Resolving the Population of Galactic Ultra-Compact Binaries

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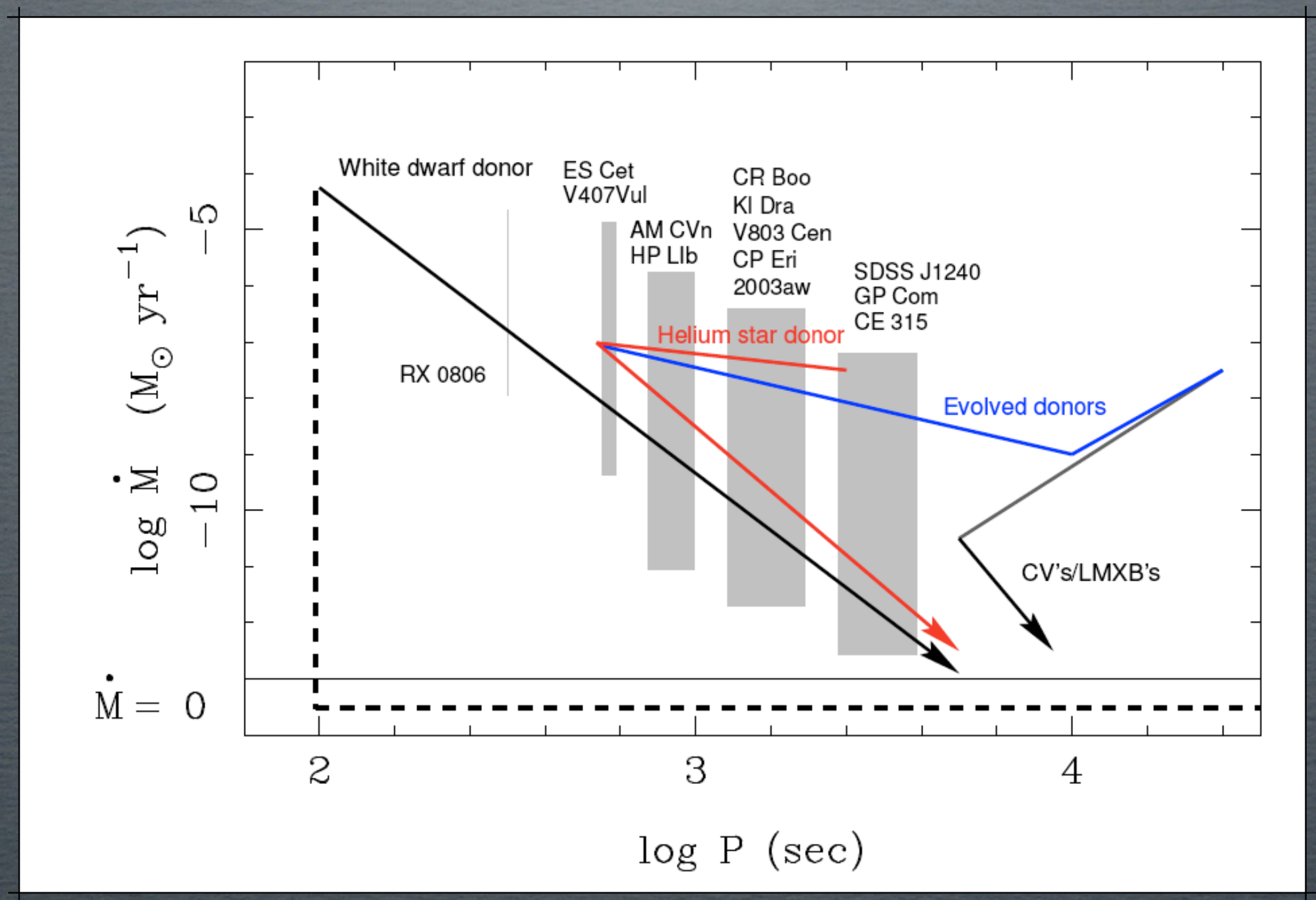
AM Canum Venaticorum Stars

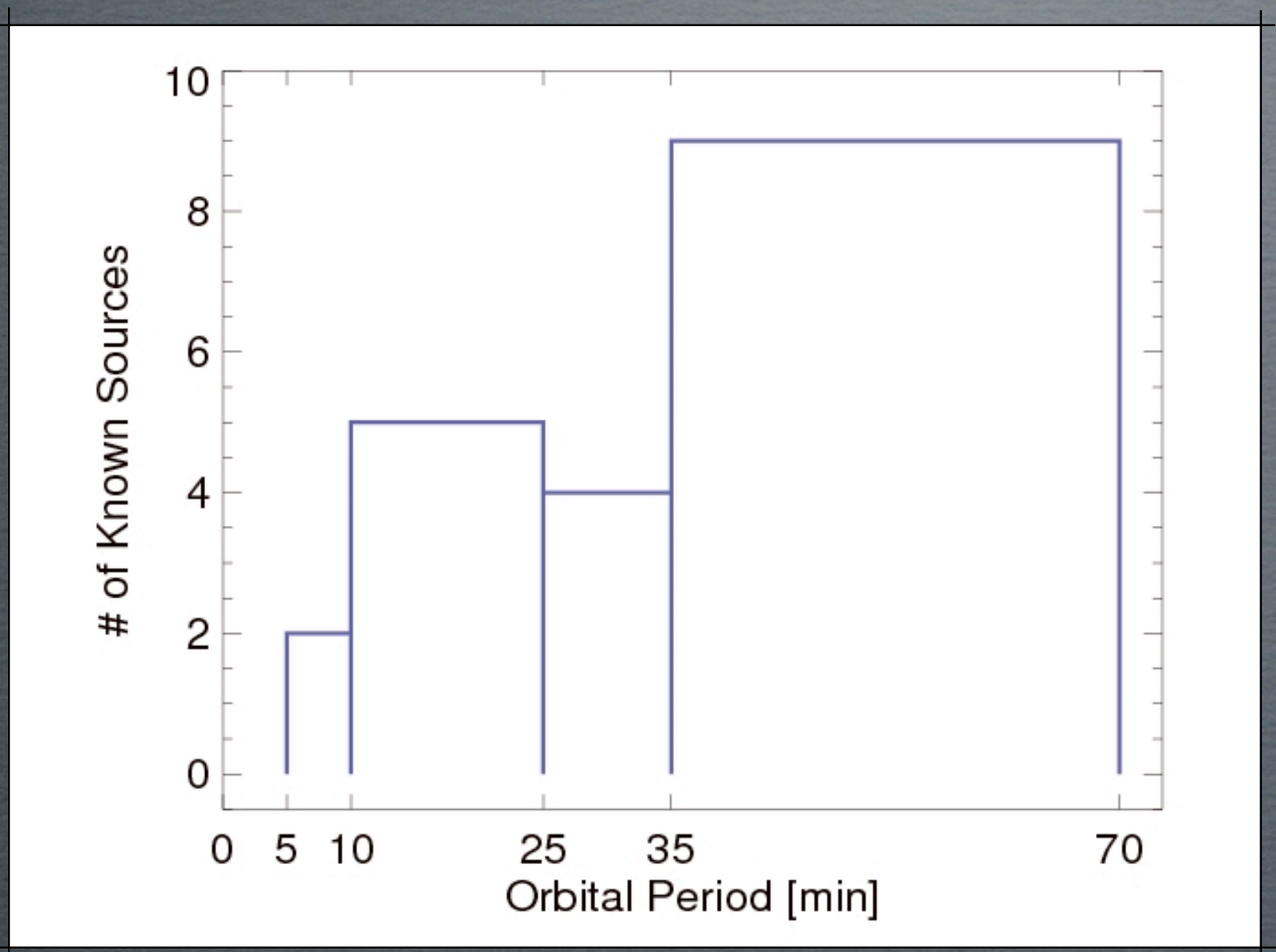
- interacting double White dwarf binaries
- WD + (semi-) degenerate, hydrogen depleted donor
- ultra-compact (10min < P_orb < 1hr)



(Nelemans 2005)

Known Sample

- 22 sources (compared to thousands of CVs)
- extremely heterogeneous sample
- spectrum varies with P_orb



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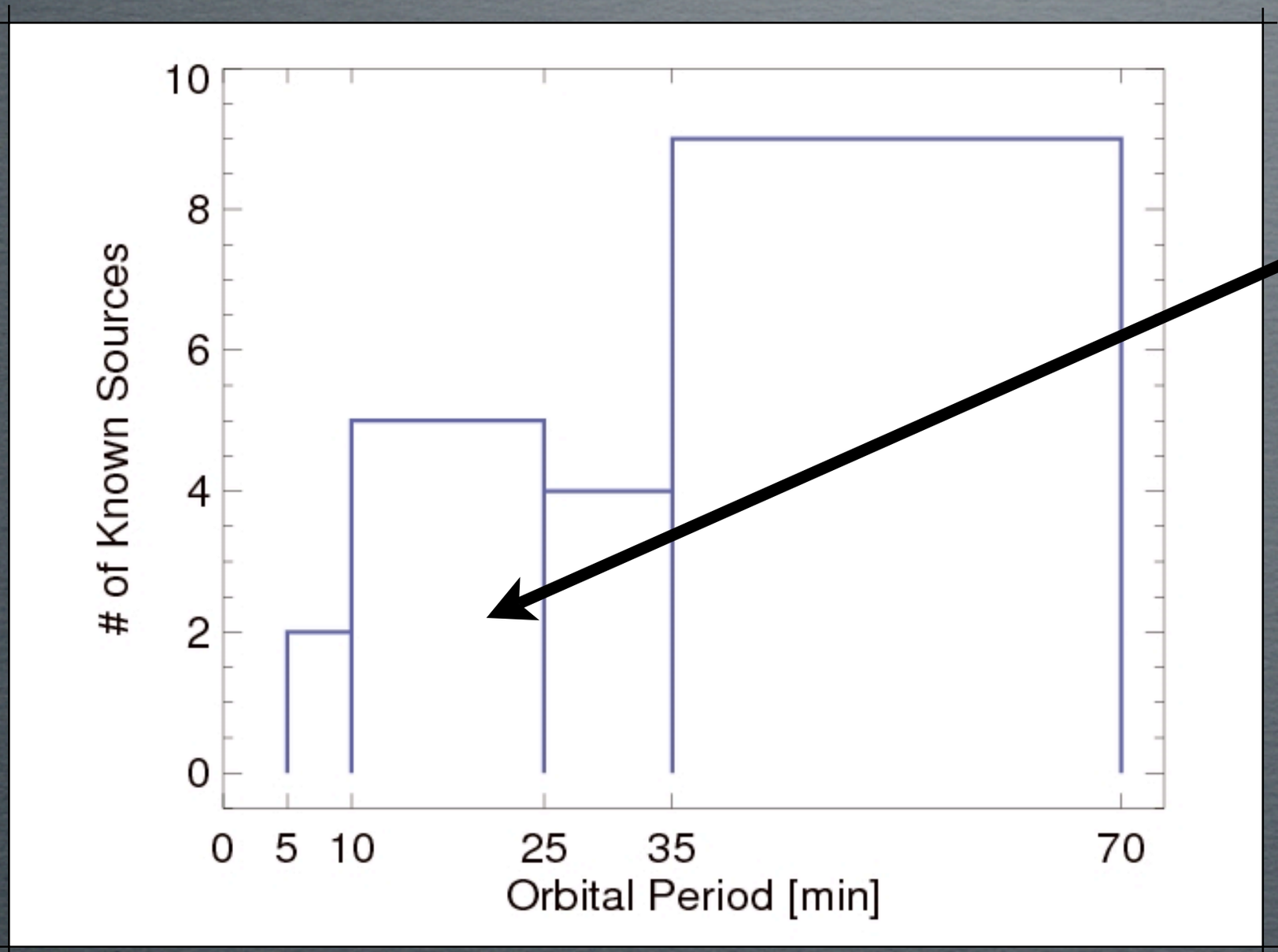

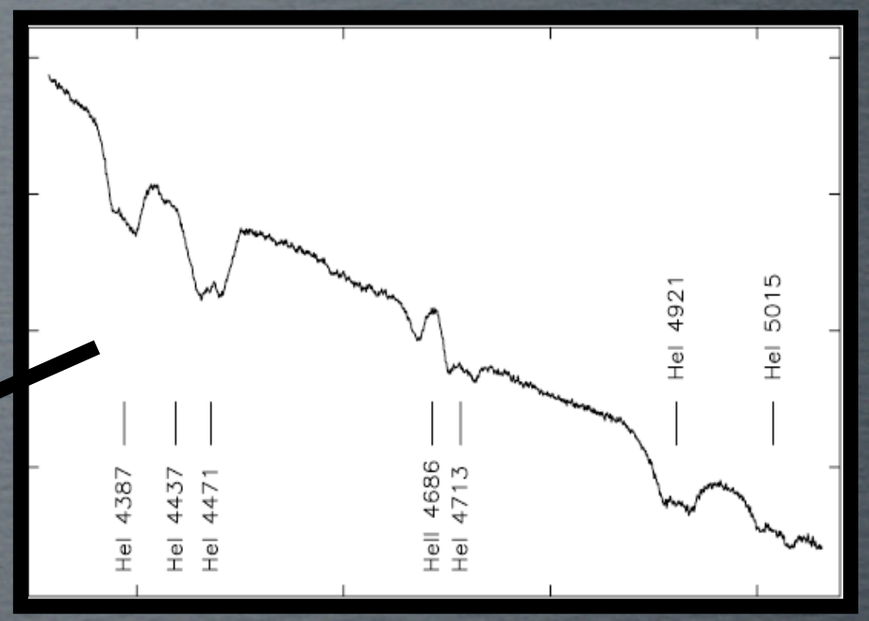

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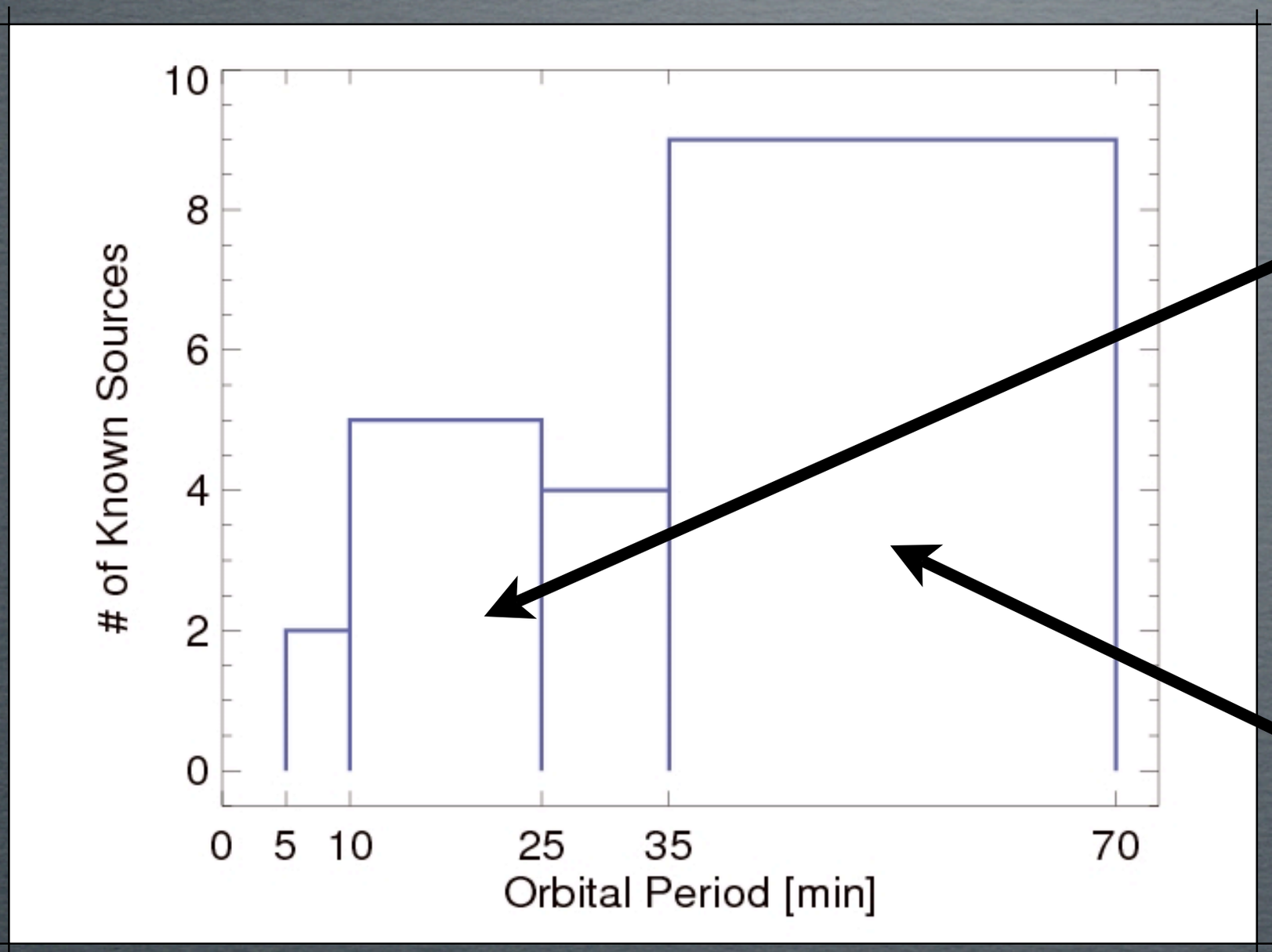
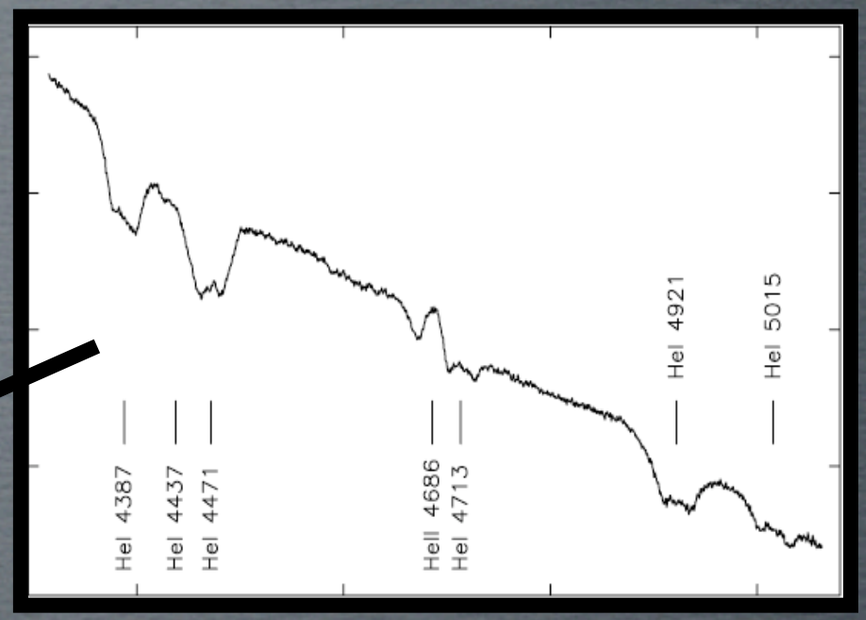
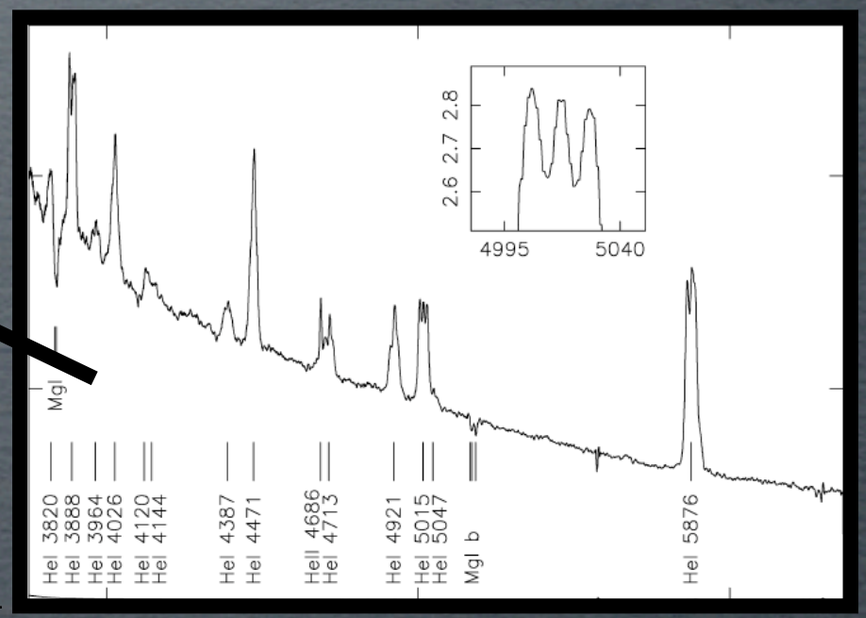
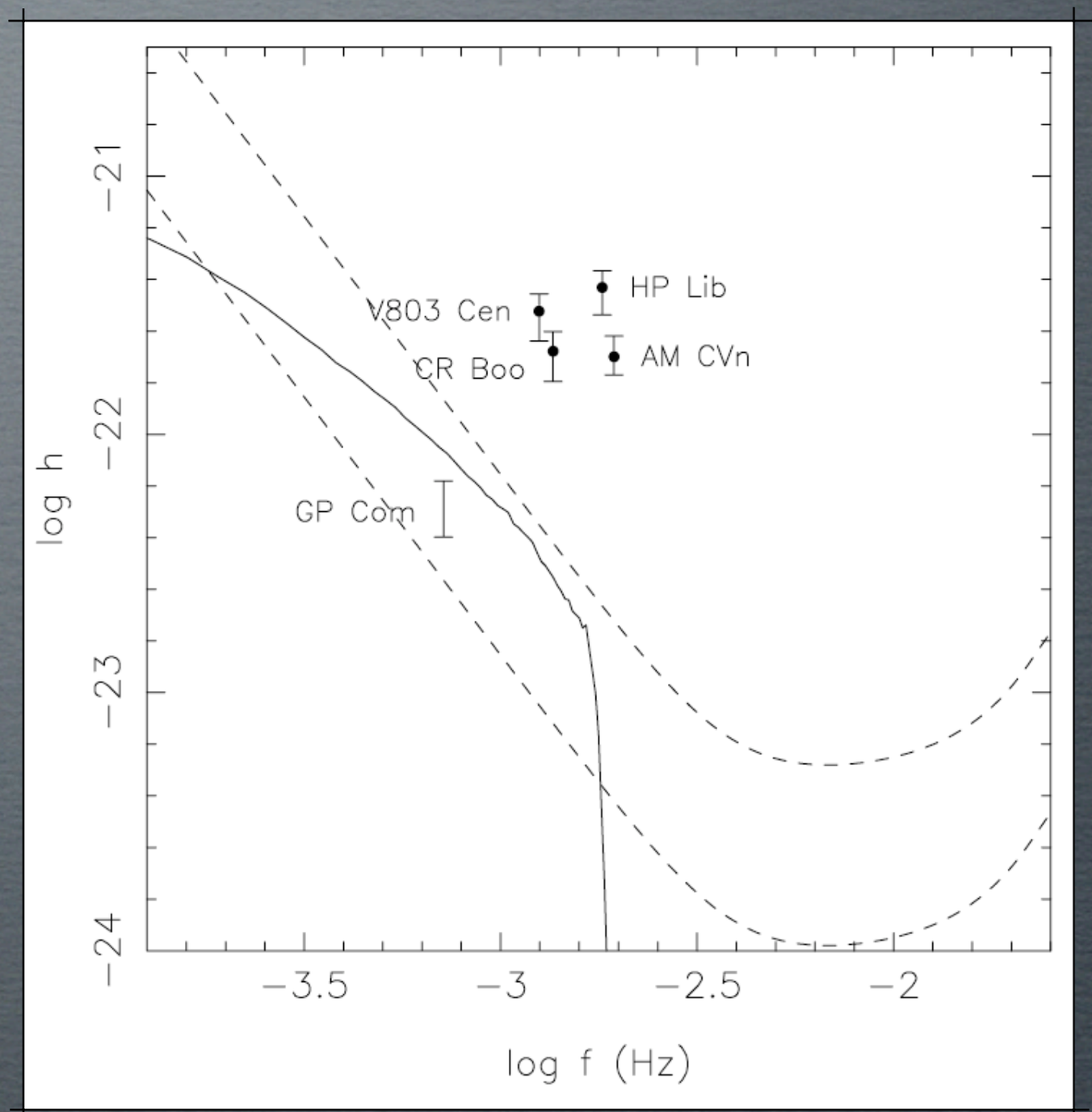






Motivation: LISA Verification

- verification sources for LISA (10^{-4} - 1Hz)
- as many as 11000 resolvable with LISA
- $h=\Delta L/L$
- foreground "noise"

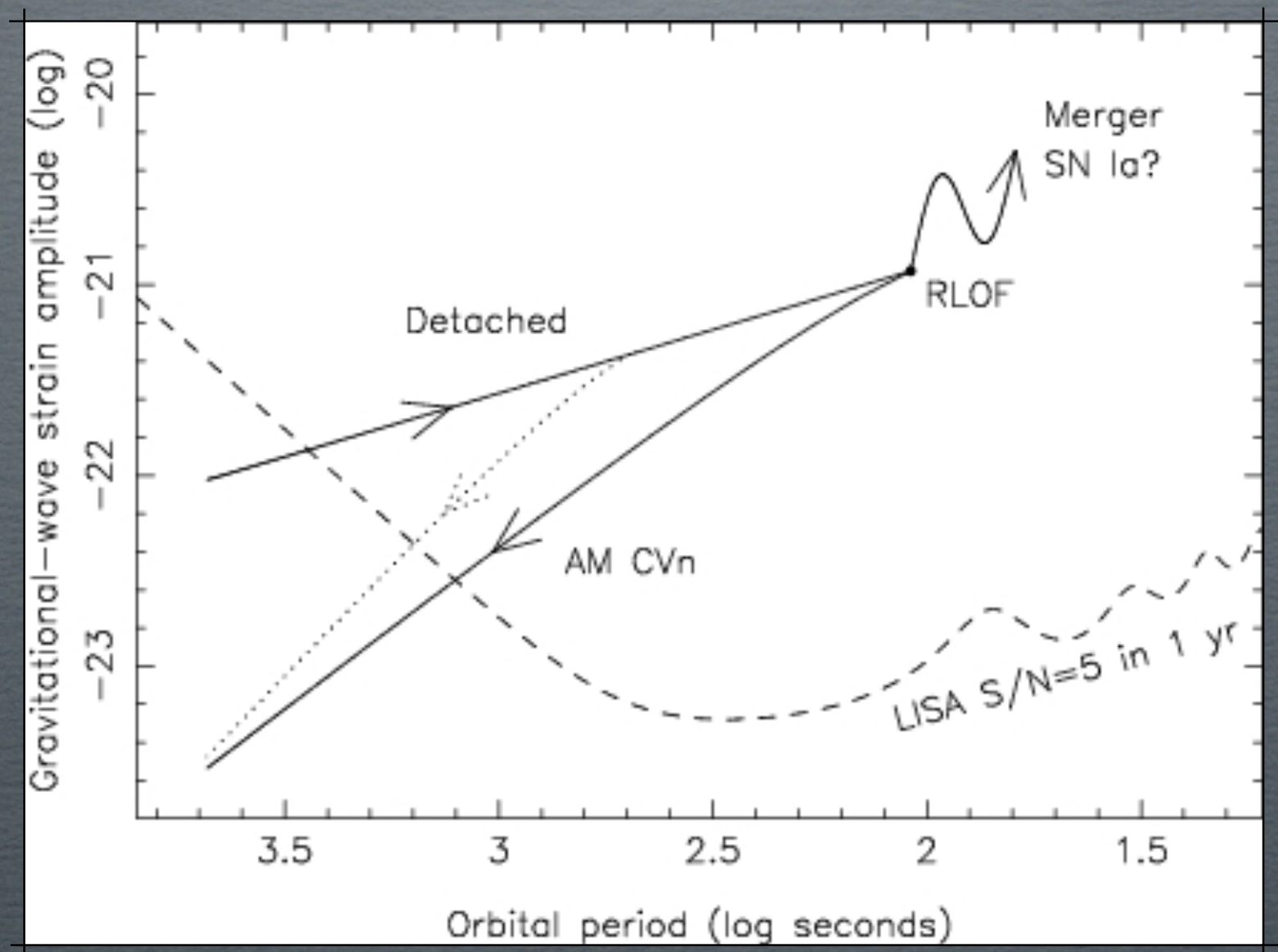


(Roelofs et al. 2007)

Motivation: Astro-Labs

- merging WDs: candidates for SN Ia progenitors
- SN Ia:"casualties" while AM CVn: "survivors"
- influx (detached) vs outflux (AM CVn)

constrains onset of Roche-Lobe Overflow



SDSS DR6 Color-Selection

- first homogeneously selected sample from SDSS spec database (6 sources)
- suggested ~50 systems in photom. database
- empty color-space (1300 out of 250Million sources)

Model	Modelled # ($N'_{\rm spec}$)	Total in SDSS-I ($N_{\rm phot}$)	Modelled ρ'_0 (pc^{-3})	Observed ρ_0 (pc^{-3})	Observed σ (deg^{-2})
Optimistic	107	52	2.6×10^{-5}	1.5×10^{-6}	6.5×10^{-3}
Pessimistic	12	67	6.2×10^{-6}	3.2×10^{-6}	8.4×10^{-3}
He star only, optimistic	16	67	8.8×10^{-6}	3.4×10^{-6}	8.4×10^{-3}
He star only, pessimistic	11	68	5.9×10^{-6}	3.3×10^{-6}	8.5×10^{-3}
WD only, optimistic	91	50	1.7×10^{-5}	1.1×10^{-6}	6.2×10^{-3}
WD only, pessimistic	0.85	57	2.4×10^{-7}	1.7×10^{-6}	7.1×10^{-3}

Table 1. Observed space densities of AM CVn stars for different assumptions regarding their populations; the observed ρ_0 is obtained by multiplying the modelled ρ'_0 by $N_{\rm spec}/N'_{\rm spec}$ where $N_{\rm spec} = 6$. 'Optimistic' and 'pessimistic' models from Nelemans et al. (2001) with the Galactic model of Nelemans et al. (2004). The total $N_{\rm phot}$ is the number of emission-line AM CVn stars in the SDSS-I photometry down to $g_{\rm max} = 21$. The measured surface density σ down to $g = 21$ holds for Galactic latitudes $b \gtrsim 30°$. The observed ρ_0 and σ are accurate to an estimated factor of 2.

Total number of AM CVn stars in Sloan: ≥ 50

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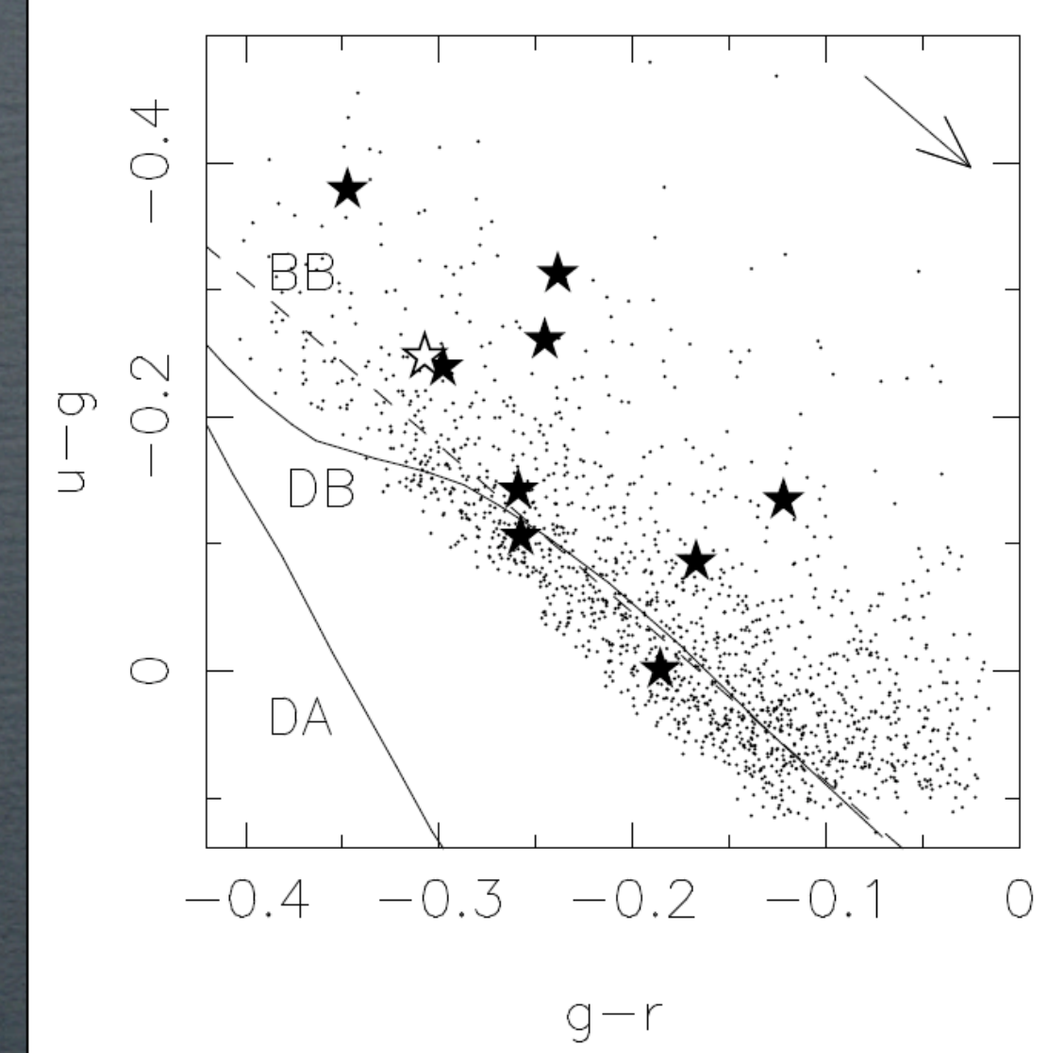
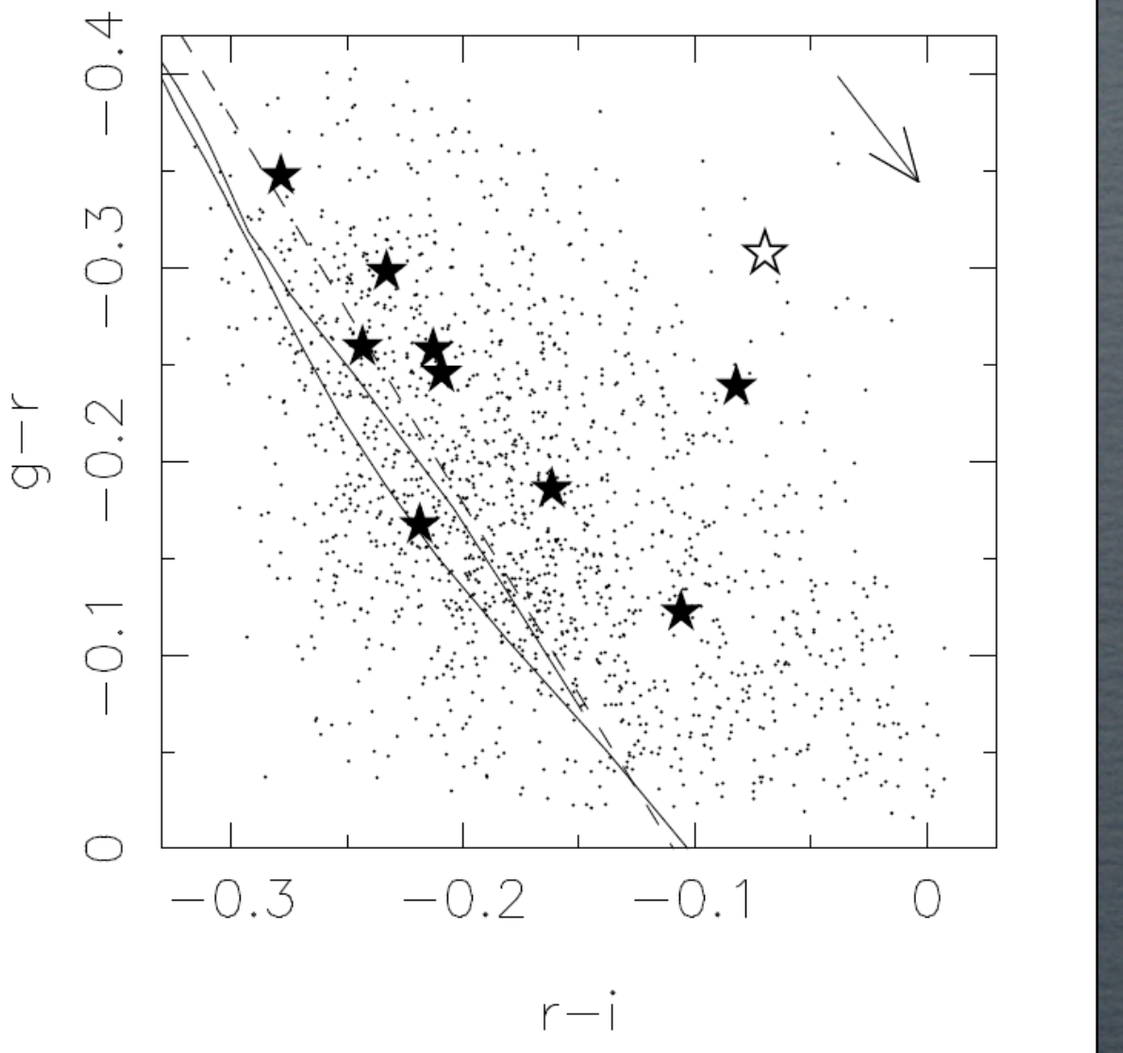
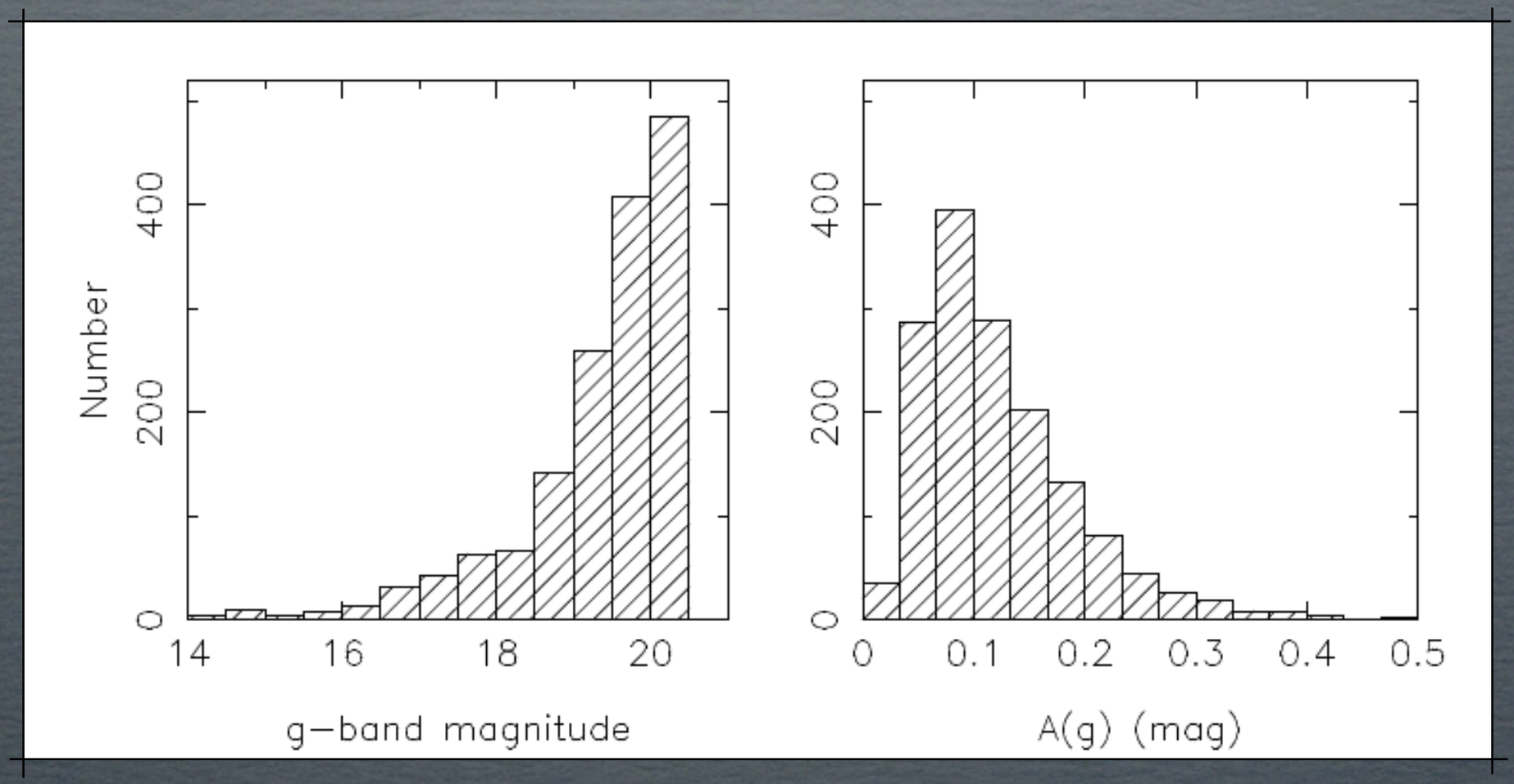




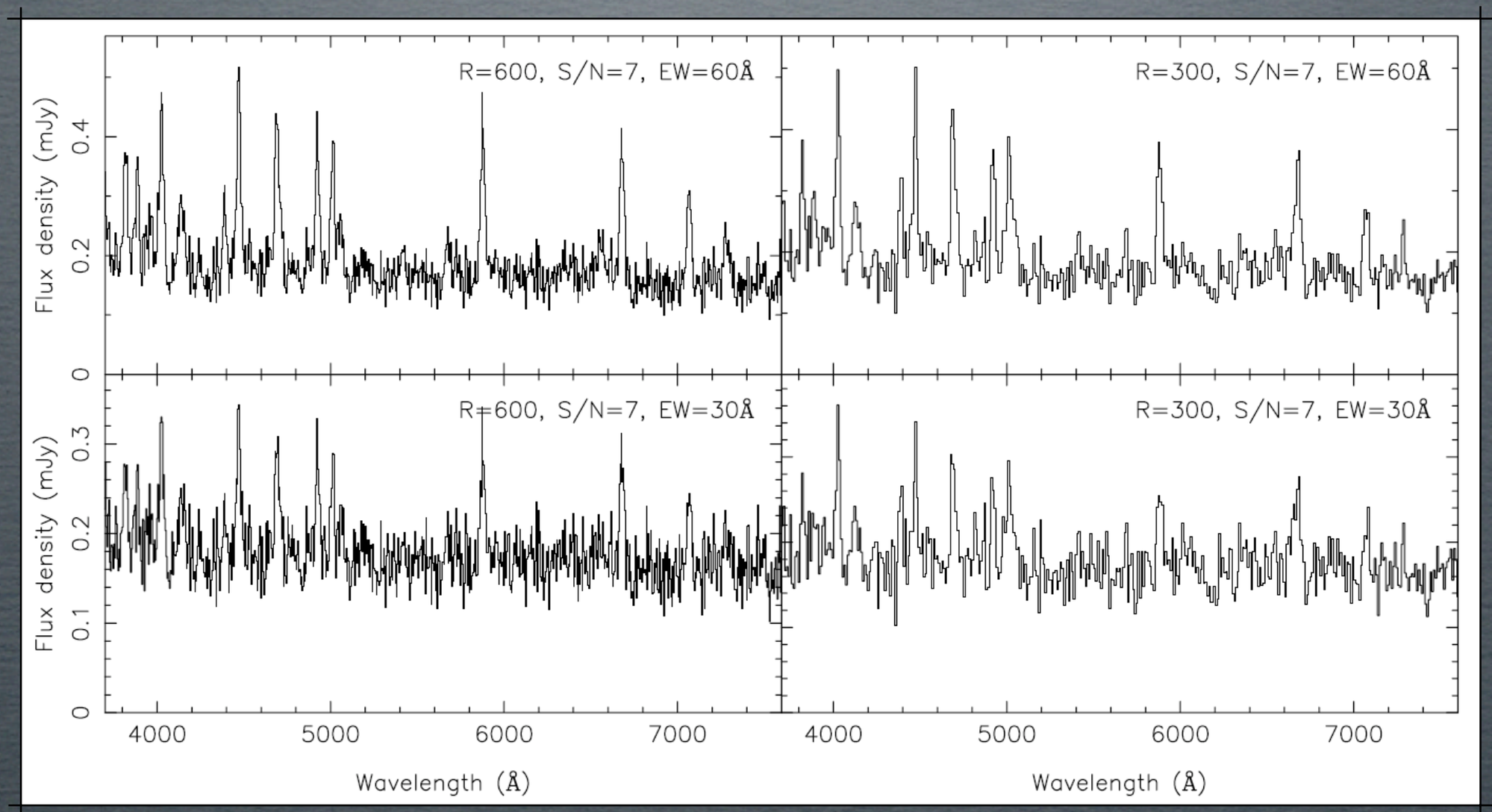
SDSS DR6 Color-Selection

- first homogeneously selected sample from SDSS spec database (6 sources)
- suggested ~50 systems in photom. database
- empty color-space (1300 out of 250Million sources)
- He emission lines stand out in low S/N spectra
- 98% of population at P-orb>30min



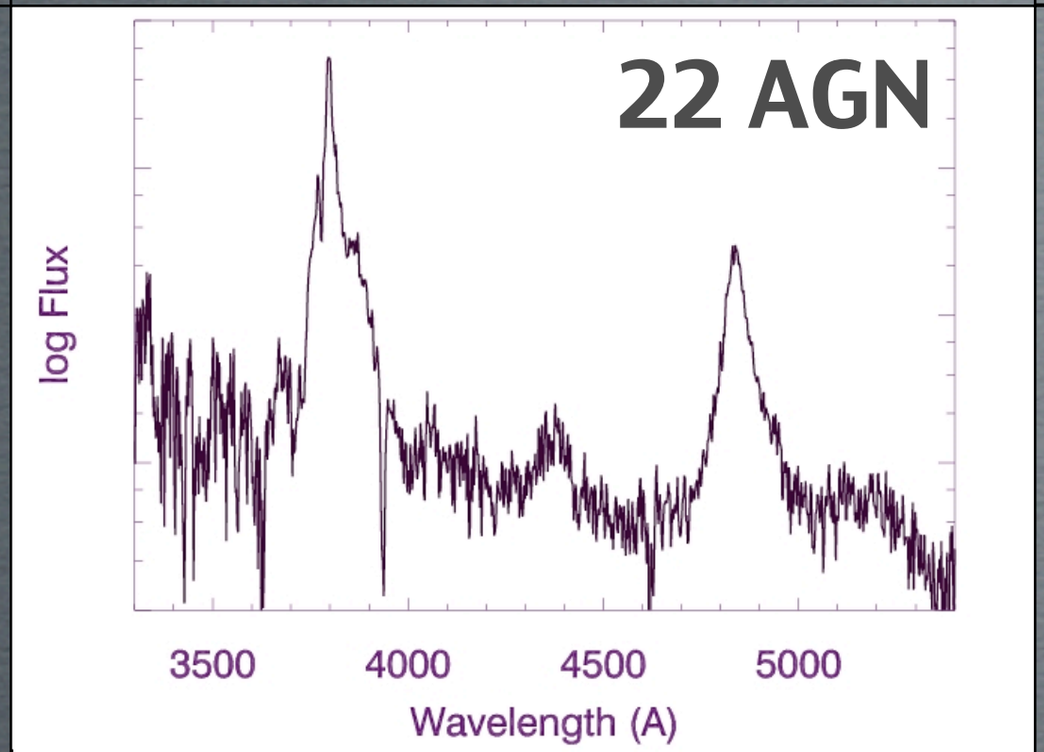
Observations

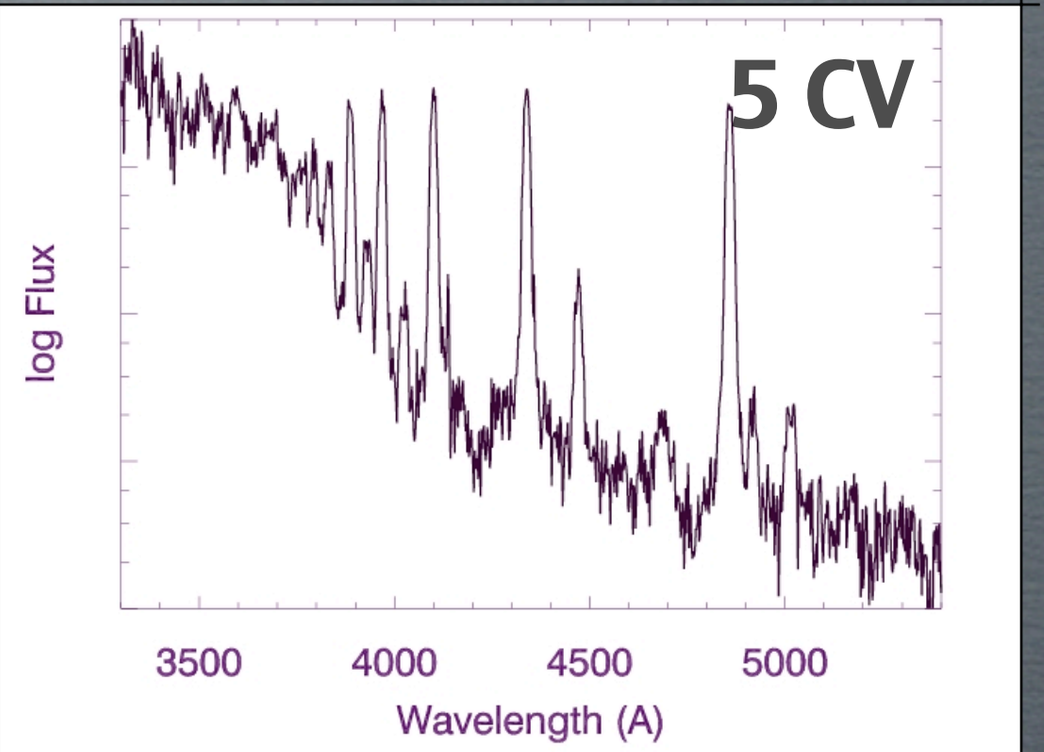
- low-res low-SN sufficient
- 6 nights DBSP (4 in 2008B, 2 in 2009A)
- 300/3990 + 316/7500 [~8Angst. FWHM]
- 19.5mag < g < 20.5mag
- supplemented by observations at: 1.5m FLWO, 2.5m INT, 4.2m WHT, 6.3m MMT, 8m gemini-N

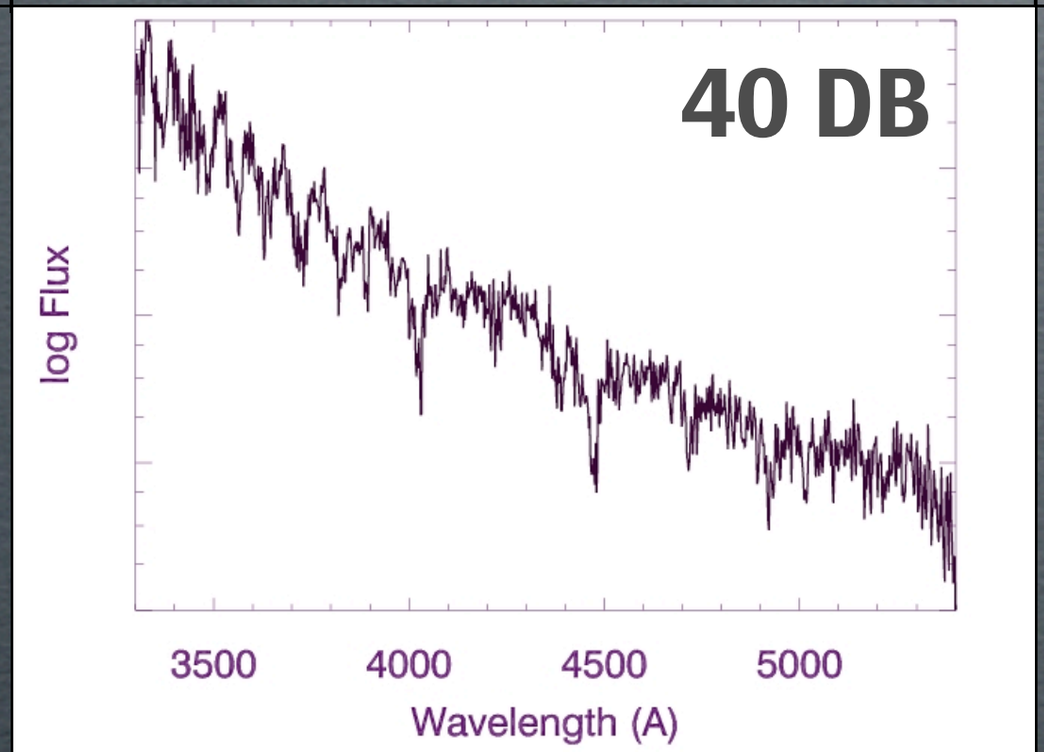


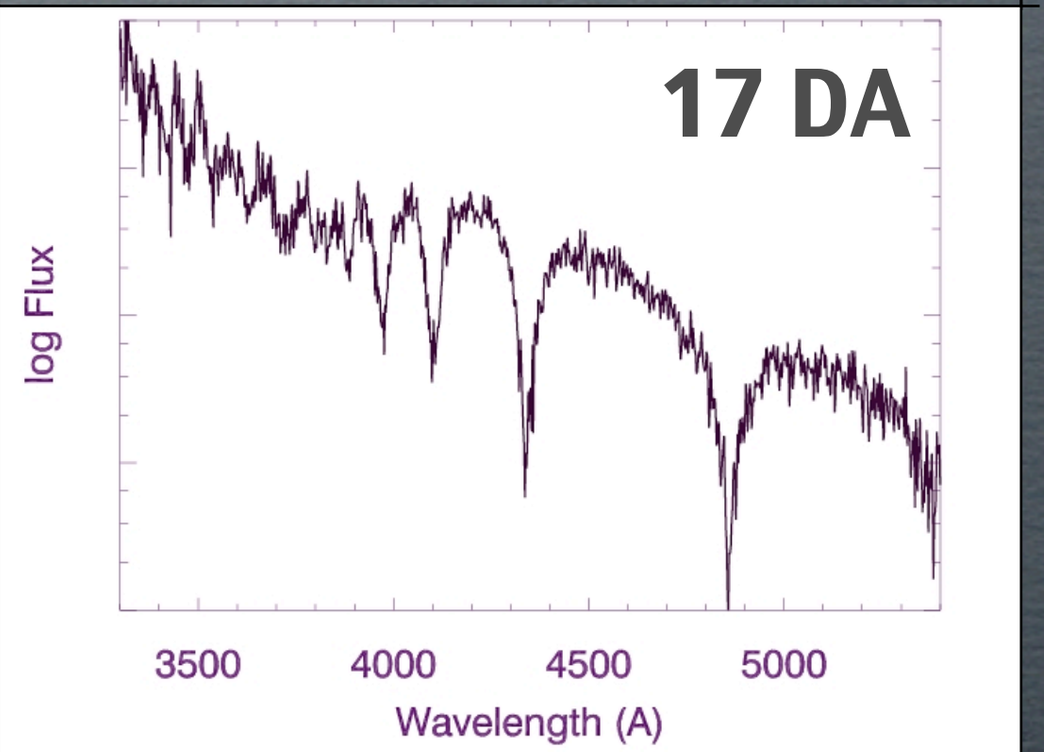
First Results

- 195 sources total









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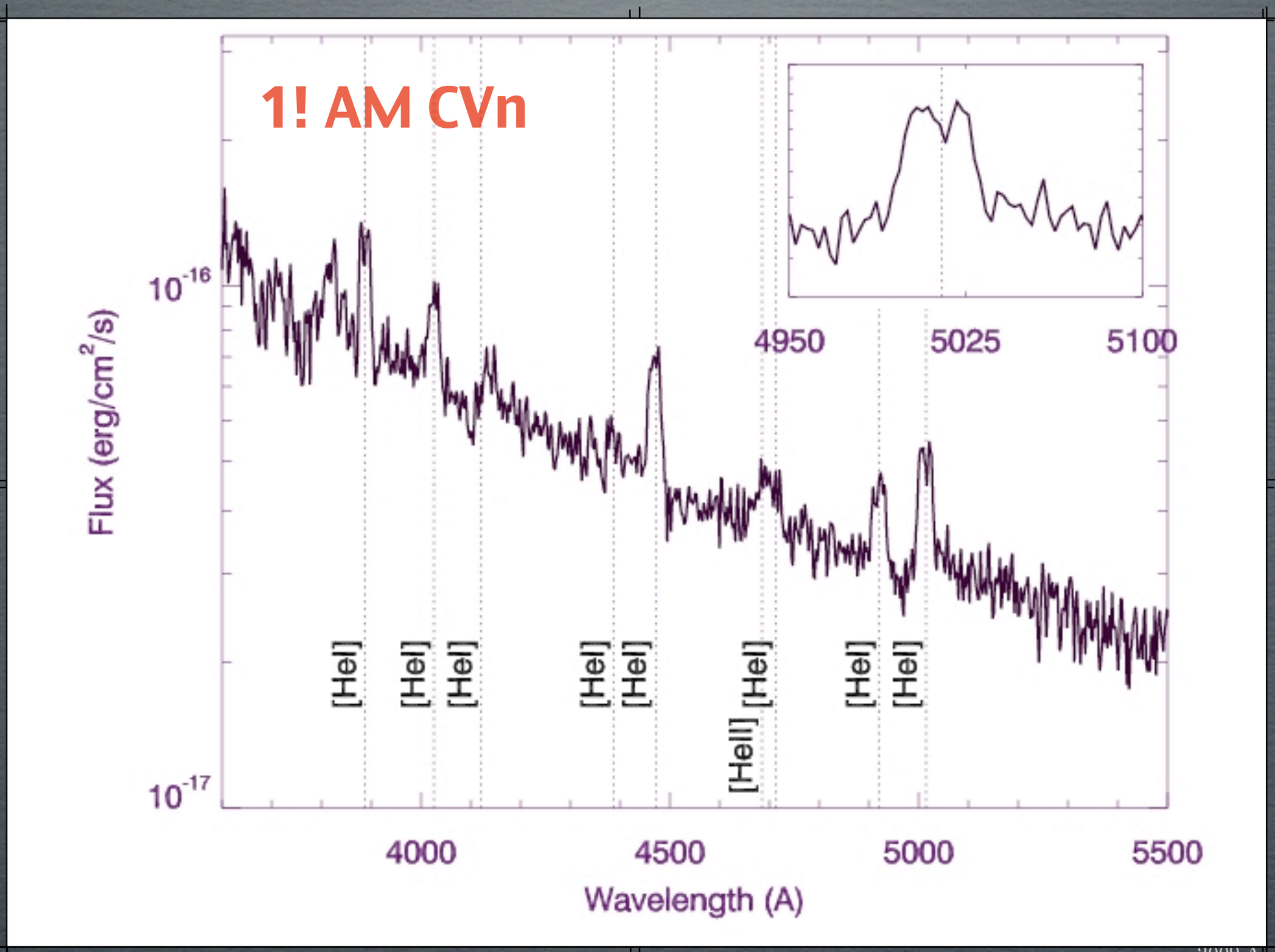
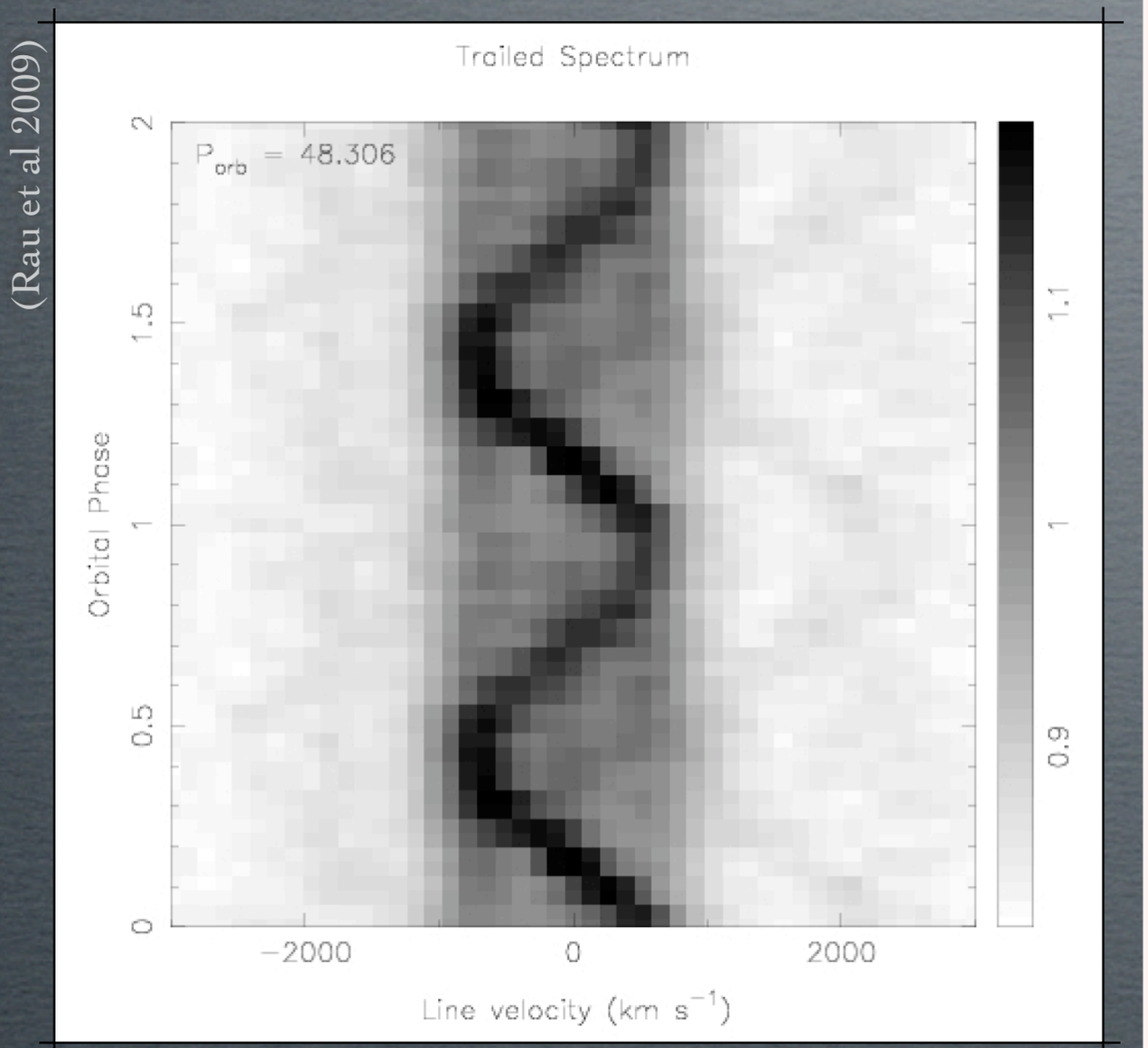
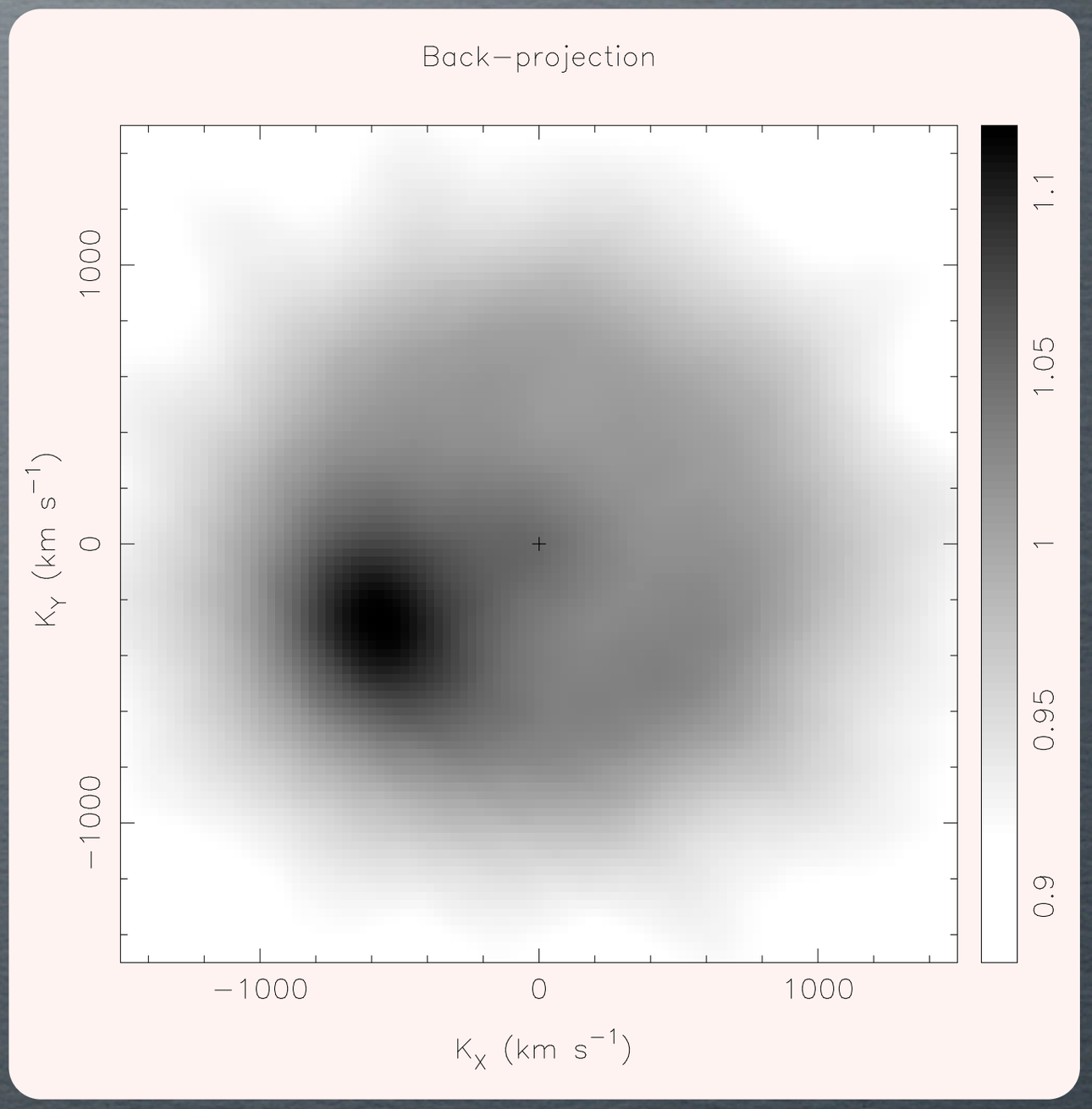


THE 1ST P200 DISCOVERED AMCVN BINARY

- FOLLOW-UP WITH KECK/LRIS (65 SPECTRA IN TWO NIGHTS)
- P_ORB = 48.31+/- 0.08MIN





Population Study - preliminary Results

- 1 AM CVn out of 195 with P200
- 2 out of ~400 total
- ~15 predicted from SDSS & population models

Ideas:

- WD-WD coupling underestimated and only few survive RLOF
- no coupling at all, He-star channel dominates
- not all long P_orb show emission lines (e.g. semi-degenerate donor cools, contracts, stops mass transfer)
- substantial fraction may undergo .1a explosion

LISA Predictions:

- Nelemans et al. 2004 -> 11000 per year
- Roelofs et al. 2007 -> 1000 per year
- P200+ -> ~100 per year ?

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