

# OAPD Days 27-28 Oct 2024

## Optical Space Surveillance and Tracking (SST) and Space Situational Awareness (SSA)

- Osservazioni ottiche e studio sensori ottici a largo campo -

**C. Arcidiacono, S. Zaggia, M. Simioni, M. Dima, M.  
Gullieuszik, R. Sordo, L. Tomasella**  
**INAF - Osservatorio Astronomico di Padova**

Sala  
multimediale



*The research activities described were performed within the ASI-INAF Contract N. 2023-50-HH.0 "Detriti spaziali e sostenibilità delle attività spaziali a lungo-termine"*

# A new team for Space Debris monitoring in OAPD

- Matteo Simioni (AdR, on MICADO)
- Marco Dima, Mechanical Design and Mechanical Solutions
- Marco Gullieuszik, Observing Strategies
- Rosanna Sordo, PA/QA
- Carmelo Arcidiacono, Simone Zagari



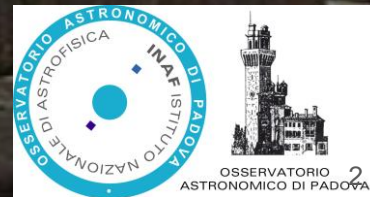
## Observations supported by:

- Enrico Cappellaro
- Paolo Ochner
- Lina Tomasella



## Other involved persons:

Silvio di Rosa, Roberto Ragazzoni, Demetrio Magrin [*MezzoCielo*]



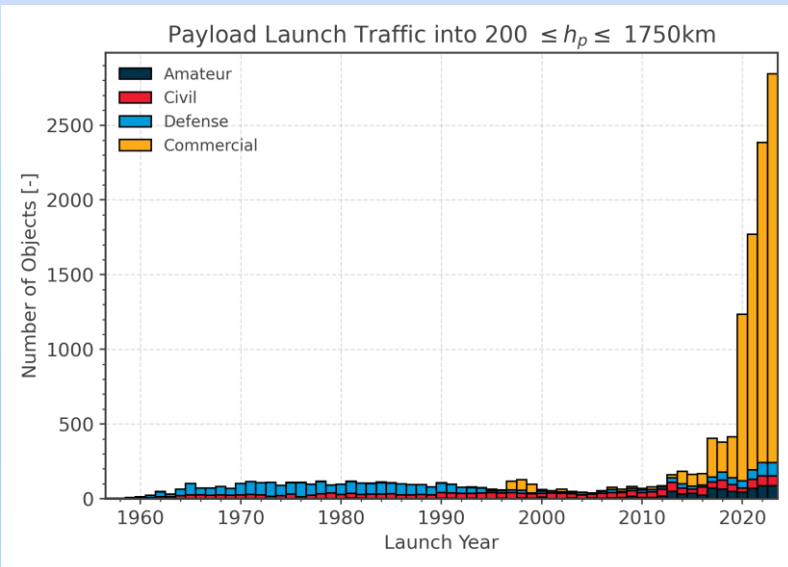


# Low Earth Orbit – LEO congestion

Space debris objects numbers:

- **40,500** - for sizes larger than 10 cm
- **1,100,000** from greater than 1 cm to 10 cm
- **130 million** from greater than 1 mm to 1 cm

[<https://sdup.esoc.esa.int/discosweb/statistics/>]

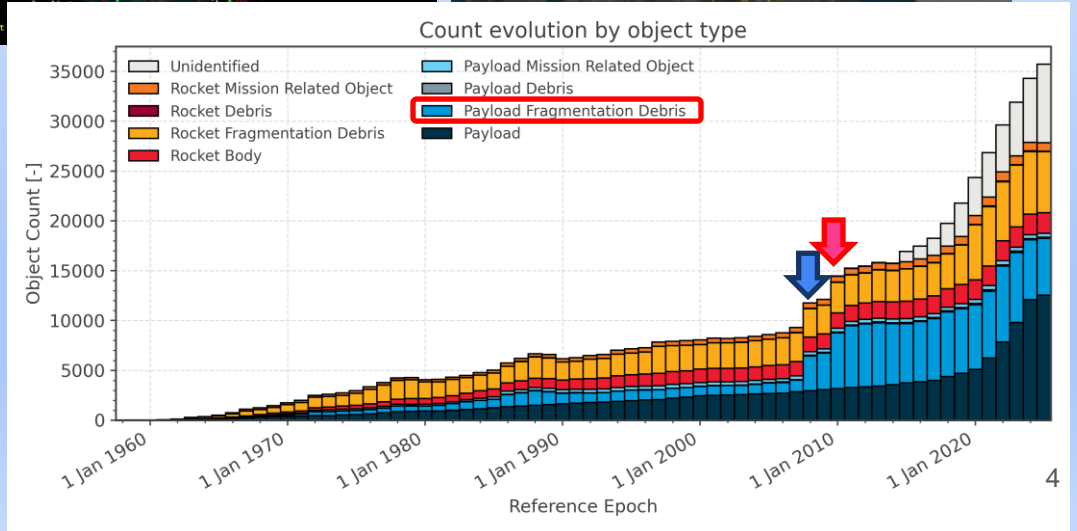
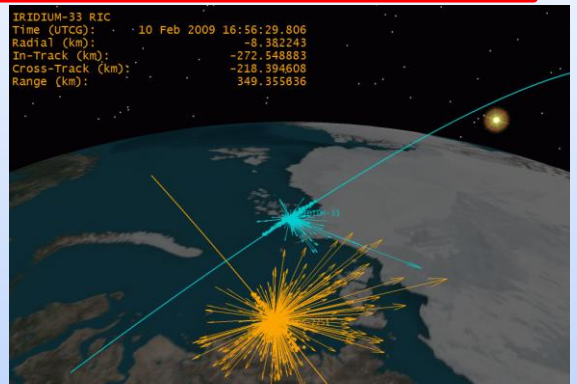
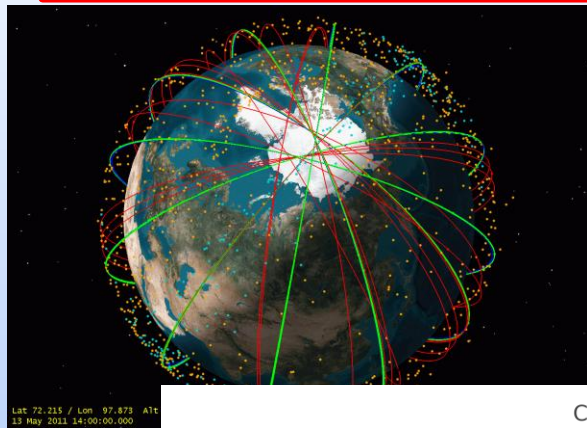


Human-generated orbital debris number is growing: the North American Aerospace Defense Command (NORAD) tracks more than **43,000** space objects as of April 2024. As for active satellites, there are more than 7,500 as of Jun 2023 most of them members of SpaceX's giant Starlink broadband mega constellation.



ISS controllers have had to move the space station out of the way of debris more than 30 times since its first modules launched in 1998. The guidelines are strict, necessitating a maneuver if any debris arrives in a "pizza box" 4 by 50 by 50 kilometers with the ISS at the center.

A fraction of the debris derives from fragmentation events.  
 I.e. Intentional explosion Chinese ASAT Test 2007 ~2000 fragments  
 I.e. Cosmos/Iridium Collision in 2009 ~2000 fragments (1-100cm sizes)

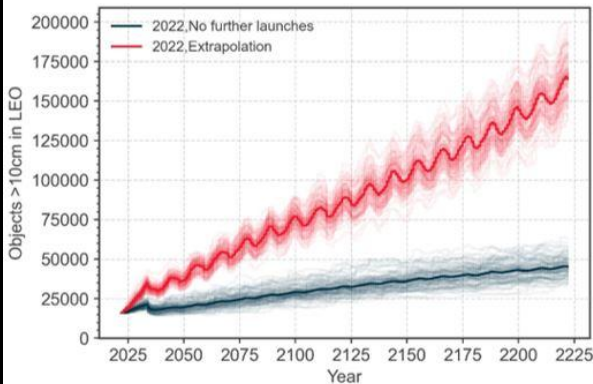


# Inter-Agency space Debris Coordination committee (IADC)

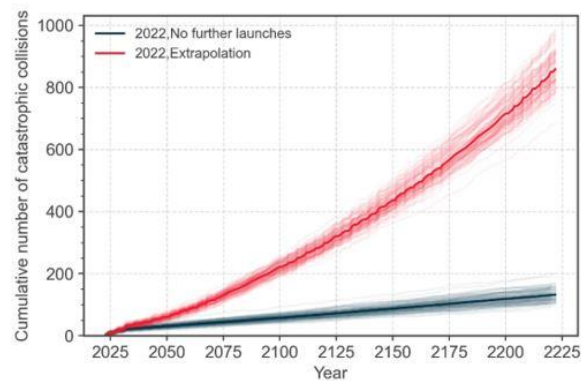
**The Inter-Agency Space Debris Coordination Committee (IADC)** is an international forum of space agencies for the worldwide coordination of activities related to the issues of man-made and natural debris in space.

The IADC also develops **guidelines for debris mitigation**, supports the development of national and international standards

ASI is part of the IADC ....



*Number of objects larger than 10 cm in LEO in the simulated scenarios of long-term evolution of the environment.*



*Cumulative number of catastrophic collisions in LEO in the simulated scenarios of long-term evolution of the environment.*



# ASI+INAF – Agreement “Detriti spaziali e sostenibilità delle attività spaziali a lungo-termine” 2024-2026

## INAF OAPD Contribution:

- Use of the Asiago telescopes for the collection of observational data of artificial objects (operational and non-operational) in the various orbital regimes, from LEO to GEO.
- Photometric and spectral characterization of artificial objects.
- Support to the ASI in the development of new observational sensors.

Others INAF institutes: OAPA, OAS, **IRA that is coordinating the activities**

## Other tasks, not INAF - OAPD:

- Development of analysis SW for re-entry prediction, orbit determination, collision risks, fragment evolution.
- Development of descriptive and predictive theoretical models of the spatial environment.
- Research on ultrafast impacts and catastrophic and non-catastrophic collision models.
- Support to ASI as part of the international IADC collaboration.



# SPACE DEBRIS LARGE PROJECTS

Thanks to the **EU Recovery Fund**, three large projects devoted to the space debris have started



**Project n°1:** Development of an **optical telescope network** for detection and tracking

- 'Flyeye' telescope, already selected by ESA for NEO
  - 16 optical cameras and 45 square degrees
- ✓ To be placed **worldwide** thanks to **international collaborations**
- ✓ Deployment completed **by June 2026**



Credit: OHB S.p.A.

# INAF OA Padova, follows the development of the FlyEye telescopes since the beginning. INAF-OHBI patent.

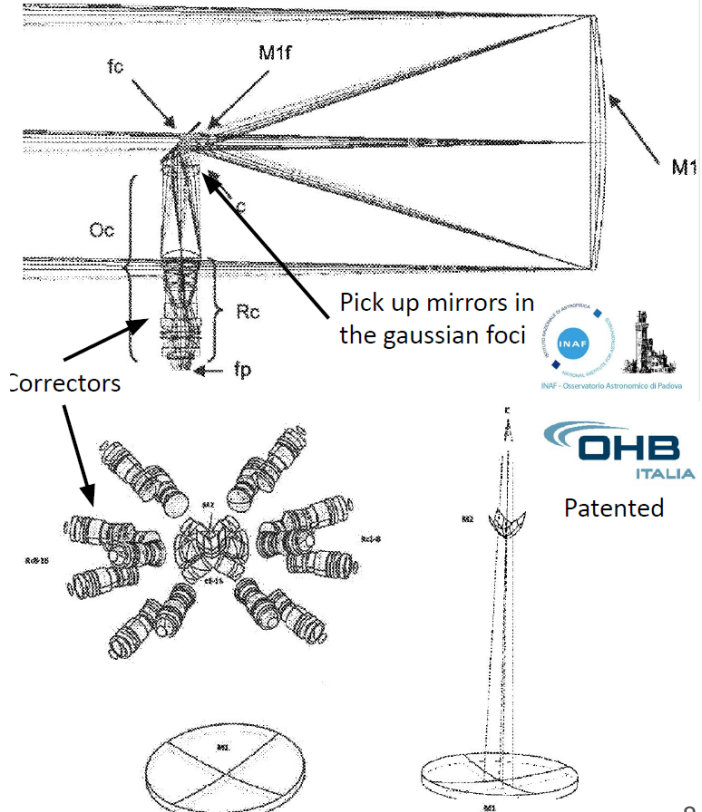
A commercial contract (it's now the third of this kind) establishes the support the INAF-OAPd provides to OHB-I for the deployments of the first FlyEye telescope, namely the ESA's NEOSTEL.



SPACE SAFETY

## Flyeye: ESA's bug-eyed asteroid hunter

21745 VIEWS 42 LIKES





# *WP ASIAGO Optical observations*

The INAF + ASI agreement implements different Work Packages, dedicated to

4.1 *Cameras installation* – Upgrading Detectors suite available in Asiago

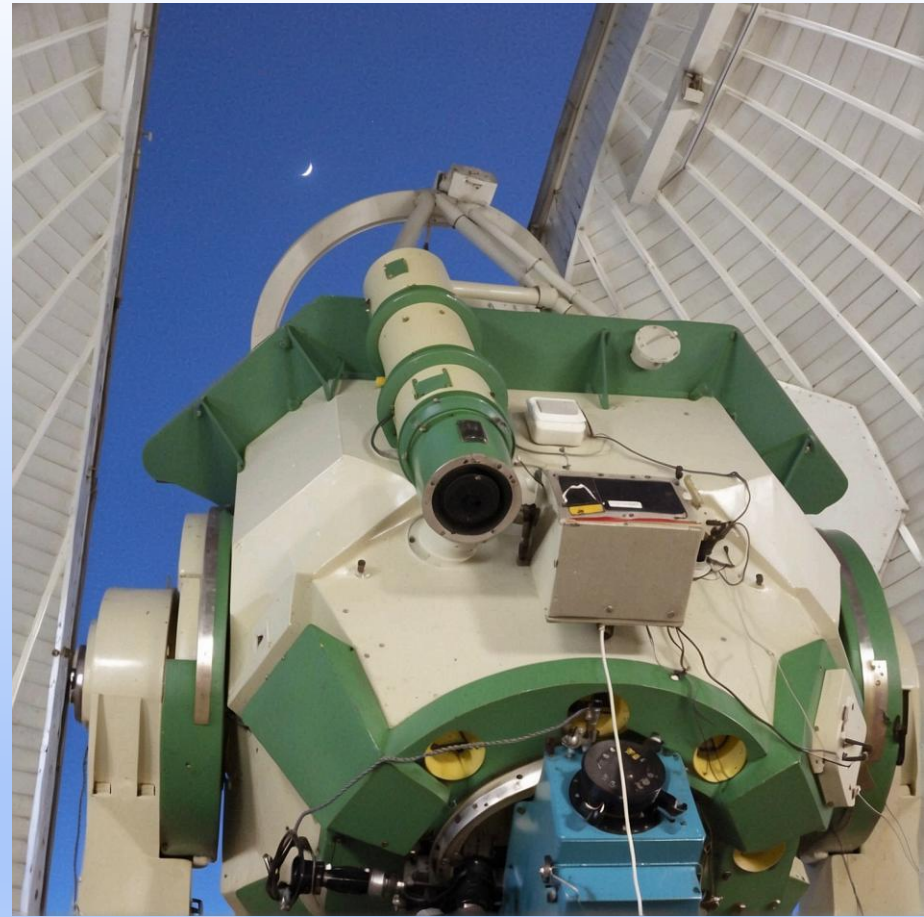
Marco Dima, Simone Zaggia

4.2 *Optical observations* from Asiago – Survey and Monitoring of Space Debris

Simone Zaggia, Marco Gullieuszik

4.3 Review FLYEYE ASI – Servicing as referee for the reviews and advancements of the four ASI's FlyEye

Carmelo Arcidiacono, Matteo Simioni



# *Cameras installation* – Upgrading the Detectors

Collecting funds: 110k for upgrading

**CCD Copernico - 90000**

CMOS Schmidt Moravian C5series - 20000 (standby)

## **Upgrade AFOSC@Copernico**

- Less noise and better reading speed
- Increased spectral coverage in the bluer bands
- Increased efficiency and reduced noise
- Greater sensitivity for all installed filters
- Reduction of reading time to improve efficiency in short exposures



**Purchase of the Andor iKon-L 936 model BEX2-DD camera, latest version of the model in use, but updated in terms of electronics and overall performance**

The cost of the BEX2-DD camera is €81,600 plus VAT. Purchase procedure in progress.

# WP4.2 *Optical observations* from Asiago

## Telescopes Used

- **Telescopio Schmidt 67/91cm:**
  - High orbit debris follow-up
  - Diff. Tracking up 7200"/h
  - Field of view: 1 square degree
  - Equipped with 4kx4k CCD and various filters
- **Telescopio Copernico 182cm:**
  - Remote observations
  - AFOSC (imaging and spectroscopy) and ECHELLE (high resolution spectroscopy modes)

- Tracking implementation linked to space-track.org
- Schmidt telescope autonomous observations in robotic mode
- Copernicus telescope remote observations, supported by INAF-OAPD astronomers
- Simultaneous use Schmidt and Copernicus to study complete orbit and spectral characteristics of space debris

## Output e Deliverables

- Deliverables: reports, images, raw data, documentation review FLYEYE telescopes
- Delivery of observational data and photometric tables



# OBSERVATION ACTIVITY - PROPOSAL «Space Debris»

- Every two years the Padua Observatory issues a "Call" for the use of the Schmidt and Copernicus telescopes.
  - The new call was almost coinciding with the formal start of the INAF+ASI agreement at the end of 2023.
  - "Space debris and sustainability of long-term space activities" program foresees the combined use of the Copernico and Schmidt telescopes of Cima Ekar for a maximum of 4 nights per month for the Copernicus and 270 hours per year for the Schmidt
- The time allotment is valid for 2 years starting February 1, 2024

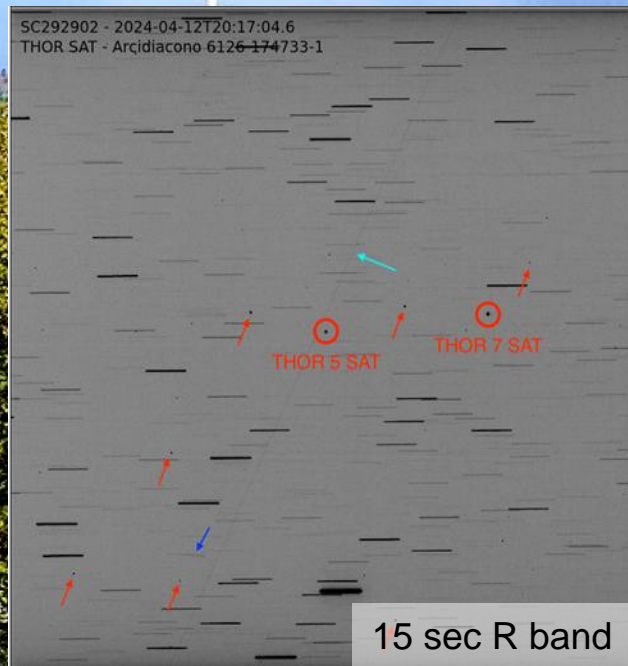
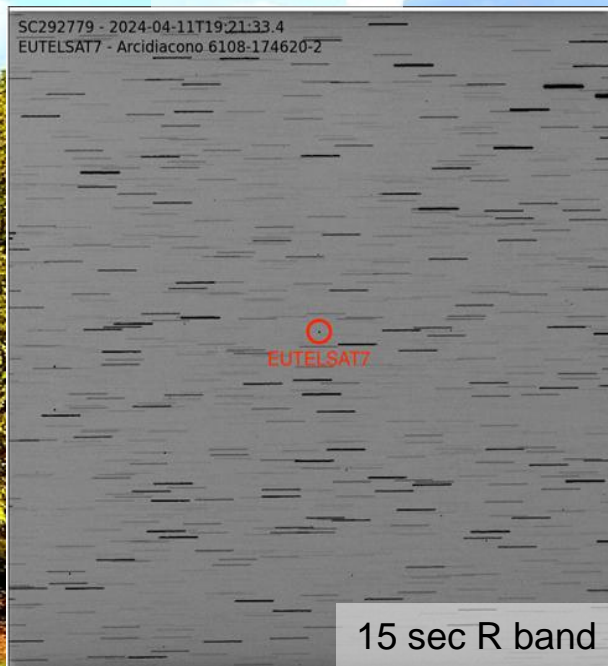
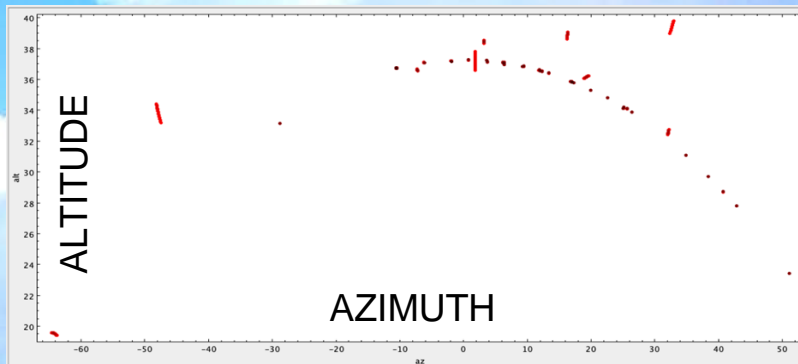
# Observations of GEO satellites

Cupola

1x1 deg FoV

To pave the road to Copernico Spectroscopy Observations we routinely monitored a few GEO Satellite in a static Alt-Az pointing mode.

What will be interesting is the build luminosity curve for different Sun/Satellite/Earth angle in different filters.



# GEO – Robotic Schmidt Upgrade

The robotic mode of the Schmidt telescope has been adapted to be able to observe GEO satellites.

- Activating AltAz telescope pointing mode.
- Activation of high priority program to "fool" the observation algorithm.
- Time observation window setting useful for maximizing the possibility of observing

*Credits to Enrico Cappellaro*



INAF - Astronomical Observatory of Padova

Mount Ekar Observing Station

Schmidt: N45° 50' 58.000" E11° 34' 07.772" - 1369.9m a.s.l.

Robotic Telescope Mode Input

0.1h (monthly maximum 45.

AltAz Epoch



2000.0 ▾

Priority

high 8 ▾

Guider



Alt limit [de

30

submit OB



# 26106 fragmentation event

Within the Inter-Agency Space Debris Coordination Committee (IADC), an observational campaign was activated to characterize a fragmentation.

Coordinated by the Rome La Sapienza group Prof. Fabrizio Piergentili for IADC-Italy.

First test to verify the needs to perform this type of observations.

Explosion of a tank of a non operative Fregat upper stage.

## Information about this event:

- <https://twitter.com/mickeywzx/status/1777734423318089924>  
(Observed a fuzzy cloud with angular Dia. 0.5 deg, at 2020 UT Apr. 8 when it reached apogee picking up sunlight)
- [https://twitter.com/s2a\\_systems/status/1783479935715152030](https://twitter.com/s2a_systems/status/1783479935715152030)  
(We come back to this event, detected by @mickeywzx, a few days ago. We created a light curve of FREGAT R/B CLUSTER 2 on 11.04.2024 at 19:00 UTC. That was before a possible second event that @shell\_jim suspected. Follow-up measurements from 23.04.2024 show a significantly accelerated rotation. It therefore seems very likely that a second event effectively occurred after April 11, which confirms Jim's theory.

**RUSSIA** – On or after 8 April, a 24-year old Russian Fregat rocket body (R/B), (SATID 26106), unexpectedly experienced a probable low-energy outgassing event. Continued observations indicate the R/B orbit, a highly elliptical track with apogee/perigee of 17281/456 km, was significantly altered around 11 April, resulting in the fragmentation of this object. Russian orbital catalog data suggests there are more than 30 pieces of debris newly observed after this event. More detailed information is anticipated in the coming days as Russian and American sources continue to monitor this event.

2024-04-08 20:17-20:24 UT

~10 minutes after the event,  
flashing at sunlight

# Survey campaign: Italian involved observatories

The observational campaign involved telescopes from the **DIMA** network of observatories as well as those from Isnello (**GRT**) and Asiago (**SCHMIDT**).

Two strategies were employed:

**Non sidereal TLE tracking** to perform **characterization of motion of the parent body** via light curve.

**Survey** sidereal strategy specifically designed to observe the fragmentation event **to detect fragments**.

**Period** of the observations:

- Start: 2024-05-03
- End: 2024-05-10



**SCHMIDT**



**GRT**

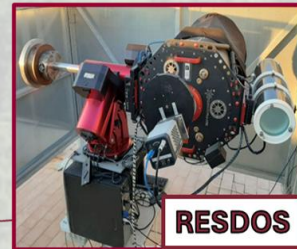


**ASIAGO**

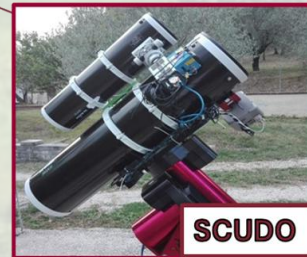
**ROMA**

**COLLEPARDO**

**PALERMO**



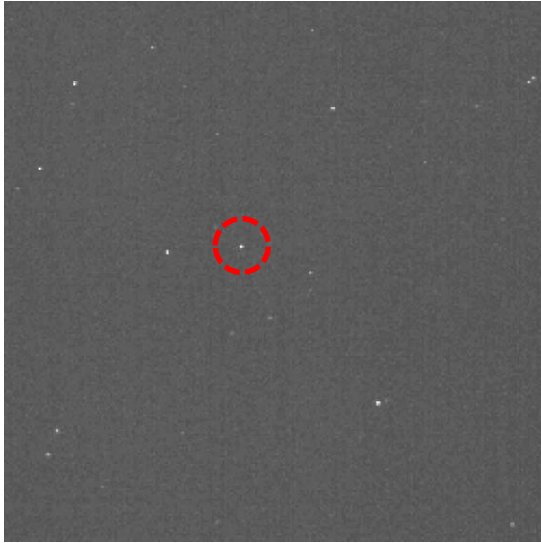
**RESDOS**



**SCUDO**



# Observation for light curve measurements

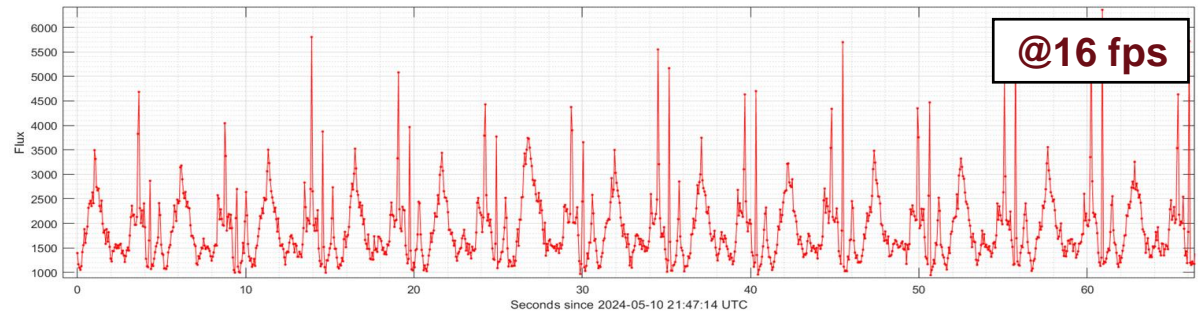


in object tracking at apogee,  
with a high cadence camera



NORAD ID	26106
Int. Design.	2000-015A
Fragmentation epoch	2024-04-08T20:17:00.000 2024-04-08T20:24:00.000
Type	Explosion/Breakup

Explosion followed by slow outgassing, which speeded-up the rotation period.

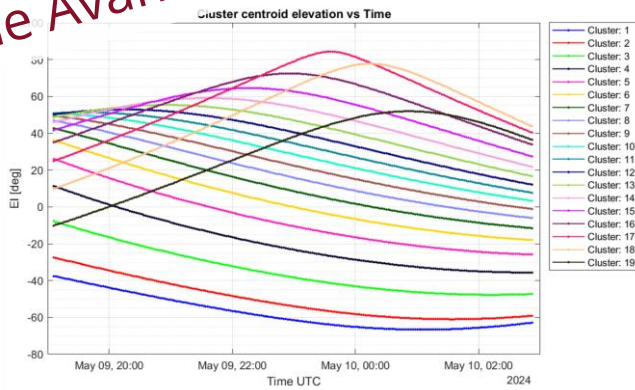
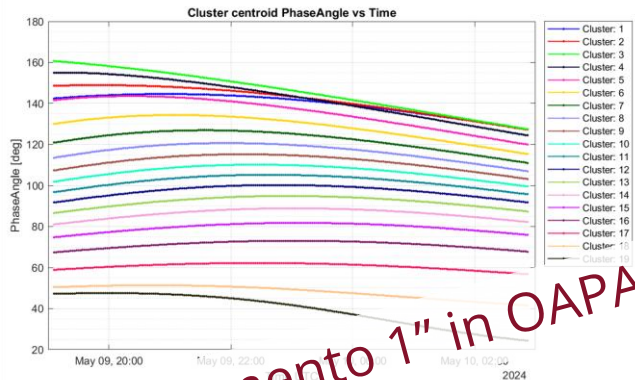
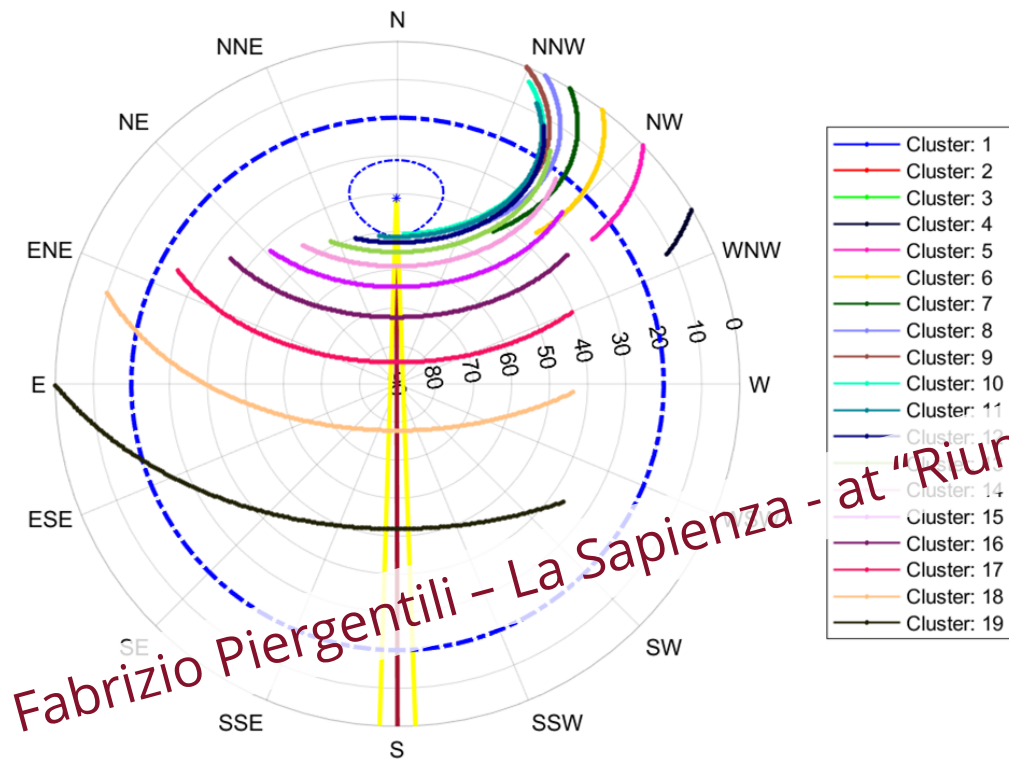


This kind of observations are beyond typical setup of MORAVIAN Schmidt detector



# IT 39.2 - Permanent IT on fragmentation

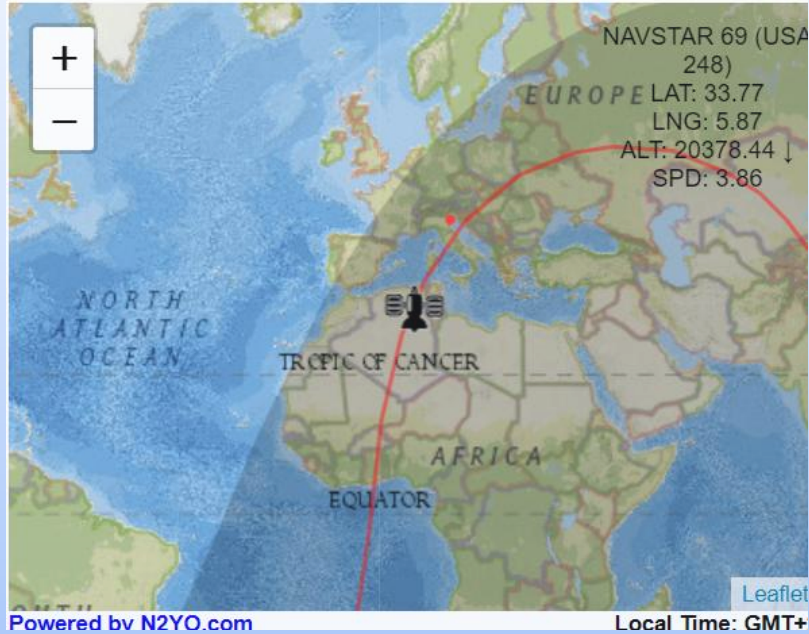
Observation of optimal region



Fabrizio Piergentili - La Sapienza - at "Riunione Avanzamento 1" in OAPA

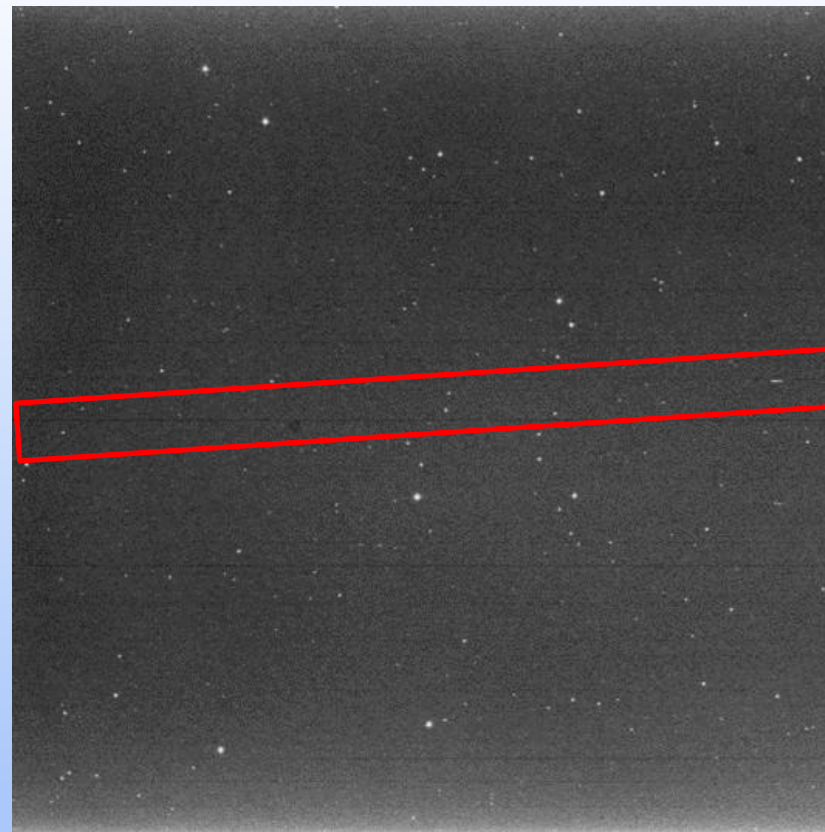


# Calibrations



The calibration of the actual time of the exposures is critical for the orbit parameters determination.

We are collecting data to determine the characteristics of the temporal bias by observing very well-known objects as the global navigation satellite system (GNSS).



The observing session starts with calibration satellite observation.  
Example of NAVSTAR (ID 40105) 19-05-2024

# IT 39.2 - Permanent IT on fragmentation

## Agencies contributions

### ASI:

- Parent body: Multiple optical sensors used for **light curve at 7 and 16 fps**. Extremely fast rotation observed in light curve at 16 fps.
- Survey: **Simulated debris cloud and developed 19 clusters to survey**. Thousand of images was collected from all the observatories involved.

### SSAU:

- Parent body: Observation from 2 sites with **8 light curves acquired at 10 fps** from 28th April to 4th May + 1 from UKSA.
- Highlighting the difficulty of such high spin rates using 0.1 seconds of exposure.

### UKSA:

- Parent body: **8 passes recorded with Neuromorphic sensor**.
- Interesting results but can't share the raw data.

### ROSCOSMOS:

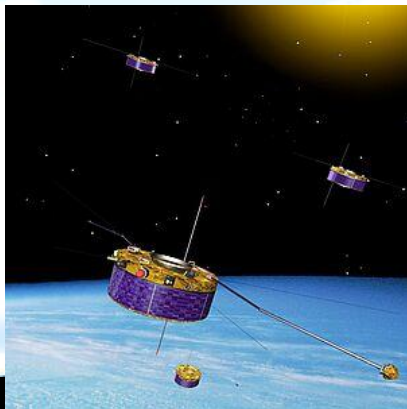
- Survey: High energy event, **approx. 180+ potential objects and many HAMR**.
- Big velocity distributions with large inclination dispersion and the detected objects presents **mag 15-17 so very faint**.
- Currently unclear what can be shared with IADC.

### NASA

- Parent body/Survey: Unable to acquire images due to poor weather conditions.

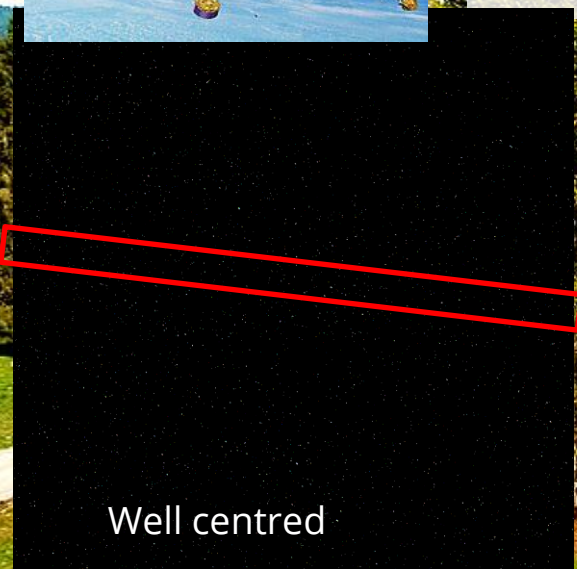
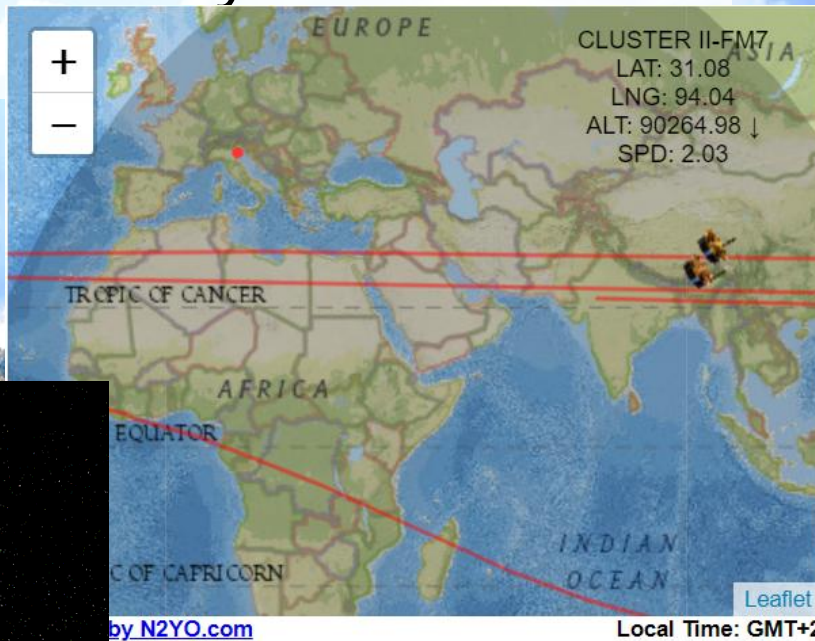


# Observational Campaign for the re-entry of CLUSTERII



About 200 frames (4sec, CLEAR),  
in sidereal tracking.

In fully Robotic Mode, the  
challenge is the proper  
scheduling to match the ~2 mins  
needed for the crossing of the  
1x1deg FoV.



Well centred

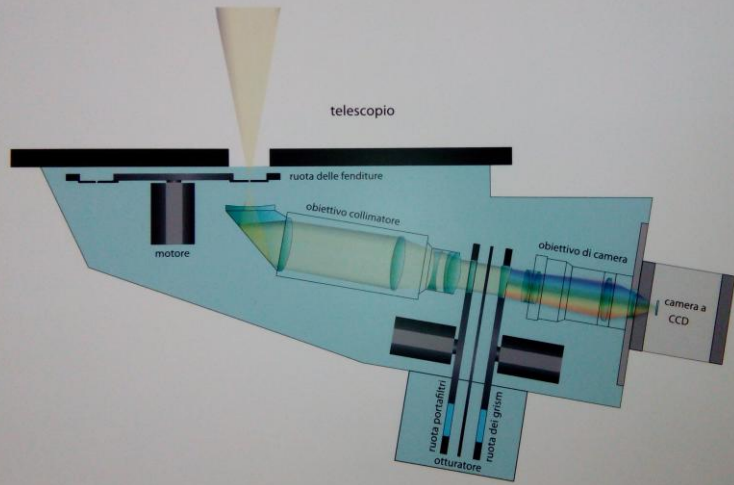


Too early



# COPERNICO TELESCOPE - spectroscopic observations

AFOSC - Asiago Faint Object Spectrograph & Camera



The small field of view (9'x9') of the AFOSC instrument makes the instrument suitable for GEO satellites characterization. Since with AFOSC, it is also possible to make spectroscopic observations.

So...



# Spectroscopic Observations – AFOSC@Copernico

- We tried grism at different resolutions
  - R500-R5000
  - Bands 320-1000

Cima Ekar  
telescopio Schmidt e Copernico



Grism	$\lambda_{\text{cen}}$ (nm)	Wavelength Range (nm)	Dispersion (Å/mm)	Dispersion (Å/pixel)	RS	gr/mm
VPH #4	660	624-696	29	0.39	5000	1720
VPH #6	800	450-1000	261	2.95	500	285
VPH #7	525	320-700	295	2.95	470	286

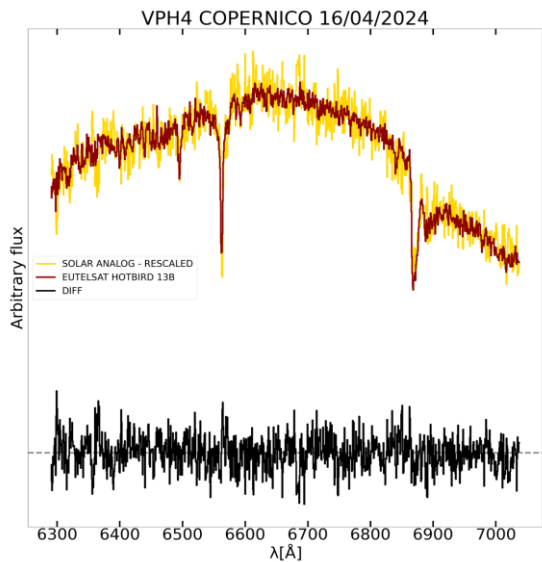
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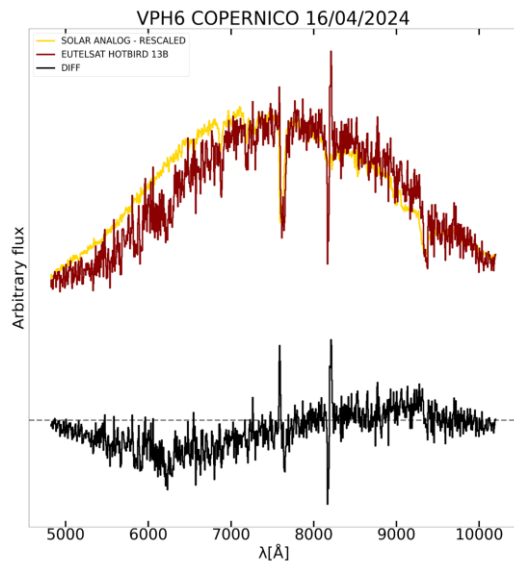


# Spectroscopic Observations – AFOSC@Copernico

Cupola



Cima Ekar  
telescopio Schmidt e Copernico



Corrected for different airmass/extinction; used normalized asiago extinction curves with average value between 7500 and 8000 AA;

Work in progress to reproduce the flat continuum between 6300-7000 AA (VPH4 range), but weak GEO signal (in fact noisy spectrum);

Comparison with solar analogue.

Obs performed by Paolo Ochner, Simone Zaggia & Andrea Reguitti.  
Data reduction by Matteo Simioni

# Conclusions

A new team started its operations for Space Debris Survey and Monitoring.

- Observation program approved
- Robotic Software Upgrade Schmidt Alt-Az
- Observations Schmidt of GEO sat
- Fragmentation Campaign 26106
- Reentry CLUSTER II campaign
- AFOSC tests in spectroscopic mode
- AFOSC camera upgrade procedure

# Working in parallel

Next generation of telescopes for space debris tracking:

## *MezzoCielo*



*(MezzoCielo mock-up by INAF-OAPd and Tomelleri)*

# Russian satellite breaks up in space, forces ISS astronauts to shelter

By Joey Roulette

June 27, 2024 11:37 PM GMT+2 · Updated 15 hours ago



The comet NEOWISE streaks above Earth, in this image taken aboard the International Space Station (ISS), July 5, 2020. NASA/Handout via REUTERS/FILE PHOTO [Purchase Licensing Rights](#)

WASHINGTON, June 27 (Reuters) - A defunct Russian satellite has broken up into more than 100 pieces of debris in orbit, forcing astronauts on the International Space Station to take shelter for about an hour and adding to the mass of space junk already in orbit, U.S. space agencies said.

There were no immediate details on what caused the break-up of the RESURS-P1 Russian Earth observation satellite, which Russia declared dead in 2022.



**SPACENEWS**  
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Civil

## Russian satellite breaks up, creating debris in low Earth orbit

Jeff Foust June 27, 2024

ieri

**-Matteo Rossetti** +39 324 588 1117  
Buongiorno a tutti  
Nuova frammentazione in LEO comunicata questa mattina da EUSST e 18SDS,  
Resurs p1, ID:39186, event epoch 2024/06/26.  
Come vogliamo agire? Bisognerebbe generare nuvola di frammenti come per 26106 11:38

**-Alessandro** +39 348 828 3108  
Exp o coll? Si sa? 11:45

**-Matteo Rossetti** +39 324 588 1117  
No viene riportato explosion break-up 11:47

**-Elisa Maria Alessi** +39 338 786 9559  
Io posso fare qualcosa domani pomeriggio se mi date le info 11:50

Se il meteo permette, possiamo fare osservazioni da Asiago 11:53 ✓

**-Matteo Rossetti** +39 324 588 1117  
Per ora viene riportata una possibile epoca di frammentazione 2024-06-26 T15:30:00UTC 11:53

Sono stati inoltre identificati 100 frammenti ancora non sono riuscito a trovarli su catalogo norad (speravo di ricavare da qualche info in più sull'evento)