Study on validation of spectral band adjustment factors using lunar hyperspectral measurements

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Matthijs Krijger
Pieter van der Meer
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Tim Hewison
Sebastien Wagner

EARTH SPACE SOLUTIONS

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SCIAMACHY, GIRO & GOME2

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Study funded by EUMETSAT

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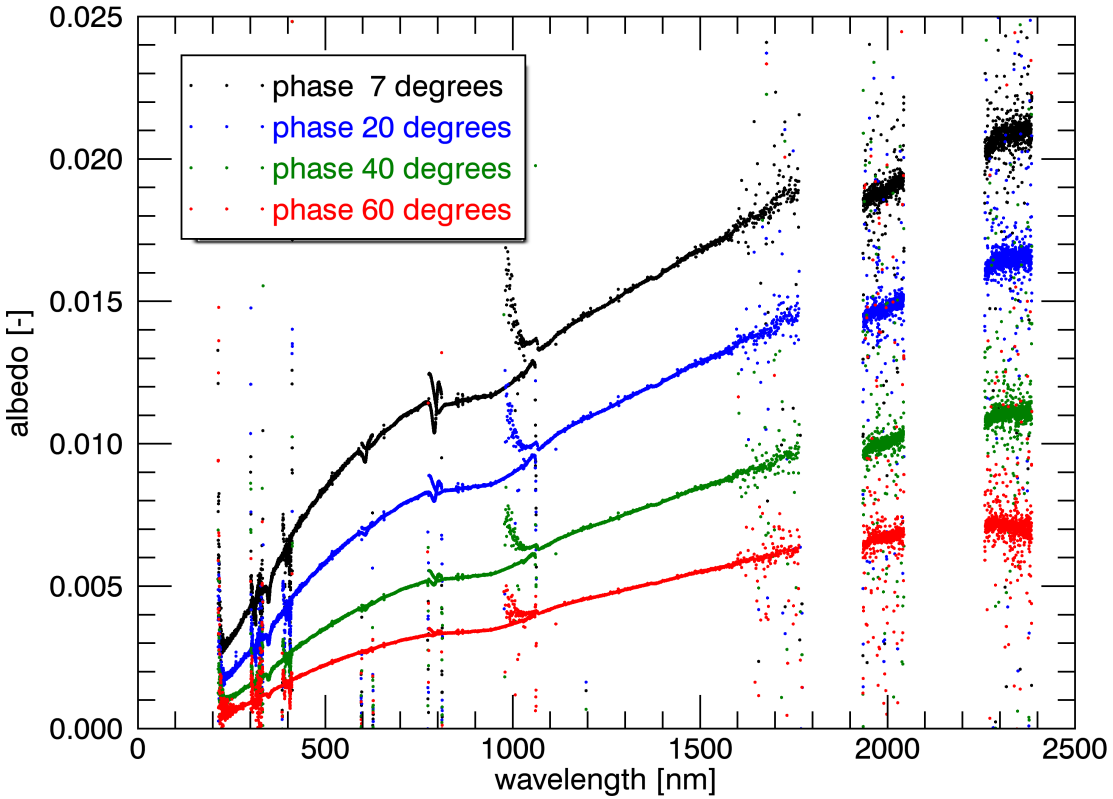
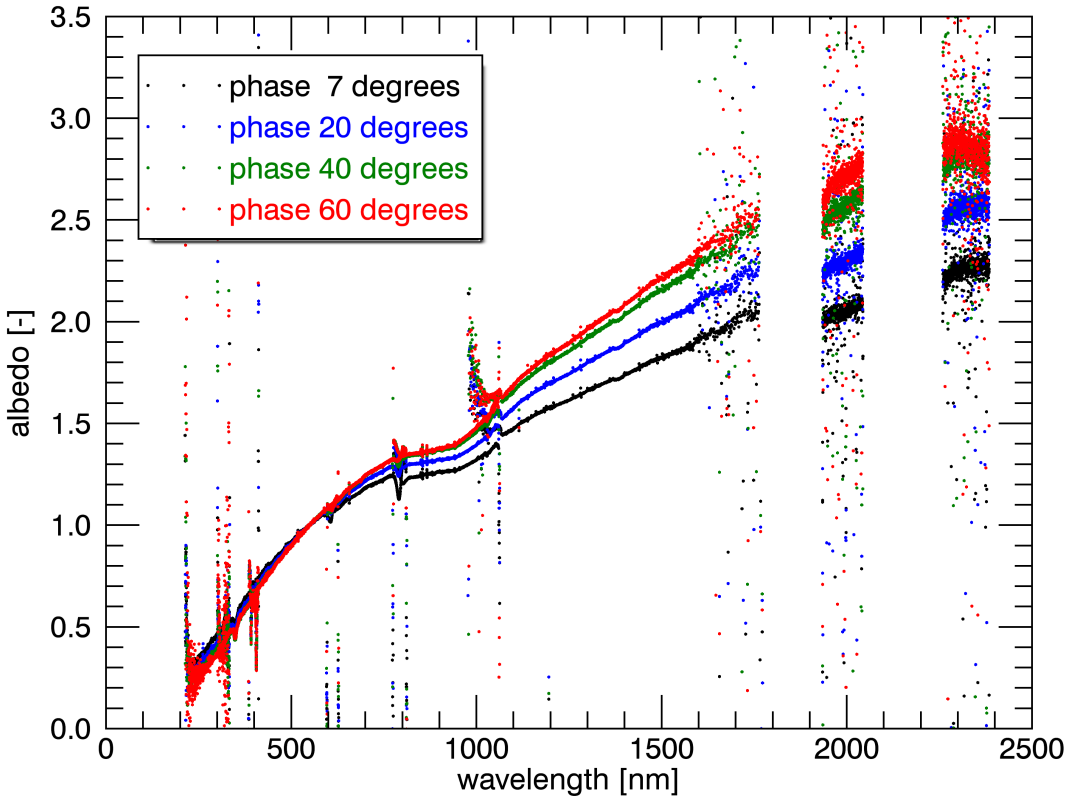
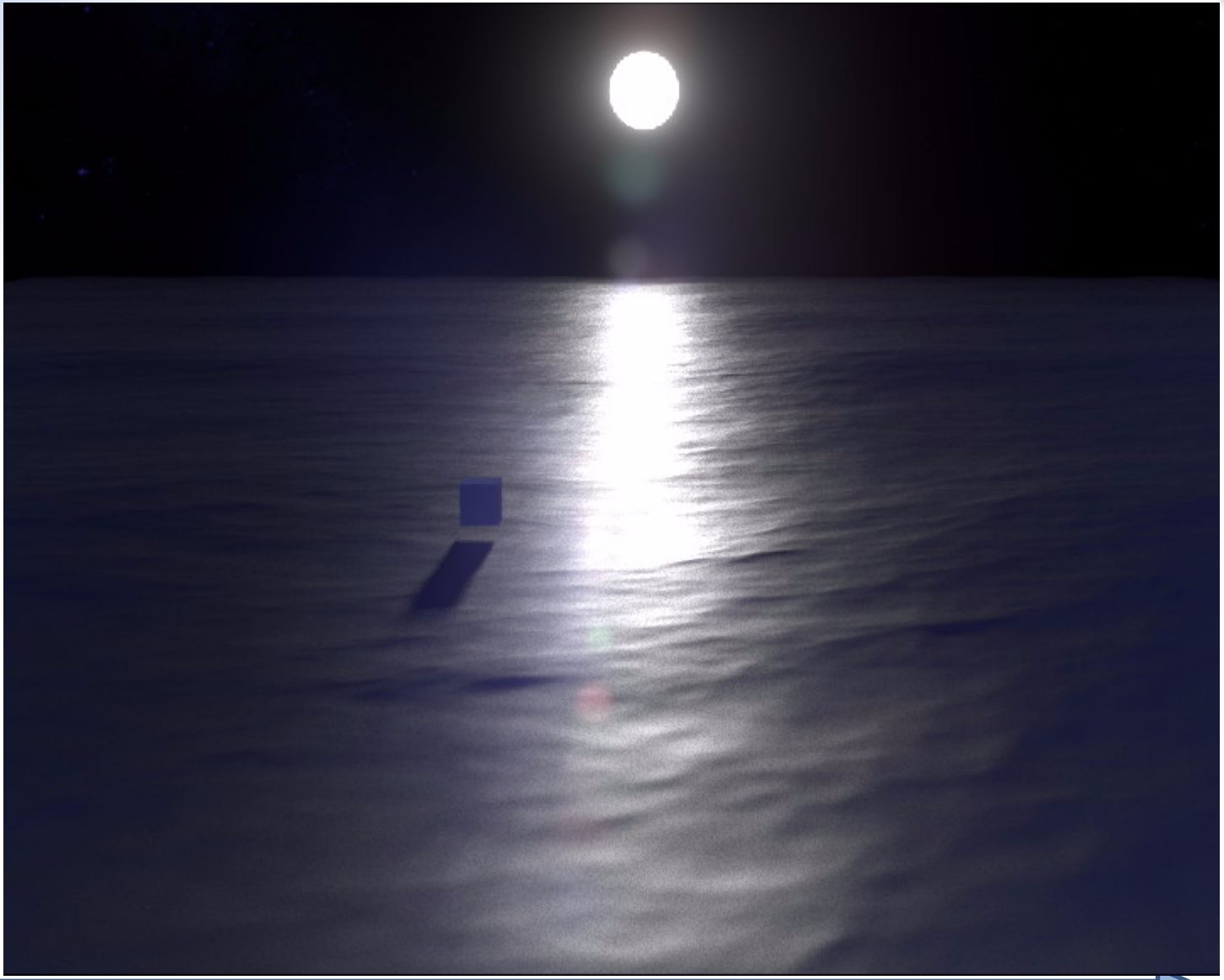
Albedo


phase 7 degrees
phase 20 degrees
phase 40 degrees
phase 60 degrees
albedo [-]
0.025
0.020
0.015
0.010
0.005
0.000
0
500
1000
1500
2000
2500
wavelength [nm]

Albedo (normalised)



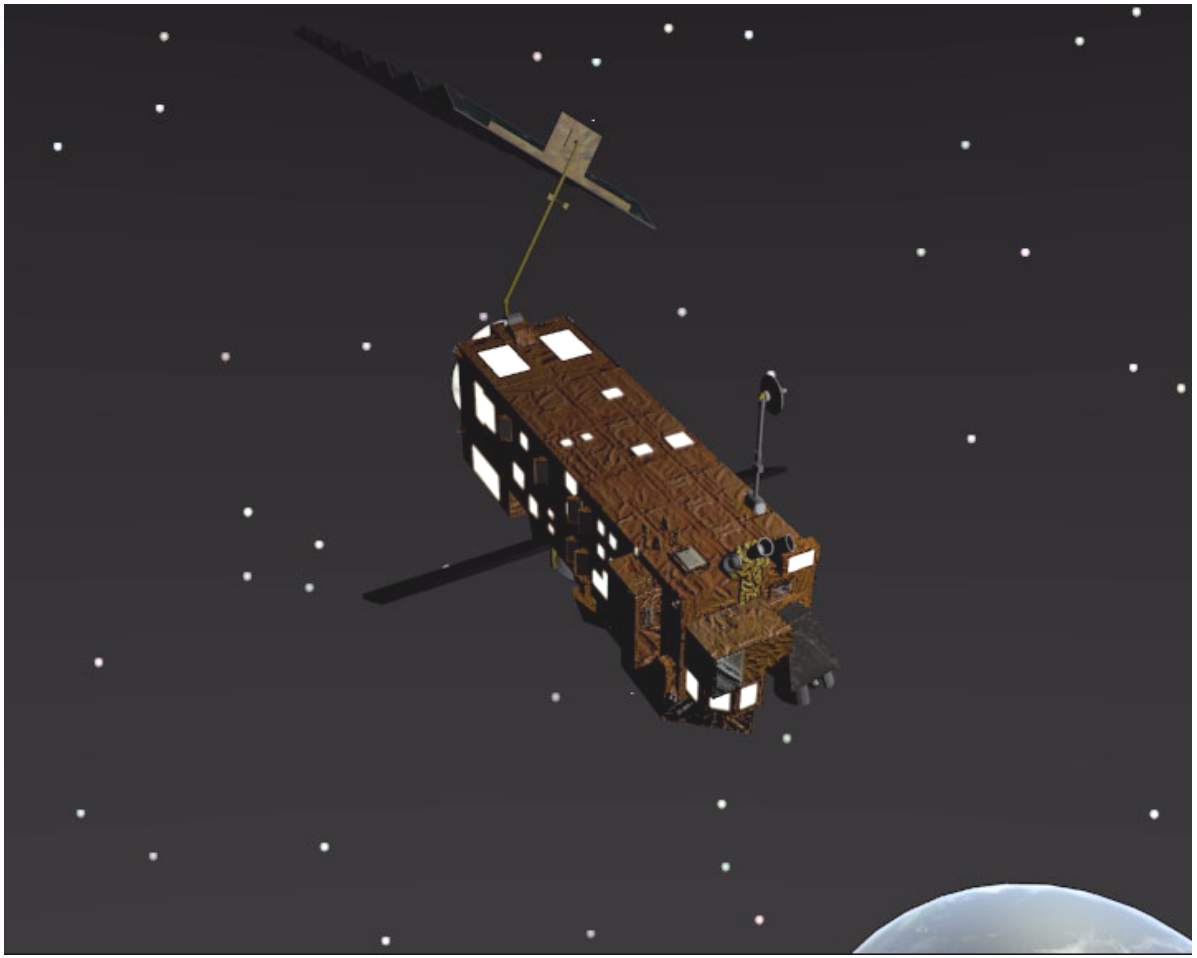
GIRO



Study

- Focus
  - Difference spectral response
    - GIRO low spectral resolution (32 bands)
      - Interpolation based on scaled Apollo-return soil
  - Definition reference calibration scale
    - GIRO absolute calibration uncertain
- Solution: SCIAMACHY

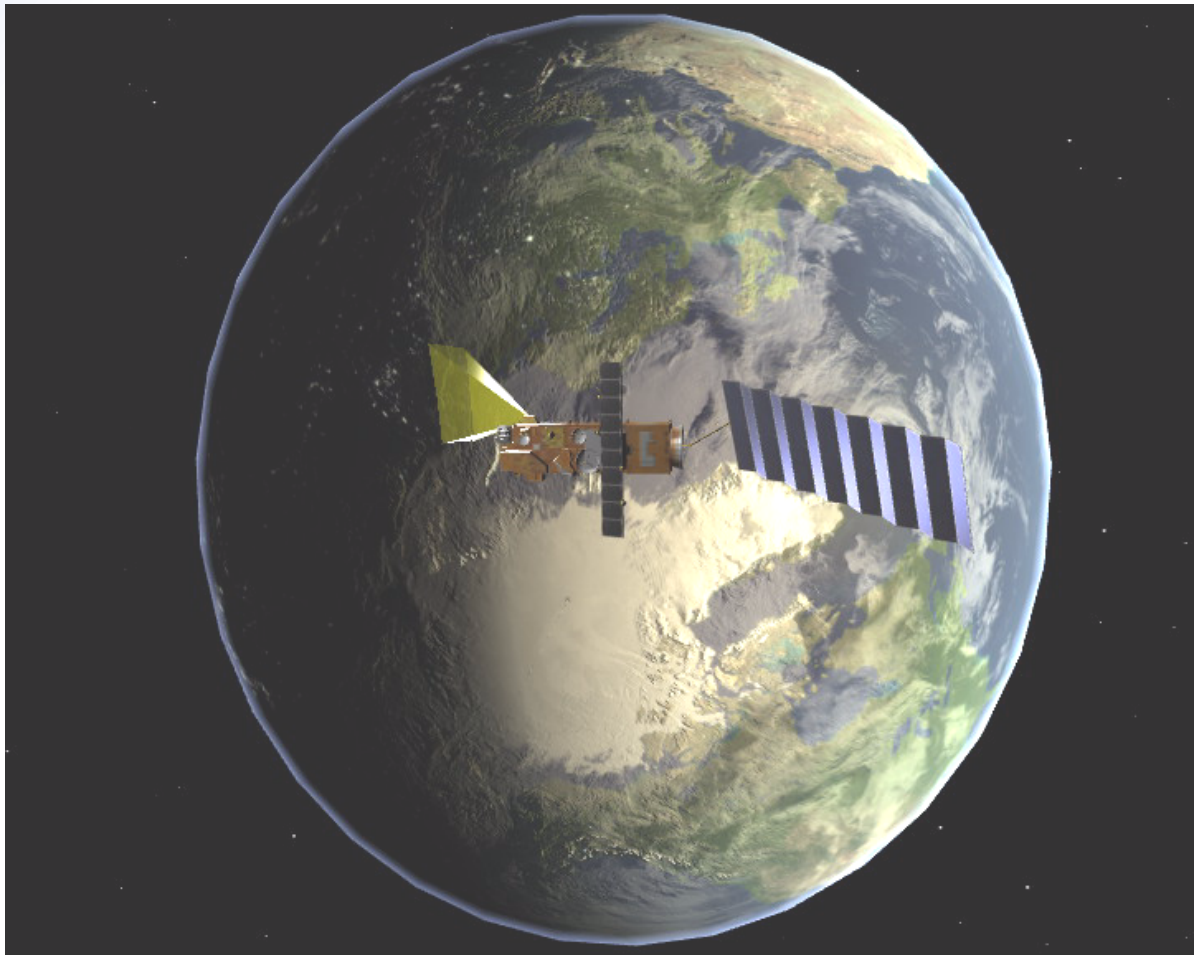
SCIAMACHY on ENVISAT



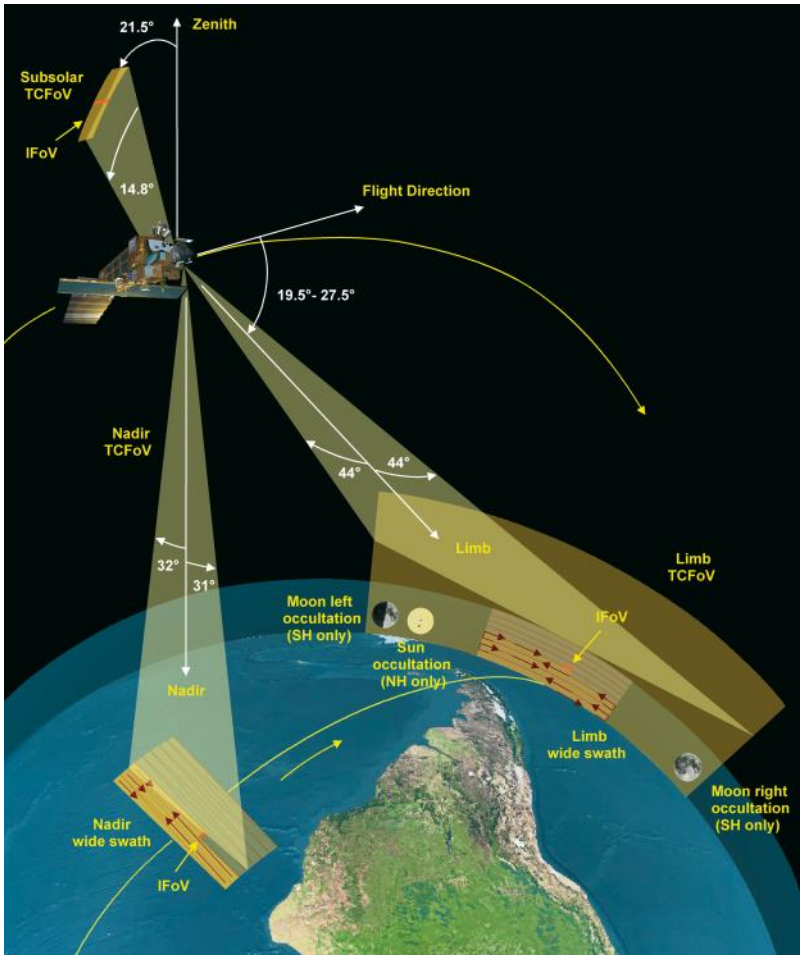
The instrument

- Imaging spectrometer
- Spatial dimensions through scan mirror(s):
  - IFoV: 0.045 degrees by 1.8 degrees
- Spectral dimension through 8-channel spectrometer, 8192 wavelengths:
  - 214 nm to 1773 nm
  - 1934 nm to 2044 nm
  - 2259 nm to 2386 nm
- Nadir, Limb, sub-solar, solar occultation and lunar occultation views
- Many in-flight calibration and monitoring modes
- Data provided by ESA

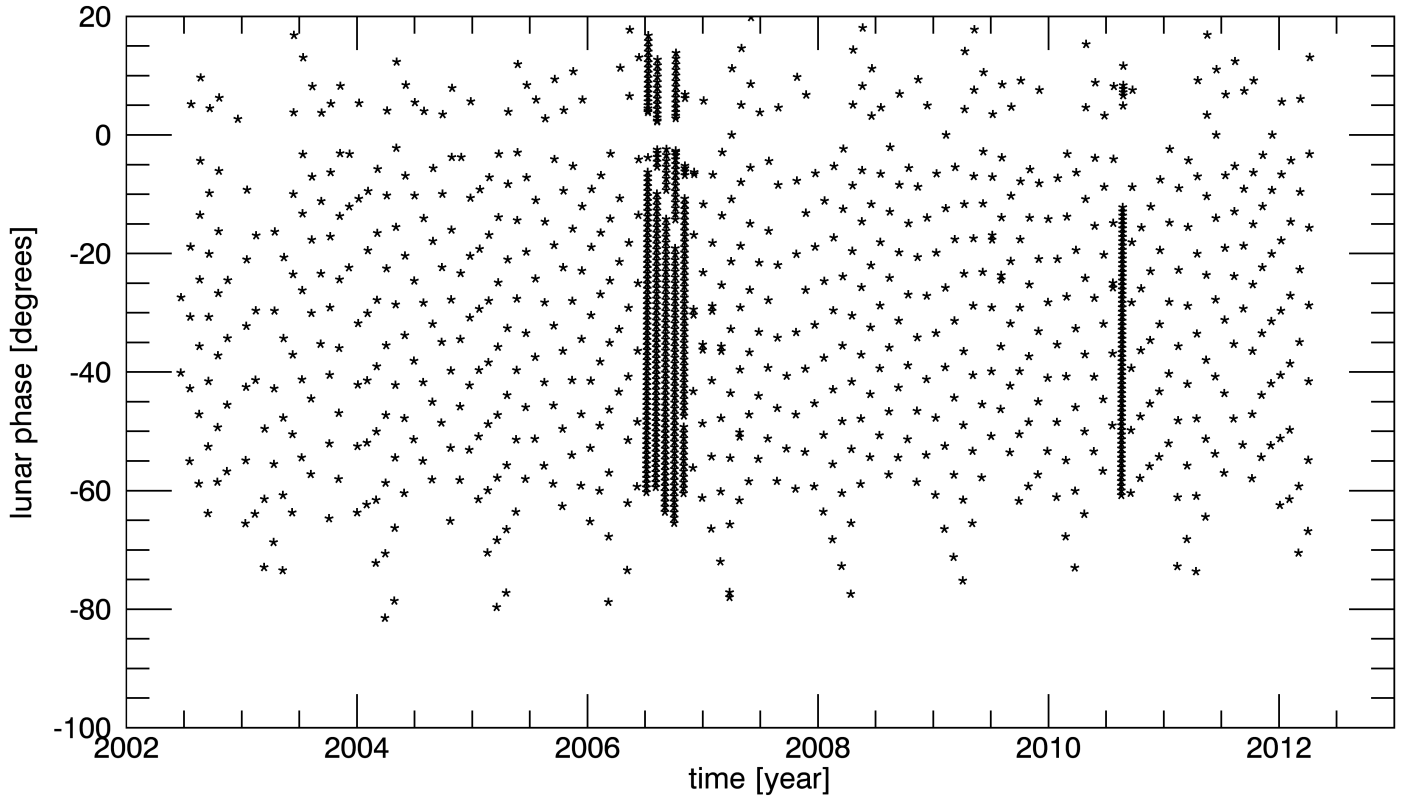
SCIAMACHY viewing modes



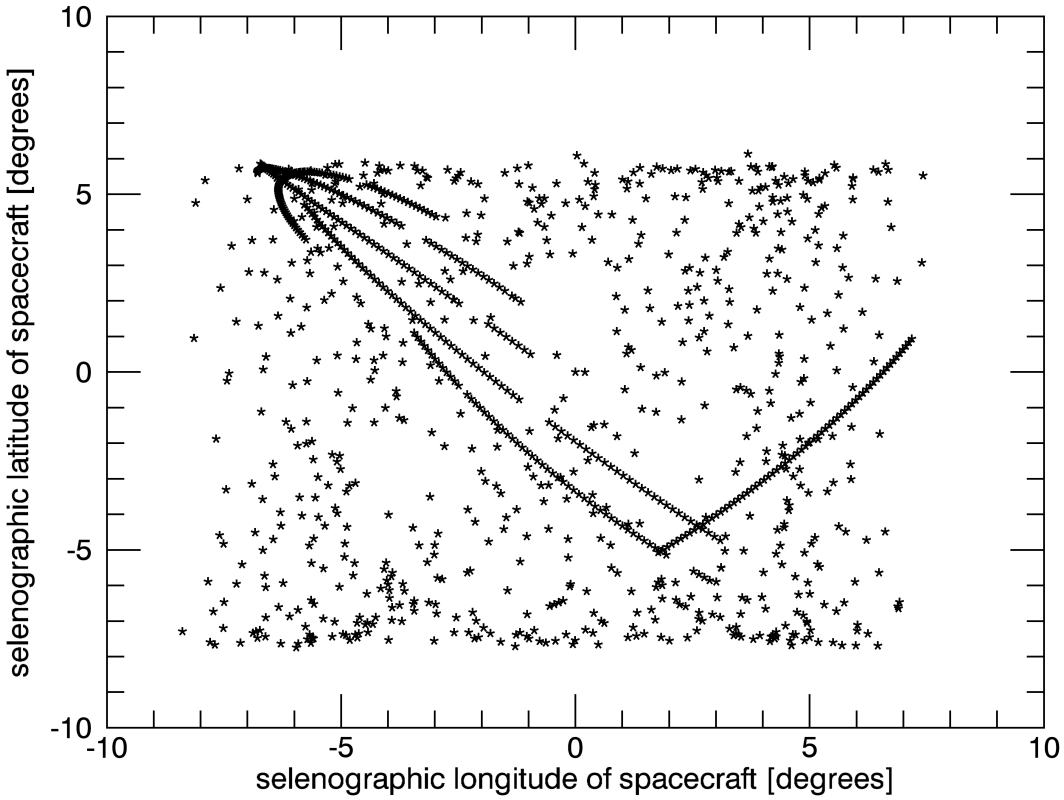
SCIAMACHY viewing modes



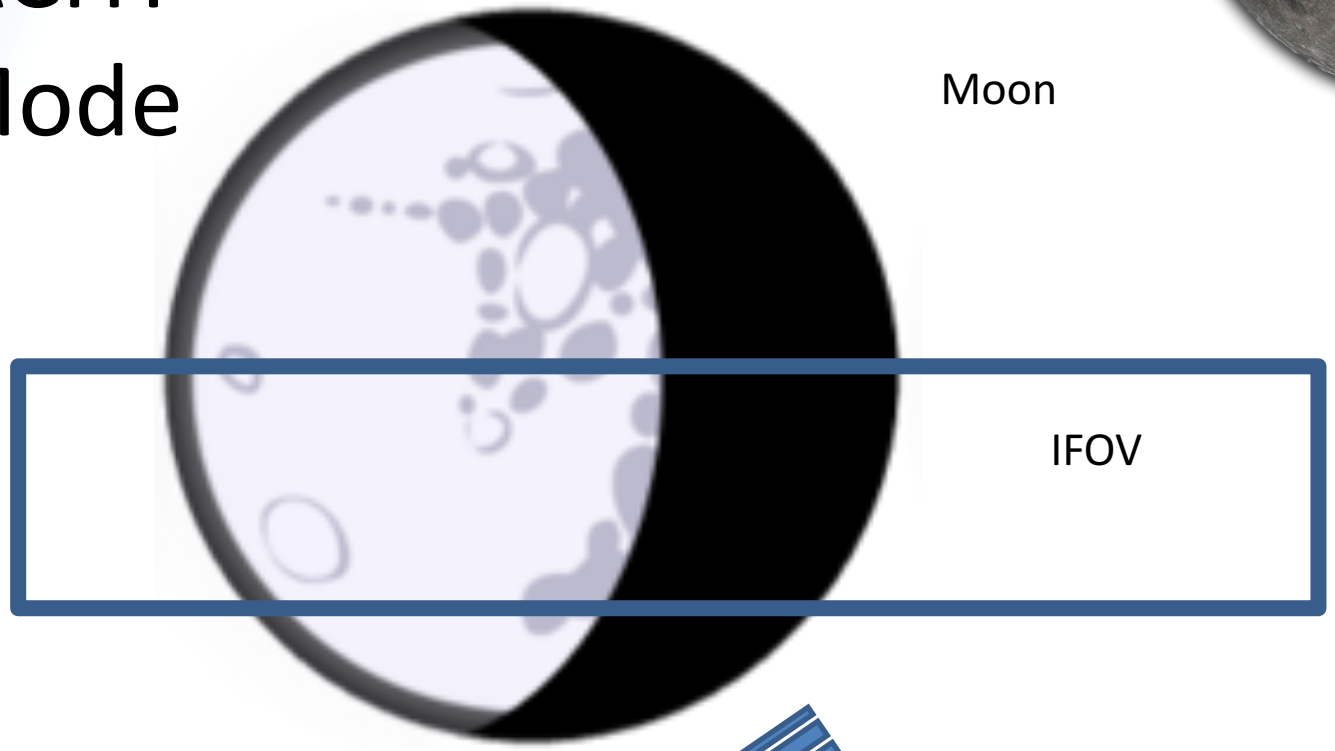
Lunar phase angle coverage



Lunar libration angle coverage

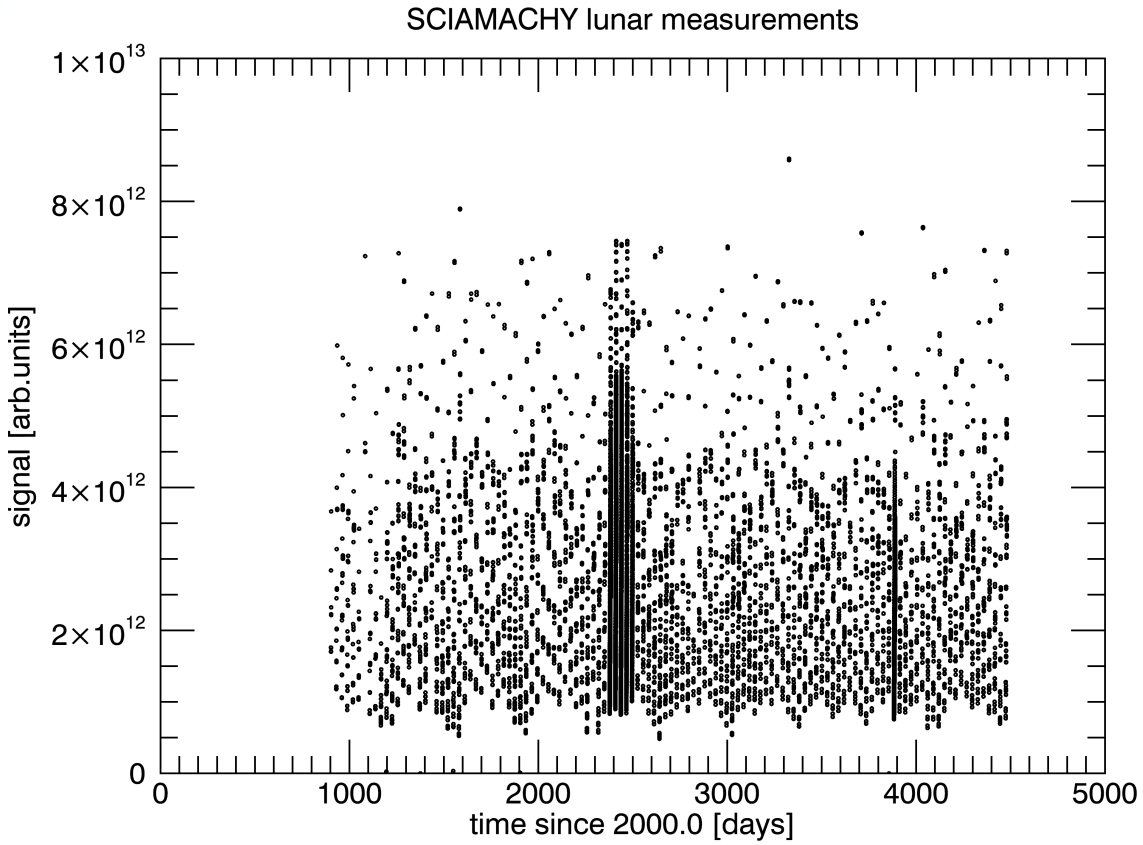


SCIAMACHY Lunar Mode

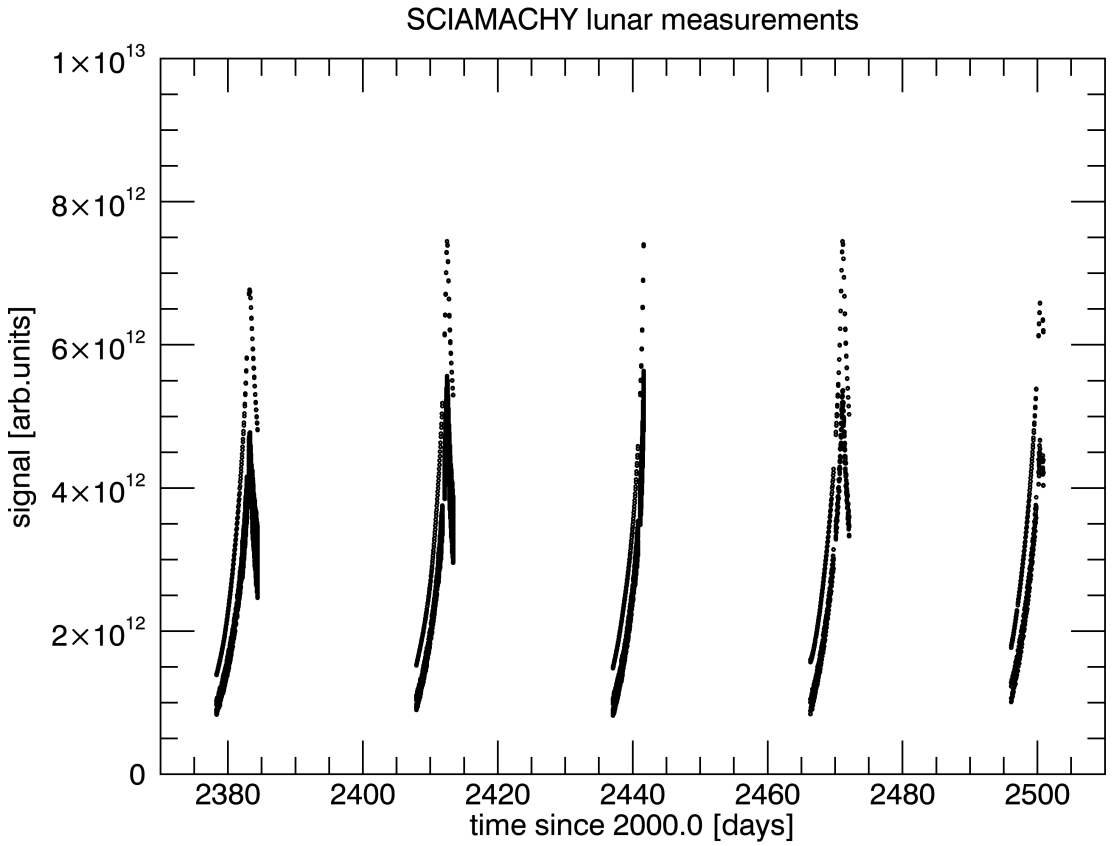


- Sun/Moon follower:
  - moon centered in slit
- + elevation scan over moon

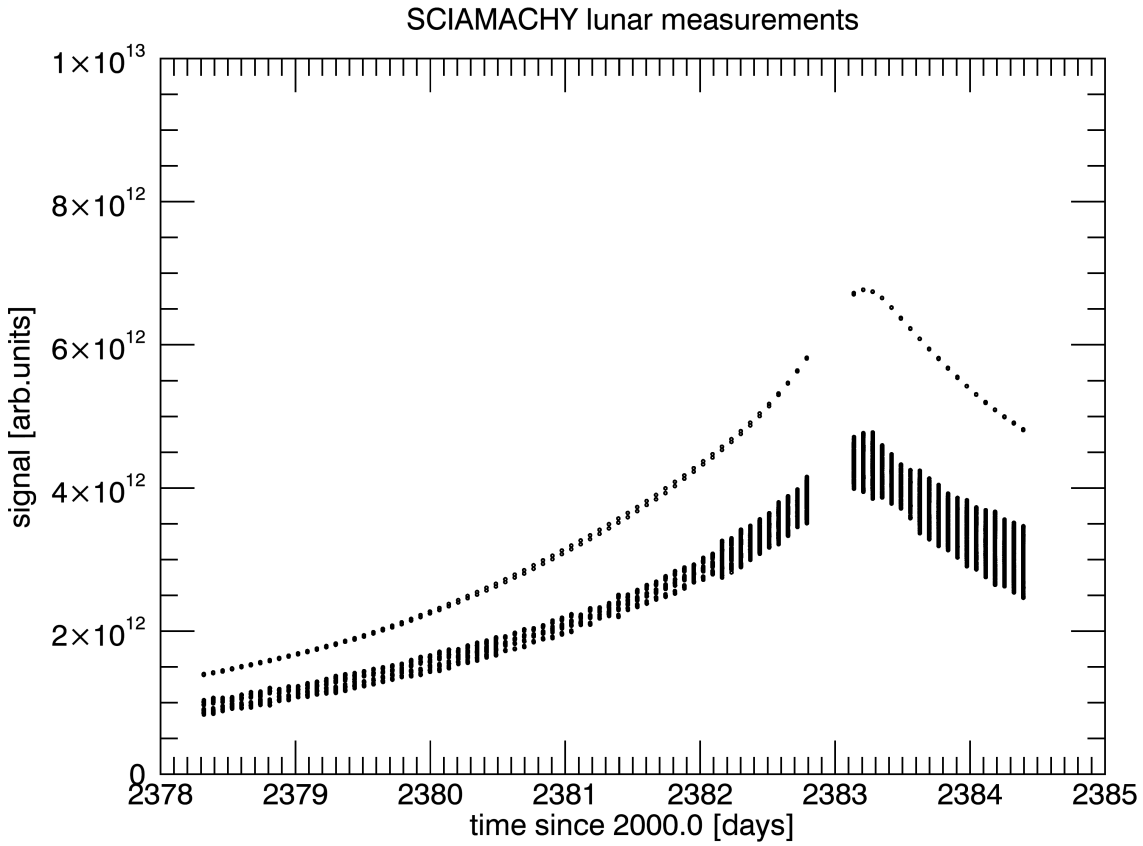
SCIAMACHY Lunar Measurements (1)



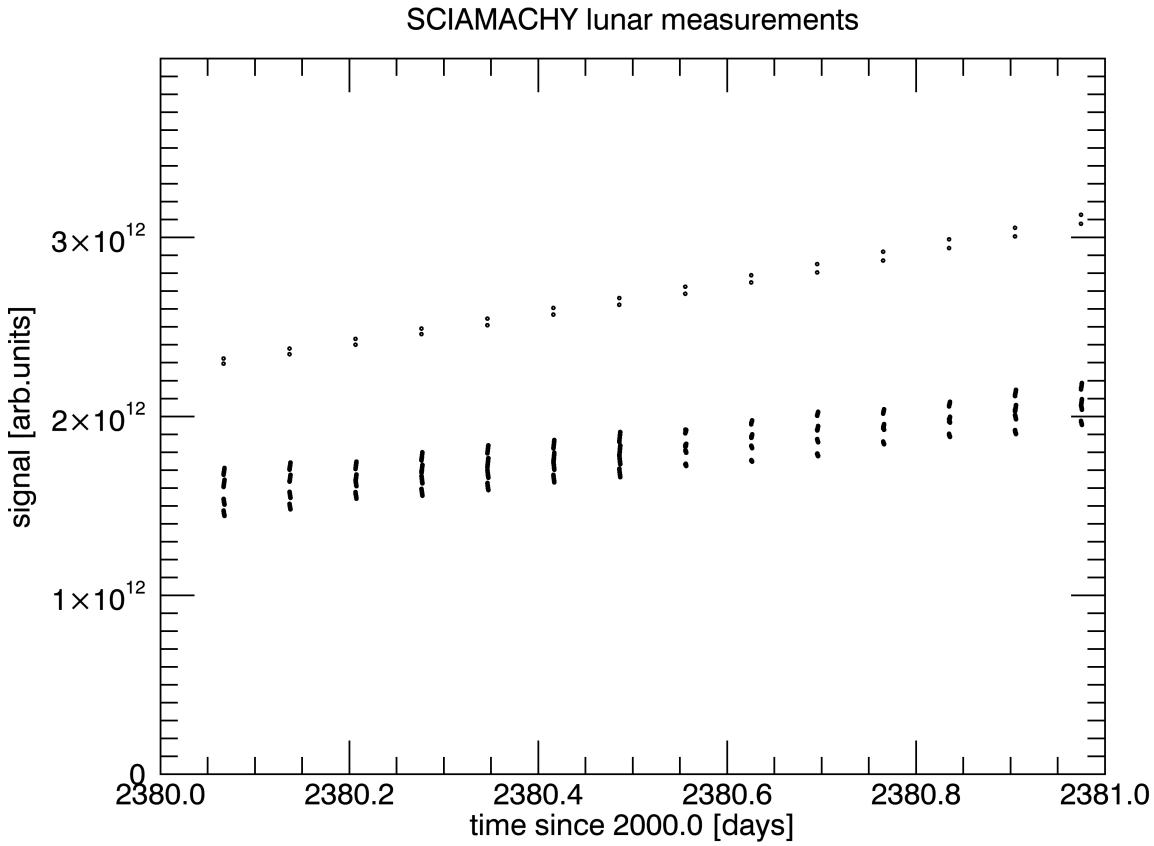
SCIAMACHY Lunar Measurements (2)



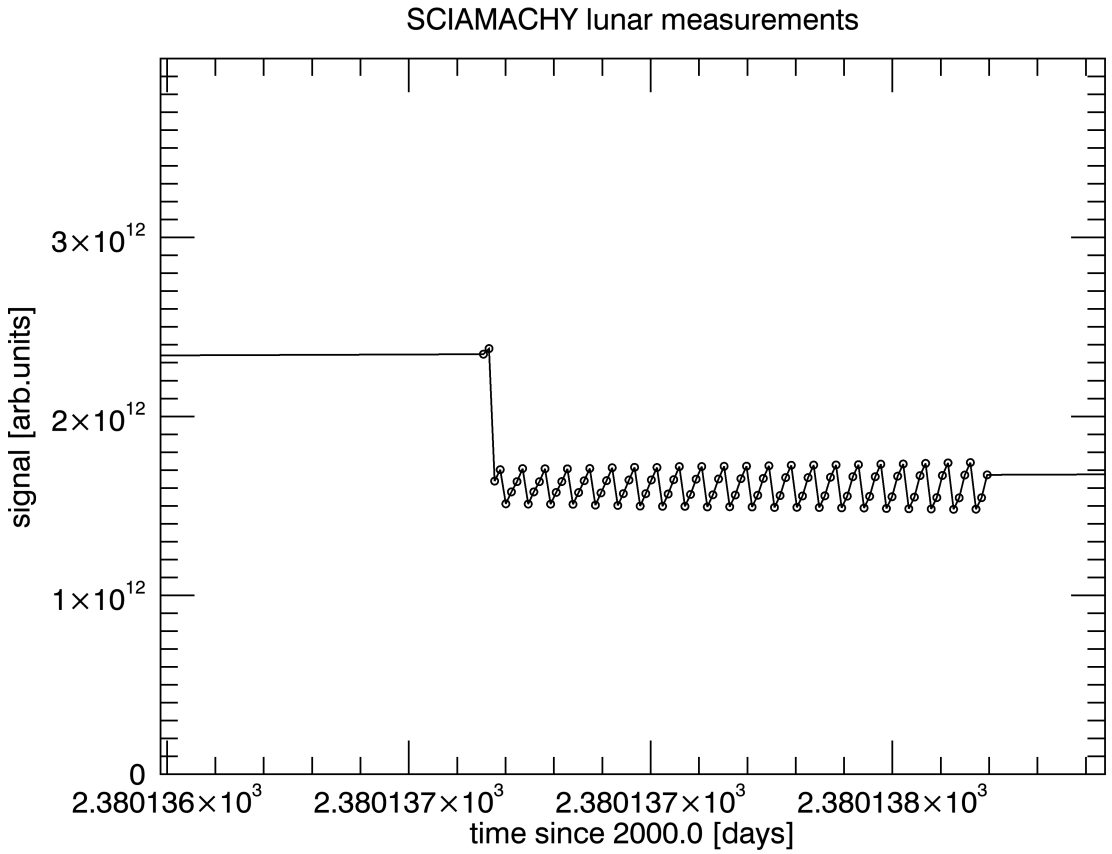
SCIAMACHY Lunar Measurements (3)



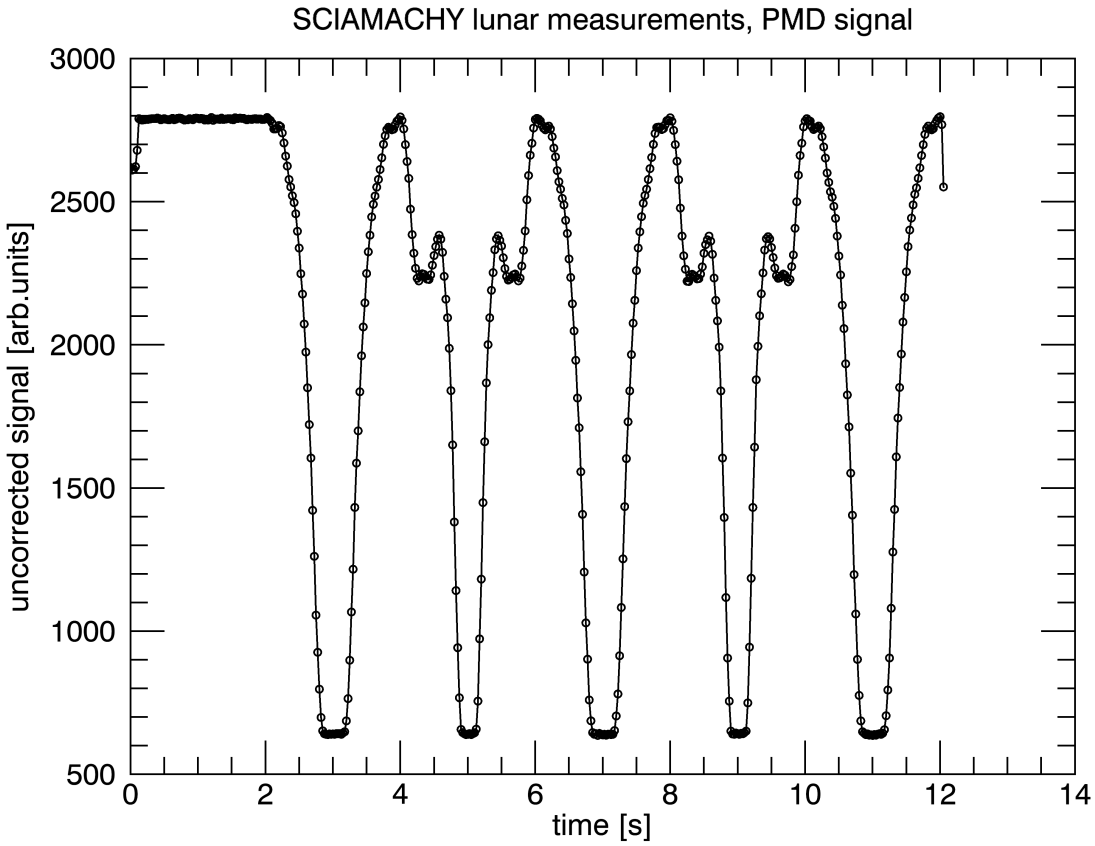
SCIAMACHY Lunar Measurements (4)



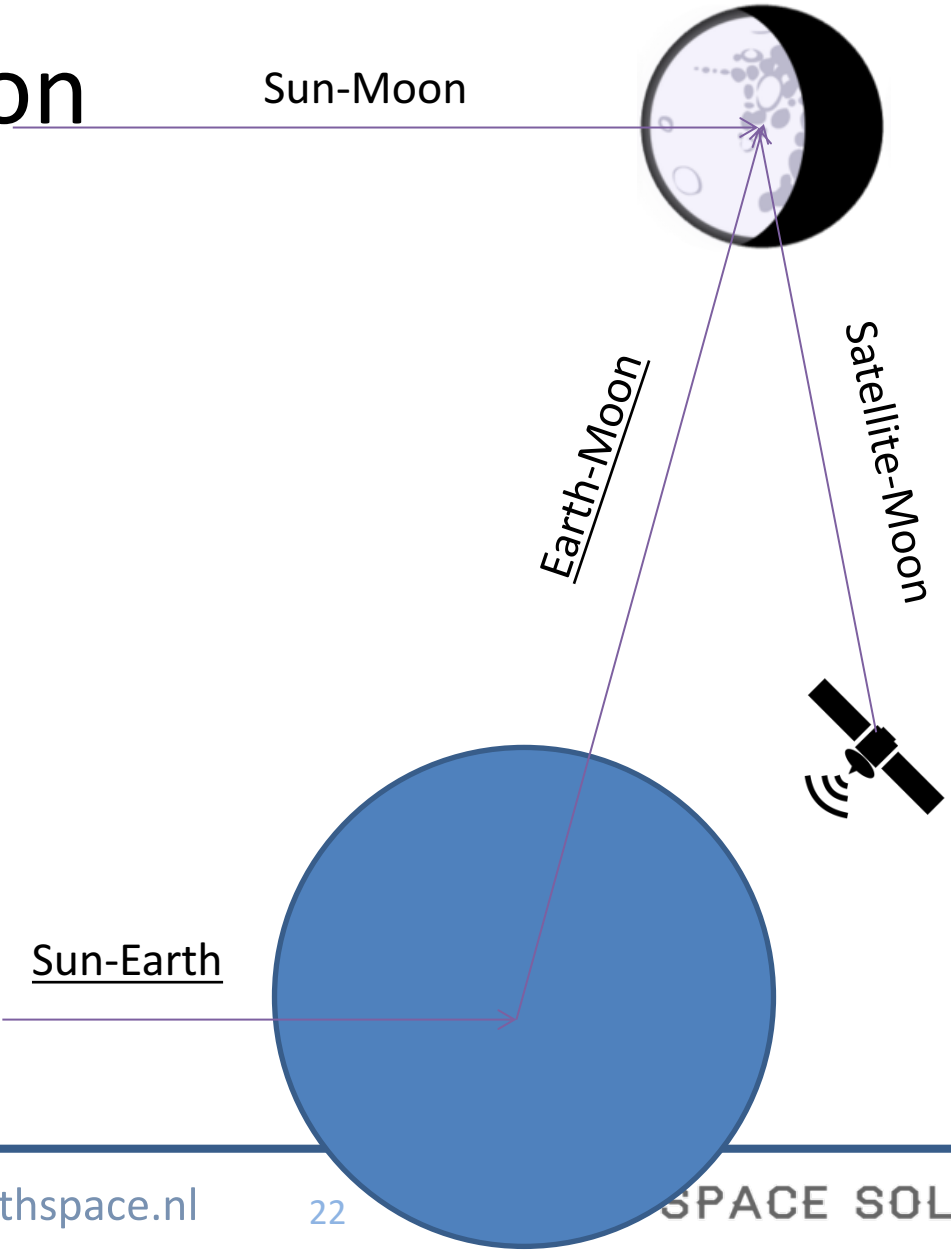
SCIAMACHY Lunar Measurements (5)



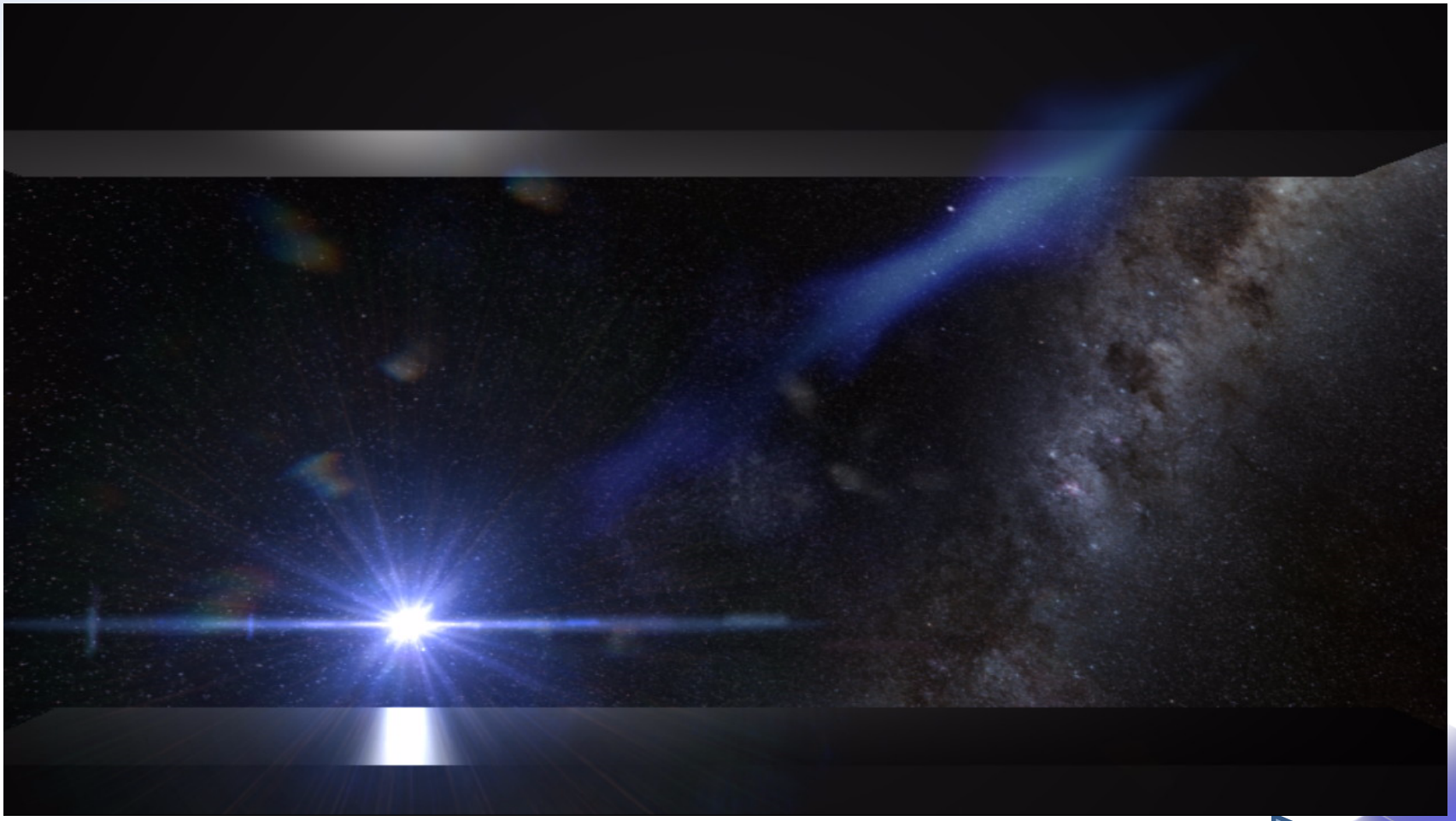
SCIAMACHY Lunar Measurements (6)



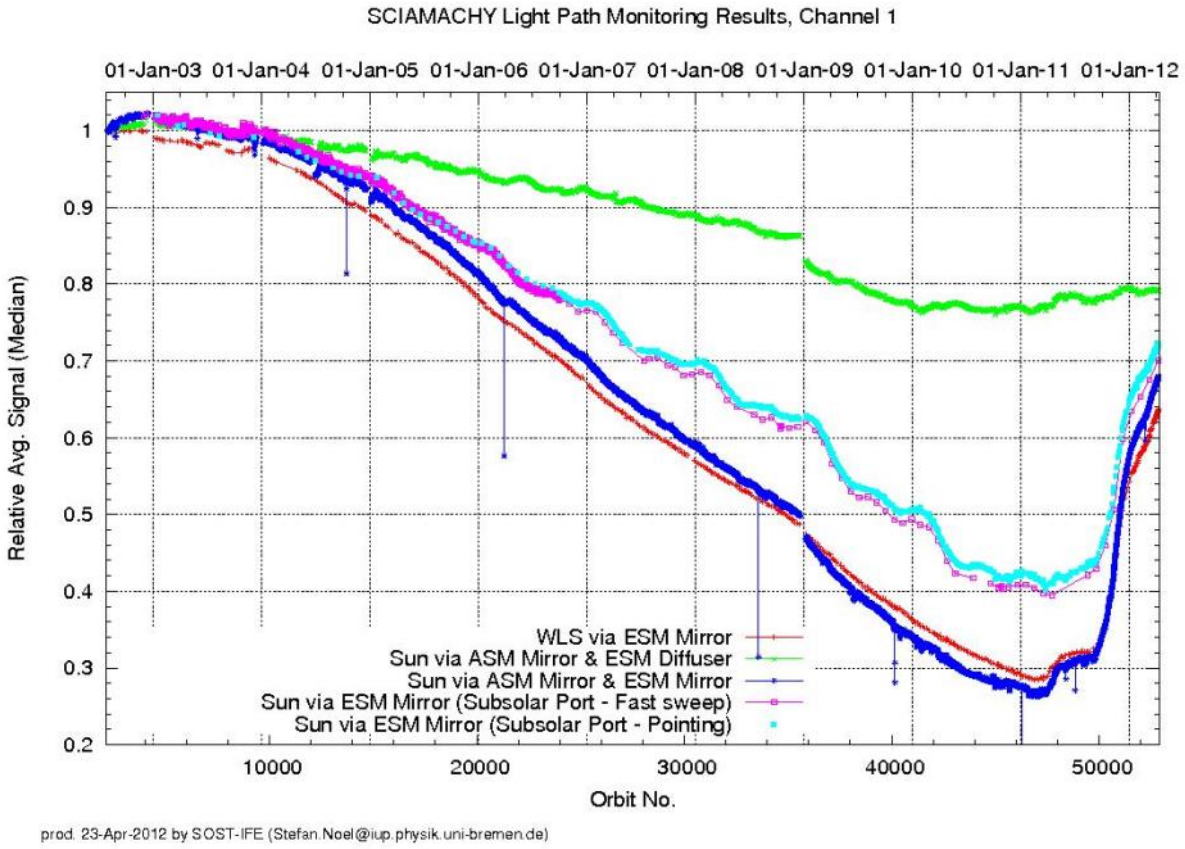
Distance normalisation



SCIAMACHY
Solar Mode

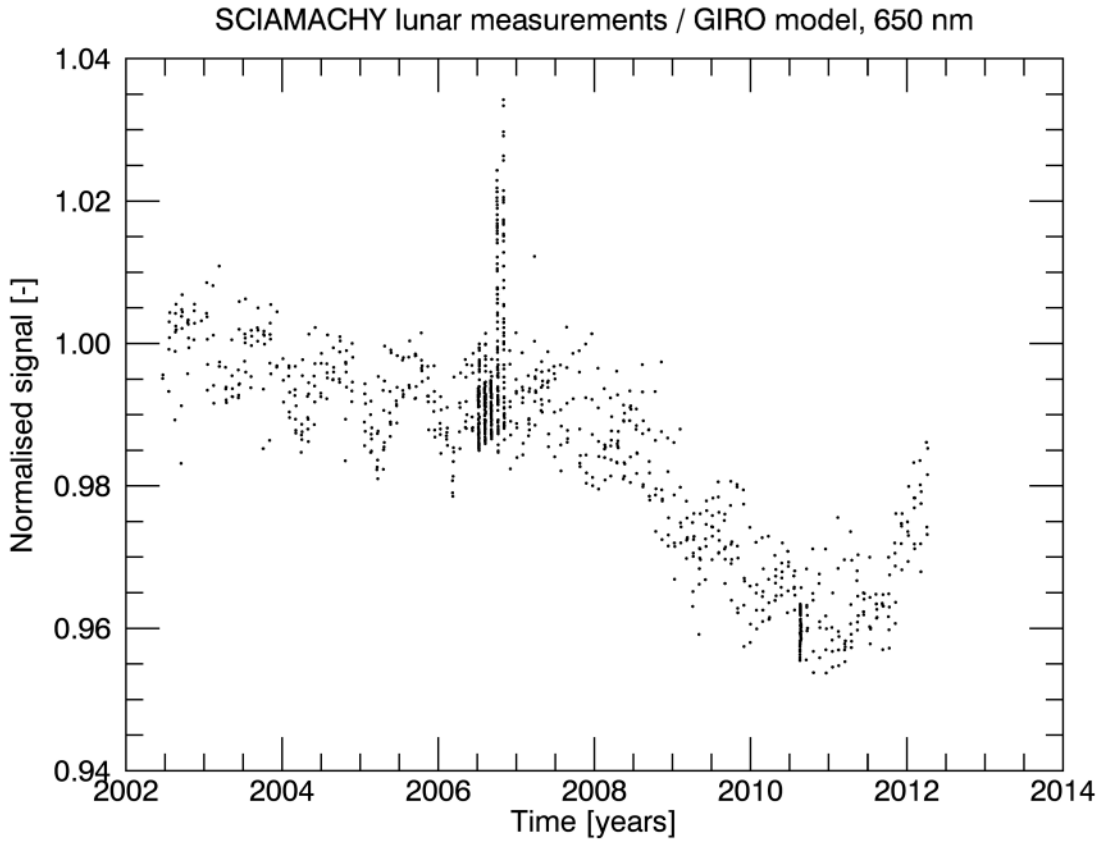


SCIAMACHY Solar Transmission Degradation

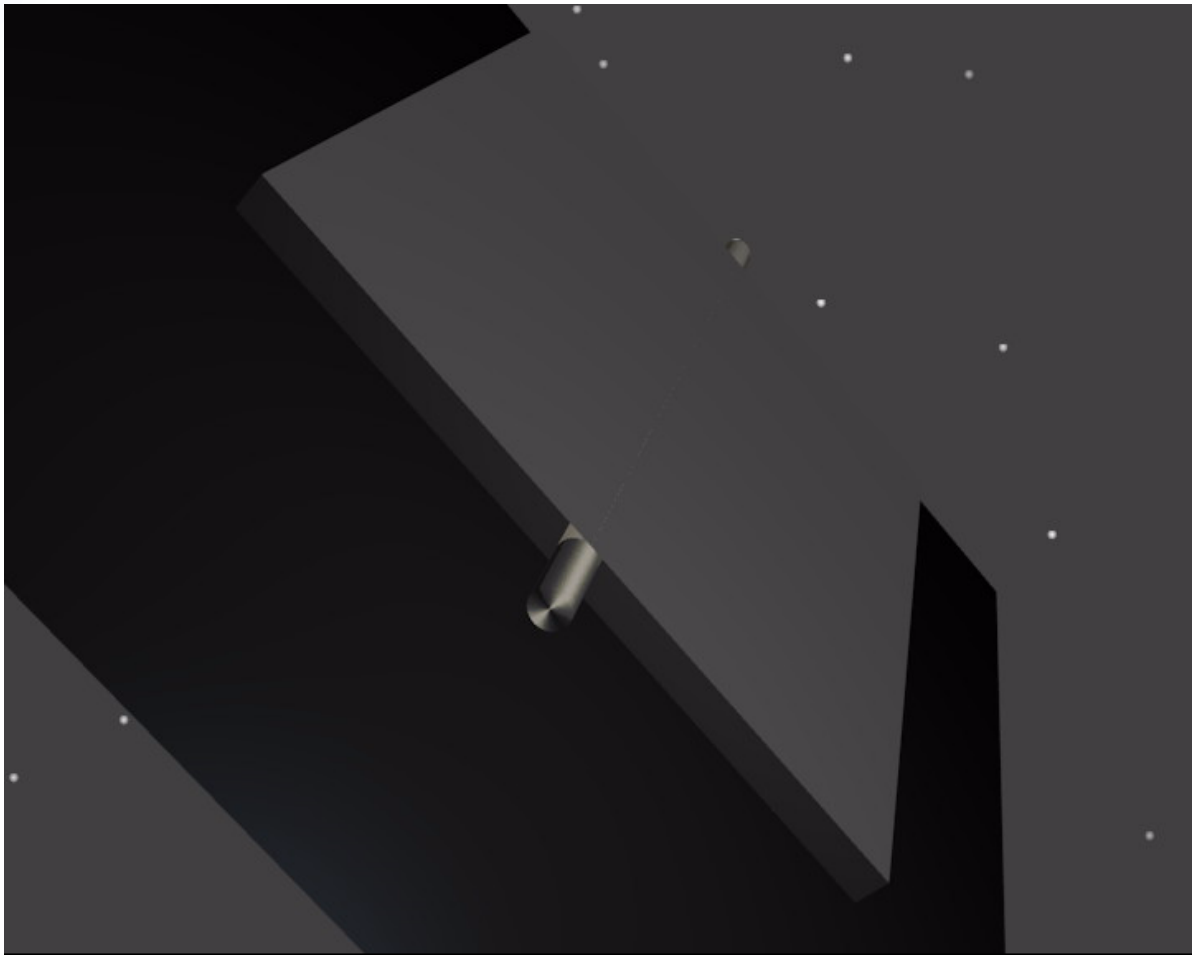


Diffusor
1 Mirror
2 Mirror
WLS

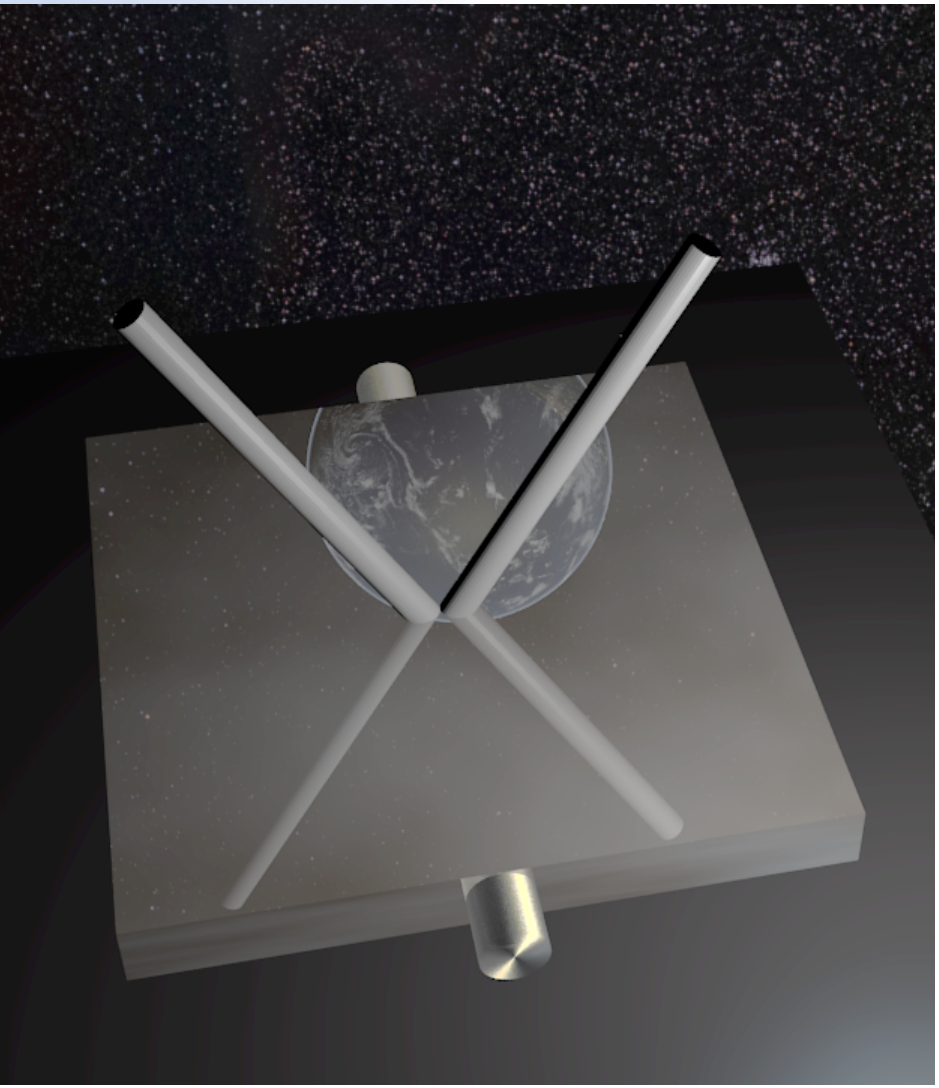
SCIA Lunar Degradation

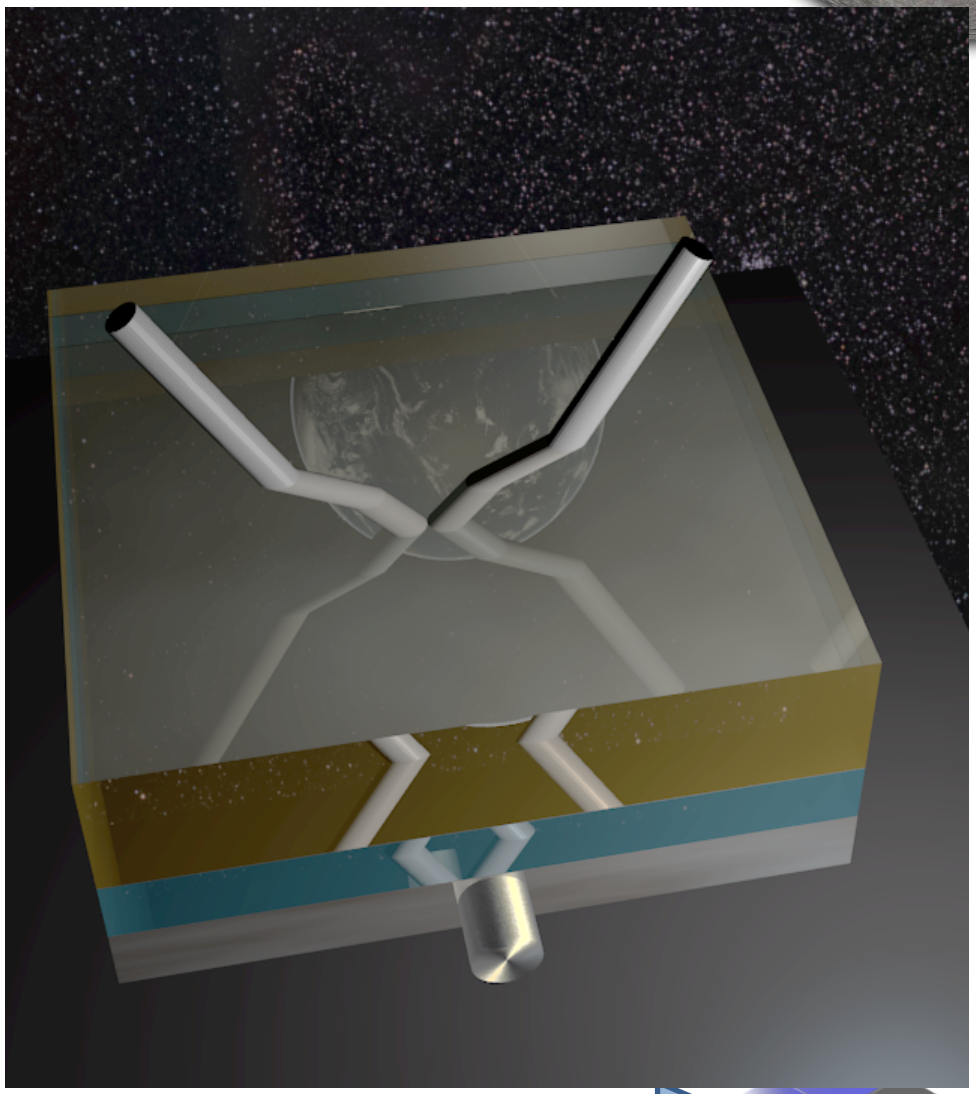


Degradation model: Dirty Mirror

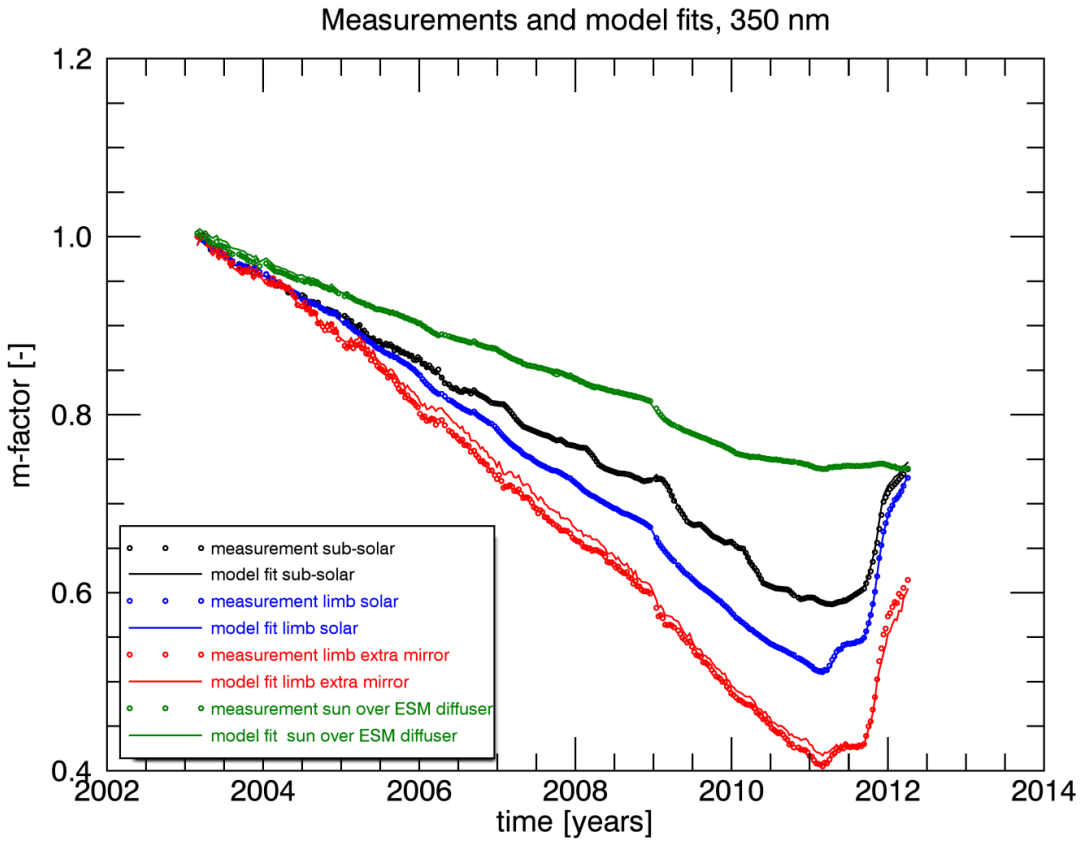


Contamination changes reflectivity

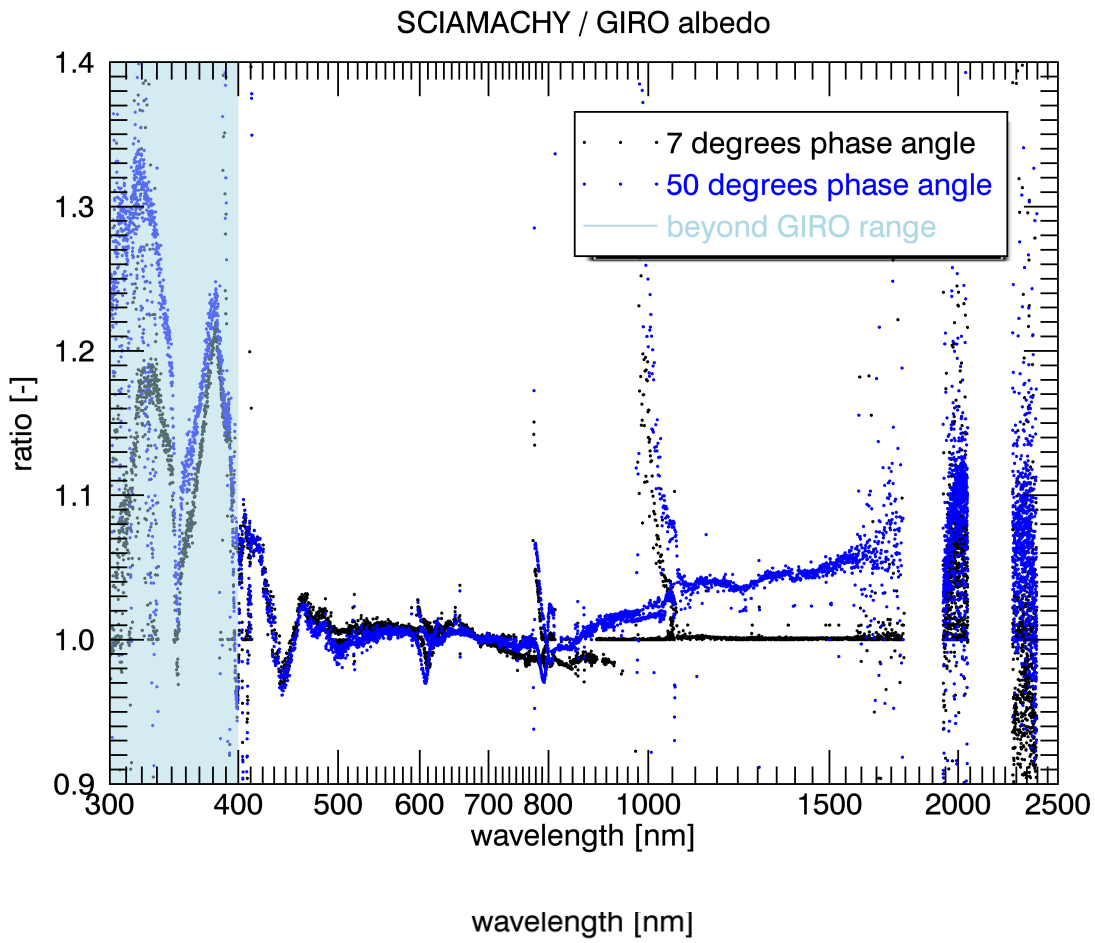




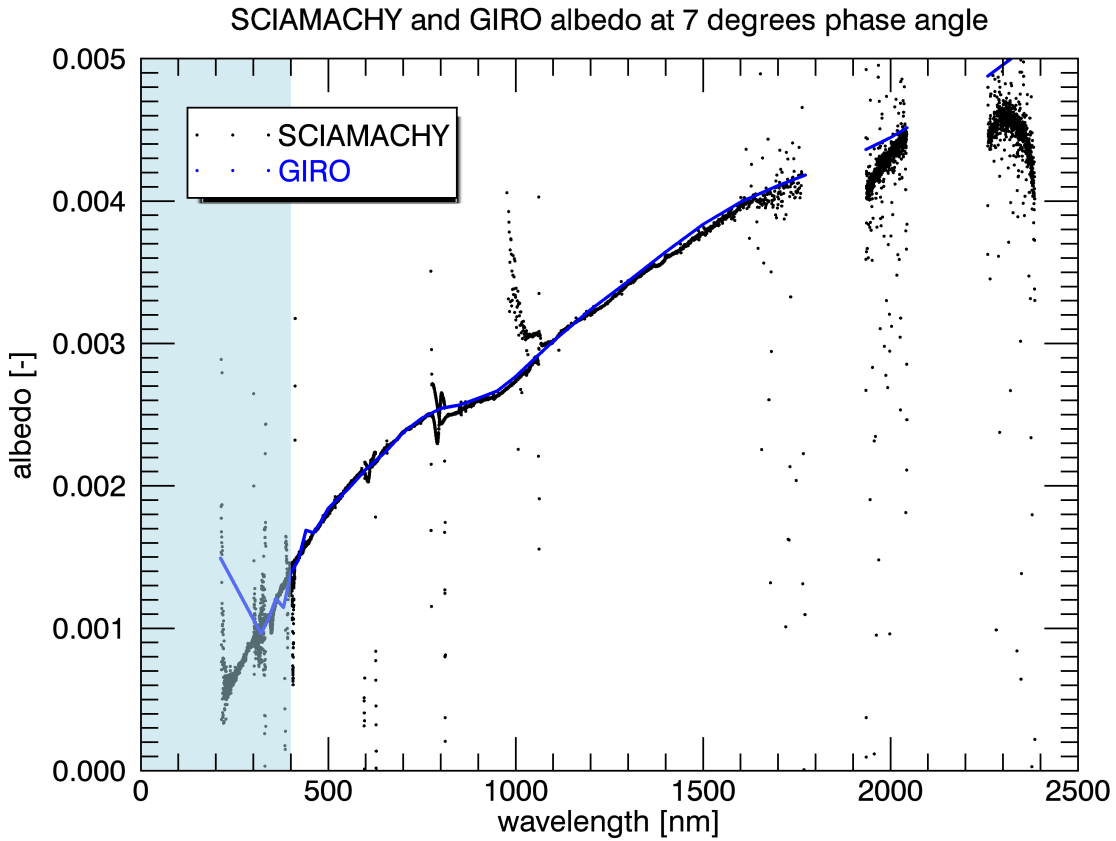
Model Results



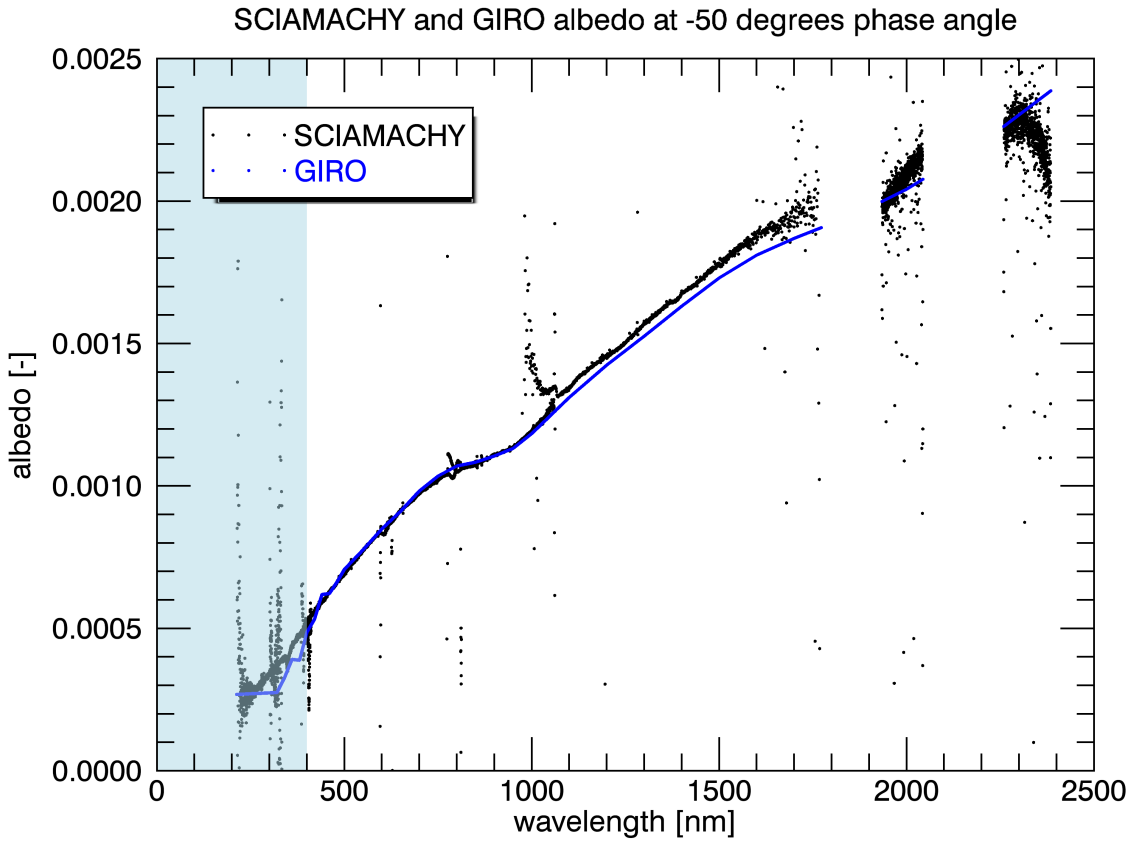
Irradiance


SCIAMACHY / GIRO albedo
7 degrees phase angle
50 degrees phase angle
beyond GIRO range
ratio [-]
1.4
1.3
1.2
1.1
1.0
0.9
300
400
500
600
700
800
1000
1500
2000
2500
wavelength [nm]
wavelength [nm]

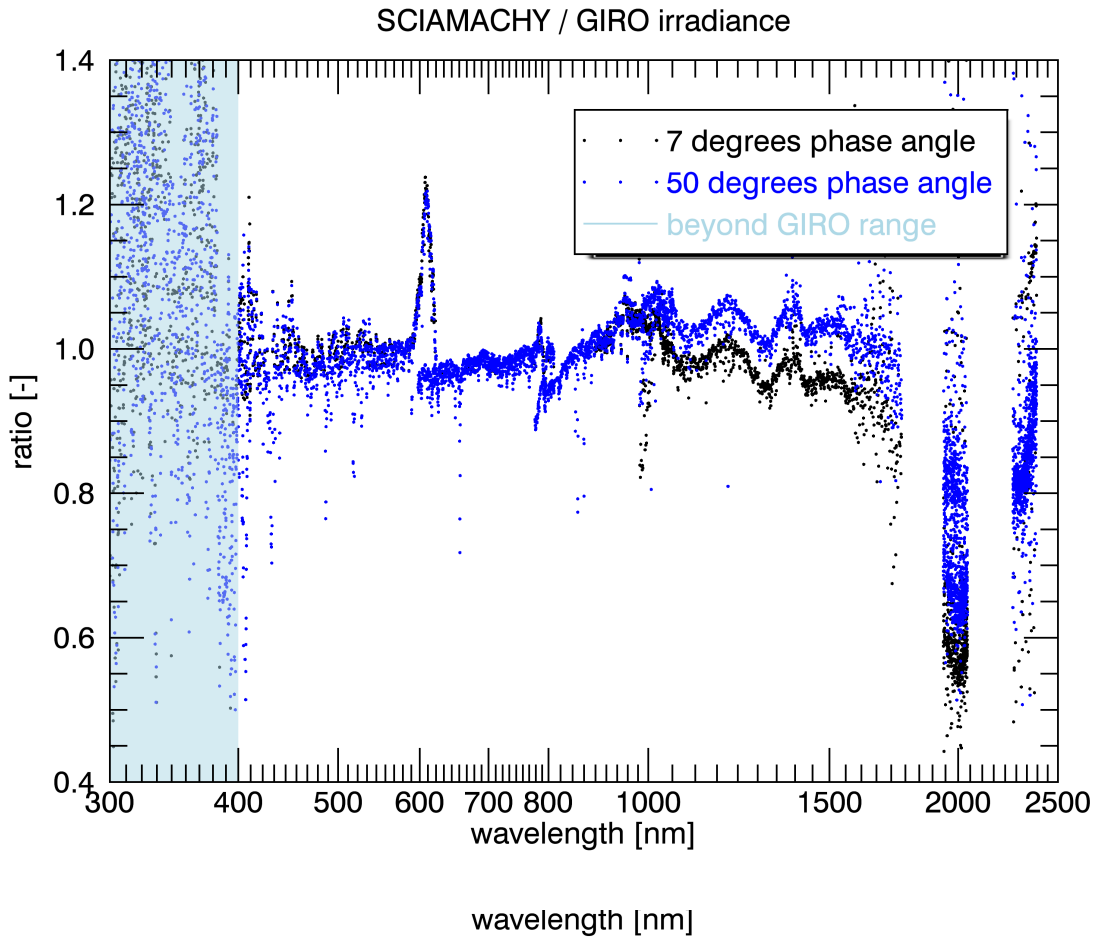
Albedo


SCIAMACHY and GIRO albedo at 7 degrees phase angle
SCIAMACHY
GIRO
albedo [-]
0.005
0.004
0.003
0.002
0.001
0.000
0
500
1000
1500
2000
2500
wavelength [nm]

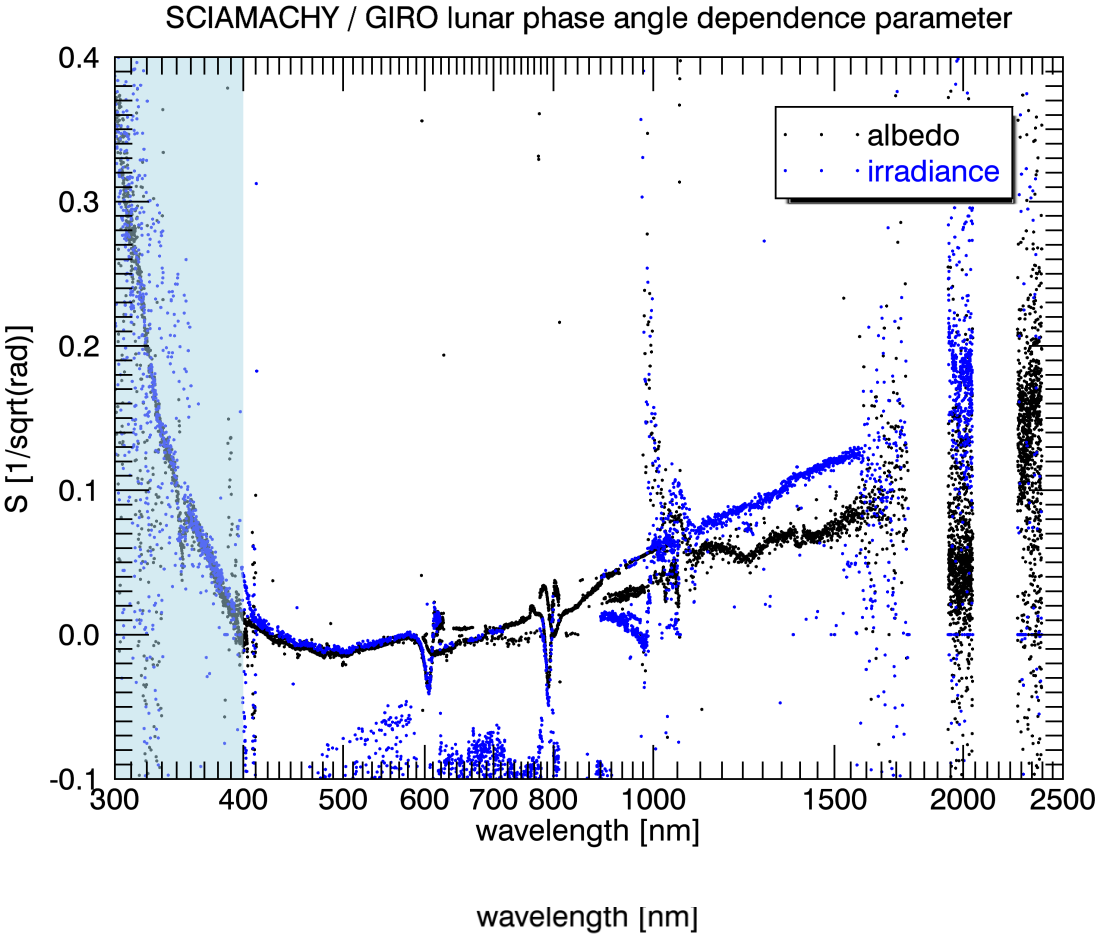
Albedo


SCIAMACHY and GIRO albedo at -50 degrees phase angle
SCIAMACHY
GIRO
albedo [-]
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
500
1000
1500
2000
2500
wavelength [nm]

Albedo

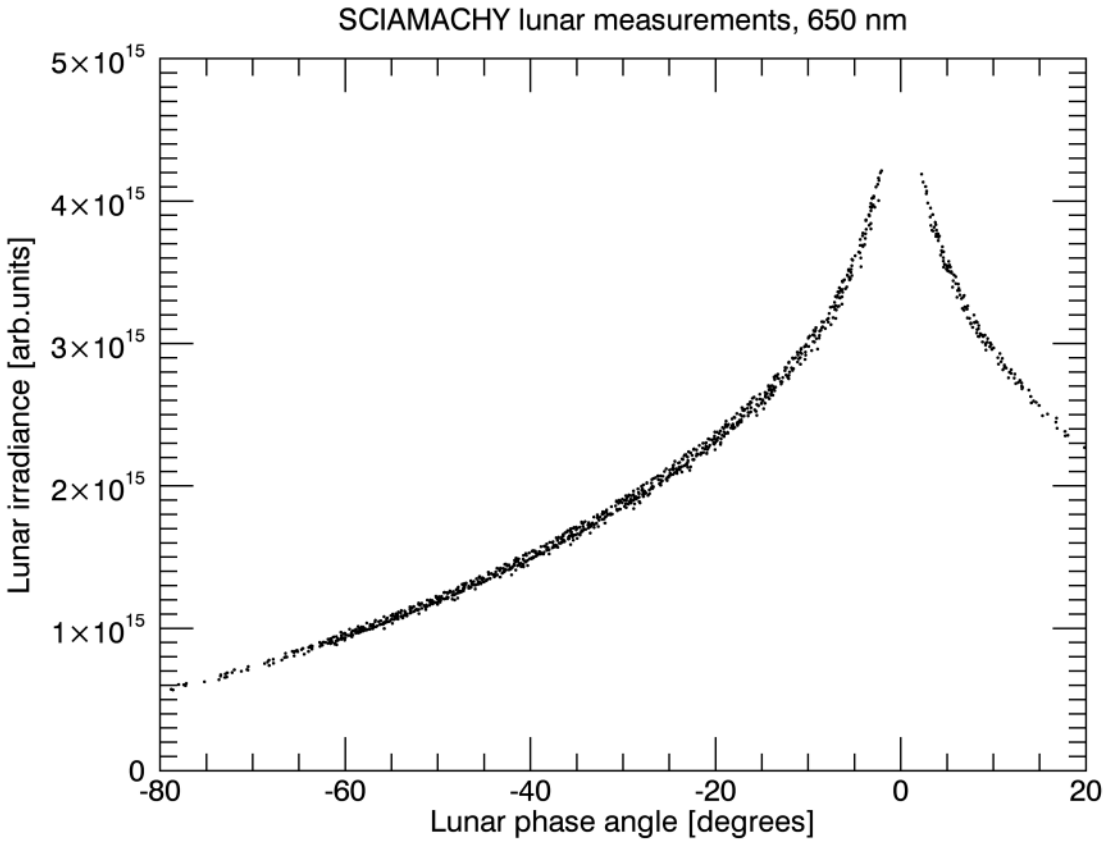

SCIAMACHY / GIRO irradiance
7 degrees phase angle
50 degrees phase angle
beyond GIRO range
ratio [-]
1.4
1.2
1.0
0.8
0.6
0.4
300
400
500
600
700
800
1000
1500
2000
2500
wavelength [nm]
wavelength [nm]

Phase angle Dependence

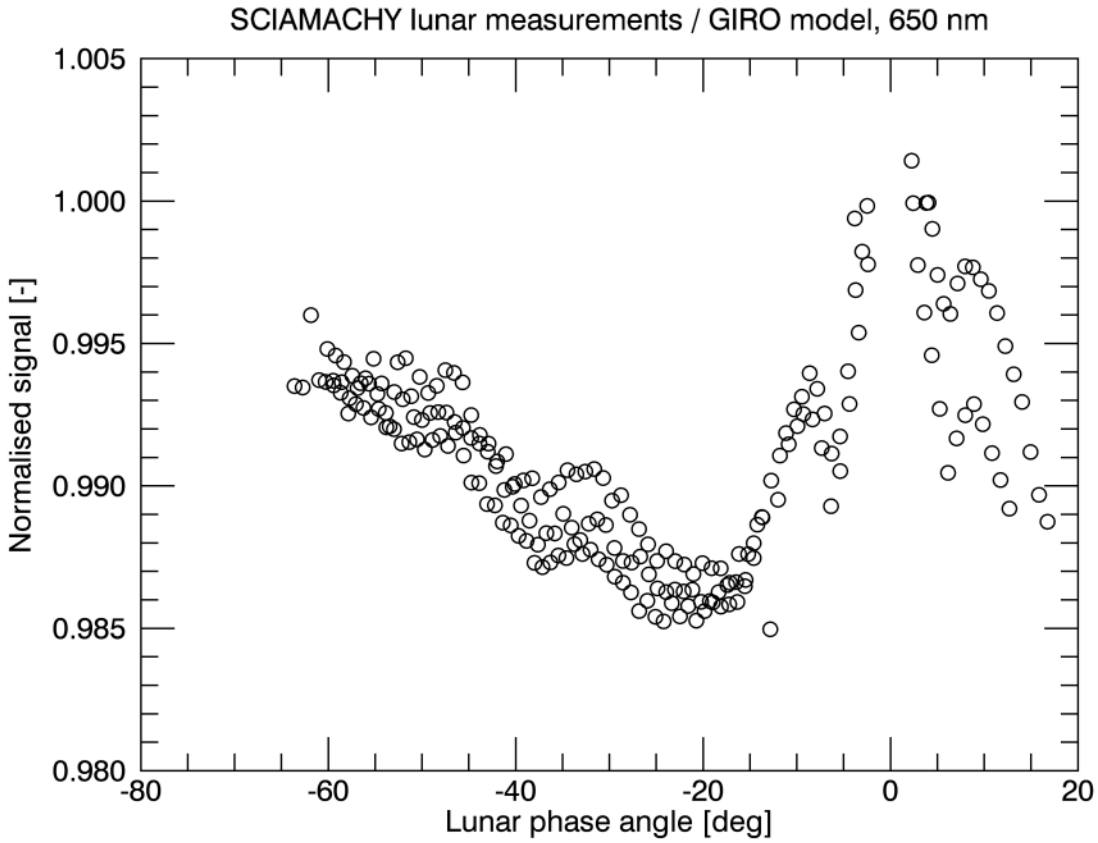


wavelength [nm]

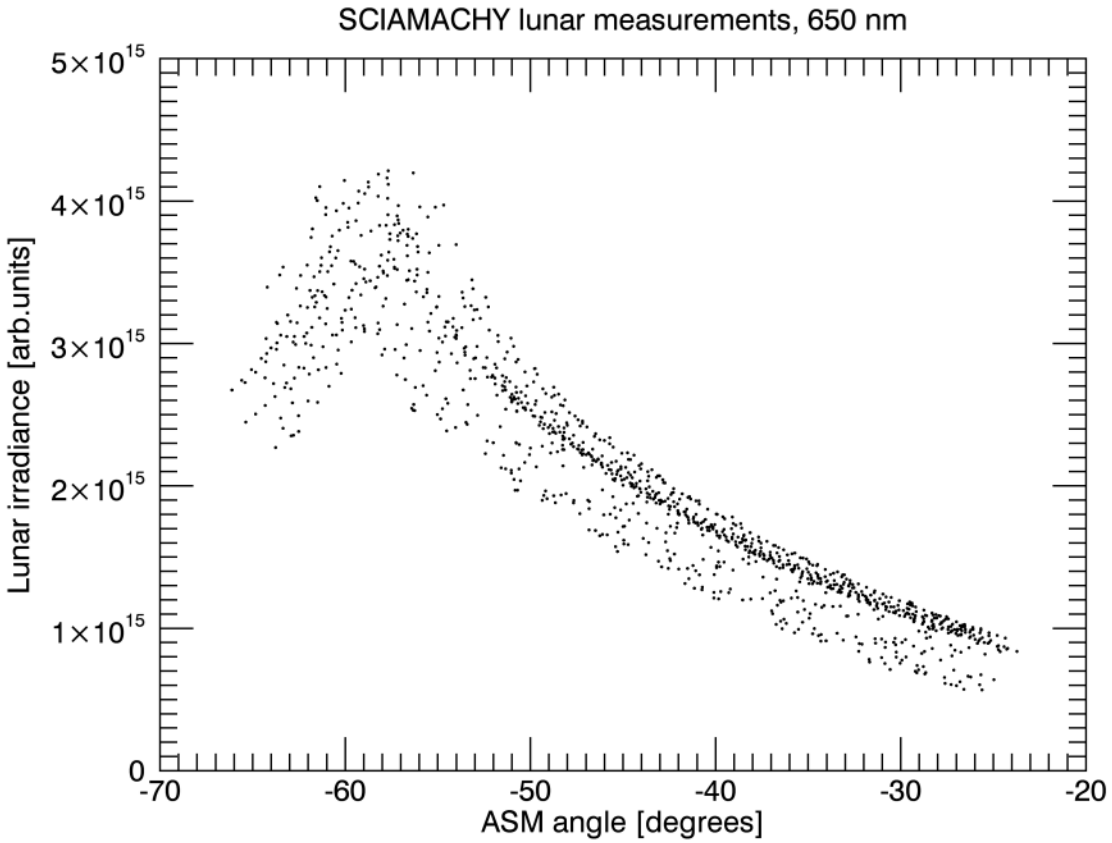
SCIA Phase Angle (1)



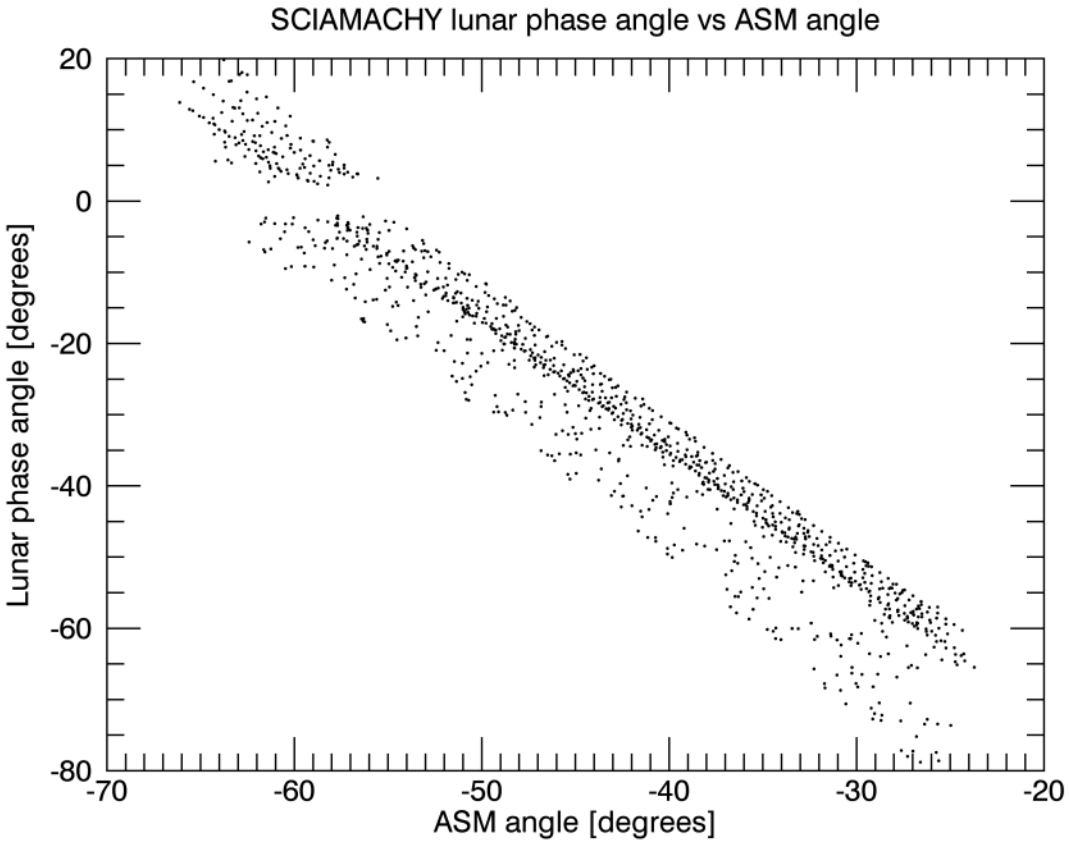
SCIA Phase Angle (2)



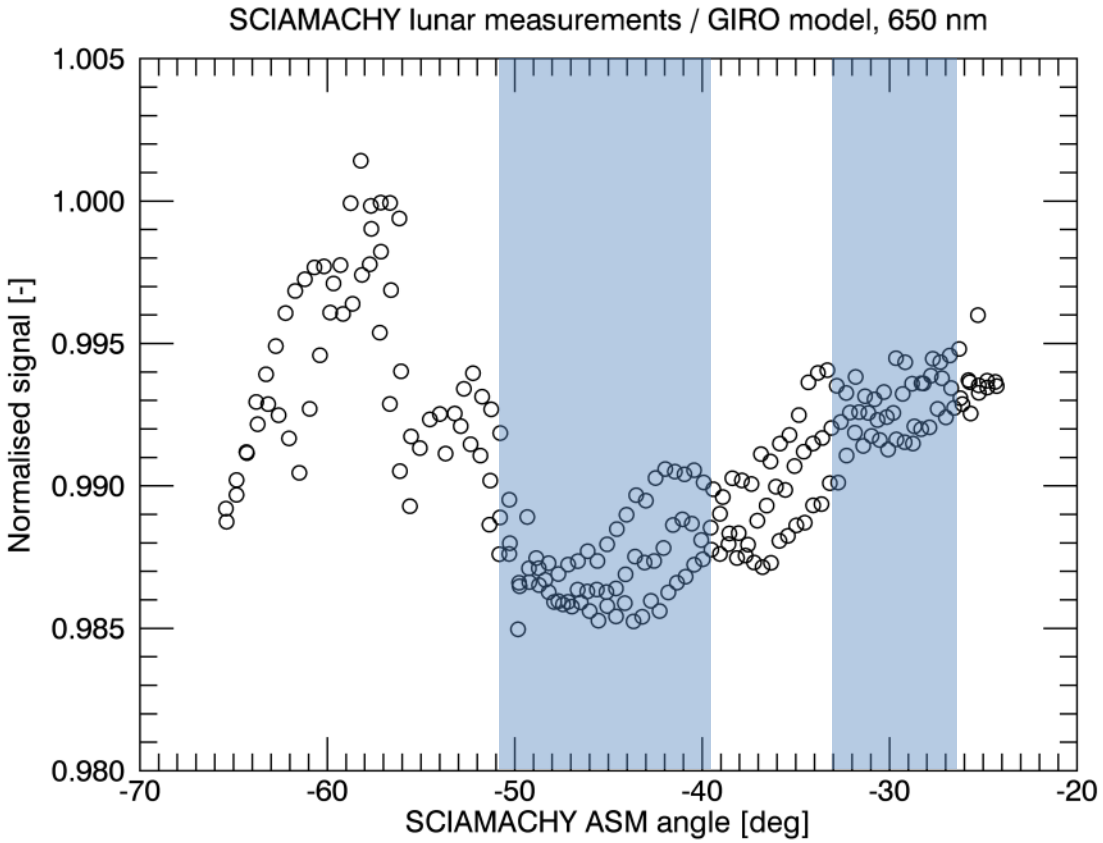
SCIA ASM Angle (1)



SCIA ASM Angle (2)



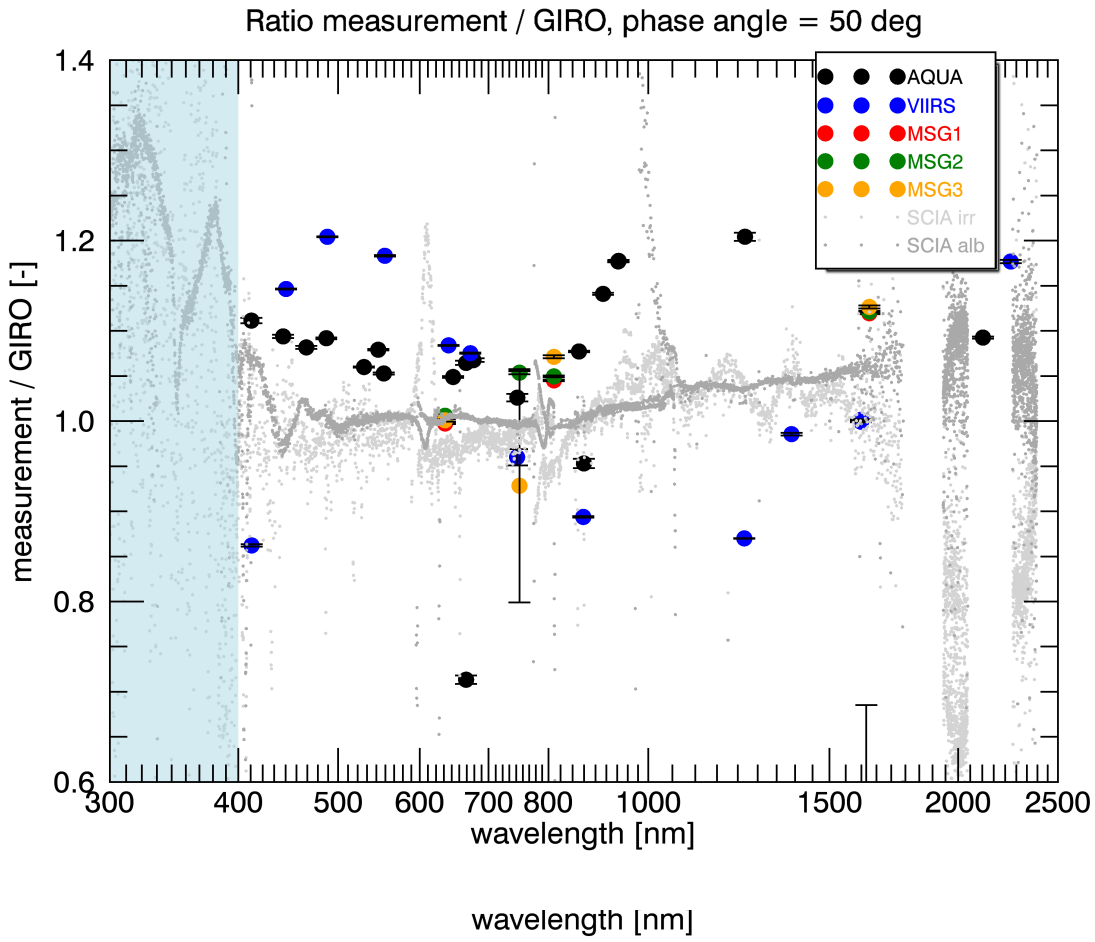
SCIA ASM angle (3)



On-ground Calibrated

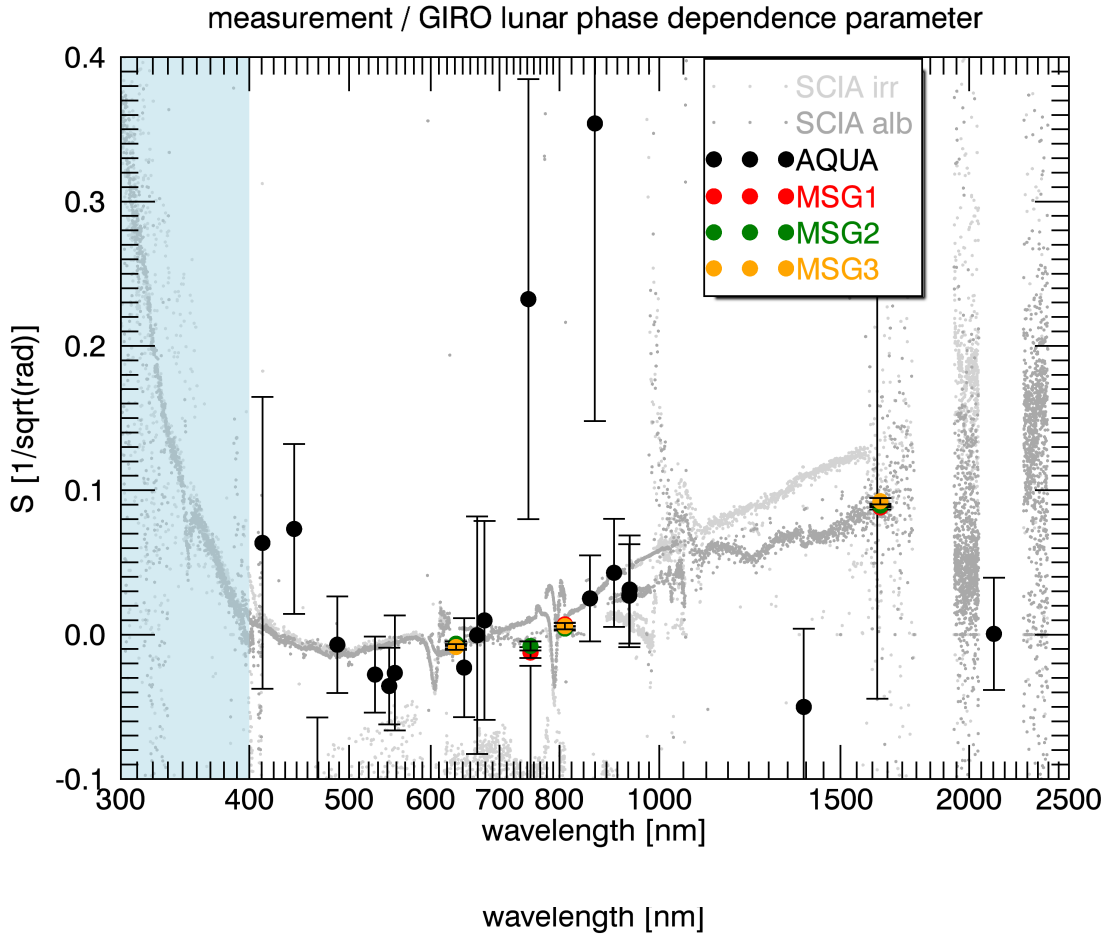
Results

Irradiances



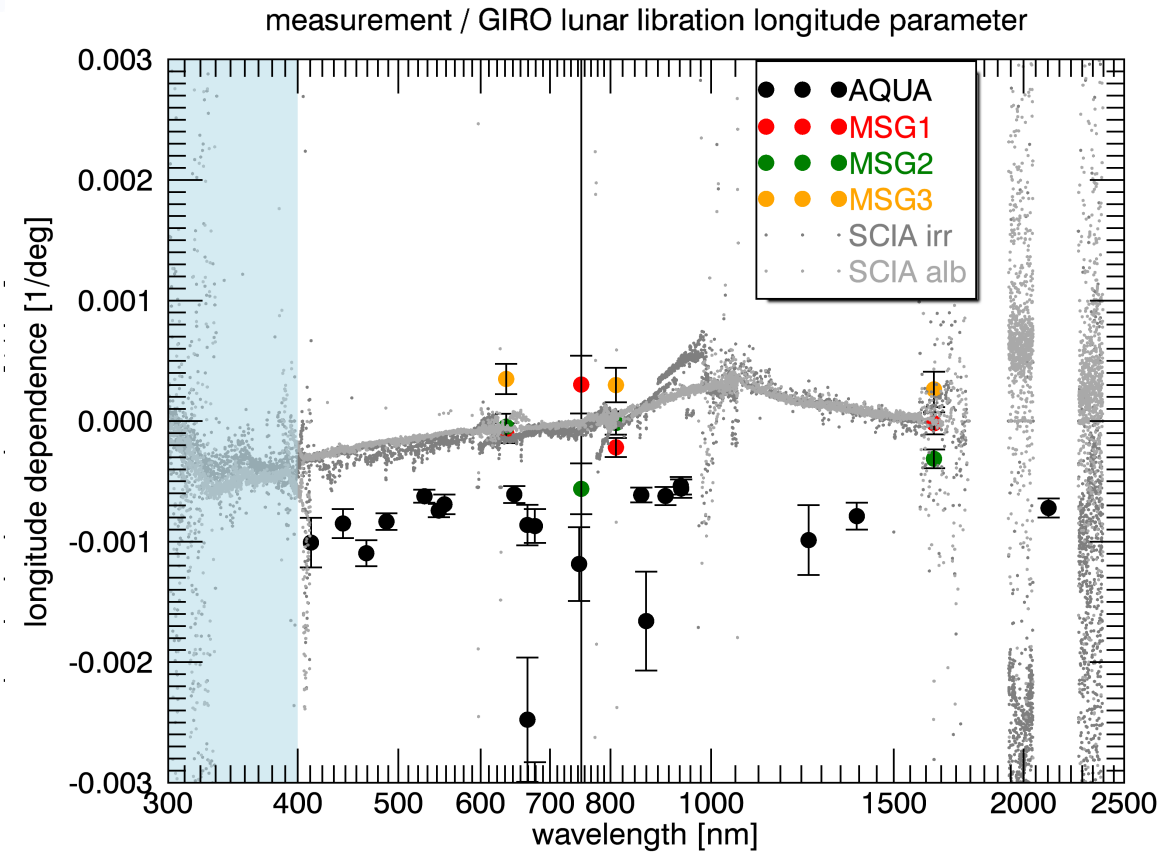
wavelength [nm]

Phase angle dependence

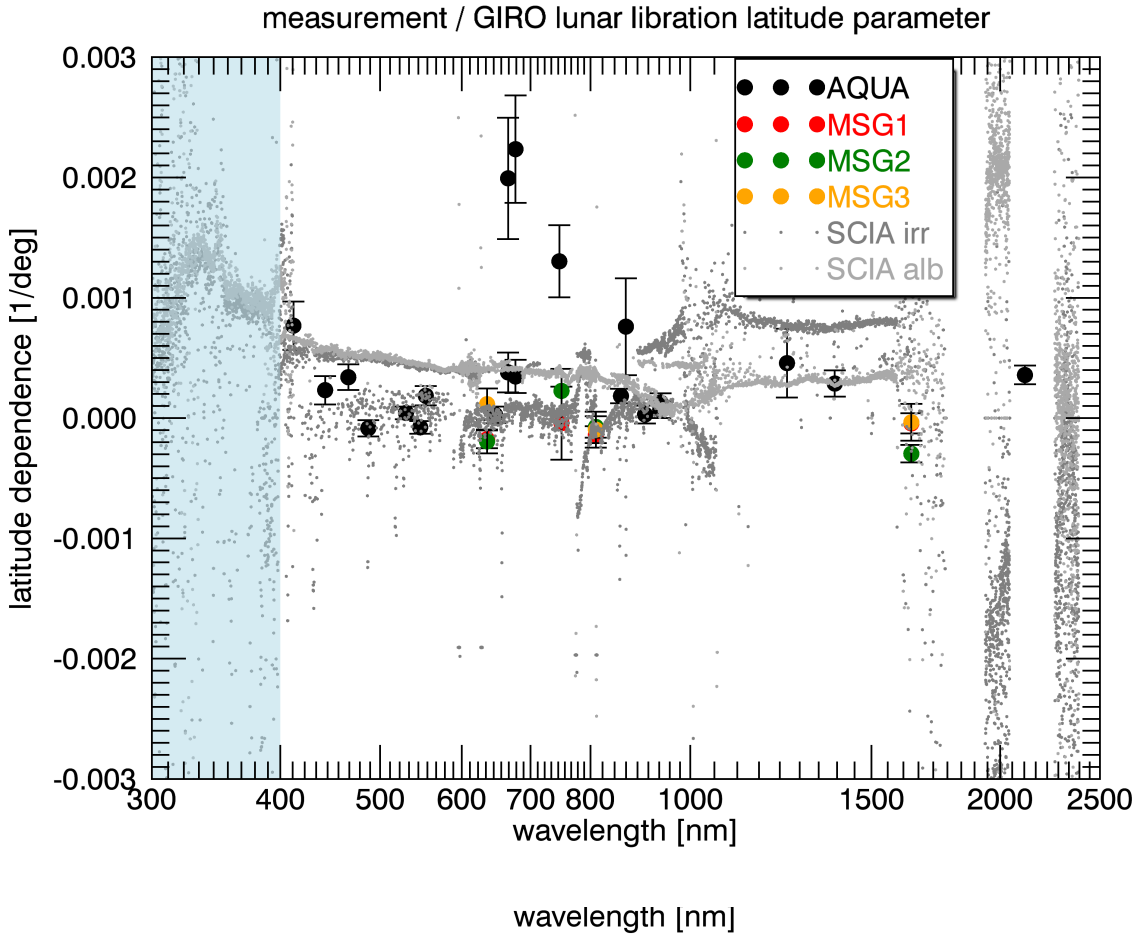


wavelength [nm]

Libration (Lon)



Libration (Lat)



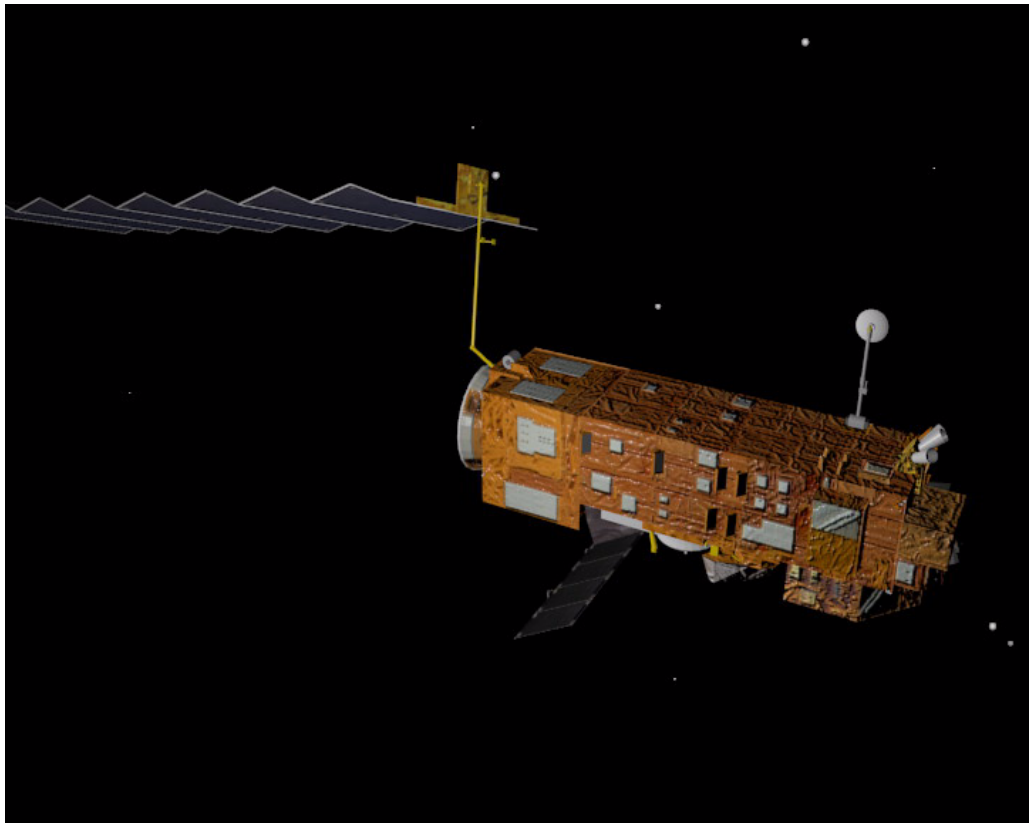
SBAFS

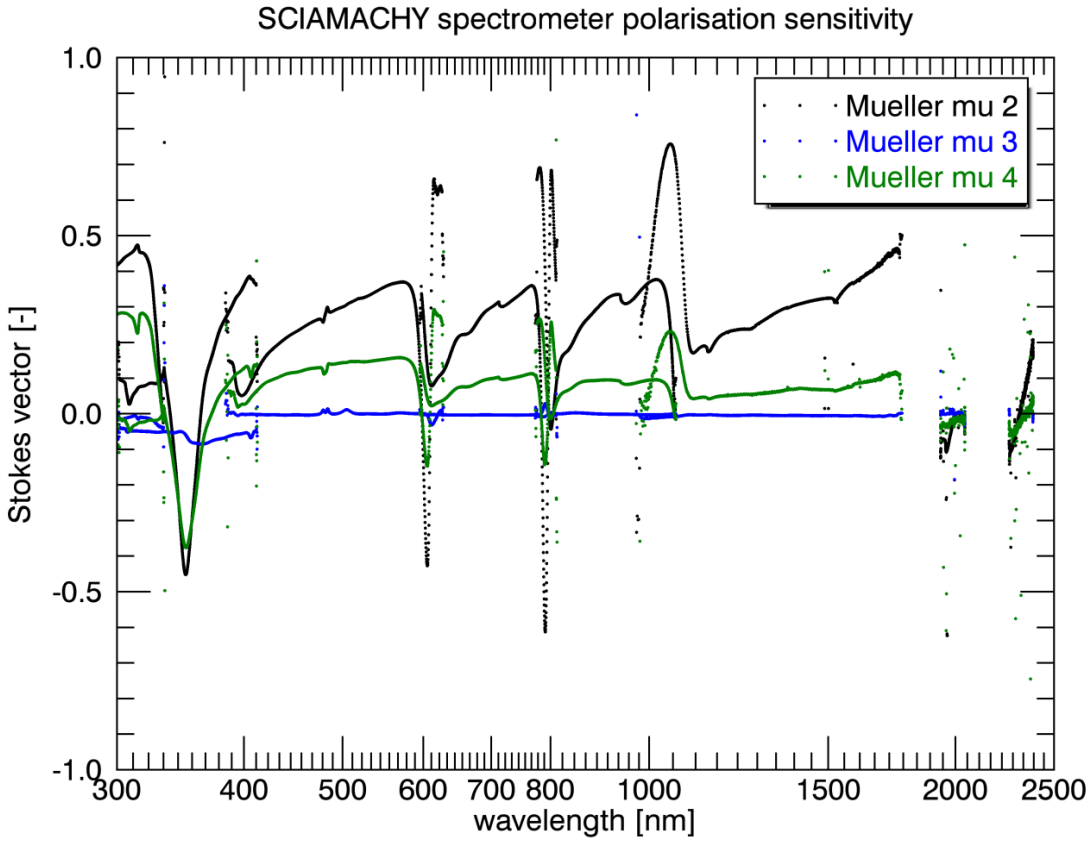
Bands	GIRO	SCIA	DCC	Libya	SCIA Ratio-1	DCC Ratio-1	Libya1 Ratio-1	SCIA phase	GIRO phase
MET7_VIS_vs_AQUA_1	0.8562	0.8407	0.8740	0.7540	-0.0182	0.0208	-0.1194	0.0077	-0.0034
MET7_VIS_vs_SNPP_I1	0.8483	0.8316	0.8560	0.7550	-0.0197	0.0293	-0.1180	0.0136	0.0012
MSG1_HRVIS_vs_AQUA_1	0.8727	0.8573	0.8820	1.0040	-0.0177	0.0289	0.1383	0.0107	0.0007
MSG1_HRVIS_vs_SNPP_I1	0.8647	0.8480	0.8640	0.7890	-0.0192	0.0188	-0.0868	0.0166	0.0053
MSG1_NIR016_vs_AQUA_6	0.9884	0.9889	1.0110	0.9560	0.0005	0.0224	-0.0544	-0.0006	0.0002
MSG1_NIR016_vs_SNPP_I3	0.9651	0.9621	1.0750	0.9530	-0.0031	0.1173	-0.1135	0.0123	0.0020
MSG1_VIS006_vs_AQUA_1	1.0074	1.0087	1.0150	1.0010	0.0013	0.0063	-0.0138	-0.0044	-0.0033
MSG1_VIS006_vs_SNPP_I1	0.9981	0.9978	0.9950	1.0020	-0.0003	-0.0029	0.0070	0.0015	0.0013
MSG1_VIS008_vs_AQUA_2	1.1134	1.1139	1.1360	1.0430	0.0004	0.0199	-0.0819	-0.0130	-0.0045
MSG1_VIS008_vs_SNPP_I2	1.1231	1.1236	1.1450	1.0460	0.0005	0.0190	-0.0865	-0.0143	-0.0046
MSG2_HRVIS_vs_AQUA_1	0.8741	0.8588	0.8850	0.7880	-0.0175	0.0305	-0.1096	0.0098	-0.0001
MSG2_HRVIS_vs_SNPP_I1	0.8661	0.8496	0.8670	0.7880	-0.0190	0.0205	-0.0911	0.0158	0.0046
MSG2_NIR016_vs_AQUA_6	0.9842	0.9845	1.0200	0.9510	0.0003	0.0360	-0.0676	0.0008	0.0005
MSG2_NIR016_vs_SNPP_I3	0.9611	0.9578	1.0850	0.9480	-0.0034	0.1328	-0.1263	0.0138	0.0022
MSG2_VIS006_vs_AQUA_1	1.0073	1.0086	1.0150	1.0010	0.0013	0.0064	-0.0138	-0.0043	-0.0032
MSG2_VIS006_vs_SNPP_I1	0.9980	0.9978	0.9950	1.0020	-0.0003	-0.0028	0.0070	0.0016	0.0014
MSG2_VIS008_vs_AQUA_2	1.1157	1.1161	1.1380	1.0460	0.0004	0.0196	-0.0808	-0.0132	-0.0047
MSG2_VIS008_vs_SNPP_I2	1.1254	1.1259	1.1470	1.0490	0.0005	0.0187	-0.0854	-0.0145	-0.0048
MSG3_HRVIS_vs_AQUA_1	0.8735	0.8581	0.8840	0.7870	-0.0176	0.0302	-0.1097	0.0099	0.0000
MSG3_HRVIS_vs_SNPP_I1	0.8654	0.8489	0.8860	0.7870	-0.0191	0.0437	-0.1117	0.0159	0.0046
MSG3_NIR016_vs_AQUA_6	0.9845	0.9848	1.0200	0.9520	0.0003	0.0357	-0.0667	0.0008	0.0004
MSG3_NIR016_vs_SNPP_I3	0.9614	0.9581	1.0840	0.9490	-0.0034	0.1314	-0.1245	0.0138	0.0022
MSG3_VIS006_vs_AQUA_1	1.0096	1.0113	1.0200	1.0000	0.0017	0.0086	-0.0196	-0.0057	-0.0043
MSG3_VIS006_vs_SNPP_I1	1.0003	1.0006	0.9990	1.0010	0.0003	-0.0016	0.0020	0.0000	0.0003
MSG3_VIS008_vs_AQUA_2	1.1156	1.1161	1.1380	1.0470	0.0004	0.0197	-0.0800	-0.0132	-0.0047
MSG3_VIS008_vs_SNPP_I2	1.1253	1.1258	1.1480	1.0500	0.0005	0.0197	-0.0854	-0.0145	-0.0048

Summary

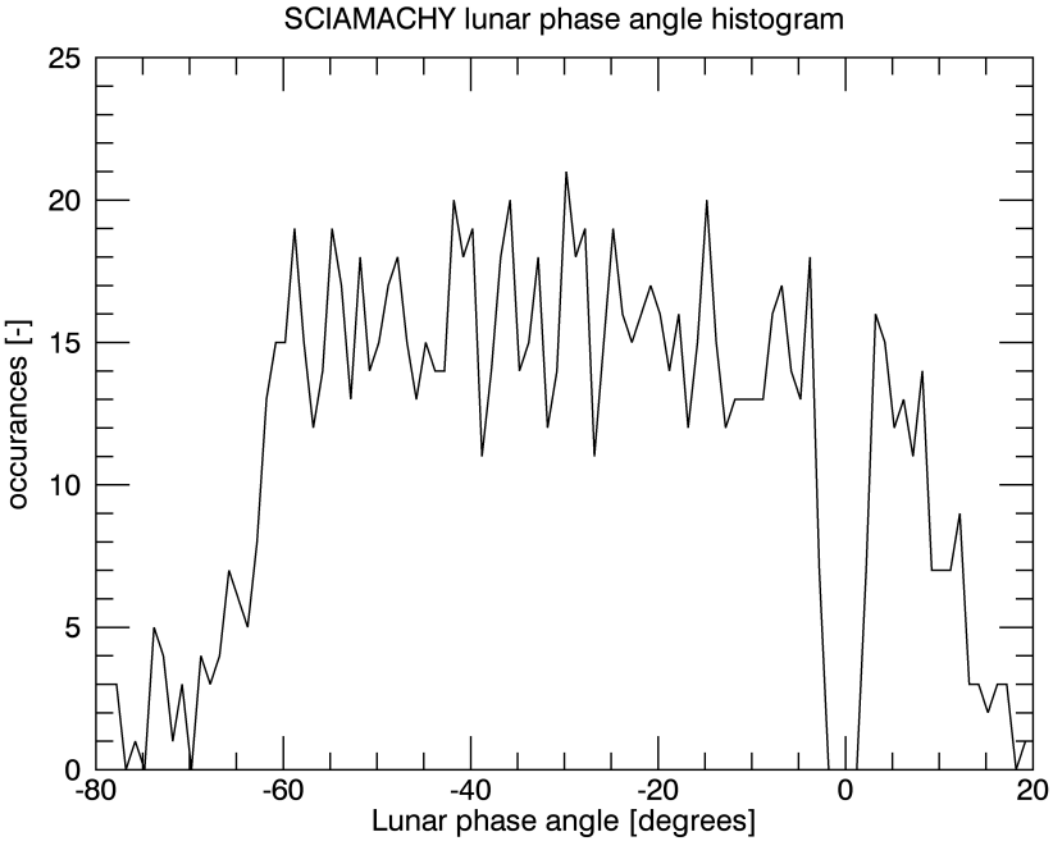
- SCIAMACHY
  - High (0.25nm) resolution lunar spectrum
  - Precise (<0.5%) lunar spectrum
  - Many (~1100) lunar measurements
  - Different geometries
  - New improved calibration (mirror model)
- Good agreement ROLO/GIRO (<2%)
  - Lunar phase angle dependence (GIRO?)
- Potentials for GIRO update
  - Phase angle dependence
  - Extension to shorter wavelength
  - GIRO polarisation?

Thank you



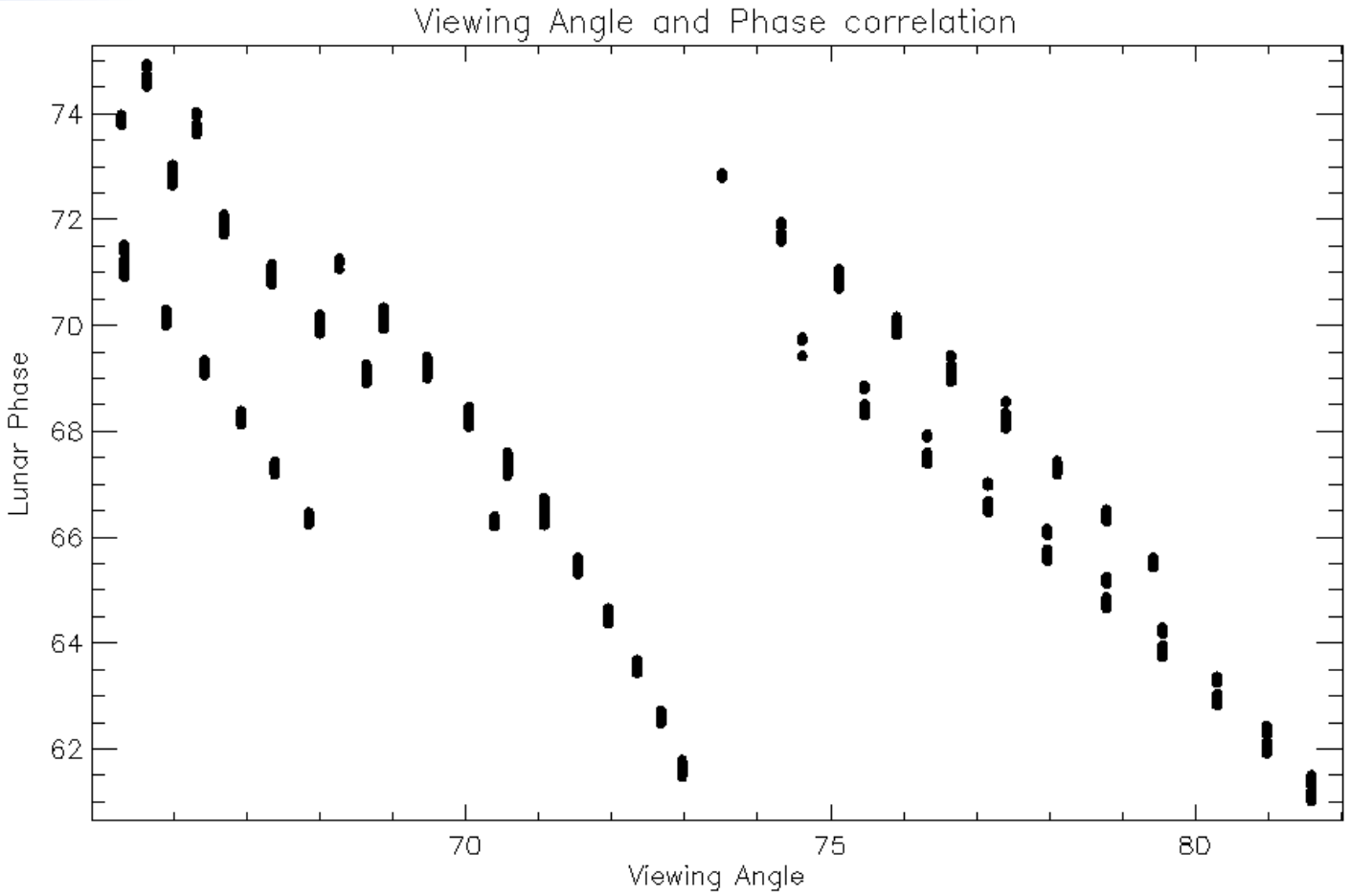

SCIAMACHY spectrometer polarisation sensitivity
Mueller mu 2
Mueller mu 3
Mueller mu 4
Stokes vector [-]
1.0
0.5
0.0
-0.5
-1.0
300
400
500
600
700
800
1000
1500
2000
2500
wavelength [nm]

Lunar phase angle coverage (2)

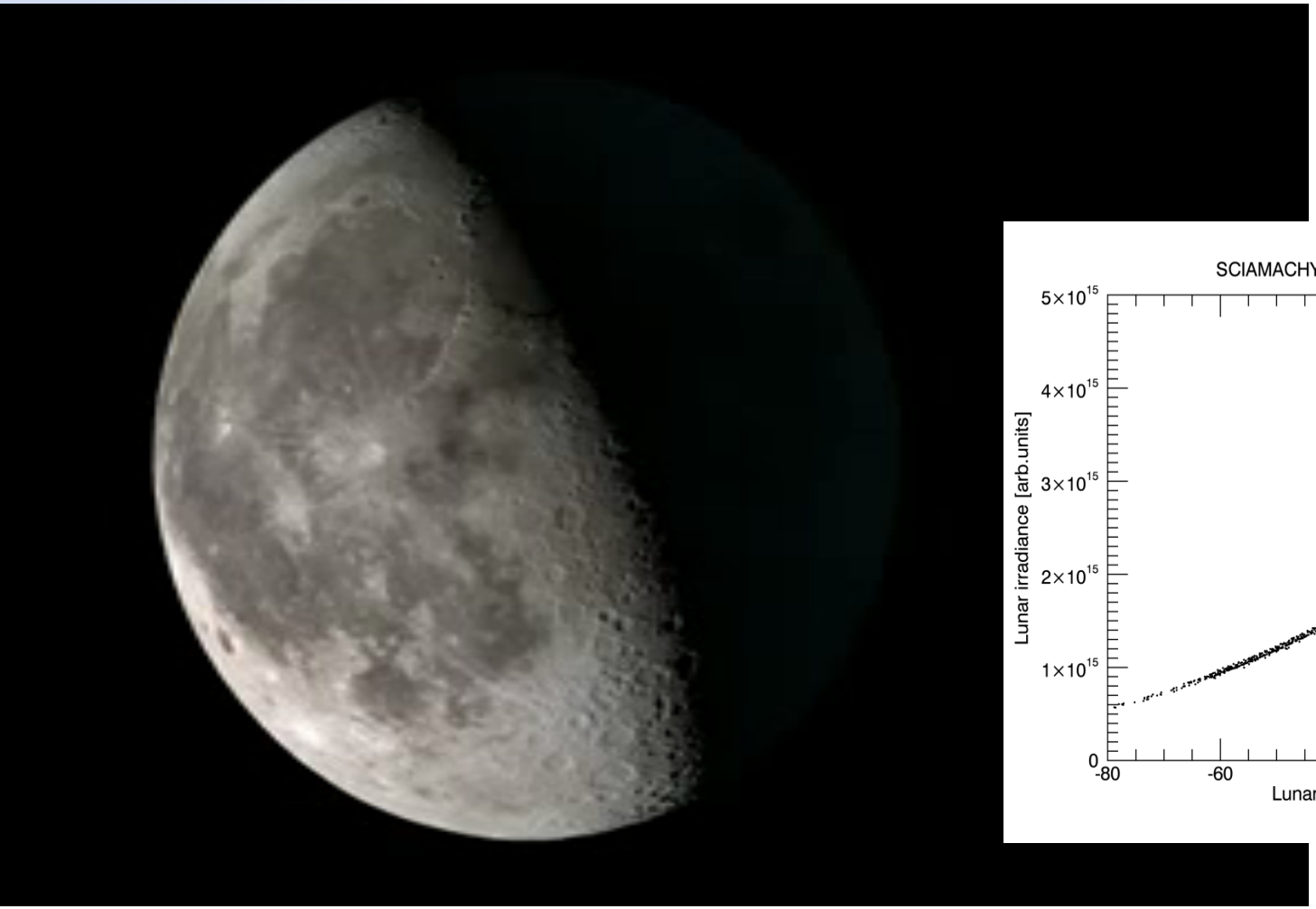


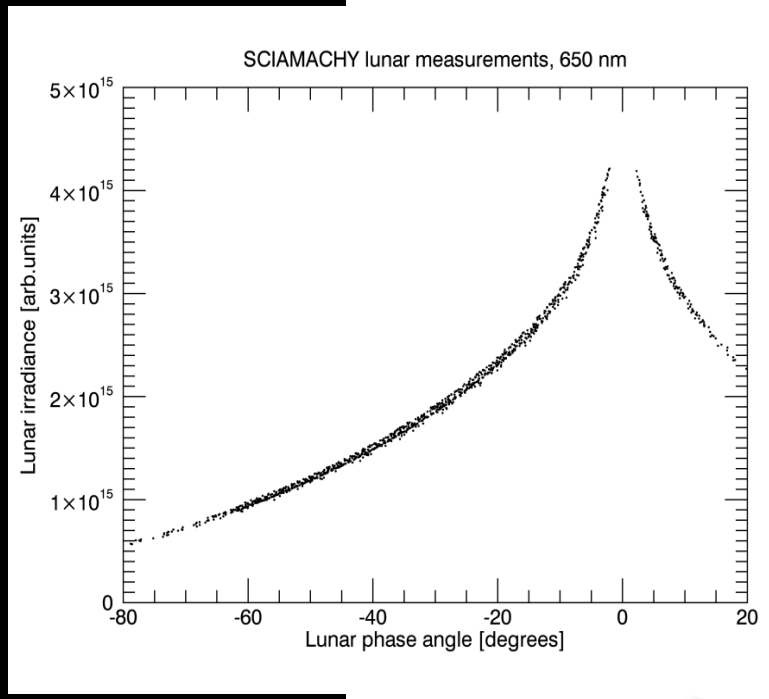
Preliminary

Problematic Correlations

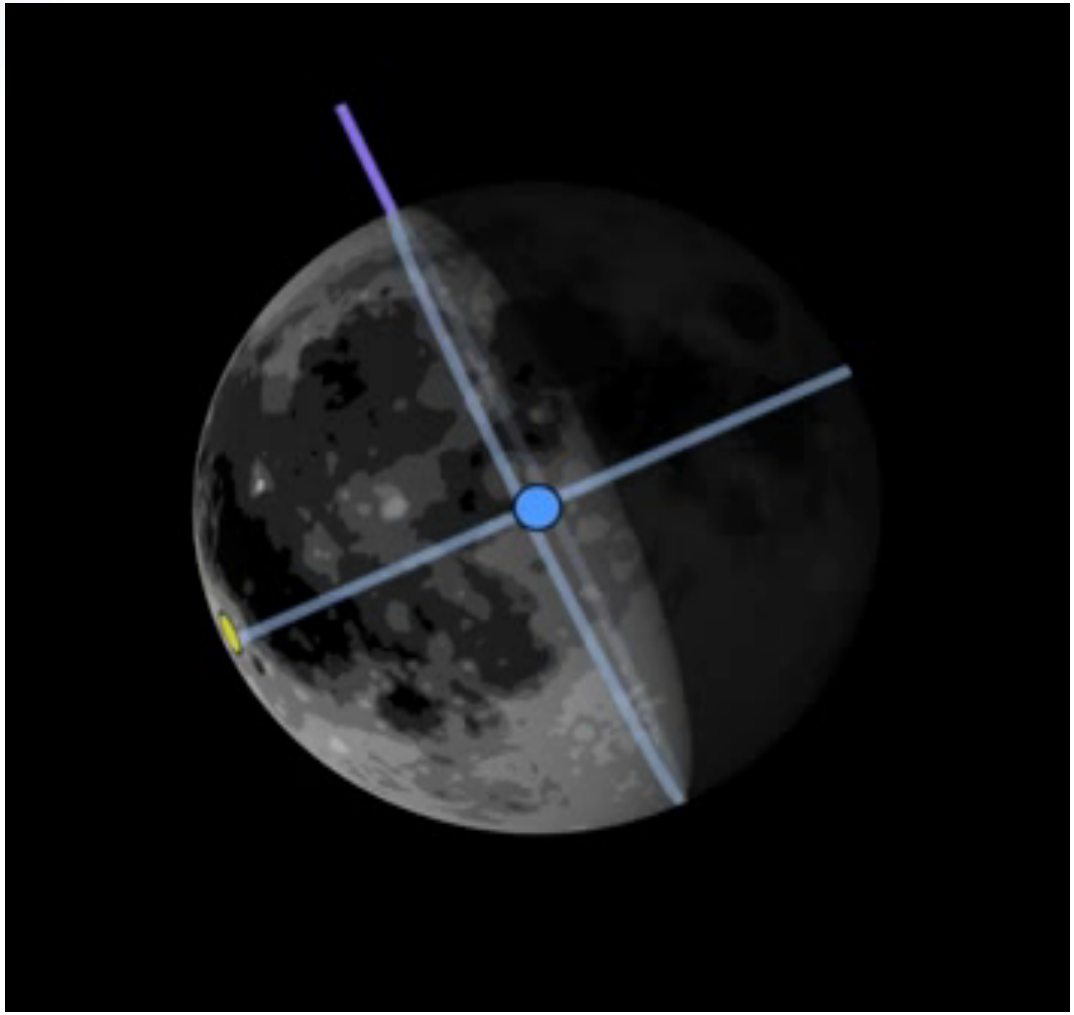


Lunar Variation



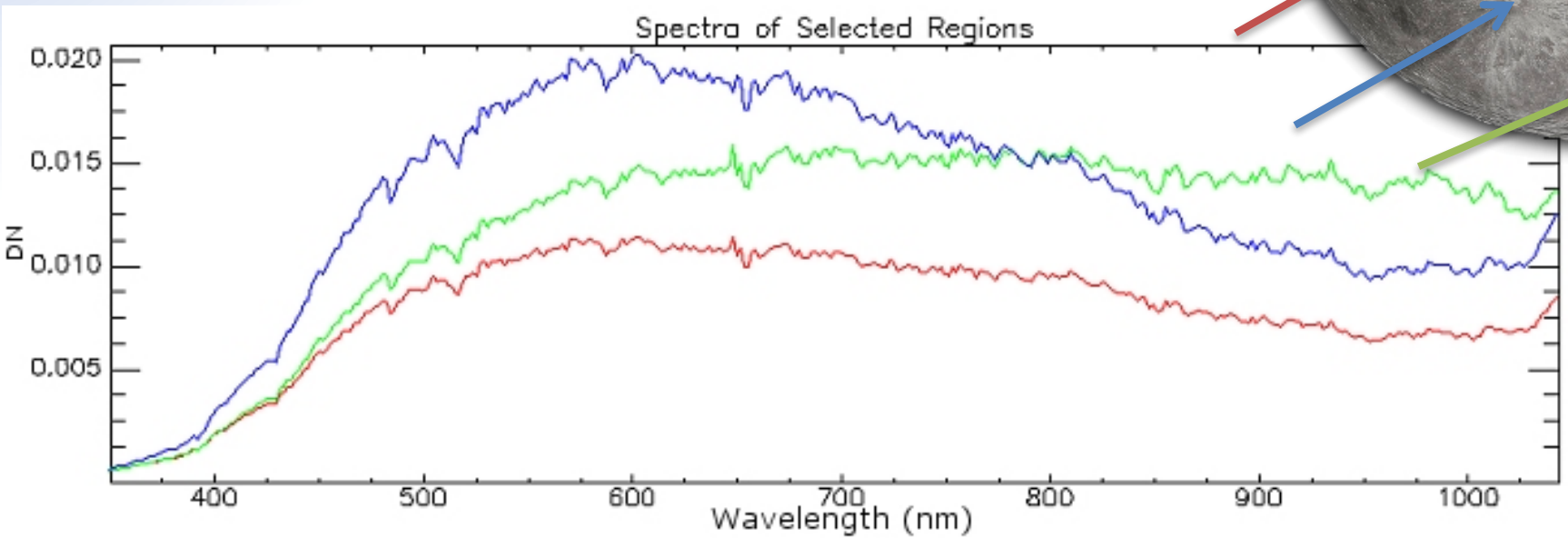


Libration



@NASA

Spectral variation



Date: 04 March 2005
Satellite: Rosetta
Depicts: Three lunar spectra
Copyright: ESA
Three spectra of three different regions on the Moon:

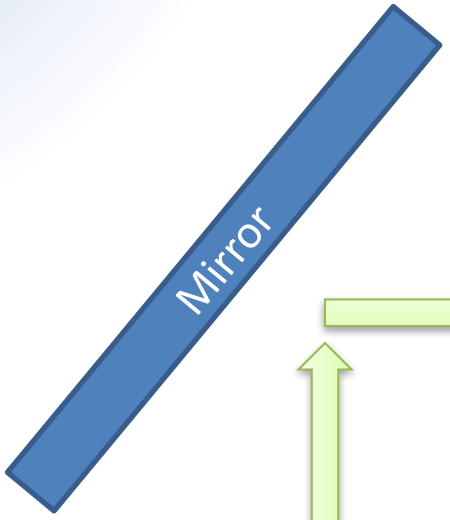
Blue = Kepler crater

Green = Mare Humorum

Red = Oceanus Procellarum

Future: GOME2

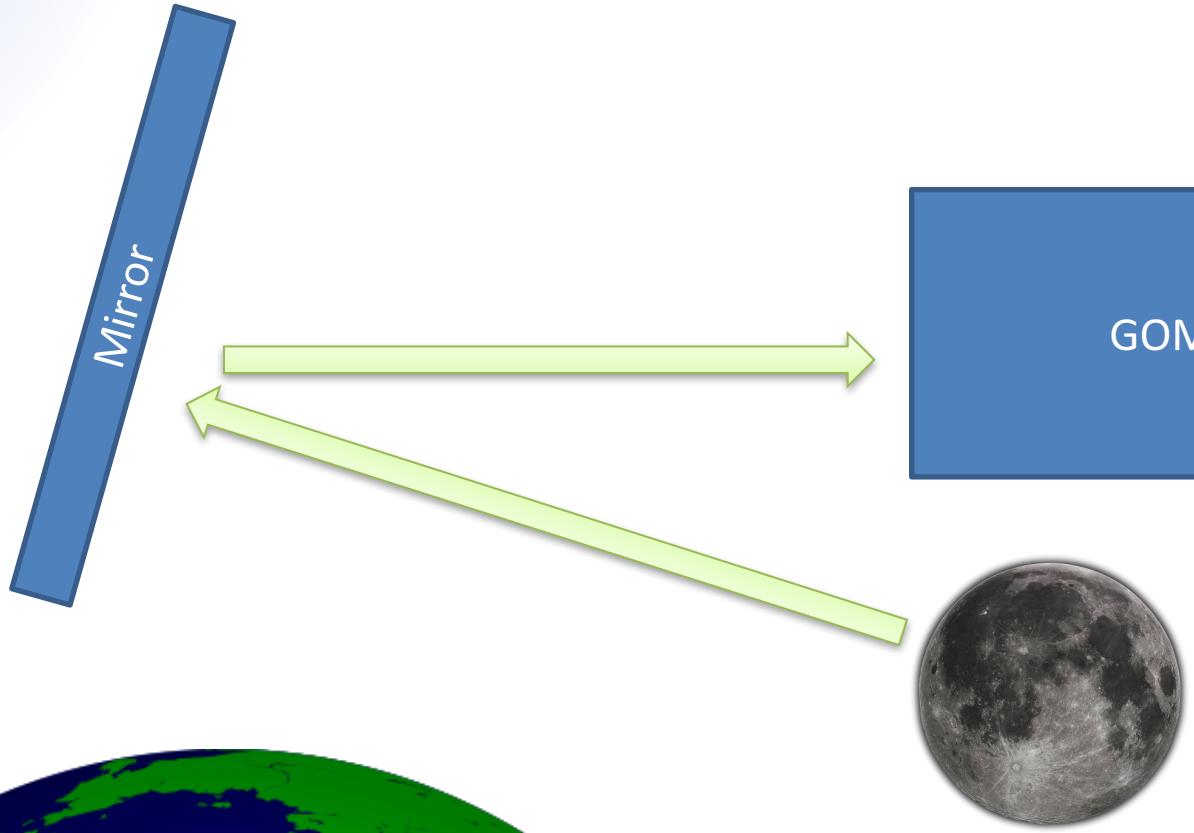
Earth Mode



GOME2

ARTH SPACE SOLUTIONS

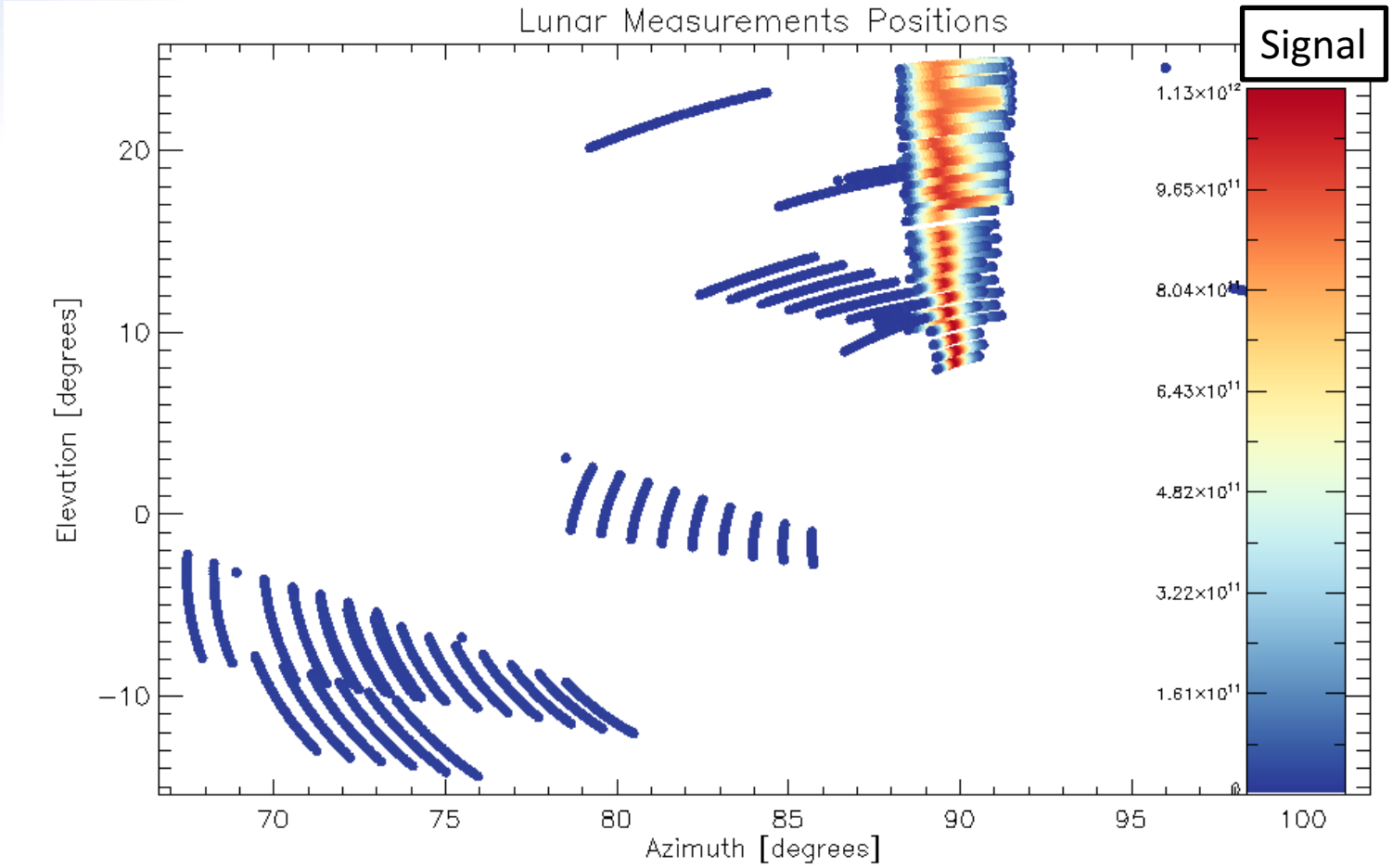
Lunar Mode



ARTH SPACE SOLUTIONS

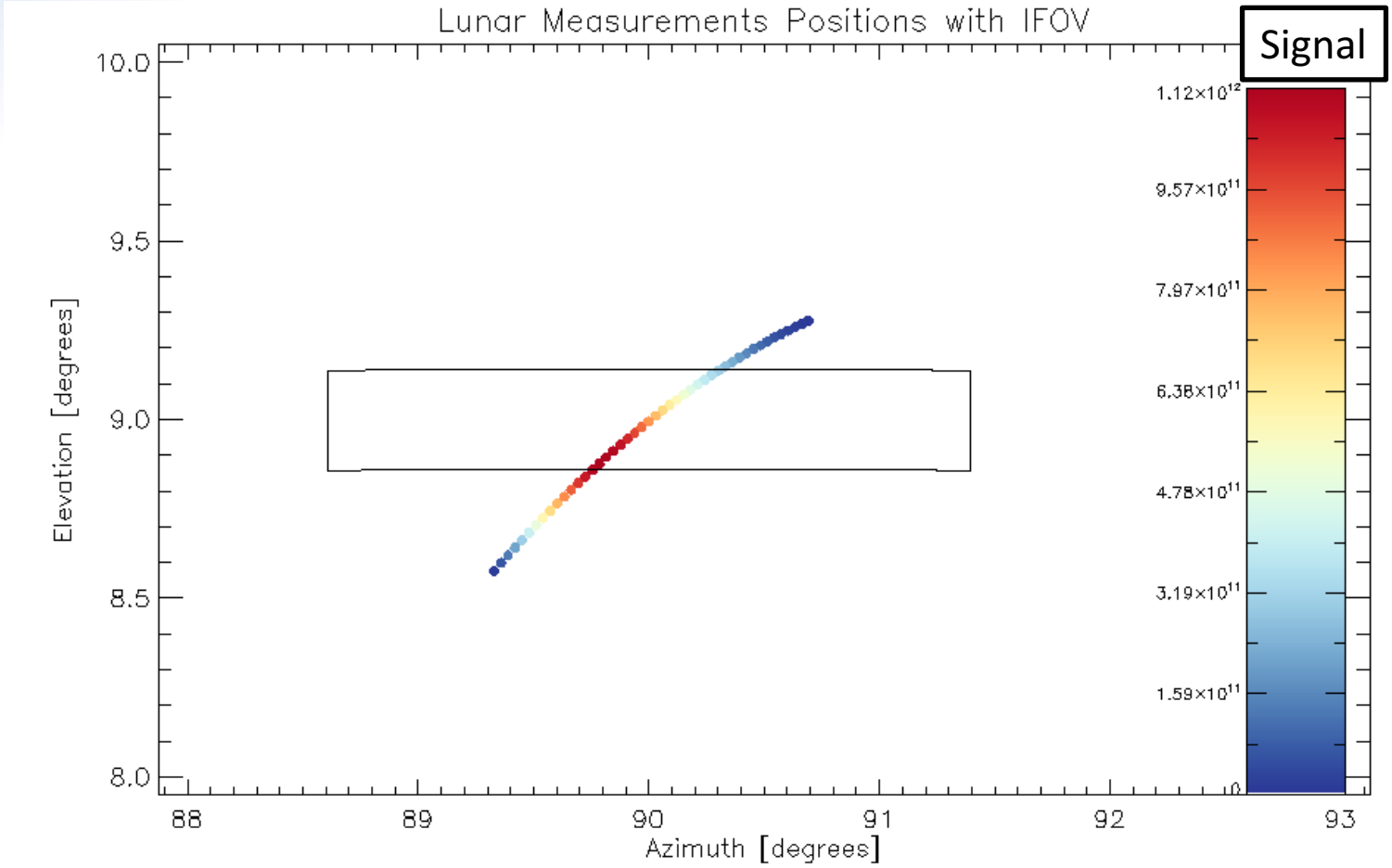
Preliminary

GOME2 Lunar Positions relative to GOME2



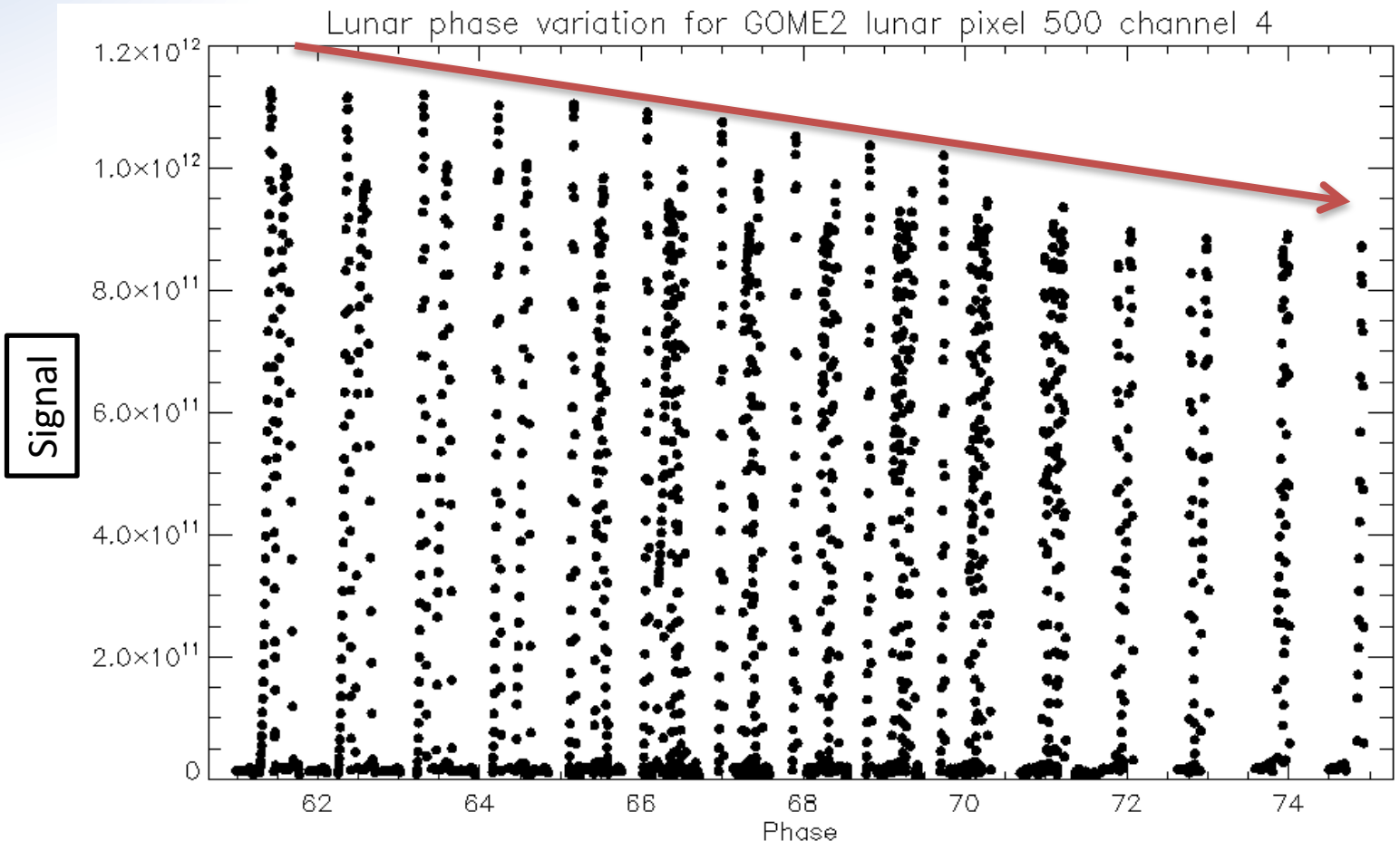
Preliminary

Single Moon Scan



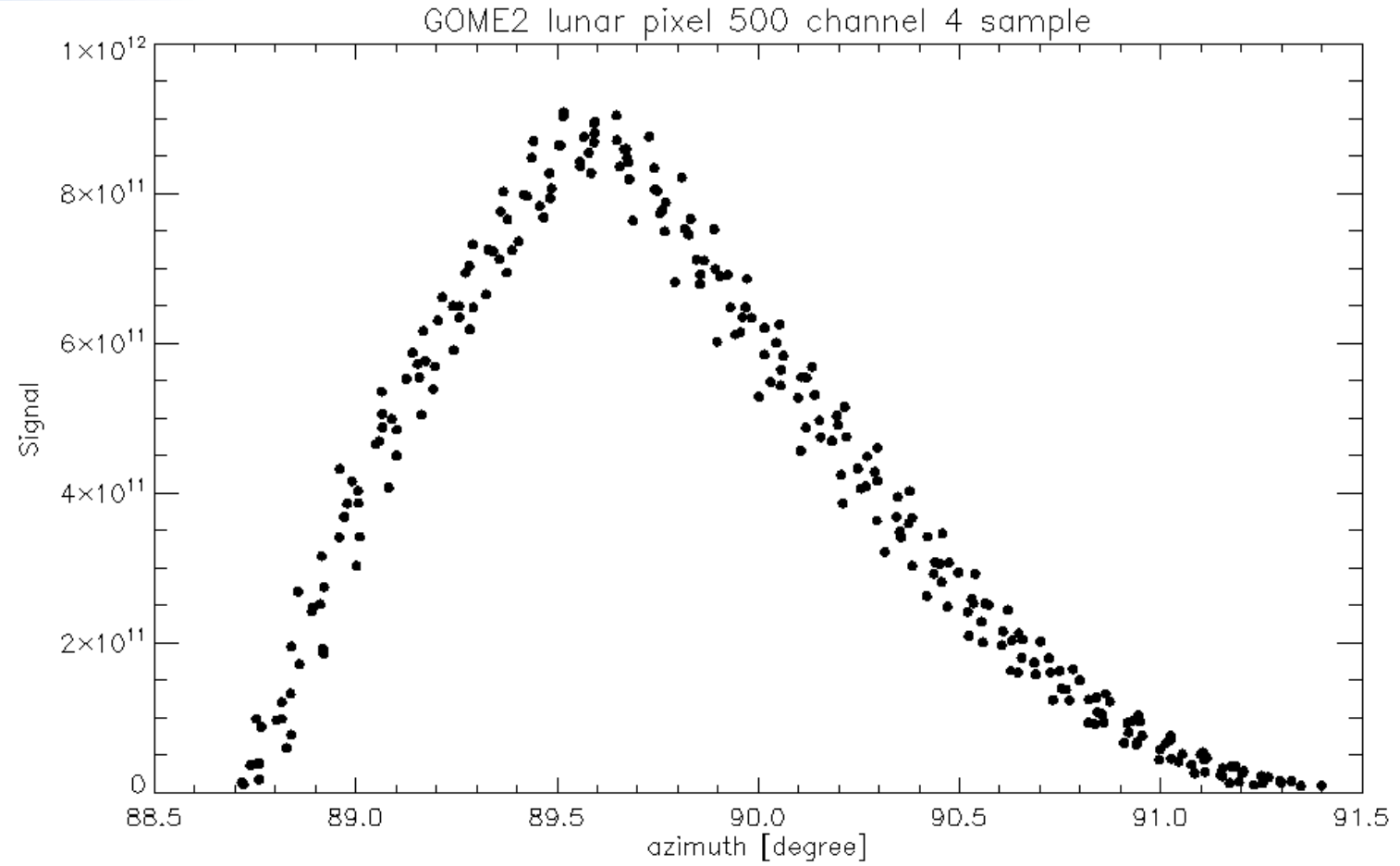
Preliminary

Signal vs Phase



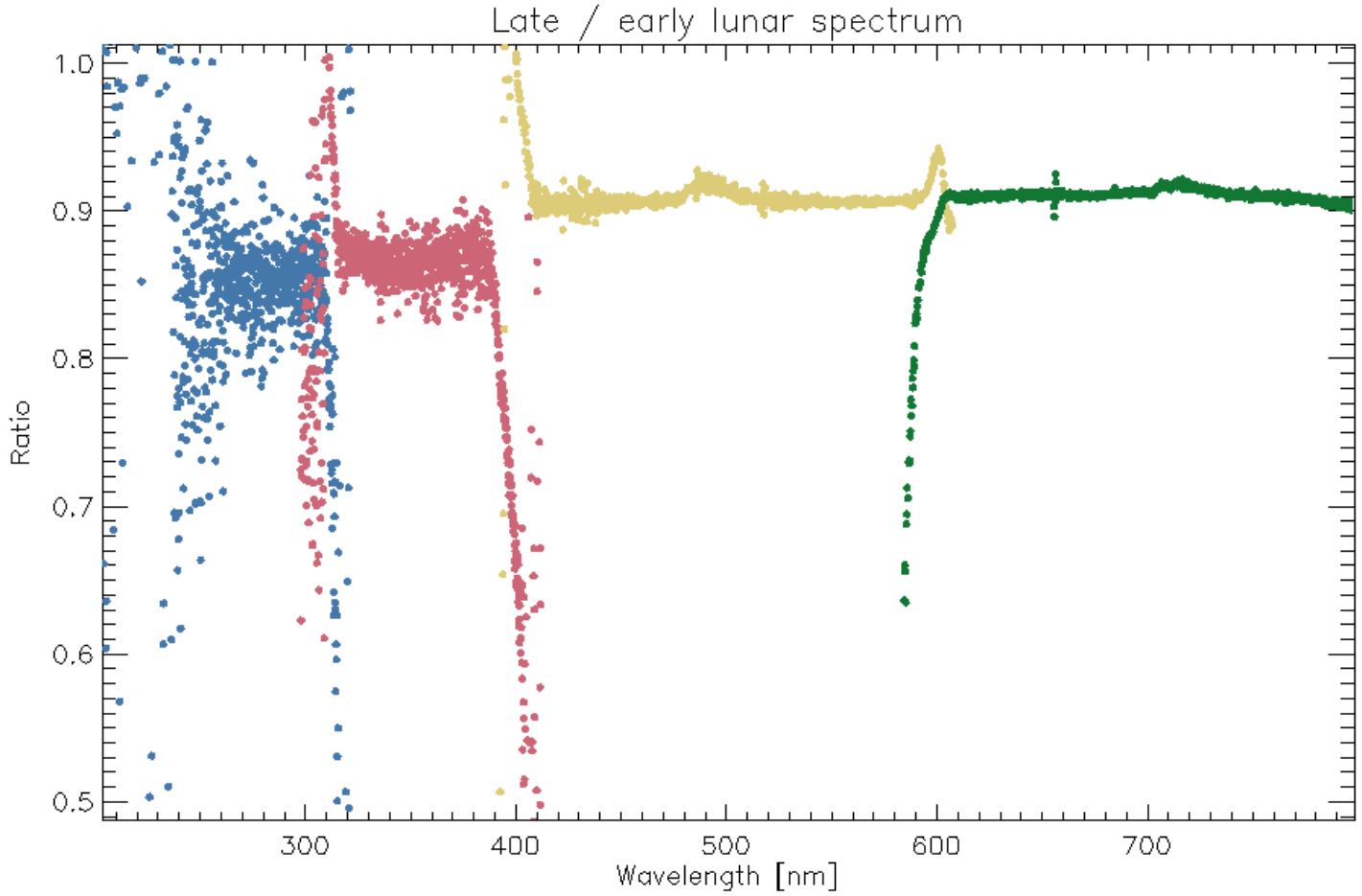
Preliminary

Azimuth Dependence



Preliminary

Degradation



SCIA vs GIRO

GIRO:

GSICS → **G**lobal **S**pace-based **I**nter-**C**alibration **S**ystem

Implementation

ROLO → **ROLO**:

model

USGS → U.S. Geological Survey

Robotic — Czech forced Labour

Lunar — Greek Goddess Moon

Observatory