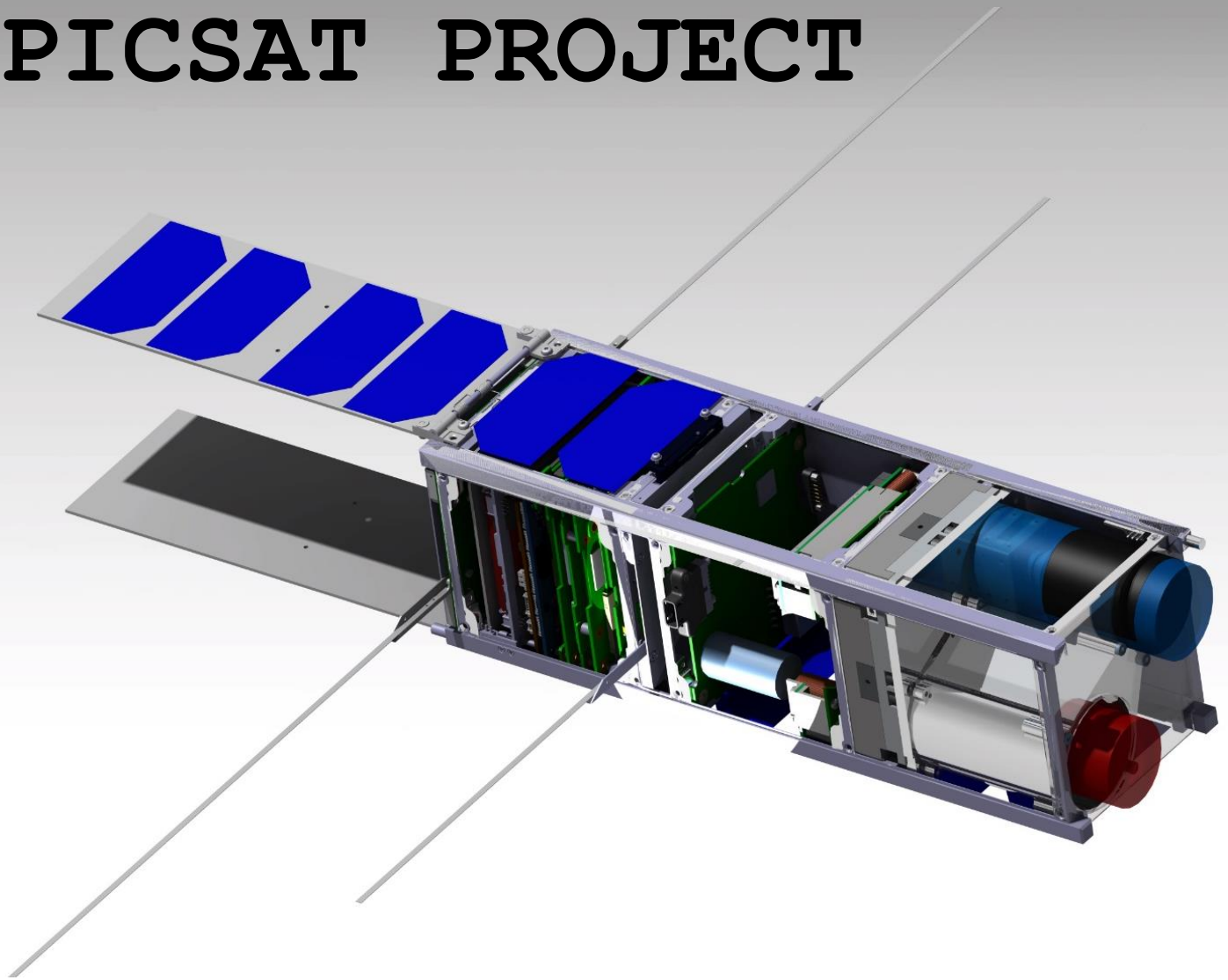
THE PICSAT PROJECT



Mathias Nowak,
PhD student LESIA/Observatoire de Paris
mathias.nowak@obspm.fr

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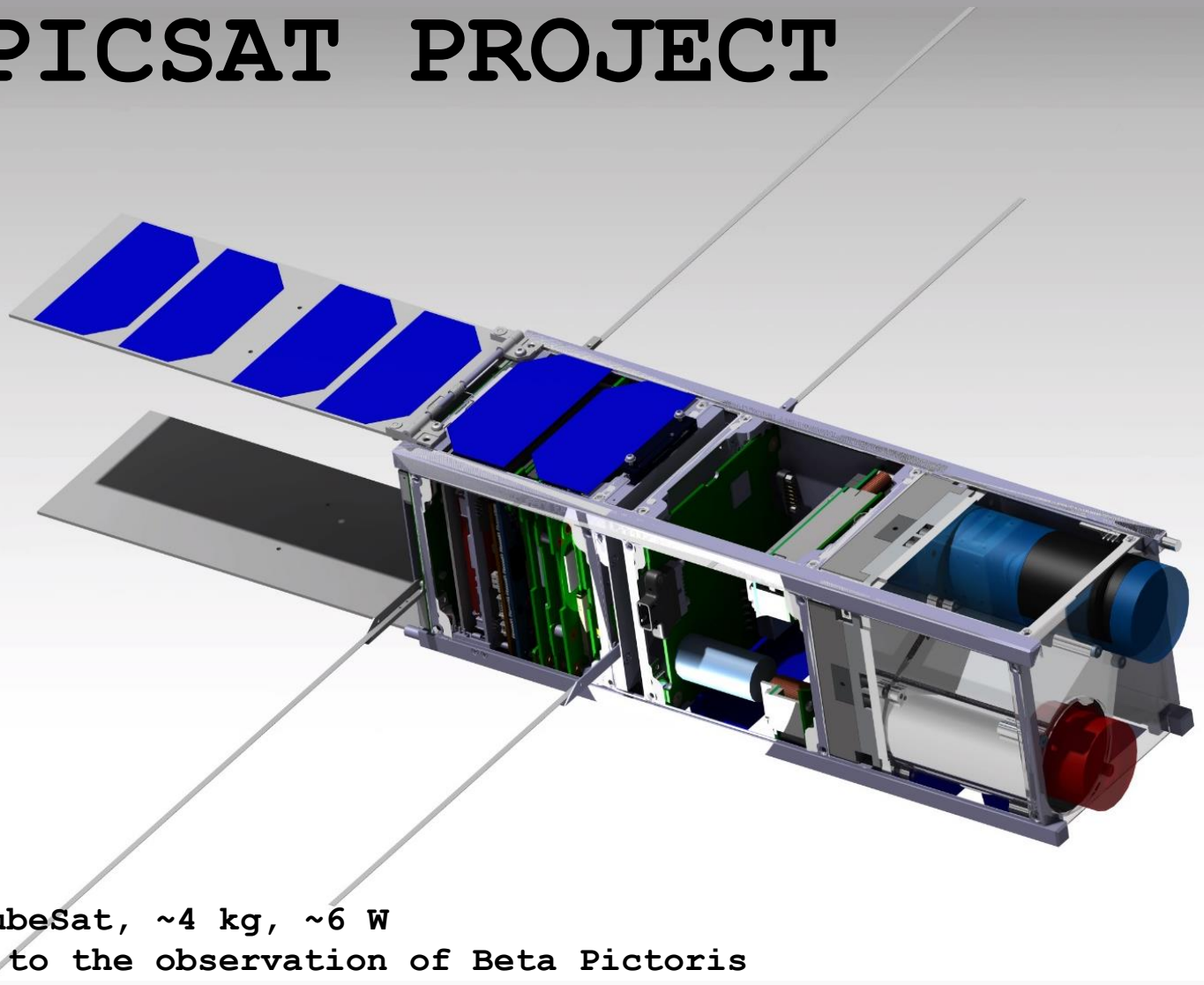


- A 3-unit CubeSat, ~4 kg, ~6 W
- Dedidacted to the observation of Beta Pictoris
- LESIA (Paris Observatory) is responsible for the payload and AIT
- To be launched in Q2 2017

BETA PICTORIS

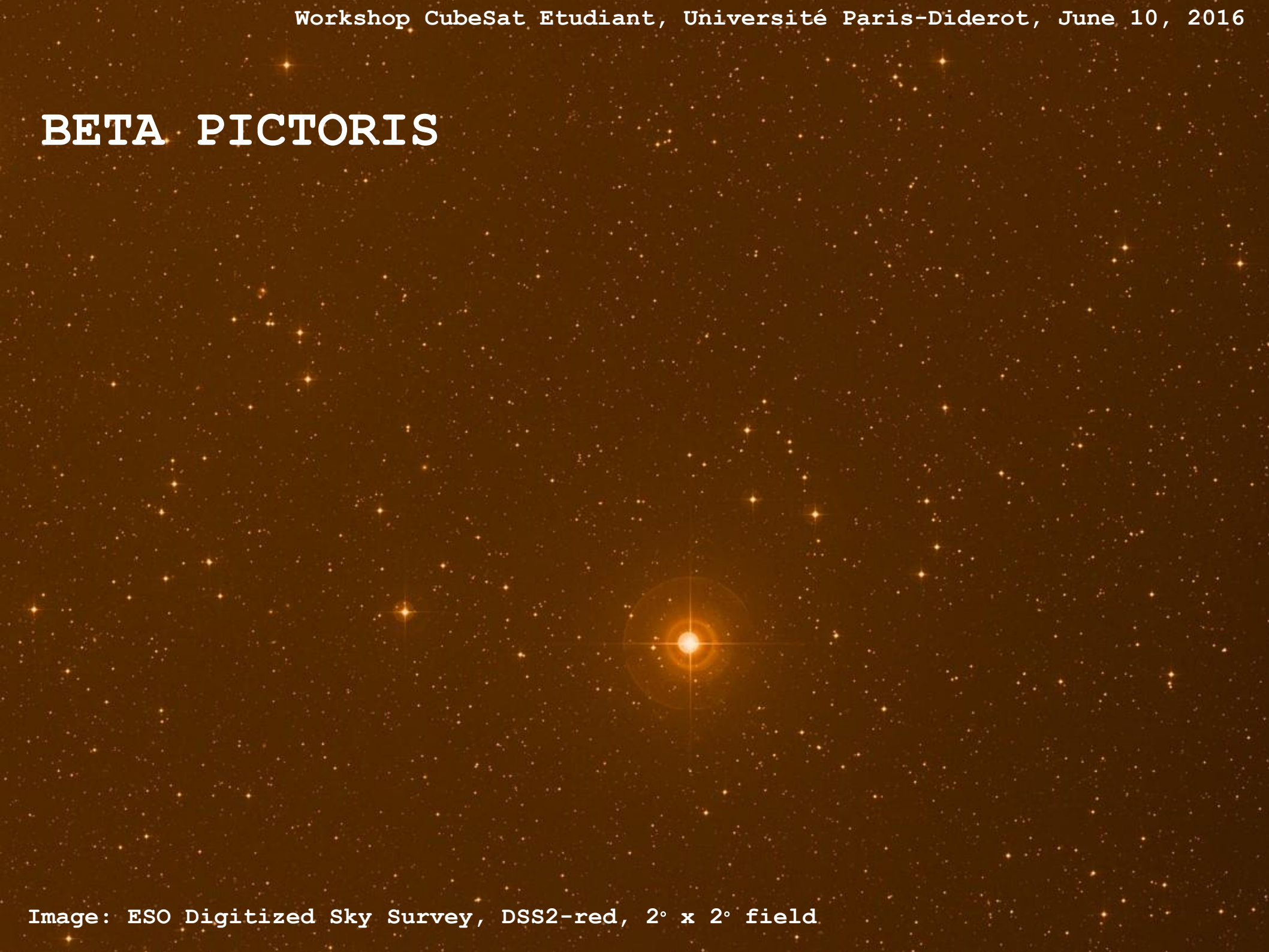
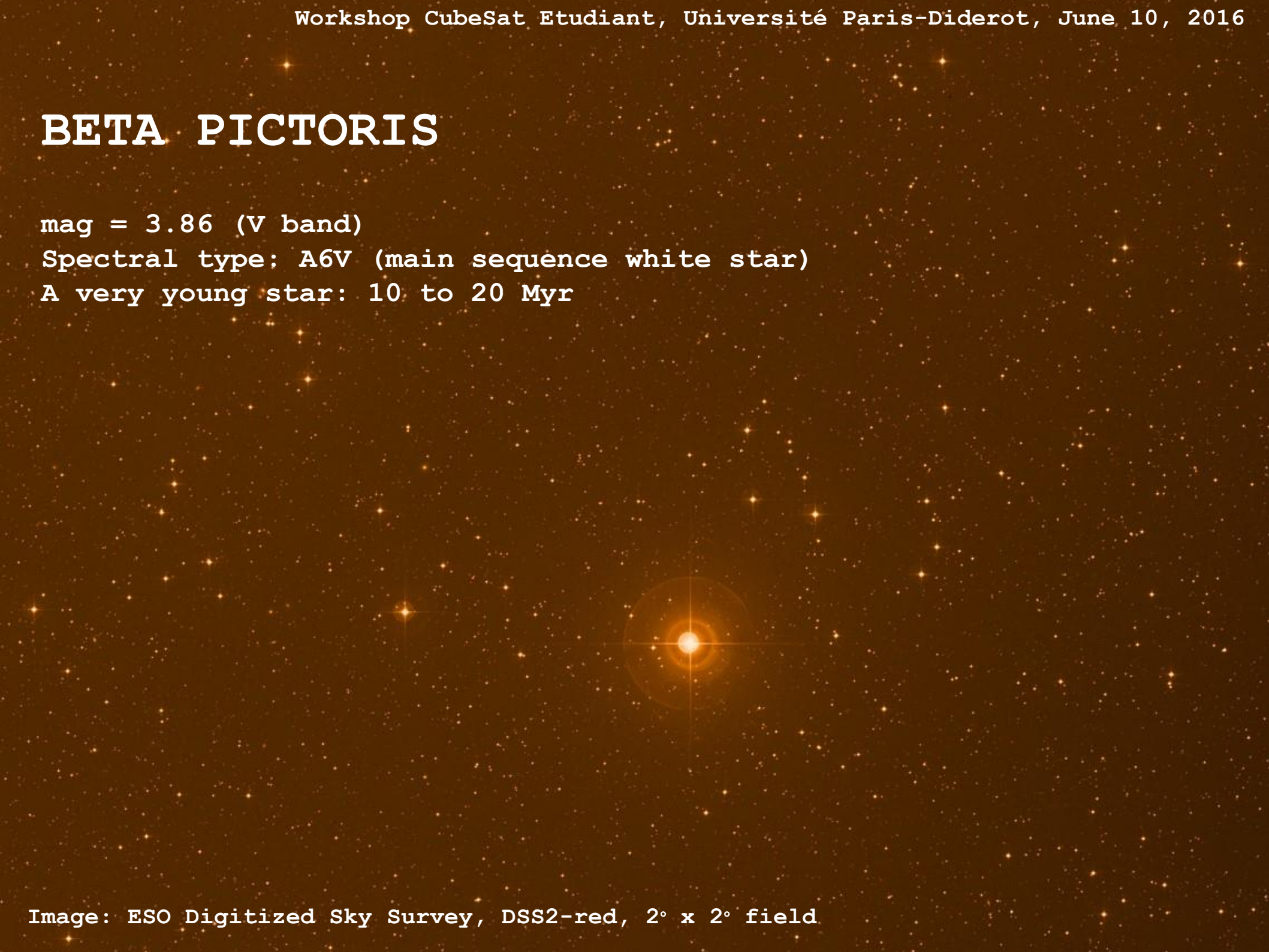


Image: ESO Digitized Sky Survey, DSS2-red, 2° x 2° field

BETA PICTORIS

mag = 3.86 (V band)
Spectral type: A6V (main sequence white star)
A very young star: 10 to 20 Myr



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BETA PICTORIS

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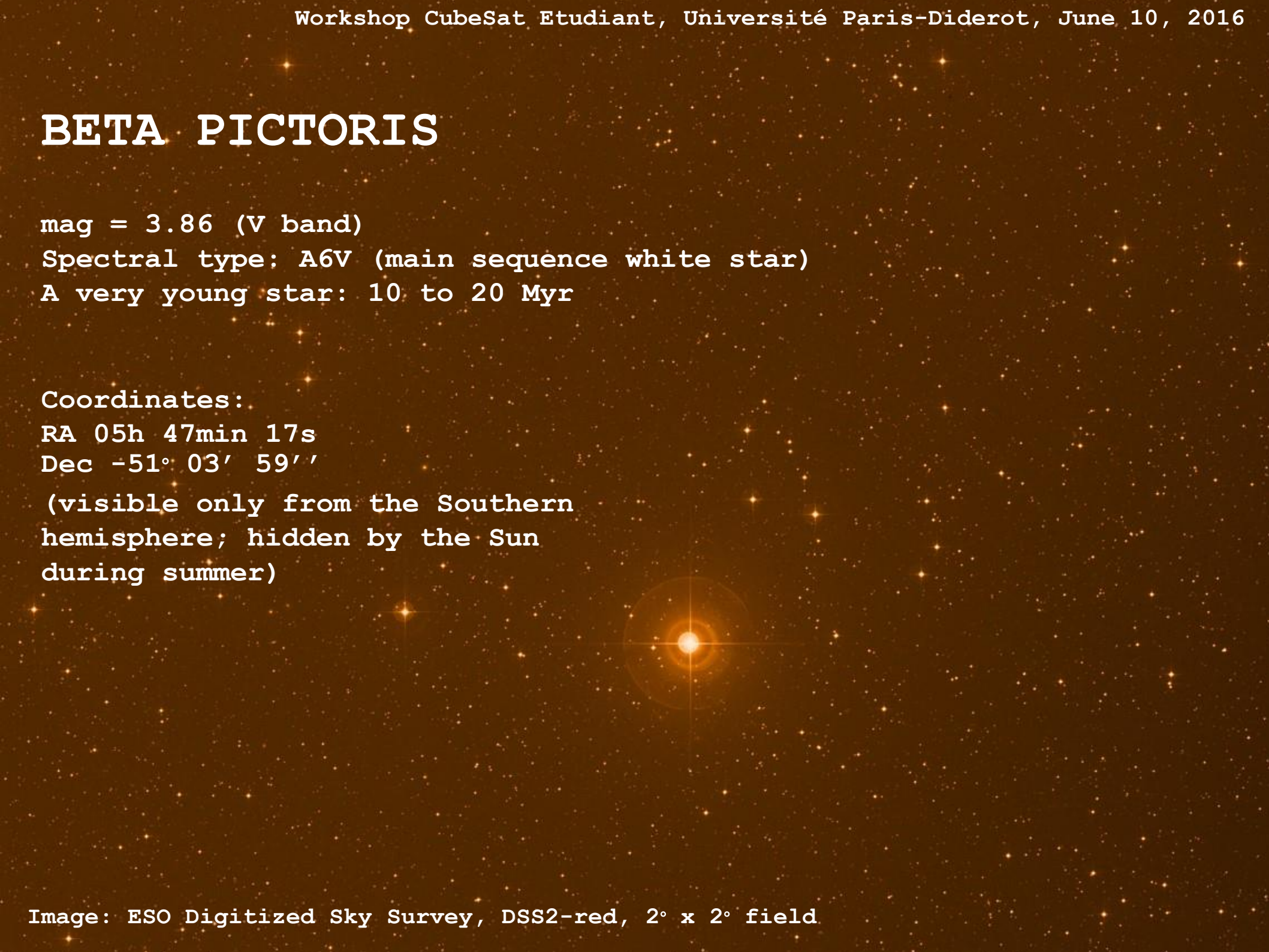
Spectral type: A6V (main sequence white star)
A very young star: 10 to 20 Myr

Coordinates:
RA 05h 47min 17s
Dec -51° 03′ 59′′
(visible only from the Southern hemisphere; hidden by the Sun during summer)



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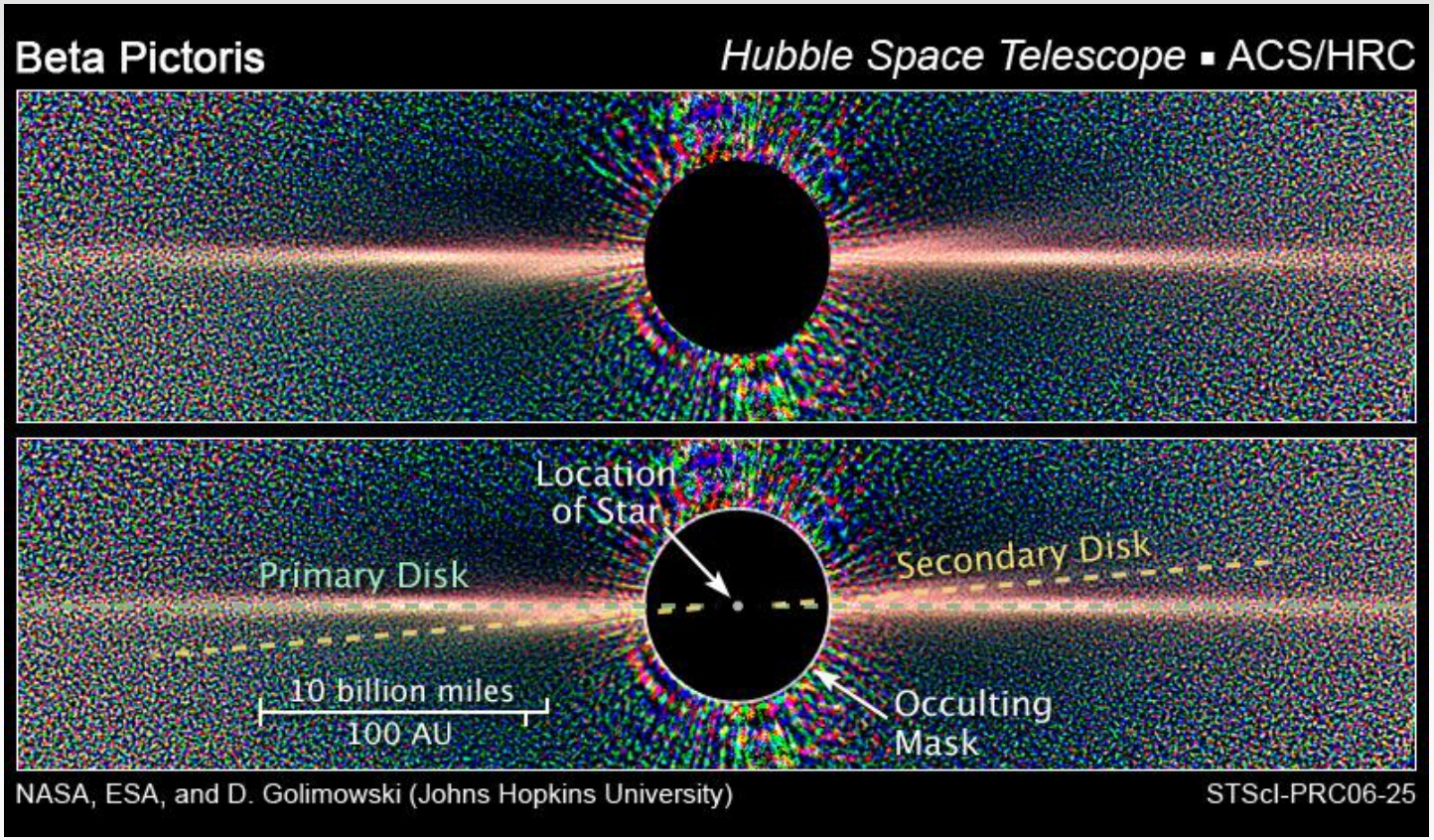
WHY BETA PICTORIS?

- Circumstellar disk discovered in 1984
- Later identified as a ``debris disk'' (second stage in the evolutionary track)
- Secondary disk identified with the Hubble Telescope



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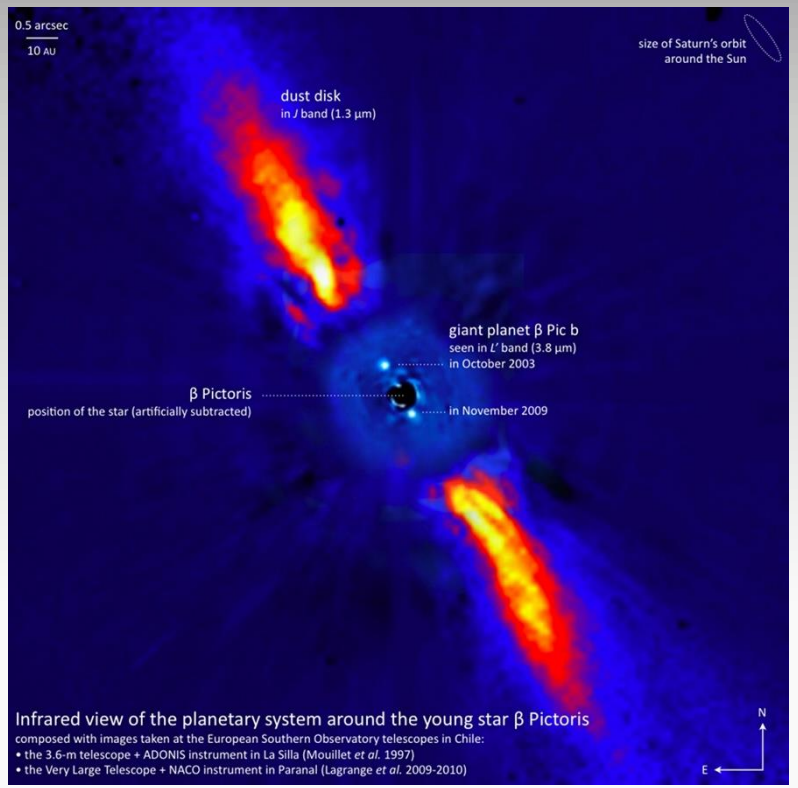

Presence of a planet (Beta Pic b), discovered in 2009

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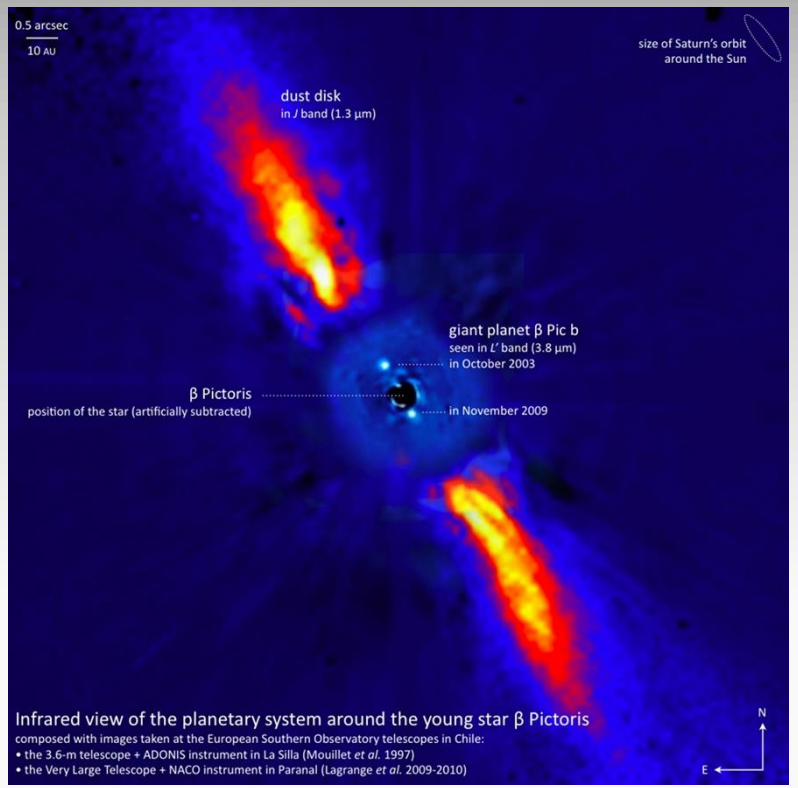

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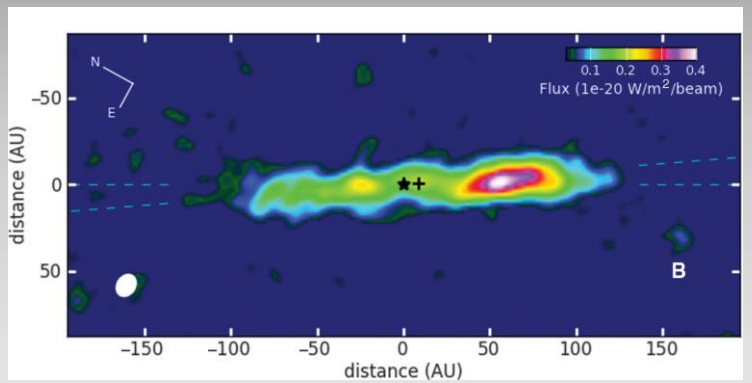

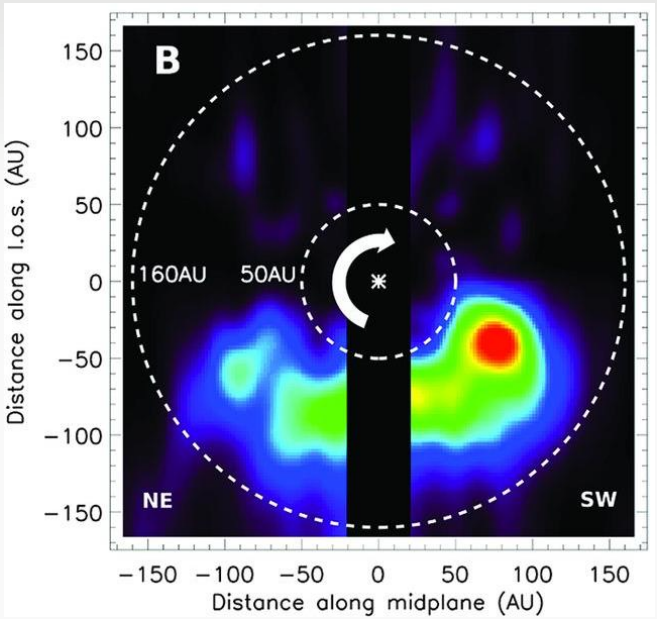

CO emission line ''deprojected'' assuming circular motion (Dent at al. 2014)

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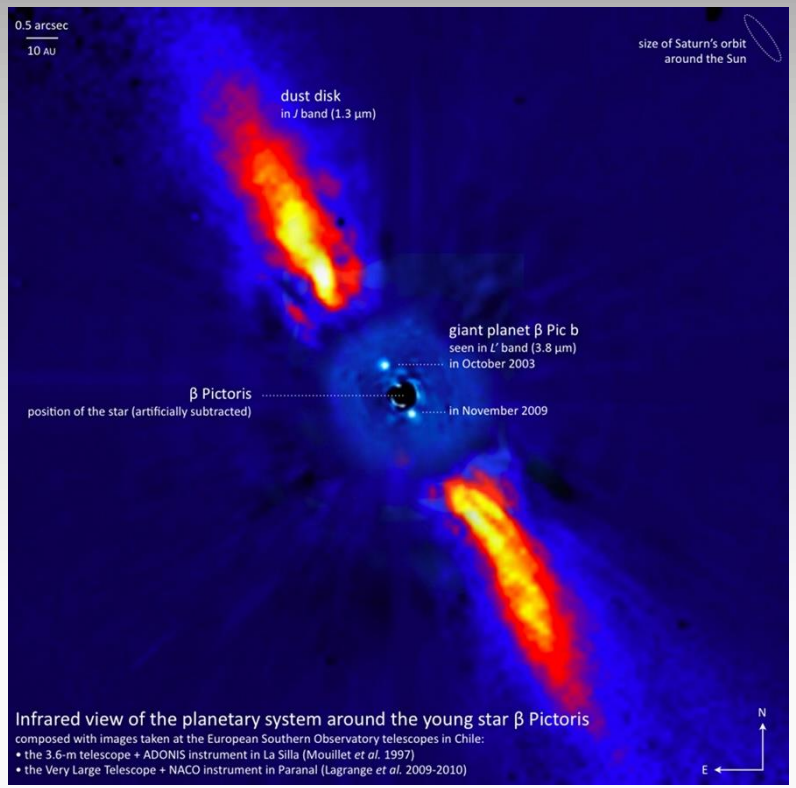

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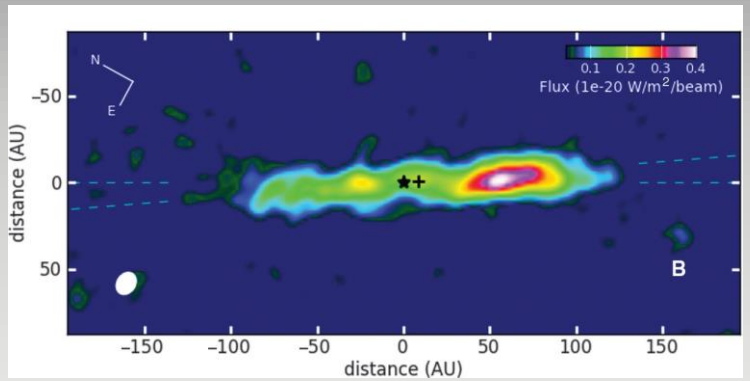
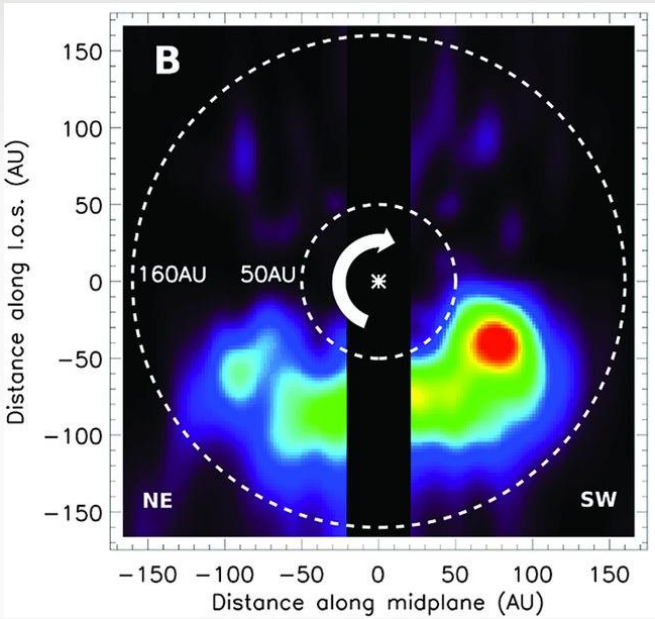


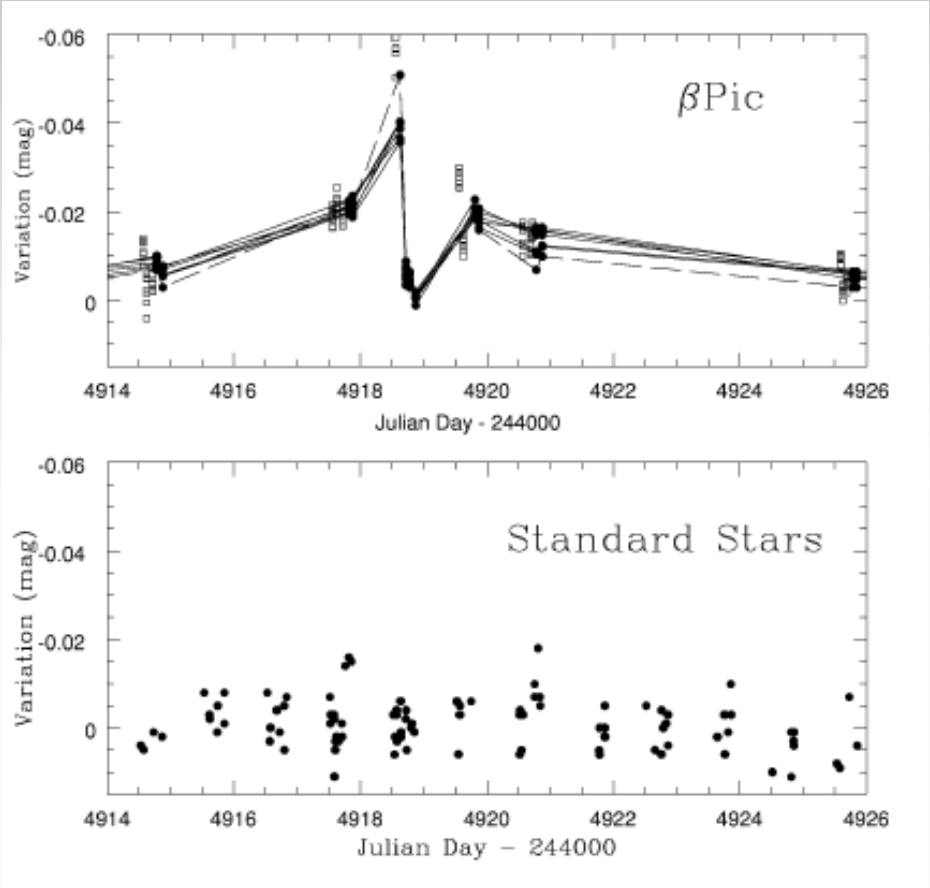


CO emission line ''deprojected'' assuming circular motion (Dent at al. 2014)

Gas + dust + debris + planetesimals + a formed planet: The PERFECT target to test planet formation models!

WHY DO WE DEVELOP PICSAT?

Because of this (Lecavelier et al. 1995):



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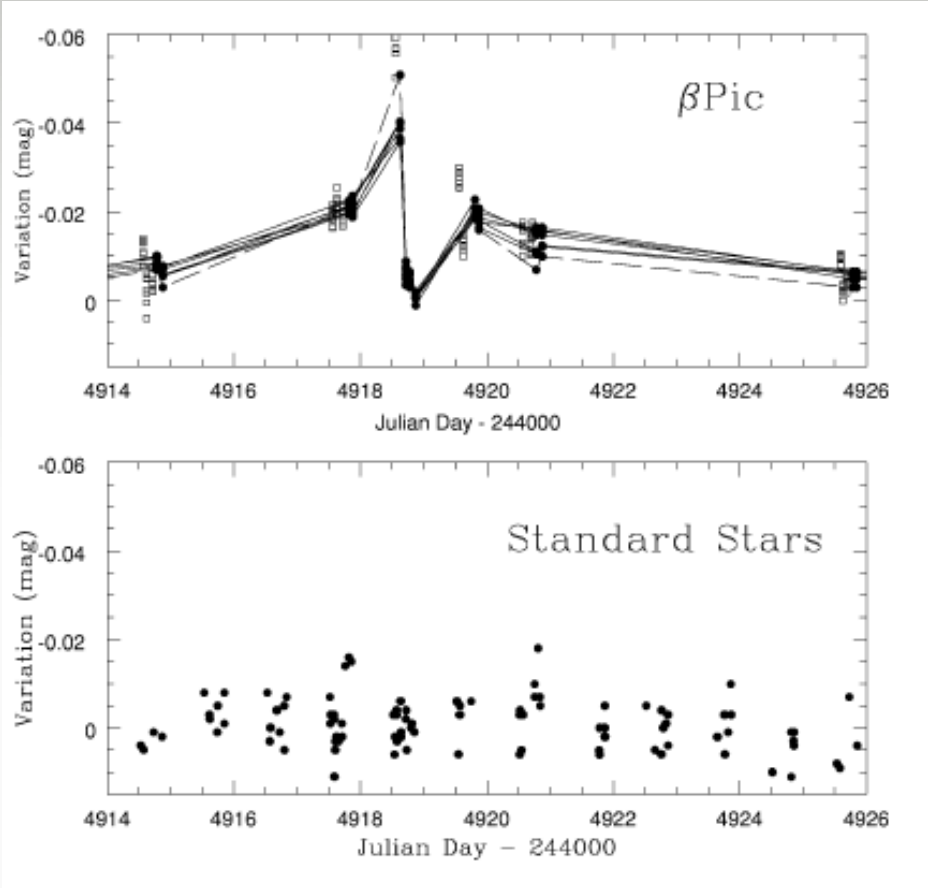
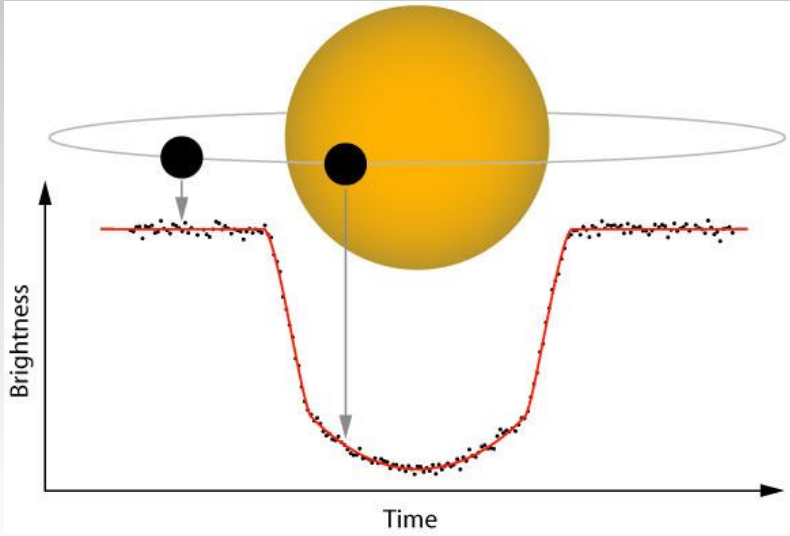
Because of this (Lecavelier et al. 1995): a transitting object seen in 1981





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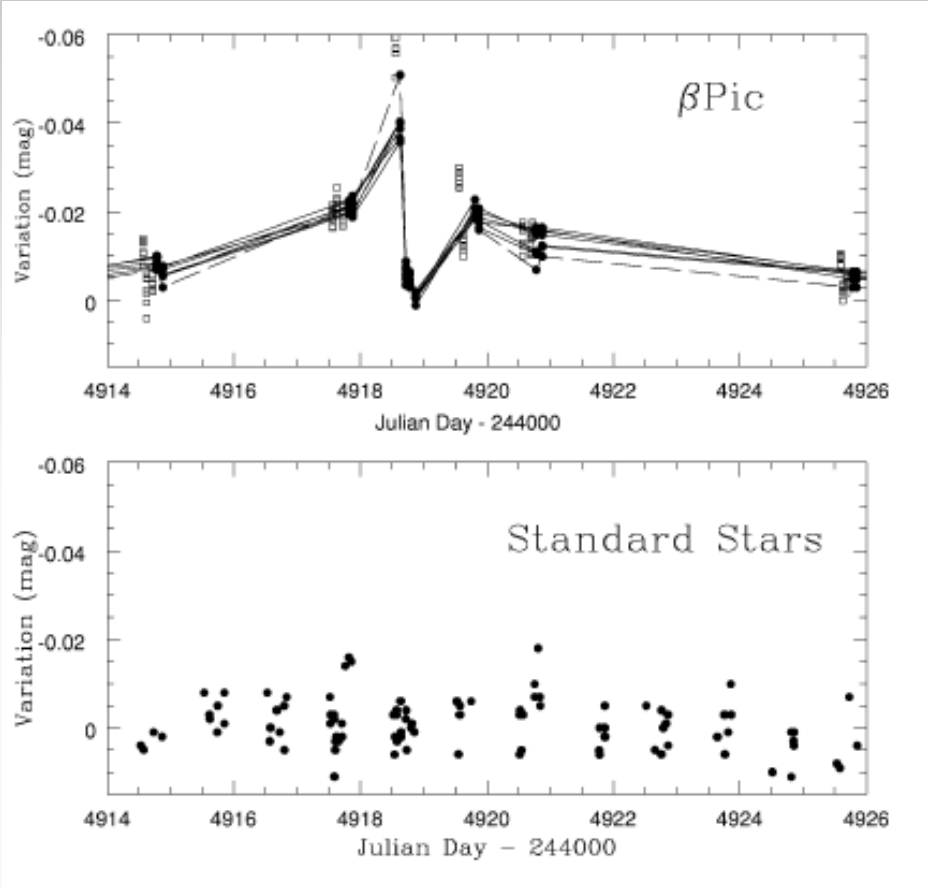

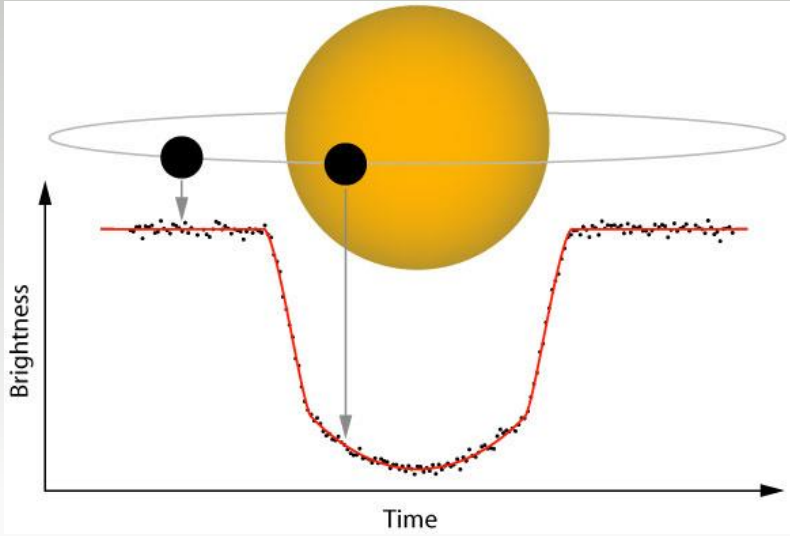

Recent observations strongly suggest that Beta Pic b is the transitting body

Next transit : between June 2017 and September 2018

WHY DO WE DEVELOP PICSAT?

Main objective of PICSAT: constant monitoring of the photometry of Beta Pic, at ~100 ppm/hour accuracy to detect the transit

-> Determine the radius of the planet
-> Characterize the Hill Sphere
-> Inohomogeneities in the disk

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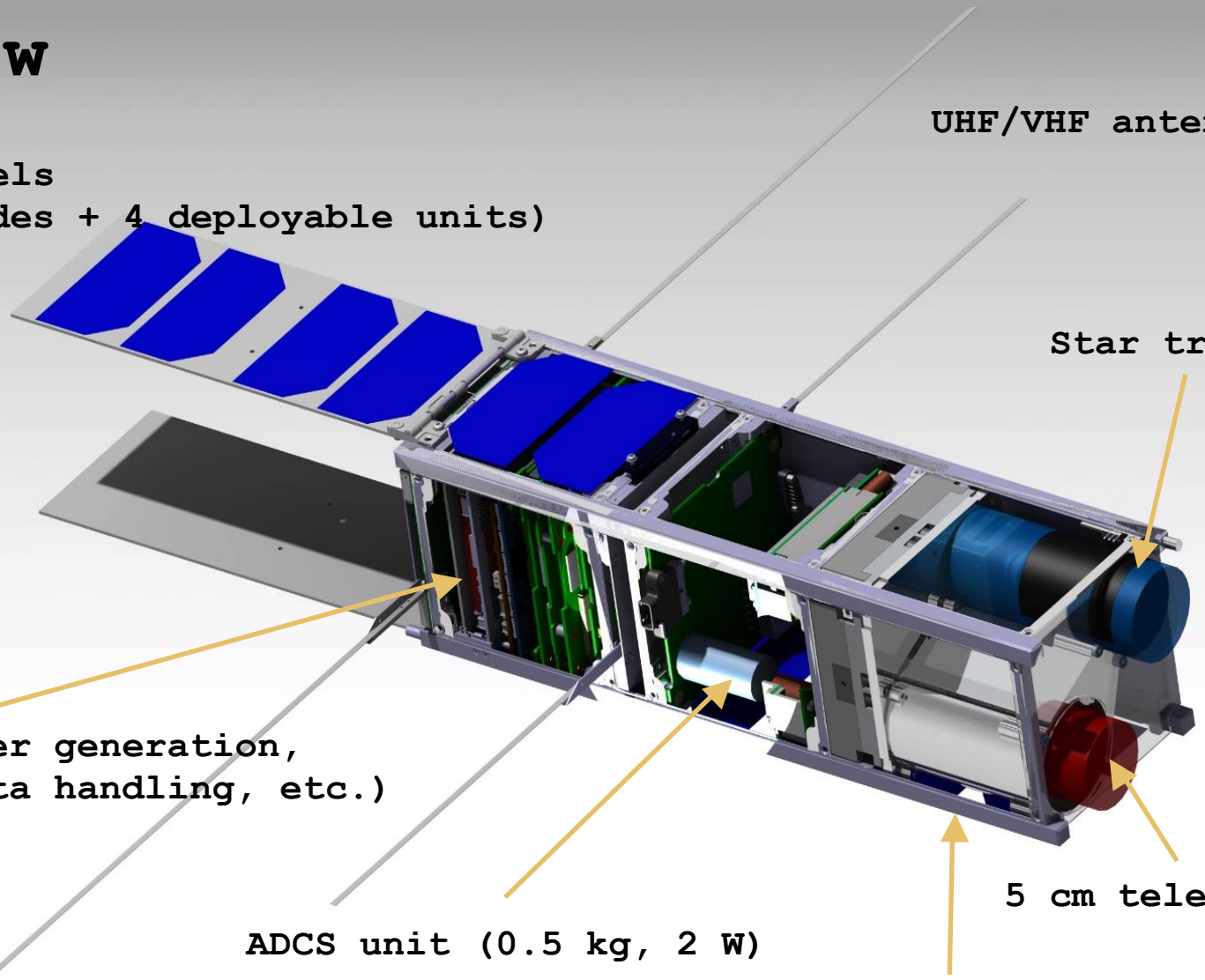
Why not use existing facilities?

- **The transit is expected between June 2017 and September 2018**
- **It is a 10 h event**

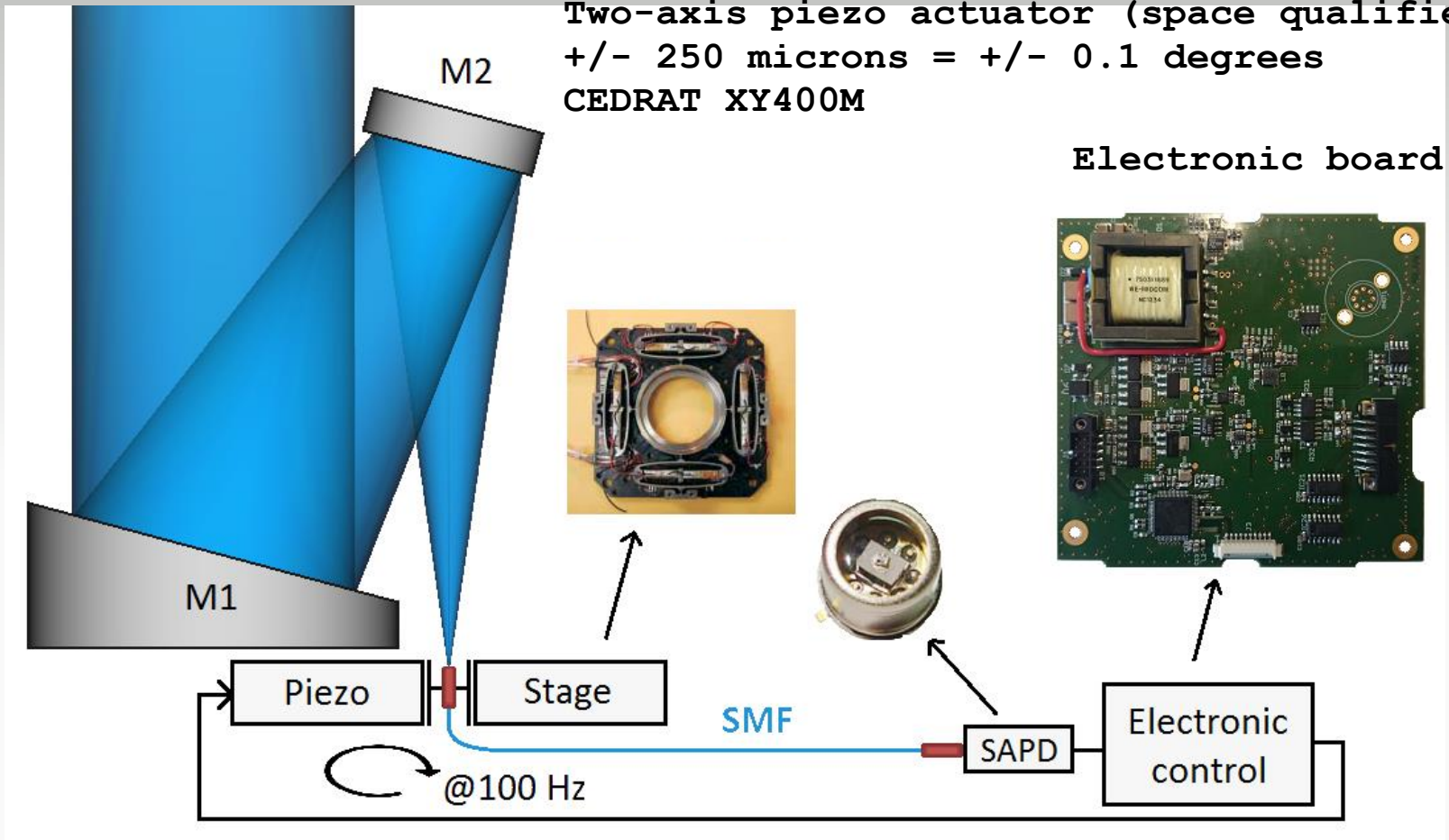
1 - Beta Pic CANNOT be observed from ground in summer
2 - Unrealistic to request one year of 24/7 observing time on a few-meter ground or space telescope in the hope of detecting a 10 hr event!

➔ **A dedicated space mission is required… but the timeframe is very short!**

PICSAT IN A NUTSHELL: Overview



PICSAT IN A NUTSHELL: The Payload



Two-axis piezo actuator (space qualified)
+/- 250 microns = +/- 0.1 degrees
CEDRAT XY400M

Electronic board

Off-axis parabola (30 deg)
Real diameter: 50 mm
Effective diameter: 35 mm
Focal length: 135 mm (f/D=2.70)

Avalanche photodiode
(photon counting detector)
IDQUANTIQUE ID101

PICSAT IN A NUTSHELL: ADCS and fine pointing

- Light is collected by a single-mode fiber
  (3 micron diameter in the focal plane)
- Required injection stability: 5% @ 100 Hz

- Fine positionning of the fiber (0.5 micron required!)

→ 1 arcsec pointing precision required!

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First stage: ADCS ''coarse pointing''

iADCS 100.60:
(Hyperion Technologies)

- 3 reaction wheels
- Gyroscopes
- 3 magneto-torquers
- Magnetometer
- StarTracker

➔ 30 arcsec accuracy (datasheet)

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Second stage: Payload fine pointing

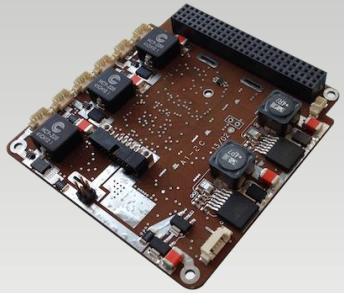
- Photometric measurements (1000 Hz)
- 3-axis gyroscope

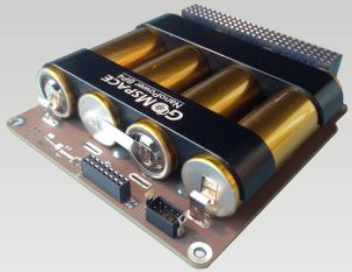
- Data fusion is made through an Extended Kalman Filter

Accuracy: < 1 arcsec (simulations)

PICSAT IN A NUTSHELL: OBC, data handling

Power:
GomSpace EPS with battery board P31us (4x2600 mAh)
~ 6 W generated with deployable panels





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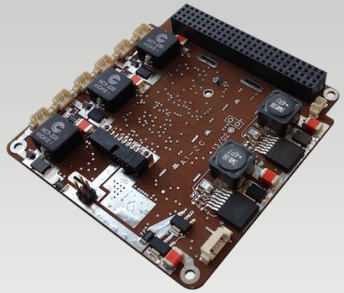
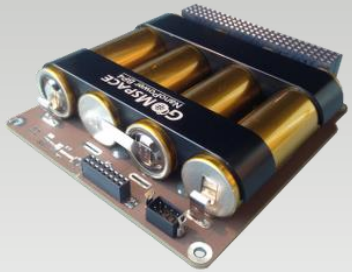
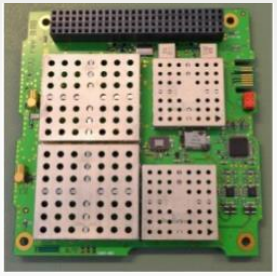




Communications:
ISIS TRXVU VHF/UHF Transceiver
ISIS AntS Deployable Antenna System
(1 Mbyte/day downlink; 0.1 Mbyte/day uplink)



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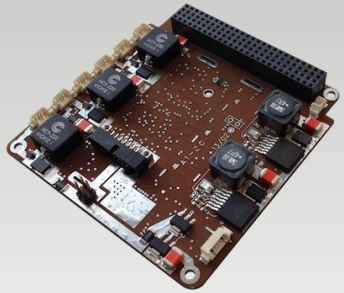

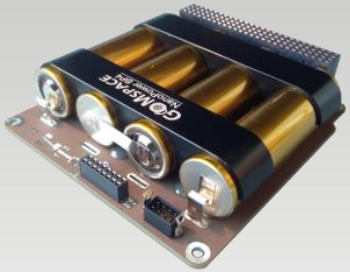

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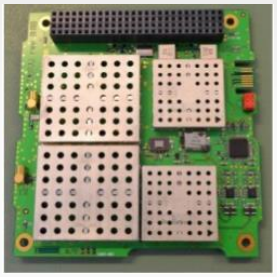

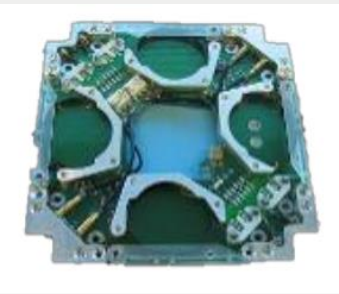

On-board computer:
ISIS OBC – 400 MHz ARM9 processor
(will be used for some in-flight
data processing)

PICSAT IN A NUTSHELL: Noise budget

Source	Assumption	Error level	Resulting error (ppm/h)
Photon noise	N=80x10^4 e/s	$\sqrt{N}$	60
Readout noise	0	0	0
Dark current	N=10^3 e/s	$\sqrt{N}$	0.1
Sky background	N=150 e/s	N	0.2
Thermal stability	0.01 K	0.4 % per K	40
Voltage stability	100 uV	20 % per Volt	20
Pointing stability	100 Hz	5 %	83

TOTAL : 111 ppm/h

CONCLUSION: current status

- For its objective, PicSat must be launched in Q2 2017
- Engineering model is currently being built in Meudon (structure, ADCS, OBC already delivered)
- Payload telescope has been designed and is now being built
- A first version of the electronic board has been tested in vibrations, thermal vacuum (radiation testing to come), and the second version will be delivered in July
- Payload algorithm and data reduction/processing are being developed (will be tested on a dedicated testbench this summer)
- Flight software also under development