

# Institut d'Estudis Espacials de Catalunya

## Un instrument de futur

Jordi Isern

UCE

Prada, 25 d'agost de 2007

# Els somnis



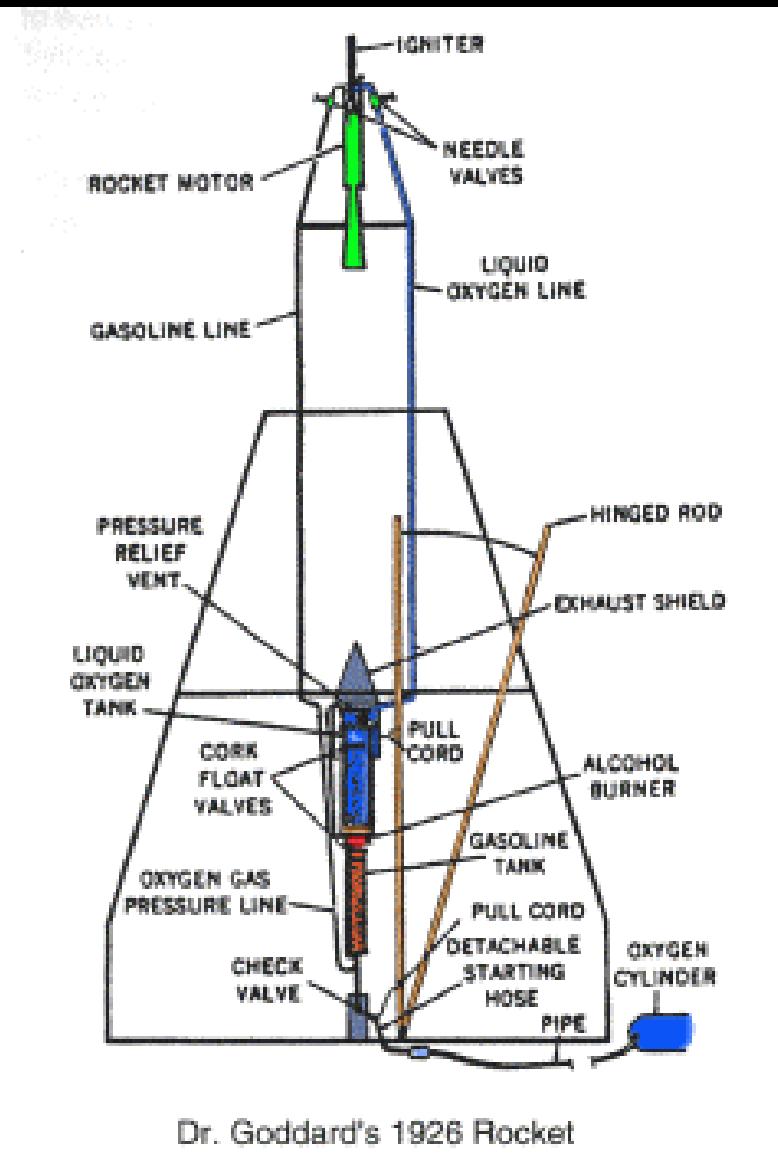
Icar

Peter Brueghel



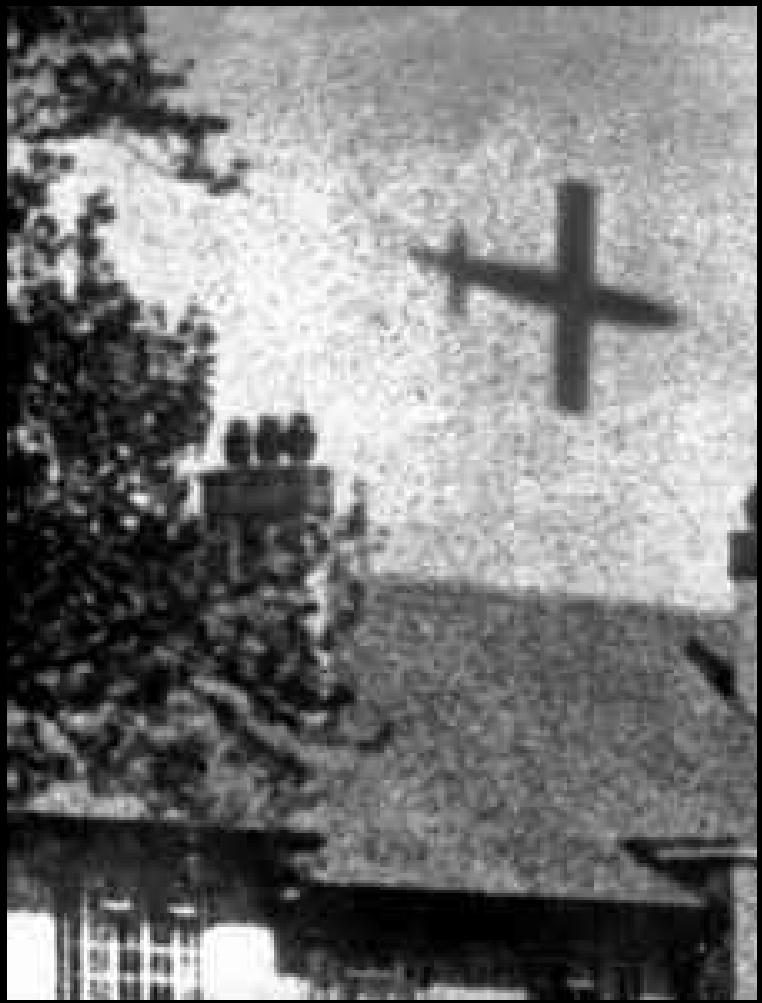
“Domingo Gonzales”  
Francis Godwin  
Bisbe de Hereford

# Els pioners



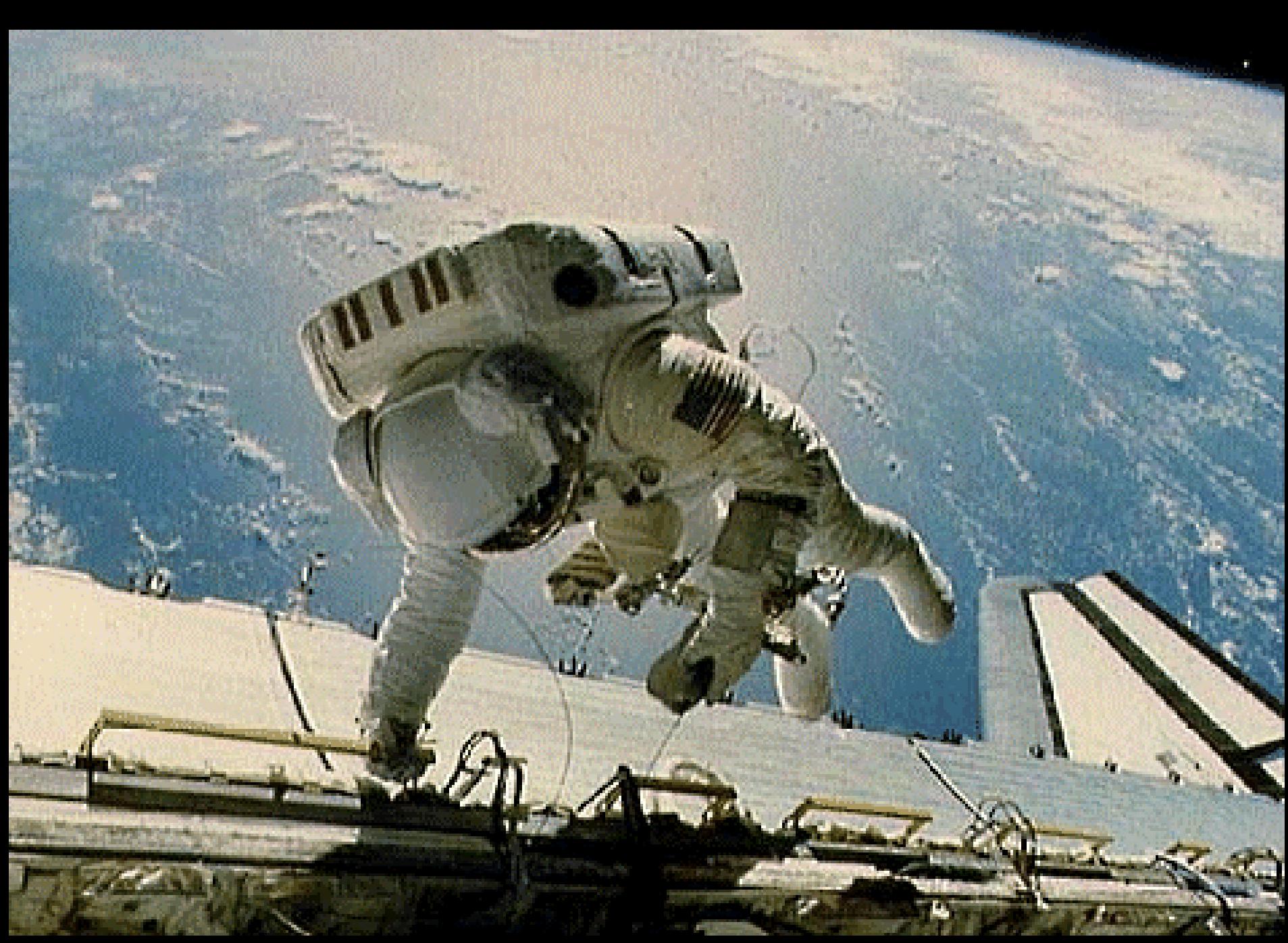
Robert H. Goddard va llançar amb èxit el primer coet líquid el 1926

- $t = 2,5$  s
- $h = 12,5$  m
- $l = 56$  m
- $v = 96$  km/h



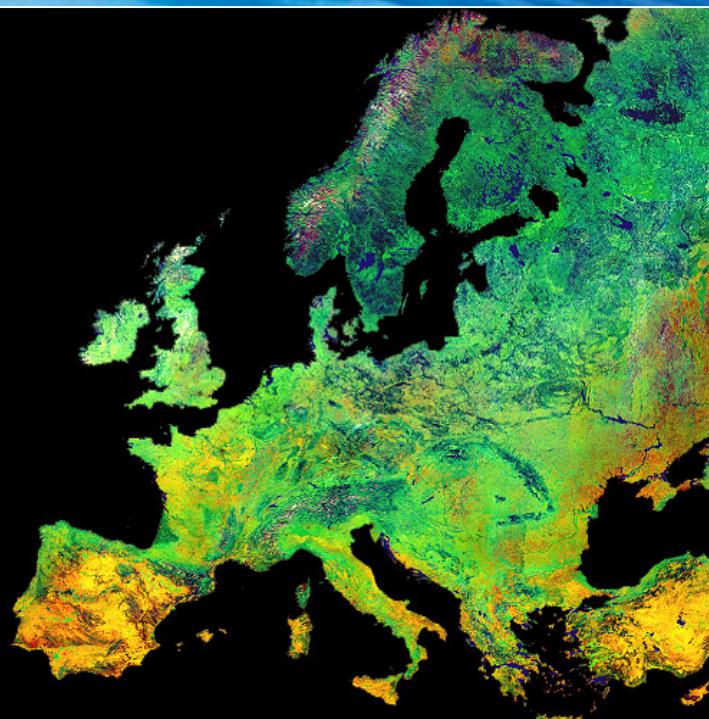
# El transbordador espacial





# *The European Space Agency*

- La idea d'una agència espacial Europea independent data de principis dels anys 60.
- ESA es va crear l'any 1975 gràcies a la fusió de dues organitzacions: ESRO i ELDO, responsables de la construcció de satèl·lits i llançadors.  
Actuament la formen 17 Estats Membres.



## Estats membres d'ESA

- 17 estats membres d'ESA :
  - Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Norway, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.
  - Canada i Hongria participa en alguns projectes via un acord de cooperació.



|      | D | B | F | I | NL | GB | DK | SP | S | CH | IRL | A | N | FIN | P |
|------|---|---|---|---|----|----|----|----|---|----|-----|---|---|-----|---|
| 2000 | ■ | ■ | ■ | ■ | ■  | ■  | ■  | ■  | ■ | ■  | ■   | ■ | ■ | ■   | ■ |
| 1995 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |
| 1987 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |
| 1975 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |
| 1973 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |
| 1962 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |
| 1962 | • | • | • | • | •  | •  | •  | •  | • | •  | •   | • | • | •   | • |

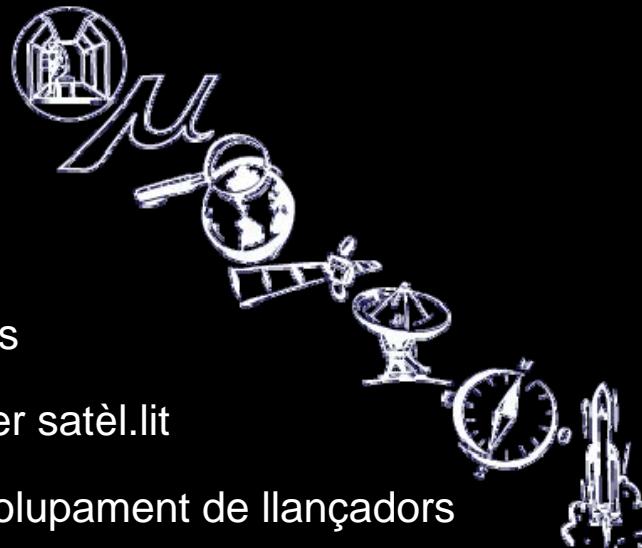
Grècia i Luxemburg hi van ingressar el 9 de desembre de 2005.

## Objectius d'ESA

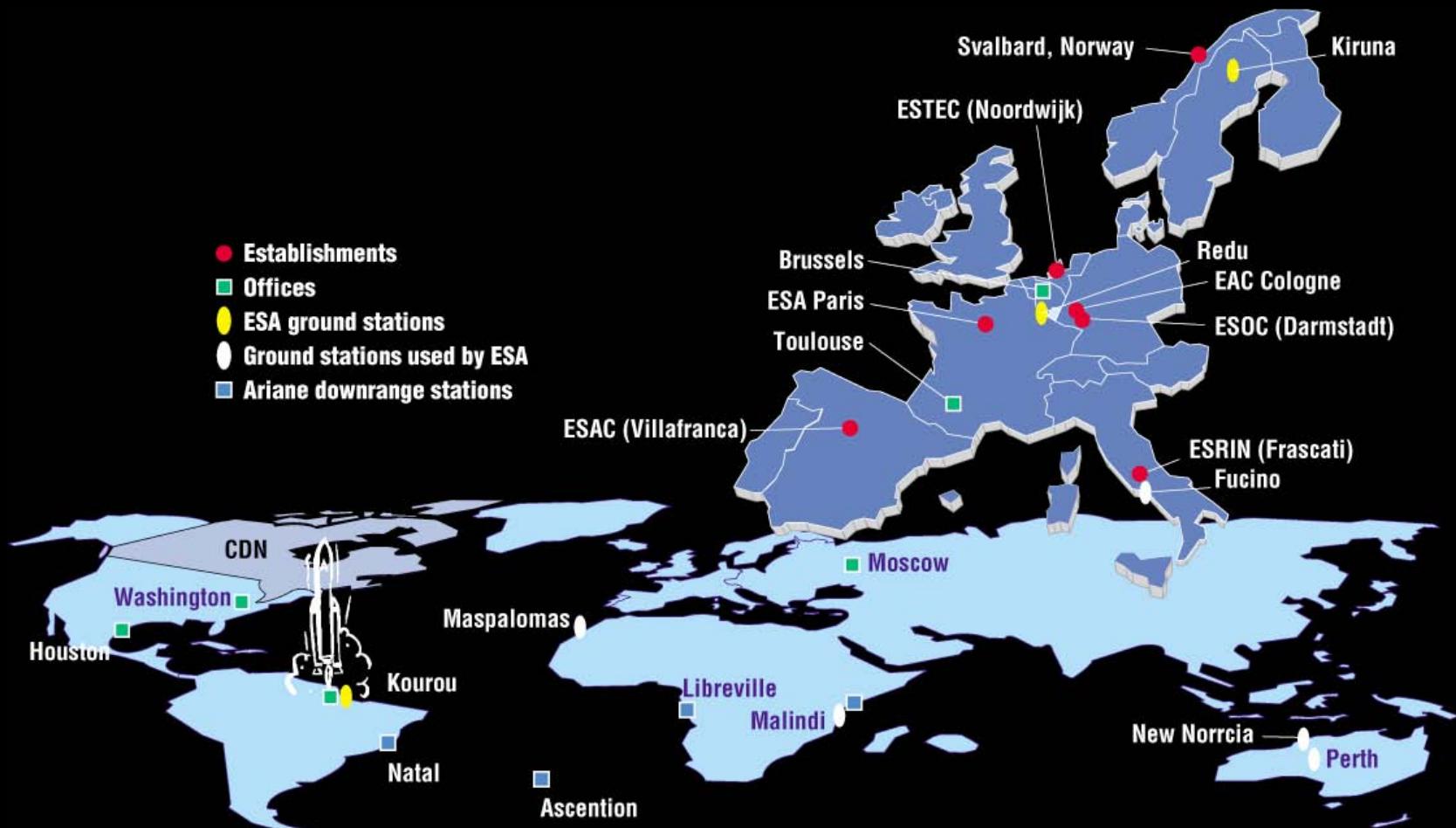
- És una organització inter-governamental que té com a missió proporcionar i promoure – amb finalitats exclusivament pacífiques - la explotació de:
  - Ciència espacial, recerca & tecnologia
  - Aplicacions espacials
- ESA ho aconsegueix a través de:
  - Activitats i programmes espacials
  - Política espacial a llarg termini
  - Una política industrial específica
  - Coordinant els programmes espacials europeus i dels estats membres.

## Programmes ESA

- Tots els estats membres participen en el programa obligatori de ciència espacial.
- Adicionalment, els socis escullen el grau de participació en els programmes opcionals:
  - Vols tripulats
  - Microgravetat
  - Observació de la Terra
  - Telecomunicacions
  - Navegació per satèl·lit
  - Desenvolupament de llançadors

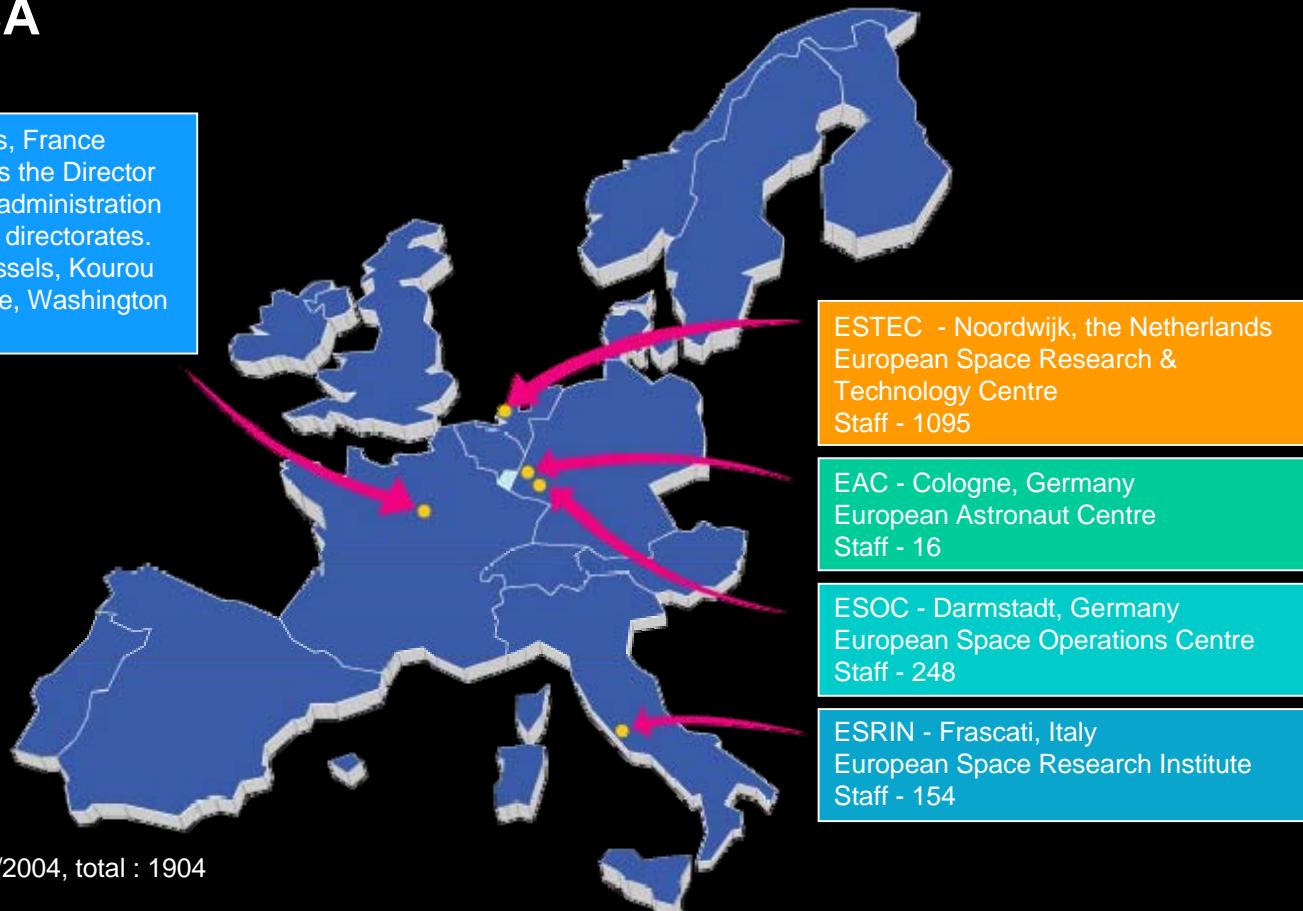


# Instal·lacions d'ESA



## Centres ESA

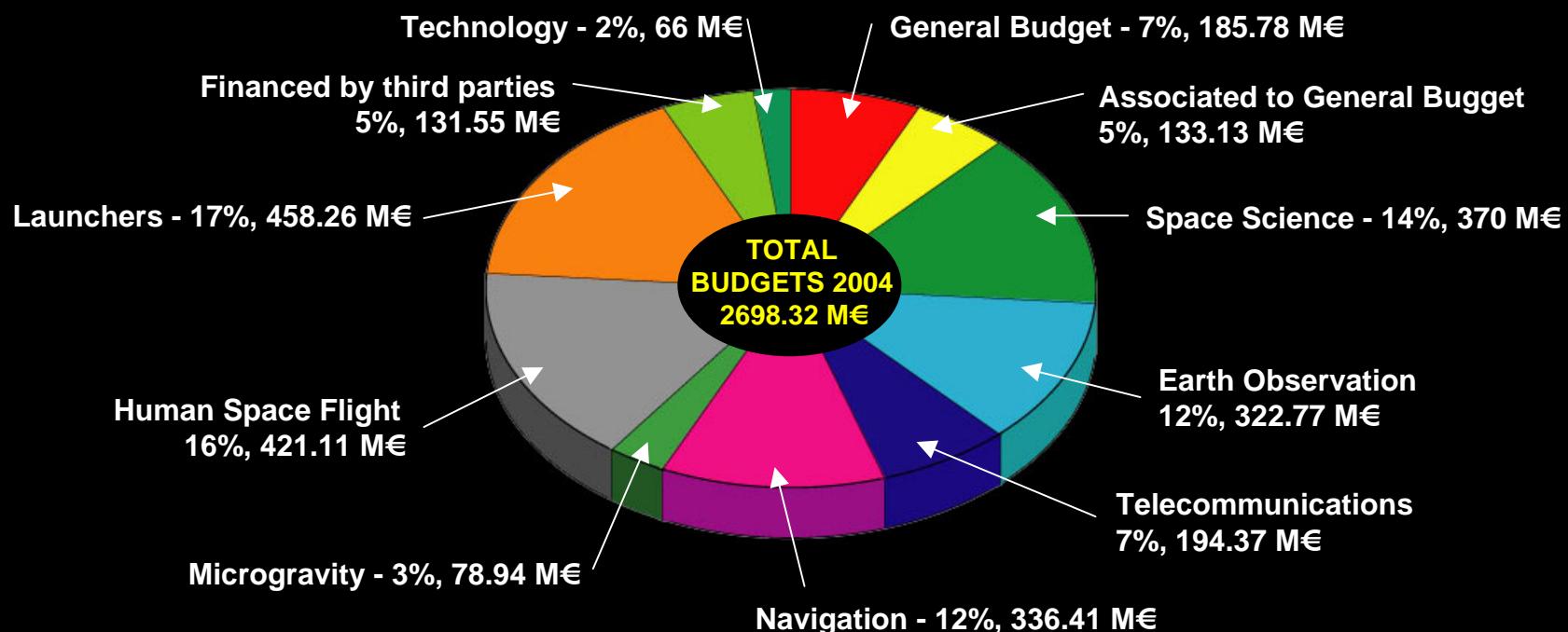
**HEADQUARTERS** - Paris, France  
ESA headquarters houses the Director General's office, general administration and the main programme directorates.  
Staff - 391 (including Brussels, Kourou liaison, Moscow, Toulouse, Washington and Houston offices).



# Pressupost 2004, distribució per programmes (pressupost 2006: uns 2900 €)



|  |              |
|--|--------------|
| APPROVED PROGRAMMES                    | : 2566.78 M€ |
| + PROGRAMMES FINANCED BY THIRD PARTIES | : 131.54 M€  |
| = TOTAL BUDGETS FOR 2004               | : 2698.32 M€ |

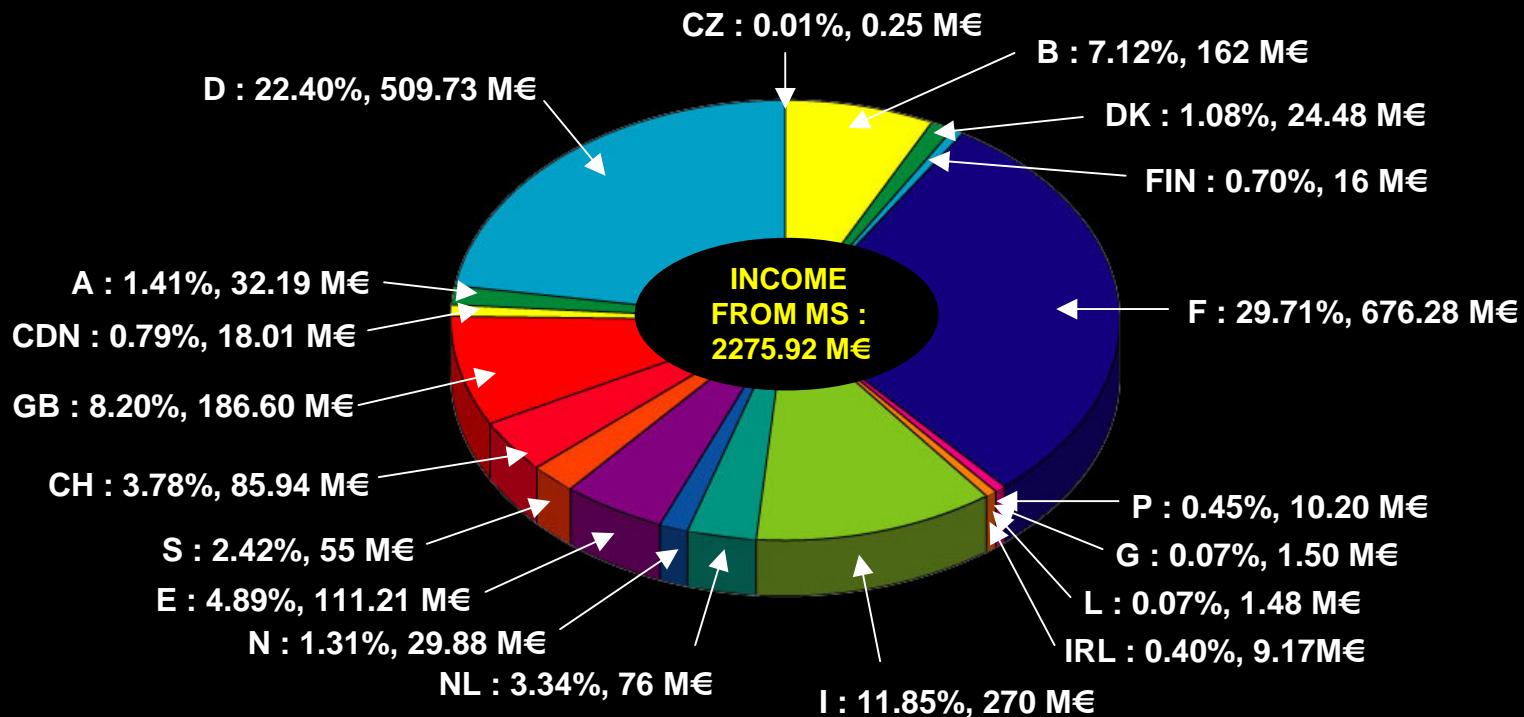


M€: Million of Euro

## Pressupost 2004, ingressos

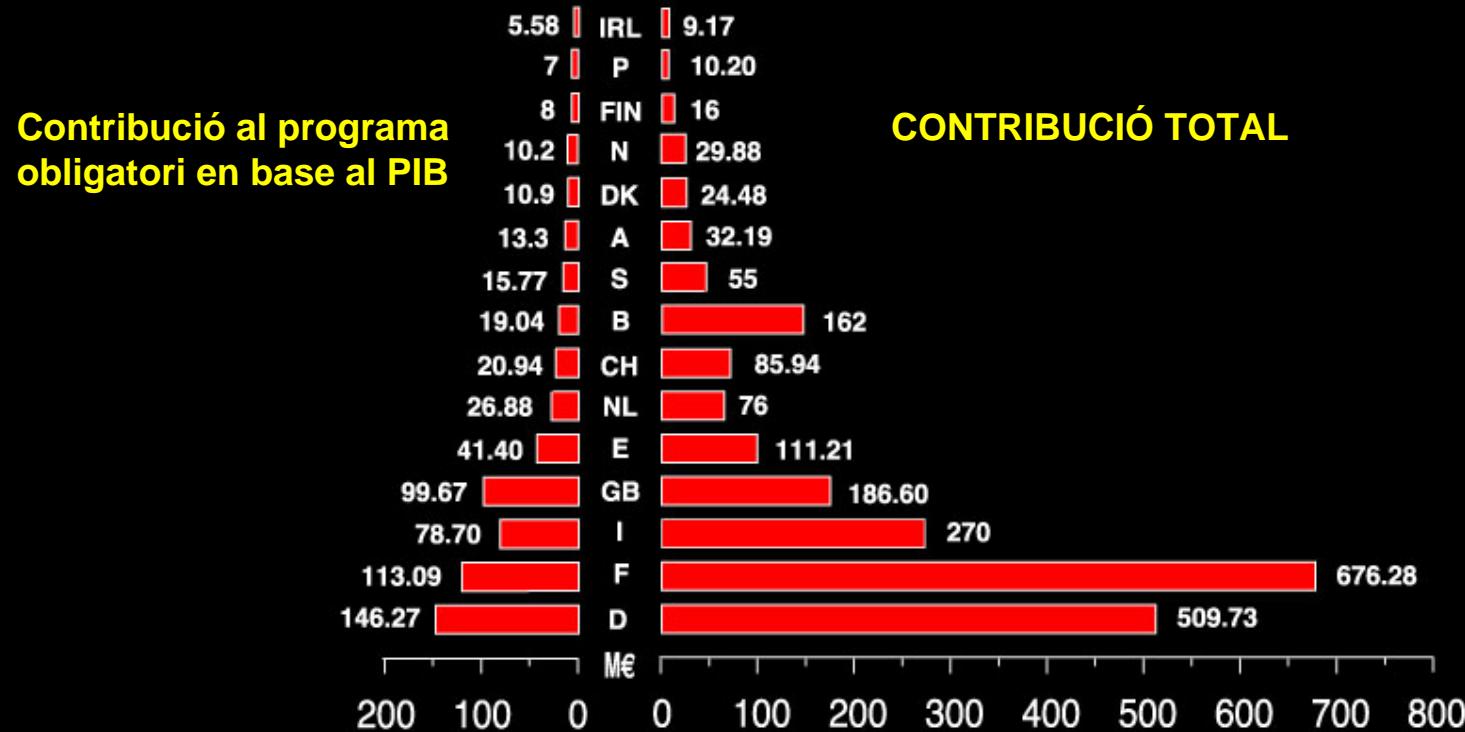


|   |              |
|---|--------------|
| INCOME FROM MEMBERS STATES AND OTHER STATES | : 2275.92 M€ |
| + OTHER INCOME                              | : 422.40 M€  |
| = TOTAL BUDGETS FOR 2004                    | : 2698.32 M€ |



M€: Million of Euro

## Comparison of Member States' mandatory contributions with total mandatory and optional contributions to ESA programmes



# Política Industrial

- El 90% del pressupost d'ESA es gasta contractes amb la indústria europea.
- Objectius de la política industrial:
  - Assegurar que tots els estats membres participen d'una manera equitativa en els contractes
  - Millorar la competitivitat de la indústria europea a escala mondial
  - Mantenir i desenvolupar la tecnologia espacial
  - Encoratjar el desenvolupament d'una estructura industrial adient amb els requeriments del mercat, fent ús del potencial industrial de cadascún dels estats membres.



# Institut d'Estudis Espacials de Catalunya

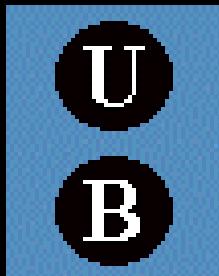
Is an R&D Institute

Created in 1996 by initiative of FCRI  
Non profit private foundation

## Board of Trustees

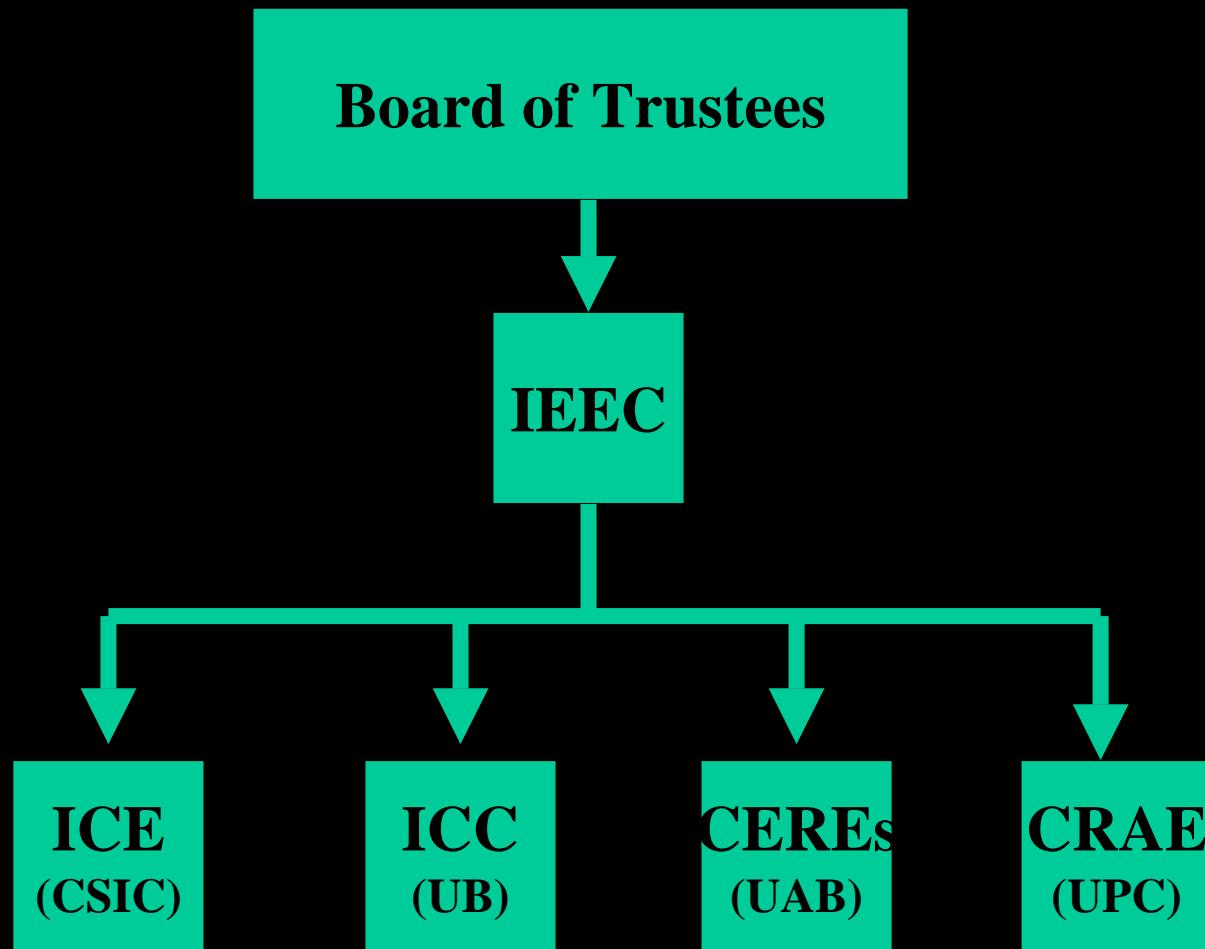


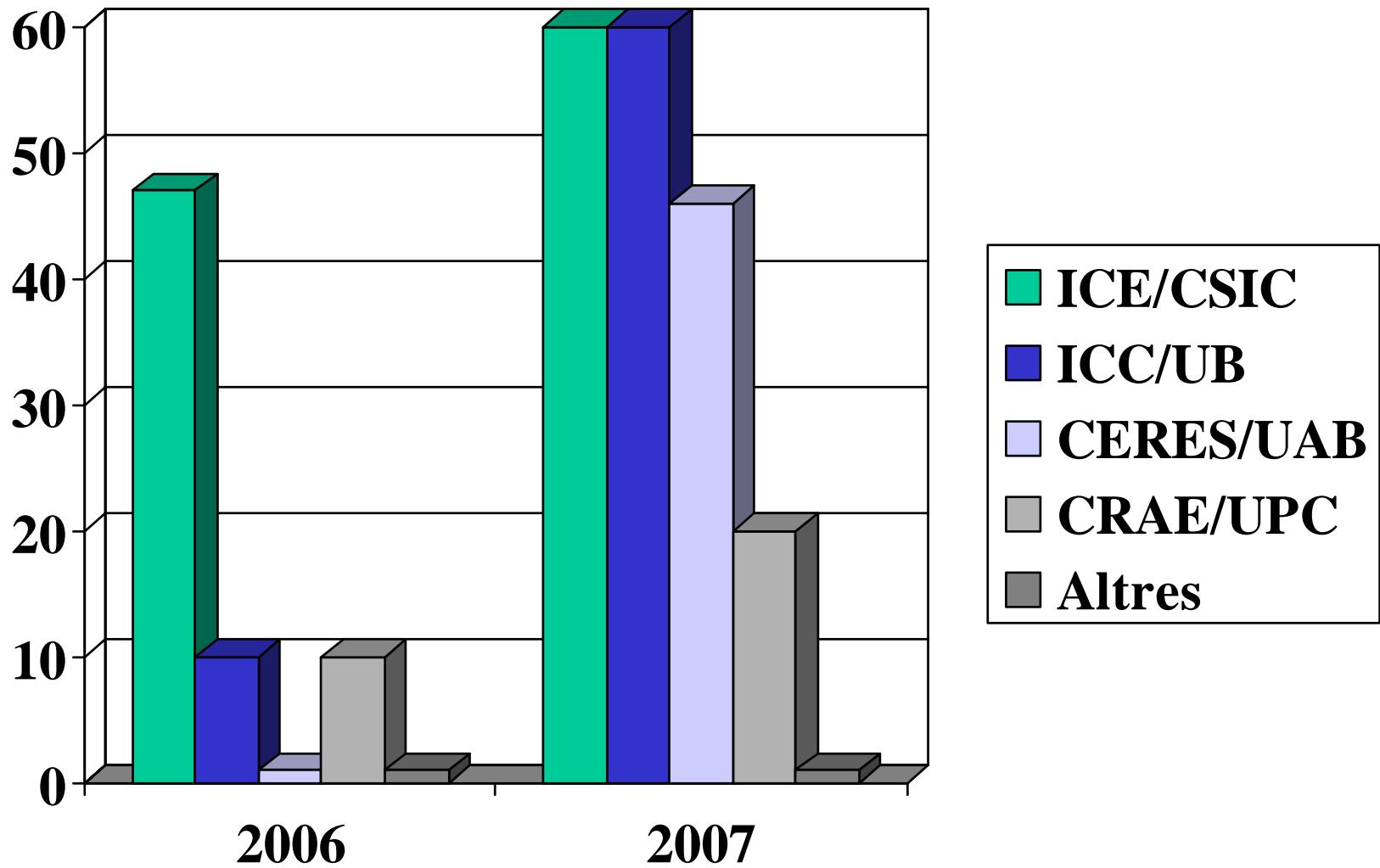
Departament d'Innovació  
Universitats i Empreses



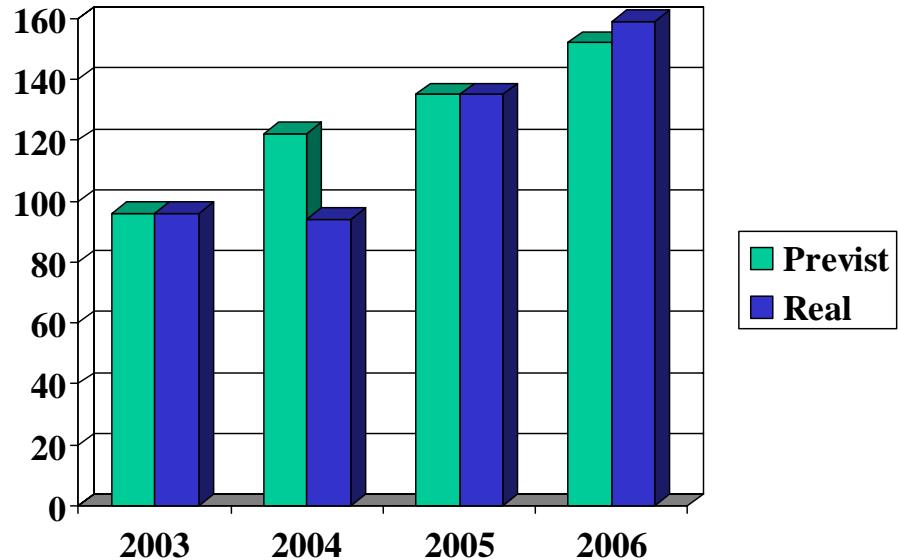
Multi-institutional  
Multi-disciplinary

# IIEC Structure



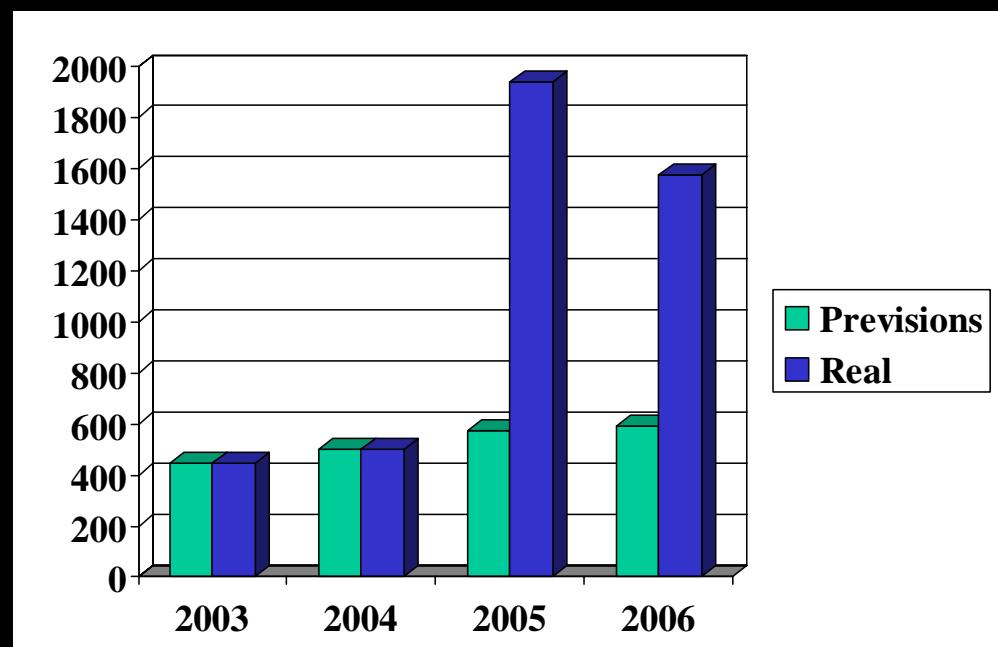


Personal IEEC



## Publications

**Income by  
competitive projects  
(k€)**



# R&D Topics

- Earth Sciences
  - Global Satellite Navigation Applications
- Astronomy
  - Astrophysics & Cosmology
  - Solar System Research
- Fundamental Physics
  - Detection of Gravitational Waves
  - Fluids under microgravity
- Astrodynamics

**WORKING MODES**

Basic research as a source of “know how”

Participation in large projects

|                       | <b>Earth Sciences</b>                          | <b>Astronomy</b>   | <b>Fundamental Physics</b>                      | <b>Astrodynamics</b>                  |
|-----------------------|--|--|---|---------------------------------------|
| <b>Basic Research</b> | GPS applications<br>Phys. Atmosph              | High energy Ap<br>Stellar Physics<br>Extragalactic A<br>Cosmology<br>Earth-Sun | Gravitational Waves<br>Microgravity             | Stability in L-points                 |
| <b>Technology</b>     | GPS processor                                  | Gamma-ray lens<br>Data bases   | Noise sources<br>Bubble formation $\mu\text{g}$ | Trajectory algorithms                 |
| <b>Industry</b>       | GMV,INDRA,EADS<br>ASTRIUM,<br>Saab-Eriksson    | GMV  | NTE   | Deimos                                |
| <b>Partners</b>       | CIRIT,MCYT,<br>ESA,UE,JPL/NASA,<br>EUMETSAT    | CIRIT, MCyT,<br>ESA  | CIRIT, MCyT                                     | CIRIT, MCyT,<br>JPL/NASA              |
| <b>Formation</b>      | Master Remote Sensing<br>Advanced Lectures GPS | Astron&Astroph<br>PhD Courses<br>(UAB,UPC)                                     |   | Advanced Lectures<br>Flight formation |
| <b>Outreach</b>       |  | Conferences.<br>TV programs  | Conferences                                     |                                       |

# New applications of the navigation satellites



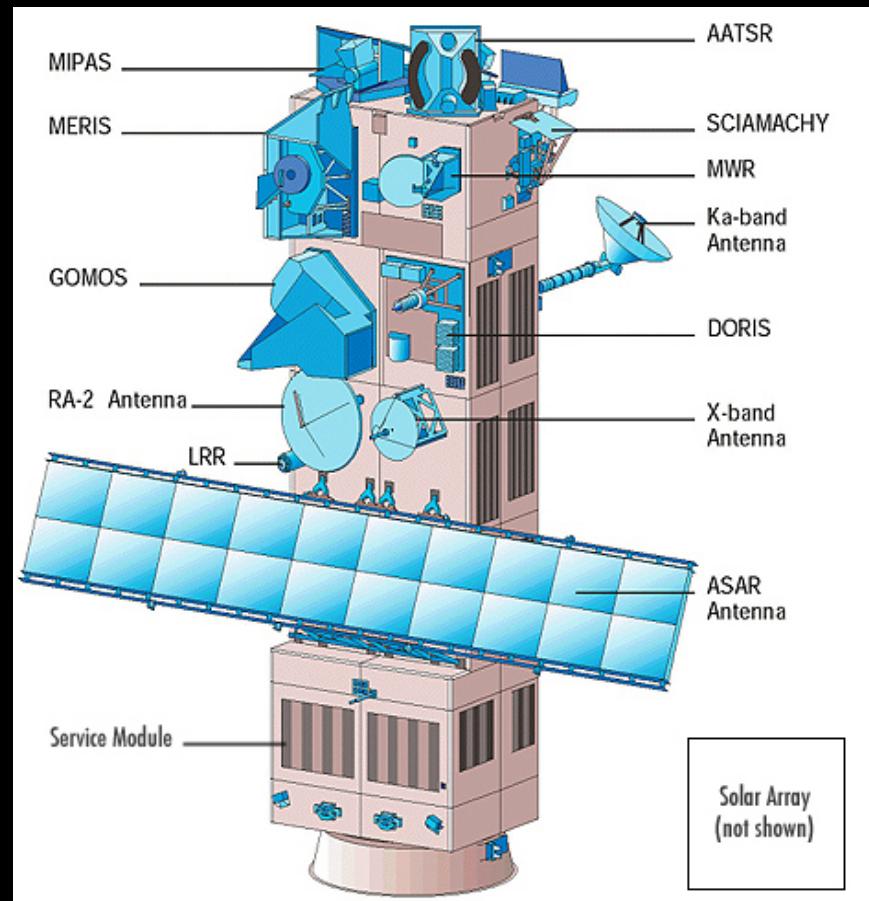
GPS  
GLONASS  
GALILEO

At the IEEC we have the techniques that are necessary to determine the position of any point respect to the Earth center with a precision better than 1 mm.

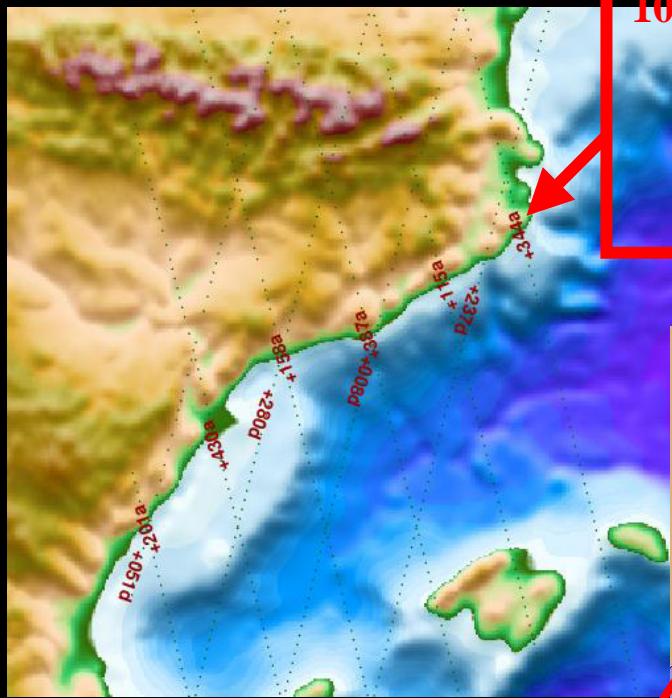
# Calibration of the radar altimeters of ENVISAT



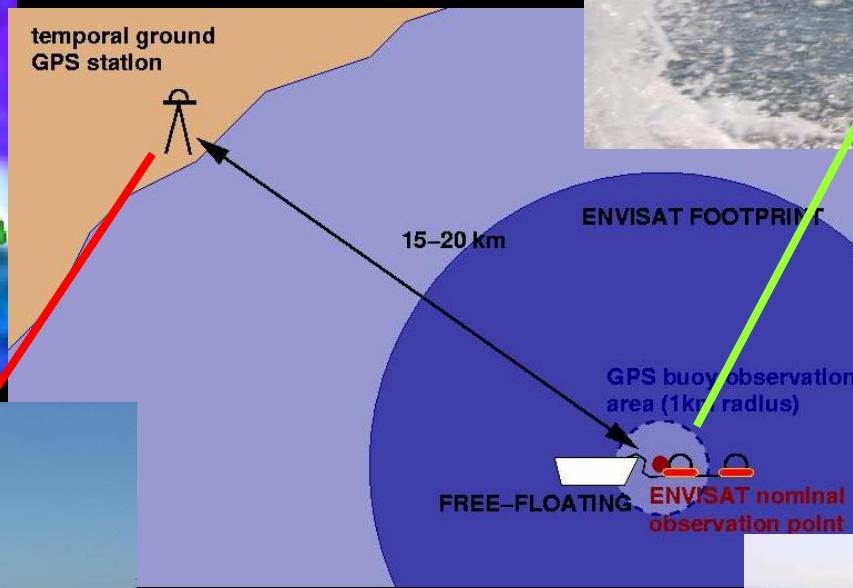
IEEC



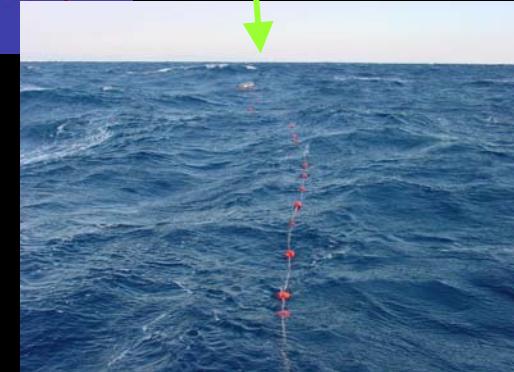
# Calibration campaigns



10 tracks & 53 ENVISAT visits  
(5 to 6 visits per track)  
~10 NM from the seashore  
6 month campaign  
45 successful experiments



Position of the buoys:  
< 3 cm

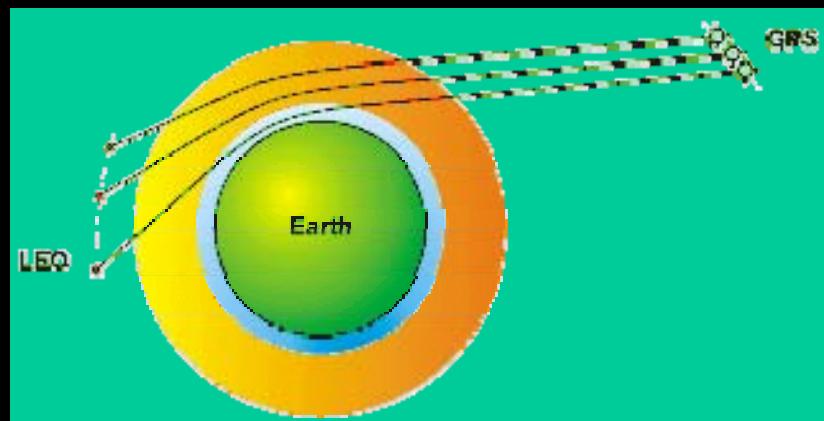
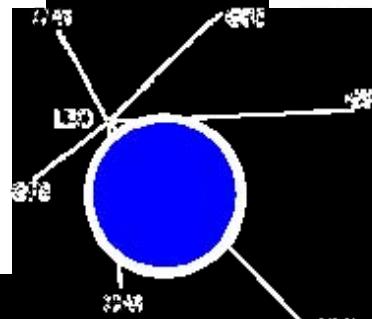
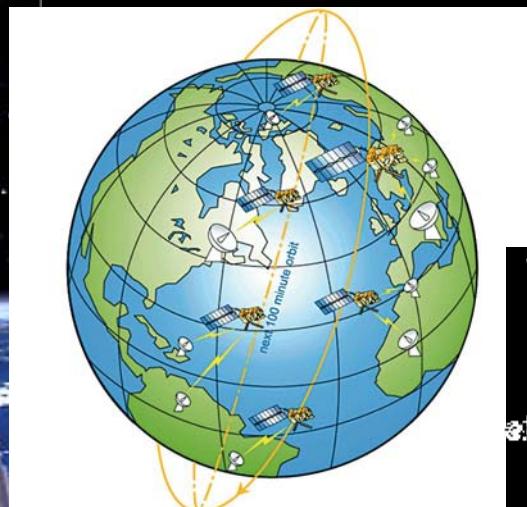


# METOP: GRAS-SAF



IEEC

GRAS SAF



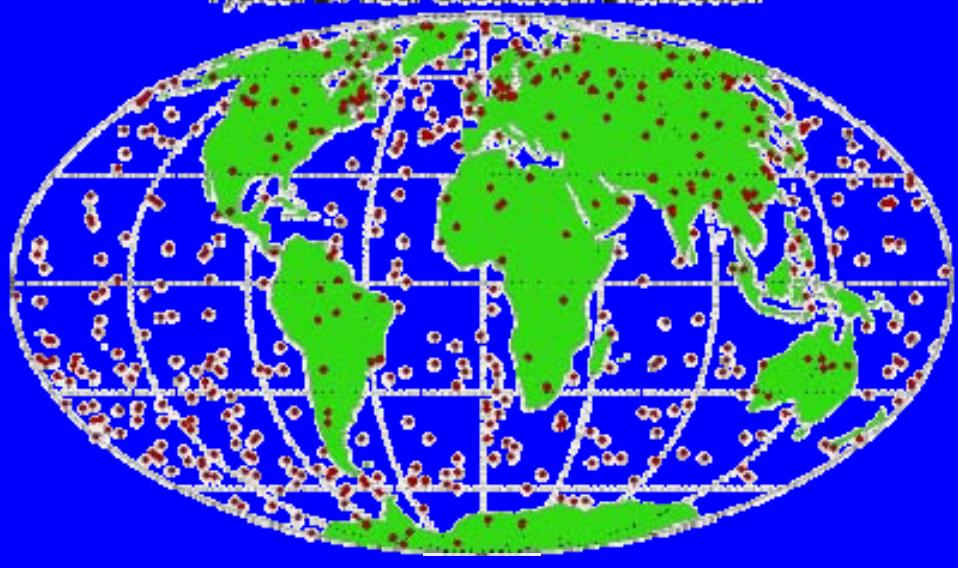
The occultation of GNSS satellites by the Earth allows to obtain the structure of the atmosphere at the planetary scale.

## Expected results:

Radio Sonde Distribution



Typical 24-hour Occultation Distribution

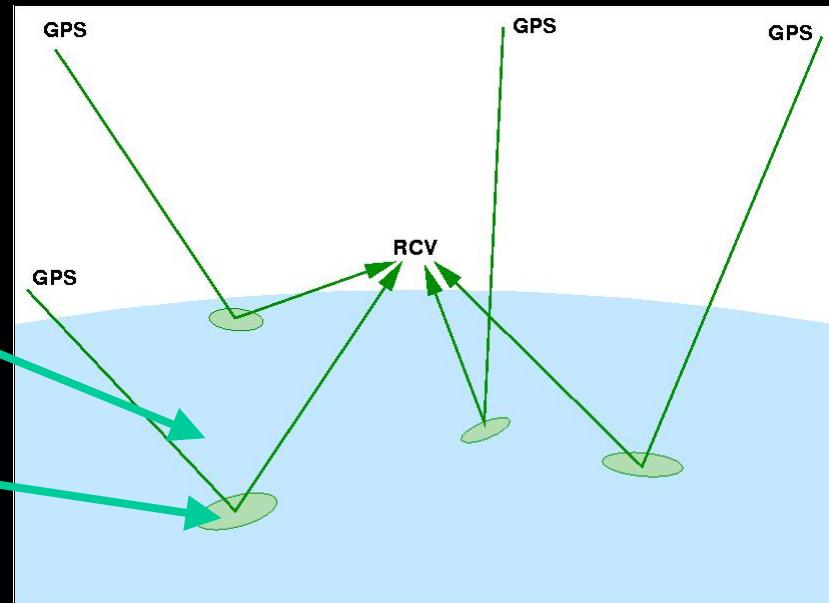


# Motivation: GNSS reflection concept

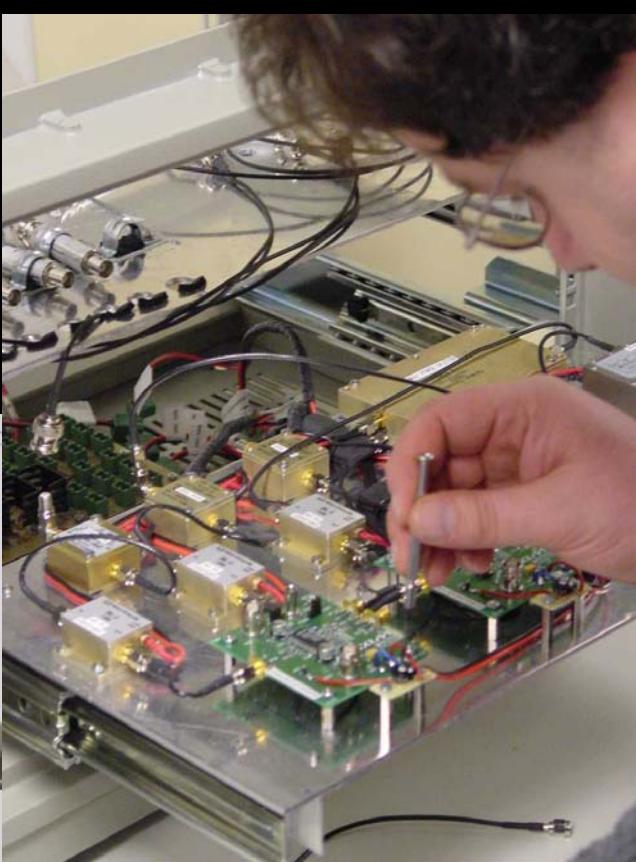
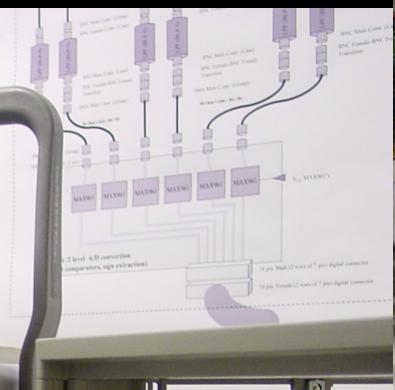
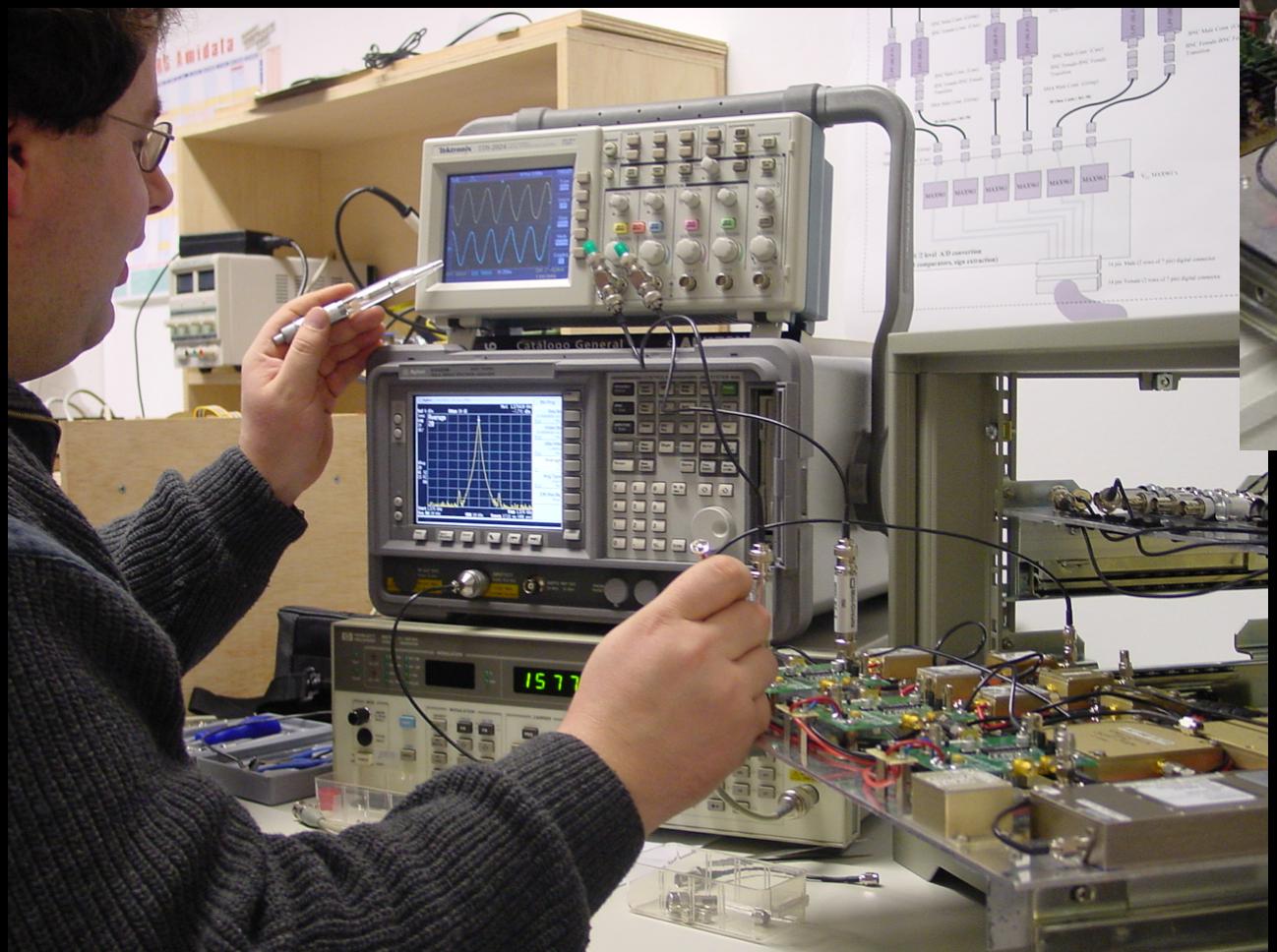
- Main advantages of the GNSSr concept:
  - FREE SIGNALS, ALREADY EXIST
  - PASSIVE
  - MULTISTATIC

Tropospheric delay

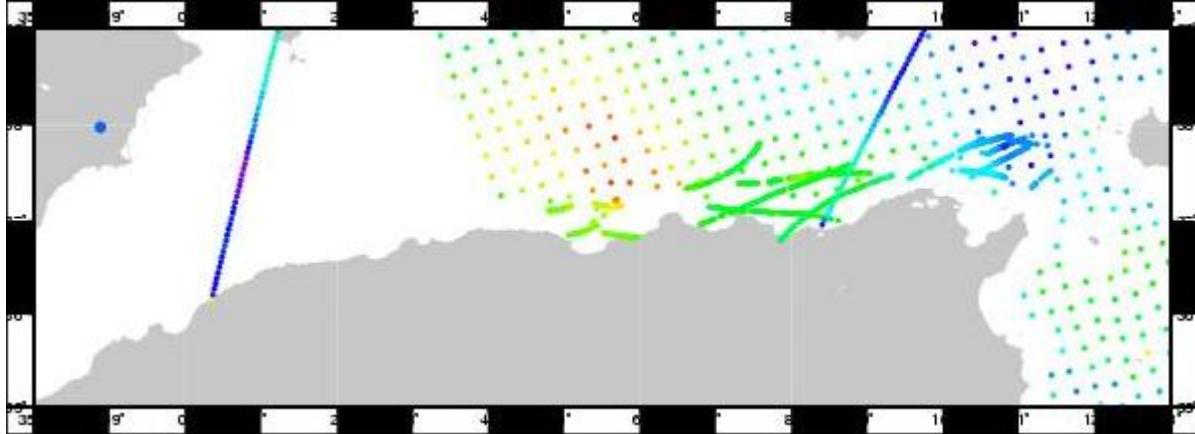
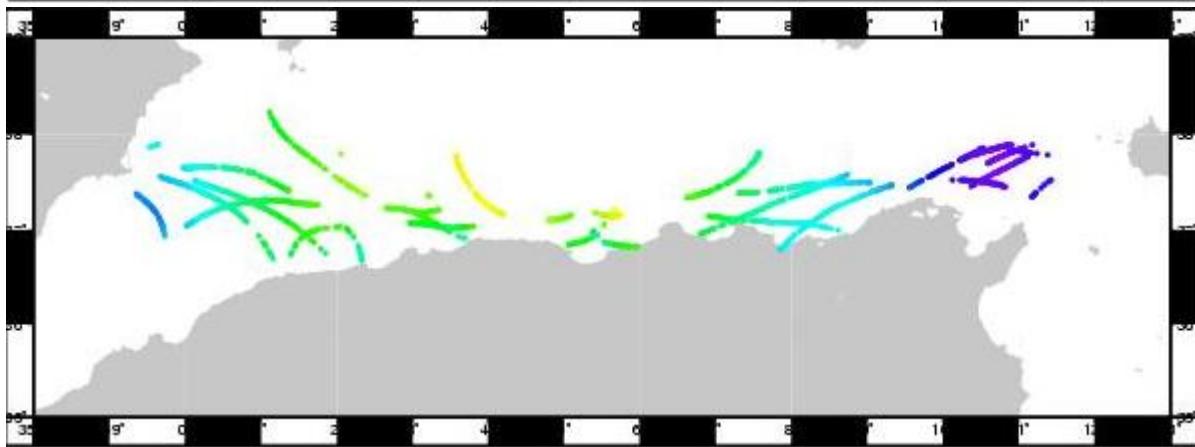
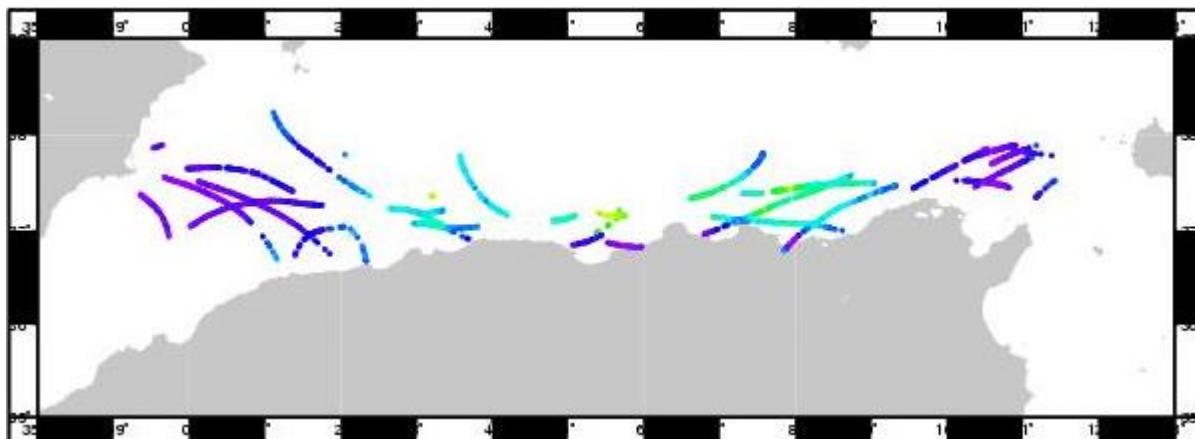
Sea level, SWH, roughness/wind  
salinity, ice, oil...



# GOLD-RTR (GPS Open Loop Differential -Real Time Receiver) It allows the processing and storage of the GPS signal in nearly real time





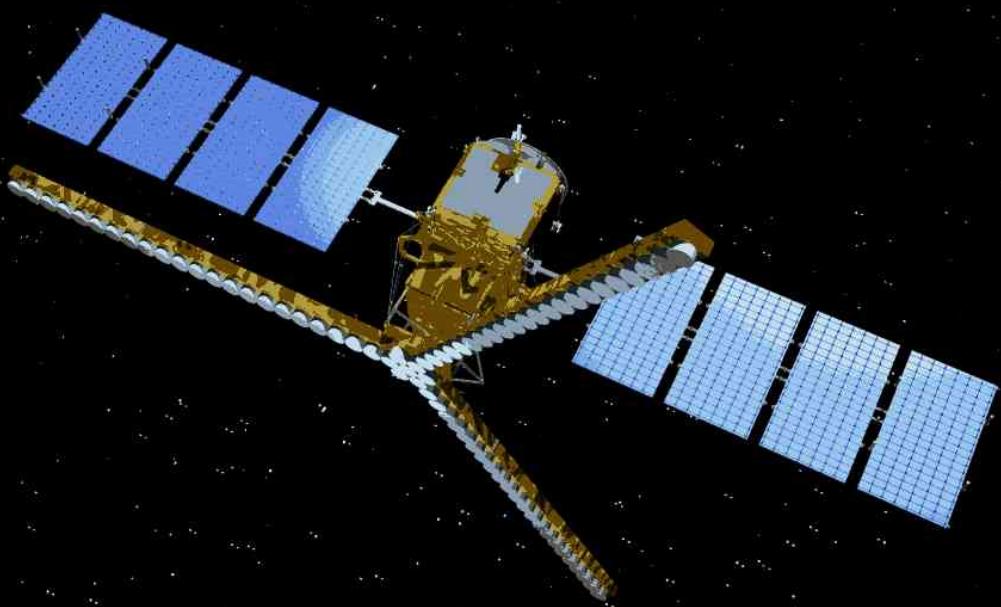




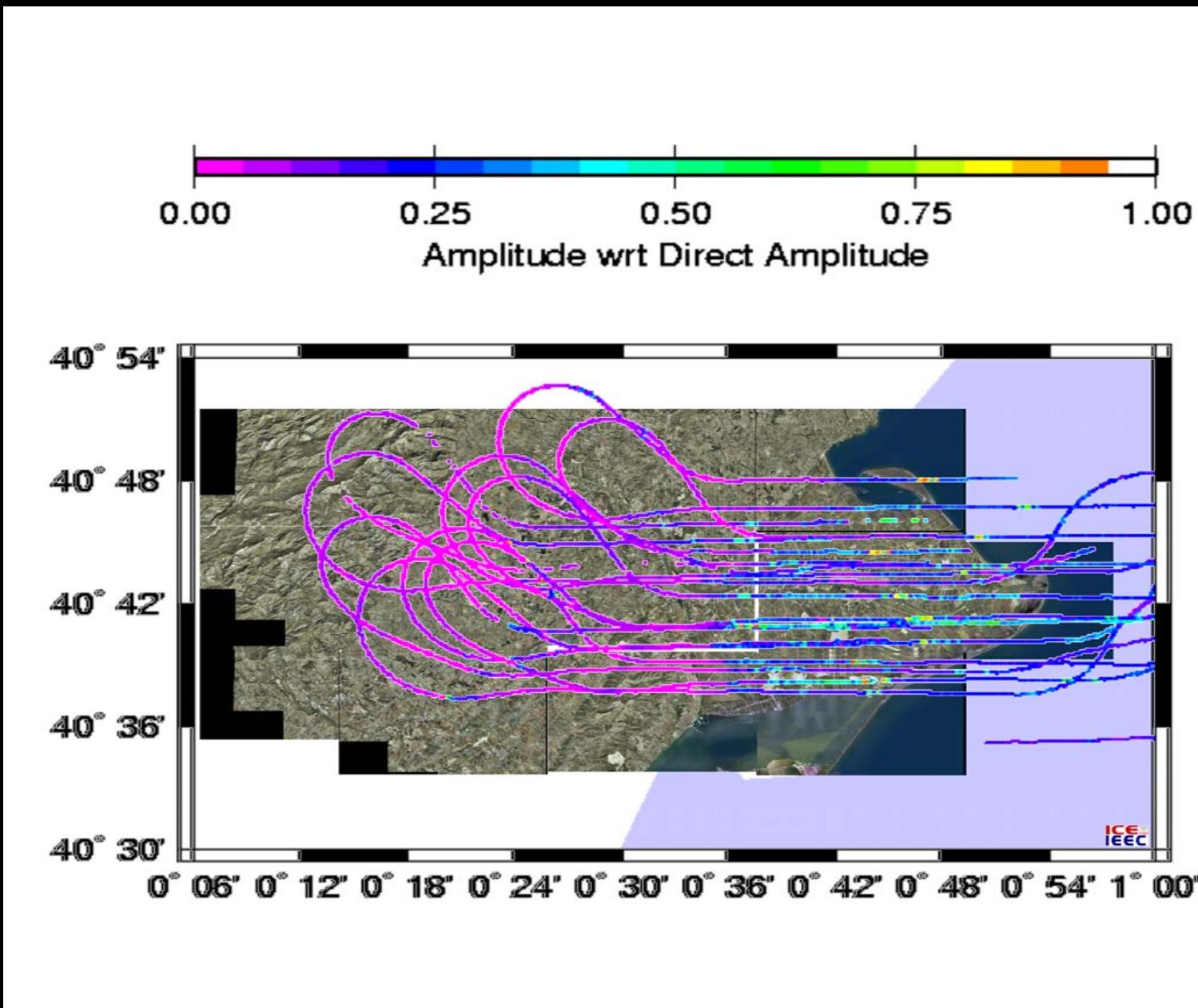
SMOS



IEEC

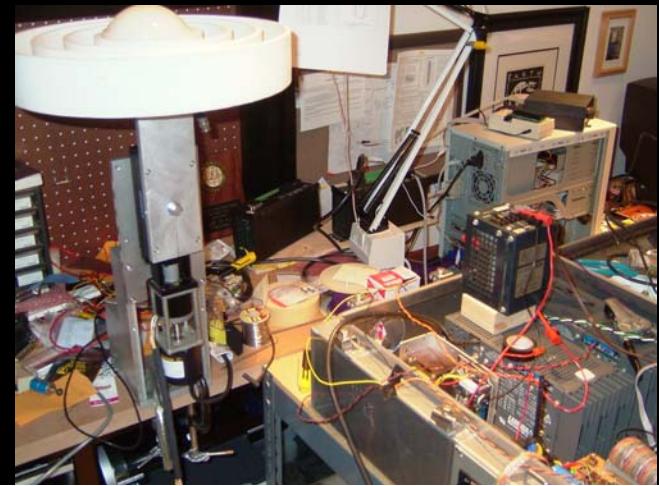


# Land Reflections: soil moisture



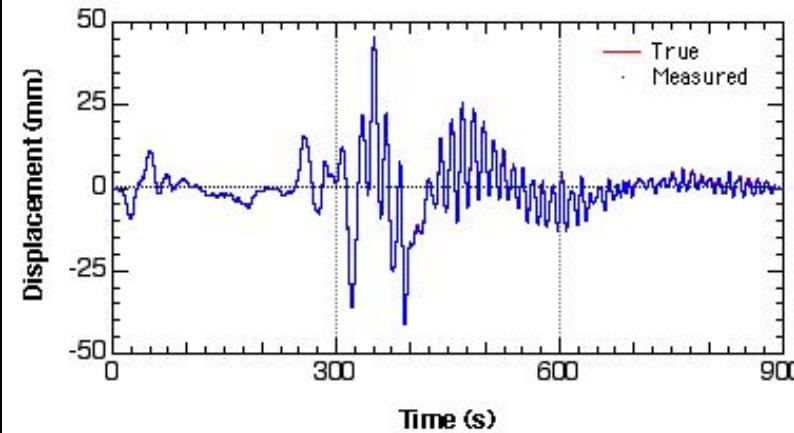
# RELATIVE POSITIONING OF MOVING PLATFORMS USING GNSS

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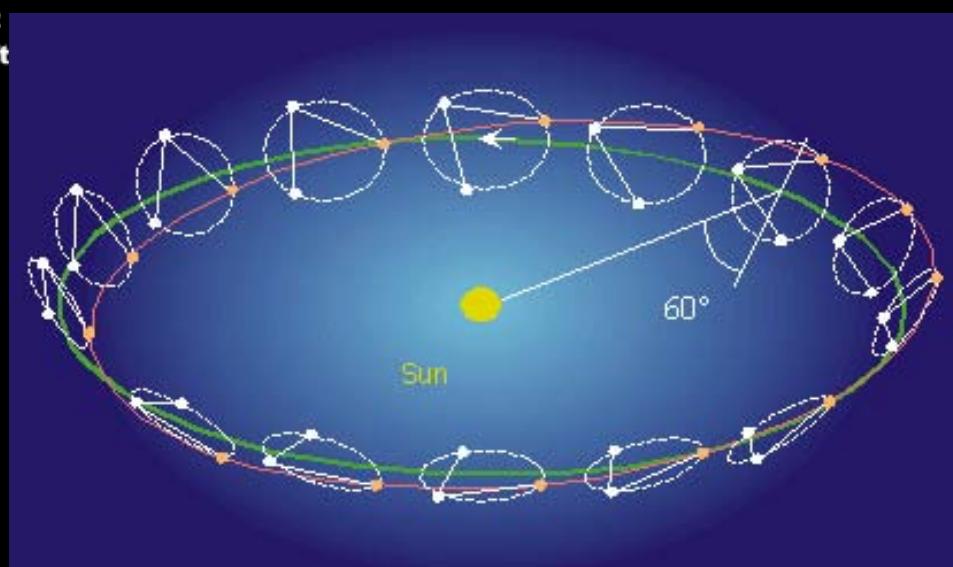
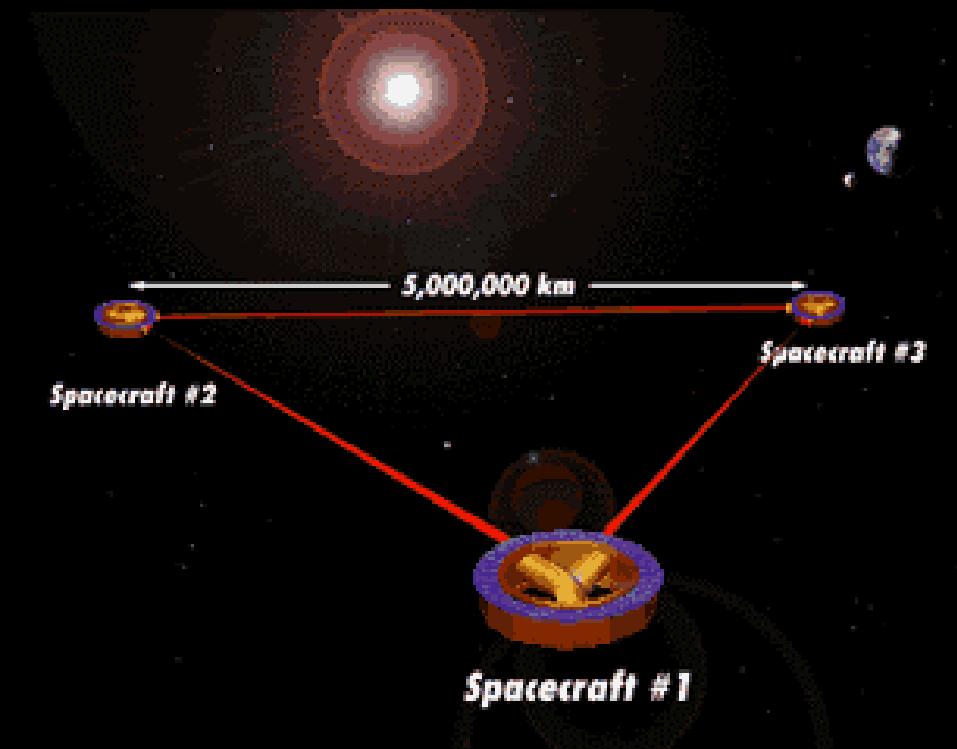
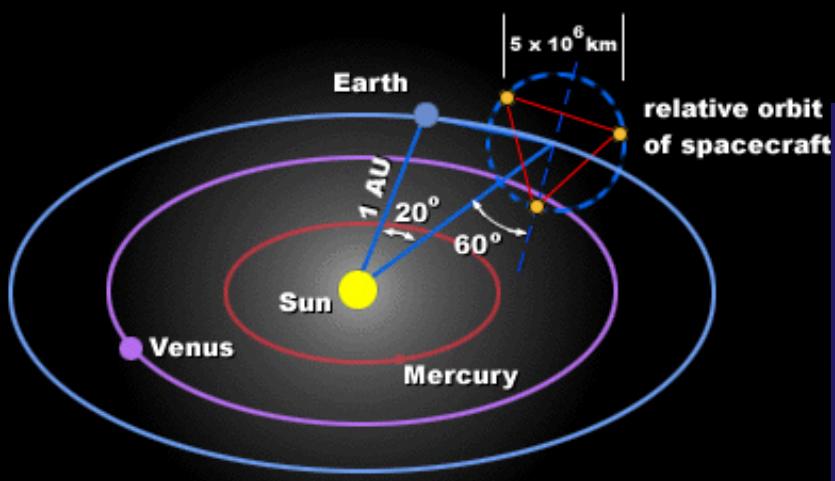


*One-dimensional Prototype of GNSS Simulator*

*Example of Simulation:  
1998 Great Antarctic Earthquake*

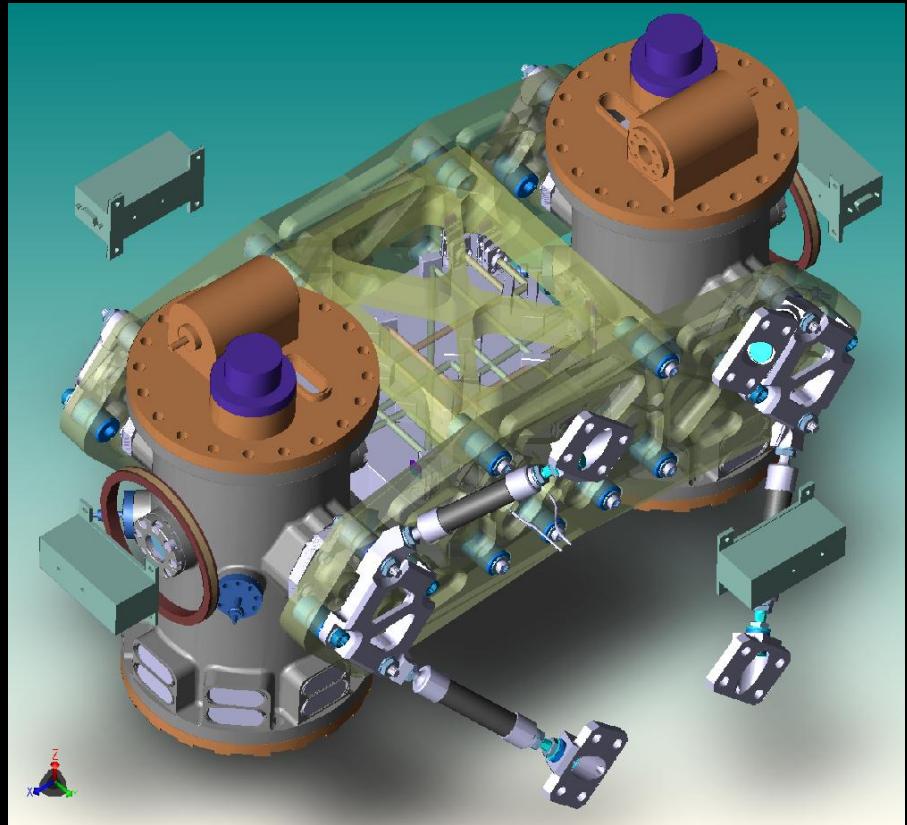
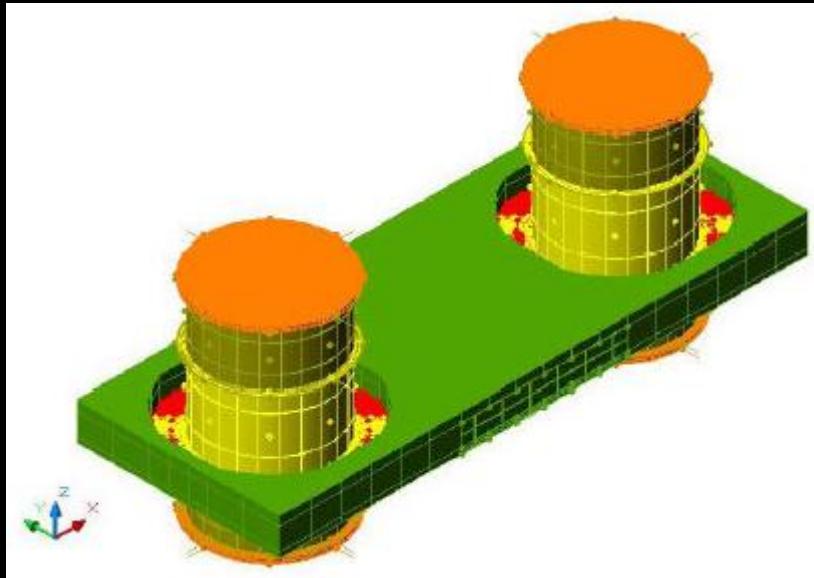


# LISApathfinder



# Gravitational wave detection

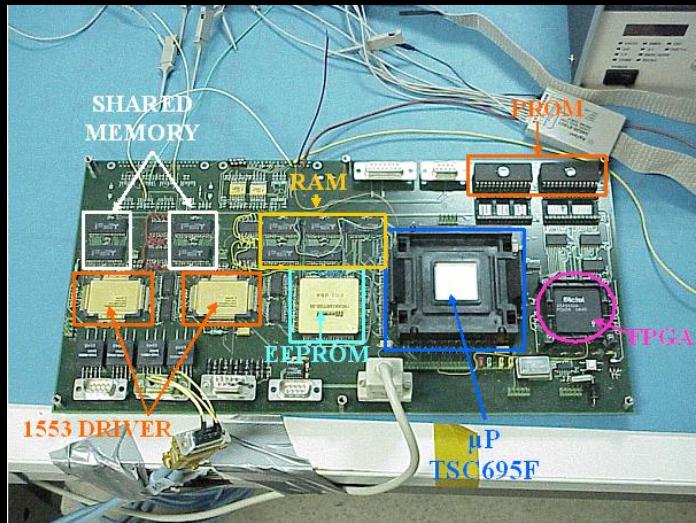
IIEEC



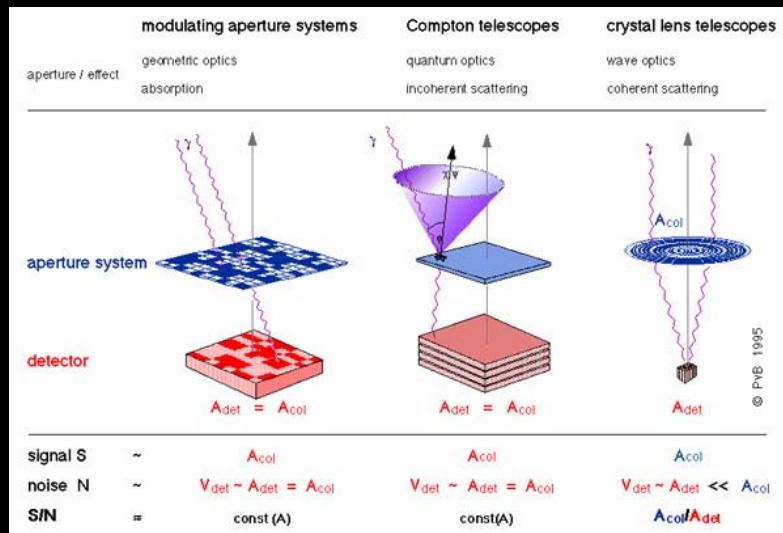
Lisa pthfinder



Figure 1. Temperature sensors and FEE



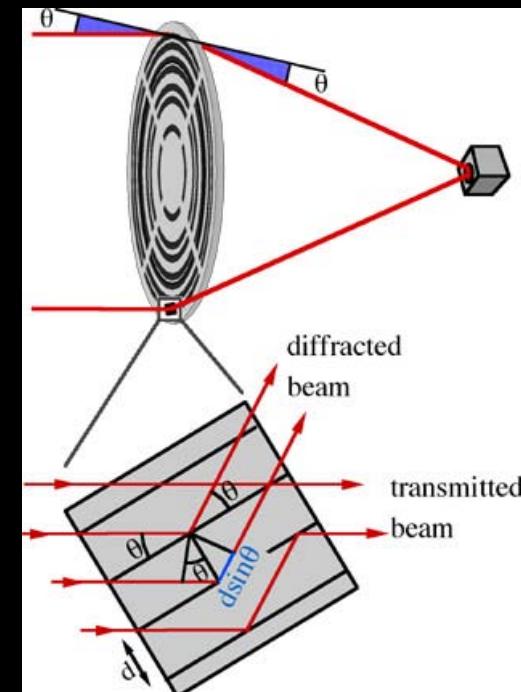
# Gamma lens: MAX/Claire

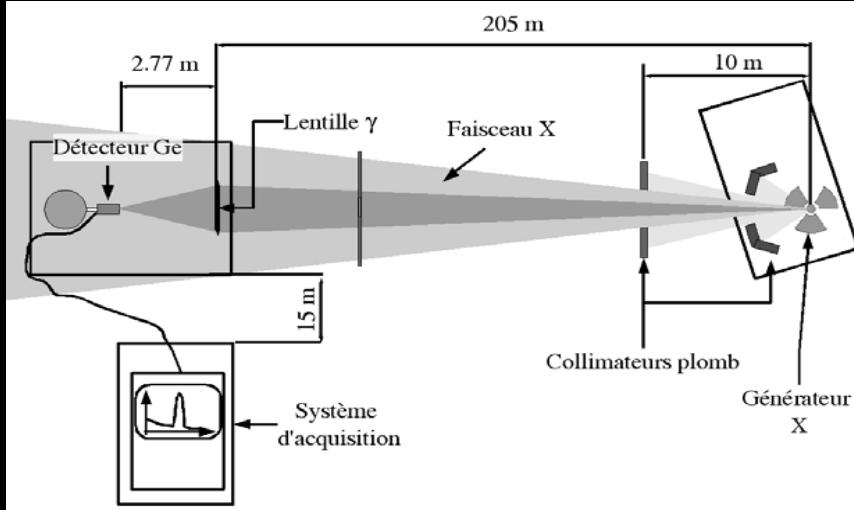


IEEC



CESR





**Ordis (Alt Empordà)**

# CLAIRES 2001



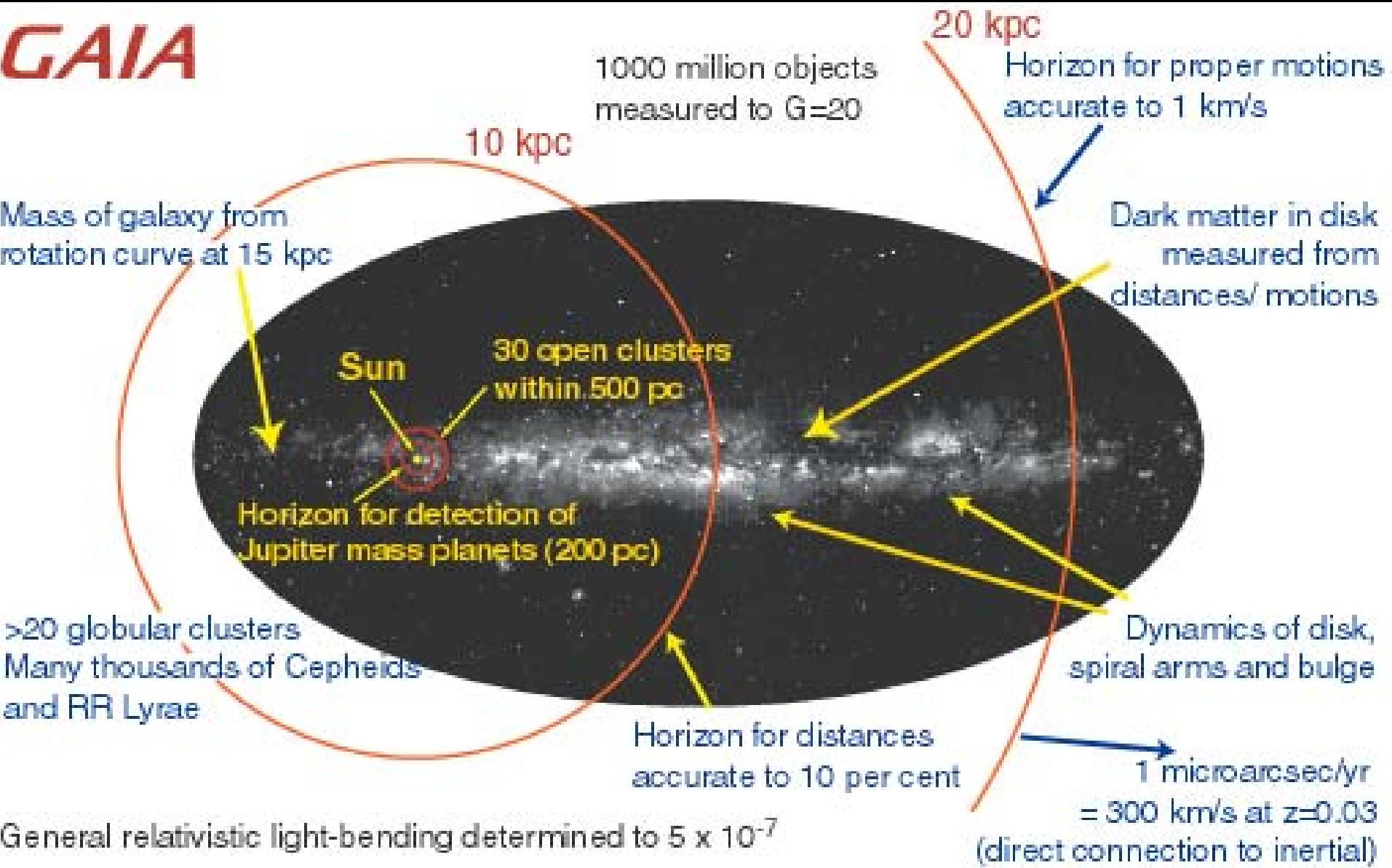
**démontrer le principe d'une lentille  $\gamma$  pour une cible astrophysique**

Lancement : 14 juin 2001, 8h15 UT, base CNES de Gap-Tallard

Ballon : Zodiac Z600 ( $600.000 \text{ m}^3$ )

altitude :  $> 41 \text{ km}$  (3.8 g/cm<sup>2</sup> atmosphère résiduelle), pendant 5h 30'

Aterrissage : 14 juin 2001, 17 h UT, Bergerac, Aquitaine

**GAIA**

# Gaia Optimum Compression Algorithm (GOCA)



- Disseny, implementació i validació d'un sistema òptim de compressió de dades per la missió Gaia de la ESA

## Equip científic:



- Pressupost total: 150 k€ (IEEC: 50 k€)
- Duració del contracte: 6 mesos
- Contracte crític per l'èxit de la missió
- Resultats satisfactoris: Factor de compressió ~2.5 sense pèrdues, usant menys d'un 5-10% de la CPU a bord
- Millors resultats que amb el sistema inicialment proposat per EADS/Astrium

## Equip Institucional:



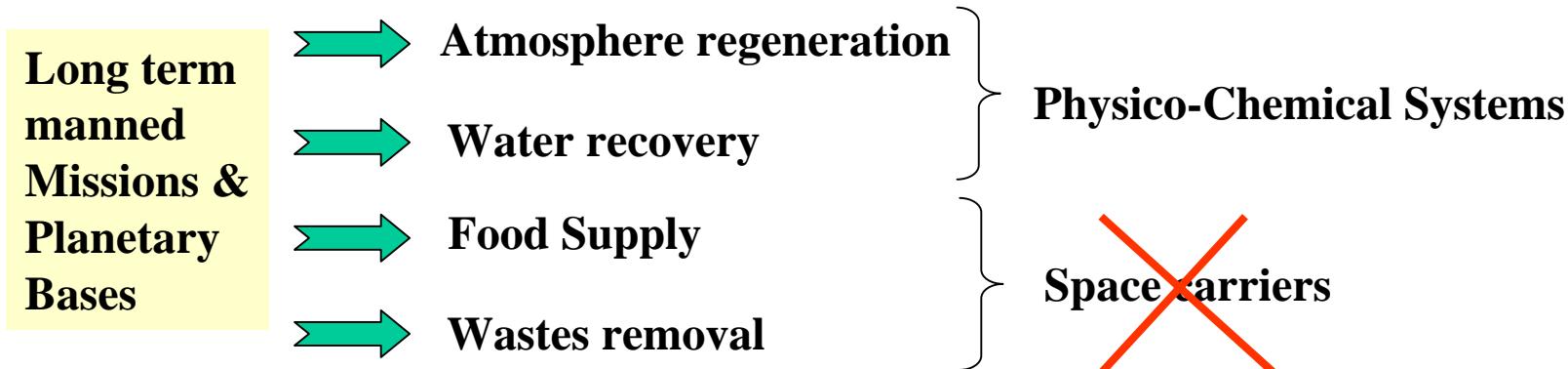
## Contractista:



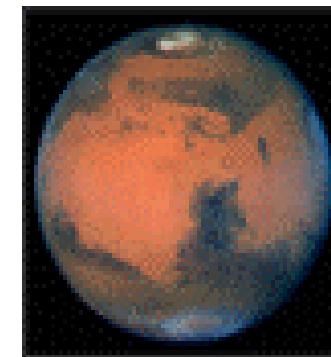
## Tests i validació:



## Life Support in Space.

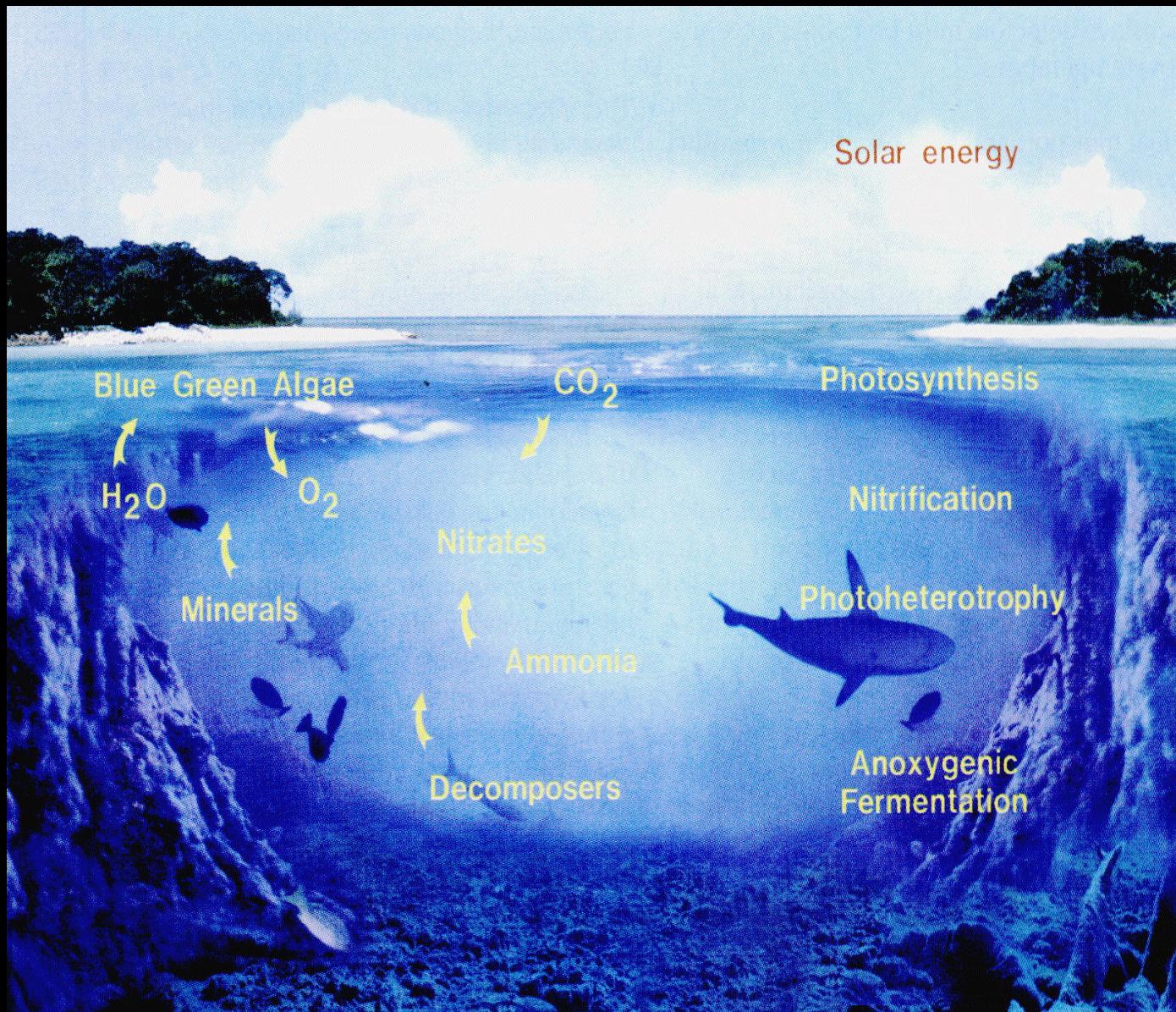


2-3 years  
6-8 persons crew

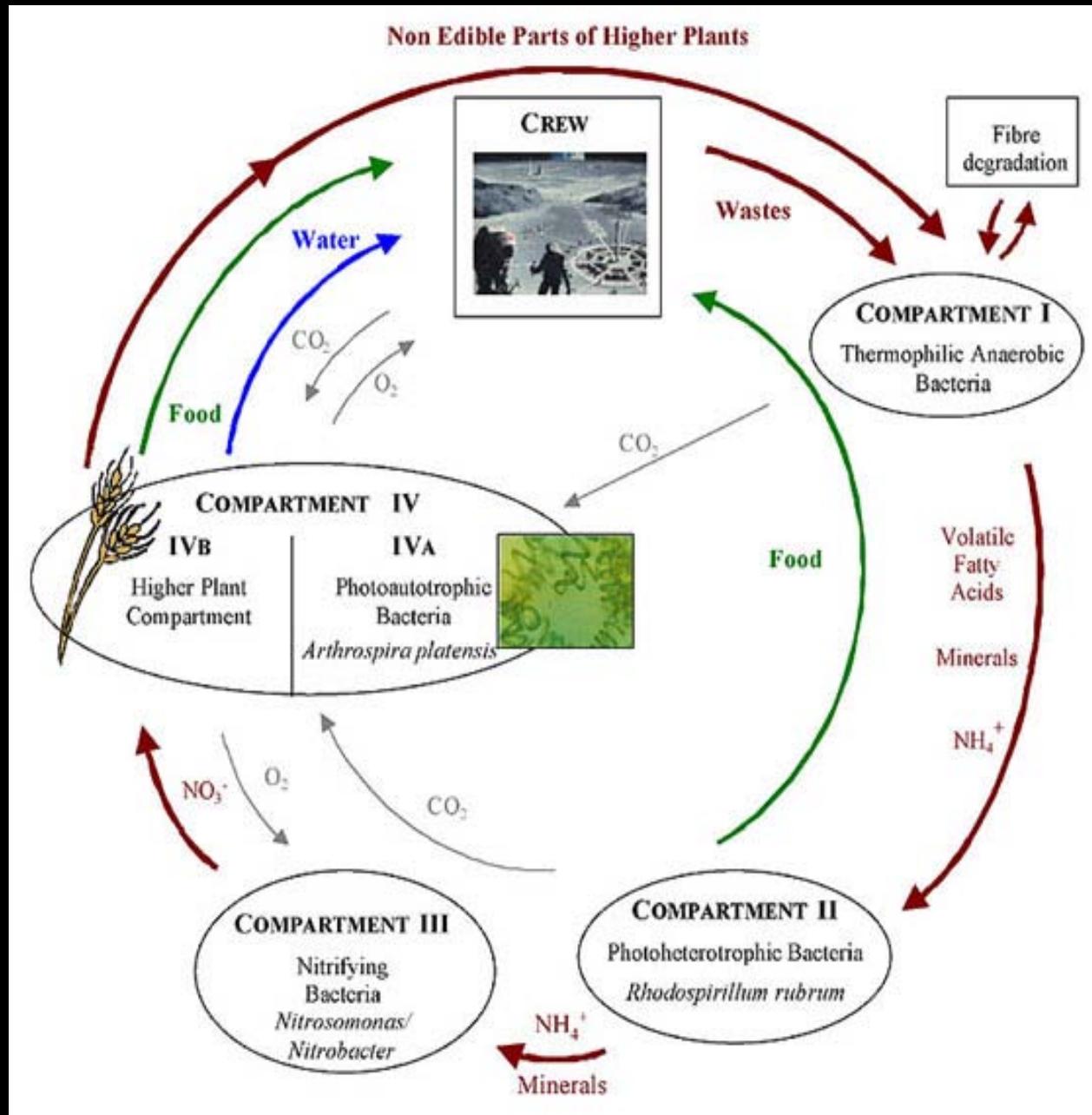


**Regenerative life support systems are required, with food generation:  
need for biological systems: Biotechnology**

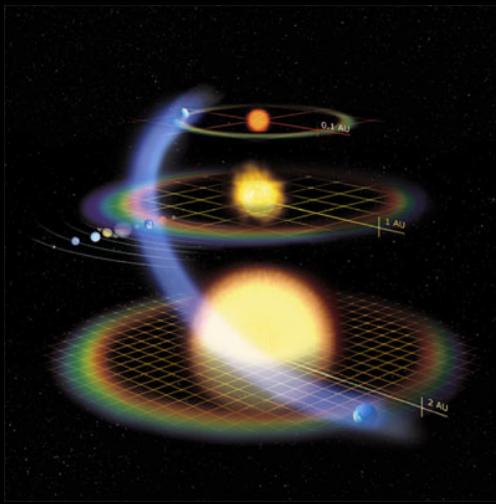
# The MELiSSA concept: natural ecosystems



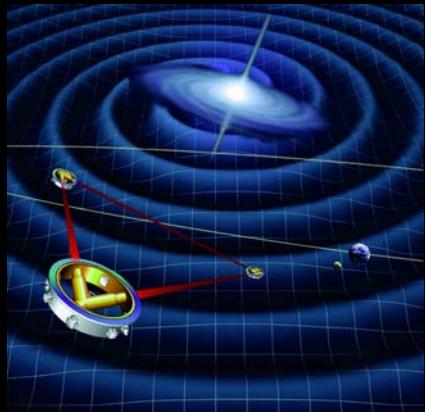
# The MELiSSA concept: systems engineering approach



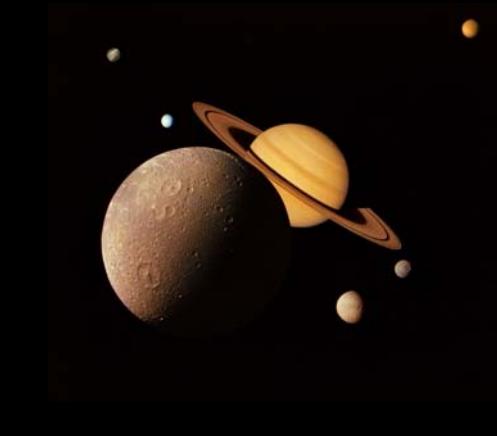
# ESA's Cosmic Vision



What are the conditions for life and planetary formation?



What are the Fundamental laws Of the Universe?



How does the Solar System work?

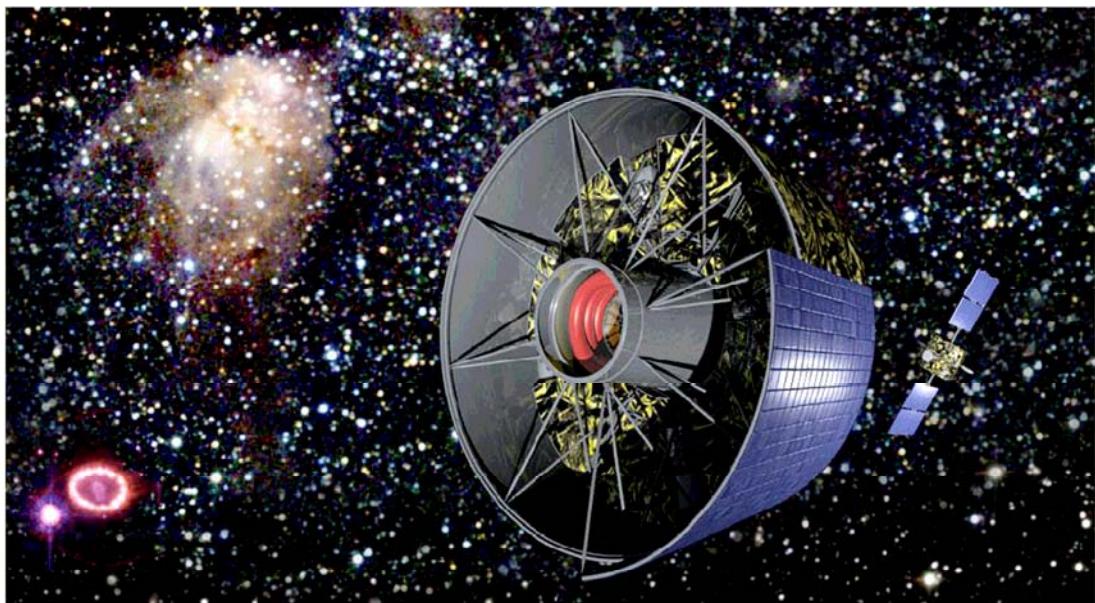


How did the Universe begin and what is it made of?



exploring the extremes

# GRI



Jürgen Knödlseder, Peter von Ballmoos (CESR, France)  
Filippo Frontera (UNIFE, Italy), Angela Bazzano (INAF/IASF-Rome, Italy)  
Finn Christensen (DNSC, Denmark)  
Margarida Hernanz (IEEC/CSIC, Spain)  
Cornelia B. Wunderer (UCB, USA)

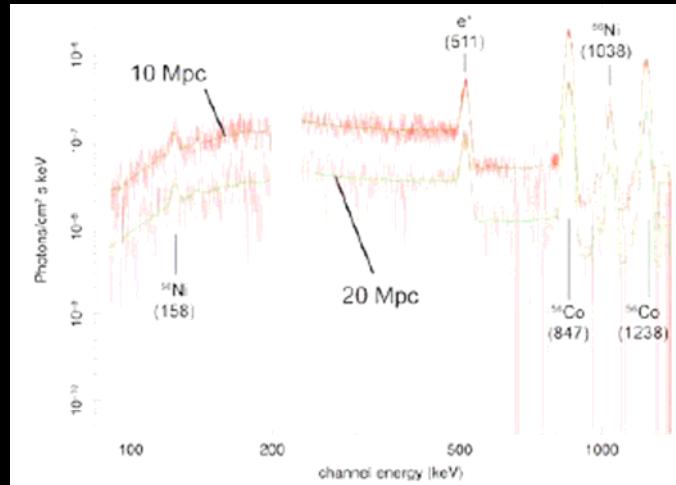


Figure 3. SNIa spectra for 10 Mpc and 20 Mpc.

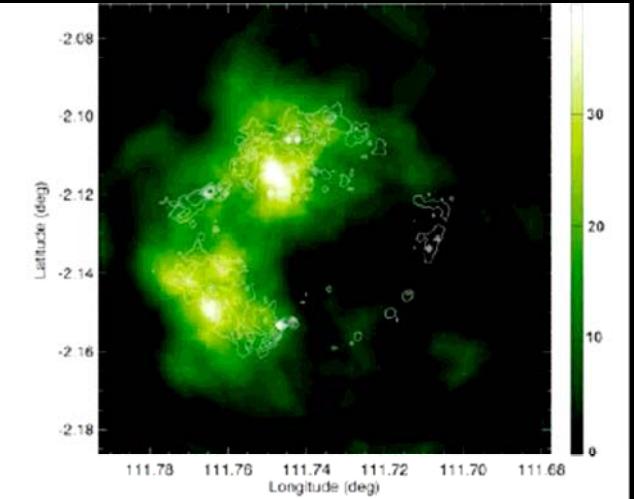


Figure 4. Image of  $^{44}\text{Ti}$  in Cas A SNR.

# DUNE THE DARK UNIVERSE EXPLORER

Proposal to ESA's Cosmic Vision

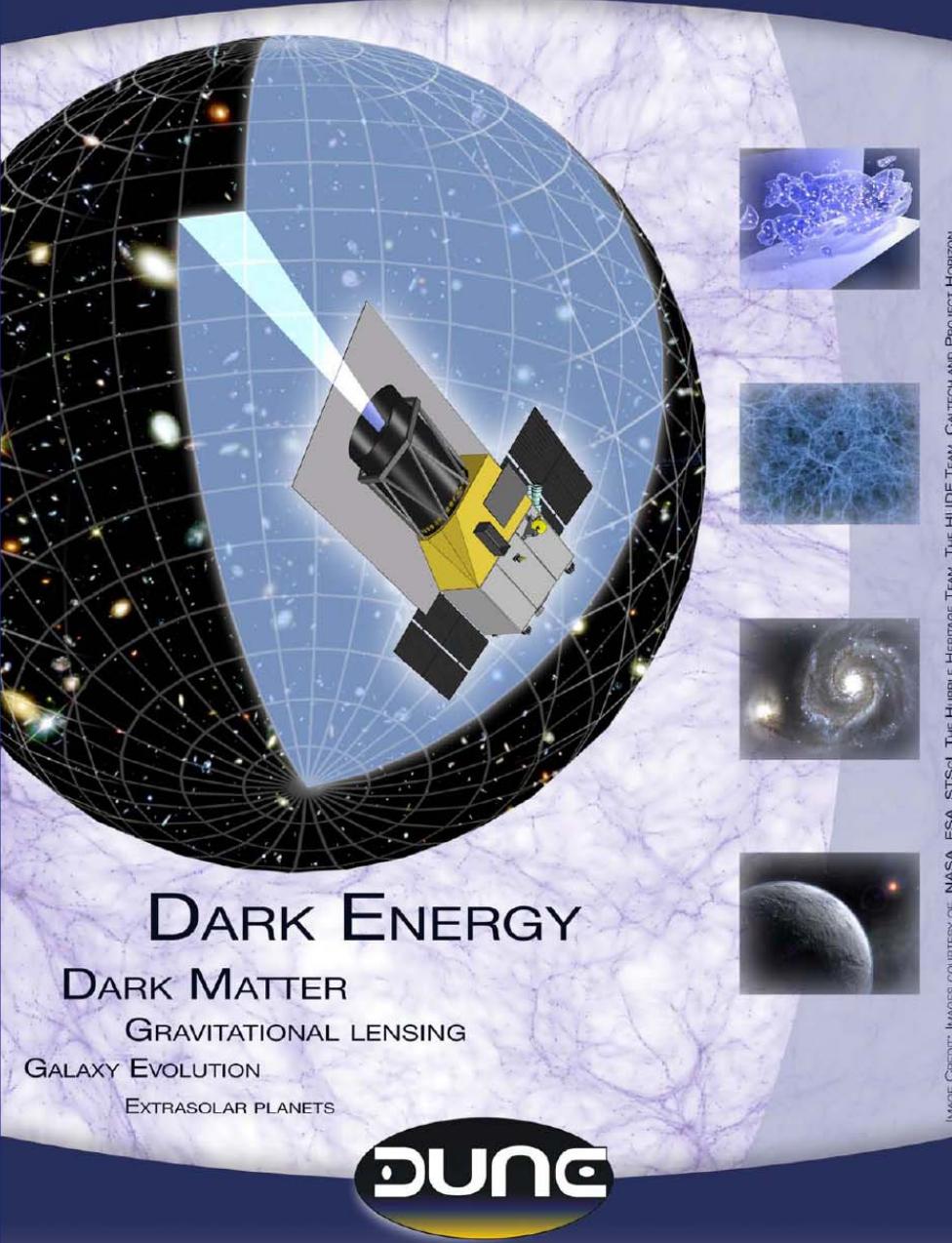


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## K) Proposing Team

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**Galactic Studies:** Eva Grebel (MPIA Heidelberg), Jean-Philippe Beaulieu (IAP Paris)

**Supernovae:** Massimo Della Valle (Arcetri), Isobel Hook (U. Oxford)

**Theory:** Luca Amendola (INAF-OARM, Rome)

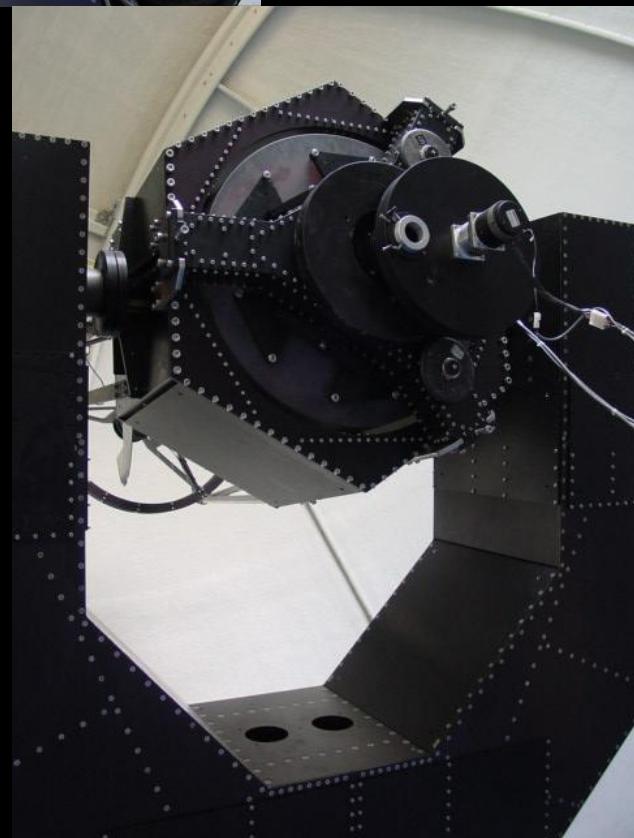
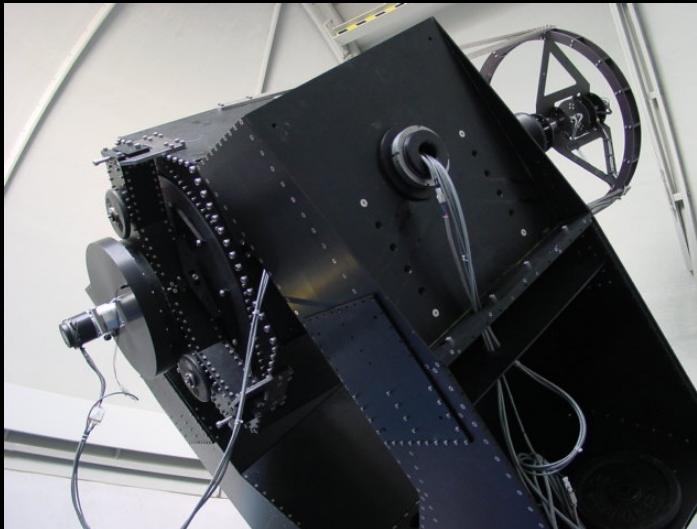
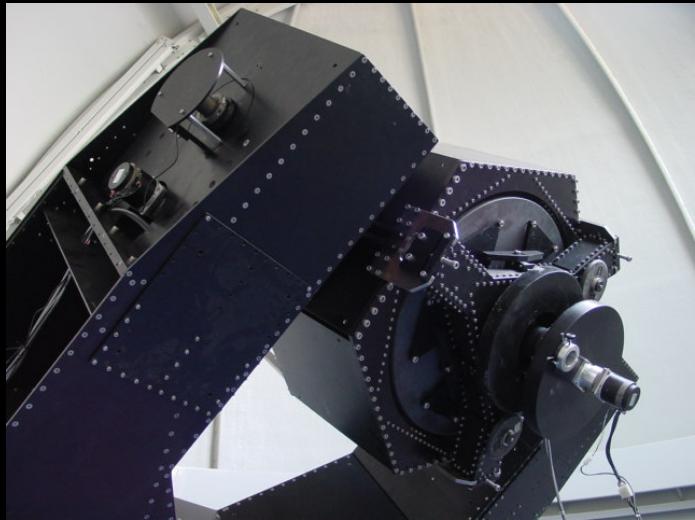
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**Image Simulation:** Jason Rhodes (JPL), Lauro Moscardini (Bologna)

**Instrument:** Didier Bederde (CEA Saclay), Jeff Booth (JPL)

# Montsec Astronomical Observatory

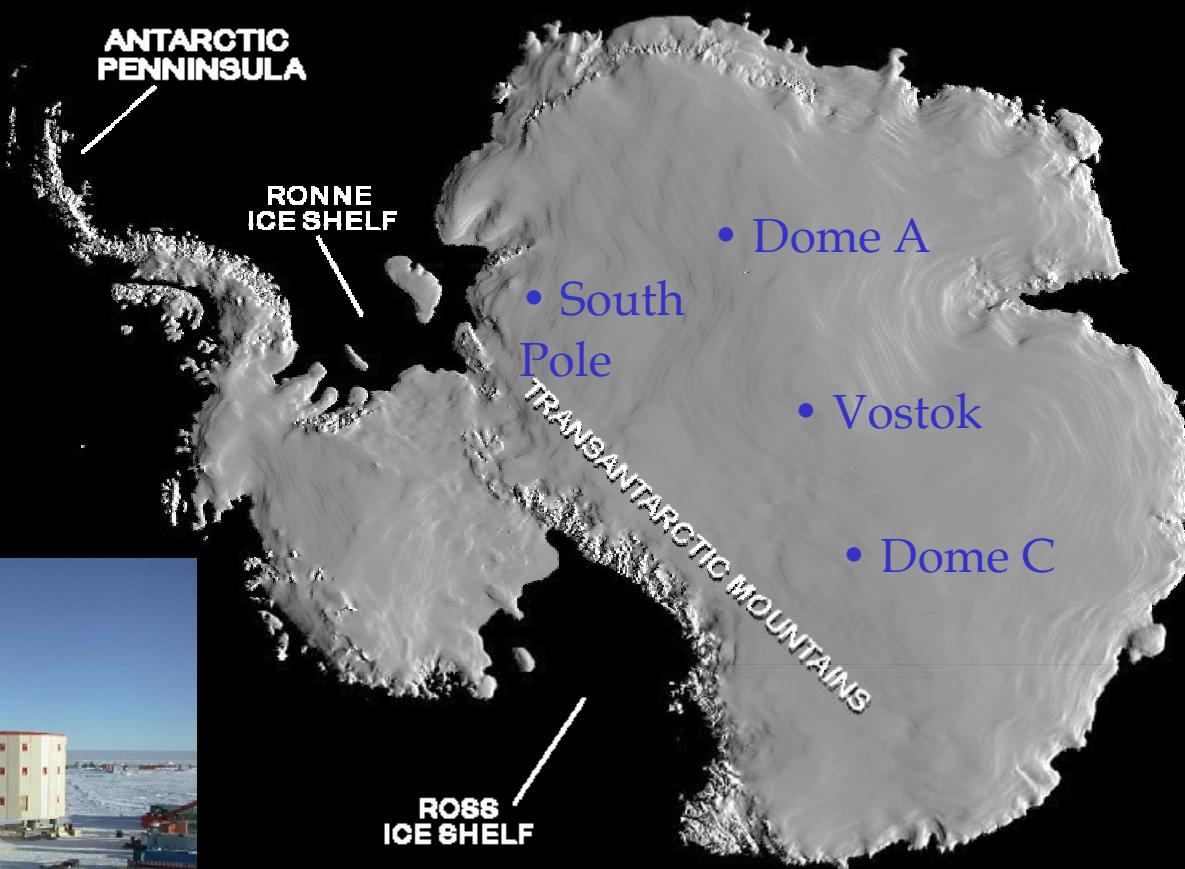




# Potential observatory sites

IEEC

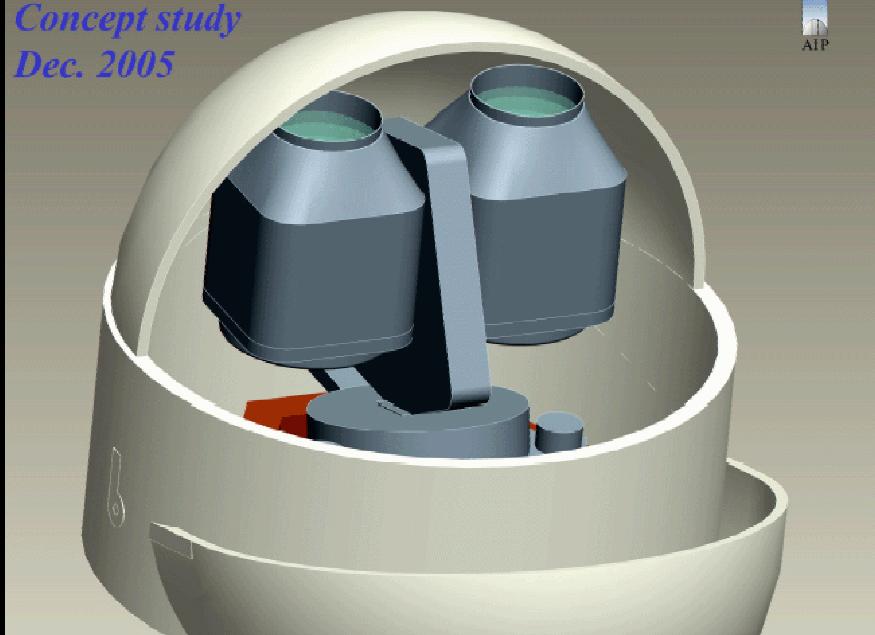
ARENA (European Consortium)



USGS image

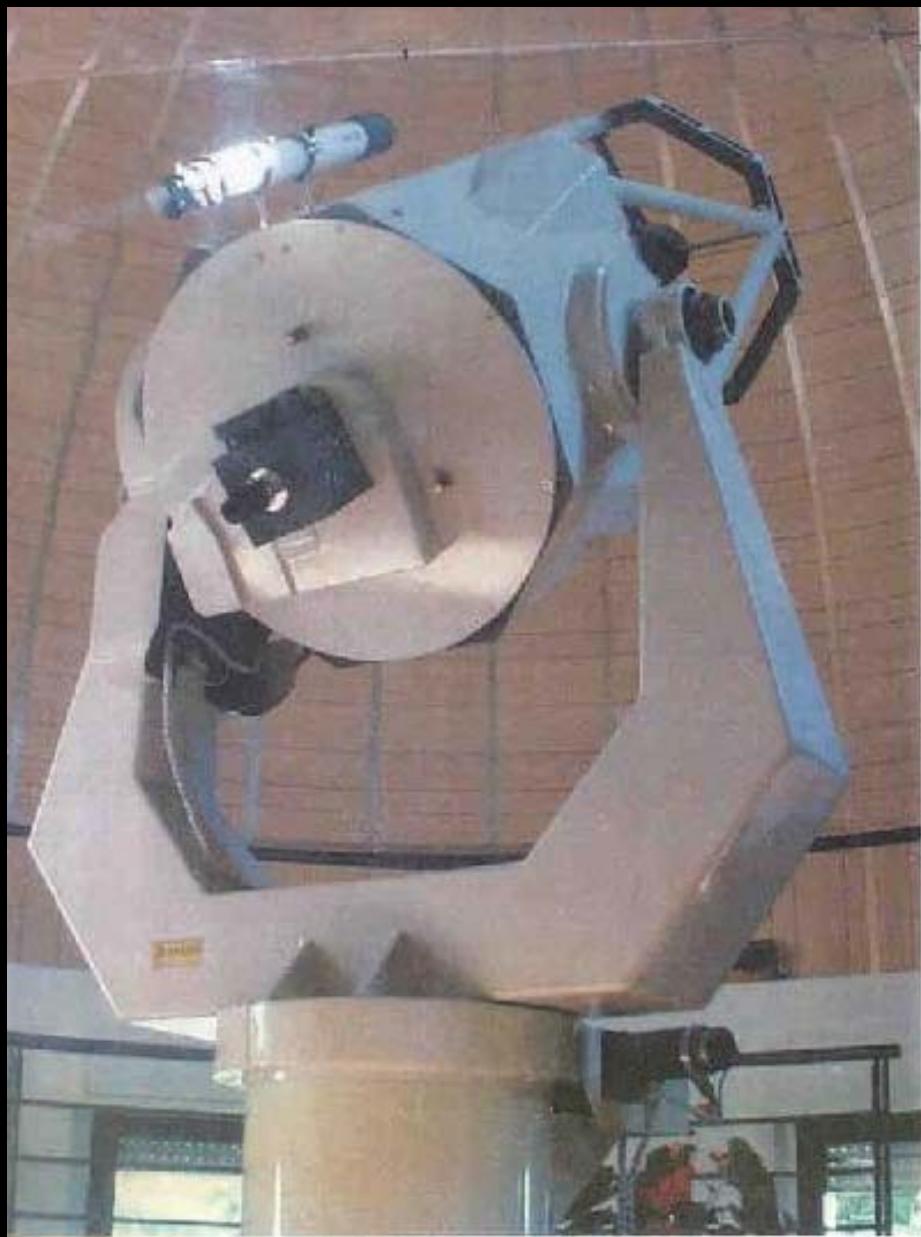
*Concept study  
Dec. 2005*

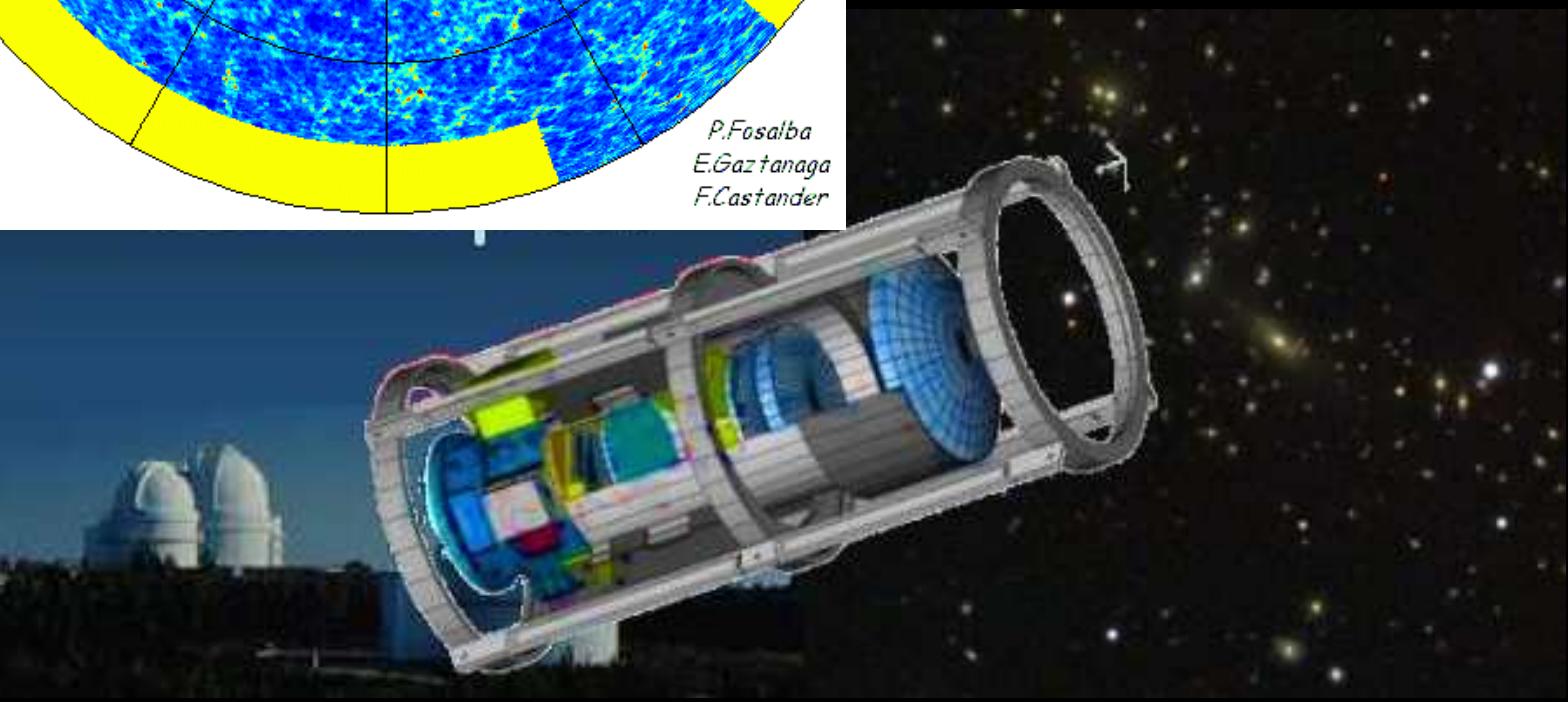
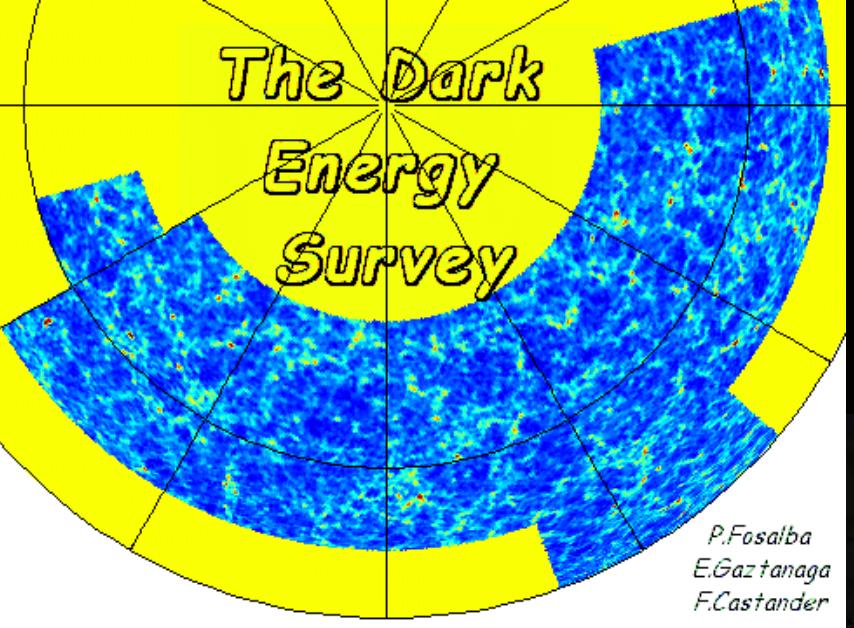
AIP



**ICE-T**

**IRAIT**





# Dark Energy Survey



IEEC



IFAN

## Bremen Drop Tower



Bremen drop tower

### General Specifications

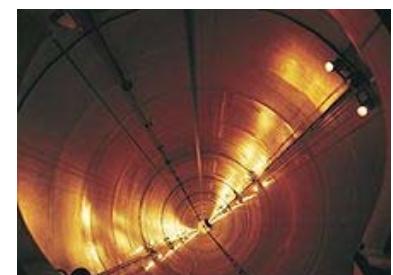
**Dropping height = 119 m**

**Compensated gravity time = 4.74 s**

**Residual accelerations =  $10^{-6}$  to  $10^{-5}$  g<sub>o</sub>**

**Vacuum pressure < 10 Pa**

**Deceleration levels = 25 - 35 g<sub>o</sub> (200 ms)**



Drop tube



Deceleration area & capsule

# Experimental Apparatus



Experiment rig

High speed camera

Test section platform

Experiment hardware

Reservoirs

Computer system

Battery pack



Drop Capsule

-Pressure environment

$p = 1.013 \text{ hPa}$

-Thermal environment

temp =  $25^\circ \text{ C}$

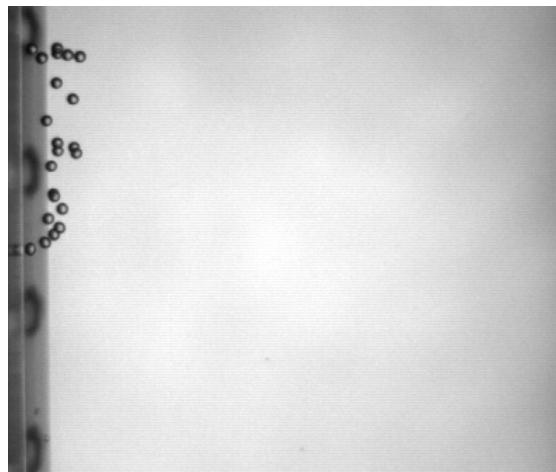
-Controlled deceleration



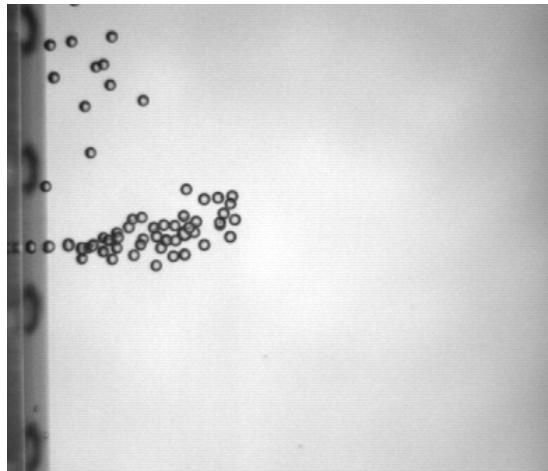
Test section platform

- Injector Diameter = 1.5 mm
- Liquid Vessel Dimensions (100 x 100 x 91 mm)
- Horizontal injection
- Purified air + Deionized Water
- Outflow Compesator by Outflow plate
- High Speed Imaging (250 fps)

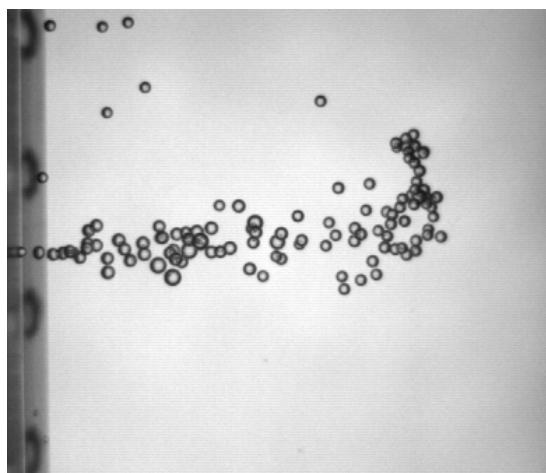
## Results



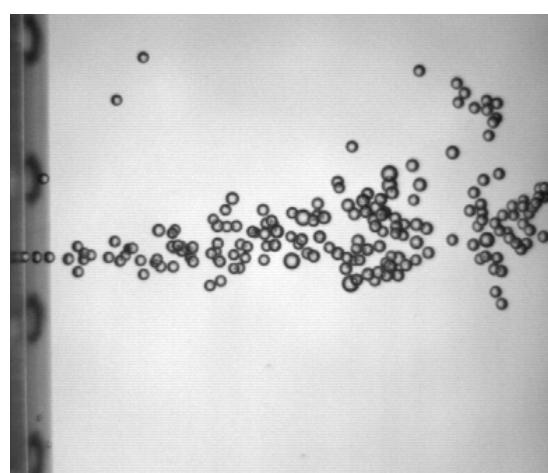
Normal Gravity



$t = 0.24$  s



$t = 0.76$  s



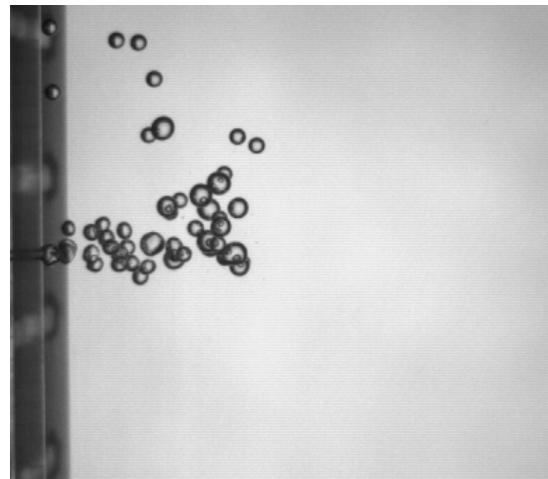
$t = 1.36$  s

$Q = 16.0 \text{ ml/min}$

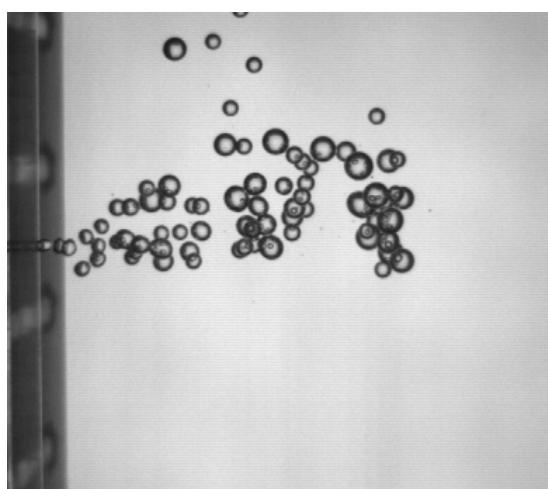
## Results



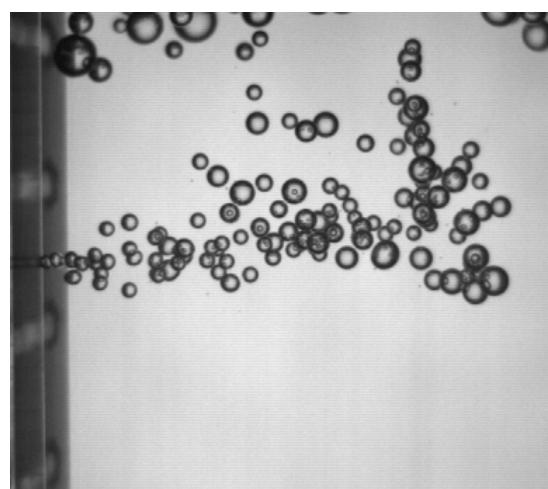
Normal gravity



$t = 0.24$  s



$t = 0.76$  s



$t = 0.136$  s

$Q = 42.2 \text{ ml/min}$