



Gaia: Past, Present and Future

Institut d'Estudis Espacials de Catalunya – ICC Universitat de Barcelona

Gaia UB Team
C. Fabricius

IGO/ESA Workshop, Cambridge, United Kingdom

19 - 21 June 1995

Future Possibilities for Astrometry in Space





Gaia timeline

- 29 June 1993: Call for post-Horizon 2000 proposals

12 October 1993: GAIA proposal

Response to Call for Mission Concepts for Horizon 2000 Follow Up
Proposal for an astrometric interferometer as an ESA Cornerstone Mission

3+ year mission

GAIA

Global Astrometric Interferometer for Astrophysics

*L. Lindegren, M.A.C. Perryman, U. Bastian, J.C. Dainty,
E. Høg, F. van Leeuwen, J. Kovalevsky, A. Labeyrie,
F. Mignard, J.E. Noordam, R.S. Le Poole, P. Thejll and F. Vakili*

We propose that a small interferometer of the Fizeau type (baseline ~ 3 m), dedicated to global astrometry, should be studied as a possible concept for an ESA Cornerstone Mission. Positions, absolute parallaxes and annual proper motions could be determined with accuracies on the 20 micro-arcsec level. The observing programme could consist of all objects to a limiting magnitude around $V = 15-16$, or some 50 million stars, extragalactic and solar-system objects.



Gaia timeline

- 29 June 1993: Call for post-Horizon 2000 proposals
- 12 Oct. 1993: GAIA proposal submitted
- July 2000: Red Book (Gaia-1 design)
- 12 Oct. 2000: Gaia approved by ESA SPC
 - Together with BepiColombo, NGST, LISA, SolarOrbiter

Gaia timeline

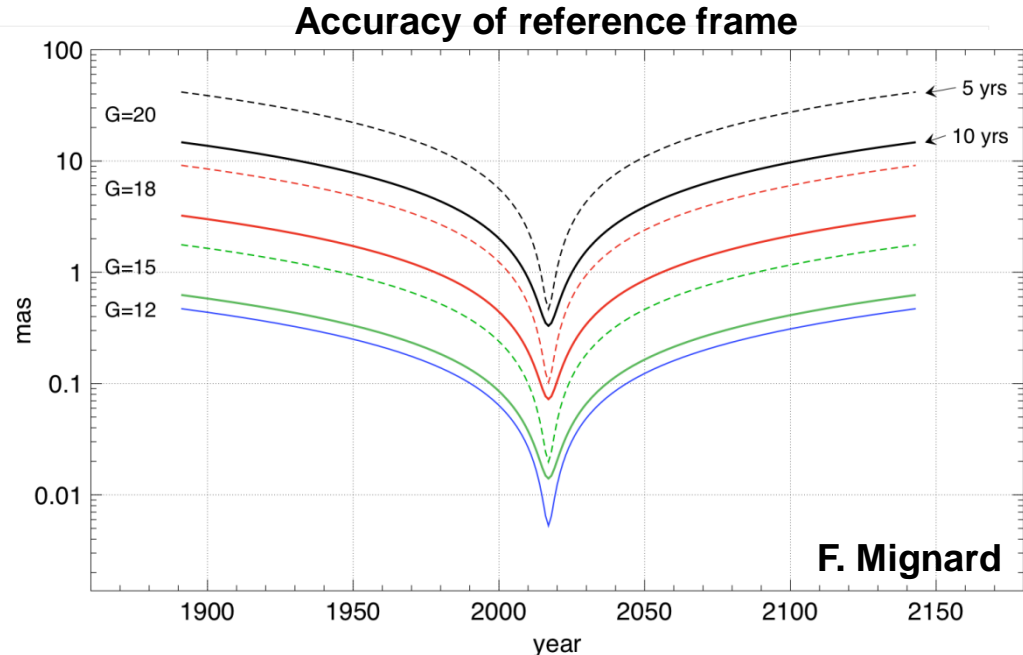
- 29 June 1993: Call for post-Horizon 2000 proposals
- 12 Oct. 1993: GAIA proposal submitted
- July 2000: Red Book (Gaia-1 design)
- 12 Oct. 2000: Gaia approved by ESA SPC
- 19 Dec. 2013: Gaia launch
- 25 Jul. 2014: Start of nominal mission
- 16 Jul. 2019: Start of extended mission, 2019-20
 - » Eclipse avoidance manoeuvre
 - » Reverse precession direction (1 year)

Gaia timeline

- 29 June 1993: Call for post-Horizon 2000 proposals
- 12 Oct. 1993: GAIA proposal submitted
- July 2000: Red Book (Gaia-1 design)
- 12 Oct. 2000: Gaia approved by ESA SPC
- 19 Dec. 2013: Gaia launch
- 25 Jul. 2014: Start of nominal mission
- 16 Jul. 2019: Start of extended mission, 2019-20
- 10 Jun. 2020: Decision on 2021-22
Indicative decision on 2023-24

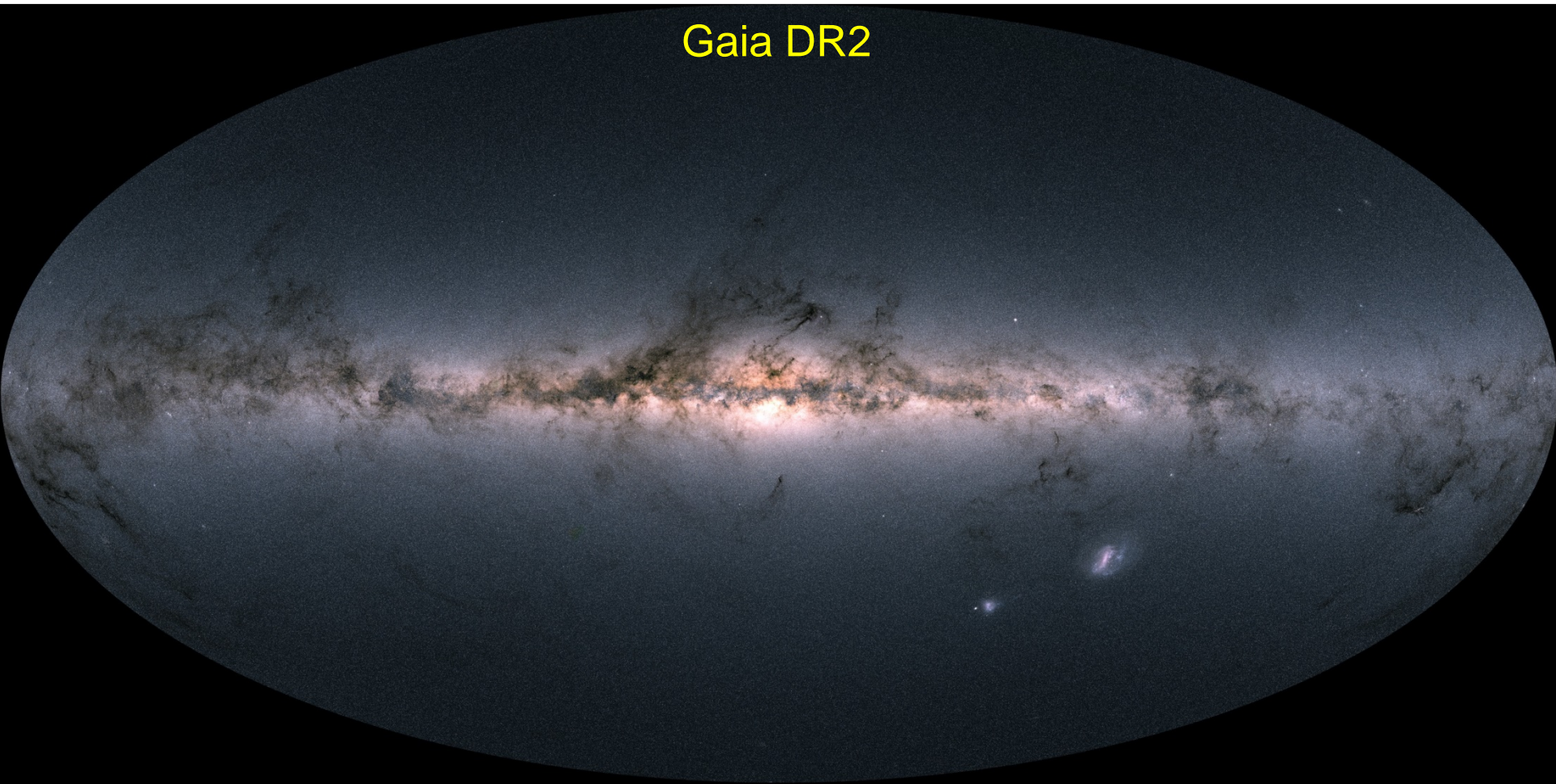
Why is an extension important

- Errors go down by $T^{-0.5}$
 - Positions, parallax
 - Photometry, Rad Vel
- Errors go down by $T^{-1.5}$
 - Proper motions
- Errors go down by $T^{-2.5}$
 - Accelerations



- Also important for orbits of binaries and minor planets

Gaia DR2



Time to start the harvest

- 1993: GAIA proposal
- 2018: Gaia DR2
 - 25 years cultivating the seed
 - Some fruit is ripe some not yet
- Gaia has already had an impact
 - 2914 refereed Gaia papers since launch
 - Similar level of papers/year as HST
- Important to remember to acknowledge Gaia



Data releases from Gaia

Release	Interval	Year	σ_{ϖ}	σ_{μ}
DR1	13 m	2016		
DR2	21 m	2018	=1.00	=1.00
EDR3	33 m	2020, Q3	0.80	0.51

- Naïve prediction
 - + calibrations may improve
 - - instrument may deteriorate

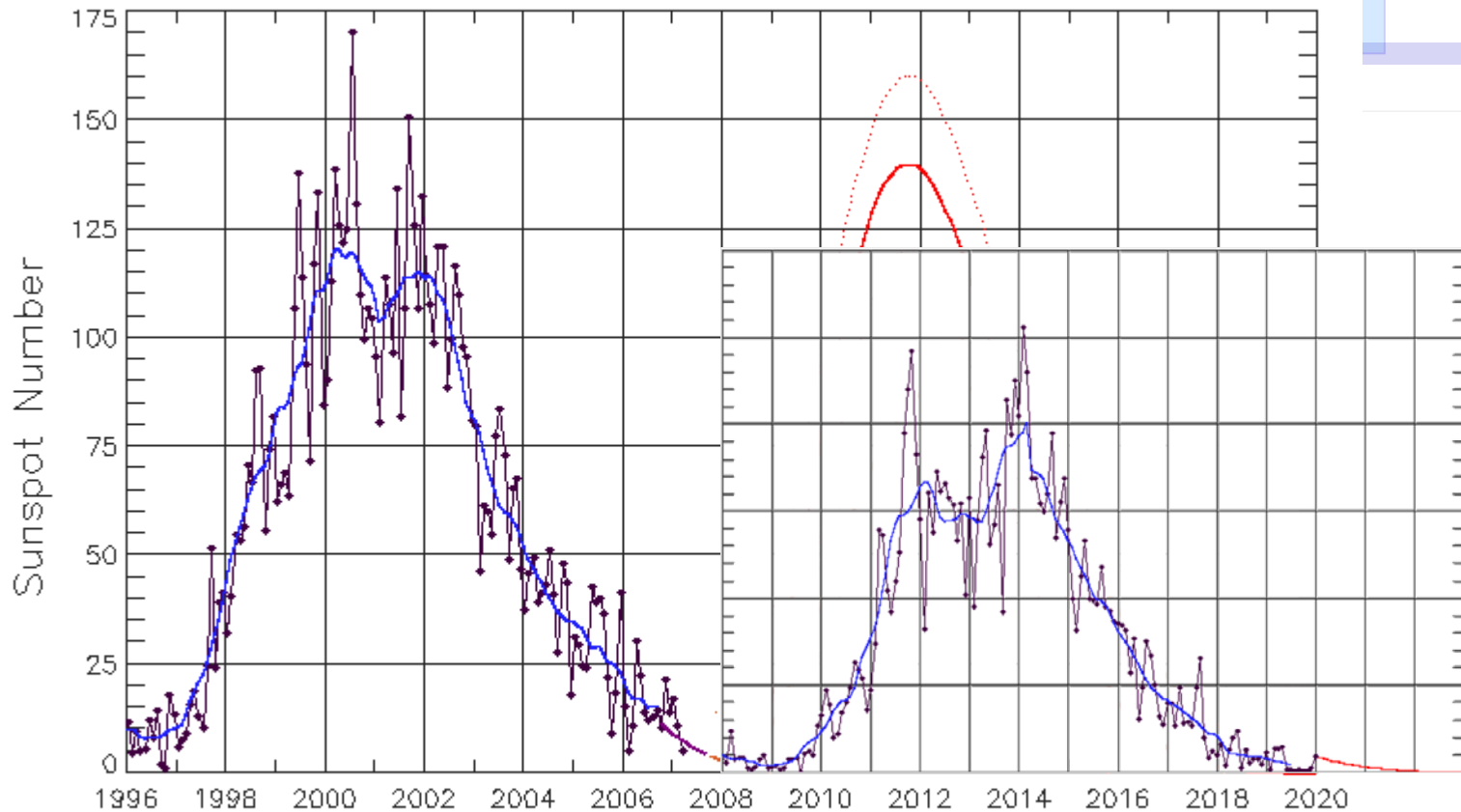
Gaia is doing well

CURRENT DATE AND TIME	2020-02-14T15:19:50 (TCB)
MISSION STATUS	
Satellite distance from Earth (in km)	1,366,603
Number of days having passed since 25 July 2014	2030
Number of days in mission extension	213
OPERATIONS DATA (collected since 2014/07/25)	
Volume of science data collected (in GB)	75,837
Number of object transits through the focal plane	143,915,115,817
Number of astrometric CCD measurements	1,418,591,855,905
Number of photometric CCD measurements	286,498,029,504
Number of spectroscopic CCD measurements	28,016,402,259
Number of object transits through the RVS instrument	9,381,756,250

Solar Cycle 24 Sunspot Number Prediction

Data Through 31 Mar 07

2007 prediction



Low activity,
Much reduced
damage to
CCDs.

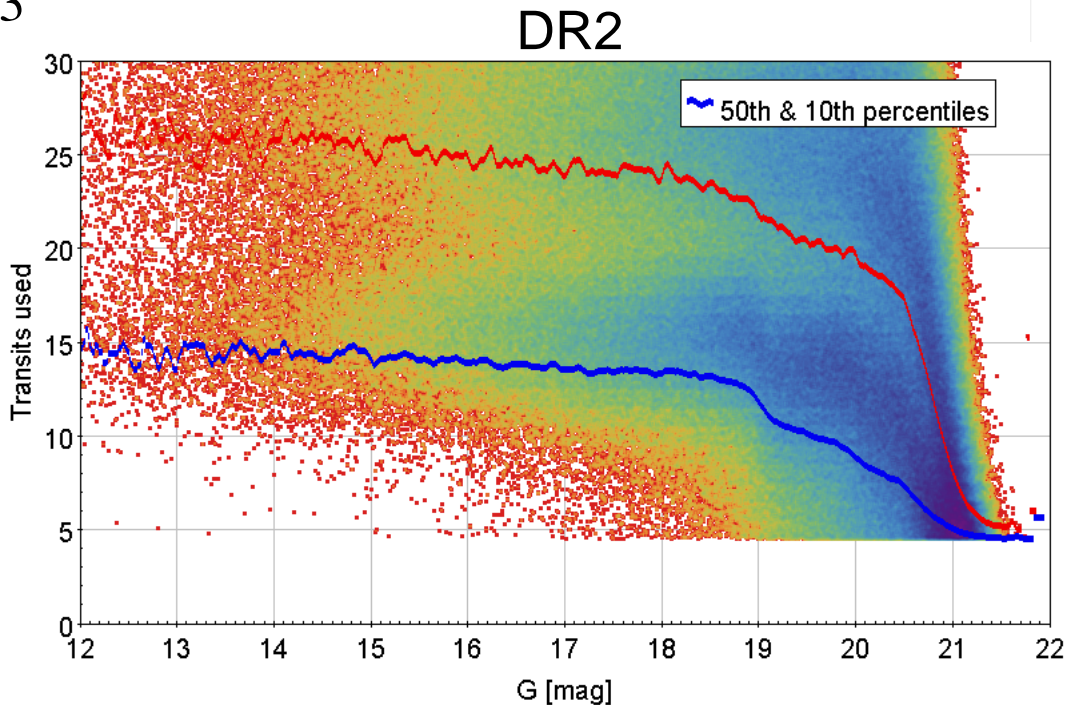
— Low Prediction (Smoothed) — High Prediction (Smoothed) 1-Sigma Error
— Smoothed Monthly Values —• Monthly Values

Updated 2007 Apr 20

NOAA/SEC Boulder, CO USA

EDR3

- Expected release date: 2020 Q3
- Announcement in due course
- ~ 1.8 billion sources (TBC)
 - 1 extra year w.r.t. DR2
 - New source list
 - Improved astrometry
 - Improved photometry
 - G , G_{BP} , G_{RP}
 - DR2 radial velocities
 - Updated data model

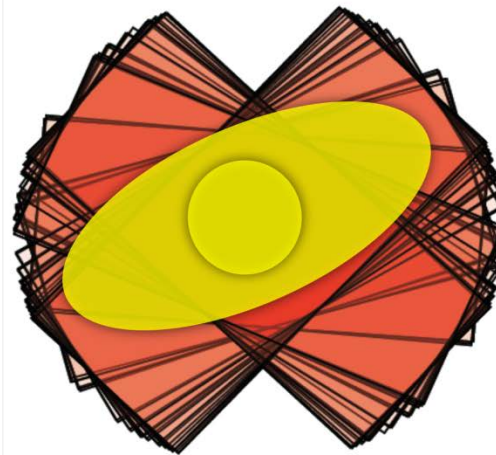


- Expected release date: 2021 H2
 - Source list, astrometry and photometry as EDR3: ~ **1.8 billion**
 - Radial velocities ~ **30 million**, $G_{\text{RVS}} < 14$ mag
 - Astrophysical parameters ~ **300 million ??**
 - XP spectra ~ **300 million ??**
 - RVS spectra **only bright sources**
 - Variable stars & light curves ~ **7 million**
 - Solar system: orbits & epoch data ~ **100 000** objects
 - Binaries **astrometric/spectroscopic/eclipsing**
 - Quasars and extended objects ~ **1 million**
 - Gaia Andromeda Phot Survey ~ **1 million**

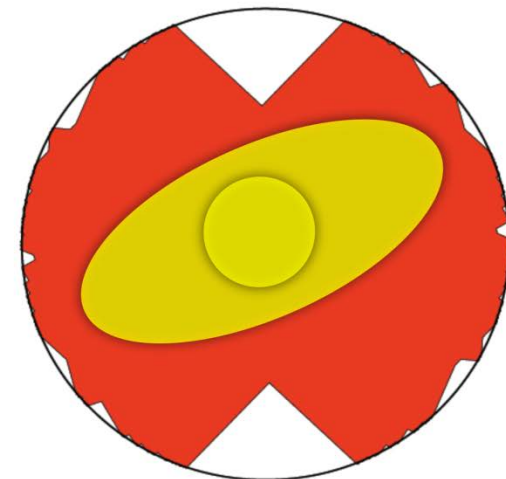
Extended objects

- Extended objects
- Detected as point sources
- Size: < 1-2 arcsec
- Extract morphology, ...
 - No images yet

SM windows around $(l,b) = (0.0,0.0)$



Individual windows (SM)
Number of Transits : 59

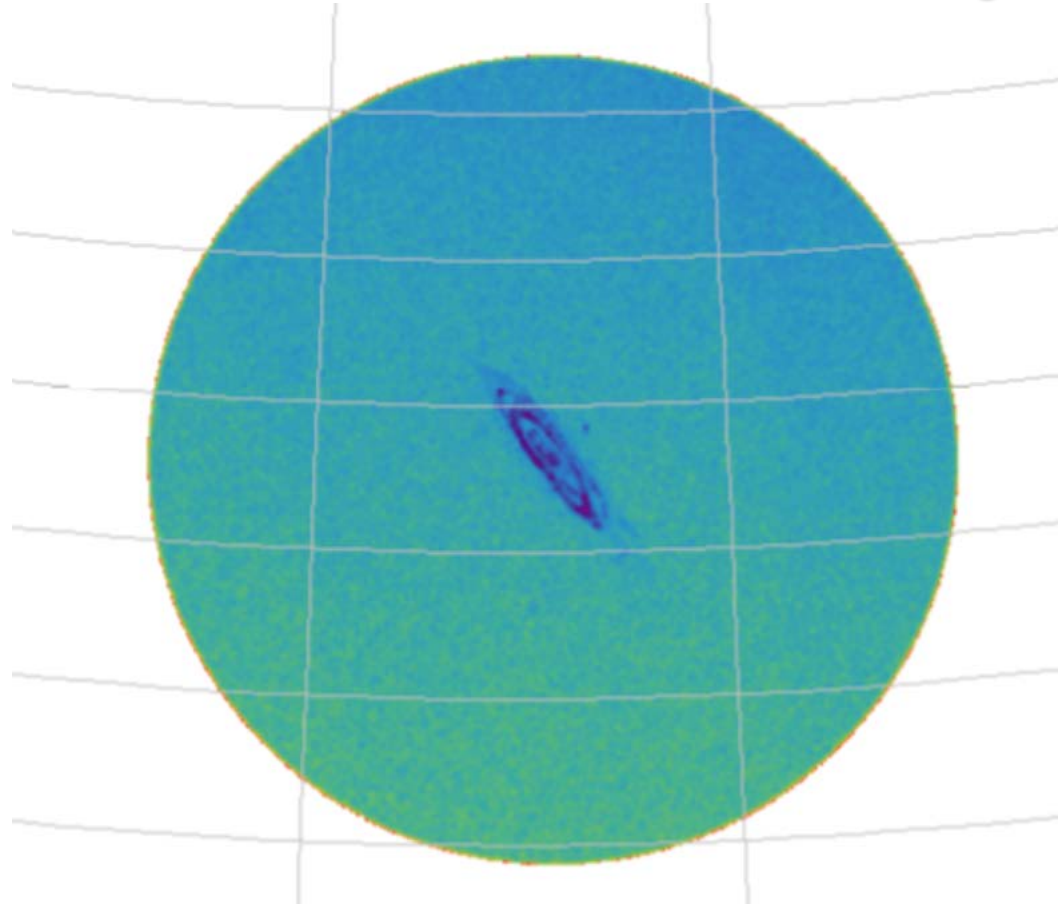


Surface covered
Coverage fraction : 87.61 %

Image: DPAC-CU4/Ducourant

Gaia Andromeda Photometric Survey

- Radius 5.5°
- ~ 1 million sources
- Raw light curves
 - calibrated epoch photometry
 - all sources



Building on past generations

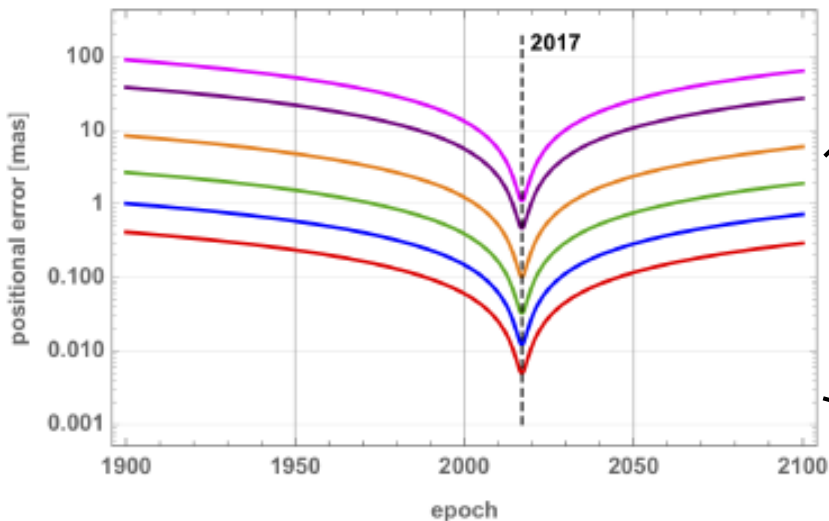
- 1989: HIPPARCOS launch
- 1993: End of observations
- 1997: DR

- 1993: GAIA proposal submitted
- 199x: ~~DIVA, FAME, SIM~~

- 2016: GaiaNIR proposal
- 2017: positive reply
- 2019: proposal for Voyage2050

- 2018: Gaia DR2
- 2024: End of observations (?)
- 2029: Final DR ??

Gaia



Gaia + GaiaNIR

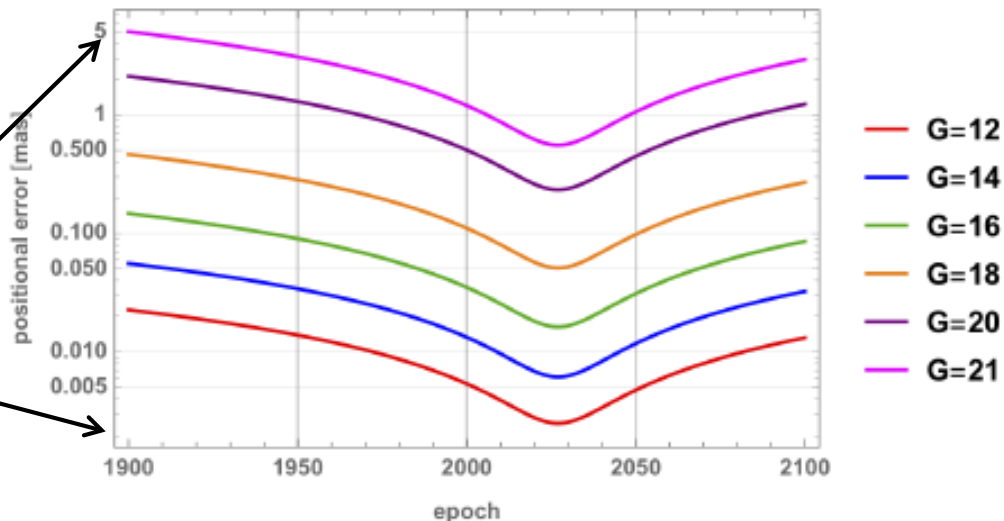
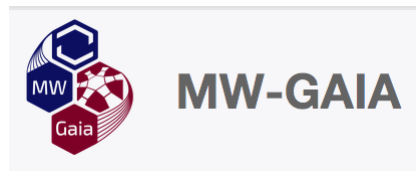


Fig. 3: *Degradation of the astrometric accuracy of the individual sources in the Gaia catalogue (left pane) and of the common solution using 10 years of Gaia and 10 years of GaiaNIR data (right pane) depending on the G magnitude and time from the reference epoch (J2017 for the Gaia catalogue and a mean epoch of Gaia and GaiaNIR taken here as J2027). Note the very different vertical scales.*

Cost action: Revealing the Milky Way with Gaia



29 paises + NNC + IPC

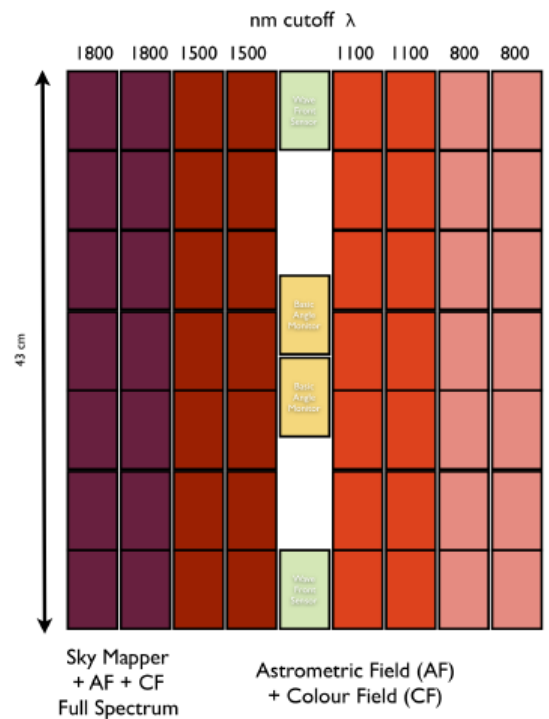
- WG1: The Milky Way as a Galaxy (Despina HATZIDIMITRIOU)
- WG2: The Life and Death of Stars (Gisella CLEMENTINI)
- WG3: Planetary Systems Near and Far (Joris DE RIDDER)
- WG4: Gaia Fundamentals: Space and Time (Sonia ANTON)
- WG5: Impact, Inclusiveness and Outreach (Sarunas MIKOLAITIS)

Workshops, schools, exchange visits
ADDITIONAL CALL: only for exchange visits in March 2020
Deadline for submissions: Thursday 20 February 2020

Voyage 2050 White Paper

All-Sky Visible and Near Infrared Space Astrometry

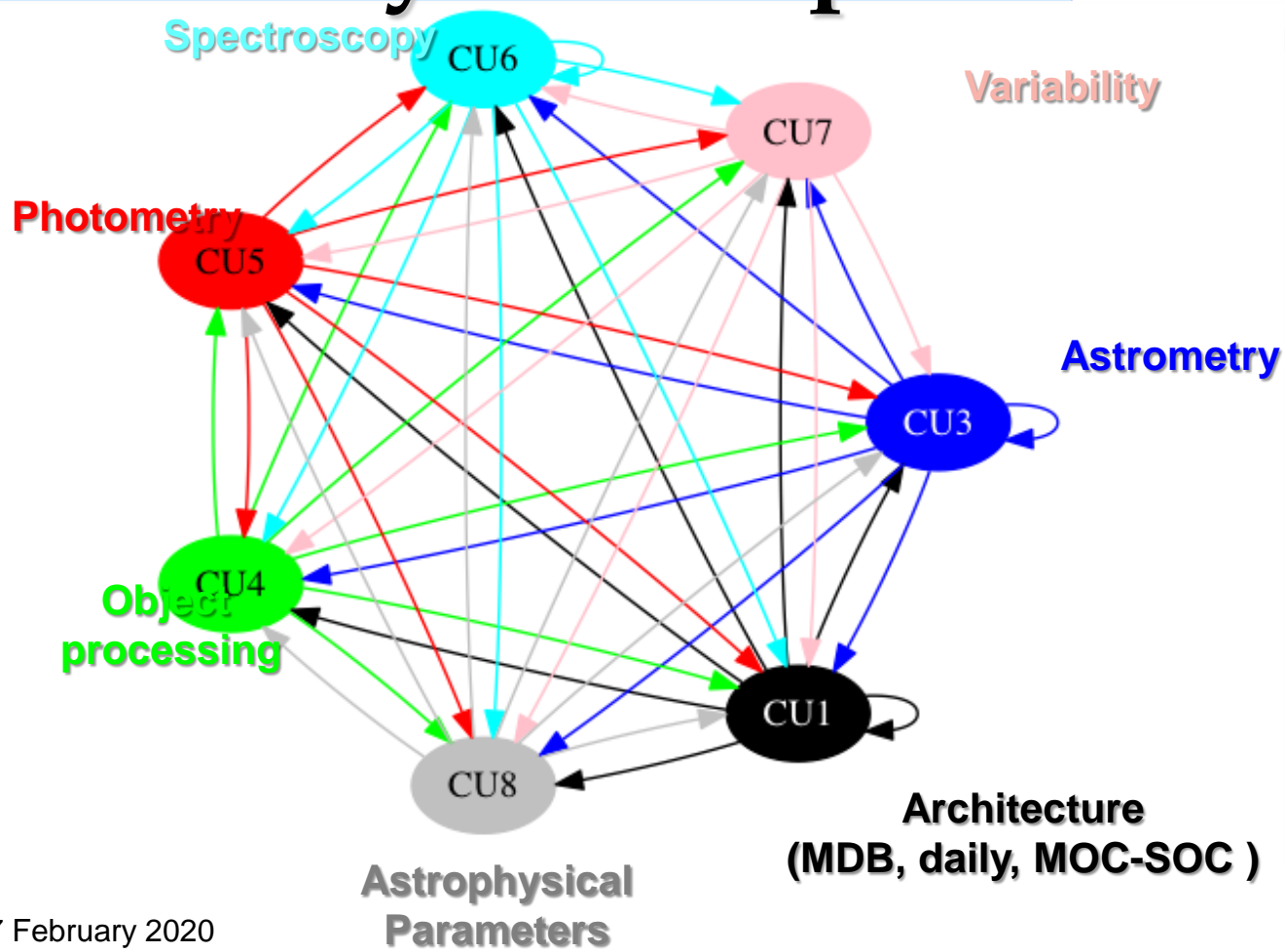
GaiaNIR Focal Plane



Casos científicos:
 zonas oscuras del disco
 brazos espirales, cúmulos embebidos
 bulbo y barra central
 enanas marrones
 exoplanetas

Fig. 4: Proposed focal plane array and filter bands used in the GaiaNIR CDF study (see page 203). The array consists of 60 NIR detectors, arranged in 7 across-scan rows and 9 along-scan strips (out of which 8 are for the astrometric/photometric field, divided into 4 photometric fields (i.e. 4 different cut-off wavelengths each starting from ~ 400 nm). The new array is less than half the size of Gaia's.

DPAC cross system dependencies

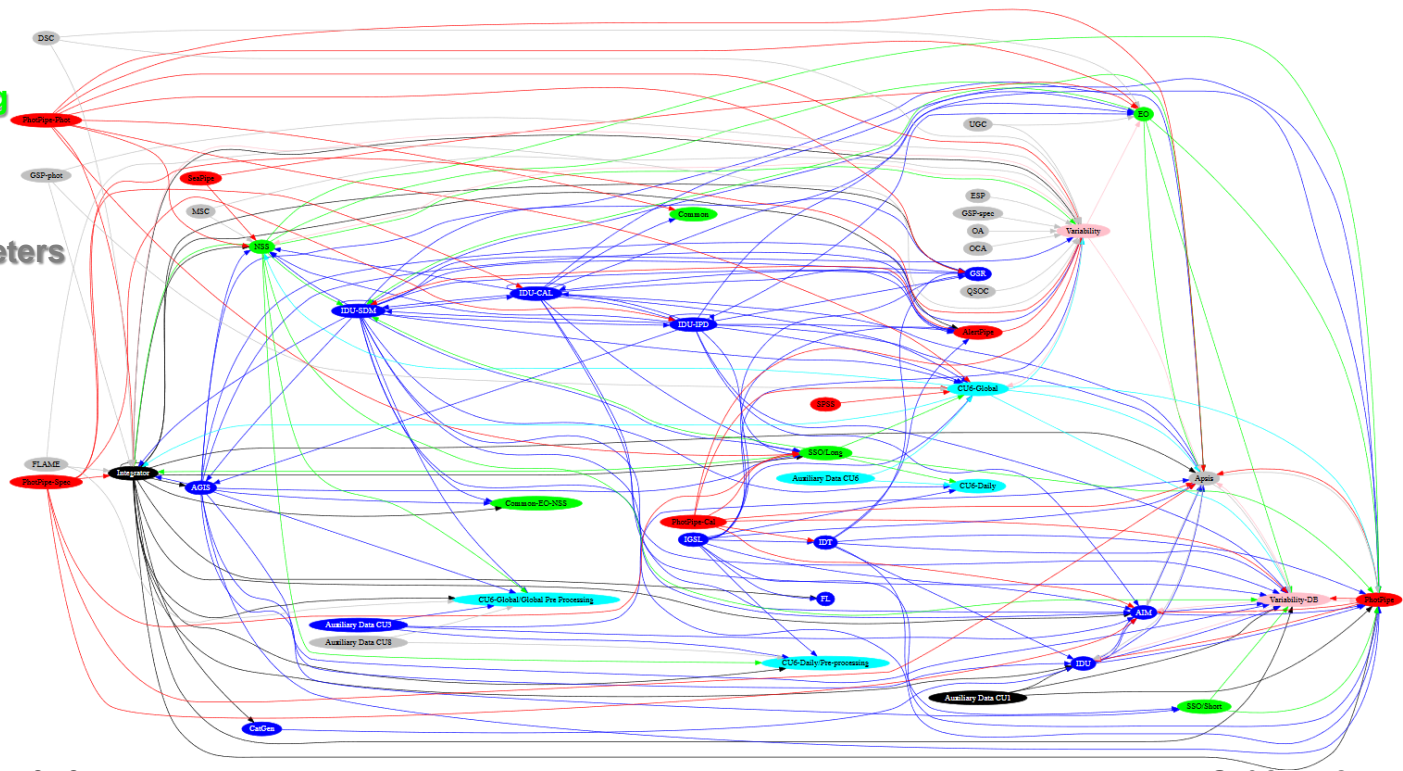


DPAC cross system dependencies

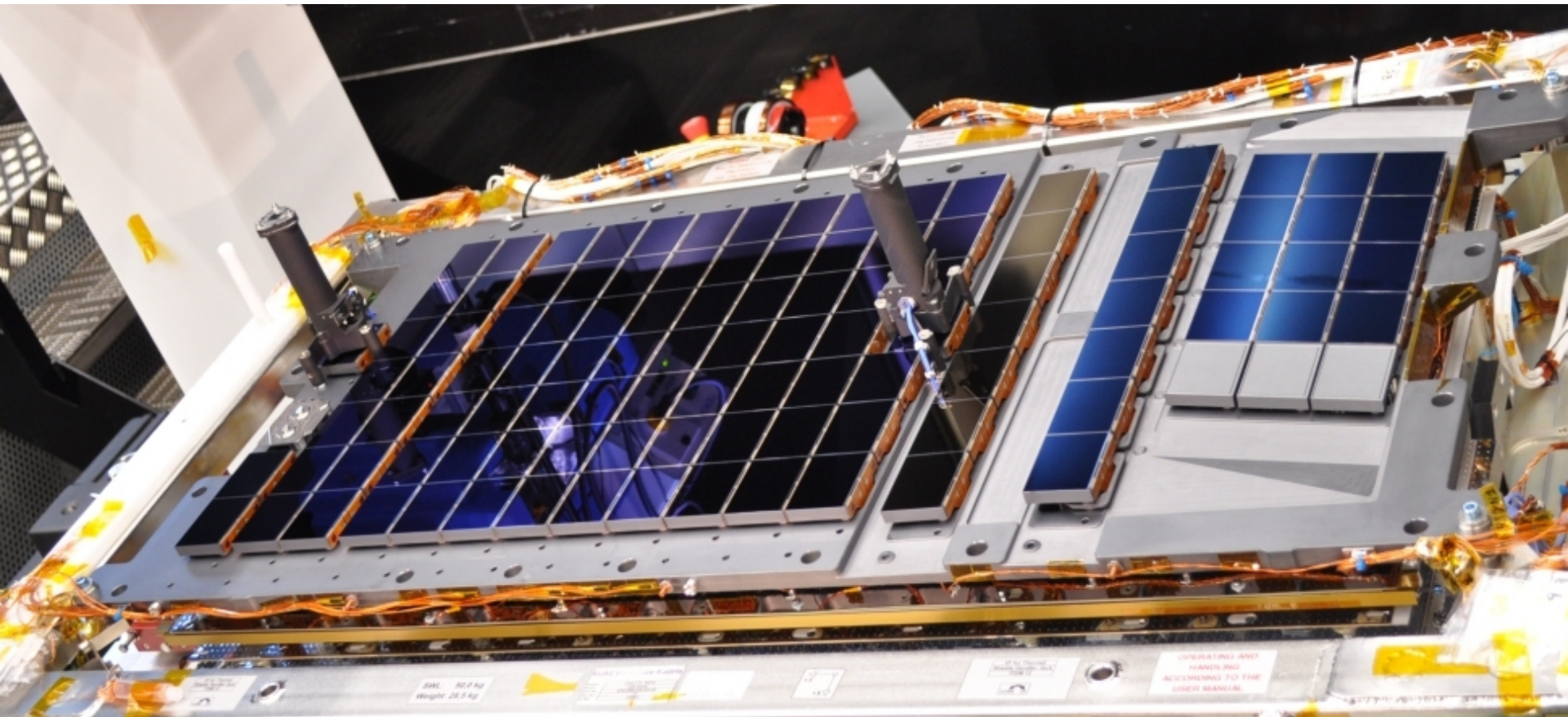
System dependencies in Cyclic processing

G. Gracia

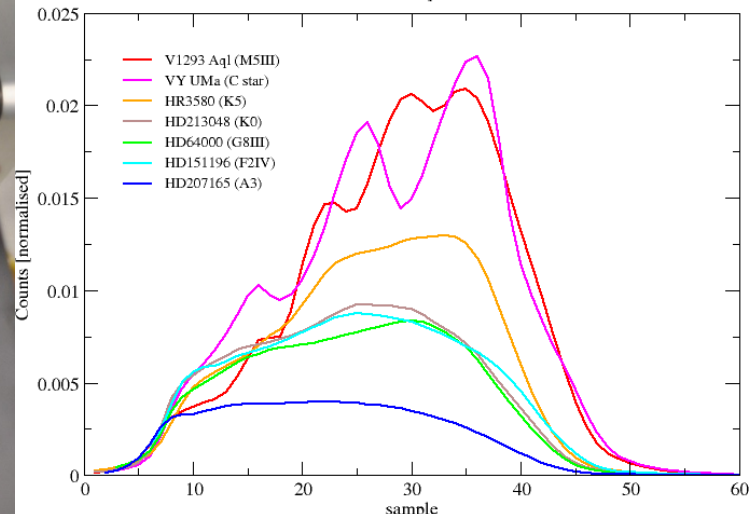
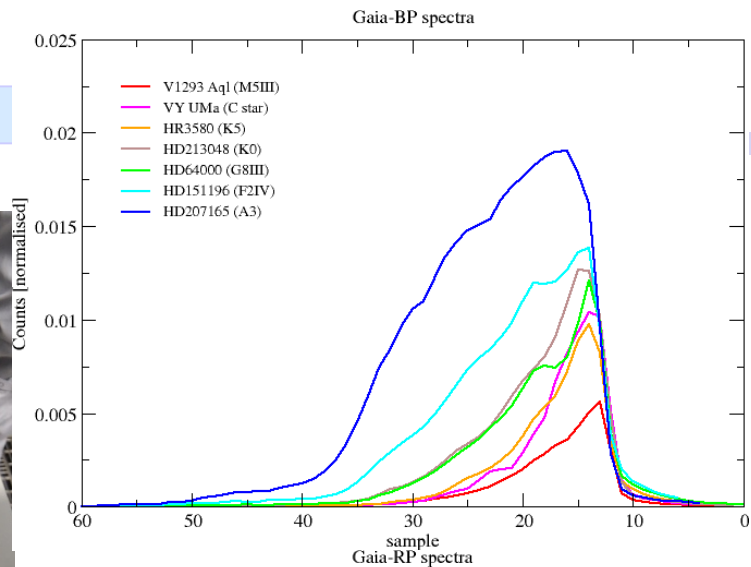
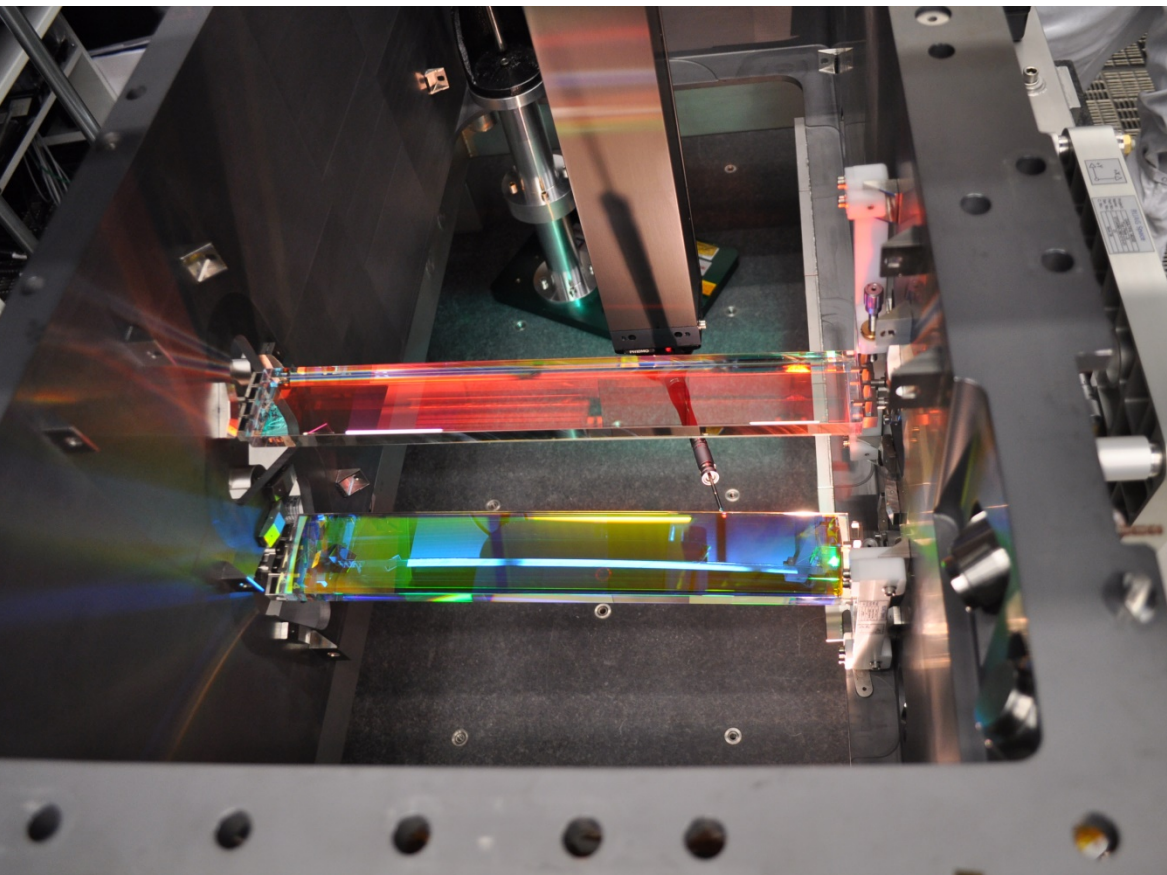
- CU1 Architecture
- CU3 Astrometry
- CU4 Object processing
- CU5 Photometry
- CU6 Spectroscopy
- CU7 Variability
- CU8 Astrophysical Parameters



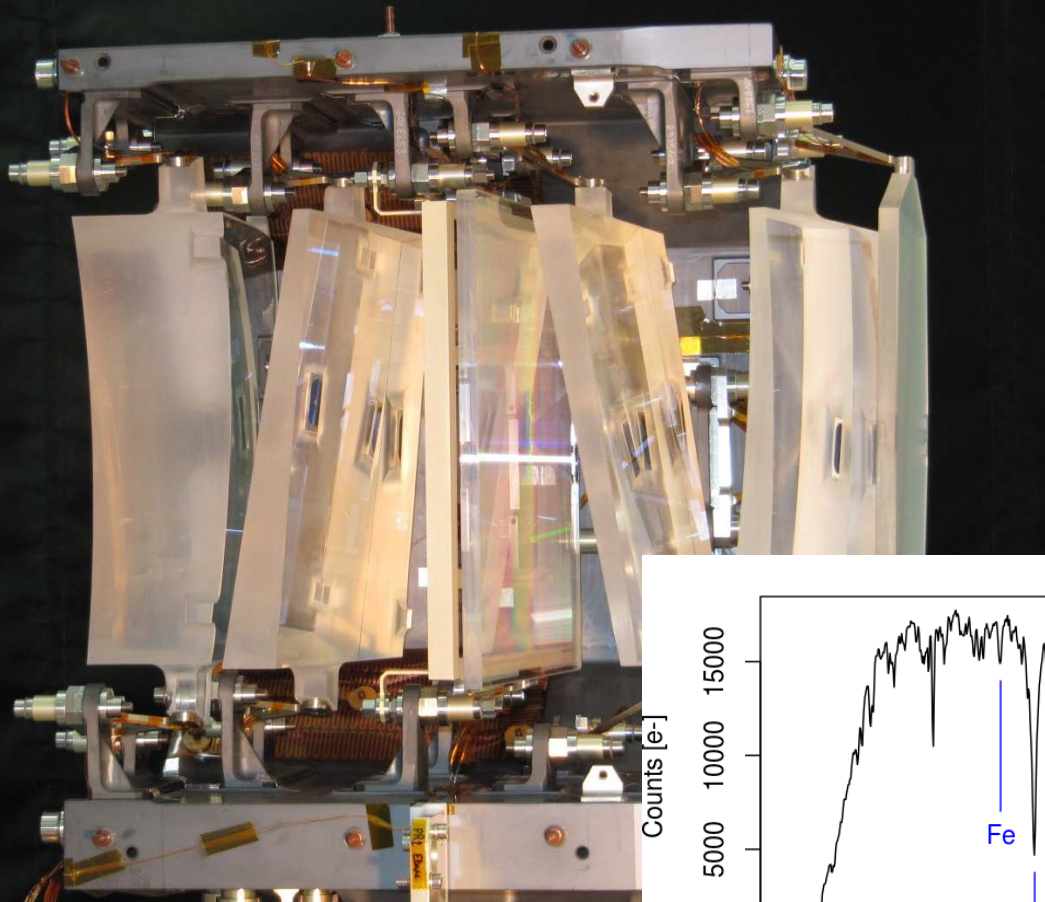
Gaia focal plane



BP & RP spectrograph



Radial Velocity Spectrograph



Gaia-RVS spectrum of HIP 86564

