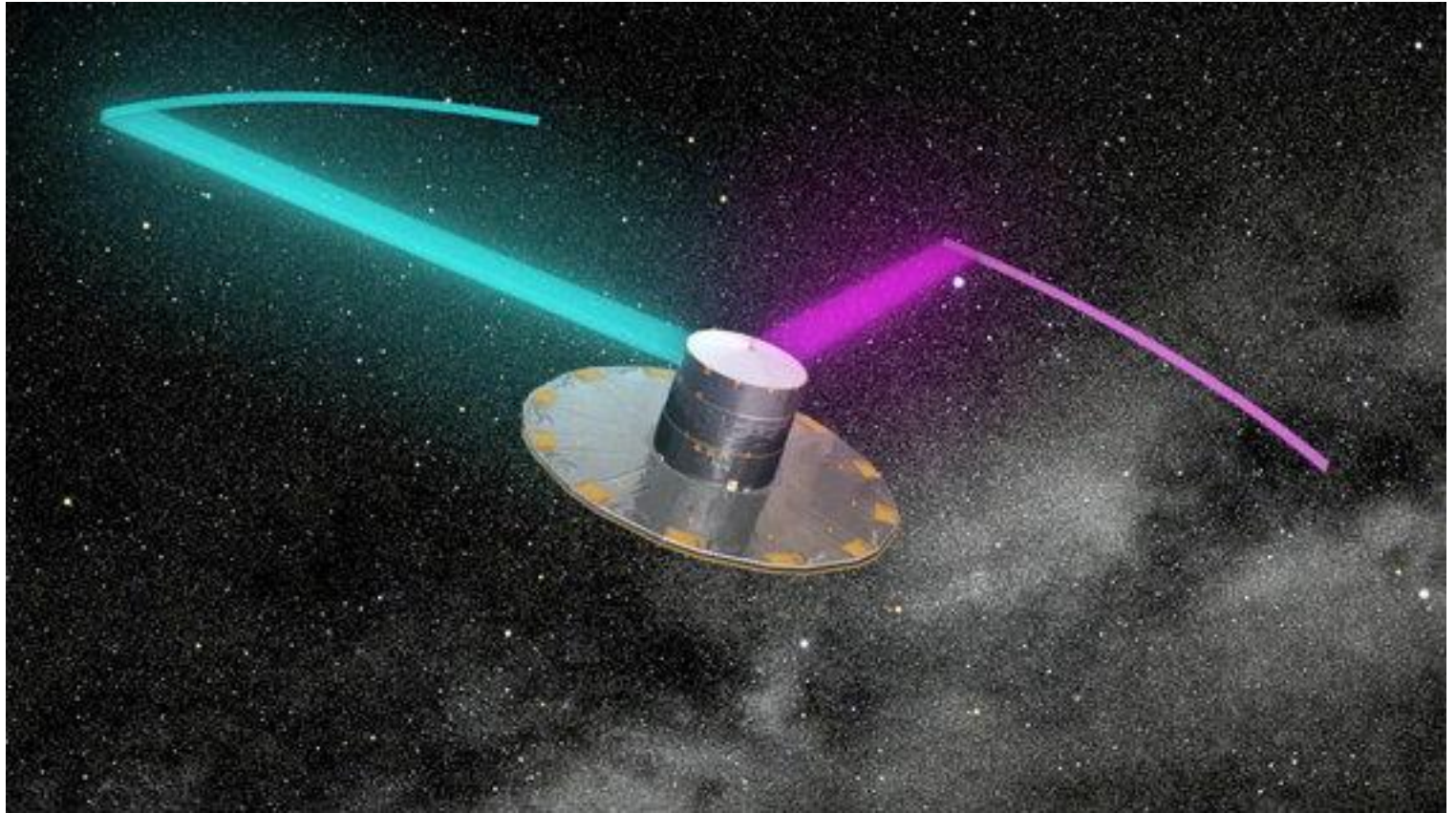# The Gaia DR1

Ernst Paunzen

Ústav teoretické fyziky a astrofyziky
Masarykova Univerzita
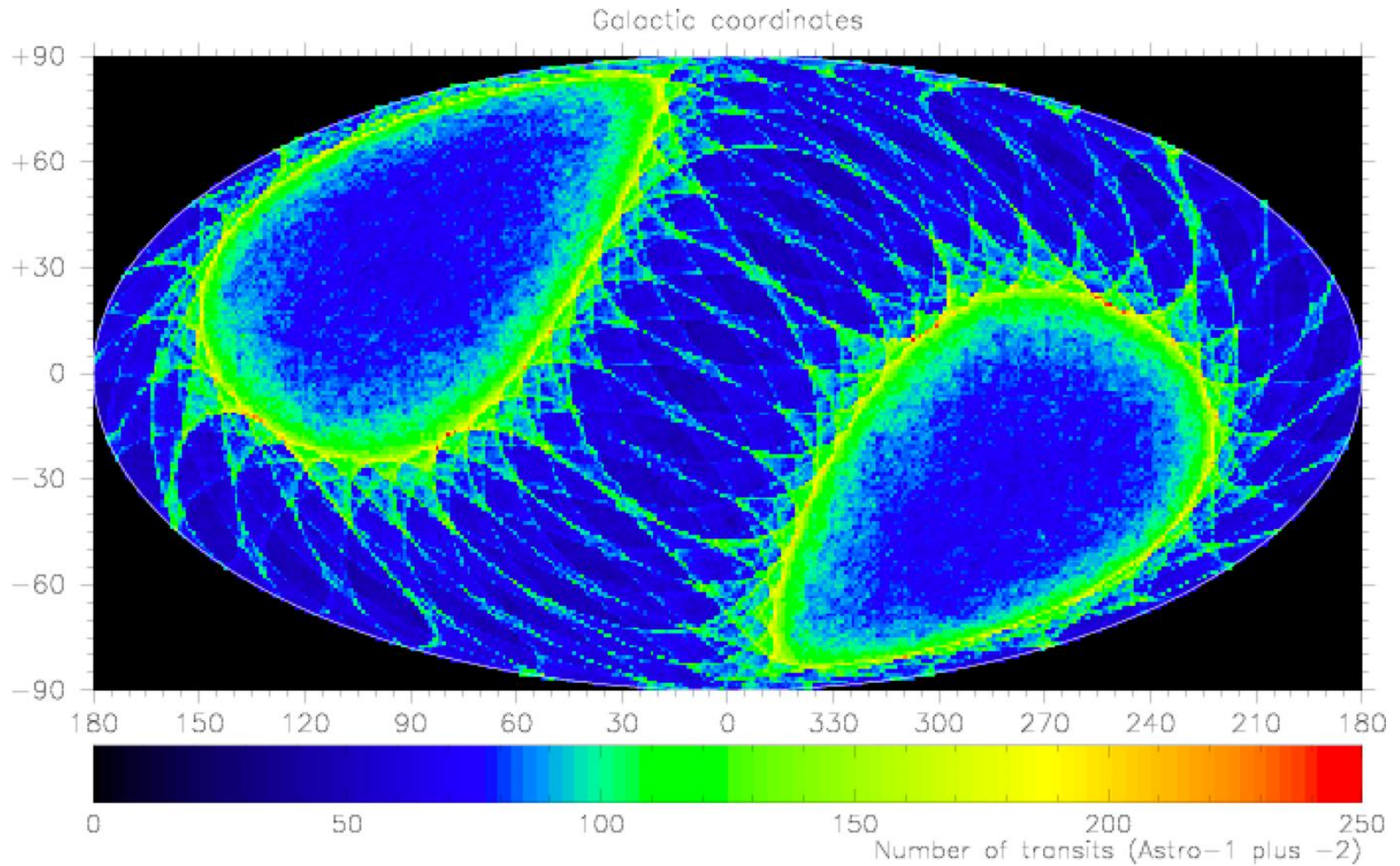
Brno

Characteristics – Gaia mission

- Launch: 19.12.2013
- Two identical telescopes
  1. Mirror: 145 x 50 cm
  2. FoV: 1.4 x 0.7 degree
  3. 106 CCDs with 4500 x 1966 pixels each
  4. Angle between telescopes: 106.5 degree
- Astrometry
- Photometry
- Spectroscopy

Characteristics
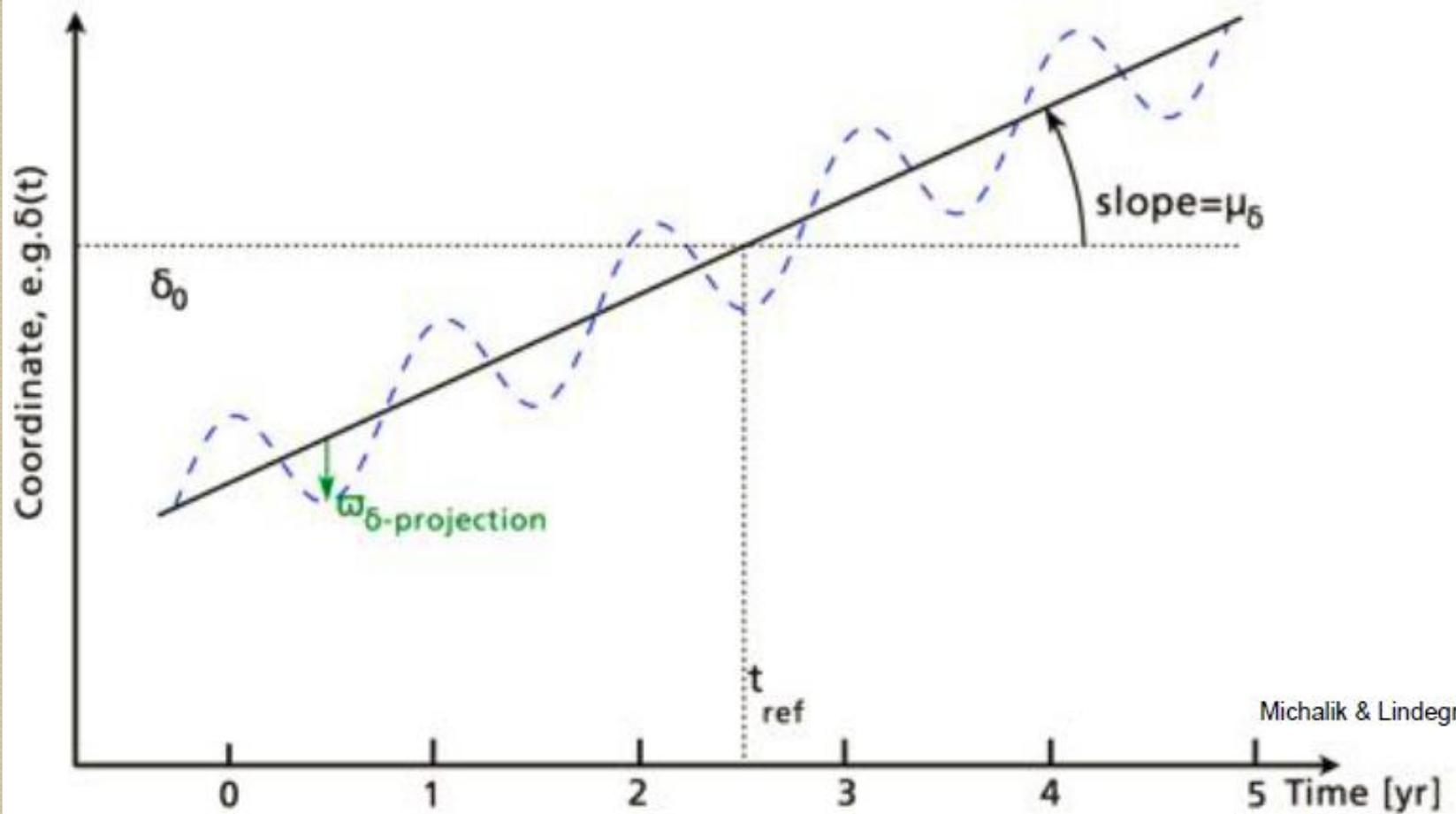

L2 Sun-Earth; precession and rotating

Sky coverage

Galactic coordinates
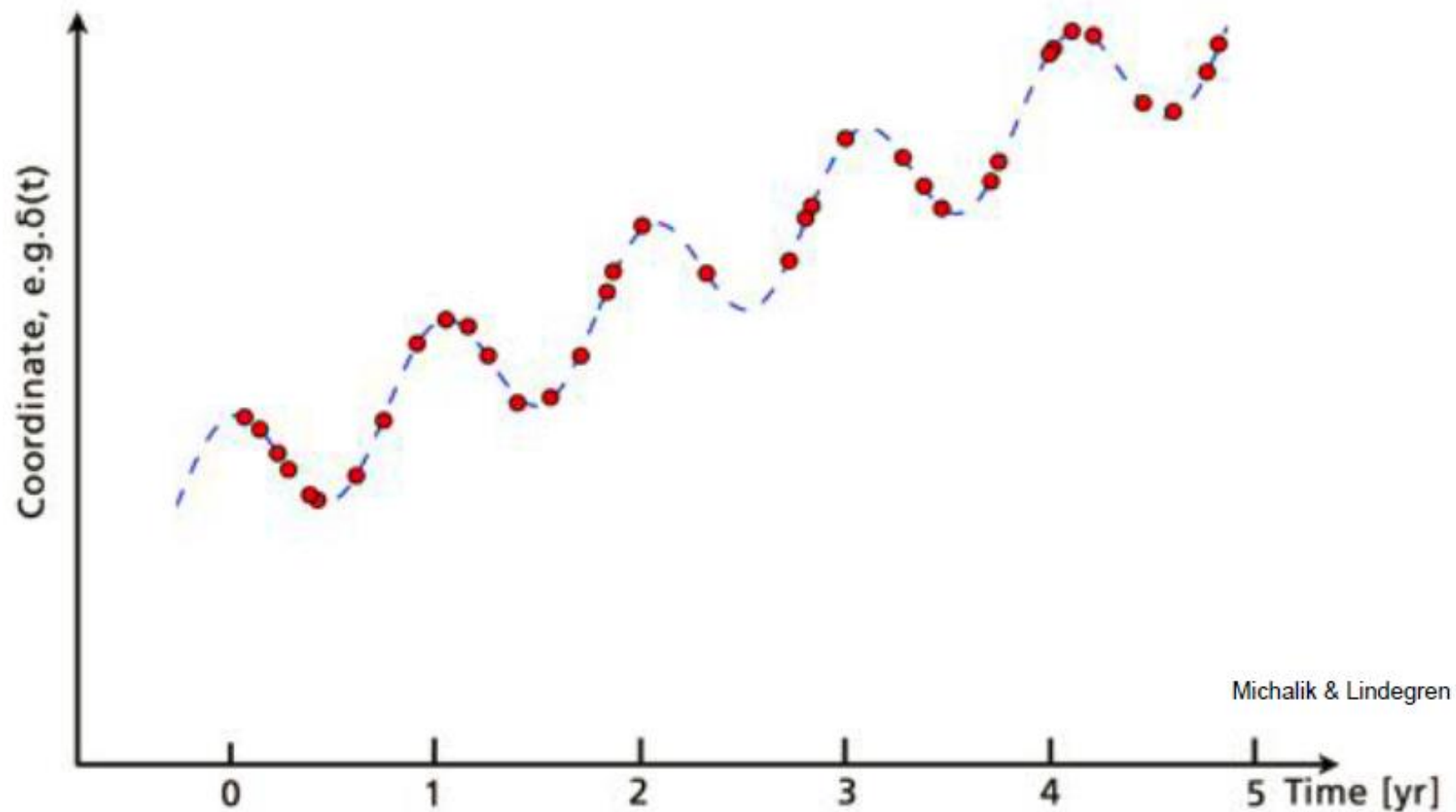
Number of transits (Astro−1 plus −2)

The Gaia DR1

- Parallaxes
- Proper Motions
- Positions
- Magnitude (G)
- Light curves of Cepheids and RR Lyrae stars
- The kinematic and astrometric data are also based on the Tycho catalogue
- Time span: 14 months

Why using Tycho data?

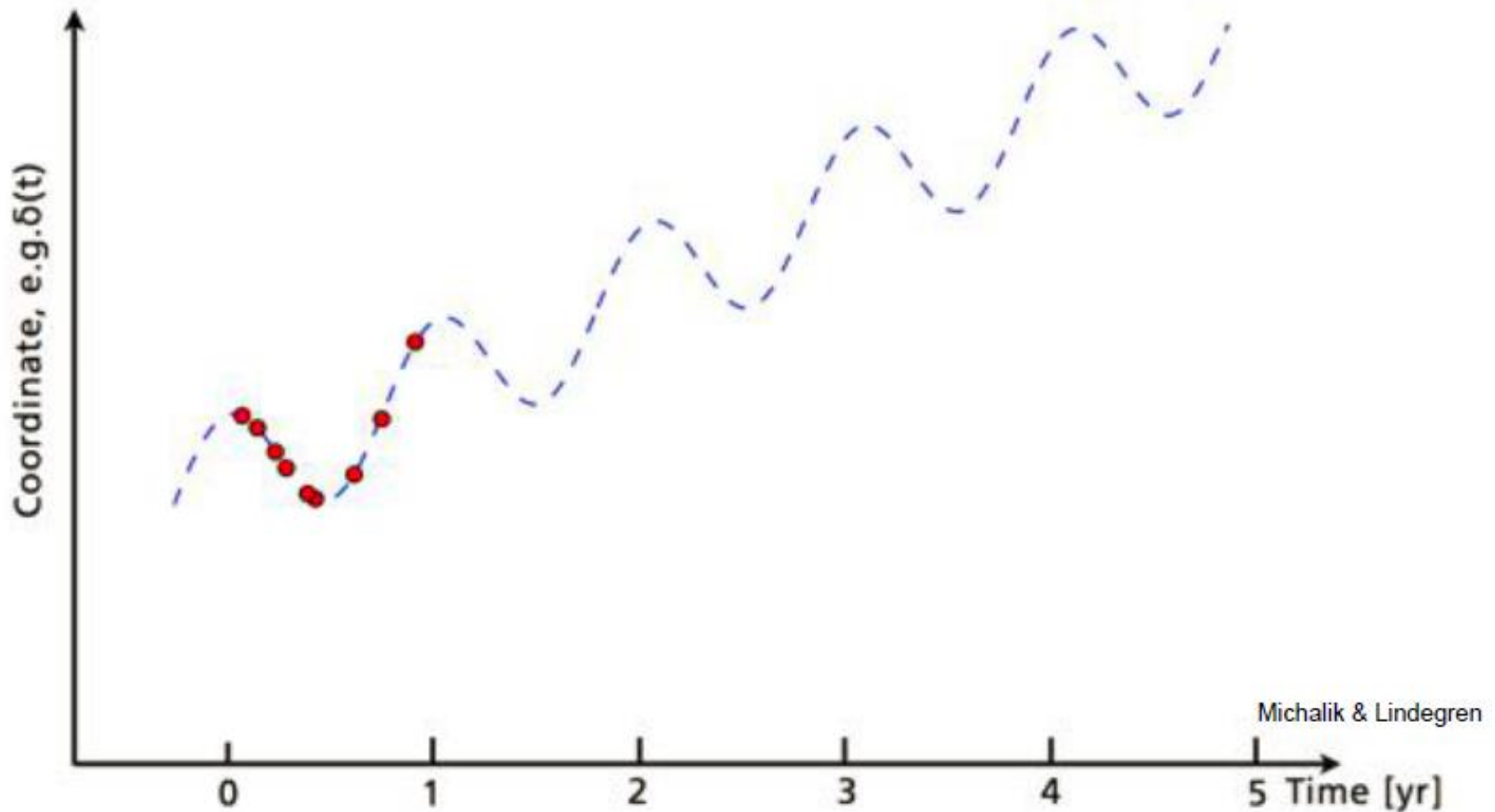Michalik & Lindegren

Why using Tycho data?

Coordinate, e.g.δ(t)

Michalik & Lindegren

0   1   2   3   4   5 Time [yr]

Why using Tycho data?

Coordinate, e.g. $\delta(t)$

Michalik & Lindegren

0   1   2   3   4   5 Time [yr]

Why using Tycho data?

Michalik & Lindegren
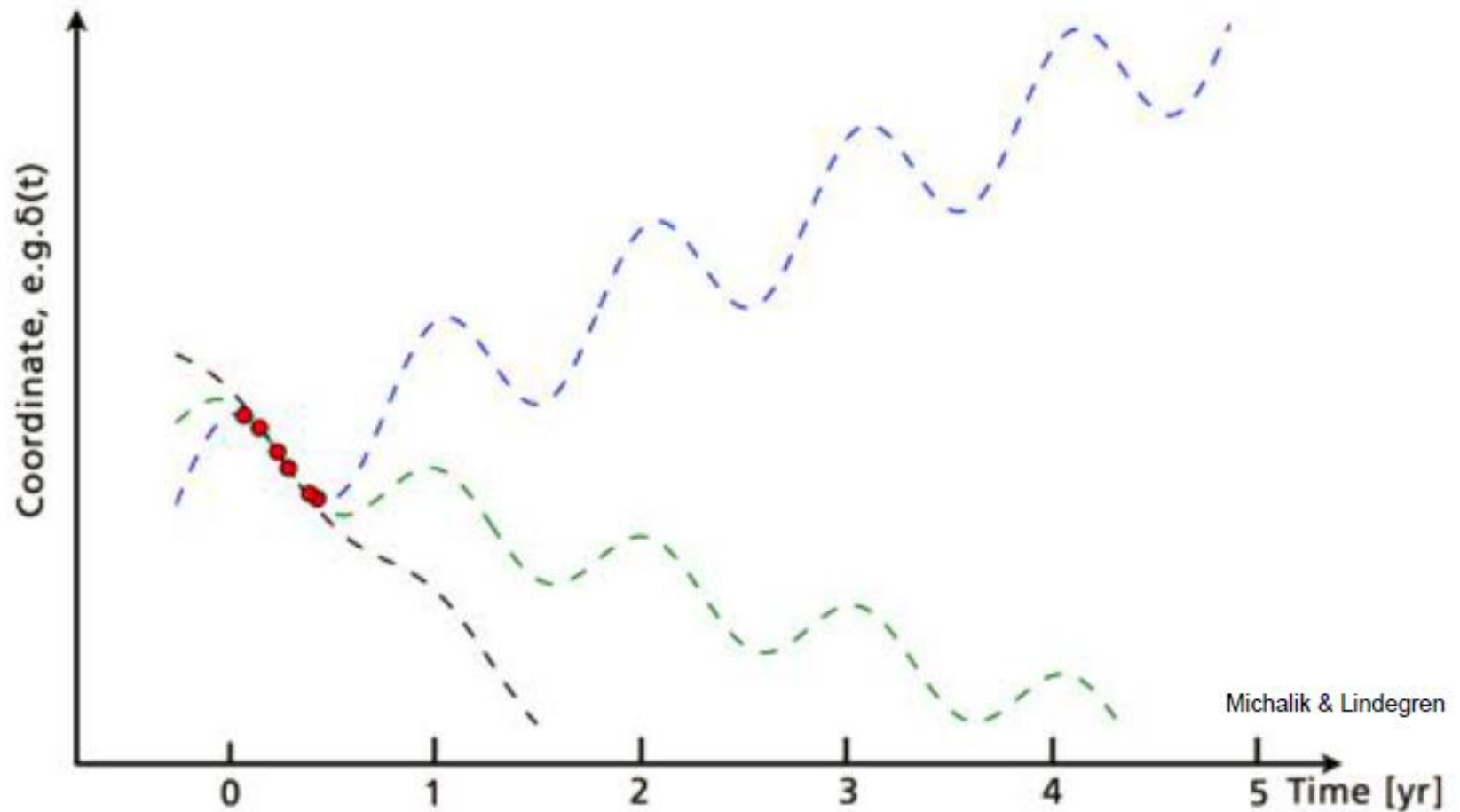
Why using Tycho data?

⇒ **Independent** long-baseline proper motions, parallaxes

Gaia

Tycho-2
position
(1991.25)

Michalik & Lindegren
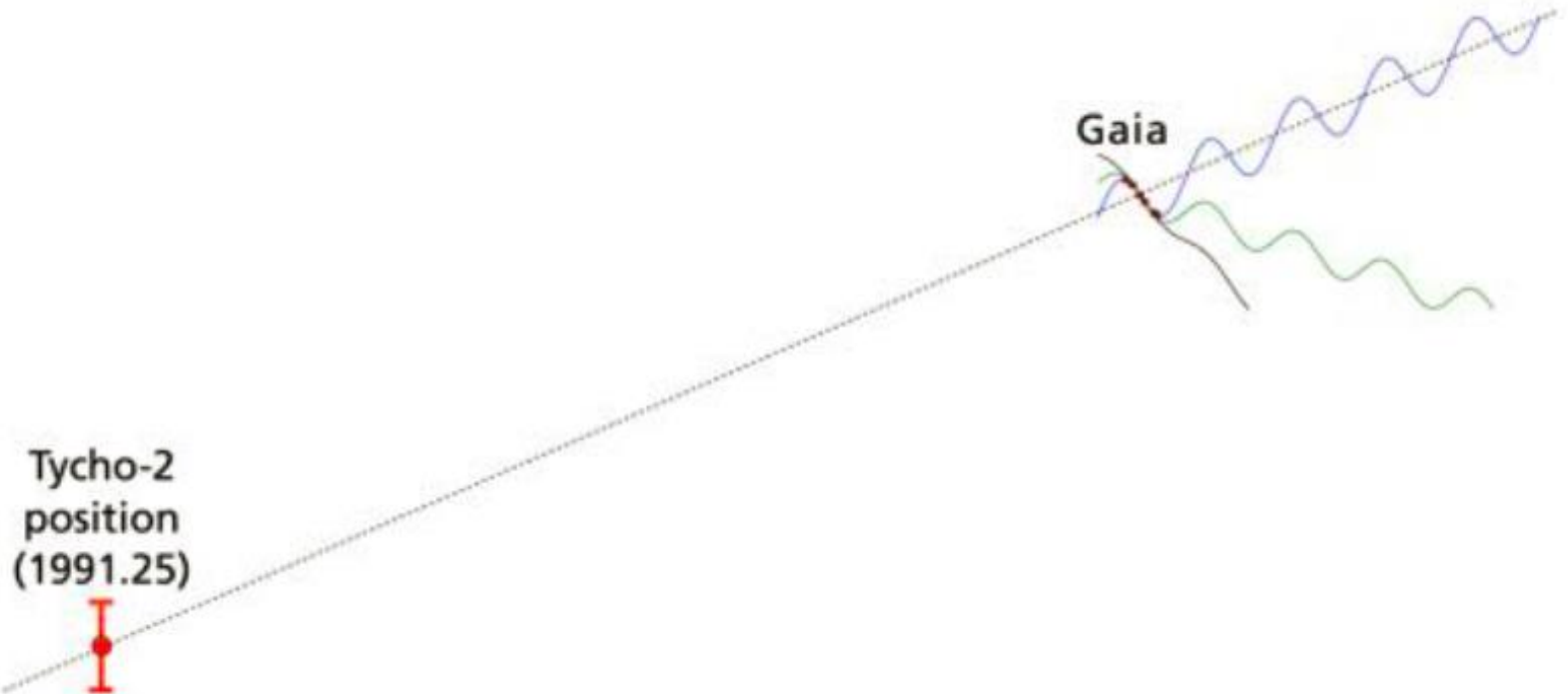
Some papers

- Gaia Data Release 1 - The Cepheid & RR Lyrae star pipeline and its application to the south ecliptic pole region (https://arxiv.org/abs/1609.04269)

- Gaia Data Release 1. Summary of the astrometric, photometric, and survey properties (https://arxiv.org/abs/1609.04172)

- Gaia Data Release 1: Astrometry - one billion positions, two million proper motions and parallaxes (https://arxiv.org/abs/1609.04303)

- Tests of the Galactic planetary nebula distance scale with the initial Gaia parallax distances of their central stars (https://arxiv.org/abs/1609.08840)

- Asteroseismic versus Gaia distances: A first comparison (http://adsabs.harvard.edu/abs/2016A%26A...595L...3D)

- The Galaxy Kinematics from OB Stars with Proper Motions from the Gaia DR1 Catalog (http://adsabs.harvard.edu/abs/2016arXiv161100794B)

- Tycho-Gaia Astrometric Solution parallaxes and proper motions for 5 Galactic globular clusters (https://arxiv.org/abs/1611.03170)

- Evidence for a Systematic Offset of -0.25 mas in the Gaia DR1 Parallaxes (http://adsabs.harvard.edu/abs/2016ApJ...831L...6S)

Full documentation

http://gaia.esac.esa.int/documentation/GDR1/index.html

The content of the Gaia DR1

Source numbers	
Total number of sources	1 142 679 769
No. of primary (TGAS) sources	2 057 050
HIPPARCOS	93 635
Tycho-2 (excluding Hipparcos stars)	1 963 415
No. of secondary sources	1 140 622 719
No. of sources with light curves	3194
Cepheids	599
RR Lyrae	2595

Magnitude distribution percentiles (G)	
0.135%	11.2
2.275%	14.5
15.866%	17.1
50%	19.0
84.134%	20.1
97.725%	20.7
99.865%	21.0

Full data set

Only positions +
G magnitudes

Limitations – What is missing?

- Many bright stars at G < 7 mag
- High proper motion stars with μ > 3.5 arcsec/yr
- Extremely blue and red objects
- Dense areas (hundred thousand objects per square degree) on the sky
- Mainly binaries for which the reduction did not converge
- Systematic instrumental error of ±0.30 mas, parallaxes can not be more precise than that

Formal errors

Quantity	All primary sources			Hipparcos subset			Unit
	10%	50%	90%	10%	50%	90%	
Standard uncertainty in α ($\sigma_{\alpha*} = \sigma_\alpha \cos\delta$)	0.147	0.254	0.601	0.158	0.224	0.391	mas
Standard uncertainty in δ (σ_δ)	0.140	0.233	0.530	0.150	0.218	0.378	mas
Standard uncertainty in ϖ (σ_ϖ)	0.242	0.322	0.644	0.229	0.283	0.499	mas
Standard uncertainty in $\mu_{\alpha*}$ ($\sigma_{\mu\alpha*}$)	0.500	1.132	2.671	0.035	0.064	0.129	mas yr^{-1}
Standard uncertainty in μ_δ ($\sigma_{\mu\delta}$)	0.441	0.867	1.957	0.031	0.056	0.109	mas yr^{-1}
Semi-major axis of error ellipse in position ($\sigma_{pos,max}$)	0.203	0.319	0.753	0.196	0.263	0.475	mas
Semi-major axis of error ellipse in proper motion ($\sigma_{pm,max}$)	0.715	1.322	3.189	0.038	0.069	0.137	mas yr^{-1}
Excess source noise (ϵ_i)	0.299	0.478	0.855	0.347	0.572	1.185	mas
Number of field-of-view transits input to the solution (N)	8	15	25	7	14	25	
Number of good CCD observations AL used in the solution (n_{good})	57	99	185	51	93	180	
Fraction of bad CCD observations AL ($n_{bad}/(n_{good}+n_{bad})$)	0.0	0.0	2.0	0.0	0.0	1.8	%
Normalised difference to Hipparcos proper motion (ΔQ)	–	–	–	0.33	2.35	11.32	
Magnitude in Gaia's unfiltered band (G)	9.27	11.04	12.05	6.84	8.28	9.70	mag

| Quantity	10%	50%	90%	Unit
Standard uncertainty in α ($\sigma_{\alpha*} = \sigma_\alpha \cos\delta$)	0.285	1.802	12.871	mas
Standard uncertainty in δ (σ_δ)	0.257	1.568	11.306	mas
Semi-major axis of error ellipse in position ($\sigma_{pos,max}$):				
$G < 16$ (7% of the secondary data set)	0.106	0.255	4.118	mas
$G = 16–17$ (7%)	0.182	0.484	11.105	mas
$G = 17–18$ (13%)	0.284	0.761	11.534	mas
$G = 18–19$ (22%)	0.501	1.444	13.027	mas
$G = 19–20$ (31%)	0.986	2.816	16.314	mas
$G = 20–21$ (20%)	2.093	7.229	21.737	mas
all magnitudes (100%)	0.349	2.345	15.699	mas
Excess source noise (ϵ_i)	0.000	0.594	2.375	mas
Number of field-of-view transits input to the solution (N)	7	13	26	
Number of good CCD observations AL used in the solution (n_{good})	41	71	157	
Fraction of bad CCD observations AL ($n_{bad}/(n_{good}+n_{bad})$)	0.0	0.0	2.0	%
Magnitude in Gaia's unfiltered band (G)	16.49	19.02	20.32	mag

The content of the Gaia DR1
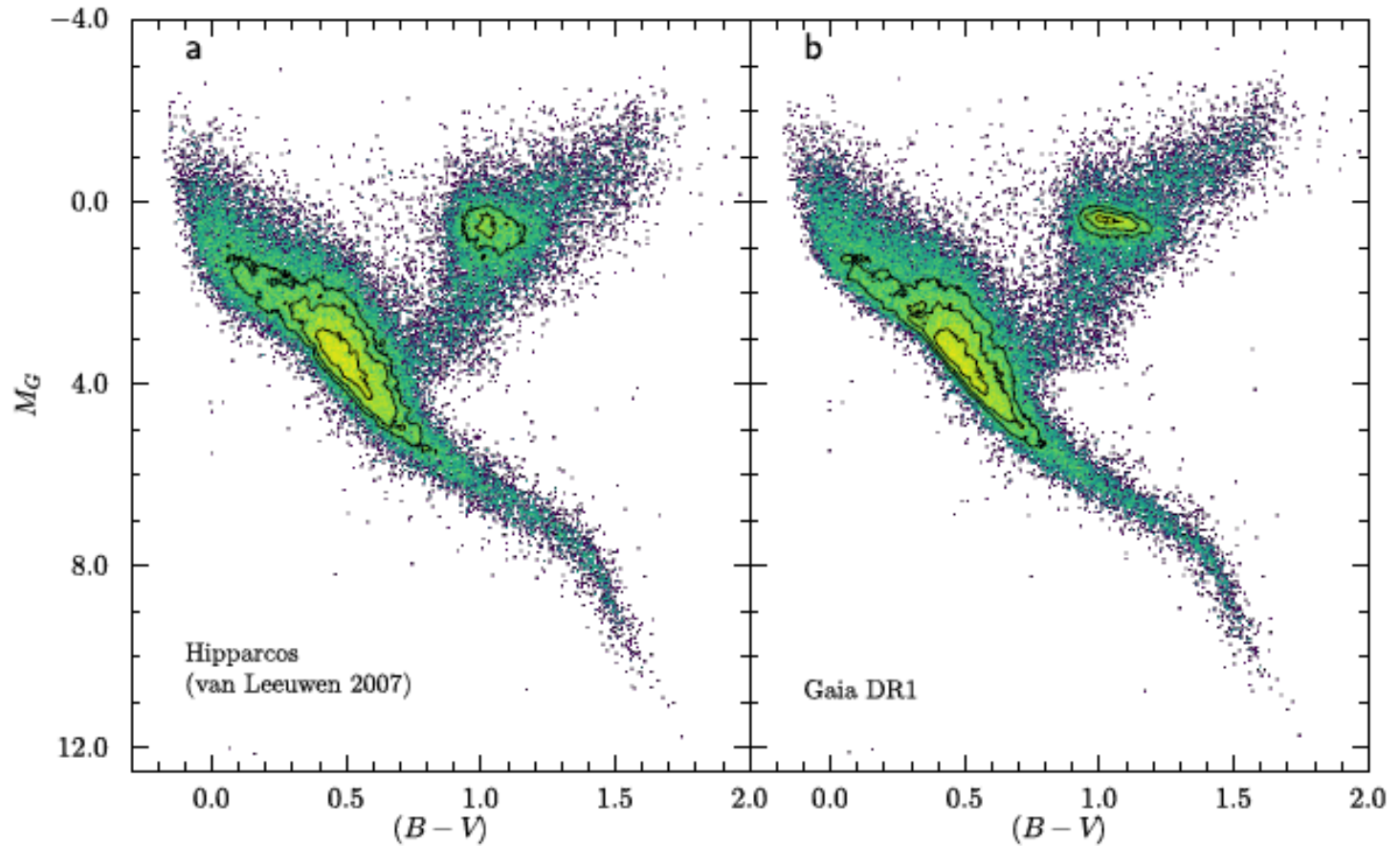
The content of the Gaia DR1
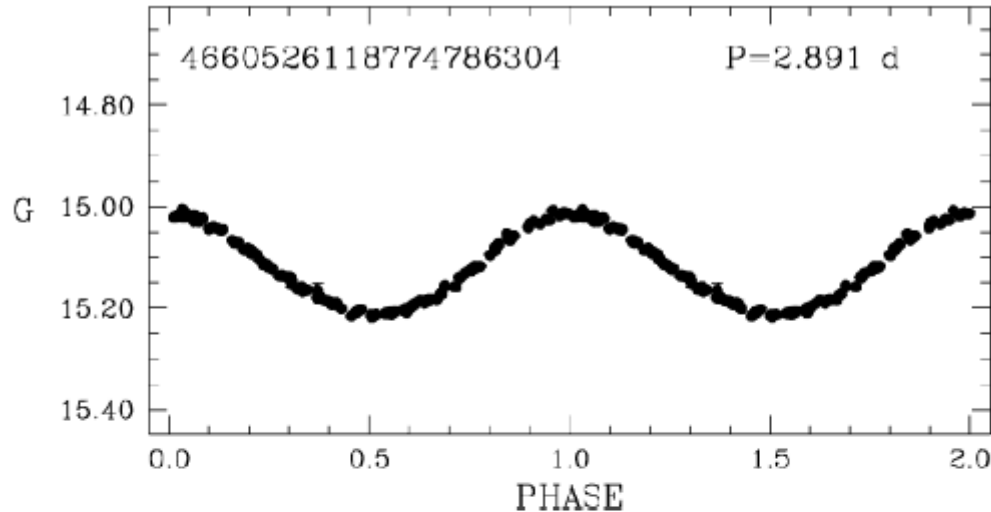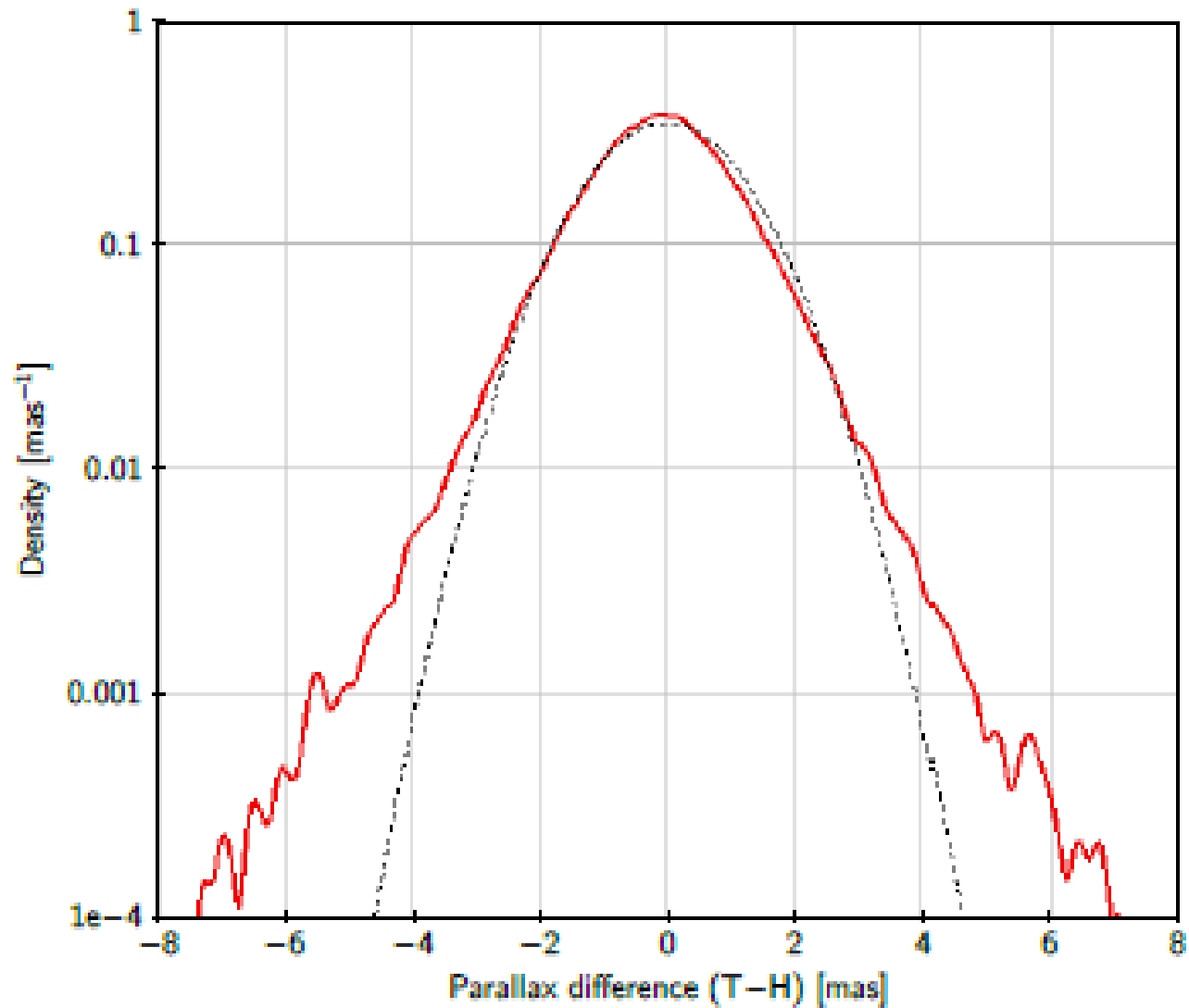

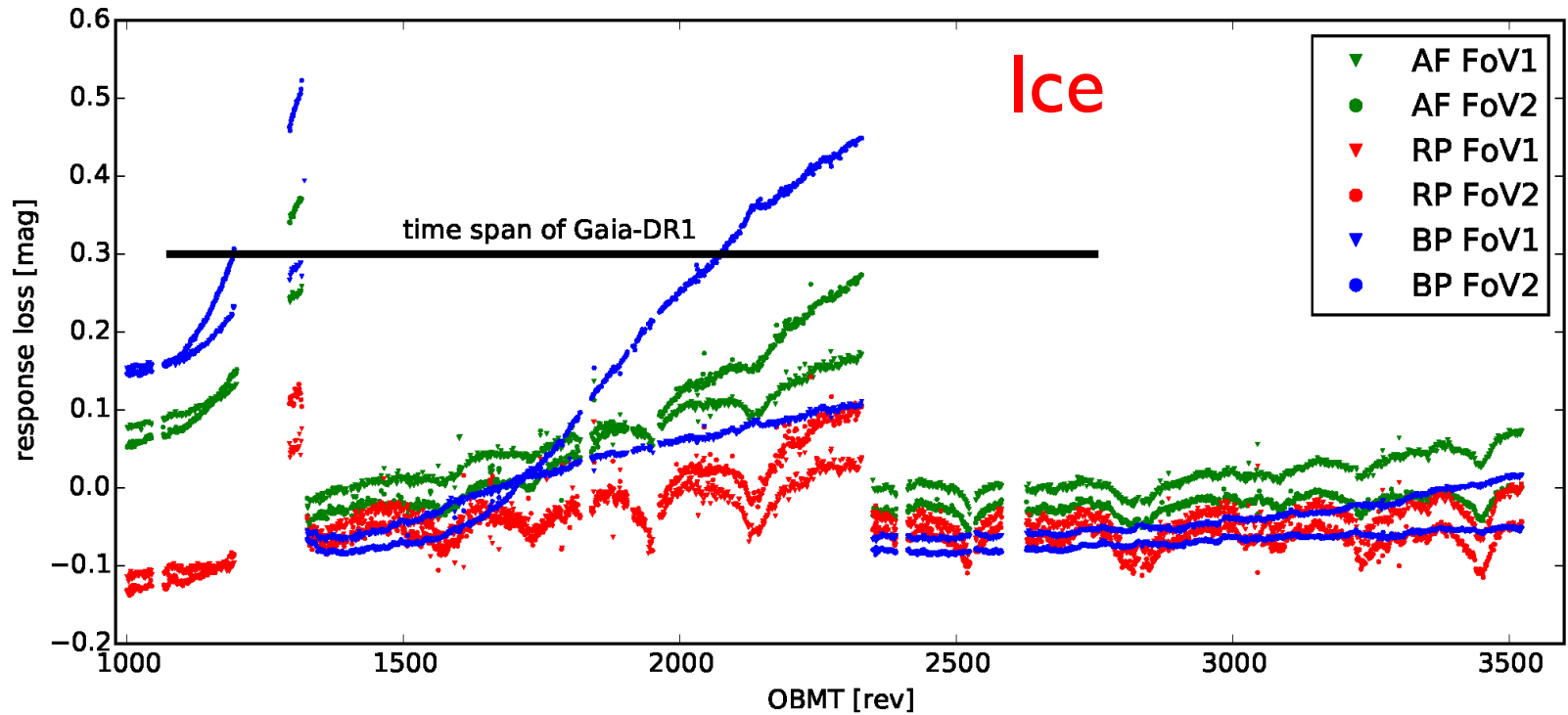Error of individual measurement is about 0.02 mag
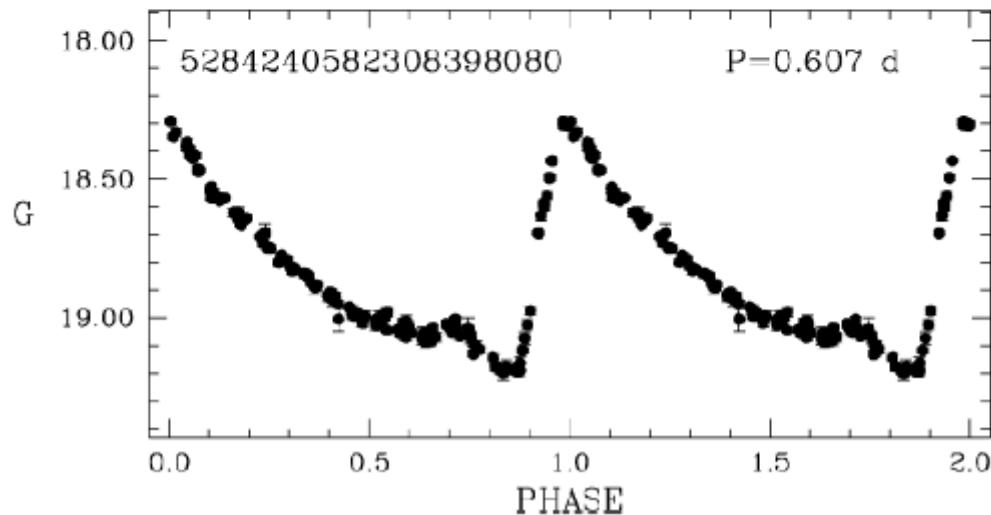
Comparison with Hipparcos
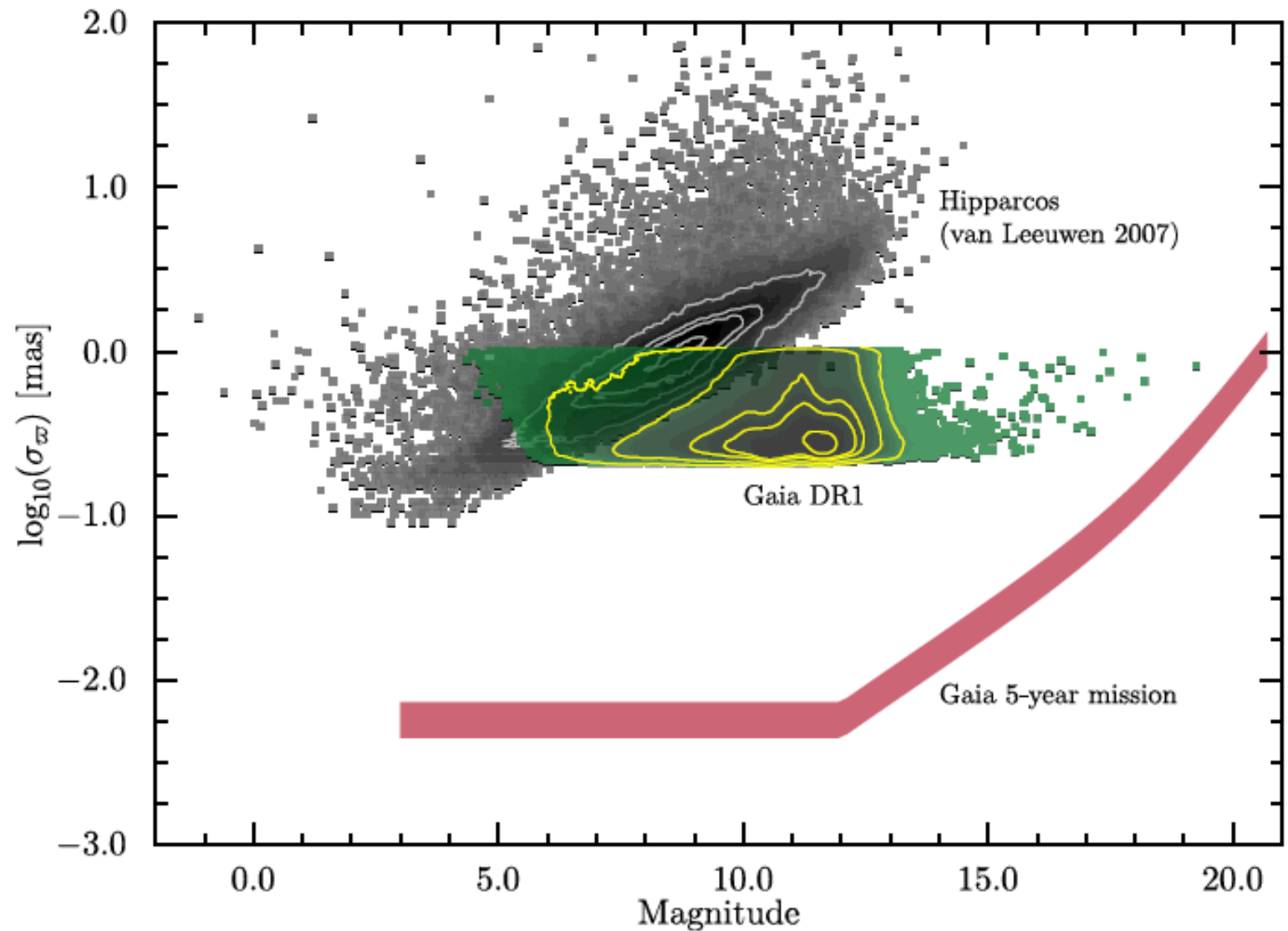
Error not depending on magnitude
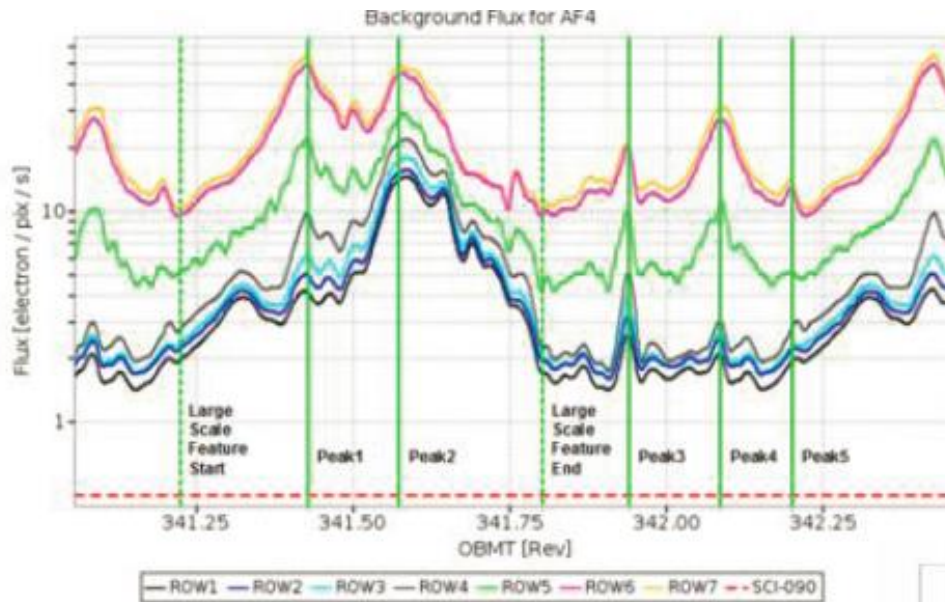
Comparison with Hipparcos

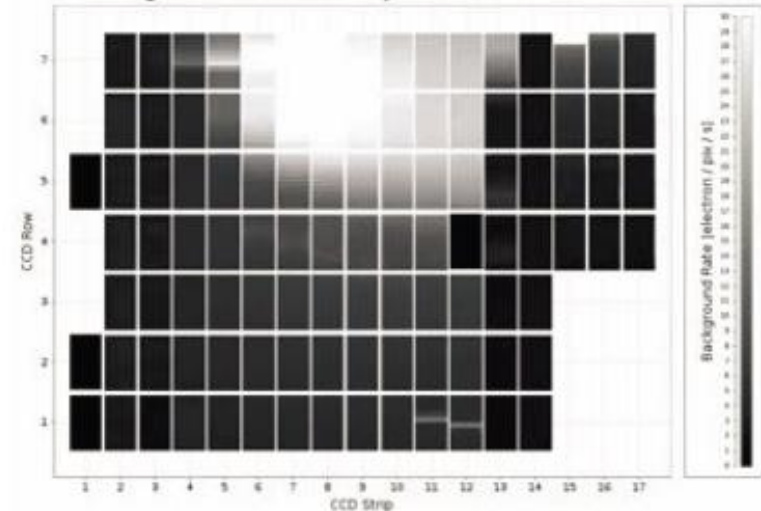

Small offset by 0.25 mas

Performance losses

Performance losses

Background Flux for AF4

Background Rate Time Step 905 OBMT [Rev]: 425.516

- Diffracted sunlight
- Milky Way
- Bright point objects
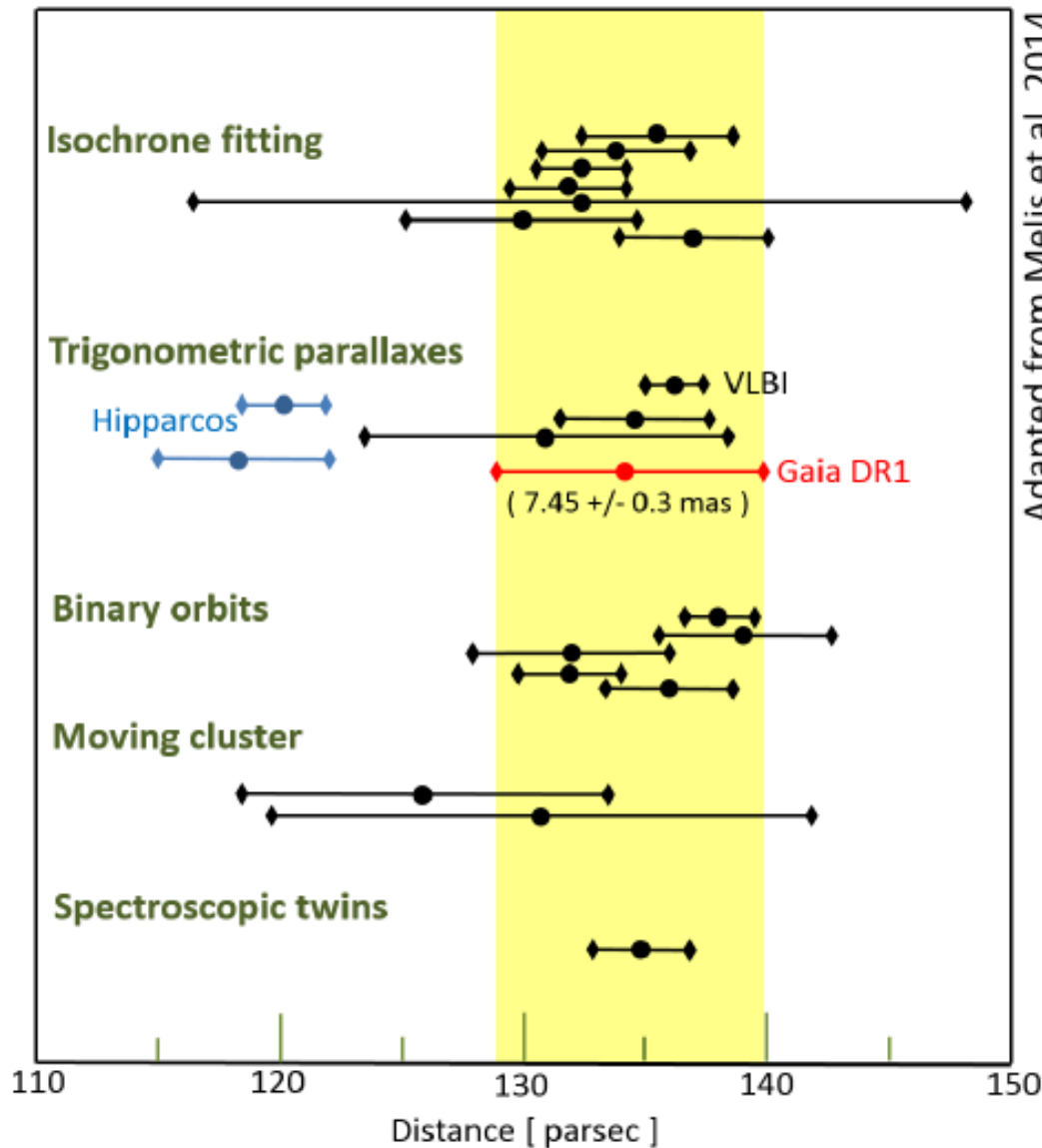
1. Sunshield
2. Insufficient baffling

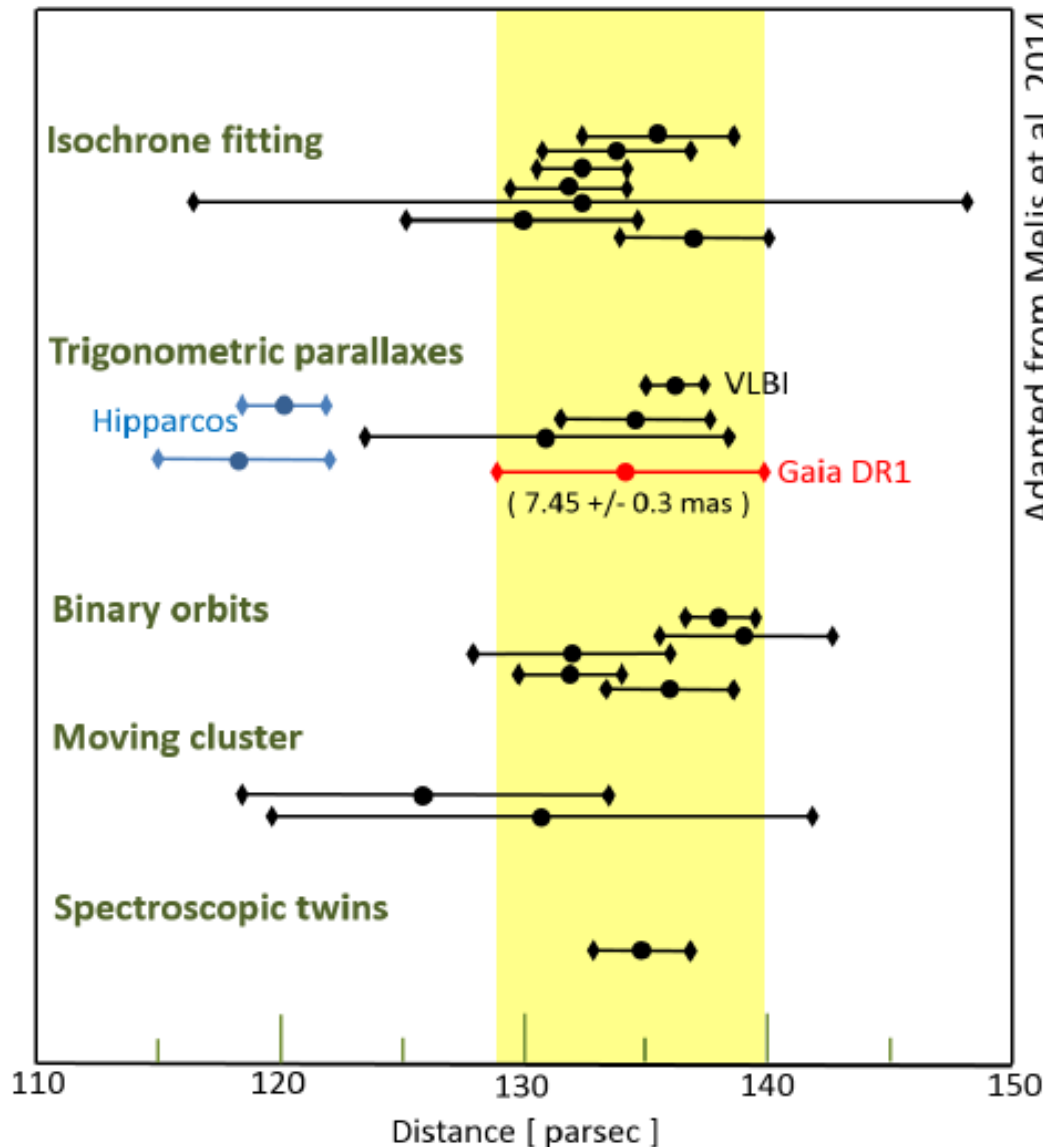Unexpected stray light

Performance losses
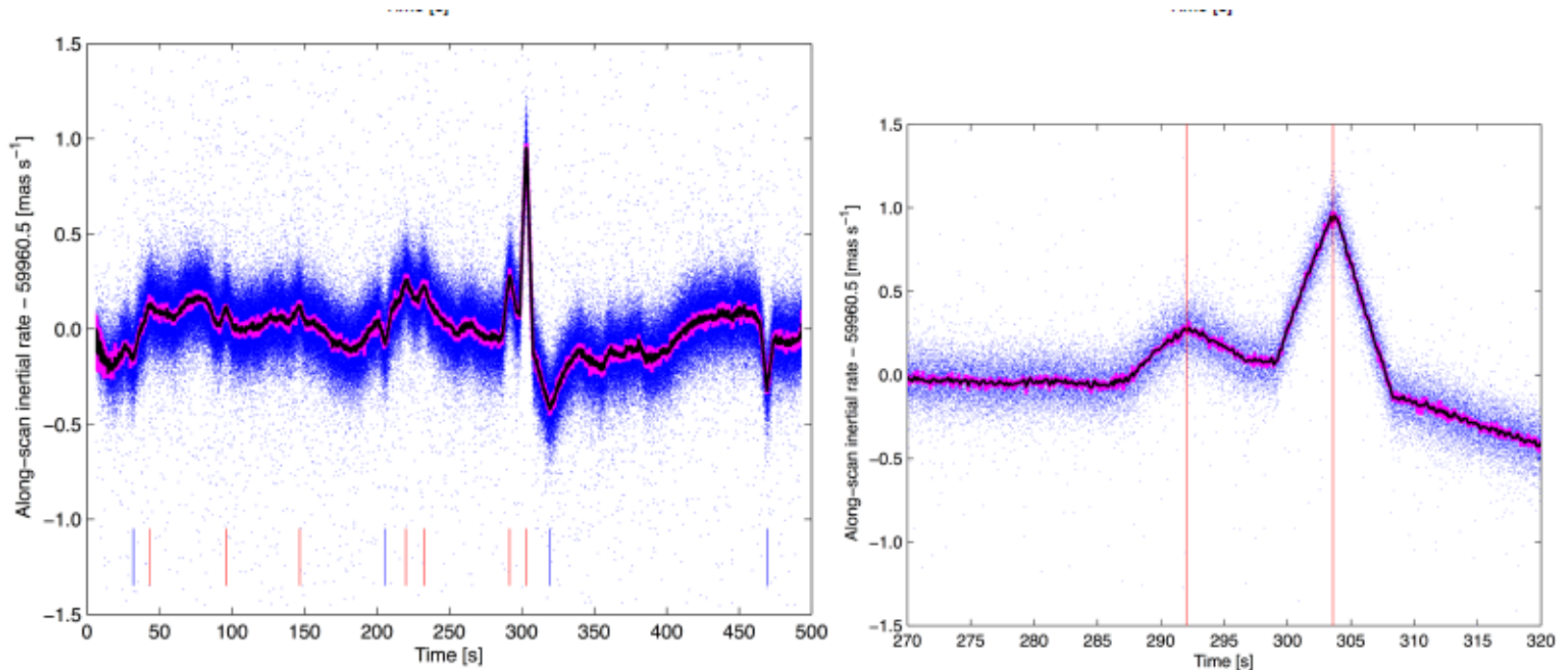
Scan over CCDs not constant
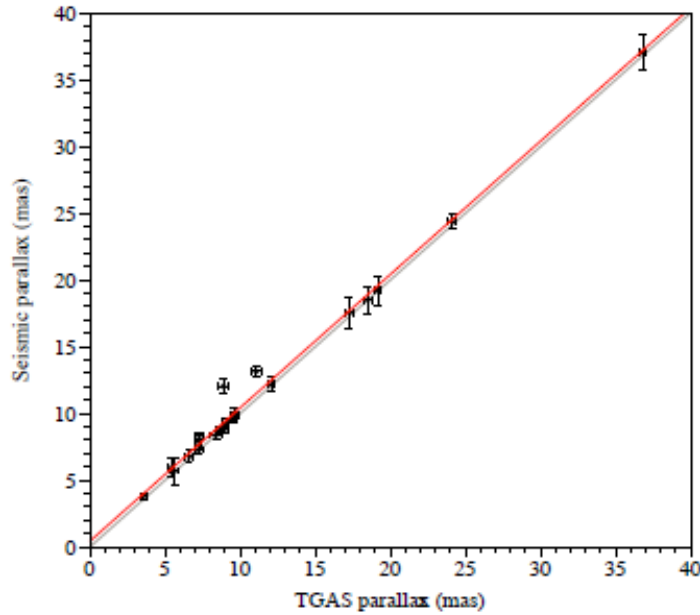
The Pleiades problem

Keep in mind that the Hipparcos data were used for the Gaia DR1 proper motions

The Pleiades problem

Keep in mind that the Hipparcos data were also used for the Gaia DR1

Asteroseismic Distances

Pulsators

Red Giants