Okayama and Subaru Planet Search Programs

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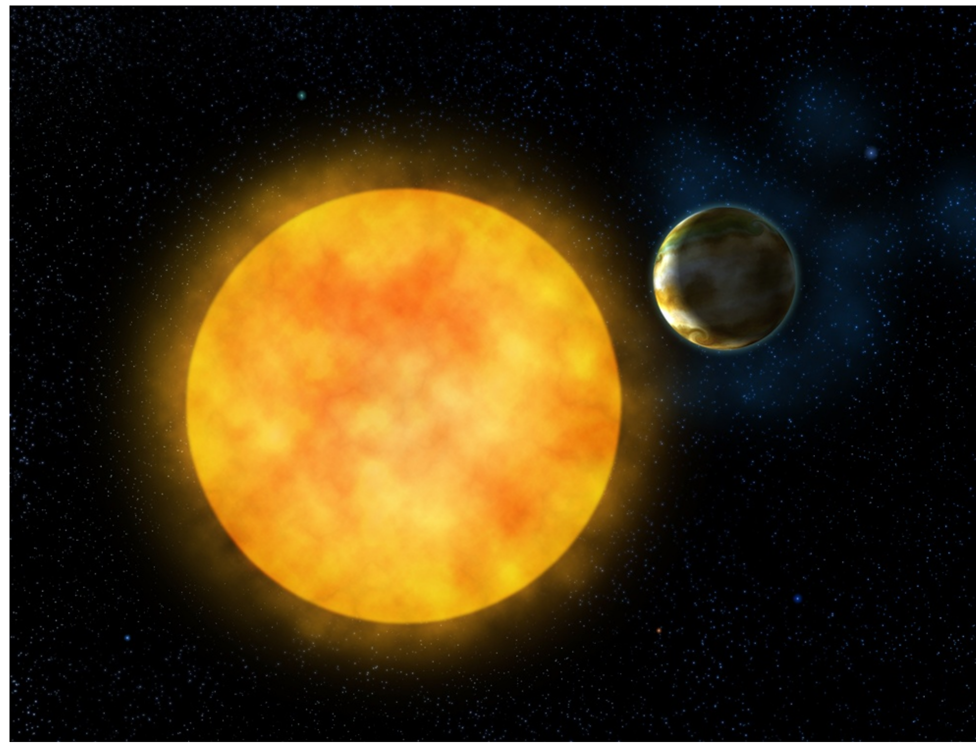
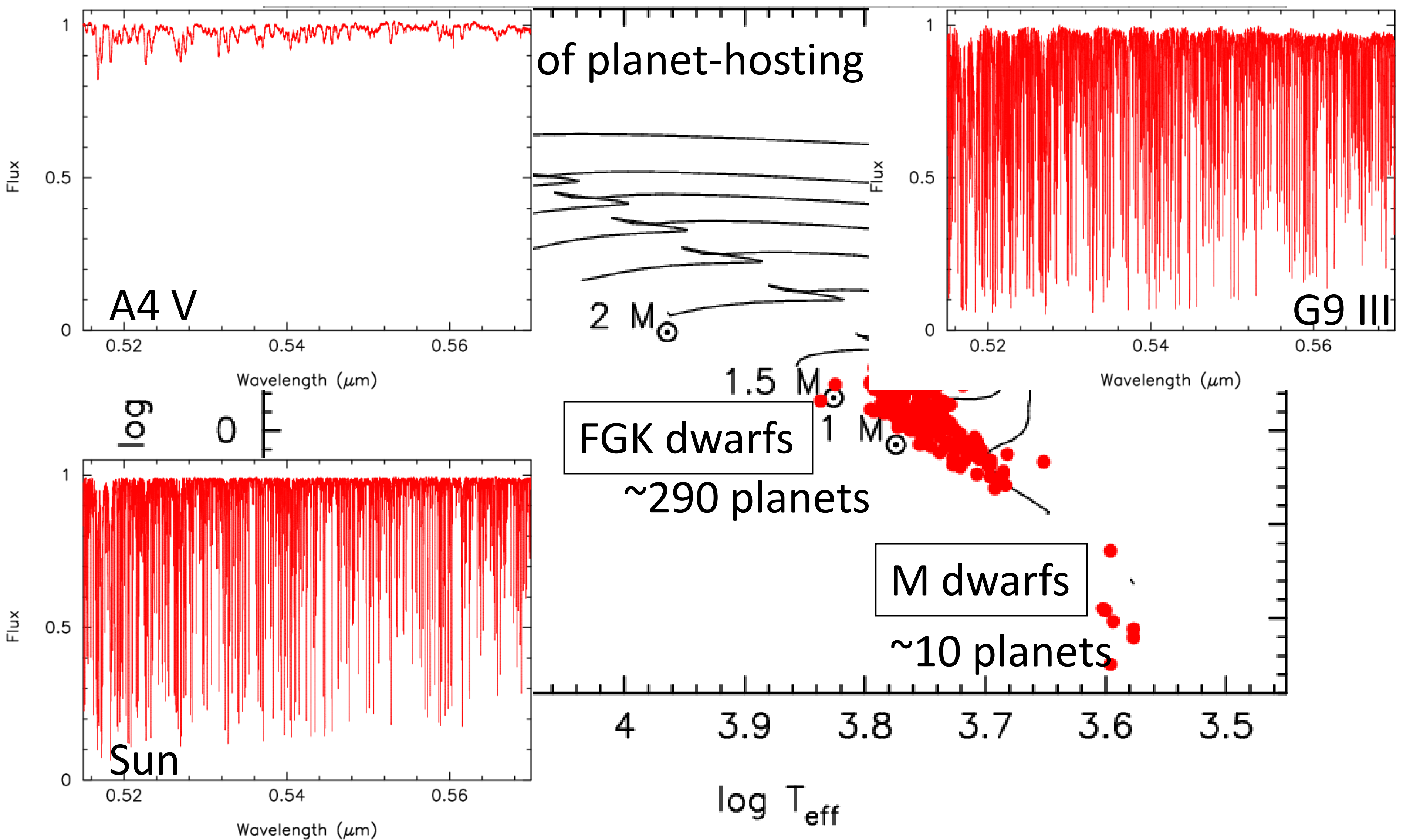
Searching for Planets around Evolved Intermediate-Mass Stars

Understanding properties of planets as a function of stellar mass, evolutionary stage, etc.



(c) Okayama Astrophysical Observatory

Why Giants?

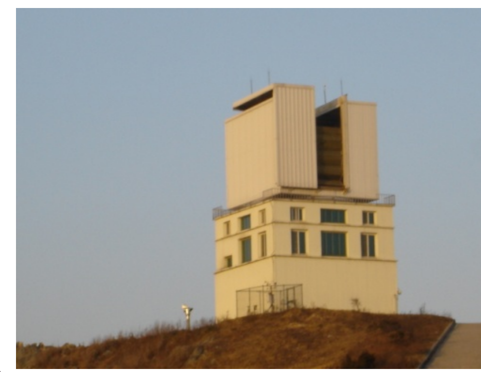


A4 V
Flux
Wavelength (μm)
of planet-hosting
2 M⊙
1.5 M⊙
1 M⊙
G9 III
FGK dwarfs
~290 planets
M dwarfs
~10 planets
Sun
log
0
4
3.9
3.8
3.7
3.6
3.5
log T_eff

East-Asian Planet Search Network (EAPSNET)

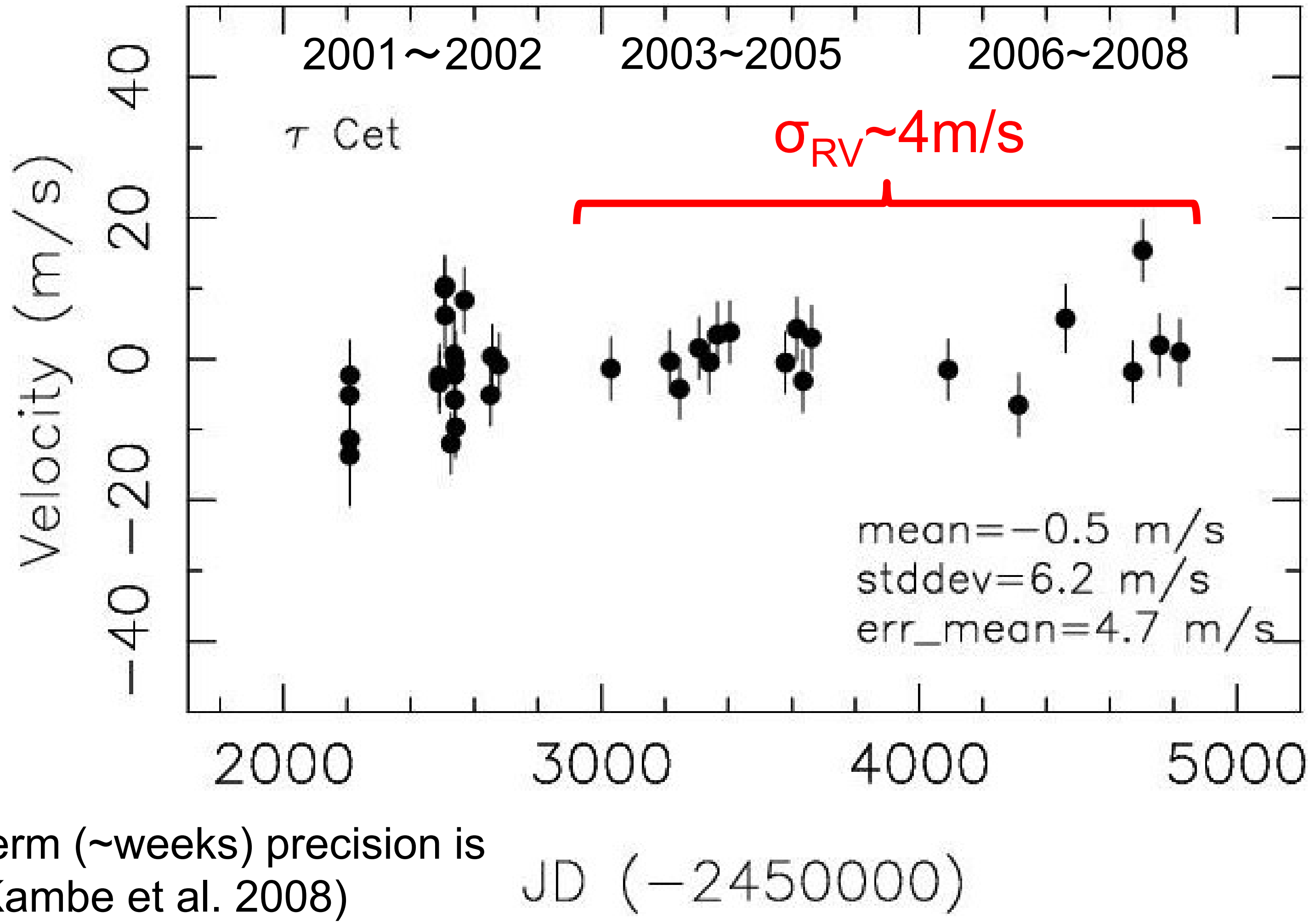
- Okayama 1.88m tel., Japan
  - 300 GK giants (V<6), since 2001
  - 10 planets and 1 brown dwarf
- Xinglong 2.16m tel., China & Okayama
  - 100 GK giants (V~6), since 2005
  - (1 planet and 1 brown dwarf)
- Bohyunsan 1.8m tel., Korea & Okayama
  - 140 GK giants (V<6.5), since 2005
  - 1 brown dwarf
- Subaru 8.2m tel., Japan & EAPSNET
  - >200 GK giants (6.5<V<7), since 2006
  - Several candidates
- TUBITAK 1.5m tel., Turkey
  - 50 GK giants (V~6.5), since 2008




Goal:
~100 planets
from 1000 stars

RV Precision with OAO/HIDES



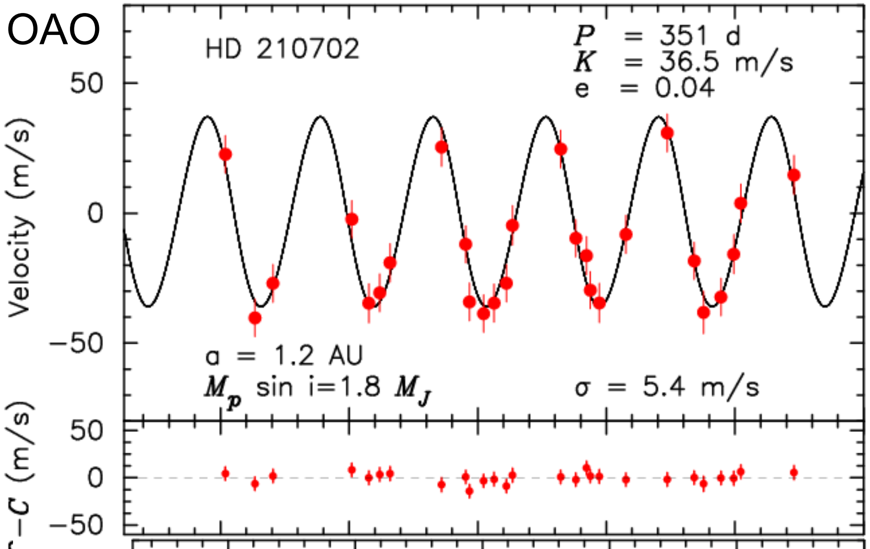
Short-term (~weeks) precision is 2m/s (Kambe et al. 2008)

Discoveries from EAPSNET

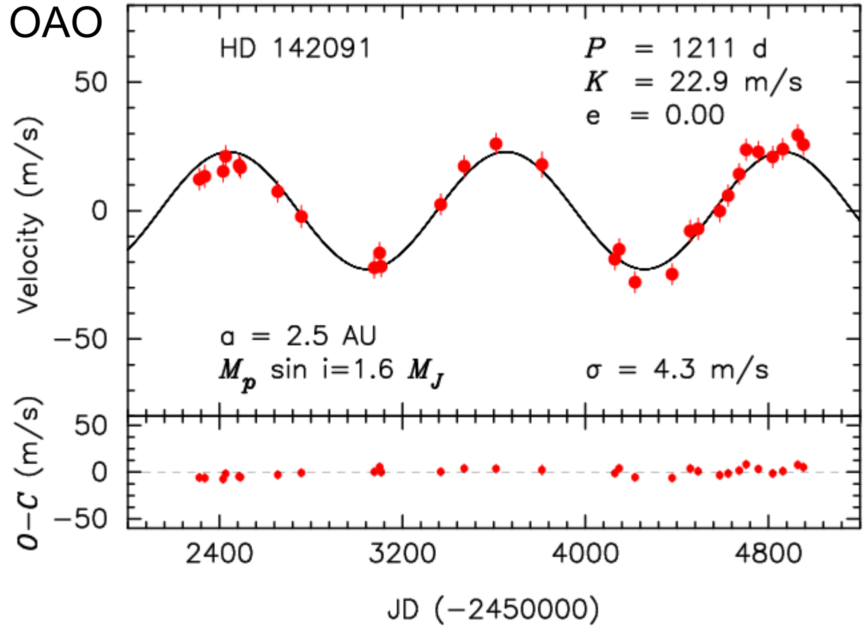
Star Name	Sp. Type	Stellar Mass ($M_\odot$)	Stellar Radius ($R_\odot$)	Planetary Mass (M_{JUP})	Semi-major Axis (AU)	Eccen tricity	Metallicity ([Fe/H]) (dex)
HD 119445	G6III	3.9	20.5	37.6	1.71	0.08	+0.04
ε Tau	K0 III	2.7	13.7	7.6	1.93	0.15	+0.13
11 Com	G8 III	2.7	19	19.4	1.29	0.23	−0.28
81 Cet	G5 III	2.4	11	5.3	2.5	0.21	+0.06
18 Del	G6 III	2.3	8.5	10.3	2.6	0.08	−0.05
HD 104985	G9 III	2.3	11	8.3	0.95	0.09	−0.35
ξ Aql	K0 III	2.2	12	2.8	0.68	0	−0.18
14 And	K0 III	2.2	11	4.8	0.83	0	−0.24
HD 81688	K0 III-IV	2.1	13	2.7	0.81	0	−0.34
HD 173416	G8 III	2.0	13.5	2.7	1.2	0.21	−0.22
6 Lyn	K0 IV	1.7	5.2	2.4	2.2	0.13	−0.13
HD 167042	K1 IV	1.5	4.5	1.6	1.3	0.10	+0.00

To be Submitted

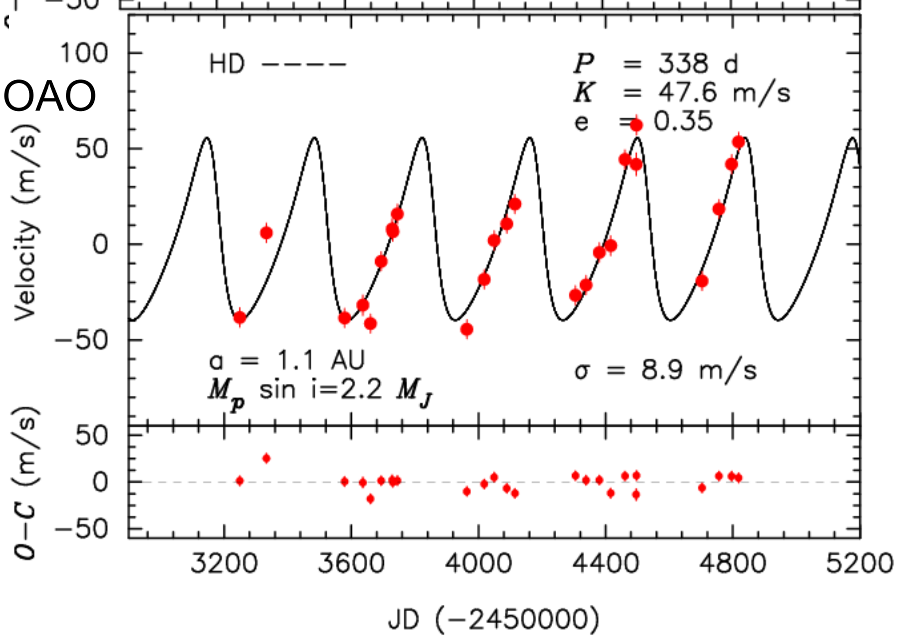
OAO



OAO

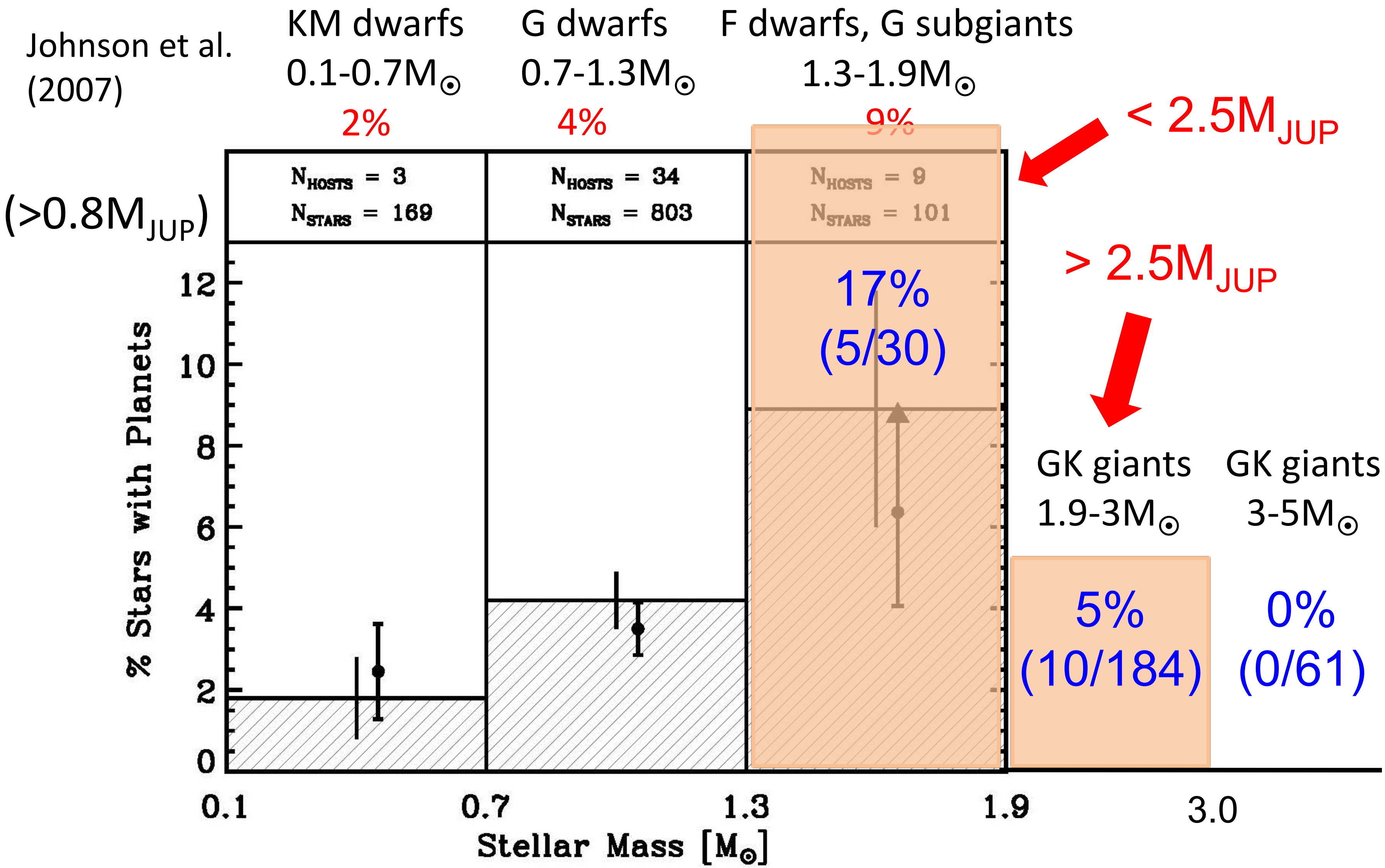


OAO

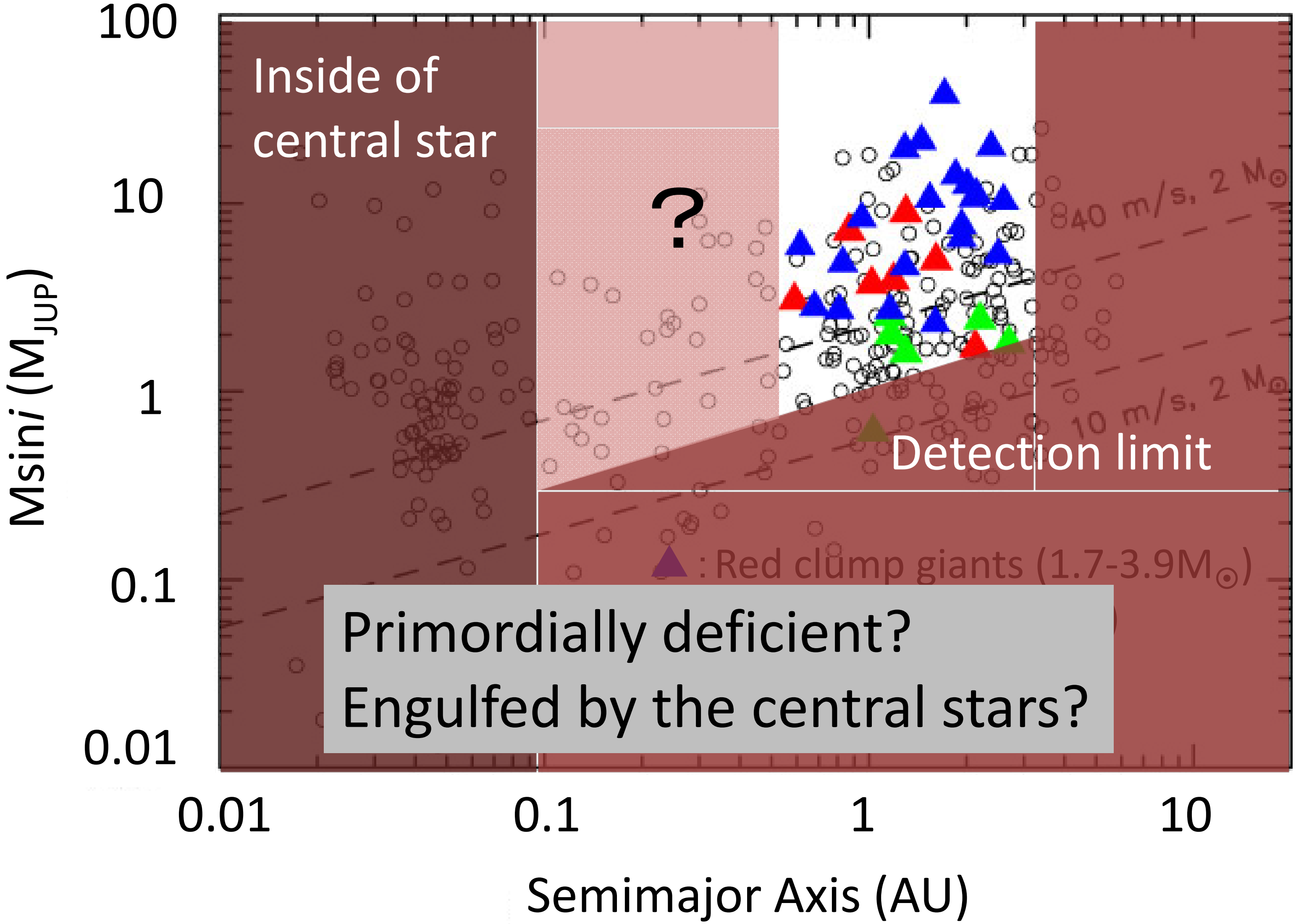


All of these are subgiants with 1.5-1.7$M_\odot$ and [Fe/H]=0.0-0.1

Planet Frequency vs. Stellar Mass

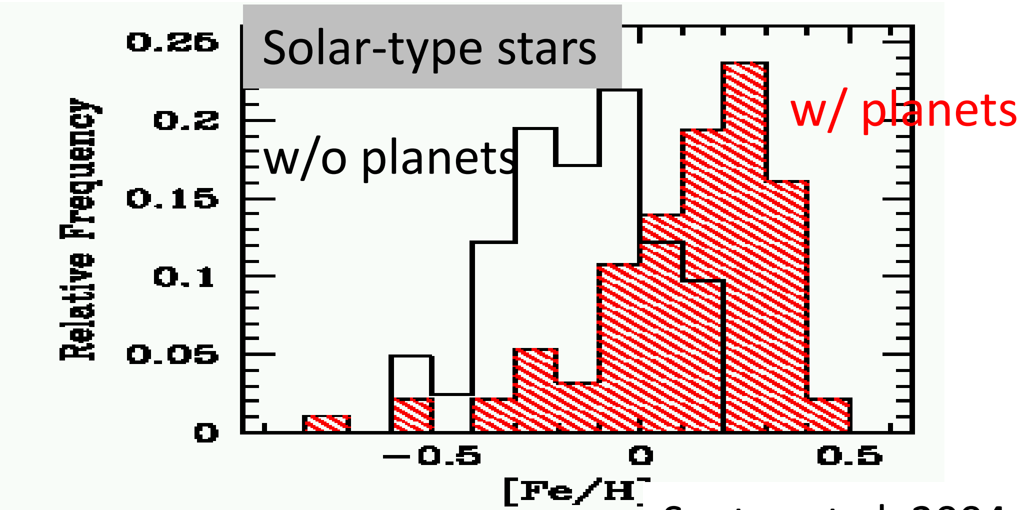


Semimajor Axis



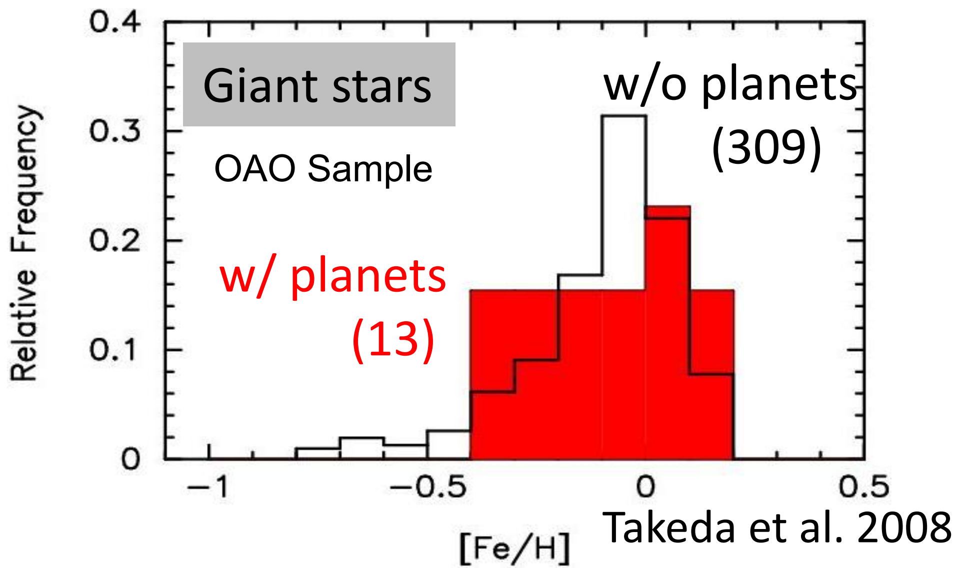
Planets vs. Metallicity

- In solar-type stars, more metal-rich stars are known to have more planets.
- In core-accretion scenario, solid cores of planets easily form in metal-rich circumstellar disks.



Santos et al. 2004

- In planet-hosting giants, however, no such metal-rich tendency has been seen so far.
- Efficient inward migration of planets in metal-rich disks or metallicity independent formation such as gravitational instability in disks or dilution by convective envelope?

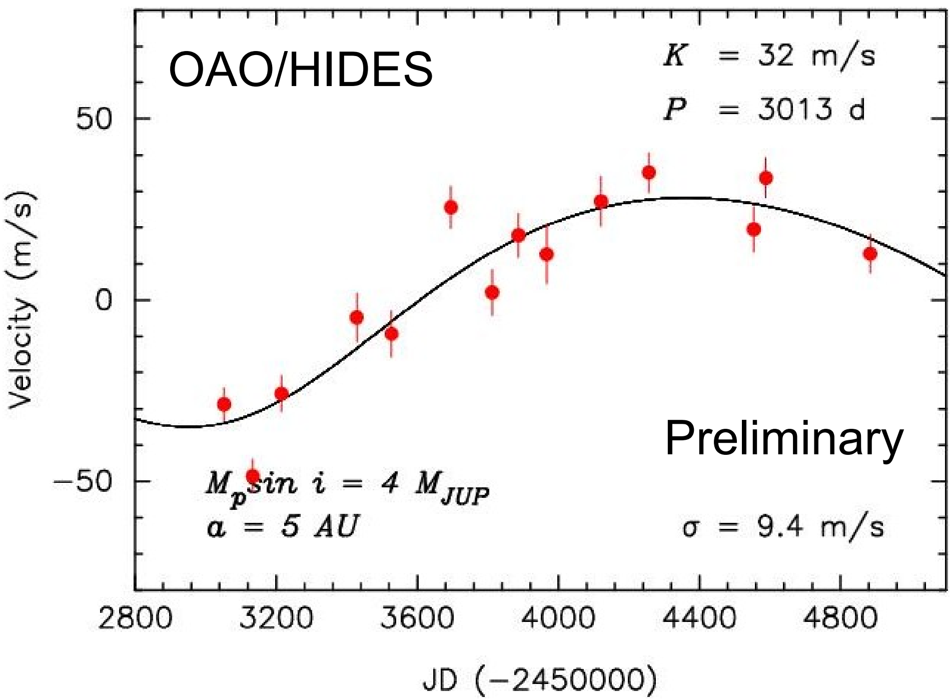


Takeda et al. 2008

What’s next ?

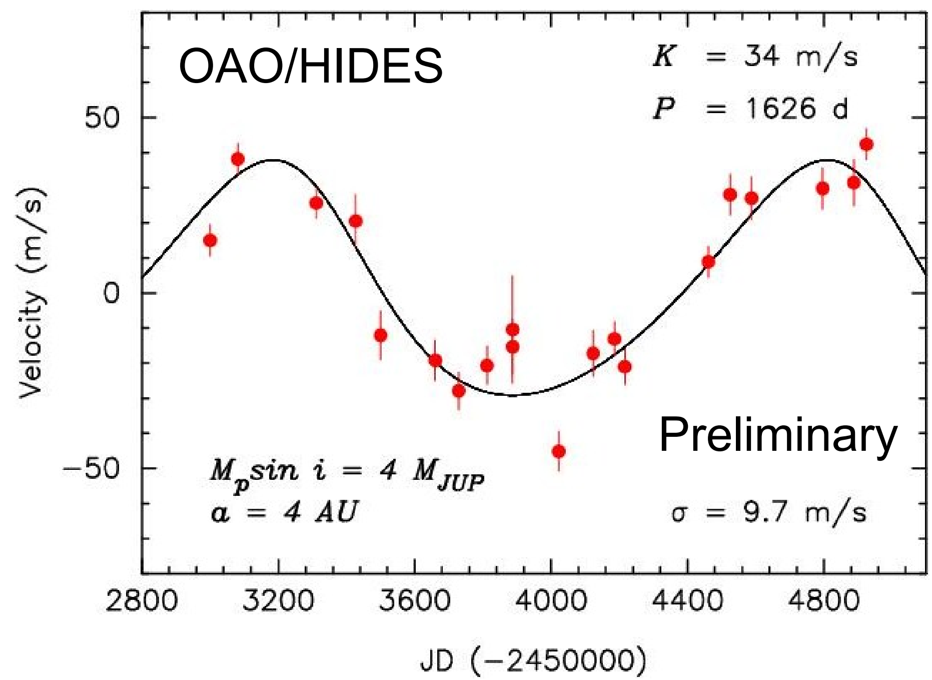
- Extending baseline beyond 3 AU
  - Continue OAO program
  - BOAO?, Xinglong??
- Enlarging samples to >1000 stars
  - Subaru survey + OAO, BOAO, Xinglong follow-up
  - Focus on relatively short-period planets (P<1yr)
- Dedicated search for planets around >3$M_\odot$ giants
  - Most of the current targets are <3$M_\odot$
  - Planet desert around >3$M_\odot$? ➔ Omiya-san’s talk
- Dedicated search for planets around [Fe/H]~+0.2 giants

Beyond 3 AU



Msini=4M$_{JUP}$
a=5AU

Msini=4M$_{JUP}$
a=4AU



Frequency of planets beyond 3 AU strongly depends on snow-line

Subaru/HDS Survey

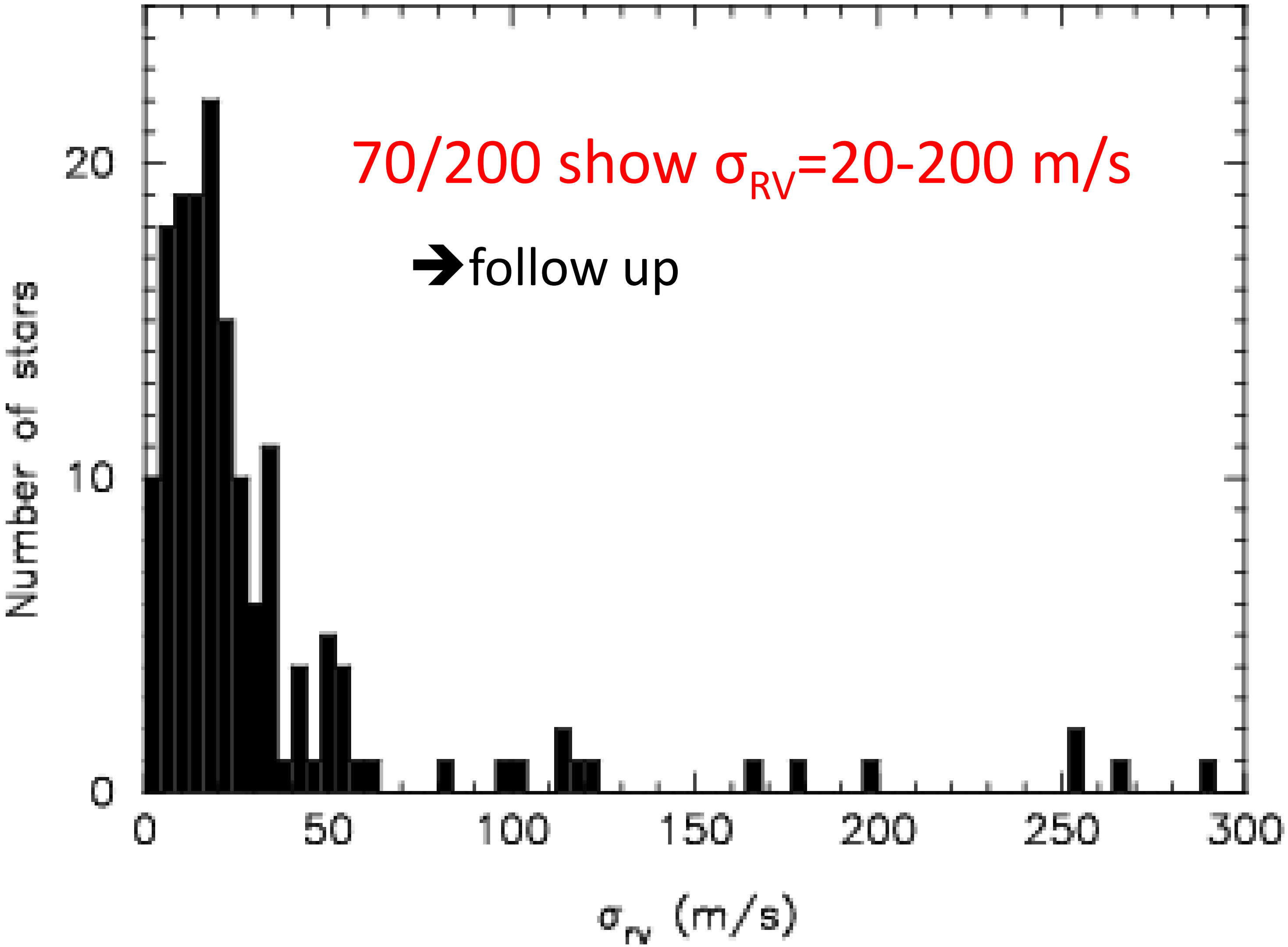
- Three obs. each star in a half year to identify large RV candidates
- Follow up using 2m-telescopes in east-Asian countries
  - 40 @Okayama
  - a few @Xinglong, BOAO
- In 2006-2008, 200 stars have been screened and ~70 of them show large (>20m/s) RV variations.

Toward 1000 stars in total

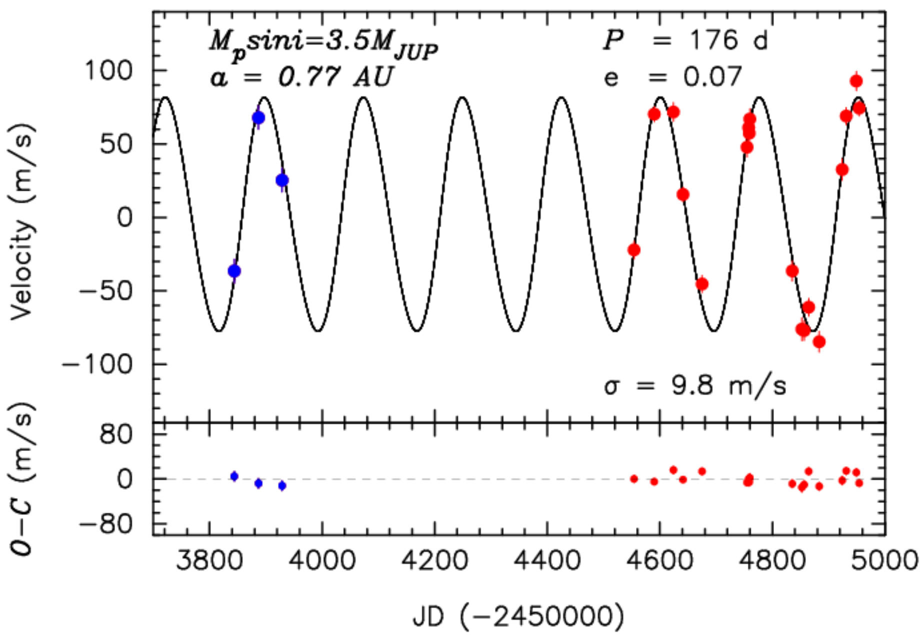
RV Variatiions

70/200 show σ_{RV}=20-200 m/s

➔ follow up



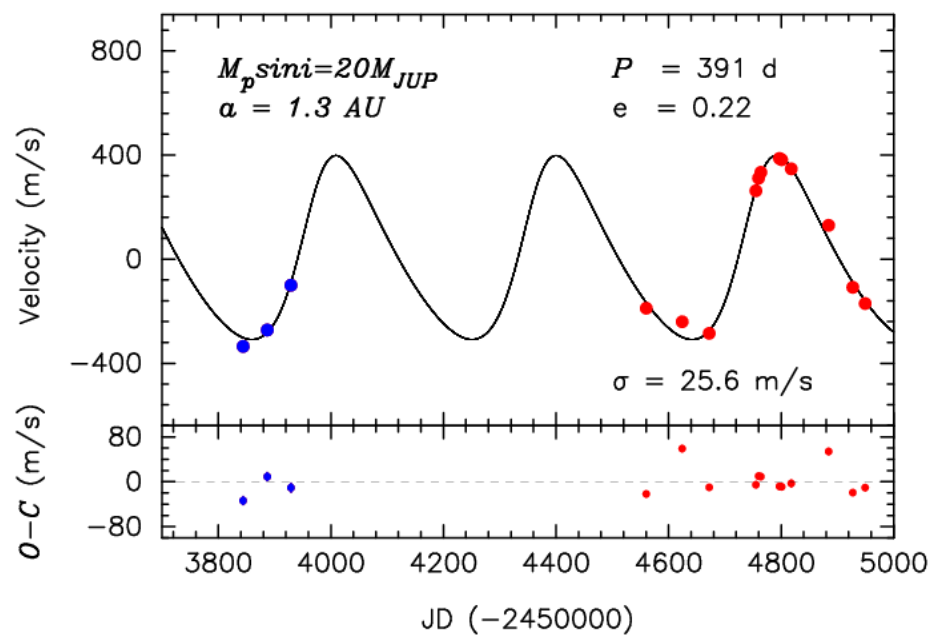
New Candidates



Msini=3.5M

Blue: Subaru
Red: OAO

Msini=20M



Summary

- Nine years of the Okayama Planet Search Programs
  - Nine planets, one BD, and several more candidates within 2.5AU
  - Different properties of planets (frequency, mass, semimajor-axis, host-star's metallicity etc.) from those around solar-like stars
- Future
  - Extending baseline beyond 3AU at Okayama
  - Enlarging sample to >1000 stars
    - Subaru survey + OAO, BOAO, Xinglong follow-up
  - New dedicated planet searches