



ASTRI PMC Software

S. Germani - Università di Perugia



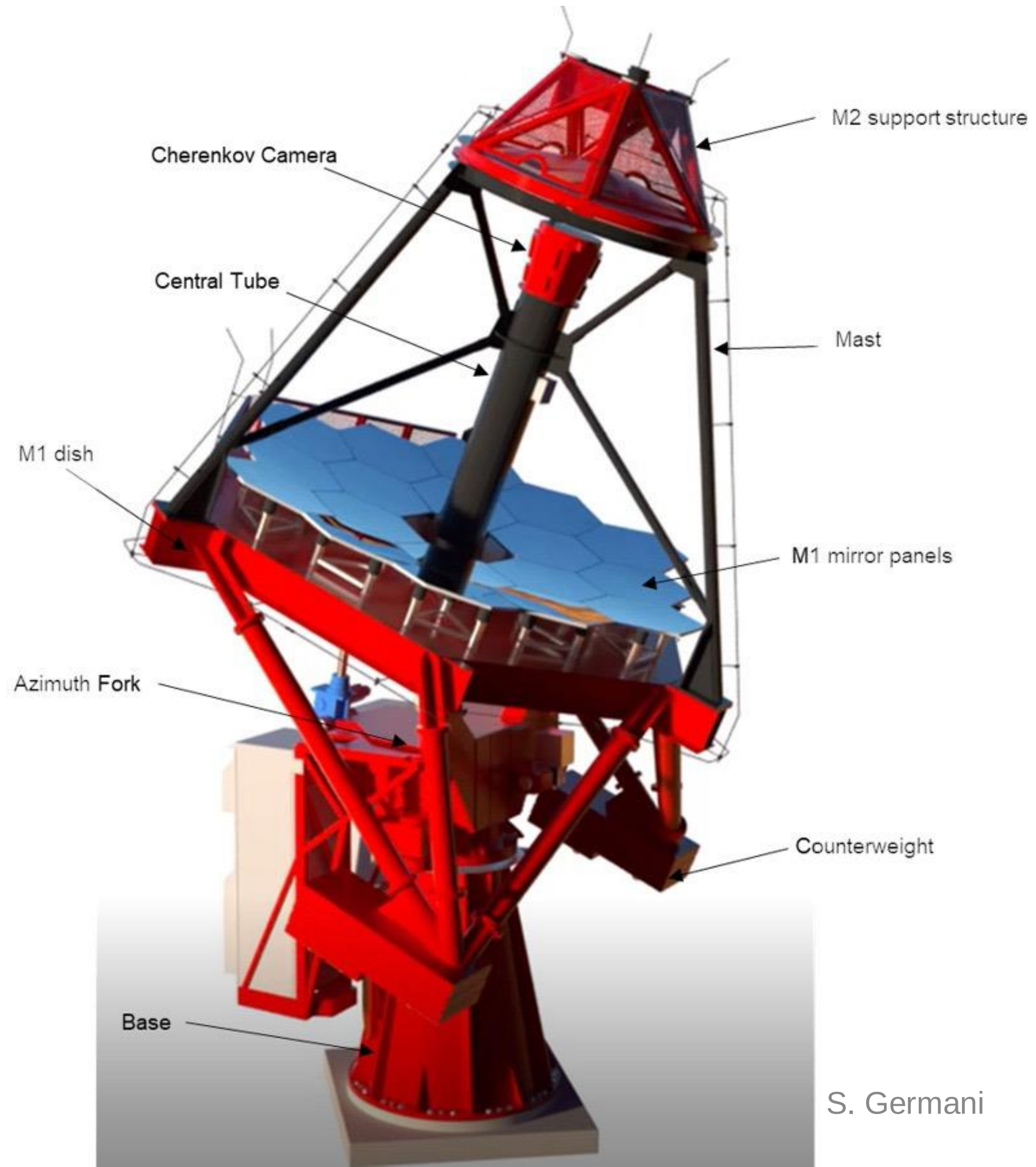
DIPARTIMENTO DI ECCELLENZA
MUR 2023/2027
A.D. 1308
unipg
DIPARTIMENTO
DI FISICA E GEOLOGIA

**CTA SST AIV Software Meeting
Milano - 20/2/2024**

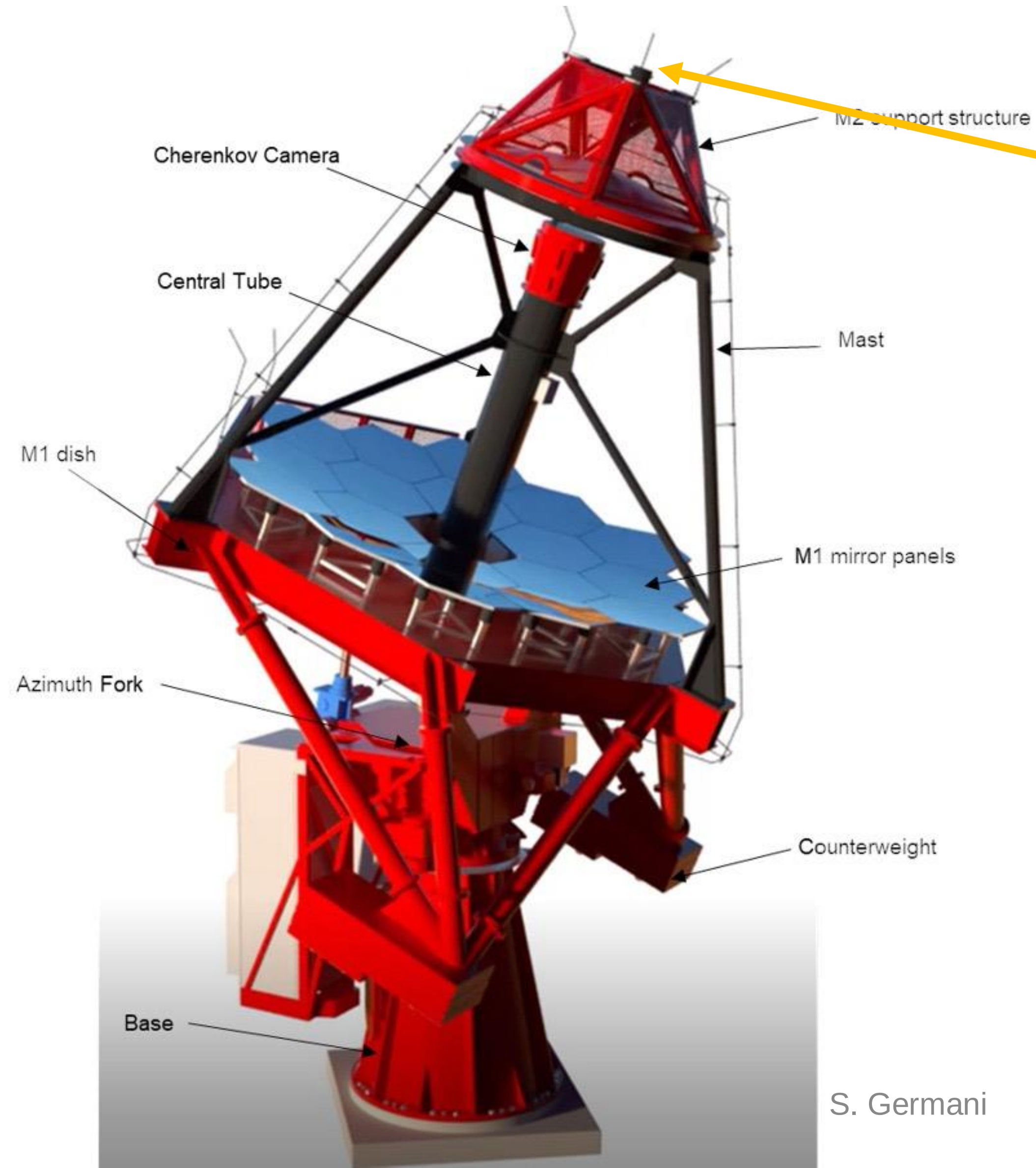


- ASTRI Mini Array PMC System
- PMC Hardware
- PMC Software
- ASTRI1 Tests

The Hardware



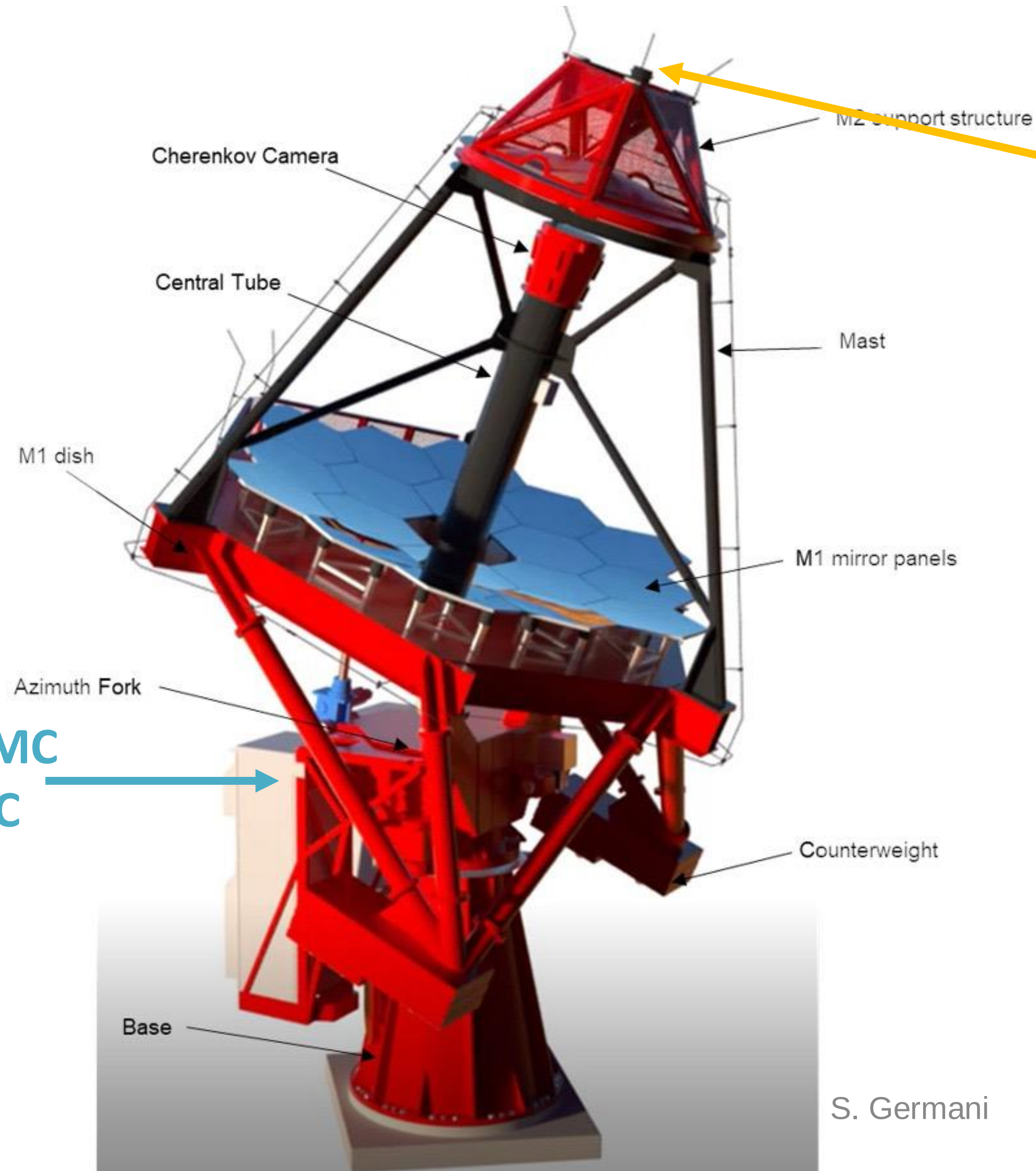
The Hardware



Pointing Monitoring Camera (PMC)



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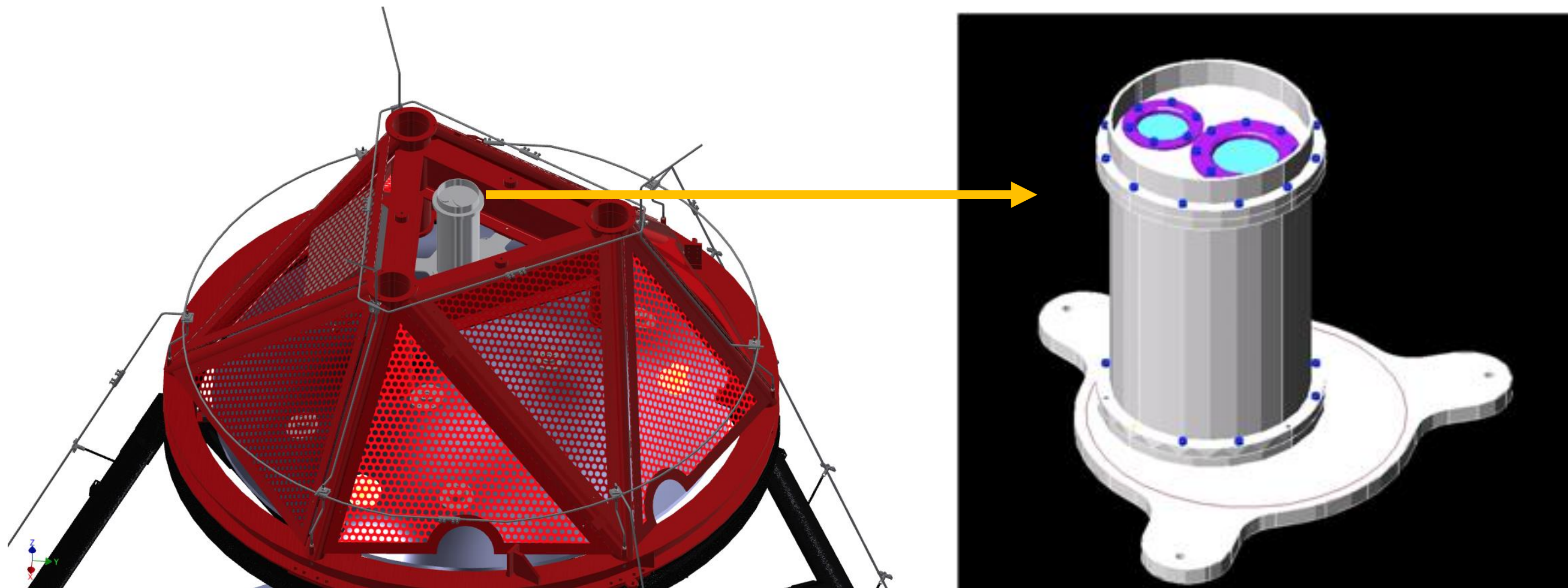
Cabinet with PMC
Local Control PC



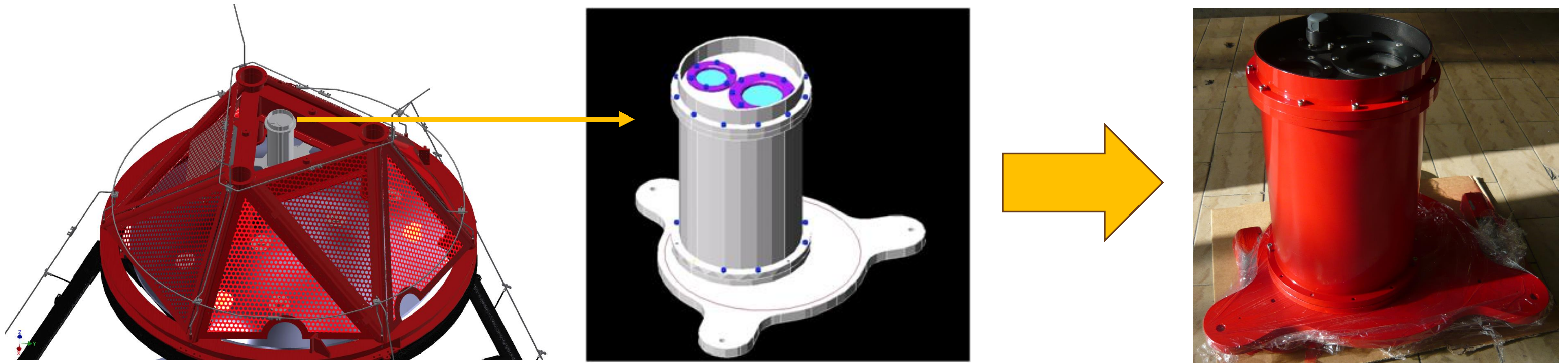
The PMC Mechanical Structure



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The PMC Mechanical Structure

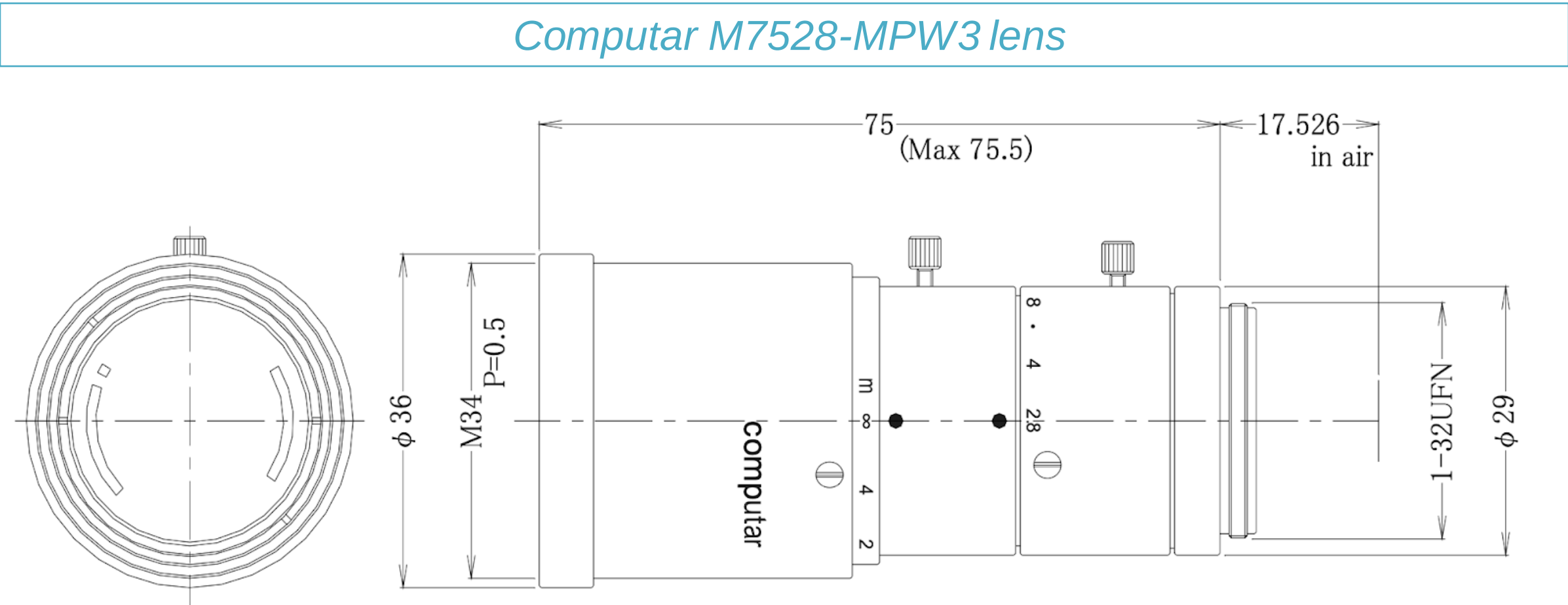


PMC Sensor and Optics

FLIR Blackfly S GigE
(Model: BFS-PGE-63S4M-C)



PMC Sensor and Optics

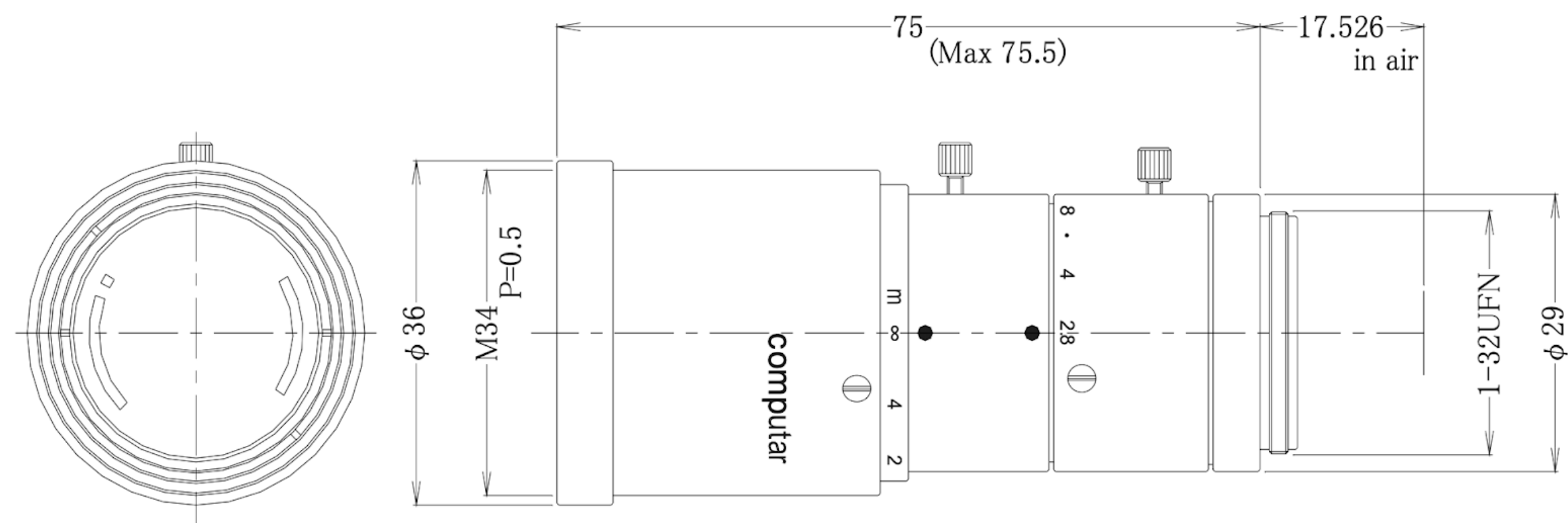


FLIR Blackfly S GigE
(Model: BFS-PGE-63S4M-C)



PMC Sensor and Optics

Computar M7528-MPW3 lens



FLIR Blackfly S GigE
(Model: BFS-PGE-63S4M-C)



PMC Local Control PC

Fanless Industrial PC
Linux OS (Ubuntu)
1 Gbit LAN ports



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PC configured as DHCP server
assigning IP to Camera

PMC Local Control PC

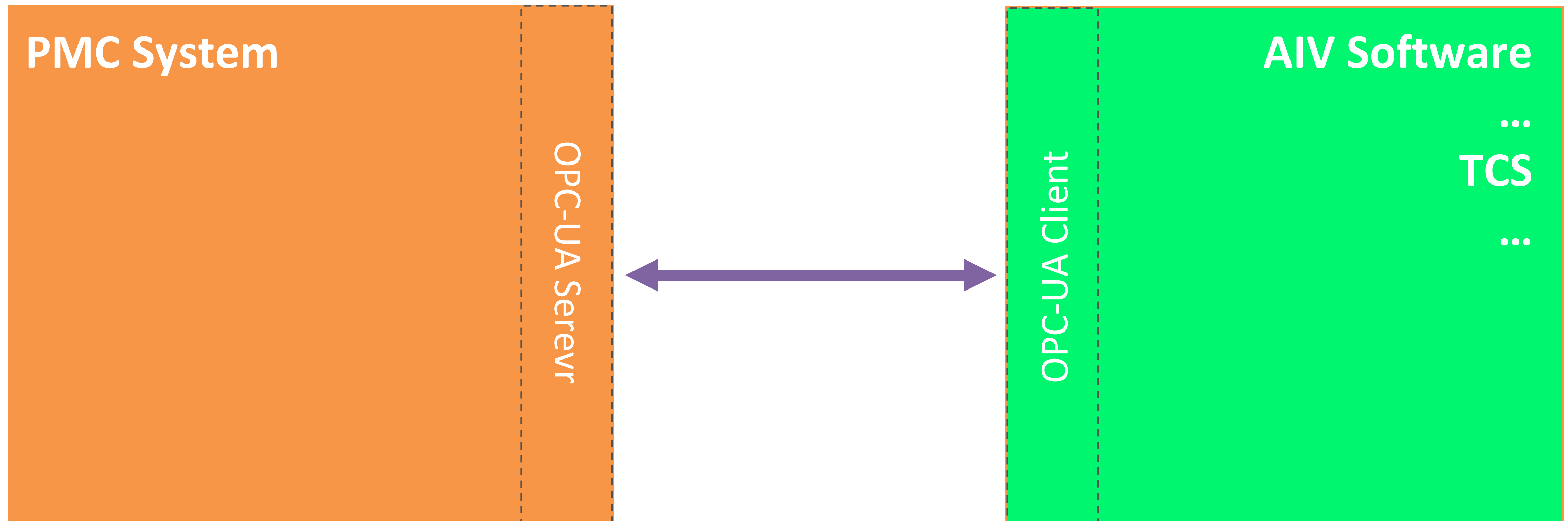
Fanless Industrial PC
Linux OS (Ubuntu)
1 Gbit LAN ports



PC configured as DHCP server
assigning IP to Camera

To Telescope
Switch





Operational Steps

Initilaisation

Connect to Camera

Set Exposure Time



Acquisition Loop (starts on OPC-UA client request)

Update Exposure Time (if needed)

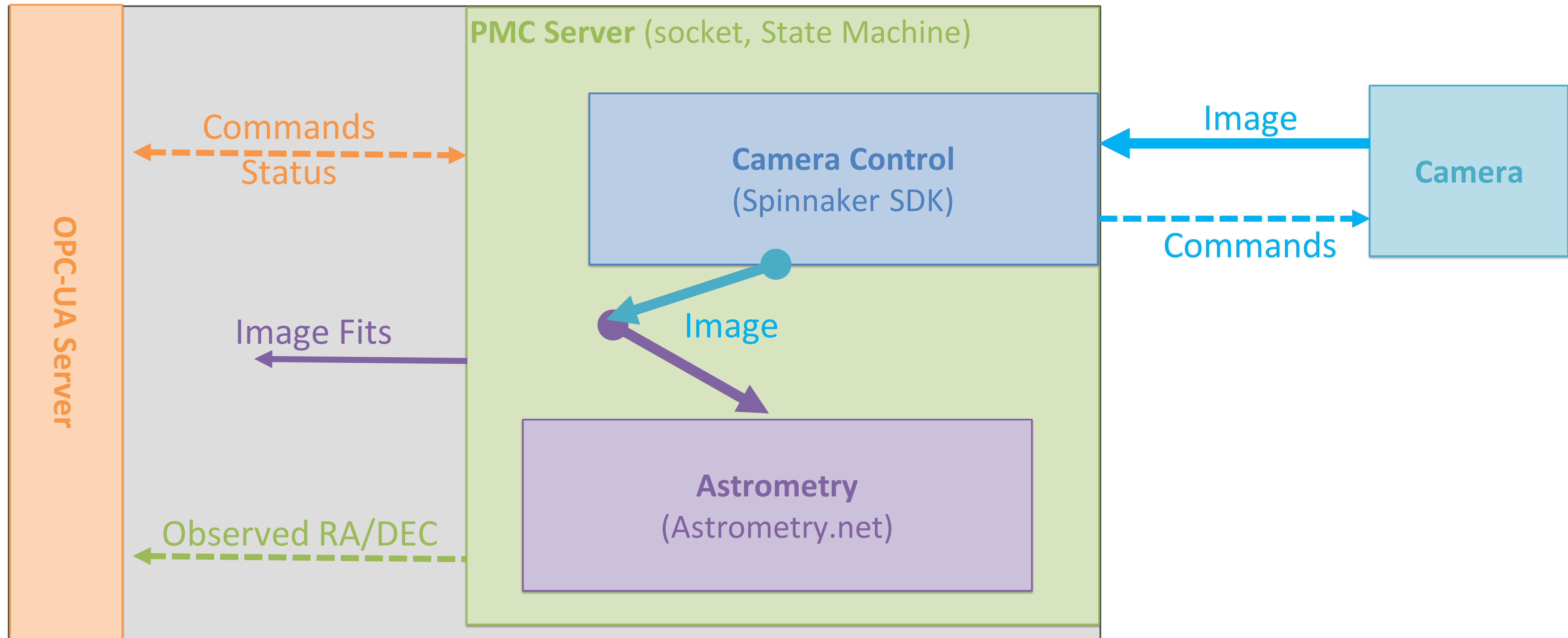
Acquire Image

Perform Astronomy

Save Acquired Image

Save / Return Astrometry Results

Functional Diagram



Reliable GigE Architecture, Exceptional Performance.

Spinnaker SDK

C++ based

Linux → Ubuntu 20.04, Ubuntu 22.04, ...

<https://www.flir.eu/products/spinnaker-sdk/>



C based

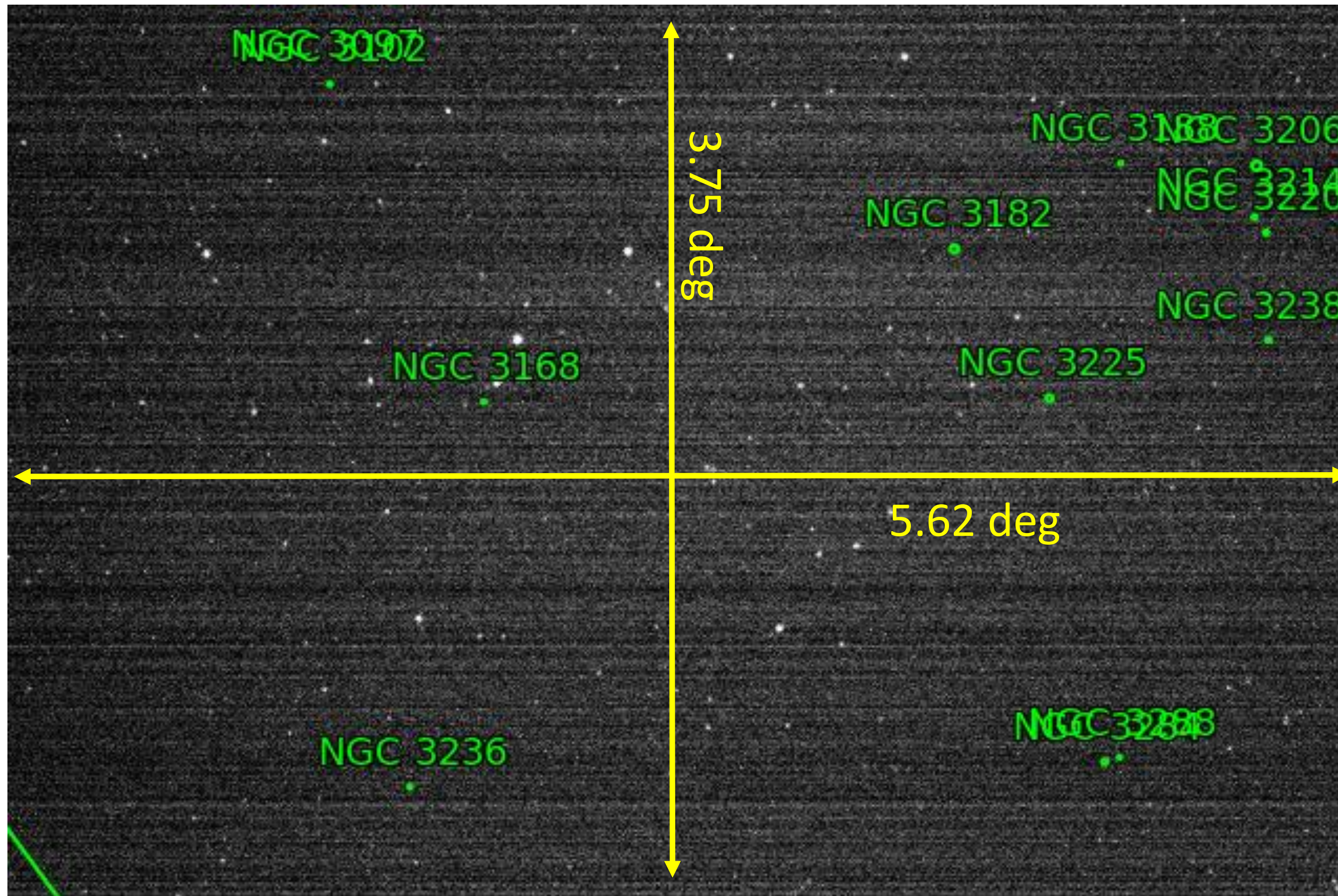
Linux → Ubuntu / Debian...

<https://astrometry.net/>



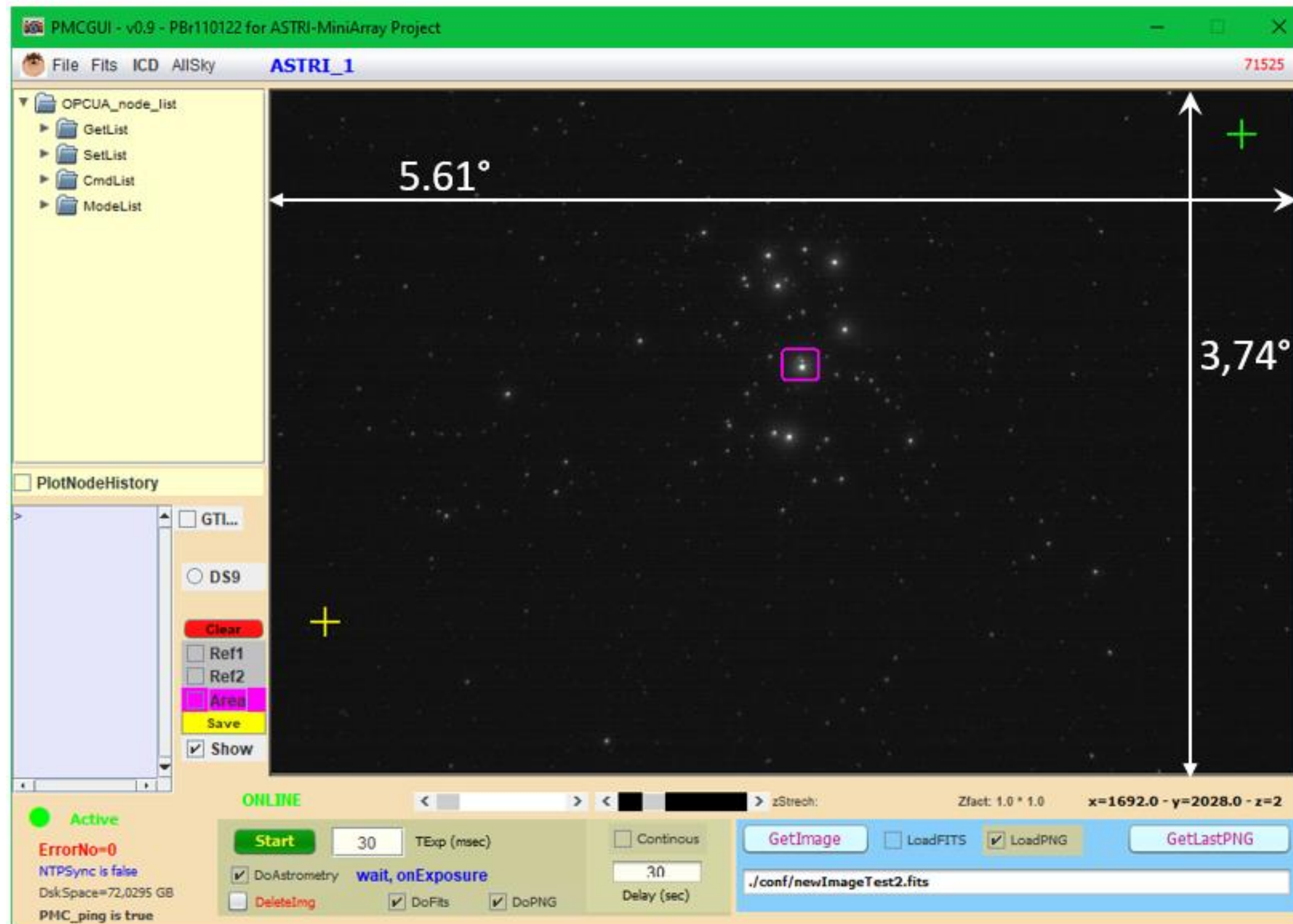
Measures





Successfully tested exposure times
below 1 ms

Typical exposure time used : 0.5-1 s



- P. Bruno (INAF OA-Catania)
- OPC-UA Server
- AIV GUI

- S. Germani
- LCS PC Setup
- PMC Server (with Camera Control and Astrometry)
developed starting from ASTRI-Horn software by D. Fugazza (INAF OA-Brera)

Repeated Measurements

For several telescope positions the PMC image has been acquired twice in order to compare Astrometry results with the same expected Alt-Az

Difference between two measurements at the same Telescope position:

$$d = \theta_2 - \theta_1$$

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Extract the error on the angle measurement:

$$\sigma_\theta = \frac{\sigma_d}{\sqrt{2}}$$

Repeated Measurements

Az: *StdDev* → 0.51 acrsec

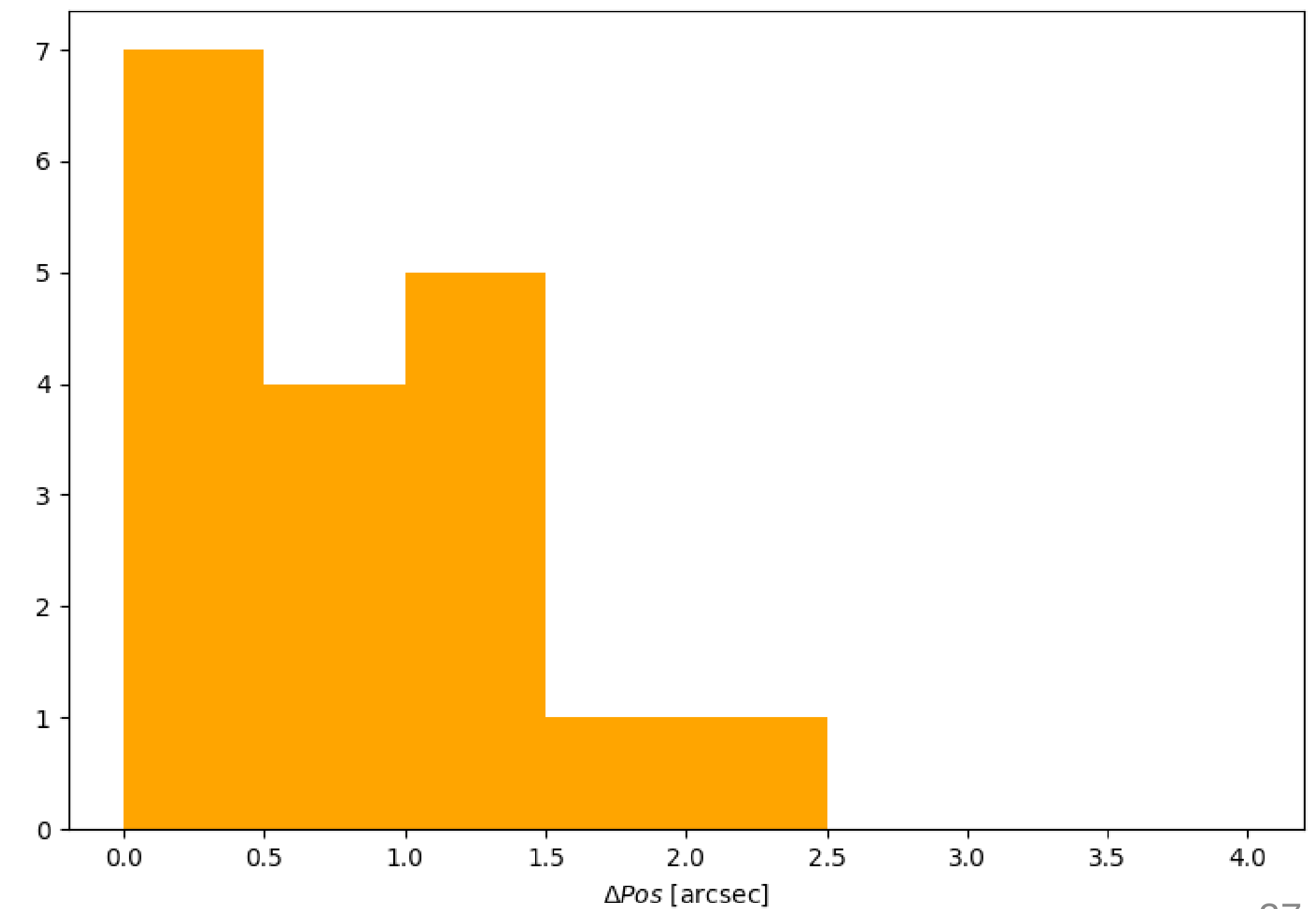
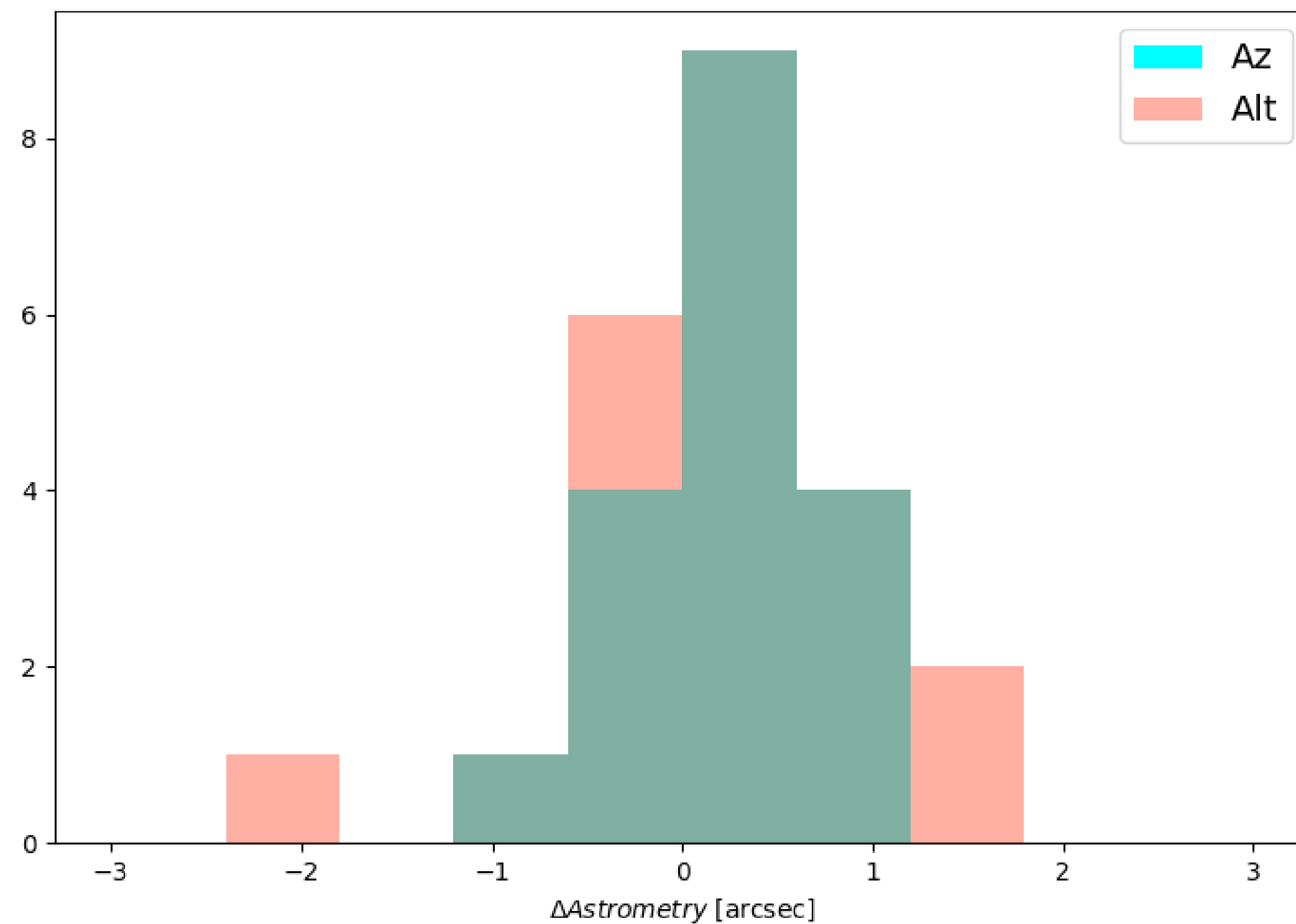
Alt: *StdDev* → 0.71 arcsec

Angle: 68% *Quant* → 1.1 arcsec

$\frac{StdDev}{\sqrt{2}}$ → 0.4 arcsec

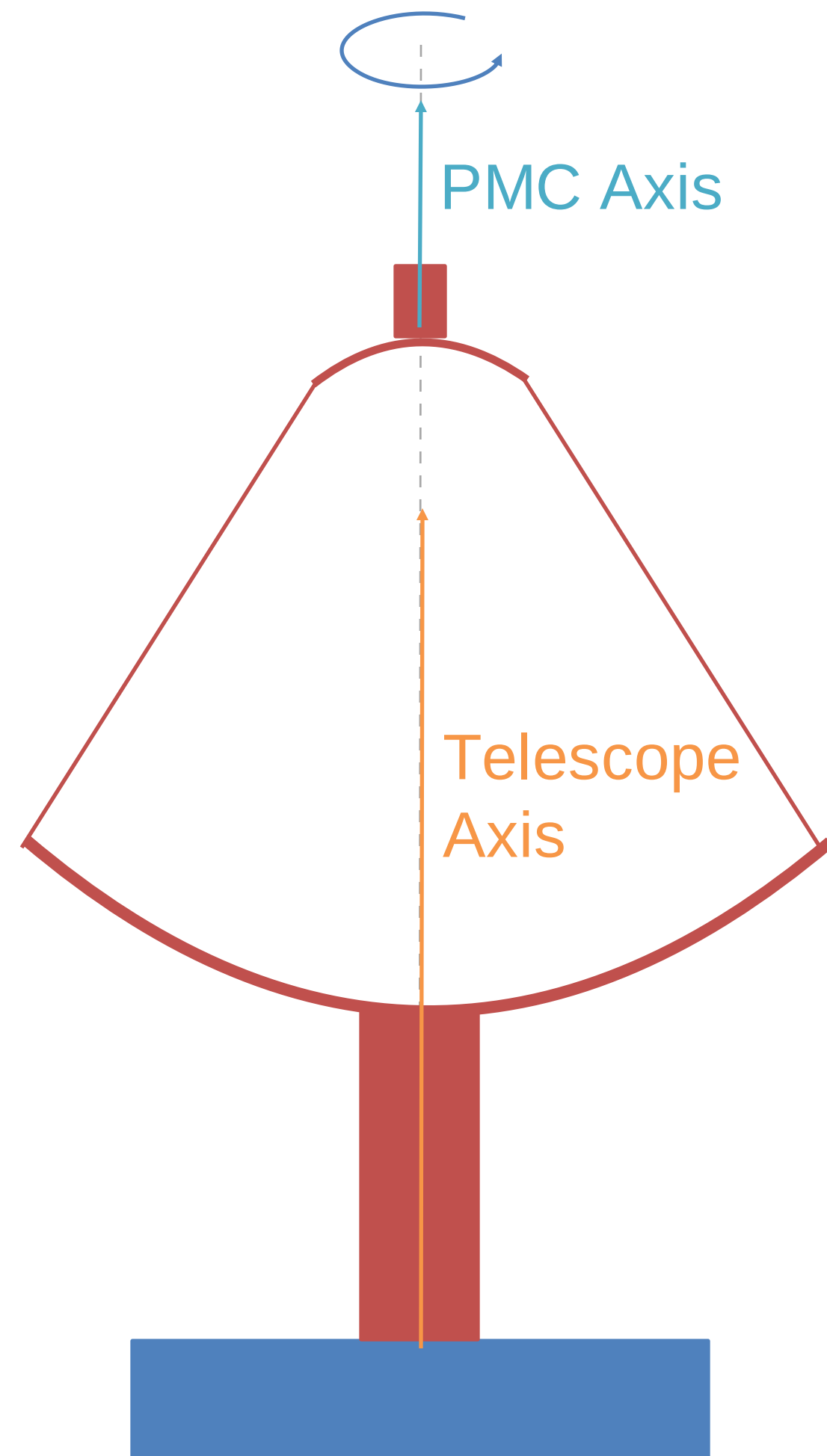
$\frac{StdDev}{\sqrt{2}}$ → 0.5 arcsec

$\frac{68\% Quant}{\sqrt{2}}$ → 0.8 arcsec

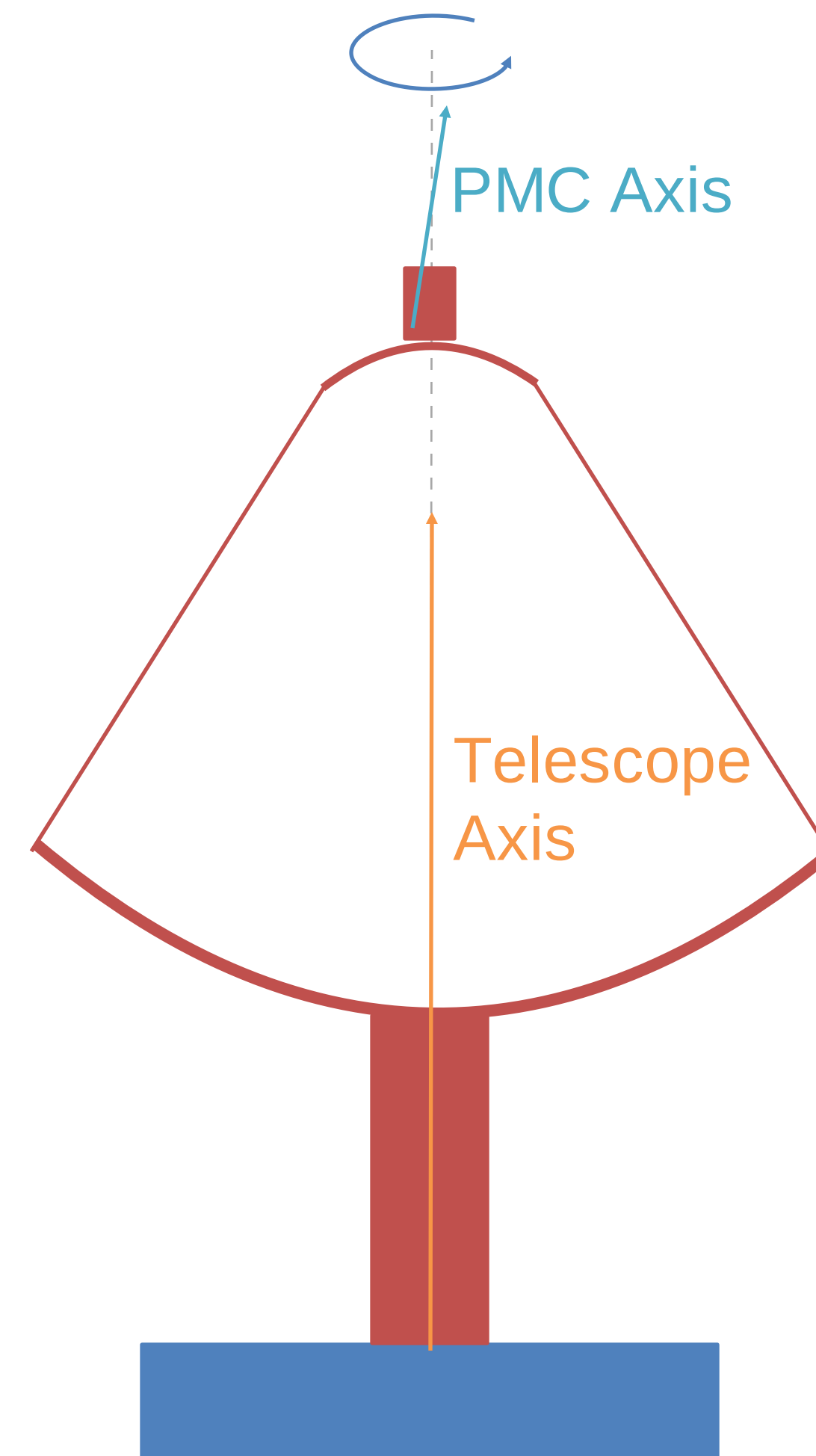


PMC - Structure Alignment Calibration

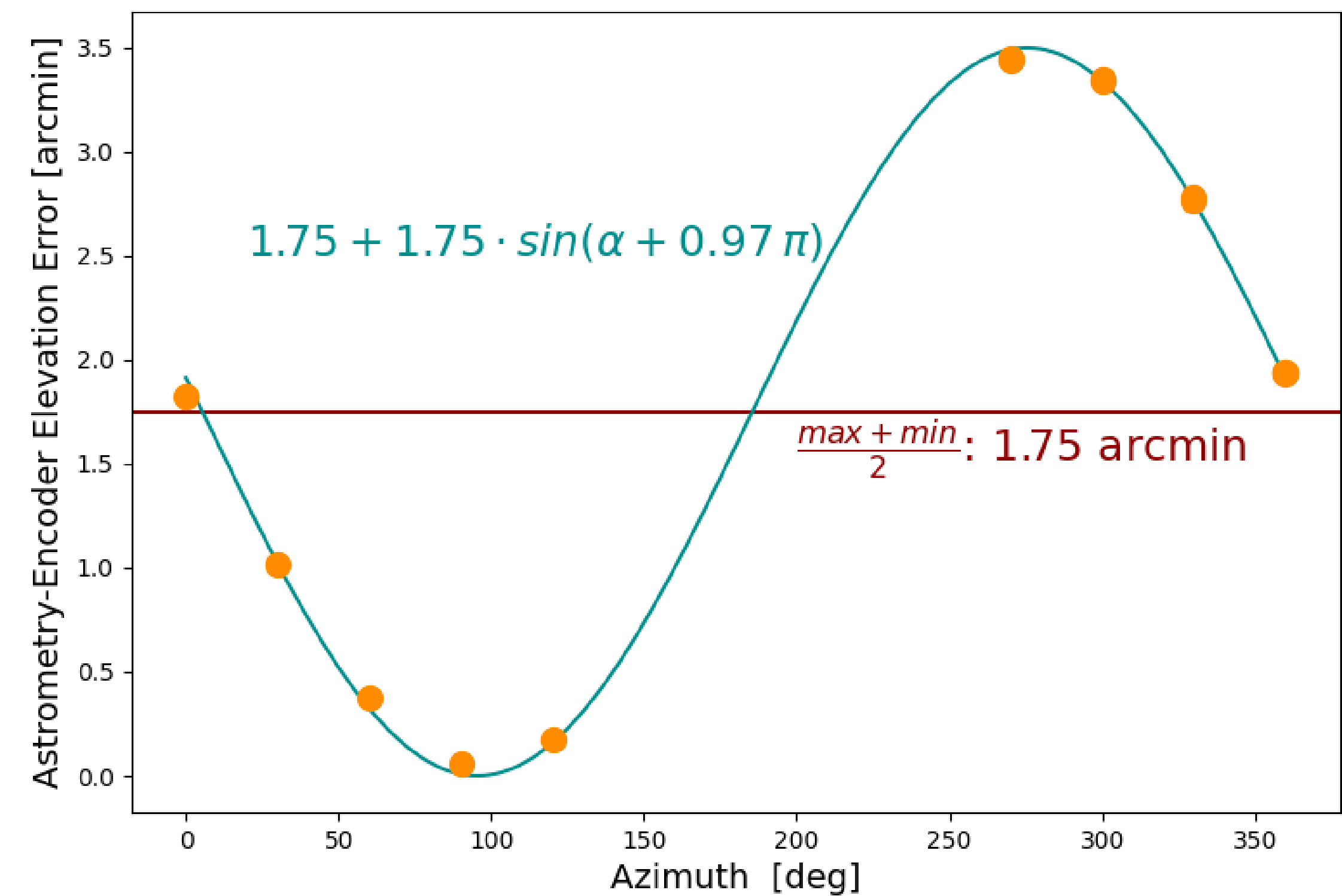
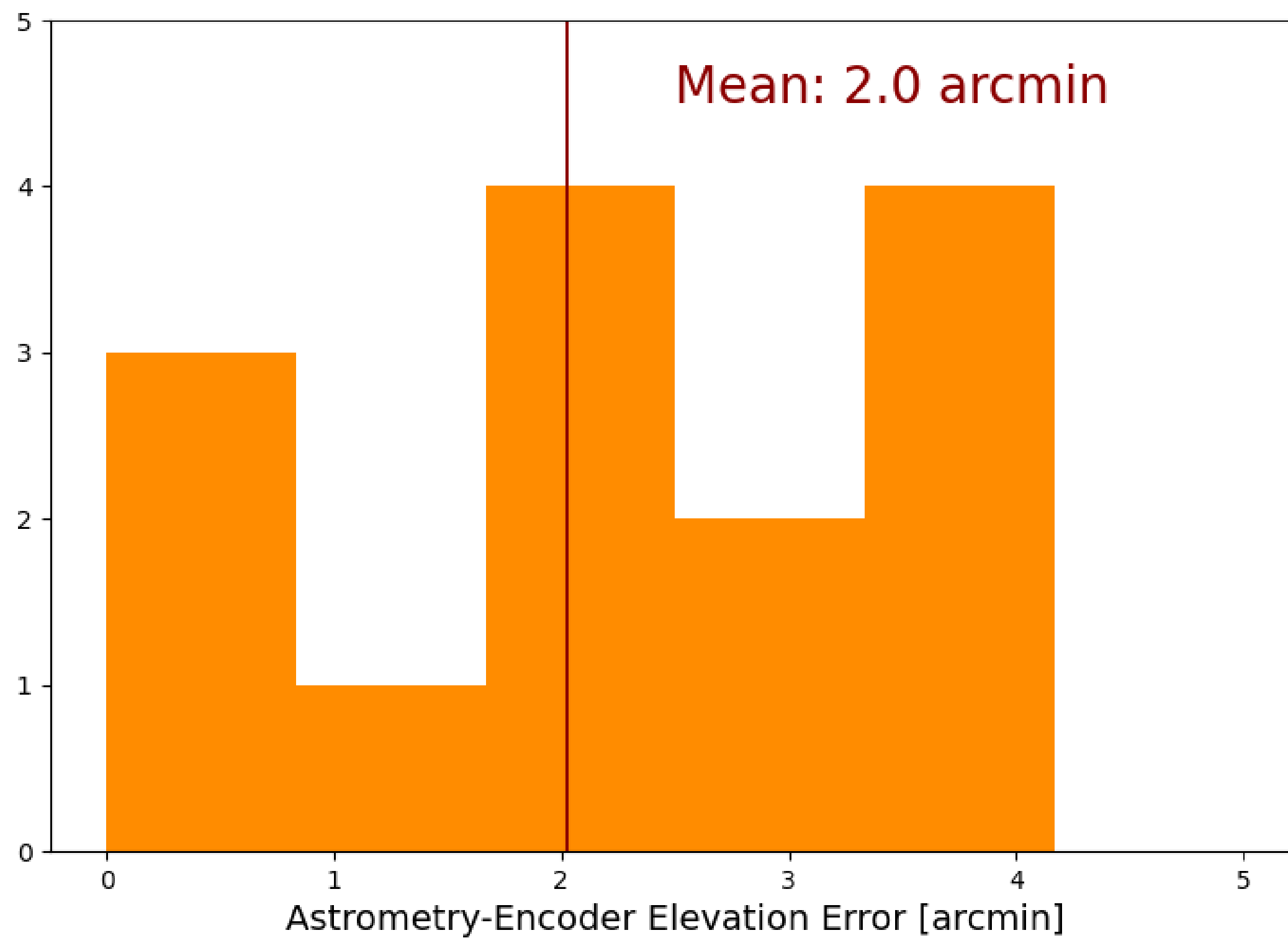
Perfect Alignment



PMC Angle



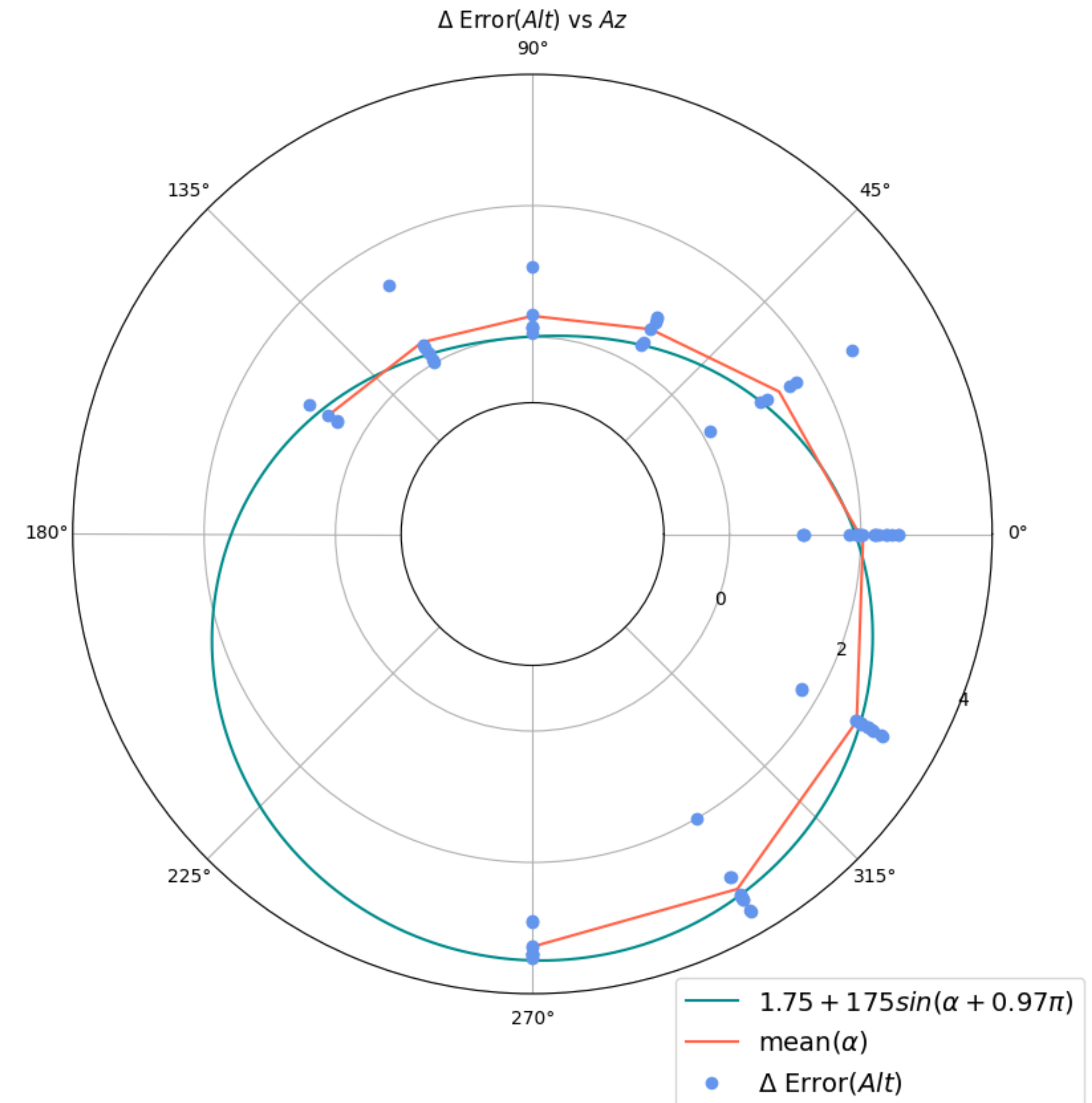
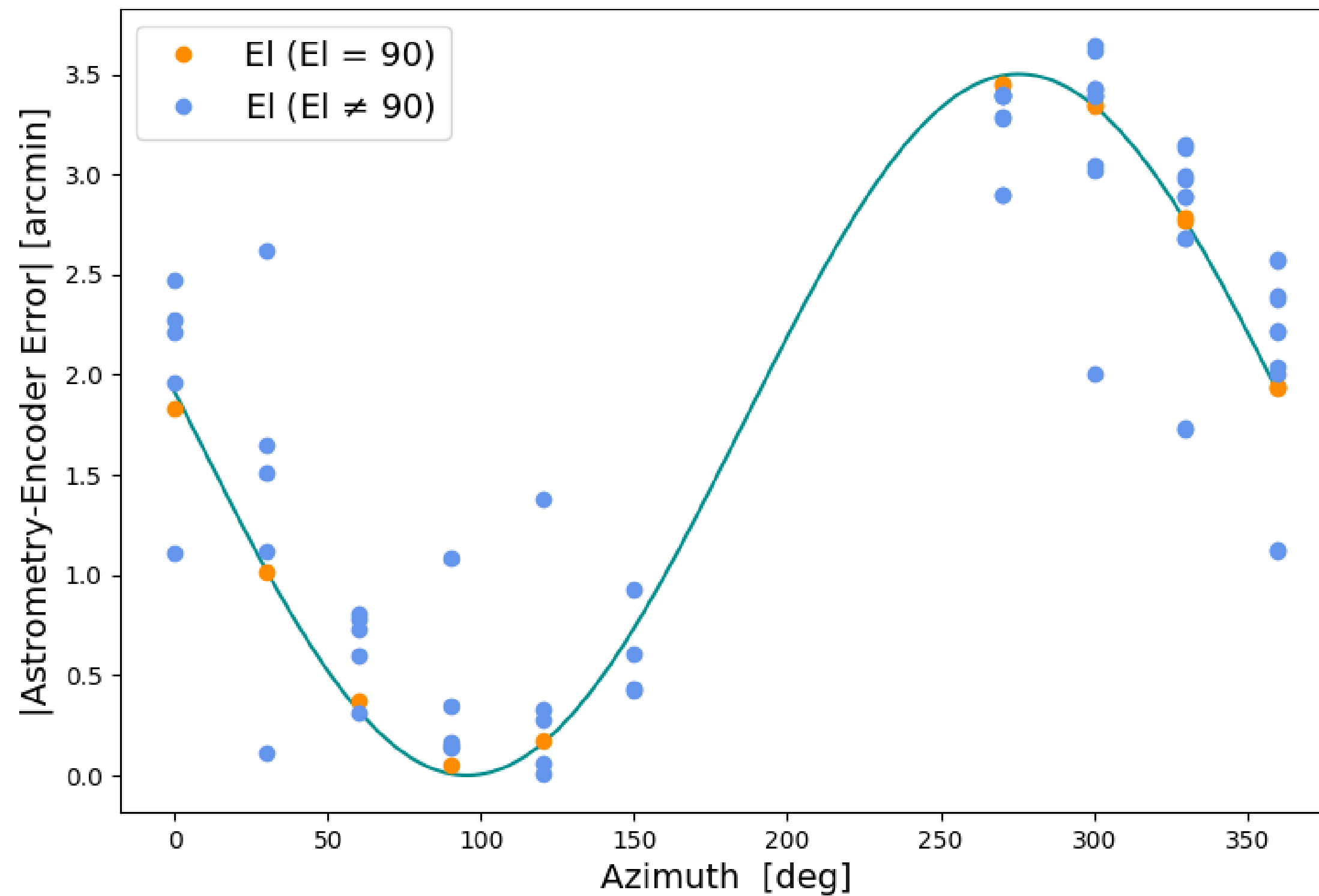
Astrometry Error – Encoder Error: Alt~90°



Alt Error Difference vs Az

Telescope Tracking Software Updated in the meanwhile – Measurement to be Repeated

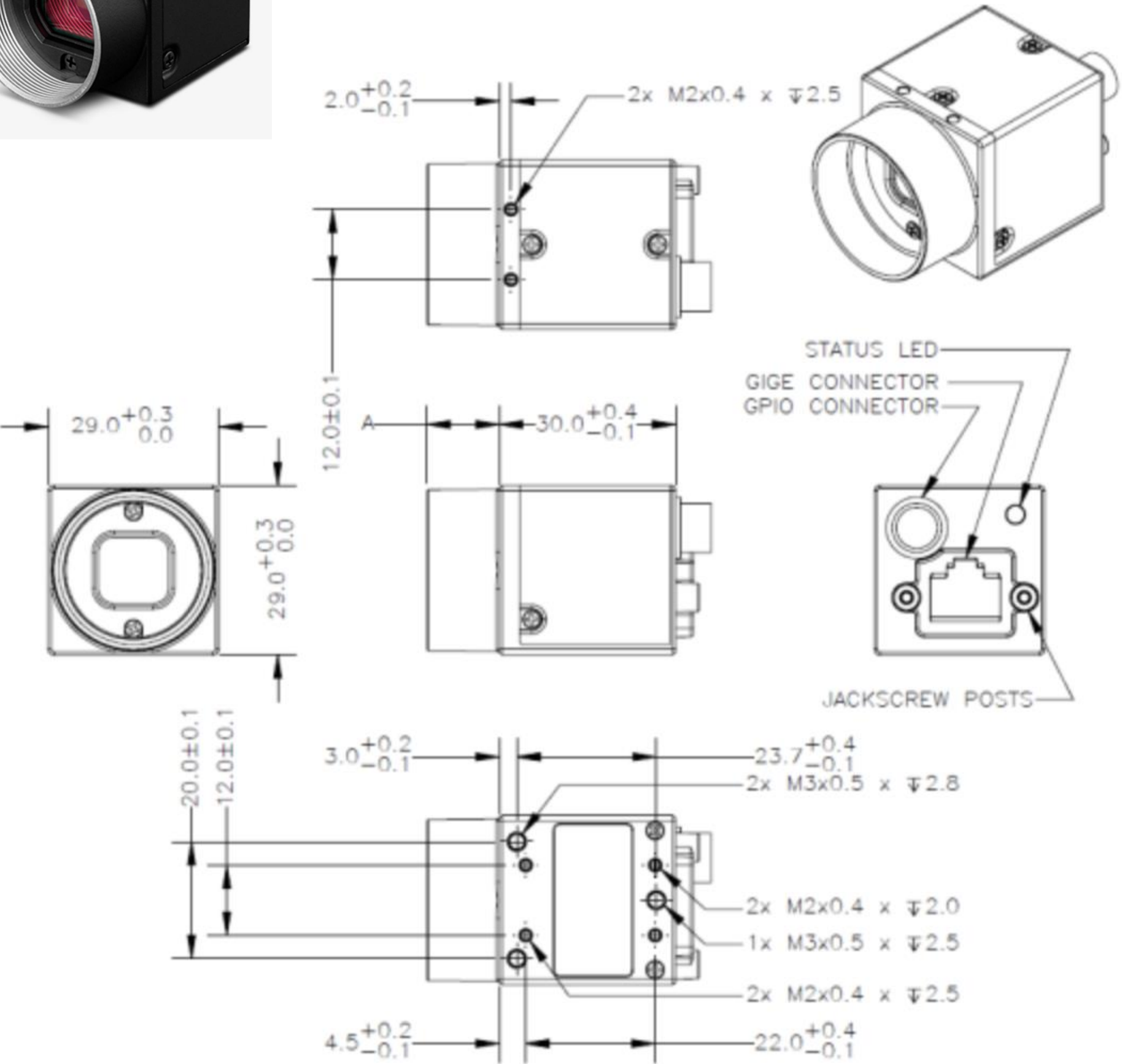
| Astrometry Error – Encoder Error |



- PMC Software
 - Dedicated LC PC Inside Telescope cabinet
 - Control and Analysis C/C++ based
 - External Interface OPC-UA based
- PMC System tested and used several times for ASTRI1 AIV
- Repeated Astrometry measurements at the same Telescope Pointing Directions (Angular measurement spread < 1 arcsec)

Backup

Camera Details

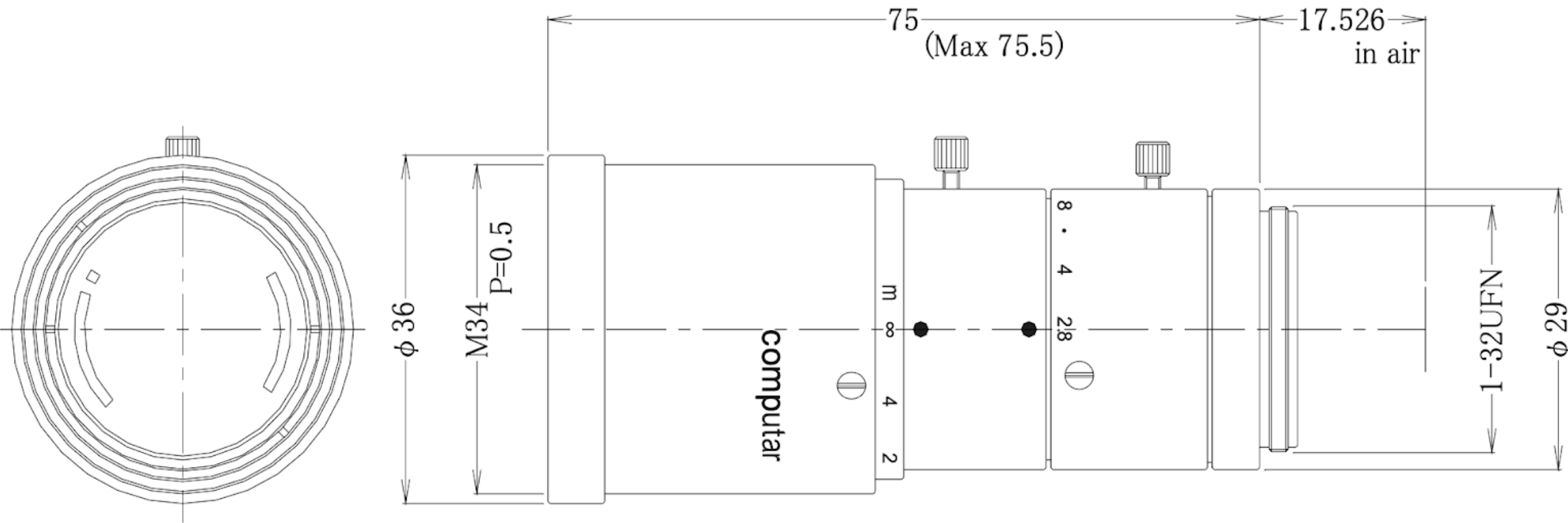


	BFS-PGE-63S4M
Firmware Version	1811.3.3.0
Resolution	3072 x 2048
Frame Rate*	19.0 FPS
Megapixels	6.3 MP
Chroma	Mono
Sensor	Sony IMX178, CMOS, 1/1.8"
Readout Method	Rolling shutter with global reset
Pixel Size	2.4 μ m
Lens Mount	C-mount
ADC	10-bit / 12-bit/ 14-bit
Minimum Frame Rate	1 FPS
Gain Range	0 to 47 dB
Exposure Range	25 μ s to 30 s
Acquisition Modes	Continuous, Single Frame, Multi Frame
Partial Image Modes	Pixel binning, ROI
Image Processing	Gamma, lookup table, and sharpness
Sequencer	Up to 8 sets using 5 features
Image Buffer	240 MB
User Sets	2 user configuration sets for custom camera settings
Flash Memory	6 MB non-volatile memory
Opto-isolated I/O	1 input, 1 output
Non-isolated I/O	1 bi-directional, 1 input
Serial Port	Supported
Auxiliary Output	3.3V, 120 mA maximum
Interface	GigE
Power Requirements	Power over Ethernet (PoE); or 12 V nominal (8 - 24 V)
Power Consumption	2.6 W (POE); 2.1 W (GPIO) maximum
Dimensions/Mass	29 mm x 29 mm x 30 mm / 36 g
Machine Vision Standard	GigE Vision v1.2
Compliance	CE, FCC, KCC, RoHS, REACH. The ECCN for this product is: EAR099.
Temperature	Operating: 0°C to 50°C Storage: -30°C to 60°C
Humidity	Operating: 20% to 80% (no condensation) Storage: 30% to 95% (no condensation)
Warranty	3 years

Optics Details

M7528-MPW3

f = 75mm F 2.8
For 2/3 type Cameras
C-Mount



Model No.		M7528-MPW3		Effective Lens Aperture	Front	φ 26.1mm	
Focal Length		75mm			Rear	φ 15.8mm	
Max. Aperture Ratio		1:2.8		Distortion	2/3 type(Y=5.5mm)	0.33%	
Max. Image Format		8.8mm x 6.6mm(φ 11mm)			1/1.8 type(Y=4.5mm)	0.21%	
Operation Range	Iris	F2.8 - 16.0			1/2.5 type(Y=3.55mm)	0.12%	
	Focus	0.4m – inf.		Back Focal Length		14.6mm	
Control	Iris	Manual		Flange Back Length		17.526mm	
	Focus	Manual		Mount		C-Mount	
Object Dimension at M.O.D.	2/3 Type	47.0 x 35.2 mm		Filter Size		M34 P=0.5mm	
	1/1.8 Type	38.4 x 28.8 mm		Dimensions		φ 36mm x 75mm	
	1/2.5 Type	30.4 x 22.9 mm		Weight		102g	
Angle of View	D	2/3 type	8.4°	1/1.8 type	6.9°	1/2.5 type	5.4°
	H		6.7°		5.5°		4.3°
	V		5.0°		4.1°		3.3°
Operating Temperature		-10°C - +50°C					

2/3
type

C

Repeated Measurements –Toy MC

