Identification of Interesting Objects in Large Spectral Surveys Using Highly Parallelized Machine Learning

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Be Stars - Introduction

Gamma Cas (Padre Angello Secchi 1866)

(Pontifical Gregorian univ. - Roman College – Gregor XIII) – visual spectrograph

Be* have or have had emission in Balmer lines

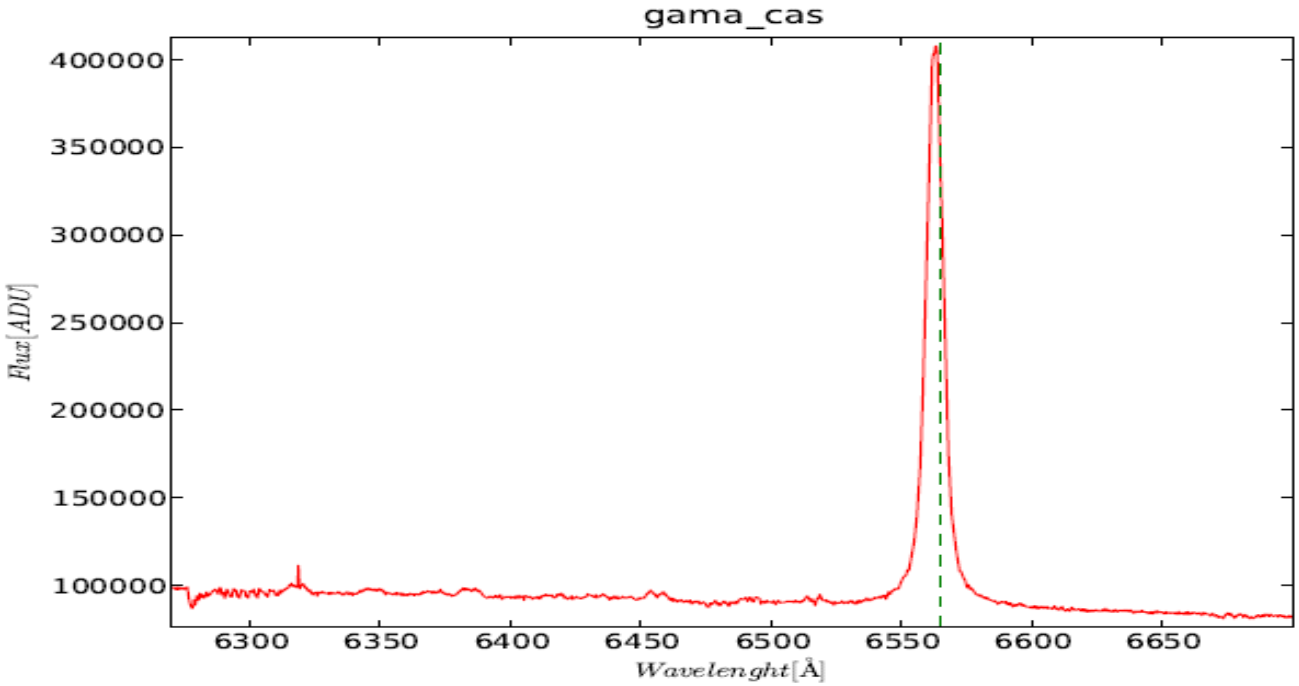
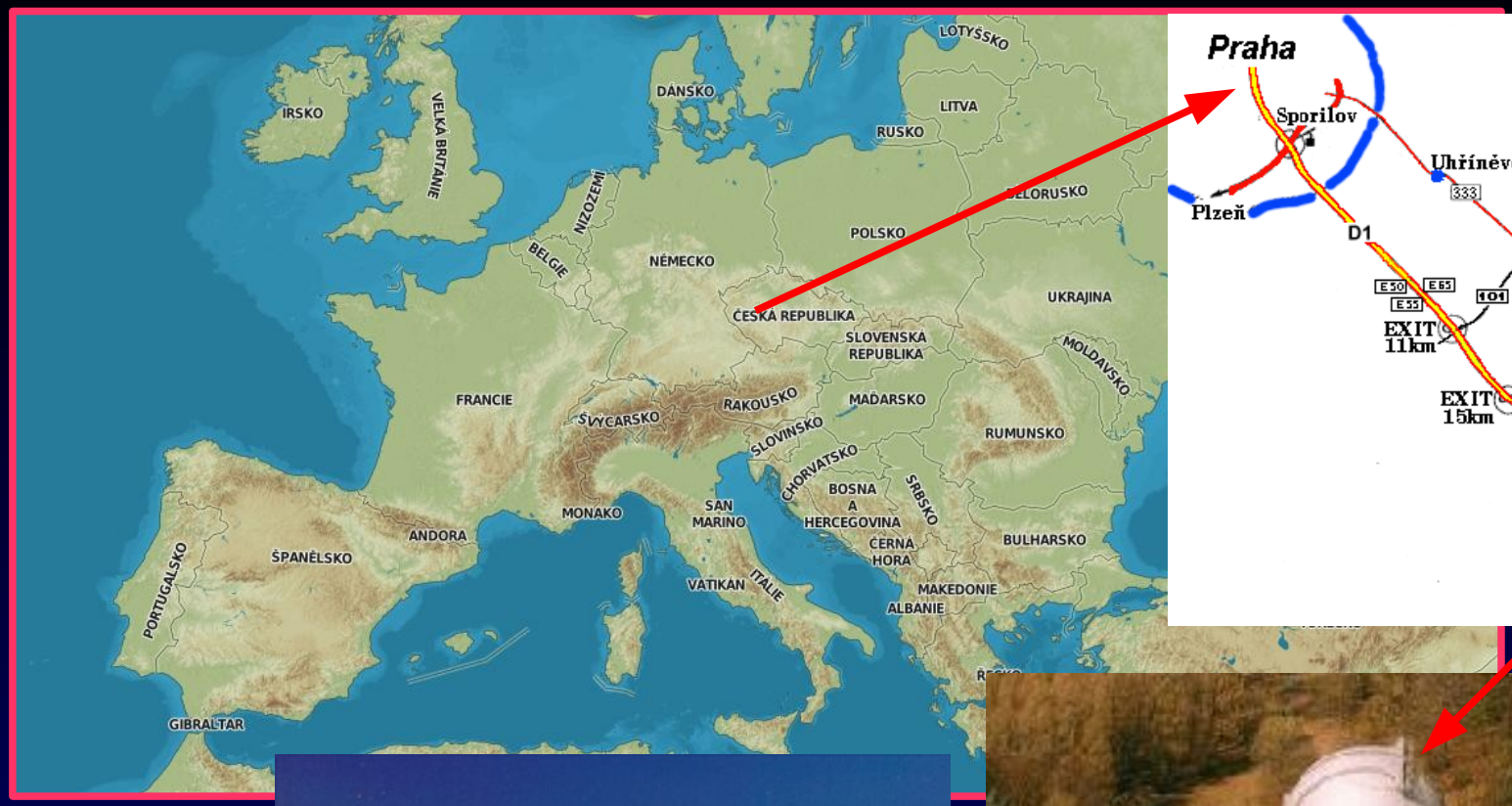
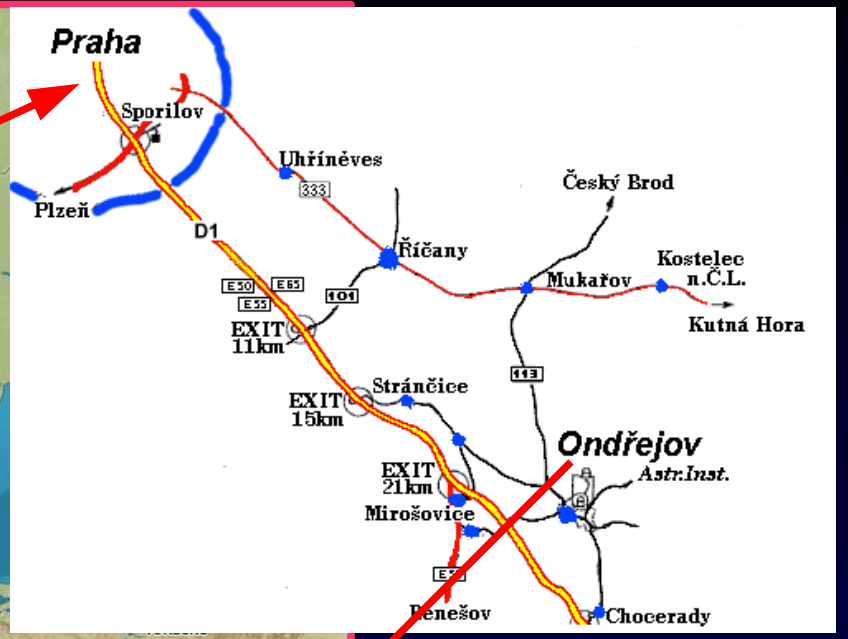


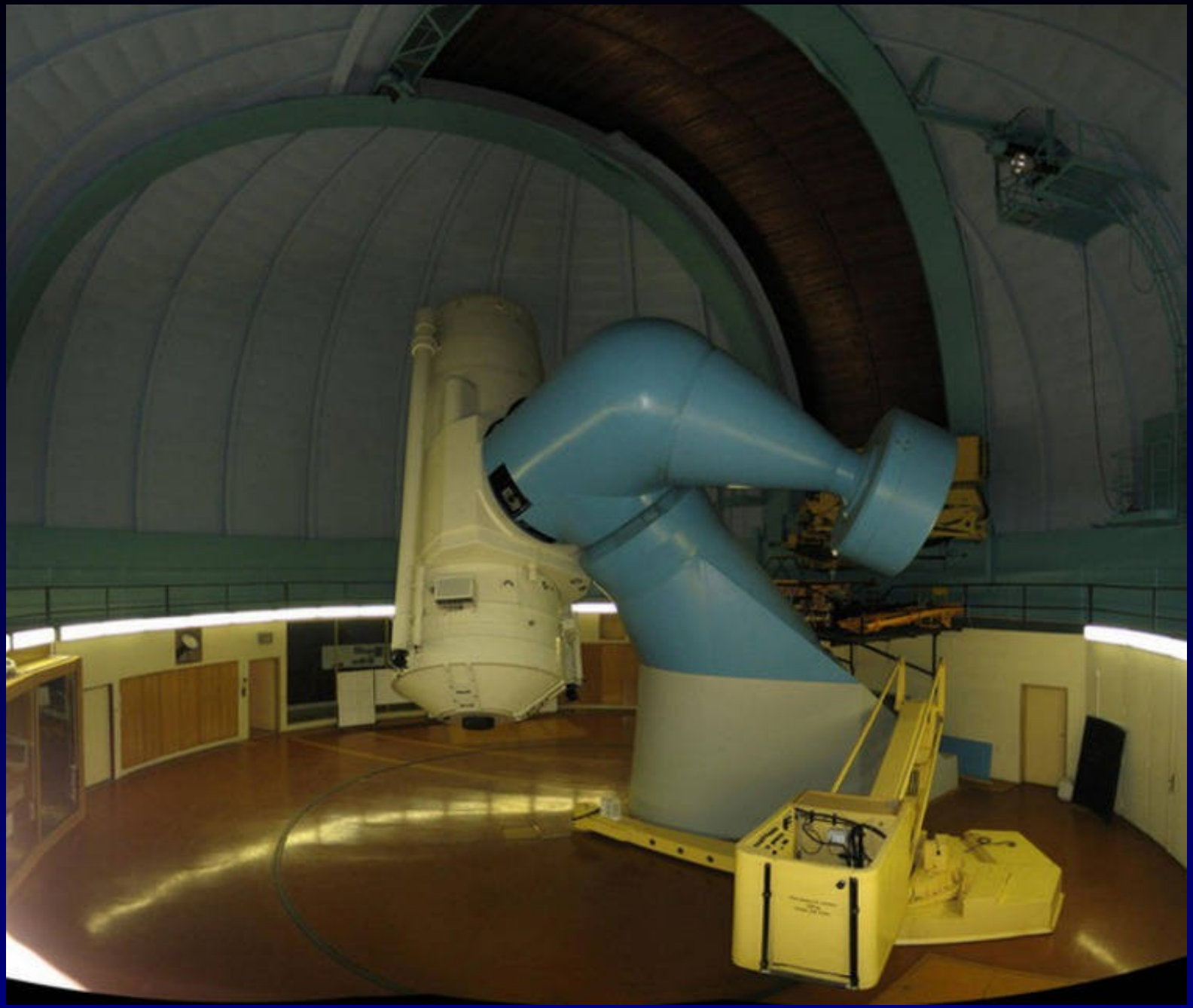
Figure 3.18: Spectrum of Gamma Cas. Be Star

Ondřejov observatory





Ondřejov 2m Perek Telescope (1967)



Motivations for Be Stars

The ~40 years of research in Ondřejov (data)

Be stars are mysterious (after >100 years)

Different time scales, quasi periodicity (not sure)

emission epizodes, can look normal (20% of B = Be!)

Zoo of line profiles (winebottle, abs+em, high em)

Transitions:

shell phase → emission, single → double peak

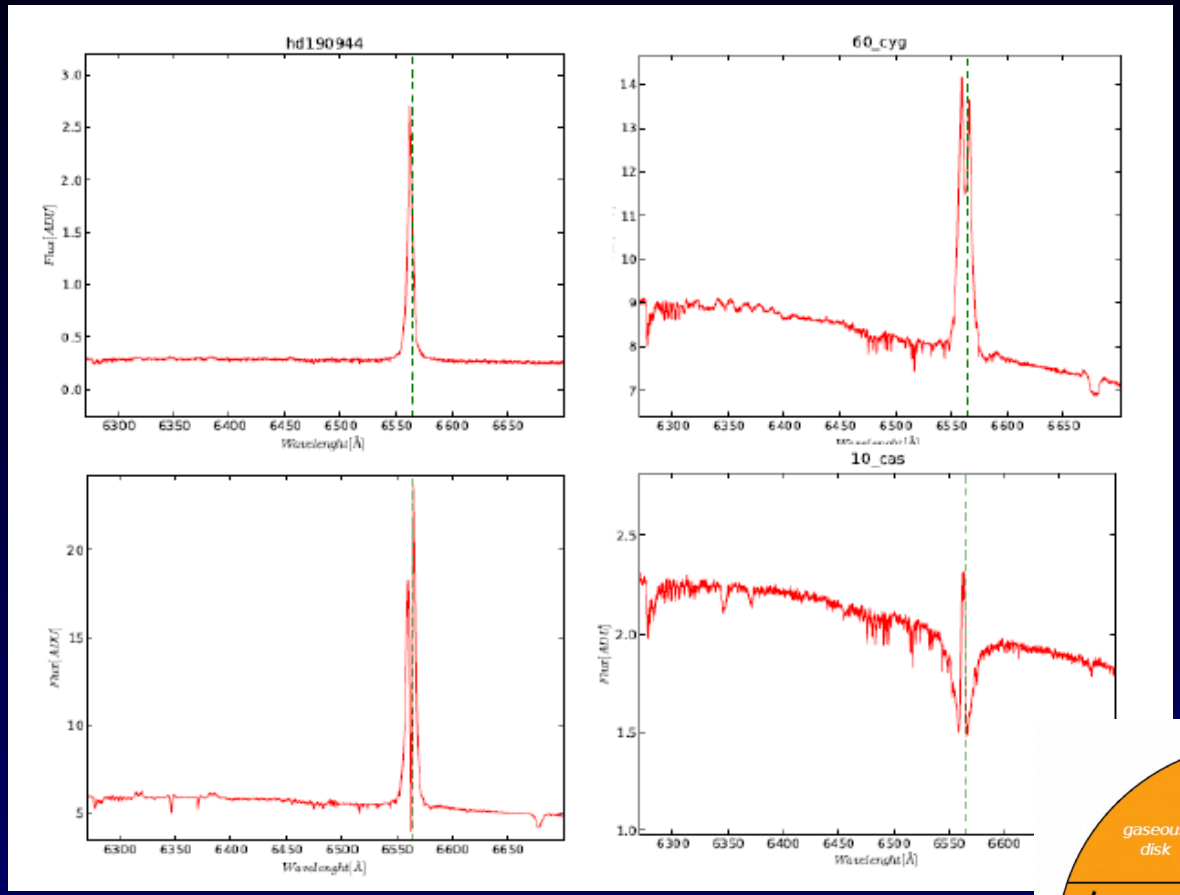
V/R changes (1/3 of double peak), some stable V=R

transition V/R var to stable (1-10s years)

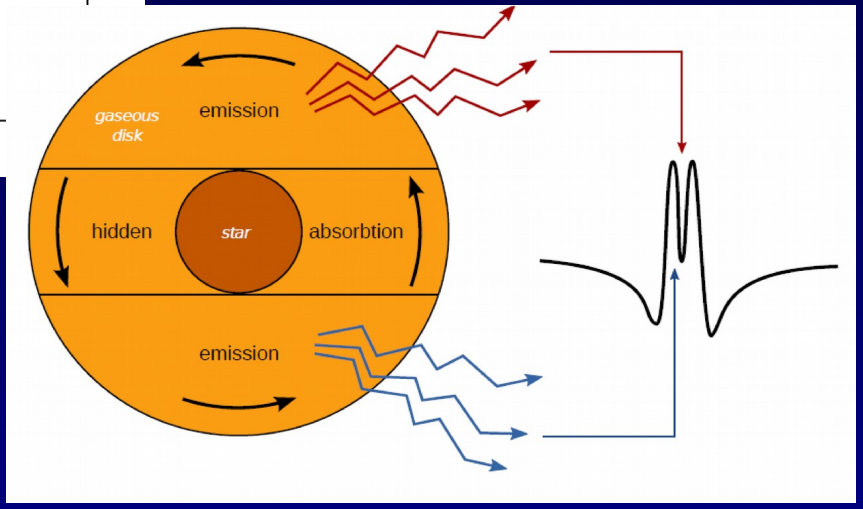
Chalenge for Machine Learning (and theory !)

Machine Learning of Spectra

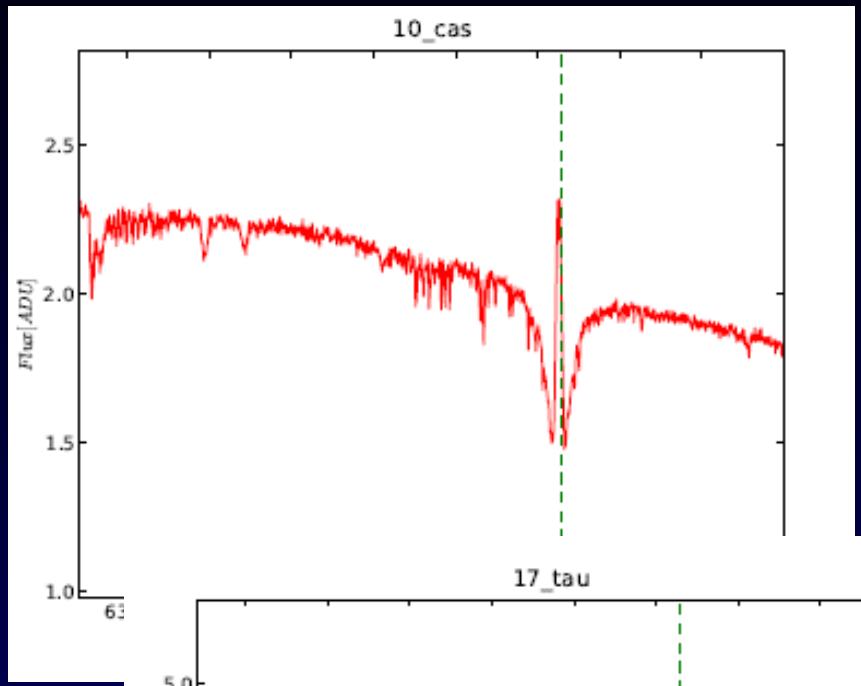
Use case: ML of spectra profile of Halpha line (Be stars)

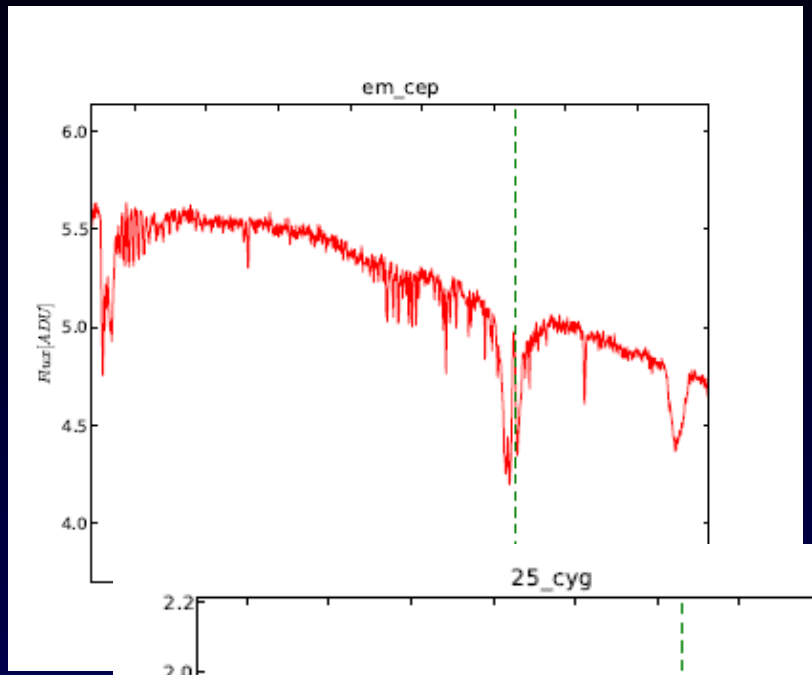


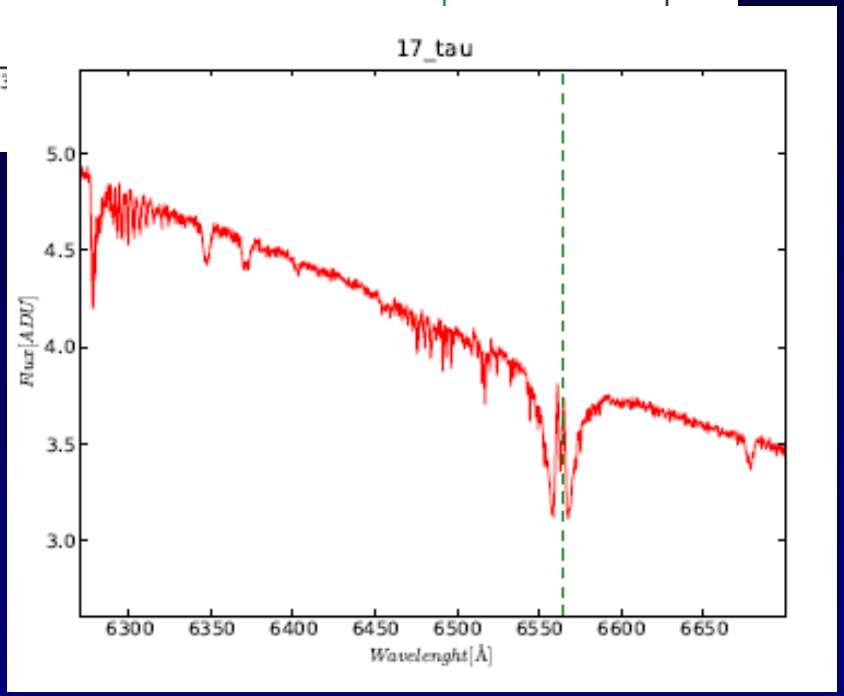
- Be stars
- Disk or envelope
- Rotates, Hot
- Origin ?????

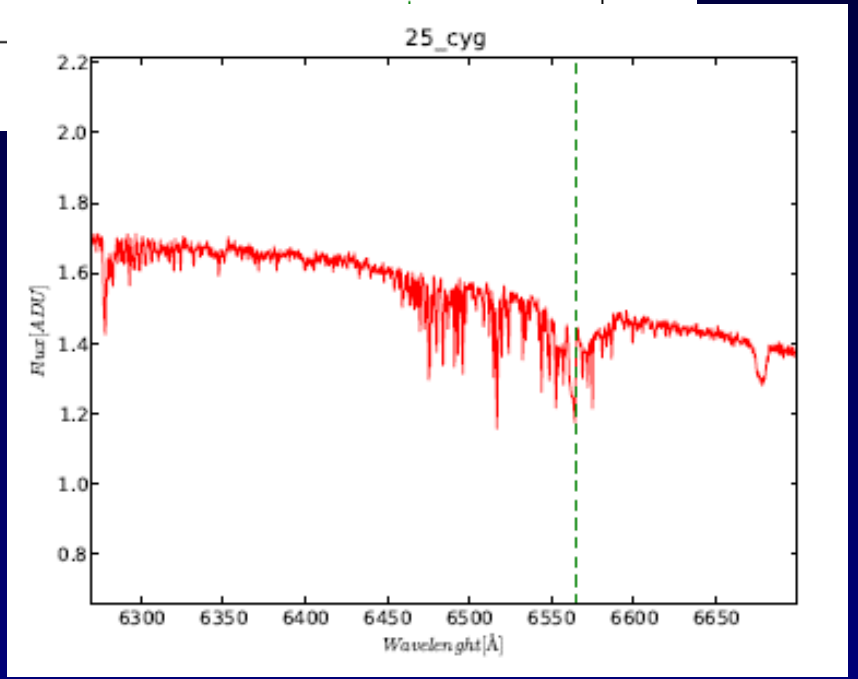


Be Stars : Emission in absorption

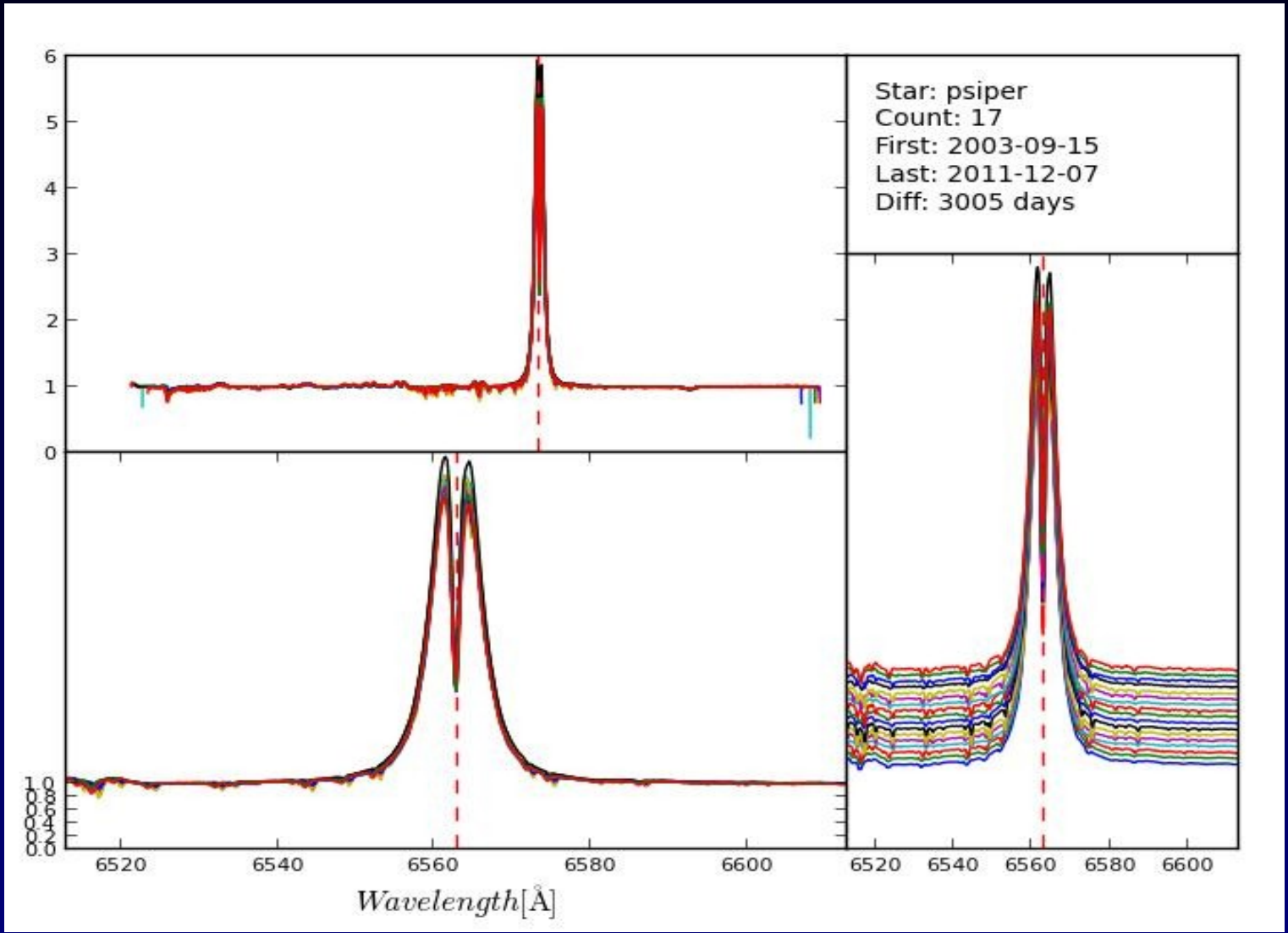








Ond2m Archive - Stable Emission



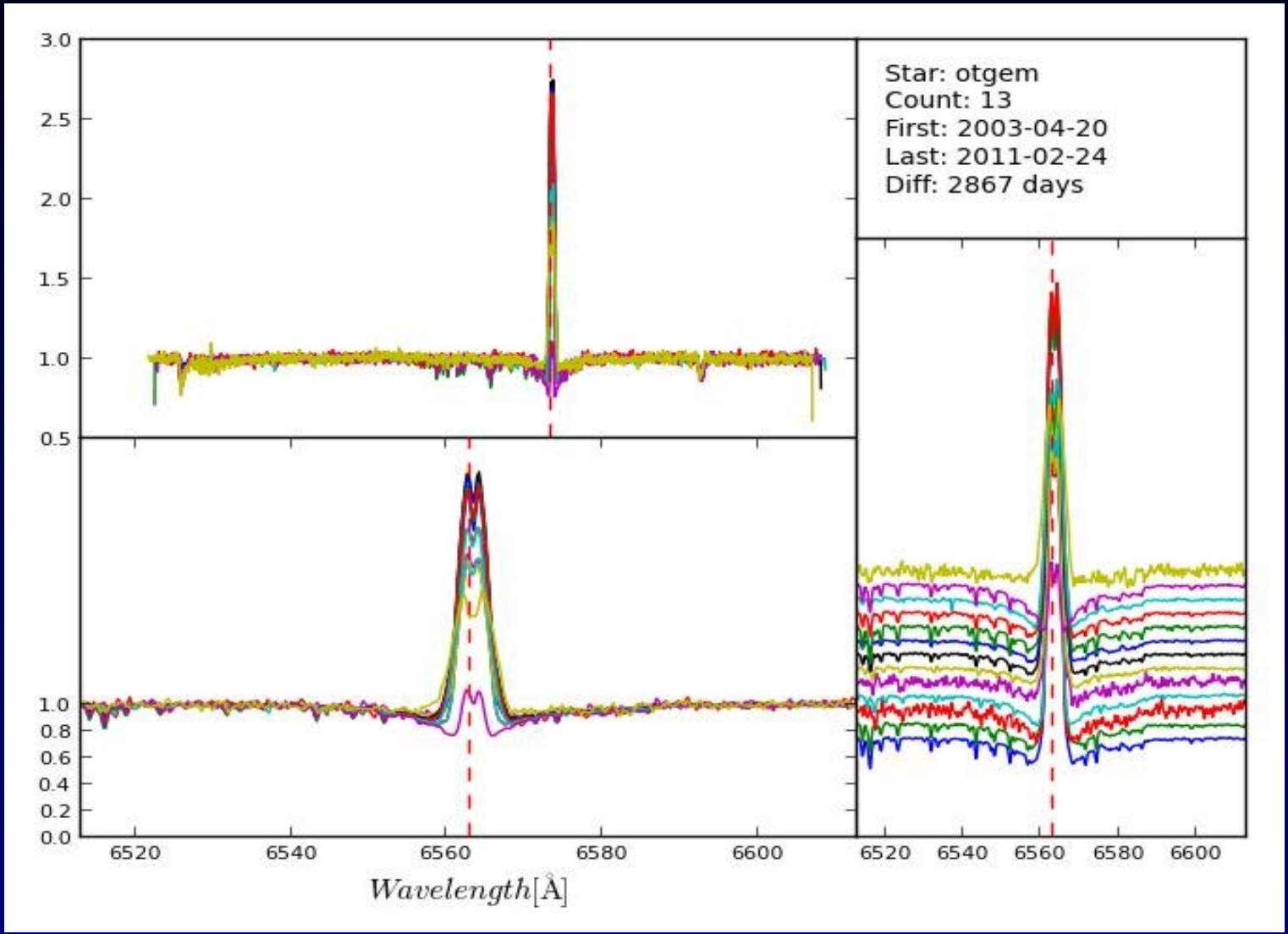
R=13000

12000 spectra of >1000 stars

Stable samples needed for ML

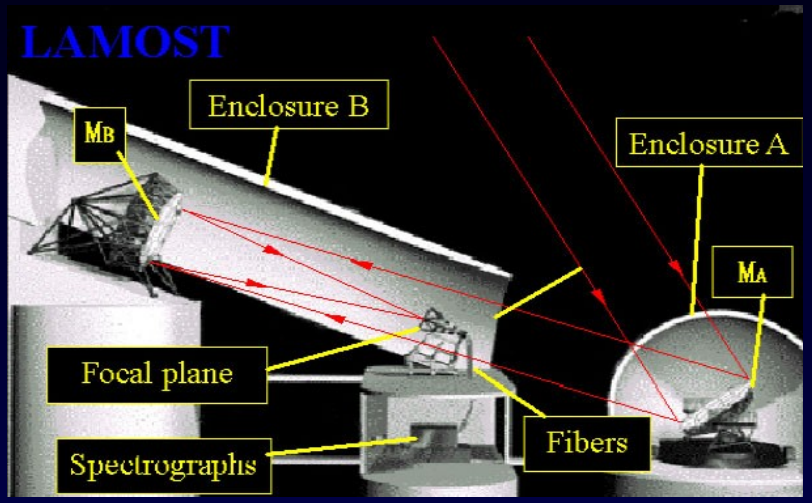
Selected 1600

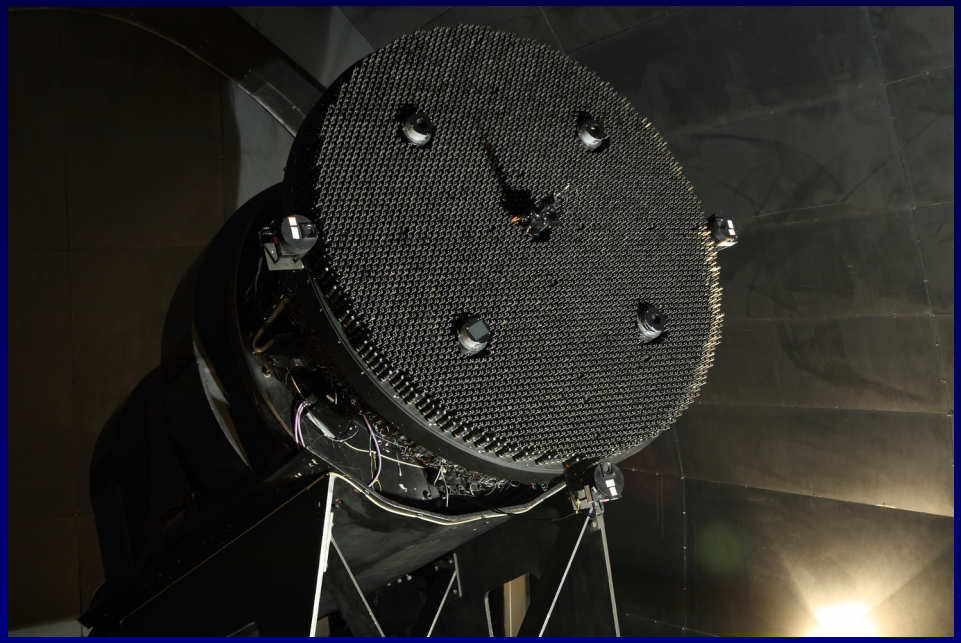
Ond2m Archive – Unstable Emission

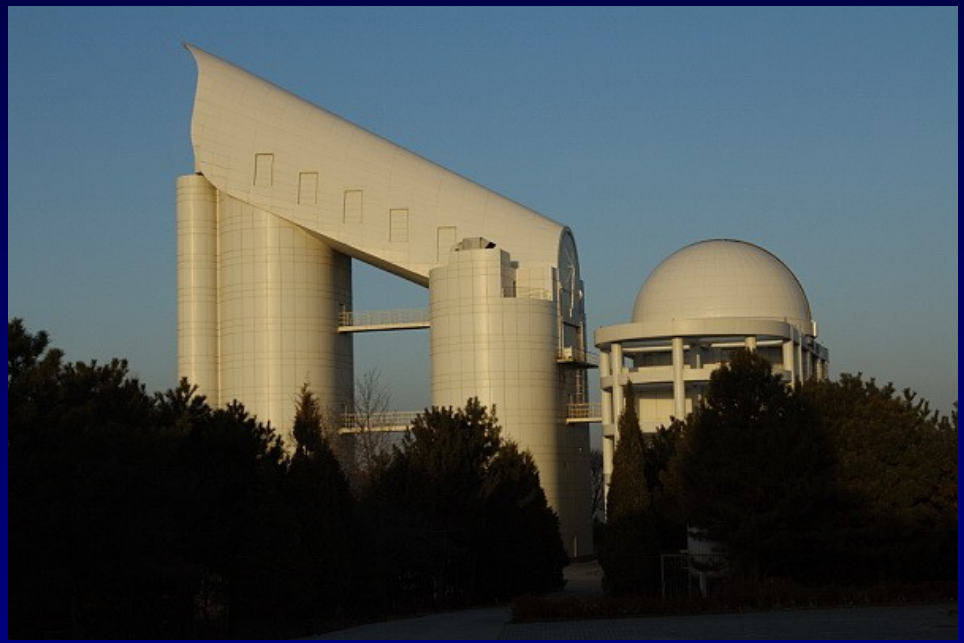


LAMOST (Guoshoujing)

Xinglong- China
4m mirror (30 deg meridian)
4000 fibers/16 spectrogr.
10 mil spectra / 5 yr
Automatic RV-z







LAMOST Spectral Surveys

DR3 (half 2015) **5 755 126** spectra
DR4 (Feb 2016) **+ 741 522**

3700-9000A R~500-5000
Limiting mag 19-20 for single exp.

Each Fiber – 2 motors
double arm 33mm circle

Fibre collects light from
3.3 arcsec circle on sky

LAMOST Spectral Surveys

DR1 (end 2013)

2 204 860 spectra including 717660 PDR

1 085 404 stars with estimated physical parameters

LEGAS extragalactic

LEGUE - galactic

3700-9000A **R~1800**

Machine Learning of Spectra

PRE-PROCESSING of LAMOST

Normalization to continuum (another FITS extension in DR1)

Cutout to Ond 2m archive range (6250-6700A)

Rebinning (same wavelegth points) + Renormalization [-1,+1]

(Reduction of dimensionality (wavelets, PCA, LLE...))

Produces feature vectors in CSV (same length, dimensions)

Machine Learning of Spectra

PRE-PROCESSING of OND 2m archive

Normalization to continuum (automatic algorithm)

Cutout to common smallest range (6250-6700A)

Convolution to LAMOST resolution (12000->1000 SRP)

Rebinning (same wavelegth points) + Renormalization [-1,+1]

(Reduction of dimensionality (wavelets, PCA, LLE...))

Produces feature vectors in CSV (same length, dimensions)

AND LABELS (1,0) – has interesting emission

Domain Adaptation

Convolve(OND2m) → LAMOST Simulated

Domain Adaptation - not Supervised Training

Learn from labelled D1- the model learnt applied on D2

In our case WE KNOW THE MODEL - spectrograph SRP

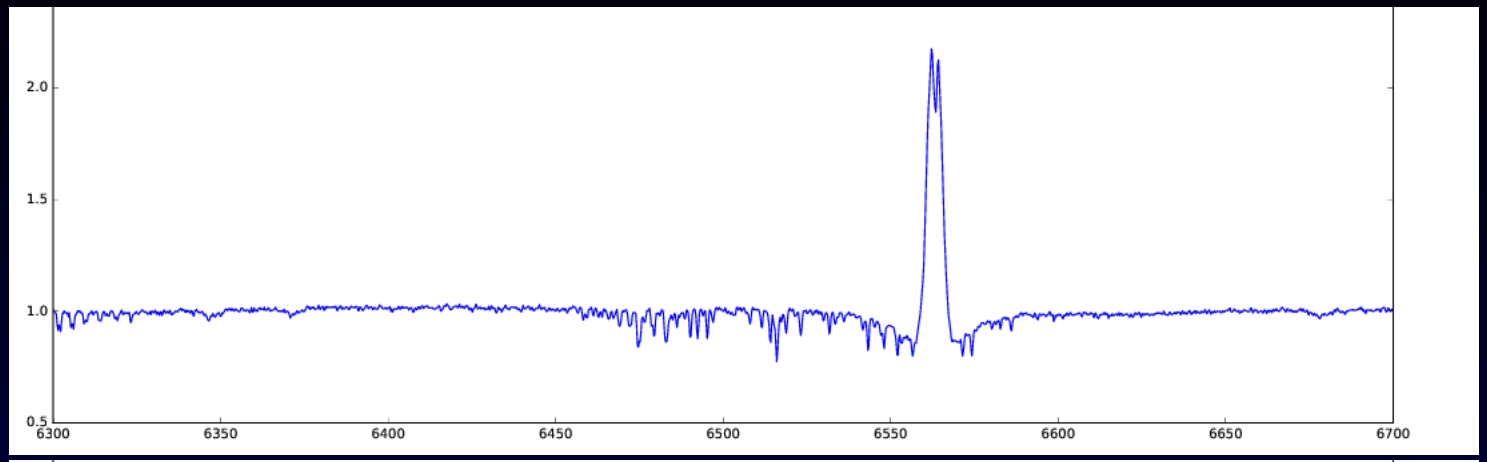
Degradation of resolution

(simply Gaussian profile convolution ~ 6 pix)

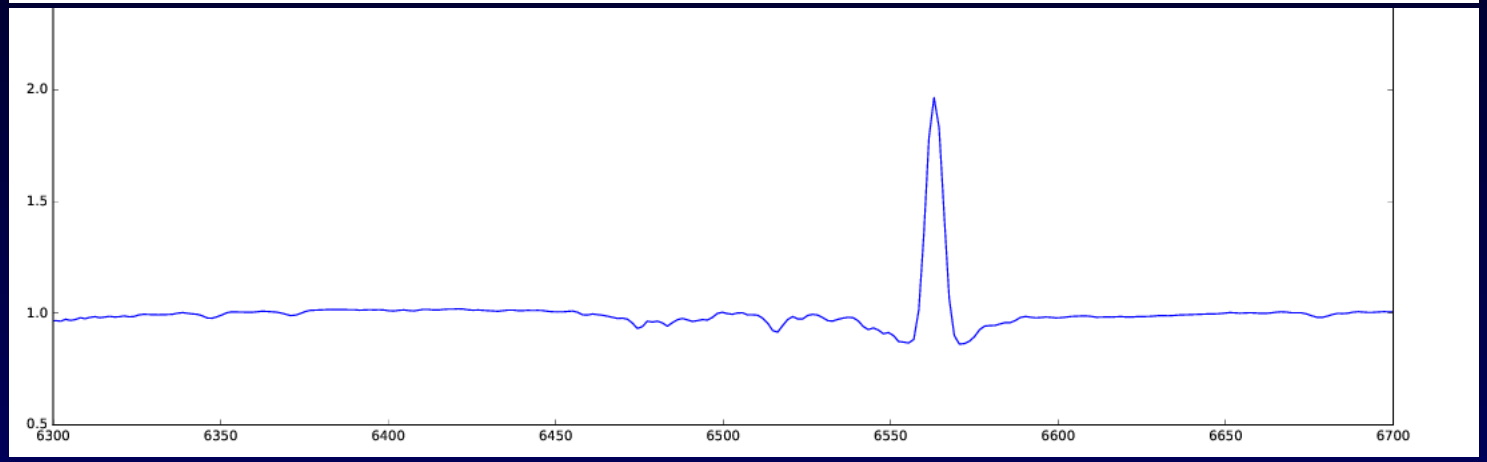
Test: Cross-matching Ond2m with LAMOST (using VO)

Found several stars observed in both archives

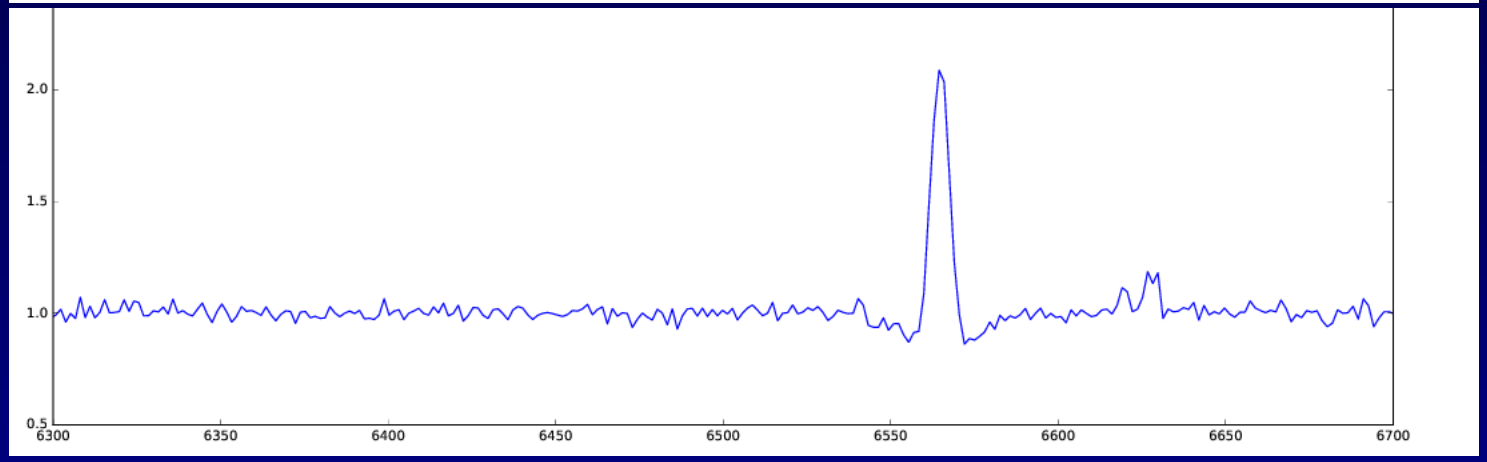
Resolution Degradation



OND R=13000

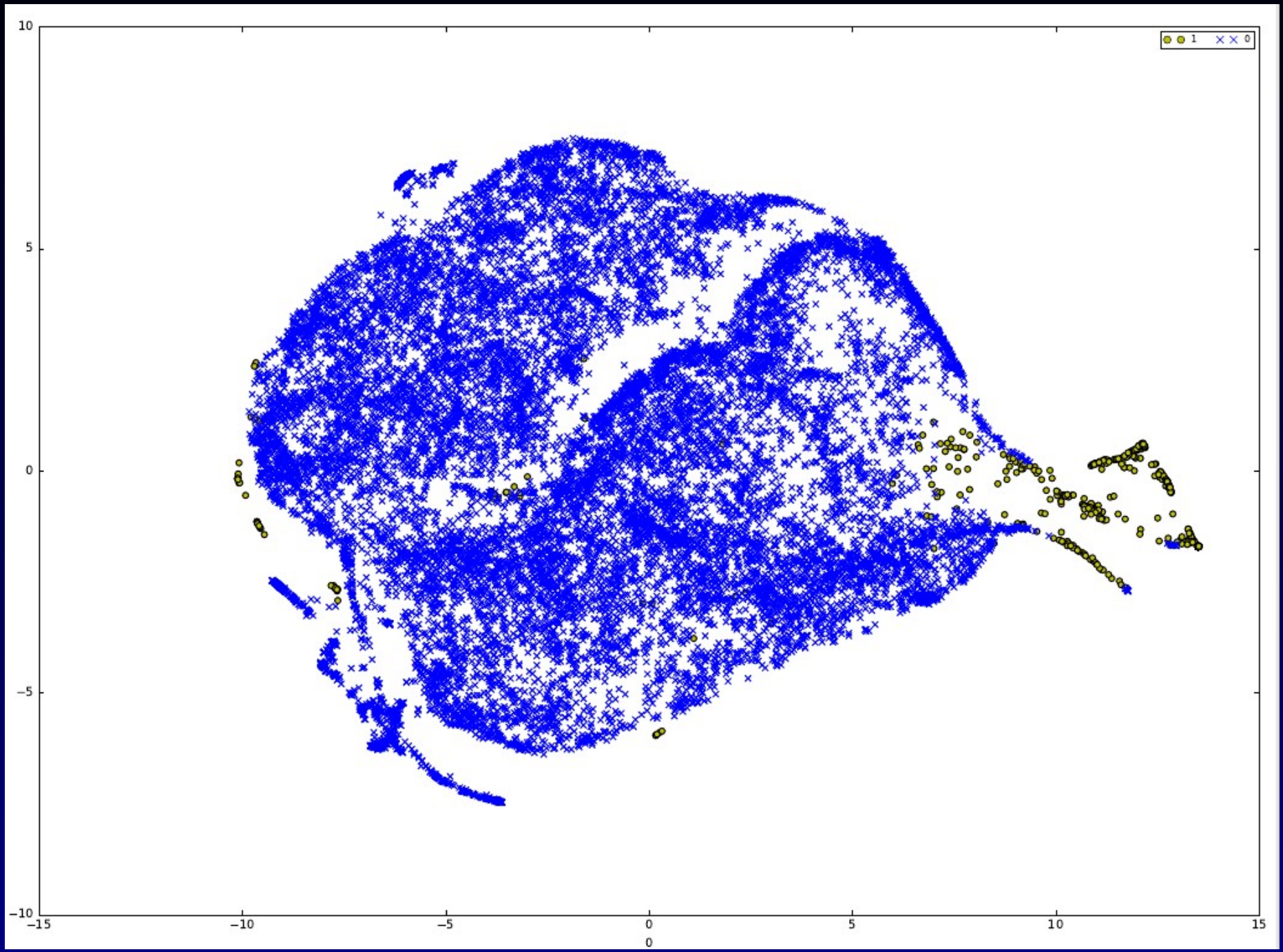


OND R=1800



LAMOST

TSNE Structure



Semi-Supervised Training

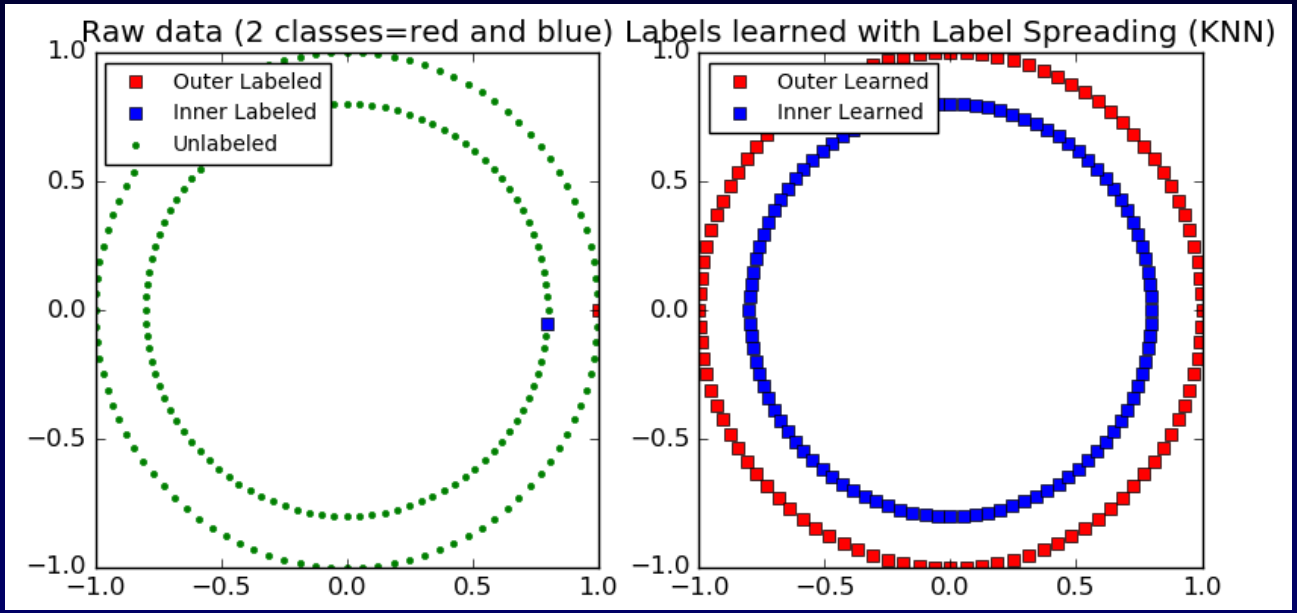
Not supervised (even if not Domain Adaptation)

- sample of labelled data - about 1600
- unlabelled (LAMOST) - HDFS limit to 1,048,576 (2^20)

Graph methods:

Label spreading

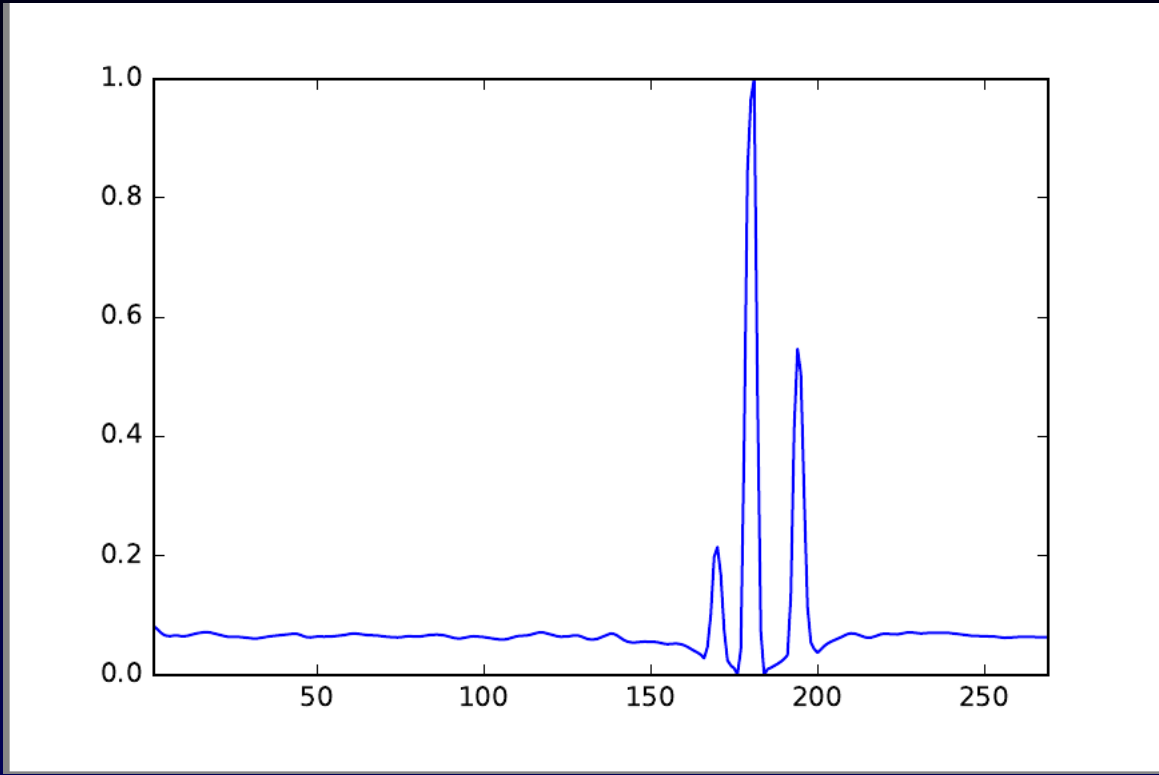
Label propagation

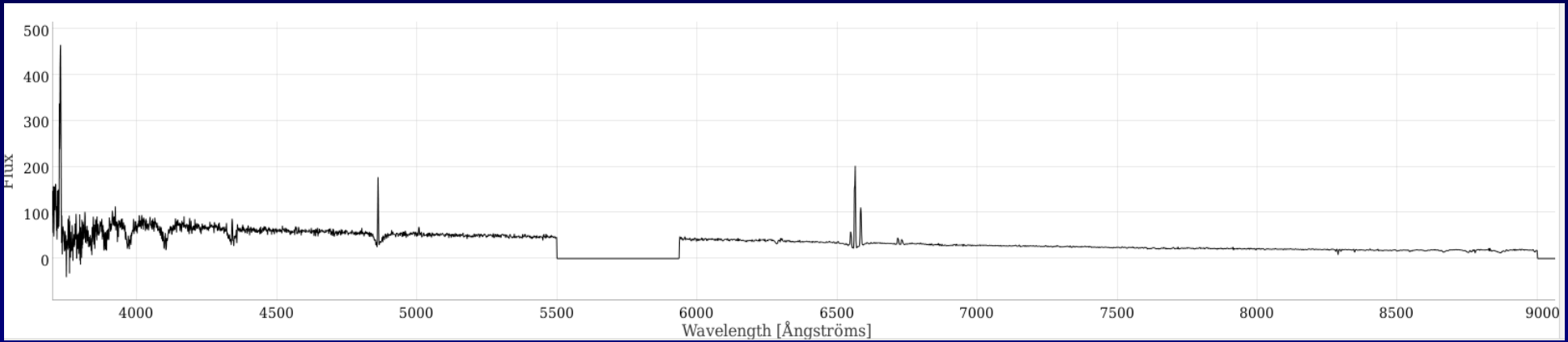


Spark on HDFS - National cloud MetaCentrum

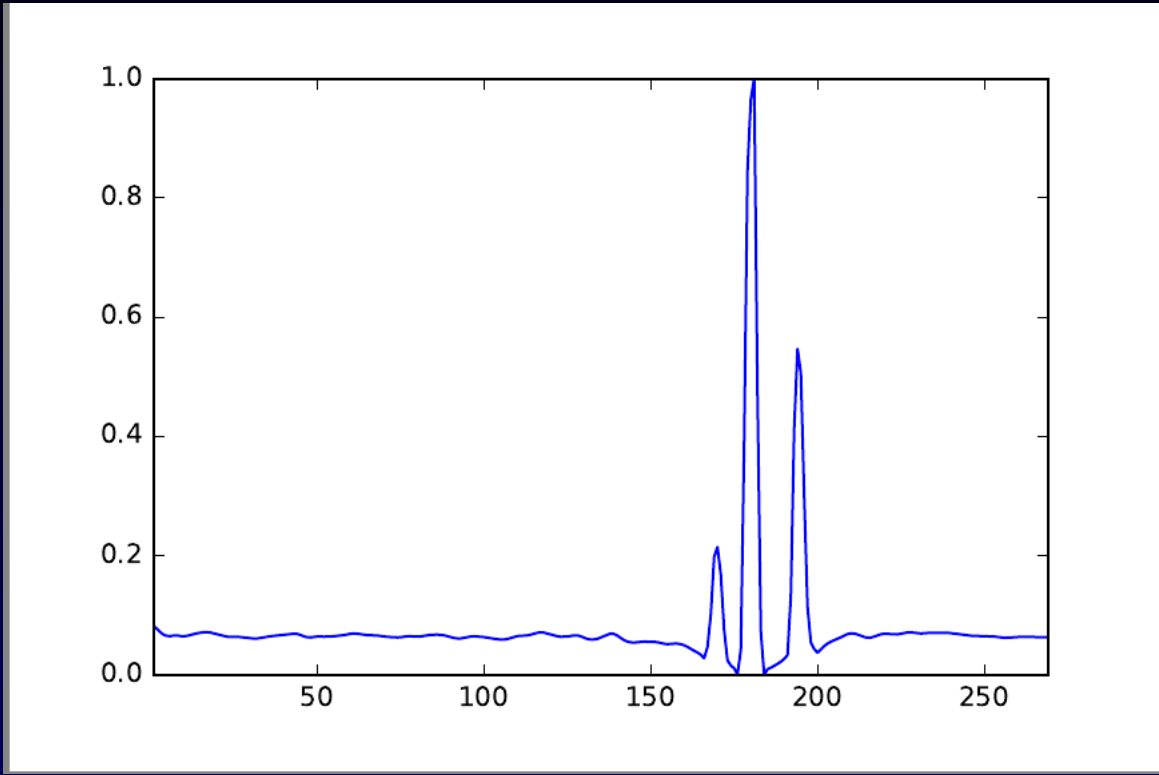
24 x16-core nodes ~ 380 nodes (real load dependent)

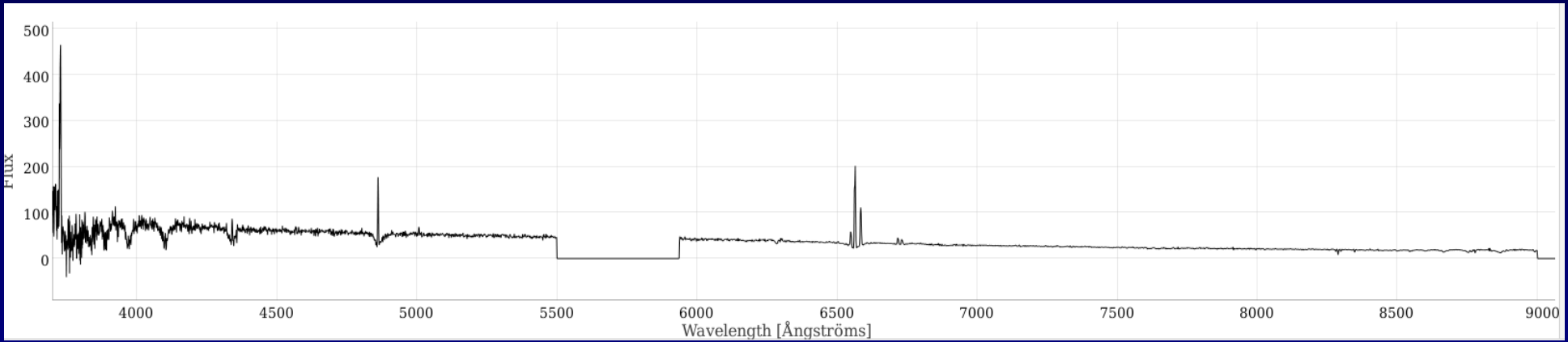
Be Candidates Foud



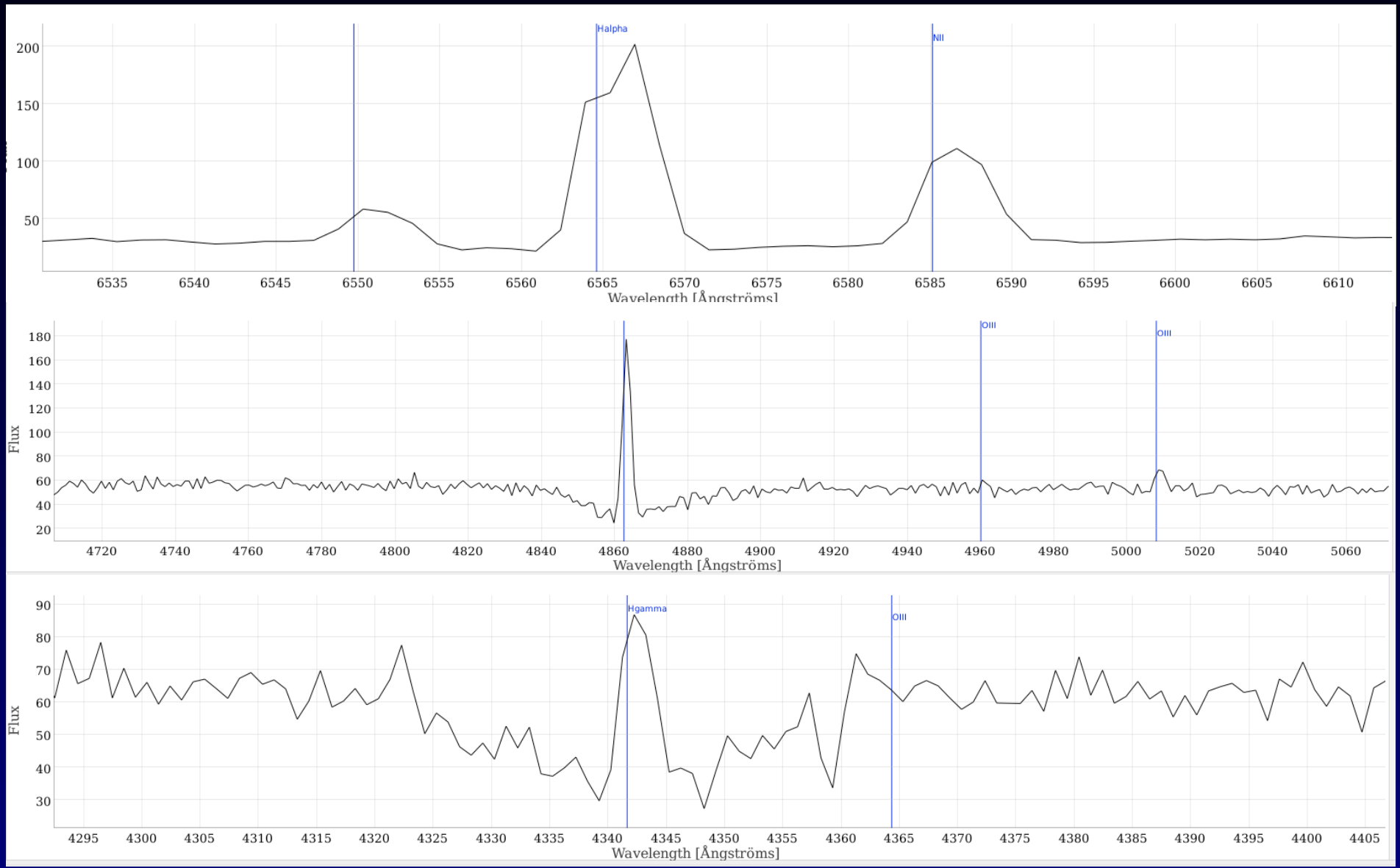


Be Candidates Foud





Be Candidates Found



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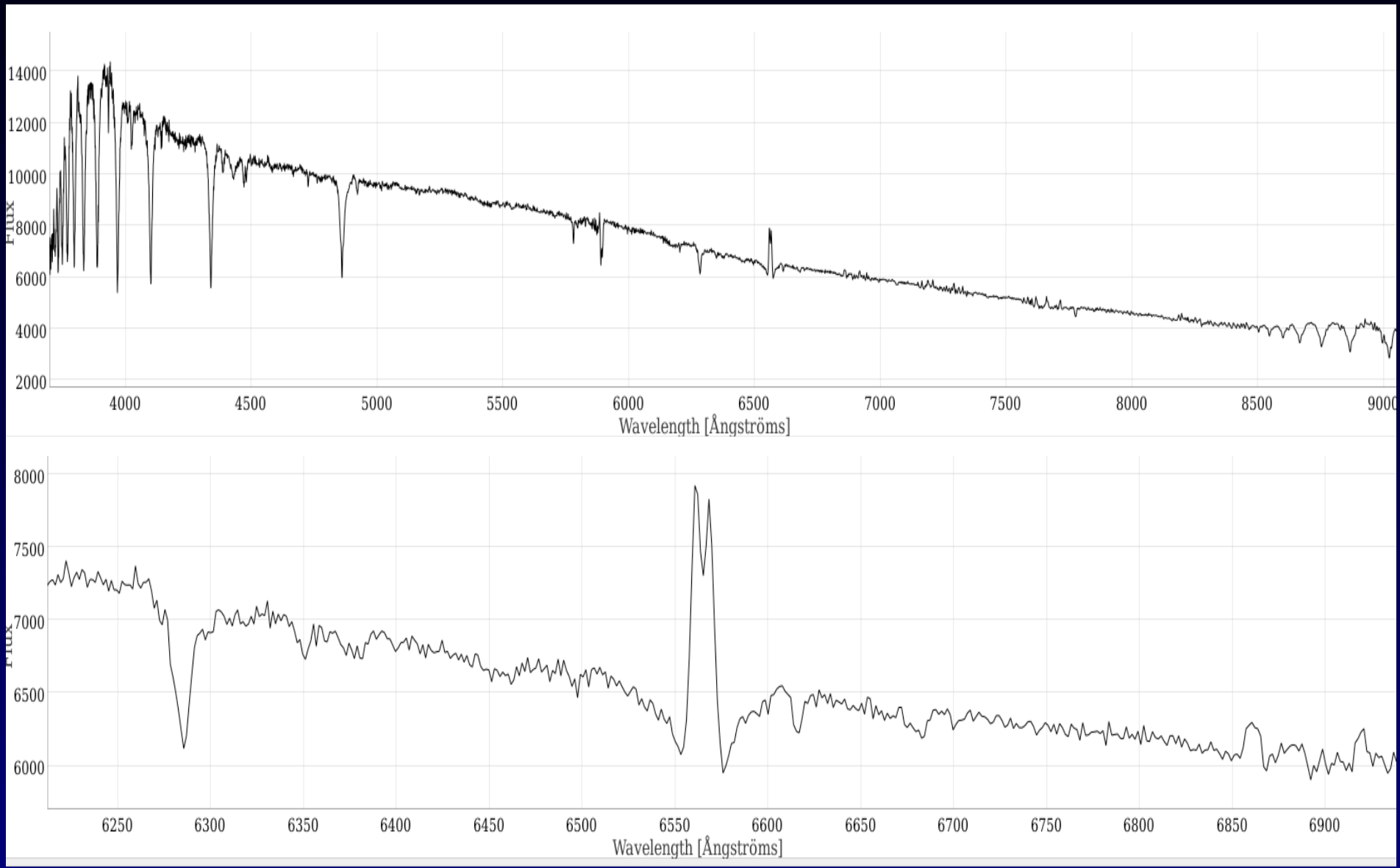
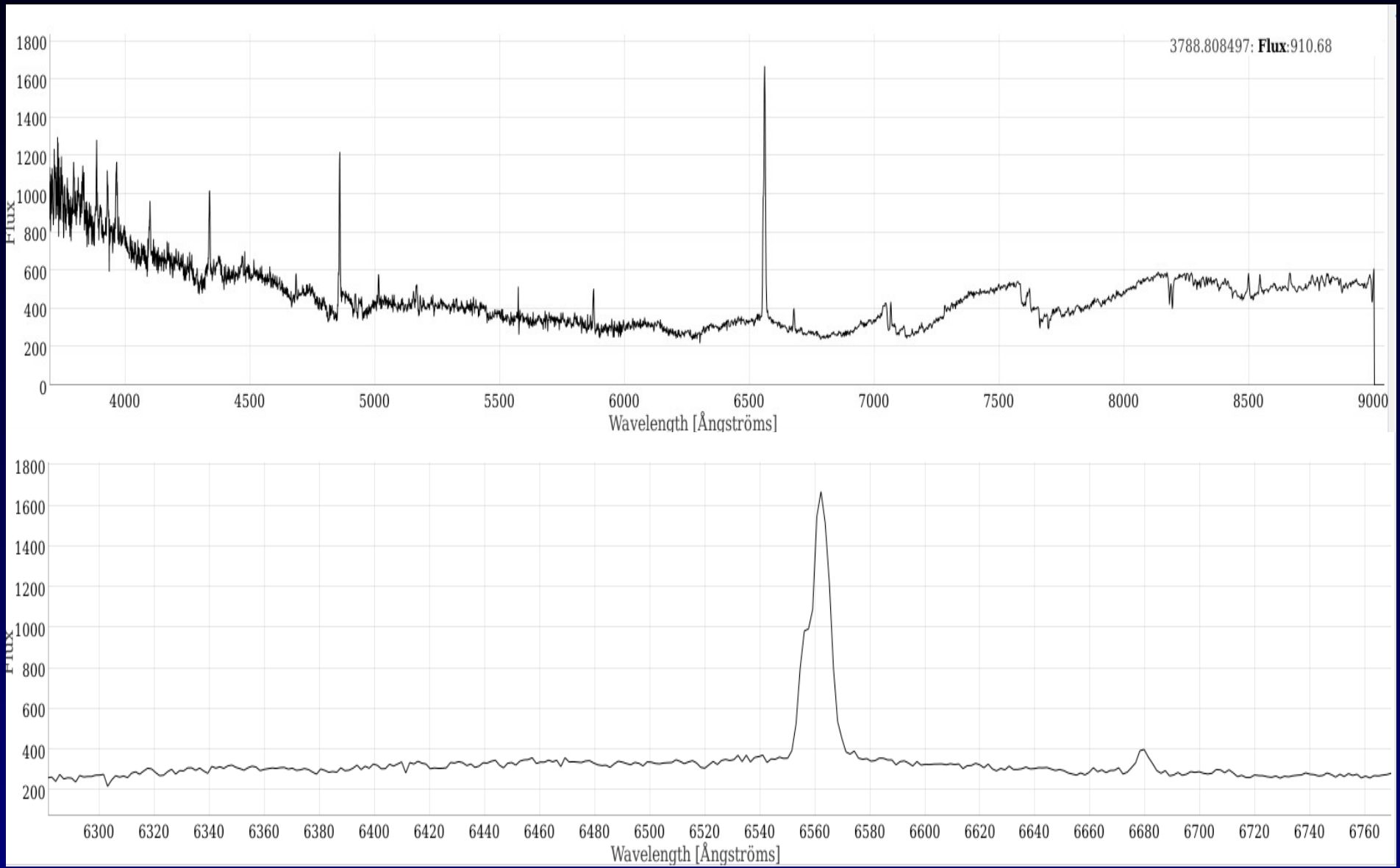
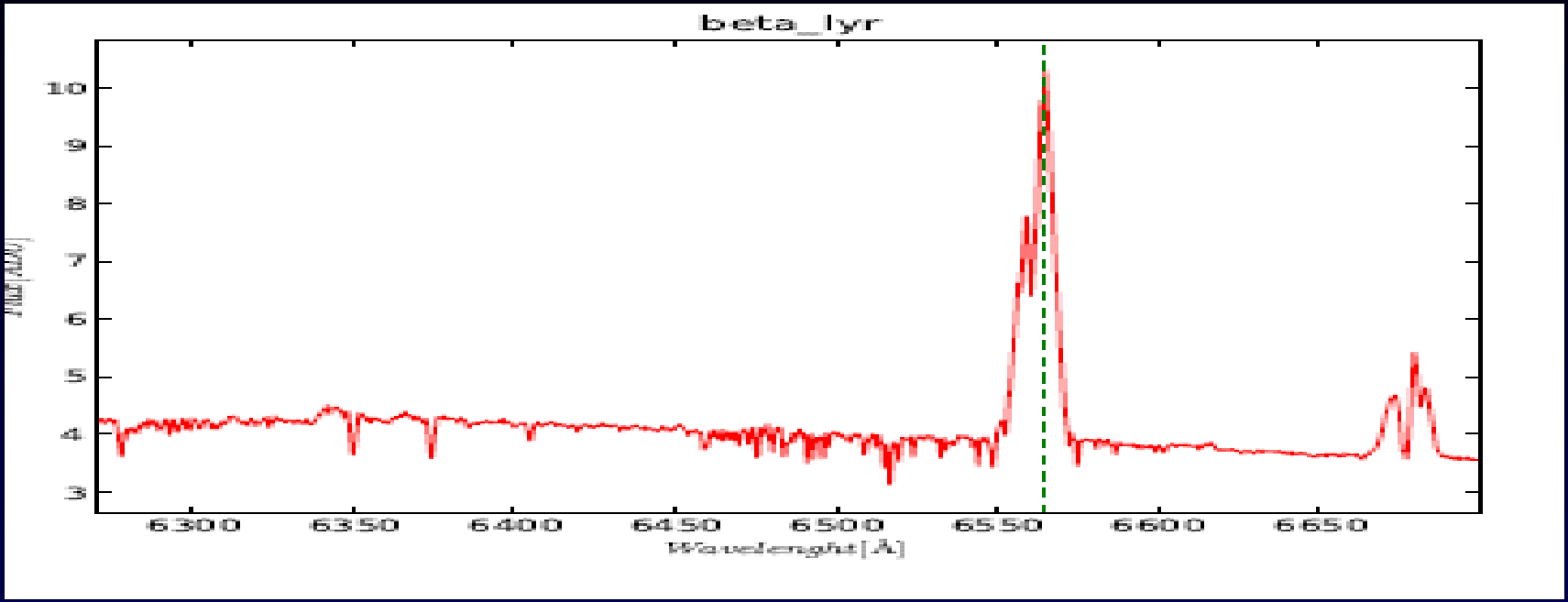
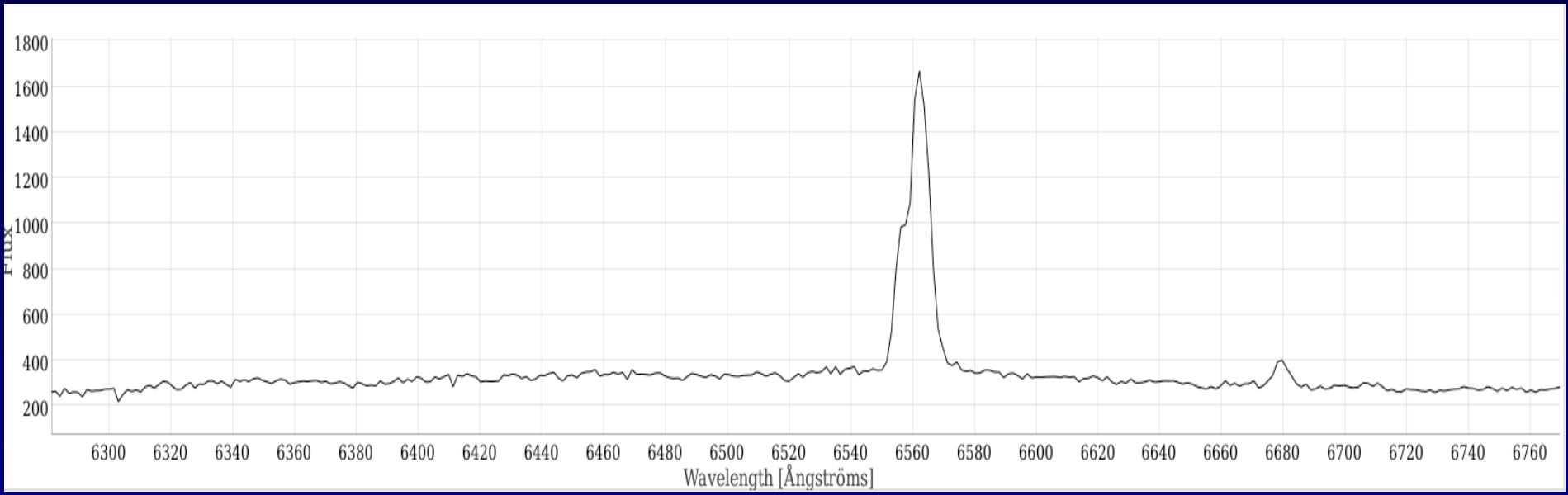


Be Candidates Found

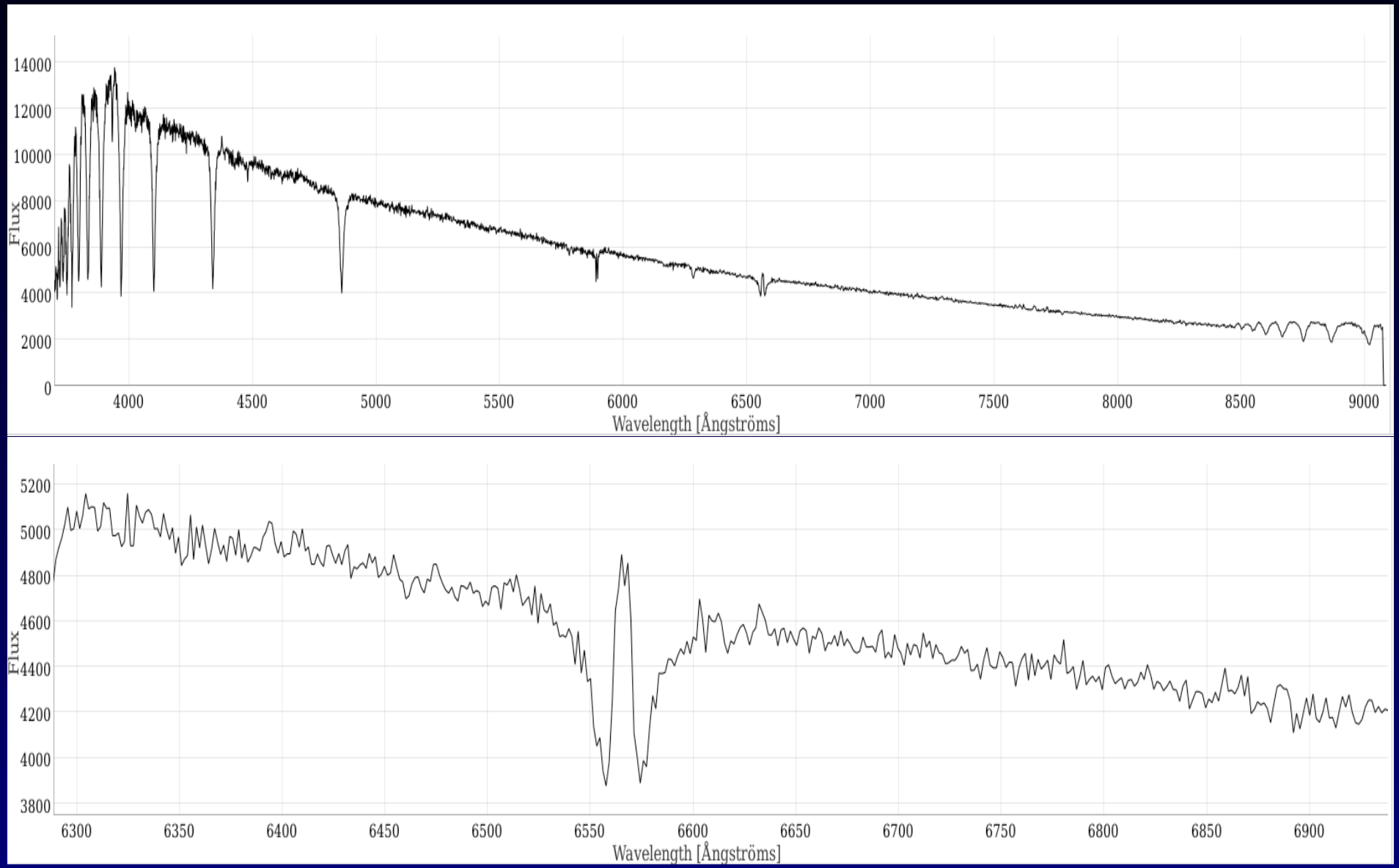


Be Candidates Found

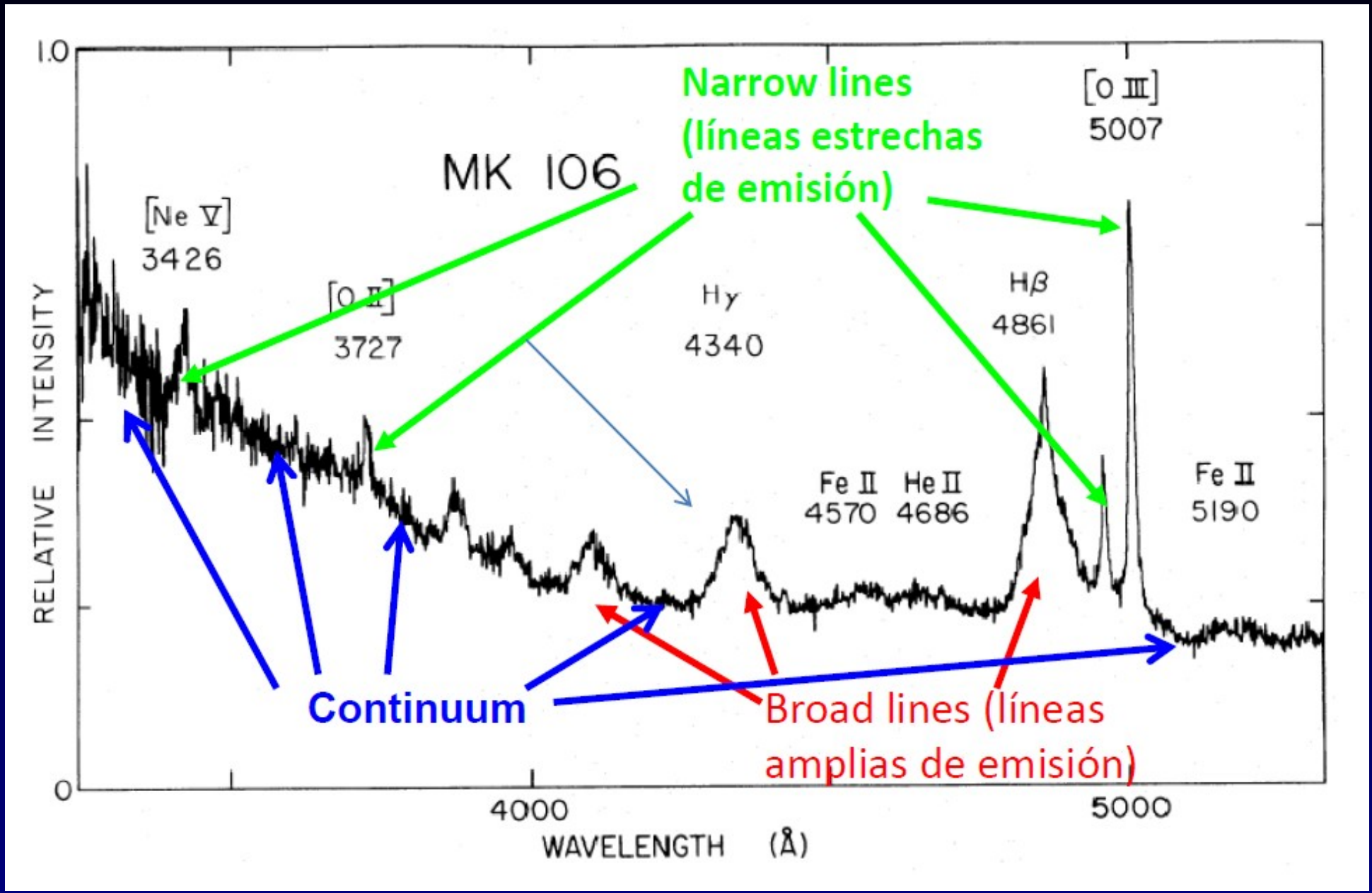




Yet Unknown Be Star

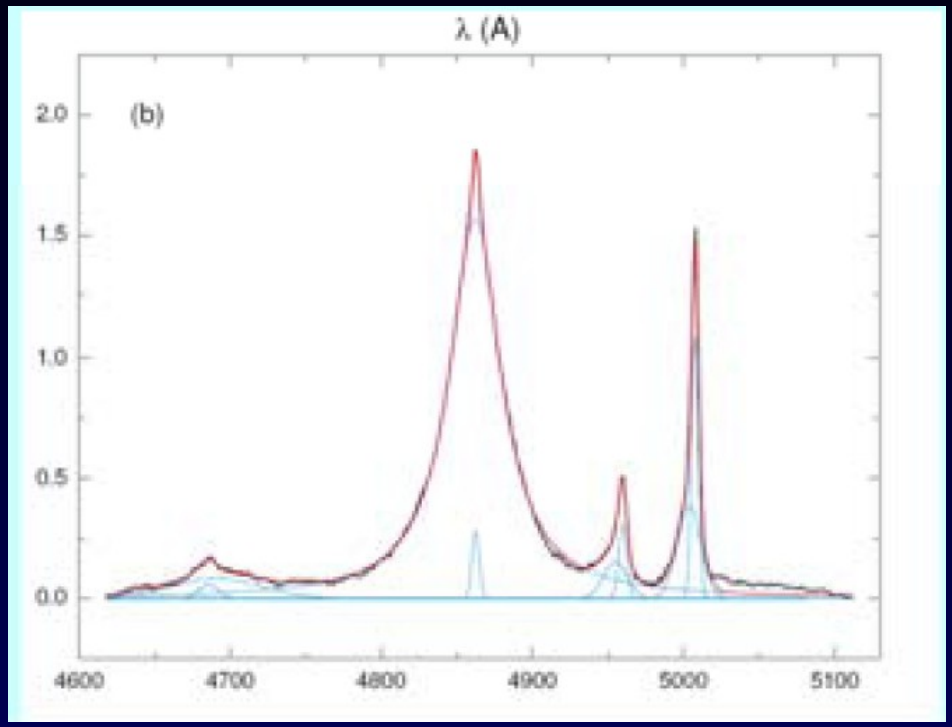


AGN Spectrum

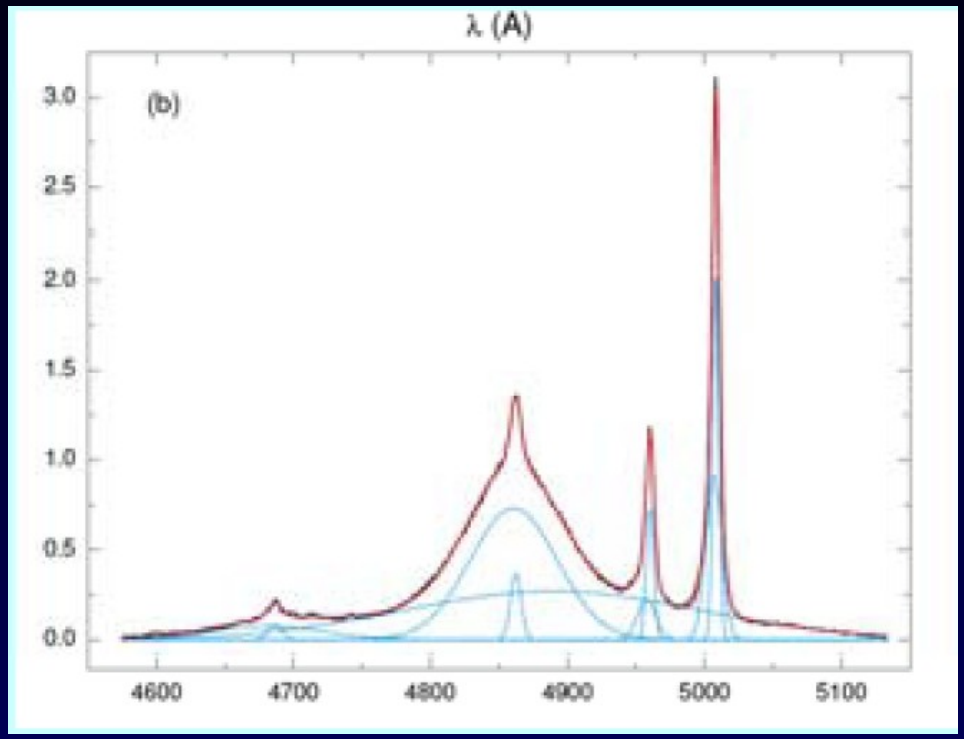


Gaskell 2009

AGN Populations



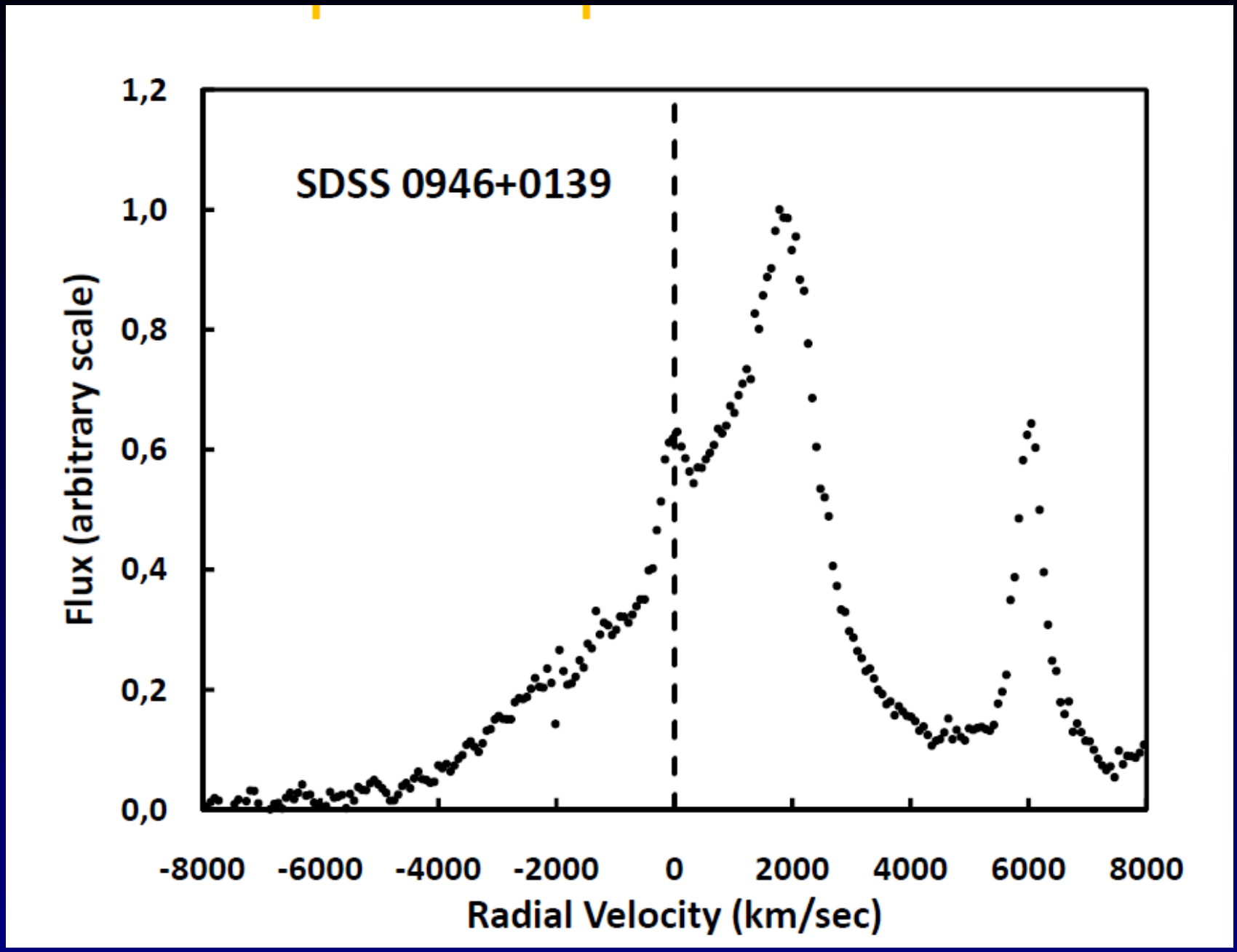
Population A



Population B

Sulentic et al. 2002

Extreme AGN Spectra



Virtual Observatory inside

- OND 2m archive on SSAP protocol (spectra access)
- LAMOST DR1 on SSAP (using DaCHS)
- Preprocessing (rectify, cutout) – DataLink on server
- SAMP (send spectra to SPLAT-VO - view details)
- Visualization of results

- VO-CLOUD – cloud engine based on UWS REST jobs
- Cross-matching (ADQL, TAP, TOPCAT, TAPhandle, pyVO, Vizier)

Conclusions

- Machine learning on big spectra archives may identify new interesting objects yet unknown
- Crucial is interactive visualization of candidates
- VO technology helps in every step

- Future vision – New VO-Cloud
  - Maintains search, acquisition and processing parameters
  - Distributes work on Spark /HDFS
  - Visualizes candidates + original spectra
  - VO server using metadata in CSV