Small bodies of the Solar System with the “Cassini” telescope

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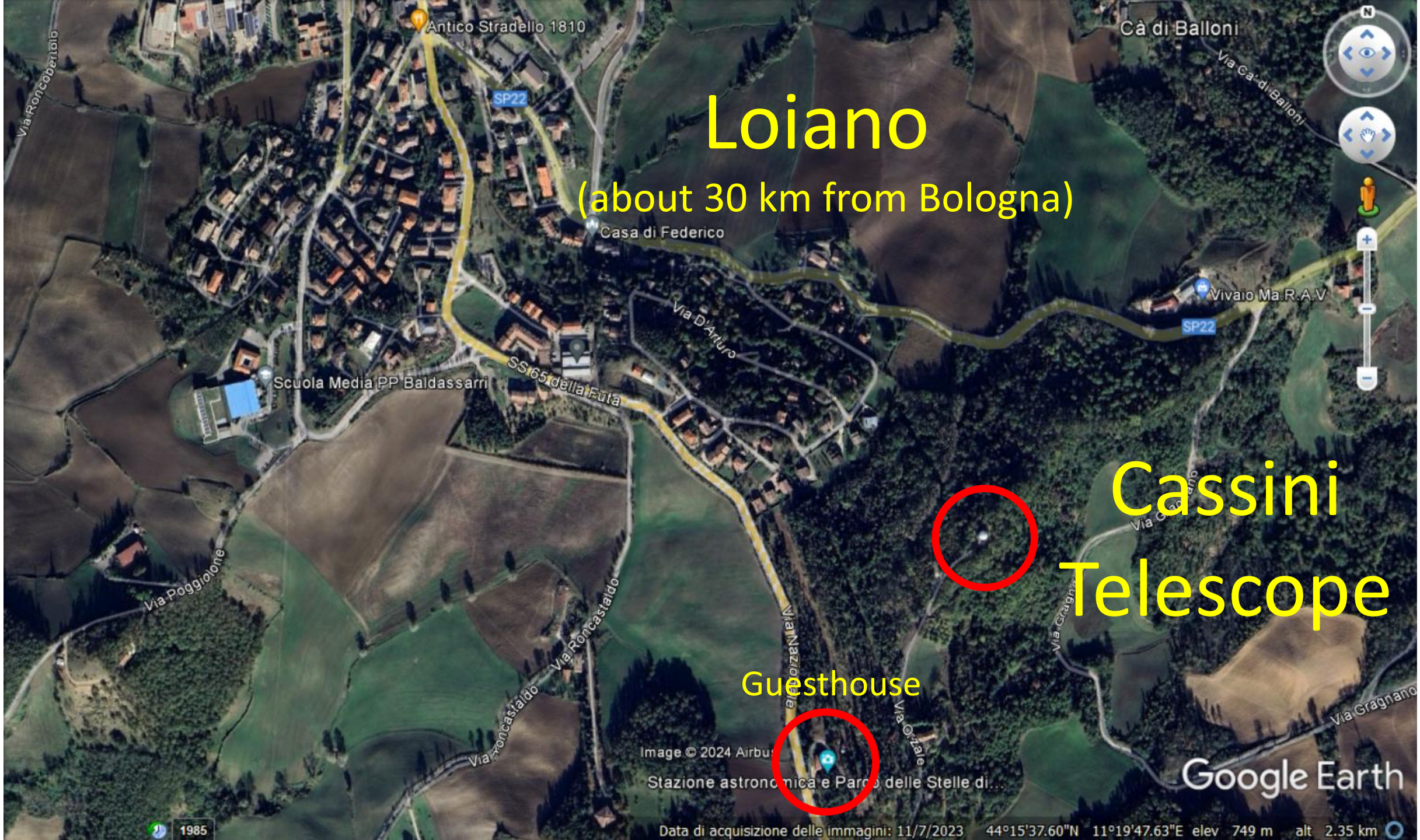
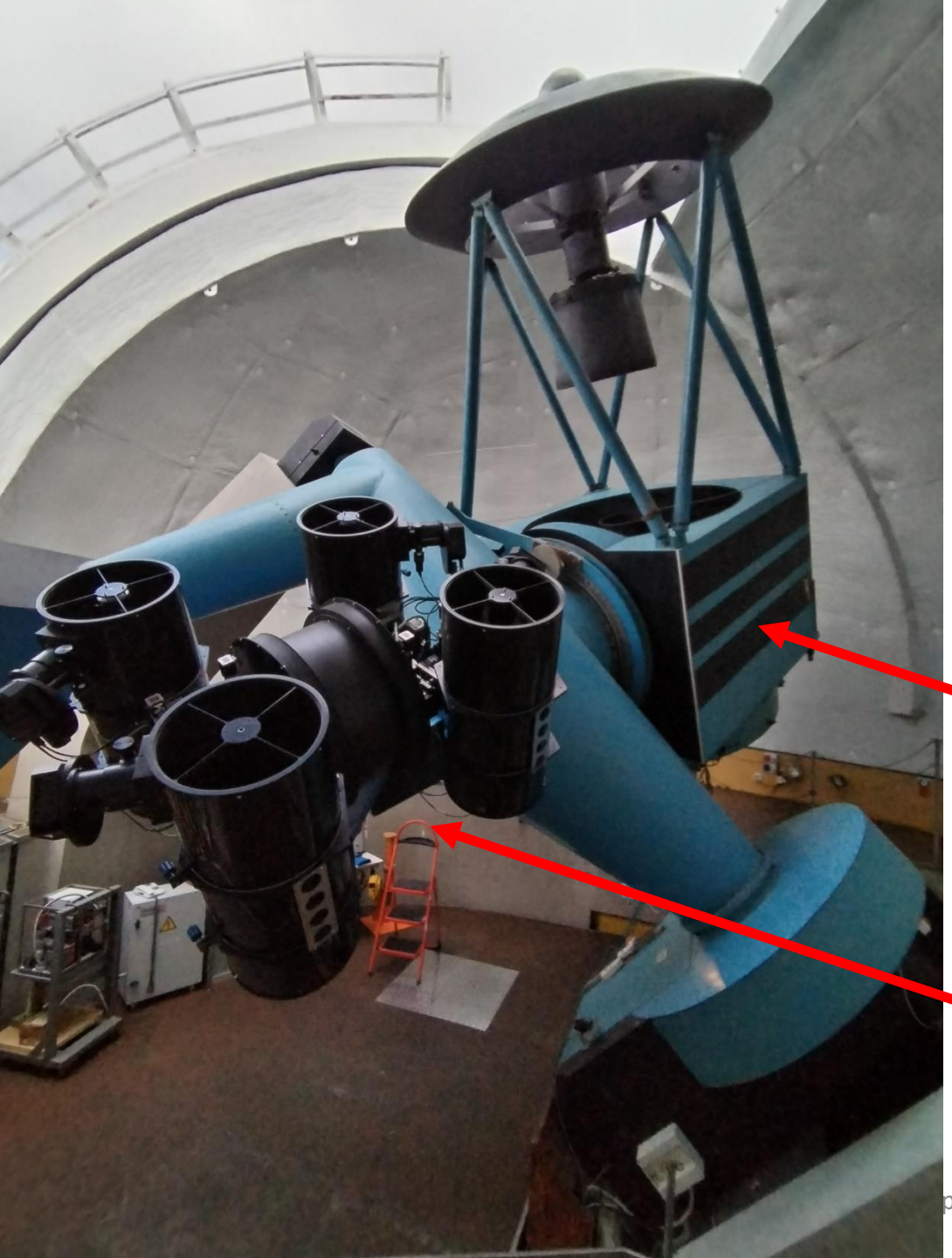

Loiano
(about 30 km from Bologna)
Cassini
Telescope
Guesthouse
Antico Stradello 1810
Cà di Balloni
Via Ca' di Balloni
Via Roncobertolo
SP22
Casa di Federico
Via D'Arturo
Vivaio Ma.R.A.V
SP22
Scuola Media PP Baldassarri
SS65 della Futa
Via Poggiolone
Via Roncastaldo
Via Nazionale
Via Gragnano
Via Gragnano
Image © 2024 Airbus
Stazione astronomica e Parco delle Stelle di...
Google Earth
1985
Data di acquisizione delle immagini: 11/7/2023 44°15'37.60"N 11°19'47.63"E elev 749 m alt 2.35 km

The “G. D. Cassini“ telescope is hosted in a building with a dome inaugurated in 1976.

The dome’s diameter is 12 meters, while the height from the ground is about 20 meters.

Recently, the dome was insulated with a new material.



The “Gian Domenico Cassini” is a 1.5-m F/4.8 Ritchey-Chretien telescope with a CCD plate scale of about 0.6 arcsec/pixel and a field of view of 13 x 13 arcmin. “Cassini” is Italy's second-largest optical telescope.

«**Cassini**» optical telescope

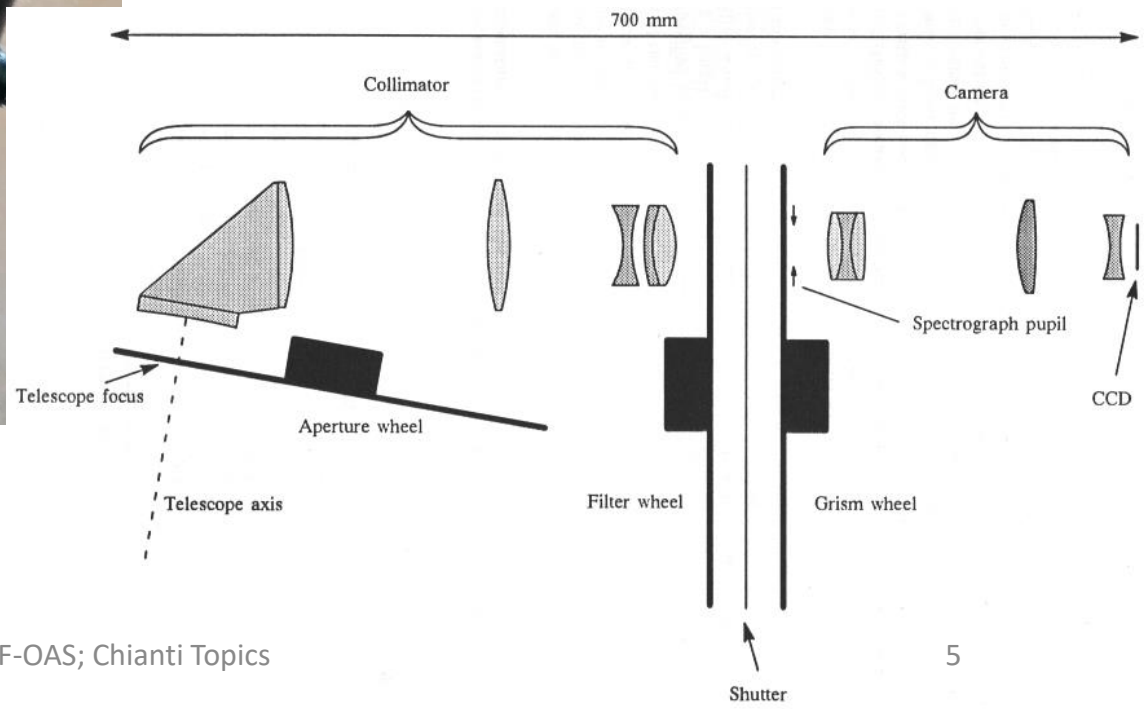
Tandem telescope array (Newtonian reflectors, 0.35-m, F/3)
Talk by Alberto Buzzoni, Wednesday, 28 February.

BFOSC = Bologna Faint Object and Spectrograph Camera

Secondary CCD, FLI 1001E
1024 x 1024 pixel, with **Peltier cell** for cooling.

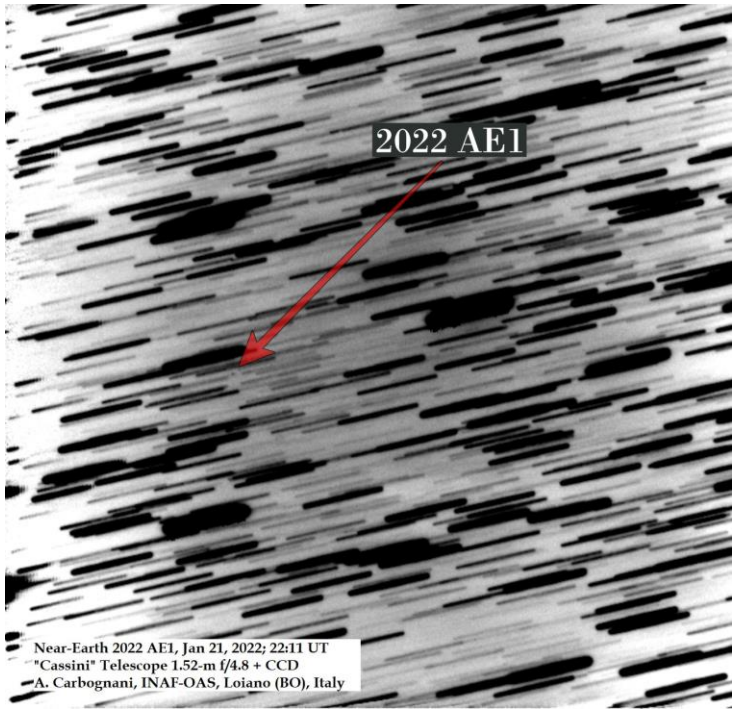
MAIN CCD, EEV LN/1300-EB/1
Back-illuminated, 1340 x 1300 pixel

Dewar for liquid nitrogen
(CCD is cooled with liquid nitrogen)

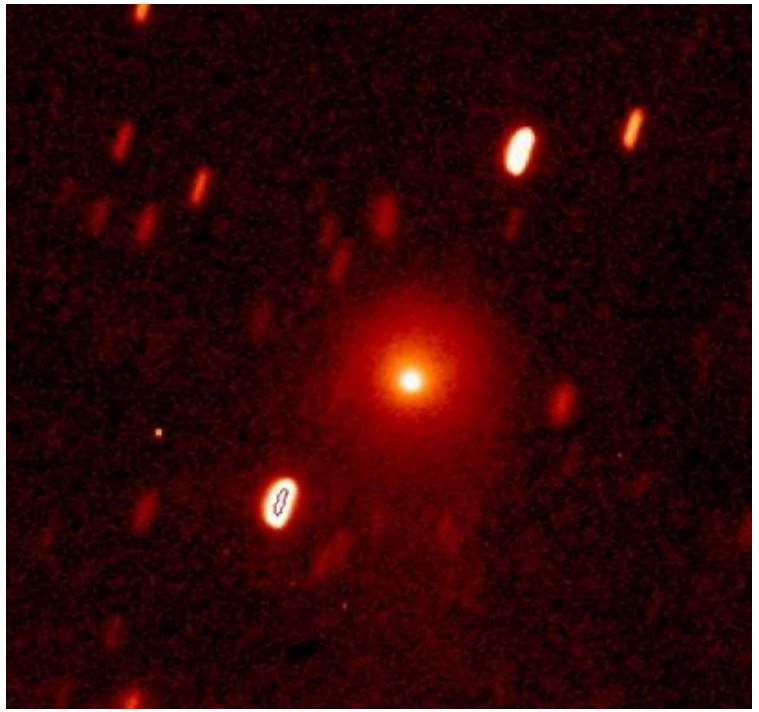


U, B, V, R, I Johnson-Kron-Cousin filters
G, R, Z, I Thuan-Gunn filters.
Spectral range 330 - 1100 nm
Spectral wavelength calibration is obtained through exposures of a Fe hollow-cathode lamp filled with He-Ar.

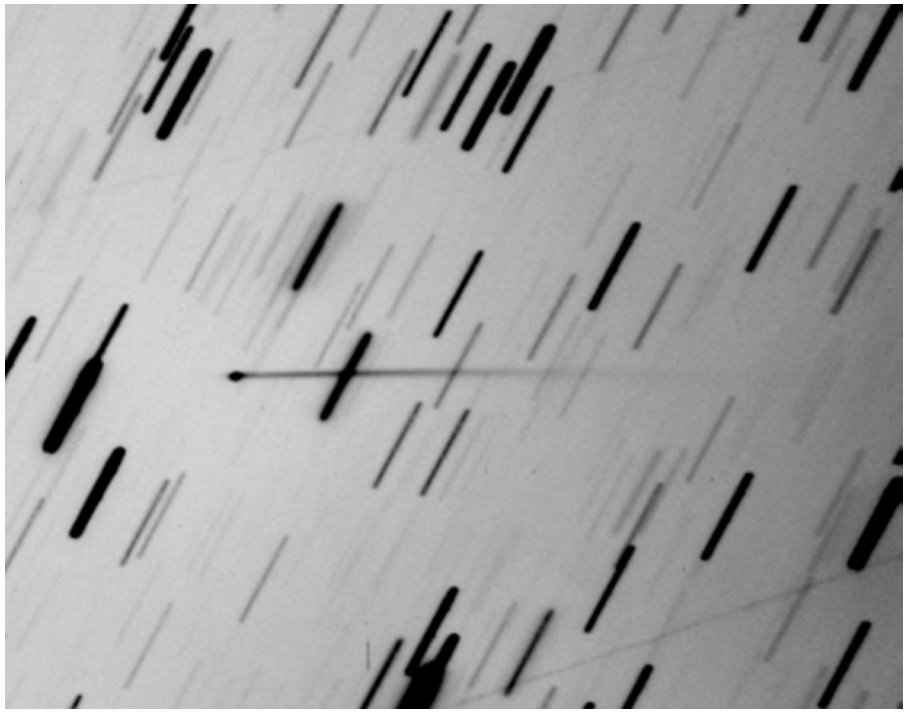
Topics related to the observations of minor bodies



NEOs follow-up



Long period comets



Active asteroids

NEO follow-up

Pan-STARRS

CATALINA SKY SURVEY

NEO detection

IAU Minor Planet Center

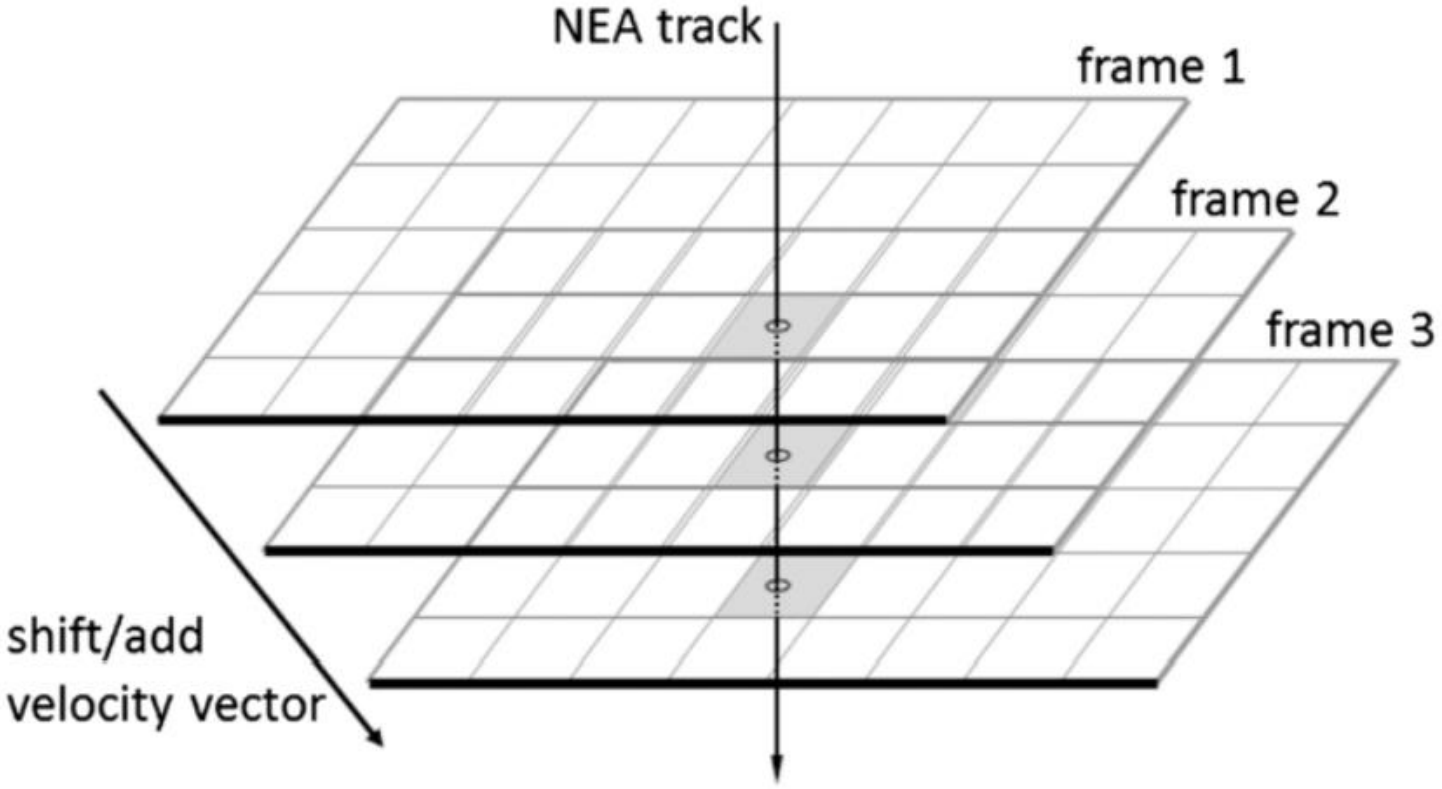
NEOCP

NEO confirmation

The NEO follow-up consists of confirming the near-Earth candidates in the **NEO Confirmation Page** (NEOCP), maintained by the **Minor Planet Center**. The astrometric measurement of the confirmed NEOs are published in the **Minor Planet Electronic Circular**.

The mitigation of the impact risk of near-Earth asteroids requires continuous monitoring of this minor body population in order to discover new members and refine the orbits of those already known. In the unfortunate event of a collision, the possibility of mitigation depends on the **warning time**.

Cassini Telescope, Carbognani et al. INAF-OAS; Chianti Topics



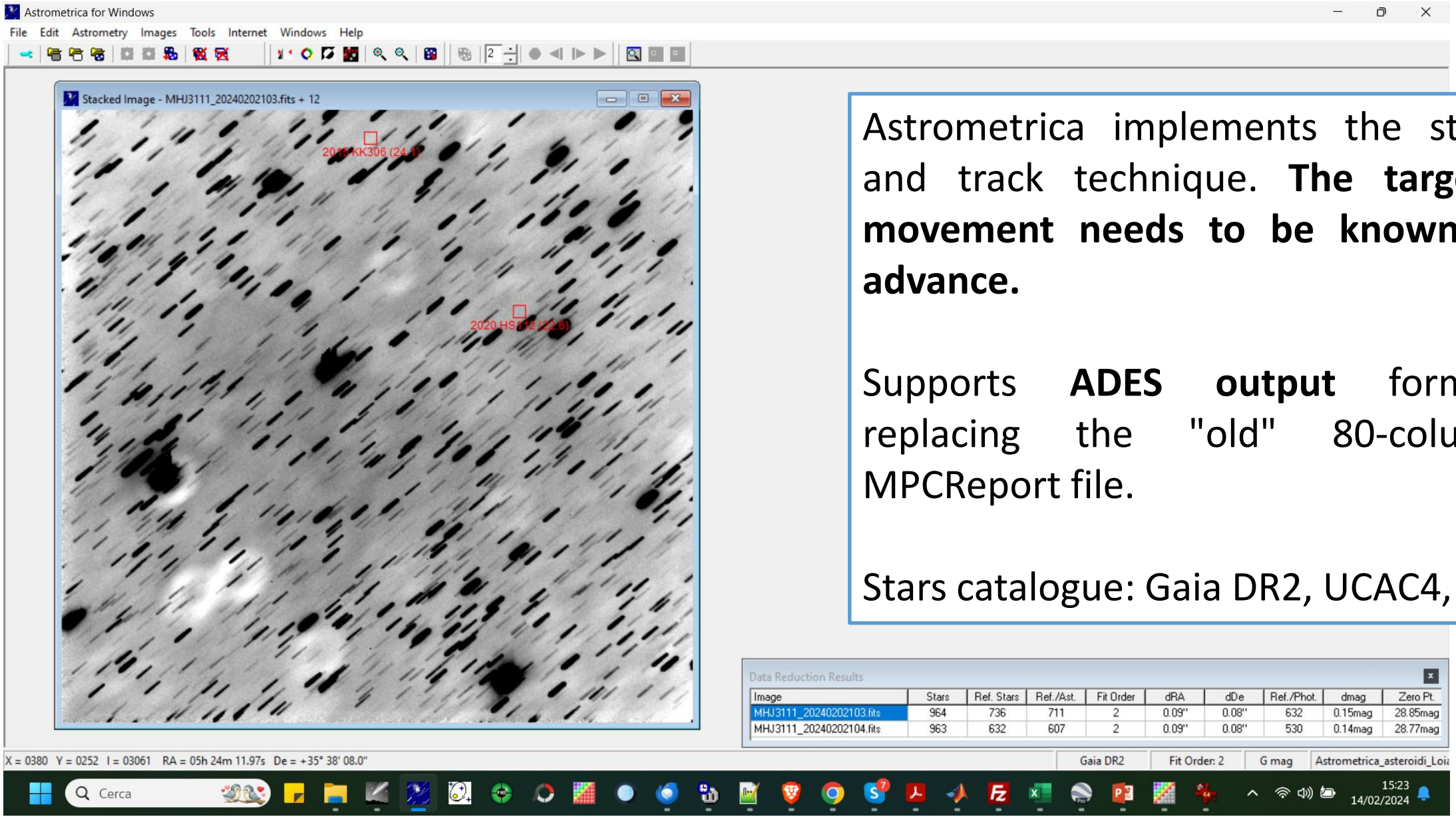
The NEOs problem: Detection of Faint Moving Objects

1 - By taking **multiple images** of the same star field, one would see a moving object, like an asteroid or comet, change positions relative to the stars.

2 - If the moving object is **not bright enough** to be seen in a single image, then the object's signal-to-noise ratio (SNR) has to be increased. Increasing the exposure time is not an efficient way of increasing the SNR of an asteroid **unless it is a slow-moving asteroid**. If the object is **fast-moving**, a long exposure time makes the asteroid a **streak** instead of a **star-like** object.

3 - A common method for **finding moving objects** is the shift and stack technique, also known as "**stack and track**". This involves taking **multiple short exposure images**, short enough that the **target appears as a point source and not a streak**, then shifting the images relative to one another so the object in each image is aligned with himself and then combining the images into one by adding the pixel values.

Software for NEOs follow-up: Astrometrica

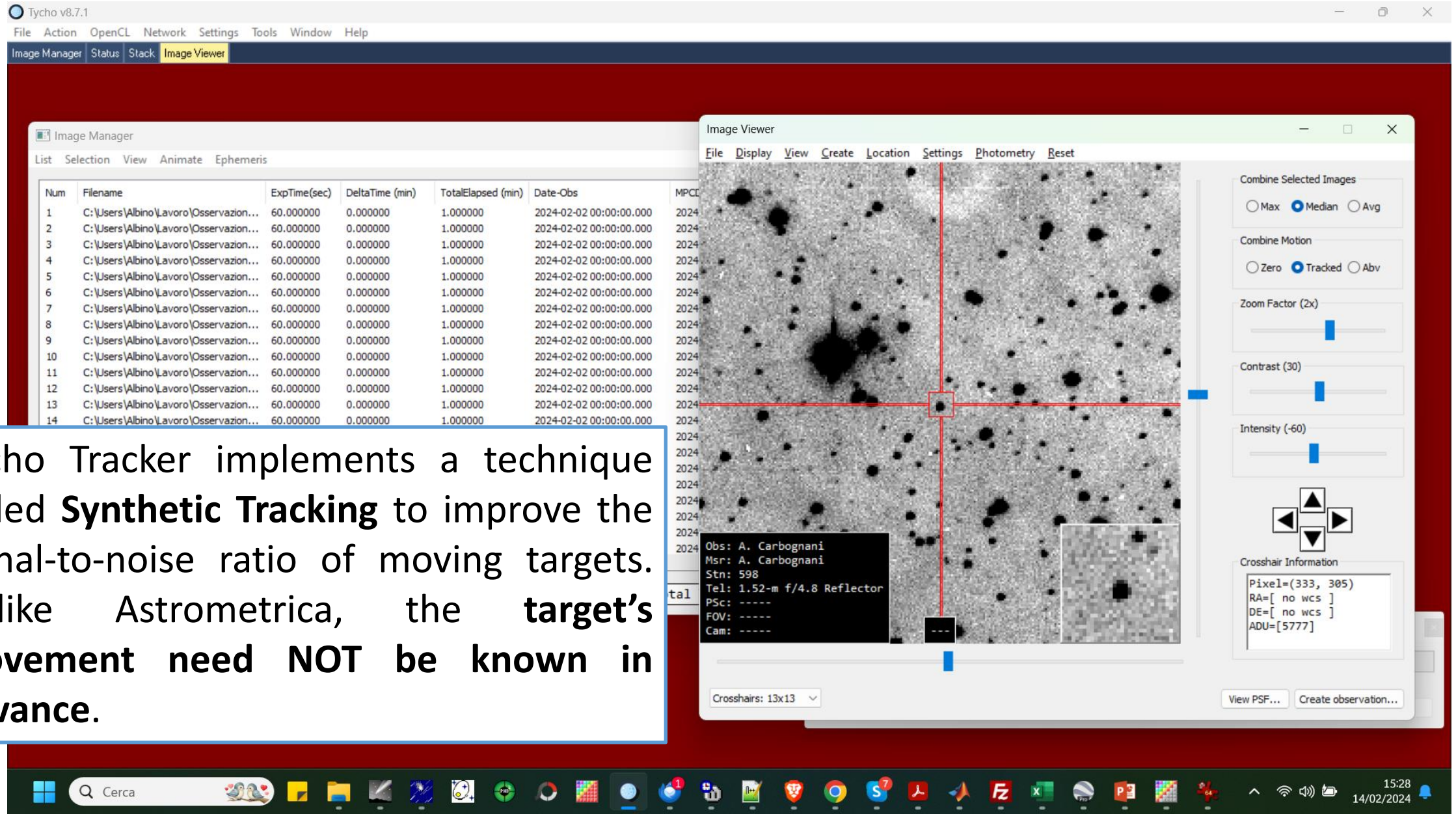


Astrometrica implements the stack and track technique. **The target's movement needs to be known in advance.**

Supports **ADES output** format, replacing the "old" 80-column MPCReport file.

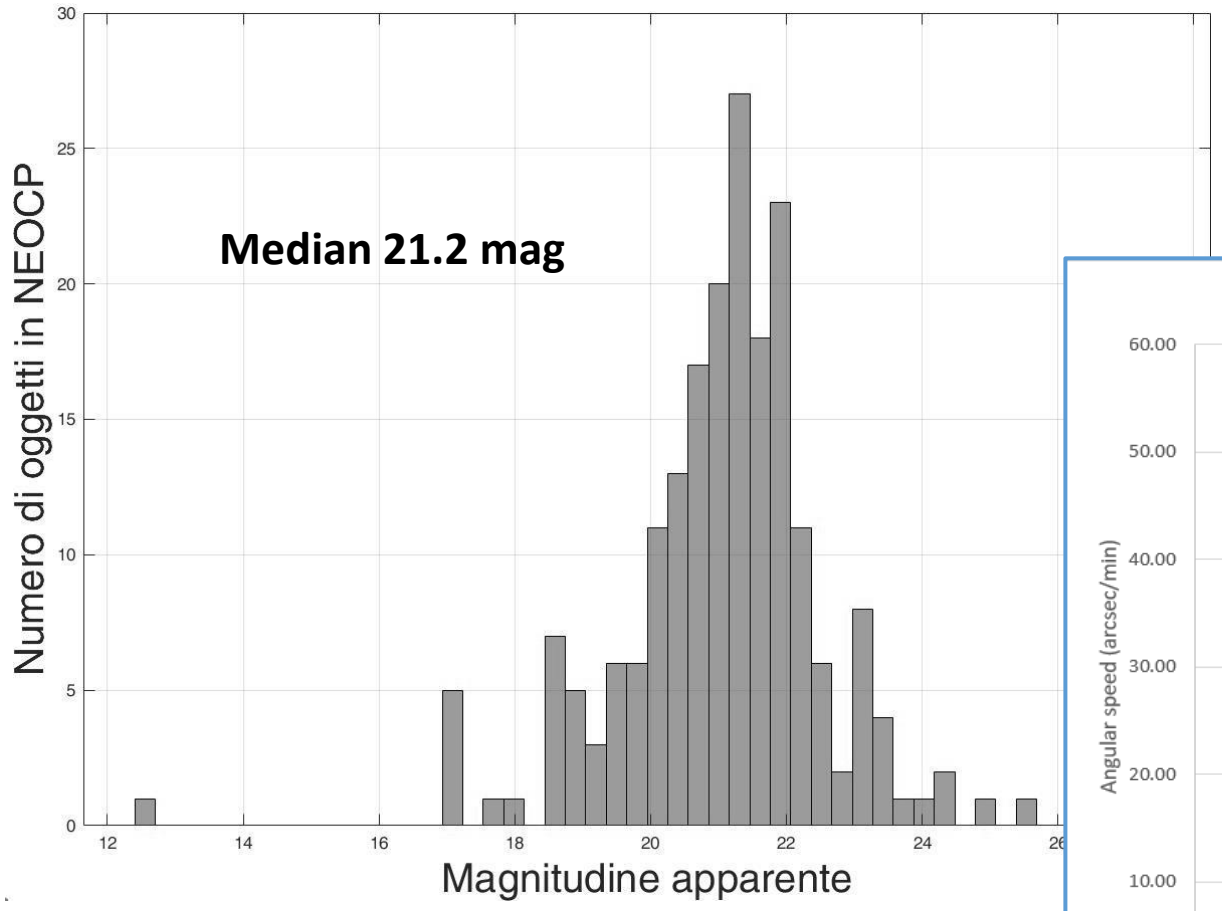
Stars catalogue: Gaia DR2, UCAC4, …

Software for NEOs follow-up: Tycho Tracker



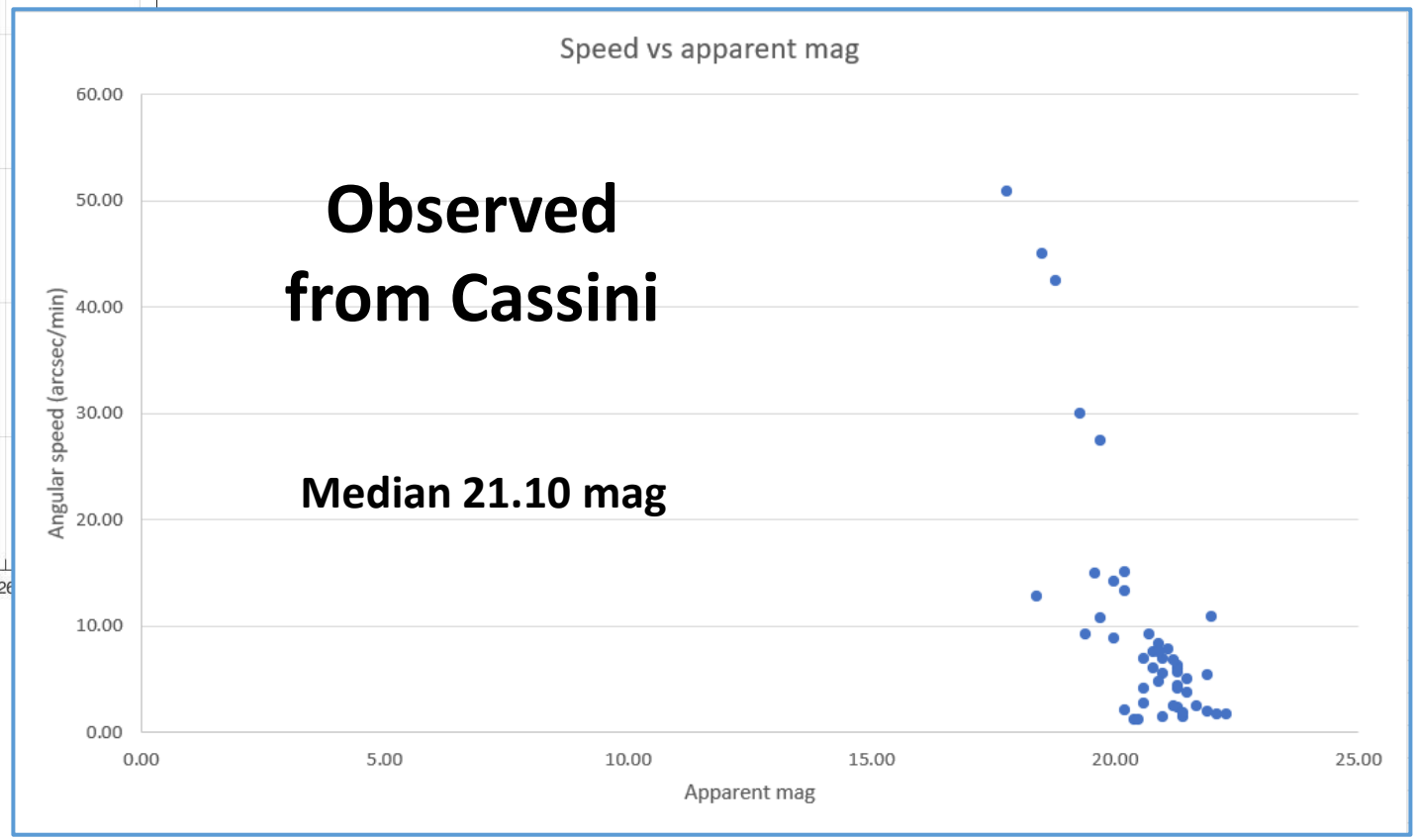
Tycho Tracker implements a technique called **Synthetic Tracking** to improve the signal-to-noise ratio of moving targets. Unlike Astrometrica, the **target's movement need NOT be known in advance**.

Apparent mag distribution for NEO follow-up

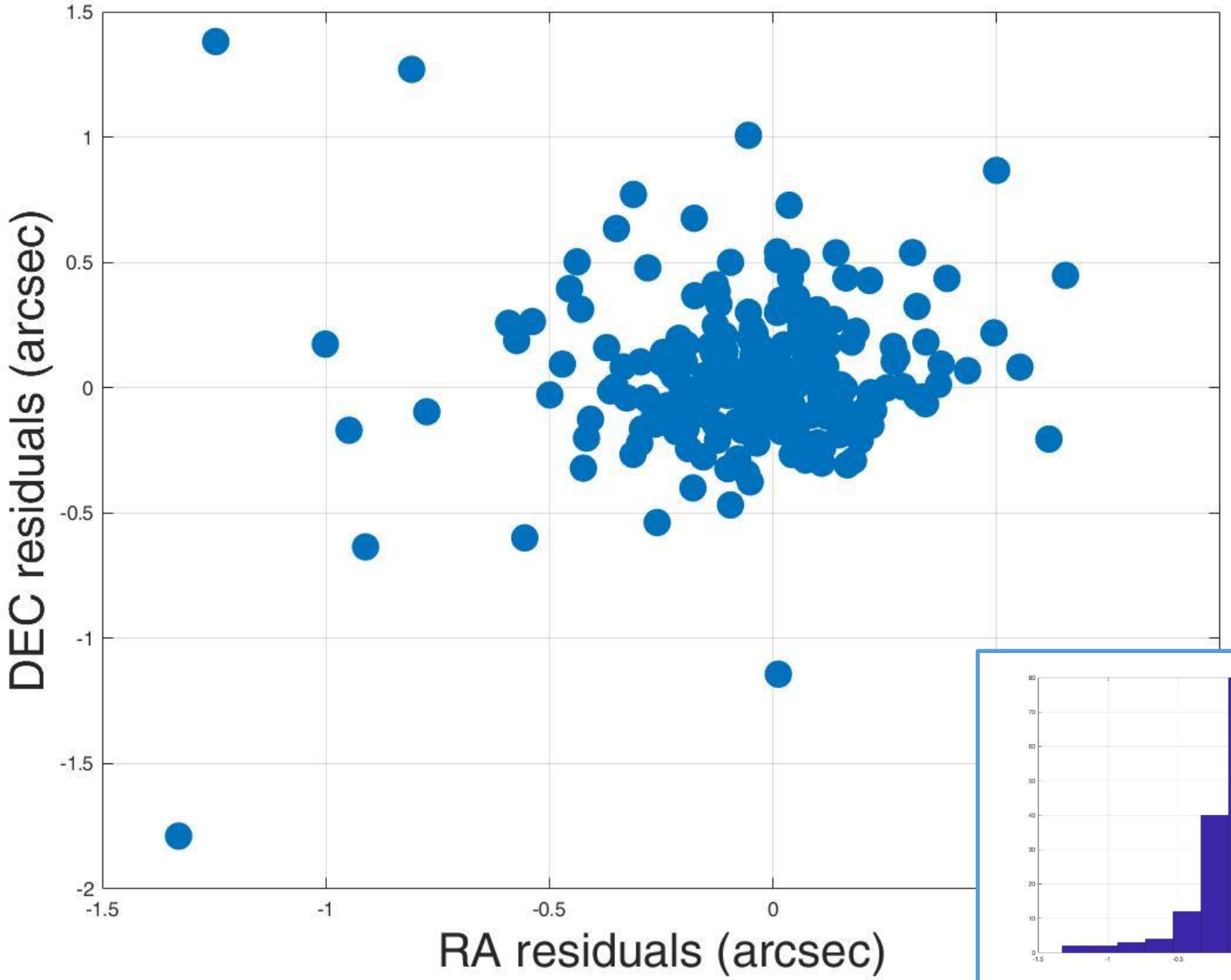


NEOCP

A histogram showing the distribution of apparent magnitudes of suspected near-Earth objects to be confirmed appeared in the NEOCP of the Minor Planet Center in the second half of May 2022.



Cassini's astrometric residuals



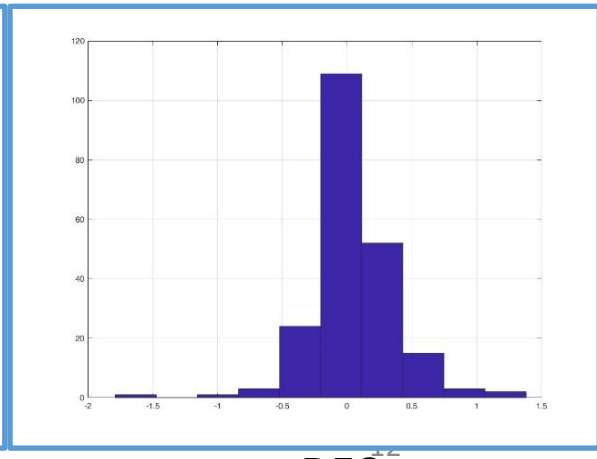
We used NEODyS-2 services from SpaceDys to compute the **mean absolute value** of the residuals in RA and DEC:

Mean RA residual = 0.201 arcsec

Mean DEC residuals = 0.215 arcsec

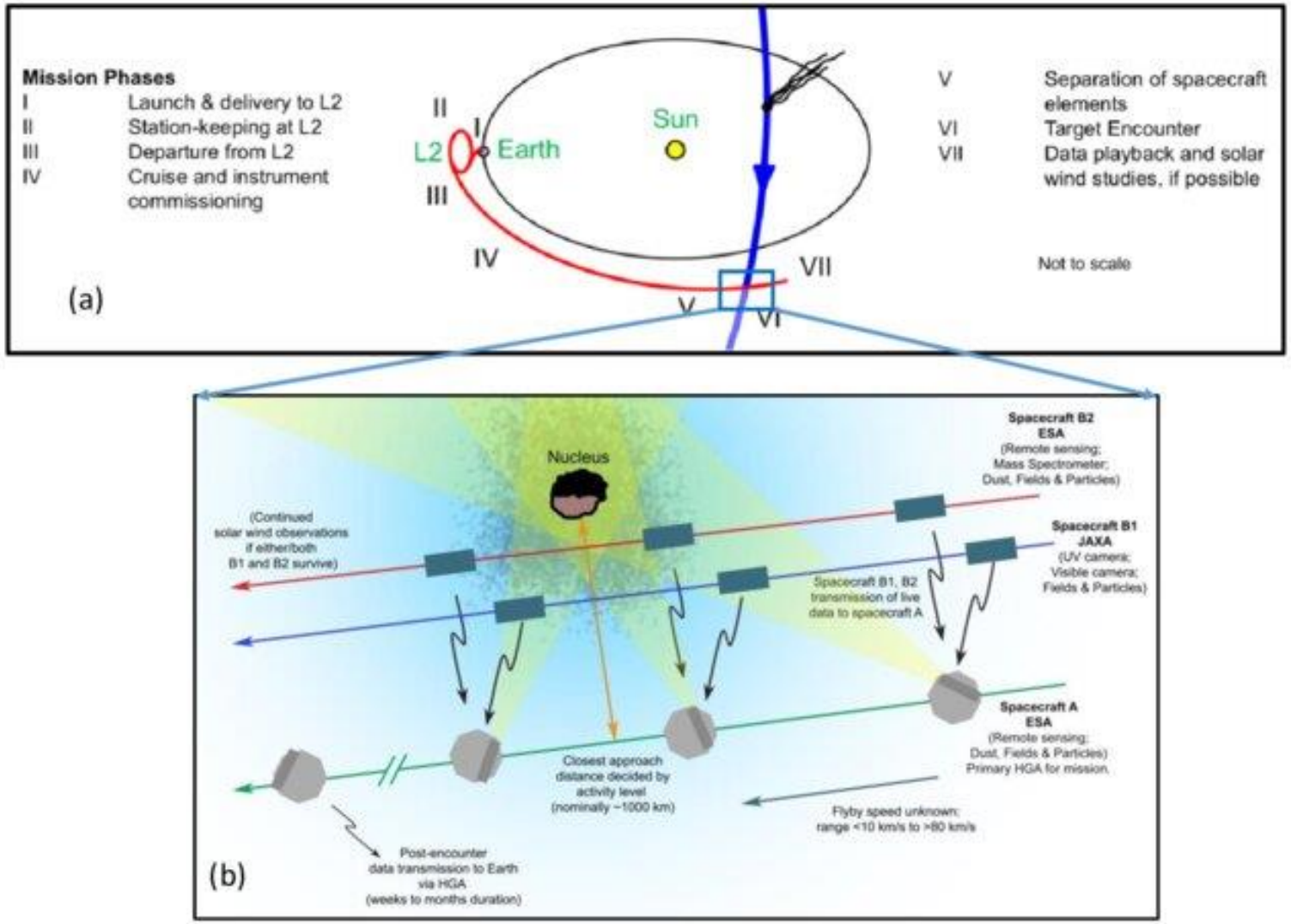
212 MPECs from 2019 to 2024

RA



DEC

Comet observations



Comet observations made with the «Cassini» are related to the **Comet Interceptor mission** conceived after discovering the first comet of interstellar origin, **2I/Borisov**, on August 29, 2019.

Comet Interceptor is led by the **European Space Agency** (ESA) and is planned for launch in 2029.

The spacecraft will be "**parked**" at the Sun-Earth **L2 point** and wait up to three years for a **long-period comet** with a trajectory and speed suitable for a flyby.

The mission's science goal is to characterise a dynamically new comet, including its **surface composition**, **shape**, **structure**, and the composition of the **gas of the coma**.

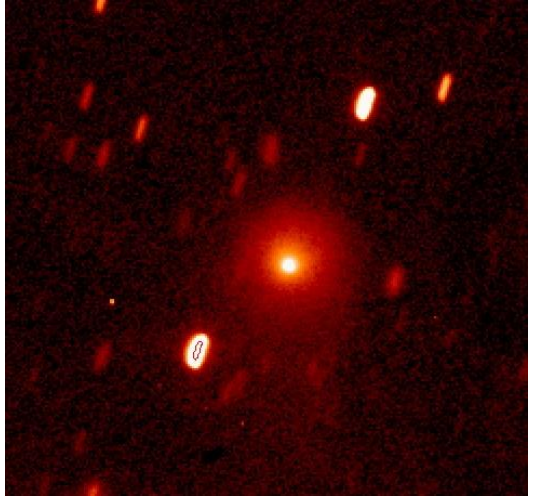
Purpose of comet observations with “Cassini”

1. **Characterise long-period comets** (LPCs), particularly their **dust environment**, vital to the Comet Interceptor (CI) mission, as the instruments are designed to survive a **dust environment equal to 1P/Halley**.

2. To characterise the activity of LPCs, we observed these objects from Earth in the years 2020-2021 and combined the results with the **dust models** developed within the Italian CI team (Fulle and Zakharov).

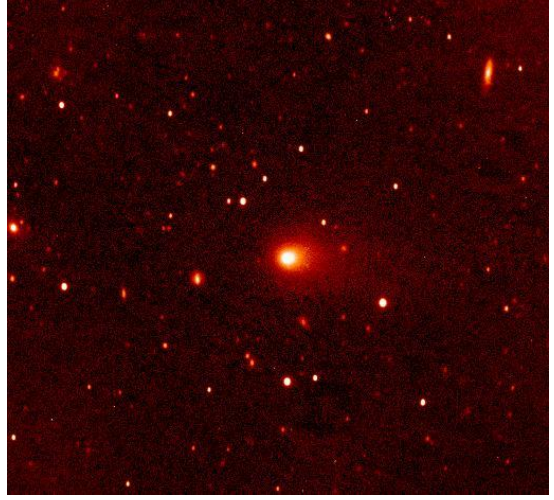
Long period comets observed list

	A	B	C	D	E
1	cometa	data osservazione	optocentro cometa (x,y)	filtro	inbound/outbound
2	C2010U3	10.03.2021	658,739	R	out
3	C2017B3	14.09.2020	564,398	R	out
4		15.09.2020	569,393	R	
5		13.10.2020	571,324	R	
6	C2017K2	17.08.2020	501,810	R	in
7		20.08.2020	500,746	R	
8		21.08.2020	550,762	R	
9		15.09.2020	404,797	R	
10		07.05.2021	972,467	R	
11	C2020K5	18.08.2020	385,799	R	in fino a 5jun21
12	C2020M3	14.12.2020	595,674	R	out
13		12.01.2021	554,694	R	
14		13.01.2021	470,766	R	
15		08.04.2021		R,V	
16	C2020N1	12.01.2021	422,825	R	in fino 12mar2021 poi out
17		10.03.2021	404,661	R	
18		07.04.2021		R,V low S/N	
19		08.04.2021		R,V low S/N	
20	C2020T2	10.03.2021	625,764	R	in
21		08.04.2021	R 520,607	R;V	
22		07.05.2021	753,790	R	
23	C2021A1	07.04.2021		R,V no astrometrica	in
24		08.04.2021		R,V no astrometrica	
25		07.05.2021		R, low S/N	
26	C2020R4	06.05.2021	788,792	R	out
27		07.05.2021	703,735	R	
28	C2020S8	07.05.2021	769,544	R	out



2017 K2

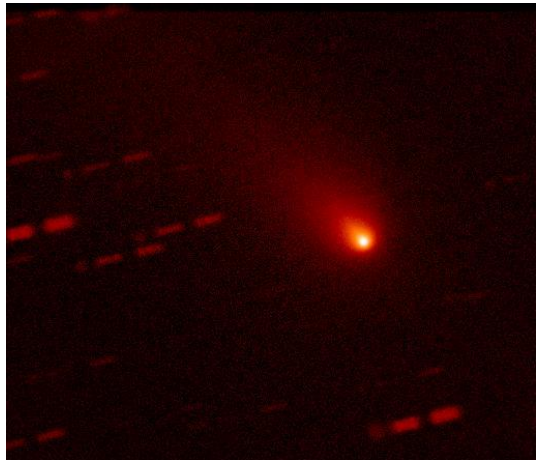
2020 T2



The properties of the comet's dust were investigated by measuring the dust production rate using the **Afρ parameter**.

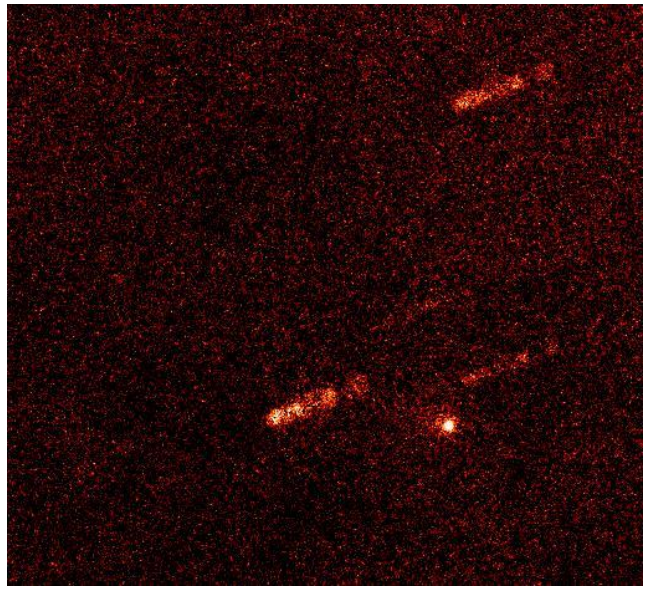
So, we measure the mag in the R band using both the UCAC4 stars catalogue as a comparison and Landolt's stars.

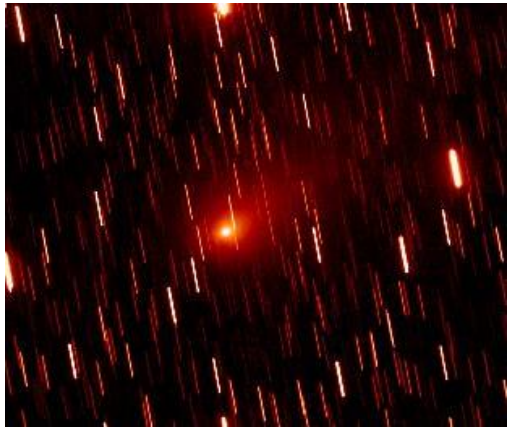
2020 N1



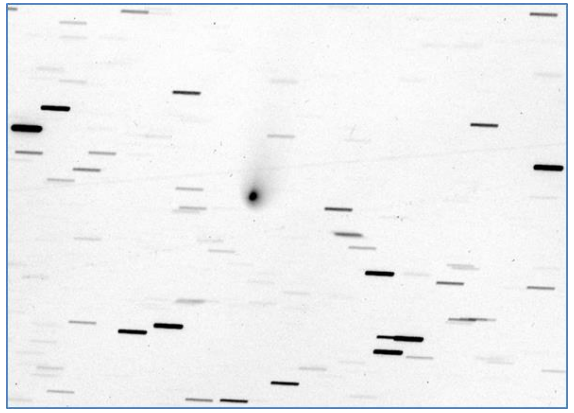
2020 R4

2020 S8

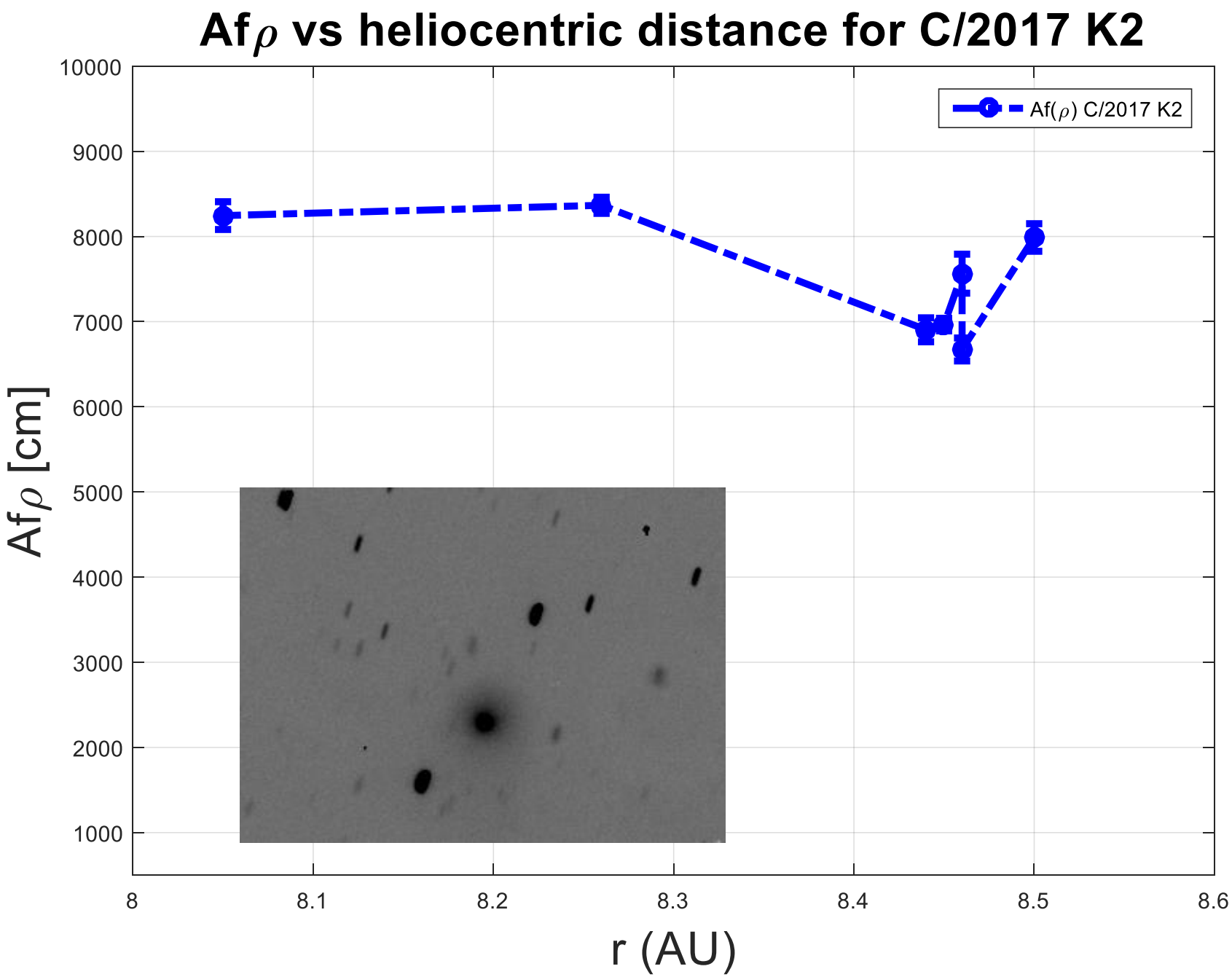




2020 M3



2017 B3



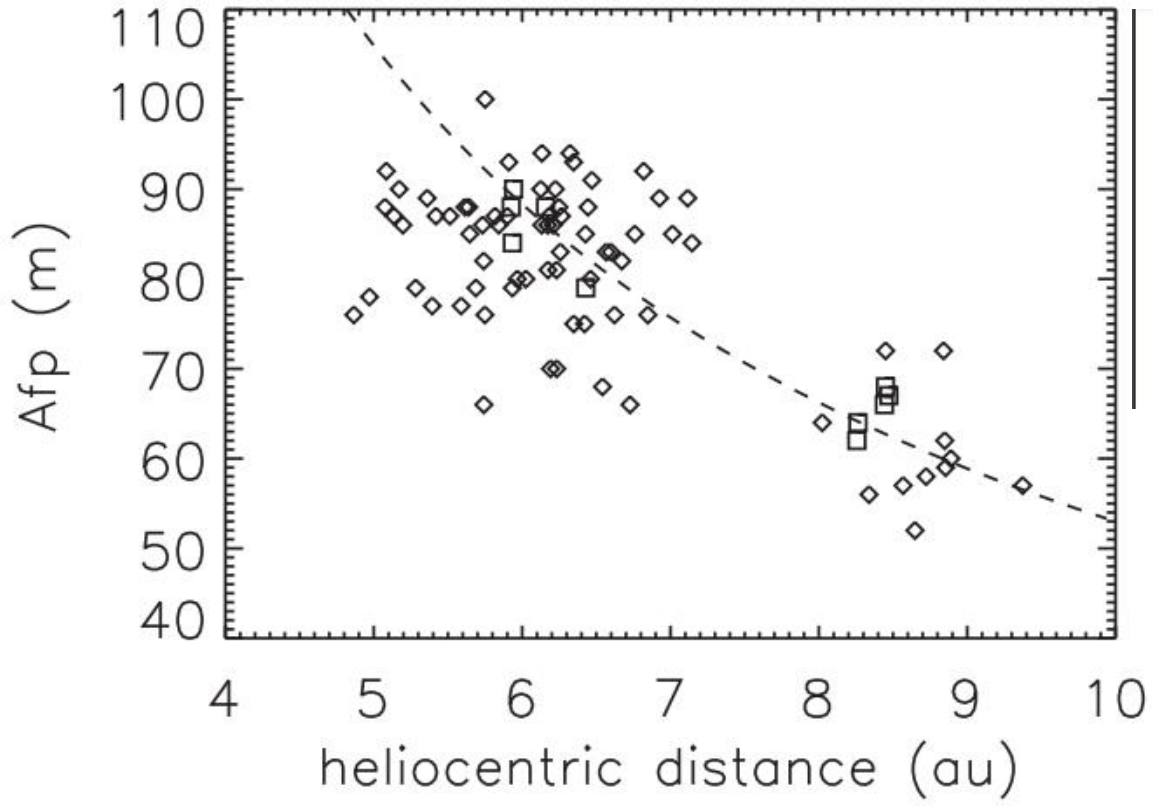
An example of Afρ observations on long-period comet C/2017 K2, observed between 8.5 and 8.0 au.

The Afρ value of about 7500 cm indicates a high dust emission in space despite the great distance from the Sun.

For comparison, the Afρ value for Comet 67P is about 200 cm.

The Afρ is the product between the albedo “A” (the reflectivity of grains), the filling factor "f" and “ρ” which is the radius of the coma under investigation.

Published paper about long-period comets



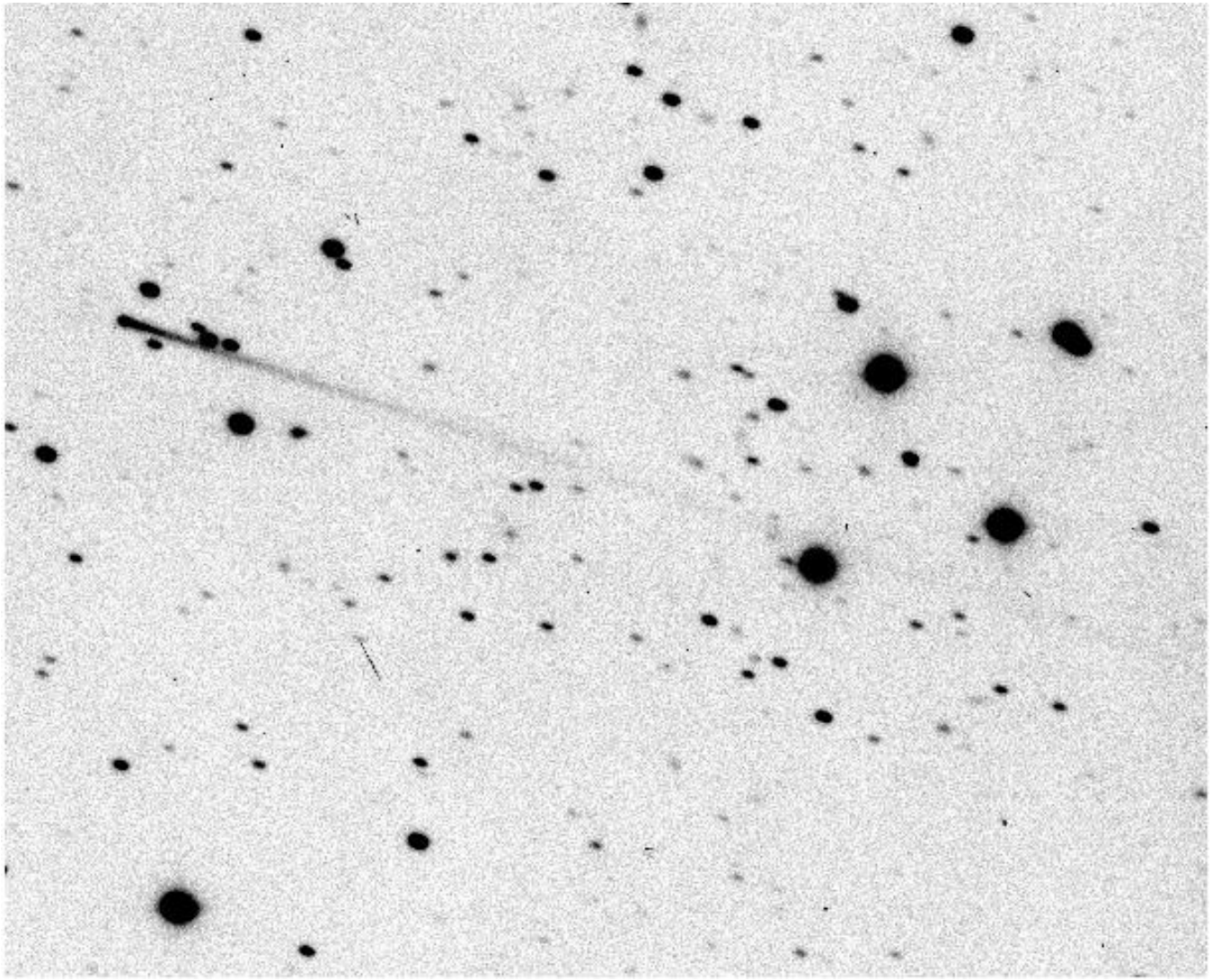
Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 513, 5377–5386 (2022)
Advance Access publication 2022 May 3
https://doi.org/10.1093/mnras/stac1218

Comets beyond 4 au: How pristine are Oort nuclei?*

Marco Fulle,[1†] M. Lazzarin,[2] F. La Forgia,[2] V. V. Zakharov,[3,4] I. Bertini,[3,5] E. Mazzotta Epifani,[6] E. Ammannito,[7] A. Buzzoni,[8] M. T. Capria,[3] A. Carbognani,[8] V. Da Deppo,[9] V. Della Corte,[3] S. Fiscale,[5] E. Frattin,[2] L. Inno,[5] A. Migliorini,[3] C. Pernechele,[10] A. Rotundi,[3,5] G. Sindoni,[7] C. Tubiana,[3] G. Milani,[11] A. Aletti,[11,12] P. Bacci,[11,13] G. Baj,[11] F. Bellini,[11,12] E. Bryssinck,[11,14] M. Di Grazia,[11,13] M. Facchini,[11,15] M. Feraco,[11] E. Guido,[11] R. Ligustri,[11] F. Kugel,[11] M. Maestripieri,[11,13] D. Tirelli,[11] A. Valvasori,[11,16] C. Snodgrass[17] and G. H. Jones[18,19]

Figure 3. $Af\rho$ of comet C/2017K2 versus the heliocentric distance r_h measured within a sky-projected coma radius $\rho_0 = 5\times10^4$ km. Diamonds: observations of the CARA network. Squares: observations at Loiano Observatory. Dashed line: best fit of Loiano's data constrained by the dust tail model (Table 5).

Active Asteroids



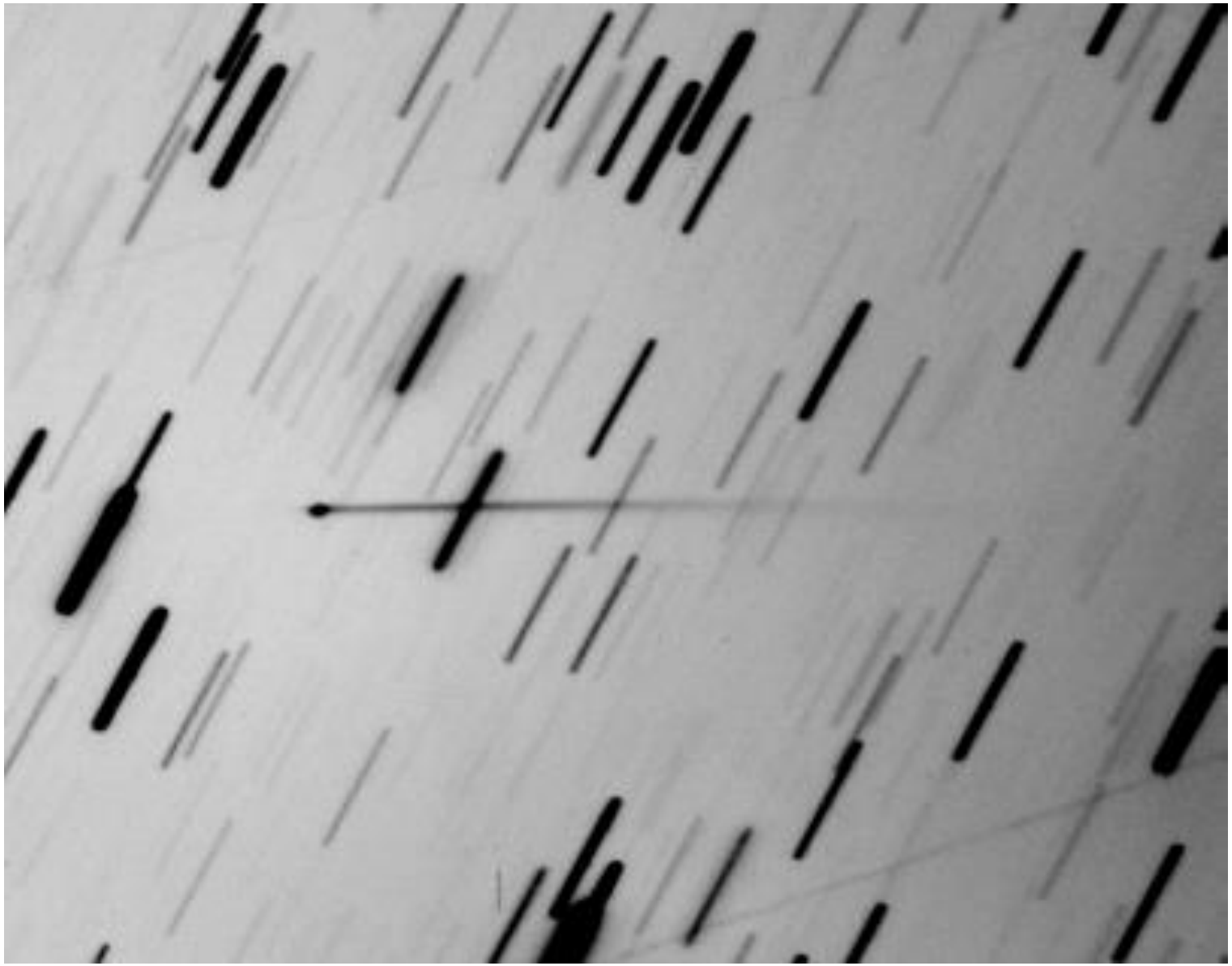
The minor bodies of this class are main-belt asteroids (TJ > 3.08), which sometimes show the **typical morphological features of comets**, such as **coma** and **tail**, i.e. mass-loss phenomena. About **50** asteroids are known in this class.

The activity causes can be heterogeneous: **sublimation of volatile materials**, **rotational disintegration**, **thermal fracturing** or **collision with smaller asteroids**.

The first active asteroid was (**7968) Elst–Pizarro**, discovered in 1979. In 1996, it showed signs of cometary activity (image on left).

On August 7, 1996, Eric W. Elst (Royal Observatory, Uccle, Belgium) reported his discovery of a cometary image on mid-July exposures by Guido Pizarro with the 1.0-m ESO Schmidt telescope at the La Silla Observatory.

(6478) Gault



Main belt asteroid (6478) Gault in 2019 surged to very special attention as an outstanding member of the active asteroids class, showing typical morphological features of comets: coma and tail.

As the outbursts appeared along the full heliocentric orbit, even about the aphelion distance of 2.75 au, this feature tends to exclude the sublimation of volatile material as a cause of the activity.

Furthermore, spectroscopic observations showed a prevailing presence of dust, rather than gas, both in the coma and the asteroid tails.

Image of (6478) Gault, with its tail taken from Cassini on 2019 March 23.

A typical light curve of Gault

Carbognani et al., 2021, MNRAS, 506, 5774-5780

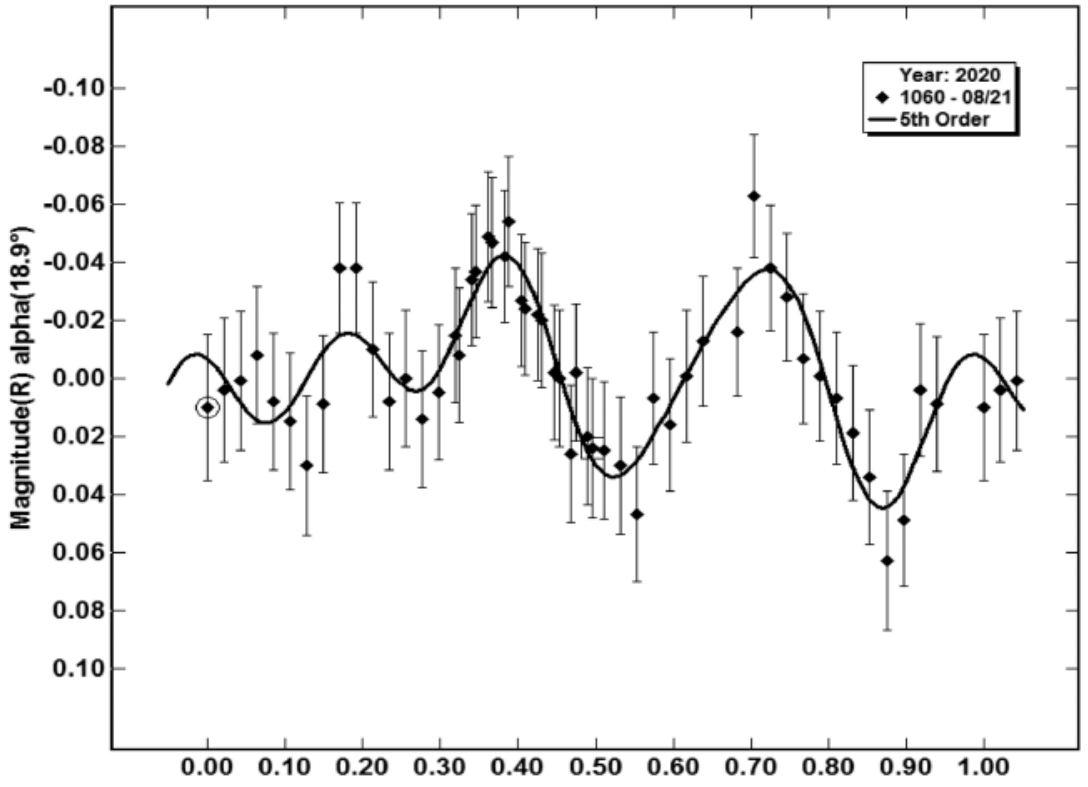


Figure 1. The phased light curves of August 22 session plotted with MPO Canopus. The best period is $2.49_{\pm 0.02}$ h, with an amplitude of about 0.09 mag. In the raw photometric data the August session has a gap of about 1 h near the end, because the asteroid passed close to a very bright background star.

Carbognani et al., 2021, MNRAS, 506, 5774-5780

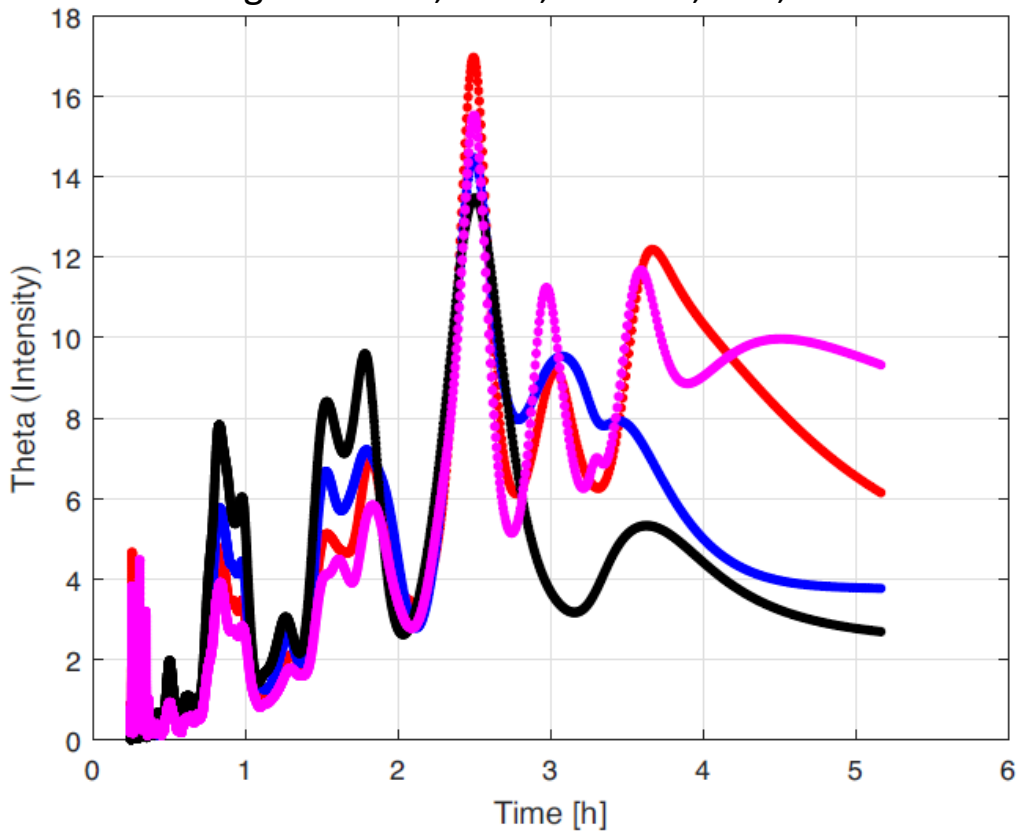


Figure 2. The period spectrum of August 22 session according to ANOVA algorithm. The power spectrum with three harmonics is the black curve, four harmonics blue curve, five harmonics red curve, and six harmonics is the magenta curve. The maximum peak is around 2.49 h.

Gault's colors

Carbognani et al., 2021, MNRAS, 506, 5774-5780

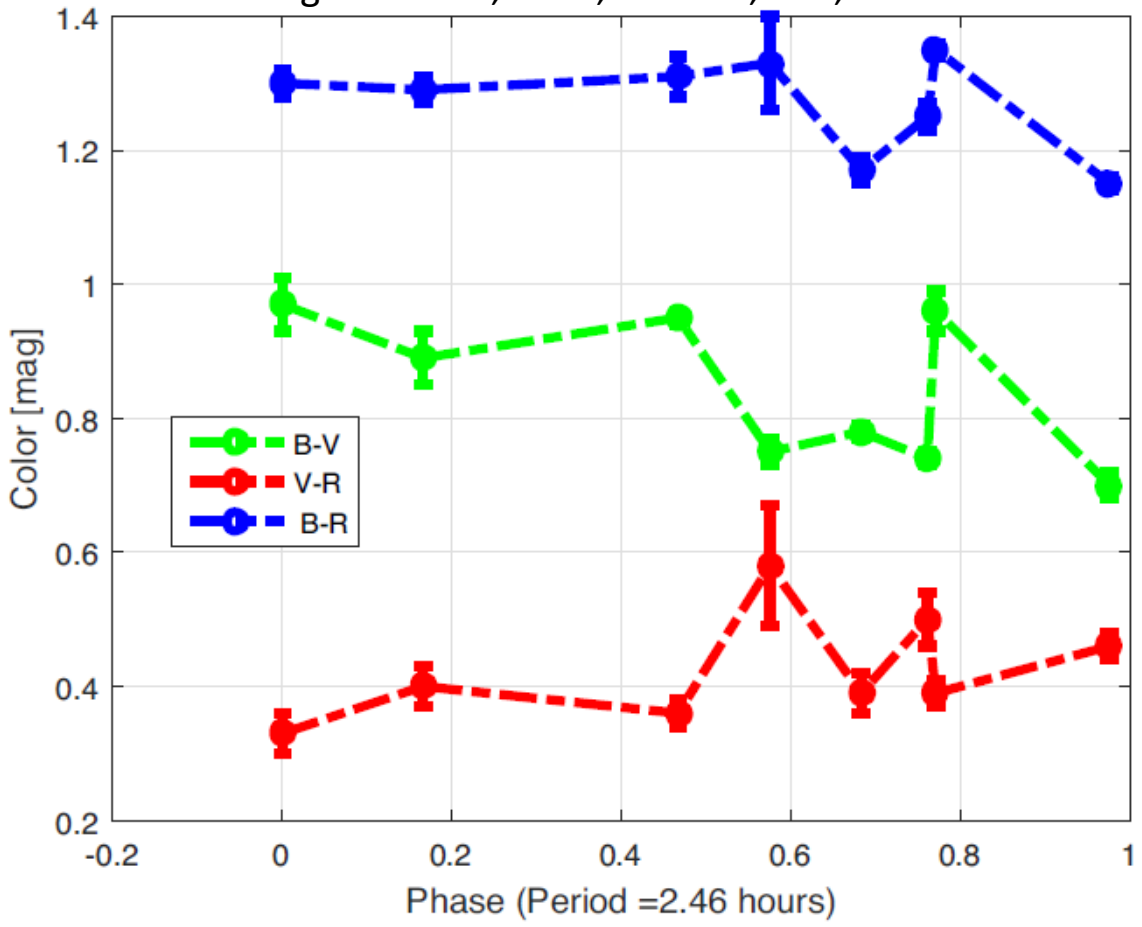


Figure 9. Gault's colours versus rotational phase with 2.46 h rotation period (light-time corrected).

From ours filtered observations we find these mean colors indices:

B − V = 0.84 ± 0.04
V − R = 0.43 ± 0.03
B − R = 1.27 ± 0.02

Which make it **very similar to an S-type** asteroid:

B − V = 0.85
V − R = 0.47
B − R = 1.32

To verify if the colors changes according to the rotational phase, we plotted the colors vs our best rotation period. It appears that colors on Gault's surface **change significantly**, apparently in a specific area of the surface.

JOURNAL ARTICLE

Spinning and colour properties of the active asteroid (6478) Gault FREE

Albino Carbognani ✉, Alberto Buzzoni ✉

Monthly Notices of the Royal Astronomical Society, Volume 493, Issue 1, March 2020, Pages 70–77, https://doi.org/10.1093/mnras/staa208

Published: 24 January 2020 **Article history ▾**

JOURNAL ARTICLE

Physical characterization of the active asteroid (6478) Gault FREE

Albino Carbognani ✉, Alberto Buzzoni, Giovanna Stirpe

Monthly Notices of the Royal Astronomical Society, Volume 506, Issue 4, October 2021, Pages 5774–5780, https://doi.org/10.1093/mnras/stab2111

Published: 23 July 2021 **Article history ▾**

Conclusions

1. The “Cassini” telescope allows us to follow NEO objects up to the apparent mag +22, thus allowing the confirmation of almost all NEOs of the NEOCP.

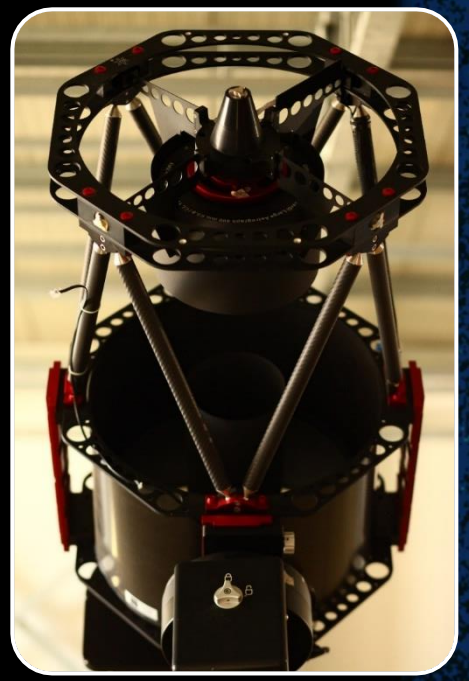
2. Useful results about dust production in long-period comets in support of the Comet Interceptor mission.

3. There were good results also with the active asteroid Gault. It is reasonable to think that small telescopes like Cassini can characterize a good part of the active asteroids in the main belt.

Thank you for your attention

The observation facilities of the GAL Hassin astronomical center

Toward a network of wide-field telescopes in Sicily

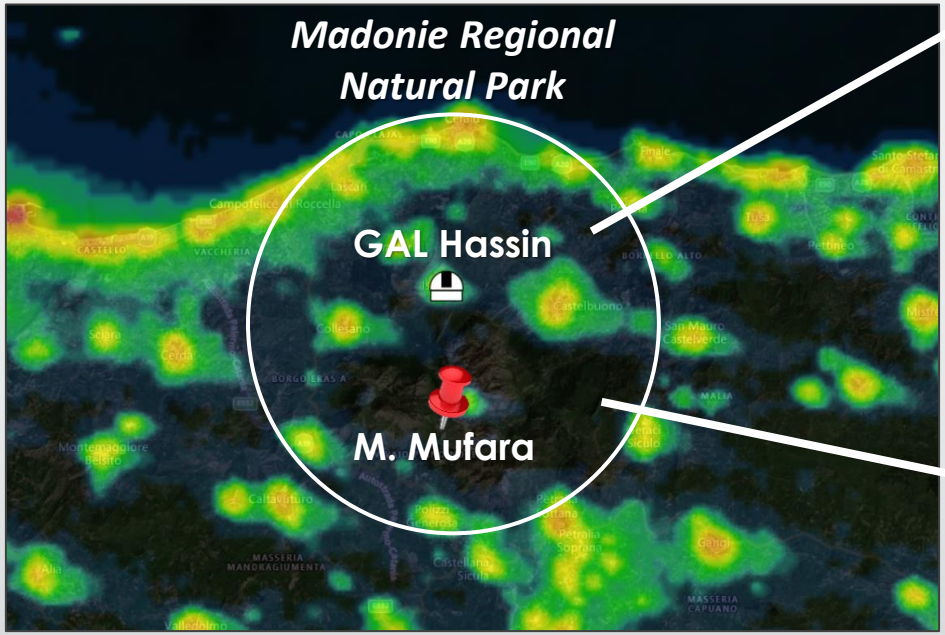


GAL HASSIN
Centro Internazionale per le Scienze Astronomiche Isnello

Alessandro Nastasi, Mario Di Martino, **Albino Carbognani**

The Madonie park in Sicily: an excellent area for astronomical research

- Excellent night sky conditions, known since the 70's.
- Very low **light pollution.**
- **>200 clear nights**/year (~60%).
- Low **latitude** (~38°).



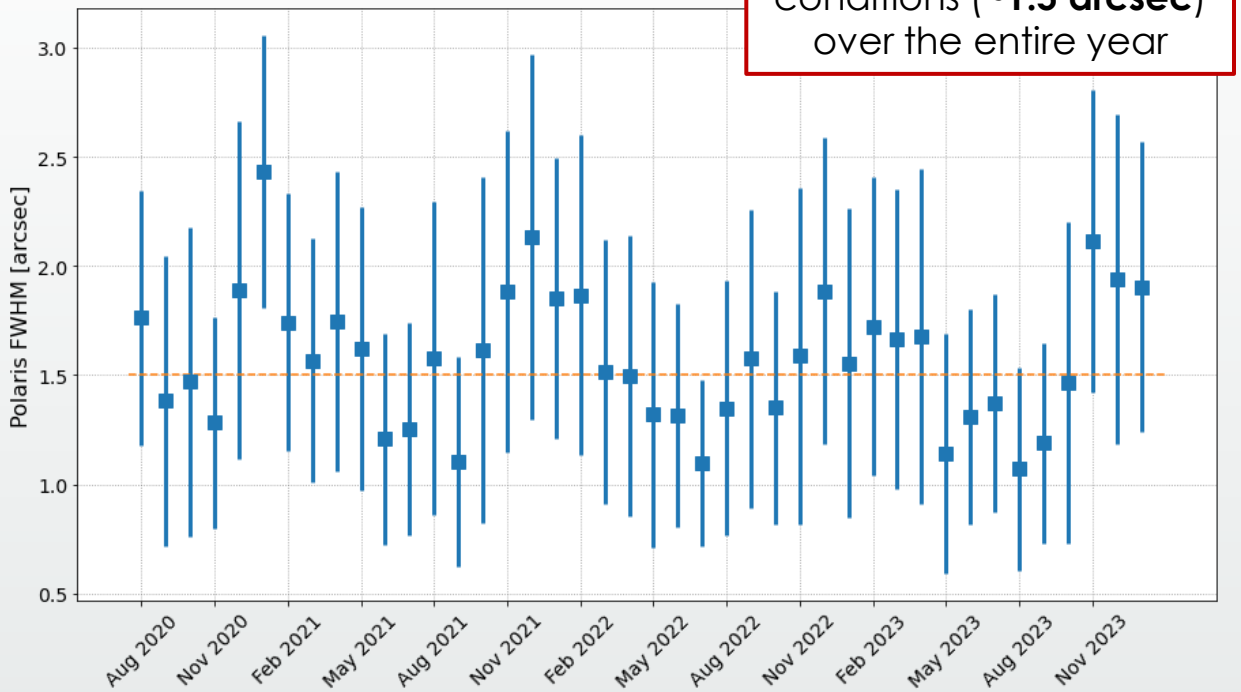
GAL Hassin astronomical center for outreach and education
Active since **2016**

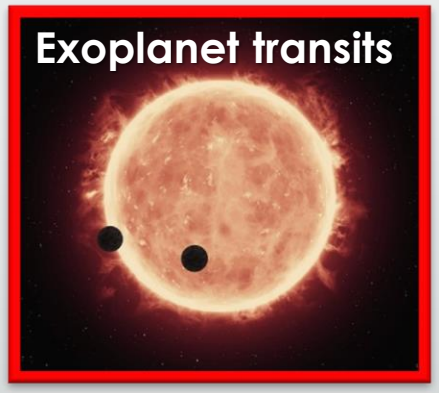
Wide Field Mufara Telescope (WMT)
Starting in mid **2024**

The **research** at GAL Hassin astronomical center

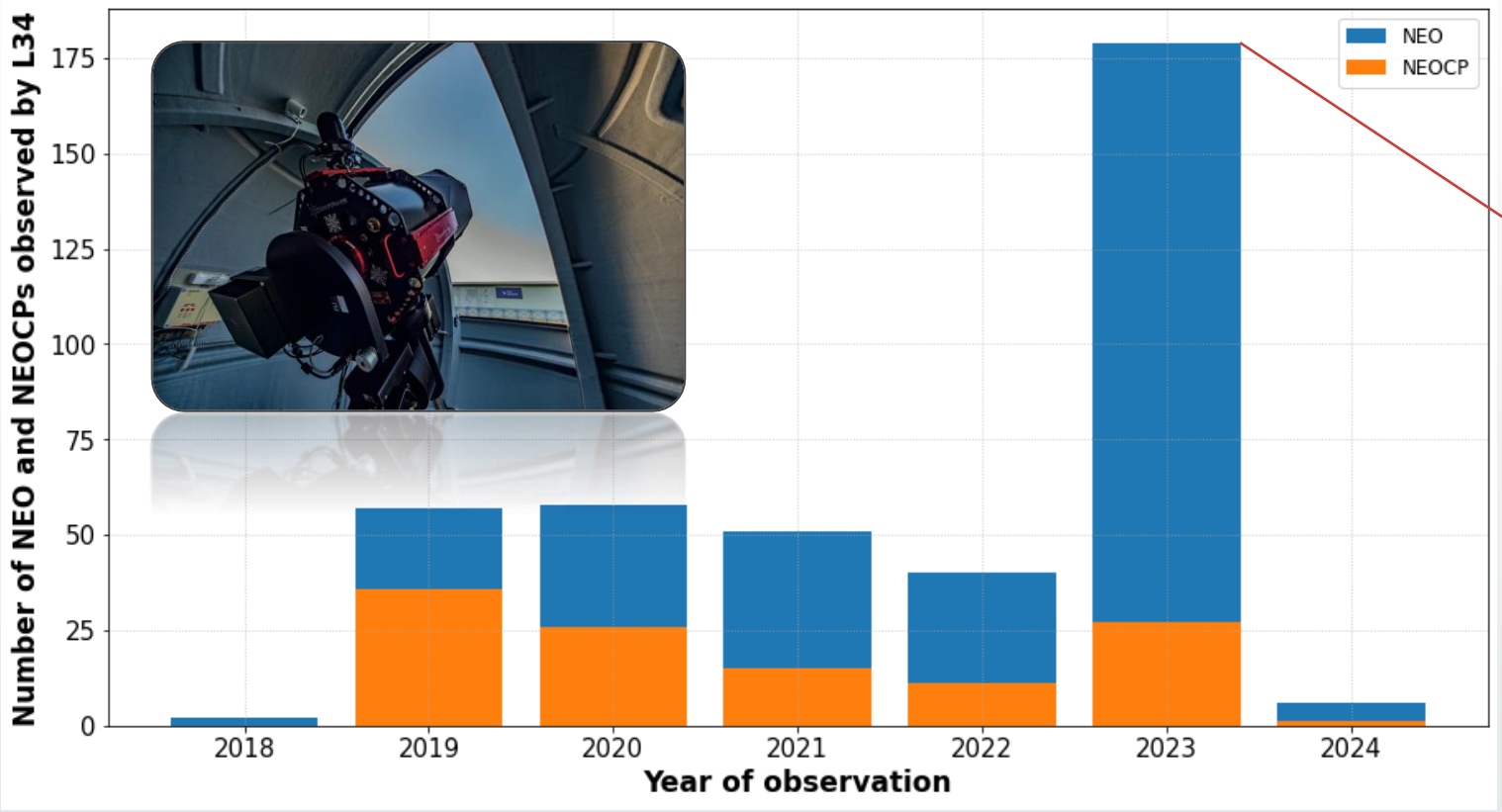
*The **Galhassin Robotic Telescope (GRT) – RC 40 cm, f/3.8***

Very good ***seeing*** conditions (**~1.5 arcsec**) over the entire year



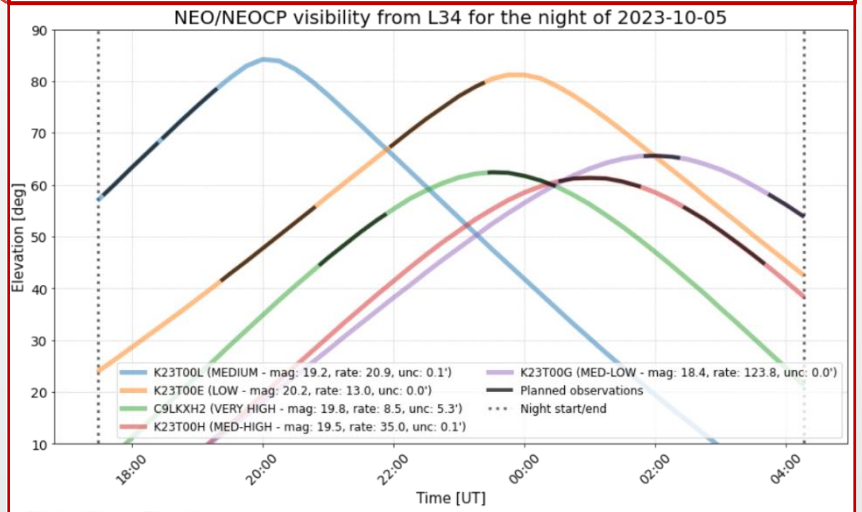


The **research** at GAL Hassin astronomical center – ***NEO monitoring***



To date ~**400 NEOs** have been confirmed & monitored with the GRT (IAU observatory code: **L34**).

2023: the GRT gets **100% automated**.




```
[16:31:07] Connecting camera.
[16:31:08] Set BINNING = 2x2
[16:31:16] Connecting TheSkyX - Scope.
[16:31:17] Unparking mount.
[16:31:17] Observing target K24A02E - set1 at 2024-01-16 17:15:00 ...
[16:31:17] Start cooling camera (T:-30°C) at 2024-01-16 17:10:00 (start in 2322 sec) ...
[17:10:01] Cooling camera at T:-30°C.
[17:10:06] Connecting Dome - Scope.
[17:10:06] Slewing to target
Slewing to RA(J2000)=02:56:00.28, DEC(J2000)=+38:24:55.50 ...
[17:10:15] Waiting 293 sec to start observing ...
[17:15:11] NEOFixer report status 'observing' for target K24A02E sent.
[17:15:11] Taking 247 x 13sec frames: 100%|████████████████████████████| 247/247 [1:16:21<00:00, 18.55s/it]
[18:31:33] NEOFixer report status 'observed' for target K24A02E sent.

[18:31:33] Moving FITS files into folder:  C:/Users/control_GRT/Desktop/GRT_images/gennaio_16_2024/K24A02E/set1
[18:31:35] Observing target K24A02E - set2 at 2024-01-16 18:35:00 ...
[18:31:35] Slewing to target
Slewing to RA(J2000)=02:55:55.70, DEC(J2000)=+38:39:34.35 ...
[18:31:35] Waiting 204 sec to start observing ...
[18:35:02] NEOFixer report status 'observing' for target K24A02E sent.
[18:35:02] Taking 247 x 13sec frames: 100%|████████████████████████████| 247/247 [1:16:19<00:00, 18.54s/it]
[19:51:22] NEOFixer report status 'observed' for target K24A02E sent.
```

The **research** at GAL Hassin astronomical center – ***Exoplanet transits***

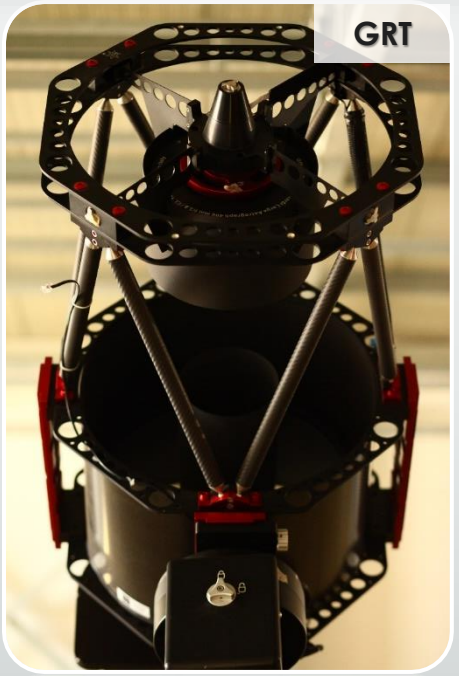
ARIEL SPACE MISSION

ExoClock

a project by the ARIEL Ephemerides Working Group

ExoClock: a project coordinating 800+ observatories from 20+ countries, to monitor the transits of hundreds of exoplanets, and thus determine their **accurate ephemeris** for **ARIEL 2029** mission.

GAL Hassin has been engaged in ARIEL-ExoClock since **2019**, with its robotic telescopes.



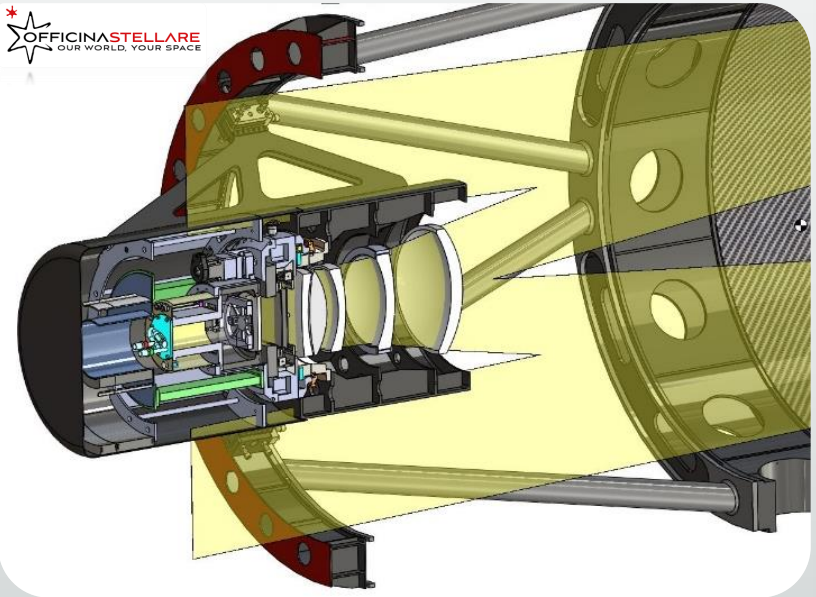
GRT2: hosted at GAL Hassin from 2019 to 2022, owned and controlled by **Dr. Carmelo Falco** (E. Majorana Association, AG)

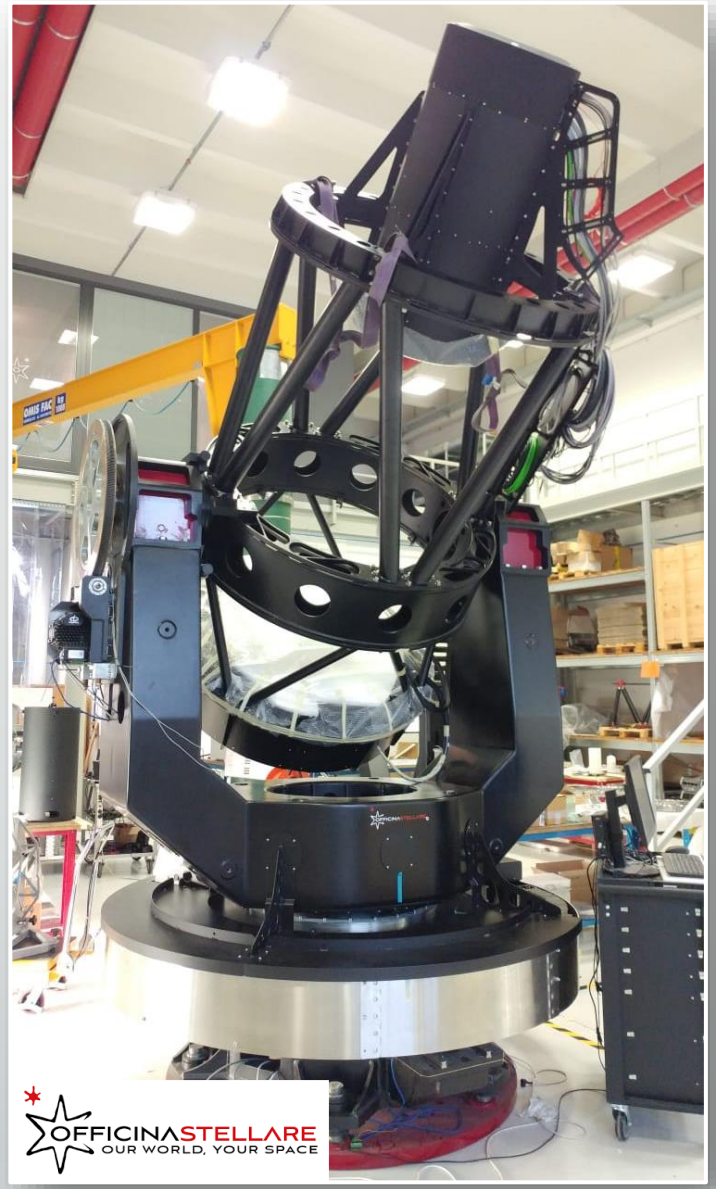
The *upcoming* Wide-field Mufara Telescope (**WMT**)

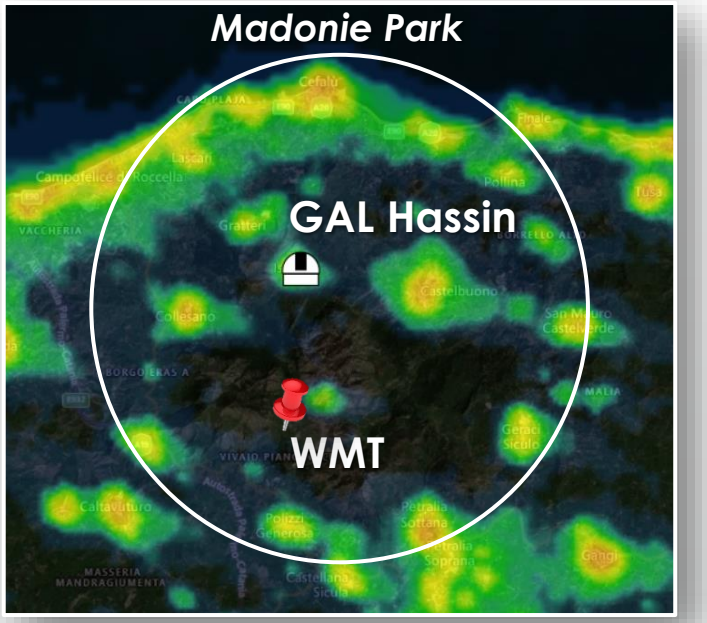
A **prime-focus** telescope, with an aperture of **1 meter** and a low focal ratio **f/D = 2.1**.

Optical distorsion corrected with five lenses.

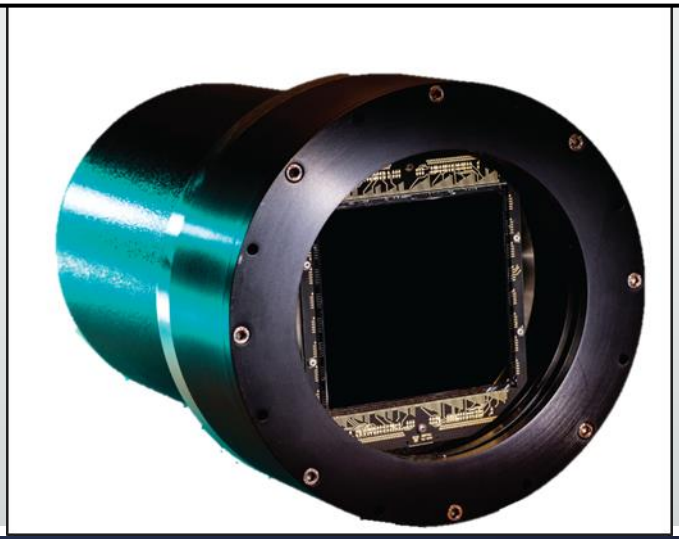
Derotation system.



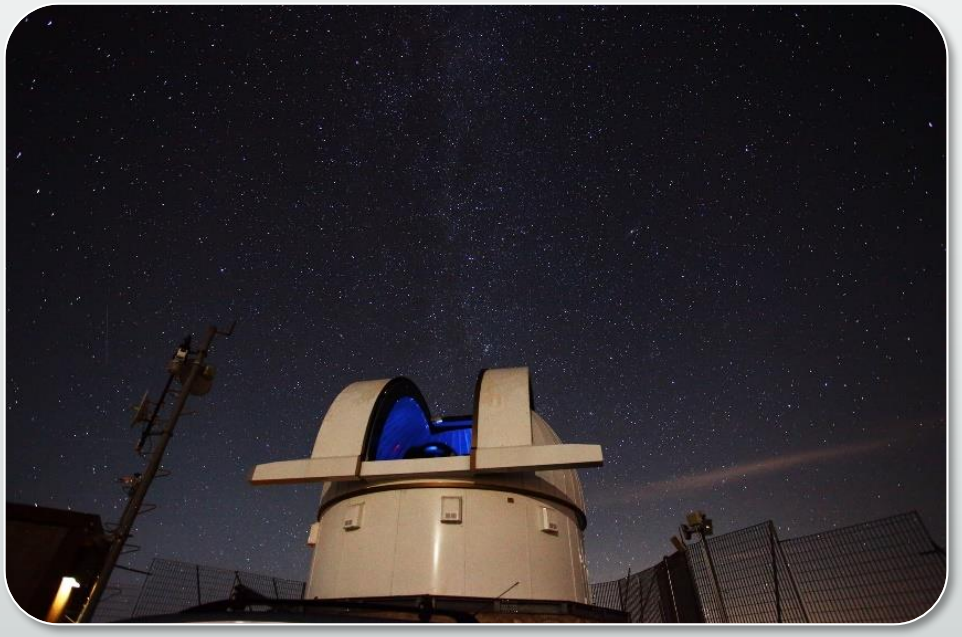




9k x 9k 10µm pixels, cryocooled, >90% QE
CCD camera (scale: **1''/px**).

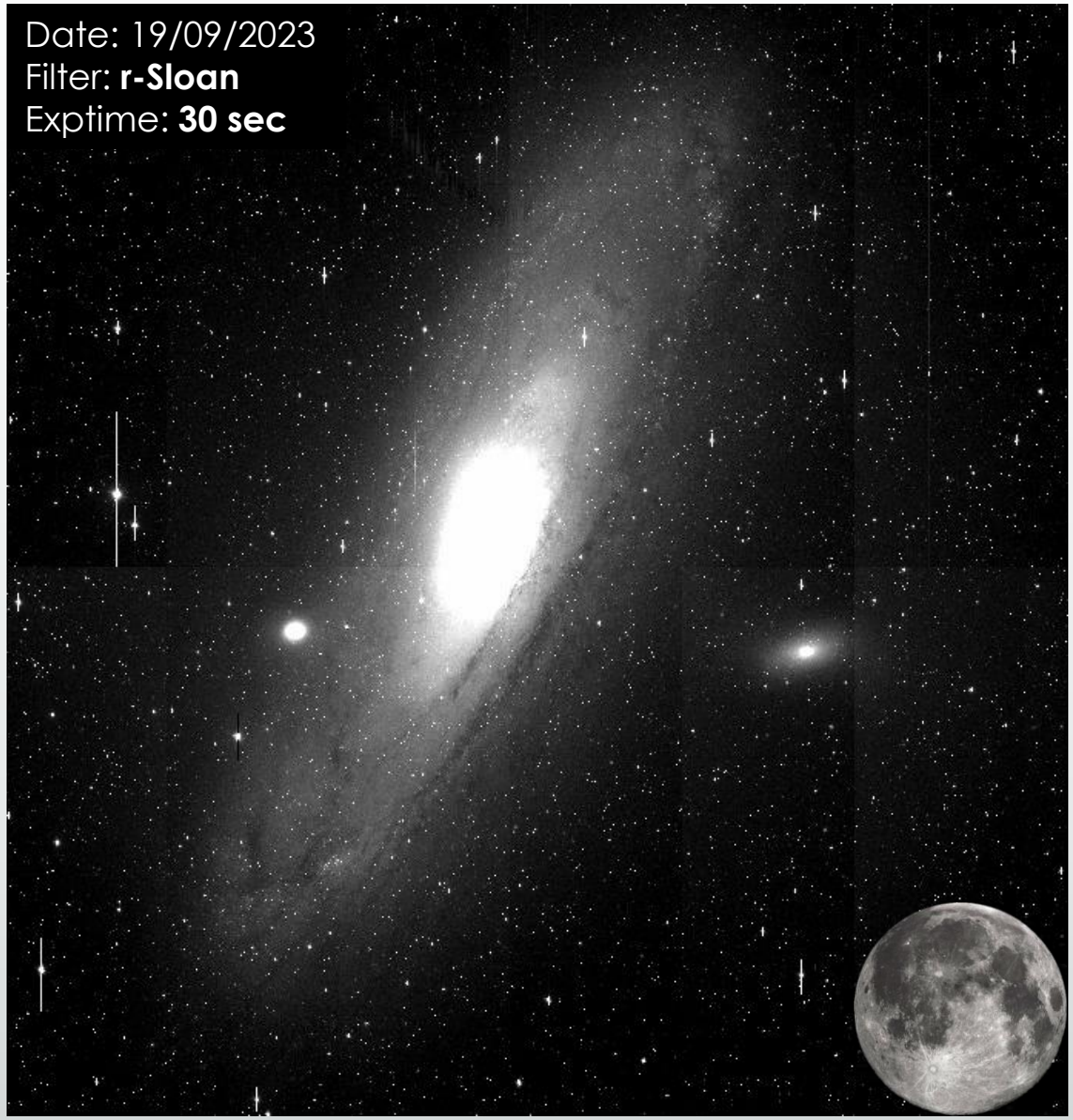


The *upcoming* Wide-field Mufara Telescope (**WMT**)

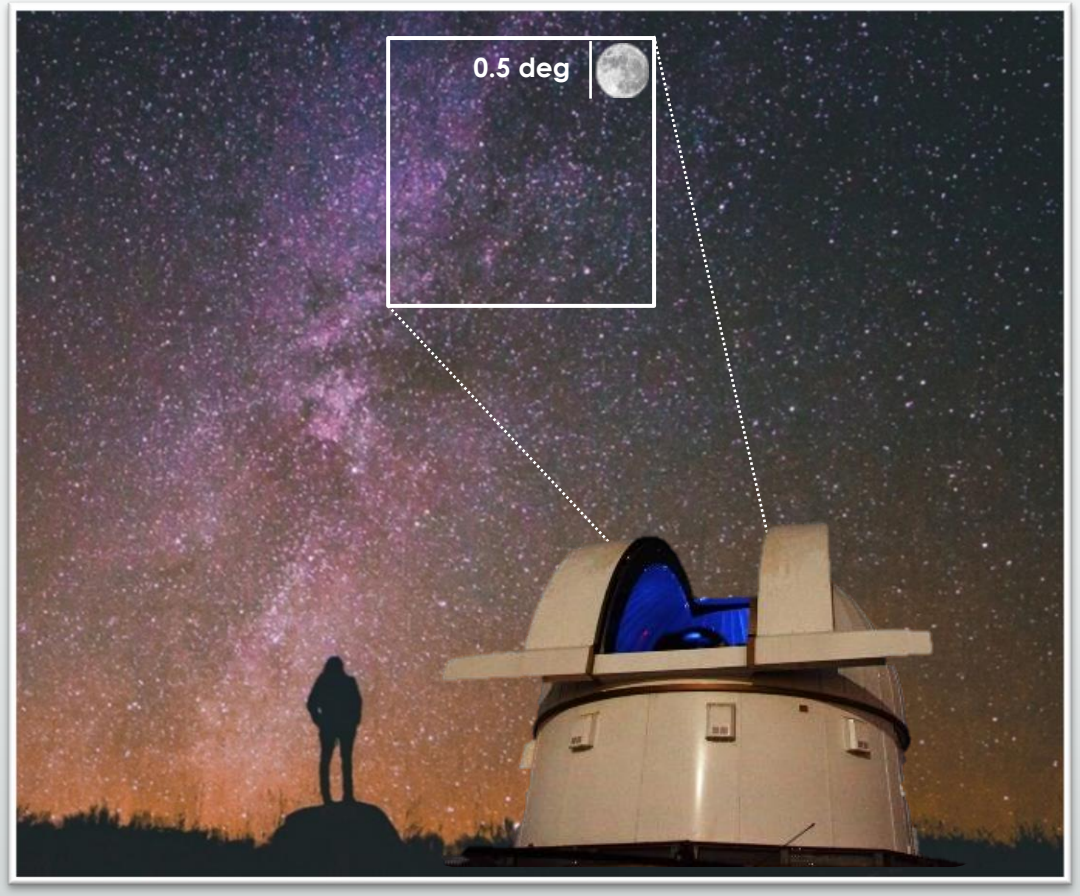


- Commissioning phase **completed** in June 2023.
- IAU observatory code: **M57** (Aug. 2023).
- Waiting for **remote control** activation and **last tests**.

The *upcoming* Wide-field Mufara Telescope (**WMT**)



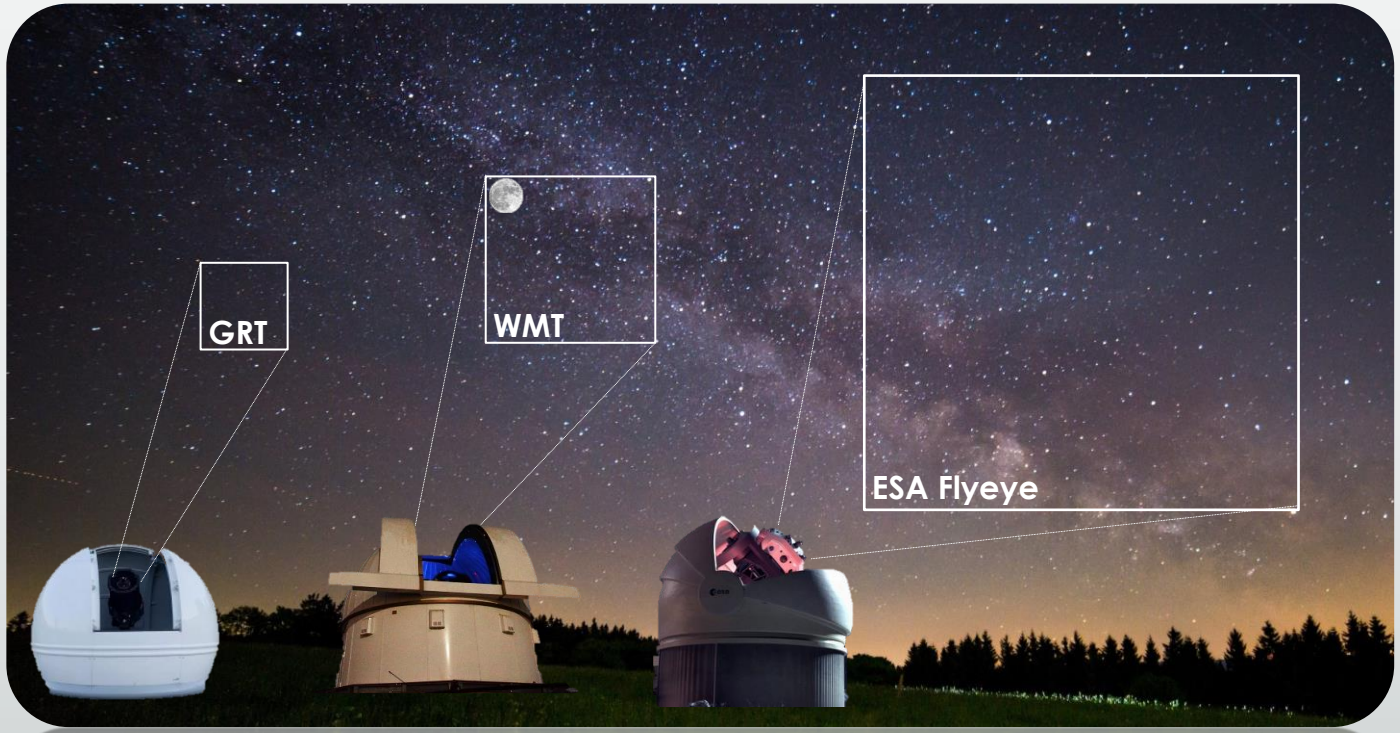
- Field of view: **2.5 x 2.5 deg** (25x full moon size), **corrected.**
- **V ~ 21** in **60 sec** (Clear filter).

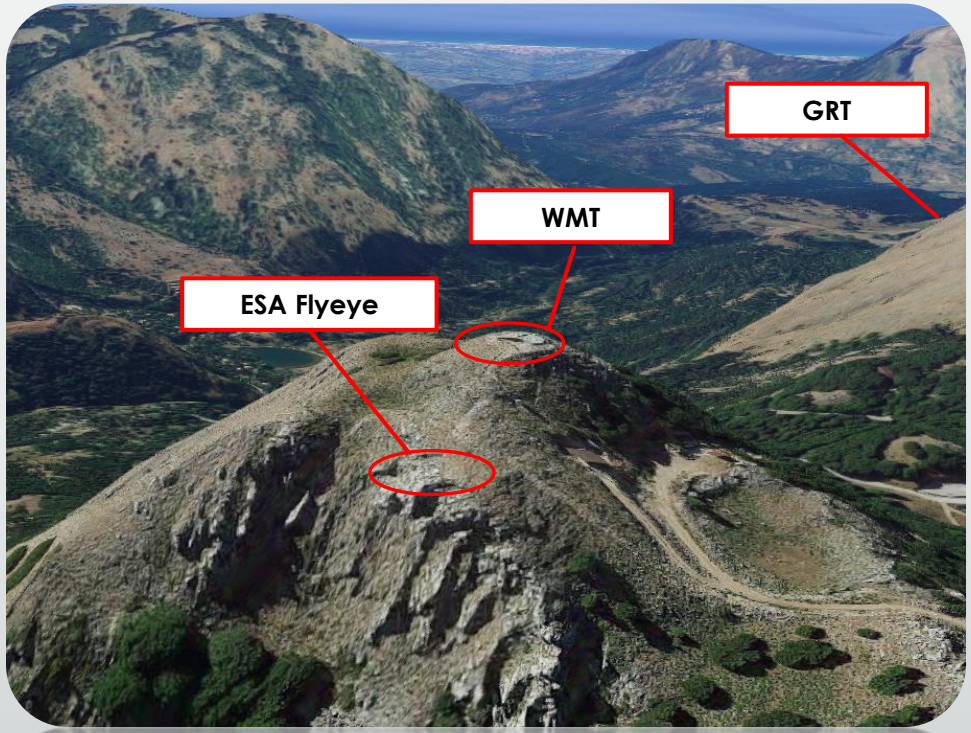


A **network** of wide field telescopes soon active in Sicily...

WMT & Flyeye will work in **synergy** as **complementary** facilities:

- **Simultaneous activities**, having the same weather conditions.
- WMT will offer prompt **confirmation** and **photometric characterization** of targets discovered by the **Flyeye**.
- A unique network of telescopes in the **Mediterranean area**.





Thank you

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- alessandro.nastasi@galhassin.it