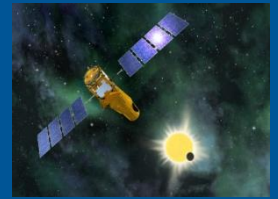




CENTRE NATIONAL D'ÉTUDES SPATIALES



# MEMORIES FROM COROT

## a precursor mission



**LAM TRONG Thien**

**Former**

**COROT Project Manager**

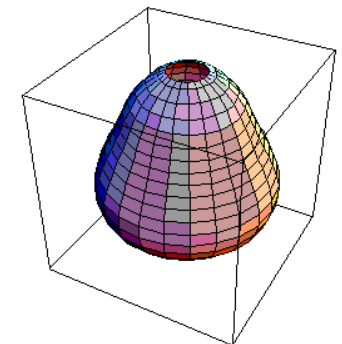
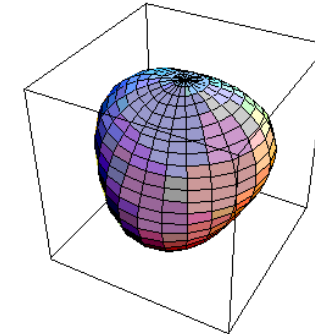
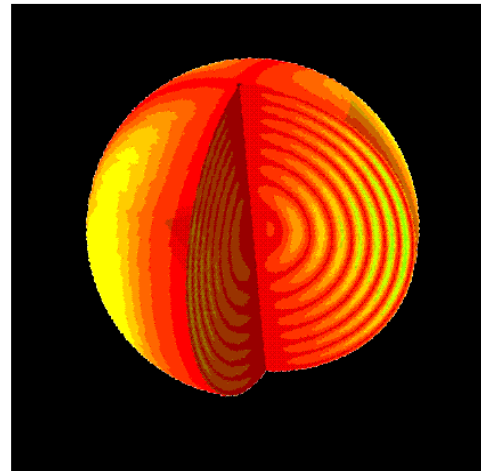
**Exoplanetary Science – Quy Nhon,  
April 2014**



## THE DOUBLE MISSION

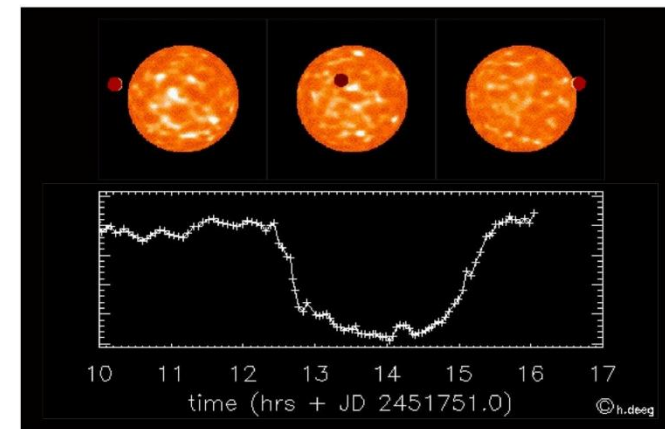
### ■ To study of the internal oscillations of the stars

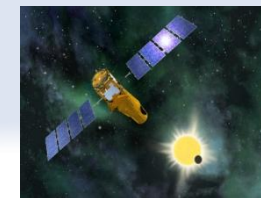
- ◆ 10 stars in the field
- ◆  $m_v$  between 6 and 9



### ■ To detect small planets by detecting the transit

- ◆ 12 000 stars in the field
- ◆  $m_v$  between 12 and 16

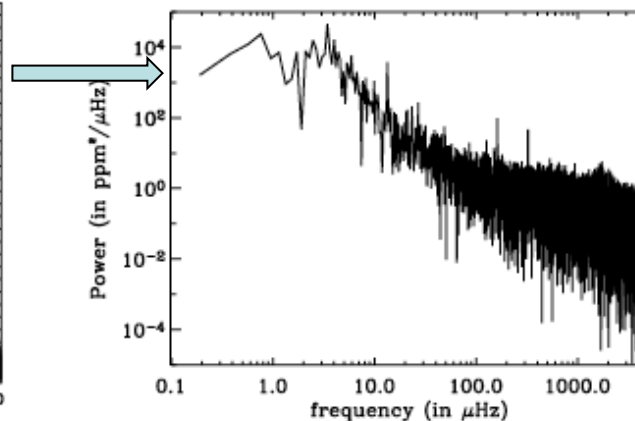
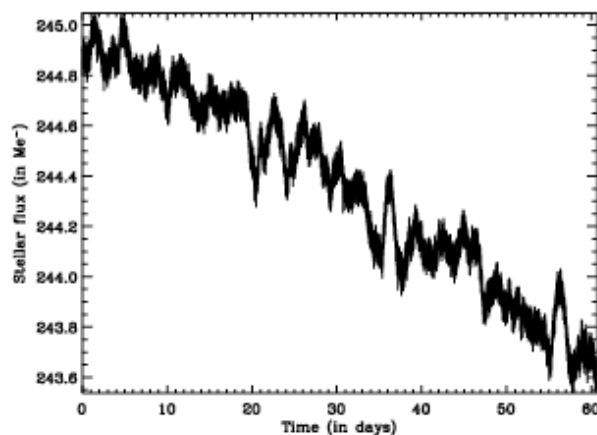
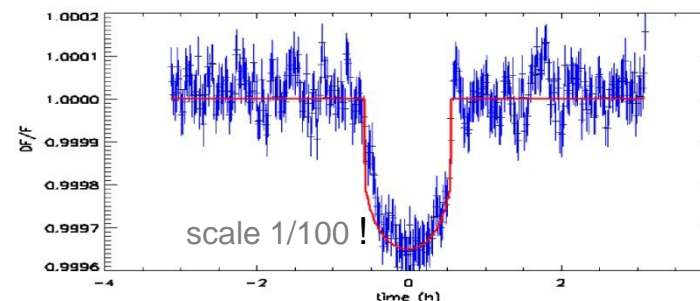
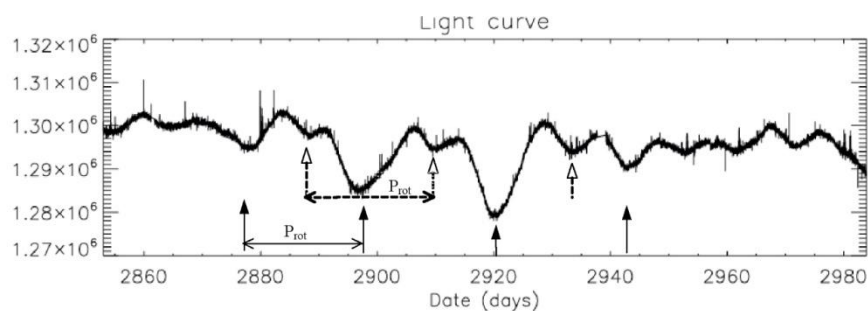




# THE DATA OF COROT

## ■ The data are light curves

COROT 7-b ,  $R = 1.7 R_{\text{Earth}}$  Period < 1day  $d \sim 5$



In FOURIER Space



## THE ORIGINS

- First discussions started on 1993
- Long maturation (10 years !) particularly carried by two persons
  - ♦ Annie BAGLIN (CNRS – LESIA)
  - ♦ Frederic BONNEAU (French Space Agency, CNES)
- The project has been stopped (cancelled ) two times
- Finally really decided (funded) in 2003 with a target date for the launch in 2006
- 10 years to decide and only 3 ans for scientists and engineers to develop the space system (instrument, satellite and ground segment) !!!
  - ♦ 13 years in the time scale of exoplanets hunting is long...





## **COROT KEY- MEMORIES**

### **■ HARD TO DO**

- ◆ **COROT is not a « flagship » mission but everything was difficult**
- ◆ **Relative modest funding**
- ◆ **Only 3 years to build the complete space system**
- ◆ **Plenty of technical issues to solve**
- ◆ **Multi-Lateral cooperation to organize**
  - Interfaces to be setup
  - difference of cultures to be managed

### **■ RISK TAKING**

### **■ SKILL OF TEAMS**

### **■ SOLIDARITY**

- ◆ **Between scientists and engineers**

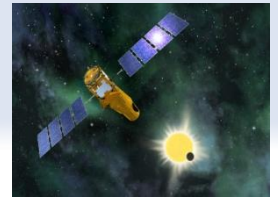
### **■ DETERMINATION (the launch has been performed on-time)**



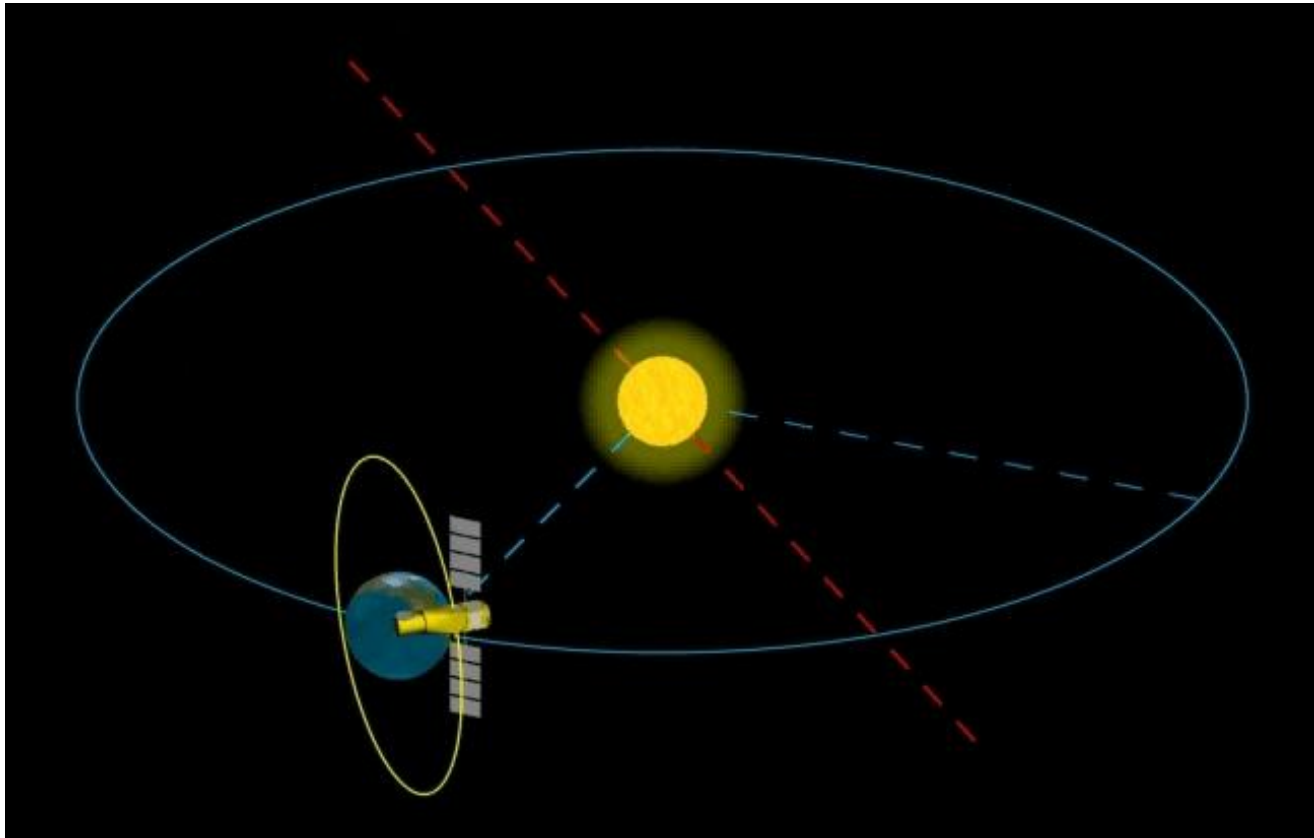
## LOW-COST CHOICES

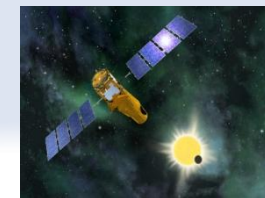
- Small satellite (600 kg, 500 W)
  - ♦ Use of a standard Bus (PROTEUS)
- Low Earth Orbit (LEO)
  - ♦ 900 km pure polar orbit ( $i = 90^\circ$ , no rotation of the orbit plane)
  - ♦ Because of the sun, each observation duration (run) is limited to 150 days → no detection of planets with a period  $> 50$  days





## MISSION ANALYSIS





## TECHNICAL ISSUES

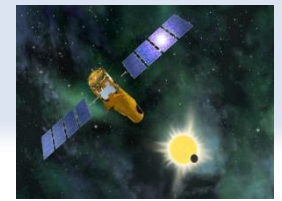
### ■ Required photometry performances

- ♦ **Measurement of eigen oscillation modes (0.1 mHz – 10mHz) → ~0.6 ppm in frequency domain (400 ppm in time domain)**
- ♦ **Detection of transits → ~ n \* 100 ppm**

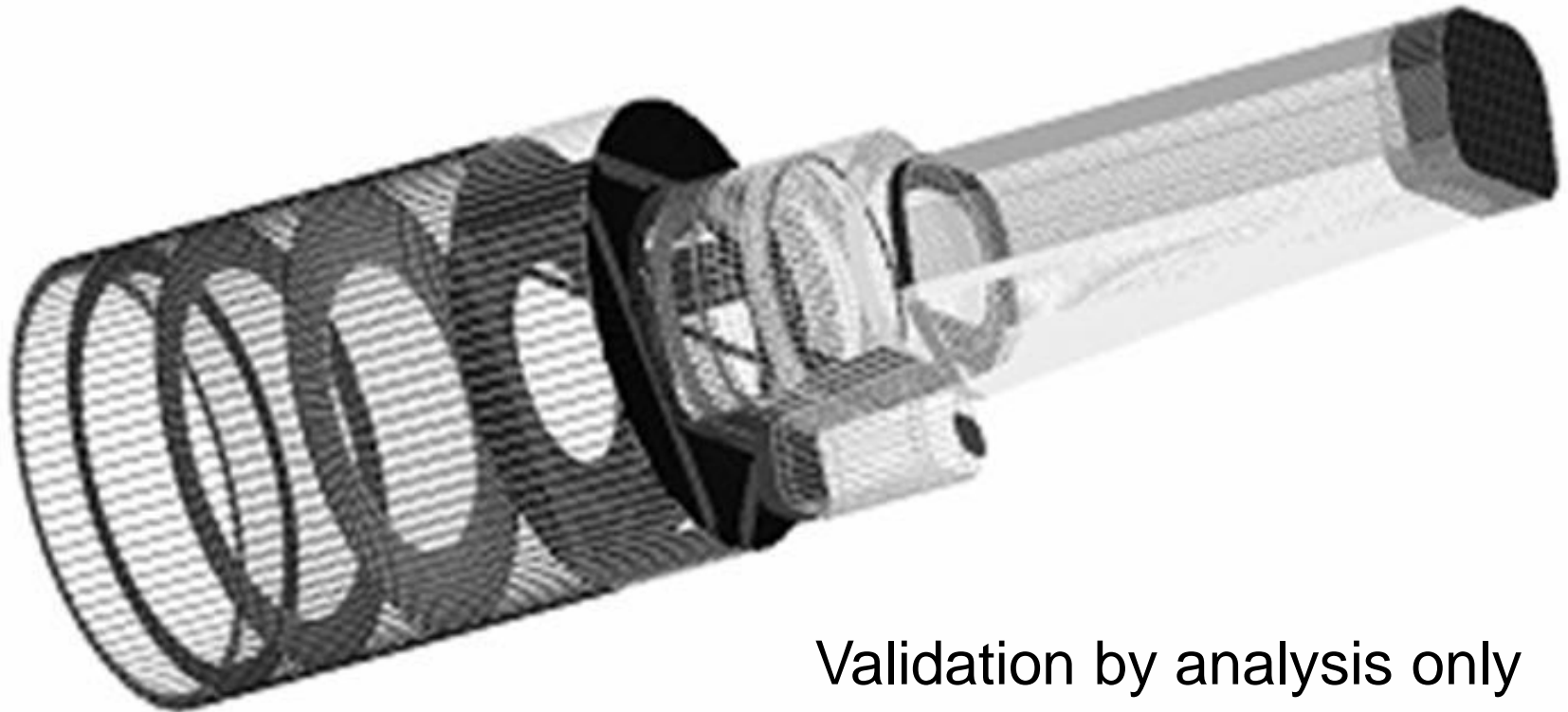
### ■ Flow down to

- ♦ **Attitude jitter lower than 0.5 arcsec**
  - → Introduction of the telescope data in the real-time loop of attitude control
- ♦ **Straylight rejection better than  $10^{-12}$** 
  - 2 stages baffle
- ♦ **Thermal stability : 0.015°C for the CCD's**
  - Accurate thermal control design
- ♦ **Plenty of requirements for limiting the noise of read-out electronics**





## THE COROT BAFFLE



Validation by analysis only  
Made by 2 independent teams



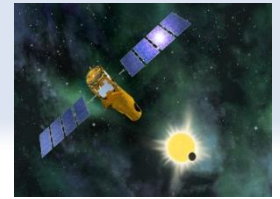
## RISK TAKING

### ■ VERIFICATION OF CRITICAL DESIGN BY SIMULATION ONLY

- ♦ Straylight and performance of the baffle analysis and simulation by two independent teams (1 belgian, & 1 french)
- ♦ No end-to-end test of the attitude control with the telescope in the loop

### ■ Late development of on-ground data processing softwares

### ■ Use of a maiden flight of the launcher (Soyuz version 2b)



# COROT RESULTS

## ■ PERFORMANCES

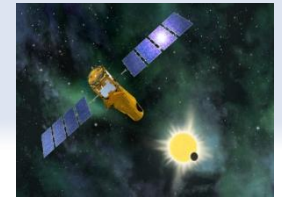
- ◆ In-orbit performances are better than specifications

## ■ COROT Data

- ◆ 26 fields have been observed
- ◆ Oscillation eigen modes of stars
  - > 150 bright stars
- ◆ Transit detection :
  - > 160 000 stars
  - Thousands of candidates

## ■ COROT Contribution to Science

- ◆ Stars in general are very different from the Sun (more complex structure, more magnetic activity, faster rotation)
- ◆ More than 30 planets are confirmed of which a Super Earth (Corot 7-b)
- ◆ Is a scout mission for addressing the issues attached to the variability of stars in the detection of small planets
- ◆ Exemple of a combined approach for the study of stars and planetary systems .



## AND BY NOW

- **The scientific activities are still going full swing!**
  - ♦ Even the satellite does no more produce new data
  - ♦ Still for a long time
  
- **COROT results are supporting and shall support a large number of publications**
  - ♦ Up to now roughly 1500 publications have already cited COROT



## CONCLUSION

- Because of its difficult context, the development of the COROT mission has been a great human adventure
- COROT is an exemple of a successful and balanced multi-lateral cooperation
- An exemple of a positive melting pot of different cultures
- An exemple of a collective effort between scientists and engineers
- An exemple of a scout mission opening the way to more ambitious missions (KLEPER , PLATO)



