The Search for the Shortest Period Binary WDs: The Latest Results from the ELM Survey

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July 23rd, 2015

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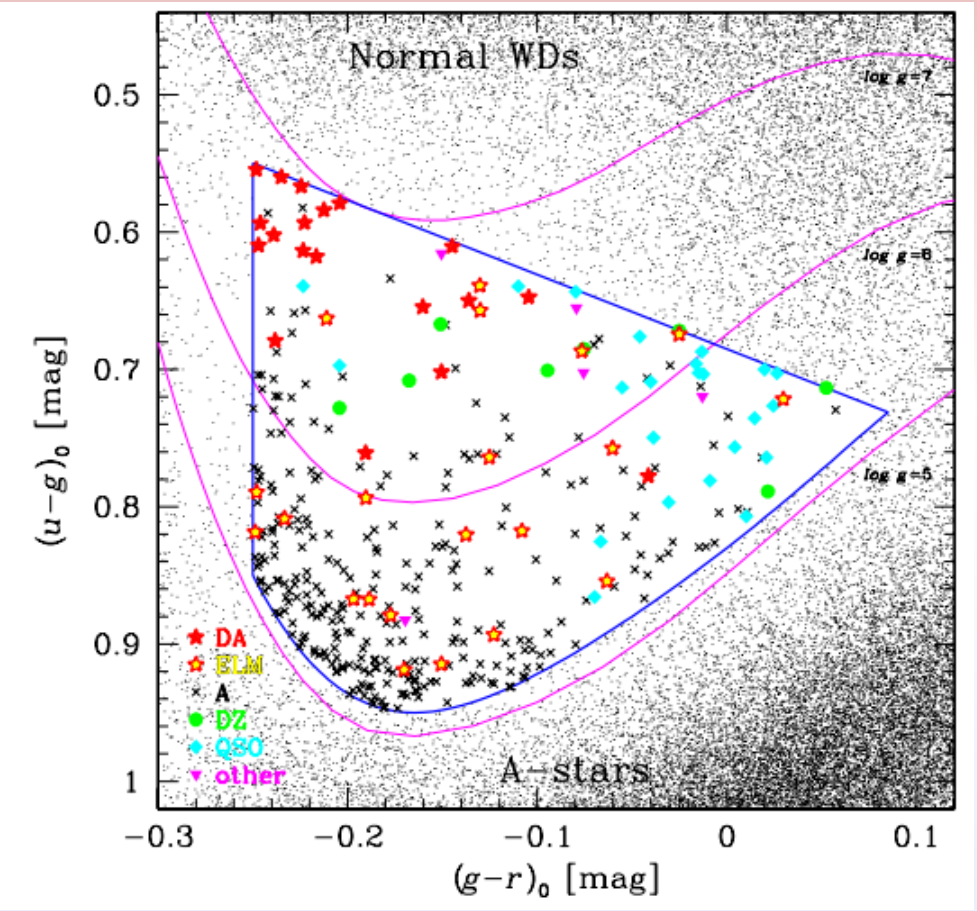
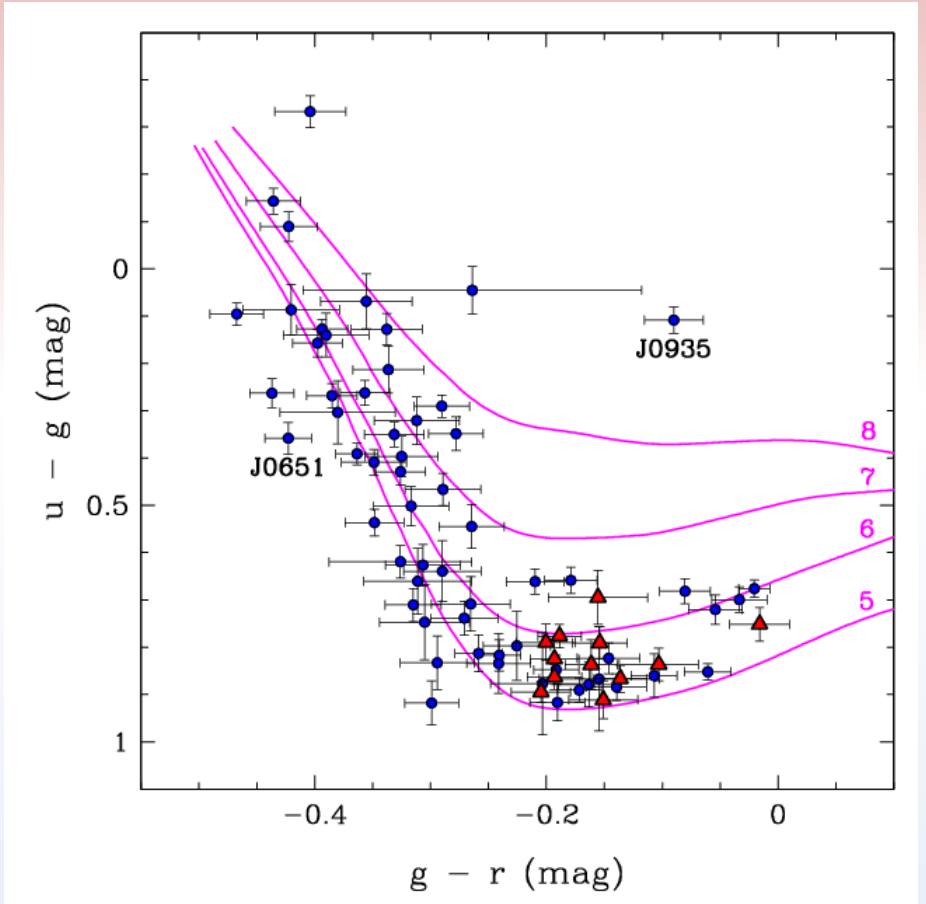
The ELM Survey

- The ELM Survey is an ongoing, targeted search for ELM WDs
  - $M < 0.30\ M_{\odot}$ ($5 < \log g < 7$)
  - Found in short-period ($P < 1$ day) binary systems
- Motivation
  - Progenitors of SN Ia, .Ia, AM CVn, R CrB, single sdBs
  - Neutron star companions
  - Gravitational wave verification sources
  - Laboratories to test GR, tidal effects (J0651)
- Papers I – V + VI : 62 + 12 new ELM WDs

SDSS colors work well for choosing ELM WD candidates

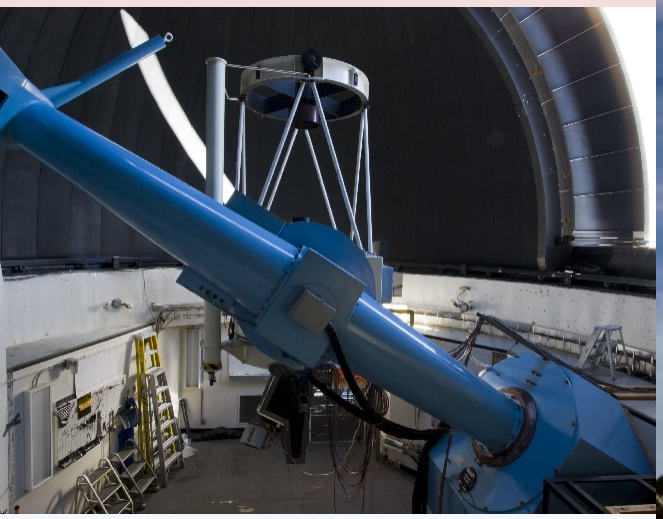


Brown et al. (2012)



Gianninas et al. (2015, submitted)

Radial Velocity Follow-Up

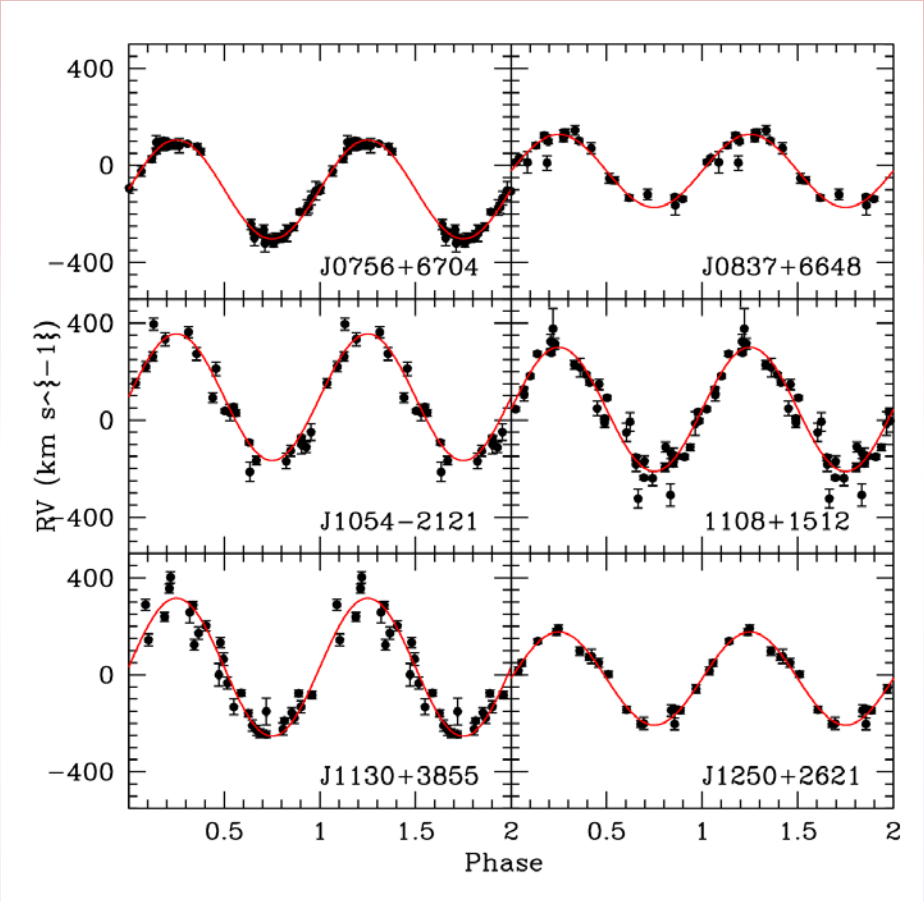


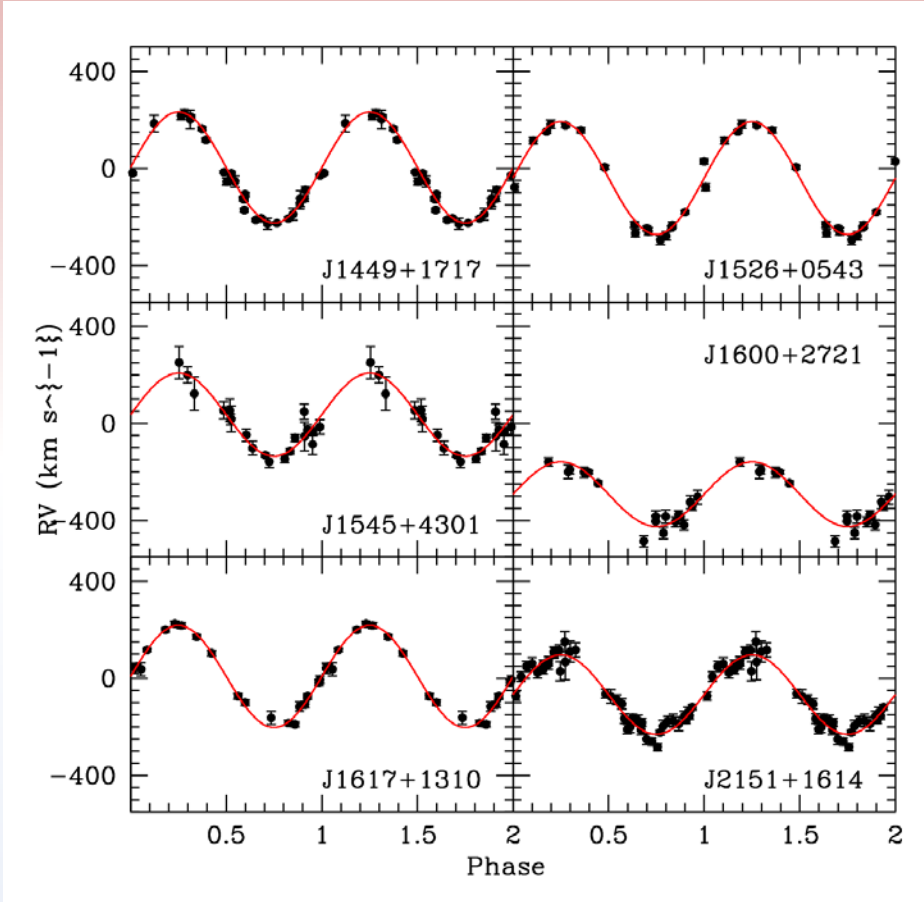
FLWO 1.5m

KPNO 4m

MMT 6.5m

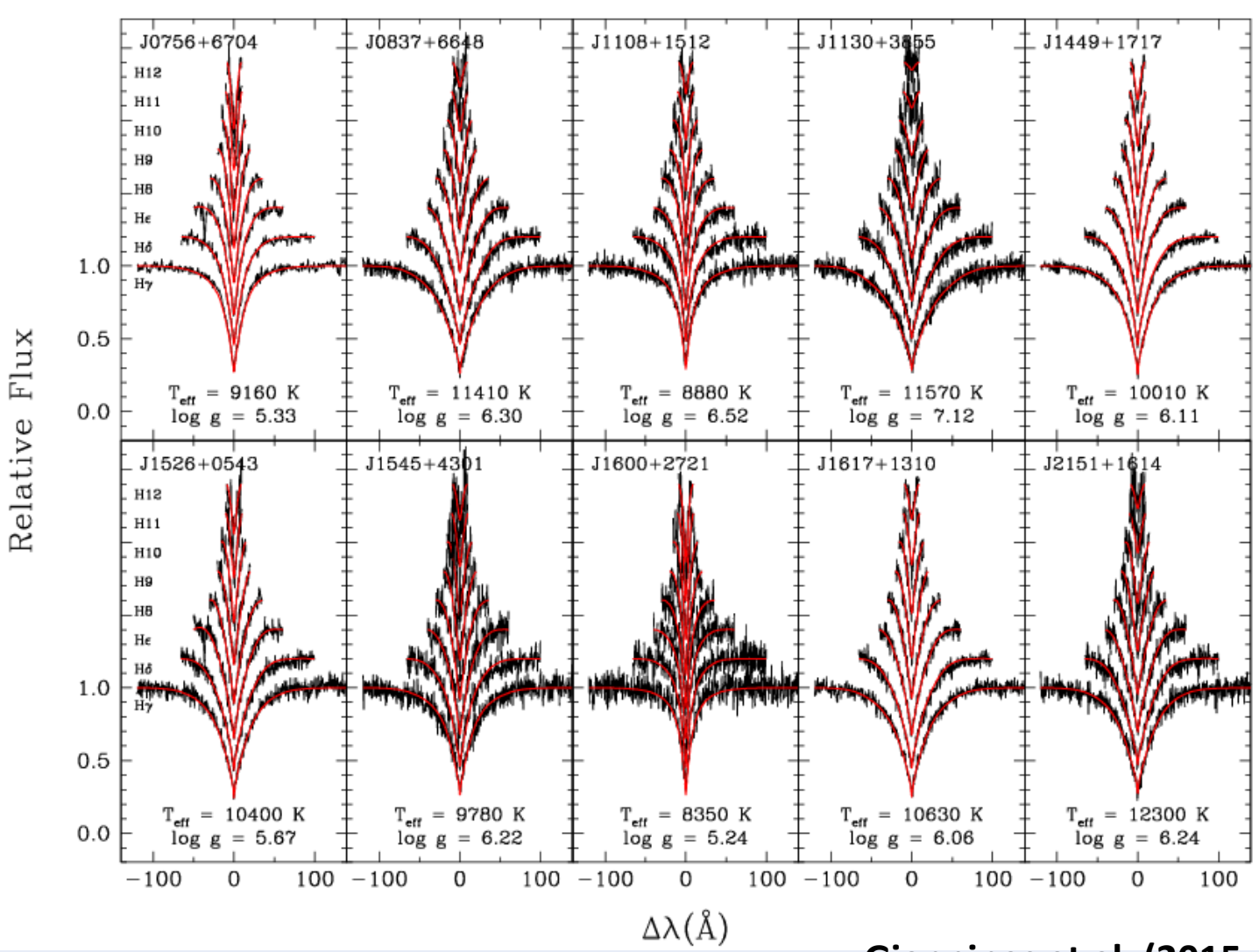
ELM VI: 12 new ELM WDs





Gianninas et al. (2015, submitted)

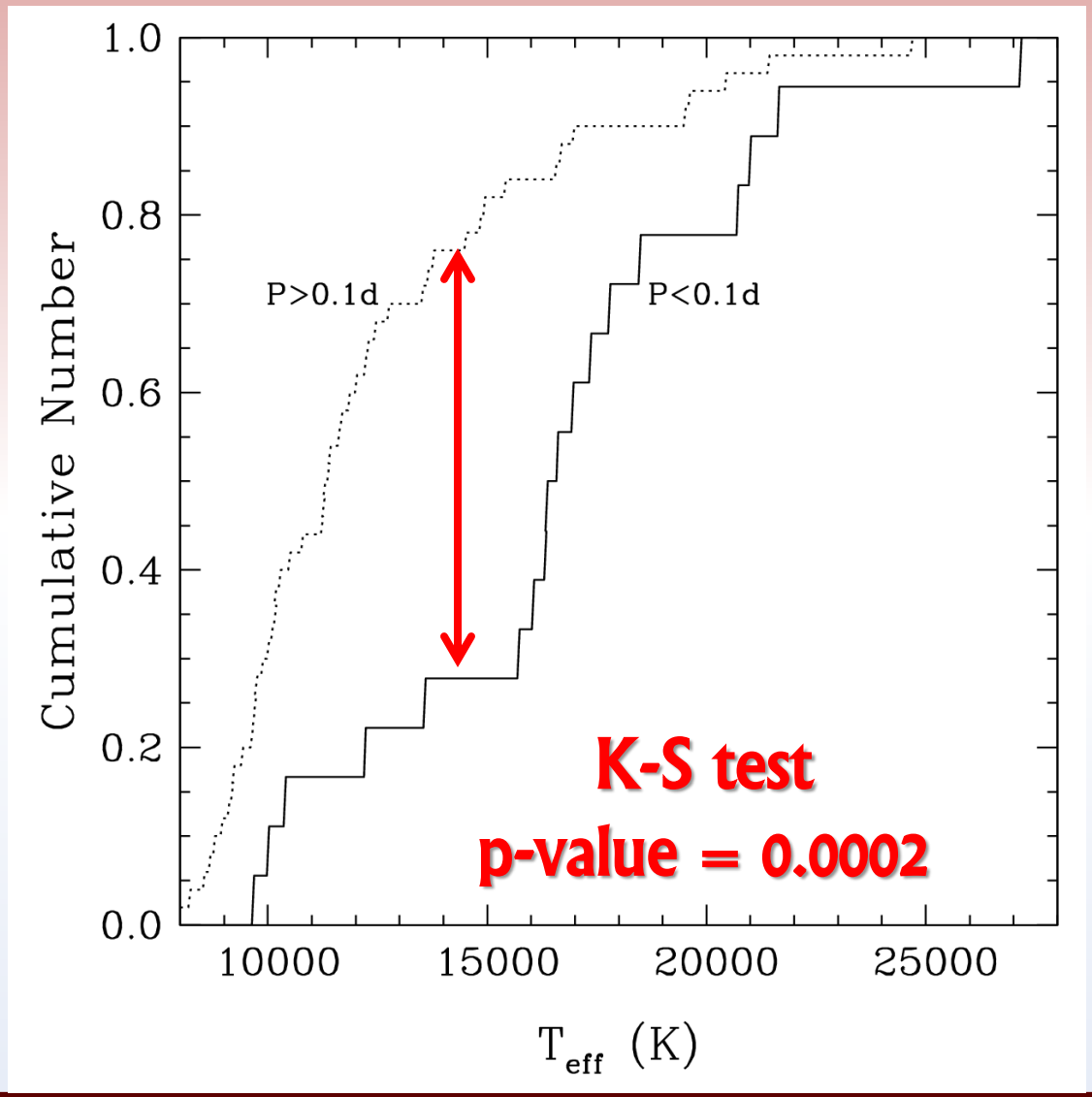
Standard Spectroscopic Technique



Gianninas et al. (2015, submitted)

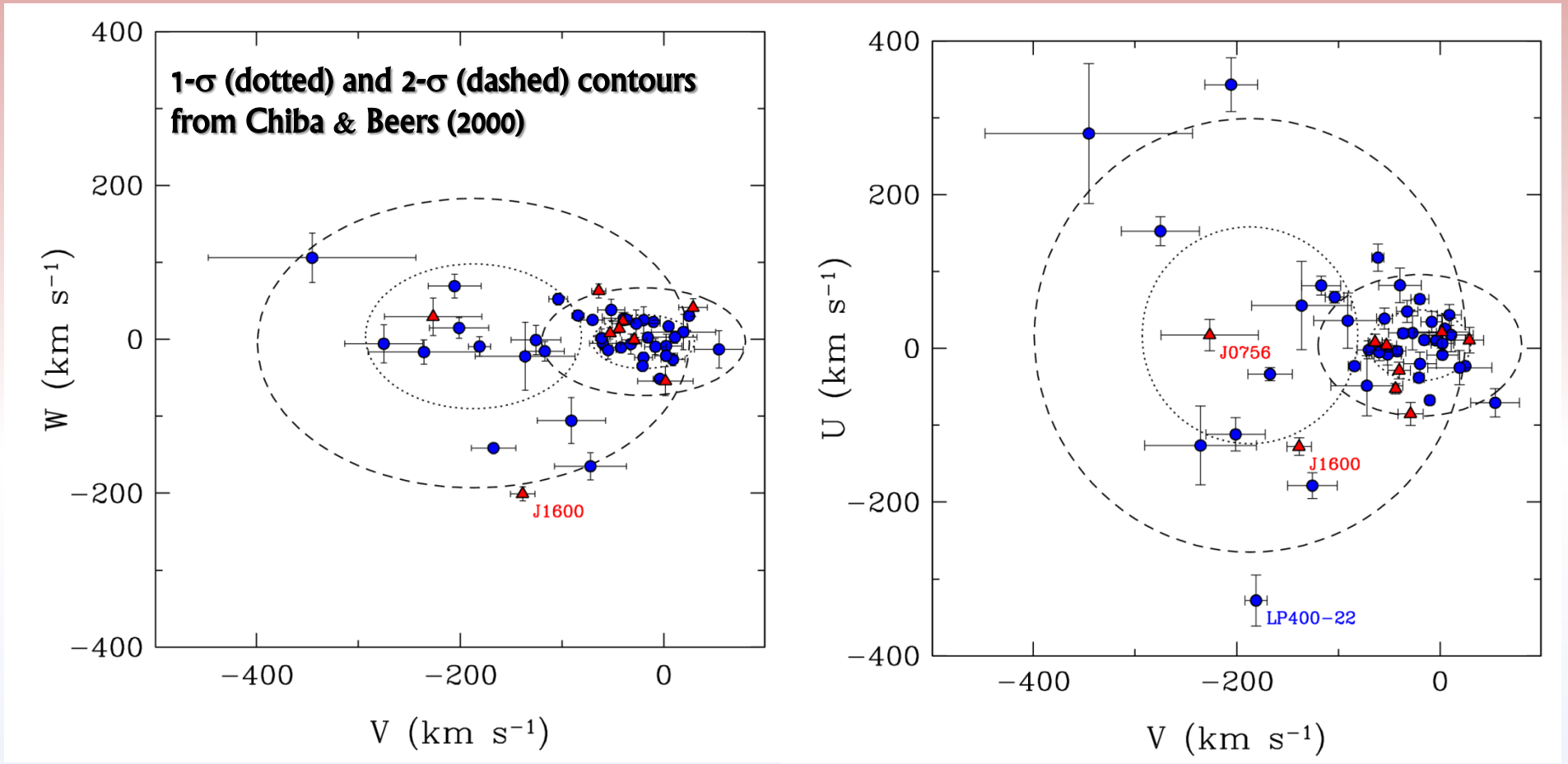
A correlation with T_{eff} is emerging

Cooler ELM WD binaries have longer periods or else they would have already merged



Gianninas et al. (2015, submitted)

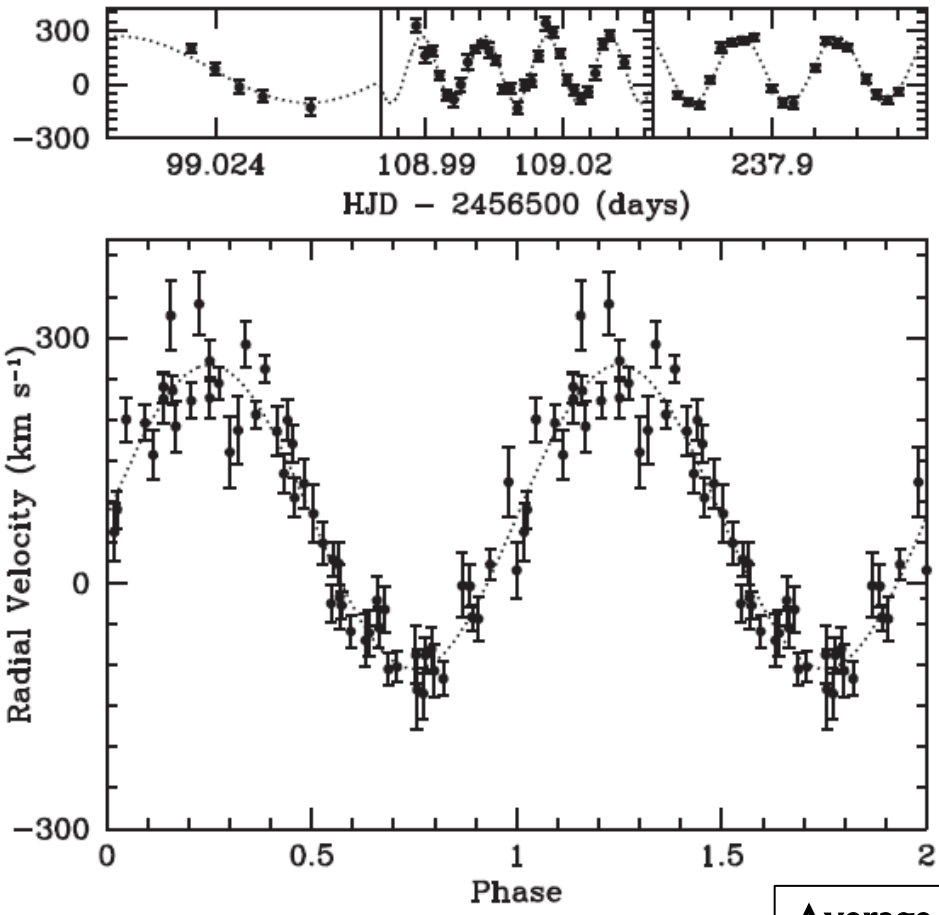
Kinematics: Space Velocities



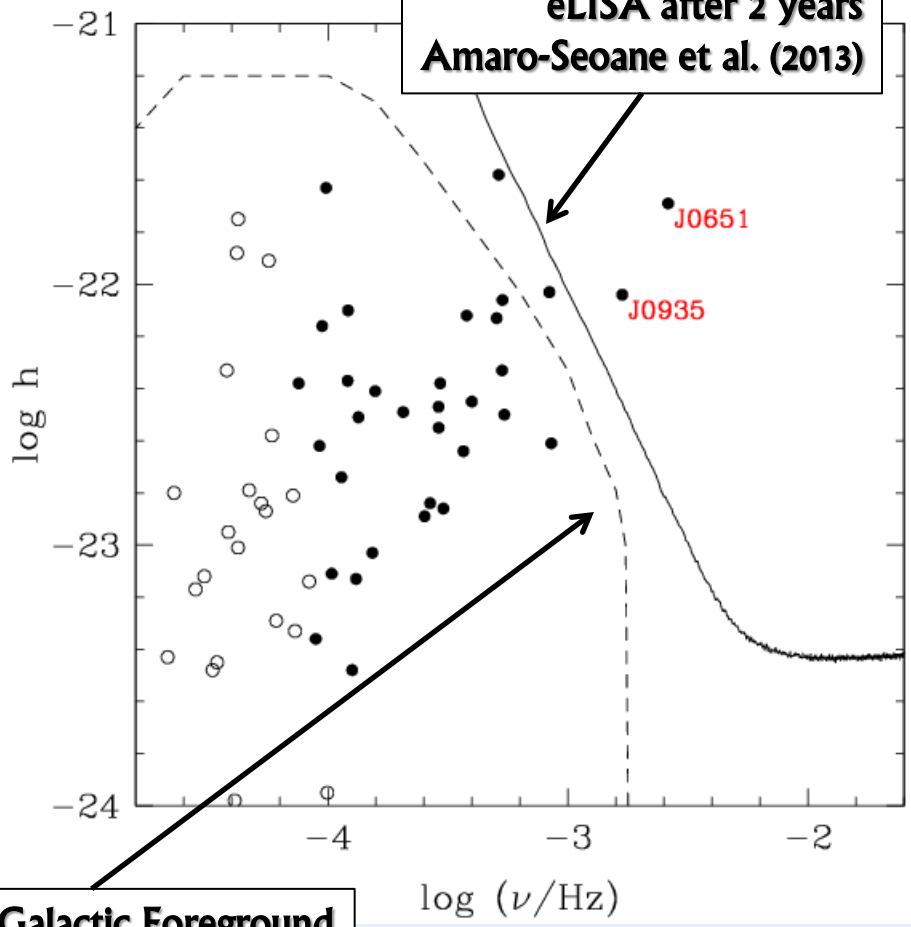
Gianninas et al. (2015, submitted)

22 of 49 ELM WDs have kinematics consistent with halo membership

WD 0931+444: a new 20-min ELM WD
Shortest period ELM after J0651!



Kilic et al. (2014)



Kilic et al. (2015)

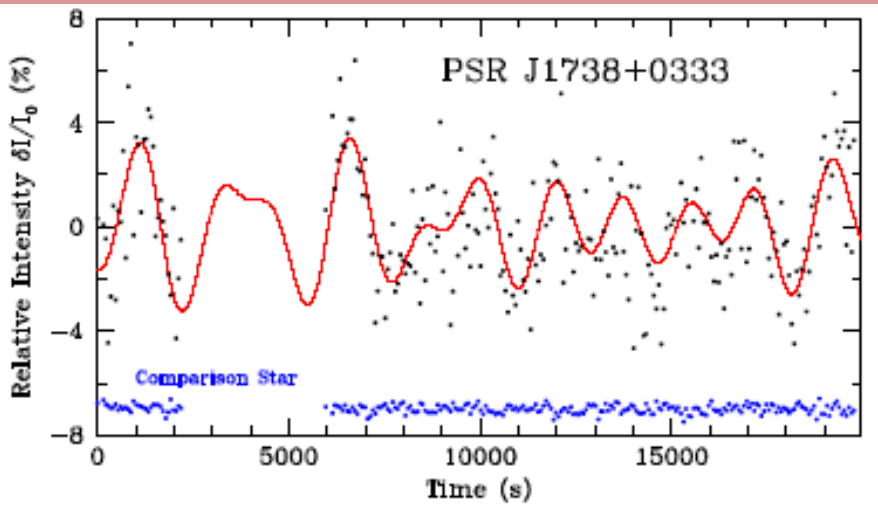
Several PSR have ELM WD companions

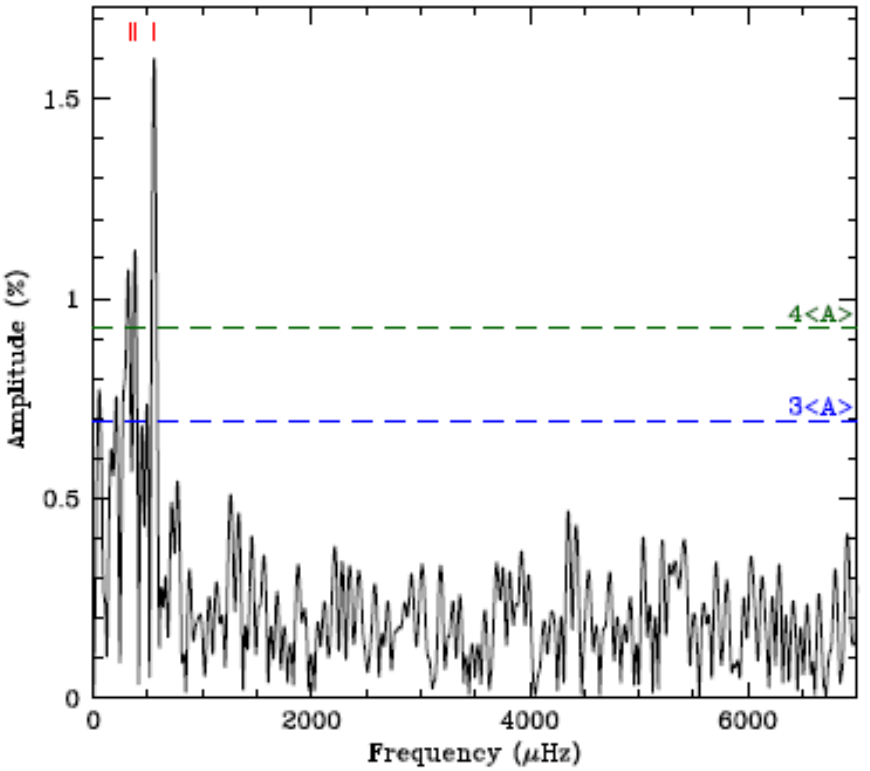
- Several of the ELM WD companions are in the correct range of T_{eff} and log g (i.e. instability strip) to pulsate
- No pulsations detected for ELM companions of PSR J1012+5307+ and PSR J1911-5958 (Steinfadt et al. 2010)

PSR J1738+0333

- First pulsating ELM WD companion to a PSR!

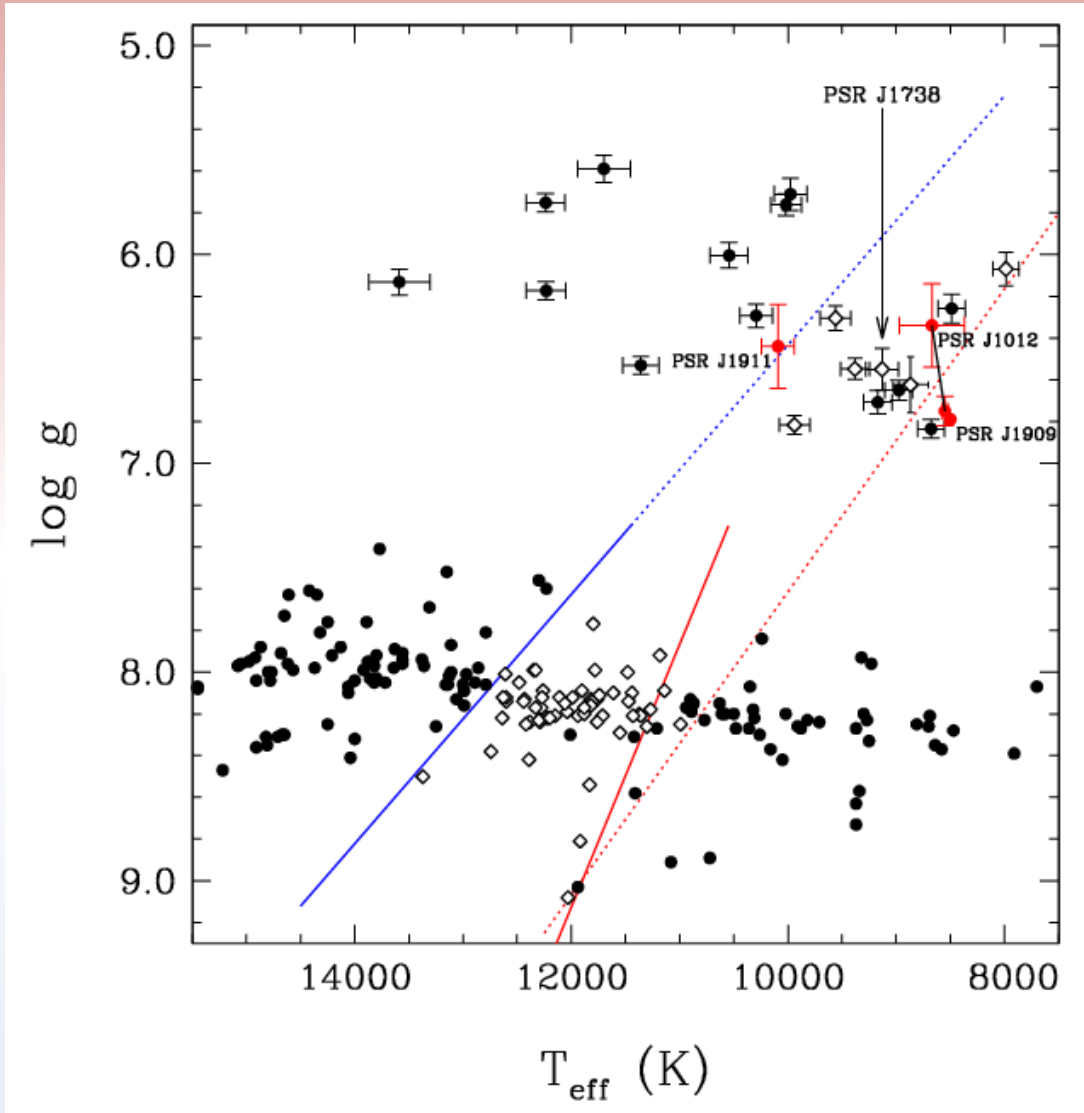
Period (s)	Frequency (μHz)	Amplitude (per cent)	Phase (s)	S/N
1788 ± 33	559 ± 10	1.27 ± 0.47	1030 ± 110	6.3
3057 ± 99	327 ± 11	1.22 ± 0.47	10 ± 190	6.0
2656 ± 80	376 ± 11	1.15 ± 0.47	2150 ± 170	5.7





Kilic et al. (2015)

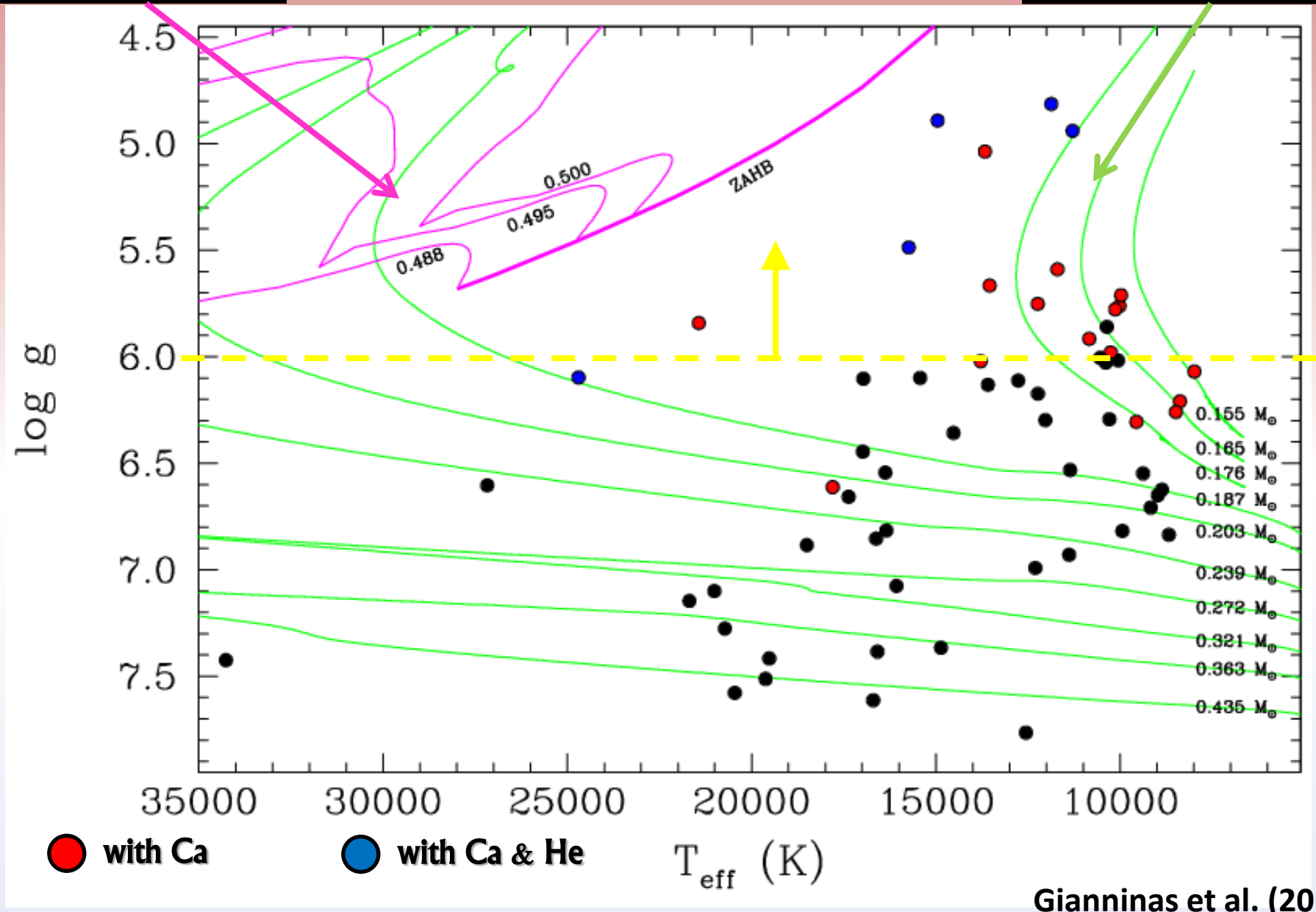
Updated ELM WD instability strip



Kilic et al. (2015)

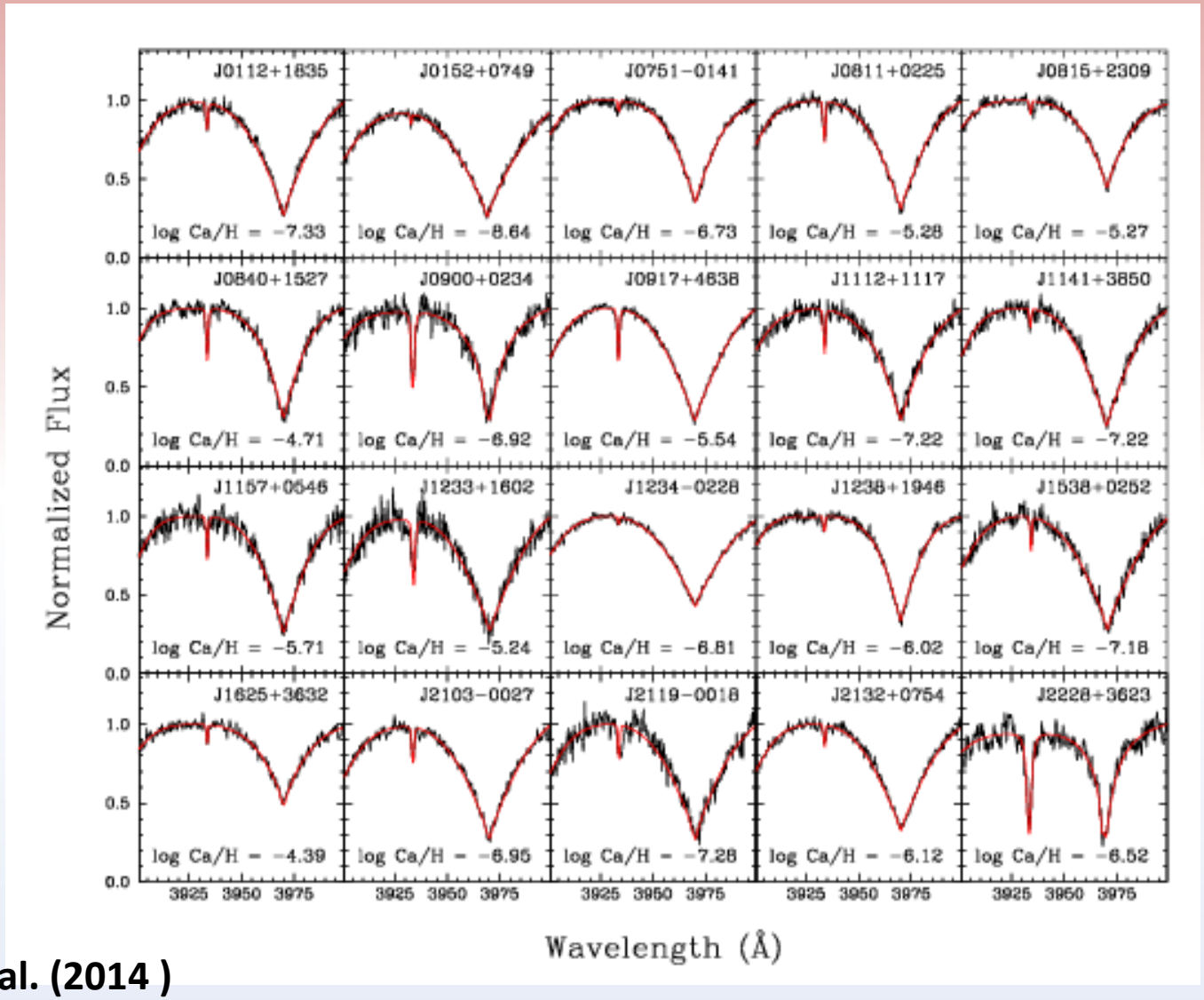
Dorman et al. (1998)

Althaus et al. (2013)



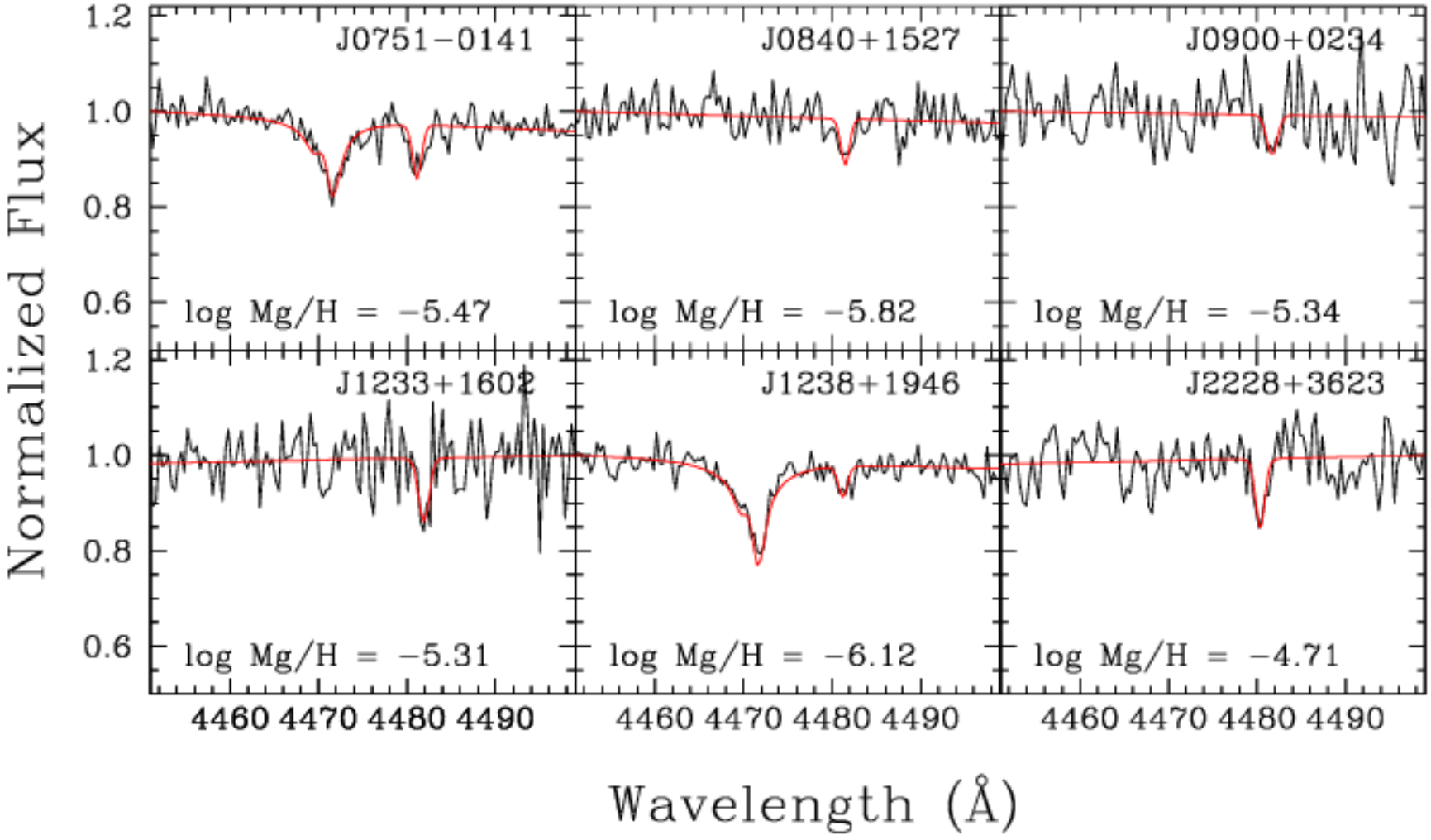
Gianninas et al. (2014)

Many ELM WDs have Ca lines…



Gianninas et al. (2014)

… some have Mg lines…



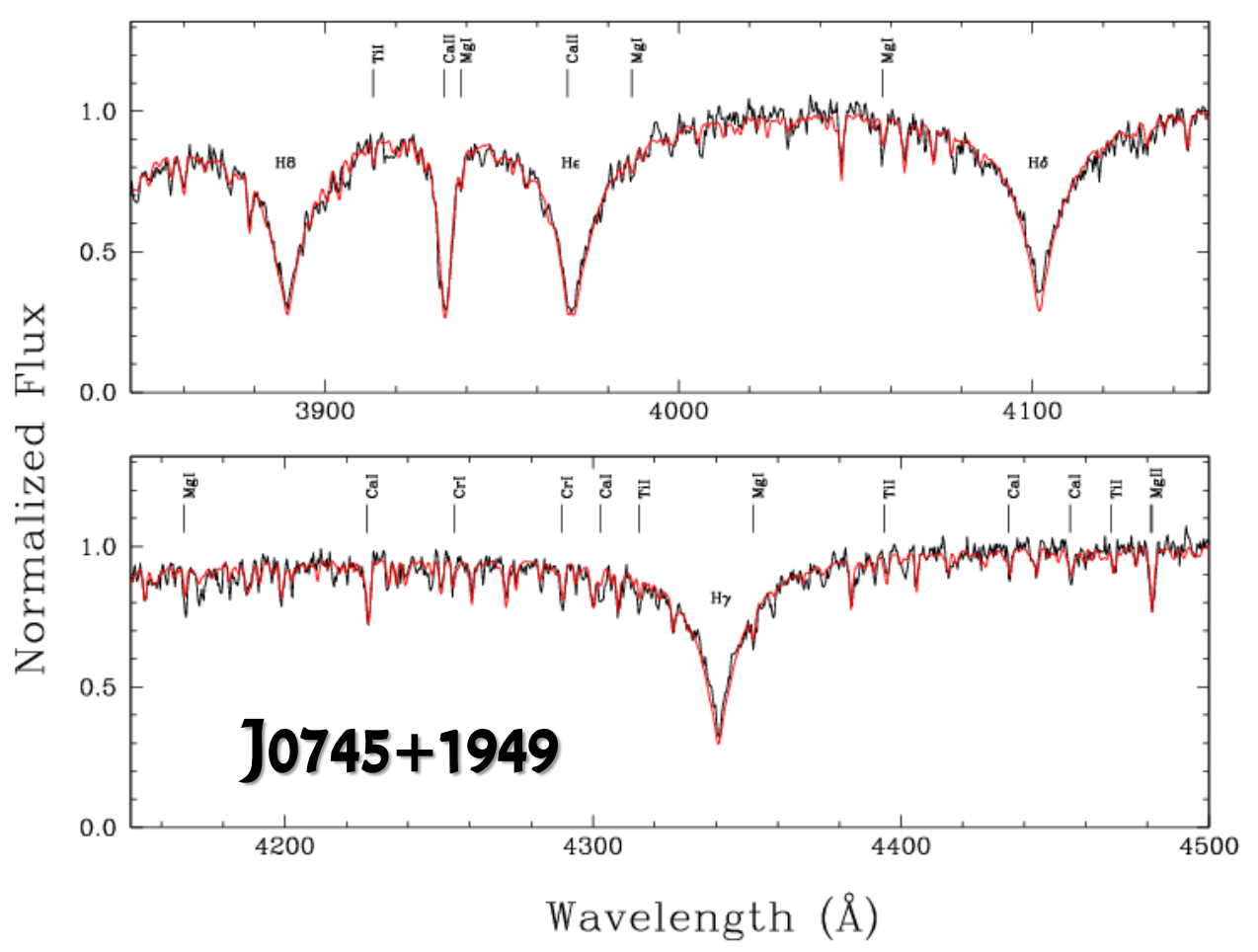
Gianninas et al. (2014)

… others have a lot more!

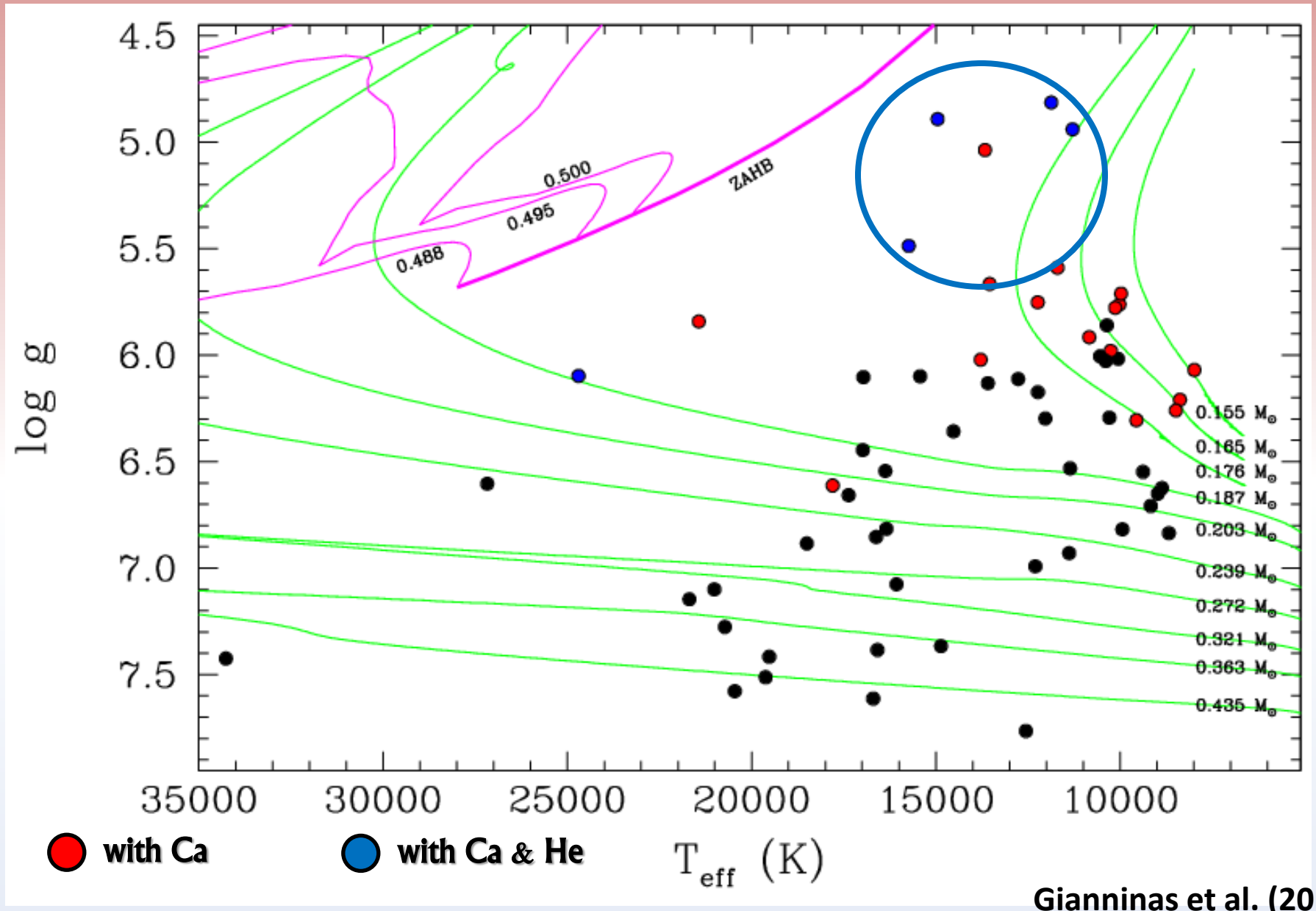
See also

GALEX J1717+6757
Hermes et al. (2014) + poster
Vennes et al. (2011)

PSR J1816+4510
Kaplan et al. (2013)



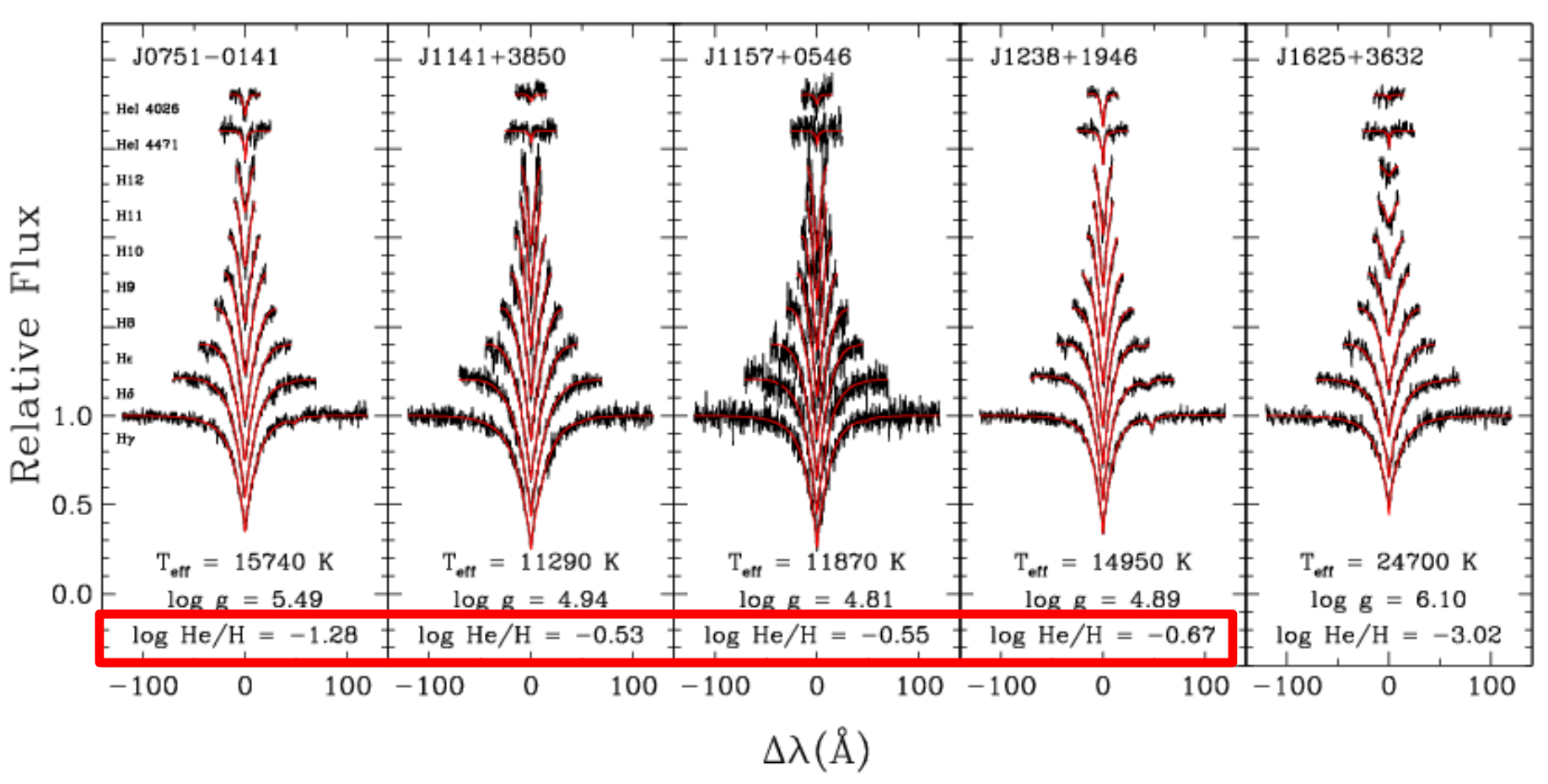
Gianninas et al. (2014)



Gianninas et al. (2014)

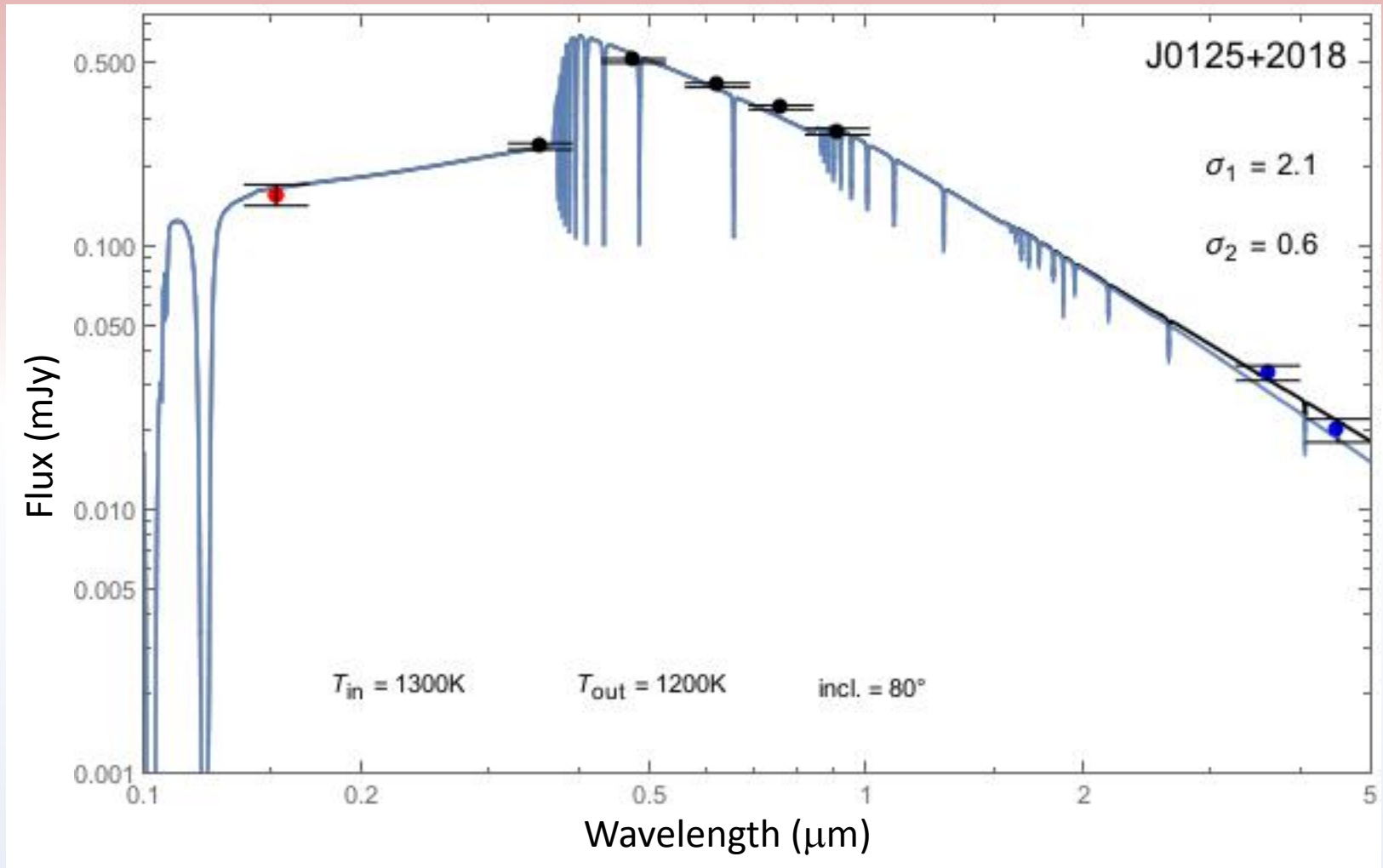
Some even have Helium

a lot of it!

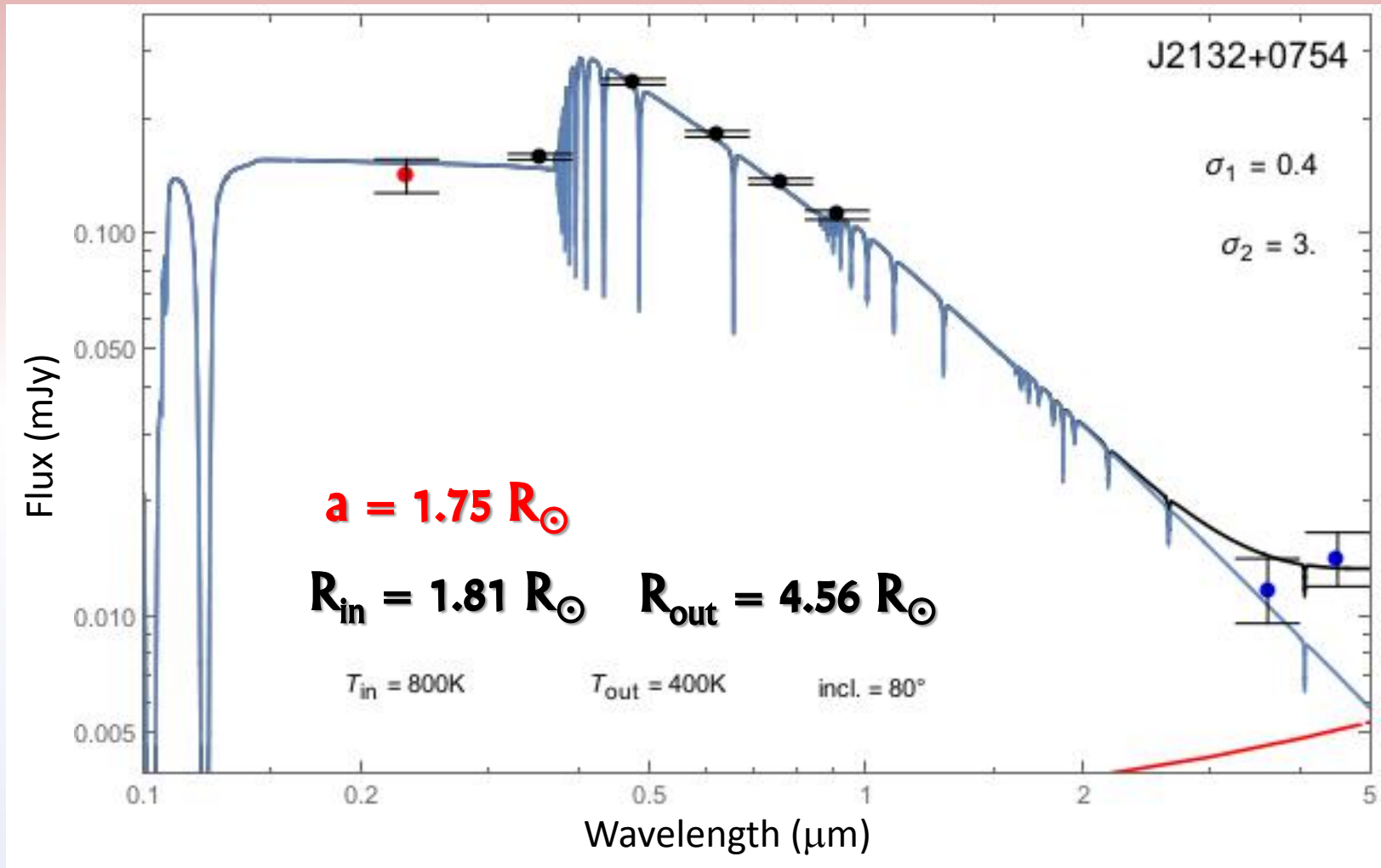


Gianninas et al. (2014)

UV-VIS-NIR SEDs including Spitzer



UV-VIS-NIR SEDs including Spitzer



CONCLUSIONS

- ELM Survey: 74 new ELM WDs and more to come
  - Starting to be able to do some statistics + kinematics
- Highlights:
  - Now two gravitational wave verification sources
  - First ever PSR+ pulsating ELM WD
- Metals:
  - Ca (Mg and more) in all ELMs with log g < 6.0
  - Presence of He could be sign of recent shell flash
  - No excesses in Spitzer data (except one…?)
- Wish list:
  - Constrain parameters of the secondary components