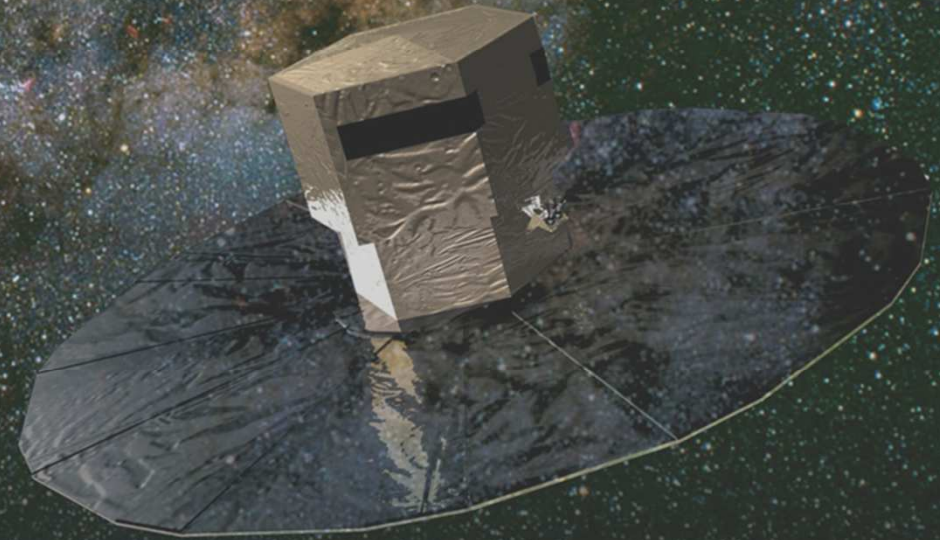


Gaia, the Galaxy in One Petabyte

Carme Jordi

University of Barcelona, Spain



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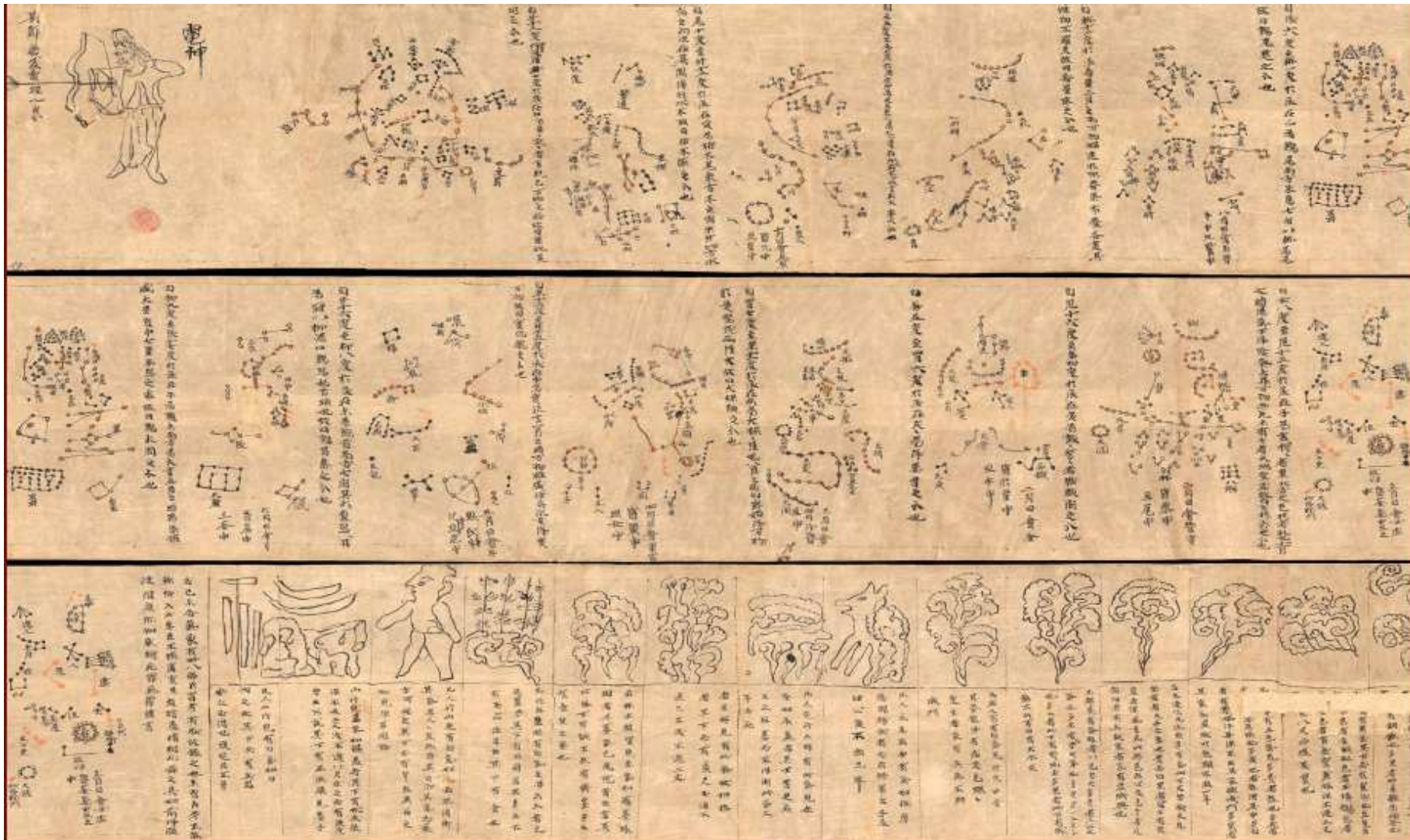






How many stars are there ?

Star catalogues



Oldest known sky map of the northern hemisphere (Tang dynasty, China 649-684). Dunhuang manuscripts (<http://dp.bl.uk>)



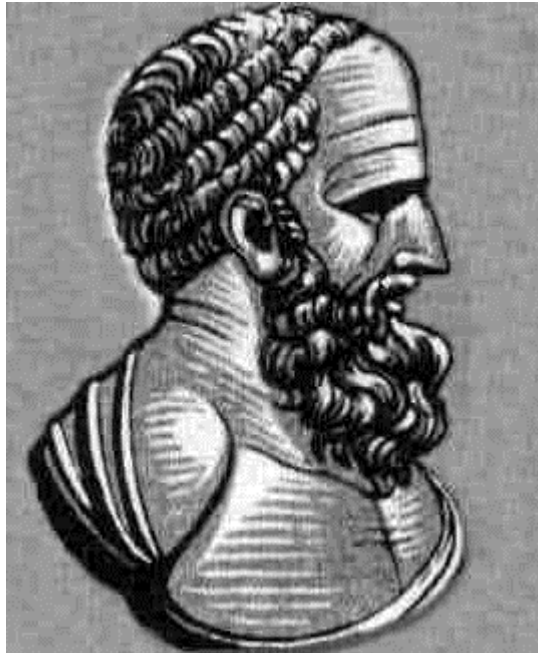
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Star catalogues



Hipparchus at about 150 BCE

the first comprehensive catalogue of the western world

1 000 stars
positions on the sky
magnitude



Tycho Brahe, XVI century



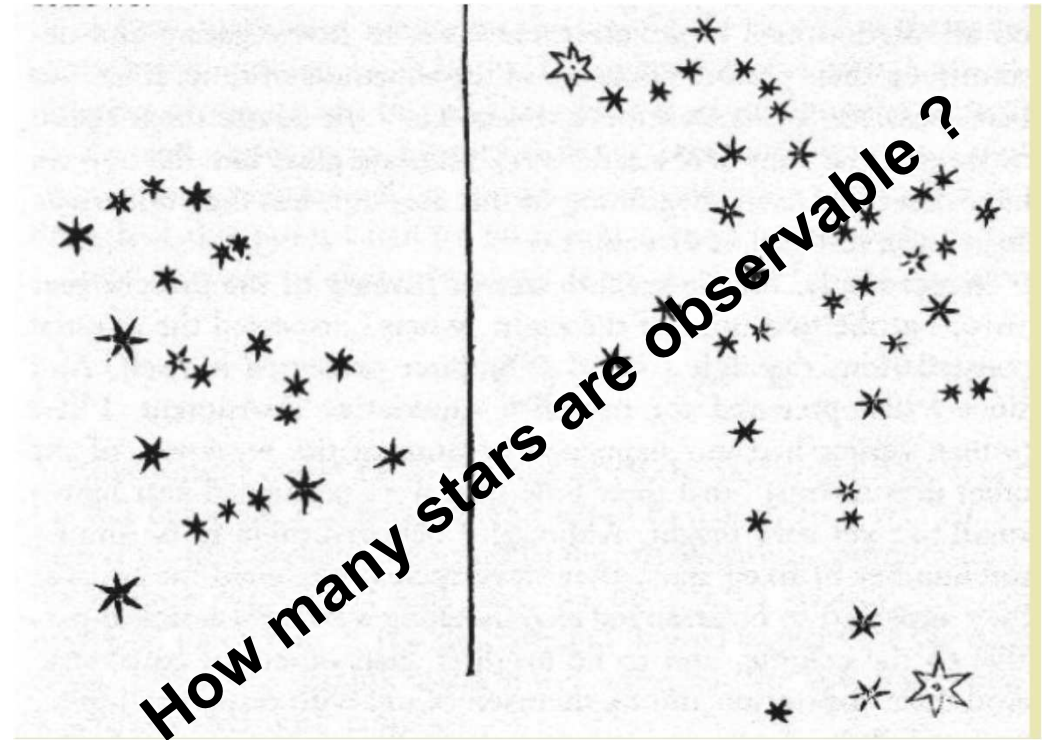
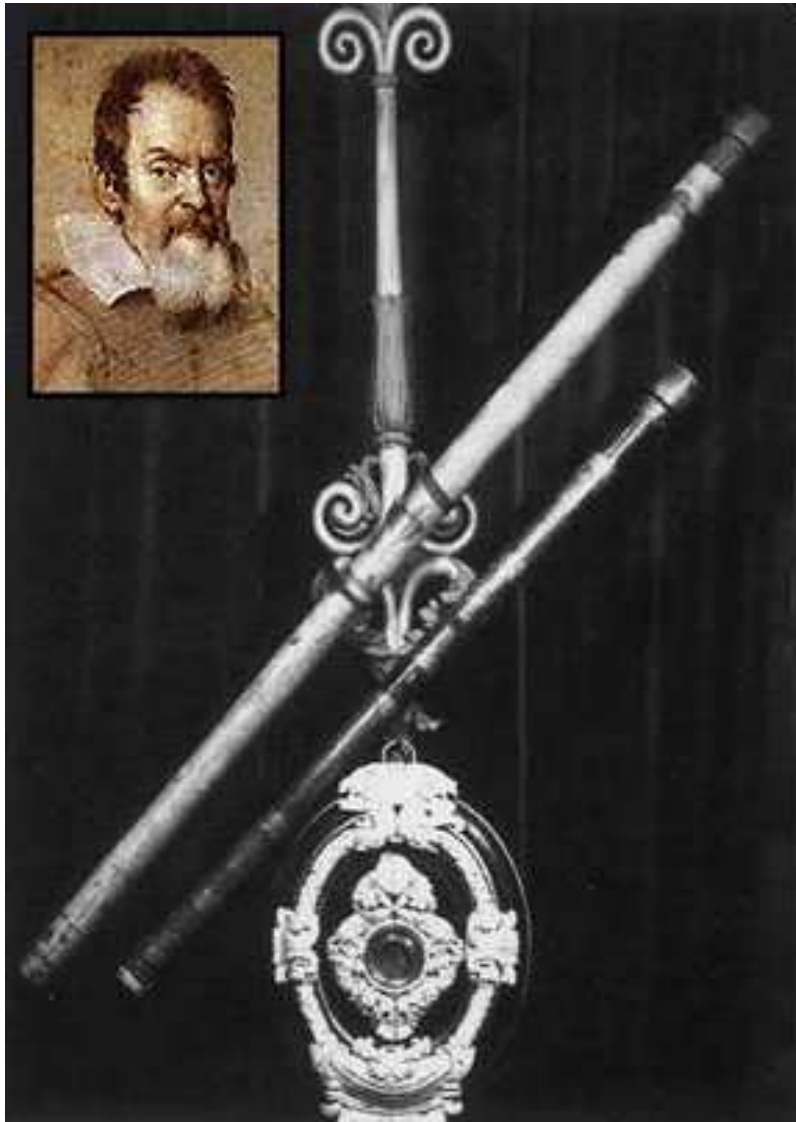
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Galileo Galilei and the telescope



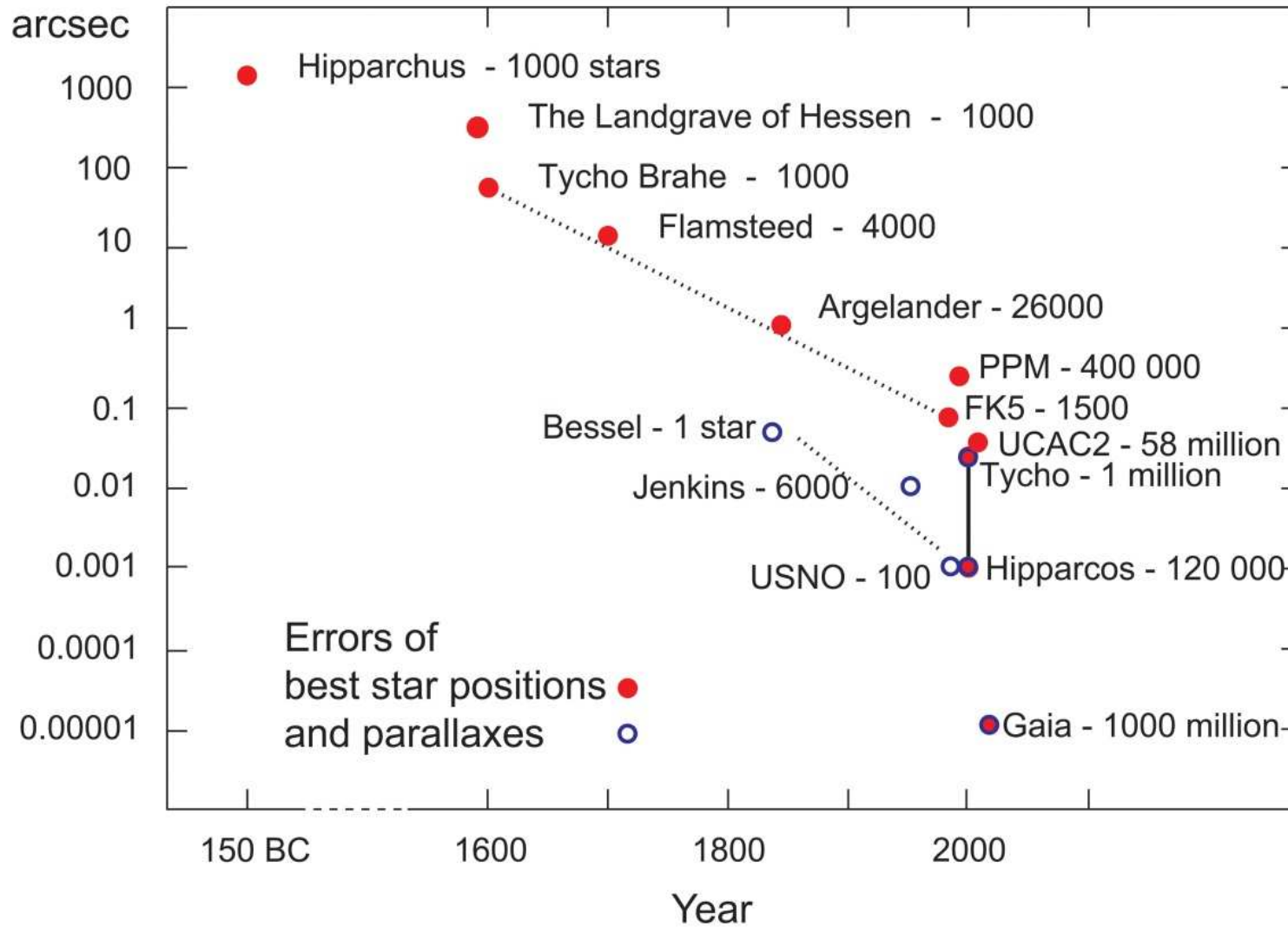
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Star catalogues



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How does Gaia measure the sky?



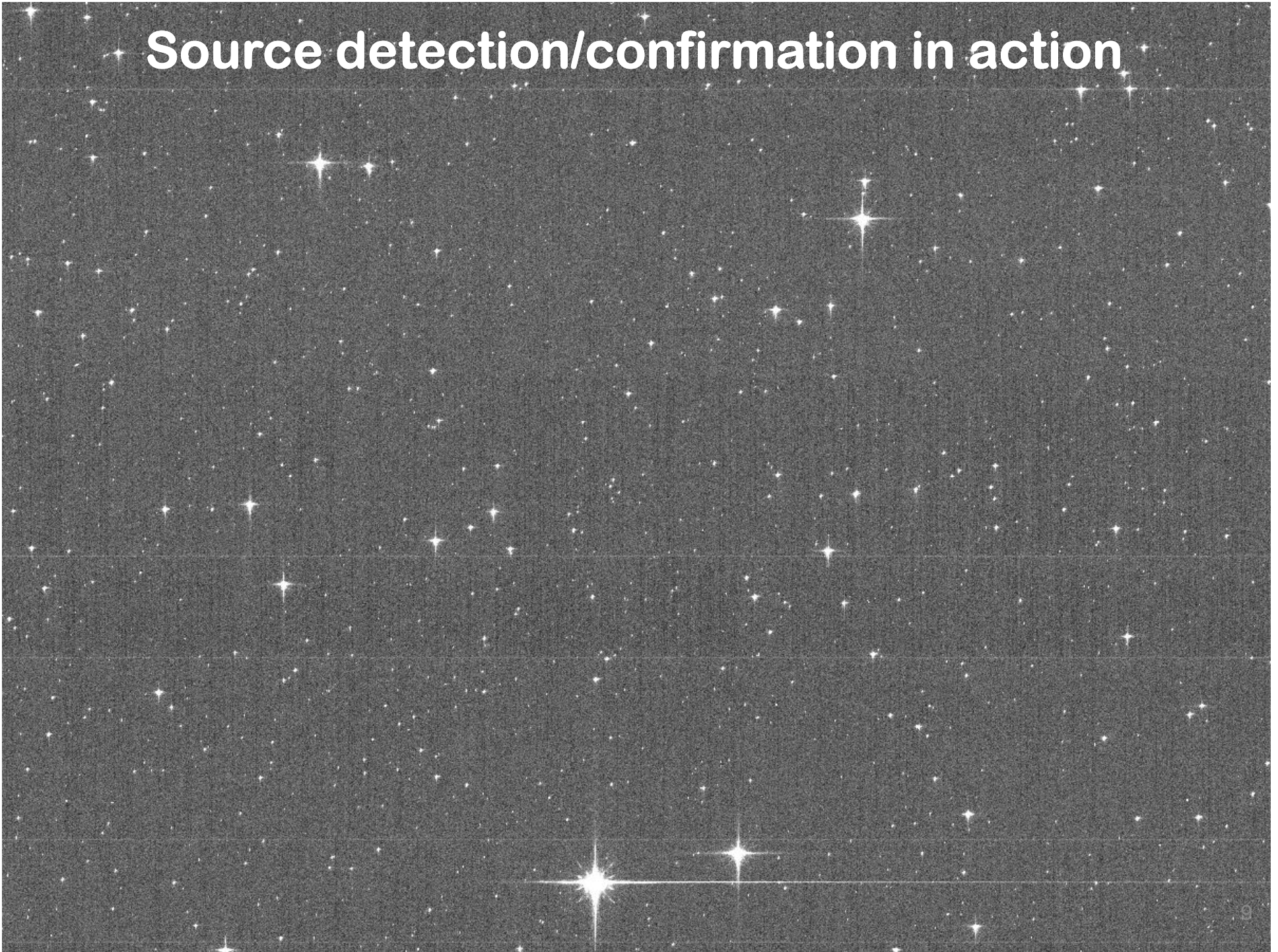
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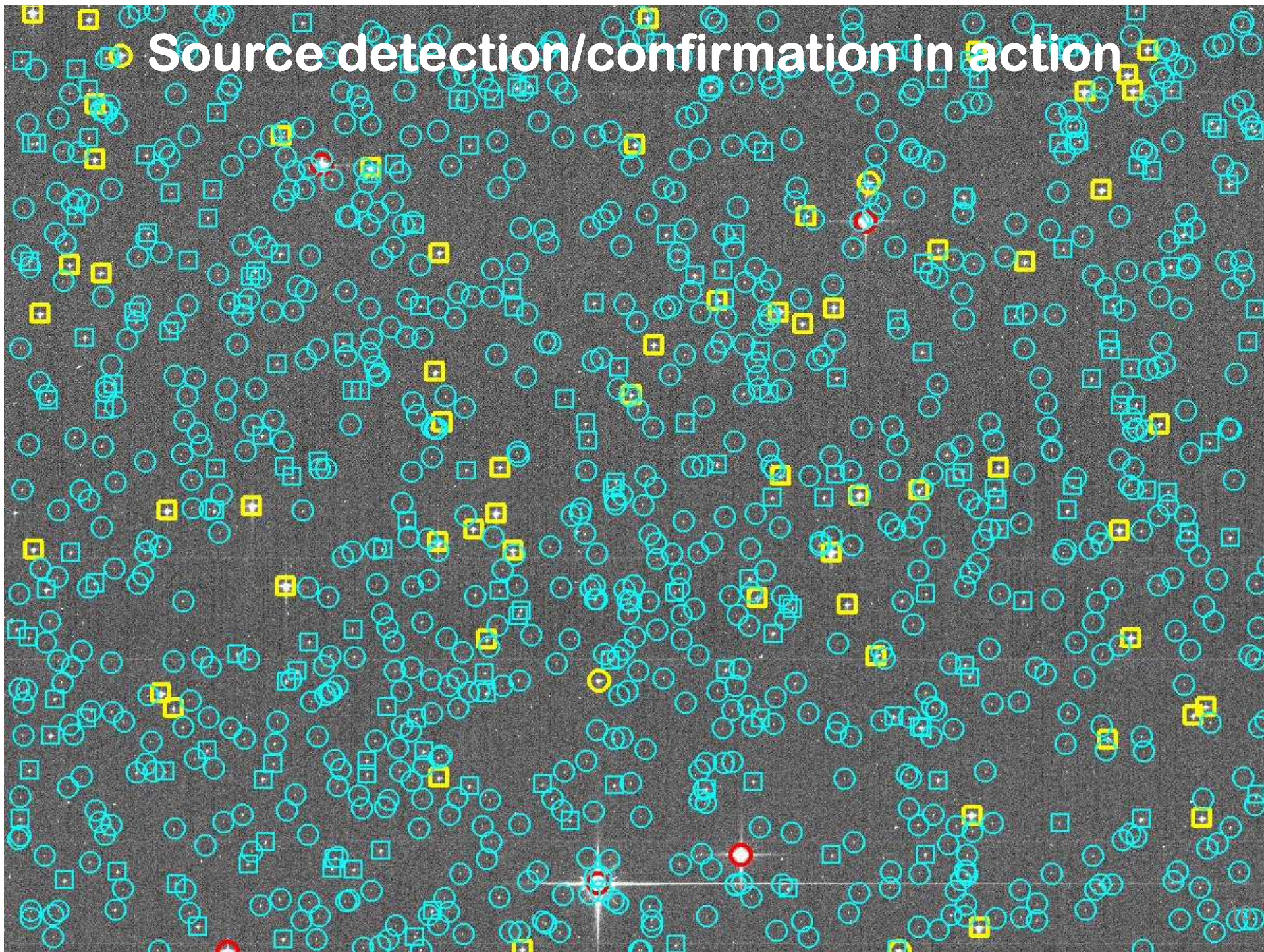
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Source detection/confirmation in action



Source detection/confirmation in action



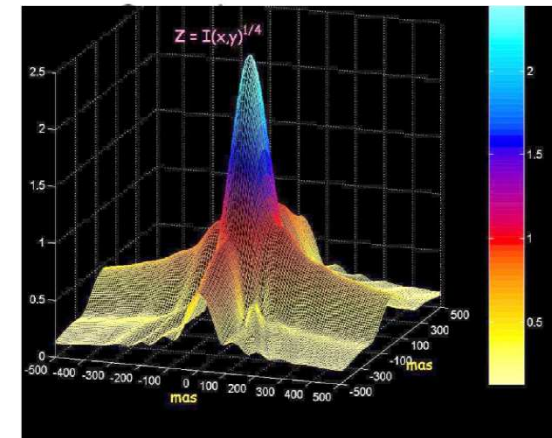
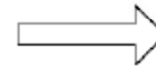
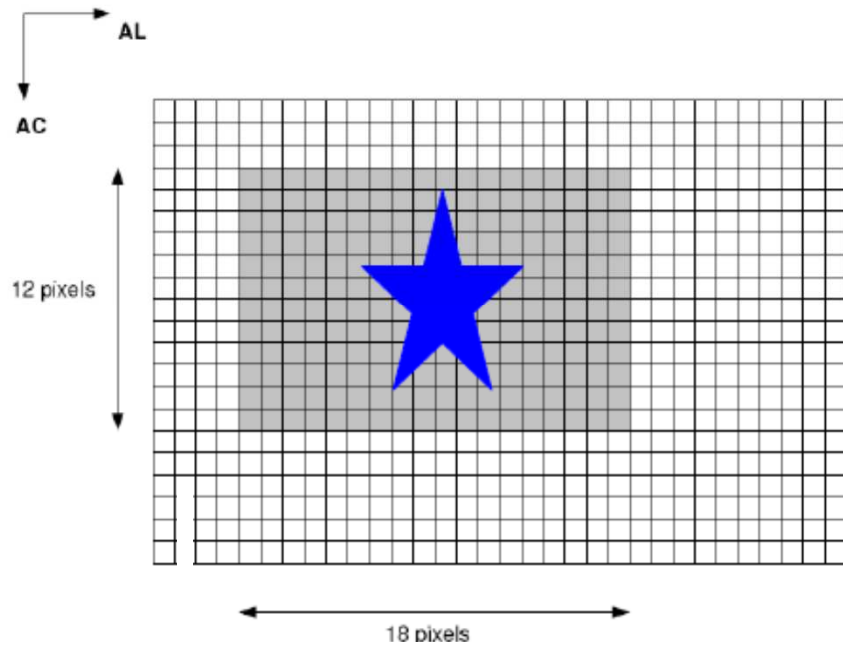
Data reception



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Complexity of the data



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Photometry

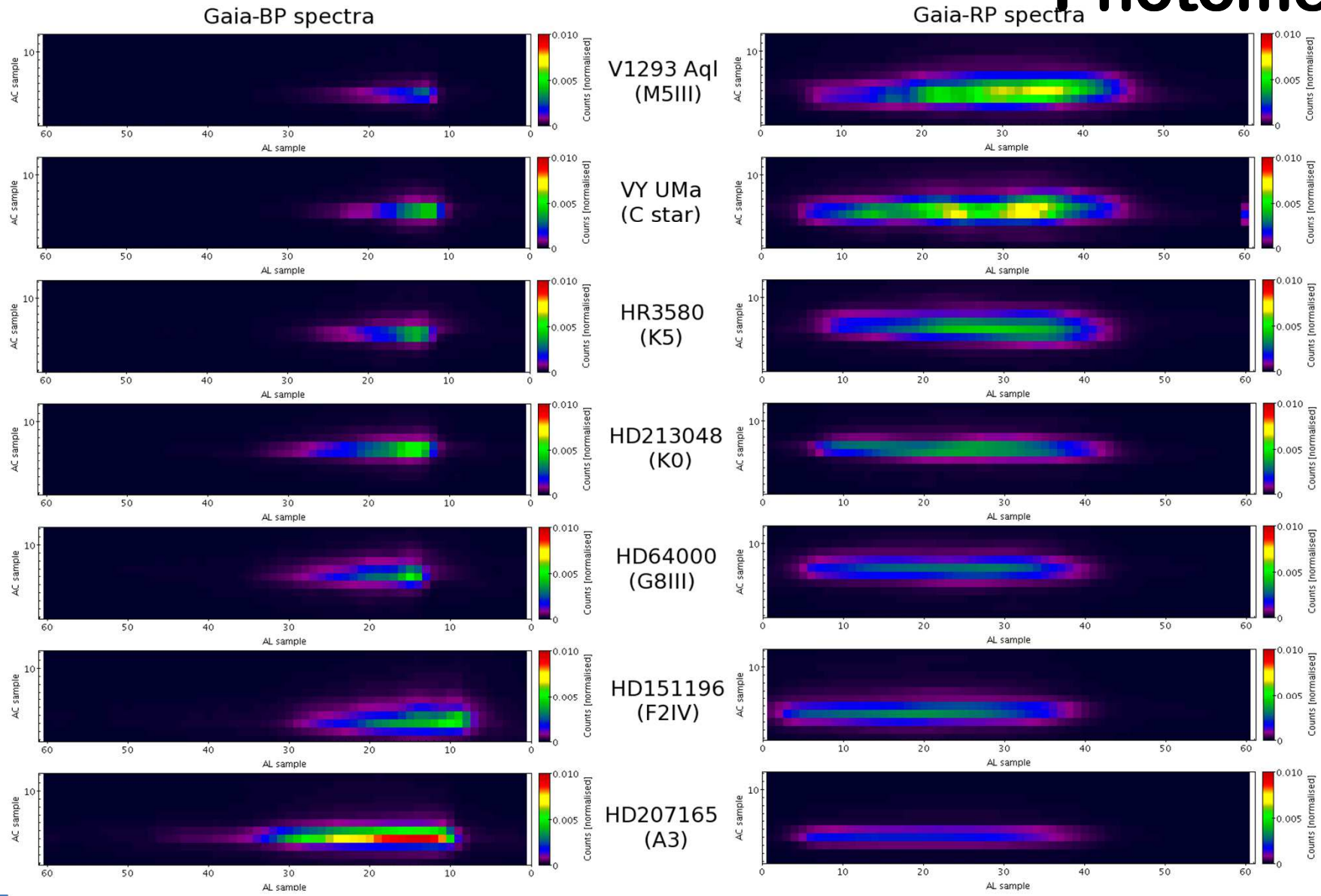
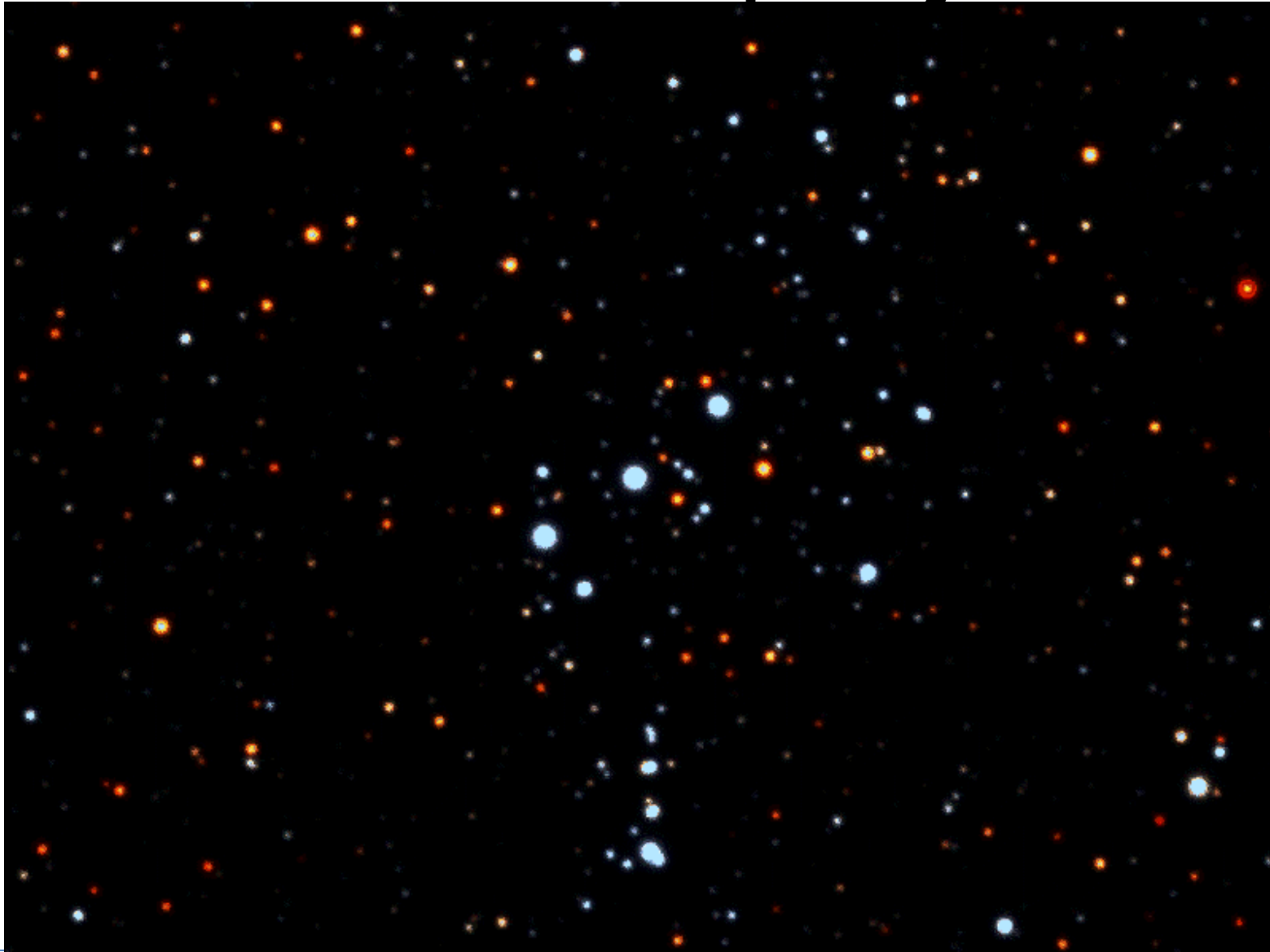


Figure by JM Carrasco



Complexity of the data



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Spectroscopy

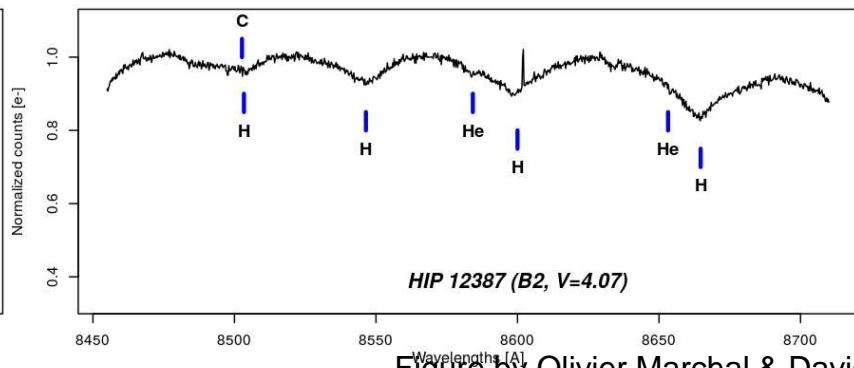
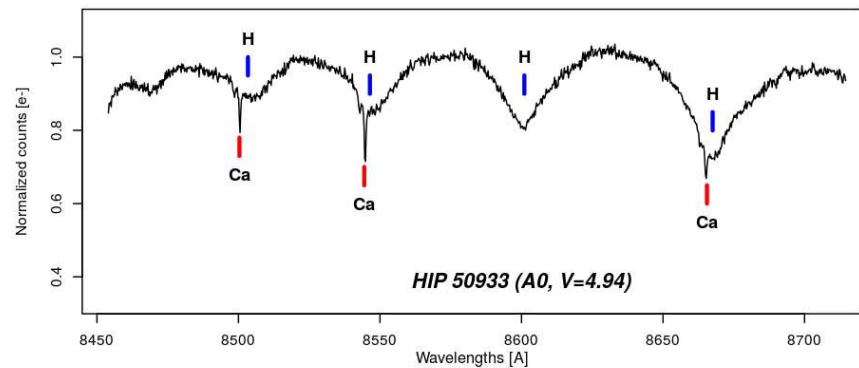
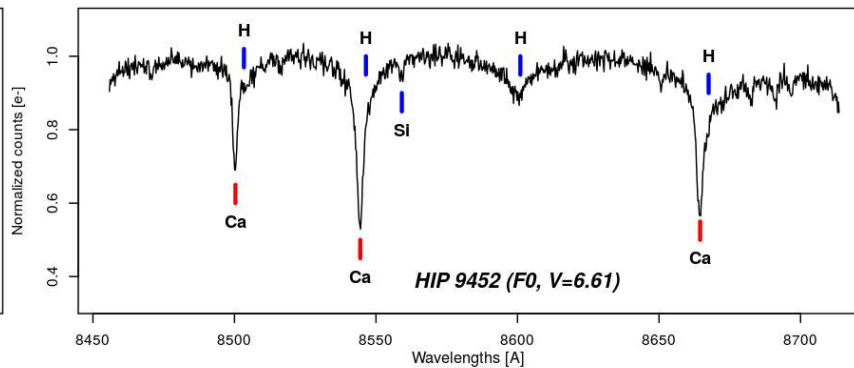
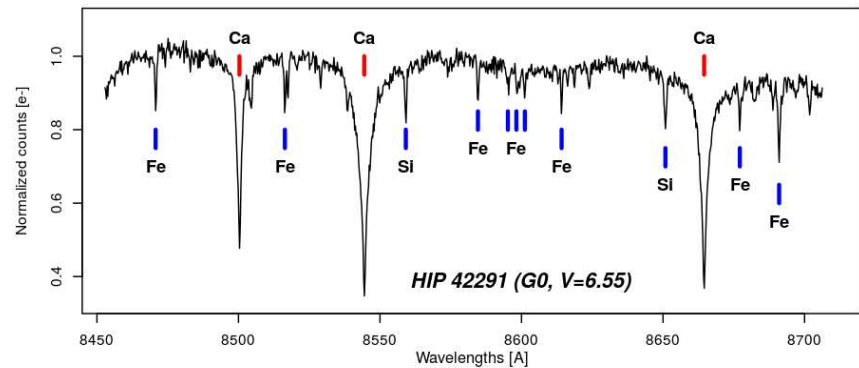
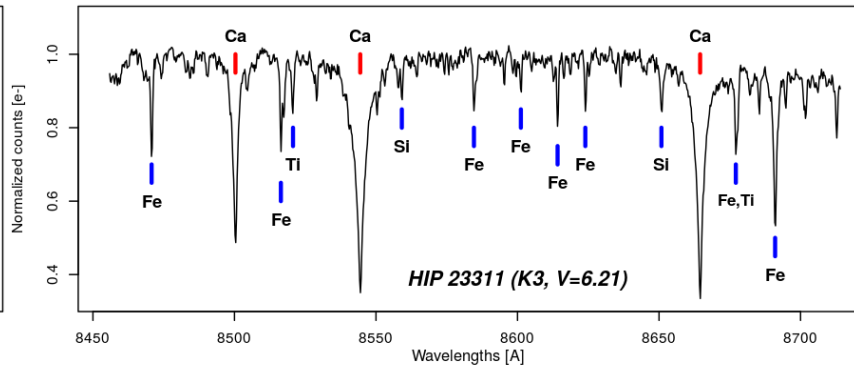
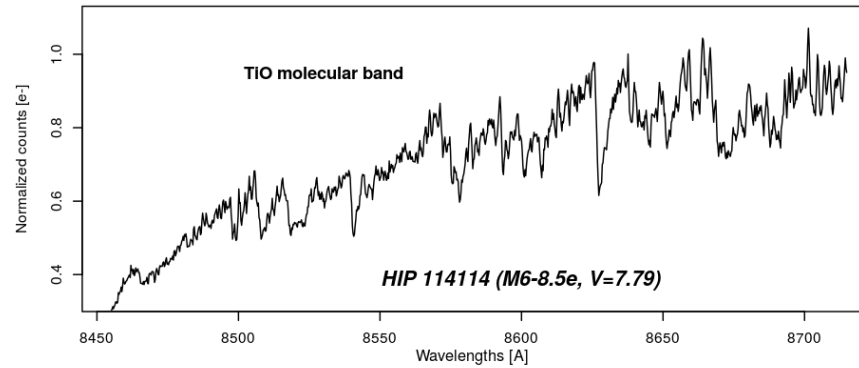


Figure by Olivier Marchal & David Katz



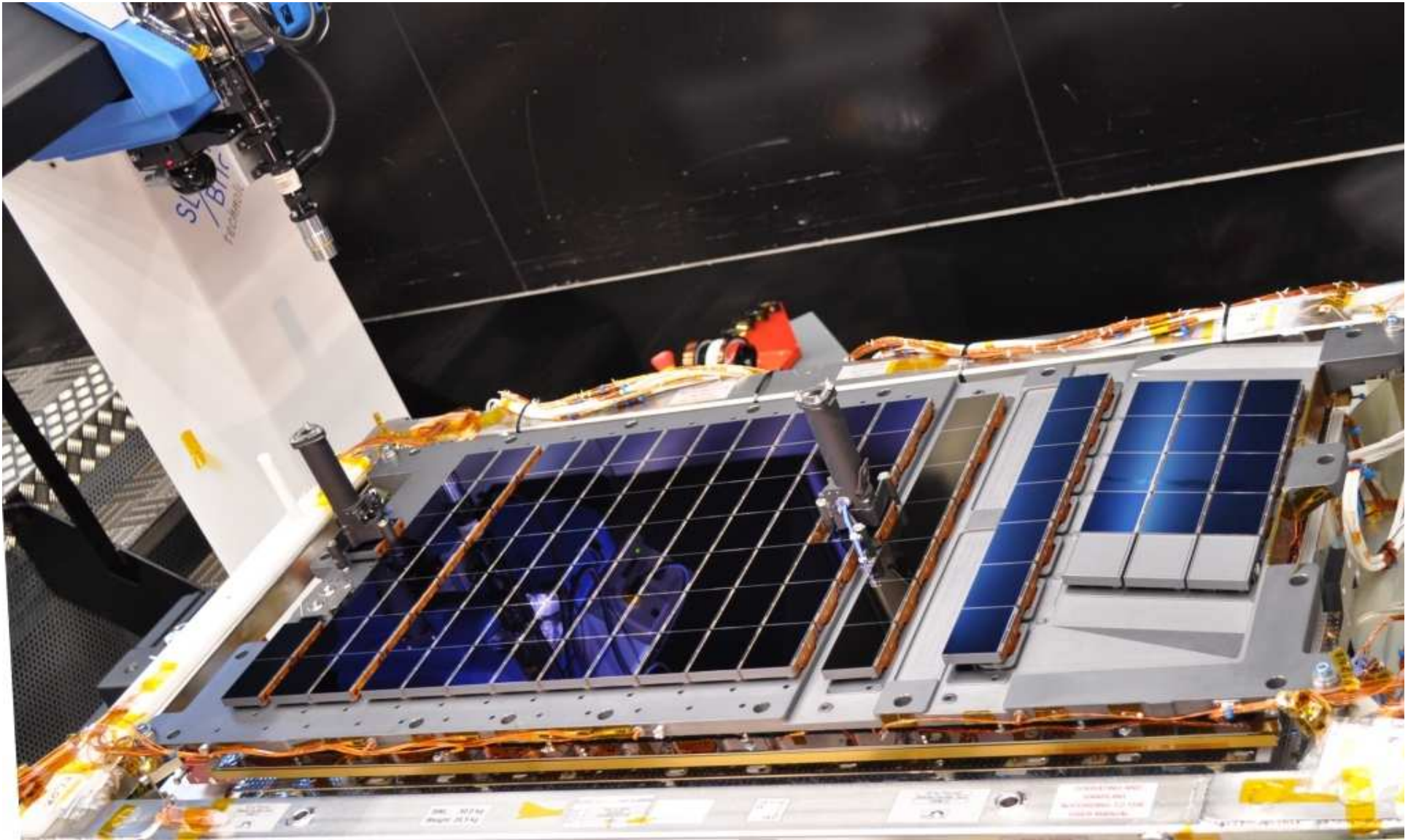
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Complexity of the data



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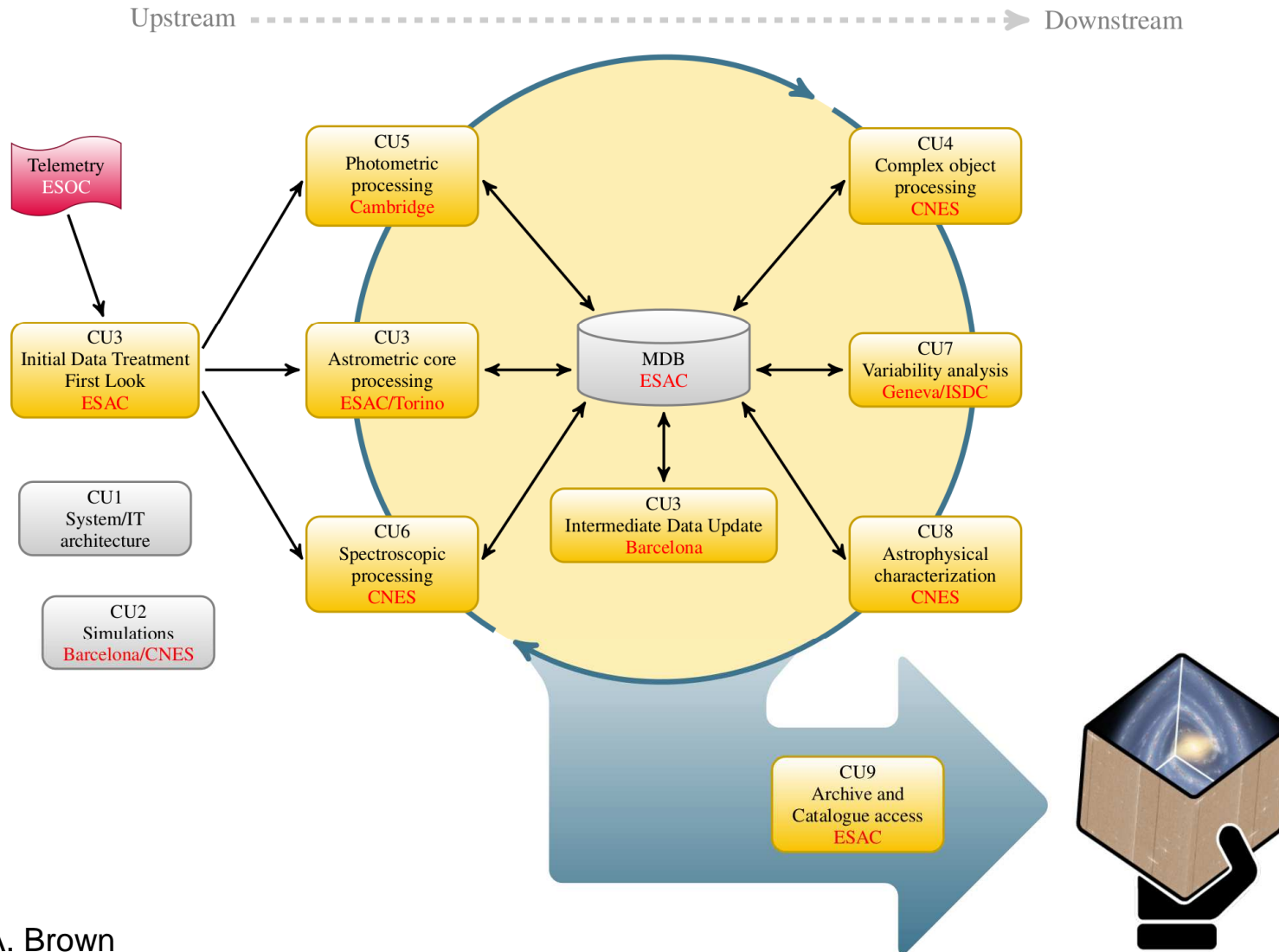


Figure by A. Brown



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Sky coverage since mid-July

Number of observations per square degree since start of nominal operations

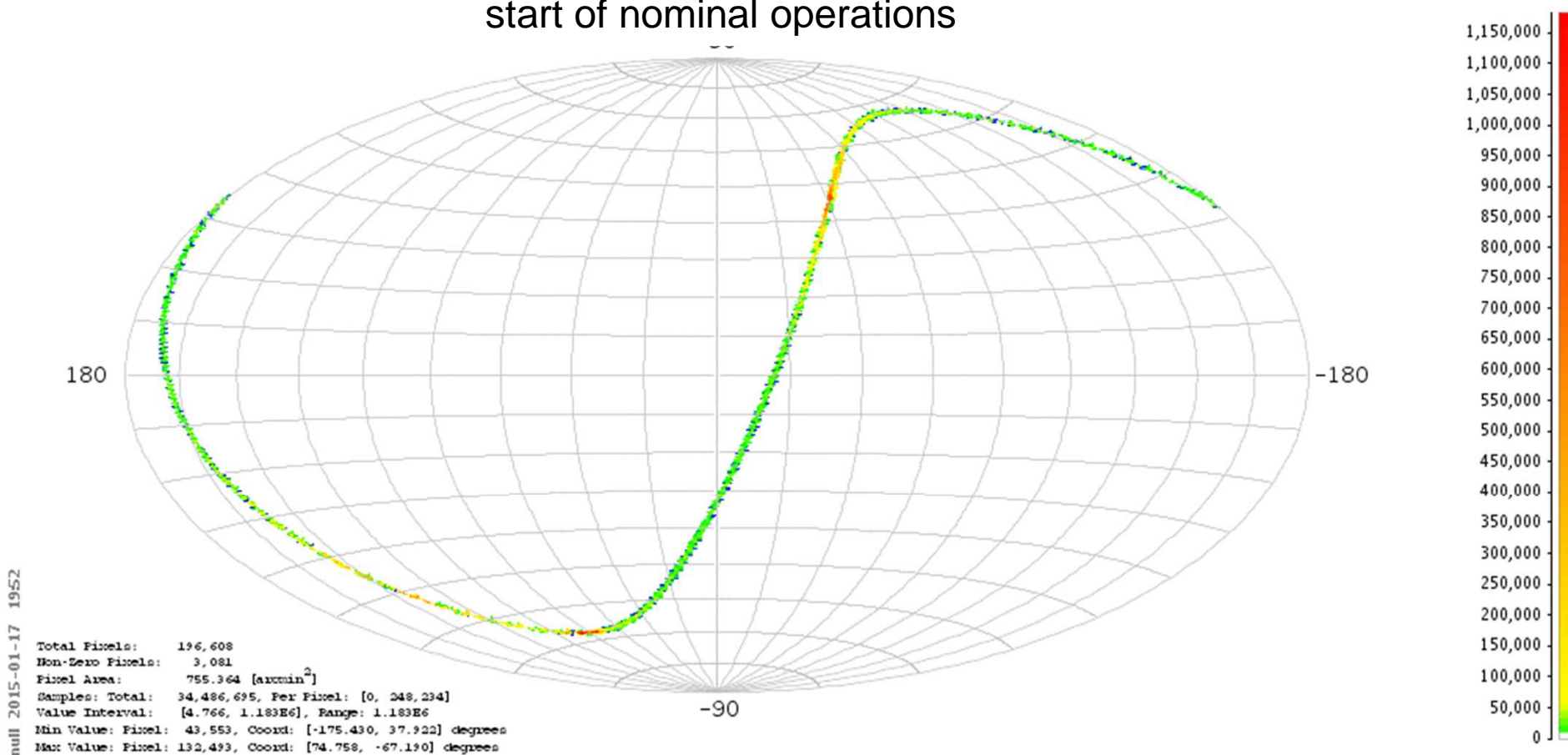


Figure by J. Portell



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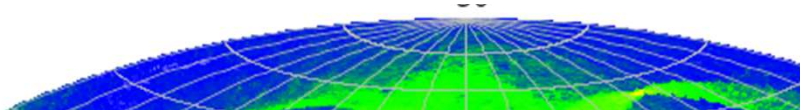


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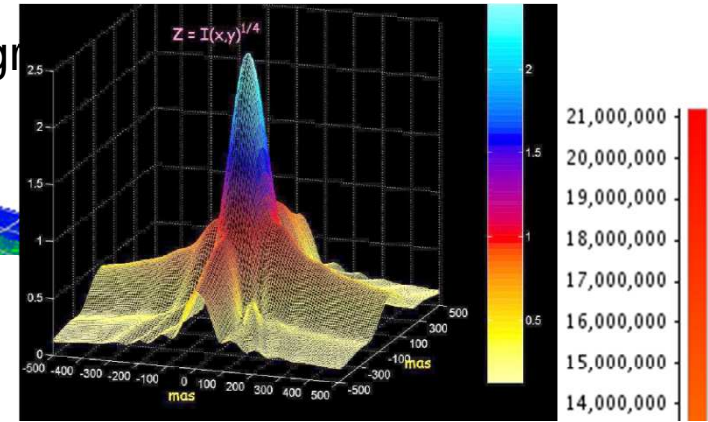


Sky coverage since mid-July

Number of observations per square degree
start of nominal operations

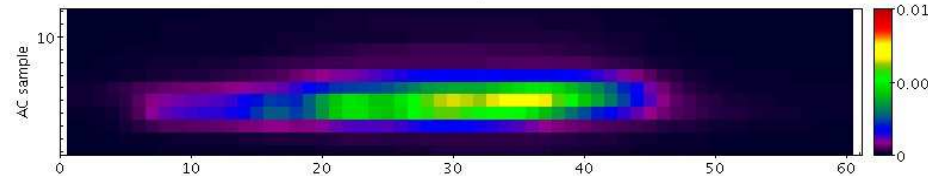


**6 months of nominal mission:
full sky coverage
10 billion observations**



Gaia-RP spectra

V1293 Aql
(M5III)

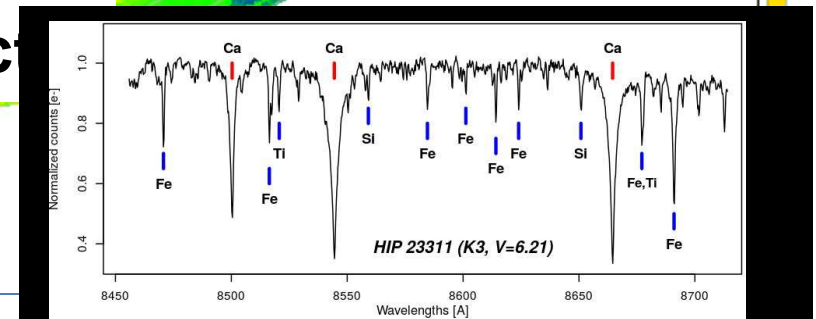


**90 billion of individual images
20 billion of low-resolution spectra
2.4 billion of high-resolution spectra**



null 2015-01-17 20:01

Tot:
Non:
Pixel Area: 755.364 [arcmin²]
Samples: Total: 8,992,998,076, Per Pixel: [260, 4,446,314]
Value Interval: [1.239.137, 2.119E7], Range: 2.119E7
Min Value: Pixel: 632, Coord: [41.484, 10.503] degrees
Max Value: Pixel: 132,452, Coord: [83.571, -66.817] degrees



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Processing needs

Raw data:

50 GB every day during 5 years → 100 TB

Ingestion

Pre-processing

Data reduction

Classification

Variability analysis

etc.



300 million hours
of CPU time

34,000 years !!!



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Processing needs



Six supercomputer centres in place for Gaia: the final data will be available around early 2020s

... and, early releases !!!!



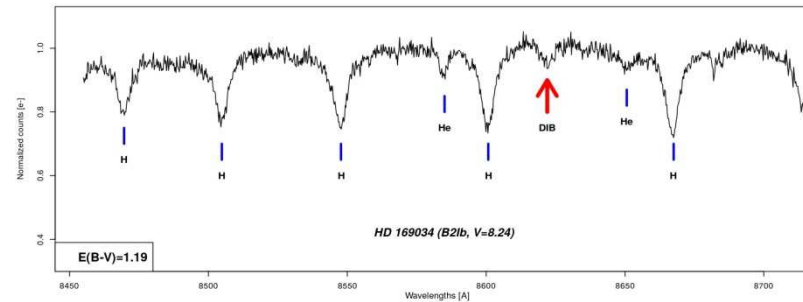
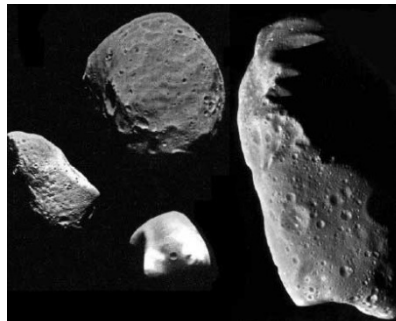
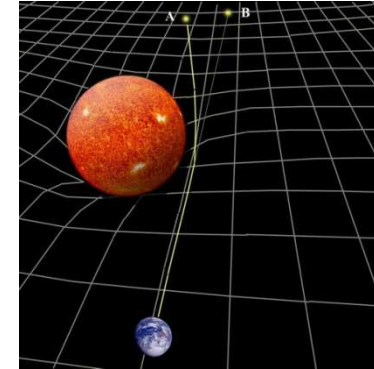
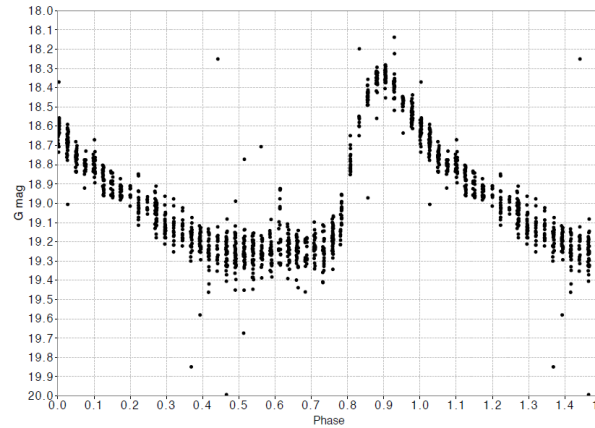
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Final archive



**Archive: DB +
Data tools for
mining,
visualization,
analysis, ...**

**Size: 1 Petabyte = 1 million GB
(movie with a run time of 50 yr in HD quality)**



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Science exploitation

Access to the archive:

No priority data rights for people involved
Free access to the world wide community

Necessary:

Sharing information
Sharing tools and models
Training young generation of scientists

GREAT: Gaia Research for European Astronomy Training



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Looking forward

10 kpc

1000 million objects measured to $1 = 20$

20 kpc

>20 globular clusters
Many thousands of Cepheids and RR Lyrae

Horizon for proper motions accurate to 1 km/s

Mass of galaxy from rotation curve at 15 kpc

Sun

30 open clusters within 500 pc

Dark matter in disc measured from distances/motions of K giants

Horizon for detection of Jupiter mass planets (200 pc)

Dynamics of disc, spiral arms, and bulge

Proper motions in LMC/SMC individually to 2-3 km/s

Horizon for distances accurate to 1.0 per cent

General relativistic light-bending determined to 1 part in 10^6

1 microarcsec/yr = 300 km/s at $z = 0.03$
(direct connection to inertial)



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A satellite with a cylindrical body and a large, flat, reflective solar panel is shown in space. The background is a dense field of stars of various colors (blue, white, orange, red) against a dark cosmic background. The satellite is positioned on the left side of the frame, angled towards the viewer.

1,000,000,000 stars

1,000,000,000 pixels

more than 1,000 people

more than 10,000 scientists

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





The promises of Gaia

- u > 1 billion stars to $G = 20$
- u 10^6 – 10^7 galaxies
- u $5 \cdot 10^5$ quasars
- u $3 \cdot 10^5$ solar system bodies
- u tens of thousands of exoplanets



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Data collected and processed

Statistics up to June 29

Data collected or processed		
Type of Data	Amount	
Science telemetry	5.9 TB	
Astrometry transits	6.5×10^9	64.5×10^9 images
Photometry transits	6.1×10^9	12×10^9 images
Spectroscopy transits	1×10^9	3×10^9 spectra



How many data ?

Since beginning of nominal mission: **137 days**

Raw data received: **3.6 TB**
(26GB/day)

Received & processed measurements: **> 6250 million**
(50-100 million/day)

Received & processed images: **> 75000 million**

Size of the main data base: **30 TB (compressed)**

Initial Data Treatment:

Accumulated processing time: **~50 yr**

Processing cores used: **~280**
(9 nodes x 32 cores, 64GB RAM/node)



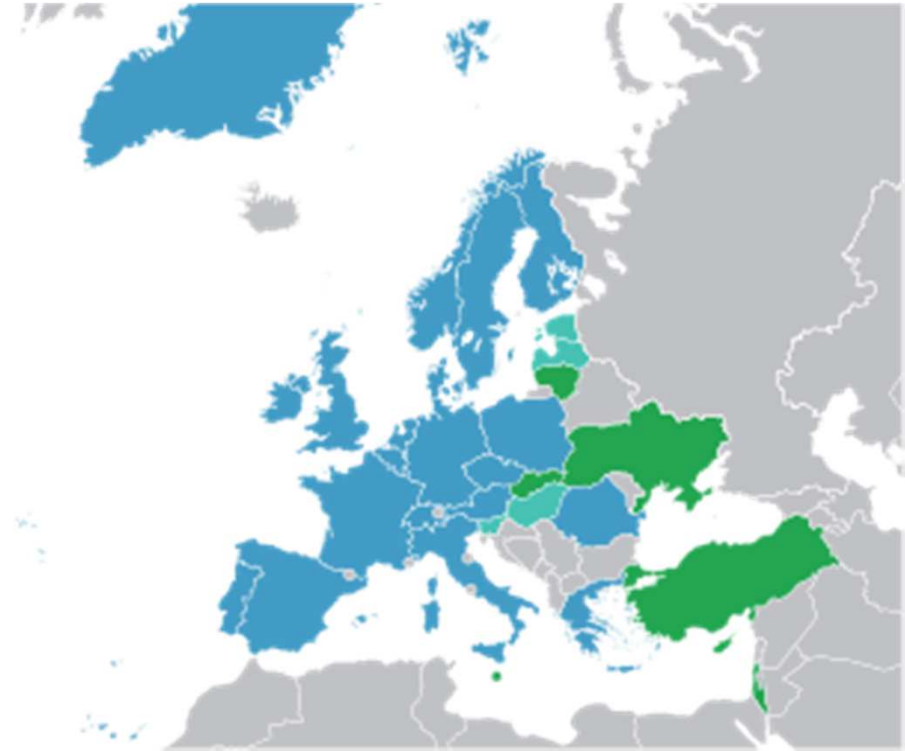
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Horizon 2000+
Cornerstone mission

Scientific mission: Astronomy

ESA's only mission



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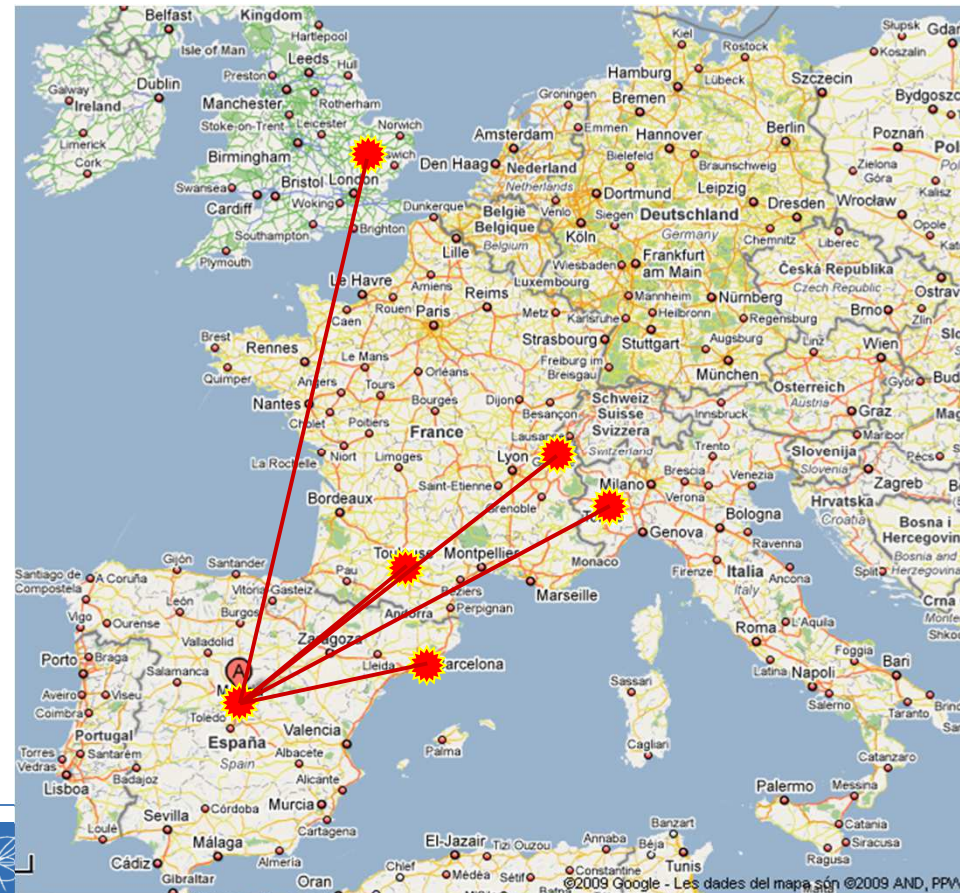


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Següents passos

- Seguir amb aquest processament diari fins al final de missió (finals 2019... en principi!)
- Acumulació regular de dades, distribuïnt-ho (com fins ara) als altres centres de processament de dades (incloent MareNostrum)
- Execució dels sistemes iteratius (cíclics) de reducció de dades
- Primera versió del catàleg: **2016**



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Processament de dades



Centre d'Operacions Científiques:
ESAC (Villafranca del Castillo, vora Madrid)

- Sistemes d'operacions de càrrega útil
- Equip de Calibració
- Interfície amb el Centre d'Operacions de la Missió (MIT)
- Descompressió de dades (DCS)
- Sistema de processament diari (IDT)
- Sistema de diagnòstic inicial i determinació de calibracions (FL)



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