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EGGS integration and commissioning report
Report

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1 Introduction

The EGGS commissioning took place between July 17th and July 20th, for a total of three nights. Four nights were scheduled, but the last one we could not observe because of clouds. The remaining nights were affected by poor observing conditions, due to passing clouds and highly varying seeing (up to $2''$). This document presents the commissioning results after in-depth analysis of the data. Preliminary results presented during the commissioning, when different from what is presented in this document, should be considered superseded.

1.1 Purpose

In this document we describe the tests and the actions taken during the commissioning and their results.

1.2 Scope

This documents is addressed to all HARPS operation people as a reference as well as the LSO management to take strategic decision about this new mode.

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 event of conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered as a superseding requirement:

1.4 Reference documents

The following documents are referenced in this document:

[1] 3M6-SPE-ESO-13100-0012 EGGS user requirements
[2] 3P6-DSD-ESO-754-0001 EGGS opto-mechanical design
[3] 3P6-PLA-ESO-90400-0002V1.1 EGGS commissioning plan
[4] INS-02-0067 Vacuum-tight feed-through for optical fibres

1.5 Abbreviations and acronyms

The following abbreviations and acronyms are used in this document:

HAM	High Accuracy Mode (the HARPS standard mode)
EGGS	Extra General Good Spectroscopy (this mode, it had to fit with HAM)
LSO	La Silla Observatory
PSF	Point Spread Function
RMS	Root Mean Square
RV	Radial Velocity
S/N	Signal to Noise ratio

1.6 Glossary

1.7 Stylistic conventions

The following styles are used:

bold	in the text, for commands, filenames, etc., as they have to be typed.
italic	for parts that have to be substituted with real content.
`teletype`	for examples.

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

2 Overview

The integration process is described at first. We later discuss the EGGS commissioning: all tests which show the functionality of the new mode, the efficiency and the RV accuracy determination. We summarize our findings in the "Conclusions" section and include our recommendation.

3 EGGS integration: 05-07-2005/16-07-2005

The EGGS project phase II was accomplished starting on July 5, 2005 and ending on July 16, 2005. The main actors of this phase were Gerardo Avila from ESO Garching and Alain Gilliotte from La Silla Paranal Observatory. All the activities during this phase involved interventions both to the HARPS spectrograph high Efficiency fibers and the 3.6 telescope HCFA. The main activities included:

1. Add the fibers protection jacket ("shower tube").
2. Splicing of the fibers connected to the spectrograph.
3. Gluing of the fibers tails into the head's ferules.
4. Head's ferules front face polishing.
5. Gluing/centering rod lenses to the fibres and the ferulełs front faces.
6. Gluing/centering the ferules into the head.
7. Mount the fibers splice point supporting box.
8. Pass the finished fiber bundle up to the 3.6 cage.

3.1 Add the fibers protection jacket

The fibers protection jacket and the corresponding un-twisters at the corresponding strategic points were mounted. From the spectrograph isolation enclosure up to the splicing point both fibers were now inside the so called shower tube. The fibers were at this point ready for starting the splicing process. The complete path of the shower tube up to the telescope was inspected and the necessary passing holes drilled where necessary.

3.2 Splicing tests and splicing of the fibers connected to the spectrograph

It was discovered that no exact practical experience was available on the splicing method we adopted, therefore, at this time it was necessary to start experimenting by doing a laboratory splicing test.

The practical experience available was the one from MEFOS. The MEFOS splice was a brass made piece that supported 64 fibers glued together with epoxy directly into the brass piece similar to the EGGS piece. The difference is that for MEFOS the cutting included brass, epoxy and 64 fibers, while for EGGS included brass, epoxy, ceramic, epoxy and a single fiber.

The first attempt was following the planned procedure ([2]). A ceramic ferule (part of a disassembled commercial FC and ST fiber connector) was glued inside the brass support piece with `Epo-Tek 301` and the fiber glued passing through the ceramic ferule with Rapid Araldite. Once the glues cured the piece was cut with a diamond circular saw. The lubricant for the cutting process was petrol. The cutting resulted clean so the polishing process started. It was found that due to the hardness of the ceramic material was very difficult to evenly polish both the ceramic and the fiber. Additionally brass contamination particles from the brass piece

or splicing tool always strongly adhered to the fiber end surface during the polishing. No cleaning method allowed the complete removal of the particles.

A new method was then formulated: the ceramic ferule was glued inside the brass support piece; these pieces, without fiber, were cut and both faces were polished. The ensemble of the glued brass support piece and the ceramic ferrule was cleaned and assembled with the three steel pins. The fiber was passed trough and the whole piece was opened approximately 3*mm*. Now the fiber was passing from one polished face to the other freely across this 3*mm* gap. The gap was filled with a big drop of Rapid Araldite and the fiber was moved slightly back and forth to allow the glue to penetrate inside the ceramic and bond everything together. After curing the epoxy drop and the fiber were cut with the diamond saw (petrol lubricant), the cut was in the center of the gap. Only two steel pins were kept during the cutting process to maintain the piece together without stressing the epoxy drop and the fiber but allowing the saw to cut the center freely. The cut was fairly clean, however, after microscopic inspection some cracks on the fiber ends were observed. Finally both ends were polished and the cracks partially disappeared. The finished splicing connector was cleaned and assembled applying alcohol in the interface between the fiber ends. The measured transmission and focal Ratio Degradation of the test piece are shown in table 1

F.R.D.	=	$97.9\% \pm 2\%$
Transmission	=	$99.2\% \pm 2\%$

Table 1: results form the laboratory splicing test (La Silla, July 2005)

Following the test results the spectrograph fibers were spliced using the same method. Some cracks were also observed over the fibers ends and, as on the test, not completely removed by the polishing process. The relative measurements during and after the splicing are:

- before cutting, one fiber was more efficient than the other by $\approx 6\% \pm 1\%$;
- after cutting one fiber, this one lost $9\% \pm 1\%$ efficiency with respect to the other one;
- after cutting the second fiber, the relative flux between the two fibers came almost back to the beginning: one fiber (the same as on the beginning) being $7\% \pm 1\%$ more efficient than the other;
- no chromatic effects from the splicing were observed.

The conclusion was that the splicing operation introduced, curiously very even, losses of about 9% for each fiber. A result far from optimum when compared to the laboratory tests.

A final comment on the steel pins fittings over the brass pieces: in general the fit was very poor, on some parts the fit was loose and on others very tight. This, apart from adding alignment errors, introduced considerable risk during opening and closing of the splices.

3.3 Gluing of the fibers tails into the head's ferules.

A relatively straight forward process, however it was necessary to enlarge the ferule's holes from 125$m\mu$ to 140$m\mu$ microns for easy insertion of the fibers and allow some space for the bonding glue. The glue used was Rapid Araldite.

Following the good results of a polishing tests done using Cerium Oxide, we could polish the fibre together with the ferrule.

At this stage the fiber protection plastic tube was added to each tail. The same external plastic removed from the fibers was used (the Kevlar threads and internal transparent plastic tube were not added).

3.4 Head's ferules front face polishing

A straight forward process, accomplished using the fiber optic connectors polishing machine. Good results were obtained, the ferule's fiber ends seating plane for the rod lens was well defined.

3.5 Gluing/centering rod lenses to the fibres and the ferules front faces

The gluing and centering process of the rod lenses over the finished ferules was basically done following the procedure described on [2] using Tool #1.

Unfortunately we had to use slightly different lenses for the two fibres. The calibration fibre uses a thicker lens ($1.0mm$) than the scientific fibre ($0.8mm$). The focal length of the two lenses (their curvature) is supposed to be the same. We discovered only during the integration phase that the set of 5 lenses we had available was constituted by 3 "thin" lenses and 2 "thick" ones. Two of the "thin" lenses were destroyed during integration tests in La Silla, while the third one was perfectly glued and aligned and it was decided not to remove it. No flux losses are expected due to this difference in the lenses.

It was decided to use the brass lens bushing in contrast to the rod lens alone alternative described in [2]. The idea of the bushing was to enhance the parallelism of the fiber and rod lens longitudinal axes.

After a successful alignment and gluing process, it was found that small bubbles appeared and disappeared from the epoxy layer in between the fiber and the rod lens, possibly connected to temperature variations ($\approx 10C$ over ambient). It seemed that the alignment bushing mounted around the rod lens, for parallelism enhancing, was pulling and pushing the rod lens when the temperature of the part was changing, generating these small bubbles.

The previous gluing and centering job was discarded and the no-bushing solution was adopted with good results. The optical alignment attained was good, in fact after the glue curing the ferule was turned around its longitudinal axis still mounted over the Tool #1 and the optical bench and almost no eccentricities were observed in the projection screen, just laser light speckles moving inside a fixed circle. The parallelism error between the ferrule axis and the back illuminated beam (optical axis defined by the fibre and lens) was measured on the calibration fibre and was 0.1 degree. A similar error can be quoted for the scientific fibre.

Overall the rod lens process was accomplished according to [2]. Except for the fact that the epoxy glue used (`Epo-Tek 302`) required higher temperature than ambient for curing properly in a practical period of time (typically $\approx 60C$). Since it was very difficult, almost impossible, to keep this temperature constant within Tool #1 and the ferule itself, frequent manual compensation on the position of the rod lens during curing was required.

3.6 Gluing/centering the ferules into the head

The complete EGGS head (without ferules and Nickel plate) was mounted over the adapter carriage (CES head position) for testing the fit and identifying the position of the science fiber. The fit was fairly good except for the fact that:

- one of the two mounting bolts was interfering with the head's body. The bolt was replaced by a standard Allen screw;
- the steel pins for mounting the head exactly on position over the adapter carriage were found displaced by about $100m\mu$. The head was fitted by enlarging the mating holes over the head with a reamer.

The 7% higher efficiency fiber was named "science fibre", and the other one "calibration fibre".

After adjusting the ferule's supporting treaded inserts inside the head both ferules were fitted in place and the distances between the rod lens top, shutter blade and Nickel plate were controlled.

Finally, over the optical bench under the microscope and following the procedure described on [2], one by one the ferules were glued in place with `Epo-Tek 312`. During the process the Nickel plate was mounted and dismounted several times with very good positioning reproduceability.

Once the glue was settled the head was completely assembled including the shutter mechanism and the Nickel plate; the shutter was tested a couple of cycles and the complete head left ready for installation.

The election of the epoxy glue was just because it was necessary a manipulation time of at least 1 hour before significant hardening to allow adjustment in the meantime. The Rapid Araldite was too fast and the normal one too slow. We used two 4 grams packs of expired `Epo-Tek 312`. It seems that in non-optical applications the final mechanical strength of the glue itself is not affected by the storage time.

3.7 Mount the fibers splice point supporting box

The splice connectors of each fibre were joined using immersion oil at the interfaces. The original splice connector support and stress/strain relief part was rendered useless by the changes on the splicing technique. The original design assumed that after the splicing both splicing connectors would end up of exactly the same dimensions, particularly in length. This is not the case now. The new splicing method ended up with the connectors slightly different in length due to the epoxy filled gap, this gap was approximately set by hand, without precise measurement of the distance.

The solution was to use only half of the original support housed inside a small box supporting the shower tube terminations and fastening rigidly, inside the box, only one side of the splicing connectors original support, the other side was left floating inside.

3.8 Pass the finished fiber bundle up to the 3.6 cage

The finished fiber bundle together with the control cable for the shutter mechanism (shower tube protected with the splice point supporting box at its ends) was passed from the spectrograph room all the way inside the telescope structure up to the Cassegrain cage.

The operation was fairly well coordinated and done with care. Finally the strategically located un-twisters were released and the fiber bundle + control cable were fastened with cable ties all along the path.

Upon receipt of the fiber end at the Cassegrain cage a quick test, just illuminate both entrances with a torch and take an exposure, confirmed that the fibers survived the operation.

However, in spite of the high care used in passing the fibres, it appeared that the scientific fibre suffered a degradation of efficiency. Measurements with the integrating sphere have shown that the transmission of the scientific fibre after passing it to the cage diminished by $\approx 19\%$: the scientific fibre was 7% more efficient than the calibration fibre at first, and it became 12% less efficient afterwards.

Finally the assembled fiber head together with the control electronics were installed and everything was made ready for the first commissioning night. When testing the shutter mechanism it was found, surprisingly and in spite of the laboratory tests, that the shutter was occasionally getting stuck.

4 Commissioning technical activities

4.1 Night 1: 17-07-2005

The shutter mechanism was systematically failing but the software was giving misleading error messages because it was receiving “not opened” and “not closed” statuses simultaneously (when failing, the shutter actuator was left at a mid travel position). The friction seemed too high and the work around was just to

increase the open and close pulse length by 100%. After this operation the system started operating and the first light came. Only very few exposures were possible due to morning twilight approaching. The preliminary results showed that EGGS was around 10% less efficient than HARPS.

4.2 Day 1: 18-07-2005

Cleaning and inspecting, trying to chase the efficiency problem.

4.3 Night 2: 18-07-2005

More efficiency series and RV series were done, measurements of systematics (de-centering, de-focusing) were performed. It was confirmed that the efficiency problem was affecting mostly the scientific fibre. The calibration fibre was carrying $\approx$ twice more flux than the HAM counterpart (tungsten lamp exposures).

4.4 Day 2: 19-07-2005

The EGGS head was dismounted and brought to the optical laboratory. After disassembly and inspection it was found that the shutter blade was touching the scientific fibre rod lens top when closing and at the end of its travel.

It was found that, due to the friction, part of the blackening material of the shutter blade was deposited over the rod lens ($\approx$ 30% of the lens front surface was blackened). The lens was cleaned and inspected for scratches, only no critical and small scratches appear over the top surface of the lens after cleaning. Despite the friction with the shutter blade the lens did not move.

Being the gap between the shutter blade and the Nickel plate $350\mu m$, it was possible to add a steel washer of $100\mu m$ in the axial constrain of the shutter axle. The shutter blade was now passing over the lenses at a safer distance. Additionally this steel washer in between the brass material of the bearing reduced the friction of the mechanism.

Using the exposure meters and illuminating simultaneously the fibers at the opened splice connectors very evenly, by the aid of a stable illumination source and using an integrating sphere, we obtain:

- 1.300.000 counts for the calibration fibre
- 1.160.000 counts for the scientific fibre

stating that now the scientific fibre is 12% less efficient than the calibration one. This result is independent from the positioning of the fibers inside the integrating sphere.

With the above setup, the fibres were slightly moved along the whole path, checking for significant flux variations that could indicate a fibre rupture. The only significant, but recoverable variations, were observed when moving the fibers near the splice connectors.

The head was mounted back and the splice connectors cleaned and assembled again using immersion oil at the interfaces. This time the small “o rings” used in the bolts to allow soft tightening of the connectors and eventually compensate for temperature variations were removed. It was found that the spring action was not effective, and for the time being it was better to leave the bolts alone and gently tighten up. This is one of the points to be improved.

4.5 Night 3: 19-07-2005

Repeated efficiency, RV, de-centering series with several stars. Now EGGS seems more efficient than HAM by 80% on average (seeing variable between 0.8″ and 1.5″ at various air-masses).

4.6 Day 3: 20-07-2005

The splice connectors were opened and a laser was injected on each tail to observe the pupil projection over the secondary mirror. Just by eye the results indicate a slight de-centering for the scientific fibre, difficult to quantify, and a much more noticeable one for the calibration fibre pupils as projected on the secondary mirror. The scientific fibre pupil approaches the edge of the sky baffle, while the calibration fibre pupil slightly overruns the edge of the baffle leading to loss of flux.

4.7 Night 4: 20-07-2005

No observations because of clouds.

5 EGGS functionality

5.1 Appearence in the slit viewer camera and focus

The EGGS mirror appears very clean on the guide camera, the fibre hole has a diameter of about 6 pixels, as it should, the fibre coordinates and guide camera focus, as well as the M2 focus offset to HAM are shown in table 2

	HAM	EGGS
Diameter (μm)	70	100
Diameter (*arcsec*)	1	1.4
Diameter (*pixels*)	4	6
X (*pixels*)	322.2	333.8
Y (*pixels*)	320.5	325.8
Camera Focus (enc. steps)	47250	46800
M2 focus (mm)	-	-0.164

Table 2: summary of the EGGS fibre head appearance on the slit viewer camera.

During observations the EGGS fibre appeared to move more than the HAM one. The maximum measured movement was of 5 pixels in Y. This result is however not conclusive, we need more data on many different positions in the sky.

5.2 Fibre carriage and shutter

After some debugging the instrument mode definition has shown to be appropriate, moving the fibre carriage and switching from the EGGS to the HAM shutter as it should. Both the carriage and the shutter did not manifest problems at any telescope position.

5.3 P2PP - OS - fits headers

All EGGS templates work well. The instrument mode can be changed properly from the OS panel. Fits headers contain the expected information. The carriage position (INS OPTI2 NAME, INS OPTI2 ID) is currently defined as CES and it should be redefined as AUX (auxiliary).

5.4 Darks, parasitic light, ghosts, cross talk

The dark level, measured with light shining on the EGGS fibre head is the same as HAM (in *DARK* mode: $0.3 e^{-}/hr$). This implies that the EGGS shutter is closing well and that there is no light contamination from EGGS to HAM.

Ghosts are about a factor of two more intense in EGGS than in HAM. Moreover some parasitic light is visible. From night time measurements of saturated *Na* lines towards bright stars we extracted a 2.9% contamination level from parasitic light, to be compared with 1.3% of HAM. The result for the EGGS diffuse light was obtained via analysis of the raw data. The higher amount of diffuse light might be due to focal ratio degradation (also responsible for a 4% loss in flux, see [4]) along the vacuum passage of the EGGS fibres. Cross talk between the two fibres is between 1/200 and 1/300, comparable with HAM.

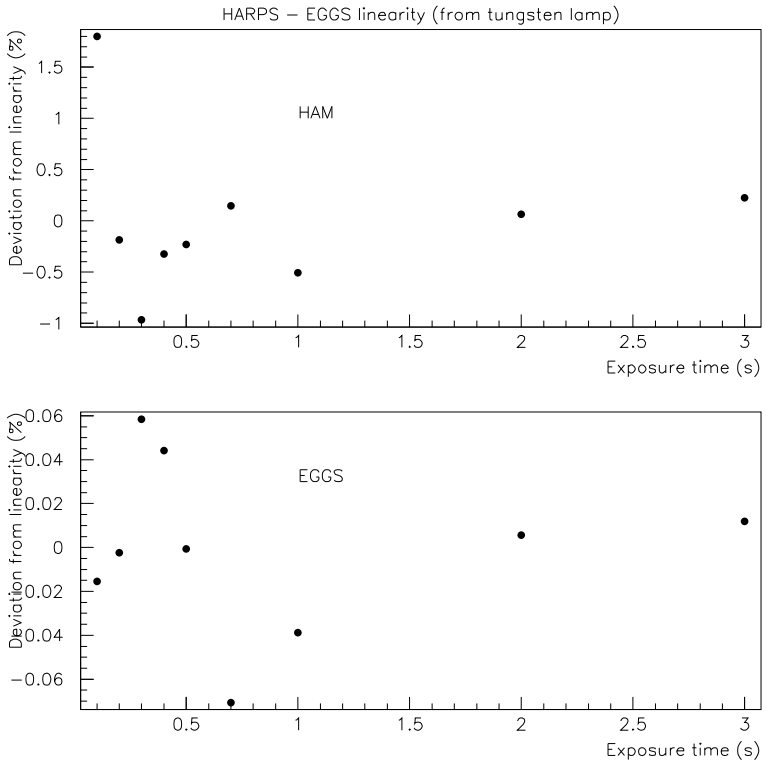

Figure 1: Deviation from linearity of HAM and EGGS as a function of exposure time.

5.5 Shutter linearity

Shutter linearity was tested exposing to the tungsten light for a time varying from 0.1s to 3s. In the range from 2000 to 73000 integrated counts (over the PSF) the EGGS shutter is linear to within 0.13% peak to peak, which indicates the excellent shutter movement reproducibility even for short exposure times. The residuals from a straight line fit are shown in figure 1 as a function of the exposure time.

5.6 Relative fibre flux A/B

The relative flux of the scientific fibre to the reference one, averaged over ten orders from the blue to the red end, was measured for both EGGS and HAM using a solar spectrum during daytime ("A" being the scientific fibre):

HAM : $A/B = 1.76$
EGGS: $A/B = 1.45$

5.7 EGGS calibrations...waiting EGGS-DRS

Sets of EGGS calibrations have been taken, but need a specific EGGS extraction to be analised in detail. Waiting.

5.8 EGGS fibres relative stability...waiting EGGS-DRS

This is a crucial test which would demonstrate whether any possible drift on the scientific fibre due to mechanical reasons (e.g. while moving the telescope), is properly traced by a corresponding drift in the reference

fibre. The data have been recorded but an optimized EGGS pipeline is needed for their analysis.

5.9 EGGS PSF and resolving power

The EGGS PSF's width is of ≈ 4.5 pixels (gaussian fit), to be compared with ≈ 3.5 pixels for HAM. This scales the average resolving power of EGGS to 90000 when compared to HAM (115000). A resolving power of ≈ 84000 was measured in correspondence of the Sodium doublet (5890$\AA$, 5896$\AA$).

6 EGGS-HAM relative efficiency

The absolute efficiency of the mode will not be quoted here because we would need an EGGS optimized pipeline we still do not have. Moreover the observing conditions were not such to allow a reliable measurement of the absolute efficiency. The efficiency data were analysed using a dedicated software based on MIDAS, not the HARPS pipeline. We will quote efficiency values relative to HAM.

The relative efficiency has been measured as the ratio between the integrated fluxes on the central part (column 2050 ± 200) of 10 different orders from the bluest to the reddest. The integral has been calculated assuming a gaussian shape of the PSF.

In the frame of the efficiency measurements we wanted also to observe very faint objects of magnitude 16-17 to monitor the behaviour of the new mode in this regime. We finally decided no do it due to the poor weather conditions.

During all night measurements the ADC was used both for HAM and EGGS.

6.1 Day measurements

We performed a sequence HAM-EGGS-HAM-EGGS... using the tungsten lamp. For the scientific fibre we obtain a gain in flux with respect to HAM of up to 2.2 at 540*nm*, 1.98 on average over the whole wavelength range. From the fits to the linearity curve we obtain a gain (efficiency) of the EGGS scientific fibre relative to HAM of 1.91 (averaged over the whole wavelength range). The difference between the two numbers (1.98 - 1.91) is an estimate of the uncertainty of the measurement. The gain in flux averaged over wavelength of the calibration fibre is 2.27. The expected efficiency gain was of the order of 2.26, taking into account the fibre diameter, the absorption from the scrambler ($\approx 20\%$) and the focal ratio degradation at the vacuum feed-through of the EGGS fibres ($\approx 4\%$, see [4]), i.e. from the numbers obtained by tungsten exposures, the scientific fibre has an efficiency 14% lower than expected, while the calibration fibre performs the expected efficiency.

6.2 Night measurements

Performing HAM-EGGS-HAM-EGGS... sequences on several stars (6) with the seeing varying between $0.8''$ and $1.5''$, the EGGS efficiency relative to HAM varied between 1.5 and 1.8. The seeing measurement used for the relative efficiency calculations was taken by the 3.6m slit viewer, thus including the image quality of the telescope and of the slit viewer; the measured spectrum however is not affected by the image quality of the latter. The slit viewer contribution to the FWHM of the star is certainly negligible in comparison with the atmospheric seeing we observe. Analyzing the data in detail we obtain for the EGGS scientific fibre an efficiency between 10% and 20% lower than expected. The indetermination is due to the highly varying seeing during the night.

The relative efficiency is a function of wavelength, with a peak to peak variation of $\approx 30\%$ in the full wavelength range; EGGS reaches its peak in efficiency relative to HAM at $\approx 540nm$ (see Figure 2).

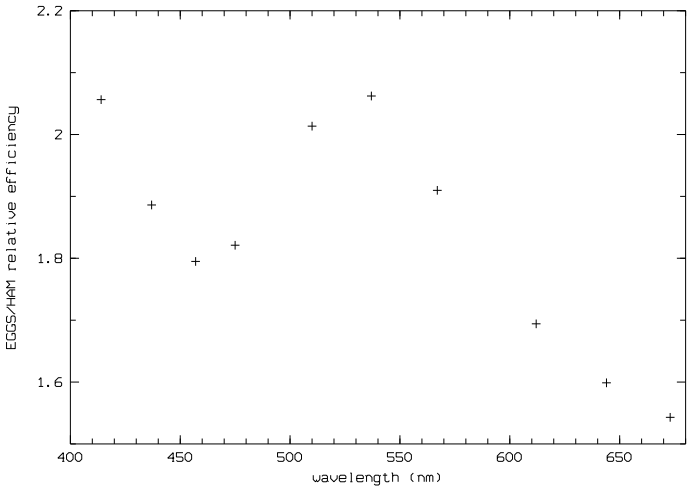

Figure 2: Relative efficiency of EGGS to HAM as a function of wavelength.

The wavelength dependance of the relative efficiency should be verified again with the EGGS optimized pipeline to make sure the fast extraction method we used is not introducing artifacts, which at the moment are not obvious.

7 RV accuracy

RV was measured for EGGS using the standard HARPS pipeline. It does process EGGS data as long as the acquisition image is taken in the HAM mode. In this way the pipeline thinks this is a standard HARPS frame. The extraction is surely not optimal, leading to loss of flux. However the cross correlation function should give reliable results as long as there are enough lines with sufficient flux. The drift correction could not be calculated for EGGS, the EGGS results could therefore in principle improve. On a series of 100 EGGS measurements on HD1581 (mv=4.81, F9V, 90s exposure time) we measure an RMS on RV of $2.5m/s$ when using only the 96 measurement with $S/N > 100$. Repeating the same measurement with HAM (only 7 spectra) we obtain an RMS on RV of $1.5m/s$. These data however were acquired in bad conditions: clouds coming and going, seeing very variable, generally above $1.5''$. These numbers are by no means final, an optimized pipeline can improve the achieved accuracy significantly. We re-observed few stars on several nights, and while the measured RV with HAM did not change significantly from one night to the next, we report a "jump" of $7m/s - 10m/s$ in the EGGS measured RV, consistent for the different stars. The absence of a "real" EGGS wavelength calibration for these data could be a justification of this effect.

We tried to look into the systematics introduced in the RV measurements on two different nights. Again conditions were far from ideal, and the test will have to be repeated, also a larger statistics is needed. The target used was HD1581, one of the HARPS "stable" stars (within better than $2m/s$ in two years) as mentioned from Lovis et al. (2005, A&A 437, 1121).

7.1 De-centering effect on RV

The adopted sequence was: EGGS ON - EGGS OFF - EGGS ON - EGGS OFF... HARPS ON - HARPS OFF... trying to average out effects due to changing atmospheric conditions. We had only 5 samples (5 de-centered frames and 5 centered ones per mode), and the RMS of the measurements are comparable with the quoted average values. We really need more statistics.

The RV variation induced by a $0.5''$ fibre de-centering has different signs for EGGS and HAM. This could

De-centering	HAM	EGGS	Conditions
$0.5''$ E	+1m/s	-3m/s	cloud, varying seeing
$0.5''$ S	+2.4m/s	-3.5m/s	varying seeing

Table 3: EGGS & HAM decentering test summary.

be due to the different optics employed by the two systems (a rod lense for EGGS, a lens doublet for HAM, which implies one image inversion). The results are summarized in table 3.

7.2 De-focussing effect on RV

We did de-focus the telescope by $0.2mm$, and observed a variation of $-4.4m/s$ in the measured RV for EGGS, while no appreciable variation was measured for HAM. We had obtained only 5 samples. The observation sequence adopted is similar to the one described for the de-centering test. The low statistics and the poor weather conditions call for a repetition of this test.

8 Conclusions

The conclusions of our run are certainly affected by the bad weather we suffered, and by the lack of a dedicated EGGS pipeline. Some firm statements can however be made:

- general software/hardware functionality: as required;
- shutter linearity: excellent (0.13% peak to peak) down to 0.1s exposure time;
- shutter "closing": excellent, dark level did not change when illuminating the closed shutter with the tungsten lamp;
- parasitic light: ghosts are more intense, diffuse parasitic light is at a 2.9% level, to be compared with 1.3% of HAM;
- the ratio of the scientific fibre flux to the calibration one is 1.45, measured with solar spectra.
- efficiency from lamp tests: $\approx$ 14% less than expected on the scientific fibre;
- efficiency from star observations: more difficult to quantify due to the highly varying seeing, but it is 10% – 20% lower than expected; the efficiency relative to HAM with a seeing of $\approx 1.2''$ for example, is 1.61, while 1.85 is expected ($\approx$ 13% loss);
- RV accuracy: it is at least 2.5m/s, but it could be better as a result of an optimized pipeline;
- RV systematics: although not conclusive, tests indicate a higher sensitivity of EGGS to focussing and fibre centering.

To assess the stability of the new mode, in particular relative stability of the two fibres as a function of position in the sky (critical) we will have to wait further pipeline developments.

We have measured a relative efficiency of up to 1.8 of EGGS with respect to HAM (averaged over wavelength) with a seeing of $\approx 1.5''$. We also measured a RV accuracy of $2.5 m/s$ with the standard HARPS pipeline; we expect the accuracy to improve as a result of an optimized pipeline.

This new mode, in its present status, allows a considerable gain in flux while still achieving a top level RV accuracy. Despite the gain in flux is a bit lower than expected, we believe the scientific targets of the new mode can still be pursued and we recommend to proceed with the scientific commissioning and the development of an optimized pipeline for EGGS.

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