3rd DTA Symposium
The Origins of Planetary Systems: from the Current View to New Horizons
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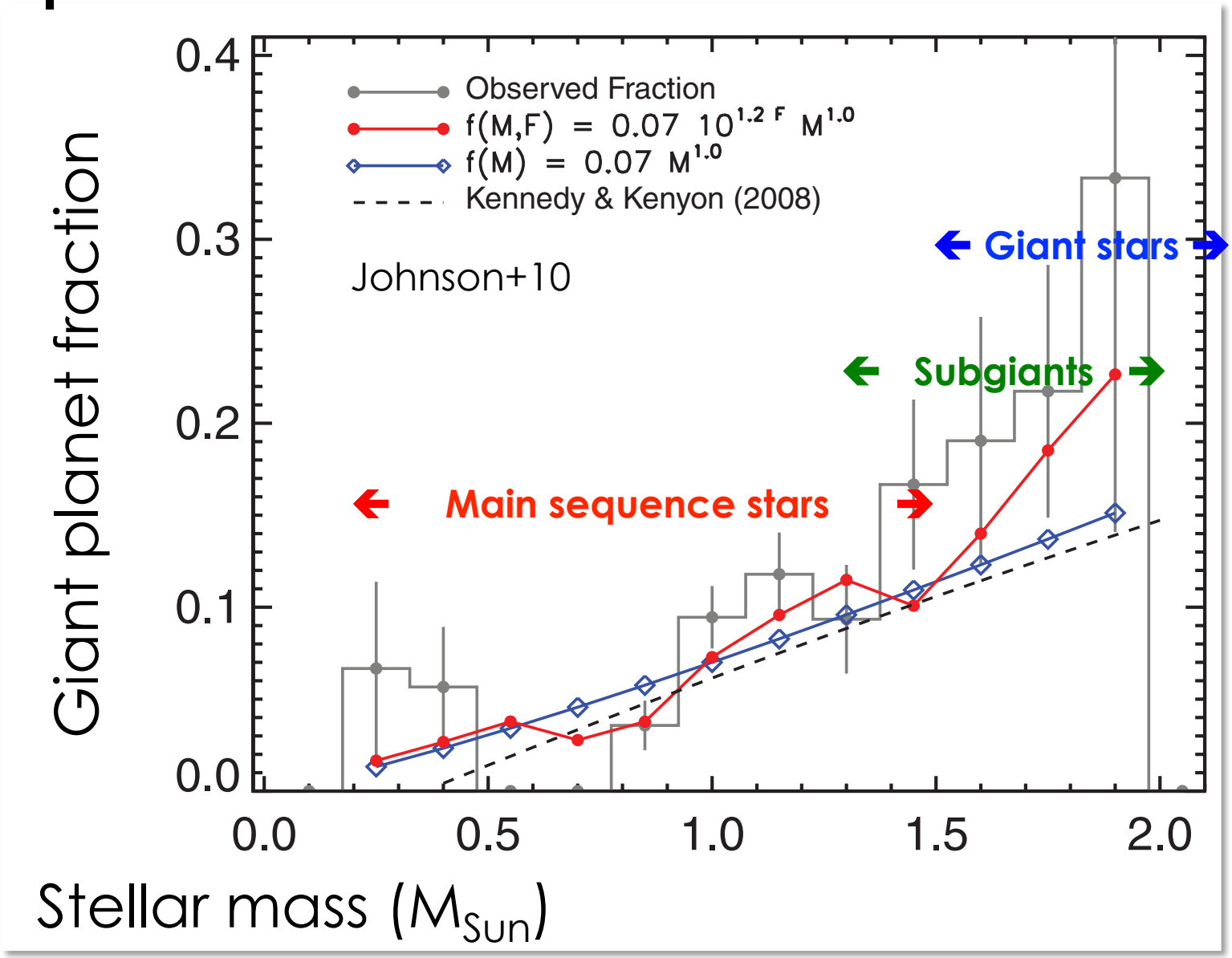
Occurrence rate of giant planets around massive stars

1. Introduction : Dependence on stellar mass
2. **Precise Radial Velocity Survey** of Massive stars
3. **Occurrence Rates** of giant planets

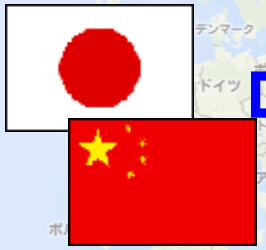
Massive stars ➔ Giant planets ➔ Occurrence rate

Dependence on stellar mass

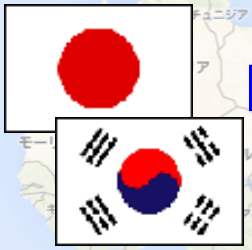


East-Asian Planet Search Network
EAPS-Net

- **Okayama planet search program**
  - @Okayama Astrophysical Observatory, OAO, Japan



- **Chinese-Japanese planet search**
  - Xinglong Station & OAO

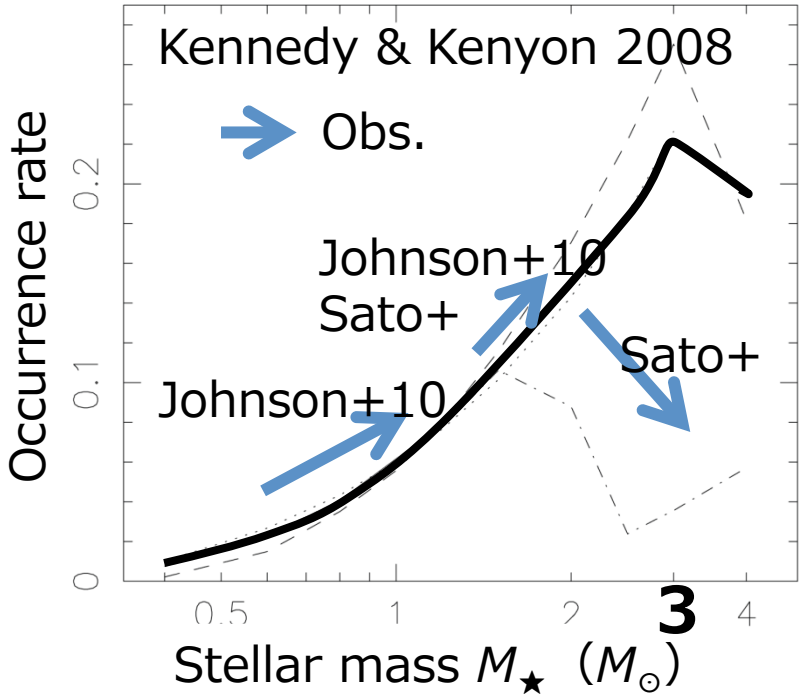


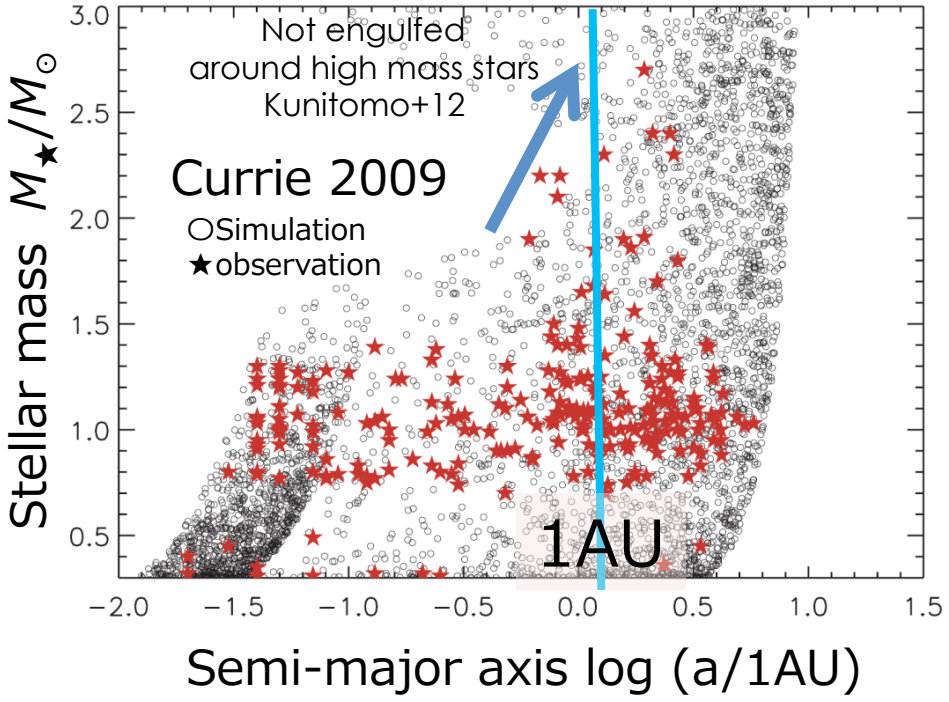
- **Korean-Japanese planet search**
  - Bohyunsan Optical Astronomy Observatory & OAO

- **Turkish-Japanese collaboration**
  - TÜBITAK - Turkish National Observatory & OAO

- **EAPS-Net with the Subaru telescope**

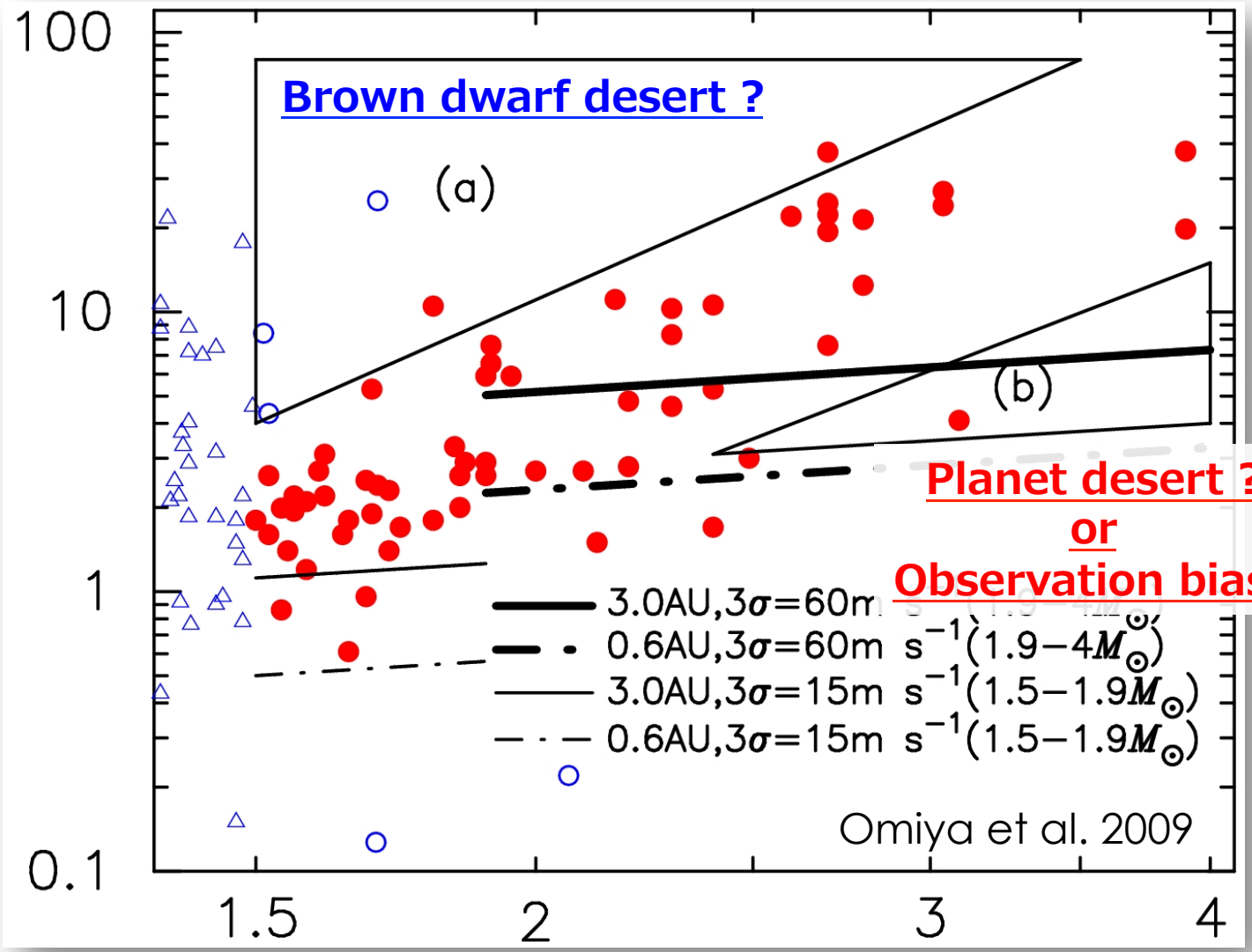
Dependence of Planetary systems





- Occurrence rate of giant planets
  - Theory : Peak at $3M_{Sun}$
  - Obs. : Peak at $2M_{Sun}$
- Type-II migration and stellar mass
  - Theory : inward
  - Obs. : further

Stellar & Planetary mass



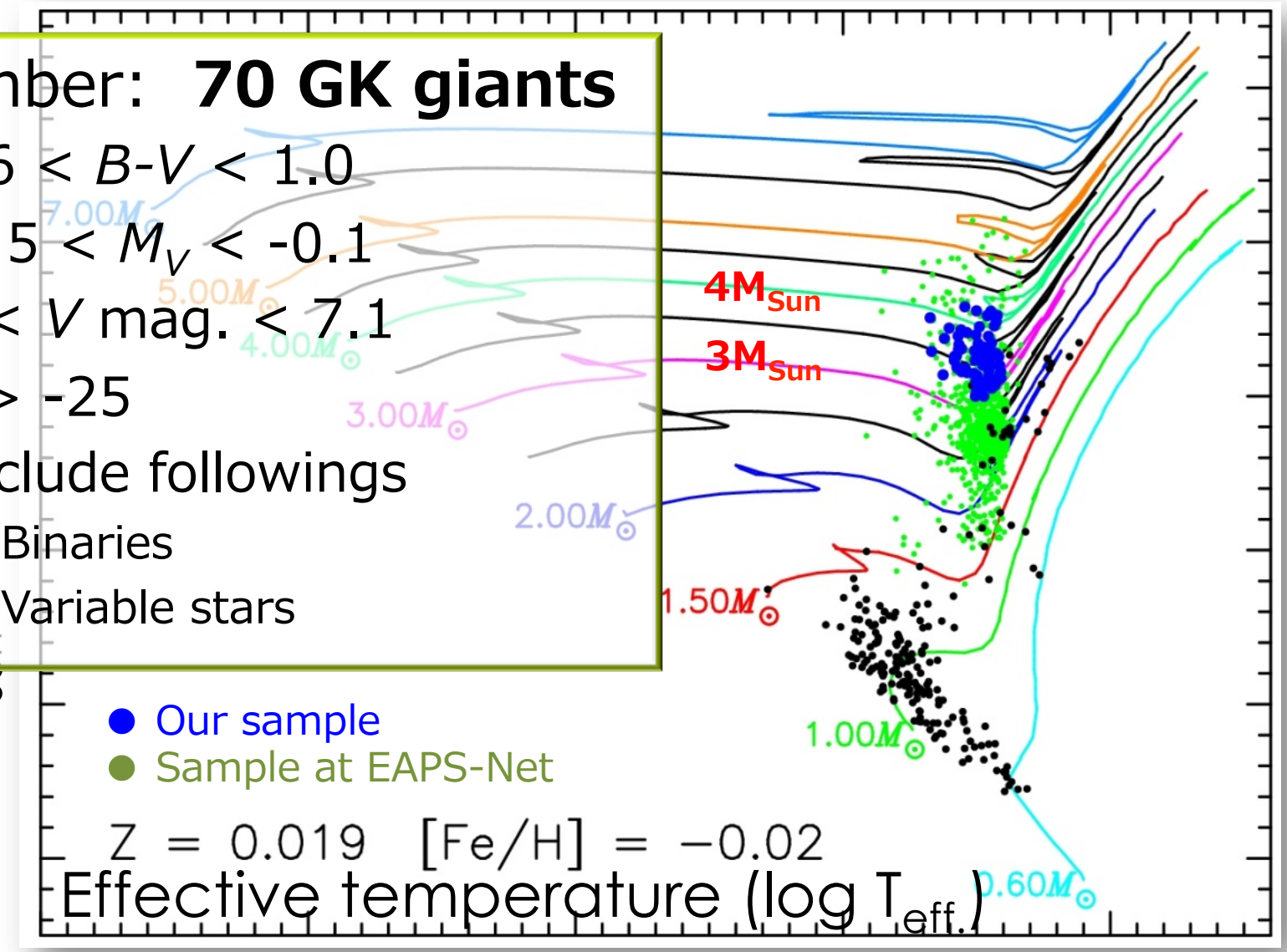
Precise Radial Velocity Survey

PRVS

- Precise RV Survey of 3~4 M_{Sun} giant stars
  - Okayama Astronomical Observatory, OAO
  - **Check planets with < 3 AU and > 3~5 $M_{Jupiter}$**
- Scientific Goals
  - To estimate an occurrence rate of planets
  - To verify the **Planet Desert** with >3M_{Sun} stars

Sample stars of PRVS

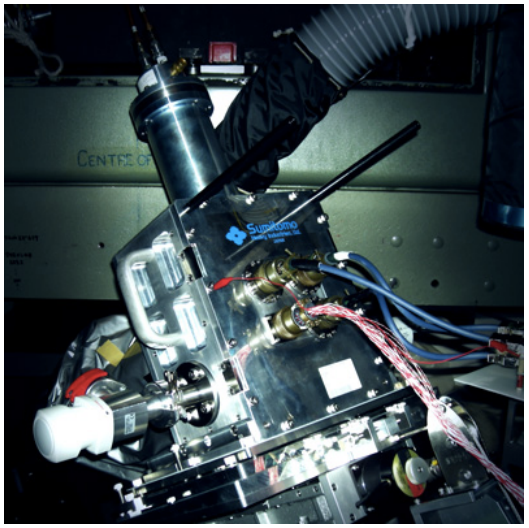
- Number: **70 GK giants**
  - 0.6 < *B-V* < 1.0
  - -1.5 < M_V < -0.1
  - 6 < *V* mag. < 7.1
  - δ > -25
  - Exclude followings
    - Binaries
    - Variable stars



Observation @ OAO

- HIDES/OAO188cm
  - HIgh Dispersion Echelle Spectrograph

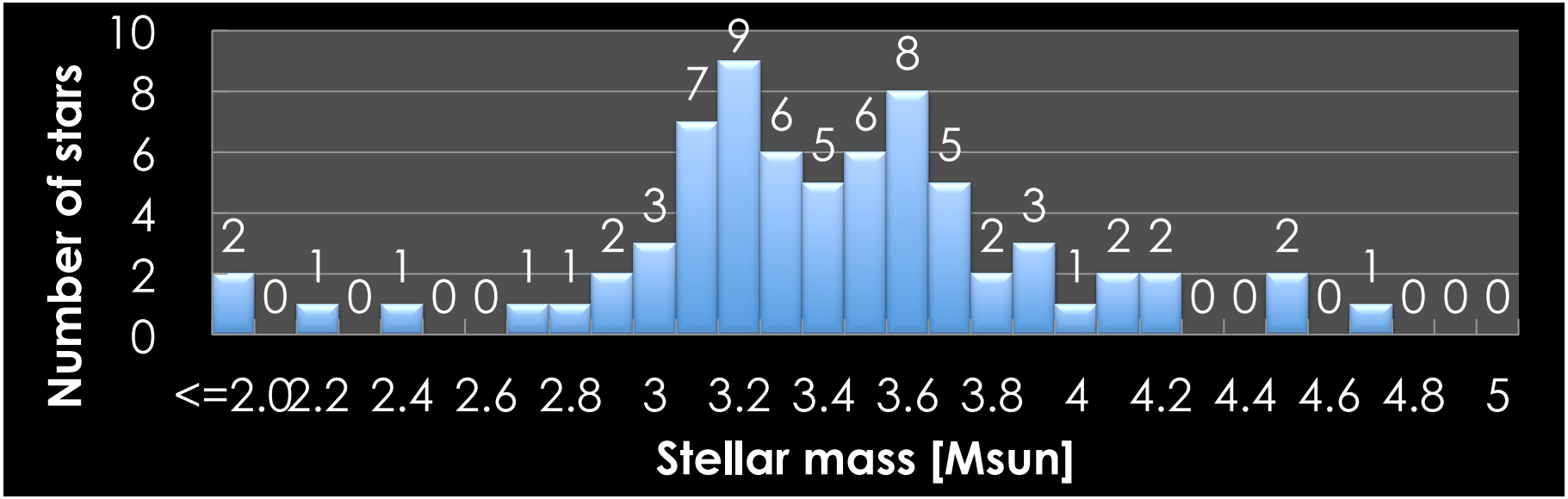
- Period: 2010.1-2013.1
  - **Long term RV monitoring!**
- Observation setting
  - Slit mode or fiber-feed mode
  - R=λ/Δλ~65,000 or 50,000
  - 3750-7500Å
  - **I2 absorption cell**
  - SN > 100 /pixel



http://www.oao.nao.ac.jp/~hides/wiki/index.php?English

Properties of samples

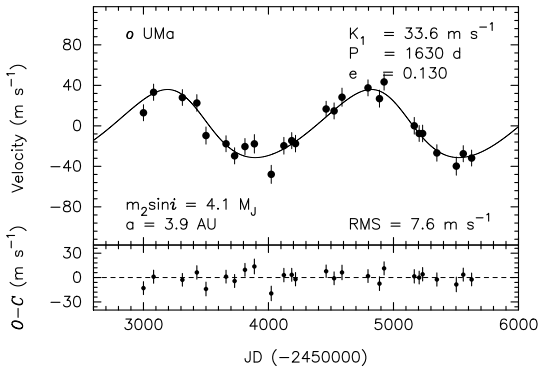
- Stellar metallicity from spectra
  - [Fe/H]=-0.1-0.3 ➔ NO trend
- Stellar mass from evolutionally tracks
  - ~3-4M_{Sun}



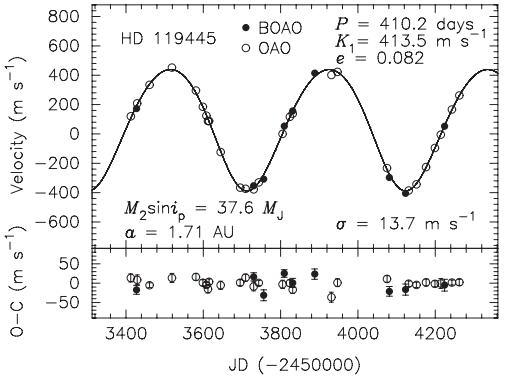
Completeness of our PRVS

- Sample: 89 stars in total
  - This survey : 41 stars
  - Okayama project : 42 stars
    - Planet: 3.1 M_{Sun} @ 3.9AU (Sato+12)
    - Brawn dwarf: 3.0 M_{Sun} (Sato+12)
    - Planet candidates: 3.1-3.3 M_{Sun}
  - Korean-Japanese planet search program : 6 stars
    - Brown dwarf: 3.9 M_{Sun} (Omiya+09)

Discovery of a planet
Sato+12

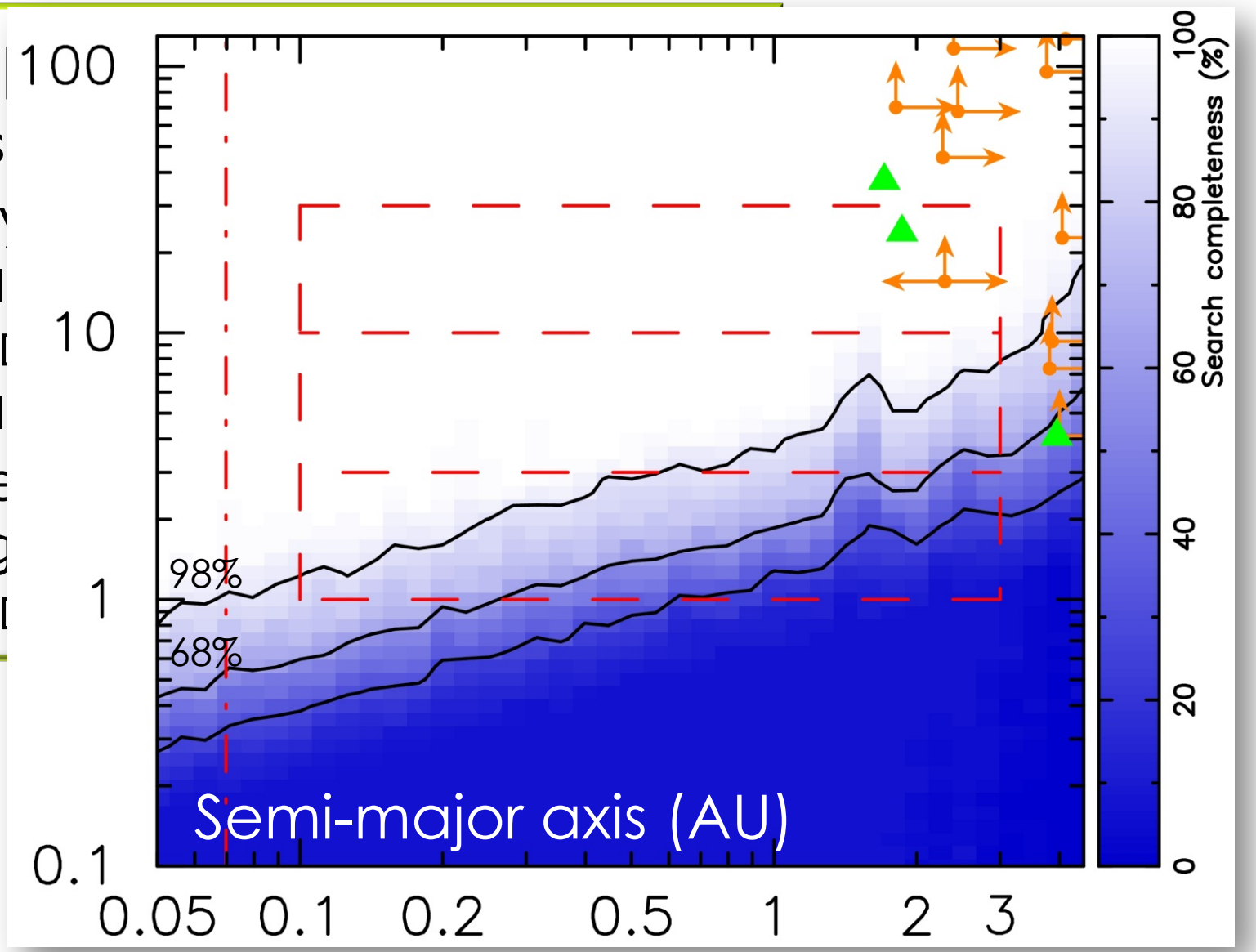


Discovery of a brown dwarf
Omiya+09

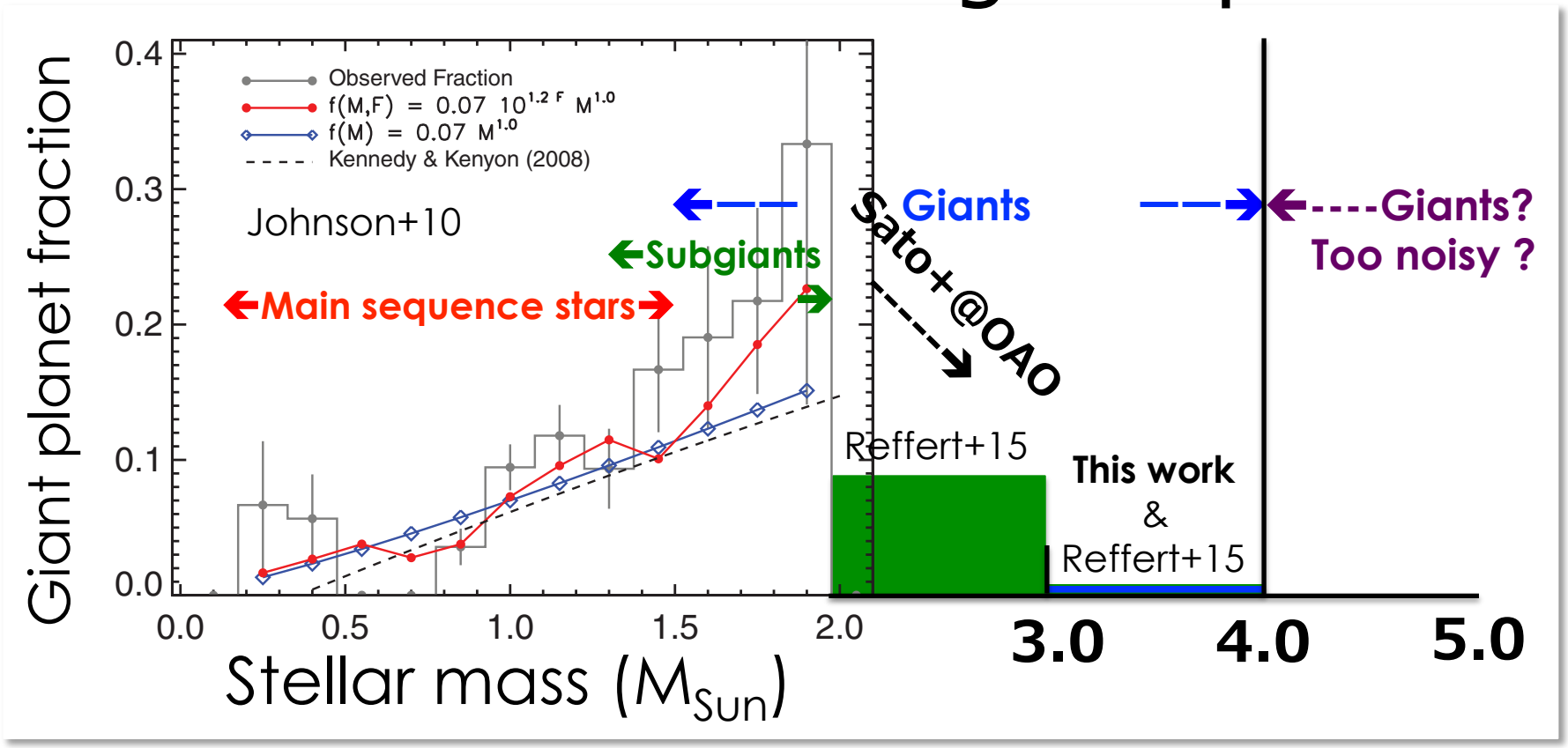


Completeness of our PRVS

- Sam
  - This
  - Oka
    - Pl
    - Bl
    - Pl
  - Kore
  - prog
    - Bl



Occurrence rates of giant planets



- Occurrence rates of giant planets with semimajor axis <3AU decrease with increasing stellar mass in >2.0M_{Sun} stars.
  - Our result is consistent with results of Reffert et al. 2015.
  - Long period planets may be fruitful around massive stars.
  - NOTICE: less massive giant planets with < 3$M_{Jupiter}$ cannot be detected around massive stars.

Summary

- Radial Velocity Survey of 3-4 M_{Sun} stars
  - **Check planets with < 3 AU and > 3-5 $M_{Jupiter}$**
  - >10 RV observations for 4 years
  - Many stars with a long term RV variation
    - ➔ **Long period planets are fruitful ?**
- Occurrence rate of giant planets around massive stars

NO GIANT PLANETS?
with >3$M_{Jupiter}$ and <3AU