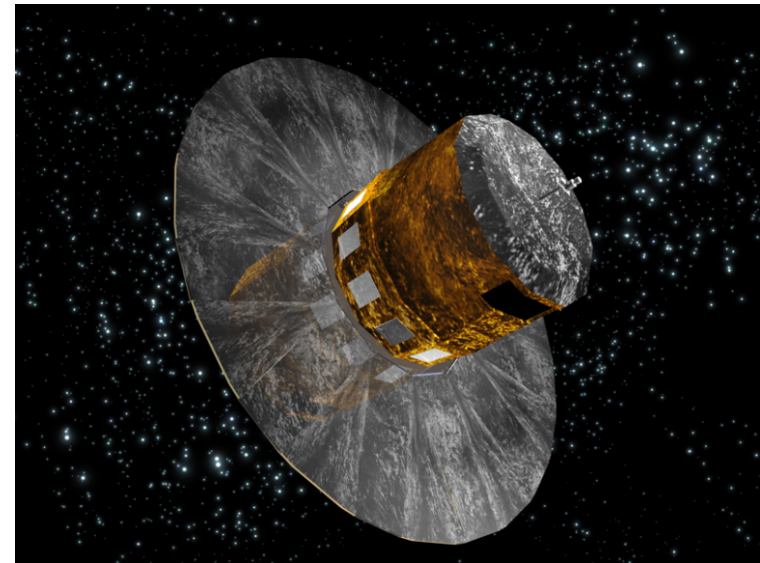


# 2,5 yrs of operations of Gaia

C. Jordi

University of Barcelona, ICCUB-IEEC



IV Reunión científica de la Red Española de Gaia, 23-25 mayo 2016



gaia



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# Mission



Launch 19-12-2013

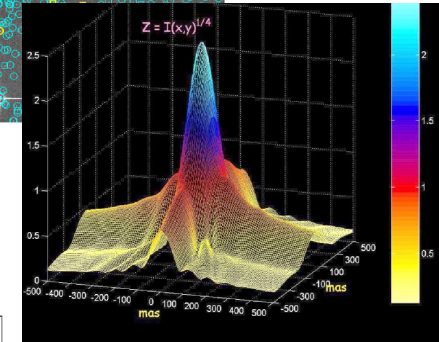
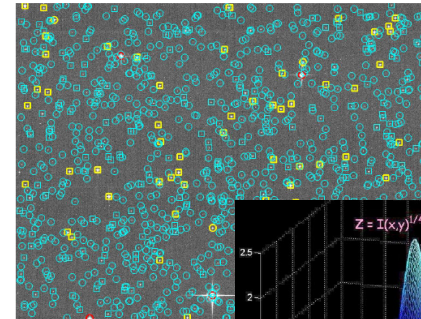
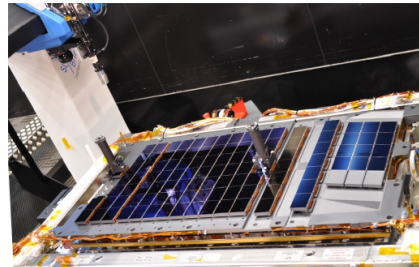
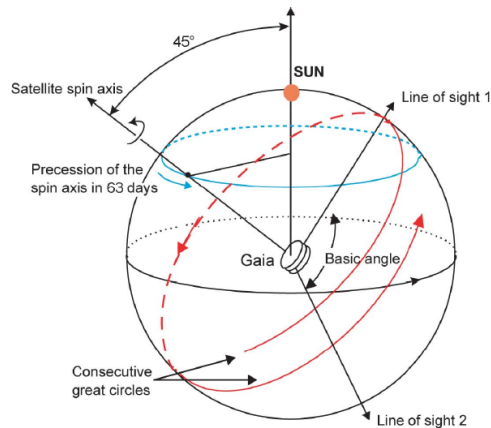
Commissioning phase ended mid Jul-14

Science operations started 25-Jul-14  
28 days of EPSL  
after NSL

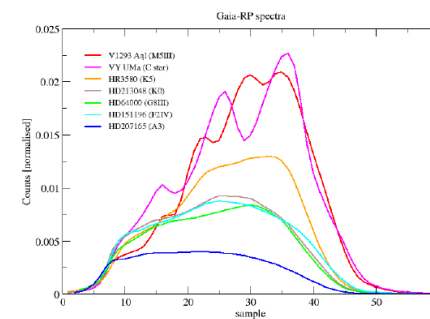
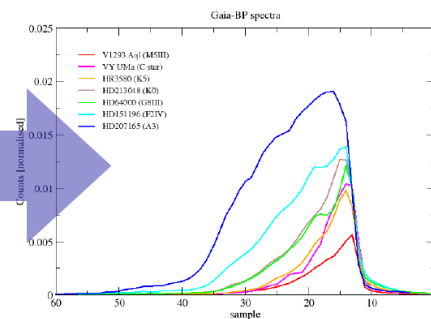
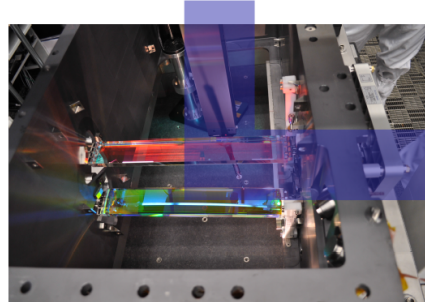
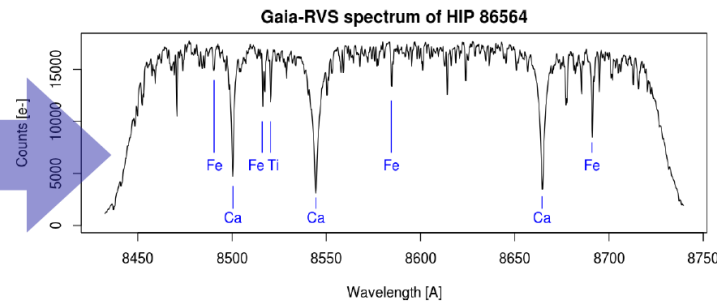
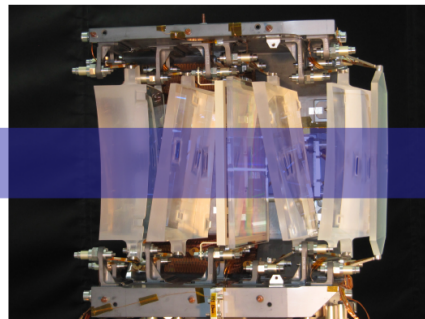
Cycle 0+1: ended 16-Sep-15 → GDR1  
(~14 months)

Cycle 2: ends 23-May-15  
→ GDR2 (+8 months)

# Observations



Figures: ESA/Gaia/DPAC/AirT



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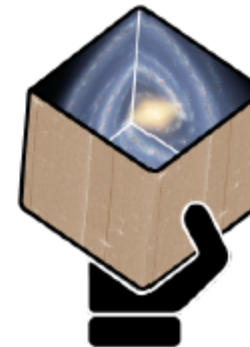
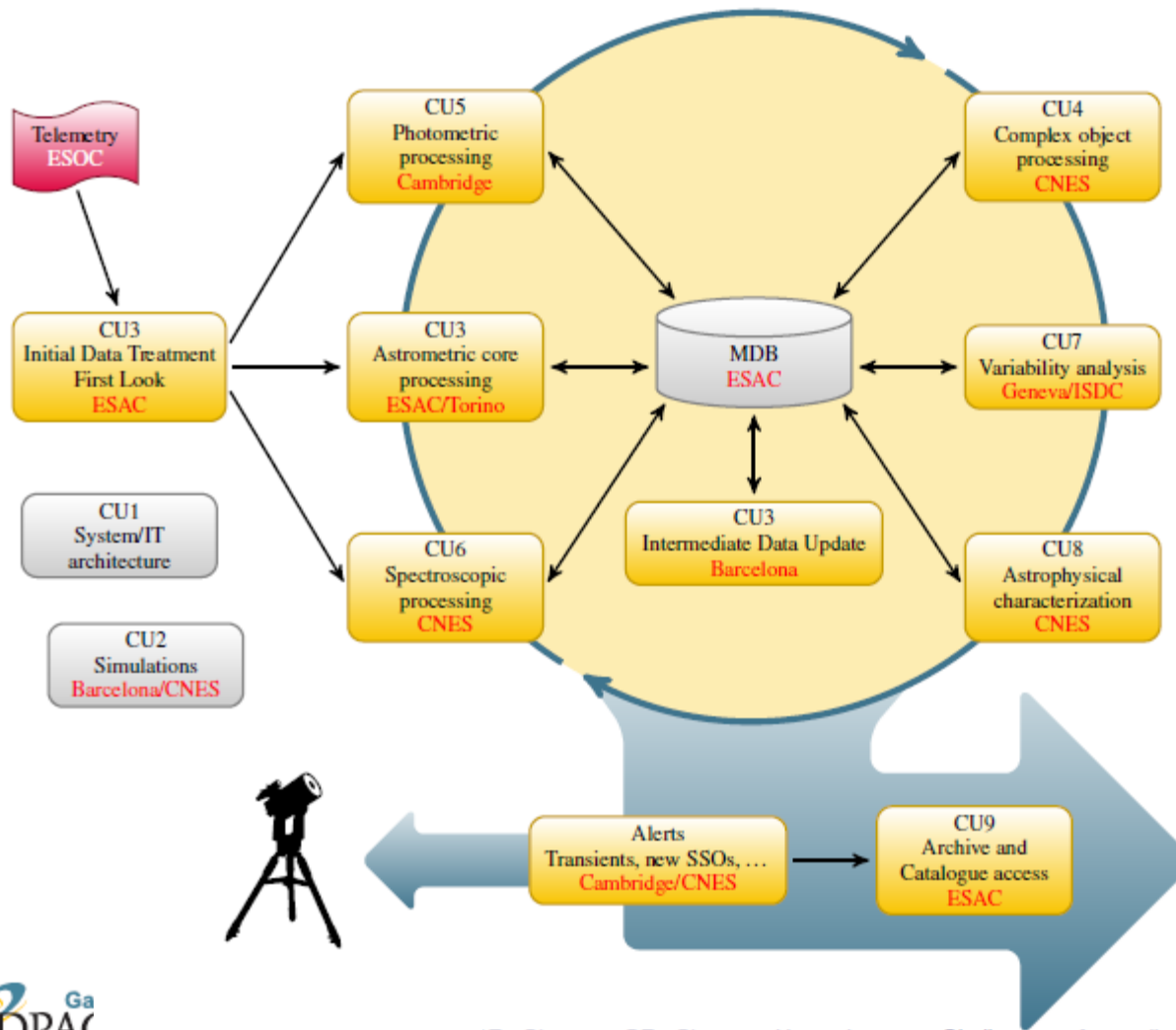
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# Data Processing and Analysis Consortium

Upstream -----> Downstream





# Data processing

Find the source parameters

$\alpha, \delta, \varpi, \mu_{\alpha*}, \mu_{\delta}, v_{\text{rad}}$ , orbit parameters multiple stars,  
 $G$ , colours,  $T_{\text{eff}}$ ,  $[\text{Fe}/\text{H}]$ ,  $\log g$ ,  $A_0$ , solar system object orbits,  
light curves, variable star classification, ...

and instrument (calibration) parameters

{Collection of parameters describing Gaia}

that best explain the Gaia observations.



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# Processing the data for Gaia-DR1

- Pre-processing of raw data
  - ▶ bias/background removal, image centroid and flux, ...
- Cross-matching
  - ▶ assign observations to sources, or create new sources
- Daily monitoring of pre-processing results
  - ▶ judge instrument health and take action if needed
- Use image fluxes in photometric processing
  - ▶ variable star processing for subset
- Use image locations in astrometric processing
  - ▶ includes the Tycho-Gaia Astrometric Solution (TGAS)



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# Sky coverage since mid-July 2014

Number of observations per square degree since start of nominal operations (**60 million transits per day**)

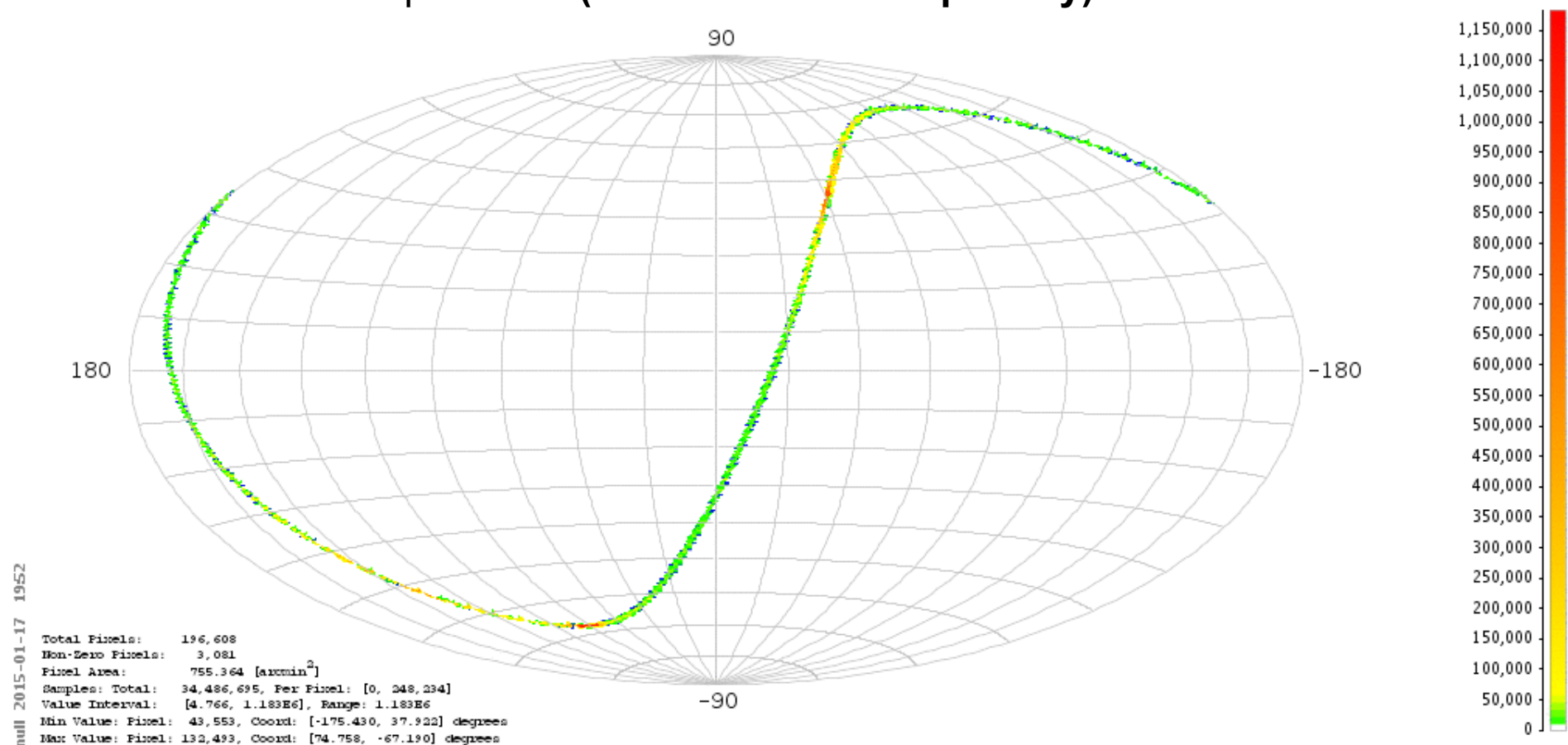


Figure by J. Portell



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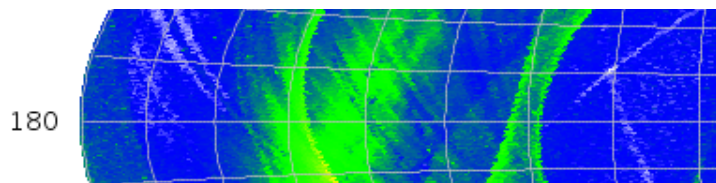


# Sky coverage since mid-July 2014

Number of observations per square degree  
start of nominal operations

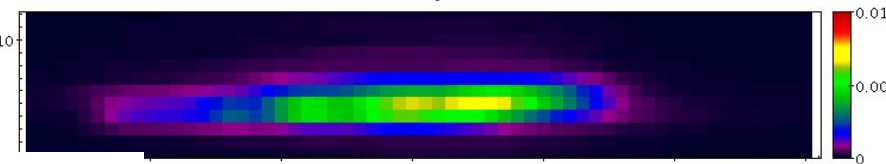


**Gaia-DR1, 14 months of mission:  
full sky coverage  
40 billion transits**

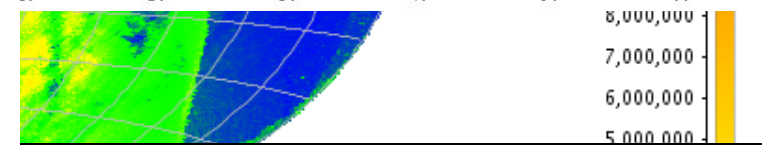


V1293 Aql  
(M5III)

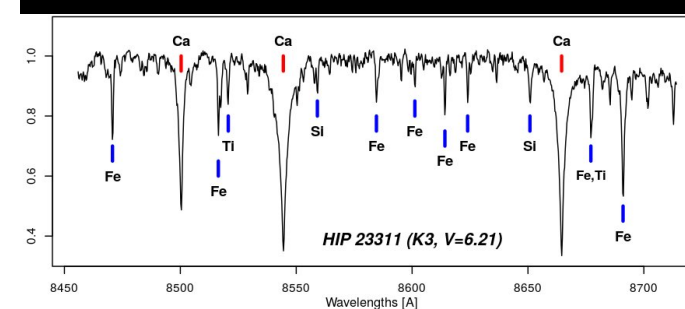
AC sample



Gaia-RP spectra



**360 billion of individual images  
80 billion of low-resolution spectra  
9 billion of high-resolution spectra**



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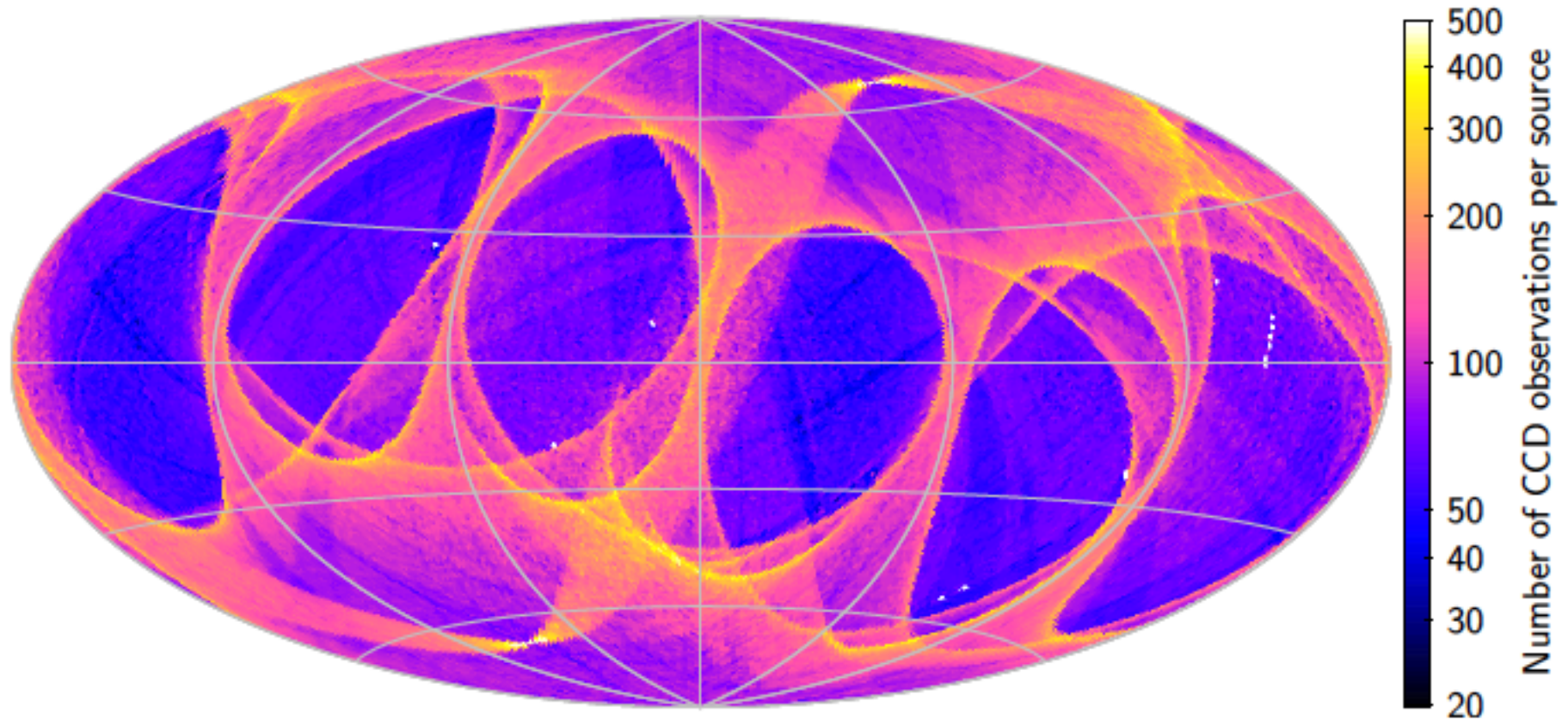
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# Observation coverage for Gaia-DR1

Gaia observation coverage



Mean no. observations per pixel ( $\sim 1 \text{ deg}^2$ )

Credits: DPAC-AGIS team



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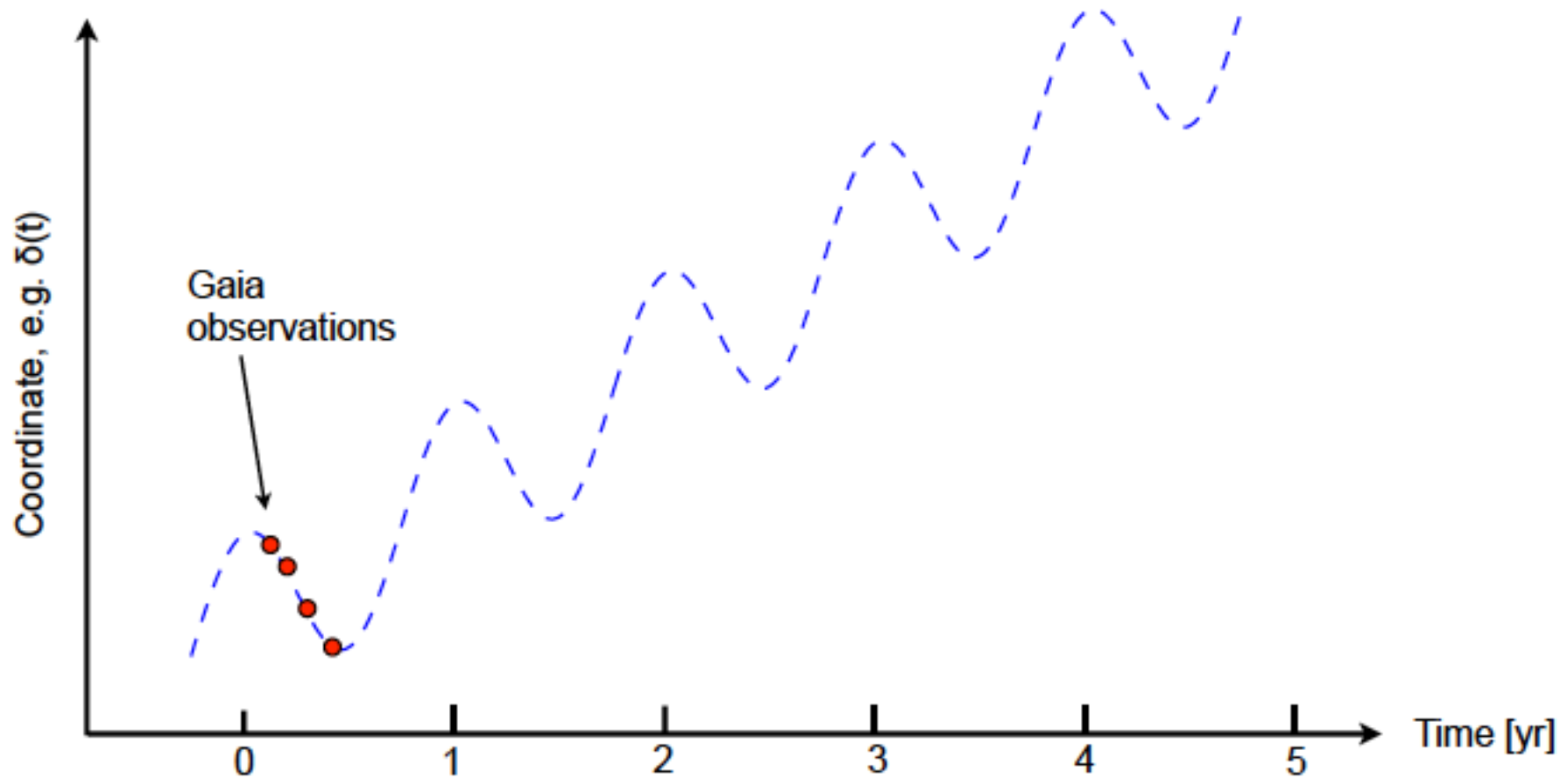


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# Astrometry solution



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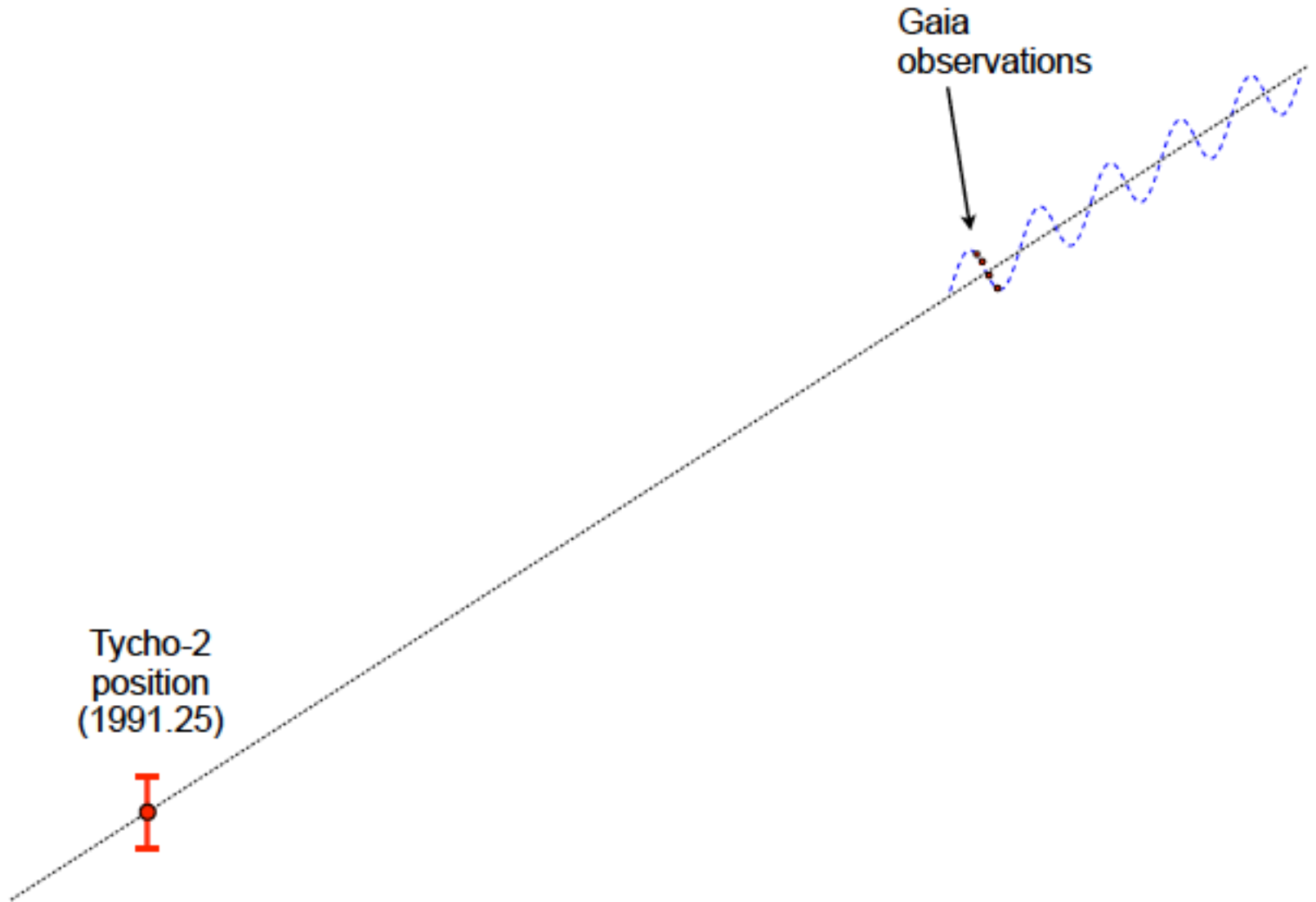
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# Astrometry solution



gaia



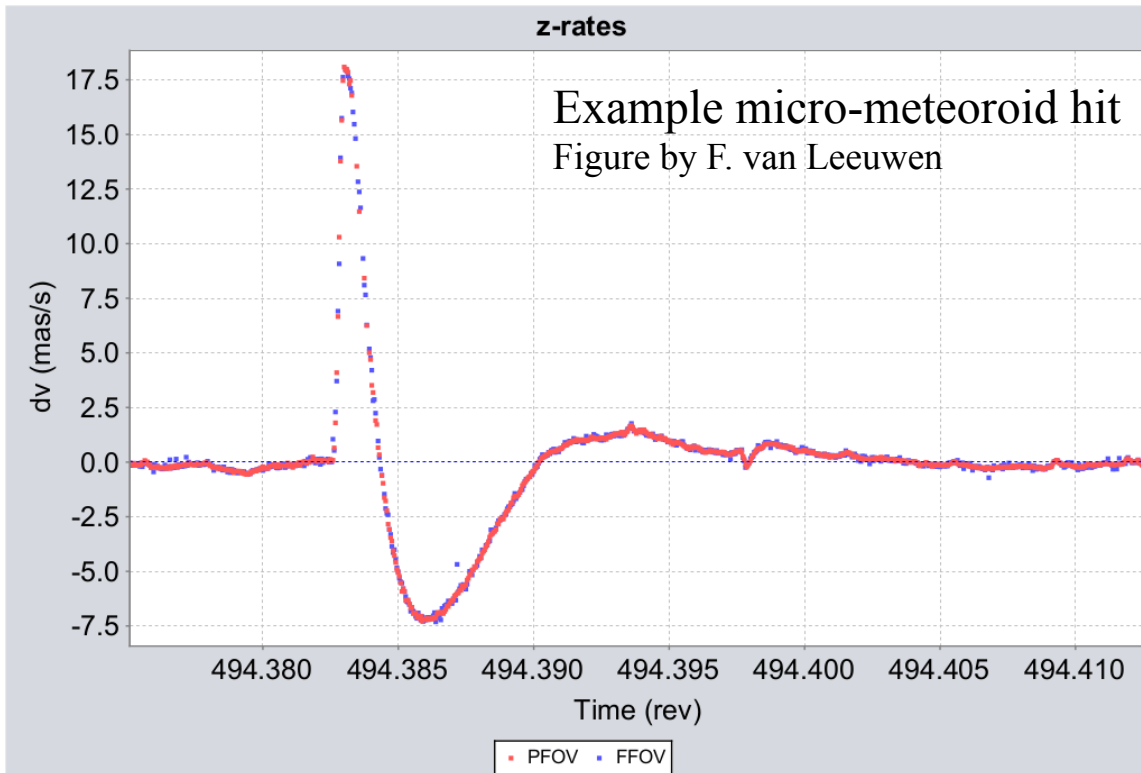
Gaia



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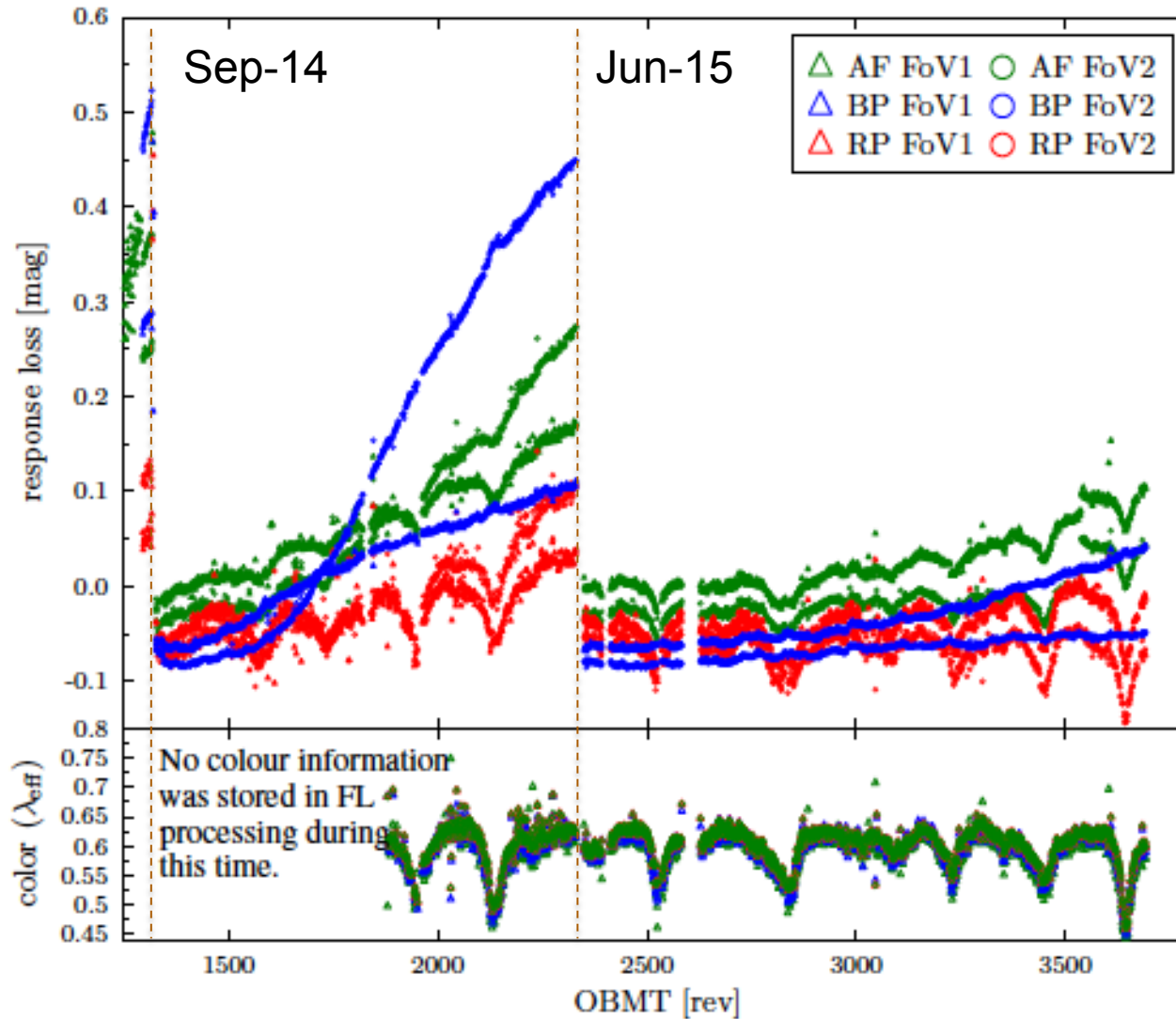
## Micrometeoroid hits

- Frequency large hits as expected
- Small micrometeoroids and micro clanks ( $< 2\text{mas/s}$ )

## Attitude calibration

- Several solutions depending on the step of processing
- Final calibration in AGIS
- There is margin for further improvement in Gaia-DR2

# Throughput time evolution



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Gaia



AIRBUS  
DEFENCE & SPACE



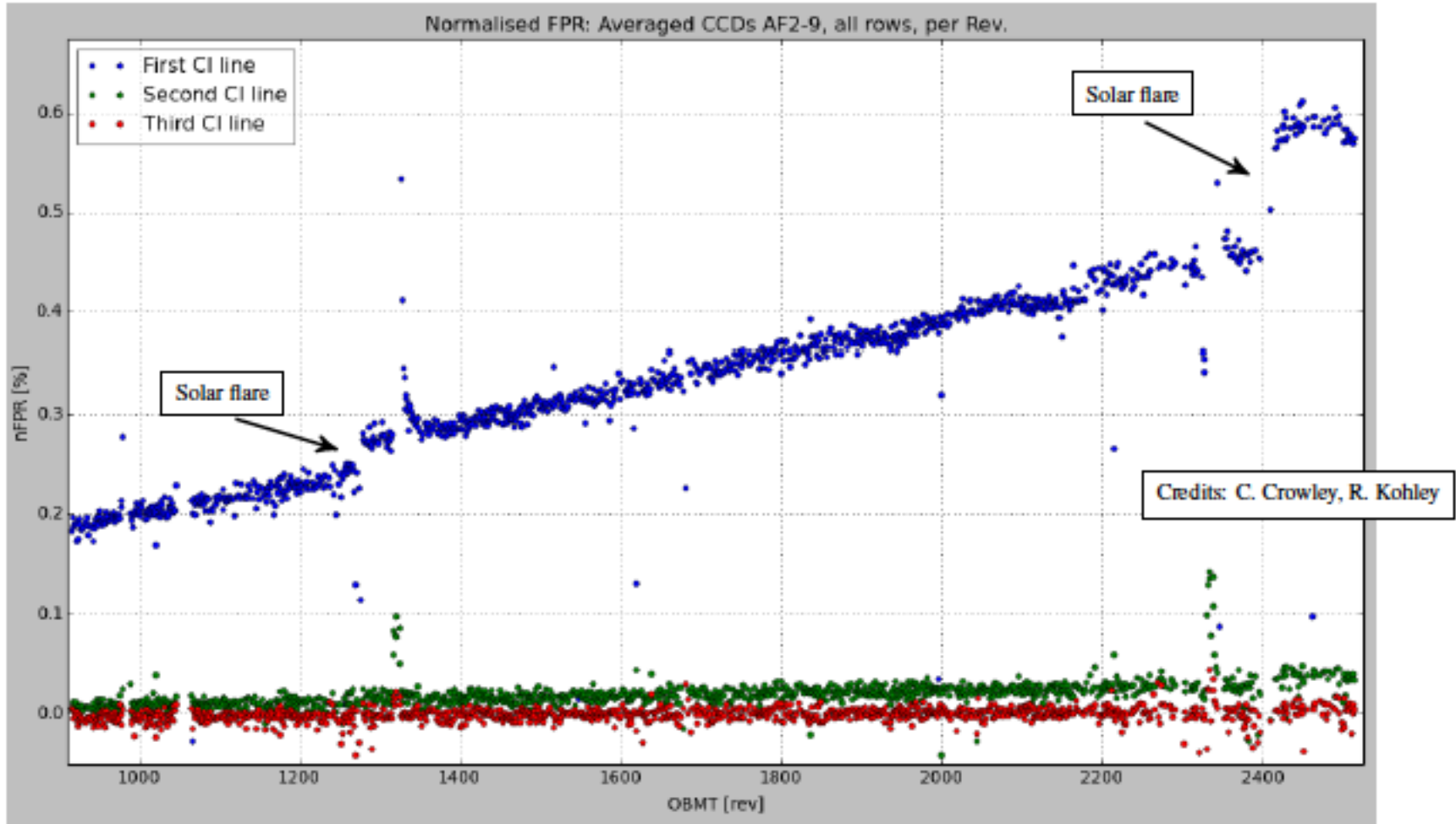
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# Radiation damage



- Radiation damage and CTI evolution monitored through charge injections
- Extrapolation indicates end-of-life radiation damage significantly lower (factor 10) than pre-launch predictions



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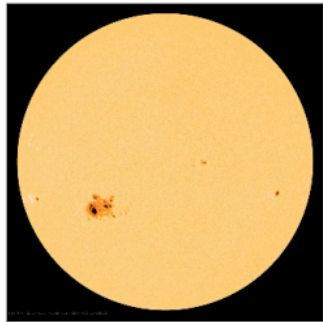


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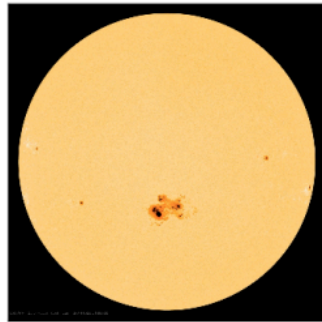


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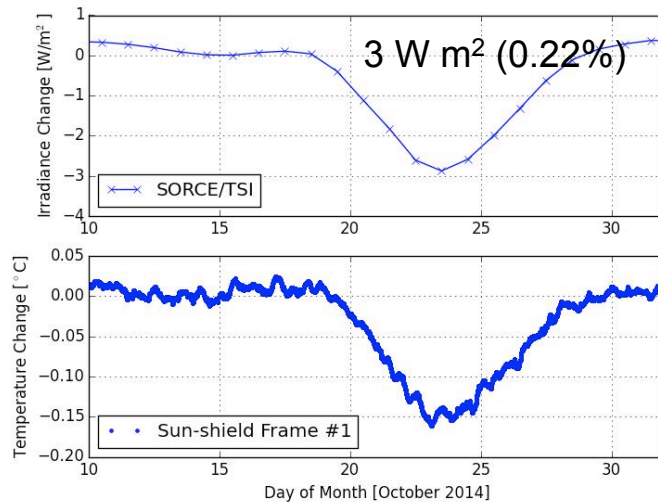
# Thermal stability



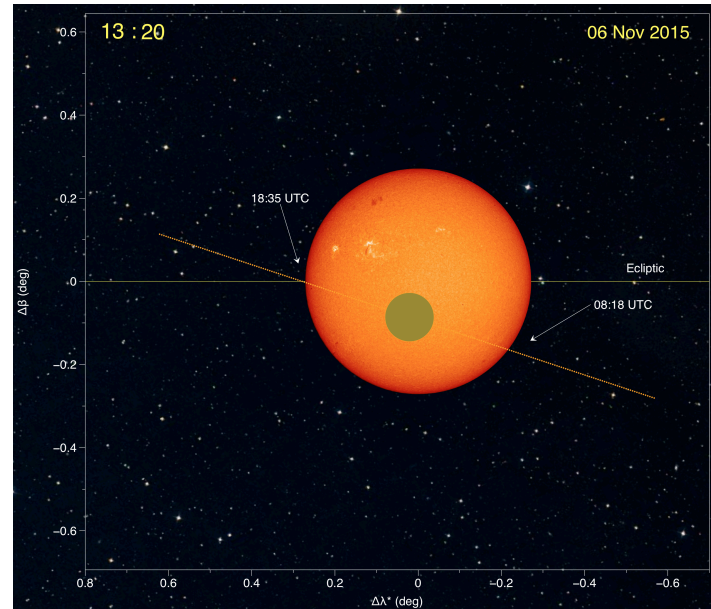
21/10/2014



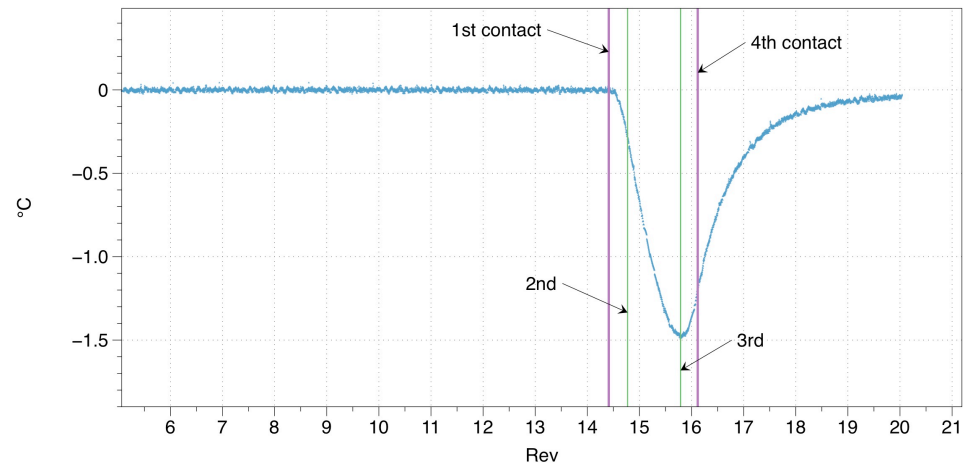
23/10/2014



no significant effect on the instrument



Lunar eclipse



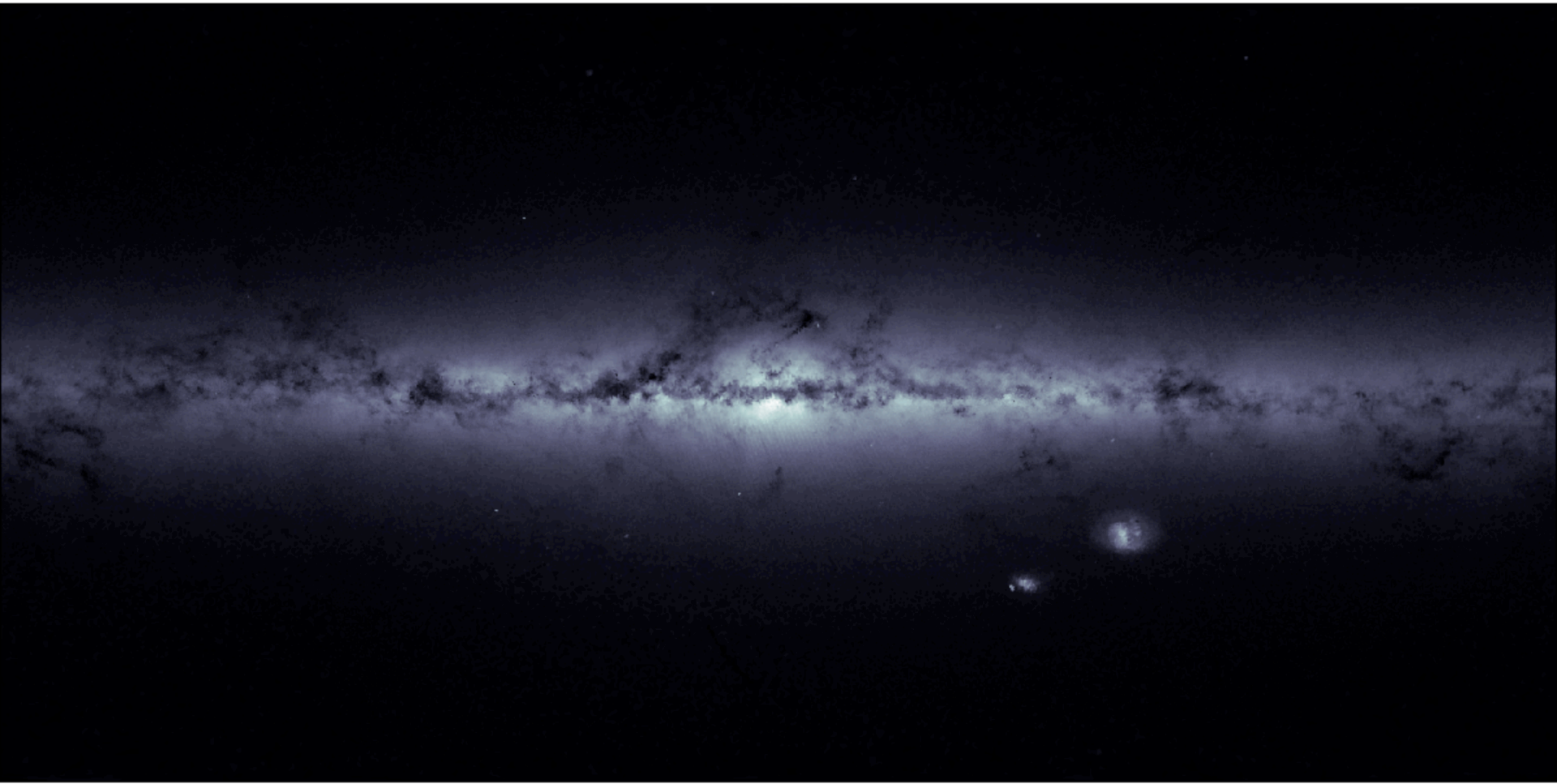
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# Star counts

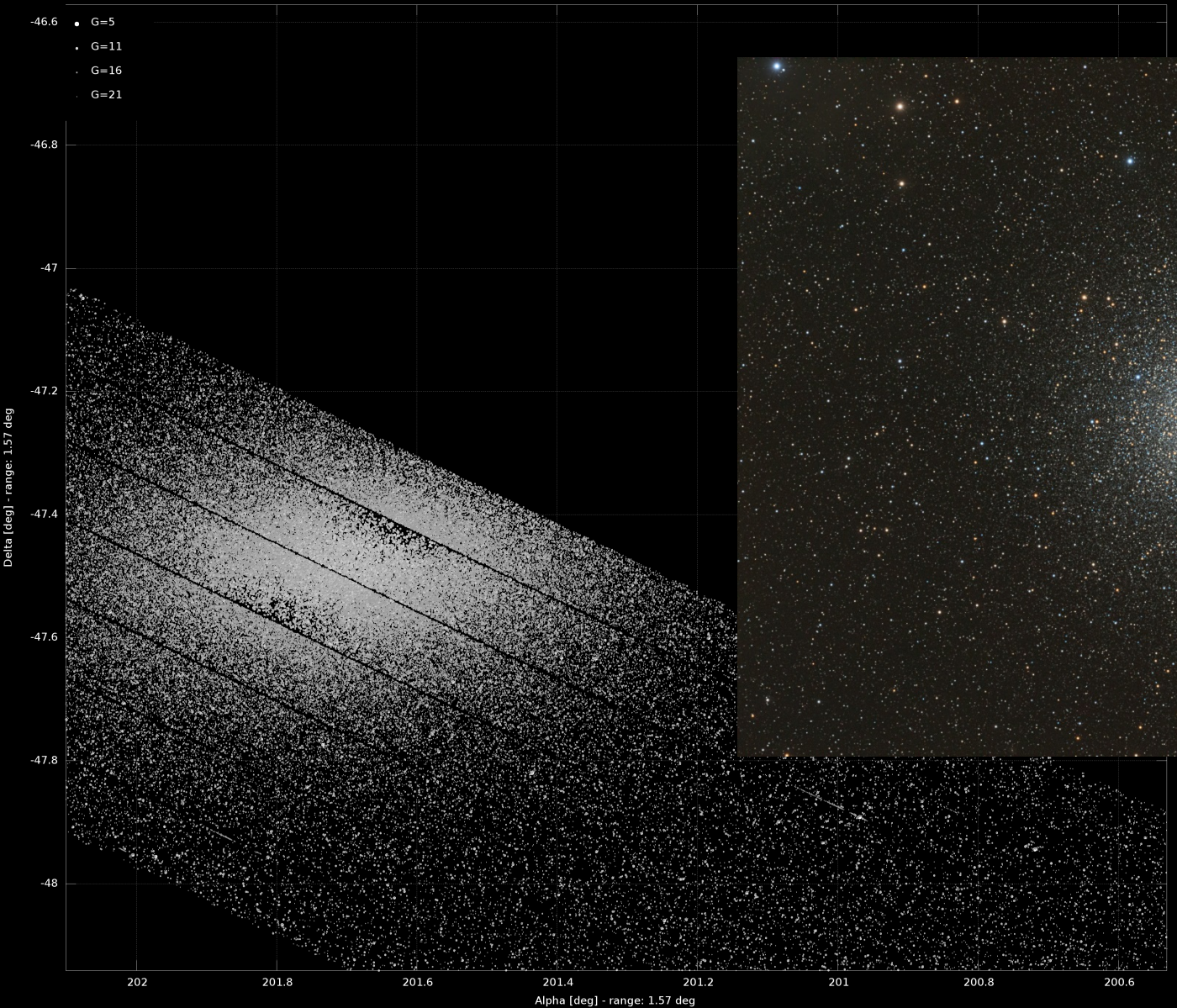


Milky Way image from Gaia housekeeping data, E. Serpell, ESOC



All in most unmatched region, IDT Run 1 (observed 14-09-29T01:44z - 14-09-29T01:46z); S2203123 (idx 43227), 137796 transits, G = 5.8 - 21.0

# $\omega$ Centauri



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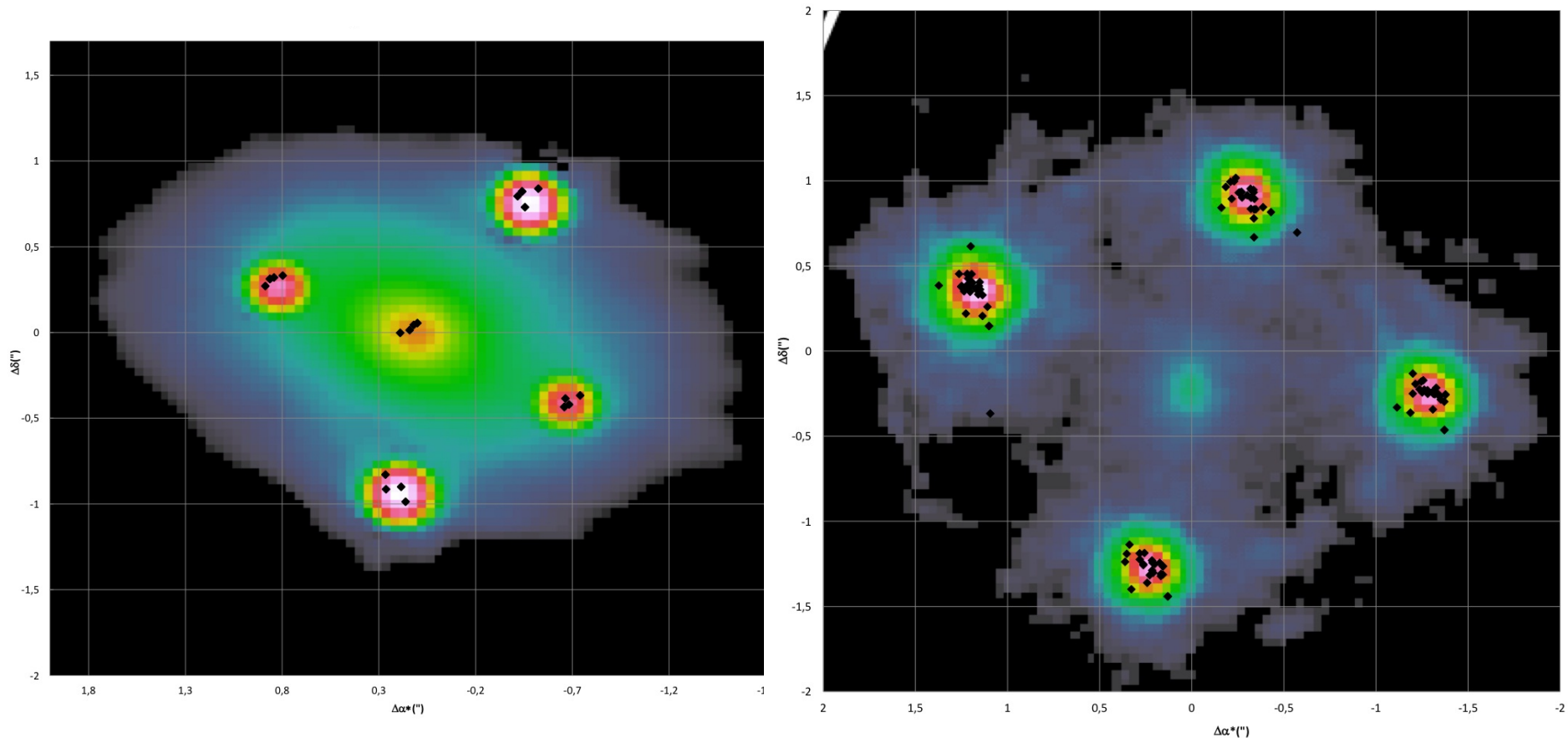


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# Detections of gravitational lenses



Einstein's Cross and HE0435-1223 with Gaia detections overplotted. Image magnitudes are 17-19 and the astrometric precision is of about 100 mas.



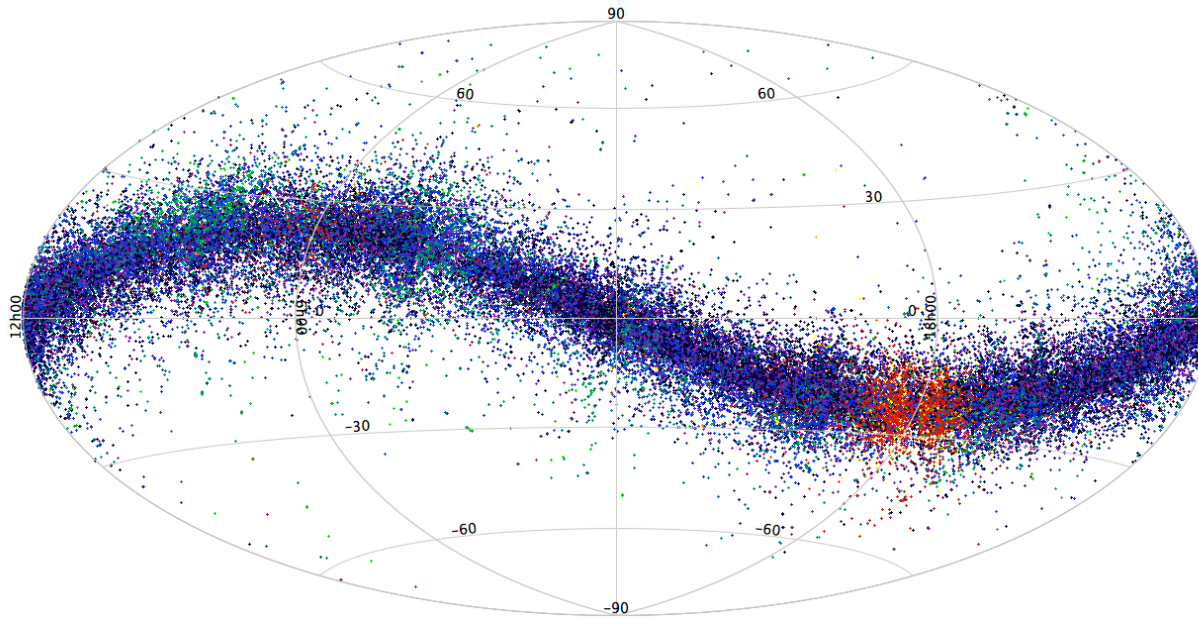
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# Asteroids detection



8-months data were used to detect the detection algorithm performance

50,000 known asteroids

Colours are function of precision



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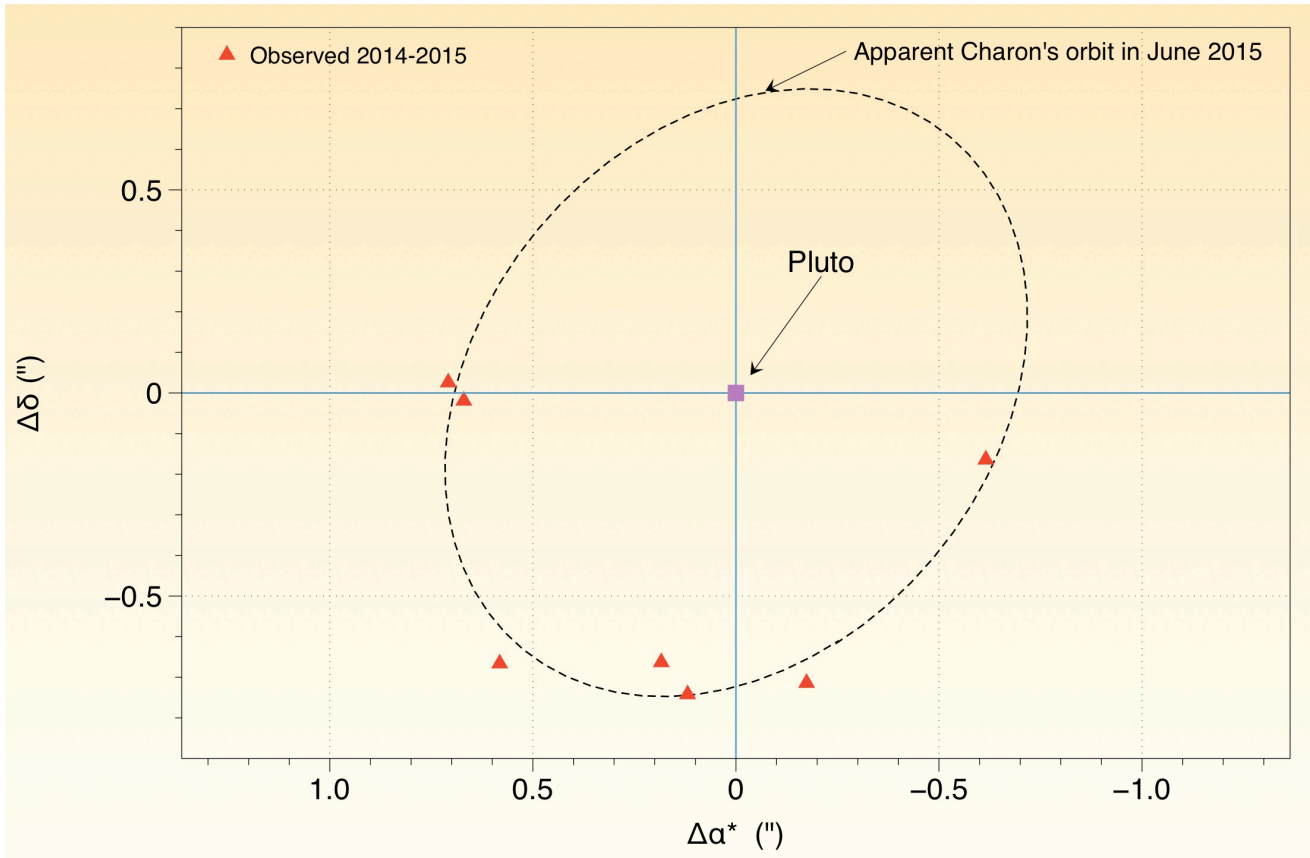


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# IDT Raw astrometry



Pluto  $G = 14.5$   
Charon  $G = 16.5$

Separation  $\sim 0.6''$

Very good  
agreement with  
prediction



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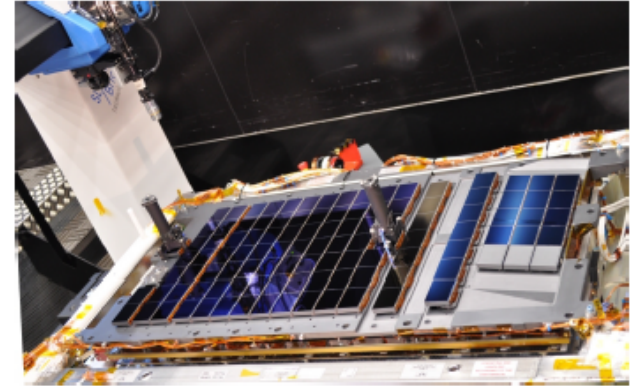
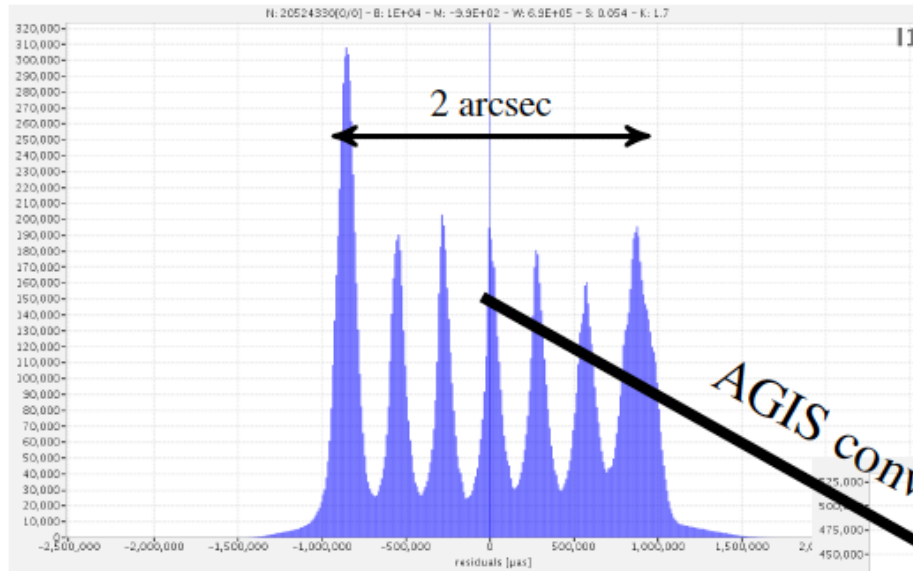


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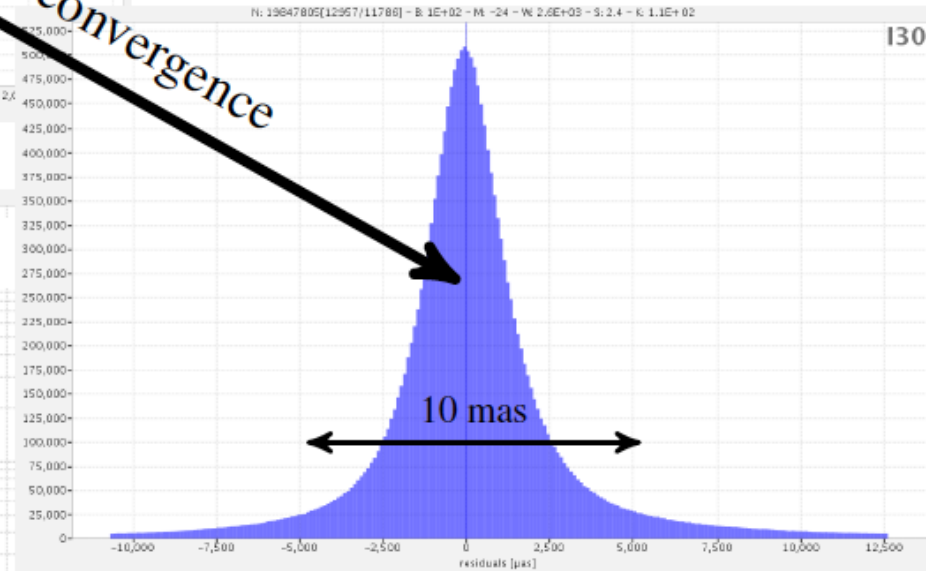
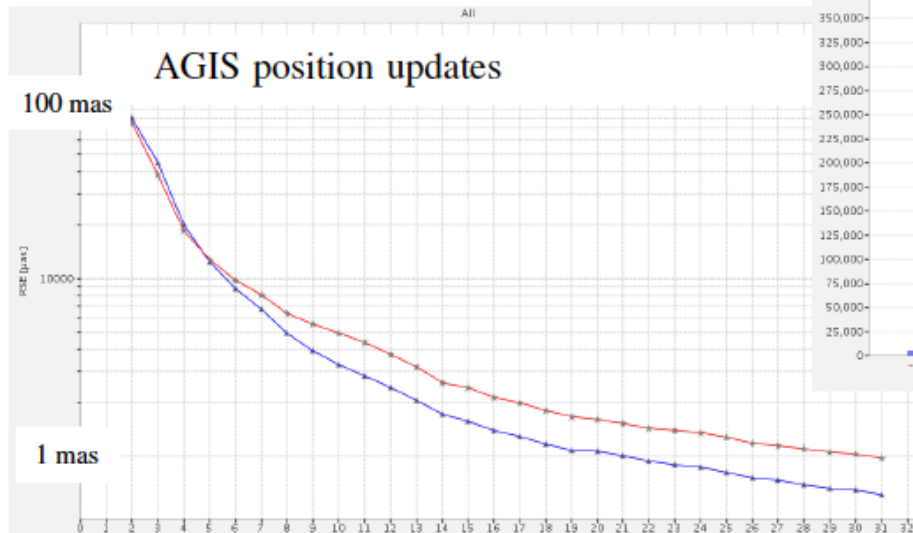


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# From IDT data to global astrometry



AGIS convergence



Figures courtesy DPAC/AGIS team, Airbus DS



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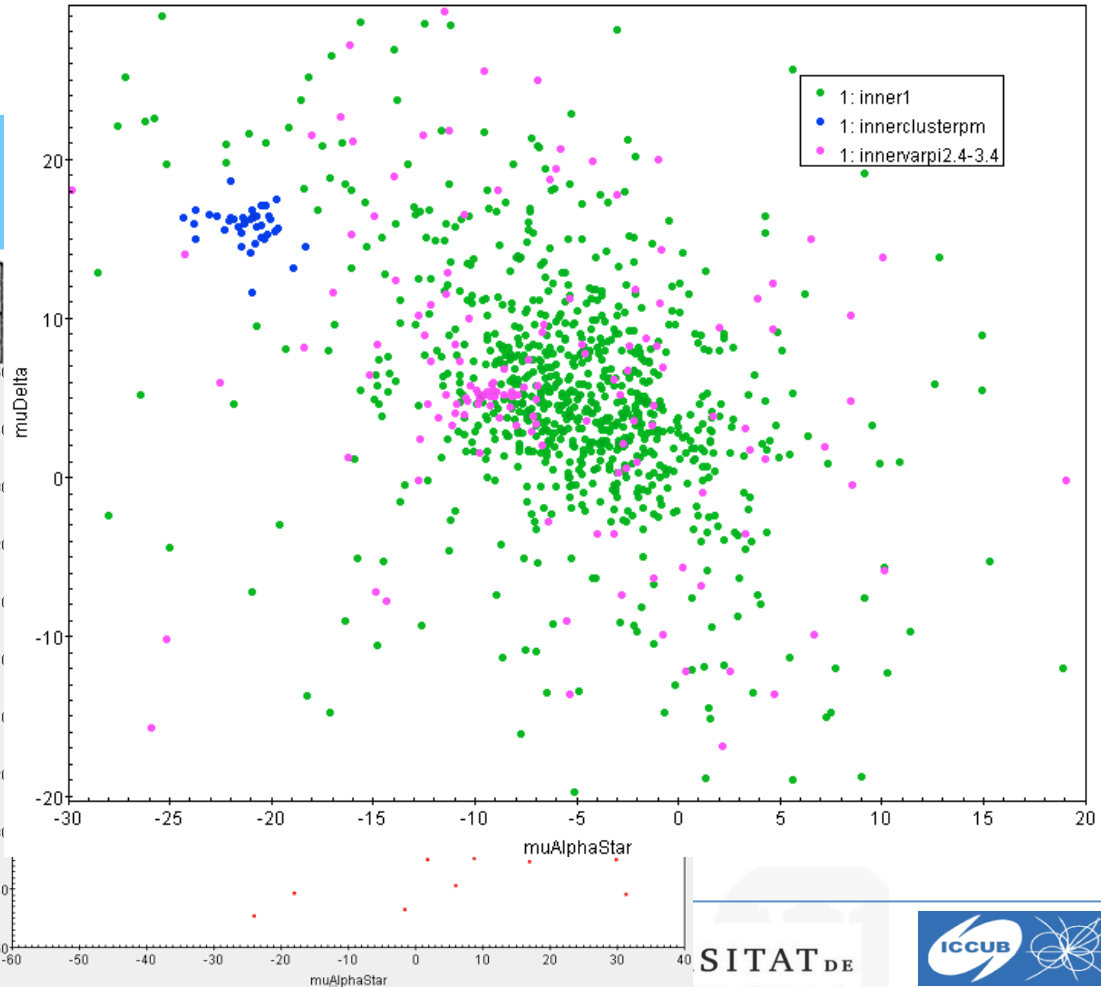
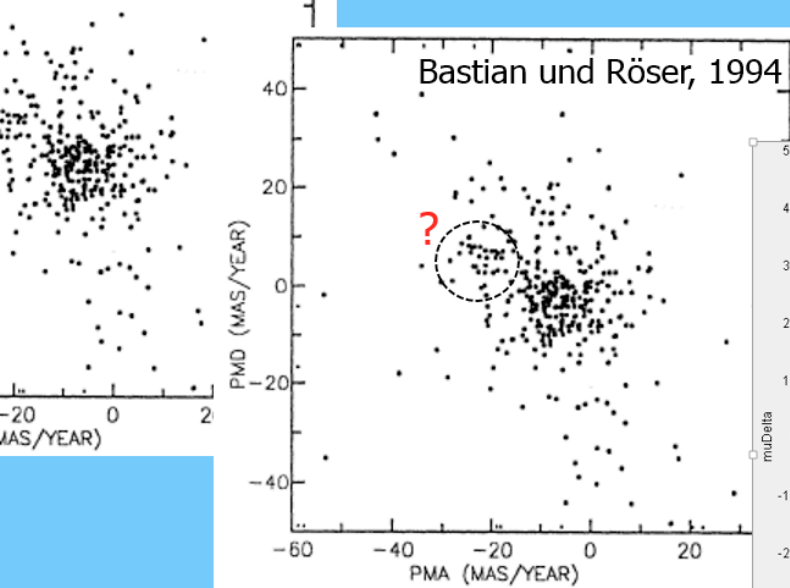




# Proper motions

NGC2451A,B

preliminary version of TGAS



# RR-Lyrae in the LMC

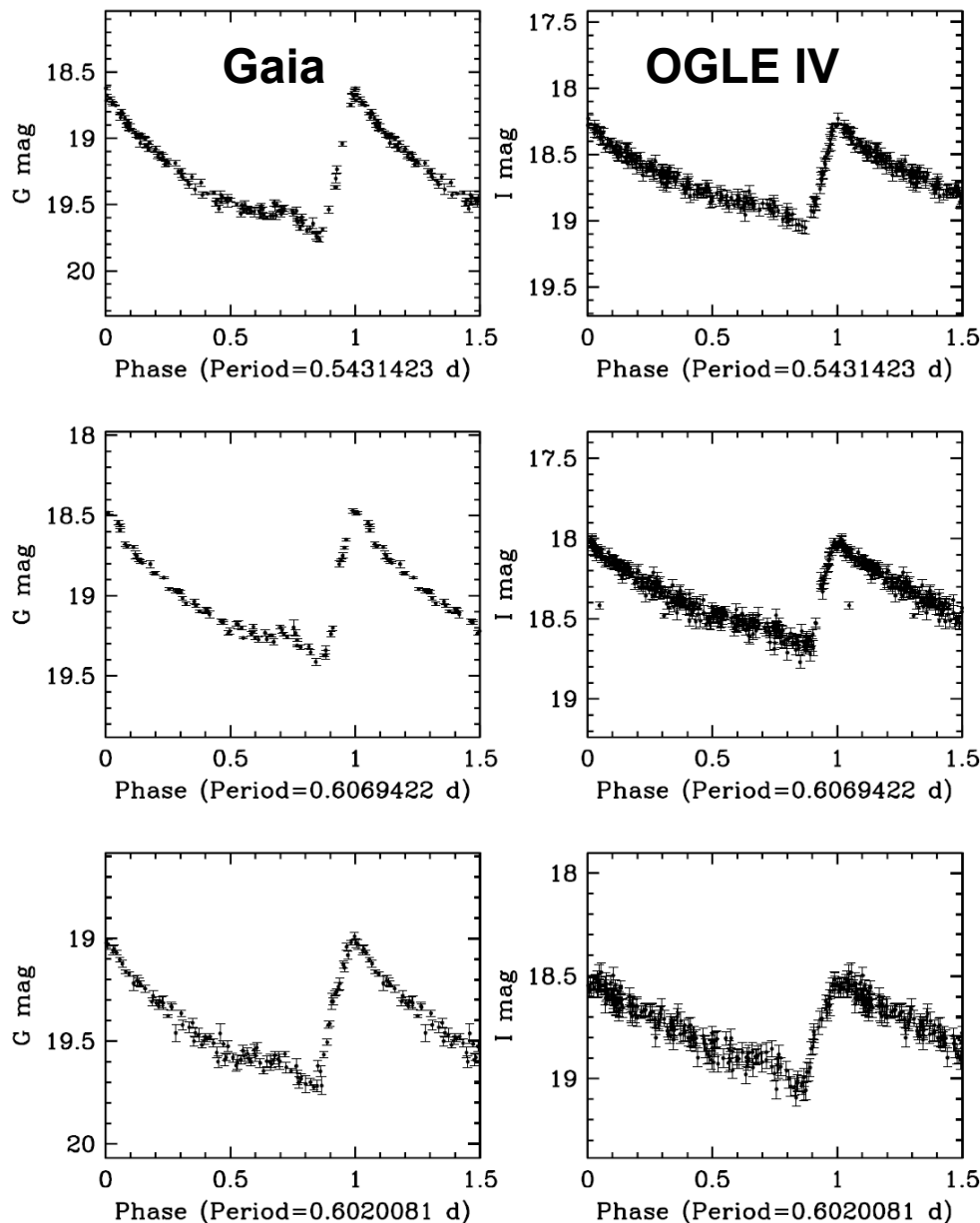
28-days Ecliptic Pole scanning

Periods from the OGLE IV catalogue  
(Soszynski et al. 2012)

Example of three fundamental-mode  
RR Lyrae (RRab) stars

Median uncertainties of the Gaia  
measurements are around 0.02 mag  
(preliminary calibration)

Gaia G-band is “bluer” than I-band.  
RR-Lyrae are fainter in G than in I.  
Amplitudes in G-band are larger, too.



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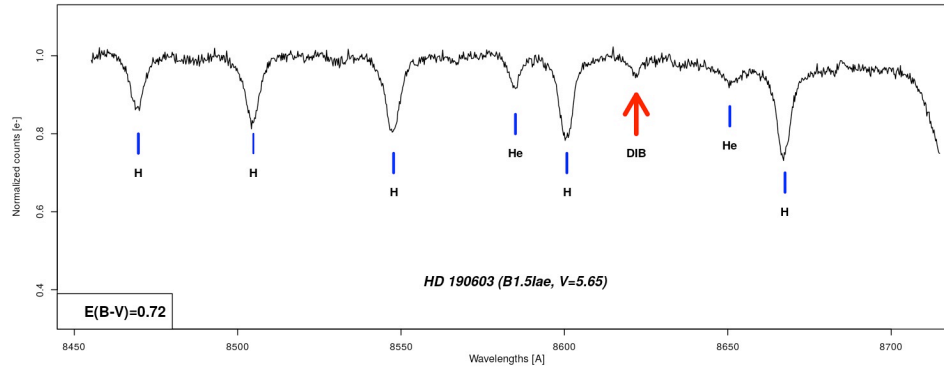


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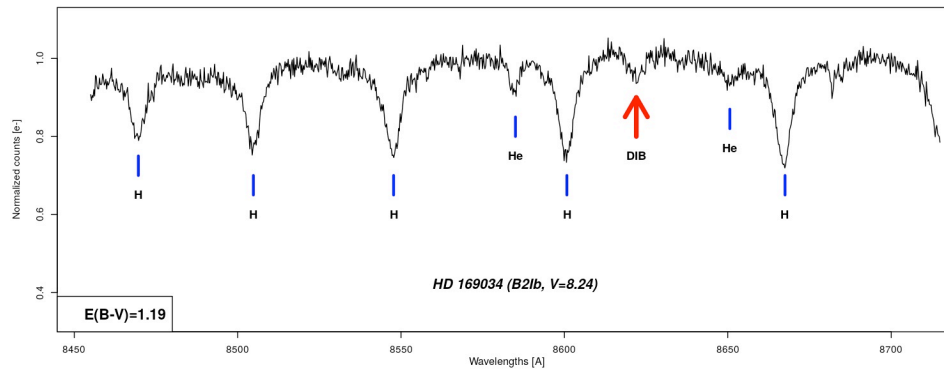
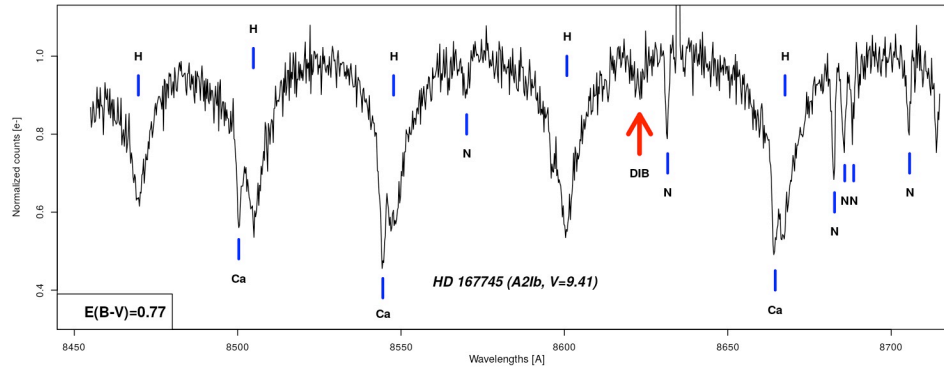


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# RVS capabilities: DIBs



Hot stars (between ~20000K and 9000K)



# Photometric science alerts

Fitxer Edita Visualitza Historial Adreces d'interès Eines Ajuda

Pàgina personal de Carme Jordi x Gaia > Data & Tools x GOST - Results x Report Mon May 11 16:01:4... x Gaia Photometric Science ... x +

gaia.ac.uk/selected-gaia-science-alerts/ Cerca

Más visitados Inici

## http://www.cosmos.esa.int/web/gaia

## http://gaia.ac.uk/selected-gaia-science-alerts/

### Gaia in the UK

Taking the Galactic Census

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You are here: [Home](#) » Gaia Photometric Science Alerts: Validation Phase

## Gaia Photometric Science Alerts: Validation Phase

Welcome! We have begun the experiment to validate our AlertPipe software. This software discovers, classifies and publishes Gaia Photometric Science Alerts. We are right at the beginning of the journey, and invite you to join in.

On this web page we are publishing coordinates and photometry for a manually selected subset of alerts as part of our validation process. These sources and the contents of the webpages come with a number of caveats (details below). The methodology used to find the alerts is also described below.

If you do measure any data for these targets, then please let us know (via [Contact page](#) and choose the category: Science alerts), and if possible we'd like to get a copy of your data (e.g. via ftp) for inclusion in our verification analysis together with data from collaborating observatories:

### Alerts science

- Guest Stars with Gaia
  - Exploding stars
  - Variable stars
  - Cosmology with Supernovae
- Supernovae in one minute
- History of Supernovae detections movie

### Alerts downloads

- Download FUGA-William Herschel Telescope follow-up spectra tarball. (353KB)

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OK, I agree No, give me more info

18:03 11/05/2015



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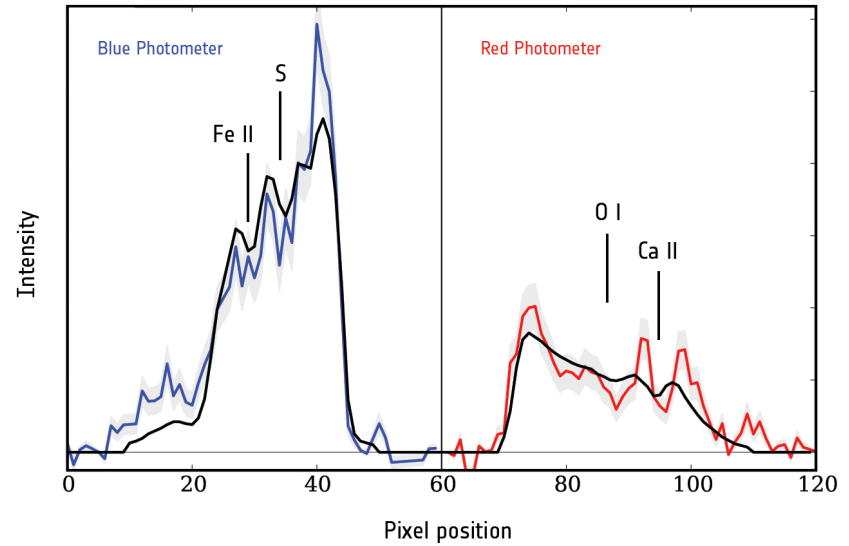
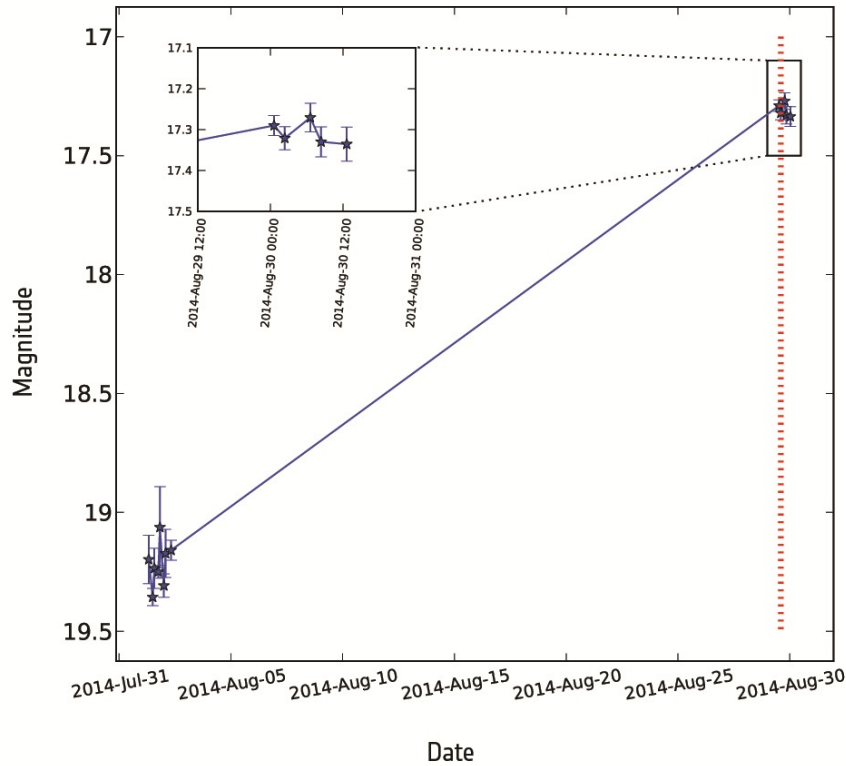


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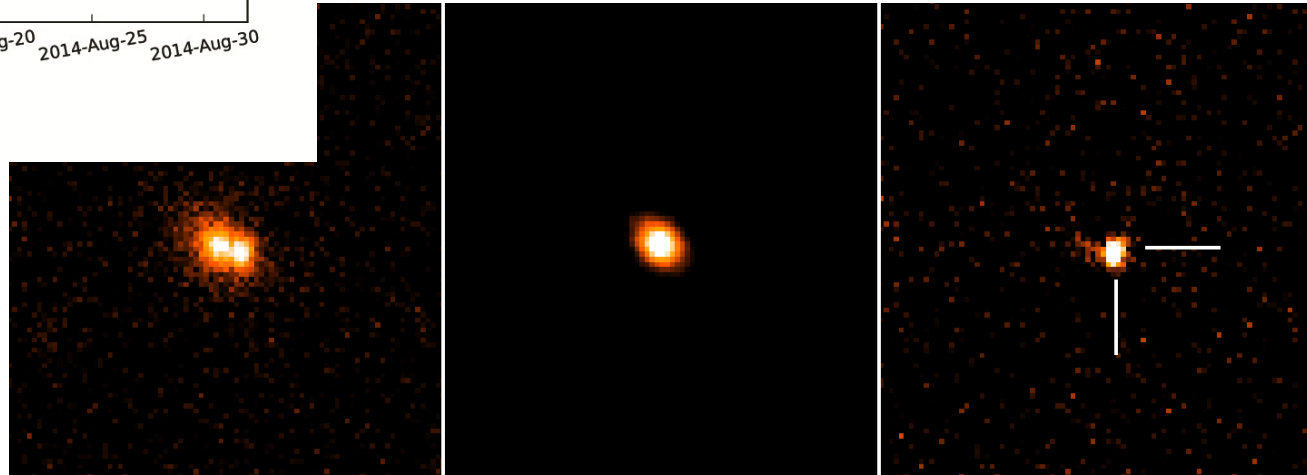




# Photometric alerts



<http://www.gaia.ac.uk/selected-gaia-science-alerts>



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# Past, present and future

- **After a long period of optimization, the spacecraft and all subsystems are working routinely since about a year ago**
  - Small changes of parameters will be introduced 23 May to reduce spurious detections (current detection threshold at 20.7 mag)
  - New decontamination campaign foreseen, second half of 2016
  - Optimization of ground stations for the next years (Mars, Rosetta)
- **Unexpected effects are understood or on the way to and handled by the data processing** (stray light, contamination on optics, basic angle variations, micro-clanks, ...)
- **Measurements of Gaia are extremely precise, much more than any other satellite**
  - micro-clanks, small micrometeoroids hits, ...
- **Segment 02 of data ends 23-May: → Gaia-DR2**



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# Past, present and future

- **DPAC: huge effort to adapt to the reality of the data; now at full speed**
  - IDT well performing
  - CU3 & CU5, CU7 → Gaia-DR1
  - CU9 is in the validation process of such data
- **Photometric alerts resumed in Jan 2016**
- **Solar system alerts to be activated in next months**
- **CU4, CU7, CU8 have already processed the first few months of real data**
  - After CU9 validation, they will start processing the data from in MDB-01
- **All CUs:**
  - Add complexity on the algorithms
  - Introduce new pieces of processing
  - Perform iterations among CUs
  - **Process data for Gaia-DR2**



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# Past, present and future

- **The success of Gaia, both satellite and DPAC, confirmed by :**
  - the operation and daily monitoring of the health of the satellite
  - the raw astrometry by IDT
  - the preliminary results of TGAS
  - the light curves of known variables
  - the detection of solar system objects
  - the photometric alerts
  - and, .... many, many others
- **Gaia-DR1 is a great success for all DPAC.** The processing is simplified, but still it will be very valuable for science (parallaxes, proper motions, ...)
- **Gaia-DR2.** Weaknesses of Gaia-DR1 will be improved in further releases, together with a longer time coverage of observations (22 months for DR2)



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# Past, present and future

- The micro propulsion propellant: expected exhaustion by 2024±1  
→ mission extension +5yrs (to be approved by SPC in Nov-2016)

Generic model of orbital stellar motion ( $P \gg T$ )

$$\theta(t) = \theta_0 + t\mu + \frac{t^2}{2}a + \frac{t^3}{6}\dot{a} + \frac{t^4}{24}\ddot{a} + \dots$$

Diagram illustrating the generic model of orbital stellar motion ( $P \gg T$ ). The equation is shown with arrows pointing to its components:

- $\theta_0$ : position at  $t = 0$
- $t\mu$ : proper motion
- $\frac{t^2}{2}a$ : acceleration ( $a$ )
- $\frac{t^3}{6}\dot{a}$ : rate of change of acceleration
- $\frac{t^4}{24}\ddot{a}$ : second derivative of acceleration

If  $\theta(t)$  is observed uniformly over  $-T/2 < t < T/2$ , the coefficient of  $t^n$  improves as  $\sigma \propto T^{-(n+\frac{1}{2})}$



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**1,000,000,000 stars**

**1,000,000,000 pixels**

**> 1000 people**

**> 10,000 scientists**

**1,000,000,000,000,000 bytes**

