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860 Hot Subdwarfs from SDSS-III

SEGUE, BOSS and DR10

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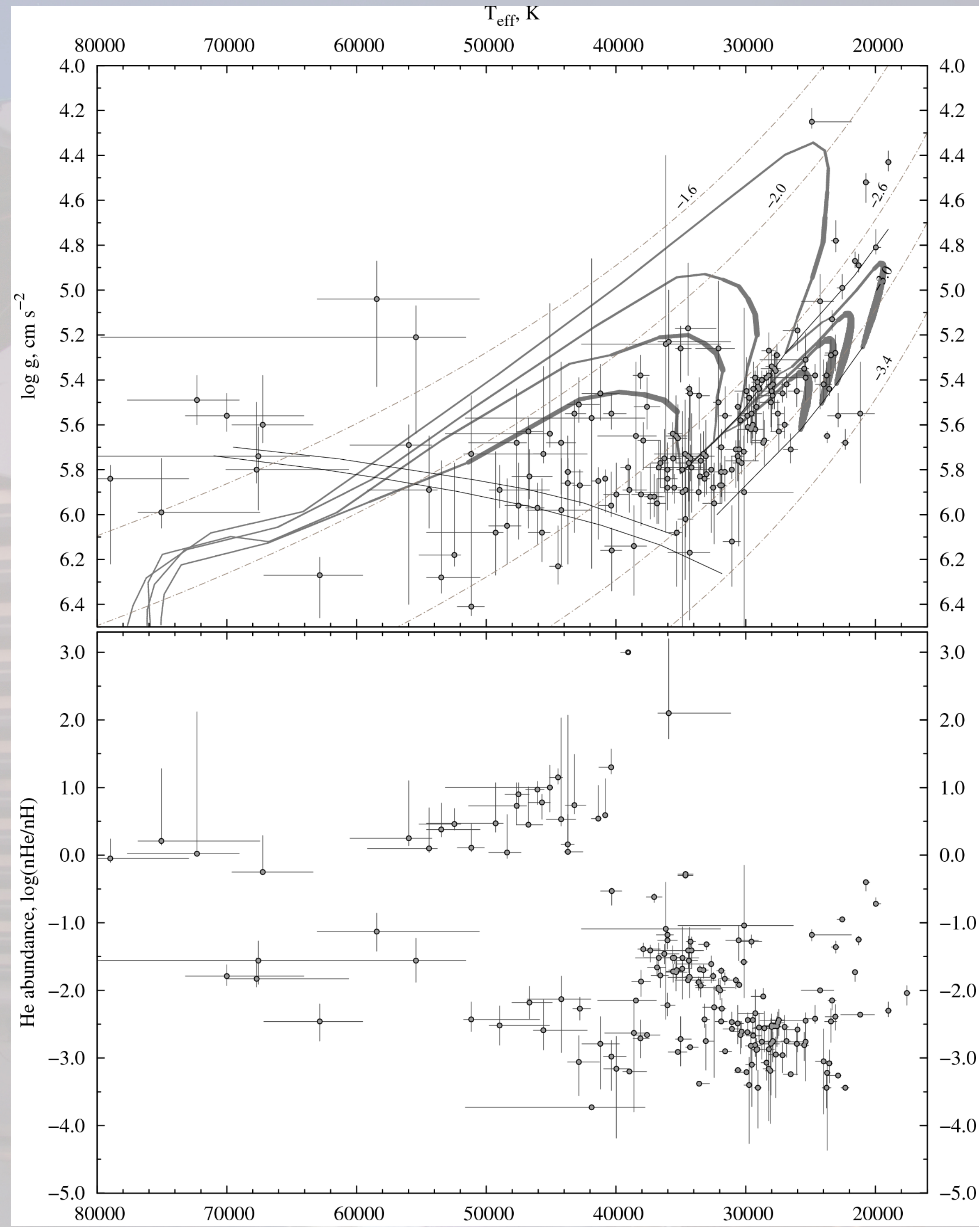
Galex sample

- 166 bright subdwarfs from the galactic disk
- Consistent results with past surveys, at least for sdB stars (Uli's talk)
- Clumpings, trends were proposed
- Abundance extremes at 38000K
- sdB population: consistent with the canonical ~0.5 solar mass models and tracks (Dorman et al., 1993)
- Some He-sdOs: gravity high
- → SD1000

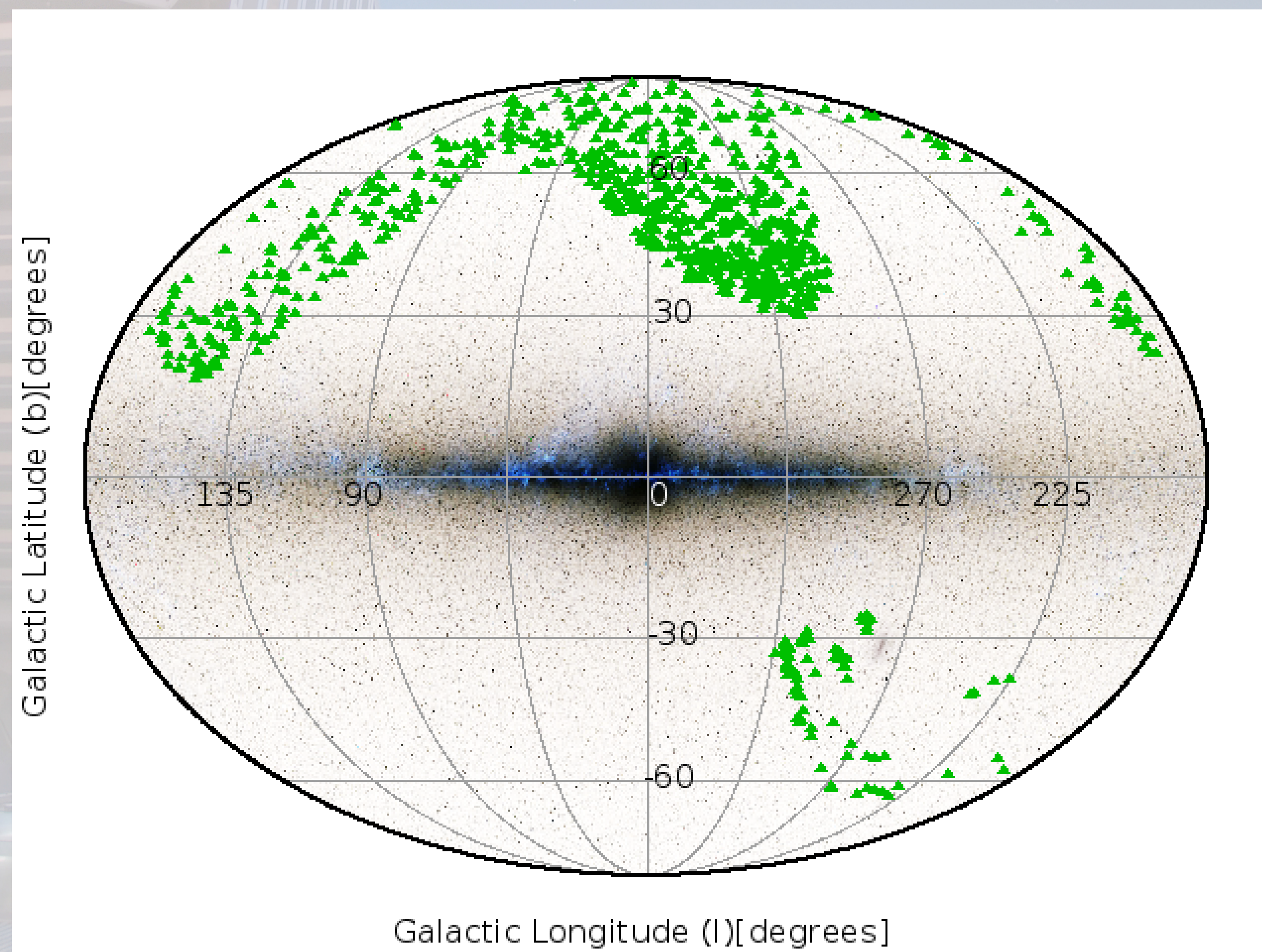


From Galex to SDSS

- Galex: 11-15, SDSS: 15-19 mag
- Different distance and populations
- Average magnitude:

  $g = 17.4 \pm 2$

- 90% over $|b| = 30°$



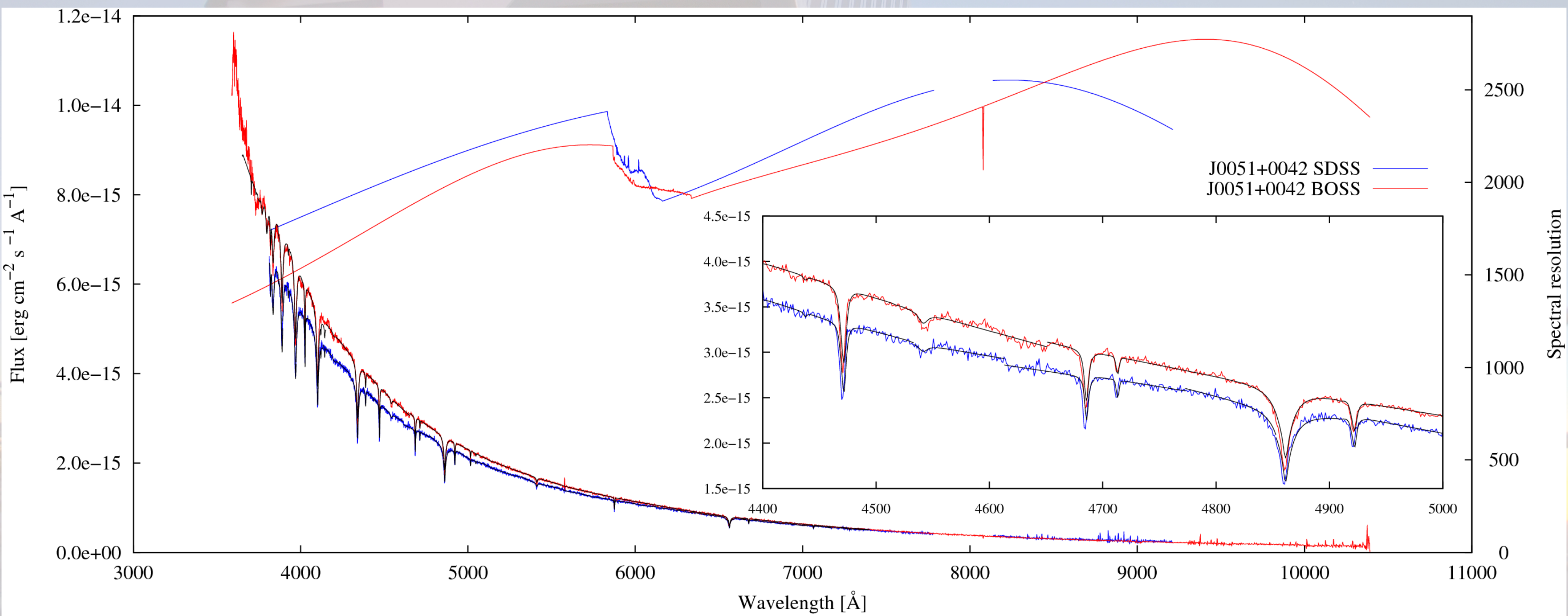
SDSS background

- 2.5 m telescope at APO, 2 spectrographs: SEGUE and BOSS
- Mapped third of sky and obtained ~3 million stellar spectra
- 4x15 minute exposures, 4x1000 spectra/hour at a pointing
- Large sample of homogeneous (well calibrated) spectra for 860 hot subdwarfs
- There are 6038 individual spectra of the 860 stars
- 1159 combined spectra of 860 stars, 238 SEGUE + 921 BOSS

Data

- Two spectrographs (SDSS, BOSS) both have two arms
- 1000 fibers in BOSS, 640 in SDSS-I/II
- R = R(fiber, λ)

	BOSS	SDSS
Spectral range	3650-10400	3800-9200
Resolution	1400-2600	1800-2000

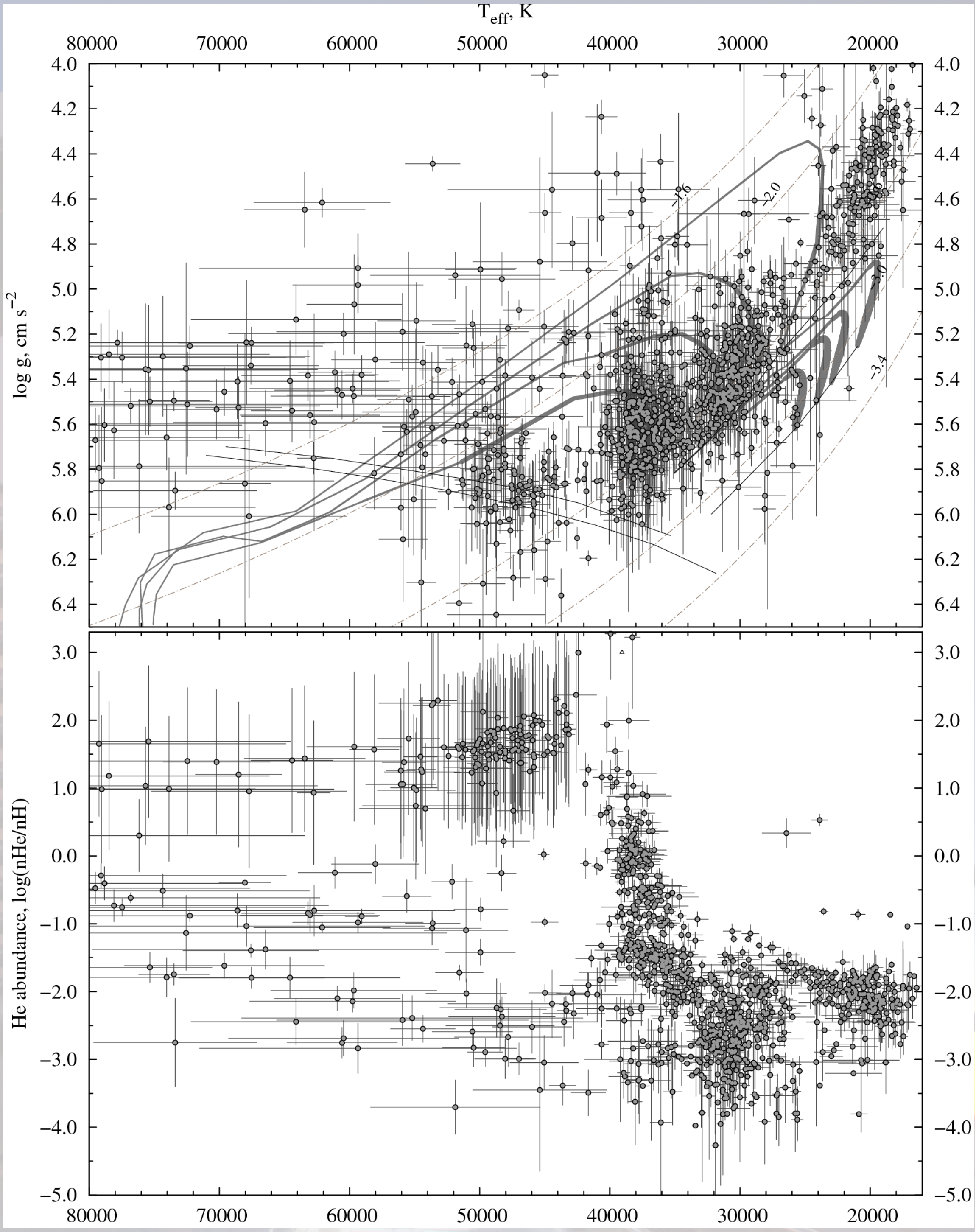


Analysis with XTGRID

- We are not (yet) after the fine details, just look for a reasonable distribution of stars in the T-g and T-He diagrams
- TLUSTY/SYNSPEC NLTE models in opacity sampling mode
- Simple analysis assuming:
  - H and He composition
  - $v_{micro} = \xi = 0$; $v_{macro} = 0$
  - $v_r \sin(i) = 0$; E(B-V) = 0 (determined from the fit)
- XTGRID fits: iterative steepest-descent method with statistical error determination
- Improvements in XTGRID:
  - ✓ New Stark broadening tables (Tremblay et al. 2010)
  - ✓ Dynamic atomic level structure (must be done for large parameter space)
  - Abundance stratification
  - More reliable spectral decomposition for F, G and K type companions
  - Irradiation effects in close subdwarf binaries with cool M-type companions (AA Dor poster)
- All fits were done on a single computer in one month

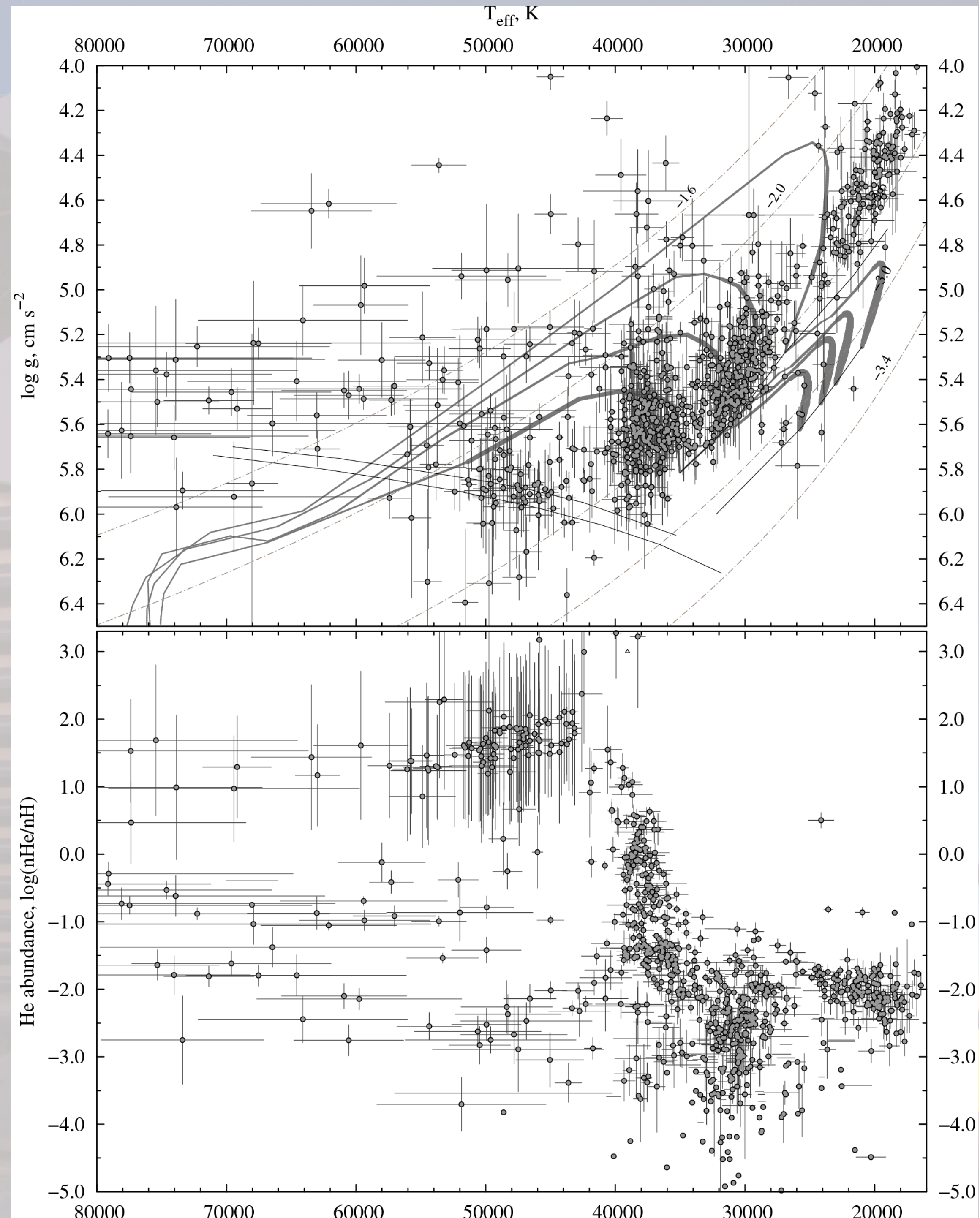
All spectra

- 1150 spectra of 860 targets from DR10
- Hot-star-zoo: scorpion and giraffe diagrams
- Immediately clear: EHB is shifted to low gravity



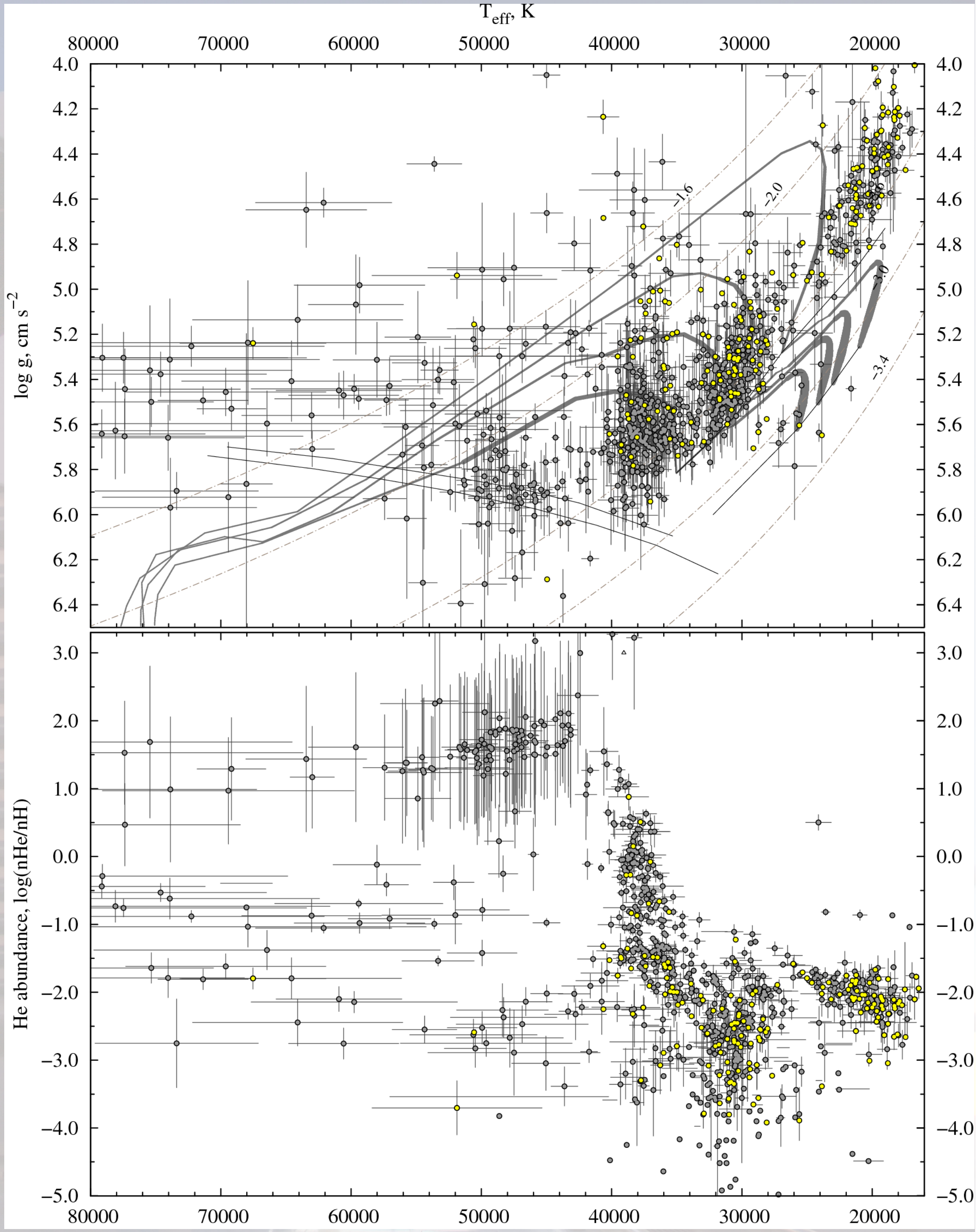
All targets

- Weighted average of all parameters for individual stars
- Canonical luminosity and mass are low?
- Intermediate He-rich population sdOB



Double lined systems

- Composite spectra selection is based on the K line, flux flattening and SNR (>50).
- Fiber loss, reddening is not considered
- Likely ~170 stars

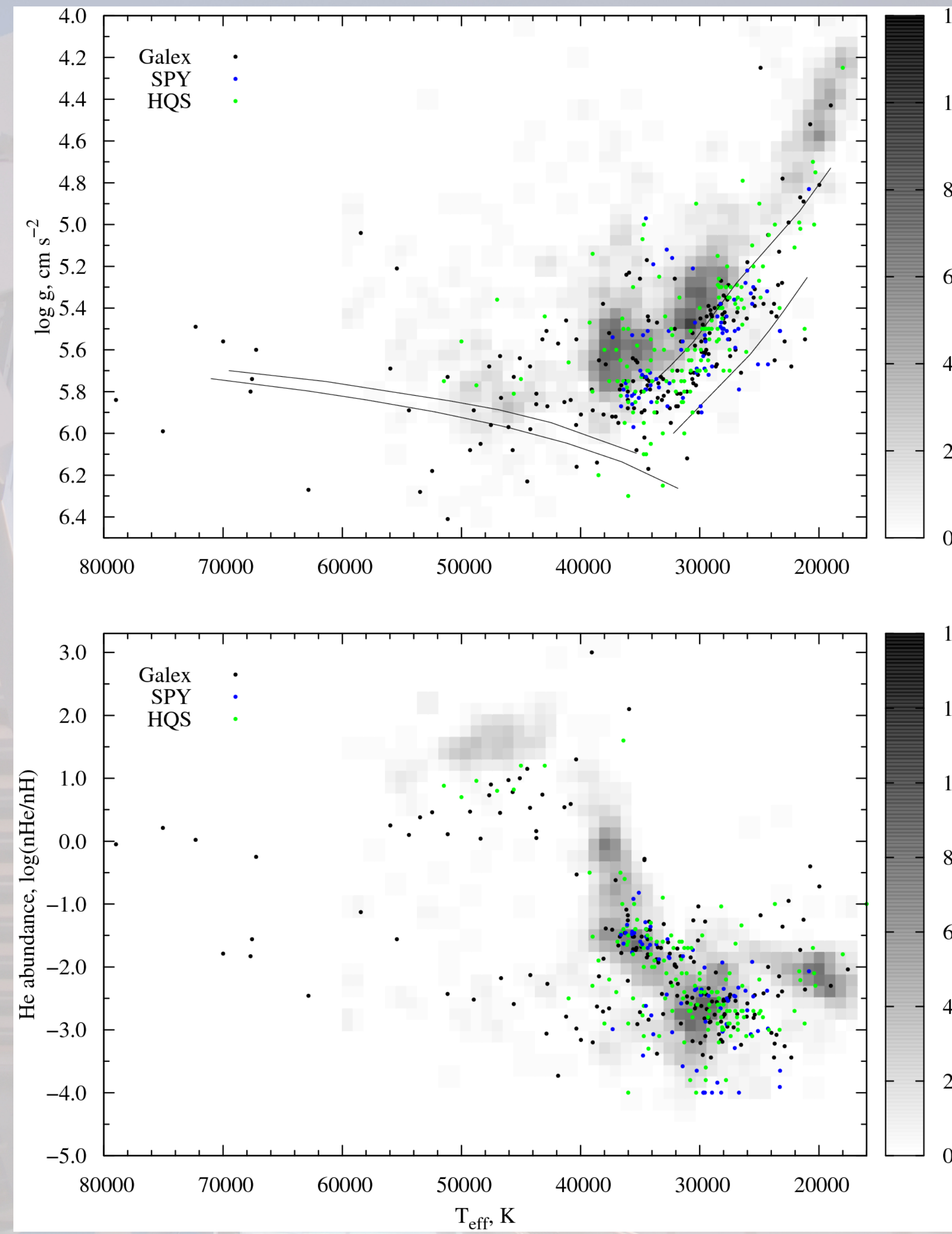


Persistent shift in the location of the EHB

- Attempts to decrease systematics:
  - CNO opacity
  - Comparison with SPAS (Hirsch et al., 2009) and Uli's models
  - Different spectral normalizations
  - Refit follow-up data
  - Different Stark tables (including none, Lemke 1997 or Tremblay et al., 2010)

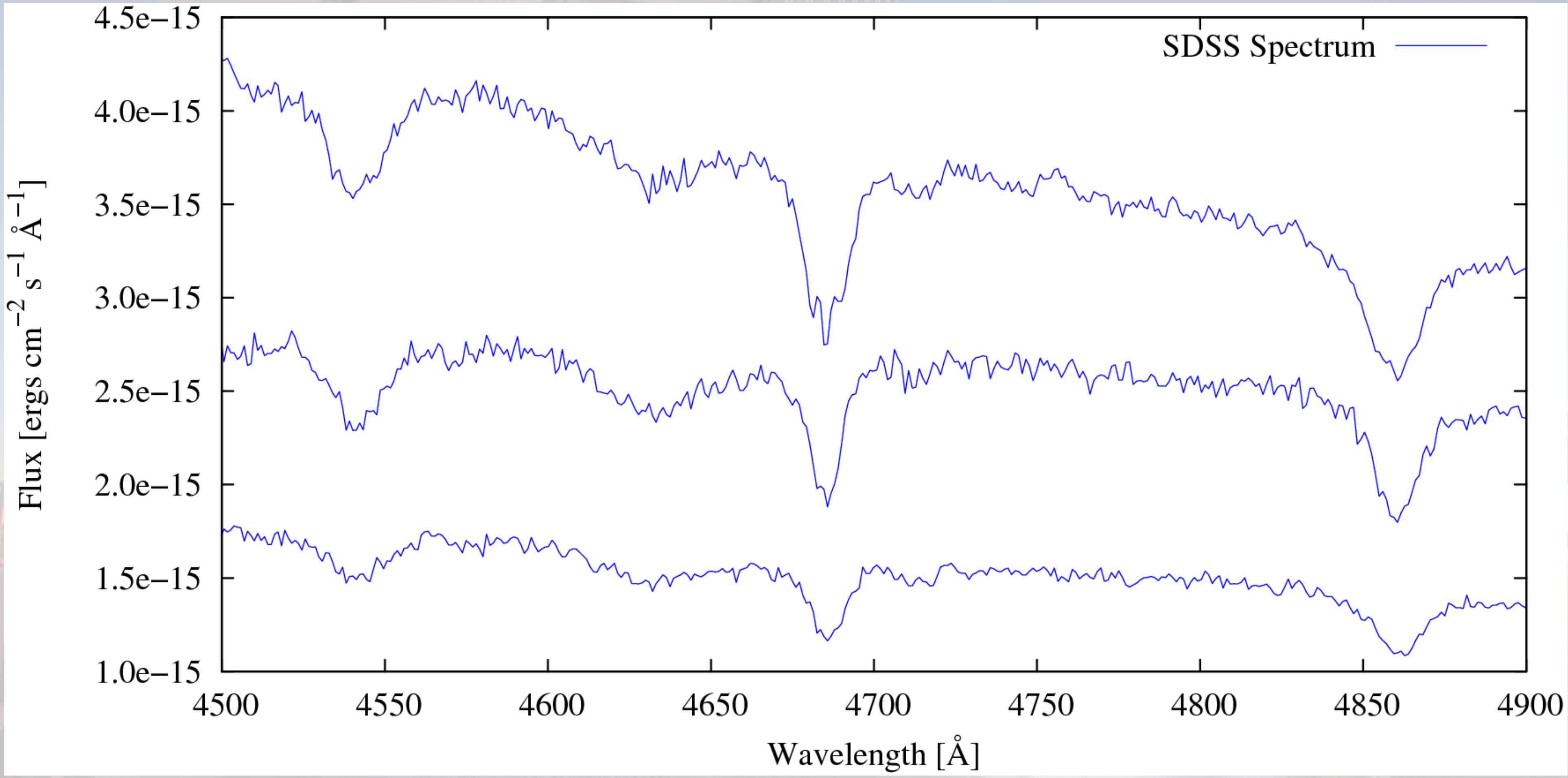
- Abundances and opacities in evolution models
- Physics in models: convection (Schindler et al., 2014)

- The displacement of the EHB is more significant than the differences in the spectral models used



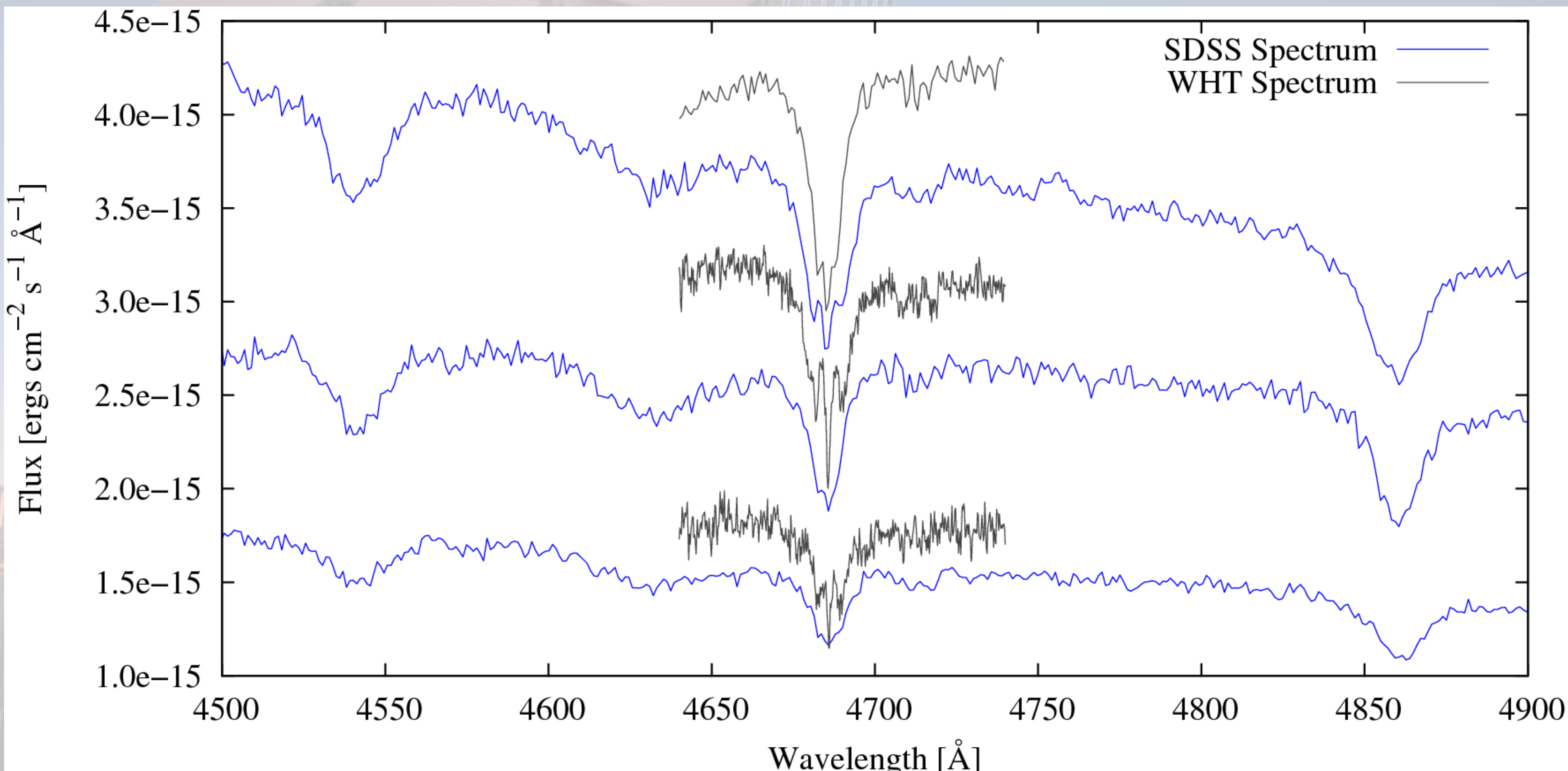
The surprise: high-gravity He-sdOs

- Rotation is not typical for He-sdOs



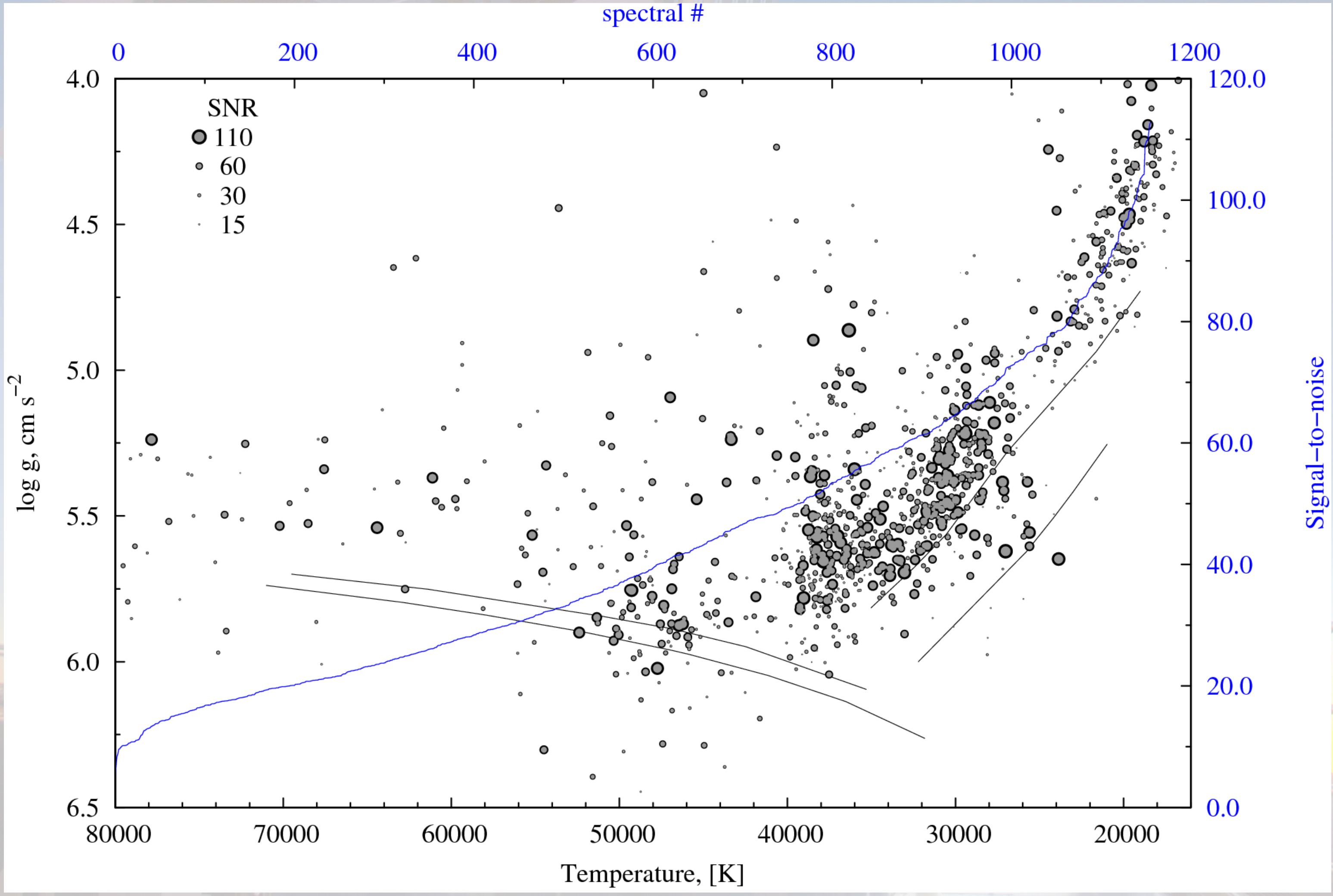
The surprise: high-gravity He-sdOs

- Rotation is not typical for He-sdOs
- Zeeman splitting is present in ~10 percent of He-sdO stars



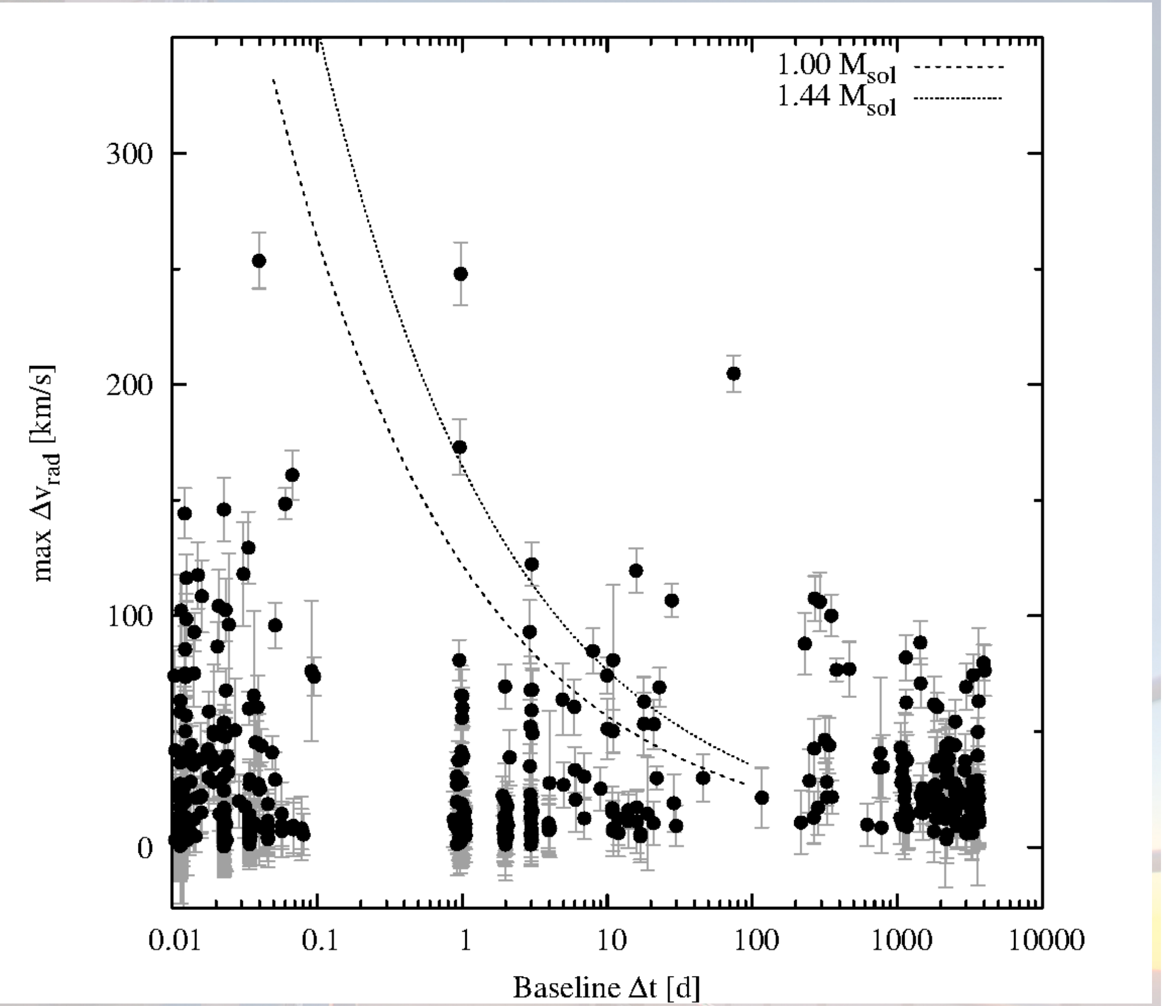
SNR distribution

Lots of consistency checks are required to make a well-calibrated sample homogeneous



RV variables?

- The 6038 individual spectra allow us to look for radial velocity variations on a baseline from ~hour to 10 years
- Followup is on-going, but it looks like Kupfer et al., 2015 and Geier et al., 2015 (DR7) did a very good job
- dRV correlates with SNR



Conclusions

- The hot subdwarf population of the thin-disk – thick-disk is different than of the thick-disk – halo
- The observed clumping of stars is similar, but sdB stars are shifted to higher temperature and lower gravity, also suggesting a higher luminosity and mass of these stars
- The distribution of stars is continuous in He abundance form sdB stars to He-sdOs, while there is a gap in this region (neck of the giraffe) in the field population (cf. Uli's talk)
- Composite spectra binaries (companions: F-type) are common to all sdB stars unlike in field stars.
- GAIA will show what models and where should be improved

To-do list for next year

- Follow-up binaries and key systems (weirdos)
- We need a new, more complete selection from the final release, DR12
- Perform an extended analysis with H/He/C/N models, ~10 times slower, but we have 3 dedicated computers: it can be done in three months
- All these must be done by next March