Overview of European Space Experience Related to spacecraft plasma interactions

- Several instruments were presented at the meeting (IRF LP, CNES Sillage and AMBER, IPM SEPS, PSI LEED, CESR/CETP spectrometers, etc…).
- There are other…
- We give a partial and not unbiased overview.

Groups with Plasma and e- Detectors Past Space Flight Experience in ESA MS

Country	Langmuir probe	Low Energy Spectrometer	MeV e-	Other
A				IWF, ARCS
Can	ComDev	ComDev		
CH			Bern U, PSI, Contraves	
F		CESR, CNES, CETP, ONERA, EREMS	CESR, CNES, CETP, ONERA, EREMS	CETP, LPCE
Dk			DMI	DMI, DSRI
Fin	FMI, Turku U.			
G	IPM	DLR, MPAe, MPE, IPM		
I	ALTA	ALTA, ASI, LABEN, Univ.		ALTA
IRL			St Patrick C.	
N		NDRE, Univ.Olso, Bergen, Tromsoe		
S	IRF-U, KTH	IRF-K		
UK		RAL, MSSL	QQ, SSTL, ICL	
ESA	D/Sci, D/TEC	D/TEC	D/TEC	

ESA MS Instruments

Launched:

- Cluster (CEASE, ASPOC)
- Columbus (EUTEF/Plegpay)
- Double Star (CEASE, ASPOC)
- Demeter ( )
- Giove-A (Merlin, CEDEX)
- METOP (SEM2)
- Oerstedt ( )
- Champ ( )
- SOHO (CELIAS)
- Spot-4 (Sillage).
- ROSETTA ( )
- Ulysses (-)

Approved:

- BepiColombo (-) - 2012
- Lisa-PF (EPDP) – 2009
- Taranis ( ) – 2011
- SWARM ( ) -

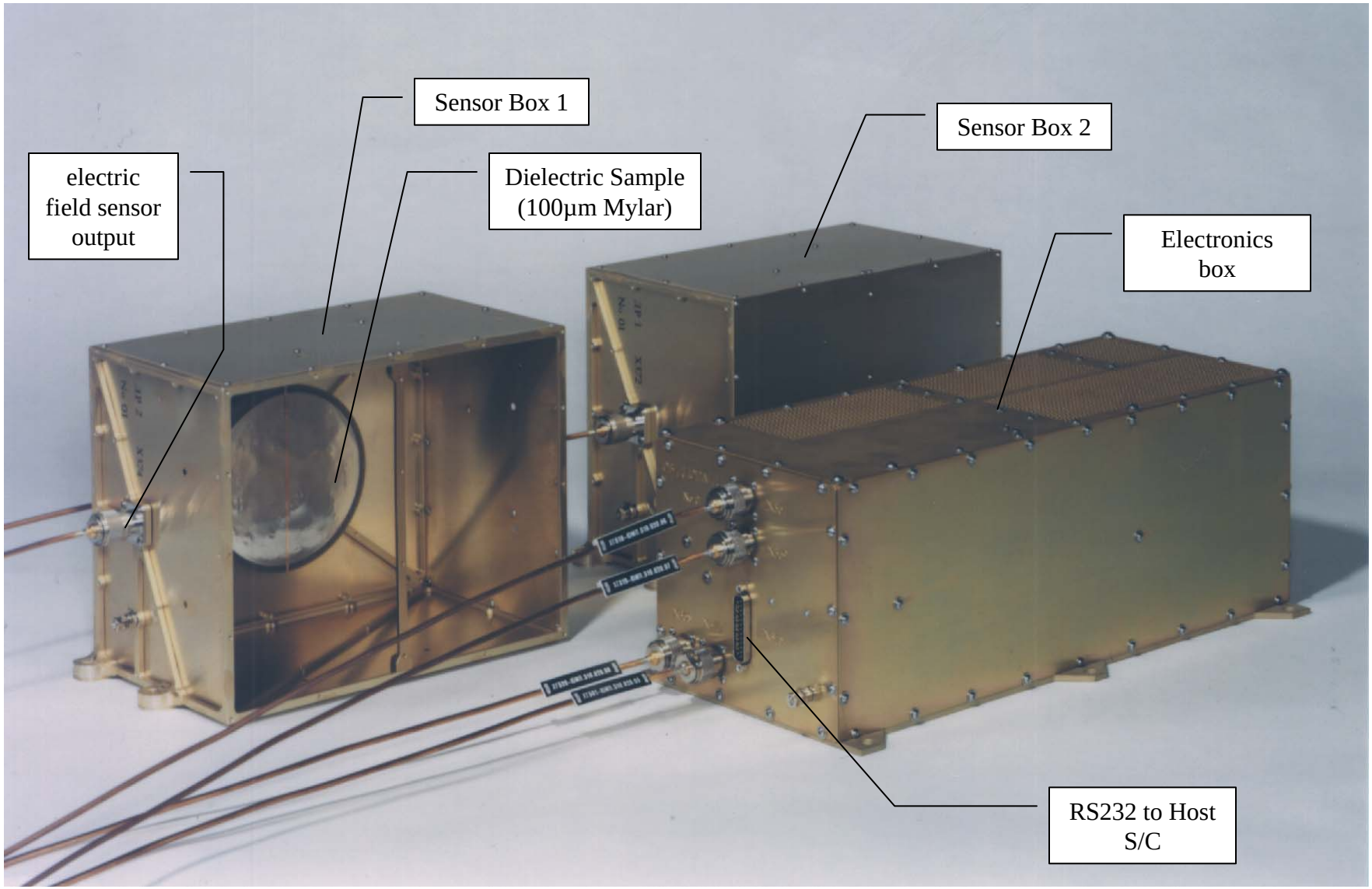
TBC:

- Alphasat ( ) - 2011
- BepiColombo (MFS) – 2012
- GALILEO-IOV- ~2010
- Small geo
- Cross-scale
- Laplace Tandem
- MTG
- METOP NG
- SSA s/c

Examples of instruments not presented at this meeting yet.

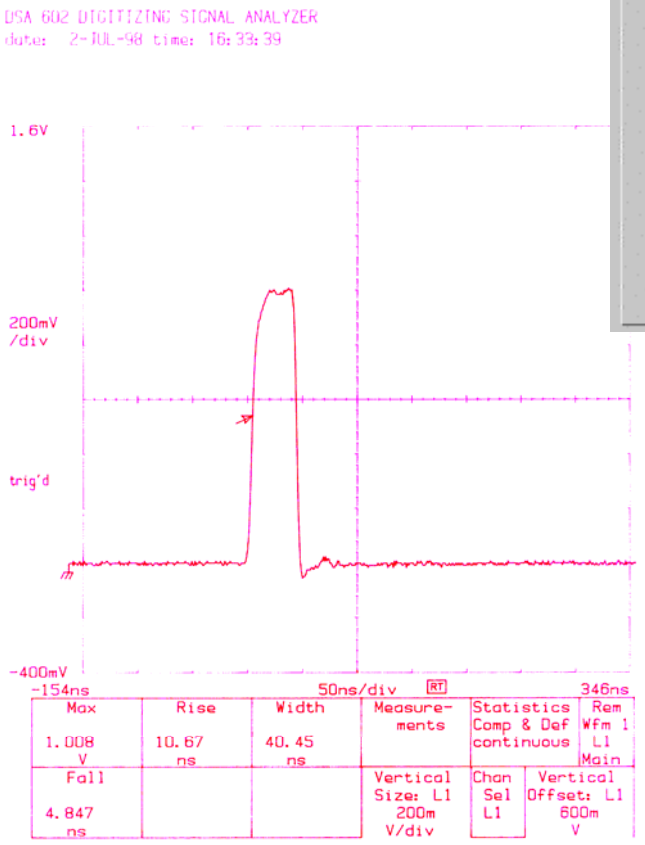
- DDE (EMC-Baden)
- CDE (QinetiQ)
- SURF (QinetiQ)
- Segmented LP (ESA,)
- EPDP (Laben)
- PlegPay (Laben)
- ASPOC (Seibersdorf, IWF)

ESA Discharge Detector Experiment (DDE) – EMC Baden

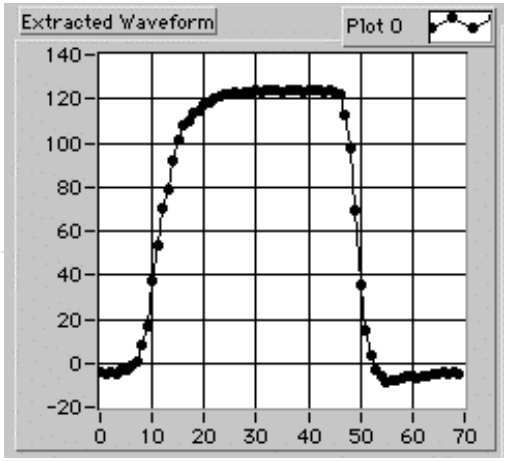


Technical Data and Calibration of the DDE

Controller	386 based PC104 25 MHz; 4 MB RAM; 3 MB flashROM
Data/Command interface	RS 232 to host S/C
Power supply	28 V max. 30 W
Total Weight	4500 g
Data acquisition	
Field sensor signals	2 (redundant) high speed ADCs
Peak detector signals	1 low speed ADC with MUX
Storage	Internal FlashROM up to 8000 events
High Speed Analogue Acquisition (field sensor)	
Analogue bandwidth	300 MHz
Sample rate	1 GSa/s
Input impedance	50 Ω
Input voltage range	± 1 V @ 50 Ω
Analogue Acquisition (peak detection)	
Sample rate	50 KSa/s
Input	high ohmic, multiplexed
Input voltage range	± 5 V



real input pulse



Response from the DDE, stored in memory and transferred via serial interface
sample rate = 1 GSa/sec (1 sample per nanosec)

Charging Detector Experiment

Developed by QuinetiQ

in the frame of ESA contract 16808/02/NL/JA

Technical Officer: J. Wolf, TEC-EEE

SPINE, 28-5-2008

CDE Main Tasks

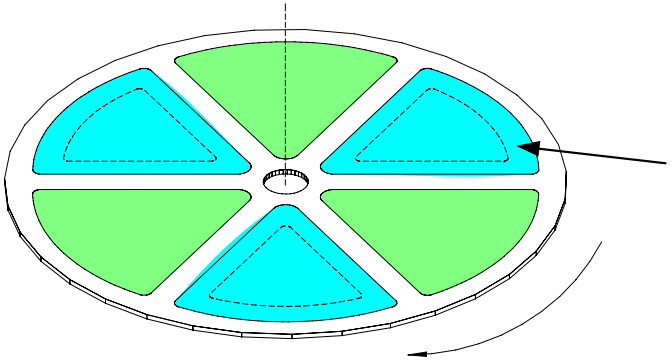
- To measure the electrostatic charge potential on a dielectric sample surface and on two embedded electrodes
- Detection of possible discharges from the dielectric under test
- To measure (option) the penetrating electron environment simultaneously (charging currents at different shielding depths)

CDE Main Features

- Detectable voltage 100V .. 4000V
- Measurement accuracy 5%
- Data storage capacity 200 data sets
- Self-test sequence once per day
- One box for the controller and one for each of two sensor units (containing the dielectrics with embedded electrodes)
- Simple serial data and command interface
- 12V-45V power Input voltage with input EMI filtering
- Overall mass < 2500g
- Operating temperature range –30 to +45 °C
- High level of autonomy for in-flight measurements
- Optional SURF sensor for the measurement of charging currents
  - Mass 300g
  - Measuring range fA/cm^2 to pA/cm^2

Measurement principle

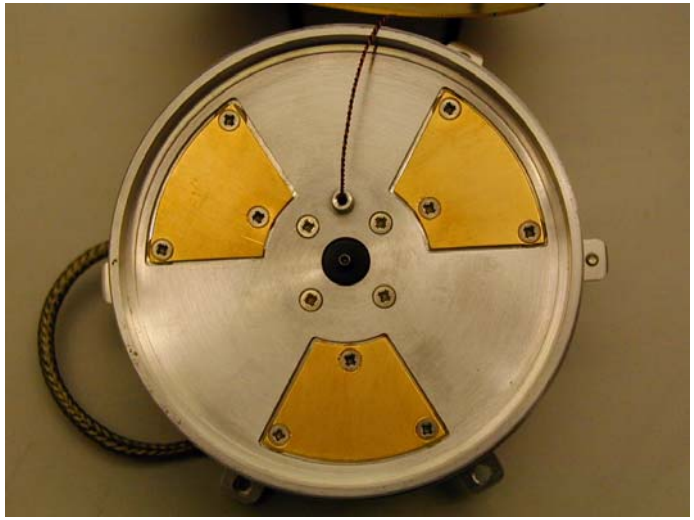
Simple induction probe

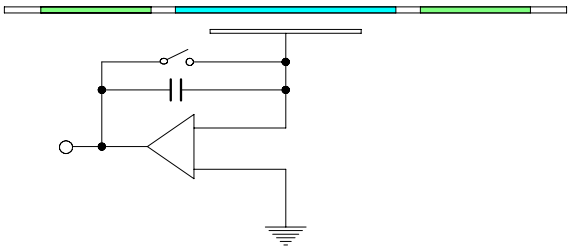


Dielectric

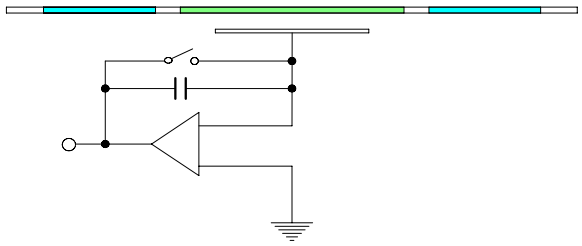
Reference electrode

Induction probes (normally located underneath reference electrodes)





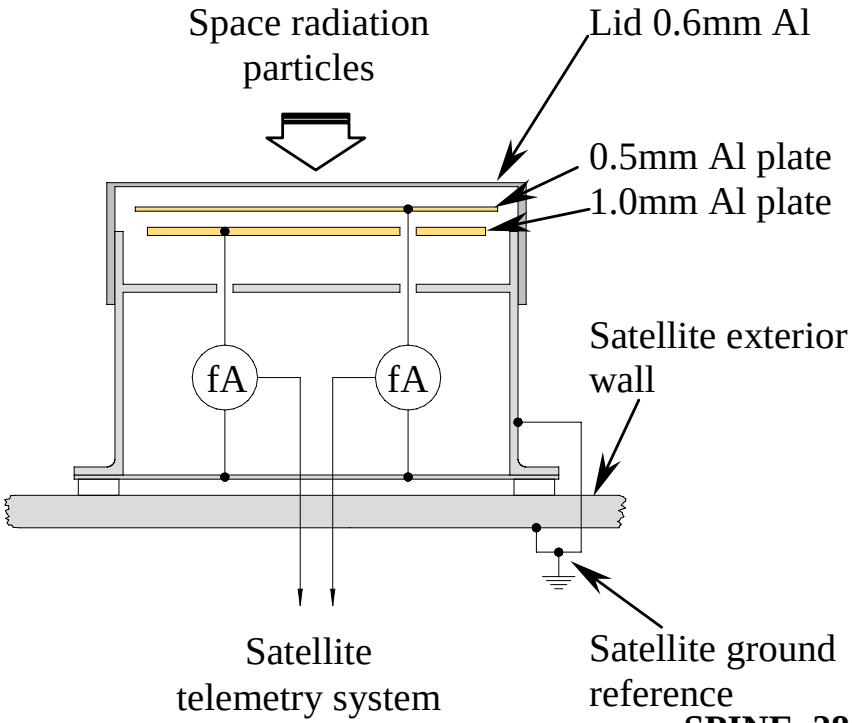
Normal disc position. Induction probe sees reference electrode, which is either grounded or has a calibration potential applied. Charge amplifier is reset to zero prior to measurement.

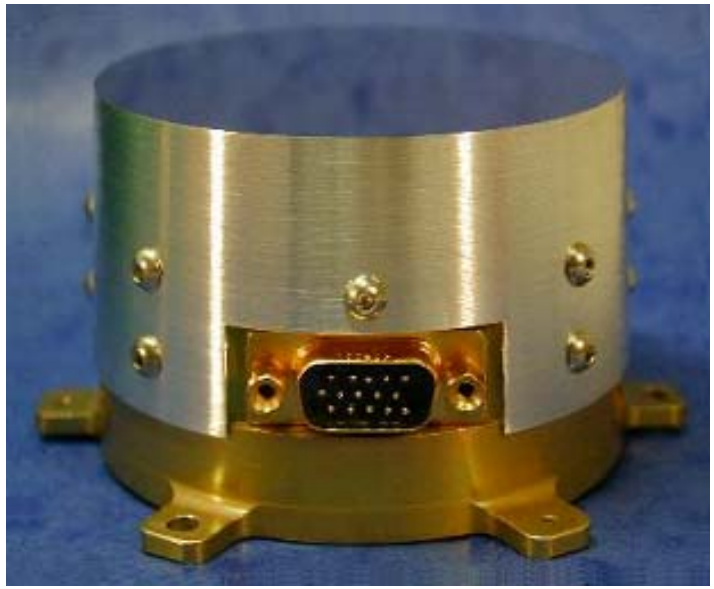


Disc rotated by 60° to the measurement position. All probes now see their associated dielectric. Disc is rotated back to normal position once measurement is completed.

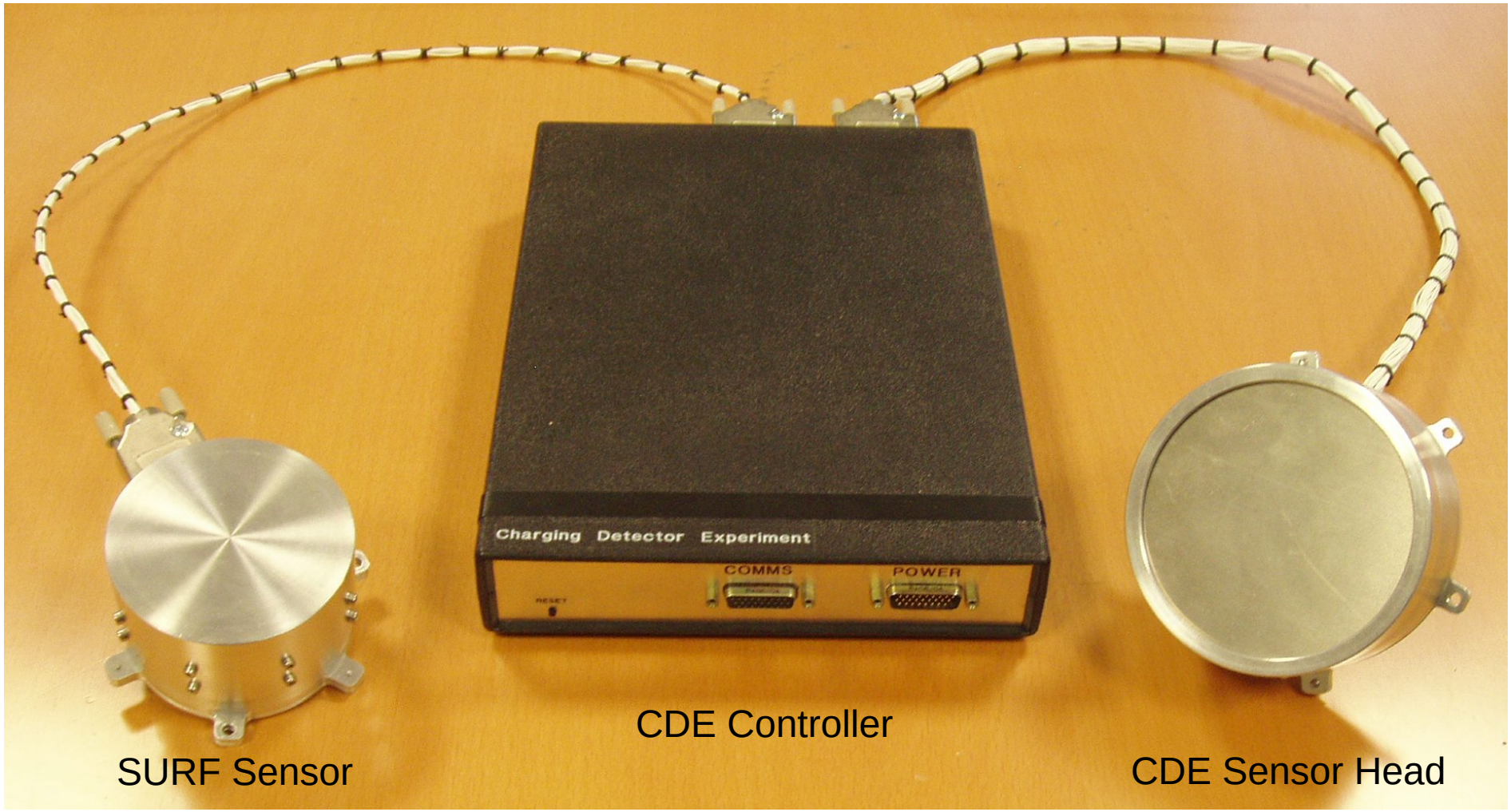
SURF Sensor

- Diagnostic for the environment local to CDE
- 300g, 100mW, +/-12V from controller





CDE Hardware



SURF Sensor

CDE Controller

CDE Sensor Head

DEMETER/Segmented LP

Fig. 2. Overview of the DEMETER Langmuir Probe instrument which is comprised of two Langmuir probe sensors: a cylindrical sensor (diameter 0.6 cm, length 5 cm) and a segmented spherical sensor (sphere diameter 4 cm).

SPINE, 28-5-2008

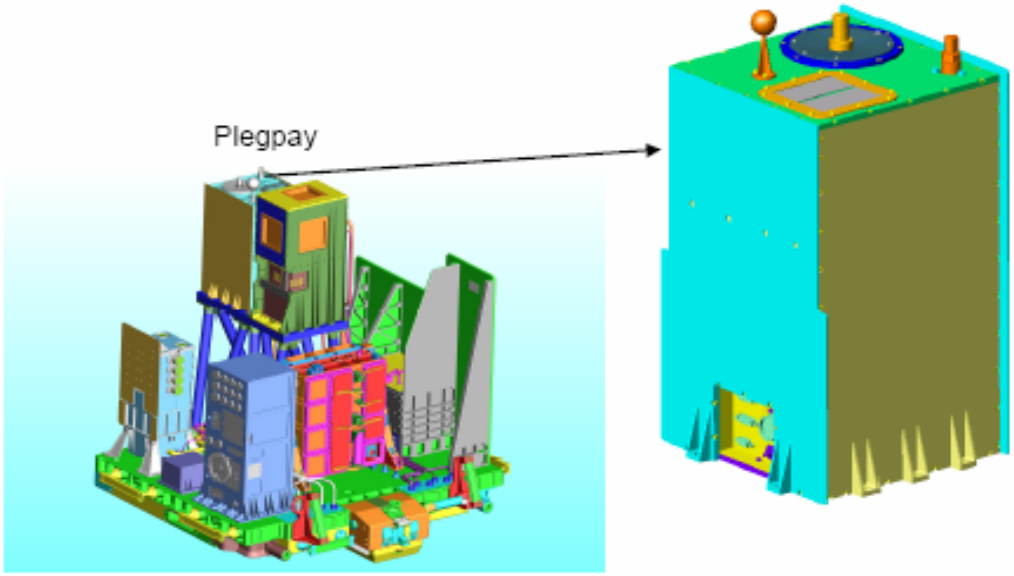
On-Going activities at TAS-I (Florence/Milano plants) in the field of Spacecraft Charging and Spacecraft-Plasma Interaction

TAS-I contribution to the 13° SPINE Meeting
28-29 May 2008

PLEGPAY Instrument

Plegpay is an experiment package on-board the ISS (EuTef platform)

OBJECTIVES:
Validation of functionality and performances of the plasma contactor technology under actual iono-spheric environmental conditions and through extensive in-flight operation.
Verification of the plasma contactor clamping capability through the measurement of the emission current as function of potential unbalance.
Investigation of the the plasma contactor operation by plasma diagnostic tools



MAIN EXPERIMENTS:

Exp1 - Plasma Contactor clamping capability investigation :

- ***forced I-V characterization*** **due to internally-generated voltage unbalance**
- ***I-V characterization in presence of natural voltage unbalance***

Exp2 - Solar Array/ Plasma interaction

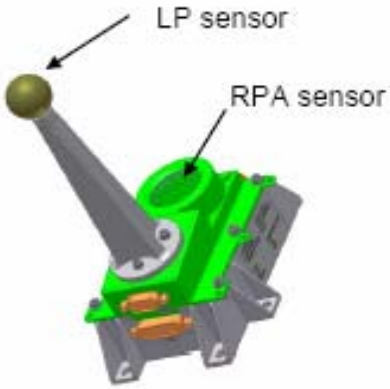
Exp4 - Long Duration Test : **1000 h operation with on-off cycles**

EPDP instrument for LISA PF

EPDP for LISA PF is an instrument devoted to the monitoring of the Electric Propulsion System on board LISA PF

OBJECTIVES:
-Monitoring of the plasma environment generated by the FEEPs thruster and their related neutralisers (also under development at TAS-I) through the use of LP and RPA sensors.
-Estimation of the S/C local Plasma potential through tracking of the LP floating potential.
-Monitoring of S/C surface contamination effects through QCM data analysis

The instrument takes fully into account SMART-1 EPDP design heritage. It is composed by three boxes and their connecting harness:
PDA: Plasma Diagnostic Assembly
PCU: Power & Controlu Unit
QCM Quartz Crystal Microbalance
Main Operational Modes:
-LP data acquisitions (-200÷200V)
-RPA data acquisitions (0÷450V)
-QCM data acquisitions



PDA box


QCM box

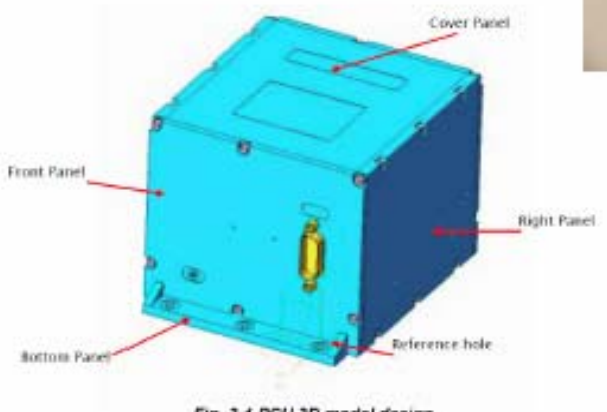


Fig. 3-1 PCU 3D model design

THALES

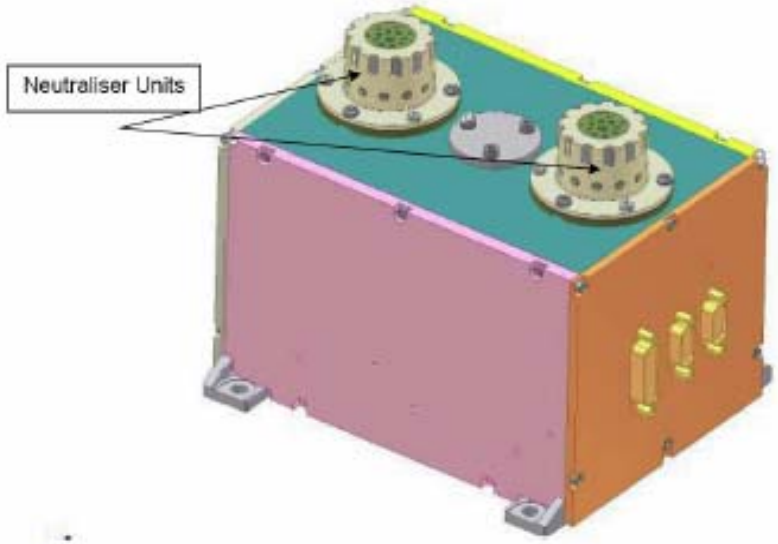
Active Charging Compensator Assembly

The ACCA (ACC Assembly) is composed by the following units:

- 2 Neutralizer Units (NU) with necessary provisions as e-gun sources to emit and accelerate the electrons outward the S/C towards the free space
- Power Supply & Control Unit (PSCU) able to:
  - ➢Power properly one of the two neutralizers (NUs)
  - ➢Switch power between any of the two neutralizers (NUs)
  - ➢Interface analog low power signal to drive heater,anode bias Voltages
  - ➢Generate the required TLM.

Between the 2 NU's a suitable room is left for eventually introducing (optional arrangement) a Langmuir Probe to perform a plasma diagnostics/ investigation.

OBJECTIVES:
-To minimise negative absolute charging of S/Cs in GEO (and LEO polar) environments.
-To alleviate differential charging phenomena (TBC).



ASPOC

A problem with accurate measurements of charged particles and electric fields in space is electrical charging of the spacecraft. This charging is created by ultraviolet radiation from the sun that knocks off electrons from the surface of the spacecraft. The negatively charged electrons remain in the neighborhood of the spacecraft, which is now positively charged up to one hundred volts. This creates an electric field that strongly influences the orbits and energies of oncoming charged particles.

A solution to this problem is the active emission of positive charges through a beam of high energy ions. The objective of the ASPOC (Active Spacecraft Potential Control) instrument is to investigate this ion beam and its interaction with the surrounding particles, connected with the reduction efficiency of the spacecraft charge to acceptable levels.

This instrument is being developed by an international workgroup, which the institute of space research of the Austrian academy of sciences chairs as principle investigator. This institute is also responsible for the complete digital electronics of the instrument. An important part is made up by the ion emitters, which were developed by the Austrian research center Seibersdorf. The liquid metal ion emitter that will be operated is especially suited for outer space because of the low melting point of Indium. The electronics for the current supply and high voltage generation is developed by Forsvarets Forskningsinstitut (FFI) in Kjeller, Norway. The instrument casing, the lid and shutter mechanism for the ion emitter module and test support are the responsibility of the Space Science Department of ESA at ESTEC. The mass of the instrument is 1.9 kg, the power usage up to 2.7 Watt.

- Function
- Setup
- Impact
- Operation

Summary

- Broad experience in Europe (especially for plasma measurements, effects mitigation).
- A few ‘effect experiments’.
- Little approved missions.
- Several TBC flight opportunities (especially for EP, and Science).