Gaia mission and data processing status

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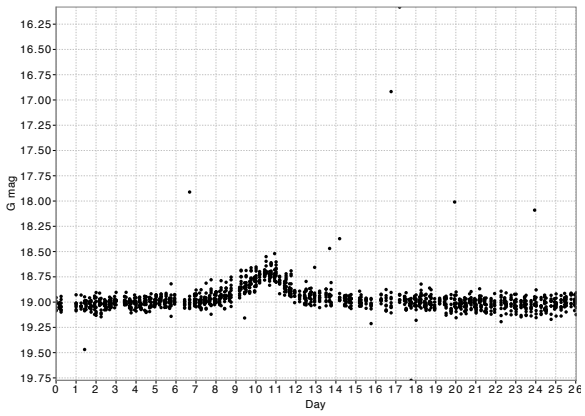
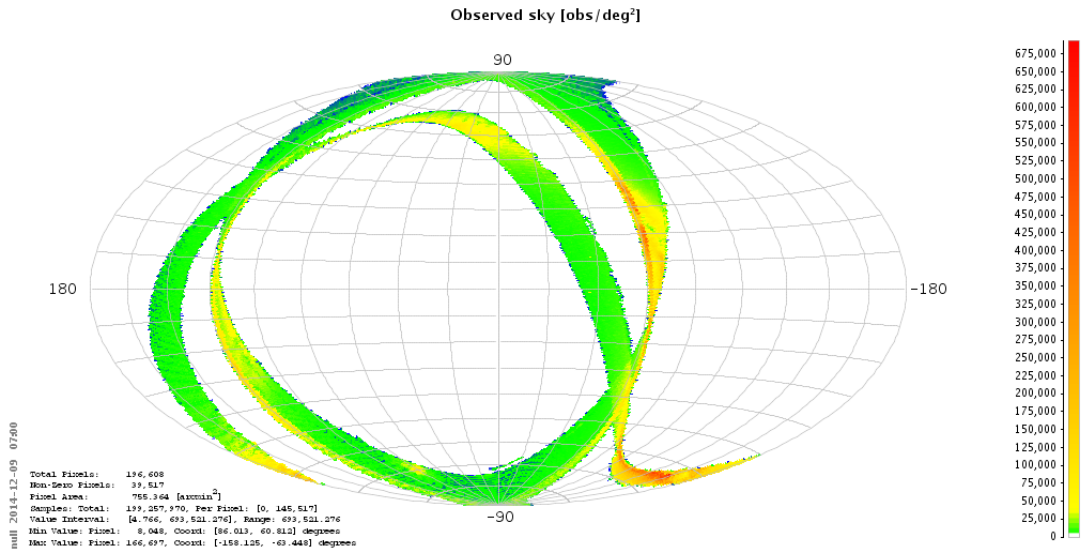




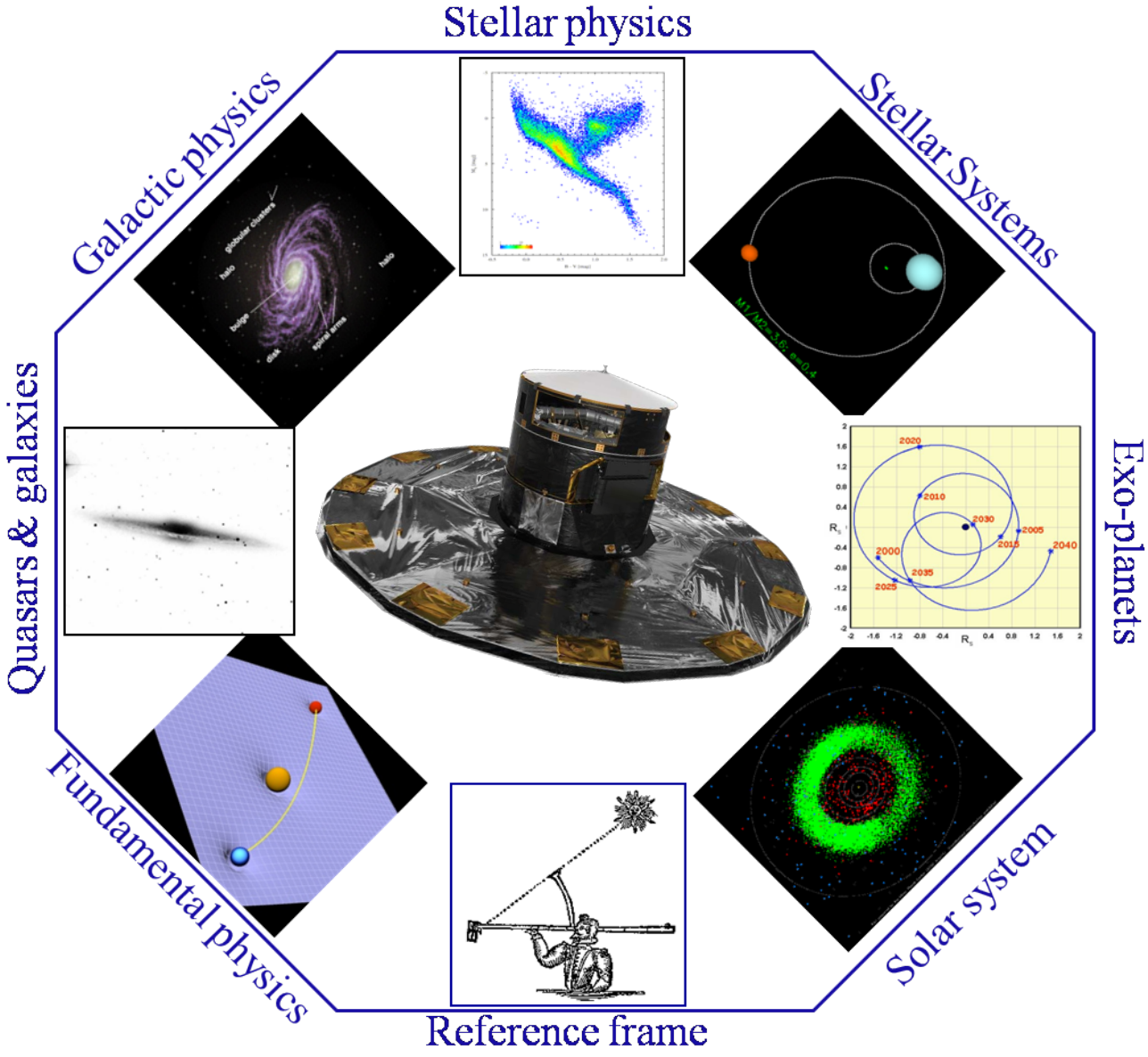
Gaia summary

- Gaia: science with 1 billion objects in three dimensions
- ESA corner stone mission building on the Hipparcos heritage
- Astrometry, Photometry and Spectroscopy
- Satellite and payload, by industry, management and operations by ESA, data processing by scientists (DPAC)
- Launch 19 December 2013 with Soyuz from Kourou
- Commissioning formally completed 18 July 2014
- 5 years of operations at L2

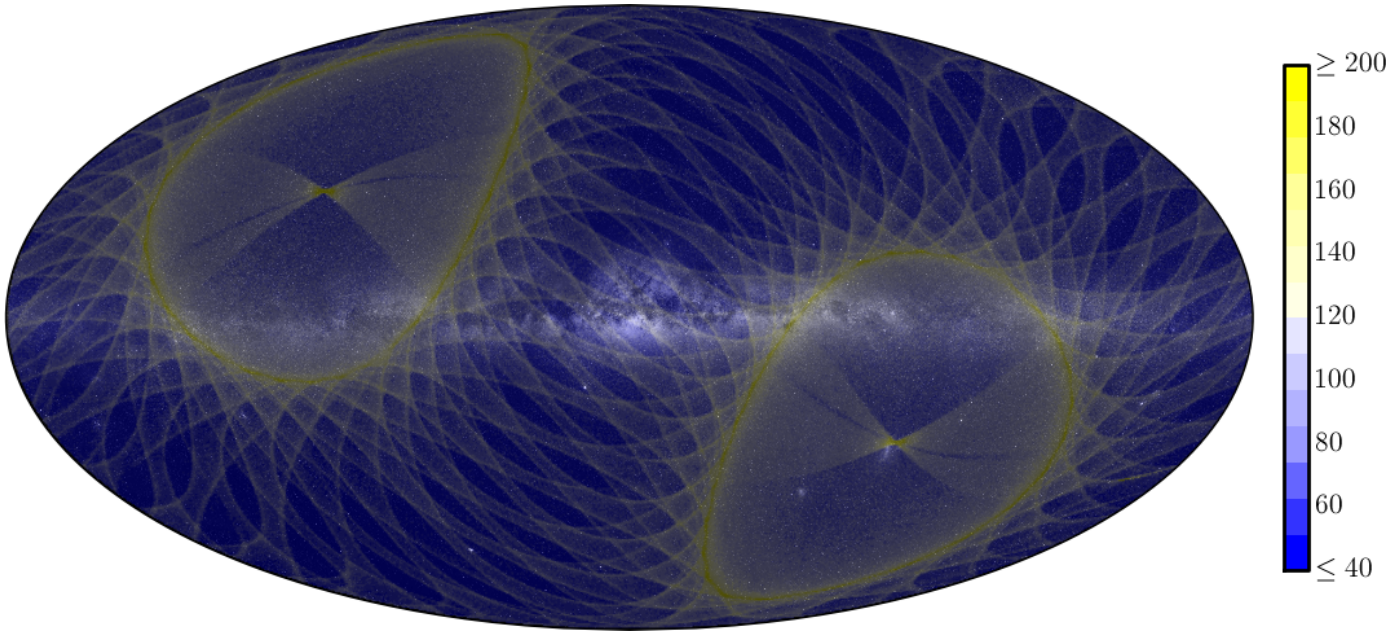
- First intermediate data release summer 2016, but Science Alerts start earlier
  - first parallaxes and proper motions in early 2017

www.cosmos.esa.int/gaia

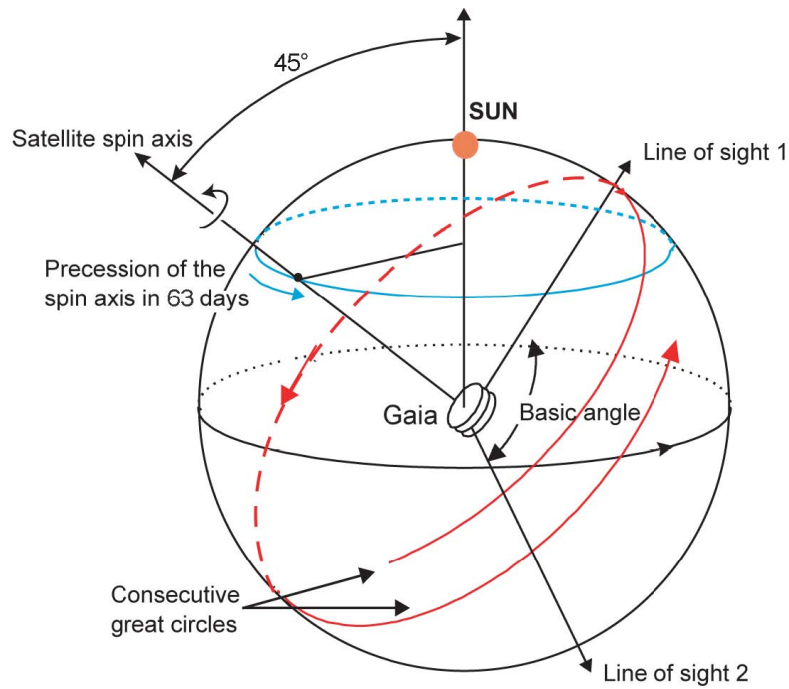
Science topics



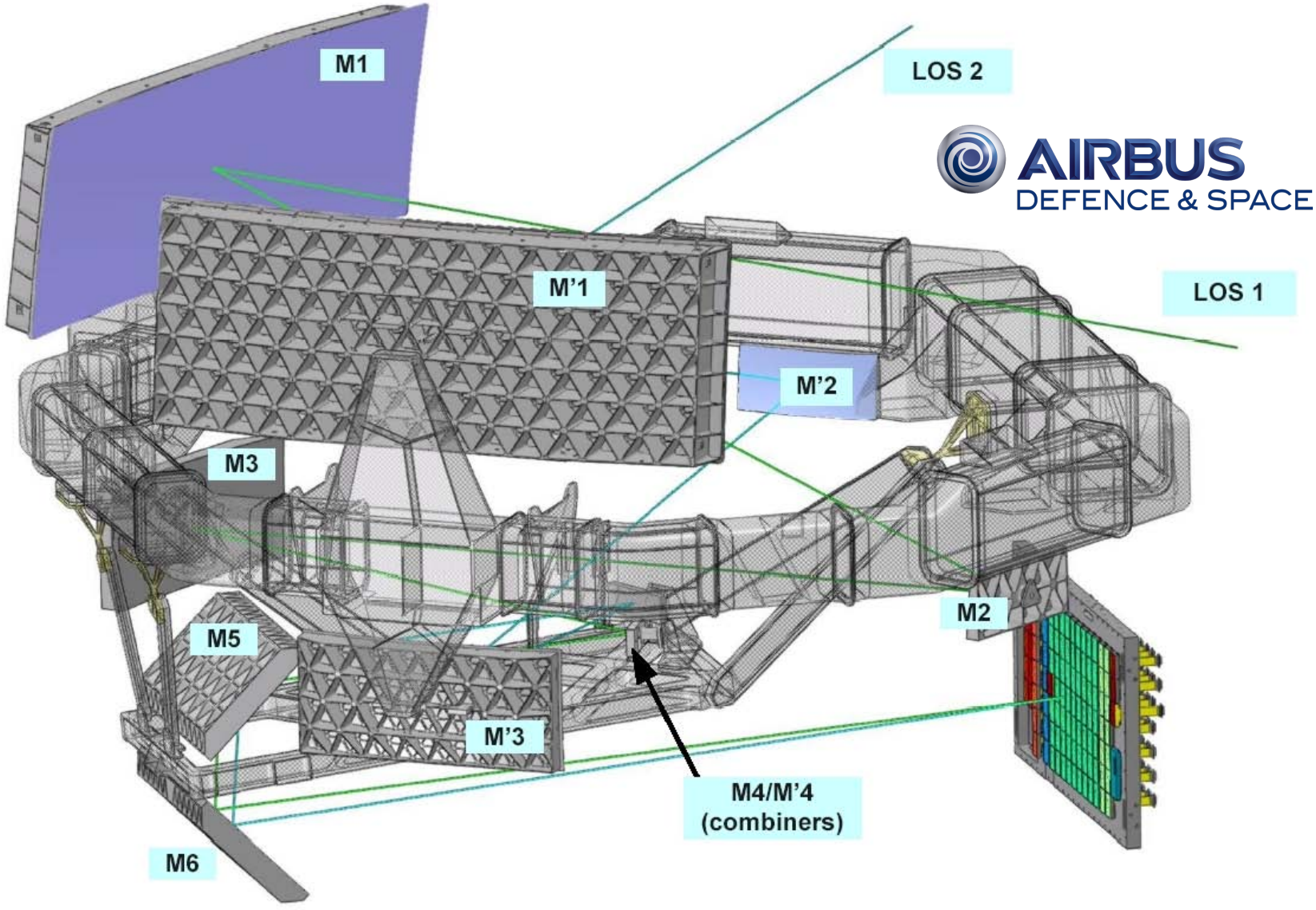
Survey principle



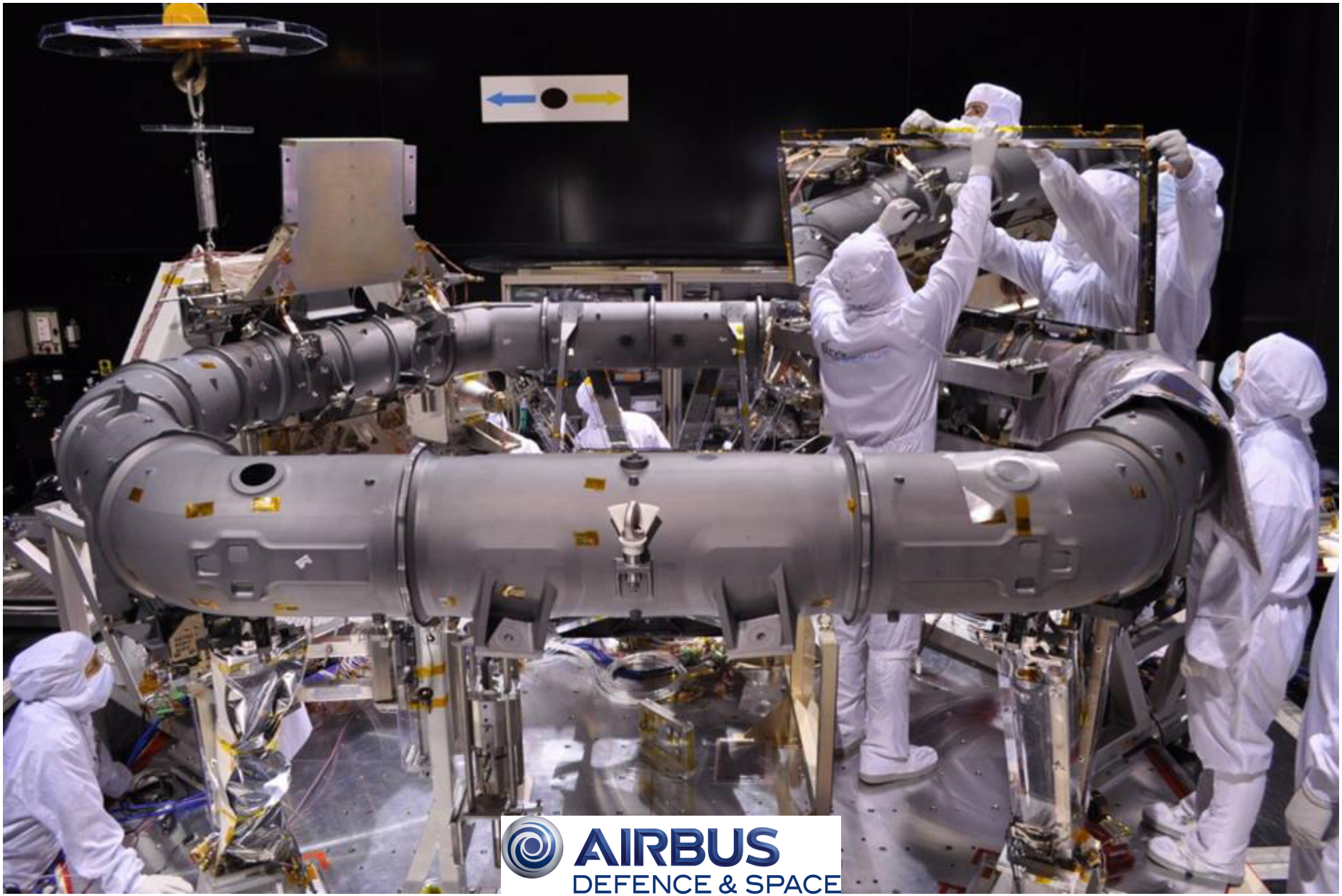
- Three simultaneous observing modes
- Two lines of sight separated by 106.5°
- Complete to $G = 20$ ($V = 20$–22) radial velocities to $G = 16$
- Observing programme: autonomous on-board detection and unbiased
- Quasi-regular time-sampling over 5 years ($\sim$ 70 observations)
- Angular resolution comparable to HST



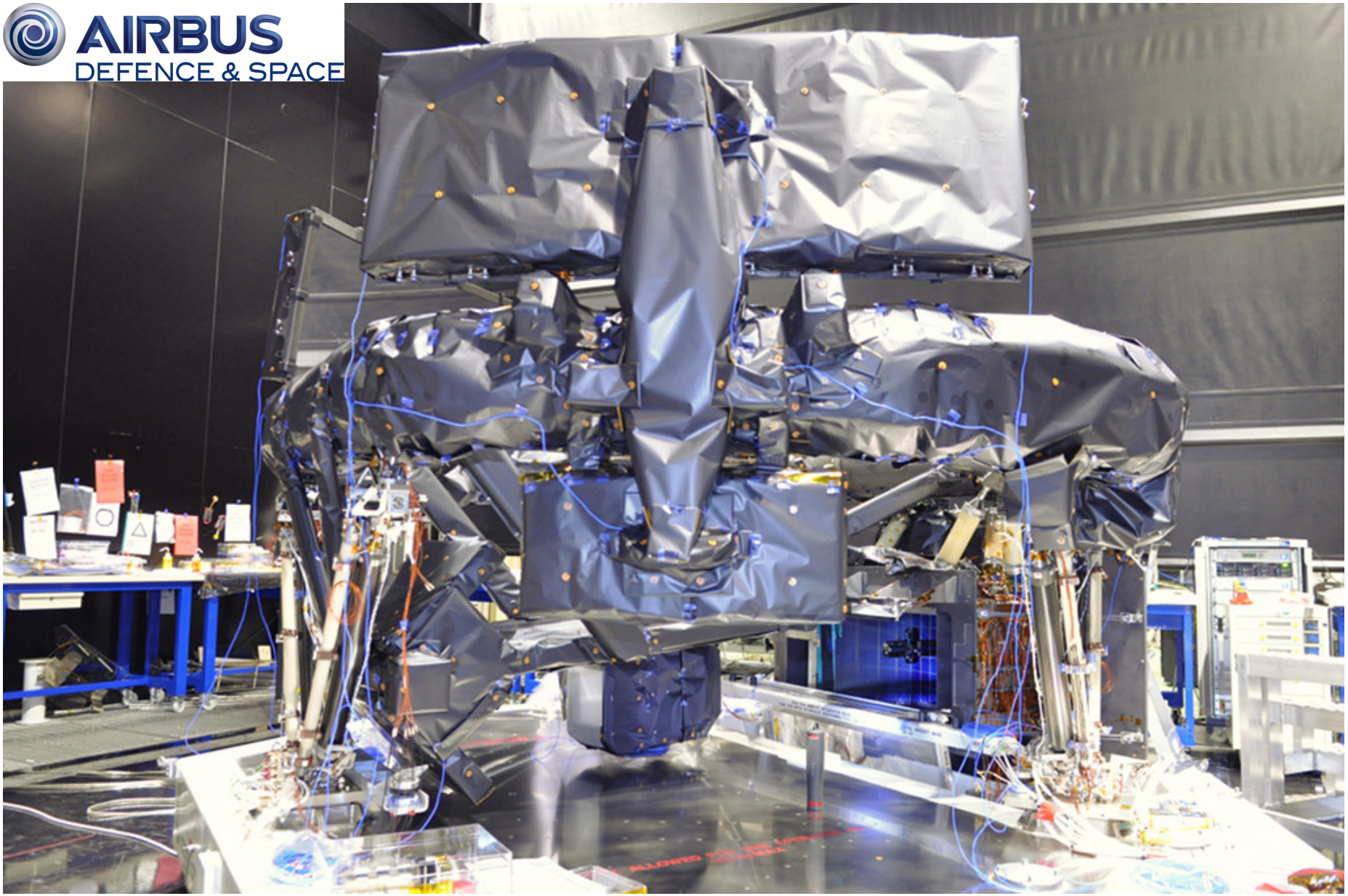
Telescope and payload



Telescope and payload

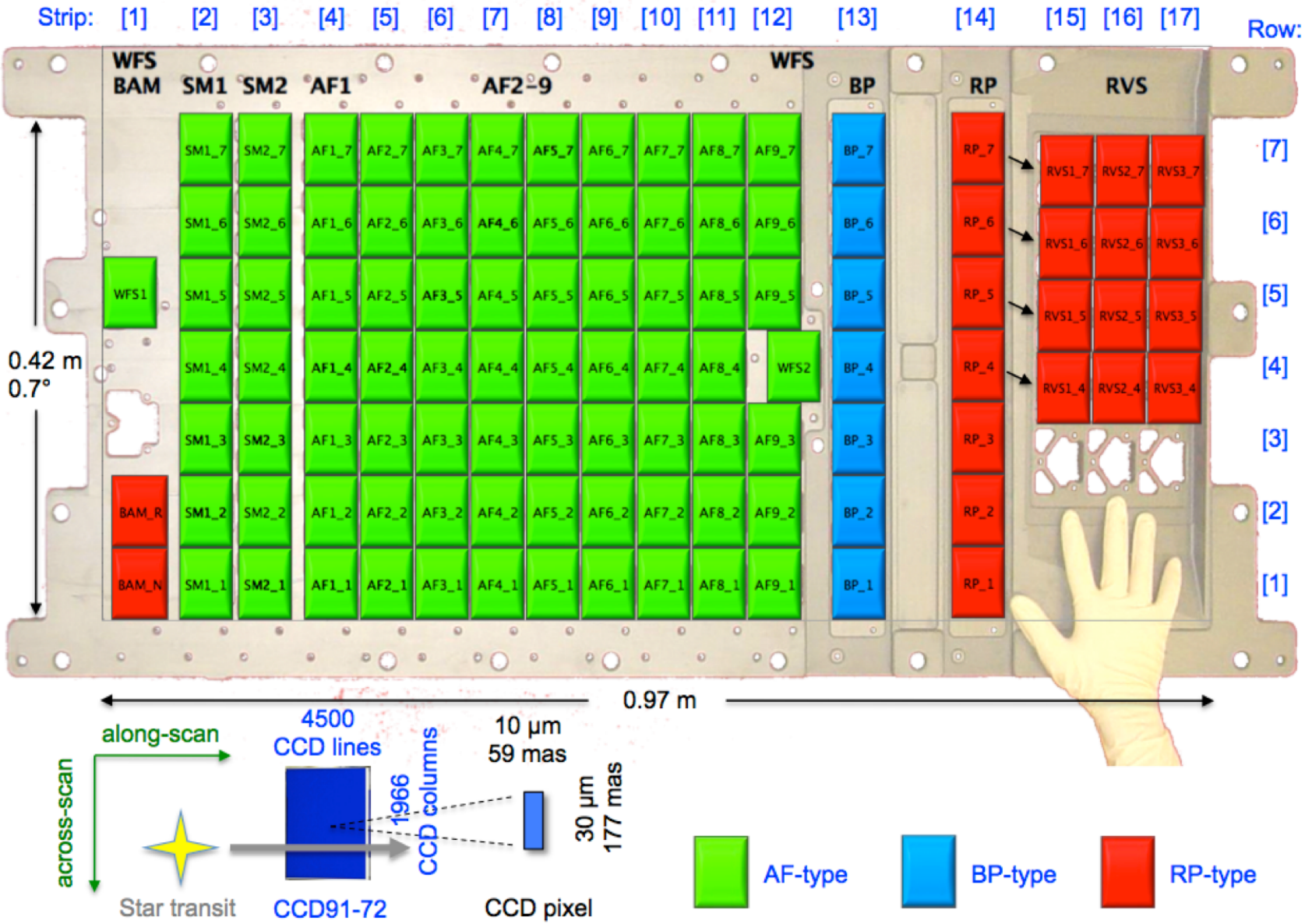


Telescope and payload

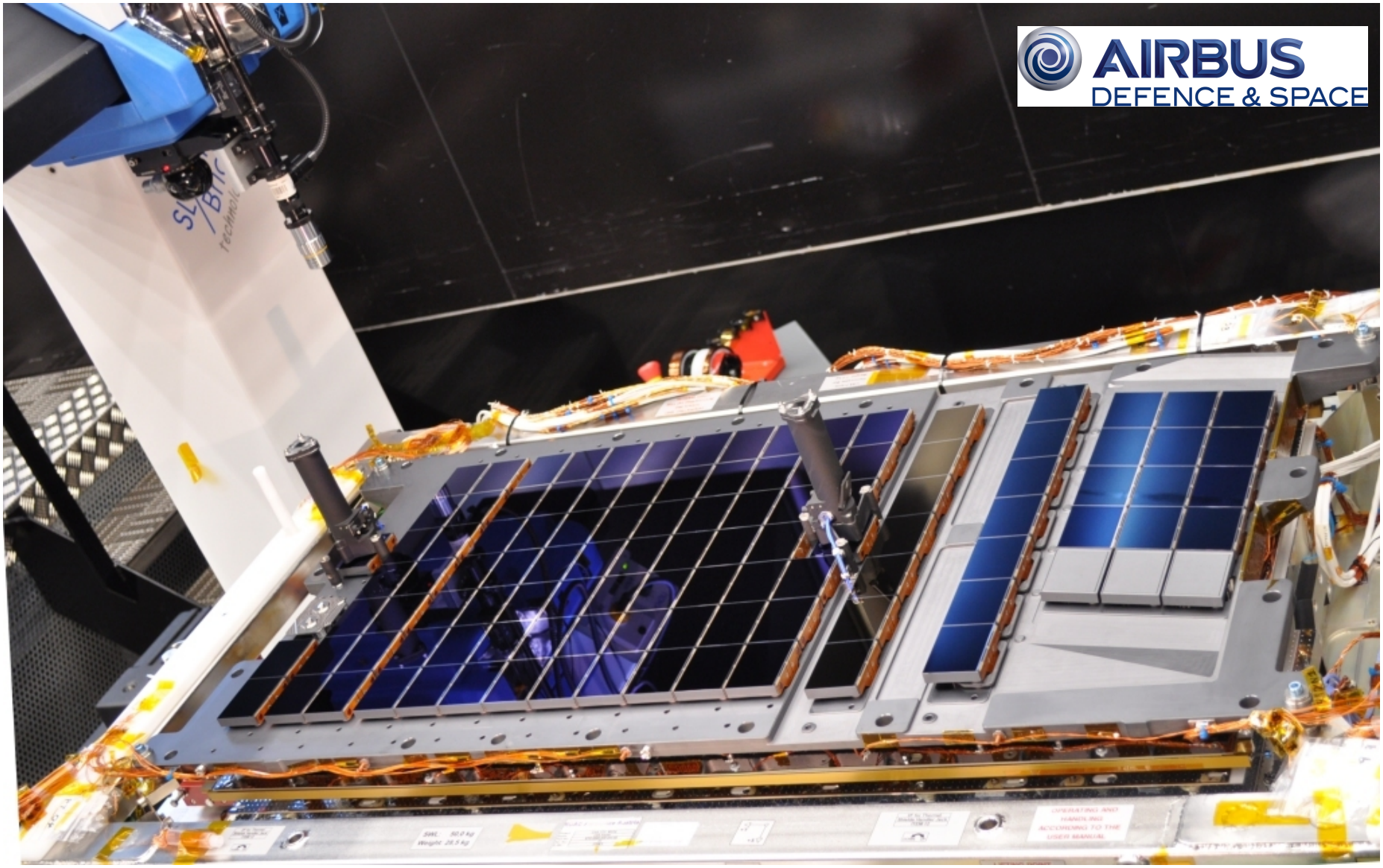


Focal plane

Figure courtesy Ralf Kohley



Focal plane



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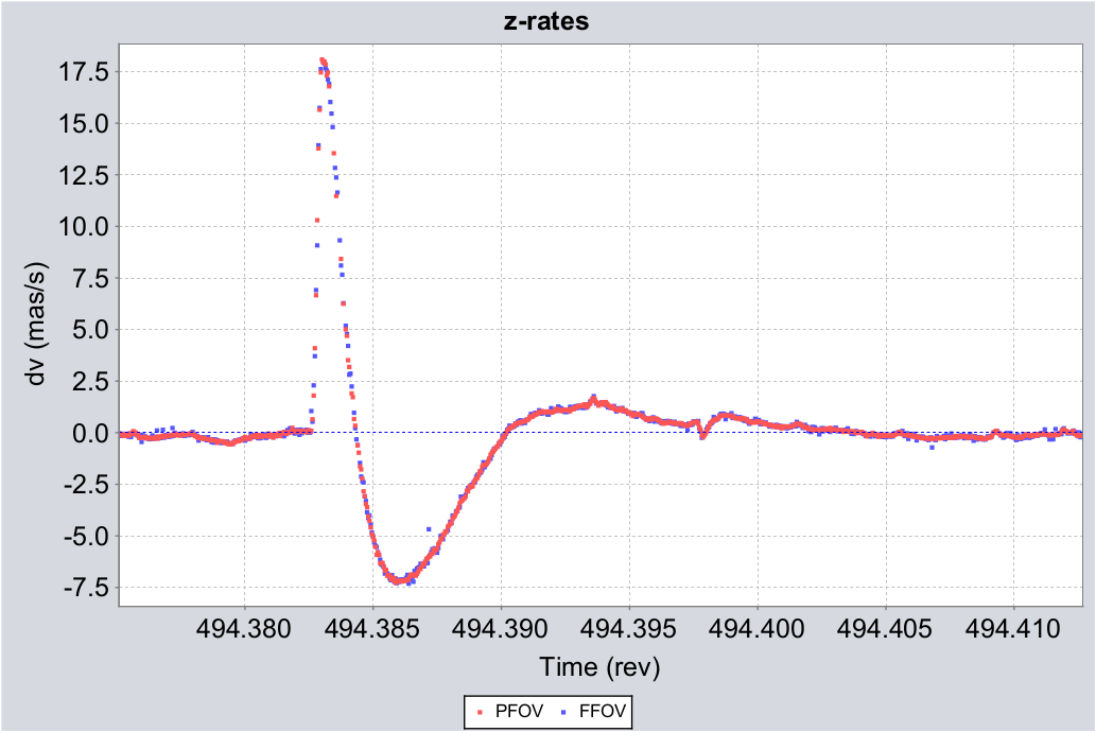
VS06 • gaia - December, 19th 2013

Commissioning results

- Micro propulsion system working well
- Attitude and orbit control system functioning well
- Phased array antenna operating with healthy link budget
- Clock working at required accuracy
- 106 CCDs, electronics, data acquisition and storage all functioning



Micro-meteoroid hit example,
figure courtesy F. van Leeuwen

Unwanted surprises

- Stray light both from astronomical sources and the Sun
  - Sun stray light due to scattering by fibres at sunshield edges
  - Impacts faint sources, especially in spectroscopy
- Transmission loss due to continuing contamination of mirrors by water
  - Water source not yet exhausted, maximum contamination rate now at 3 mmag/day
  - Currently primarily blue light is affected
- Basic Angle variation larger than expected
- Video Processing Unit (VPU) resets observed around high density regions

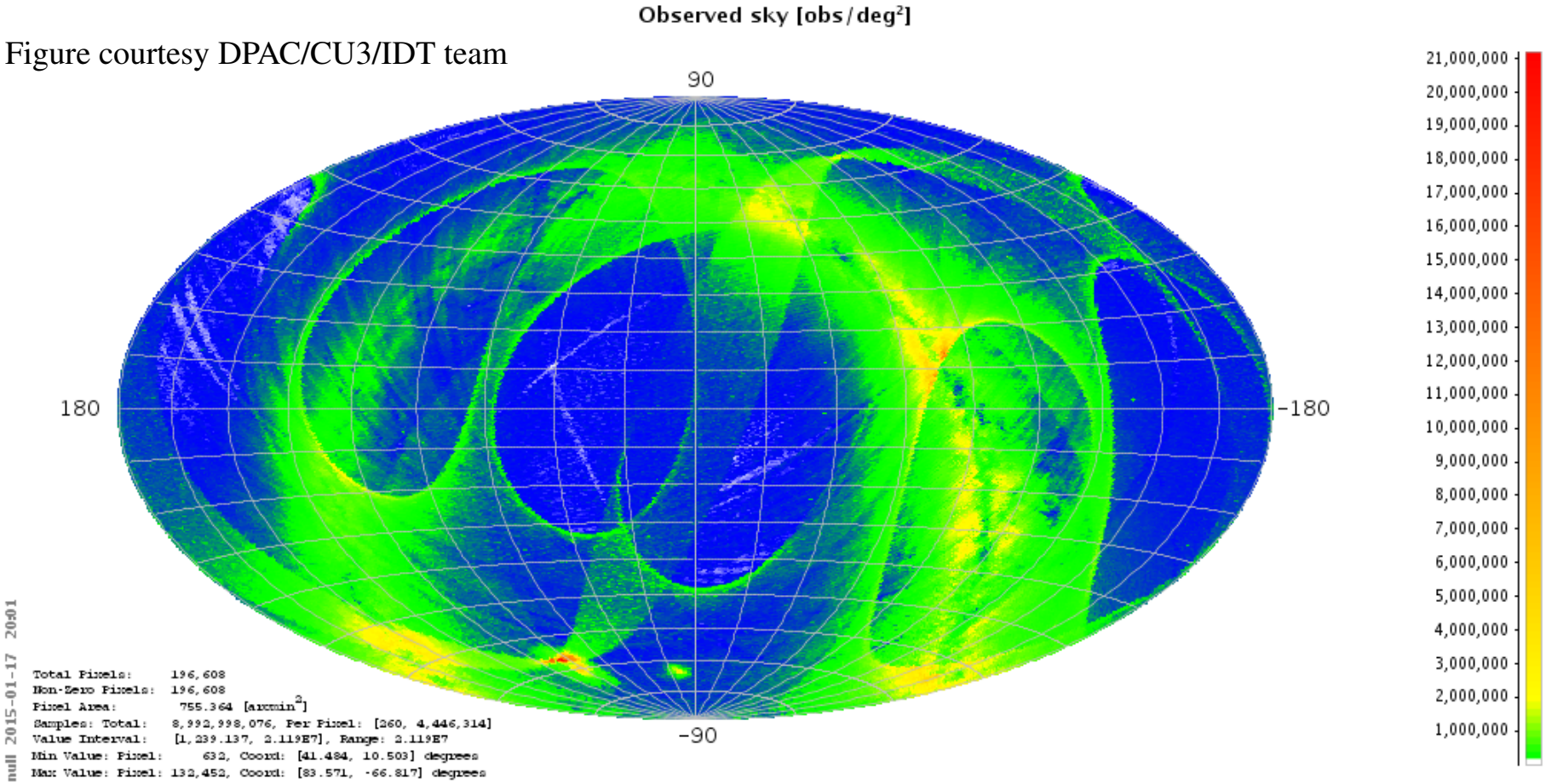
Next steps

- Stray light
  - Root cause understood
  - Data processing software adapted to model background fluctuations
  - On-board S/W modification being implemented for the spectroscopy
- Contamination
  - A new decontamination procedure has been executed involving a short heating of mirrors (executed 22–23 September) → full transmission recovery and re-focus 24 October with continued monitoring
- Basic Angle variation larger than expected
  - Analysis of dedicated measurements have verified reality of Basic Angle variation
  - Working group established to chase the root cause of the variations
- VPU software patch with more diagnostics was uplinked

Data collection stats

Number of astrometric observations per square degree up to end of January

Figure courtesy DPAC/CU3/IDT team



Whole sky seen by Gaia! — Up to 21 million per square degree

As of End Jan 2015: 16 billion astrometric/photometric transits, 1.6 billion spectroscopic

Early astrometric performance assessment

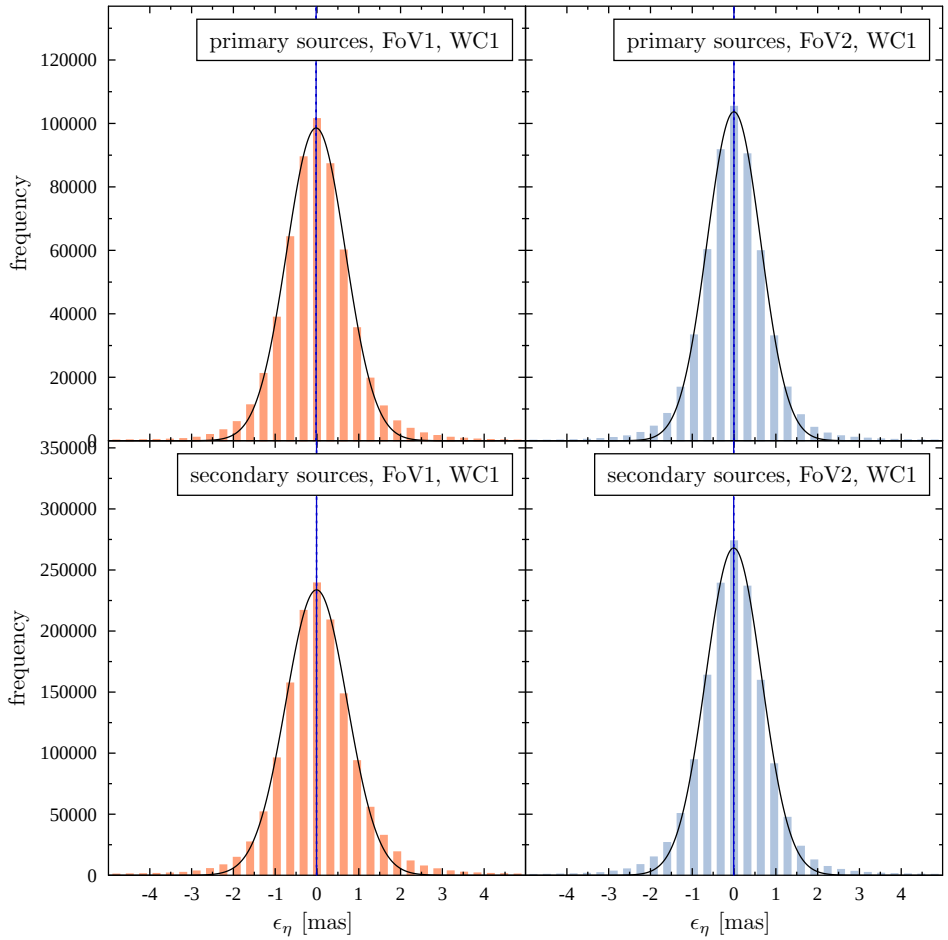
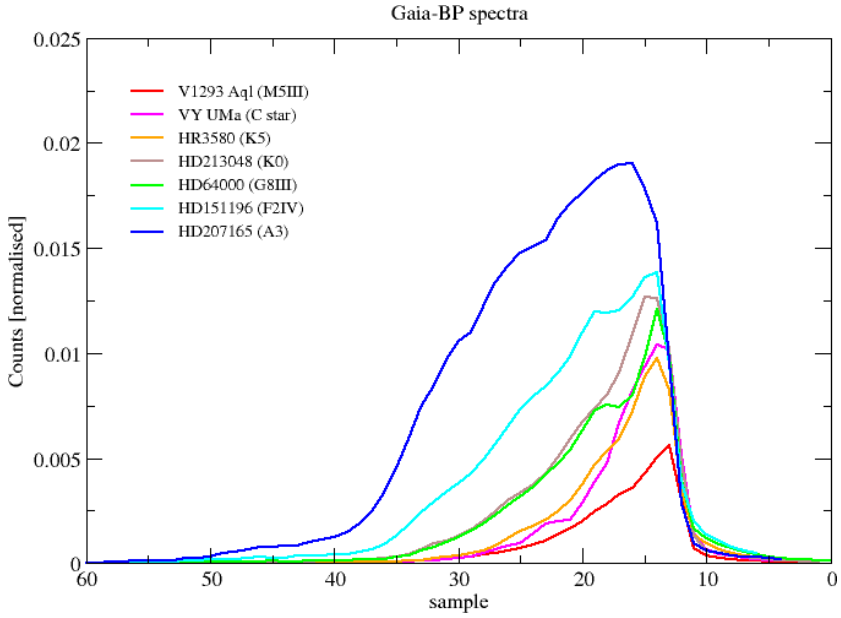
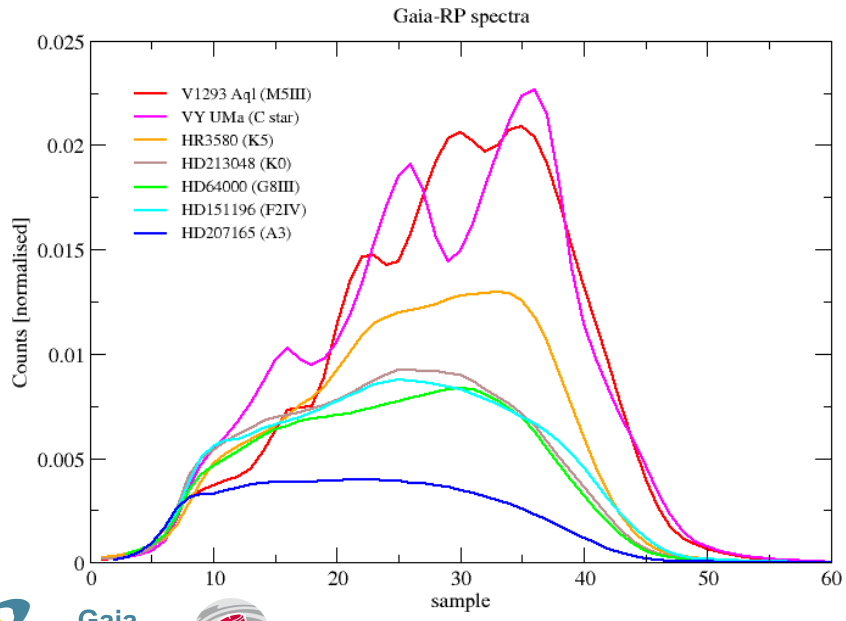


Figure courtesy First Look team

- ODAS Residuals 0.6 mas at $G = 15$ in June/July
  - target is 0.3 mas
- Caveats at this stage
  - coarse attitude model
  - poor PSF calibrations, no source colours
  - imperfect stray light corrections
  - throughput loss
- For clean telescopes throughput is as expected
- Read noise within requirements
- Corrections for bias non-uniformity under control
- High accuracy timing works nominally (detailed verification pending)

Early photometric performance assessment

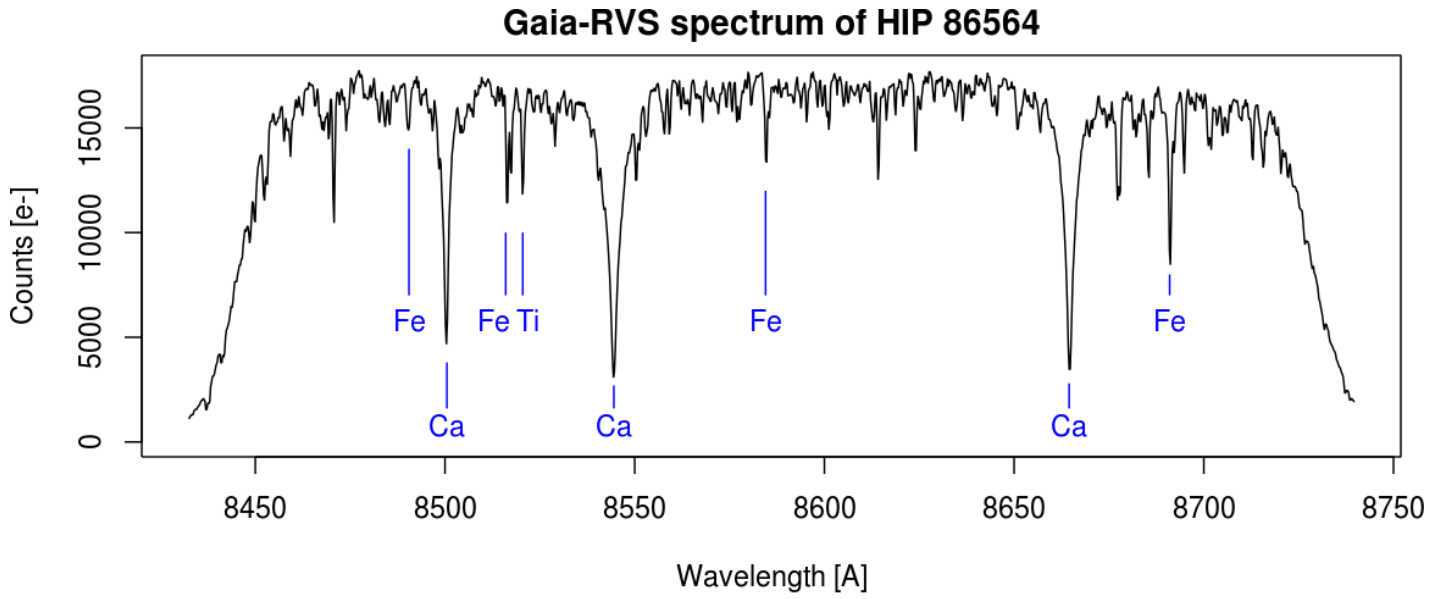




- Spectra appear as expected: classification and parametrization possible
- For clean telescopes throughput is as expected
- Read noise within requirements
- Corrections for bias non-uniformity under control

Figure courtesy C. Jordi & J.-M. Carrasco

Preliminary RVS performance at bright end



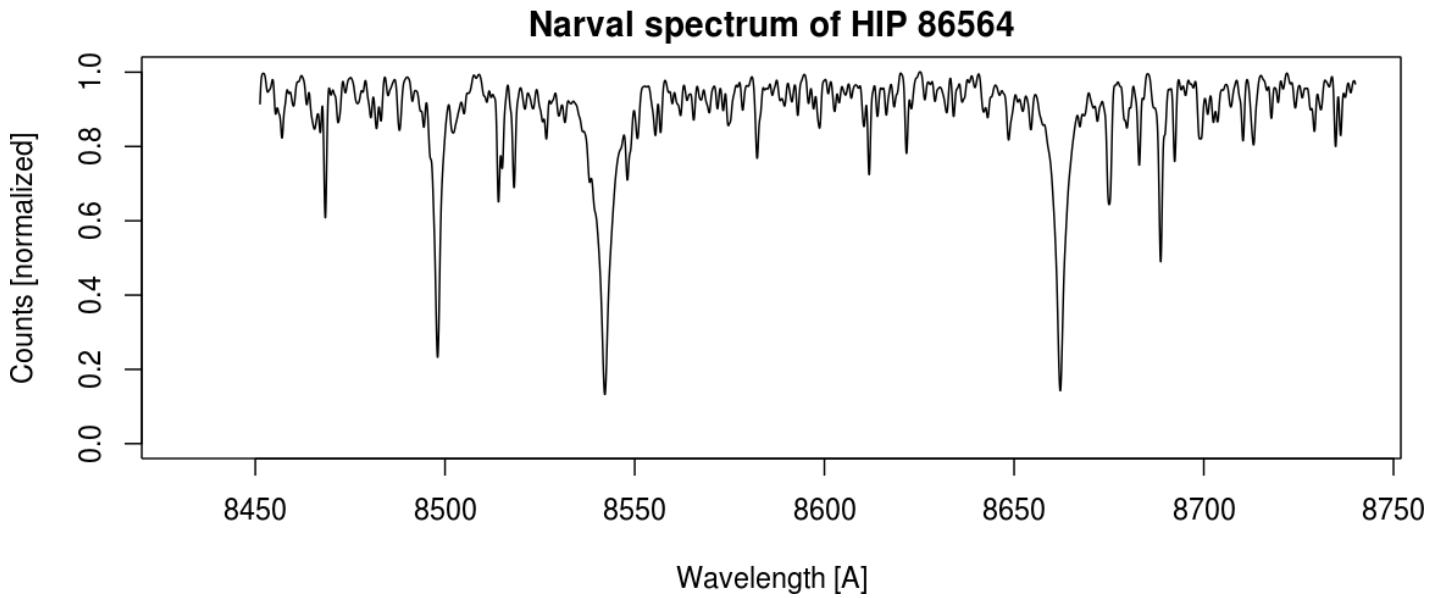
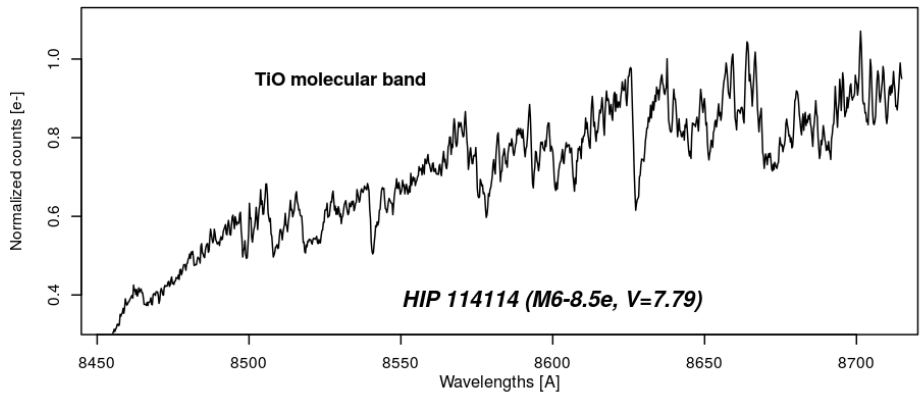
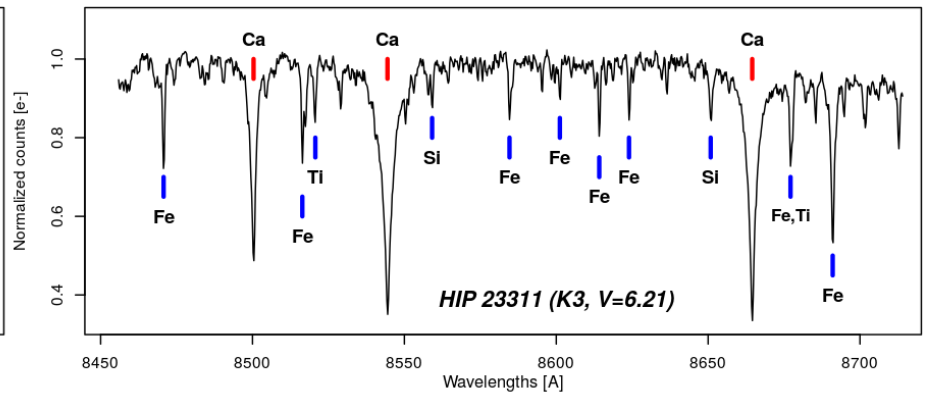
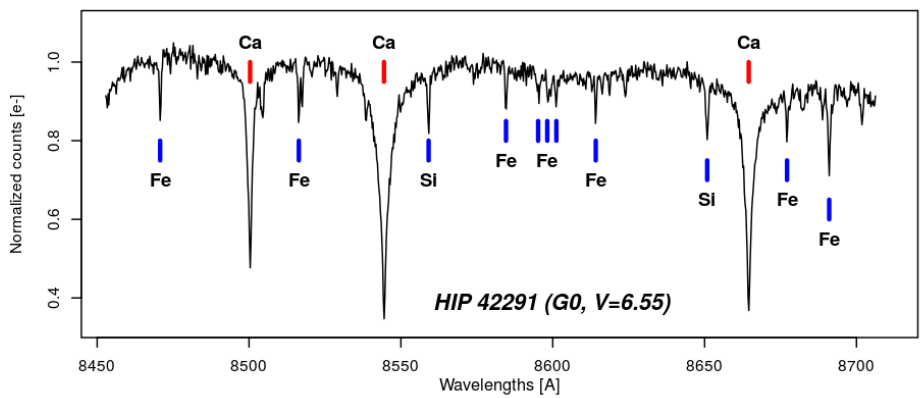


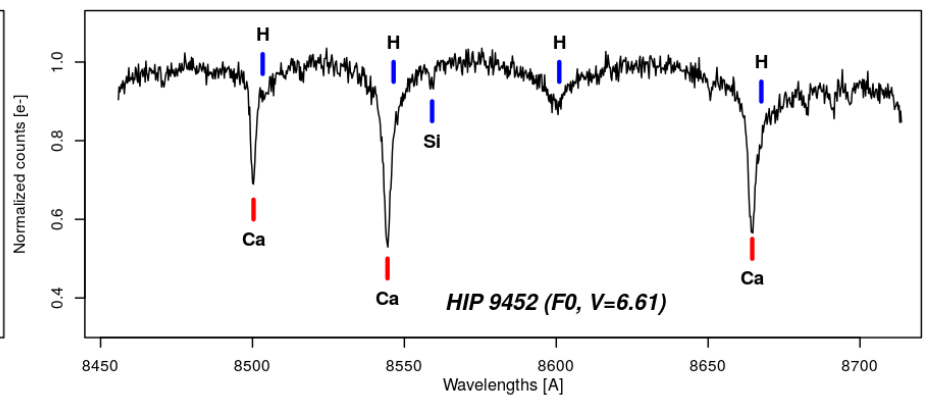
Figure courtesy D. Katz, O. Marchal, C. Soubiran

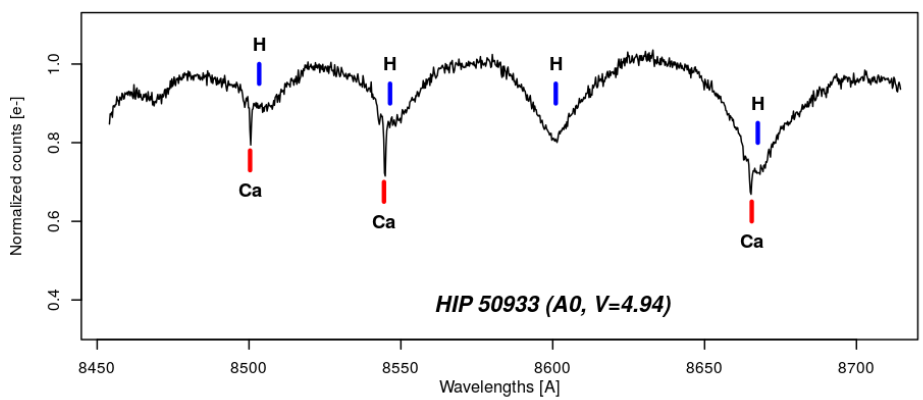
Preliminary RVS performance at bright end

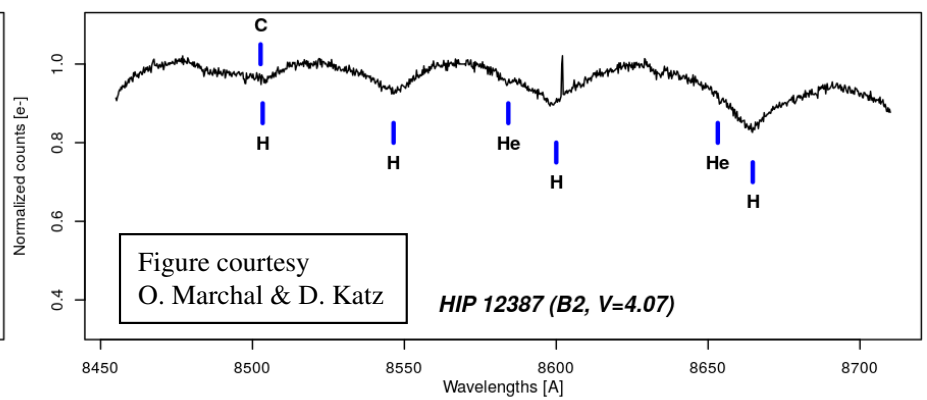












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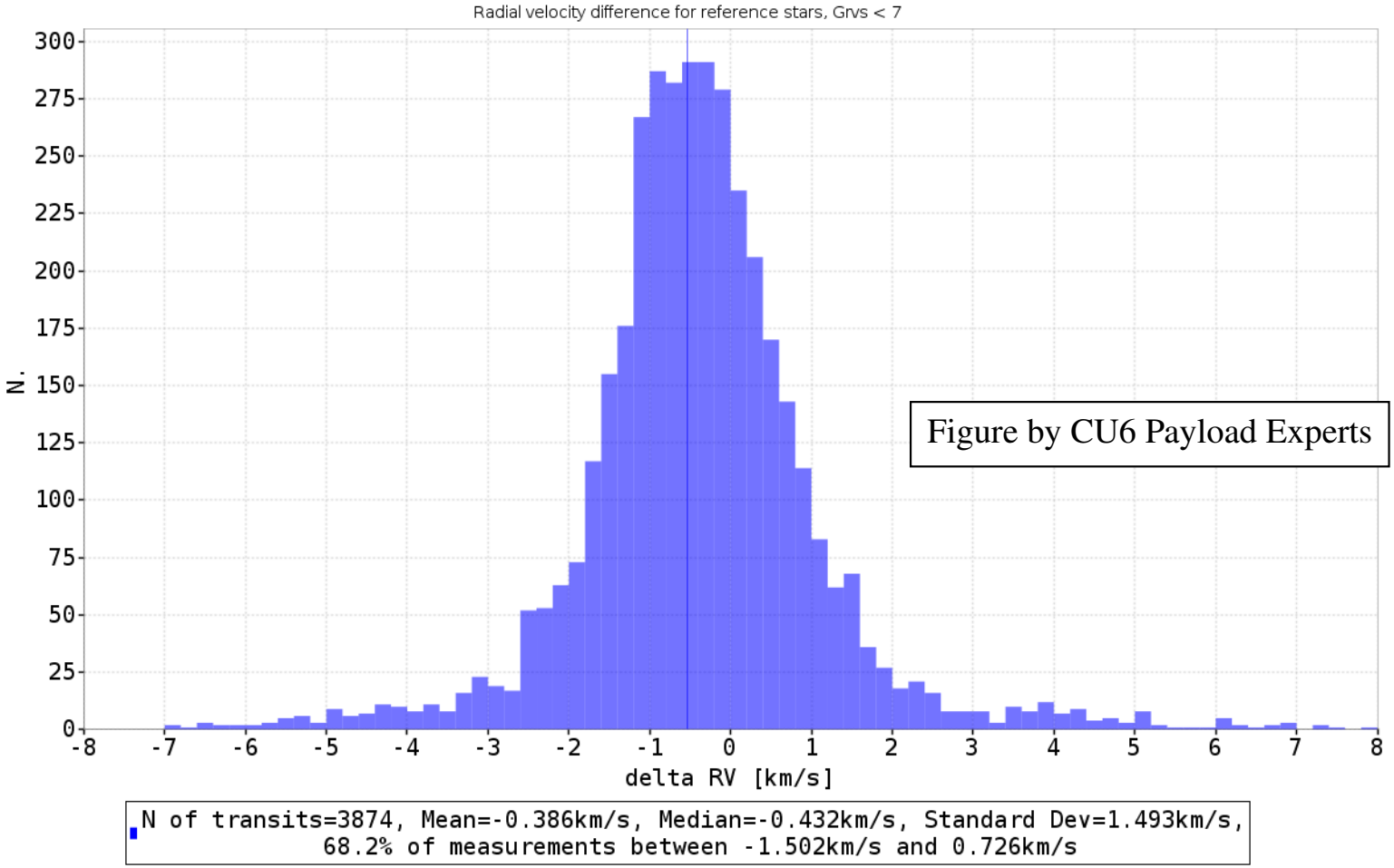
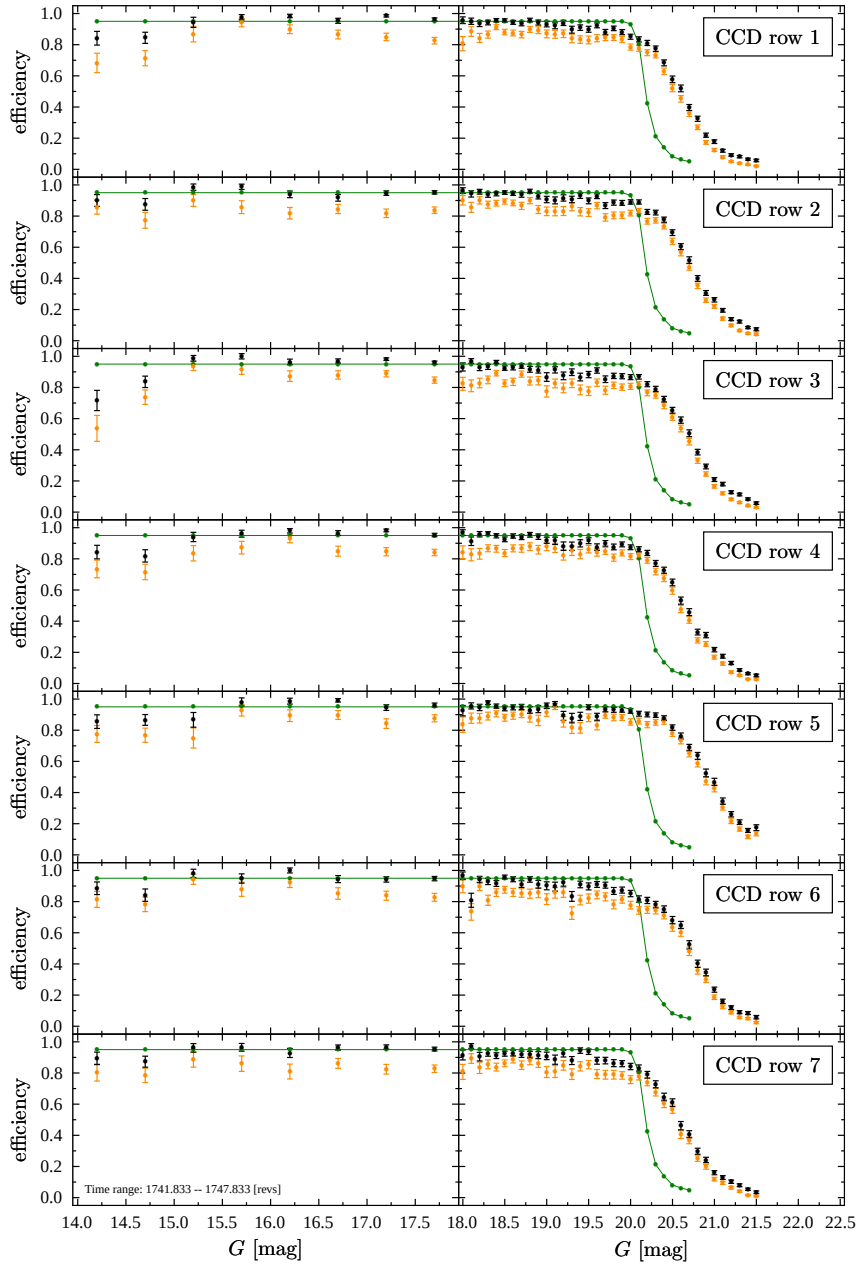
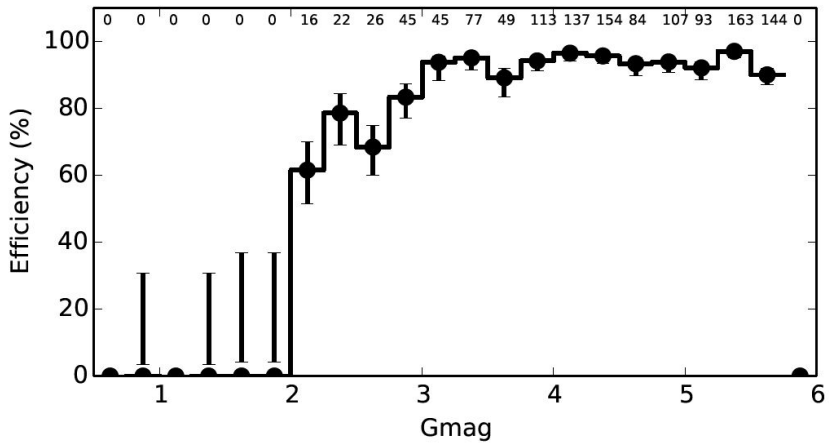


- Differences between measured and expected $v_{\rm rad}$ for bright ($G_{\rm RVS} < 7$) ground based radial velocity standards
- 68% of measurements are within 1.1 km s^{-1} from the median

Detection efficiencies

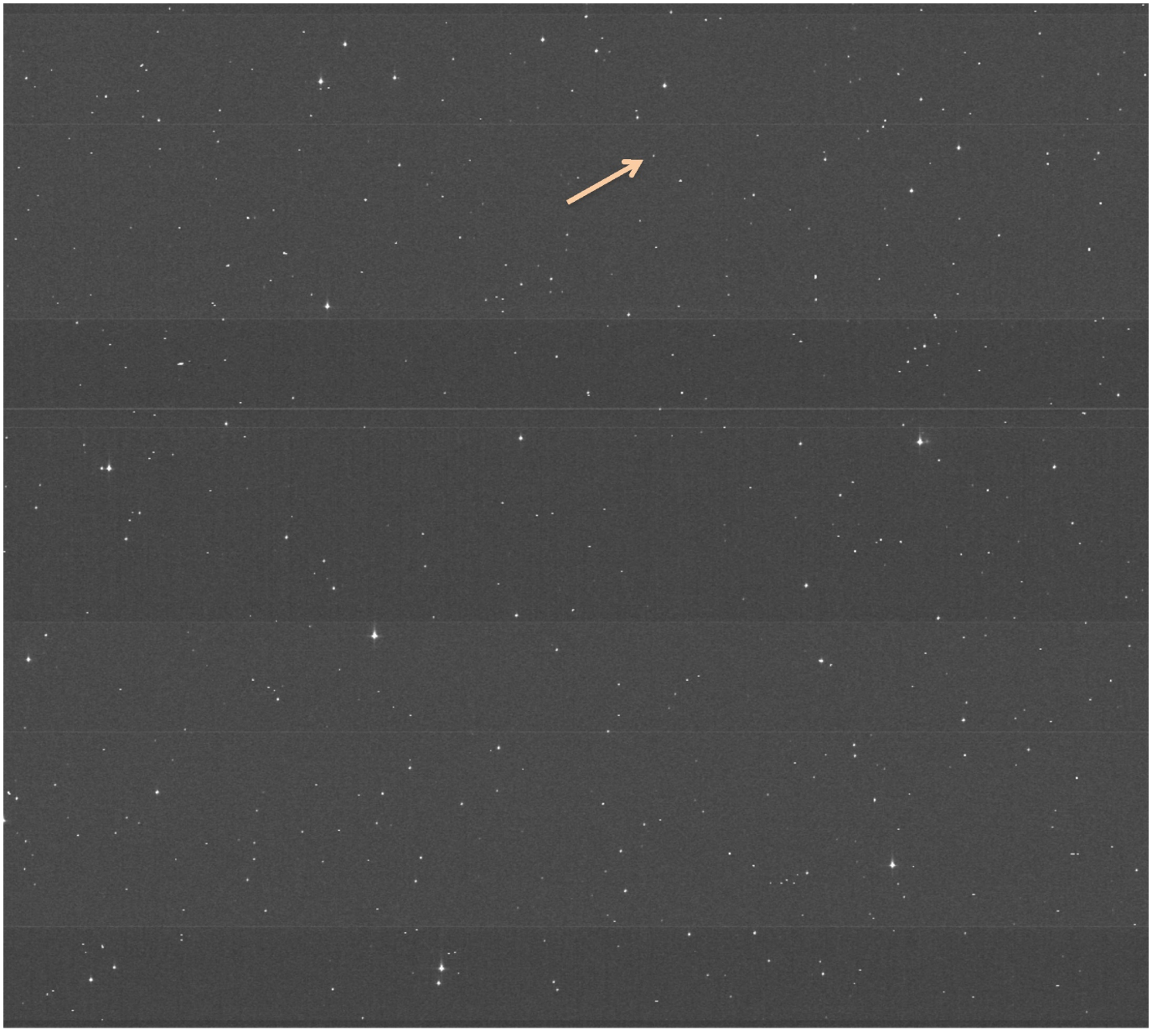




- Faint end efficiencies measured against dedicated Ecliptic Pole survey
- Bright end extended to $G \approx 0$ through detection algorithm improvements and employment of special observing mode

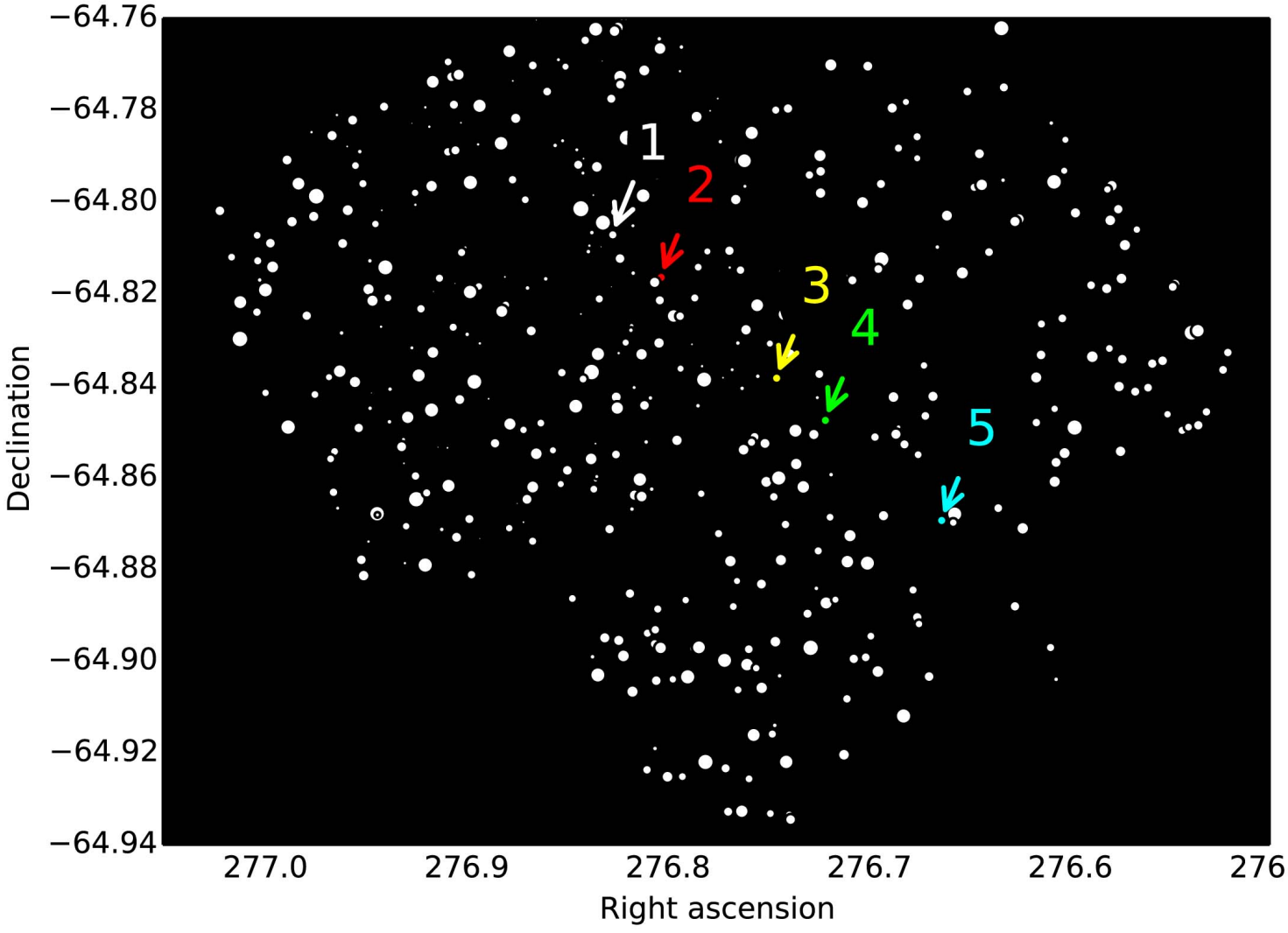
Figures courtesy DPAC-FL team and SOC Calibration Team

Solar system objects



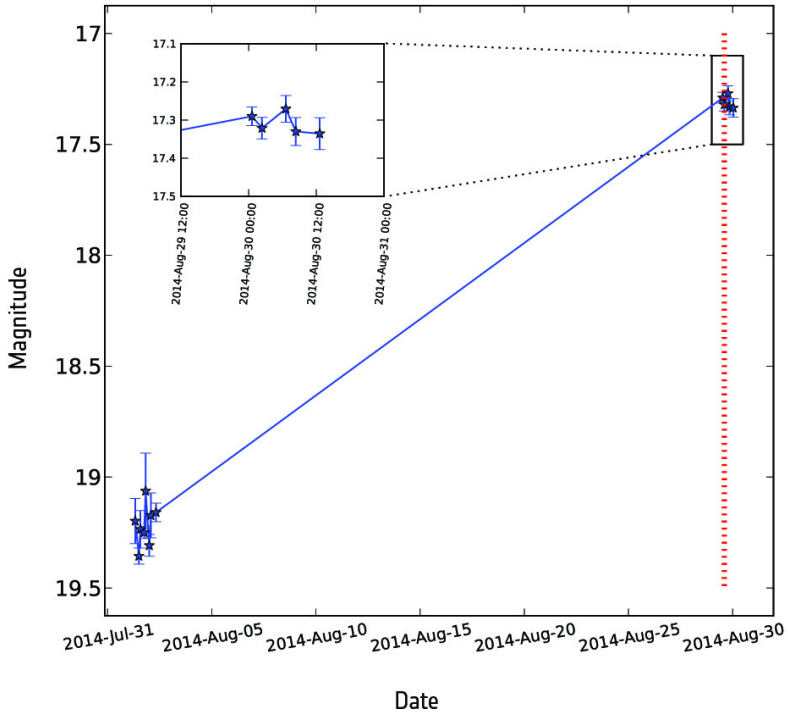
Credits: ESA/Gaia/DPAC/Airbus DS, UB-IDT, OCA-SSO

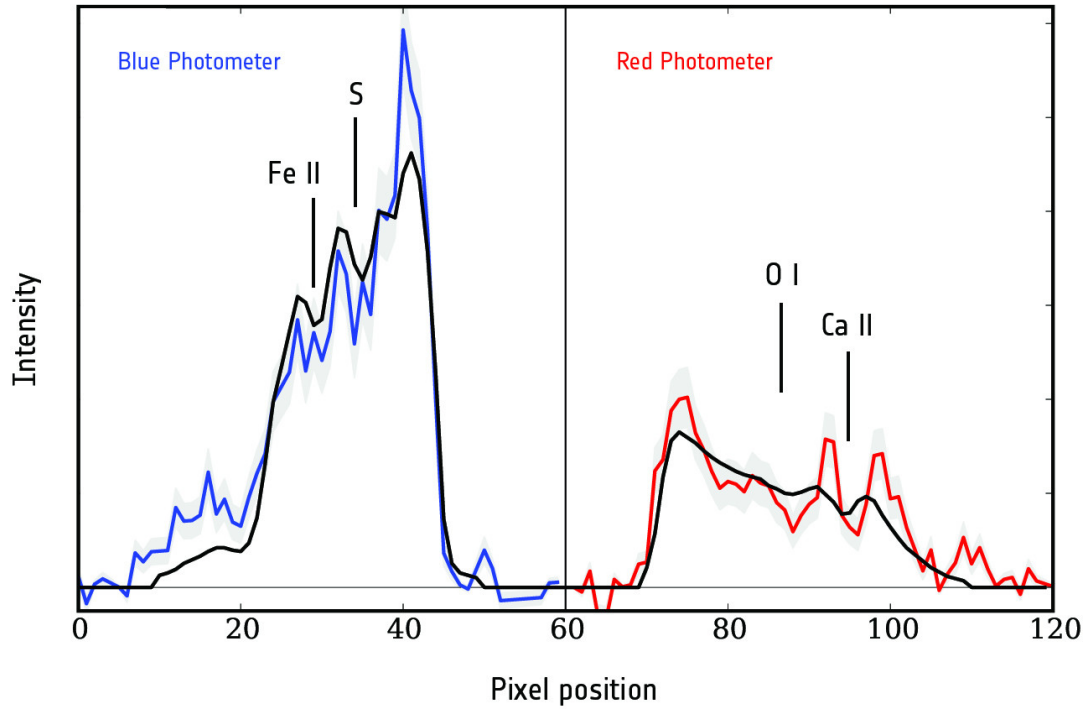
Solar system objects

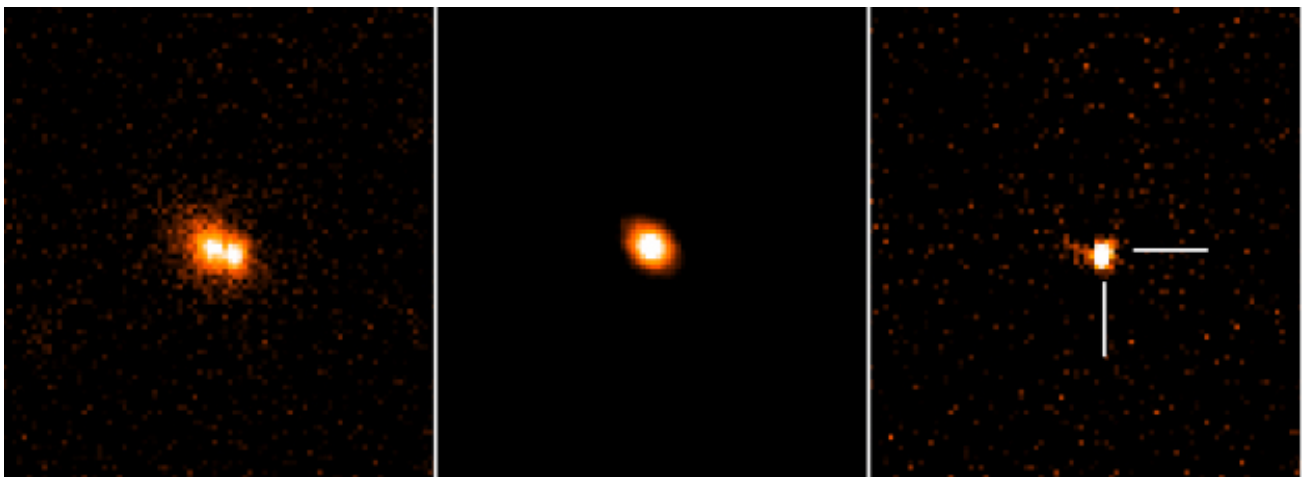


Credits: ESA/ Gaia/ DPAC/
Airbus DS, UB-IDT, OCA-SSO

First supernova discovery

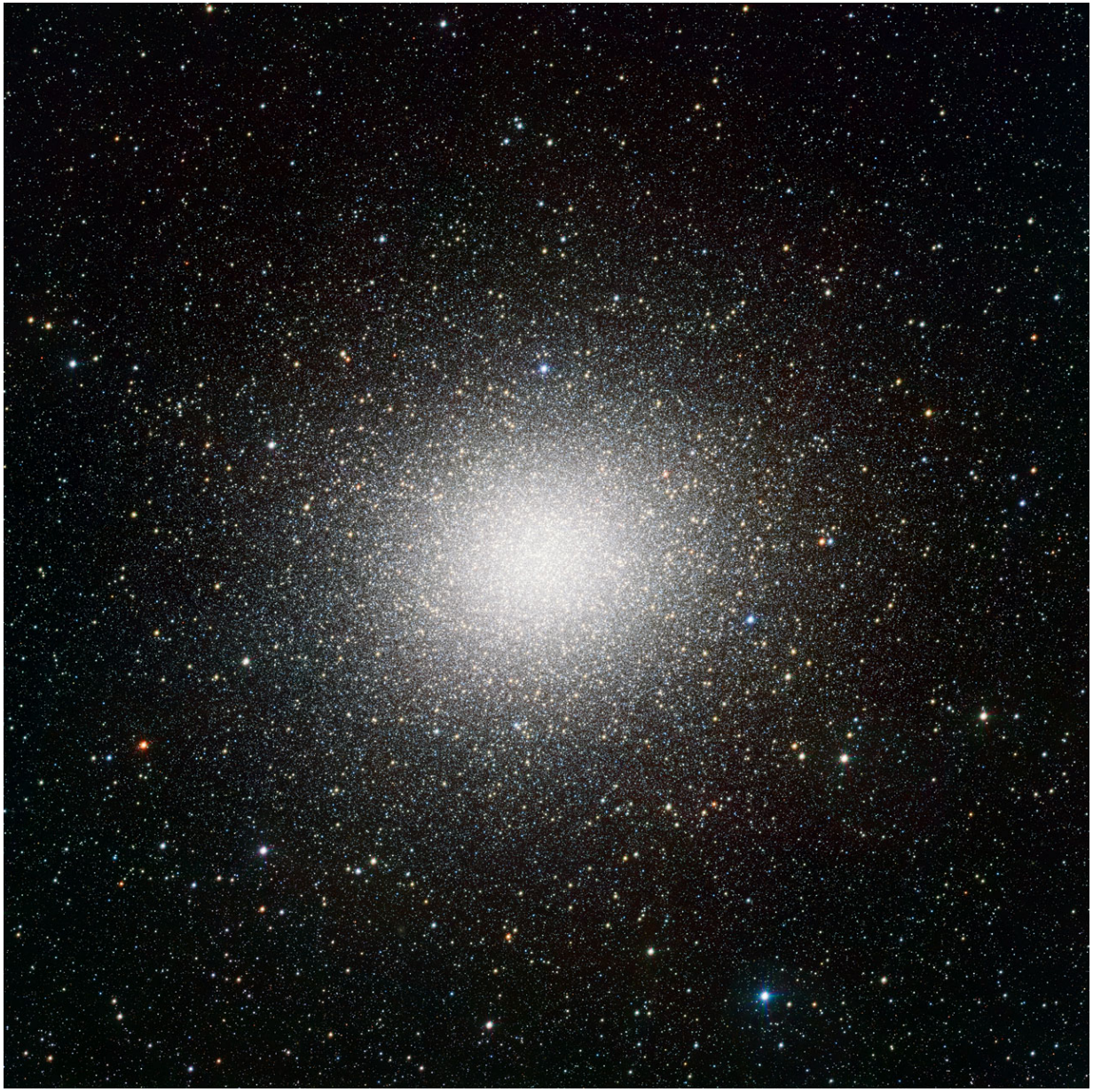






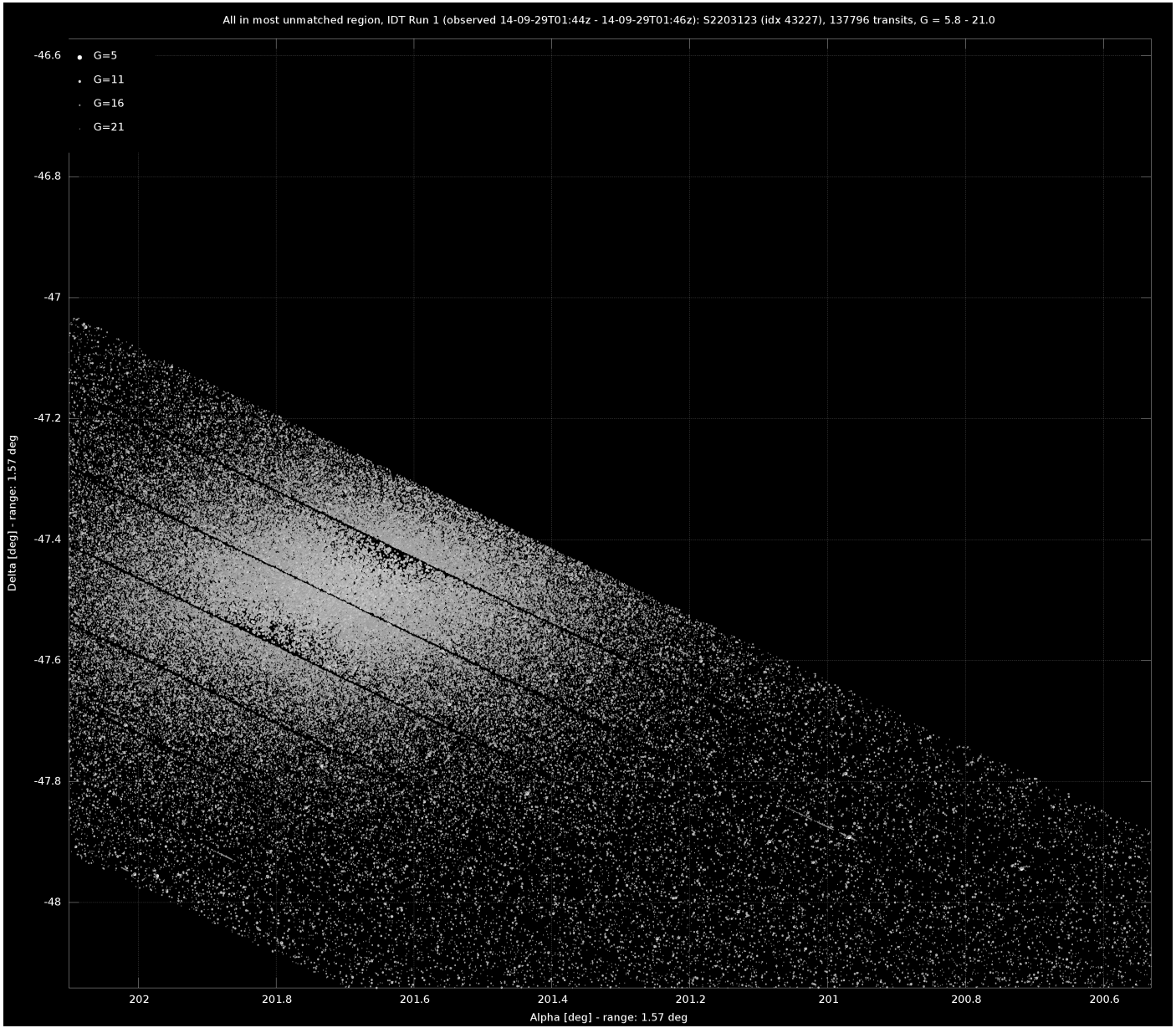
Credits: M. Fraser/ S. Hodgkin/ Ł. Wyrzykowski/ H. Campbell/ N. Blagorodnova/ Z. Kostrzewa-Rutkowska/ Liverpool Telescope/ SDSS/ ESA/ Gaia/ DPAC

Omega Centauri



Credits: ESO/ INAF-VST/ OmegaCAM

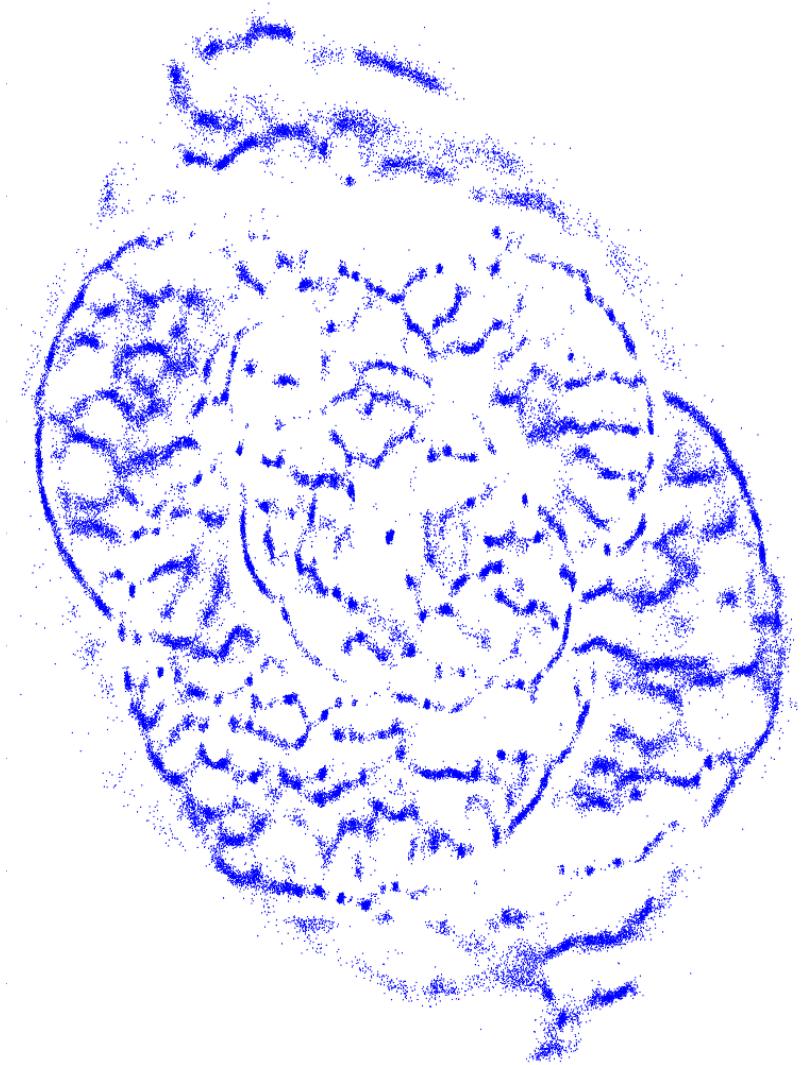
Omega Centauri



The Gaia view

Credits: ESA/ Gaia/ DPAC/ UB/ IEEC

The Cat's Eye

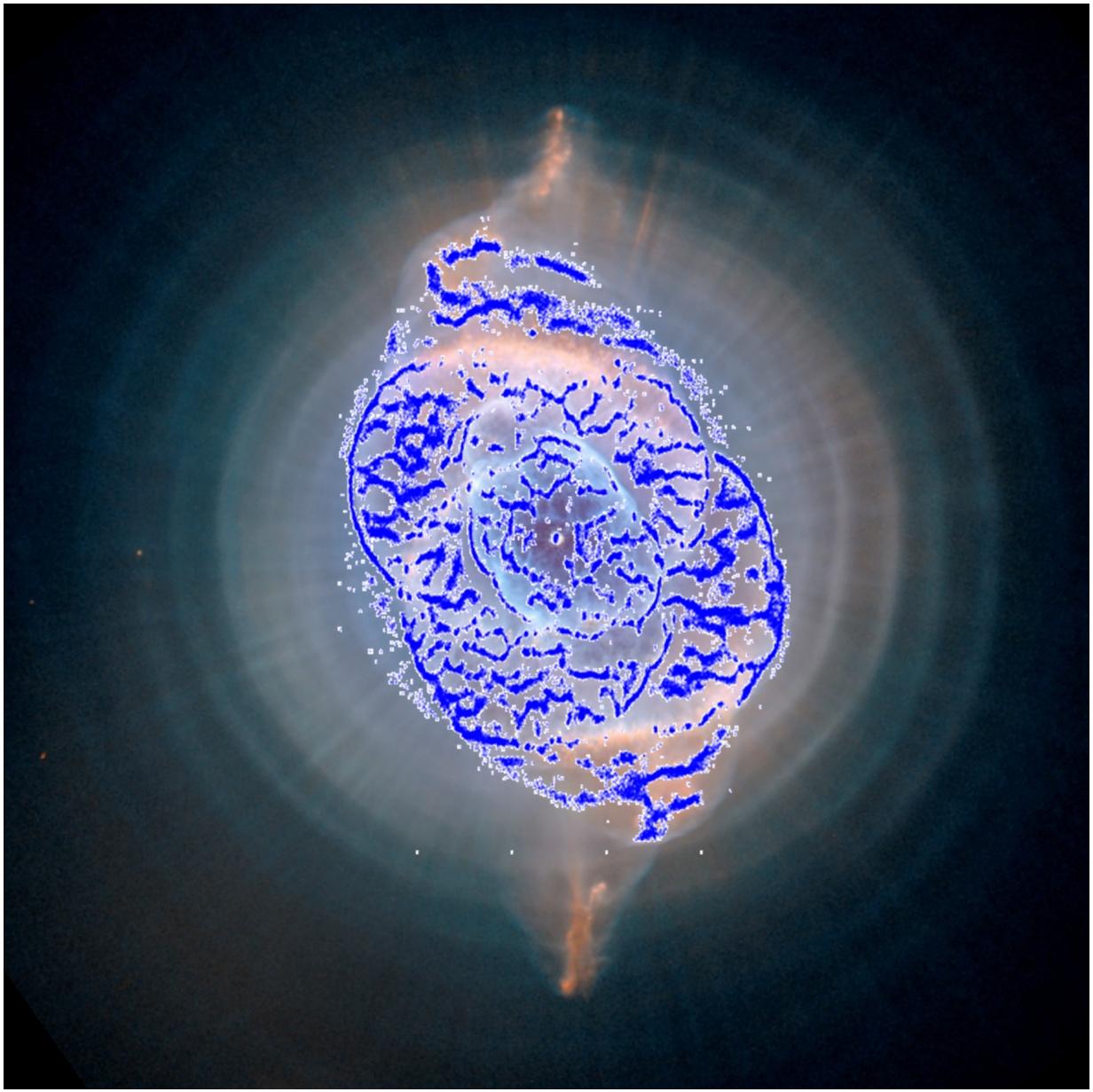


Credits: ESA/ Gaia/ DPAC/ UB/ IEEC

The Cat's Eye

Credits: NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

The Cat's Eye



Credits: NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

Credits: ESA/ Gaia/ DPAC/ UB/ IEEC

Scientific performance predictions

Performance predictions for G2V star			
V magnitude	Astrometry (parallax)	Photometry (BP/RP integrated)	Spectroscopy (radial velocity)
3 to 12	5–14 μas	4 mmag	
3 to 12.3			1 km s^{-1}
15	24 μas	4 mmag	
15.2			15 km s^{-1}
20	540 μas	60 (RP) – 80 (BP) mmag	

Calculations by: Airbus DS, D. Katz, C. Jordi, L. Lindegren, J. de Bruijne

Up-to-date information always at:
`http://www.cosmos.esa.int/web/gaia/science-performance`

Time line

- Routine phase started with 28 days of Ecliptic Pole Scanning
- Now operating in optimised Nominal Scanning Law
  - catch bright stars near Jupiter in 2017 to detect quadrupole light bending
- No bright magnitude limit
  - Stars $G = 3$–20.7 observed in nominal mode (and $G = 2$–3 with 75% probability)
  - Stars brighter than 3 mag with Sky Mapper imaging
- Activities to be finished:
  - Magnitude limit for astrometry and photometry (now 20.7)
  - Magnitude limit for spectroscopy (now 16.2)
  - Upgrade of on-board SW to optimize spectroscopy
  - Decontamination as needed followed by focus check
  - Completion of BA and stray light WG tasks and possible follow-up
  - Sort out ground station time for larger amounts of telemetry
  - Consolidate intermediate release schedule for summer 2016 and early 2017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Satelliet Gaia 19-12-2013 van 19h08m-19h12m U.T.
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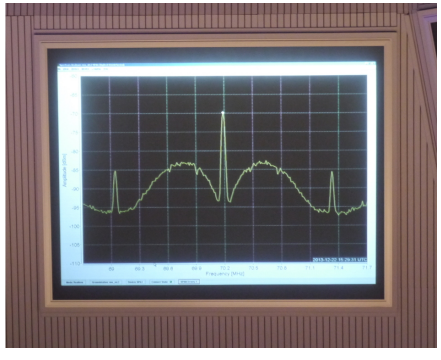


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SWARM A-B-C
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19 12 13
LAUNCHER
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ARIANE 5
SOYUZ
ROCKOT
SOYUZ

Discussion points

- Provide your wishes for Gaia data access facilities here:
  - `http://great.ast.cam.ac.uk/Greatwiki/GaiaDataAccess`
  - For already collected inputs see: `http://www.rssd.esa.int/SA/GAIA/docs/library/AB-026.htm`
- Back to basics
  - $\sim$ 10 million stars with 1% parallaxes over 2.5 kpc volume around sun
  - precise CMDs, calibration of luminosities, stellar physics, (re-)calibration alternative distance indicators
- Can I trust the Gaia data?
  - Extensive data validation effort before each release
  - Keep in mind: Gaia will observe $\sim$ 500 000 quasars
  - Feedback on 'features' in the data will be much appreciated (and used)
- Can the user be trusted with the Gaia data?
  - Make sure you understand the data (covariance matrix astrometric parameters, star-to-star error correlations, observational coverage, ...)