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HARPS

HCFA and Calibration Unit Design, Analysis and Performance Report

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Chapter 1: Introduction

1.1 Scope

This document describes the Final Design of the HARPS Cassegrain Fiber Adapter and the Calibration Unit. It is based on the “HARPS Preliminary Design, Analysis and Performance Report” [AD-3] and gives details of the design approach taken for the realization of the system. A list of all assembly drawings is supplied in the appendix. The optical alignment/adjustment procedure of the CFA and CU can be found there too.

1.2 Documents

1.2.1 Applicable Document

| | | | | |
|------|---|------------------------|-----|------------|
| AD-1 | HARPS Calibration, Operation and Maintenance Plan | 3M6-PLA-HAR-33100-0005 | 1.0 | 4/12/2000 |
| AD-2 | DFS Software User Requirements and Design Report | 3M6-TRE-HAR-33110-0001 | 1.1 | 17/01/2000 |
| AD-3 | HARPS Preliminary Design, Analysis and Performance Report | 3M6-TRE-HAR-33100-0003 | 1.0 | 26/06/2000 |

1.2.2 Reference Document

| | | | | |
|------|--|------------------------|-----|------------|
| RD-1 | HARPS CCD Detector Final Design, Analysis and Performance Report | 3M6-TRE-HAR-33104-0002 | 1.0 | |
| RD-2 | HARPS ICD between Detector Unit and Spectrograph | 3M6-TRE-HAR-33100-0010 | 1.0 | |
| RD-3 | HARPS Temperature-Control System of the Spectrograph | 3M6-TRE-HAR-33102-0005 | 1.0 | |
| RD-4 | ICD between the ESO 3.6m Telescope and HARPS | 3M6-ICD-HAR-33100-0009 | 1.0 | 31/06/2000 |

1.3 Acronyms

| | |
|------|--|
| AD | Applicable Document |
| CCD | Charge-Coupled Device |
| CES | Coudé Echelle Spectrograph |
| CFA | Cassegrain Fiber Adapter |
| CFC | Continuous-Flow Cryostat |
| DFS | Data-Flow system |
| DRS | Data-Reduction Software |
| ESO | European Southern Observatory |
| FDR | Final Design Review |
| FRD | Focal Ratio Degradation |
| FTS | Fourier Transform Spectrometer |
| HW | Hardware |
| ICD | Interface Control Document |
| ICS | Instrument Control Software |
| IP | Instrument Profile |
| IWS | Instrument Work Station |
| LCU | Local Control Unit |
| LSF | Line Spread Function |
| NA | Not Applicable |
| OG | Observatoire de Genève |
| OHP | Observatoire de Haute-Provence |
| OPS | Observing Preparation Software |
| OS | Observing Software |
| OSS | Observing Support Software |
| PAE | Preliminary Acceptance in Europe |
| PAC | Provisional Acceptance in Chile |
| PDR | Preliminary Design Review |
| PSF | Point Spread Function |
| RD | Reference Document |
| RON | Read-Out Noise |
| RV | Radial Velocity |
| S/N | Signal-to-Noise ratio |
| SW | Software |
| TBC | To Be Confirmed |
| TBD | To Be Defined |
| TCCD | Technical CCD |
| TCS | Telescope Control System |
| ThAr | Thorium-Argon (calibration lamp) |
| UVES | UV to Visible Echelle Spectrograph (VLT) |
| VLT | Very Large Telescope |
| WS | Work Station |

Chapter 2: Mechanics Description

2.1 HARPS CASSEGRAIN FIBER ADAPTER

(ESO-360.905.00.00. 1/2 and ESO-360.905.00.00. 2/2)

The assembly drawings show the overall side view and top view of the HCFA. Please refer to these drawings to locate the individual units described below. The numbers given in the description of these units refer to the parts in the corresponding unit assembly drawings

2.1.1 CFA Body (Upper And Lower Part)

(ESO-360.905.01.00 and ESO-360.905.02.00)

The CFA Body is mounted on to the instrument adapter of the 3.60m-telescope and oriented by a pin. It includes an upper part, which contains all opto-mechanical components. These components are mounted in such a way, that one has good access in order to align, to repair, and to make maintenance or to dismount the individual units. The lower part protects only the fiber heads and the fiber going to the spectrograph. It can be easily removed for maintenance (cleaning) of the Fiber Heads.

The upper part (main part) is built from a cast aluminium ring (G-Al Cu 4Ti) and two flanges: a cover and a bottom flange. The material: thermally treated aluminium.

2.1.2 Drive System

Before describing the opto-mechanical subassemblies, a description of the common drive systems will be given of the following units:

1. Fiber Head Carriage
2. Mirror Unit
3. Atmospheric Dispersion Corrector
4. Iodine Cell Unit
5. Fiber Head Protection Slide

All these mentioned units are doing an in-out movement. The drive consists of a DC-motor (8000 R/min) with tacho generator and a gear unit (43:1). A standard ball screw spindle (2 mm pitch) is driven by two gear wheels. The one on the motor shaft is equipped with a friction coupling. An incremental encoder (1000 lines) is connected by a precision coupling to the ball screw (spindle). The nut of the spindle is connected by a spring steel tappet to the carriage. This one is mounted on a THK linear guide system, which is free of backlash. The speed of the moving unit amounts to 6mm/sec. On both sides of the carriage are in each case two mechanical stops and two end switches mounted. They will be actuated before the mechanical end-stop is reached. The

remaining inertia of the motor will be absorbed by the friction coupling. One of the limit switches is used as initialisation switch. A cut-off current of about 1 Volt keeps the carriage at the respective mechanical stop. This low voltage is not producing any excessive heat (tested).

2.1.3 Fiber Head Carriage

(ESO-360.905.03.00)

The Fiber Head Carriage is mounted on a steel flange, sitting underneath the bottom flange of the upper housing and serves also to center the lower housing. The carriage contains two fiber heads; one for HARPS and one for the CES. The drive is described in 2.1.2

The design of the fiber heads has not yet been defined and therefore the mounting and adjustment is still TBD.

2.1.4 HARPS Fiber Head

(ESO-360-905.04.00)

Not yet designed and prototype not tested. At PDR, it has been decided to test two prototypes of the fiber heads, in order to find out which of the two proposed designs would provide the better performance. These tests are about to be concluded and only then, the detail design of the mechanics for the heads can be done.

2.1.5 CES Fiber Head

(ESO-360.905.05.00)

Not yet designed and prototype not tested.

See also 2.1.4

2.1.6 Mirror Unit

(ESO-360-905.06.00)

The mirror, which projects the calibration light onto the fibers, can be moved into four different positions. It allows selecting the mode of observation/calibration. A small shield is fixed on the mirror, which avoids that reflected calibration light from the fiber head enters the path of the slit viewer camera in the instrument adapter and produces glaring on the TCCD. The whole unit is compact and it is mounted on the bottom flange of the housing. The drive of the mirror is described in point 2.1.2 In this case, it is not only an in-out movement.

2.1.7 Calibration Light Projection Optics

(ESO-360-905.07.00)

It is located between Fiber Connection Unit 2.1.7 and the Mirror Unit 2.1.6 The projection optic is mounted inside a rectangular tube, which contains two optical paths with a separation of 16 mm for the two calibration beams. The two optics are identical. The exit lenses (achromats) are

fixed and the entrance lenses are mounted into a thin tube, which can be moved back and forth and be rotated too. This rotation is required for the proper positioning of the pupil masks, which are fixed at the end of each of the two tubes. The two light paths in the rectangular tube can be adjusted bi-directionally with the help of two pairs of eccentrics. The access from outside of the housing is easy: a door is foreseen for this operation.

2.1.8 Neutral Density Filter Wheel

(ESO-360-905.08.00)

It is a filter wheel with 152mm diameter, which is located between the Calibration Light Projection Optic 2.1.7 and the Fiber Connection Unit 2.1.9. It is mounted onto two ball bearings and has a friction break at the end of the axis, in order to avoid backlash. The DC-motor (3600 R/min) has adapted a tacho generator and a harmonic drive reduction (100:1). The transmission between motor ensues with the help of gear wheels (1:1) and the transmission to the incremental encoder (1000 lines). In this case, anti-backlash gears are used. In order to clean or to adjust the optics of the Calibration Light Projection Optic the Neutral Density Filter Wheel can be removed easily.

2.1.9 Fiber Connection Unit

(ESO-360-905.09.00)

Two fibers feed the light from the calibration unit, which is located in the HARPS room, to the CFA. The fibers are protected by a special flexible hose and they are connected with standard SMA connectors to the Fiber Connection Unit. This unit can be removed easily, when necessary. Each fiber is held and guided by an individual mount consisting of three translation stages, which allow three motions: left and right, up and down and focusing. Both mounts are attached to a THK linear guide system, which allows readjusting, changing or cleaning of the fibers by simply sliding the unit out manually. The unit is protected by a cover against dust and stray light.

2.1.10 Atmospheric Dispersion Corrector

(ESO-3.60-905.10.00)

It is mounted underneath the cover flange of the housing. The complete mechanism is mounted on a carriage (THK linear guide system), which is doing an in-out movement: in for HARPS and out for CES. The drive is described in point 2.1.2. The table of the carriage contains a main housing with two sets of prisms and two drives for the prism rotation. Each prism set is mounted in an individual thin housing and its outside diameter is toothed (84 teeth), to be driven by a tooth belt. The two prism sets can be turned independently from each other. The drive unit for one prism set consists of a DC-motor (8000R/m) with tacho generator and gear unit (3.71:1). A worm sits on the shaft, which is driving a worm wheel (35:1). On the same axis of this wheel, a fixed gear wheel is mounted for the tooth belt (42 teeth) and a gear unit with a transmission ratio of 2:1. So, the total transmission ratio encoder – prism is 1:1.

2.1.11 Iodine Cell Unit

(ESO-360.905.11.00)

The complete mechanism is mounted on a carriage (THK linear guide system), which is doing an in-out movement: in for CES and out for HARPS. The drive is described in point 2.1.2 The Iodine Cell (when used during CES observation) is placed between the fiber head and the 45° mirror that provides for an alternative observing mode.

This unit shall not be described in more detail, because it is only used for CES observations. What has to be guaranteed is the requirement that HARPS functionality is not being impaired by the Iodine cell.

2.1.12 Fiber Head Protection Slide

(ESO-360-905.12.00)

A protection cover is mounted on a carriage (THK linear guide system). The drive is described in point 2.1.2, however without encoder. The protection slide covers the fiber heads when the instrument is not being used.

2.2 HARPS CALIBRATION UNIT

(ESO-360-906.00.00)

This unit is located in a cooled 19" standard electronic rack. It contains two Hollow Cathode Lamps (ThAr), one of them is a spare, a Halogen Lamp (white light) and two fibers, which could contact a laser light source or a white light. The idea is to have the possibility to feed any spectrograph fiber with any one of the calibration sources. This results in five lamp positions with a 'dark' position in between every source. 'Dark' means, that no light is fed into the fiber, even if one or more lamps are turned on.

2.2.1 Hollow Cathode Lamp Unit

(ESO-360.906.01.00)

The units have three movements for the adjustment. The first one is given by a THK linear guide system, which allows focusing, by push pull screws. The second one is a small transverse movement on the same type of linear guide, moved by two screws with conical ends. A side plate is mounted on this rail and the lamp housing is fixed in such a way on it, that an up-down movement is made possible because of a spring-loaded device. The lamp housings are equipped with ribs in order to guarantee a good cooling. A photo diode is controlling the status of the lamp. Hollow cathode lamps can be changed easily and quickly.

2.2.2 Halogen Lamp Unit

(ESO-360.906.02.00)

The Halogen light sources are nearly identical in its design as the Hollow Cathode Lamp Units explained before in 2.2.1.

2.2.3 Fiber Illumination Unit

(ESO-360-906.03.00)

This unit contains the optics to project the calibration light into the fibers. For the two movements are provided which are identical to the ones explained in 2.2.3. The third movement is achieved by means of a translation stage, on which the fiber is plugged in.

2.2.4 Fiber Drive Unit

(ESO-360-906.04.00)

The system consists of two independent fiber-positioning devices. The idea is, as mentioned before, to have the possibility to feed any spectrograph fiber with any light source.

The drive consists of a DC-motor (5000 R/min) with tacho generator and a gear unit (43:1). A standard ball screw (5 mm pitch) is driven through two gear wheels. The one on the motor shaft is equipped with a friction coupling. An incremental encoder (1000 lines) is connected to the ball screw (spindle). The nut of the spindle is connected by a spring steel tappet to the carriage. This one is mounted on a THK linear guide system, which is completely free of backlash. The speed of the moving unit amounts to 9 mm/sec. A limit switches and a mechanical end-stop for safety is mounted on both ends of the carriage. The limit switches will be actuated before the mechanical end-stop is reached. The remaining inertia of the motor will be absorbed by the friction coupling. One of the limit switches is used as initialisation switch.

2.2.5 Rack Housing

(ESO-360.906.05.00)

It is a simple 19" rack crate made of six aluminium plates. In case of lamp change or repair, it can be slide out of the rack and opened easily, the cover plate is fixed with only four screws. Cables and fibers are leaving the housing through slots. It is equipped with many openings (with lattices), which guarantee a constant exchange of the warm air, which will then be absorbed by the rack cooler. Another 19" crate in the same rack contains the power supplies for the calibration lamps.

Chapter 3: Appendix

3.1 List of Drawings

| Drawing No. | Issue | Date | Author | Description |
|--------------------|--------------|-------------|---------------|---|
| HA-FA-A00-A | 1 | 05.12.2000 | W. Eckert | HARPS Cassegrain Fiber Adapter Assembly |
| HA-FA-B00-A | 1 | 26.12.200 | W. Eckert | Housing Upper Part |
| HA-FA-C00-A | 1 | 15.09.2000 | W. Eckert | Housing Lower Part |
| HA-FA-D00-A | 1 | 26.09.2000 | W. Eckert | Fiber Head Carriage |
| HA-FA-E00-A | 1 | | W. Eckert | HARPS Fiber Head |
| HA-FA-F00-A | 1 | | W. Eckert | CES Fiber Head |
| HA-FA-G00-A | 1 | 22.09.2000 | W. Eckert | Mirror Unit |
| HA-FA-H00-A | 1 | | W. Eckert | Calibration Light Projection System |
| HA-FA-I00-A | 1 | 03.08.2000 | W. Eckert | Neutral Density Filter |
| HA-FA-K00-A | 1 | 14.12.2000 | W. Eckert | Fiber Connection Unit |
| HA-FA-L00-A | 1 | | W. Eckert | Atmospheric Dispersion Corrector |
| HA-FA-M00-A | 1 | 14.10.2000 | W. Eckert | Iodine Cell |
| HA-FA-N00-A | 1 | 27.10.2000 | W. Eckert | Fiber Head Protection Slide |
| HA-CU-A00-A | 1 | 24.01.2001 | W. Eckert | Calibration Unit Assembly |
| HA-CU-B00-A | 1 | 19.12.2000 | W. Eckert | Hollow Cathode Lamp Unit |
| HA-CU-C00-A | 1 | 10.01.2001 | W. Eckert | Halogen Lamp Unit |
| HA-CU-D00-A | 1 | 12.01.2001 | W. Eckert | Fiber Illumination |
| HA-CU-E00-A | 1 | 15.01.2001 | W. Eckert | Fiber Carriage Drive |
| HA-CU-F00-A | 1 | 24.01.2001 | W. Eckert | Calibration Housing |
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| | | | | |

3.2 Optical Alignment Manual