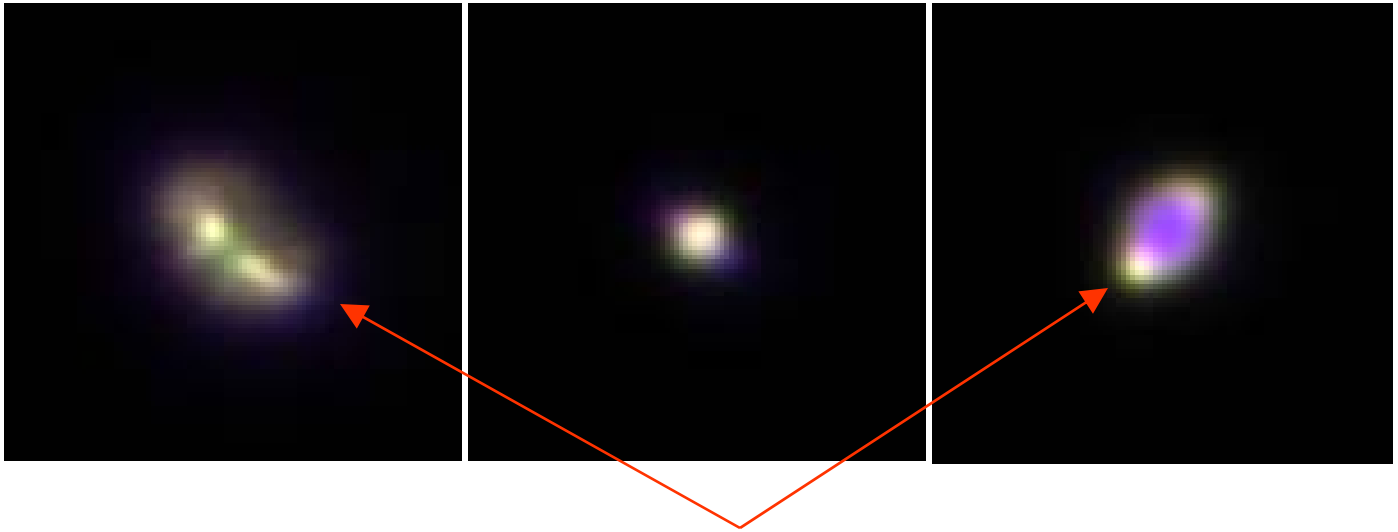
IMPROVING BEAM QUALITY
NEW TELESCOPE ALIGNMENT PROCEDURE

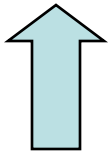
by Laszlo Sturmann

Fiber coupled combiners and visual band observations are more sensitive to telescope alignment problems than bulk combiners in IR

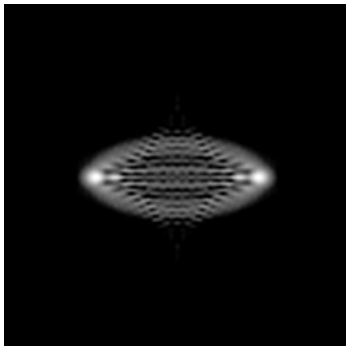


W1

characteristic double images were reported

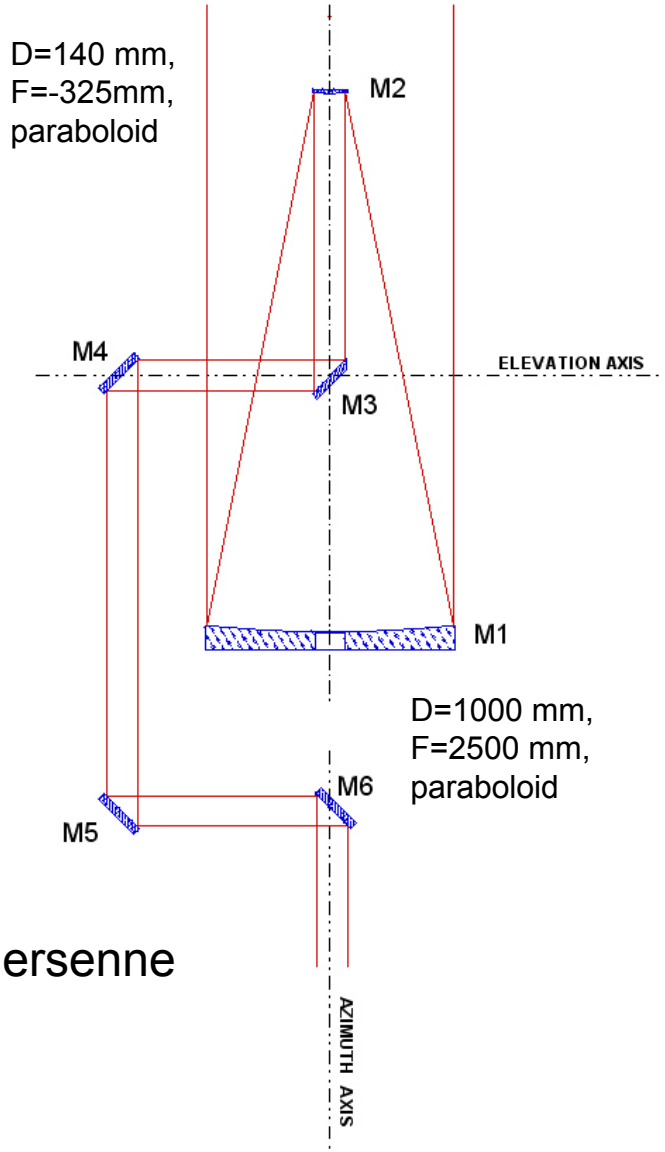


astigmatism + defocus + spherical aberration

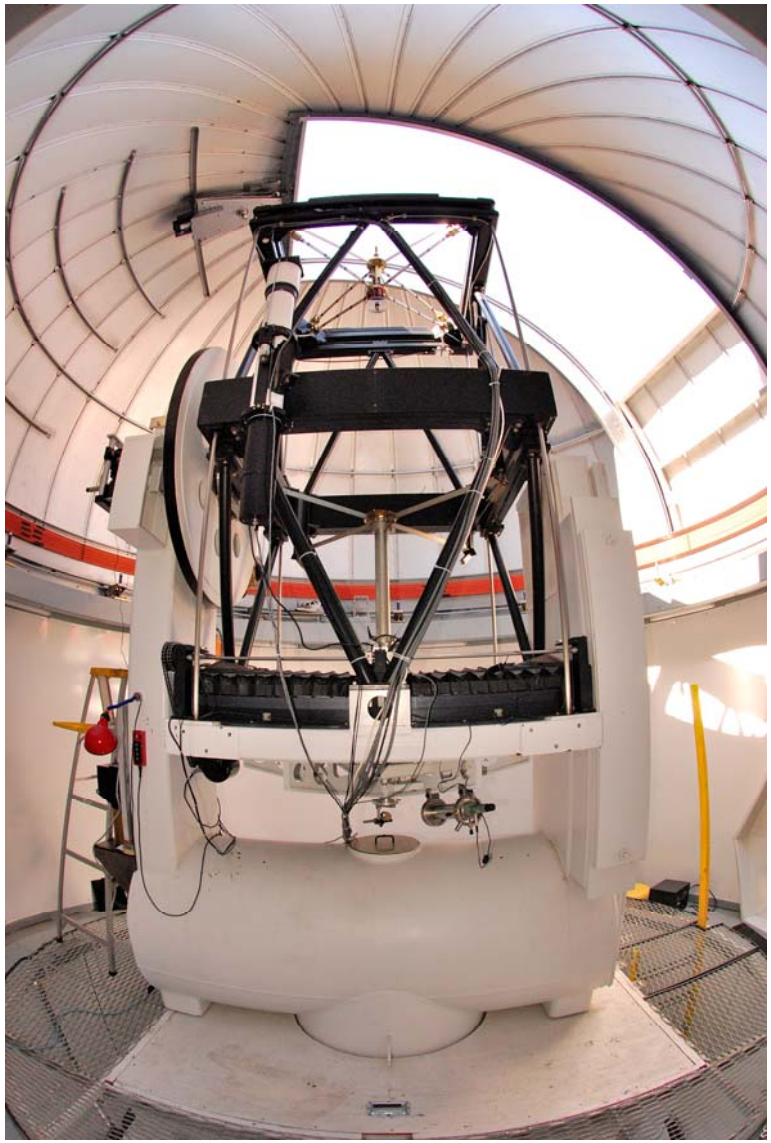


What causes the astigmatism in W1?

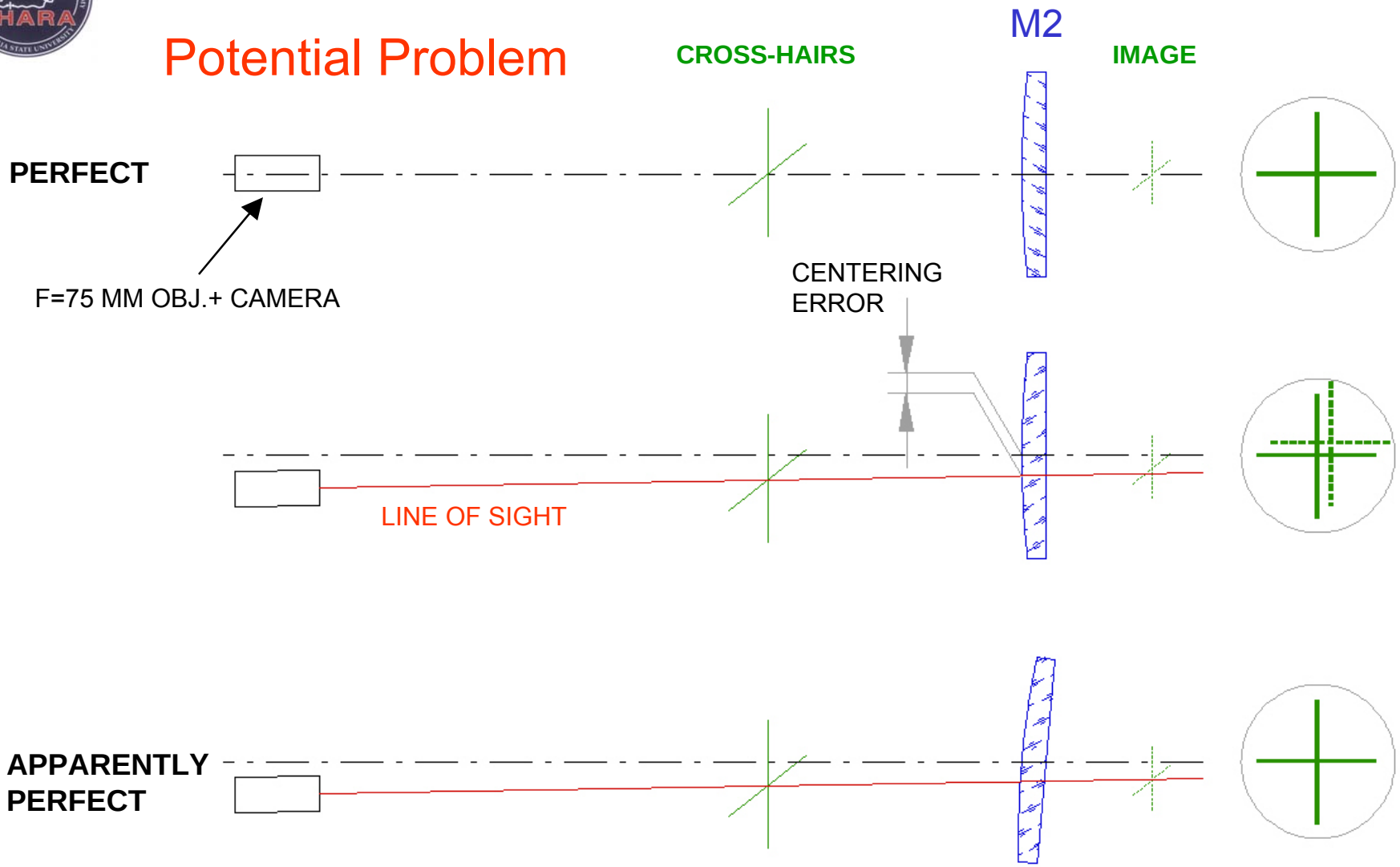
- Inherent in the optics - the least likely
  worst case scenario
- The mounts distort the optics – possible
  potentially difficult to fix
- Optical misalignment – likely
  relatively easy to fix


D=140 mm,
F=-325mm,
paraboloid
M2
M4
ELEVATION AXIS
M3
M1
D=1000 mm,
F=2500 mm,
paraboloid
M6
M5
AZIMUTH AXIS

Mersenne



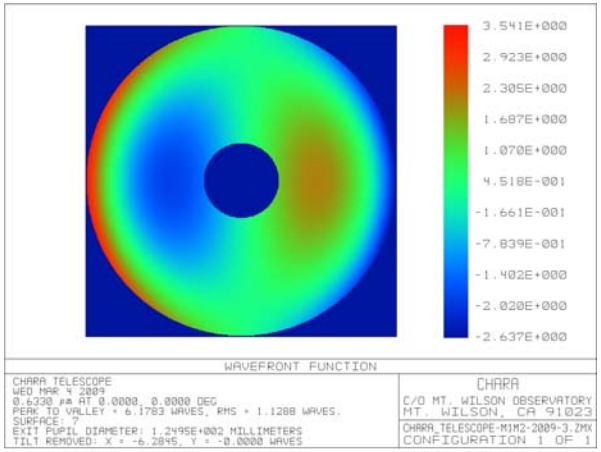
Potential Problem

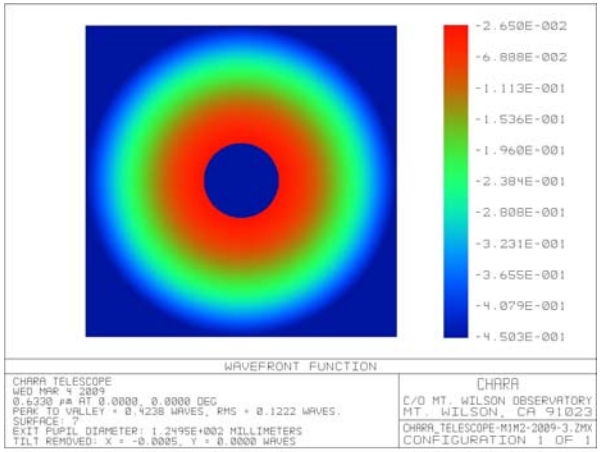


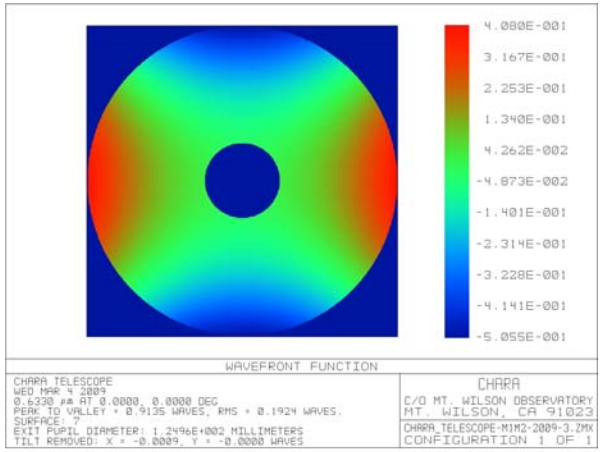
DECENTERED M2

CORRECTING COMA BY TILTING M2

CORRECTIN BEAM DIRECTION BY TILTING M1







COMA

DEFOCUS

PURE ASTIGMATISM

STREHL IS HIGH
BUT THE BEAM
DIRECTION IS OFF

STREHL IS LOW
BUT THE BEAM
DIRECTION IS
CORRECT

Goals:

The axes of M1 and M2 coincide

The common axis intersects the elevation axis perpendicularly

Correct spacing between M1 and M2

Expectation:

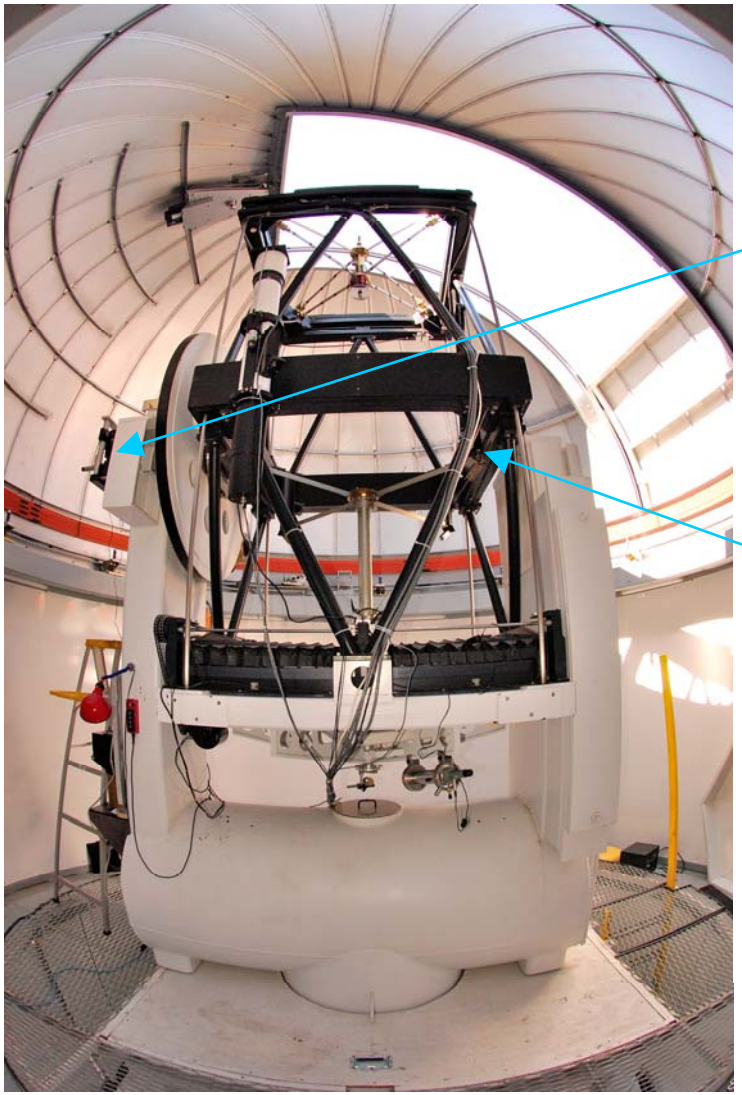
Better beam quality

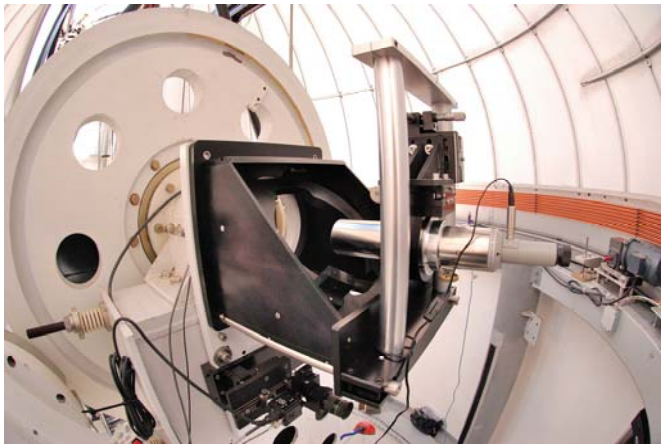
The telescope alignment procedure

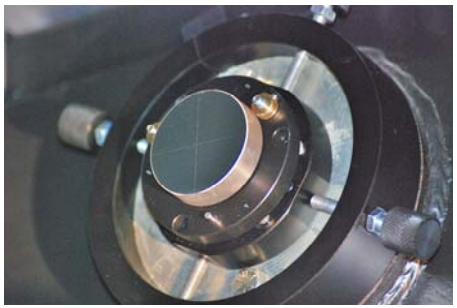
1. Centering and tilting the mirrors

2. Fine tuning

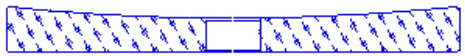
The elevation axis is realized by the line of sight of an alignment telescope

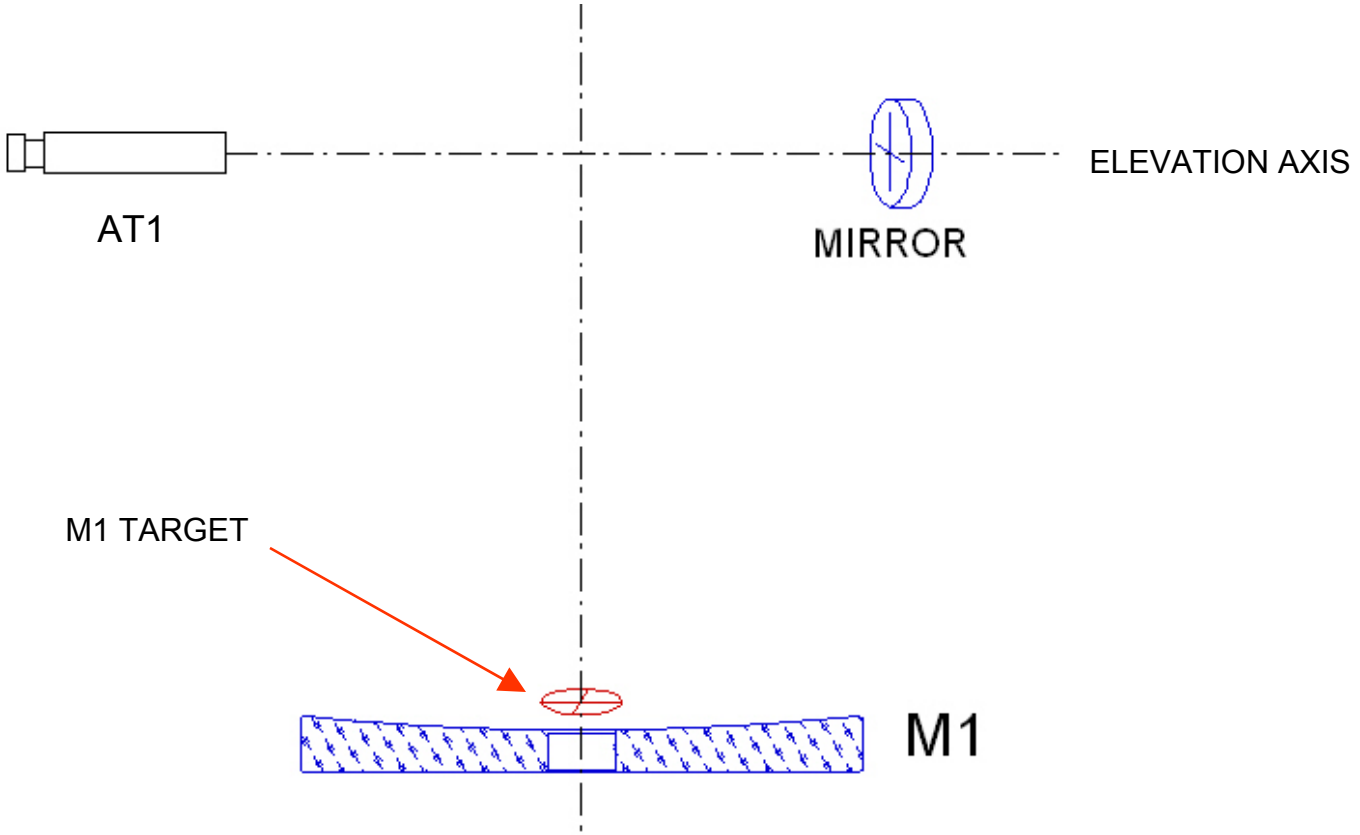




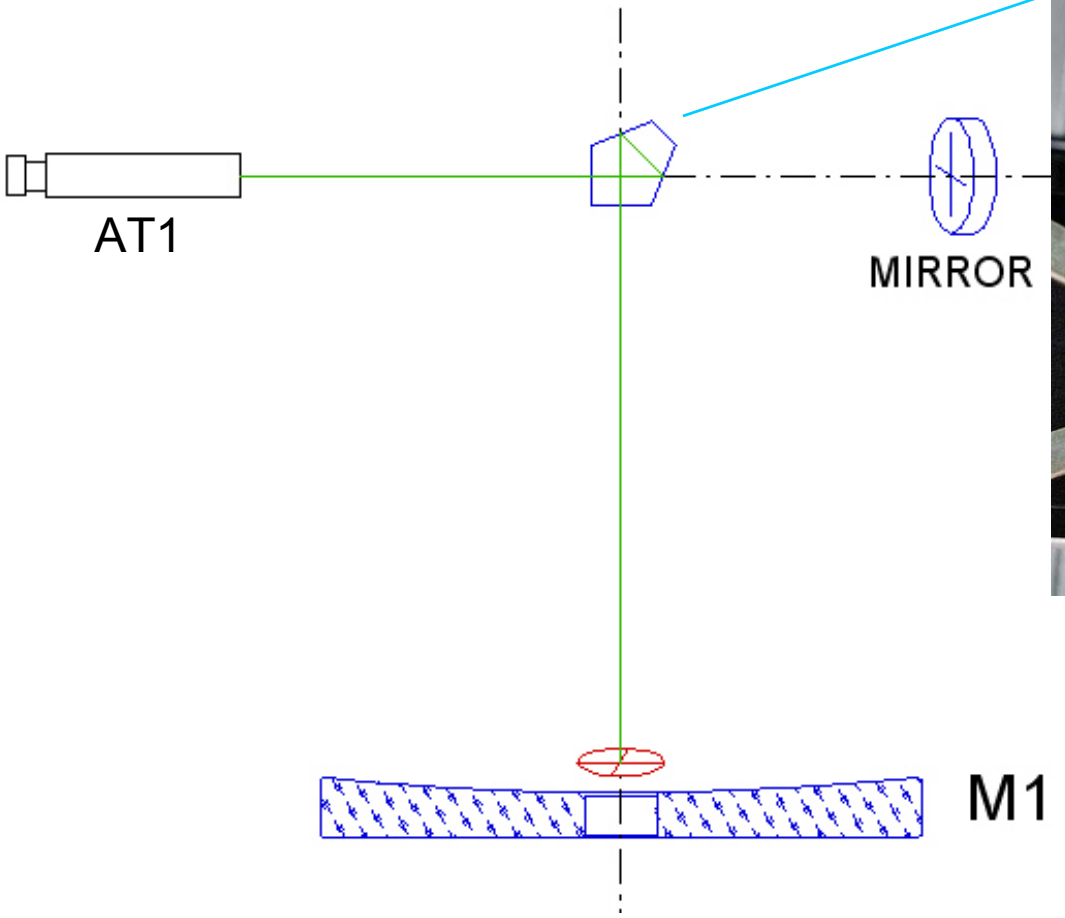


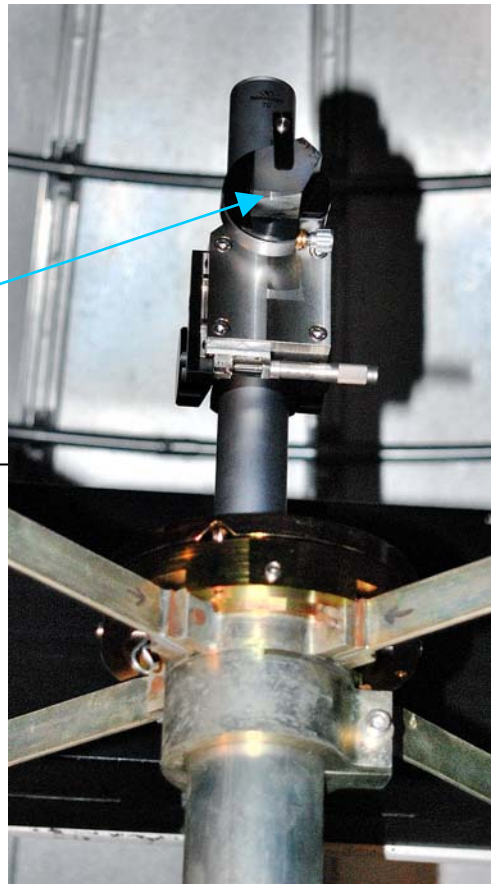
Auto-collimating telescope with auto-reflection target (AT1)



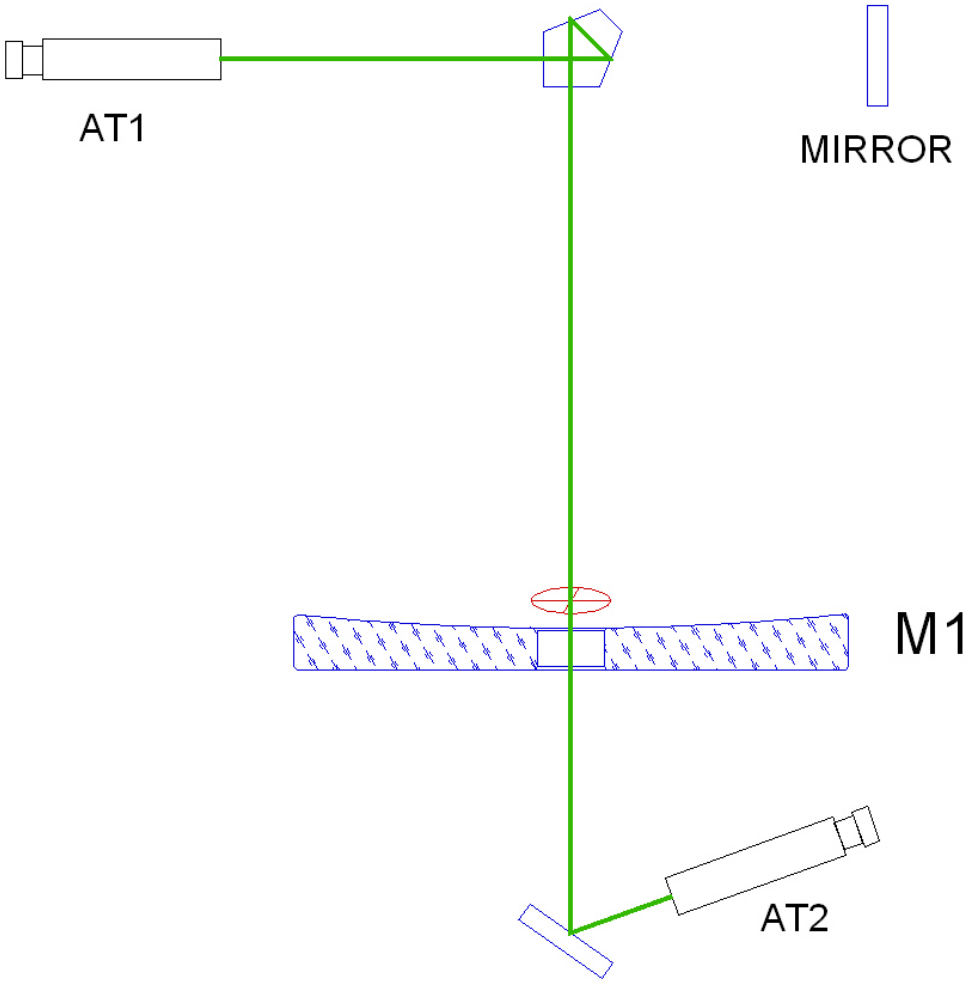

ELEVATION AXIS
AT1
MIRROR
M1 TARGET
M1

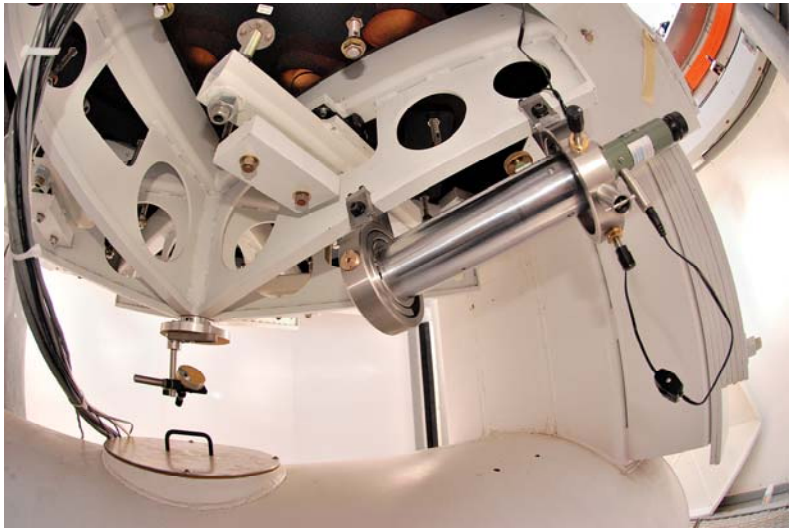
A pentaprism is aligned to aim the target at M1



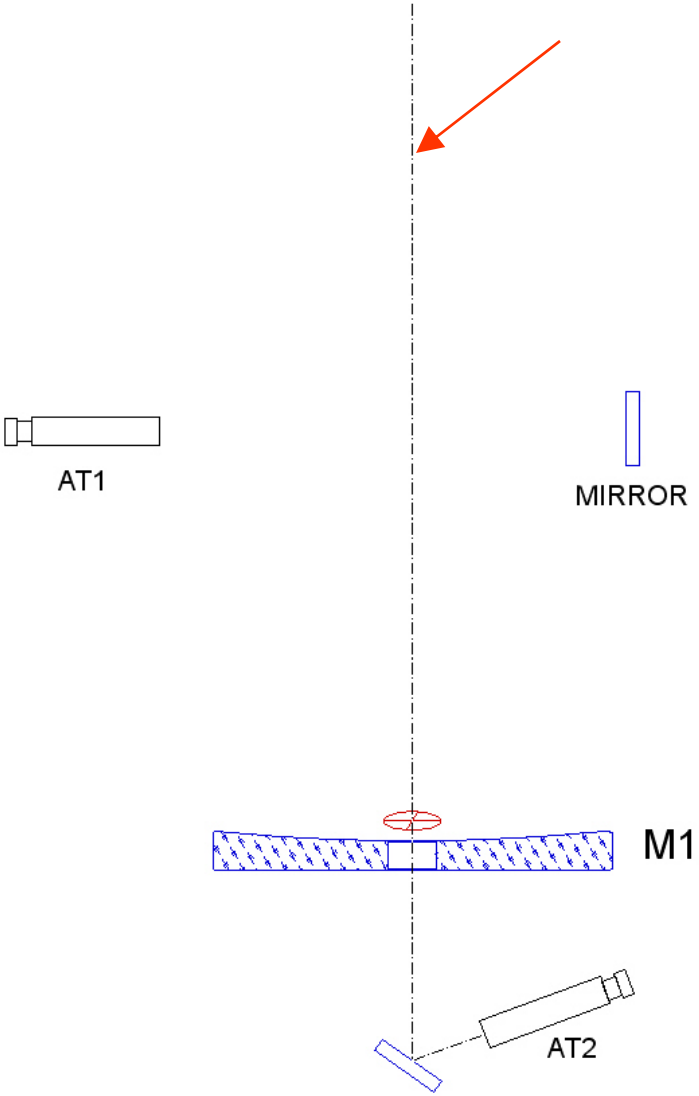


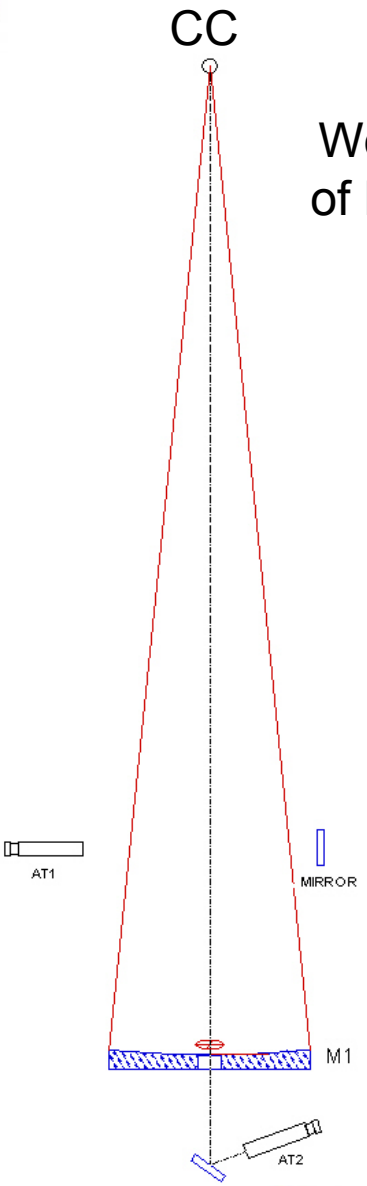
AT2 is adjusted until its line of sight coincides with that of AT1





The line of sight of AT2 sets the optical axis of the telescope

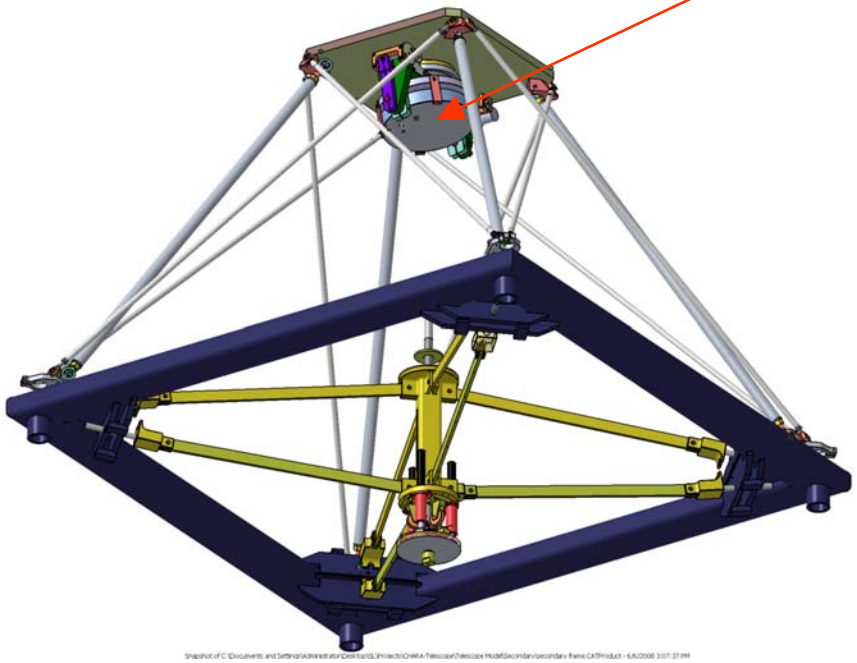




We want to put a point source at the center of curvature (CC) of M1 and tilt M1 until the point source and its image coincide.

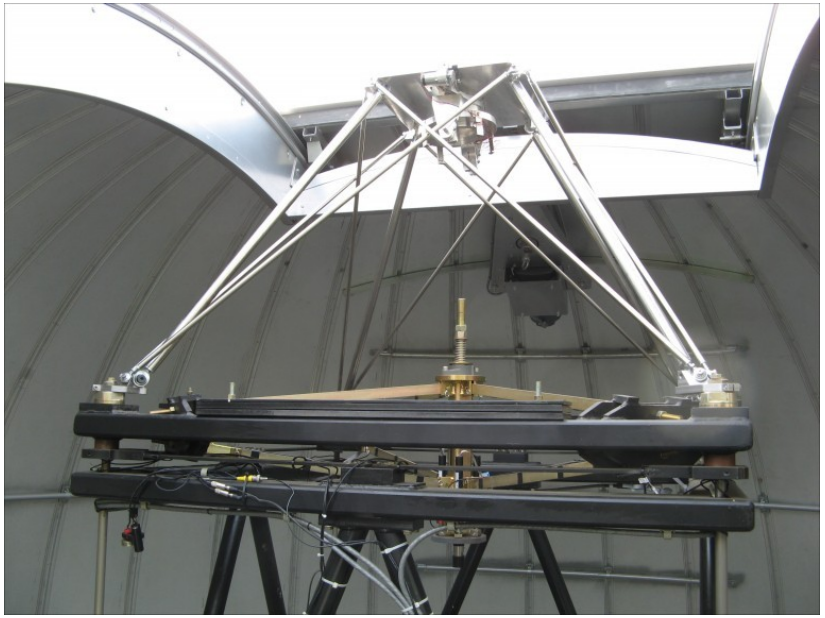
However, the CC is 5 m above M1 that is way outside the dome, so a fold mirror is needed to reach it.

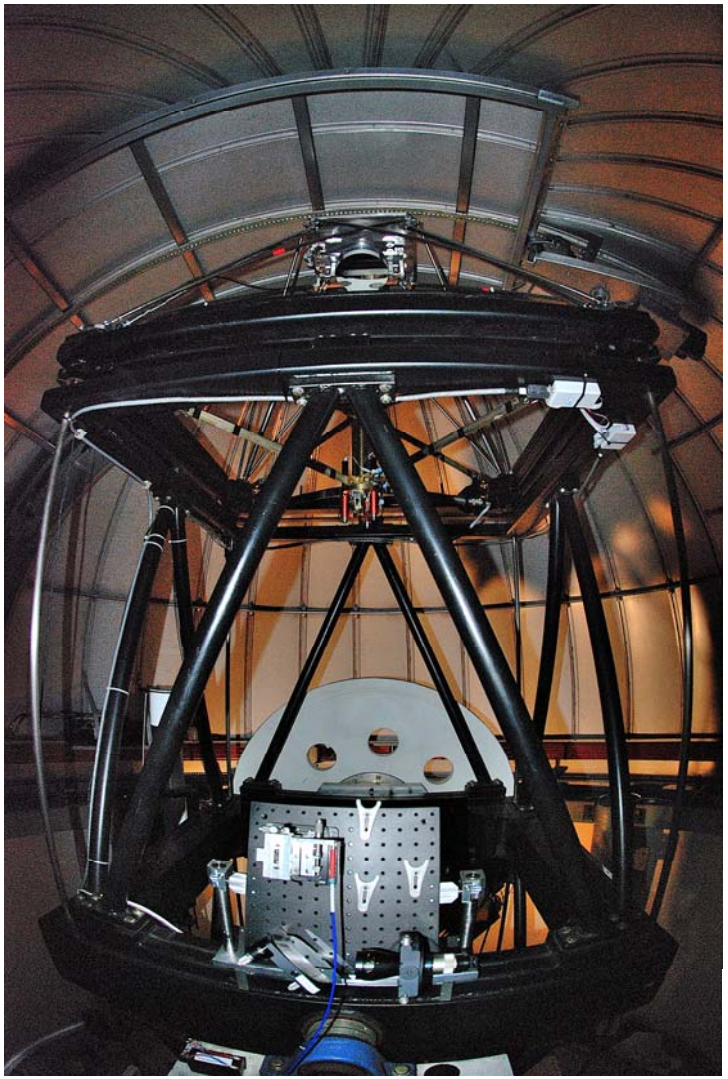
8-inch fold mirror



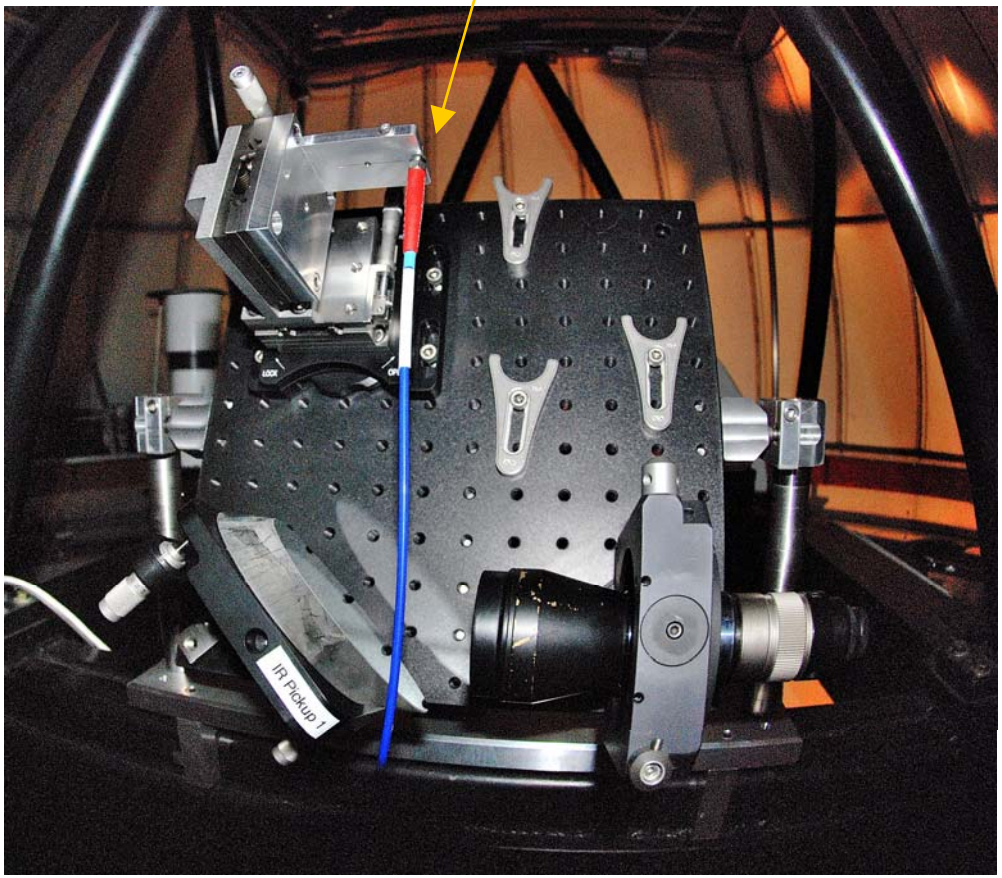
The 3D model of the supporting structure

Fold mirror mounted on W1



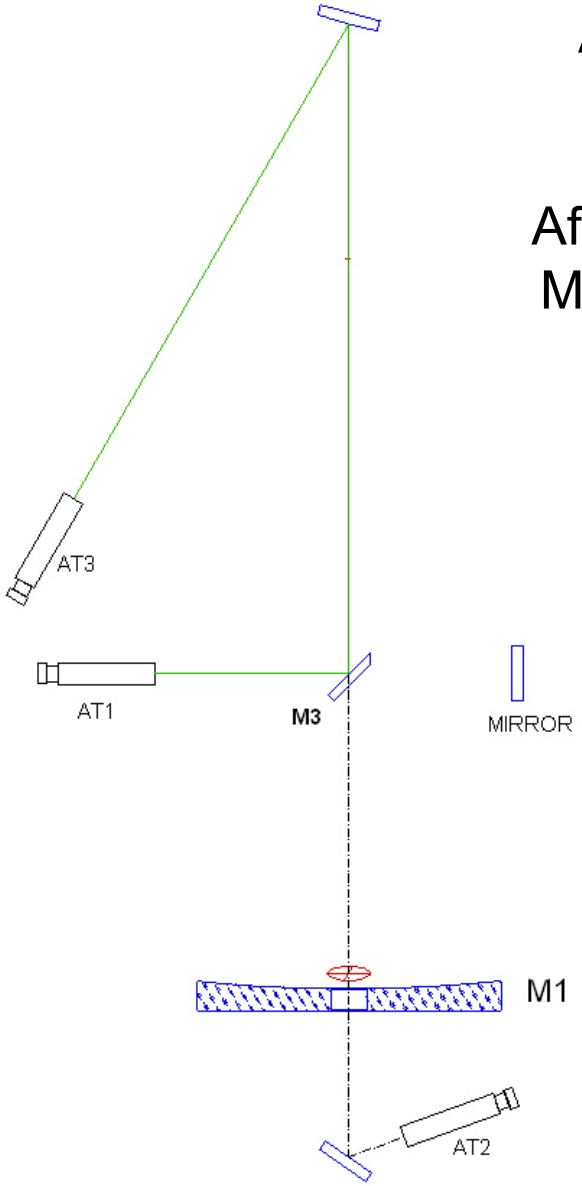


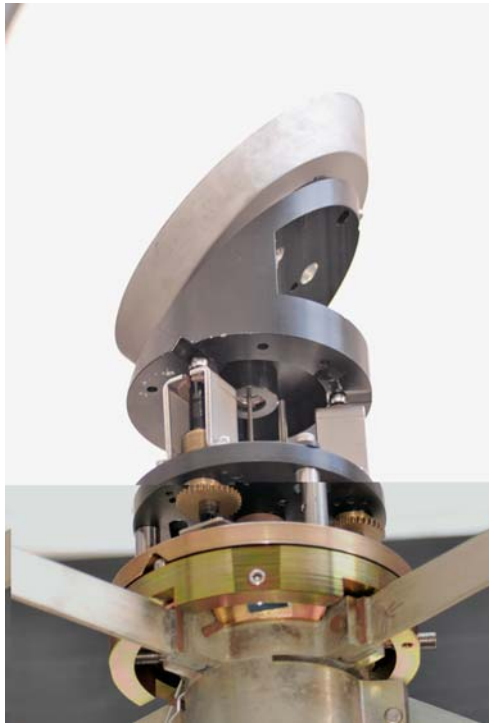
50 µm core fiber based light source

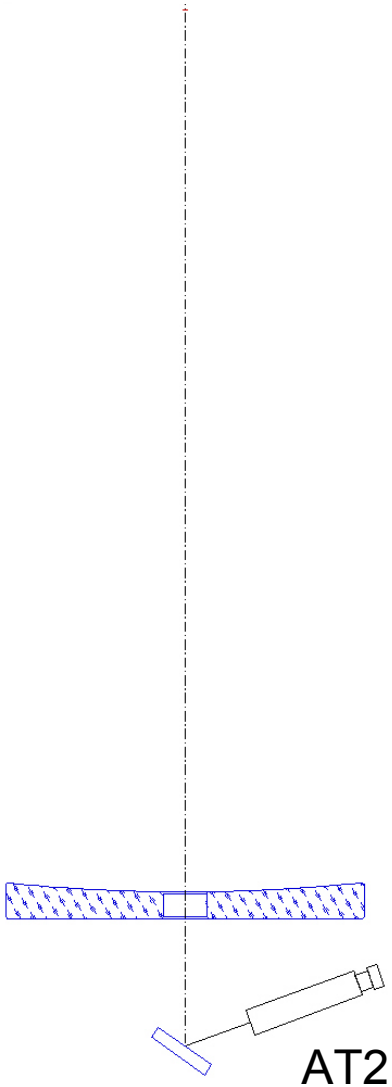


AT3 is aligned to AT2 then M3 is properly positioned and tilted.

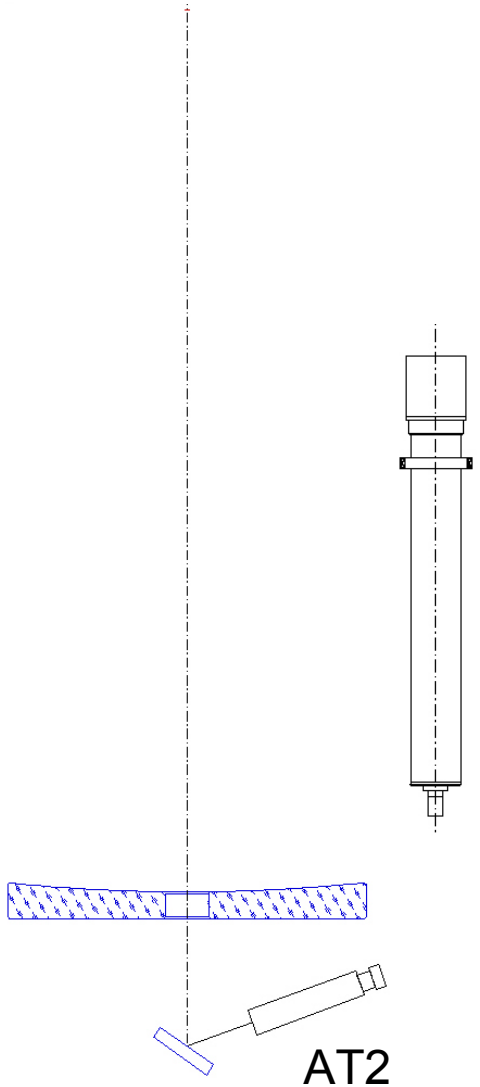
After this, M3 is removed to align M2. M3 has a new kinematic mount so it can be put back precisely.







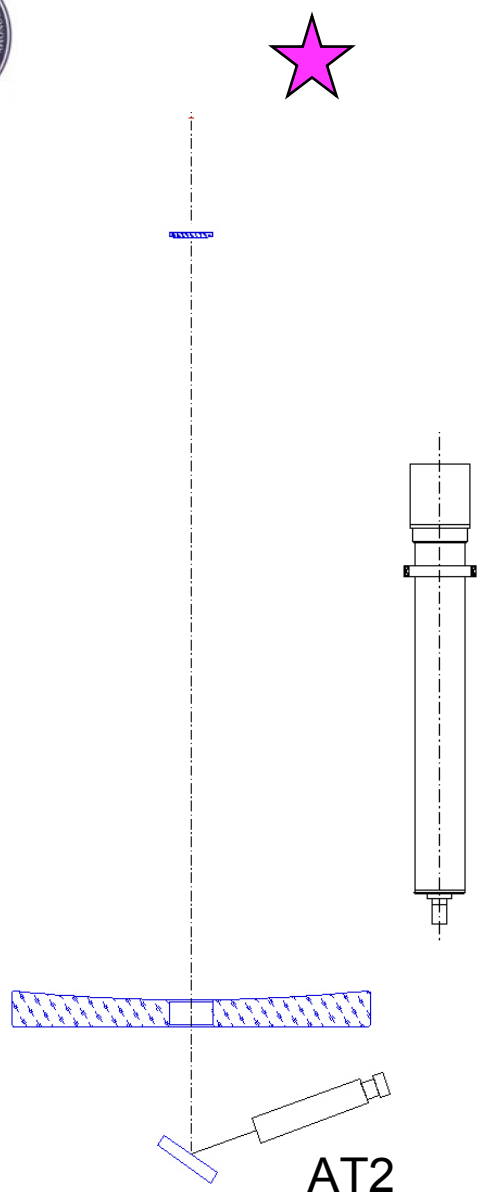
• AT2 is pointed to a star by moving the main telescope



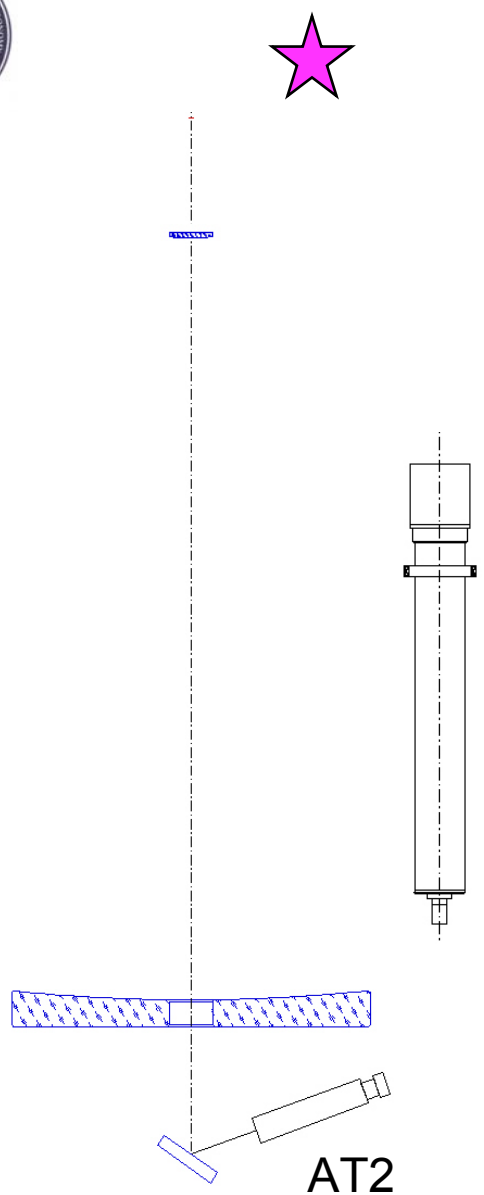
• AT2 is pointed to a star by moving the main telescope

• The finder telescope is adjusted until the star is centered in its field

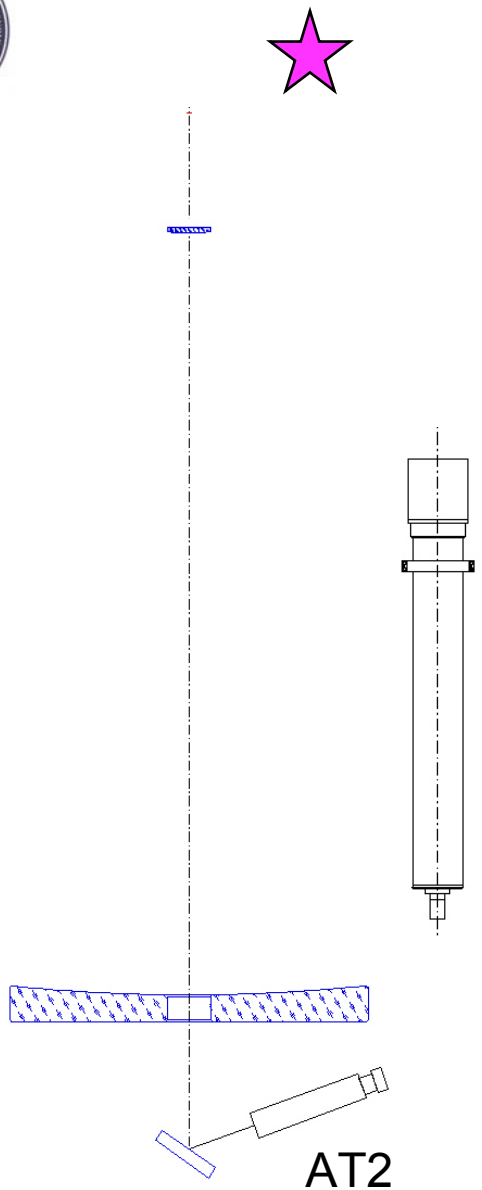
the focal length of the finder is extended 5 fold to improve sampling



- AT2 is pointed to a star by moving the main telescope
- The finder telescope is adjusted until the star is centered in its field
- M2 installed, a star is centered in the finder



- AT2 is pointed to a star by moving the main telescope
- The finder telescope is adjusted until the star is centered in its field
- M2 installed, a star is centered in the finder by moving the main telescope
- Iterating between shifting and tilting of M2 until the star is also centered in AT2



- AT2 is pointed to a star by moving the main telescope

- The finder telescope is adjusted until the star is centered in its field

- M2 installed, a star is centered in the finder by Moving the main telescope

- Iterating between shifting and tilting of M2 until the star is also centered in AT2

The axes of M1 and M2 coincide and intersect the elevation axis perpendicularly.

After reinstalling M3 and M4 an auxiliary telescope (TAS) is used to evaluate beam quality by measuring the wavefront curvature

Zernike	Name				RMS nm				
			2/28/2008			3/12/2009			
			100mm	200mm		100mm	100mm	200mm	200mm
4	focus		155	233		-912	-882	-965	-935
5	astigmatism (sin)		-424	-360		-436	-410	-565	-595
6	astigmatism (cos)		410	320		452	402	431	288
7	coma (sin)		30.9	88.4		301	387	285	477
8	coma (cos)		-39.4	-87		-29.2	-39.5	-94.6	-220
9	trefoil (sin)		-101	-69.6		15.5	-5.76	-26.1	-88.9
10	trefoil (cos)		-81.2	-52.5		112	27.5	32	1.83
11	spherical		-42.6	-28.4		-6.79	-33	16.2	10.9
12	sph astig (cos)		-15.7	-22.3		-52.1	-37.7	-53.3	-41.9
13	sph astig (sin)		35.2	43.8		13	6.97	19.5	16

Conclusion

- After a much more precise alignment, but before any tweaking

the beam quality is worse from W1

Inherent in the optics - the least likely

The mounts distort the optics - likely

Optical misalignment – less likely