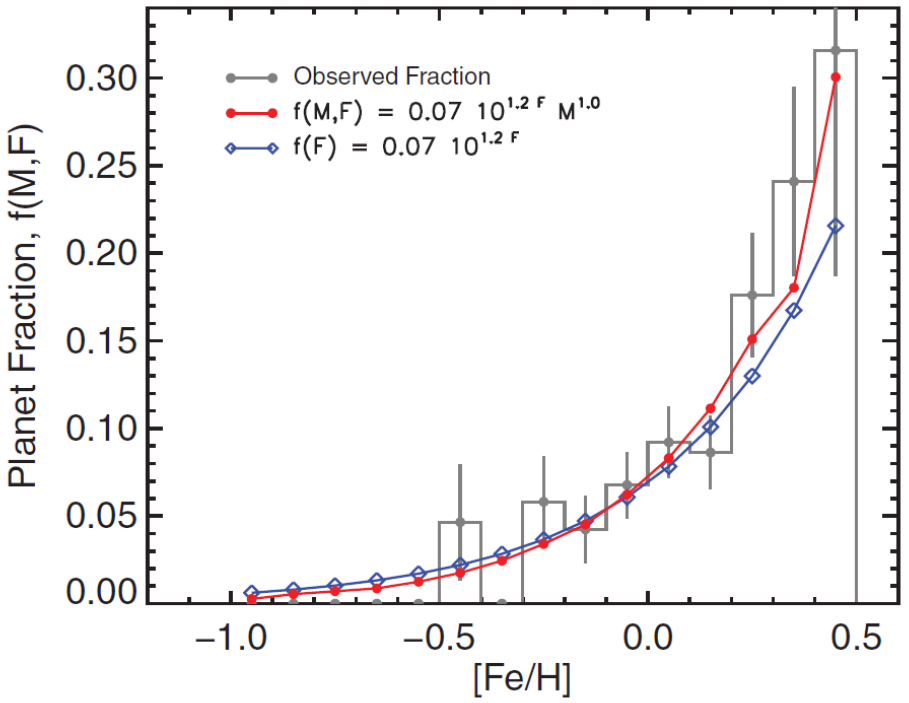
Alpha Elements' Effects on Planet Formation & the Hunt for Extragalactic Planets

Matthew Penny
Ohio State University

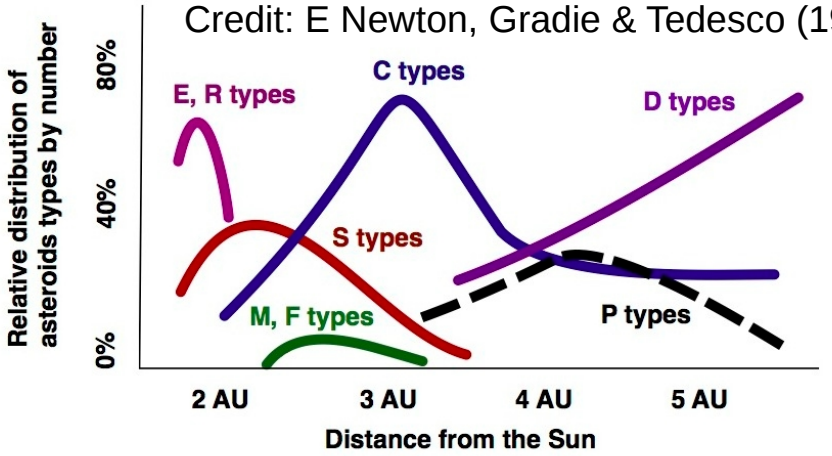
Planet Frequency & Metallicity

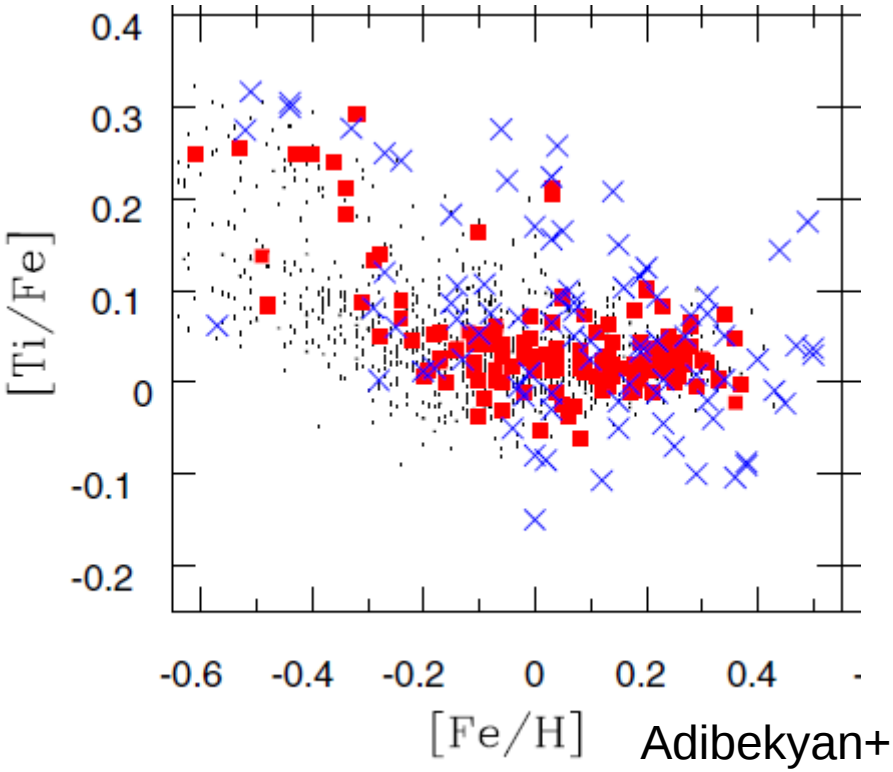


Johnson+2010

- Well known, strong correlation for RV giant planets (Gonzalez 1998, Santos 2004, Fischer & Valenti 2005, Johnson+2010, …)
- Similar results for hot Jupiters (e.g., Guo+2016)
- Mixed results for smaller planets

Iron or Rock?

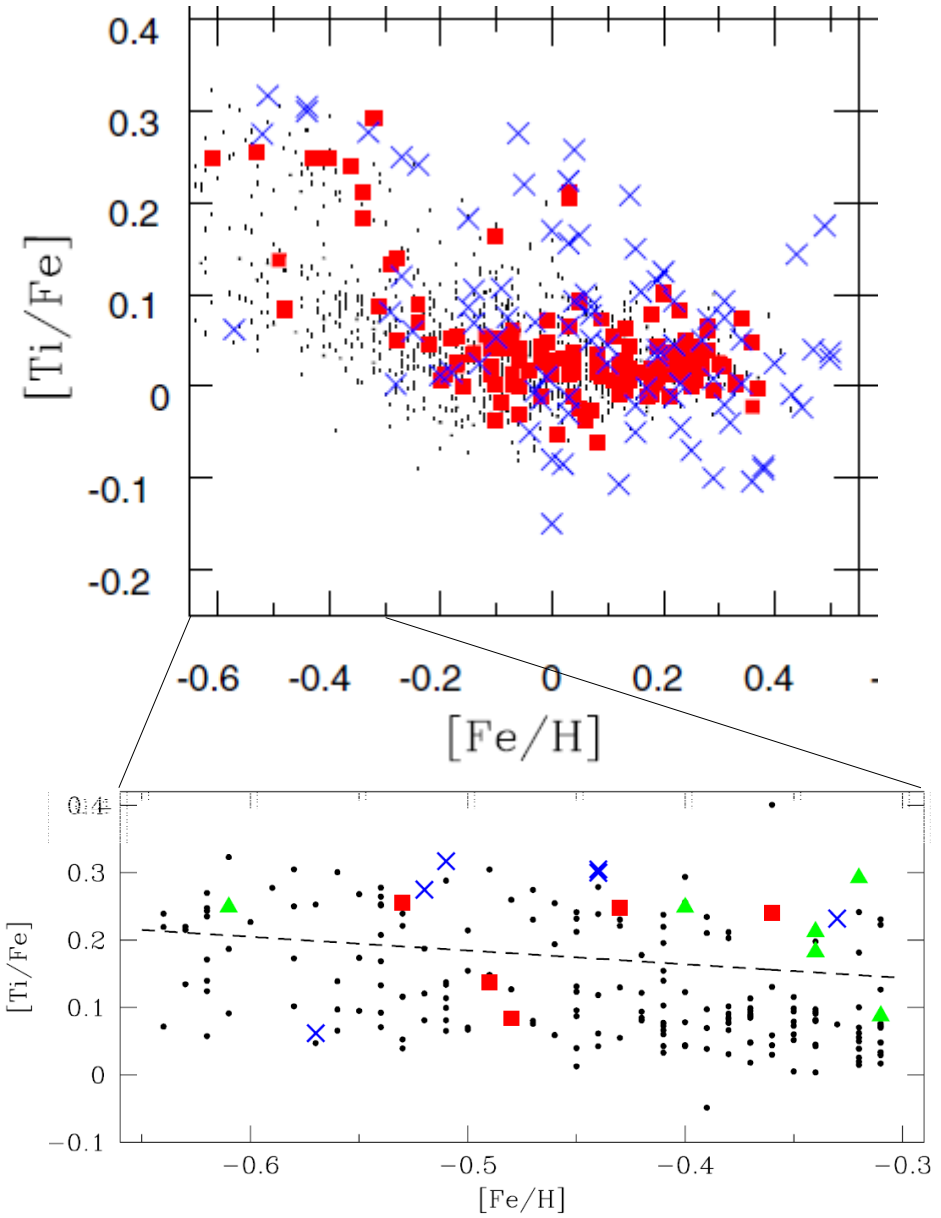




Adibekyan+2012

- Differentiation of asteroid composition as function of semimajor axis
- Assumed that HJs form past snowline (ices, e.g. H_2O, CH)
- Might alpha be a better correlate?

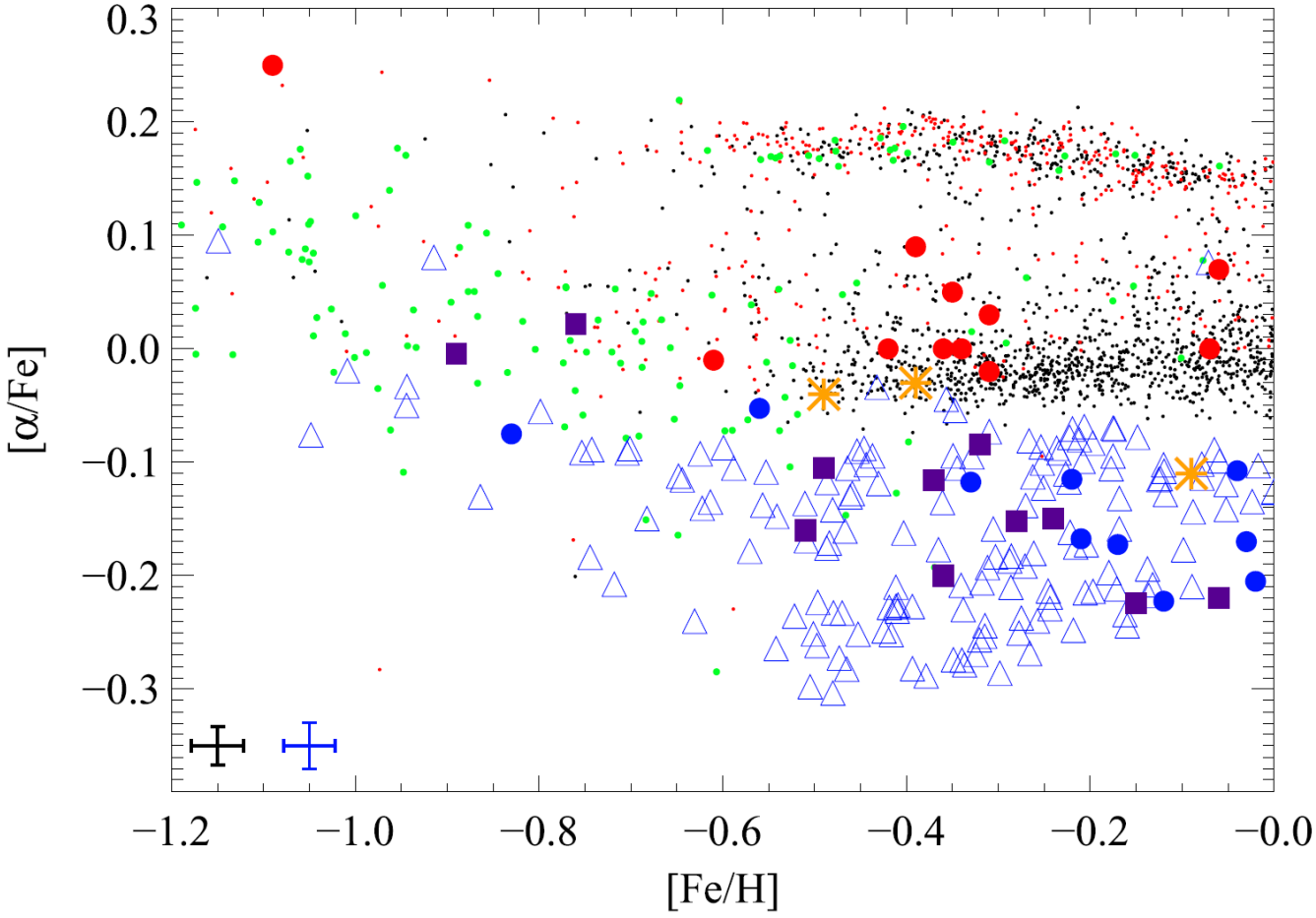
Alpha Elements are Important



- Low [Fe/H] planet hosts tend to be α-enhanced, thick disk stars (e.g Adibekyan+2012)
- Does α-enhancement help higher metallicity stars?
- Too few SN & Kepler stars with high-Fe & high-α
- What about low-α?
- Are Hot Jupiters different?

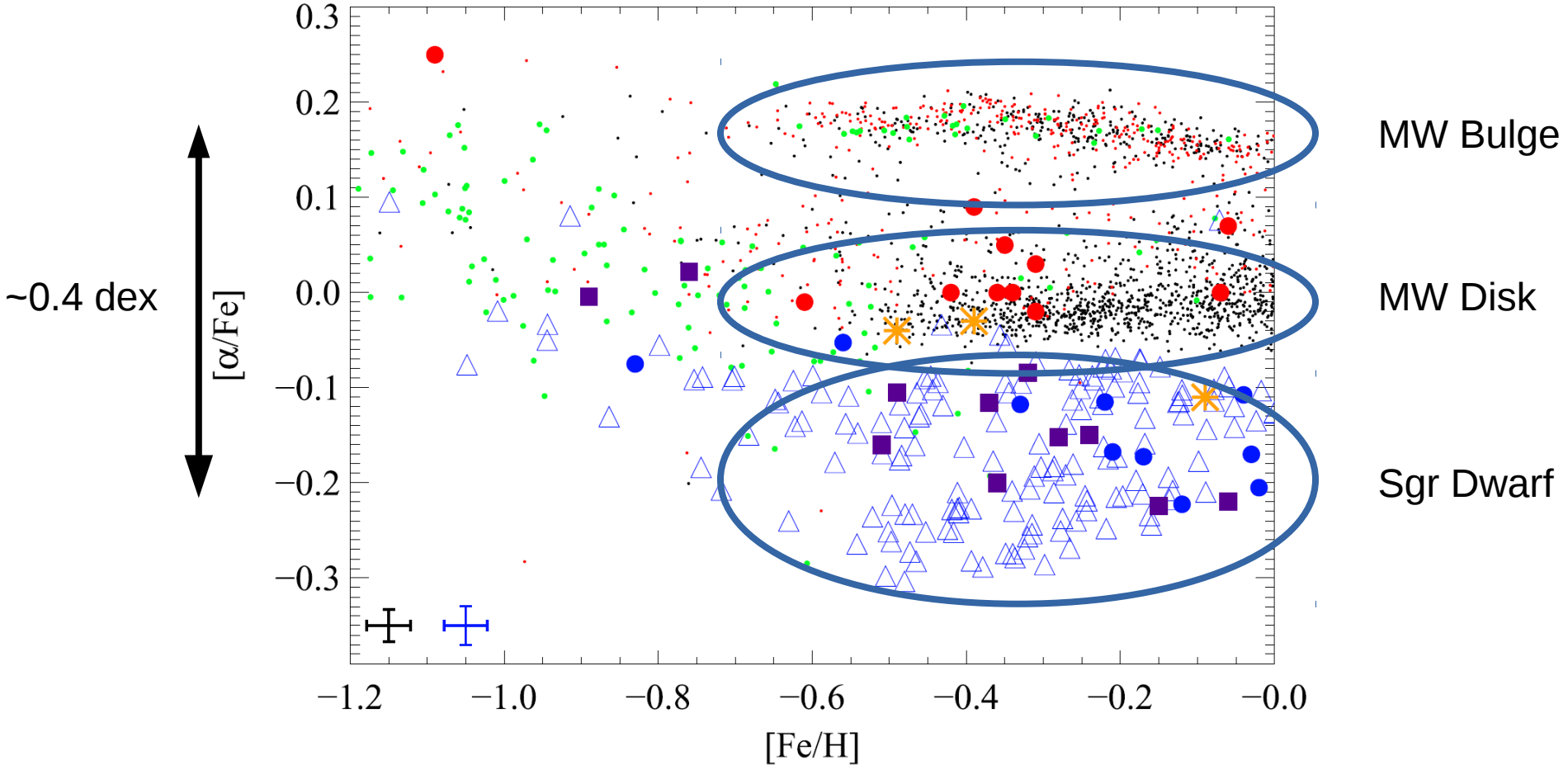
Adibekyan+2012

Stuck in the Neighborhood



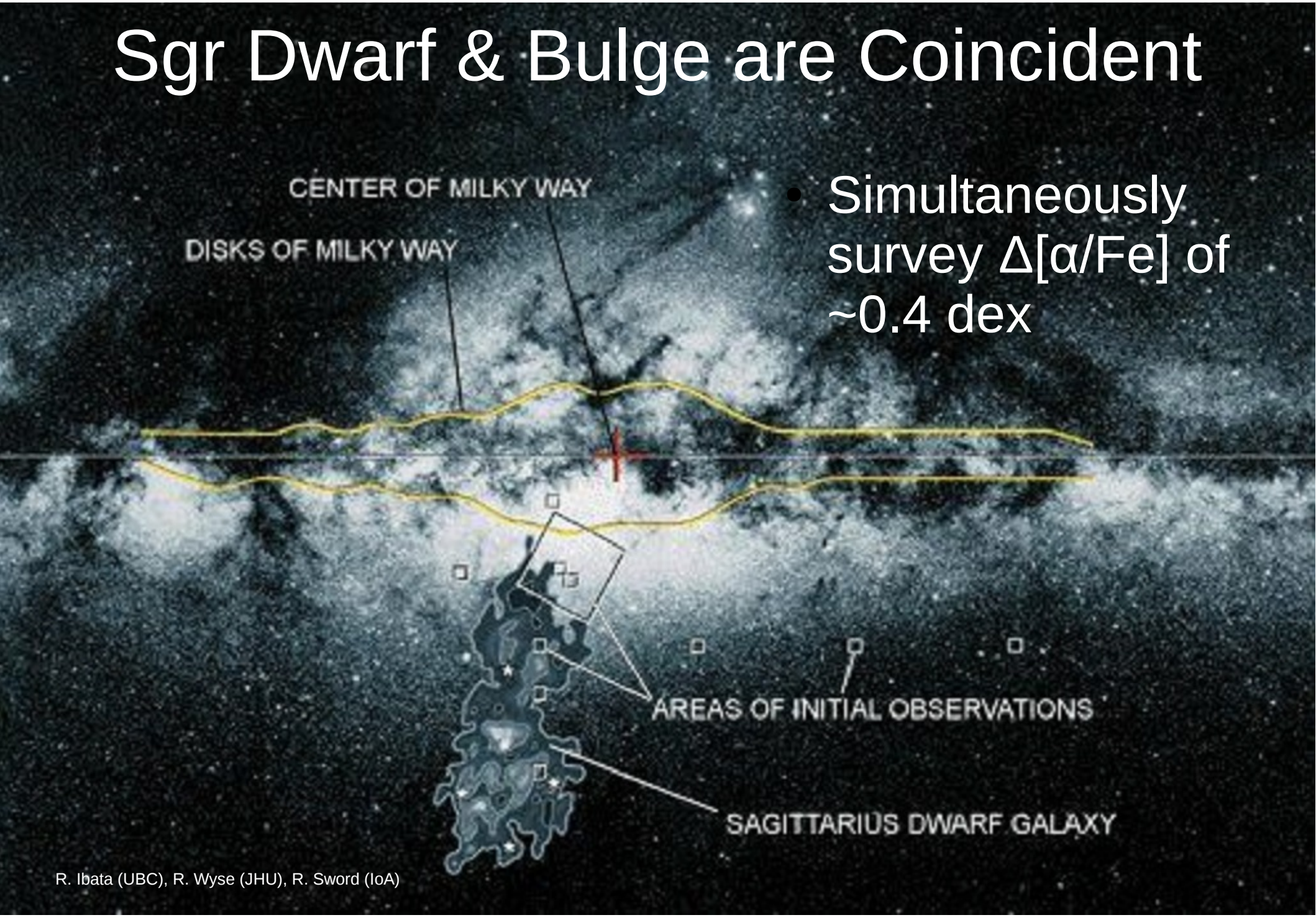
Hasselquist+2017 (APOGEE)

Stuck in the Neighborhood

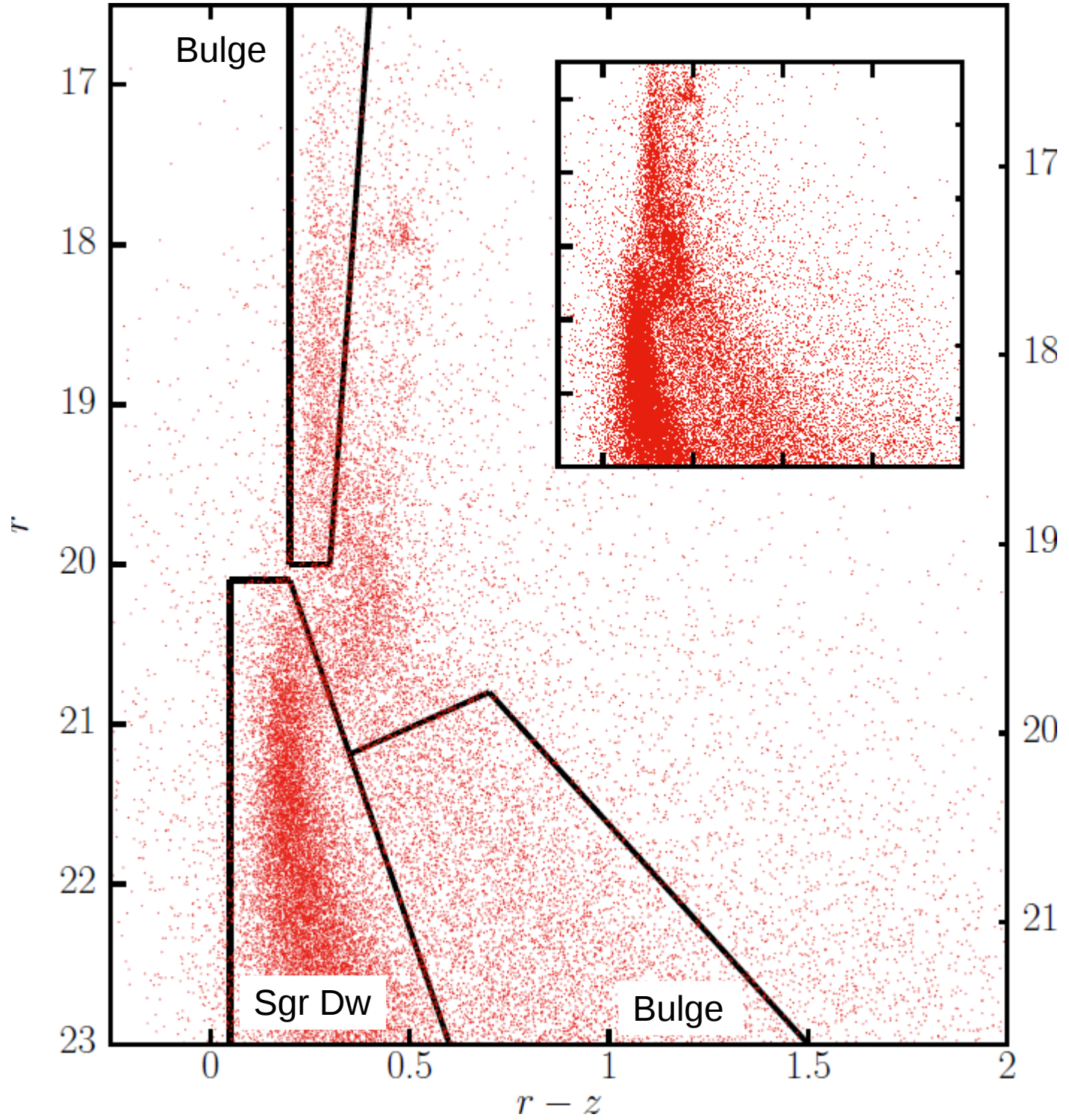


Hasselquist+2017 (APOGEE)

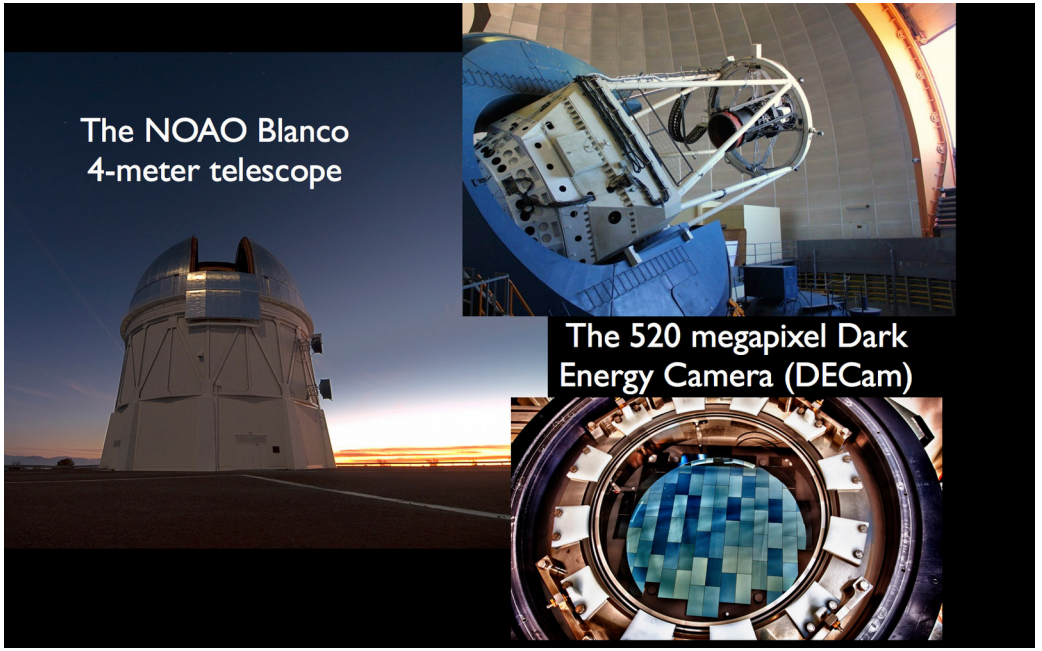
Sgr Dwarf & Bulge are Coincident



- Simultaneously survey Δ[α/Fe] of ~0.4 dex


Bulge
Sgr Dw
Bulge
17
18
19
20
21
22
23
0
0.5
1
1.5
2
r
$r - z$

A DECam Transit Survey



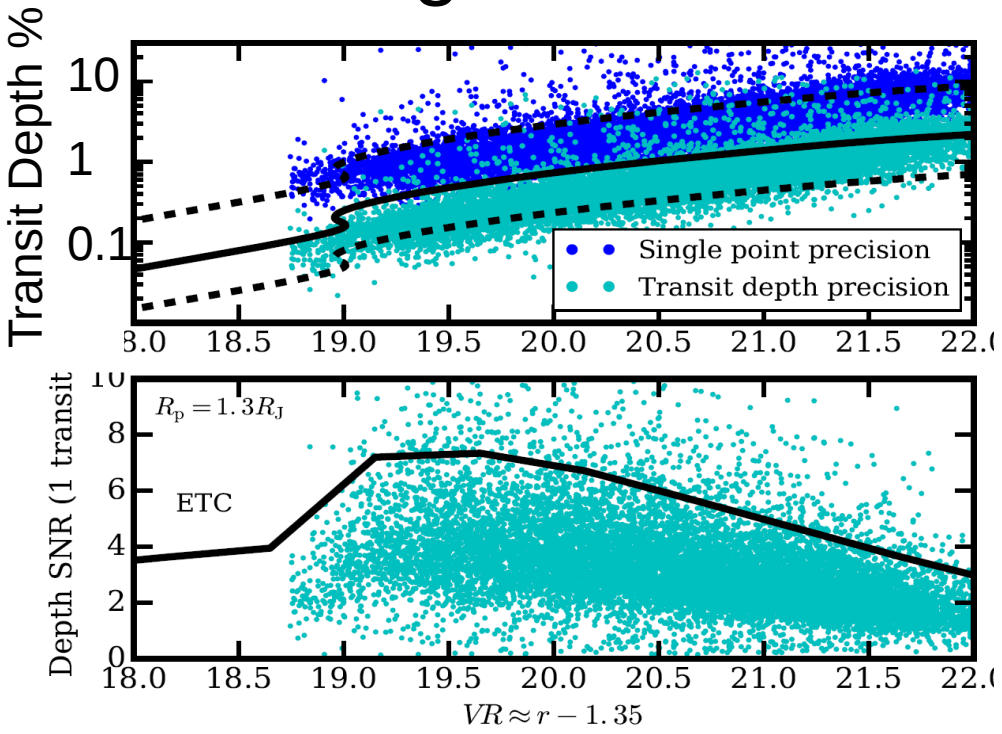
- 3 deg^2 field, 4m scope
- Efficient (20s readout, filter changes)
- Wide VR filter, red sensitve CCDs

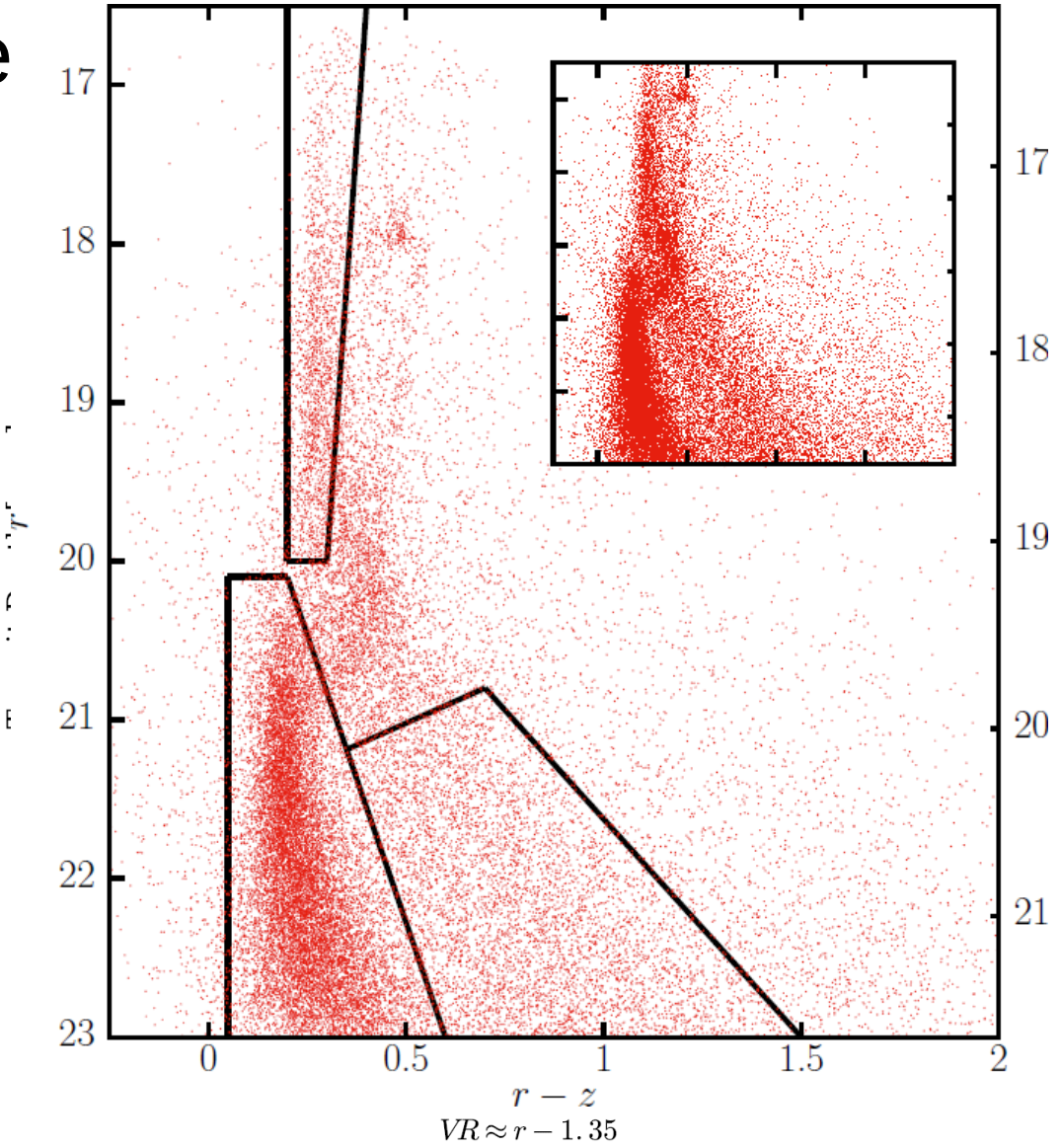
- ~1% phot. in 3 min for Sgr main sequence
- Faint, so survey must rule out false positives alone
- 5 nights x 3 years
- P<3 days, simplifies interpretation (e.g., can assume e=0)

Transit Detectability

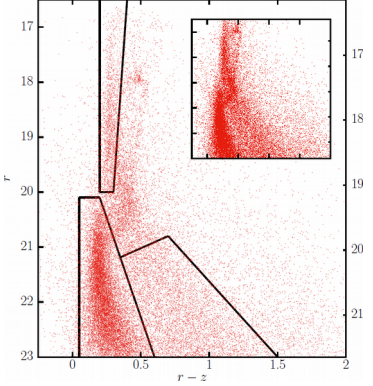
- Test run of survey-like observations & quick photometry

Sgr Dwarf





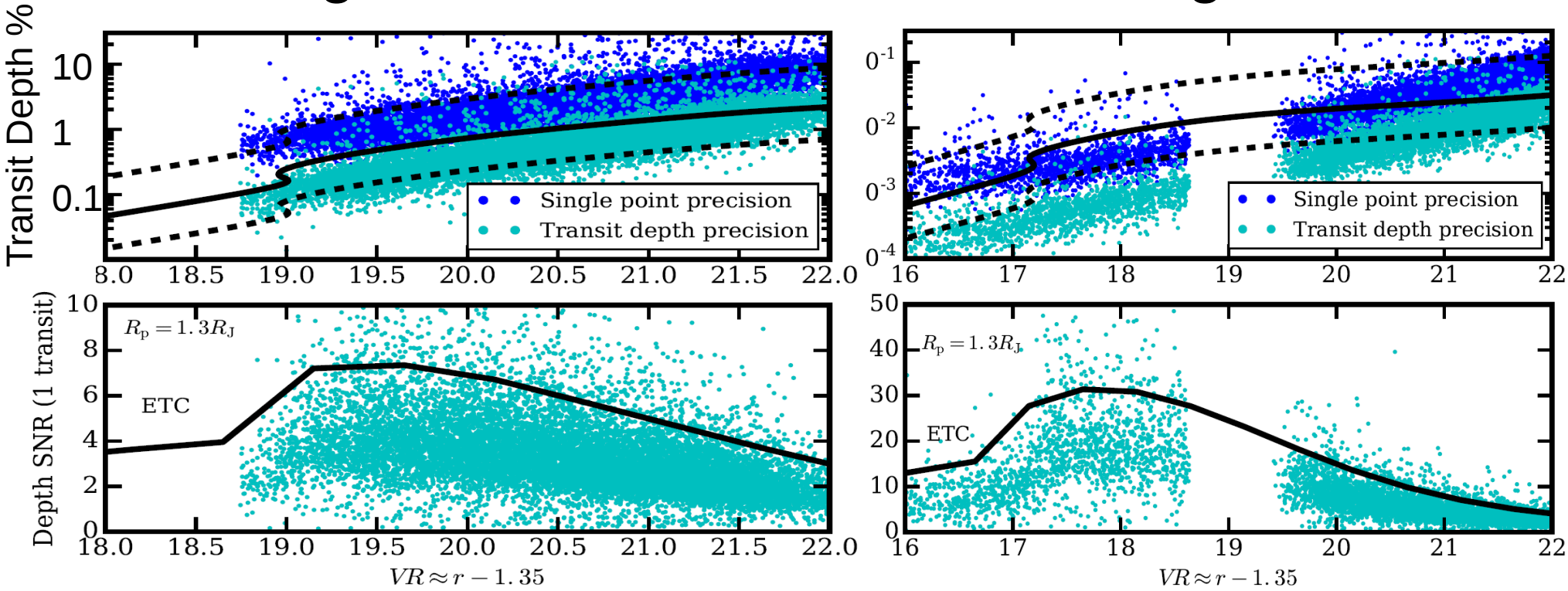
Transit Detectability



- Test run of survey-like observations & quick photometry
- Carter+2008 fisher matrix estimates (single transit)

Sgr Dwarf

Bulge

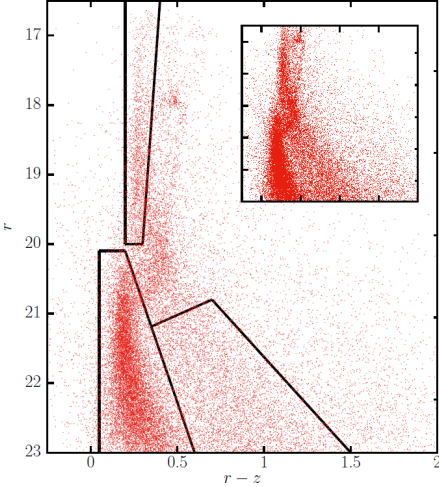


But what about False Positives?

- FGK-M eclipsing binaries
- Heirarchical Triples
- Blended Ebs (foreground/ background or coincident)
- Grazing EBs

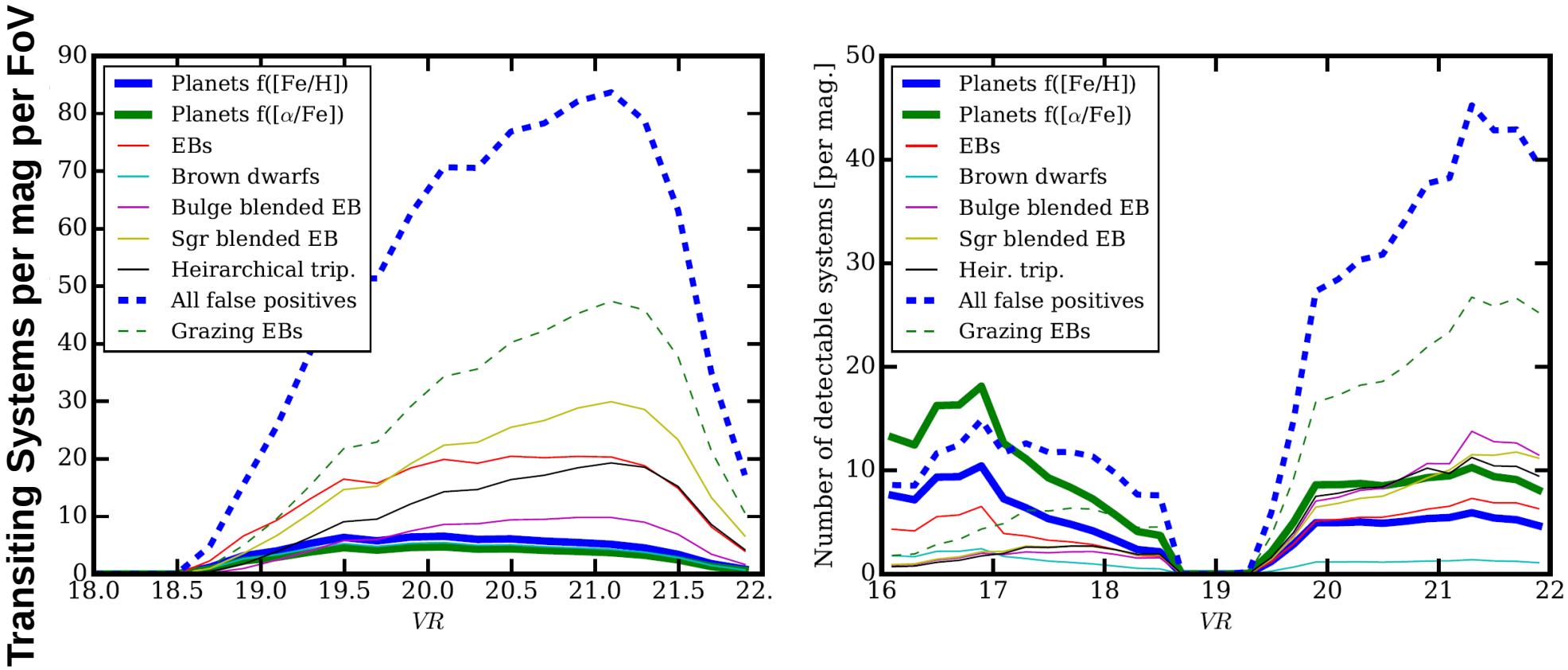
- Assume bulge and Sgr are thin screens with same age & metallicity
- Use isochrones + IMF + binary/planet frequencies to estimate the ratio of transiting planet impostors $(R_B/R_A)^2 \sim 0.01$

False Positives



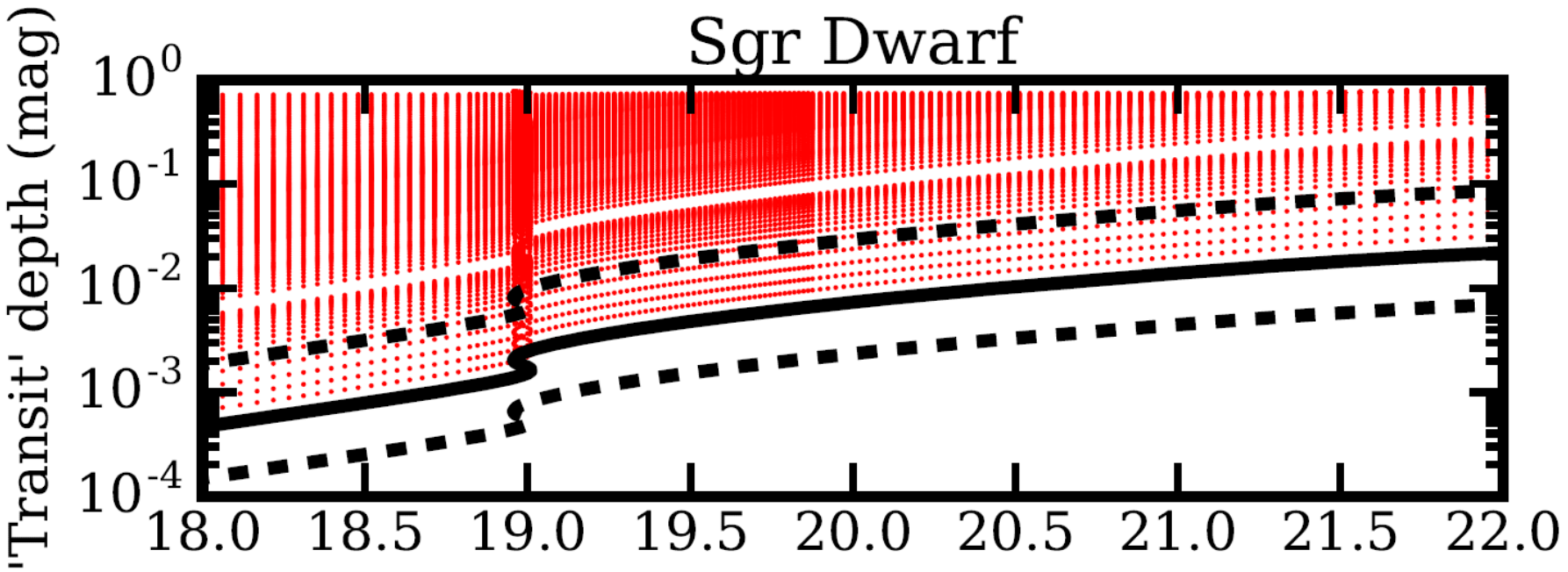
Sgr Dwarf

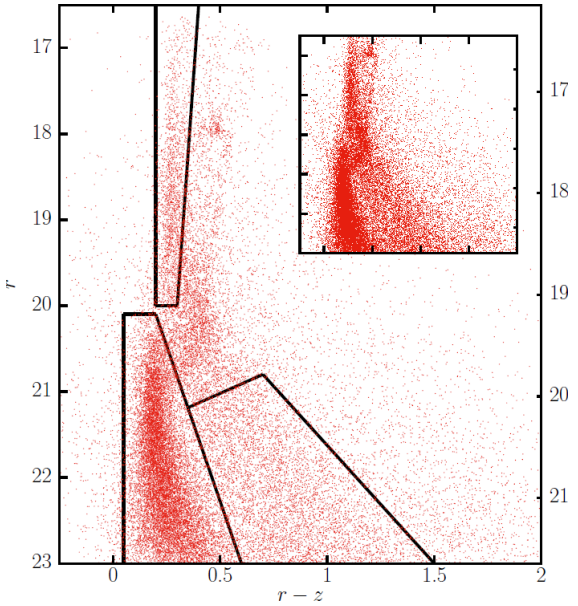
Bulge



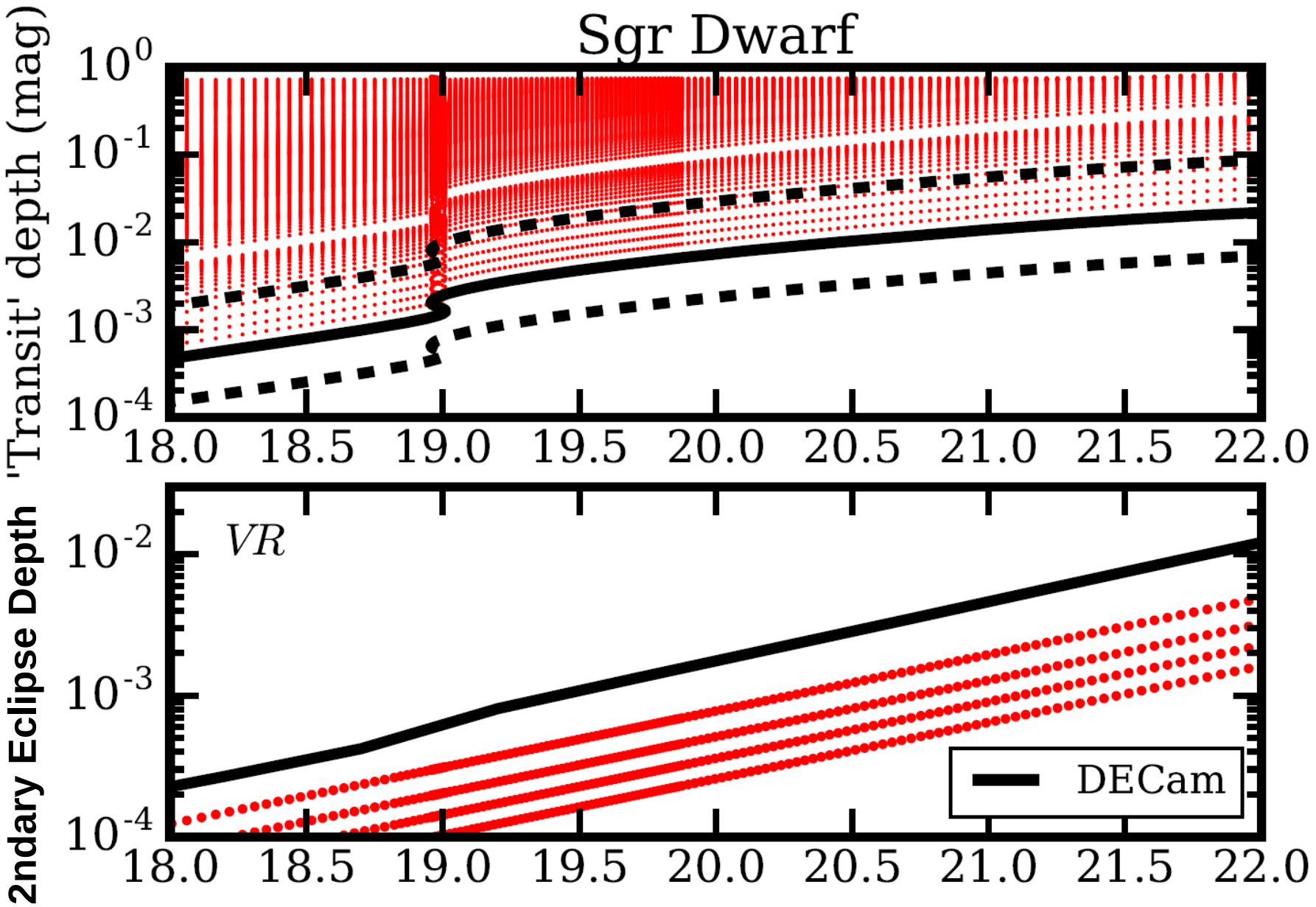
Based on stars detected in images (+ assumed incompleteness for blends)
Planet frequency assumes mean [Fe/H]

Transiting Planet Impostors: EBs

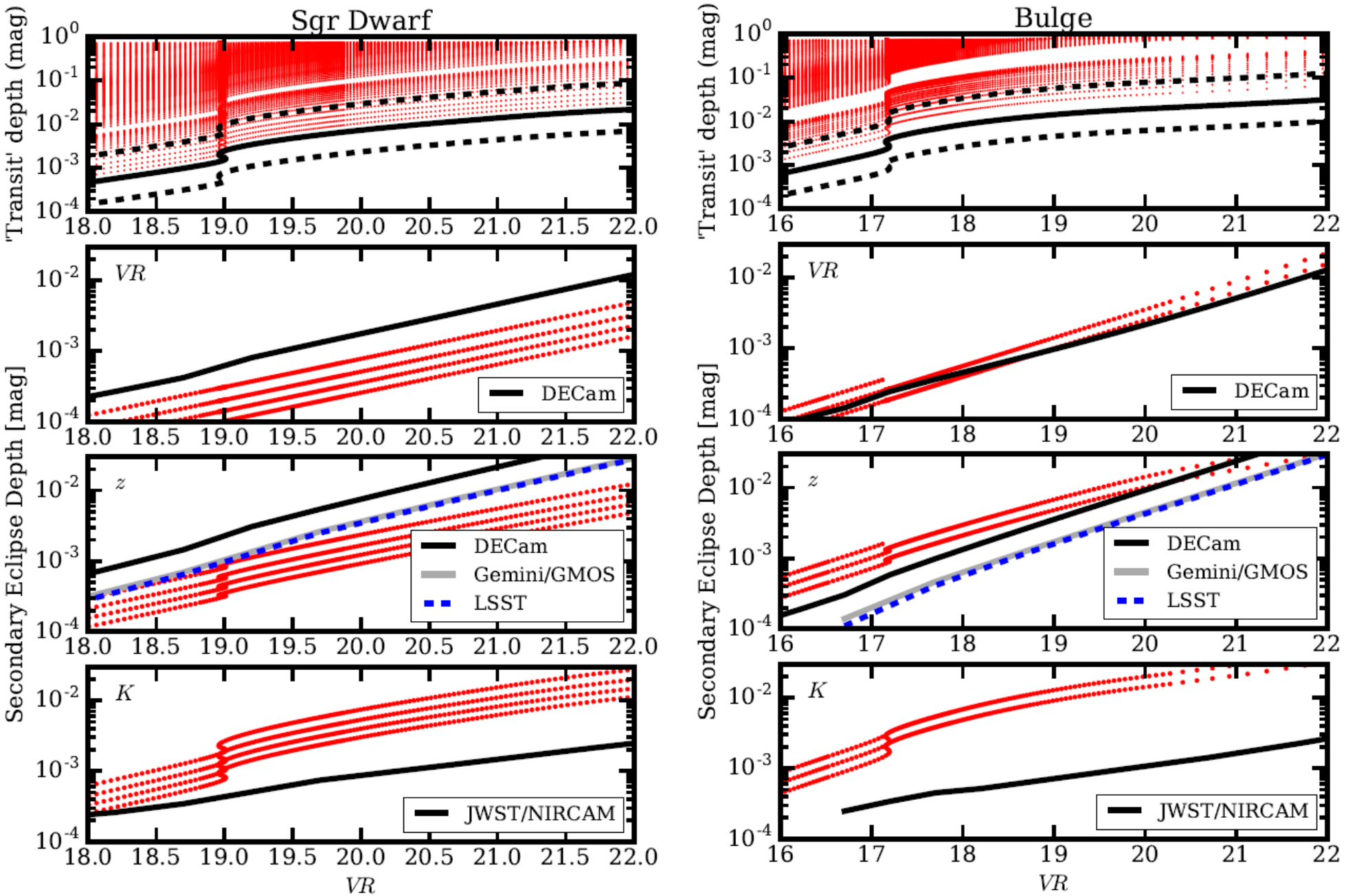




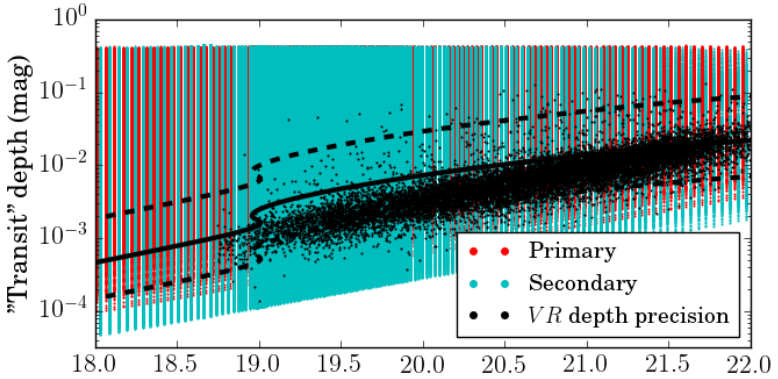
Transiting Planet Impostors: EBs

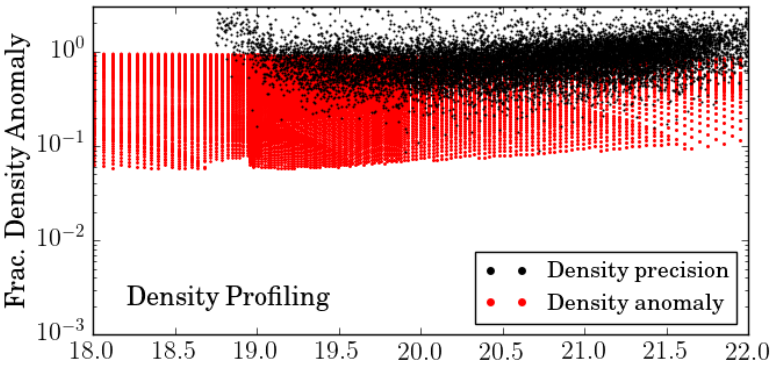


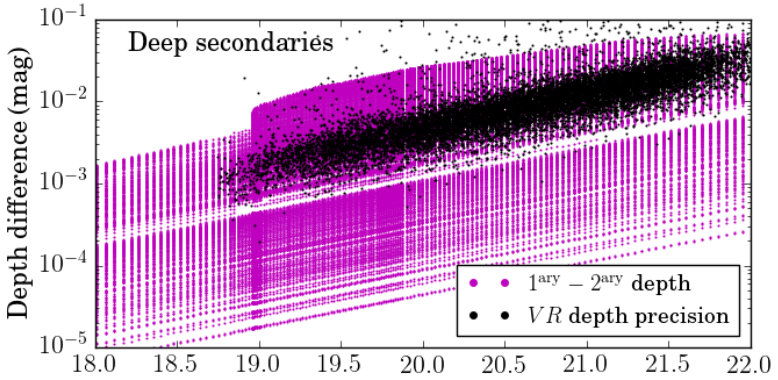
Ruling out Impostors: EBs

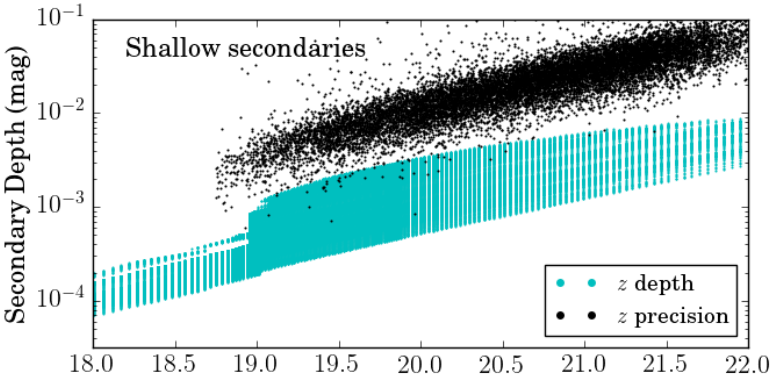


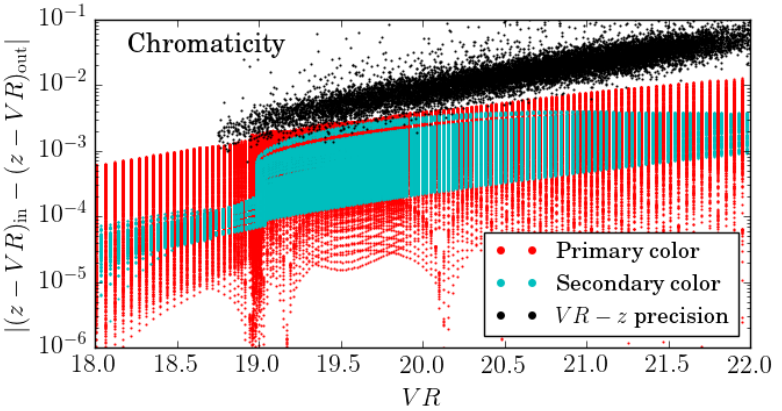
Blended EB = Heirarchcal Triple ± μ





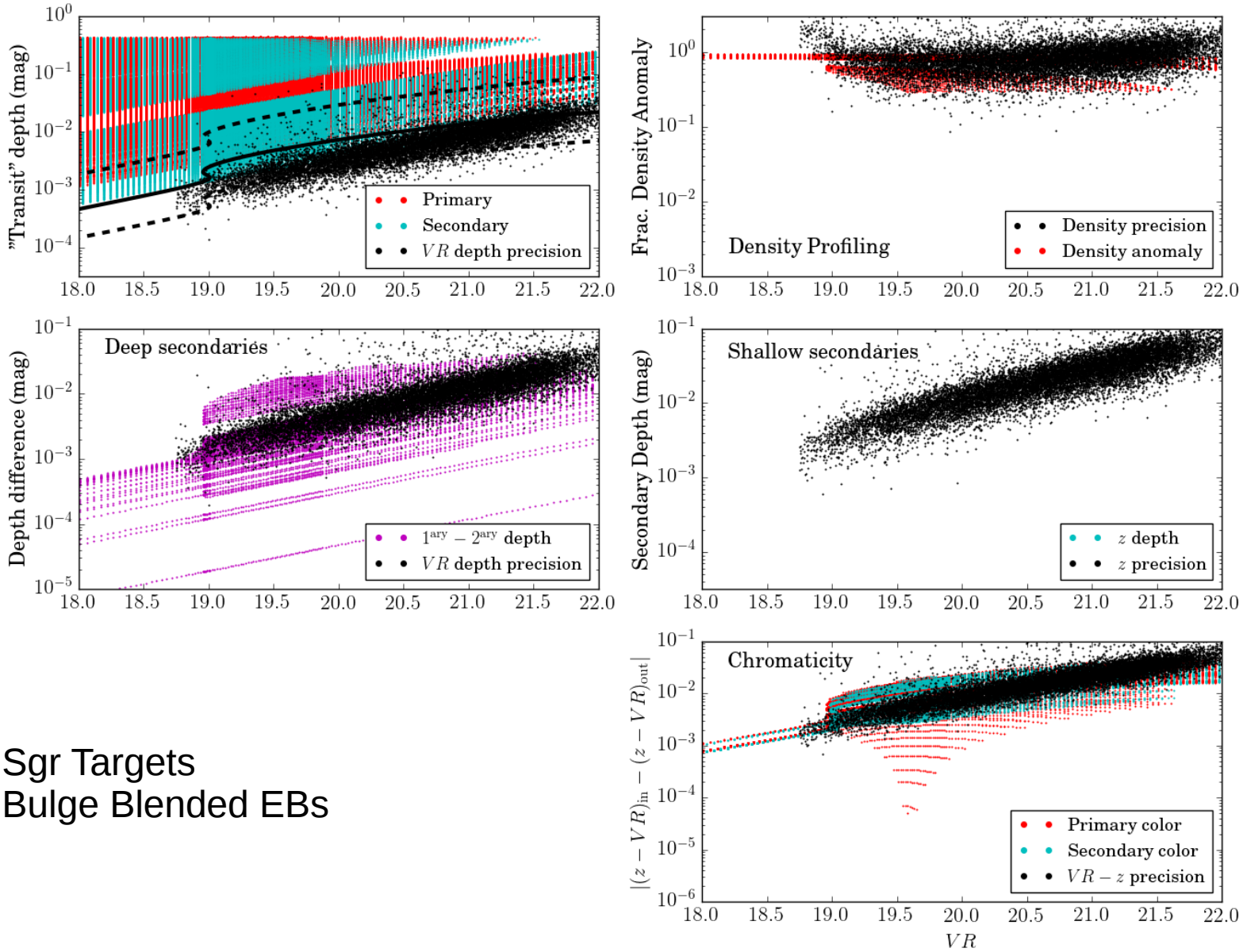






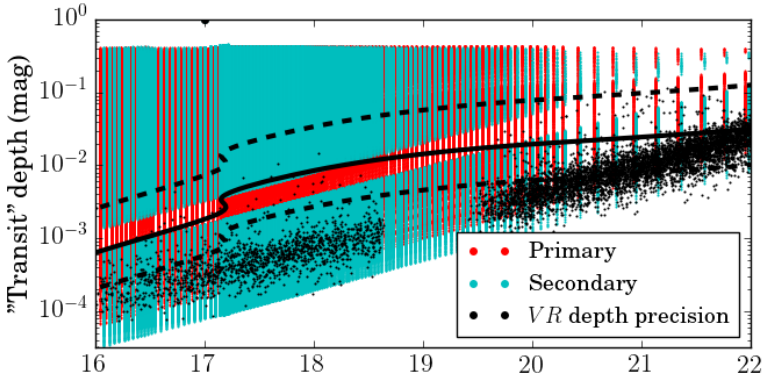
Sgr Targets
Sgr Blended EBs
Sgr Heirarchical Triples

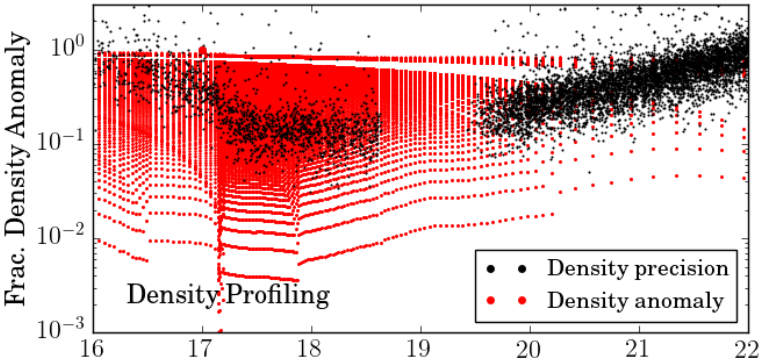
Blended EB = Heirarchcal Triple ± μ

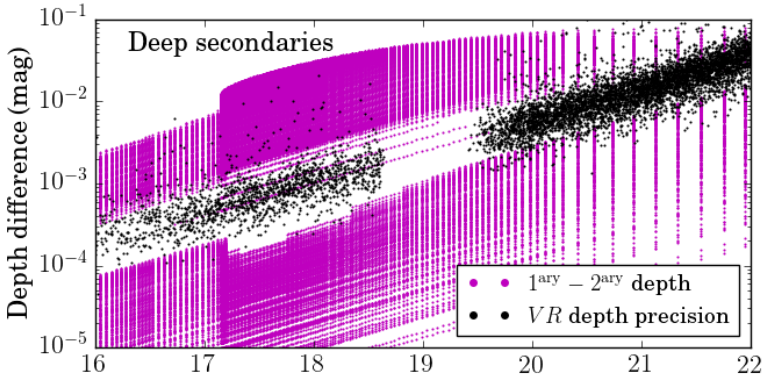


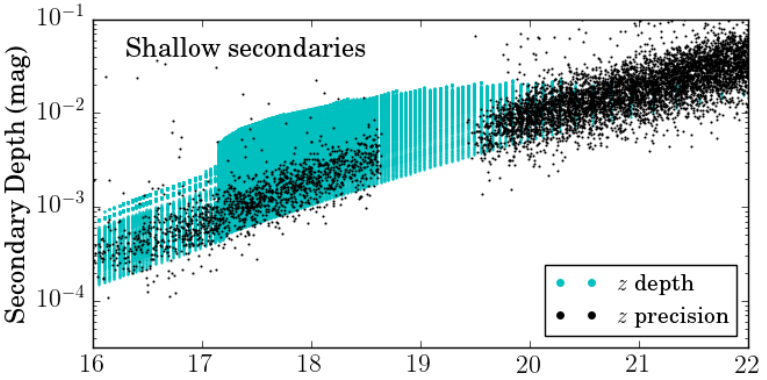
Sgr Targets
Bulge Blended EBs

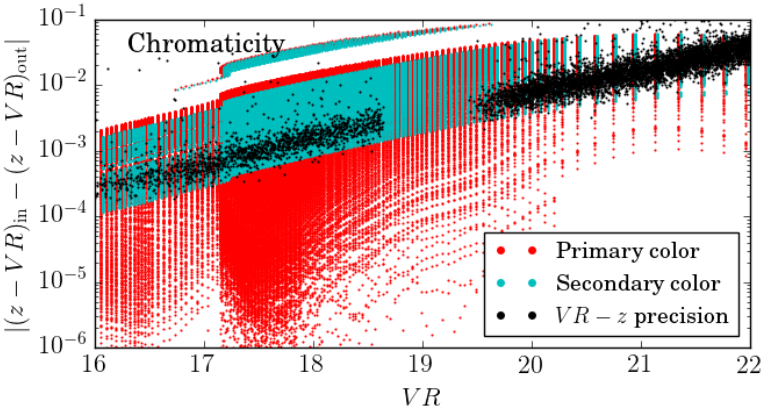
Blended EB = Heirarchcal Triple ± μ





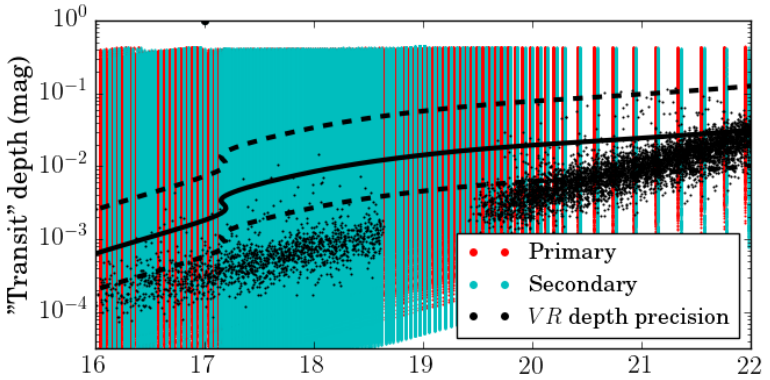


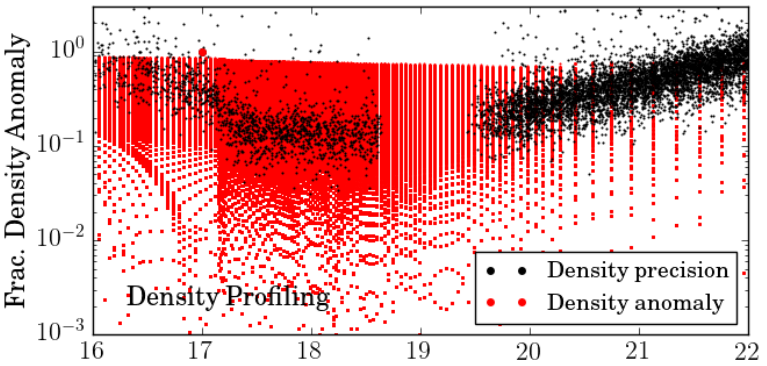


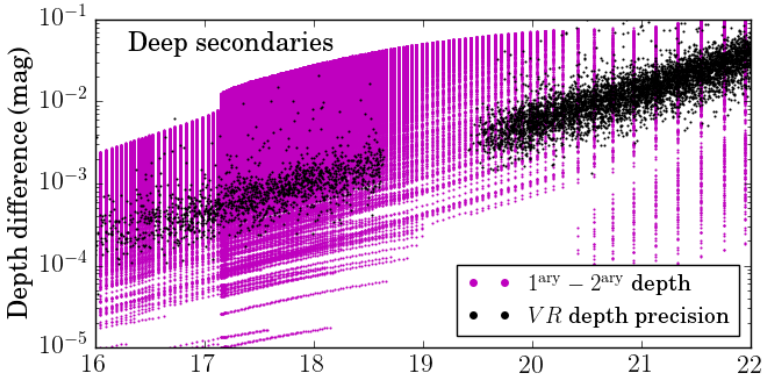


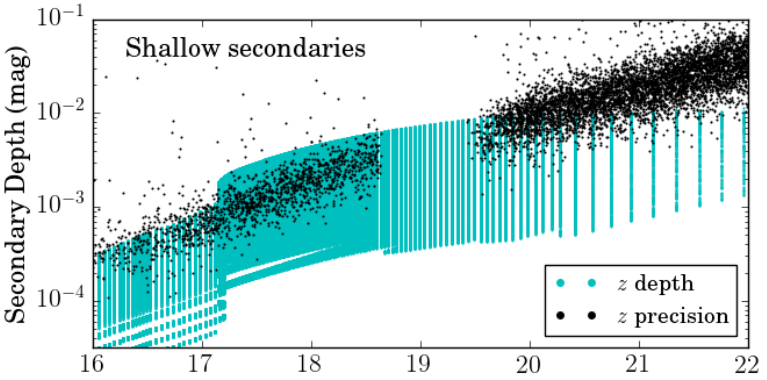
Bulge Targets
Bulge Blended EBs
Bulge Heirarchical Triples

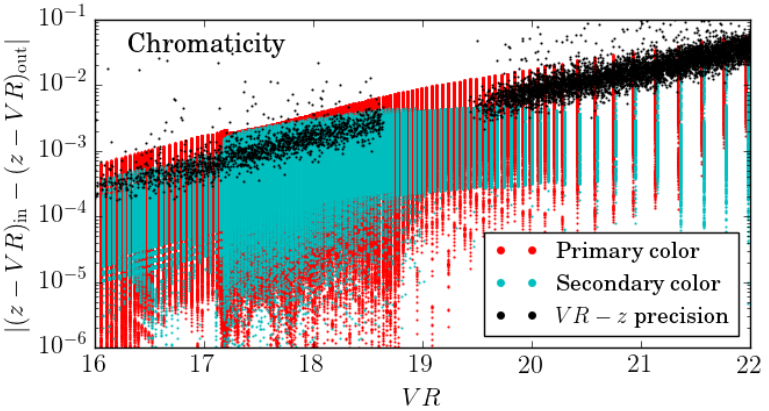
Blended EB = Heirarchcal Triple ± μ





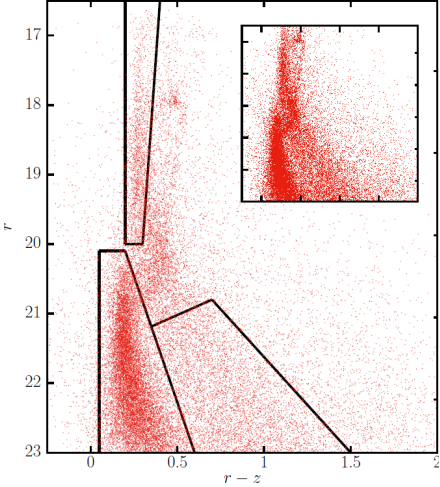






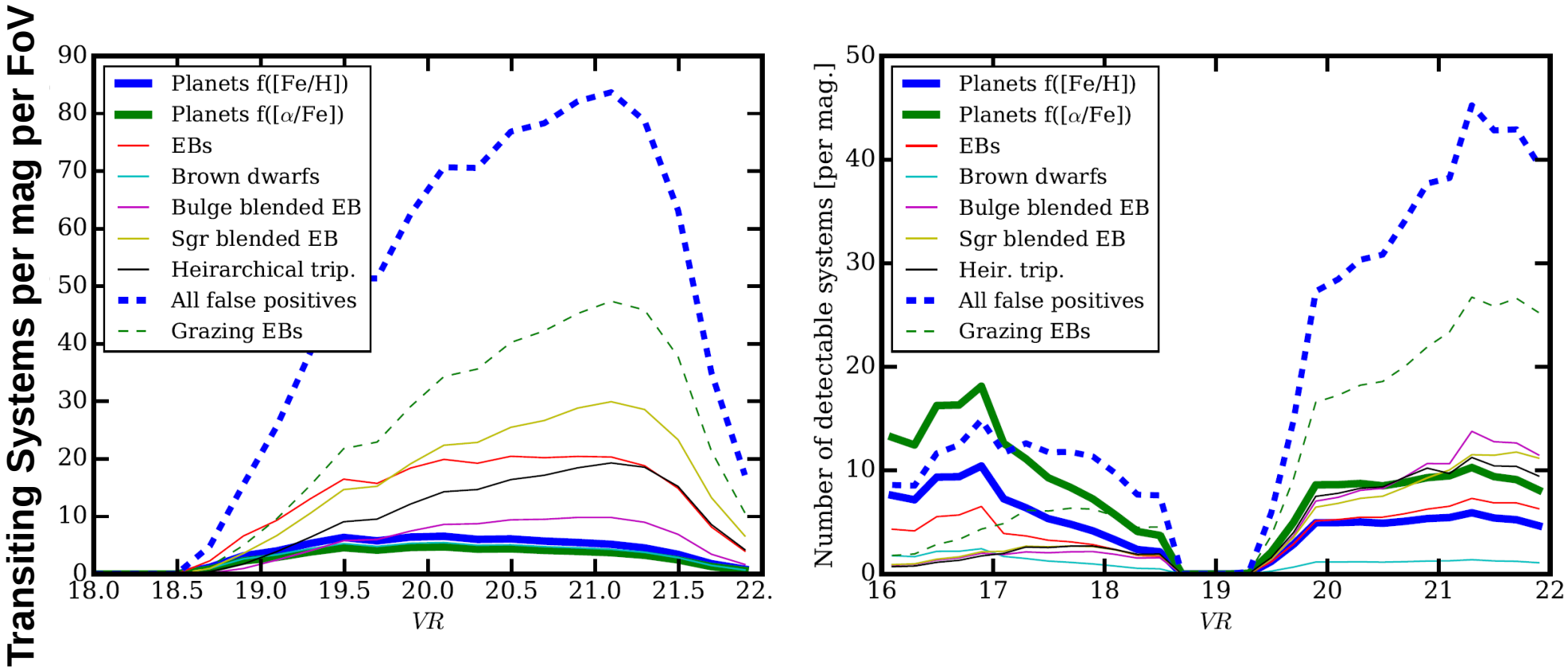
Bulge Targets
Sgr Blended EBs

False Positives



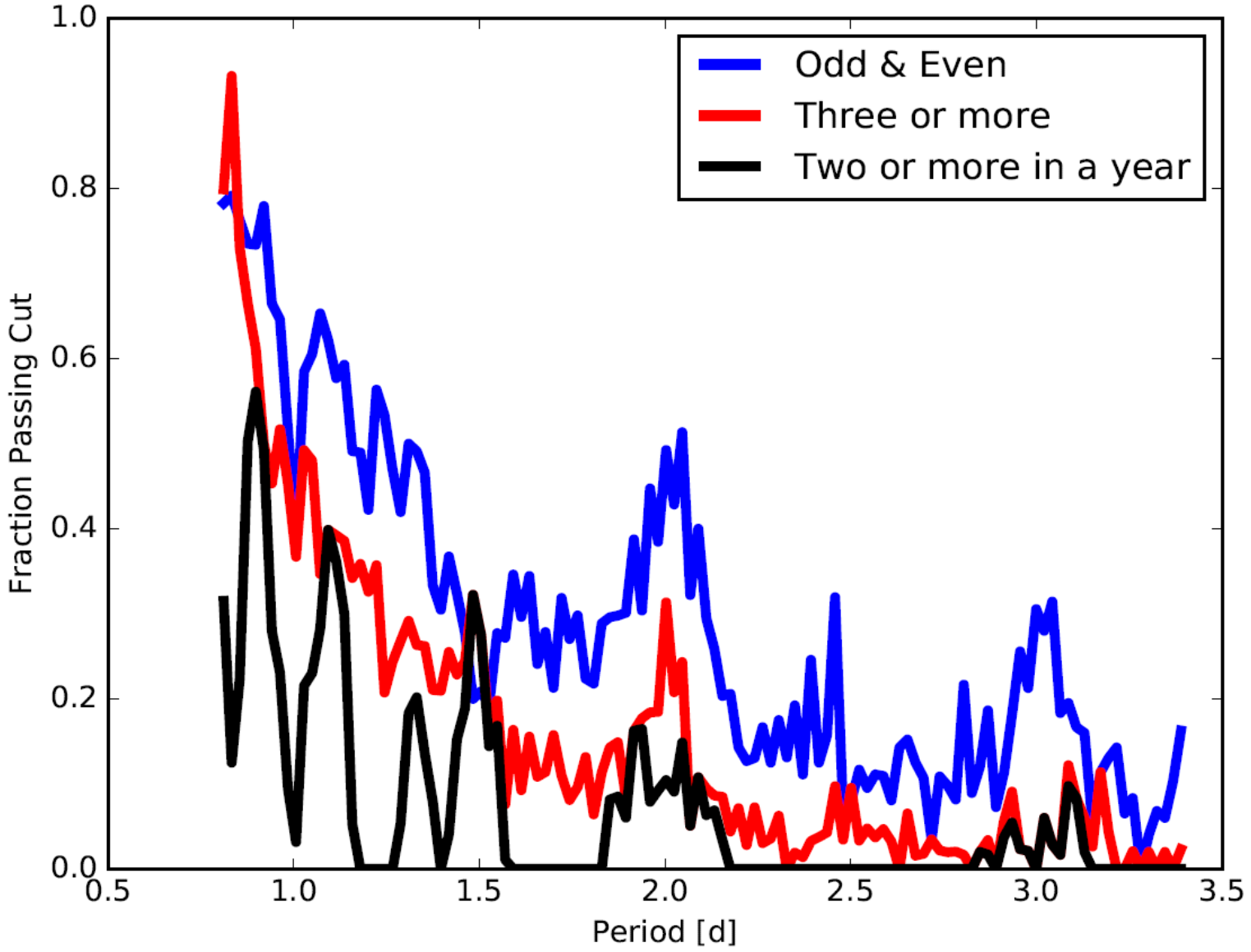
Sgr Dwarf

Bulge

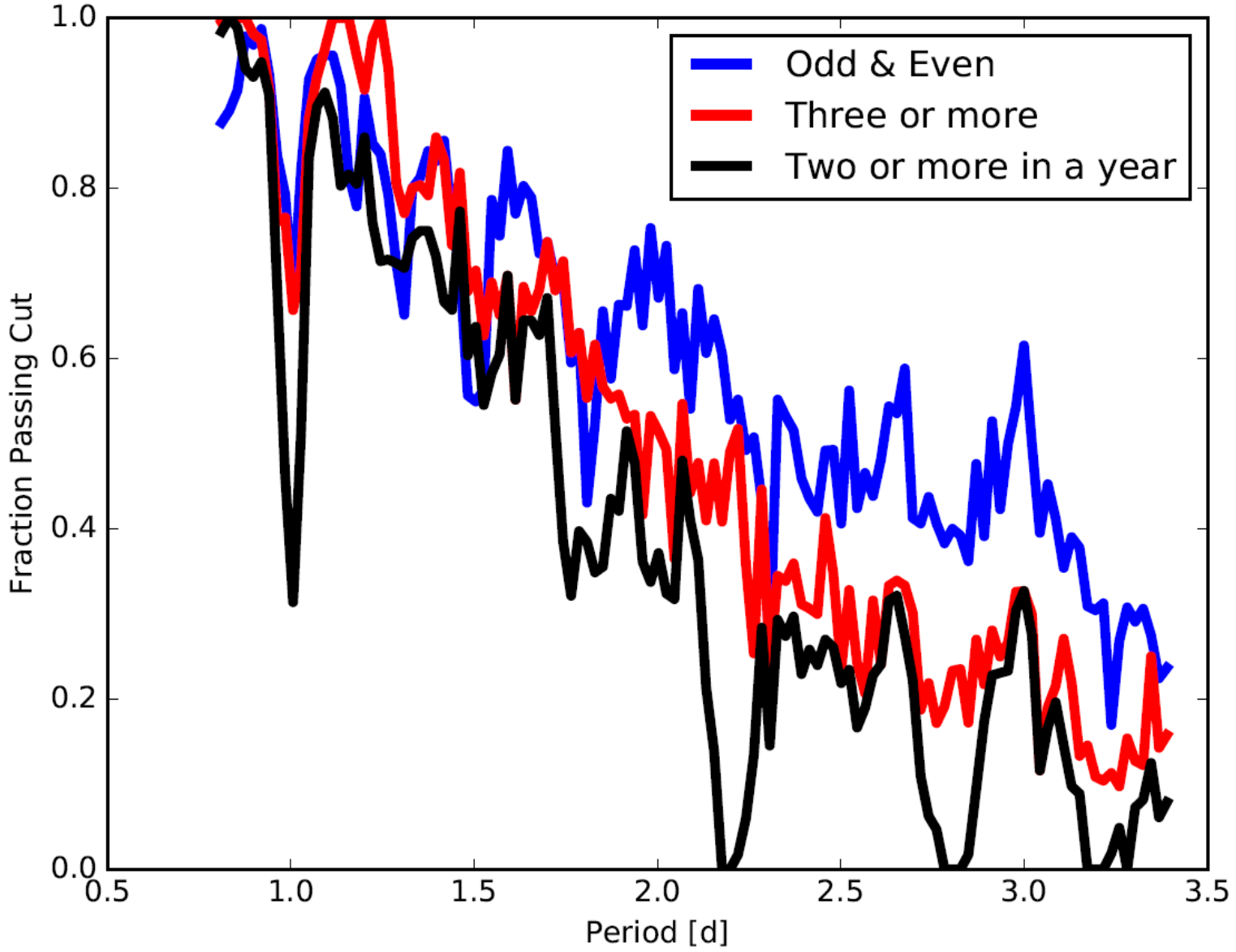


Based on stars detected in images (+ assumed incompleteness for blends)
Planet frequency assumes mean [Fe/H]

Closing the Window Function



Closing the Window Function



Conclusions

Sgr Dwarf

- Transits are detectable
- But, high false positive rate and lack of rejection in survey style observations makes project unfeasible
- RV virtually impossible

Bulge

- Transits easily detectable!
- Lower false positive fractions
- Many can be rejected with survey photometry only
- RVs hard, but attainable (esp. recon)

- Bulge Transit surveys a promising route to probe high-Iron high-alpha planet formation
- Can be done with modest amounts of telescope time