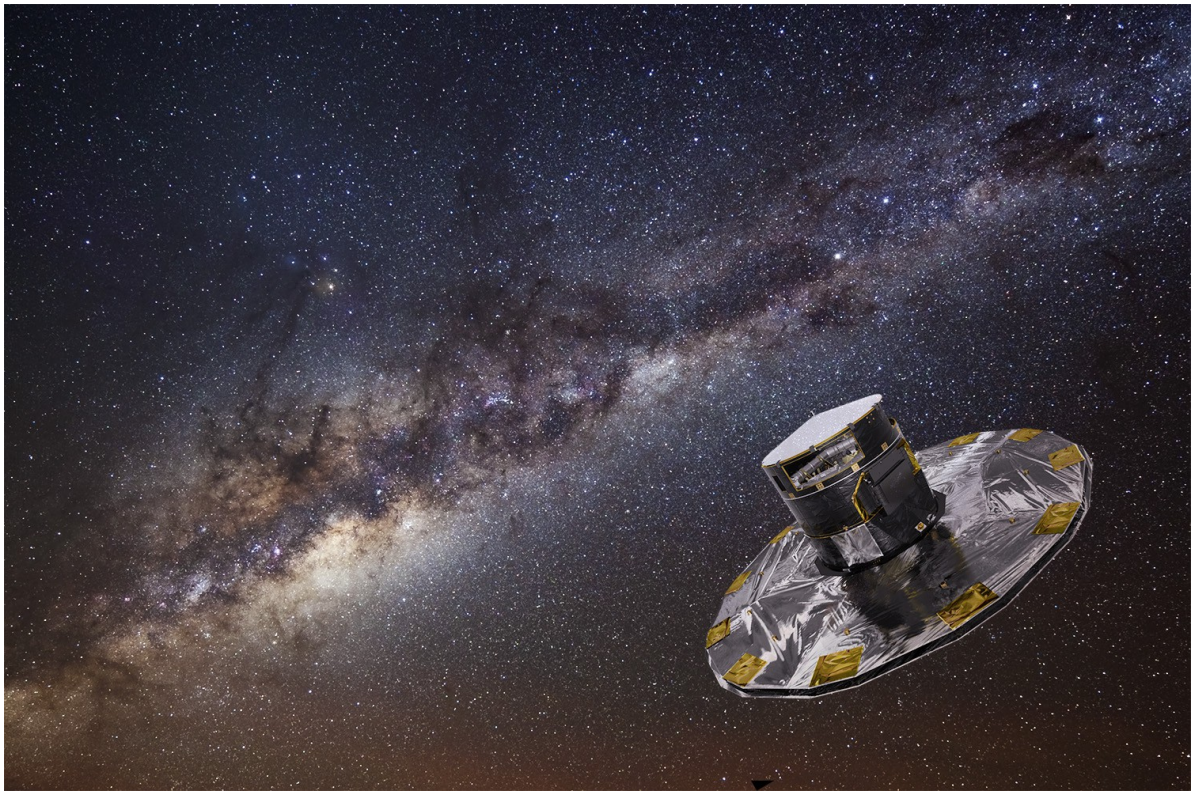
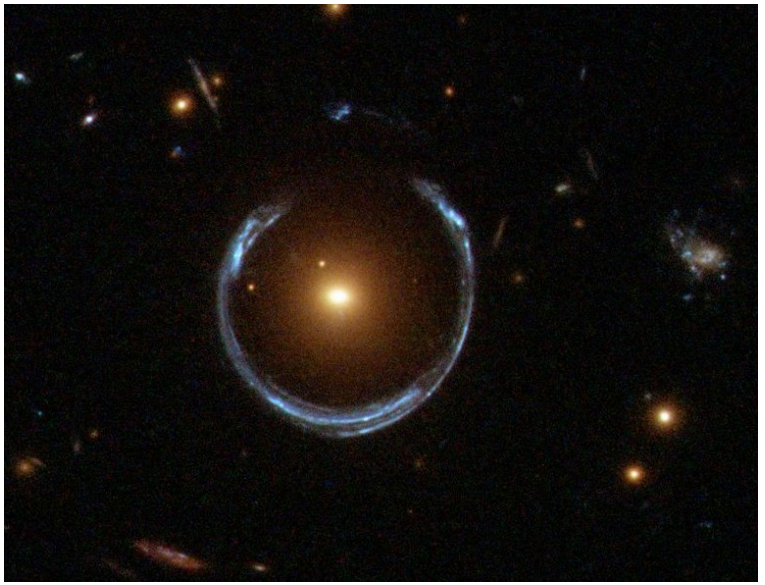


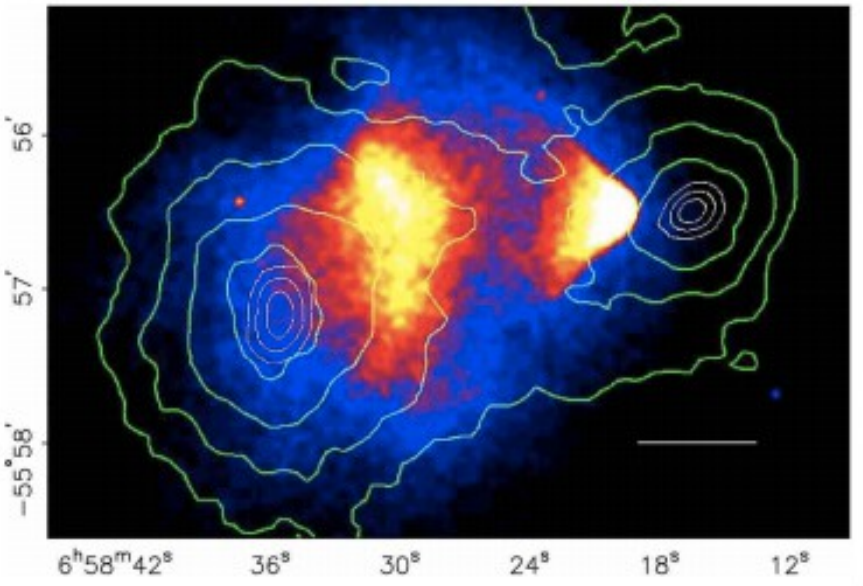
Photometric microlensing observed by Gaia

K. Kruszynska, L. Wyrzykowski, M. Gromadzki, K. Rybicki, P. Zielinski

Gravitational Lensing

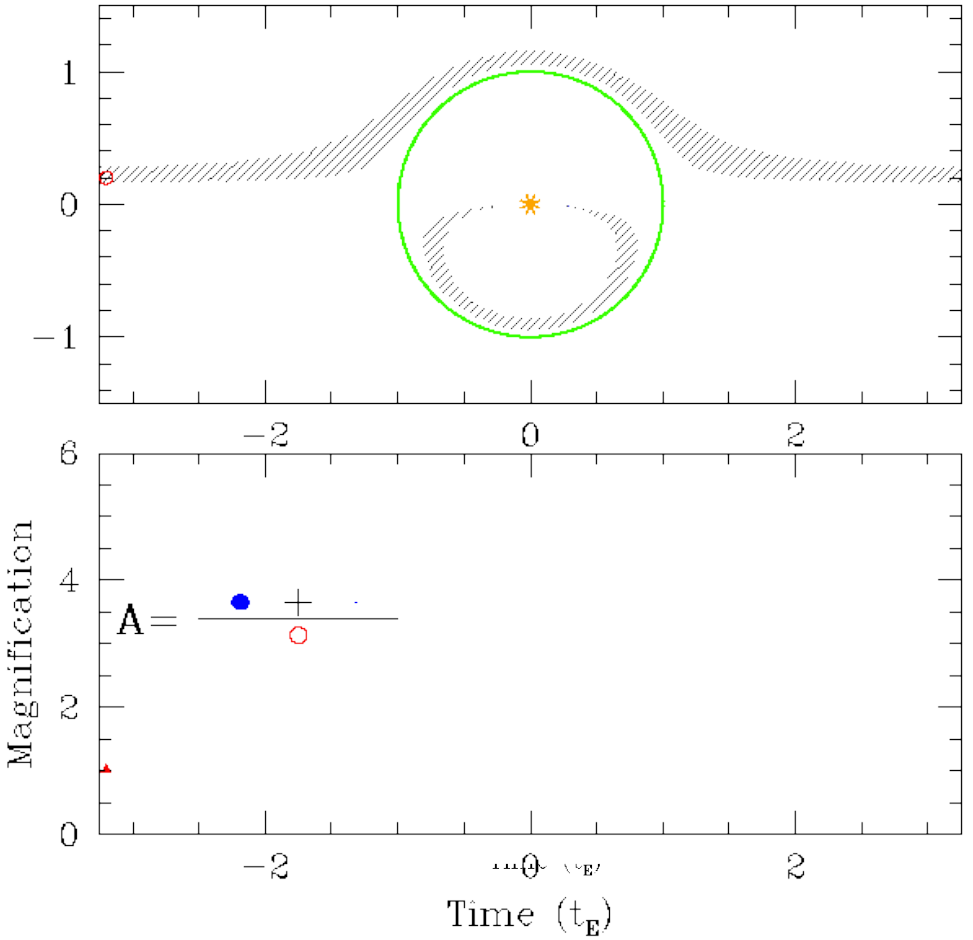
- A massive object is passing passing in front of the source
  → source image is deformed
- Regimes: strong and weak – cosmological scales, microlensing – in our Galaxy and Local Group





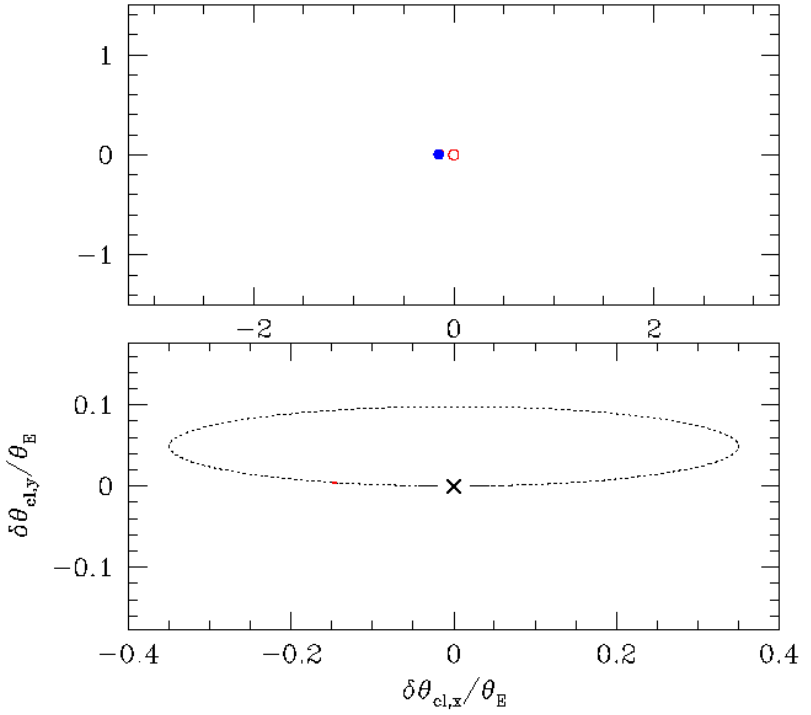
Gravitational Microlensing

- Theoretical lightcurve → Paczynski curve (Paczynski 1986, 1996)
- Model parameters for single lens: impact parameter u_0, time of maximum t_0 and timescale of event t_E (Einstein time)



Why Gaia is important for microlensing?

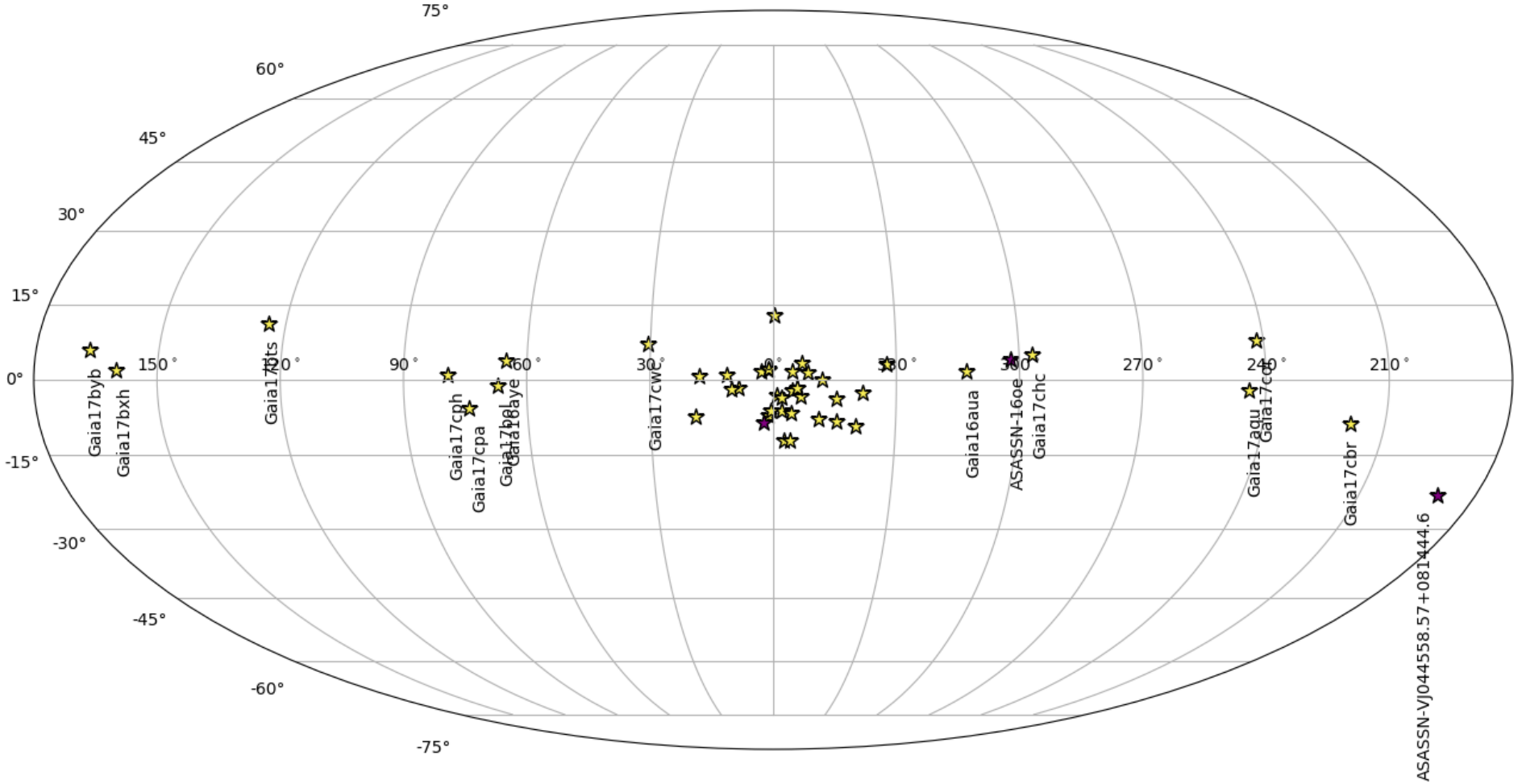
- Astrometric microlensing
- Gaia's main goal is astrometry!!
- Possibility of detecting astrometric centroid shift on a massive scale for stars with G < 16mag
- Possible way to detect single black holes!



Microlensing observed by Gaia

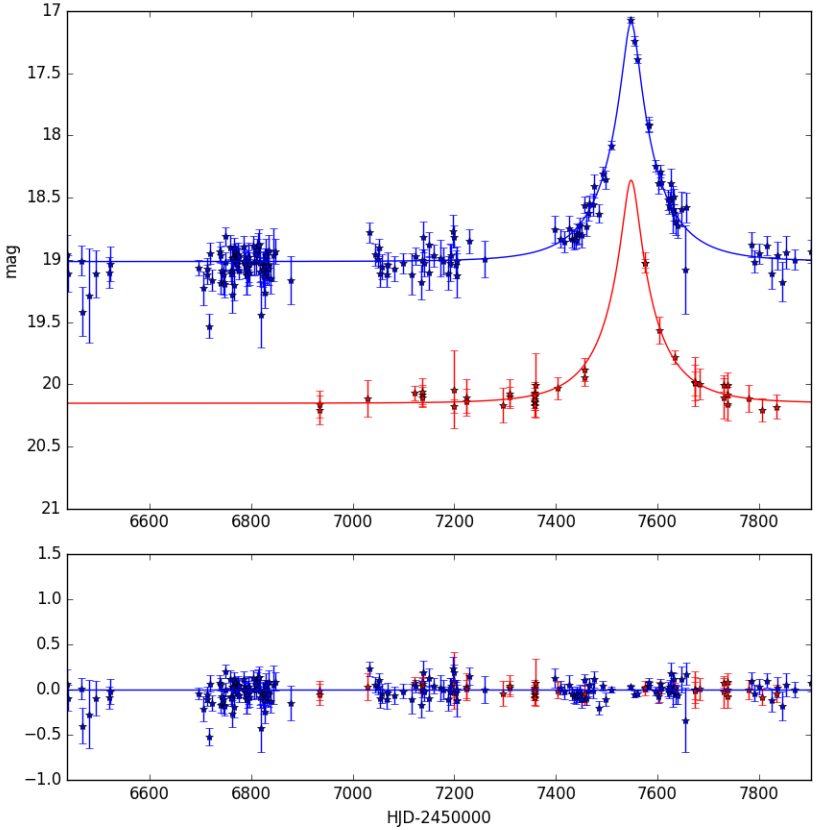
- Gaia Science Alerts: almost 4000 since 2015, 30+ microlensing candidates
- Most microlensing candidates occur in Bulge (a lot of sources → highest chance for a microlensing event to occur)
- To model an event properly – follow-up is needed; one point/30 days is not enough!!!

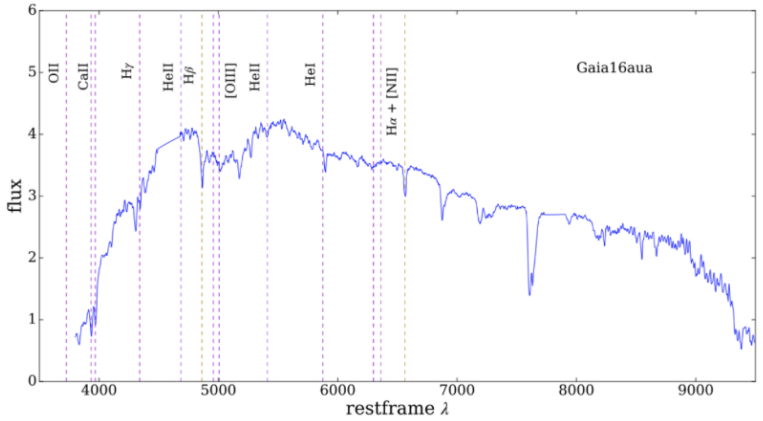
Event Gallery



Gaia16aua ‘Auala’

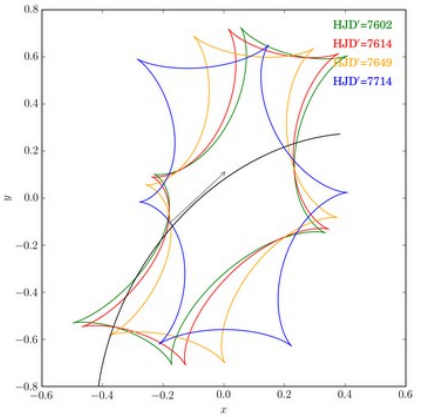
- Single source – single lens
- First confirmed microlensing event
- Towards Galactic Bulge
- Event observed by Gaia and OGLE
- Spectrum: 14th Jul 2016 (SALT)



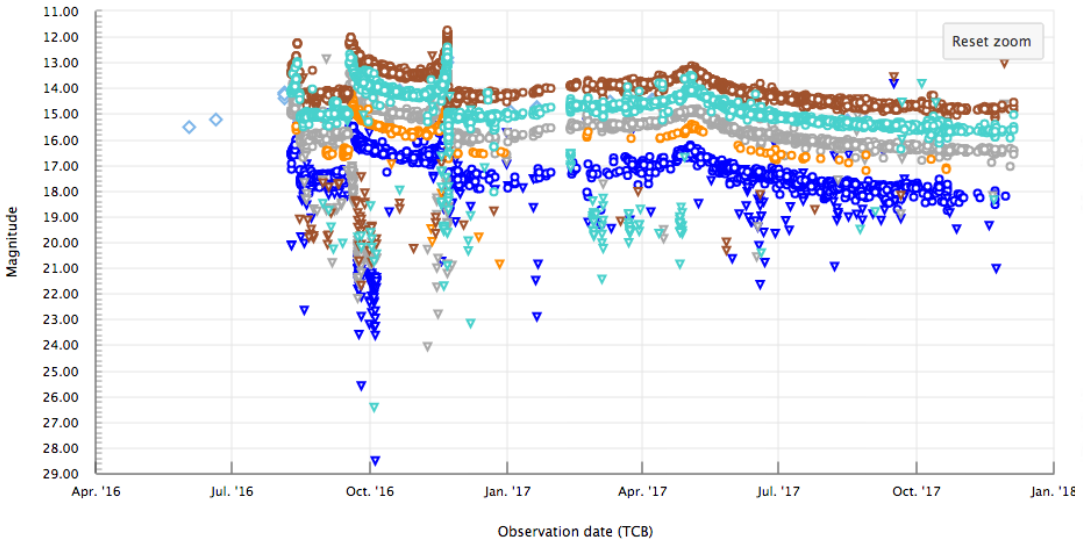


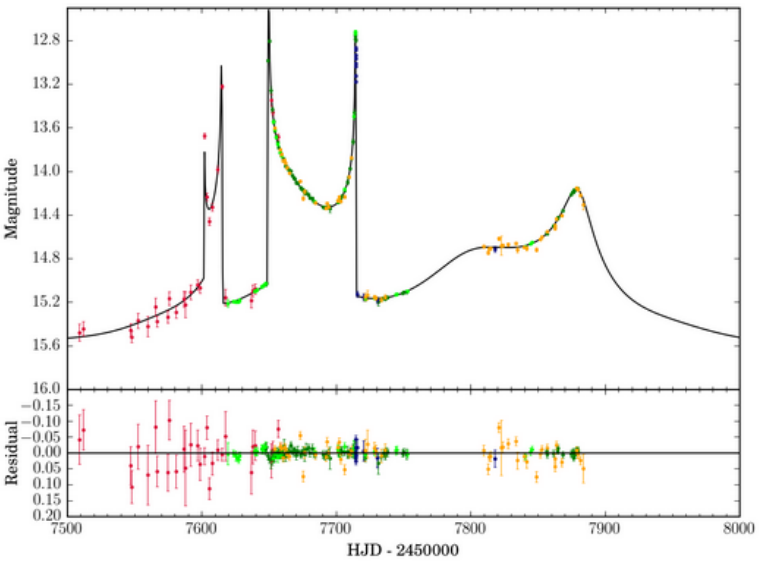
t_0	t_E	u_0	$I_{0,OGLE}$	f_{b1}	I_{Gaia}	f_{b2}	χ^2
7548.34	110.92	0.140	20.15	0.32	19.01	0.21	201.07

Gaia16aye ‘Ayers Rock’



- Event with double lenses and single source
- Towards Northern Galatcic Disk
- Follow-up obtained with OPTICON and many other collaborators; 24,000+ points!
- Multiple spectra obtained for various amplification factors

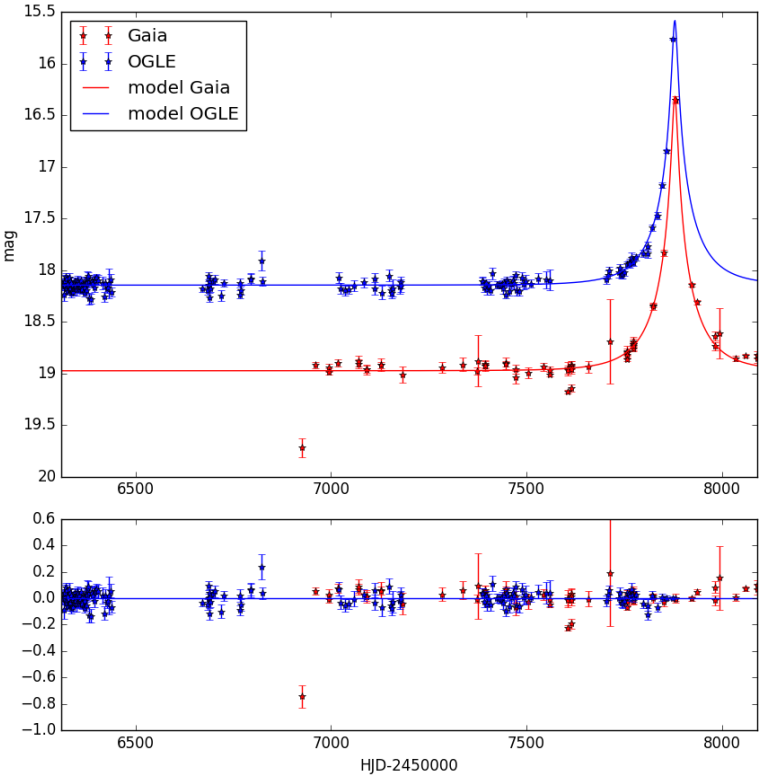


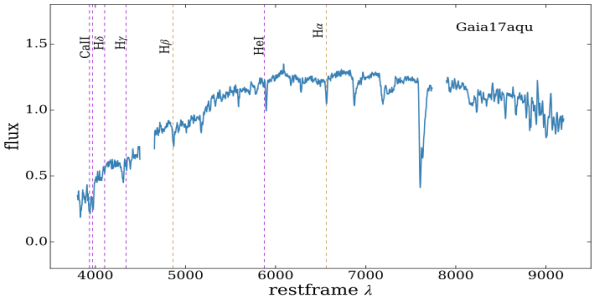


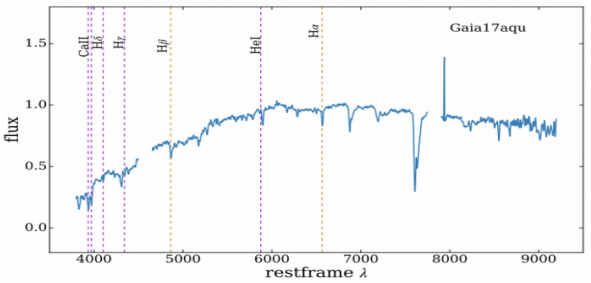
Model by Przemek Mróz

Gaia17aqu ‘Aqua’

- Single lens – single source event
- Towards Southern Disk
- Observed from the ground by OGLE
- Spectra: 28thMar and 4thApr (SALT



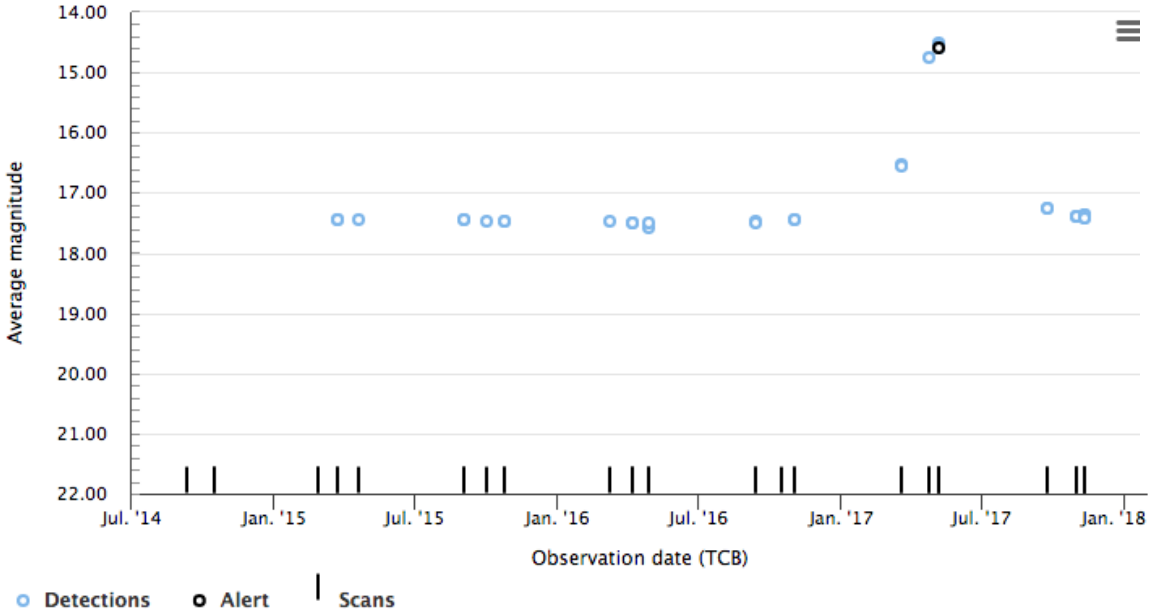


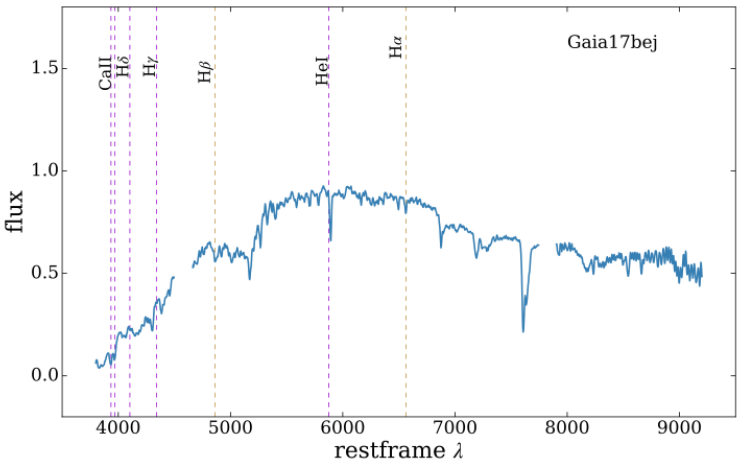


t_0	t_E	u_0	$I_{0,OGLE}$	f_{b1}	I_{Gaia}	f_{b2}	χ^2
7879.74	112.06	0.058	18.15	0.41	18.97	0.35	538.74

Gaia17bej ‘Bejeweled’

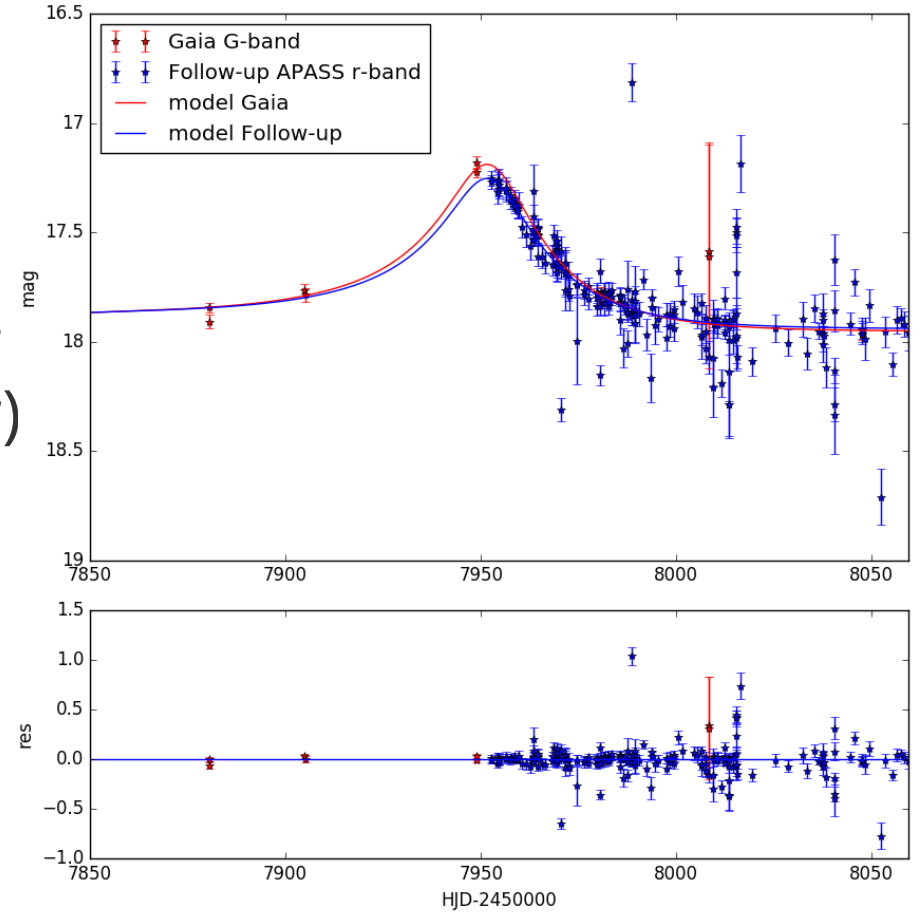
- Single lens – single source event
- Towards Galactic Bulge
- Follow-up observations obtained by SMART1.3m
- Spectrum: 5th May 2017

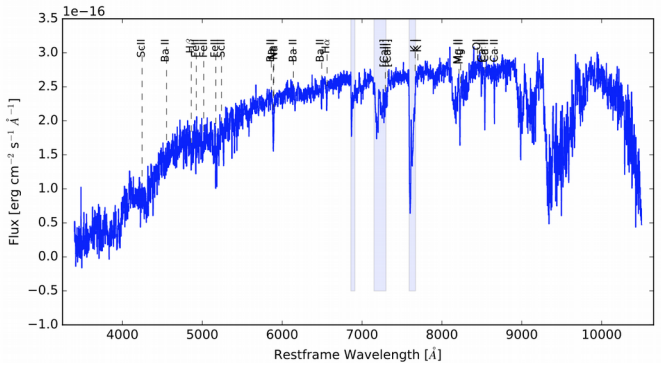




Gaia17bts ‘Bangtang Boys’

- Single lens – single source
- Towards Northern Disk
- Follow-up by OPTICON+others
- Spectra: 29th Jul 2017 (Palomar)
  17th Sept 2017 (Keck)
- Best model: with parallax

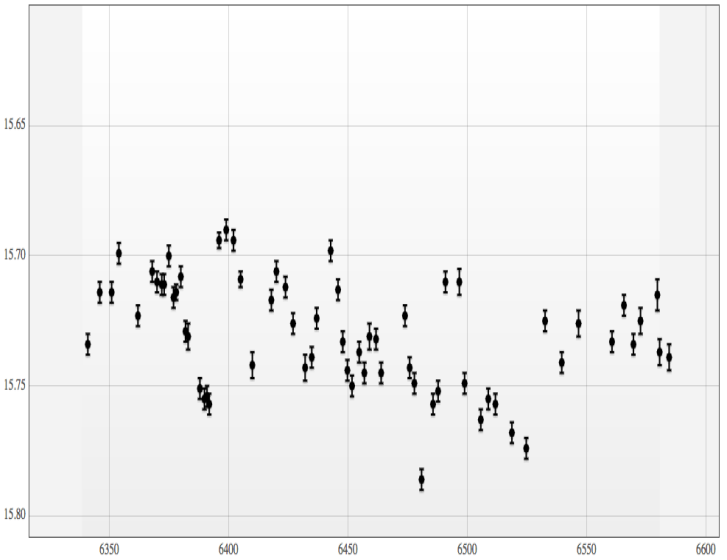


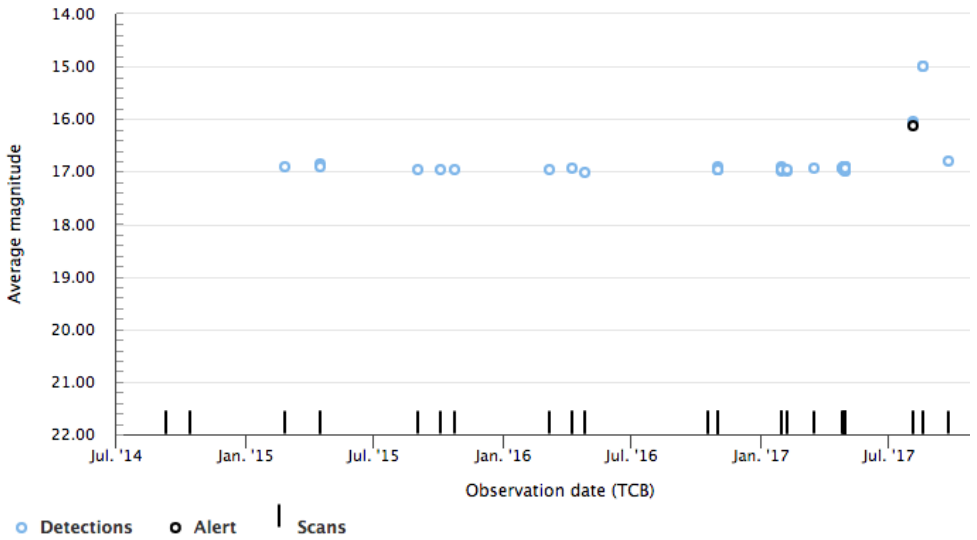


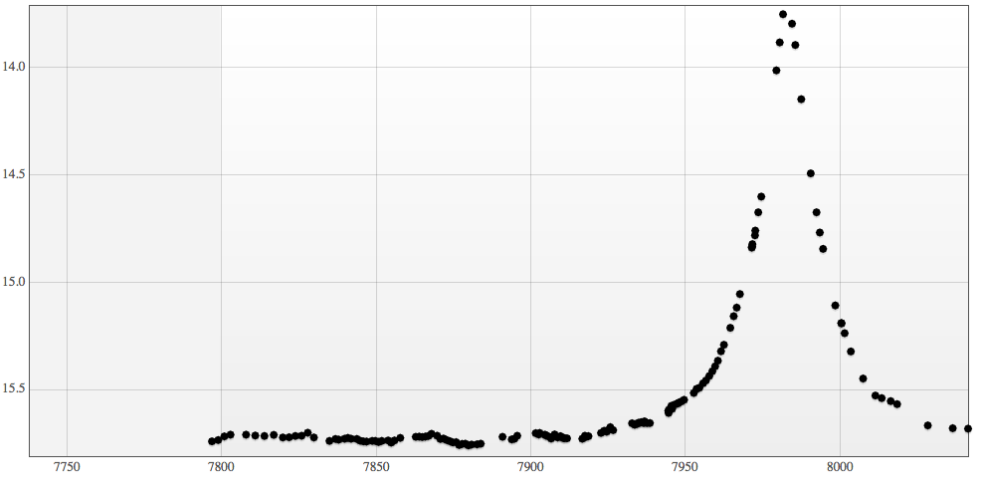
t_0	t_E	u_0	π_{EN}	π_{EE}	$I_{0,Gaia}$	f_{b1}	$I_{0,APASSr}$	f_{b2}	t_{0par}	χ^2
7951.45	45.97	0.226	0.26	-1.01	17.95	0.71	17.94	0.75	7948.94	900.87

Gaia17cad ‘Caddis Fly’

- Single lens – single source event
- Variable source!!! (visible in OGLE)
- Towards Galactic Bulge
- Ground-based observations by OGLE
- Spectrum: 7th Sept 2017

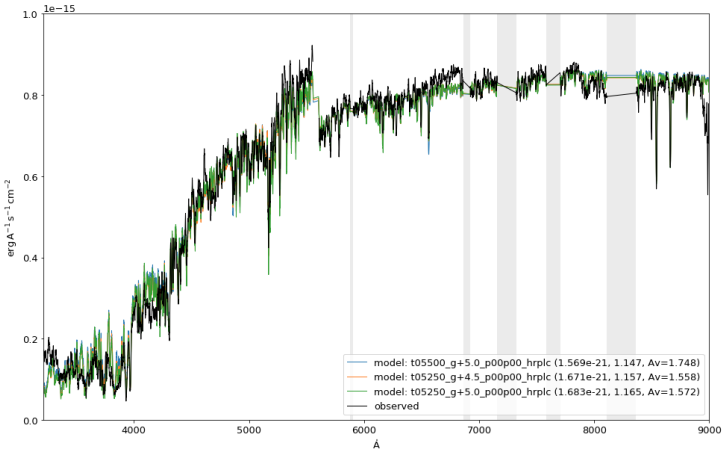


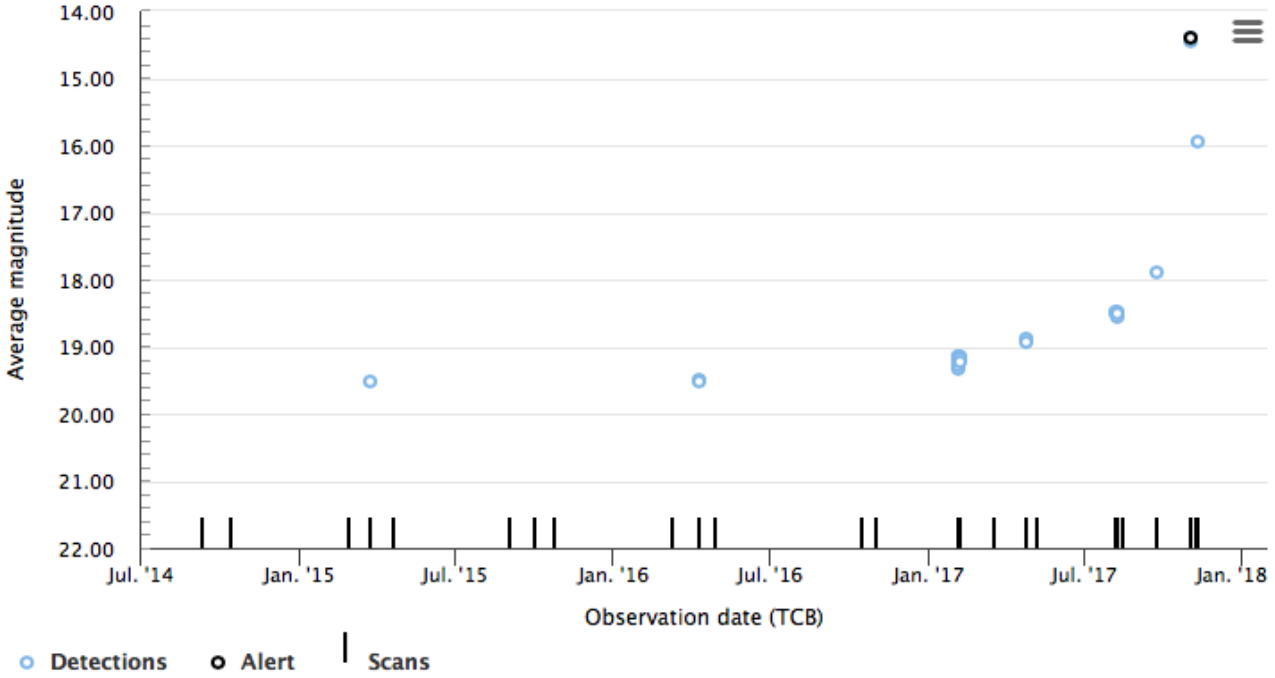




Gaia17ctl ‘Catalonia’

- Towards Galactic Bulge
- Detected when Bulge started to set
- Gaia17ctl: spectrum on X-SHOOTER
- No ground-based follow-up (yet)





Gaia17ddi and Gaia17ddp

- New events! (alert on 02.12.2017)
- Towards Northern Disk
- Close to frequently sampled fields

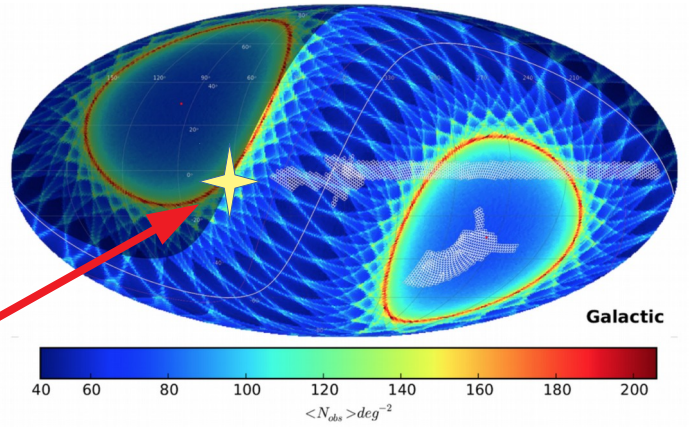
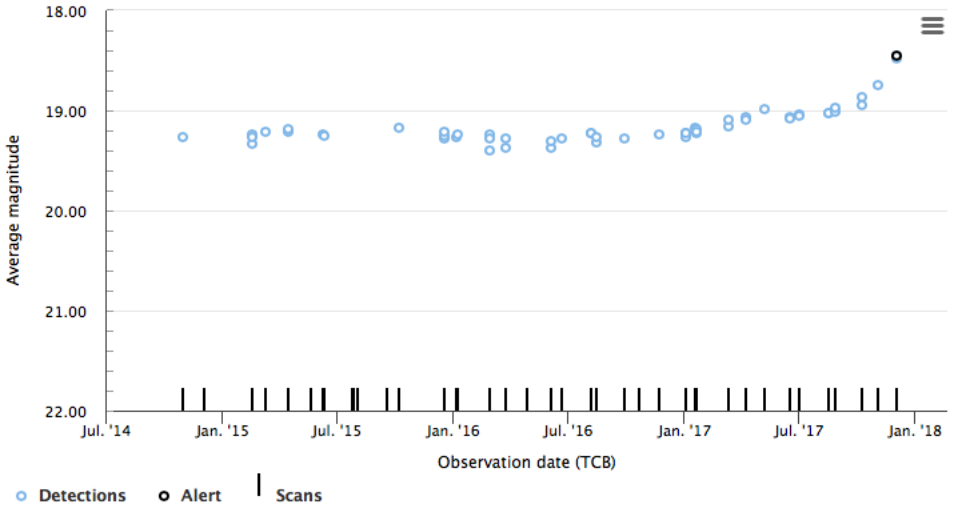
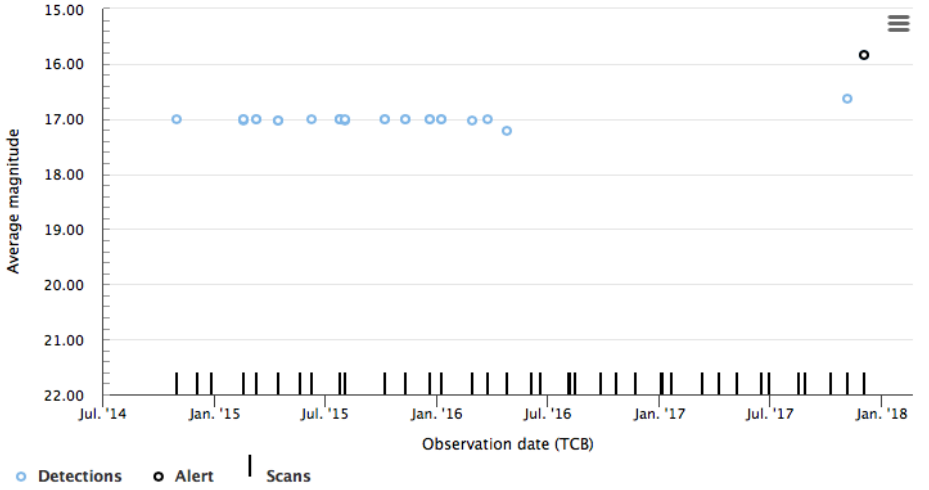


Image: N. Blagorodnova, J. Skowron



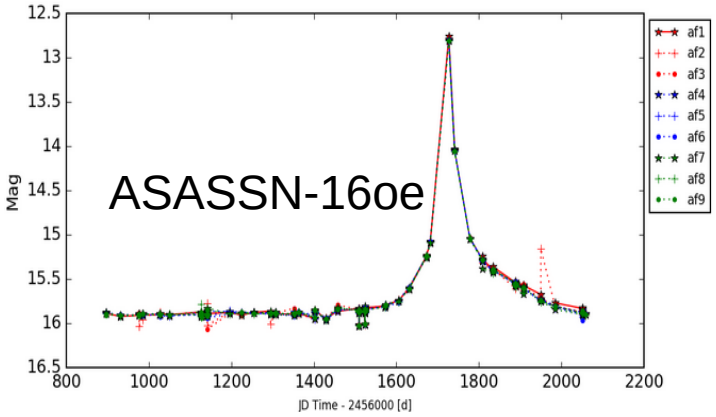
Gaia17ddi

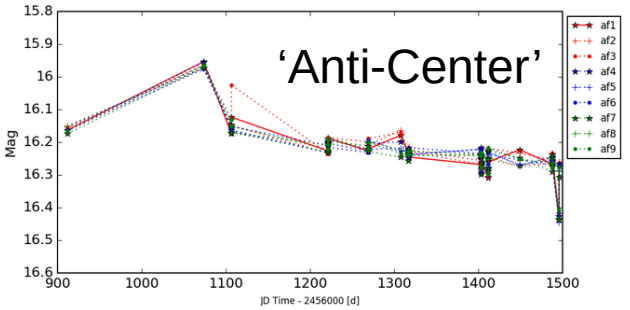


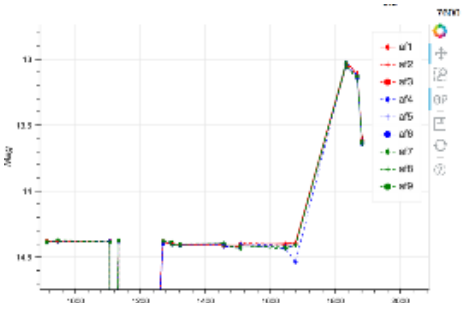
Gaia17ddp

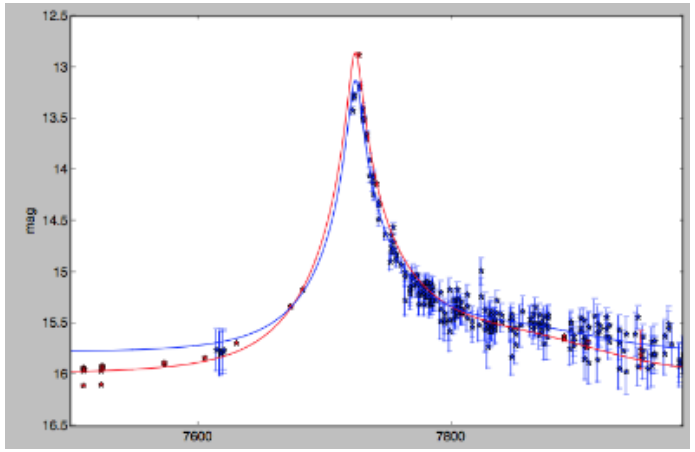
Missed Events

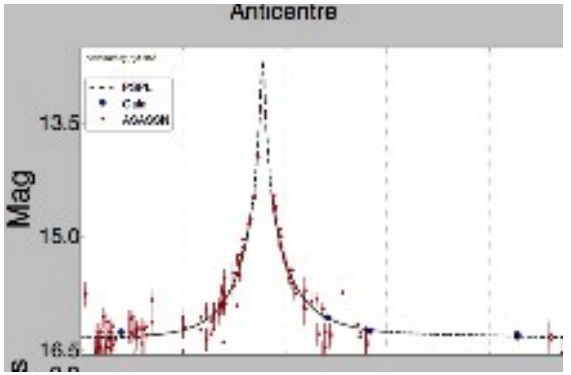
- AlertPipe missed at least four microlensing events by now
- Three: discovered by ASAS-SN (ASASSN-16oe, ASASSN-V J044558.57+081444.6, ASASSN-V J182456.34-305816.7)
- One: by amateurs (Kojima event, TCP J05074264+2447555)

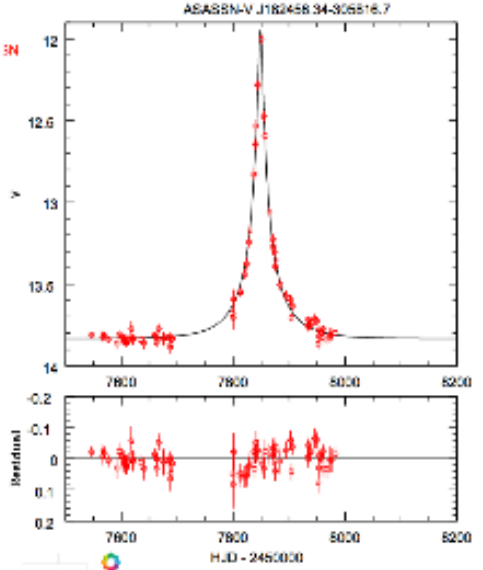












Summary

- Many microlensing candidates detected
- AlertPipe seems to miss events (or reports them lately)
- Gaia may find single BH via microlensing thanks to it’s astrometry
- We need follow-up!!! Please help if you can :)