

# Direct Imaging of Exoplanets:



*So You've Seen A Pale Blue  
Dot. Now What?*

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NASA Voyager 1, 1990

# Why Direct Imaging?

→ To detect small planets around sunlike stars, including in the habitable zone.

- Not affected by stellar variability, jitter.
- Can quickly access longer period planets.

A/F stars: hot planets, FGK stars: hab zones, M stars: screwed.

A Star



The Sun  
G Star

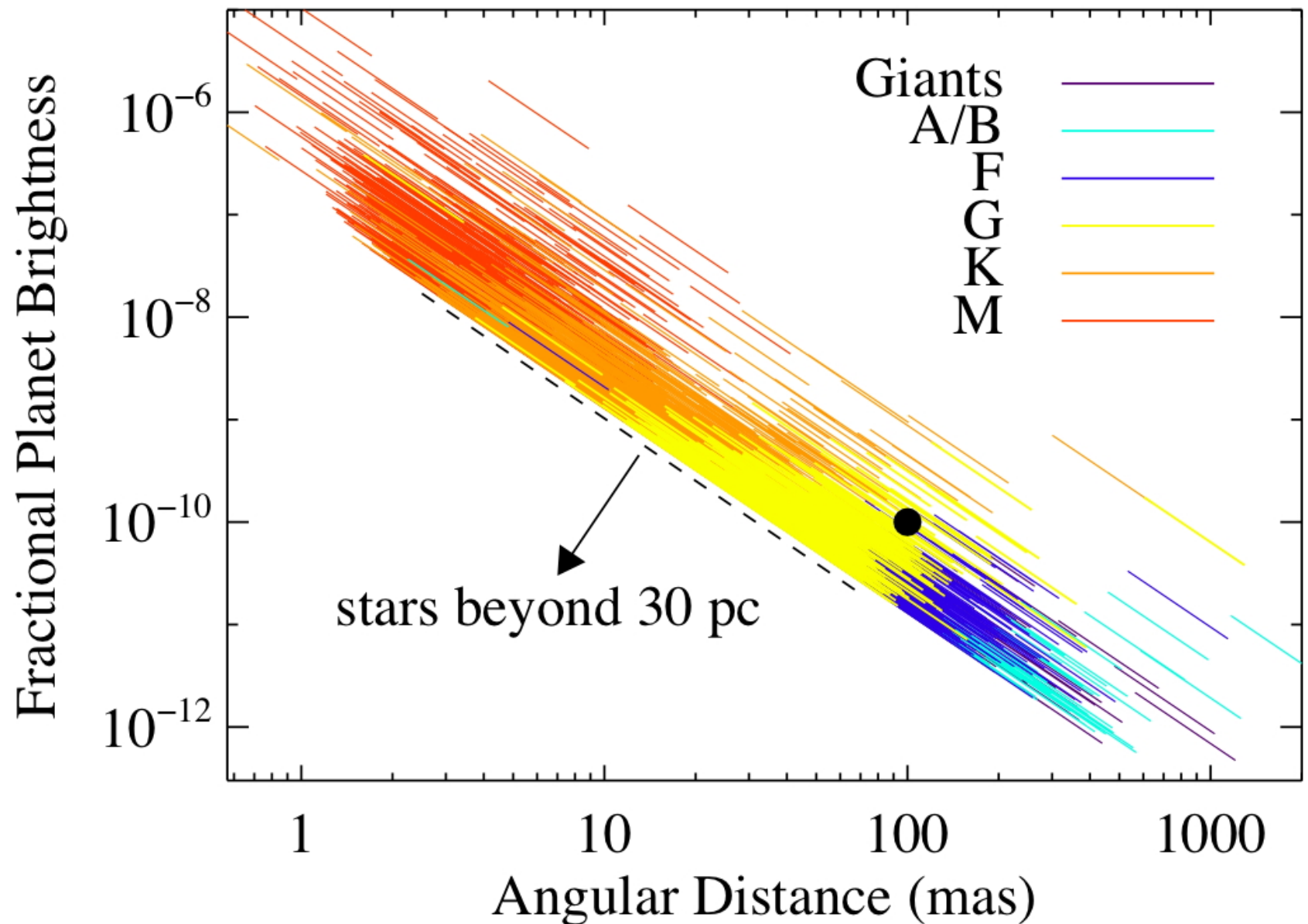


M Star



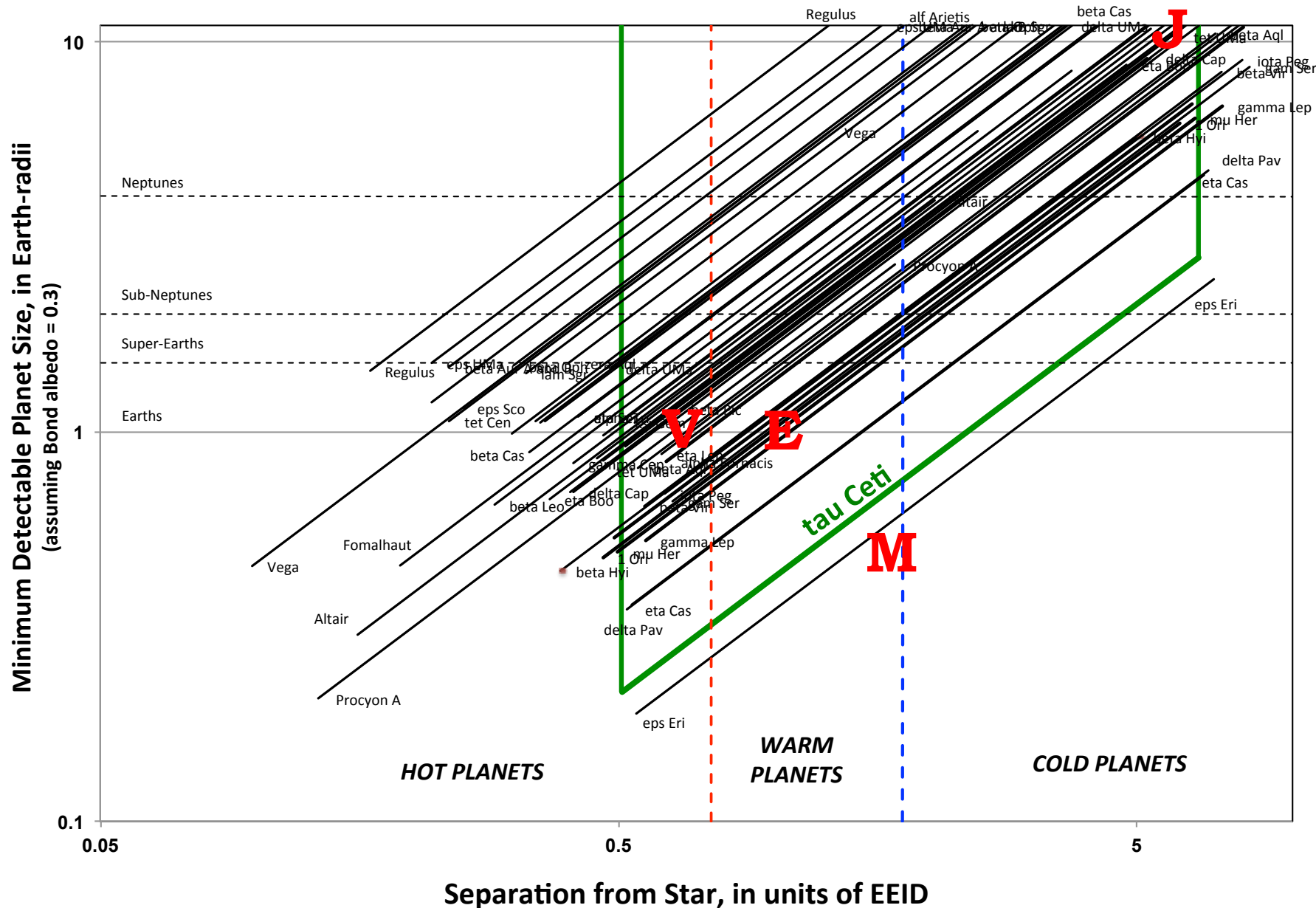


A/F stars: hot planets, FGK stars: hab zones, M stars: screwed.



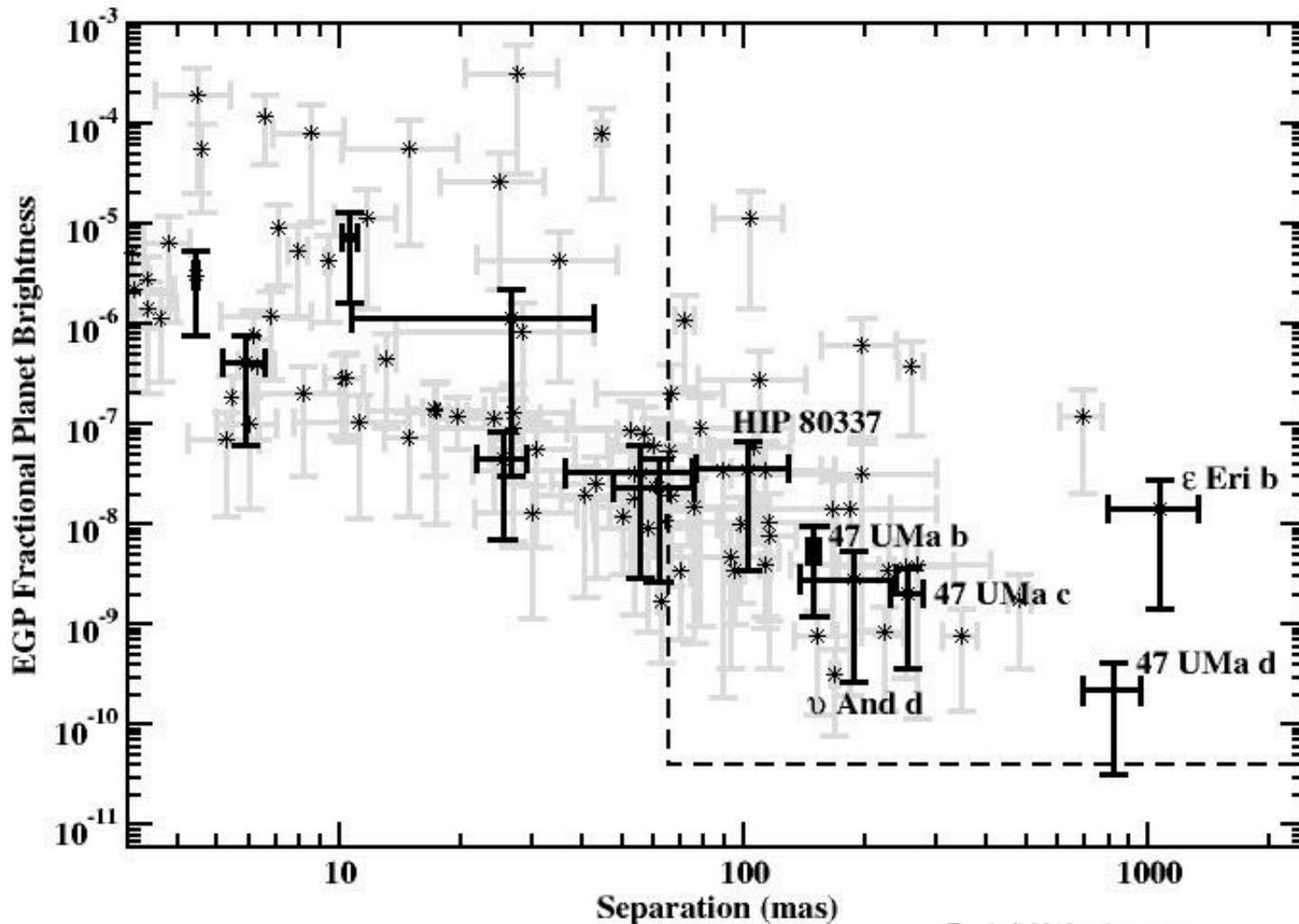


# Exo-S: Smallest Detectable Planet Size, In and Around the HZ (planets brighter than V = 30; IWA=100mas, FPB>4e-11)



# Why Direct Imaging?

→ To follow up on RV discoveries.



# Why Direct Imaging?

→ To study exoplanet atmospheres, including biogenic and greenhouse gases relevant to climate modeling.



**"Blue of the sky"**  
measures  
total amount  
of atmosphere

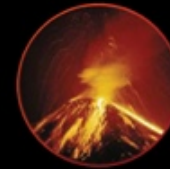
**"Vegetation  
jump"**  
indicates  
presence of  
land plants



## Earthshine spectrum

Spectroscopic signatures indicate the possible conditions conducive to life

**Carbon dioxide**  
suggests possible  
volcanic activity



**Methane**  
indicates  
presence of  
anaerobic  
bacteria



**Oxygen  
and ozone**  
were produced  
by living organisms



**Water  
vapor**  
suggests  
habitability



Brightness

WAVELENGTH

Optical

Visible

Near

# Why Direct Imaging?

- To study surface signatures, including vegetation and glint from oceans.
- To explore variability caused by continents, weather, and seasons.

# The Many Faces of Earth: continents, oceans, weather, seasons

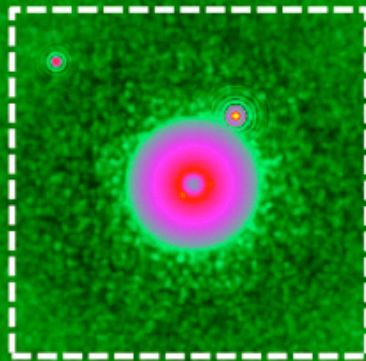


2005-08-02T22:31:51.787612



# Astrophysical Threats and Prep Science

→ Exozodiacal dust may bury planet signals – or give them away

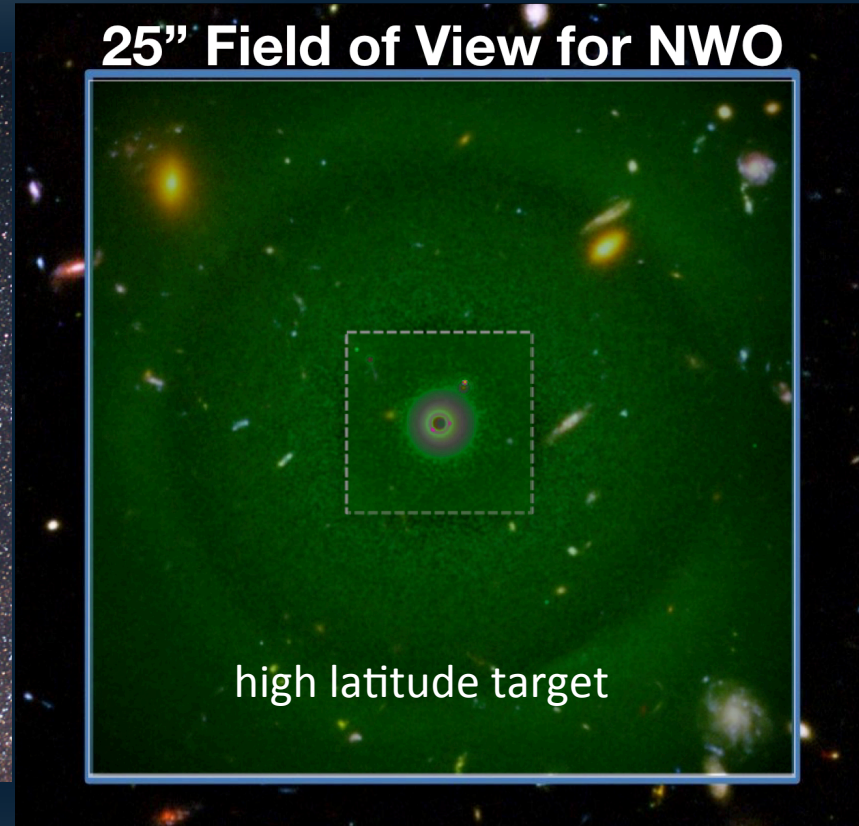


→ Must know this in advance for high priority targets.

# Astrophysical Threats and Prep Science

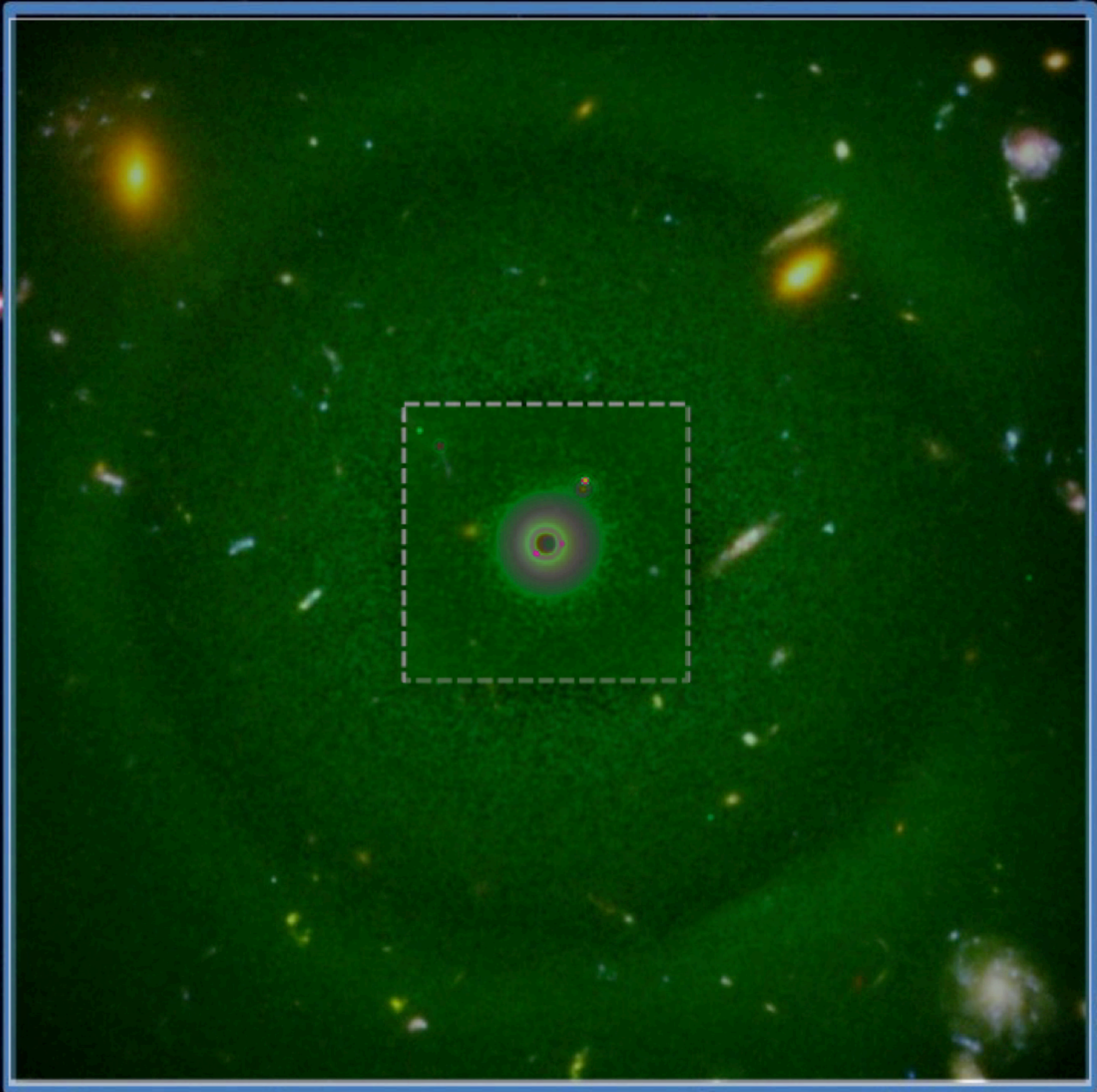
→ Background down to  $V=30$ .

What does it look like???



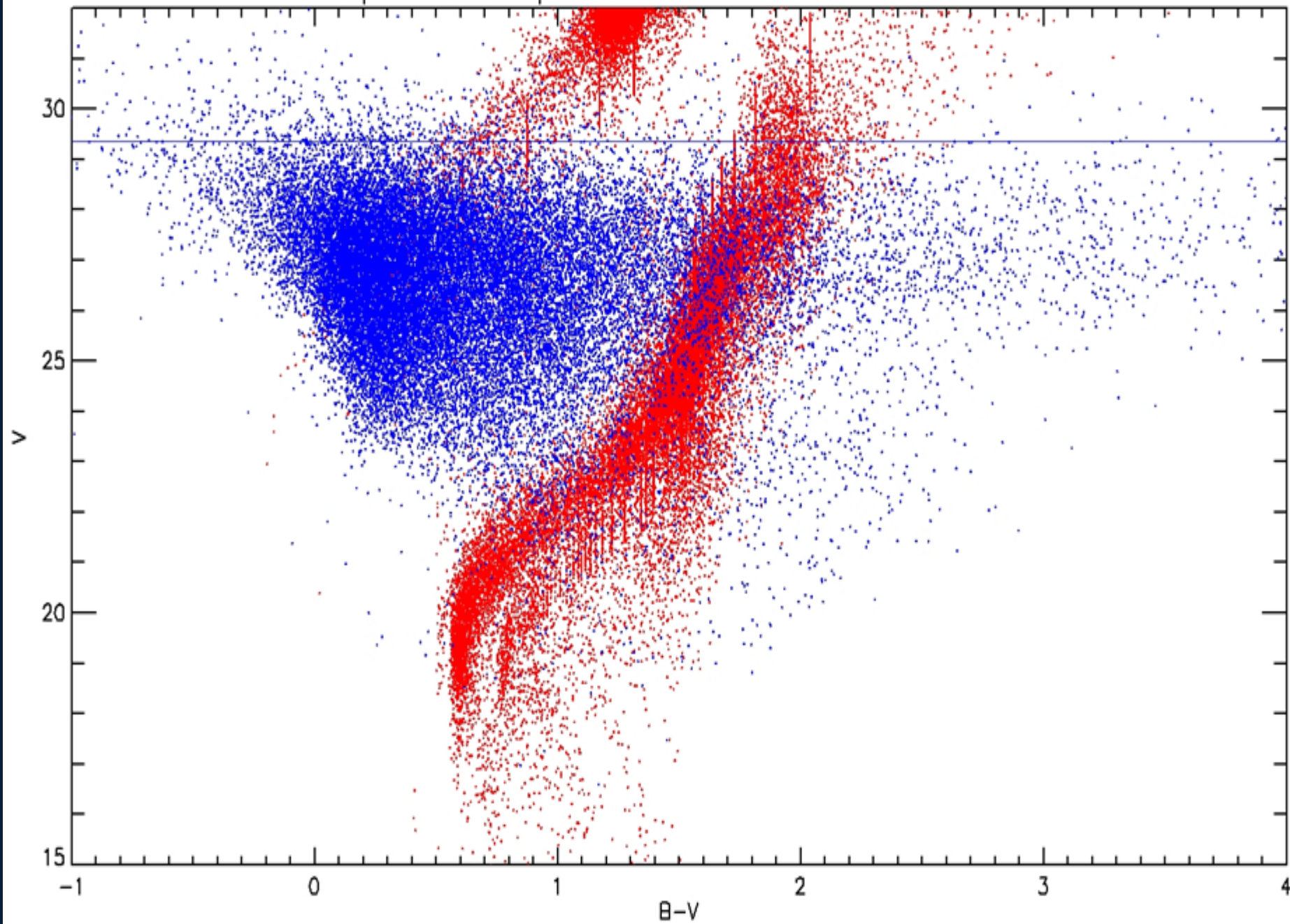
→ Characterize this in advance for high proper motion systems



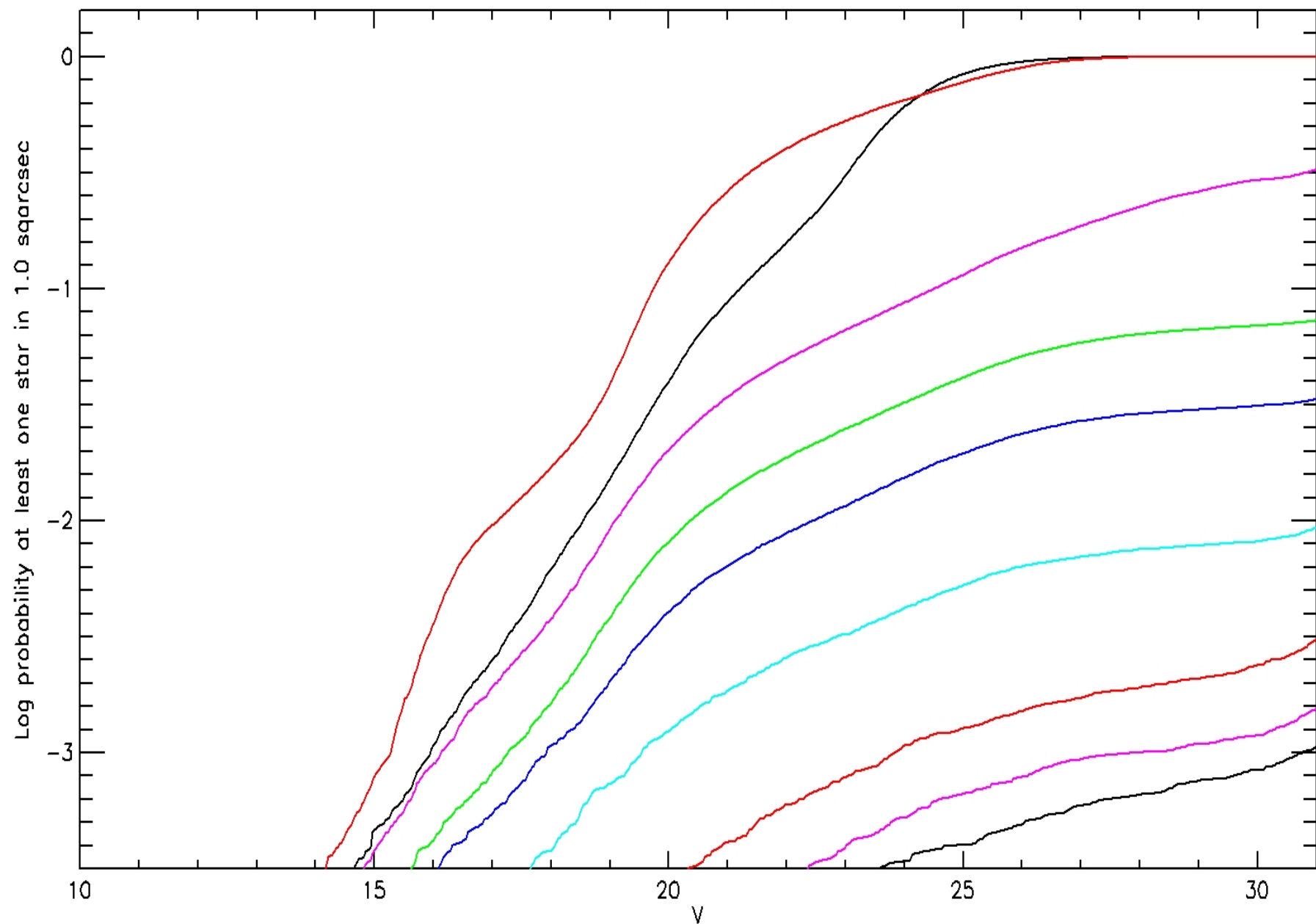




Complete ACS sample CANDELS GOODS-S + Besancon b=10



# Galactic stars



Complete sample CANDELS GOODS-S + Besancon b=10

