PDC WP 334 600 : Science Flux Alerts

Steve Boudreault (lead)
Laurent Gizon, Raymond Burston, Pablo Gutierrez-Marques, Matthias Ammler-von Eiff

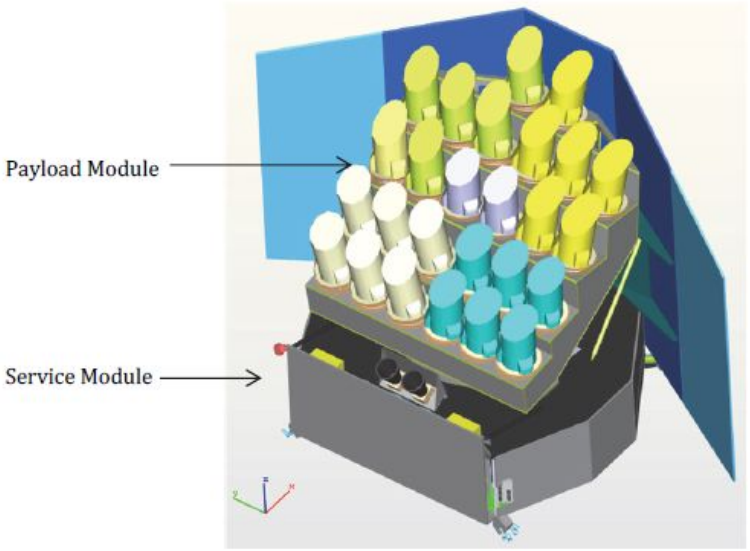
Highlight of the presentation

- Short overview of what would be the PLATO mission
- Sources of alerts vs what is already covered by the core-science
- Light curve using PIS (PLATO Imagette Simulator)
- Event reporting
- Open issues (e.g. questions to Galactic / extraGalactic astronomers)

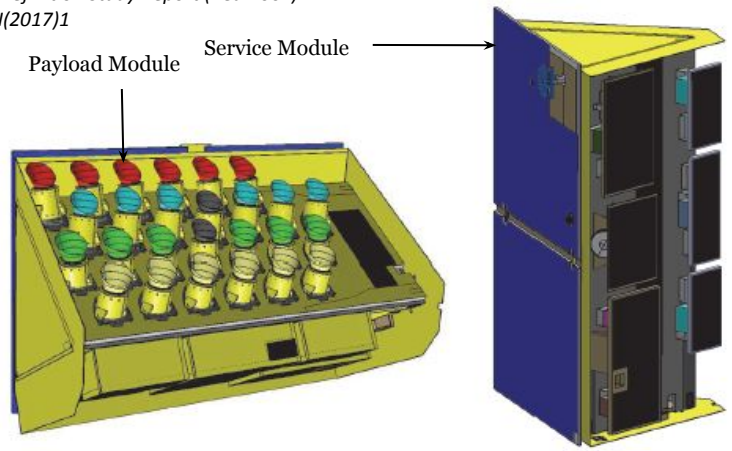
PLAnetary **T**ransits and **O**scillations of stars (**PLATO**)
[mission adopted by ESA in June 2017]

PLATO in a nutshell

- To obtain light curves of a few 100 000 stars to detect planetary transits and characterise the host star with asteroseismology
- Payload concept : 24 normal cameras (~500nm to ~1um), 4 groups of co-aligned telescopes
- Short stares (3 months) and long stares (up to 2 years) for light curves of 600 sec, 50 sec, 25 sec (imagettes) light curves for $V \gtrapprox 11$ - 16 mag stars
- 2 fast cameras, blue (~500nm to~665nm) and red (~670nm to ~1um), with sampling of 2.5 sec (imagettes)
- 104 CCDs (4 CCDs per camera) with 4510x4510 (18µm) pixels, ~15 arcsec/px
- 2232 deg2, with 4 groups of cameras respectively looking on 301 deg², 247 deg², 735 deg², and 949 deg²
- Targets observed in 6x6 pixel windows (i.e. 1.2 x 1.2 arcmin)
- Launch planned for end 2026



OHB (above) and Airbus (below) Spacecraft design
PLATO Definition Study Report (Red Book)
ESA-SCI(2017)1

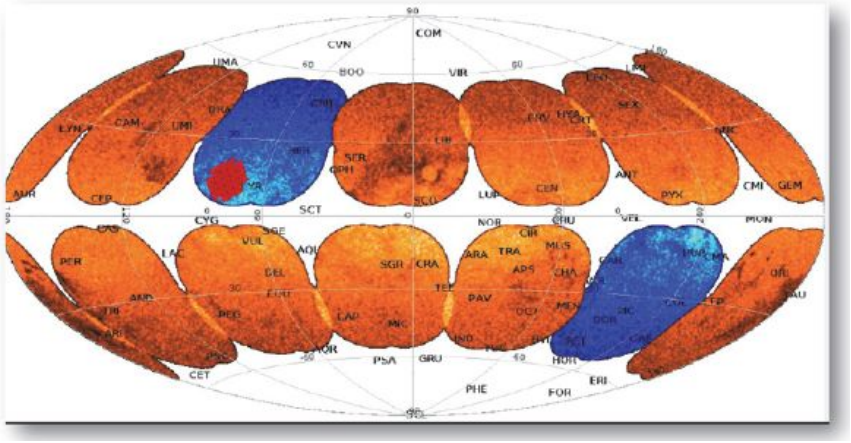


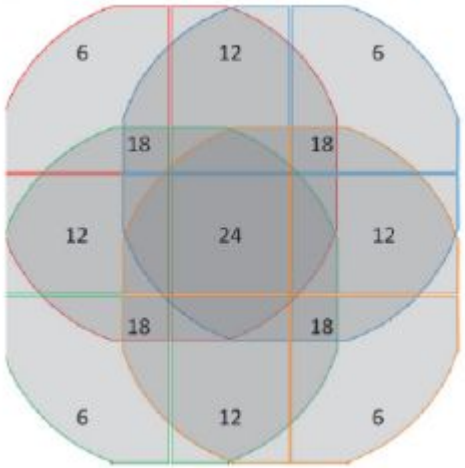
PLATO Definition Study Report (Red Book)
ESA-SCI(2017)1

PLAnetary **T**ransits and **O**scillations of stars (**PLATO**)
[mission adopted by ESA in June 2017]

PLATO in a nutshell

- To obtain light curves of a few 100 000 stars to detect planetary transits and characterise the host star with asteroseismology
- Payload concept : 24 normal cameras (~500nm to ~1um), 4 groups of co-aligned telescopes
- Short stares (3 months) and long stares (up to 2 years) for light curves of 600 sec, 50 sec, 25 sec (imagettes) light curves for $V \gtrapprox 11$ - 16 mag stars
- 2 fast cameras, blue (~500nm to~665nm) and red (~670nm to ~1um), with sampling of 2.5 sec (imagettes)
- 104 CCDs (4 CCDs per camera) with 4510x4510 (18µm) pixels, ~15 arcsec/px
- 2232 deg2, with 4 groups of cameras respectively looking on 301 deg², 247 deg², 735 deg², and 949 deg²
- Targets observed in 6x6 pixel windows (i.e. 1.2 x 1.2 arcmin)
- Launch planned for end 2026



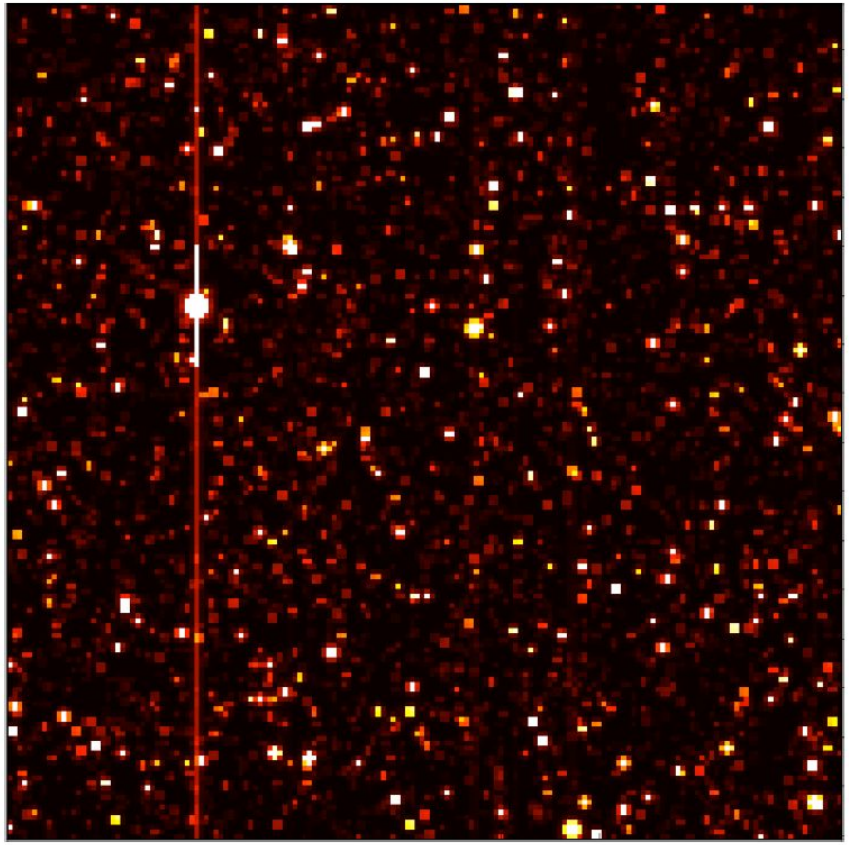


PLATO Definition Study Report (Red Book)
ESA-SCI(2017)1

PLAnetary **T**ransits and **O**scillations of stars (**PLATO**)
[mission adopted by ESA in June 2017]

PLATO in a nutshell

- To obtain light curves of a few 100 000 stars to detect planetary transits and characterise the host star with asteroseismology
- Payload concept : 24 normal cameras (~500nm to ~1um), 4 groups of co-aligned telescopes
- Short stares (3 months) and long stares (up to 2 years) for light curves of 600 sec, 50 sec, 25 sec (imagettes) light curves for $V \gtrapprox 11$ - 16 mag stars
- 2 fast cameras, blue (~500nm to~665nm) and red (~670nm to ~1um), with sampling of 2.5 sec (imagettes)
- 104 CCDs (4 CCDs per camera) with 4510x4510 (18µm) pixels, ~15 arcsec/px
- 2232 deg2, with 4 groups of cameras respectively looking on 301 deg², 247 deg², 735 deg², and 949 deg²
- Targets observed in 6x6 pixel windows (i.e. 1.2 x 1.2 arcmin)
- Launch planned for end 2026



PLATOsim
Joris de Ridder, et al., KU Leuven

PLATO Definition Study Report (Red Book)
ESA-SCI(2017)1

PDC WP 334 600 – SCIENCE FLUX ALERTS

- To **goal** of the **W**ork **P**ackage **Science Flux Alerts** is to ***detect*** **astronomical transient**, ***and*** **to send** an ***alert*** about **a possible detection** of **rare events of scientific interest** for additional observations (e.g. optical spectroscopic observations for supernovae events), **considering their brevity and non-repeatability, while they are in progress**.

- For events related to the **core science of PLATO** (i.e. **planet-transiting** and **asteroseismology / stellar** events), an alert ***should be given*** with a **possible** change of sampling mode for the P5 sample (i.e. swap between 600 seconds light curves to 50 seconds sampling, or imagettes for 25 seconds sampling), although ***detection*** and ***analysis*** of such events are covered by other **W**orking **P**ackages (i.e. core science)

PDC WP 334 600 – SCIENCE FLUX ALERTS

- The **Science Flux Alerts** will be a module in the L0/L1 pipeline, performed on-ground (after light curve averaging, detrending, …)

- Developed at the **PDC** (**P**lato **D**ata Center), based at the **MPS** (**M**ax **P**lanck Institute for **S**olar System Research) in Göttingen, Germany

- There is a **W**orking **P**ackage, **WP16 Complementary Science**, in charge to exploit **PLATO** data for science excluding planet-transiting and asteroseismology. However, its goal is not to detect astronomical transient.

PDC WP 334 600 – SCIENCE FLUX ALERTS

The possible sources of alerts are, as PLATO targets or occurring in the background or foreground,

- For **planet-transiting** and **asteroseismology / stellar** events :
  - a. Planet transiting for sources in the P5 (lower priority) sample
  - b. Superflares
  - c. Pulsating eclipsing binaries
  - d. Hybrid pulsators

- For **non-planet-transiting** and **non-asteroseismology / stellar** events
  (possible triggers for GAIA Science Alerts - perhaps not all applicable, considering the PLATO observations [e.g. T Tauri])
  - a. Supernovae
  - b. Gravitational Microlensing
  - c. Gamma-Ray Burst (optical) afterglow
  - d. Classical Novae
  - e. Dwarf Novae
  - f. Cataclysmic Variable
  - g. X-ray bursters (e.g. X-ray binaries)
  - h. AGN (e.g. blazar)
  - i. LBV
  - j. Be stars
  - k. R Corona Borealis stars
  - l. FU Orionis

PDC WP 334 600 – SCIENCE FLUX ALERTS

The possible sources of alerts are, as PLATO targets or occurring in the background or foreground,

- Other **unexpected or rare events** which **can, or cannot, be classified**, e.g. occultations by debris disks, cometary material, extrasolar ring system [e.g. J1407], asteroids passing in the line of sight of a star in an observing window, unclassified Galactic [e.g. KIC 8462852, aka the Tabby's Star, variation *observed* on March 2011 and February 2013 … but reported in 2015] or extraGalactic [e.g. SCP 06F6, with M_u ~ -23 mag] events.

- Using the **fast camera** to spot **transient** which would have **variability in colours**, but **stable** light curve from the **normal camera**.

- *What else ?*

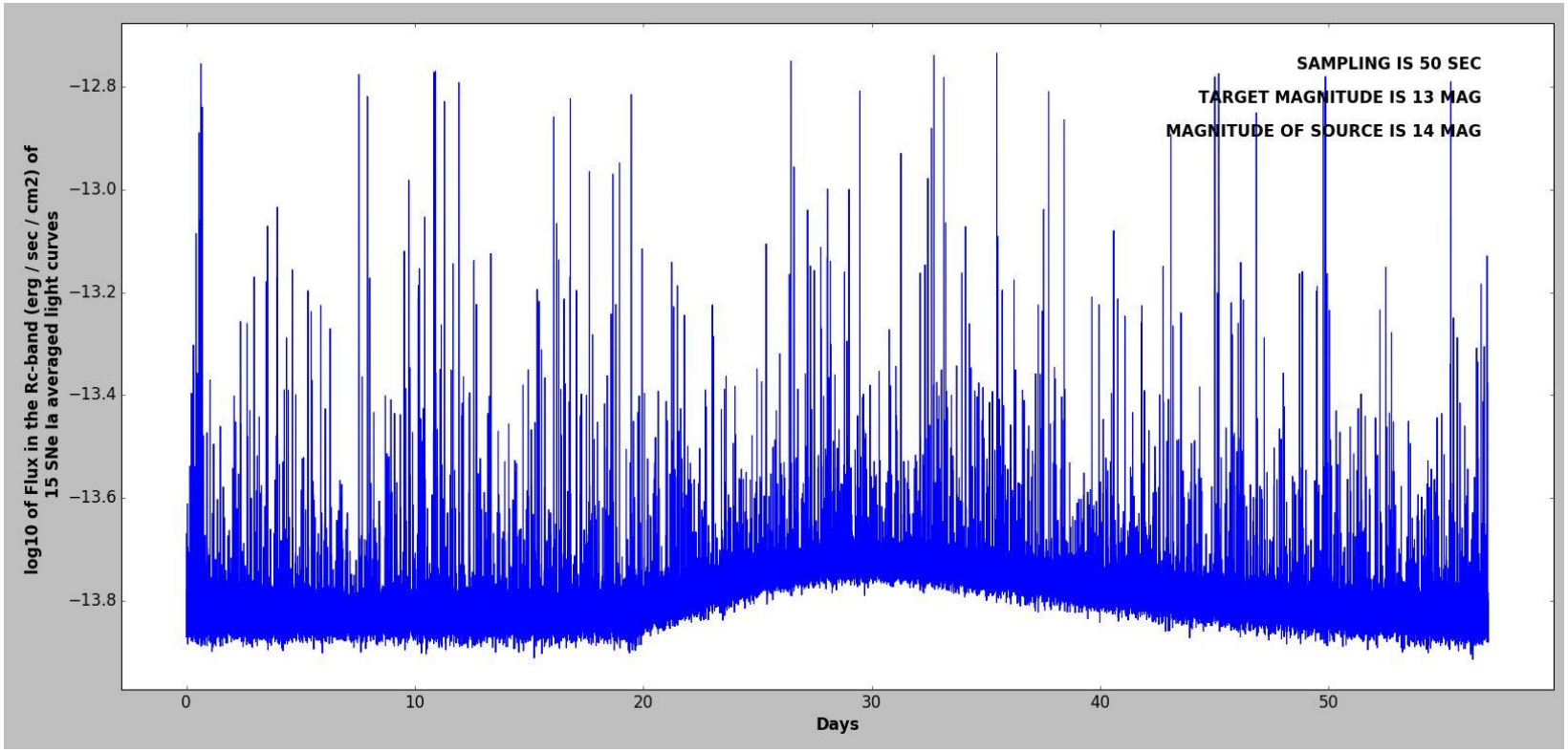
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

"Simulation" of light curves of selected transient, **if** they are occurring in (or in the vicinity of) a window (i.e. 1.2 x 1.2 arcmin) where PLATO is observing a **V~13 magnitude star :**

- Supernovae Type 1a
- Gravitational Microlensing Event (i.e. approximation of OGLE-2015-BLG-0966)
- Gamma-Ray Bursts (optical afterglow)

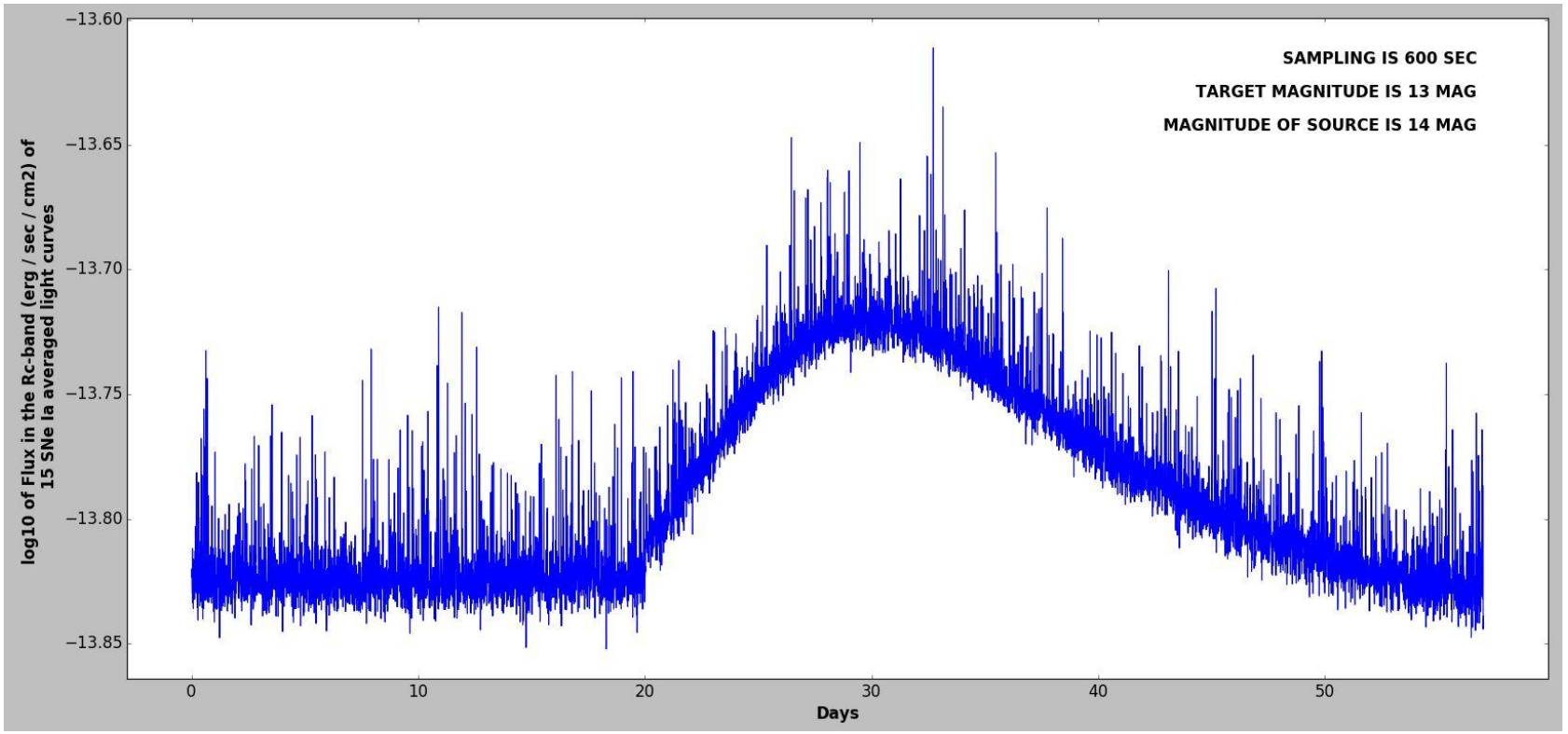
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

Supernovae 1a light curve (Li, Leaman, Chornock, et al. 2010)



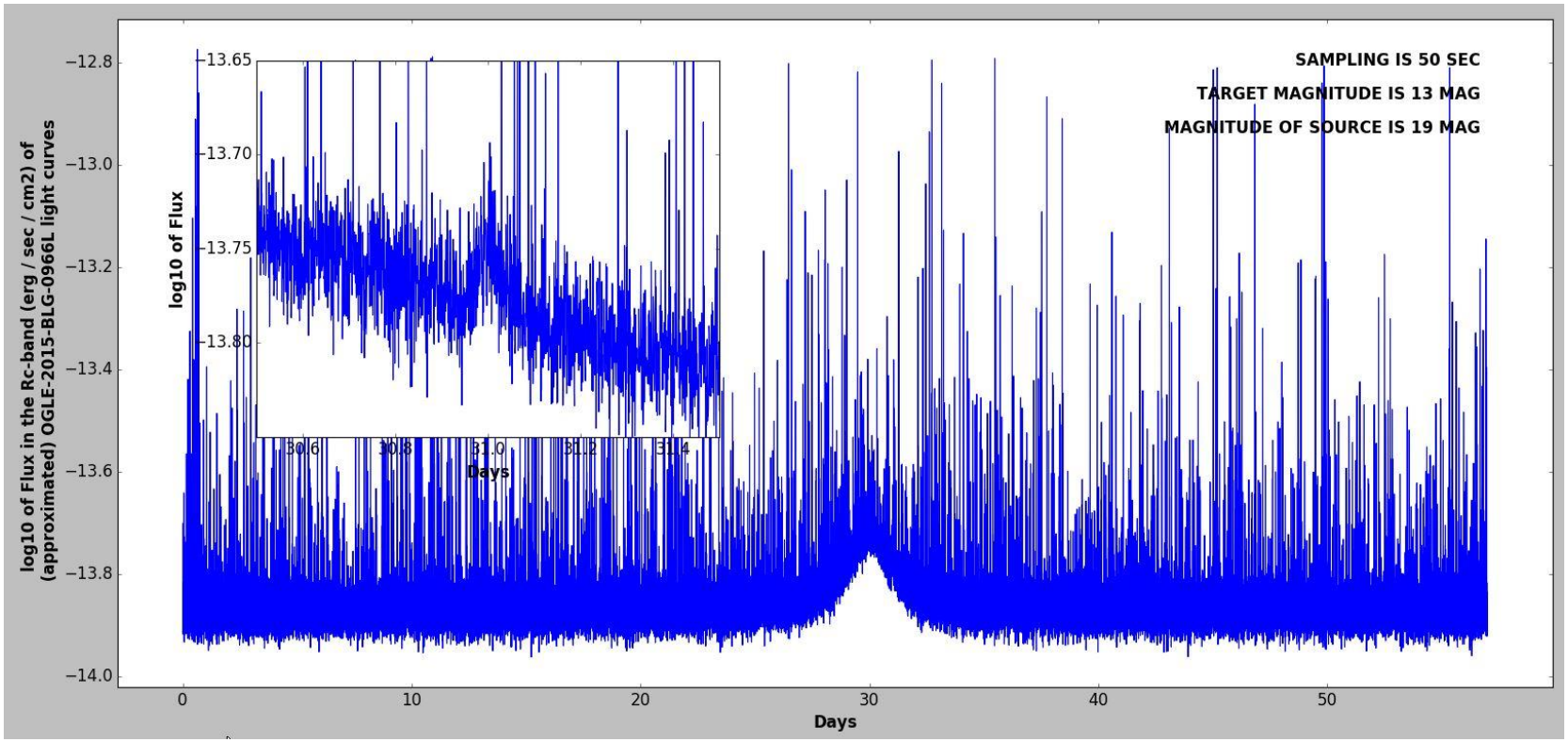
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

Supernovae 1a light curve (Li, Leaman, Chornock, et al. 2010)



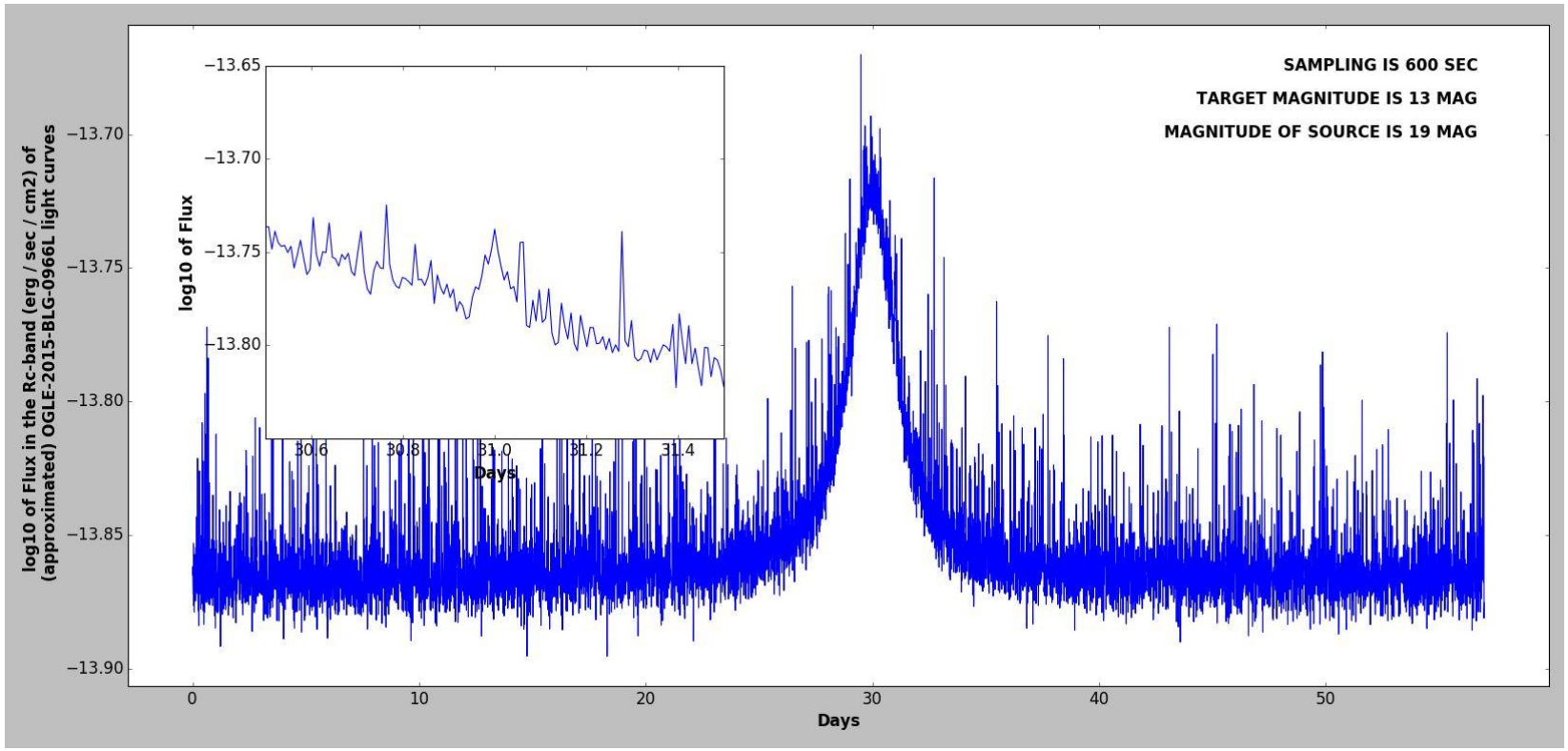
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

OGLE alert for OGLE-2015-BLG-0966 was issued on 11 May 2015 (Street et al. 2016)



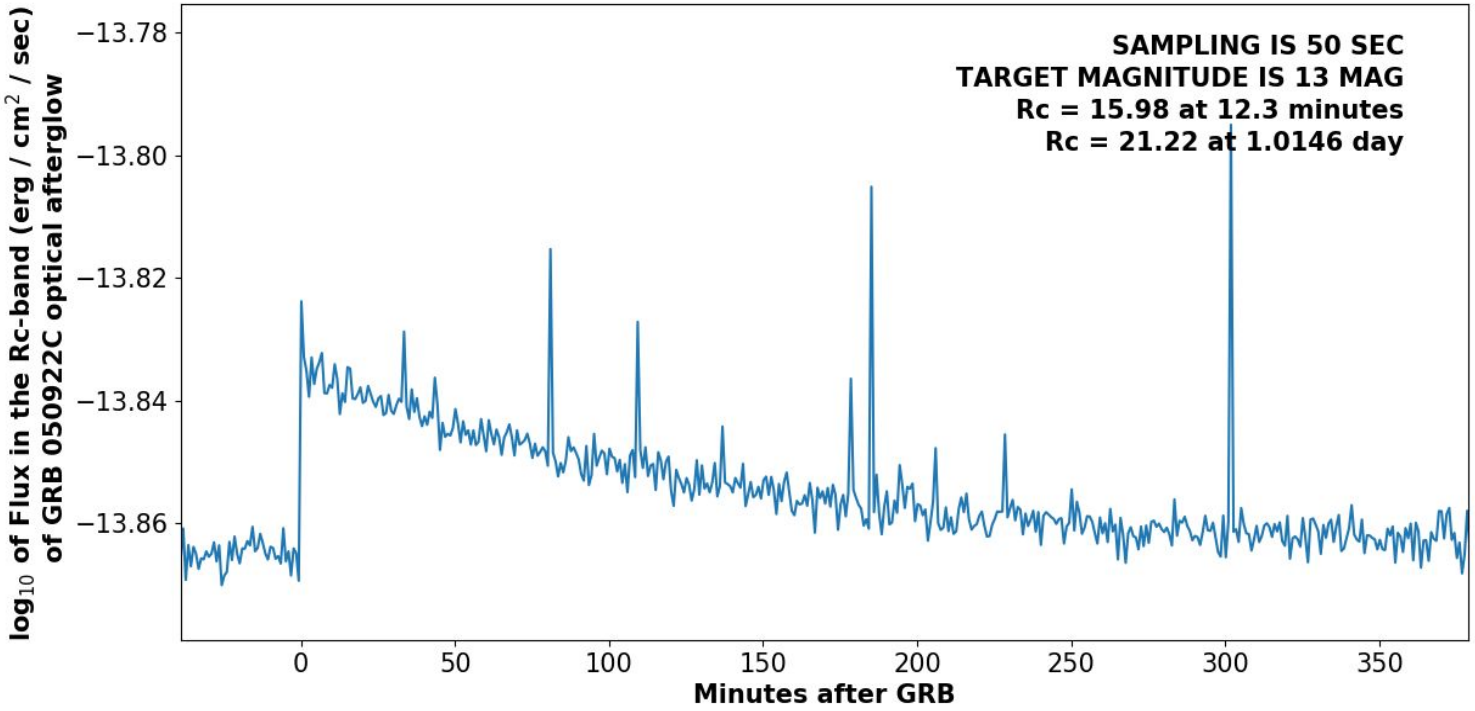
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

OGLE alert for OGLE-2015-BLG-0966 was issued on 11 May 2015 (Street et al. 2016)



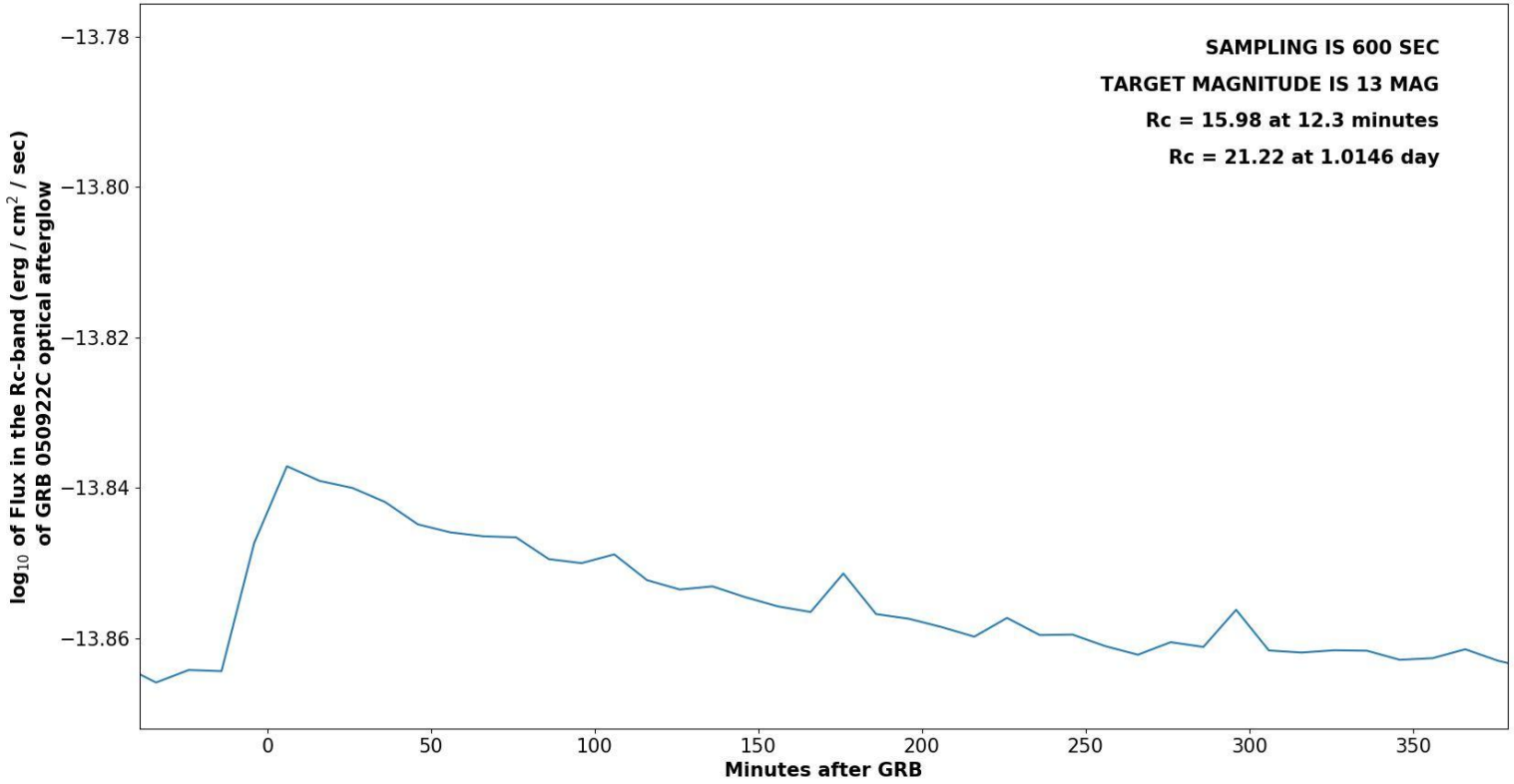
Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

GRB optical (Rc-band) afterglow light curve (Kann, Klose, Zhang, et al. 2010)



Light curves using PIS
(PLATO Imagette Simulator, developed at LESIA, Obs. Paris)

GRB optical (Rc-band) afterglow light curve (Kann, Klose, Zhang, et al. 2010)



Event reporting

- Current **ground observations planned for PLATO** : L0 → L1 → L2 → **Lg** → L3 … for **planetary targets** (e.g. spectroscopic follow up)

  ⇒ *not planned for transient detected by the Science Flux Alert*

- There are currently no defined strategy in the **PLATO** consortium on how to carry an follow up observations, following the detection of an astronomical transient

- **IVOA** (International Virtual Observatory Alliance) **Sky Event Reporting**, i.e. **VOEvent** (in XML format)

- **Gamma-ray Coordinates Network**

- OPTICON ?

- **Fully automatic** … or **"first look"** by an astronomer preferable ?

- *Others ?*

Open Issues

- Like other aspects of the L0/L1 data processing, the **WP 334 600 Science Flux Alerts** is still *in the definition phase*

- **Inputs needed** on targets to observe, to better know **what** would be the **best follow up**, and if it is worth for higher cadence

  ⇒ e.g.: a Supernovae is detected in a 600 sec light curve. **What are the best follow up** planned? (Optical spectroscopy?) Would it be worth to request and **increase the sampling** of 50 sec? (What is the scientific justification in this case?)

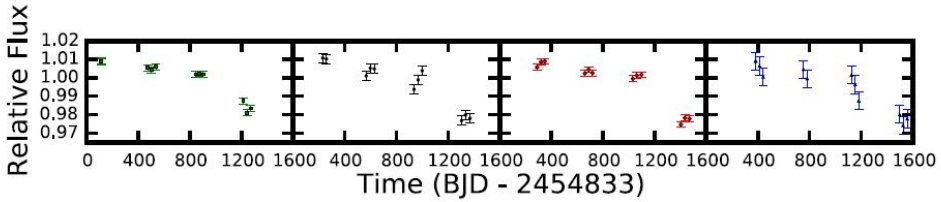
- Experience from previous similar mission :
  a. **CoRoT** : *alarm mode* to change sampling from 510 sec to 32 sec for transits (no transients)
  b. **Kepler** and **TESS** pipeline : detect *threshold crossing events*, but no changing mode, or transients

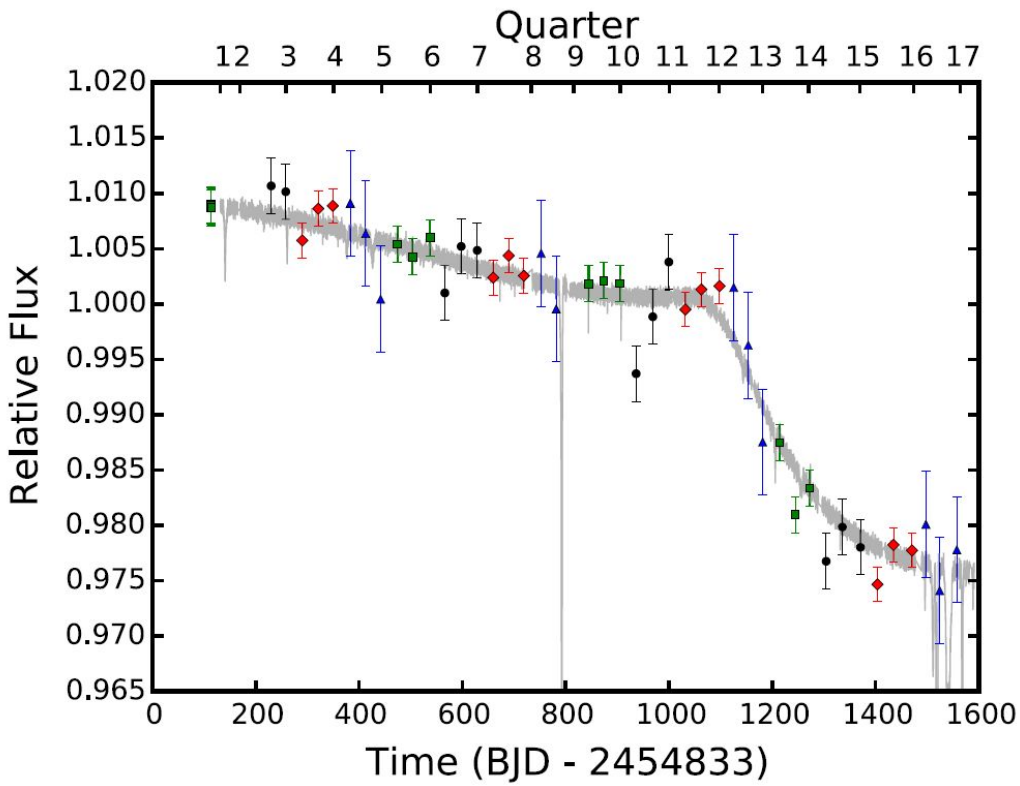
- **Gaia Alerts** :
  a. How many people involved? (i.e. FTE?) Is it **fully automated**, or **"*human eye*" first** to cross-check?
  b. Interested in what was done : Web page, Apps (!), yearly meetings starting from L-4yrs?, ...
  c. Timeline? (i.e. wrt lunch date, e.g. L-1yr web interface in place?)

Thank you !

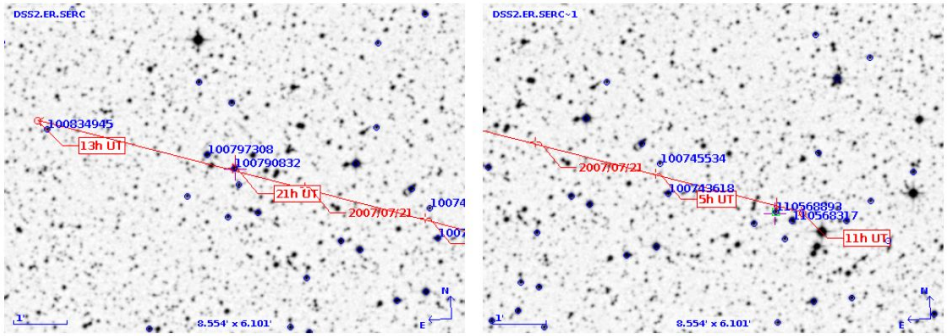
Questions ?

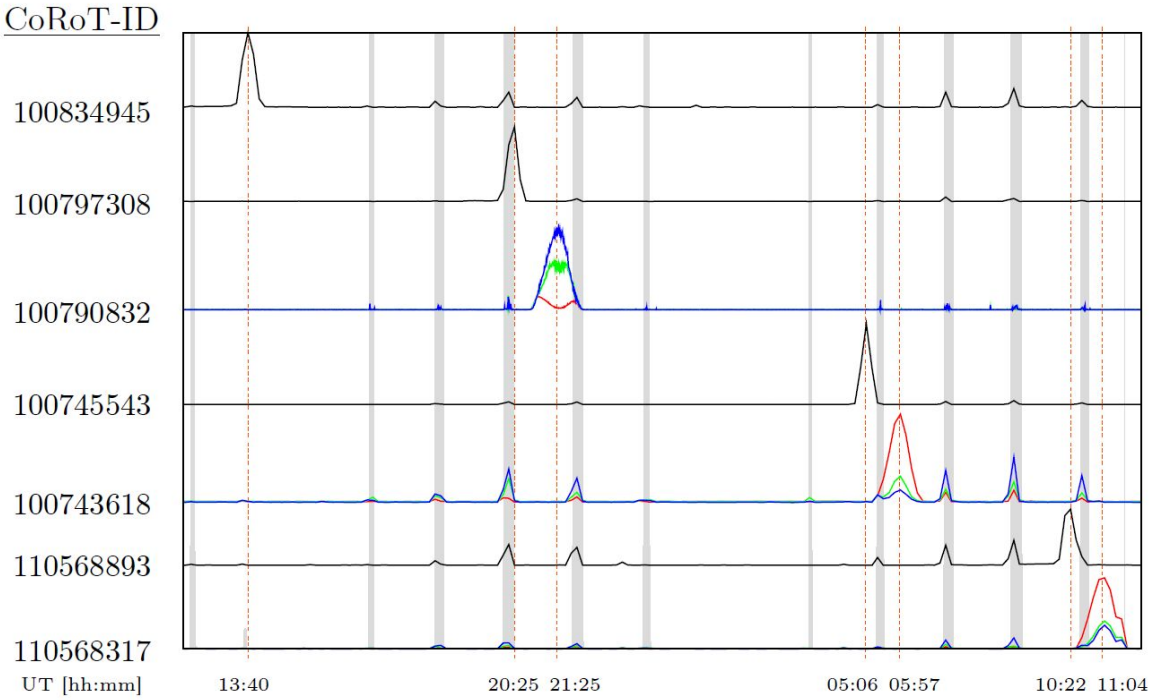
Additional material





Light curve of KIC 8462852 (aka the Tabby's Star), variation *observed* on March 2011 and February 2013 … but *spotted* by **amateur** astronomer in 2015 (arXiv:1509.03622)





Top two panels.: ESO DSS2 plates showing CoRoT targets (blue) and the trajectory of **Asteroid 137 Meliboea** (red solid line) starting on 20 July 2007 (left panel) until 21 July 2007 (right panel) with UTC time. *Lower panel.:* Light curves of several CoRoT targets (CoRoT-ID on the Y axis) versus UTC time (X axis). The horizontal dashed line indicates when the asteroids 137 Meliboea crossed the line of sight of the corresponding CoRoT targets. Taken from "Analyse von Flares mit Hilfe von CoRoT-Lichtkurven" (Alexander Drabent, Diplomarbeit, Friedrich-Schiller-Universität Jena, Physikalisch-Astronomische Fakultät 2012), Figure 5.7 (top panels) and Figure 5.8 (lower panel).