Removal of WHT Flip Ring

Removal of the WHT Flip Ring

The top end of the 4.2-m William Herschel Telescope (WHT) consists of an outer fixed ring, which is supported by eight Serrurier trusses, and an inner flip ring. The flip ring is attached to the outer ring such that it is allowed to rotate around an axis that allows it to be flipped through 180^{o}. This flipping procedure permits the telescope to be configured with a secondary mirror or with an instrument at prime focus (see Figure 1).

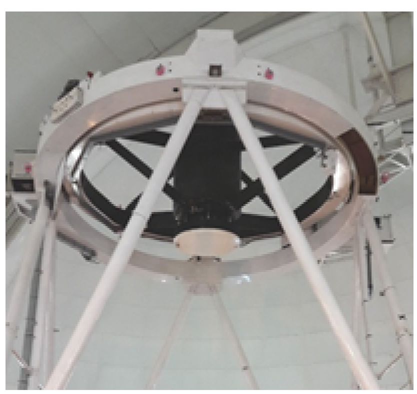


Figure 1: The WHT top end showing the flip ring inside the fixed ring. The configuration is such that the secondary mirror, which is covered, is facing the primary mirror.

The WEAVE top-end assembly requires that this inner ring, along with the vanes and the prime focus corrector, is removed; an activity that had never been attempted in the history of the telescope. Prior to removal, an alignment telescope, positioned in the Nasmyth focal station, was used to record the position of the secondary mirror with respect to a reference mark within the alignment telescope (see Figure 2).

Figure 2: A collimated green beam was propagated through the crosshair of the alignment telescope, reflected off the secondary mirror and its position, with respect to a circular reference mark on the mirror, was recorded.

ING astronomers then carried out a Shack-Hartmann analysis to characterise the combined optical quality of the primary and secondary mirrors. The results of this analysis can be seen in Table 1.

Elevation (^{o})	Raw image RMS	Raw image 80%	Sub	Sub RMS	Sph RMS	Coma RMS	Coma extent	Astig RMS	Coma PA
80	0.15	0.52	0.42	0.11	0.01	0.04	0.27	0.08	152
48	0.11	0.40	0.29	0.08	0.00	0.06	0.36	0.05	176
37	0.10	0.38	0.31	0.08	0.01	0.04	0.23	0.05	-164
23	0.11	0.41	0.28	0.08	0.01	0.07	0.44	0.03	177

Table 1: The Shack-Hartmann test results, in arcsec, prior to removing the ring. For more information see the WHT optics log.

The following day, on the 19th of July 2016, ING engineering staff successfully removed the 5.5-tonne flip ring by separating the two bearing housings of the ring from its interface to the outer fixed ring (see Figure 3).

Figure 3: The left-hand bearing, with the dowel pins (only one shown in picture) removed, showed no movement of the bearing housing with respect to the outer ring. After removing the four bolts, a small movement (80µm) to the left of the bearing housing was seen. Before continuing with the process, it was confirmed that this displacement could be recovered.

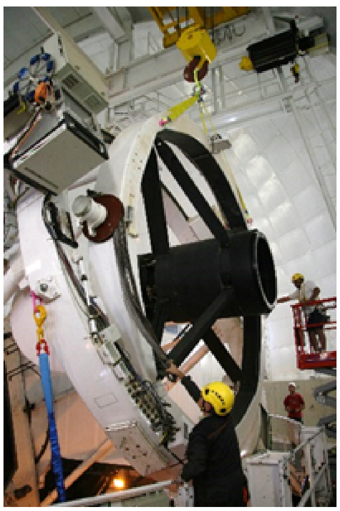
The WHT 25-tonne crane, with a series of lifting strops, was used to lift the flip ring (Figure 4). The crane, which is supported from the dome, has a limited patrol range but was proven to be sufficient to allow the rings to be separated.

Figure 4: The flip ring is lifted using the WHT 25-T crane.

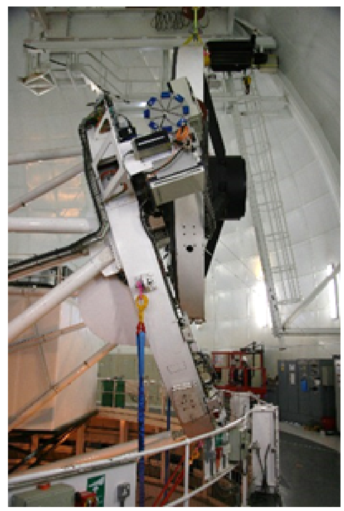
Figure 5 shows a series of photographs that were taken at the moment that the two rings were separated.

The bearings are unbolted and separated from the fixed ring.

The flip ring is moved up and outwards.



The ring is completely detached.



Due to the travel limitations of the crane, the ring cannot be moved further to the right.

Figure 5: Images showing the moment when the flip ring was separated from the fixed ring.

Although the task was well-planned, there were a couple of issues that had to be addressed as the activity progressed and these did produce some sweat but thankfully no blood (see Figure 6).

Figure 6: The ring clears a support bracket, on the fixed ring, by millimetres leaving the Head of the Mechanical Section somewhat apprehensive.

Once the ring was separated from the fixed ring, it was manoeuvred above GHRIL and lowered to the ground floor (see Figure 7). This was a delicate and slow operation which took about 30 minutes.

Figure 7: The ring is lifted over GHRIL (left) and lowered to the ground floor (right).

The flip ring was stored overnight in a purpose-built trolley, constructed by SENER and provided by the *Instituto de Astrofísica de Canarias* (IAC) as part of its contribution to the WEAVE project (see Figure 8).

Figure 8: Whilst WEAVE is on the telescope, the flip ring is stored in its trolley on the ground floor of the telescope building.

Figure 9 shows the WHT without the flip ring. In this configuration, the telescope was out of balance by 5.5T but was held in position by a 7-T load which was placed on the ground floor and attached to the blue strops. A secondary restraining system, achieved by securing the fixed ring to the telescope support structure, was also implemented.

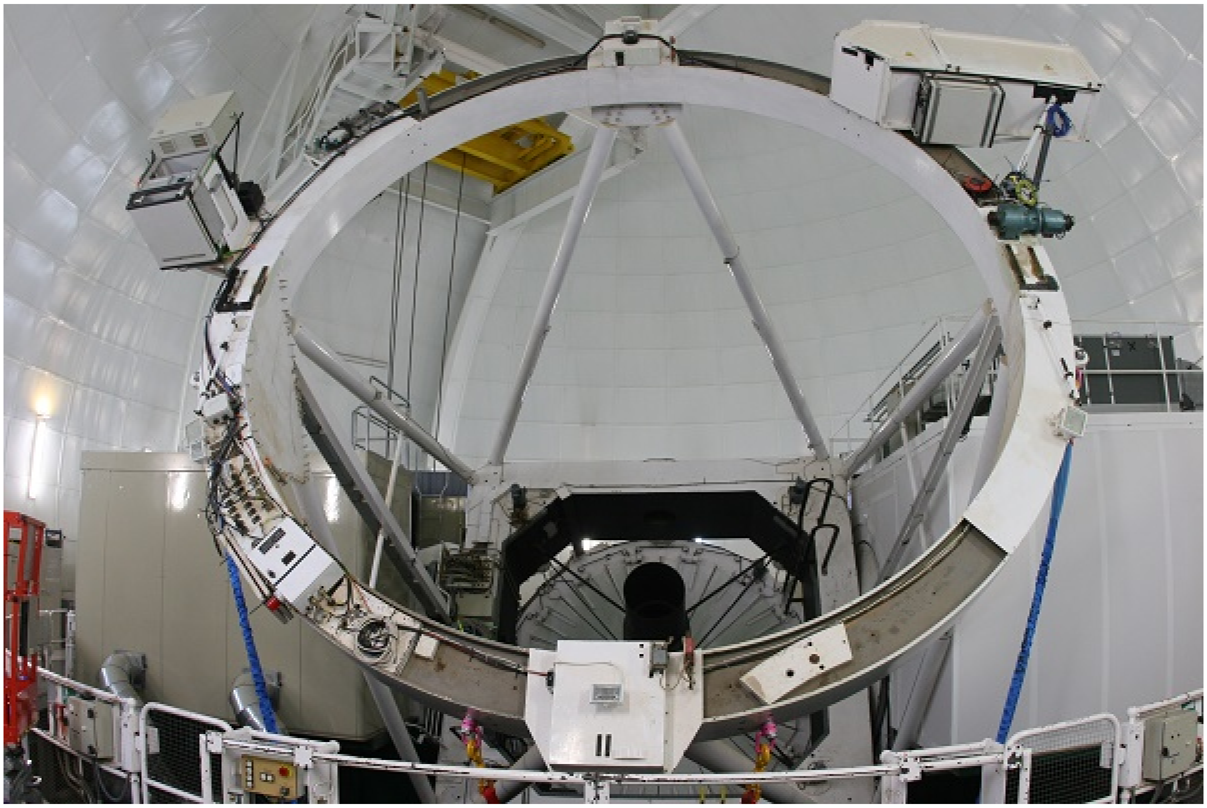


Figure 9: The WHT top end without the flip ring. Movement of the telescope in elevation is restricted using a restraining system.

On the 20th of July, the process to replace the flip ring was initiated and four hours later the ring was back on the telescope. The remainder of the day was dedicated to adjusting the ring to its original position, recabling and replacing the items that had to be detached to allow the flip ring to be removed. On the 21st, the telescope was balanced and the test using the alignment telescope was repeated (see Figure 10). This test showed no discernible differences when compared with the results of the test that was carried out prior to removing the ring.

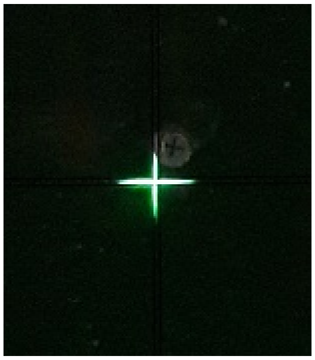


Figure 10: A collimated green beam was propagated through the crosshair of the alignment telescope, reflected off the secondary mirror and its position, with respect to a circular reference mark on the mirror, was recorded.

During the night of the 21st, the astronomers repeated the Shack-Hartmann analysis and concluded that there was no significant change in the optical quality of the telescope (see Table 2). Interestingly, there was a reduction in the amount of coma observed.

Elevation (^{o})	Raw image RMS	Raw image 80%	Sub	Sub RMS	Sph RMS	Coma RMS	Coma extent	Astig RMS	Coma PA
80	0.11	0.38	0.34	0.09	0.00	0.03	0.14	0.05	168
59	0.11	0.41	0.32	0.09	0.01	0.03	0.15	0.06	170
31	0.11	0.31	0.30	0.09	0.01	0.06	0.34	0.05	157
27	0.10	0.35	0.29	0.08	0.02	0.04	0.25	0.04	171

Table 2: The Shack-Hartmann test results, in arcsec, after the ring was replaced. For more information see the WHT optics log.

The telescope is now fully operational and a plan of additional work is being proposed to simplify the removal process. This marks a significant milestone in ING's preparations to receive WEAVE. The current expectation is that this procedure will need to be carried out once per semester with the removal taking less than seven hours to complete.

	Don Carlos Abrams Head of Engineering 23rd July 2016