

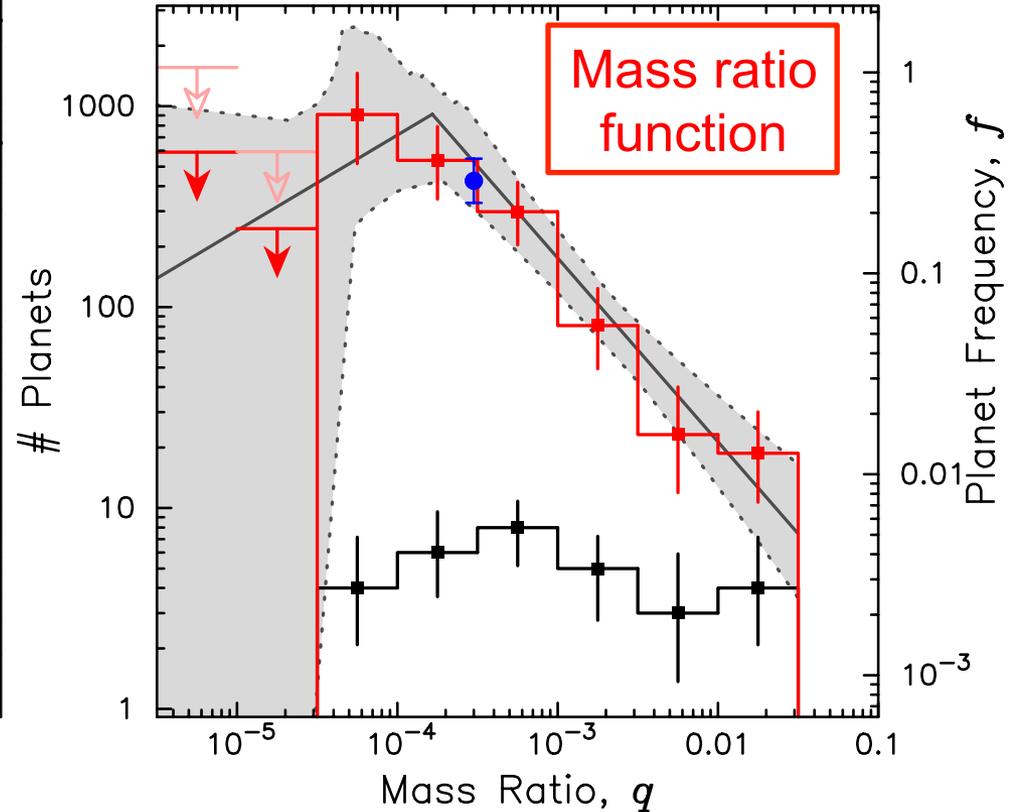
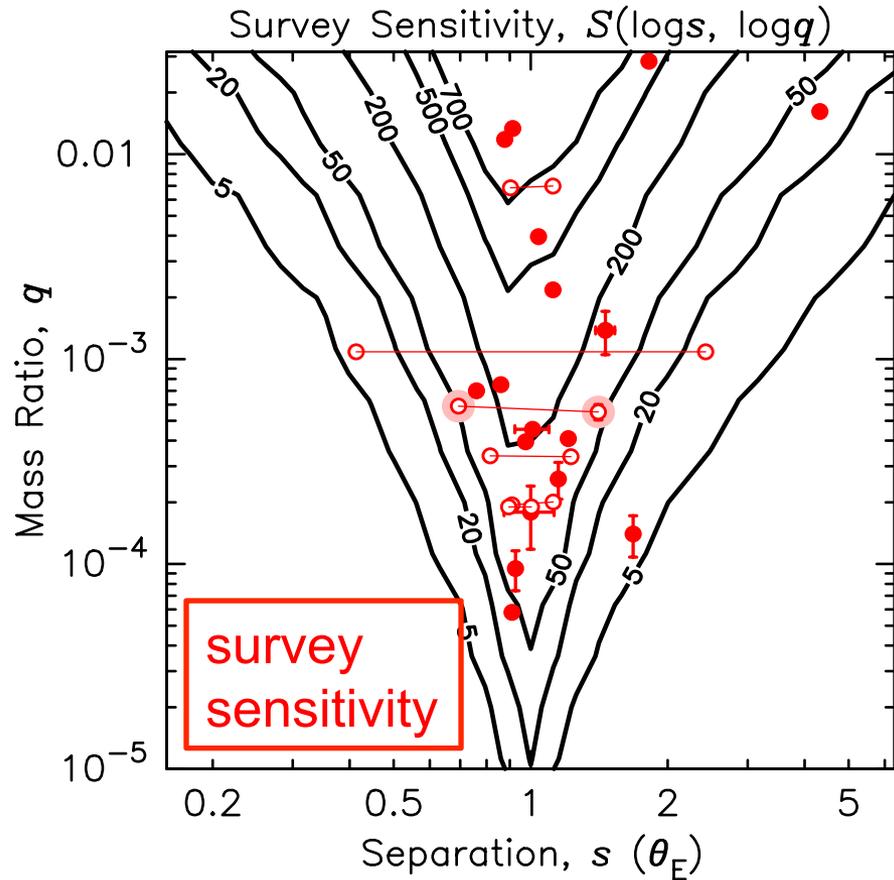


Project Observations and Analysis in 2016 and Beyond

David Bennett
NASA Goddard



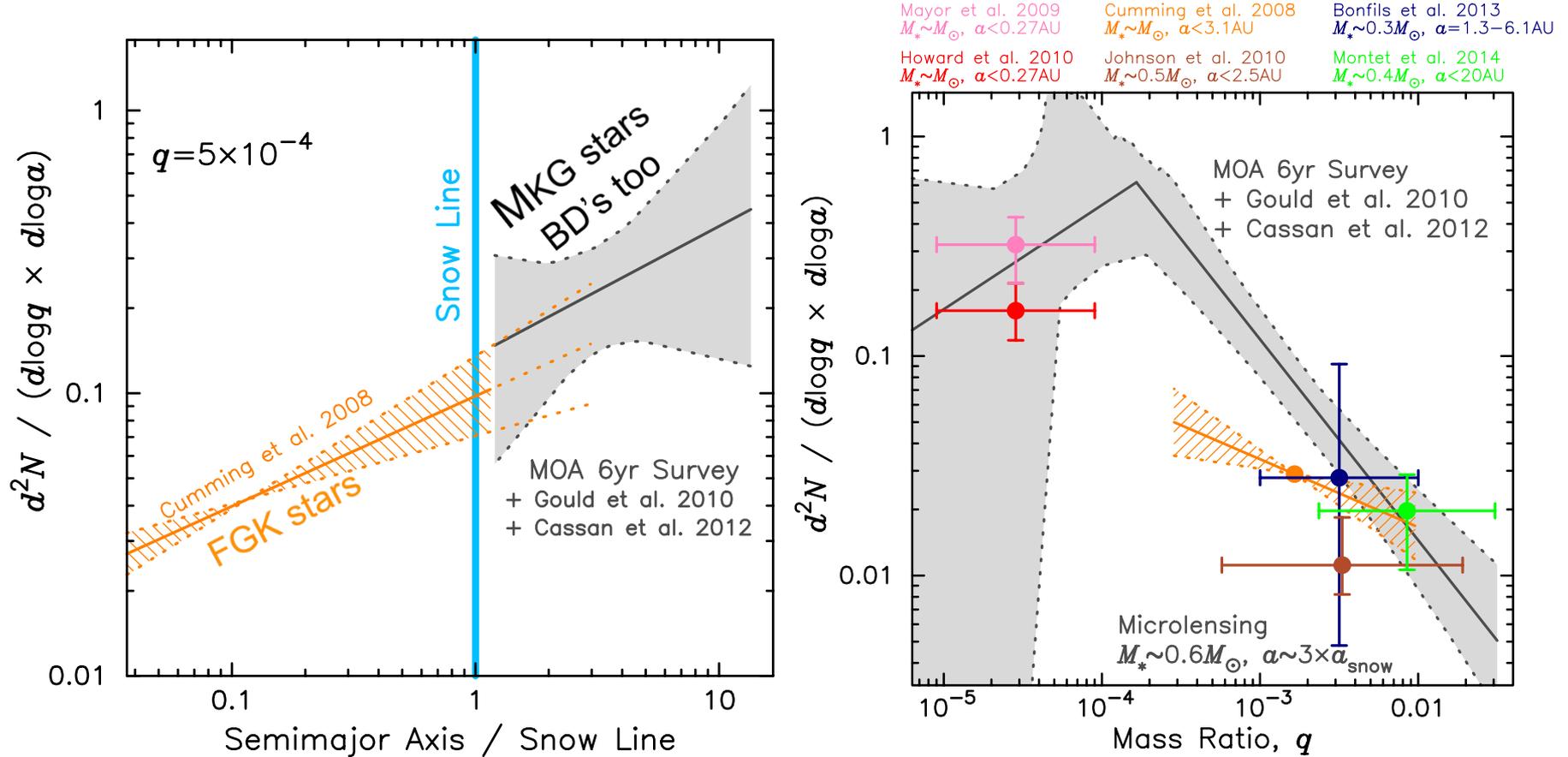
Statistical Results from MOA Survey



Suzuki et al. (2016) MOA-II analysis, 29 planets + 1 ambiguous (planet/stellar-binary) event. Detections are mostly near the Einstein Ring, and the mass ratio function shows a break at $q \sim 10^{-4}$

1st Exoplanet mass function from a microlensing survey, ~ 1470 events

MOA Exoplanet Mass (ratio) Function



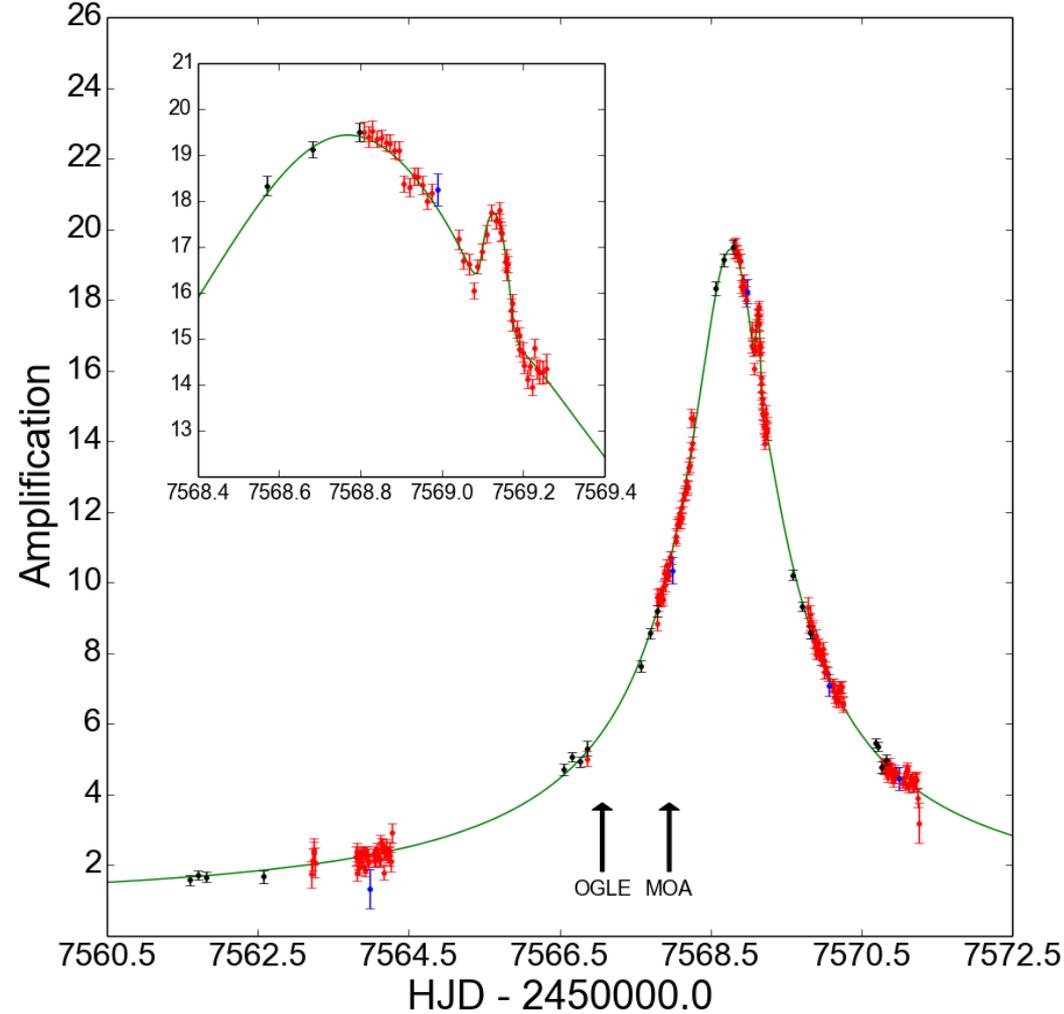
Consistent with RV results, when presented in terms of mass ratios

- ML results from M, some GK stars
- RV results from FGK stars
- Lower than previous ML; for $q > 2 \times 10^{-4}$, $d^2N / (d \log q d \log a) \sim q^{-0.85 \pm 0.13}$

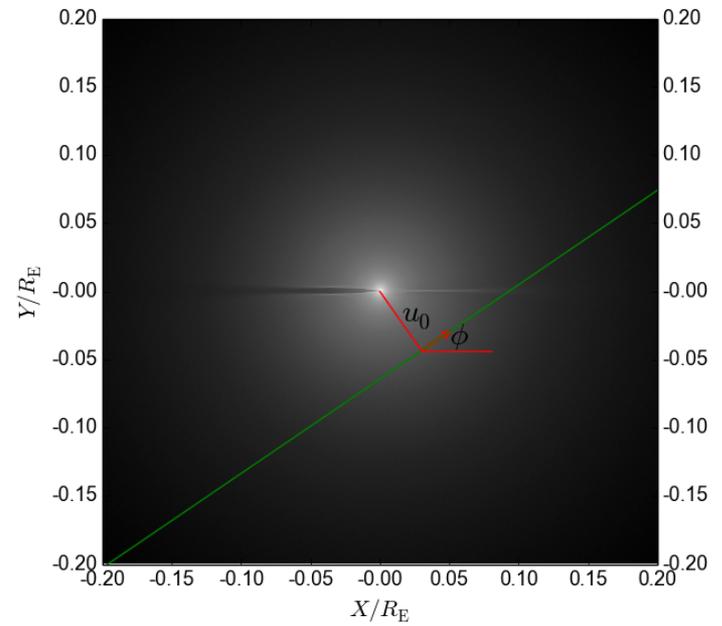
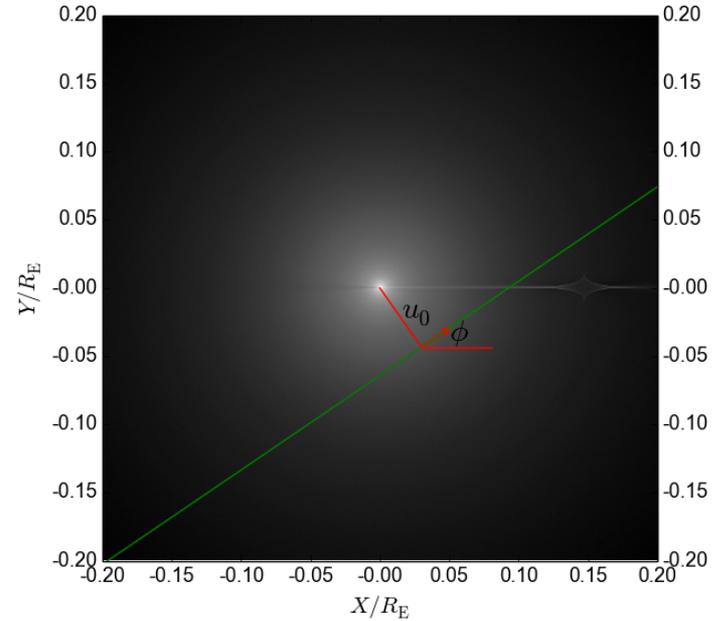
Notable 2016 MOA Anomaly Alerts

- MOA-2016-BLG-142 – April 4
 - ambiguous stellar binary or planet
- OGLE-2016-BLG-0241 / MOA-2016-BLG-132 – April 14 – planet
 - K2 parallax
- MOA-2016-BLG-181 / OGLE-2016-BLG-722 – April 17
 - Short duration stellar mass ratio in K2 superstamp
- MOA-2016-BLG-227 – May 9 – planet
- OGLE-2016-BLG-0548 / MOA-2016-BLG-242 – May 19
 - Stellar binary in K2 superstamp
- OGLE-2016-BLG-1067 / MOA-2016-BLG-339 – June 24 – planet
- OGLE-2016-BLG-1195 / MOA-2016-BLG-350 – June 29 – planet
- OGLE-2016-BLG-1190 / MOA-2016-BLG-383 – July 11 – planet
- MOA-2016-BLG-430 – July 21 – end of planetary anomaly?
- OGLE-2016-BLG-1514 / MOA-2016-BLG-469 – Aug. 11
 - Low S/N planet?
- MOA-2016-BLG-542 / OGLE-2016-BLG-1469 – Sept. 15
 - Brown dwarf mass ratio

OGLE-2016-BLG-1195/MOA-2016-BLG-350



Bond et al. (2017): Lowest q exoplanet microlens with $q = 4.2 \pm 0.7$
(see Bond et al. poster)



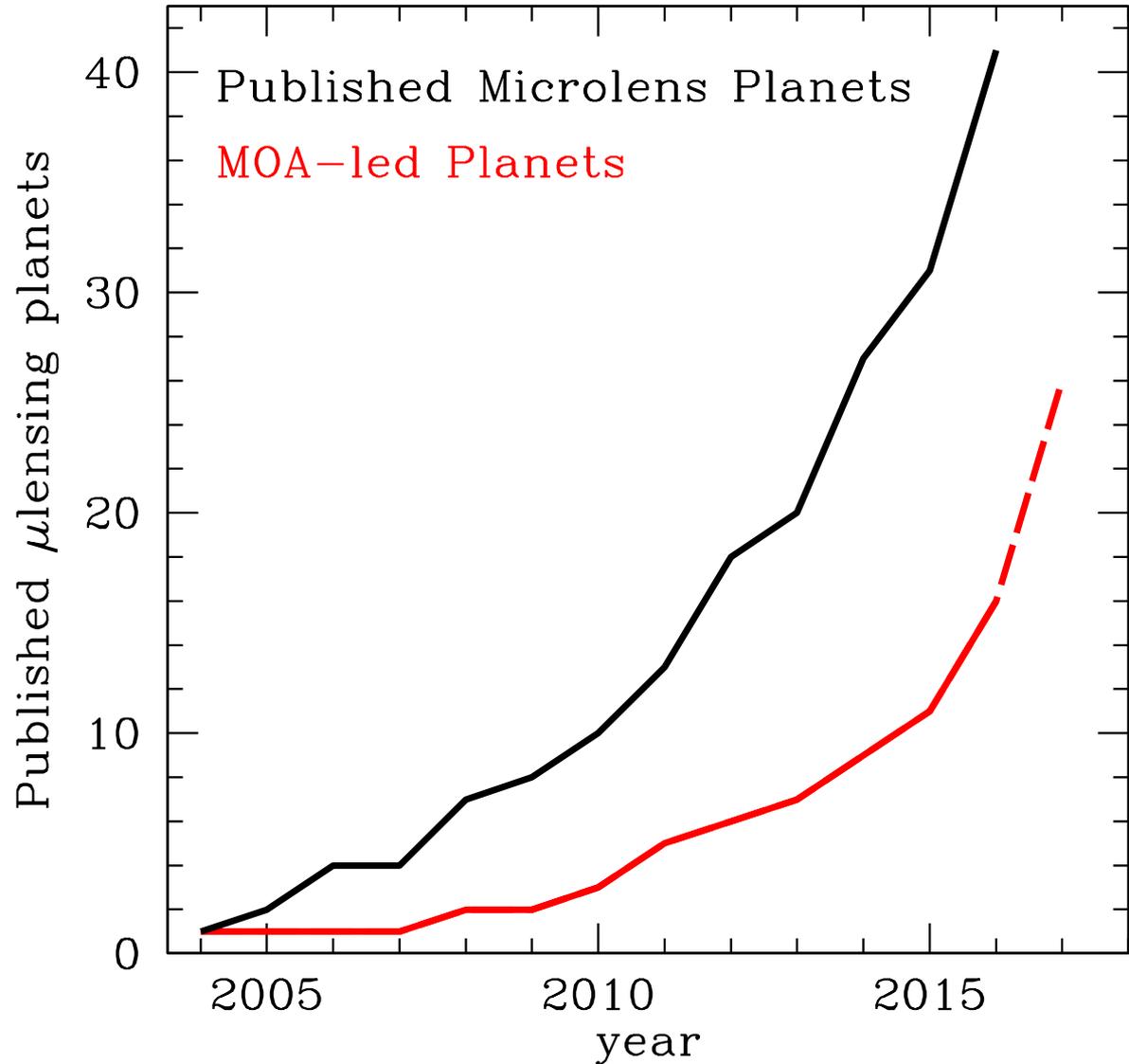
MOA is Catching Up on Planetary Microlensing Analysis

Published events with planetary mass ratios

MOA faced a backlog with events discovered in Suzuki et al. (2016)

Discovery papers for 9 planets in draft form – not yet posted on astro-ph

MOA has significantly increased modeling capability in the past few years



Near Future MOA-led Planet Discoveries

- OGLE-2016-BLG-1195Lb (MOA-2016-BLG-350Lb) Bond et al. (2017)
 - See poster
- MOA-2016-BLG-227Lb (Koshimoto et al. 2017)
 - talk on Thursday, includes systematic analysis of “contamination” for lens flux detection
- MOA-2010-BLG-117Lb (Bennett et al. 2017)
 - planet with binary source
- MOA-2011-BLG-291Lb (Bennett et al. 2017)
 - source behind bulge?
- MOA-2012-BLG-505Lb (Nagakane et al. 2017)
 - in Suzuki et al. (2016) sample
- OGLE-2013-BLG-1761Lb (Hirao et al. 2017)
- OGLE-2014-BLG-1722Lb,c (Suzuki et al. 2017)
 - first low-mag 2-planet event
- OGLE-2015-BLG-1649Lb (Lee et al. 2017)

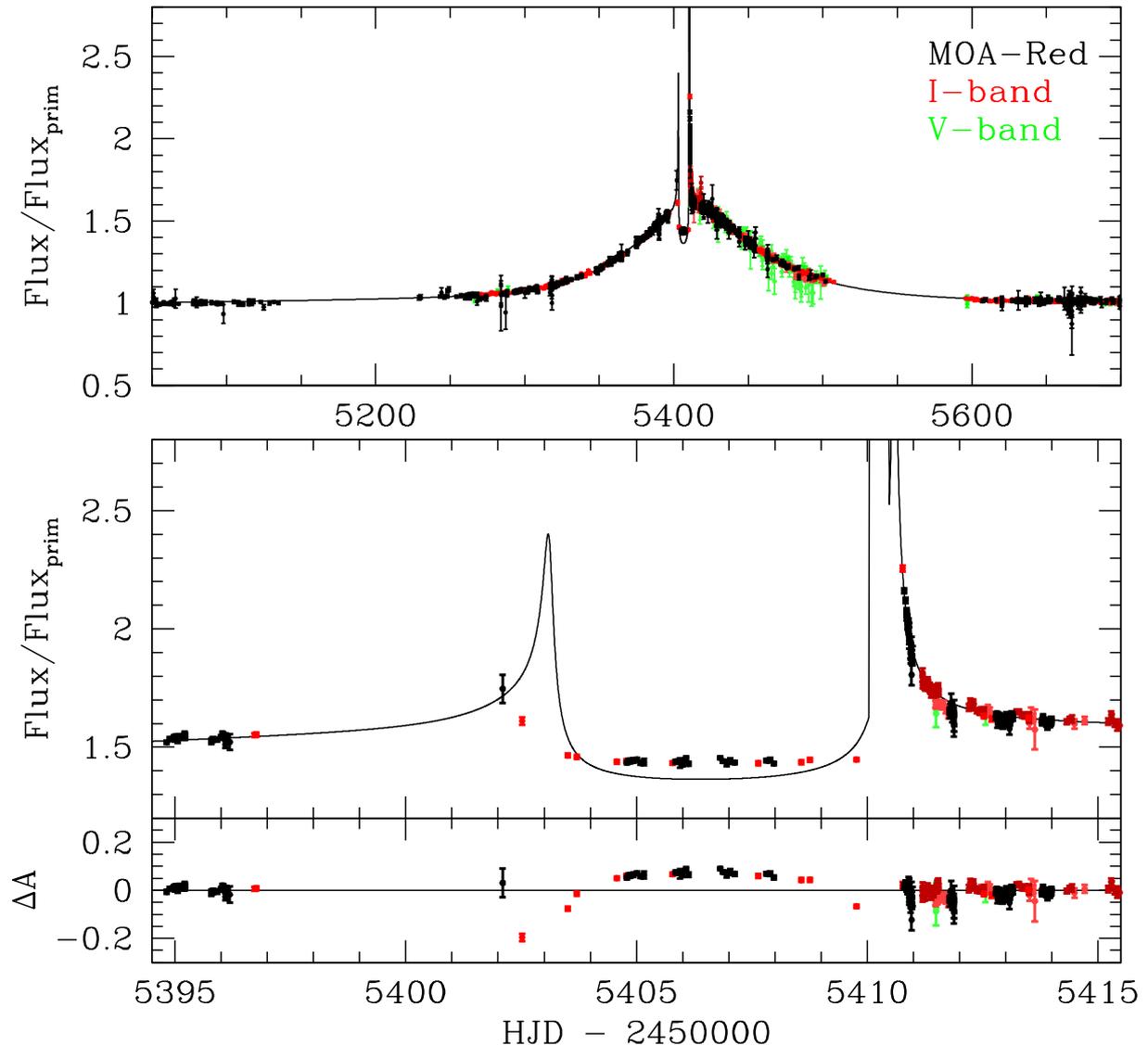
(papers that I have seen drafts of)

MOA-2010-BLG-117: An Obvious Planet without a Good Binary Model

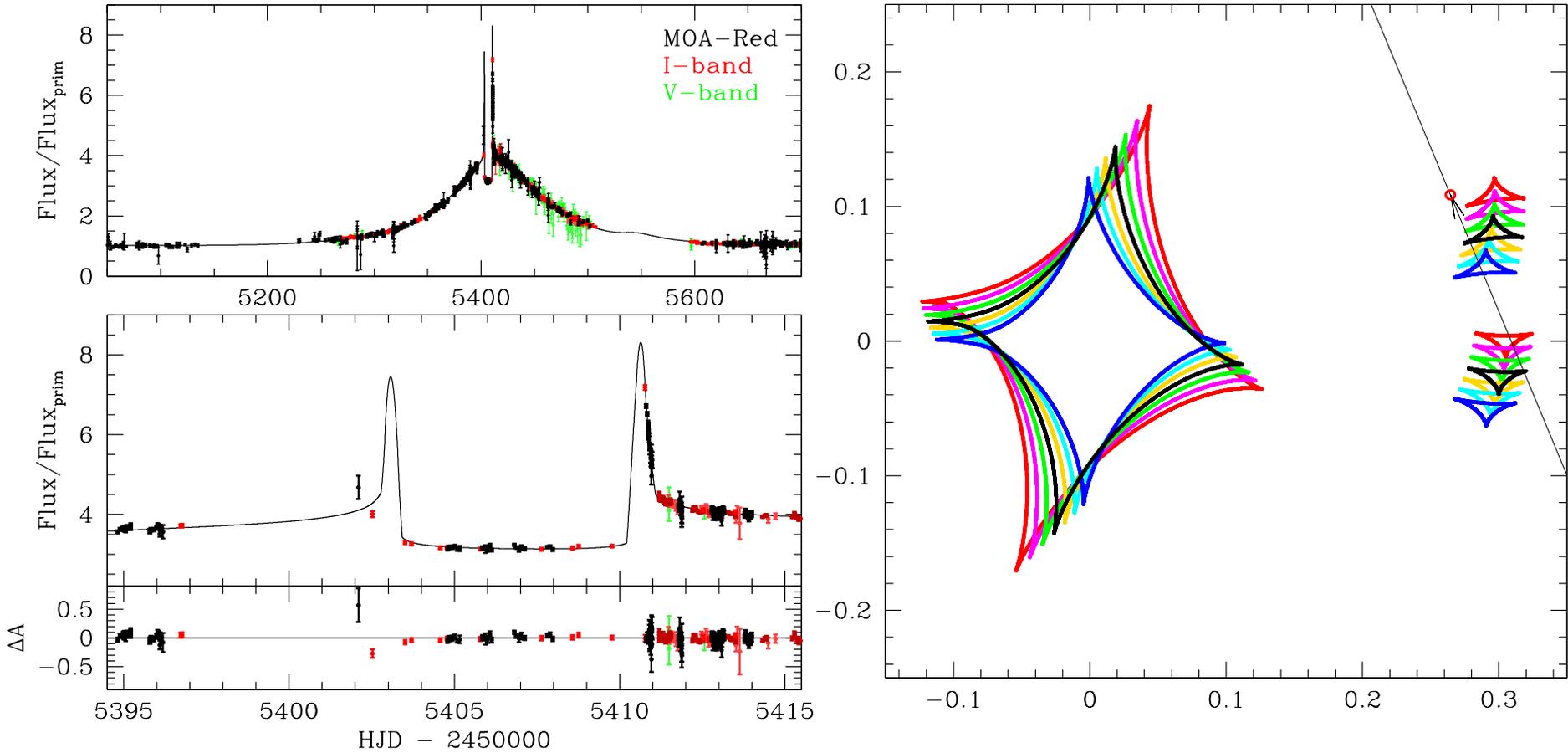
Light curve morphology indicates a planetary minor image caustic crossing event, but light curve doesn't fit.

De-magnification trough is too shallow.

Fill it in with another lens or another source.



MOA-2010-BLG-117: Circumbinary Model



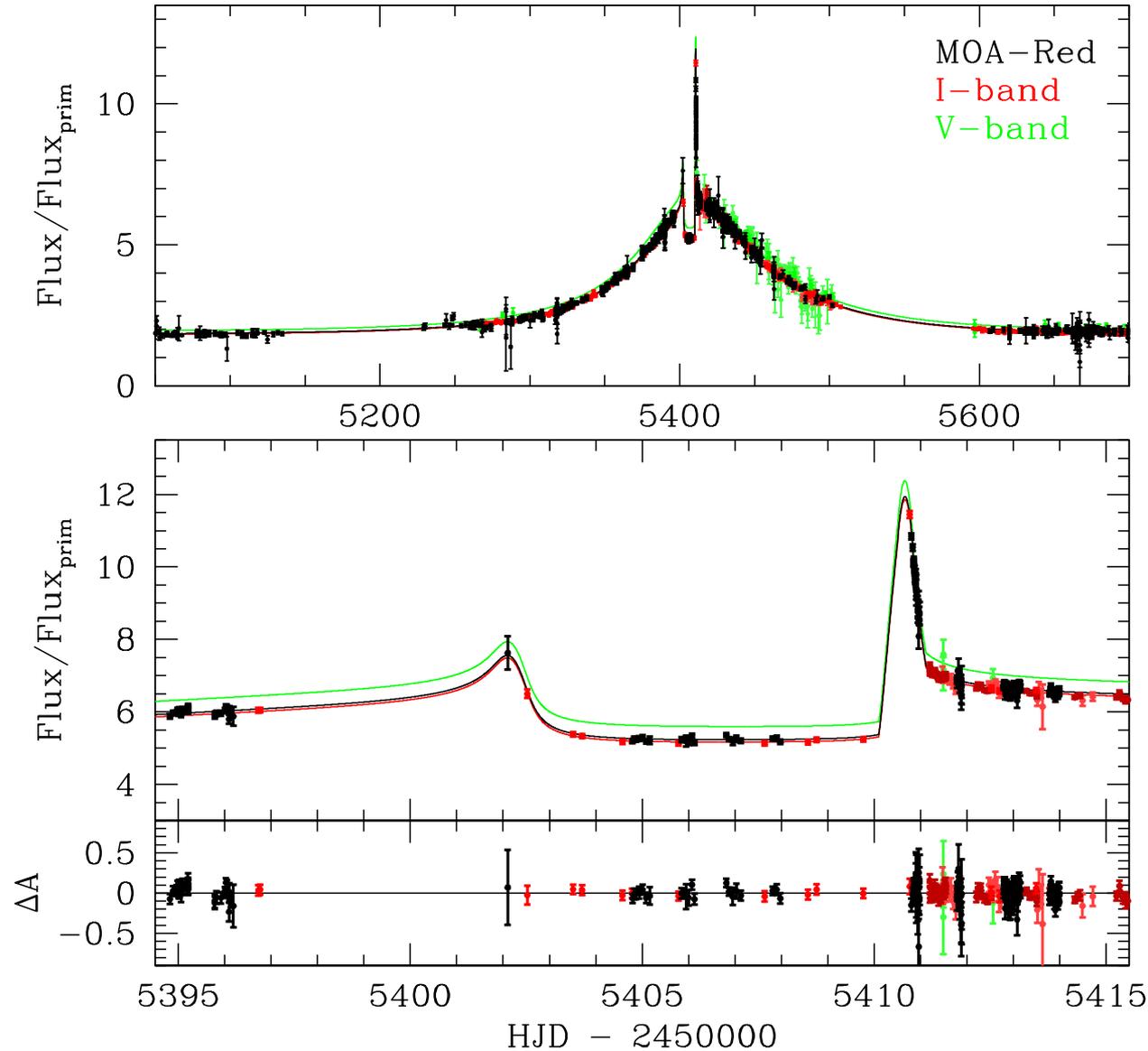
Circumbinary is a better fit – better than first attempts at binary source, but the cusp motion tracks the source at an implausibly large velocity,

MOA-2010-BLG-117: Binary Source Model

Source flux ratio was fixed to be consistent in the different data sets.

This removed local χ^2 minima and allowed a much better solution to be found.

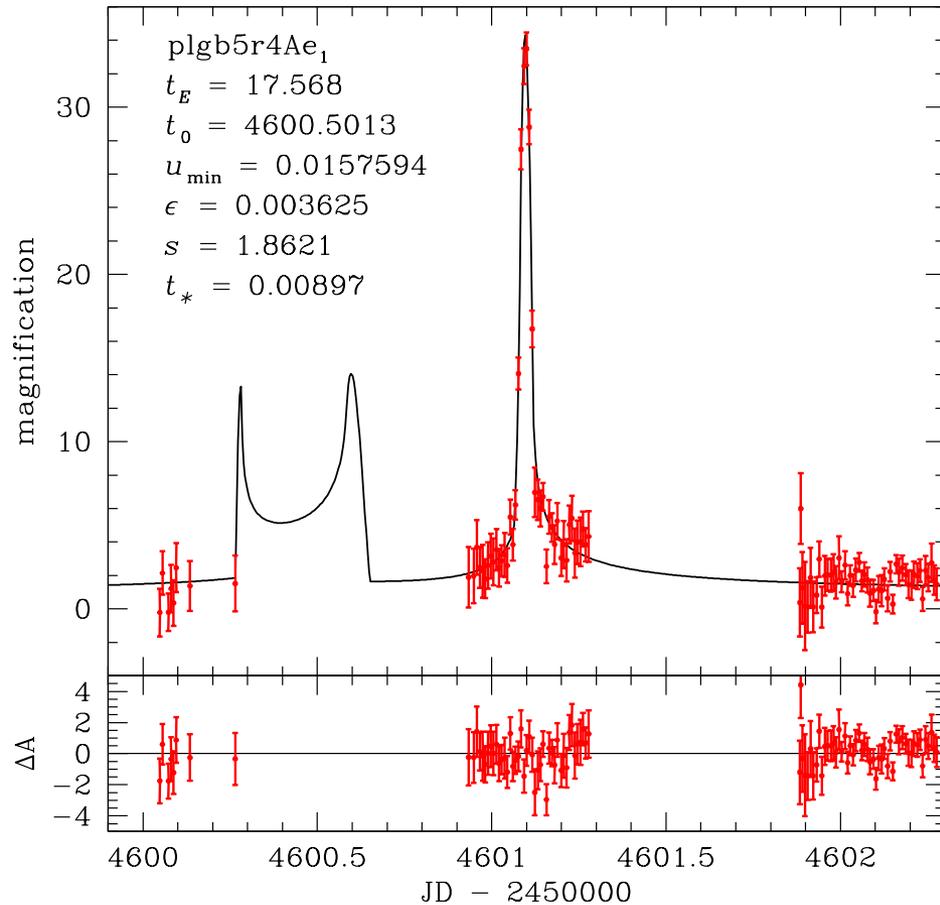
Note the different light curves in different passbands.



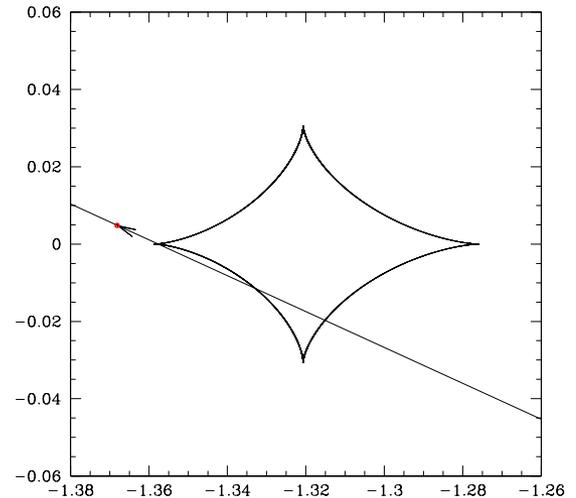
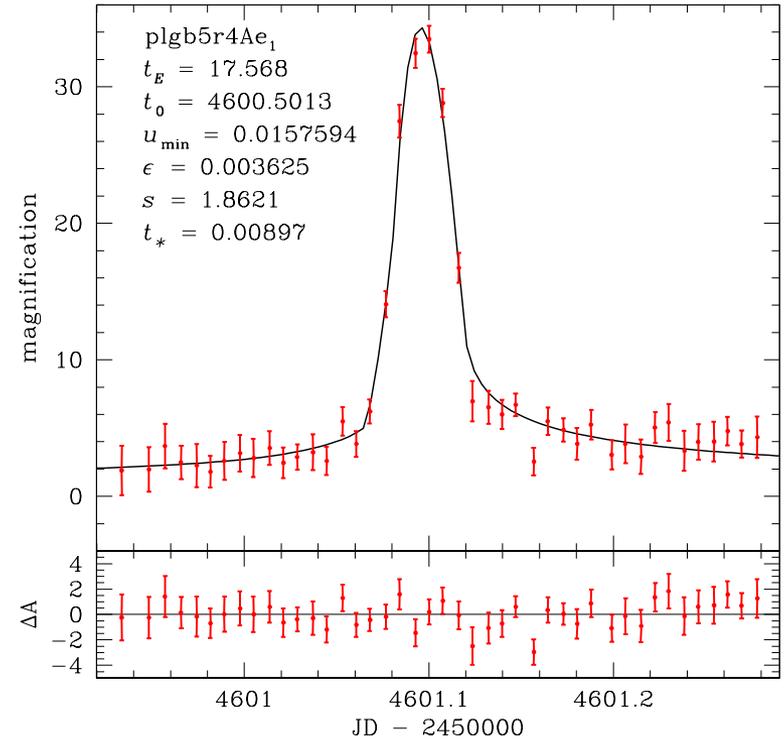
2006-2014 MOA Galactic bulge analysis

- Retrospective analysis of 9 years of MOA data
 - Similar to 2006-2007 analysis that led to Sumi et al. (2011) rogue planet paper
- Finds events, including planets, that were missed by the alert system
 - So far, 3 new Chang-Refsdal events, including a planet
- Will enable several new analyses
 - 9-year rogue planet analysis including wide vs. rogue analysis
 - 9-year event rate/optical depth analysis
- **Public Release Planned**
 - ~100,000 light curves to NASA Exoplanet Archive
 - R_{MOA} and V-band data
 - but V-band coverage is poor in some years
 - We'd like to release images but NExSci can't handle them

2006-2014 MOA Galactic bulge analysis



2008 Chang-Refsdal planet
Similar to MOA-bin-1
2 other similar events



Exoclipse 2017

Boise, Idaho

Includes 21 August 2017
excursion to Eastern Oregon
for “lunar starshade”
demonstration.

Focus is on wide-orbit
planets.

We recommend that hotel
rooms be reserved early!

Exploring New Worlds in the Shade

August 20-24, 2017

EXOCLIPSE

physics.boisestate.edu/exoclipse

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Exoclipse is an exoplanet conference designed to shed light on the growing population of known planets on wide orbits. Hosted by Boise State University, the conference spans five days (Aug. 20-24, 2017) and includes a trip to view the total solar eclipse on Aug. 21. Friends and family are welcome to attend the eclipse-viewing, although space will be limited.



BOISE STATE UNIVERSITY

