

# Gaia16 **AYers Rock\***

spectacular Galactic disk binary microlensing event from Gaia

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\*Uluru



gaia



UNIVERSITY OF  
CAMBRIDGE



NATIONAL SCIENCE CENTRE  
POLAND

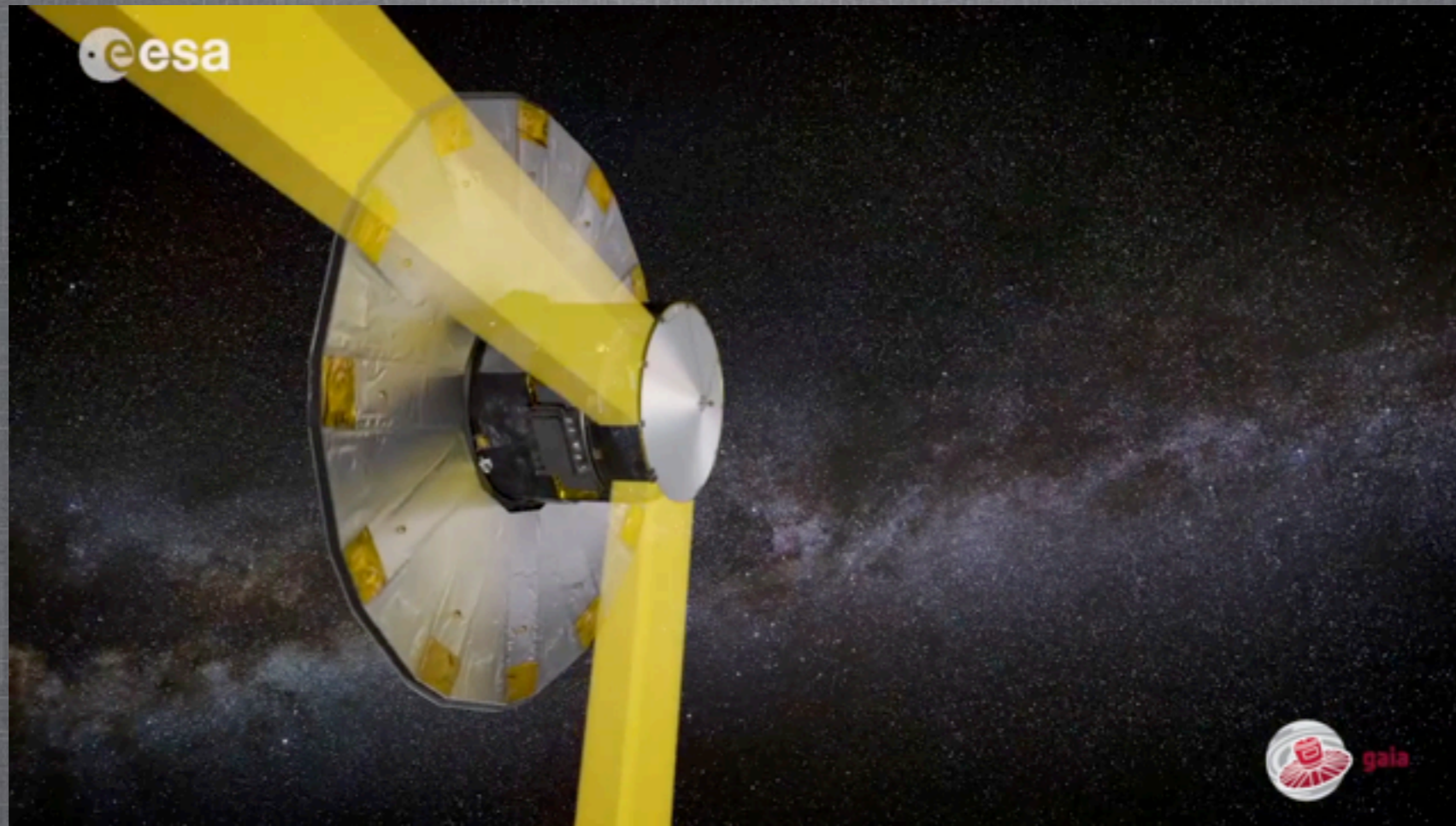


21th International Microlensing Conference, Pasadena, CA, 1-3 February 2017

# COLLABORATORS

- Przemek Mroz (Warsaw) - real-time binary modelling
- Krzysztof (Kris) Rybicki (Warsaw) - real-time data reductions
- Mariusz Gromadzki (Warsaw) - spectral analysis
- Nikolay Britavskiy (Odessa/IAC) - spectral analysis
- Zbyszek Kołaczkowski (Wrocław) - photometric data improvement
- Kirill Sokolovsky (Athens) - early coordination, AAVSO, Swift
- Nadia Blagorodnova (Caltech) - spectra and photometry
- + ~100 observers from around the world
- Gaia Alerts team in Cambridge / Utrecht / Warsaw

# GAIA SPACE MISSION



- ESA space mission with 2x1.4m telescopes located in L2
- In operation since 2014
- Scans the entire sky for 5 years to get parallaxes and proper motions
- 1 billion stars monitored every 30 days (on average)
- Gaia Science Alerts: ~1000 transients, including 4 disk microlensing

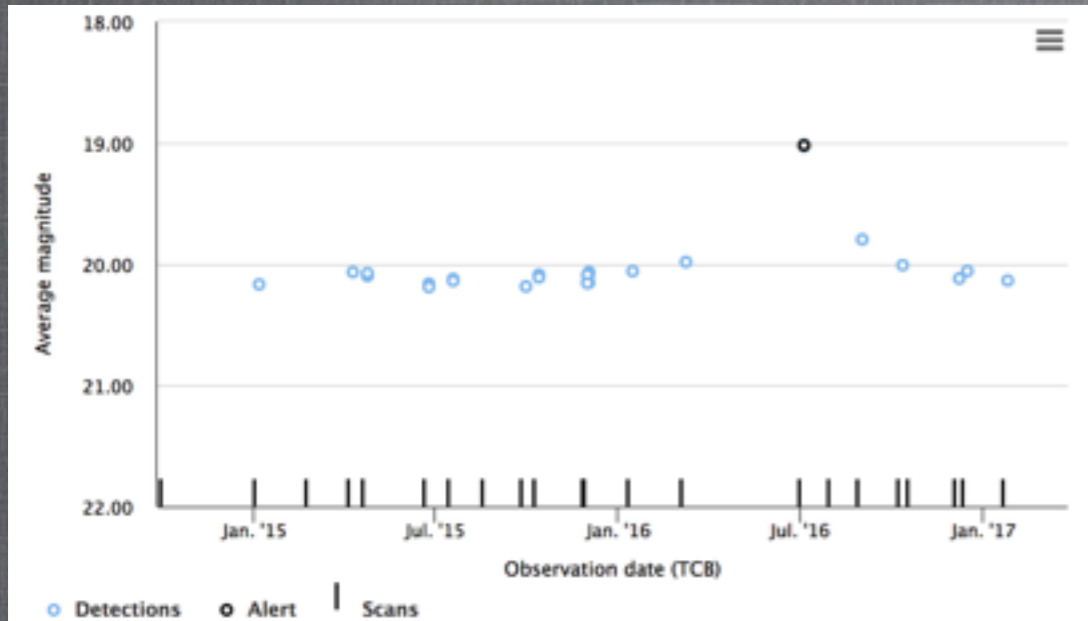
<http://gsaweb.ast.cam.ac.uk/alerts/>

# GAIA16AUA (AUALA)

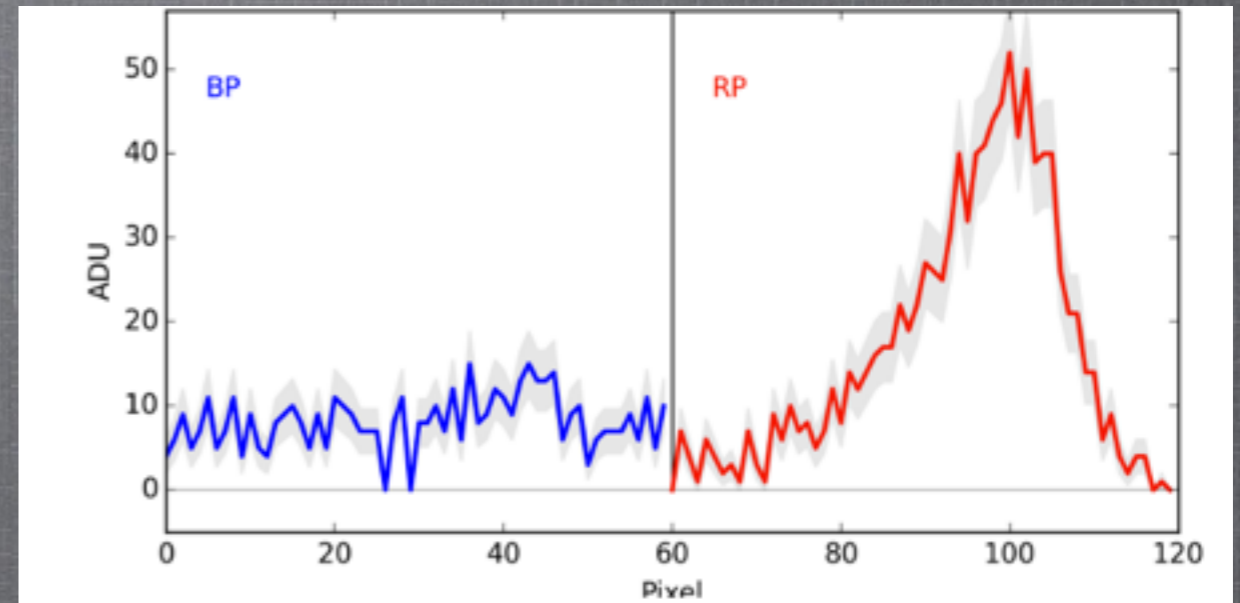


*First confirmed Gaia microlensing event in the Galactic disk*

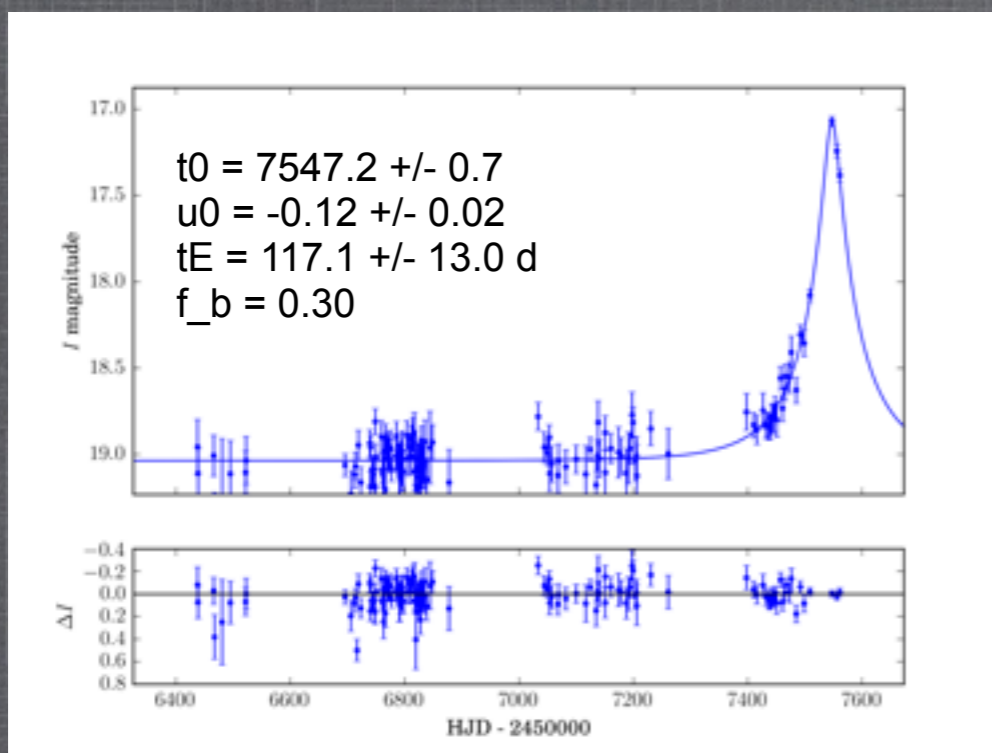
## Gaia Alert



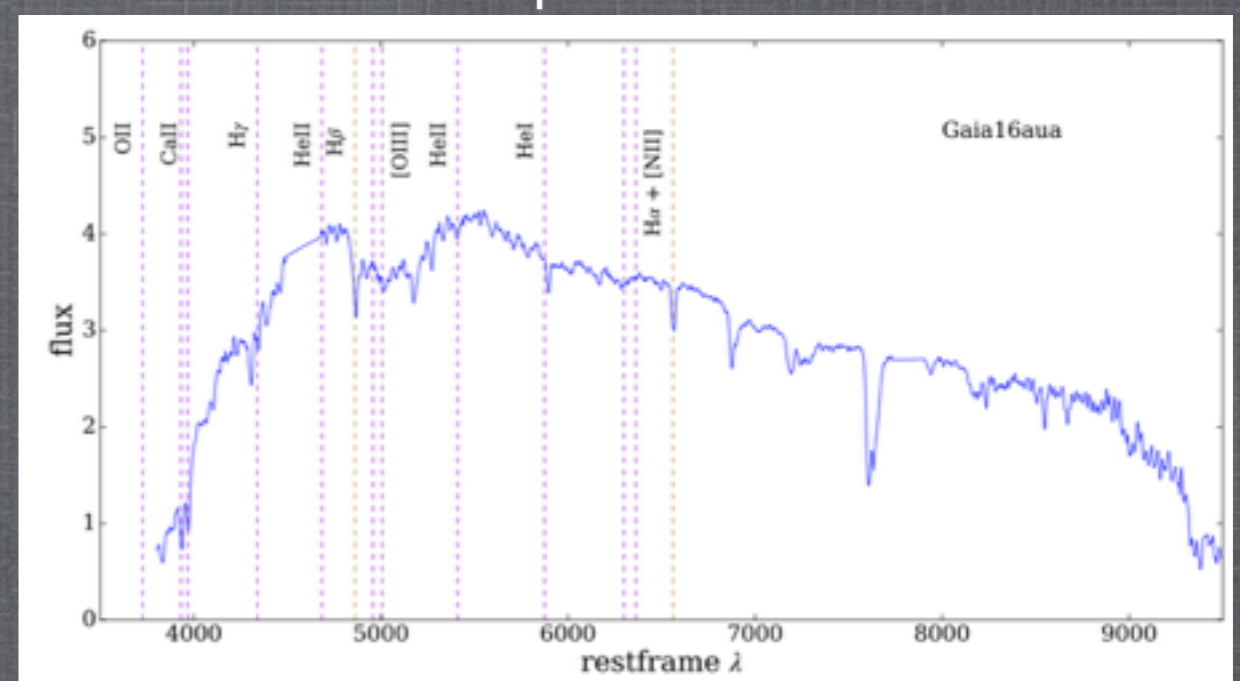
## Gaia low-res spectrum (raw)



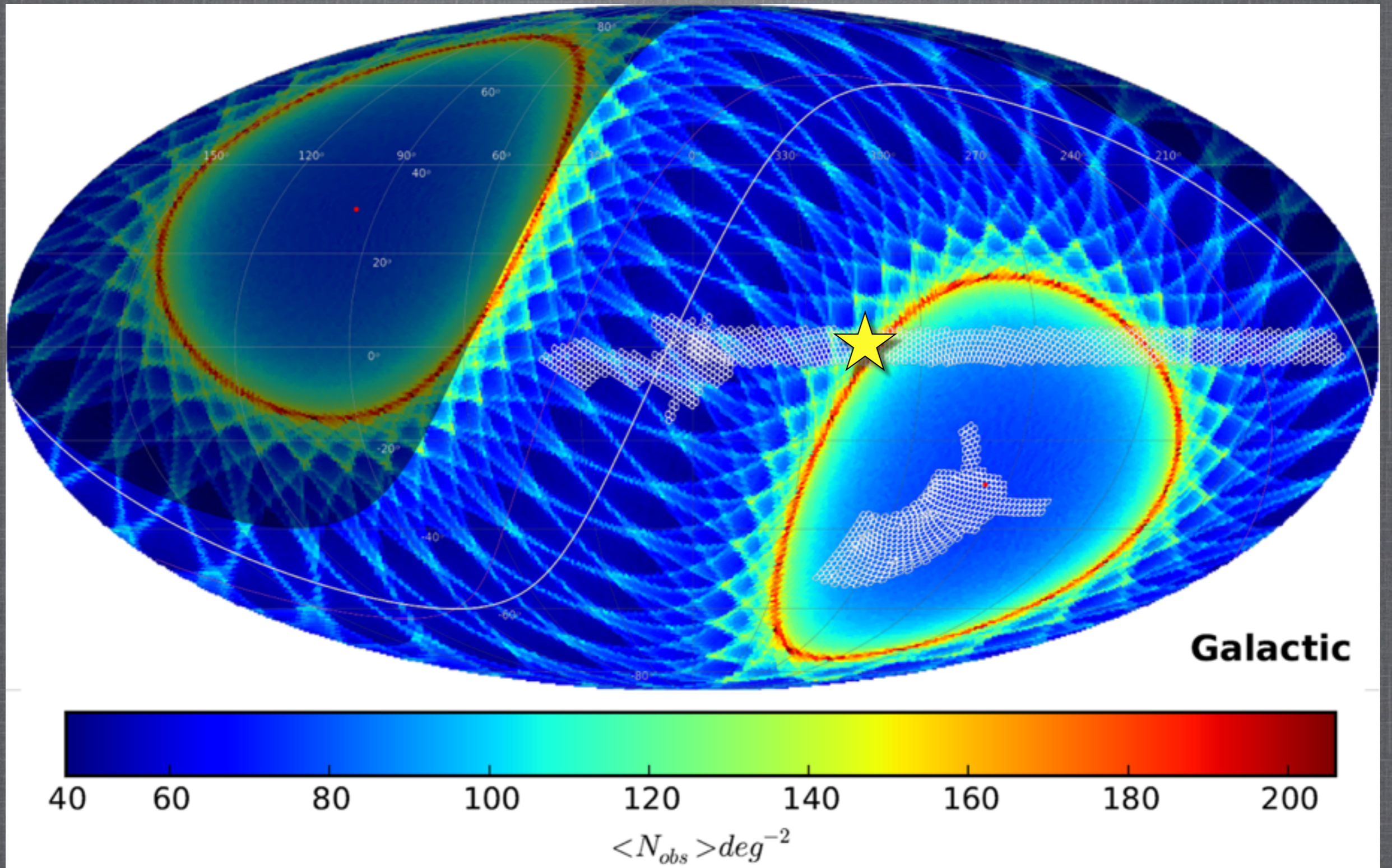
## OGLE-IV disk data



## SALT spectrum



# OGLE-GAIA SKY



# GAIA16AYE (AYERS ROCK)

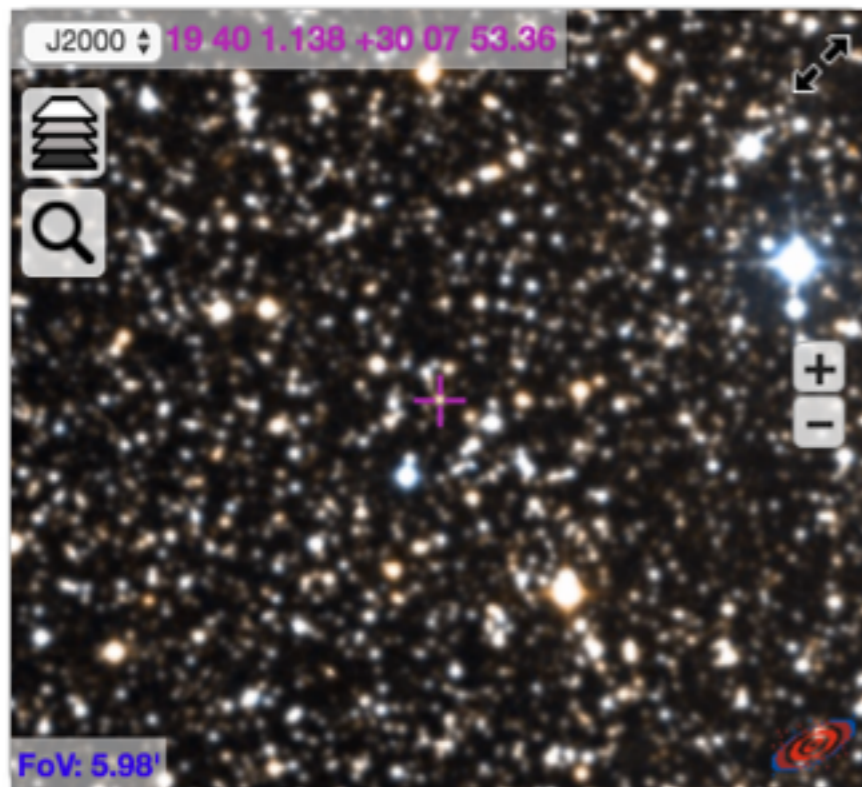
*Gaia Alert on a red bright star in Cygnus constellation*

Gaia Alerts

## Gaia16aye

Details

Follow-up



**RA - DEC**  
295.00474 30.13149  
19:40:01.14 30:07:53.36

**Alerting date**  
2016-08-05 00:53:52

**Julian date**  
2457605.54

**Alerting magnitude**  
14.27

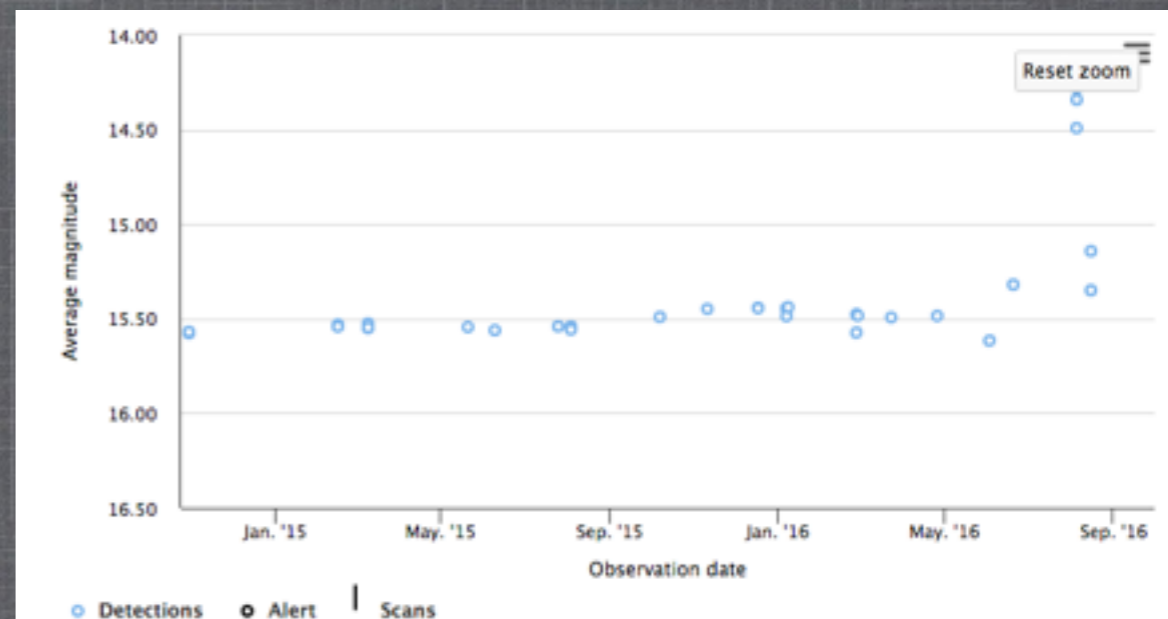
**Historic magnitude**  
15.51

**Historic StdDev**  
0.06

**Class**  
ULENS

**Publication date**  
Aug. 9, 2016, 10:45 a.m.

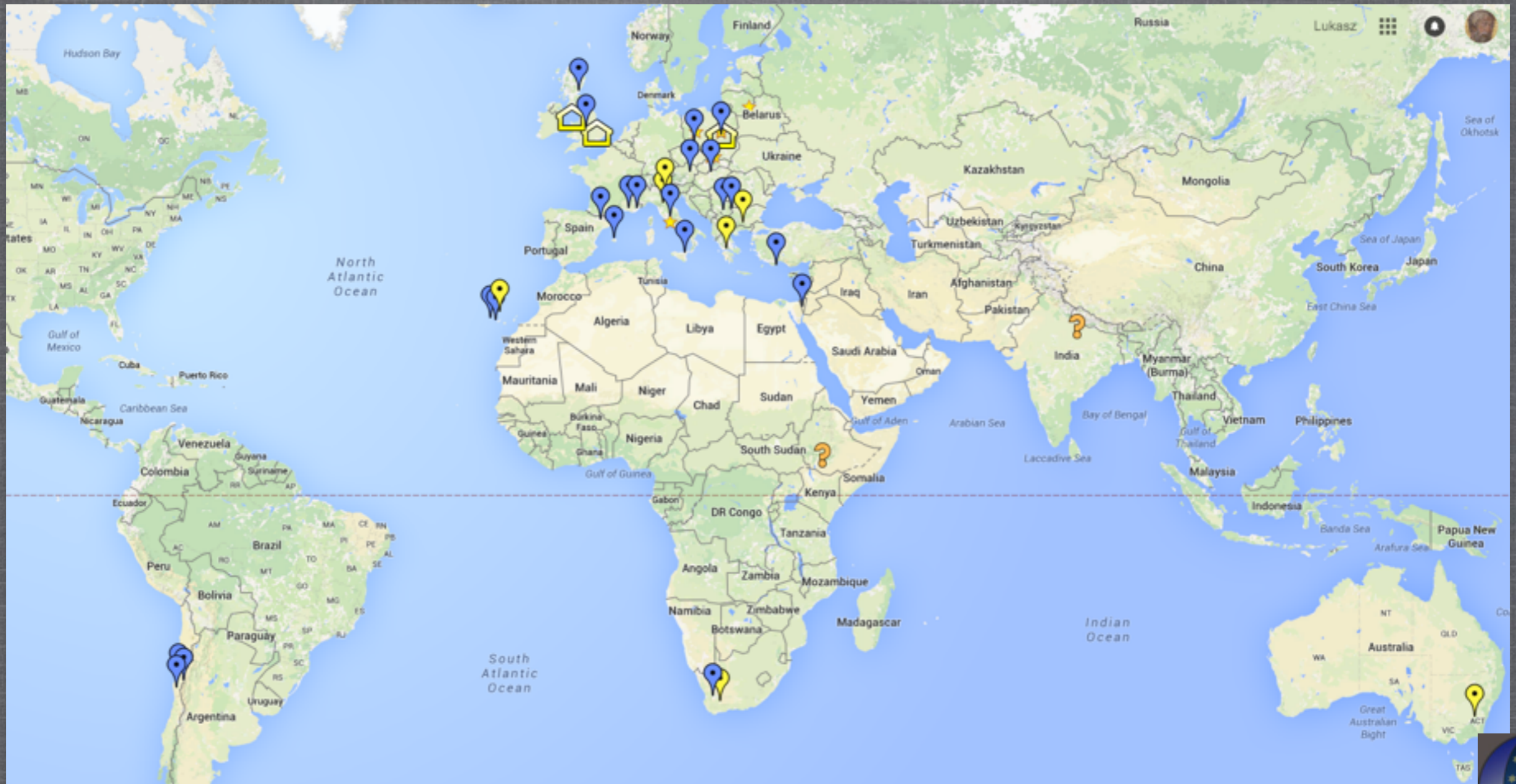
Found in data from Aug 5th,  
alerted Aug 9th 2016,  
unusual jump  
from 15.5 to 14.3 mag;  
ground-based follow-up started



# OPTICON FOLLOW-UP NETWORK

~20 active partners, ~30000 data points collected 2014-2016

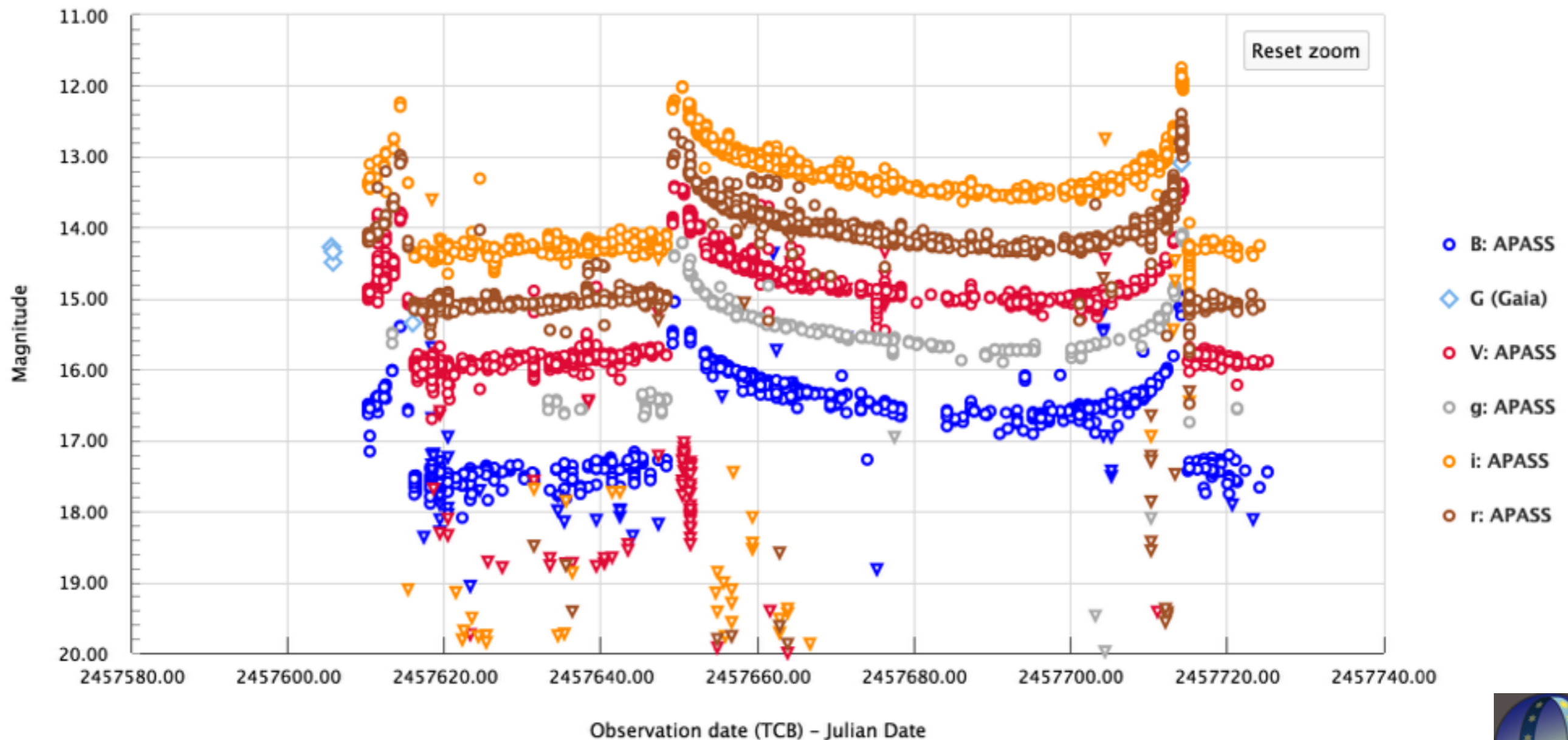
2017-2020: continuation under OPTICON H2020



# FOLLOW-UP CALIBRATION SERVER

[gsaweb.ast.cam.ac.uk/followup/](http://gsaweb.ast.cam.ac.uk/followup/)

Central repository for photometry  
Automatic zero-point calibrations for multi-site observations



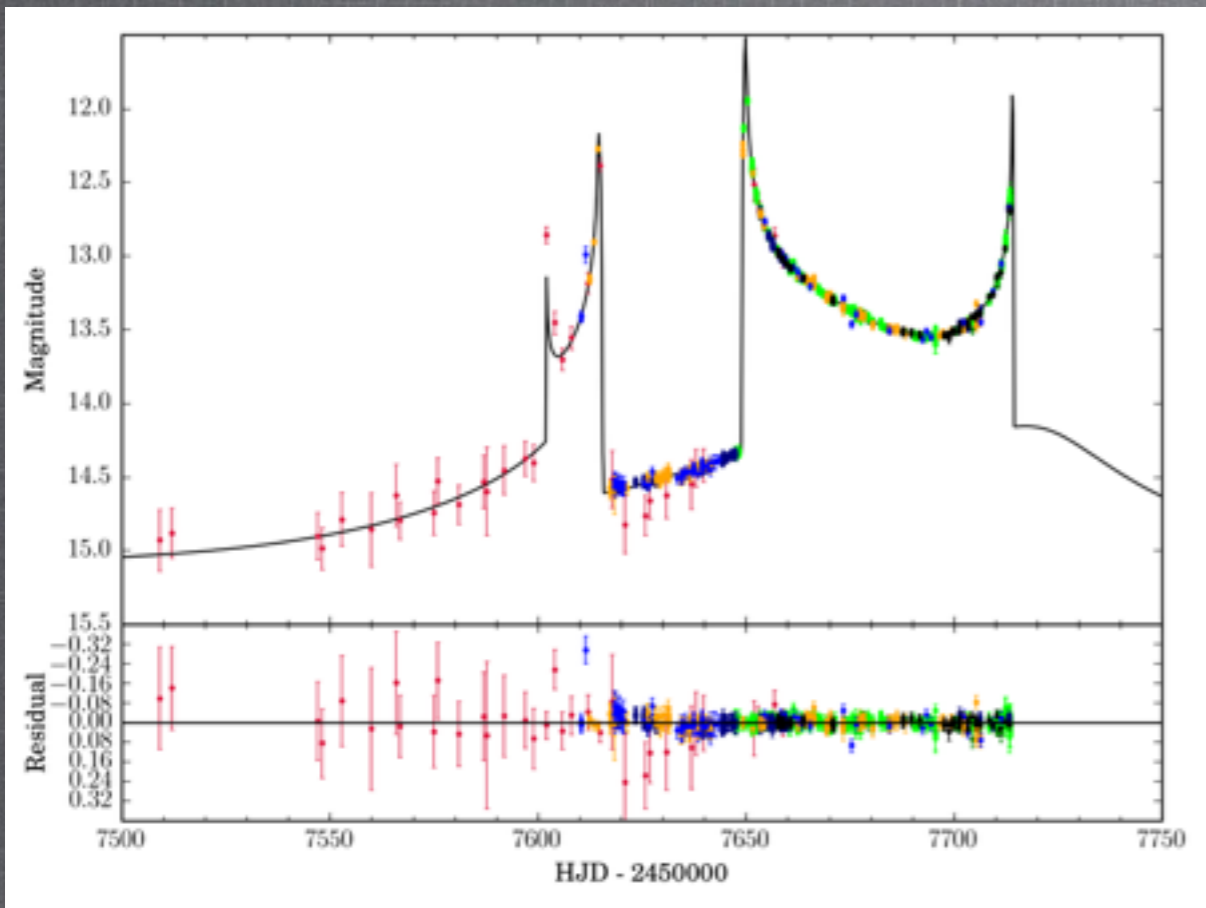
More than 20,000 data points collected in multiple bands





# GAIA16AYE (AYERS ROCK)

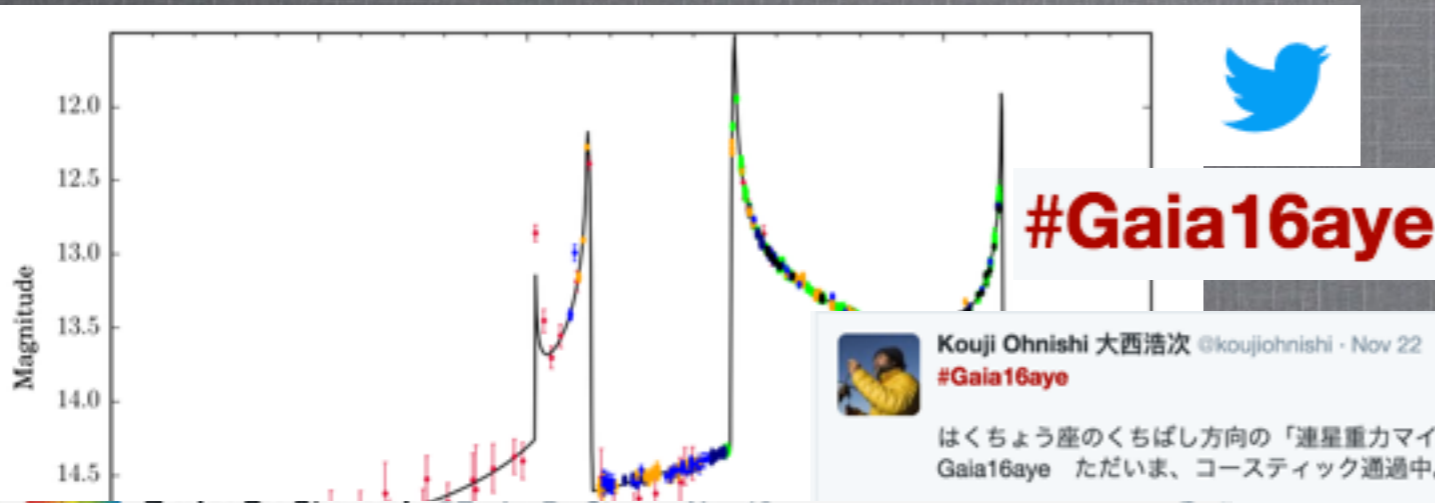
*Catching the 4th caustic exit*



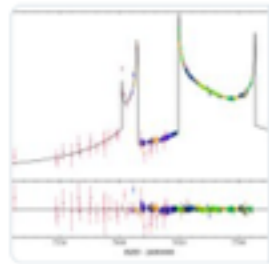
Model prediction  
Caustic exit 21 November 2 am UT

# GAIA16AYE (AYERS ROCK)

*Catching the 4th caustic exit*



ZauberDerSterne.de @ZauberDerSterne · Nov 19  
Die (Mikro-)Gravitationslinse #Gaia16aye für Amateurlteleskope: [abenteuer-astronomie.de/microlensing-i...](http://abenteuer-astronomie.de/microlensing-i...), [himmelslichter.net/update-mikro-g...](http://himmelslichter.net/update-mikro-g...) und



**Gaia16aye: Seltenes Microlensing-Ereignis mit Ans...**  
Zurzeit ereignet sich im Schwan nahe des hellen Sterns phi Cyg ein spektakuläres Himmelsphänomen. Das Microlensing-Ereignis Gaia16aye (Spitzname Ayers Ro...  
[zauberdersterne.wordpress.com](http://zauberdersterne.wordpress.com)

2 2

Gaia-GOSA and 2 others follow



Jan Hattenbach @JanHattenbach · Nov 19  
Morgen abend gibt's Gravitationslinse: [himmelslichter.net/update-mikro-g...](http://himmelslichter.net/update-mikro-g...)  
#Gaia16aye



**Update: Mikro-Gravitationslinse Gaia16aye soll Son...**  
Ein neues Modell sagt das vierte und letzte Aufleuchten der Mikro-Gravitationslinse Gaia16aye für Sonntag, den 20. November kurz vor 22 Uhr MEZ (20,8 UT) voraus. ...  
[himmelslichter.net](http://himmelslichter.net)

1 6 3

Jos de Bruijne Retweeted



Jan Hattenbach @JanHattenbach · Nov 18  
Discussion on the final caustic crossing of #Gaia16aye

Simon Hodgkin and 3 others Retweeted

Eric Jensen @einjensen · Nov 23  
What a difference a day makes! #Gaia16aye fades dramatically as caustic crossing part of microlensing event ends. #GaiaMission

21 November 2016 22 November 2016  
Gaia16aye  
Data from Peter van de Kamp Obs. Swarthmore College

18 15

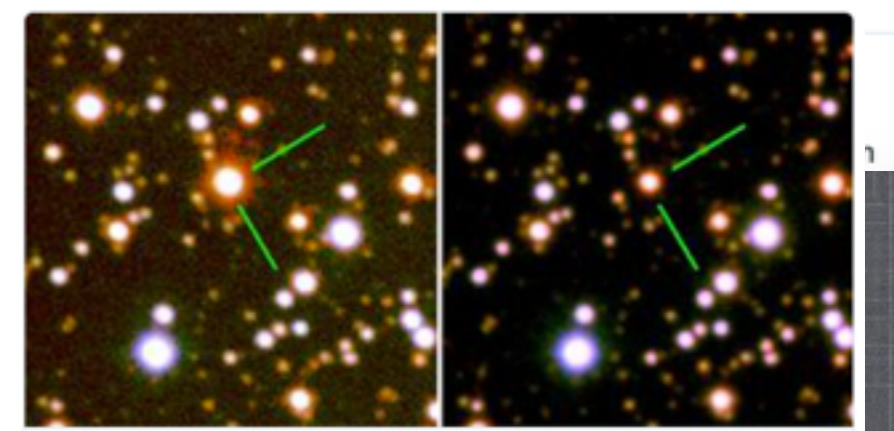
Daniel Fischer @cosmos4u · Nov 22  
Light curve from Turkey could nail down peak time of the final #Gaia16aye caustic crossing: [astronomerstelegam.org/?read=9780](http://astronomerstelegam.org/?read=9780) - 17:54 UTC yesterday.

1 1

Lukasz Wyrzykowski @lukasz206265 · Nov 22  
#Gaia16aye magnitude drop by 2.5 from last night - clearly the caustic crossing is over!

Daniel Fischer @cosmos4u · Nov 27  
In Turkey they are celebrating their measurements ([astronomerstelegam.org/?read=9780](http://astronomerstelegam.org/?read=9780)) of #Gaia16aye's final caustic crossing:

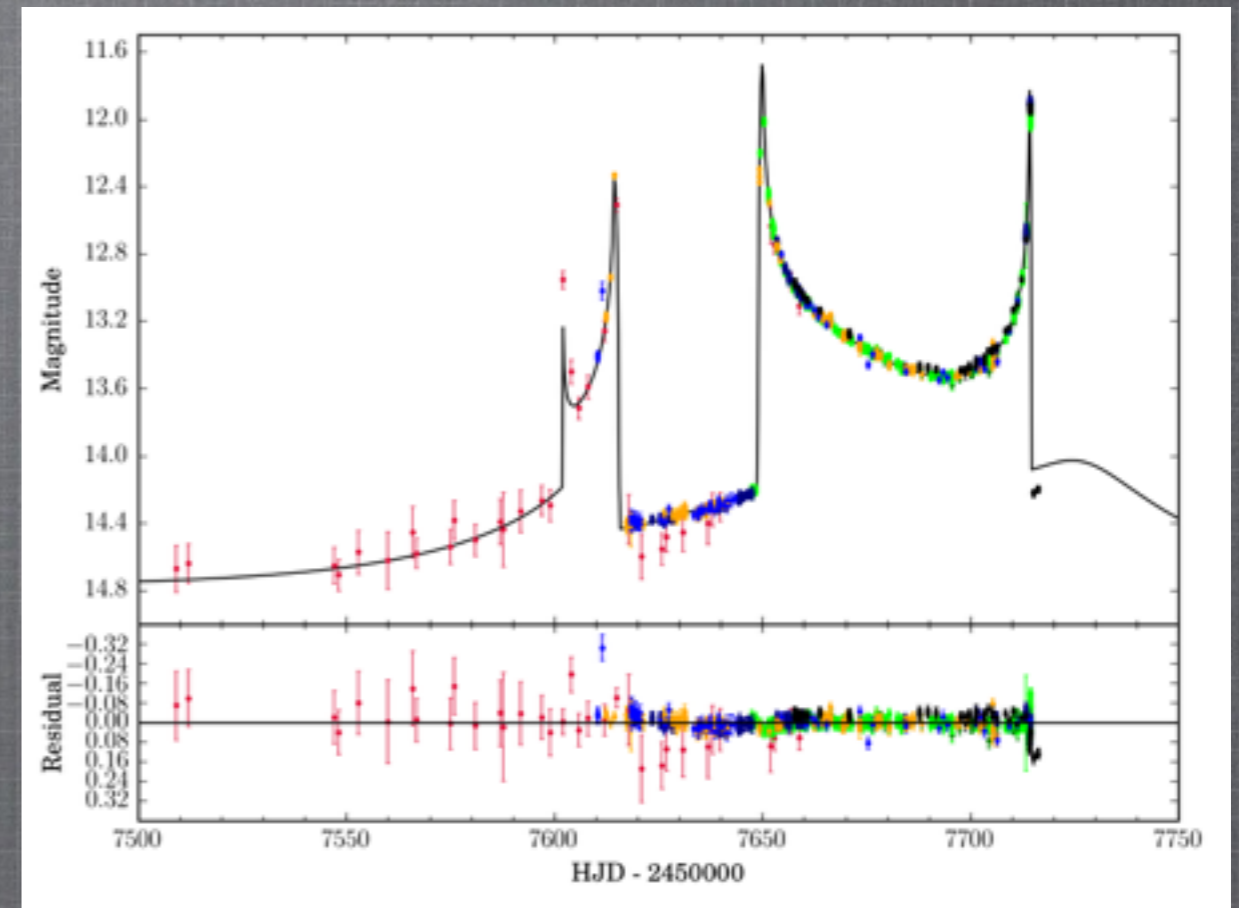
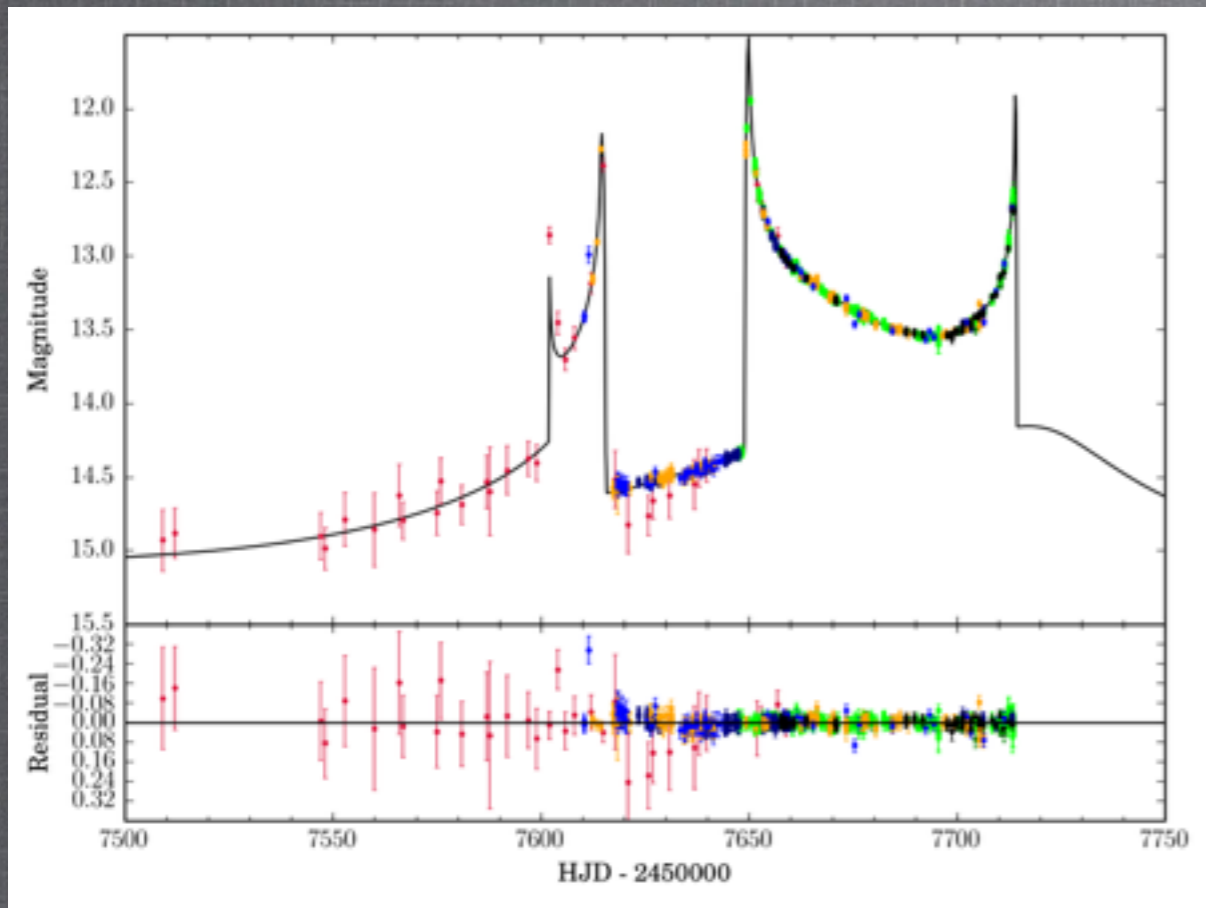
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**Parlayan yıldızın ışığını TÜBİTAK yakaladı**  
TÜBİTAK Başkanı Ergin, "TÜBİTAK Ulusal Gözlemevinin, coğrafi konum ve atmosferik koşullarının avantajını kullanarak, Gaia16aye isimli yıldızdan ...  
[aa.com.tr](http://aa.com.tr)

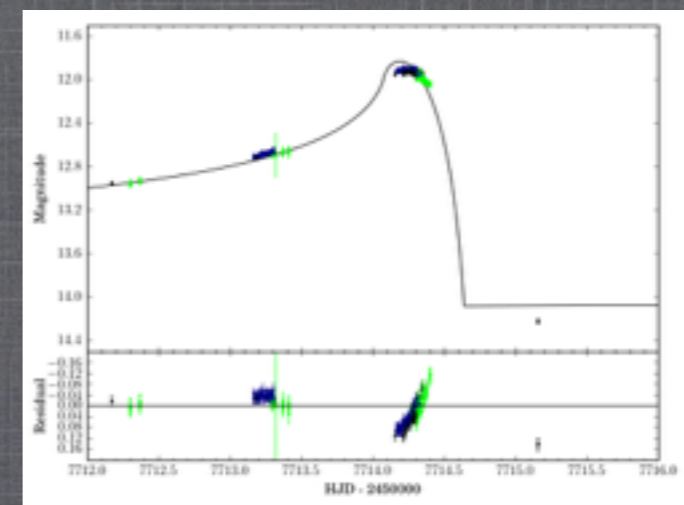
# GAIA16AYE (AYERS ROCK)

*Catching the 4th caustic exit*

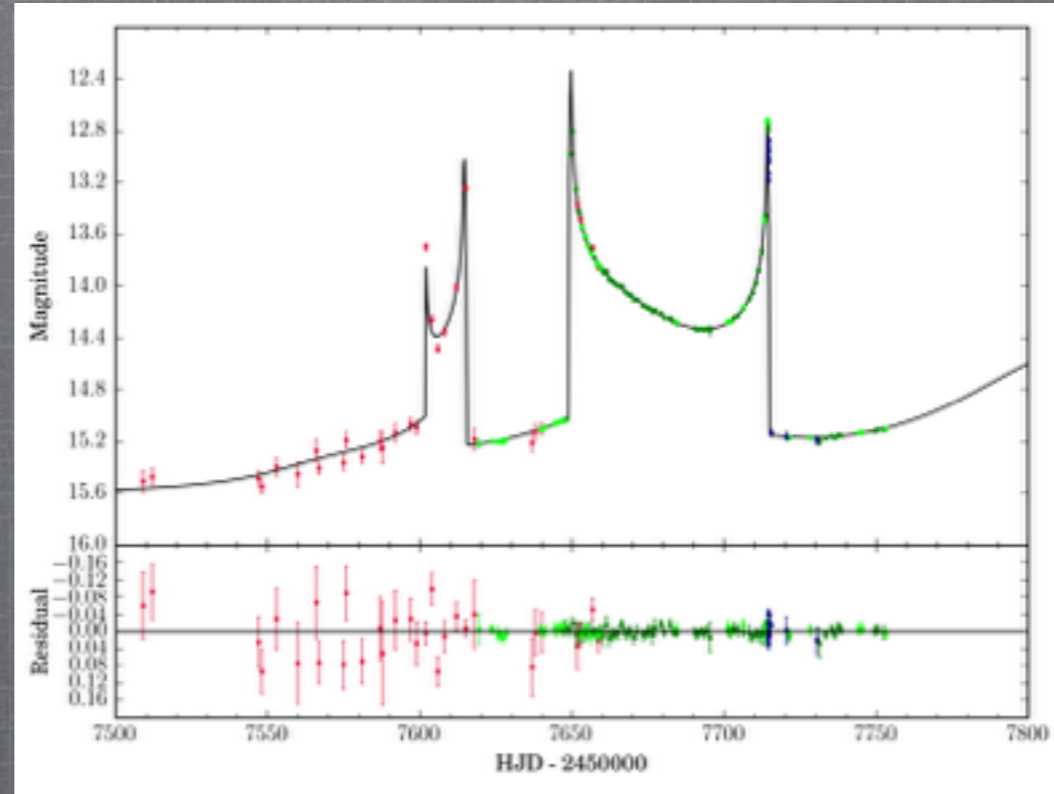
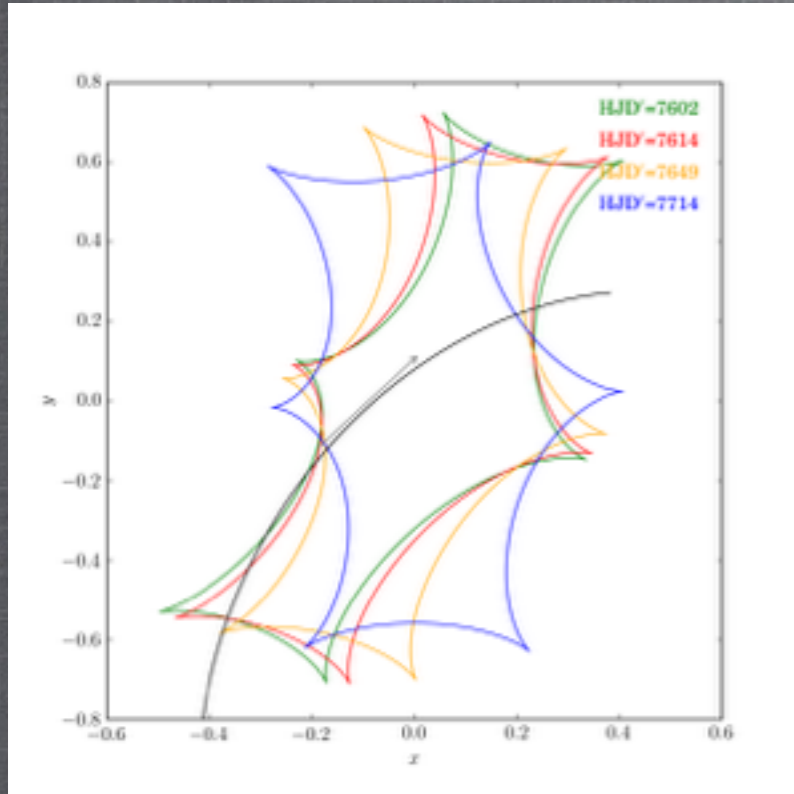


Model prediction  
Caustic exit 21 November 2 am UT

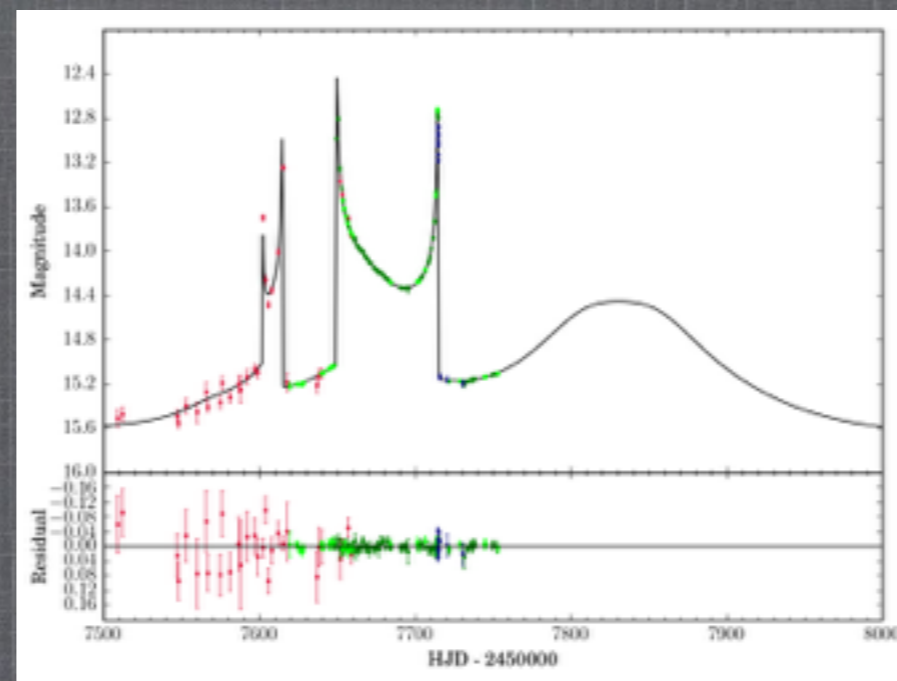
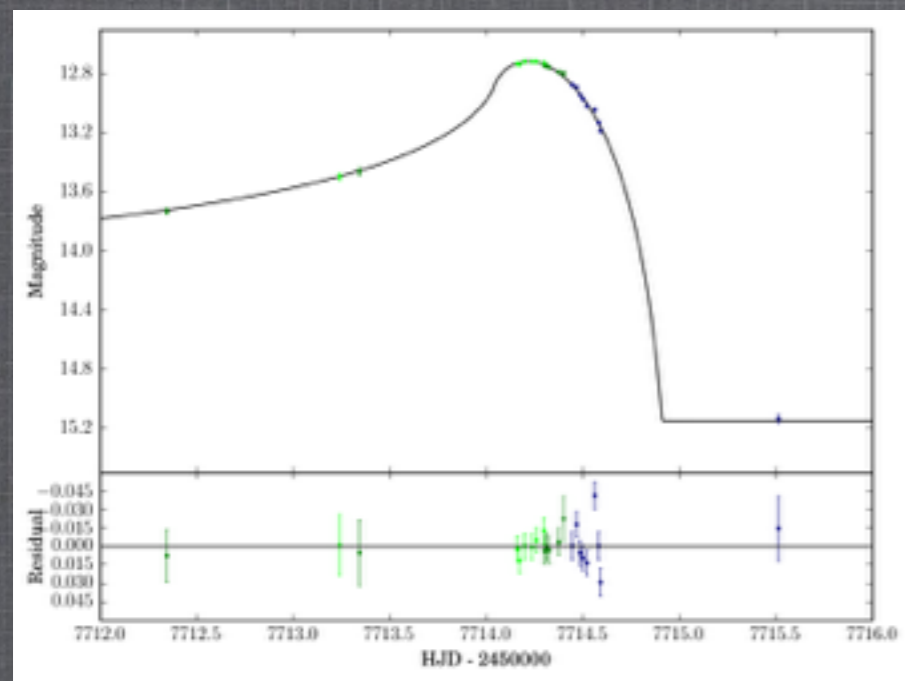
actual peak: 21 Nov ~16 UT



# PRELIMINARY FULL-KEPLERIAN SOLUTION



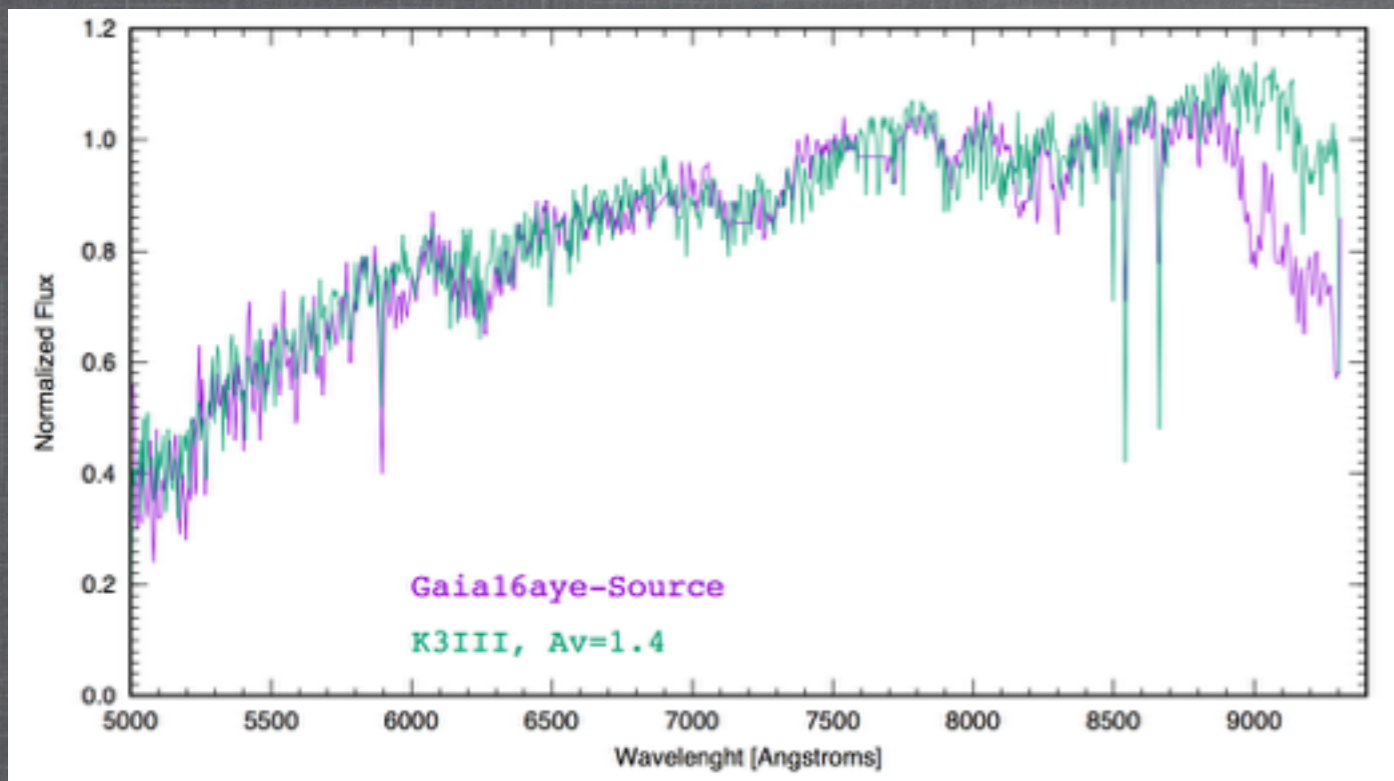
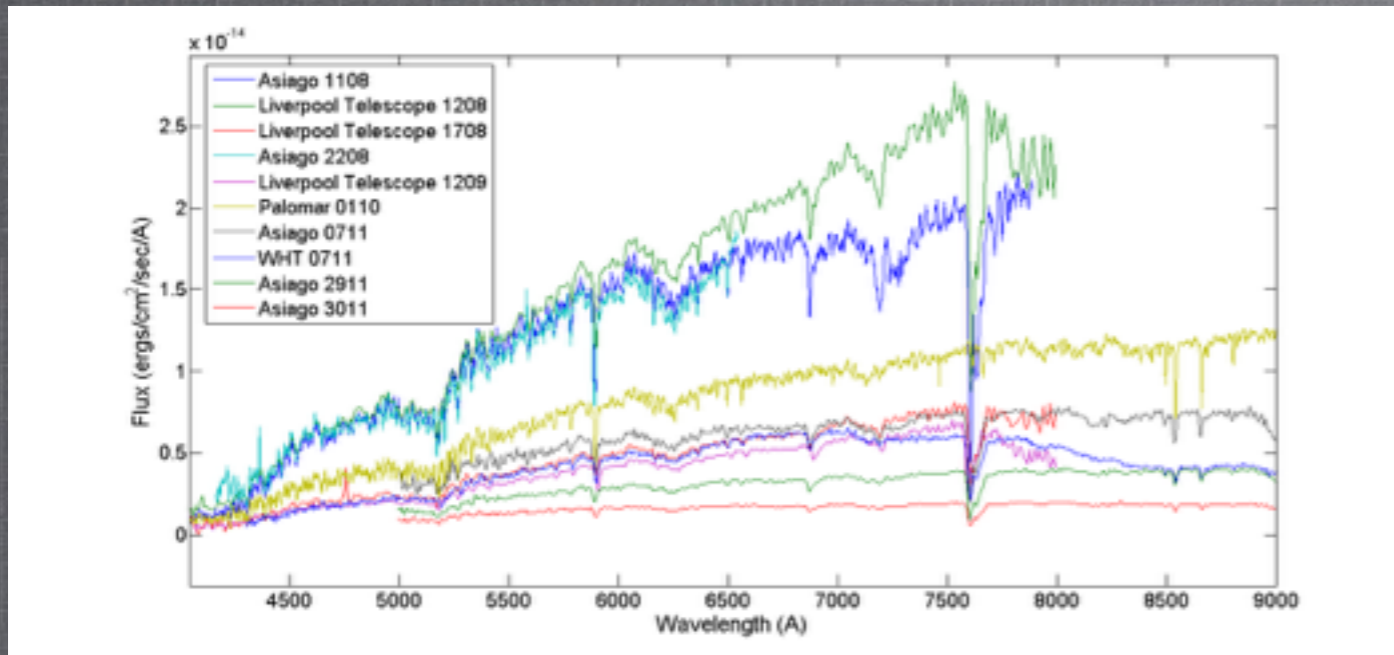
$tE = 141d$   
 $\pi E = 0.39$   
 $\theta E = 3 \text{ mas}$   
 $\mu_{rel} = 7 \text{ mas/yr}$   
 $q = 0.57$   
 $s = 1.0$   
 $f_s = 0.75$



model by P.Mroz  
and J.Skowron

# SPECTROSCOPY

*Spectral type and distance of the source star*



removing the lens light:

$$S_S = \frac{S_1 - S_2}{A_1 - A_2}$$

**best match:  
K3III at ~8kpc  
with  $A_v=1.4$  mag**

# PRELIMINARY SOLUTION



$$M_1 = 0.4 M_{\text{Sun}}$$

$$M_2 = 0.6 M_{\text{Sun}}$$

$$P = 3.4 \text{ yrs}$$

$$\text{incl} = 60 \text{ deg}$$

$$\text{ecc} = 0.473$$

K3 giant  
 $R = \sim 10 R_{\text{Sun}}$

# SUMMARY

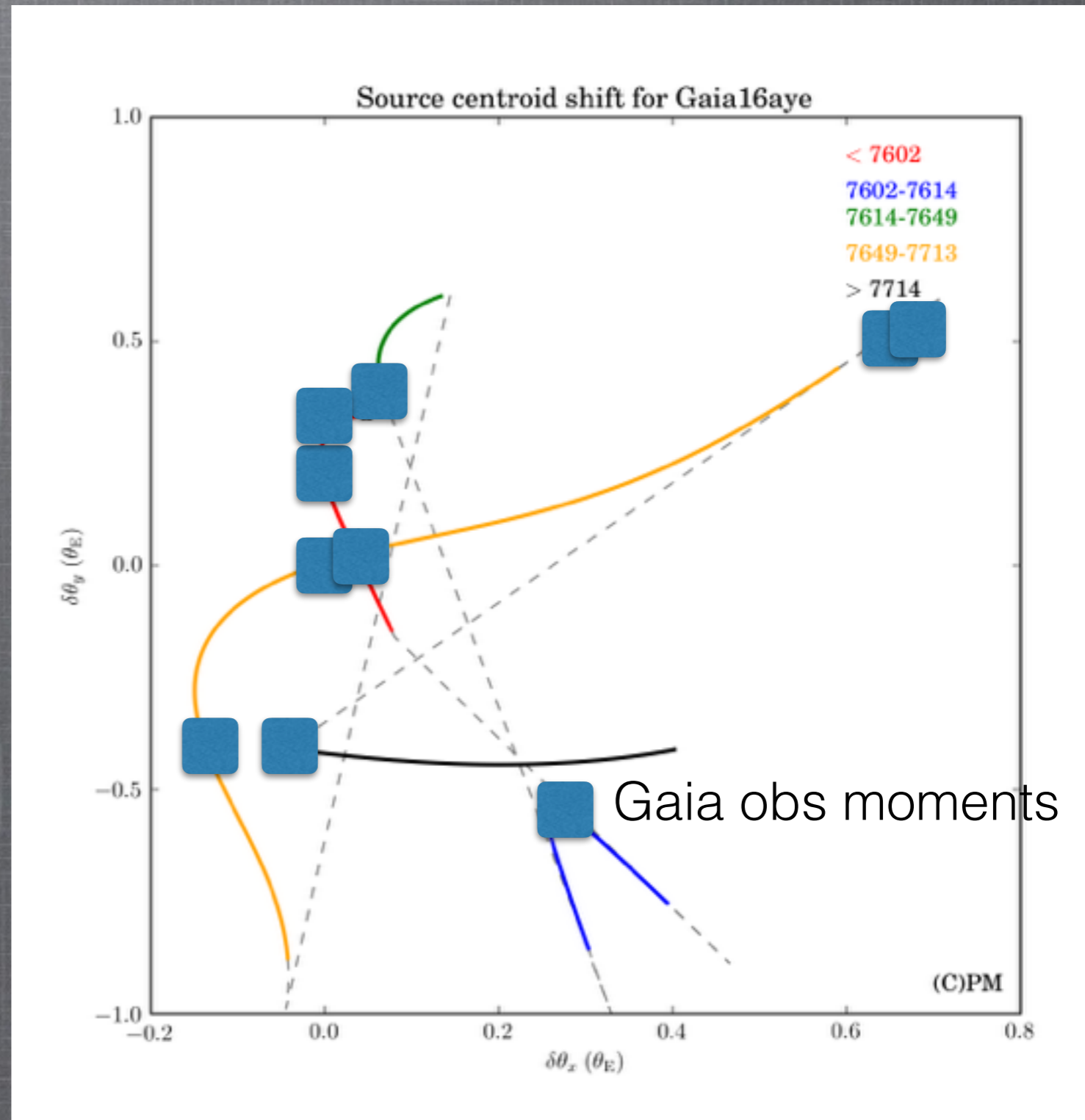
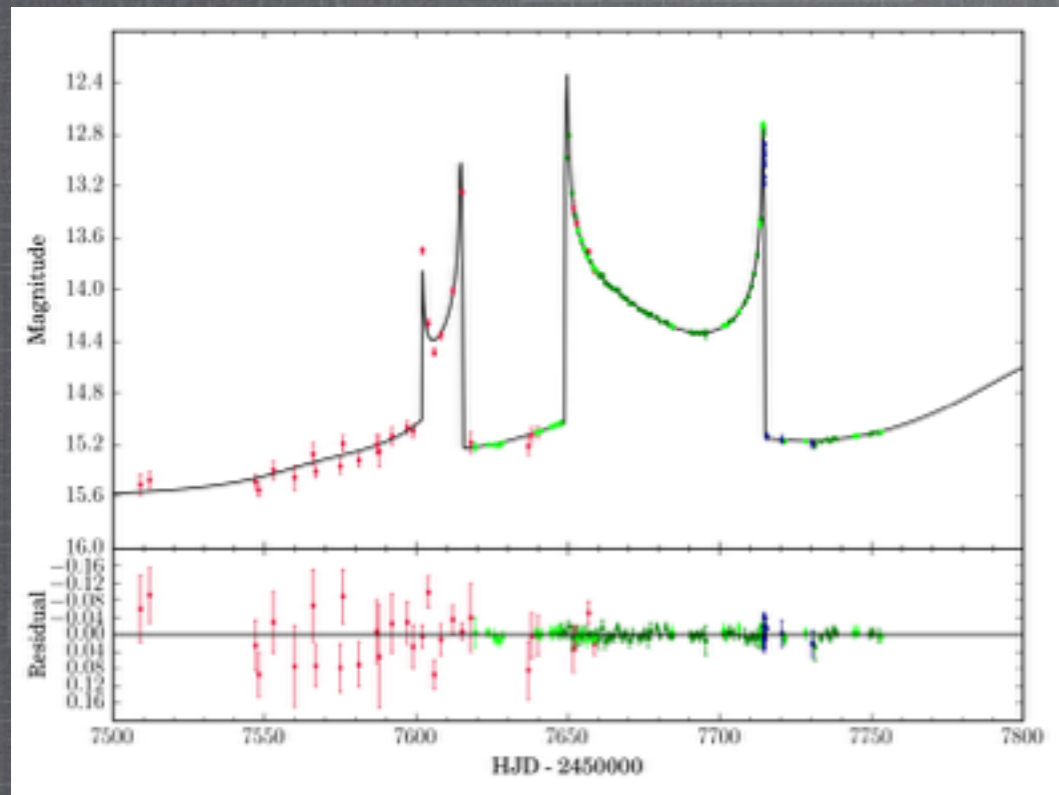
- Gaia has become a microlensing survey of the Galactic disk (both North and South)
- Gaia16aye – multiple caustic crossing event – full solution of the binary
- Astrometric data from ~2020 for Gaia microlensing events – chance to measure mass of lenses and recognise black hole lenses **see talk of Kris Rybicki**
- More events to come - follow-up needed (photo+spec)

**THANK YOU!**



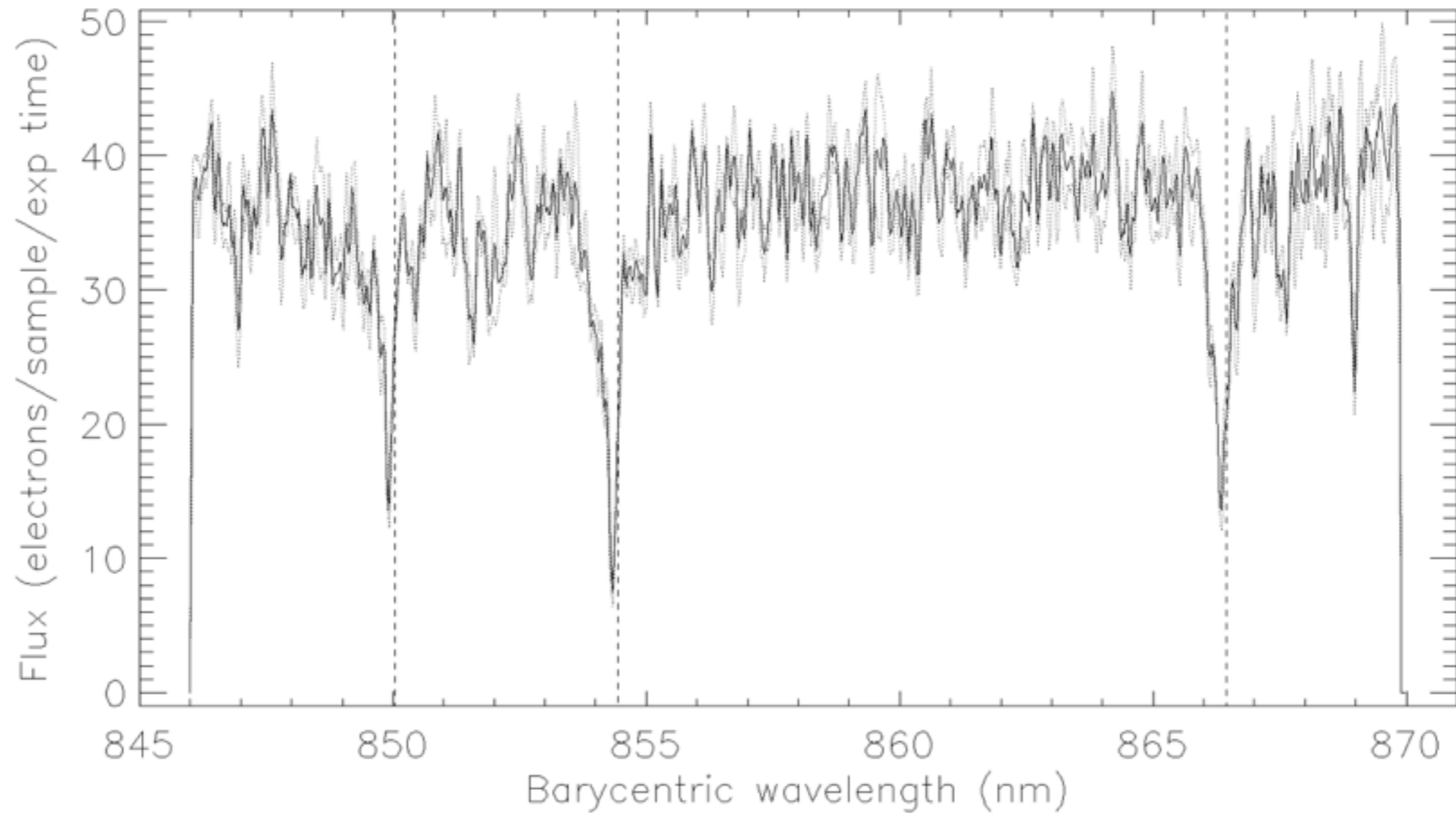
# ASTROMETRY

*First time ever chance to detect binary astrometric microlensing!*



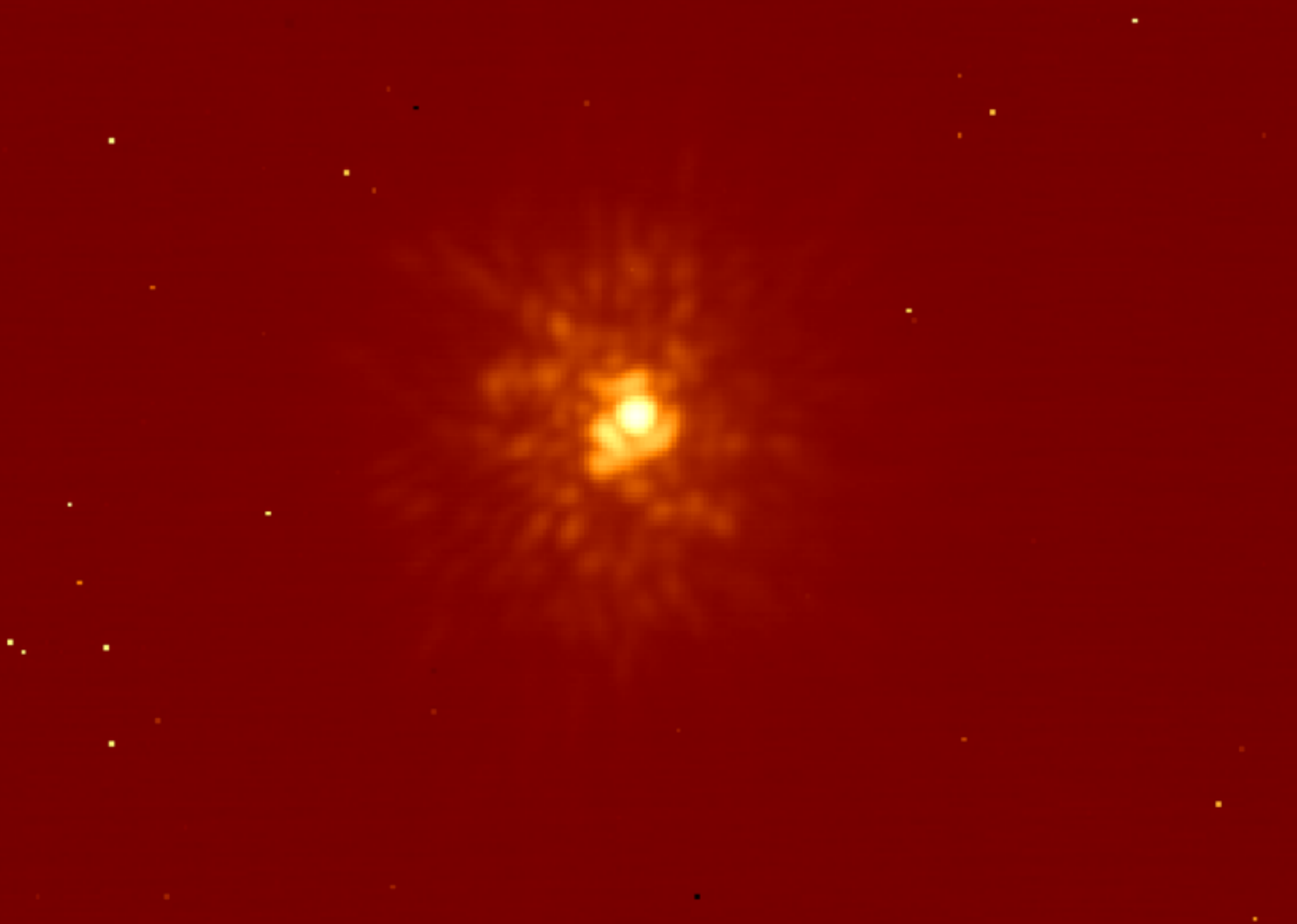
# GAIA RVS SPECTRUM

*A chance for Radial Velocity measurement from Gaia RVS*



credit: George Seabroke  
& ESA/DPAC/CU6

# Adaptive Optics (Keck)



credit: Jessica Lu