

PRIME Wide FOV 1.8m Telescope at SAAO

Funded by JSPS

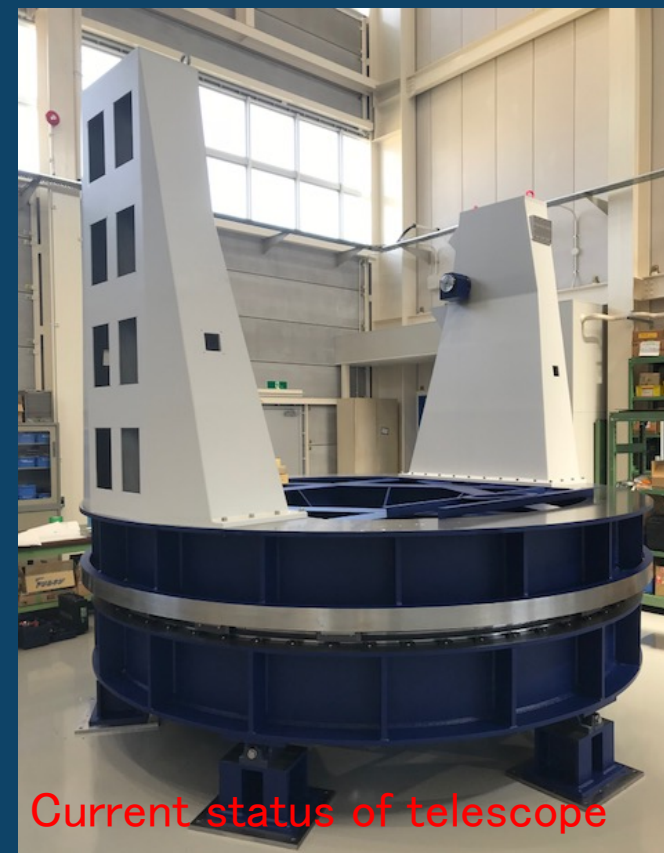
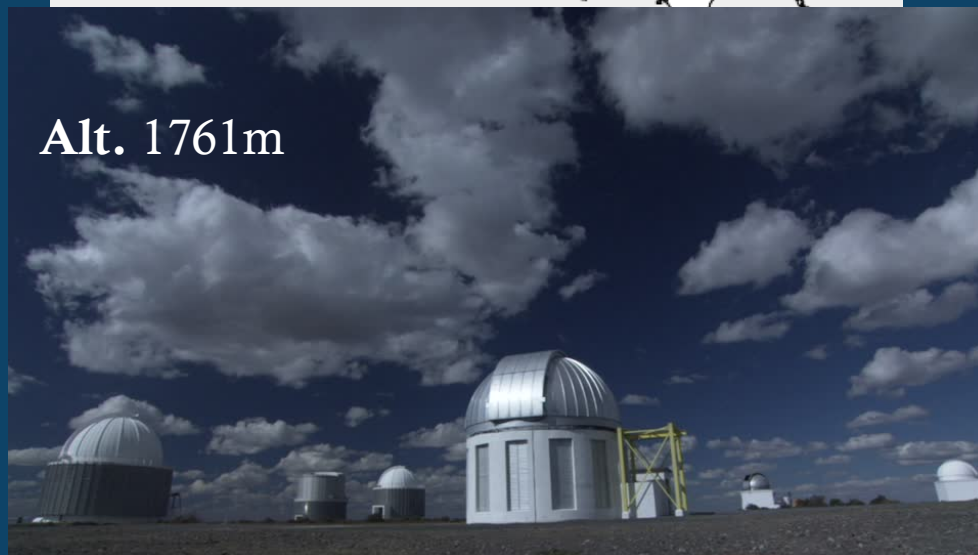


Diameter: 1.8m, (f/2.29)

FOV: $1.25\text{deg}^2 = 1.56\text{deg}^2 (0.5''/\text{pix})$

(6x full moon) **World Largest FOV**

With H-band Hi-res spectrograph



PRIME (PRime-focus Infrared Mirolensing Experiment)

Objectives:

1. Microlensing Exoplanets ($\sim 50\%$)

- Study low-mass planets outside of snowline
- Planet frequency in the Galaxy Center
- WFIRST microlensing survey field optimization
- Concurrent observations with WFIRST

2. Other sciences ($\sim 50\%$)

- IR RV survey
- IR transit
- Transient GW, GRB, SNe etc.

PRIME collaboration

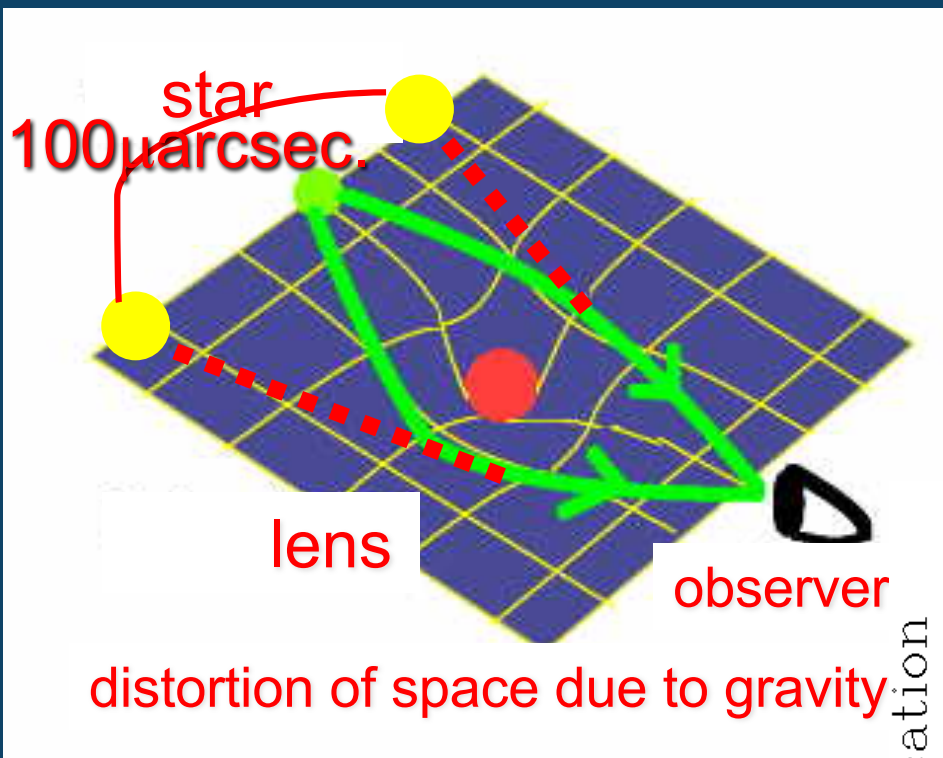
- **Osaka Univ.:** T Sumi (PI), H. Shibai, T. Matsuo, Naoki Koshimoto Yuki Hirao , M. Nagakane
- **ABC (Astro-Biology Center):** M. Tamura (Director. & U Tokyo)
- **JAXA:** D. Suzuki
- **NASA GSFC:** D. Bennett, R. K. Barry , Alexander Kuttyrev,
- **U of Maryland:** Sylvain Veilleux, Drake Deming
- **SAAO:** David Buckley, Ted Williams +

Bond(Massey U), N. Rattenbury (U Auckland), J-P. Beaulieu (IAP), A. Fukui (NAOJ), T. Nagayama (Kagoshima U), N. Matsunaga, Norio Narita (U Tokyo), Yasushi Muraki, Fumio Abe (Nagoya U), Mikio Kurita (Kyoto U), Joachim Wambsganss, Luigi Mancini (U Heidelberg), Eamonn Kerins (U Manchester), David Charbonneau (Harvard, Mearth PI, TESS CoI) , Cullen Blake (Pennsylvania, TESS CoI)

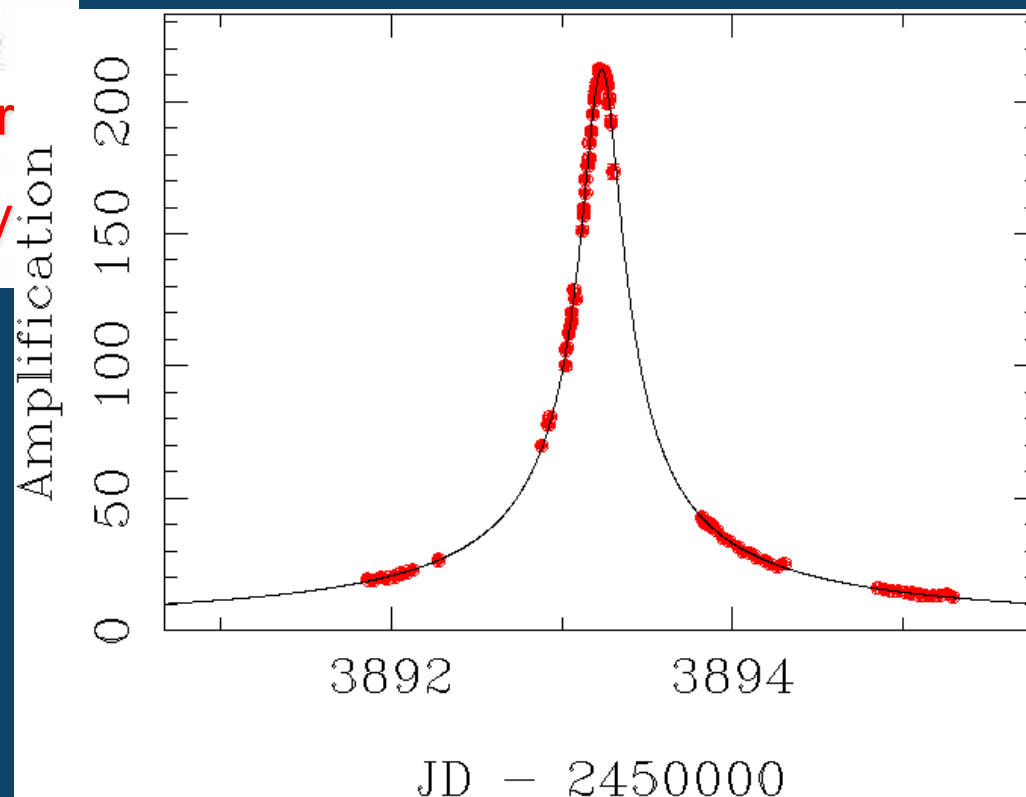
Gravitational Microlensing



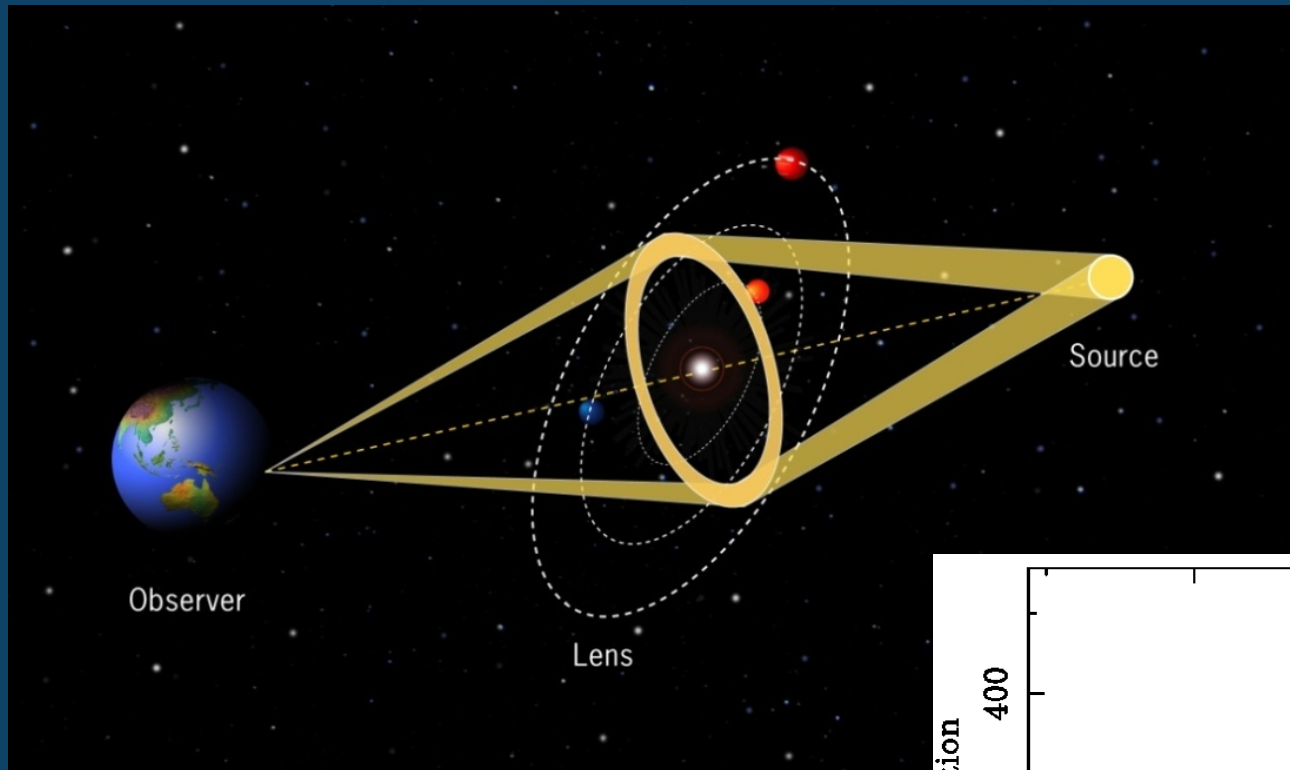
Science, 1936



- ✧ If a lens is a star, elongation of images is an order of $100\mu\text{arcsec.}$
- ✧ Just see a star magnified

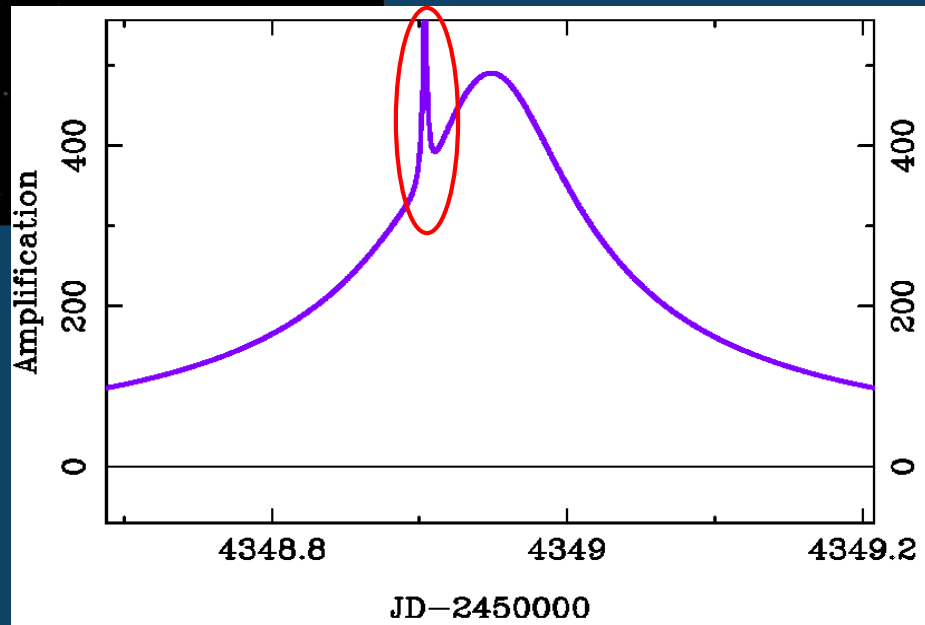


planetary microlensing

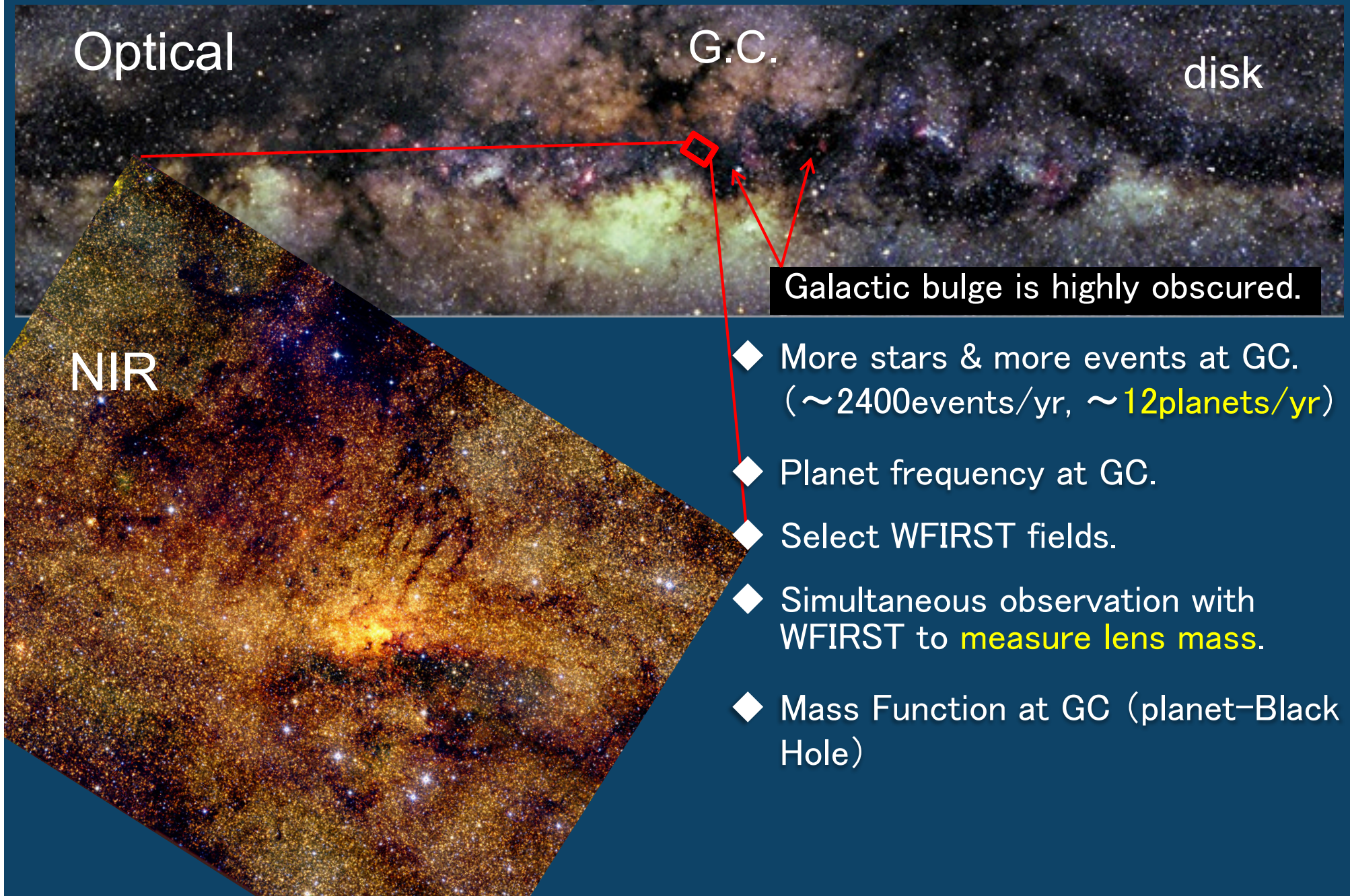


Time scale: $t_p \sim M^{1/2} \sim 1 \text{ day} (M_J)$
 $\sim \text{a few hours} (M_E)$

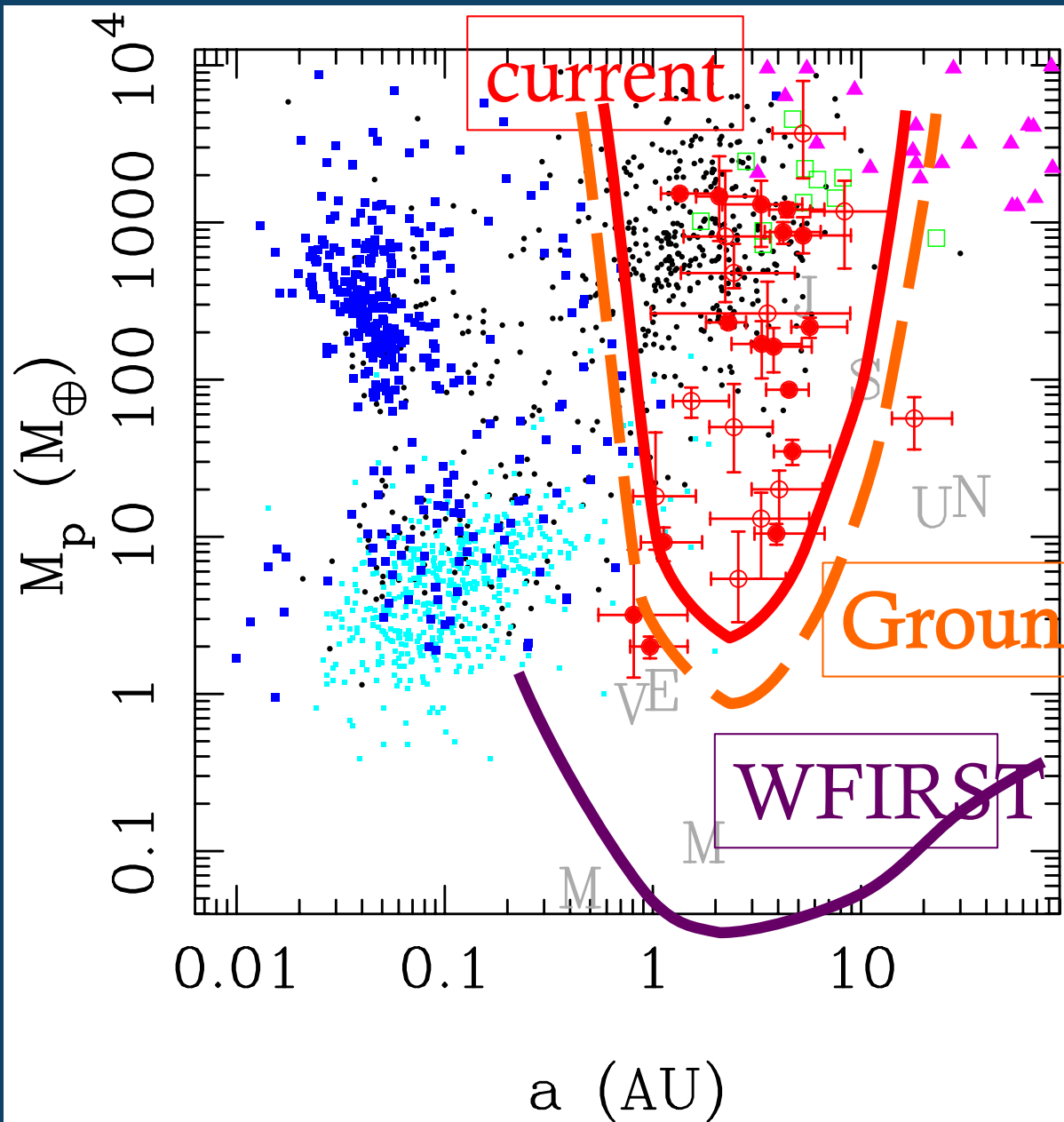
Sensitive to Cold planets
outside of snowline ($\sim 3a_{\text{snow}}$)



More events & planets in NIR at G.C.



Discovered exoplanets and sensitivity



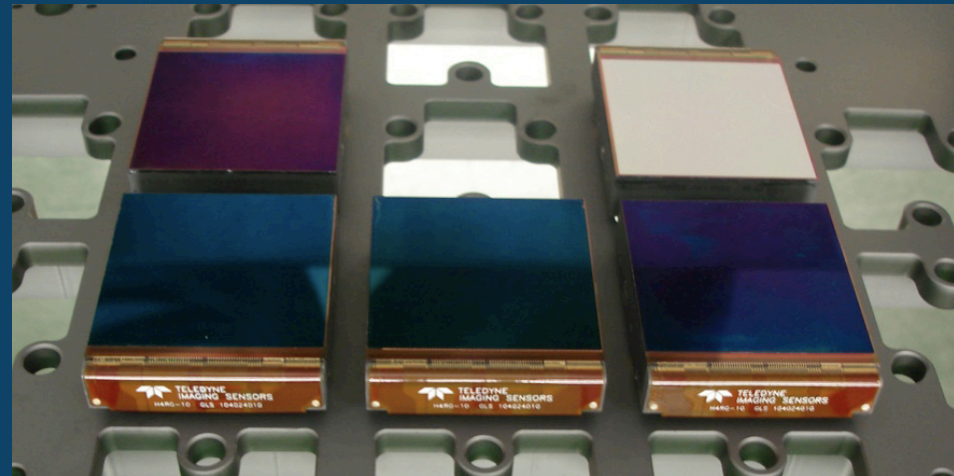
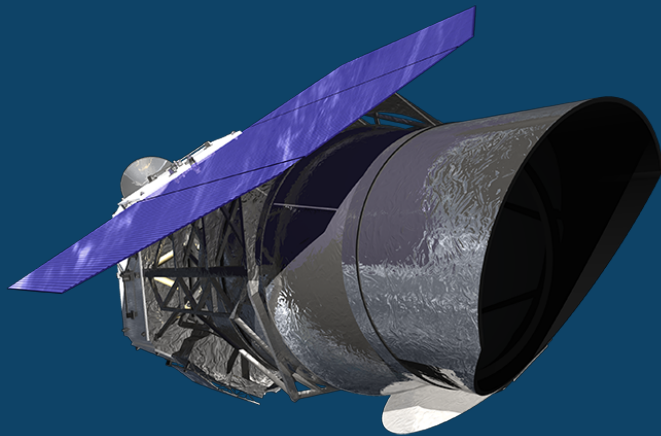
- RV
- Transit (Kepler)
- Direct image
- Microlensing
- Mass measurements
- Mass by Bayesian

Ground NIR survey

WFIRST

The World Widest FOV in NIR with World Largest class NIR camera

Loan Four Teledyne HgCdTe 4kx4k H4RG-10 (10 μ m pitch)
from WFIRST team (NASA)



Four H4RG-10 which WFIRST
Team owns. (1 chip is dummy)

Diameter: 1.8m, f/2.29,

FOV: 1.25° x 1.25° = 1.56deg²

0.5arcsec/pix

Will be Manufactured by University of Maryland @GSFC

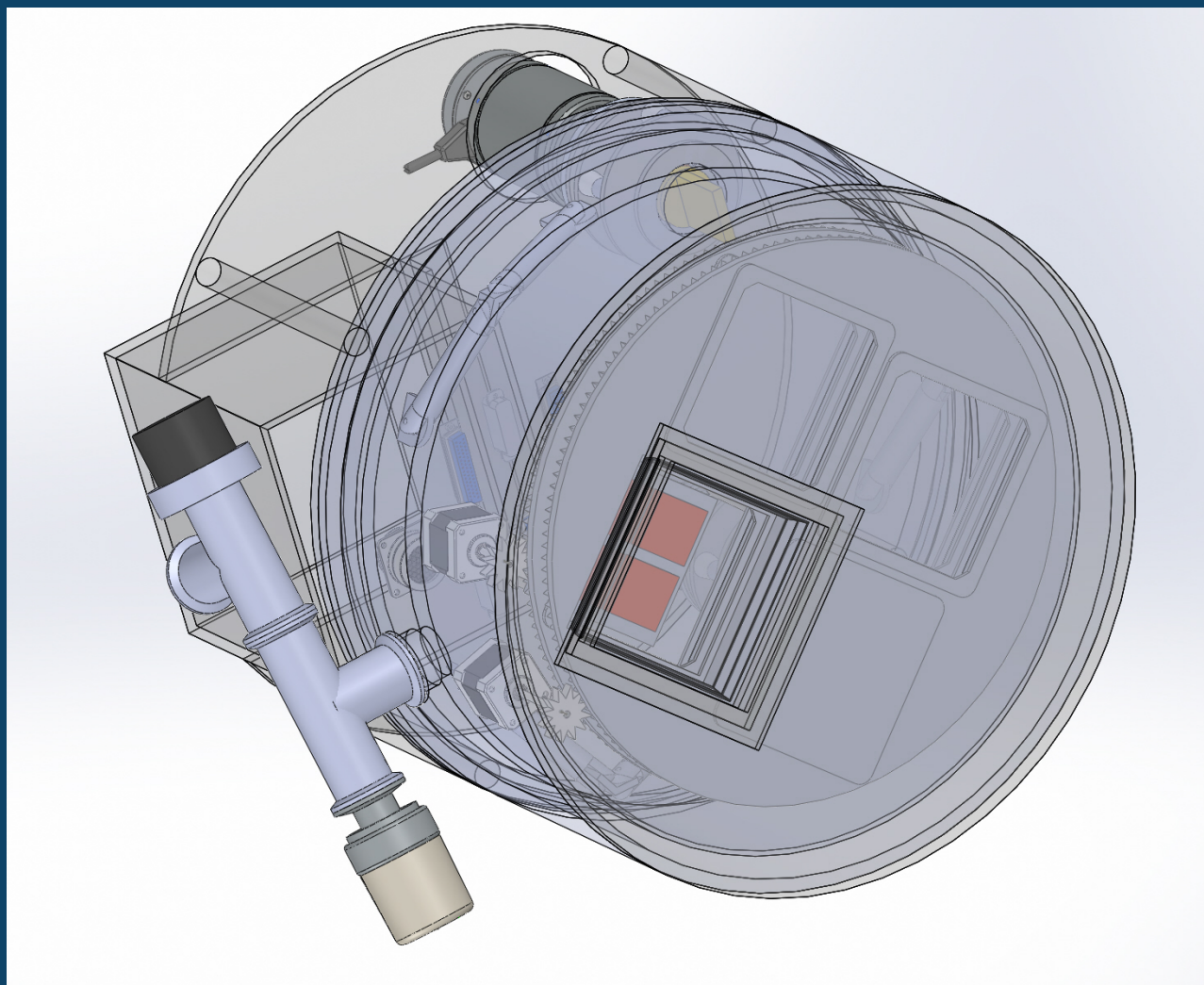
Camera

Alexander Kuttyrev (NASA/GSFC,UMD)

Yuki Hirao (Osaka U./GSFC:D2)

manufactur@GSFC

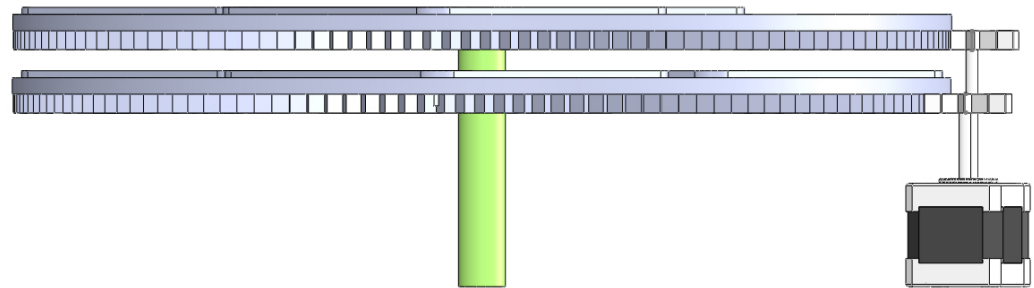
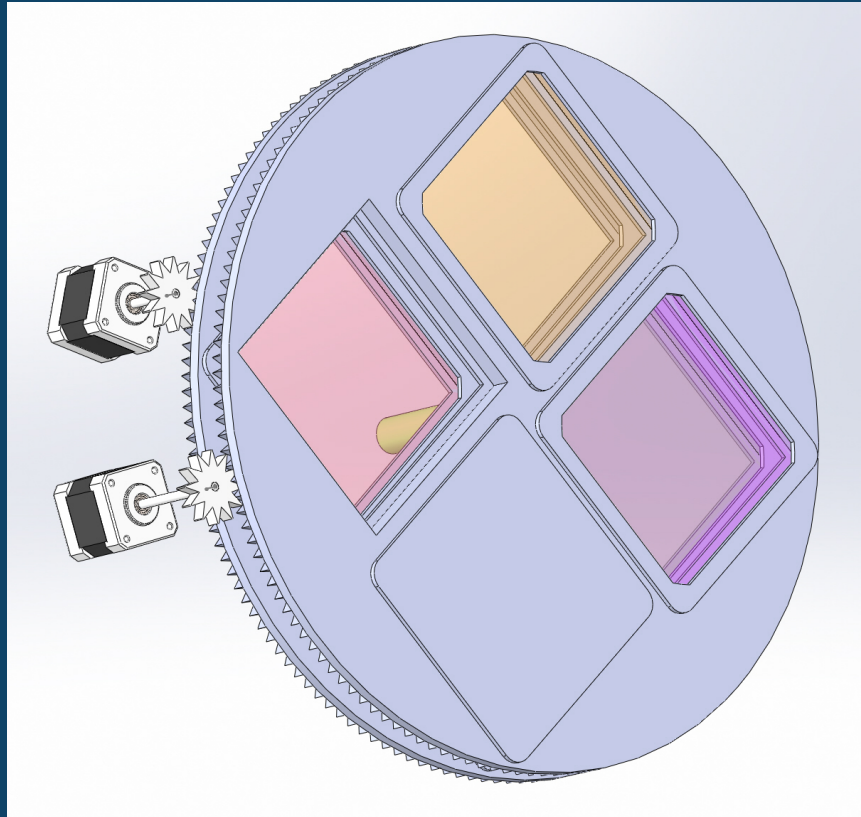
- 4 H4RG-10
- 2GTcryocooler
- 2 filter wheels



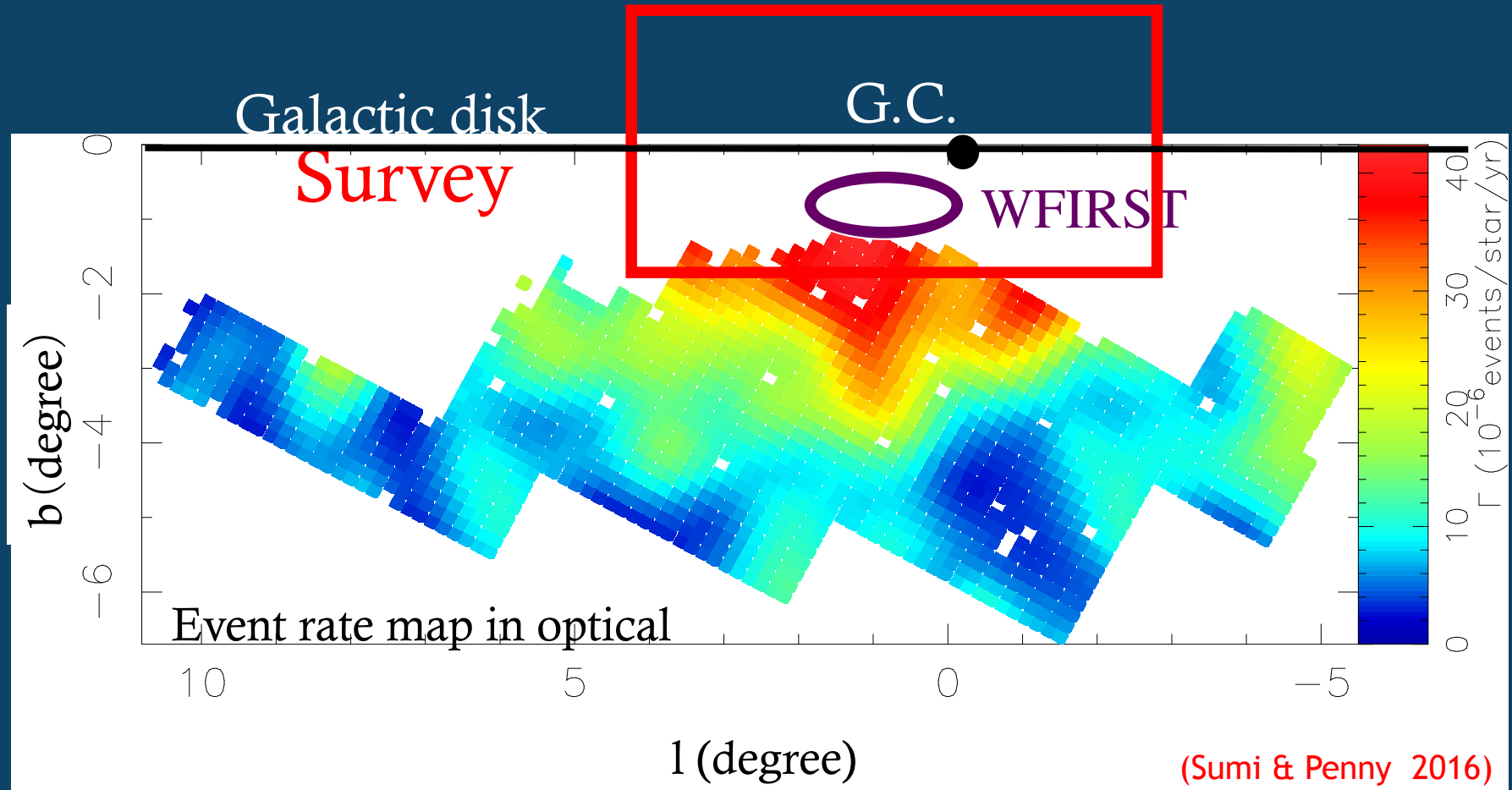
Filter wheels

Filter size: 112mm x 112mm

5 filters: z, Y, J, **H (Primary)**,
+Narrow band ([FeII], Pa β ,
HeI etc)



Study the galactic structure & Optimize WFIRST microlensing survey fields by mapping the event rate in NIR



Event rate vary by a factor of 2 (peak is at $l=1^\circ$)

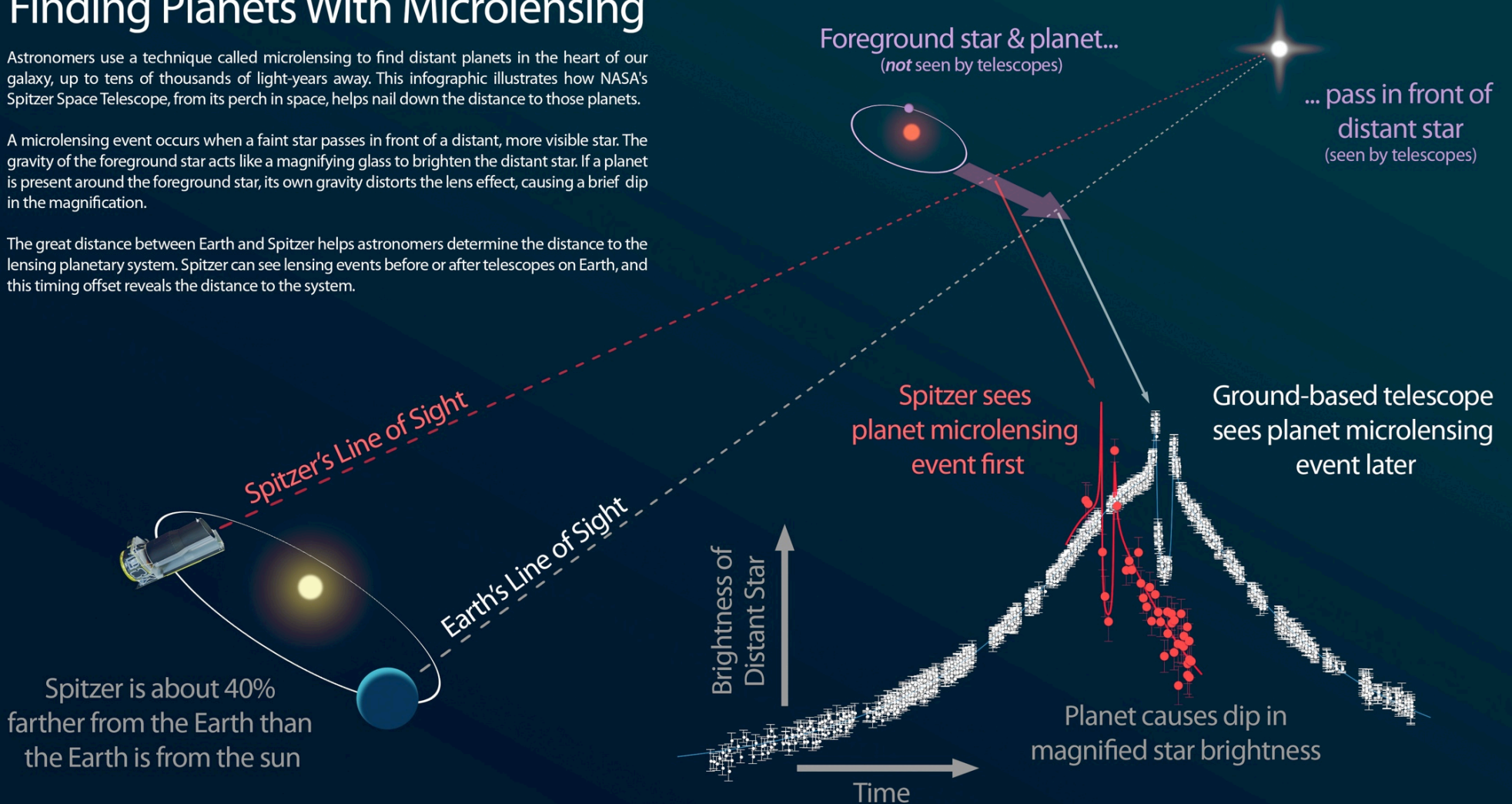
Mass Measurements via Simultaneous WFIRST-Ground obs.

Finding Planets With Microlensing

Astronomers use a technique called microlensing to find distant planets in the heart of our galaxy, up to tens of thousands of light-years away. This infographic illustrates how NASA's Spitzer Space Telescope, from its perch in space, helps nail down the distance to those planets.

A microlensing event occurs when a faint star passes in front of a distant, more visible star. The gravity of the foreground star acts like a magnifying glass to brighten the distant star. If a planet is present around the foreground star, its own gravity distorts the lens effect, causing a brief dip in the magnification.

The great distance between Earth and Spitzer helps astronomers determine the distance to the lensing planetary system. Spitzer can see lensing events before or after telescopes on Earth, and this timing offset reveals the distance to the system.



Off-bulge season sciences

● Transit search for M-dwarfs:

- Search for habitable planets around M-dwarf which is bright in IR
- Follow-up transit candidates by HAT-South, Mearth projects for select real planets and measure the atmosphere.
- Systematics due to Sunspot and limb darkening is smaller in IR.
- Wide FOV enable us to observe many reference stars for high precision photometry.
- Follow-up TESS candidates. TESS is optical. Need IR for M-dwarfs. Collaborators:

David Charbonneau (Harvard, Mearth PI, TESS CoI) 、
Cullen Blake (Pennsylvania, TESS CoI) 、
Narita (NAOJ, TESS CoI) 、 Fukui (Okayama)

● Search for counterparts of high-z GRB, GW etc.

→ ToO observation

● H-band spectrograph: RV for giant planets around M-dwarf.

Schedule

2016 detail design

2017 manufacture

2018 manufacture, construction

2019 install, first light.

2020 observation start

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2023 create event rate map in the bulge

2025 WFIRST launch,

Concurrent observation start

2030 continue to the end of the WFIRST

Summary

- PRIME is first NIR microlensing exoplanet survey
- Detect ~ 2400 events/yr & ~ 12 planets/yr down to **Earth-mass planet** outside of the snowline
- **Galactic distribution** of exoplanets
- Optimize WFIRST fields
- **Simultaneous observation with WFIRST to measure lens mass.**
- Mass Function at GC (planet-Black Hole mass)
- **Other sciences w/ bulge data**
- **H-band spectrograph: RV for giant planets around M-dwarf**