The background of the slide is a photograph taken from space, showing the curved horizon of the Earth. A bright, glowing arc of light, likely the sun or a bright star, curves across the upper left portion of the frame. In the dark, black expanse of space to the right, a small, thin crescent moon is visible.

ESA Optical Surveys to Characterize the Small-Size Space Debris Environment in GEO and HEO

T. Schildknecht

*Astronomical Institute, University of Bern,
Switzerland*

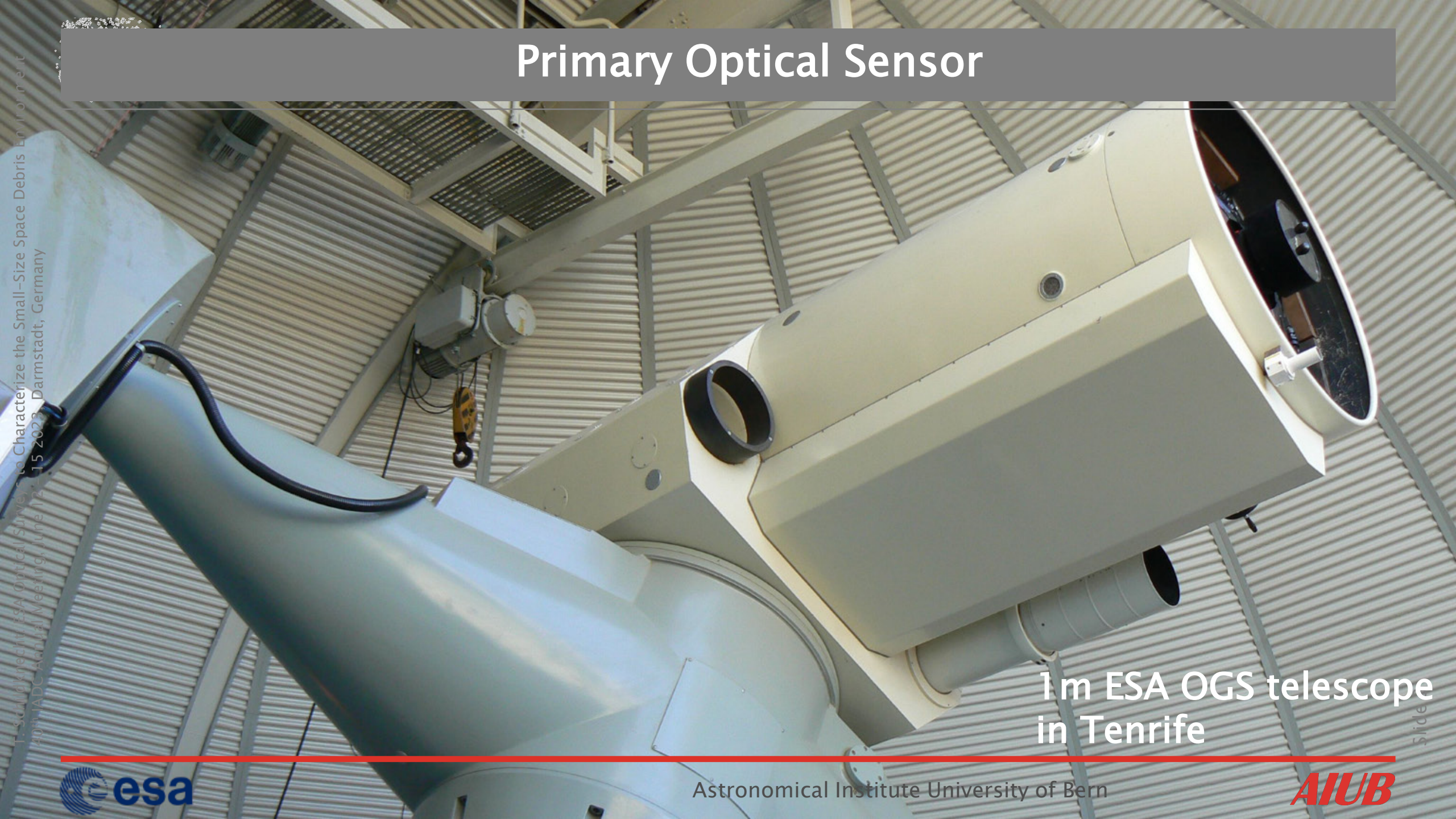
*41th IADC Annual Meeting,
June 12th – 15th 2023, Darmstadt,
Germany*

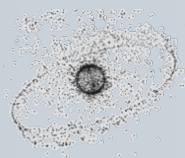
Objectives

- **Survey Objectives**
 - **GEO/HEO surveys for sub-catalogue objects**
 - statistical data for MASTER model upgrades
 - **breakup fragment surveys**
 - OGS for new fragmentation events only (small FoV)
- **HAMR/breakup fragment follow-up**
 - **follow-up of HAMR**
 - OGS for faint fragments only
 - follow-up at SwissOGS
 - **follow-up of breakup fragments**
 - OGS for faint fragments only
 - follow-up at SwissOGS

Primary Optical Sensor

1m ESA OGS telescope
in Tenerife





Sensors for Follow-up Observations

Swiss Optical Ground Station and Geodynamics Observatory Zimmerwald



0.8m ZimMAIN
Switzerland



1-m ZIMLAT
Switzerland



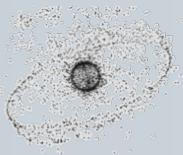
AIUB ZimSMART

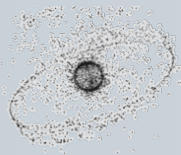


2x0.4-m ZimTWIN
Switzerland

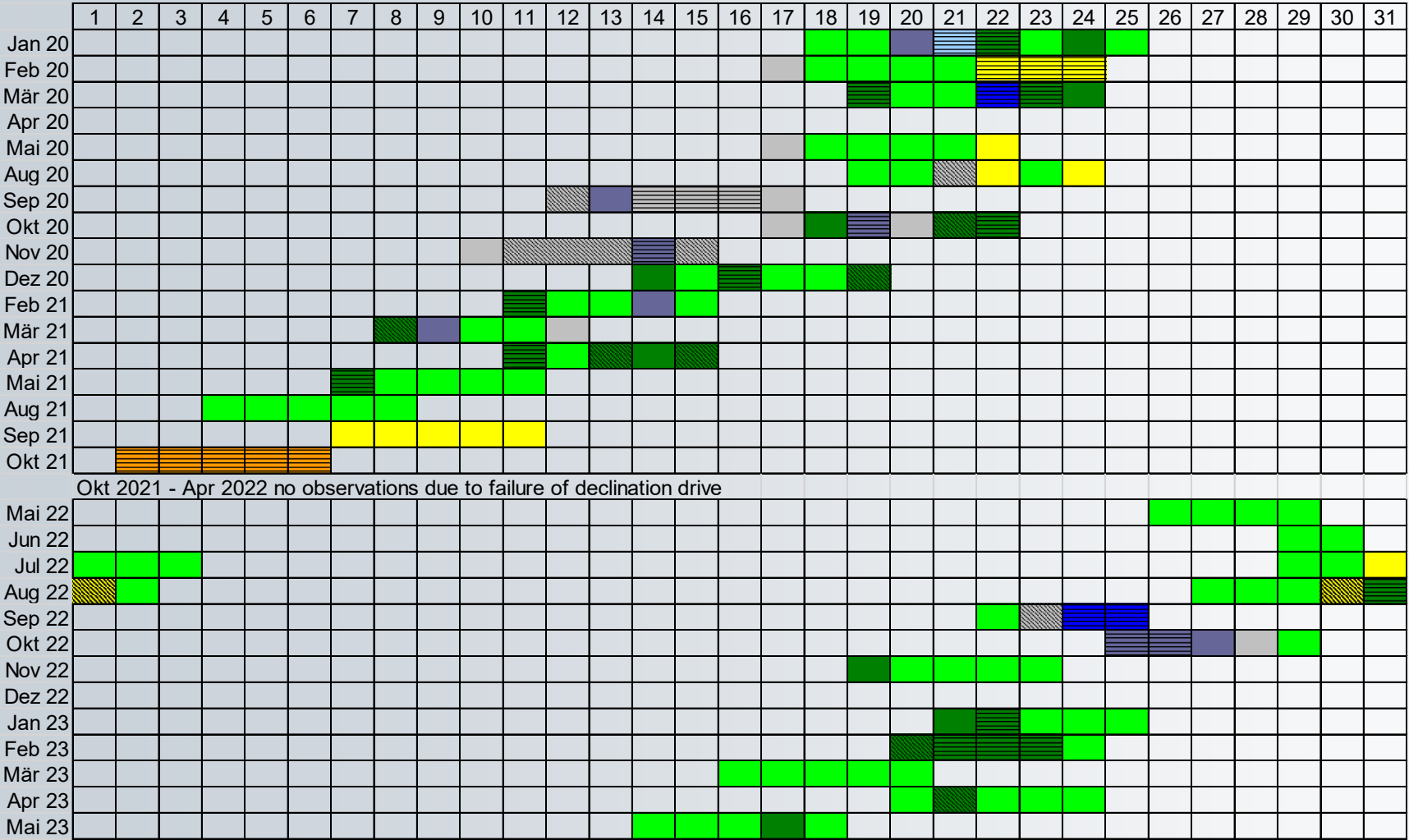
Observations

- **1 m ESA Telescope Tenerife**
 - 19–36 good nights per year (~25–45 scheduled)
 - GEO surveys (3–4 night campaigns at New Moon)
- **1 m ZIMLAT / 0.8m ZimMAIN (SwissOGS)**
 - follow-up of objects discovered by ESA telescope
 - continuous follow-up of HAMR objects
- **0.2m ZimSMART / 0.4m ZimTWIN (SwissOGS)**
 - continuous catalogue maintenance (bright objects)

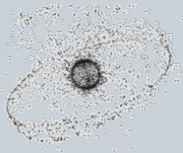




OGS Observations



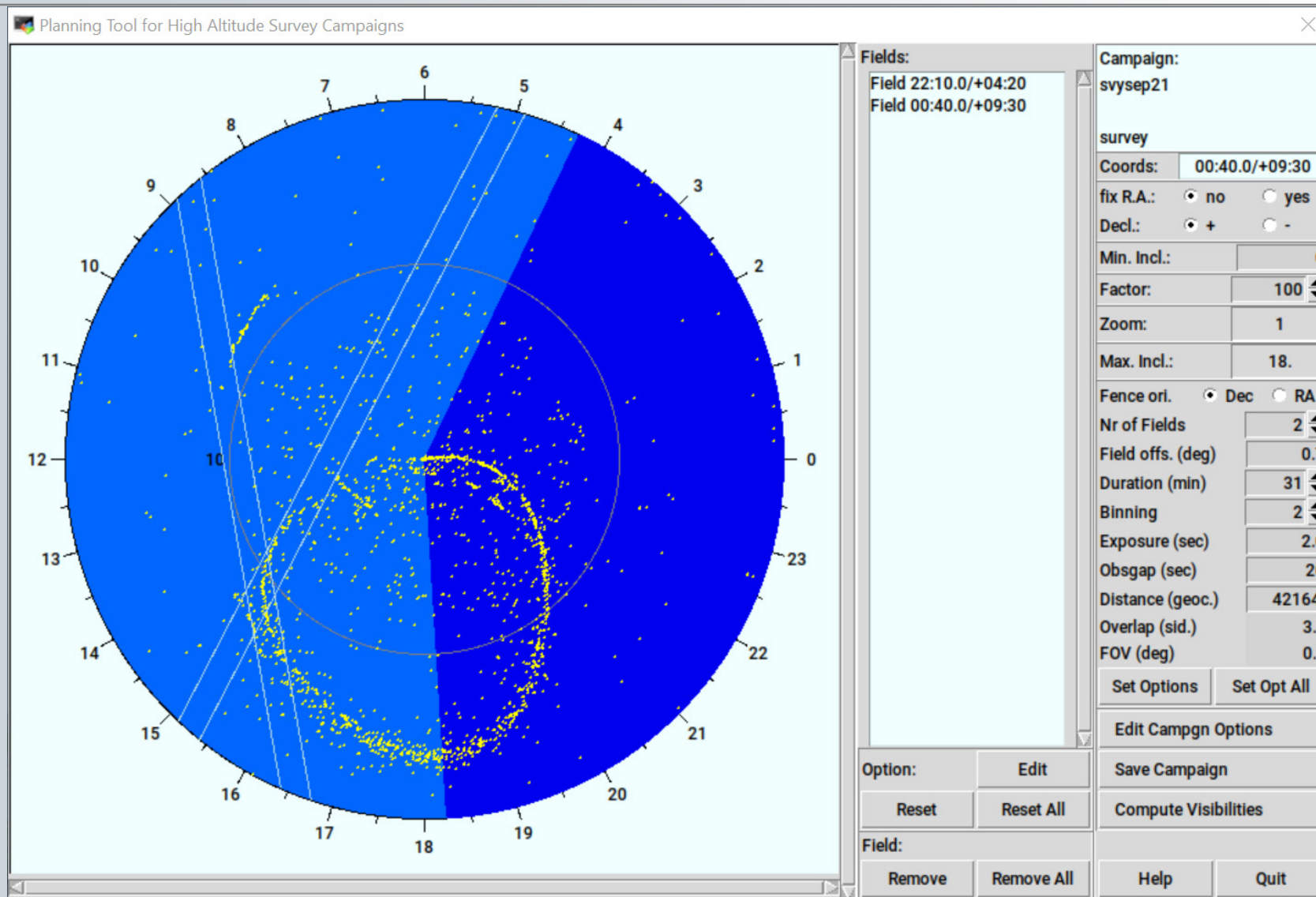
		0h	<4h	>4h
planned night				
good night				
high humidity				
rain or snow				
clouds				
ice on dome				
dust				
wind				
technical problems				



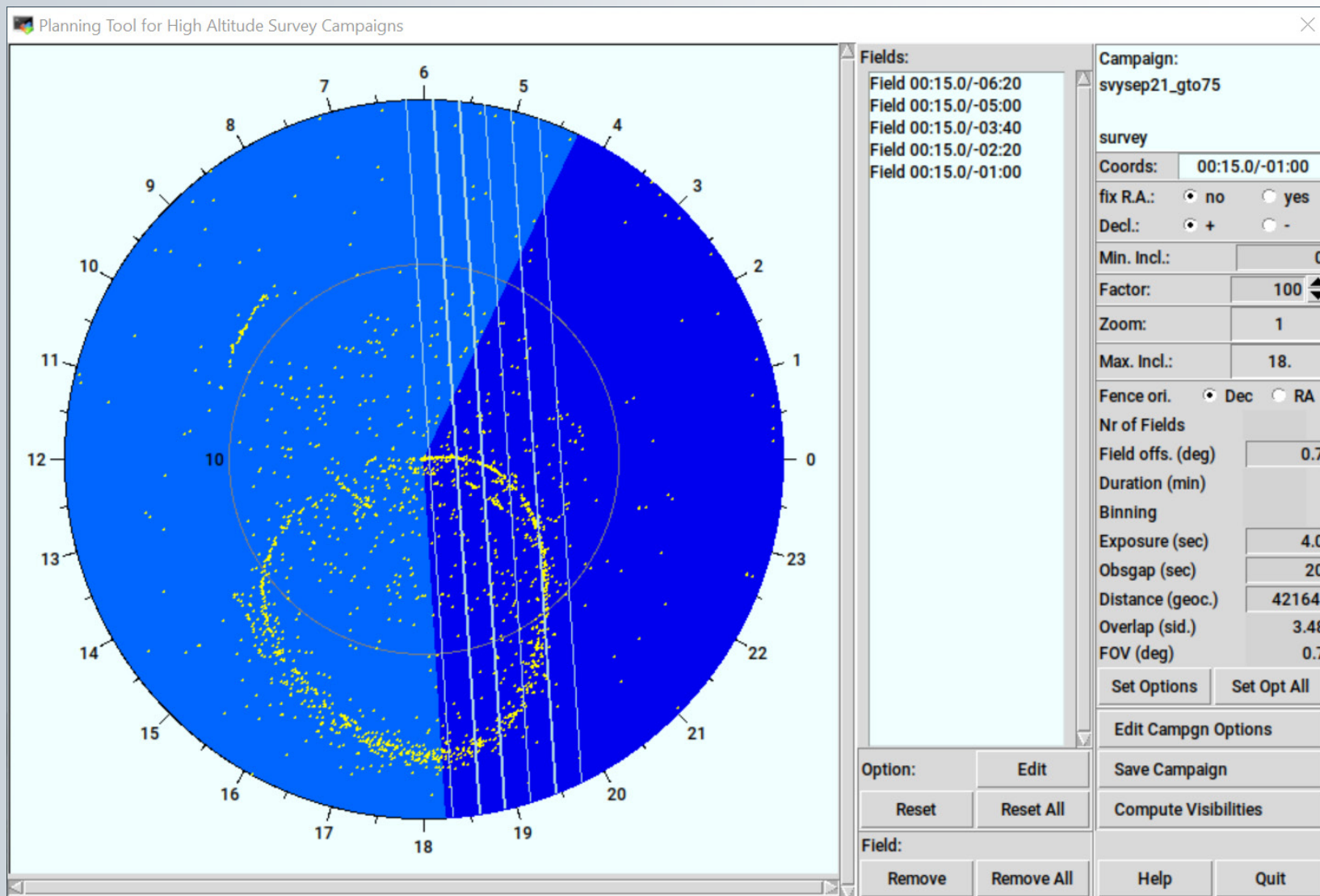
Planning, Data Acquisition, Processing

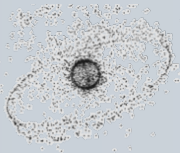
- Monthly planning cycles for OGS
- Daily planning for SwissOGS (follow-up)

Planning of Survey Fields



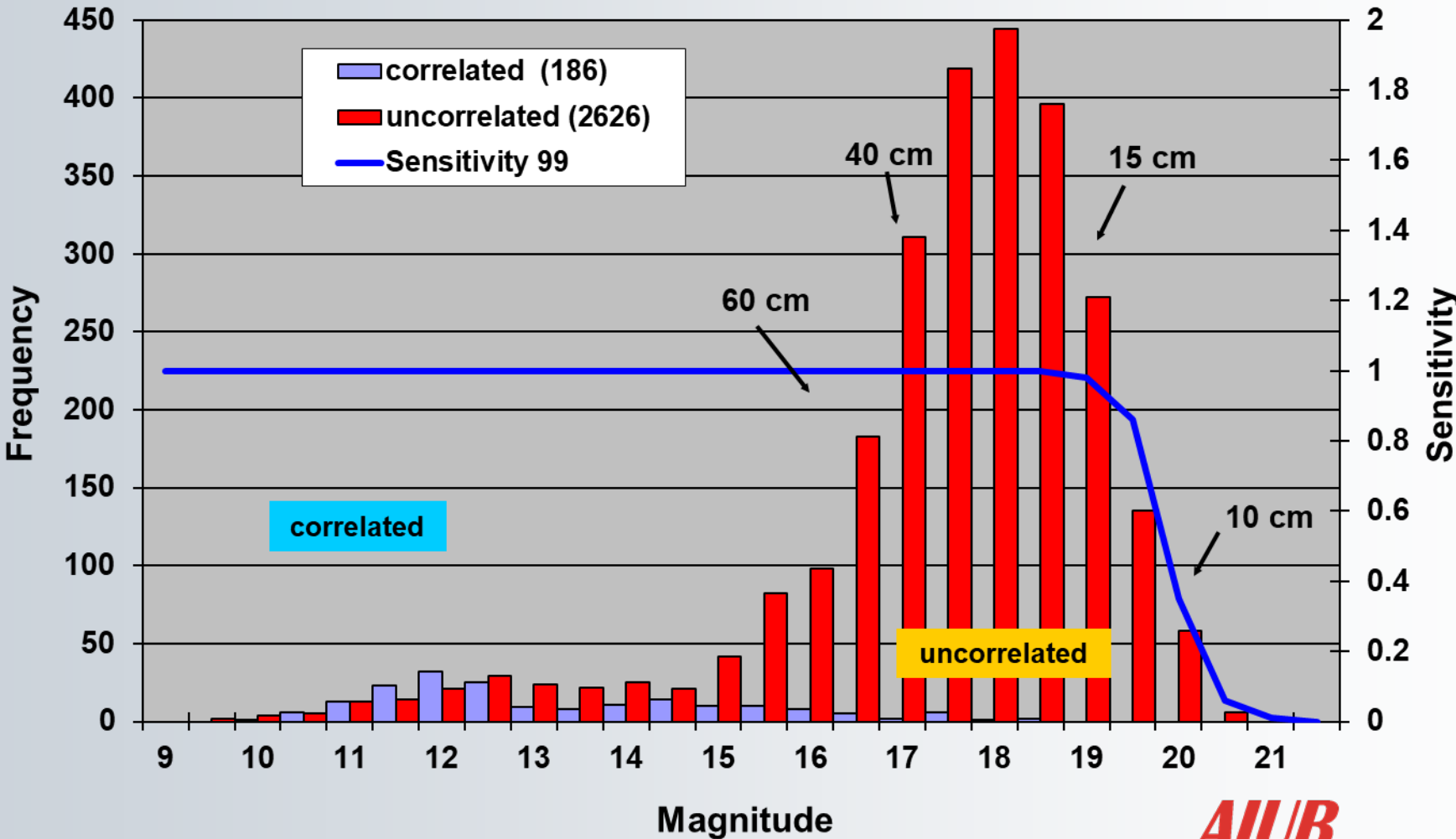
Planning of Survey Fields



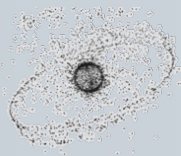


High-Altitude Surveys GEO/GTO

Objects (Jan 2002 - May 2023; elliptical orbits)

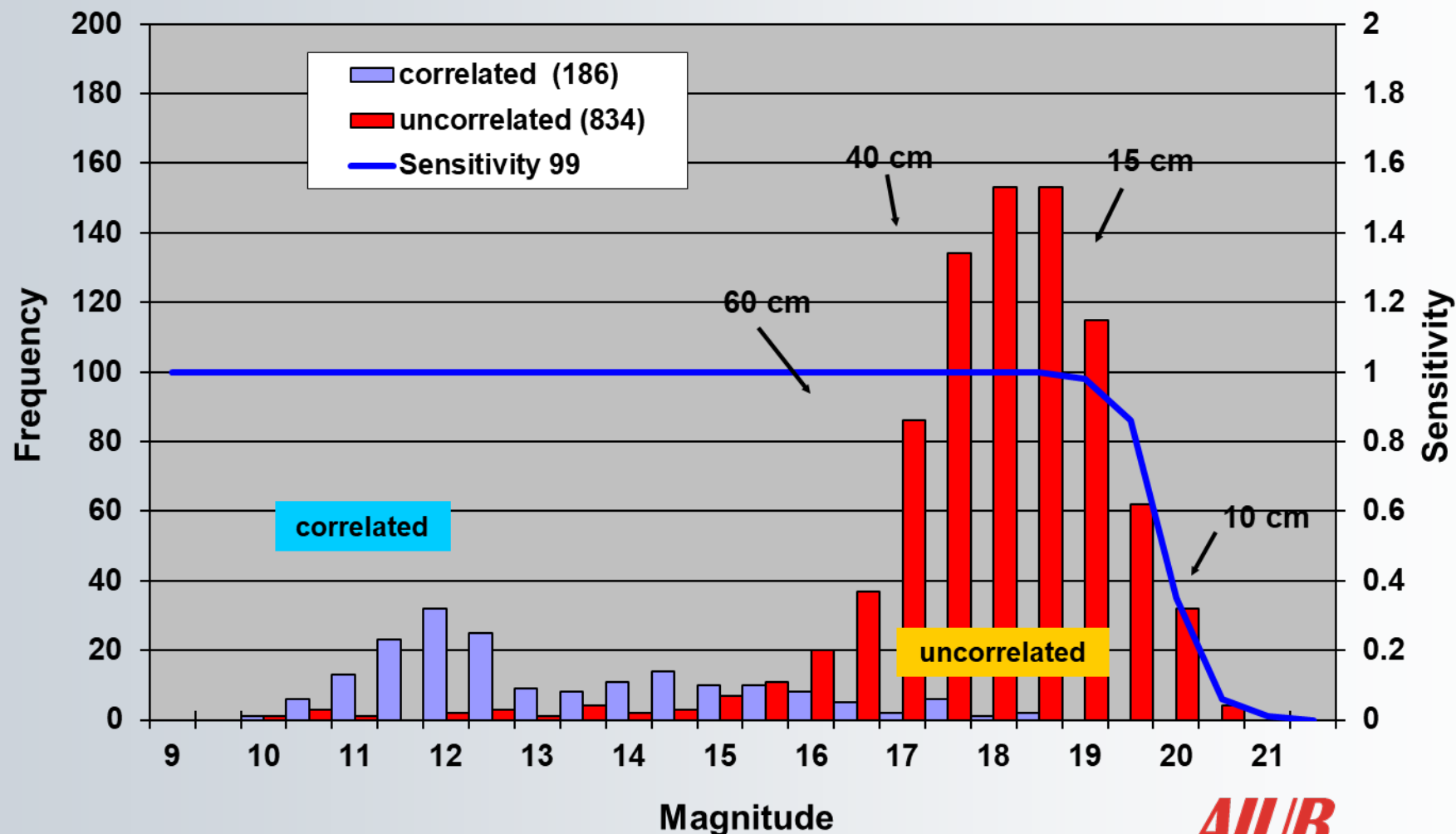


AIUB

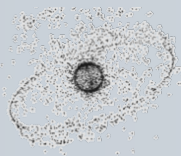


High-Altitude Surveys 2019–2023

Objects (Jan 2019 - May 2023; elliptical orbits)

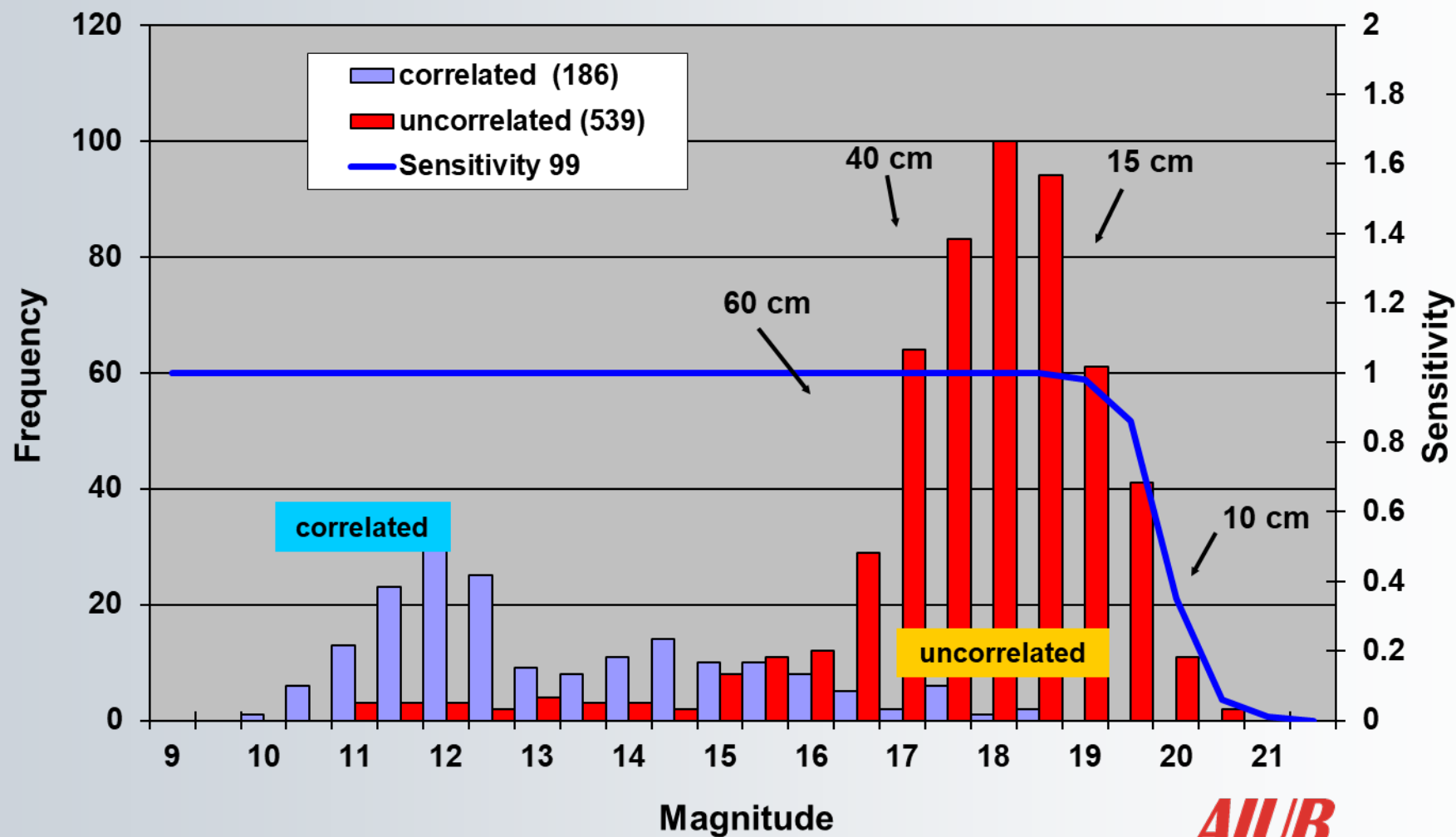


AIUB

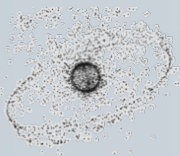


High-Altitude Surveys 2014–2018

Objects (Jan 2014 - Dec 2018; elliptical orbits)

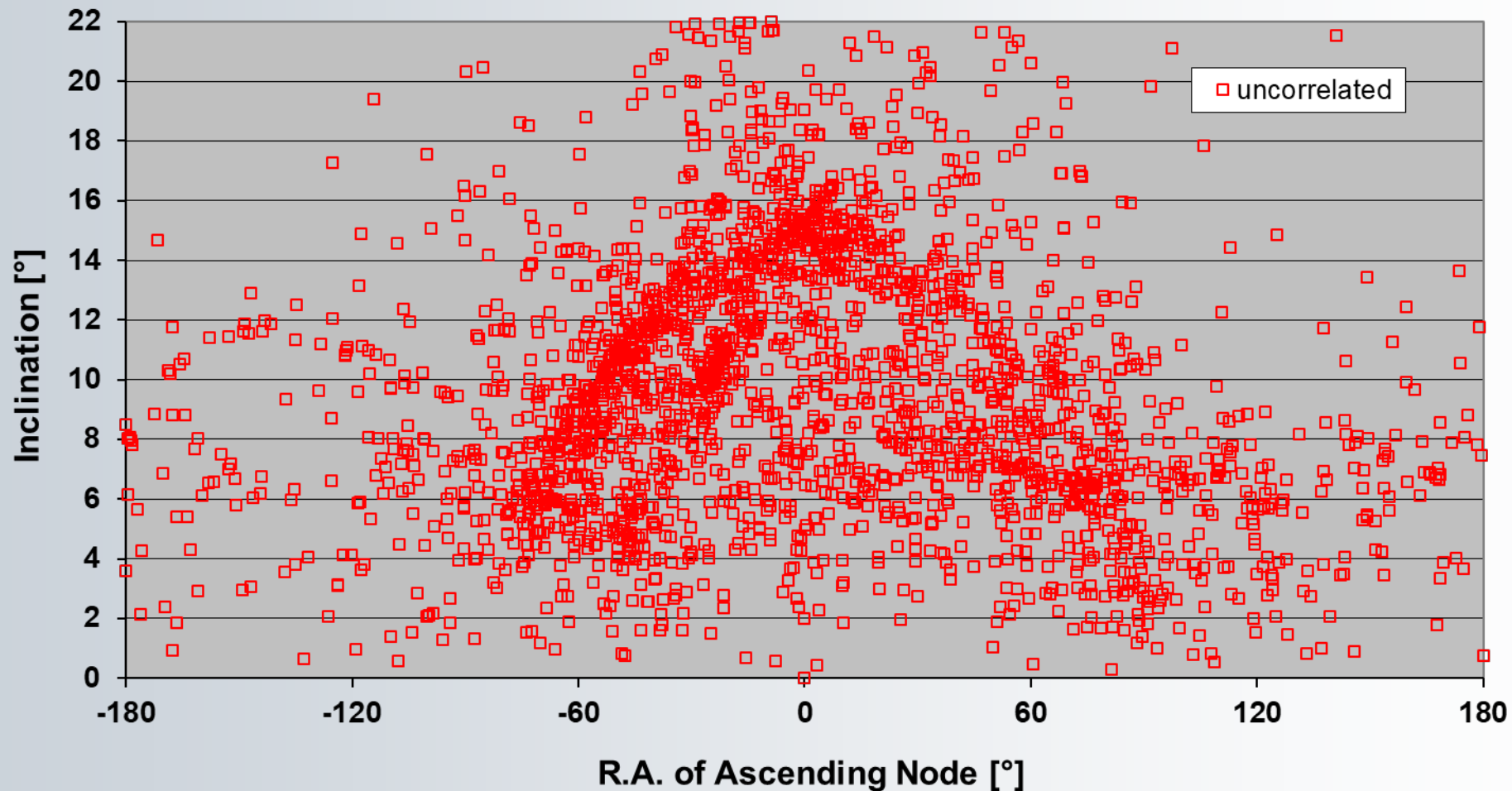


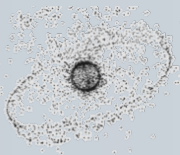
AIUB



High-Altitude Surveys GEO/GTO

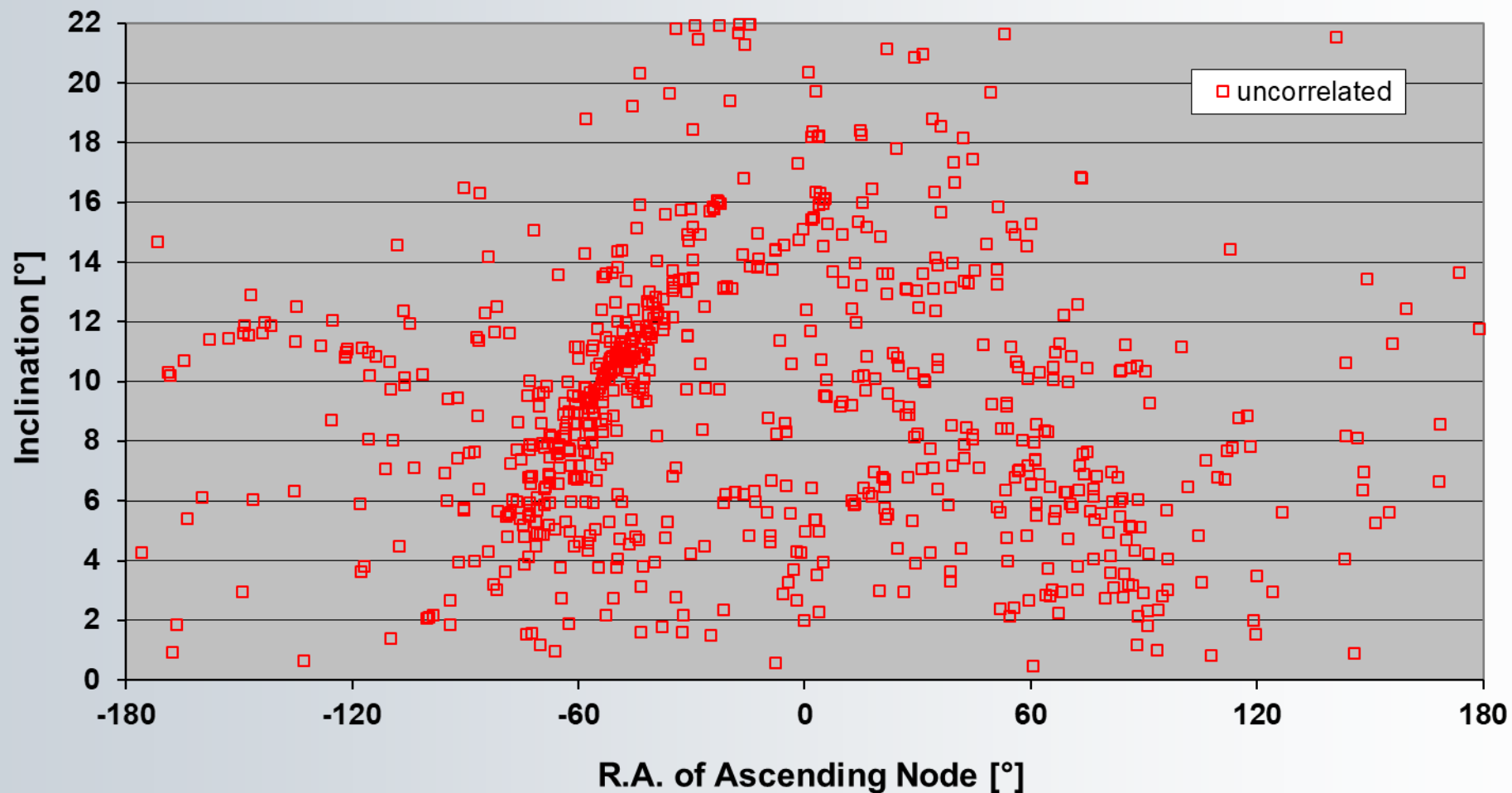
Orbital Elements (Jan 2002 - May 2023; elliptical orbits)

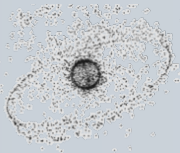




High-Altitude Surveys 2019–2023

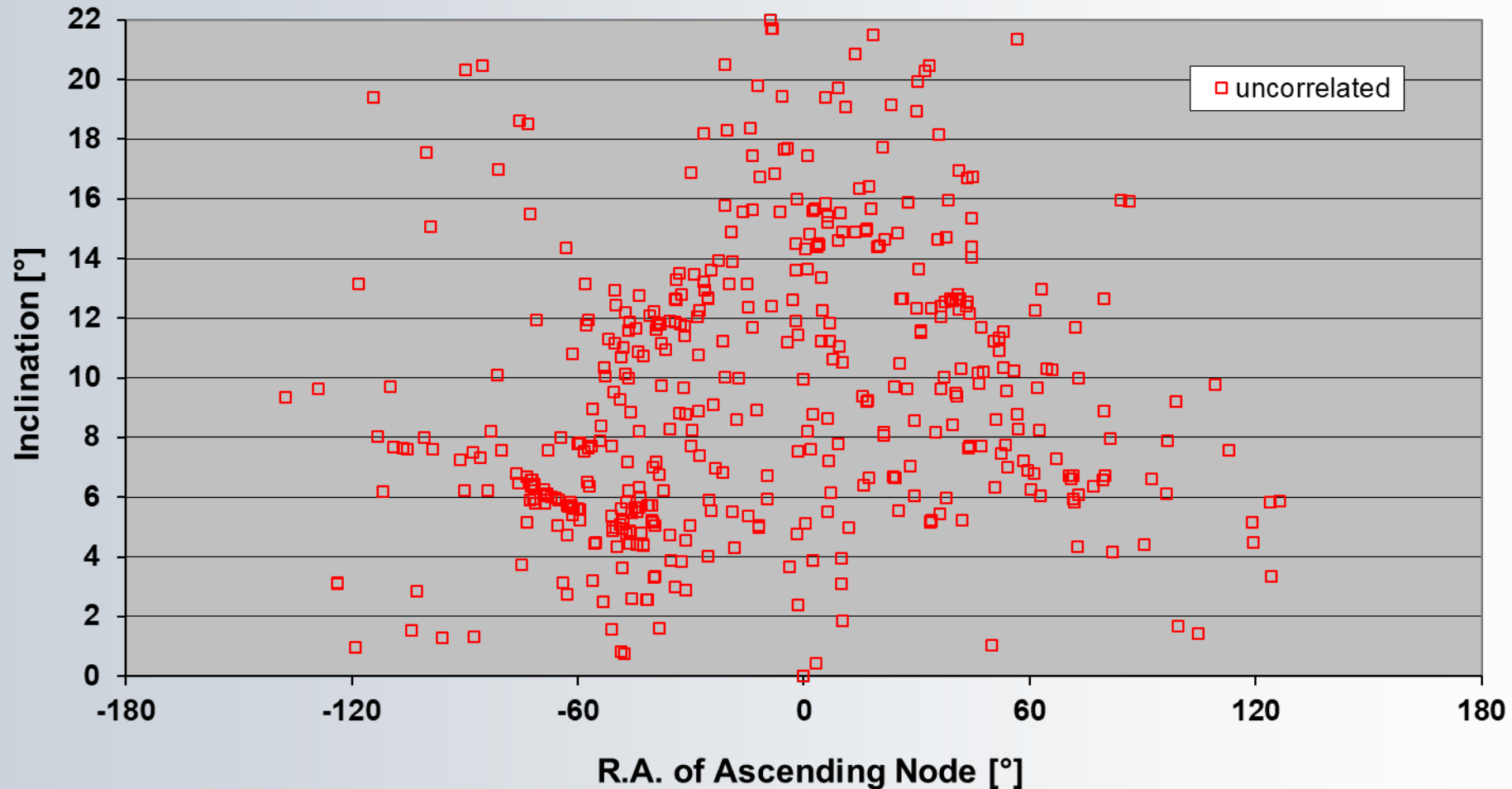
Orbital Elements (Jan 2019 - May 2023; elliptical orbits)

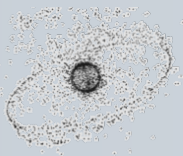




High-Altitude Surveys 2014–2018

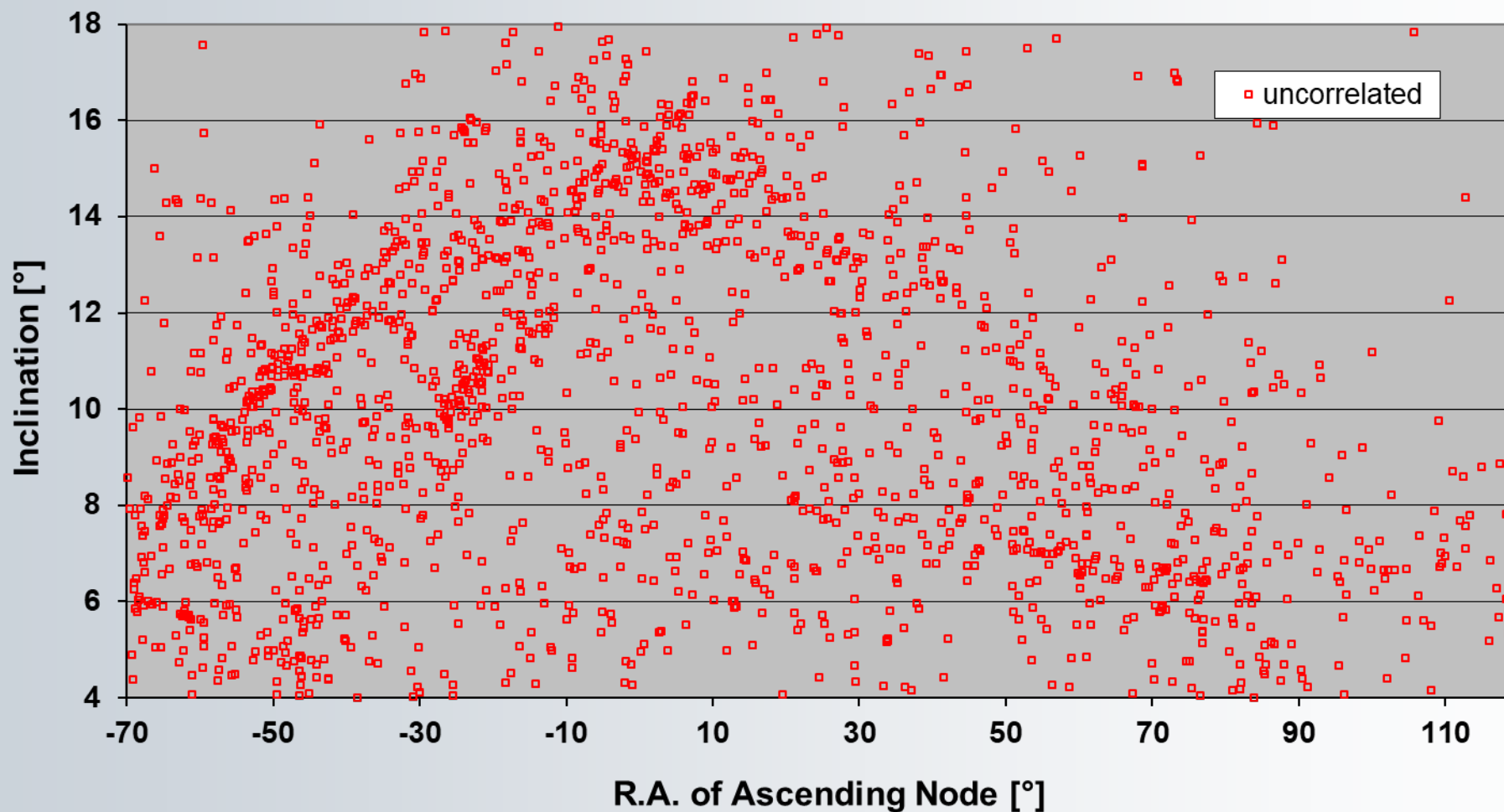
Orbital Elements (Jan 2014 - Dec 2018; elliptical orbits)

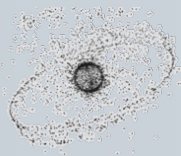




High-Altitude Surveys GEO/GTO

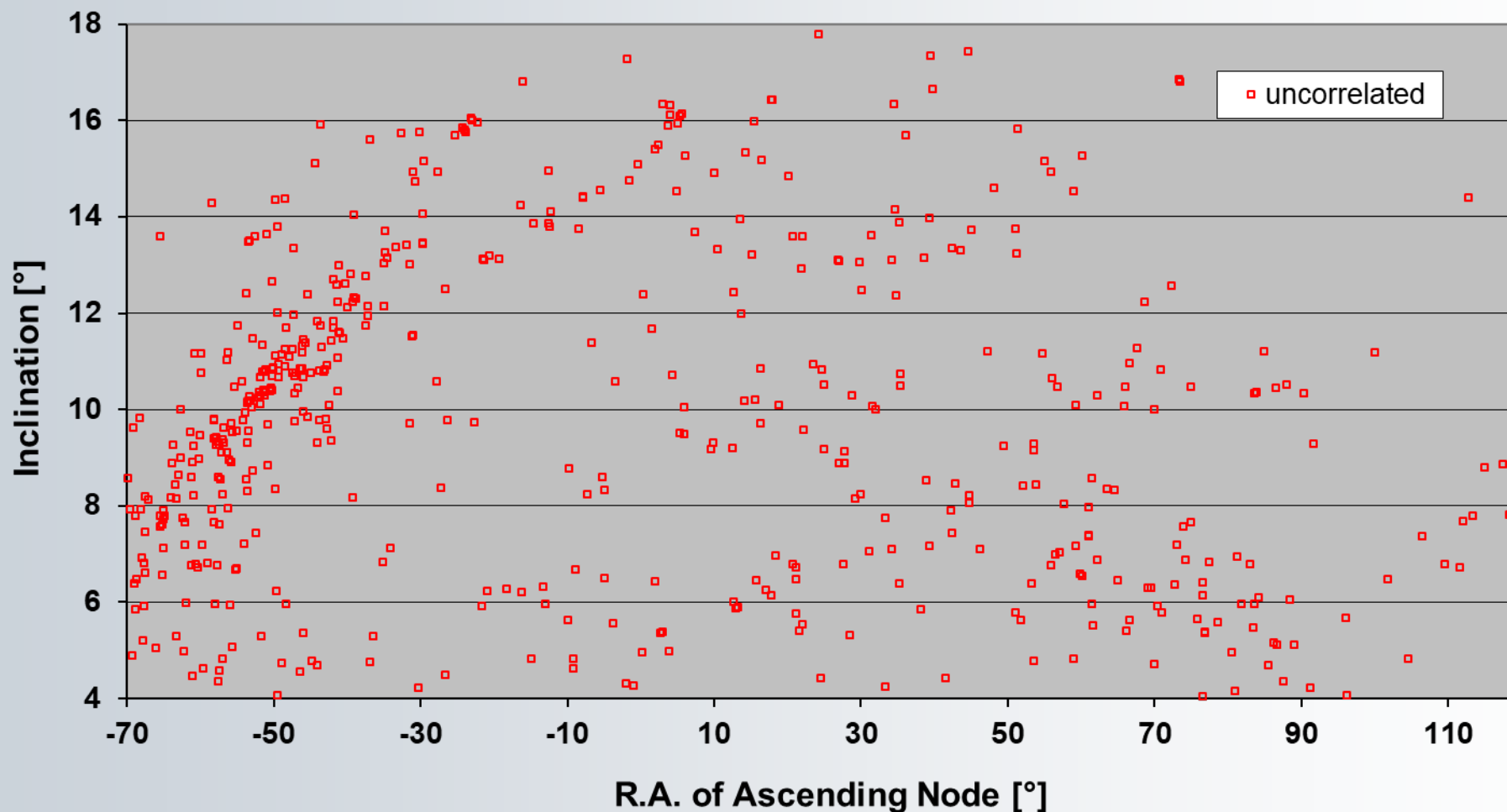
Orbital Elements (Jan 2002 - May 2023; elliptical orbits)

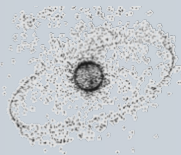




High-Altitude Surveys 2019–2023

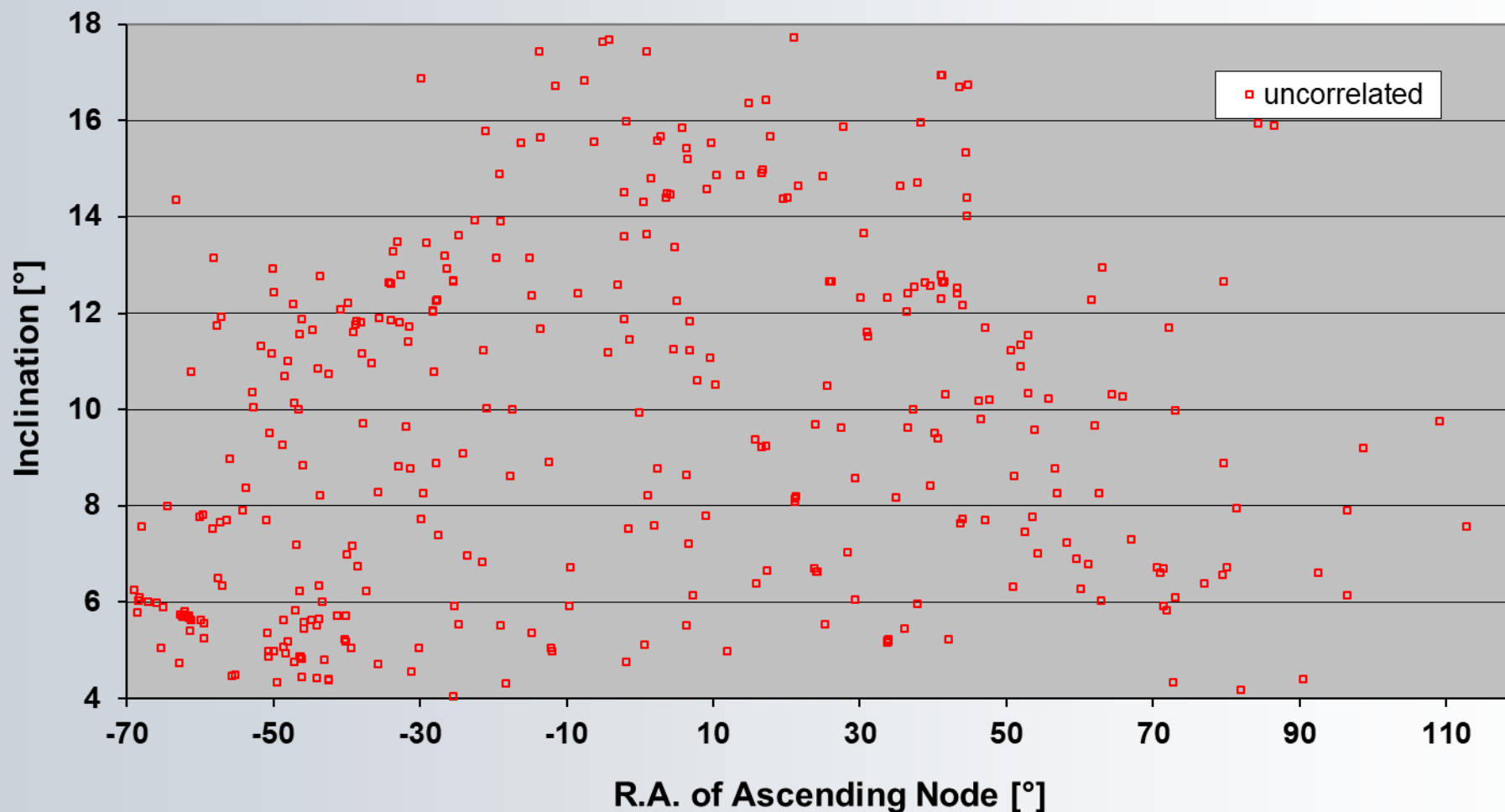
Orbital Elements (Jan 2019 - May 2023; elliptical orbits)

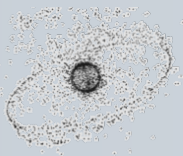




High-Altitude Surveys 2014–2018

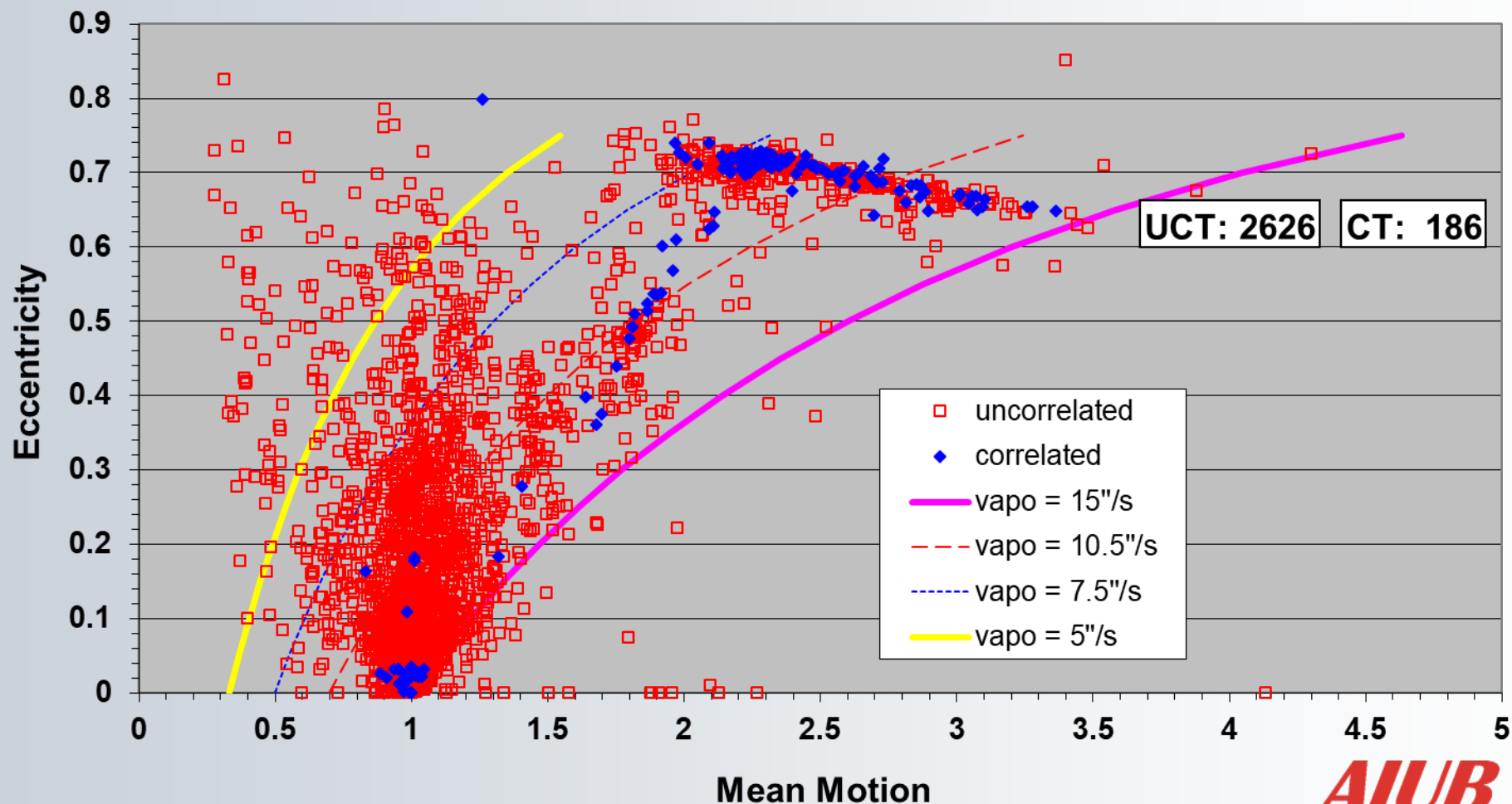
Orbital Elements (Jan 2014 - Dec 2018; elliptical orbits)

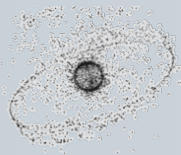




High-Altitude Surveys GEO/GTO

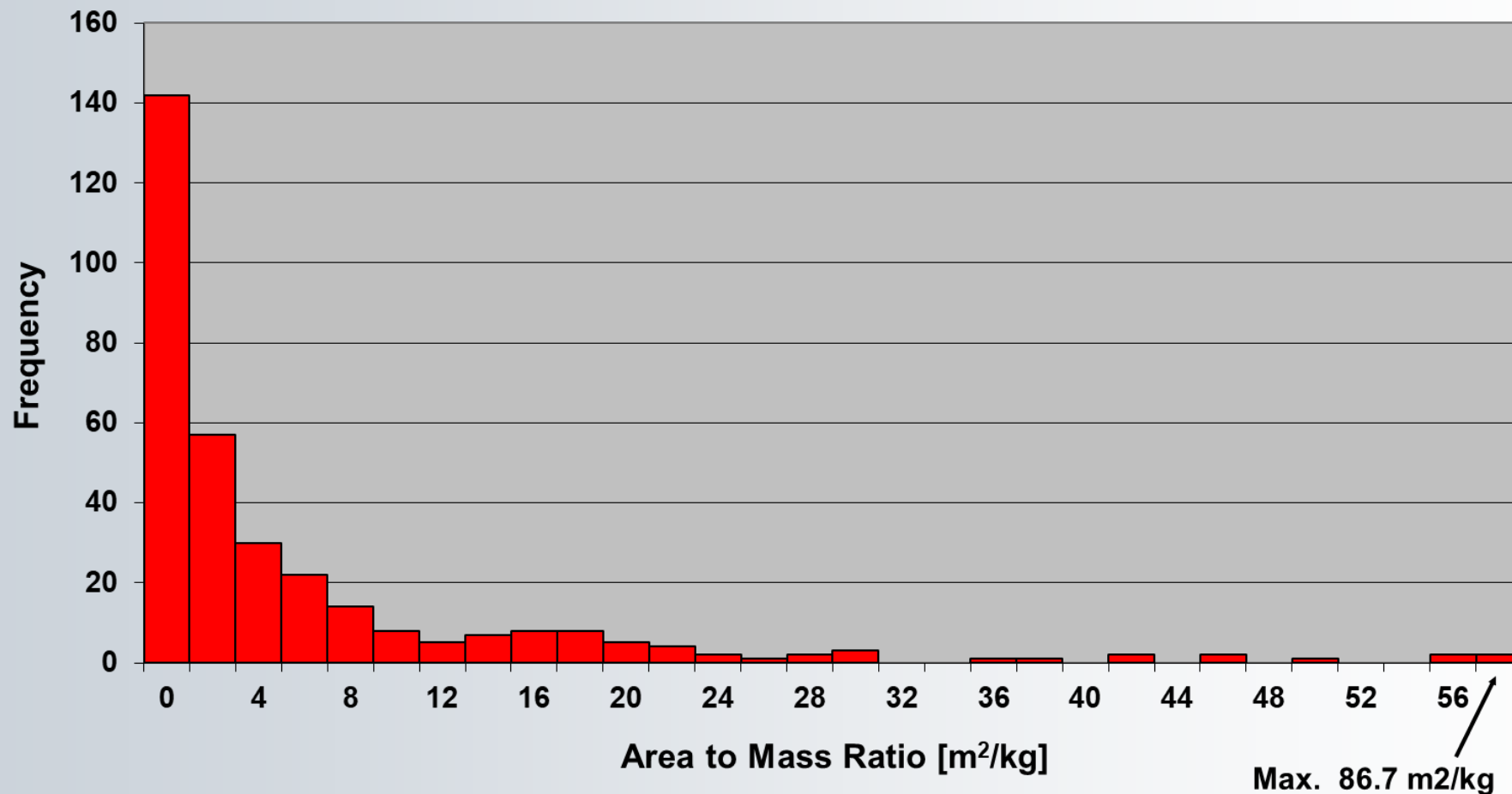
Eccentricity vs Mean Motion (Jan 2002 - May 2023; elliptical orbits)

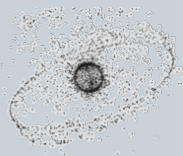




High-Altitude Surveys GEO/GTO

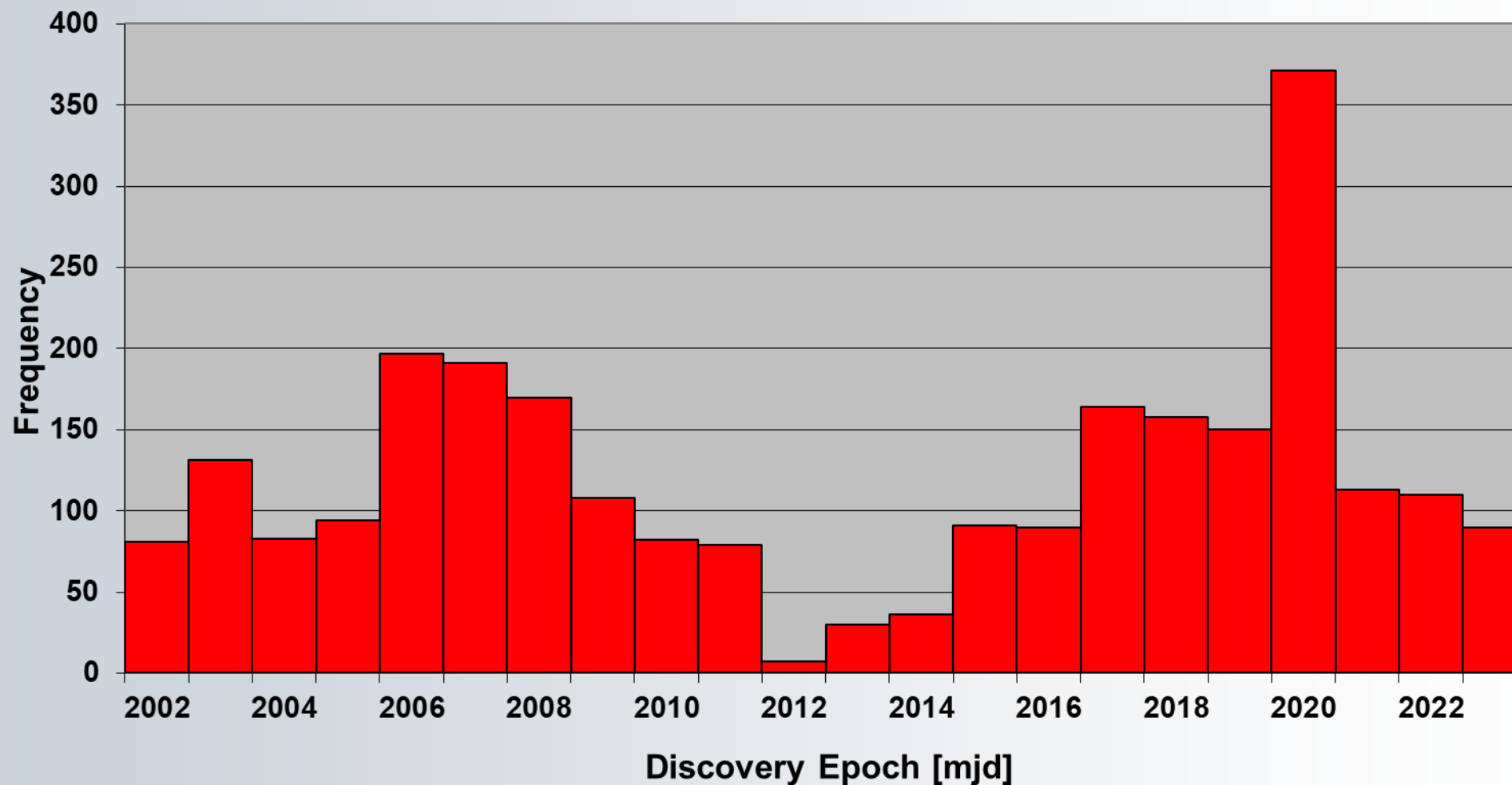
Area-to-Mass Ratio (329 Uncorrelated Objects)





High-Altitude Surveys GEO/GTO

Discovery Rate (Jan 2002 - May 2023; elliptical orbits)



Summary – Lessons Learned

- Regular optical survey at the ESA–OGS essential to
 - monitor changes in the environment (breakup events, ...)
 - provide statistical data to validate models (MASTER)
 - maintain a catalogue of high A/m–ratio objects to allow physical characterization
- ESA continues optical surveys in GEO and HEO
- Recent results show that the debris environment in GEO and HEO is still very dynamic!

