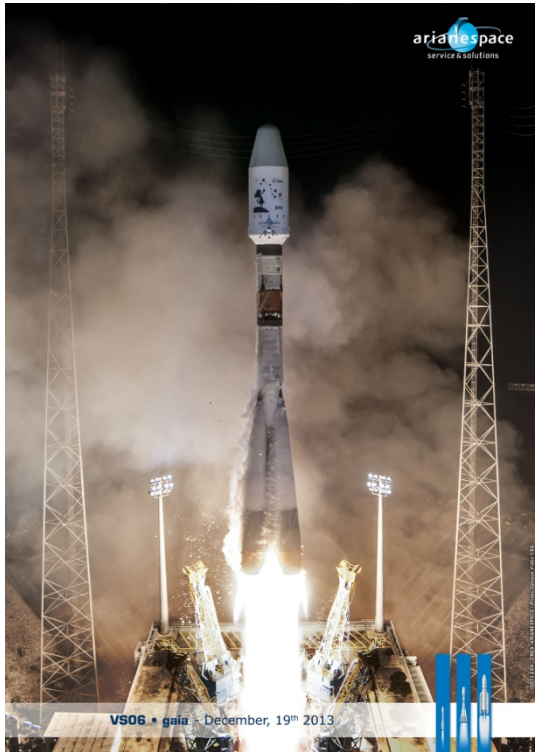
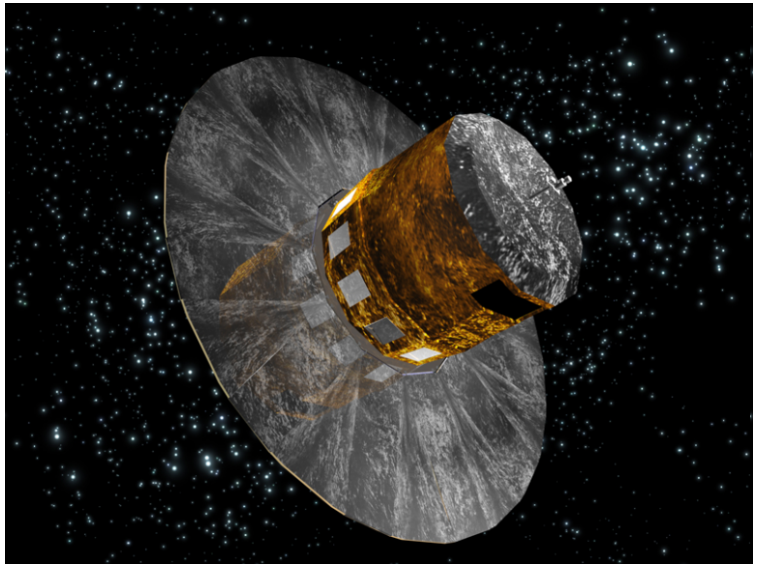
2,5 yrs of operations of Gaia

C. Jordi

University of Barcelona, ICCUB-IEEC





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

Mission

Launch 19-12-2013

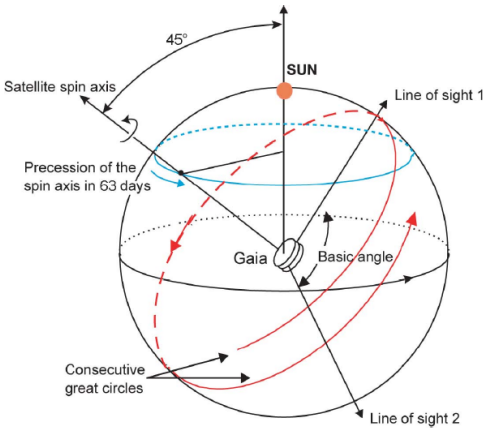
Commissioning phase ended mid Jul-14

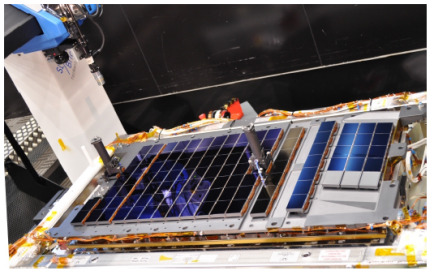
Science operations started 25-Jul-14
28 days of EPSL
after NSL

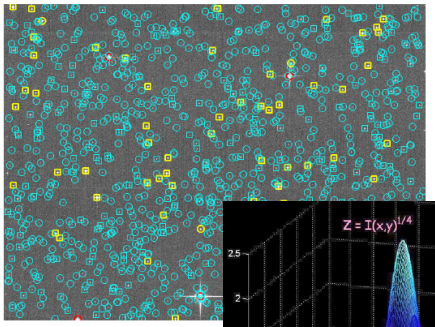
Cycle 0+1: ended 16-Sep-15 →GDR1 (~14 months)

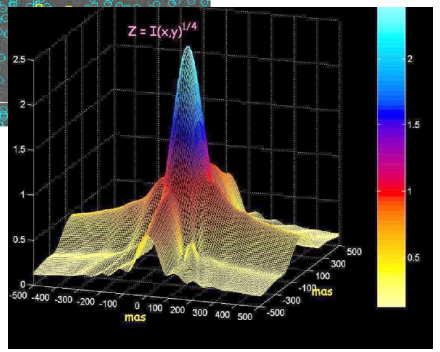
Cycle 2: ends 23-May-15
→ GDR2 (+8 months)

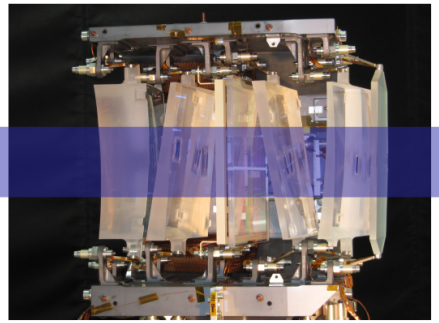
Observations

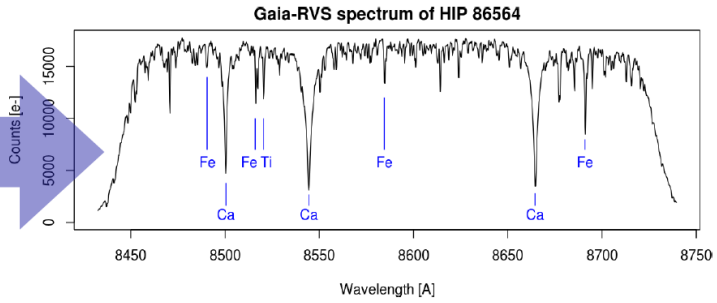




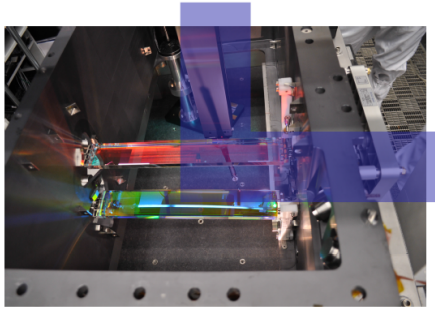


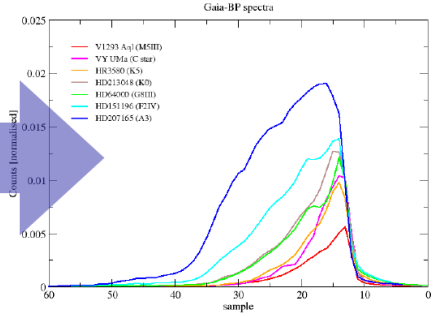


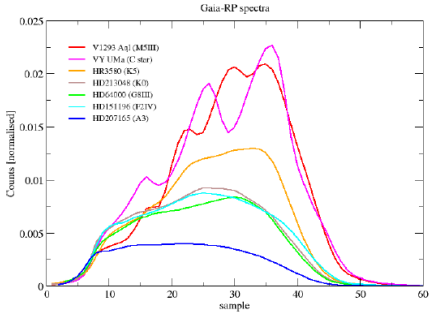




Figures: ESA/Gaia/DPAC/Airb







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Data Processing and Analysis Consortium

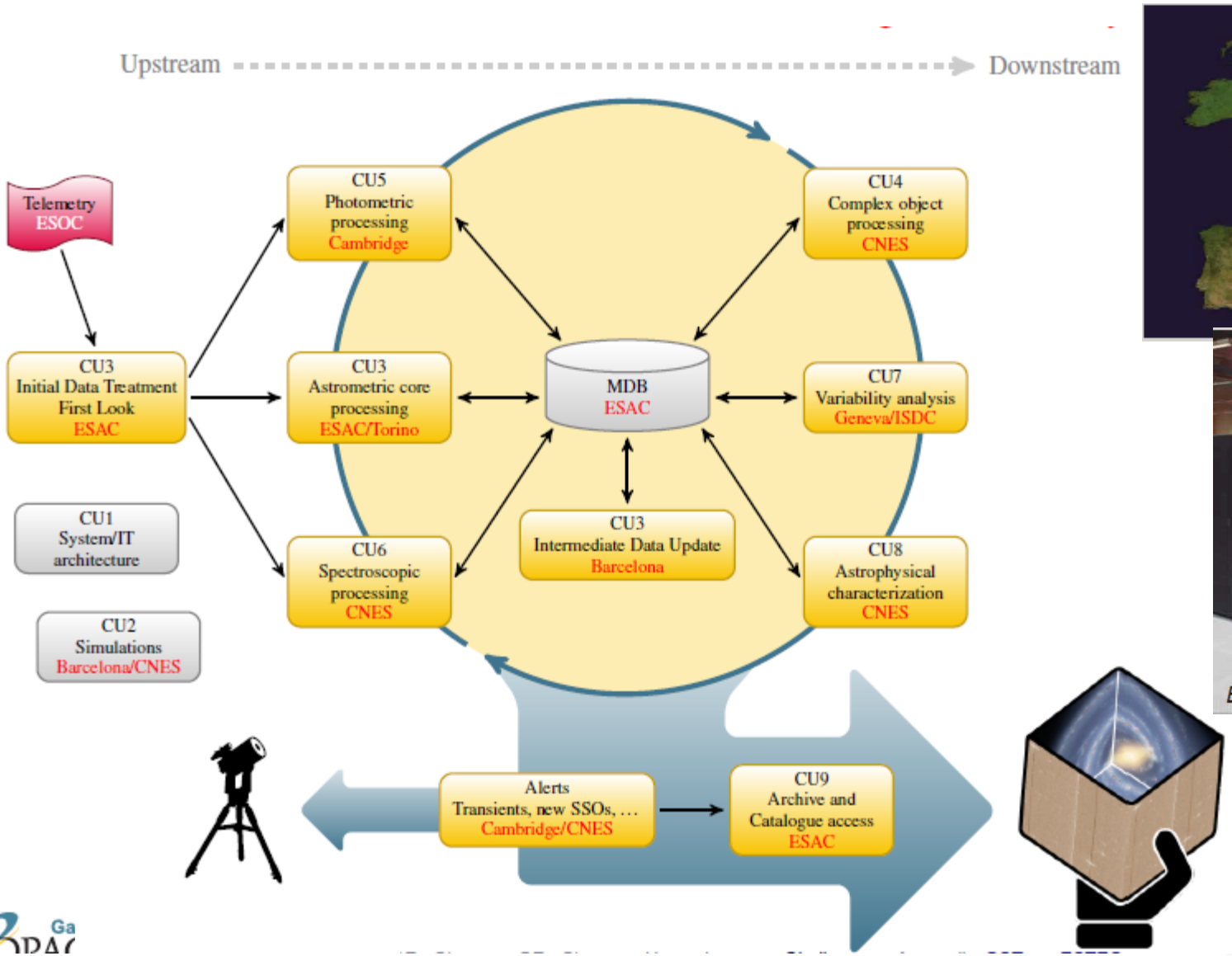


Figure by A. Brown

Data processing

Find the source parameters

α, δ, ϖ, $\mu_{\alpha*}$, μ_δ, $v_{\rm rad}$, orbit parameters multiple stars,

G, colours, $T_{\rm eff}$, [Fe/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.

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)

Sky coverage since mid-July 2014

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

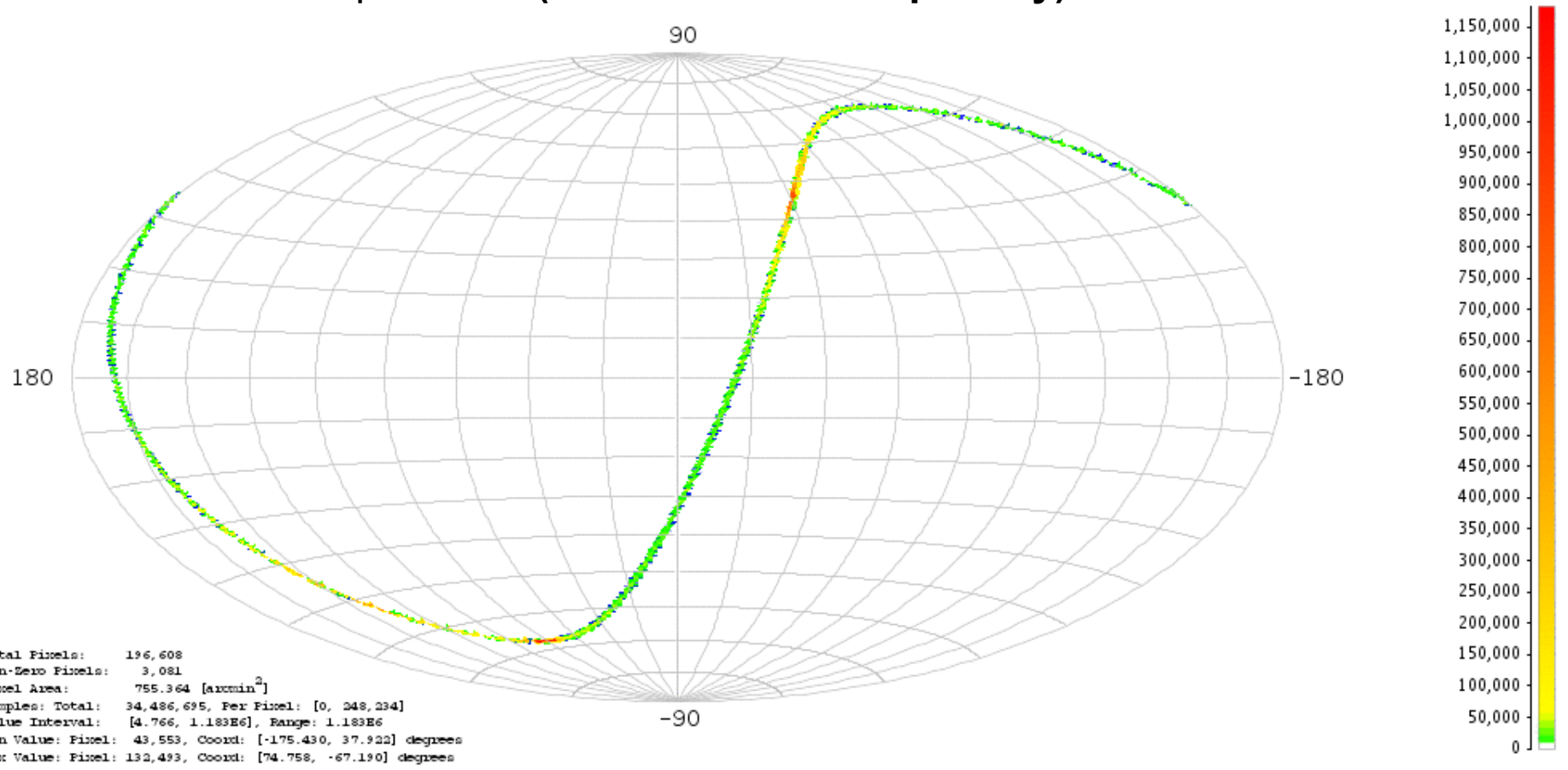
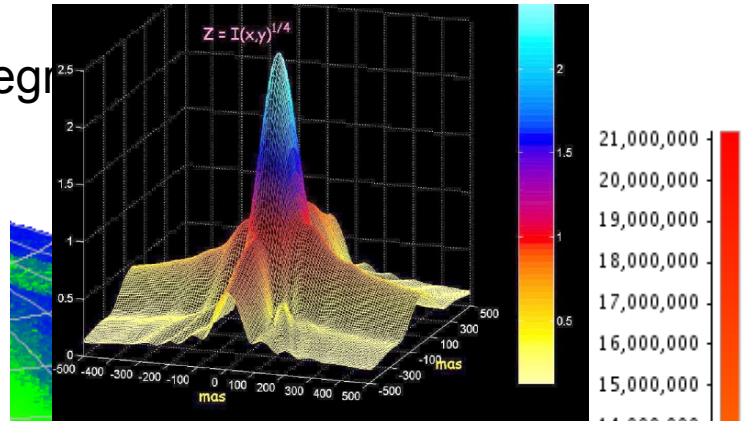


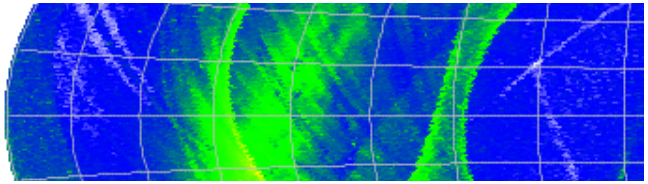
Figure by J. Portell

Sky coverage since mid-July 2014

Number of observations per square degr
start of nominal operations

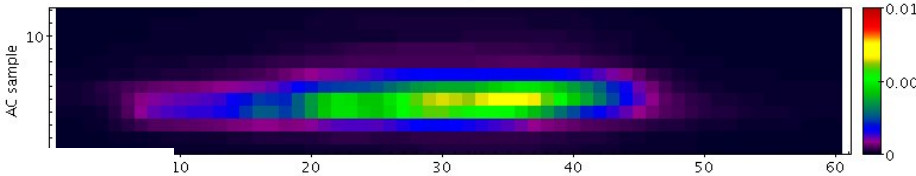


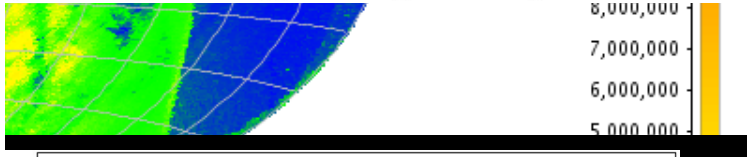
Gaia-DR1, 14 months of mission:
full sky coverage
40 billion transits



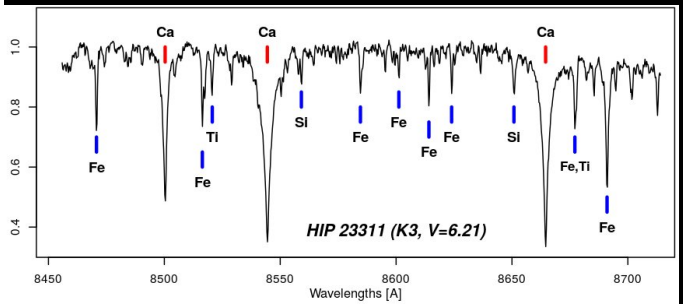
V1293 Aql
(M5III)

Gaia-RP spectra

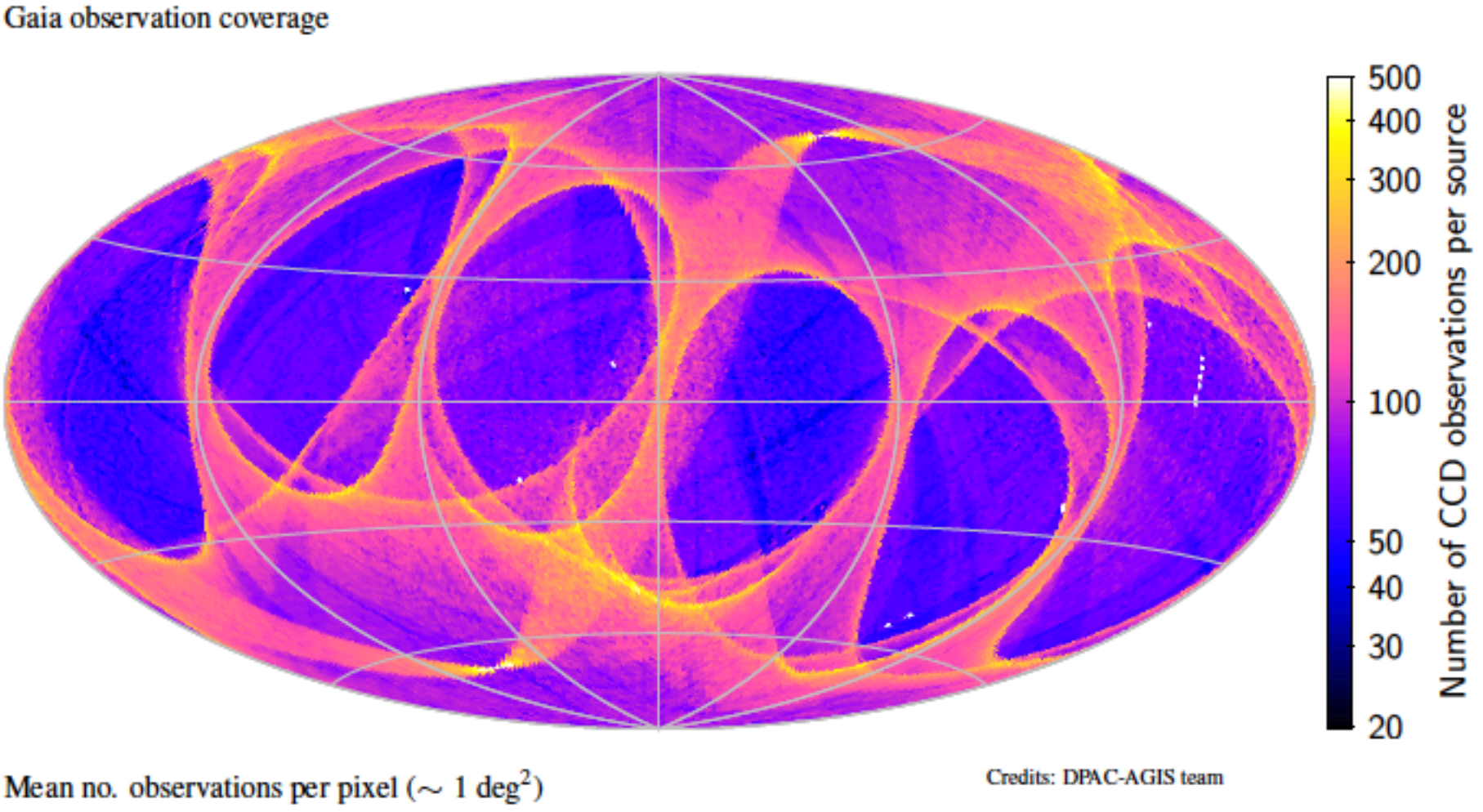




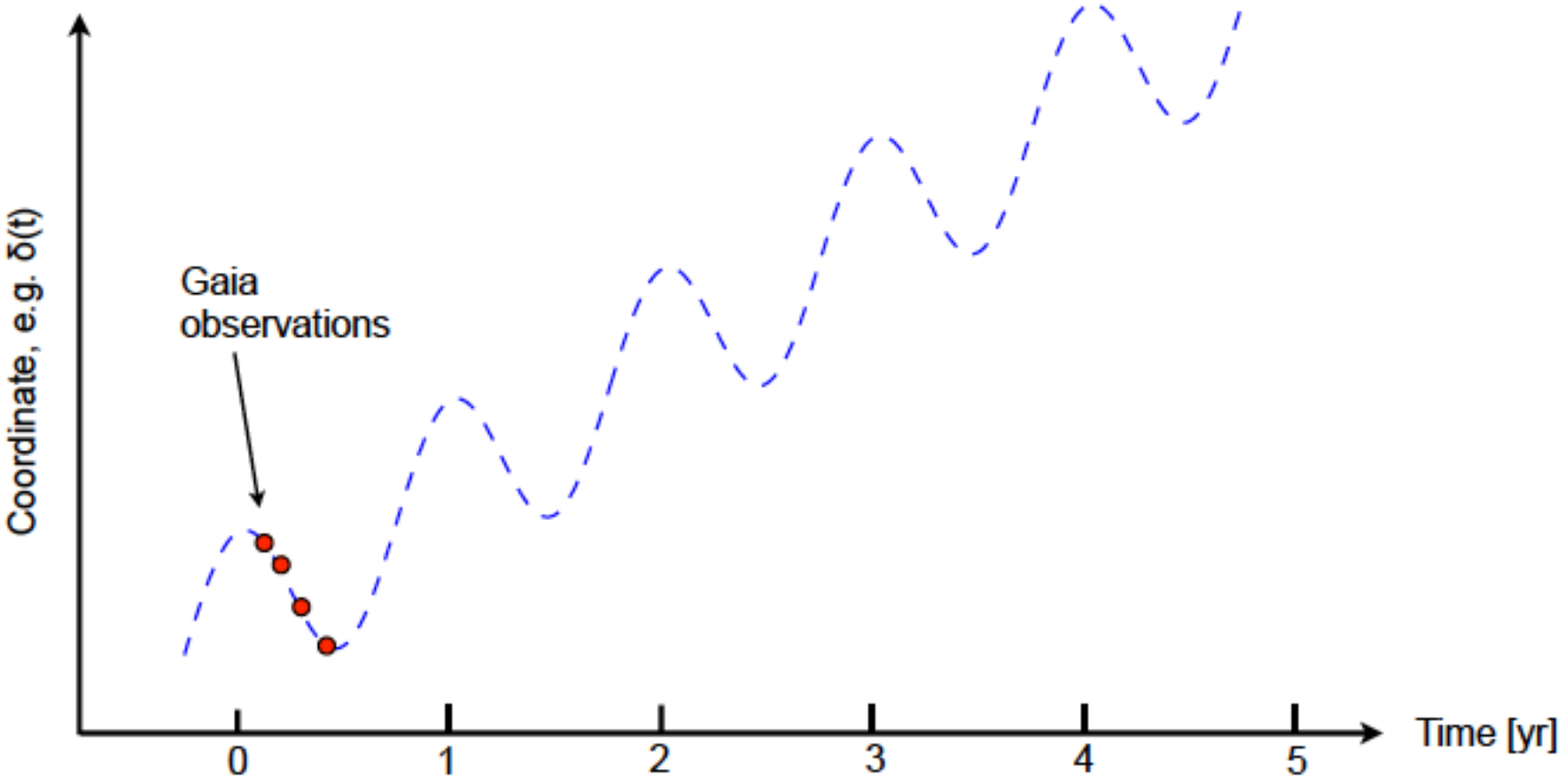
360 billion of individual images
80 billion of low-resolution spectra
9 billion of high-resolution spectra



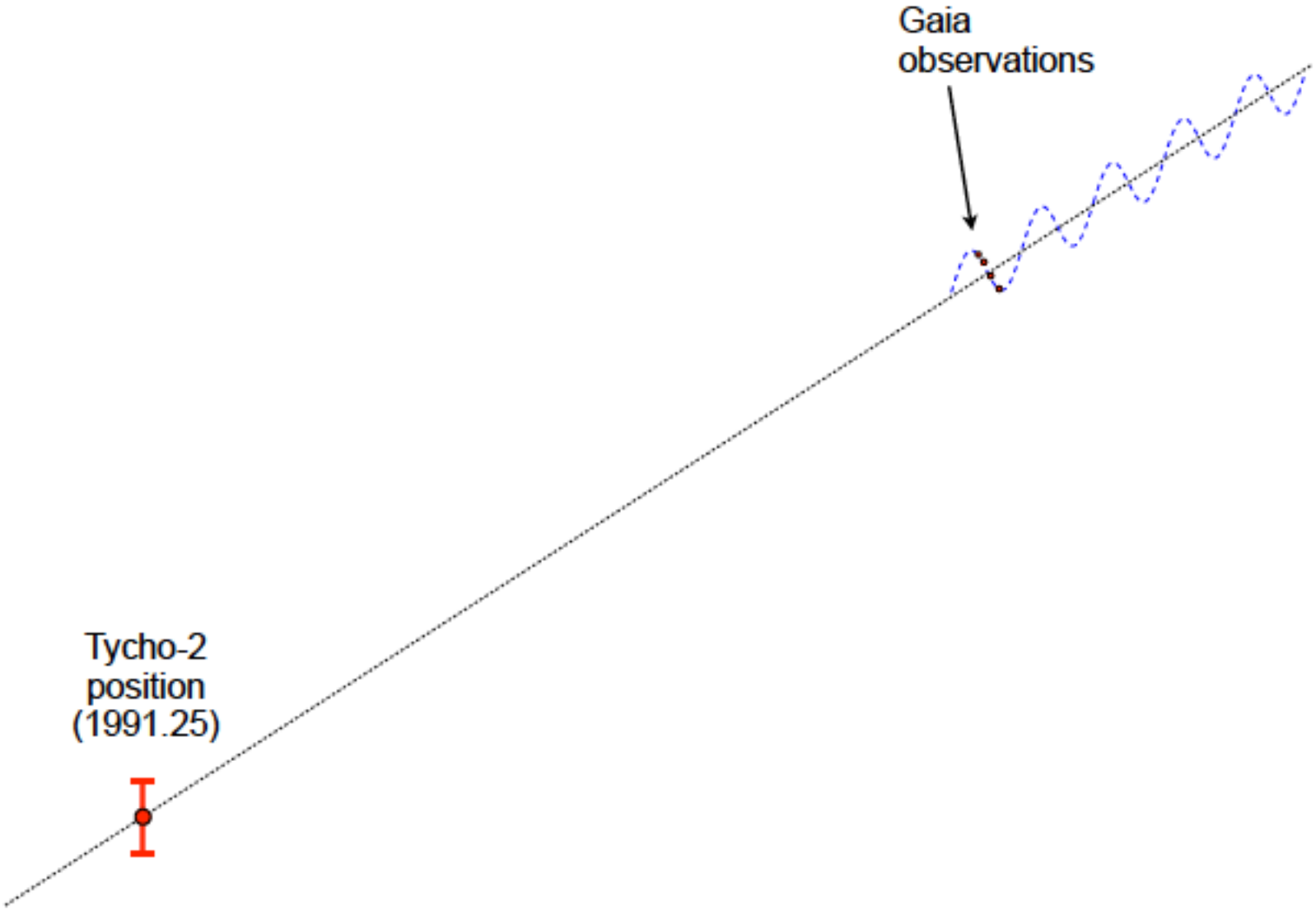
Observation coverage for Gaia-DR1



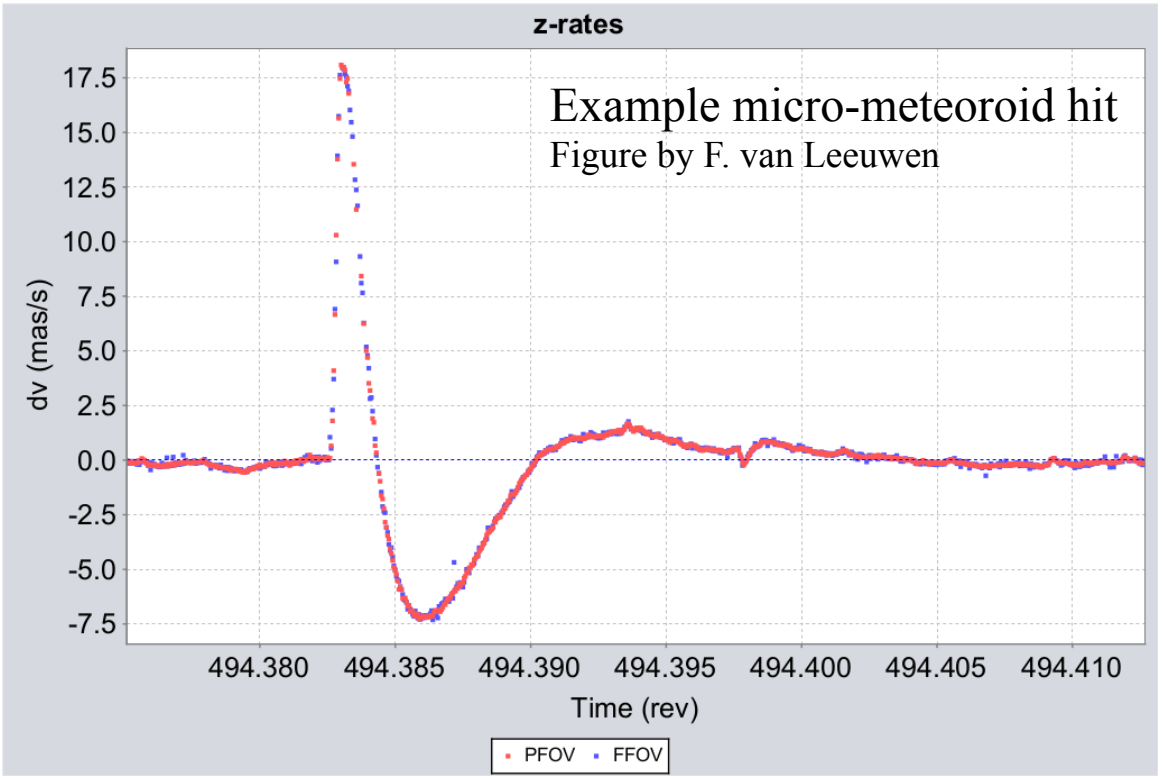
Astrometry solution



Astrometry solution



Attitude



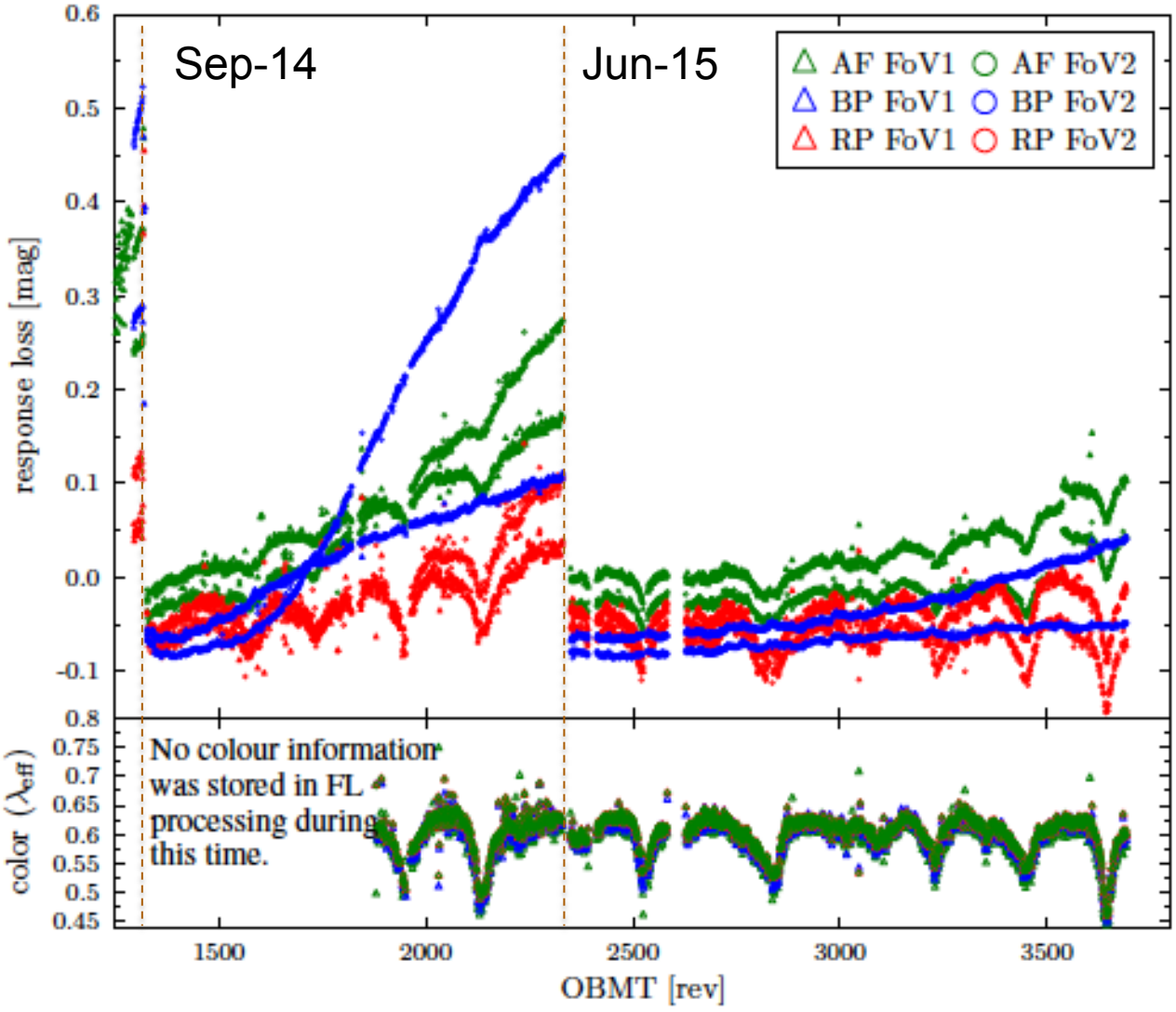
Micrometeoroid hits

- Frequency large hits as expected
- Small micrometeoroids and micro clanks (< 2mas/s)

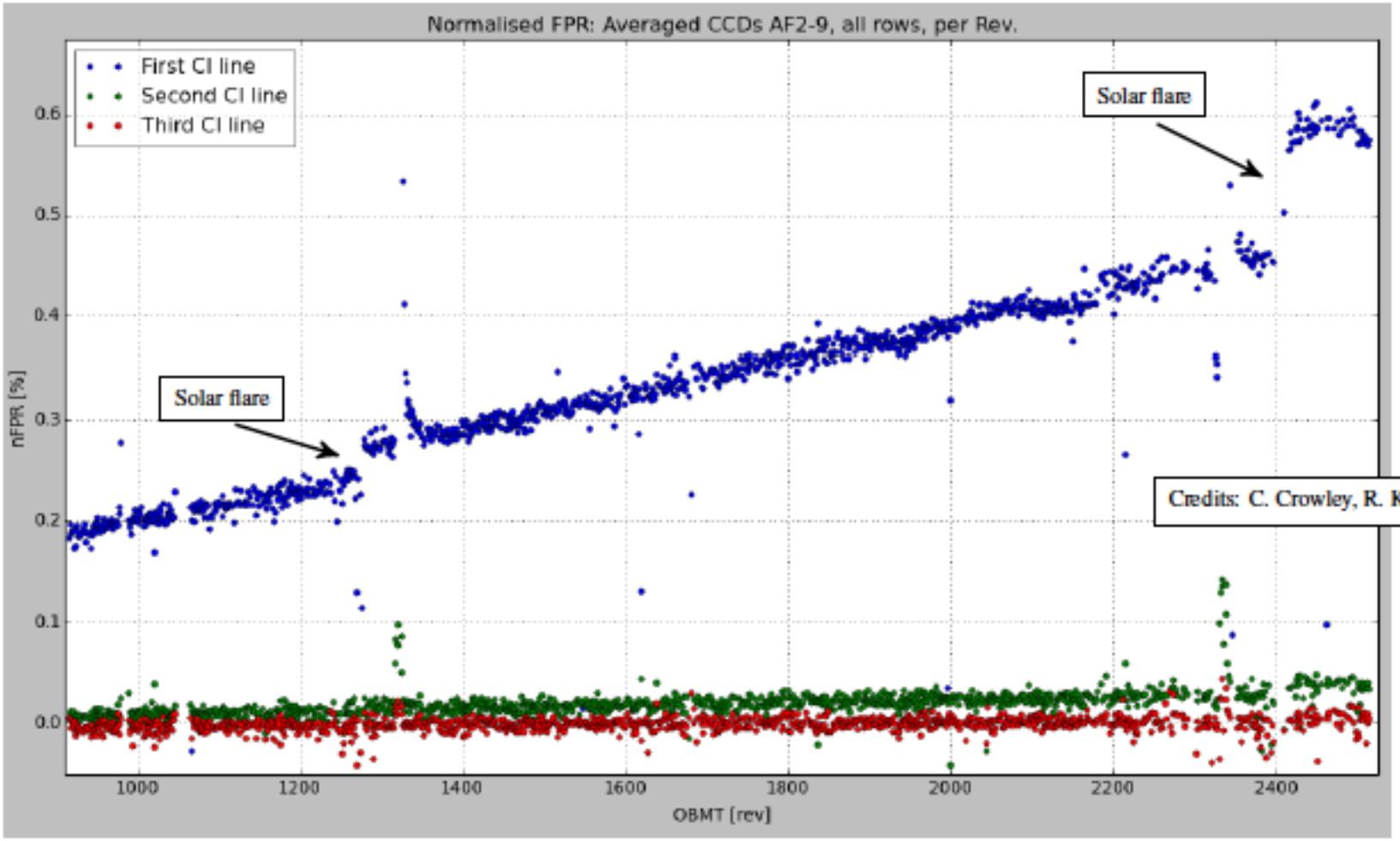
Attitude calibration

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

Throughput time evolution

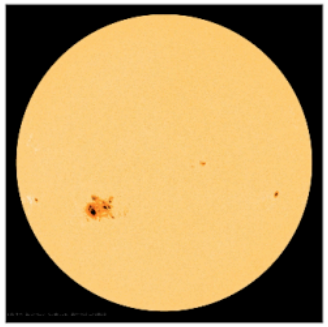


Radiation damage

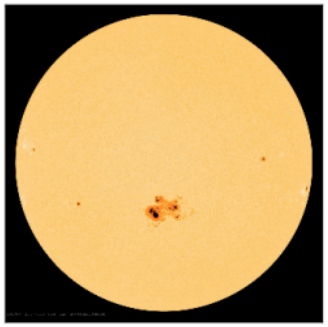


- Radiation damage and CTI evolution monitored through charge injections
- Extrapolation indicates end-of-life radiation damage significantly lower (factor 10) than pre-launch predictions

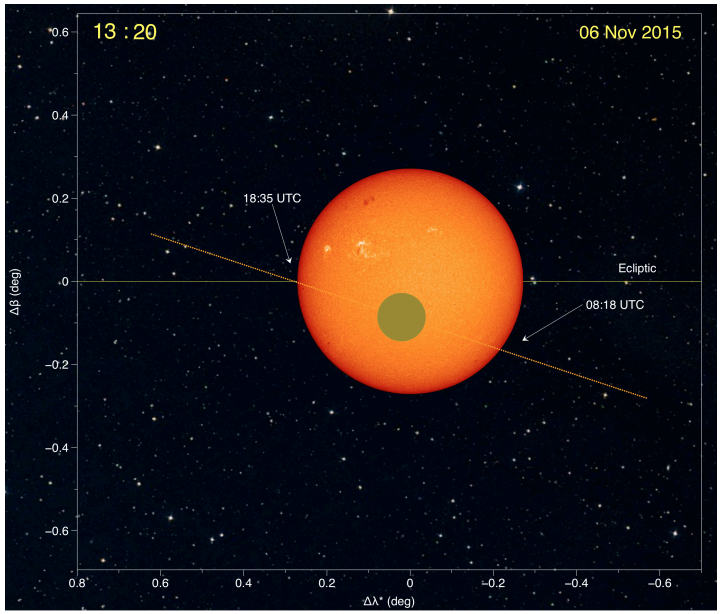
Thermal stability



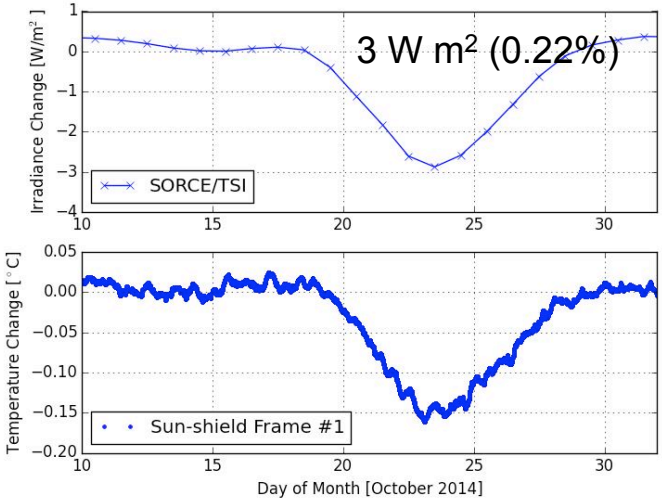
21/10/2014



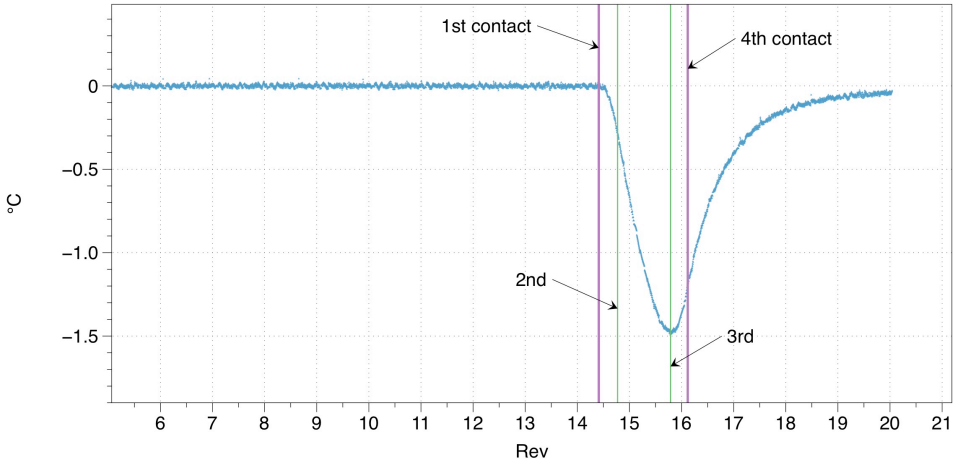
23/10/2014



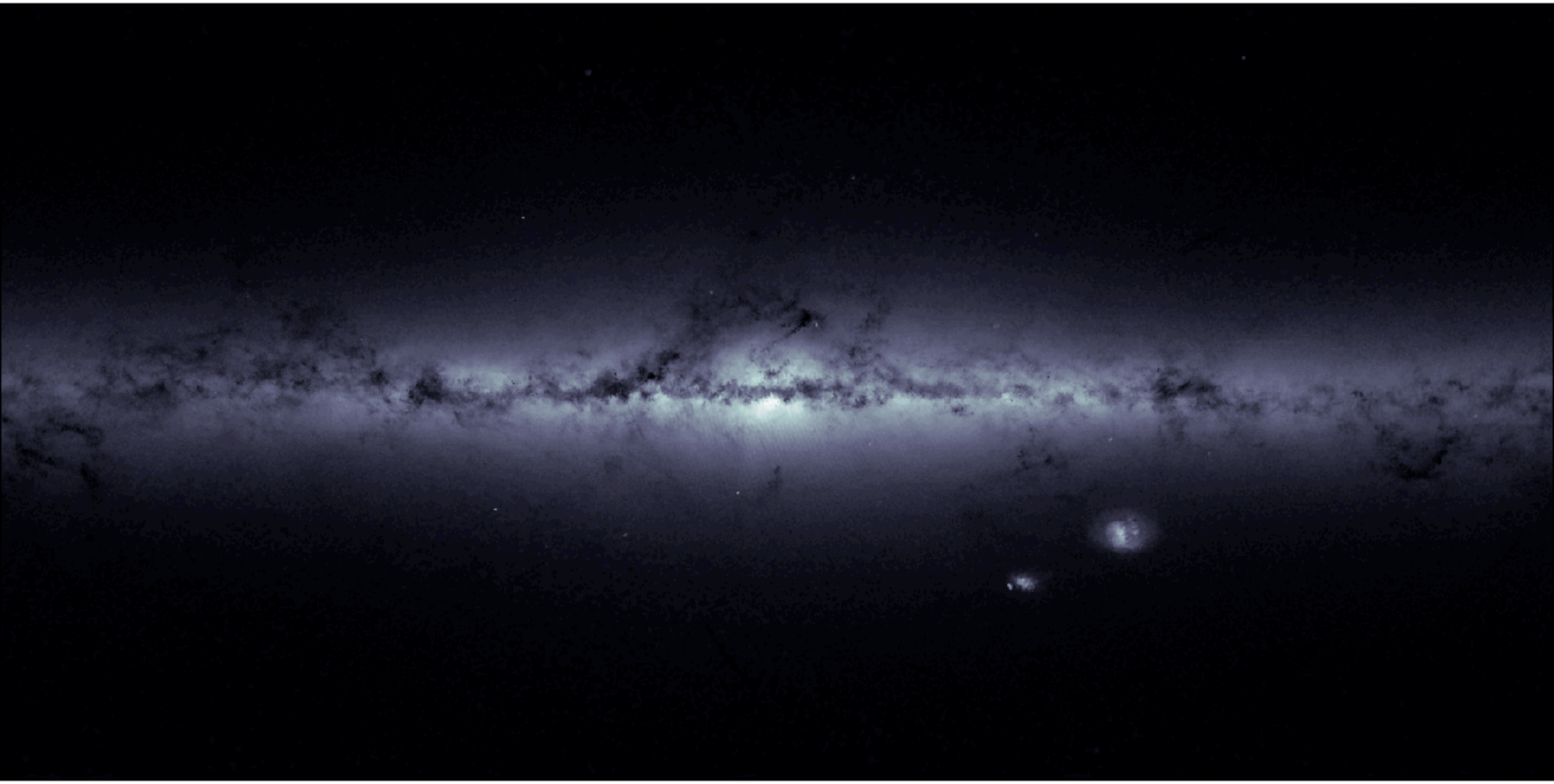
Lunar eclipse



no significant effect on the instrument

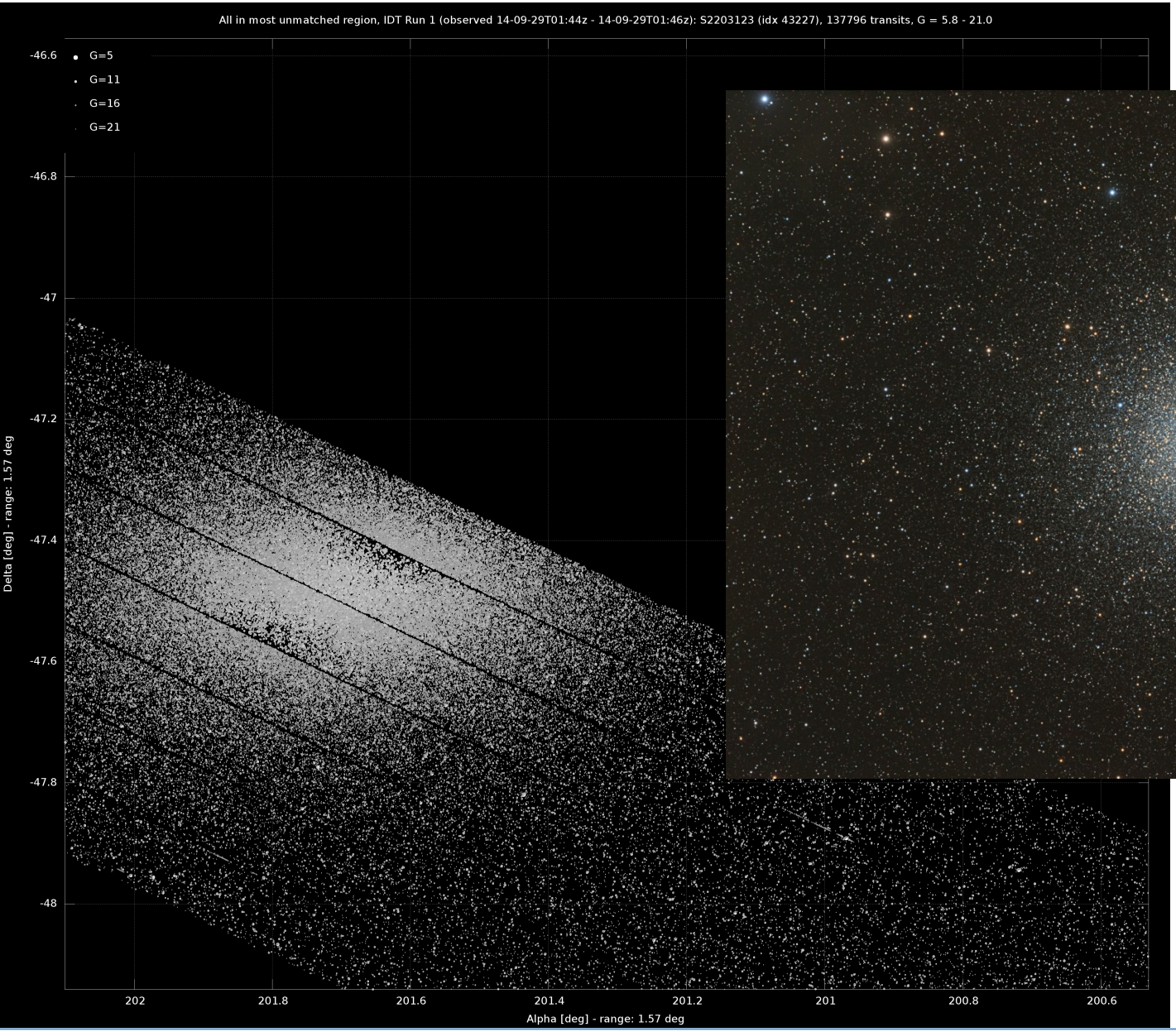


Star counts



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

ω Centauri



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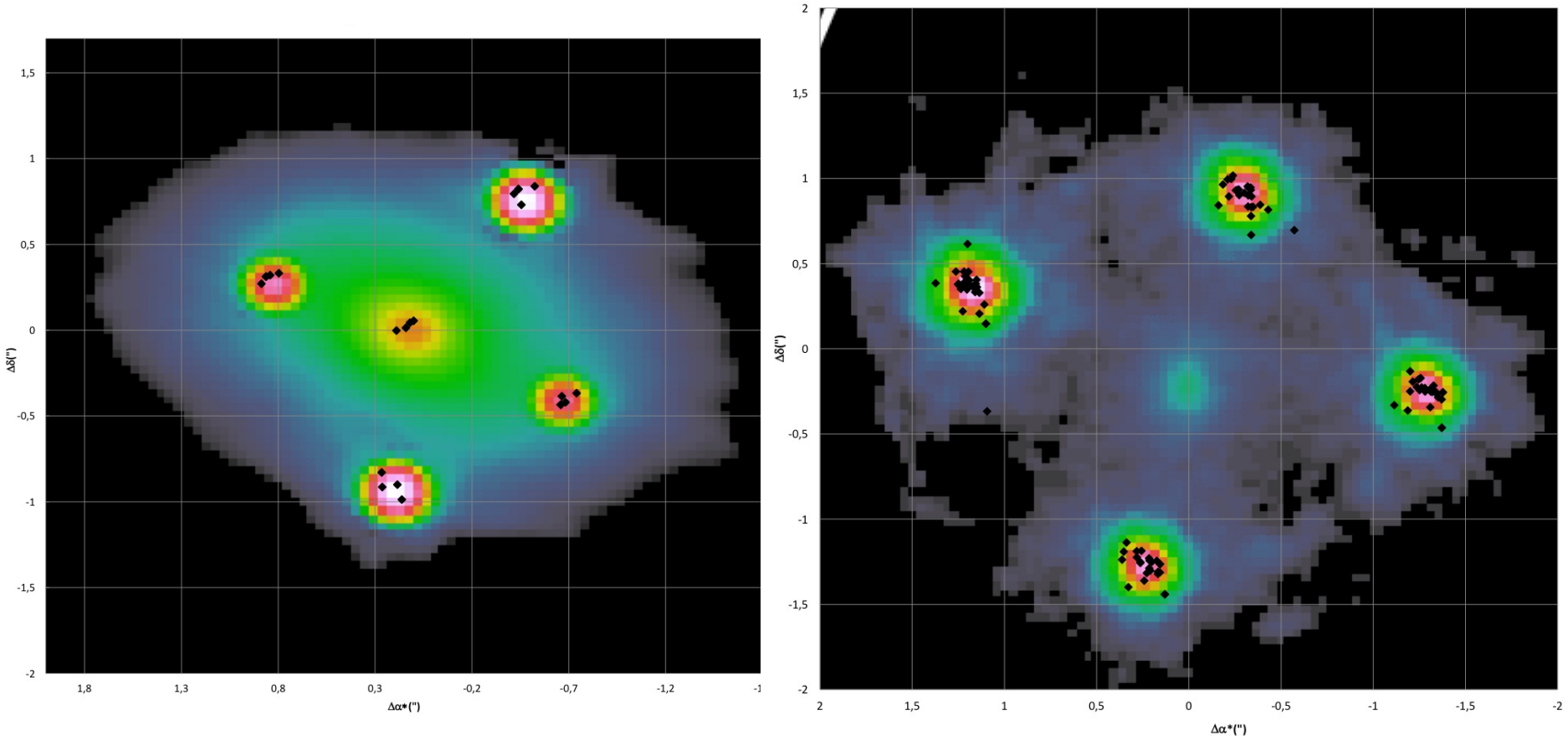
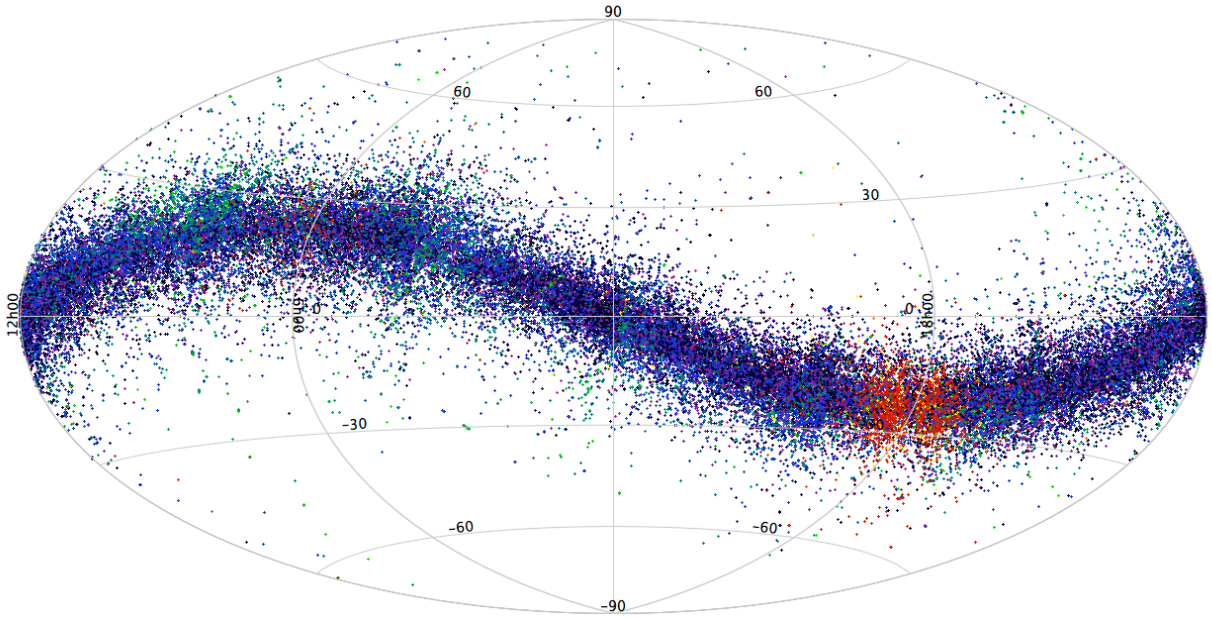
Detections of gravitational lenses



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

Asteroids detection

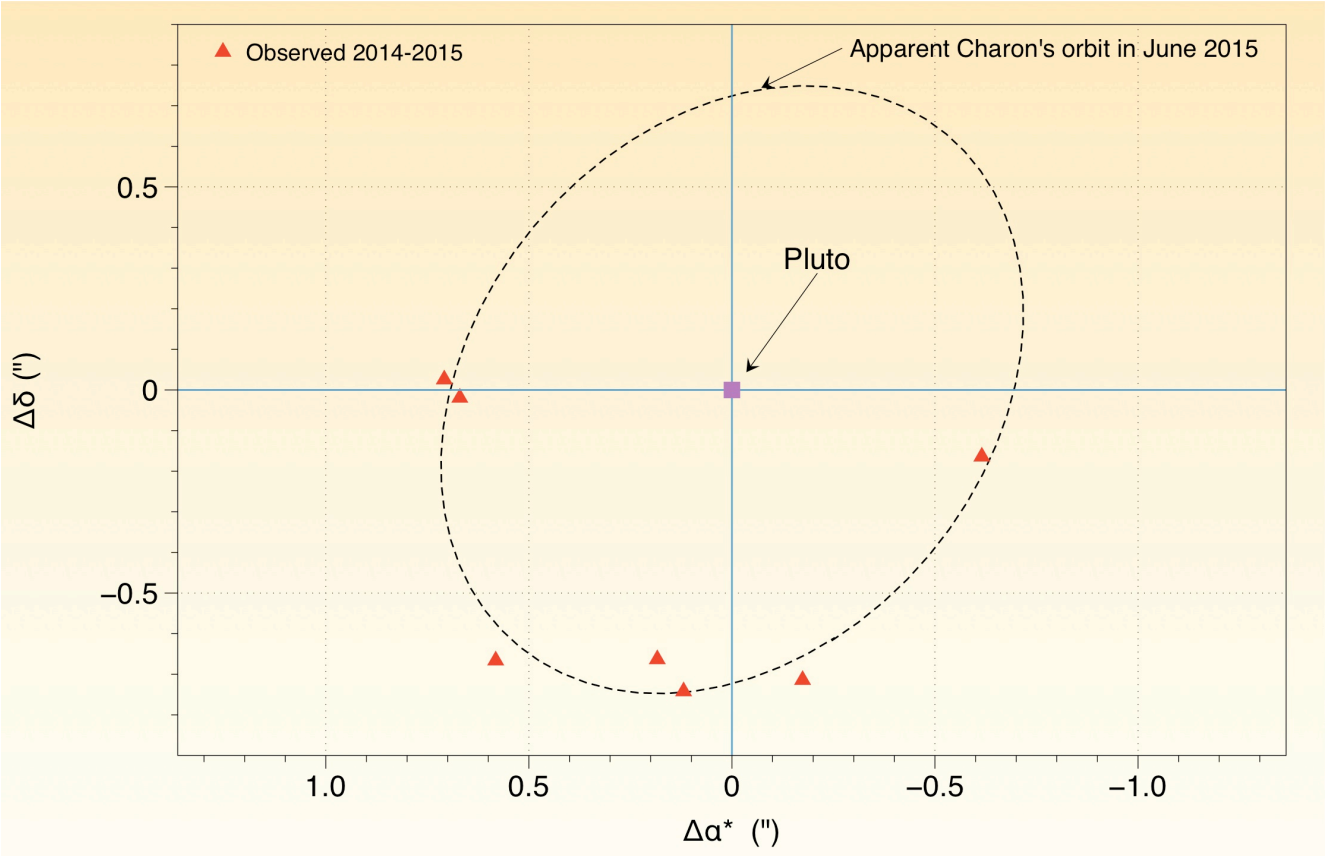


8-months data were used to deted the detection algorithm performance

50,000 known asteroids

Colours are function of precision

IDT Raw astrometry

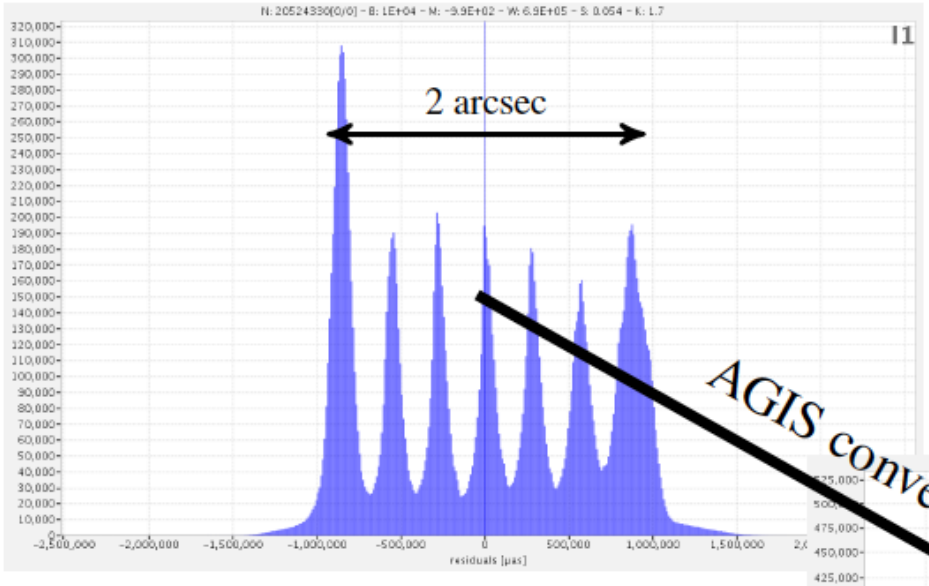


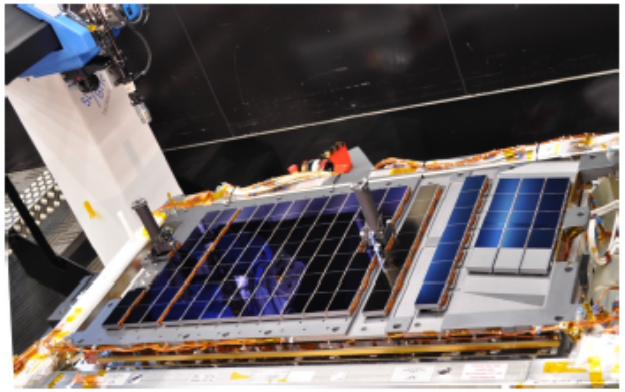
Pluto G = 14.5
Charon G=16.5

Separation ~0.6”

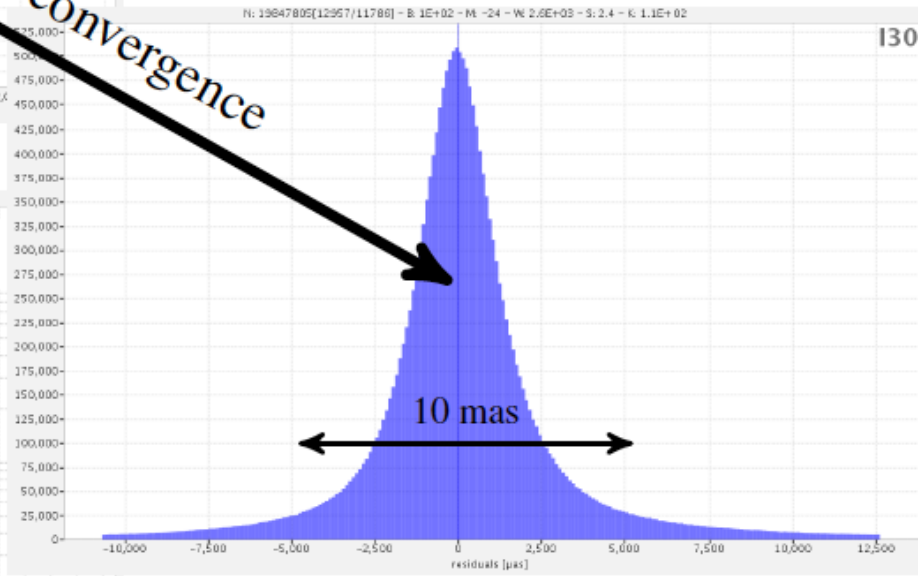
Very good agreement with prediction

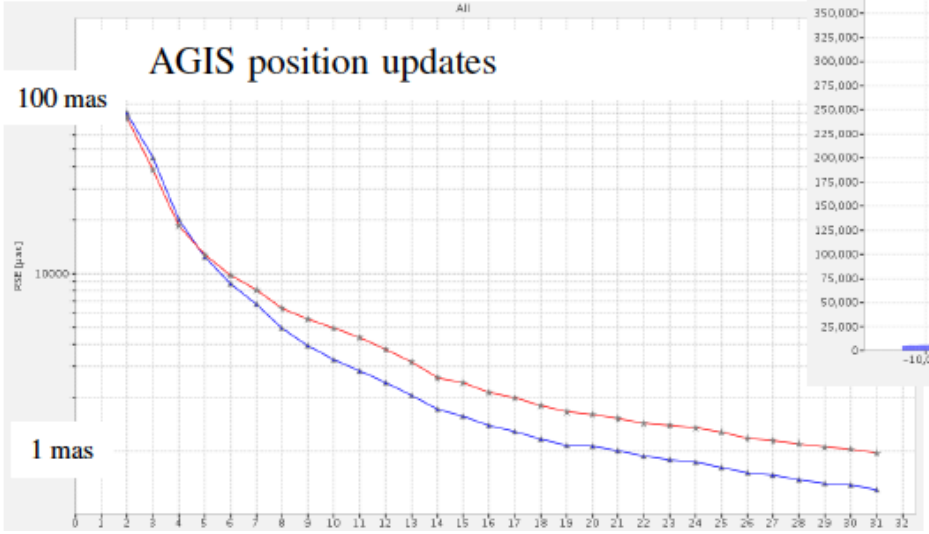
From IDT data to global astrometry





AGIS convergence





Figures courtesy DPAC/AGIS team, Airbus DS

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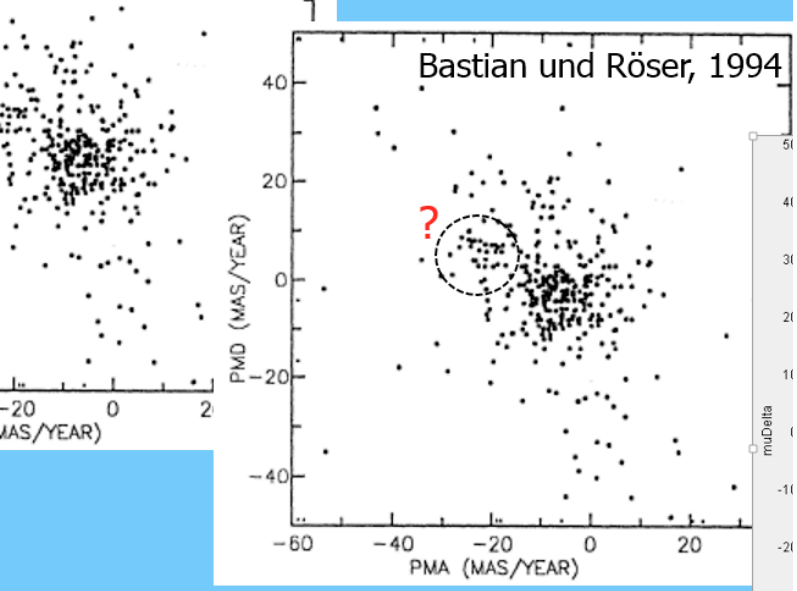
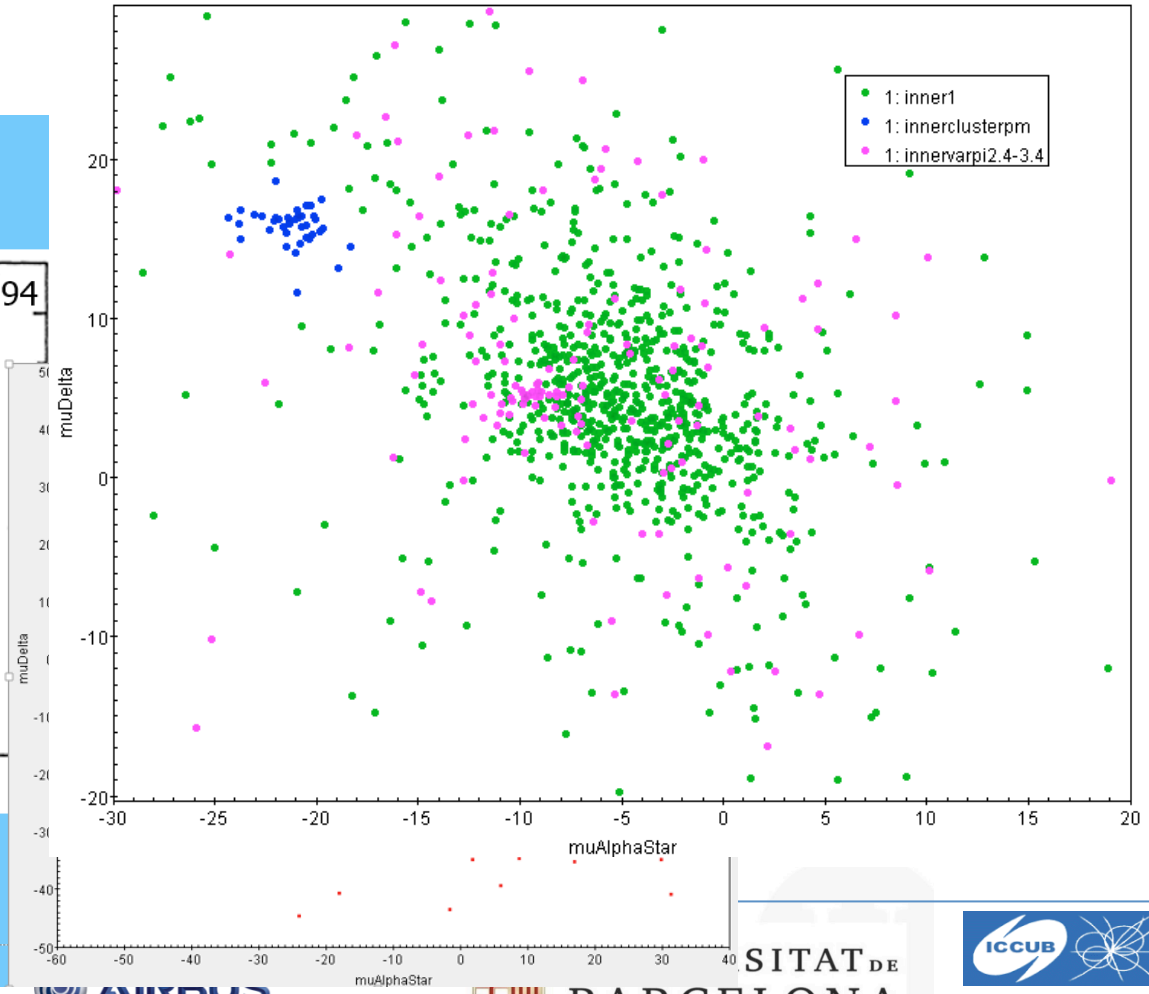
Proper motions

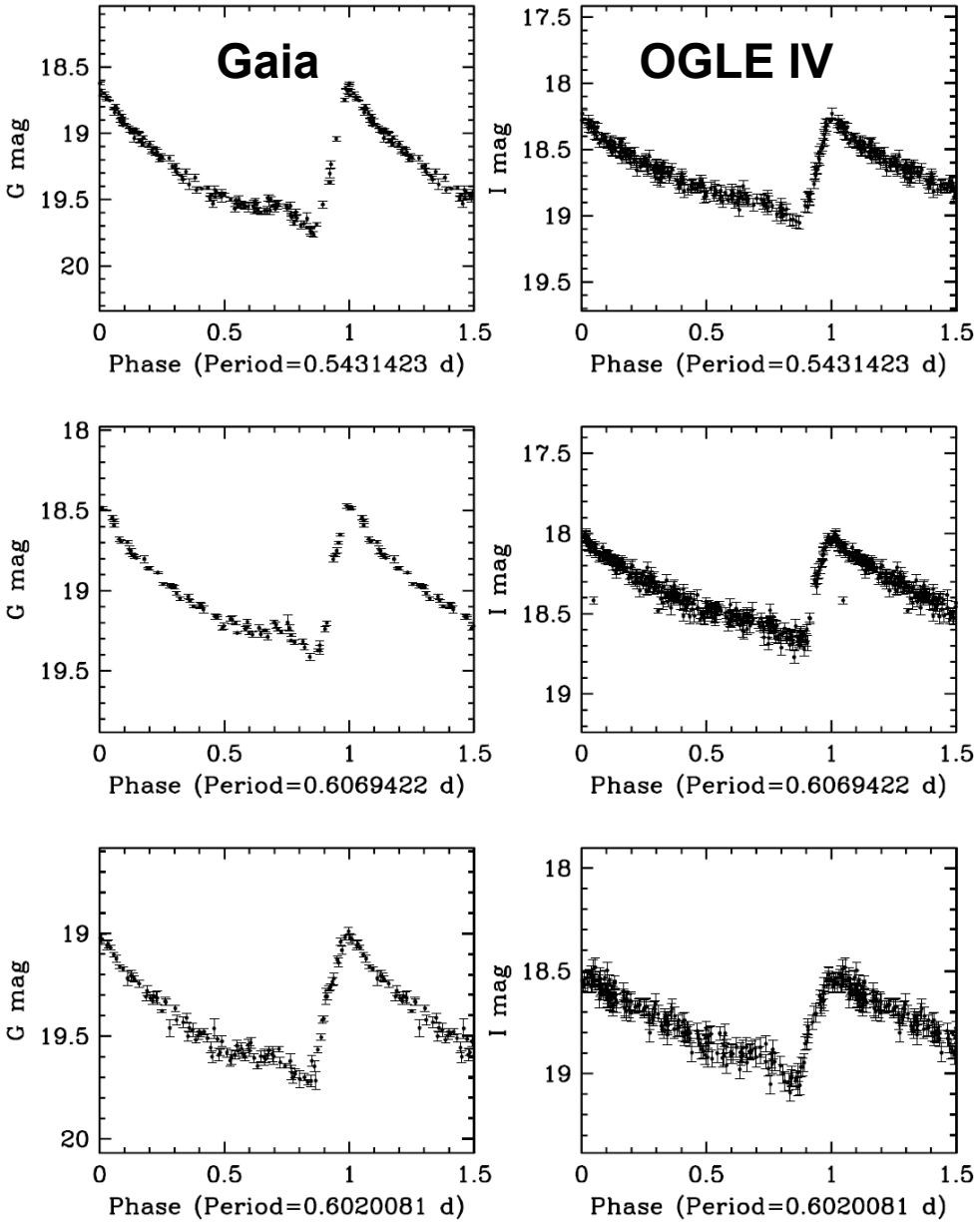
NGC2451A,B

preliminary version of TGAS





RR-Lyrae in the LMC



28-days Ecliptic Pole scanning

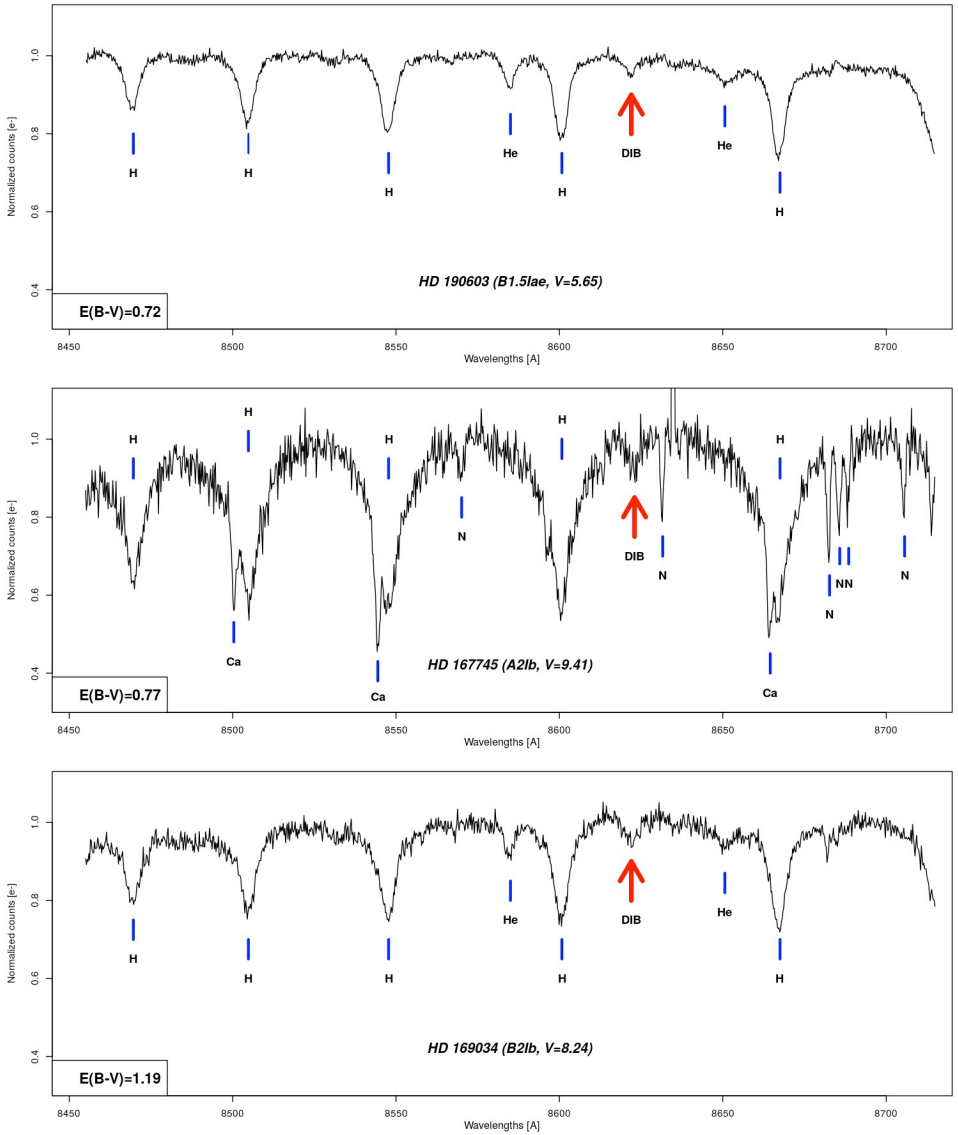
Periods from the OGLE IV catalogue (Soszynski et al. 2012)

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

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

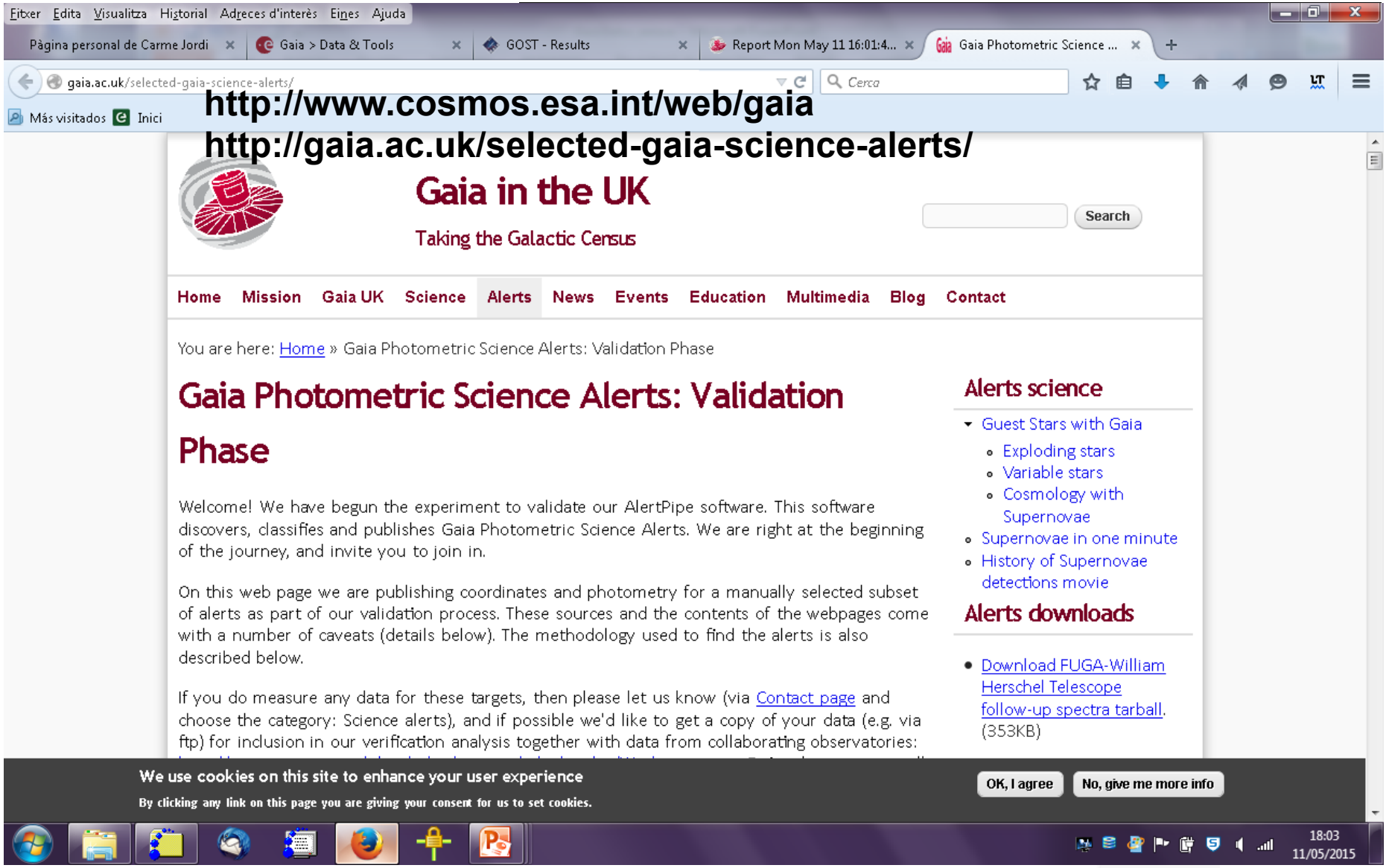
Gaia G-band is “bluer” than I-band. RR-Lyrae are fainter in G than in I. Amplitudes in G-band are larger, too.

RVS capabilities: DIBs



Hot stars (between ~20000K and 9000K)

Photometric science alerts



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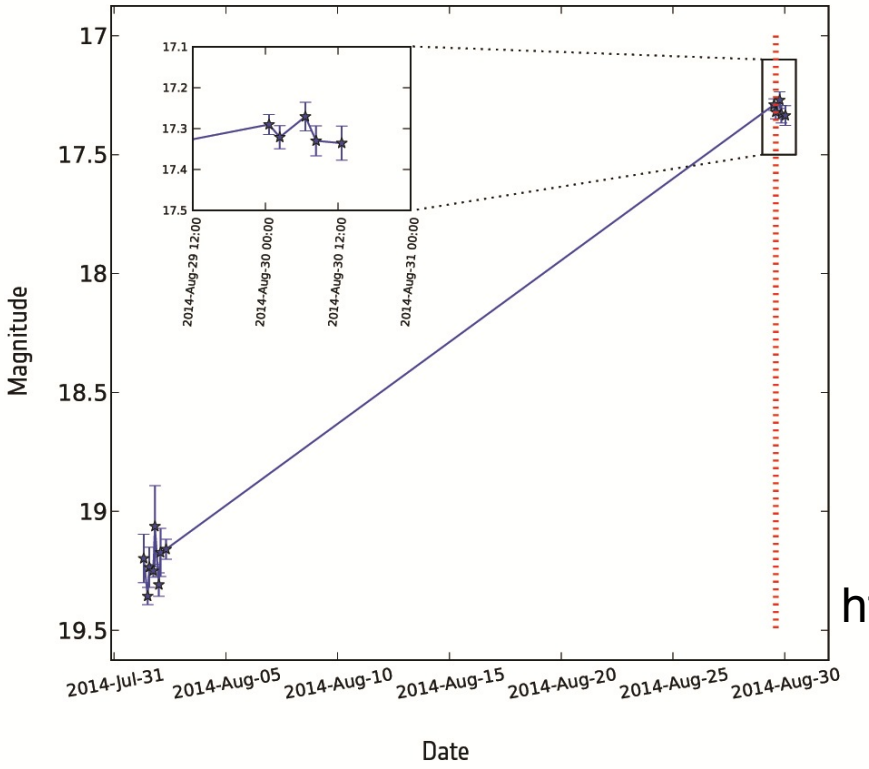
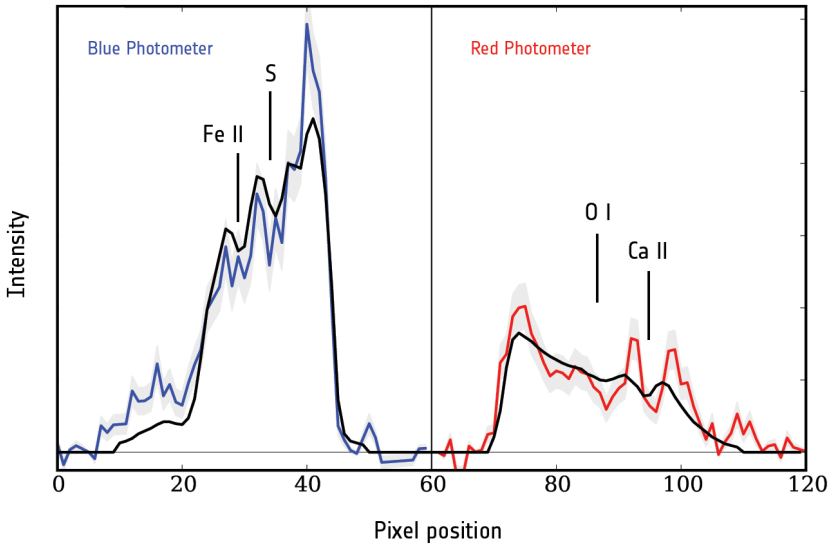
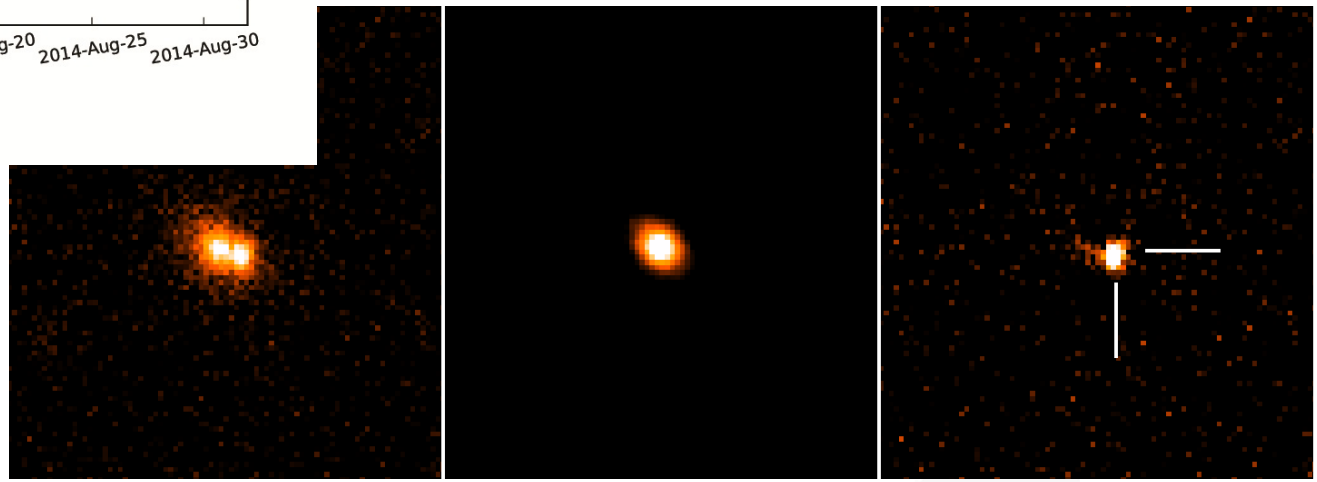
Photometric alerts





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



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**

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**

Past, present and future

- **The success of Gaia, <u>both satellite and DPAC</u>, 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)

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 ($P \gg T$)

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

position at $t = 0$

proper motion

acceleration (a)

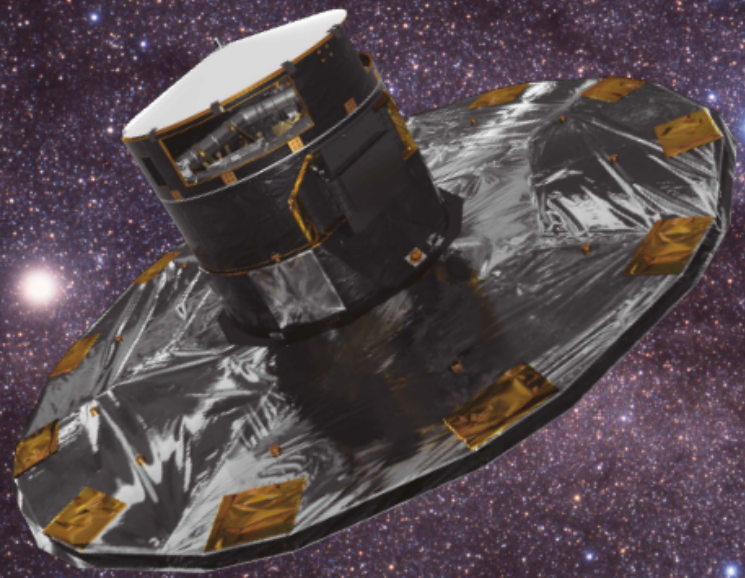
rate of change of acceleration

second derivative of acceleration

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

1,000,000,000 stars

1,000,000,000 pixels



> 1000 people

> 10,000 scientists

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