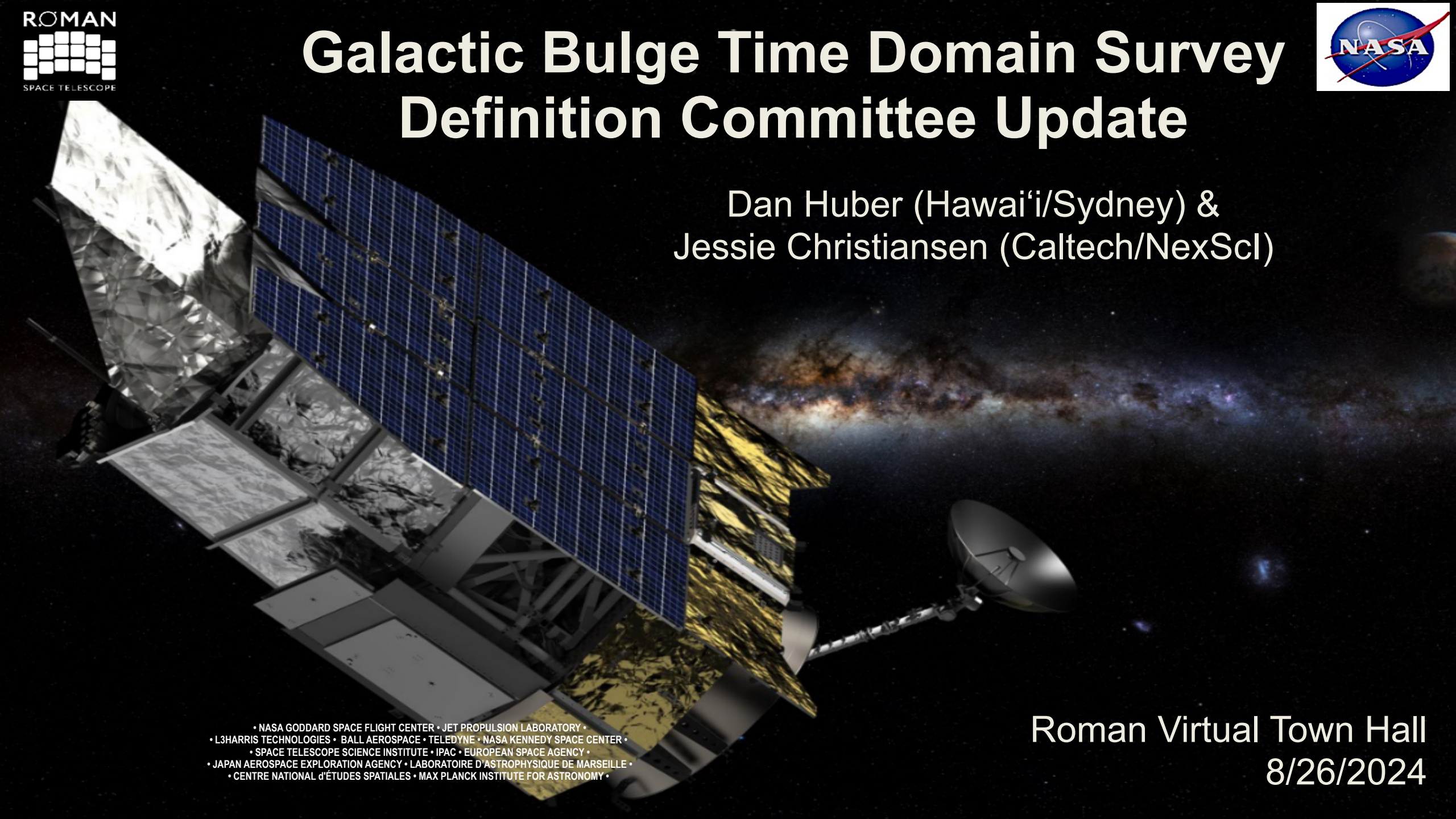
Galactic Bulge Time Domain Survey Definition Committee Update

Dan Huber (Hawai‘i/Sydney) &
Jessie Christiansen (Caltech/NexScI)



• NASA GODDARD SPACE FLIGHT CENTER • JET PROPULSION LABORATORY •
• L3HARRIS TECHNOLOGIES • BALL AEROSPACE • TELEDYNE • NASA KENNEDY SPACE CENTER •
• SPACE TELESCOPE SCIENCE INSTITUTE • IPAC • EUROPEAN SPACE AGENCY •
• JAPAN AEROSPACE EXPLORATION AGENCY • LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE •
• CENTRE NATIONAL d'ÉTUDES SPATIALES • MAX PLANCK INSTITUTE FOR ASTRONOMY •

Roman Virtual Town Hall
8/26/2024

Roman Observational Program

Large Core Community Surveys (CCS) *majority of observing time*

Dark Energy

High-latitude wide area survey
Enables Weak Lensing, Baryon Acoustic Oscillation cosmology investigations

High-latitude time-domain survey
Enables Supernovae Ia cosmology investigations

Exoplanets

Galactic Bulge time-domain survey
Enables exoplanet microlensing investigations

Astrophysics with Wide Field IR Surveys

General Astrophysics Surveys (GAS) *at least 25% of observing time*

- Include **Galactic Plane Survey** (Early Definition Community Call)
- Primarily selected via a peer-review process
- First call for proposals Oct 2025

Archival Investigations

- All data will be public immediately
- Anticipated to be main component of community involvement

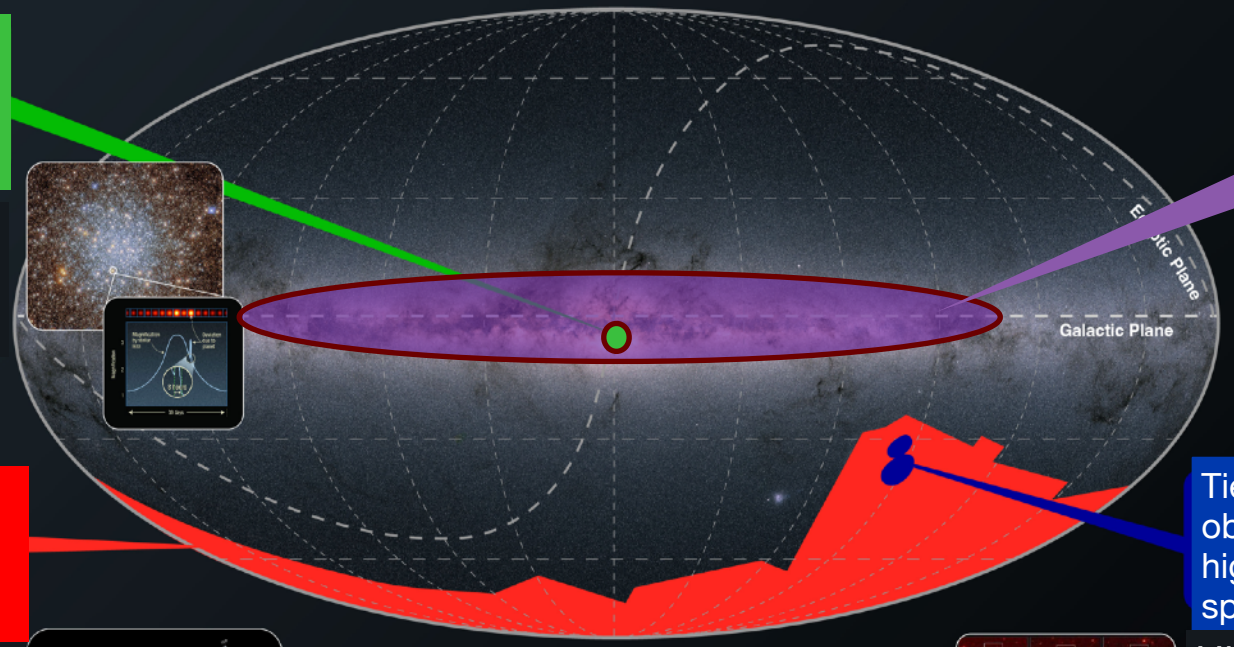
Also Coronagraph Technology Demonstration Observations

Roman Core Community Surveys (CCS)

Example implementation:

~< 15 min cadence observations over few deg² towards Galactic bulge

Galactic Bulge Time Domain Survey

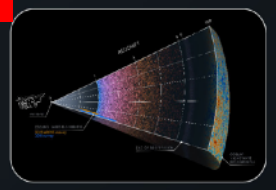


Galactic Plane Survey

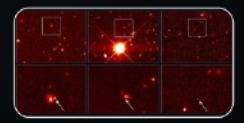
~1000 deg² in three bands (~JHK)

Wide area (thousands of deg²) survey including multiband imaging and slitless spectroscopy

High Latitude Wide Area Survey



Tiered, multiband time domain observations of ~10s of deg² at high latitudes with slitless spectroscopy



High Latitude Time Domain Survey

ROMAN SPACE TELESCOPE

Core Surveys

Roman Space Telescope's larger view and fast survey speeds will unveil the evolving universe in ways that have never been possible before.

GBTDS Definition Committee Members

Jessie Christiansen
(NExScI/Caltech, Co-chair)

Dan Huber
(UH/USyd, Co-chair)

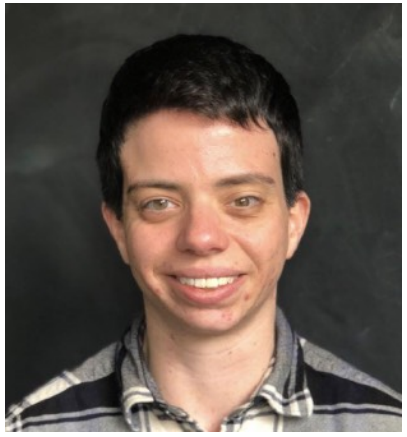
Annalisa Calamida
(STScI)

Jennifer Sobeck
(IPAC)

Matthew Penny
(LSU), PIT Liasion

Ben Montet (UNSW)

Hans-Walter Rix (MPIA)



Kris Pardo (USC)

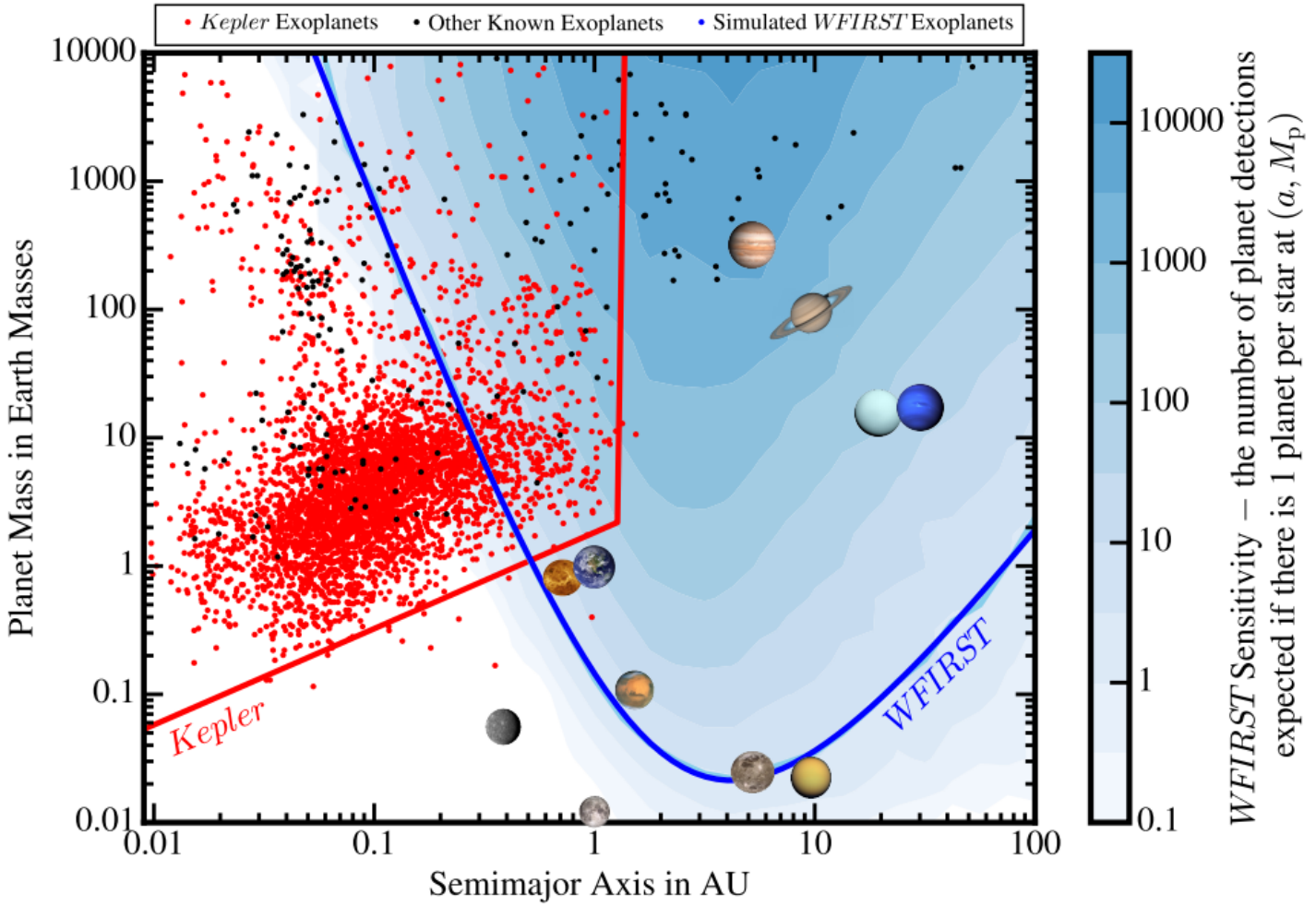
Jessica Lu (Berkeley)

Eduardo Martin (ESO)

Solar system liaisons: Susan Benecchi (PSI) & Rosemary Pike (CfA)

Roman GBTDS: Science Requirements

Roman will carry out a statistical census of exoplanetary systems in the Galaxy, from the outer habitable zone to free floating planets, including analogs to all of the planets in our Solar System with the mass of Mars or greater, by monitoring stars toward the Galactic bulge using the microlensing technique.



Penny+ 2019

Roman GBTDS: Science Requirements

EML 2.0.1: RST shall be capable of measuring the mass function of exoplanets with masses in the range 1 M_{Earth} < m < 30 $M_{Jupiter}$ and orbital semi-major axes ≥ 1 AU to better than 15% per decade in mass.

EML 2.0.2: RST shall be capable of measuring the frequency of bound exoplanets with masses in the range 0.1 M_{Earth} < m < 0.3M_{Earth} to better than 25%.

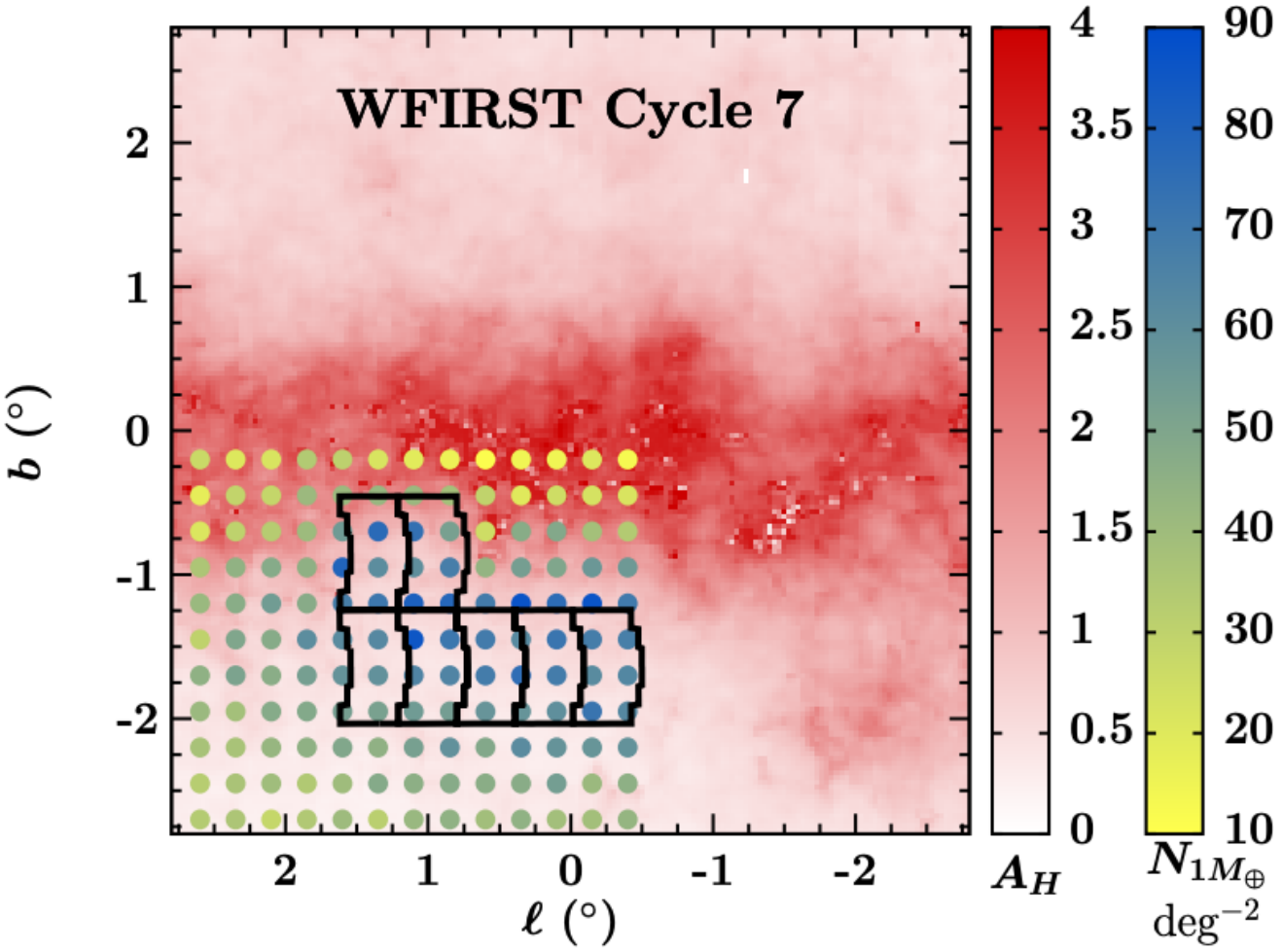
EML 2.0.3: RST shall be capable of determining the masses of, and distances to, host stars of 40% of the detected planets with a precision of 20% or better.

EML 2.0.4: RST shall be capable of measuring the frequency of free floating planetary-mass objects in the Galaxy from Mars to 10 Jupiter masses. If there is one M_{Earth} free-floating planet per star, measure this frequency to better than 25%.

EML 2.0.5: RST shall be capable of estimating η_{Earth} (defined as the frequency of planets orbiting FGK stars with mass ratio and estimated projected semimajor axis within 20% of the Earth-Sun system) to a precision of 0.2 dex via extrapolation from larger and longer-period planets.

see white papers by Bennett+ and Yee+ for impact of survey design choices

Roman GBTDS: Science Requirements



Penny+ 2019

Penny+ 2019 survey:

- 6 x 72 day observing seasons
- 7 fields observed in each season (~2 deg^2 survey area)
- 15 minute cadence with broad filter
- 12 hour cadence with narrow filter

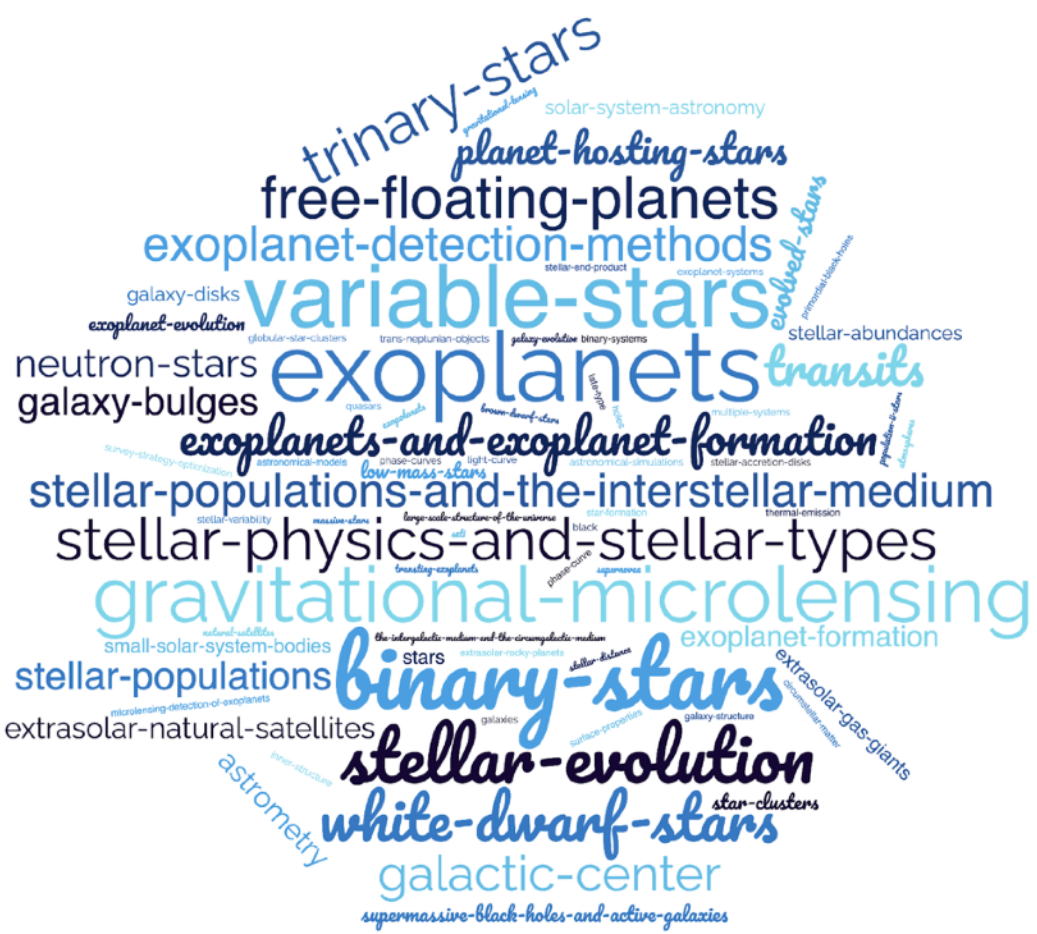
Survey changes considered:

(while meeting science requirements)

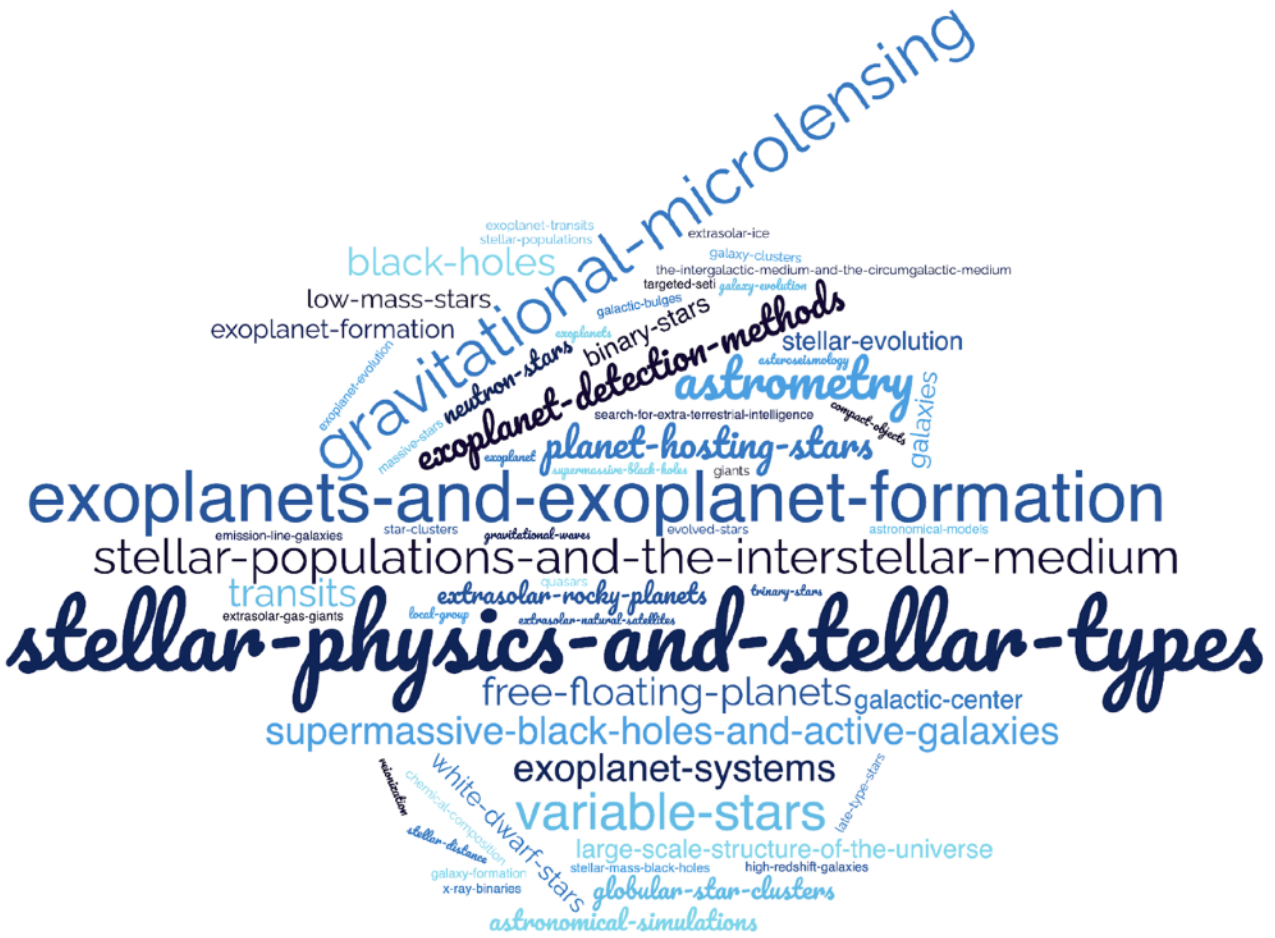
- 60-72 day observing seasons
- 5-9 fields observed in each season
- 7-15 minute cadence with broad filter
- 3-12 hour cadence with narrow filter(s)

Roman GBTDS: Community Input

23 White papers



43 Science Pitches



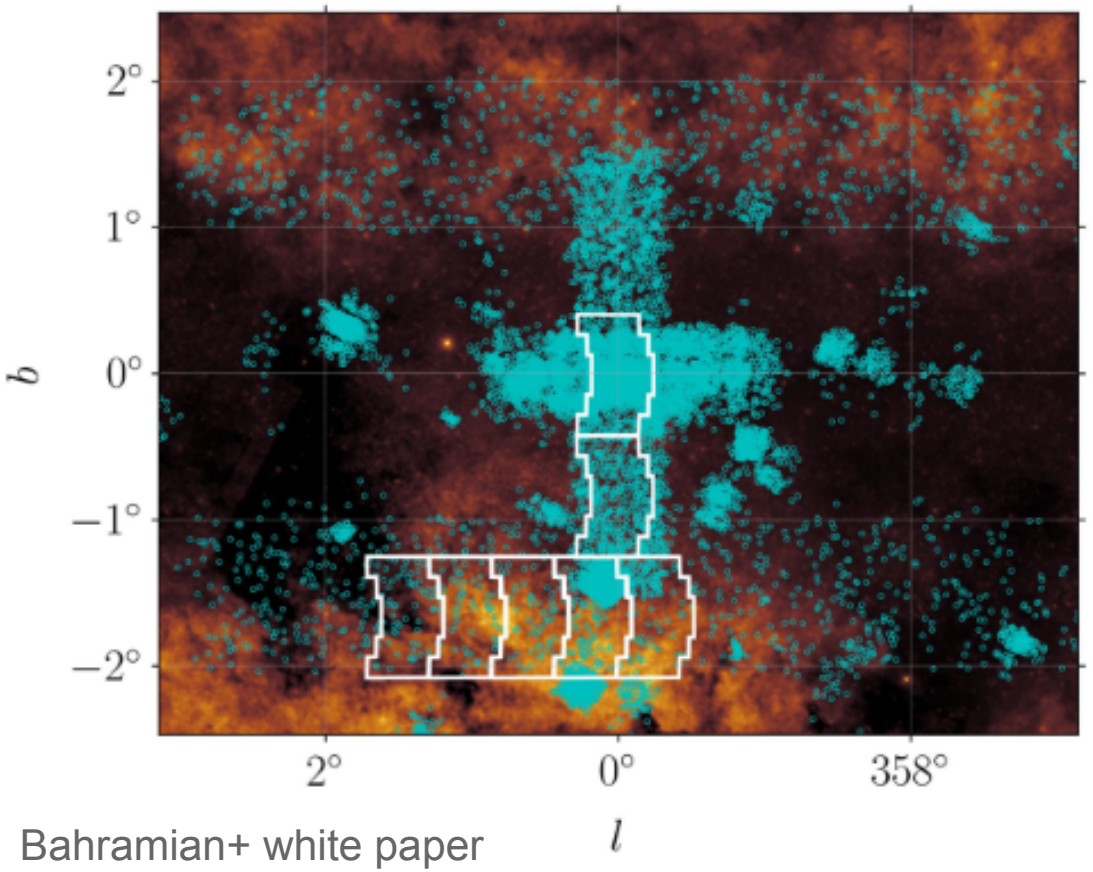
Follow-up call for updates sent to white paper authors in March 2024

GBTDS Definition Committee: Where we stand

- **Feb 2024:** Kick-off meeting
- **Mar 2024:** Design & organize review process for white papers & science pitches
- **Apr-Jun 2024:** Reviews, rankings & discussion of science ideas
- **Jul-Aug 2024:** Report to community for feedback and iteration.
  - Jul 9-12: Roman Science Conference, Pasadena, CA
  - Jul 24: Roman Community Forum (online)
  - **Aug 26: Virtual Town Hall (we are here!)**
- **Sep 2024:** Refine trade studies, simulations and develop implementation plans
- **Oct 2024:** Preview results of survey definitions to community for feedback
- **Nov 2024:** Report due to Roman project

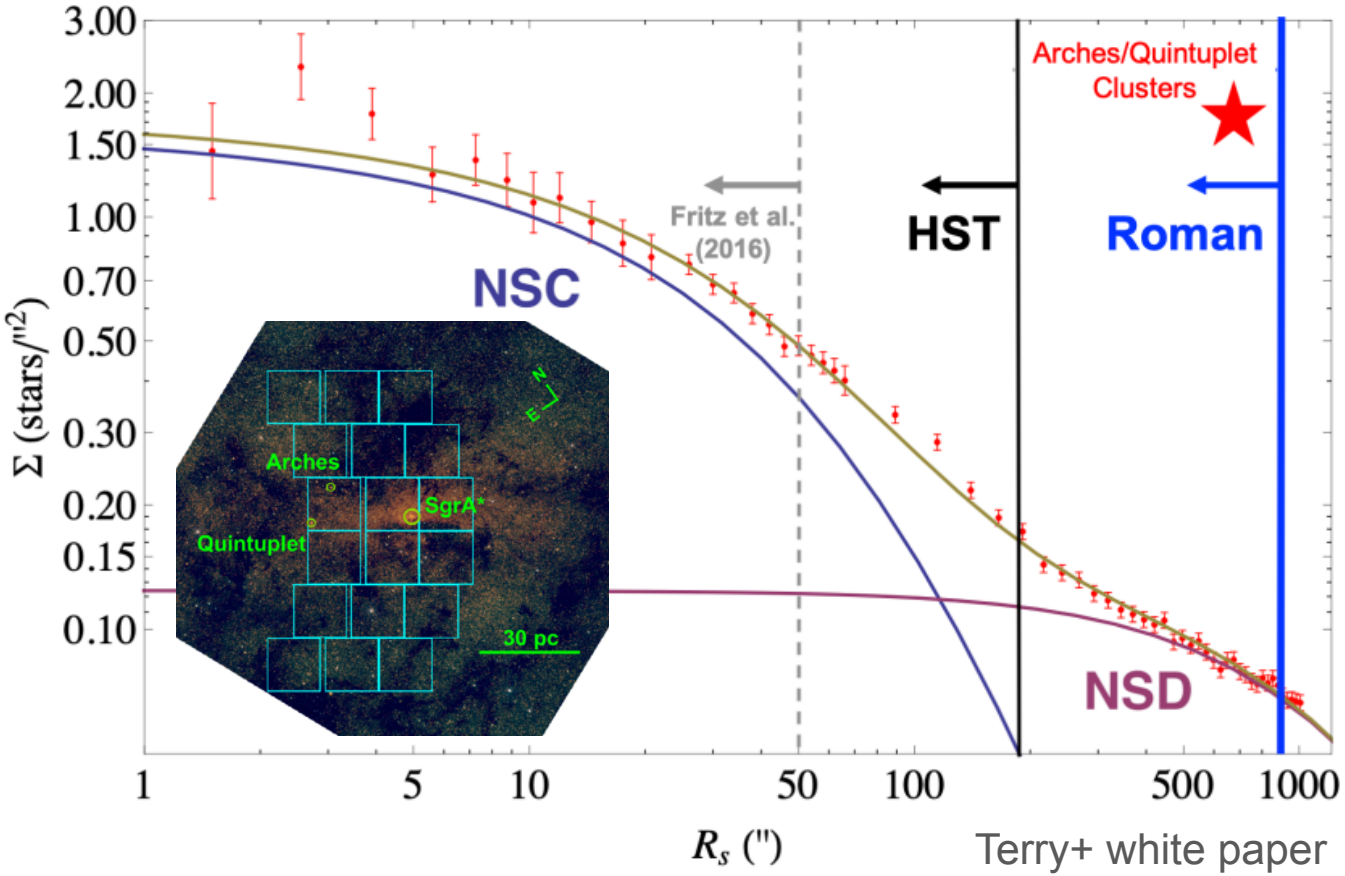
Likely Modification: Add Field at the Galactic Center

Increase overlap with CHANDRA X-ray sources



Bahramian+ white paper

Probe stellar populations in the galactic center

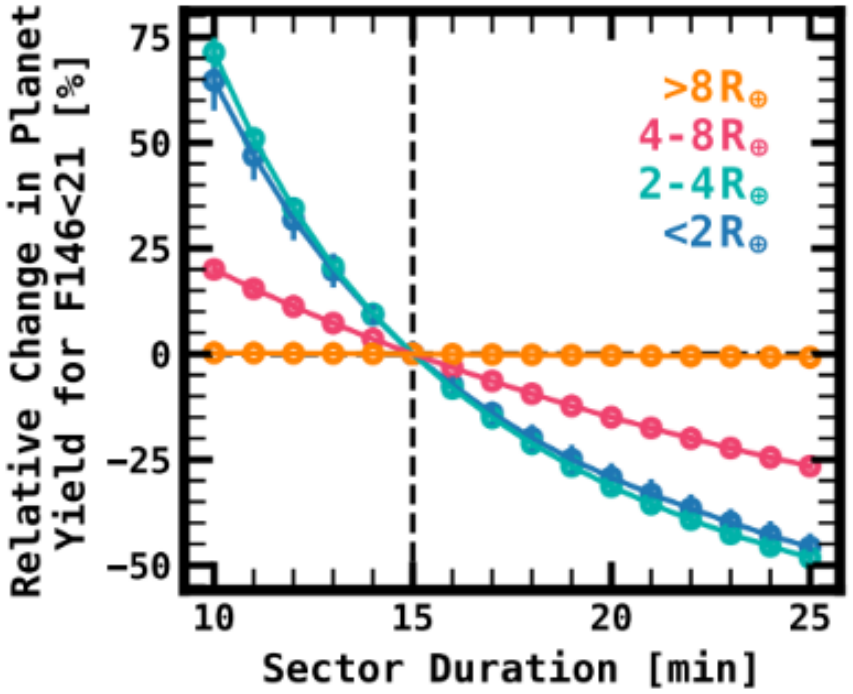


Terry+ white paper

Additional science: stellar/compact object binaries, variable stars, transiting exoplanets

Possible Modification: Faster Cadence

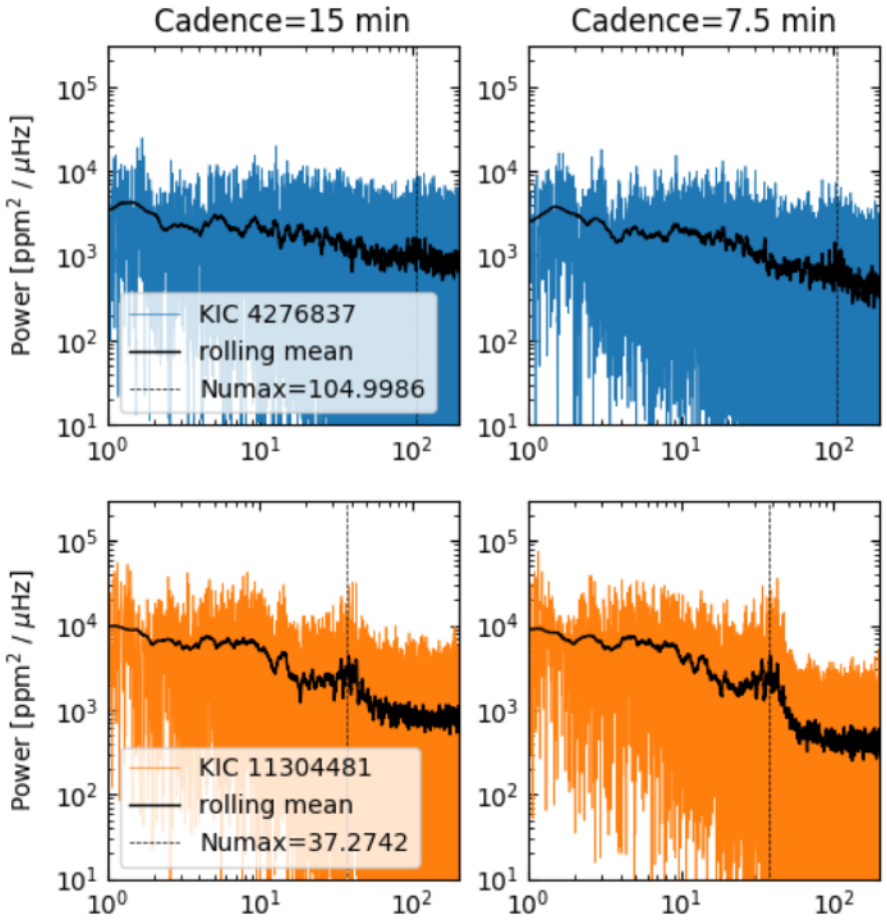
Transiting Exoplanet Yield



Wilson+ white paper, see also recent Gould, Yee & Dong white paper for FFPs

Requires balance with adding more fields. Possible variation: observe 1 field at twice cadence or overlapping fields?

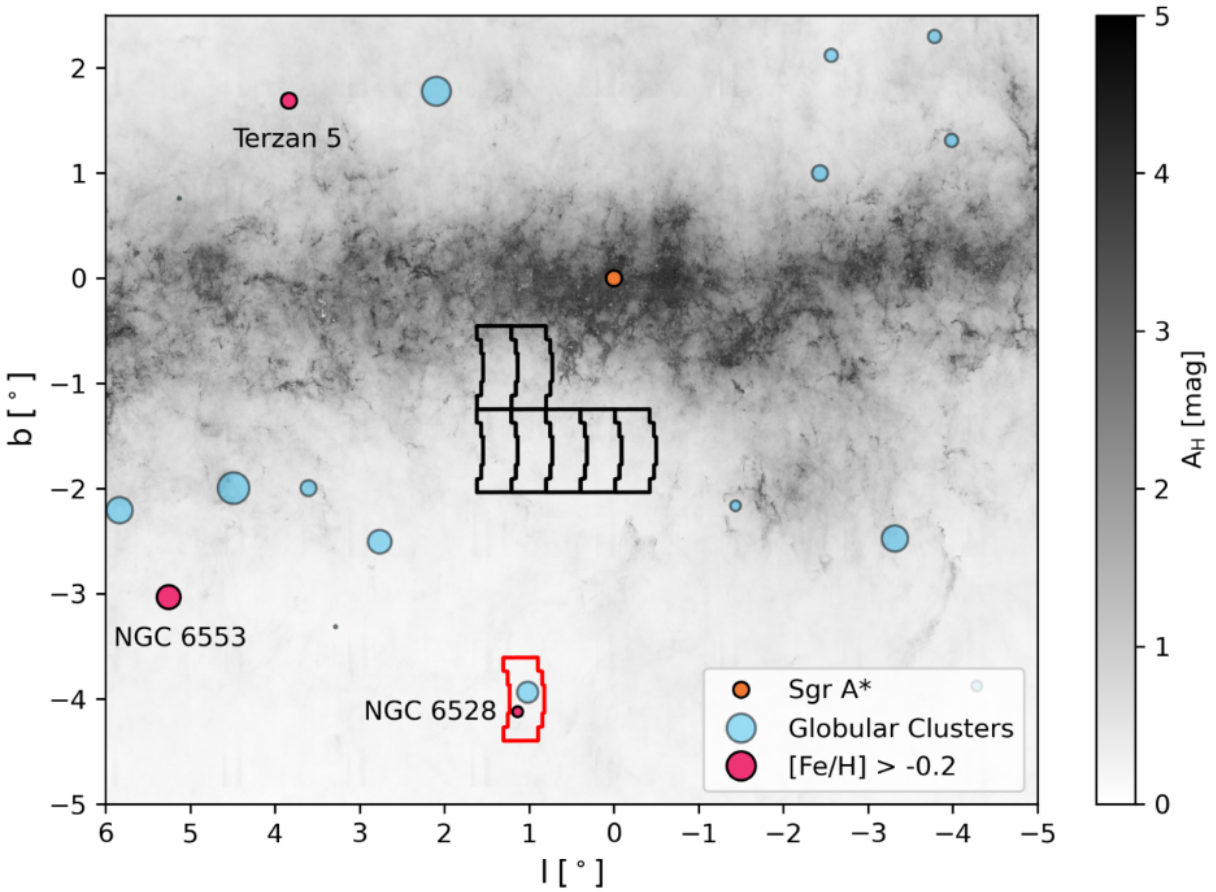
Asteroseismology of Red Giants



Downing, Weiss, Pinsonnault & Zinn; Huber+ white paper

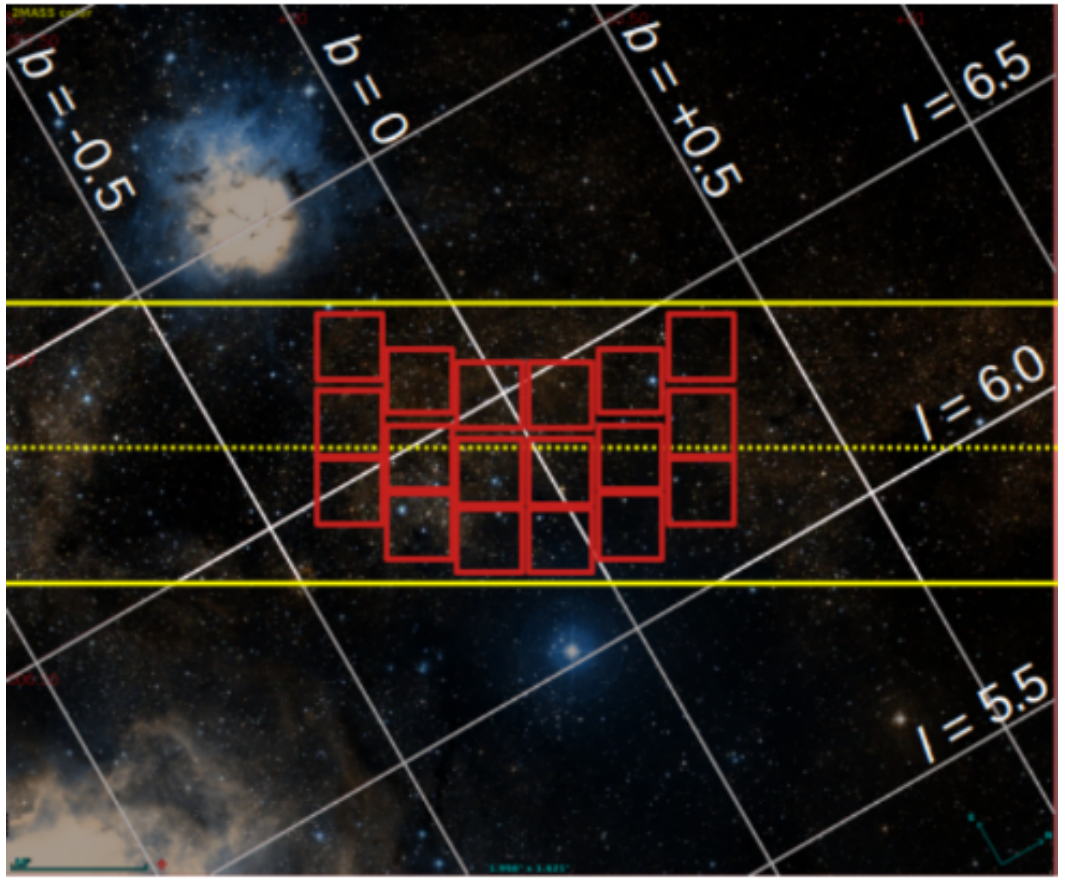
Unlikely Modification: Adding Longer Slew Fields

Stellar astrophysics & exoplanet science enabled by observing globular cluster



White papers by Grunblatt+ & Molnar+

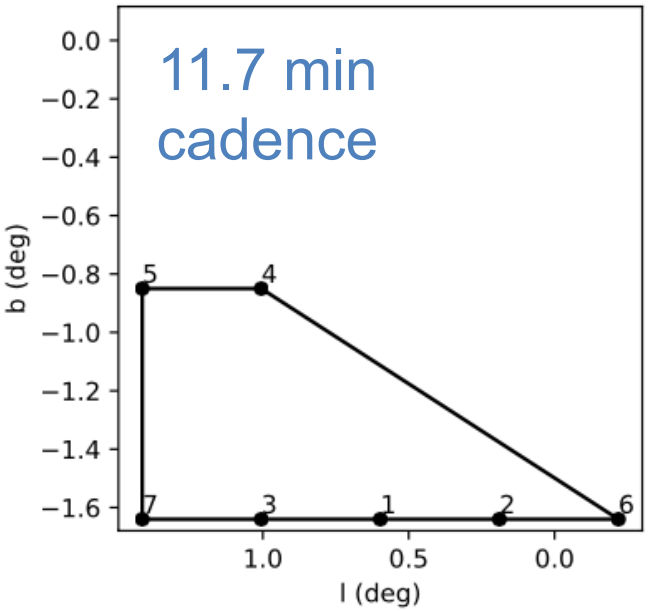
Detect transiting planets orbiting stars in the Earth Transit Zone



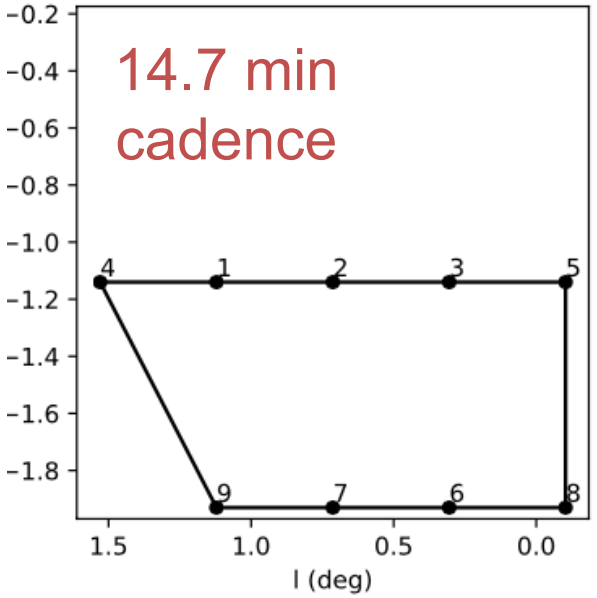
Kerins+ white paper

Tradeoffs: Cadence, Fields, Exposure Time

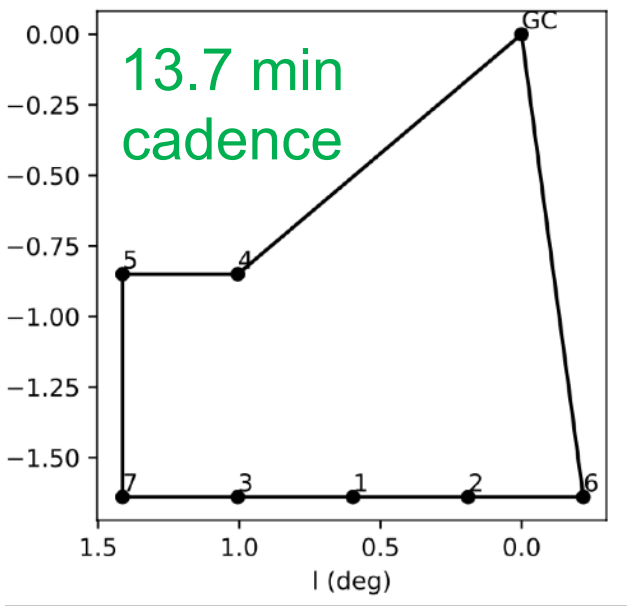
7 contiguous



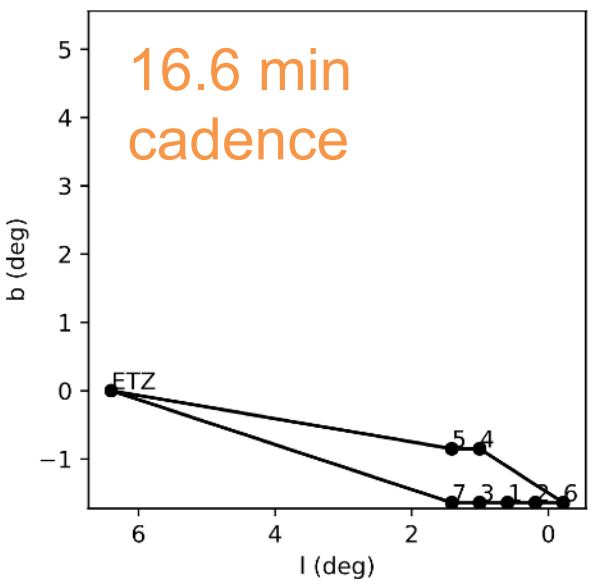
9 contiguous



7 cont. + GC



7 cont. + ETZ



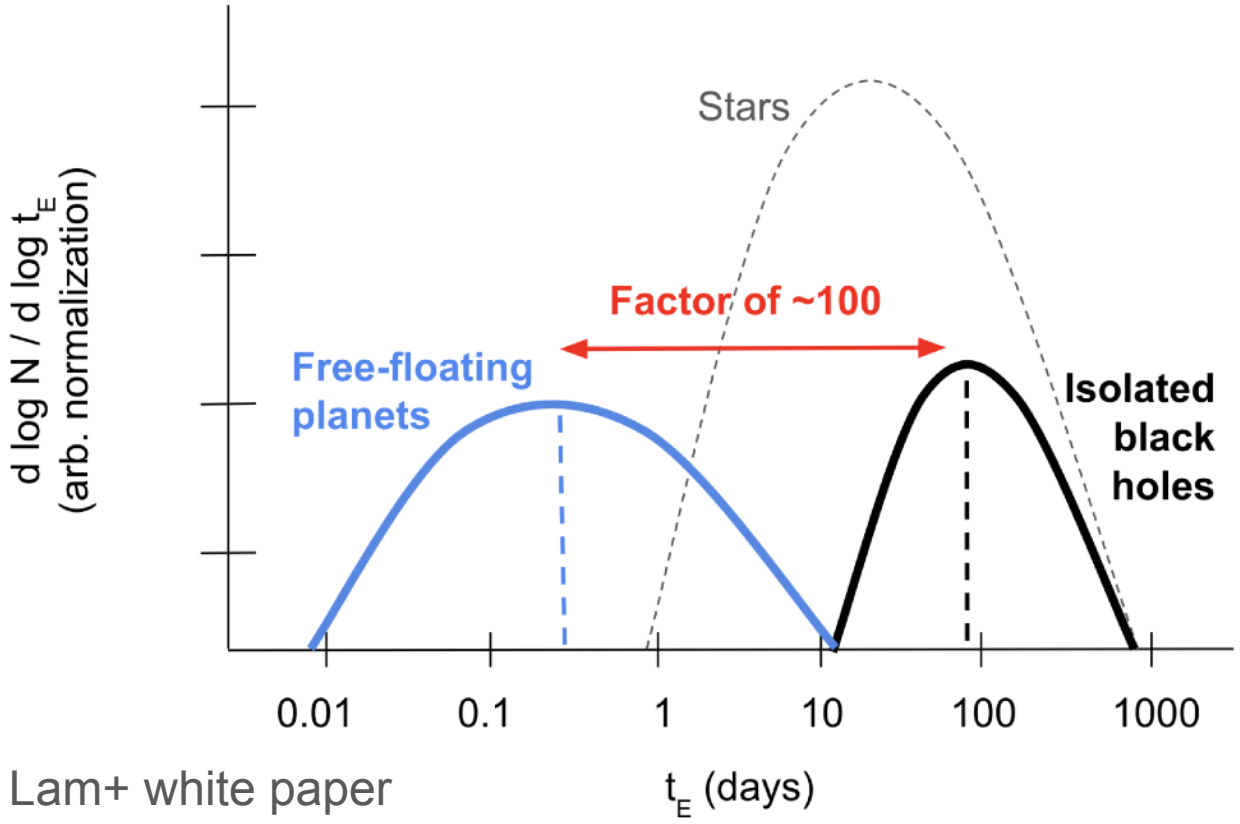
Simulations by Matthew Penny

for fixed exposure time (48 sec)

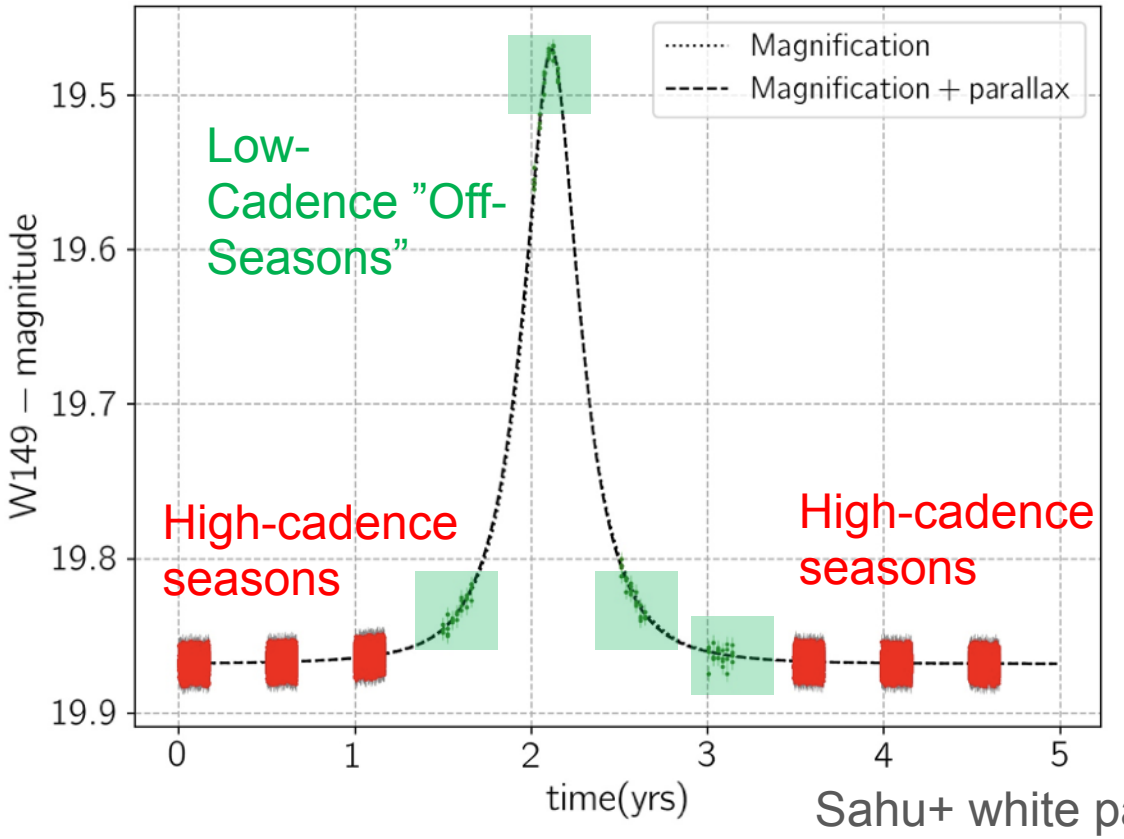
Fields requiring long slews may be prohibitively expensive in terms of cadence or sensitivity and better suited for General Astrophysics programs

Likely Modification: Off-Season Observations

Low cadence observations during “off-seasons” will enable well-sampled light curves and astrometry for isolated black-hole microlensing events



Lam+ white paper

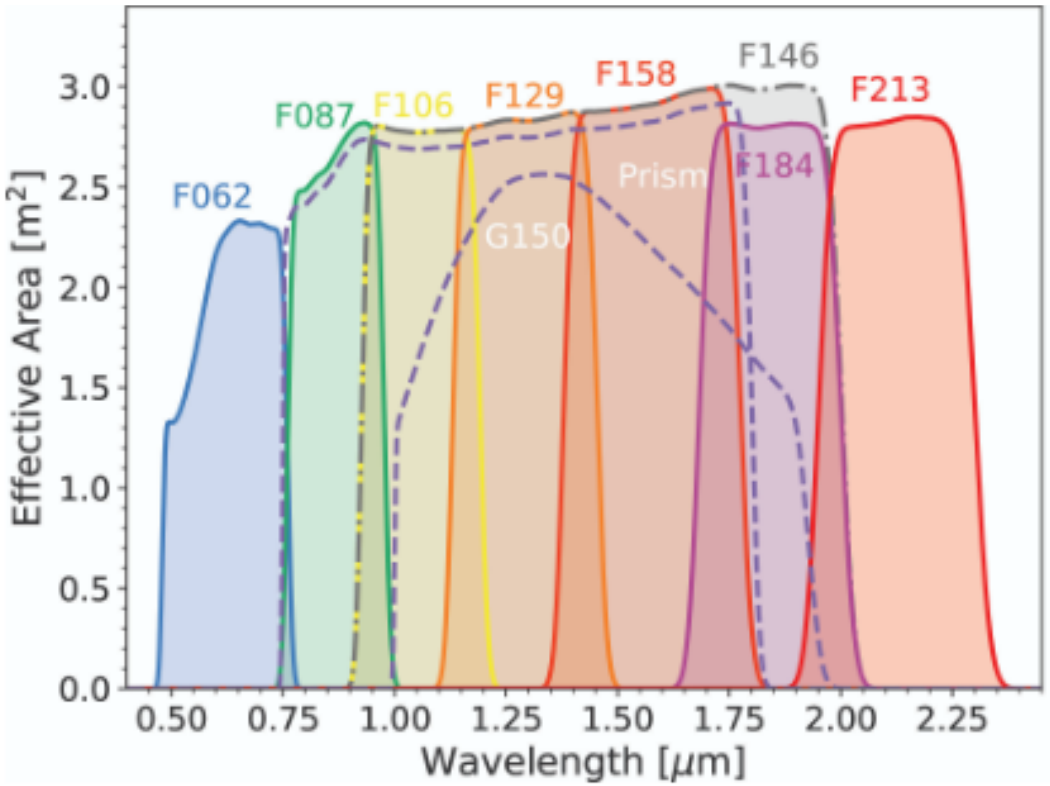


Sahu+ white paper

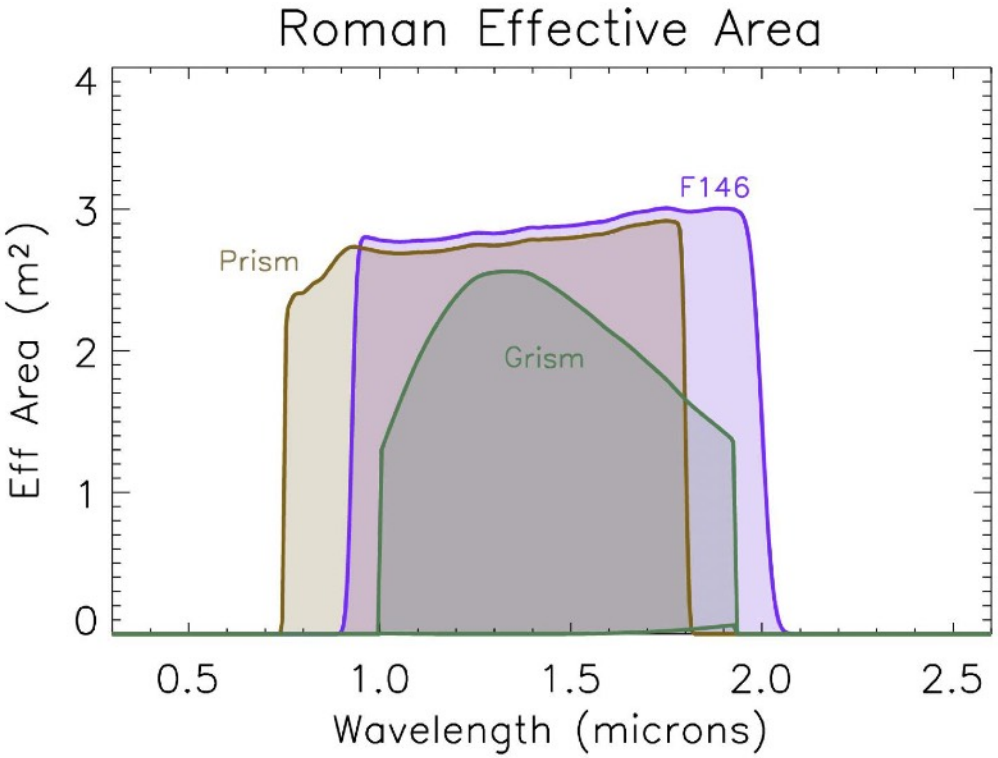
Possible cadences: 1 obs / 1-10 days. Would likely not be strictly periodic! See also recent Gould white paper for moving high-cadence seasons (https://arxiv.org/abs/2407.06484)

Likely Modification: Multiband Photometry & Spectroscopy

Observe each field in each one of the Roman filters



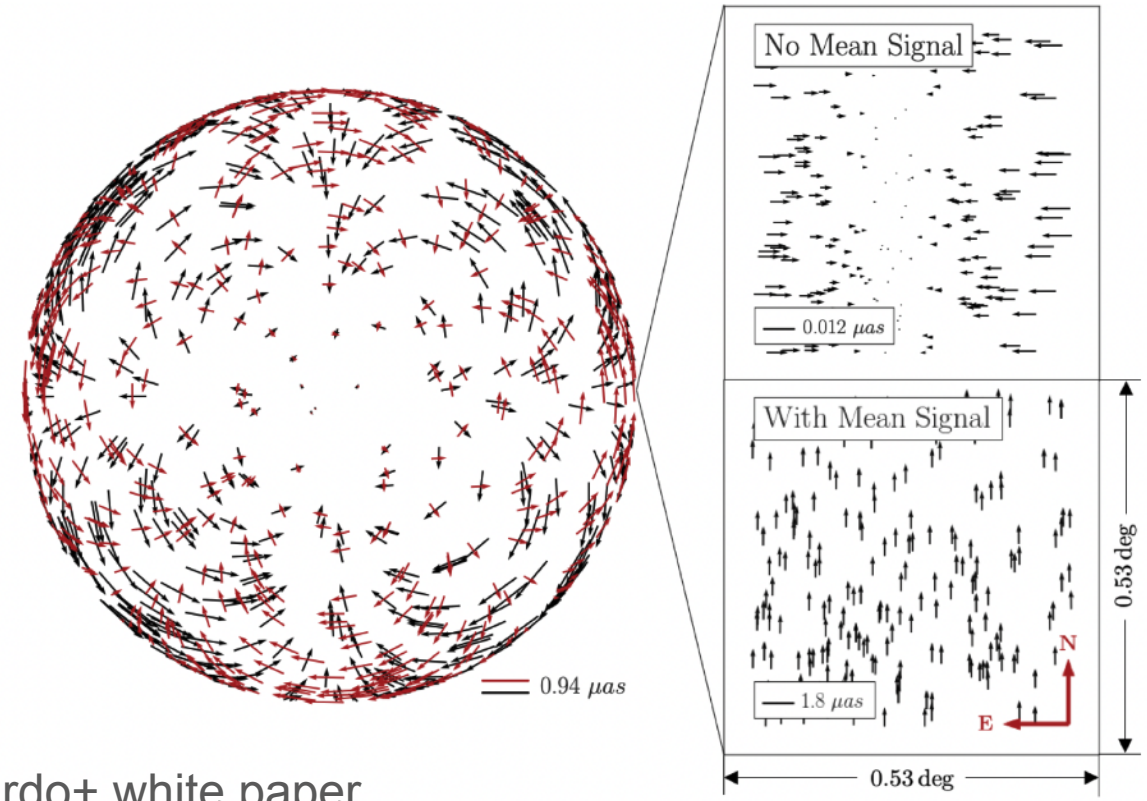
Observe each field with R~500 GRISM



Could be done either once at the beginning of the survey, at the beginning & end of each season, or with low cadence throughout the seasons

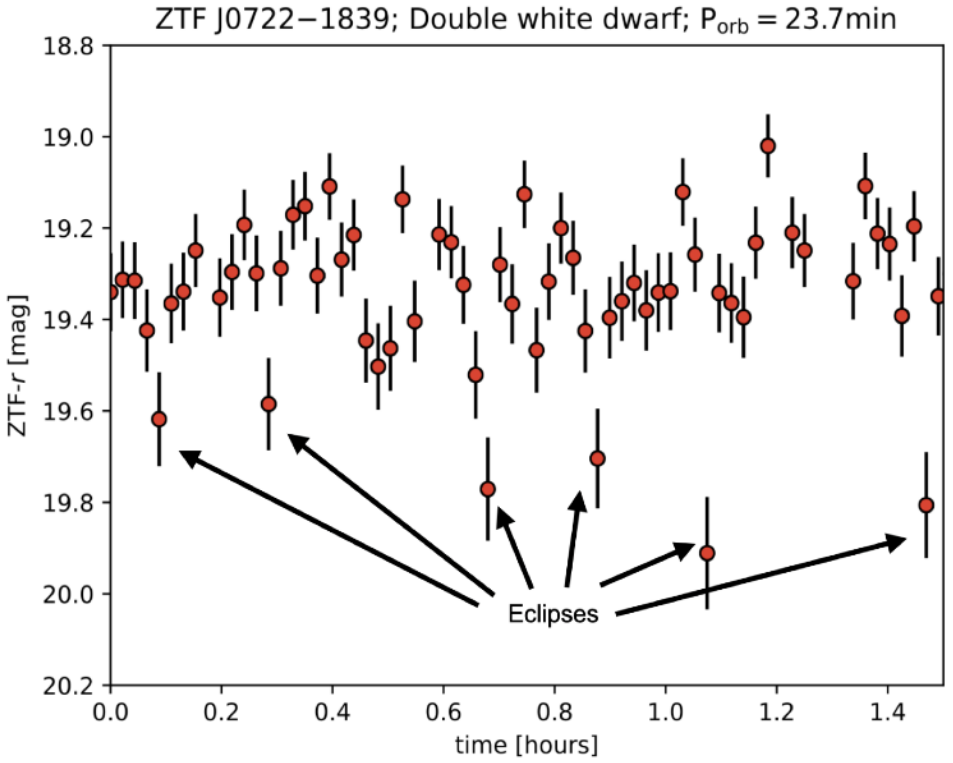
Possible Modification: Observe 1 Field at High Cadence

Gravitational wave detection



Pardo+ white paper

Short-period eclipsing binaries

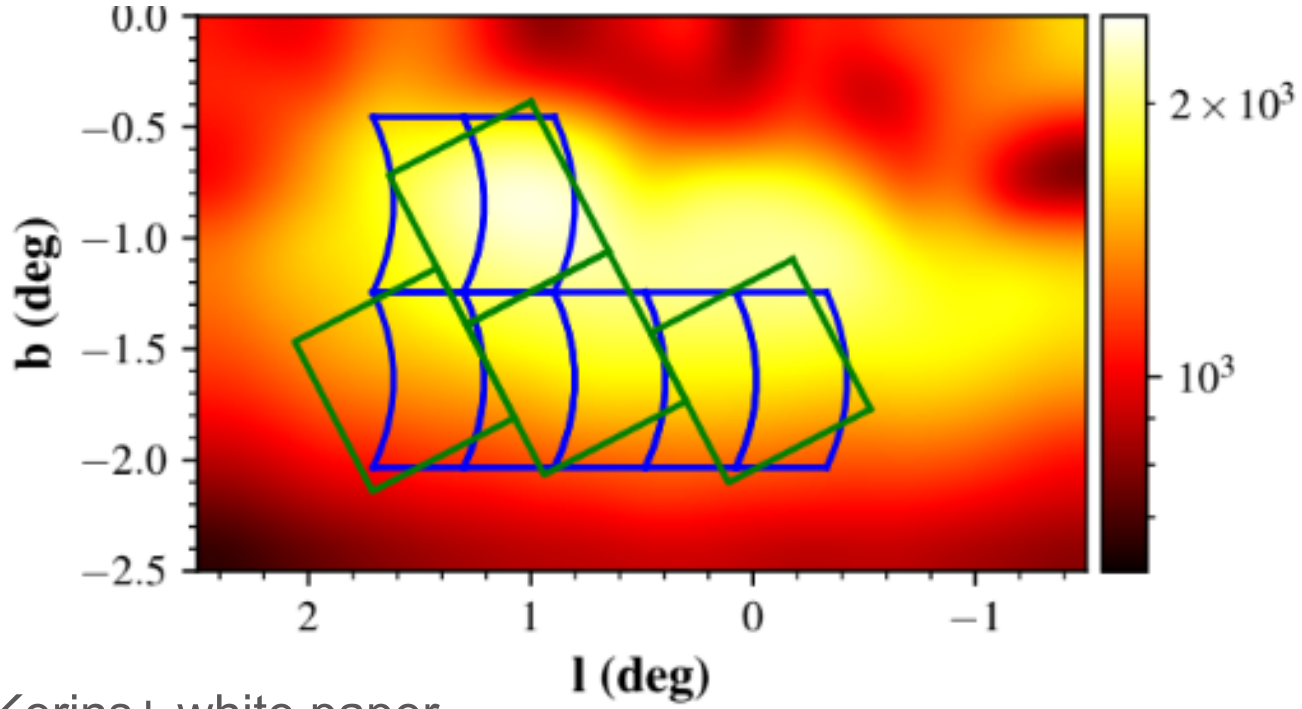


Kupfer+ white paper

Time investment may become too expensive unless only done for 1-2 seasons (in which case General Astrophysics program may be suitable)

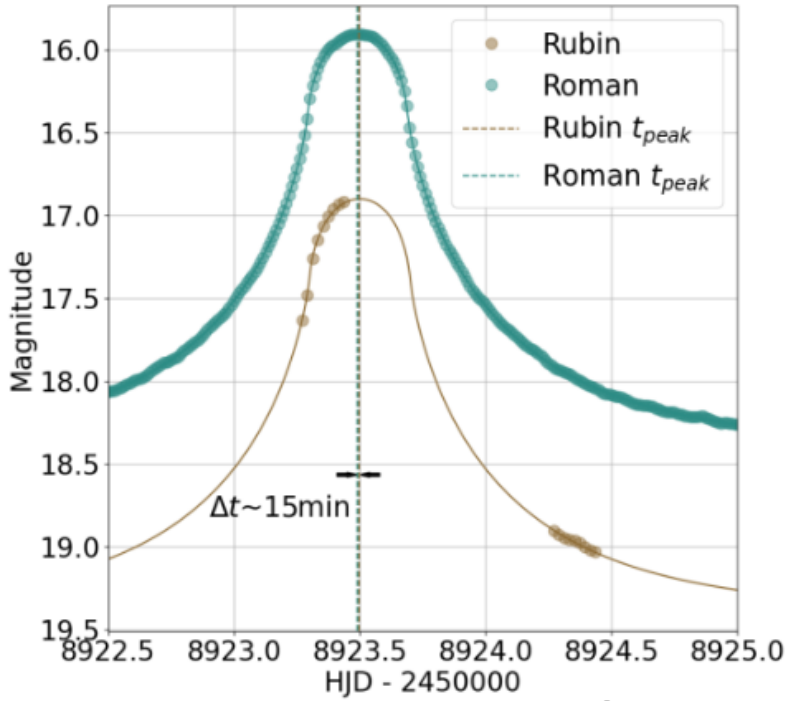
No Modifications (yet): Synergies with other Surveys

Simultaneous observations with Roman and Euclid



Kerins+ white paper

Free-floating planet observed by Roman & Rubin

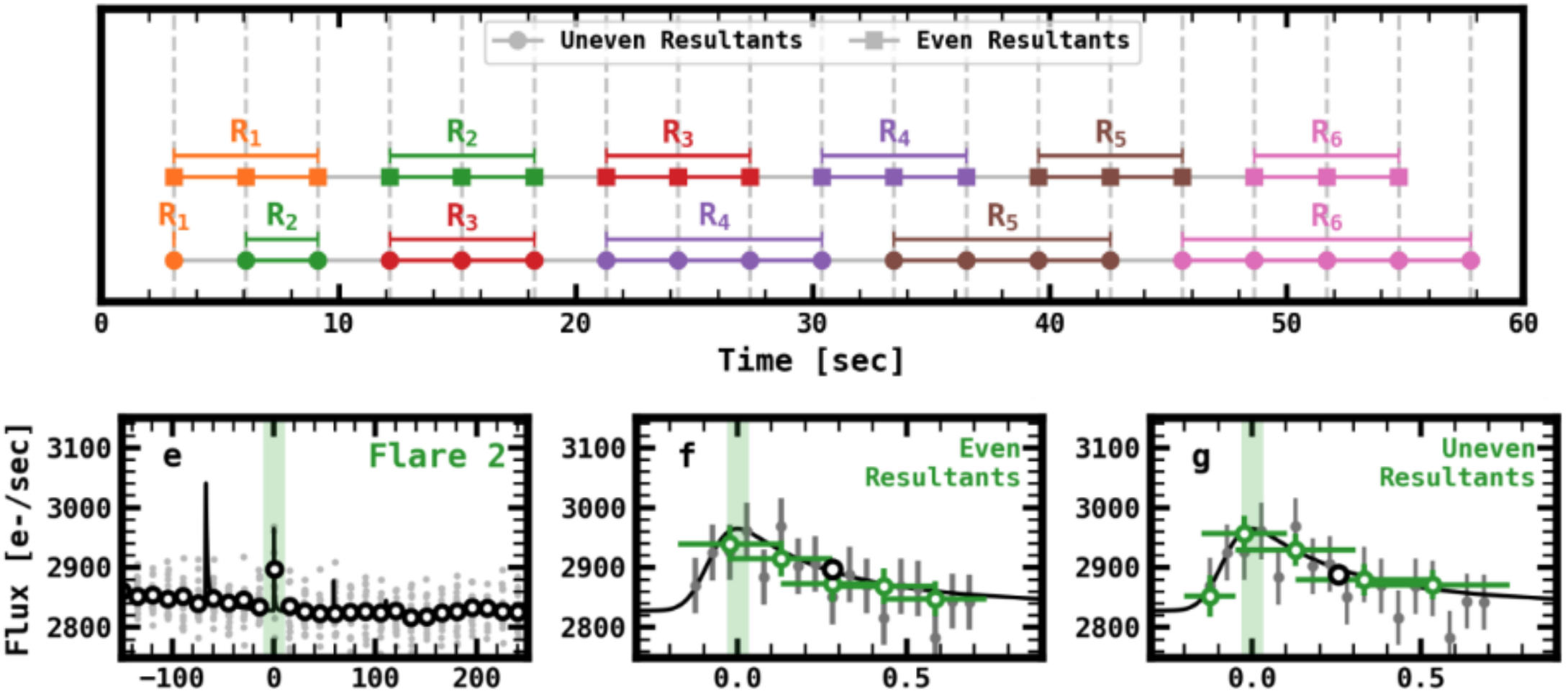


Street+ white paper

(Currently) no impact on survey design, but important to keep flexibility to enable and support these synergies!

No Modifications (yet): Read Out Schemes

Recovery of short duration flares through uneven resultants



Mendoza+ white paper

Roman GBTDS: A Straw Design

Underguide (380 days)

Nominal (420 days)

Overguide (440 days):

Next steps: simulate impact on exoplanet microlensing yields!

Roman GBTDS: A Straw Design

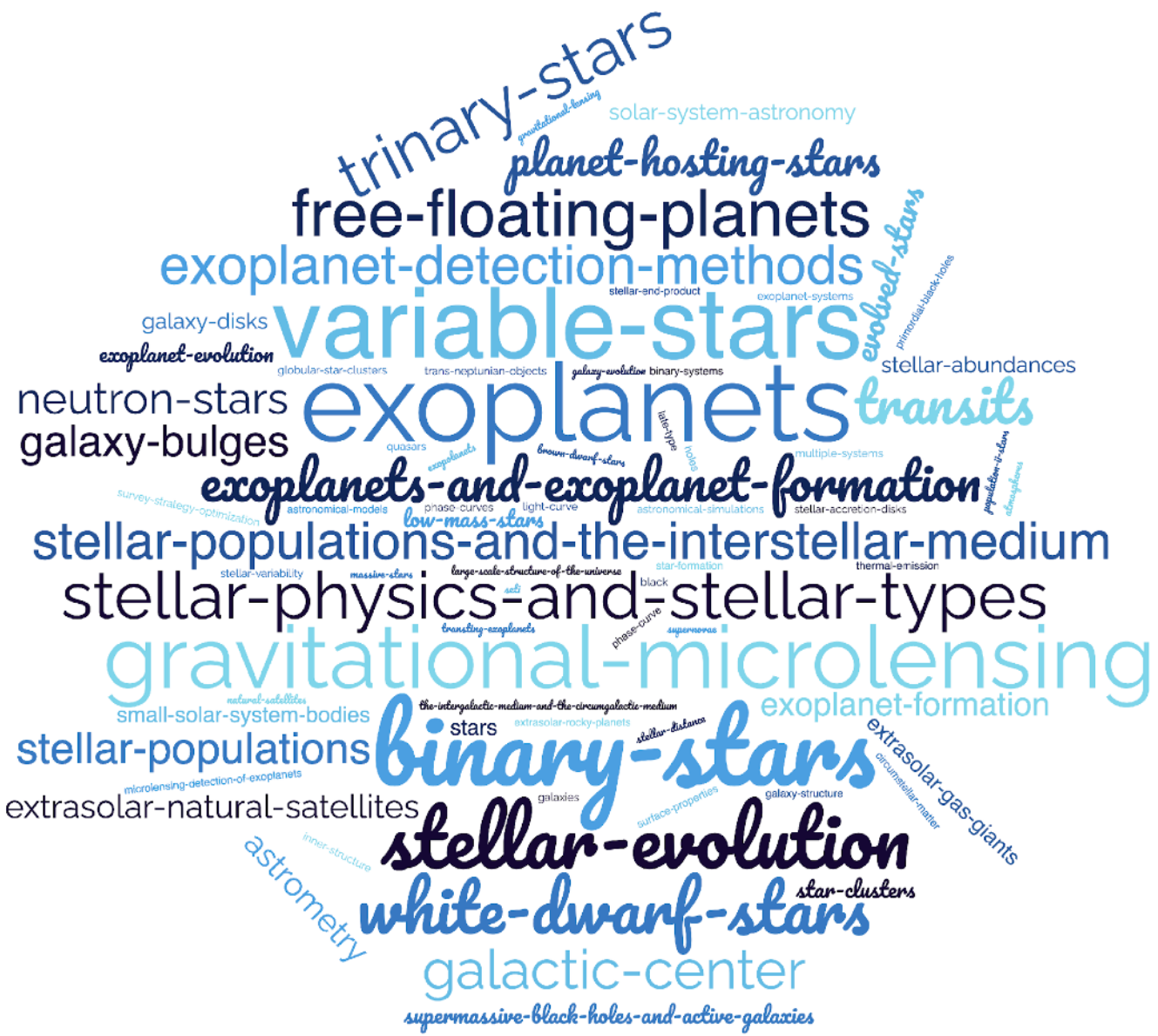
Underguide (380 days)
6 x 63 day seasons with contiguous fields only
Take one image of all microlensing fields in all filters

Nominal (420 days)
6 x 70 day seasons including galactic center
Take one image of all microlensing fields in all filters
Take one spectrum of all microlensing fields

Overguide (440 days):
6 x 72 day seasons including galactic center
Take one image of all microlensing fields in all filters
Take one spectrum of all microlensing fields
4 off-season 1 obs/1 day cadence observations
1 day high-cadence observations of 1 field in each season

Current work: simulate impact on exoplanet microlensing yields, quantify off-season cadence and high-cadence observations

Science Enabled by the Roman GBTDS!



Roman GBTDS: Let us know your thoughts!

Questionnaire:

https://forms.gle/4UogRf4KS2RkADHY7

Email the committee co-chairs:
christia@ipac.caltech.edu,
huberd@hawaii.edu,
daniel.huber@sydney.edu.au