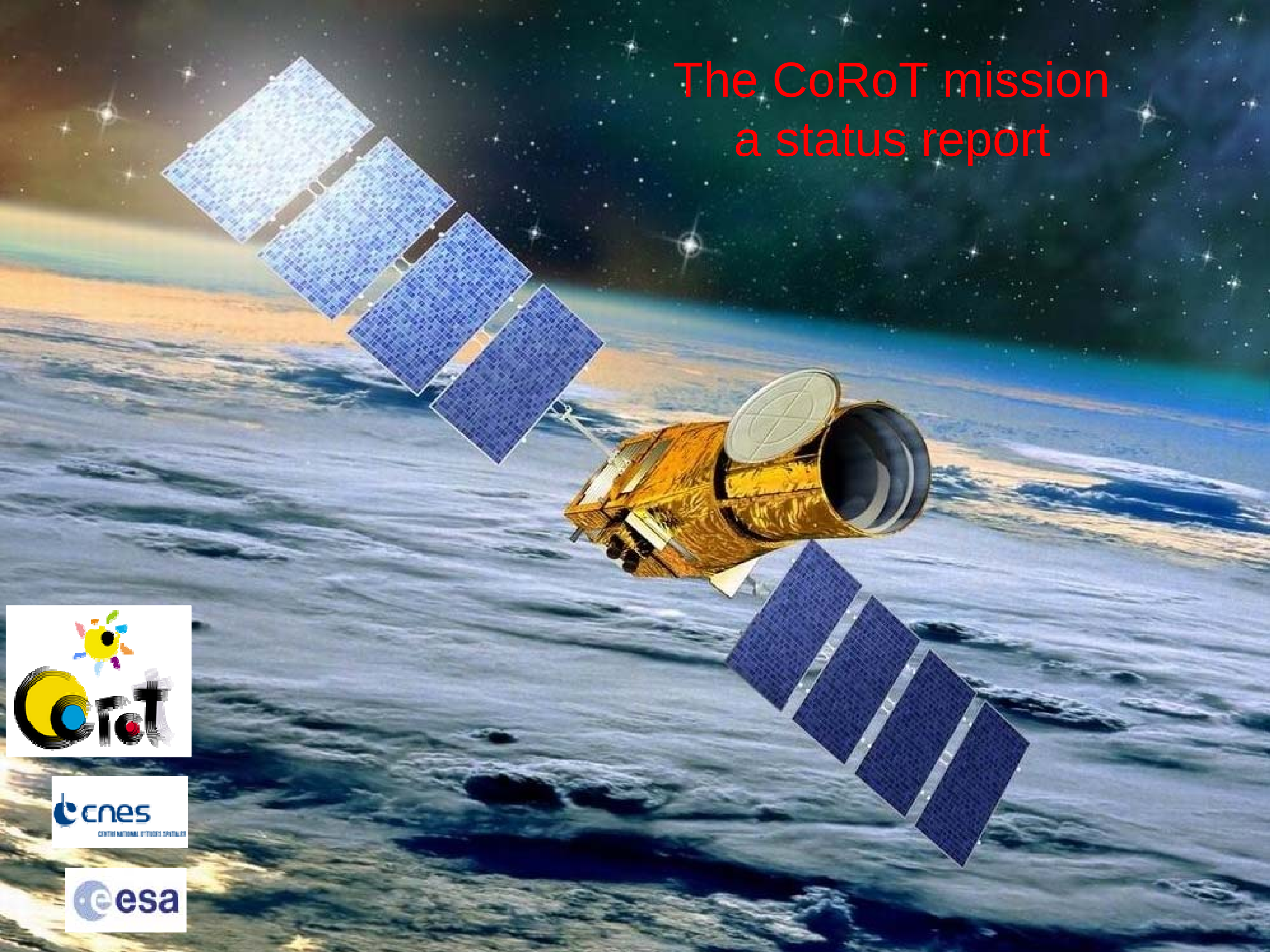
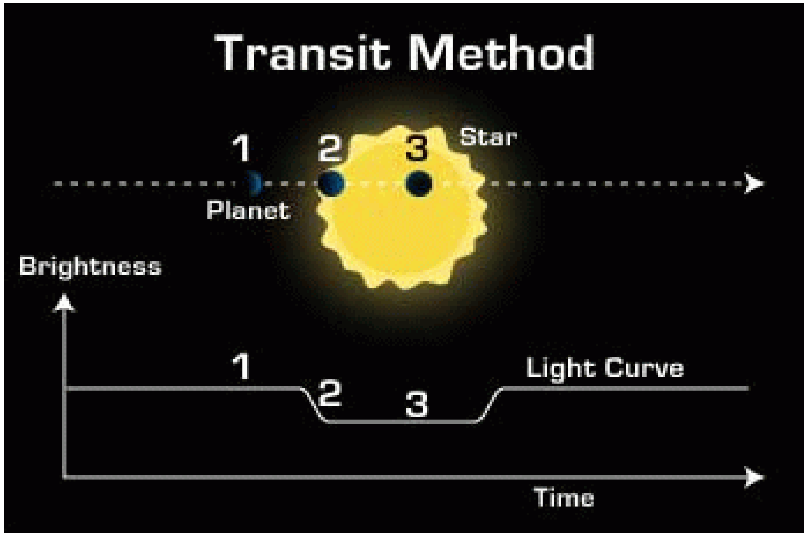
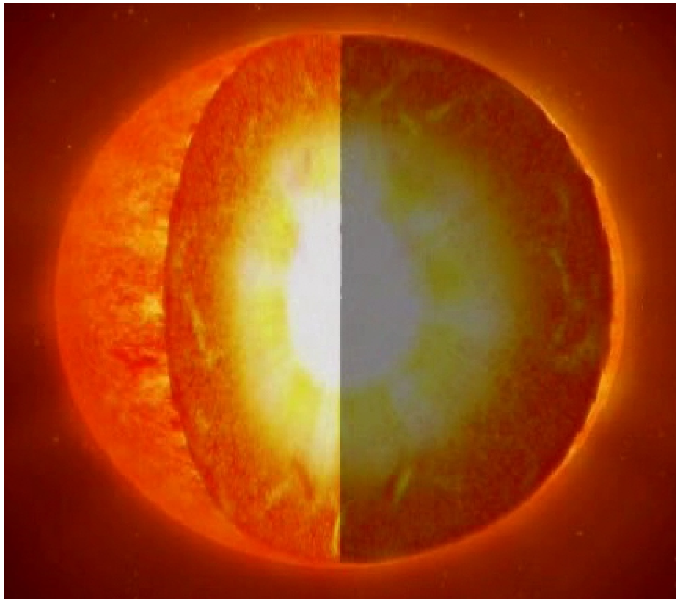

The CoRoT mission
a status report

Objectives





COROT has two design objectives:

- Searching for planets of a type similar to our own Earth
- Studying the inner parts of stars by measuring the changes in light output caused by acoustical sound waves travelling through the star.

COROT is essentially a very precise photometer. It can measure changes in stellar flux to an accuracy better than1 part in 1 000 000!

It can discriminate between colors → COROT can tell what the cause of variations in stellar flux is:

a) Intrinsic changes caused by activity or by waves travelling through the star, or

b) Occultations by a (small) planetary body passing in front of the star

COROT:

- **S/C 4.2m x 1.9m x 9.6m, 650kg, 530w**
- **Payload**
  - **Telescope: afocal, 27cm aperture, Baffle**
  - **Detectors: dioptric, 4 CCD frame transfer 2048 x 4096**
- **Short observing runs (20 - 60 days) on asteroseismology fields**
- **Up to 150 days on exo-fields**

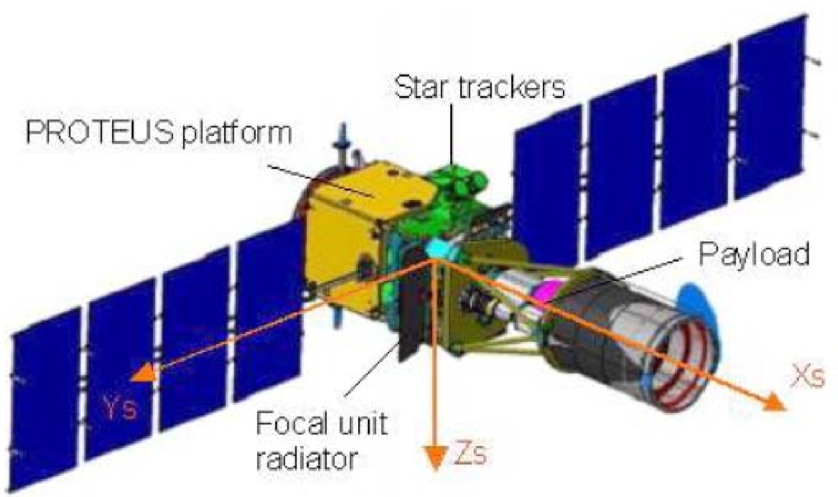
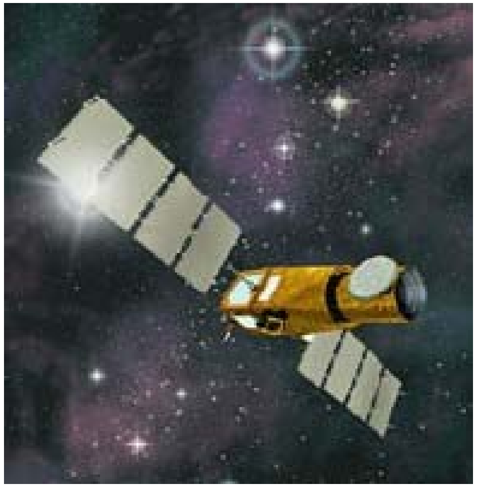


Figure 4. Satellite overview (4.20 mx9.60m)



Launched 27 Dec 2006;

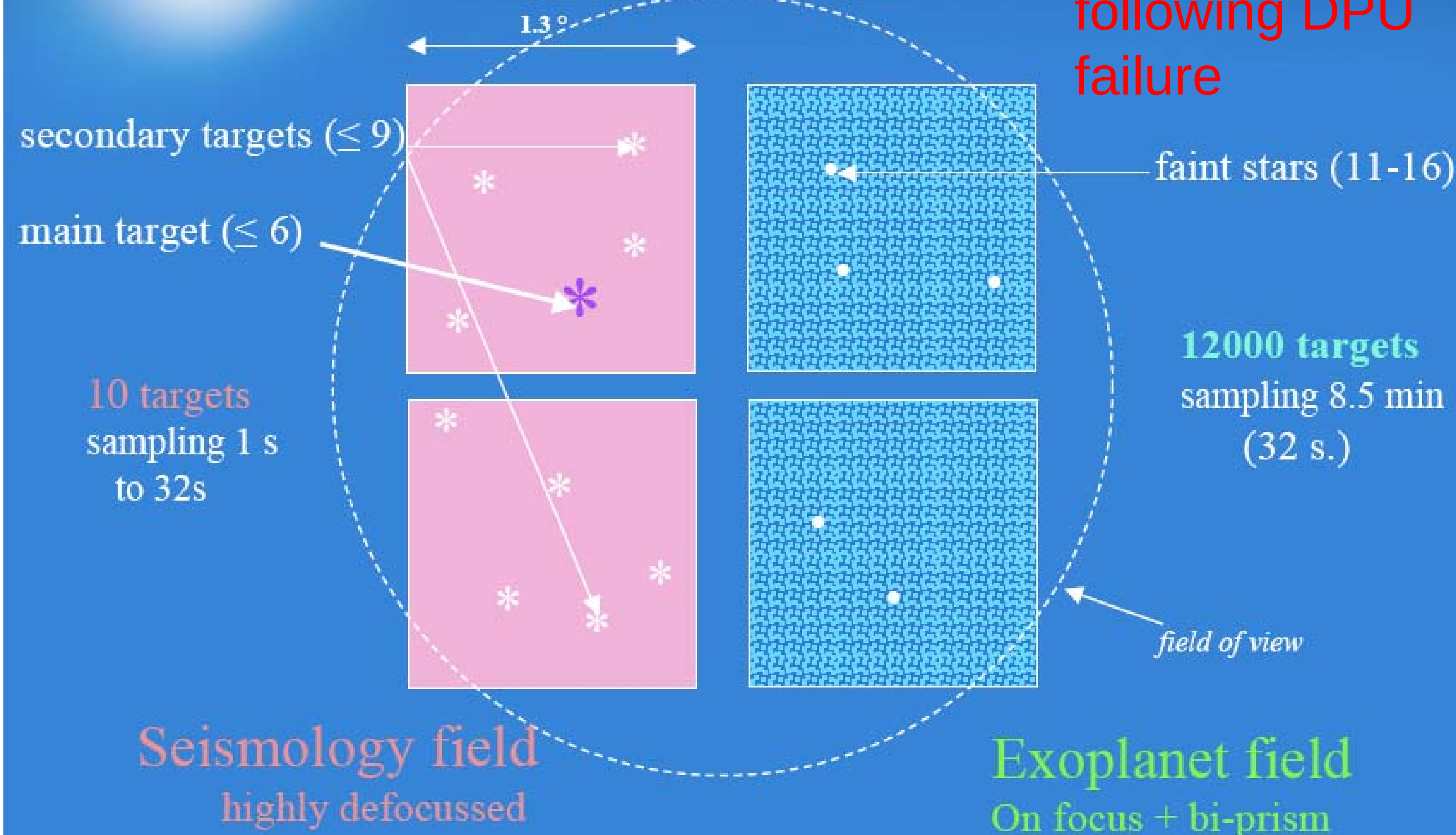
Operated since 15 Feb, 2007;

> 1130 days in Space

About 80000 light curves collected;

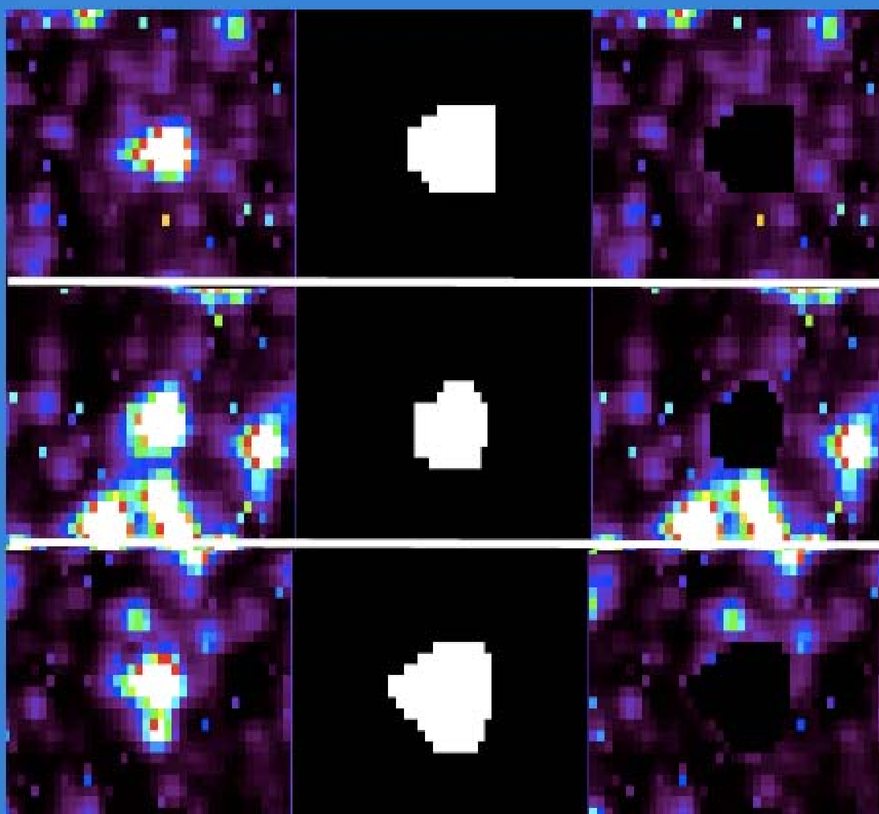
The focal plane

The 2 top CCDs are out of action following DPU failure

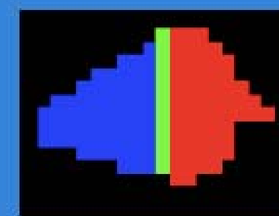


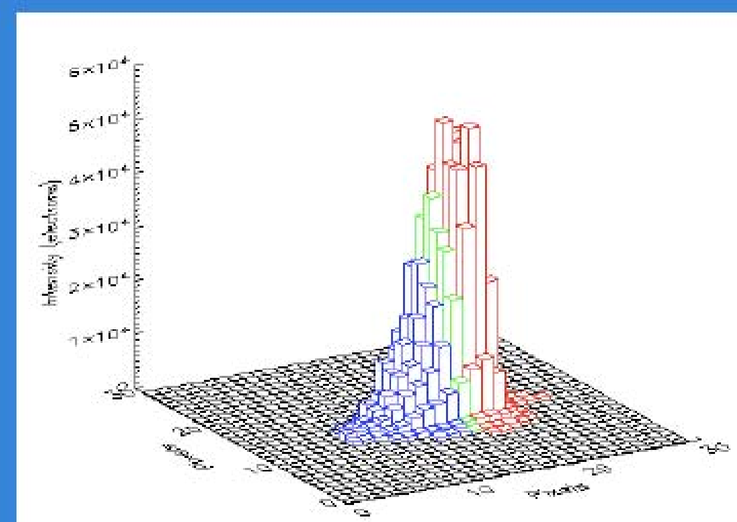
Aperture (coloured) photometry in the exofield

Each selected target is given a photometric template chosen in a predefined set



For the brightest stars (R<14.5)

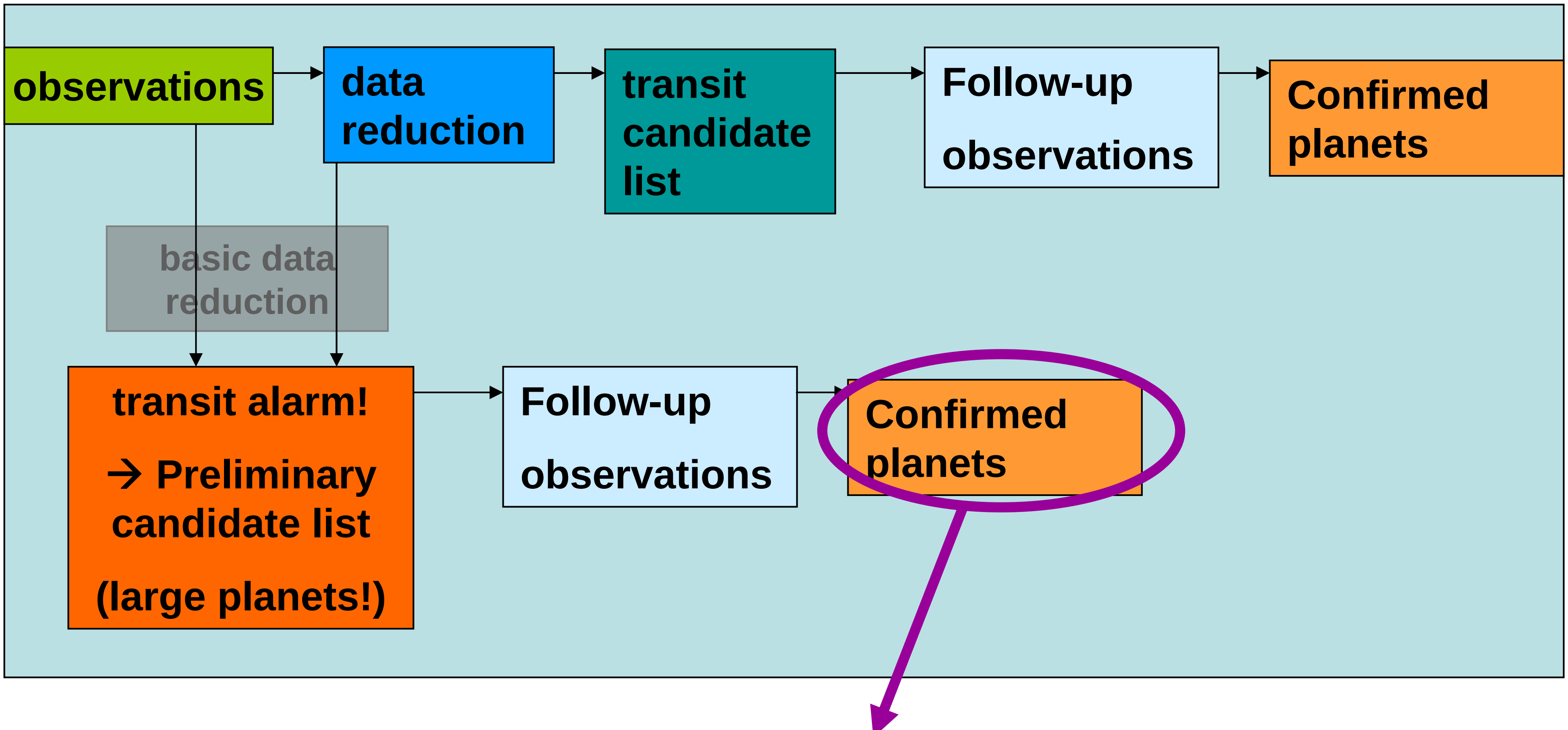




Mission status

- The mission is extended by CNES until May 1 2013
- S/C operates nominally except for Data Processing Unit (DPU) chain 1
  - All attempts to restart DPU have failed. No new attempts will be made until:
    - A) DPU 2 fails
    - B) Mission extension is over
- In the frame work of a NASA-CNES agreement, NASA has developed improved software for the extraction of light-curves & detection of transits in exchange for a mirror of the CoRoT archive at NExSci (NASA Exoplanet Science institute) at Caltech

How CoRoT planet detection works…



Giant (and even small) planets can be detected already in ‘‘alarm mode“!

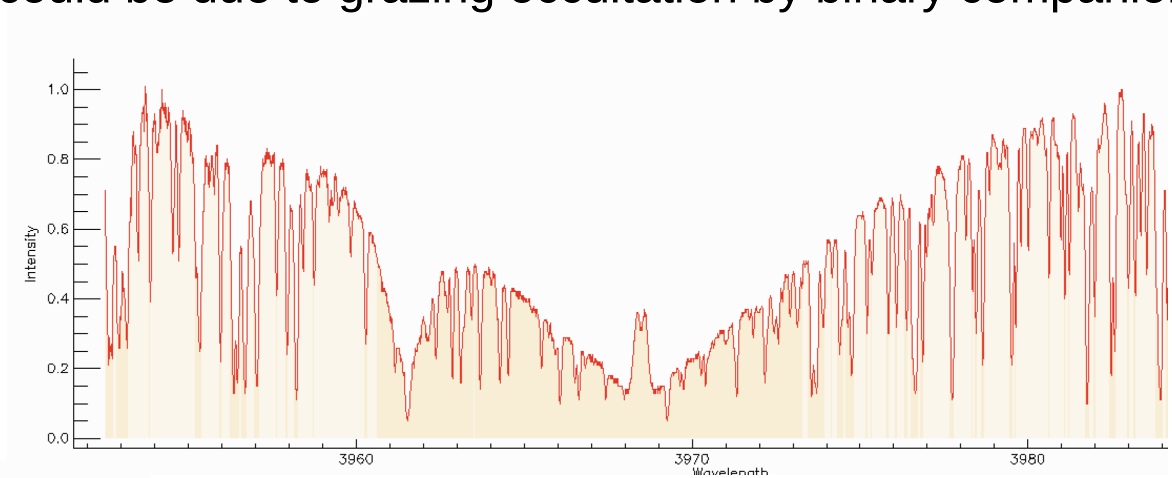
Follow-up: 1. Spectroscopy

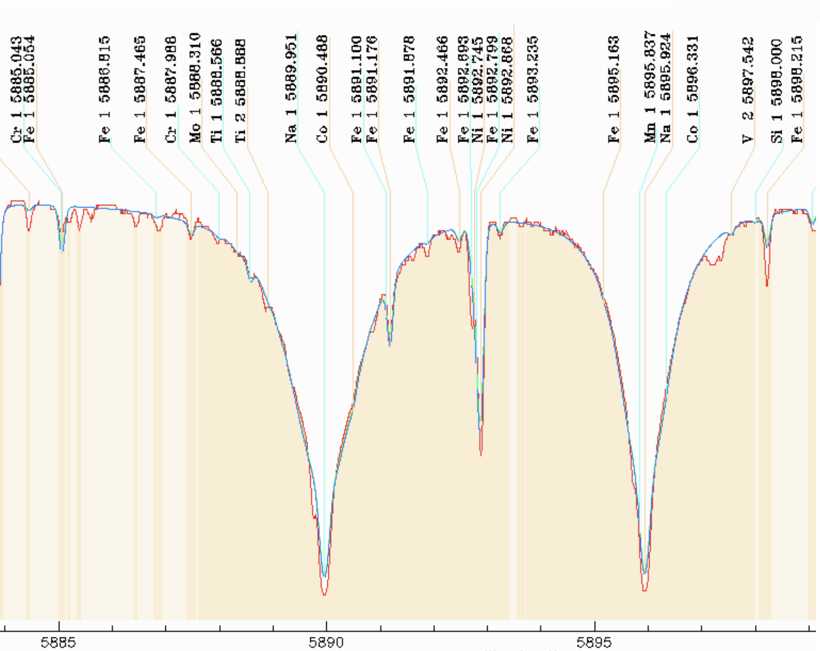
This is of two kinds:

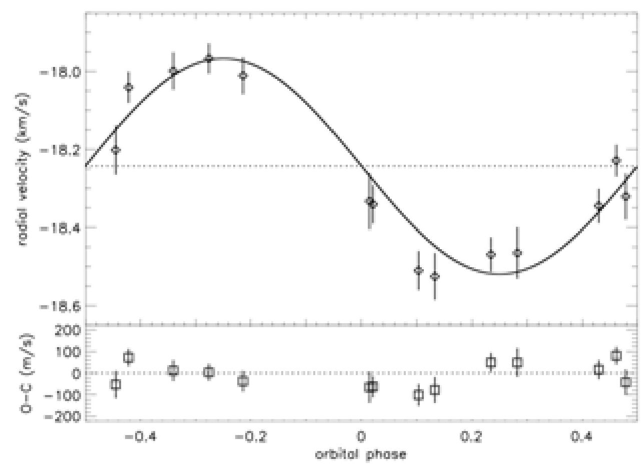
→ Radial Velocities

→ high s/n & high resolution spectra to infer stellar parameters.

Alternatively, transit signature could be due to grazing occultation by binary companion





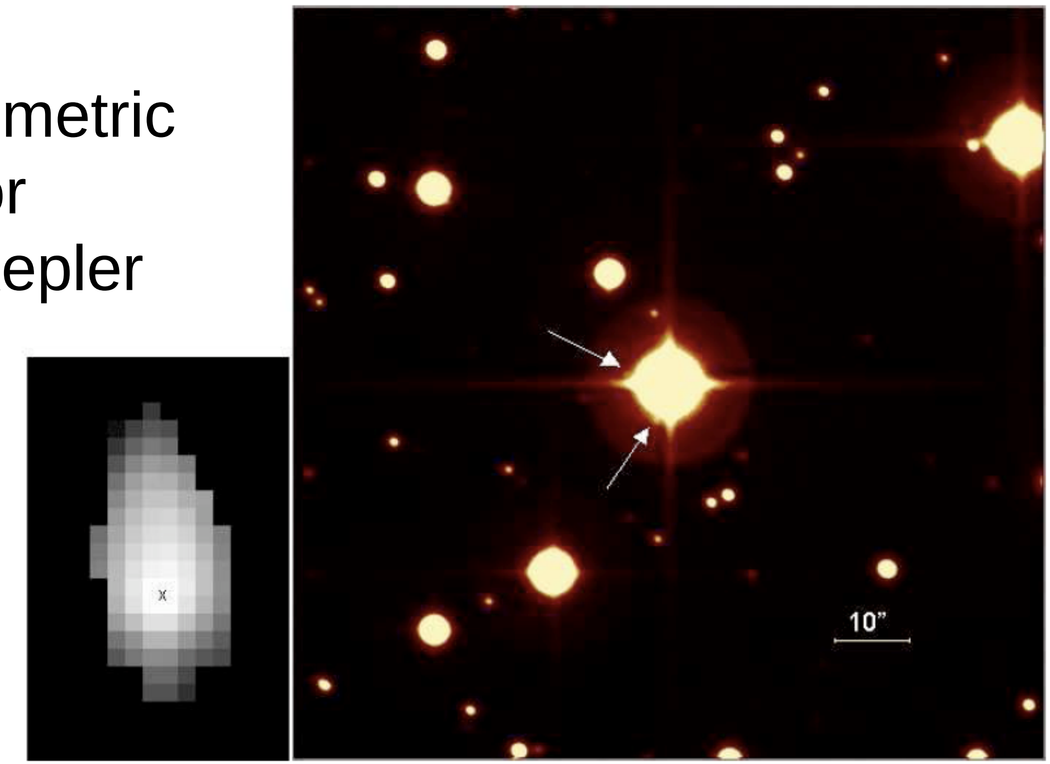


Follow-up: 2. Photometetry

A variable background object in the large CoRoT Point Spread Function (PSF) can mimic planetary transits. This possibility has to be excluded by follow-up ground based photometry of the candidate parent star

ESA’s OGS telescope fills a gap here!

Spectroscopic and photometric follow-up are essential for missions like CoRoT & Kepler

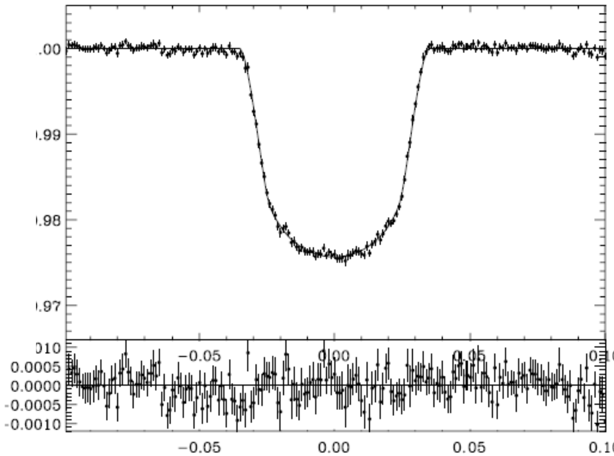


PSF of CoRoT 7b

Planets – The "first four"!

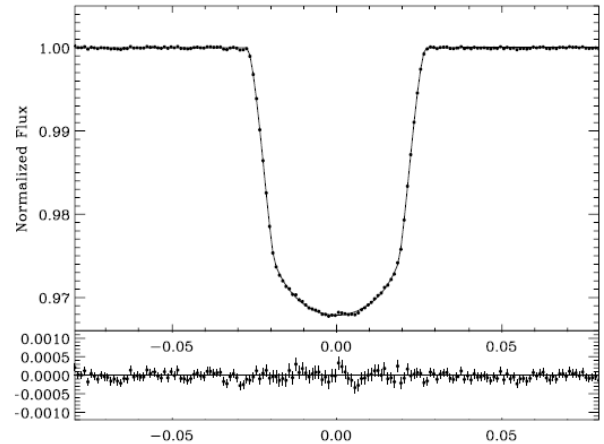
CoRoT-Exo-1b

CoRoT-Exo-1b:
P: 1.5089557 d
r: 1.49 R_J
m: 1.03 M_J
The star:
G0V
V = 13.6 mag



Barge et al. 2008

CoRoT-Exo-2b

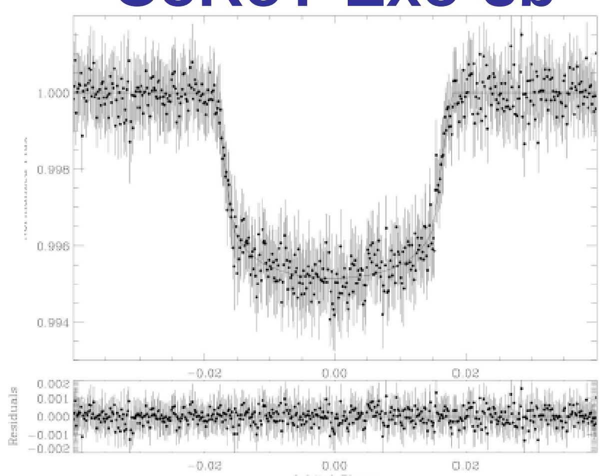


Alonso et al. 2008

CoRoT-Exo-2b:
P: 1.742996 d
r: 1.465 R_J
m: 3.31 M_J
The star:
K0V
V=12.6 mag

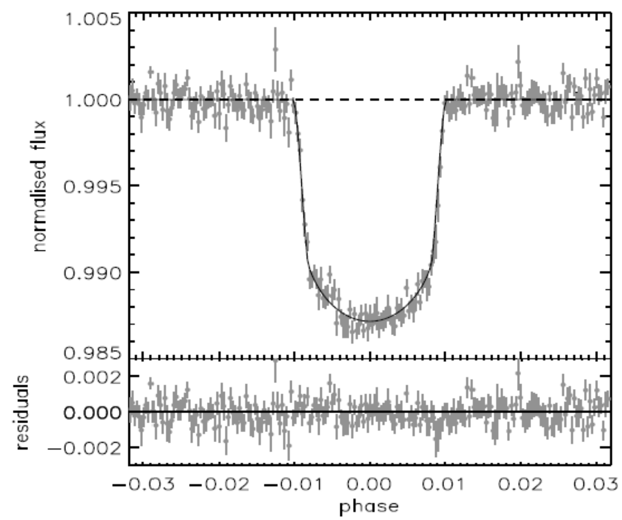
CoRoT-Exo-3b

CoRoT-Exo-3b:
P: 4.2568 d
r: 1.01 R_J
m: 21.66 M_J
The star:
G0V
V = 13.3 mag



Deleuil et al. 2008

CoRoT-Exo-4b



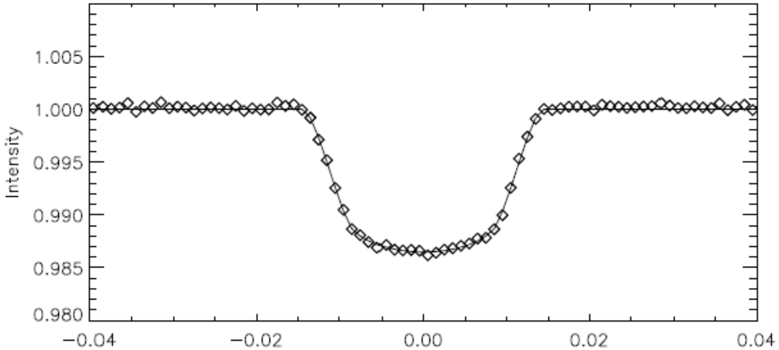
Agrain et al. and Moutou et al. 2008

CoRoT-Exo-4b:
P: 9.20205 d
r: 1.19 R_J
m: 0.72 M_J
The star:
F0V
V=13.7 mag

Change of name!!!

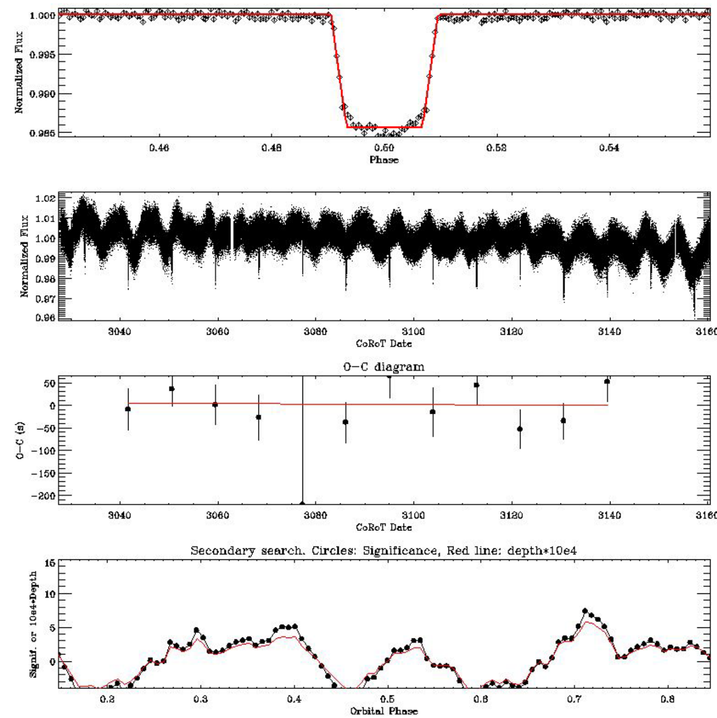
The “next two”

CoRoT-Exo-5b

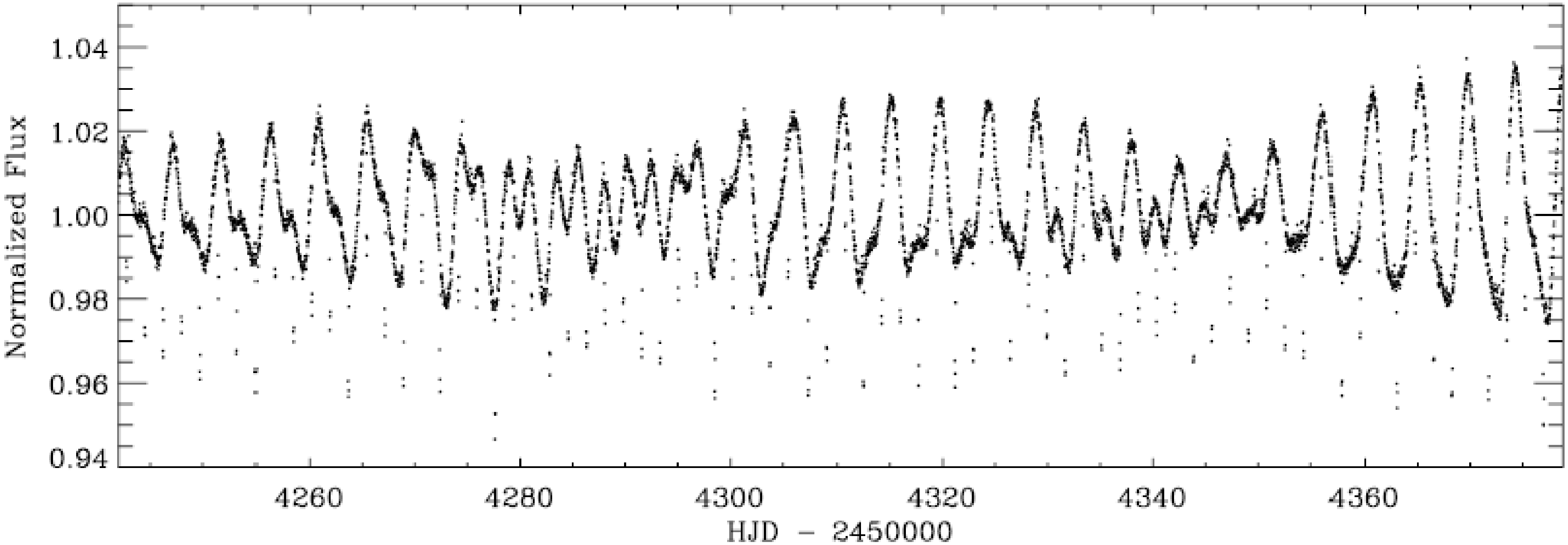


	parameters from photometry
a [r_{star}]:	9.05±0.23
r_p [r_{star}]	0.115±0.007
i [∘]	85.20±0.59
u_+	0.600±0.032
u_-	0.046±0.020
Third light:	0.00±0.02
P [d]	4.0378962±0.0000019
T0 [HJD]	2 454 400.19885±0.00002
	planet parameters
a [AU]	0.049
m_p [m_{Jup}]	0.99
r_p [r_{Jup}]	1.32
ρ [g cm^3]	0.499
T_{eq} [K]	1100

CoRoT-6b



Transiting planets around variable stars – the case of CoRoT-2b



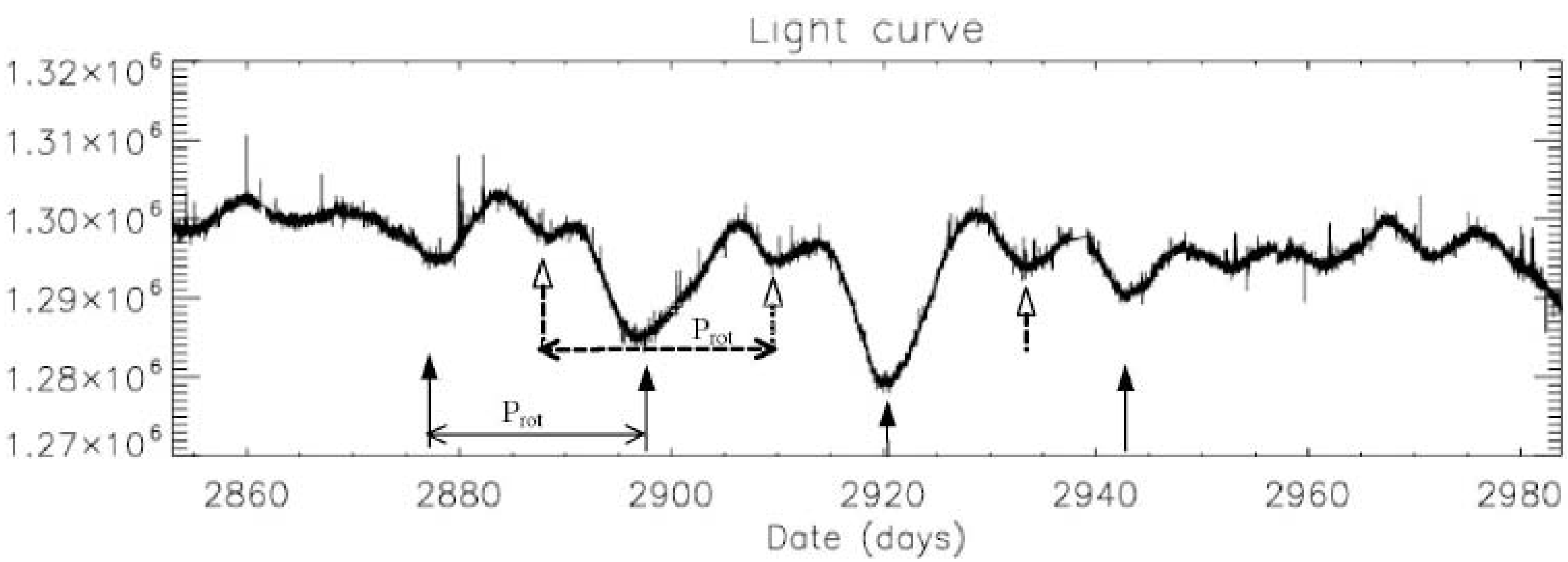
- Observations made during the first "long run" of CoRoT of 152 days duration
- ~369,000 flux measurements with 512 s (1st week) and then 32 s sampling
- **The star shows periodic variation over several days due to surface spots**

The planet:	
Period:	1.742996 days
Radius:	1.465+/-0.029 R_{Jup}
Mass:	3.31+/-0.16 M_{Jup}
The star:	
Type:	G7
Magnitude:	V=12.6 mag
Mass:	0.97+/-0.06 M_{sun}

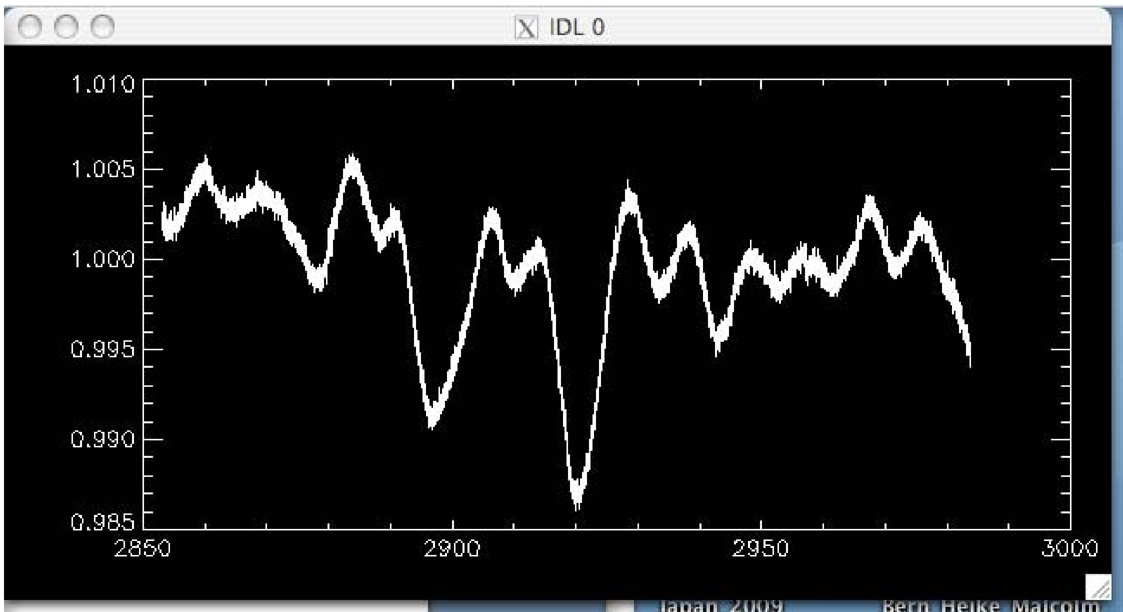
Alonso et al. 2008

CoRoT-7b, the raw light curve!

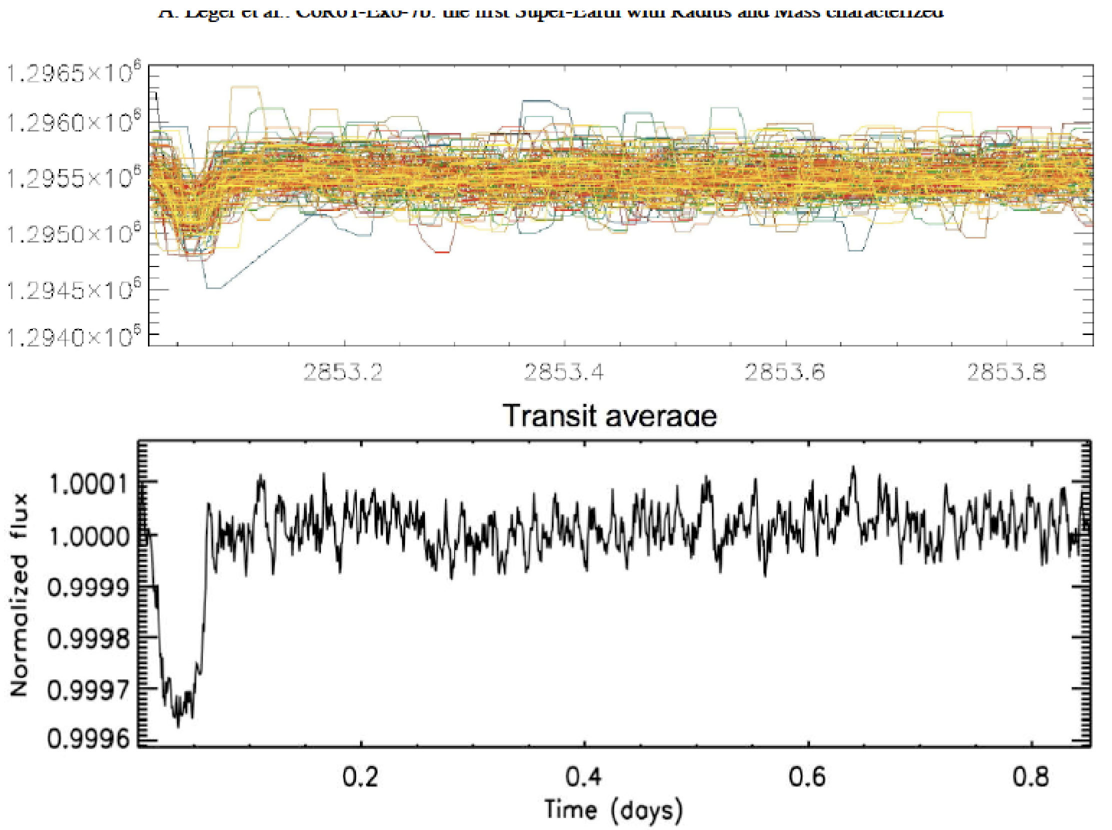
Light-curve of 144 days demonstrating a 22-23 day rotation period



Cleaned and normalised ➔
Sun-like star, somewhat colder and smaller



After running the search algorithms on the CoRoT-7b light-curve, a transit signature is discovered



Individual light curves in colour (top) and summed light curve in white light (bottom) ➔ The derived stellar parameters and transit signature imply that the planet has a diameter 1.58 * R_{earth}

Follow-up required ≥ 110 radial velocity observations with HARPS

The inferred planet mass is low – definitely “super-Earth” class (4.8 M_{Earth})

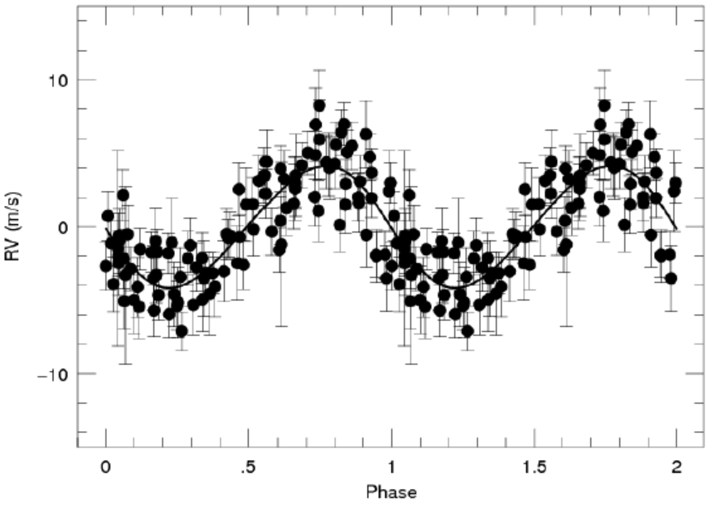
Star is similar to the Sun – Somewhat cooler, 90% mass, 85% of radius

→ This is the planet with the smallest radius so far

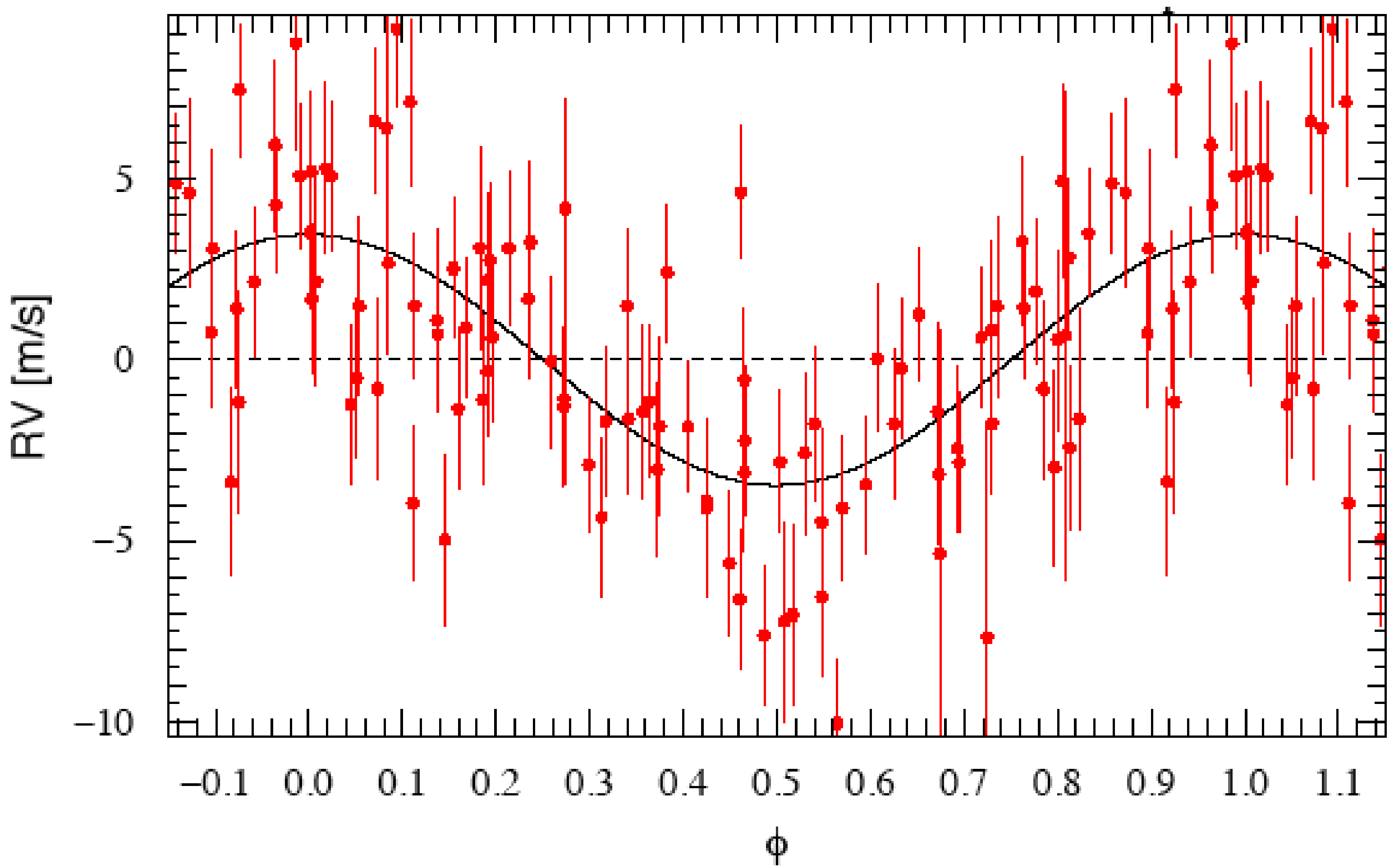
Together with mass determination from radial velocity measurements

→ Average density r = 5.5 g cm^{-3}, similar to Mercury, Venus & Earth

But there is still more in the data: Another planet!



Subtract this signal from the data and look at residuals ...



RV [m/s]
5
0
−5
−10
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
φ

CoRoT-7c

Mass = $8.4 \pm 0.9\ M_{earth}$
Period = 3.7days

Possibly one more planet (CoRoT-7d?) ~15 times M_{earth} and 9 days period but confirmation requires 100 – 200 additional observations with HARPS

CoRoT-7b is very close to its star (only ~ 5 stellar radii) and thus hot (~ 2000K) and has a short “year” (20.2h)
→ Definitely not earth-like…in climate!

Another slightly larger super Earth was found by the Mearth project”:
$M \approx 10\ M_{earth}$
$R \approx 2\ R_{earth}$
Orbiting a red dwarf star.
Density like Neptune or “icy moons”

Other planet candidates:

CoRoT-8b:	A&A in prep
CoRoT-9b:	Nature accepted
CoRoT-10b:	A&A in prep
CoRoT-11b:	A&A in prep

- IRa01: 15 unsolved candidates
- LRc01: 21 unsolved candidates
- LRa01: 34 unsolved candidates
- LRc02: 29 unsolved candidates
- LRa02: 32 unsolved candidates
- LRc03_E2: 20 unsolved candidates (Alarm)
- LRc04_E2: 17 unsolved candidates (Alarm)
- LRa03_E2: 11 unsolved candidates (Alarm)

~ 10-12 of these candidates are probably planets

Out of the122 articles published over the period 2007 – 2010, 45 are dedicated to exoplanets; a further 30 are in preparation

≥100 objects observed in astroseismologic mode

NGC 2264 observed for > 1 month for extensive variability study; NGC 2264 will be re-observed

Several solar type stars (and somewhat earlier) observed. P-modes detected, granulation studied

δ Scuti and β Cephi also monitored

What comes next?

Following CNES decision, CoRoT operations will continue for another 3 years

Longer observation periods again (155d – 80d – 140d)

Revisit LRa01 ➔ data over a 6 years time baseline

Focus on small planets

Doubling number of astroseismologic targets, with emphasis on solar type stars

The End

Kepler has measured asteroseismological characteristics of 1 F-star: HAT-7

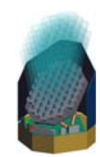
→ Stellar parameters: Mass to 1%, radius to 1%, age to 260 Myrs

→ Improvement in planetary parameters from > 50% to < 5% accuracy on ρ_{pl}

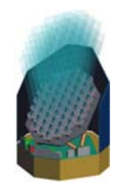
Kepler will be able to reach this accuracy for ≤150 stars only (one with a known transiting planet) → 1 or 2 exoplanets

Barely opens the field of comparative planetology for PLATO!

20 

150   25000

20   150

 25000