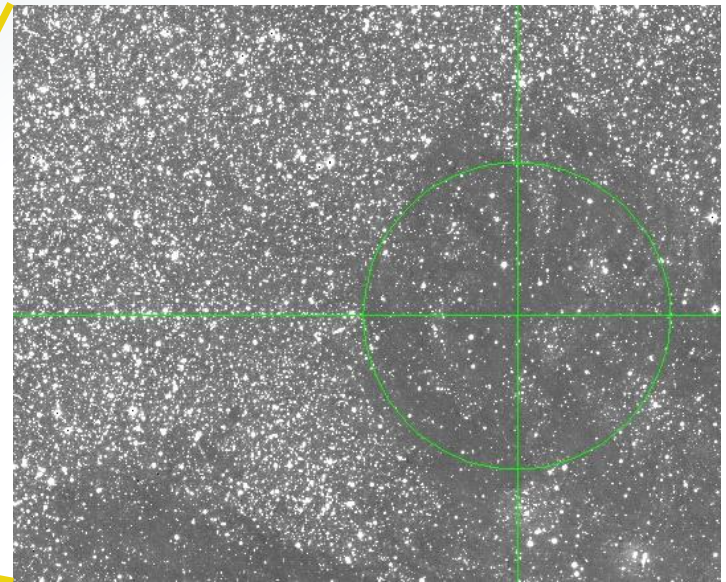
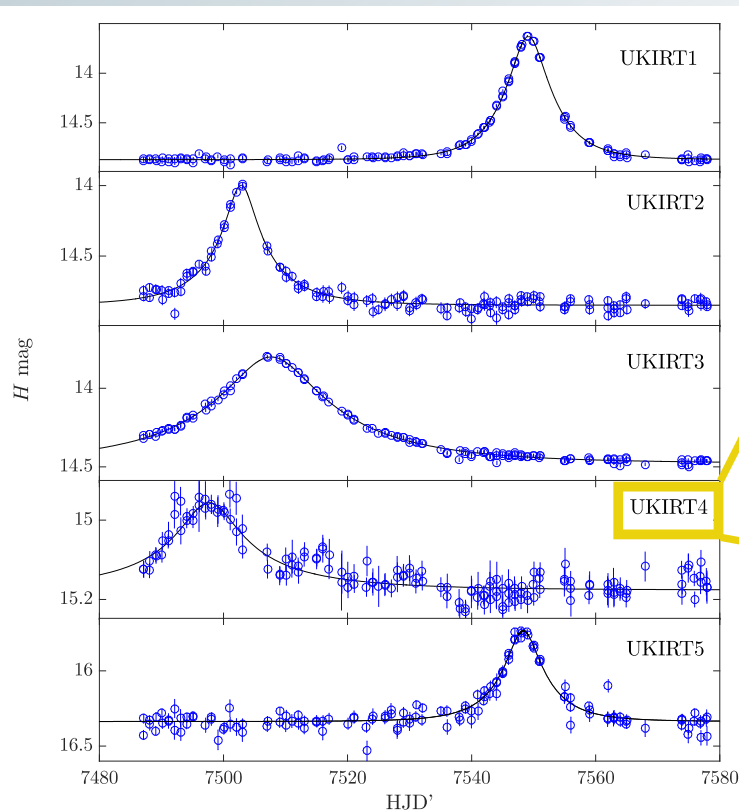


# UKIRT microlensing surveys as a pathfinder for *WFIRST*



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Collaborators: Geoff Bryden, Andy Gould,  
Calen Henderson, Steve Howell, Chas  
Beichman, Sebastiano Calchi Novati

Shvartzvald et al. 2017, *AJ*, 153, 61

# Scientific goals of UKIRT surveys

## NIR event rate as a function of $(l,b)$ :

- Crucial for WFIRST field optimization
- Combined with dust models -> Galactic structure

## Event timescale as a function of $(l,b)$ :

- Bulge-bulge events are expected to be shorter (Gould 1995)

## NIR coverage of events (Spitzer 2015/K2C9 2016):

- Source color - for Einstein radius (with finite source effects)
- NIR source flux - for future AO lens flux measurements

# UKIRT 2015-2016 microlensing surveys

## General:

- UKIRT – 3.8m telescope @ Mauna Kea
- WFCAM – Four 13.6' x 13.6' NIR detectors, 0.4"/pixel
- Filter – *H* band

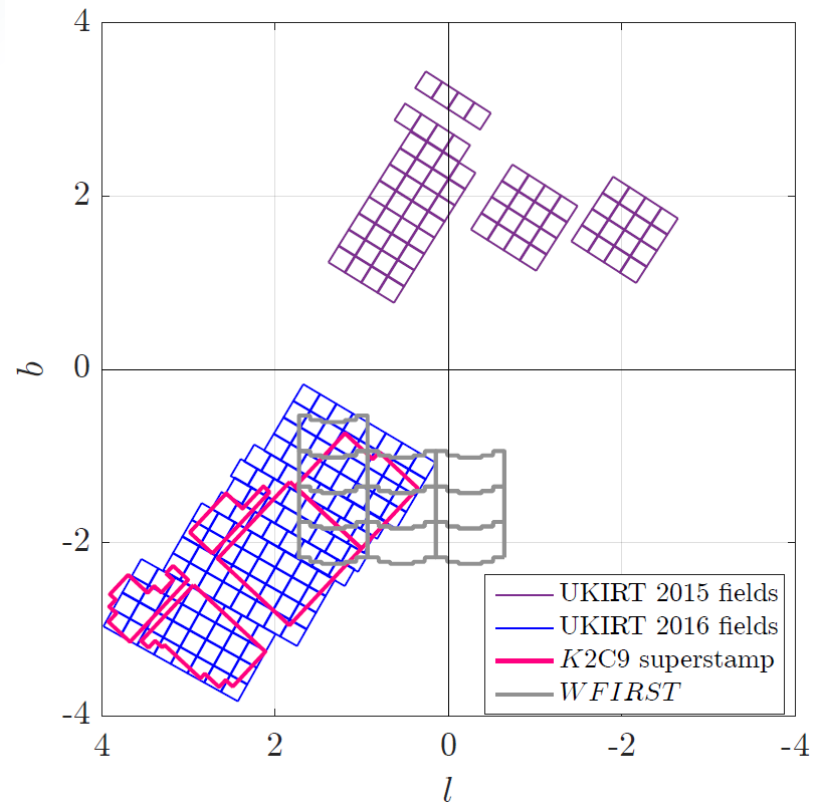
## 2015 survey – Spitzer:

- Area: 3.4 deg<sup>2</sup>
- Duration: 39 nights
- Cadence: 5 epochs/night

## 2016 survey – K2C9:

- Area: 6.0 deg<sup>2</sup>
- Duration: 91 nights
- Cadence: 2-3 epochs/night

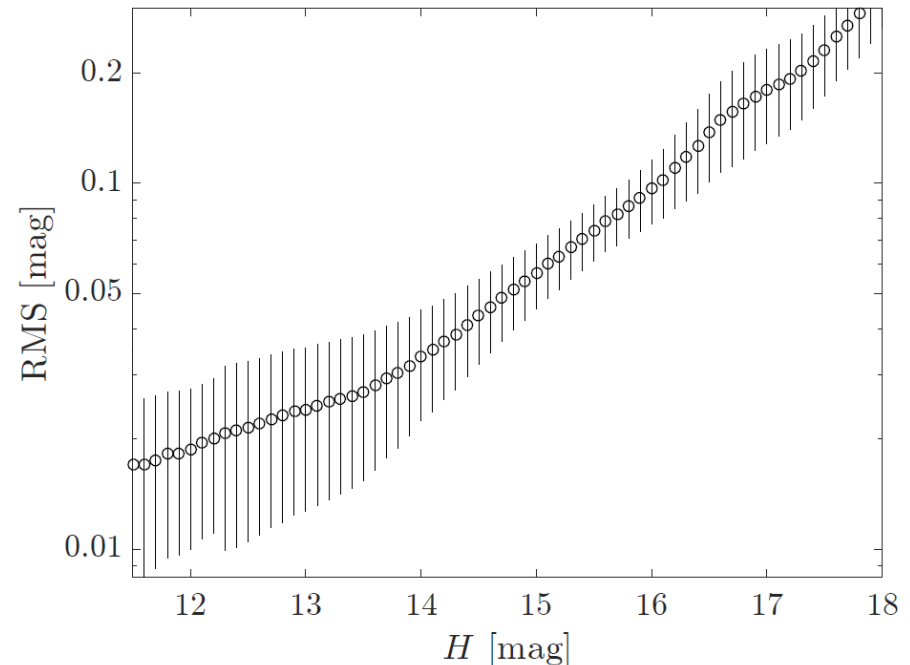
Shvartzvald et al. 2017



# UKIRT 2015-2016 microlensing surveys

## Photometry methods:

1. Soft-edged aperture photometry by CASU (Hodgkin et al. 2009)
2. PSF photometry using SExtractor (Bertin & Arnouts 1996) and PSFEx (Bertin 2011)
3. DIA photometry for specific events using pySis (Albrow et. al. 2009)



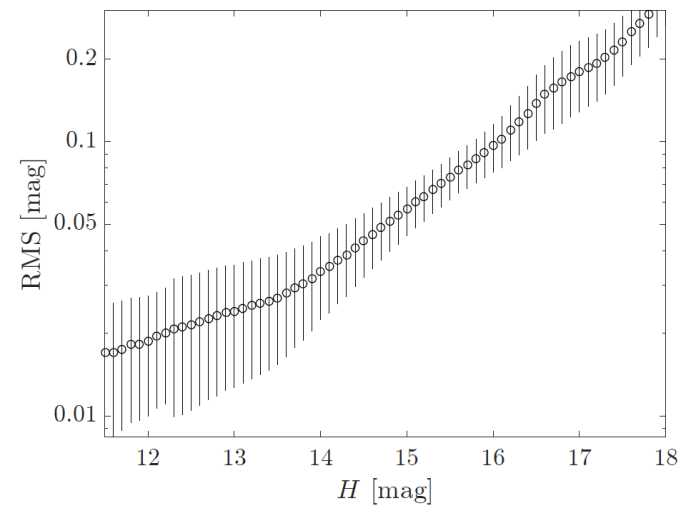
# UKIRT 2015-2016 microlensing surveys

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## ALL products will be PUBLIC:

- Images and raw CASU catalogs –  
WFCAM Science Archive (WSA)
- *K2C9* events –  
NExSci, ExoFOP
- Full catalog and all light curves (10-20M) –  
NExSci, NASA Exoplanet Archive



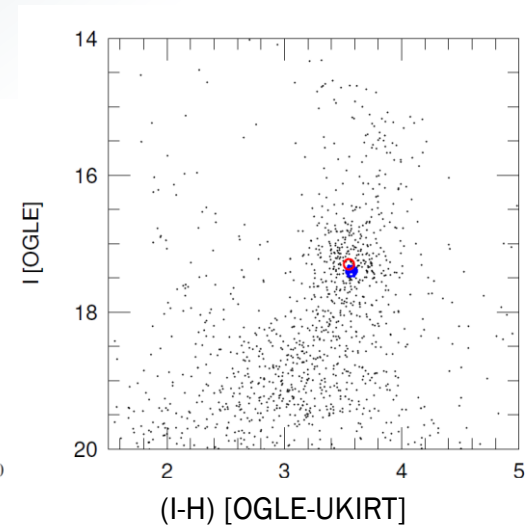
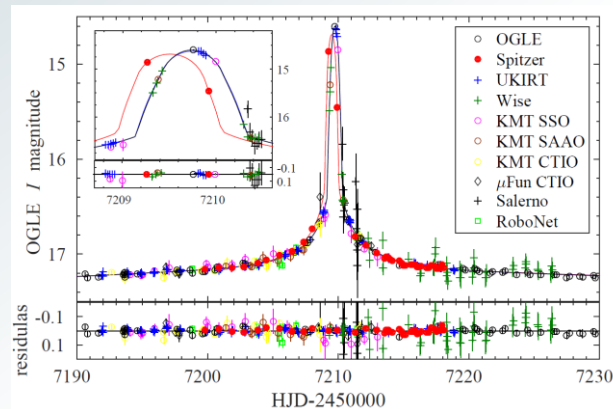
# UKIRT 2015-2016 microlensing surveys

## 2015 survey – Spitzer.

- 32 OGLE events
- 12 Spitzer events
- Example:

OGLE-15-1285

Shvartzvald et al. 2015





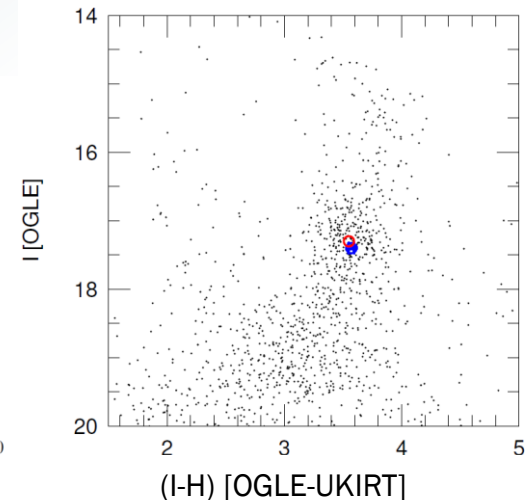
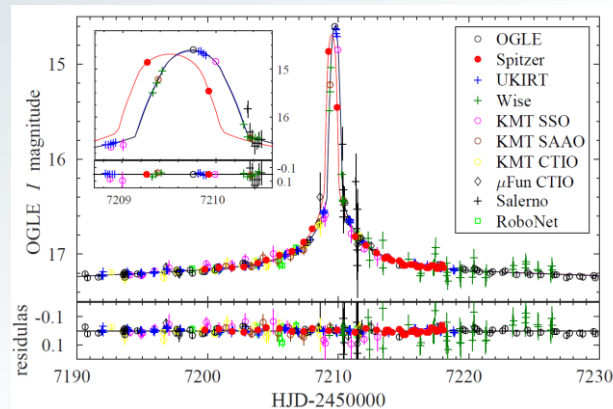
# UKIRT 2015-2016 microlensing surveys

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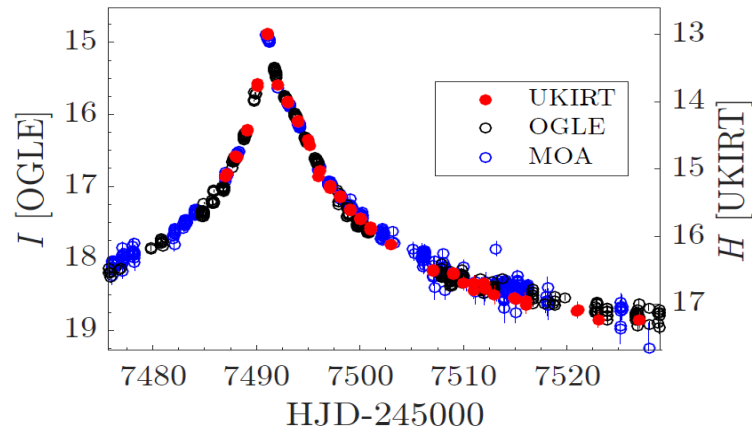
- 32 OGLE events
- 12 Spitzer events
- Example:

OGLE-15-1285

Shvartzvald et al. 2015



OB160241/MB16132



## 2016 survey – K2C9:

- ~140 OGLE/MOA events
- Examples:

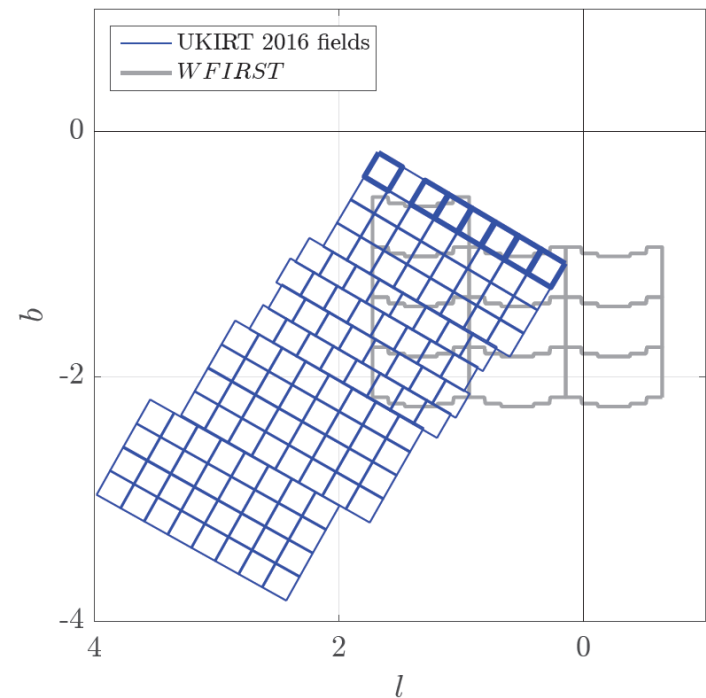
OGLE-16-0124

MOA-16-227 (Koshimoto talk tomorrow)

# UKIRT 2015-2016 microlensing surveys

## Preliminary exploration of 2016 data:

- 7 subfields searched, 333,336 light curves
- New event detection algorithm (Kim et al., in preparation)



Shvartzvald et al. 2017



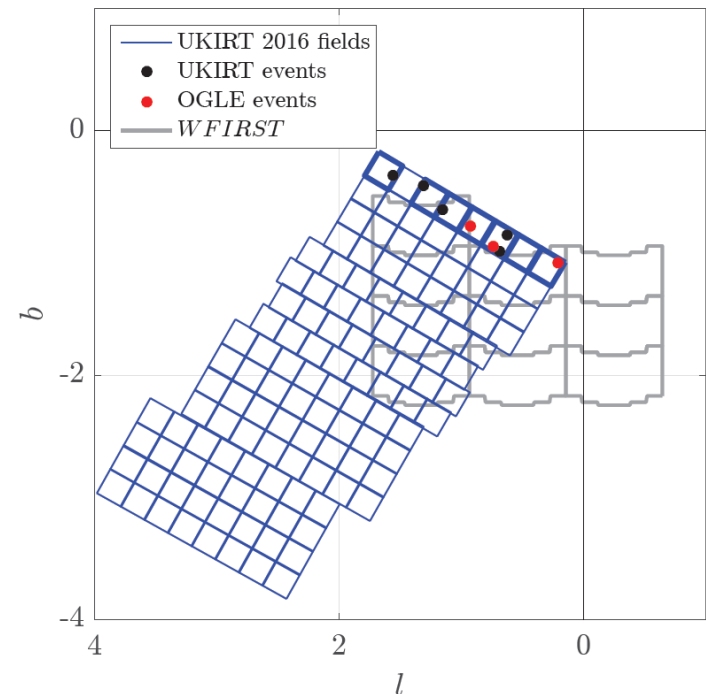
# UKIRT 2015-2016 microlensing surveys

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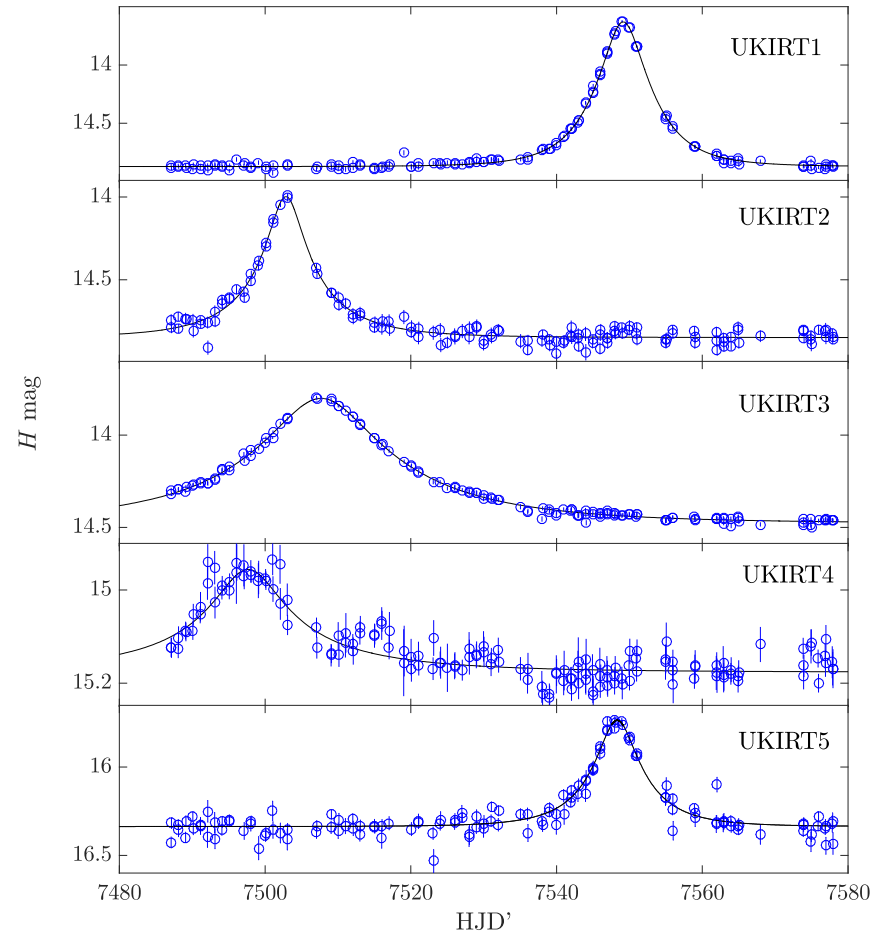
## 8 microlensing events detected

- 5 new UKIRT events
  - Highly extinguished:  
 $A_H = 0.81 - 1.97$  ;  $A_I \geq 2.8$
  - Low Galactic latitude:  
 $-0.98 \leq b \leq -0.36$
- 3 OGLE events



# UKIRT 2015-2016 microlensing surveys

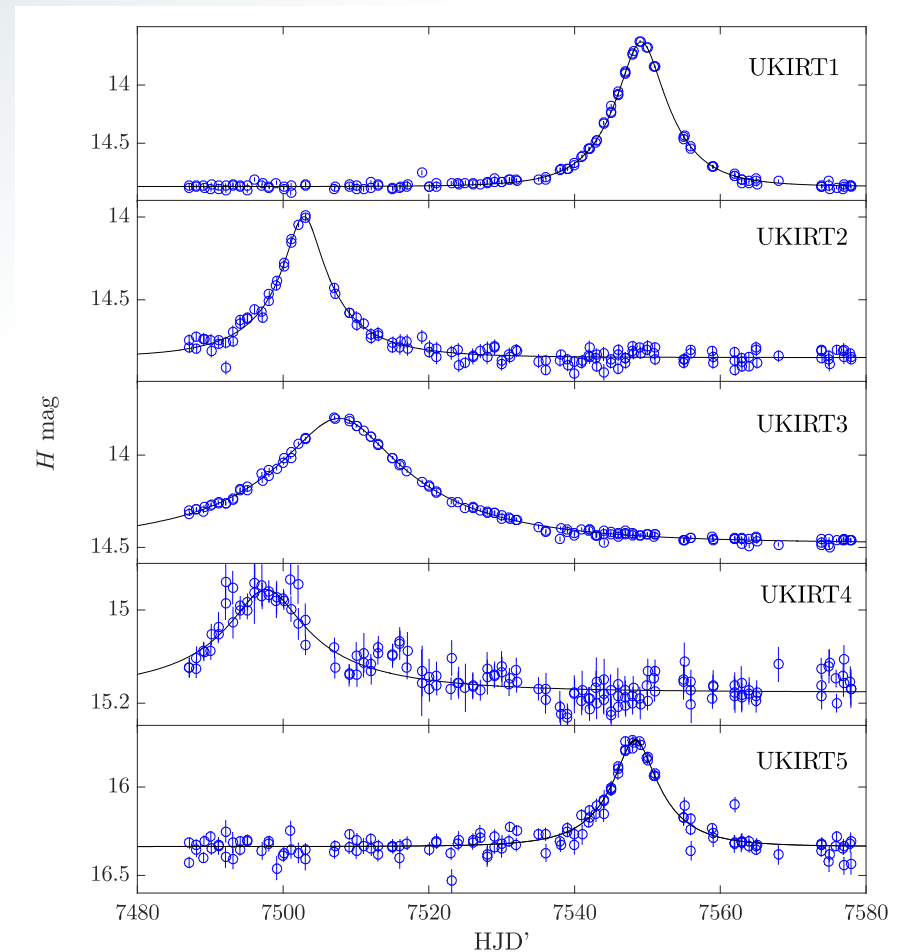
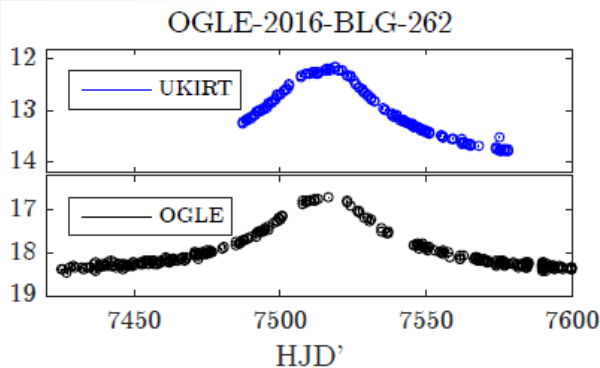
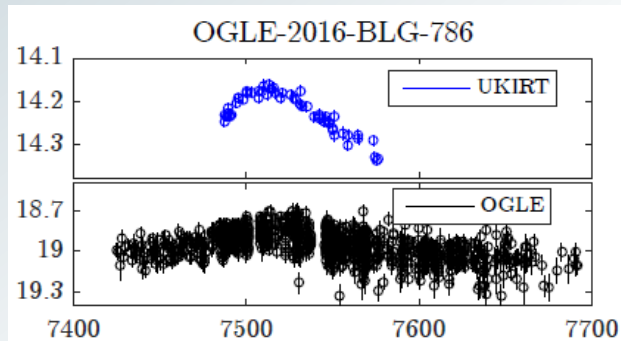
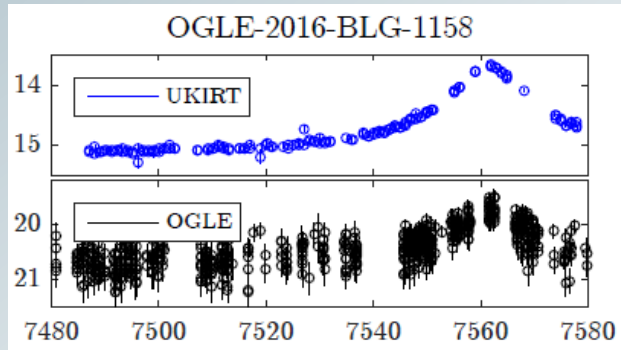
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Shvartzvald et al. 2017

# UKIRT 2015-2016 microlensing surveys

8 microlensing events detected



Shvartzvald et al. 2017

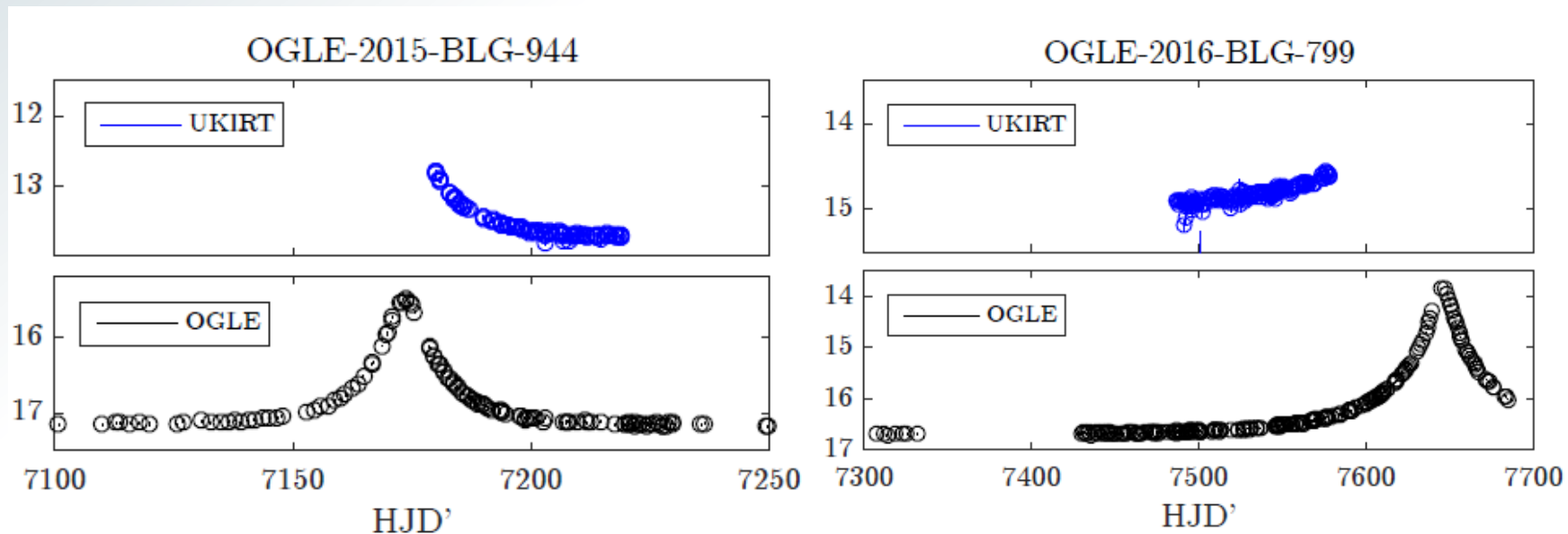
# UKIRT 2015-2016 microlensing surveys

## Short survey duration – timescale bias:

Problems with “long” timescale events

- No baseline / no peak
- Challenge for deriving physical properties

Relevant for *WFIRST* (72 days campaigns)



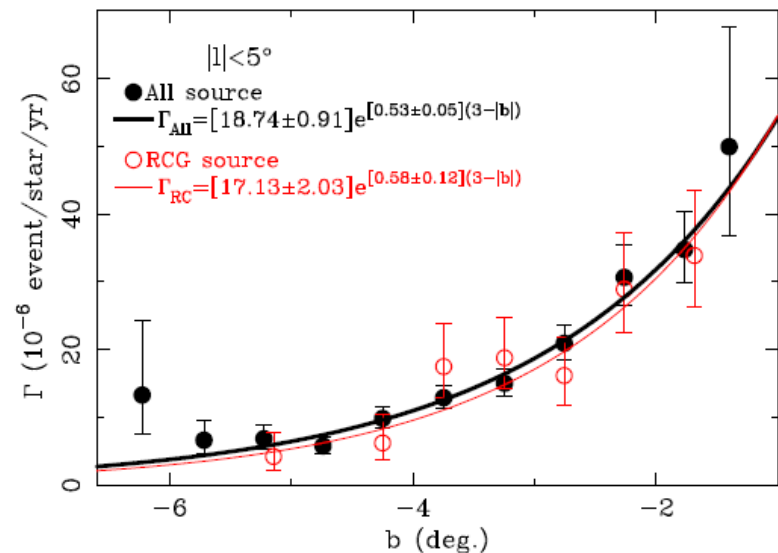
# UKIRT 2015-2016 microlensing surveys

## Preliminary estimation of the NIR event rate:

Rates:  $89_{-31}^{+44}$  events /deg<sup>2</sup>/year

$96_{-33}^{+47}$  events /star/year

- Assuming 100% detection efficiency
- Not the full dataset
- Timescale bias
- No correction for source counts  
(Sumi & Penny 2016)



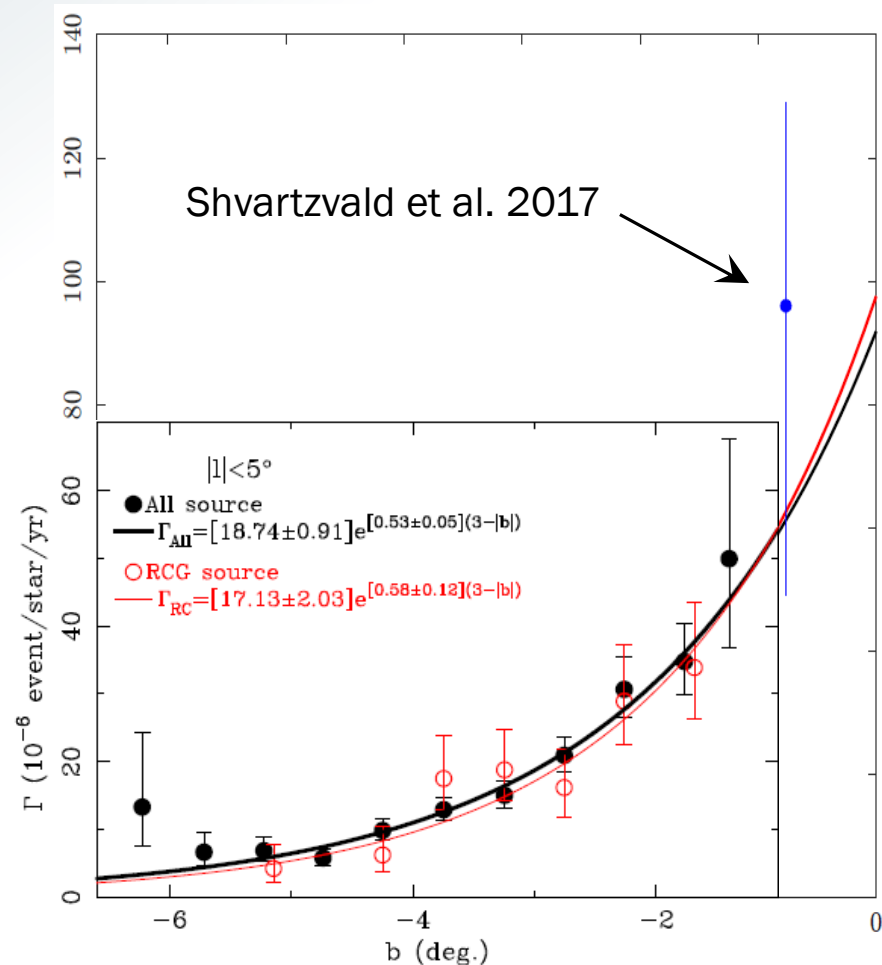
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Sumi & Penny 2016



# UKIRT 2017(+...) survey

## Goals:

- Facilitate trade studies to optimize *WFIRST* survey strategy
- Measure the NIR event rate / *WFIRST* field to a precision of ~20%
- Measure the NIR event rate / deg<sup>2</sup> to a precision of ~10%

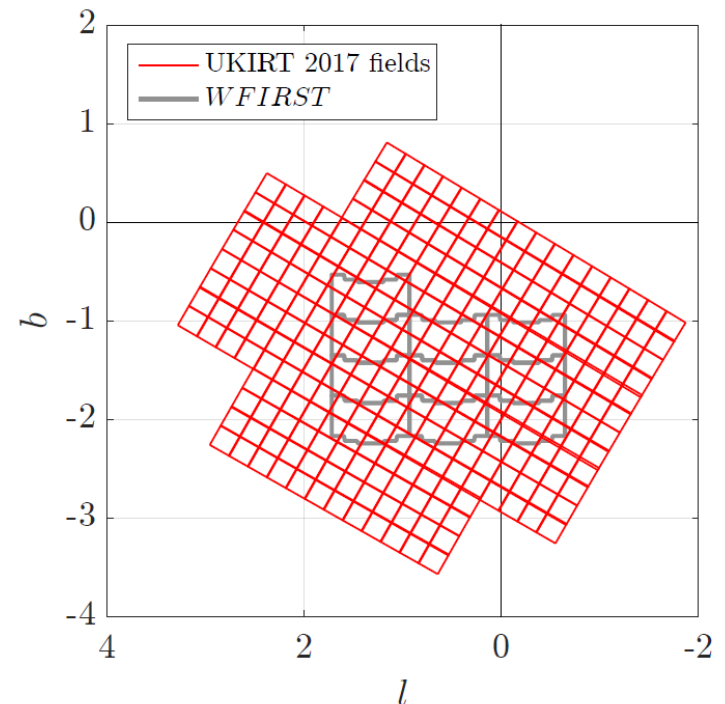
# UKIRT 2017(+...) survey

## Goals:

- Facilitate trade studies to optimize *WFIRST* survey strategy
- Measure the NIR event rate / *WFIRST* field to a precision of  $\sim 20\%$
- Measure the NIR event rate /  $\text{deg}^2$  to a precision of  $\sim 10\%$

## Current 2017 survey plan:

- Duration: 123 nights  
(16/Apr – 21/Aug)
- Area: 13.5 or 6.75  $\text{deg}^2$
- Cadence: 1 or 2 obs/night
- Filters: *K* - nightly (*J* - 1/3 nights?)



# Summary

## UKIRT 2015-2016 surveys

- Over 10 million publicly available light curves
- NIR coverage of *K2C9* microlensing events
- Discovery of 5 highly-extinguished low- $|b|$  microlensing events
- Preliminary estimation of NIR event rate
  - Consistent with optical rate extrapolation
- Long timescale events – challenge for *WFIRST* microlensing surveys

## UKIRT 2017 (+...) survey

- NIR event rate across the possible *WFIRST* fields – field optimization
- New science?