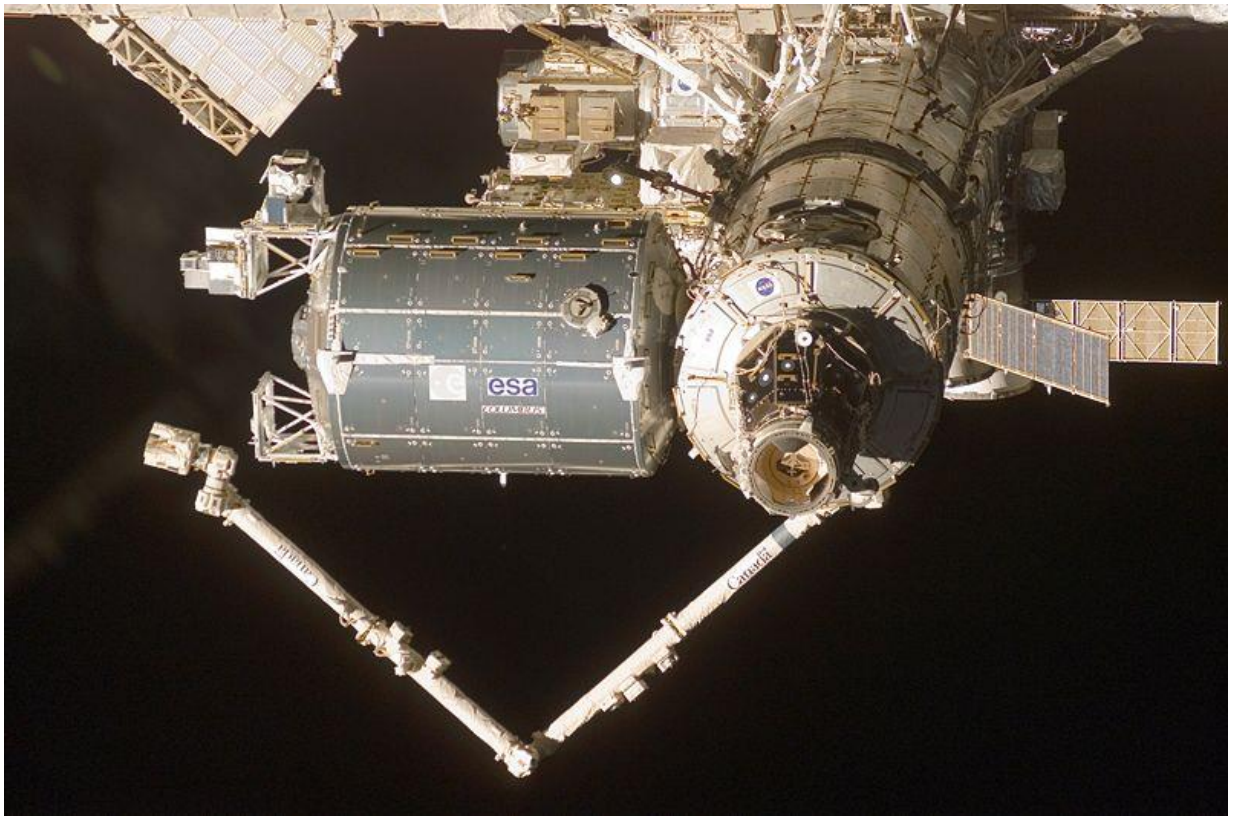
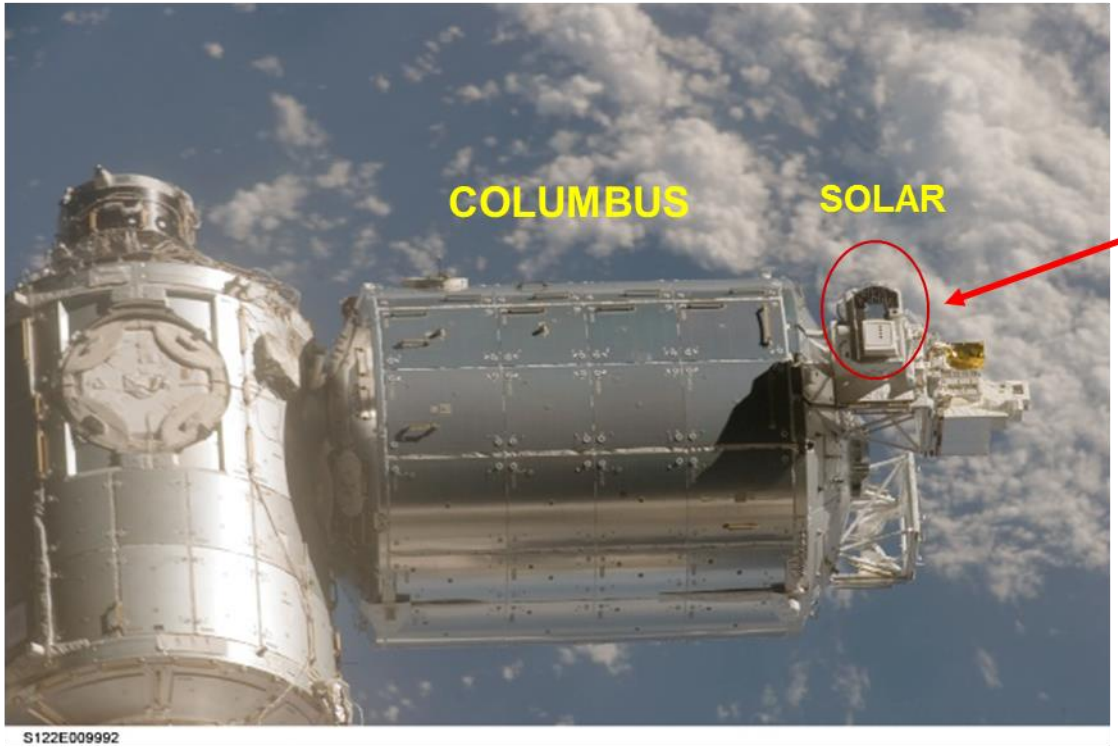
Full solar rotations observed by the SOLAR payload on the ISS in December 2012 and June 2013.

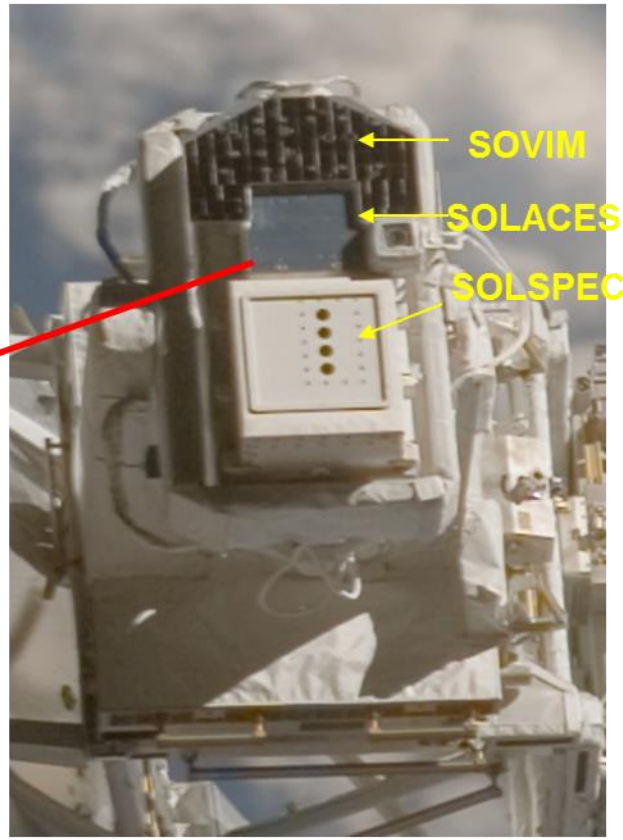


C. Muller and the SOLAR operation and science teams,

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





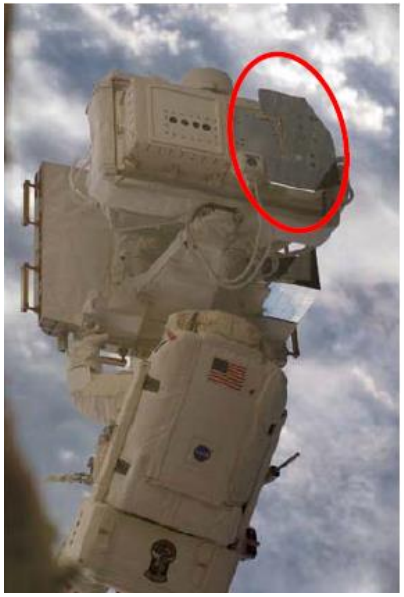
SOLAR was launched in February 2008

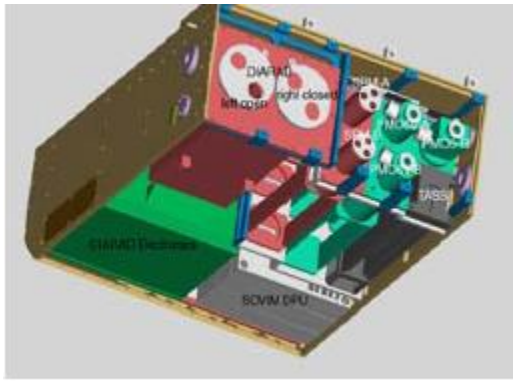
SOLAR instruments: SOVIM

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

pmod wrc

RMI





SOLAR instruments: SOLSPEC

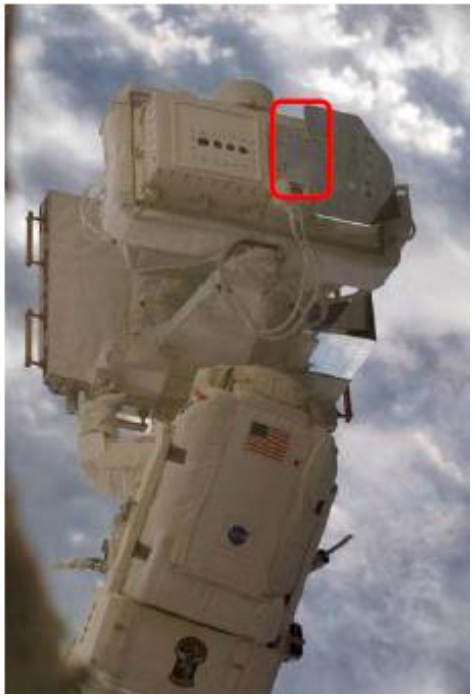
- Measure the solar spectrum irradiance from 180 nm to 3000 nm
- Precision measurement of irradiance variability
- Study of solar variability at short and long term
- Absolute measurements (2% in UV and 1% above)

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)

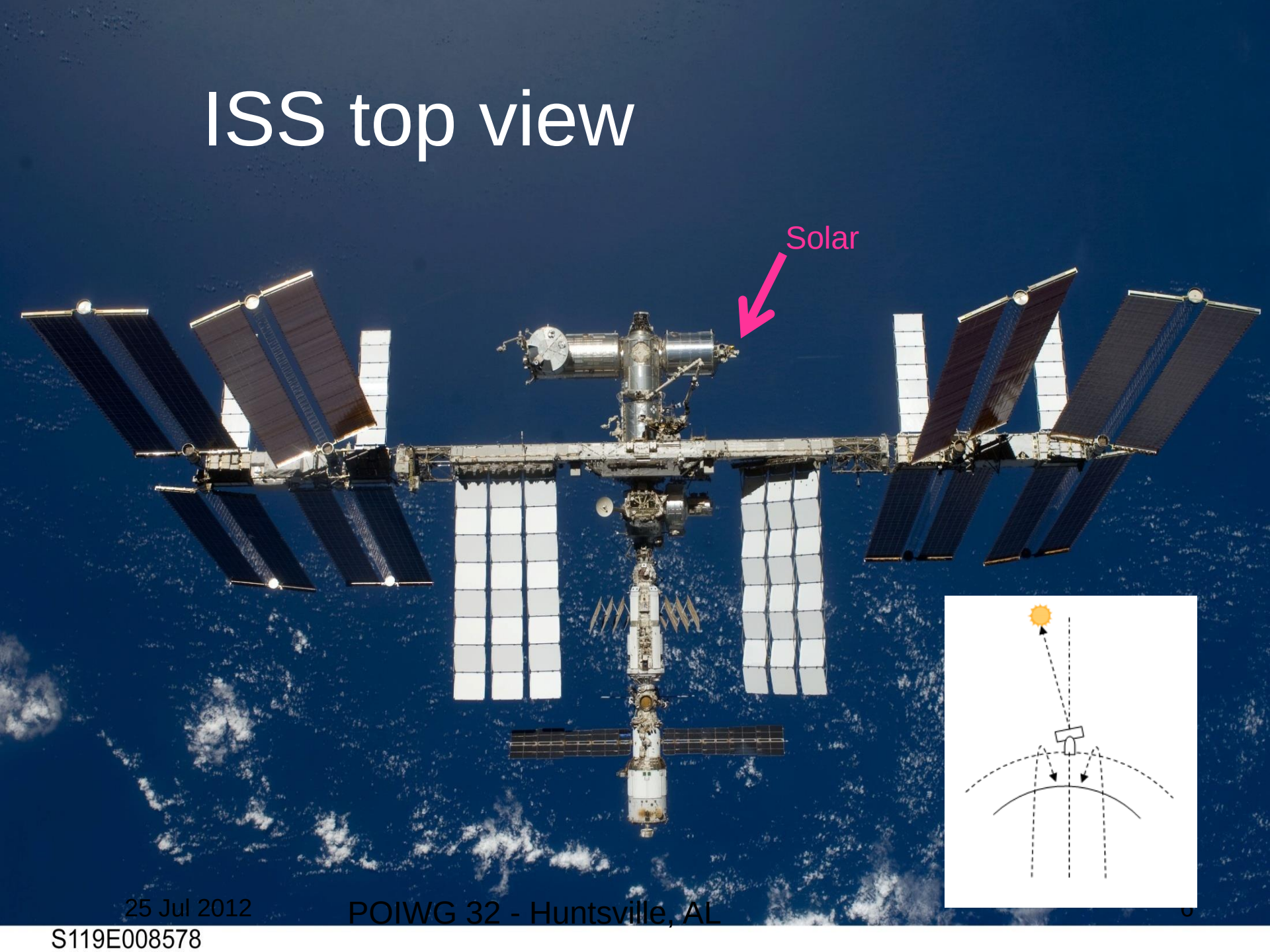
- Auto-calibration capability: high absolute resolution

- Absolute calibration with ionization chambers as secondary instruments



Fraunhofer IPM

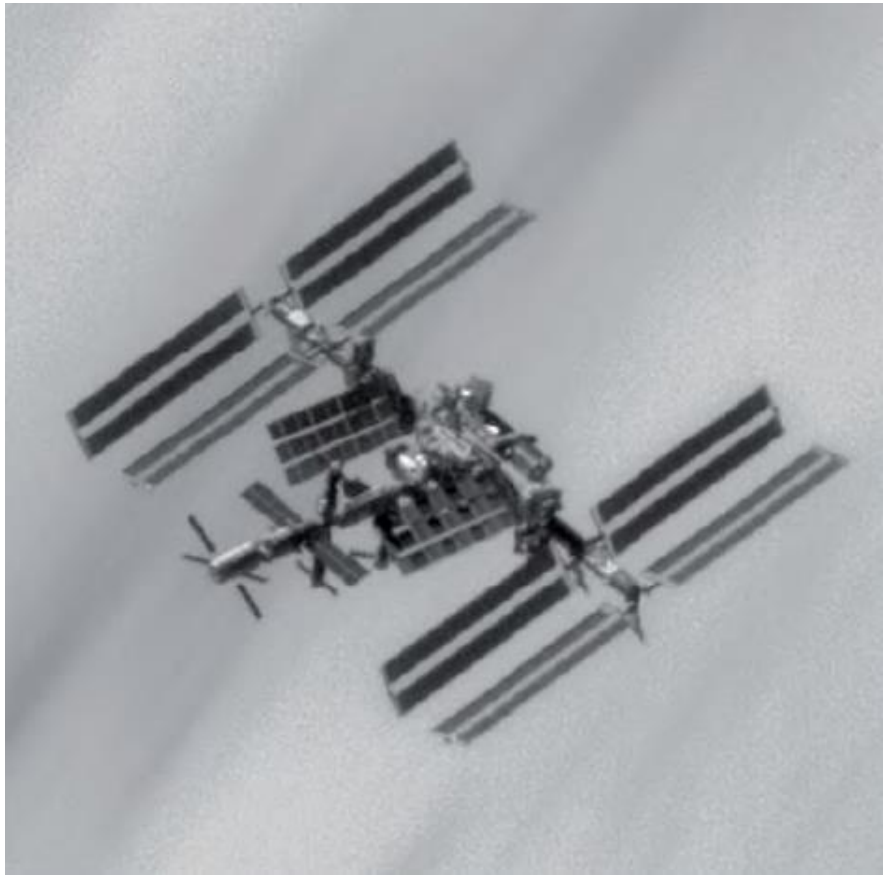
ISS top view



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

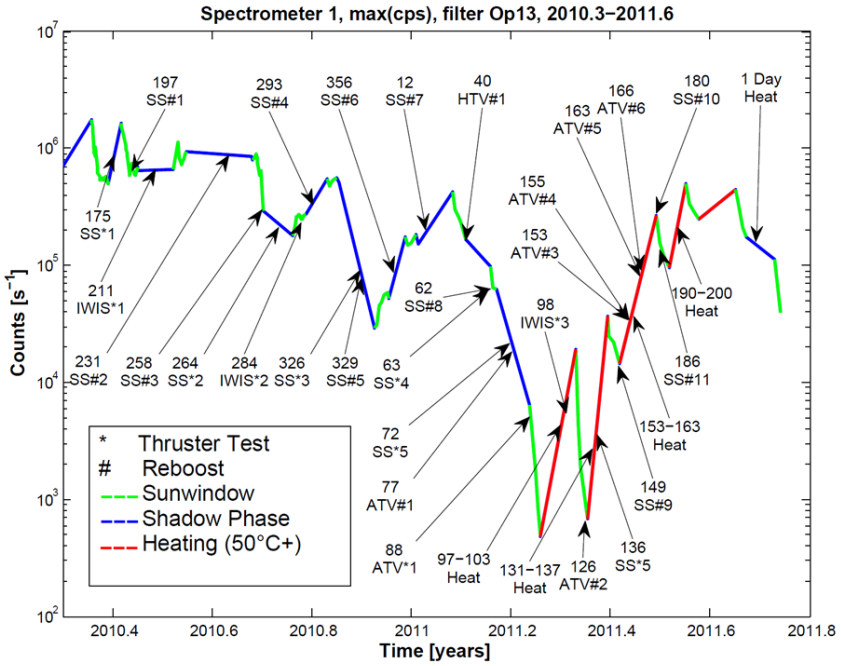


ISS seen from the CNES-EU pléiades satellite

- 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 bridging of two periods in December 2012, June 2013 and December 2013.
- Chemical propulsion, vehicle activities and space weather limit also the use of the payload.

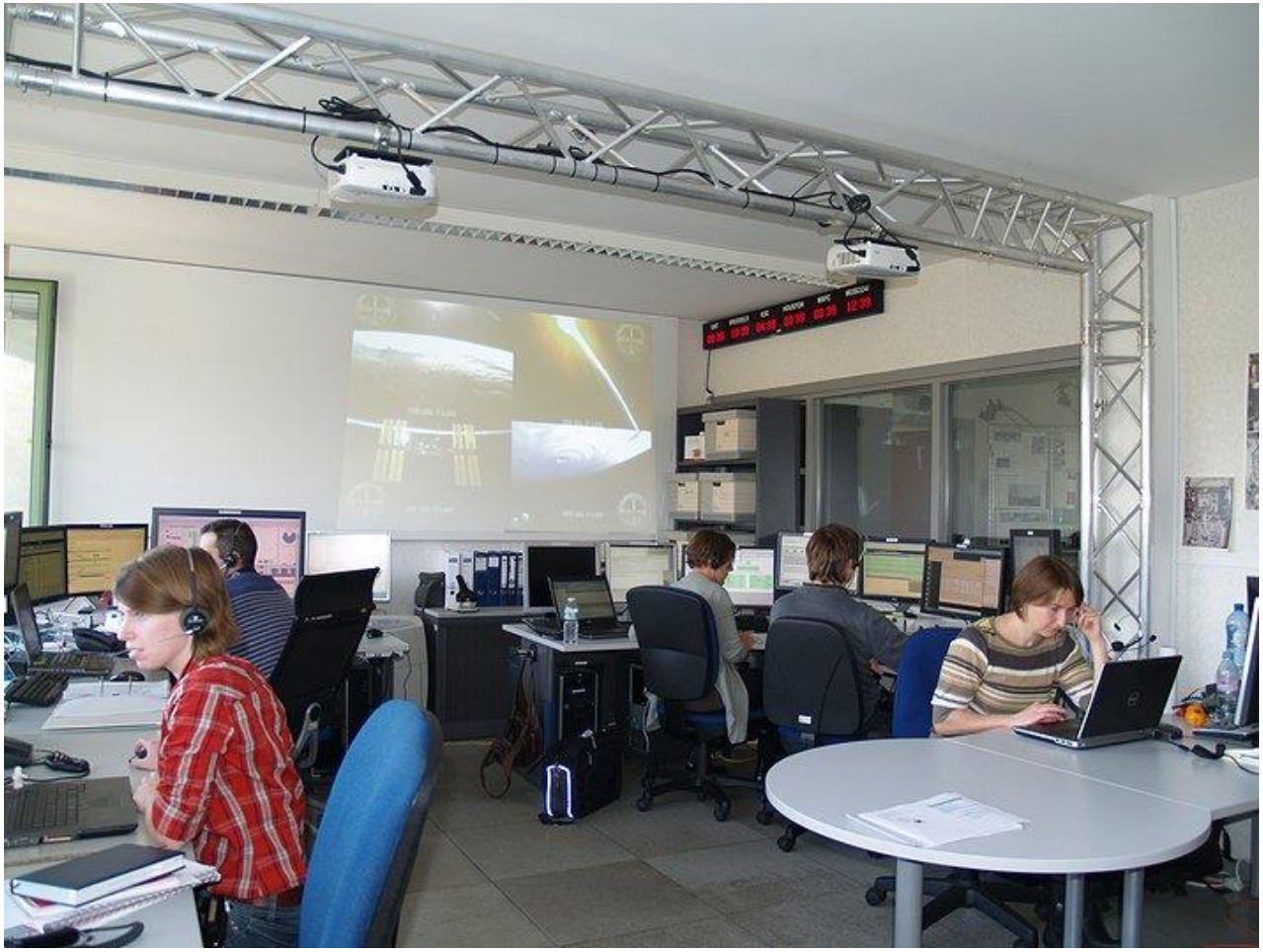
ISS related problems and mitigation

- 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, its complexity can also lead to unexpected interruptions of operations.

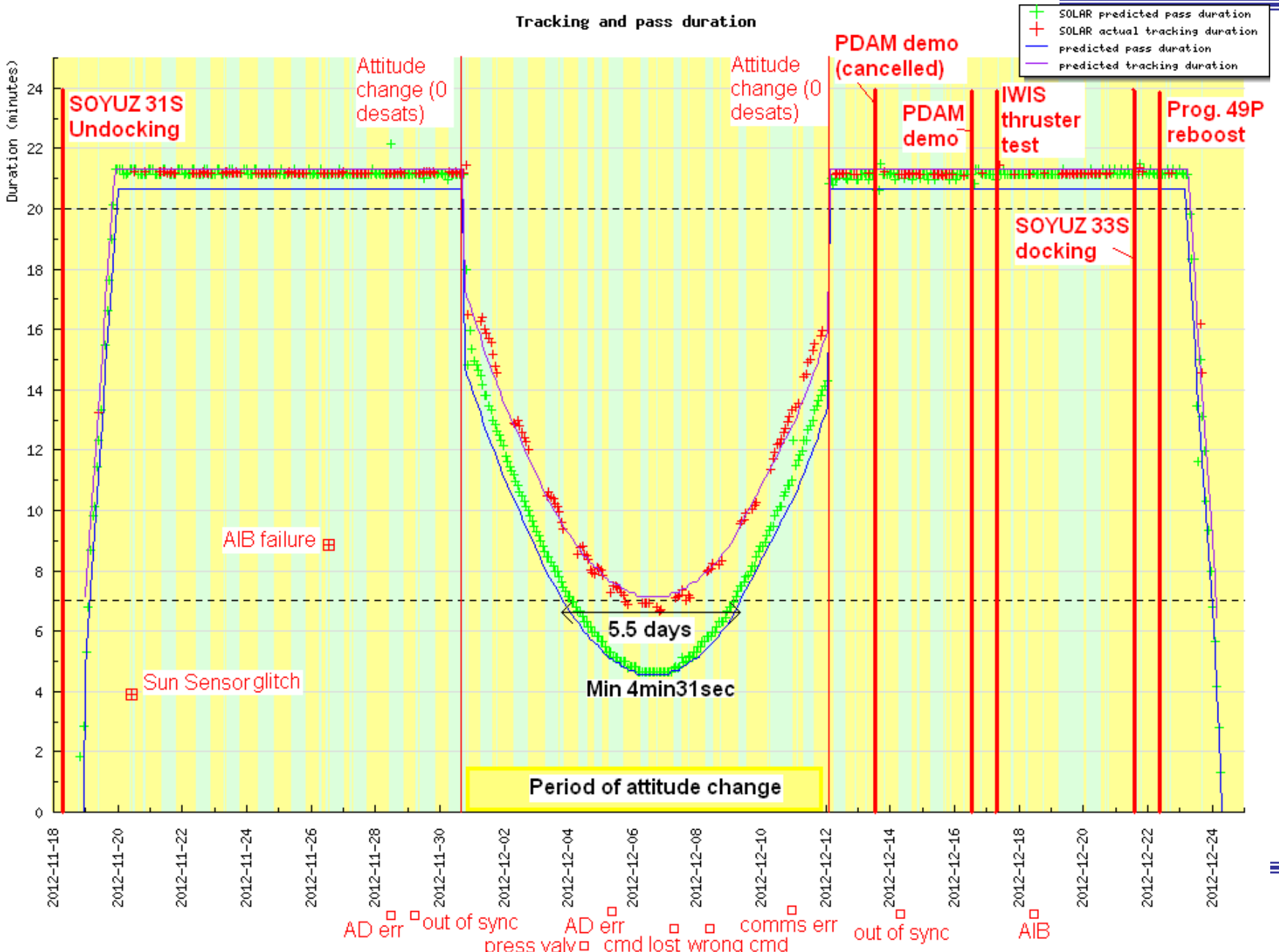


Despite these interruptions, the ISS has still invaluable value for the monitoring of solar climate.

The BUSOC operation room during SOLAR operations.

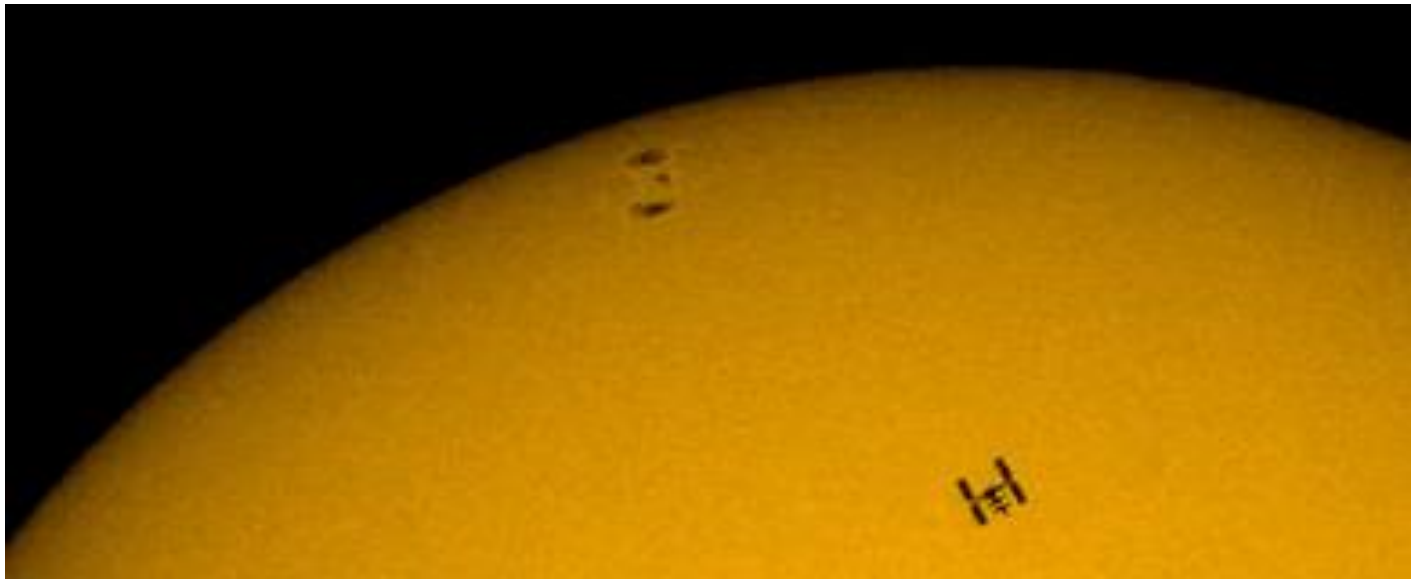


Schematics of the bridging



First Bridging operations

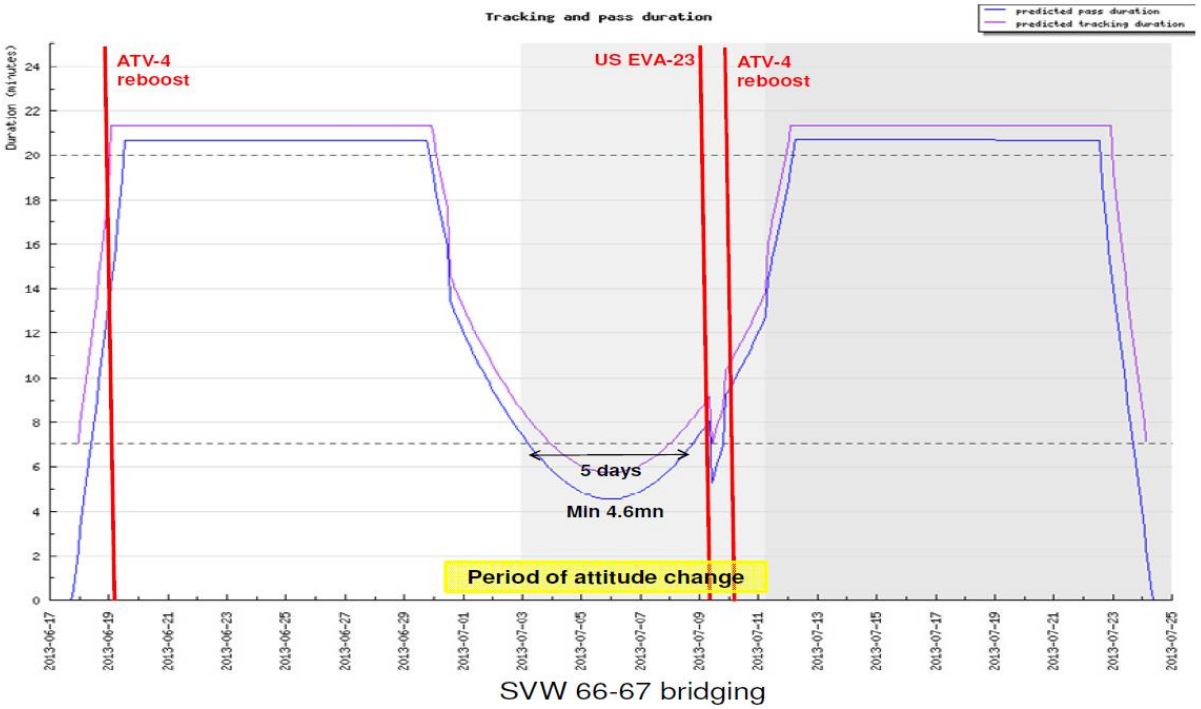
- The bridging attitude correction was applied between December 1 and December 11, 2012, allowing observations from November 22 to December 24.
- Both SOLACES and SOLSPEC regularly recorded data.



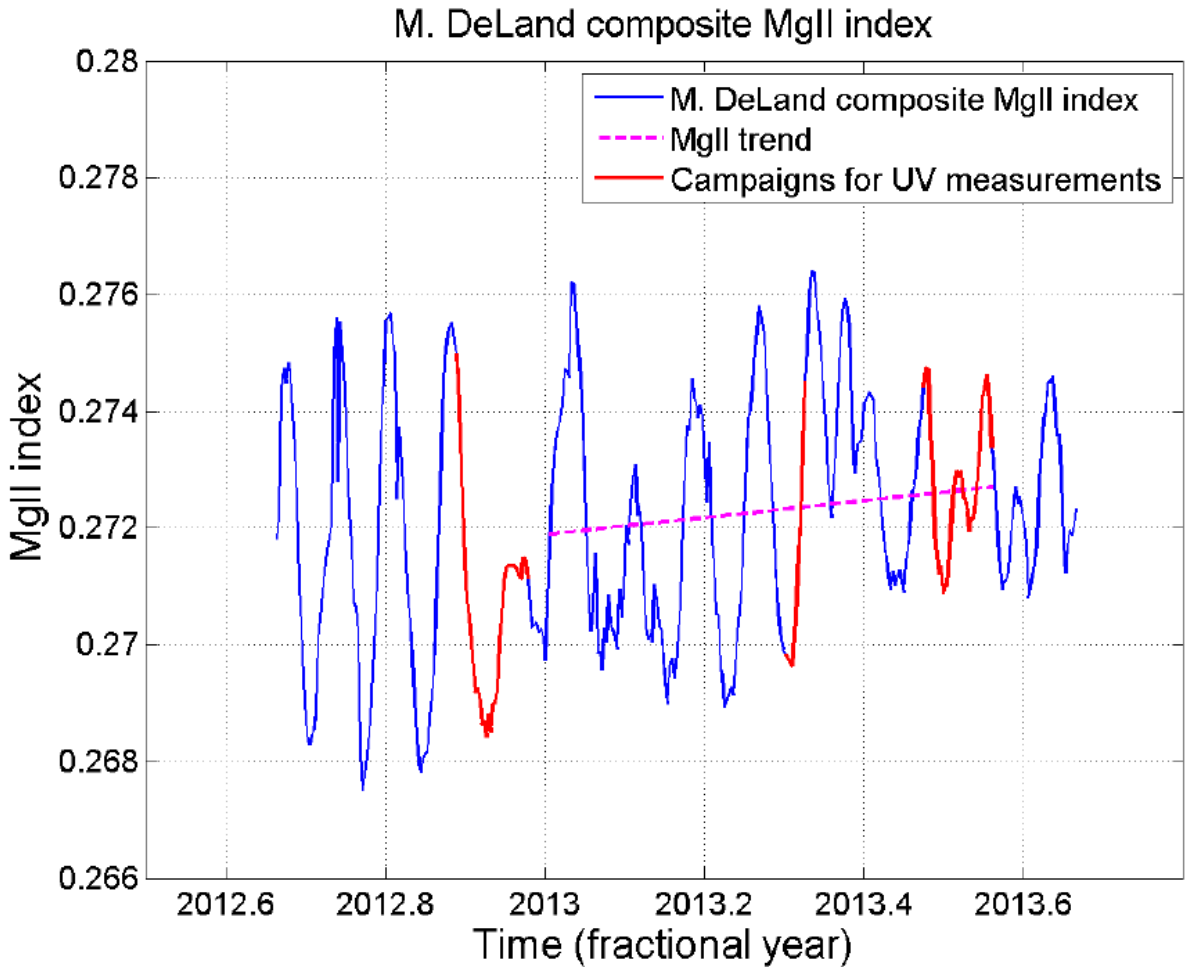
ISS and sunspot group 664 (photograph by Jerry Lodriguss in 2007).

Second Bridging operations

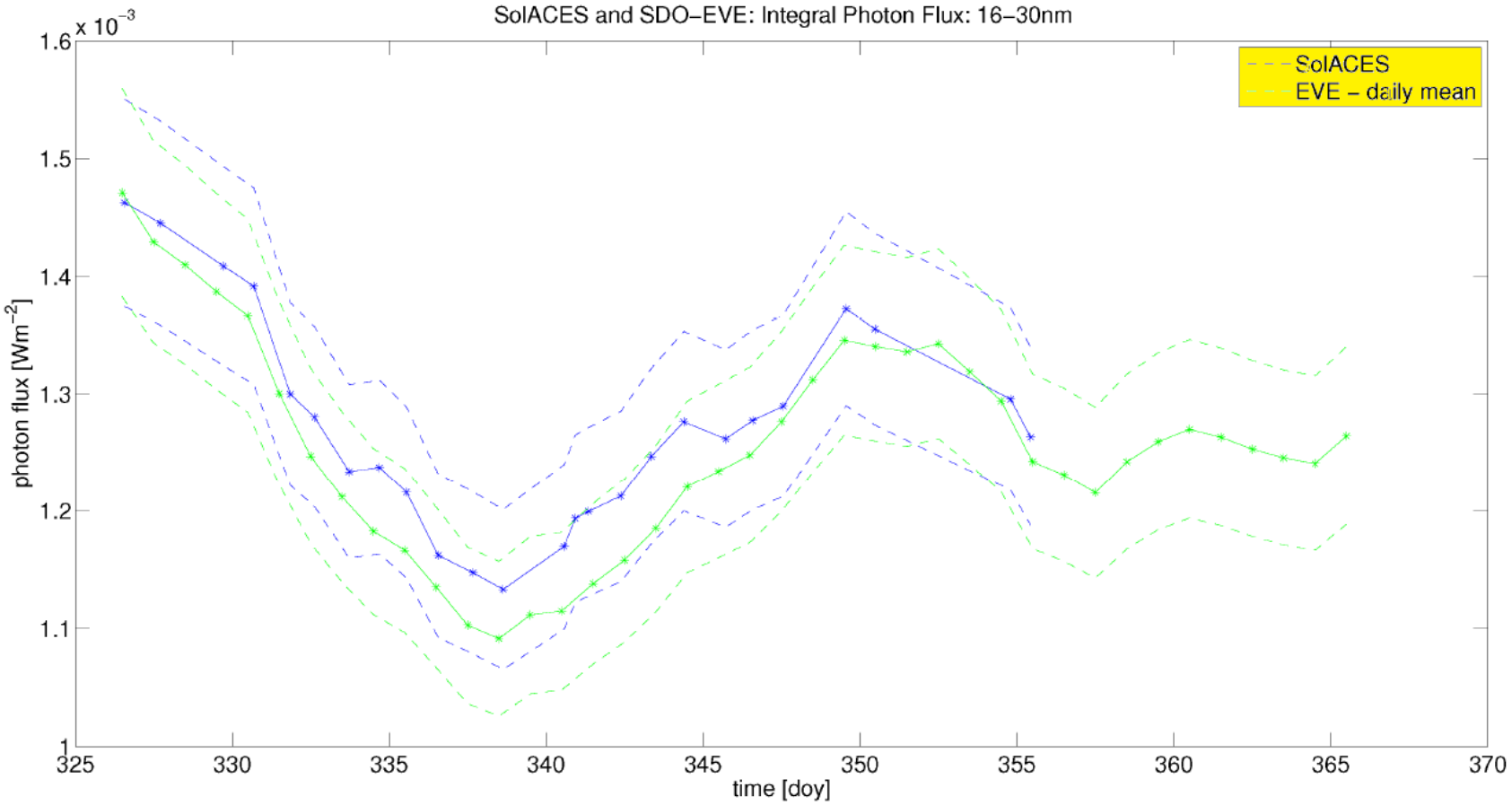
- 17th June to 23rd July 2013. The ISS attitude change was applied from June 30th June to 11th July rotating ISS by 7 degrees. This attitude change allowed the bridging with some limitation in solar tracking duration.



SOLAR activity in 2012 and 2013.

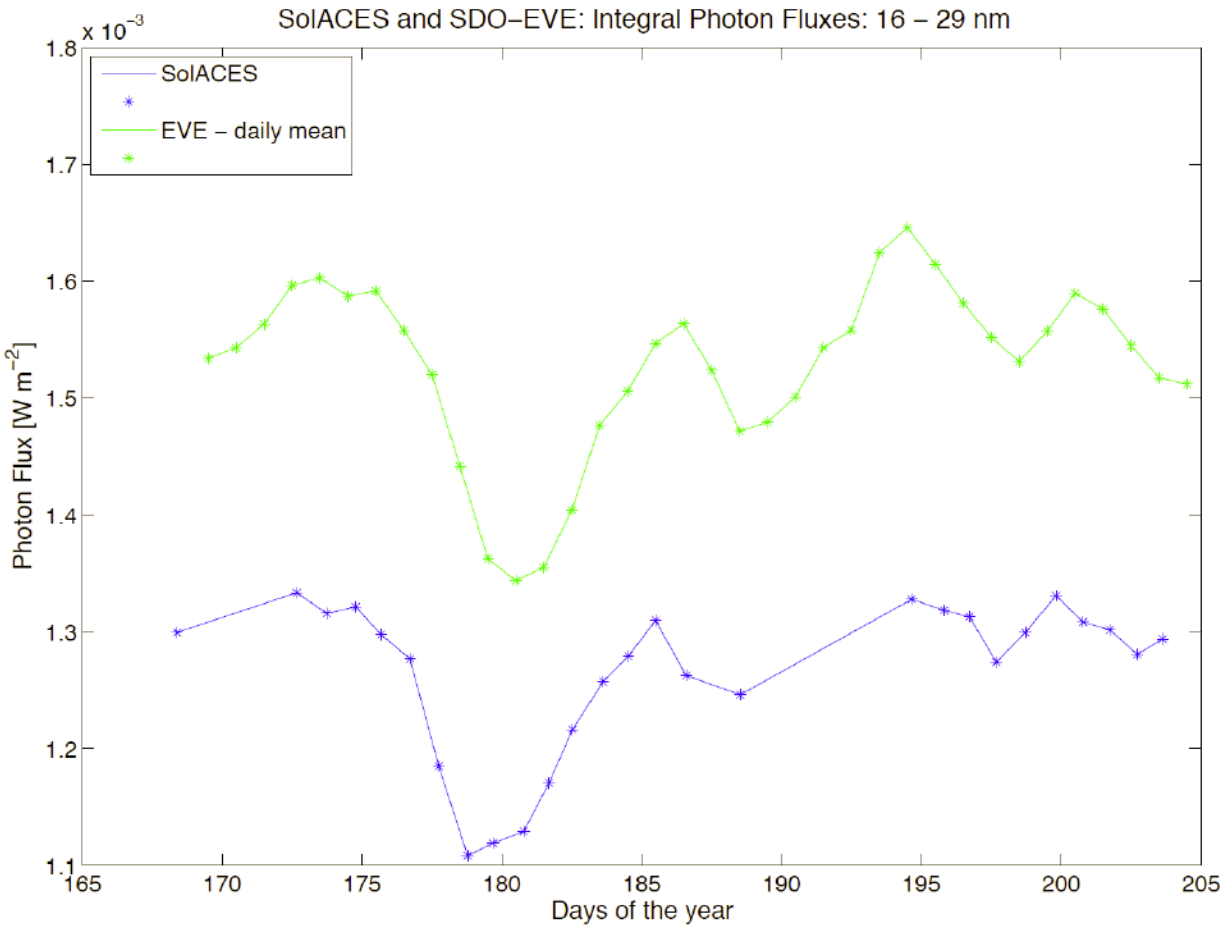


Intercomparisons of SOL-ACES and SDO-EVE

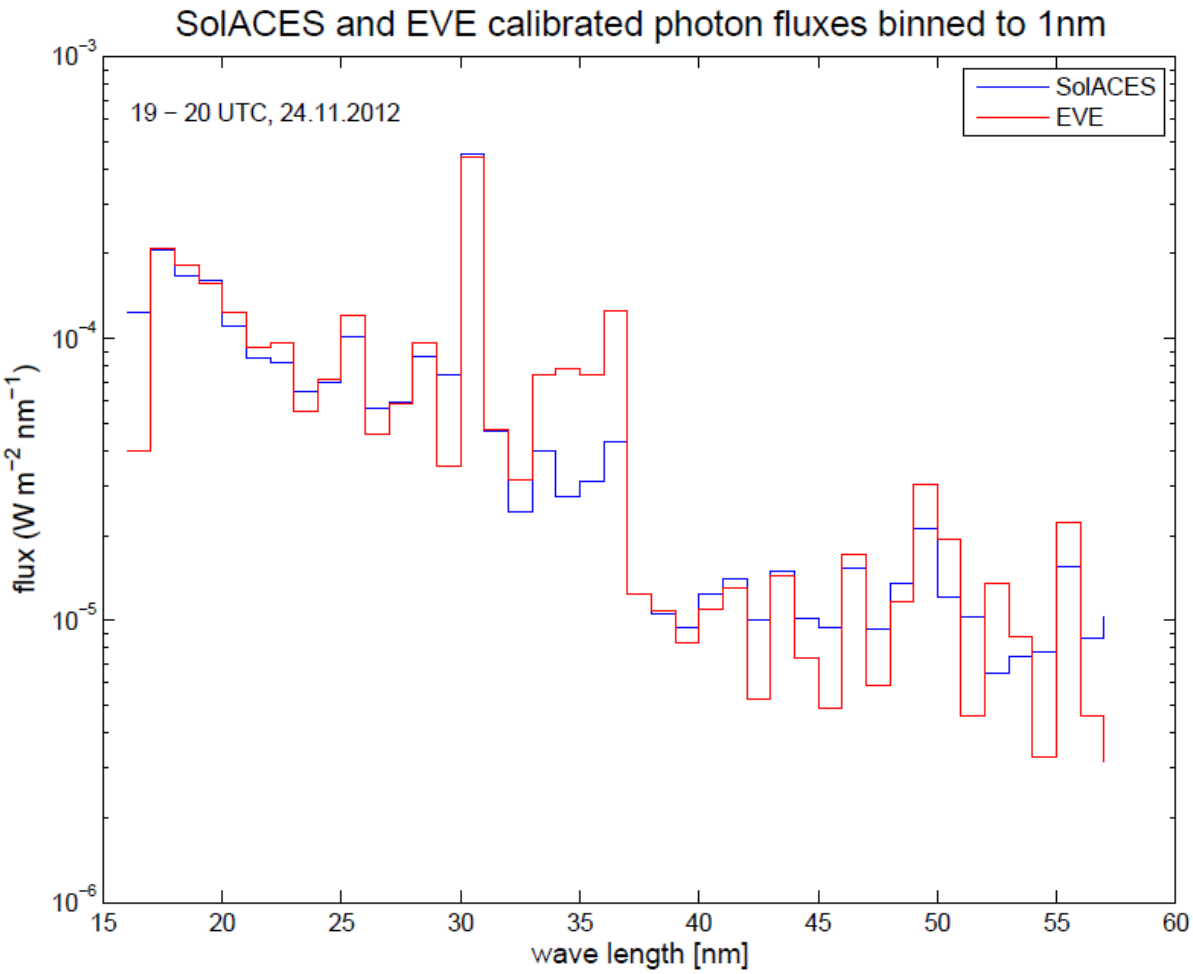


The dotted curves correspond to 10% error bars for both instruments.

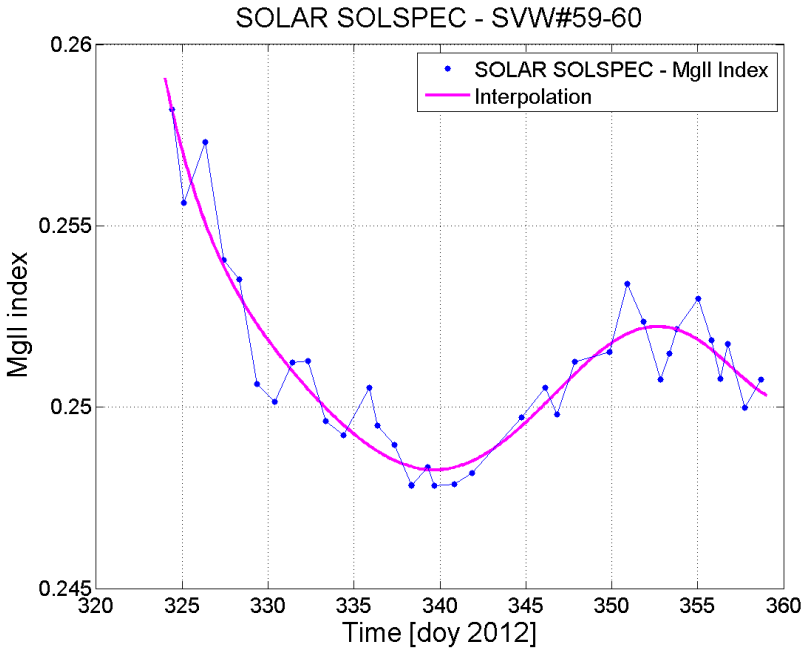
Second bridging: same similarity.

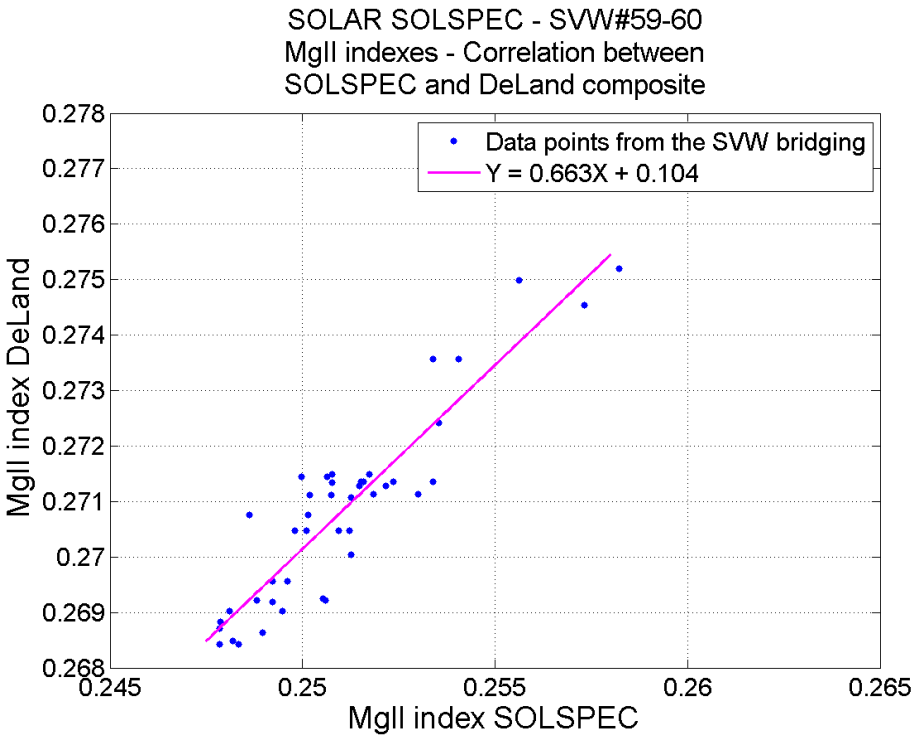


Intercomparisons of SOL-ACES and SDO-EVE

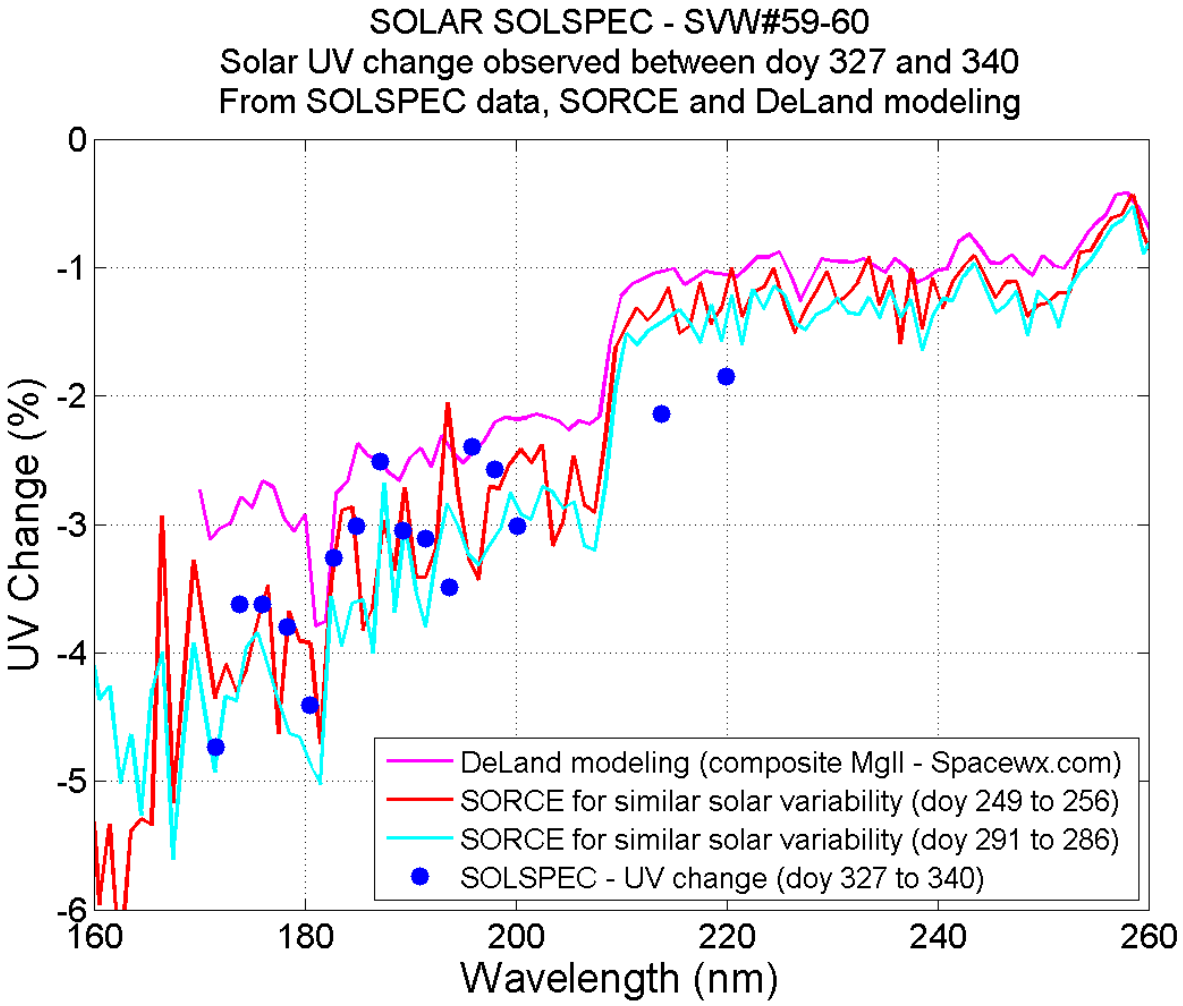


Intercomparisons of DeLand composite Mg II index and SOLSPEC





SOLSPEC as a UV short time variation monitor.



Conclusions of the current operations.

- Both 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 bridging reinforces the intercomparisons with other solar monitors.
- The operations of the third bridging were interrupted by a power reduction of the ISS after 25 days.
- Follow up: SOLAR operations are extended now up to 2017, the operation team introduces a request to the agencies for new bridgings and a successor instrument on the ISS is under study.

Data future in Europe.

- Data preservation and reuse is a priority of the frame work programme of the E.U.: the PERICLES programme has taken SOLAR as one of its space case studies.
- The E.U. SOLID intends to consolidate the science series of solar observations.
- The ESAC space science centre (ESA) plans to use SOLAR data in a virtual solar observatory, ESA has taken also formal steps towards LTDP (Long Term Data Preservation).