WFIRST Exoplanet Imaging: Datacubes, Community Challenges, and the Starshade Study

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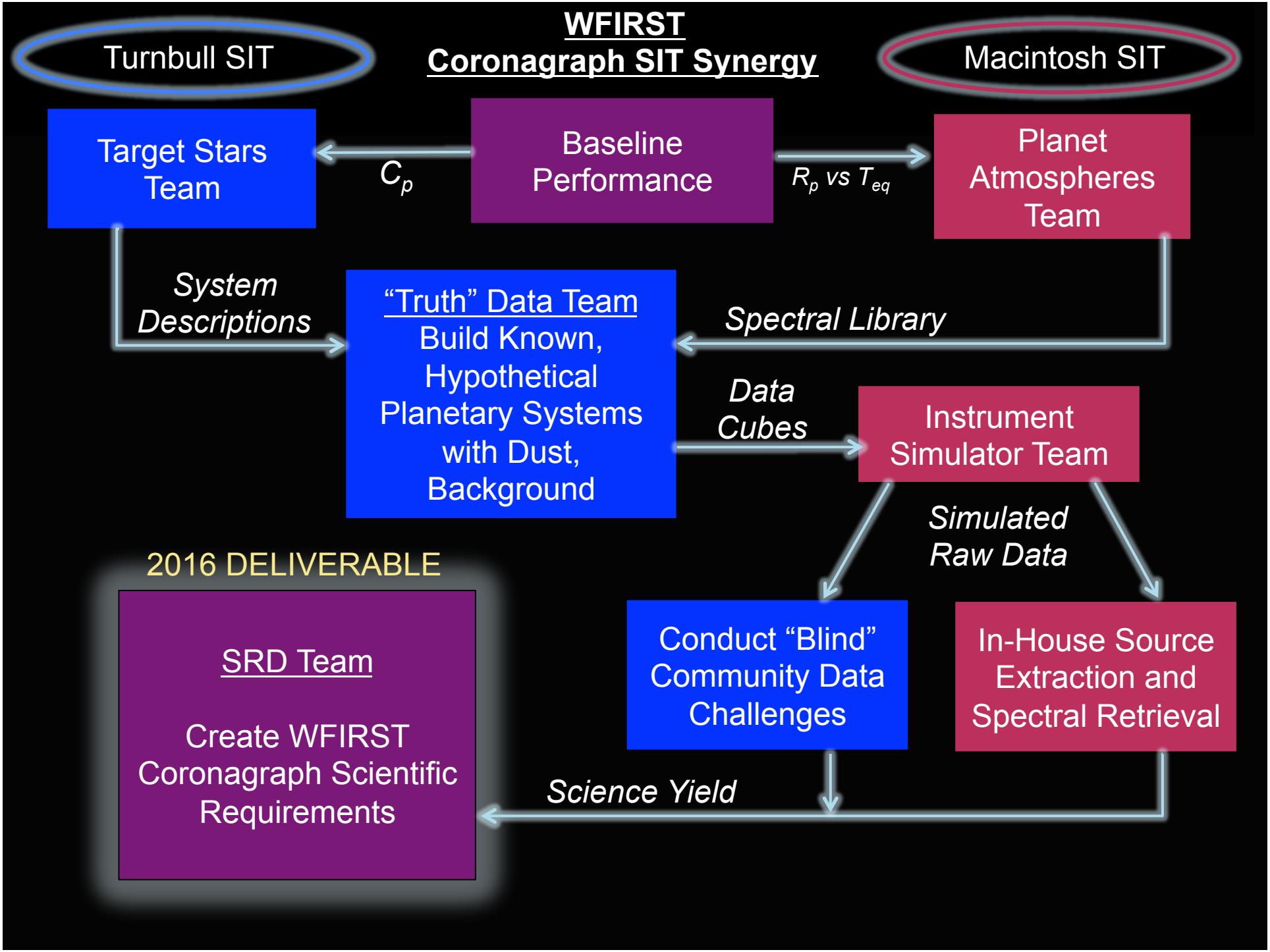
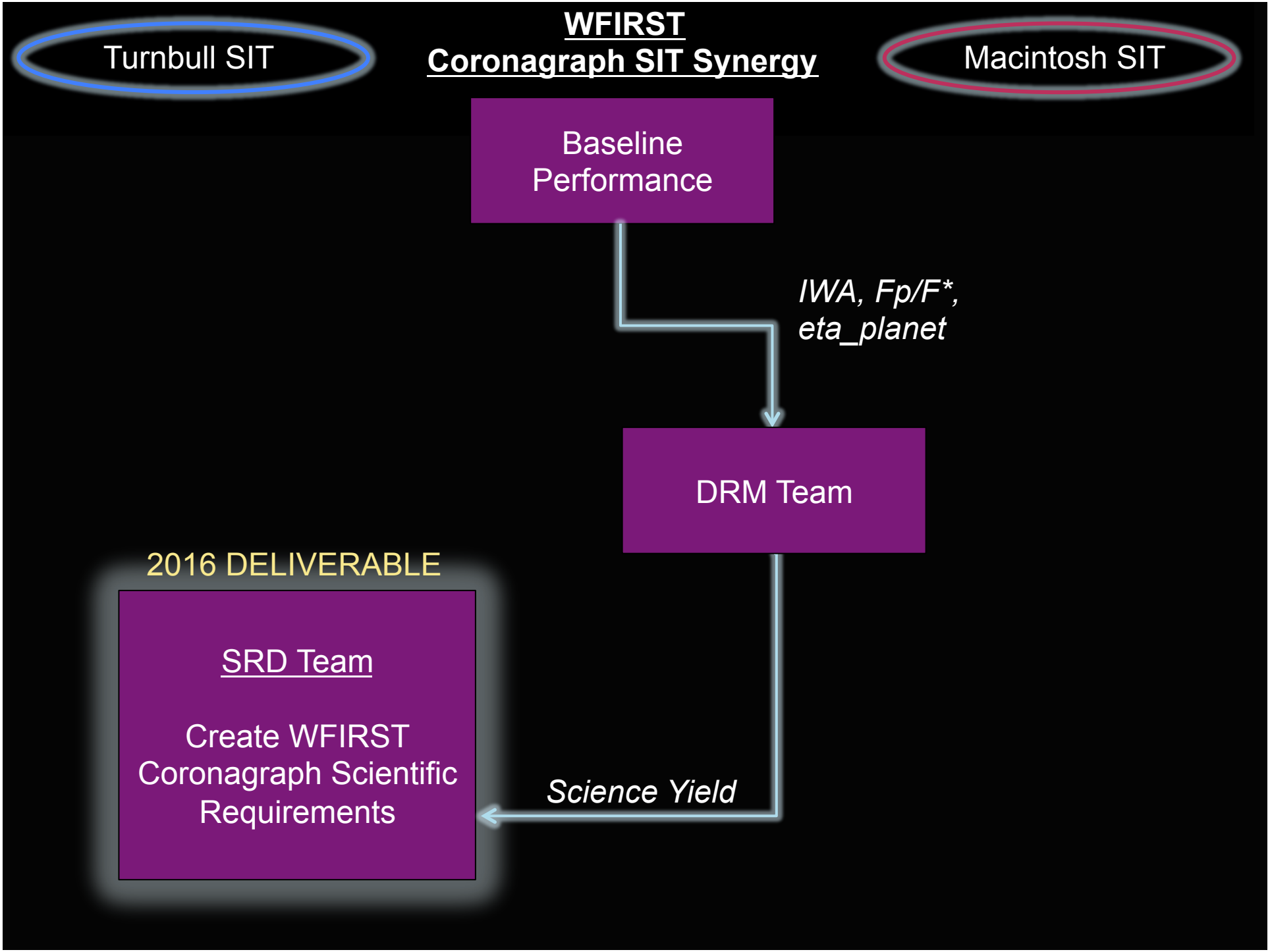
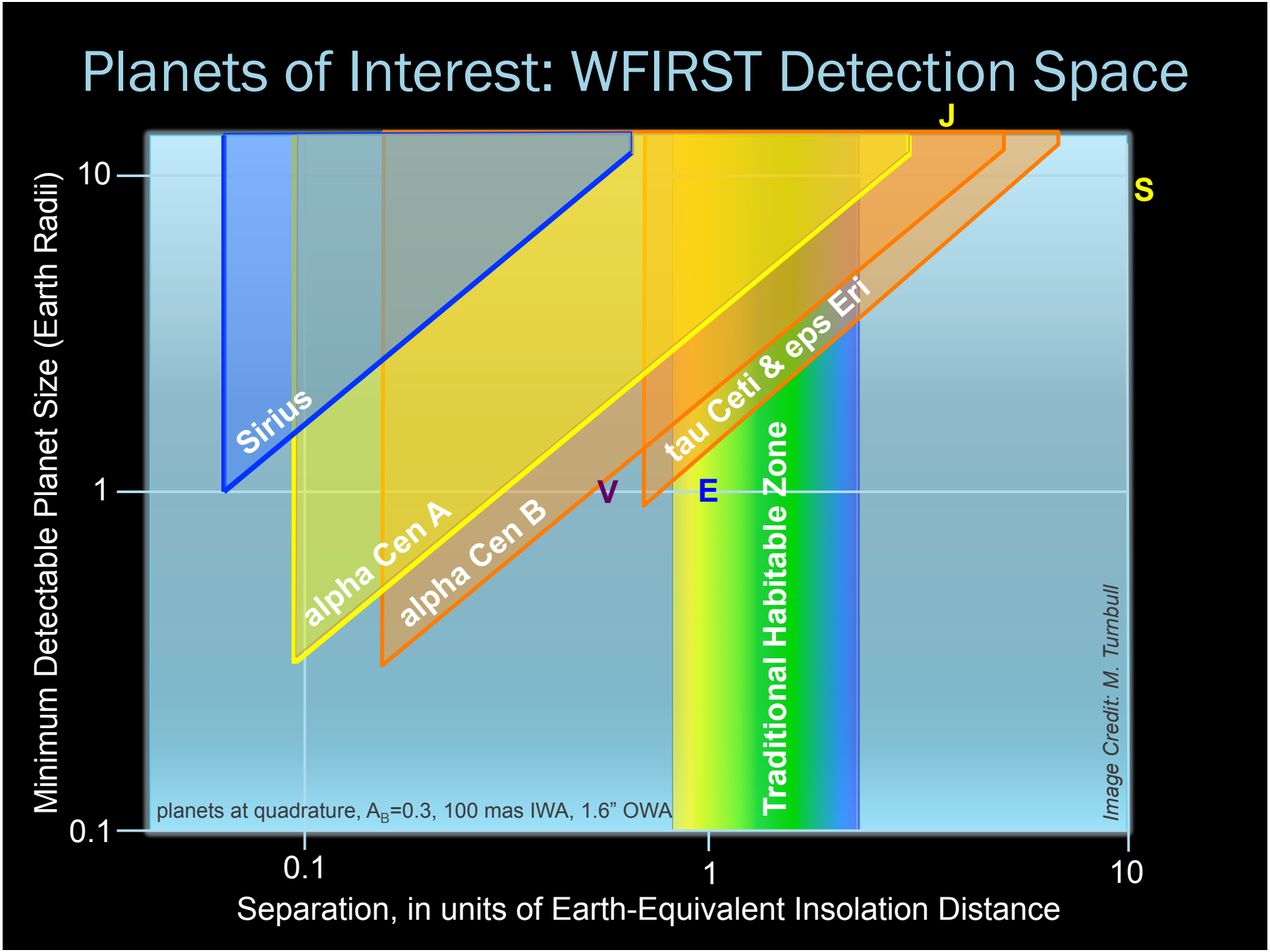
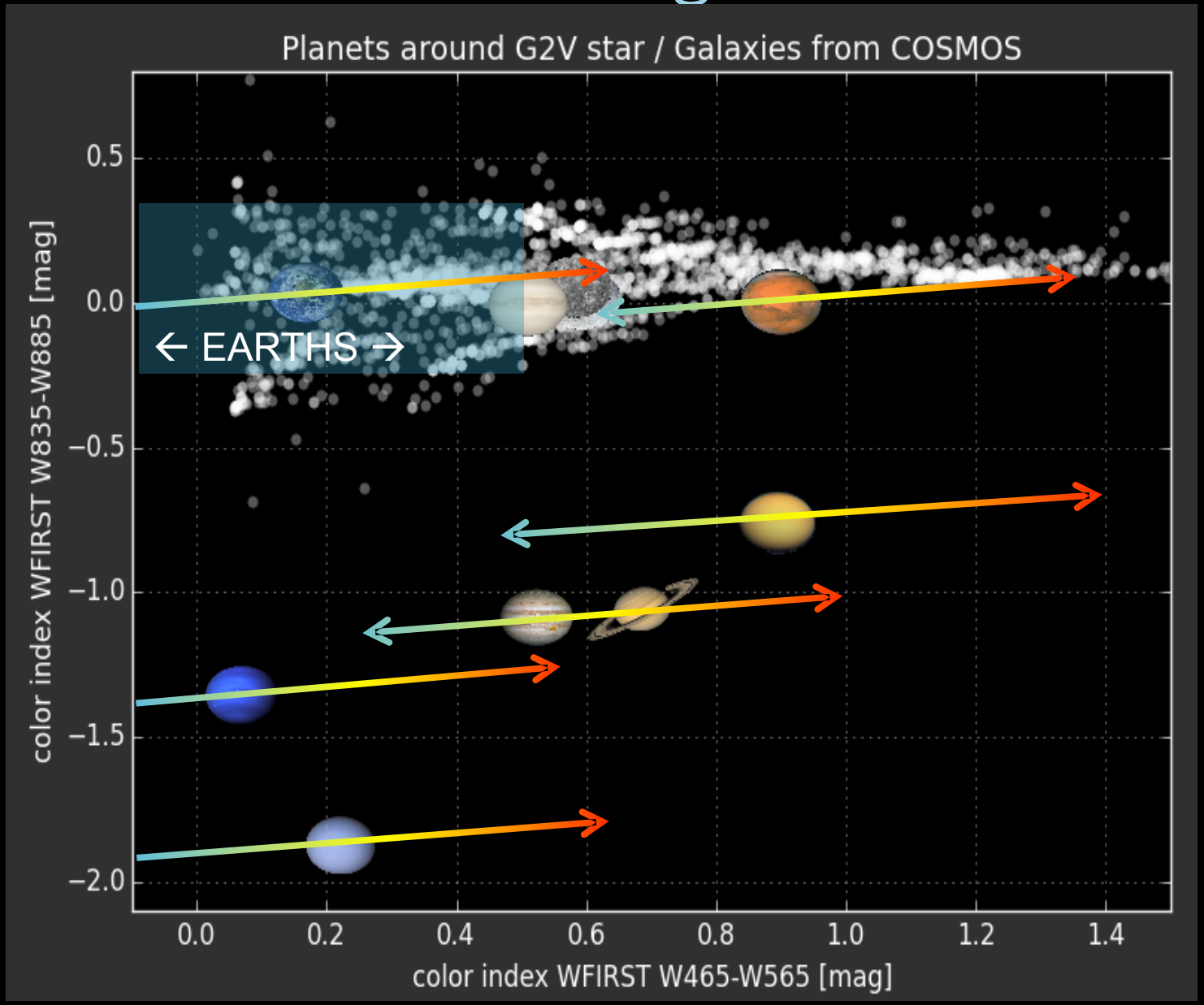

WFIRST
Coronagraph SIT Synergy
Turnbull SIT
Macintosh SIT
Target Stars Team
C_p
Baseline Performance
R_p vs T_{eq}
Planet Atmospheres Team
System Descriptions
"Truth" Data Team
Build Known, Hypothetical Planetary Systems with Dust, Background
Spectral Library
Data Cubes
Instrument Simulator Team
Simulated Raw Data
2016 DELIVERABLE
SRD Team
Create WFIRST Coronagraph Scientific Requirements
Conduct "Blind" Community Data Challenges
In-House Source Extraction and Spectral Retrieval
Science Yield


Turnbull SIT
WFIRST
Coronagraph SIT Synergy
Macintosh SIT
Baseline Performance
IWA, Fp/F*, eta_planet
DRM Team
2016 DELIVERABLE
SRD Team
Create WFIRST Coronagraph Scientific Requirements
Science Yield


Planets of Interest: WFIRST Detection Space
J
S
V
E
Sirius
alpha Cen A
alpha Cen B
tau Ceti & eps Eri
Traditional Habitable Zone
10
1
0.1
Minimum Detectable Planet Size (Earth Radii)
0.1
1
10
Separation, in units of Earth-Equivalent Insolation Distance
planets at quadrature, A_B=0.3, 100 mas IWA, 1.6” OWA
Image Credit: M. Turnbull

Planets Around Other Targets: WFIRST Bands



"R-I"

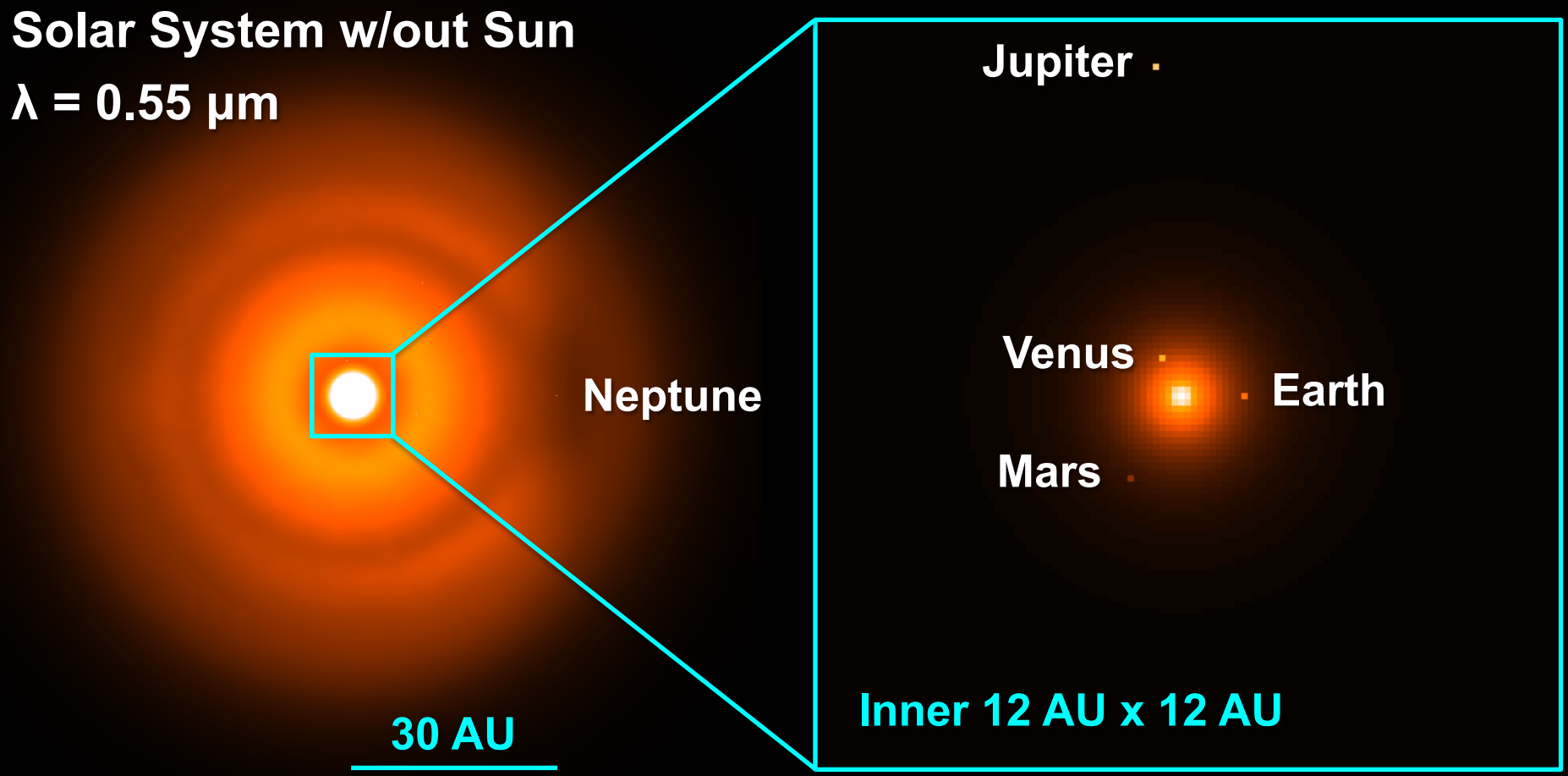
"B-V"

Finding the Needles in the Haystacks

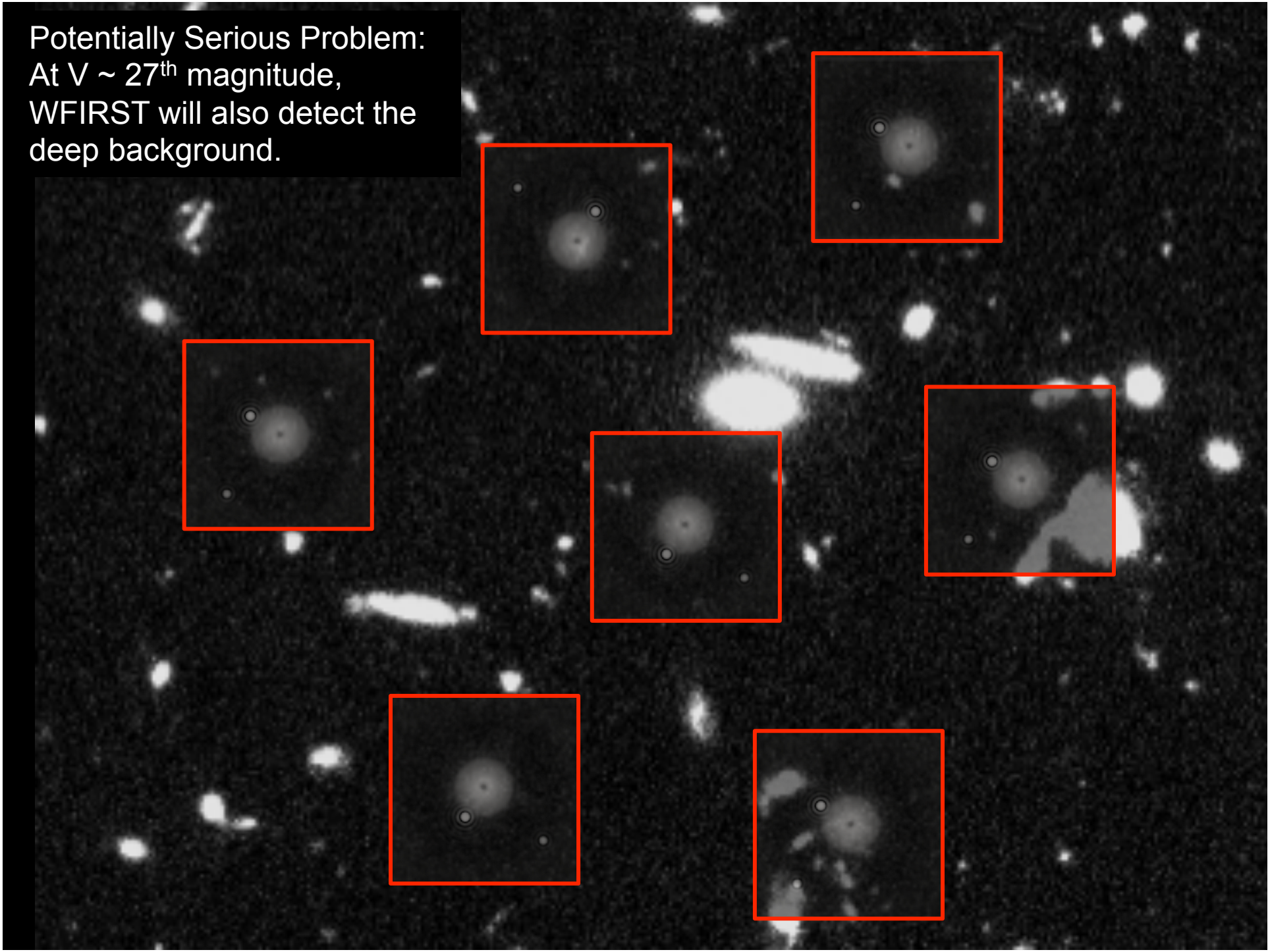
Spectral image cubes: 0.3 μm – 2.5 μm

Contain star, planets, consistent dust

Option to add galactic & extragalactic background sources



Credit: A. Roberge & the Haystacks team


Potentially Serious Problem:
At V ~ 27th magnitude,
WFIRST will also detect the
deep background.

WFIRST CGI: Preparing for Discovery

Stellar Target Data

+

Known and Hypothetical Planets

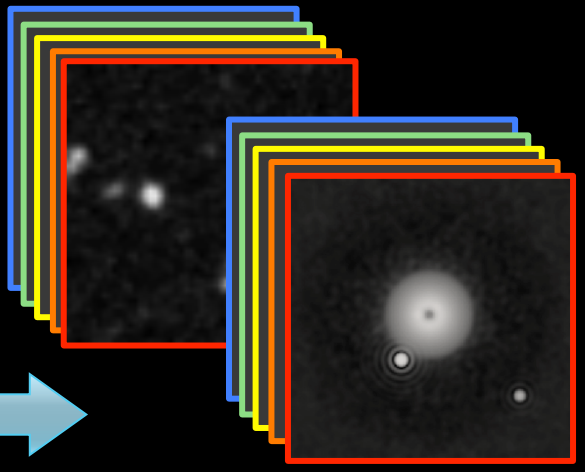
+

Dust

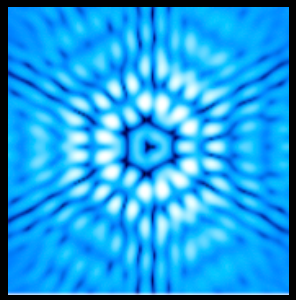
+

Astrophysical Background

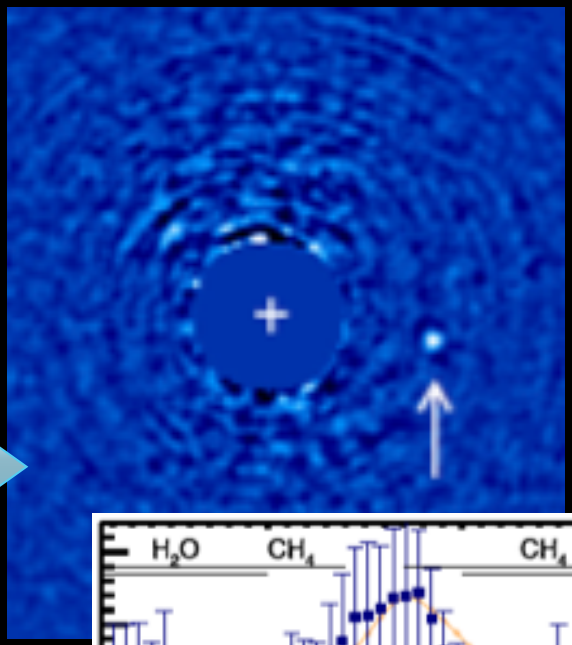
Spectral Data Cubes

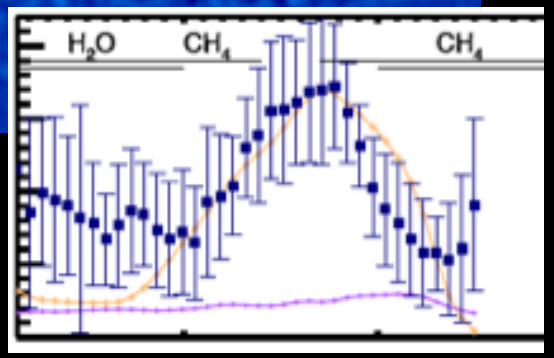


Instrument Response Simulator



Blind Retrieval Exercises: Community Challenges and In-House Studies



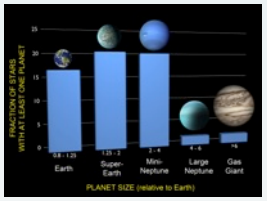


Mission yield Master calculations style

Stark et al. (2014)
Stark et al. (2015)

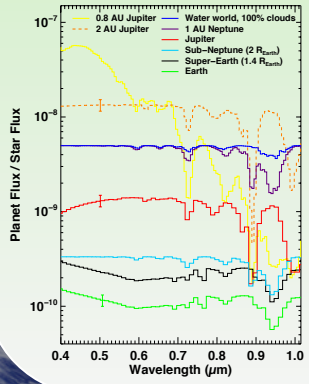
Astrophysical Constraints

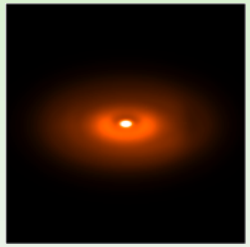
- η_{planet}
- $\eta_{exozodi}$
- Planet sizes
- Albedos
- Phase functions



Observational Requirements

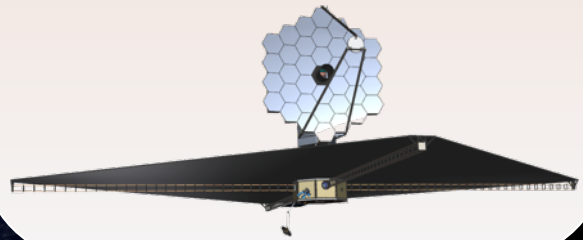
- Central wavelength
- Total bandpass
- Spectral resolution
- Signal-to-Noise
- Observing strategy





Technical Requirements

- Telescope diameter
- Contrast
- Contrast floor
- Inner working angle
- Outer working angle
- Total throughput
- Overheads



Design reference mission (DRM)

WFIRST WITH A STARSHADE: EXO-S-ES FOLLOW-UP REPORT FEB 2016

Exoplanet Exploration Program

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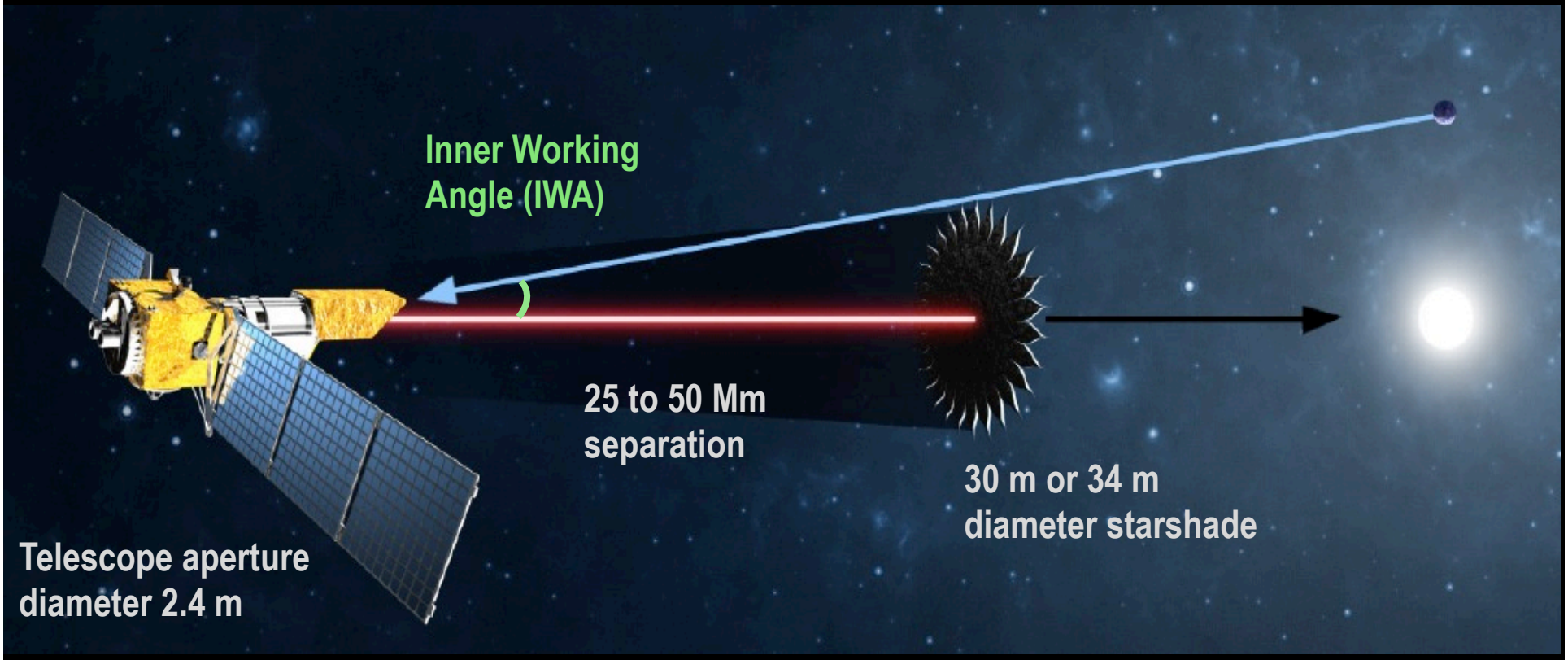
Starshade Basics



- PRO: Contrast and IWA decoupled from telescope aperture size
- PRO: No outer working angle
- PRO: Few reflections = high throughput, broad wavelength bandpass
- PRO: Starlight does NOT enter telescope
  - High quality telescope not required, wavefront correction unnecessary
- CON? Retargeting requires long starshade slews (days to weeks)

A WFIRST-Starshade Rendezvous Mission

- Starshade launches for a rendezvous with an existing telescope
- Telescope: WFIRST/AFTA 2.4-m diameter
- Starshade: 34 m diameter
- Orbit: Earth-Sun L2 (assumption for the purposes of the Exo-S study)
- Retargeting: by the starshade spacecraft with chemical propulsion
- Three year Class C mission
- Minimal impact to current mission design
  - No stringent requirements are imposed on the WFIRST/AFTA spacecraft
  - No new instrument, only modification to the existing coronagraph

Take-Away Message

WFIRST/AFTA can be leveraged for a unique and timely opportunity

- Rendezvous Mission can access up to 50 unique target stars for exoEarths in the habitable zone
- Minimal modification needed for starshade readiness
- Starshade technology is on track for TRL-5 by 2017 and for new start by 2018, but not fully funded
- Mission cost ~ $627M, CATE raised no issues with schedule