Inter-Agency Space Debris Coordination Committee

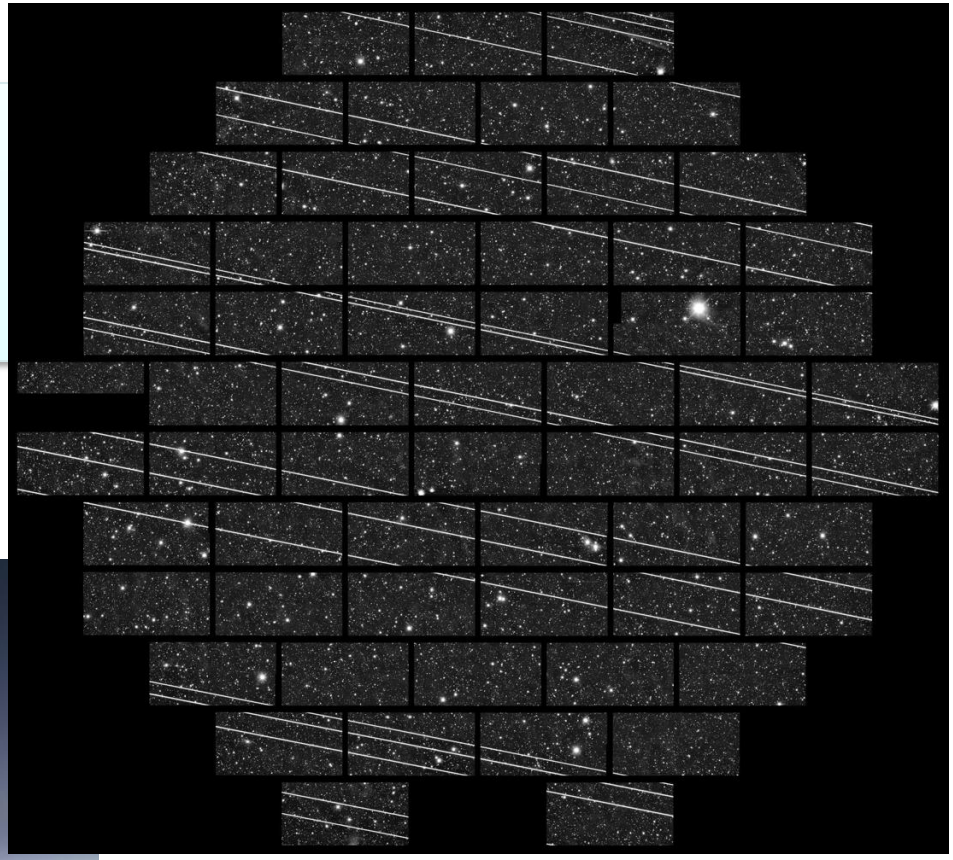
Mega-constellation photometry

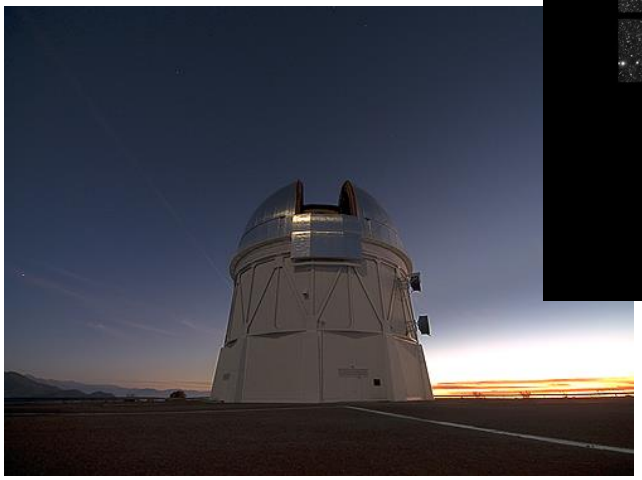
Light pollution from starlink

2019-Nov-18 0800 UT

NSF Blanco 4.0-m telescope

Cerro Tololo, Chile





19 Starlinks

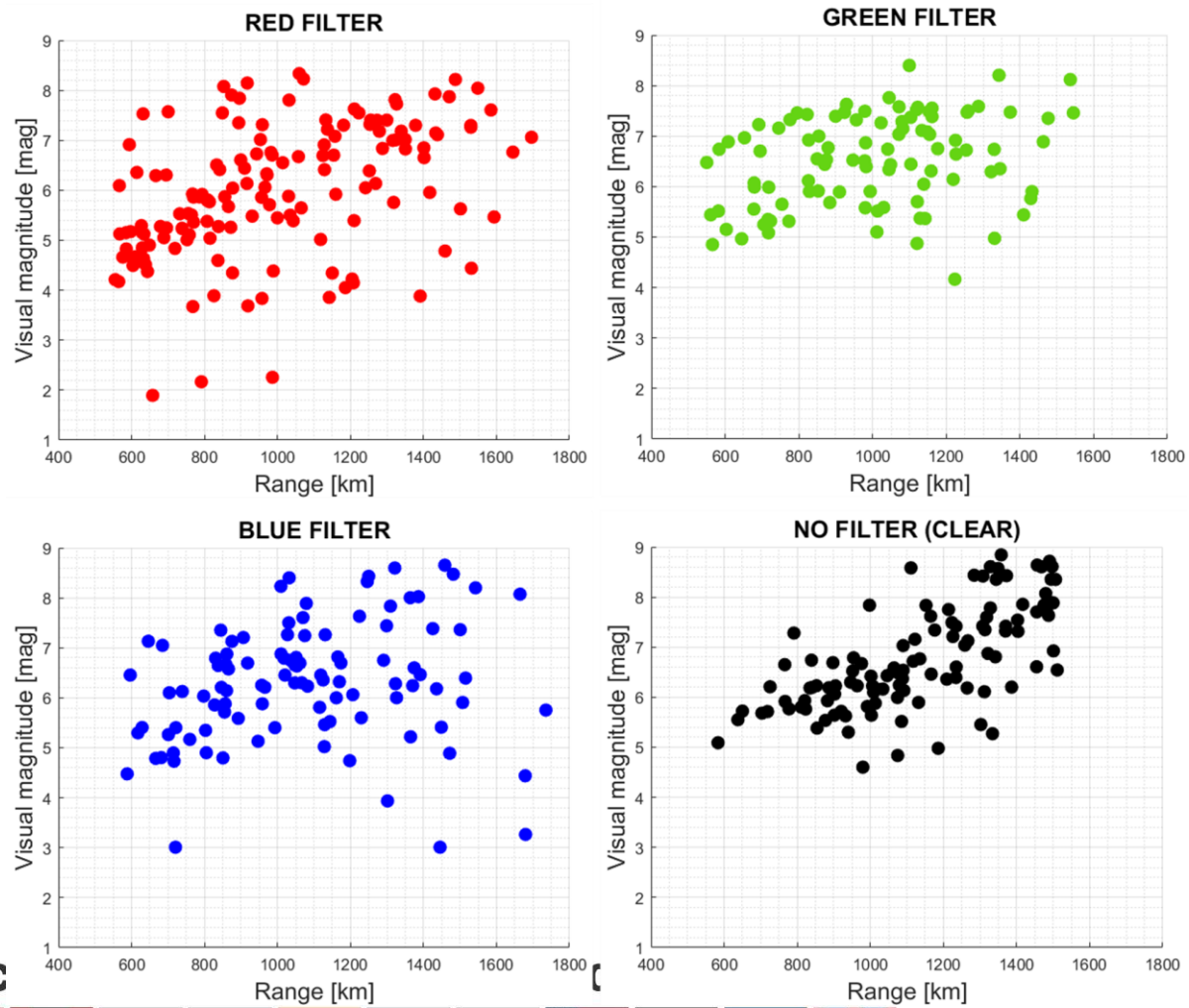
~4 sec

4 x moon diameter

Starlinks observed not intentionally

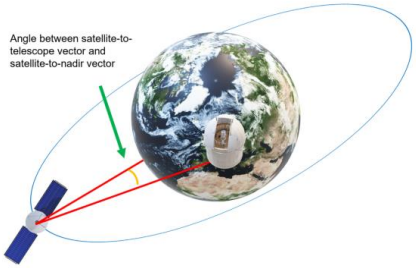
Courtesy: Prof. Patrick Seitzer, UMICH

Starlink observations
Range vs.magnitude

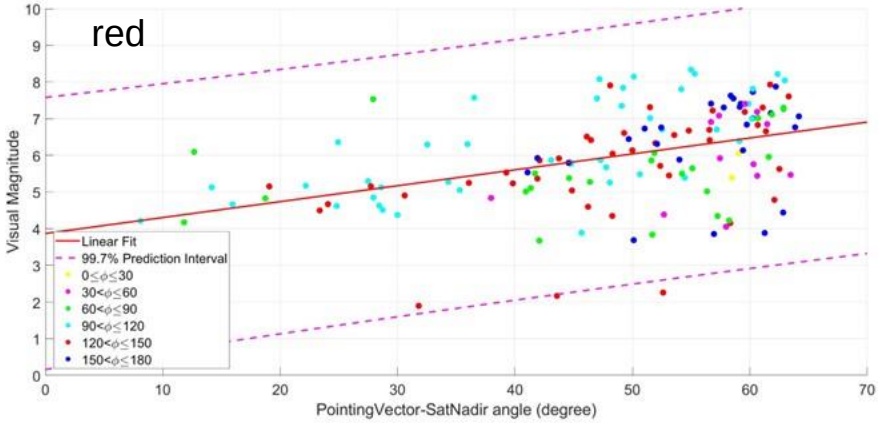


Starlink observations

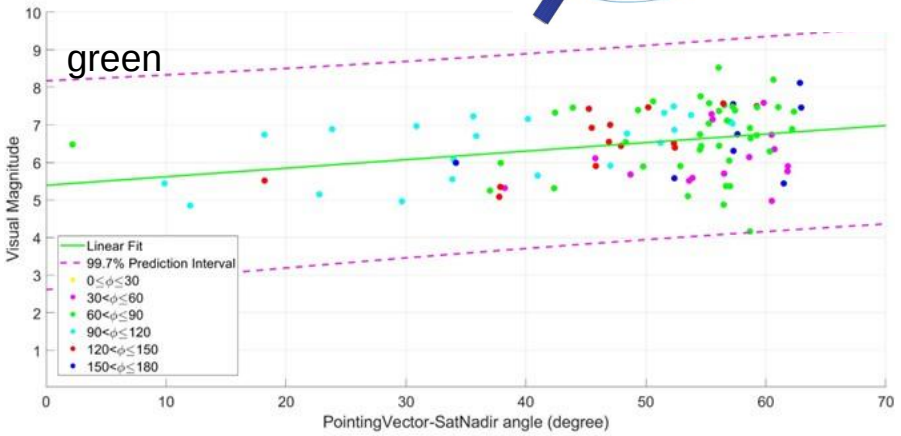
Magnitude vs phase angle



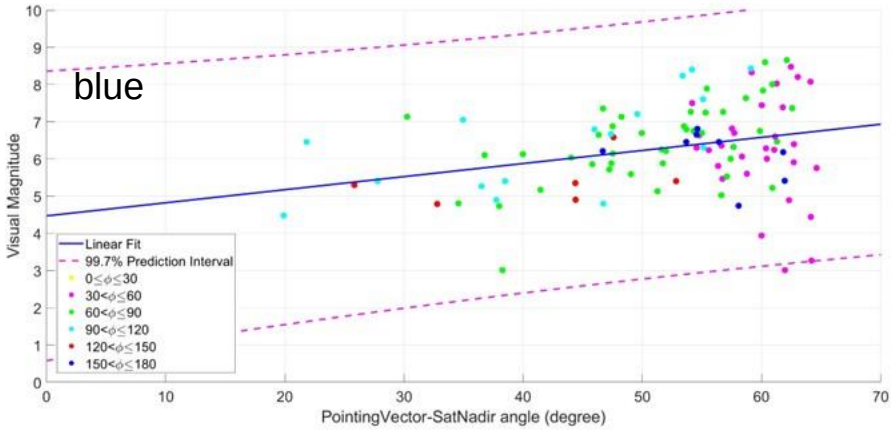
red



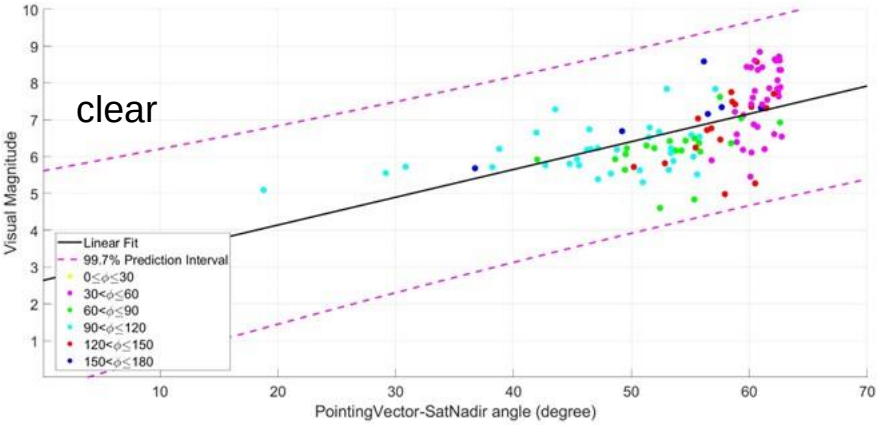
green



blue



clear



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Photometric characterization of Starlink satellite tracklets using RGB filters

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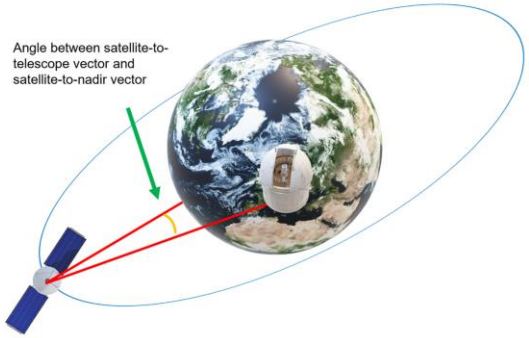
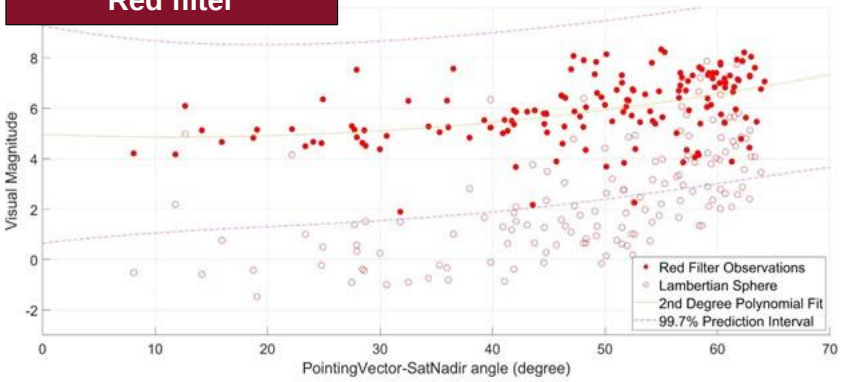
Starlink observations

Magnitude vs Nadir Angle, different phase angles

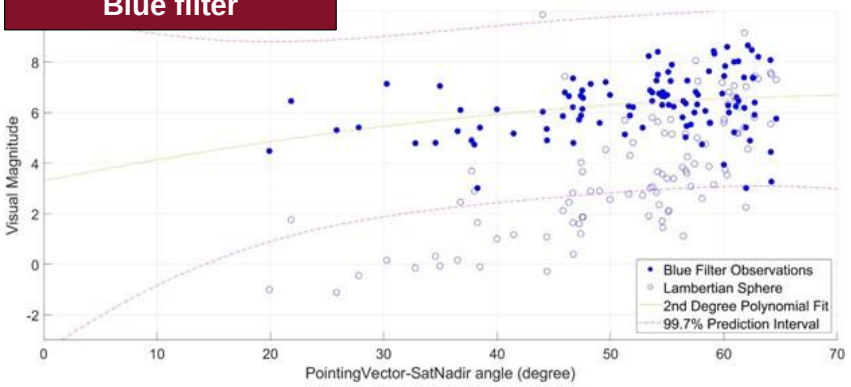


Starlinks result less bright than Lambertian spheres

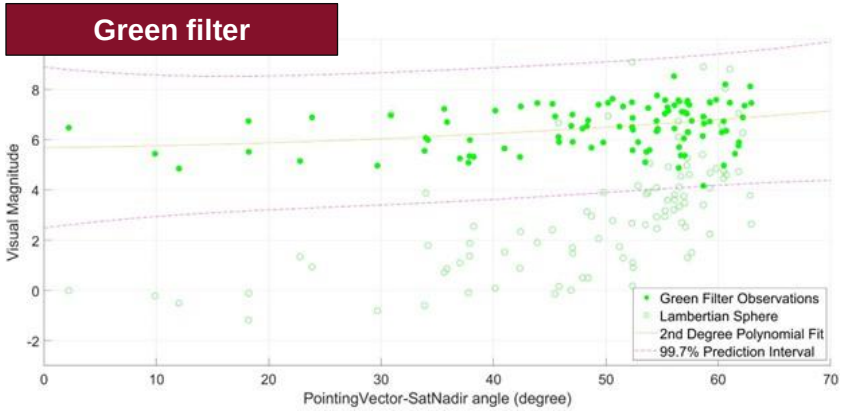
Red filter



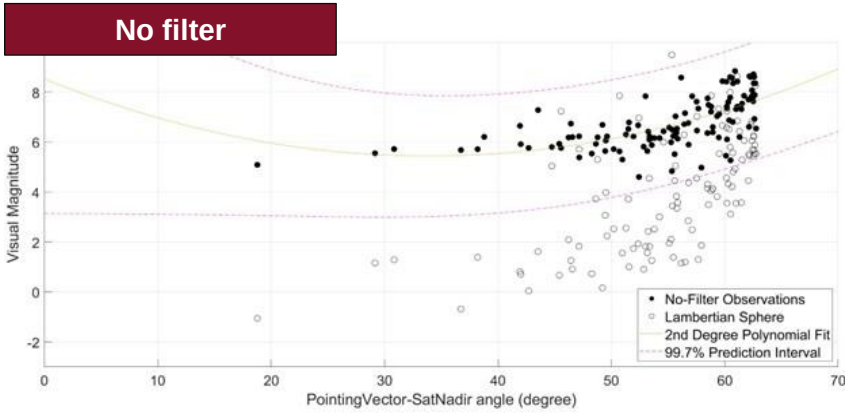
Blue filter



Green filter

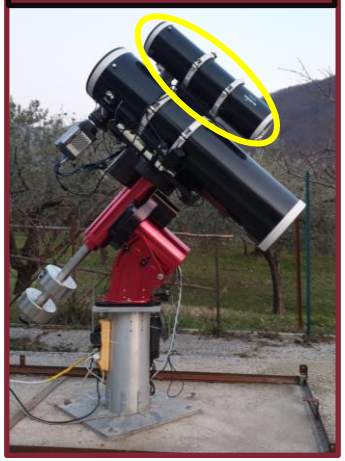


No filter



Starlink observations visorsat

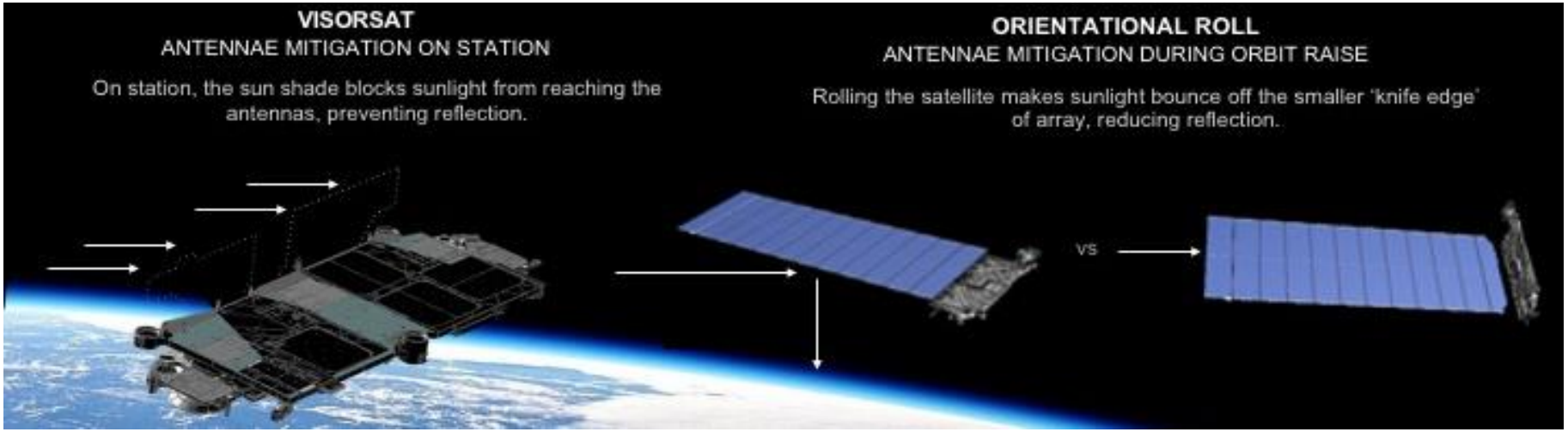
Observation system and overview of the collected data

SCUDO


Lens diameter	250 mm
Focal length	1200 mm
Field of View	1.73° x 1.15°
Optical sensor	CCD
Mount type	Equatorial

Filter	N frames	VisorSat	Mean Magnitude
Red	148	25	8.2350
Green	98	33	8.1607
Blue	103	29	8.3335
No filter	111	24	8.2128

Non-VisorSat	Mean magnitude
123	7.0129
65	7.2251
74	7.0519
87	7.2259



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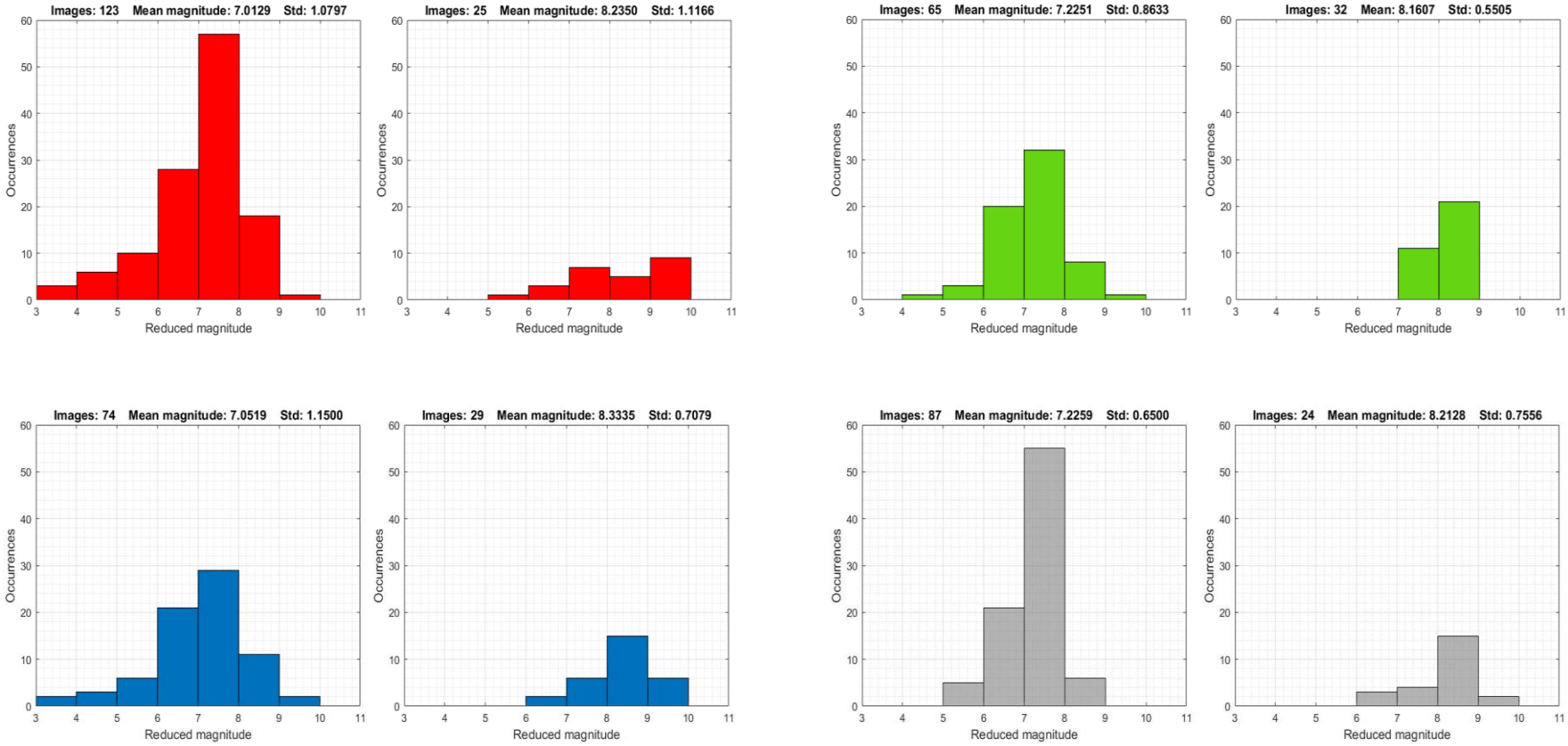
Starlink photometric observations

Comparison between magnitudes of VisorSat and non-VisorSat Starlinks



73rd International Astronautical Congress (IAC), Paris, France, 18-22 September 2022.

IAC-22-D1,IPB,2,x73606

Photometric analysis for testing Starlink solutions to light reflection mitigation

Lorenzo Cimino**, Shariar Hadji Hossein[a], Lorenzo Mariani[a], Gaetano Zarcone[a], Matteo Rossetti[a], Mascia Bucciarelli[a], Fabio Santoni[b], Alessandra Di Cecco[c], Patrick Seitzer[d], Fabrizio Piergentili[a]

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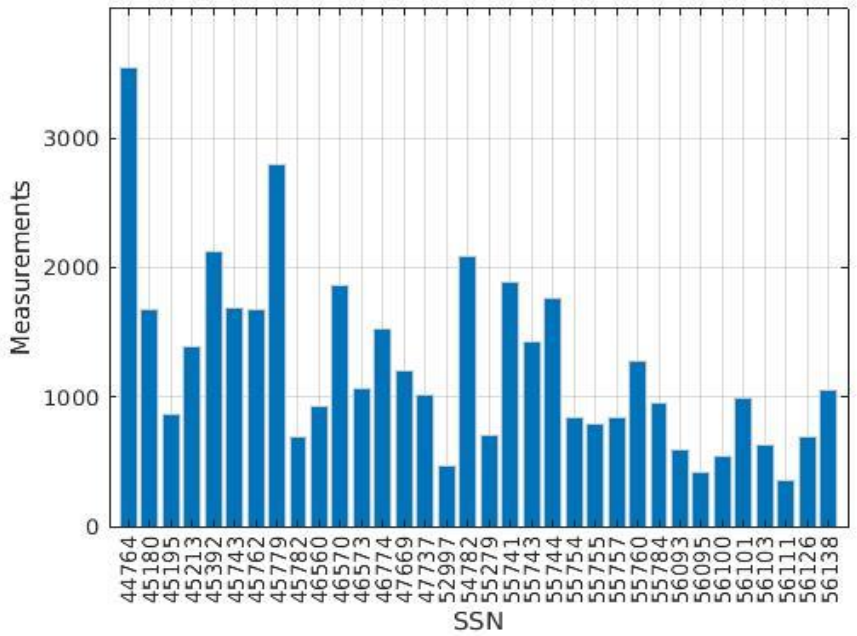
Starlink observations orbital assessment

TLE tracking

- in orbit raising and satellites in atmospheric re-entry
- Study on the impact of the mega-constellations on the night sky



2023 BOXSCORE	
Starlink observed	34
Number of observations	51
Descending phase	23
Ascending phase	28
Measurements	**25000+**
Filter	V-Johnson (peak 540 nm)

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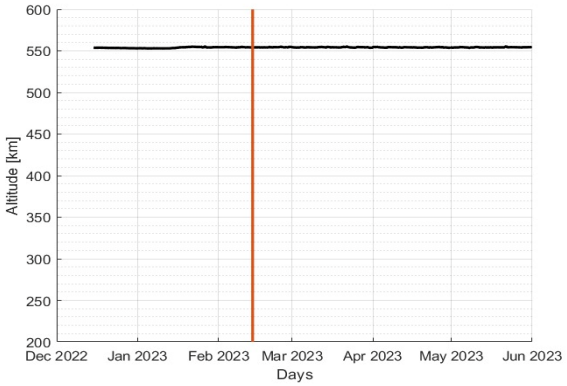
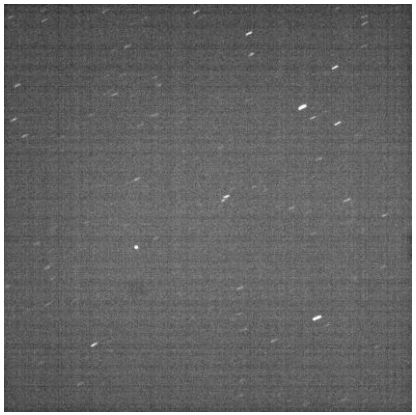
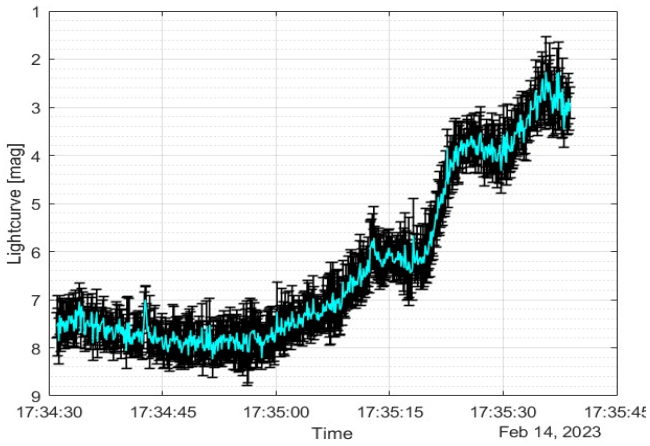
Starlink observations orbital assessment

Constant/Descending phase in TLE tracking

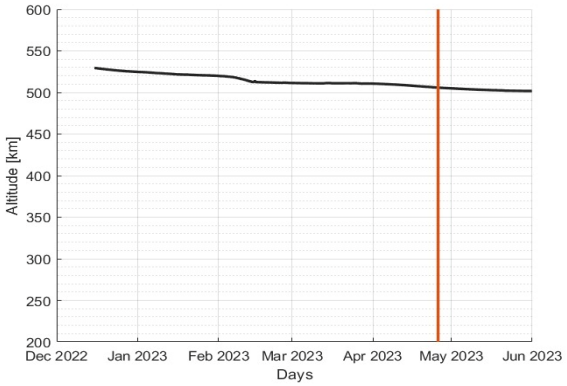
46674 – 2023/02/14

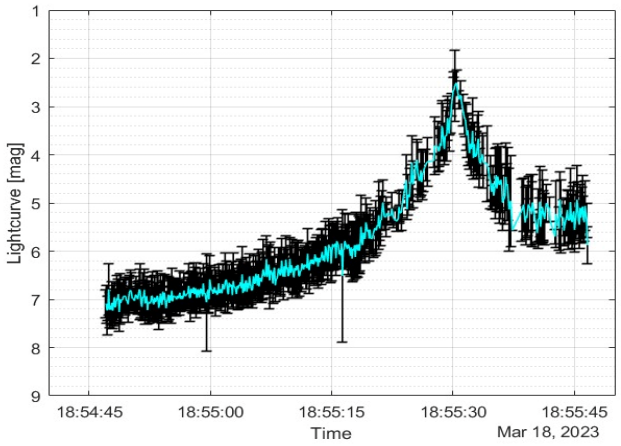






46570 – 2023/03/18





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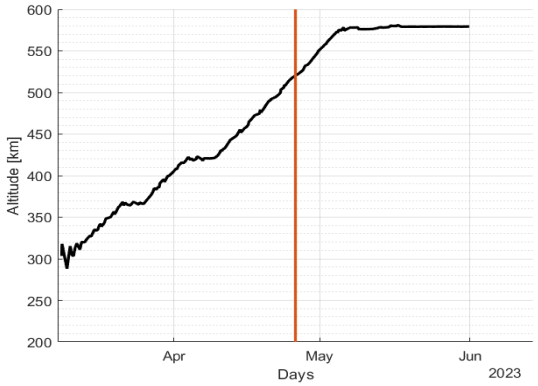
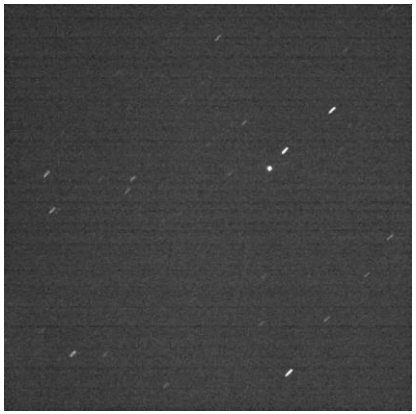
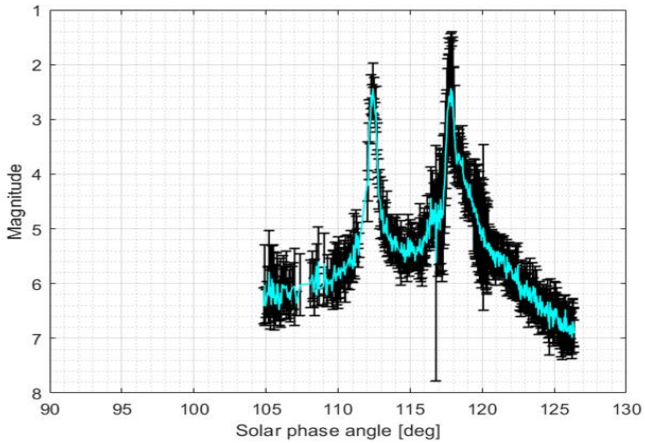
Starlink observations orbital assessment

Raising phase in TLE tracking

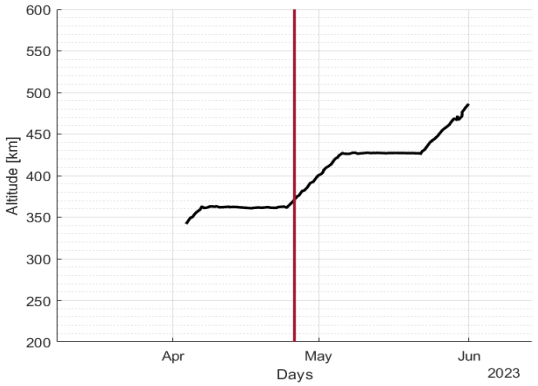
55760 – 2023/04/26

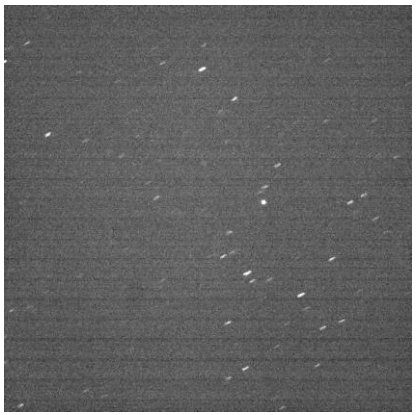


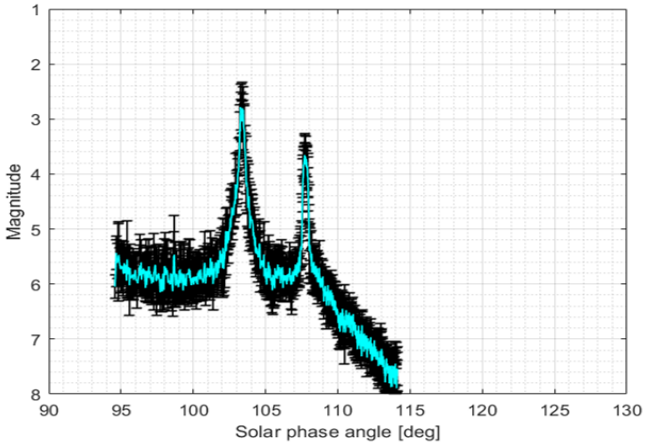




56138 – 2023/04/26





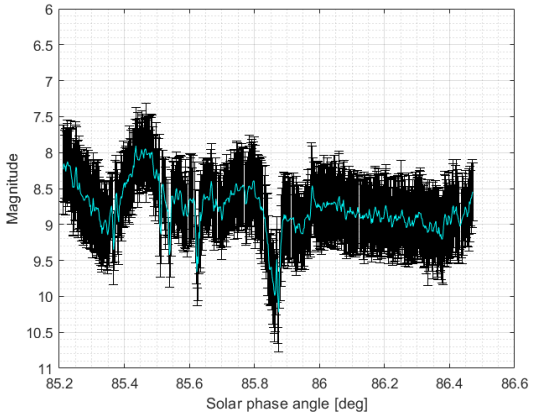


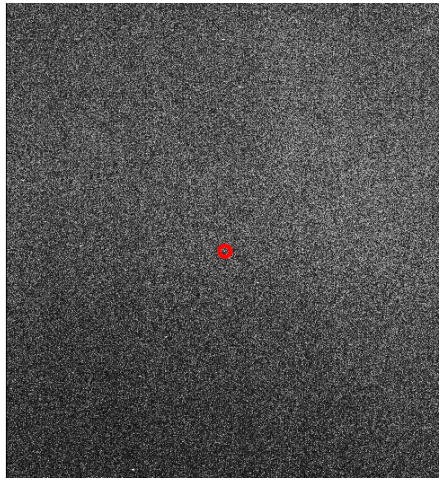
Oneweb observations

phase angle vs. magnitude

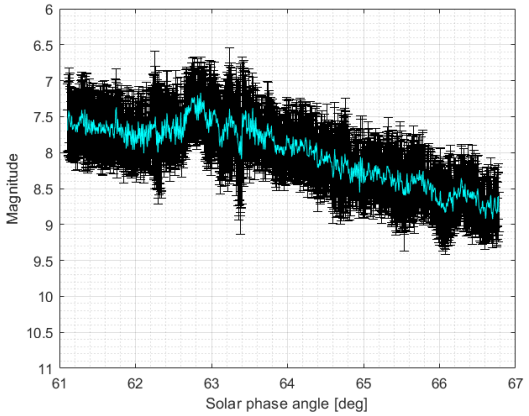
Collaboration with University of Michigan

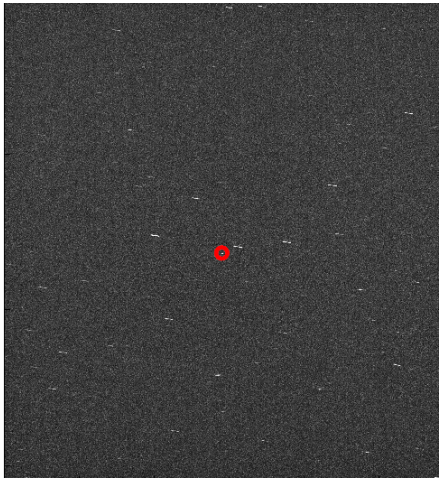
47265 – 2022/08/13



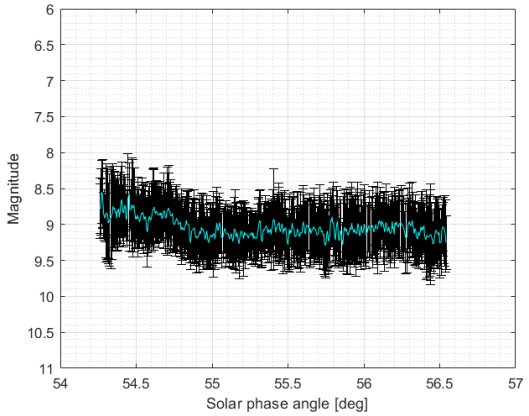


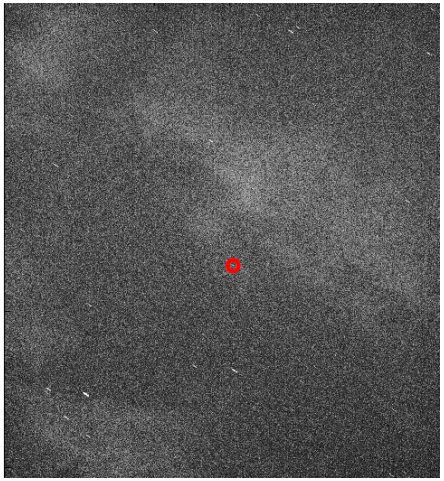
45445 – 2022/08/13





45143 – 2022/08/13





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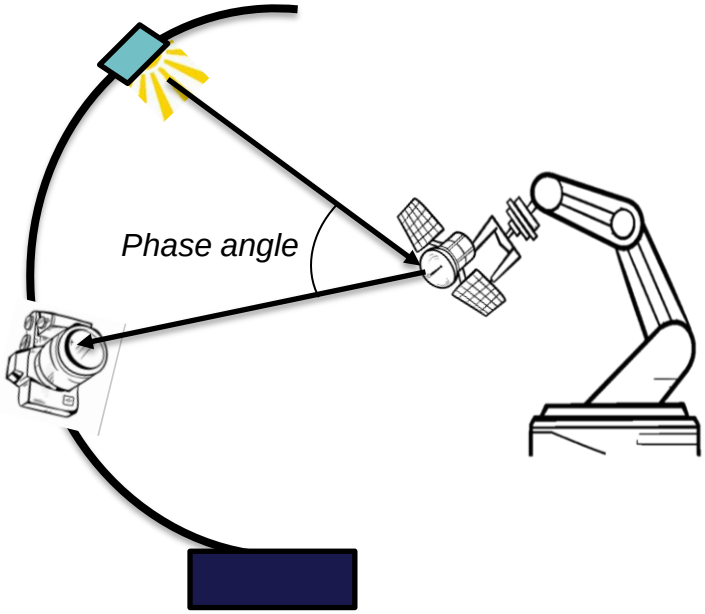
Involve laboratory facilities

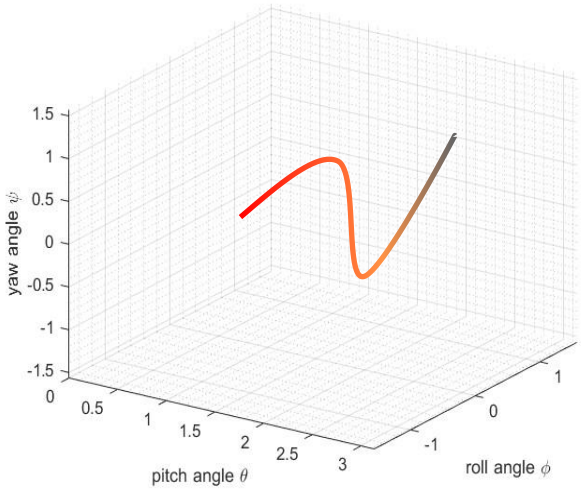
ARM4NDO



Satellite attitude variations during a simulated scenario using the robotic arm

Generation of a light curve wrt satellite attitude:
(φ, θ, ψ) → brightness

Light curve inversion:
processing simulations data for associating brightness values to attitude initial condition



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Involve laboratory facilities

ARM4NDO

Arm for Near Distance Observations

1. **Attitude reconstruction from light curve**

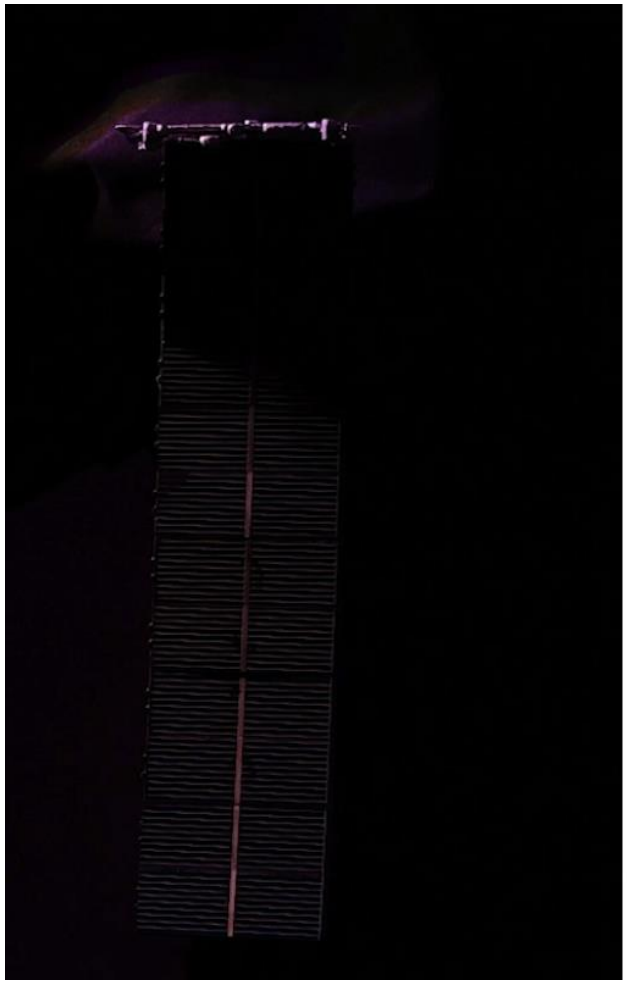
Satellite attitude variations during a real passage simulated using the robotic arm

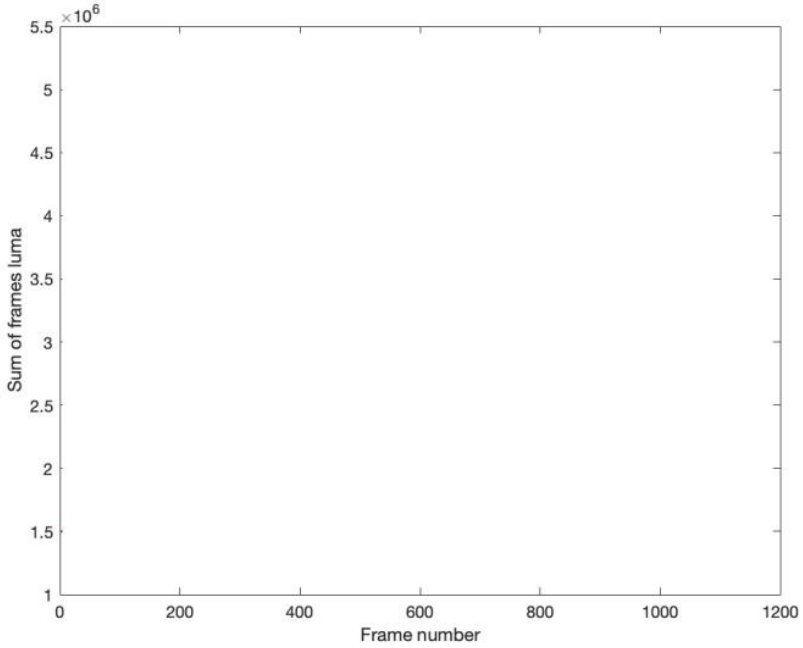
2. **Support the design of low impact satellites for the reduction of light pollution**

The realization of a reflection model before launch permits to implement mitigation actions in order to prevent excessive brightness for constallations such as IRIDE, Starlink and OneWeb

Involve laboratory facilities

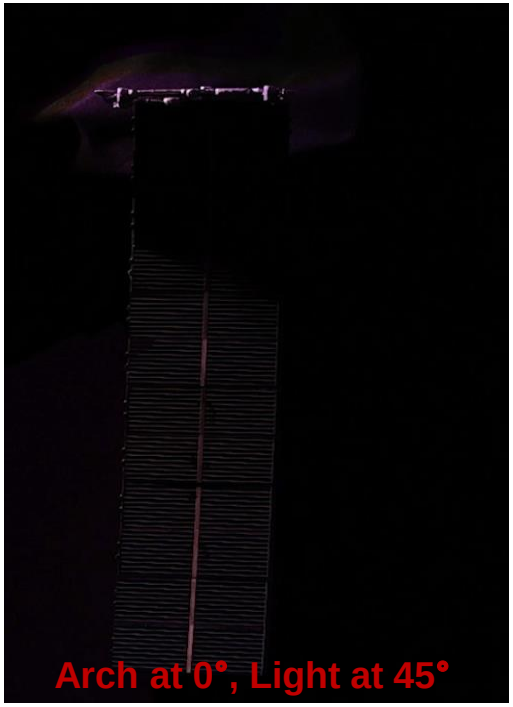
Test



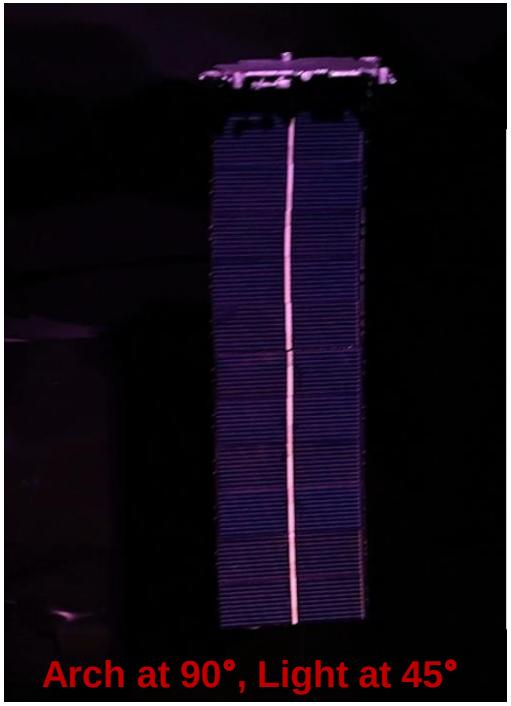


Involve laboratory facilities

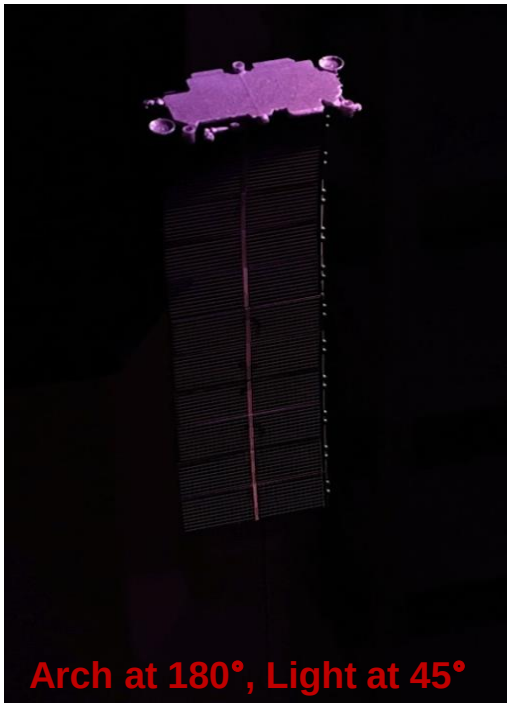
Test



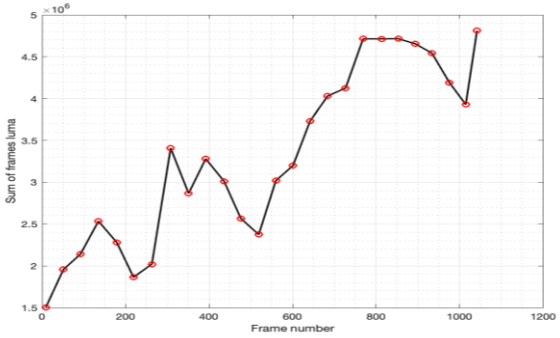
Arch at 0°, Light at 45°

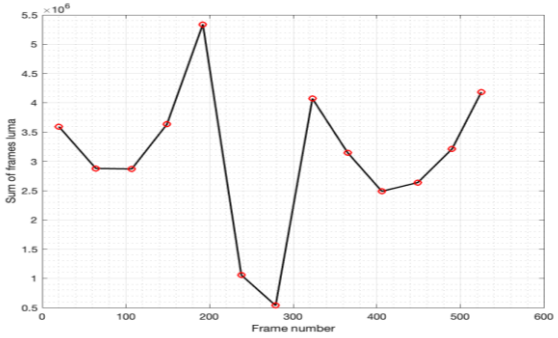


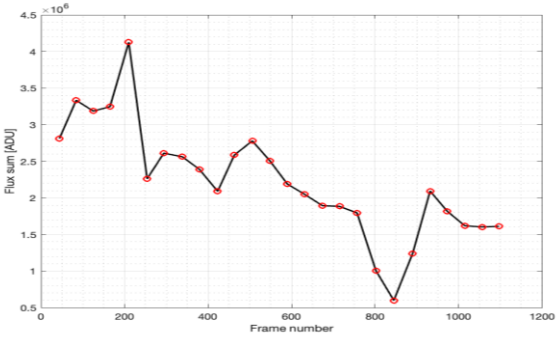
Arch at 90°, Light at 45°



Arch at 180°, Light at 45°







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Conclusion

- Mega-constellations poses a serious **space sustainability** risk
- New **standards and guidelines** are being studied from different institution
- Paramount importance of satellites in mega-constellation for:
  - Evaluating effectiveness of **mitigation systems** (paints, visors, maneuver…)
  - Evaluating **polluting effects** on different bands (optical, infrared, microwaves…)
  - Evaluate the effects of different **observation geometries**, distance and phase angle
  - Evaluate **new design solutions** to mitigate polluting effects through ground characterization (lab measurements)

- Measurements of Mega constellations target are easy to obtain

- Exctracting reliable informatons for Megaconstellations is not trivial –strong effect from geometry, satellite design updates and orbital phase

- Different constellation could have different behaviour

- **Using lab facilities to produce experimental light curve could be useful - digital twin seems not to be enough accurate or needs to be validated from experimental data**

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