MORE AUTOMATION

Laszlo Sturmann

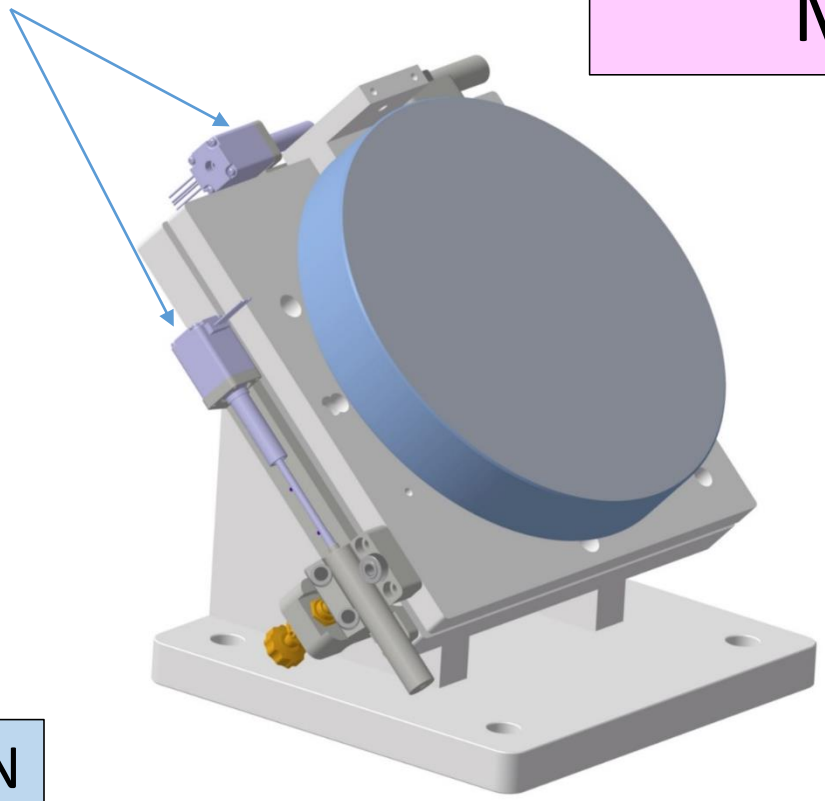
M7 ACTUATORS

LAB. LASER ALIGNMENT

TELESCOPE OPTICAL ALIGNMENT

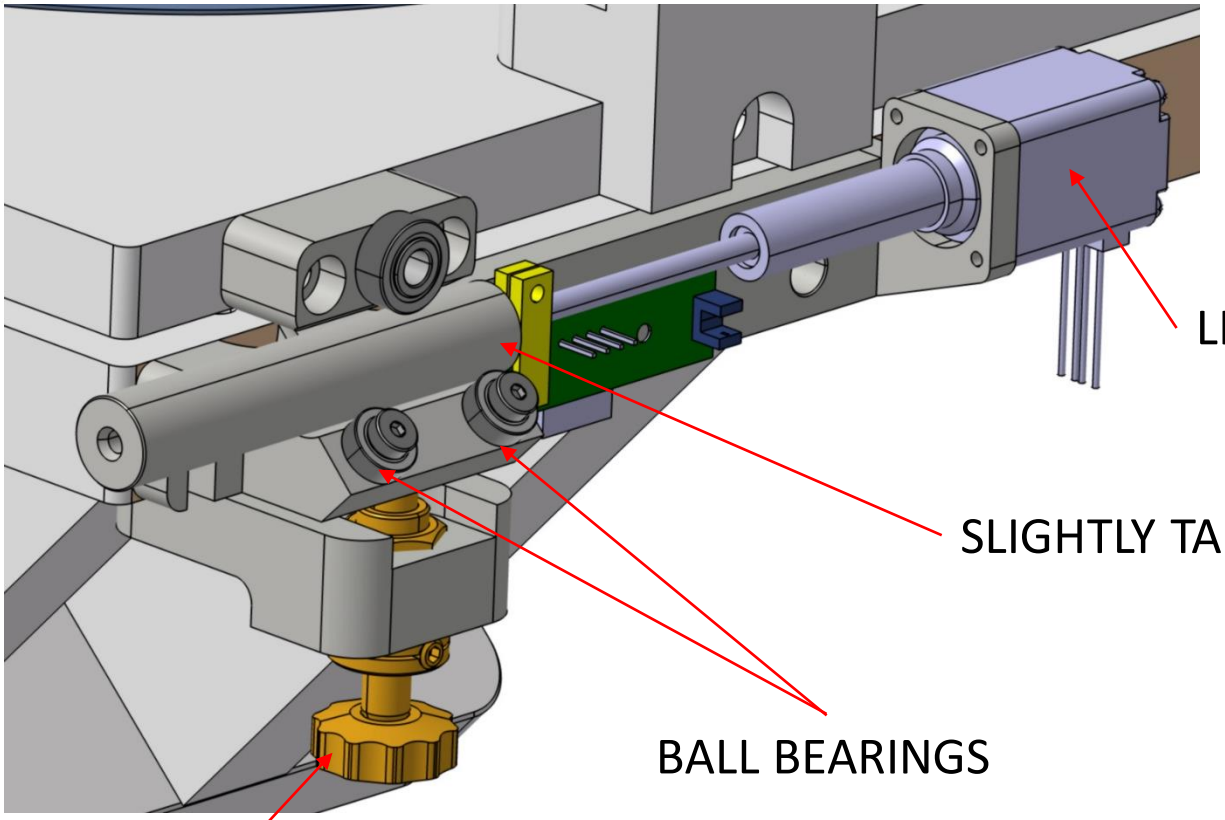
REMOTELY ACTUATED M7 MOUNT

NEW ACTUATORS



MOTIVATION

THE PRECISION OF THE COUDE ALIGNMENT WAS NOT SUFFICIENT WITH MANUAL FINE SCREWS



LINEAR ACTUATOR,

SLIGHTLY TAPERED PIN

BALL BEARINGS

COARSE MANUAL ADJUSTMENT

SUB-ARCSEC RESOLUTION,
WIDE ADJUSTABLE RANGE,
LOW DRIFT

LAB. LASER ALIGNMENT TOOL

MOTIVATION

THE LASER ALIGNMENT IS BASIC TO PROPER ARRAY OPERATION
MORE SO WITH AO INSTALLED BUT IT'S STILL DONE BY EYE

SUBJECTIVE, LASER DRIFTS

THIS DEVICE AIMS TO MAKE THE LASER ALIGNMENT

OBJECTIVE, REPEATABLE, QUICK

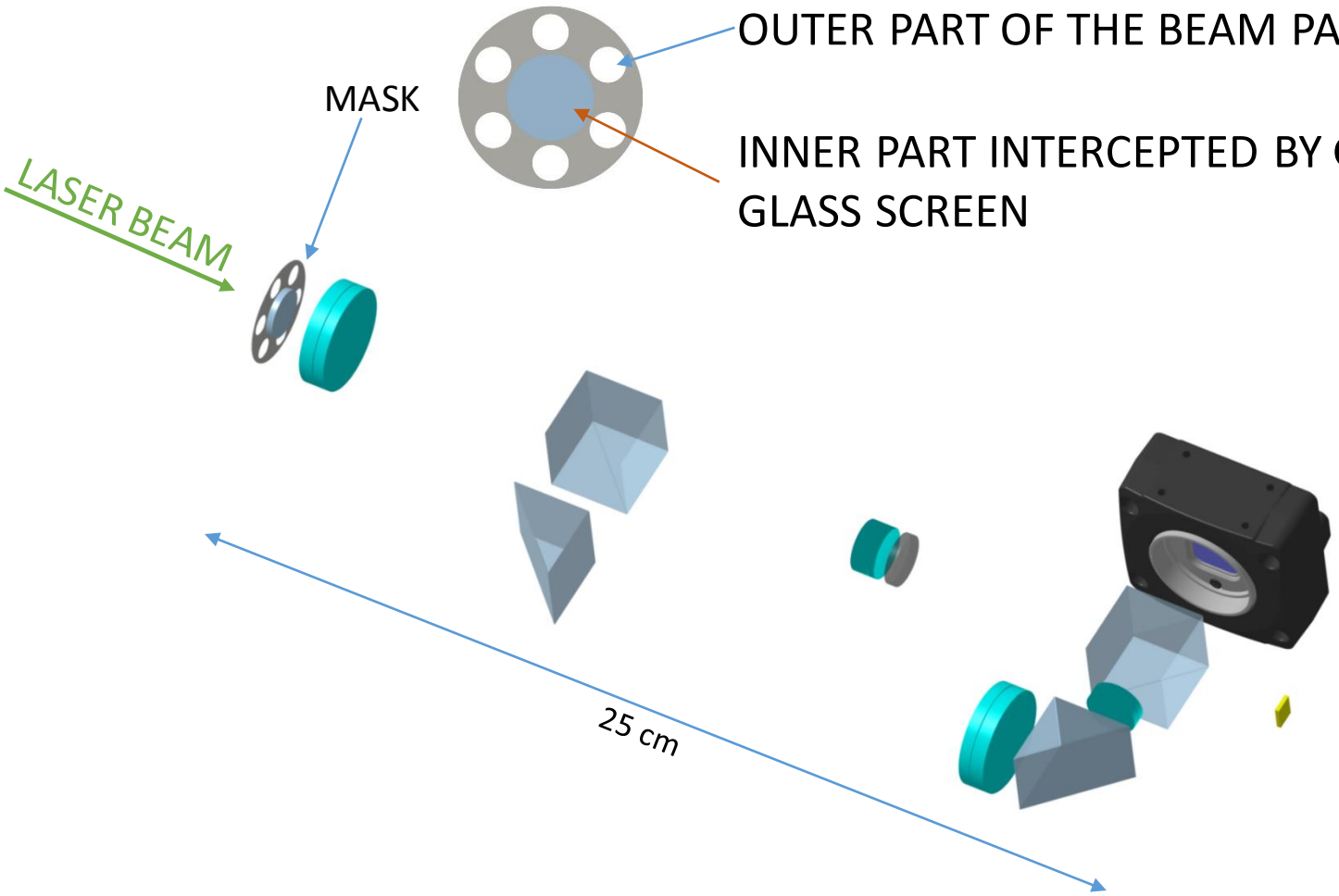
SENSITIVITY TO BOTH BEAM ANGLE AND SHEAR

LAB. LASER ALIGNMENT TOOL

WE WANT TO DETECT BEAM DIRECTION AND BEAM SHEAR SIMULTANEOUSLY

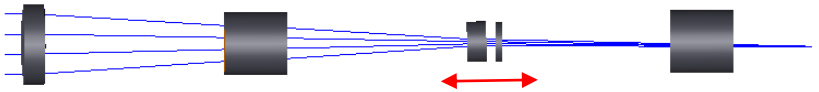
OUTER PART OF THE BEAM PASSES THROUGH

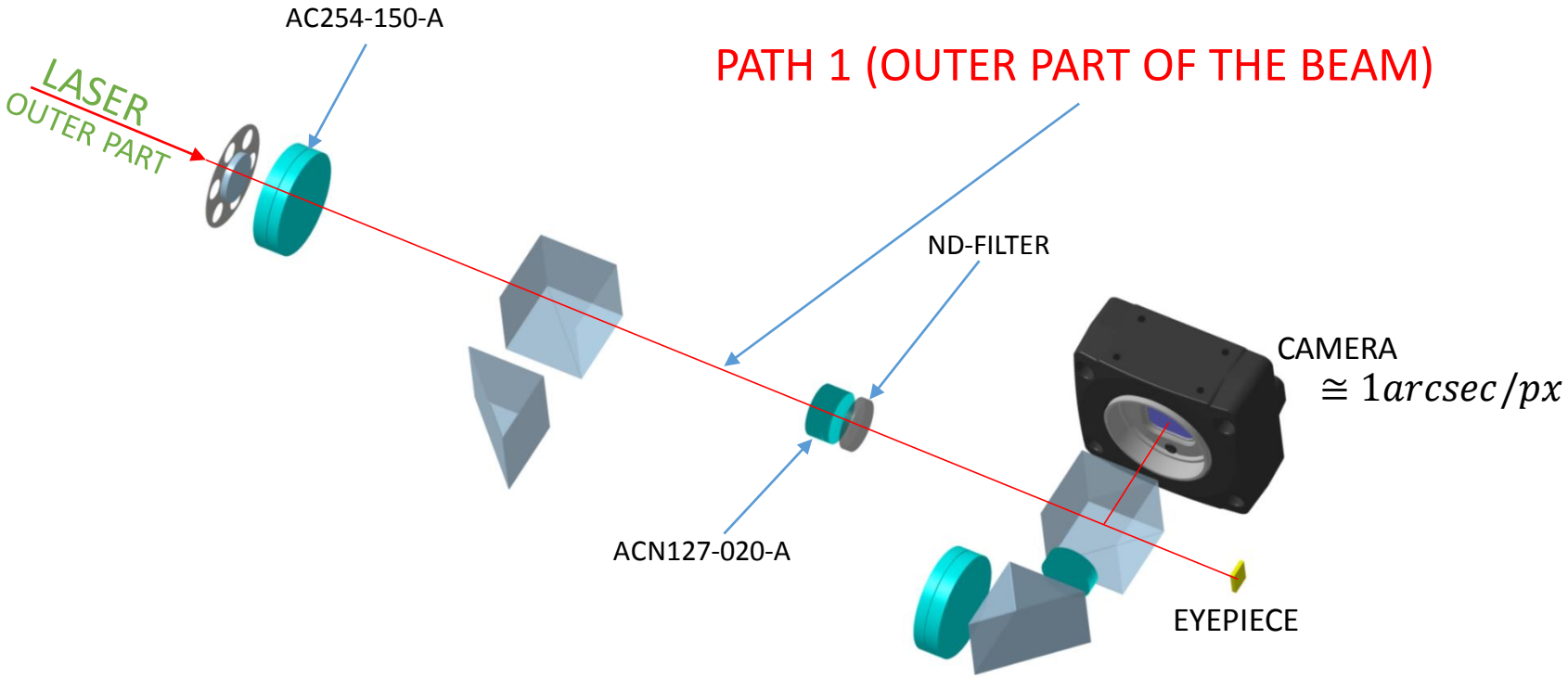
INNER PART INTERCEPTED BY GROUND GLASS SCREEN



ANGULAR PART

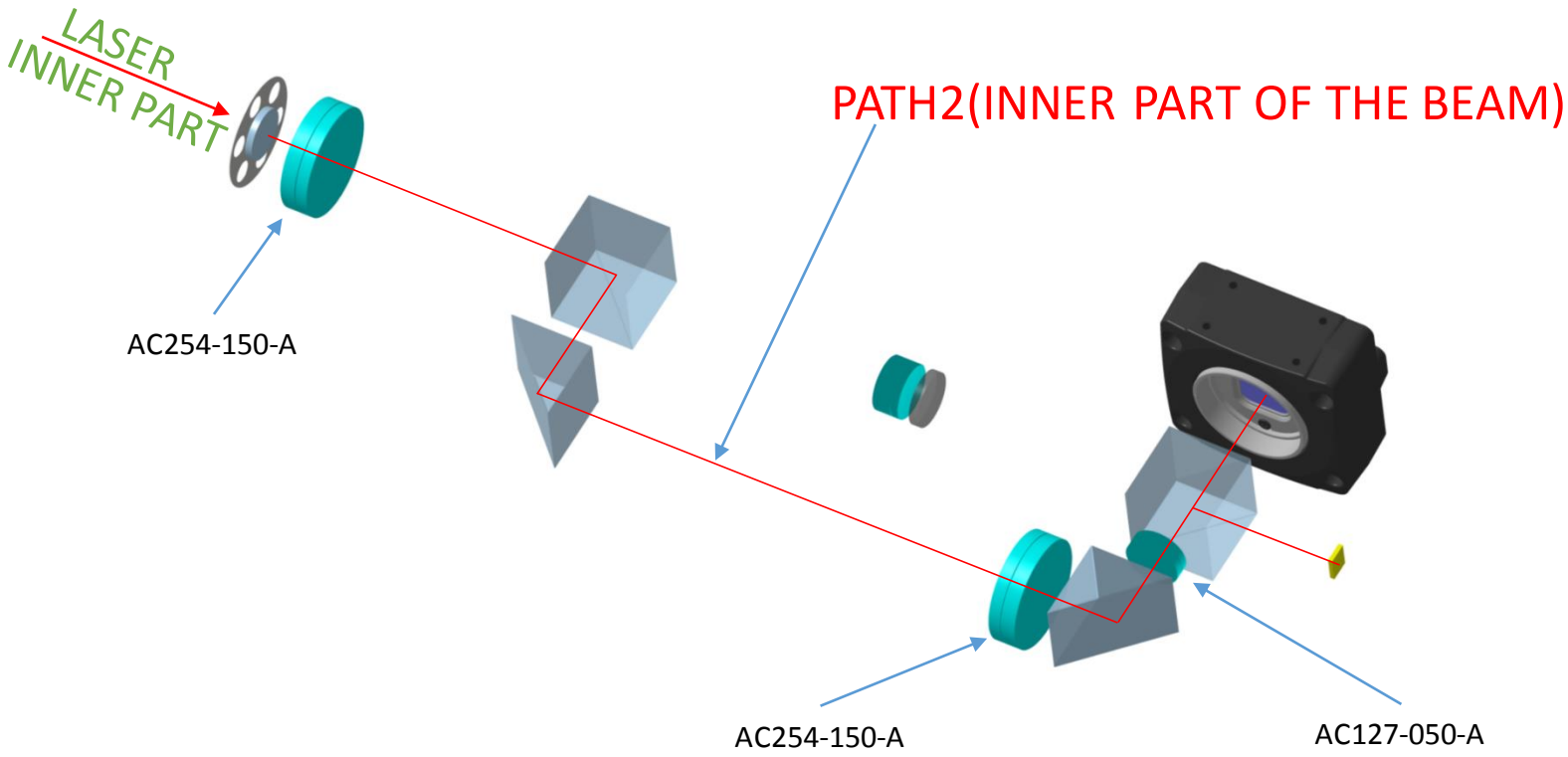
F_{eff} ADJUSTABLE TO MATCH DETECTOR

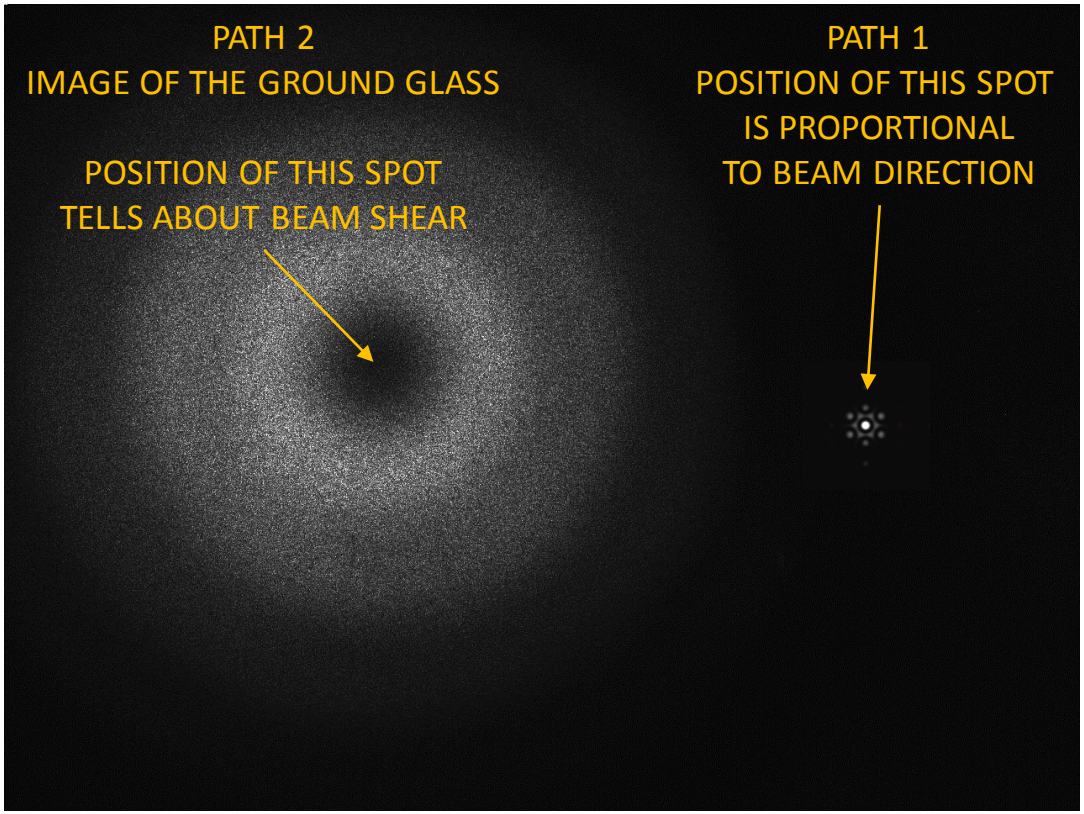




SHEAR PART

THE GROUND GLASS IS
IMAGED TO THE DETECTOR

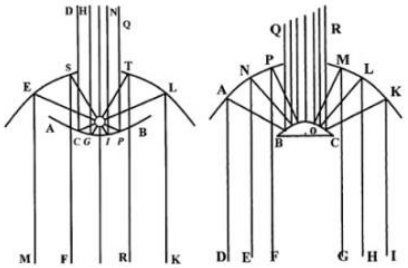


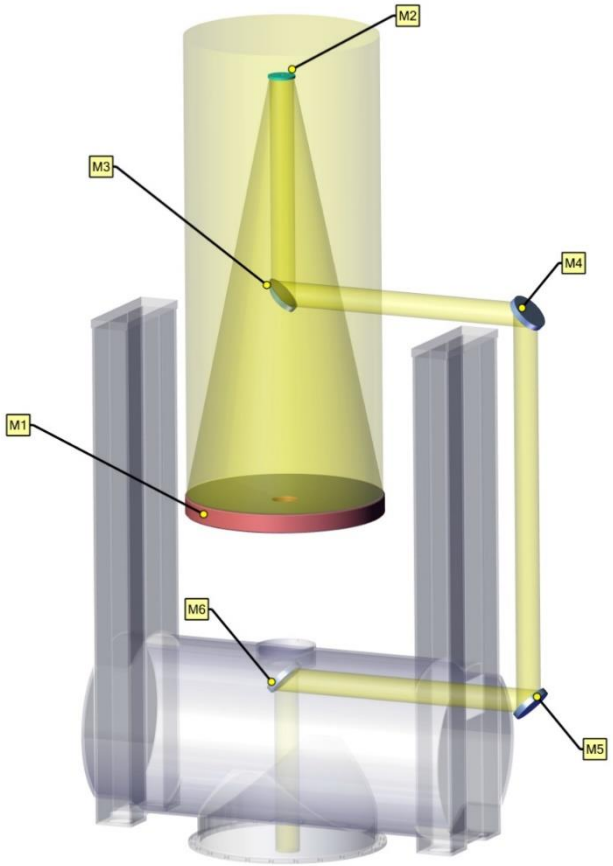


SOFTWARE TO PROCESS THESE IMAGES AND CONTROL THE MIRRORS

TELESCOPE OPTICAL ALIGNMENT (Part N)

CLASSICAL TWO MIRROR TELESCOPE (MERSENNE 1636)





M1: D = 1m
F = 2.5 m
CONCAVE PARABOLOID

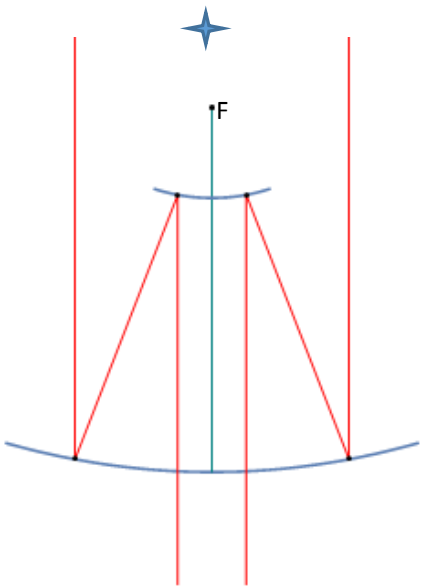
M2: D = 0.14 m
F = - 0.312 m
CONVEX PARABOLOID

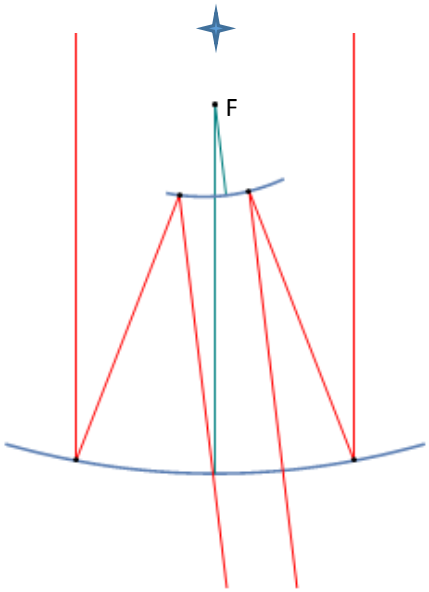
M1 AND M2 CONFOCAL

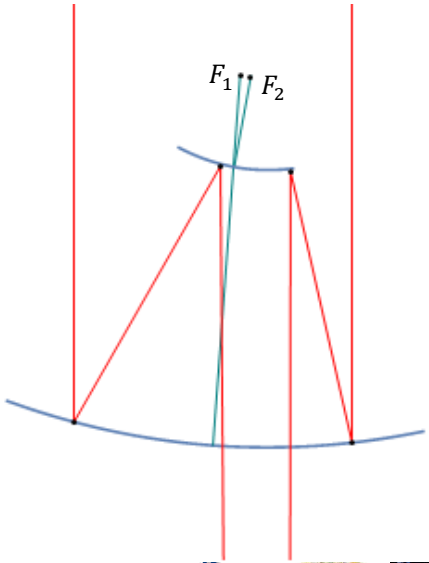
1:8 BEAM COMPRESSION

M3,M4,M5,M6… FLATS

COLLIMATED OUTPUT BEAM ∅ 0.125 m







PERFECTLY ALIGNED IF

1. FOCI ARE COINCIDENT
2. THE AXIS OF M1 POINTS THE STAR

IF ANY OF THESE TWO CONDITIONS IS VIOLATED

ABERRATIONS

THE PHASE OF THE OUTPUT BEAM OF THE TELESCOPE IS EXPANDED INTO A SERIES OF ZERNIKE POLYNOMIALS

$$\varphi(\rho,\Theta) = \sum_i a_i Z_i(\rho,\Theta)$$

ASSUMING PERFECT MIRRORS AND SUPPORT, OPTICAL MISALIGNMENT SHOW UP ONLY IN THE LOW ORDER TERMS ($a_4 \ldots a_{8,} a_{11}$)

a_4 - defocus

$a_{5,6}$- astigmatism ← MAIN ENEMIES

$a_{7,8}$- coma ←

a_{11} - spherical aberration

STARTING FROM AN ESSENTIALLY RANDOM STATE OF THE MIRRORS, TELESCOPE ALIGNMENT ATTEMPTS TO

1. MINIMIZE COMA AND ASTIGMATISM
2. WHILE THE BEAM PROPAGATES IN THE CORRECT DIRECTION

THE PRIMARY ABERRATION IS COMA

COMA IS PROPORTIONAL TO THE LATERAL DISPLACEMENT BETWEEN THE FOCI OF M1 AND M2

$$(P-V)_C[\text{nm}] \cong 1273\,\Delta\,[mm]$$

WHEN COMA IS ELIMINATED, ASTIGMATISM BECOMES VISIBLE

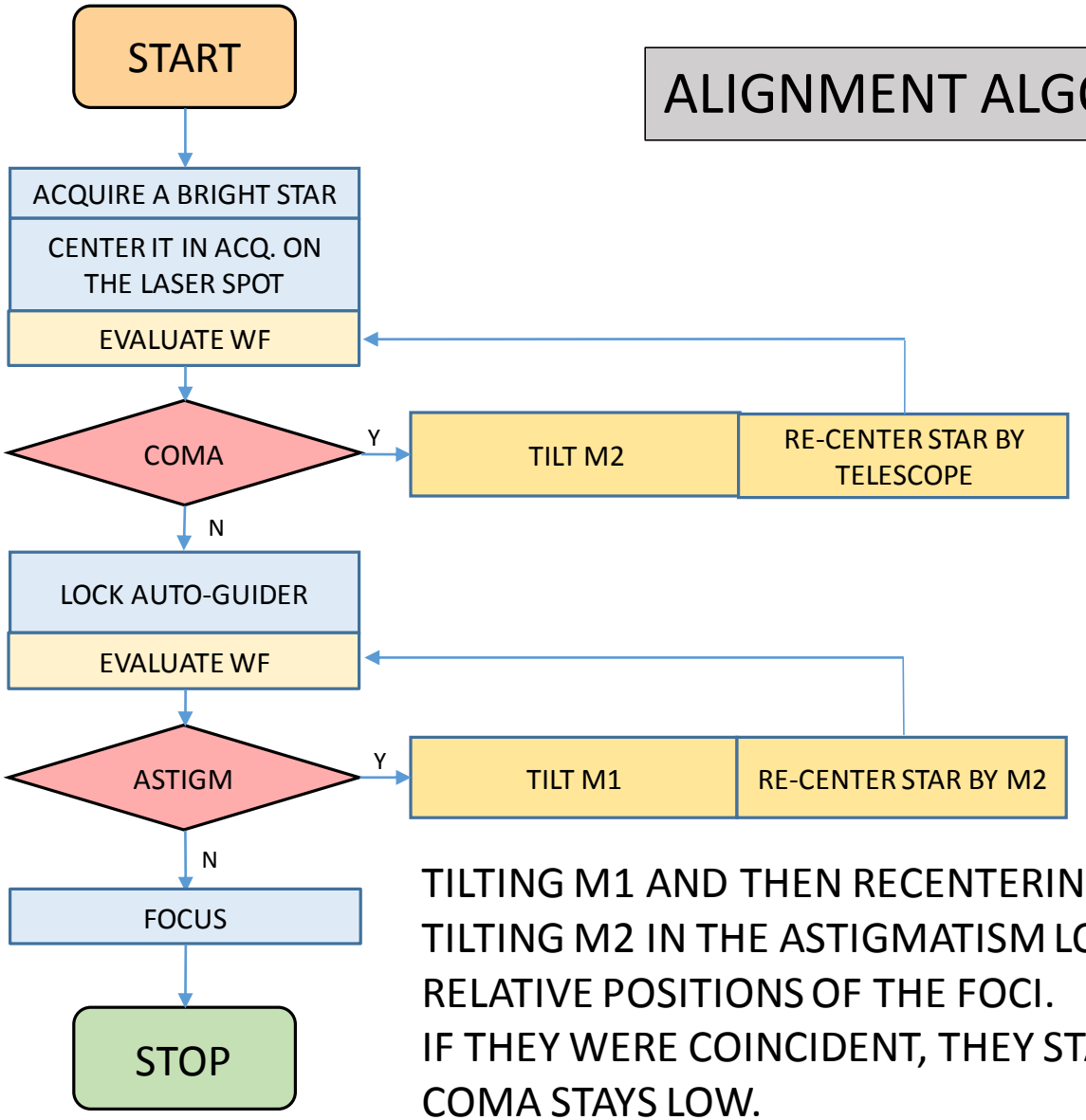
$$(P-V)_A[\text{nm}] \cong 3.4\times 10^8\,\delta^2\,[rad]$$

WHERE δ IS THE ANGLE BETWEEN THE AXIS OF M1 AND THE DIRECTION OF THE STAR

OPTICAL ALIGNMENT IS NECESSARILY AN ITERATIV PROCESS BECAUSE THE POSITIONS AND ANGLES OF M1 AND M2 ARE COMPLETELY UNKNOWN

THERE IS MORE THAN ONE WAY TO ACHIEVE OPTICAL ALIGNMENT
IN OUR CASE, THE BEST WAY SEEMS TO BE TILTING M1 AND M2

ALIGNMENT ALGORITHM



ELIMINATING COMA

ELIMINATING ASTIGMATISM

TILTING M1 AND THEN RECENTERING THE STAR BY TILTING M2 IN THE ASTIGMATISM LOOP PRESERVES THE RELATIVE POSITIONS OF THE FOCI.
IF THEY WERE COINCIDENT, THEY STAY COINCIDENT AND COMA STAYS LOW.

PREREQUISITIES TO AUTOMATE THE ALIGNMENT PROCEDURE

WAVEFRONT SENSOR ON TELESCOPE

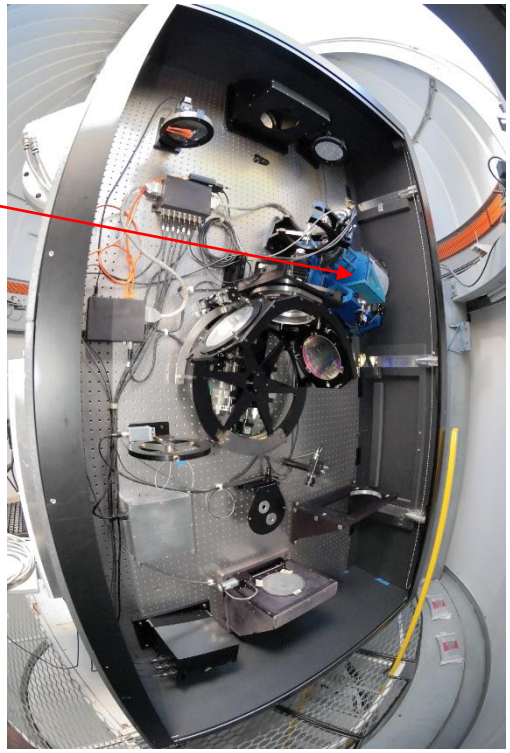
ACTUATORS ON M1 AND M2

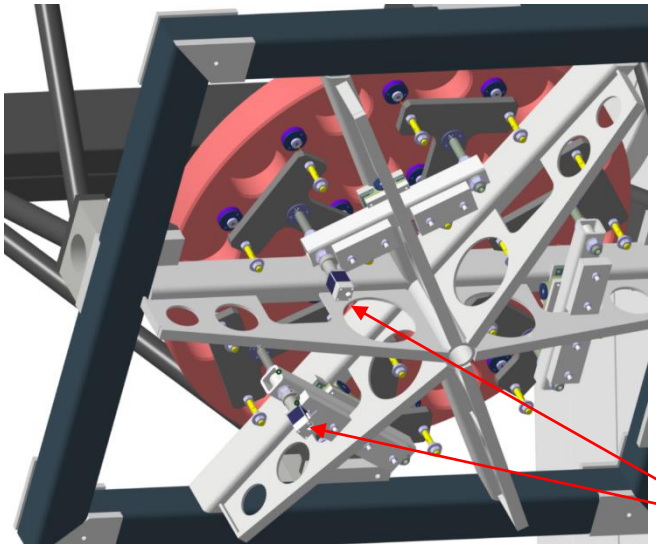
AUTO-GUIDER ON THE FINDER TELESCOPE

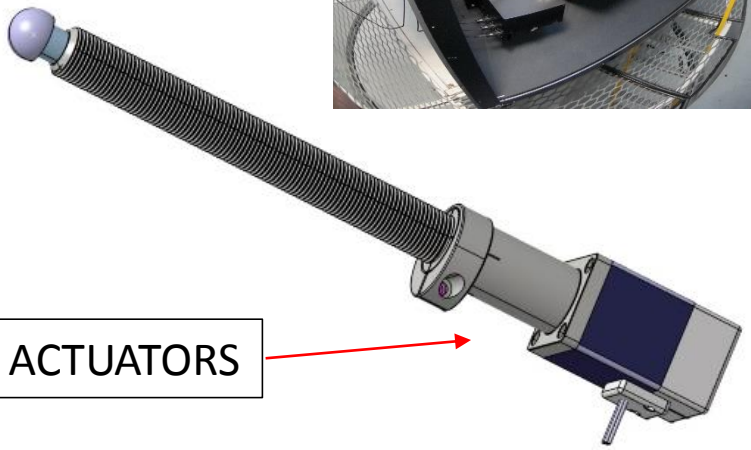
AUTO-GUIDER ON THE ACQUISITION TELESCOPE

NEW PI CONTROLLERS ON M2

PERMANENT WFS







M1 ACTUATORS

THE GOAL IS TO ALIGN THE TELESCOPES REMOTELY, QUICKLY AND ULTIMATELY AUTOMATICALLY

THANK YOU FOR YOUR ATTENTION