# Single and binary star population synthesis in the Kepler field

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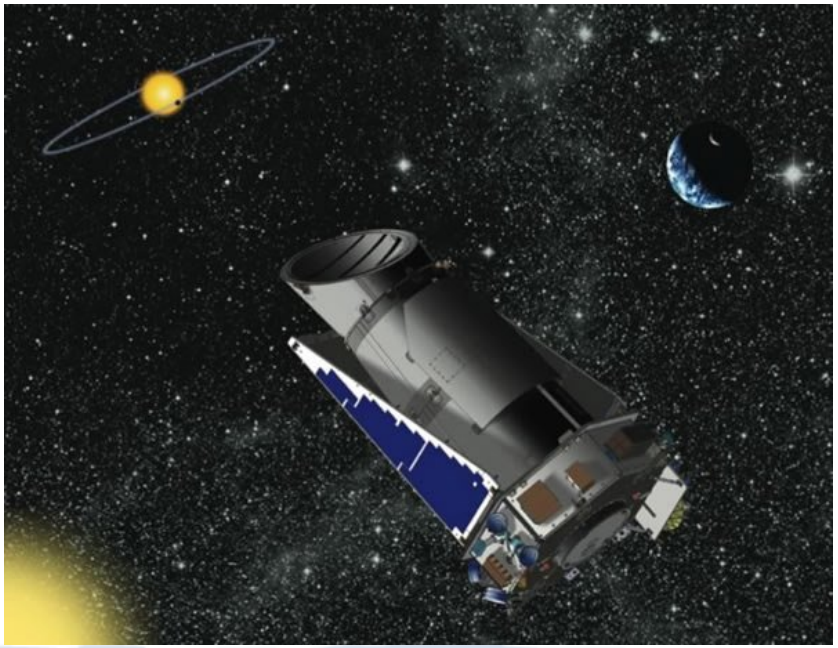
# What kind of binaries does Kepler observe?

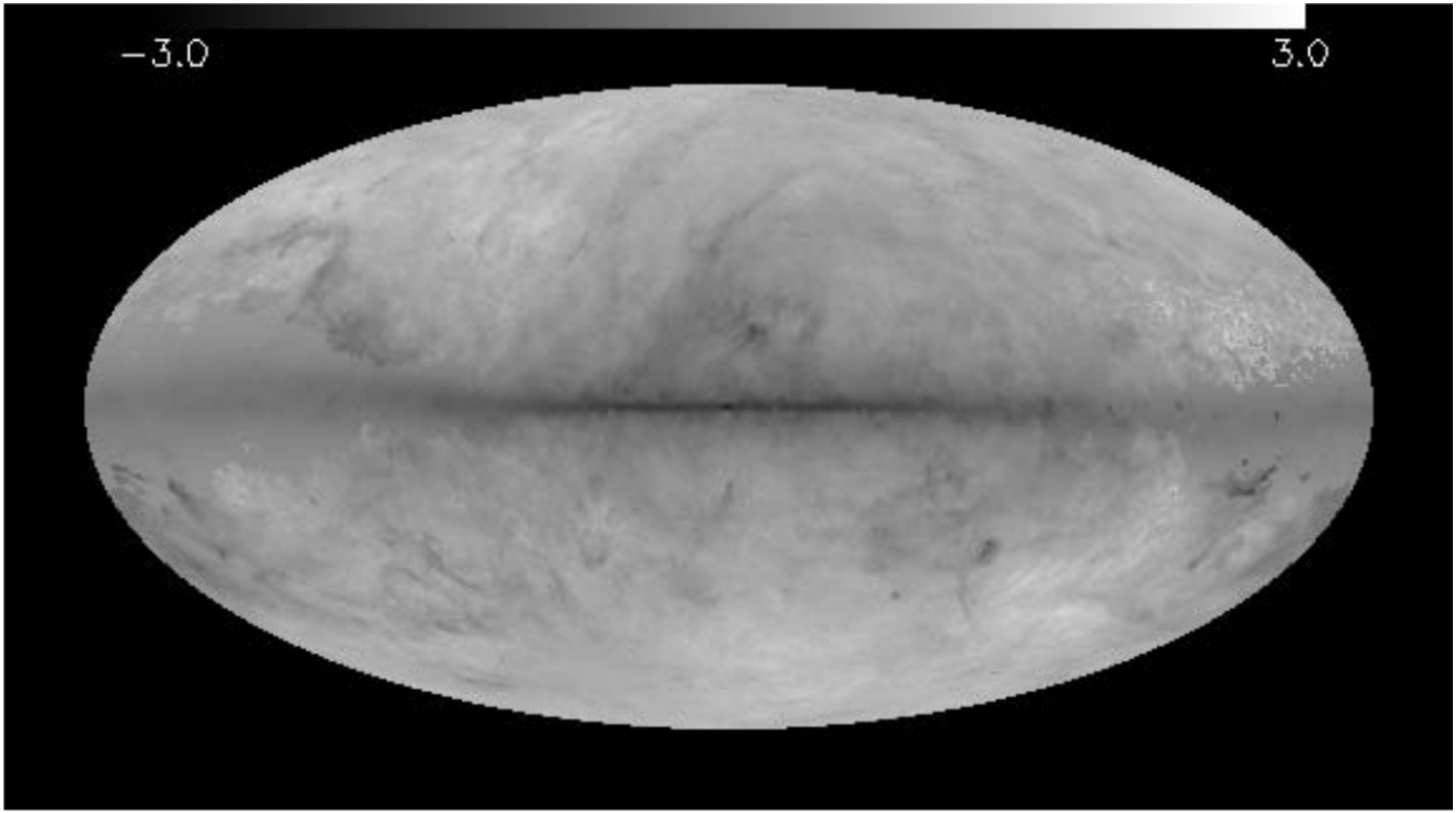
- Population synthesis
- Kepler Input Catalog (KIC)
  - Why does it matter?
  - How do we reproduce it?
- Results
  - Mass distributions
  - Period distributions
- Summary



# Population Synthesis

- BiSEPS (Binary and Stellar Evolution and Population Synthesis)
- Evolves systems over wide range of initial masses and initial periods from ZAMS to death

- Two component disk structure
- Extinction given by Drimmel et al (2003)




*Drimmel et all (2003) A&A 409*

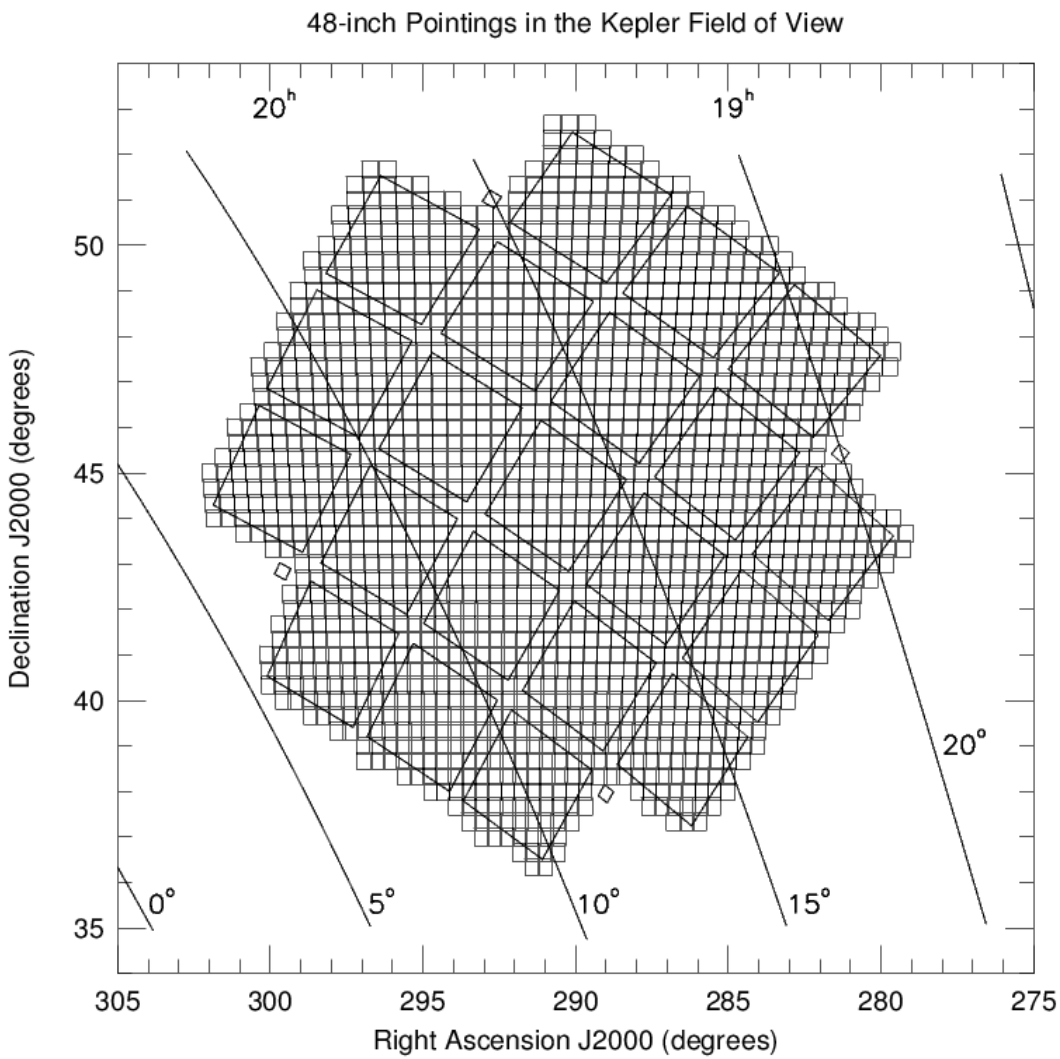
# Introduction
## Population Synthesis

- BiSEPS (Binary and Stellar Evolution and Population Synthesis)
- Evolves systems over wide range of initial masses and initial periods from ZAMS to death

- Two component disk structure
- Extinction given by Drimmel et al (2003)
- Constant star formation rate
- Weighted random distribution of objects

# Kepler Input Catalog (KIC)

- Ground based
- 5 Band g,r,i,z,D51
- Fits Teff & log g
- Derives mass and radius
- Assumes only single stars!



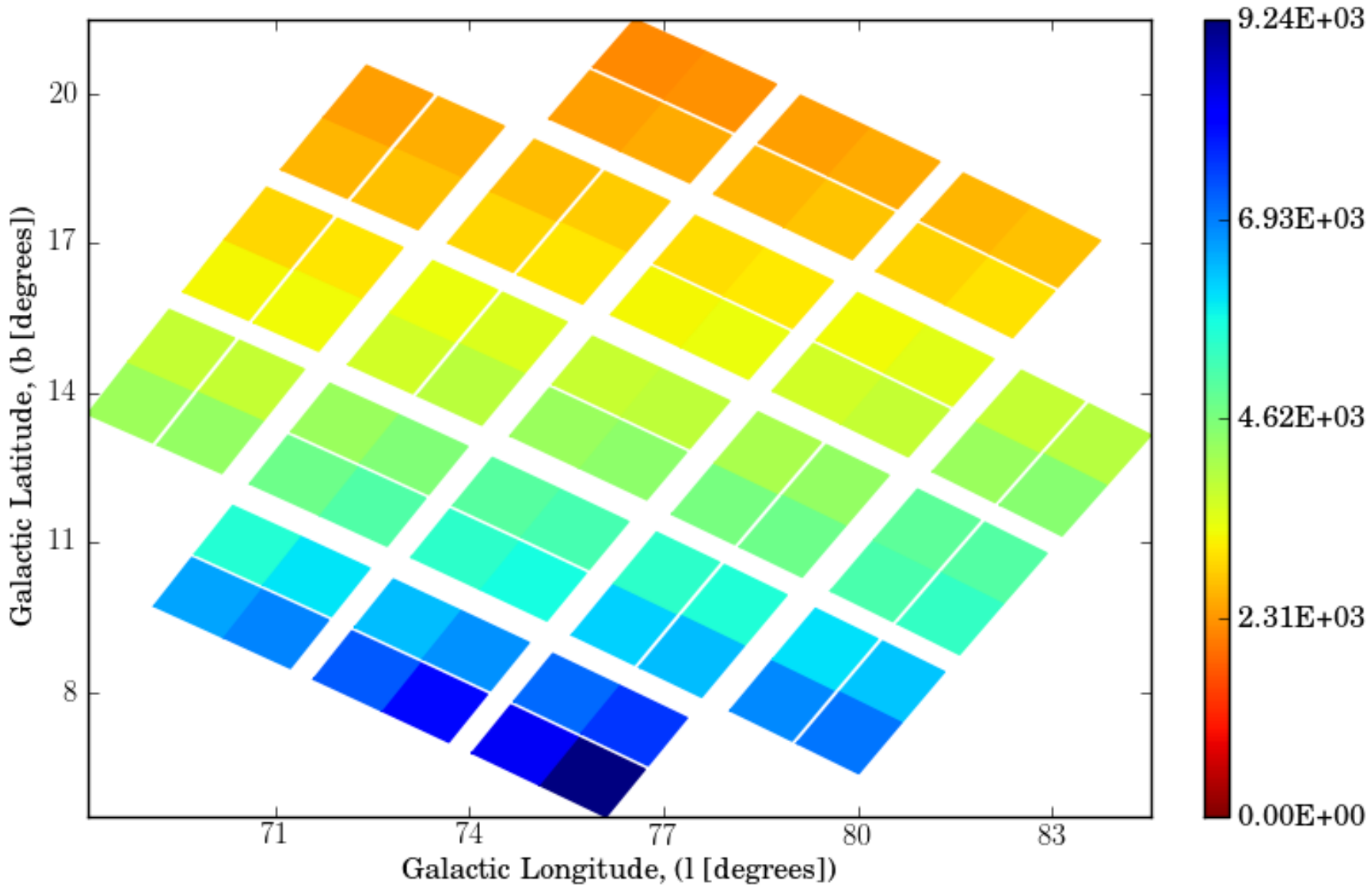
# Kepler target grouping

- Bandwidth limited
- Target selection, dwarfs vs giants
- Optimize search for Earth size planets in habitable zones
- Categorize into groups, based on:
  - Magnitude of star
  - Minimum detectable planet radius at different orbital separations
  - Number of transits

# Method

- Convert magnitudes to Sloan+D51 band passes
- Map Kepler CCD area

# Kepler field of view



# Method

- Convert magnitudes to Sloan+D51 band passes
- Map Kepler CCD area
- Put our stars through KIC code
  - Use KIC's estimate of mass and radius
- Calculate PRF & FPG

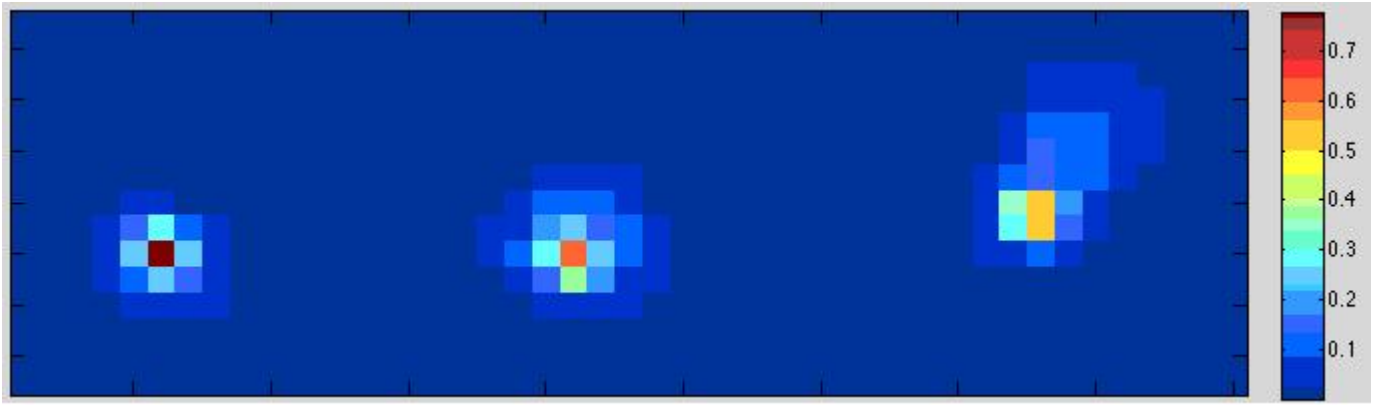
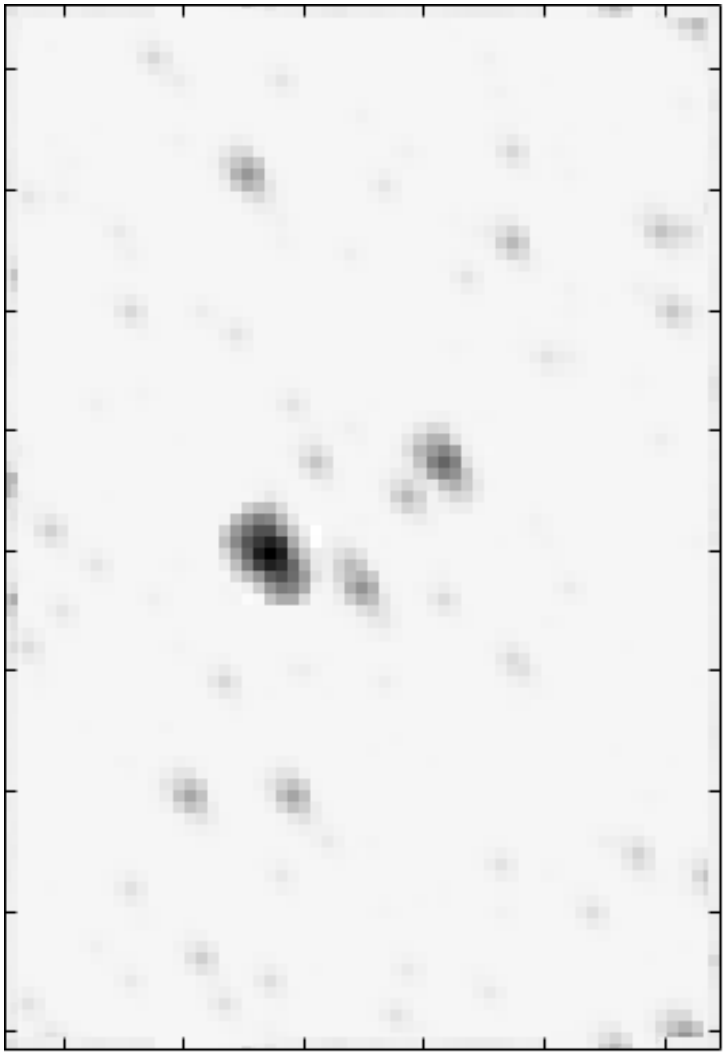
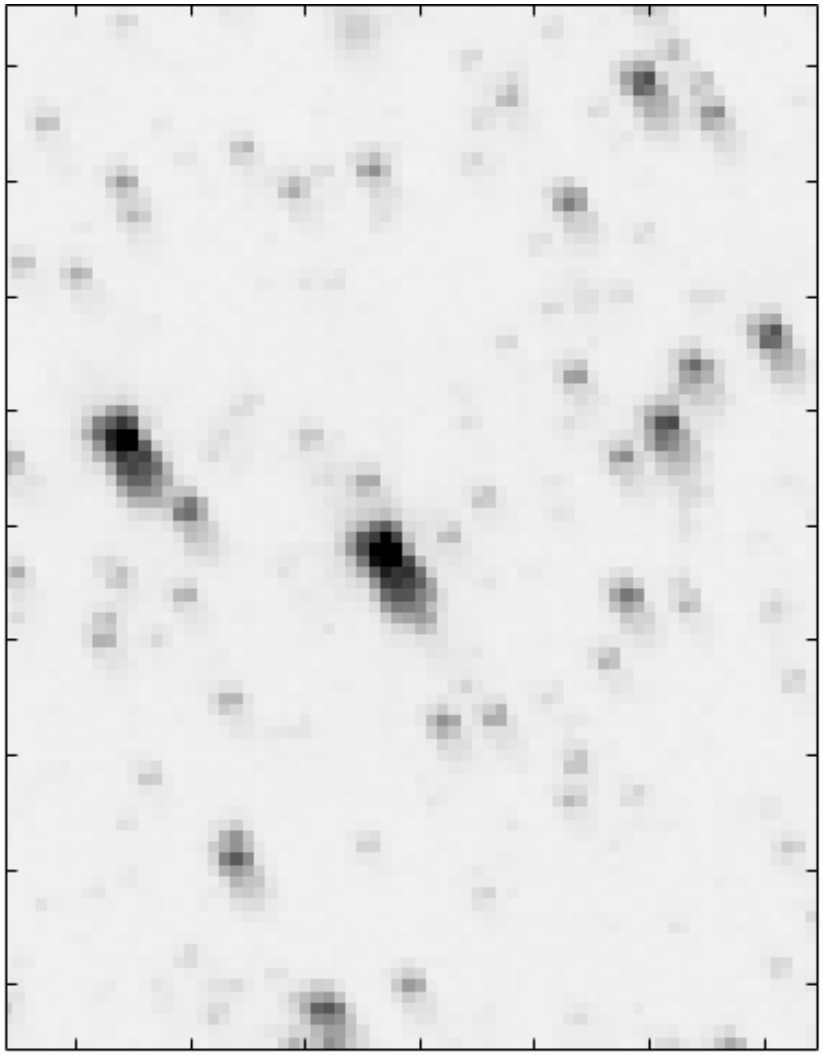



*Image: http://keplergo.arc.nasa.gov/CalibrationPSF.shtml*

## Our synthetic image



## Kepler's synthetic image



Bryson et al (2010) APJ 713L

# Target selection criteria

$$R_{p,min} = R_s \sqrt{\frac{7.1\sigma}{r}}$$

$R_{p,min}$ =Minimum detectable planet radius
$R_s$ =Stellar Radius
$\sigma$ =Noise
$r$ =Crowding metric

- Optimal aperture
  - Saturation
  - Poisson noise and CCD noise
  - Number of measurements

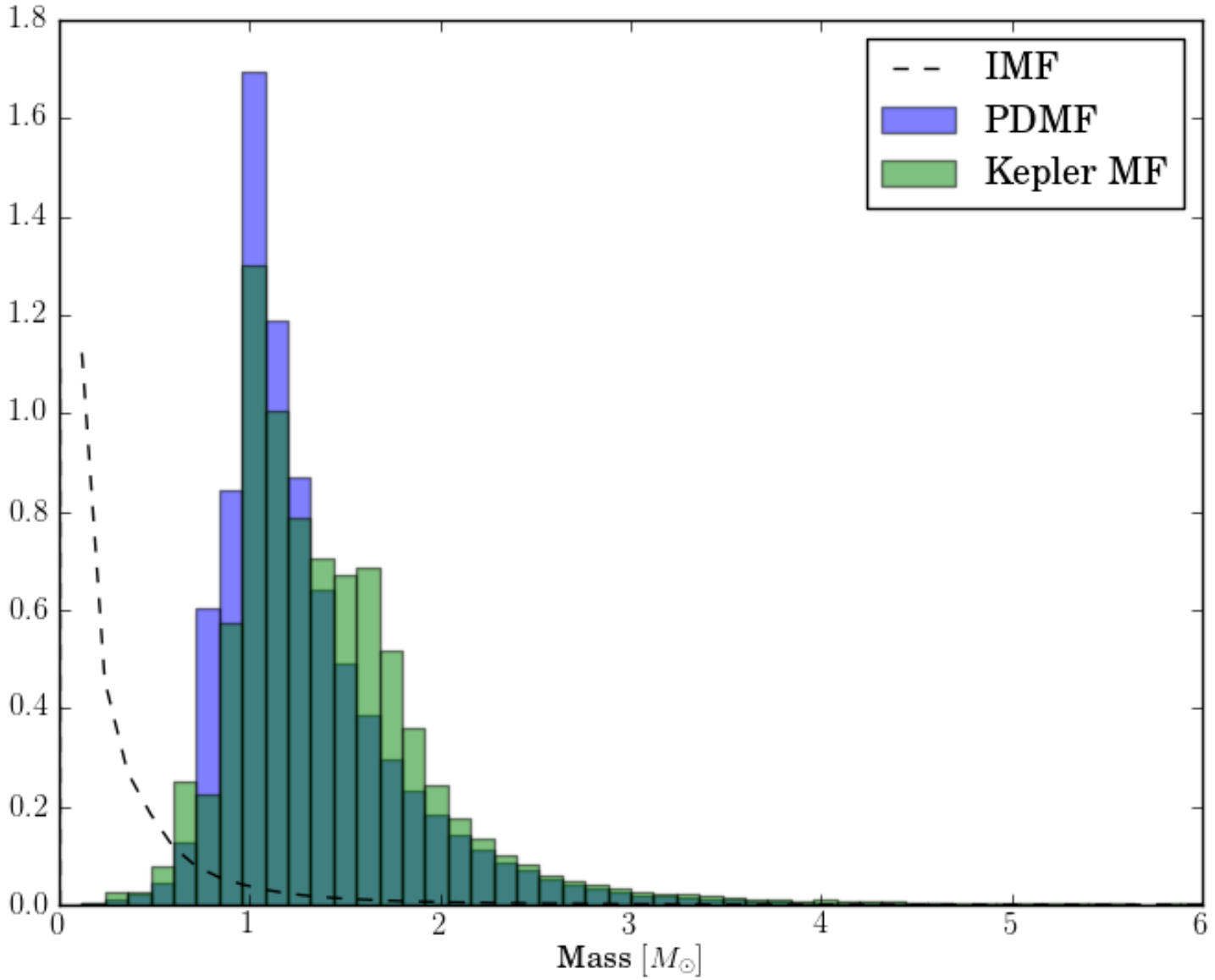
# Results

## Assume binary fraction of 50%

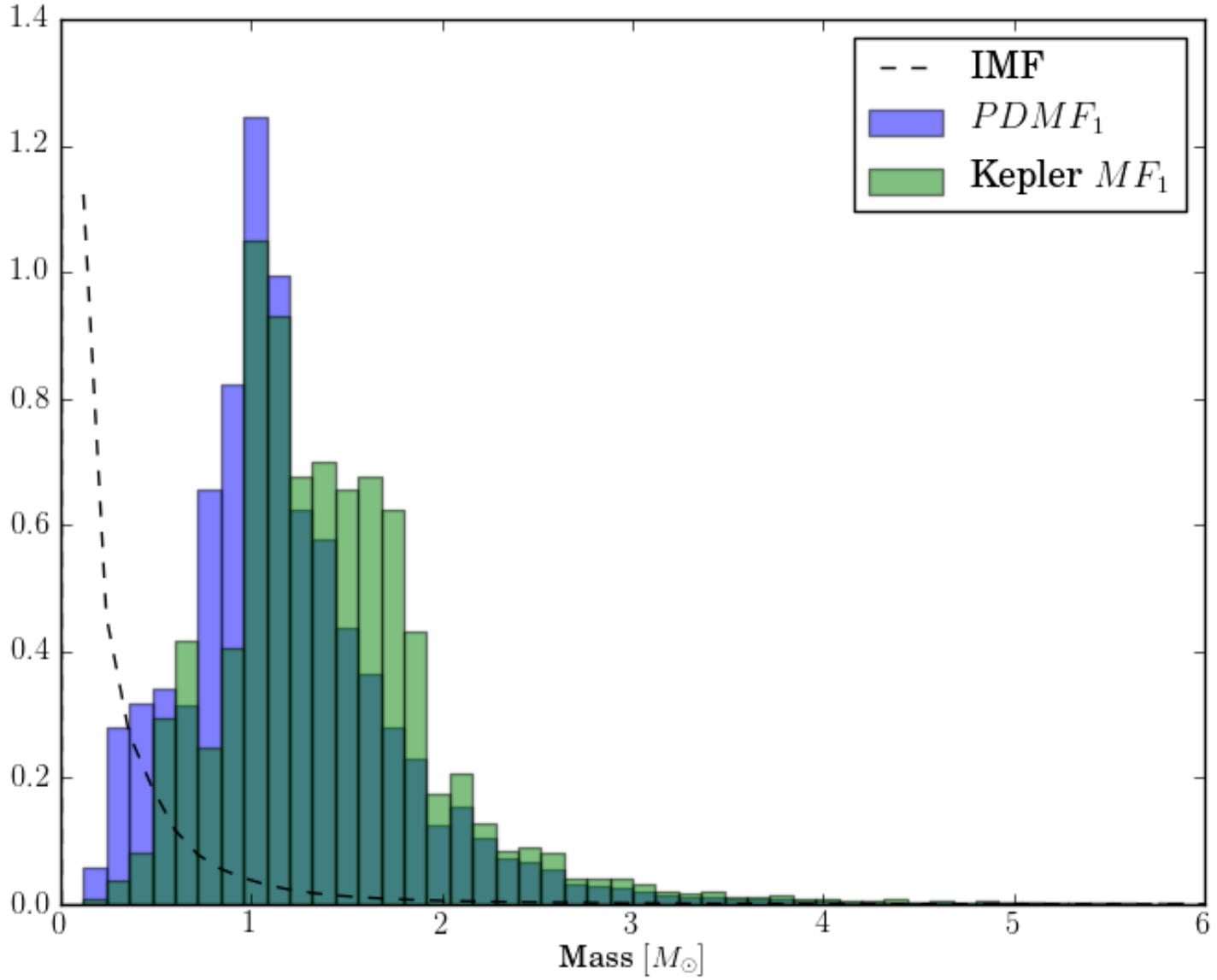
| | KIC | Our code, KIC data | Our data |
|---|---|---|---|
| Total Stars | 405091 | 405091 | 370468 |
| Target Stars | 154008 | 131361 | 122678 |
| % | ~38% | ~32% | ~33% |
| | | | |
| # Single Stars | | | 60632 |
| # Binary Stars | | | 62046 |

## Kepler target selection does not alter binary fraction

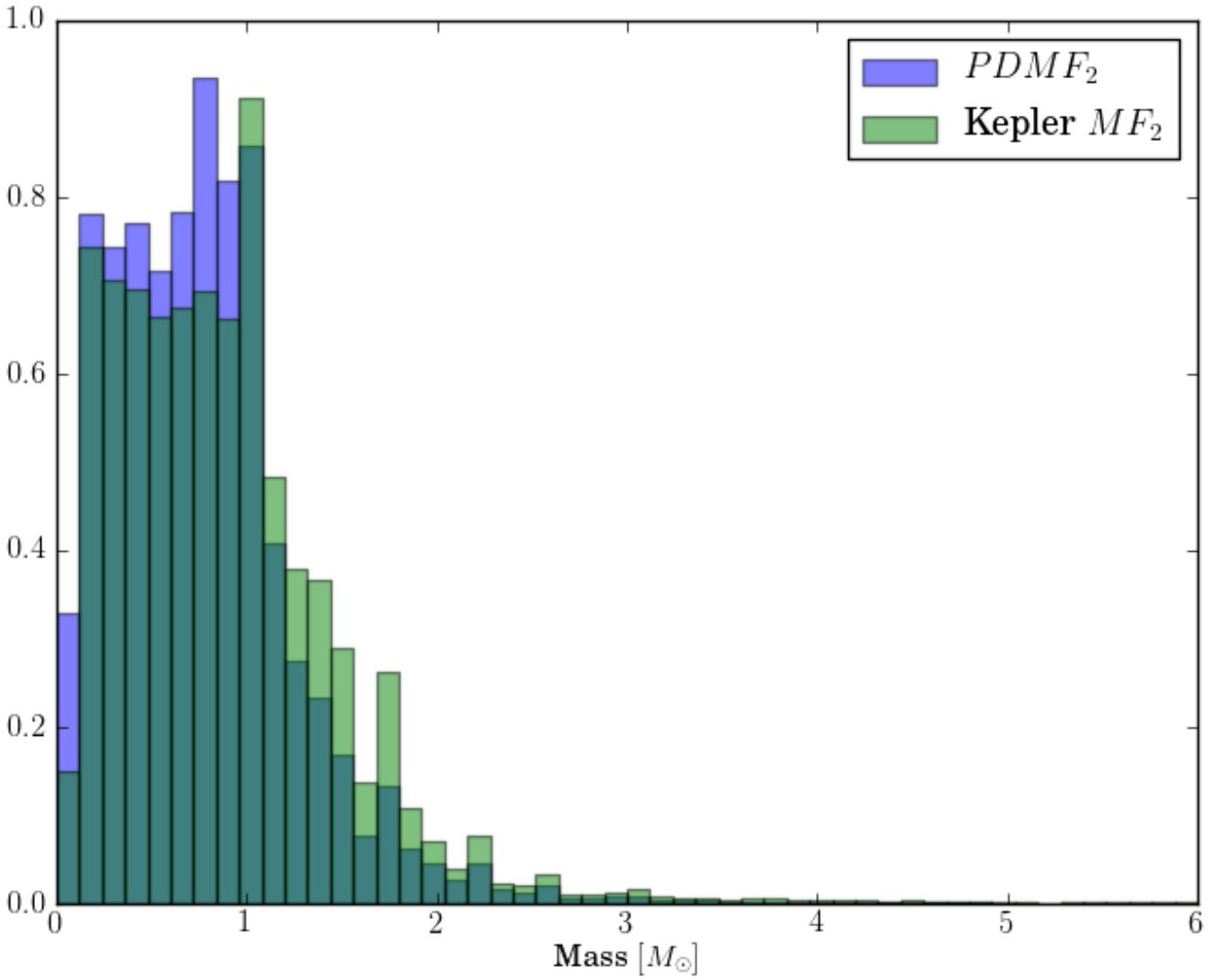
# Single star mass distribution



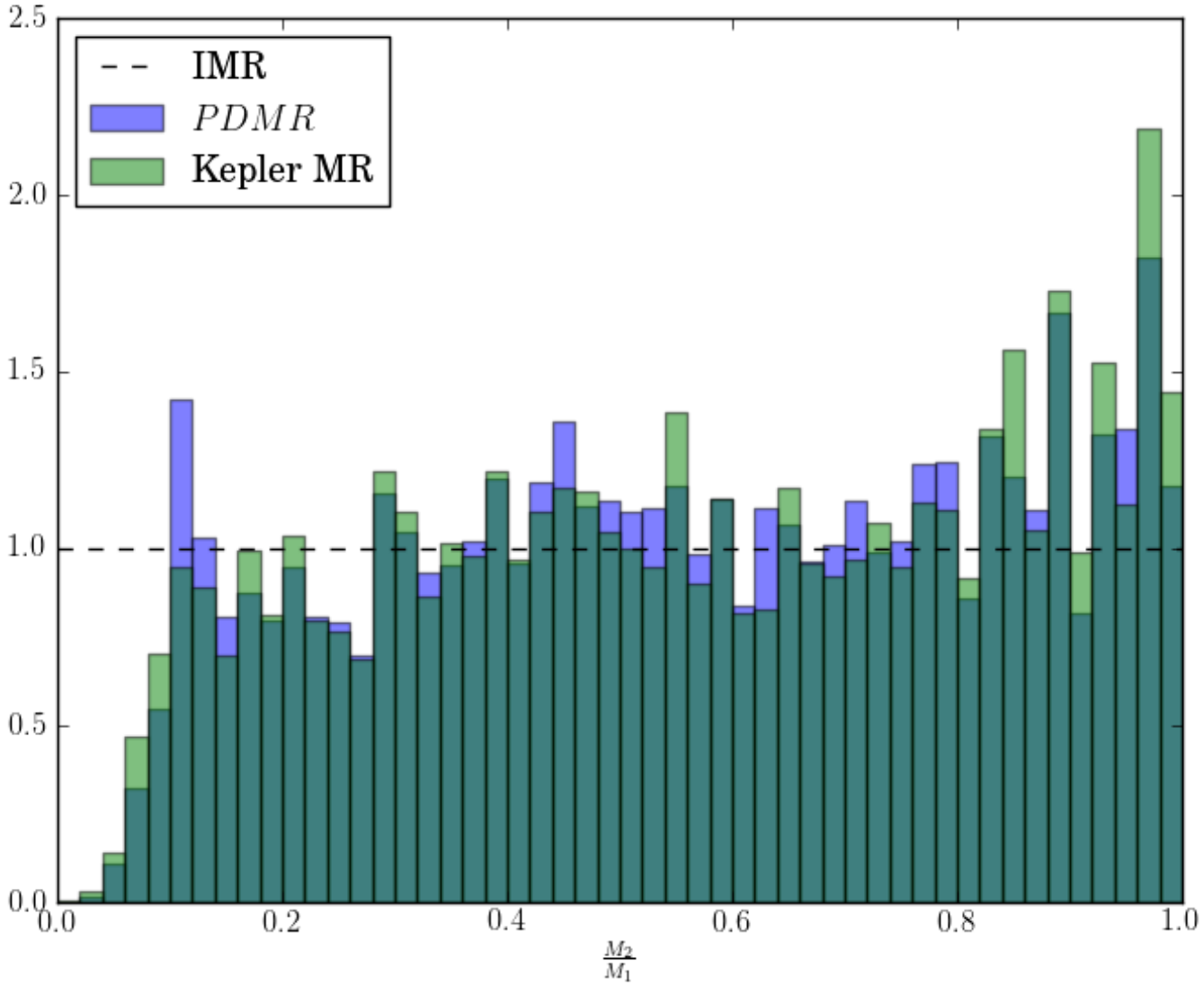
# Mass distribution of star 1



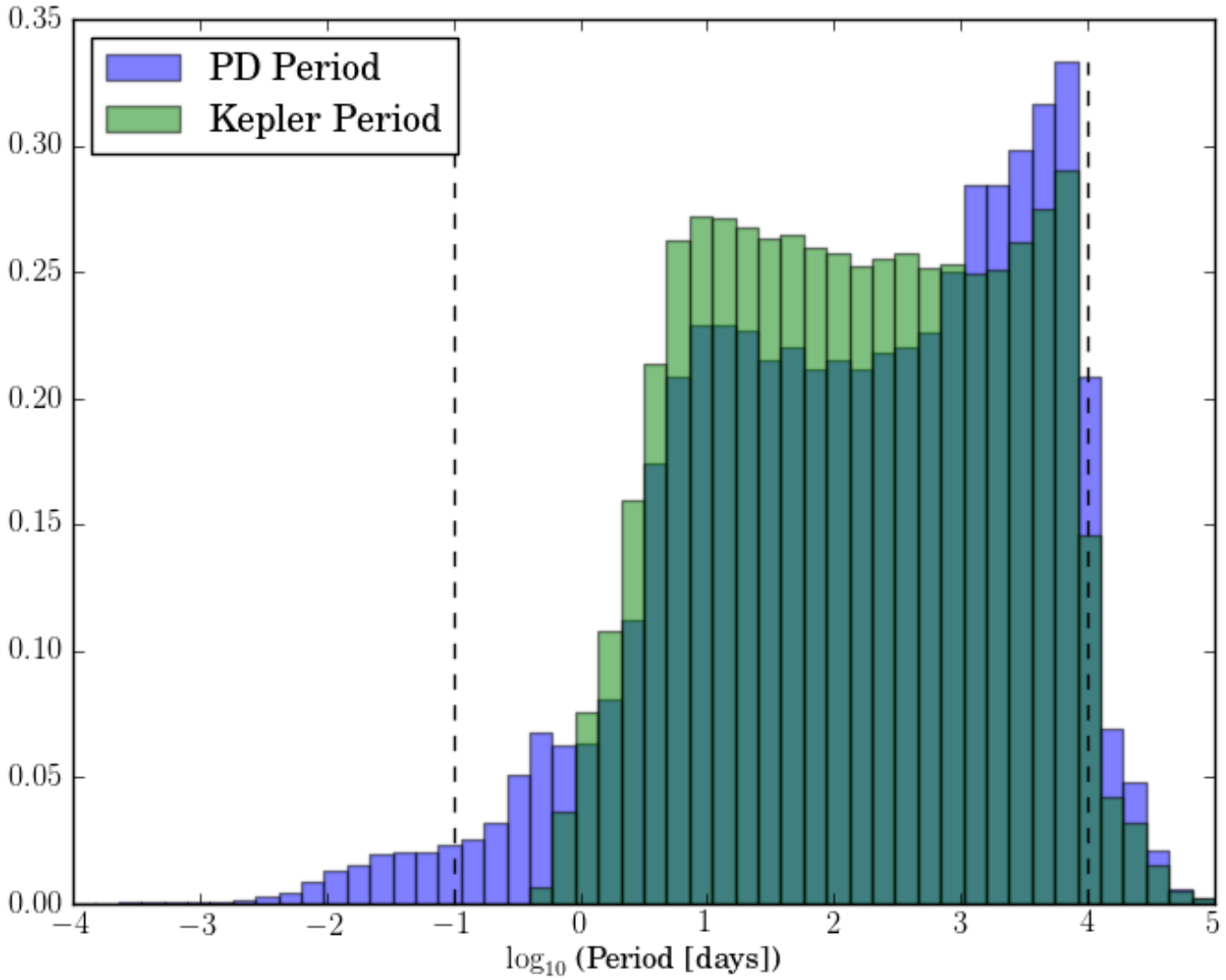
# Mass distribution of star 2



# Mass ratio

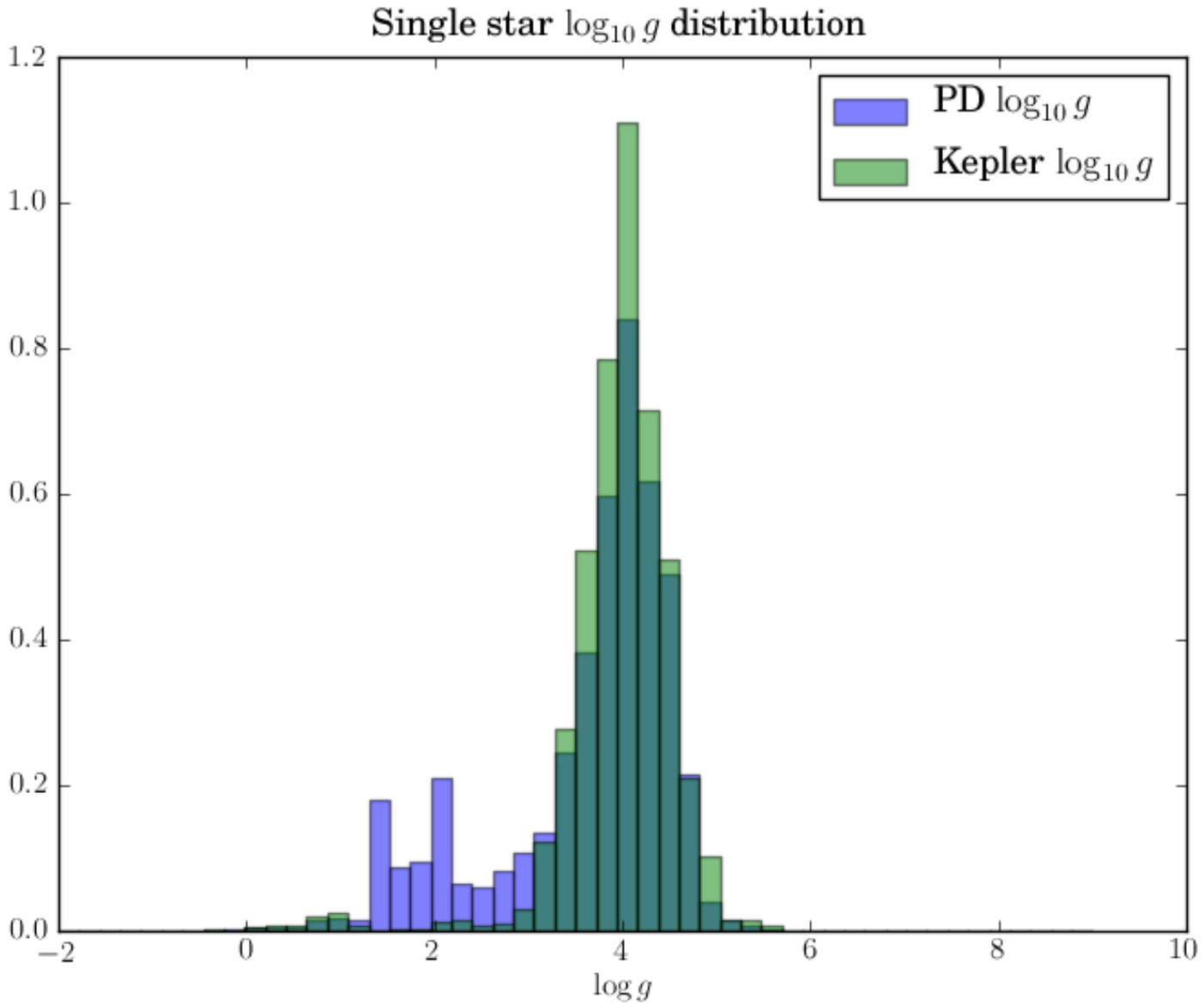


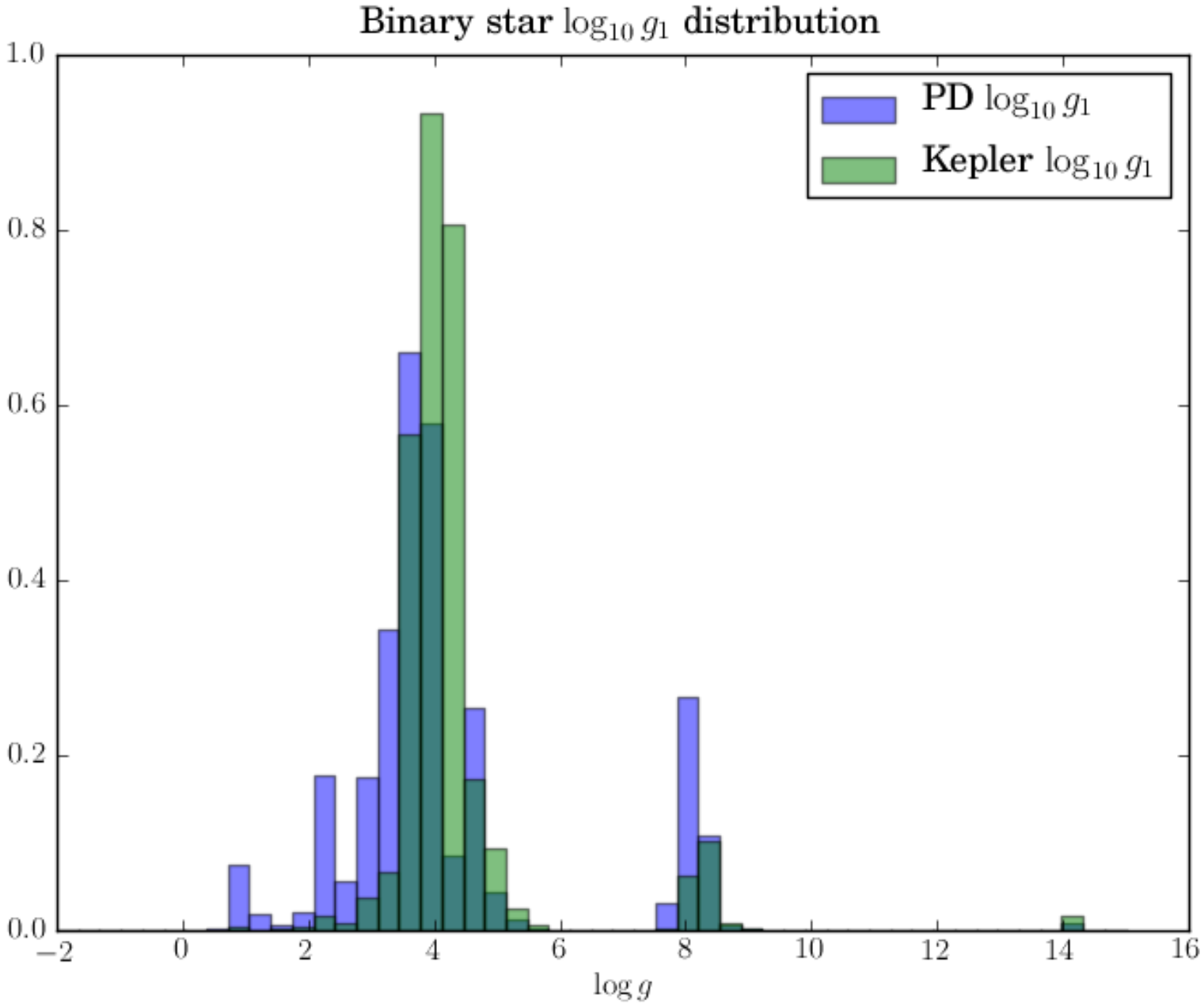
# Period distribution

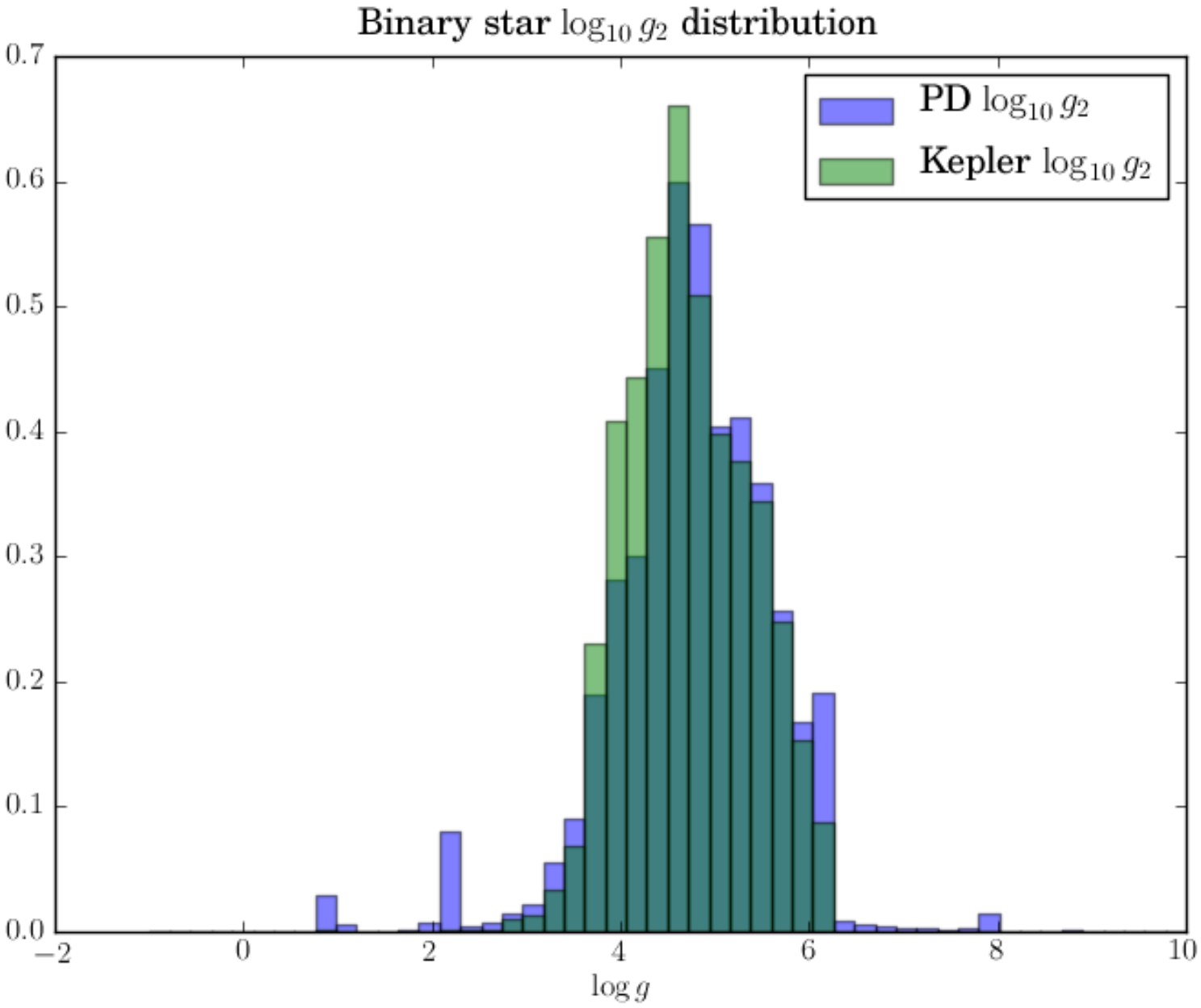


# Summary

- Generated a population synthesis model of Kepler's FOV
- Modelled Kepler's CCD structure and target selection criteria
- Kepler target selection preserves binary fraction
- Most binaries are detached MS+MS
- Future plans:
  - Eclipsing Binaries
  - Blending


Single star $\log_{10} g$ distribution
PD $\log_{10} g$
Kepler $\log_{10} g$
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−2
0
2
4
6
8
10
$\log g$


Binary star $\log_{10} g_1$ distribution
PD $\log_{10} g_1$
Kepler $\log_{10} g_1$
1.0
0.8
0.6
0.4
0.2
0.0
−2
0
2
4
6
8
10
12
14
16
$\log g$


Binary star $\log_{10} g_2$ distribution
PD $\log_{10} g_2$
Kepler $\log_{10} g_2$
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−2
0
2
4
6
8
10
$\log g$