GES-WG13:
OBA star spectrum analyses

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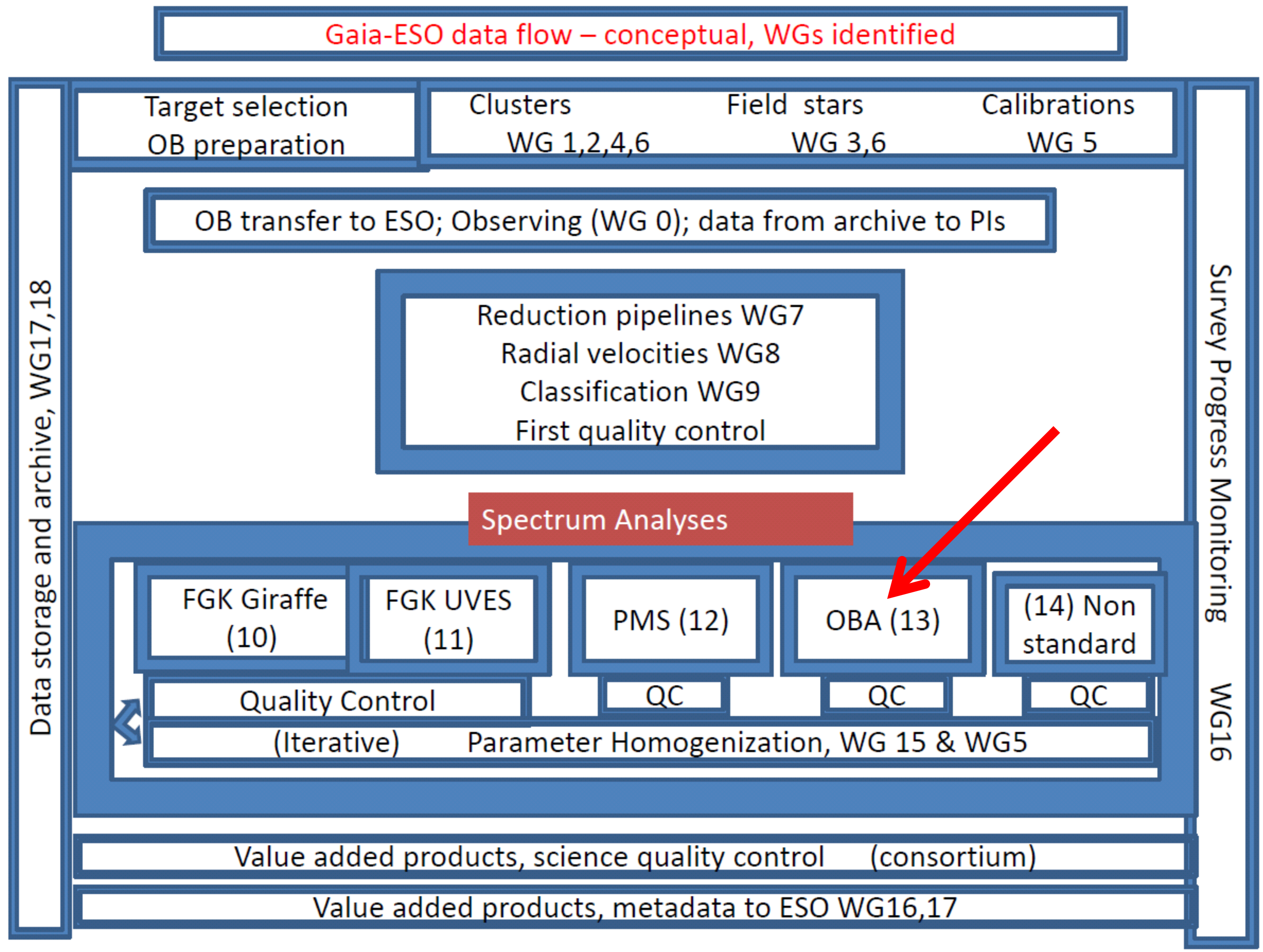
On behalf of: the Gaia-ESO WG13 team

- **Admin talk, not science**

- **What is the role of WG13?**
- **What are the various groups ("nodes")?**
- **What data does it work on?**
- **How to determine the recommended parameters (homogenisation)?**
- **Future developments**

- **GES is a very large survey – need to distribute the work**



- **Raw data are public immediately**
  - **GES Workgroups provide the added value**
  - **Access to reduced data + spectrum analysis results limited to Co-Is**
  - **Later: become public in ESO archive**
- **What is the role of WG13?**
  - **Spectral analysis of OBA-type stars**
  - **Deliver: Teff, log g, Vrad, v sin i, Mdot, abundances; errors on all these**
- **Core ideas (coming from cool stars)**
  - **Many groups work on analysis of these type of stars. So, which analysis are you going to choose?**
  - **Alternative: let everyone have a go at it (“nodes”)**
  - **But: in the end, you still want a set of “recommended” parameters. So, you homogenize the results of all the nodes**

- **Iterative nature of the process: various data releases**
  - **As our understanding of the data increases, better data reduction is possible**
  - **Stellar parameters have to be redetermined**

- **Organizationally, this means:**
  - **Schedules and deadlines**
  - **Telecons to follow up the work**

- **Publication policy**
  - **Only recommended values for astrophysical parameters to be used**
  - **Invite collaboration co-Is by announcing paper on GES wiki**
  - **Internal review**
  - **Co-authorship of those who significantly contributed to building the Survey**

Which are the nodes in WG13?

- 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
  - L. Mahy: O-type stars with CMFGEN

- In the WG13 workgroup, each node uses its own techniques to determine stellar parameters and (possibly) abundances

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

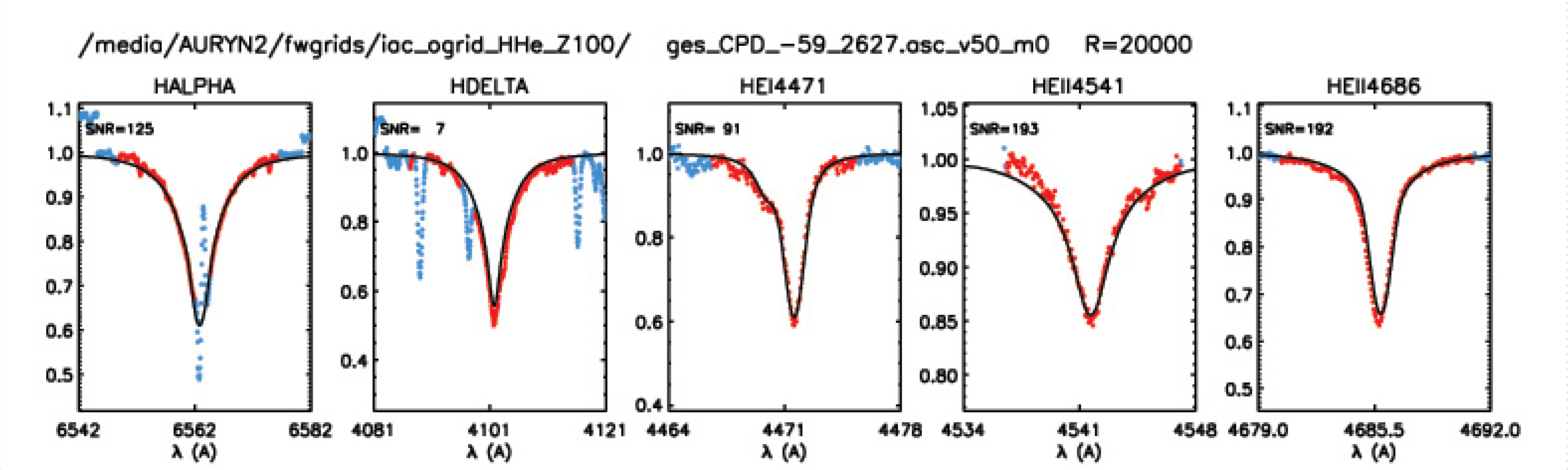


Fig: S. Simon-Diaz

- 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

Other nodes:

- J. Maíz Apellániz: spectral classification
- F. Martins: O-type stars with CMFGEN
- A. Tkachenko: AB-type stars with GSSP

What kind of data do these nodes work on?

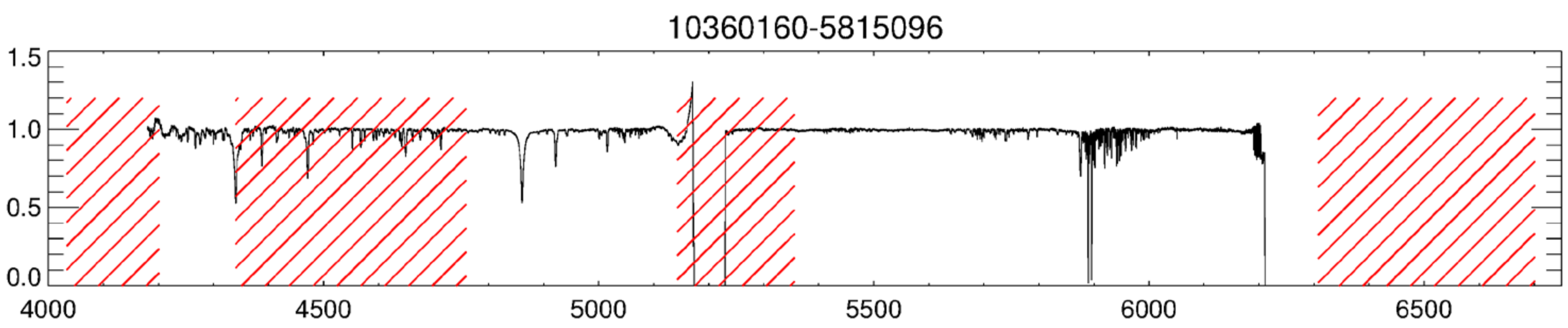
Cluster	Age	Distance (kpc)
Berkeley 25	4 Gyr	11.3
Trumpler 20	1.4 Gyr	3.0
NGC 6005	1.2 Gyr	2.7
Pismis18	1.2 Gyr	2.2
Berkeley 81	1 Gyr	3.0
NGC 6802	1 Gyr	1.8
Trumpler 23	0.9 Gyr	1.9
NGC 6633	0.6 Gyr	0.4
NGC 4815	0.5 Gyr	2.5
NGC 6705	250-300 Myr	1.9
NGC 2516	150 Myr	0.4
IC 2391	53 Myr	0.2
NGC 2451	50 Myr	0.4
NGC 2547	35 Myr	0.4
IC 2602	32 Myr	0.2
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 iDR4.
- Older clusters were also analyzed because observations were taken in at least one of the hot-star gratings.

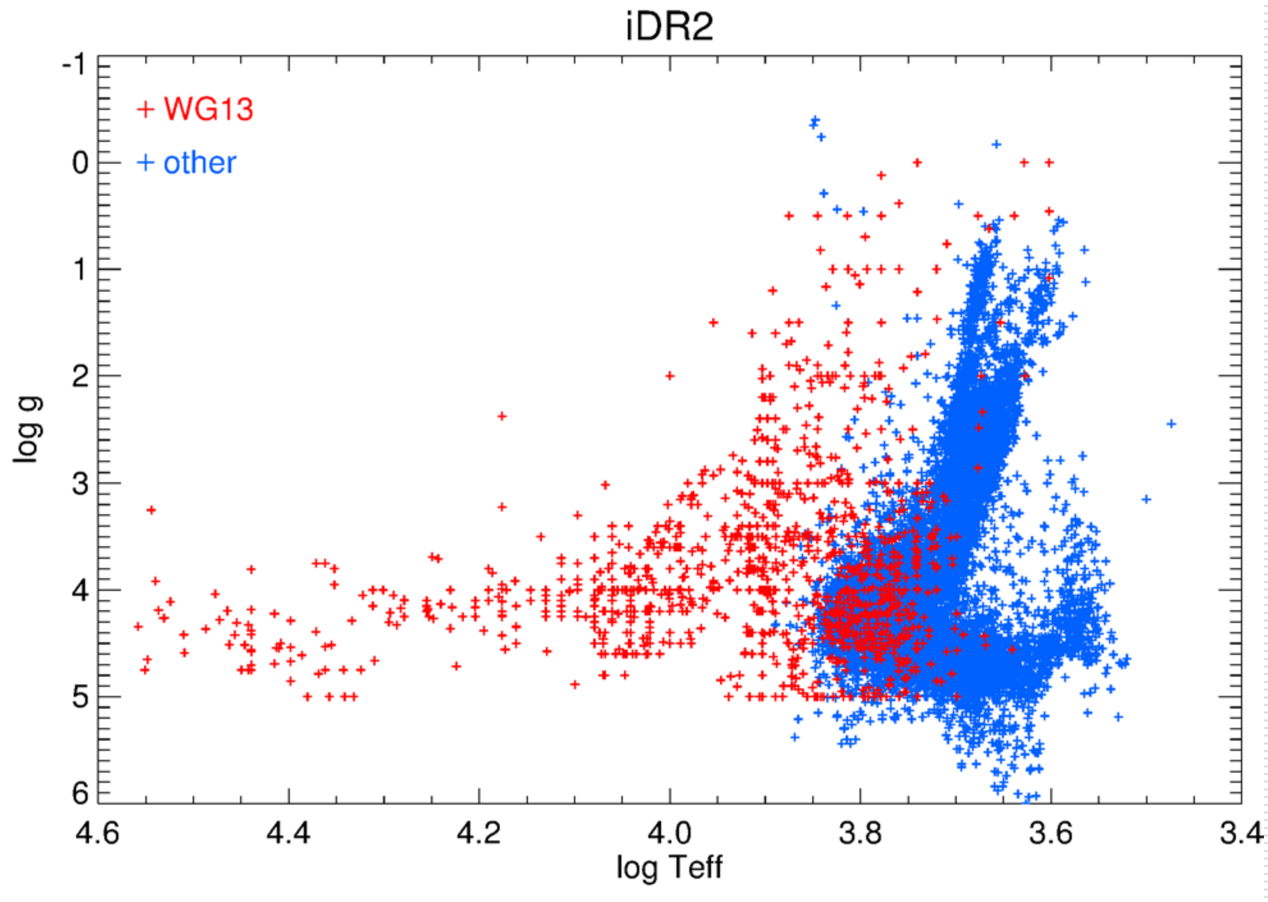
Gratings

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



Stars selected



- Stars selected are the higher-probability members of a cluster. (NGC 3293: also less probable members).
- UVES on the brightest targets
- WG13 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.

Number of stars (iDR4)

Cluster	Age	Distance (kpc)	Number stars
Berkeley 25	4 Gyr	11.3	81
Trumpler 20	1.4 Gyr	3.0	953
NGC 6005	1.2 Gyr	2.7	222
Pismis18	1.2 Gyr	2.2	51
Berkeley 81	1 Gyr	3.0	118
NGC 6802	1 Gyr	1.8	108
Trumpler 23	0.9 Gyr	1.9	97
NGC 6633	0.6 Gyr	0.4	120
NGC 4815	0.5 Gyr	2.5	113
NGC 6705	250-300 Myr	1.9	175
NGC 2516	150 Myr	0.4	16
IC 2391	53 Myr	0.2	11
NGC 2451	50 Myr	0.4	4
NGC 2547	35 Myr	0.4	23
IC 2602	32 Myr	0.2	7
NGC 3293	10 Myr	2.3	530
NGC 6530	2.3 Myr	1.3	38
Trumpler 14	1-3 Myr	2.3	135

Problems

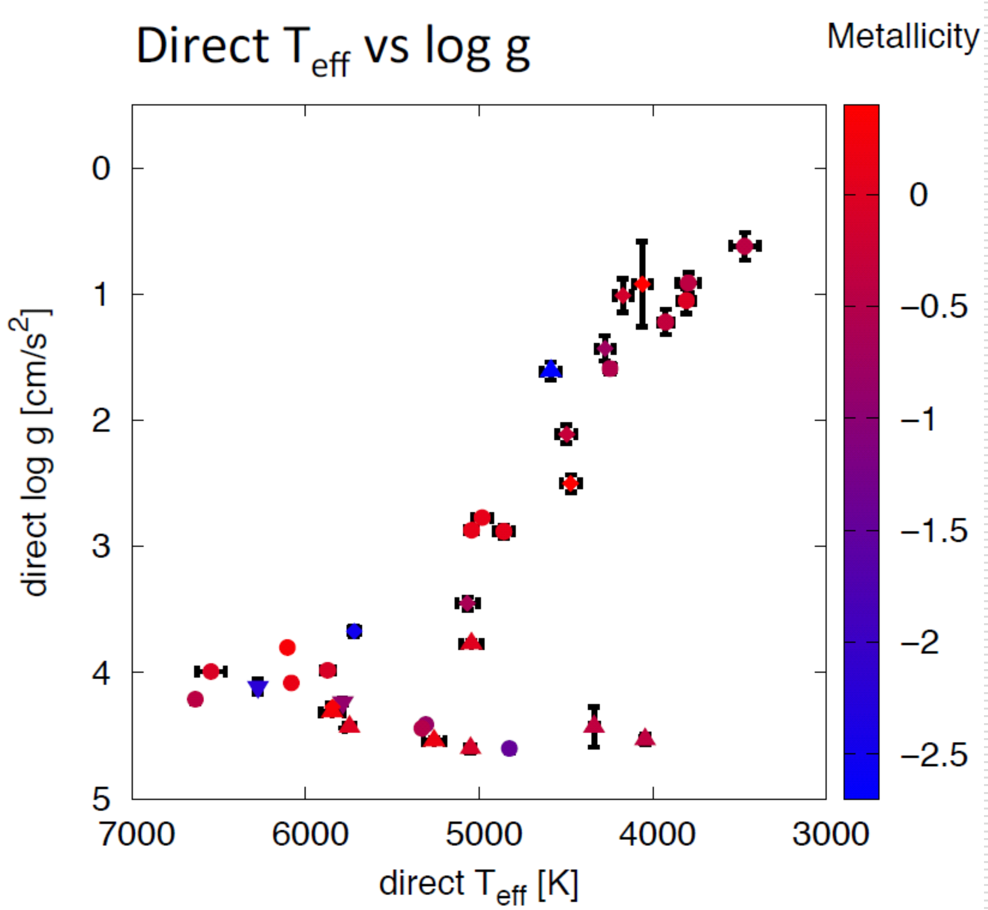
- S/N in blue gratings
- Normalization
- Background subtraction

- Quantity of data
  - Problem to apply the more sophisticated codes to lots of data
  - ROBGrid can handle quantity, but does not determine abundances

- **Homogenization**
  - **GES will deliver a set of recommended stellar parameters and abundance**
  - **Need to combine the results of the different nodes**
  - **Details of this procedure not yet fully worked out**
- **Cool stars: use of benchmark stars**

Benchmark stars

- **Astrophysical parameters determined independently of spectroscopy**
  - **Interferometric radius + Hipparcos distance -> radius of the star**
  - **+ bolometric fluxes -> Teff**
  - **Compare position in HR diagram to evolutionary tracks -> log g**
  - **Or: asteroseismology -> log g**



Heiter et al. 2014

- **Procedure:**
  - **Each node determines parameter benchmarks**
  - **Correct Teff/log g scale for offsets**
  - **Give different weights to node results in determining the average (= recommended) values**

- **What about the hot stars?**
  - **No non-spectroscopic stellar parameter determination**
  - **Instead, use stars that are well studied in the literature**
  - **And where the different stellar parameter determinations agree well**

  - **Thierry Morel and Alex Lobel: ~20 AB “benchmarks”**
  - **O-type stars…**

Future developments

- Ask not what WG13 can do for you…
- The spectrum analysis of this large dataset requires a lot of effort
- Please, join us in doing this work!

Thank you!