Solution to: Simplified study of a telescope equipped with an adaptive optics system (exam dec 2009)- Drawings are not represented here

A. <u>Study of the telescope :</u>

<u>Resolution of the telescope</u>

1. f-number=5 ; α'=0.1 rad (5.7°)
2. Resolution limited by diffraction: 2.5" ($1.22.10^{-5}$rad)
3. Resolution limited by the pixels: 8" (20 µm /500mm)

Precision of positioning of CCD (=depth of focus)=20µm/α'=200µm

<u>Relative positions of all the elements</u>

4. focal length is negative. S_2S_1=130mm, transverse magnification gy=-5 for M2, S_1F'=20mm.
5. see drawing
6. Exit pupil: S_2P_s=18.4mm, P_sF'=131.6mm, diaPS= 26.3mm, diaPS/(2* P_sF')=0.1rad=α'
7. see drawing

<u>Study of the field of view of the telescope :</u>

8. $2\theta_{BF}$ = 0.02 rad=1.15° $2y_{BF}$=2mm
9. see drawing
10. Diahole in $M_1 \geq$12.5mm, Dia $M_2 \geq$31.4mm, Dia $M_1 \geq$104mm

B. <u>Lenses L1 and L2</u>

11. Diameter of parallel beam=2α' $\mathbf{f'_2}$ =30mm
12. F=F_2, H=O_2, focal length **f'**=FH= $\mathbf{f'_2}$. F' is in the middle of O_1O_2, H'F'= $\mathbf{f'_2}$
13. O_2O=96mm
14. see drawing
15. $2\theta'_{BF}$=10mm/150mm=0.067rad=3.8°
16. Dia$L_1 \geq$10mm, Dia $L_2 \geq$36;4mm (30mm+$2\theta'_{BF}$ .O_2O)

C. <u>Deformable mirror M</u>

17. see drawing
18. DiaM≥43.8mm(≈(30mm+$2\theta'_{BF}$ .15mm) *√2). It could be a rectangle with size 43.8*32mm

D. <u>Study of the afocal system</u>

19. Transverse magnification g_y=-1/5. f'_3 =5f'_4=250mm
20. if O=F3 then matrix of microlenses is in F'4, at 50mm after O4. Total distance OO'=600mm
21. F_3O=250-90mm=160mm, so F'_4O'=160* g_y^2=6.4mm. Finally O_4O'=56.4mm. See drawing.
22. $2\theta''_{BF}$ =5*$2\theta'_{BF}$ =0.33rad (19.1°). Dia$L_3 \geq$36mm (30mm+$2\theta'_{BF}$. OO_3), Dia$L_4 \geq$24.8mm (6mm+$2\theta''_{BF}$. O_4O')

E. <u>Study of the final imaging on the CCD camera</u>

23. focal length of the whole system f'_{ws} ==2m ($f'_{telescope}$*power of (L_1+L_2)*angular magnification of (L_3+L_4)*focal length of L_5= 500mm*(1/150mm)*5*120mm)
24. Diameter of bright field in the plane of the CCD=$2\theta_{BF}$.f'_{ws}=40mm
25. Resolution in the object space due to the pixels=20µm/ f'_{ws} =10^{-5}rad. The limit is diffraction ($1.22.10^{-5}$rad). The numerical aperture in the image space is now $\alpha''=\alpha'/4$ (focal length increased by a factor of 4 compared to the telescope alone) and the resolution in the image space is 24.4µm. The corresponding precision of positioning of the CCD is 24.4µm/α"=0.98mm.