Developing the WFIRST Mass Measurement Method Using HST Observations

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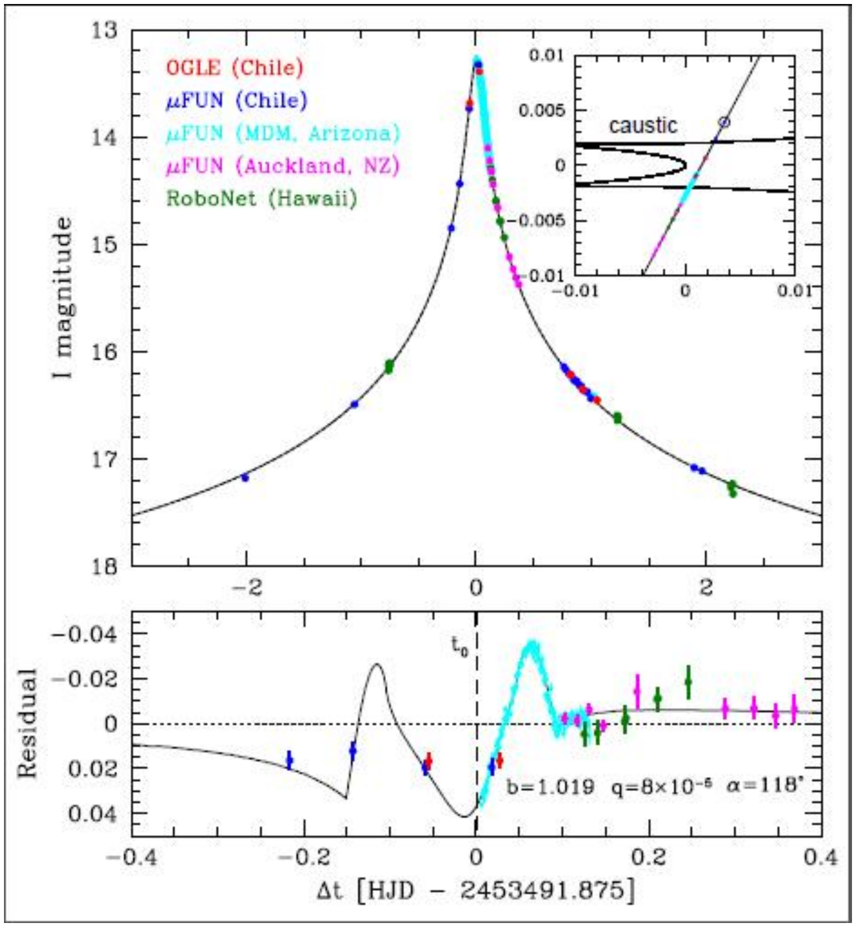
WFIRS 2014 – Nov 18, 2014

OGLE-2005-BLG-169 Discovery Paper



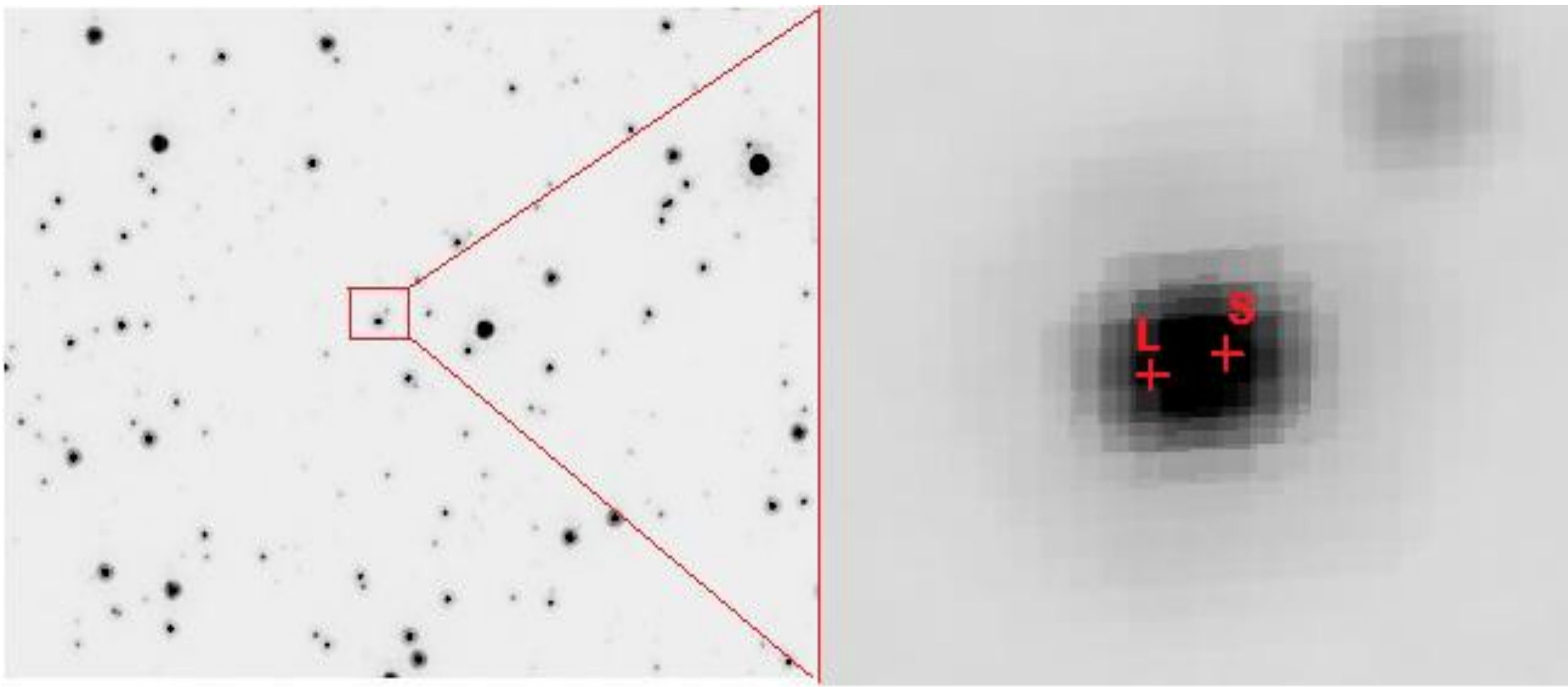
Gould et al (2006, ApJ, 644L,37G)

q (planet – host star mass ratio) determined, but planet host star mass and their separation in physical coordinates not determined

space based follow up observations needed

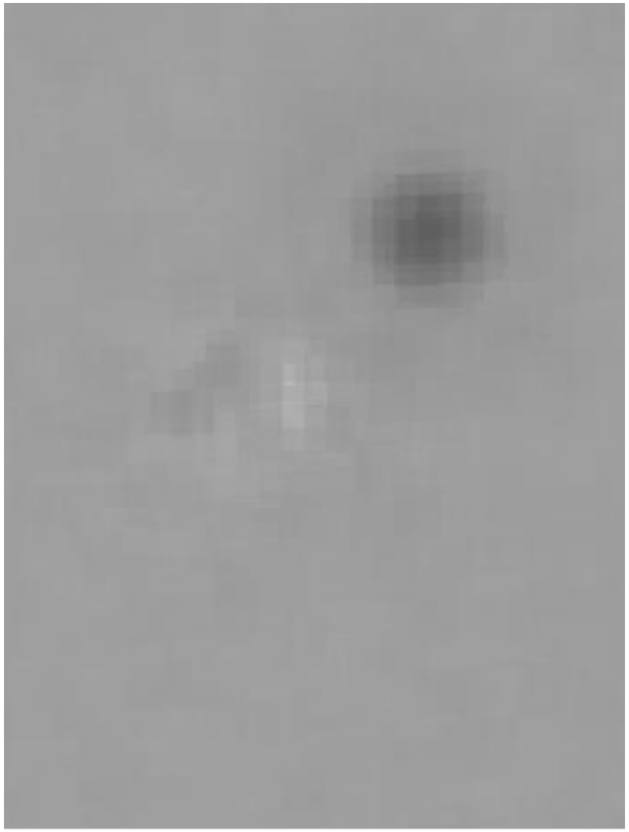
HST Observations & PSF fitting

Elongated target object OGLE-2005-BLG-169 observed in 2012 – 6.5 years after discovery



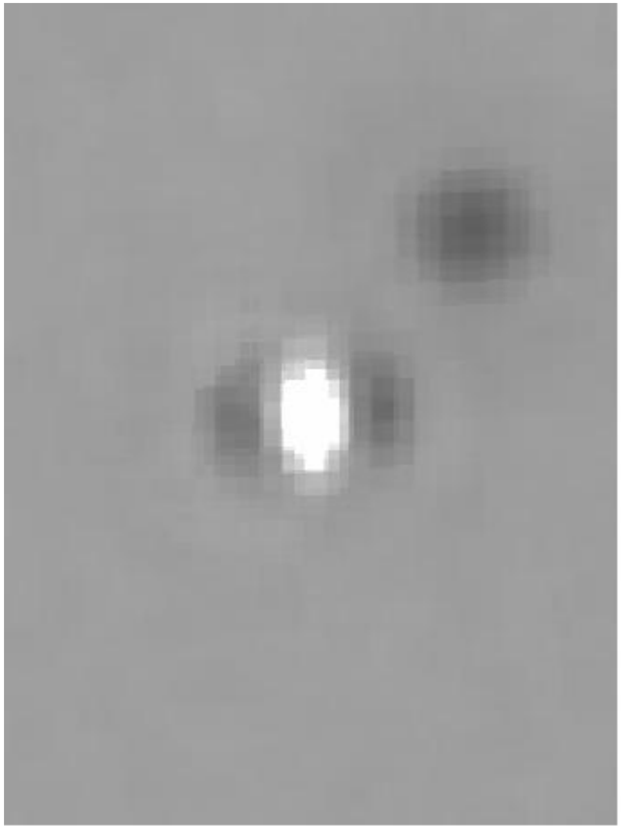
HST Observations & PSF Fitting

Dual Star Fit Residual



Vs

Single Star Fit Residual



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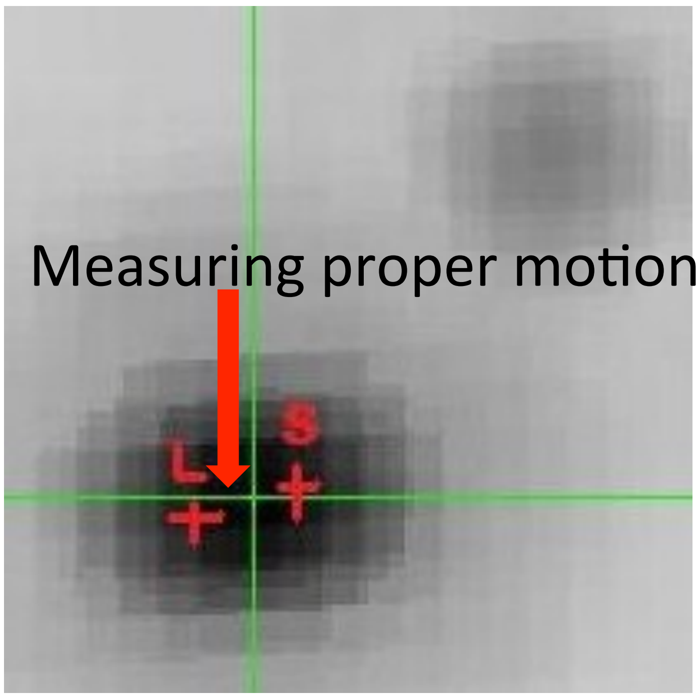
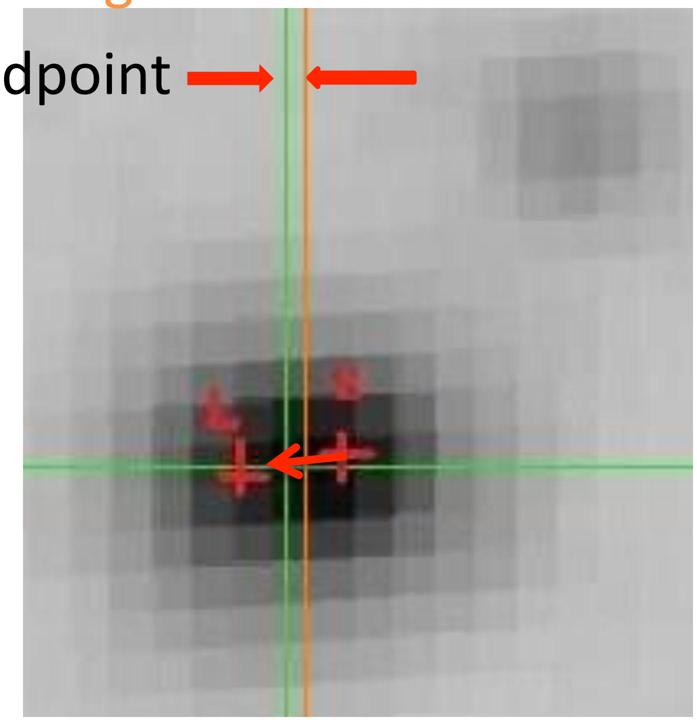
HST Observations & PSF Fitting

Midpoint and flux centroid are same in I band

Flux Centroid shifted from midpoint in V band → Source is brighter than Lens





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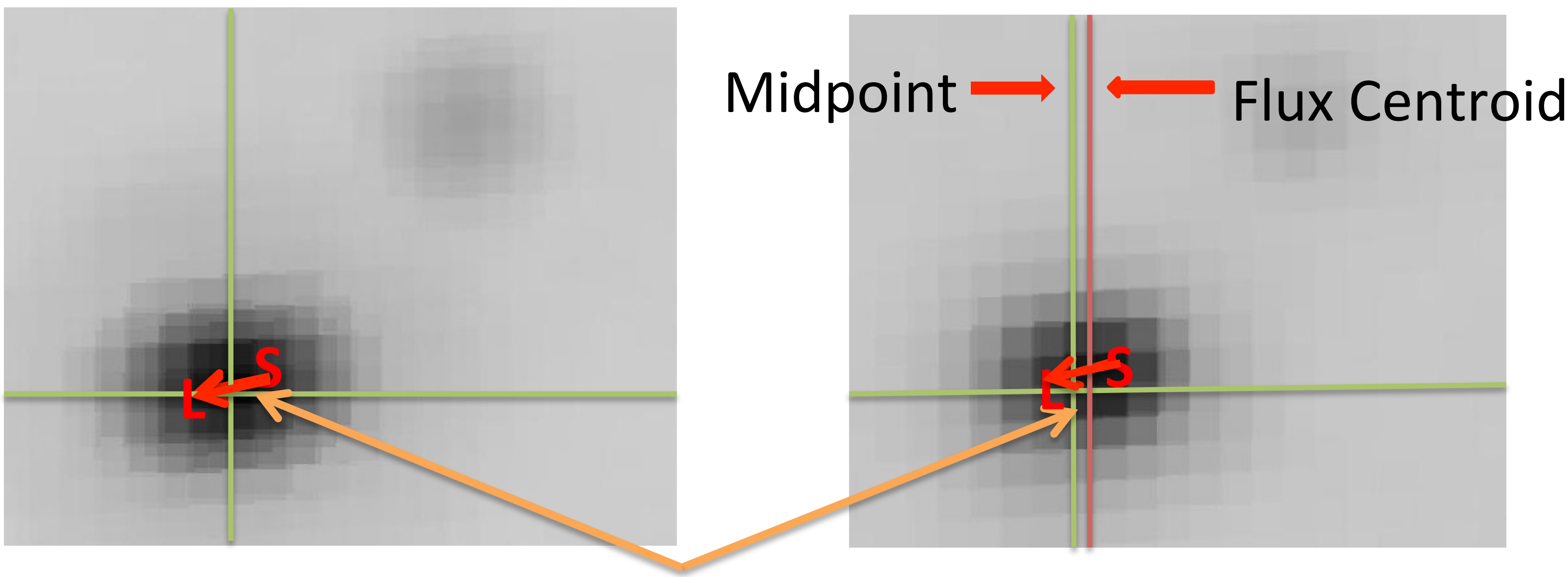

Measuring proper motion

First Direct Proper motion of Planetary Microlens Host Star Measured

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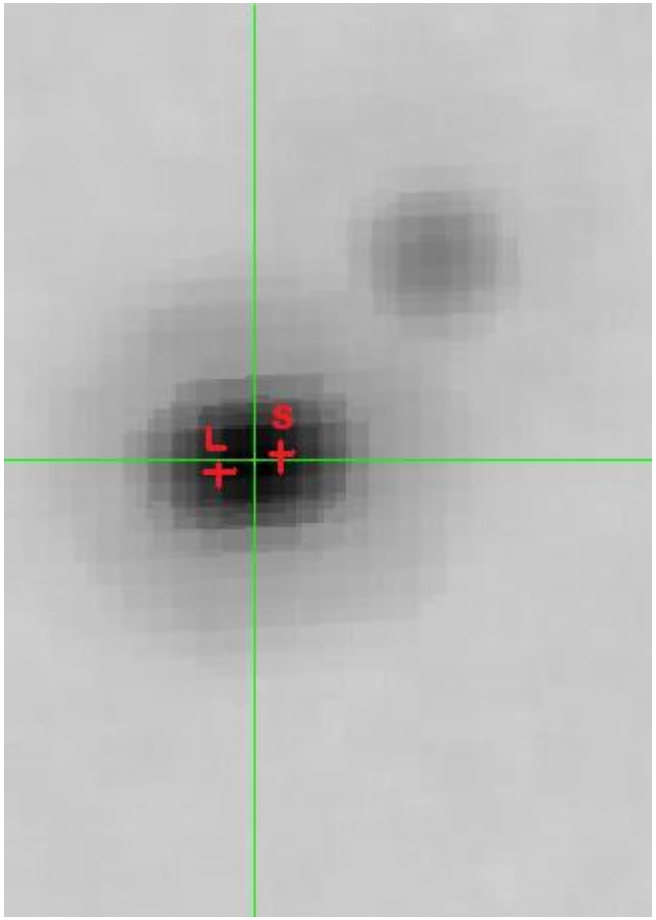
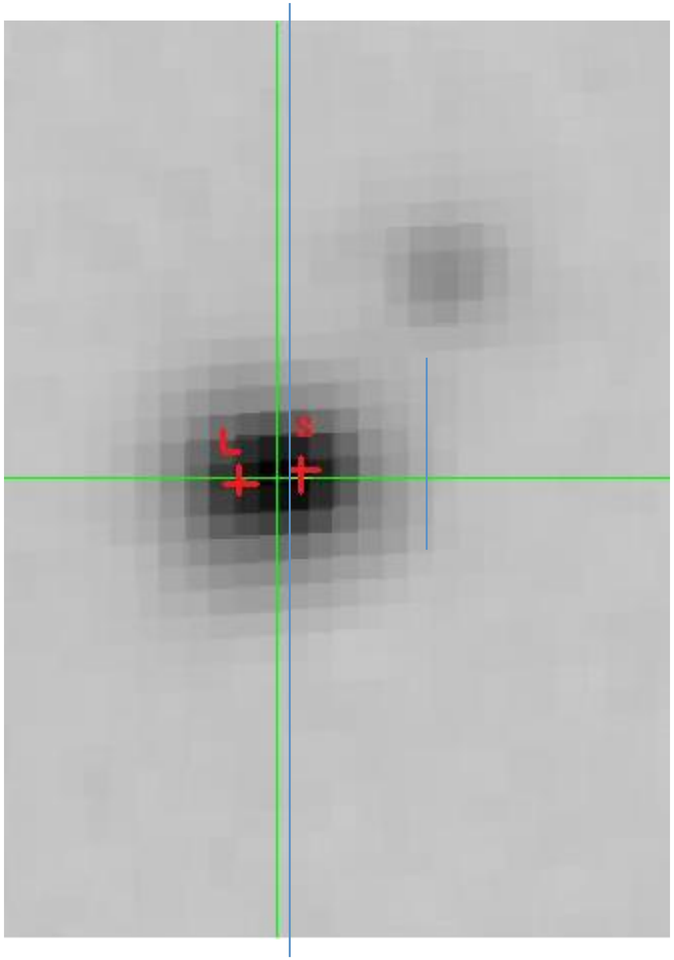
HST Observations & PSF Fitting

Centroid in I band



Centroid in V band



Centroid shift implies Source star has higher flux ratio

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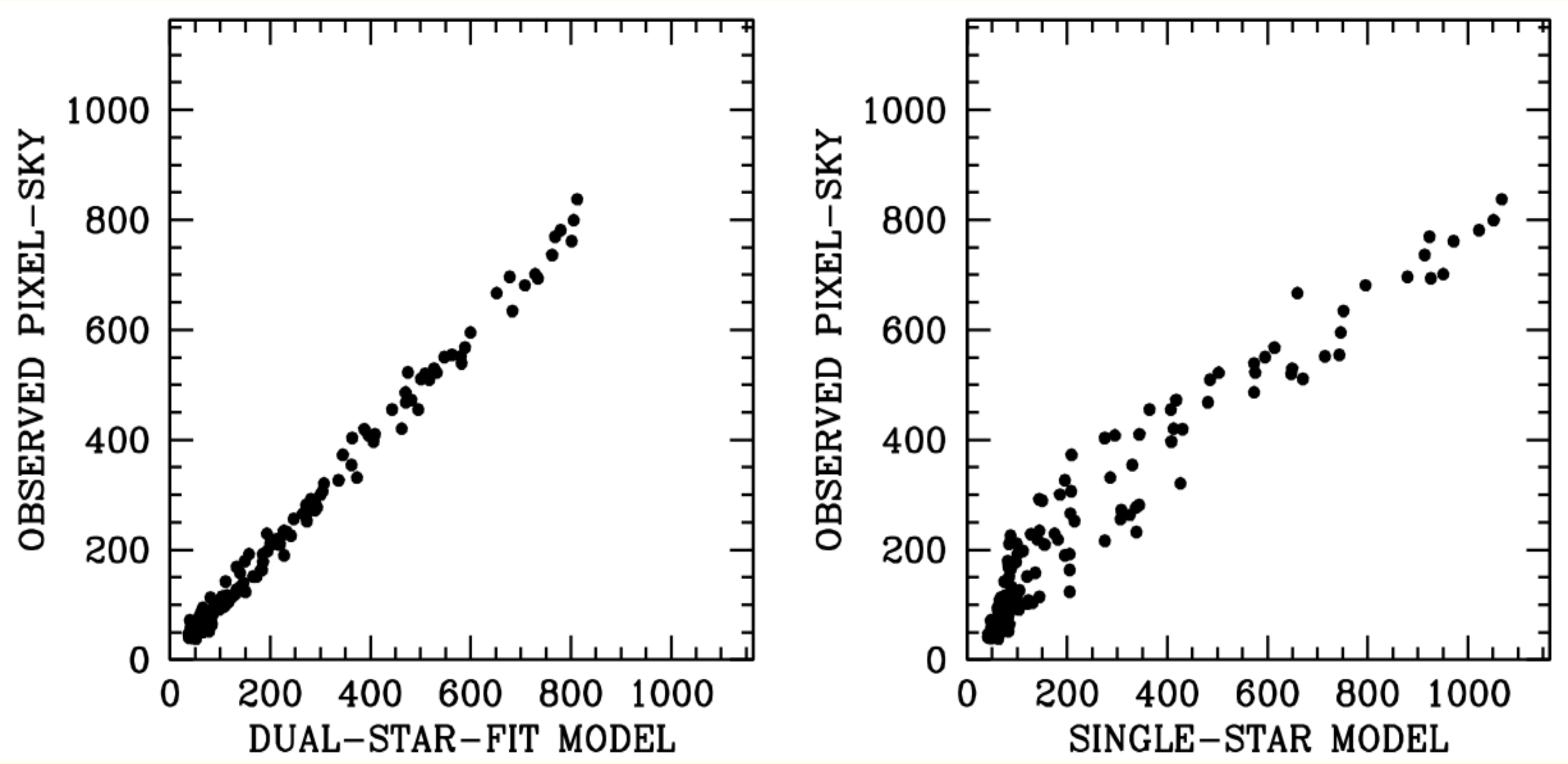
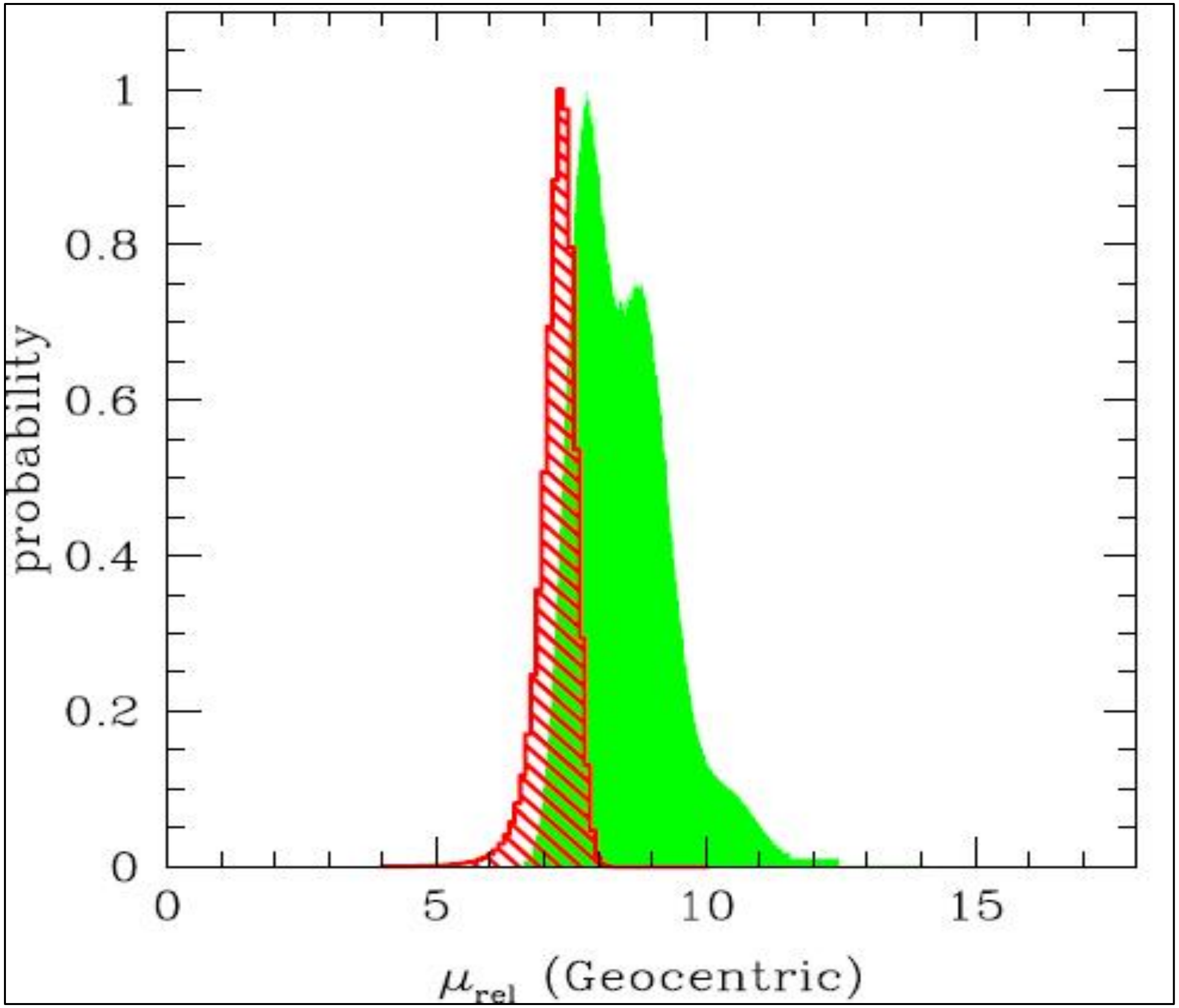
Fit between dual star and single star model



Proper Motion : Confirmation of Microlensing Planet

- Green predicts μ_{rel} from light curve
- μ_{rel} = 7.2 ± 0.4 mas/yr
- First Confirmation of Microlens Planet



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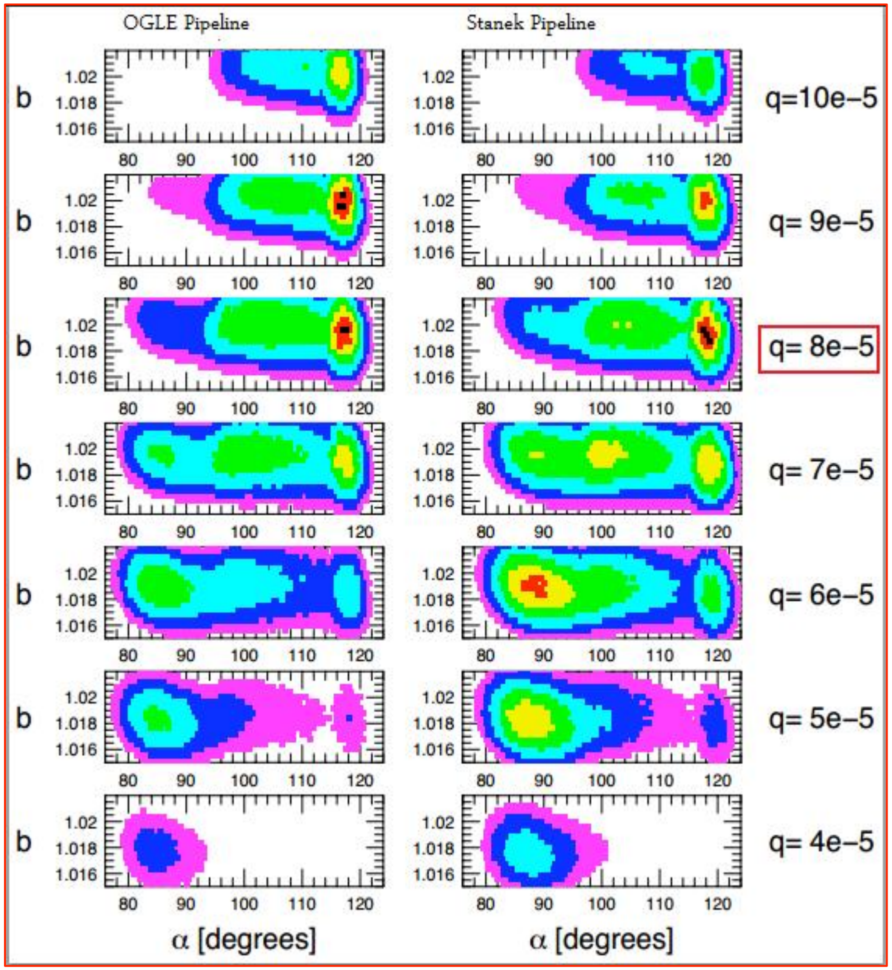
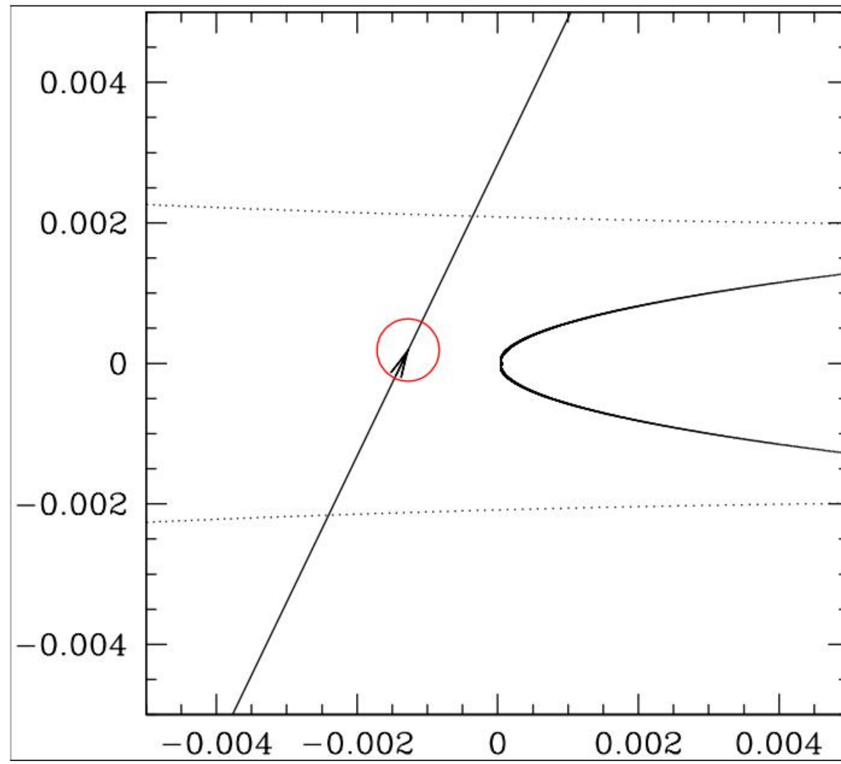
Proper Motion: Constrains Star - Planet Mass Ratio

- Before:

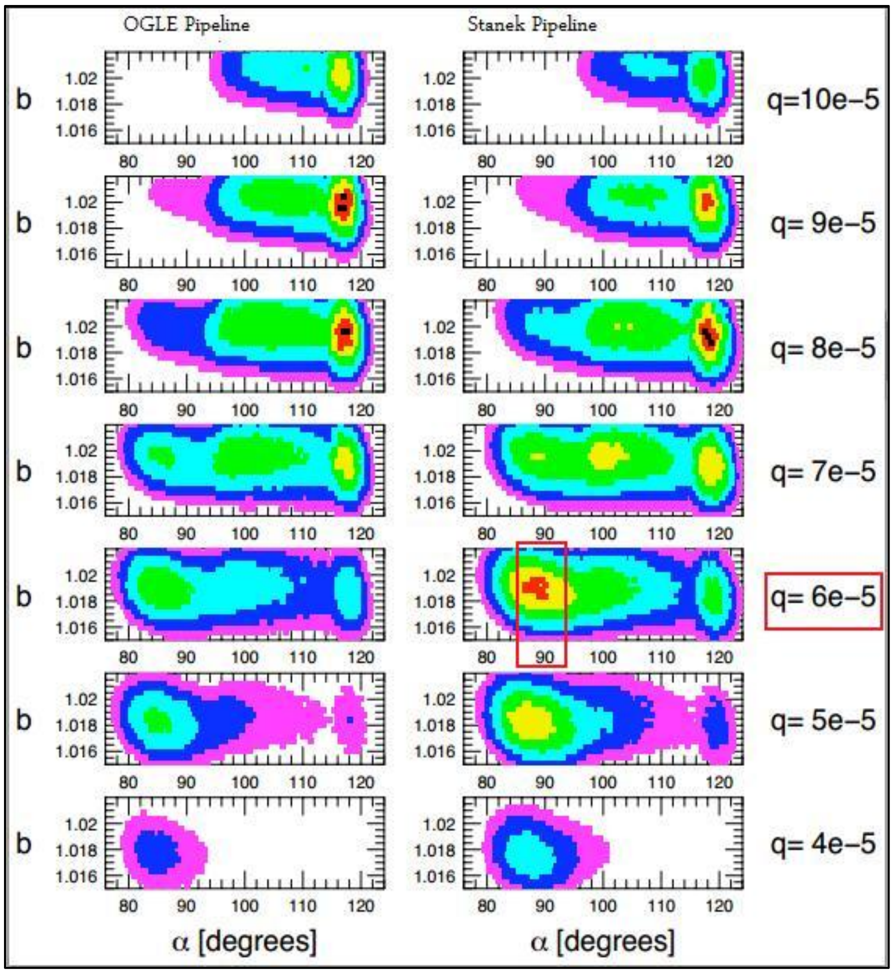


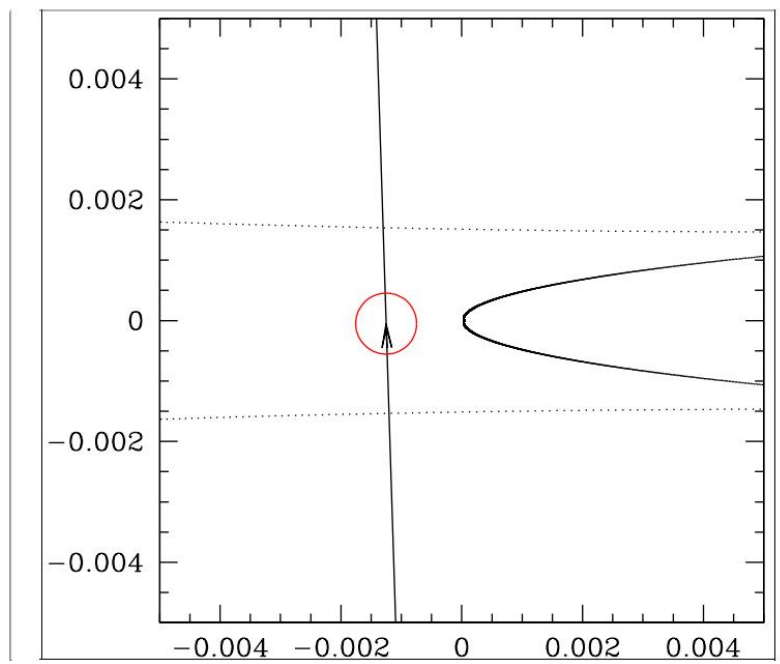


1. Gould et al (2006, ApJ, 644L,37G)

Proper Motion: Constrains Star - Planet Mass Ratio

- Now:

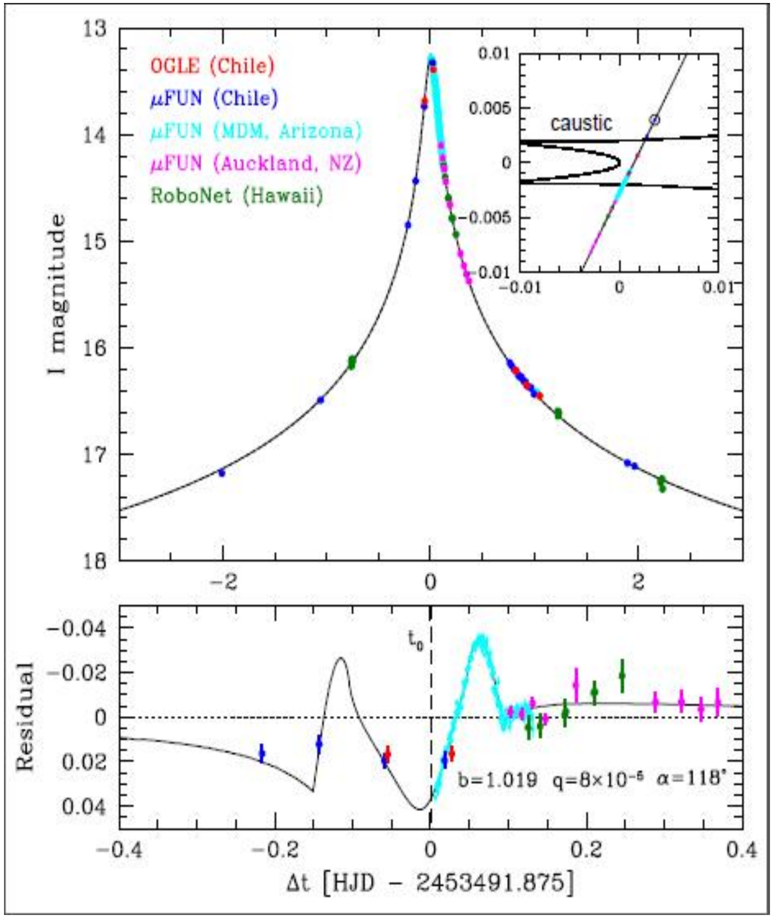




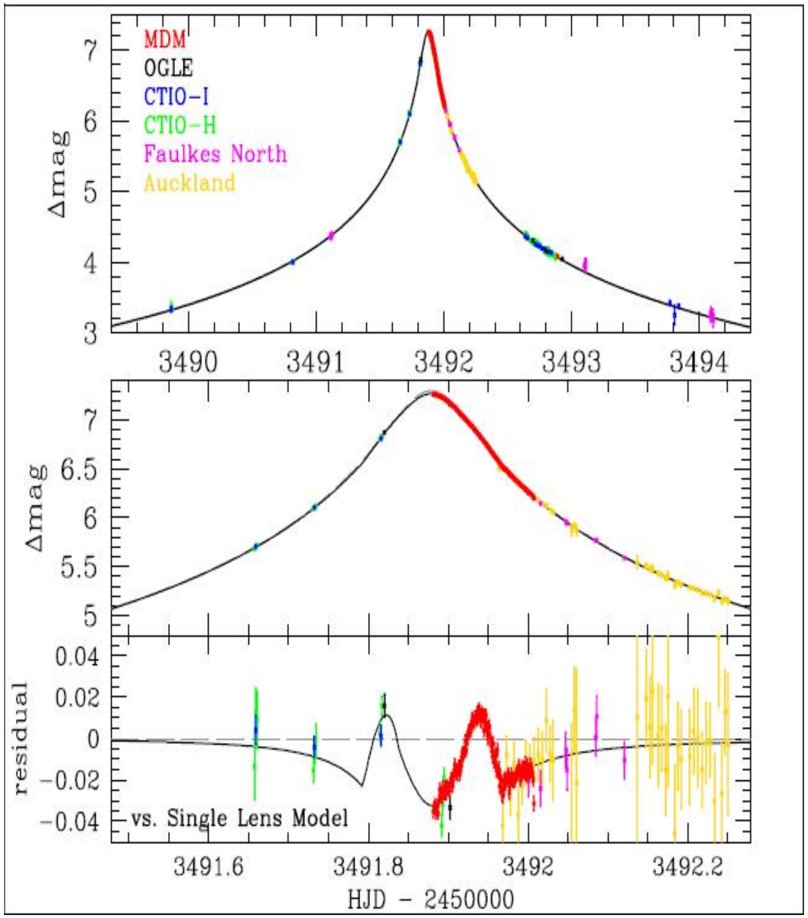
1. Gould et al (2006, ApJ, 644L,37G)

Comparing results(1):Discovery and Follow UP

Discovery paper light curve[1]



Light curve consistent with HST



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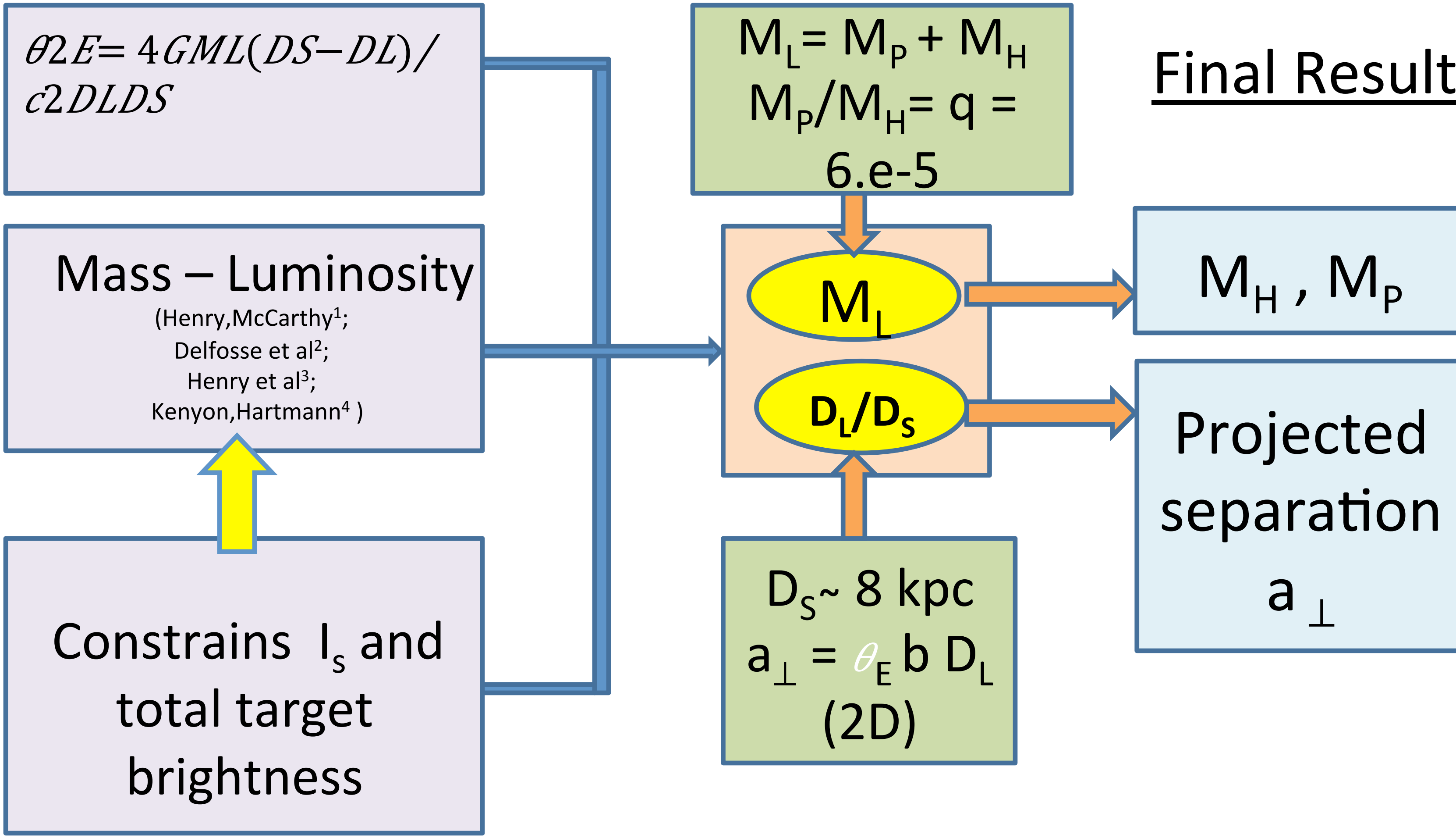
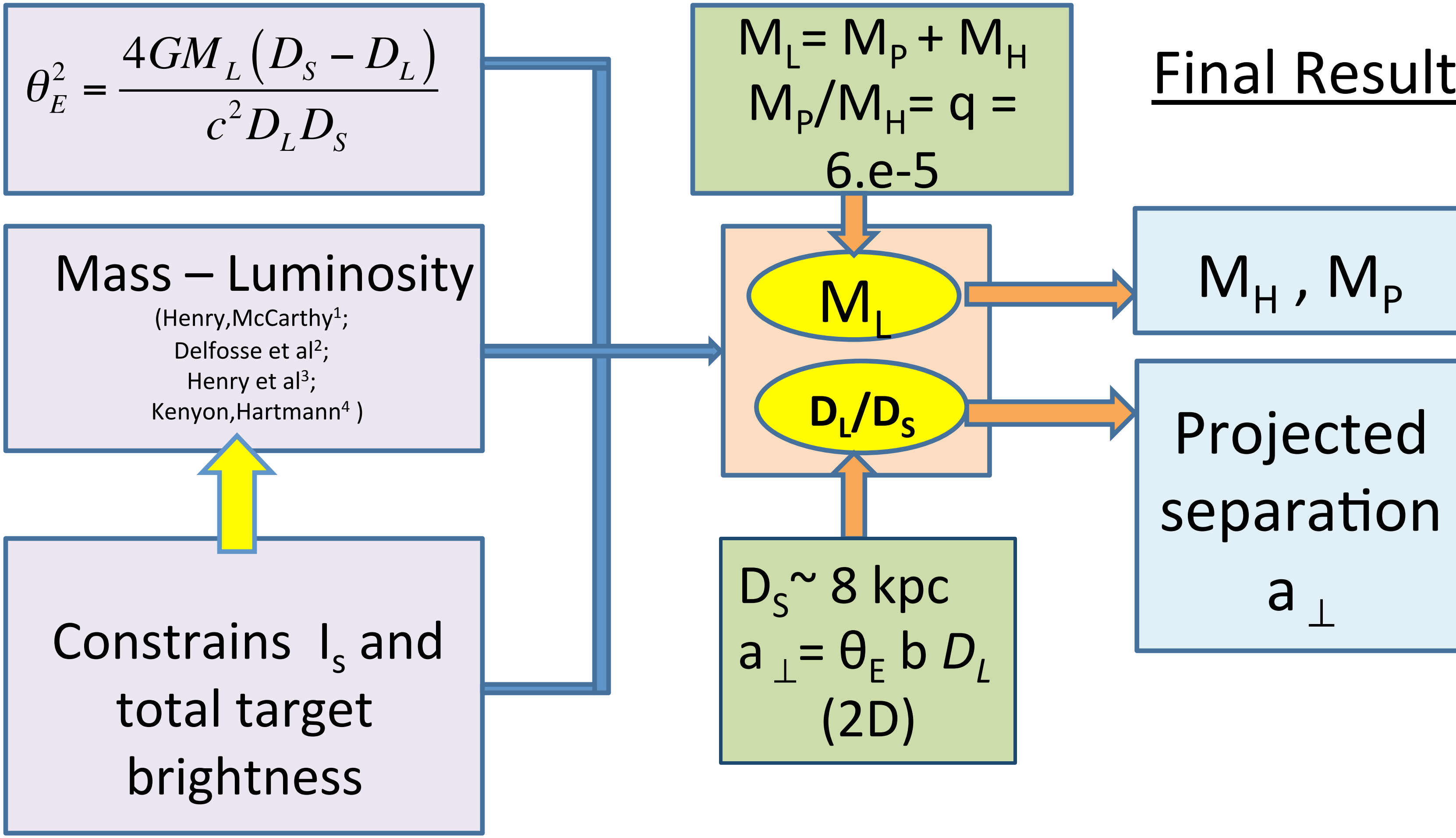
Determination of Host Star and Planet Mass



1. Henry and McCarthy (1993, AJ, 106, 773)
2. Delfosse et al (2000 A&A 364, 217)
3. Henry et al (1999, ApJ, 512, 864)
4. Kenyon and Hartmann (1995, ApJS, 101, 117)

Determination of Host Star and Planet Mass



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Comparing Results(2): Discovery and Follow Up

Discovery paper[1]

- μ_{rel} = 8.4 ± 1.7 mas/yr
- α ~ 120˚, q = 8.e-05
- Host mass: $0.49^{+0.23}_{-0.29}$ $M_{\odot}$
- Planet Mass: ~13 $M_{\oplus}$
- D_L = $2.7^{+1.6}_{-1.3}$ kpc
- Projected Separation($a_{\perp}$): 2.7 AU(2d)

HST

- μ_{rel} = 7.2 ± 0.4 mas/yr
- α ~ 90˚, q = 6.e-05
- Host mass: 0.687 ± .021 $M_{\odot}$
- Planet Mass: 14.1 ± 0.9 $M_{\oplus}$
- D_L = 4.1 ± 0.4 kpc
- Projected Separation($a_{\perp}$): 3.5 ± 0.3 AU(2d)

1. Gould et al (2006, ApJ, 644L,37G)

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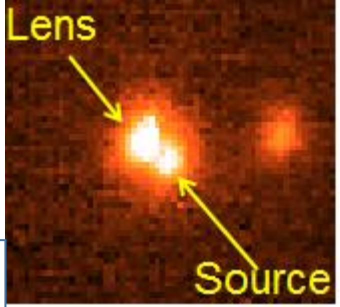
Comparing Results (3): HST & Keck



8.3 years after discovery[1]

HST

μ_{rel_l} = 7.39 ± .20 mas/yr
μ_{rel_b} = 1.33 ± .23 mas/yr

Keck

μ_{rel_l} = 7.28 ± .12 mas/yr
μ_{rel_b} = 1.54 ± .12 mas/yr

Both supports α ~ 90˚ and q = 6.e -05 model

HST

- Host mass: 0.687 ± .021 $M_\odot$
- Planet Mass: 14.1 ± 0.9 $M_\oplus$
- D_L = 4.1 ± 0.4 kpc
- Projected Separation($a_\perp$): 3.5 ± 0.3 AU

Keck

- Host mass: 0.667 ± .049$M_\odot$
- Planet Mass: 13 ± 1.5 $M_\oplus$
- D_L = 3.9 ± 0.4 kpc
- Projected Separation($a_\perp$): 3.4 ± 0.3 AU

1. Batista et al - in preparation

Conclusions & Future Work

- Space based data provides host star and planet mass, their separation, lens distance.

Prepares us to deal with future WFIRST microlensing data

- Demonstrates WFIRST Mass Measurement Method
- Resolved degeneracy in planetary models
- Many such measurements will build statistics for planetary mass function depending on host star mass and distance
- Similar techniques will be used to analyze HST WFC3 IR data which is more like WFIRST

THANK YOU