Sol-ACES

Solar Auto-Calibrating EUV Spectrometers

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Solar EUV (extreme ultraviolet) radiation:

primary energy source of the thermosphere/ionosphere

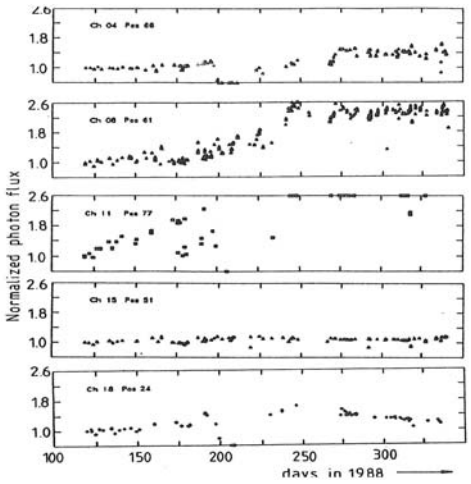
~ $6*10^{15}$ photons m^{-2} s^{-1} with energies of 10…100 eV

Interaction with spacecraft (charging/discharging):
typical work functions of photo effect: 3…6 eV
there is no material without EUV photo effect

EUV technology:

Degradation is THE challenge. Due to non-traceable surface effects the efficiency of EUV instrumentation is changing in a non-reproducable way.

This Figure shows the parallel recording of the solar hydrogen Lyman-alpha emission at 121 nm in the Airglow-Solar Spectrometer Instrument (ASSI) in five channels (San Marco 5 satellite 1988).



EUV **efficiency changes** depend on time and on wavelength, different in each spectrometer as measured in the Airglow-Solar Spectrometer (San Marco 5, 1988)

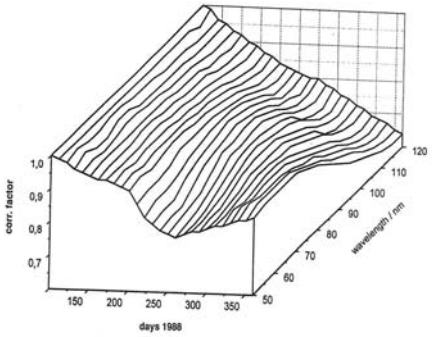


Fig. 2: Efficiency chances as normalized to day 100 in Channel 16 of ASSI/San Marco 5

Sol-ACES / SEPS: Philosophy

- Continuous time coverage of EUV measurment is requested and will be achieved by space missions with sophisticated instrumentation to be added by low-cost instruments.

- In order to derive these data with highest possible accuracy, re-calibration of the sophisticated space instrumentation is mandatory.

Instrument & Measurement Principle

Scientific Objectives:
(Quasi) continuous spectral monitoring (15 spectra per day) of the extreme UV (EUV) & UV radiation of the Sun in the wavelength range 17…220 nm with a high absolute radiometric accuracy (< 5%)

- **Standard Spectroscopic Measurement**
  - ⇨ **two twin spectrophotometers with channel electron multipliers**

- **Auto-Calibration Procedure**
  - ⇨ **determination of absolute EUV / UV fluxes by ionization chamber measurements with filters**
  - ⇨ **determination of instantaneous filter transmissions by spectrophotometric measurement with & without filters**

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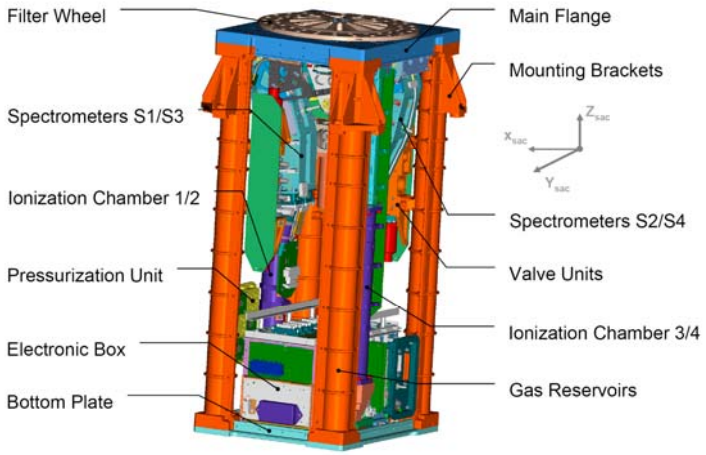
Proto Flight Model

SolACES Subsystems



Mission & Instrument Characteristics

Mission Characteristics:

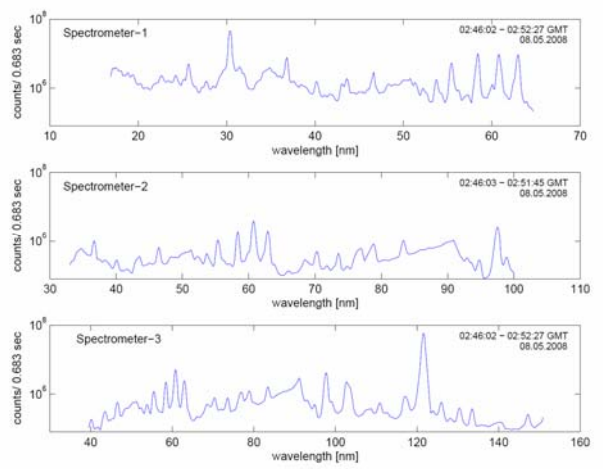
- **Start of operation / launch:** April 2008
- **Launcher:** Space Shuttle (NASA)
- **Nominal / potential mission duration:** 18 / 36 months
- **Orbit characteristics:** ISS orbit (altitude ~400 km)
- **Observation schedule:** max. 20 minutes per orbit

Instrument Characteristics:

- **Mass:** 23.0 kg
- **Size:** 25 x 29 x 60 cm3
- **Electrical power consumption:** typ.< 25 W / max. 60 W
- **Data rate:** ~1.0 kbit/s
- **Spectral range:** 17…220 nm (EUV/UV)
- **Spectral resolution:** 0.5…2 nm
- **Radiometric accuracy:** < 5%

SolACES instrument with subunits (size: 25 x 29 x 60 cm^3)

First Measurement Result



raw data

Summary

Primary Goal:

(Quasi) continuous spectral monitoring of the EUV & UV radiation of the Sun in the wavelength range 17…220 nm with a high absolute radiometric accuracy

Deduced Goals & Applications:

Determination & modelling of the solar EUV / UV spectral irradiance

- **Modelling of the terrestrial thermosphere & ionosphere (EUV / UV indices)**
- **Semi-empirical modelling of active regions on the Sun**
- **Aspects of space weather (impacts on satellite communication & navigation)**
- **EUV / UV space instrumentation & its calibration**

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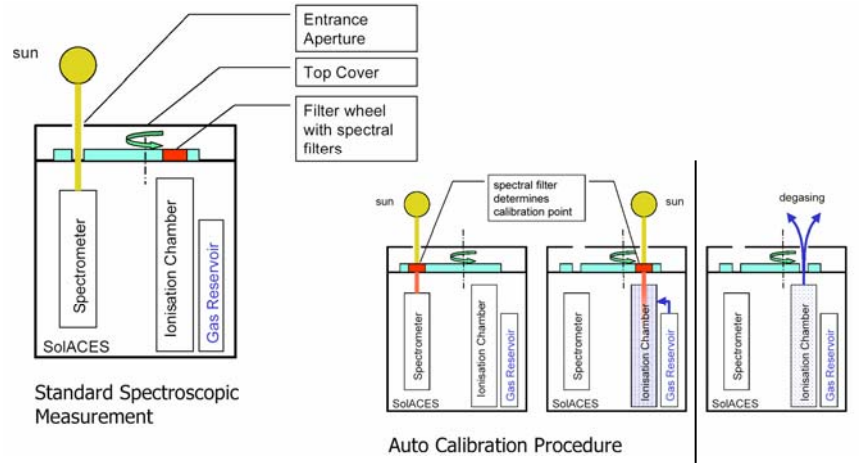
Spectroscopic Measurement and Calibration Procedure



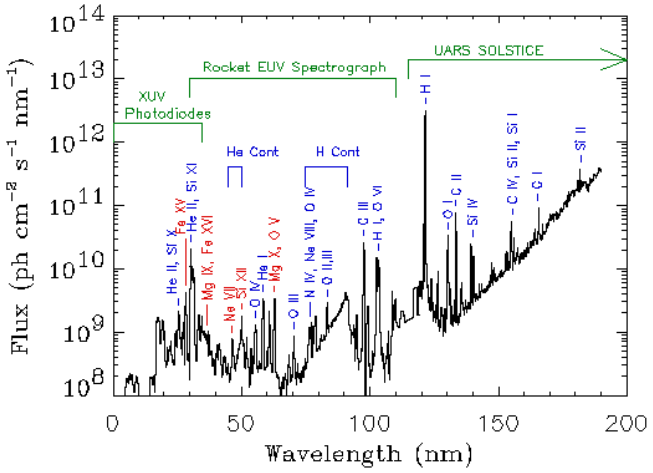
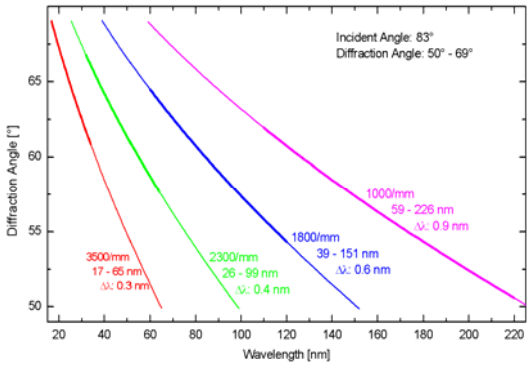


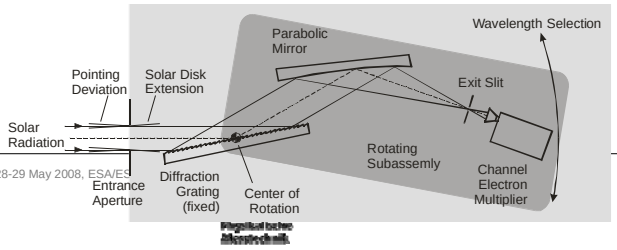
TABLE 4. Comparison of Measured and Modeled Solar Irradiance

Wavelength (nm)	Ion	ASSI Channels	Variability Differences Hinteregger	Variability Differences EUV91	Absolute Flux Ratio Hinteregger	Absolute Flux Ratio EUV91
58.4	He I	12,16,18	0.16	0.13	1.36	1.91
61.0	Mg X	12,16,18	0.18	0.18	0.938	1.11
63.0	O V	12,16,18	0.11	0.12	1.46	1.01
77.0	Ne VIII	12,16,18	0.40	0.39	0.991	1.25
79.0	O IV	12,16,18	0.18	0.17	0.380	1.12
80 - 85	H I,OII,OII	12,16,18	0.098	0.077	0.384	0.639
83.4	O II, OIII	12,16,18	0.088	–	1.44	–
85-90	H I cont.	12,16,18	0.087	0.080	0.481	0.867
95.0	H I Ly-δ	16	0.12	0.14	0.983	–
97.7	C III	16,18	0.13	0.096	0.856	1.06
102.5	H I Ly-β	16,18	0.070	0.075	0.942	1.13
121.5	H I Ly-α	18	0.073	–	1.00	–

The variability differences are the RMS differences between the ASSI measurement and the *Hinteregger* [1981] and EUV91 [*Tobiska*, 1991] models. The ratio of the absolute flux from ASSI to model predictions is for November 10, 1988. A dash indicates that there exist no predictions from the EUV91 model at these specific wavelengths.

Optical Principle of Spectrometer





Ionization Chamber Principle