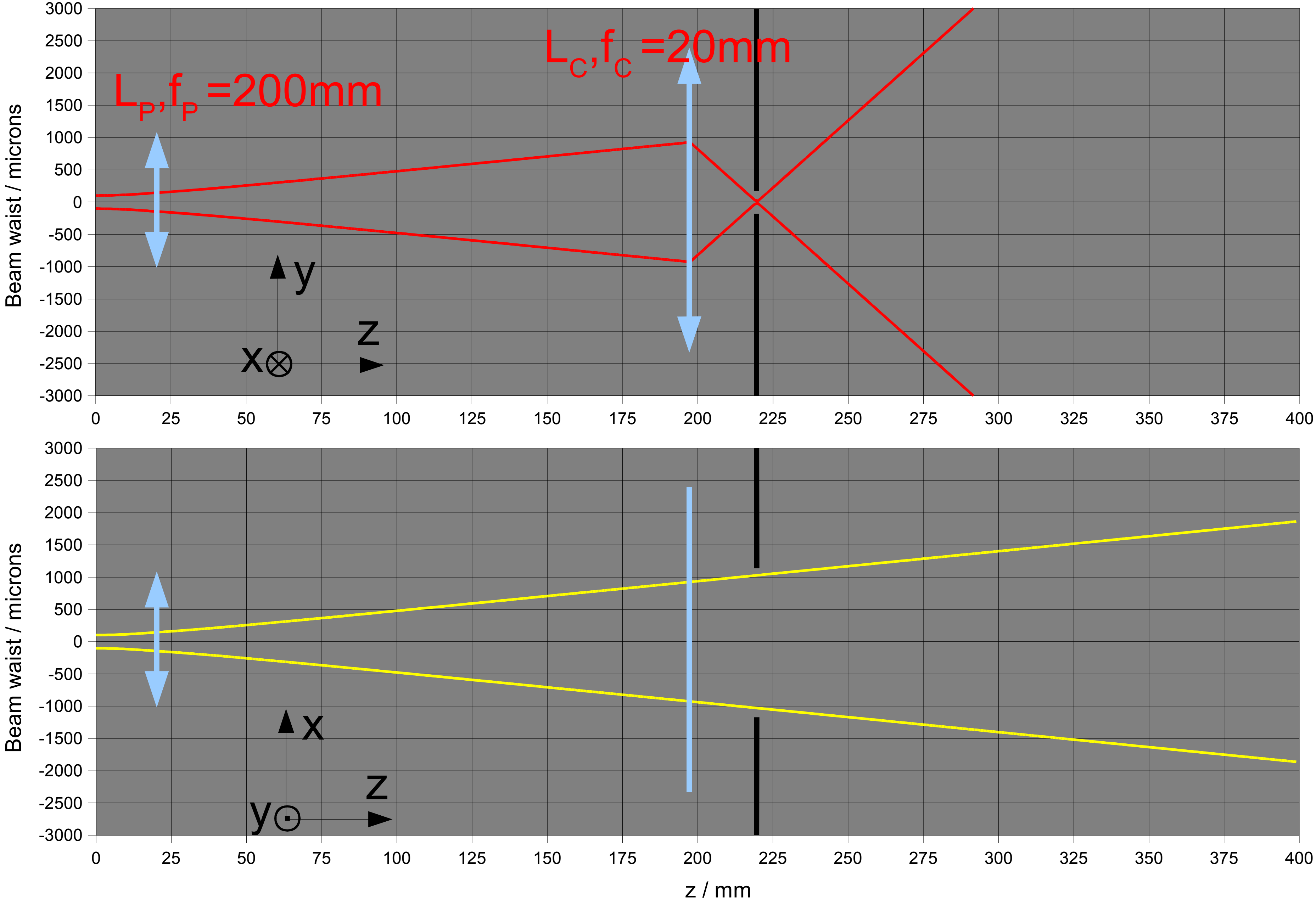


Diffracted beam profile

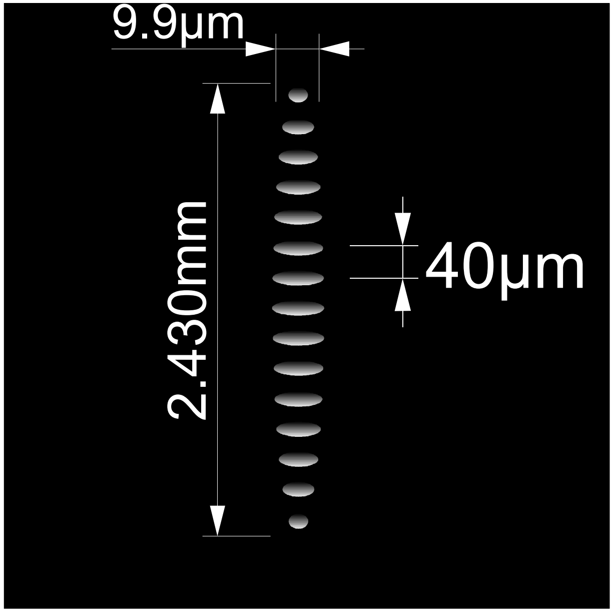




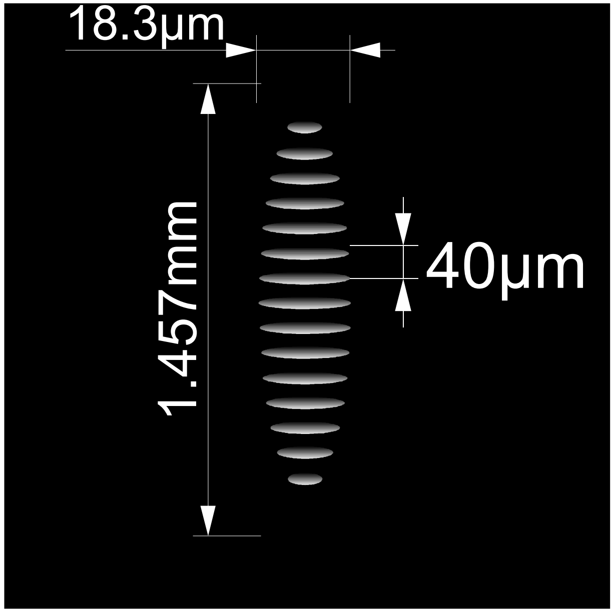
Diffracted beam profile



Images in L_P focal plane

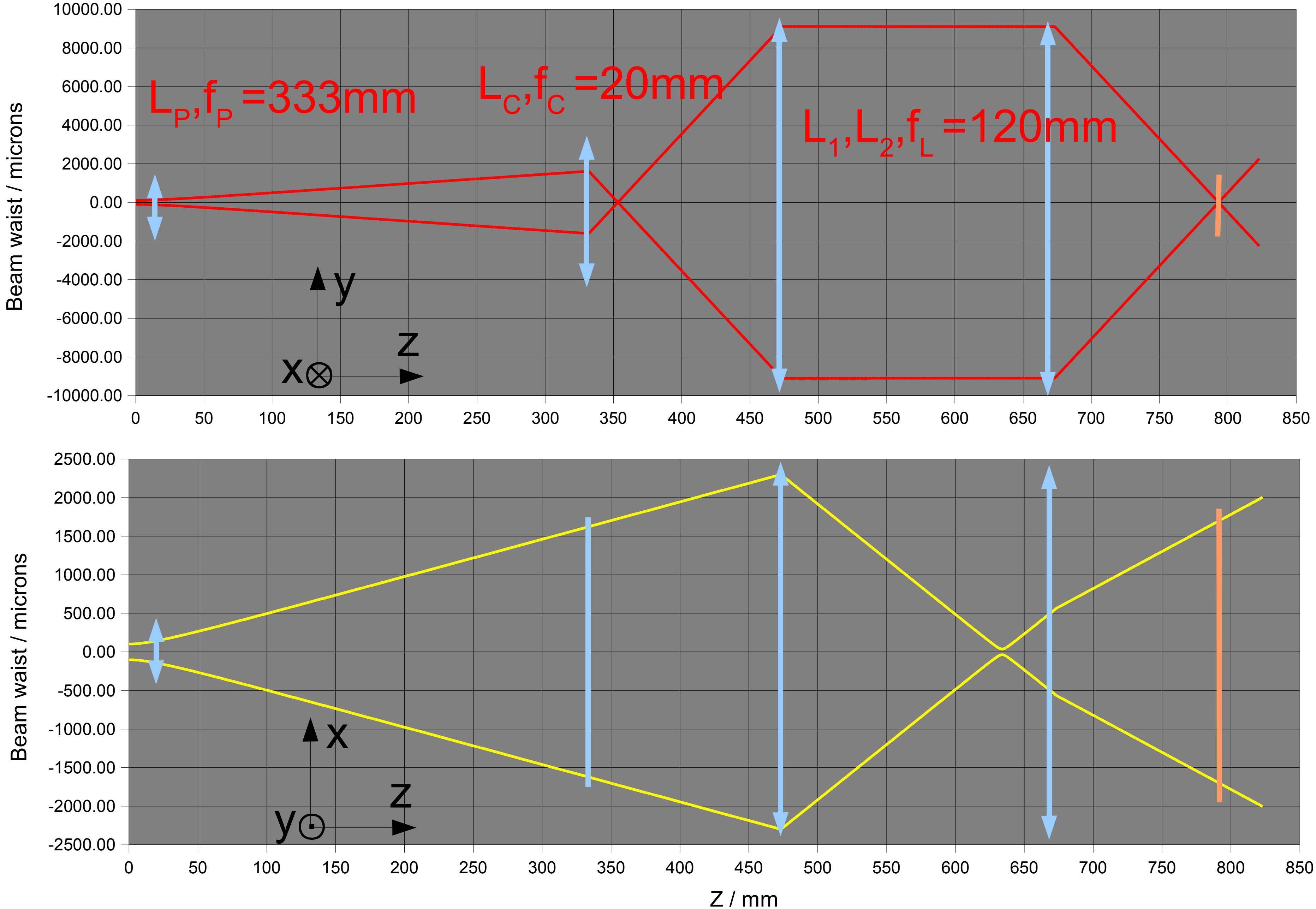


f_P=333mm

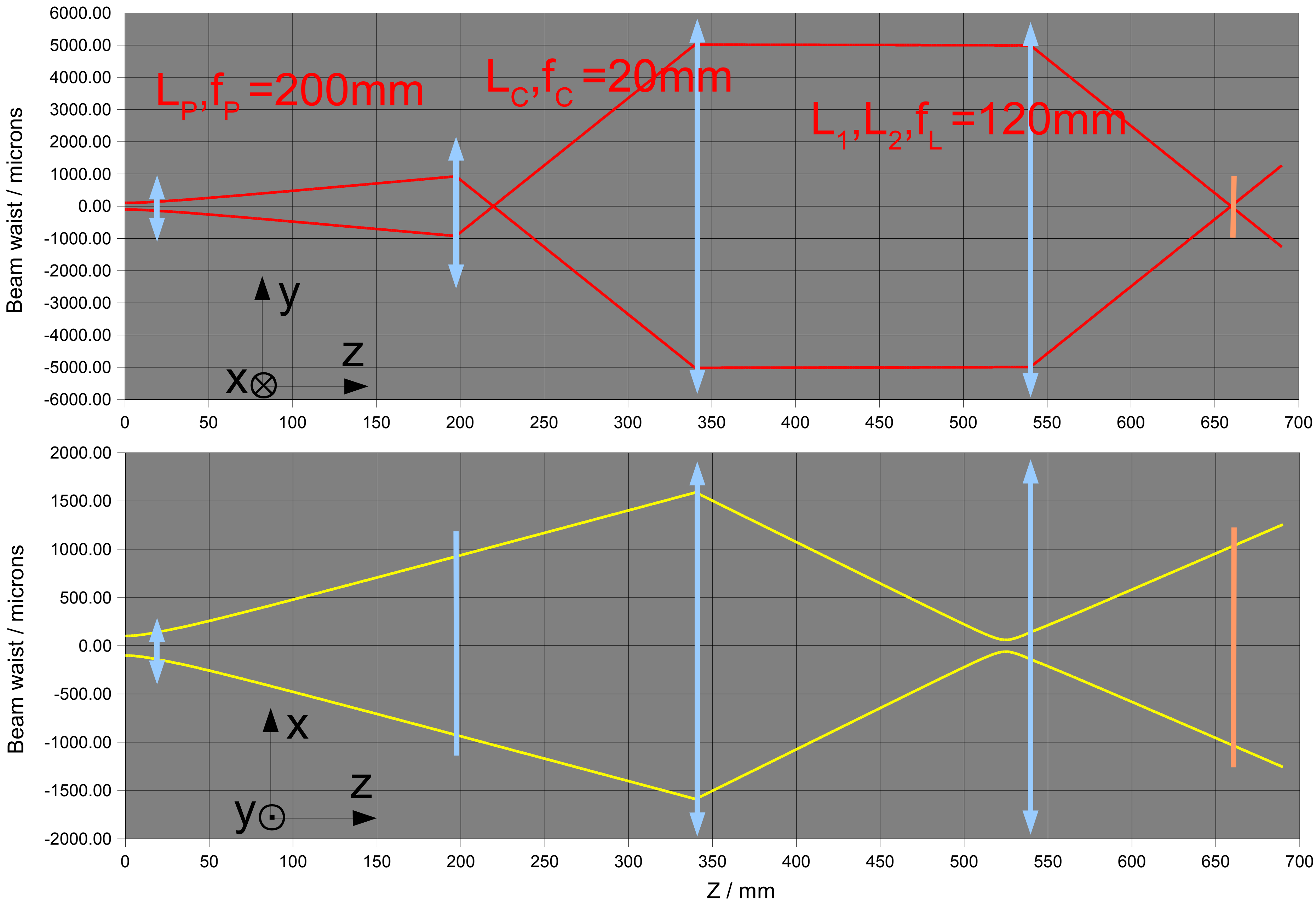


f_P=200mm

Diffracted beam profile

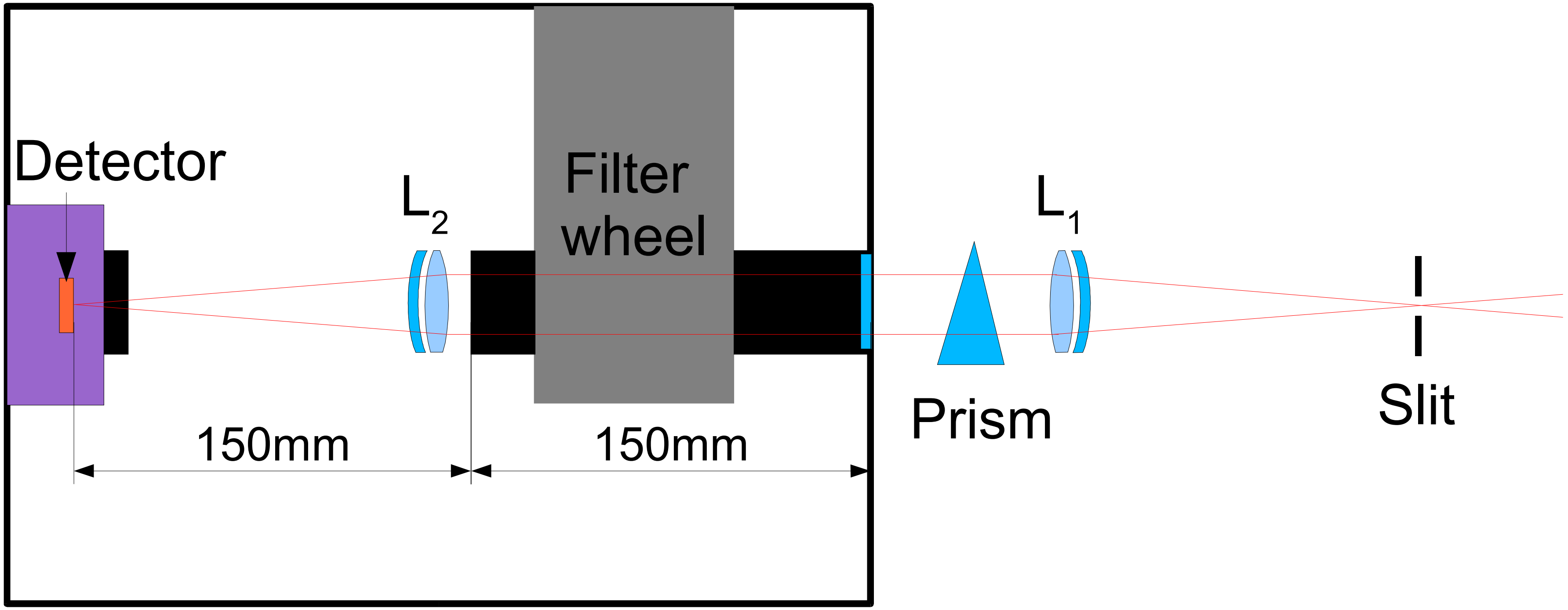


Diffracted beam profile



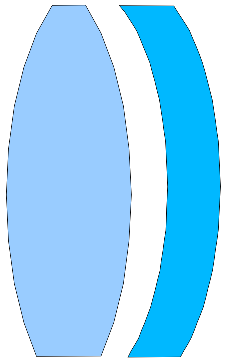
L_1 and L_2 doublets - 1

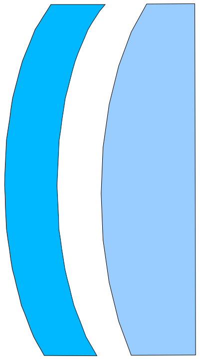
- Role: transport the dispersed image onto the detector
- L_1, L_2: same focal length
- L_2 in the detector dewar: f_L =100-120mm



L_1 and L_2 doublets - 2

- Chosen design:
  - Air spaced Fraunhofer "crown" in front configuration





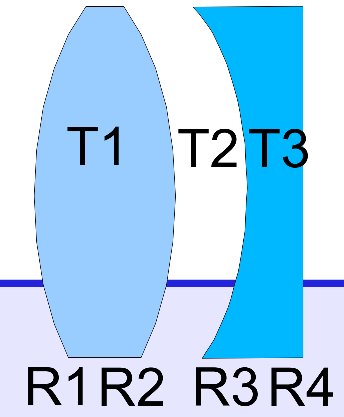
Steinhel configuration

Crown glass is one of the two principal types of optical glass, the other being *flint* glass. **Crown** glass is harder than *flint* glass, and has a lower index of refraction and lower dispersion.

- Selected glasses:
  - **CaF_2** + *Fused Silica* (Keck design)
  - **CaF_2** + *FTM16*

L_1 and L_2 doublets - 3

- Lens designed using zemax



1. Select a starting design:
   R_1, $R_2=R_3=-R_1$, $R_4=\infty$
2. Create a merit function controlling only the focal length
3. Use the optimisation routine to change R_1
4. Create the intermediate merit function which contains 4 operands controlling: the focal length, the longitudinal colour, the spherical aberration, and the coma.
5. Use the optimisation routine to change R_1, R_2, R_3, and R_4
6. Create the final merit function and run the optimisation routine

L_1 and L_2 doublets - 4

Lens Data Editor

Edit Solves Options Help

	Surf:Type	Comment	Radius	Thickness	Glass	Semi-Diameter	Conic	Par 0(unused)	Par 1(unused)	Par 2(unuse
OBJ	Standard		Infinity	Infinity		Infinity	0.000000			
STO	Standard		Infinity	100.000000		5.000000	0.000000			
2*	Standard	EDGE THICKNESS 2M..	69.235121 V	5.128400 E	CAF2	12.700000 U	0.000000			
3*	Standard	EDGE THICKNESS 4M..	-42.256299 V	4.212222 E		12.700000 U	0.000000			
4*	Standard		-38.317635 V	3.000000	FTM16	12.700000 U	0.000000			
5*	Standard		-88.577678 V	108.676325 M		12.700000 U	0.000000			
IMA	Standard		Infinity	-		6.289214	0.000000