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# Report on the second run of the ESO LP 182.D-0356 (HARPS@3.6m)

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## EXECUTIVE SUMMARY.

The ESO Large Programme 182.D-0356, started with the HARPS instrument at the 3.6m ESO telescope in December 2008 and January 2009, has continued with the runs in June and July 2009. The log of these observations, the problems encountered in the spectra reduction, some tips, the situation of the publications, and a look to the future are given. The following actions/items are emphasized:

1. The observations in the 15 nights were disturbed by clouds, humidity, and wind. The  $\delta$  Sct stars HD 174966 (SRc1) and HD 174532 (SRc2), the  $\gamma$  Dor star HD 171834 (LRc2), and the  $\beta$  Cep HD 170580 (LRc05) were observed to study line profile variations. Spectra were obtained for five red giants and for one HADS, all belonging to the CoRoT Additional Programs.
2. The filling program was completed. A backup program (HD 189631) was performed in two nights.
3. We are on the way to solve the serious instrumental problem we met in the reduction of the HARPS spectra.
4. The FEROS reduced spectra of the targets which have been published in a refereed paper have been deposited in the ESO archive.

## 1. Introduction

The ground-based spectroscopic monitoring of the CoRoT targets continued in June and July 2009. Four sites have been involved: European Southern Observatory (La Silla, Chile; HARPS@3.6m), Observatoire de Haute Provence (France; SOPHIE@1.9m), Calar Alto (Spain; FOCES@2.2m), Canary Islands (Spain; FIES@NOT). As in the previous cases, the goals of this sixth (the second of the HARPS series) internal report are to circulate useful information about the ESO observations within the team and to keep the record of the observations.

The next HARPS runs are scheduled from December 8 to 18, 2009 and from December 24 to 29, 2009. Monica Rainer (Brera Observatory) and Markus Hareter (Vienna University)

will be the observers. There will be neither OHP and NOT (proposals not accepted) nor FOCES (decommissioned instrument) runs. We can only count on the equivalent of 6 additional nights in the interval from December 14 to 24, 2009, at the MERCATOR telescope (HERMES instrument; Canary Islands). Our program will be merged with the others running on the same nights.

A new proposal for a Large Programme lasting 6 ESO Periods (i.e., three years) was submitted answering the P85 call (September 2009).

## 2. The contribution of our LPs to the A&A special volume

The special A&A feature devoted to CoRoT is now available. Table 1 lists the references of the papers based on the spectra collected in the framework of the LP178.D-0361. We also mention that a paper based on the characterization of HD 172189 has been accepted for the publication in A&A (Crevey, Uytterhoeven, Martin-Ruiz et al., *HD 172189: another step in furnishing one of the best laboratories known for asteroseismic studies*, arXiv:0909.3435). Table 1 also lists the studies still pending and the new attributions. **We also transferred to the ESO archive the reduced FEROS spectra of each target after the publication of the refereed paper, accomplishing for the ESO rules on the data obtained in a Large Programme.**

Two different strategies have been used to present the CoRoT results: the ground-based and space observations are analyzed either together (papers on HD 50844, HD 50846, HD 50209, HD 51146+HD50747, and HD 181231), or separately (papers on HD 49330 and HD 180642). The first papers on HD 49434 (Uytterhoeven et al. 2008) and HD 172189 (Crevey et al. 2009) discussed only the preparatory photometry and spectroscopy; the new spectroscopic data and the CoRoT timeseries are the subjects of ongoing analyses.

The current policy about co-authorship is to include the PIs of the Large Programmes (i.e., P. Amado, P. Mathias, E. Poretti), the observers of the specific star and, if the ESO data are used, M. Rainer, who reduced the ESO spectra for the whole team. The contribution of other instruments (HER-

CULES, FIES, NARVAL, FRESCO,...) should be evaluated case by case. **I suggest that in the second round of papers at least one of the above persons will be included in the first positions, to reward the great and long effort made to support CoRoT photometry with ground-based spectroscopy.**

### 3. The spectroscopic data of stars observed in June and July 2009

The CoRoT observations performed by CoRoT from April to September in the Center direction were splitted into two Long Runs (LRc03 and LRc04), each spanning 80 days. The direction of the pointings were decided on the basis of the stellar content satisfying the science in the exofield. As a result, the asteroseismic targets had no relevant impact on the science of our Large Programme. Therefore, we firstly selected three targets already observed by CoRoT, namely the  $\delta$  Sct HD 174966 (observed in the SRc01, just a couple of spectra were taken with FOCES in 2007), the  $\delta$  Sct HD 174532 (SRc02, never observed in high-resolution spectroscopy), and the  $\gamma$  Dor star HD 171834 (LRc02, already observed with FEROS in 2008). Then, we added the  $\beta$  Cep star HD 170580, which will be observed by CoRoT in 2010 (LRc05).

These stars were also observed:

- with the FIES instrument at the Nordic Optical Telescope by K. Uytterhoeven in a single run (4 nights from June 30 to July 4), getting 94 spectra of HD 174532, 48 spectra of HD 171834, 36 spectra of HD 170580, and 1 spectra of HD 174966;
- with the SOPHIE instrument at the Observatoire Haute Provence in two runs. P. Mathias and K. Uytterhoeven were the observer in the first (from July 4 to 13) and in the second (from July 30 to August 5) run, respectively. They got 42+40=82 spectra of HD 174966, 38+35=73 spectra of HD 174532, 19+23=42 spectra of HD 171834, 20+19=39 spectra of HD 180580;
- with the FOCES instrument at the Calar Alto Observatory in two runs (from June 12 to 16 and from July 1 to 16). Observations were performed in Service Mode (P.I. P. Amado) and the weather was good on 18.5 nights out of 21. We got 158 spectra of HD 174966, 154 spectra of HD 174532, and 163 spectra of HD 171834. This summary is preliminary because two nights still have to be reduced.

### 4. The ESO observations

The observers were Ennio Poretti (INAF-Brera Observatory, 20-30 June, 2009) and Juan Carlos Suarez (IAA, 14-19 July, 2009). Table 2 reports the logs of both runs. The setup of the HARPS instrument is summarized in the Appendix of the previous report. We just remind that the instrument must be set in the EGGS mode (i.e., lower resolution mode), corresponding to  $R=80,000$ , as measured on the spectra we obtained.

#### 4.1. Instrumental problem in the spectra reduction

At the beginning of June Michele Floquet reported the detection of a strange feature in the HARPS spectra collected in the December-January runs. The mean profile of the HE I line at 4921 Å shows some “oscillations” in the spectra of the Be star HD 51452, both on the line profile and on the continuum. The peak-to-peak amplitude is 0.5% of the continuum. The

origin is clearly instrumental and it was detected also in the spectra of the other stars observed in the same runs. Moreover, Peter De Cat promptly analyzed the spectra obtained with HARPS in July 2008. Though he observed with the instrument in the HAM configuration, the strange feature was noticed. These oscillations resulted to be strongly enhanced in the spectra obtained in June, the amplitude being raised to 2%. After interaction with the ESO staff, the problem was identified in the misalignment of a filter on the path of the flat-field lamp. Indeed, the “oscillations” were visible in the raw images of the flat field, but not in those of the stars (or, at least, they are not so evident). The strong misalignment occurred few weeks before, at the end of May 2009. The HARPS instrument scientist, Gaspare Lo Curto, corrected the misalignment and he sent us the HARPS spectra re-reduced with the new flat-field. The spurious oscillation was reduced to the same level as in the December-January spectra. These spectra still show the oscillation in the mean profile of a given line, but very good mean LSD profile. Since this constitutes a serious problem for our analysis, we (i.e., Brera team and ESO staff) investigated new solutions. In late July, it seemed we got a good trade-off by removing the filter from the optical path of the calibration lamp. We asked ESO staff to re-run the complete reduction of the HARPS spectra (i.e., all those collected in December 2008, January, June and July 2009). For some other commitments (including his move from Chile to Germany), G. Lo Curto has not yet been able to do it. He promised to run the new reduction in early November, when a version of the HARPS pipeline will be installed in Garching.

**When the new spectra will be available to us, we will made them available to the PIs of the different stars. Note that the spectra with the residual oscillation are available if someone would like to play with them.**

#### 4.2. Observing cycle

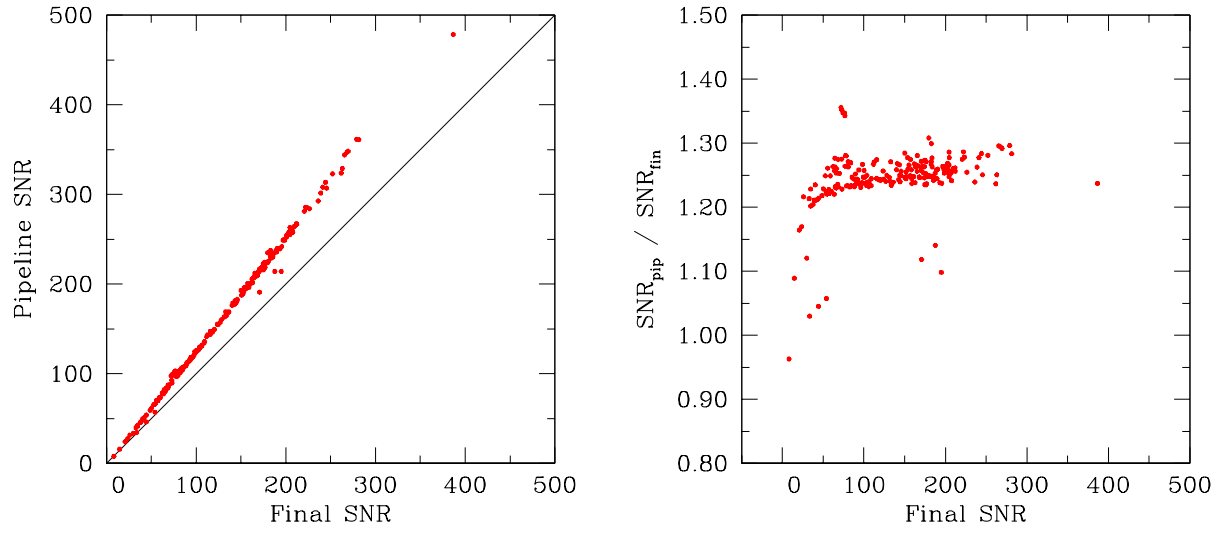
Exposure times have been set to 1200 sec for HD 174966, to 600 sec for HD 174532, to 450 sec for HD 170580, and to 150 sec for HD 171834. However, these exposure times were often modified accordingly to the weather conditions (clouds, poor seeing, ...). The observing sequence was

HD 170580 - HD 174966 - HD 174532 -  
 HD 171834 - HD 174966 - HD 174532 -  
 ...

The above sequence lasted 90 min, thus ensuring 5-6 cycles per night. **Moreover, the spectra of five red giants (HD 171427, HD 170008, HD 169689, HD 169370, HD 169751) and of one HADS star belonging to the CoRoT Additional Programs (in the exofield) were obtained in the 10-nights run.** HD 135240 was observed at the beginning of the night to better define the blaze function (exposure time: 150 sec).

#### 4.3. Length of the nights

The nights were about  $12^h30^m$  long. At the declination of the CoRoT field (from  $+6^\circ$  to  $-3^\circ$ ), the HARPS observations could be performed from  $-4^h20^m$  to  $+4^h20^m$ . At these extreme hour angles the airmass is 2.8, i.e., the critical telescope pointing limit. The CoRoT field could be observed for  $9^h$  in both runs. The night of 23-24 June started at UT  $22^h25^m \equiv$  ST  $11^h51^m$  and ended at UT  $10^h56^m \equiv$  ST  $24^h23^m$ .



**Fig. 1.** Differences between on-line and calculated SNR values. *Left:* the values sorted by the HARPS lines vs. the values calculated on the reduced spectra. *Right:* the ratio between the two SNR values vs. the SNR.

**Table 1.** Targets observed in the framework of the ESO ground-based complementary observations (LP 178.D-0361 with the FEROS instrument at the 2.2m ESO/MPI telescope). The responsables of the analysis of the spectroscopic data are also listed.

| Star                                        | Type                  | Investigators<br>Spectroscopic data | Papers                                   |
|---------------------------------------------|-----------------------|-------------------------------------|------------------------------------------|
| <i>Initial Run</i>                          |                       |                                     |                                          |
| HD 50747                                    | Am                    |                                     | Dolez et al., 2009, A&A, 506, 159        |
| HD 51106                                    | SB2                   |                                     | Dolez et al., 2009, A&A, 506, 159        |
| HD 50844                                    | $\delta$ Sct          |                                     | Poretti et al., 2009, A&A, 506, 85       |
| HD 50846                                    | Be, EB                |                                     | Desmet et al., 2009, MNRAS, in press     |
| <i>Long run center direction (LRc1)</i>     |                       |                                     |                                          |
| HD 180642                                   | $\beta$ Cep           |                                     | Briquet et al., 2009, A&A, 506, 269      |
| HD 181555                                   | $\delta$ Sct          | Mantegazza, Rainer and Zima         | Michel et al., in preparation            |
| HD 181231                                   | Be                    |                                     | Neiner et al., 2009, A&A, 506, 143       |
| <i>Long run anticenter direction (LRa1)</i> |                       |                                     |                                          |
| HD 49434                                    | $\gamma$ Dor          | Uytterhoeven (Dec. 2006-Jan. 2007)  | Uytterhoeven et al., 2008, A&A 489, 1213 |
| HD 49434                                    | $\gamma$ Dor          | Mathias (Dec. 2007-Jan. 2008)       | Rodriguez et al., in preparation         |
| HD 50209                                    | Be                    |                                     | Diago et al., 2009, A&A, 506, 125        |
| HD 49330                                    | Be                    |                                     | Floquet et al., 2009, A&A, 506, 103      |
| <i>Long run center direction (LRc2)</i>     |                       |                                     |                                          |
| HD 172189                                   | $\delta$ Sct, EB, SB2 | Martín                              |                                          |
| HD 171834                                   | $\gamma$ Dor          | Mathias                             |                                          |
| HD 171586                                   | Ap                    | Weiss                               | Luftinger et al., in preparation         |
| <i>Long run anticenter direction (LRa2)</i> |                       |                                     |                                          |
| HD 50870                                    | $\delta$ Sct          | Mantegazza                          |                                          |
| HD 51452                                    | Be                    |                                     |                                          |
| HD 51193                                    | Be                    |                                     |                                          |

#### 4.4. Weather statistics

The observations were often disturbed by clouds, humidity, and strong wind. In the first run we lost 29.0 hours (out of 125) due to bad weather (12.5 hours during the visibility of the CoRoT targets, 16.5 hours during the filling program). The CoRoT field was monitored for 73.5 hours, the filler stars for 22.5 hours. In two nights of the second run the strong wind hampered the pointing of the CoRoT field. Also considering a third night with high humidity, this means that the CoRoT field was observed for 17.5 hours only. The filler stars were monitored for 30.5 hours. Thus, in total, observations were performed for 48 hours (out of 62.5) in the second run.

#### 4.5. Signal-to-noise ratio evaluation

The SNRs listed in Table 2 are the median values of the SNRs in the region 5802–5825 Å. They have been computed during our reduction taking into account photon noise, readout noise and flat field correction. At the telescope, the HARPS pipeline provides an estimate of the SNR at three different wavelengths (4500, 5500 and 6500 Å). Figure 1 shows how the SNR values given by the HARPS pipeline at 5500 Å are a little too optimistic. The displayed values should be reduced by a factor of 1.25 to get the real SNR values. At the telescope the observer can also estimate the SNR in another way, i.e., by plotting the SNR values in the different orders and taking the maximum values.

#### 5. Backup and filling programs

The strong wind blowing from North forced J.C. Suarez to move to the *backup program* in two nights (16-17, 17-18 July). The backup star was HD 189631, the target of a multisite campaign chaired by P. De Cat. We add 49 HARPS spectra to the database.

Other targets have been observed at the beginning and at the end of nights (*filling program*), strictly following the ESO rules in the submission of these additional targets. In particular, the T Tau variable V2129 Oph was observed in the first parts of the 10-nights run: this monitoring was explicitly requested by J. Bouvier, the PI of a multisite campaign coordinated with the CHANDRA satellite. In total, 7 spectra were obtained. All the targets proposed by the CoIs of the Large Programme were observed. In addition to  $\epsilon$  Lup (P.I. K. Uytterhoeven, 18 spectra) and HR 6139 (P.I. L. Mantegazza, 14 spectra), we observed:

*Be stars* (P.I. A.M. Hubert) – HD 87203 (1 spectrum), V337 Vel (1), V958 Cen (1), HD 131168 (1), HV Lup (3), HD 143578 (3), HD 144965 (1), HD 146444 (2), OZ Nor (2), V1063 Sco (1), NT Peg (1).

*$\gamma$  Dor stars* (P.I. P. De Cat) – HD 11462 (1 spectrum), HD 79039 (1), HD 79416 (1), HD 80859 (1), HD 83297 (1), HD 85012 (1), HD 84809 (1), HD 86659 (1), HD 103257 (1), HD 118285 (1), HD 121190 (1), HD 131058 (1), HD 137785 (1), HD 206481 (1), HD 205879 (1). For some stars, the single spectrum is composed of 5 short-exposure spectra.

**Table 2.** Log of the observing runs (June 2009–July 2009) at ESO with the HARPS@3.6m instrument. The number of spectra and the measured SNR range are indicated for every star on each night. Spectra with low SNR have not been counted.

| Night                  | HD 174966<br><i>V</i> =7.7 | HD 174532<br><i>V</i> =6.9 | HD 171834<br><i>V</i> =5.4 | HD 170580<br><i>V</i> =6.7 | Seeing    | Notes                                    |
|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|-----------|------------------------------------------|
| Exp. Time<br>(Default) | 1200 sec                   | 600 sec                    | 150 sec                    | 450 sec                    |           |                                          |
| June 20-21             | 4<br>[65-160]              | 3<br>[68-170]              | 12<br>[60-387]             | 1<br>[85]                  | 1''0–1''7 |                                          |
| June 21-22             | 9<br>[90-180]              | 11<br>[80-245]             | 8<br>[64-158]              | 5<br>[100-200]             | 1''1–1''8 | 1 <sup>h</sup> lost due to bad weather   |
| June 22-23             | 7<br>[144-190]             | 7<br>[128-180]             | 3<br>[180-195]             | 3<br>[124-158]             | 1''1–1''6 | 6.5 <sup>h</sup> lost due to bad weather |
| June 23-24             | 12<br>[154-212]            | 10<br>[172-227]            | 6<br>[150-260]             | 6<br>[140-200]             | 1''1–1''4 |                                          |
| June 24-25             |                            |                            | 5<br>[90-120]              | 1<br>[90]                  | 1''3      | 10 <sup>h</sup> lost due to bad weather  |
| June 25-26             | 10<br>[127-207]            | 10<br>[90-250]             | 5<br>[140-240]             | 4<br>[113-200]             | 1''1–1''5 | 1 <sup>h</sup> lost due to bad weather   |
| June 26-27             | 11<br>[120-243]            | 11<br>[149-265]            | 6<br>[187-267]             | 5<br>[98-208]              | 1''0–1''4 | 3 <sup>h</sup> lost due to bad weather   |
| June 27-28             | 9<br>[84-163]              | 8<br>[76-189]              | 7<br>[93-203]              | 5<br>[77-170]              | 1''4–1''8 | 3 <sup>h</sup> lost due to bad weather   |
| June 28-29             | 9<br>[103-206]             | 9<br>[124-205]             | 4<br>[140-225]             | 4<br>[133-186]             | 1''0–1''5 | 4.5 <sup>h</sup> lost due to bad weather |
| June 29-30             | 12<br>[140-220]            | 12<br>[104-260]            | 5<br>[170-220]             | 6<br>[130-207]             | 0''7–1''2 |                                          |
| July 14-15             |                            |                            |                            |                            |           | Clouds, high humidity                    |
| July 15-16             | 9<br>[82-180]              | 10<br>[150-250]            | 9<br>[137-203]             | 10<br>[92-200]             | 1''3–1''8 |                                          |
| July 16-17             |                            | No CoRoT observations      |                            |                            | 1''5–2''0 | Strong wind                              |
| July 17-18             |                            | No CoRoT observations      |                            |                            | 1''5–2''4 | Strong wind                              |
| July 18-19             | 8<br>[107-180]             | 8<br>[108-216]             | 9<br>[180-190]             | 9<br>[100-180]             | 1''3–1''8 |                                          |
| <b>Total ESO</b>       | <b>100</b>                 | <b>99</b>                  | <b>79</b>                  | <b>59</b>                  |           |                                          |
| <b>Total OHP</b>       | <b>82</b>                  | <b>73</b>                  | <b>42</b>                  | <b>39</b>                  |           |                                          |
| <b>Total NOT</b>       | <b>1</b>                   | <b>94</b>                  | <b>48</b>                  | <b>36</b>                  |           |                                          |
| <b>Total CAHA</b>      | <b>&gt;158</b>             | <b>&gt;154</b>             | <b>&gt;163</b>             | <b>0</b>                   |           |                                          |

*LBV stars* (P.I. K. Uytterhoeven) – HD 269858 (2).

We remind that both backup and filling programs have to be submitted by the PI 10 days before the observations and then approved by the ESO staff.