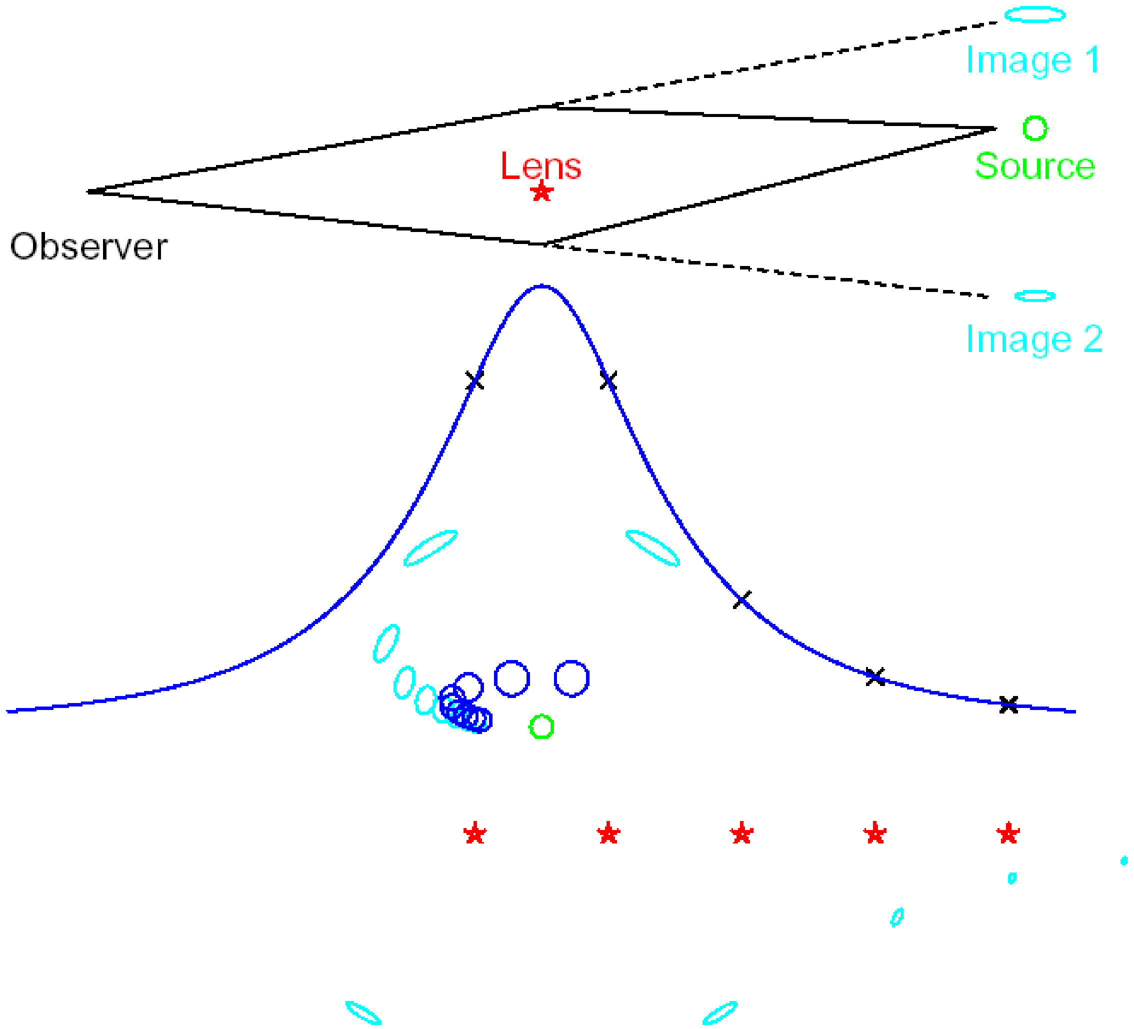
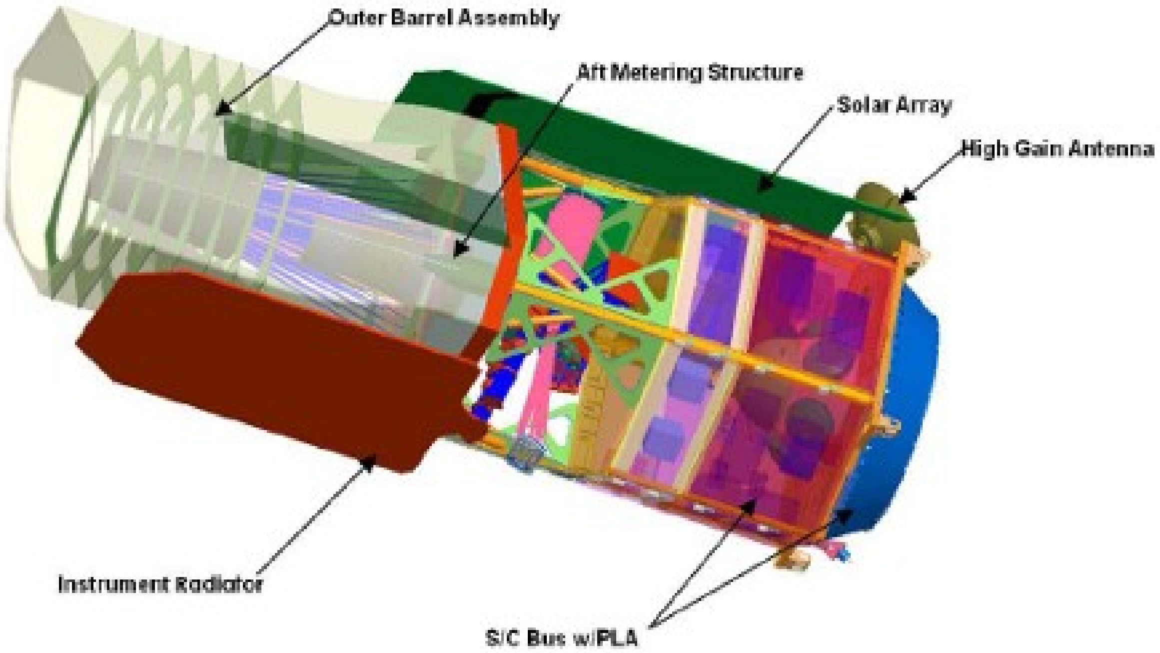
Non-Microlensing Science from WFIRST Microlensing Data

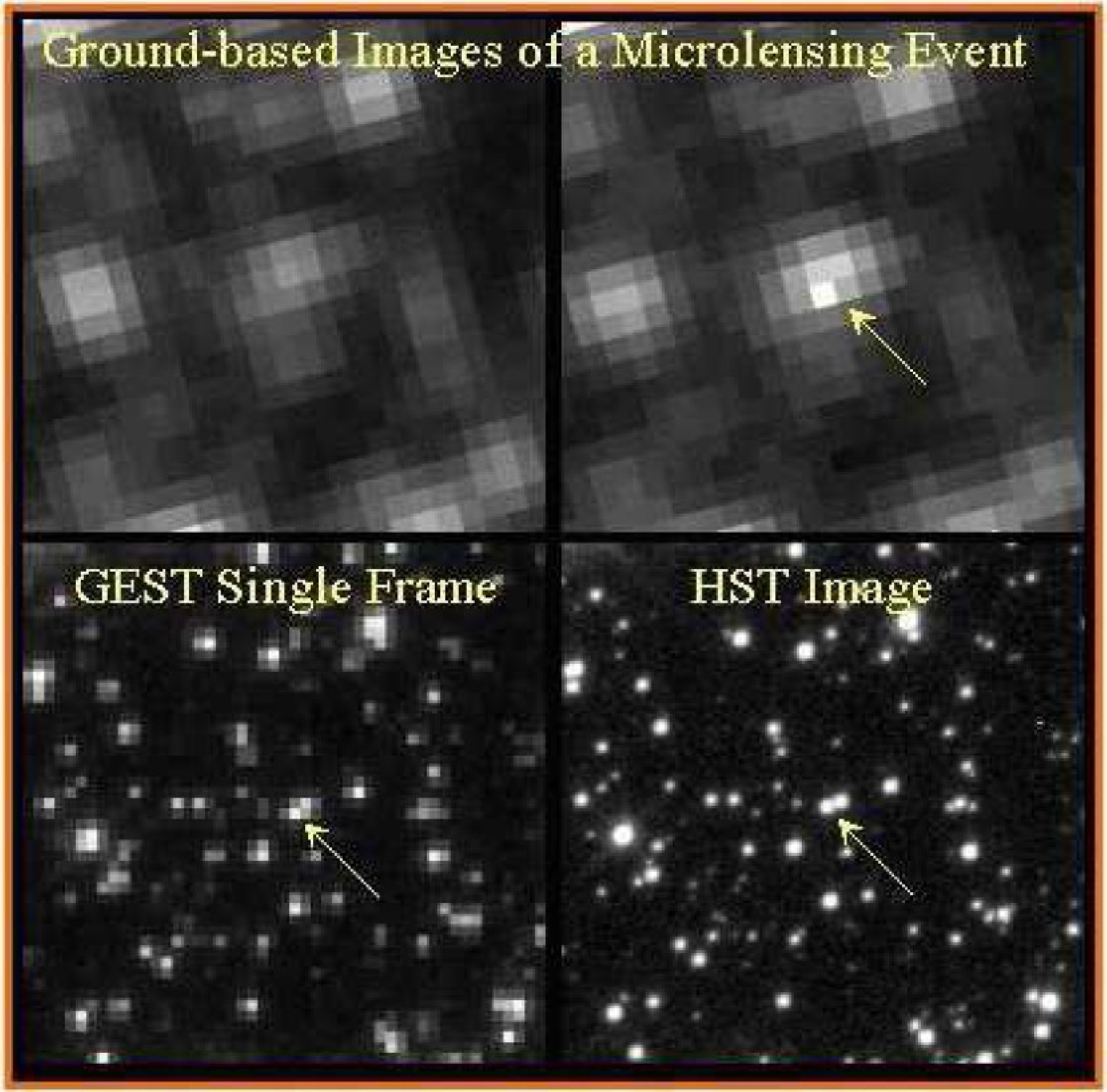
Andy Gould (Ohio State)

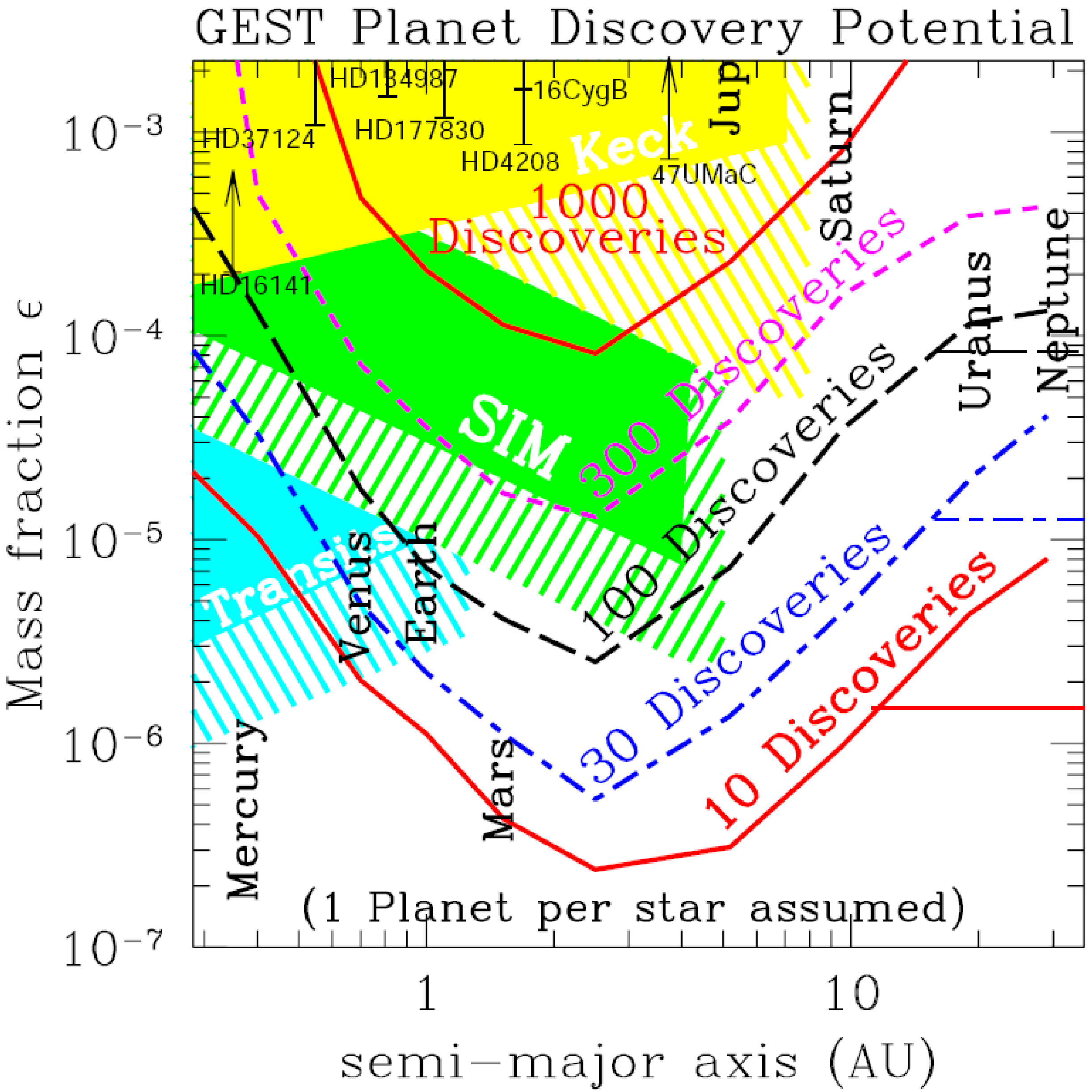


WFIRST


Outer Barrel Assembly
Aft Metering Structure
Solar Array
High Gain Antenna
Instrument Radiator
S/C Bus w/PLA

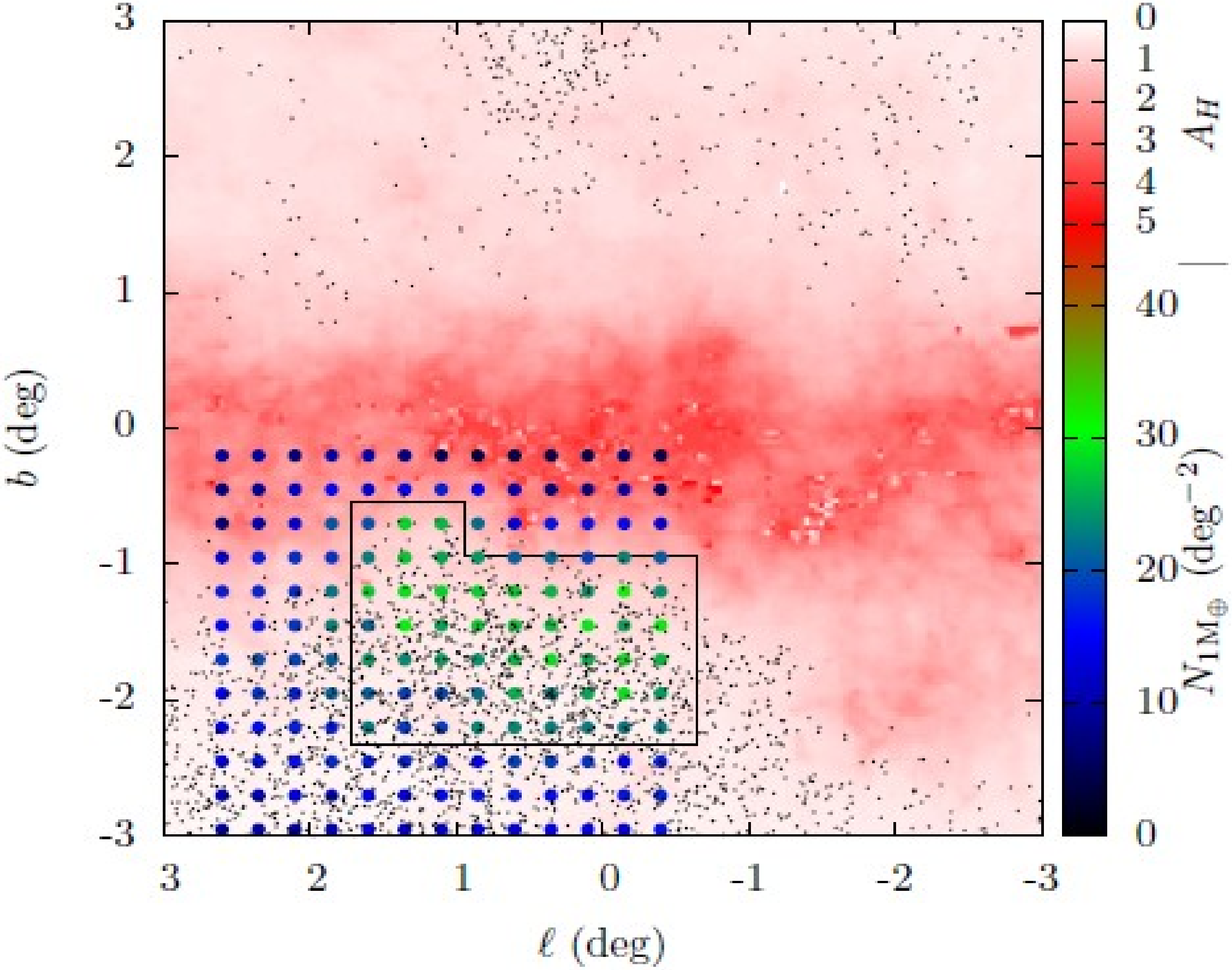
Seeing Better In Space (also weather)





Bennett & Rhie 2002, ApJ, 574, 985

WFIRST Microlensing Field

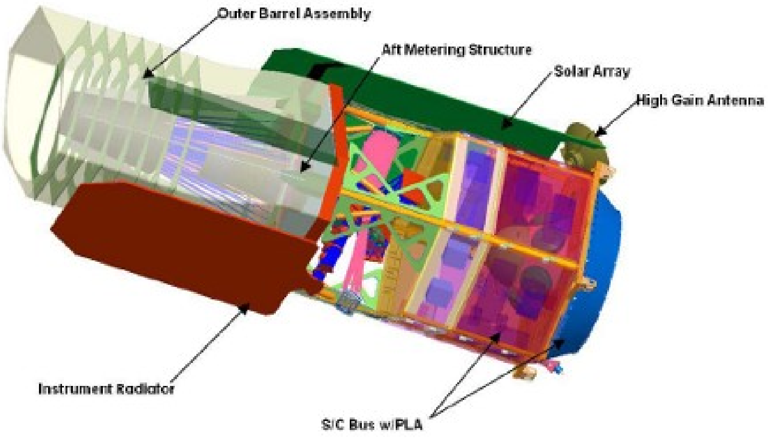


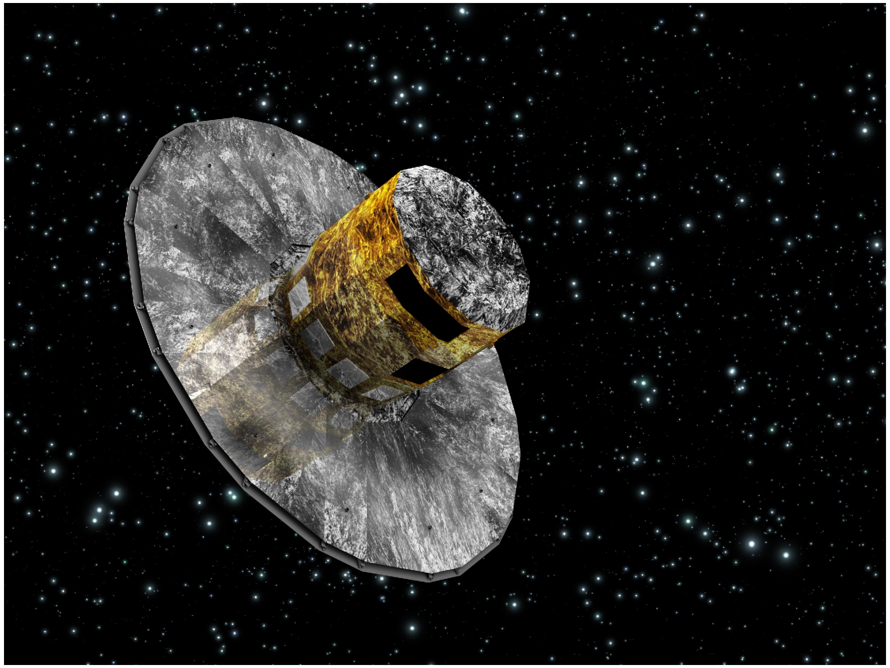
WFIRST “Microlensing” Survey Characteristics

- 40,000 images (52 sec)
- 2.8 sq.deg.
- 6 continuous 72-day campaigns (at quadrature)
- 100 images per day
- SNR = 10^{0.4(Hzero-H)} Hzero = 26.1

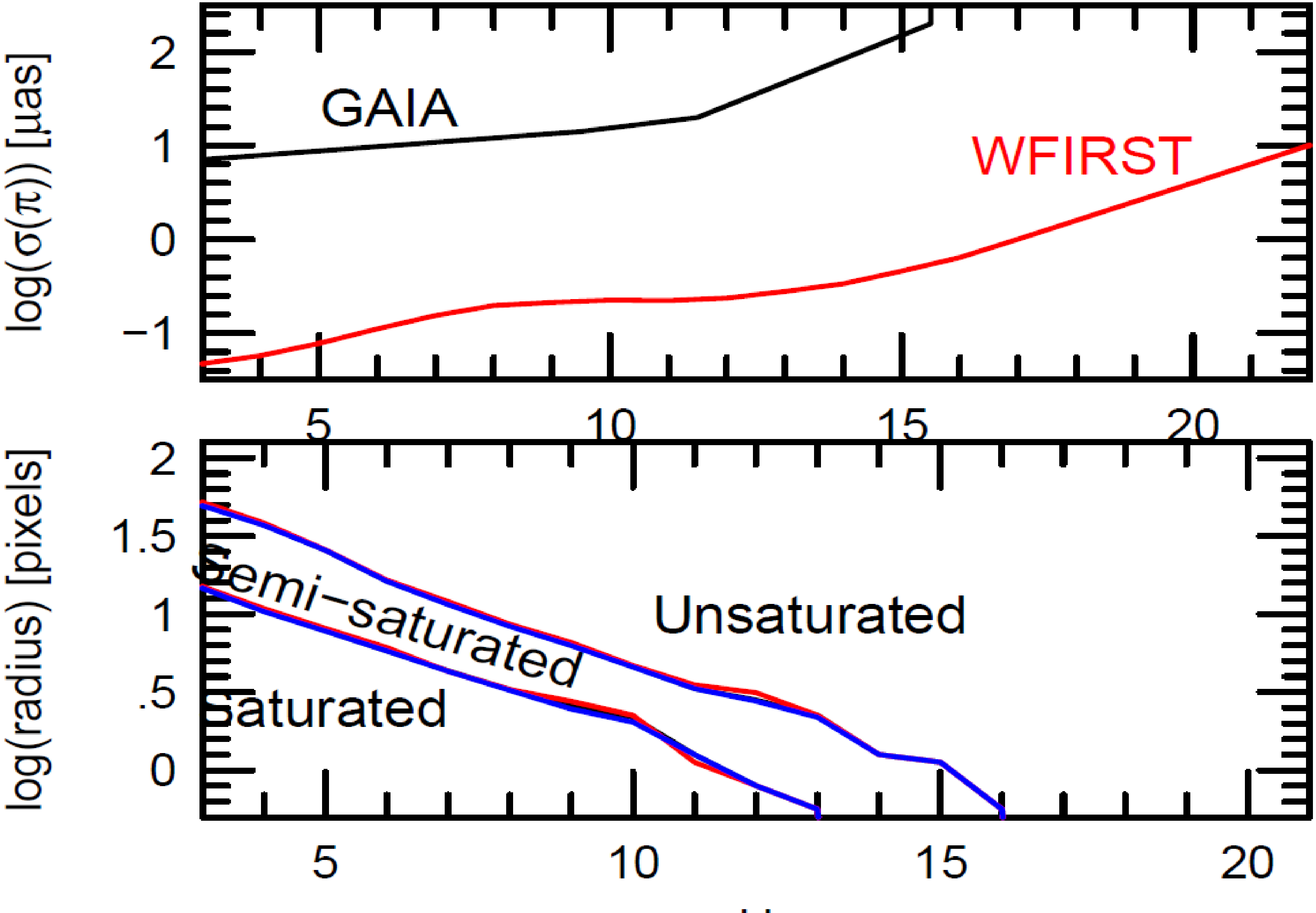
Gould 2014 JKAS, (almost) in press

WFIRST vs. GAIA





WFIRST vs GAIA
Parallax Precision



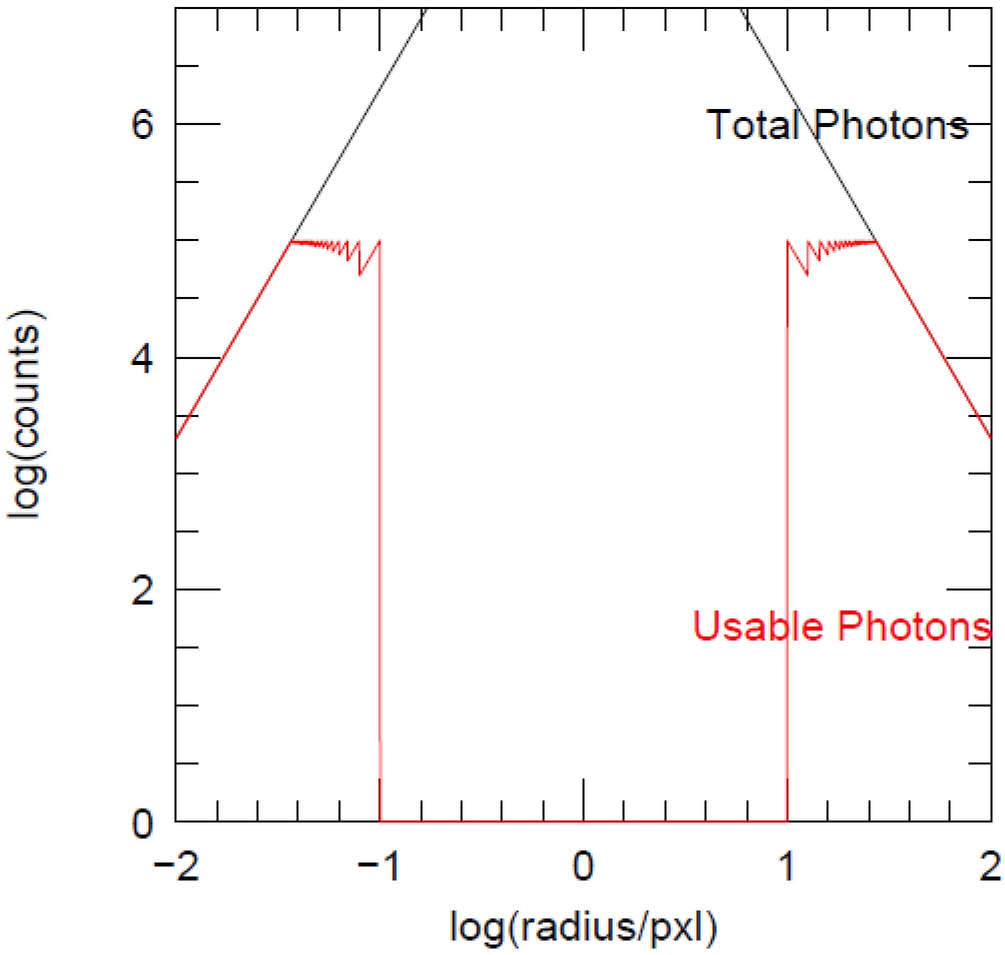
Non-Microlensing WFIRST Science:

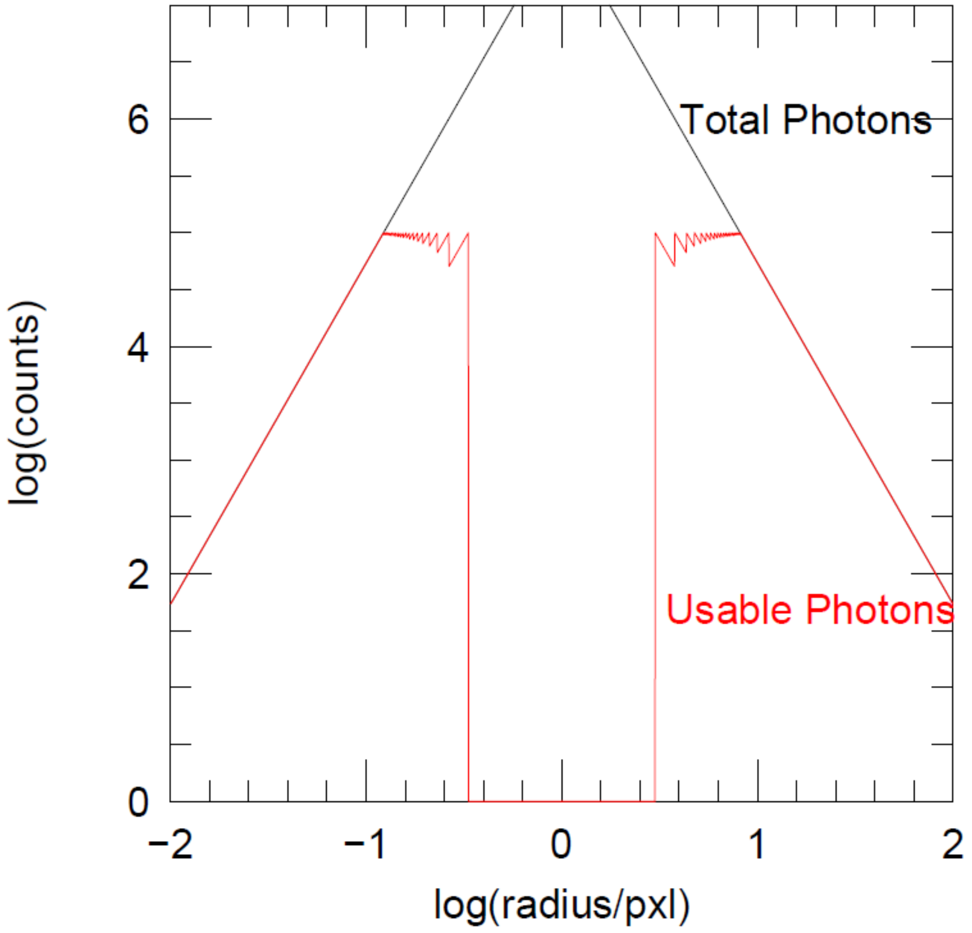
Ultra-precise Parallaxes

- $H<14.0$; $\sigma(\pi) < 0.3$ μas; 1,000,000 stars
- $H<19.6$; $\sigma(\pi) < 3.7$ μas; 40,000,000 stars
- $H<21.6$; $\sigma(\pi) < 10$ μas; 120,000,000 stars

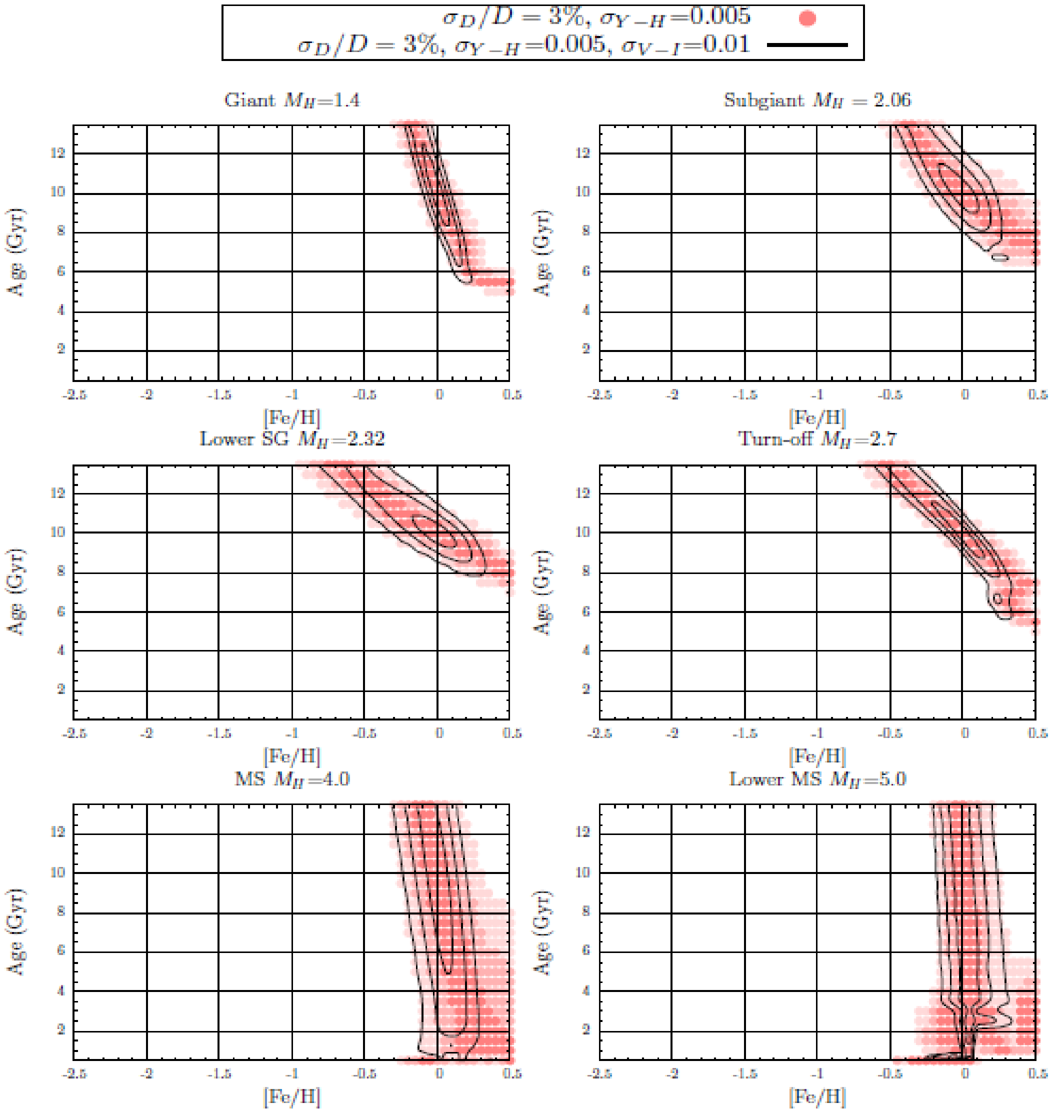
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

WFIRST
Astrometric Information Flow

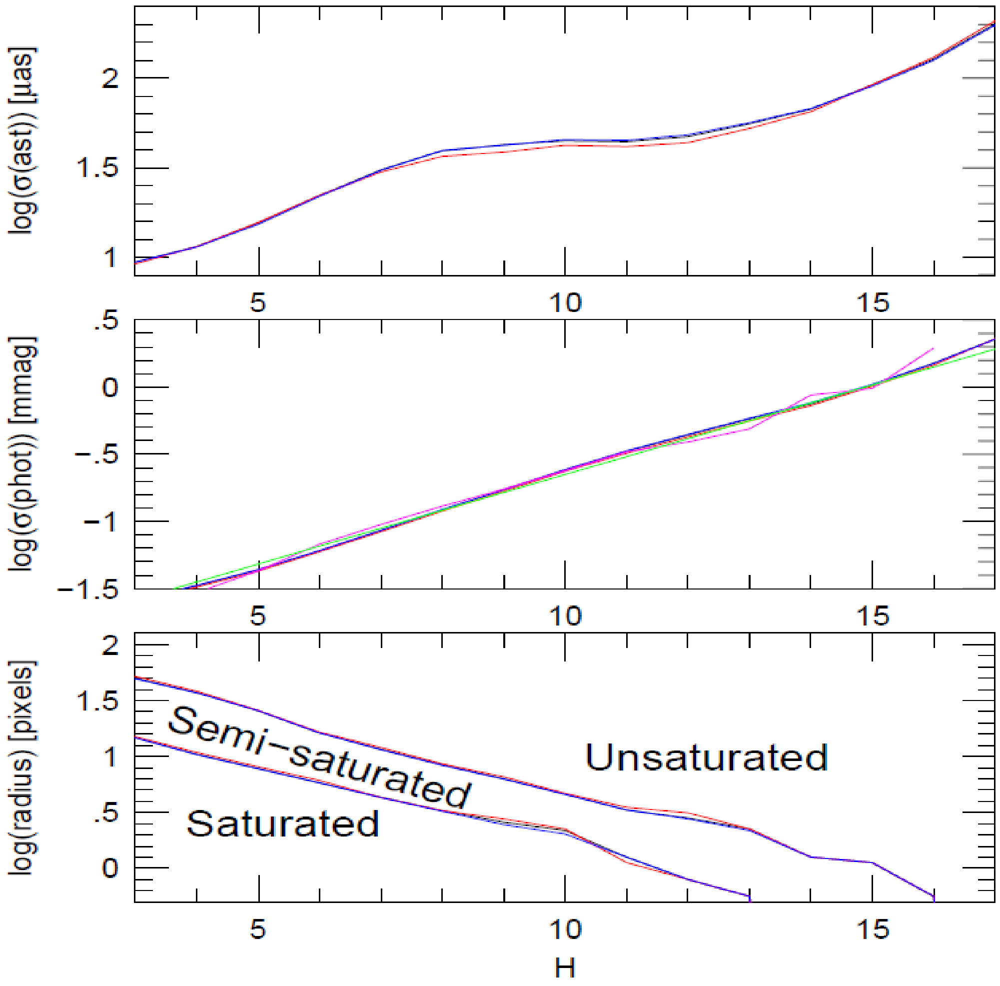




Age & [Fe/H] for 7,000,000 stars (first four panels) [needs V/I-band]

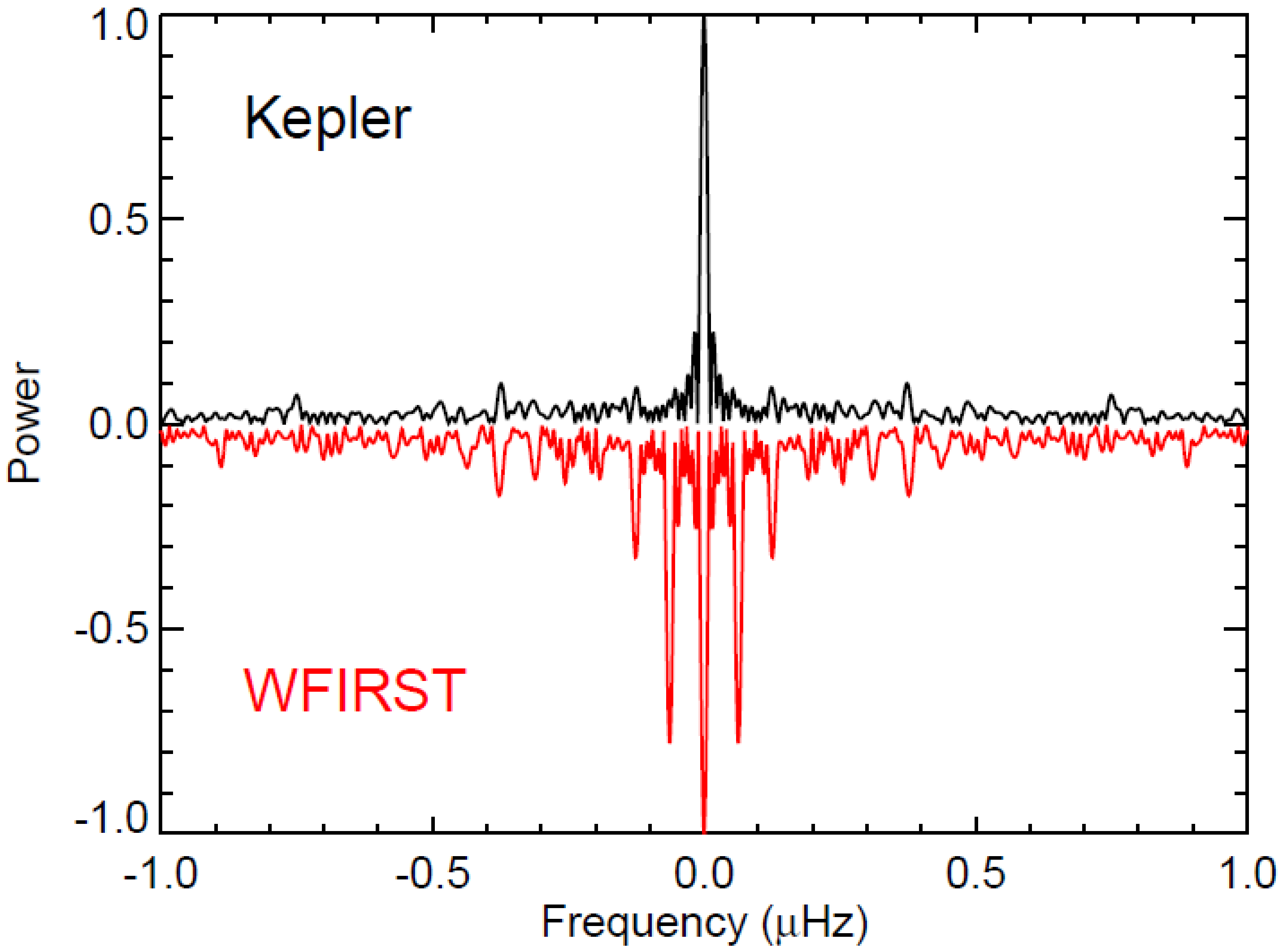


Non-Microlensing WFIRST Science:
Ultra-precise Parallaxes and Photometry



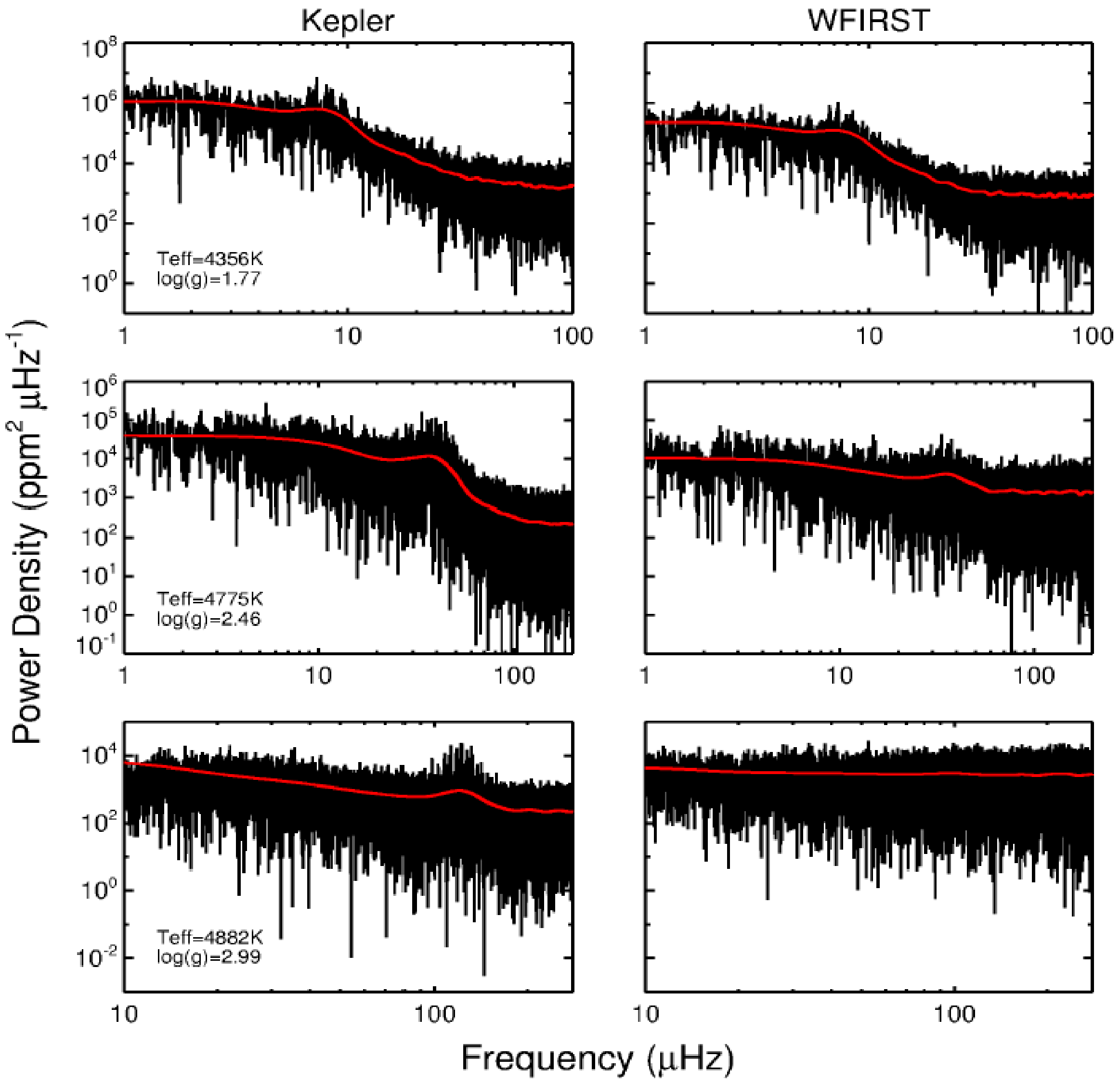
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

Non-Microlensing WFIRST Science: Asteroseismic Window Function



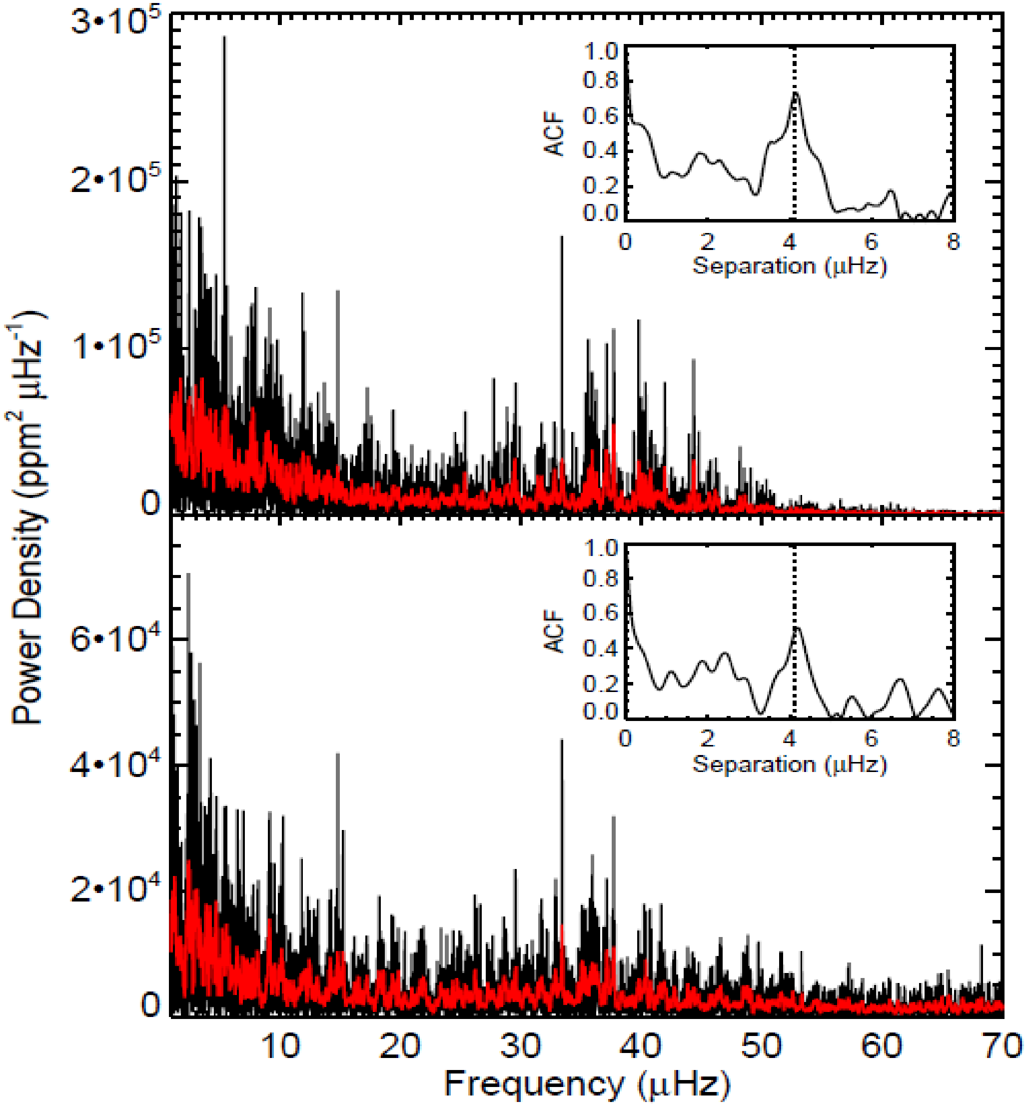
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

Non-μlens WFIRST Science: ν_{max}



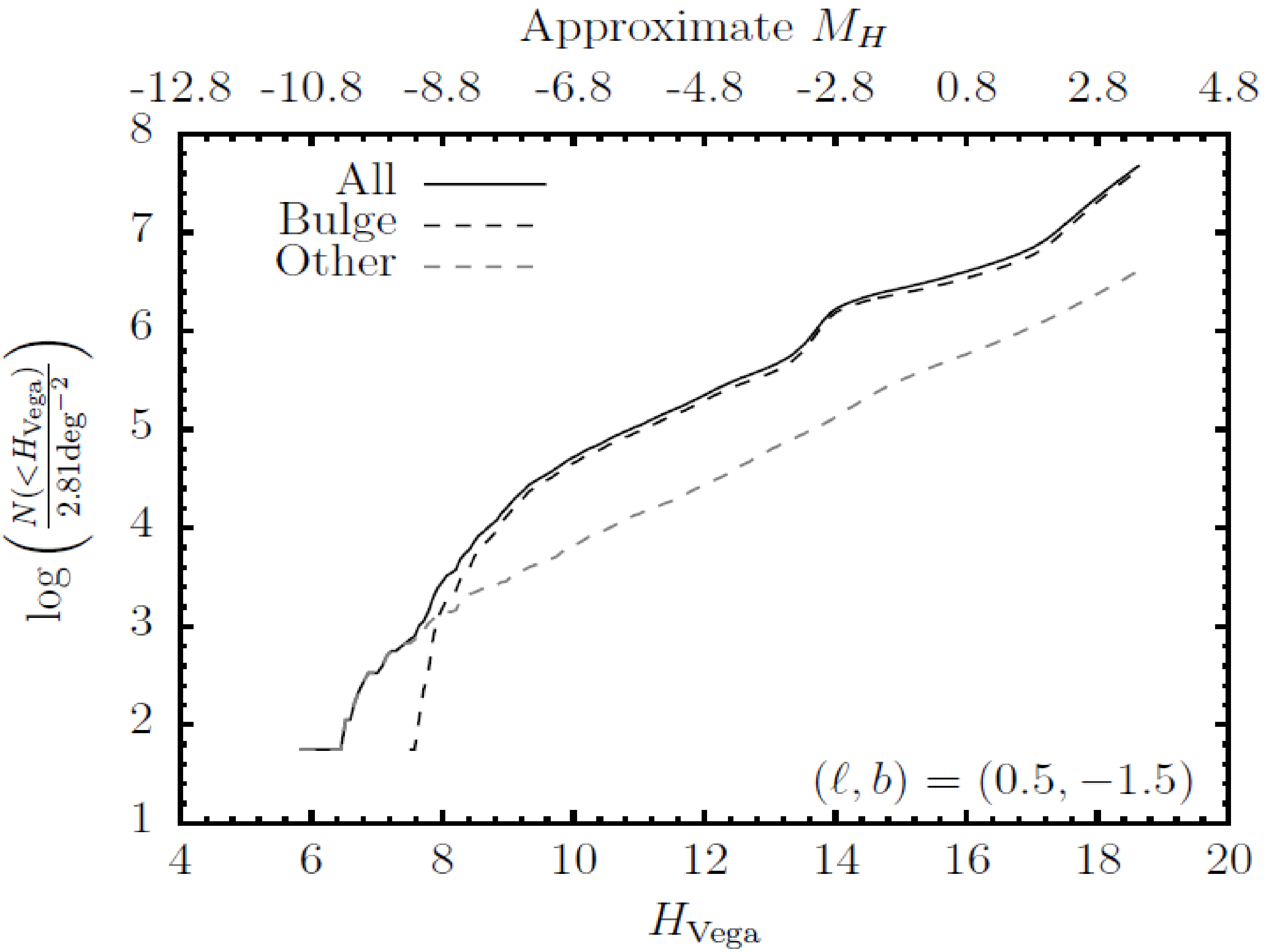
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

Non-μlens WFIRST Science: Δν



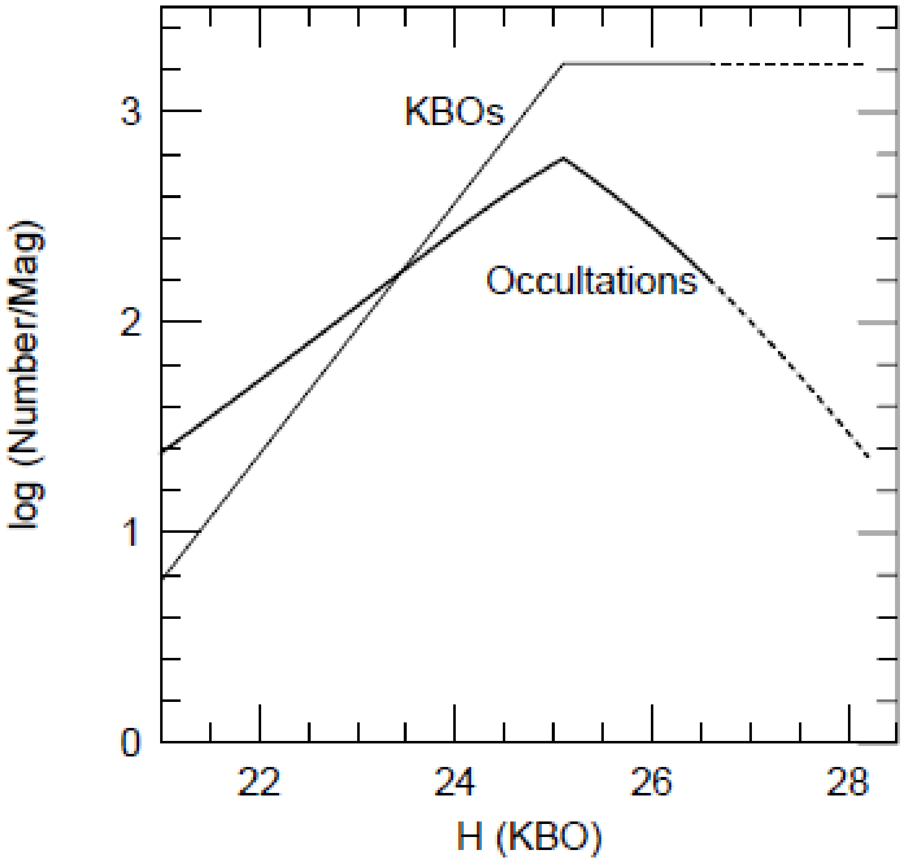
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

Non-μlens WFIRST Science: 10% Disk Stars



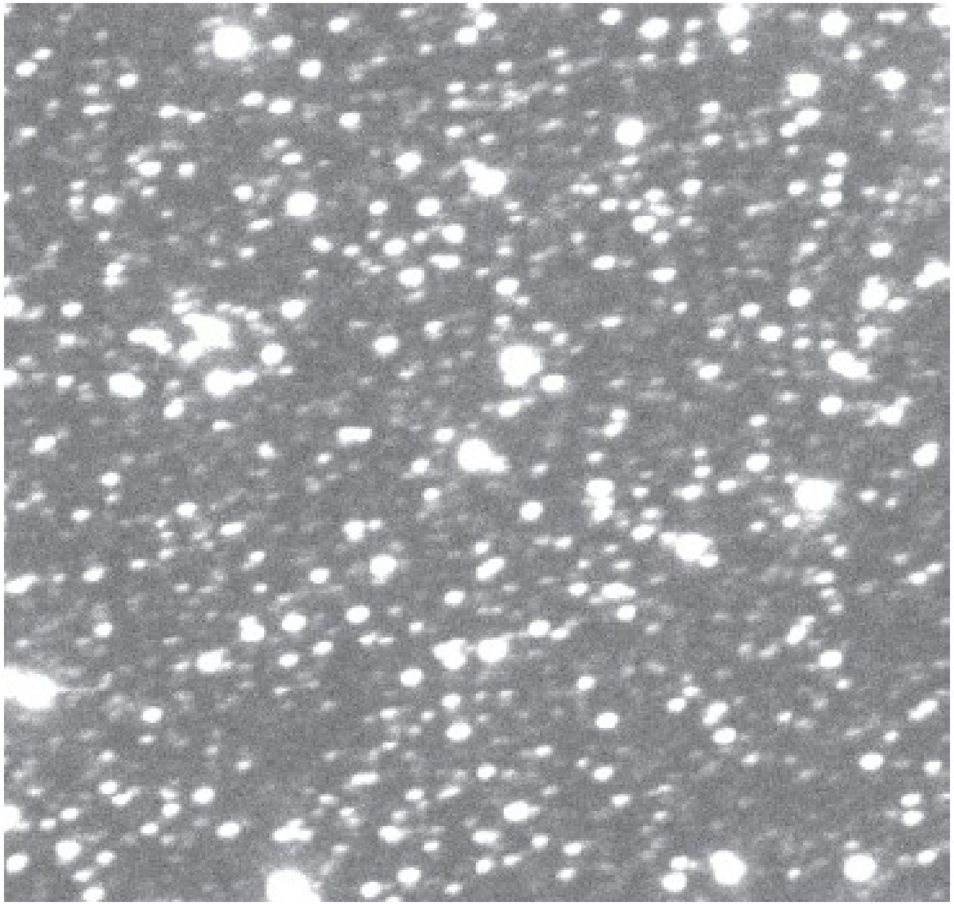
Gould, Huber, Penny, Stello, 2014 JKAS, sub.

Non-μlens WFIRST Science: KBOs



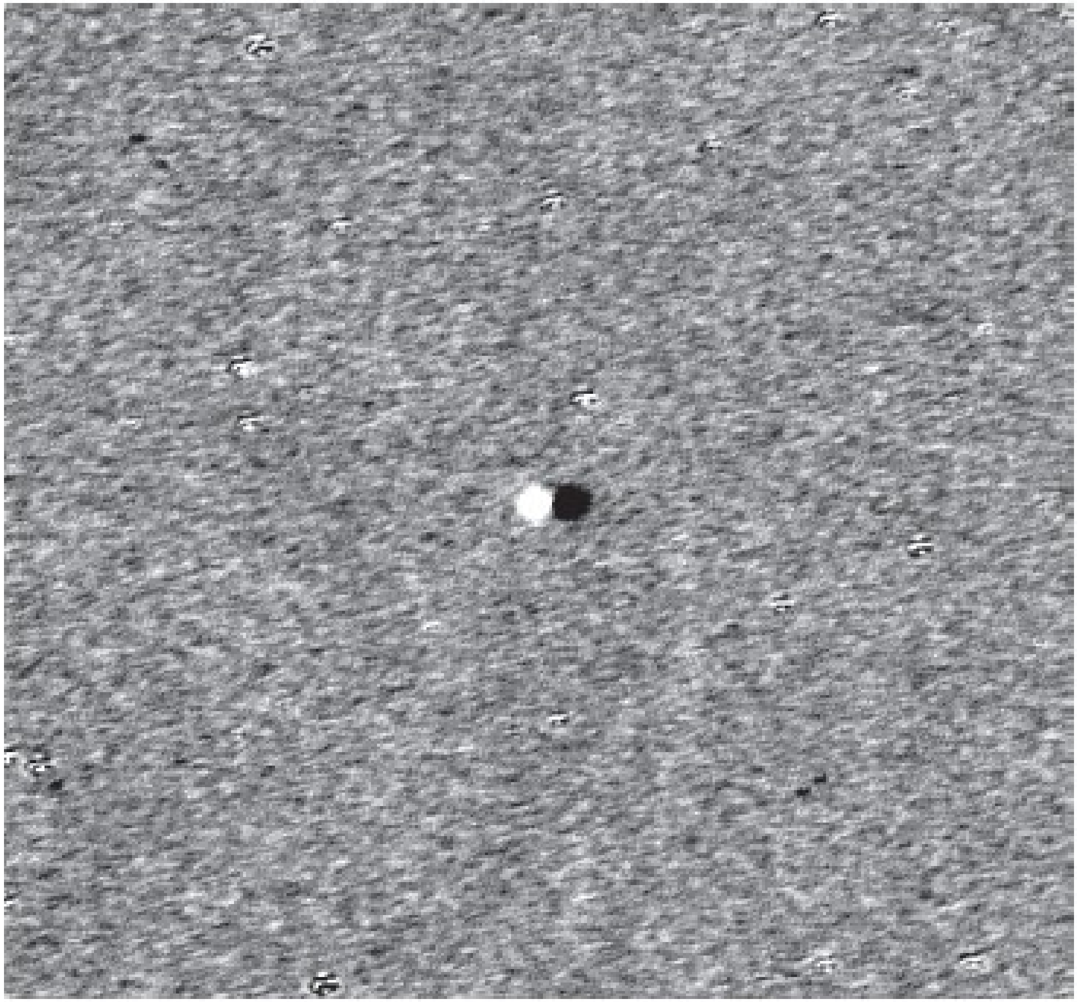
Gould 2014 JKAS, (almost) in press

KBOs possible in microlensing fields?



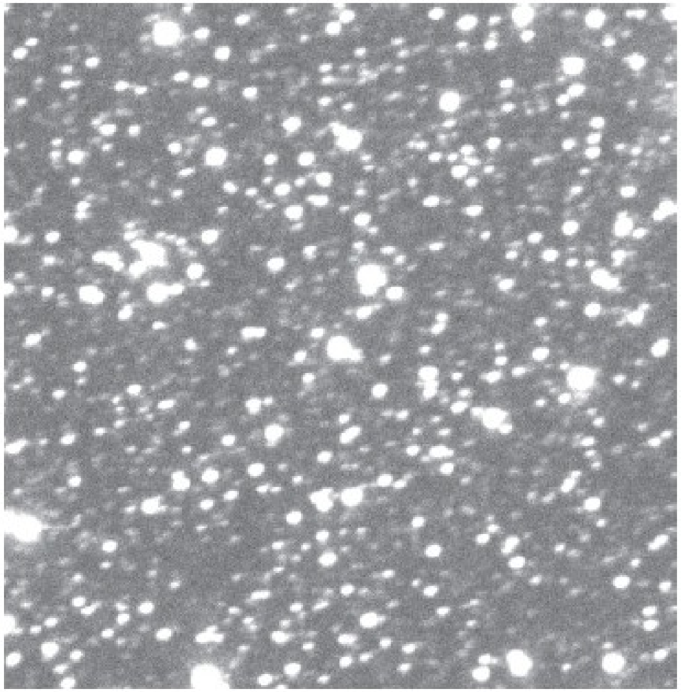
Shepard et al. 2011, AJ, 142, 98

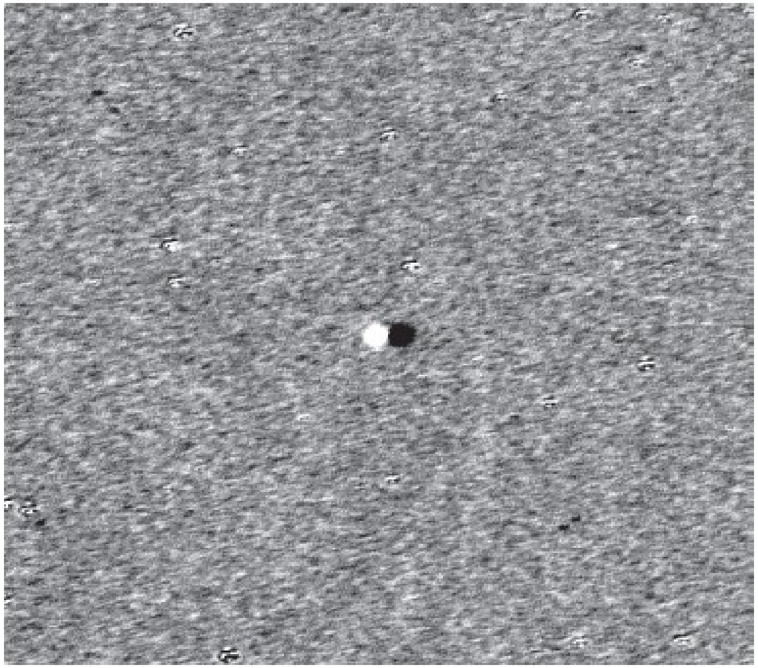
Yes! Microlensing fields are not crowded ...



Shepard et al. 2011, AJ, 142, 98

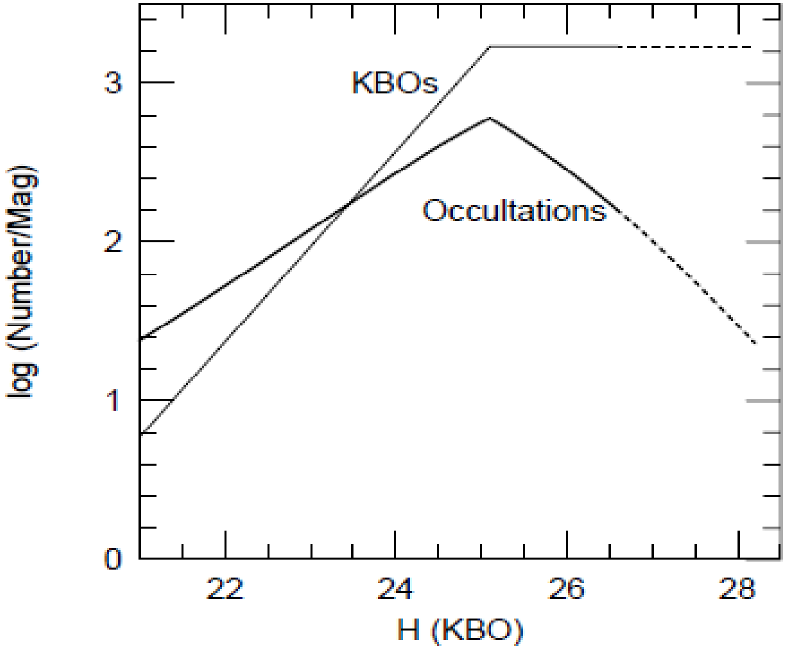
Yes! Microlensing fields are not crowded after image subtraction!





Shepard et al. 2011, AJ, 142, 98

Non-μlens WFIRST Science: KBO Precision orbits



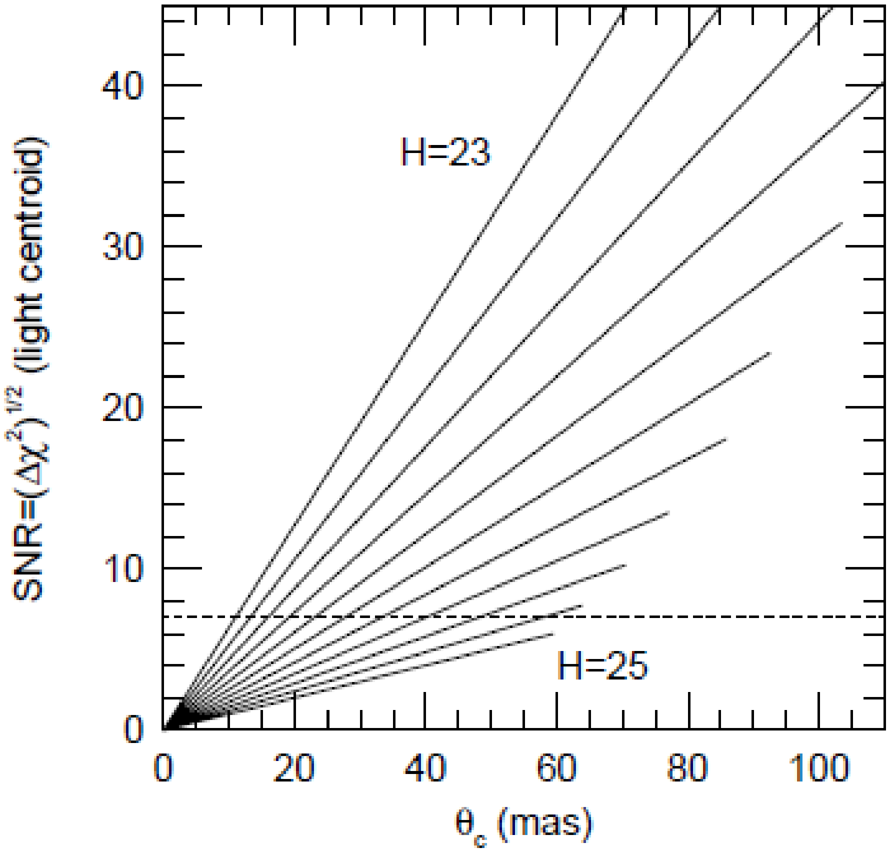
$$\sigma(P)/P \sim 0.09\%$$

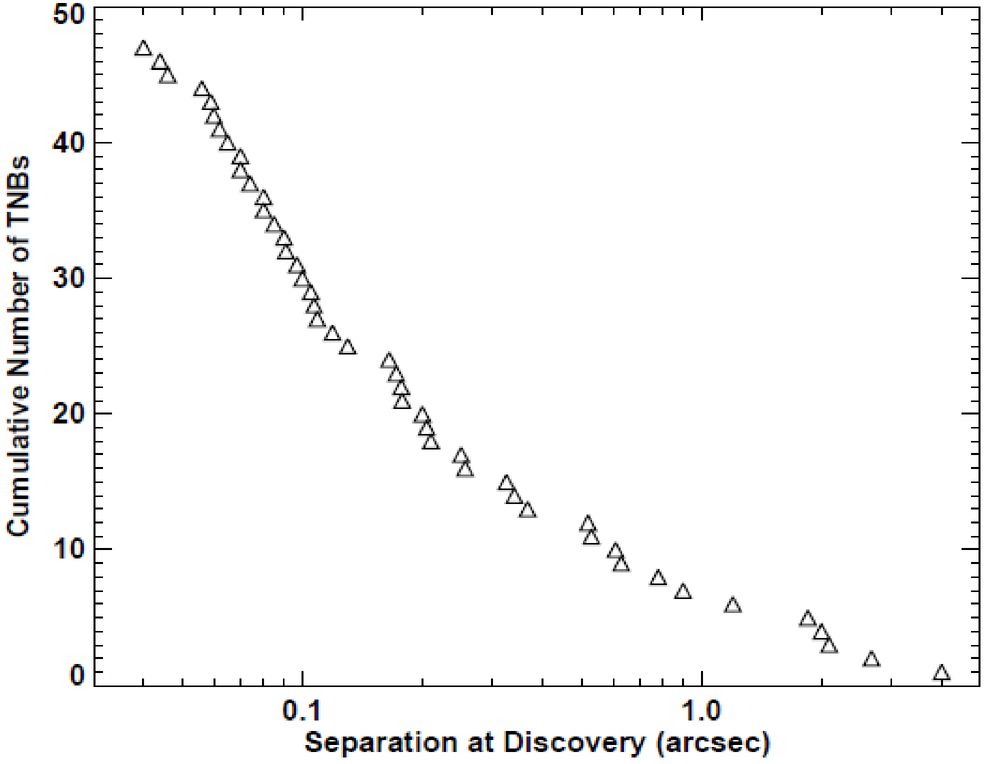
$$H \sim 25.1$$

Gould 2014 JKAS, (almost) in press

Non-μlens WFIRST Science:

KBO Binaries





Gould 2014 JKAS, (->) in press; Noll et al. 2008

Non-μlens WFIRST Science: Transits:
-> Galactic Distribution of Hot Planets

- Bulge G dwarf: 8 mmag
- $\Delta\chi^2 = 100$ requires: $p_{\rm transit} = 0.0025/(\delta/0.008)$
- Jupiters: $a < 160\ R_{\rm sun}$; $P < 250$ days
- Neptunes: $a < 25\ R_{\rm sun}$; $P < 15$ days
- Earths: (not feasible at bulge)

Non-μlens WFIRST Science:
BH + NS in Wide Orbits

- BH+star (5+1) -> 500 μas orbit at P = 5 yr
  - ==> 50 σ detection for 120,000,000 stars
  - ==> 17 σ at P=1 yr
- NS+star (1.4+1) -> 270 μas orbit at P = 5 yr
  - ==> 27 σ detection for 120,000,000 stars
  - ==> 9 σ at P=1 yr

Non-Planet WFIRST μlens Science:
Isolated BH Mass & Velocity Functions

(Gould & Yee 2014 ApJ 784 64)

Conclusions

- WFIRST “microlensing” survey:
  - Will deliver far more astrophysics than μlensing
- WFIRST astrometry: 100 X better than GAIA
  - 40,000,000 stars: $\sigma(\pi) < 4$ μas
  - 1,000,000 stars: $\sigma(\pi) < 0.3$ μas
  - Will RESOLVE Galactic Bugle in Depth
- WFIRST Ages 7,000,000 stars
- WFIRST photometry < 1mmag: 1,000,000 stars
  - Asteroseismology for bulge clump & brighter
- At faint end: Precision orbits for 4000 KBOs
- + Transits, BH/NS companions for 1.2e8 stars