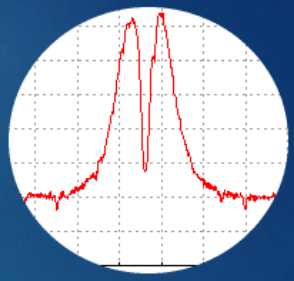
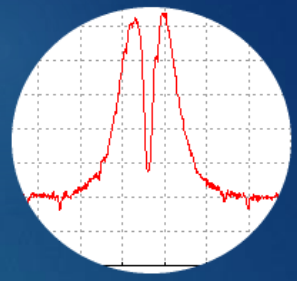


Looking for new Be stars among B stars

BE STARS AND THE BESS DATABASE, MEUDON, 23-27 OCTOBER 2017

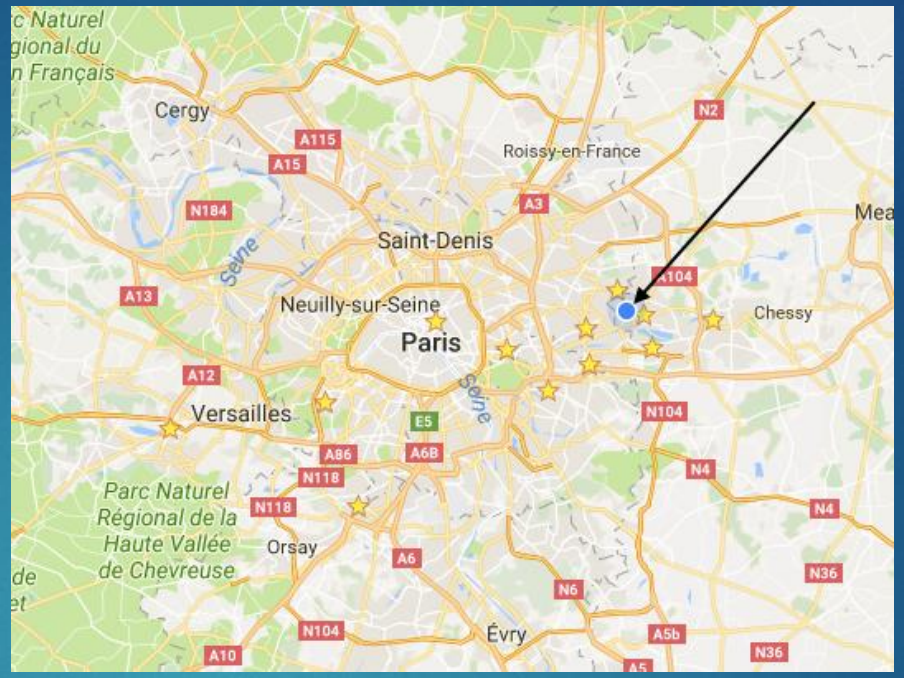
THIERRY LEMOULT@GMAIL.COM

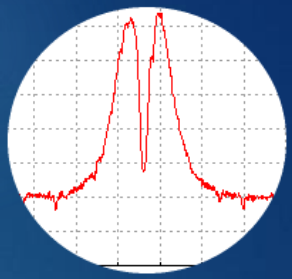
Content



- My observatory
- Survey definition
- Survey Results
- What next ? How to improve ?

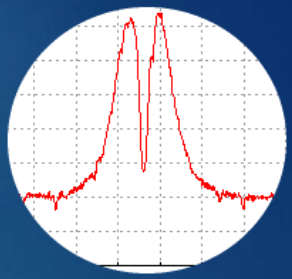
My observatory



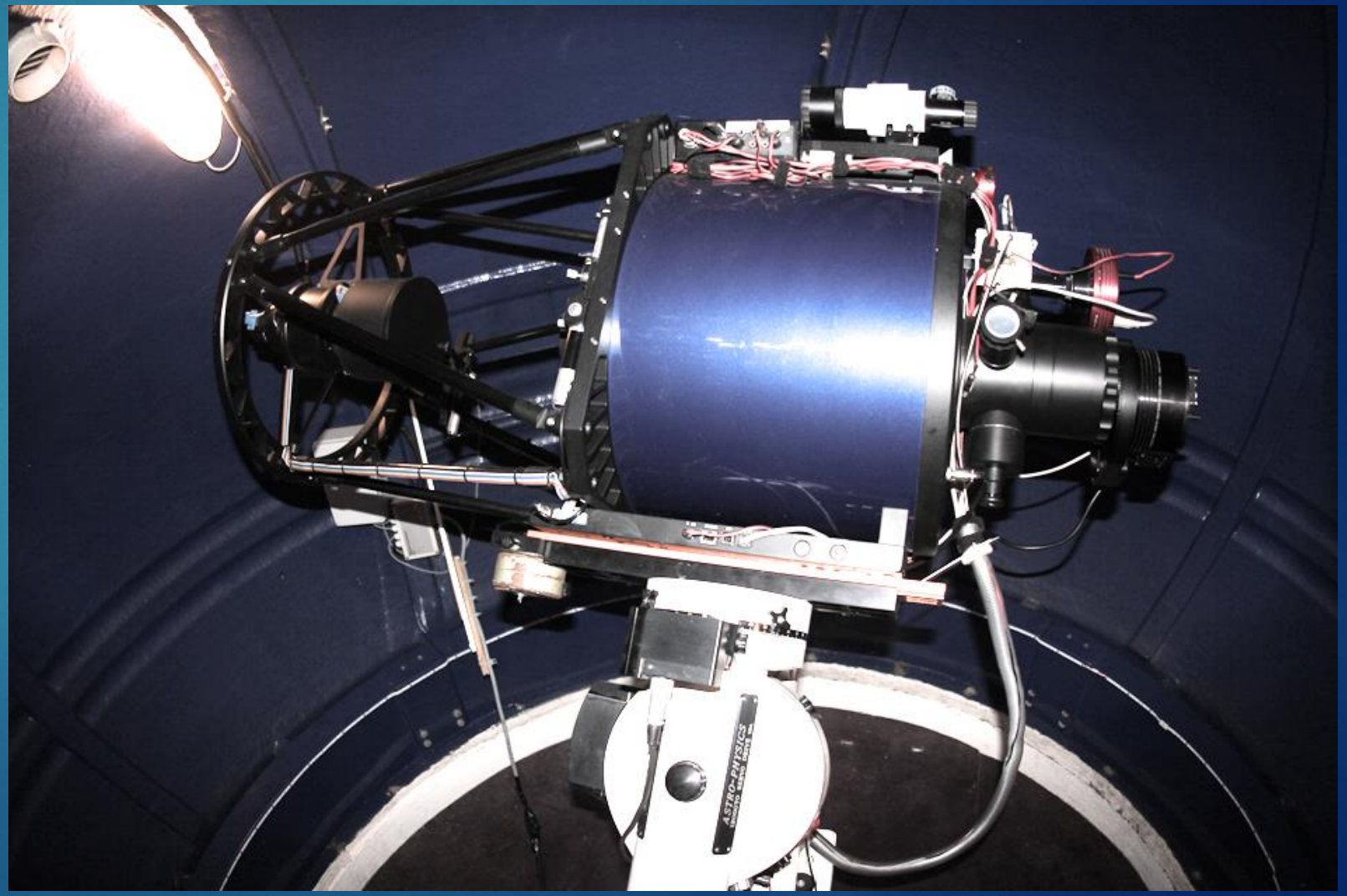


- IAU C61 Chelles
- 15km east Paris
- Urban environnement
- Seeing 2..3 arc sec
- Build in 2011
- Automated in 2014

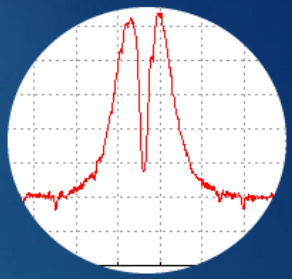
The equipement



- RC 0.36 m F/D=8
- Spectrograph
  - eShel R=11000
  - LISA R=800
- Fully automated
  - PRISM/python
  - Select targets list.
  - Run when weather is OK.
- Database
  - Raw acquisition
  - Reduced spectrum



The Survey idea

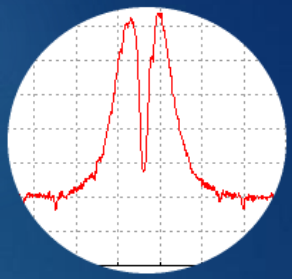


- Automated telescope but for what project ?

- We know around 2200 Be stars.
- 20% of B type star are a Be.

- Let's try find new Be stars !

Selecting star to observe

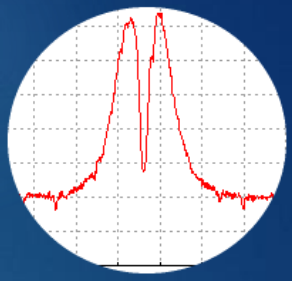


- Spectral type B
- Luminosity class
  - Not a supergiant (Class I)
  - Not a sub-dwarfs (Class VI) ?
- CDS type is "star"

- Brightness
  - Very bright star excluded. => Bmag>6
  - Low resolution spectrum (R=800) with SNR=100 in less than 5 minutes with my 0.36m telescope => Bmag<11

- Well placed in Paris sky => dec>0

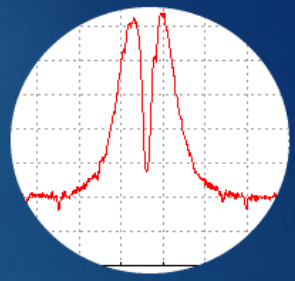
Selecting star to observe
CDS request from criteria

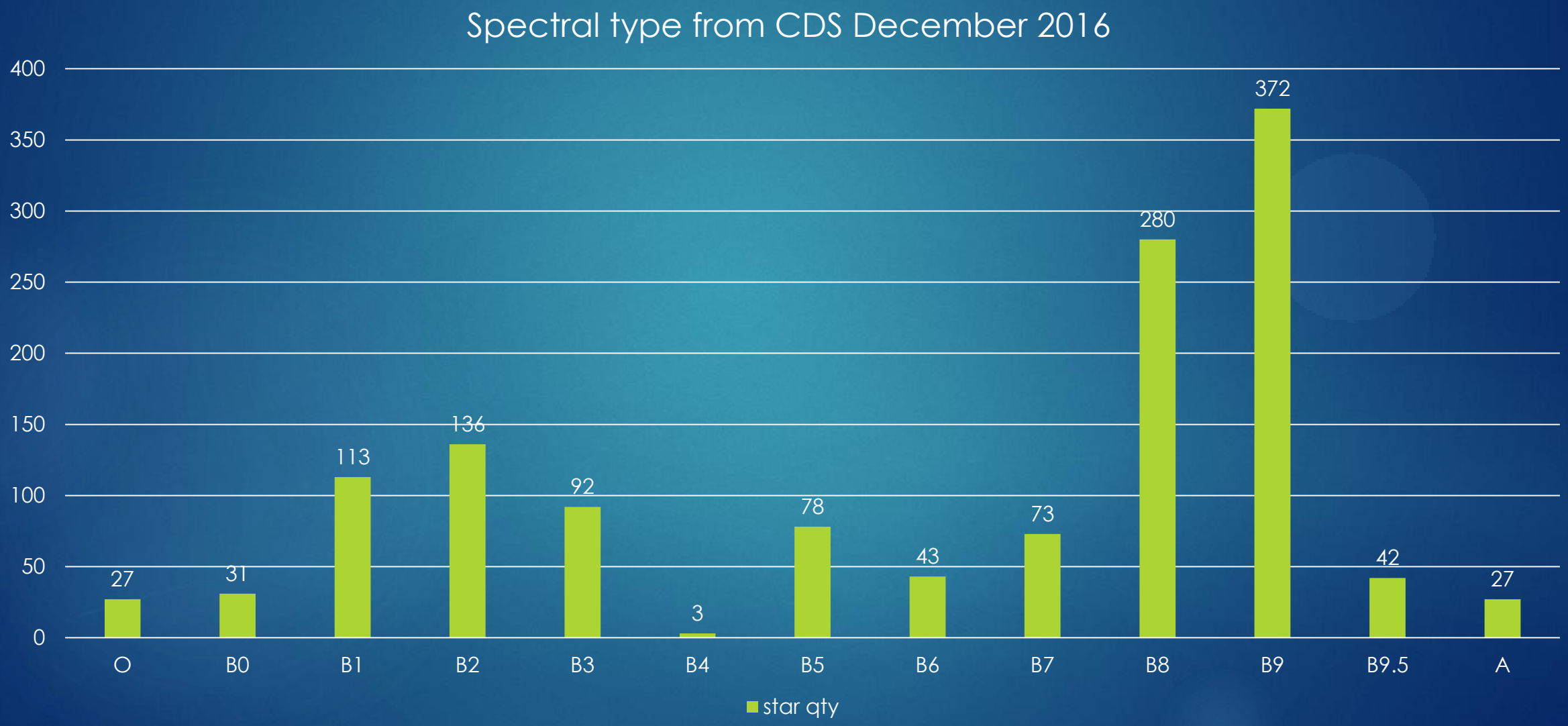


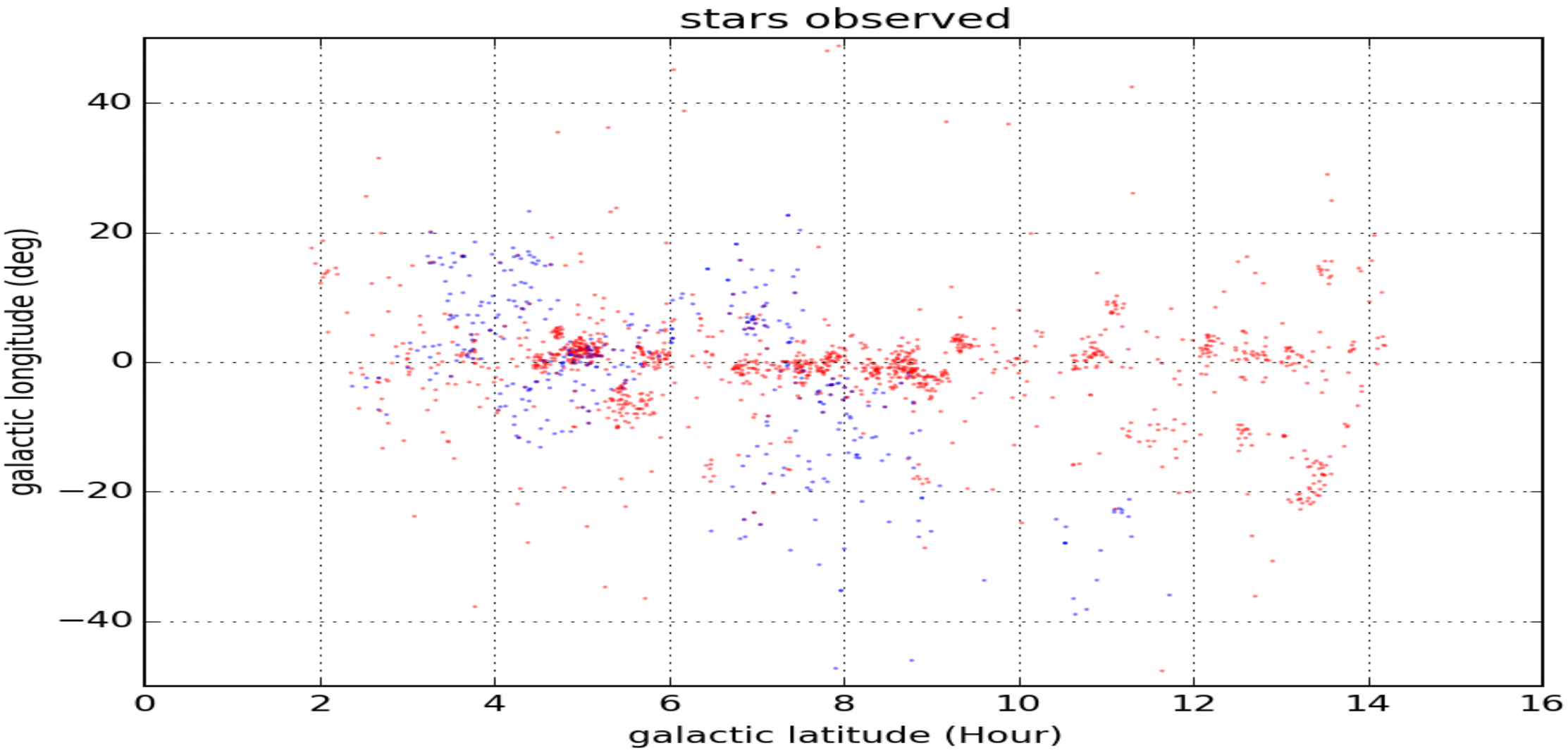
- sptypes in ('B0','B1','B2','B3','B4','B5','B6','B7','B8','B9','B9.5') &
- (splum in ('V','IV', 'III','II')) &
- Bmag>6 & Bmag<11 &
- maintype='*' &
- dec>0

Total: 1382 objects found in October 2014

1322 observed stars

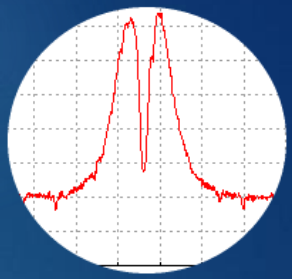






- Red dot: Thierry Lemoult survey 1322 stars
- Blue dot: Andrew Smith (UK) 410 stars

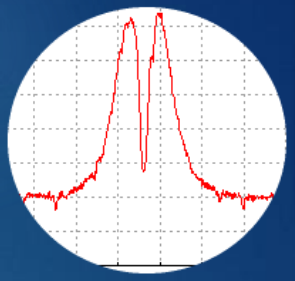
Survey figures



- 2 month in debug mode for a new automated telescope
- 180 observation of reference stars
- 1322 targets stars (1382 planned)
  - 96% pointing success with astrometry
  - Up to 80 targets per night

	September 2014	October 2014
Observation QTY	844	654
Nigh QTY	19	20
Total exposure	53 hours	41 hours

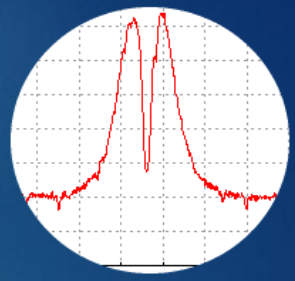
Survey results



- Reduction
  - No pipeline available, only visual detection on raw 2D image spectrum
  - Processed spectrum when emission seen or suspected

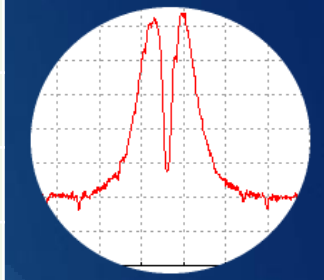
- How many detection expected ?
  - 1322 B stars observed
  - Expected 20 % of B are Classical Be
  - Expected Be are in emission 15% of the time
  - Detection efficiency 50 % ? (low resolution & visual detection)
    - 1322 x 0.20 x 0.15 x 0.50
    - => **We expect find 20 new classical Be stars candidates**

Survey results

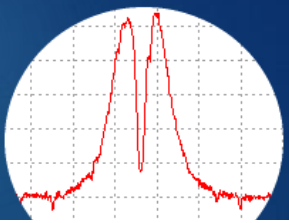


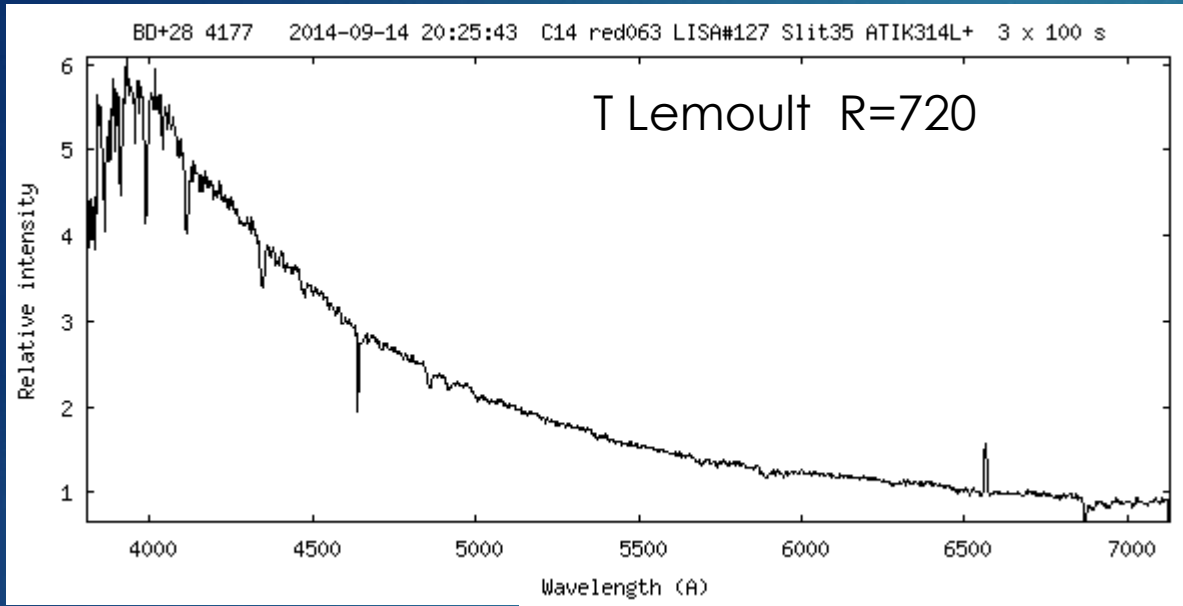
- Archive on ARAS web site
- Stats
  - 19 new emission stars
  - 4 rediscovered emission stars
  - “x” know star of Bess
- Note: 2 additions find after the survey
  - HD184061 by Pberardi in October 2015
  - HD9878 by Martineau/ Buchet in october 2016

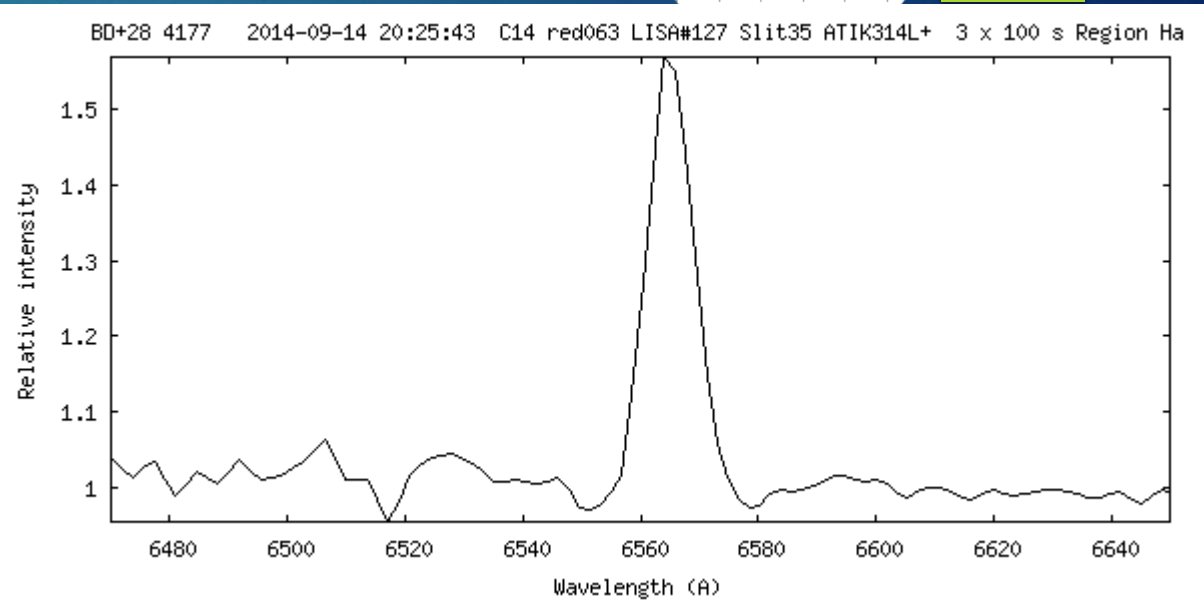
name	B mag	H-K	Sp Type	observation date	resol	link	note
HD16485	6.59	+0.06	B9V C ~	2014-09-28T00:01:39	568	plot	
HD12243	7.99	+0.02	B8V C ~	2014-09-30T22:54:22	576	plot	
BD+63 1964	8.49	+0.12	B0 D	2014-09-10T22:01:36	409	plot	
BD+03 3861	8.63	+0.06	B8 D	2014-10-05T20:09:51	603	plot	Be star Apogée 2017
HD179793	8.64	+0.06	B9IV C	2014-10-05T20:30:03	613	plot	
HD191494	8.74		B8V C ~	2014-10-13T22:32:25	590	plot	
HD225859	9.11	-0.02	B9V D ~	2014-10-03T23:50:30	575	plot	
HD253928	9.14	+0.04	B8V C ~	2014-10-21T02:53:45	584	plot	
BD+60 2645	9.42	+0.01	B3V D ~	2014-10-21T18:17:50	590	plot	
HD237126	9.48	+0.07	B7III C ~	2014-09-09T23:52:55	396	plot	
BD+60 133	9.54	+0.08	B9III C	2014-09-26T22:06:48	587	plot	
BD+54 2775	9.60	+0.04	B1V C ~	2014-10-14T03:49:17	592	plot	
BD+28 4177	9.86	-0.07	B0.5IIIk C	2014-09-14T20:25:43	724	plot	
BD+60 2523	9.94	+0.12	B2 D	2014-09-11T21:53:16	544	plot	
BD+57 2581	10.08	+0.14	B0III C ~	2014-09-11T21:06:58	556	plot	
BD+58 310	10.29		B1V D ~	2014-09-28T21:41:09	670	plot	
BD+59 2675	10.34	+0.20	B6II D ~	2014-09-10T21:48:39	393	plot	

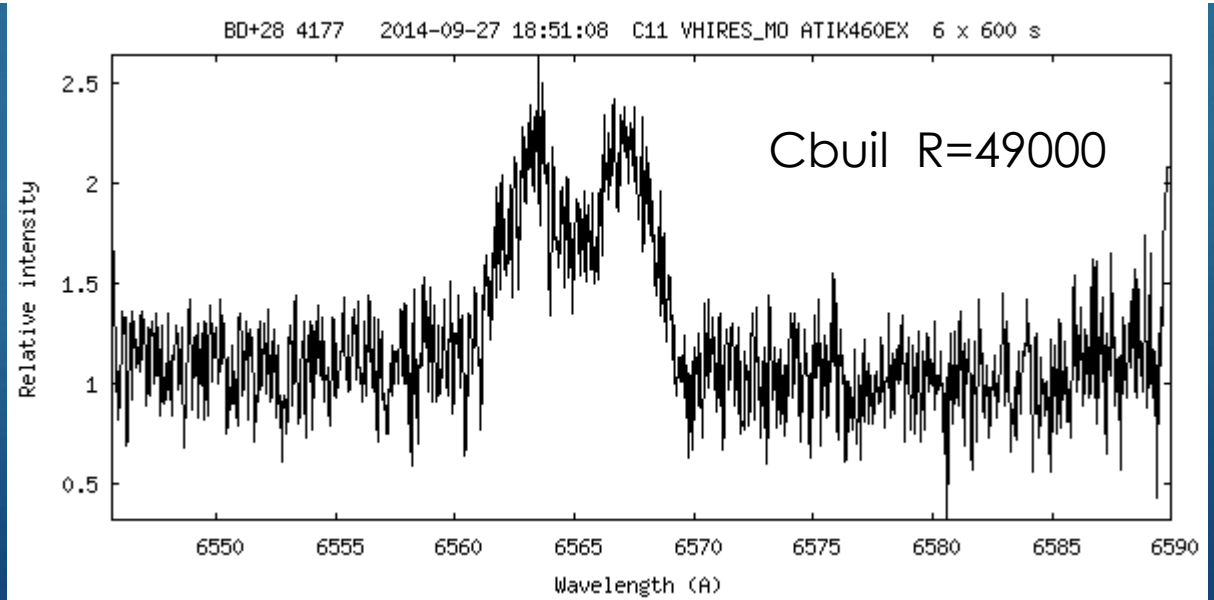


BD+28 4177





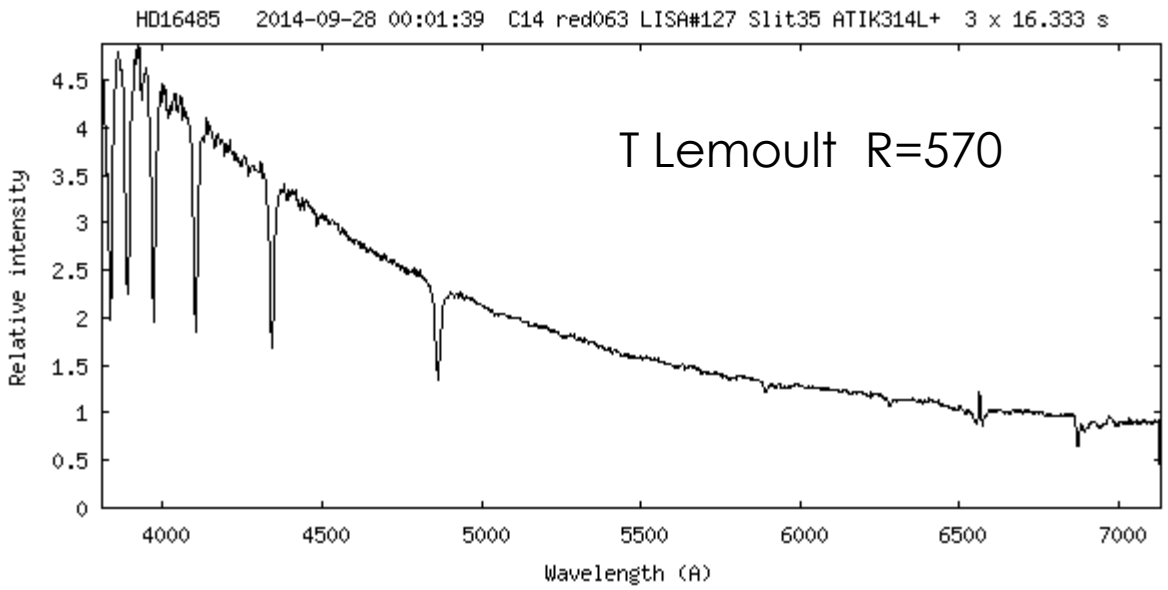


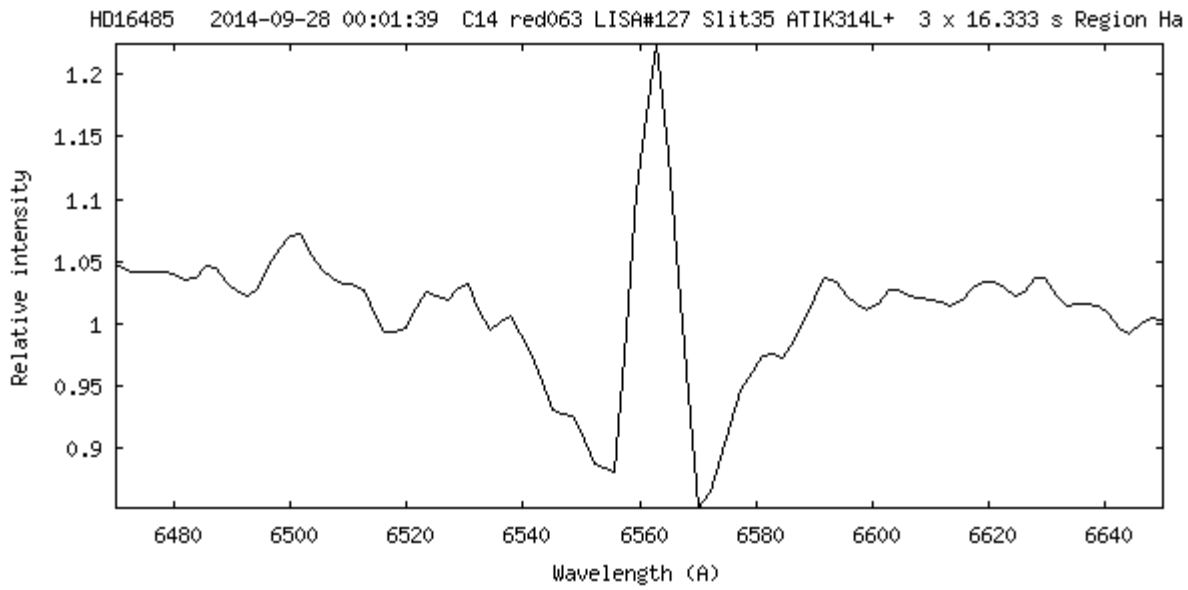


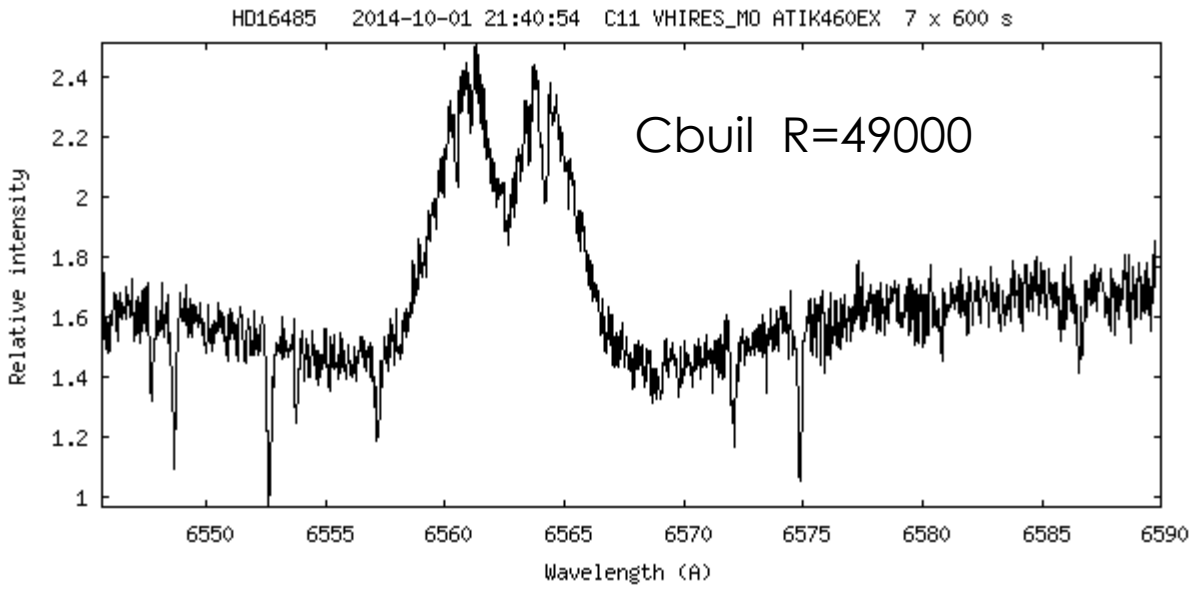
Vmag=9,86
B0.5IIIk
H-K=-0.07

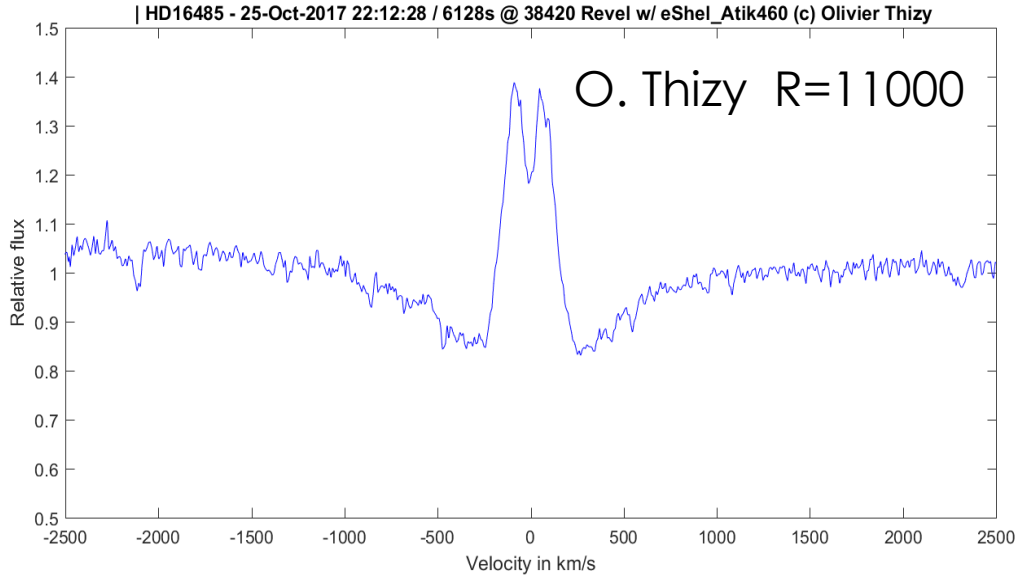
HD16485

Vmag=6,59
B9V
H-K=+0.06



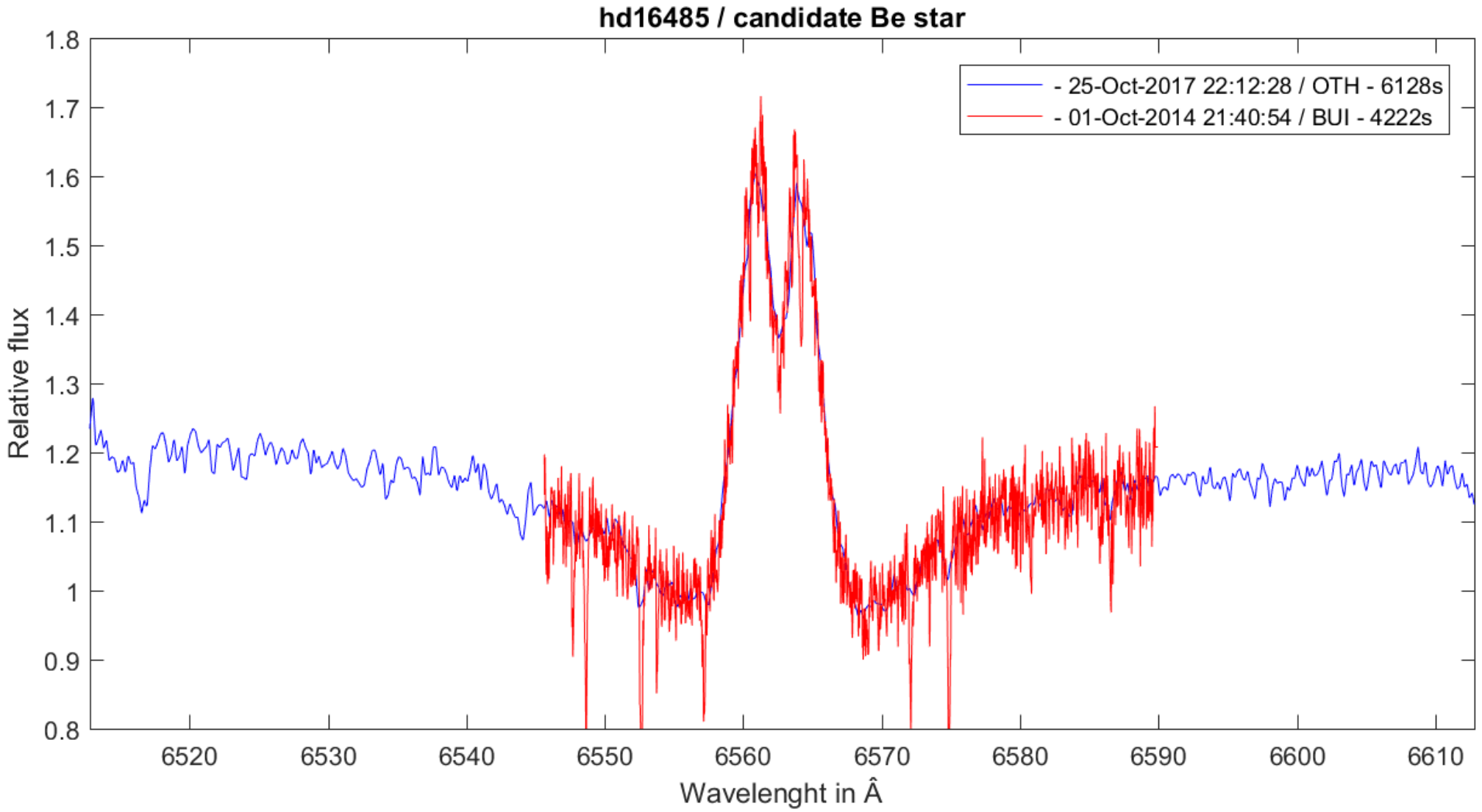




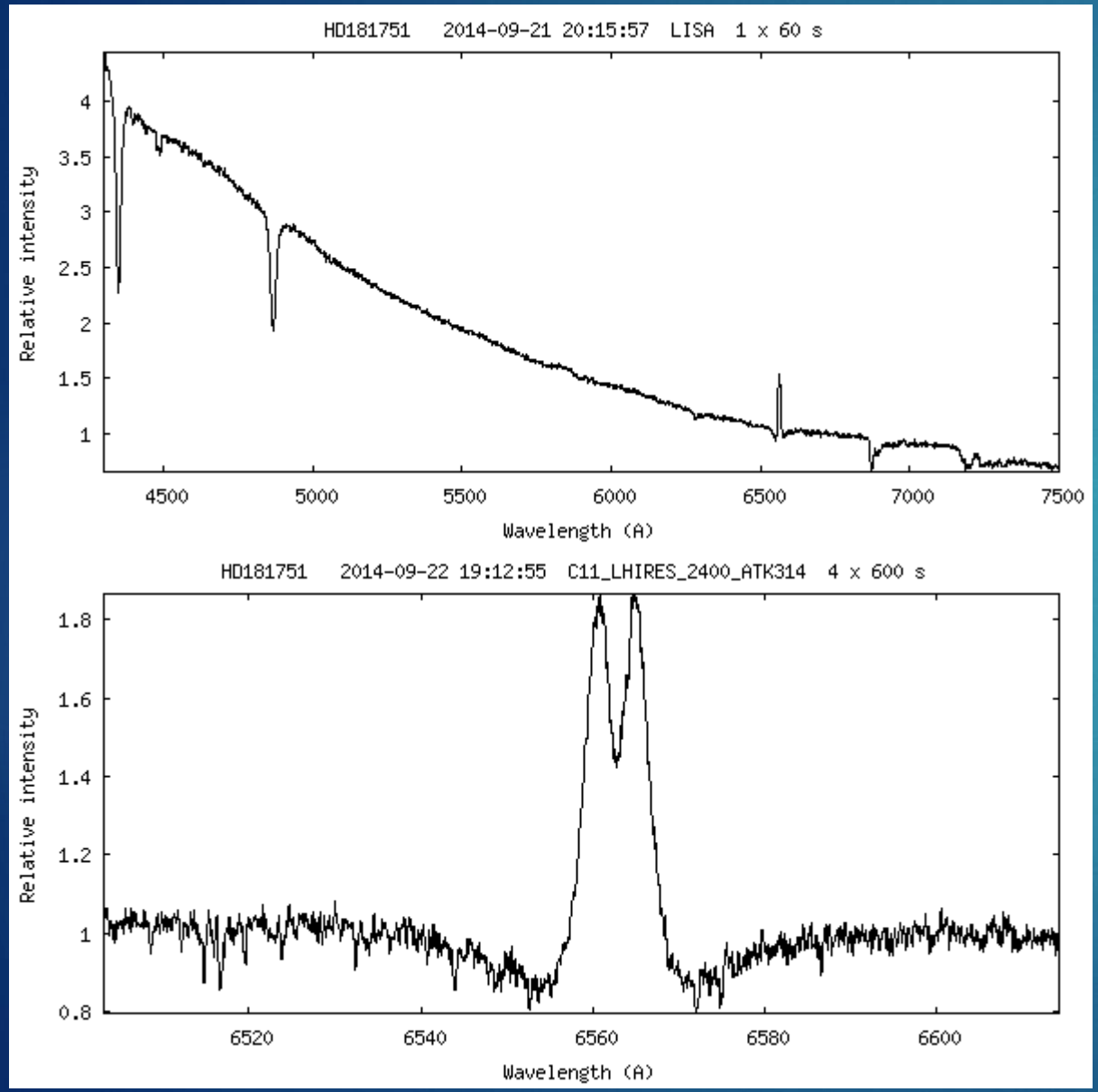


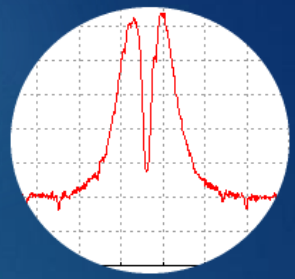
HD16485

Vmag=6,59
B9V
H-K=+0.06



HD181751



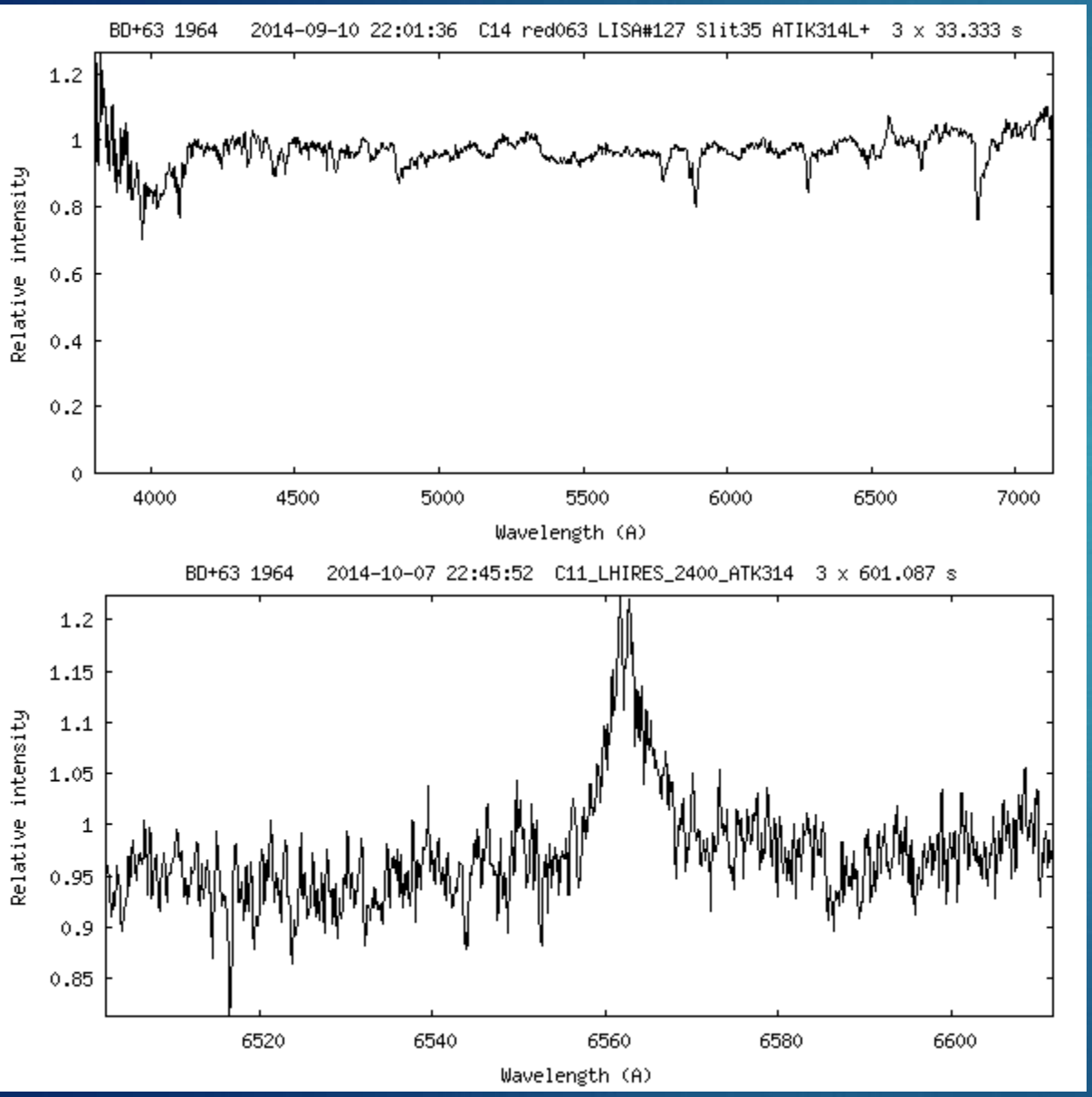


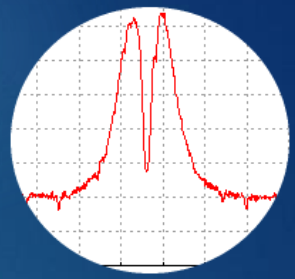
- Andrew Smith
- R=320

- Robin Leadbeater
- R=15000

Vmag=6.55
B8
H-K=-0.28

BD+63 1964



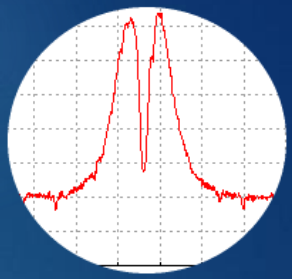


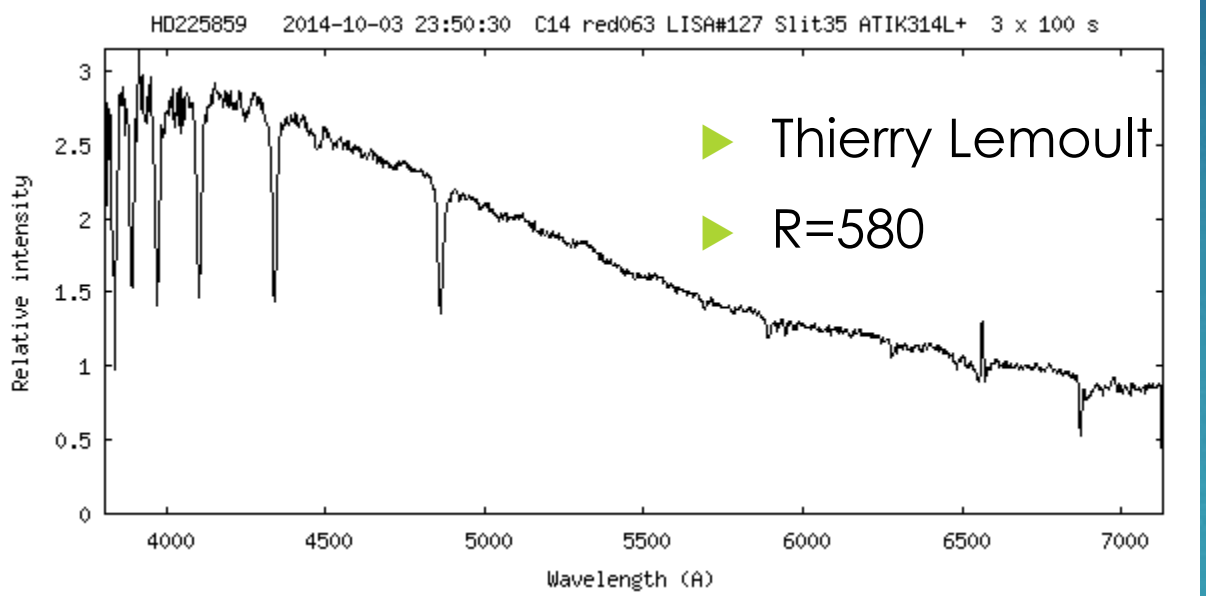
- Thierry Lemoult
- R=400

- Robin Leadbeater
- R=15000

Vmag=8.5
B0
H-K=0.12

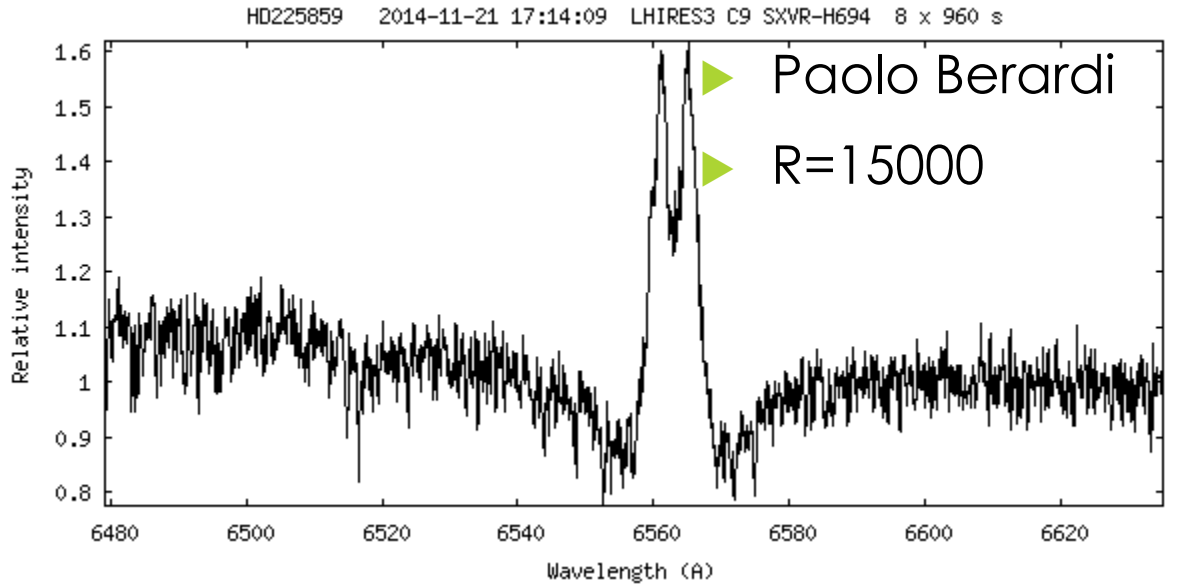
HD225859



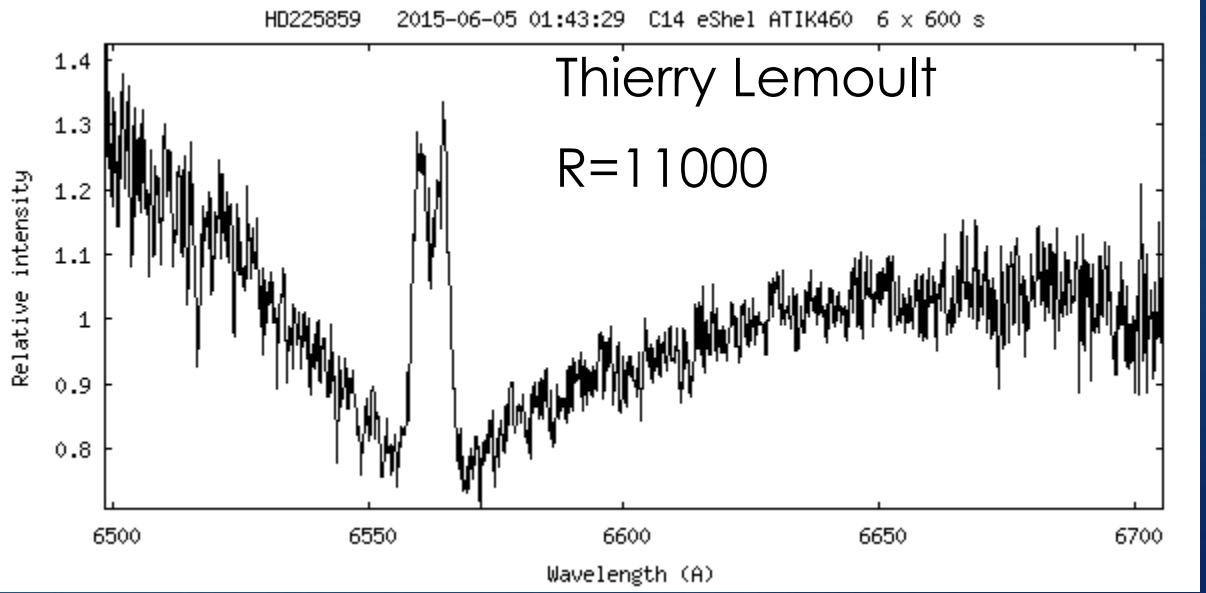


- Thierry Lemoult
- R=580

Vmag=9.1
B9V
H-K=-0.02



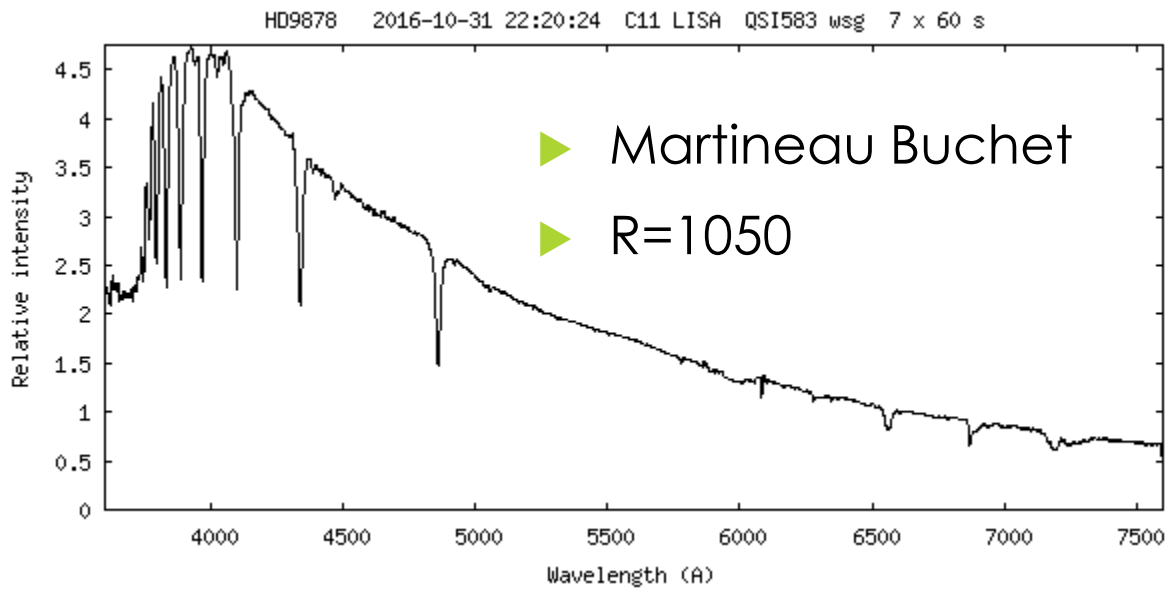
- Paolo Berardi
- R=15000



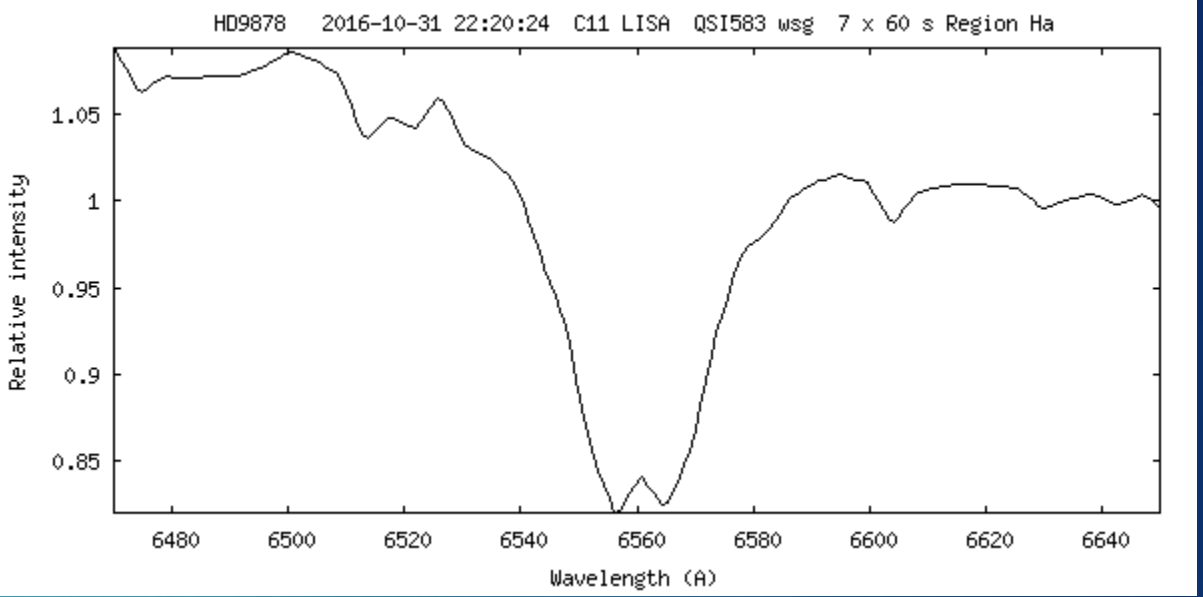
Thierry Lemoult

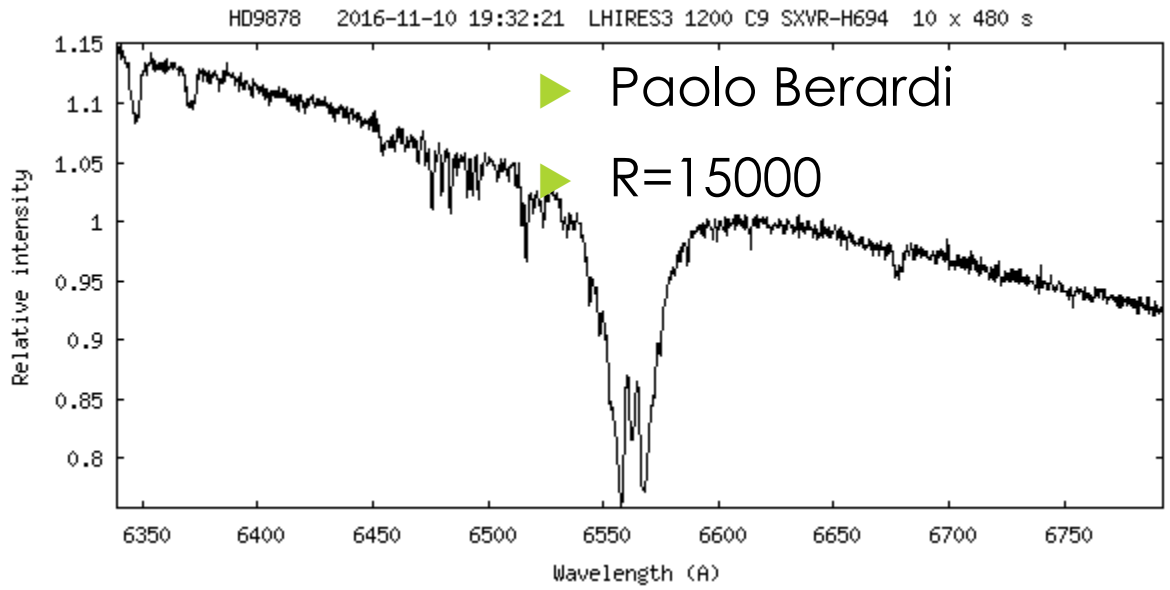
R=11000

HD9878



- Martineau Buchet
- R=1050

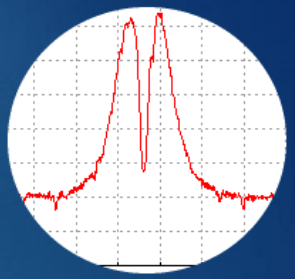




- Paolo Berardi
- R=15000

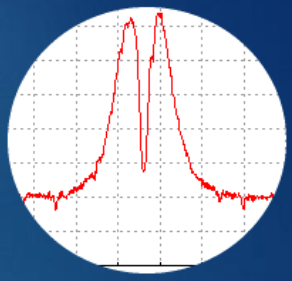
Vmag=6.7
B7V
H-K=0.03

What Next ?



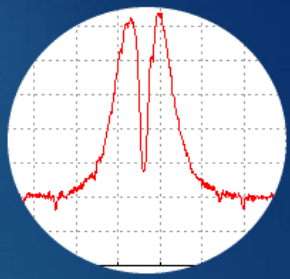
- Scientific interest ?
- Method Improvement ?
- How validate Be candidate as Classical Be ?
- Help wanted

Selecting more candidates



- spectral type O,B,A even F0
- All sky
- CDS database evolve, with the same request
  - October 2014 => 1382 objects
  - April 2017 => 1751 objects

A method to detect emission



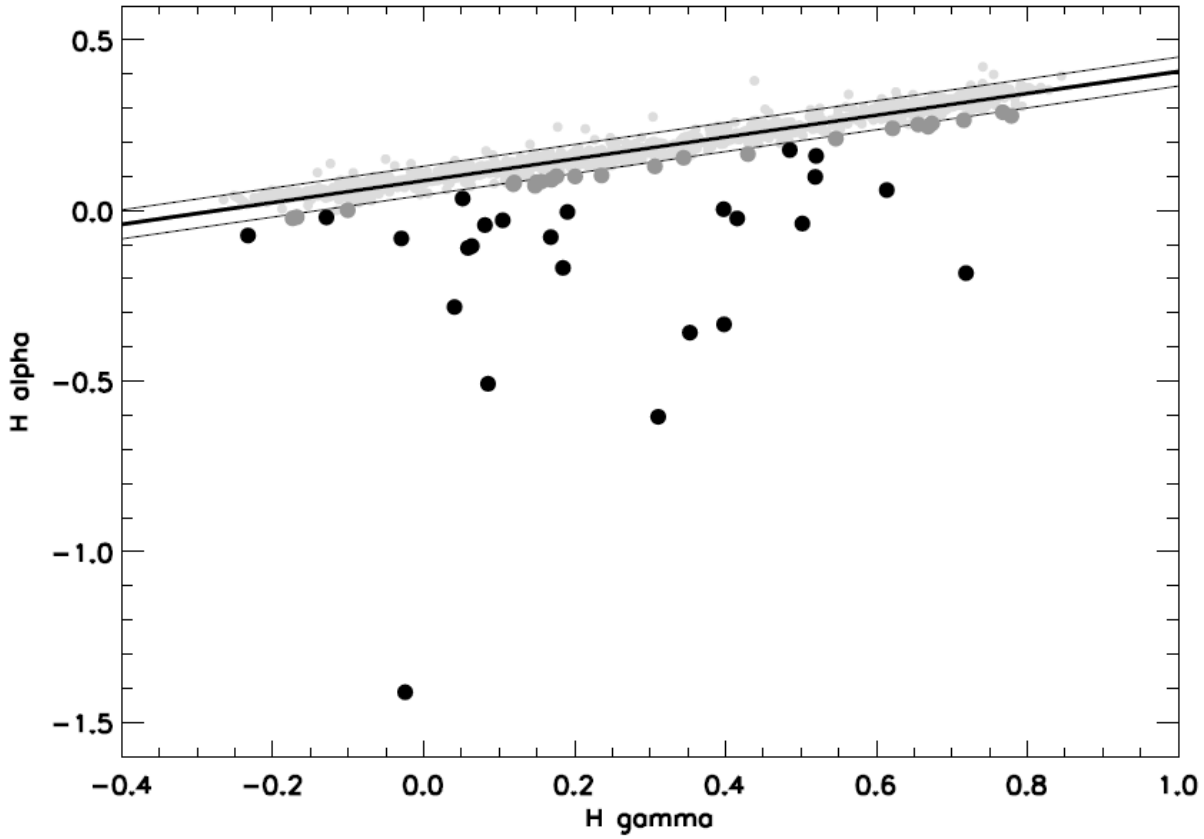
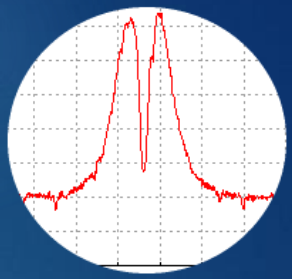


FIG. 1.—$I(\mathrm{H}\alpha)$ vs. $I(\mathrm{H}\gamma)$ diagram for stars in the spectroscopic sample, showing the linear relation fitted to the indices (*dark line*) and the 2 σ limits (*light lines*), the normal main-sequence stars (*light gray dots*), the candidate emission-line objects (*gray dots*), and the obvious emission-line objects (*black dots*).

Zoltan Balog, A&A, 2002
SPECTROSCOPIC SURVEY OF THE GALACTIC OPEN CLUSTER NGC 6871. I. NEW EMISSION-LINE STARS

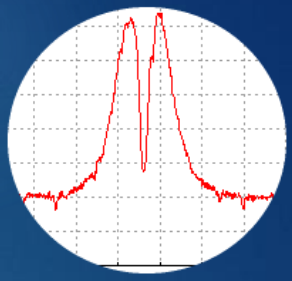
Relative equivalent width

Bibliography check



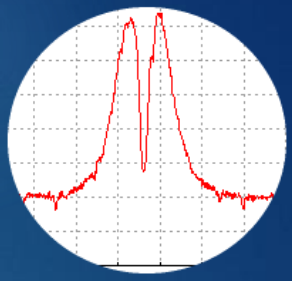
- Is the star present in Bess database ?
- Is the star tagged with emission in Simbad ? spectral type, e mean emission star
- Is star already published in other Be survey ?
  - APOGEE list http://arxiv.org/abs/1409.4668
  - …
- What is the spectral type from the Catalogue of Stellar Spectral Classifications (Skiff, 2009-2014)
- Check other CDS reference.

Is it a Be ? To Be or not to Be criteria



- Shows Balmer line(s) in emission (or has done in the past).
- Non super-giant star.
- High resolution spectra of Balmer lines does not show P Cygni or inverse P Cygni profiles.
- High resolution spectra do not show forbiden emission lines. [Be]
- Does not show a strong infrared excess. Allen & Swings 1976 AA 47 293-302 are quoted in The Astrophysics of Emission-Line Stars by Kogure & Leung as saying "The H-K color takes the values of -0.1 - +0.5 in ordinary Be stars."H and K value can be checked at CDS SIMBAD or 2MASS catalog.
- Does not have a Roche lobe filling companion.
- Does not have variability in which the circumstellar environment shows variability with strictly the same period as the photosphere.

Is it a Be ? To Be or not to Be



Data needs

- IR excess ?
  - photometry H-K
  - Other band infrared photometry
- UV discontinuity ?
  - UV spectrum, or photometry B-U
- Spectrum serie that show an outburst
  - Low resolution is sufficient for monitoring ?
- High resolution spectrum
  - One at SNR > 100
  - SNR 30, to confirm outburst

process

Millions of stars from CDS

Fulfil some criteria of Be star

Spectral type/ luminosity class

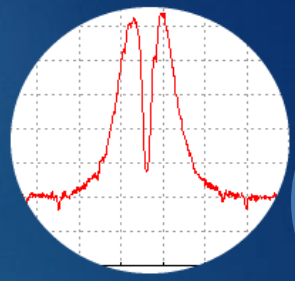
5000 stars to explore

Seen one time in emission

100 new Be candidate

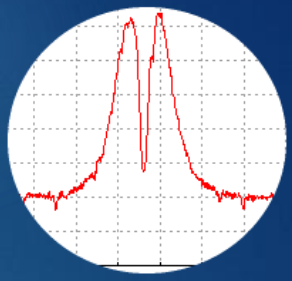
Observe More Collect data

Meet criteria



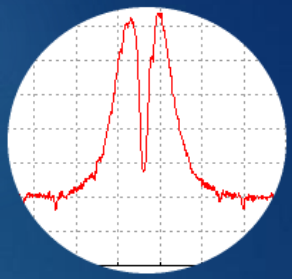
new Be In Bess

Who did it ?



Step	Who	Periodicity	
Define star to explore	Coralie	Each year	
Explore	Observer	6 month	Observer roles • acquisition • data reduction • emission detection
Validate as candidate	Coralie	On request	Biblio check
Observe candidate	Observer	1 month	
Validate as Be star	Coralie	6 month	

Reference



•The frequency of Be Stars, Jaschek, 1983 http://adsabs.harvard.edu/abs/1983A%26A...117..357J
•Classification of Be Stars, Jaschek, 1980 http://adsabs.harvard.edu/abs/1980A%26AS...42..103J
•APOGEE star list article http://arxiv.org/abs/1409.4668
•IPHAS Classical Be http://www.iphas.org/classical-be-stars/
•Review article: Classical Be stars, T. Rivinius & al, 2013, A&A Rev 21:69