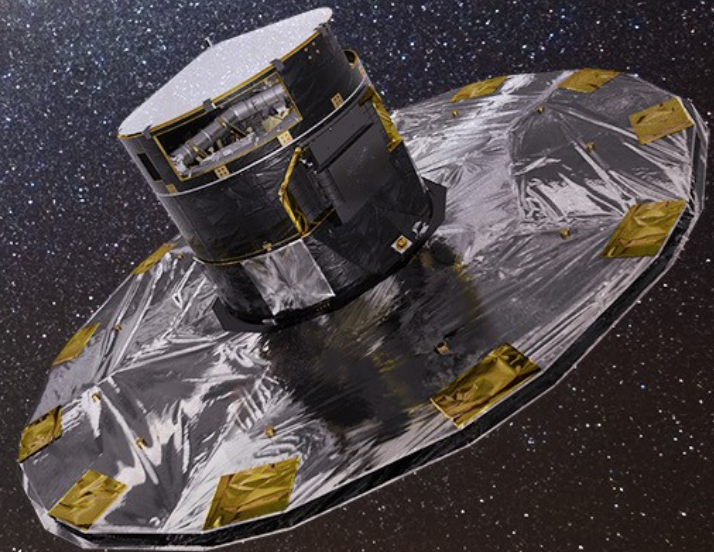




UNIVERSITY OF
CAMBRIDGE



Gaia and Gaia Alerts



Morgan Fraser (with guest star
Simon Hodgkin)

Many people involved...

Lukasz Wyrzykowski
Guy Rixon
Heather Campbell
Nic Walton

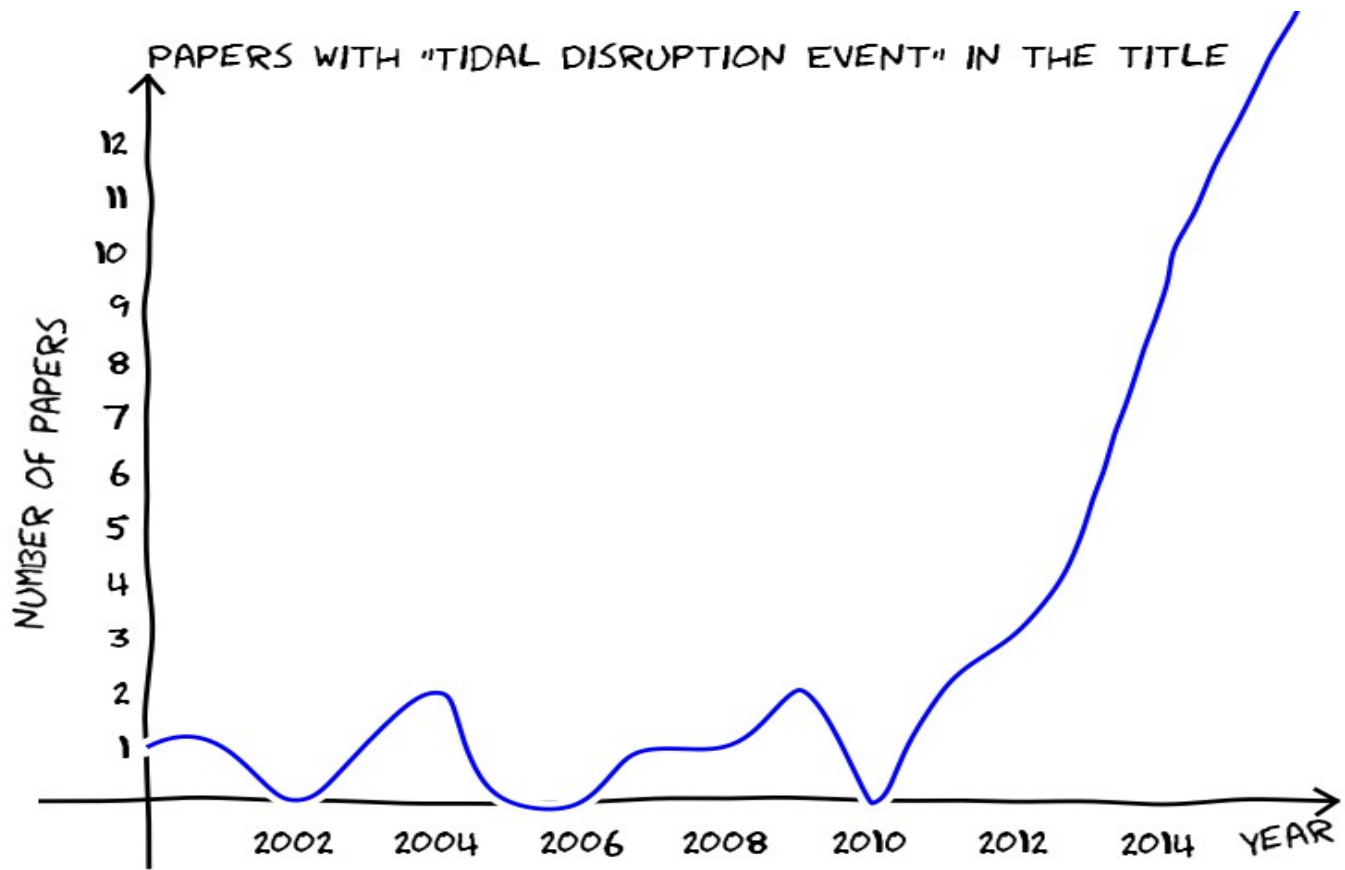
Simon Hodgkin
Nadia Blagorodnova
Sergey Kuposov
Gerry Gilmore



University of Cambridge	St. Andrews	Open University	} Not an exhaustive list
University of Warsaw	University of Warwick	ING	
University College Dublin	Queens University Belfast	SRON/Utrecht	
University of Padova	LJMU	Tuorla Obs.	
University of Bologna	OHP	CBA	
SAAO	University of Geneva	...	
University of Sheffield	Sorbonne Universites	...	

See longer list at:

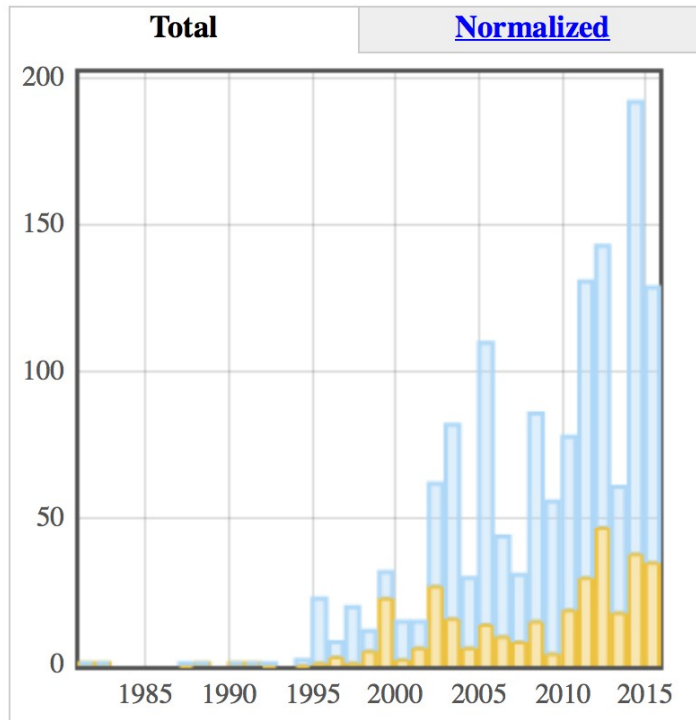
http://www.ast.cam.ac.uk/ioa/wikis/gsawgwiki/index.php/Working_groups



Courtesy of Iair

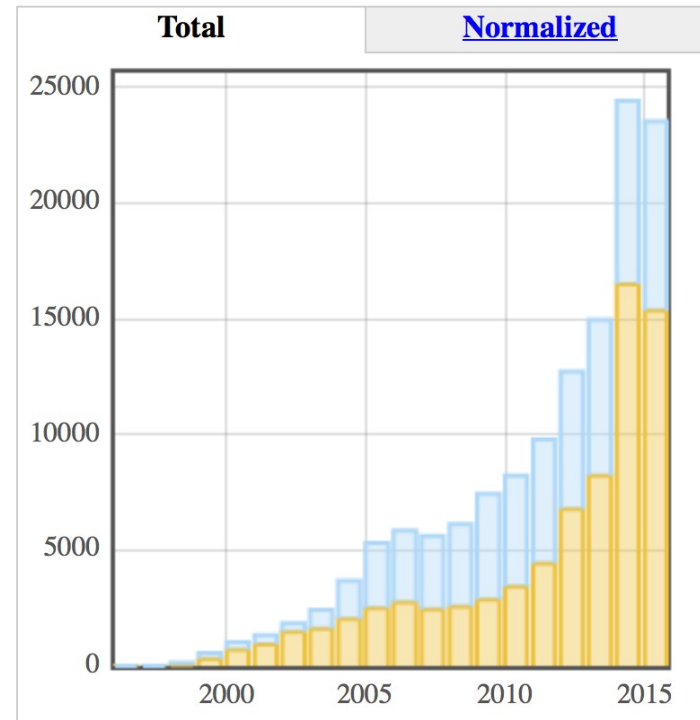
Paper with "Gaia" in the title

Publications per year



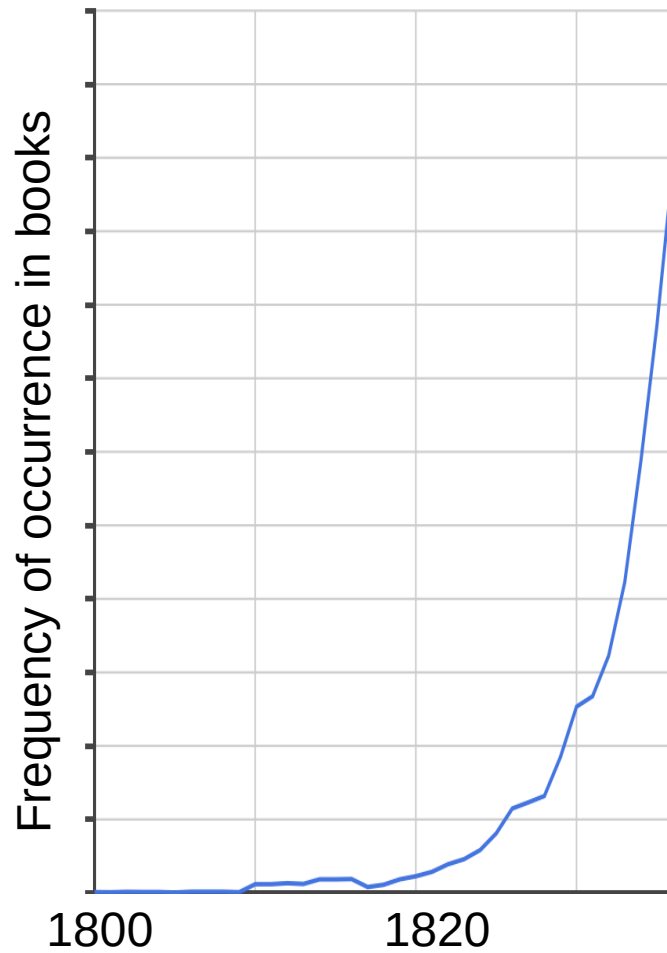
Refereed
Not Refereed

Reads per year



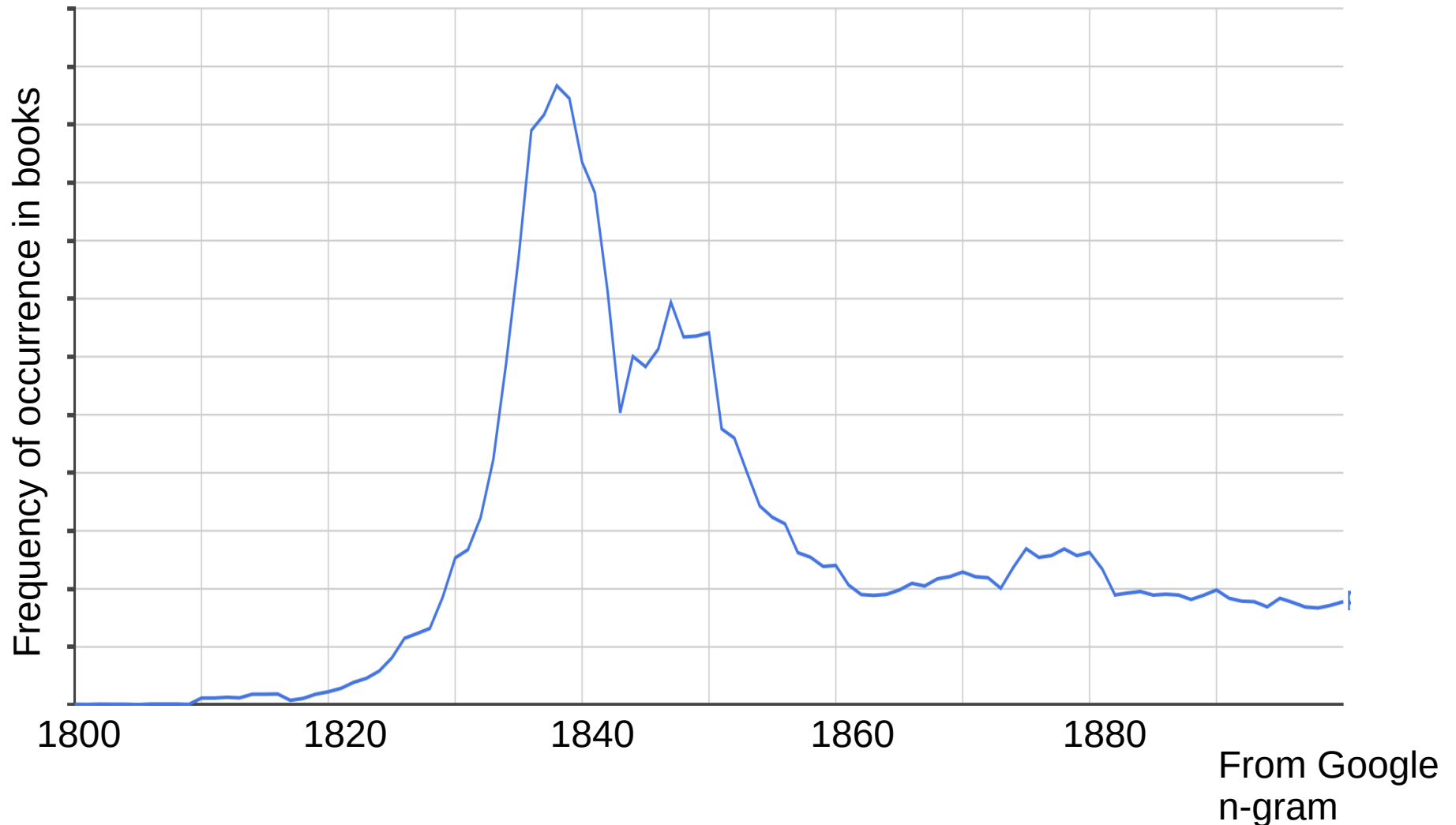
Refereed
Not Refereed

Books containing mentions of “phrenology” in text



From Google
n-gram

Books containing mentions of “phrenology” in text

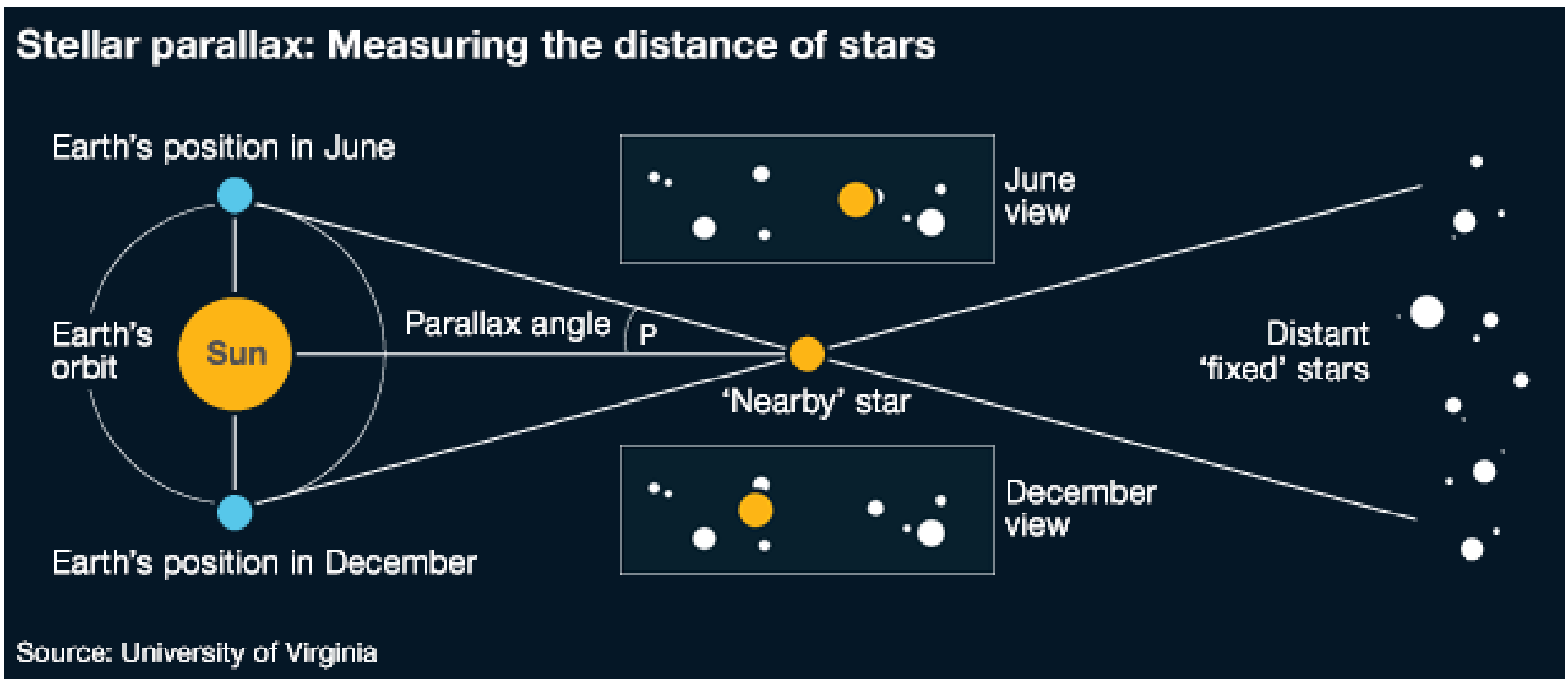


Why Gaia?



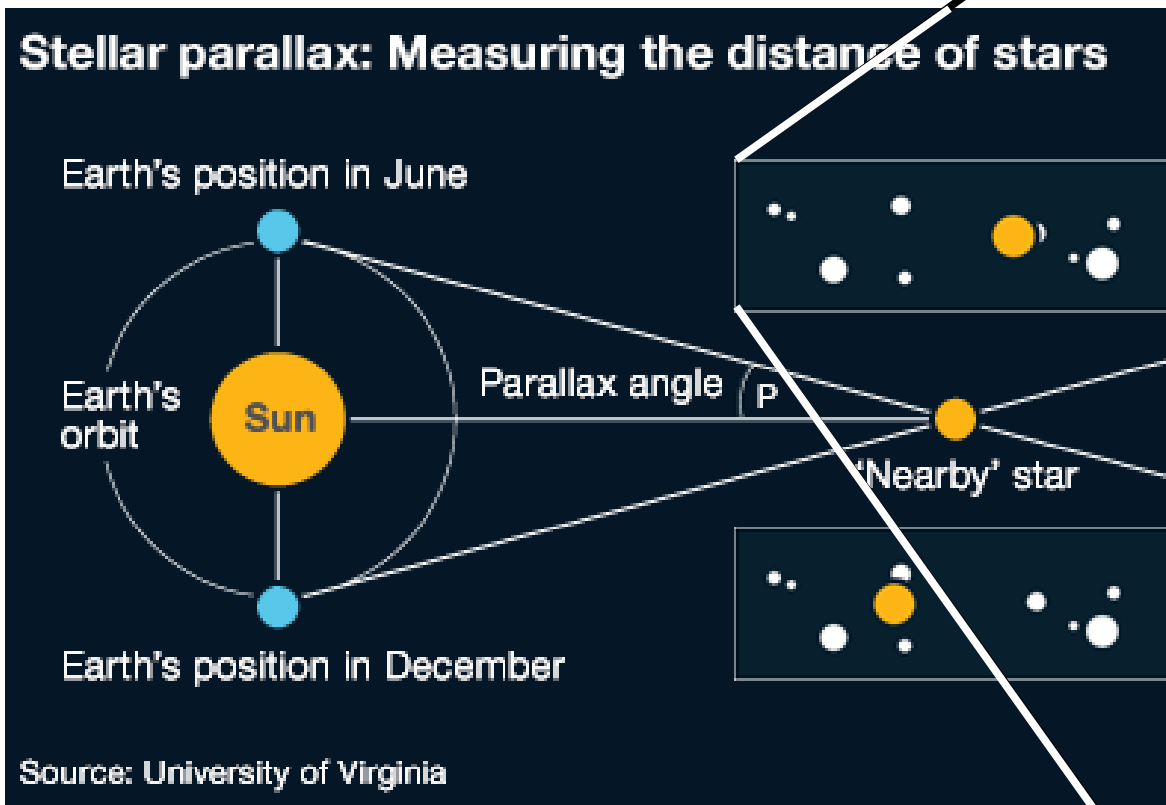
Parallax

Parallax 0.7" for Proxima Centauri



Parallax

Parallax 07" for Proxima Centauri



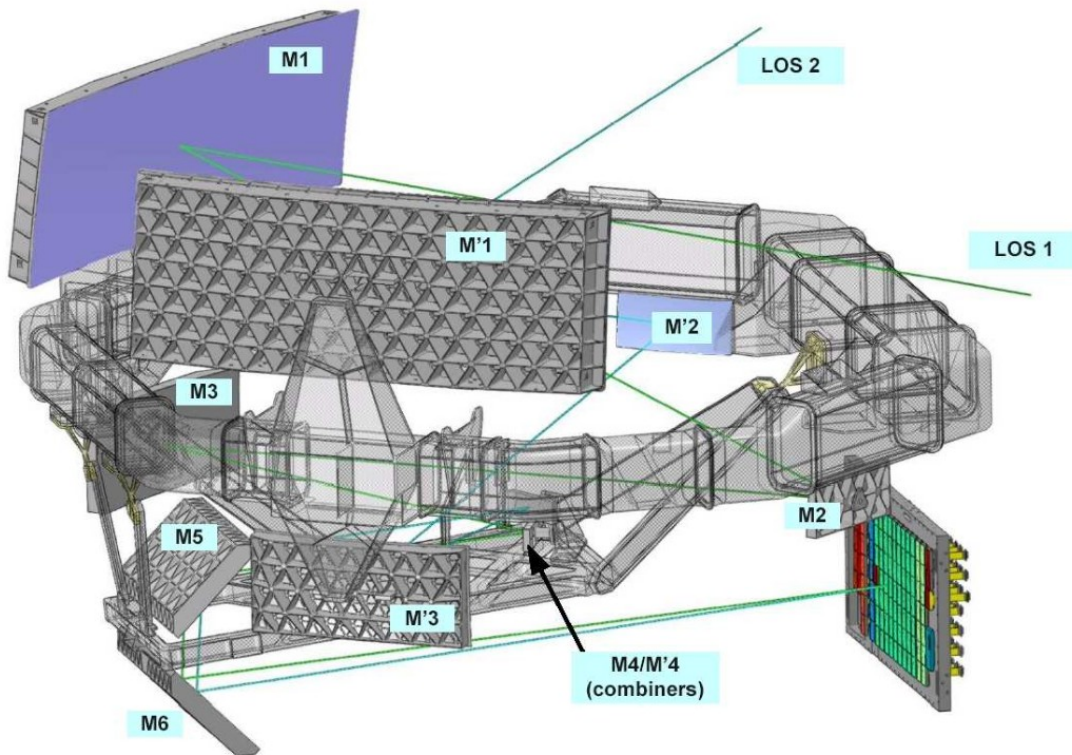
History of parallax measurements

Year	Survey	<i>N</i>	Resolution
1831	Bessel, 61 Cyg	10^0	~arcsec
1800-1980	Photographic plates	10^2	~arcsec
1989-1993	Hipparcos	10^5	~milli''
2013-	Gaia	10^9	~micro''

Gaia astrometric performance

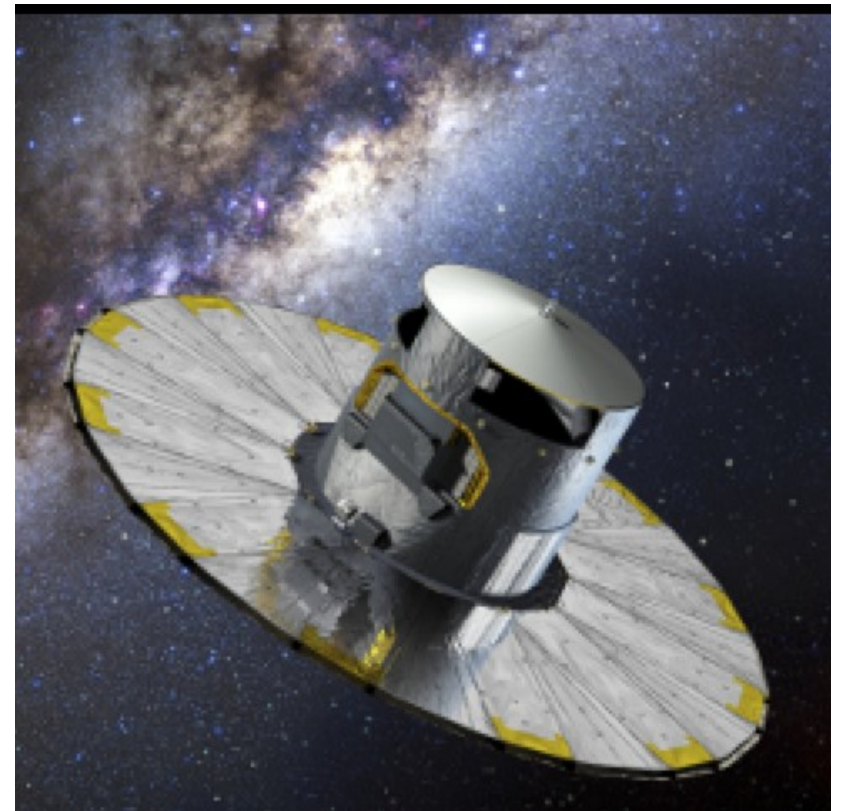
	B1V	G2V	M6V
V-I_C [mag]	-0.22	0.75	3.85
Bright stars	5-16 μ s (3 mag < V < 12 mag)	5-16 μ s (3 mag < V < 12 mag)	5-16 μ s (5 mag < V < 14 mag)
V = 15 mag	26 μ s	24 μ s	9 μ s
V = 20 mag	600 μ s	540 μ s	130 μ s

The Gaia satellite



Two telescopes/mirrors/fields-of-view, imaged onto a common CCD

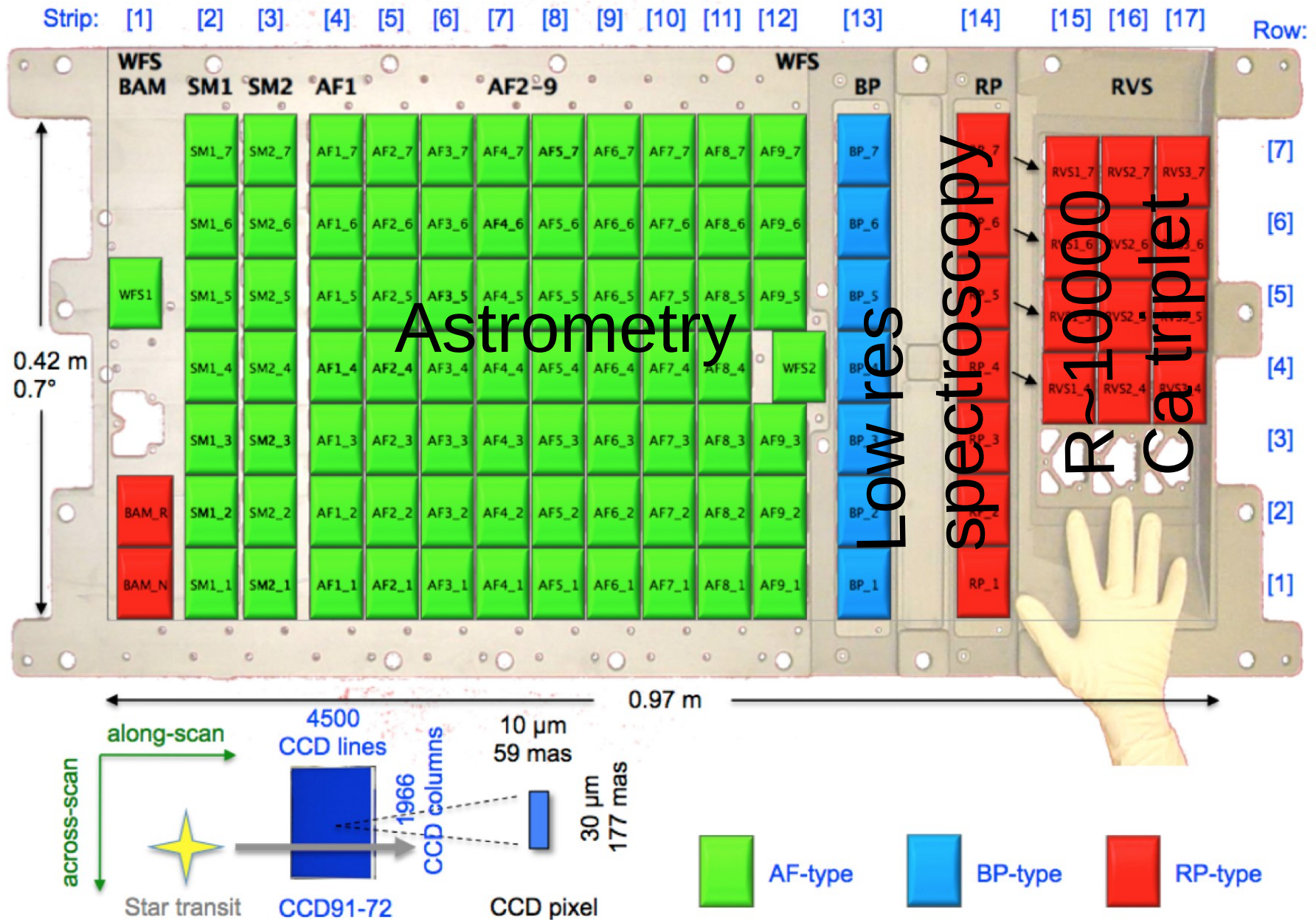
Continuous scanning and readout over entire sky...



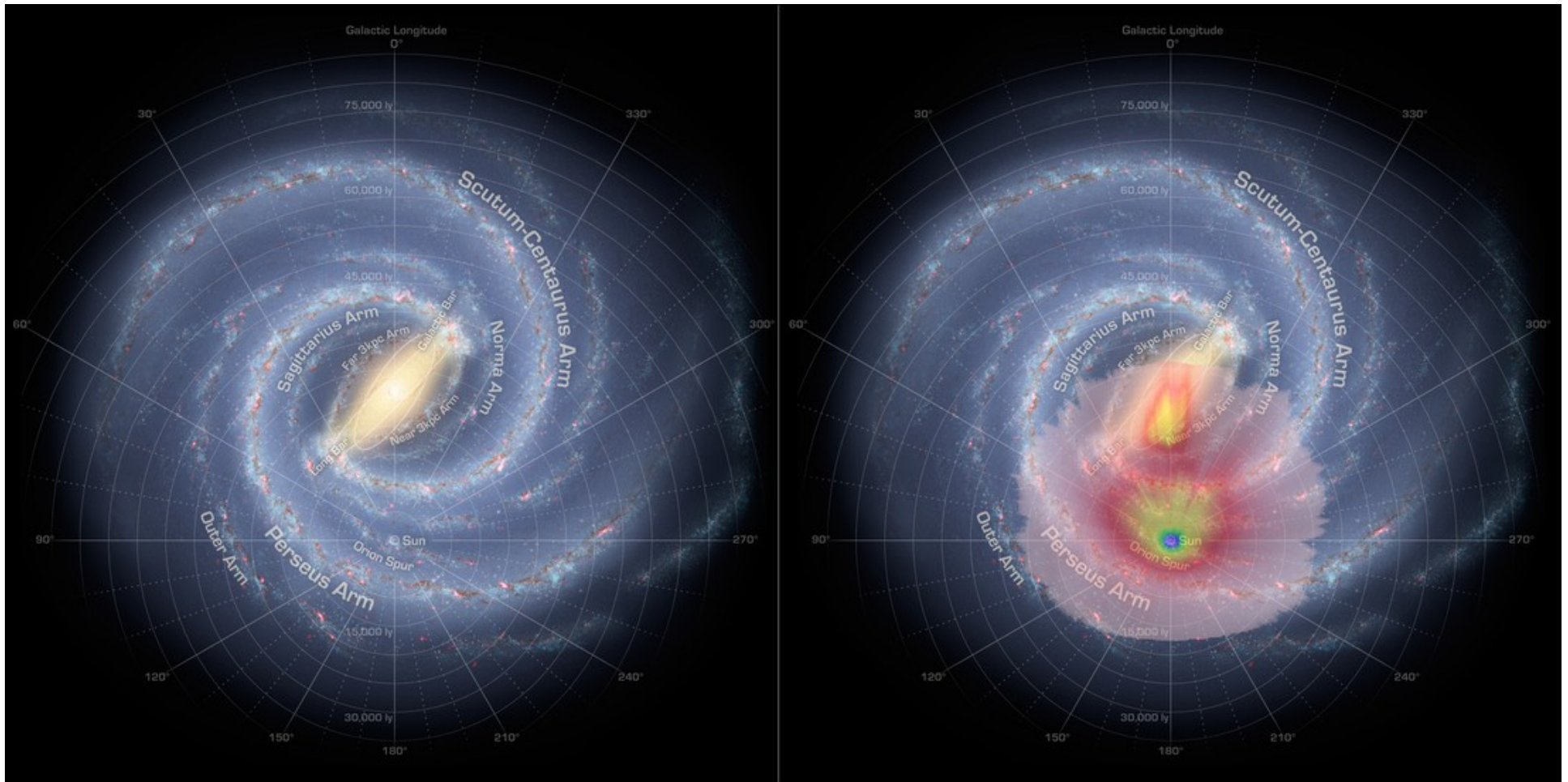
Launched Dec. 2013

Focal Plane

Figure courtesy Ralf Kohley



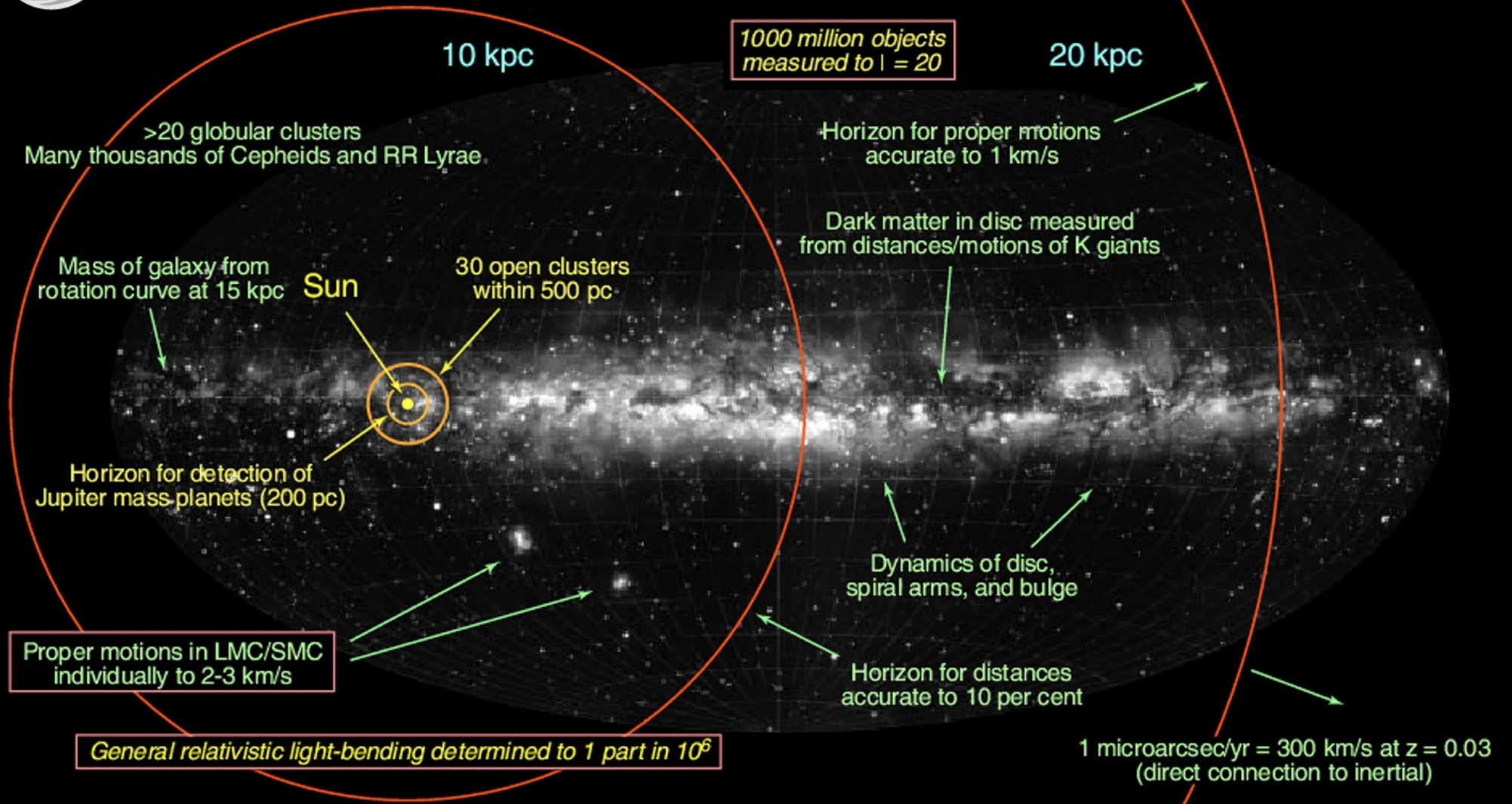
How much of the MW can Gaia see



Science from Gaia



gaia

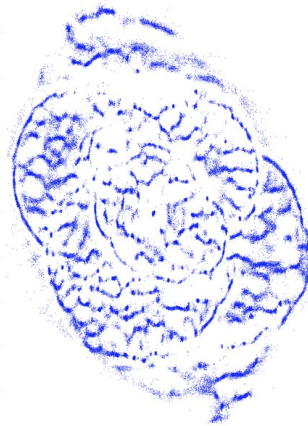


Resolution

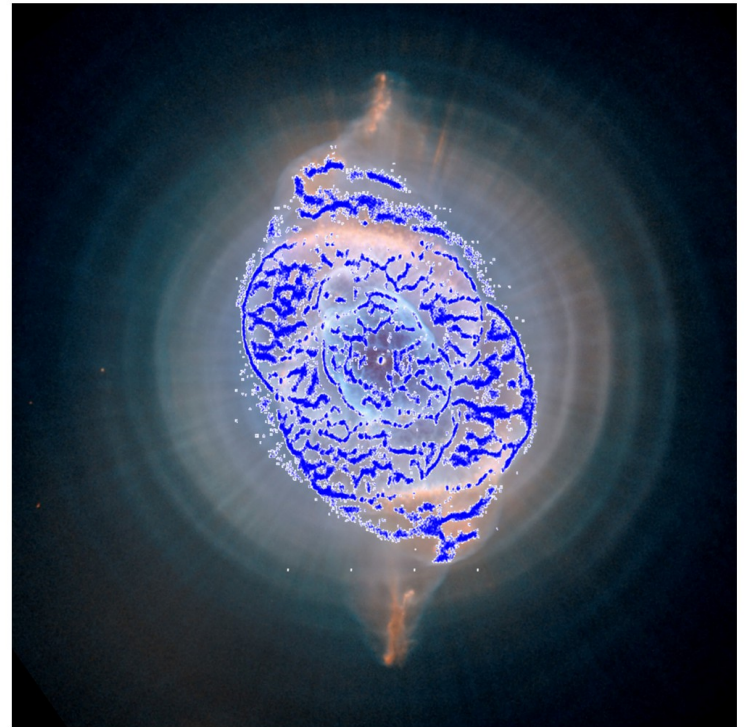
HST



Gaia



Gaia + HST



~~Problems~~ Unexpected Features

- Sun stray light
 - Impacts faint sources and especially in spectroscopy
 - Stray light both from astronomical sources and the Sun
- Transmission loss due to ice accumulation
 - Water source not yet exhausted although maximum contamination rate dropped below 1 mmag/day
- Basic Angle variation larger than expected

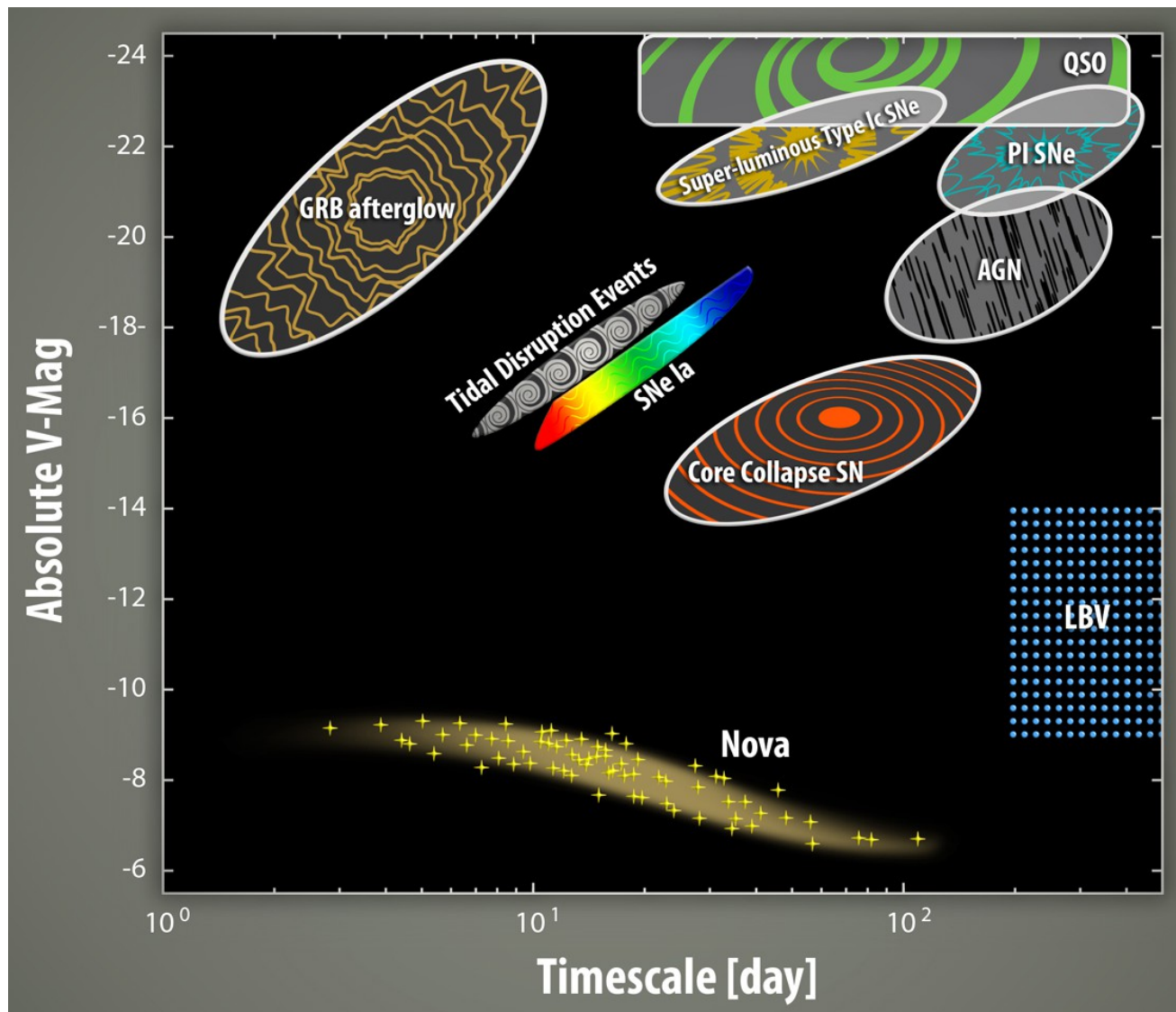
Gaia Alerts

We want to find:

Extragalactic (SNe, AGN flares, TDEs, GRB afterglows...)

Galactic (CVs, M-star flares, Flare stars, W UMa's, microlensing, LMXBs...)

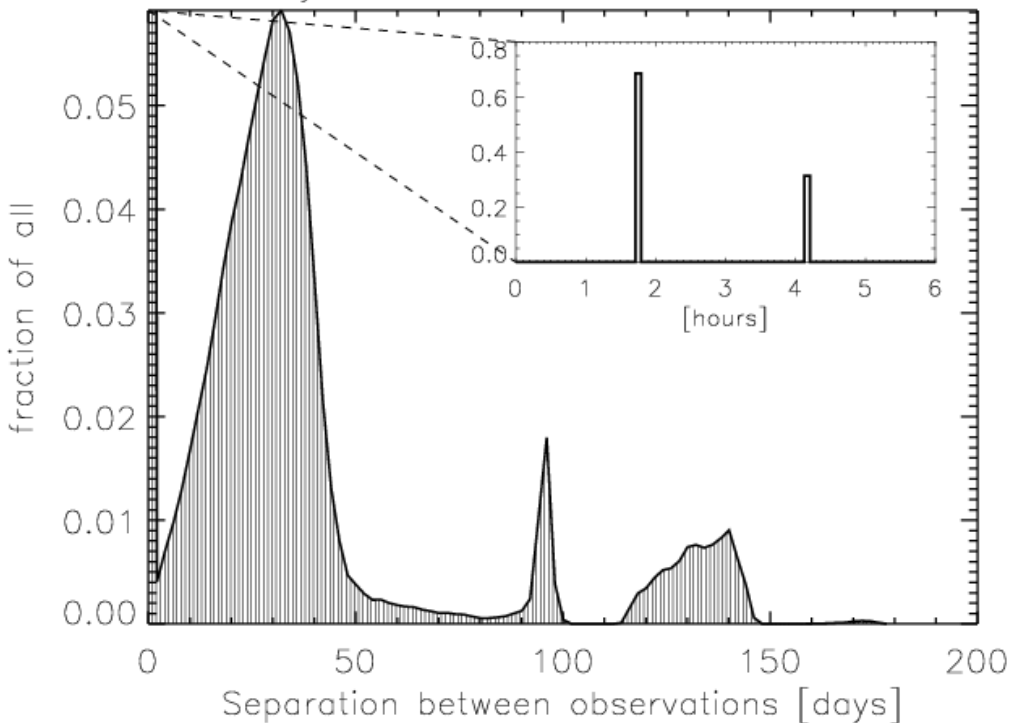
The unknown...



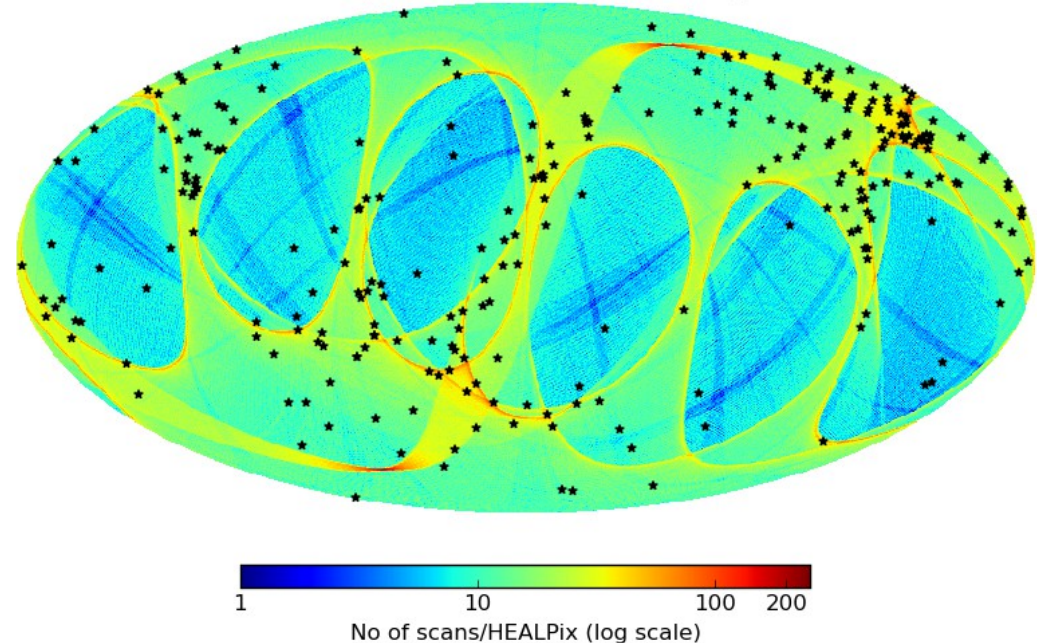
Gaia Scanning Law

Typical cadence ~1.5 hr, 4hr, 30d...
Exactly known, but unevenly sampled

All sky GOG simulated observations



Scan coverage at HEALPix level 8 on 22 Jun 2015



Early mode of operation

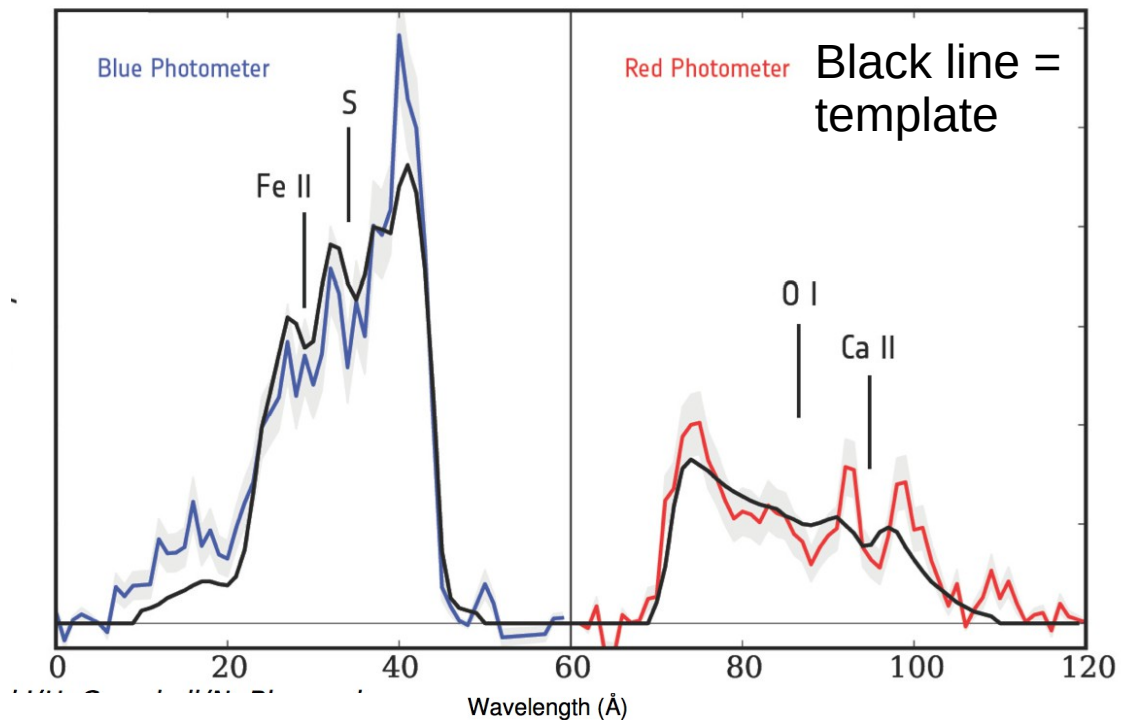
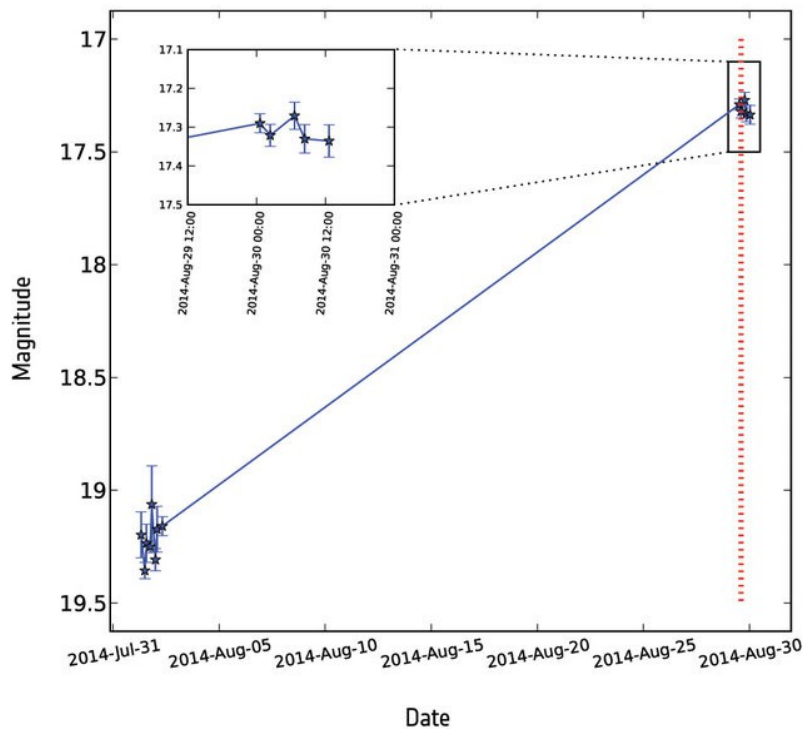
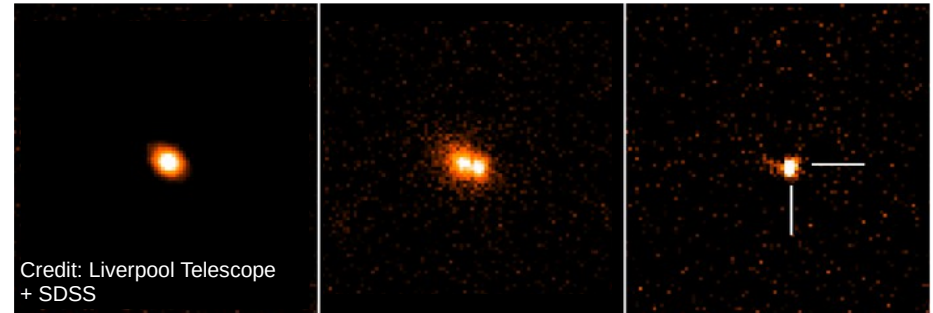
- We have no “template” images for Gaia Alerts
- All detections are made via cross-match
- Reference catalog is steadily improving, many issues in early mission with diffraction spikes etc.
- As interim measure, limited ourselves to searching for high amplitude (>1.5 mag) transients within ~few arcsec of known SDSS/DSS sources.
- Now we have a new Gaia Source catalog (just finished ingesting into DB).

Mission so far

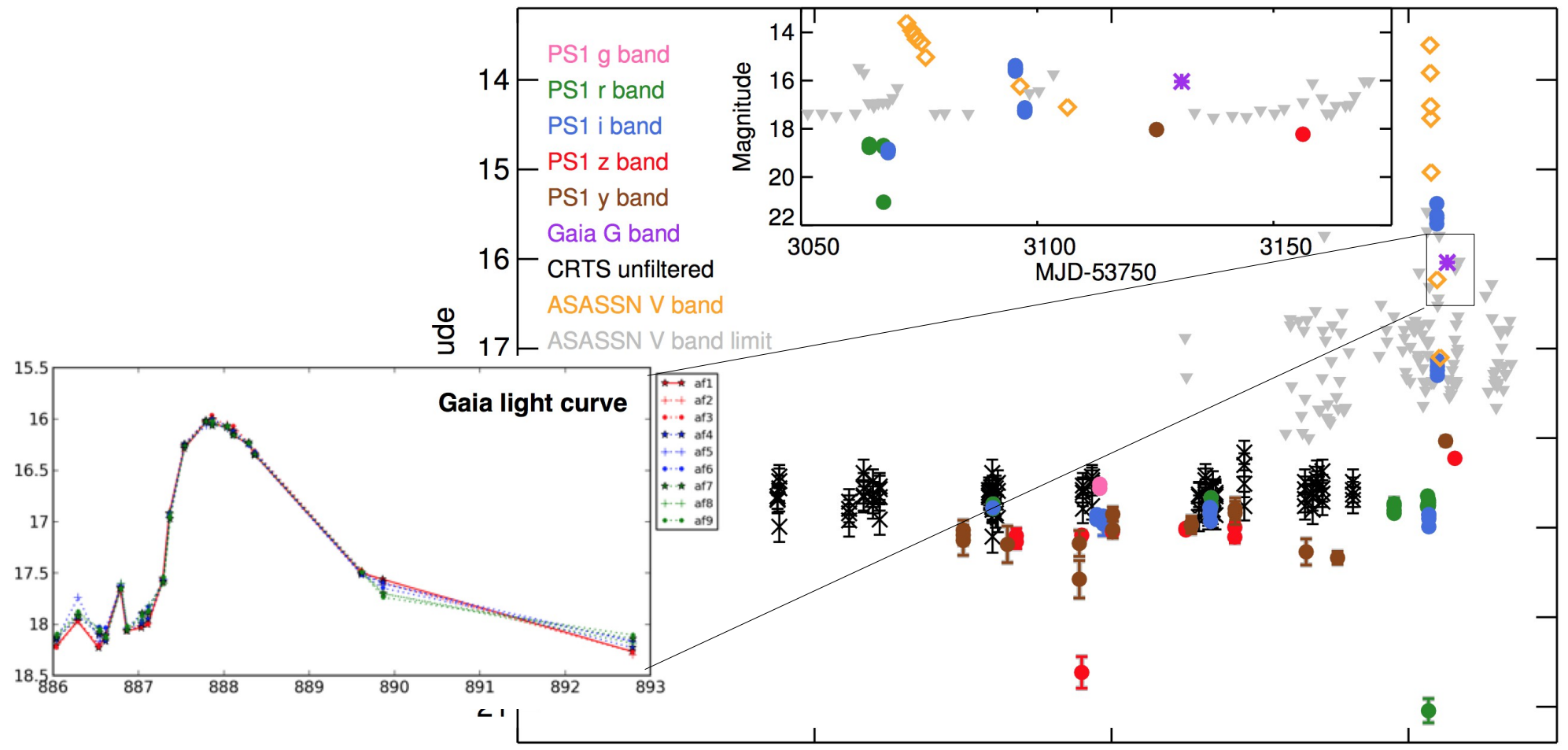
- 40 million of observations on average processed everyday
- up to 180 million seen in one day
- 48h typical delay between observation and processing (min 20h)
- 1-2h typical processing time (80h in extreme case)
- 0.5-2% of observations produce an alert every day ~4 new candidate transients selected every day
- 271 alerts so far (166 in 2015)

Gaia's first SN - Gaia14aaa

Discovered October 2014
Confirmed with imaging from
Liverpool Telescope
Classified as a Type Ia SN



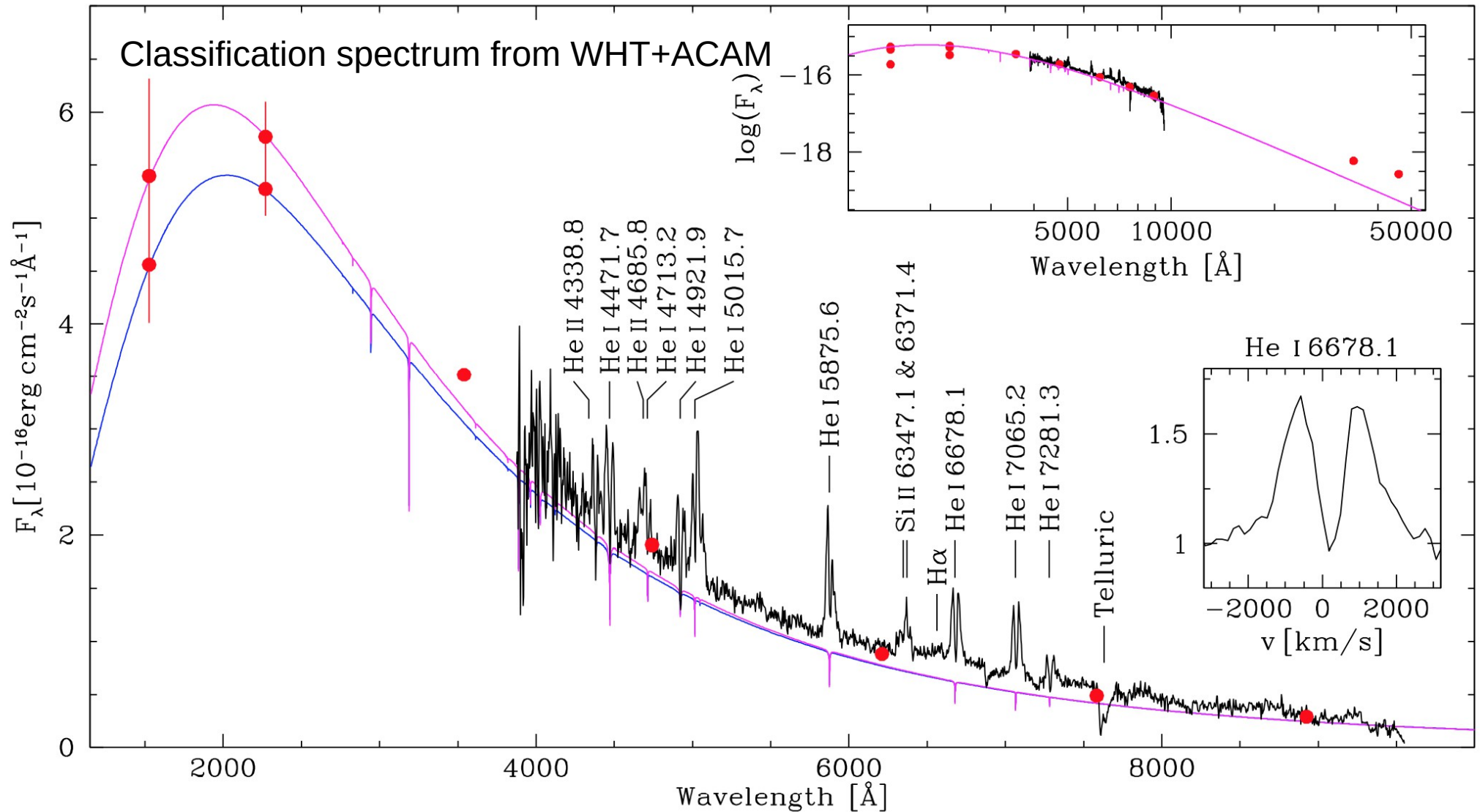
First Alerts Science - Gaia14aae



Total eclipse of the heart: The AM CVn Gaia14aae / ASSASN-14cn

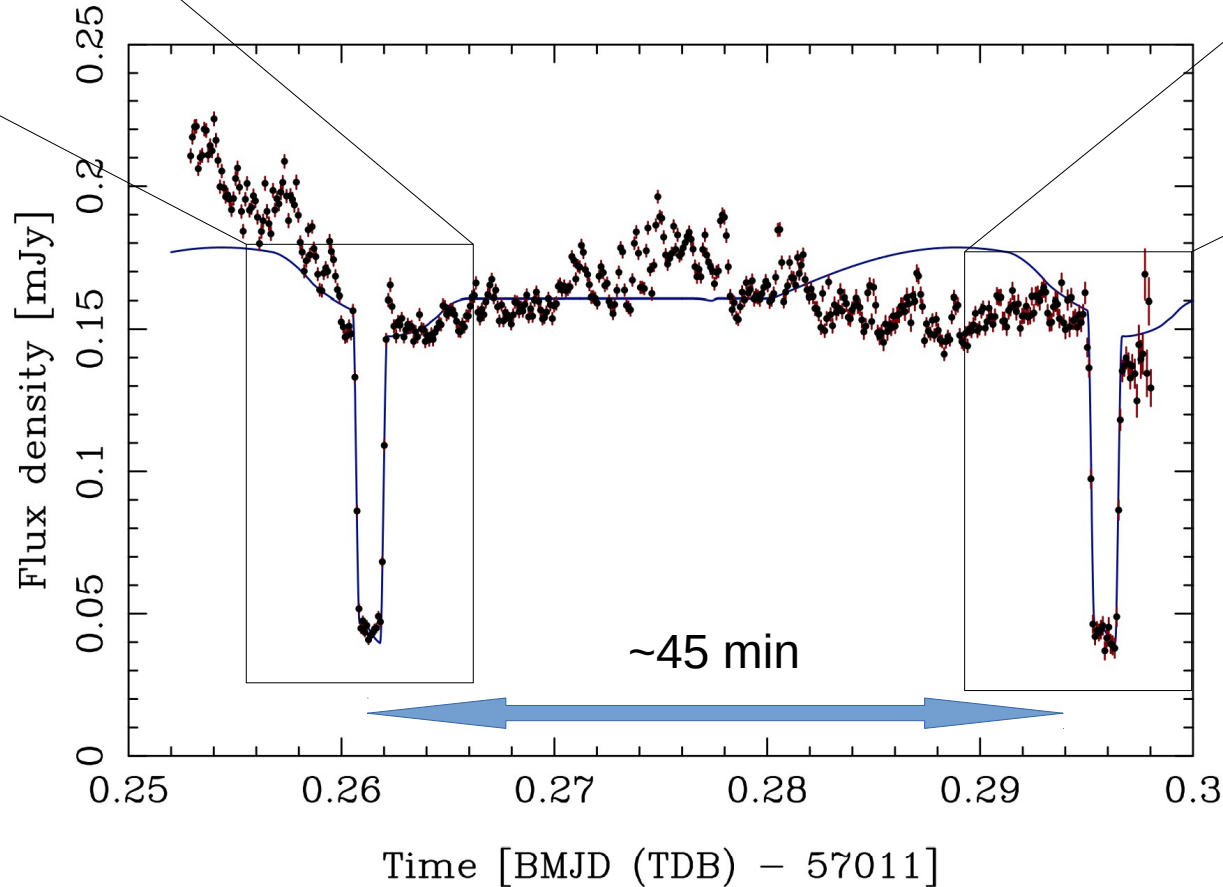
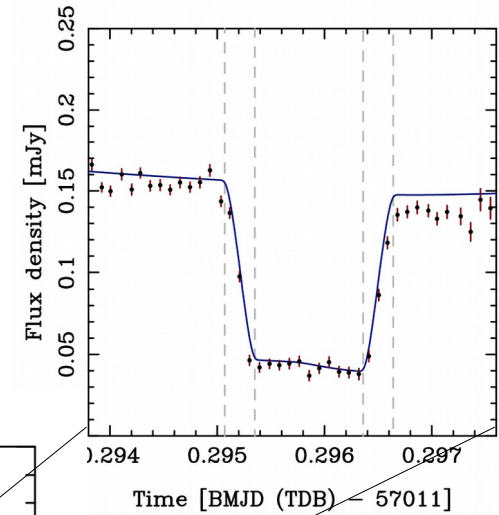
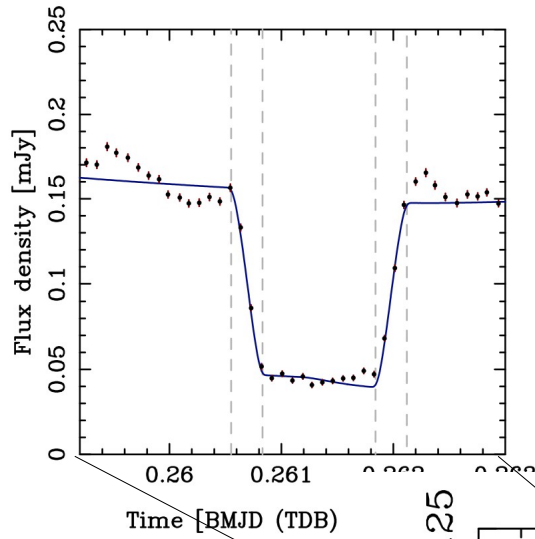
H. C. Campbell^{1*}, T. R. Marsh², M. Fraser¹, S.T. Hodgkin¹, E. de Miguel^{3,4},

Gaia14aae



Gaia14aae

High cadence lightcurve from
WHT+ACAM, Loiano+BFOSC



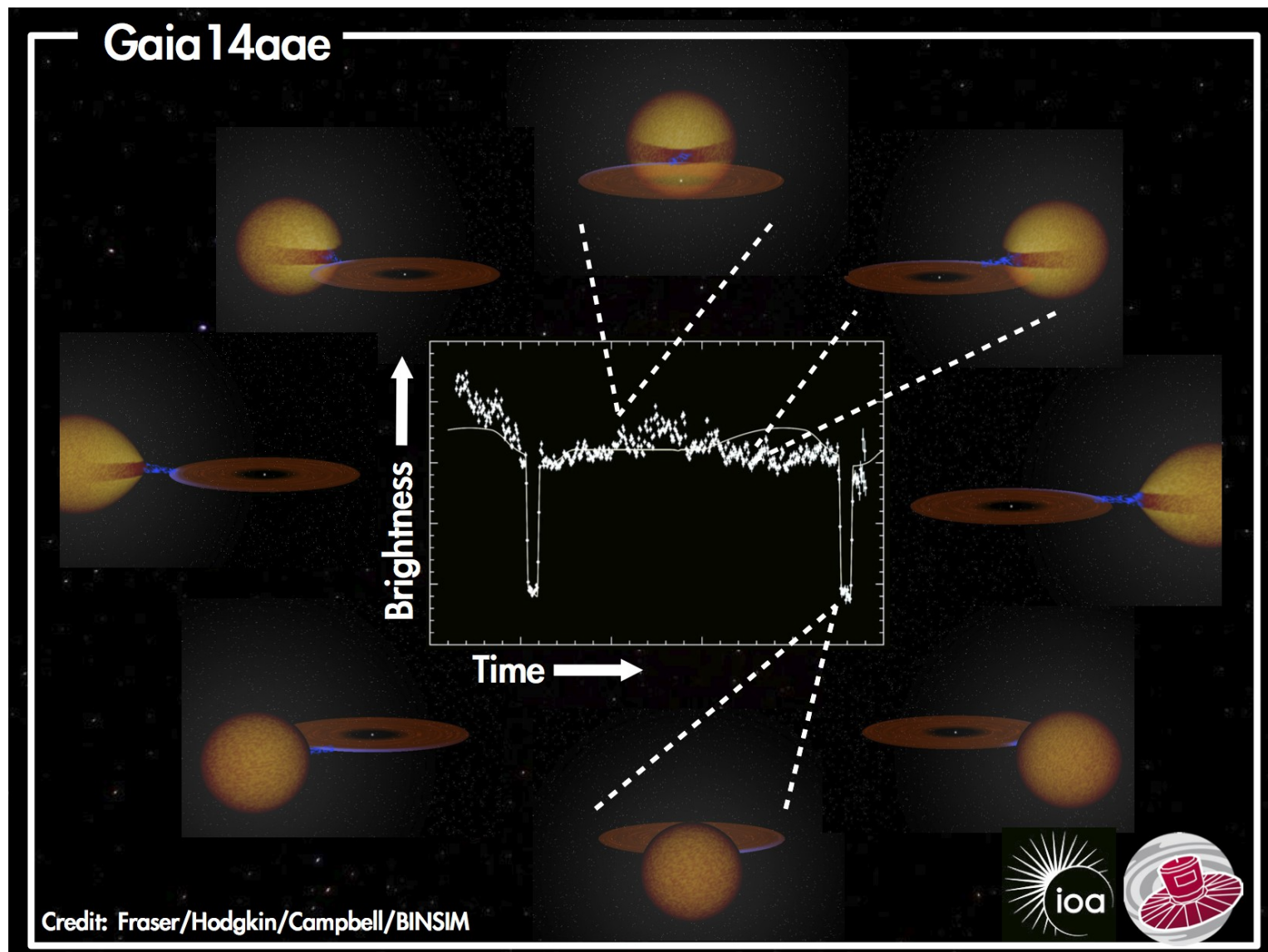
Gaia14aae

System parameters
from lightcurve
modeling by T.
Marsh

Flickering dominates
lightcurve, ongoing
WHT+Ultracam
photometry will
allow us to average
this out.

$$M_{\text{primary}} > 0.8 M_{\text{sun}}$$
$$M_{\text{secondary}} > 0.02 M_{\text{sun}}$$
$$a = 0.4 R_{\text{sun}}$$

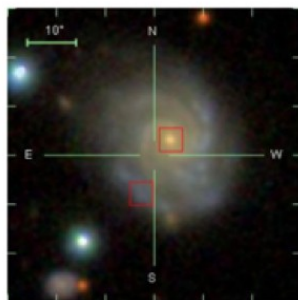
...



Improvements – new webpages

Cross-match with other surveys

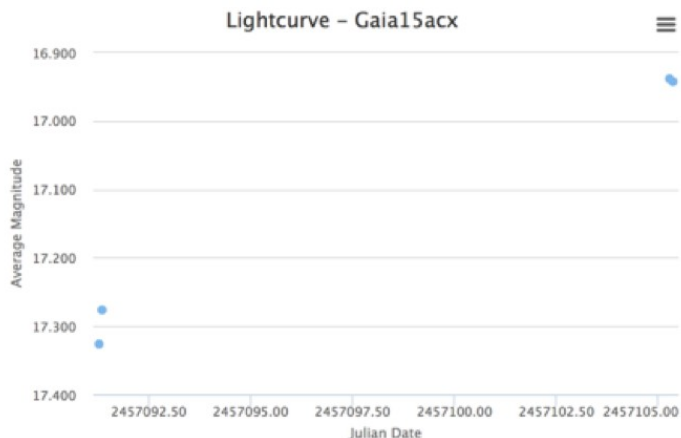
Gaia15acx



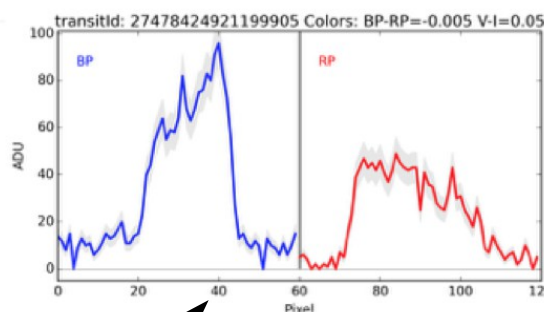
Other surveys detections
PSN_J08593491+4555343 magnitude 16.64, distance 1 arcsec, RA 134.895750, dec 45.926028
Comments
aka PSNJ08593491+4555343, ATEL #7222

RA (deg)
134.89546
Dec (deg)
45.92583
Julian date
2457091.28
Observed
March 9, 2015, 6:38 p.m.
Alert magnitude
17.28
Historic magnitude
None
Historic StdDev
None
Class
SN Ia
Published
March 18, 2015, 6:03 p.m.

Contextual information



Lightcurve



Low resolution BP/RP spectra

Gaia as a transient machine

- 10^3 deg sq per day comparable with current surveys (CRTS, PS1 etc), modulo cadence...
- But upcoming surveys (ZTF, ATLAS etc) will cover 10^4 deg sq per day (with ~ 24 hr cadence)
- Gaia Alerts has USP beyond these surveys..

Spatial resolution

Stable cadence /
selection biases

Bp/Rp spectra/colours
for all targets

Fast transients

Data release (provisional)

- **Summer 2016**

- Positions of all single stars
- Gaia-Hipparcos cross-match (Hundred Thousand Proper Motion)

- **Early 2017**

- 5-parameter solution (parallax, position and proper motions) for single stars
- Low resolution BP/RP spectra
- Mean radial velocities

- **2017/2018**

- Orbital parameters
- Derived astrophysical properties

- **2018/2019**

- Variable stars, binaries
- Solar System objects

- **2022**

- Final catalogs
- All epochs of data
- Exoplanets

Gaia

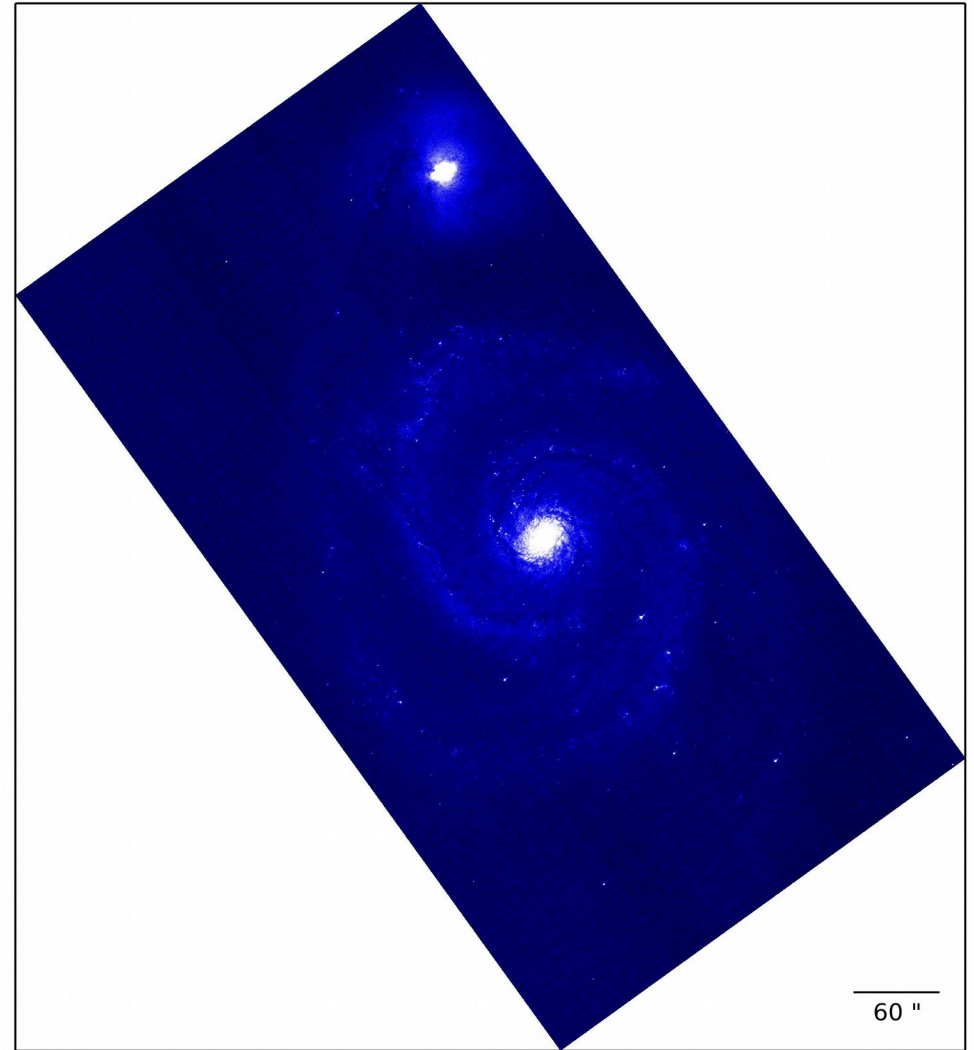
Gaia Alerts

Name	UTC timestamp	RA	Dec	AlertMag	HistMag	HistStdDev	Class	Comment	Published
Gaia l5agm	2015-06-01 14:51:25	358.98623	-43.72412	17.35	Not known	Not known	unknown	candidate SN	9 Jun 2015, 11:27
Gaia l5agl	2015-06-01 20:34:37	337.79327	-37.82735	18.71	Not known	Not known	unknown	candidate SN	9 Jun 2015, 11:27
Gaia l5agk	2015-06-03 02:38:28	337.70660	-43.04732	18.80	Not known	Not known	unknown	candidate SN	9 Jun 2015, 11:27
Gaia l5agi	2015-06-03	147.74682	37.96674	18.49	Not	Not	unknown	candidate SN	9 Jun 2015.

<http://gaia.ac.uk/selected-gaia-science-alerts>

The experience so far...

- Scattered light issue – but not a show-stopper for key science goals.
- Alerts are hard. We need a clean, complete catalog of the whole sky (which we have only just got).
- Have taken a break over the summer to fix issues over alerts. Back online in October...
- The best is yet to come...





Thank You

mf@ast.cam.ac.uk