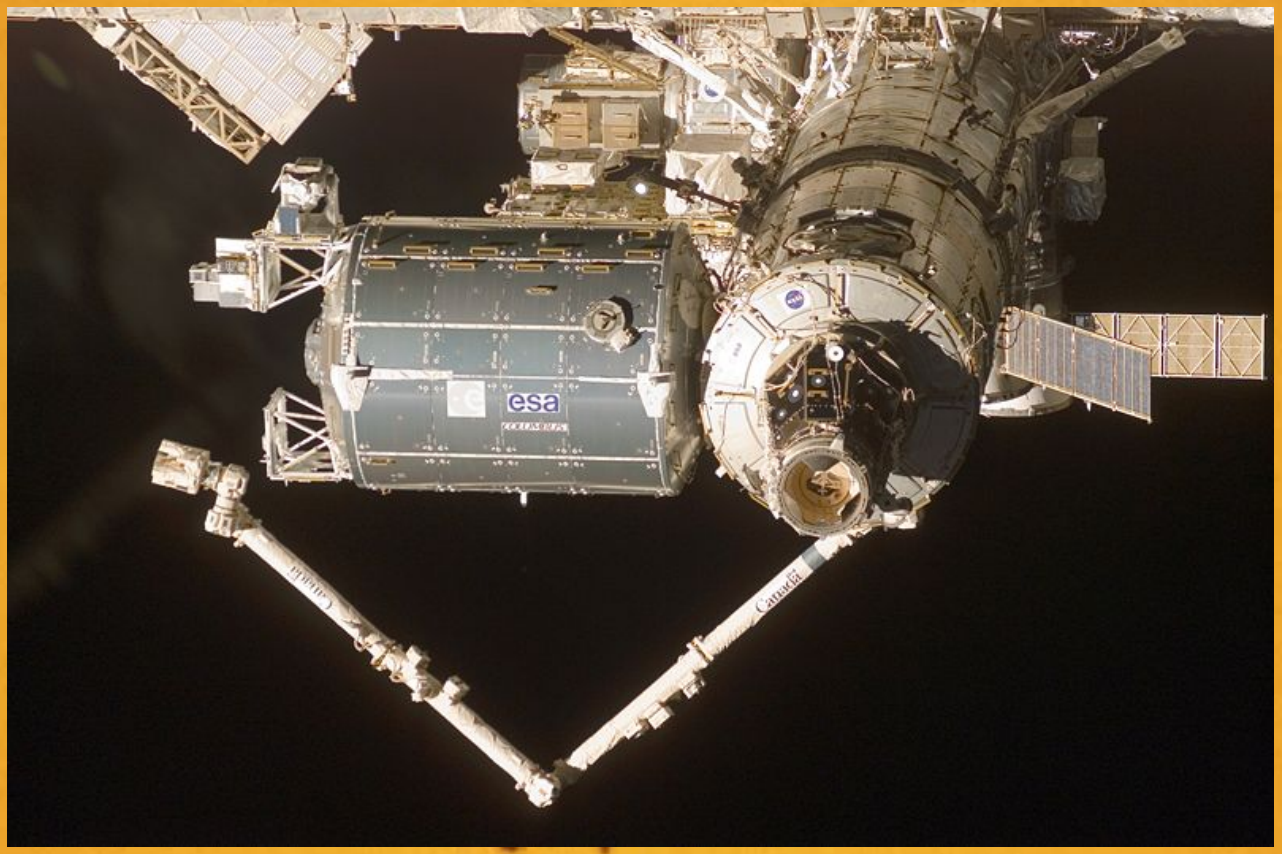
Operations of the solar package on the ISS

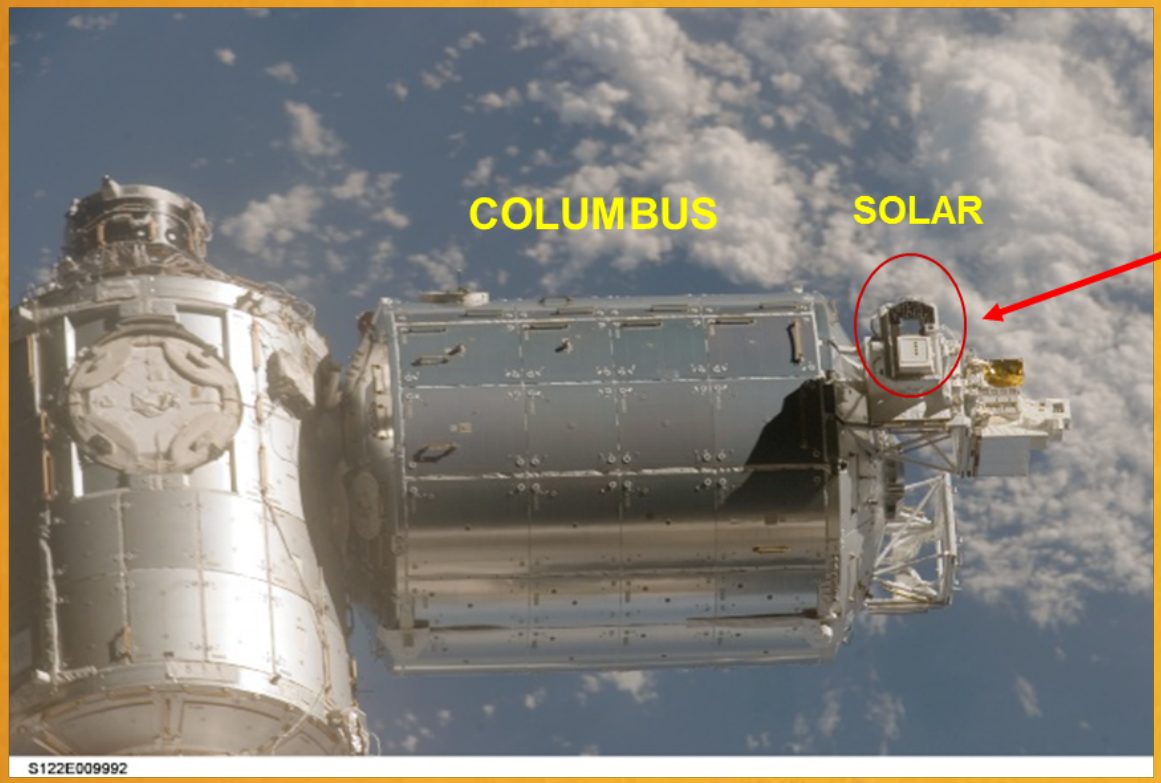


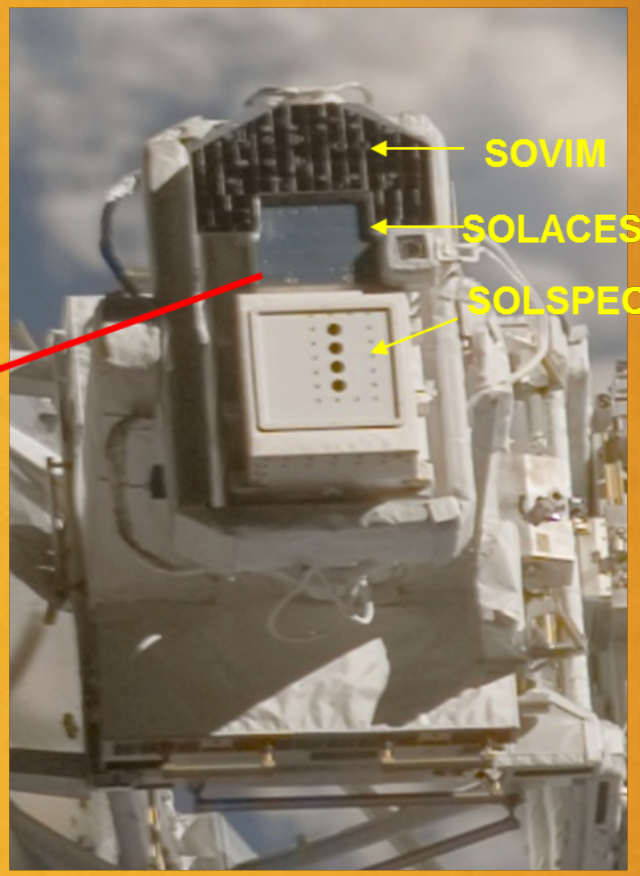
C.Muller and the B.USOC SOLAR team, thanks to the science teams

SOLAR is a set of instruments observing spectral irradiance

SOLAR Platform of the European COLUMBUS Module at the ISS

SOLSPEC - Solar UV-IR Spectrometers
SOLACES - Solar Auto-Calibration EUV Spectrometers
SOVIM - Total Solar Irradiance and Spectral Solar Irradiance





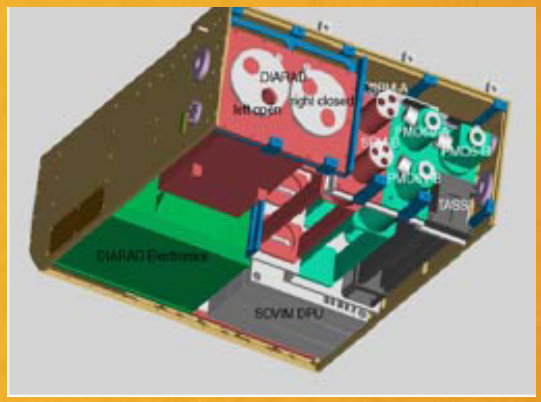
SOLAR was launched in February 2008

SOLAR instruments: SOVIM

- Total sun irradiance measurement
- Precision measurement of irradiance variability
- Instrument stopped functioning (power supply board failure)

pmod wrc

RMI

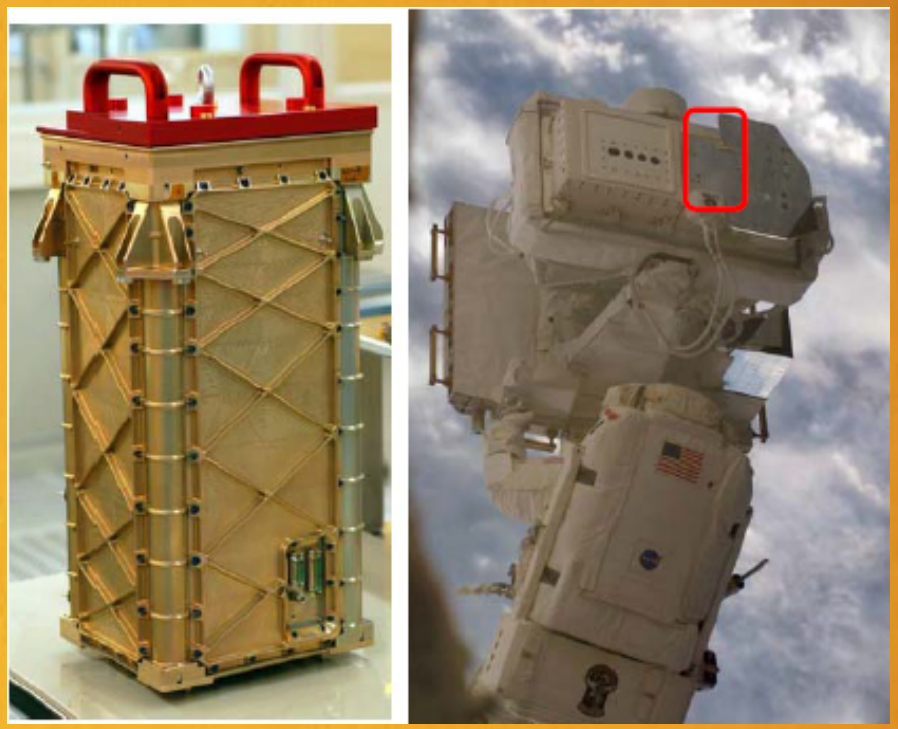


SOLAR instruments: SOLSPEC

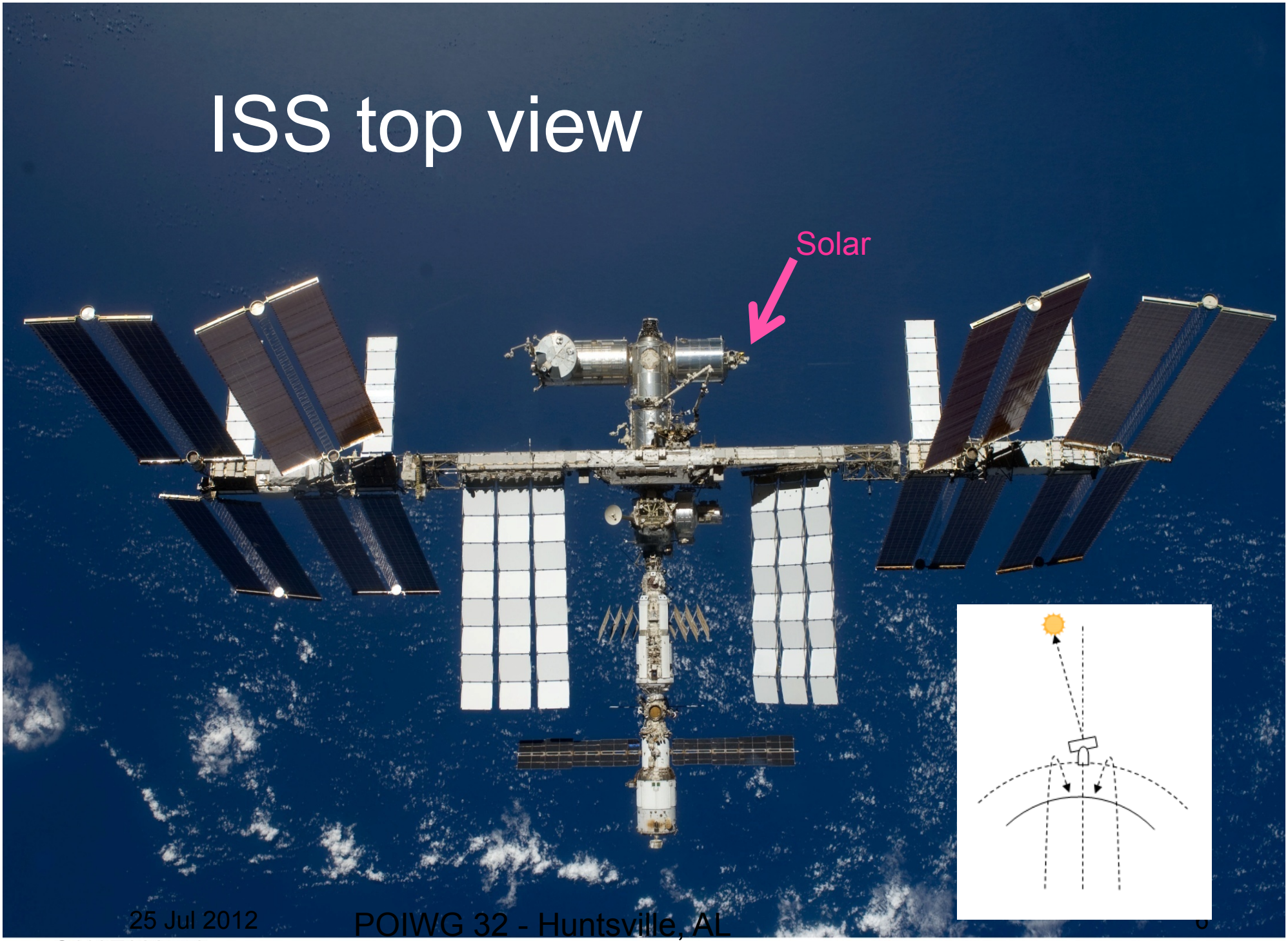
- Measure the solar spectrum irradiance from 180 nm to 3000 nm
- Precision measurement of irradiance variability
- Study of solar variability at short and long term
- Absolute measurements (2% in UV and 1% above)

SOLAR instruments: SOLACES

- Solar spectral irradiance of the full disk from 17 to 220 nm at 0.5 to 2 nm spectral resolution (4 EUV spectrometers)
- Auto-calibration capability: high absolute resolution
- Absolute calibration with ionization chambers as secondary instruments



ISS top view



S119E008578

- SolACES is measuring the extreme UV solar irradiance from 16 to 134 nm using a set of spectrophotometers with in-orbit recalibration capability using on board small gas cylinders and ionization chambers. Absorption gases (xenon, neon, a mixture of 90 % xenon + 10 % nitric oxide) exposed to solar radiation is used to monitor the response of the channels with high efficiency.
- The SOLAR SOLSPEC is a spectroradiometer with 3 channels measuring the UV-VIS and NIR solar irradiance, from 166 to 3088 nm (96 % of the total solar irradiance). This is the heritage of the SOLSPEC SpaceLab-ATLAS version, refurbished for the long term SOLAR mission. An upgraded internal unit using stable lamps provides capabilities for maintaining the absolute response of each channel.
- Both instruments were calibrated in absolute against the PTB radiometric scale (Physikalisch-Technische Bundesanstalt, Germany) using the blackbody radiation and synchrotron radiation (BESSY II) respectively for SOLSPEC and SolACES.

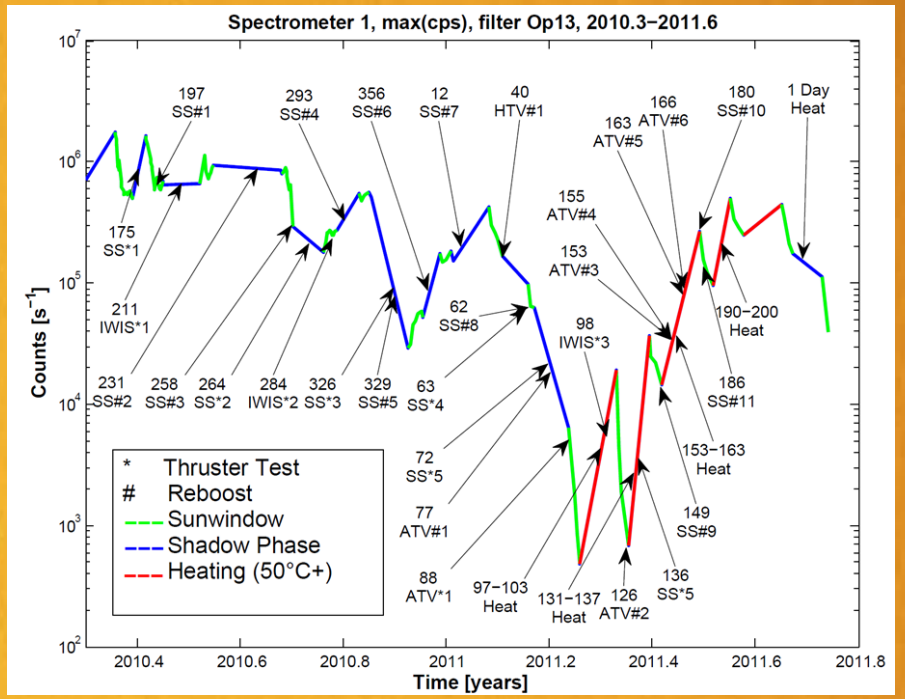
Operation restrictions on the ISS

ISS seen from the CNES-EU pléiades satellite

- ISS cannot give full target access to a pointing payload.
- SOLAR has thus successions of solar viewing opportunities of several earh days in a row.
- Close to solstices, a small change of attitude allows for a longer sequence combining two periods and thus covering a full solar rotation.
- NASA and the other ISS agencies approved a bridging of two periods in December 2012.
- Chemical propulsion, vehicle activities and space weather limit also the use of the payload.

ISS related problems and mitigation

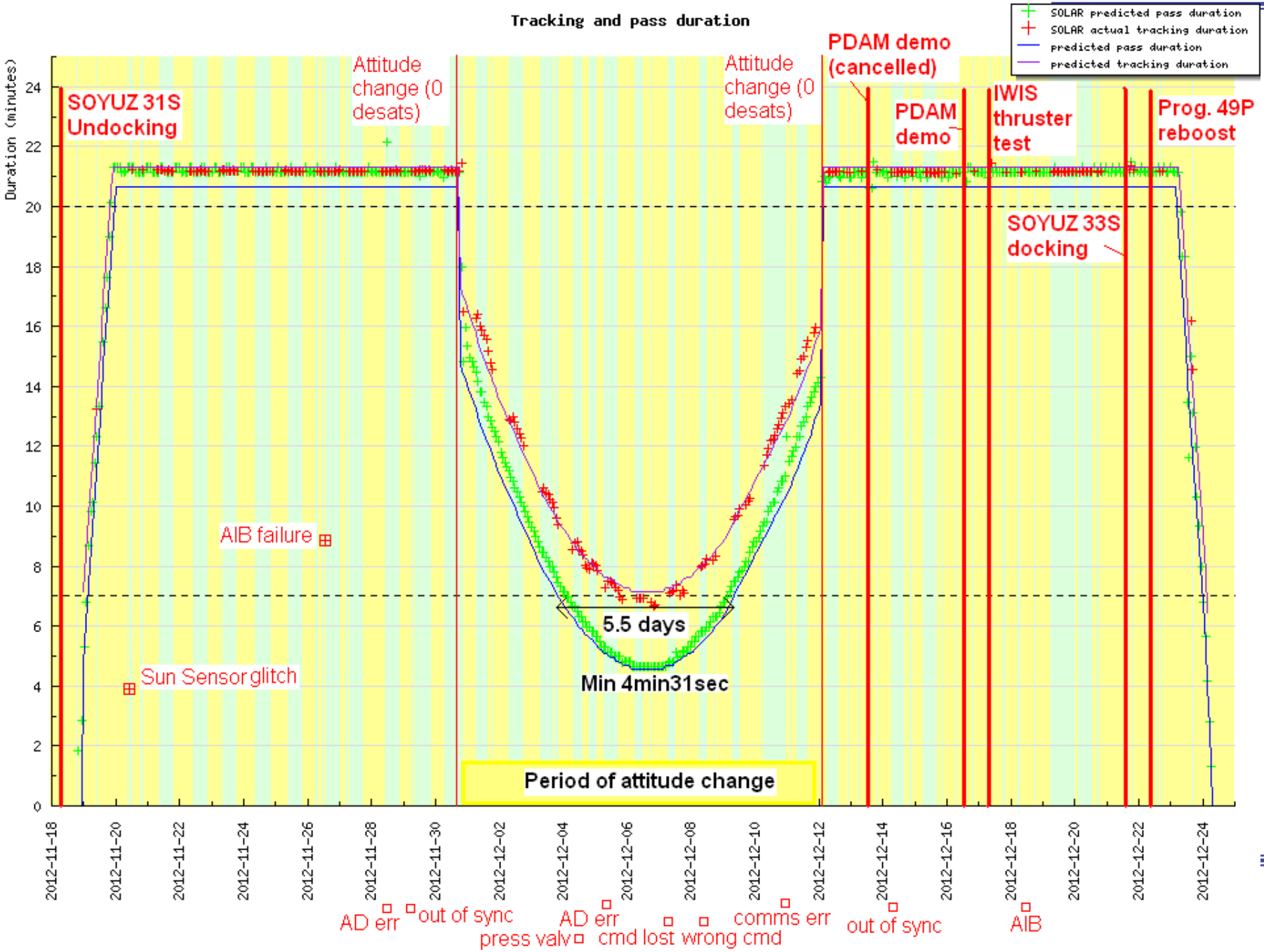
- degradation/contamination of detectors of SOL-ACES. The transmission of the spectrometer is restored by electron regeneration periods between solar spectrum measurements and heating to 50°C. **The correction process needs both attended operations and an instrument science team.**
- The analysis of this and other contamination/degradation incidents on the ISS is still in progress.
- The ISS has both the characteristics of a navigating vehicle and of a shared laboratory.



Despite these interruptions, the ISS has still invaluable value for the monitoring of solar climate.

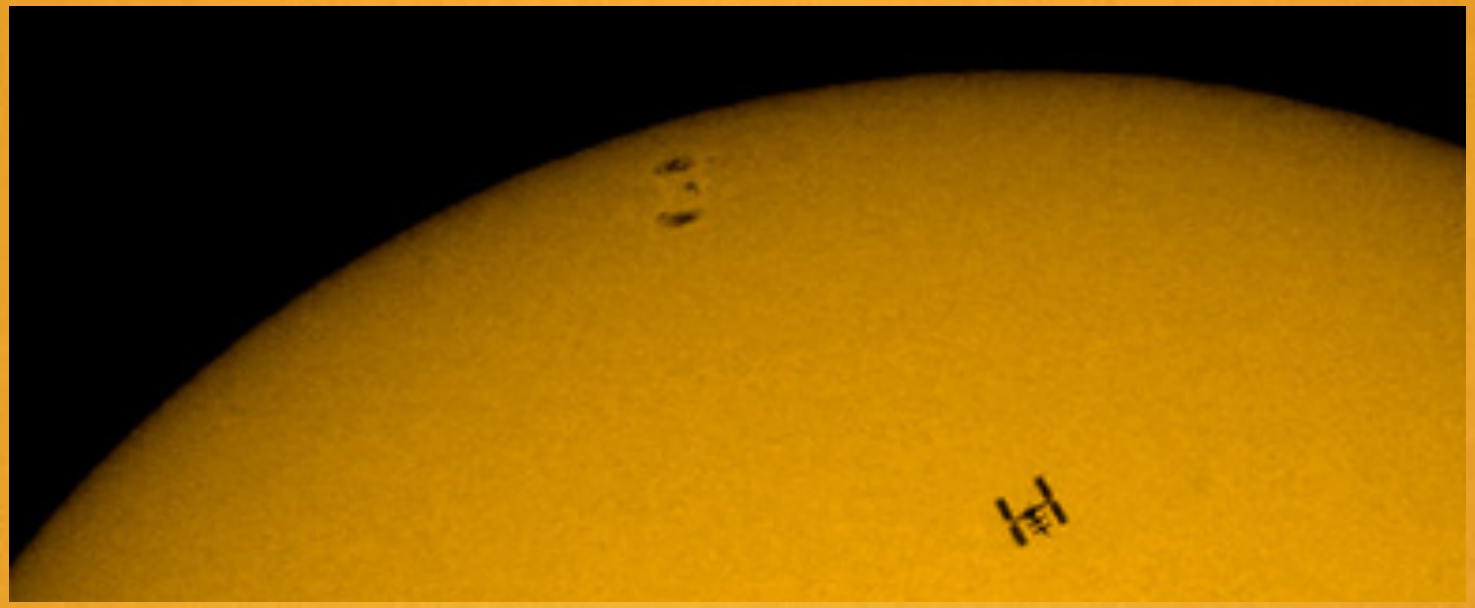
The BUSOC operation room during SOLAR operations.

Schematics of the bridging



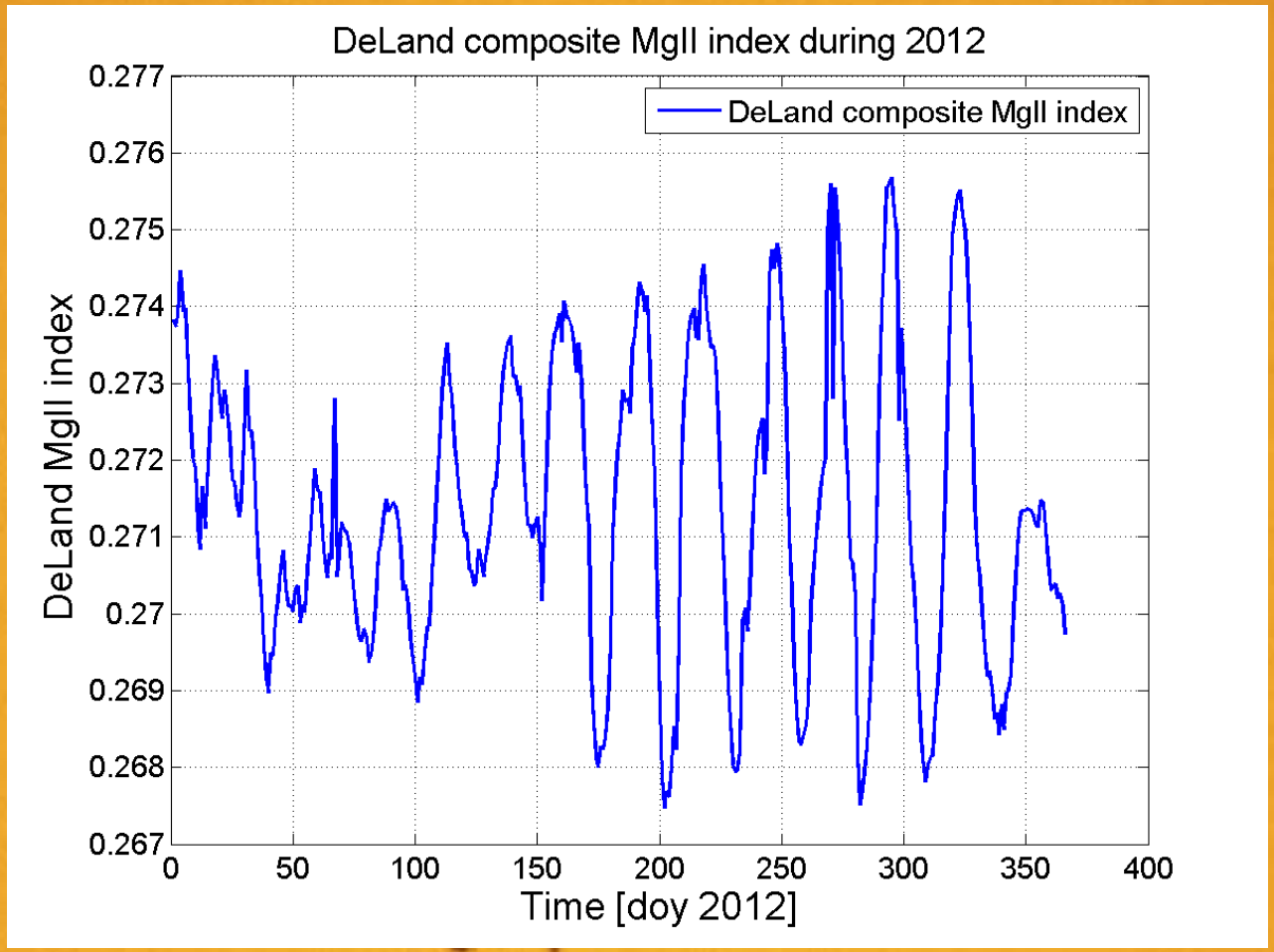
First Bridging

- The first bridging attitude correction was applied between December 1 and December 11, 2012, allowing observations from November 22 to December 24.
- These bridging operations are possible with a small change of attitude during solstices (around 7°).



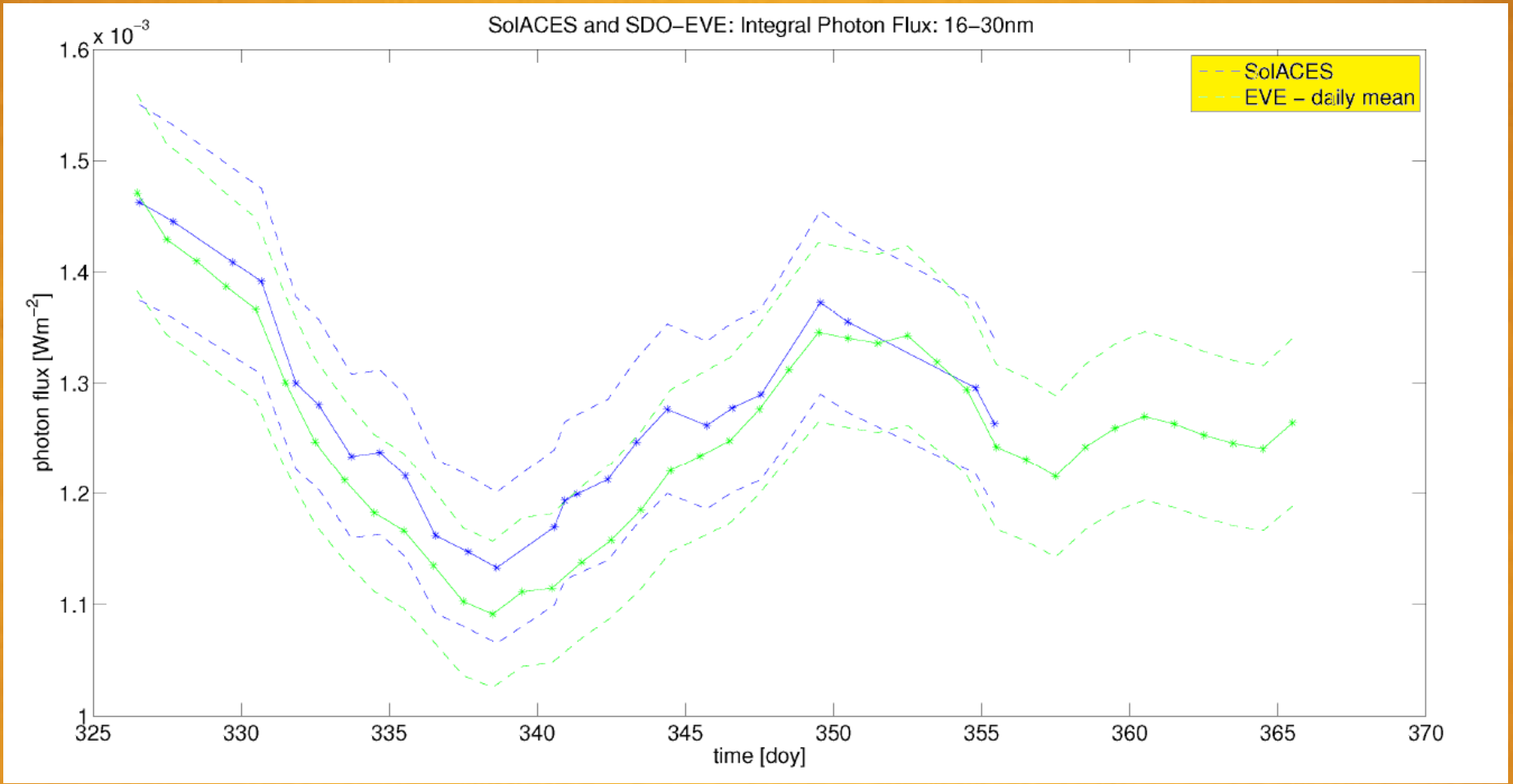
ISS and sunspot group 664 (photograph by Jerry Lodriguss in 2007).

SOLAR activity in 2012.



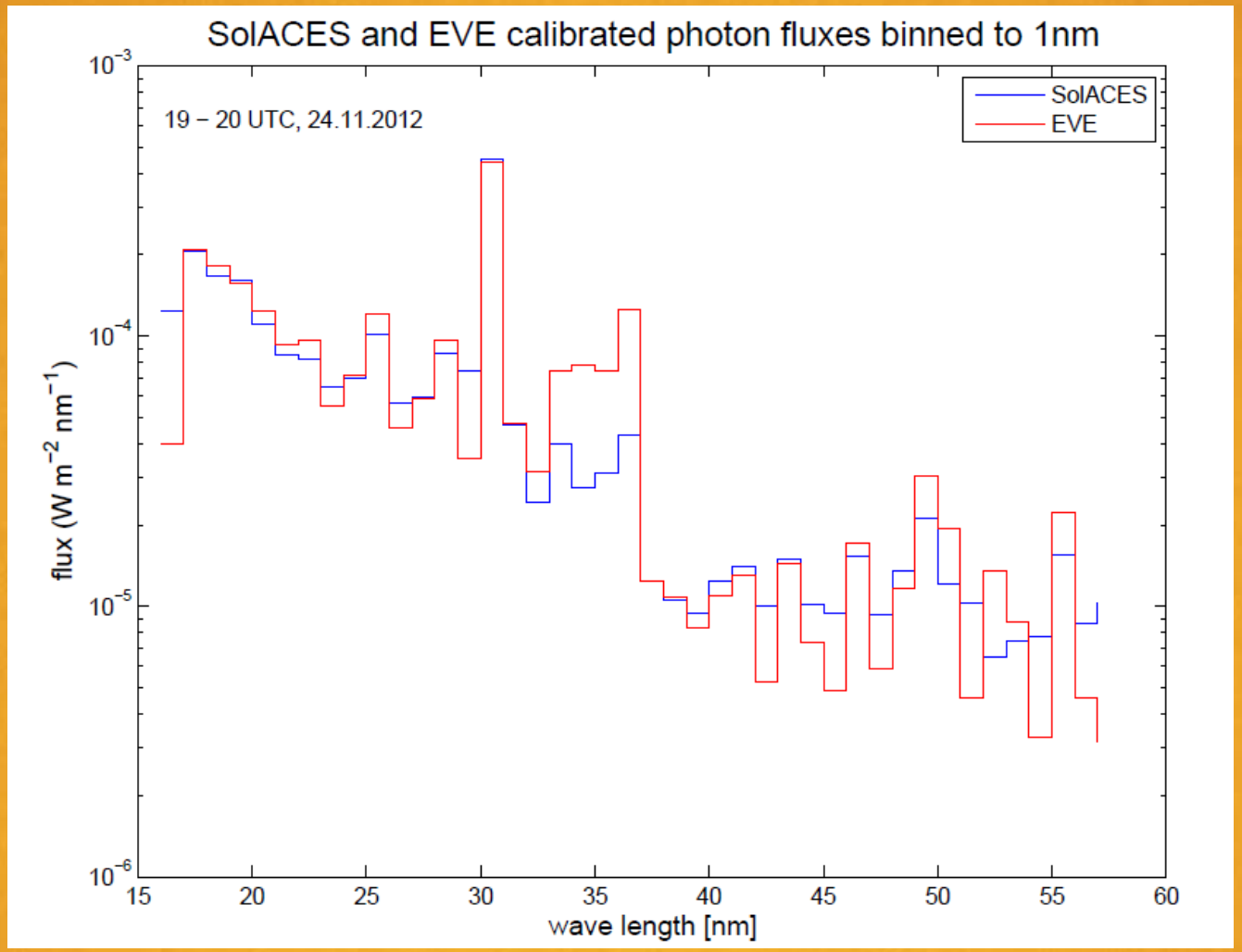
Signature of solar activity during 2012 using the DeLand composite MgII index

Intercomparisons of SOL-ACES and SDO-EVE

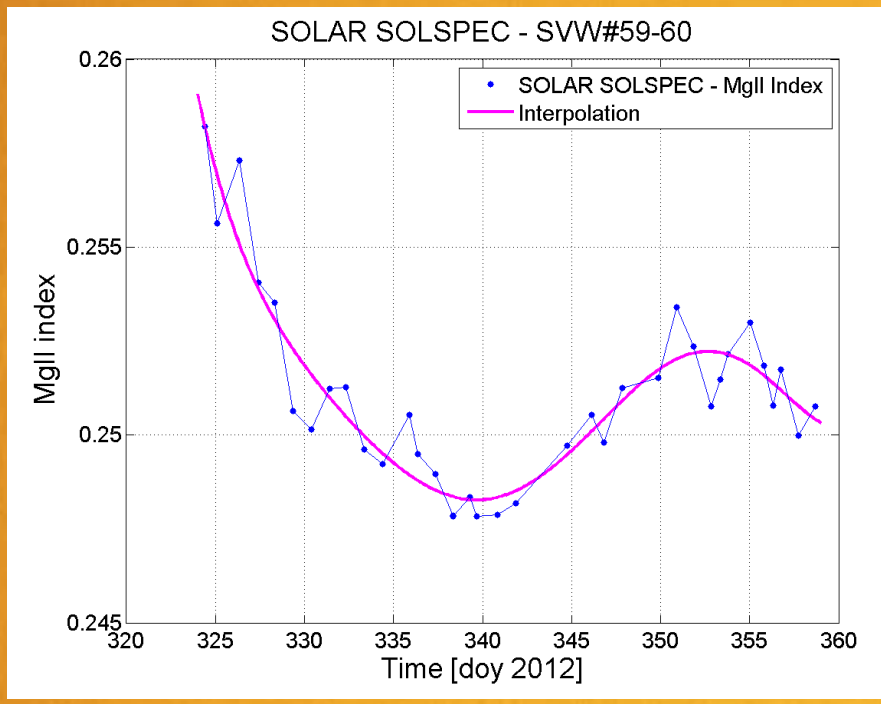


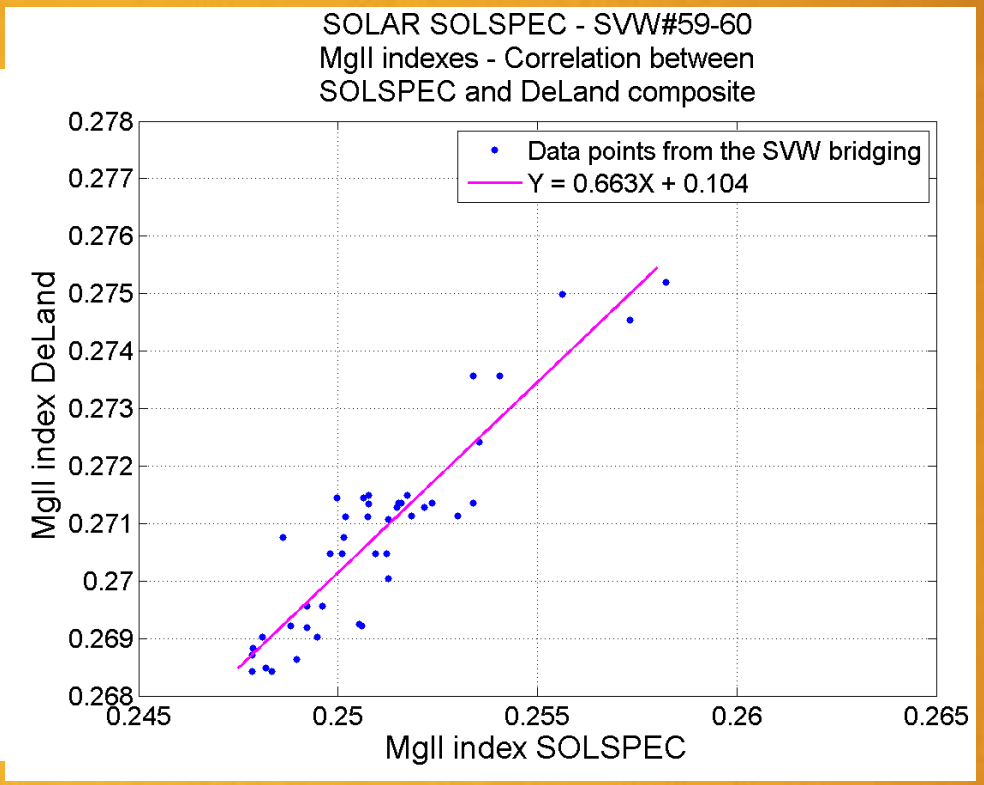
The dotted curves correspond to 10% error bars for both instruments.

Intercomparisons of SOL-ACES and SDO-EVE

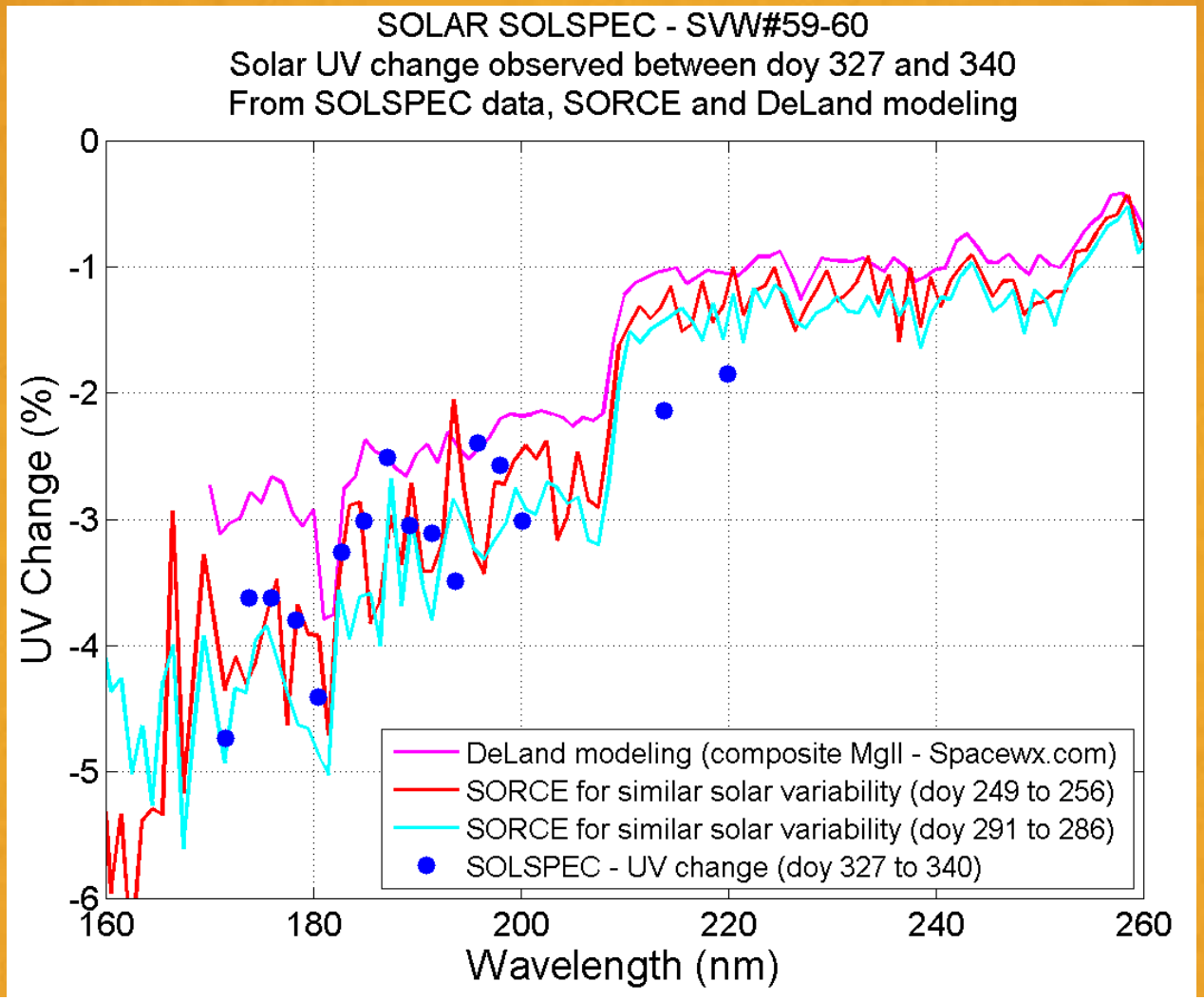


Intercomparisons of DeLand composite Mg II index and SOLSPEC



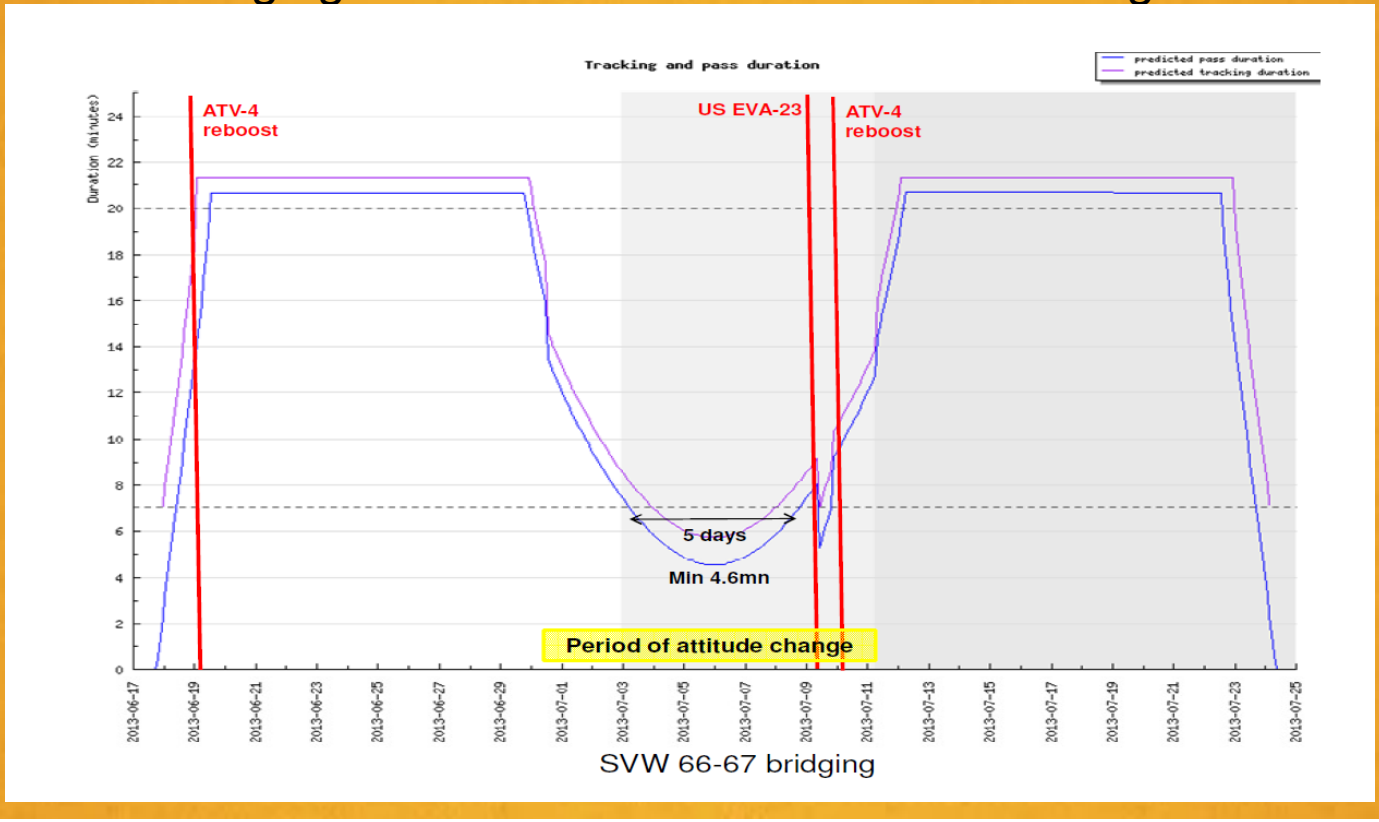


Work still in progress showing the quality of SOLSPEC as a UV short time variation monitor.

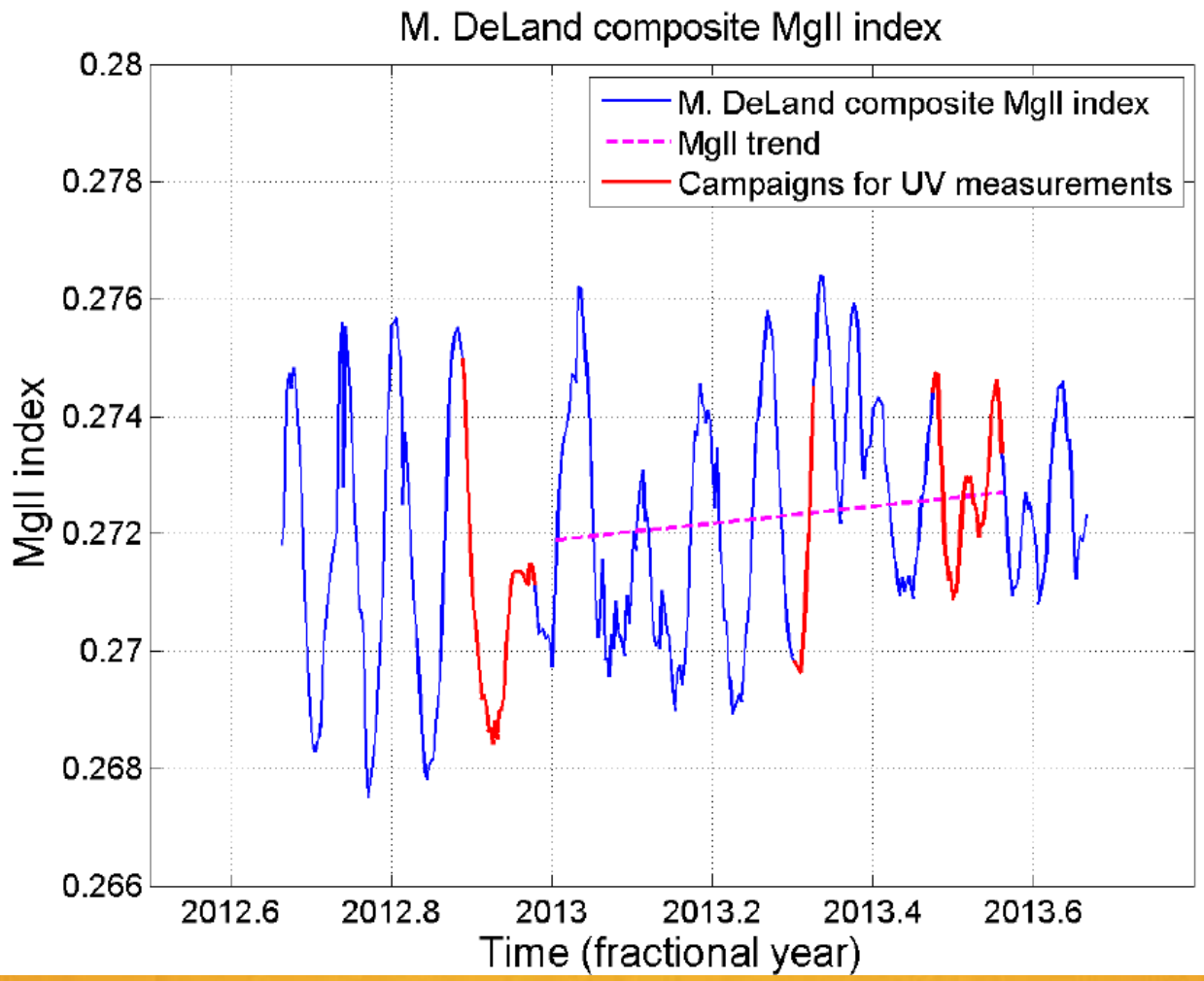


Second Bridging operations

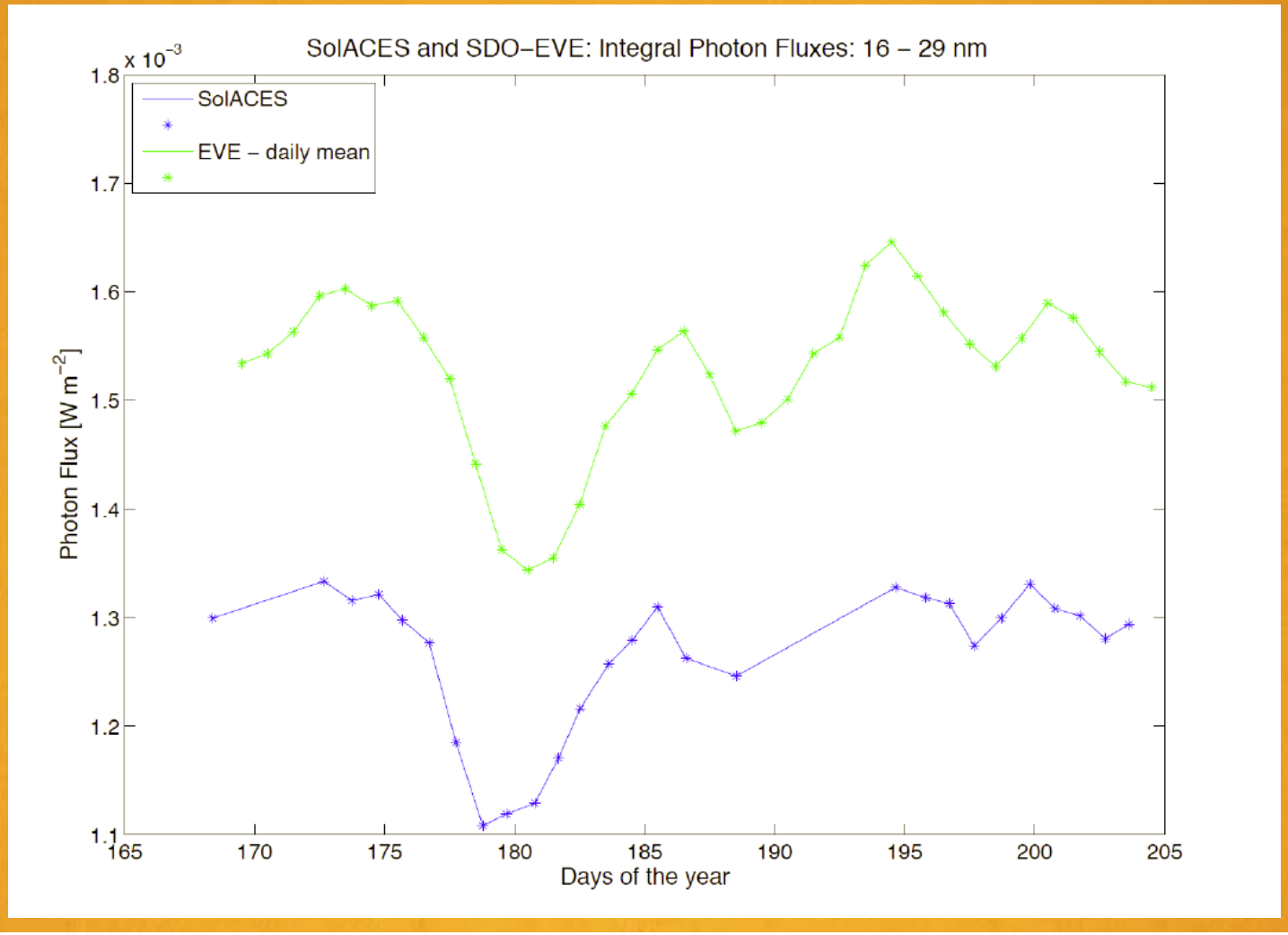
- 17th June to 23rd July 2013. The ISS attitude change was applied from June 30th June to 11th July rotating ISS by 7 degrees. This attitude change allowed the bridging with some limitation in solar tracking duration.



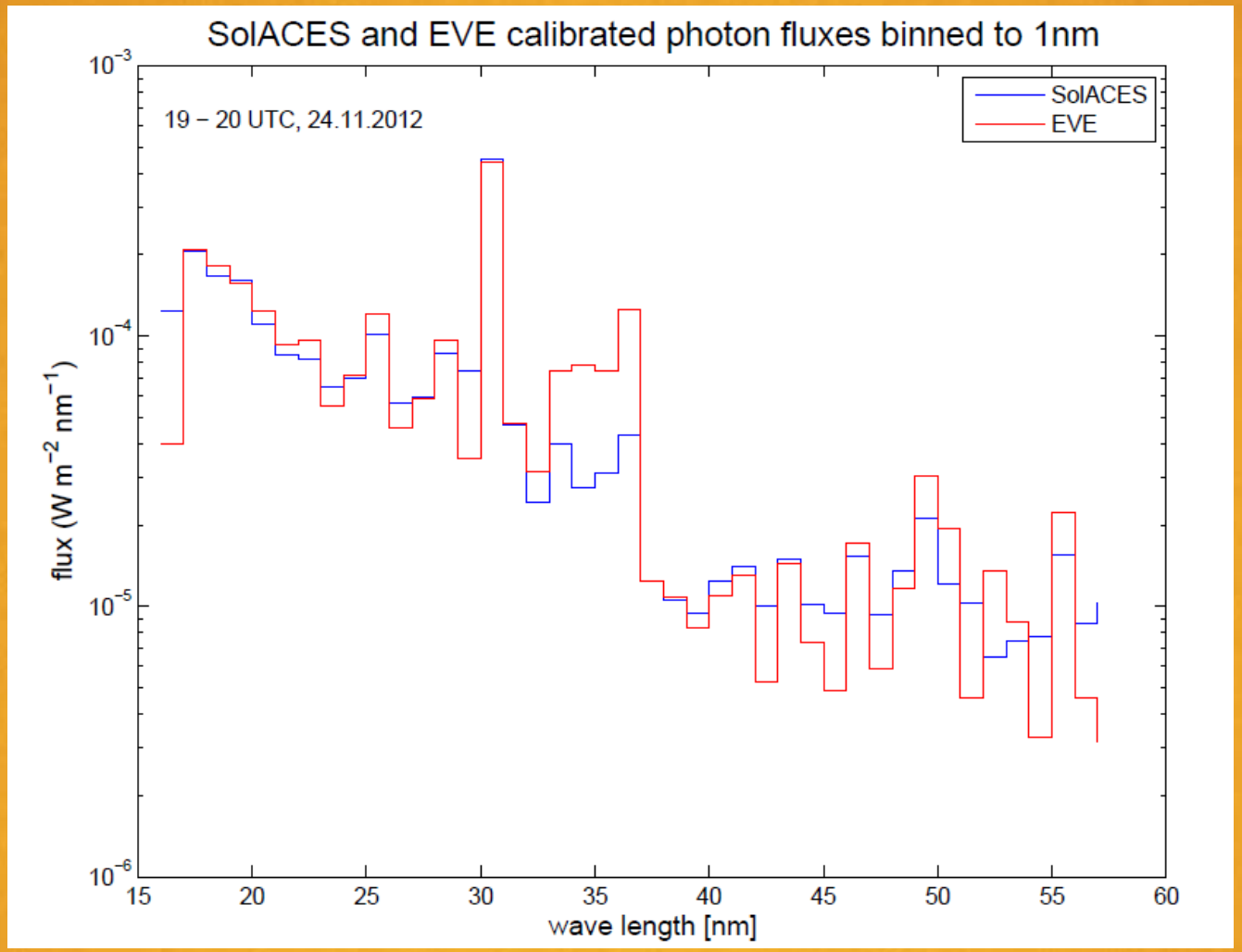
SOLAR activity in 2012 and 2013.



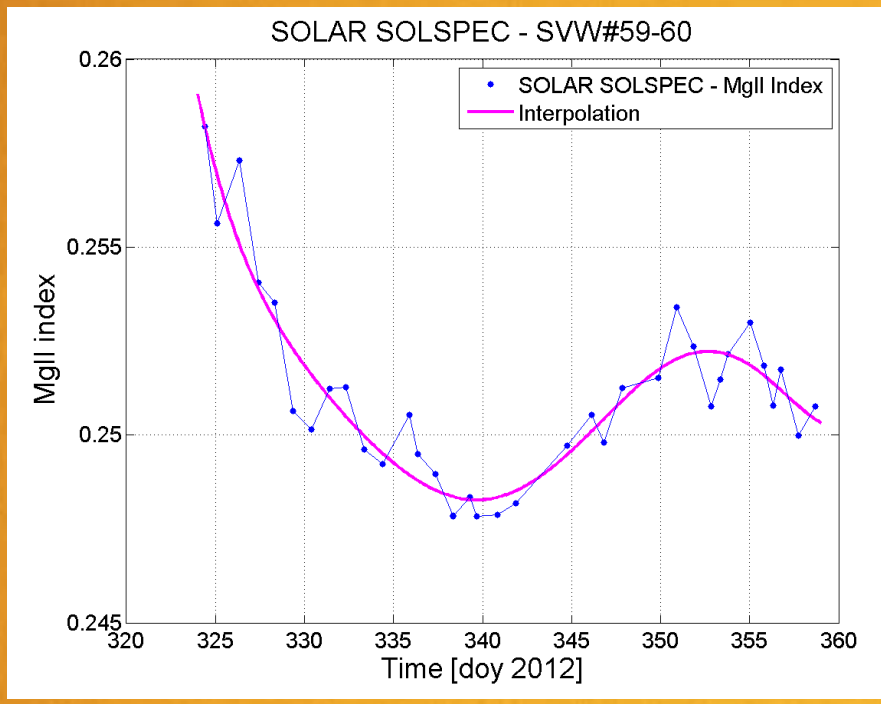
Second bridging: same similarity as during the first bridging.

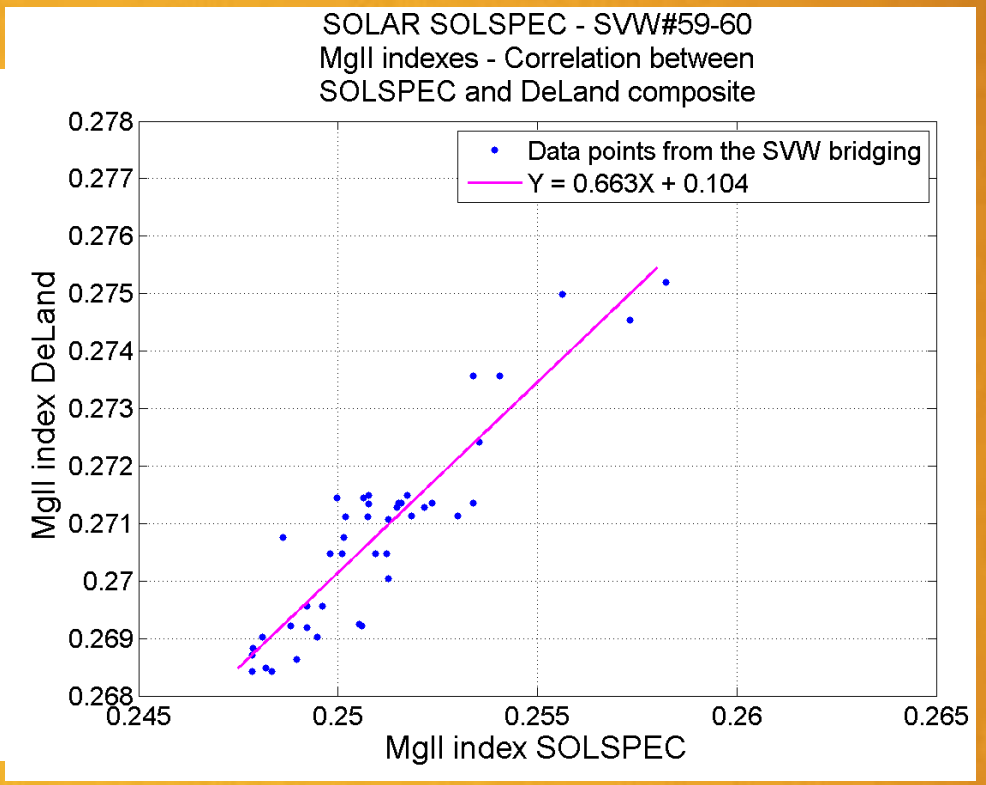


Intercomparisons of SOL-ACES and SDO-EVE



Intercomparisons of DeLand composite Mg II index and SOLSPEC





Conclusions

- The first and second bridgings were a success both in validating SOLAR and in demonstrating its uses as a short term variations monitor.
- SOLAR achieves thus its initial objective: ”The primary objective of the ISS-SOLAR mission on Columbus is the quasi-continuous measurement of the solar irradiance variability with highest possible accuracy.”
- The bridgings reinforce the intercomparisons with other solar monitors and especially confirm the value of the SOLAR series.

Third bridging

- Tracking between November 17, 2013 and December 13, interruption by a failure of one of the ammonia cooling systems of the ISS which limited power use to essential activities until early January.
- The results obtained are however very rich as they provide a full data analysis similar to the one of the two first bridgings.

Bridging 3 conclusions

- The December 13 interruption did not affect the general results of the operations.
- The combination of the three bridgings, SORCE ,SDO instruments and NASA rocket payloads increase the confidence of the entire data set.

General conclusion

- The observation of many solar rotations presenting different level of solar activity is one of the main objectives. When it is combined to the ability of SOLAR to detect the solar UV variability, a better understanding of the role of active regions and their effect on UV irradiance can be achieved.
- The results of all three bridging periods confirm the breakthrough to provide a complete set of solar spectral irradiance EUV data first time. Elaboration of the data set extending the periods from the bridgings back and forth is continuing with respect to time.
- Having in mind that degradation will proceed in all instruments another bridging period is highly desirable to select reliable data sets to improve the accuracy of the data on one side and to fill up the data pool in a way that a full solar cycle will be covered.
- The scientists will produce a reference solar spectral irradiance variability with time as an input to climate model.

Latest news

- **A new bridging is planned for June 2014, it is highly likely as no new operational requirements would inhibit a station tilt during the period (the next ATV arrives now in July 2014).**