The release of a faster ITM

SCAR AAA 7th workshop 2023, Longyearbyen, Svalbard,Norway

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Fondazione C. Fillietroz-ONLUS
Astronomical Observatory of the Autonomous Region of the Aosta Valley (OAVdA), Italy

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Electronic upgrades: one box per functionality

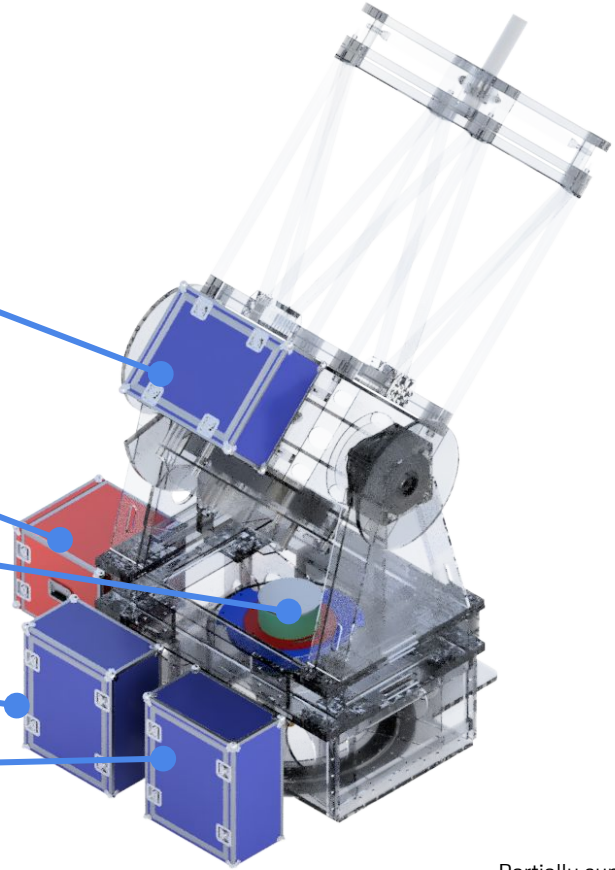
Box Control: manages mount and focus movements

Box Motor: drives the axis motors in closed loop with encoders

Slip-ring: derotates 400V power and LAN

Box Web: manages the telescope LAN

Box Power: distributes electrical power to the boxes



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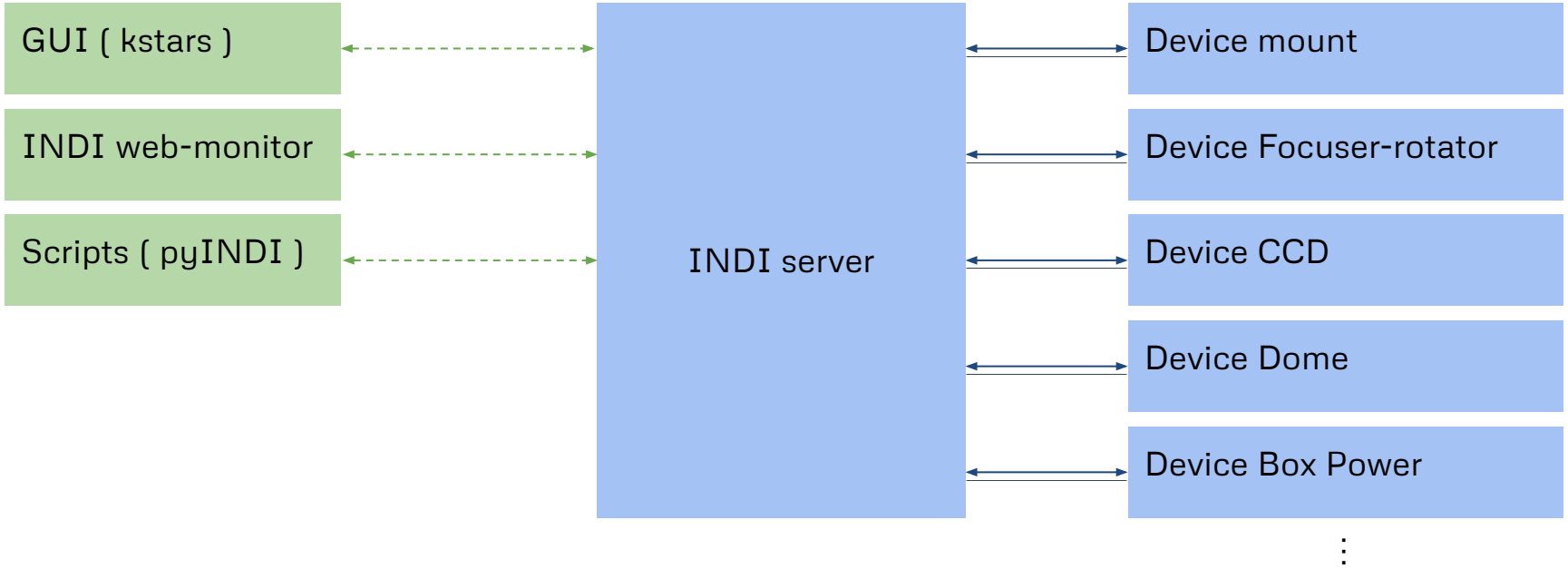
SW upgrades: INDI architecture



INDI White Paper: http://www.clearskyinstitute.com/INDI/INDI.pdf

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SW upgrades: pyINDI@OAVdA architecture

- Pure python INDI-protocol implementation
- AsyncIO based
- MMT Observatory repository (focused on monitoring via web)
- Our repository (forked) focuses on schedule observation automation:
  - Flat-field acquisition
  - Best focus procedure
  - Mount goto
  - CCD acquisition
  - Autoguide loop

https://github.com/MMTObservatory/pyINDI

https://github.com/stefano-sartor/pyINDI

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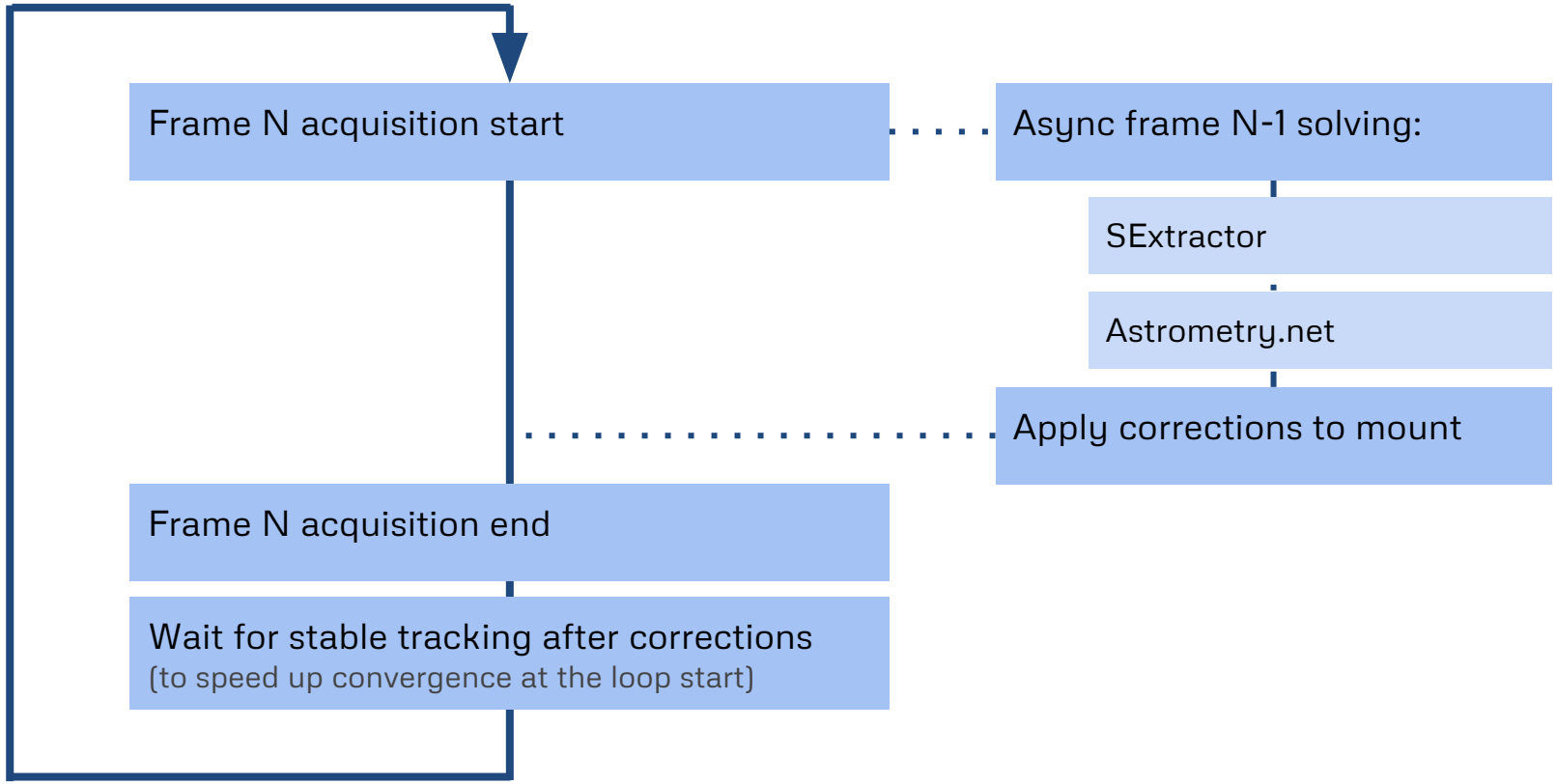
SW upgrades: Autoguide loop using science frames



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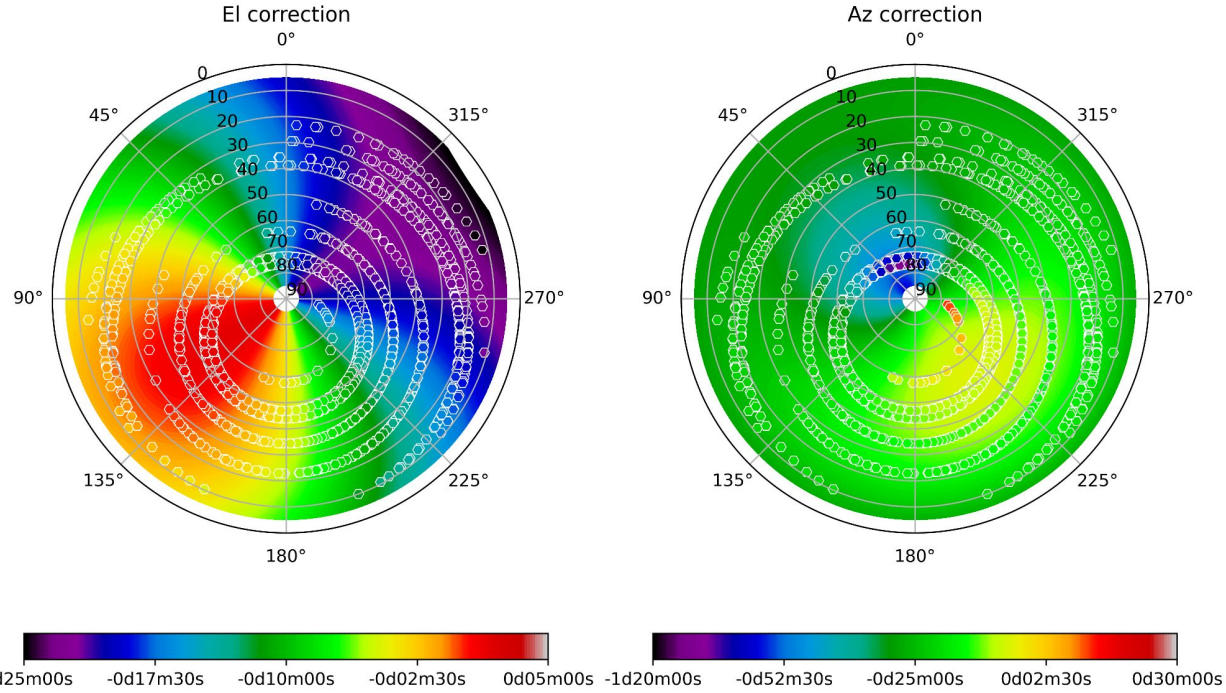
Pointing Model: Analytical approach WholeSky (ALMA*)



$$\delta Az = A_1 + A_2 sin(El) + A_3 cos(El) + A_4 sin(El) sin(Az) + A_5 sin(El) cos(Az)$$

$$\delta El = E_1 + E_2 cot(El) + E_3 cos(El) + E_4 cos(Az) + E_5 sin(Az)$$

*ALMA Memo #366,A Telescope Pointing Algorithm for ALMA,J. G. Mangum, 04/30/2001

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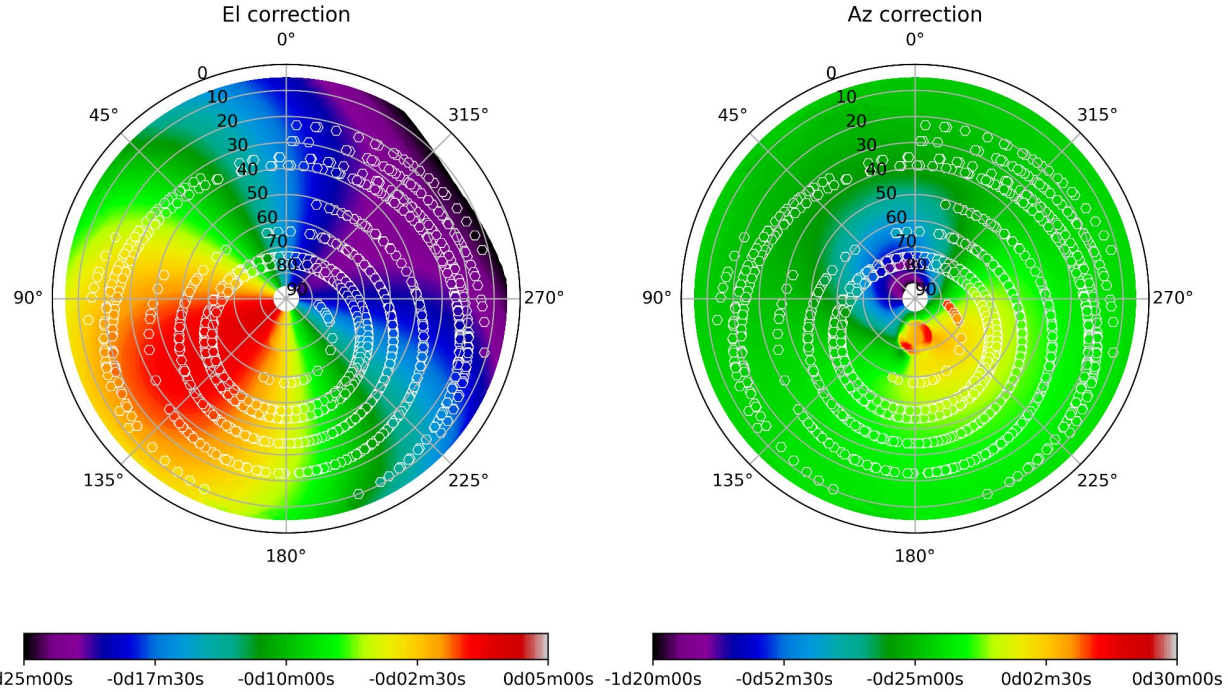
Pointing Model: Analytical approach NN-Segmented (ALMA*)



$$\forall\,[\Delta Az,\ \Delta Alt]\begin{cases}\delta Az = A_1 + A_2 sin(El) + A_3 cos(El) + A_4 sin(El) sin(Az) + A_5 sin(El) cos(Az)\\ \delta El = E_1 + E_2 cot(El) + E_3 cos(El) + E_4 cos(Az) + E_5 sin(Az)\end{cases}$$

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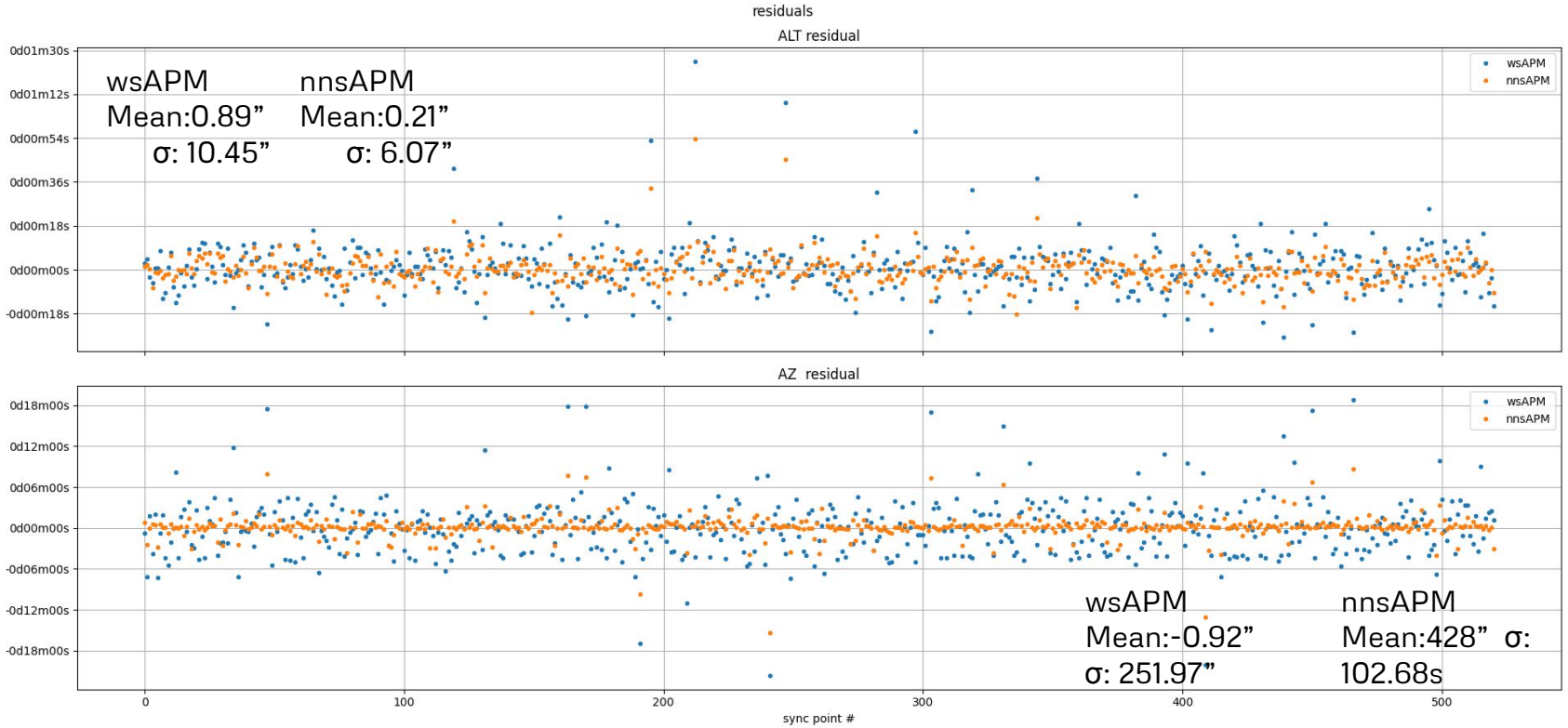
Pointing Model: Analytical approach residuals



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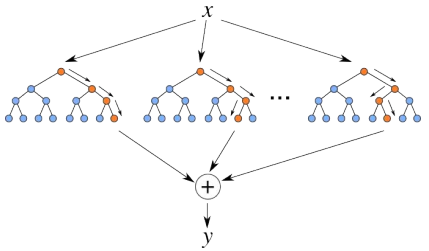
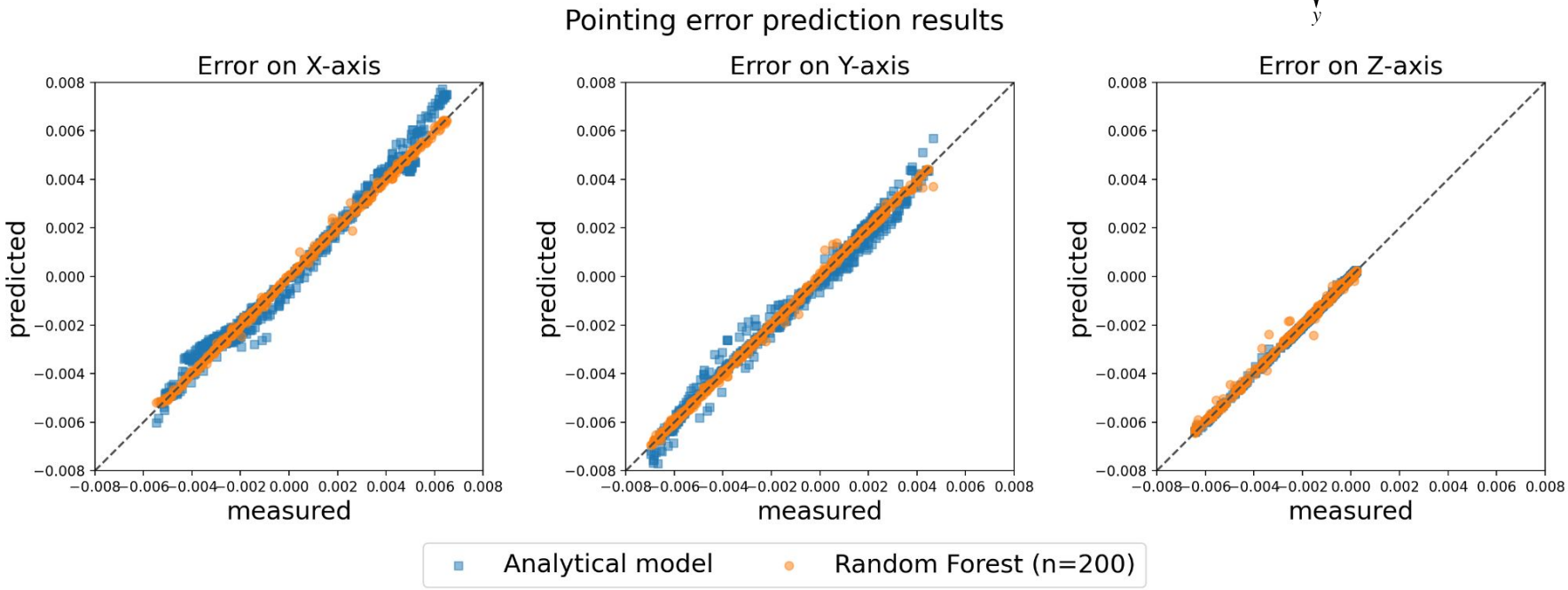
Pointing Model: AI approach - RF





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Observations: Scheduling

For each TESS Object of Interest (TOI) the following constraints, which must be valid during all the transit duration, are checked:

- astronomical night
- Moon separation >= 45 deg
- Sun separation >= 60
- Elevation >= 20 deg
- Elevation <= 82 deg
- Transit depth >= 4 mmag
- Transit duration <= 5 hours
- Star mag <= 12.5
- At least 5 stars in the field with similar magnitude (+/- 0.5 mag)

Overlapping scheduled TOIs are manually handled

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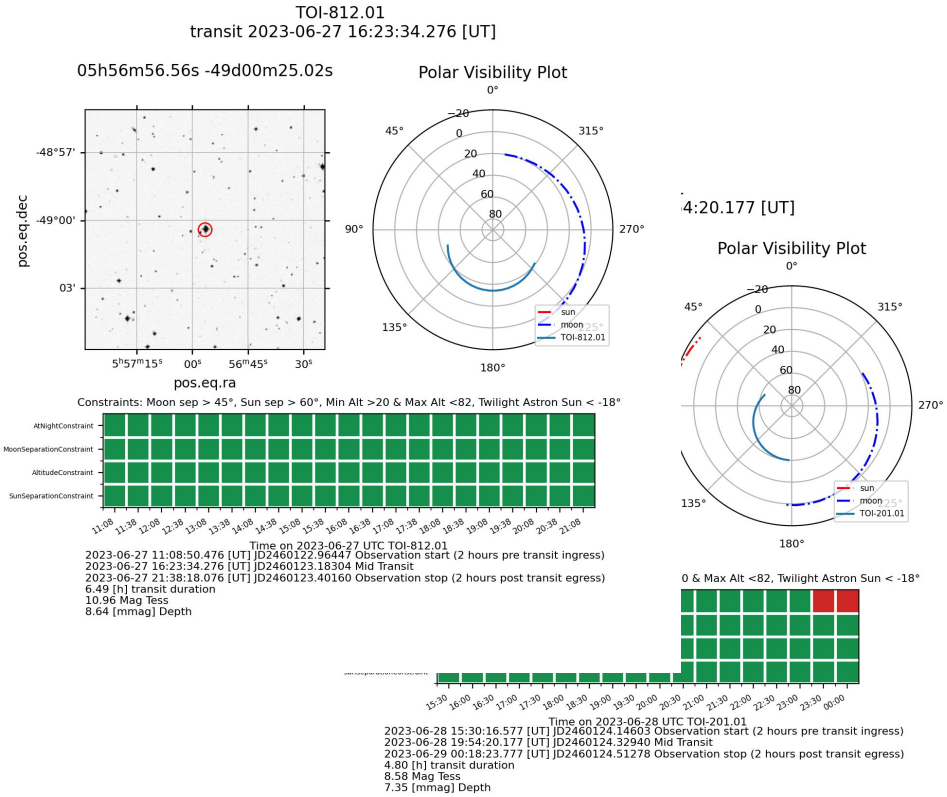
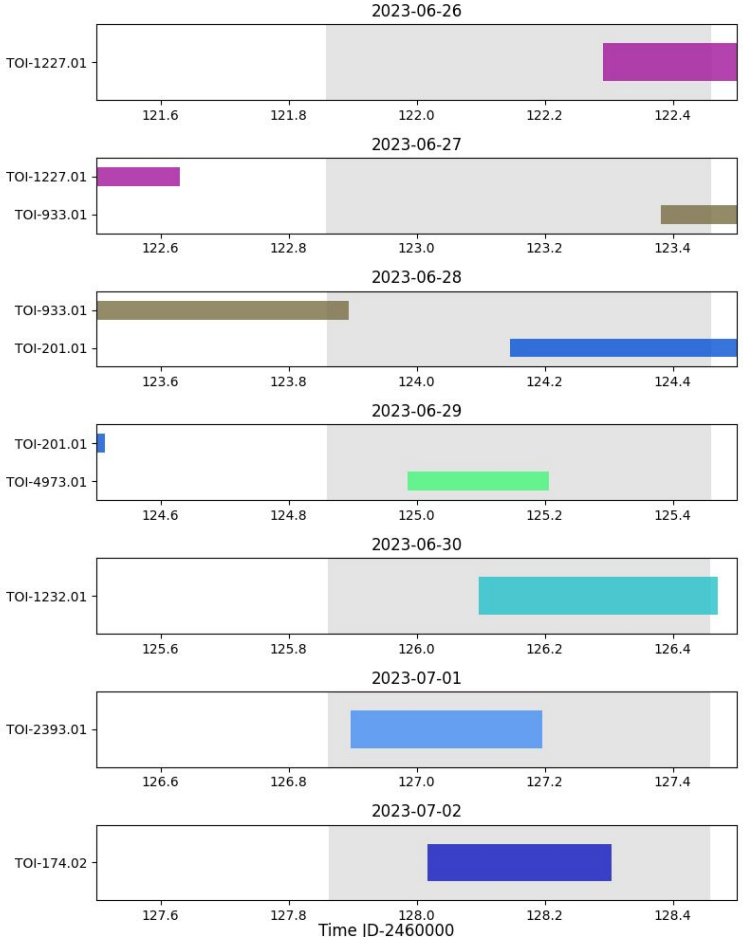
Observations: Scheduling





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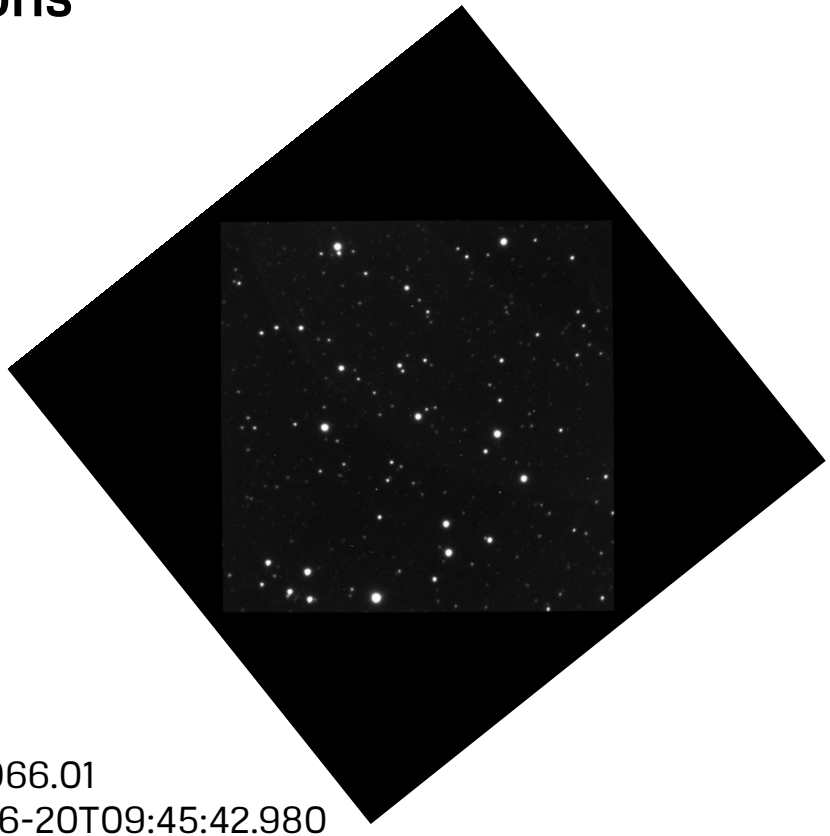
Observations: Image Acquisitions

TOI_3066.01
2023-06-20T09:45:42.980
Exptime: 60
Binning: 4x4



TOI_3066.01
2023-06-20T09:45:42.980
Equivalent exptime: 360 (6*60)
Binning: 4x4

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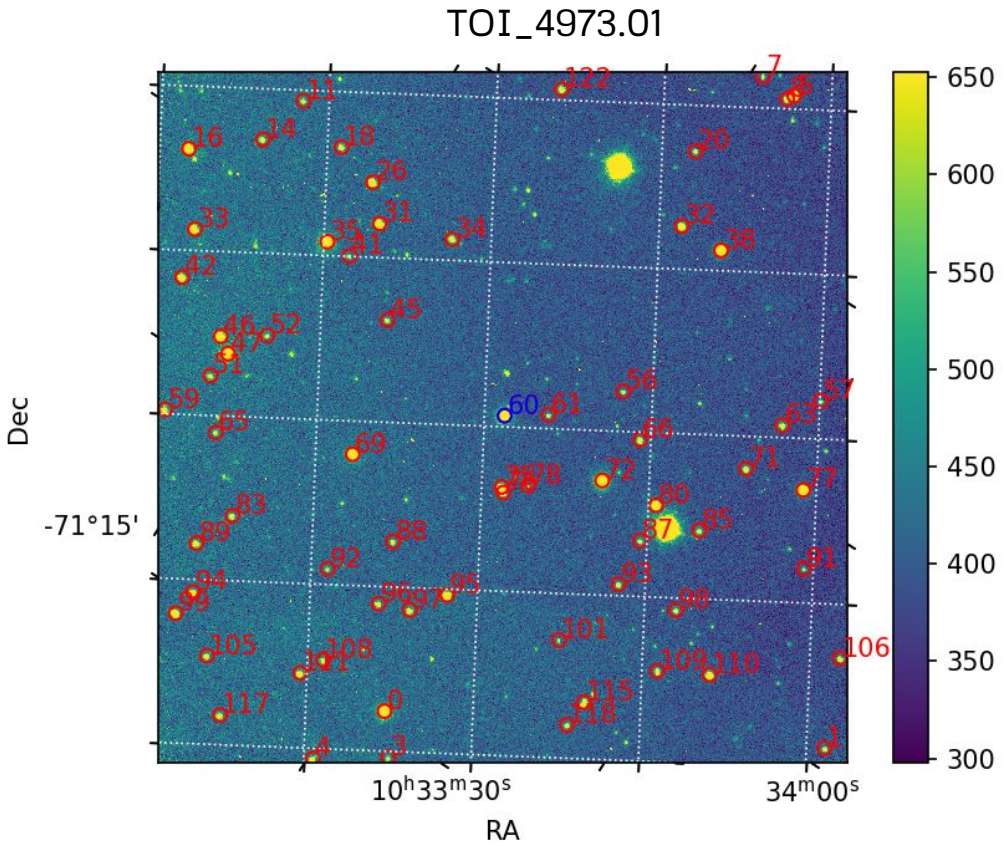
Observations: FOV solving and indexing



Astrometry.net **solve field** ran after acquisition

Sextractor **source extraction**

Source filtering on flux and FWHM, object shapes

Matching indexes on all images on WCS and proximity

Target identification

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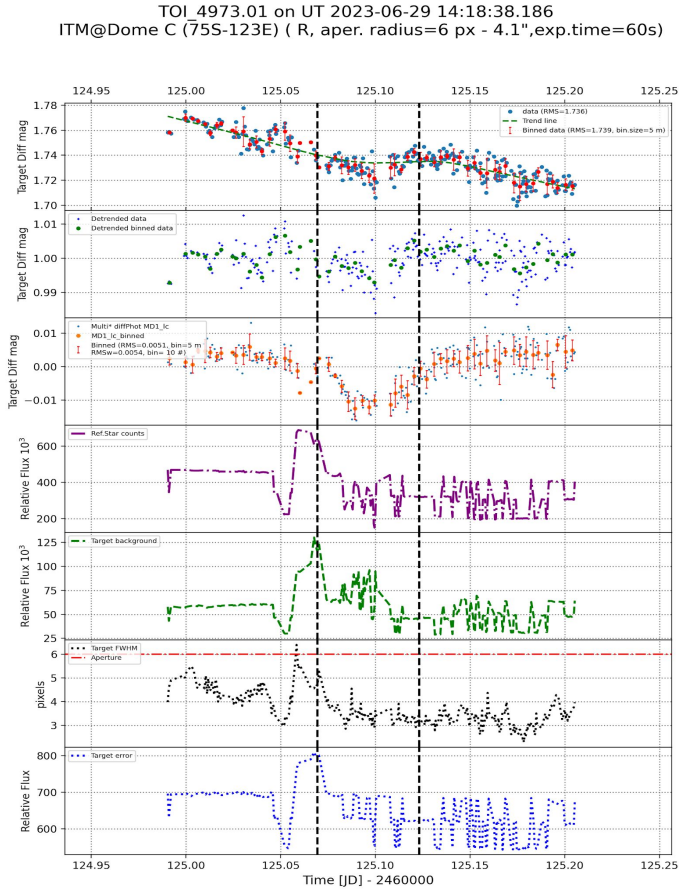
Observations: Photometry



Δ magnitude

Detrended data

Quality checks

Ref.Star counts

Target background

Target FWHM and best aperture

Target error

Single Star Photometry

Aperture photometry for all sources; local background computation + annulus

Differential photometry:
Δ magnitude =
(Targ. - Reference Star)

Find **best aperture** based on a minimum-RMS for the target light curve

Reference Star selected from the sample

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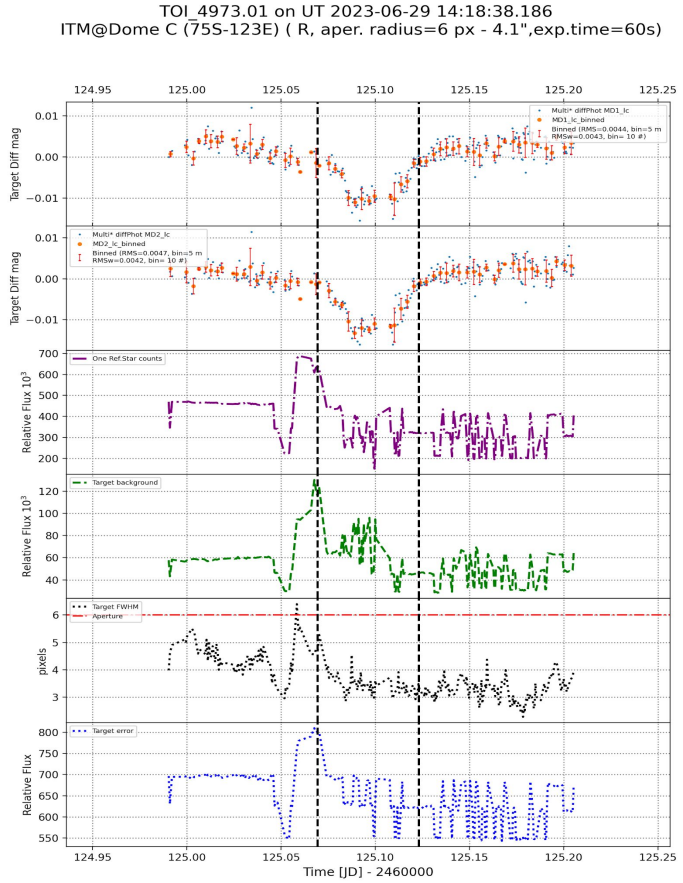
Observations: Photometry



Model Differential 1

Model Differential 2

Quality checks

MD1 Photometry

Photometric light curves **using all stars** detected in the field

Differential photometry between target and all stars:
Δ magnitude(i) =
Targ. - Reference Star(i)

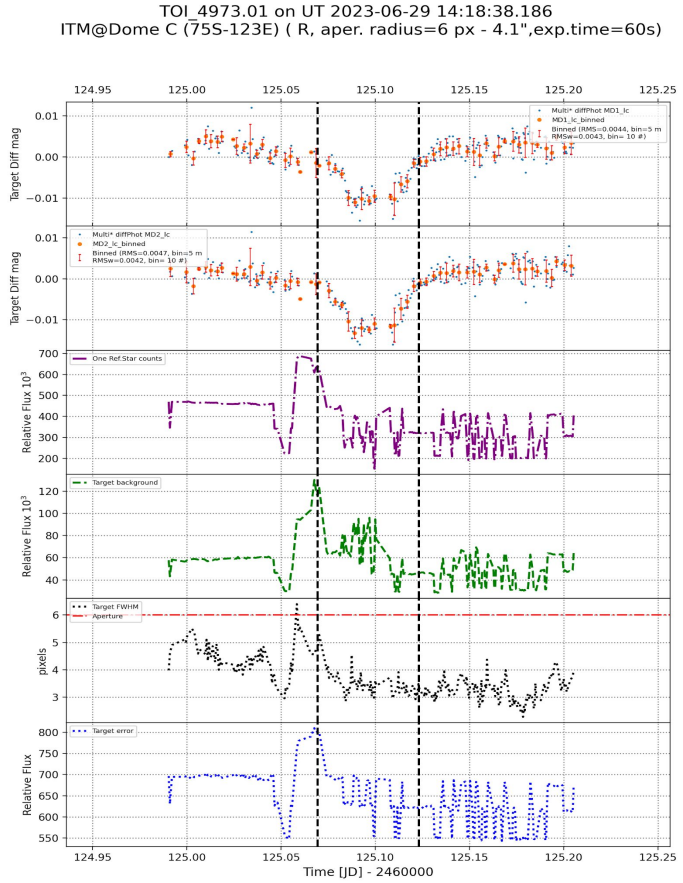
Reference stars are the **subset which minimizes the RMS** of the differential light curve of the **target**

Find best aperture

Burke et al. 2006
Giacobbe et al. 2012

Partially supported by
Fondazione CRT

Observations: Photometry



Model Differential 1

Model Differential 2

Quality checks

MD2 Photometry

Photometric light curves **using all stars** detected in the field

Differential photometry between target and all stars:
Δ magnitude(i) =
Targ. - Reference Star(i)

Reference stars are the **subset which minimizes the RMS** of the differential light curve of **each potential reference star**

Find best aperture

Burke et al. 2006
Giacobbe et al. 2012

Partially supported by Fondazione CRT

Observations: Photometry

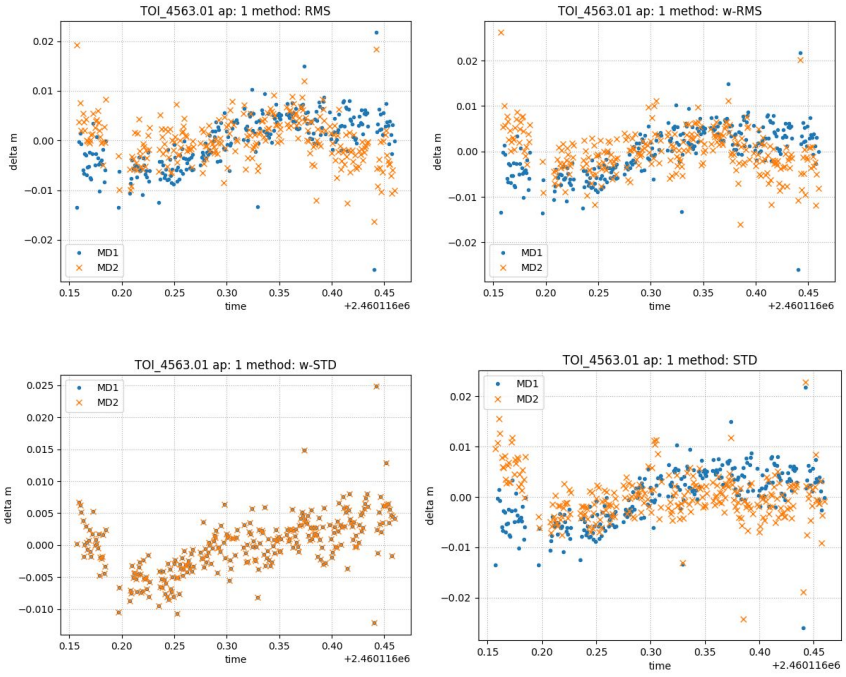
How to quantify dispersion in light curves?

Best aperture is the one which **minimizes the dispersion** in the lightcurve of the target

Four methods to quantify this dispersion:

- RMS: Root mean squared
- RMS-w: Root mean squared with a moving window
- STD: Standard Deviation
- STD-w: Standard Deviation with a moving window

Pipeline computes light curves for all these four methods (for MD1 and MD2 model), **case by case investigation** to choose the most relevant light curve



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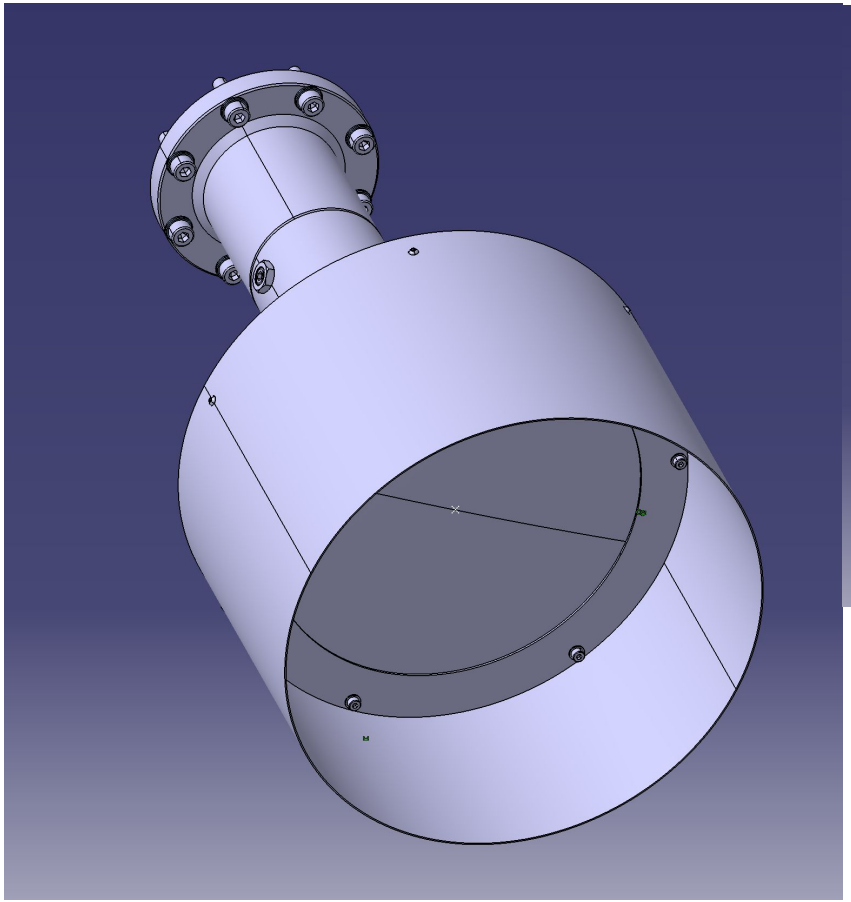
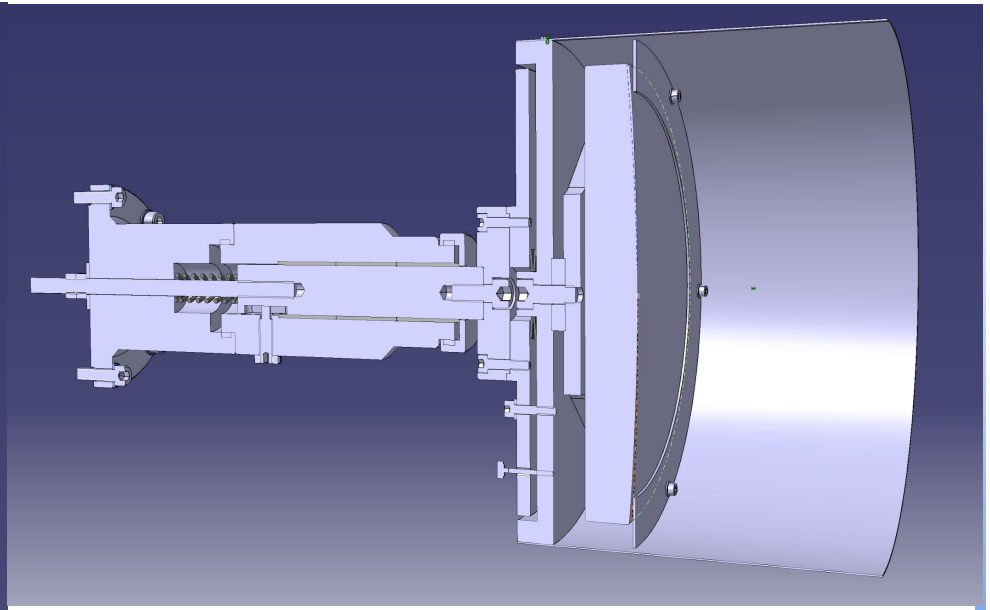
New Optical Scheme: M2 mechanical support





Secondary mirror
Vertex radius: 1697.697 mm
Conic constant: -2.78
Diameter: 250 mm
Substrate: Fused Quartz
Coating: near-infrared optimized Silver

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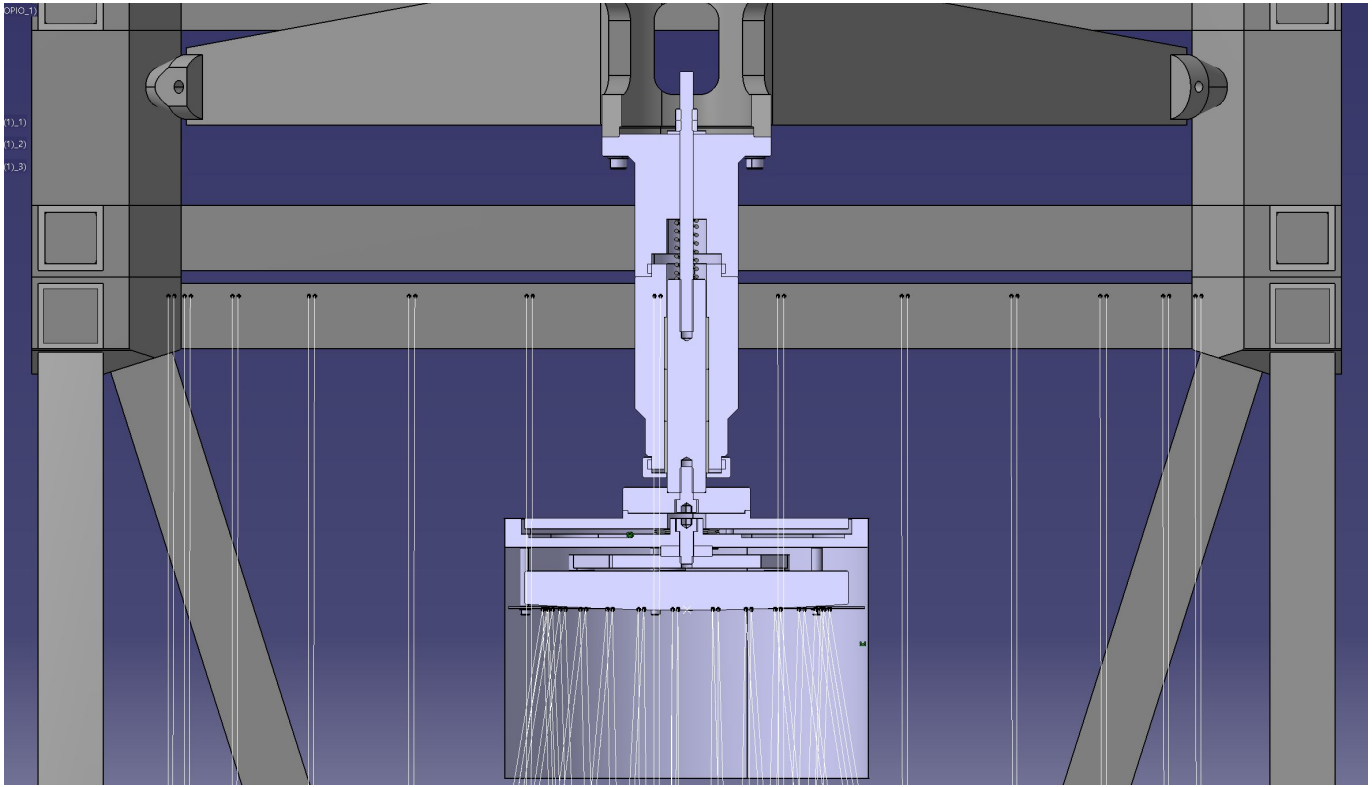
New Optical Scheme: M2 mechanical support



Partially supported by
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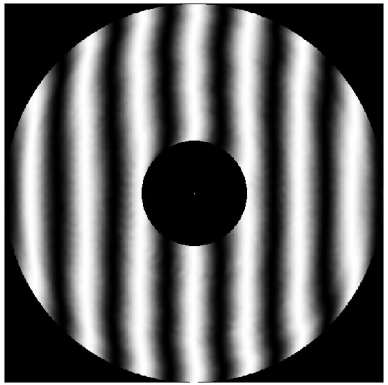
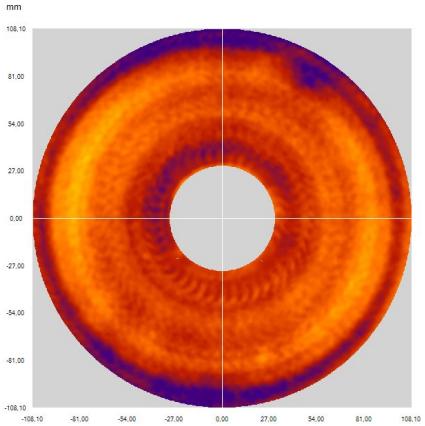
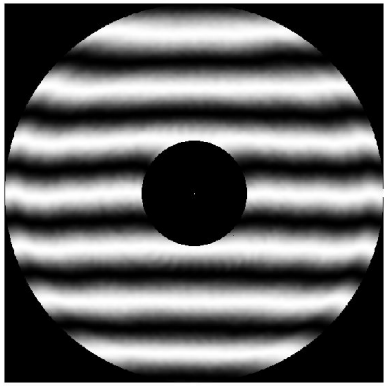
New Optical Scheme: M2 interferogram







PV: 0.168 wv @ 632.8 nm

RMS: 0.028 wv @632.8 nm

Strehl ratio: 0.969

Excellent work ASA!

ASA
seeing is believing

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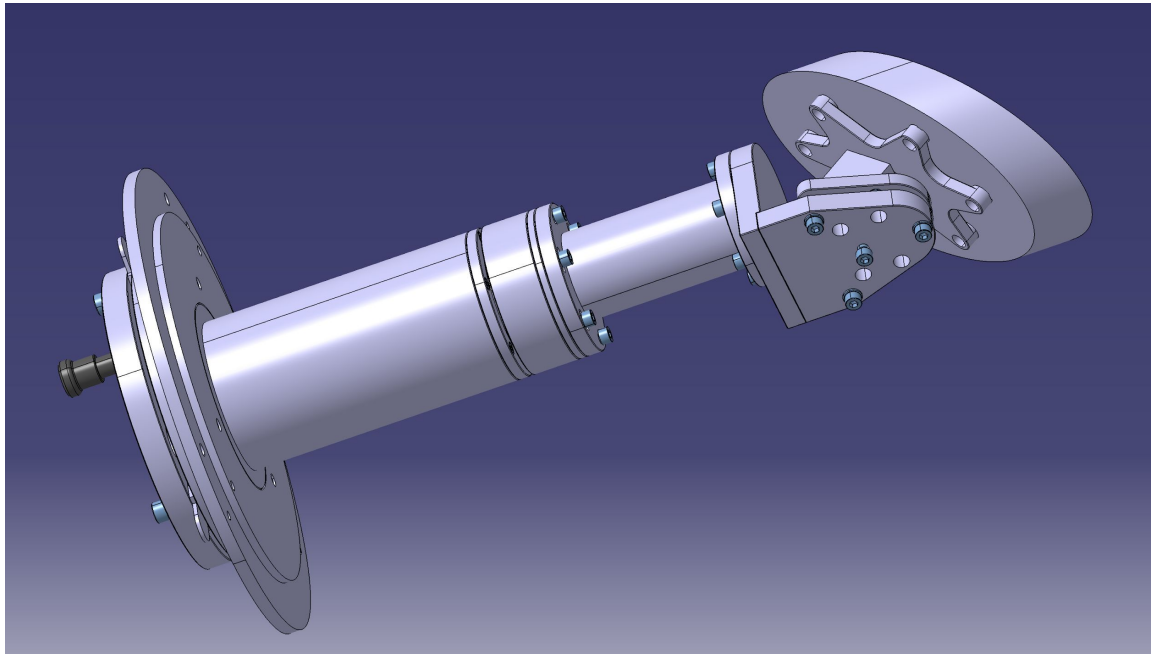
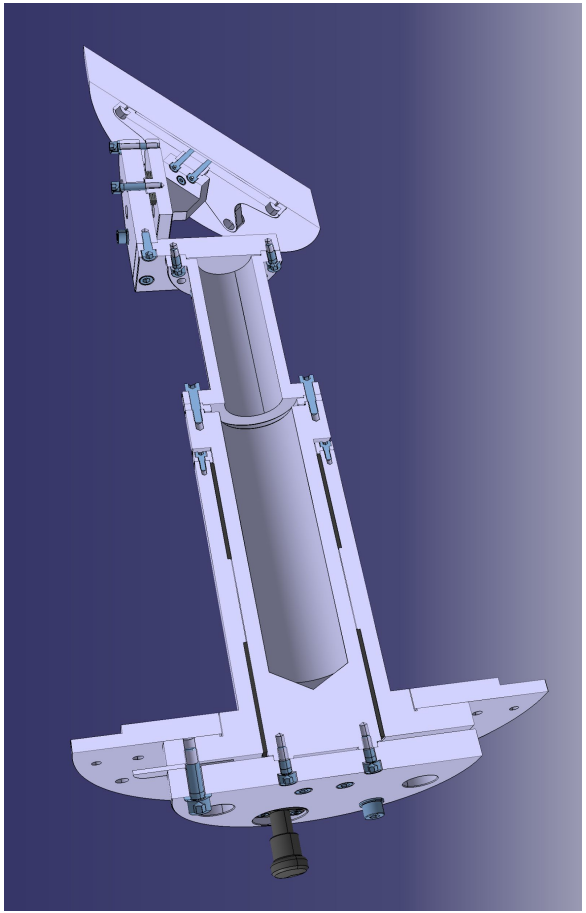
New Optical Scheme: M3





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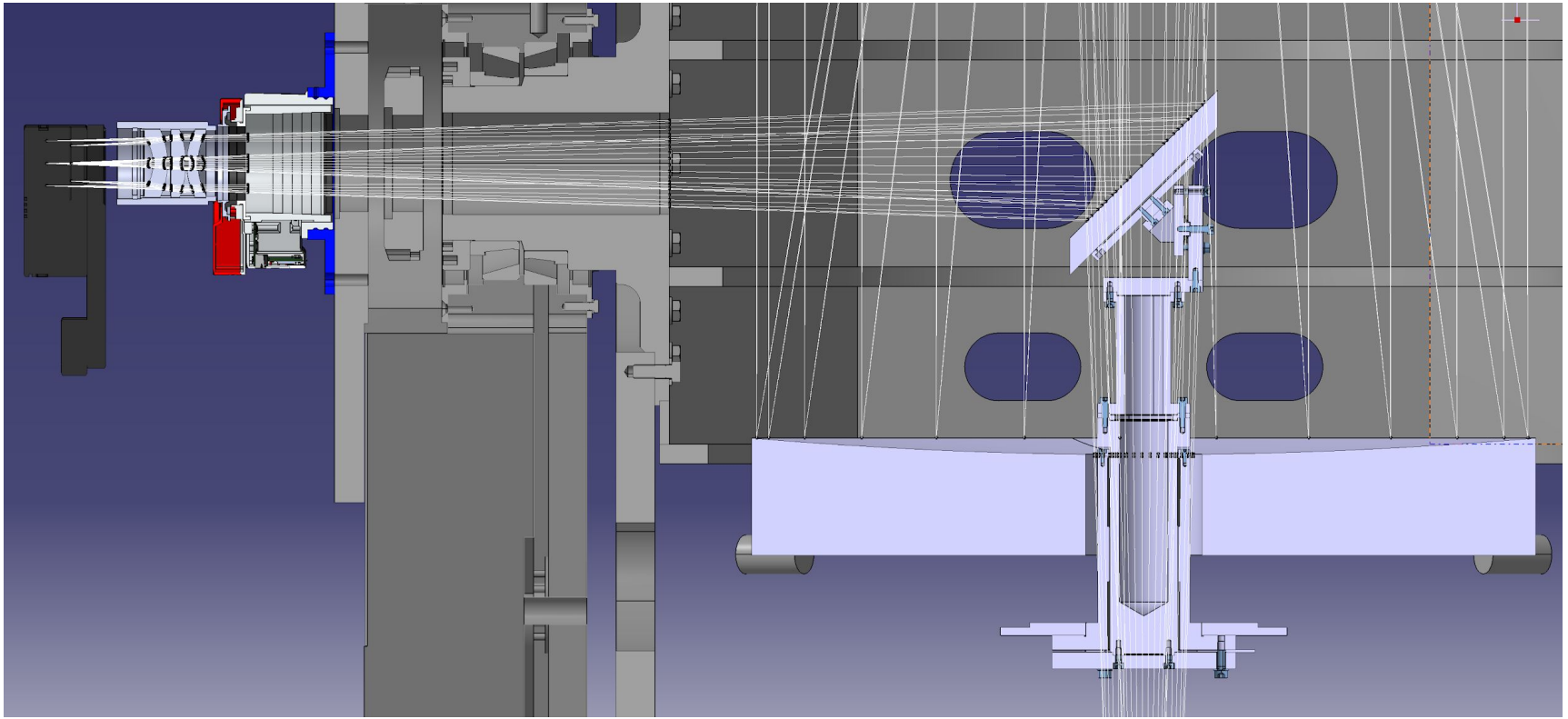
New Optical Scheme: M3



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New Optical Scheme: M2-M3 mirror's coating

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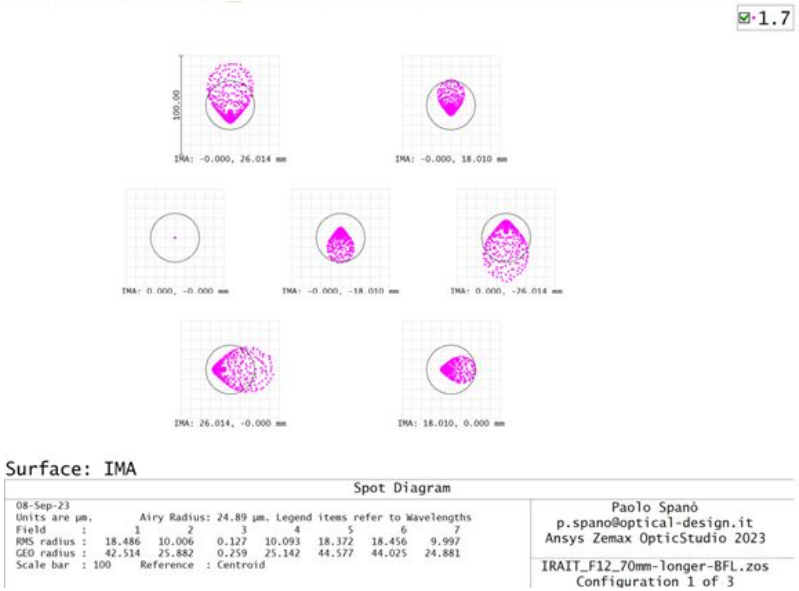
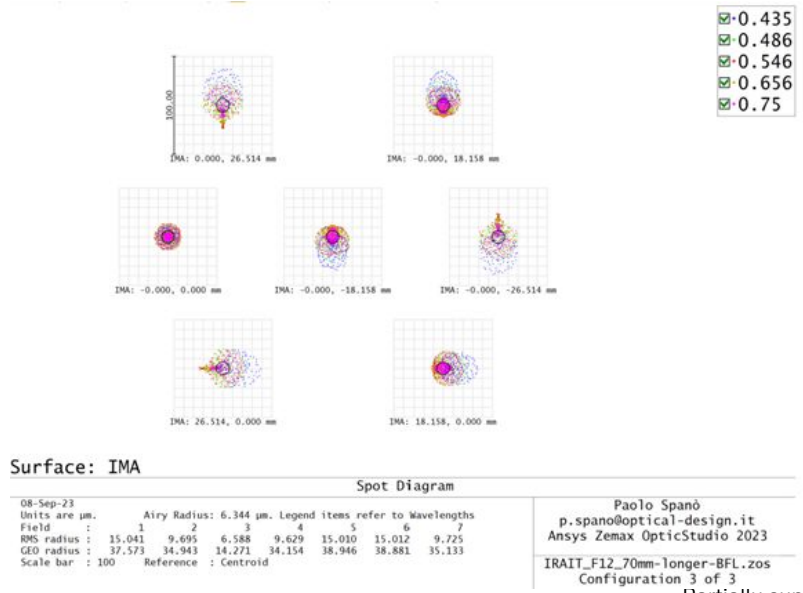
New Optical Scheme: Spot Diagram

Configuration: RC
Telescope focal length: 9600 mm (F/12)
Unvignetted FOV: 22 arcmin diameter
Wavelength: UV-Visible-Infrared (300 nm – 10 um)
Scale plate: 21.5 arcsec/mm



Configuration: RC + 0.75X focal reducer
Telescope focal length: 7613 mm (F/9.5)
Unvignetted FOV: 18 arcmin diameter
Wavelength: Visible (435 – 750 nm)
Scale plate: 27.1 arcsec/mm



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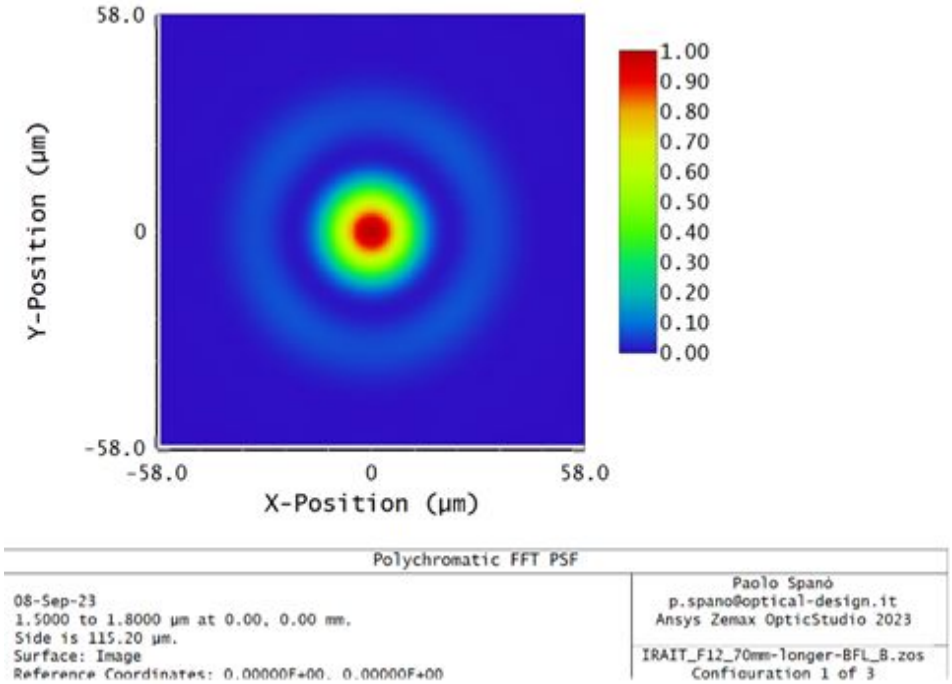
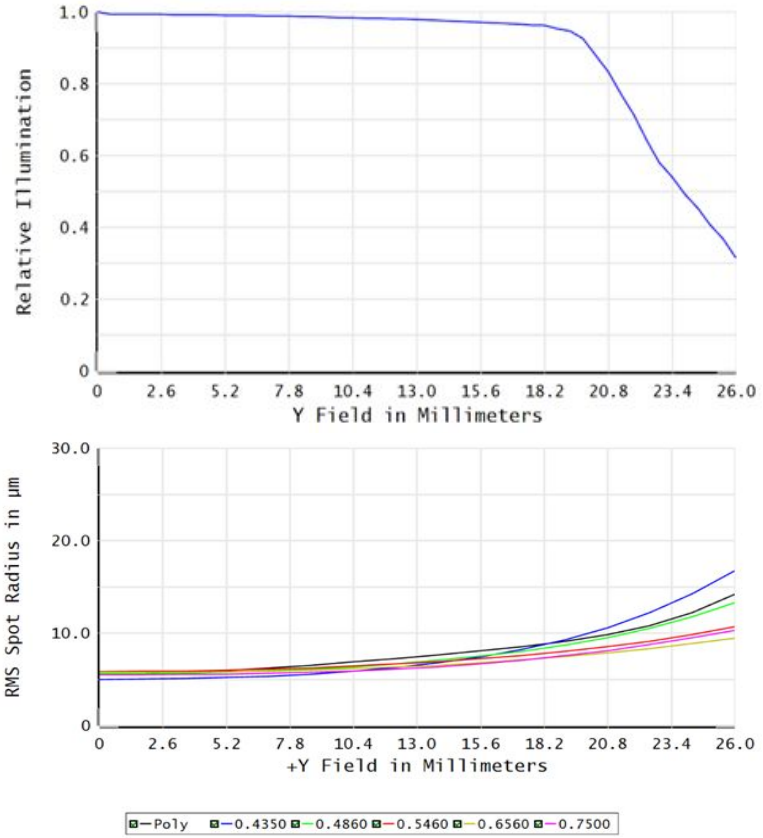
New Optical Scheme: PSF and RMS spot radius



PSF on-axis
RC at NIR (H-band)



Fondazione CRT

New Optical Scheme: Focuser

- Crayford style focuser with 40 ball bearings, specially designed for very high load capacity (up to 10 kgs) with no flexure
- Low profile design with only 65mm thickness (91mm with internal flange).
- 35mm focuser travel with an incredible resolution of 0.04 microns per step!

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Fondazione CRT

New Optical Scheme: Rotator

- Low profile rotator - 23mm of body thickness
- 1 arc second resolution per step
- 76.3mm of free aperture
- Specially designed full aluminum case, for rotating heavy cameras and accessories without any flexure
- M81 threaded

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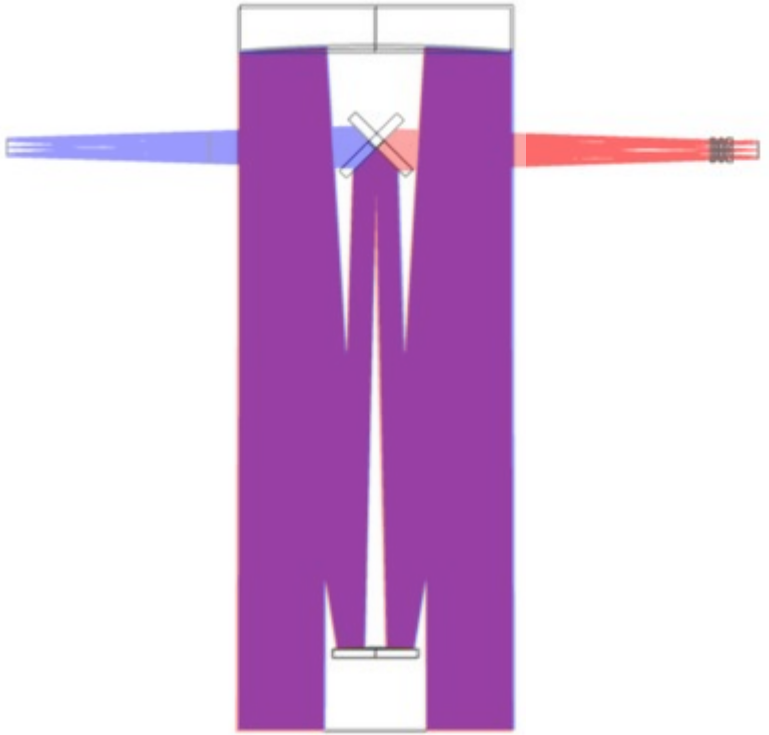
Thanks!



Any questions?

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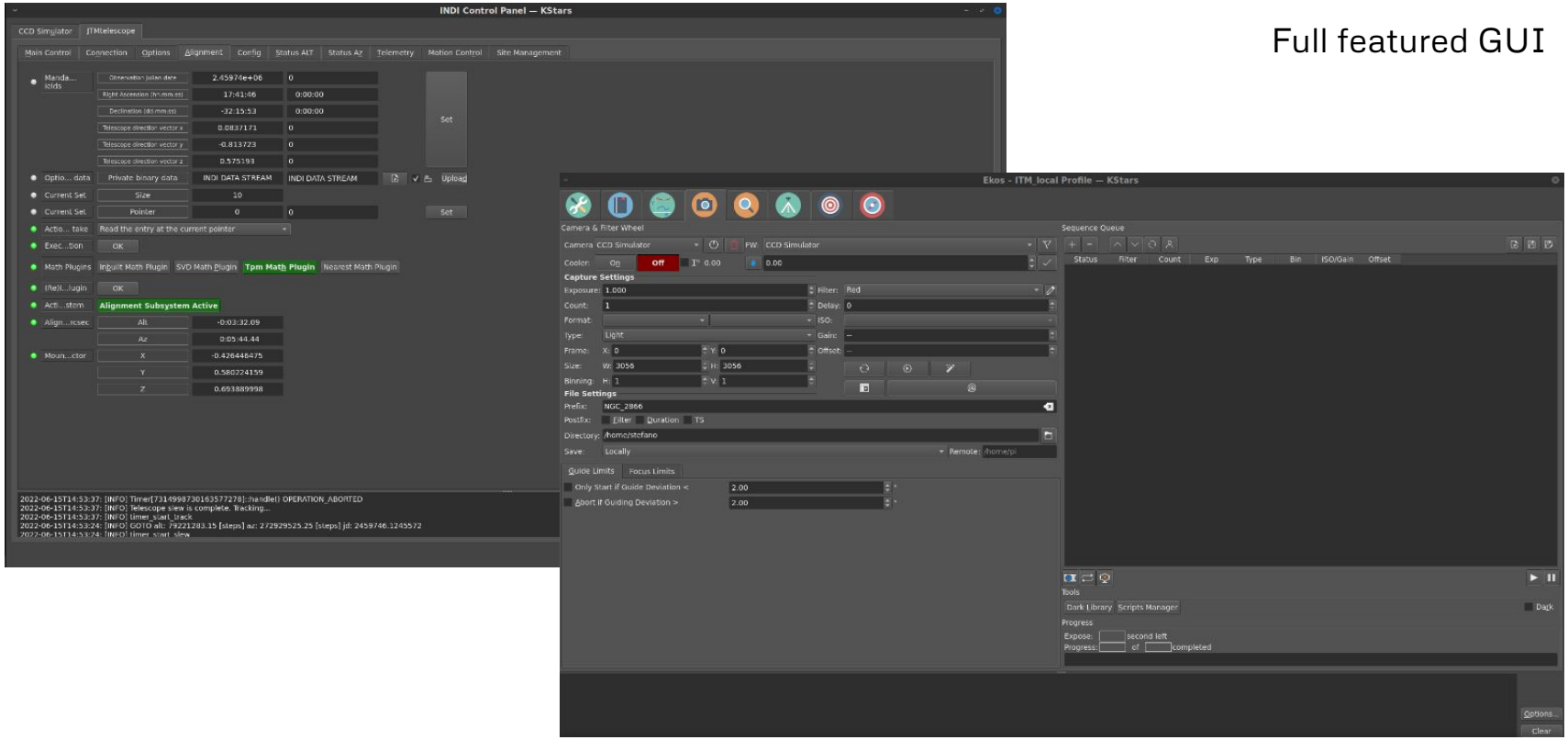
Software upgrades: INDI-Ekos-Kstars



Full featured GUI

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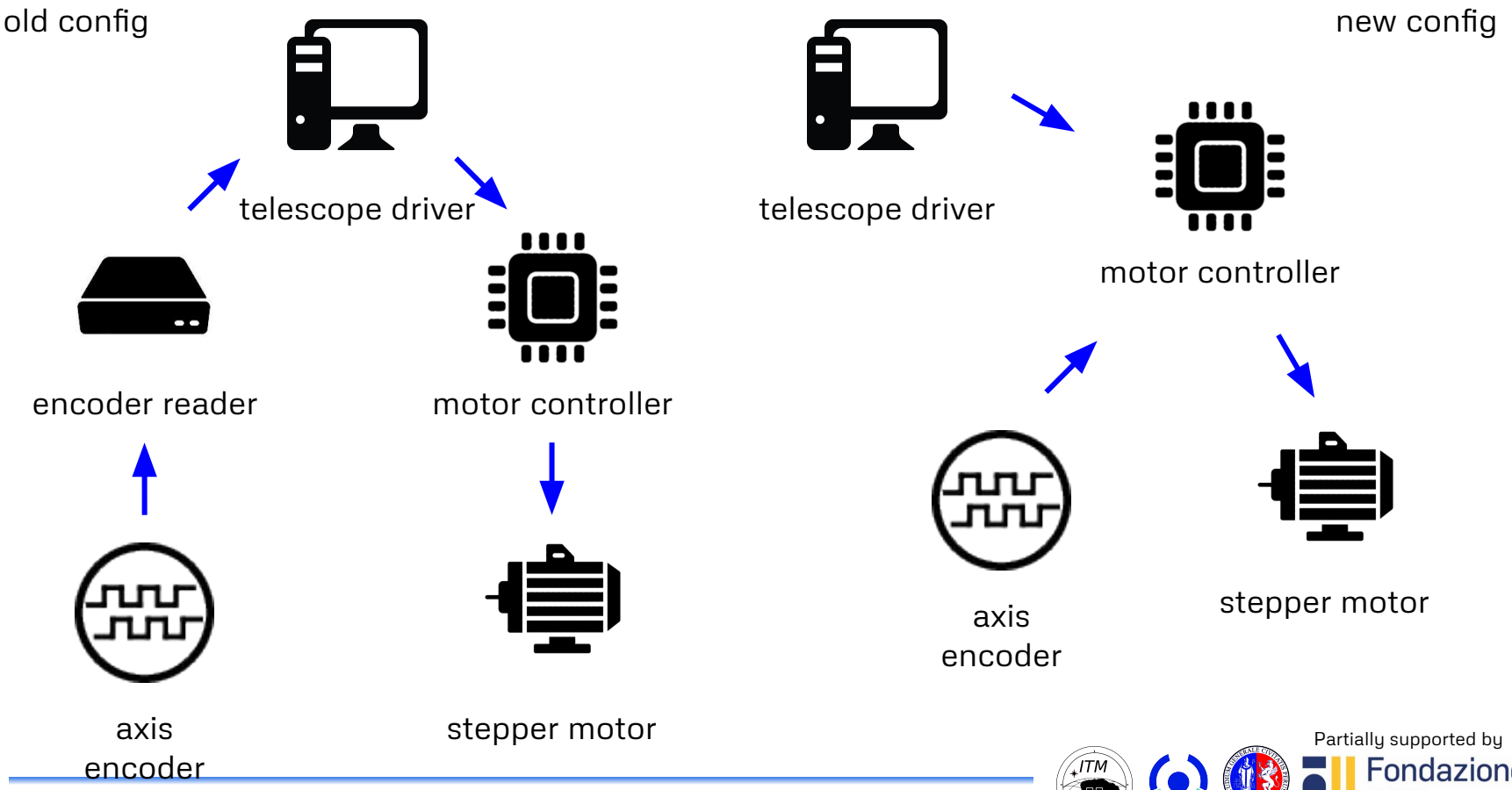
Software upgrades: Encoder closed loop



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