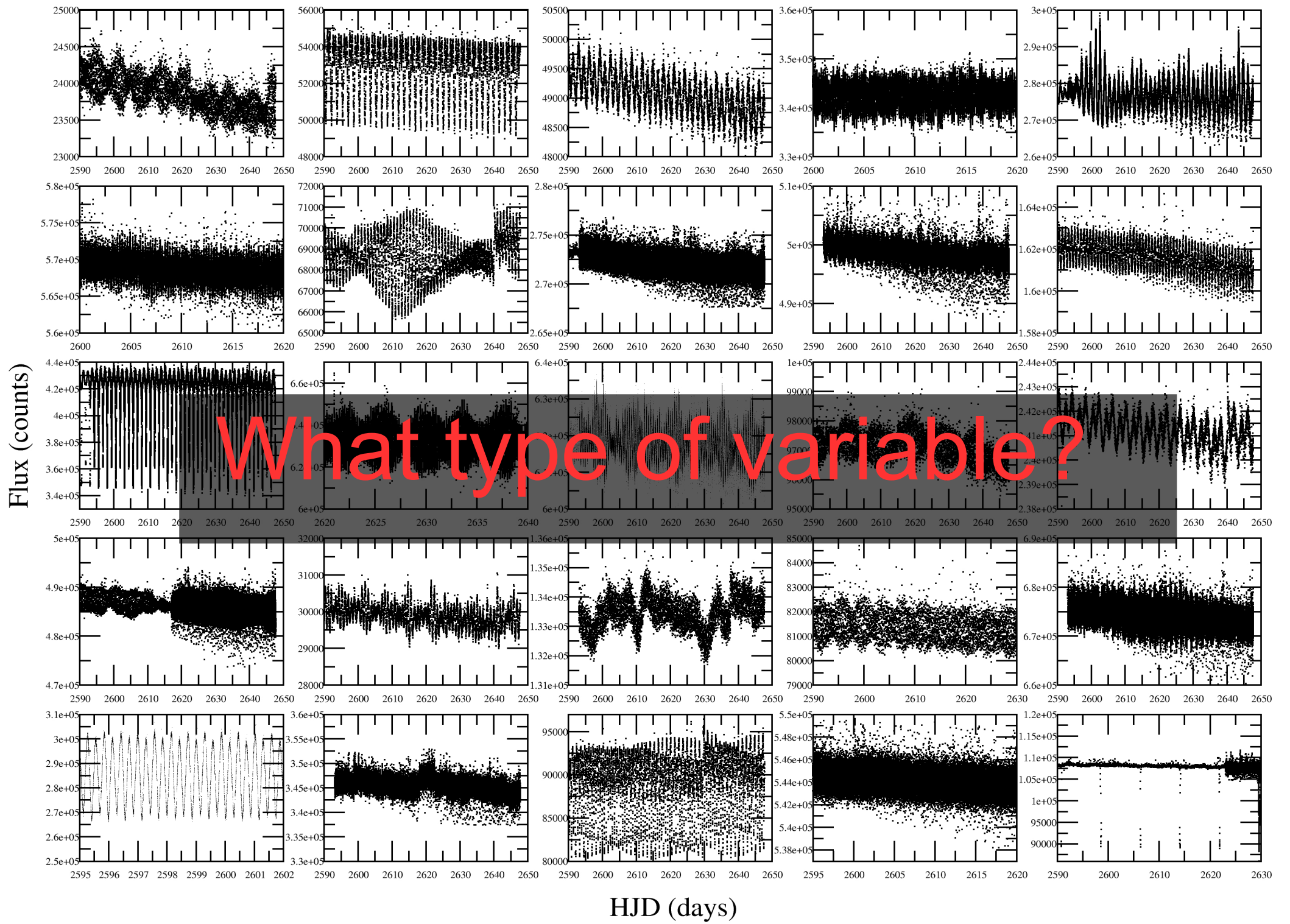
The CoRoT Variability Classifier (CVC)

J. Debosscher
Instituut voor Sterrenkunde, KU Leuven
L. M. Sarro
Dpt. de Inteligencia Artificial, UNED, Madrid

& collaborators

CoRoT Week 11, La Laguna, Tenerife, 19-22 March 2013


What type of variable?
Flux (counts)
HJD (days)

CVC in brief: light curve classification process

CoRoT N2 light curves

$$y(t) = \sum_{i=1}^{3} \sum_{j=1}^{4} (a_{ij} \sin 2\pi f_i jt + b_{ij} \cos 2\pi f_i jt) + b_0$$

Filtering and characterization (e.g. Fourier decomposition)

Set of parameters, describing the light curves up to a desired level of accuracy

Feature selection

Classification attributes

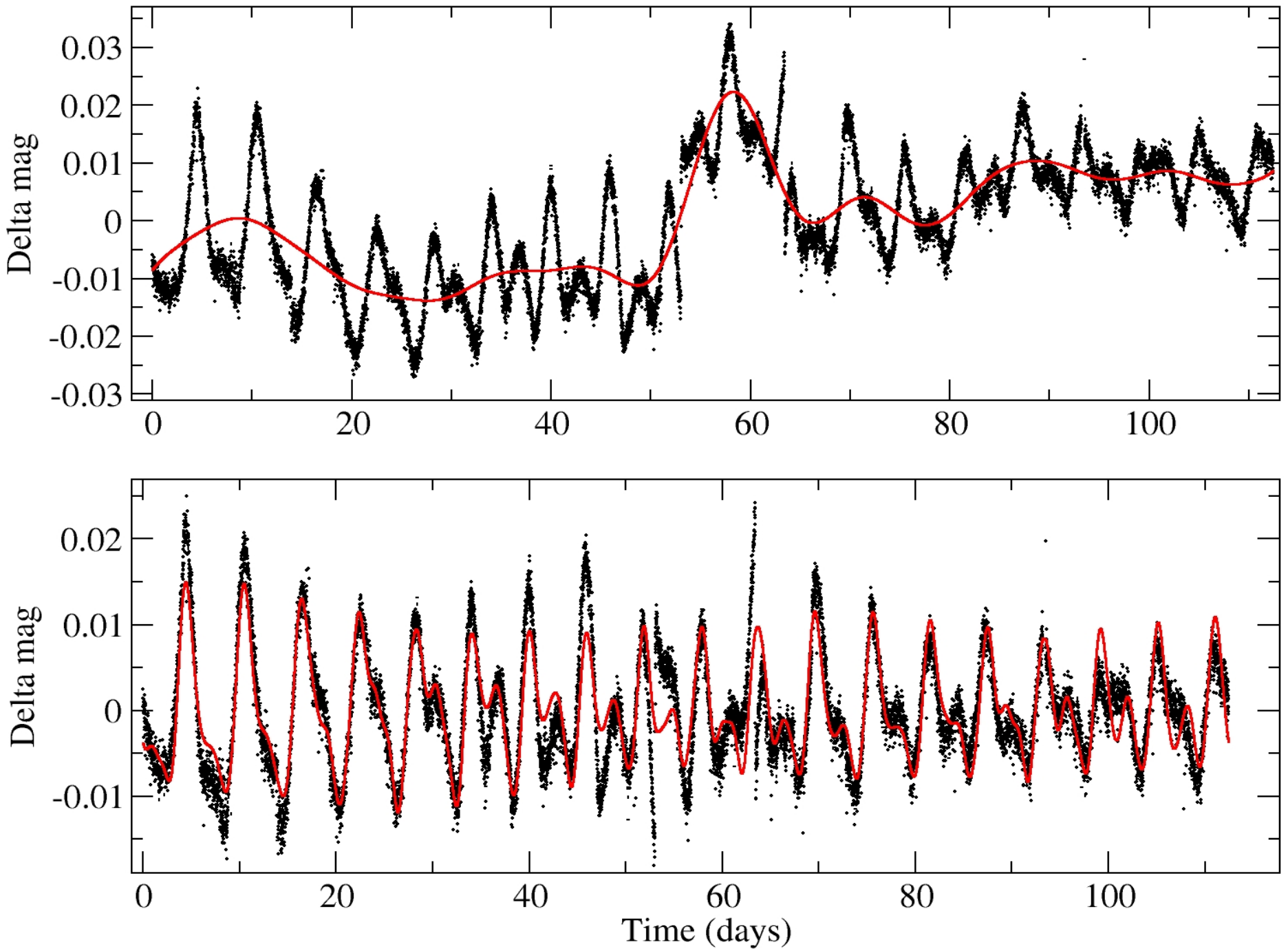
CVC

Supervised classifier + training set

Unsupervised classifier

Class labels / probabilities

Cluster labels / probabilities


High-pass filtering (cutoff at 0.15 c/d) and light curve fitting
Delta mag
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
0
20
40
60
80
100
Delta mag
0.02
0.01
0
-0.01
0
20
40
60
80
100
Time (days)

CVC N3 product

- What is included?
  - **Light curve characteristics:** dominant frequencies (3 max) and harmonics (4 max), significance parameters, amplitudes, phases, variance reduction of light curve fit
  - **Supervised classification results (16 variability classes):** 3 most probable class labels, probabilities, statistical distance to class centers (way of detecting outliers)

N3 product user guidelines

- Please consult the Readme file (updated on 19/02)!
- Example: selecting good candidate δ Scuti stars:

  - e.g. select all targets with ***classcode1*=DSCUT, *classprob1* > 0.8, *Mah.dist1* < 1.5 and *Pf1* < 0.01**

Part of the N3 product readme file

Column description:
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1) objectname=CoRoT ID
2) normalized Mahalanobis distance to the centre of the most probable class (class 1)
3) normalized Mahalanobis distance to the centre of the second most probable class (class 2)
4) normalized Mahalanobis distance to the centre of the third most probable class (class 3)
5) classprob1=relative probability for class 1
6) classprob2=relative probability for class 2
7) classprob3=relative probability for class 3
8) classcode1=variability class 1
9) classcode2=variability class 2
10) classcode3=variability class 3
11) Pf1=significance parameter frequency 1 (probability)
12)Pf2=significance parameter frequency 2 (probability)
13)Pf3=significance parameter frequency 3 (probability)

- Larger samples (but more false positives!) can be obtained by using less strict cutoff values and by considering the second and third class probabilities and distances

Results

- 23 CoRoT runs, in total 159 759 exo-field light curves analyzed
- Results available online at the IAS CoRoT data center (some public): http://idoc-corot.ias.u-psud.fr/
- Updated on 19/02/2013, N3 files now all consistent
- Please read the documentation (and have a look at the references) when using and interpreting the results

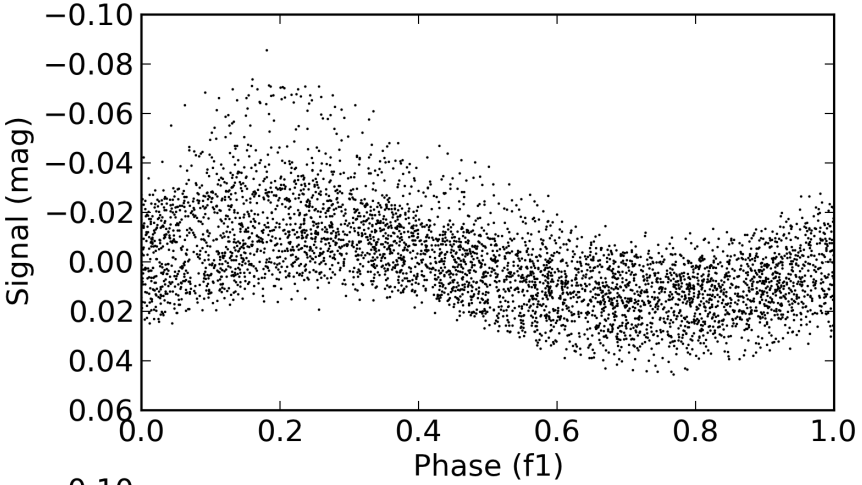
Class statistics (for long runs)

Center vs. Anticenter direction

Numbers are conservative, obtained using strict cutoff values for class probability and distance
classprob1 > 0.8, *Mah.dist1* < 1.5 and *Pf1* < 0.01

Variability class	# objects Center direction 53 703 total	# objects Anticenter direction 38 262 total
δ Scuti (and β Cephei)	151 (0.28%)	252 (0.66%)
γ Doradus (and SPB)	98 (0.18%)	240 (0.63%)
RR Lyrae (ab)	7	0
RR Lyrae (c)	5	1
RR Lyrae (d)	1	0
Classical Cepheids	0	0
Binaries (eclipsing, ellipsoidal)	505 (0.94%)	433 (1.1%)
Rotational modulation	378 (0.7%)	484 (1.26%)

CVC results



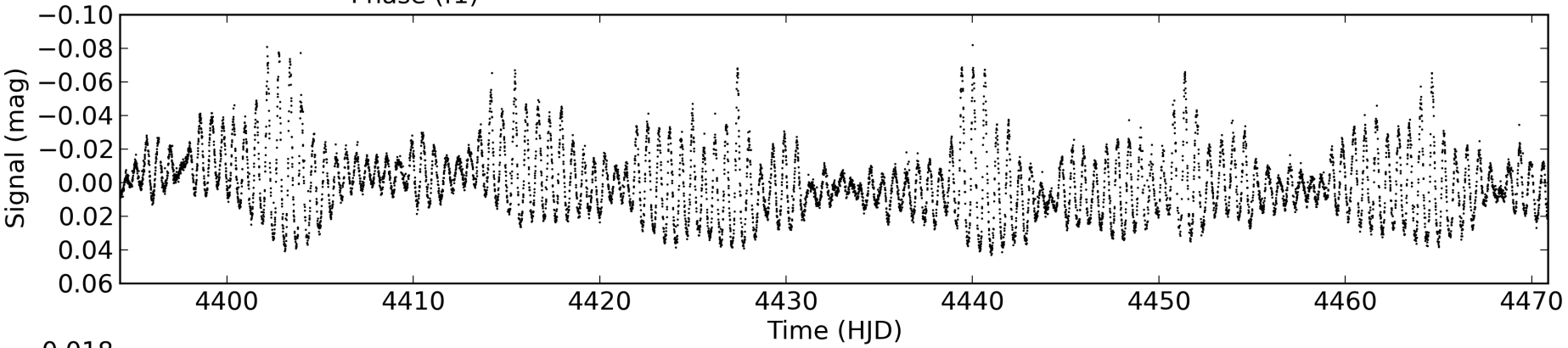
102678037

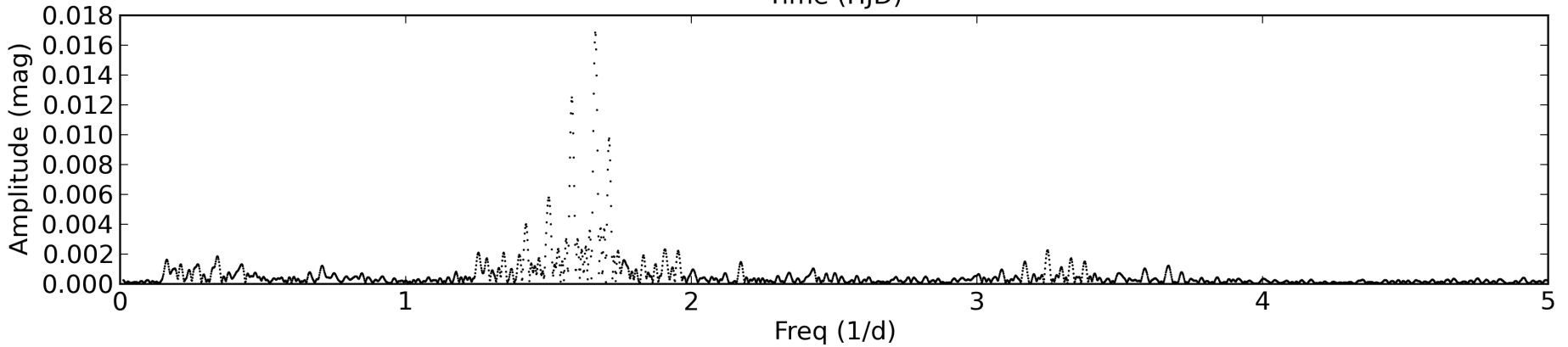
f1=1.665 c/d

f2=1.582 c/d

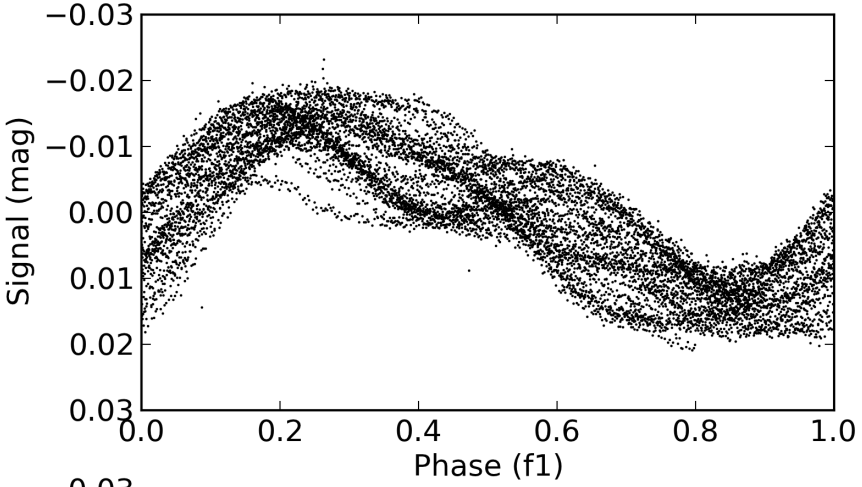
SPB / γ Dor

MD=1.09 prob=0.99





CVC results



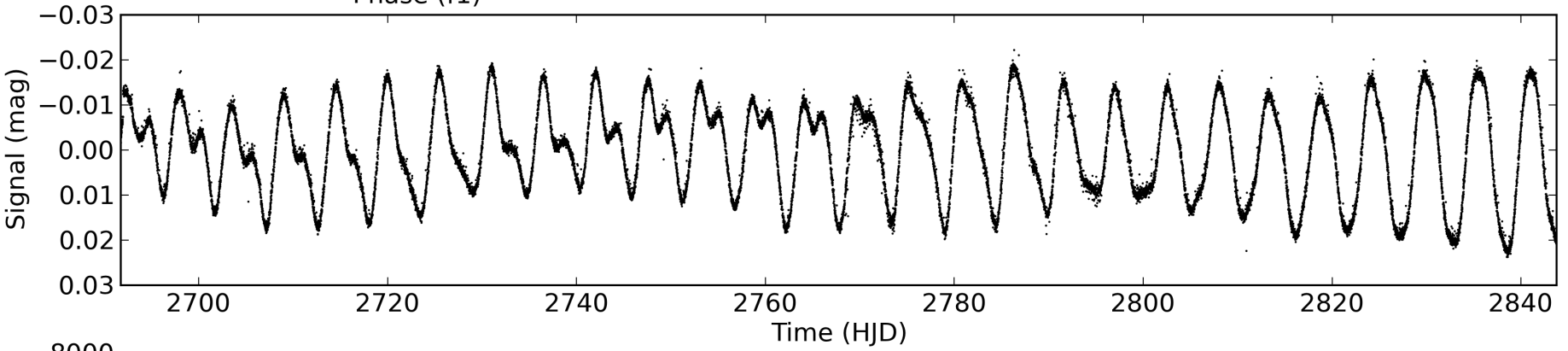
101455904

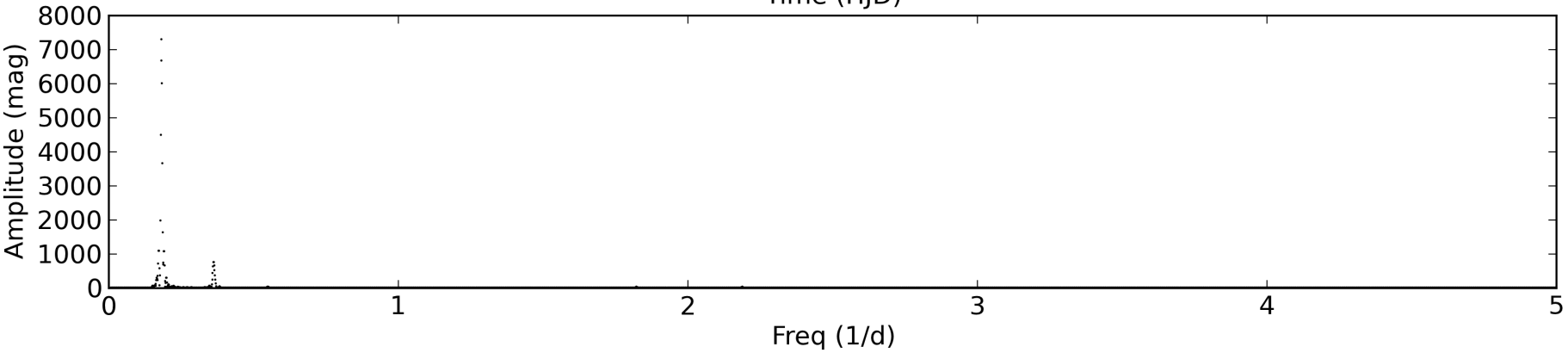
f1=0.183 c/d

f2=0.188 c/d

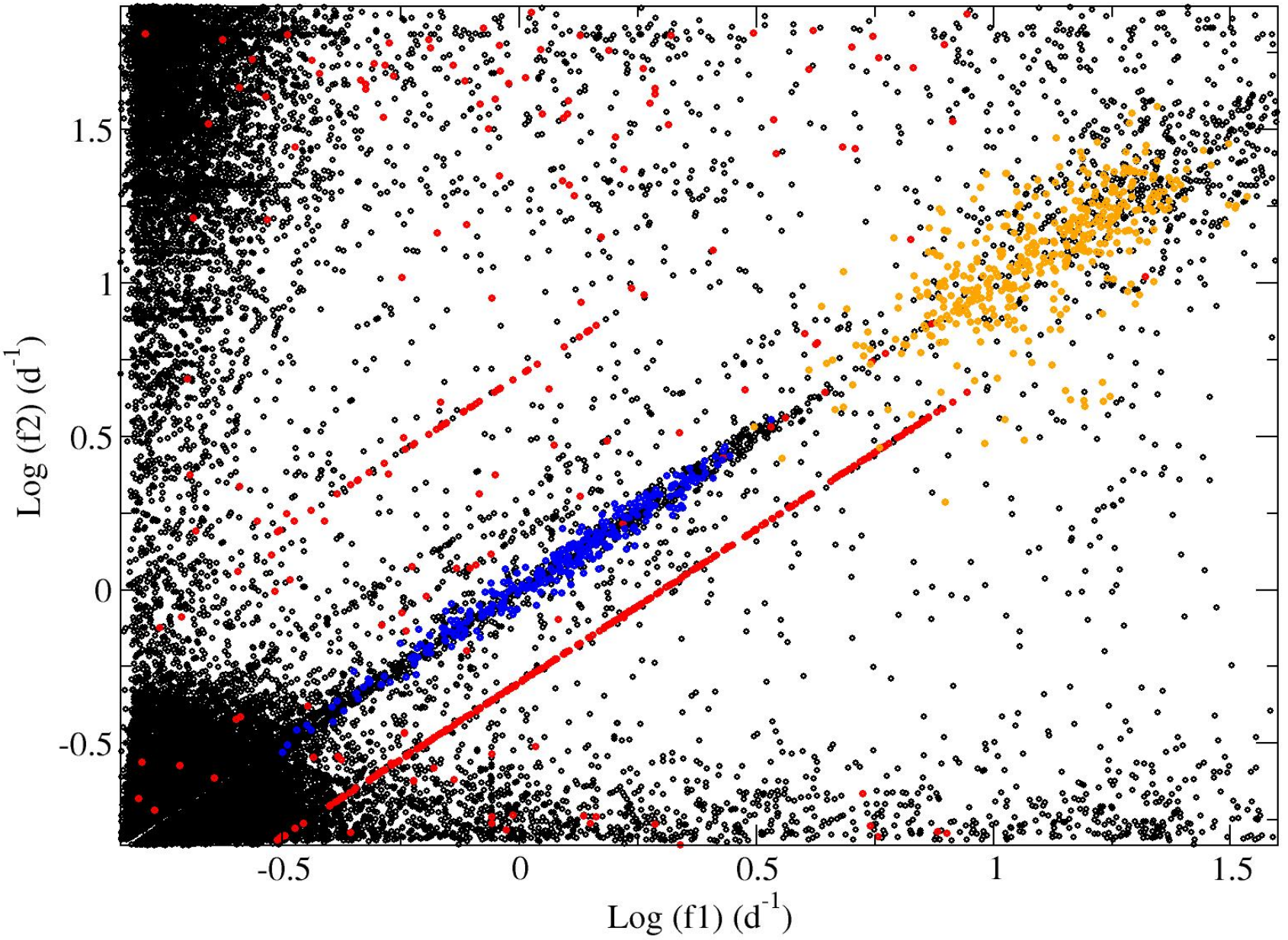
ROT

MD=0.48 prob=1.00





Sample studies (anticenter direction)



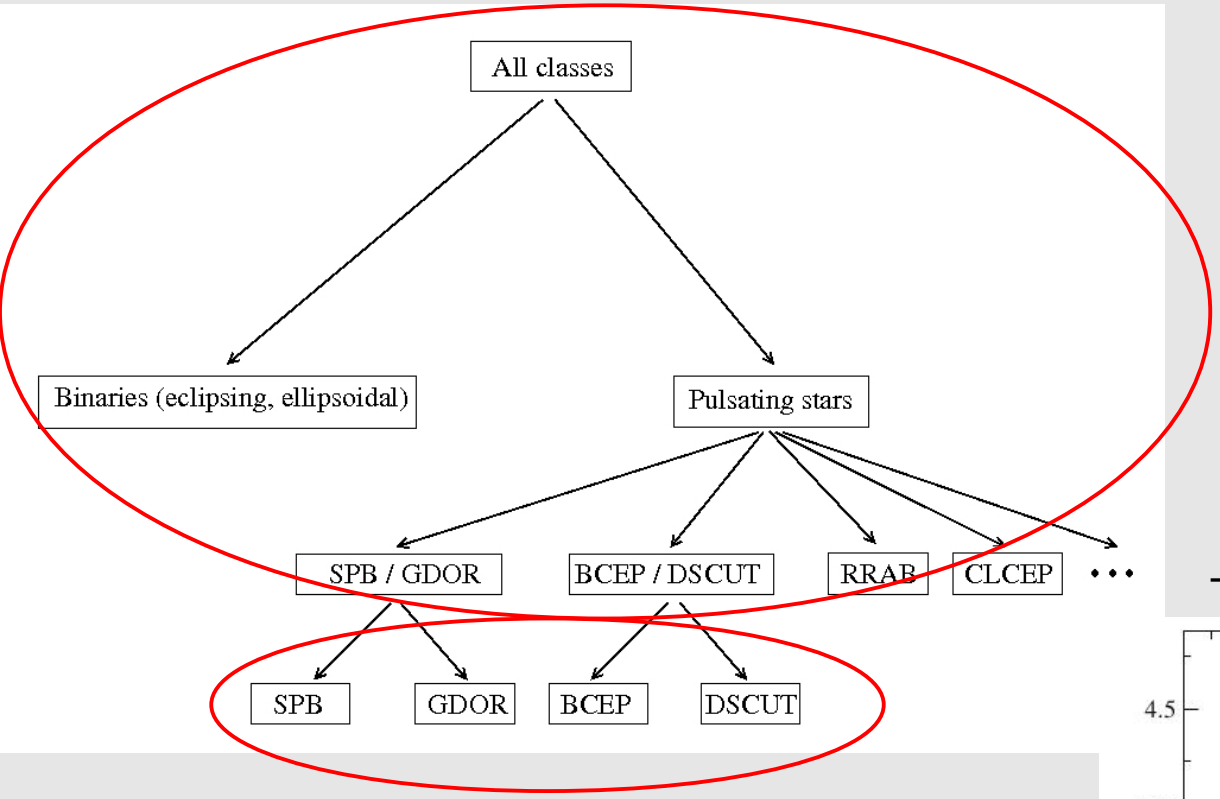
Binaries

γ Dor / SPB

δ Sct / β Cep

CoRoT spectral classifier

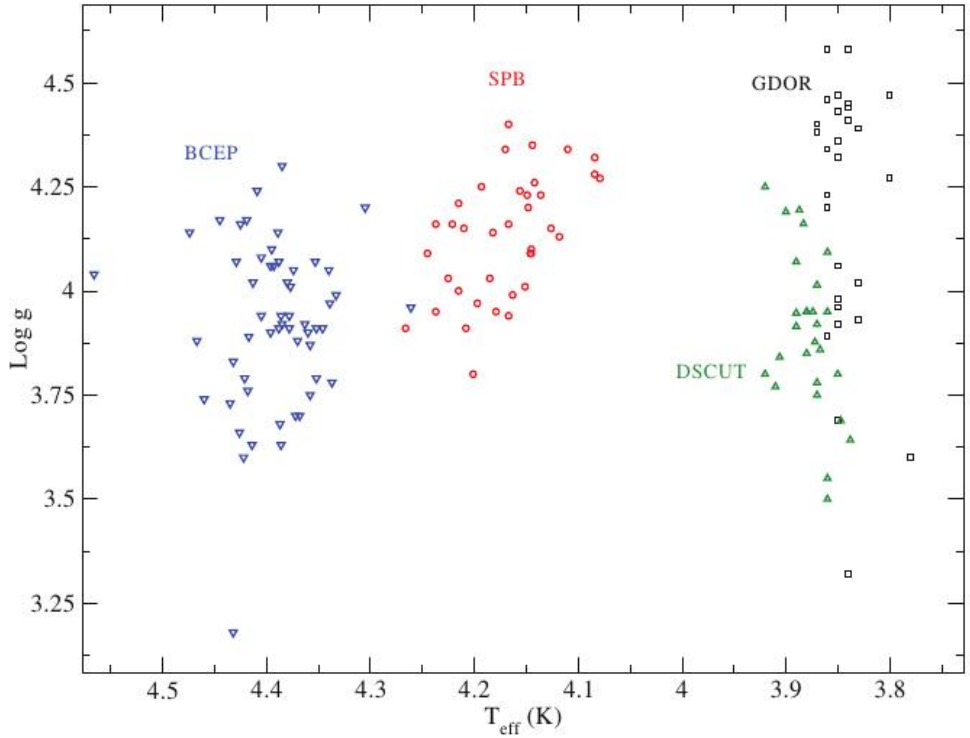
(Sarro et al., 2013)



Multistage Gaussian-mixture classifier

Classif. based on
light curve attributes only

Training set for spectral classification stage



Classif. based on spectral attributes T_{eff} and
Log g, derived from Giraffe spectra
using data mining techniques

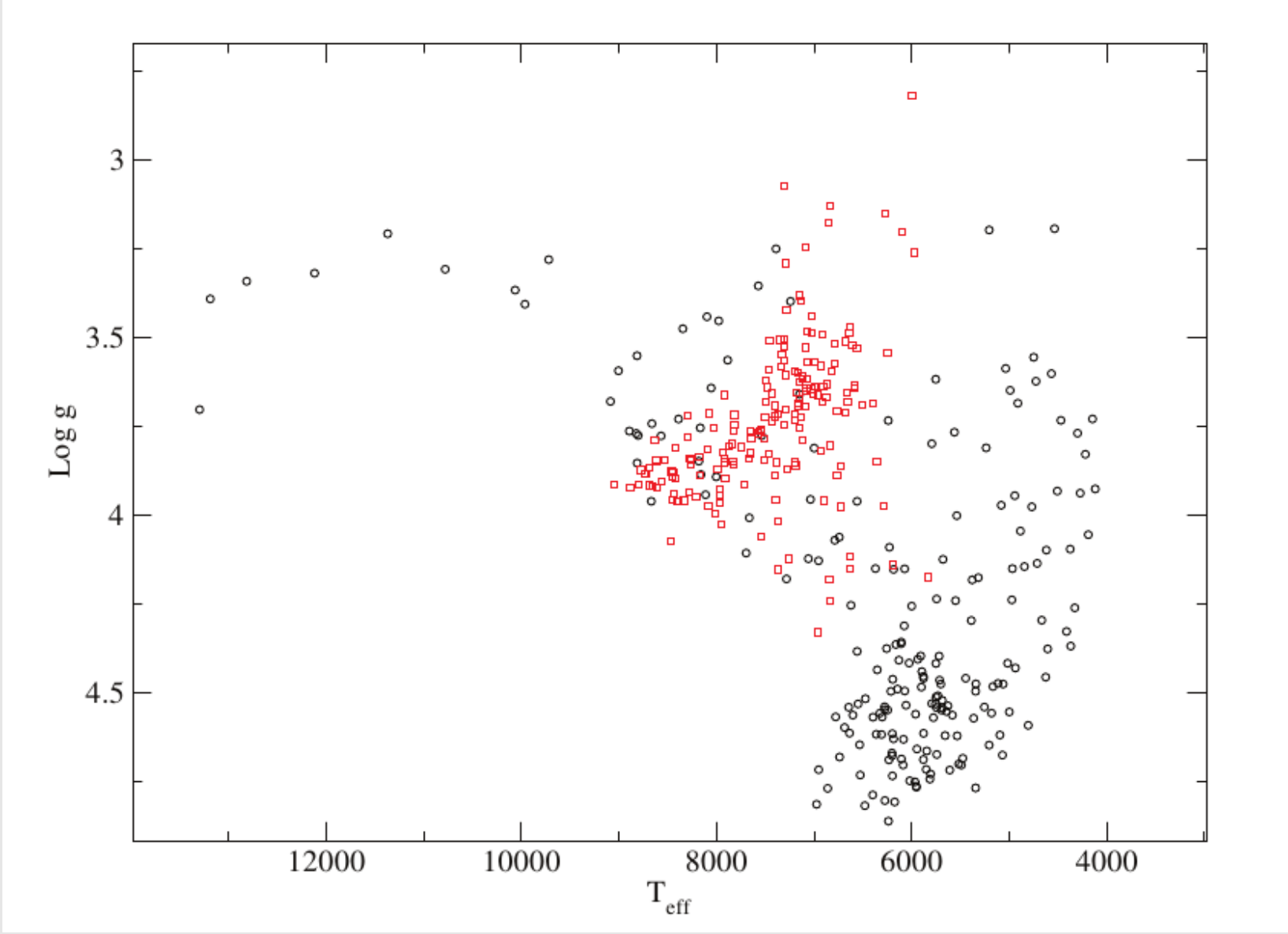
Results of spectral classification

- Classification of a sample of ~10.000 CoRoT light curves with additional spectral attributes derived from Giraffe spectra

Variability class	# (LC attributes only)	# ($T_{\rm eff}$ and log(g) added)	# (additional inspection)
γ Dor	159	330	-
δ Sct	285	343	-
SPB	207	8	-
β Cep	86	6	-
RR Lyrae (RRab)	4	-	-
RR Lyrae (RRd)	1	-	-
Binaries (eclipsing /ellipsoidal)	259	-	-
Rotational modulation	203	-	-
Be	-	-	9
Hybrid γ Dor/δ Sct	-	-	28

Rotational modulation in CoRoT light curves

(see also session yesterday)



Rotational modulation sample (black) and δ Scuti sample (red) for comparison

Future developments

- Training set updates and extensions, include more classes and more class members, avoid biases:
  - rotational modulation
  - solar-like oscillations (in progress)
- Improve characterization and correction of instrumental effects in light curves (e.g. jumps, CoRoT orbit)
- Adding spectral information for improved classification, extending CoRoT spectral classifier
- Keep updating and improving the N3 data product

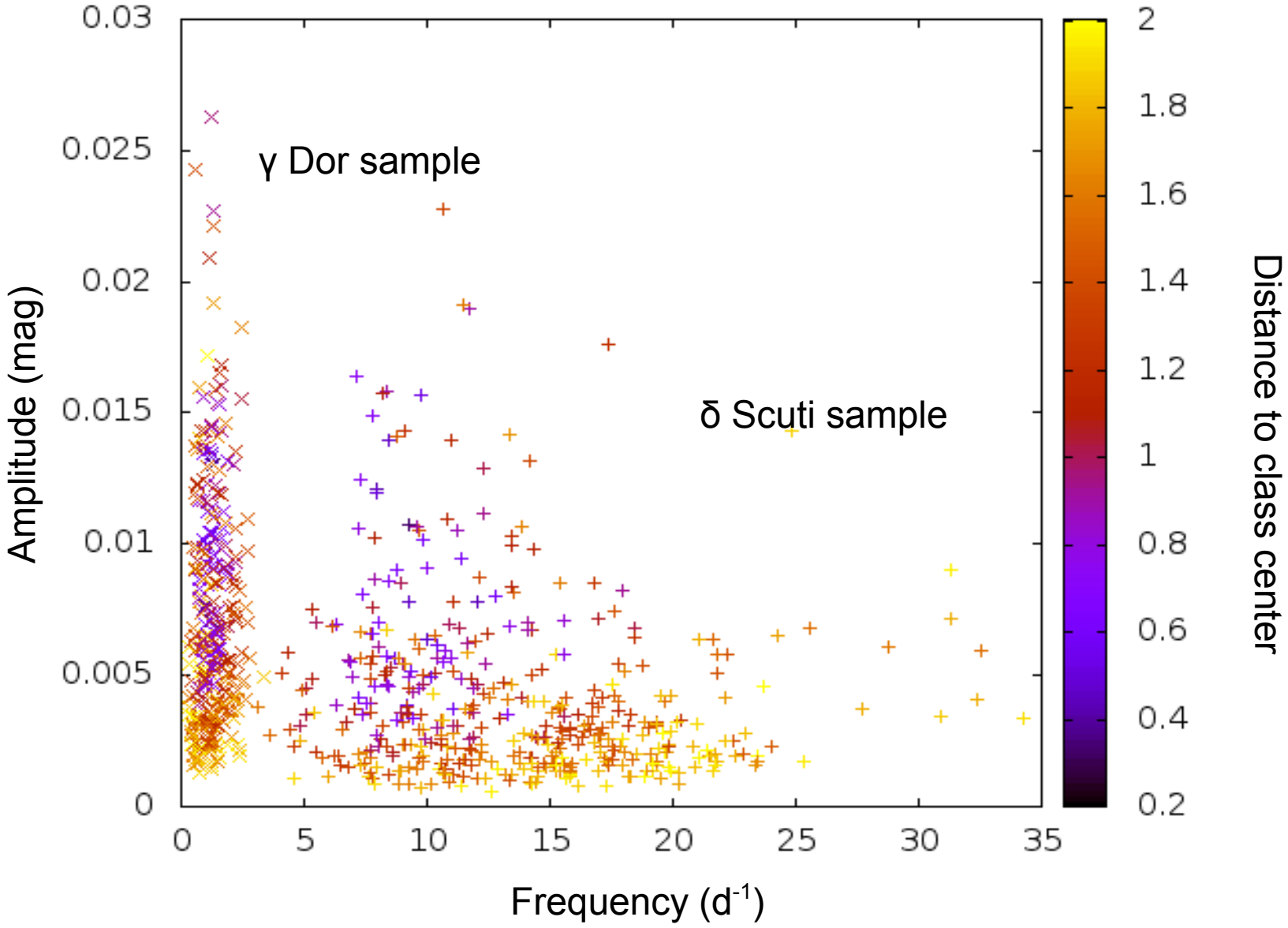
Thanks for your attention!

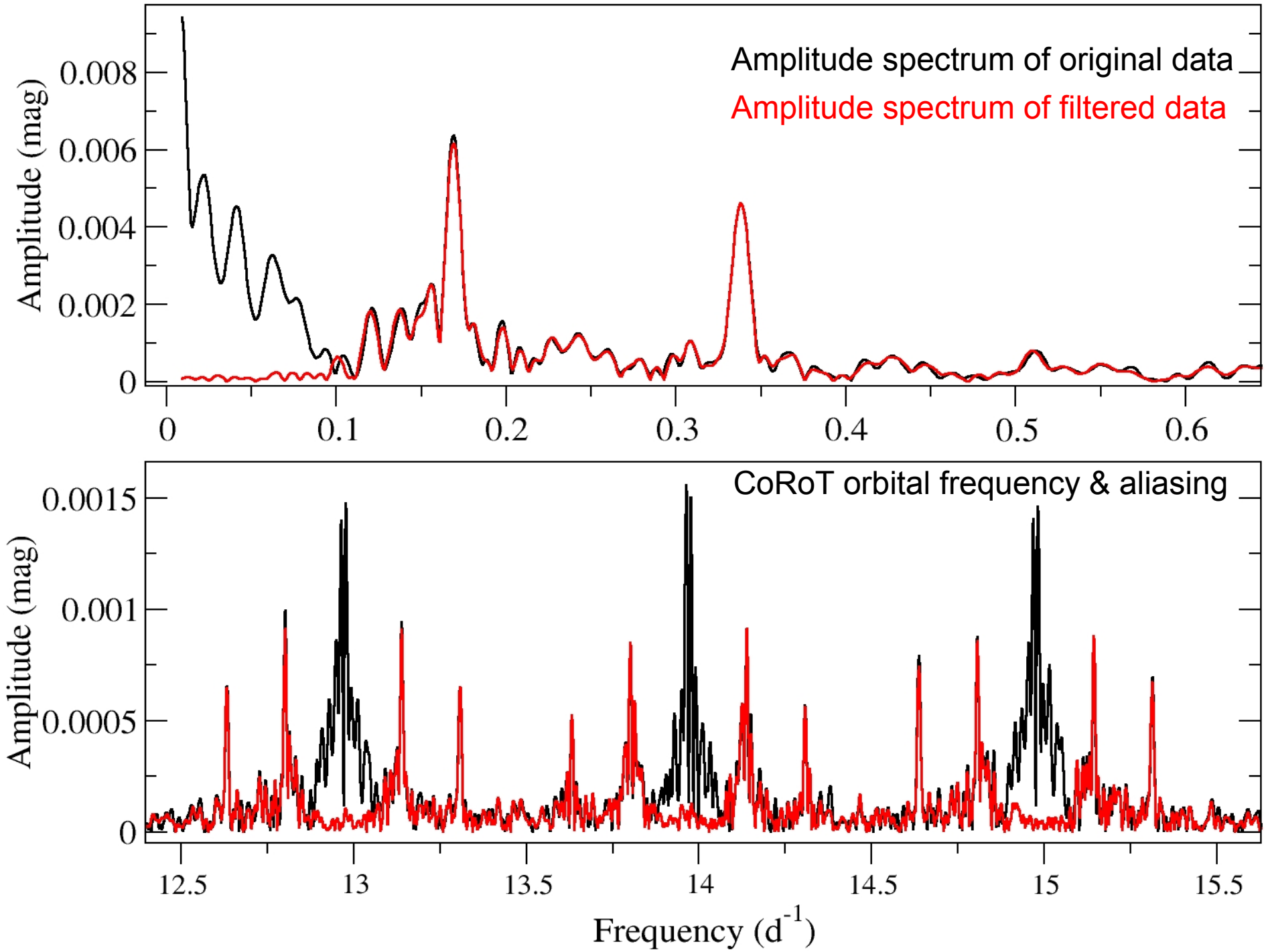
For questions / requests regarding the CVC N3 products, please contact J. Debosscher: jonas@ster.kuleuven.be

References:

-Debosscher et al., 2007 (A&A): Automated supervised classification of variable stars. I. Methodology.
-Sarro et al., 2009 (A&A): Automated supervised classification of variable stars. II. Application to the OGLE database.
-Debosscher et al., 2009 (A&A): Automated supervised classification of variable stars in the CoRoT programme.
-Sarro et al., 2009 (A&A): Comparative clustering analysis of variable stars in the Hipparcos, OGLE Large Magellanic Cloud, and CoRoT exoplanet databases.
-Debosscher et al., 2011 (A&A): Global stellar variability study in the field-of-view of the Kepler satellite.
-Sarro et al., 2013 (A&A): Improved variability classification of CoRoT targets with Giraffe spectra.

Sample studies (anticenter direction)




Amplitude spectrum of original data
Amplitude spectrum of filtered data
Amplitude (mag)
0.008
0.006
0.004
0.002
0
0
0.1
0.2
0.3
0.4
0.5
0.6
CoRoT orbital frequency & aliasing
Amplitude (mag)
0.0015
0.001
0.0005
0
12.5
13
13.5
14
14.5
15
15.5
Frequency (d-1)