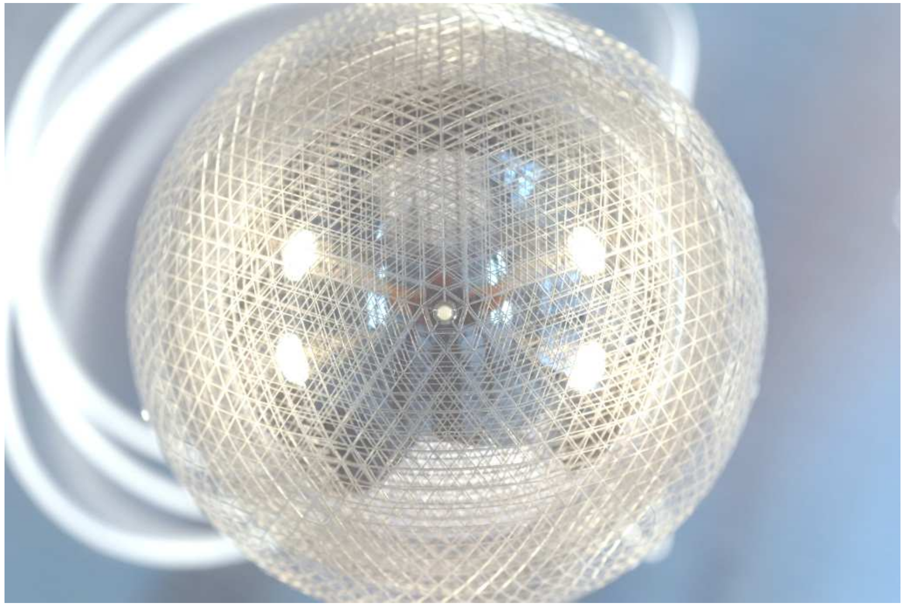
# Spherical EUV and Plasma Spectrometer (SEPS-LEED) – typical measurement results and modeling

SPINE Workshop – 17-19. January, IRF Uppsala

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funded by

# Overview

- scientific goals
- instrument description and sensor design
- laboratory measurements and current status
- first modelling results with SPIS

# Primary Applications: SEPS - LEED

SEPS shall become a new development of a space weather sensor to monitor the following parameters:

- solar wind
- terrestrial plasma (ionosphere through magnetosphere)
- suprathermal electron fluxes **(1 eV - 200 keV)**
- solar EUV radiation

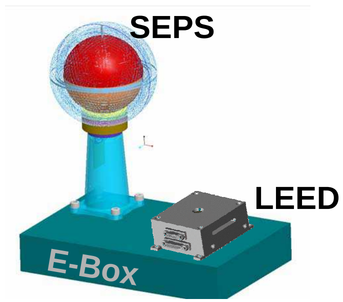
These requirements result in a dynamic range of up to eight orders of magnitude from $10^{-12}$ A – $100 \cdot 10^{-6}$ A for SEPS and a range of 1 keV – 200 keV for the suprathermal electron flux monitor (LEED)

# Measurement/Scientific goals of SEPS

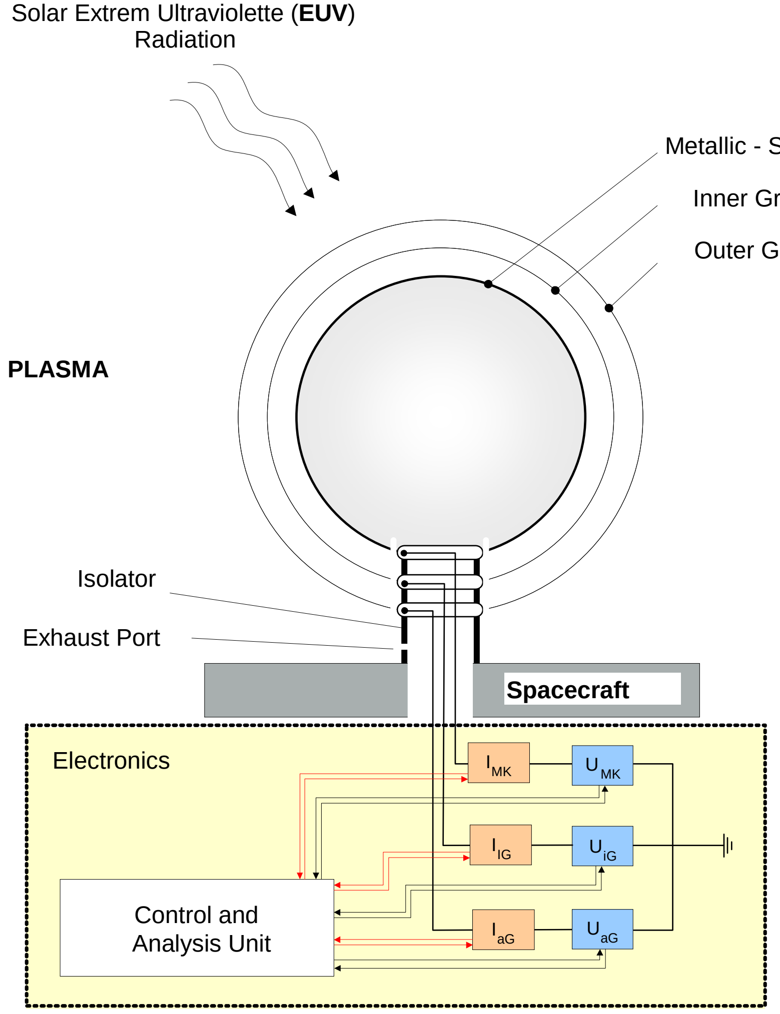
Measurement of solar EUV radiation and plasma environment in the energy range of 0 eV – 100 eV during >10 years:

- densities of ions and electrons: 1 $cm^{-3}$ – $10^6$ $cm^{-3}$
- total solar EUV flux: absolute accuracy of 10 % and variability <1 %
- one sample of all parameters: every 10 s
- SEPS shall be able to operate at spacecraft potentials from -50 V - +50 V
- integration of the LEED detector (PSI / CH) for higher energy ranges 5 -200 keV



# Measurement principle of SEPS

- The device consists of three isolated spheres, the metallic sphere (MS), a highly transparent Inner Grid (IG) and Outer Grid (OG). Each one is being connected to sensitive floating electrometers.
- Simply by setting different potentials to the outer grid as well as to the sphere and varying the voltage to the inner grid, measurements of the ambient plasma parameters and of the extreme ultraviolet (EUV) radiation can be achieved.



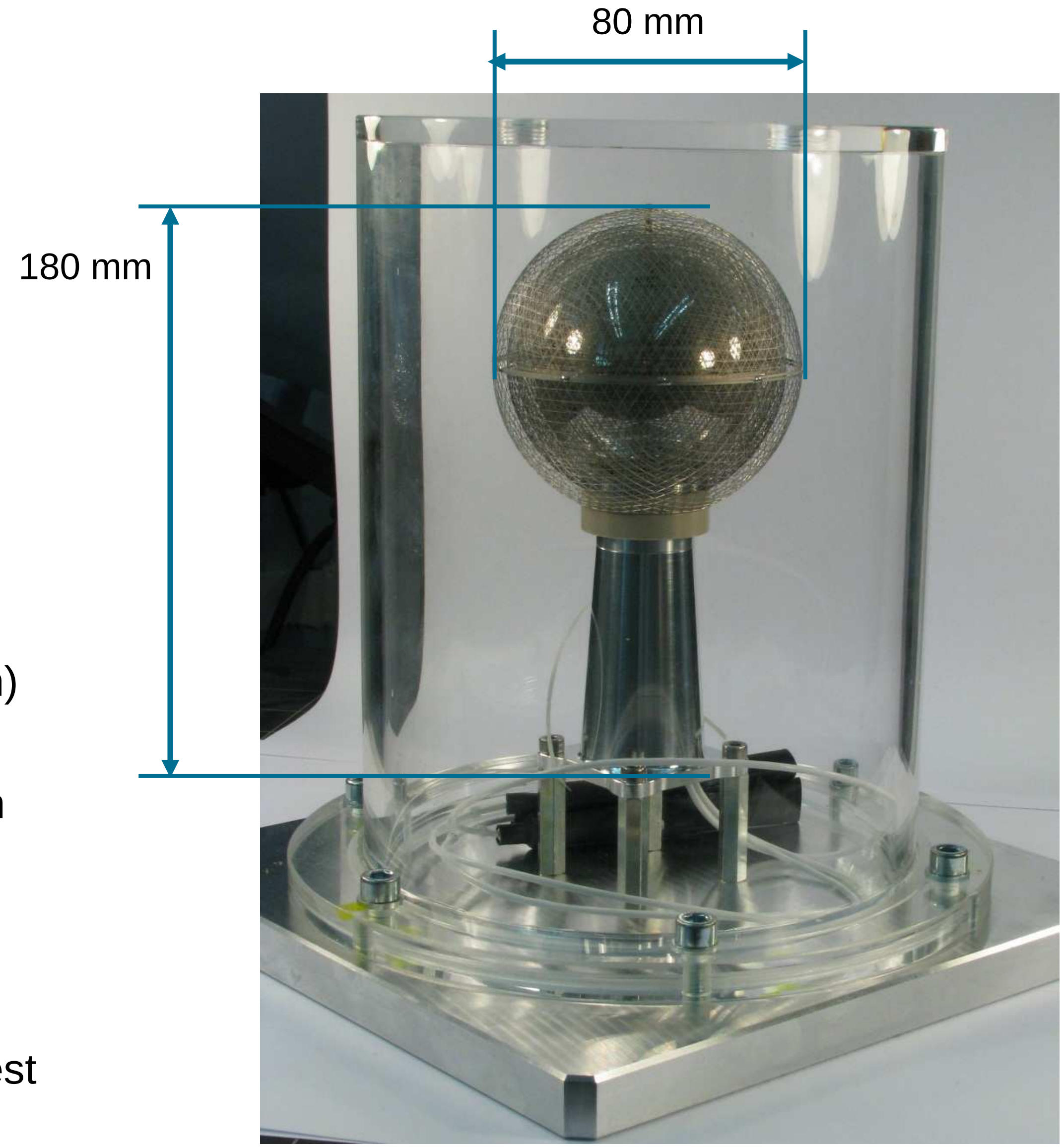

present dynamics:
3 x Electrometer: 150 pA – 100 µA
3 x DC: – 70 V to + 70 V

# Measurement Modes

| Mode | Voltage | | |
|---|---|---|---|
| | **sphere (MS)** | **inner grid (IG)** | **outer grid (OG)** |
| Langmuir | +8…-8 = | +8…-8 = | +8…-8 |
| Plasma shielded Langmuir | +20…-70 | $V_{pl}$ = | $V_{pl}$ |
| RPA plasma electron | +20 | +10…-70 | $V_{pl}$ |
| RPA plasma ion | -20 | +70…-10 | $V_{pl}$ |
| EUV | +70…-70 | -50 | +50 |
| Calibration | 0 | -70 | +70 |
| Debris (side effect, under evaluation) | different voltage between IG and OG | | -- |

$V_{pl}$: plasma potential, also determined by the sensor
RPA: Retarded Potential Analyzer

# Mechanical Design

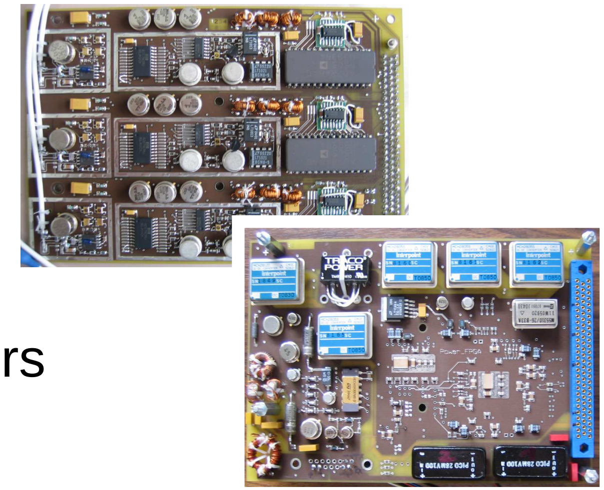



- SEPS Sensor with protection cover (Plexiglas)
- Optimal symmetrical grid configuration for best optical transparency (about 50 % in the centre region)
- Mesh (bar) thickness: ~ 120 µm
  Shell thickness: ~ 100 µm
- Grids: nickel
- Sphere: aluminum with electro plated platinum layer
- Successful random vibration test was performed up to **20 grms**

# SEPS Electronics Features (EADS, Wilfried Pfeffer)

- Two current measurement ranges
  - ± 100 µA (± $10^{-4}$ A), resolution ± 3,05 nA
  - ± 125 nA (± $10^{-7}$ A), resolution ± 150 pA
- Voltage sweep for SEPS with different parameters

  (see table with measurement modes)
- FPGA control for commando interface and data handling
- Radiation resistant design
- Memory 256 MB for intermediate data storage
- Auxiliary Power, RS422 data interface



**Electrometer PCB,**

**FPGA-Power PCB**

# Deduced Parameters from SEPS

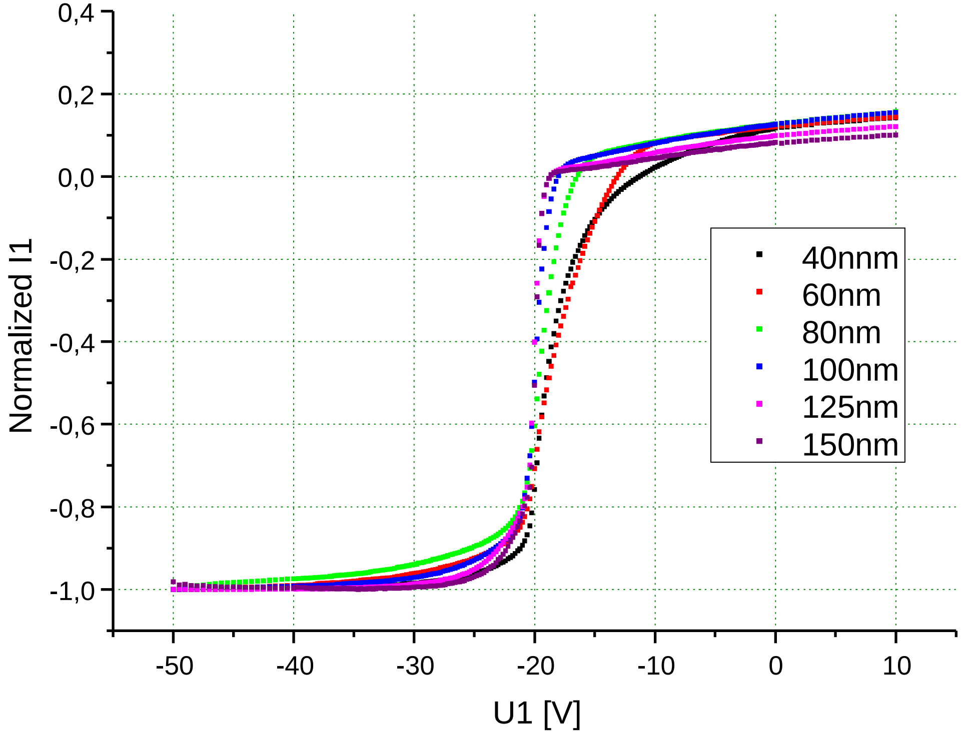
| Deduced parameter | Description<br>(derived from different measurement modes) |
|---|---|
| $\eta_e$, $\eta_i$ | electron density, ion density |
| $T_e$ | plasma temperature |
| $E_e$, $E_i$ | energy distribution of electrons and ions |
| $V_{sc}$, $V_{pl}$ | space craft potential, plasma potential |
| EUV | EUV spectra, important range ~ 6 – 70 eV, rough resolution |
| TEC, $EUV_{sun\ activity}$ … | several deduced indices like<br>total electron content, sun activity etc. |
| $\delta_{debris}$ | density of debris dust (1-100µm)<br>(detection of impact plasma events – under evaluation!) |



EADS astrium Fraunhofer IPM

# Measurements at BESSY-Synchrotron

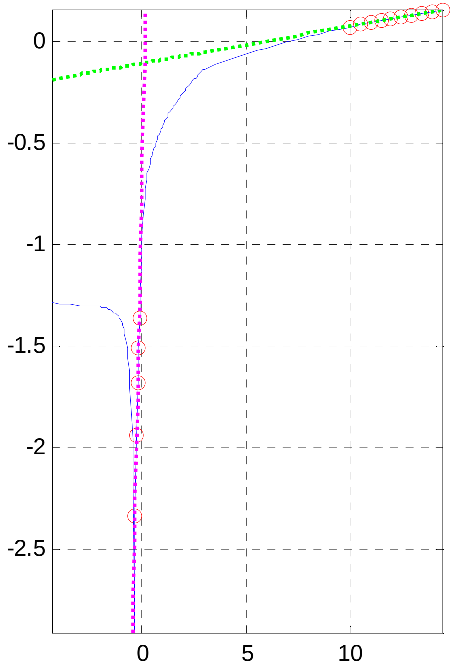
**EUV Mode**
Measurements of 40, 60, 80, 100, 125 and 150 nm photons, normalized

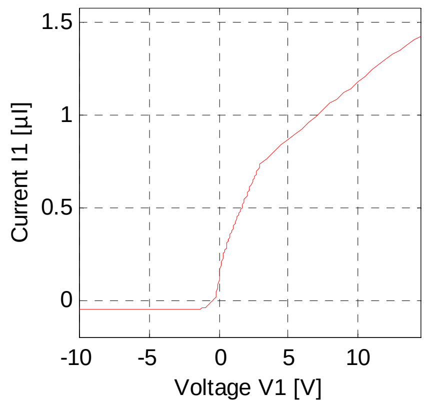



| MS | tuned + meas. |
|---|---|
| IG | - 20 V |
| OG | - 10 V |

# Comparative Langmuir measurements

## SEPS Langmuir Mode



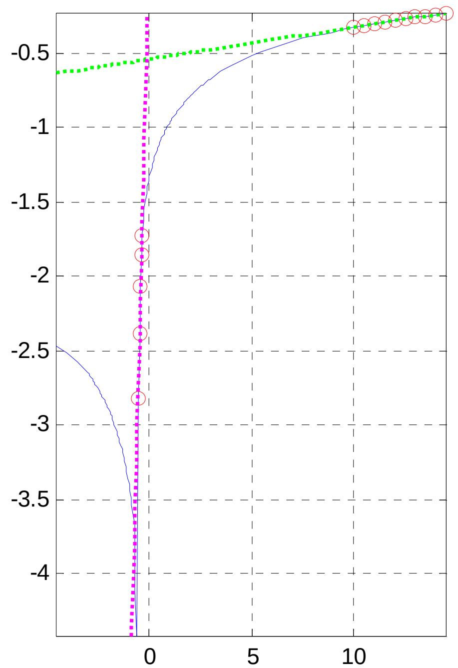

meas_27Sep2007_115016.dat

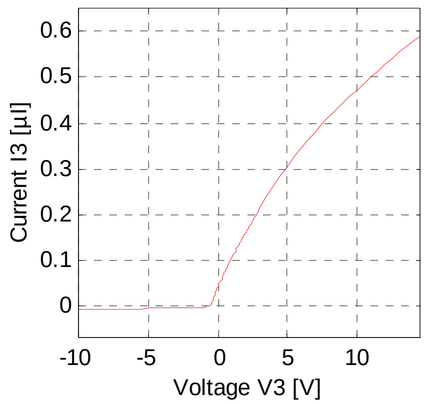
Te=2440K

Vf=-0.39V

SEPS Mokup III

## Langmuir Sensor (ESA/ESTEC)




meas_27Sep2007_115016.dat

Te=2123K

Vf=-0.55V

ESA/ESTEC Sensor

# Modeling of SEPS as plasma instrument

## Diploma Thesis

**Test of SEPS as plasma instrument**

Credit:

Work performed by Donia El Boudali (Master, UPMC, Paris, France & ESA).

Supervised by: A. Hilgers

With contribution from: ESA (D. Rodgers, J.-P. Lebreton, D. Drolshagen, F. Cipriani), Astrium (W. Pfeffer), IPM (W. Konz, G. Schmidtke, R. Brunner).

Content:

- SEPS instrument
- Sample of test results in plasma chamber
- Modelling needs
- Modelling grid current collection effect
- Modelling  grip potential effect
- Conclusion

ESA Presentation | DD/MM/YYYY | Slide 1 European Space Agency

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