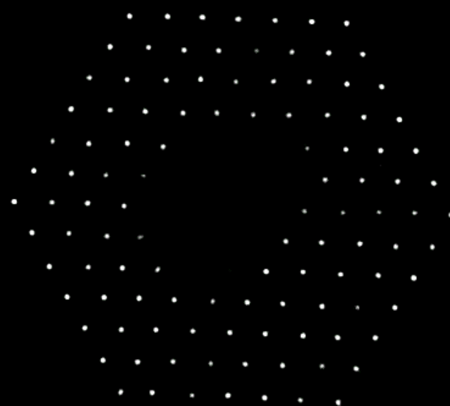
Telescope Alignment and Wavefront Sensing

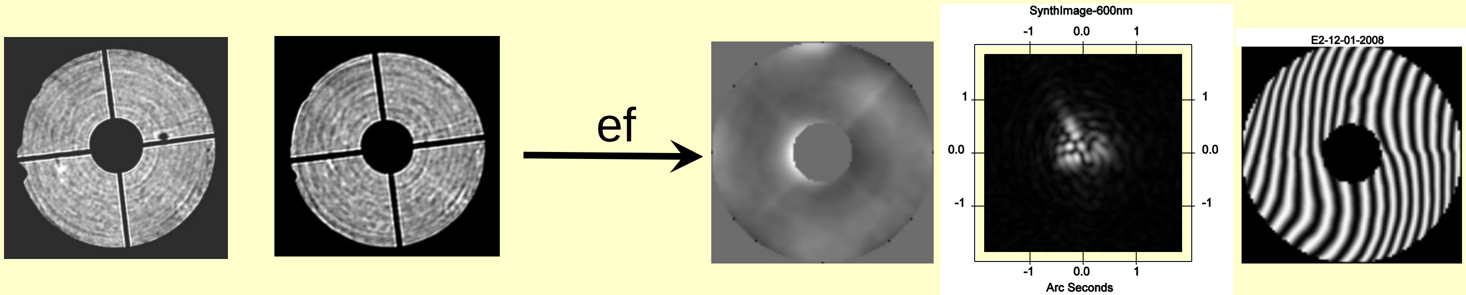
Laszlo Sturmann



Atlanta 2011

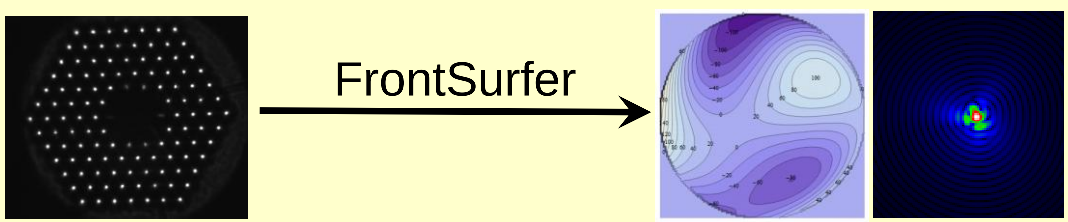
Wavefront Evaluation at CHARA

- 2001-2010 Wavefront is computed from its Laplacian (Roddier)



not for alignment

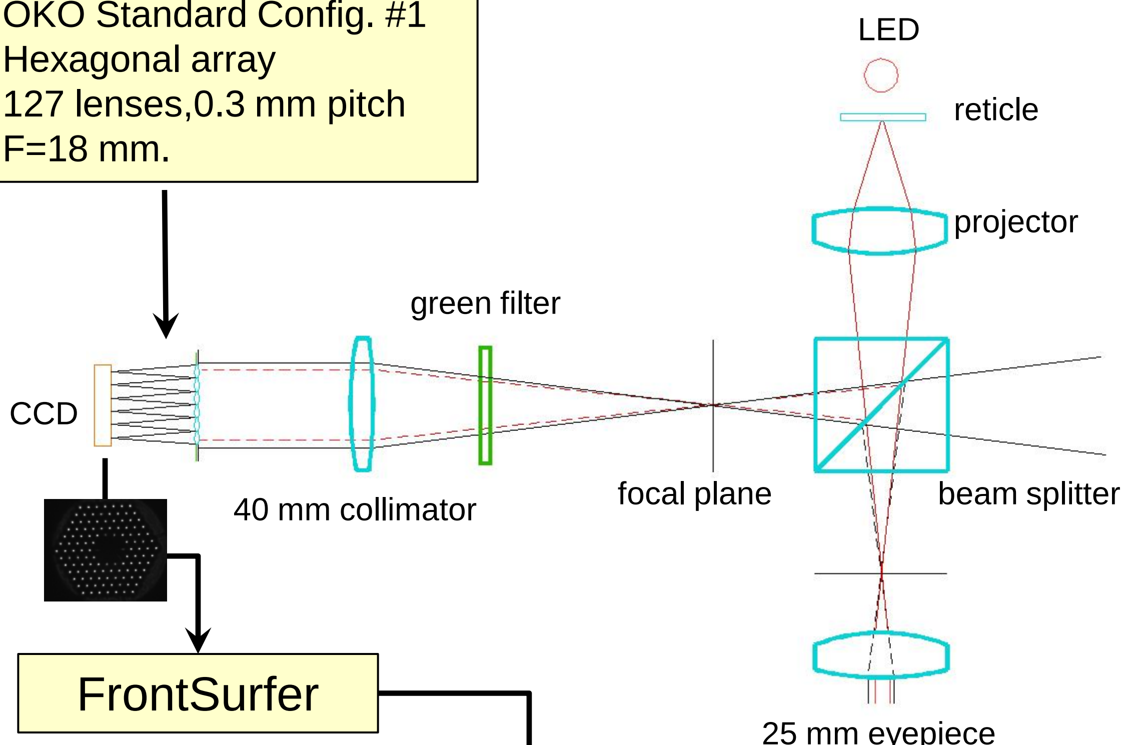
- 2010 Wavefront is computed from its gradient (Shack-Hartmann Sensor)

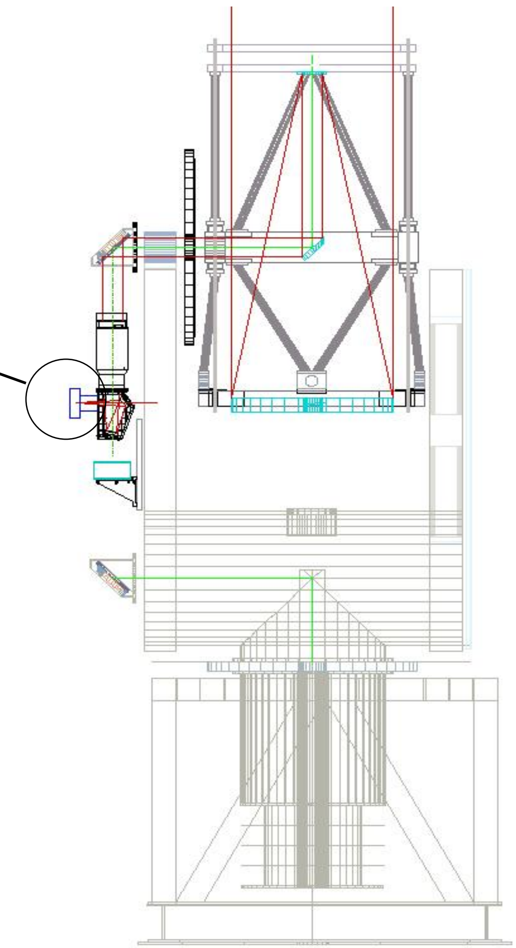


better for alignment

Optical Setup

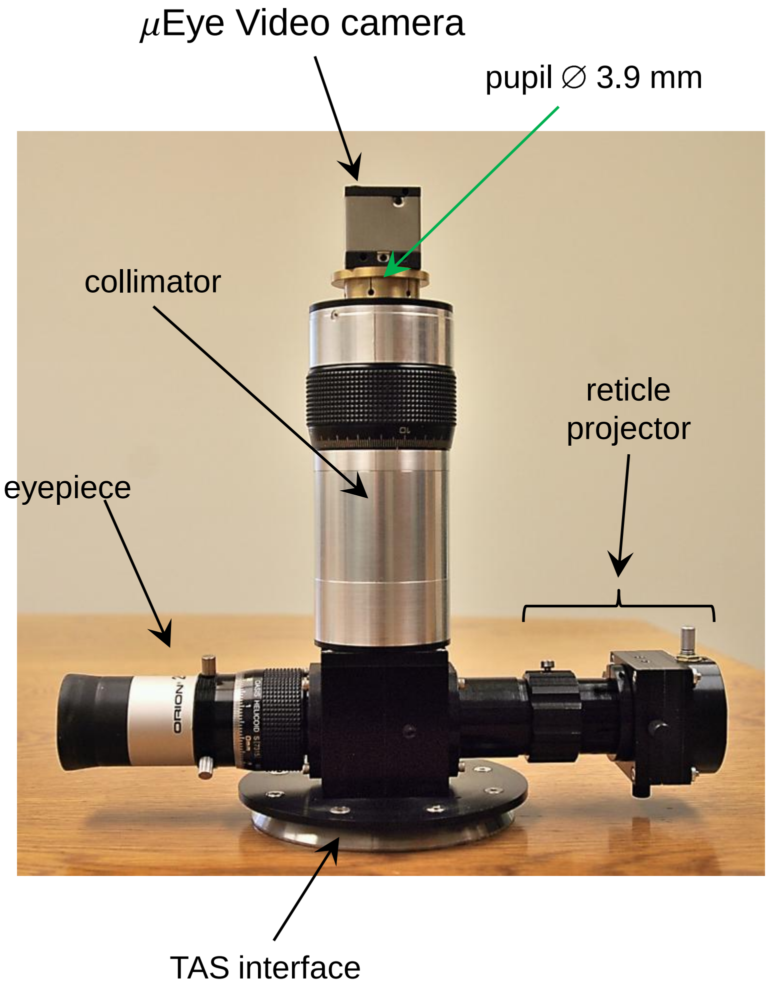
WFS
OKO Standard Config. #1
Hexagonal array
127 lenses,0.3 mm pitch
F=18 mm.

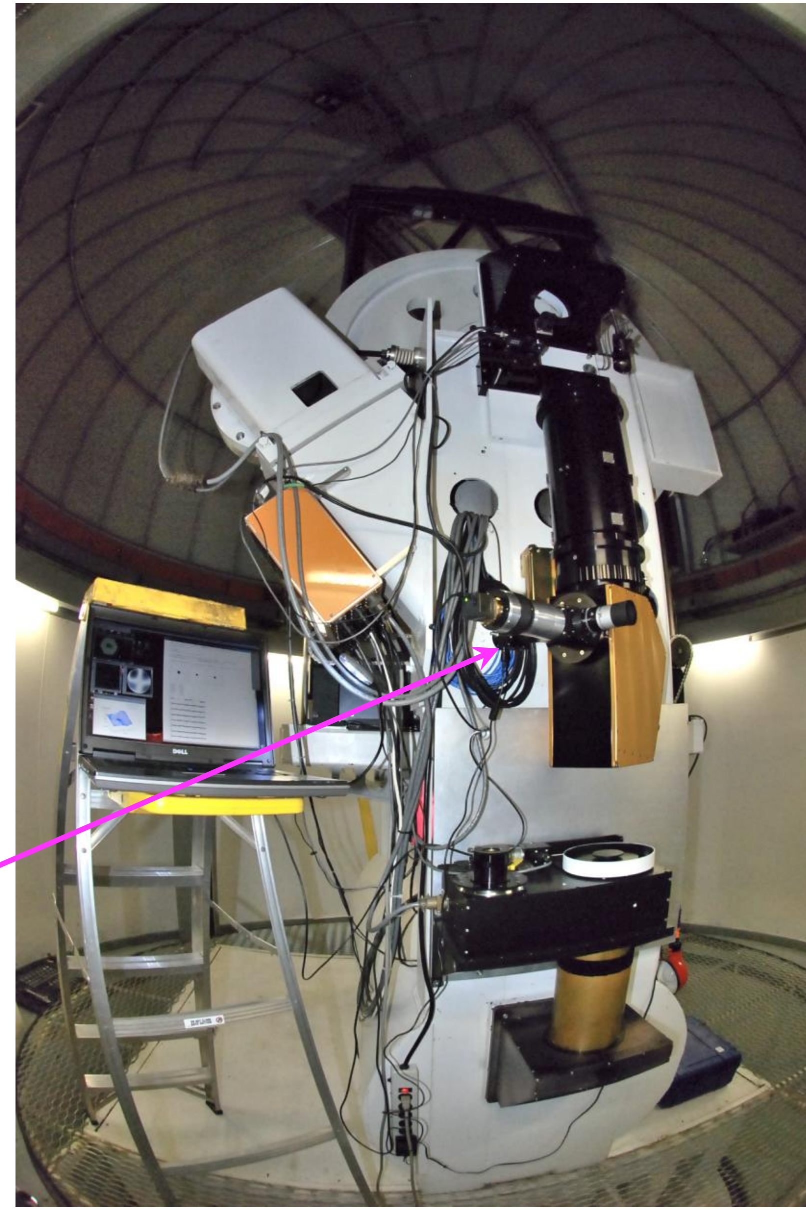




FrontSurfer

Wavefront expanded into Zernike polynomials


μEye Video camera
pupil ∅ 3.9 mm
collimator
reticle
projector
eyepiece
TAS interface



CALIBRATION

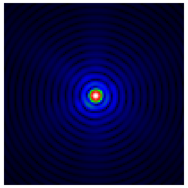
px: 9.922 μm × 9.907 μm

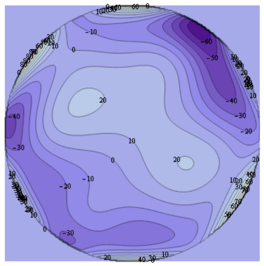
TAS

9/13/2010

ZERNIKES [*nm*]

PINHOLE SOURCE, TAS OBJECTIVE





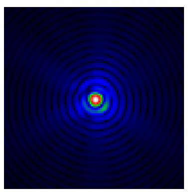
Strehl = 0.95

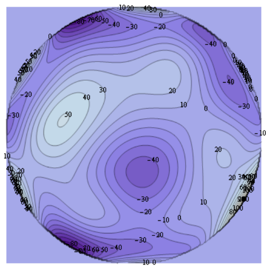
RMS = 17 *nm*

P – V = 152 *nm*

$Z_5 = -28$
$Z_6 = -2$
$Z_7 = -7$
$Z_8 = 1$
$Z_9 = -8$
$Z_{10} = 11$
$Z_{11} = 31$

PINHOLE SOURCE, TAS COMPLETE





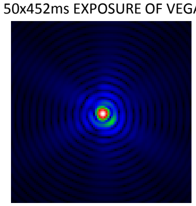
Strehl = 0.92

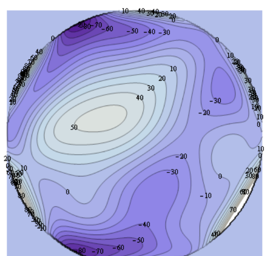
RMS = 22 *nm*

P – V = 196 *nm*

$Z_5 = -15$
$Z_6 = 27$
$Z_7 = -25$
$Z_8 = 22$
$Z_9 = -24$
$Z_{10} = -18$
$Z_{11} = 6$

50x452ms EXPOSURE OF VEGA





Strehl = 0.89

RMS = 27 *nm*

P – V = 237 *nm*

$Z_5 = -7$
$Z_6 = 36$
$Z_7 = -25$
$Z_8 = 31$
$Z_9 = -25$
$Z_{10} = -22$
$Z_{11} = 41$

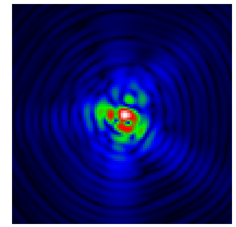
contours in nm

E1

9/28/2010

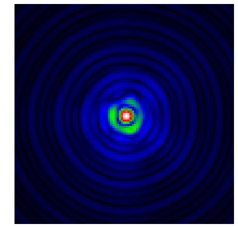
1000 x 10ms exposures of Vega

540 *nm*



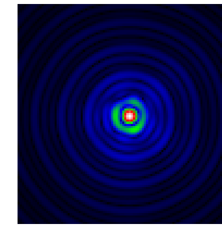
Strehl = 0.35

1600 *nm*



Strehl = 0.89

2200 *nm*



Strehl = 0.94

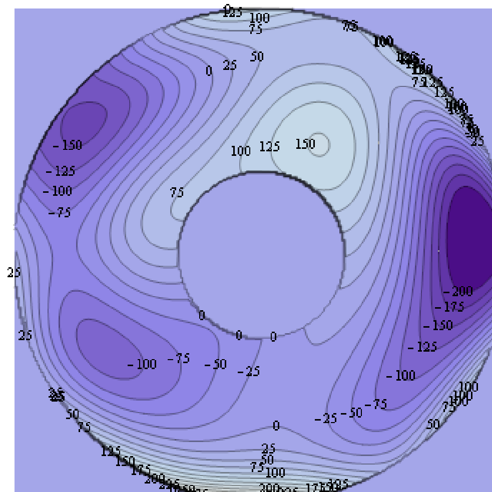
RMS = 78 *nm*

P – V = 558 *nm*

ZERNIKES [*nm*]

$Z_5 = 58$
$Z_6 = -141$
$Z_7 = -114$
$Z_8 = -5$
$Z_9 = 0$
$Z_{10} = -66$
$Z_{11} = 90$

WAVEFRONT MAP



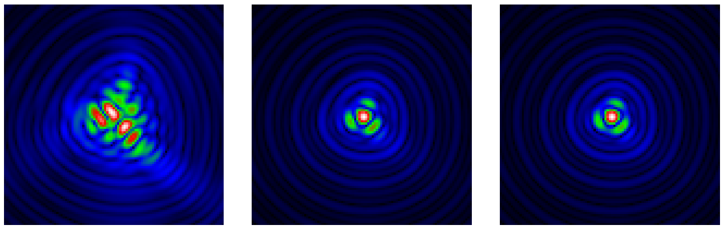
contours in nm

E2

9/17/2010

1000 x 10ms exposures of Vega

540 *nm* | 1600 *nm* | 2200 *nm*



Strehl = 0.14 | Strehl = 0.82 | Strehl = 0.90

RMS = 95*nm*

P – V = 606*nm*

ZERNIKES [*nm*]

$Z_5 = 55$

$Z_6 = -41$

$Z_7 = -154$

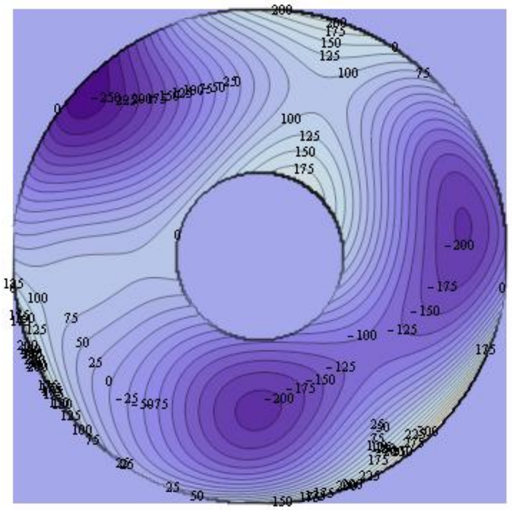
$Z_8 = 53$

$Z_9 = -158$

$Z_{10} = -166$

$Z_{11} = 149$

WAVEFRONT MAP



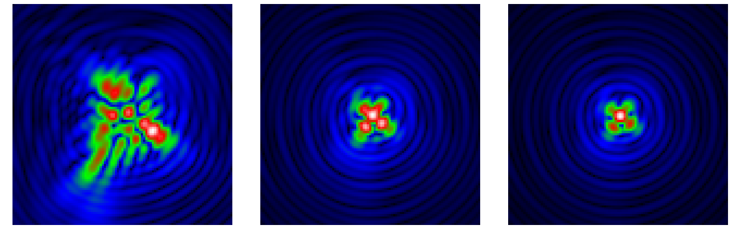
contours in nm

S1

9/23/2010

1000 x 10ms exposures of Vega

540 *nm* | 1600 *nm* | 2200 *nm*



Strehl = 0.02 | Strehl = 0.26 | Strehl = 0.52

RMS = 231*nm*

P – V = 1211*nm*

ZERNIKES [*nm*]

$Z_5 = 568$

$Z_6 = -226$

$Z_7 = -307$

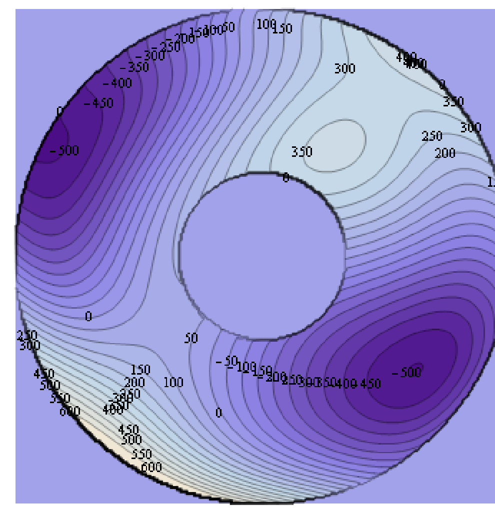
$Z_8 = 27$

$Z_9 = 14$

$Z_{10} = 40$

$Z_{11} = 147$

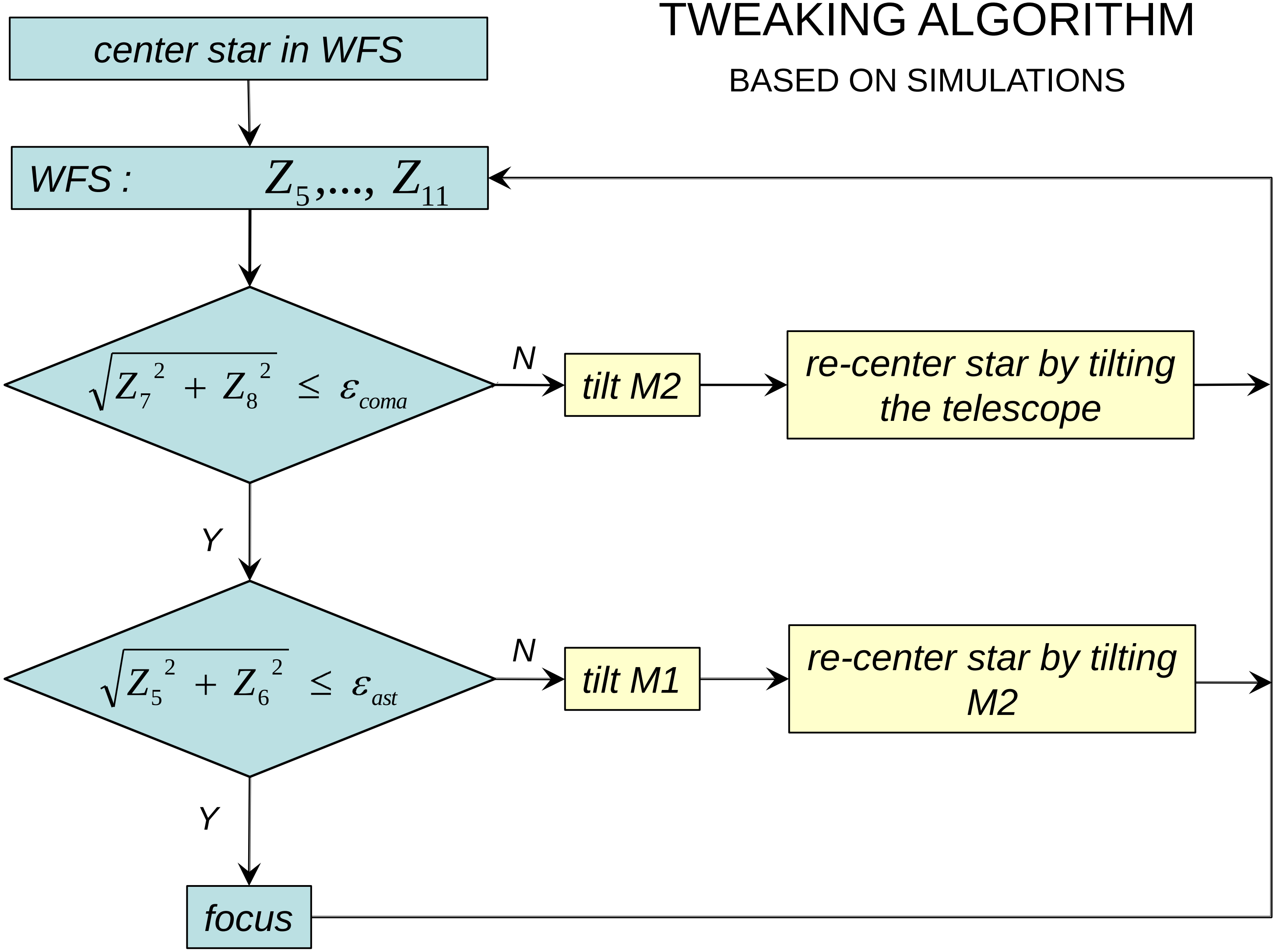
WAVEFRONT MAP



contours in nm

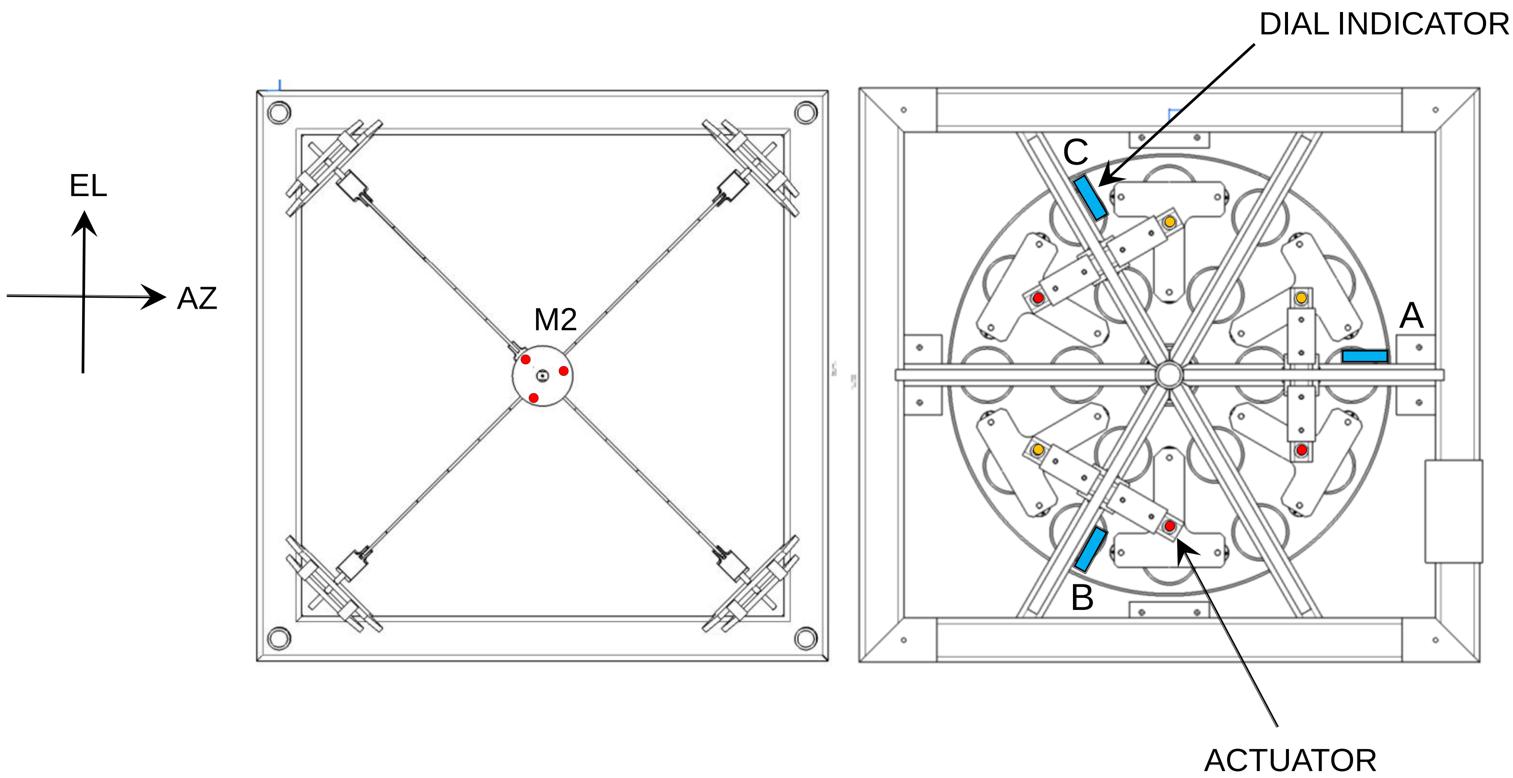
TWEAKING ALGORITHM

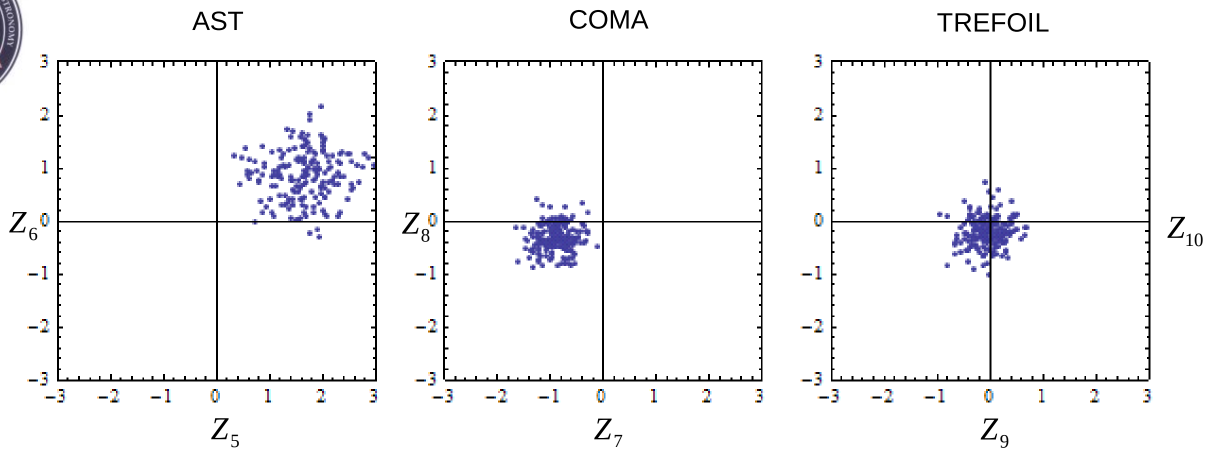
BASED ON SIMULATIONS

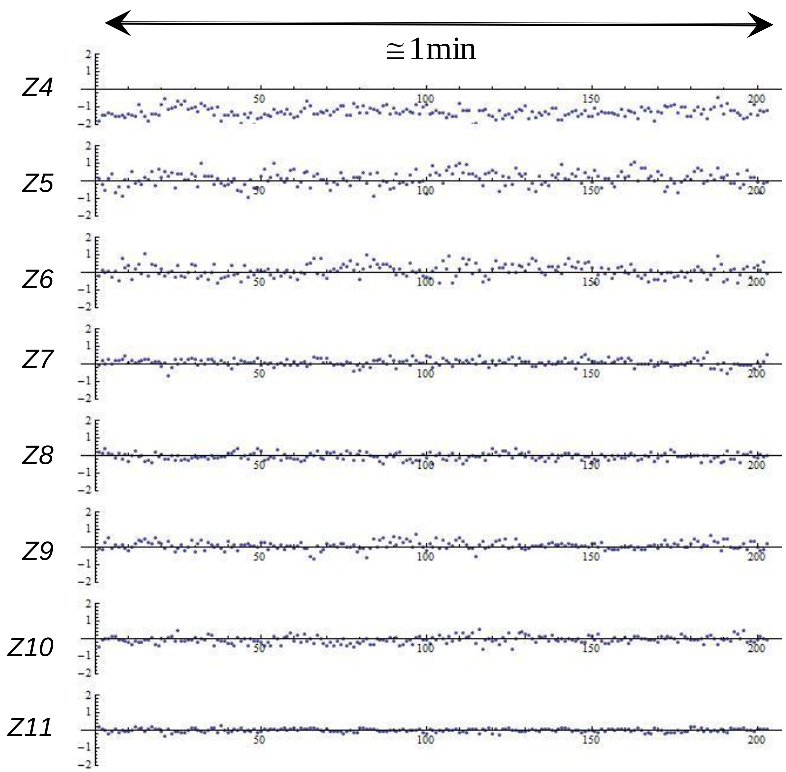


ORTHOGONAL *AZ-EL* ADJUSTMENT AT M2 BUT NOT AT M1

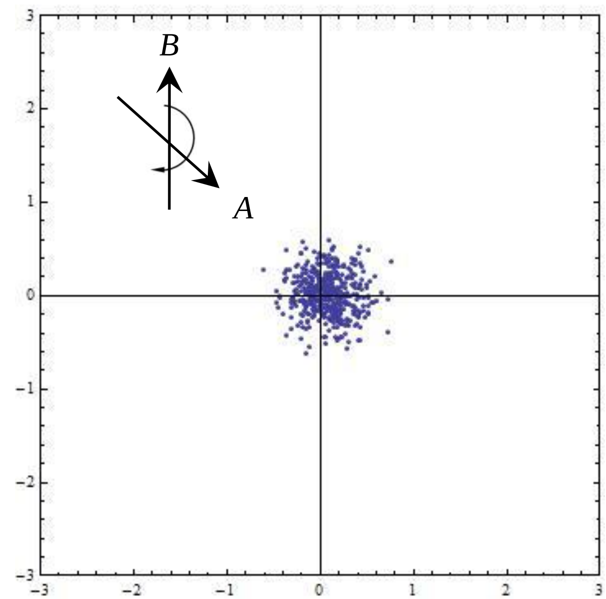
SOFTWARE





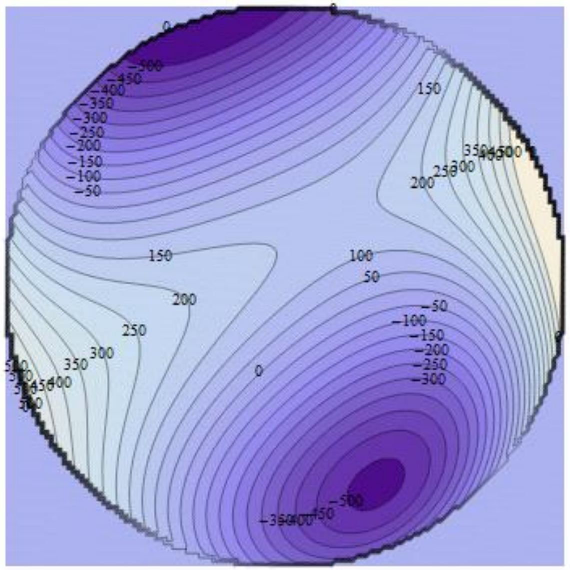


PUPIL ROTATES WITH TIME

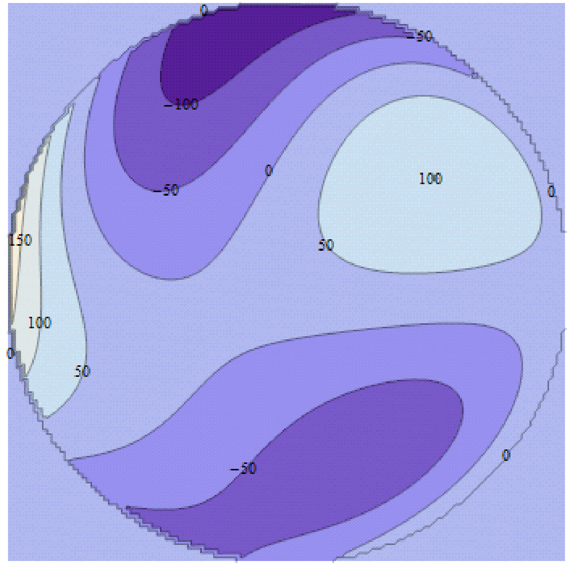


W1

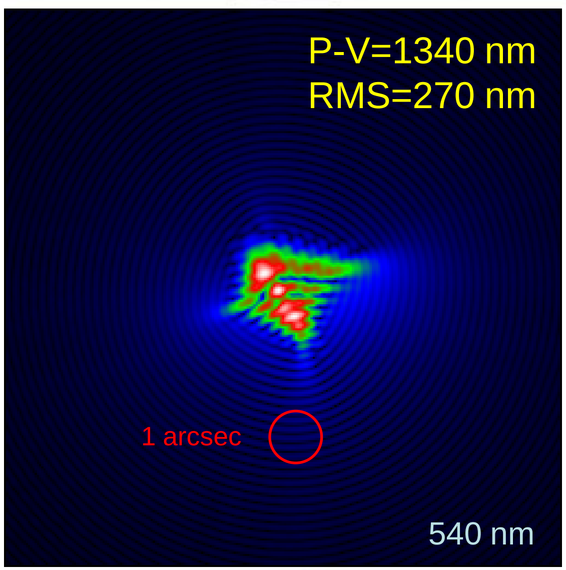
02-03-2011

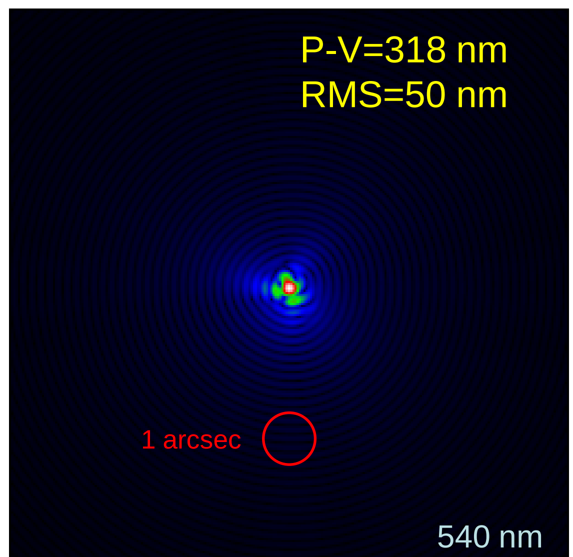


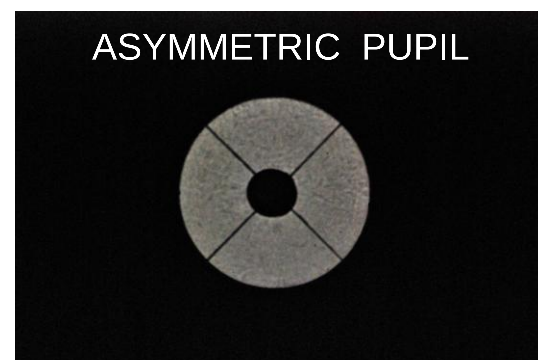
02-12-2011



	02/03/11 [nm]	02/12/11 [nm]
Z_5	540	27
Z_6	570	145
Z_7	-175	-41
Z_8	196	-40

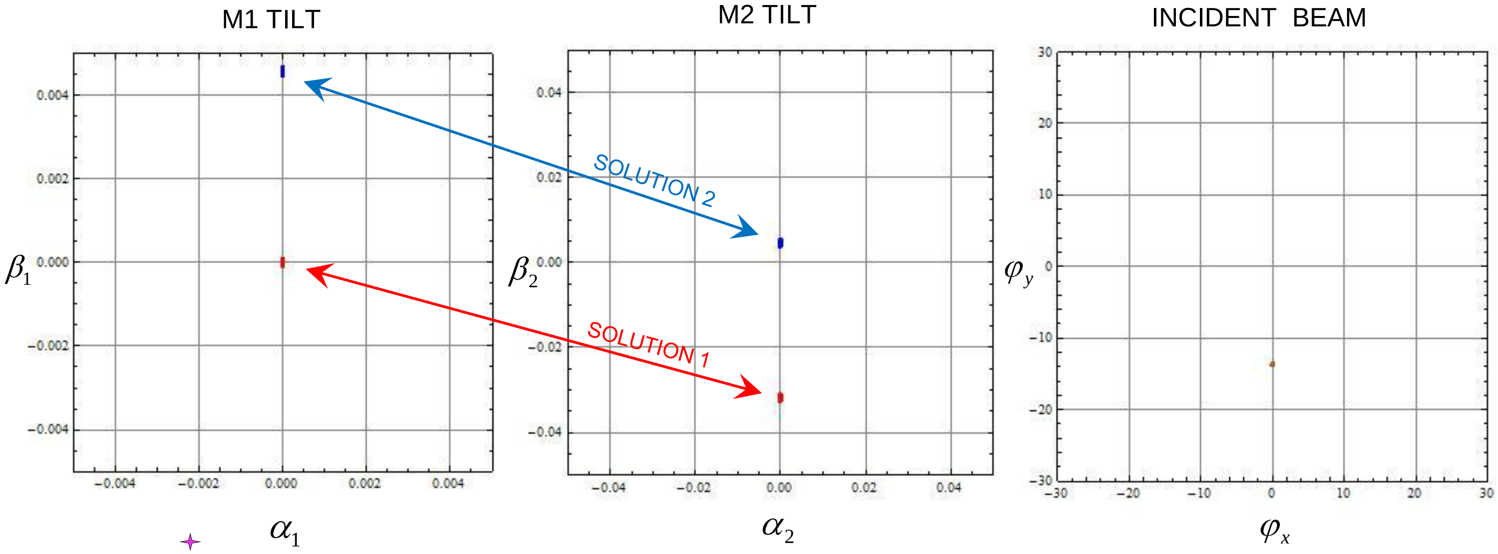


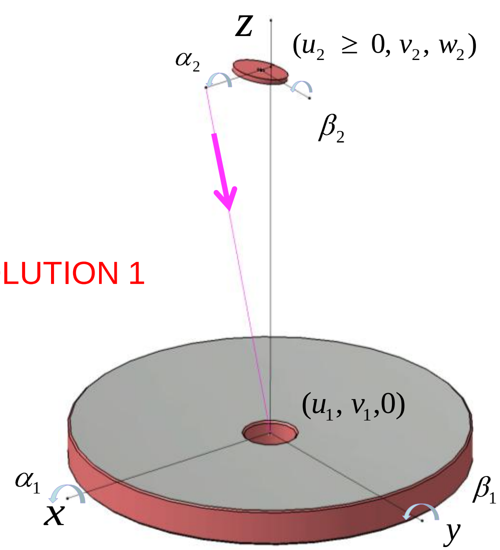




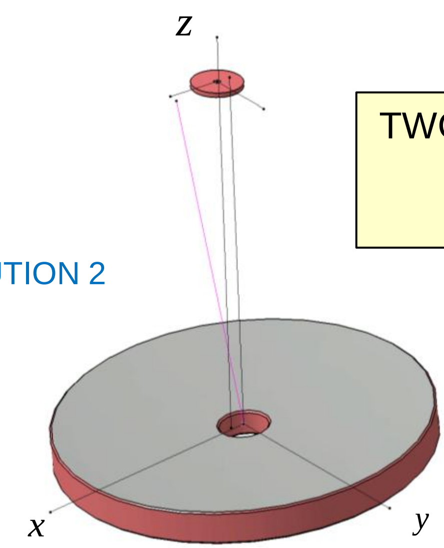

M3
Nikon D80 20s
W1 2/12/11

MONTE CARLO SIMULATION





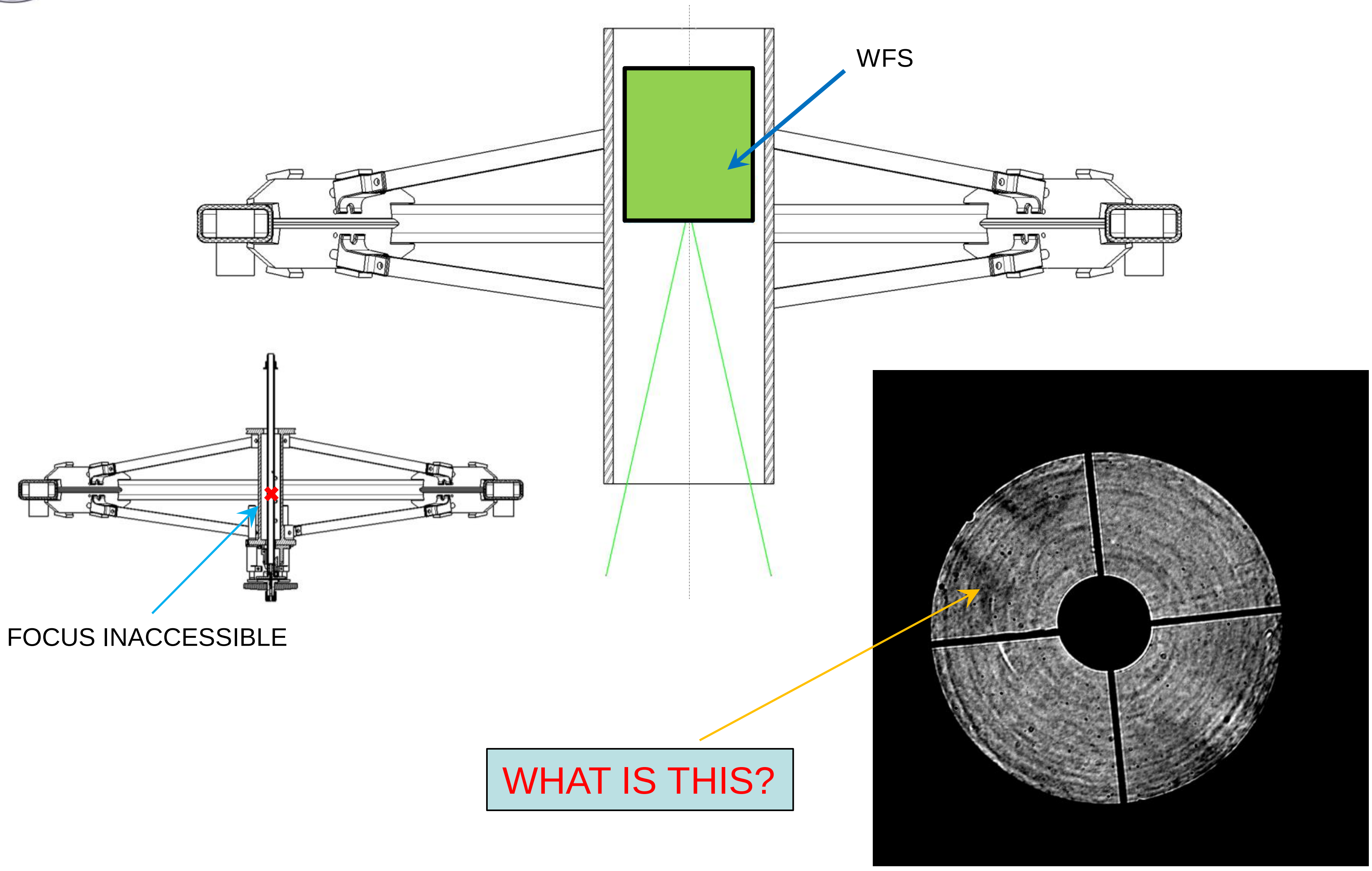
SOLUTION 1



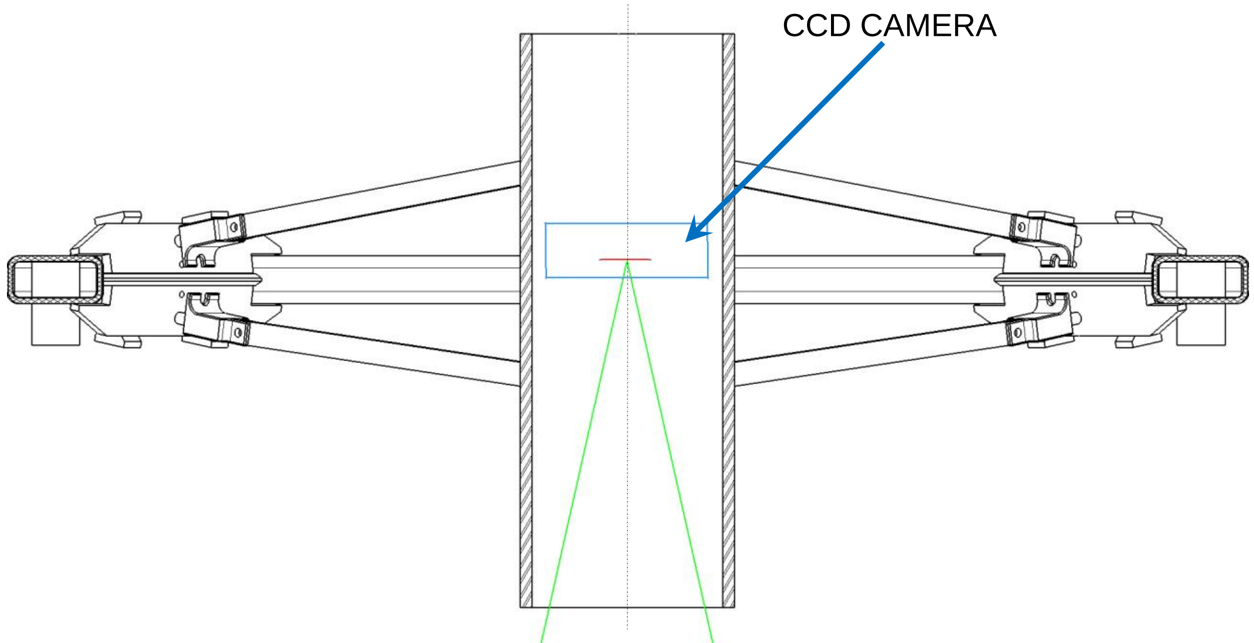
SOLUTION 2

TWO SOLUTIONS AT A GIVEN M1,M2 LATERAL DISPLACEMENT

FUTURE PLANS: TESTING M1 IN SITU



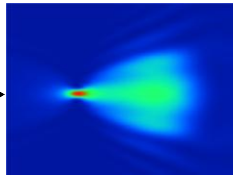
FINDING THE VERTEX OF M1



M1 is F/2.5

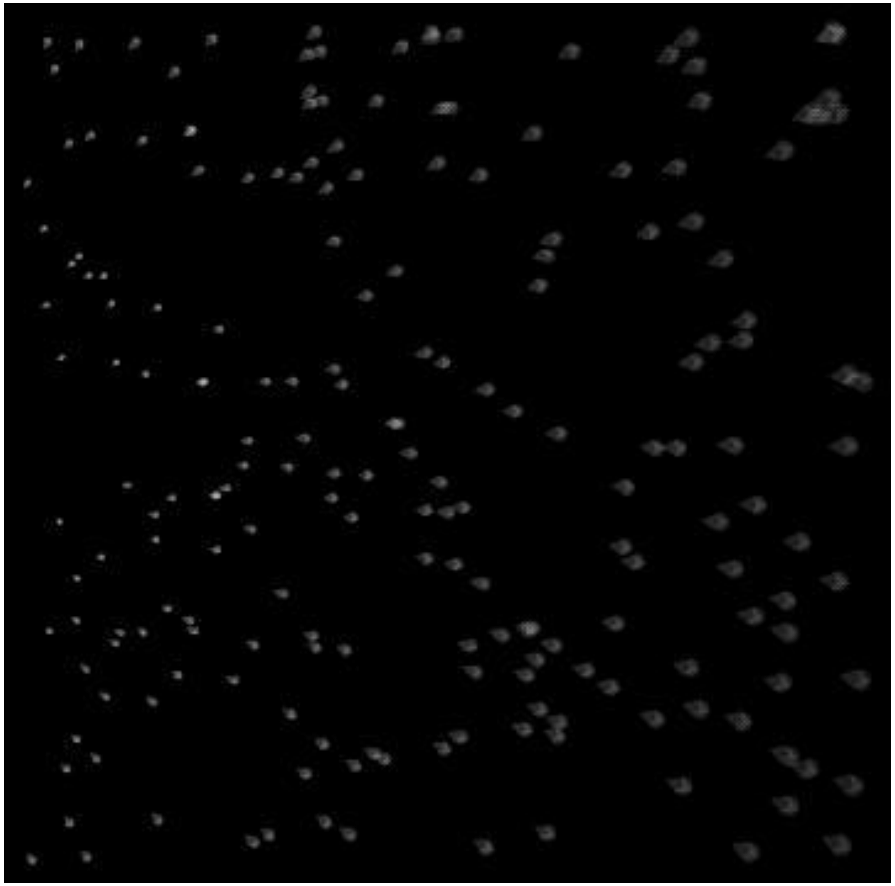
VERY SENSITIVE TO MISALIGNMENT

COMA

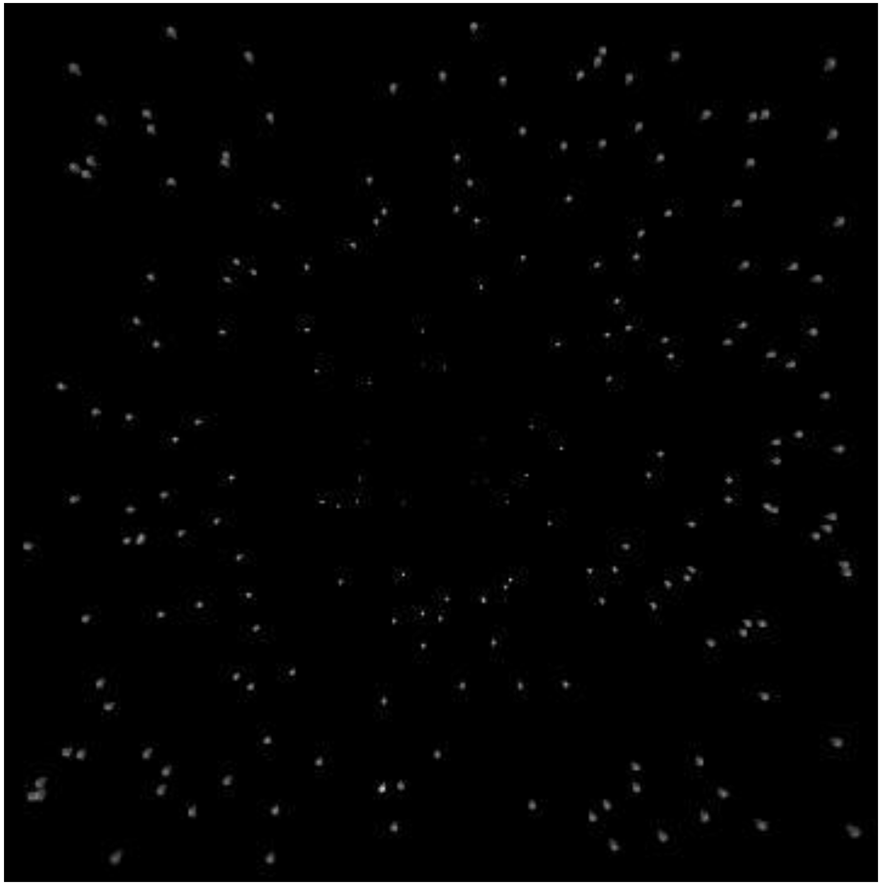


SIMULATED PRIME FOCUS IMAGES

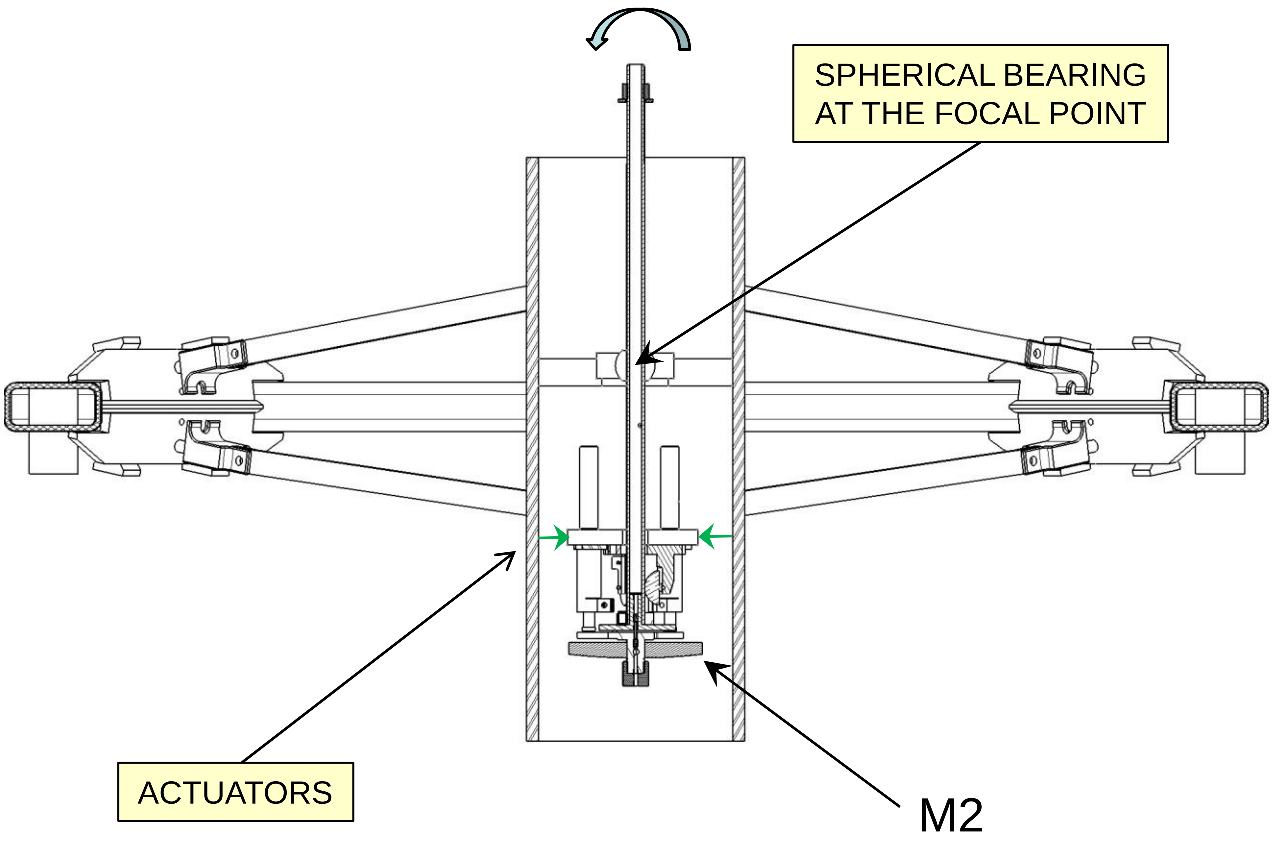
OFF-AXIS



ON-AXIS

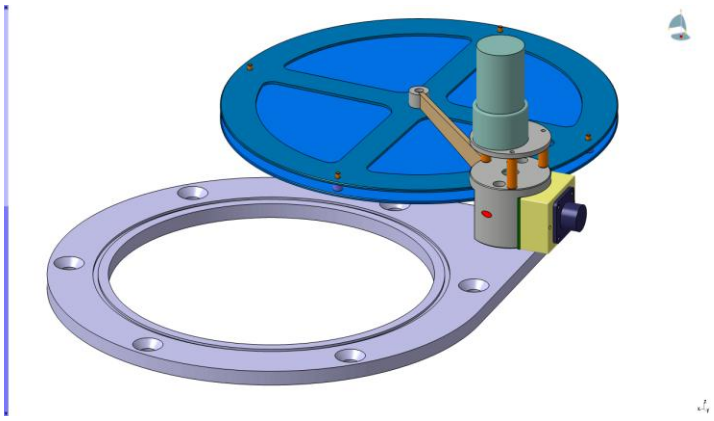


COMA FREE TILTING OF M2



ODDS & ENDS

• COUDE-BOX COVER



• HUMIDITY-TEMPERATURE SENSORS IN THE DOMES