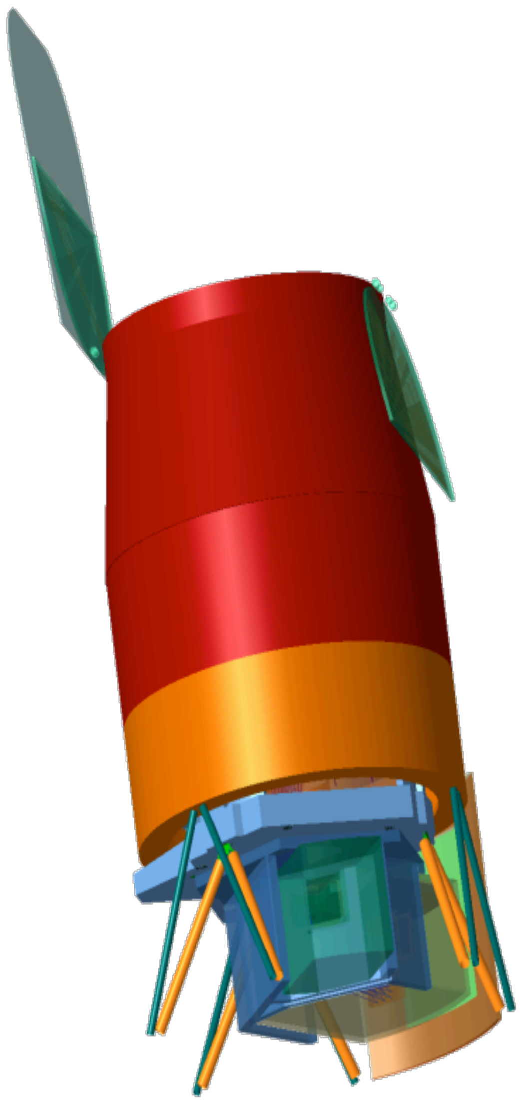
WFIRST-AFTA
Exoplanet Microlensing Precusor Observations



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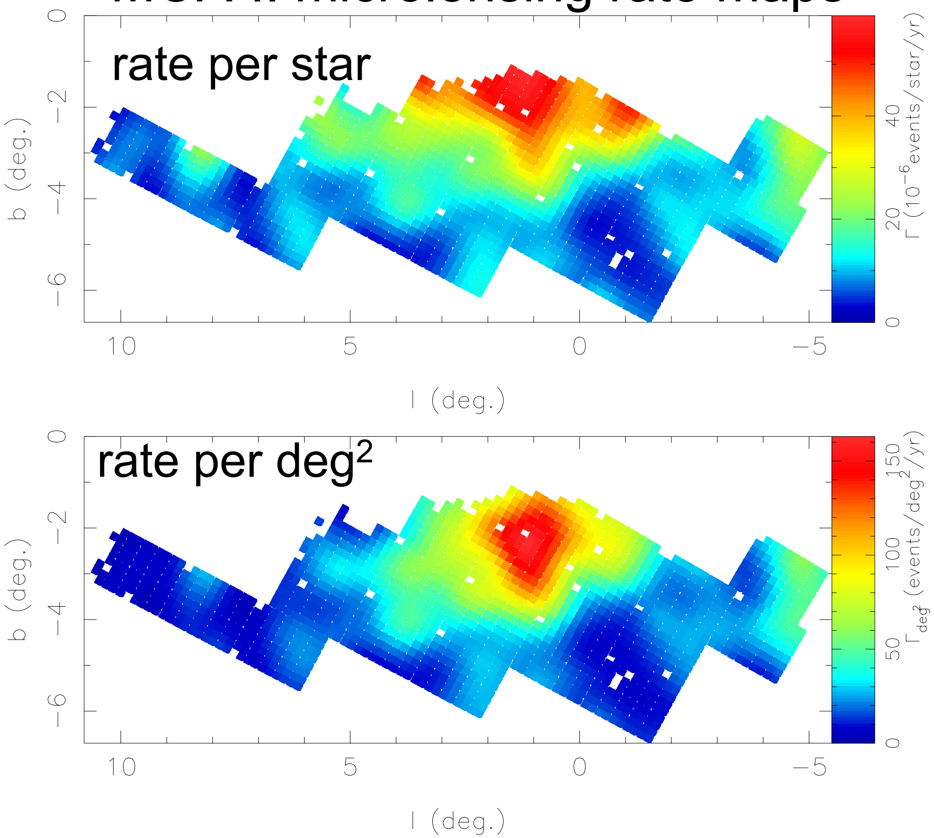
Recommended Precursor Observations

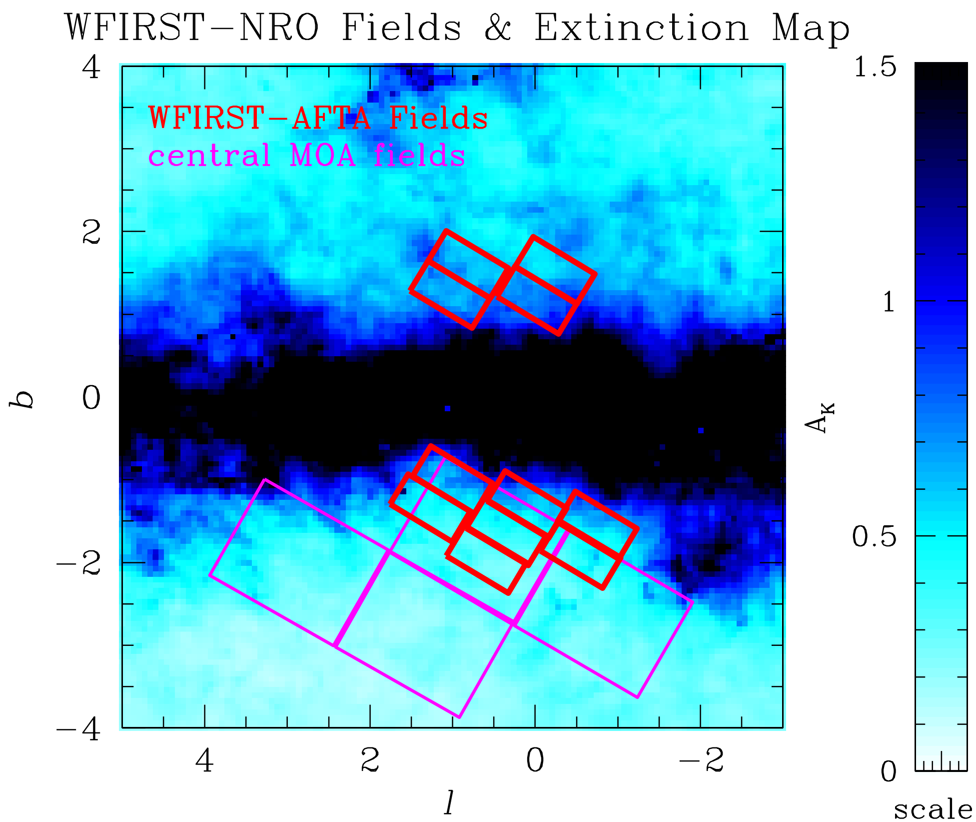
- IR microlensing survey from the ground to measure lensing rate and select WFIRST-AFTA microlensing fields
- HST survey of selected fields (WFC3/IR + ACS in parallel?) for proper motion measurements
  - Early observations allow precise lens-source relative proper motion measurements
- HST/WFC3/IR time series observations for photometry/ astrometry code development
- HST and AO follow-up of current planet detections
- Kepler (K2) and Spitzer parallaxes

- ExoPAG – SAG-11 led by Jennifer Yee to address this

Measure the Microlensing Rate in Target Fields with an IR Survey

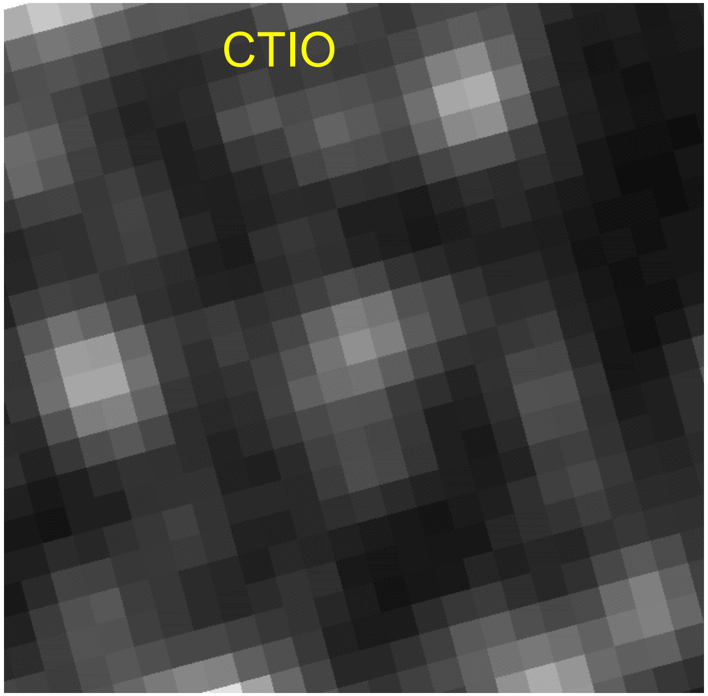
MOA-II microlensing rate maps

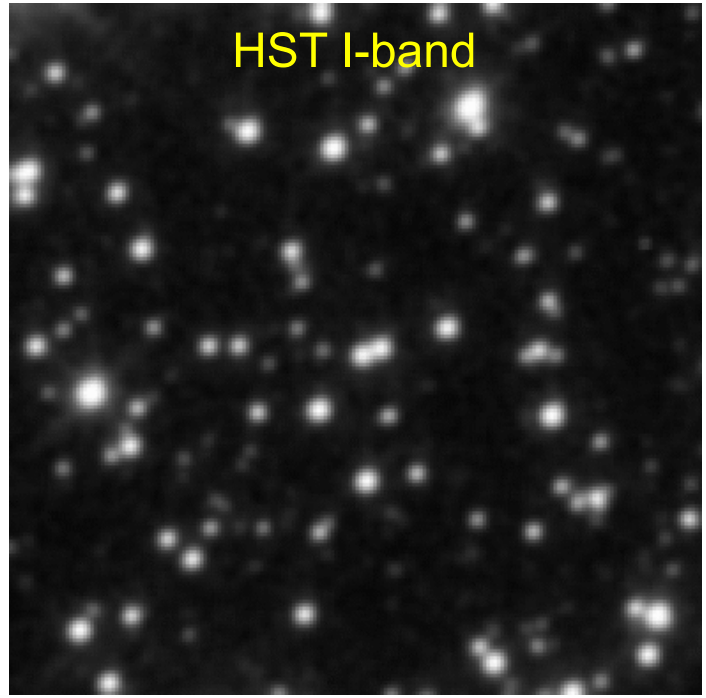


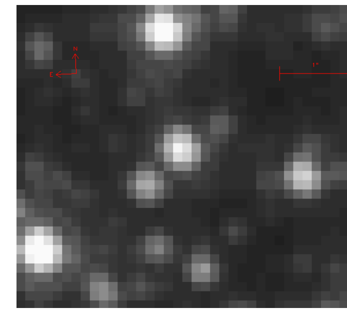


MOA-II measurements show maximum lensing rate at *l* = 1°, but this depends on extinction. Existing models are too simplistic to capture the detailed rate structure in *l* and *b*

New Photometry/Astrometry code needed



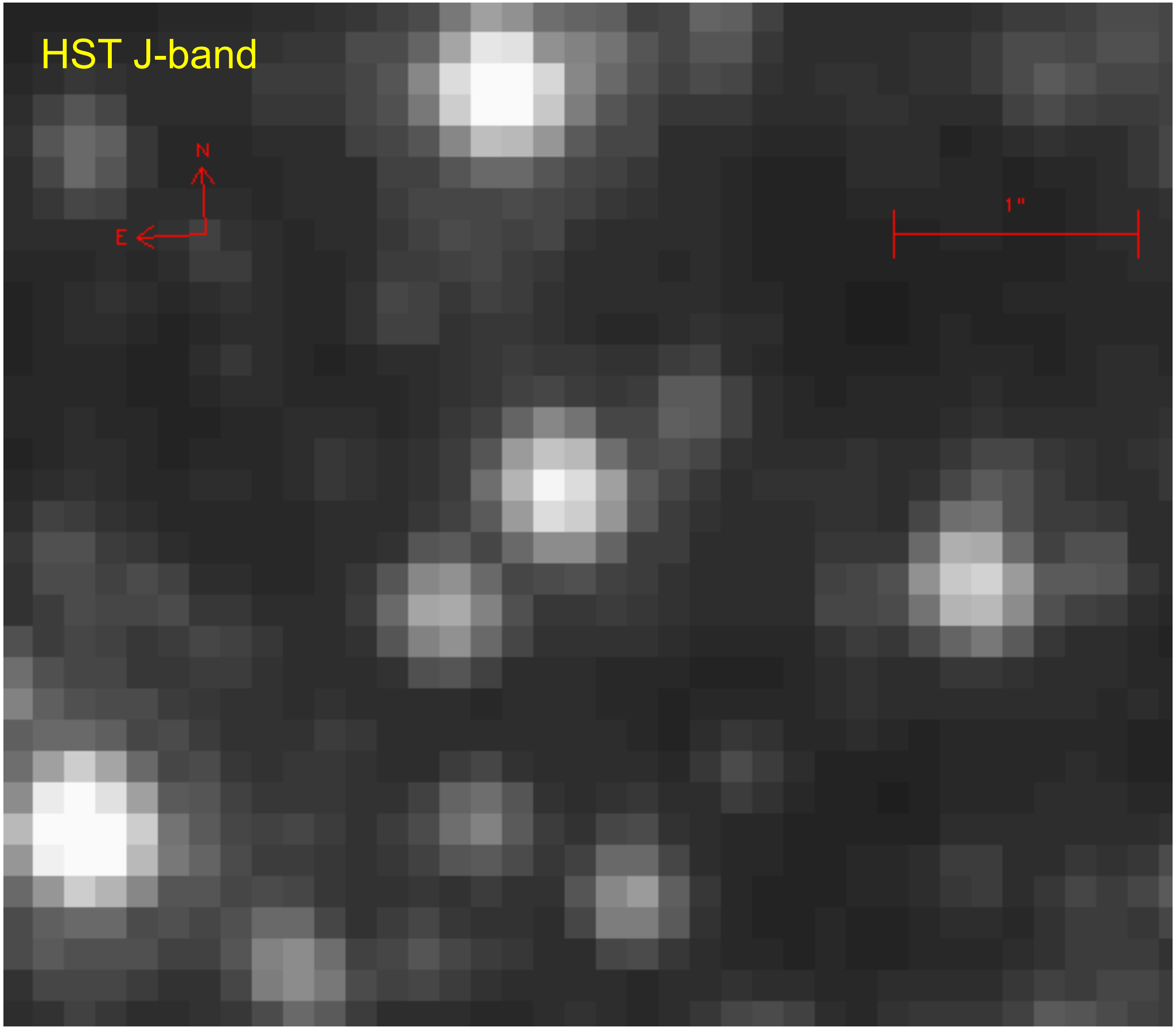




HST J-band

- These images are from MACHO fields with low extinction
- WFRIST-AFTA fields will be closer to the plane with 2-3 × the stellar density
- Proper motion of neighbor stars will be a significant source of photometry errors
- A time series of HST/WFC3/IR data will allow us to test photometry code

Blow-up of HST/WFC3/IR Image



Microlensing Survey Stars Will Not Be Isolated

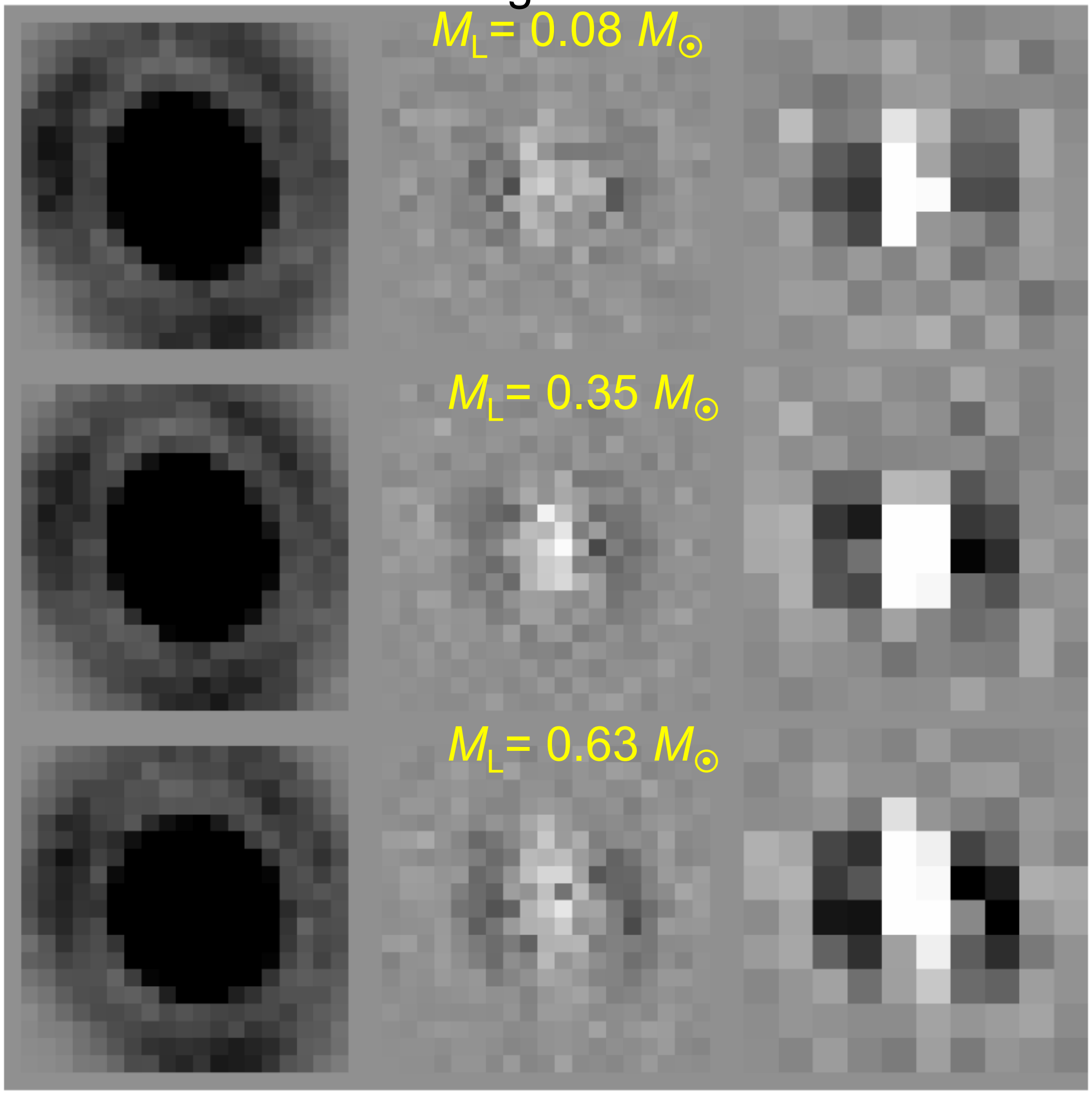
- Proper motion of neighboring stars will contribute to photometry noise
- We need astrometry information for our determination of host star properties
- We want a WFIRST-AFTA exoplanet microlensing pipeline that generates
  - Photometry
  - Astrometry
  - A catalog of detector defects

- Develop exoplanet microlensing photometry+astrometry pipeline pre-launch using HST/WFC3/IR data

Lens Star Identification from Space

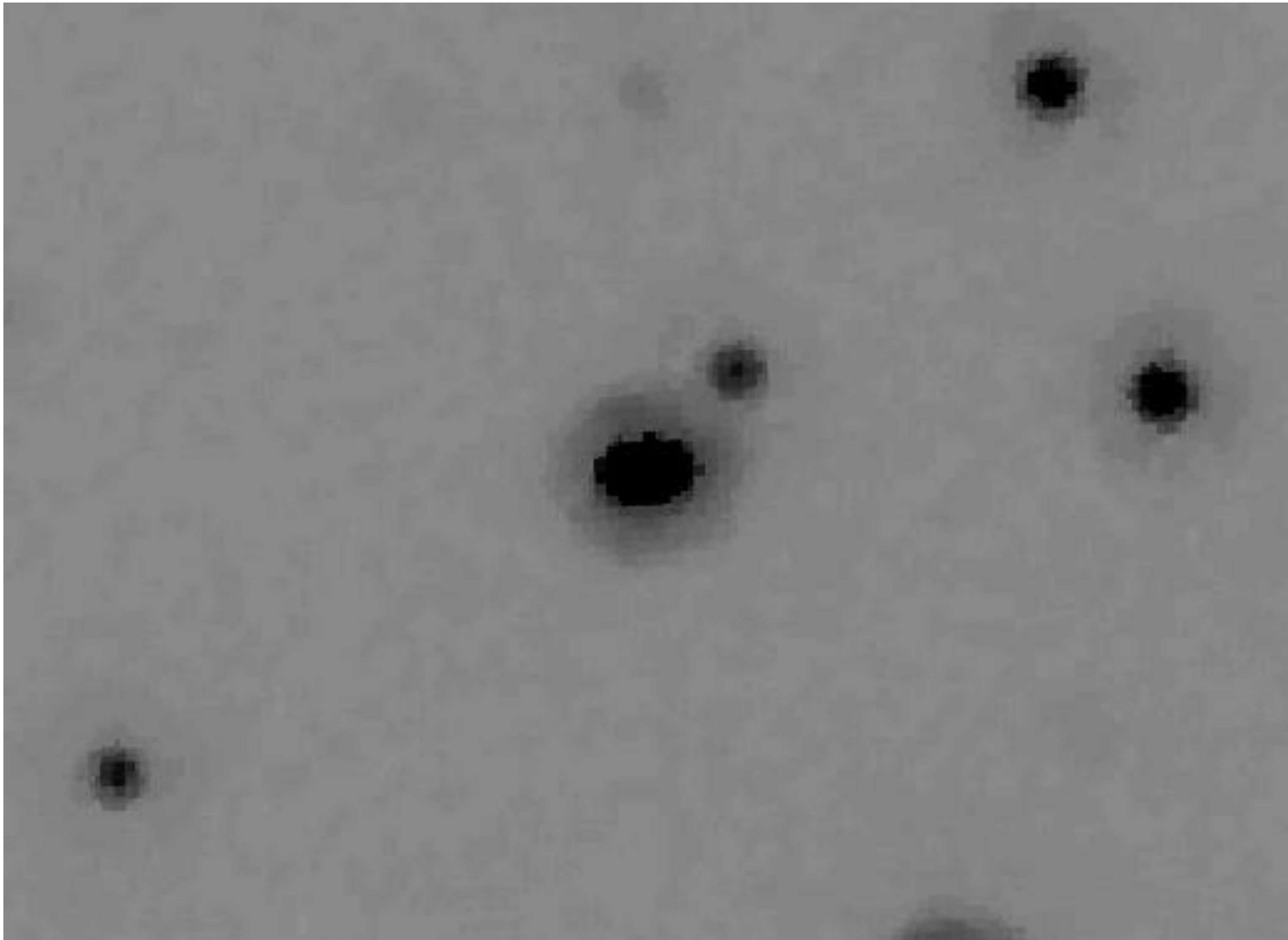
- Lens-source proper motion gives $\theta_E = \mu_{rel} t_E$
- μ_{rel}= 8.4±0.6 mas/yr for OGLE-2005-BLG-169
- Simulated HST ACS/HRC F814W (*I*-band) single orbit image "stacks" taken 2.4 years after peak magnification
  - 2× native resolution
  - also detectable with HST WFPC2/PC & NICMOS/NIC1
- Stable HST PSF allows clear detection of PSF elongation signal
- A main sequence lens of any mass is easily detected (for this event)

Simulated HST images:



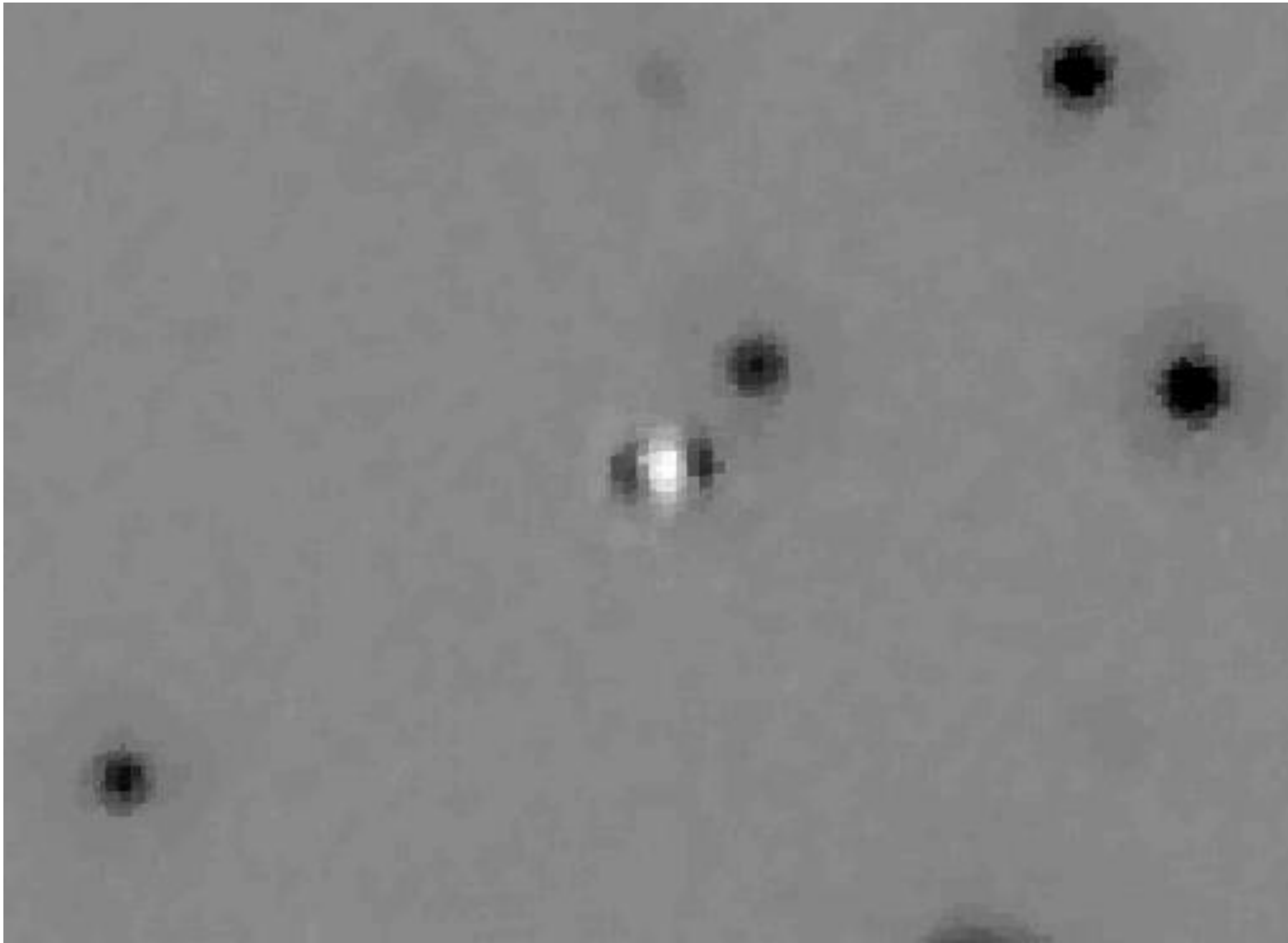
Stacked HST I-band Image of OGLE-2005-BLG-169 Source

Source *looks* elongated relative to neighbors



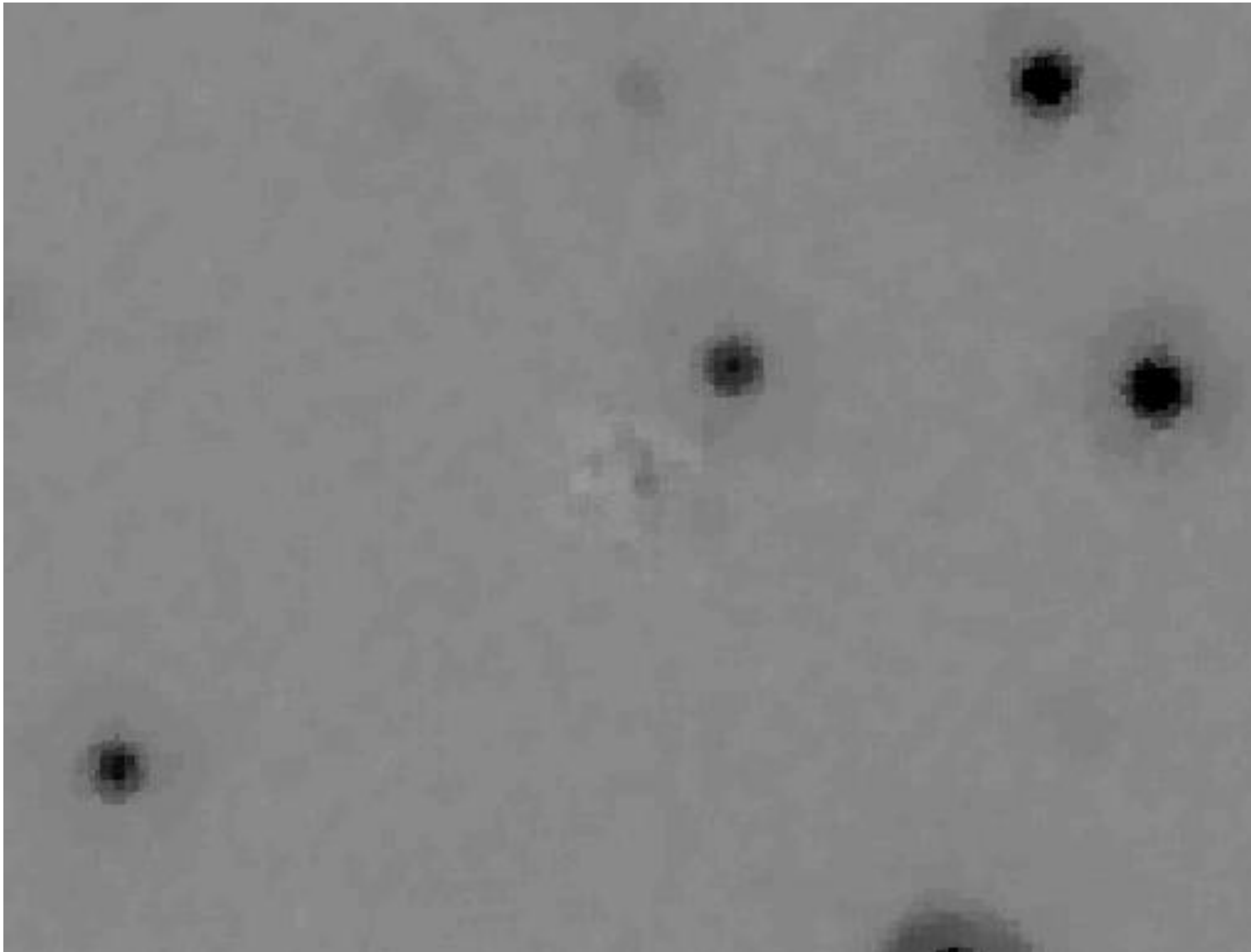
PSF for a Single Star Subtracted

Residuals in X when we subtract a PSF from each image and stack…



Fit and Subtract Two Stars: Source & Lens

Very good subtraction residuals when we fit for *two* sources



Lens+Source Solution:

- Offset consistent in the F814W, F555W, and F438W data:
  - Δx = 1.25 pixels = 50 mas
  - Δy = 0.25 pixel = 10 mas
  - FLUX: (left) (right)

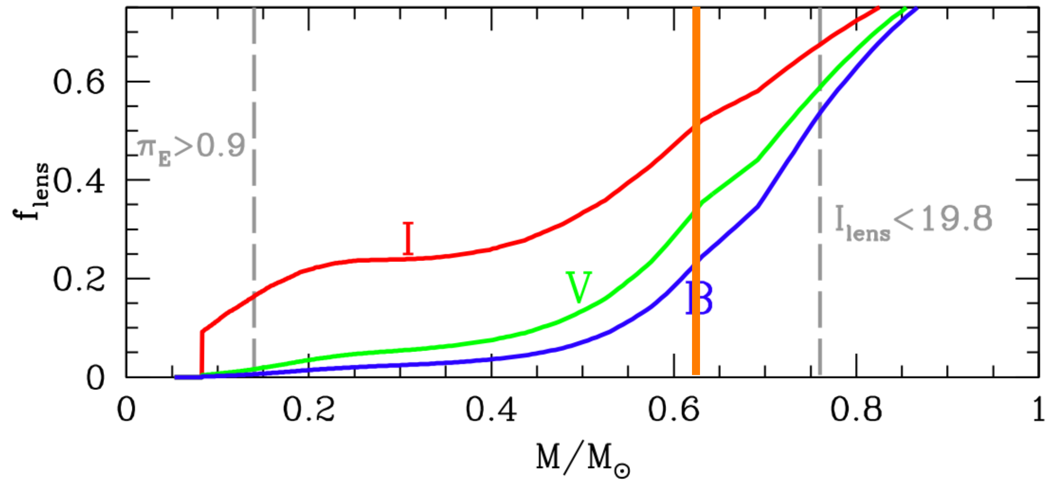
	(left)	(right)
F814W	3392 e^-	3276 e^-
F555W	2158 e^-	3985 e^-
F438W	338 e^-	1029 e^-

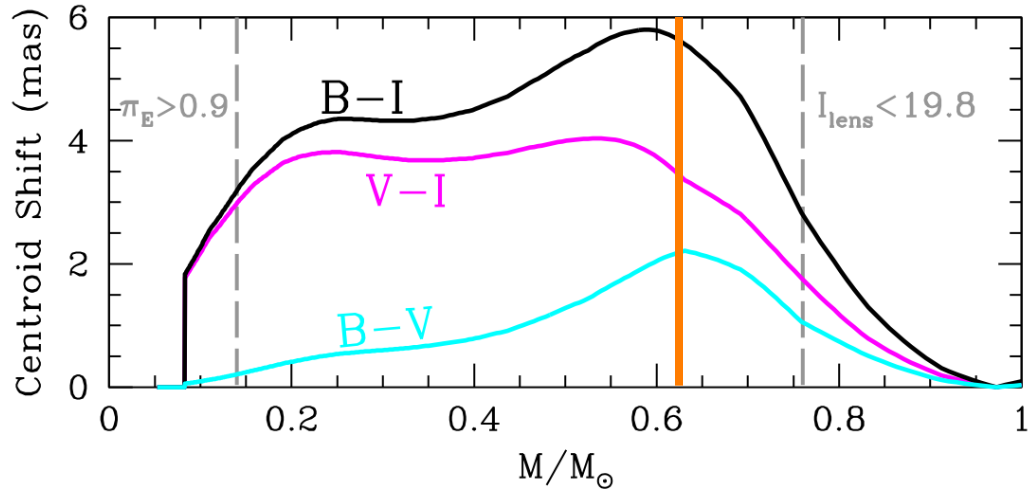
    - $f_I = 0.51$
    - $f_V = 0.35$
    - $f_B = 0.25$

HST BVI observations imply

$M_* = 0.63\ M_\odot$

$M_p = 17\ M_\oplus$





observed separation of 51 mas confirms planet model prediction of 54.3±3.7 mas