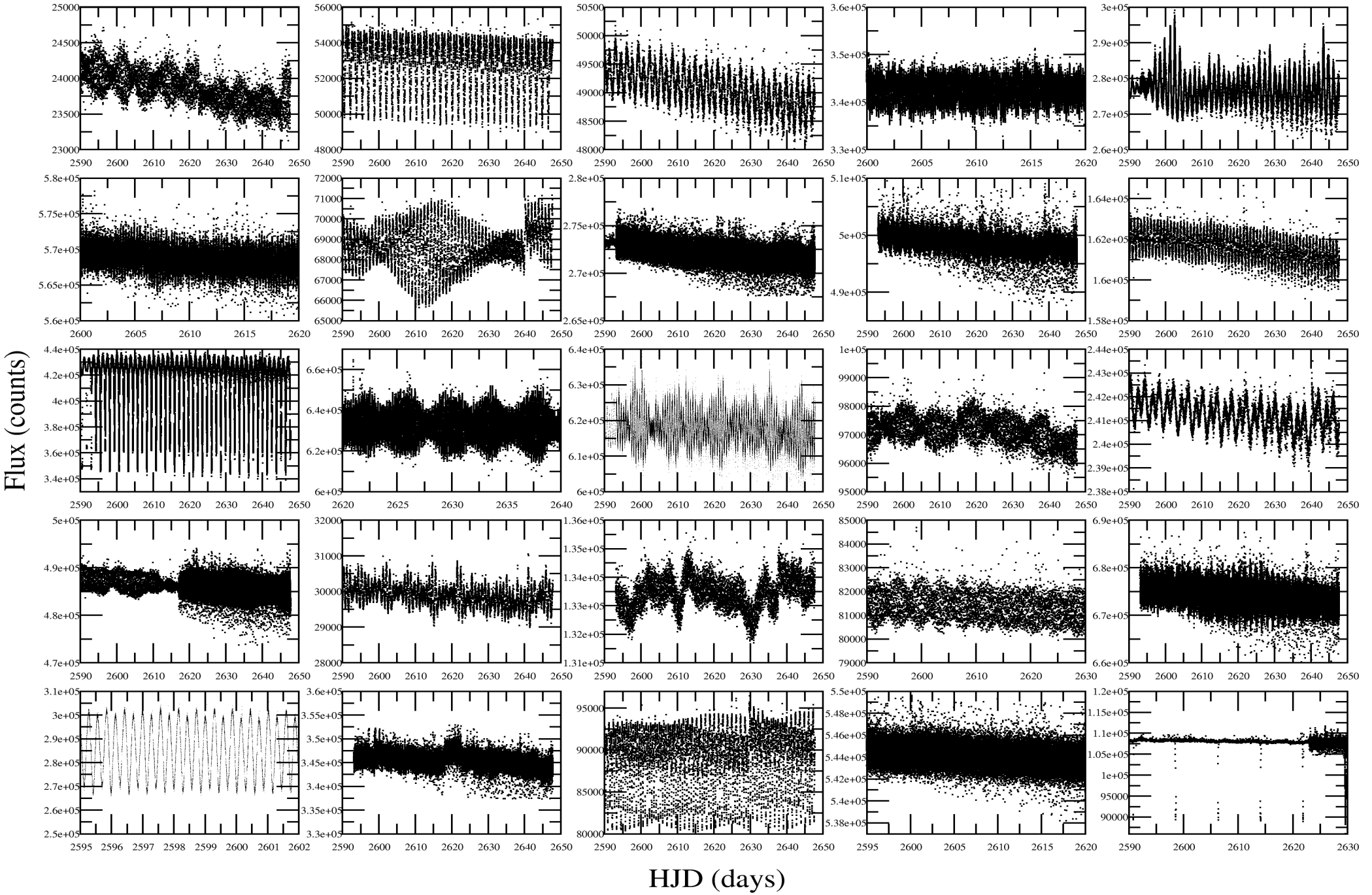
Classification of CoRoT Exofield Light Curves

Report of the CVC Working Group

J. Debosscher & L. M. Sarro & C. Aerts & W. Weiss

SC, 14 March 2008

Automated classification of variables



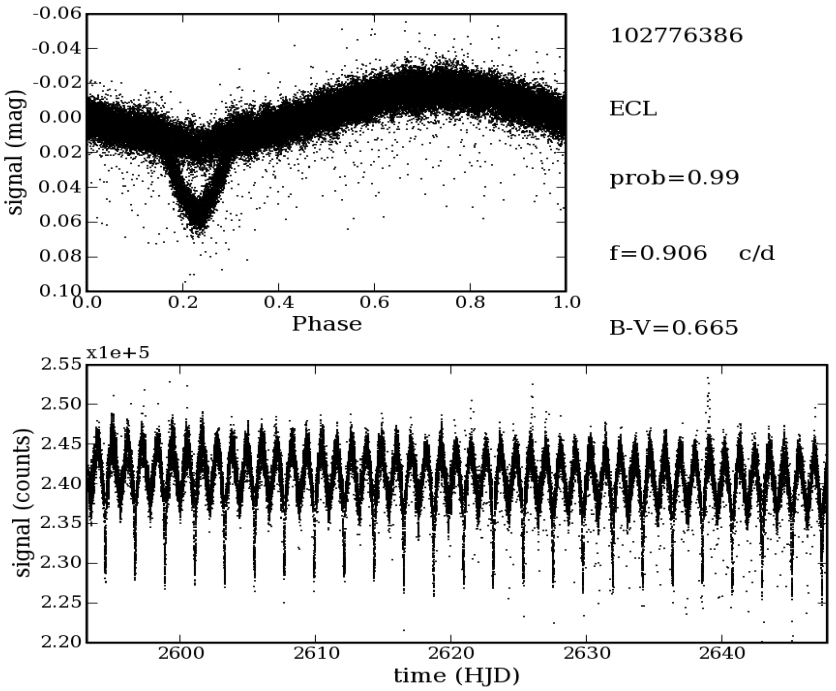
Current CVC implementation

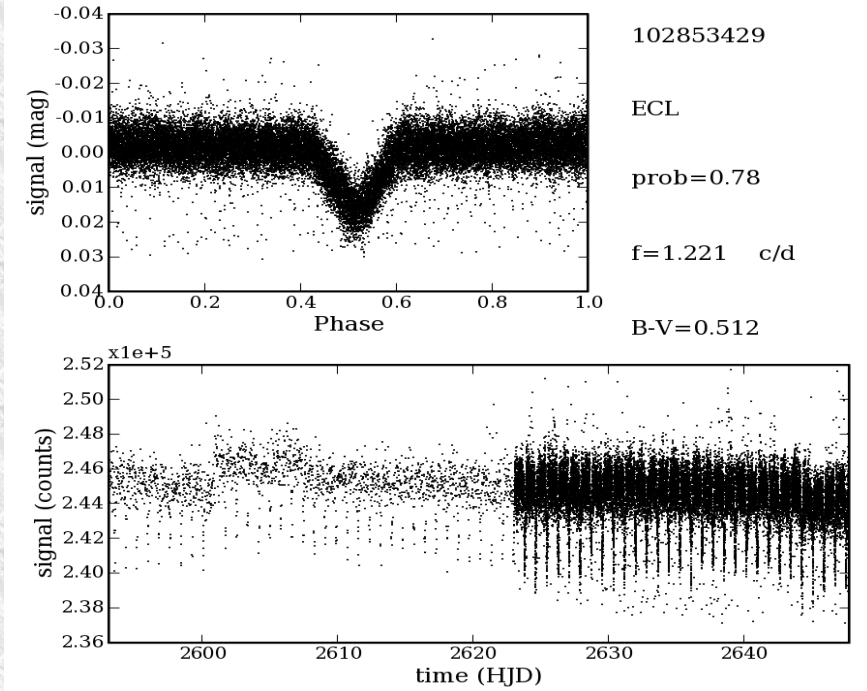
- **Automated pipeline:**
  - **Input: CoRoT ASCII light curves (HJD, flux)**
  - **Output:**
    - **set of derived light curves parameters, including variability indicators (freqs, ampl, var.red.,...)**
    - **LCs phased with the dominant period**
    - **Summarized results: codes and probabilities for 3 most likely classes + some important LC parameters: main frequency, significance indicator,...**
- **CVC uses only white light information:**
  - **B-V colours are available, but seem to be rather unreliable (extinction for the CoRoT fields, typical errors?) + private inhomogeneous data**

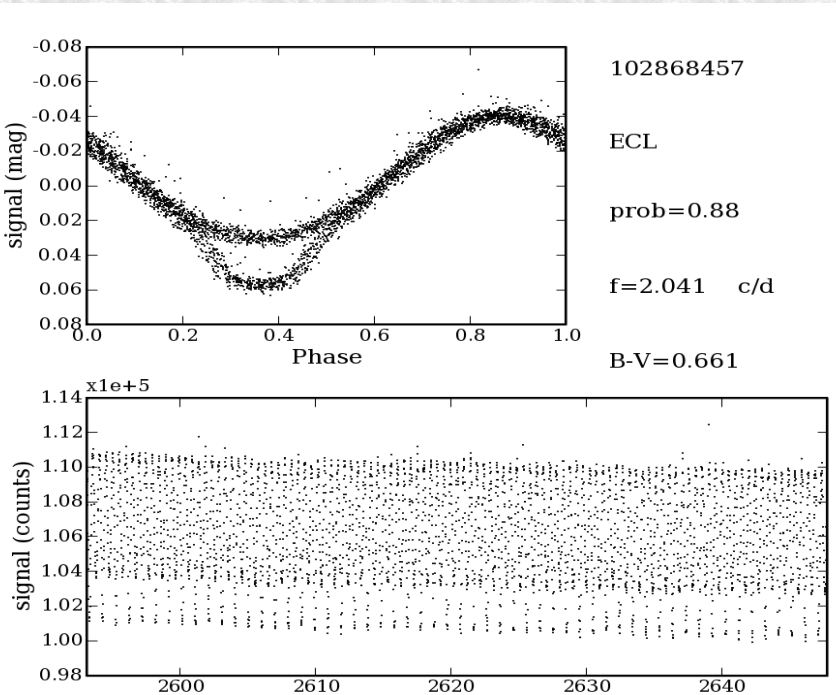
Initial Run results

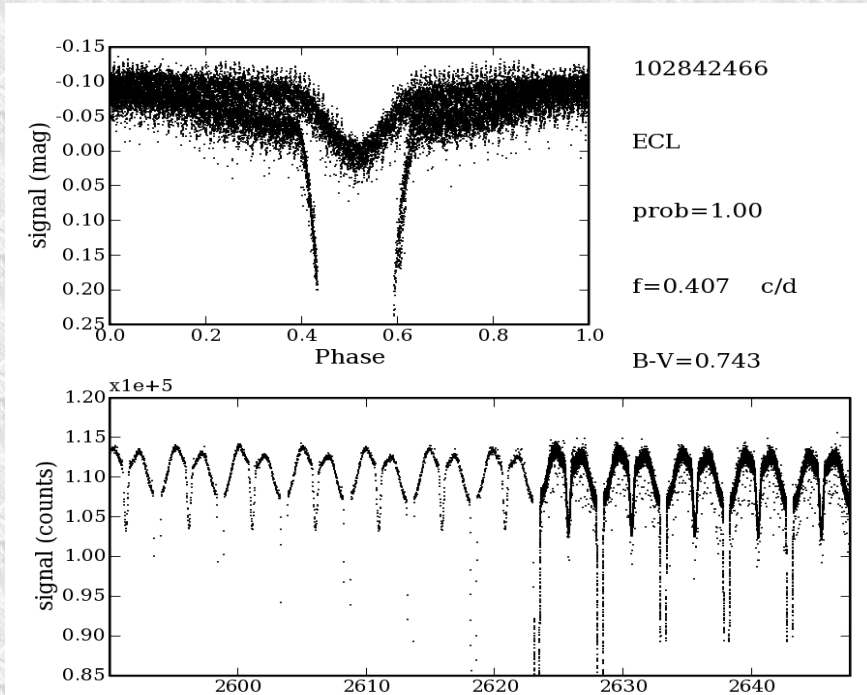
- The LC analysis code subtracts non-linear trends and orbital frequencies, prior to the 'real' frequency search: avoid instrumental frequencies in the set of classification attributes
- About 10.000 CoRoT light curves have been classified using our methods (white light information only for the moment):
  - estimated fraction of variables: ~40%
  - most populated classes:
    - High probability candidates (+visually checked):
      - Eclipsing binaries > 120
      - Delta-Scuti > 50
      - Beta-Cephei > 70
      - SPB > 70
      - Ellipsoidal variables
      - Gamma-Doradus
    - Low probability candidates (contaminated classes):
      - Chemically Peculiar
      - Periodically Variable Super Giants
    - A few classical pulsators (RR Lyr, Cepheids)

Eclipsing binaries (1)

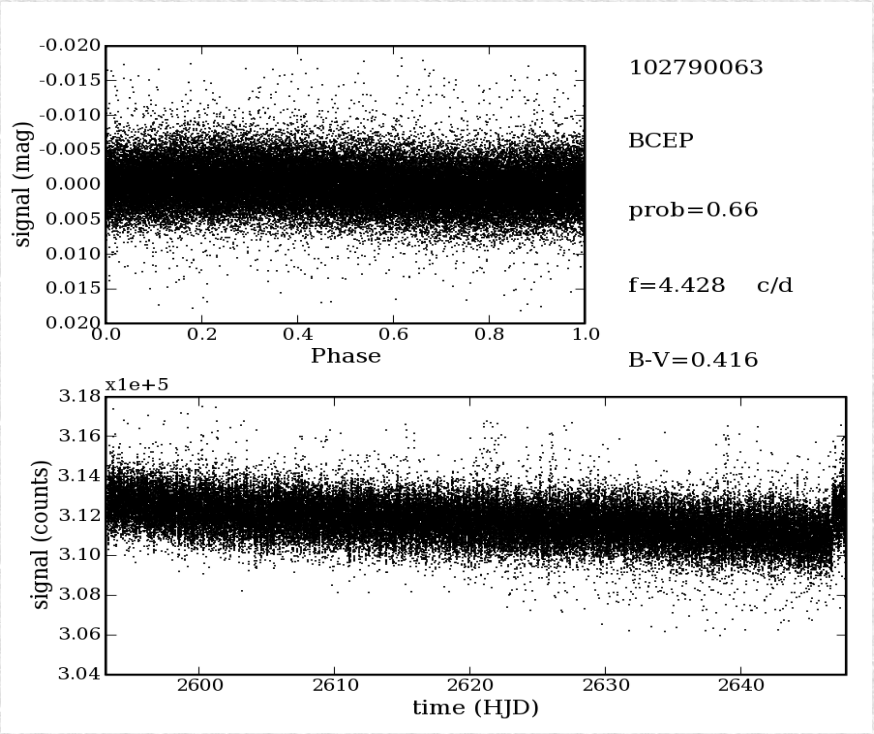


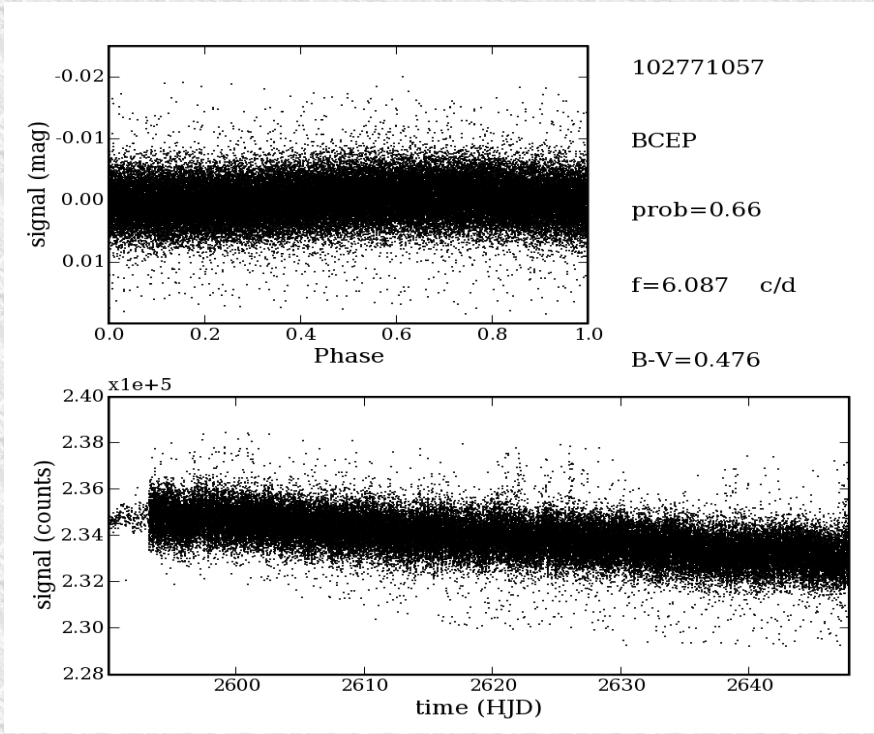


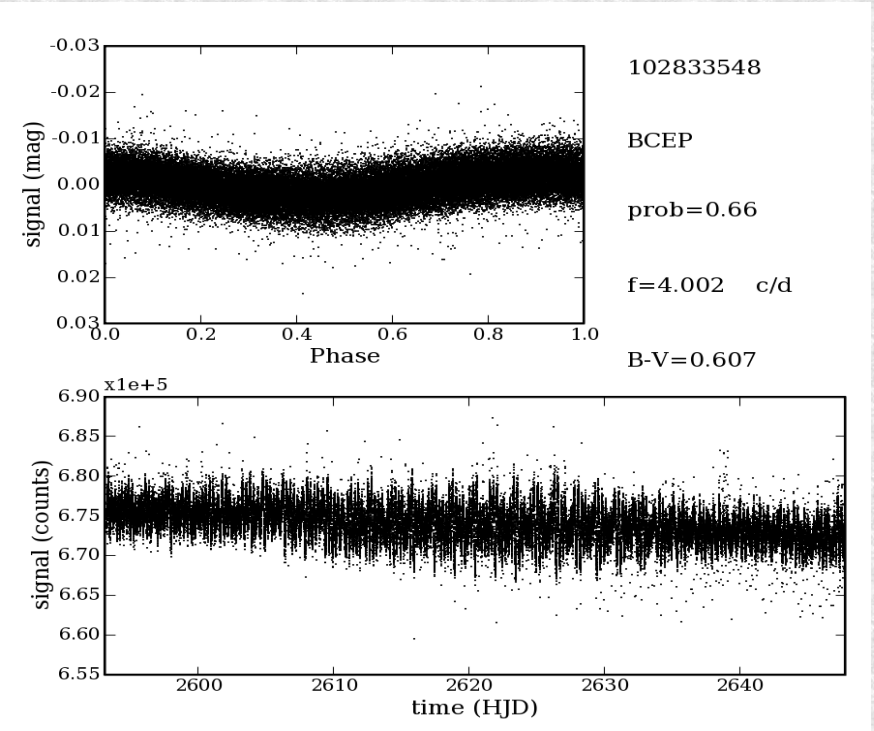


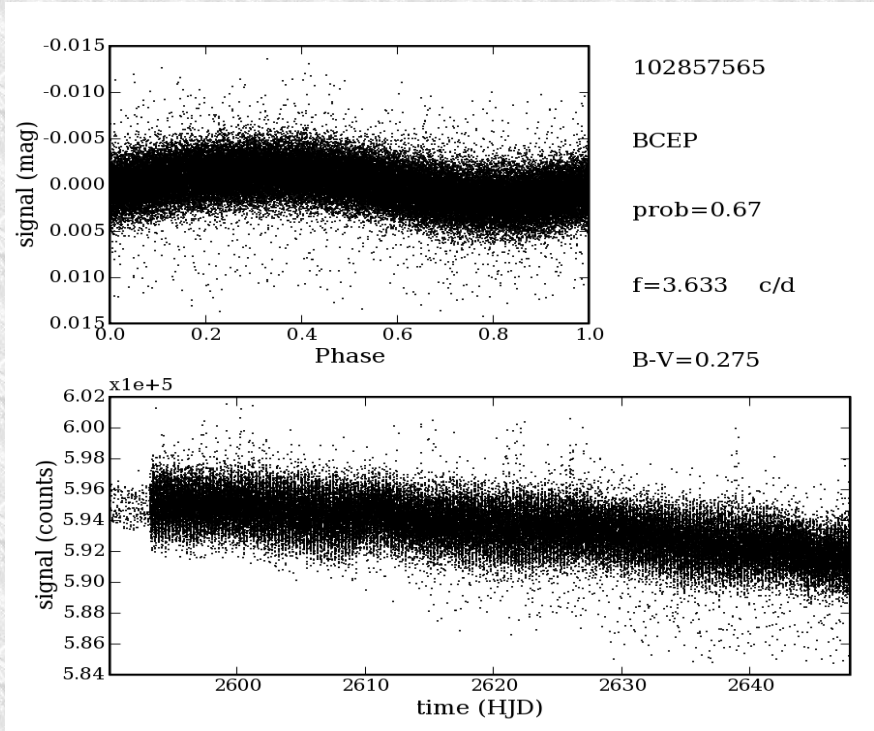


Beta-Cephei stars (1)

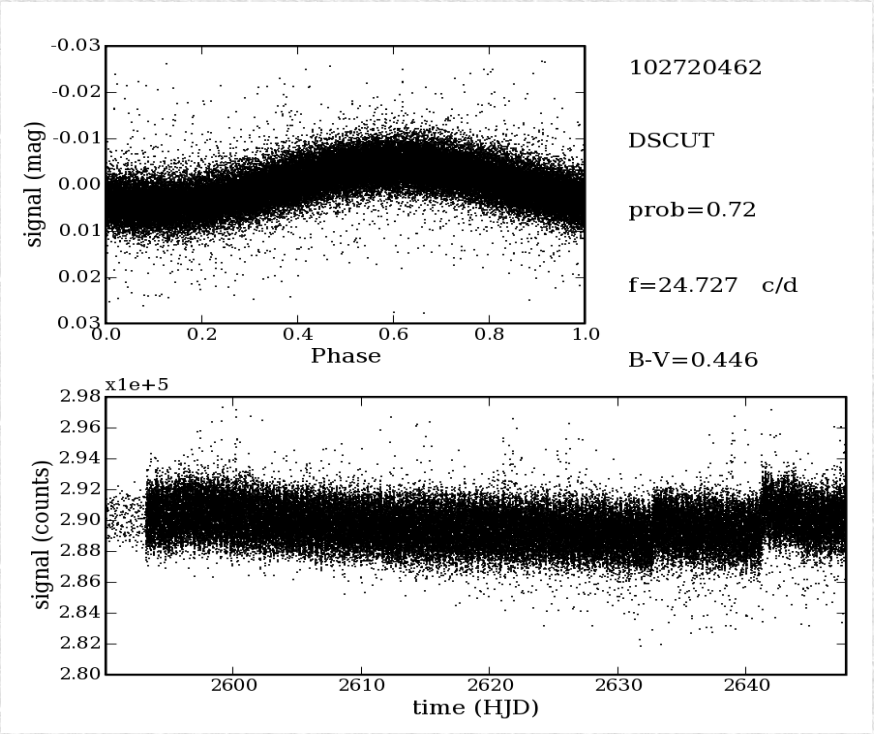


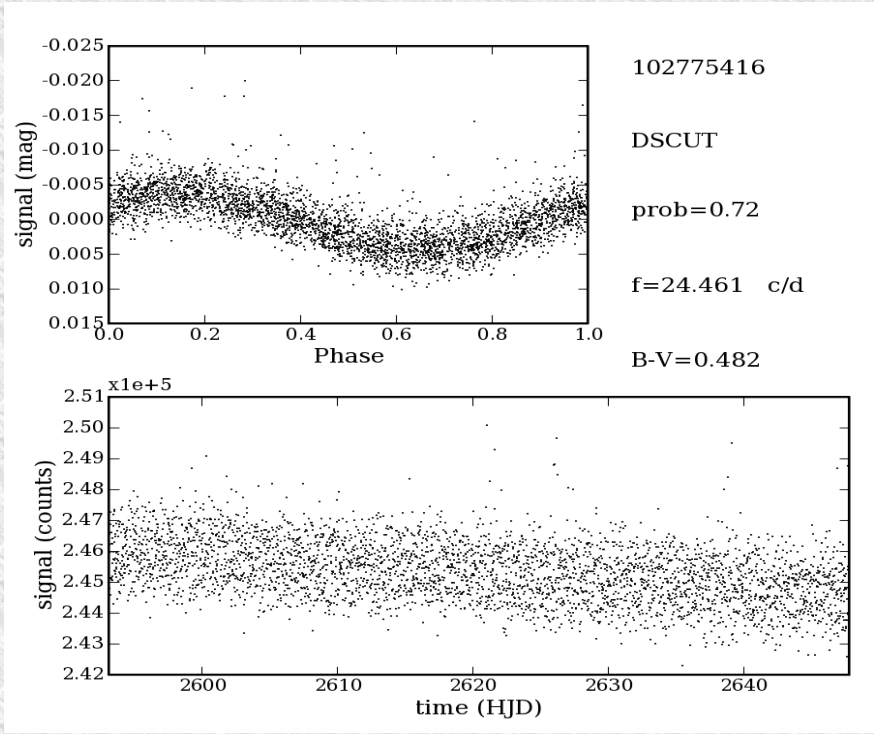


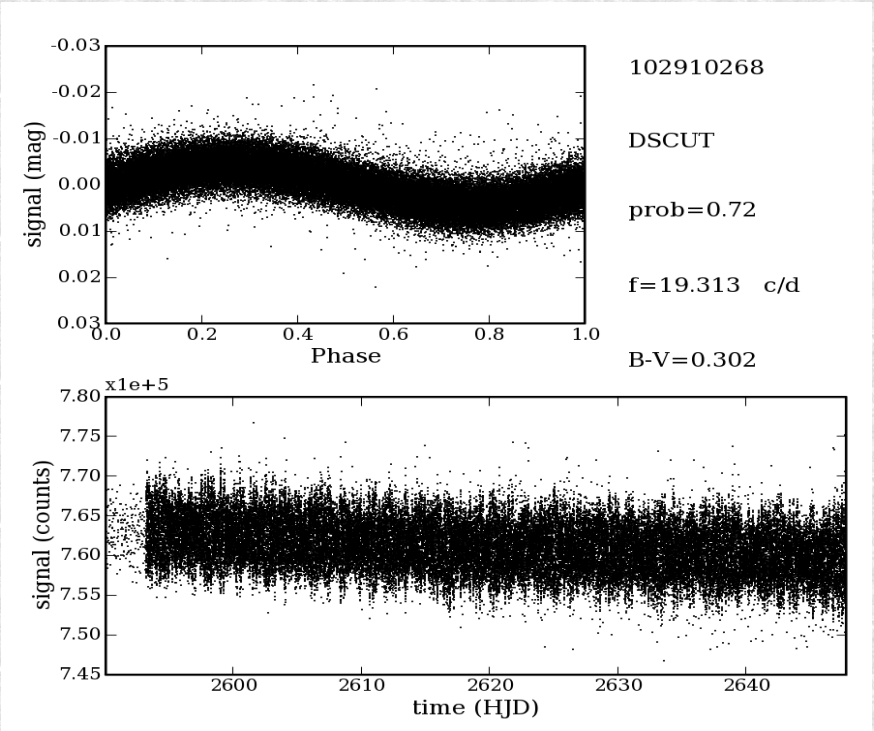


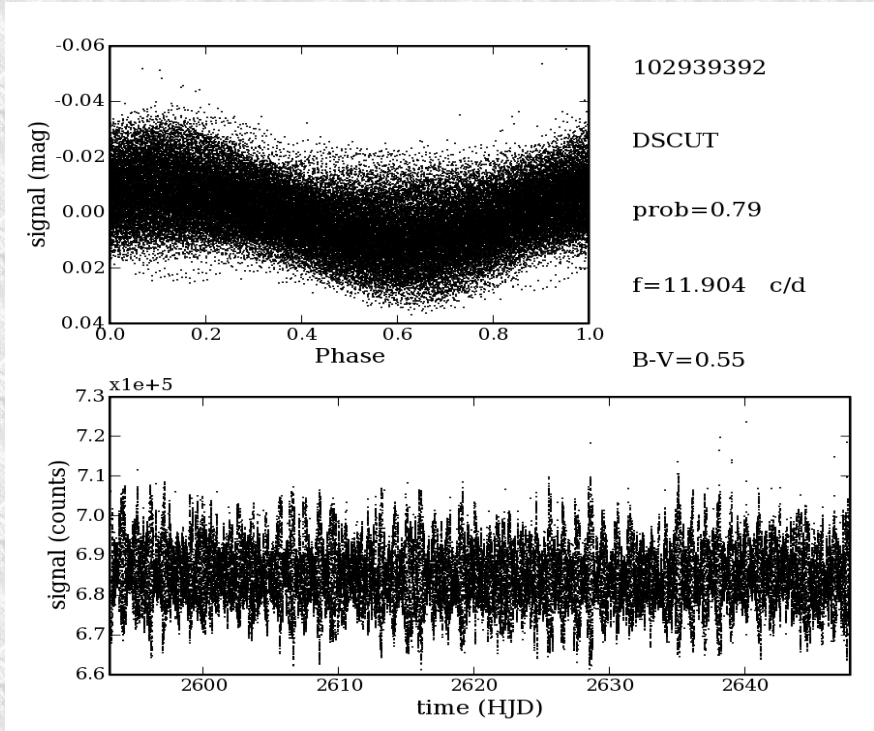


Delta-Scuti stars (1)

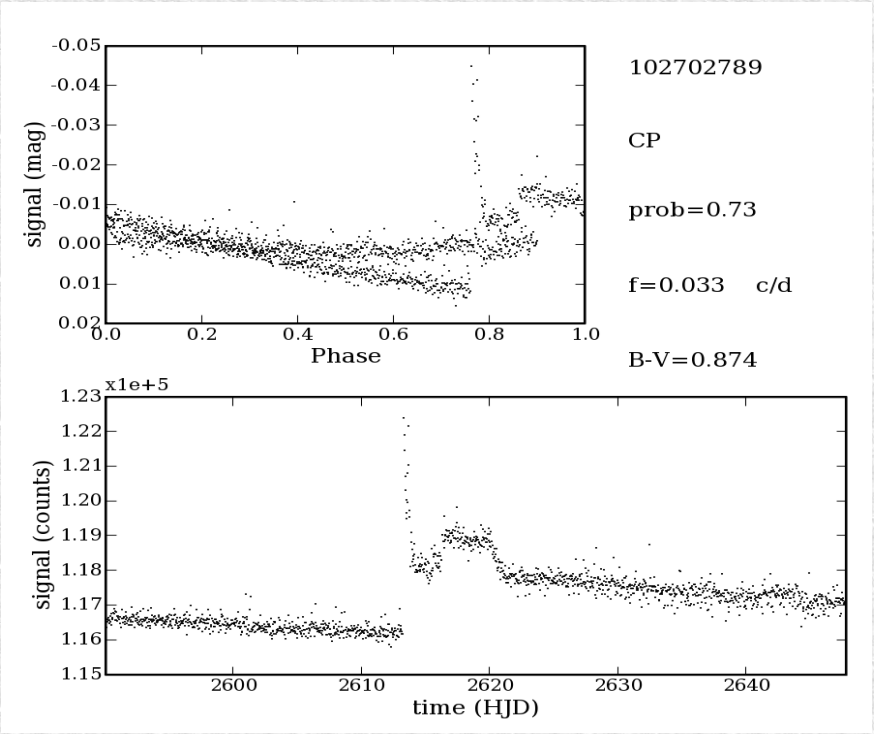


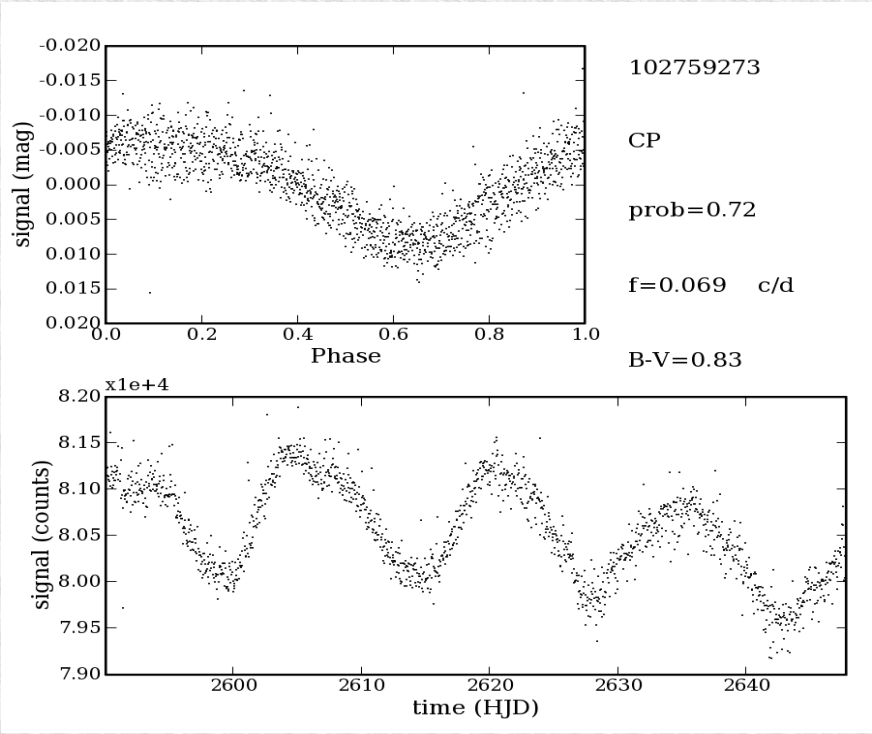


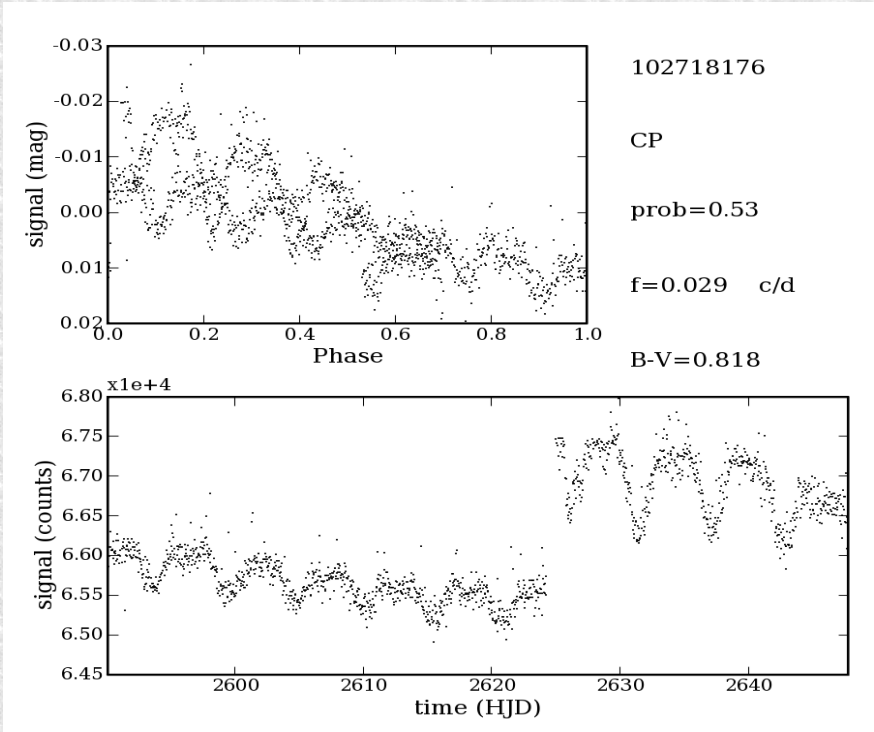


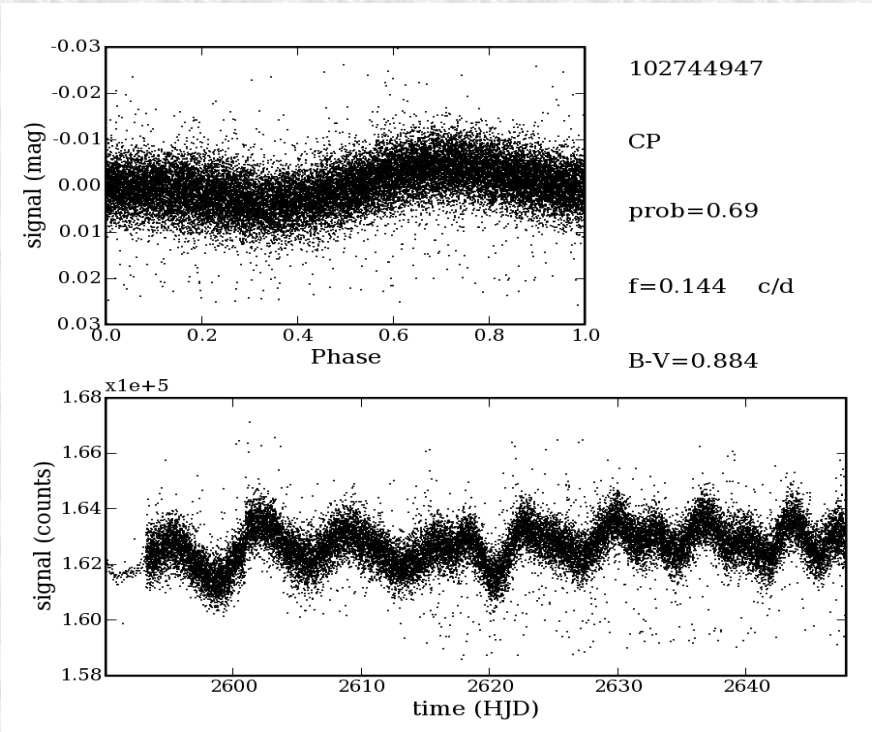


CP class

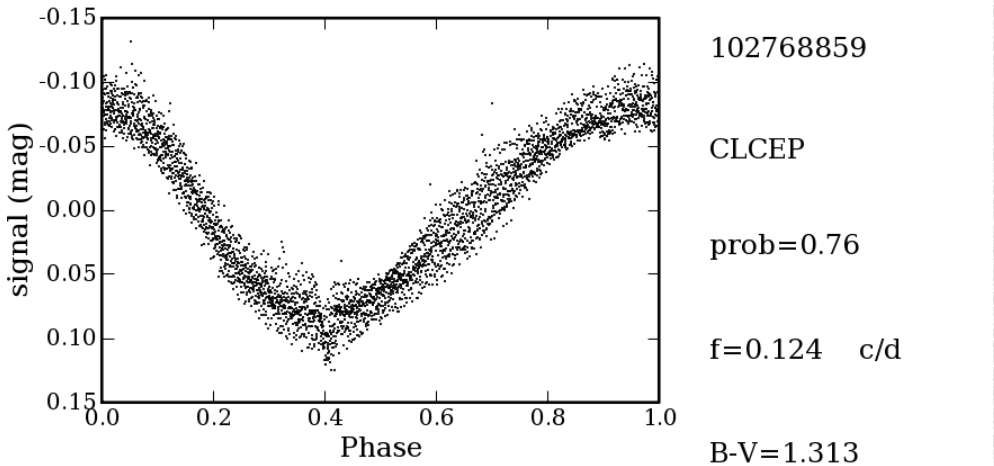

102702789
CP
prob=0.73
f=0.033 c/d
B-V=0.874
signal (mag)
Phase
signal (counts)
x1e+5
time (HJD)

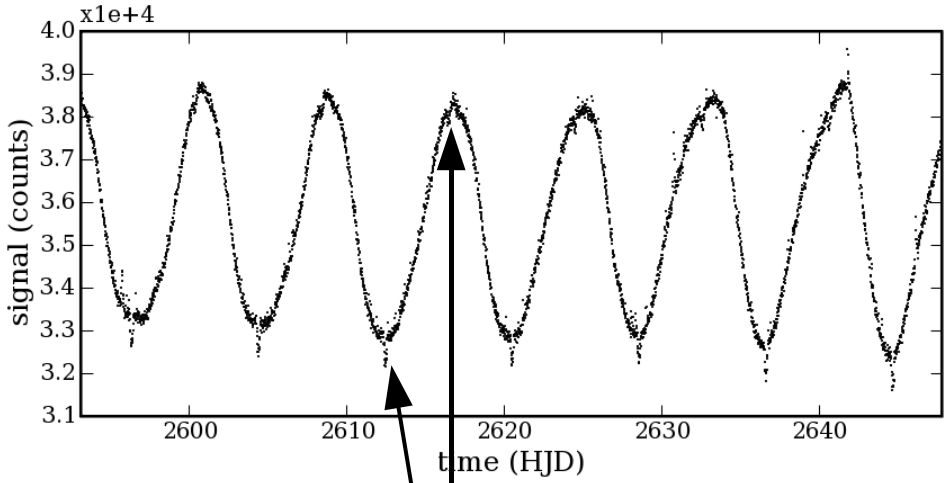

102759273
CP
prob=0.72
f=0.069 c/d
B-V=0.83
signal (mag)
Phase
signal (counts)
x1e+4
time (HJD)


102718176
CP
prob=0.53
f=0.029 c/d
B-V=0.818
signal (mag)
Phase
signal (counts)
x1e+4
time (HJD)

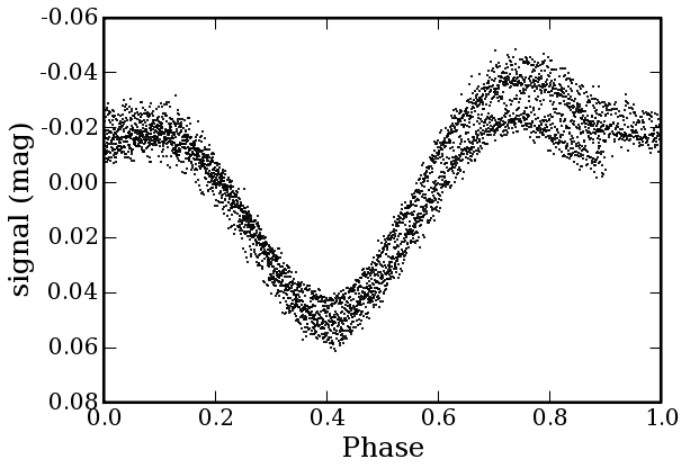

102744947
CP
prob=0.69
f=0.144 c/d
B-V=0.884
signal (mag)
Phase
signal (counts)
x1e+5
time (HJD)

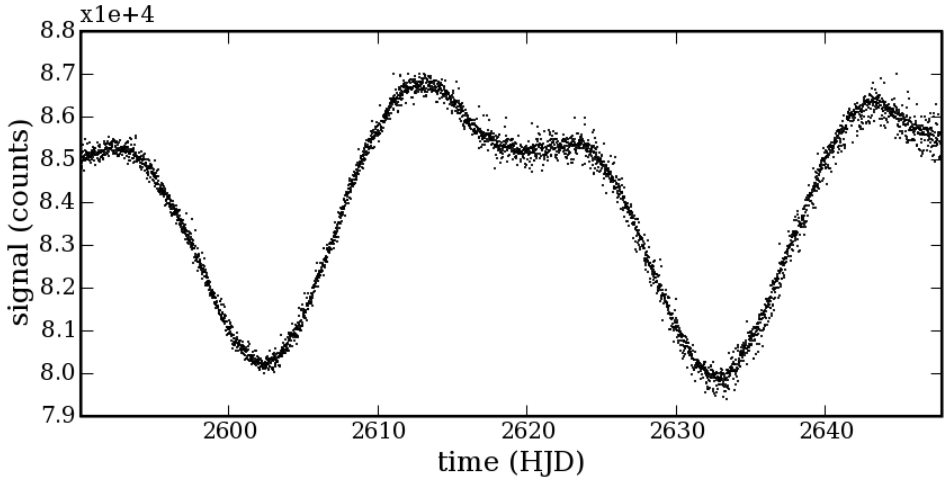
Cepheids (only 2!)





Eclipses!

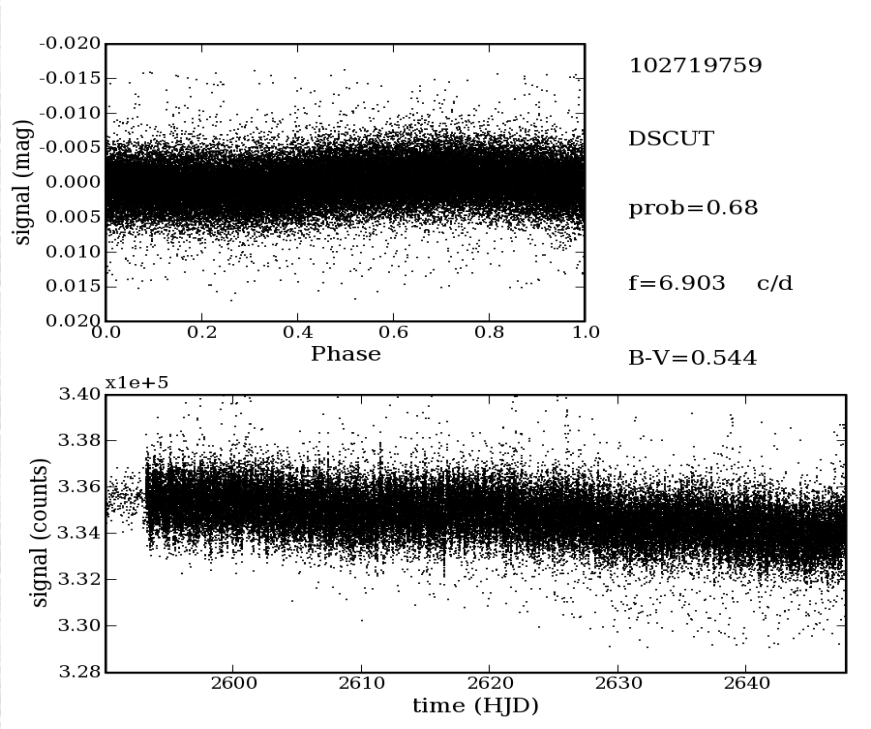


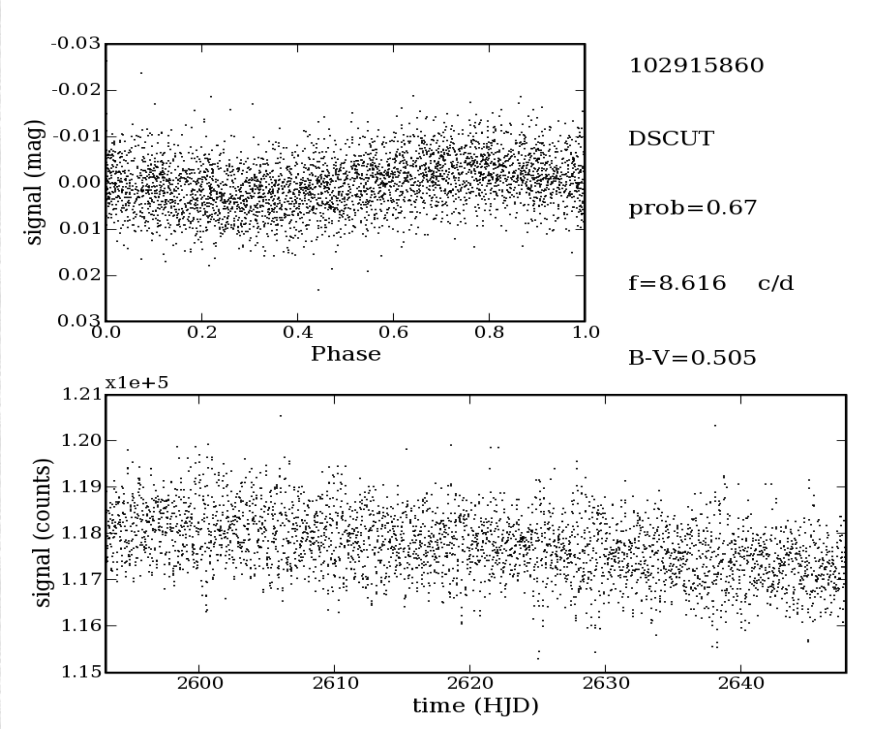


Confusion between classes

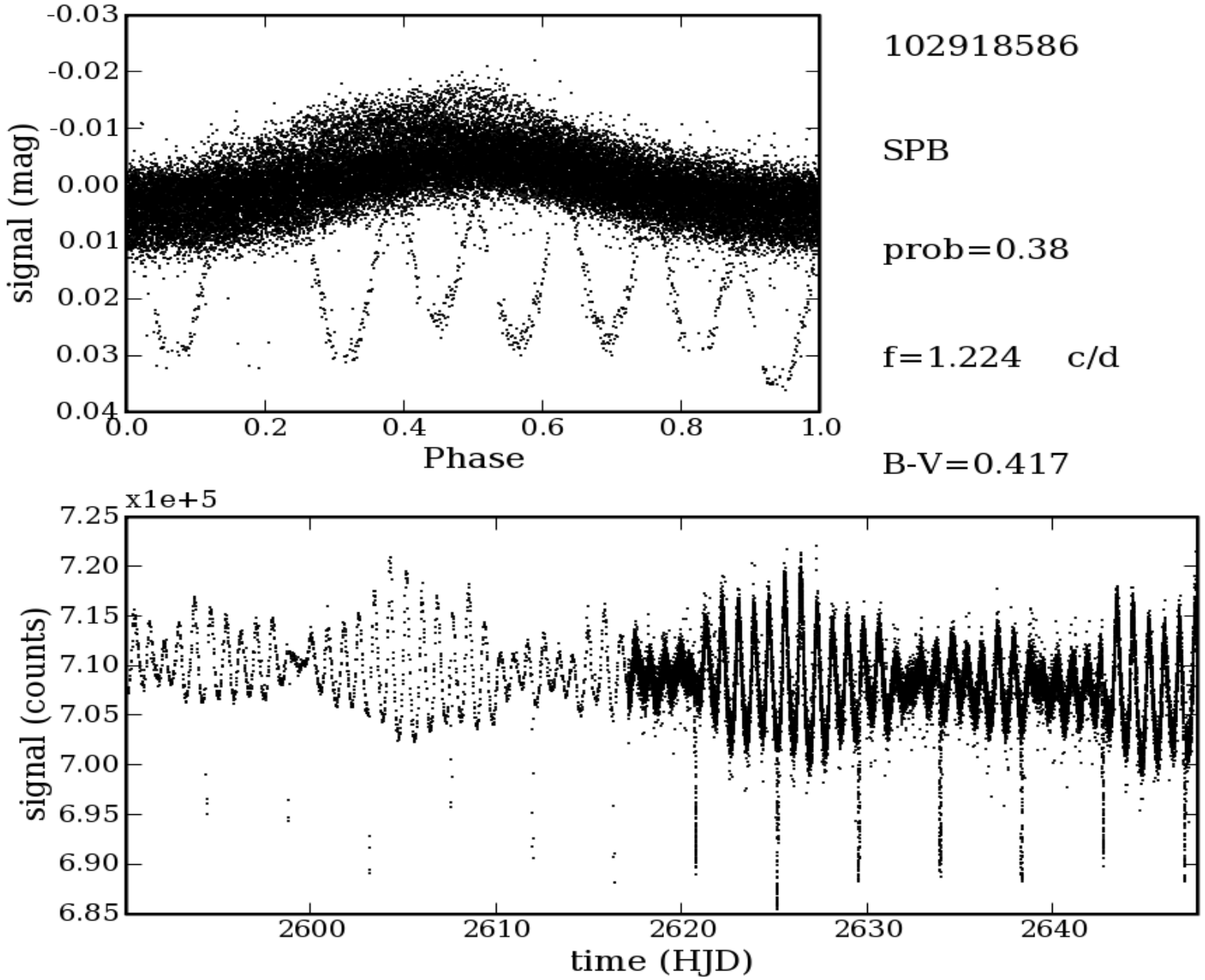
- **Some classes show considerable overlap (using only white light info): e.g. the DSCUT/BCEP classes and the ELL/SPB classes**

DSCUT or BCEP?



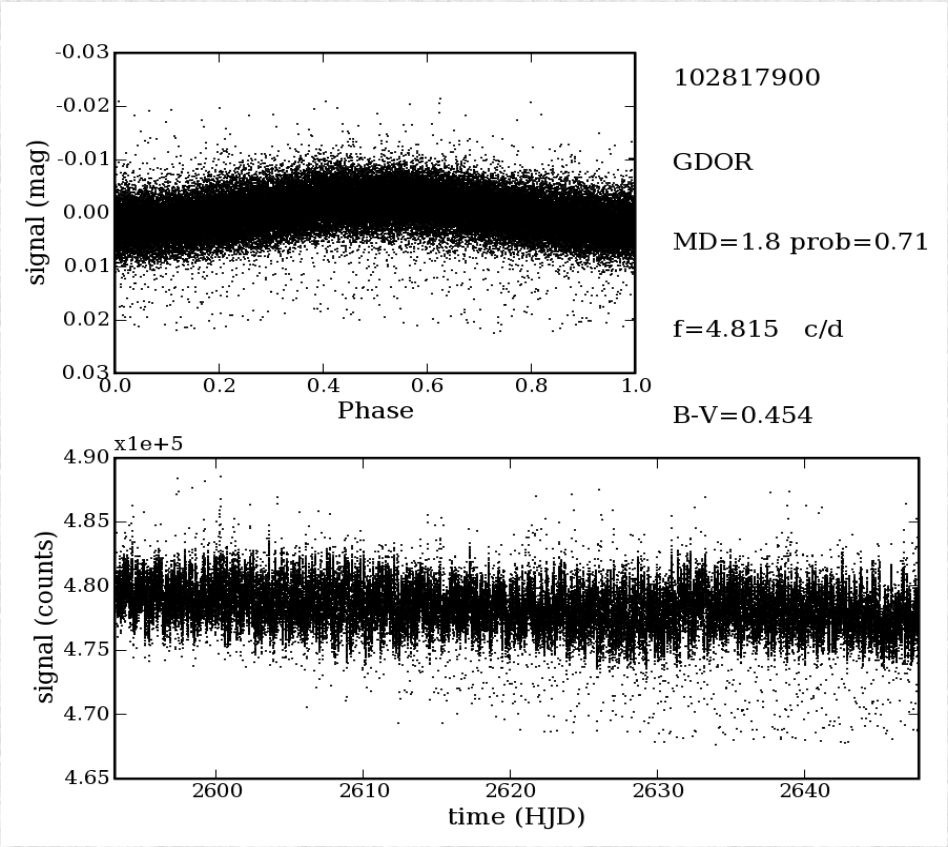


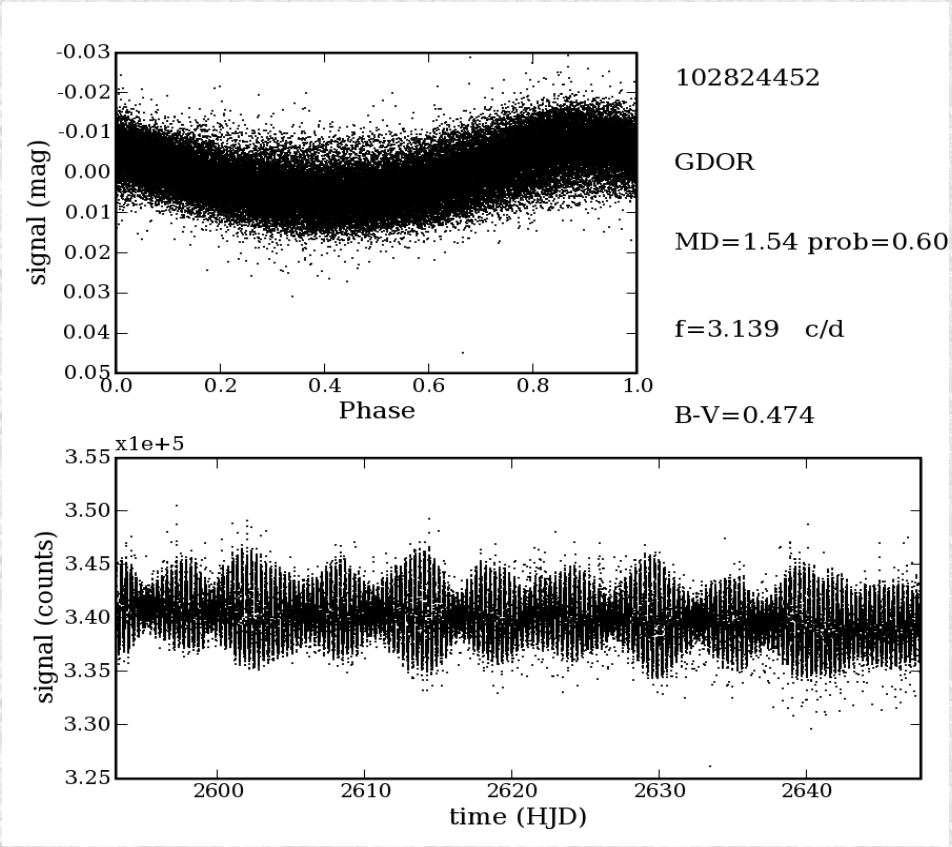
SPB in binary system!



Gamma-Doradus stars

- No detections with the BN classifier, good candidates with the GM classifier, though they might as well be SPB or BCEP candidates (overlap between classes):





What about planetary transits?

- The current implementation of the CVC does not include a class definition for planetary transits
- Light curves with transits will be classified as eclipsing binary, unless the light curves show additional variations (pulsations, spots) which dominate the transits.

What about mixed cases?

- Some objects actually belong to more than one class
- They can end up in either class, depending on the relative importance of the typical class characteristics in the light curves
  - e.g. a Cepheid showing eclipses that are small in depth compared to the pulsation amplitude will be classified as Cepheid
  - e.g. an eclipsing binary with a pulsating component will be classified as eclipsing binary if the pulsation amplitudes are small compared to the depth of the eclipses

First meeting of the Corot Classification Working Group

Table of Contents

Agenda:

Edit

1. Rafael Garrido: Recall of the CVC project
2. Jonas Debosscher: Present status of the CVC & Preliminary results on the IRa01
3. Werner Weiss: Use of the CVC for oversampling
4. Conny Aerts: Development of CVC
5. Enrique Solano: Long Term Archive
6. Christian Surace: Data delivery to LAM
7. Carla Maceroni: Strömgren photometry of Exofields
8. Discussion (Moderator: Annie Baglin)

Participants

Edit

- Werner Weiss
- Jonas Debosscher
- Gonzales Walter
- Coralie Neiner
- Anne Marie Hubert
- Conny Aerts
- Magali Deleuil
- Annie Baglin
- Merieme Chadid
- Nicolas Crouzet
- Philippe Mathias
- Eric Michel
- Michel Auvergne
- Christian Surace
- Roi Alonso
- Eduardo Janot-Pacheco
- Zoltan Kollath
- Luis Sarro
- Enrique Solano
- Stéphane Charpinet

Edit

Discussion:

Schedule for the evolution of the CVC

Annie puts forward a **schedule for the evolution of the CVC**. She proposes to use the present classification as an N30 product by the Guest Investigators teams (GIs). The classification team agrees to produce object lists according to this N30 product and send them to the Scientific Committee (Annie Baglin) by mid february. The GI teams are requested to produce clean samples of confirmed candidates for their target classes by mid March. These object lists will then be used as templates in a second version of the training set and classifiers. The procedure will be iterated in the coming runs. Issues raised:

- There is not a responsible for each and every class in the training set. Annie appoints Conny as responsible for filling the missing boxes.
- Coordination of GIs and Classification team: It is agreed that it is impractical that Annie passes the information to the GIs. It is proposed that the classification team itself is responsible for contacting the GIs and informing them on the requested tasks and the deadlines. Luis Sarro agrees to setup a Wiki page in order to have all the information available.

Colour indices

Jonas reported during the morning that the available colour indices like B-V seem to be far too red and thus cannot be used for classification. He points to uncorrected reddening as a possible source for the evident discrepancy between the expected colours and the available ones. Could Magali please write something about the origin of the colour indices?

Use of CoRoT bands

Conny suggests that phase lags between light curves in different CoRoT bands could be used for mode identification. Agreed to proceed with feasibilty studies.

Use of external data

Addition of external data, colours, spectral info.

- Annie makes it clear again that the official policy is not to include any external information in CoRoT products. We all agree that two parallel implementations of the classifier are needed: one working only with CoRoT information and another one also incorporating external information. It is agreed to ask the GIs for a minimal report on the optimal information that can help to separate their classes from neighbouring ones by the same time as the new templates (mid March). Coralie asks if, for example, H-alpha profiles can be incorporated in the classifier. Luis Sarro explains that it is possible to use only certain attributes for separating a small subset of classes. Therefore, the answer is yes. Luis Sarro stresses the importance of having whatever additional information is incorporated not only for CoRoT targets but also for the objects in the training set. This implies that there has to be a feasibility study for each proposal.

Unsupervised Classification

The importance of having unsupervised classification of the CoRoT Database is stressed, in order to discover new classes and exotic objects, but it is agreed that it is too soon to do this. We therefore postpone the tackling of this task until a better understanding of the CoRoT data and artifacts is gained by improving the existing supervised classifiers. Also, more data are necessary in order to have statistically meaningful results.

N3 products

On the N3 products generation and archive, it is remarked by Annie that this is a subject to be sorted by the scientific committee. Enrique Solano wants to ask for the clarification of who and how will incorporate the N3 products. He quotes one of the CoRoT official documents (minutes of the 21st Scientific Committee) where it is stated that the Mission Archive at IAS is responsible only for the N1 and N2 products but nothing has been agreed upon the N3 products. He also pointed out that in the same Scientific Committee it was decided to have a discussion among the Centres interested in managing CoRoT data (IAS, LAEFF and, probably IPAC), a discussion that has not yet taken place.

Edit

The meeting ended around 17:00.

Improvement of CVC from GI & co-I input

- **Lots of excellent LCs of multiperiodic pulsators!**
  - ***Make optimal use of exodata for Additional Programme***
- **Continuous improvement of N2 level quality: orbit + jumps**
- **Replace the LCs training set by the CoRoT LCs of best cases:**
  - **populated classes containing high probability candidates:**
    - ***Eclipsing binaries: GI give us their preferred definition stars***
    - ***Delta-Scuti, SPB, Beta-Cephei, Gamma Doradus : GI give us their preferred definition stars (GI can use external info)***
    - ***Ellipsoidal variables : EB team will validate the results***
  - **large and low-probability classes (the 'trash' classes):**
    - ***PVSG: GI give us a few confirmed definition stars***
    - ***CP: GI give us their preferred definition stars***
  - ***(nearly) empty classes (as expected, but is ok....):***
    - ***Classical pulsators: Cepheids, RR-Lyrae are very well recovered***

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Corot Classification Working Group

Table of Contents

This is the web page created as a result of the agreement of the attendants to the first Corot Classifier Working Group meeting at Marseille, and to be used as the place for information exchange and storage.

Edit

Past Meetings Minutes

Marseille Meeting Minutes (composed by Luis Sarro and Jonas Debosscher)

Improvement plan for CVC

Edit

- Addition of new attributes
- Irregular variables treatment: power spectra?
- Short Run for Pre-Main Sequence Pulsators: new attributes?
- Error estimates?
- The use of power spectra for classification. The problem here is that it needs a homogeneous training set constructed only from CoRoT data, and unfortunately CoRoT will only provide significant samples for a limited subset of classes.
- Importance of distinguishing between survey dependent attributes (power spectrum, variance ratios, frequency detection significance...) and survey independent ones. We clearly see the need to branch development and generate CoRoT optimal classifiers and optimal general purpose classifiers.
- Variable number of attributes. Check Paper by chechik

Action Items

Edit

1. Jonas and Luis to write the minutes of the Meeting. **Done**
2. Luis to create wiki page for information exchange. **Done**
3. Conny to contact G and Cols to inform of the agreements and deadlines for the delivery of new templates and information on new useful attributes. Also of the existence of the wikipage. **Done**
4. Co and GIs to deliver the CoRoT identifiers of template light curves to Jonas and Luis for improvement of the CVC by mid March 2008
5. Jonas, Conny and Luis: Teleconference programmed for March 28th to discuss the modifications to the classifiers. Before that, Jonas analyses the quality of the light curves and substitutes the original templates by Corot ones. He produces a new training set and the classifiers are retrained and reassessed using cross validation.

+ classification of LR01: done!

Edit

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Done

Distribution of N3 products to co-Is and Gis of AP, after the re-application of CVC with CoRoT definition stars: How? Who? When?

- SC has to decide on the final N3 product (flagg, light curve properties, FTs, ...)
- SC must define procedure to upload N3 product in database
- SC must decide if we allow the distribution of private, extractor results on CVC website (I prefer not, is GI responsability....)
- SC must decide if/how to contact the co-Is and GIs of AP

PROPOSAL: publication of CVC methodology and application to the IR, SC01, LR01 in A&A instrumentation section. Led by Jonas Debosscher and Luis Sarro; Co-authors: all involved co-Is and GIs of APs + builders + Marseille team Approval of SC?