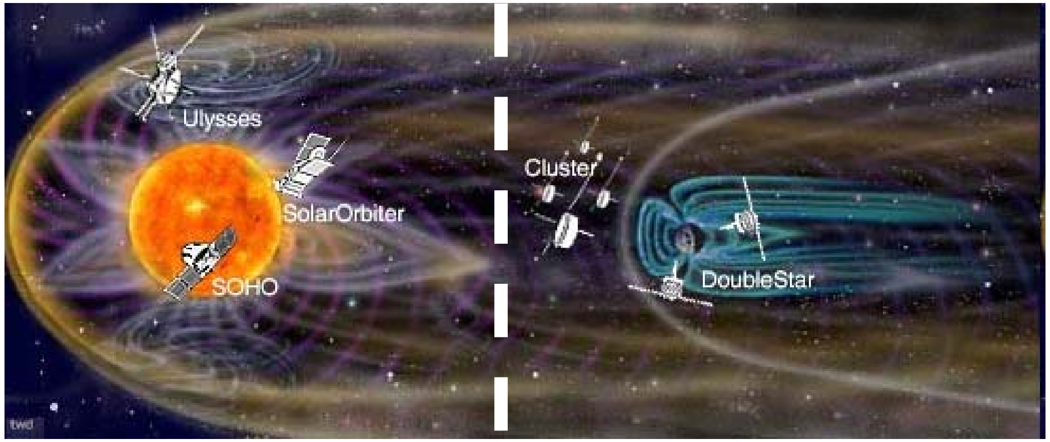
Spacecraft Charging European overview

- European Space Agency
  (Alain Hilgers, David Rodgers)
- Centre Nationale d'Etudes Spatiales
  (Denis Payan)

ESA's relation to spacecraft charging

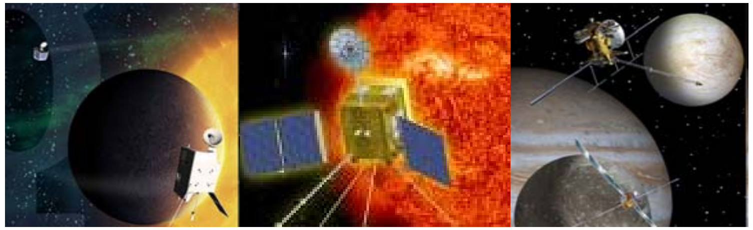
- ESA runs a space programme on behalf of its 18 member states.
  - Science
  - Application
  - Technology
  - Education
  - Other ...

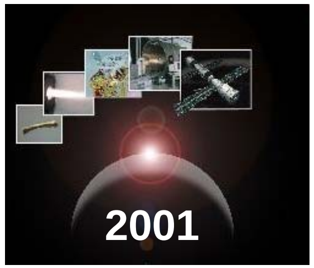


- Plasma is a factor to take into in spacecraft operations :
  - Instrumental
  - Detrimental

Activities

- Coordination activities
  - Define European space programme in coordination with member states :
    - Space missions
    - Support R&D activities
  - Reinforced coordination on spacecraft-plasma interactions :
    - SPINE
    - -> SEENoTC (B, E, F, G, SE, UK)
    - -> Harmonisation board -> MS programmes
    - -> ESA Technical dossier -> R&D programme
  - International collaborations:
    - Standards: ECSS, ISO
    - Support to SCTC-1998, 2001, 2003, 2005, 2007, 2010, 201?






ECSS-E-ST-20-06C
31 July 2008

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space engineering

Spacecraft charging

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

Some European priority needs

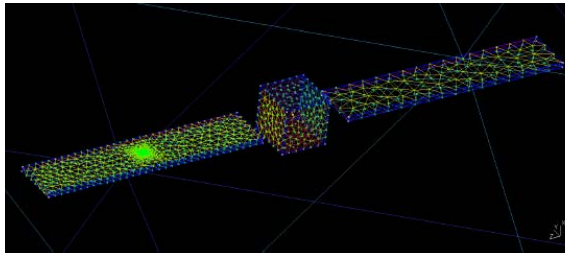
– Generic:
  - ESD characterisation and mitigation
    – ESD model (laboratory test and numerical models)
    – ESD detector
    – ESD mitigation
    – Charge alleviation
  - Electric propulsion system characterisation
  - Development of modelling capacities
    – Standardisation of models
    – Material properties characterisation

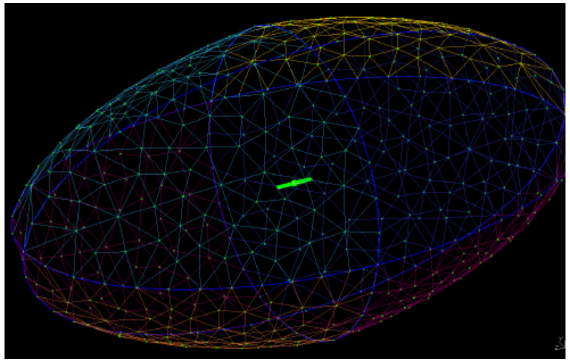
Some European priority needs

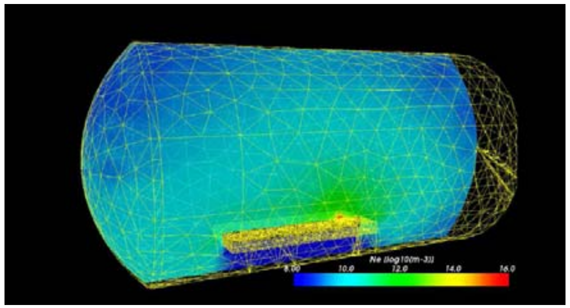
- Programme specific needs:
  - Galileo satellite environmental specification verifications
    - Analysis of data collected on Giove A & B
    - Development of new monitors
  - Jovian environment specifications
  - ESA space situational awareness programme preparation :
    - Cold plasma monitor
    - Hot plasma detector
    - Solar wind plasma monitor
    - High fidelity energetic electron monitors
    - Tether for de-orbiting

Examples of achievements : SPIS

- 3D charging-PIC code
- Become a standard in spacecraft-plasma interaction modelling in Europe.
- Recent applications:
  - Modelling of FEEP-thruster plumes
  - Modelling of ESD initiation in solar cells gap.
  - Modelling of wire boom antenna plasma environment.
- On-going developments:
  - Improvements for geo type of charging
  - Improvements for science type of applications







Example of achievements: ESD characterisation

- Cf Denis Payan

CNES R&D Activities related to spacecraft charging

Denis PAYAN CNES

With collaboration of ONERA, ASTRIUM, TAS, CRIL Technology, SUPELEC, ARTENUM, CESR, COMAT, EREMS, Paul Sabatier University, CNRS, …

& ESA

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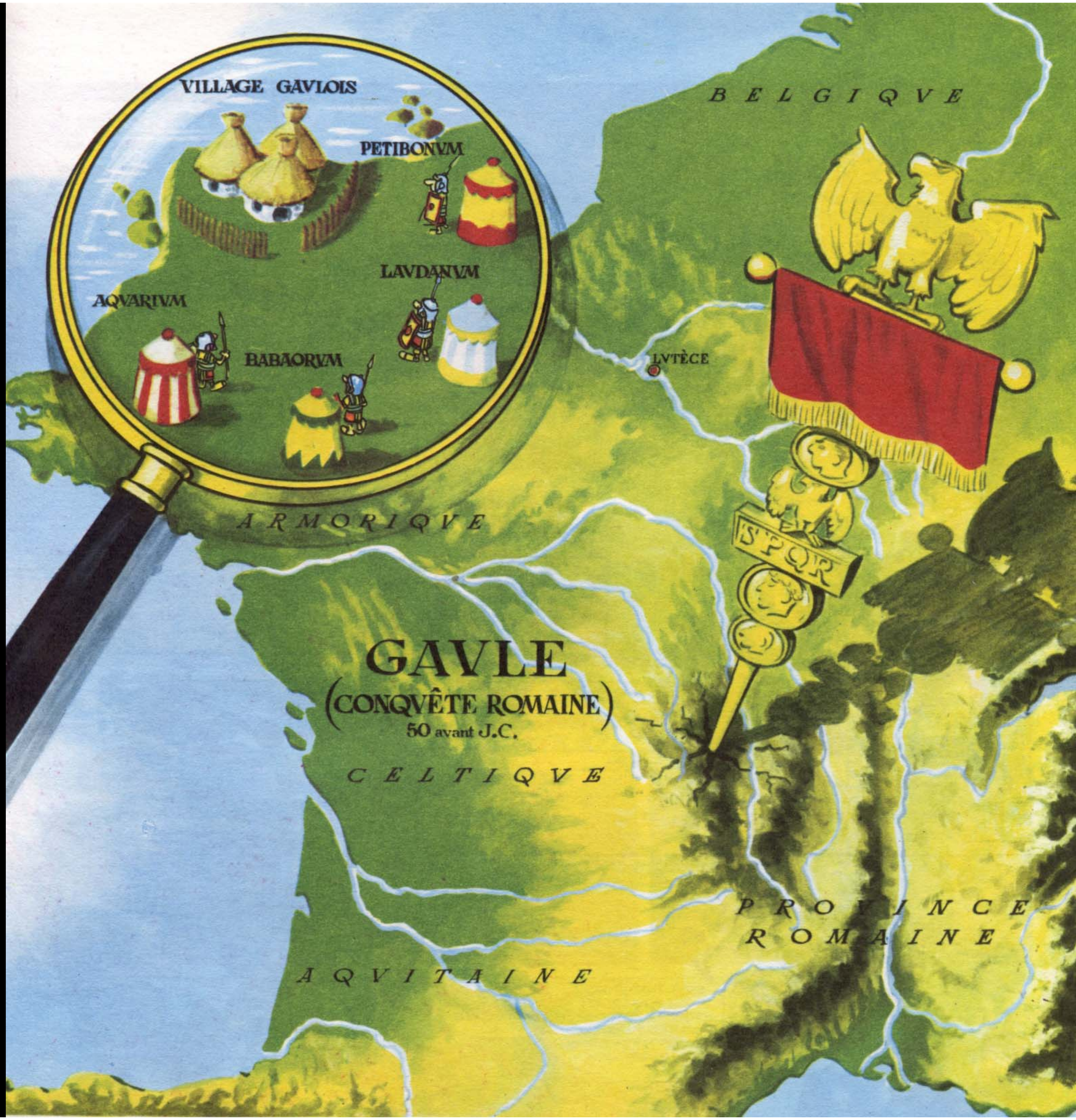
VILLAGE GAVLOIS
PETIBONVM
LAVDANVM
AQVARIVM
BABAORVM
BELGIQVE
LVTÈCE
SPQR
ARMORIQVE
GAVLE
(CONQVÊTE ROMAINE)
50 avant J.C.
CELTIQVE
PROVINCE ROMAINE
AQVITAINE

European coordination

- Standard & Harmonisation

Standard & Harmonisation

- **European Coordination for Space Standardisation**
  - **E20-06** Spacecraft Charging
  - **E20-08** Inrush current for solar cells (One panel; 11A)
- Active participation to SEENoTC, Space Environments and Effects Network of Technical Competences

  SEENoTC aims to reinforce the coordination of existing and planned space environments and effects related activities in Europe, through the implementation of a coherent European programme of activities in the domain
- **General Coordination on SPIS, Standard, facilities, linked R&D activities with ESA.**
- **Coordination with Primes and manufacturers**

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Monitoring

- Radiation monitor development and flight opportunities. No datas widely available related to spacecraft charging.
  - At CNES : Detector development (CESR participation)
  - At European level : SEENoTC program

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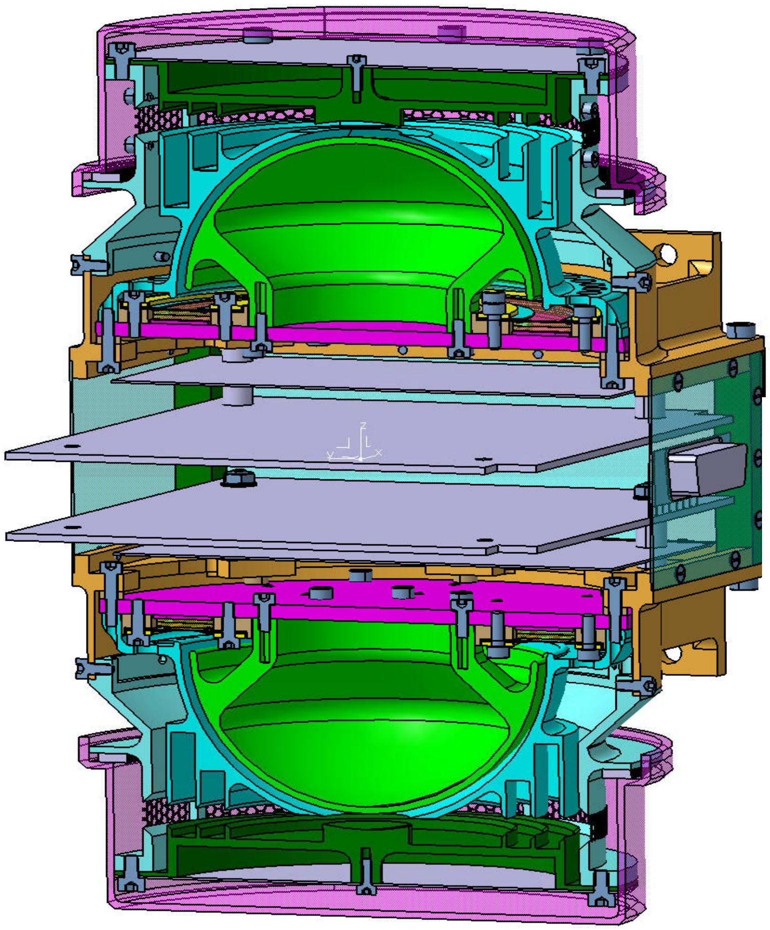
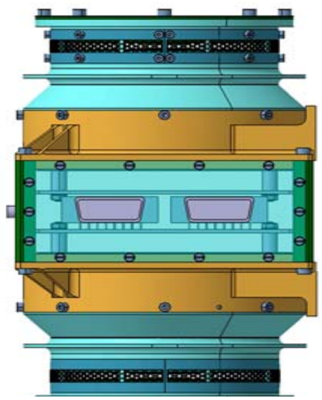
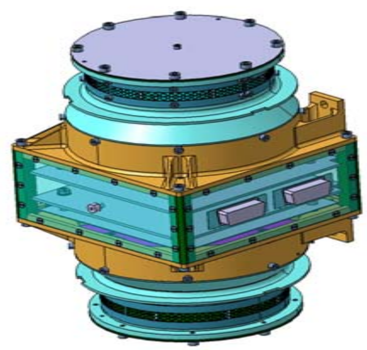
AMBER sensor

Active Monitor Box of Electrostatic Risk







- **Angle of visibility 180°**
- **Electrons and Ions measurement**
- **Flux from some pA/cm² to some nA/cm². Energy from 80eV up to 35keV.**
- **Sphere Radius internal 36 mm, external 37.8mm.**
- **Consumption 1W**
- **Weight below 1.5kg.**
- **Spacecraft interface : ICARE or Alone**

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Facilities

- **Develop facilities able to**
  - Represent space environment to provide a better qualification test for our primes, which warranty good behaviour of materials in space to their customers. (i.e. Sirene flux versus inadapted monoenergetic irradiation)
- **Need a lot of up stream studies in R&D**

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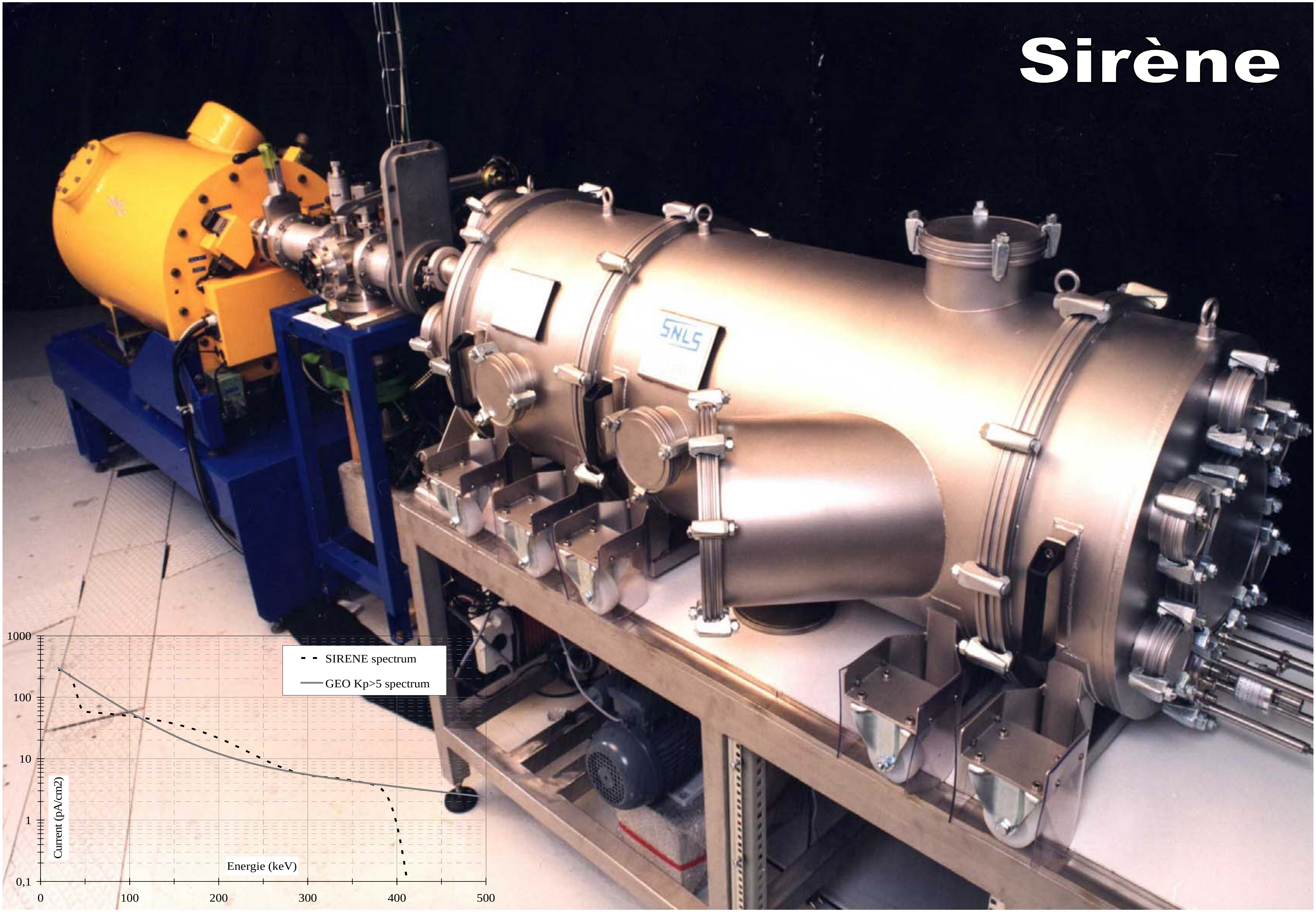
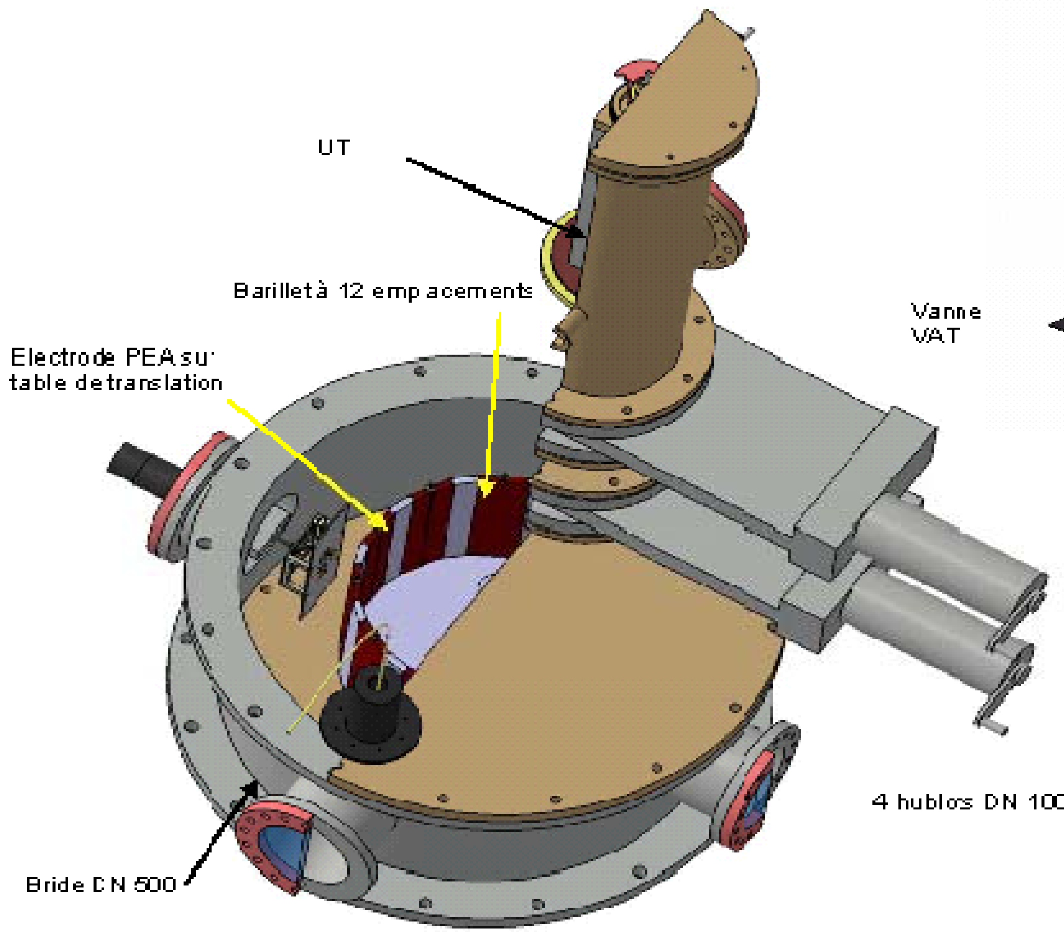
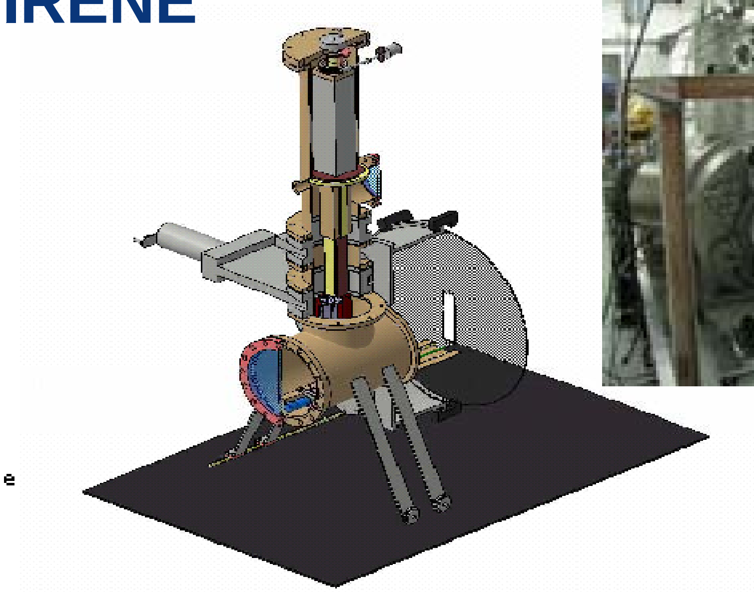
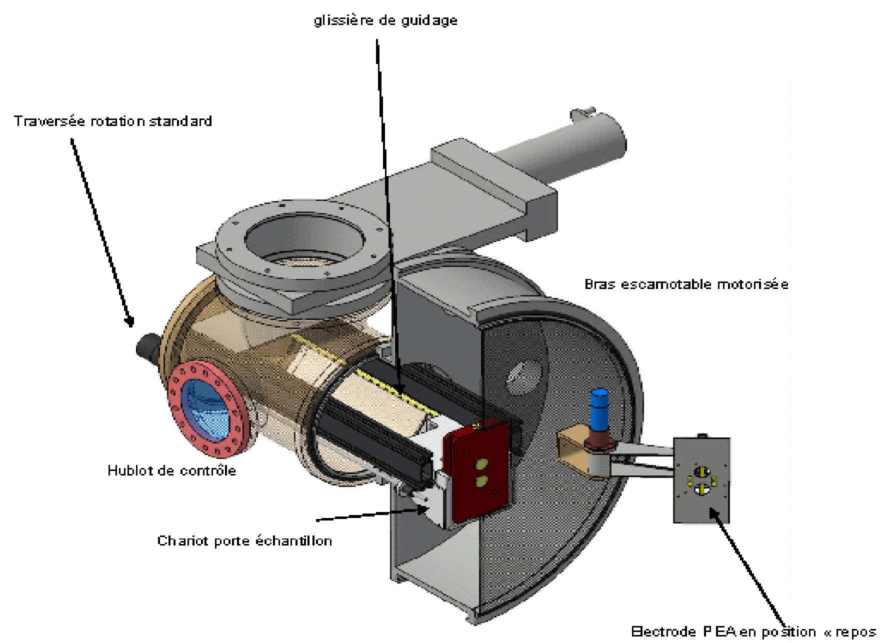

Sirène
SNLS
SIRENE spectrum
GEO Kp>5 spectrum
Current (pA/cm2)
Energie (keV)
1000
100
10
1
0,1
0
100
200
300
400
500

Transfer and Storage Unit for SIRENE







Experimental activities

- **Qualification on materials & assembly**
  - Knowledge of Material versus time, temperature, ageing, dose, UV, BOL to EOL
  - Properties evolution during life in orbit
- **Reproduce discharges in simulated condition of space ant not overestimated.**

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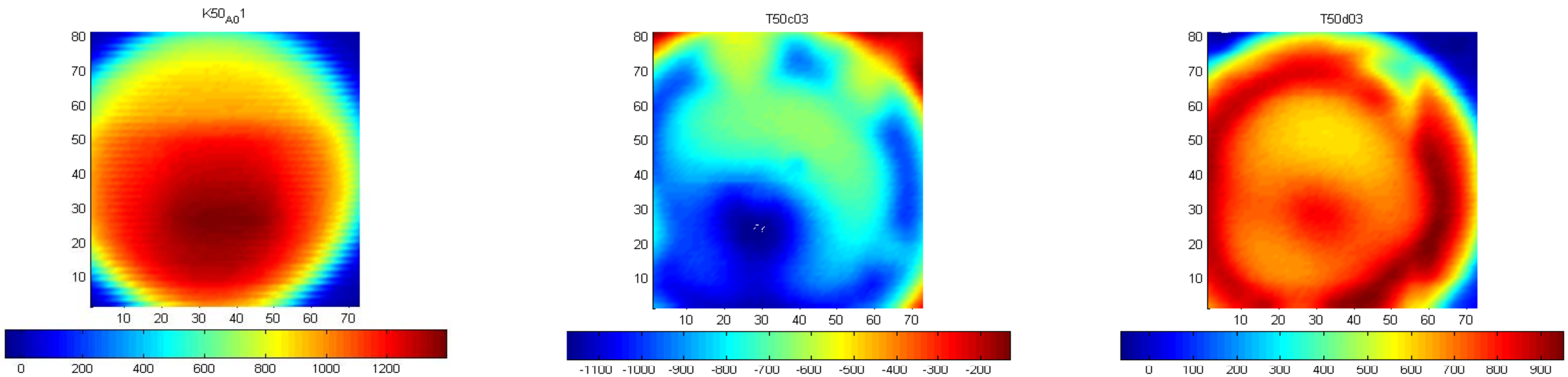
Dielectric behaviour Knowledge

- From the beginning; NEW materials and storage before use



Potential mapping on 50µm Kapton® & FEP Teflon ®

- Behaviour during all life in space

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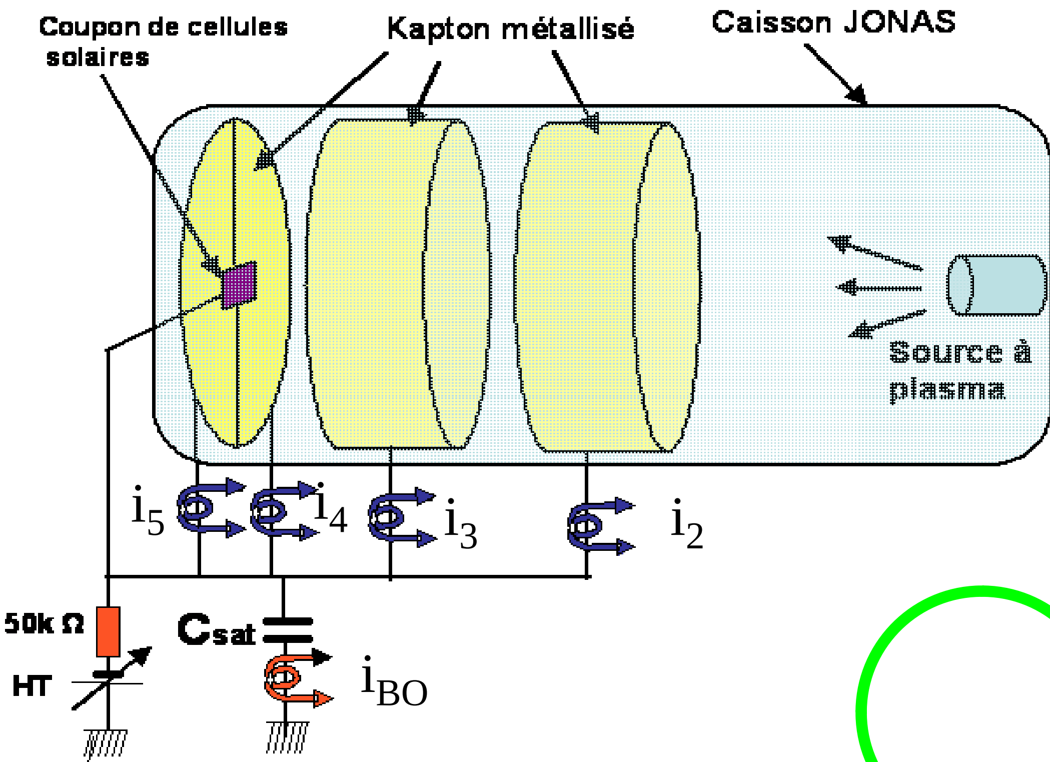
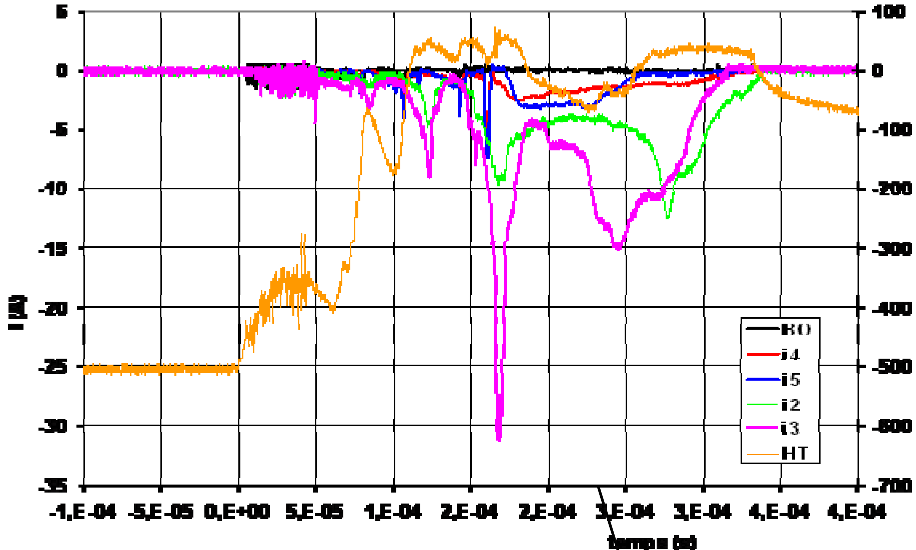
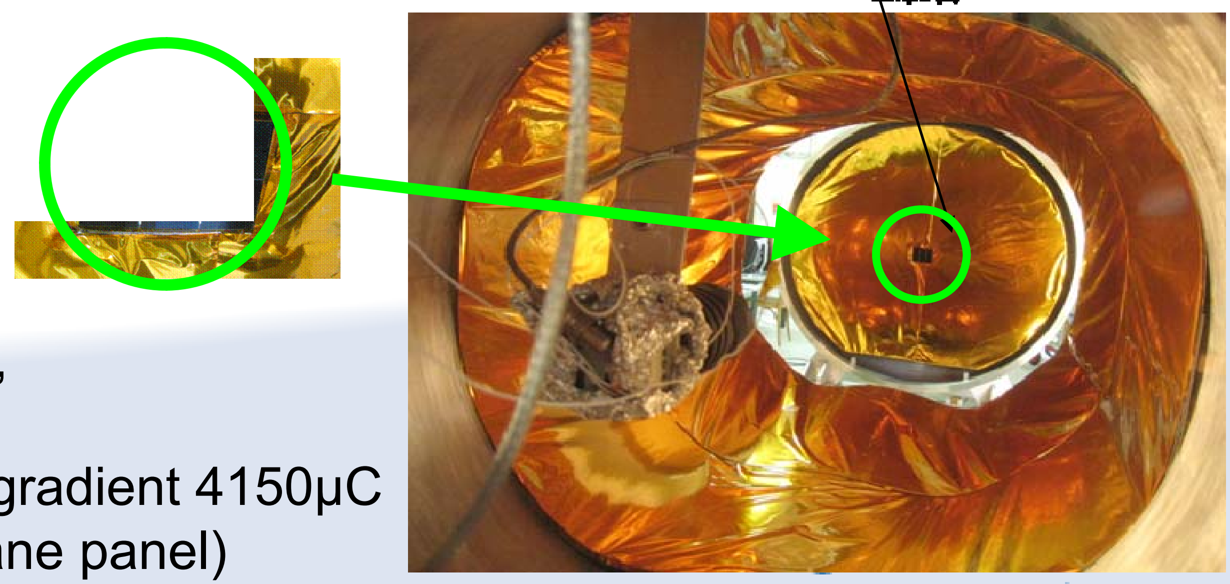
FO on large surfaces : experimental setup







Total surface in gradient 14.3m²,
Cvg Capacitance 8300nF
Theoriyical charge under 500V gradient 4150µC
Flashover radius 2.5m (a full plane panel)

SPIS Studies

- ■ Complete ESA development thanks to general or specific development
  - SPIS time dependant, Field emission, Boxes
- ■ Risky configurations
  - Cells edge, glue overlap

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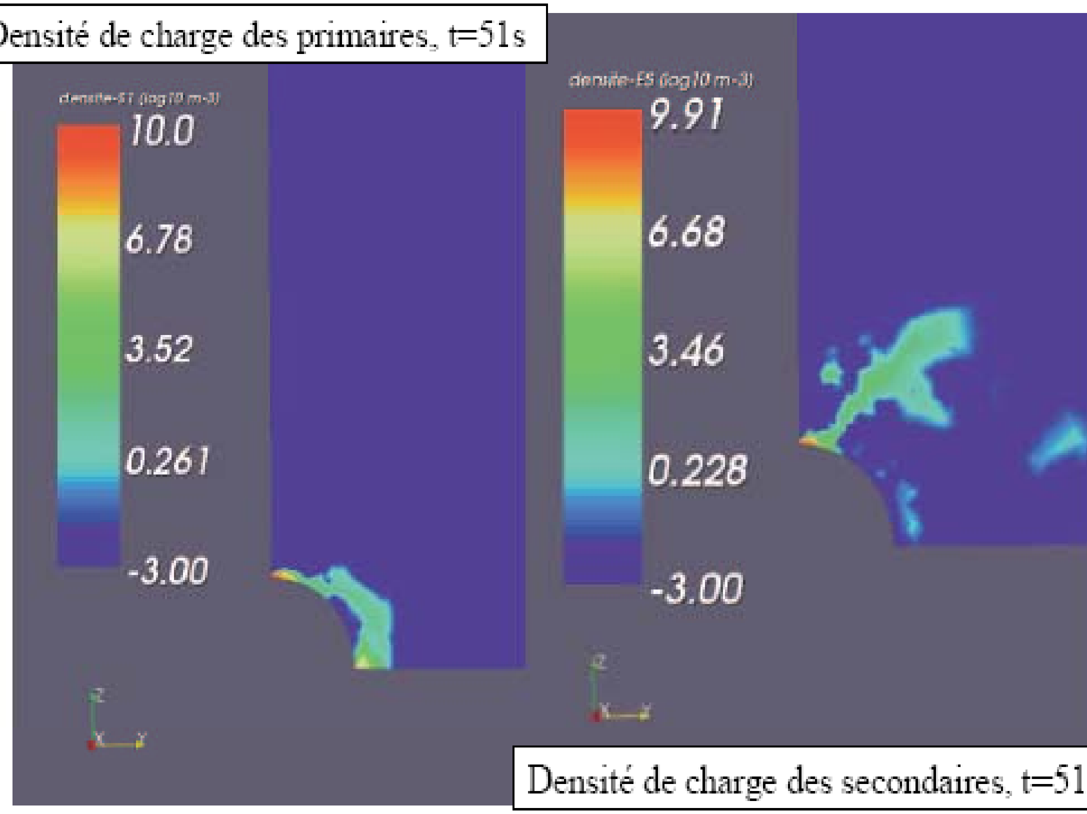
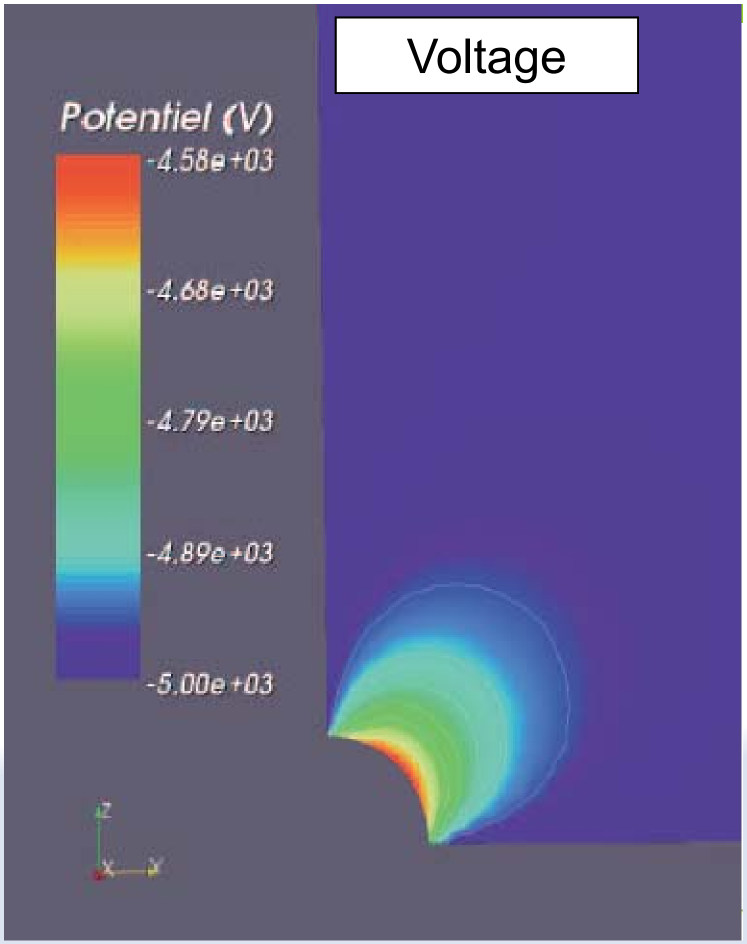
IVG situation and Discharge

Densité de charge des primaires, t=51s



Densité de charge des secondaires, t=51s

Voltage



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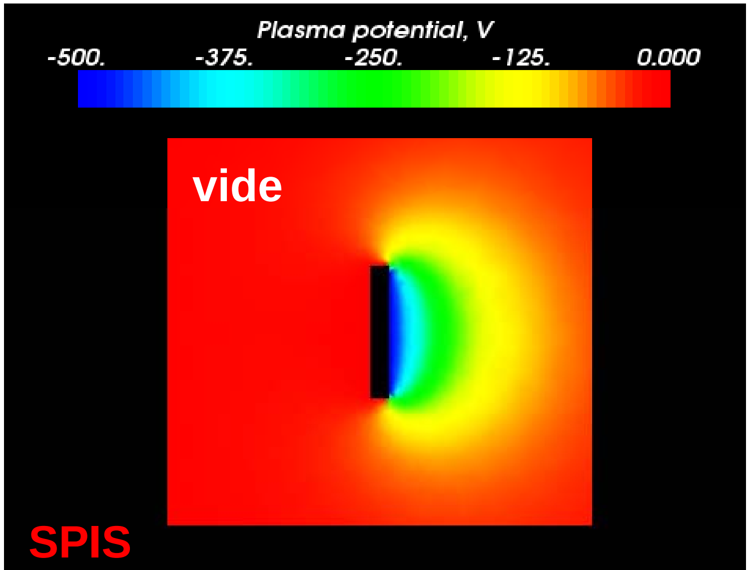
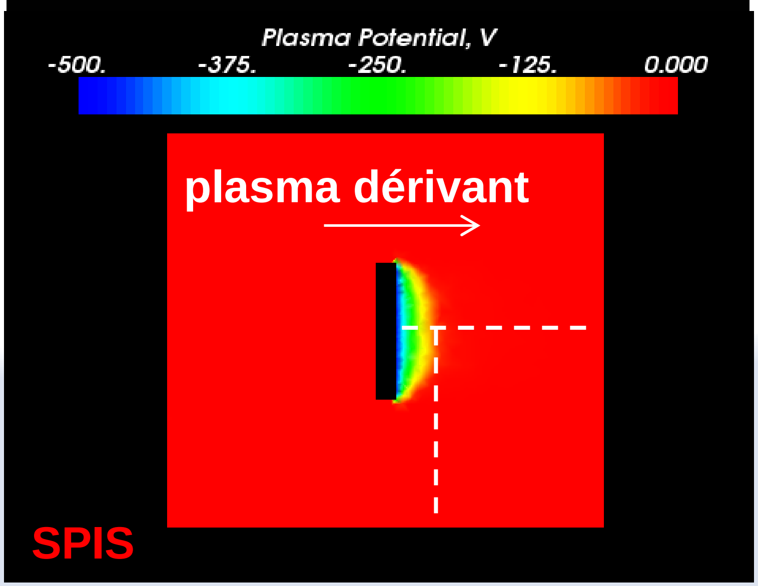
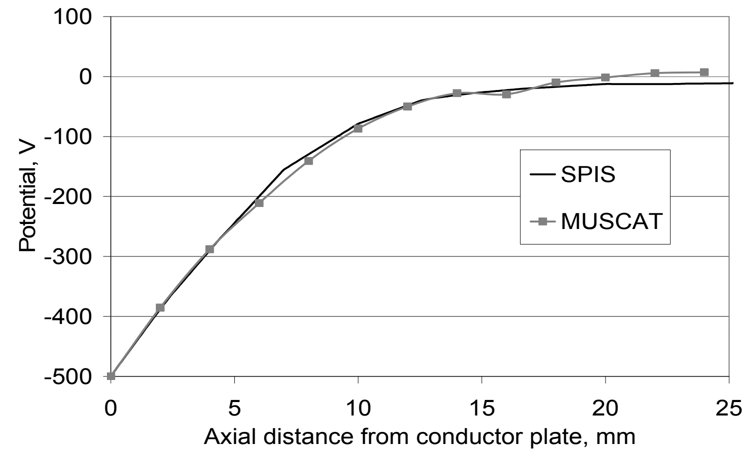
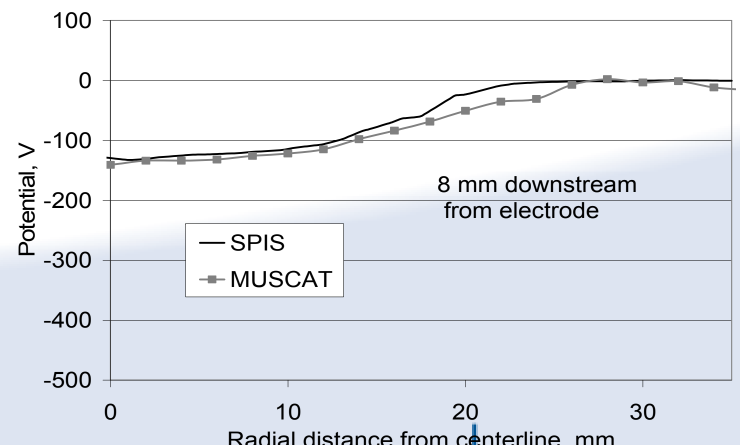

Plasma potential, V
-500.
-375.
-250.
-125.
0.000
vide
SPIS


Plasma Potential, V
-500.
-375.
-250.
-125.
0.000
plasma dérivant
SPIS


Potential, V
Axial distance from conductor plate, mm
SPIS
MUSCAT


Potential, V
Radial distance from centerline, mm
8 mm downstream from electrode
SPIS
MUSCAT

EMAGS III

- The real case

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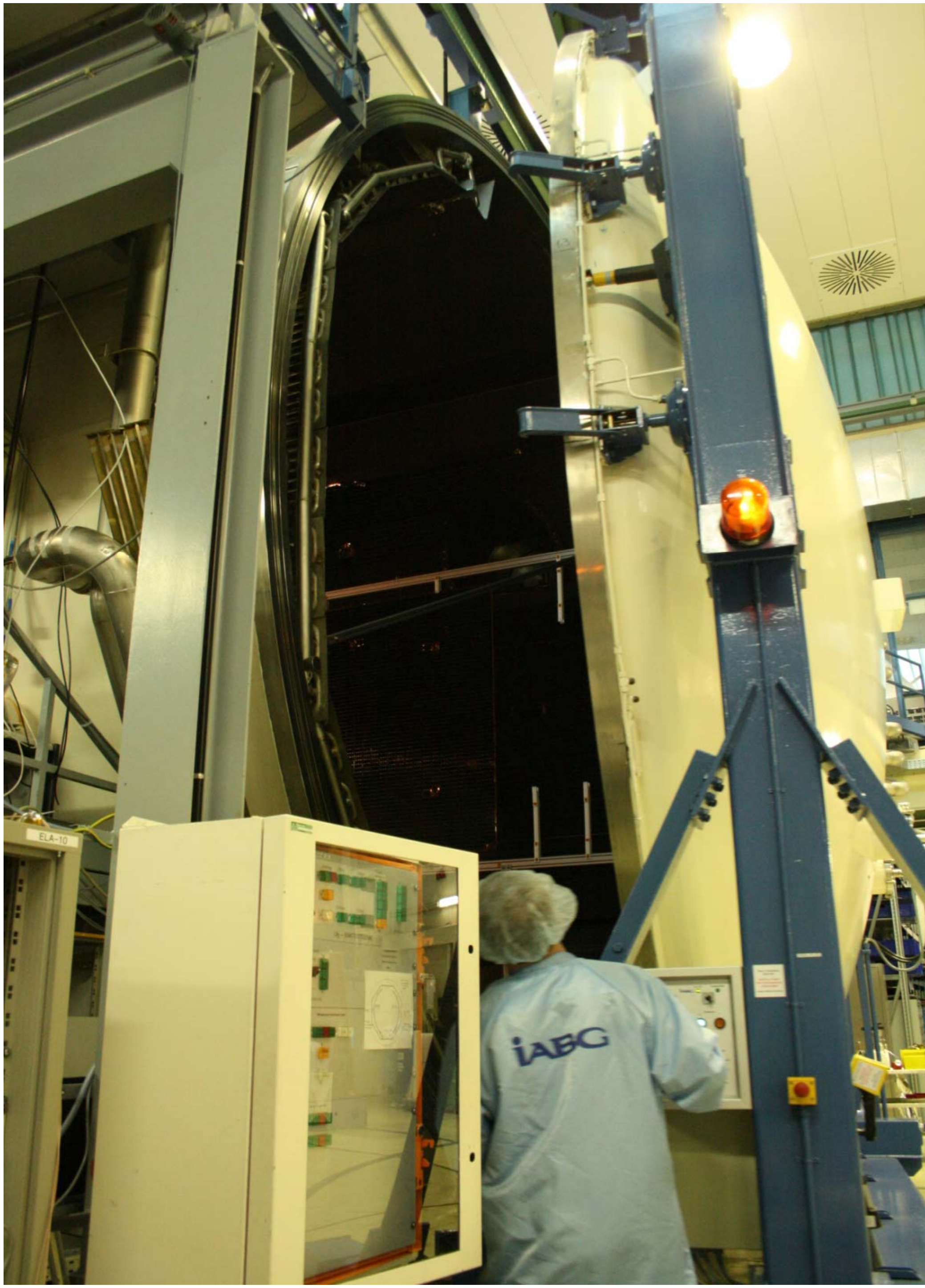

EMAGS 3


Good Luck
to USAF & NASA & all others
for the 11th SCTC,
Thank You