Hot Stars in the Gaia-ESO Survey

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- The era of large surveys
  - SDSS, UKIDSS, IPHAS, Pan-STARRS, SkyMapper, LSST, LAMOST, VVV, VPHAS+, AAT-HERMES, RAVE, …
  - Astronet review of European 2-4m telescopes
    - ~ 20 telescopes
    - Complementary programmes in support of European space missions
    - Possibly with new instrumentation
    - Used by large consortia of astronomers
  - Gaia
    - Astrometry and photometry of 1 billion stars, 80x each
    - Spectroscopy of 150 million stars, 40x each
  - **Industrial astrophysics**

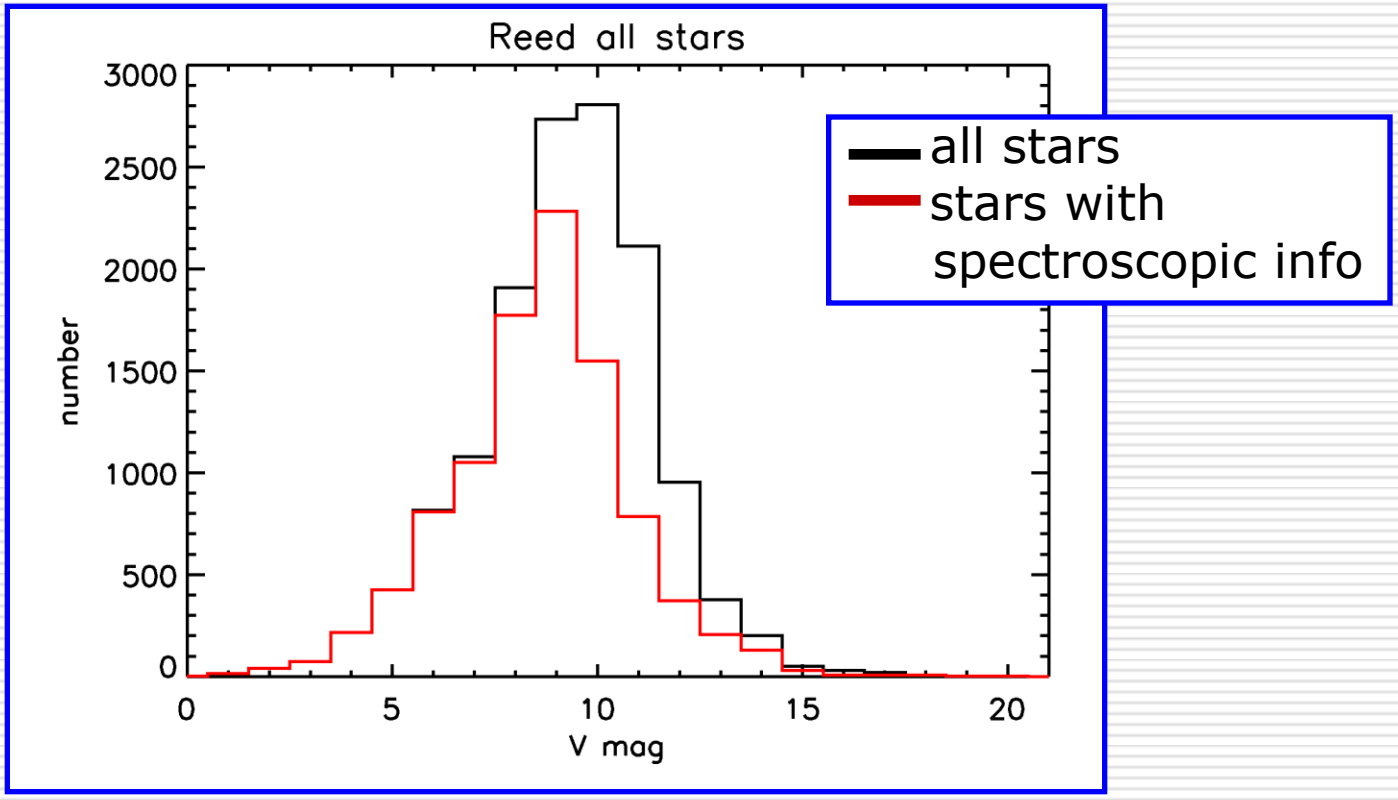
- What will Gaia provide?

Astrometry	V=20
Photometry	V=20
Radial velocities	V=17
Rotational velocities	V=13
Atmospheric parameters	V=13
Element abundances	V=12

- spectroscopic estimates maybe too optimistic for massive, early-type stars

- How many massive stars do we expect in our Galaxy?
  - at least 10,000 O-type stars (Maiz Apellaniz)
  - 100 clusters of 30 Dor type (Hanson 2008): order of 100,000 massive stars
  - Besançon Universe model (Jordi and Carrasco 2007): Gaia will observe about 900,000 B-type stars

- How many do we know for the moment?
  - Reed catalogue (`http://othello.alma.edu/~reed/OBfiles.doc`)
  - 19,766 stars (incomplete main-sequence > B2)



- Good news: Gaia will provide:
  - at least 1 order of magnitude more stars than before
  - distances for all of these stars
  - improved census allows us to address a number of scientific questions
    - organisation of the Galactic Plane
    - allows crucial quantitative tests of massive star evolution
    - number statistics of various evolutionary phases
    - better detection and statistics of the important, short-lived phases (LBVs, binary mergers, …)
- Bad news:
  - no spectroscopic information for most of these stars
  - will have difficulty to recognize the massive stars (T_{eff} – A_V degeneracy)

Gaia-ESO Survey (GES)

- Why? Need additional spectroscopic information

- Led by G. Gilmore and S. Randich, 250+ Co-Is
- Will use VLT Flames (UT2), Giraffe and UVES
- 300 nights, over 5 years
- > 10^5 Giraffe spectra, > 10^4 UVES spectra
- Sampling all major components of the Milky Way: bulge, thick and thin disk, halo, open clusters

- 60 old clusters (> 100 Myr)
- 40 young clusters, 13 of those massive-star clusters

Gaia-ESO Survey

- O, B, A-type stars in the young/massive-star clusters
- Science:
  - Determination of stellar and wind parameters
  - Compare with evolutionary tracks, isochrones
  - Constrain the upper IMF
  - Nitrogen abundance: rotation has important evolutionary effects
  - Galactic gradients in abundances: a large range in distance, present-day abundances
  - Mass loss rate determinations from H-alpha, clumping
  - Be stars: evolution of angular momentum, disentangle age/mass effect

- Observation strategy (Late-type stars: HR10, HR15N, HR21)
  - HR03 (4033-4201)
    - Hdelta 4102 O+B stars, O stars;
    - HeI 4121, 4144, Si IV 4089, 4116, Si II 4129 B stars
    - O II
  - HR05A (4340-4587)
    - HeI 4387, 4471 O+B stars; HeII 4542
    - Si III 4552, 4568, 4575, Mg II 4481 B stars
    - N II, O II
  - HR06 (4538-4759)
    - HeI 4713, HeII 4541, 4686 (wind line) O+B stars;
    - Si IV 4631, 4654 Bstars
    - C III, N II, O II
  - HR14A (6308-6701)
    - Halpha 6563 (wind line) O stars;
    - He I 6678, He II 6527, 6683, Si II 6347 Bstars
    - C II

- Observation strategy:
  - UVES: CD3, 520 nm setting
  - Astrometry: from 2MASS
  - S/N = 100 in O, B stars: RV accuracy 0.5 km/s
  - S/N = 50 in UVES for abundance determination
  - Expect ~ 1500 stars

Cluster selection

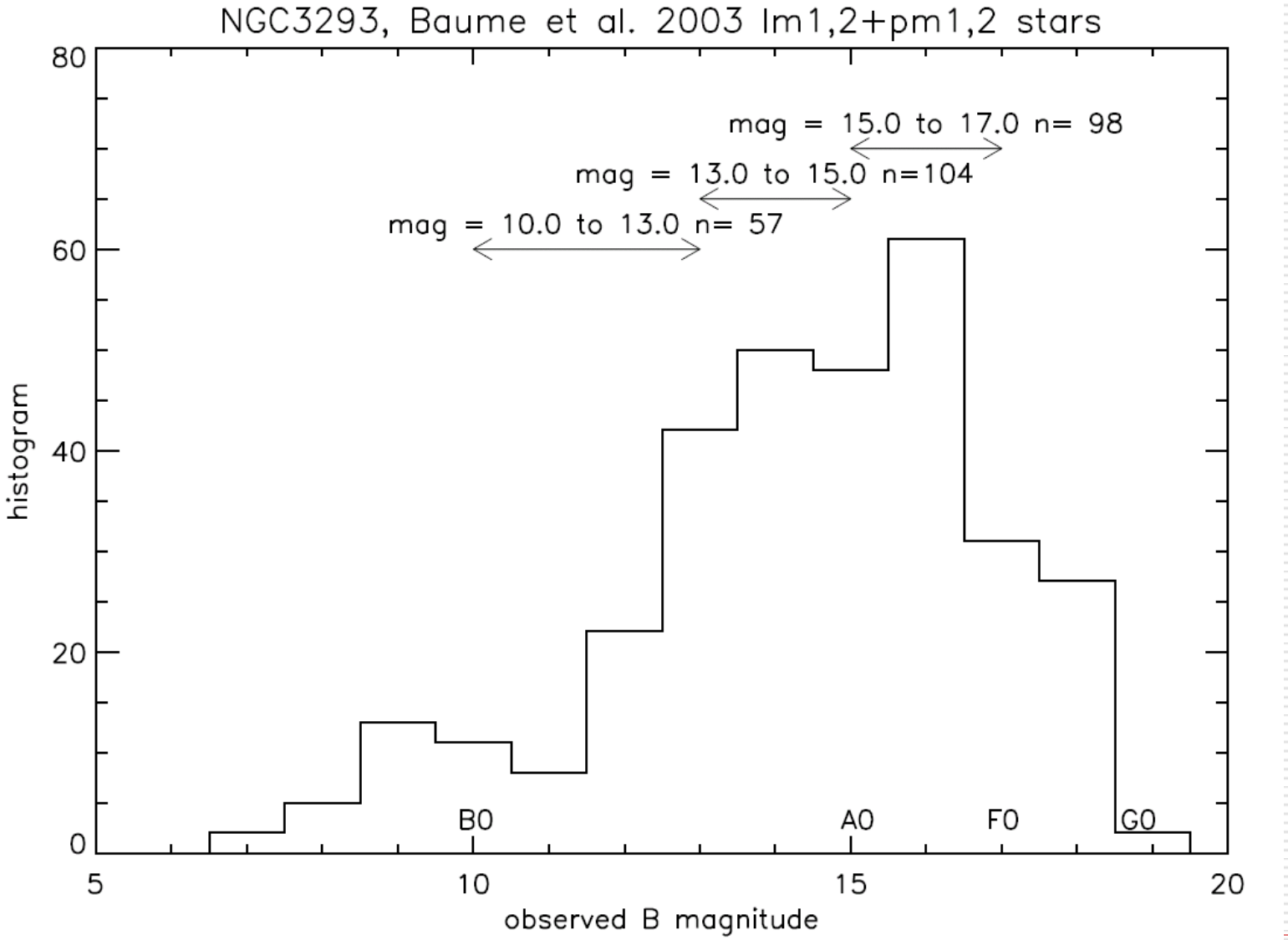
- First version done (still room for changes)

- Science interest
- Membership
- Efficiency of use of Flames fibres
  - ~ 130 fibres
  - Limited magnitude range

Gaia-ESO Survey – Massive stars

name cluster	central coordinates	total exp time	semester month+-month	notes
NGC 6611	18 18 48, -13 48 24		07 ± 3	see young clusters
NGC 3293	10 35 51, -58 13 48	12 hr	03 ± 3	down to F0, repeat OB stars (1)
NGC 4755	12 53 40, -60 22 05	12 hr	04 ± 3	(2)
NGC 3603				too compact for Flames
Westerlund 1				others already doing Flames
NGC 2244	06 31 55, +04 56 30		12 ± 2	see young clusters
Trumpler 14				see young clusters
Trumpler 16	10 44 58, -59 43 00	16 hr	03 ± 3	also includes Tr 14
Dolidze 25	06 45 06, +00 18 00	12 hr	01 ± 2	
NGC 3766	11 36 14, -61 36 30	8 hr	03 ± 3	
Collinder 228	10 42 04, -59 55 00	6 hr	03 ± 3	
Trumpler 27	17 36 20, -33 31 00	8 hr	06 ± 3	
Westerlund 2	10 24 02, -57 46 00	4 hr	03 ± 3	drop this cluster? (3)
NGC 6649	18 33 27, -10 24 12	20 hr	06 ± 3	(4)
IC 2944	11 37 53, -63 21 00	8 hr	03 ± 3	
NGC 6231	16 54 10, -41 49 30		06 ± 3	see young clusters, should be higher in list says Maiz-Apellaniz
NGC 6530	18 04 31, -24 21 30		06 ± 3	see young clusters
NGC 2264	06 40 58, +09 53 42		12 ± 2	see young clusters
Collinder 70	05 35 31, -01 06 00	–	01 ± 2	too extended for Flames
NGC 2362	07 18 41, -24 57 18			see young clusters
Trumpler 15	10 44 43, -59 22 00		03 ± 3	not done yet
Pismis 24	17 25 32, -34 25 00		06 ± 3	not done yet
NGC 6193	16 41 20, -48 45 48		06 ± 3	see young clusters
Ruprecht 44	07 58 51, -28 35 00		01 ± 3	not done yet
Pismis 20	15 15 23, -59 04 00		05 ± 3	not done yet
Cl 1715-387				not done yet
M11				priority ???

Gaia-ESO Survey – Massive stars



WP Hot, Massive stars

- Determine stellar parameters and abundances from spectra O, B, A stars
  - Teff, log g
  - Luminosity, Radius, Mass (if distance known)
  - Radial and rotational velocity
  - Mass-loss rate (assuming no clumping)
- Using comparison with synthetic spectra and/or equivalent widths
- Who will do this?

Gaia-ESO Survey – Massive stars

- ROB (Blomme)
- Alicante (Negueruela)
- Granada (Maiz-Apellaniz)
- AIP (Schnurr)
- MPIA (Bailer-Jones)
- Leuven (De Ridder)
- IAC (Herrero)
- Madrid-ESA (Huelamo)
- Uppsala (Kochukhov)
- Univ. Nice (Monier)
- Liege (Morel)
- Armagh (Vink)
- Herts (Napiwotzki)
- Paris (Zorec)
- ZAH (Grebel et al.)
- Calar Alto (Barrado)

Interested to collaborate on this?

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