
SolACES

Solar Auto-Calibrating EUV / UV spectrophotometers
on the International Space Station



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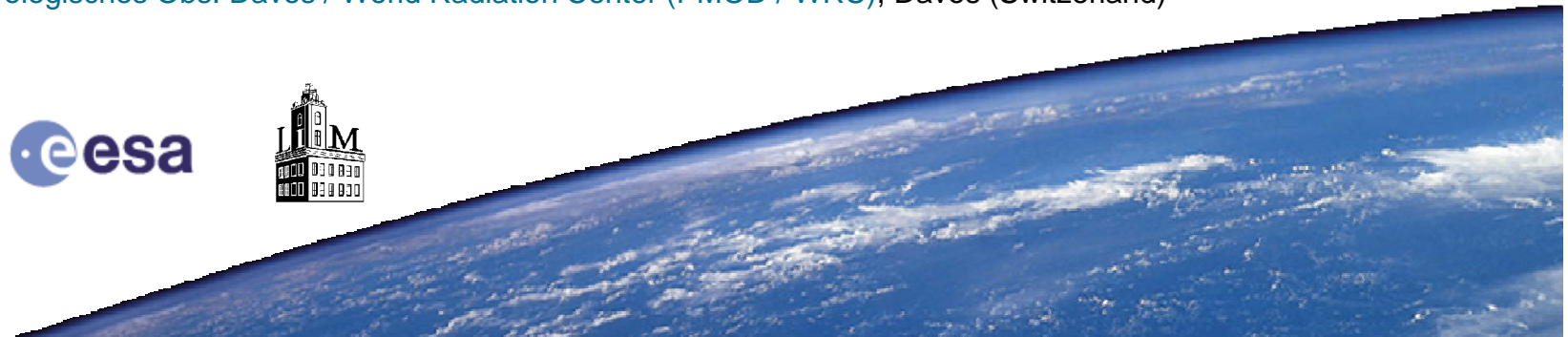
[Space Environment Technologies](#), Los Angeles, CA (USA)

[Laboratory for Atmospheric and Space Physics \(LASP\)](#), Boulder, CO (USA)

[Space Science Center \(SSC\) of the University of Southern California](#), Los Angeles, CA (USA)

[LATMOS-CNRS](#), F-78280 Guyancourt, (France)

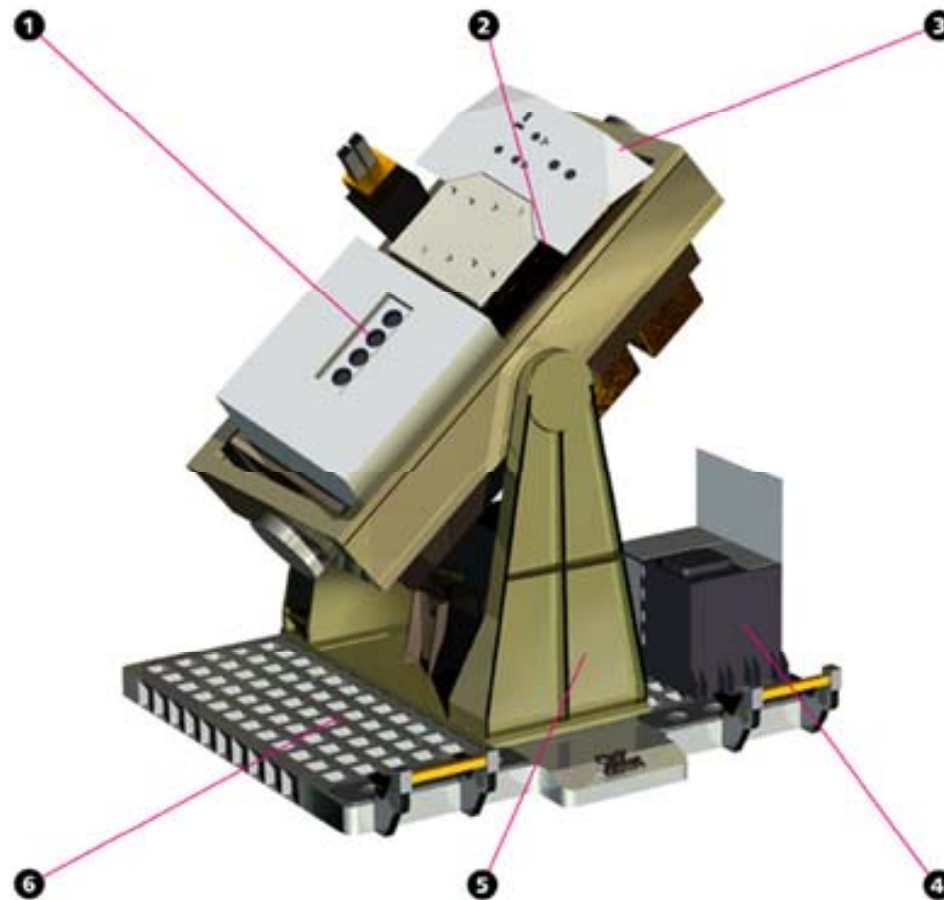
[Phys.-Meteorologisches Obs. Davos / World Radiation Center \(PMOD / WRC\)](#), Davos (Switzerland)



Overview

- Background and scientific objectives
- SolACES instrument, subsystems
- Current operation
- Future activities

SolACES on SOLAR Payload



1-SOLSPEC (F, SOLar SPECTral irradiance)
instrument for solar observations
between 160 and 3000 nm with high
spectral resolution

**2-SOLACES (D, SOLar Auto- Calibration
EUV/UV Spectrometer)** measures the
EUV/UV spectral regime (17 nm -220 nm)
with moderate spectral resolution – new
development.

**3-SOVIM (CH, SOLar Variability and
Irradiance Monitor)** covers near UV,
visible and thermal regimes (200 nm –
100 μ m)

4-Control Unit to control the instruments
and Coarse Pointing Device

5-Coarse Pointing Device (CPD) for
accurate Sun pointing

6-Express Pallet Adapter for mounting of
payload

Scientific goals of SOLAR mission

In the field of terrestrial climatology:

quasi-continuous measurement of the solar irradiance with highest possible accuracy ($< 10\%$, 17 - 150 nm). The irradiance data will be provided for the investigation of the impact of the solar irradiance variability on the Earth's climate changes.

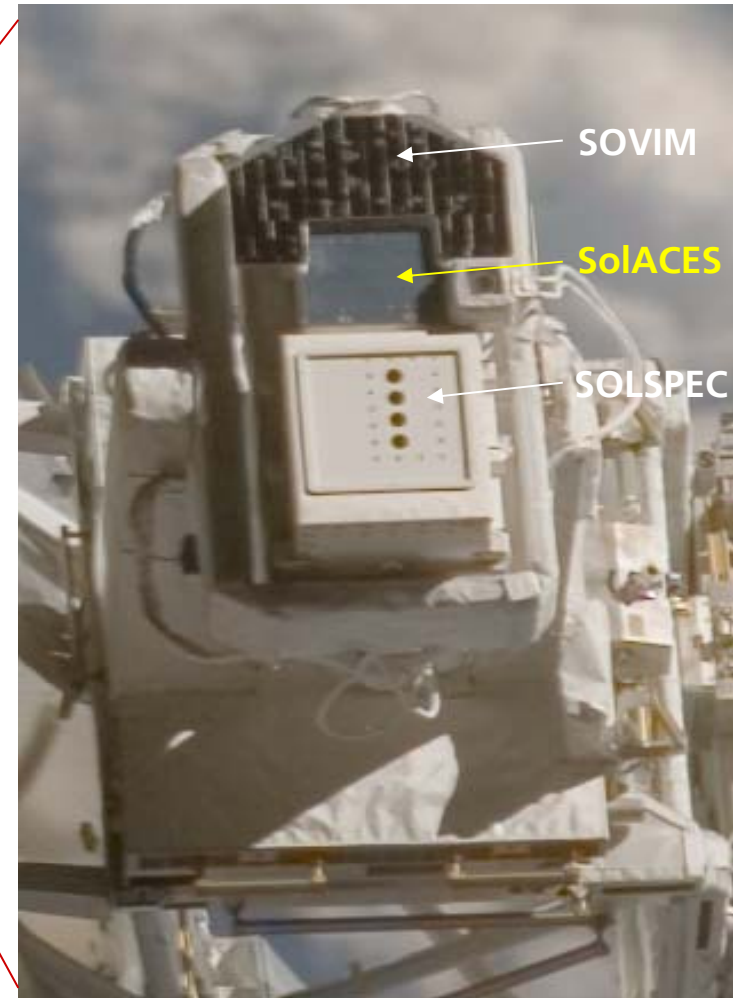
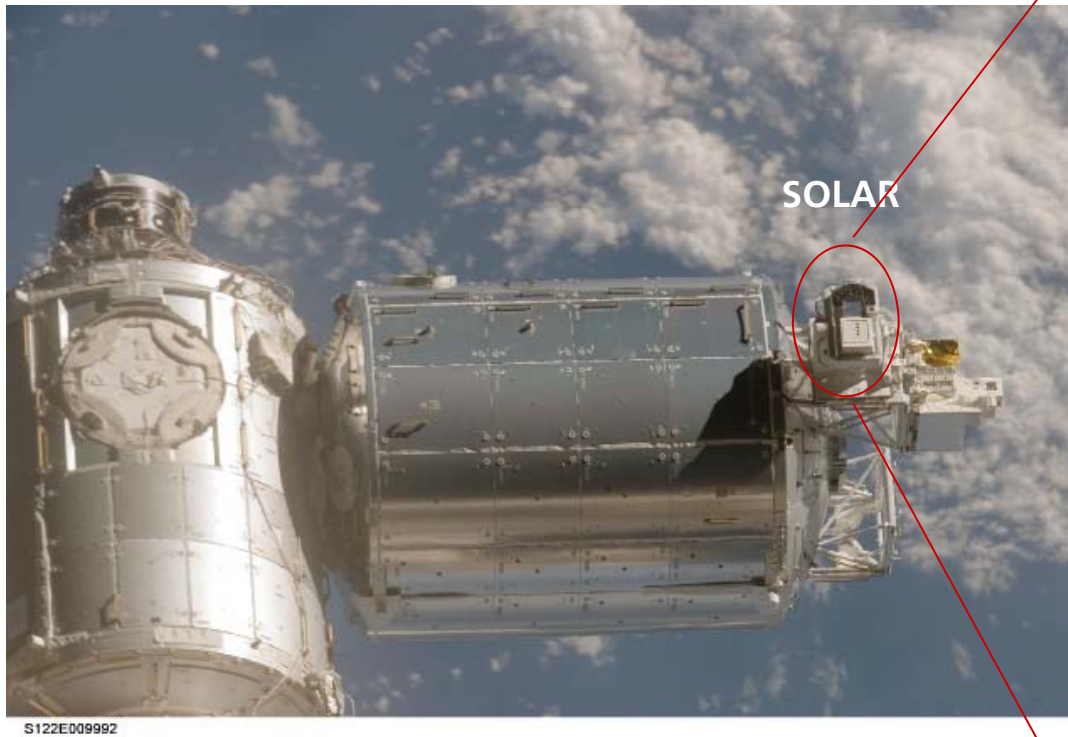
In the field of atmospheric physics:

more accurate solar spectral irradiance data will support the further modelling of the altitude regions from ground to the exosphere with the numerous physical and chemical processes involved.

In addition to the climatic aspects SolACES data will contribute to the

- derivation of EUV/UV indices,
- semi-empirical modelling of active regions of the sun,
- investigation of solar-terrestrial relations (earth altitude region 80 to 1000 km),
- improvement of EUV/UV space instrumentation and its calibration.

Space View to COLUMBUS/SOLAR



Mission & Instrument Characteristics



Mission Characteristics:

- Instrument launched in February 2008
- Launcher: Space Shuttle STS 122 (NASA)
- Mission duration: 18 / 40 months → **End 2013**
- Orbit characteristics: ISS orbit (altitude < 400 km)
- Observation schedule: max. 20 minutes per orbit

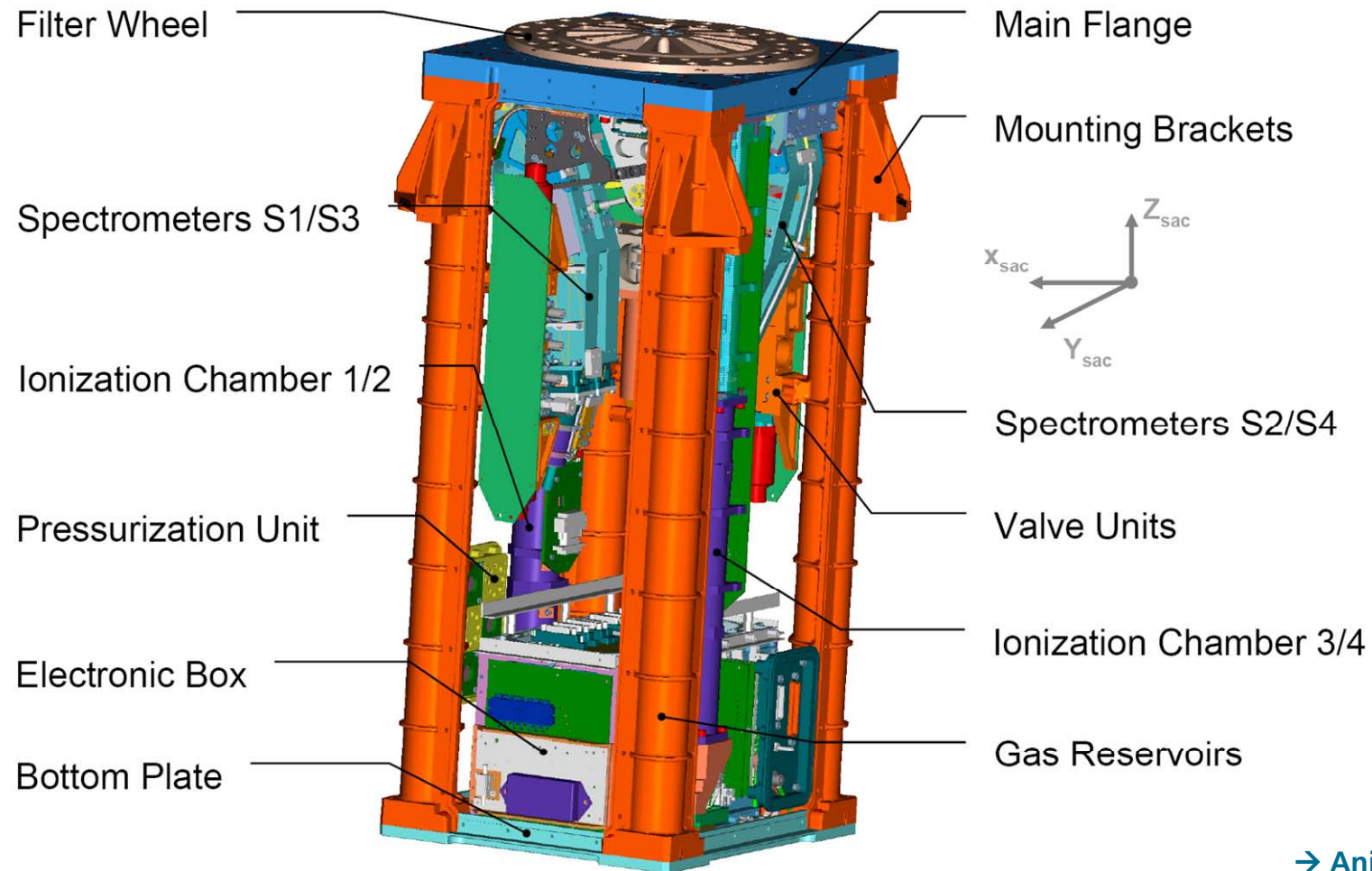
Instrument Characteristics:

- **Three spectrometers:** 17...150 nm (EUV)
- **Two double ionization chambers**
with gases Ne, Xe, Xe/NO
- Mass: 23.0 kg , Size: 25 x 29 x 60 cm³
- Power consumption: typ.< 25 W / max. 60 W
- Data rate: ~1.0 kbit/s
- Spectral resolution: 0.3...2 nm
- Radiometric accuracy: < 10% (goal: < 3...5 %)



SolACES
Proto Flight Model

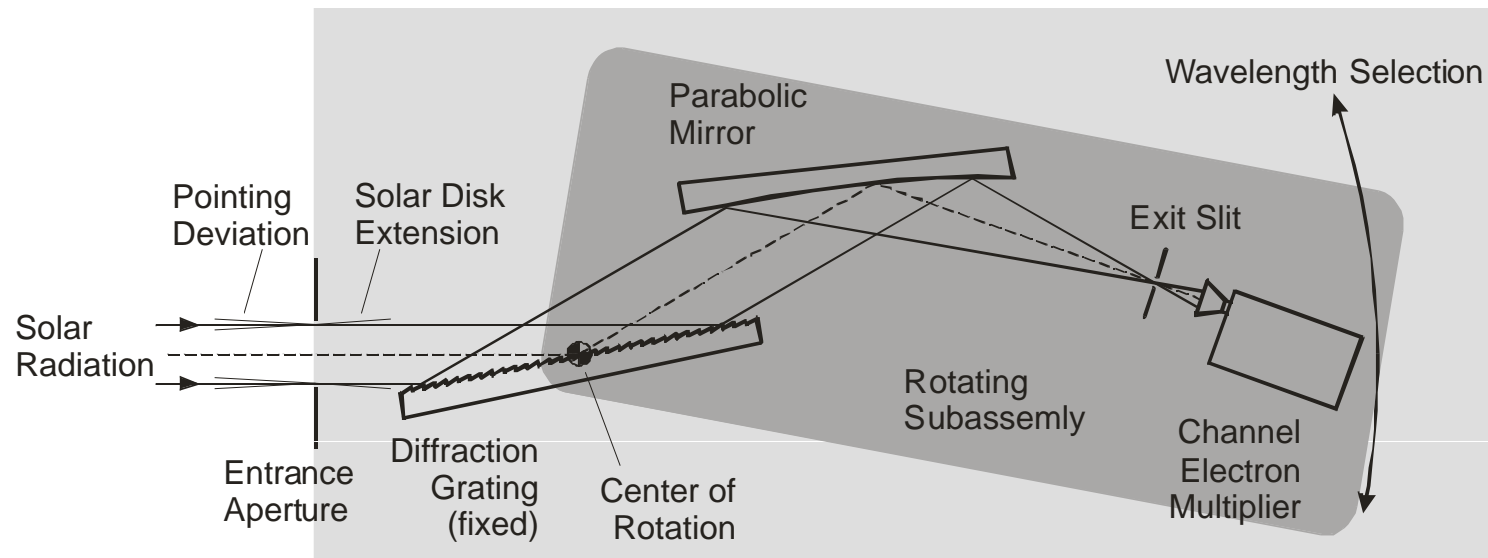
SolACES Subsystems

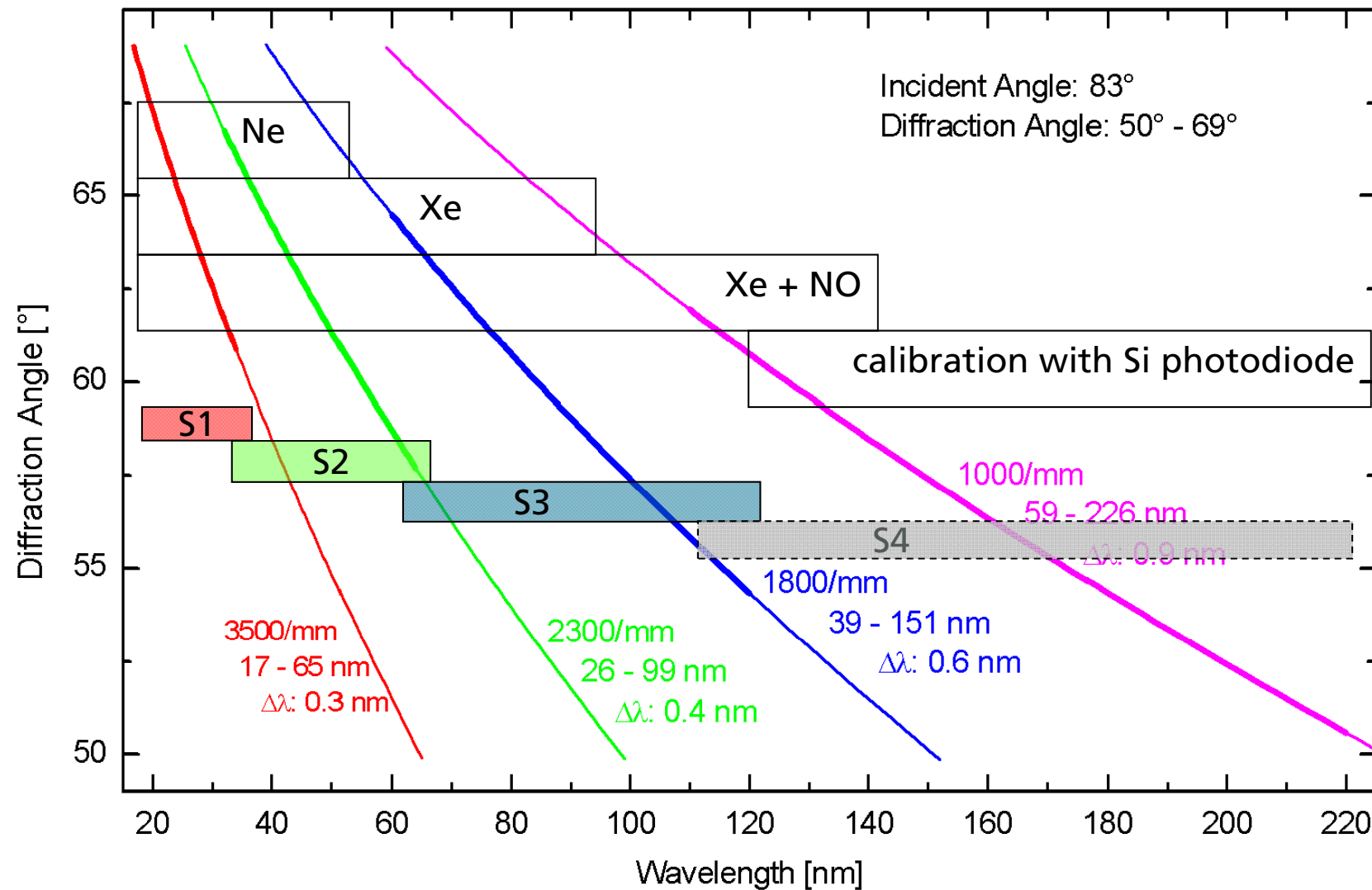


→ [Animation](#)

Optical Principle of Spectrometer

	lines / mm	spectral range	diffraction angle
#1	3500 / mm	16,8 – 64,7 nm	69° – 50°
#2	2300 / mm	25,6 – 98,5 nm	69° – 50°
#3	1500 / mm	39,3 – 151,0 nm	69° – 50°
#4	1000 / mm	59,0 – 226,5 nm	69° – 50°



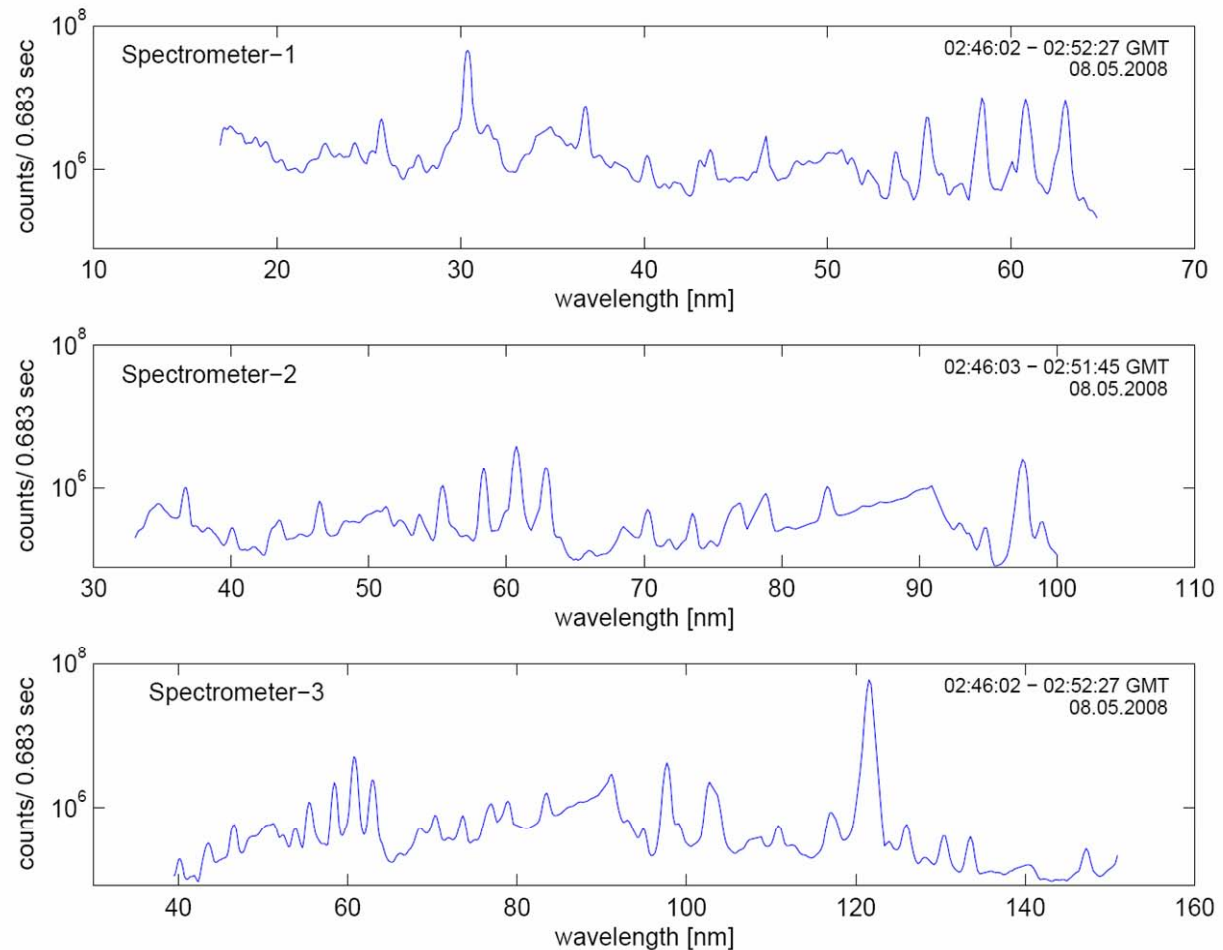


Spectrometer Measurements

High dynamic ally
measurement results
for EUV spectra

→ very good data statistic
→ negligible background
noise (< 10 c/s if it all)

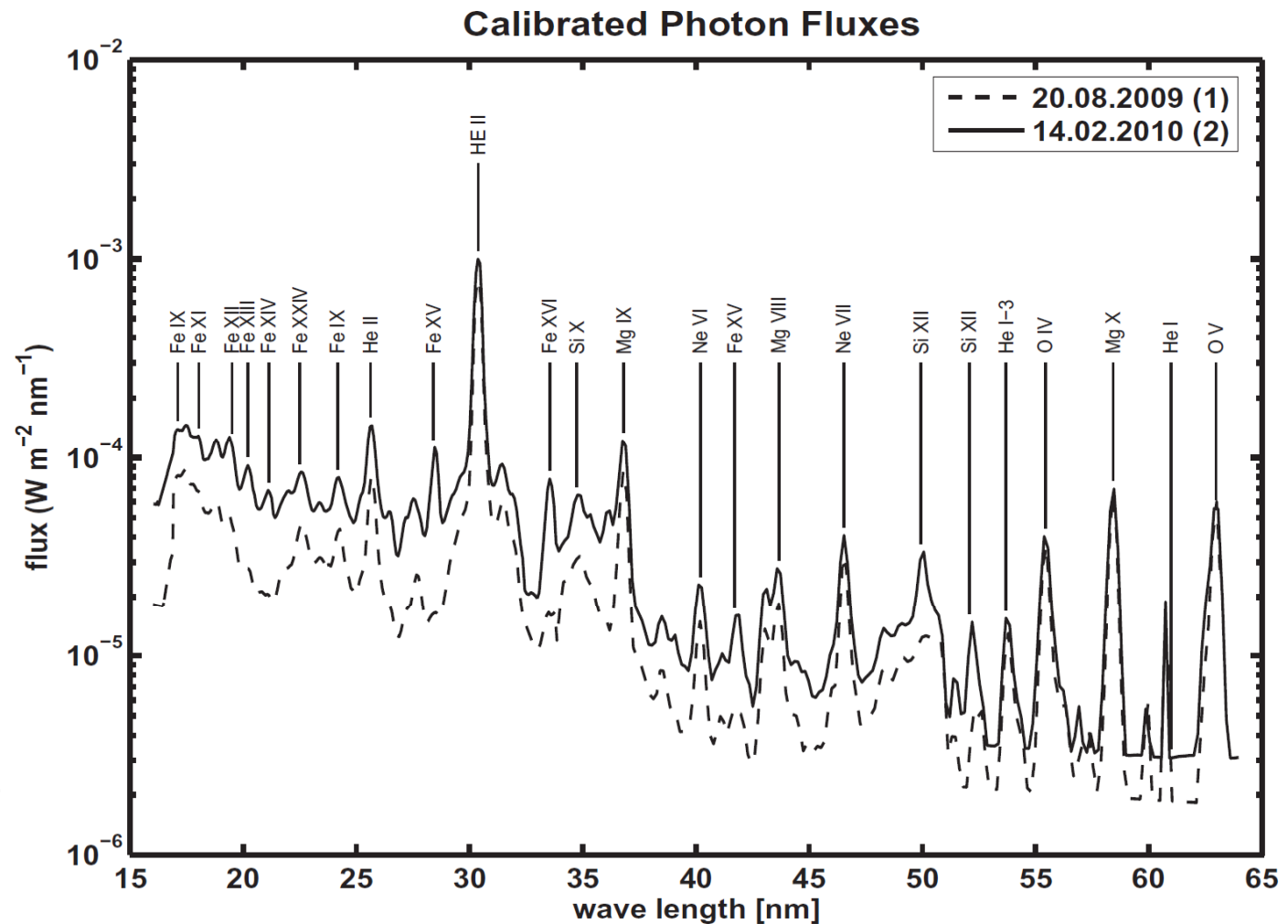
(raw data spectra,
not calibrated, including
second harmonic spectral lines)



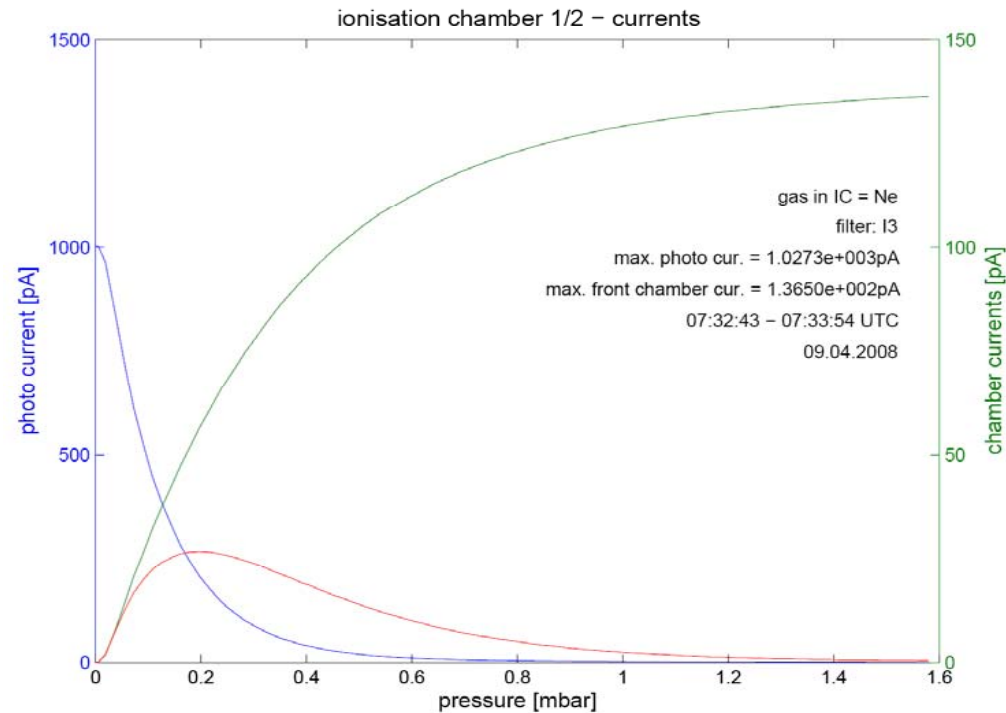
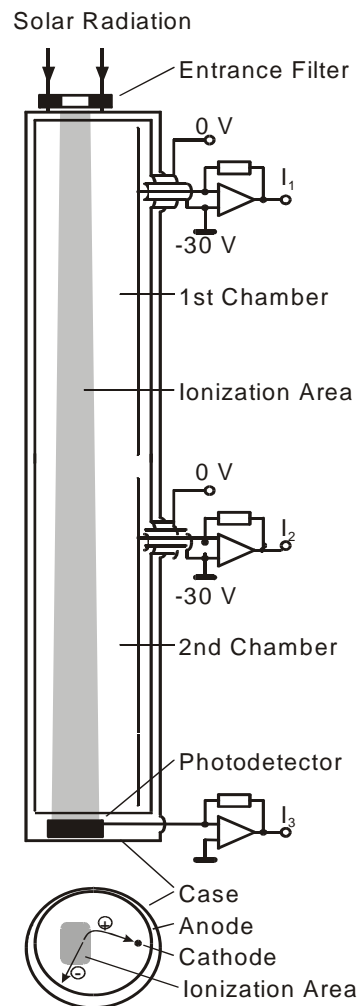
SolACES Results

Assignment of Spectral Emissions to Elements

Strong solar emissions as recorded by spectrometer S1/S2 at different times



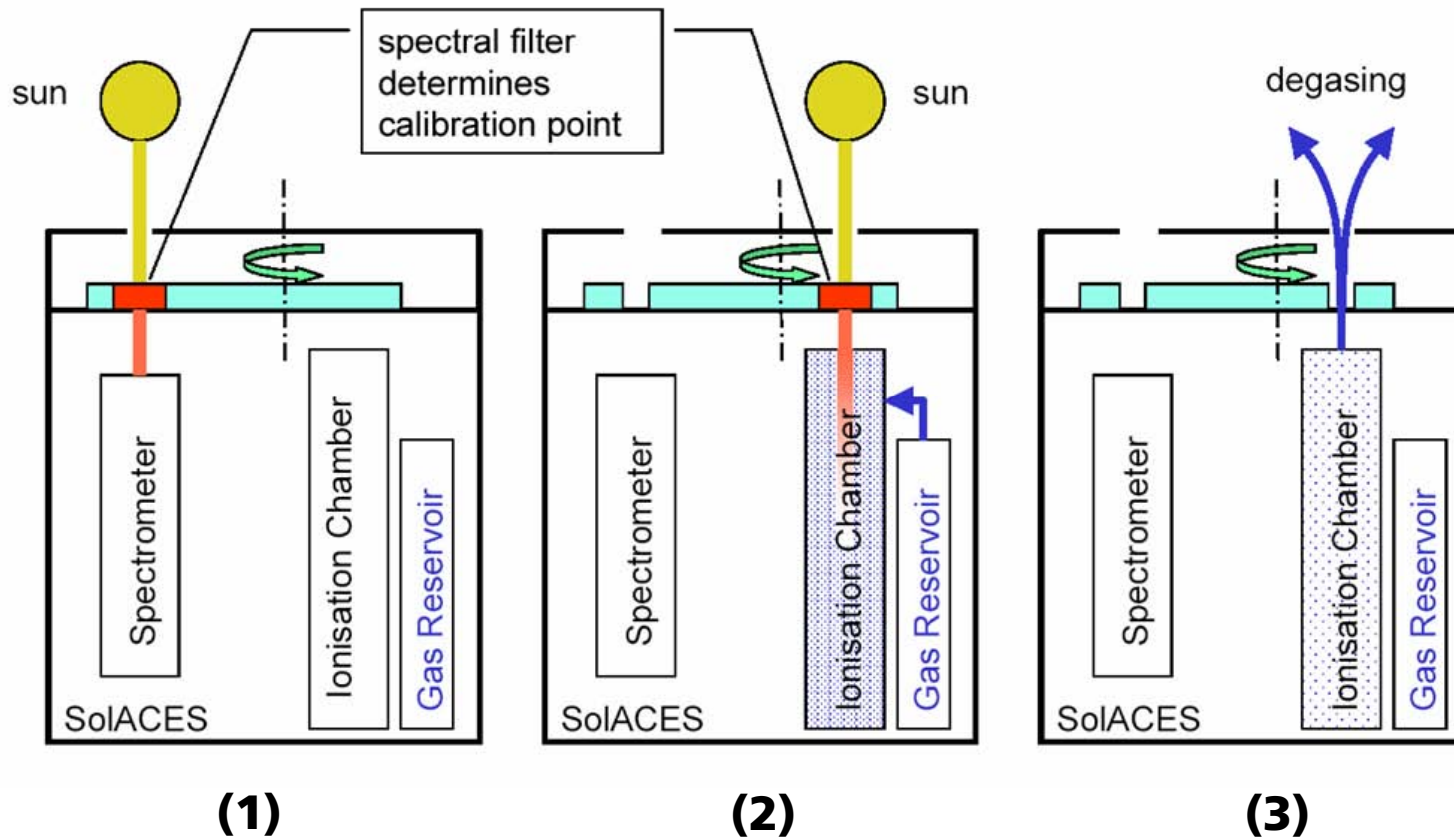
Ionization Chamber Signals/Data



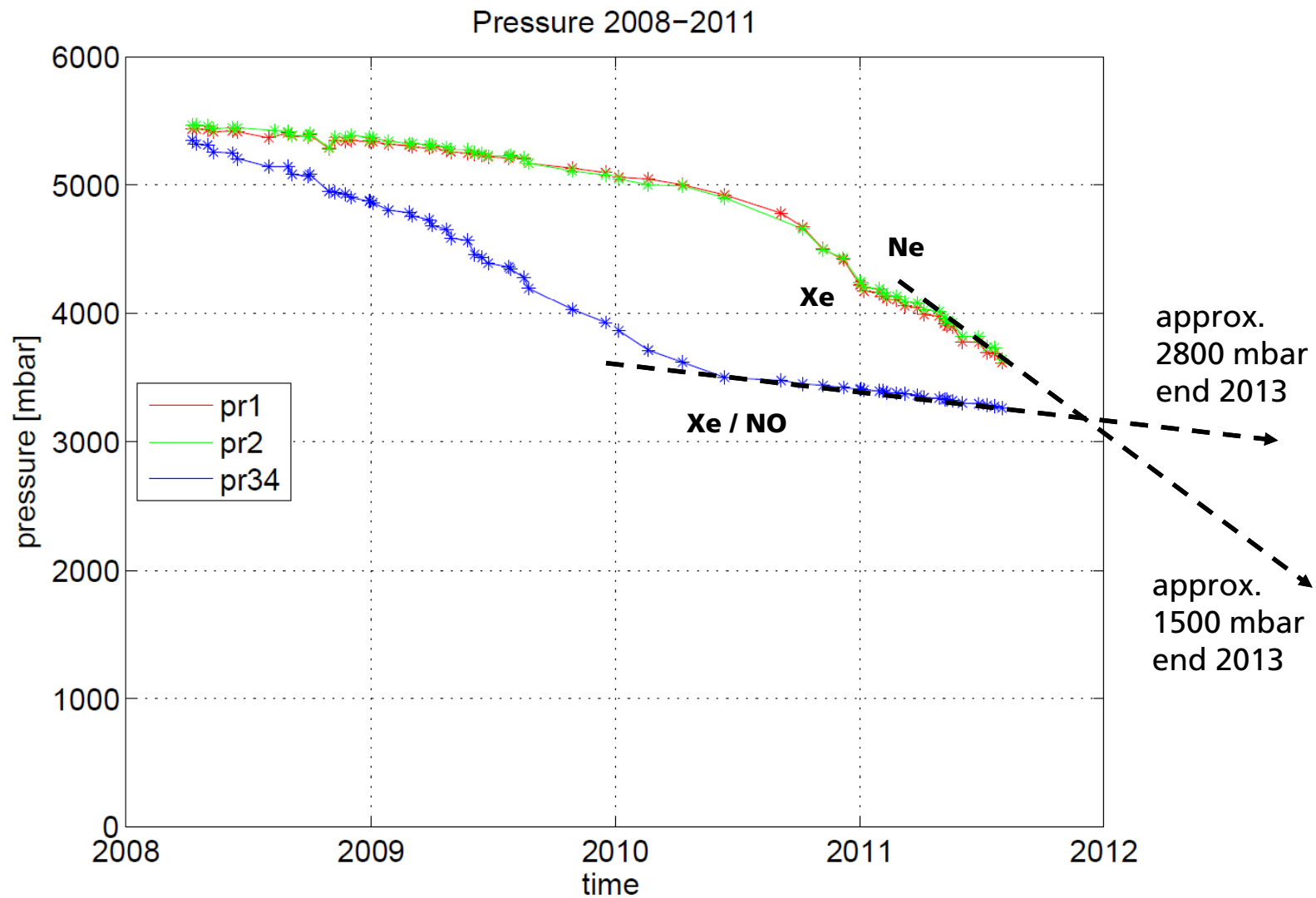
- The current signals deliver the quantity for the photons absorbed (incoming flux)
- The modeling of these curves by photon and secondary electron ionization relates the **absolute photon fluxes** to the ionization chamber currents

The two double chambers could be filled with Ne, Xe, or Xe/NO.

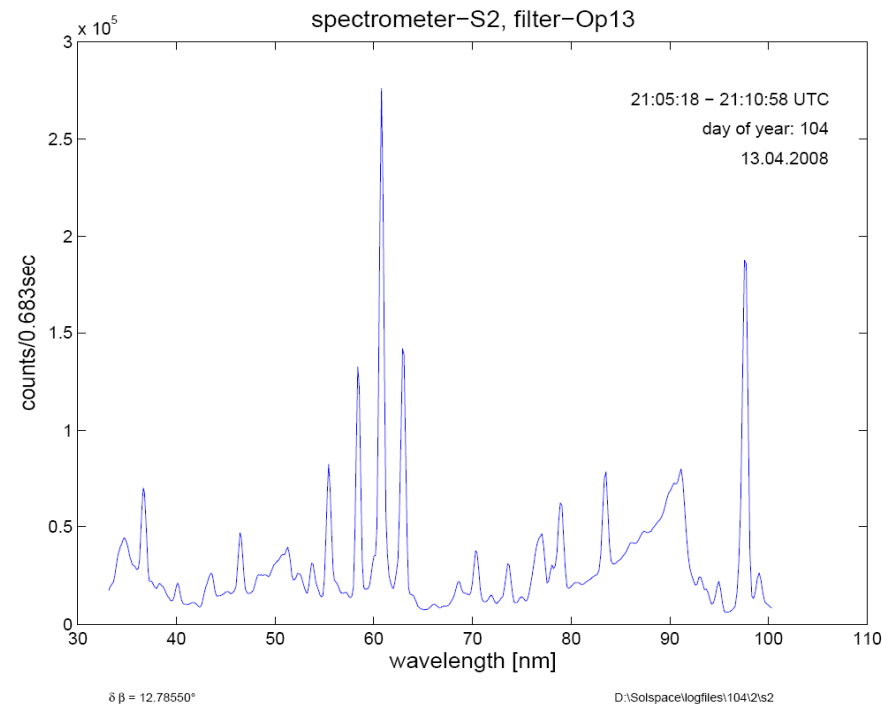
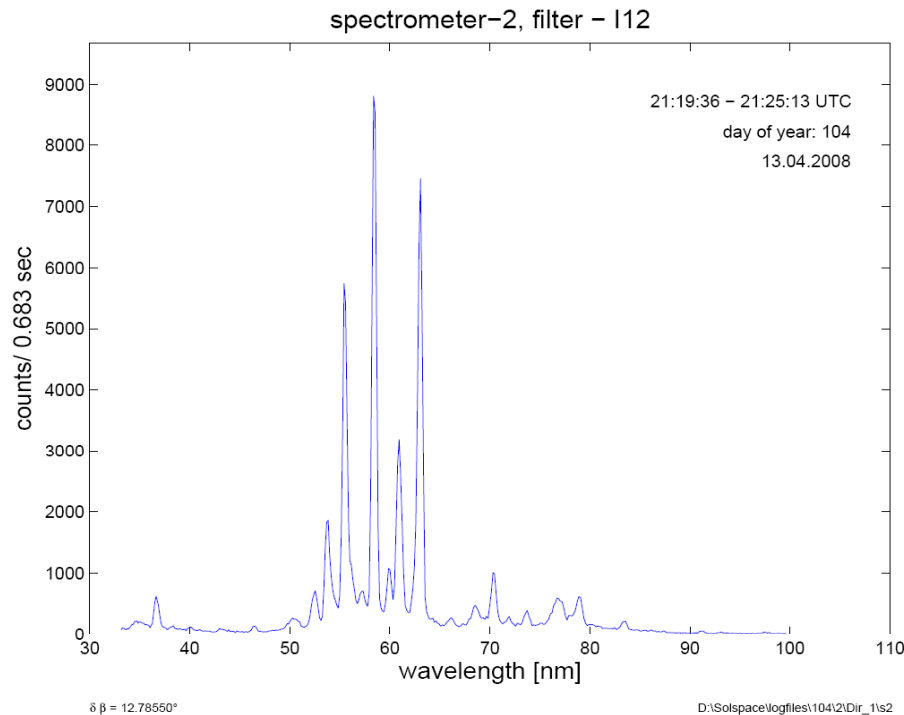
Calibration Measurement Procedure



Ionisation Chamber pressure



Spectra measurement example with and without filter



I12: Sn/Ge filter

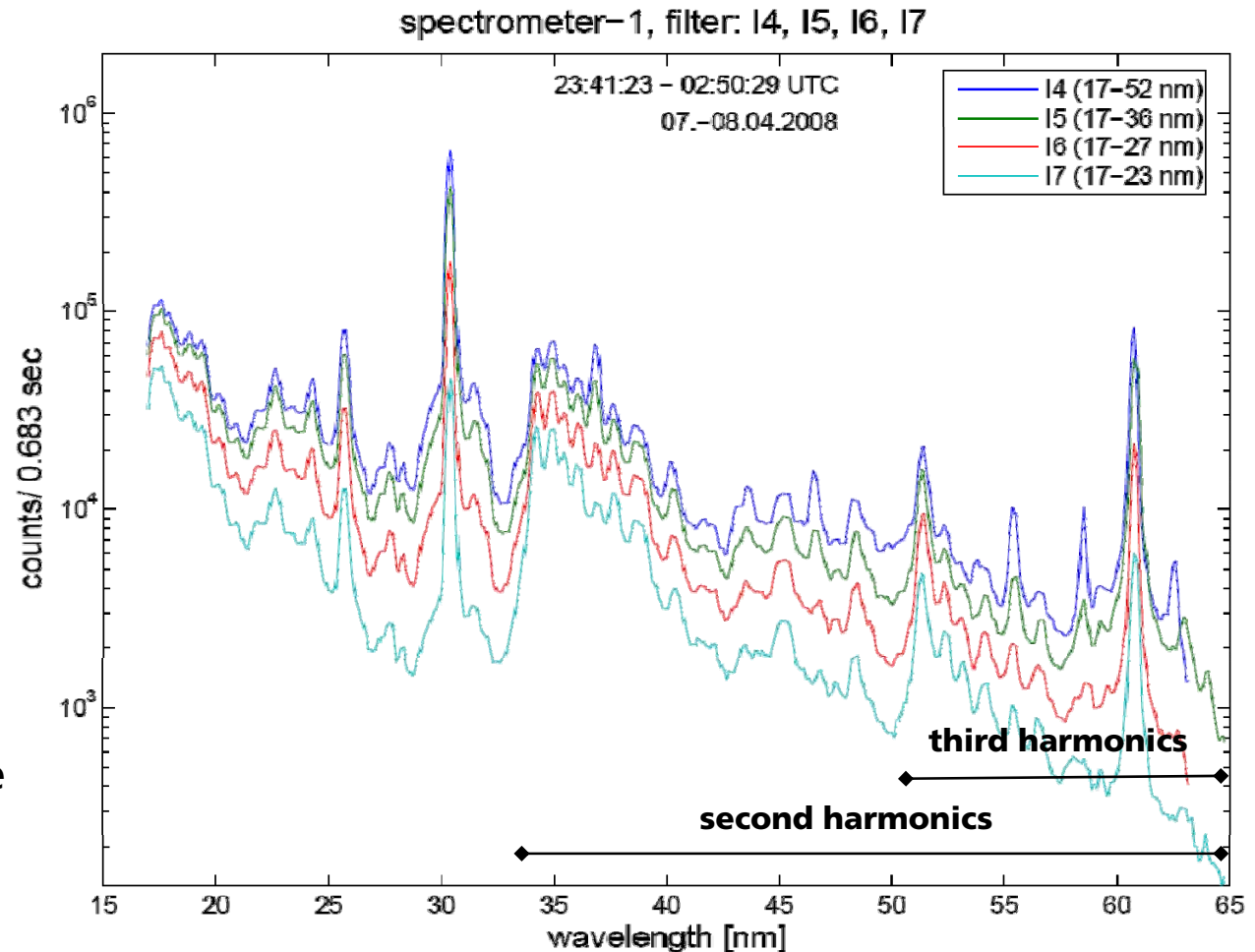
In general the stray light is
very low (< 40 counts / 0.683 s)

Data Evaluation with Filters

Non linear filter characteristics with different thickness will help to optimize the weighing function for emissions at different wavelengths

Filter techniques allows:

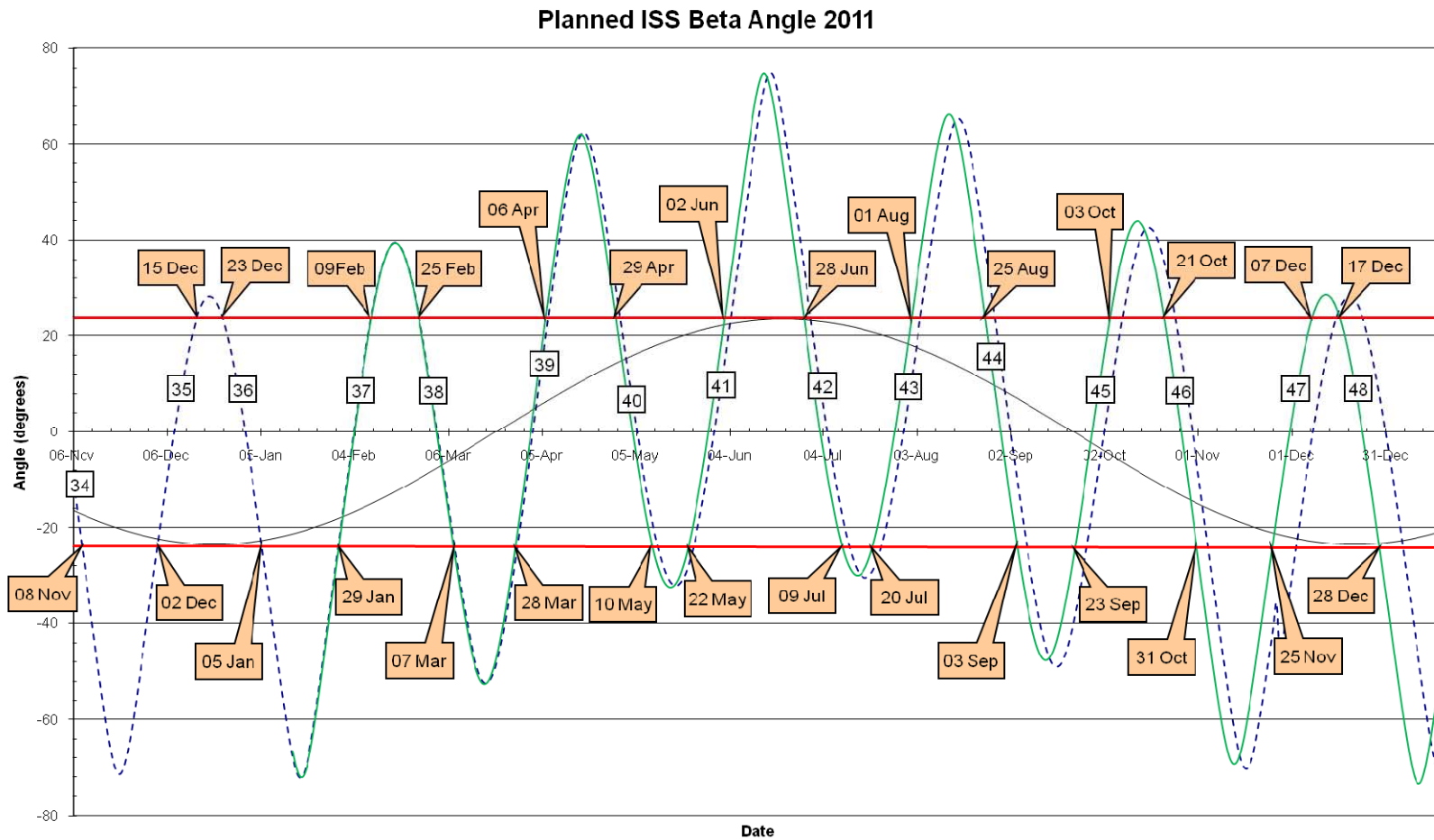
- to identify and correct higher harmonics contributions
- to determine stray light levels
- to perform more precise correction of non linear Channeltron response



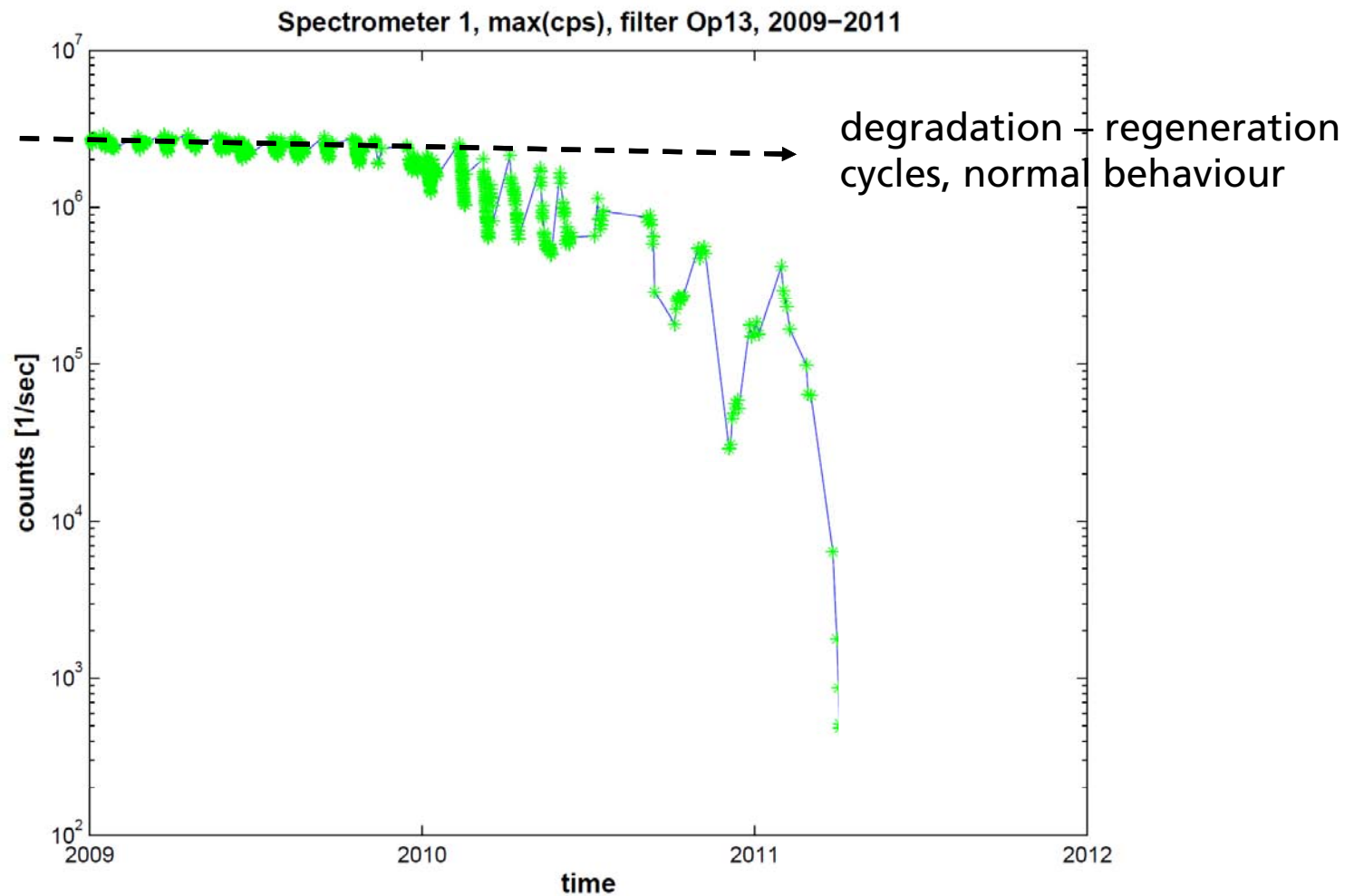
Prediction of ISS orbits



Solar alignment, sun visibility of SOLAR



Spectrometer sensitivity, trend

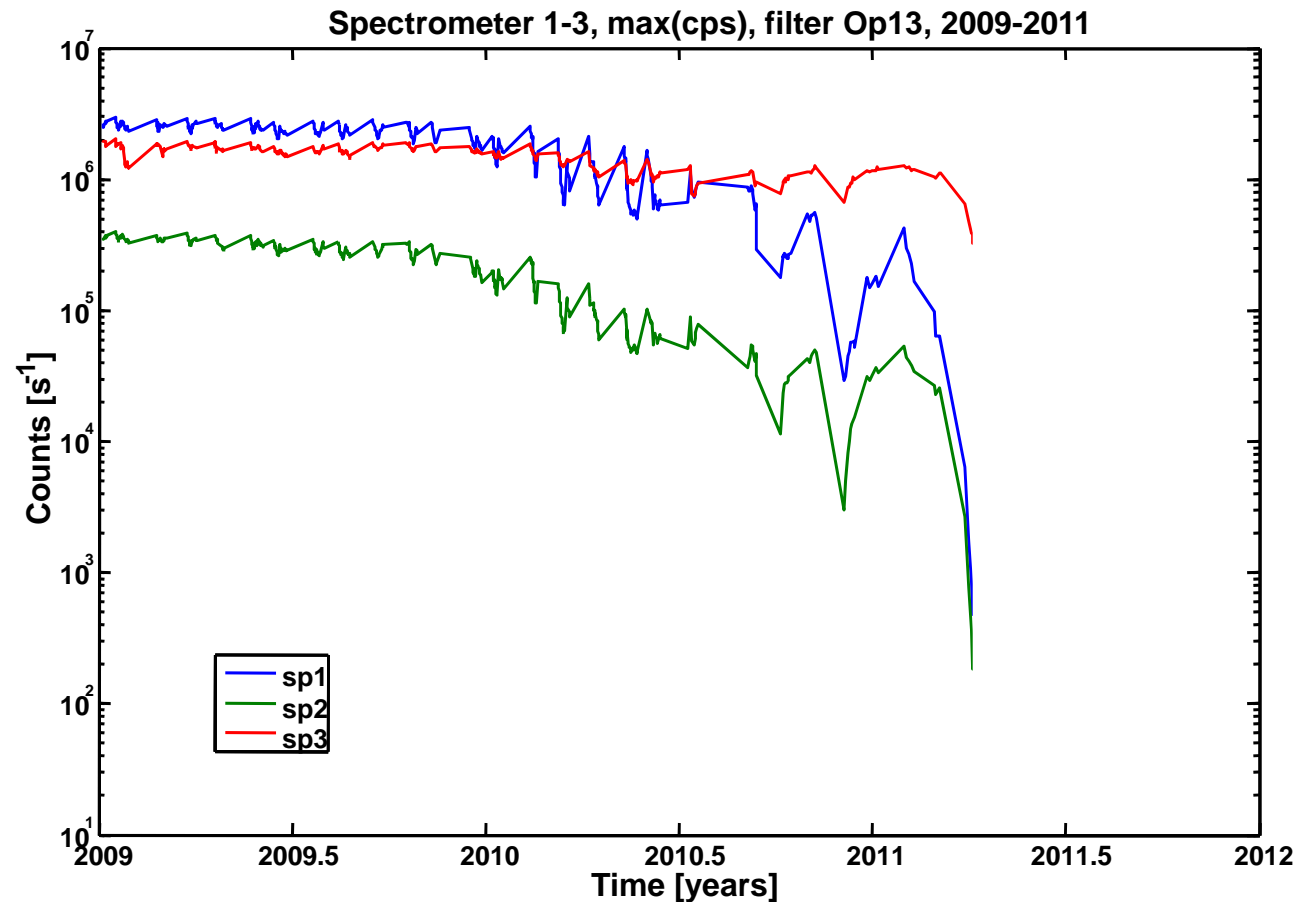


Spectrometer sensitivity, trend

Very correlated,
behaviour, tendency
in all spectrometers
alike

→ external influence,
pollution from ISS
(thruster propellants).

→ absorption analysis
shows DMHC
(Dimethylhydrazin)



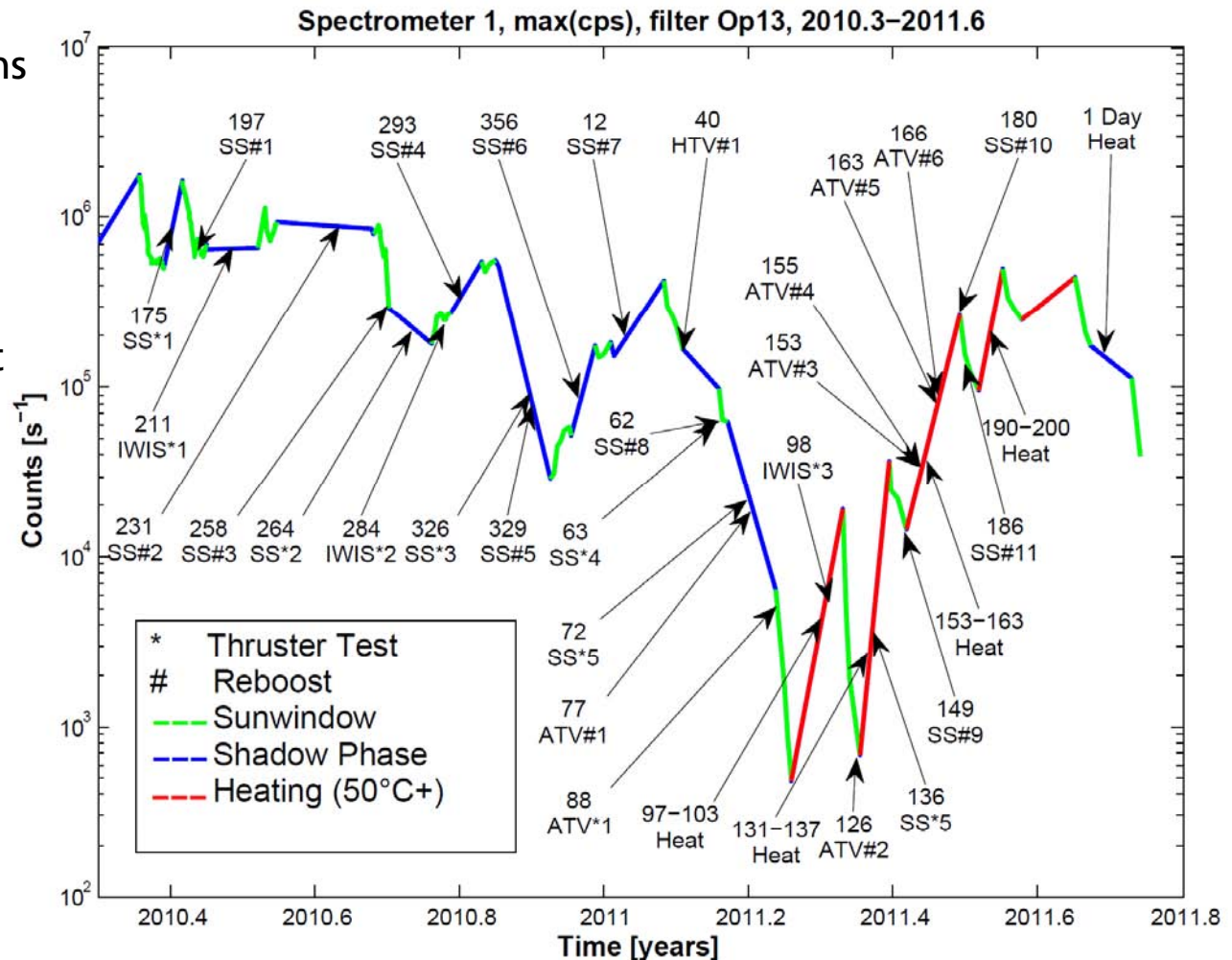
Consequences for mission operations



Future mission operations with regular bake-out periods

Change of measurement philosophy: calibration measurements before and after spectrum measurements

→ Self calibration is possible at all times!



ESA - AO for Climate Studies on ISS

The ESA Directorate of Human Spaceflight and Operations (HSO), in coordination with the ESA Directorate of Earth Observation Programmes (EOP), releases an **Announcement of Opportunity** for International Space Station (ISS) Experiments relevant to the study of Global Climate Change.

Key Topic:

- **(AO p6) Research fields** may include, but are not limited to **Atmosphere**
 - Variability and causes of changes in the Earth global climate system
 - Modelling and forecast of atmospheric composition and air quality
 - Troposphere/Stratosphere/Mesosphere/Thermosphere/Ionosphere coupling processes ...
- **(AO p9) Fast track proposal**
- ...

SOLAR – 2

Measurements and observations of SSI variability with high accuracy .

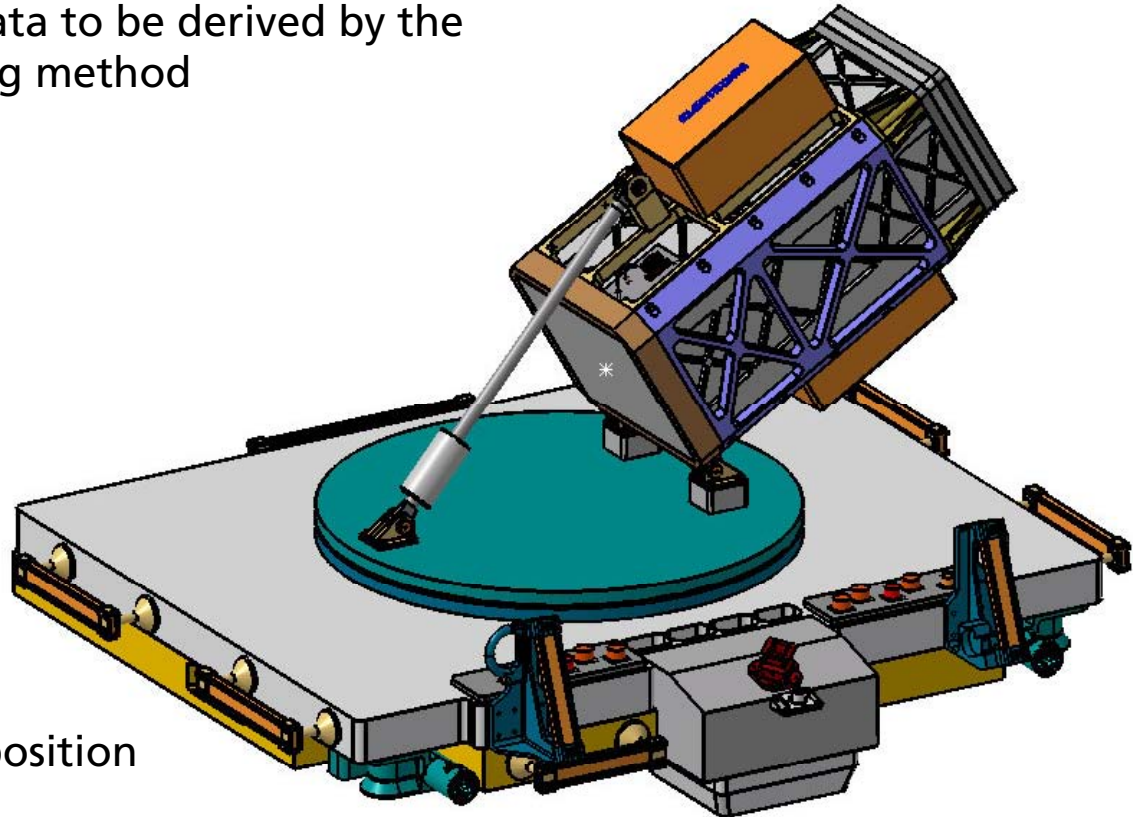
Unique chance to provide SSI data to be derived by the same auto-calibrating measuring method covering a full solar cycle.

Instrument 1:
SolACES-2, 2 – 270 nm

Instrument 2:
,SOLSPEC-2', 270 – 2600 nm

mounted externally at zenith position

pointing device for movement
within +/- 60° in X- and Y-direction



SUMMARY

- SolACES is the first instrument flown with internal recalibration capability
- It offers advantages over EUV spectrometers flown, so far with respect to the determination of second order and stray light contributions as well as non linearity effects
- We are presenting first approximation of EUV irradiance data. The data evaluation is still going on. The data will be public, SolACES homepage is coming soon (www.solaces.eu)
- After >50 years first series of calibrated solar EUV irradiance data is being established in cooperation with the Boulder group of Tom Woods filling up the periodical ISS gaps

How to proceed?

Tasks:

- Common data pool starting with solar minimum period SC23/24, modelling of solar EUV/UV spectral irradiance
- Upgrading the Tabulation of solar emissions from Hinteregger (Handbook of Geophysics)
- Activity indices (corona, transition region, upper chromospheres and lower chromospheres)
- Tabulation for σ (O_2 , O , N_2 , $\text{N}\dots$) with σ_{eff} included
- Evaluation of calibration techniques
- Common development of an ESA/NASA Instrument 1-220 nm with in-flight calibration (SOLAR-2?)
- TIGER Symposium at COSPAR 2012 in Mysore, India:
→ Presentation of common EUV/UV data set

SolACES - Team



(not shown above: Helmut Wolf, Christian Erhardt)

EUV Workshop Oct. 2011, LASP Boulder, CO 80303

Thank you very much for your attention !