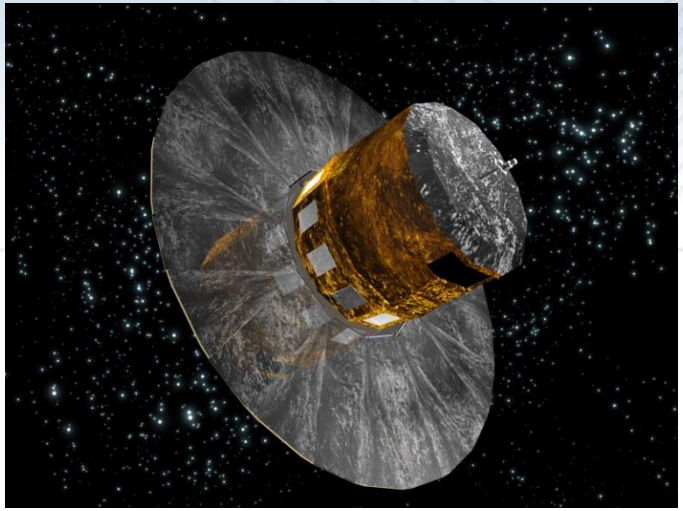


Gaia for AGN and Extragalactic Science
8 July 2015

The Radial Velocity Spectrometer (RVS)
A spectrograph on-board Gaia

D. Katz (on behalf of the RVS people)

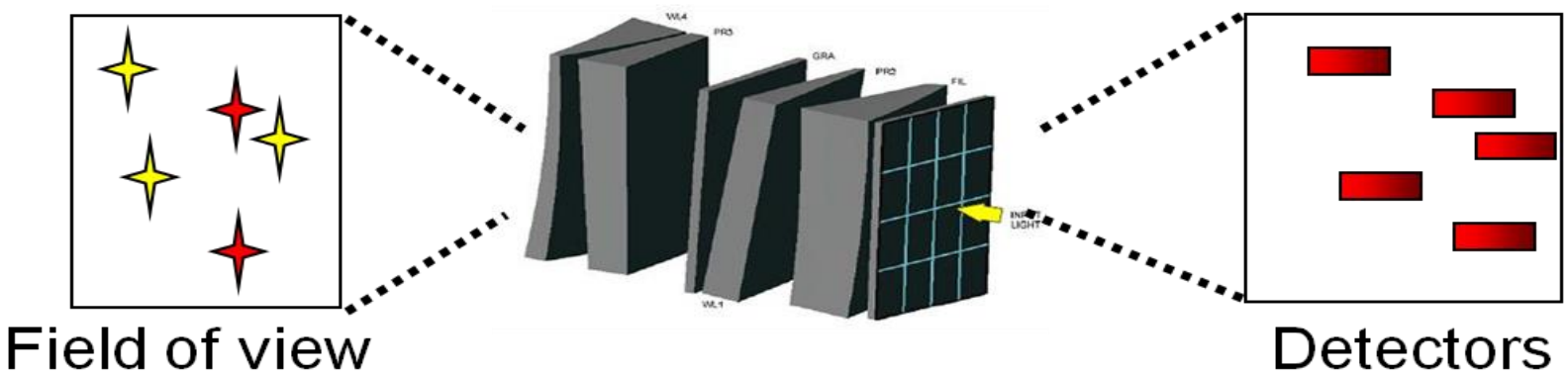
l'Observatoire de Paris | GEPI

Galaxies Étoiles Physique et Instrumentation

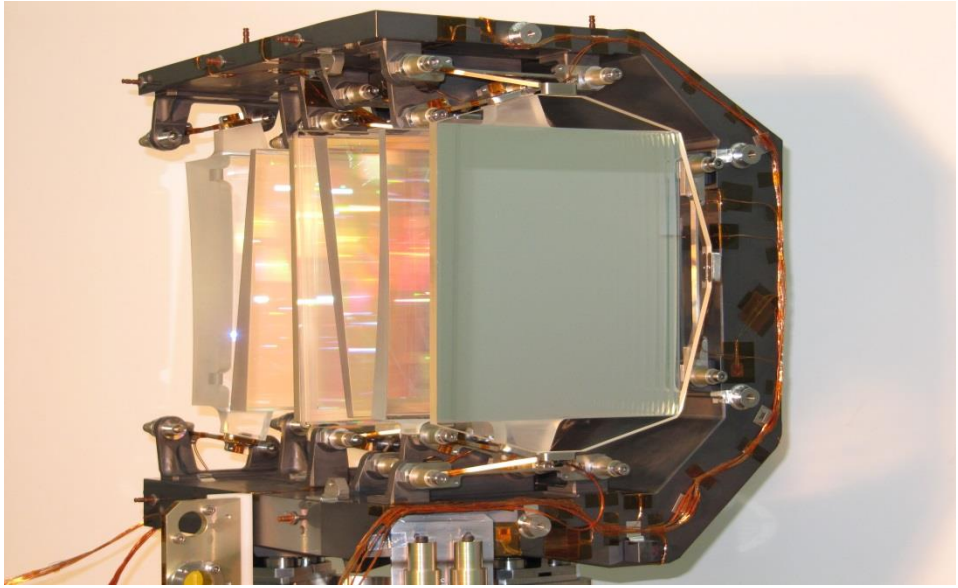
Radial Velocity Spectrometer Concept

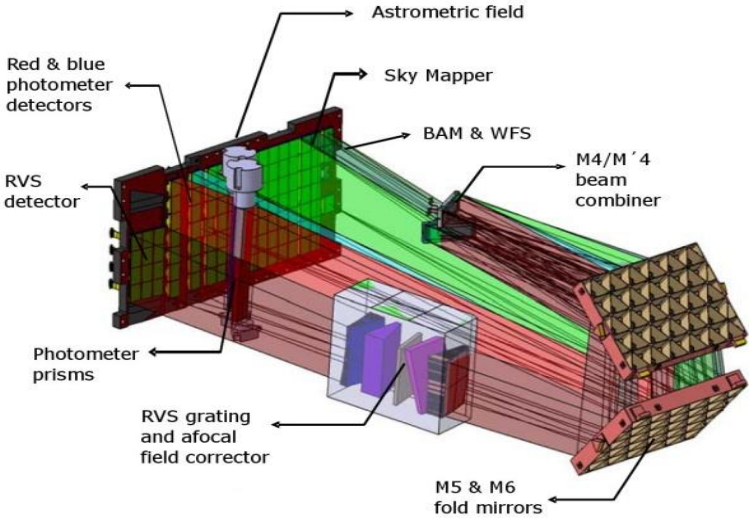
- **Integral field spectrograph**
  - All the light entering the field of view is dispersed on the focal plane

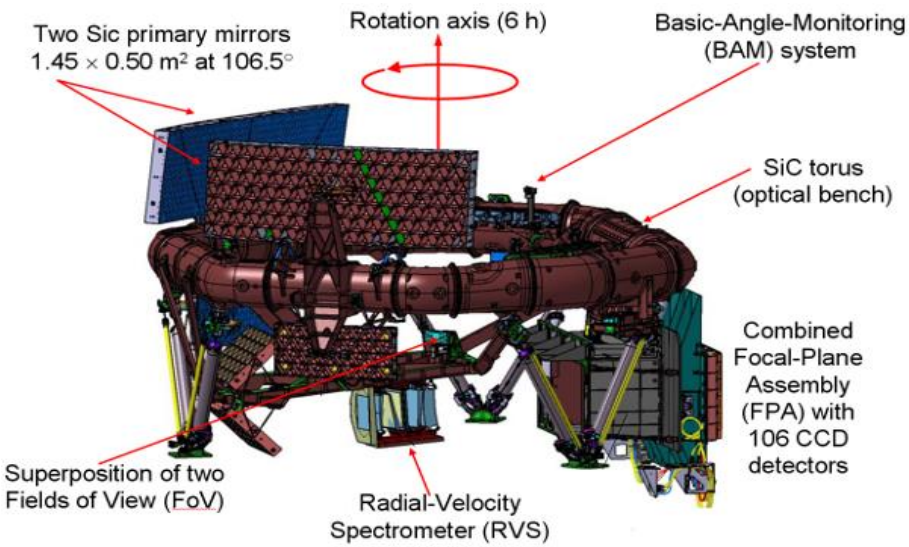
- **Resolving power** $R = \lambda / \Delta\lambda = 11\,500$
- **Wavelength range** [845, 872] nm
- **Multi-epoch scan** 40 epochs on average over 5 years



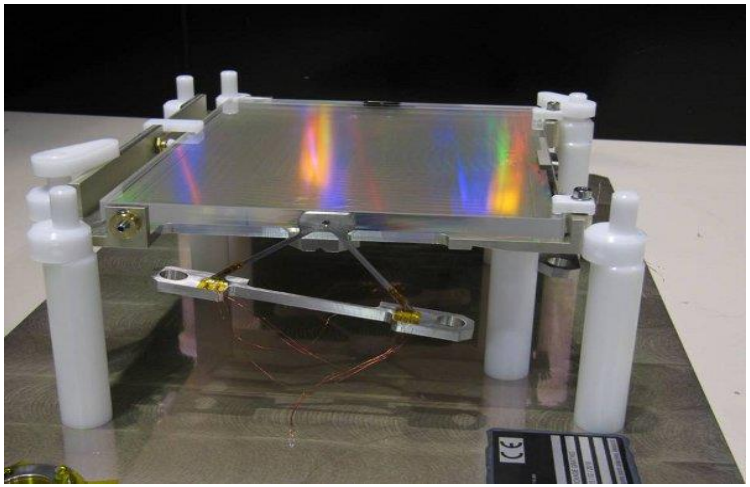
RVS design



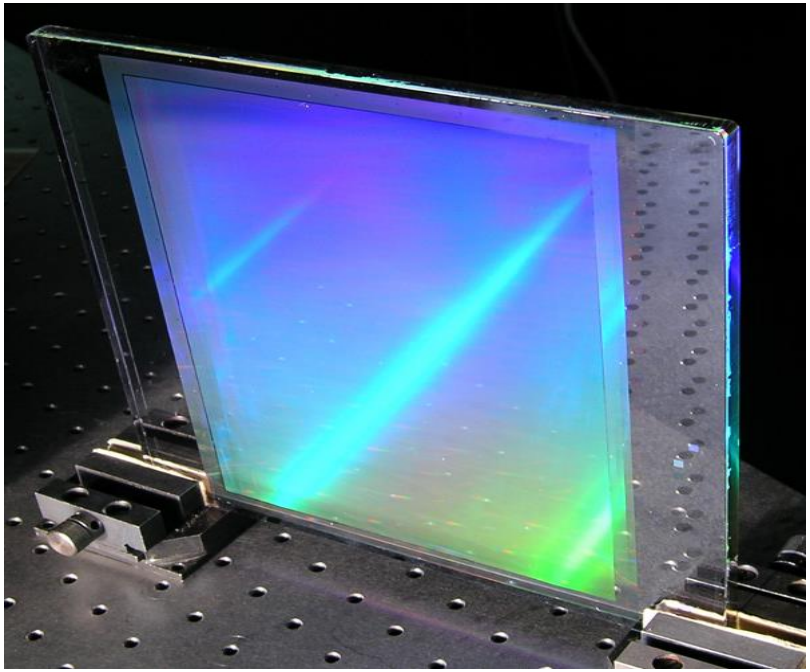

Astrometric field
Red & blue photometer detectors
Sky Mapper
BAM & WFS
M4/M´4 beam combiner
RVS detector
Photometer prisms
RVS grating and afocal field corrector
M5 & M6 fold mirrors

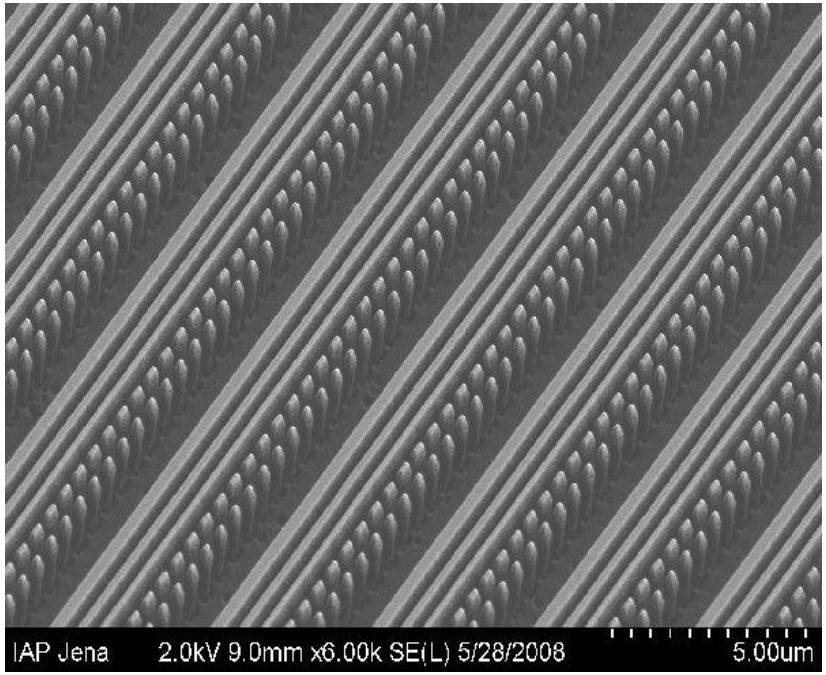

Two Sic primary mirrors 1.45 × 0.50 m² at 106.5°
Rotation axis (6 h)
Basic-Angle-Monitoring (BAM) system
SiC torus (optical bench)
Combined Focal-Plane Assembly (FPA) with 106 CCD detectors
Superposition of two Fields of View (FoV)
Radial-Velocity Spectrometer (RVS)

RVS grating

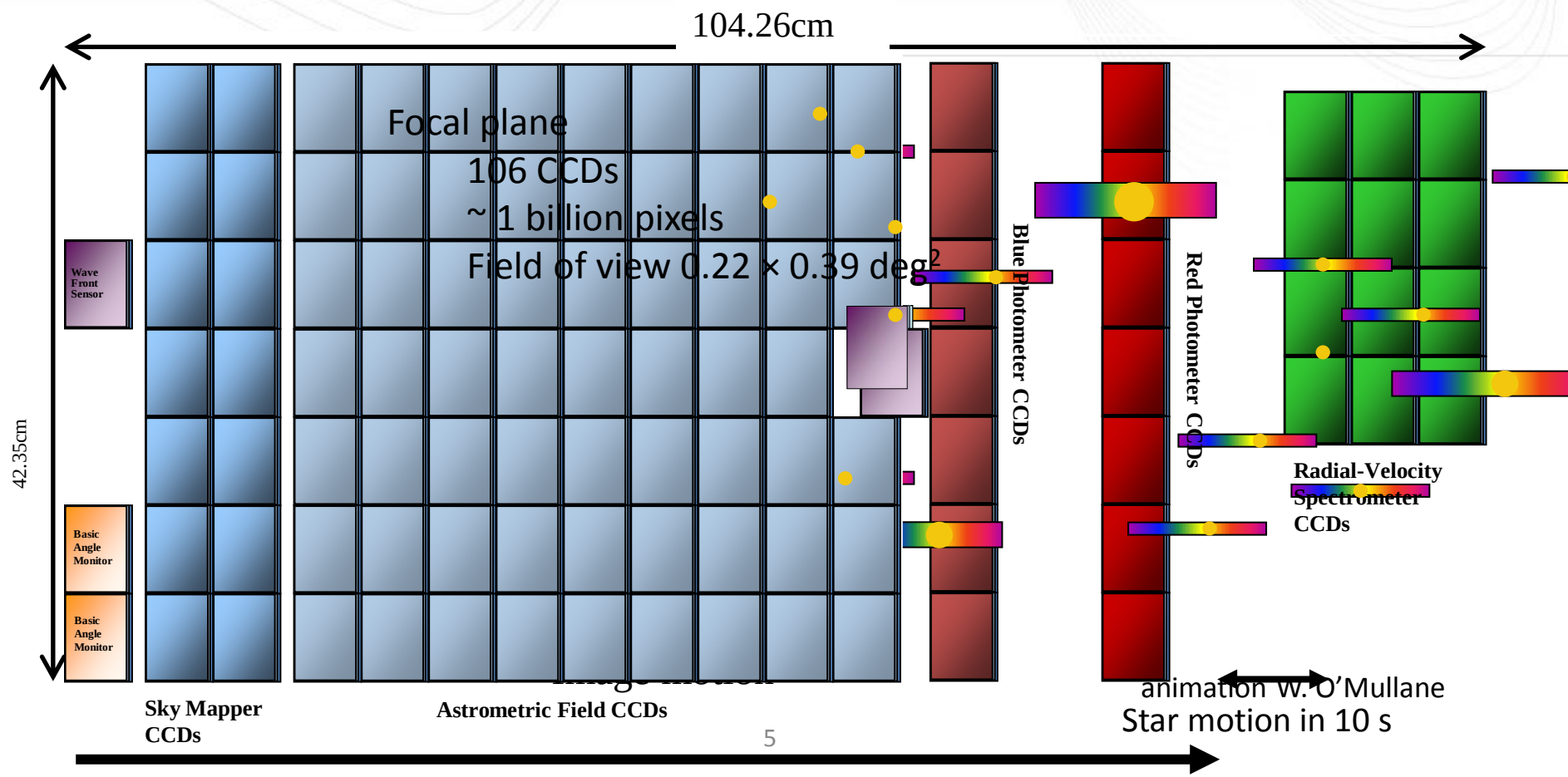


- **Grating**
  - 20.5 × 15.5 × 0.9 cm
  - Specific design for high transmission > 80%





Astrometry, photometry and spectroscopy

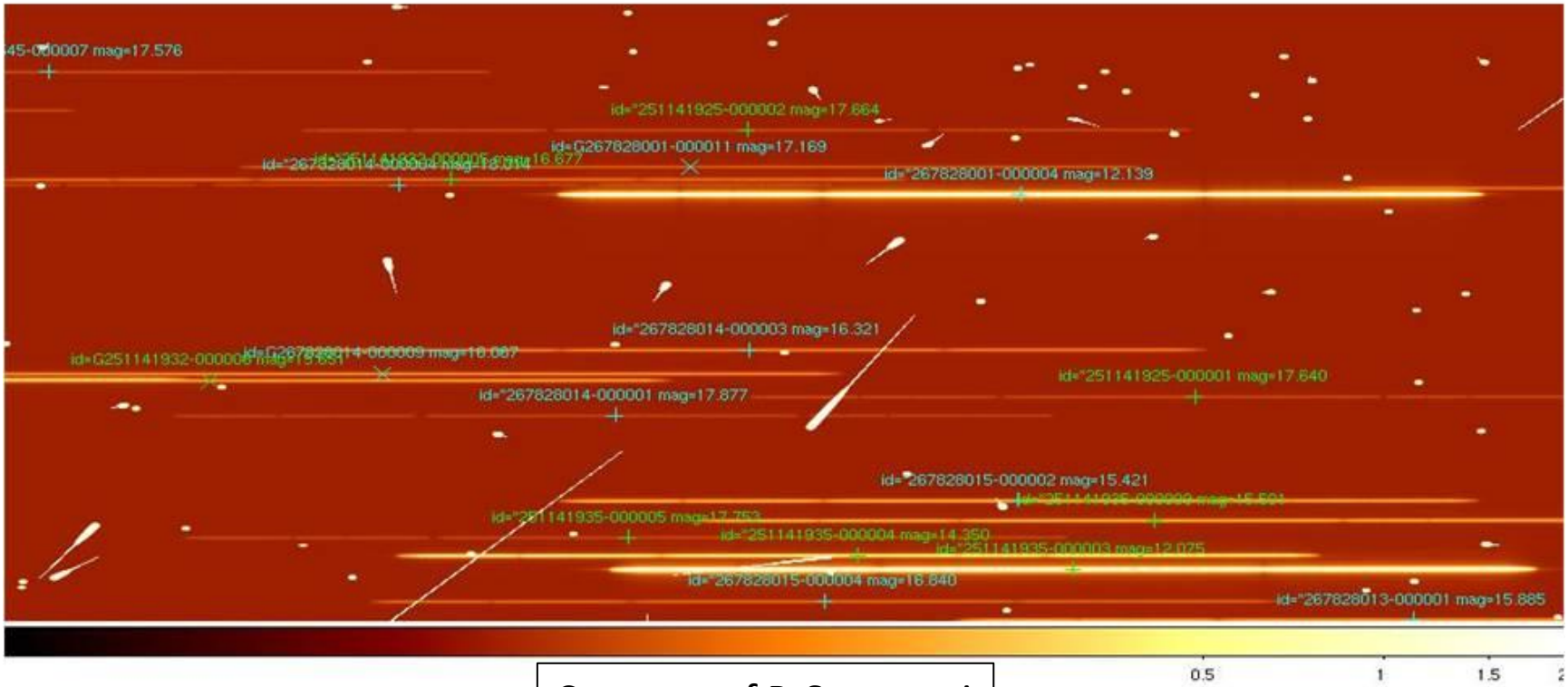


- 106 CCDs
- ~ 1 billion pixels
- Field of view 0.22 × 0.39 deg^2

- 4500 (AL) × 1966 (AC) pixels
- Pixel: 59 × 177 mas (spatial resolution)
- 2 types: **blue enhanced** and **red enhanced**
- Exposure time 4.42 s
- Operated in Time Delay Integration (TDI) mode

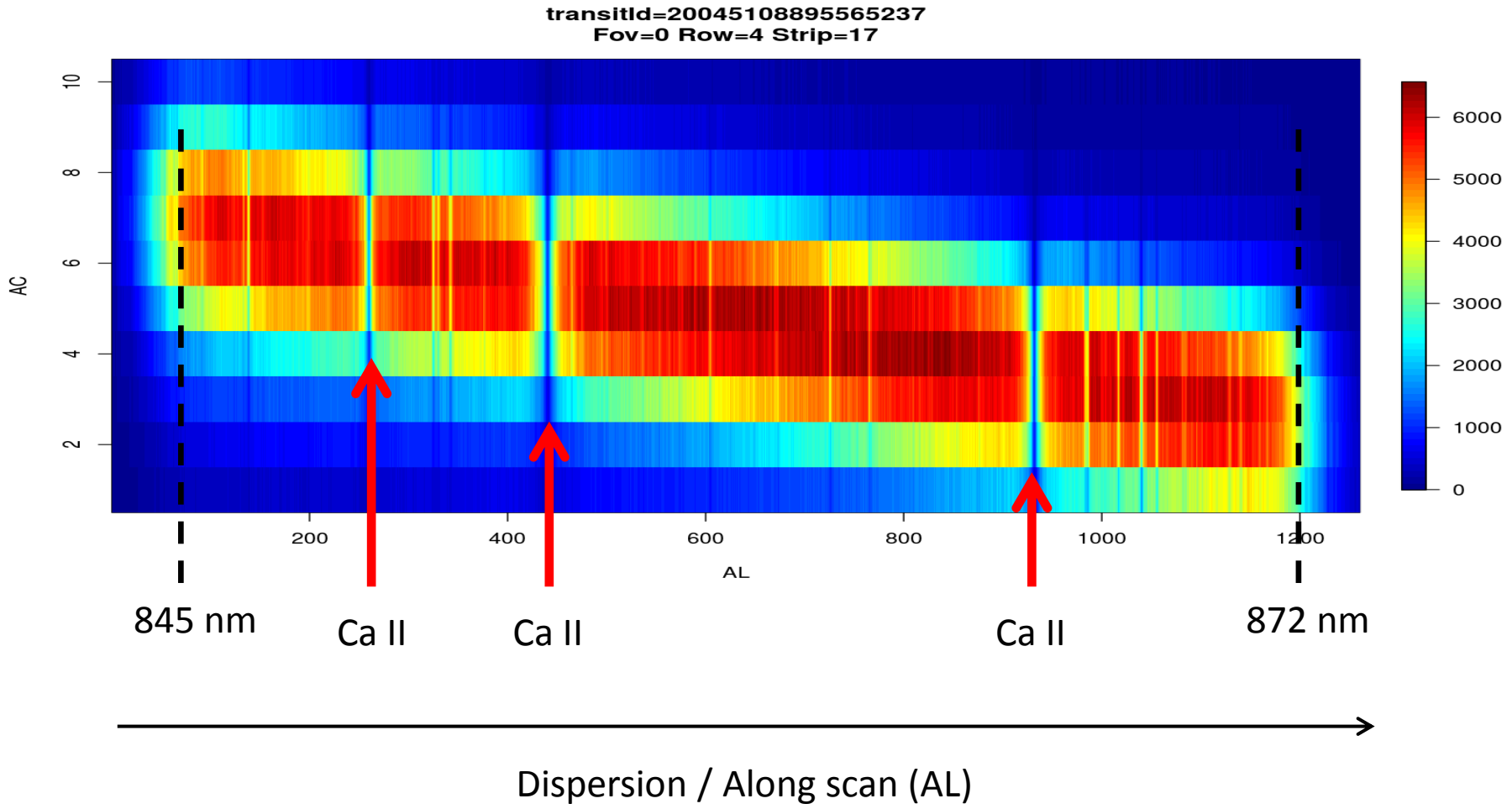
RVS "images"

- **Simulated "image" of the RVS** (using the Gibis simulator)
  - Spectra are 1260 × 10 pixels dispersed parallel to the scan direction
  - Bluest wavelength are leading

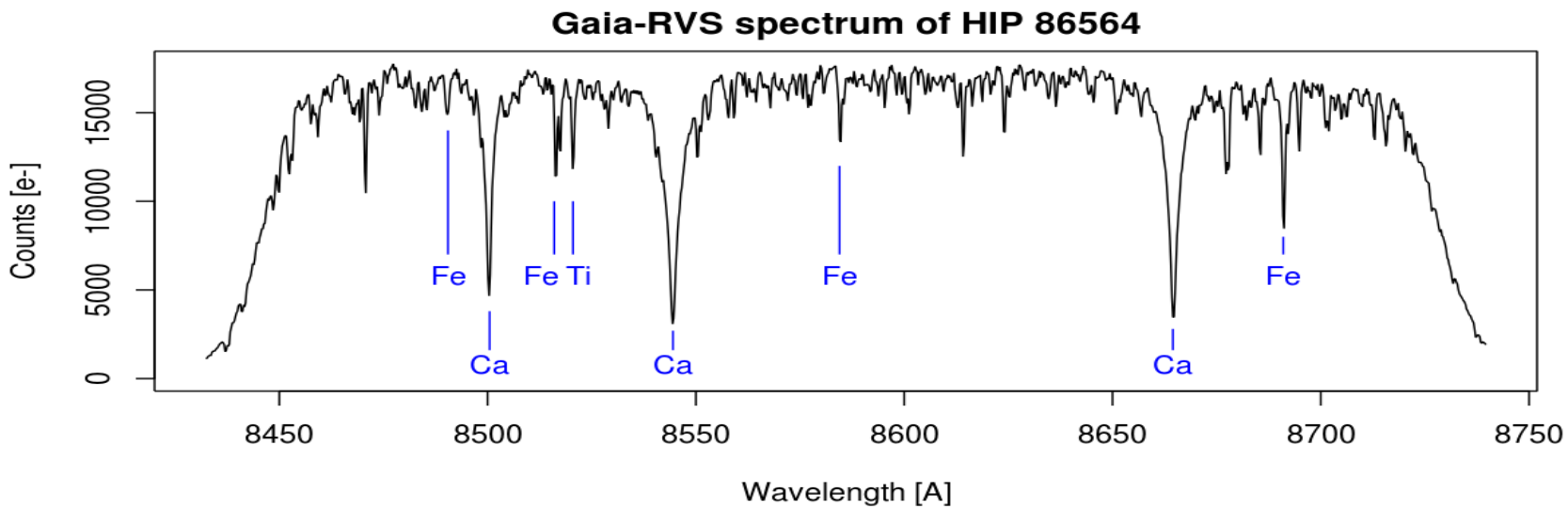


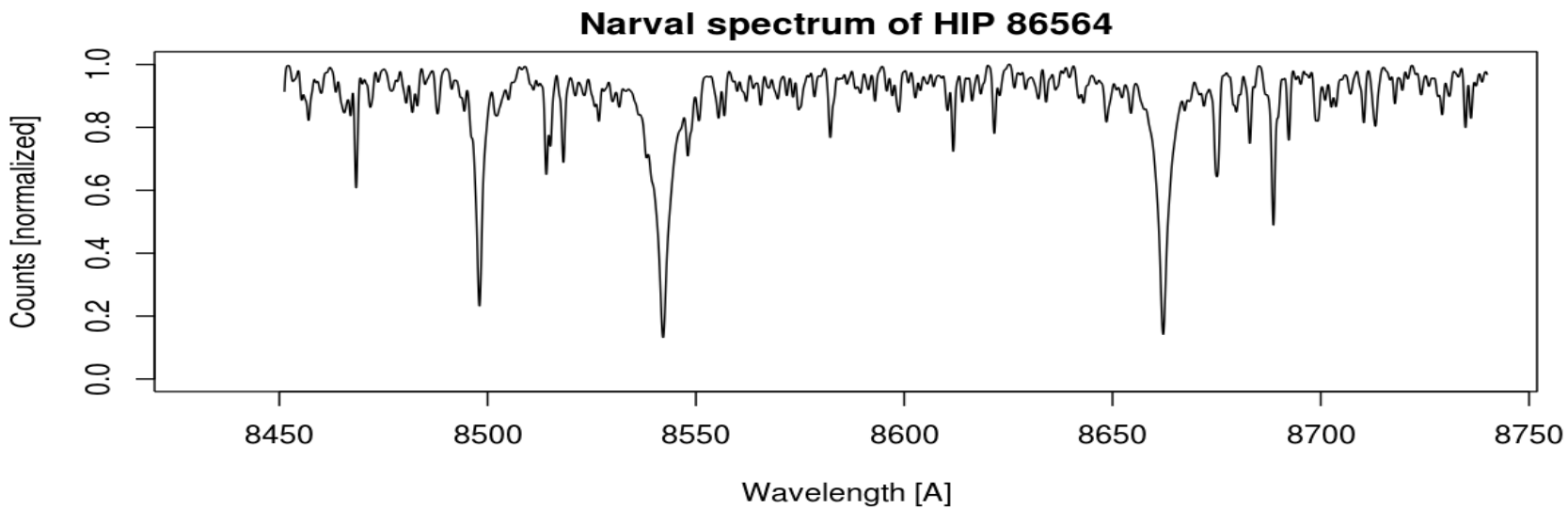
Courtesy of P. Sartoretti

RVS 2D spectrum



1D Spectrum

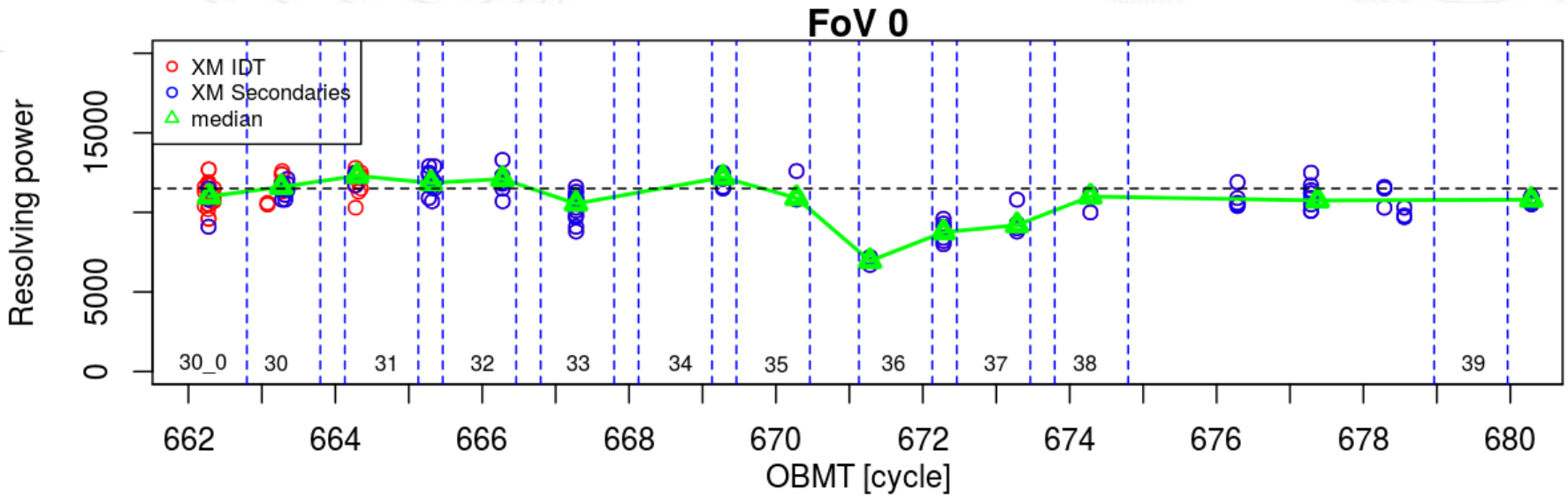


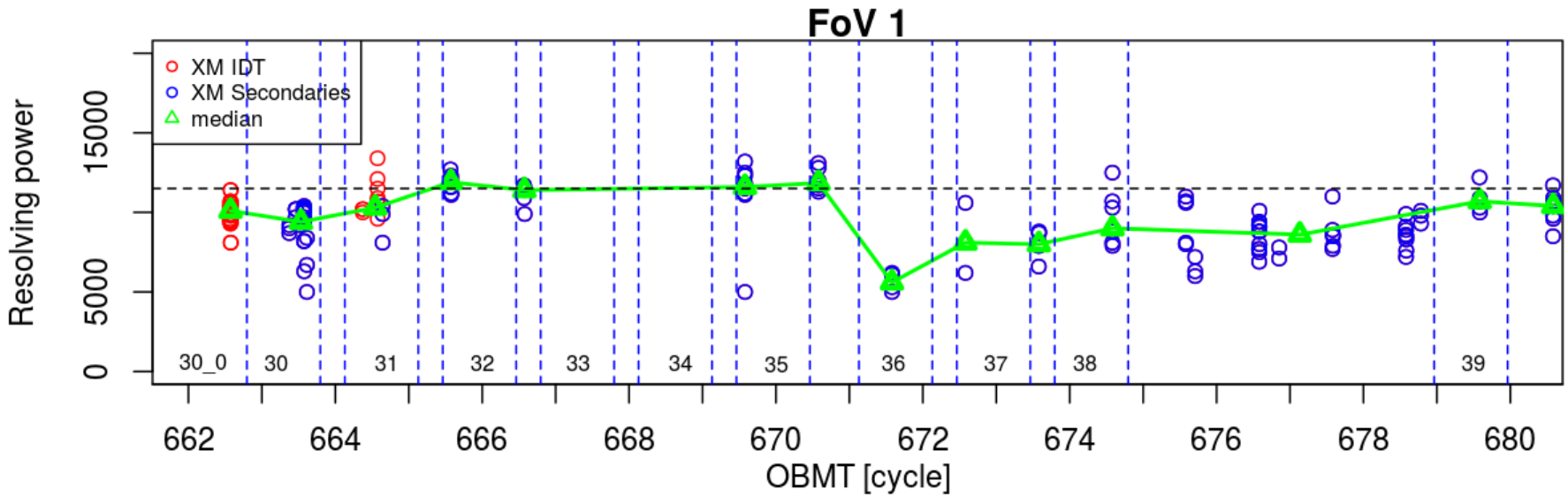


http://www.cosmos.esa.int/web/gaia

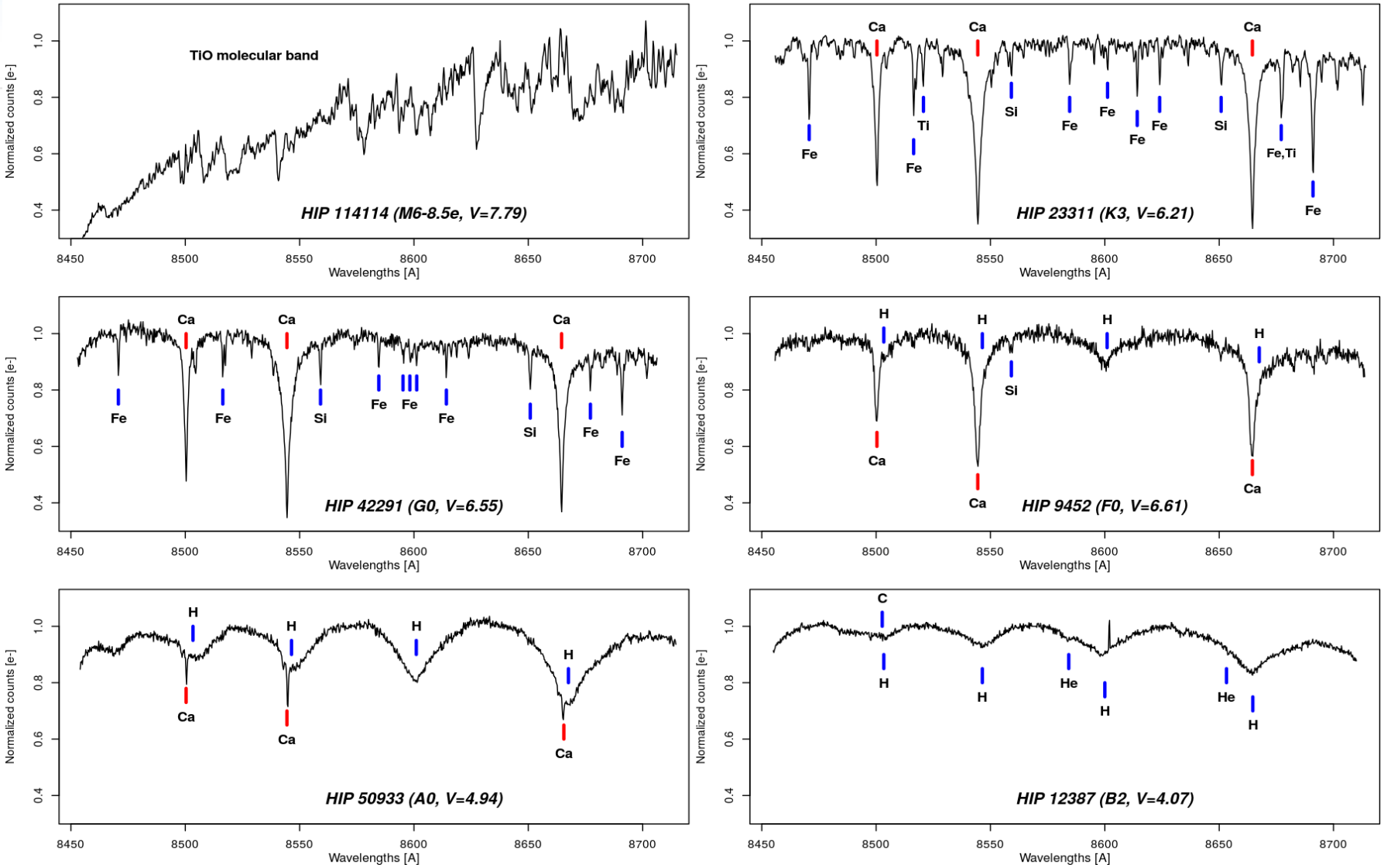
Credits: ESA/Gaia/DPAC/Airbus-DS/
David Katz, Olivier Marchal and Caroline Soubiran

Gaia and RVS focus search (commissioning 2014)





1D Spectra



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

Credits: ESA/Gaia/DPAC/
Olivier Marchal , David Katz

Commissioning

Deep space radio antenna
in Cebreros (Spain)
Credits ESA

December/January: start of the commissioning

- Activation of the data processing and commissioning centres:
  - ESAC (Science Operation Centre)
  - Paris observatory
  - MSSL
  - Heidelberg
  - Cambridge, Edinburgh, …

Commissioning/calibration activities

- CCDs
- On-board software
- Resolving power
- …

RVS is nominal.

Nominal mission started 18 July 14

Volume of data

- June 14 **1.5 10^9 spectra**
- July 14 - June 15 **4.4 10^9 spectra**

Issues

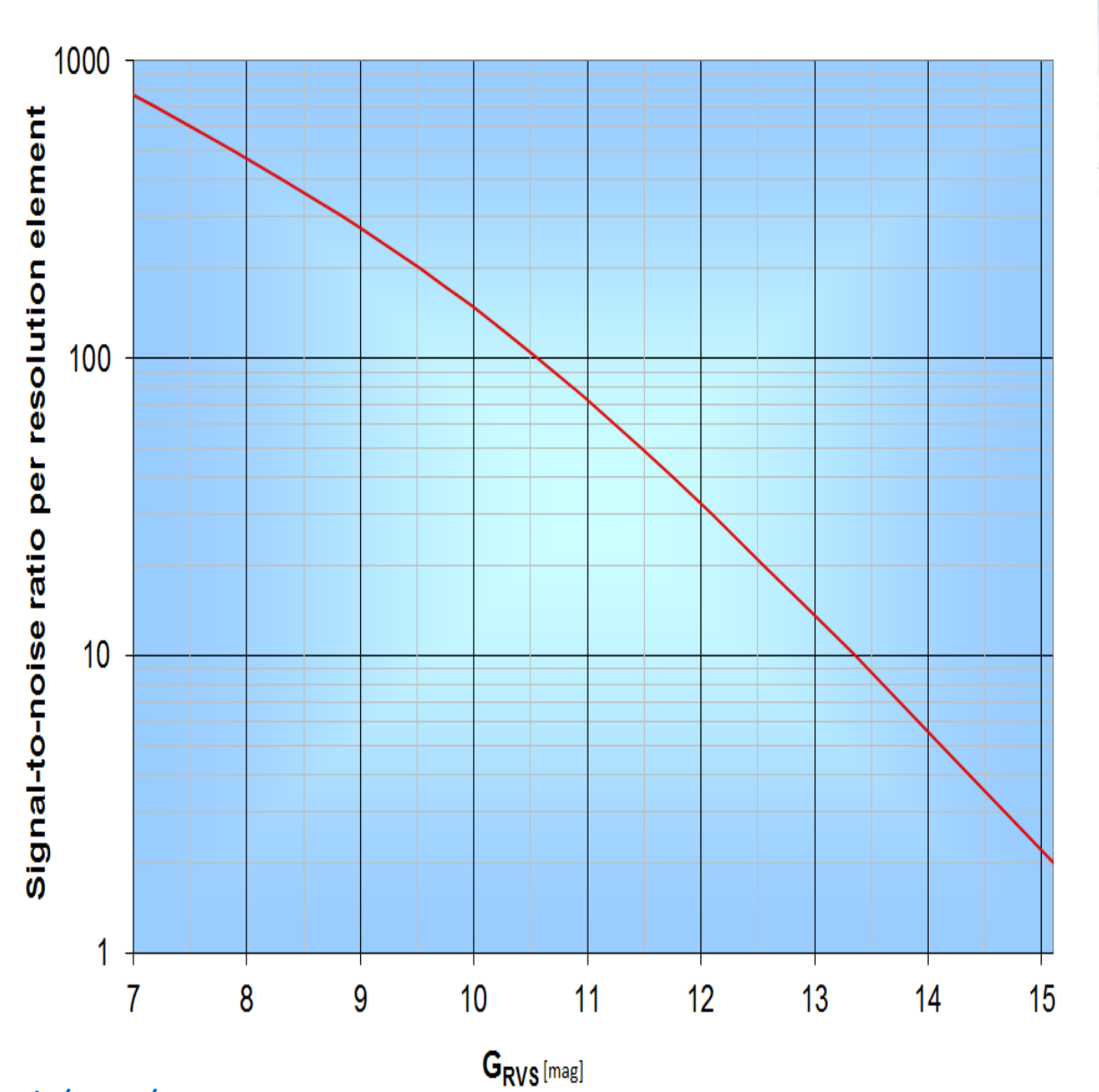
- **Higher level of straylight than expected**
  - ✓ Some impact, in particular, on the RVS faintest stars.
  - ✓ Mostly sun light (for the RVS)
  - ✓ <u>Mitigation:</u> on-board software upgraded to “adapt” the RVS to the straylight (software uploaded and tested in April-May 15).

- **Telescopes slow transmission loss**
  - ✓ Condensation of water ice
  - ✓ <u>Mitigation:</u> heat specific mirrors
  - ✓ Firsts decontaminations fully successful

Signal to noise

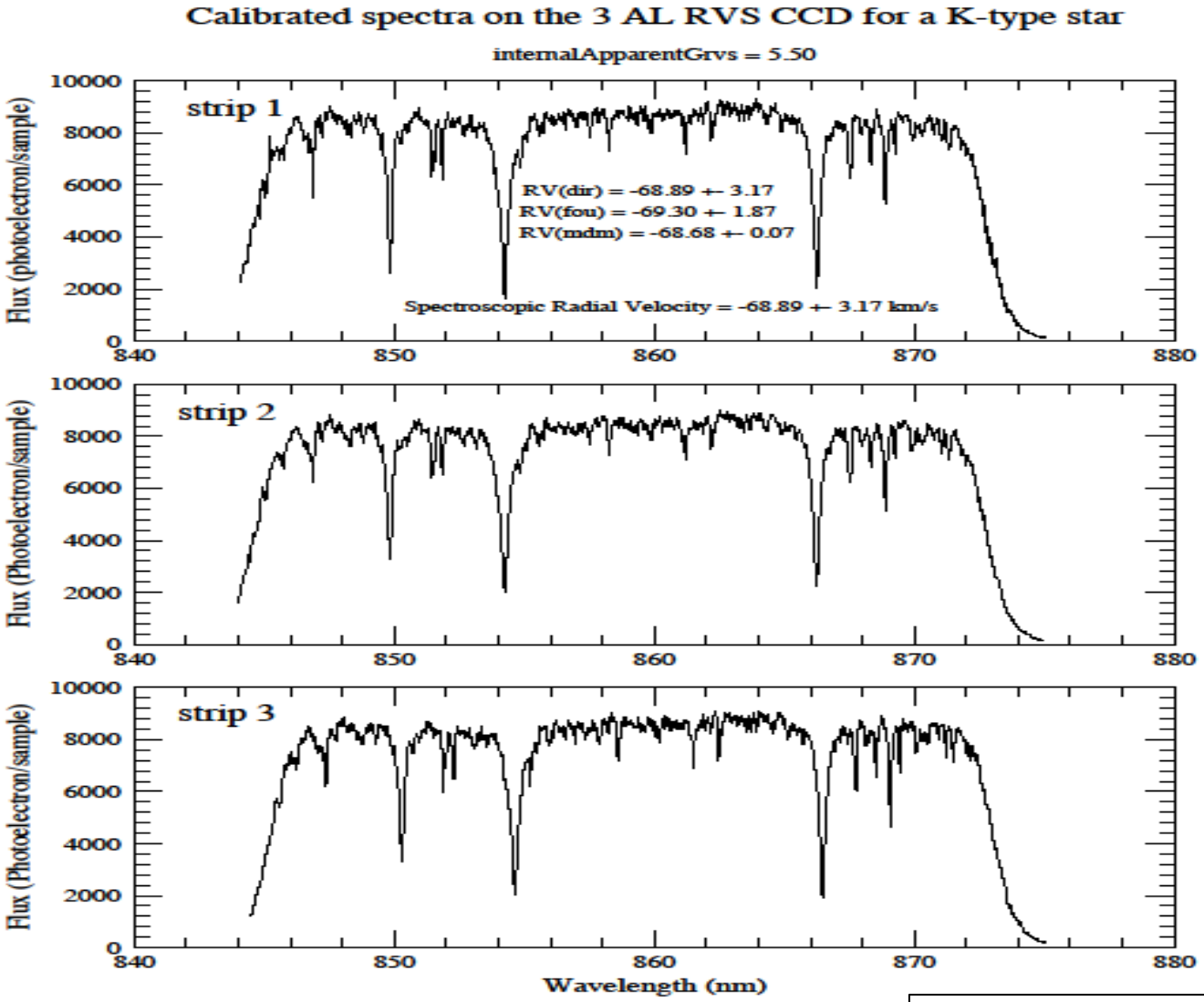
Signal to noise ratio

Grvs	S/N / mission
7.2	700
10.6	100
11	75
13.3	10
15.1	2



http://www.cosmos.esa.int/web/gaia/sn-rvs

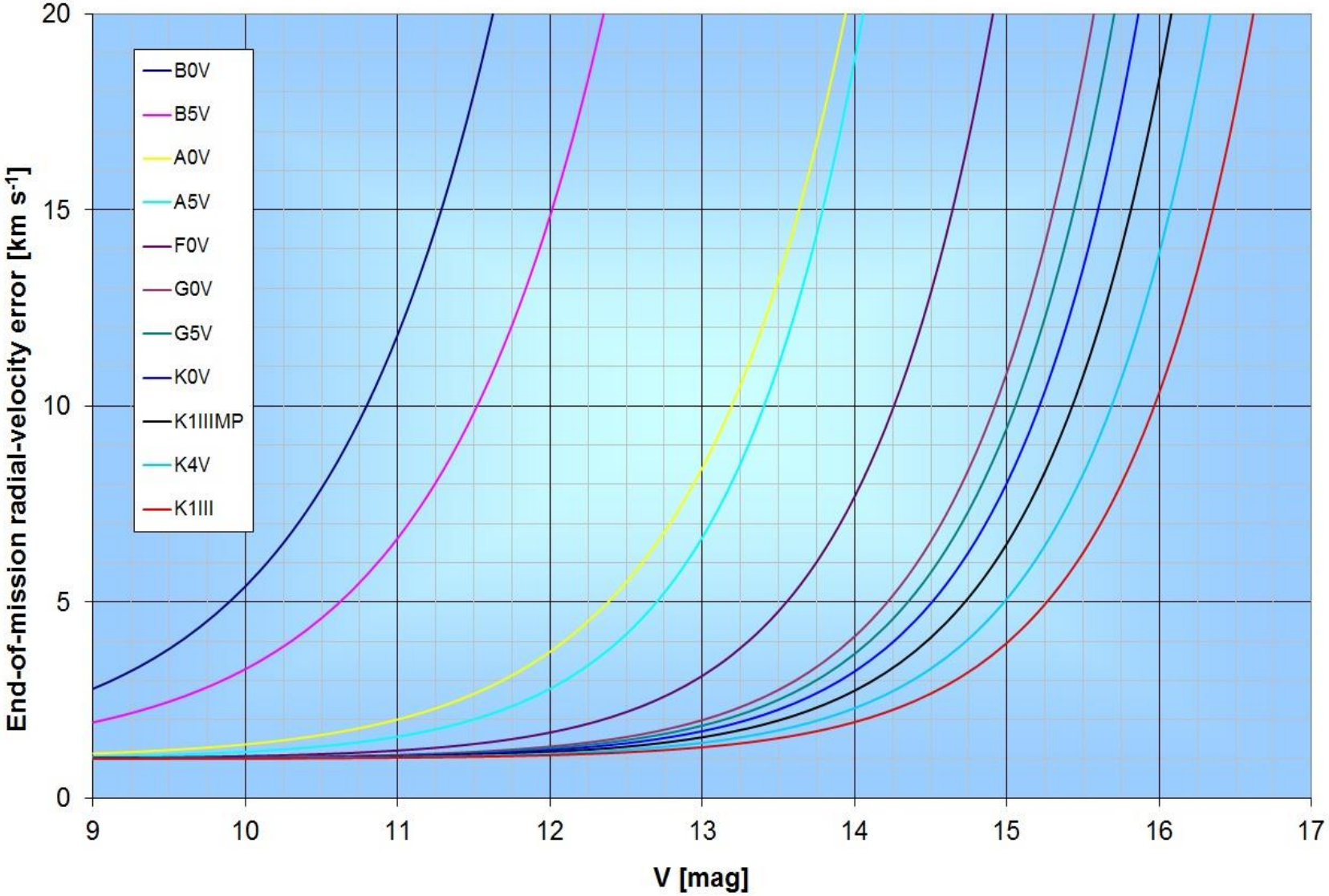
Radial velocities



Credits: ESA/Gaia/DPAC/
Yves Viala , Françoise Crifo

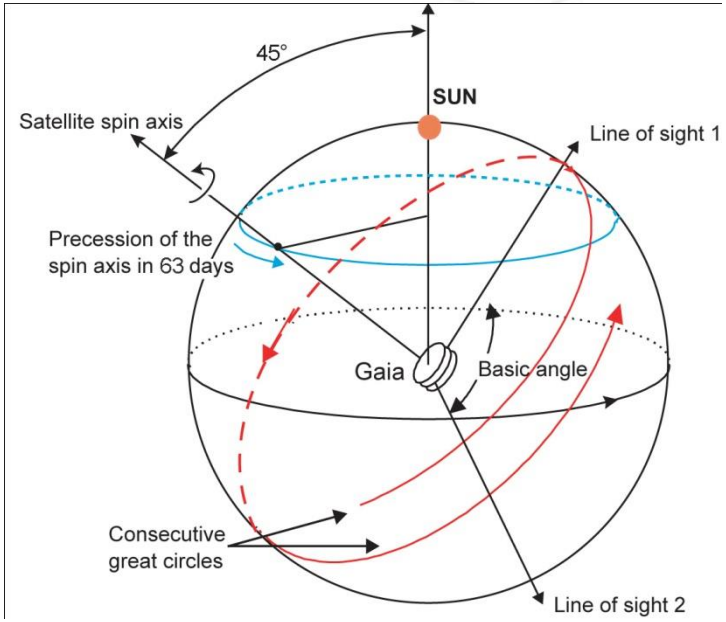
http://www.cosmos.esa.int/web/gaia

Radial velocities



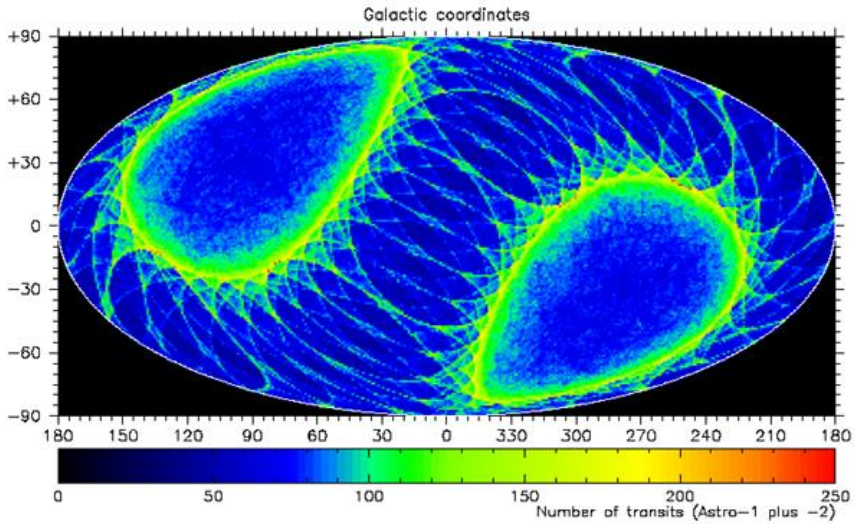
http://www.cosmos.esa.int/web/gaia/rvsperformance

Vr versus scanning law



K1III star: 15 km/s
(assuming 20% dead-time)

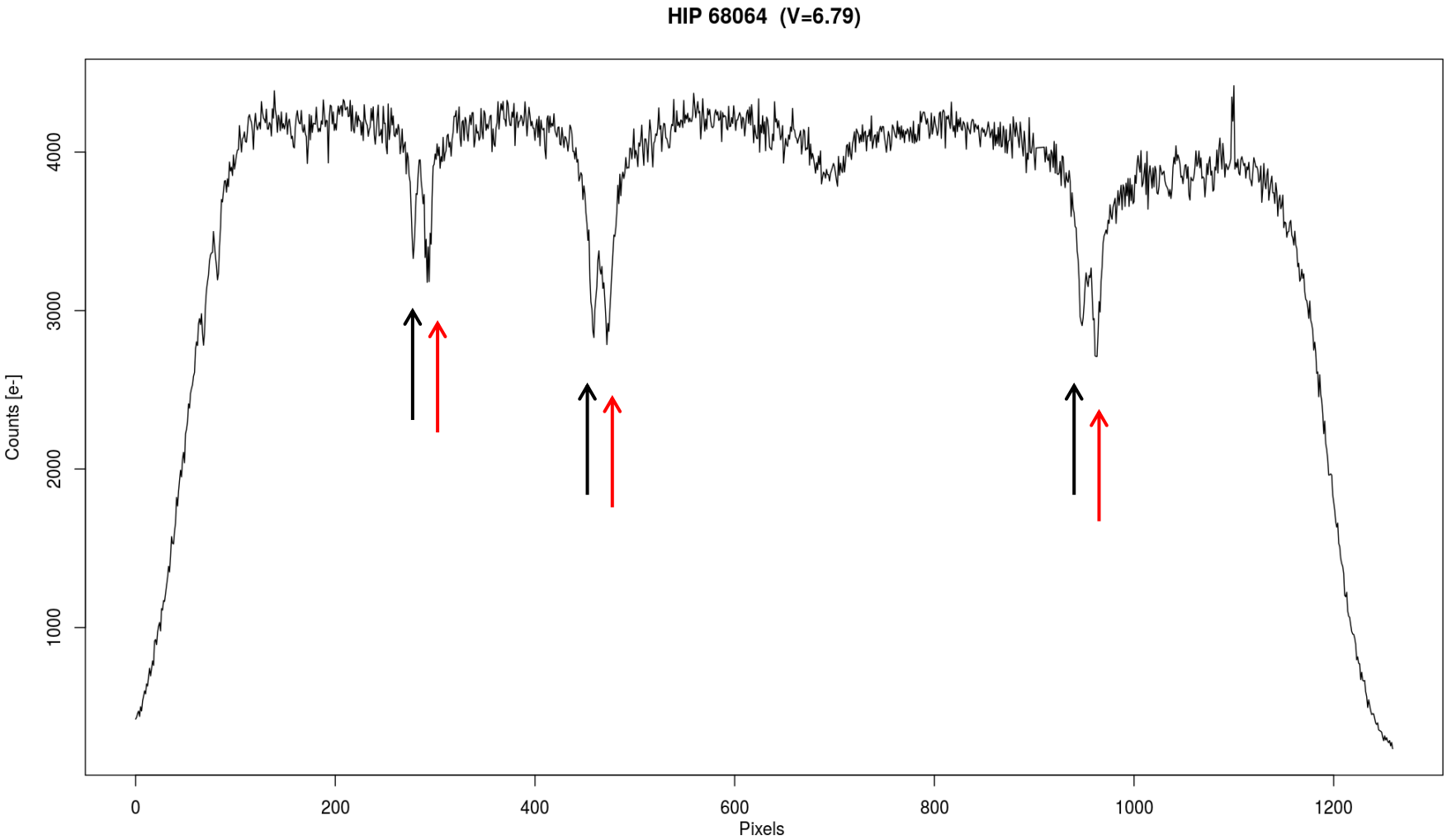
	Nb. transit	ΔV
➢ 5% minimum	< 23	-0.3
➢ Average	40	0
➢ 5% maximum	> 62	+0.25



- ➢ Moderate impact on Vr
- ➢ Stronger impact on variability studies

The time domain

HIP 68064
Eclipsing binary of Algol type (detached)



credits: ESA/Gaia/DPAC/CU6/Observatoire de Paris-Meudon/Olivier Marchal & David Katz

Parameters from the RVS

❖ Stellar and interstellar parameters

- *Radial velocities* V ≤ 16-16.5 (K giants)
- *Rotational velocities* V ≤ 12-13

- *Atmospheric parameters* V ≤ 12-13

  and much fainter with spectro-photometer

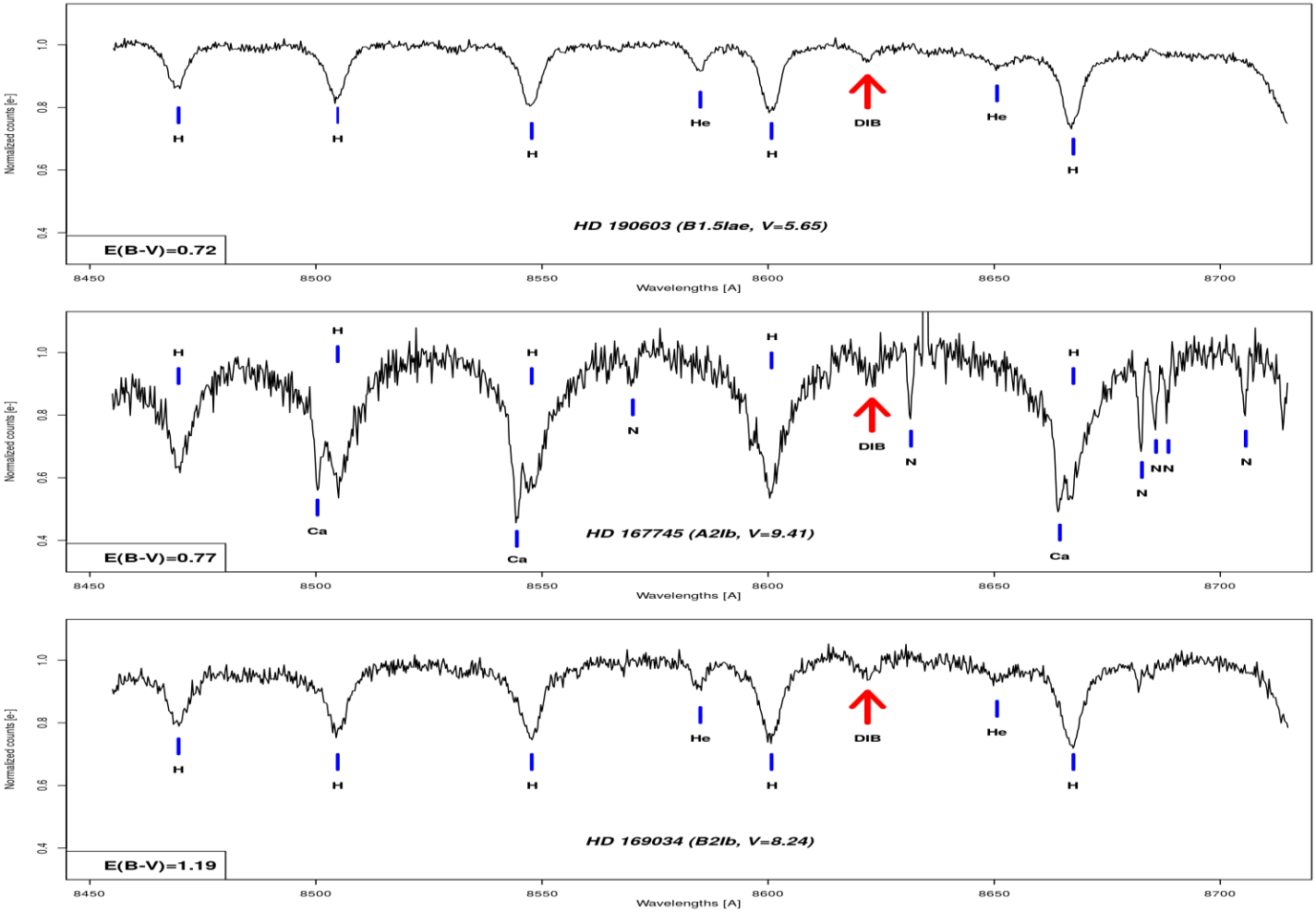
- *Abundances* V ≤ 11-12

- *Interstellar reddening* V ≤ 12-13 from 862 nm DIB

❖ Diagnostics

- *Binarity/multiplicity, variability, …*

Interstellar reddening



credits: ESA/Gaia/DPAC/CU6/Observatoire de Paris-Meudon/Olivier Marchal, Carine Babusiaux & David Katz

RVS will contribute to the determination of the reddening down to

V~12-13

BP/RP will provide information for fainter targets

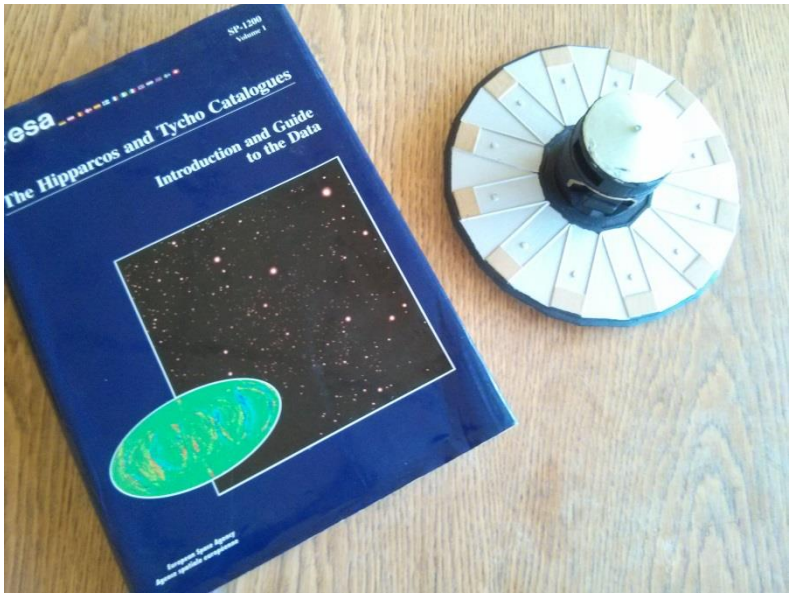
Diffuse Interstellar Band(DIB): 8620 A

Correlates with E(B-V): **E(B-V) = 2.72 × EW (Ang)**

Munari, Tomasella, Fiorucci et al., 2008, A&A, 488, 969

First data releases

- *1st release (2016)*
  - ✓ Positions (α,δ) and G magnitudes
  - ✓ Proper motions for Hipparcos stars
- *2nd release (2017)*
  - ✓ 5 astrometric parameters (single stars)
  - ✓ Integrated G, Bp, Rp photometry
  - ✓ **Mean Vr (single stars)**
- *3rd release*
  - ✓ Better
- *4th release*
  - ✓ Even better
- *Final release*
  - ✓ Best



Hipparcos catalogue volume 1 (ESA SP-1200) and Gaia model

Ground-based projects

Very Large Telescopes

William Herschel Telescope

- **MOONS**
  - ✓ MOS LR-HR IR spectrograph @VLT
  - ✓ Dense Galactic areas → bulge and disk
- **WEAVE**
  - ✓ MOS LR-HR spectrograph @WHT
- **Maunakea Spectroscopic Explorer – MSE**
  - ✓ Upgrade CFHT 3.6 → **10 m**
  - ✓ **Wide field** MOS LR-HR spectrograph @CFHT
  - ✓ Dedicated to large spectroscopic surveys

Canada-France-Hawaii Telescope