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Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

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SciOps

Technical report
EGGS system: re-commissioning after repair.

3P6-TRE-ESO-90200-00010
Issue 1.0
Date: 19/01/2008

keywords: HARPS, EGGS

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CHANGE RECORD

Issue	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
1.1	dd/mm/yyyy		
1.0	19/01/2008	All	Creation

TABLE OF CONTENTS

1. INTRODUCTION

The high efficiency mode of HARPS: EGGS, suffered a major damage on July 2007.
After the EGGS damage documented in [1], the EGGS mode was decommissioned.
The repair involved replacement of the splicers of both fibres with commercial fibre connectors and the re-installation and alignment of the scientific fibre within the fibre head.

1.1 PURPOSE

Here are reported the tests performed after the repair mission and the readiness for science of the mode is assessed.

1.2 SCOPE

Day and night tests are described and their results are discussed.

1.3 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this document to the extent specified herein. In the even of conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered a superseding requirement.

1. 3M6-SPE-ESO-13100-0012, Issue 1.3, 14/12/2004 --- EGGS user requirements

1.4 REFERENCE DOCUMENTS

The following documents are referenced in this document.

2. 3P6-TRE-ESO-90200-0007, Issue 1.1, 13/09/2005 --- EGGS comm.. rep. 1
3. 3P6-TRE-ESO-90200-0010, Issue 1, 20/01/2007 --- EGGS comm.. rep. 2
4. 3M6-TRE-HAR-33105-0001, Issue 1, 28/02/2001 --- Fibre link performance report
5. 3P6-TRE-ESO-90200-0011, Issue 1, 02/08/2007 --- EGGS damage

1.5 ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this document:

EGGS	HARPS high efficiency mode (Extra Good General Spectroscopy)
HAM	High Accuracy Mode of HAM
HARPS	High Accuracy Planet Searcher
HCFA	HARPS Cassegrain Fibre Adapter
LSO	La Silla Observatory
N/A	Not Applicable
RV	Radial Velocity
TBC	To Be Confirmed
TBD	To Be Defined

1.6 STYLISTIC CONVENTIONS

This subsection is optional. Use it if it makes sense. The following is just an example. Change it according to your needs.

The following styles are used:

Bold
In the text, for commands, filenames, pre-suffixes as they have to be typed.

Italic
In the text, for parts that have to be substituted with the real content before typing.

`Teletype`
For examples.

`<name>`
in the examples, for parts that have to be substituted with the real content before typing.

Bold and *italic* are also used to highlight words.

2. OVERVIEW

The motivation for the re-commissioning of EGGS is to assess the functionality, the efficiency and the RV accuracy of the system after the repair. The nights of January 22nd and 23rd were used in part for this purpose.
The first night we could observe under mediocre conditions, while the second night the telescope was closed for high humidity. The data of the first night showed evidence of mechanical instability of the EGGS fiberhead, this problem was tackled and possibly solved by a slight displacement (<1mm) of the fibre carriage towards the West. More tests should be performed to confirm solution of this problem.
Day tests are described in section 3, night tests in section 4.
Section 5 reports the conclusions of this study.

3. DAY TESTS

Day tests involved calibrations, a check for differential drift as measured from the two fibres as a function of telescope position, and observations of the day sky.

3.1 Fiber hole appearance in the slit viewer

The EGGS science fibre appears to be at the very edge of the calibration beam spot; the calibration/sky fibre cannot be seen in the camera. The position of the fibre changes when moving the green cylindrical protection shield of the fibres at the HARPS adapter. This is not acceptable and should be understood and fixed.
Currently the EGGS and the HAM (for comparison) fibres have coordinates (at Zenith):

	X	Y	Focus (camera)
HAM	557.6	405.5	38500
EGGS	577.5	420.2	38500

3.2 Standard calibrations

The standard calibrations sequence is successfully executed on EGGS by reducing the exposure times by a factor 2 compared to HAM. The pipeline reduces the calibration flawlessly indicating the good quality of the data. As already measured during the first commissioning [2] the RV drift of EGGS with respect to HAM is of approximately -13.4km/s, corresponding to about 15 pixels or 225μm on the detector. The drift along the cross dispersion direction is less than 2 pixels.

3.3 Differential drift

Fibre stability was measured by a sequence of wavelength calibration frames taken at different telescope position. After each exposure a second exposure was taken to reset the differential quantities. The measurements were collected after a temporary re-adjustment, on the second day, of the end point at the West end of the fibre carriage. This intervention increased the mechanical stability of the EGGS system. The data are shown in the table below.

Position	EGGS diff. drift (m/s)	EGGS Flux ratio (A / B)	EGGS fibre (X ; Y)	HAM Diff. drift (m/s)	HAM Flux ratio (A-B)	HAM fibre (X ; Y)
Zenith	-0.16	1.000 / 1.000	578 ; 418	+0.12	1.000 / 1.000	557 ; 403
N 60 deg.	-1.14	0.999 / 1.007	579 ; 413	+0.57	0.976 / 0.971	559 ; 398
Zenith	+1.18	1.009 / 1.002	577 ; 416	-0.23	1.026 / 1.019	557 ; 404
S 60 deg.	+0.98	1.004 / 0.996	579 ; 419	-0.04	1.037 / 1.037	558 ; 406
Zenith	-0.36	0.994 / 0.984	578 ; 418	+0.15	0.976 / 0.987	557 ; 403
W 60 deg.	-0.37	1.003 / 1.038	580 ; 412	-0.08	1.004 / 1.000	560 ; 398
Zenith	-0.35	0.997 / 0.985	578 ; 418	+0.18	1.000 / 1.017	557 ; 404
E 60 deg.	+0.33	1.001 / 1.000	579 ; 419	-0.48	0.997 / 0.961	558 ; 402
Zenith	-0.25	1.002 / 1.006	578 ; 418	-0.27	1.008 / 1.007	557 ; 403

The EGGS and the HAM science fibres move by 3 pixels peak to peak in the X (N-S) direction and 8 pixels peak to peak in the Y (E-W) direction in the slit viewer camera. On the previous night, before the temporary adjustment described above, the EGGS fibre was moving up to 20 pixels when pointing the telescope far to the West.

3.4 Daily sky spectra

We can obtain an estimate of the efficiency of the system by observing the daily sky.
It has to be taken into account that the illumination of the sky varies with time, therefore comparison of the fluxes of exposures taken in a sequence is nsot straightforward. The sky was observed simultaneously with the science and the calibration/sky fibres, therefore making the fluxes of the fibres A (science) and B (calibration/sky) directly comparable.

The flux ratio of the two fibres (A/B) as a function of wavelength was measured for the two systems on several exposures, the spread of the measurements defines the uncertainty:

	EGGS Flux A/B	HAM Flux A/B
450nm	1.53±0.01	1.91±0.03
550nm	1.63±0.01	1.53±0.03
650nm	1.67±0.02	1.84±0.03

The flux of fibre B is lower due to vignetting of the support of the slit viewer optics (moreover fibre B is not on the optical axis by design). To this has to be added the large misalignment of the EGGS B fibre (1.96 degrees), which causes a vignetting of ~24% (G. Avila, private communication). The relative flux of the science fibre with respect to the calibration/sky fibre is in the expected range, suggesting the individual fibres are not suffering any major damage or loss of efficiency.

In order to measure the relative efficiency of EGGS with respect to HAM, a series of exposures of the varying sky was taken, interposing EGGS and HAM observations. A comparison of the flux ratios of the EGGS exposures with respect to the HAM exposures taken just before and just after defines the range of uncertainty of the relative flux of the two modes. The following table displays the EGGS/HAM flux ratio for both fibres as a function of wavelength.

EGGS/HAM	Fibre A	Fibre B
450nm	2.30±0.07	2.85±0.07
550nm	2.55±0.07	2.44±0.07
650nm	2.26±0.07	2.49±0.07

For reference, the expected increase in flux, when taking into account the geometry of the fibres (the EGGS fibre has a diameter of 100μm, the HAM fibre of 70μm) and the losses in the image scrambler (20%, [4]) is of 2.45.

From the measurements on the daily sky, we conclude that the EGGS fibres and the fibres connections at the the EGGS head, have recovered their nominal efficiency.

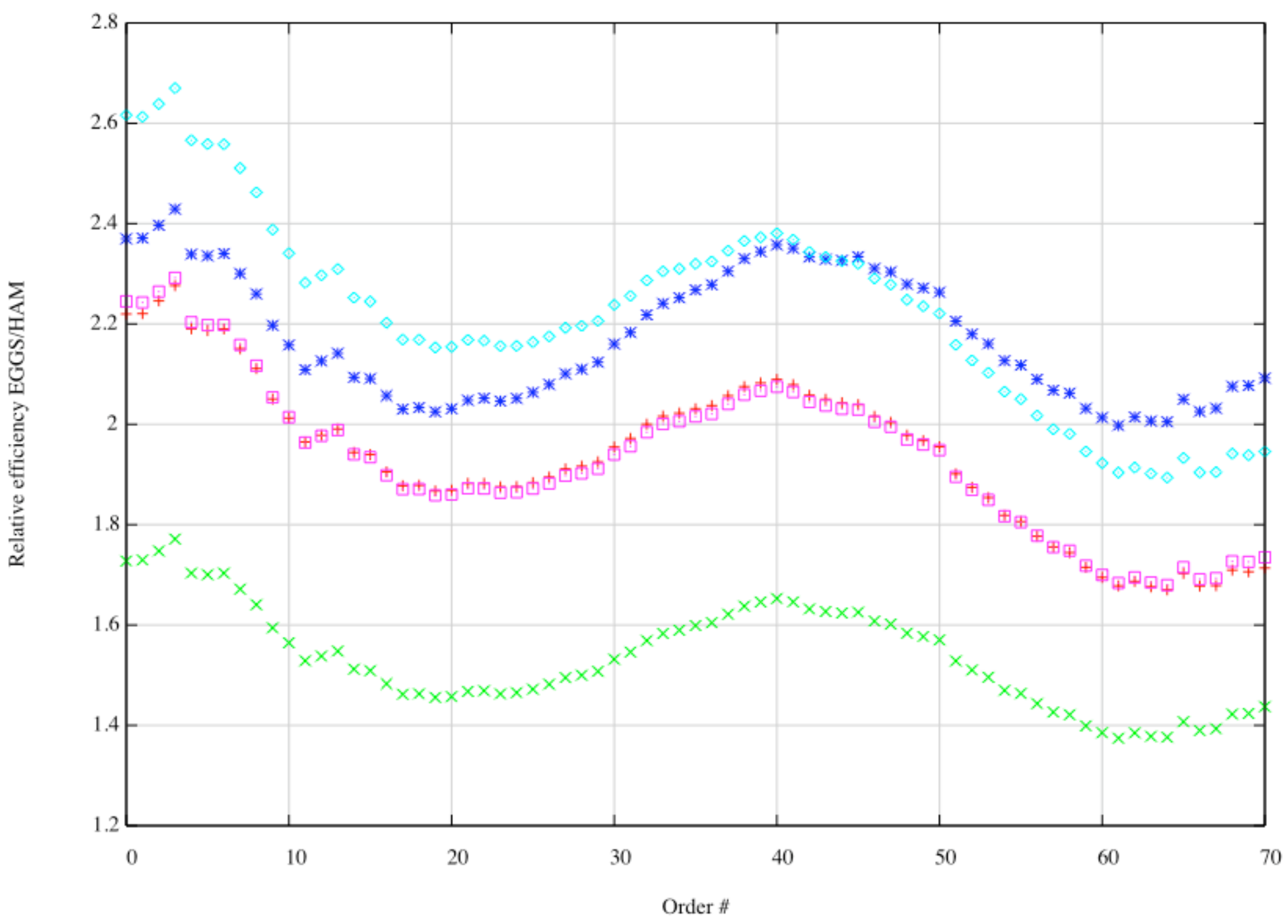
The quality of the light injection into the fibres will be measured on night-time by the observations of standard stars.

4. NIGHT TESTS

The nights of January 22nd and 23rd 2008 were available to perform the EGGS tests. The second night was totally lost due to high humidity. On the first night the conditions were highly variable, with seeing in the range of 0".9 to 2".0 and thin cirrus passing by.

4.1 System efficiency

The quality of the only night we had available was not adequate for an absolute measurement of the system efficiency, which is therefore left to another test night. We could however estimate the relative efficiency of EGGS with respect to HAM. This was accomplished by observing a spectro-photometric standard star in rapid sequence EGGS-HAM, and repeating the sequence few times. The rapidly varying seeing conditions made even this task quite challenging. Having acquired several frames we compare only those frames with comparable seeing. In the figure below the ratio of efficiency EGGS/HAM is plotted versus the order number (from blue to red).

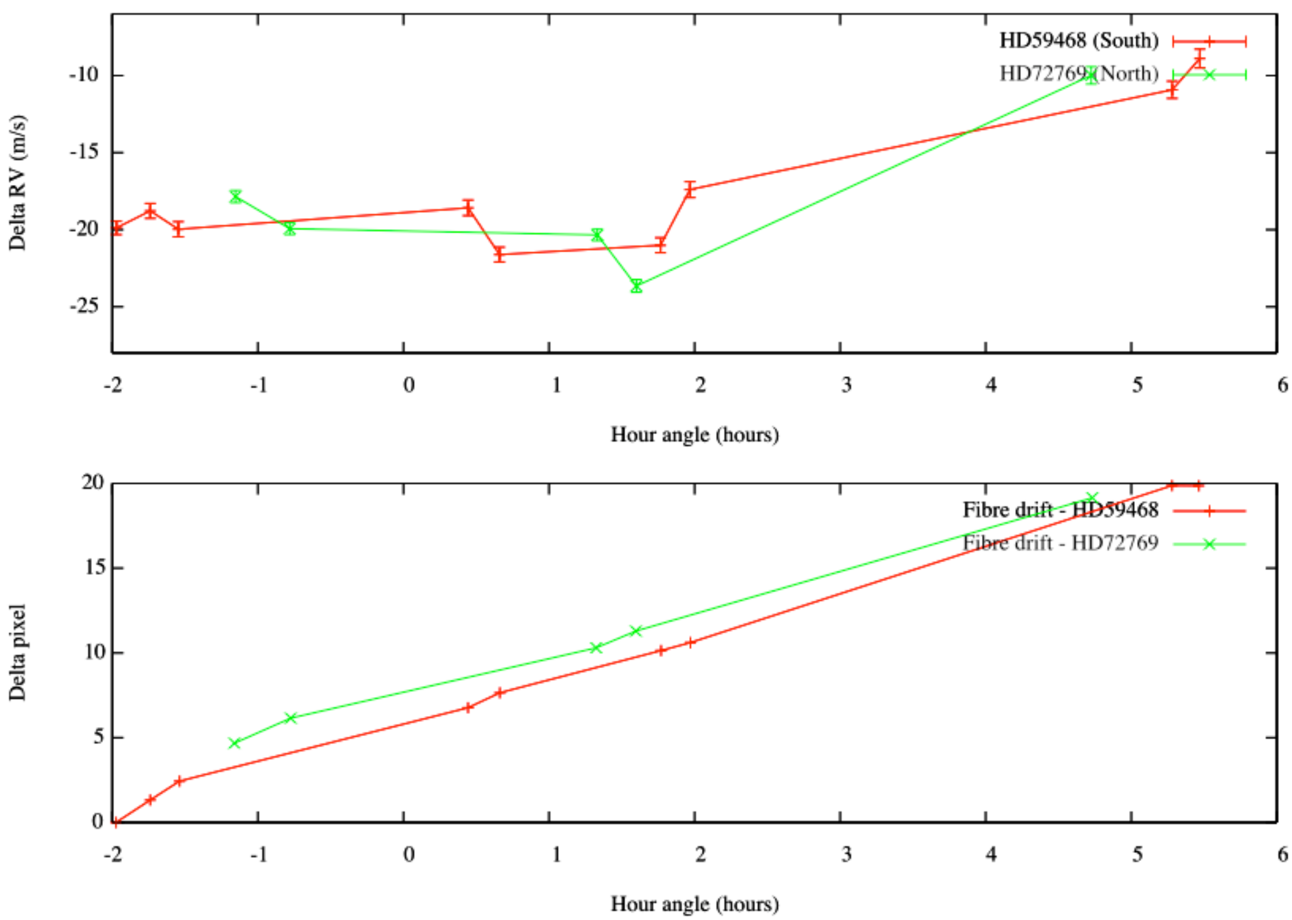


The spectra reported in the figure were acquired with seeing between 0".9 and 1".7.

Although weather conditions were far from ideal we can conclude that EGGS is substantially more efficient than HAM, with a gain in efficiency approximately compatible with the expected one [1]. Measurements on a stable and good night are needed in order to quantify accurately the gain achieved by EGGS. The details of the shape of the efficiency ratio are still being investigated.

4.2 Radial velocity accuracy

To assess the RV accuracy of the EGGS system, 2 stars with known RV variation (<4m/s) were measured alternatively with HAM and with EGGS. The two stars are located one to the North (-23 deg.) and one to the South (-51 deg.), to verify that the system is subject to the same systematics in the two hemispheres. Every few hours a sequence on these stars was performed: HAM-EGGS-HAM-EGGS. The graphics below shows the offset of the EGGS RV data with respect to the first HAM RV measurement for each star. On the bottom panel is visible the movement of the EGGS fibre in the E-W direction, measured in pixels. The RV sudden increase for large hour angle seems correlated with the fibre displacement towards the West. The fibre does not move in the N-S direction.



These data suggested to investigate the mechanical stability of the EGGS fibre. It was found that, when the instrument mode is set to EGGS, the fibre carriage, and with it the HAM fibre head, touches the large green cylinder that support the fibres on the HCFA. This introduces a mechanical stress on the fibre carriage. As a corrective action the fibre carriage was displaced towards the West (< 1mm), and the calibration light projectors were moved on the translation stages to center the beam spots simultaneously on HAM and on EGGS. Sufficient pre-load was insured for the fibre carriage in both the HAM and the EGGS positions (no pre-load was possible on the EGGS position before).

This intervention should have improved the mechanical stability of the whole fibre head systems, and it could have the effect to improve significantly the RV accuracy of EGGS. HARPS is currently offline, and we will have to wait for the next HARPS technical night, in mid-February, to demonstrate the achieved stability.

4.3 Stability of the wavelength solution

The stability of the wavelength solution has been tested on two stars, using 20 wavelength calibration frames acquired in the EGGS and, for comparison, in the HAM mode. The RV of the star was recomputed for each wavelength calibration, and the RMS of the sample was recorded. The test has been performed on EGGS and, for comparison, on HAM.

	EGGS RMS (m/s)	HAM RMS (m/s)
HD59468	1.55	0.41
HD72769	1.66	0.30

The lower accuracy of the EGGS wavelength solution is due to the different algorithm used to compute it. It should be re-addressed whether it would be worth to make the effort of improving the wavelength solution accuracy of EGGS, depending on the magnitude of the other sources of RV uncertainty.

5. CONCLUSIONS

The functionality of the EGGS mode is completely recovered.
The increase in efficiency with respect to HAM, is of the order of a factor 2, depending on the seeing. A precise measurement shall be performed on nights with more stable atmospheric conditions.
A source of mechanical instability of the EGGS fibre head was identified and an intervention was carried over aiming to fix this problem. Tests, both on the night sky and on day time by mean of the calibration lamps should be carried over once the instrument is online at the telescope. The improved mechanical stability will likely improve the EGGS RV accuracy.
The EGGS mode, although a detailed quantitative characterization is postponed to the next available HARPS technical night (mid-February) should be considered ready for science operations.

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