SAG 11: Preparing for the WFIRST Microlensing Survey

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Charter

1. Identify both mission critical and mission enhancing programs,

2. Identify immediate science to come out of each program, as well as the program's direct impact on the WFIRST mission,

3. For each proposed program, quantify the improved scientific return for the WFIRST mission,

4. Emphasize programs that can be executed using existing (NASA) resources.

Three Key Areas for *WFIRST* Microlensing Science:

- *WFIRST* Planet Masses
- Field Selection
- Microlensing Techniques

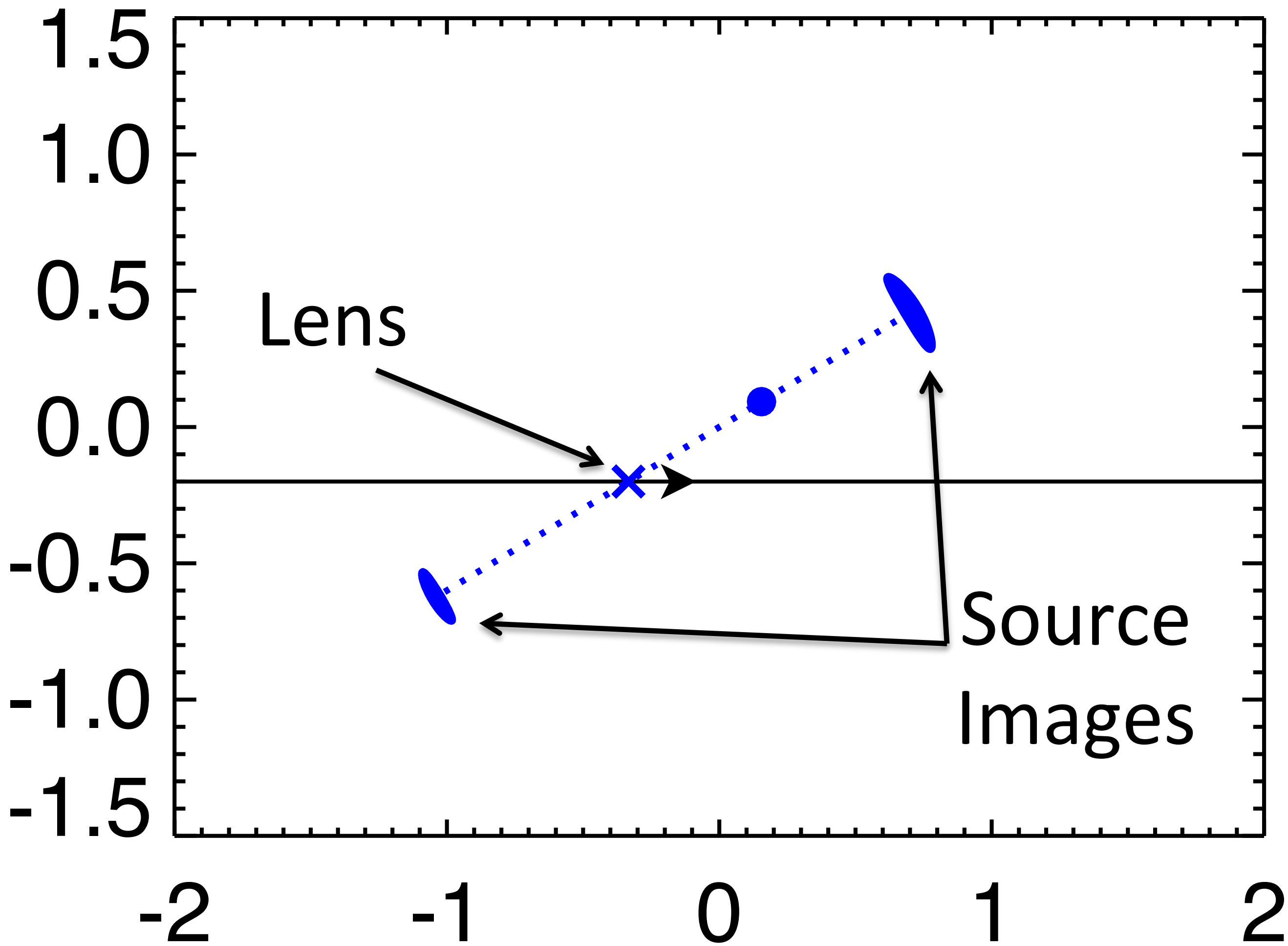
Major Observational Programs

1. Directly support WFIRST science and reduce its scientific risk
2. Develop techniques for measuring planet masses
3. Development of WFIRST analysis pipelines

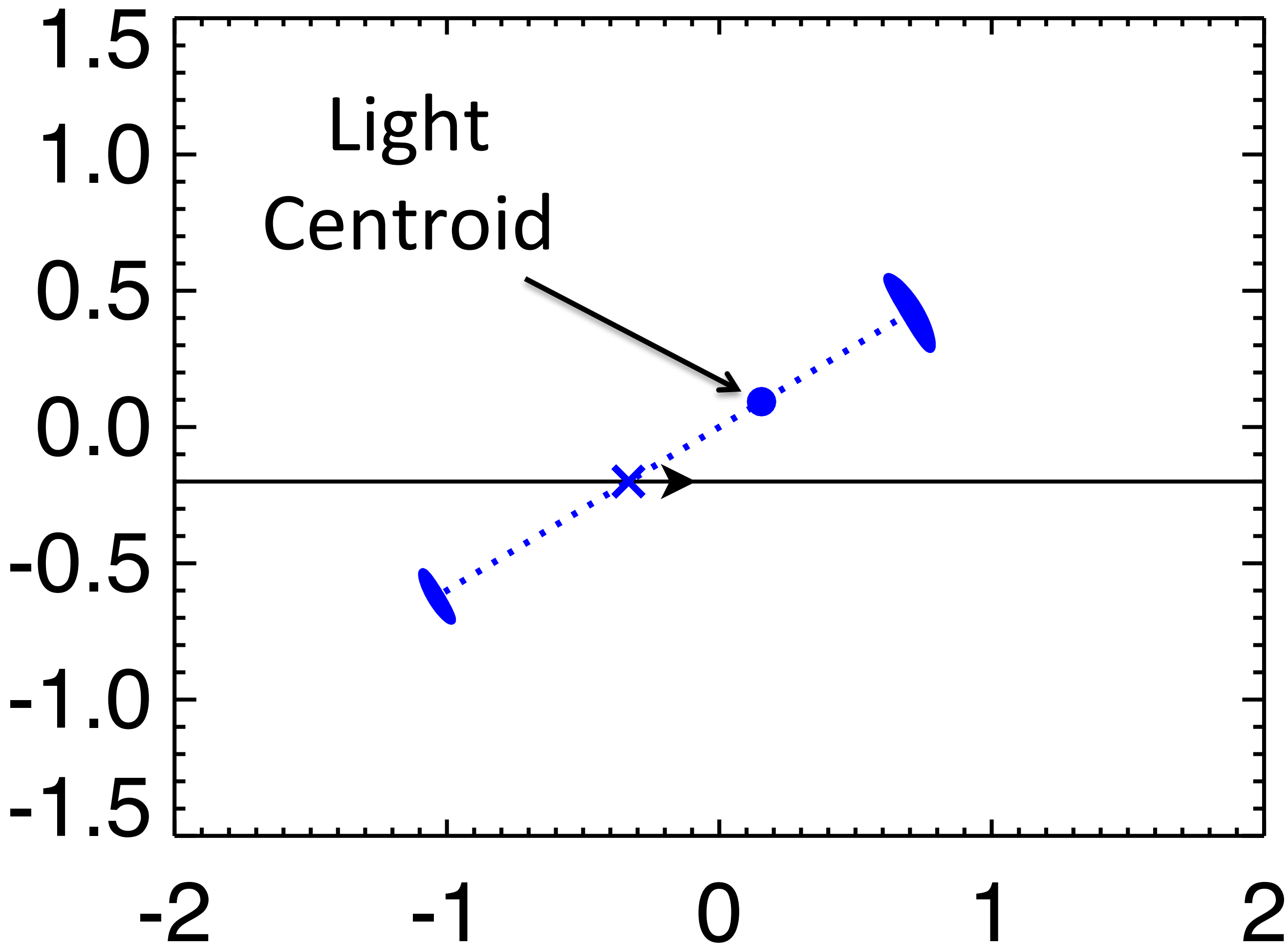
1. Directly support WFIRST science and reduce its scientific risk

- Early, optical, HST imaging of the WFIRST field
- A preparatory, ground-based, microlensing survey in the near-IR

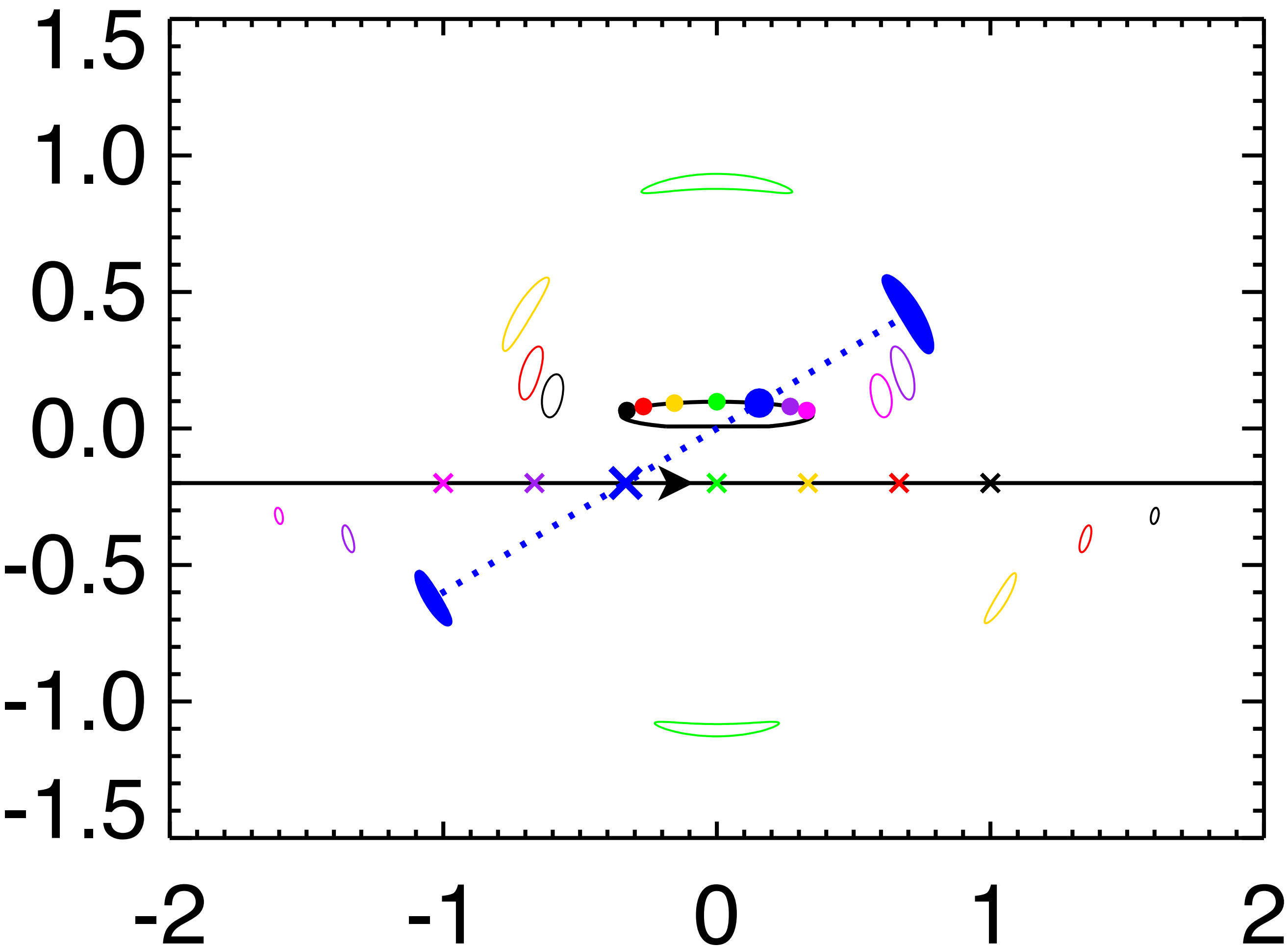
Astrometric Microlensing



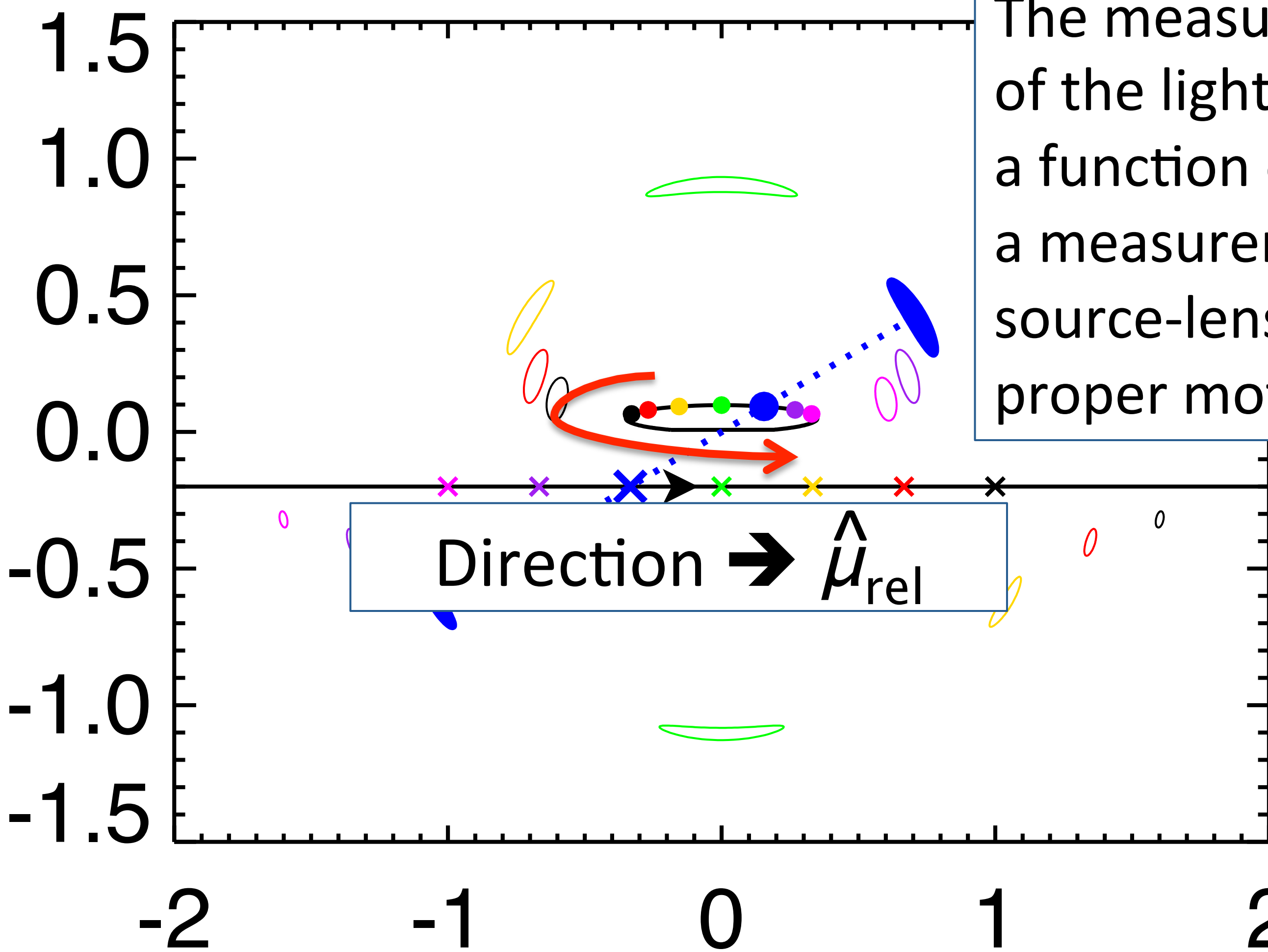
Astrometric Microlensing



Astrometric Microlensing



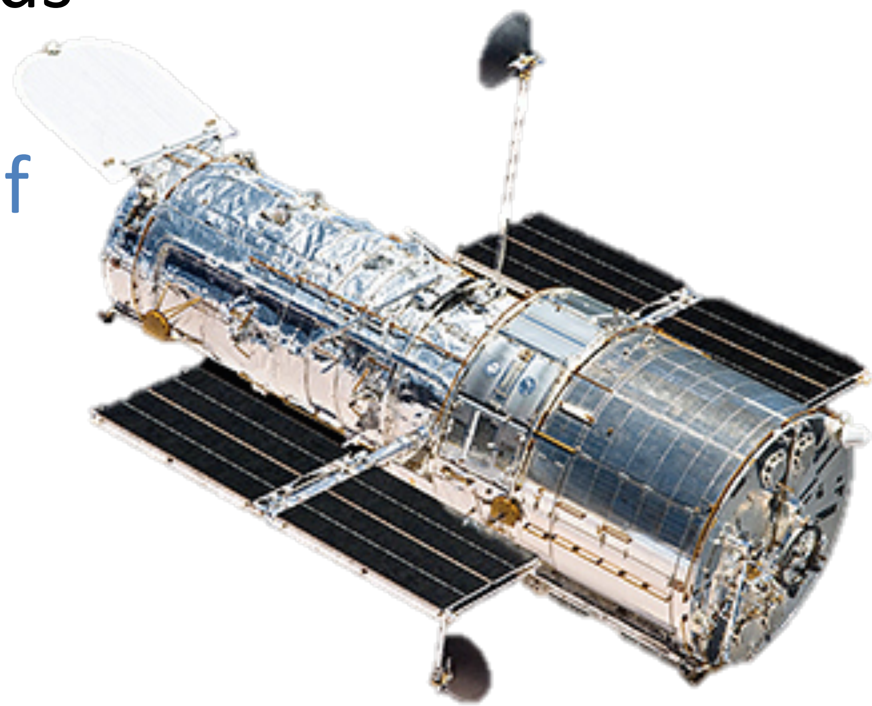
Astrometric Microlensing



The measured motion of the light centroid as a function of time gives a measurement of the source-lens relative proper motion.

Optical HST Imaging

An immediate, optical HST survey of the WFIRST fields will allow proper motion measurements for 22% of WFIRST stars → Direct verification of WFIRST microlens astrometry.

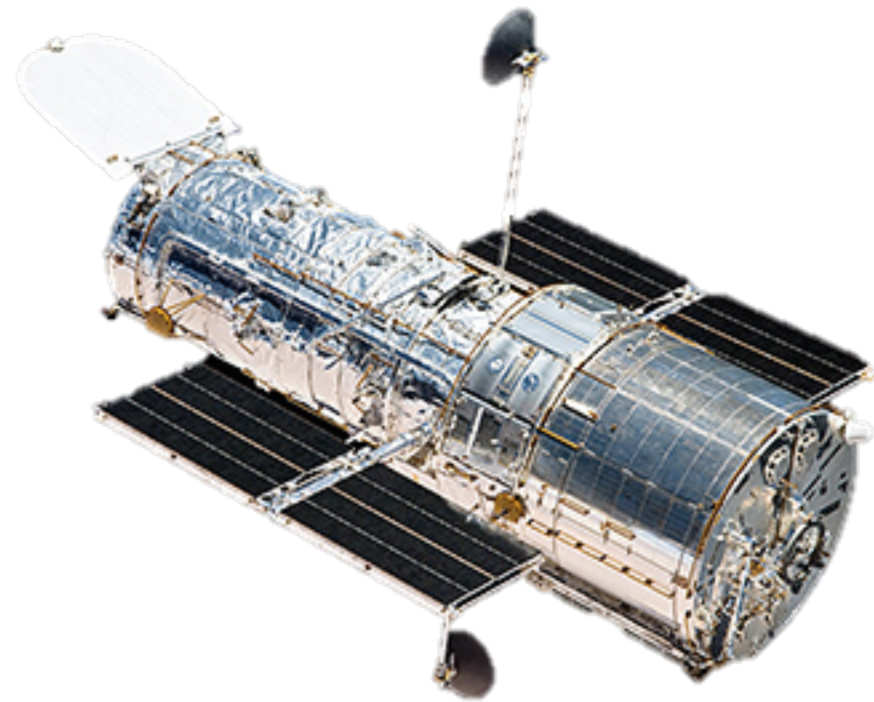


Reliable microlens astrometry measurements are vital to measuring planet masses with WFIRST.

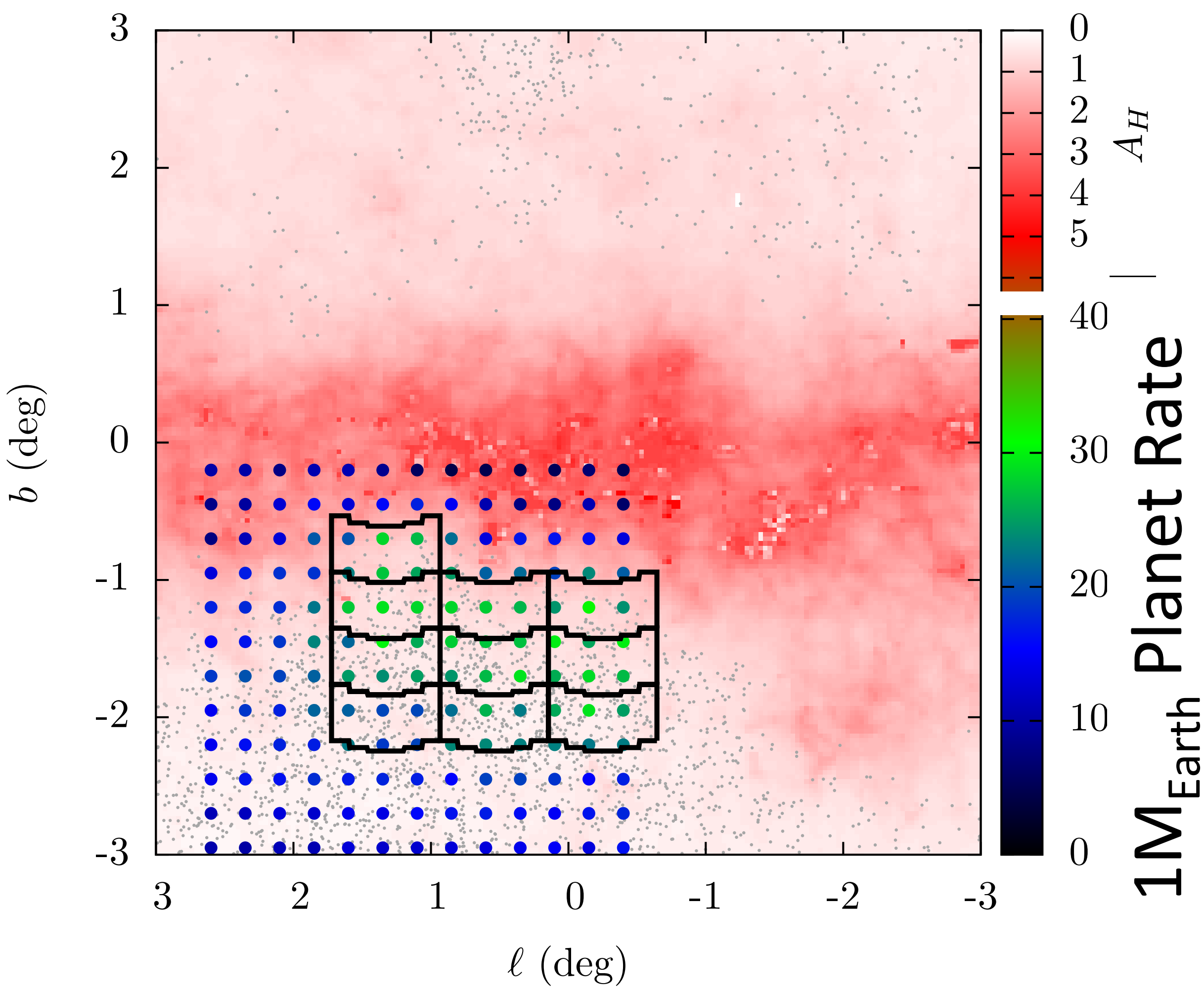
Optical HST Imaging

Colors of stars in WFIRST field → temperature, extinction, metallicity

WFIRST relative astrometry + GAIA absolute astrometry + HST colors → Detailed structure of the galaxy



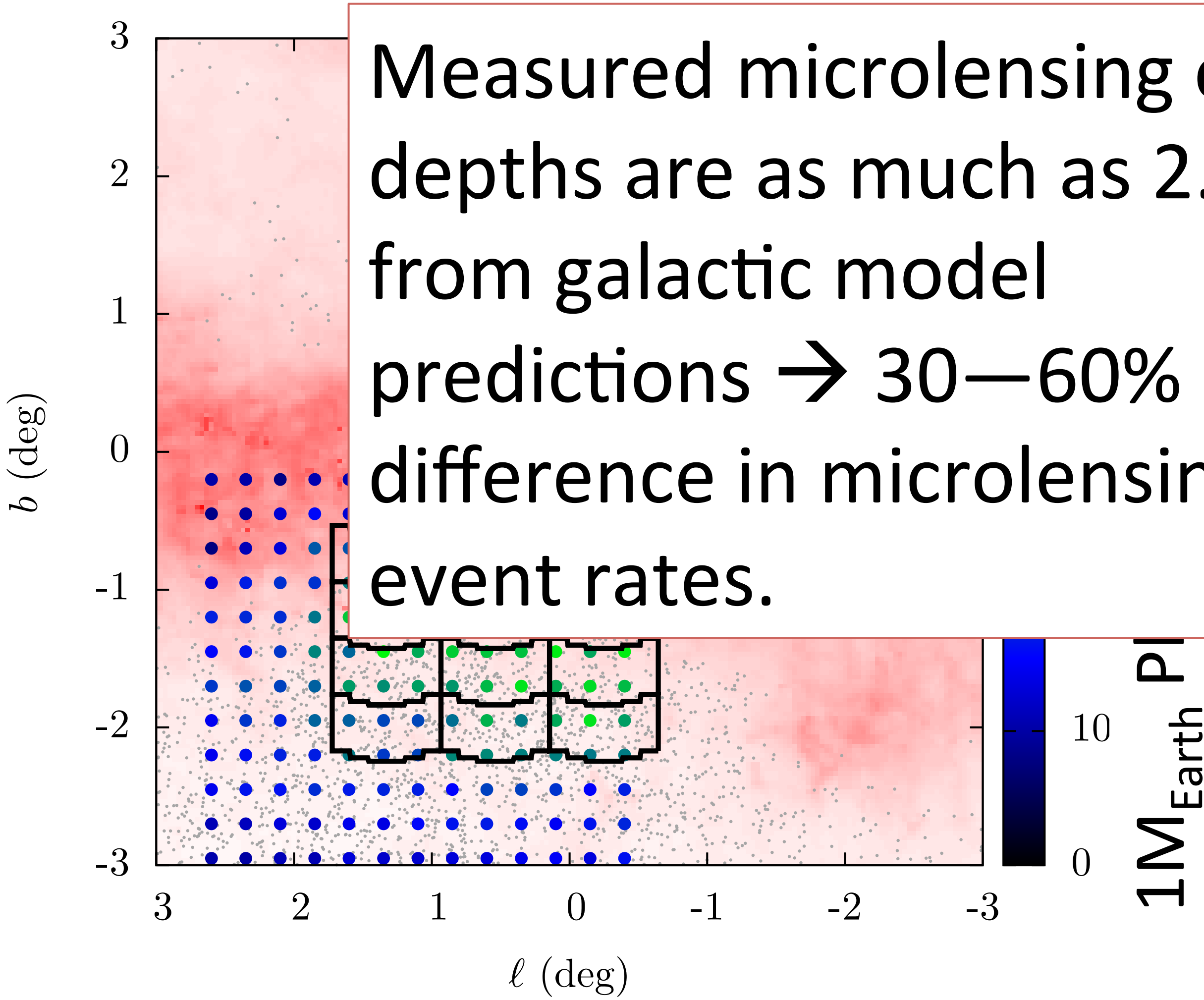
Ground-Based, Near-IR, Microlensing Survey



Tentative WFIRST field based on our current understanding, extrapolations, and assumptions.

Extinction map: Gonzalez et al. 2012

Ground-Based, Near-IR, Microlensing Survey



Extinction map: Gonzalez et al. 2012

Measured microlensing optical depths are as much as 2.8σ off from galactic model predictions → 30—60% difference in microlensing event rates.

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Ground-Based, Near-IR, Microlensing Survey

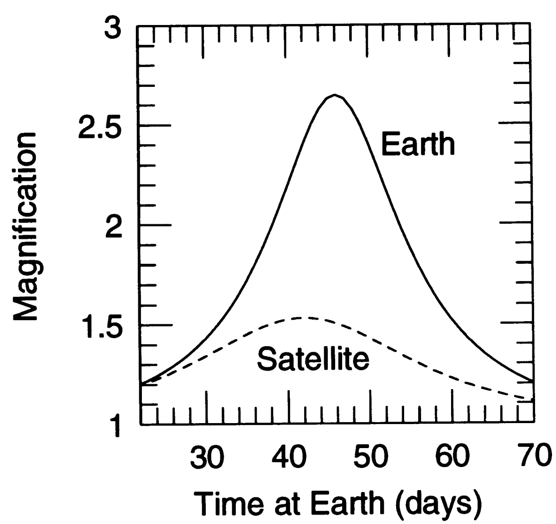
1. Direct measurement of the near-IR event rate
2. Characterization of the source star population
3. Discovery of giant planets
4. Complementary to optical, ground-based microlensing
   - Near-IR source flux measurements
   - Check for chromatic (non-microlensing) effects

2. Develop techniques for measuring planet masses

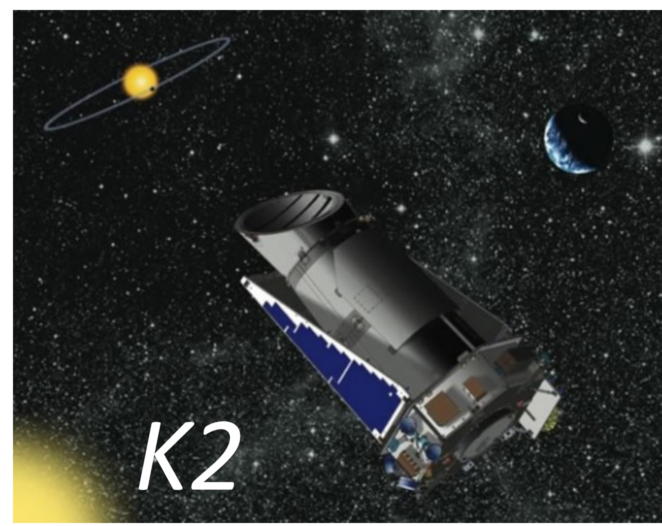
- Satellite parallax observations using Spitzer, Kepler, and TESS
- HST or AO flux measurements of lenses in ground-based microlensing events
- Measurements of microlens astrometry for black holes

Satellite Parallaxes

1. Mass measurements for ground-based microlensing planets.
2. Measured distances can be used to probe the relative frequency of planets in the bulge and the disk → WFIRST field selection

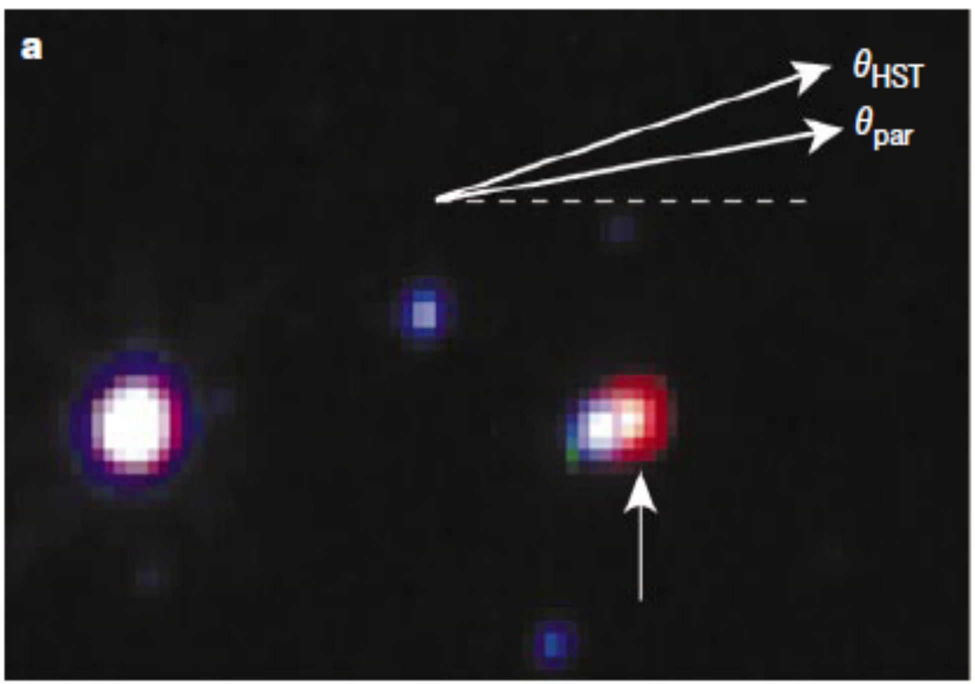


Gould 1994 ApJL, 421, 75



Flux Measurements

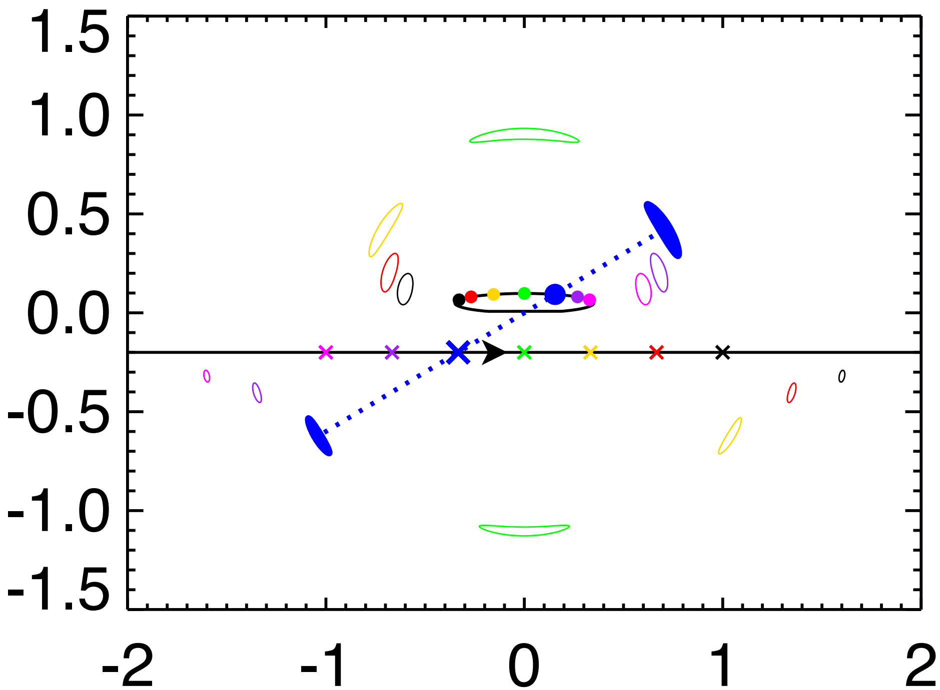
High-resolution imaging of known microlensing events can directly measure the lens flux (and mass).



Alcock et al. 2001 Nature, 414, 617

If these observations are made with HST (rather than AO), it is possible to resolve the source and lens and measure their relative proper motion.

Microlens Astrometry of Black Holes

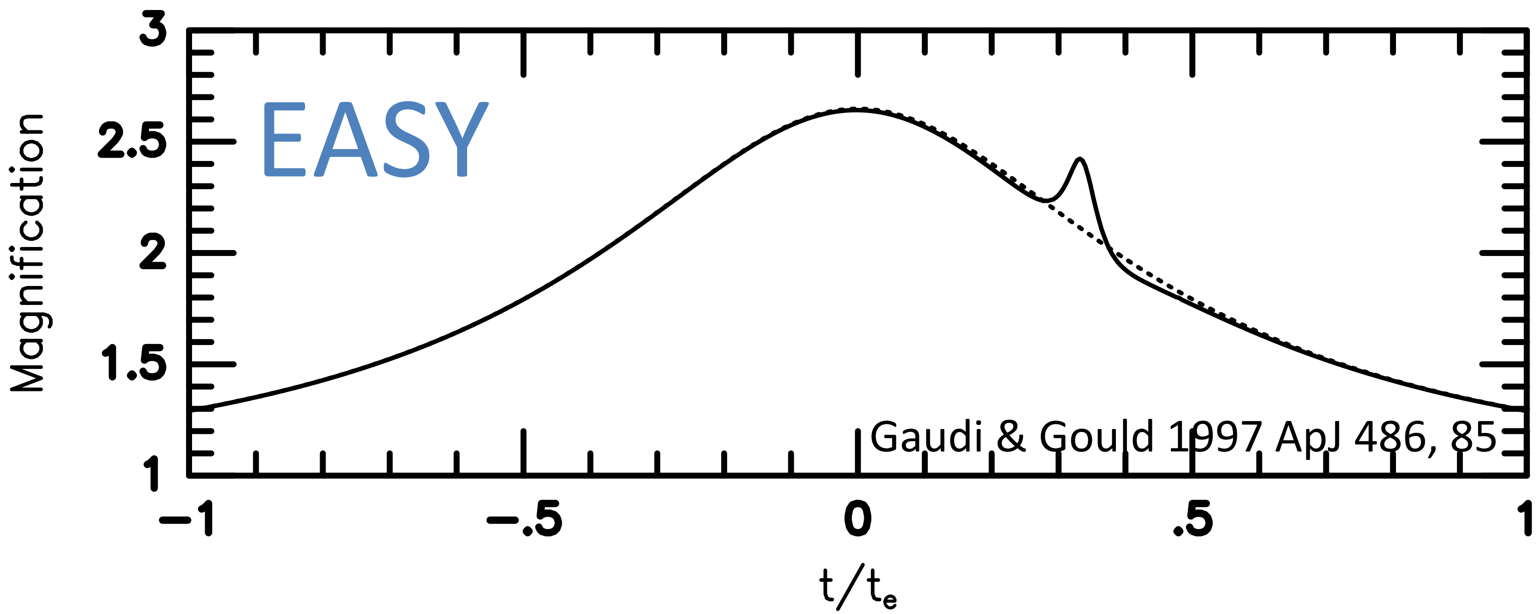


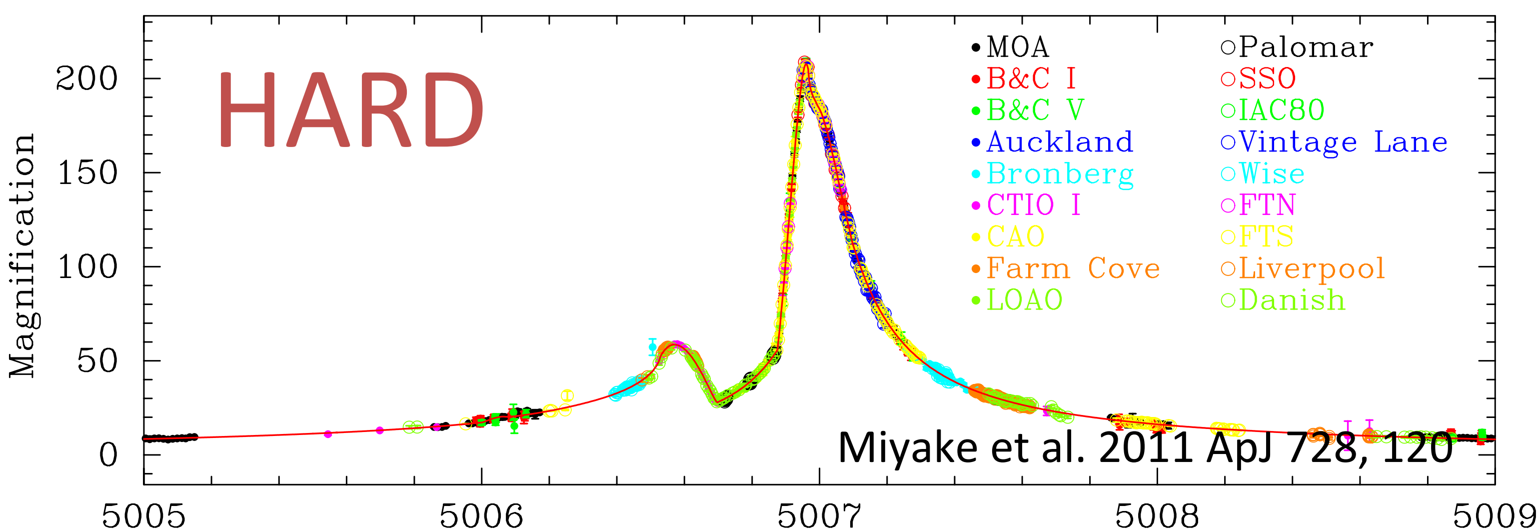
The astrometric microlensing effect for stellar mass black holes is large enough to measure with current capabilities.

3. Development of WFIRST analysis pipelines

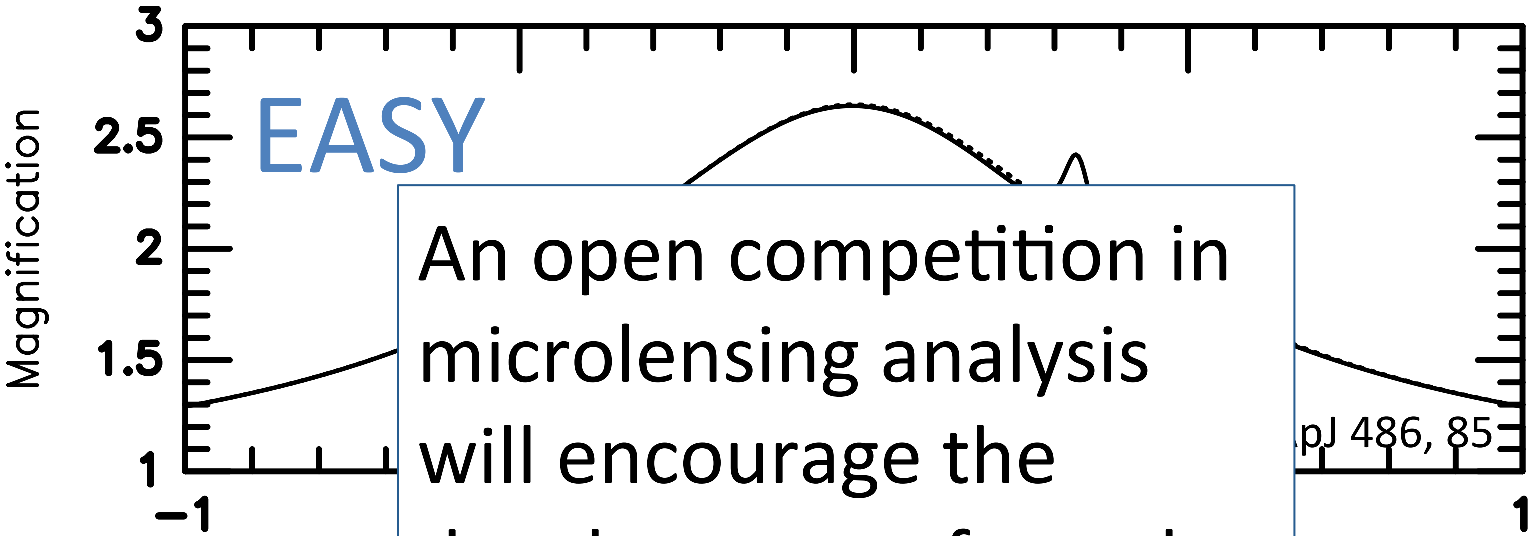
- Multi-epoch HST/WFC3/IR observations of the bulge
- An open competition in microlensing analysis

Competition in Microlensing Analysis

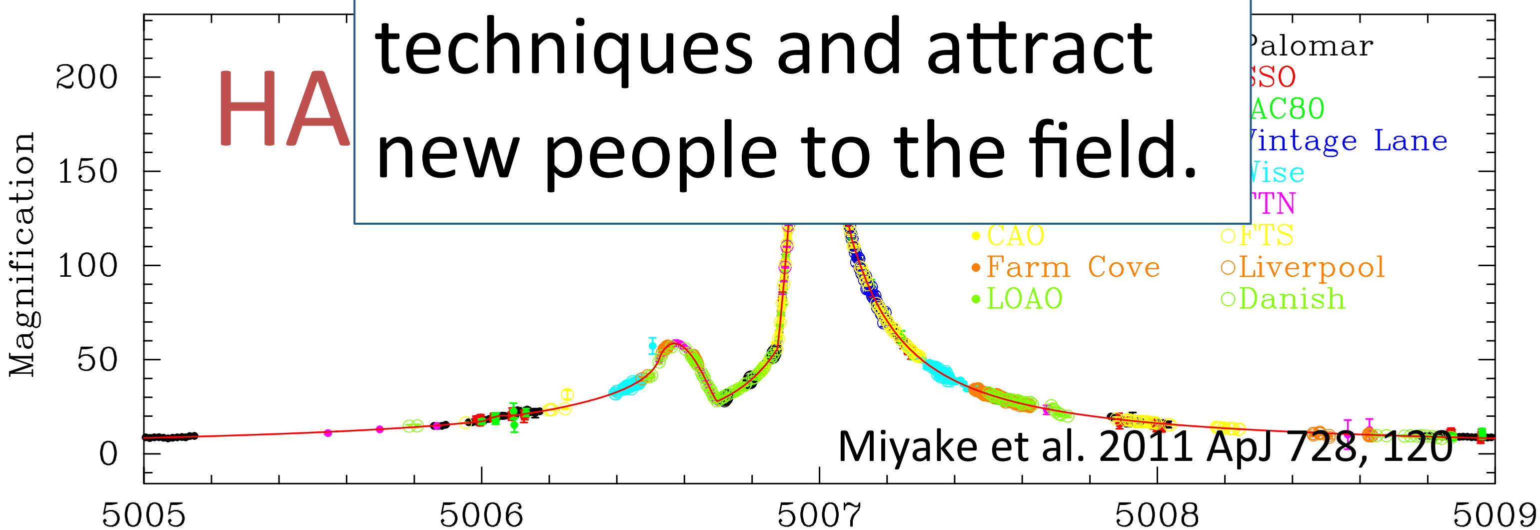




Competition in Microlensing Analysis

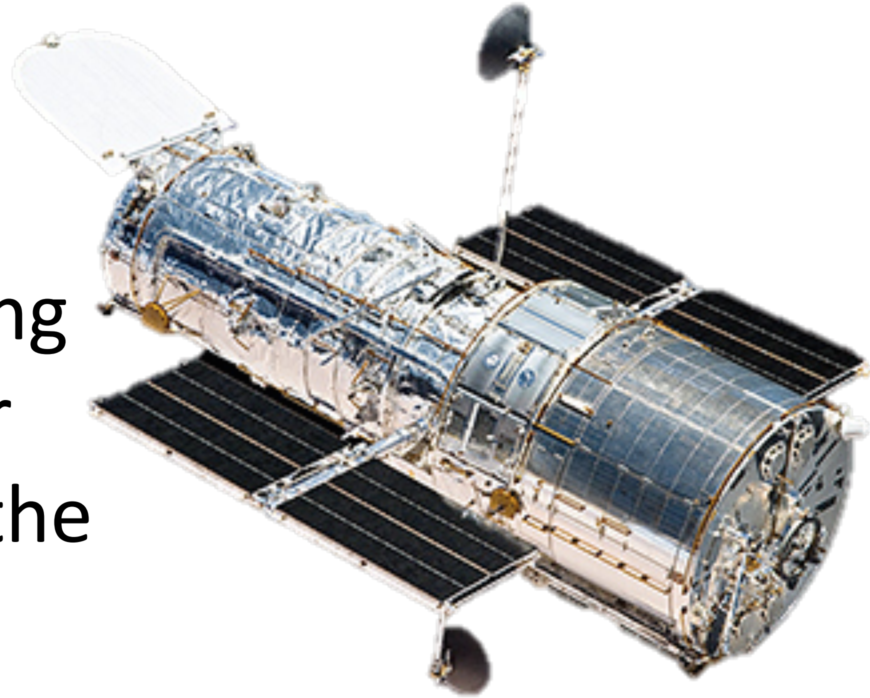


An open competition in microlensing analysis will encourage the development of novel techniques and attract new people to the field.



Multi-Epoch, IR, HST

A multi-epoch, HST/WFC3/IR survey of a few fields in the bulge is necessary for developing the WFIRST astrometry/photometry pipeline and understanding how well a random dither pattern will characterize the WFIRST detector.



Multi-Epoch, IR, HST

A multi-epoch, HST/WFC3/IR
survey of a few fields in the
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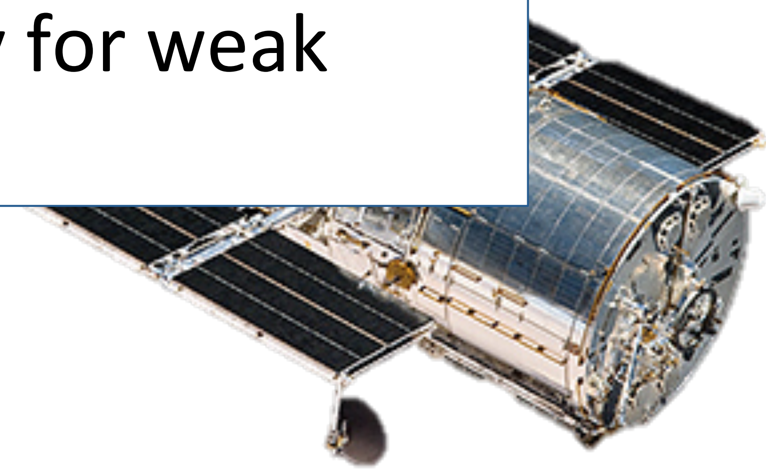
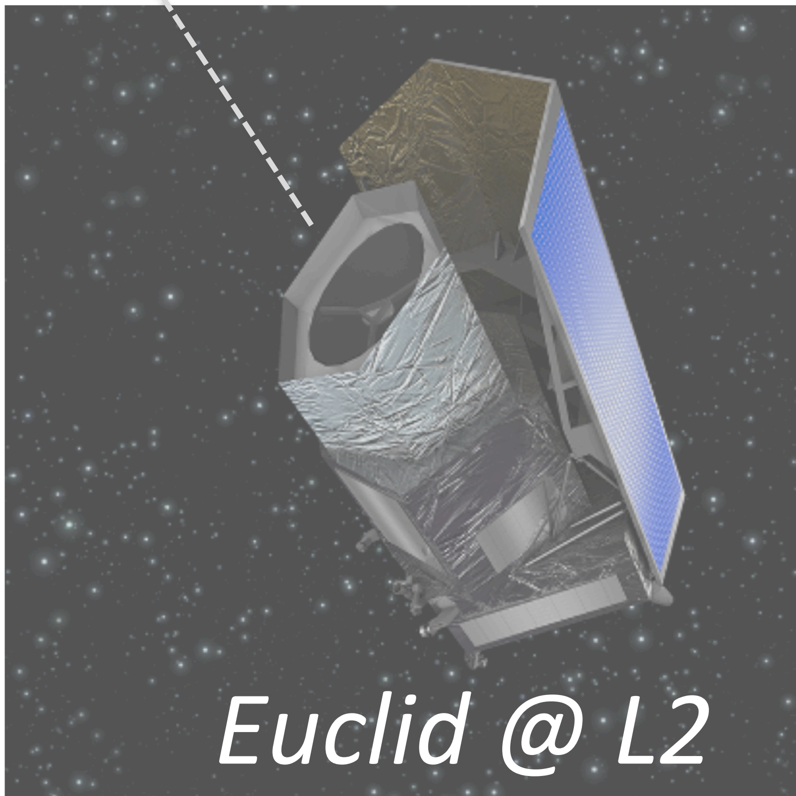
pattern will characterize the
WFIRST detector.

Done right, the WFIRST microlensing observations can be used to understand the detector at the sub-pixel level, a necessity for weak lensing.



4. Synergies with Euclid

Simultaneous observations from Euclid and WFIRST can directly measure masses for 15% of 10 M_{Earth} free-floating planets.



SAG 11 Timeline

Dec 15, 2013	Announcement of the SAG
Jan 4-5, 2014	Overview of the SAG at ExoPAG 9
Jan 22, 2014	First meeting of the SAG
Feb 24, 2014	Second meeting of the SAG
Mar 19, 2014	1st draft of the report
Apr 25, 2014	2nd draft of the report
May 29, 2014	3rd draft of the report
Jun 6, 2014	Status update at ExoPAG 10
???	Final Draft

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