Wide Field Imaging

Delft University of Technology/Knowledge Centre Aperture Synthesis
Optics Research Group
Iciar Montilla
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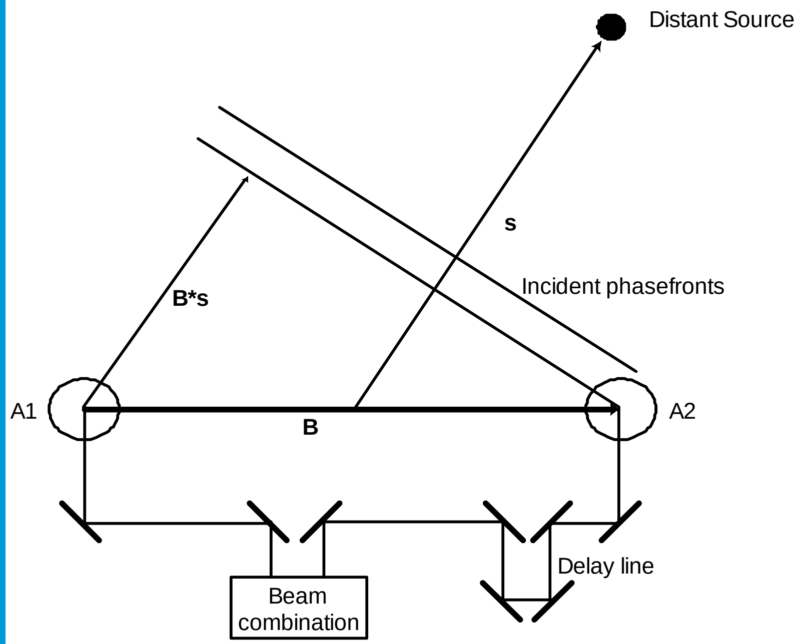
Introduction

- Aperture Synthesis technique first developed for radio astronomy (one resolved point per antenna)
- Optical telescopes have the advantage of a wide Field Of View (FOV)
- It is useful to keep this advantage for observation of extended or multiple objects



Telescopes A1 and A2 collect the light coming from a distant stellar source in the direction s. But the light "arrives" at the telescopes with a time difference

$$\tau = \frac{\vec{B} \cdot \vec{s}}{c}$$

To detect interference fringes we have to make $\tau \cdot c < L_c$

where L_c is the coherent length and τ*c is called the Optical Path Difference (OPD). This OPD is corrected using a delay line.

When OPD > L_c no interference : Narrow coherent field

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Dual-feed technique

Separates the fields of two stars and sends each wavefront to a different delay line.
Useful for fringe acquisition/tracking on a nearby strong source.
But separating the wavefronts we lose light.

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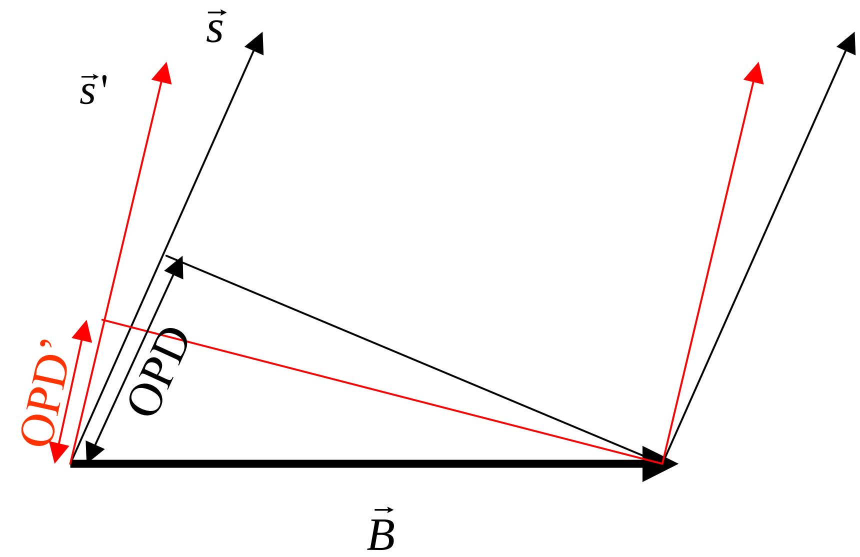
New approach

$\vec{B}$ baseline vector
$\vec{s}$ pointing vector



$$OPD = \vec{B} \cdot \vec{s}$$

$$\Delta OPD = \vec{B} \cdot \left(\vec{s}' - \vec{s} \right)$$

$$OPD' = \vec{B} \cdot \vec{s}'$$

If we compensate the ΔOPD as function of the field angle:
Wide field of view

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Field-Angle Dependence of the ΔOPD

(E, A) pointing vector coordinates

$(E+\delta E, A+\delta A)$ off-axis vector coordinates

(B_x, B_y) baseline coordinates

$$\Delta OPD = B_x\left[\delta E \sin E \sin A - \delta A \cos E \cos A\right] - B_y\left[\delta E \sin E \cos A + \delta A \cos E \sin A\right]$$

With B~10^2 m the second order terms are negligible for a ~ 10 arcmin field

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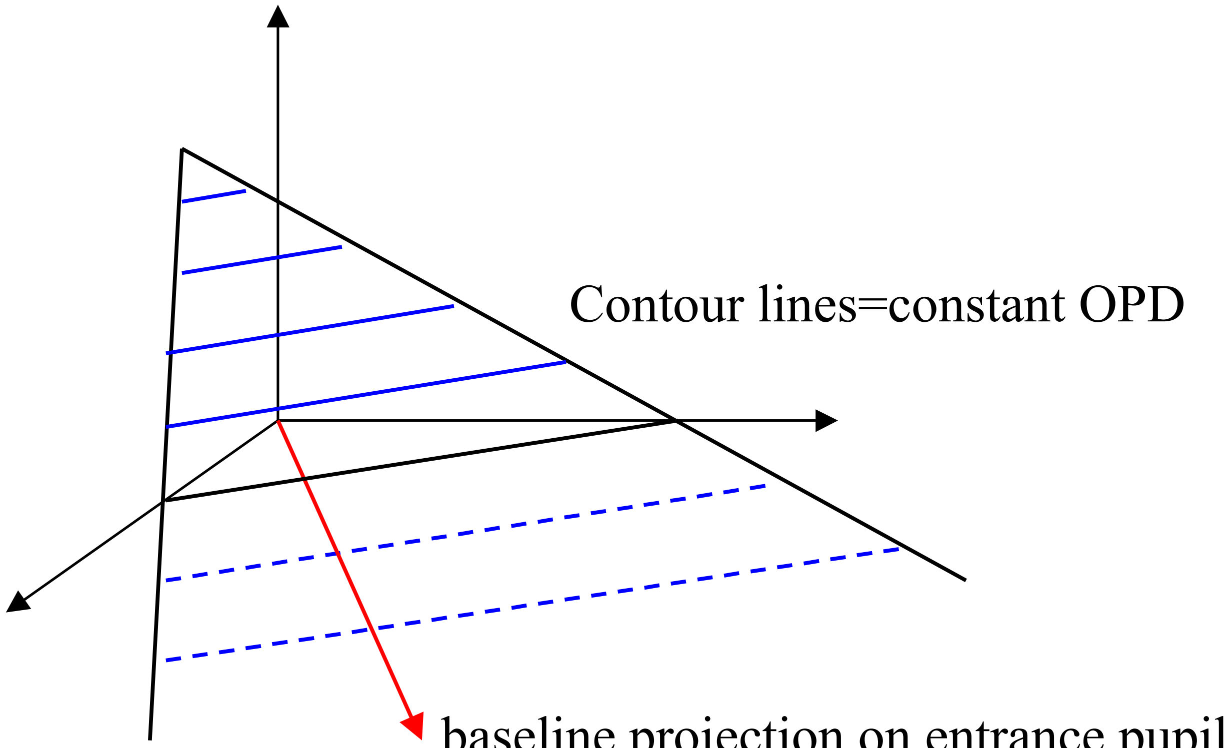
ΔOPD function is a tilted plane



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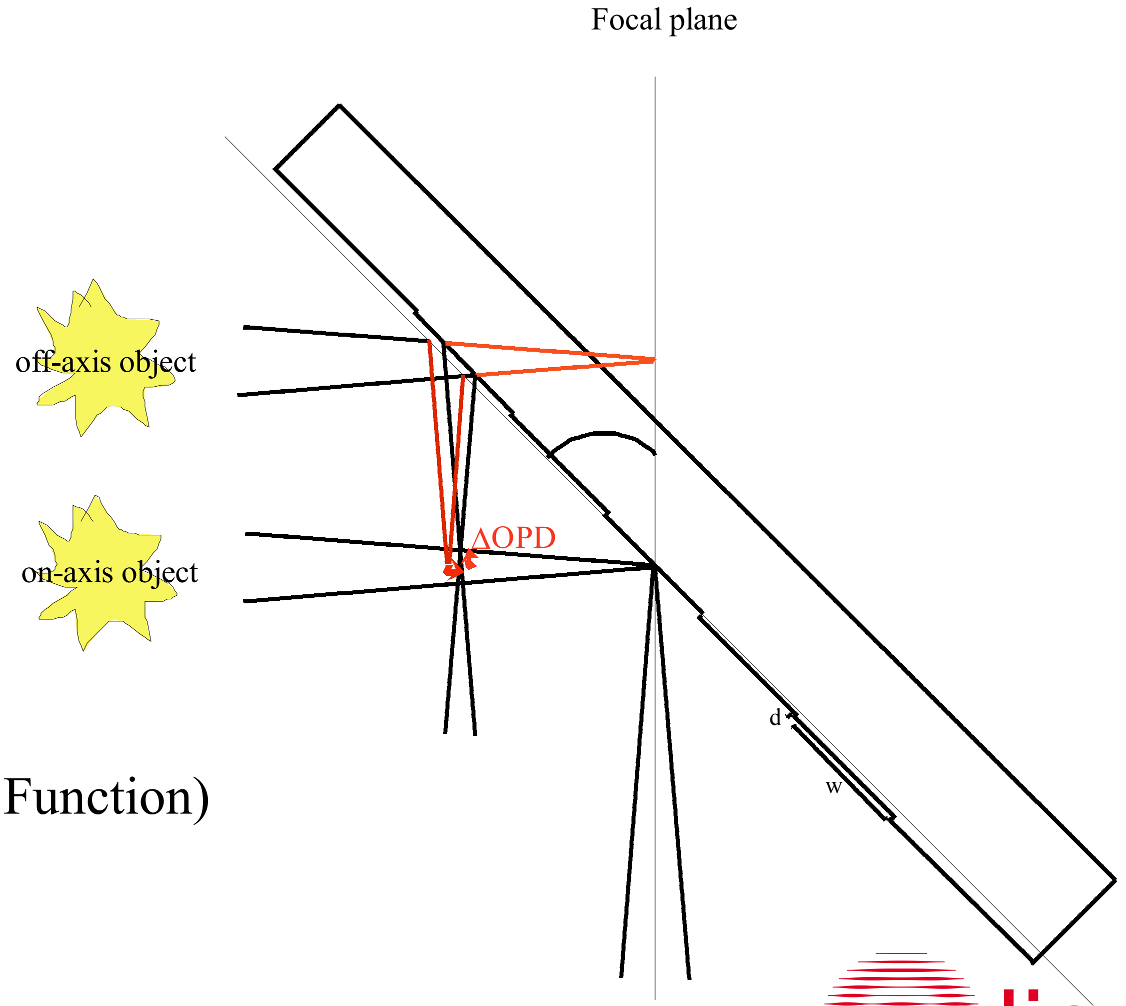
Equalization of the ΔOPD

Staircase Mirror
working principle



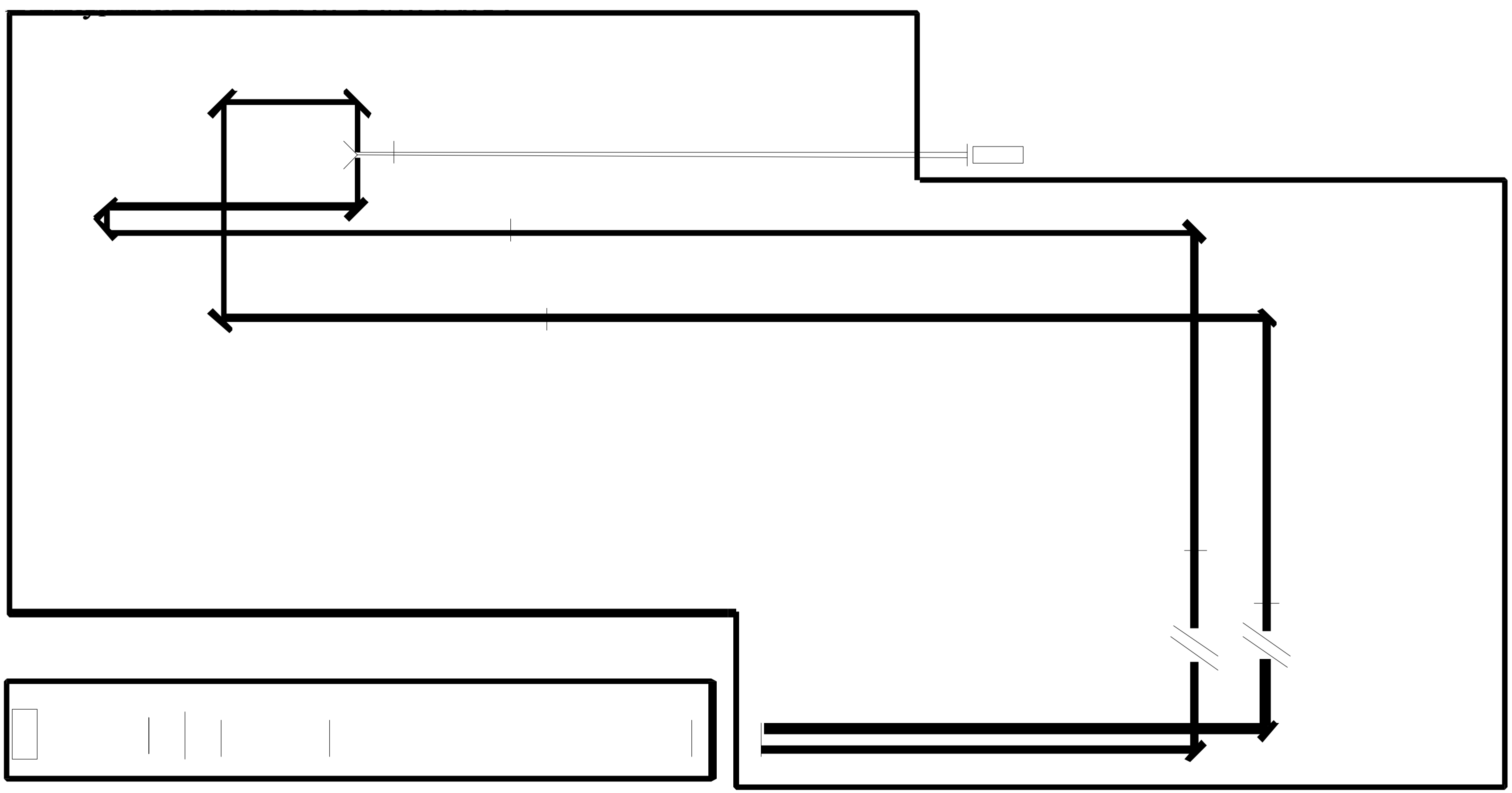
requirements:

•long focal depth

•small ΔOPD/PSF(Point Spread Function)

•large w/PSF

Experimental setup



Application to VLTI

Calculation of the step depth and rotation angle of the equalization mirror

Input:

•declination and right ascension of the stellar object

•u,v site coordinates of the telescopes

Output:

•staircase mirror shape with fixed width and adaptable depth and rotation angle as a function of Local Sidereal Time (LST) for object tracking.

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VLTI parameters

VLTI optical parameters:

- entrance pupil 8,000 mm
- focal length 408,000 mm
- field of view in Coudé focus 2 arcmin diameter
- scale 1.98 mm per arcsec on the sky
- L = 24° 38’ S
- Central wavelength $\lambda = 2.2\ \mu m$
- Bandwidth $\Delta\lambda = 0.2\ \mu m$
- Mirror angle $\alpha = \pi/4$ rad

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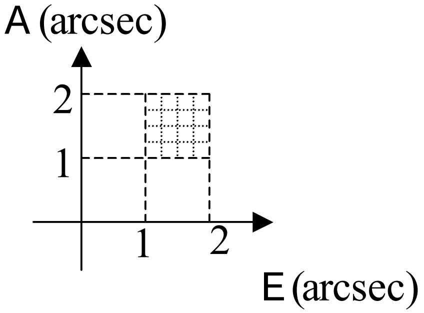
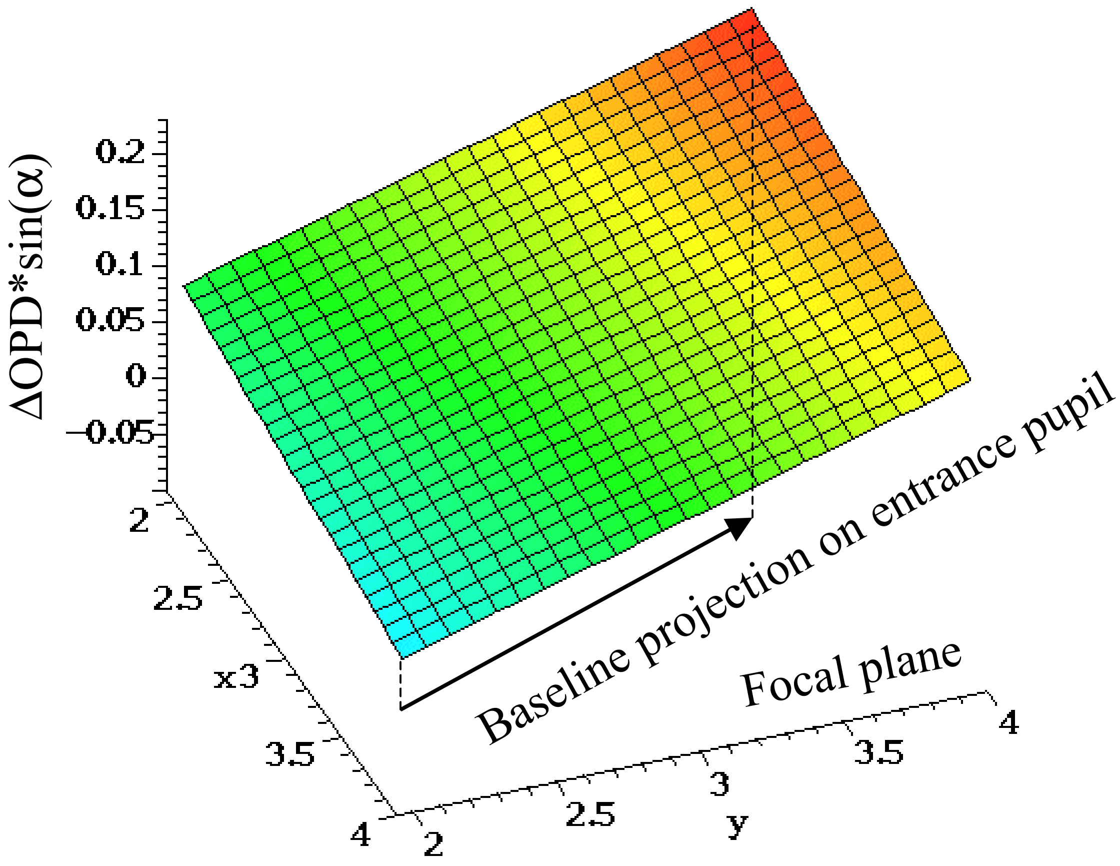
ΔOPD surface



UT2 (24,24) and UT4(112,8)



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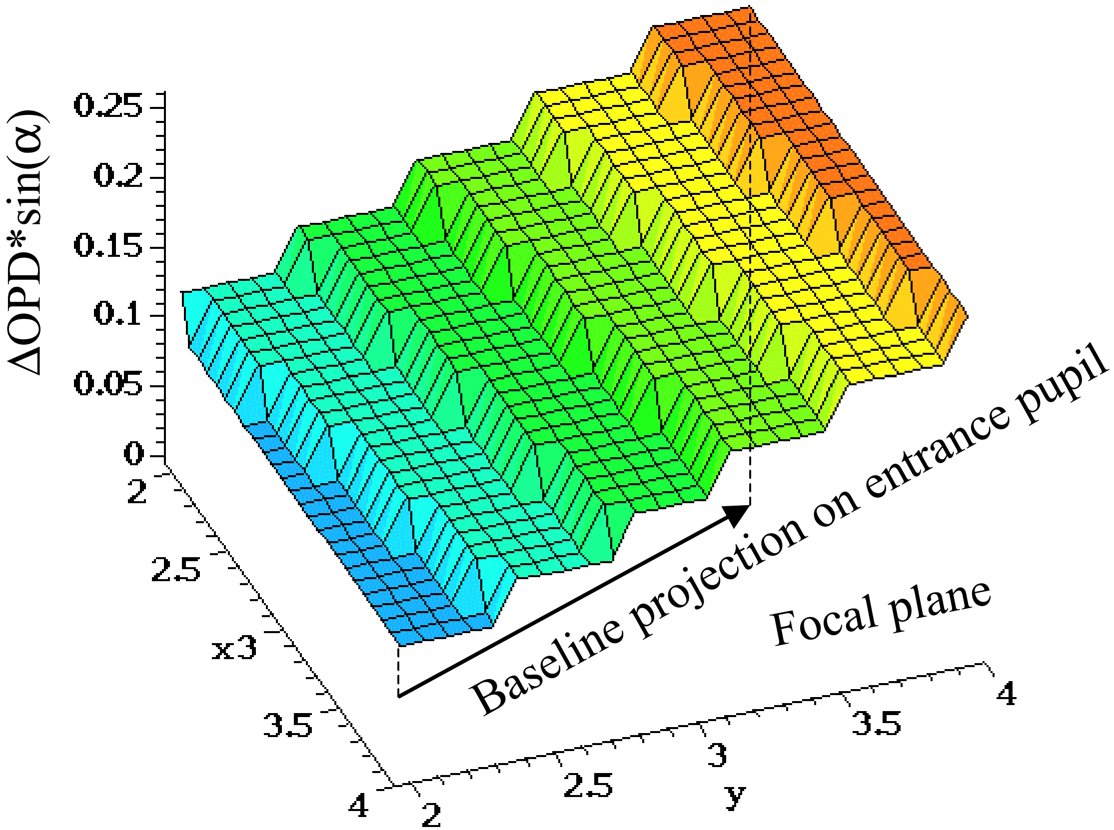
Mirror shape

UT2 (24,24) and UT4(112,8)
w≈ 400 μm (0.2 arcsec)
d_{max}=30 μm



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Conclusions

•Wide FOV of several arcmin can be reached using this technique.

•Shape of the mirror changes with pointing direction. An actuated mirror is needed for earth-based interferometers.

•The w/PSF ratio for the Coudé focus on the VLTI is small (only 2 PSF's per step). It is necessary to decrease the PSF or increase the scale.

Future work

- Performing a simulation in order to study the effect of the steps on the detected visibility
- Setup implementation and "first fringes"

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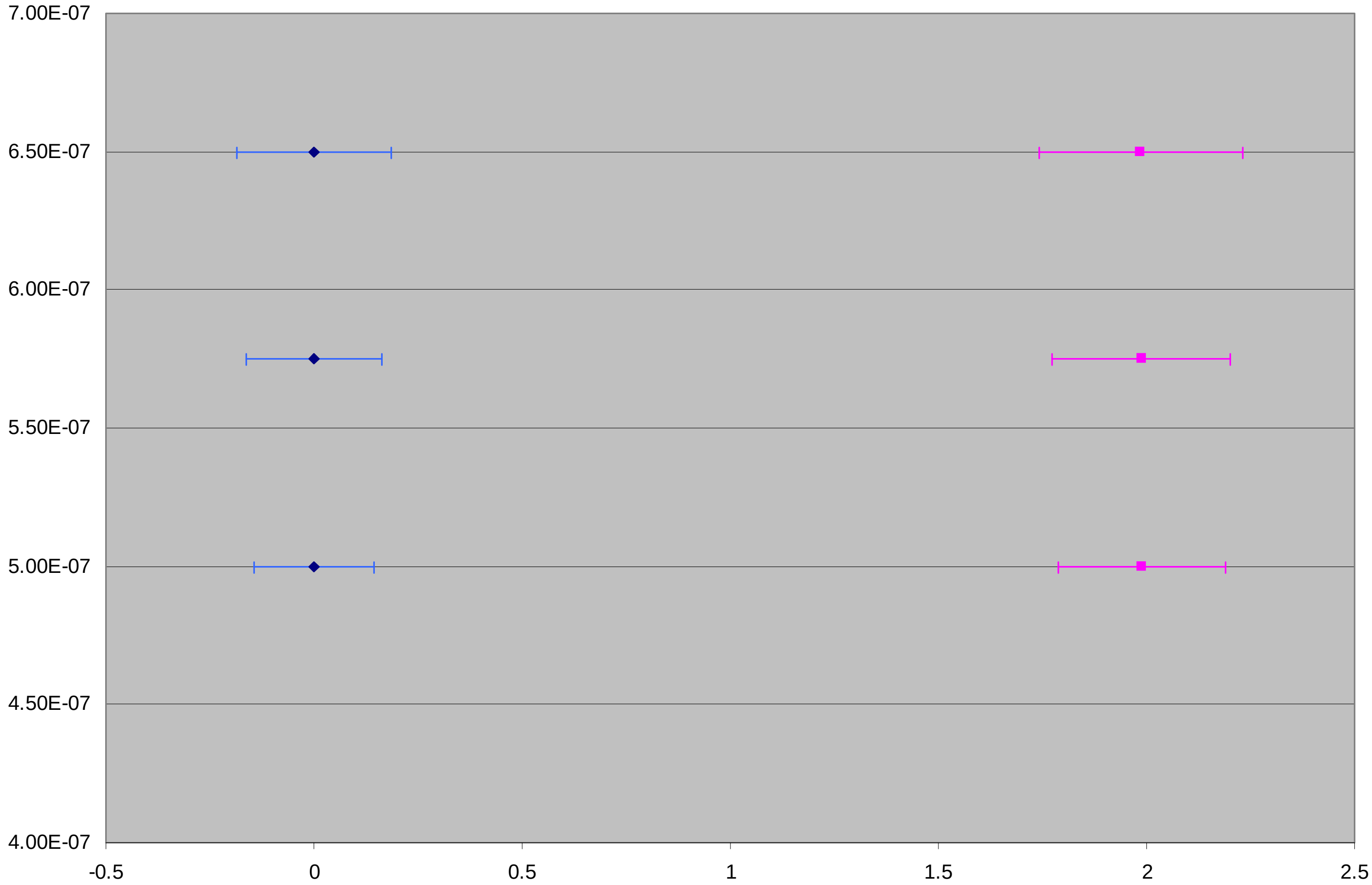
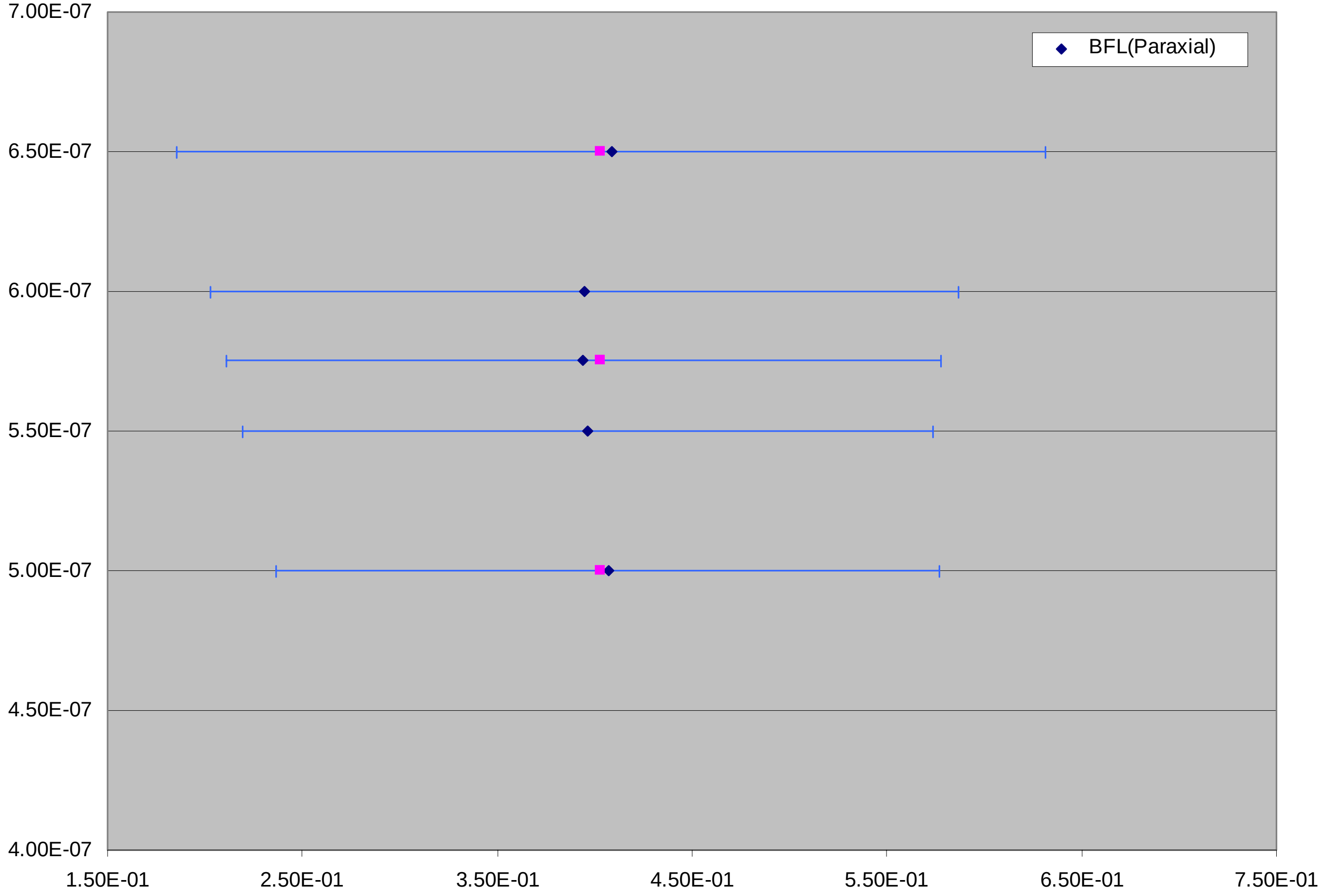
System parameters

Θ (rad)	0.00029089	**F4 (mm)**	+800	**s (μm/arcs)**	32.46
D2 (mm)	20	**F (mm)**	6563.567	**δ (μm)**	328
B (mm)	30	**BFL (mm)**	394.22	**d (μm)**	1948
F2 (mm)	+1330	**NA**	1.25e-3	**D3 (mm)**	3.047
F2' (mm)	-100	**Z_f (mm)**	367.214	**b (mm)**	4.571
F2-F2' (mm)	1258.67	**λ_0 (nm)**	575	**Θ' (rad)**	0.0019055
F2'-I (mm)	394.218	**δλ (nm)**	150	**δ' (μm)**	151
F2 –I (mm)	1652.888	**L_c (μm)**	2.2	**d' (μm)**	1903
F3 (mm)	+1000	**m**	6.563		

Spot size vs. wavelength



Back focal length vs. wavelength



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OPTICAL LAYOUT