Spectrum Analysis of Hot Stars

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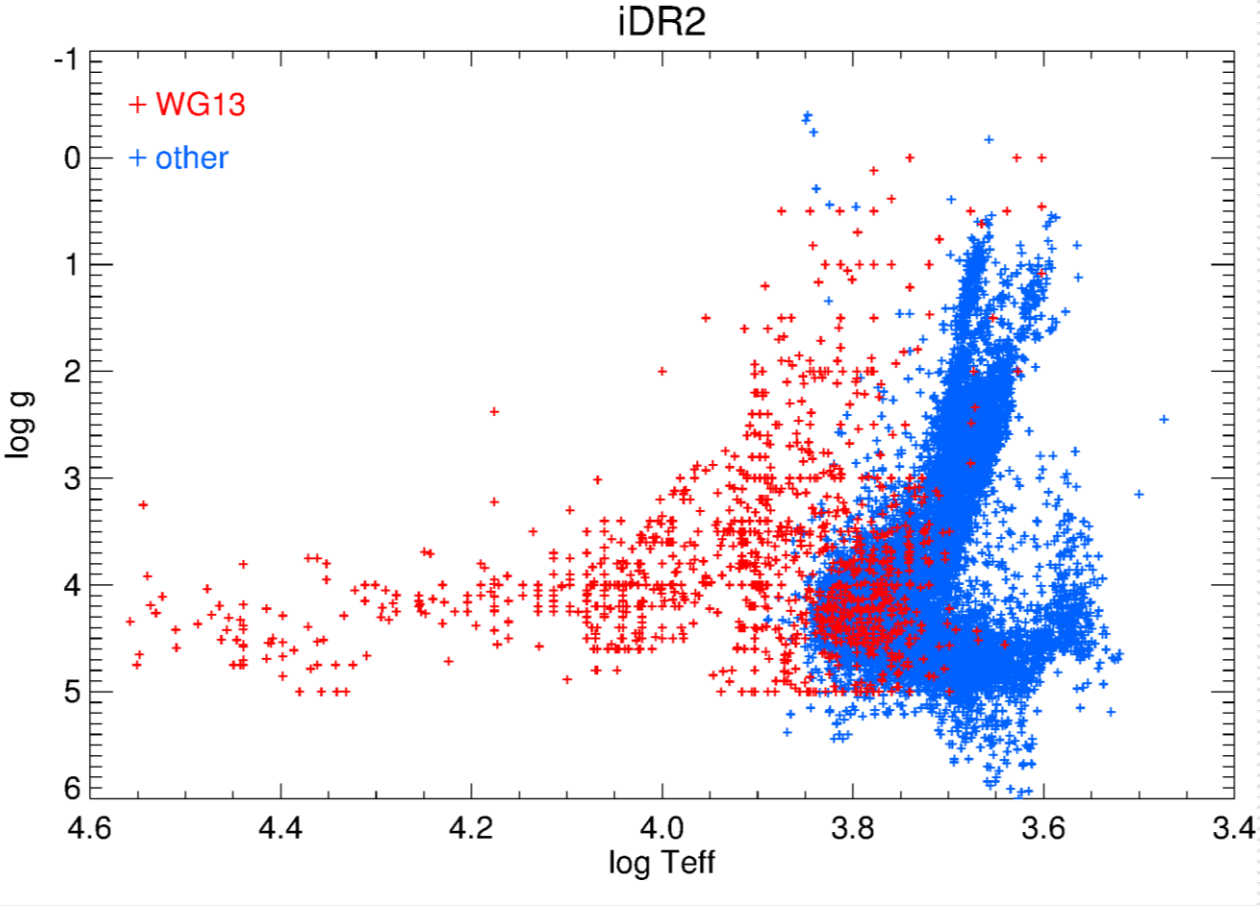
WG 13: OBA Star Spectrum Analyses



- OBA spectral analysis covers a large range in temperature.
- Specific codes therefore need to be used for sub-ranges of temperature.
- Some cooler stars can also end up in WG13.

Workgroup nodes

- ROB (A. Lobel)
  - Models: Kurucz (LTE), refined grid
  - Scanspec: LTE spectrum synthesis
  - Compare EWs of selected lines
  - A-type stars
- Liege (T. Morel, T. Semaan)
  - Models: Kurucz (LTE) or Tlusty (NLTE)
  - Synspec: NLTE spectrum synthesis
  - Compare spectral lines - shapes
  - B-type stars

- In the OBA workgroup, each node uses its own techniques to determine stellar parameters and (possibly) abundances

- IAC (A. Herrero, S. Simon-Diaz)
  - FASTWIND models (NLTE)
  - chi2 fitting to spectral line shapes
  - O-type stars

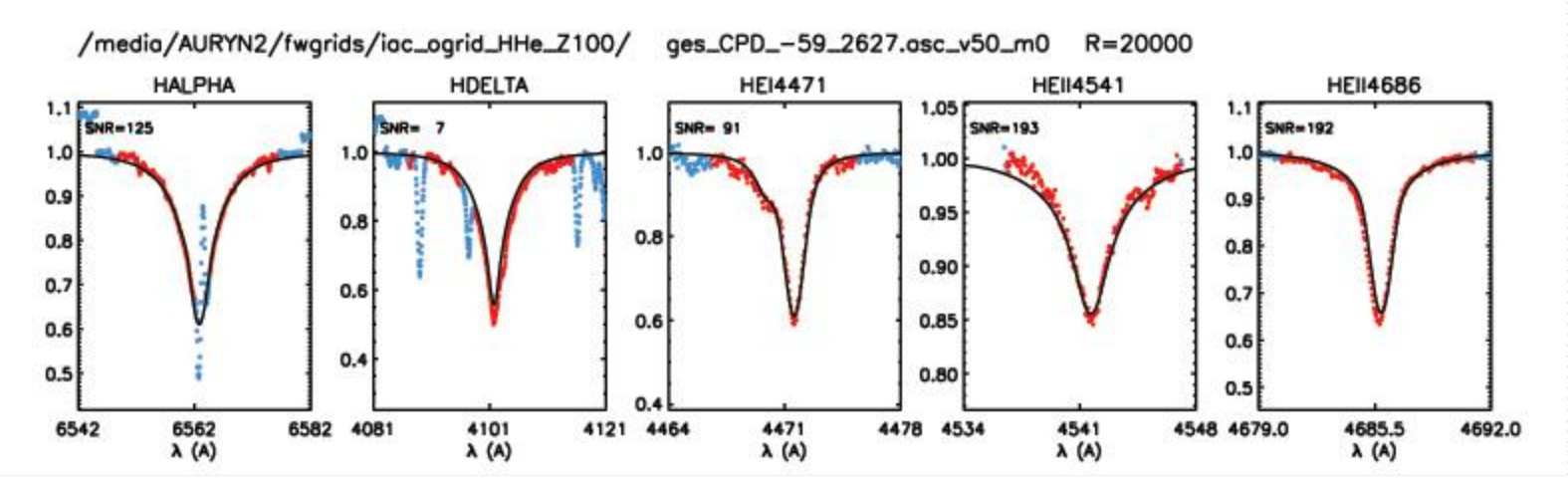


Fig: S. Simon-Diaz

- ROBGrid (R. Blomme, D. Volpi)
  - Models: grids from the literature

Grid	T_{eff} range
Bertone et al. 2004	4,000 – 50,000 K
Munari et al. 2005 – new ODF	3,500 – 9,750 K
Munari et al. 2005 – old ODF	3,500 – 47,500 K
Pollux - Atlas	7,000 – 15,000 K
Tlusty B2006	15,000 – 30,000 K
Tlusty O2002	27,500 – 55,000 K

  - chi2 fitting full spectral range
  - All spectral types

Gratings used

Grating	Wavelength range
HR03	4033-4201
HR05A	4340-4587
HR06	4538-4759
HR09B	5143-5356
HR14A	6308-6701
UVES 520	4140-6210

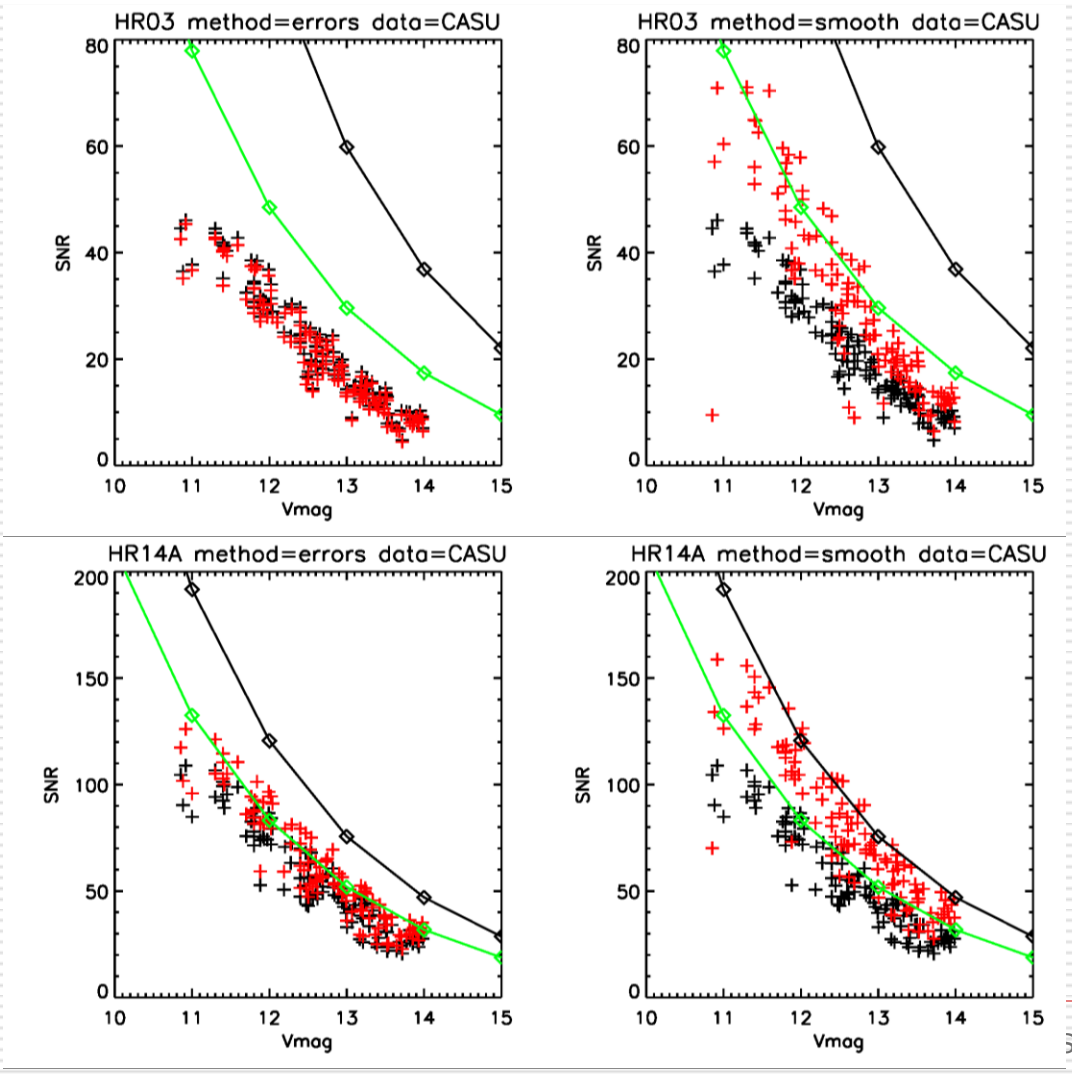
- GES uses the FLAMES instrument on UT2, with both the Giraffe and UVES fibres.
- For the hottest stars, specific gratings are used to cover the spectral lines that have the best diagnostic value.
- These gratings are different from the cool-star gratings
- For the UVES fibres, the 520 setting is used

Open clusters analyzed by OBA workgroup

Cluster	Age	Distance (kpc)
Berkeley 25	4 Gyr	11.3
Berkeley 81	1 Gyr	3
NGC 6633	0.6 Gyr	0.4
NGC 4815	0.5 Gyr	2.5
NGC 6705	250-300 Myr	1.9
NGC 2516	150 Myr	0.4
NGC 2547	35 Myr	0.4
NGC 3293	10 Myr	2.3
NGC 6530	2.3 Myr	1.3
Trumpler 14	1-3 Myr	2.3

- Cluster selection is based on science interest, coverage of ages and metallicities. Overlap with existing data is generally avoided, except for calibration purposes.
- The table lists the clusters analyzed for iDR3.
- Older clusters were also analyzed because observations were taken in at least one of the hot-star gratings.

Signal-to-noise ratio problem



- The earlier observations did not reach the aimed-for S/N. For later observations, longer integration times were used.
- The effect is especially strong for the bluer gratings.
- ESO has now updated the instrumental efficiencies in the Exposure Time Calculator.

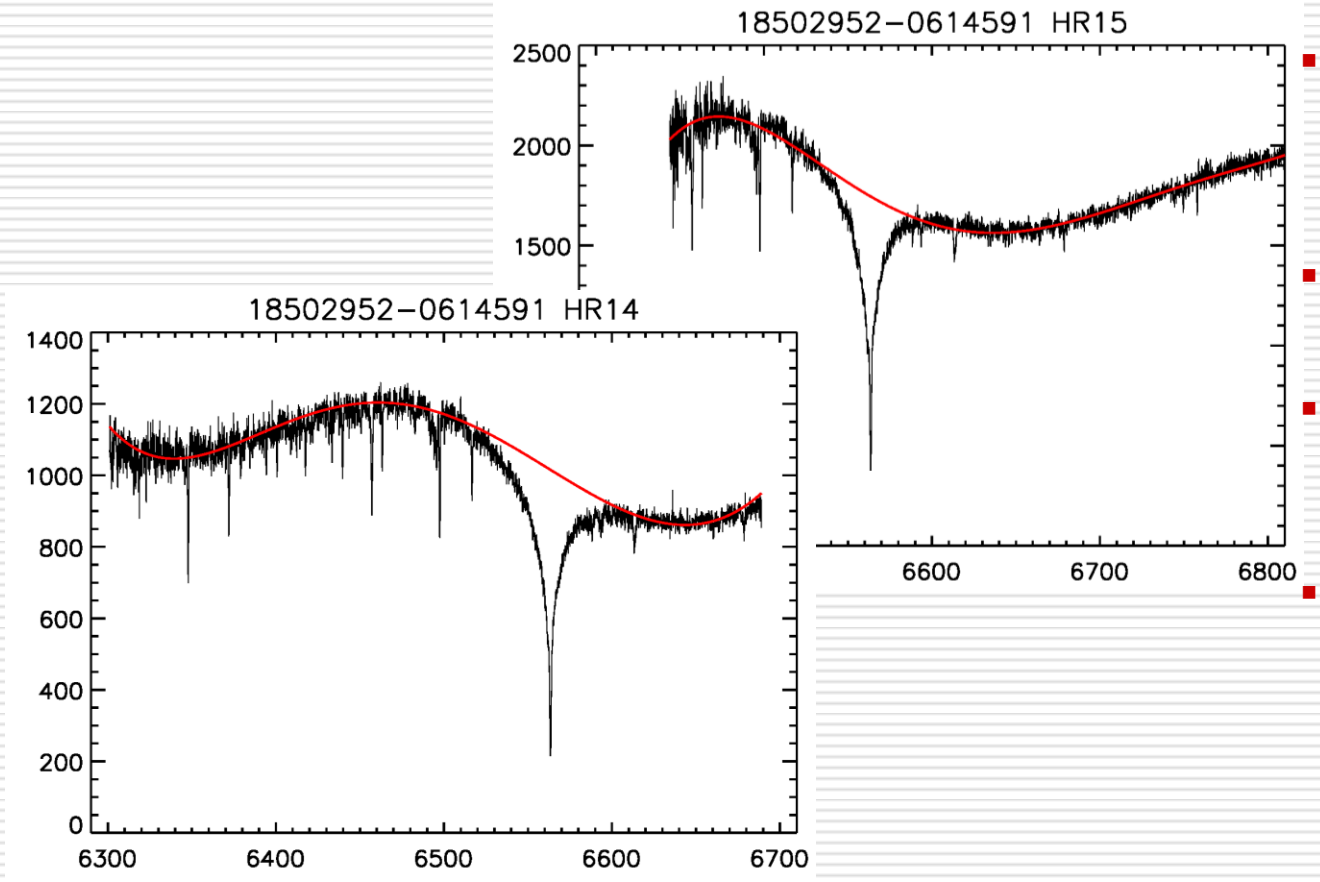
aimed-for S/N

expected S/N actual obs. conditions

\+ CASU S/N

\+ alternative S/N

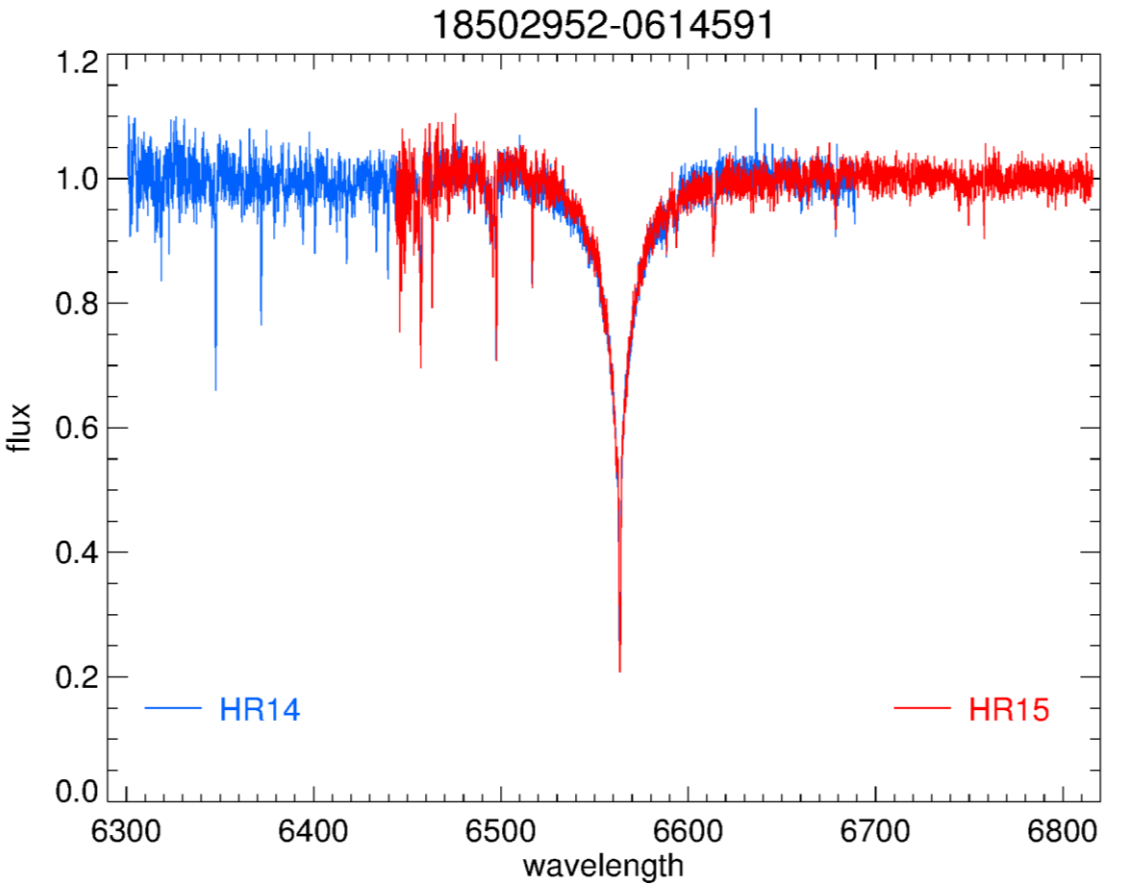
HR14 continuum normalization

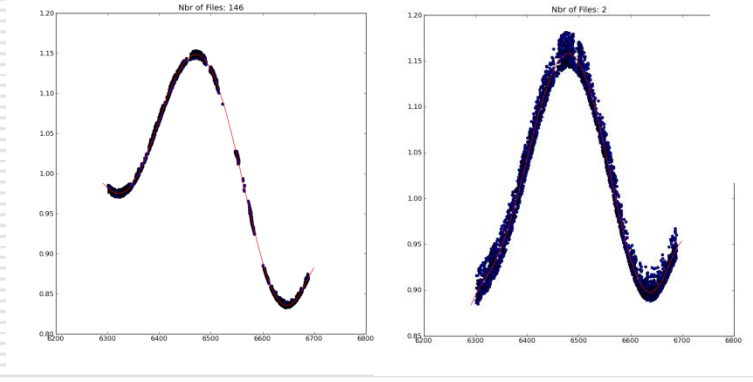


- In ROBGrid, we normalize the spectrum by fitting a (relatively) low order polynomial through a set of presumed continuum points.
- This procedure gives different results for the Hα line in HR14 vs HR15.
- HR14 and HR15 data are available only for NGC 6705.
- For iDR3, most nodes did not use the HR14 data.

HR14 continuum normalization

- Yves Frémat solved this problem.
- He uses a 10-degree polynomial, and groups spectra into “families” with similar continuum shapes.
- All information from a single “family” can then be used to define the continuum shape.
- This shape is then scaled and applied to each spectrum individually.





Results (iDR3)

Cluster	ROB	Liege	IAC		ROBGrid	
Berkeley 25					81	
Berkeley 81					118	
NGC 6633						16
NGC 4815					113	
NGC 6705	97				168	10
NGC 2516						16
NGC 2547						26
NGC 3293	97	120			528	8
NGC 6530						44
Trumpler 14		12	11	3	135	6

- The table lists, per cluster, the number of stars that were analyzed by each of the nodes.
- When two numbers are given the first refers to the Giraffe data, the second to the UVES data.

Results – parameters provided

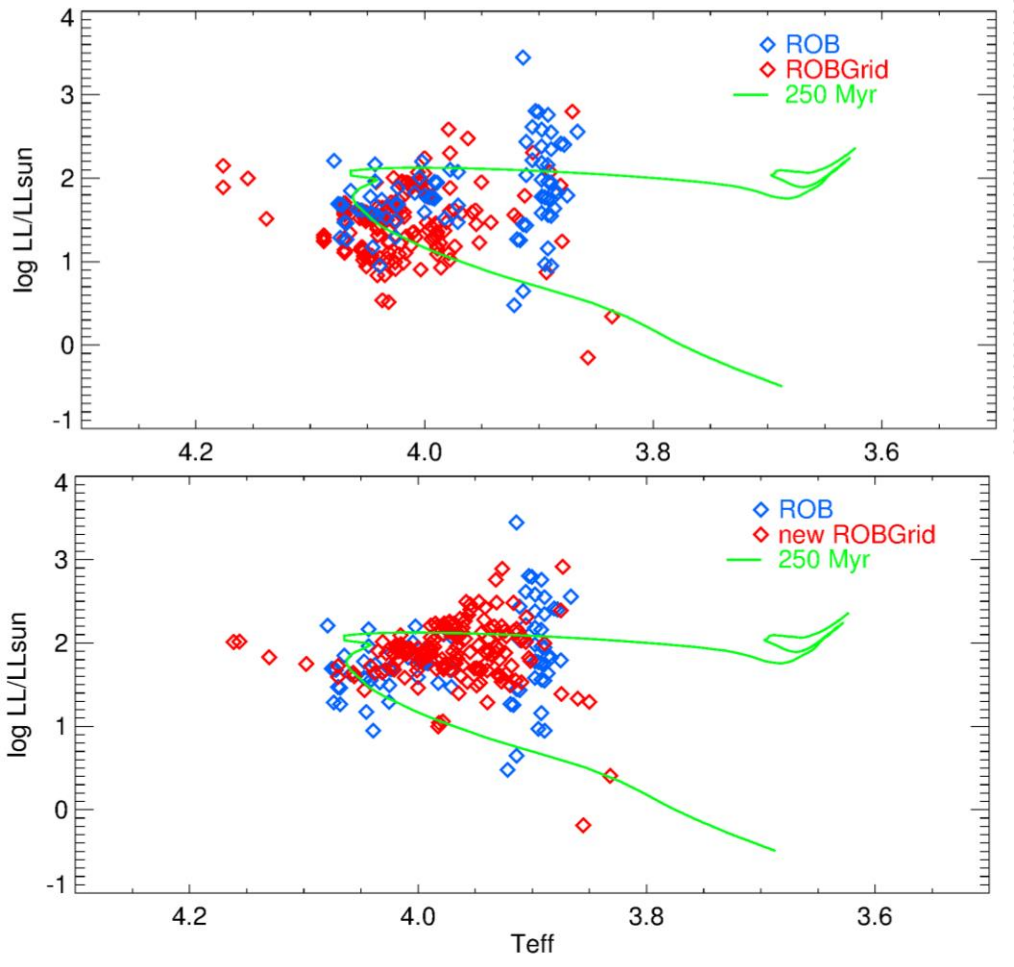
	Teff	Log g	Metal.	Micro.	Vsini	Vrad	Abund.	Flags
ROBGrid	✓	✓			✓	✓		✓
ROB	✓	✓	[Fe/H]	✓	✓			✓
Liege	✓	✓			✓	✓	He, Mg, Si	✓
IAC	✓	✓			✓		He	

- All nodes provide Teff, log g and v sin i. Other parameters provided differ from one node to the other.

Comparison nodes

- ROBGrid and Liege are in good agreement (B-type stars). ROBGrid and IAC agree well, with one outlier (O-type stars).
- Agreement ROBGrid and ROB (A-type stars) is not so good.
- We plot the stars in a so-called “spectroscopic” HR diagram.
- The y-axis is log T_{eff}^4/g = log L/M (relative to solar value).
- Experimenting with normalization of ROBGrid improves the agreement.
- The distribution of the ROB values of the A-type stars is odd: many stars fall in region that should not be densely populated.

NGC 6705

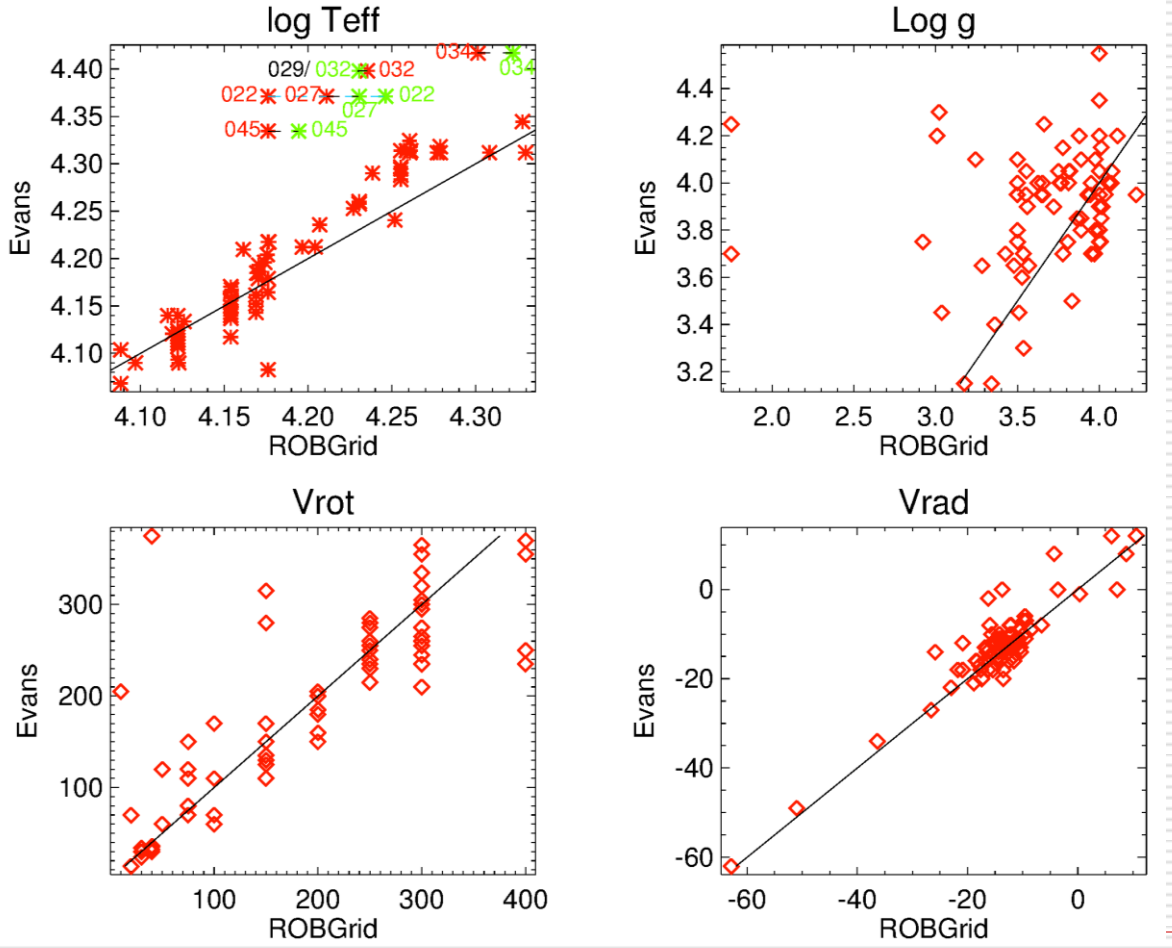


Homogenization

- If ROB, Liege or IAC values exist, use those
  - Use ROB if ROB-Teff < 12000 K
- Use ROBGrid otherwise

B-type stars

Comparison with Evans results

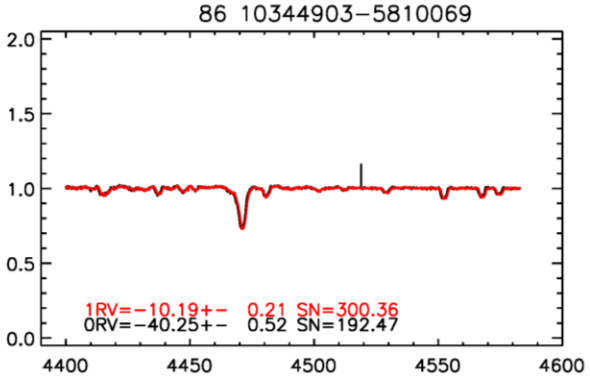


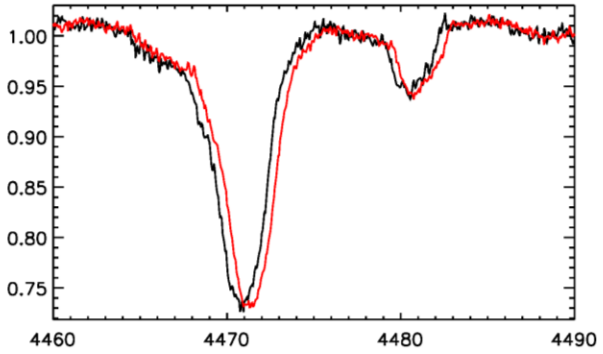
- One of the reasons we observed NGC 3293 was for a comparison with the VLT-Flames Survey of Massive Stars.
- The agreement between GES and VLT-Flames Survey is good.
- We are currently looking into the few discrepant points.

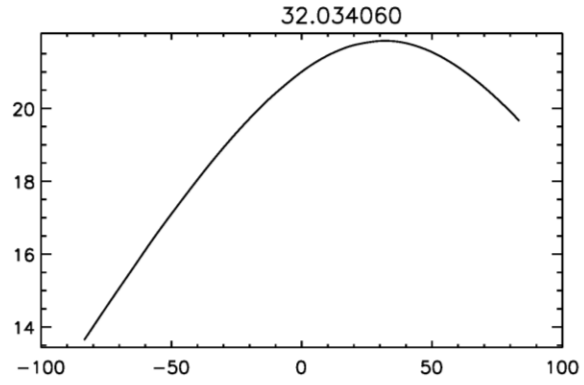
Fig: D. Volpi

Binarity

- We use the repeat observations to check for radial velocity changes that may indicate binarity.
- We judge the significance of these changes by using Monte-Carlo simulations.
- The standard deviation on the Monte-Carlo result is also a good indicator of the radial velocity precision we can hope to attain.



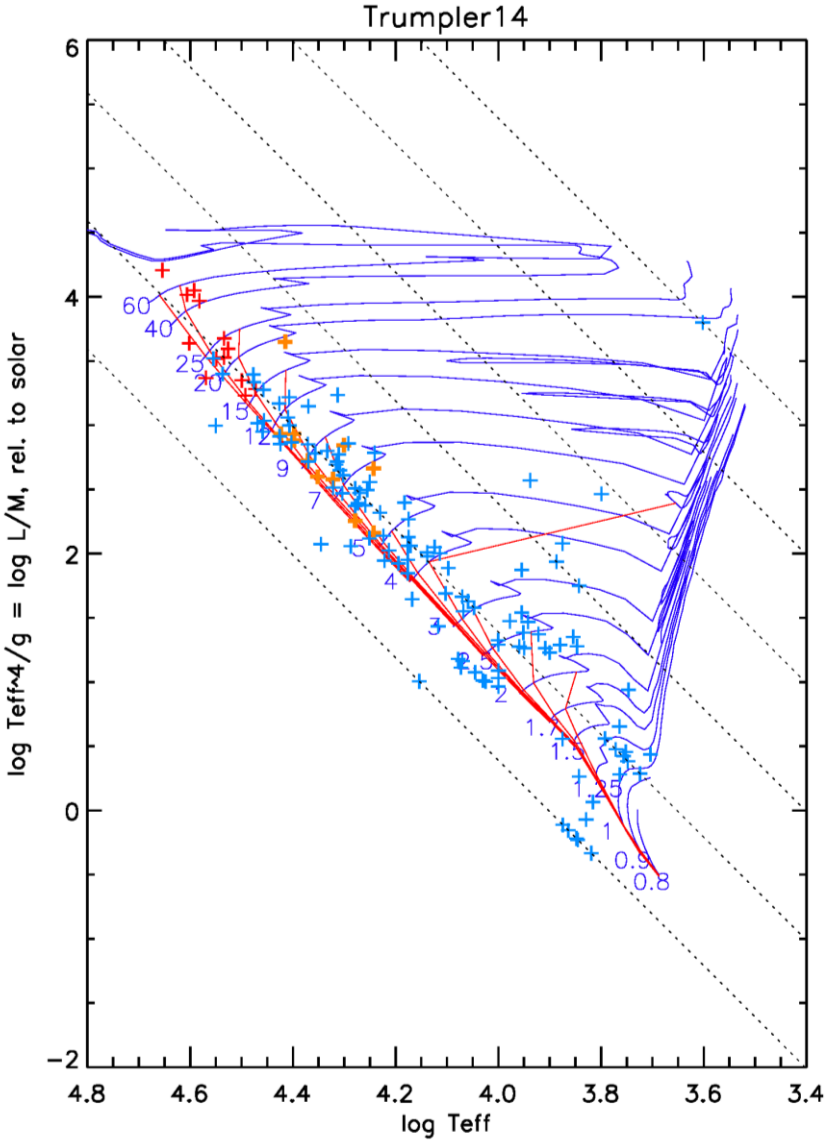




Monte Carlo simulations:
avg= −0.071323844
median= −0.058478904
stdev= 0.85827757
max= 2.5526870

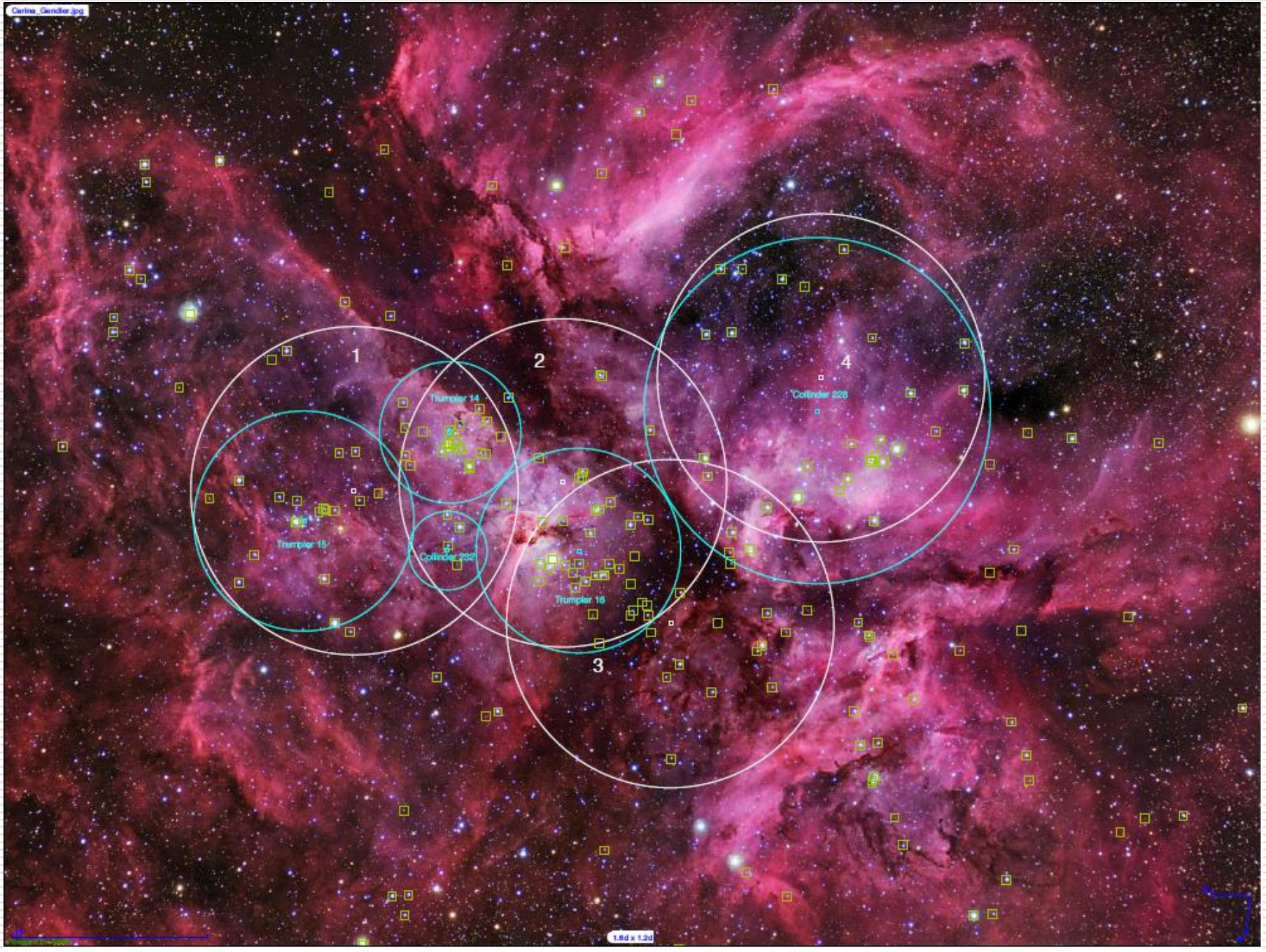
HR diagram Tr 14

- We plot the Trumpler 14 stars in a so-called “spectroscopic” HR diagram.
- Red + = IAC, orange = Liege, blue = ROBGrid
- Evolutionary tracks (blue) and isochrones (red) are from Schaller et al. 1992.
- Dotted lines have constant log g.
- The isochrones show the cluster to be a few Myr old.
- A number of ROBGrid determinations have incorrect log g values.



Plans for iDR4 and beyond

- 3 additional nodes:
  - F. Martins (O-type stars)
  - A. Tkachenko (A-type stars)
  - J. Maíz Apellániz (spectral classification)
- Abundances of more elements
- Benchmark stars – see poster Thierry Morel
- More systematic search for binarity
- Carina region (Tr 14+16 +Coll 228)


Carina_Gendler.jpg
1
2
3
4
Trumpler 14
Trumpler 15
Collinder 232
Trumpler 16
Collinder 228
1.6d x 1.2d