

Size estimation of orbital debris using a zenith-pointing telescope

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@ 2nd BINA WORKSHOP
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A greener planet ?

OUTLINE

- Space awareness
- Optical observations of Space Debris
- Characterization
- Conclusion and Future perspectives

Space situational awareness

What is out there ?

- Man-made objects that are in orbit around the Earth that no longer serve any useful purpose to us.
- Used rocket stages and defunct satellites to explosion fragments, paint flakes, dust, slag from solid rocket motors.
- Currently, 200 new objects are added annually.

Space situational awareness

Why is this bad ?

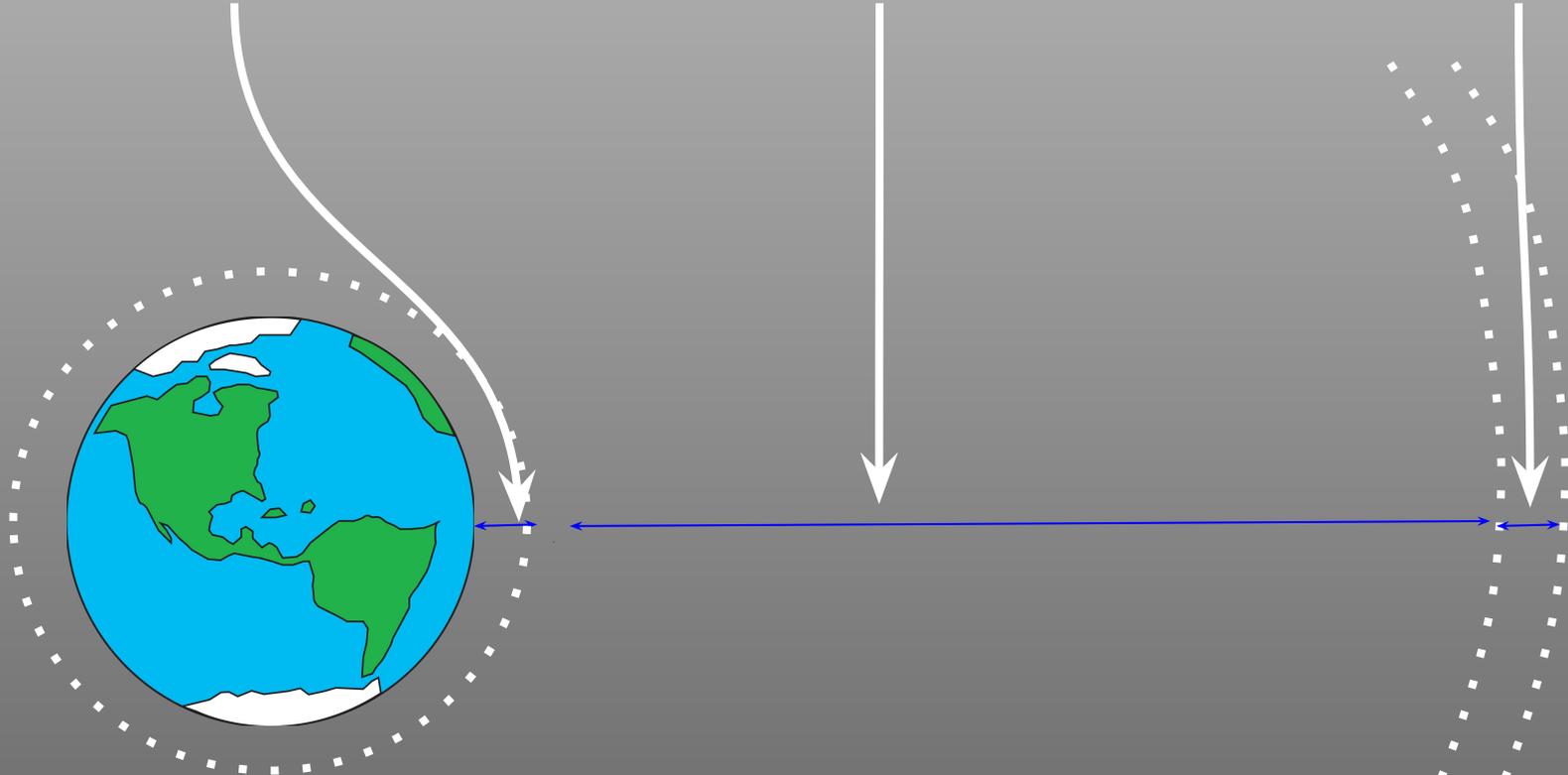
- **Erosive damage** to satellites, when they come into contact with clouds of very small particles in space.
- **Collisions** can be highly damaging to satellites due to the extremely high orbital velocities (**tens of thousands of km/h**)

Space situational awareness

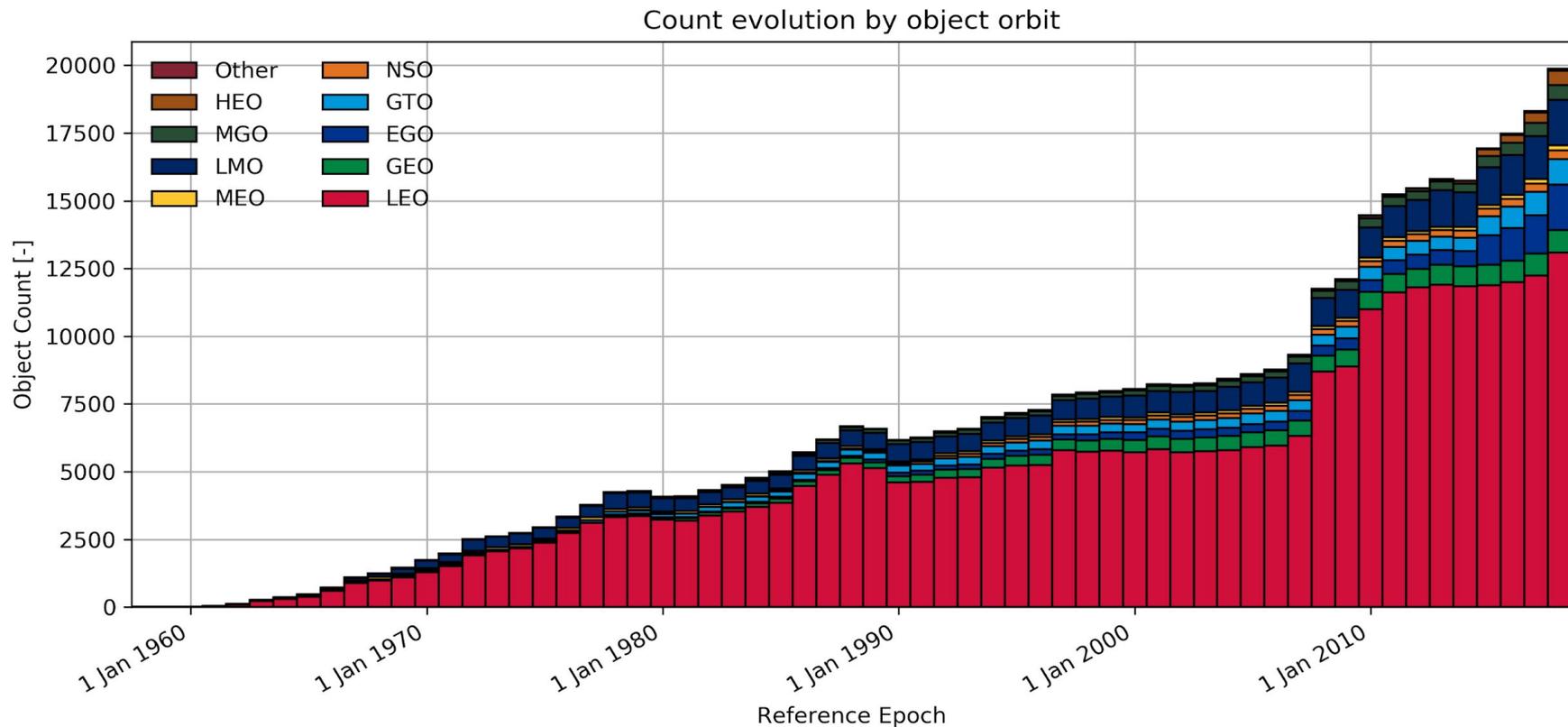
LEO (Low-Earth Orbit)
Up to 2,000 km

MEO (Medium-Earth Orbit)
Between 2,000 and 35,000 km

GEO (GEostaionary Orbit)
Around 35,000 km



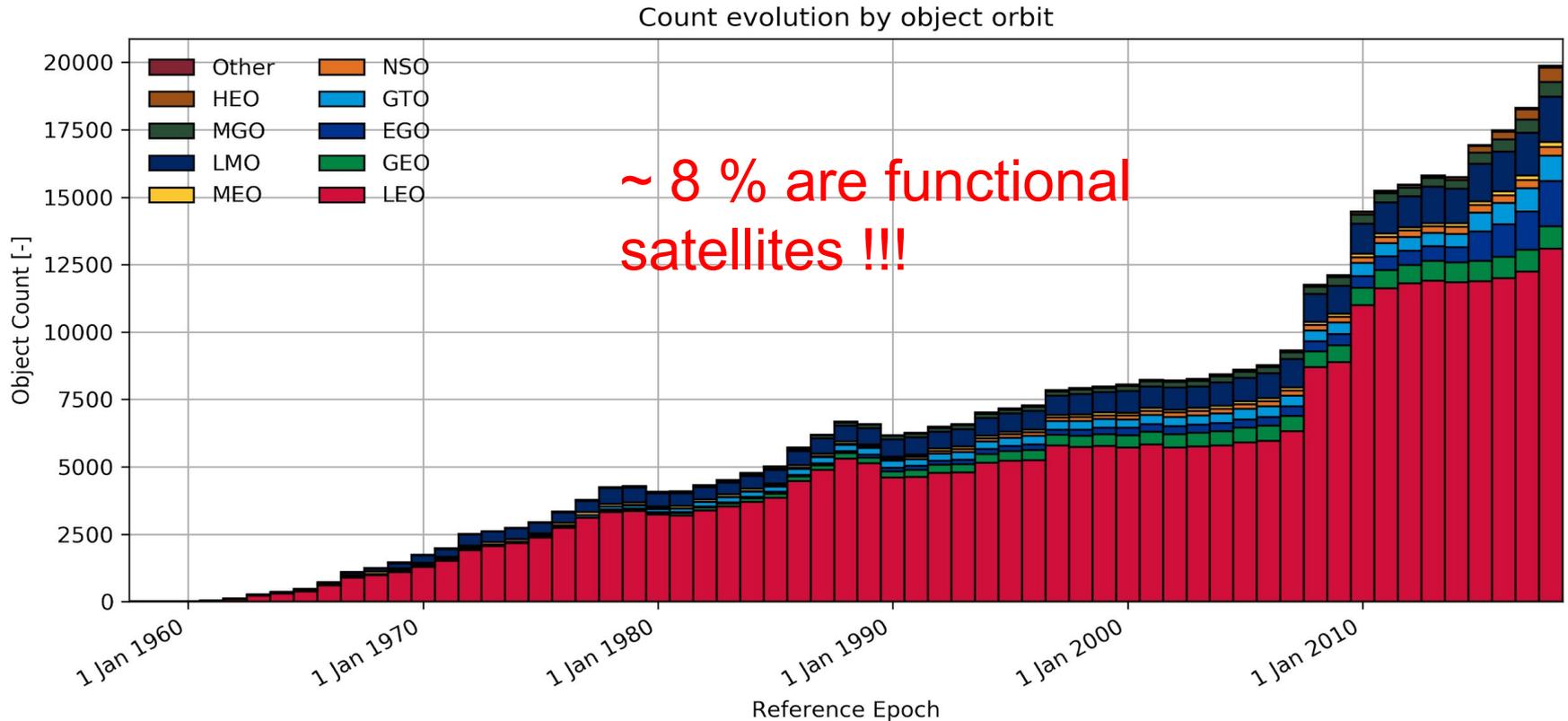
Space situational awareness



Number of objects in Earth orbits cataloged by US Space Surveillance Network

Source : https://www.esa.int/Our_Activities/Operations/Space_Debris/Analysis_and_prediction

Space situational awareness



Number of objects in Earth orbits cataloged by US Space Surveillance Network

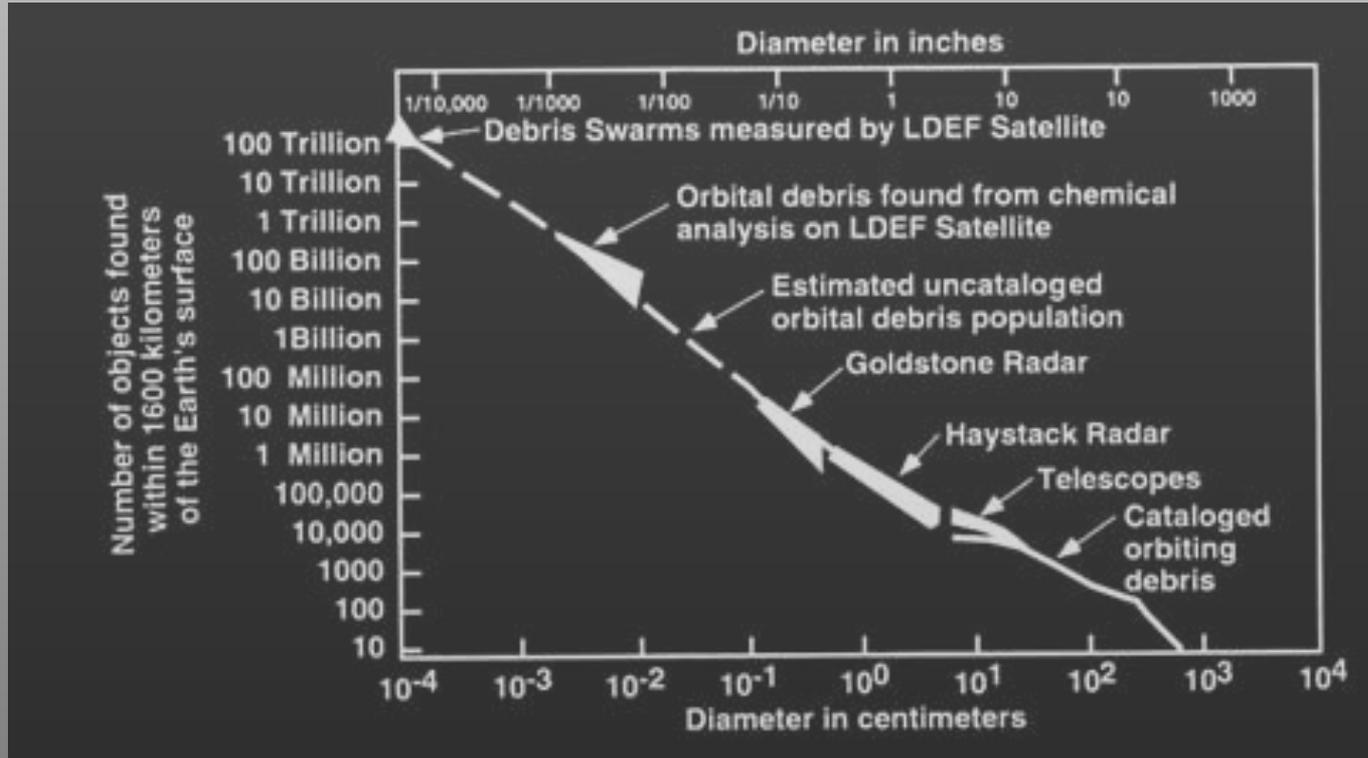
Source : https://www.esa.int/Our_Activities/Operations/Space_Debris/Analysis_and_prediction



Altitude (Km) :

19 121

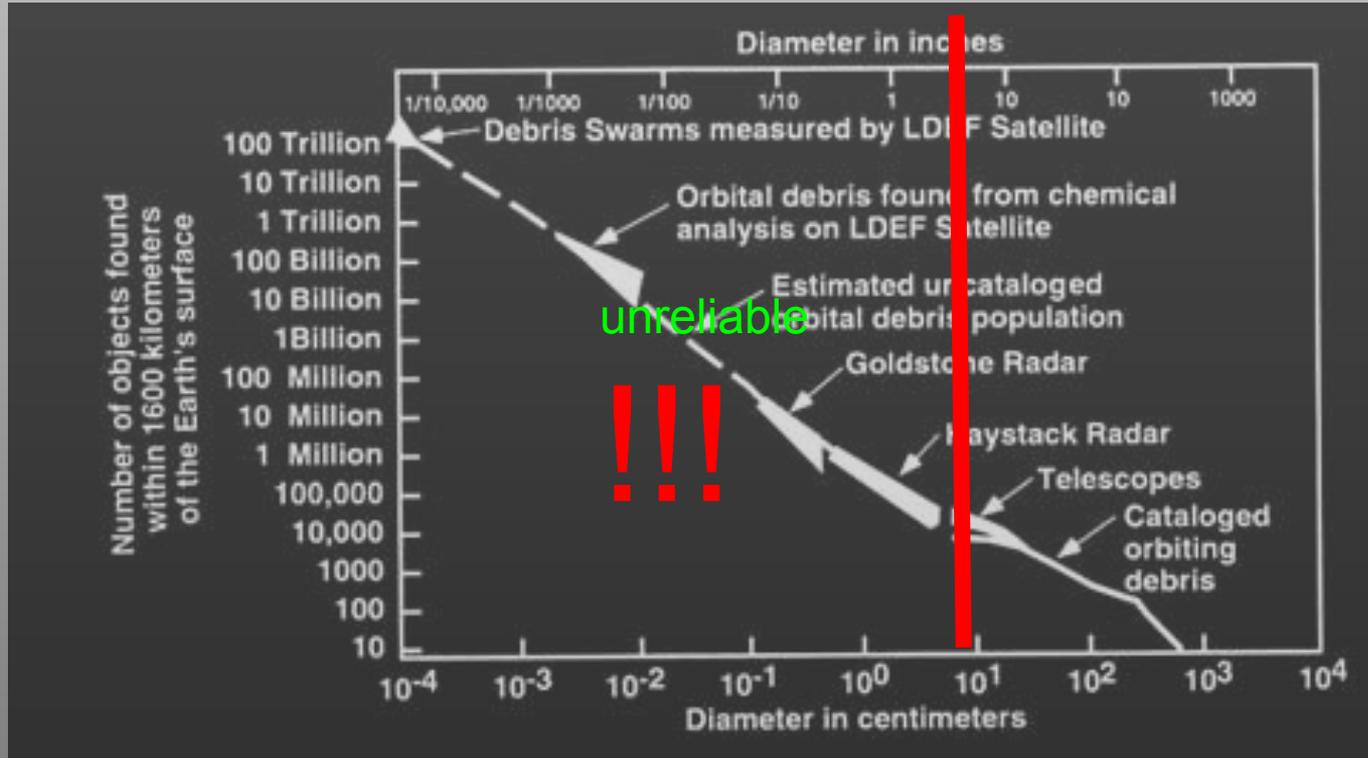
Space situational awareness



Number of objects in LEO as estimated from various measurements.

SOURCE: National Aeronautics and Space Administration.

Space situational awareness



Number of objects in LEO as estimated from various measurements.

SOURCE: National Aeronautics and Space Administration.

Optical observation of space debris



4-m International Liquid Mirror Telescope (ILMT)



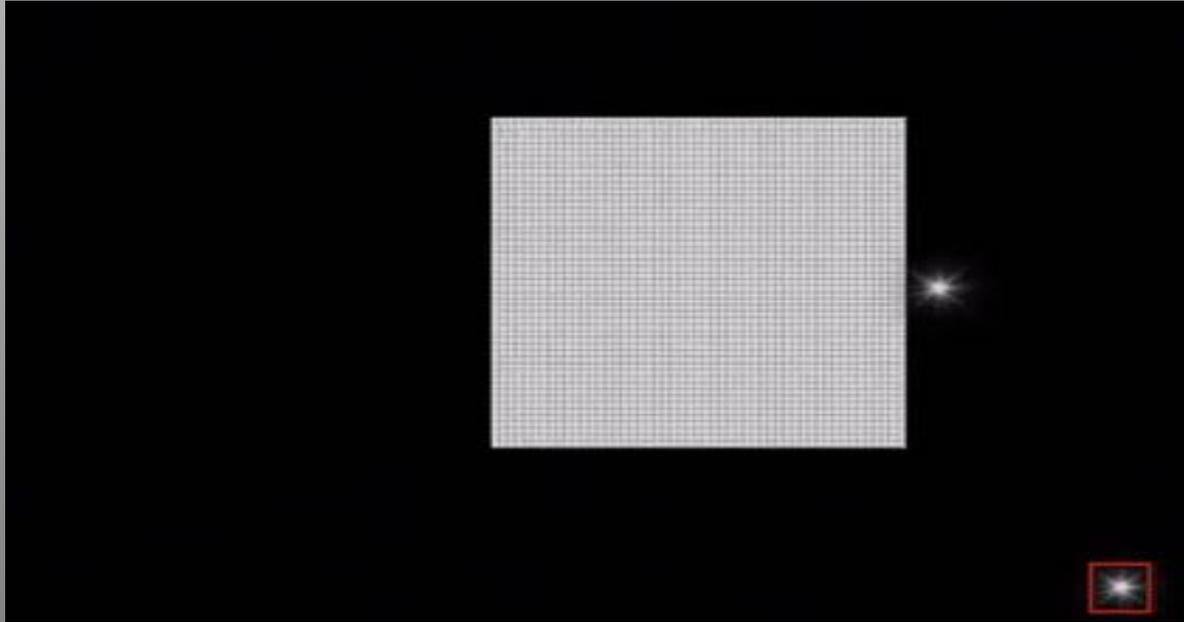
1.3-m Devasthal Fast Optical Telescope (DFOT)

Optical observation of space debris

Time Delay Integration

/

Drift scan



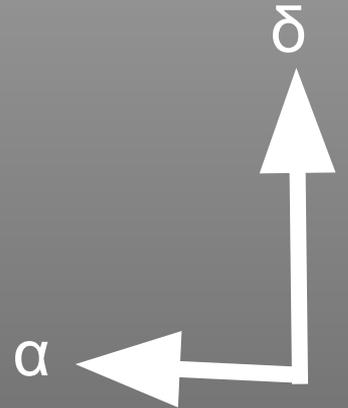
t(final)

42 sec
102 sec

t(initial)

0 sec
0 sec

DFOT
ILMT

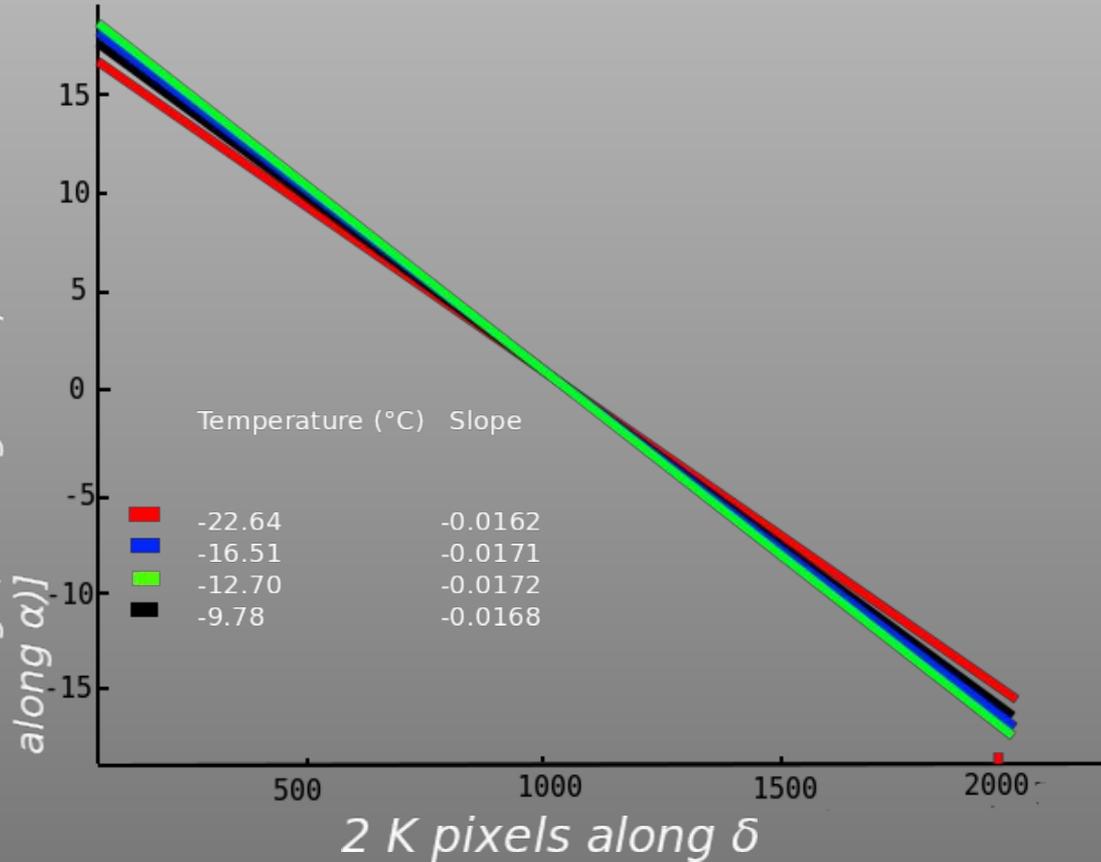


Optical observation of space debris

Data Processing :

Dark subtraction :

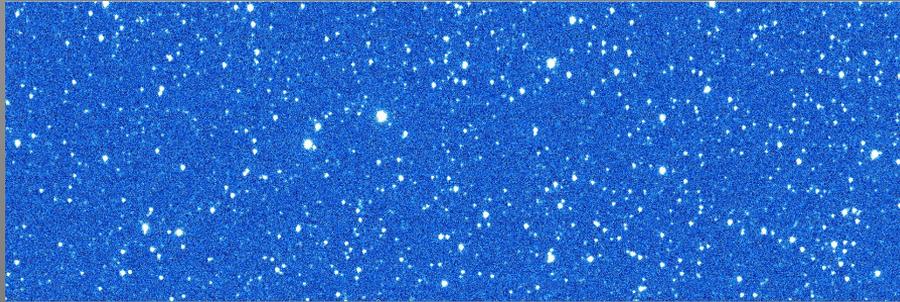
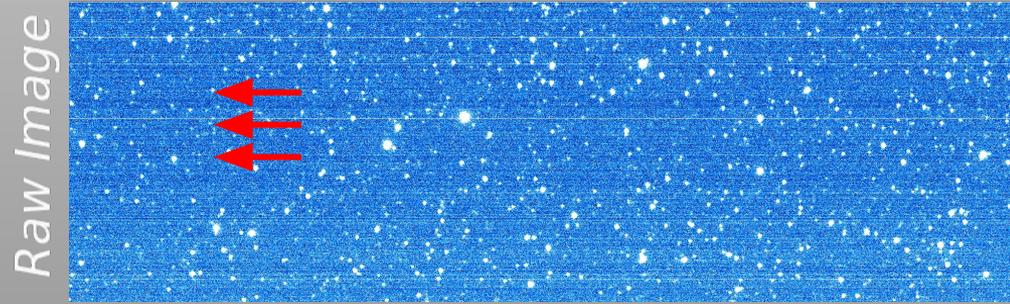
Degree 1 polynomial fit to [averages
of pixel values along α (= 1D dark) -
average(averages of pixel values
along α)]



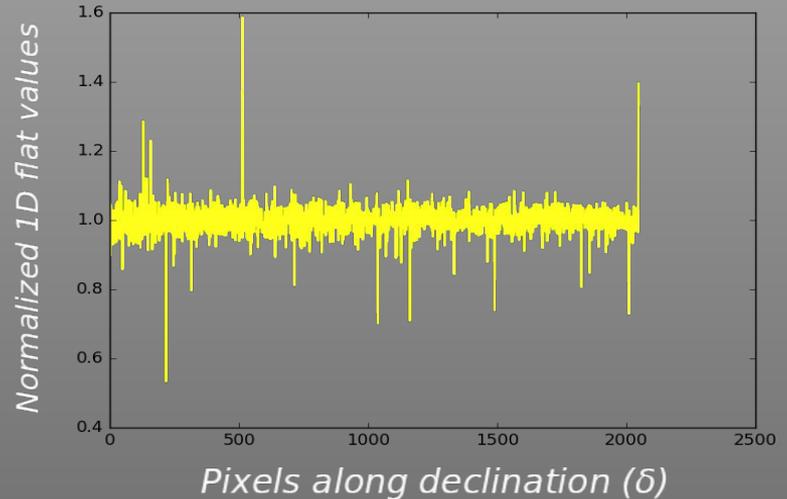
Optical observation of space debris

Data Processing :

Flat field correction :



Flat field corrected image

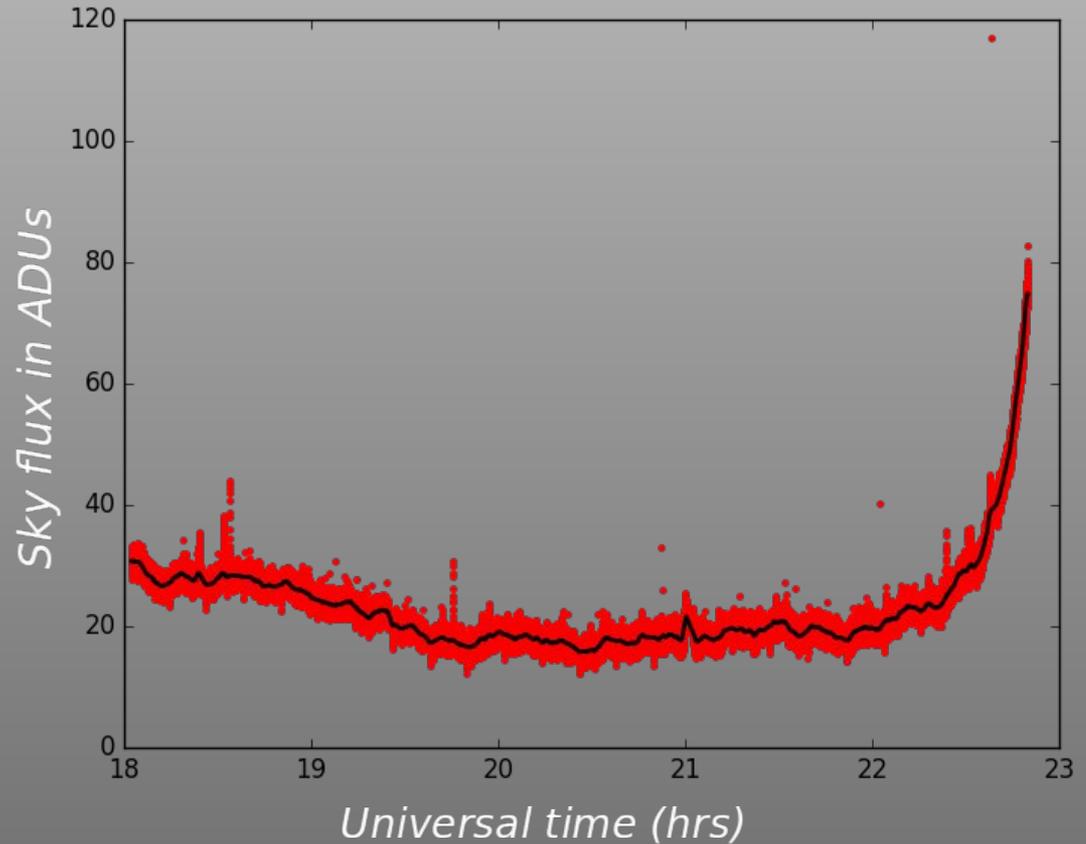
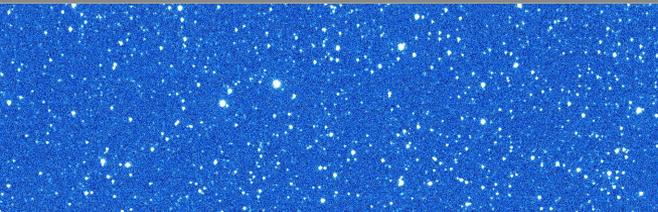


Optical observation of space debris

Data Processing :

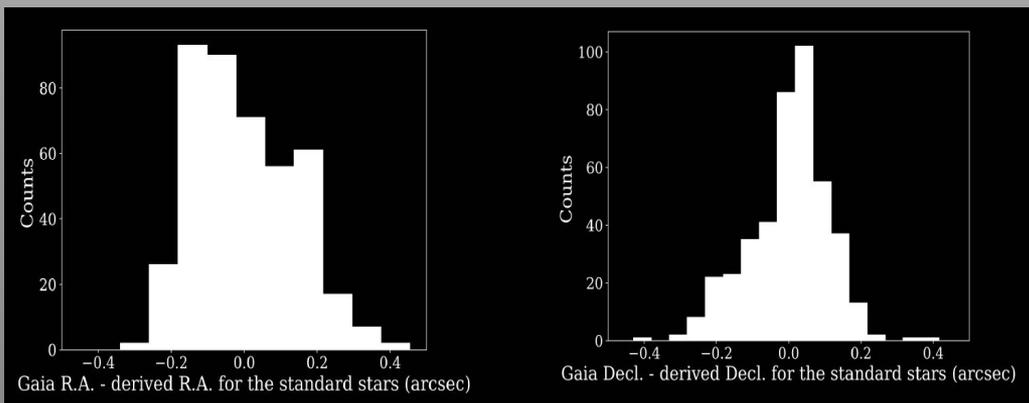
Sky subtraction :

sliding average method
+
two_dimensional polynomial fit



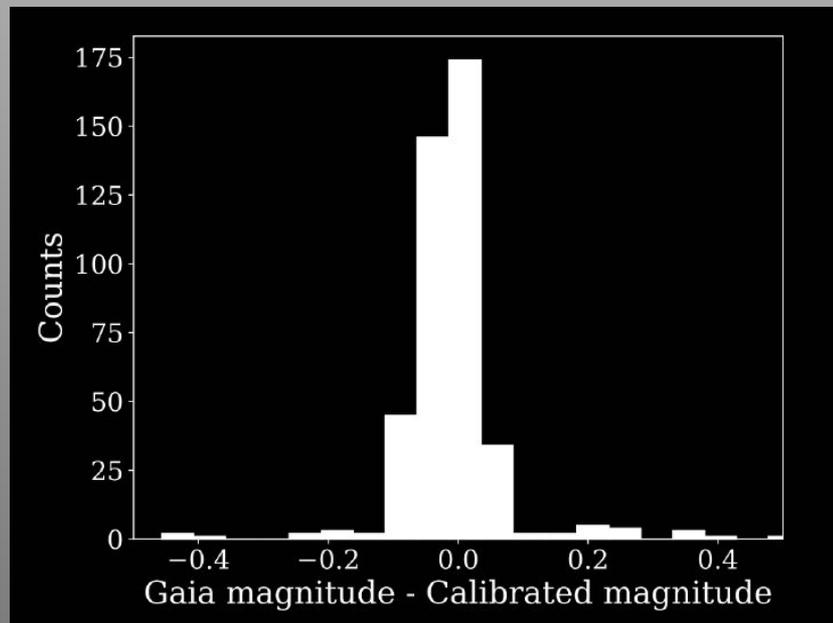
Optical observation of space debris

Astrometry :



- Precision = 0.1 arcsec

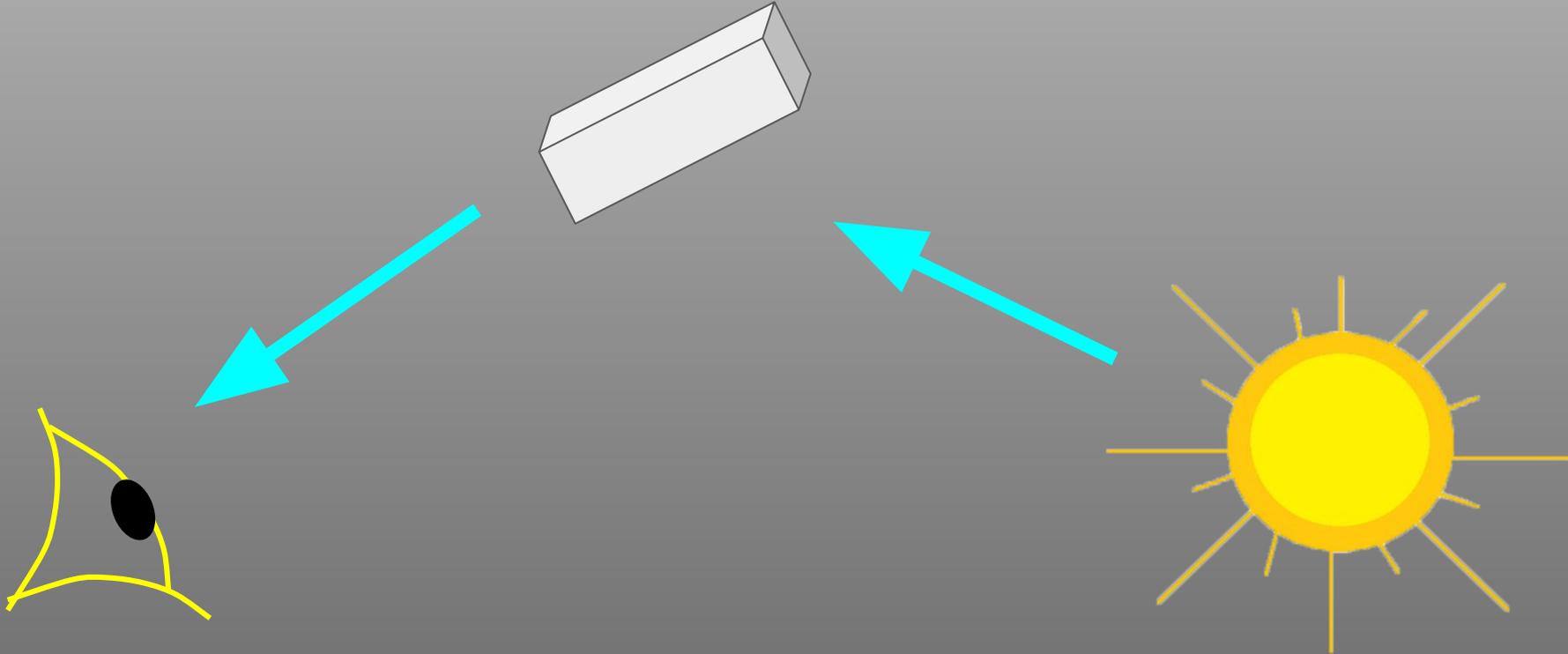
Photometry :



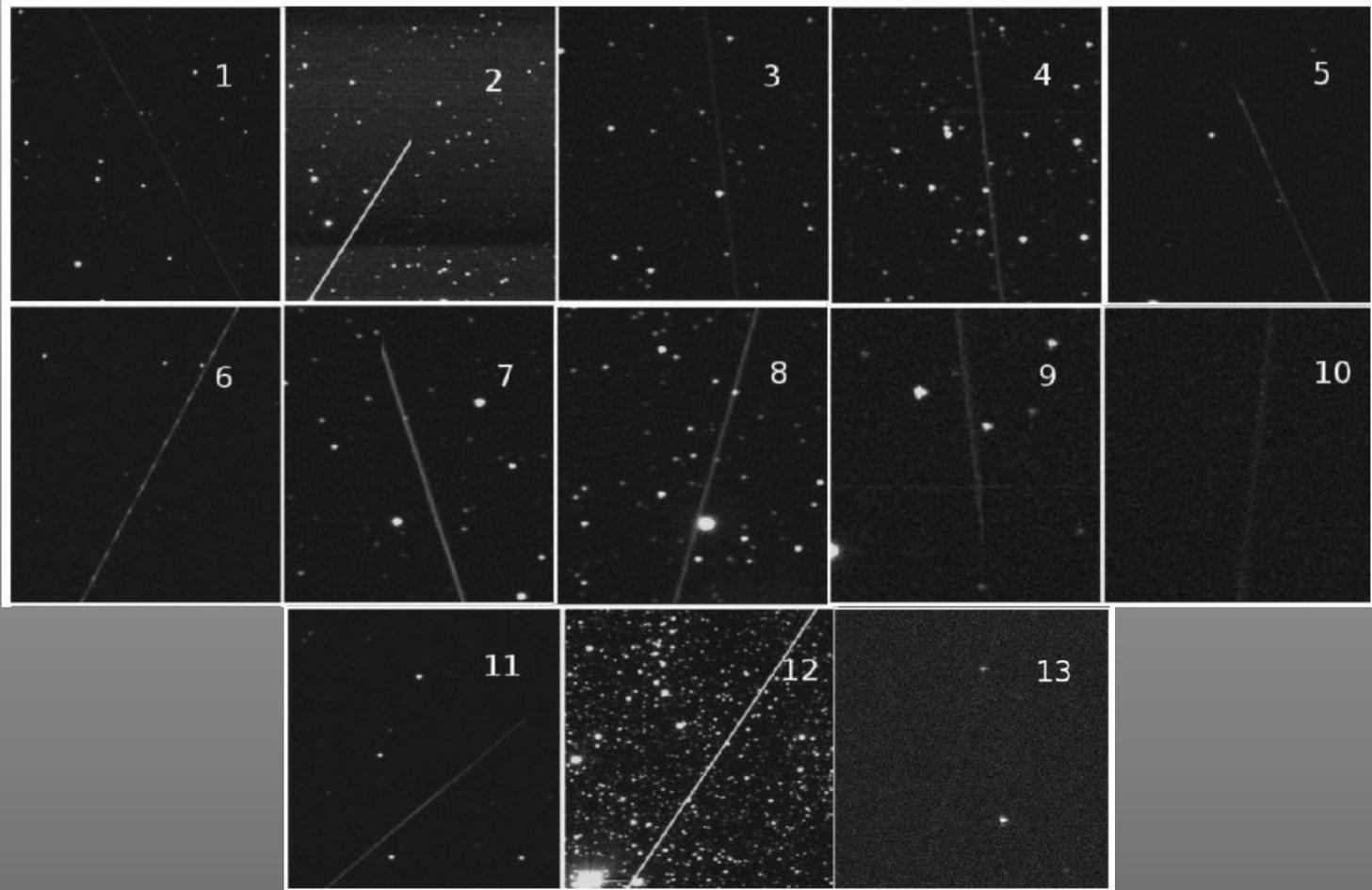
- Precision = 0.04 mag

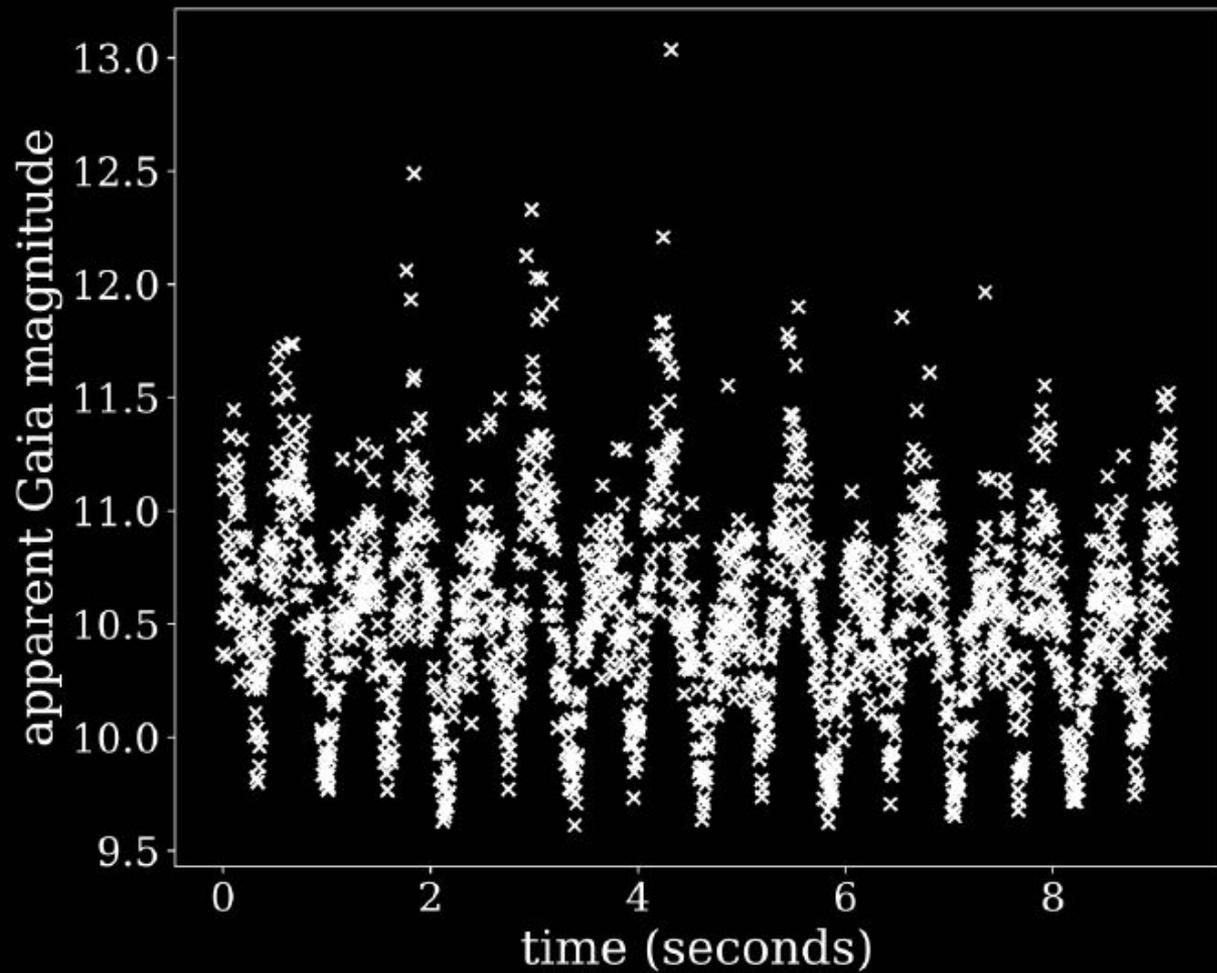
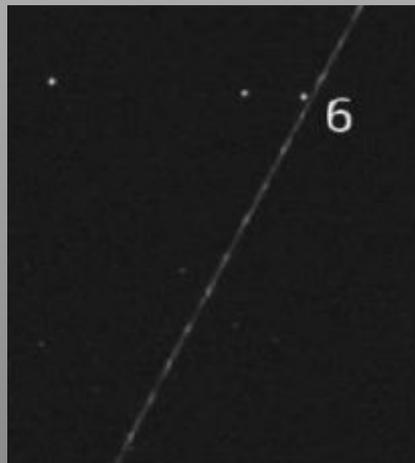
Optical observation of space debris

Debris Observation

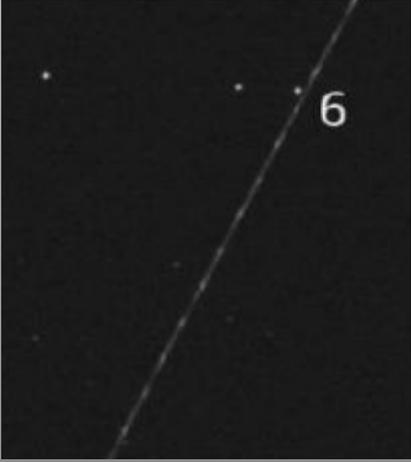


Optical observation of space debris





Identification



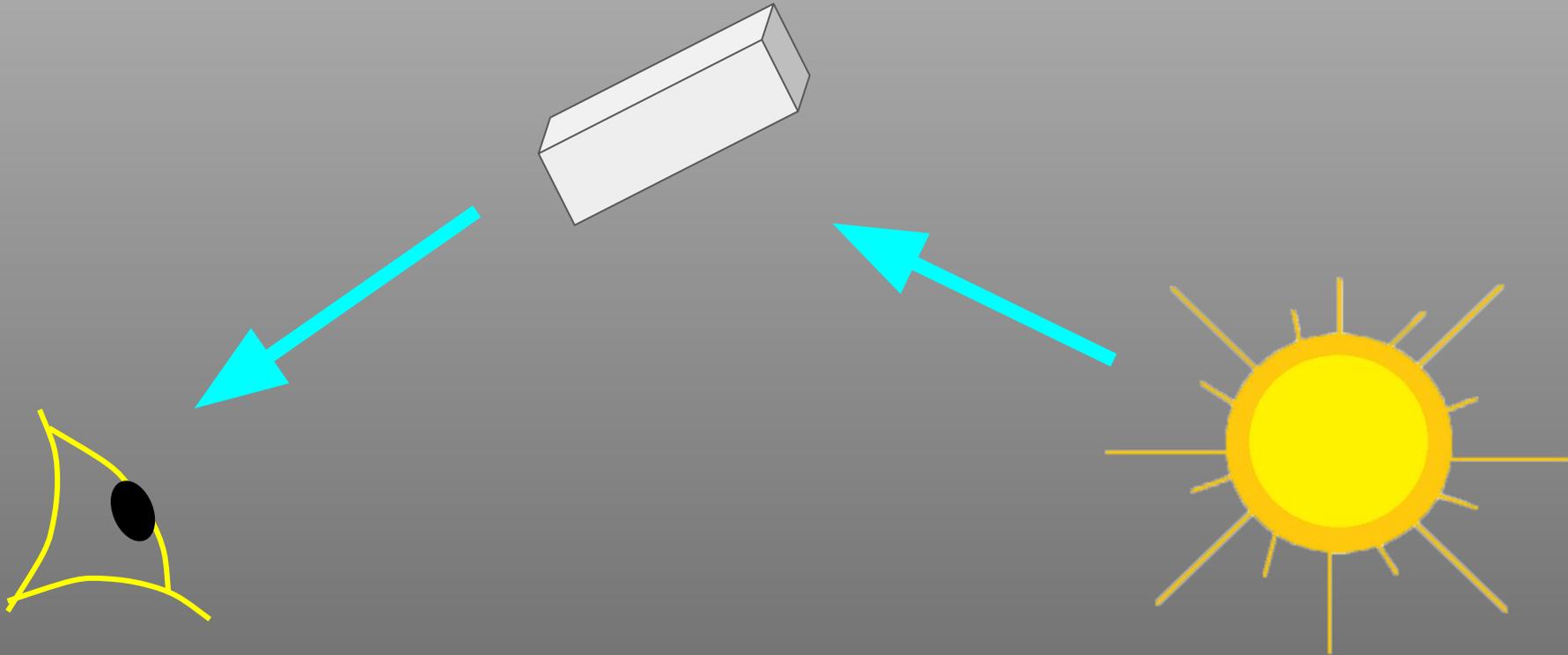
By crossmatching :

position and orientation of
streak,

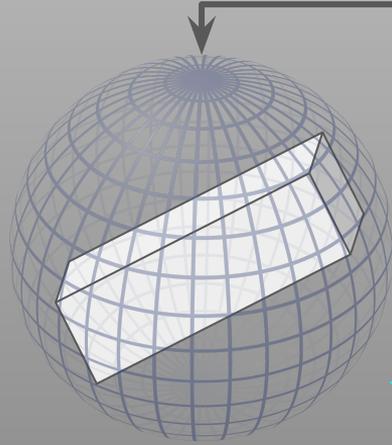
With

Entries in two-line-element
(TLE)

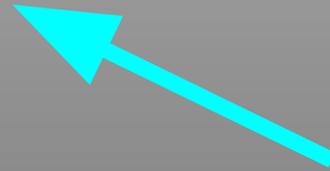
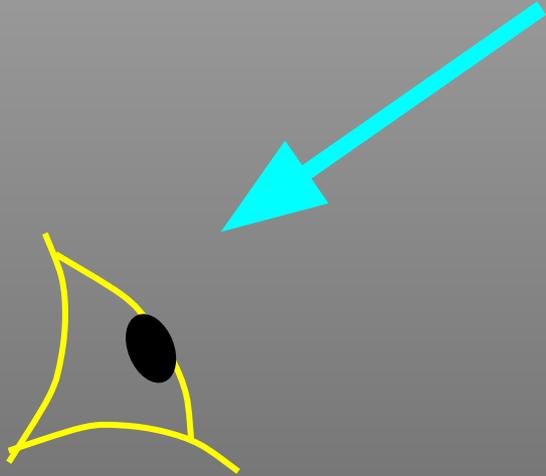
Characterization



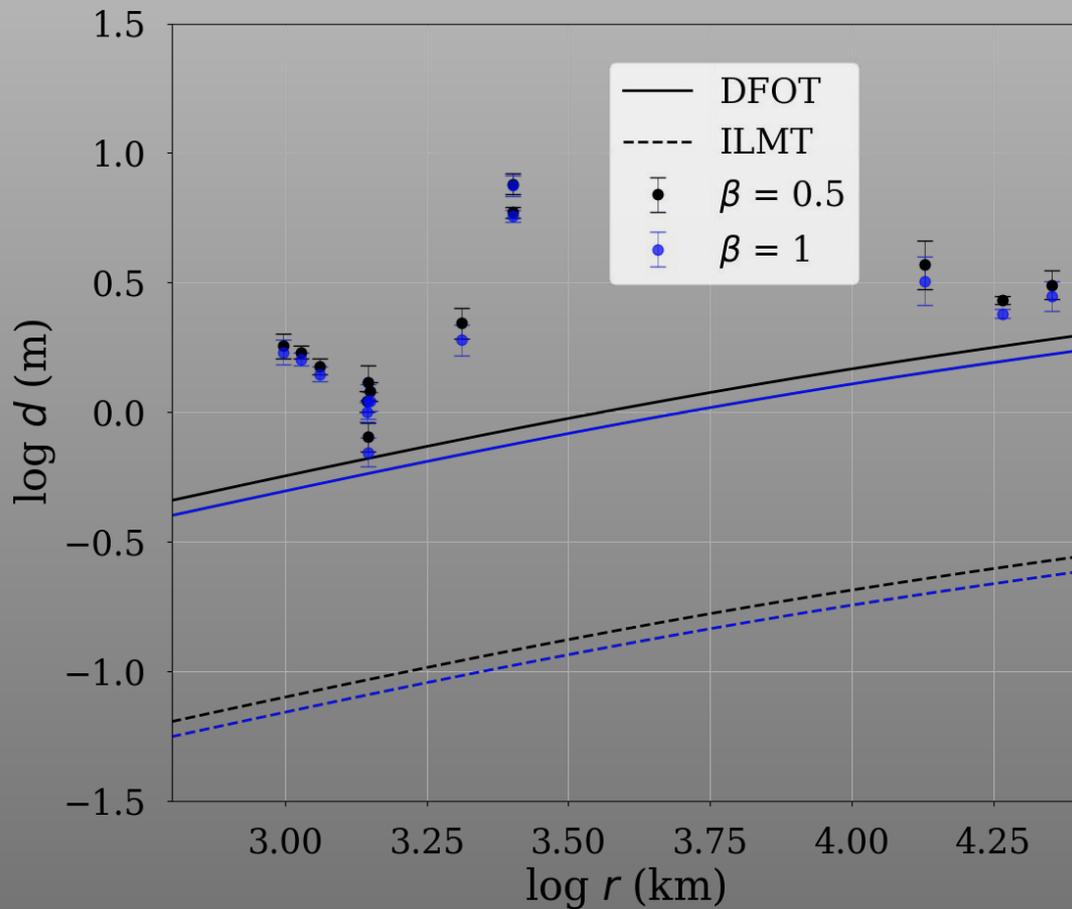
Characterization



Diffuse Lambertian Sphere
Albedo = 0.175
(Hejduk et al., 2011)



Results



SSN	Cataloged Cross-section (min)	Our estimated Cross-section	Cataloged Cross-section (max)
13070			
24827			
22689			
29669			
32271			
4367			
17582			
22646			
25770			
16759			

Summary

- Operating in TDI mode, observation is without interruption and are sensitive to any objects passing through their field of view.
- Diffuse-specular Lambertian sphere can be an acceptable model to derive effective optical size of Debris.
- ILMT will be able to detect ~ 10 times smaller objects as compared to DFOT.