Calibration at elevation of the WEAVE fibre positioner

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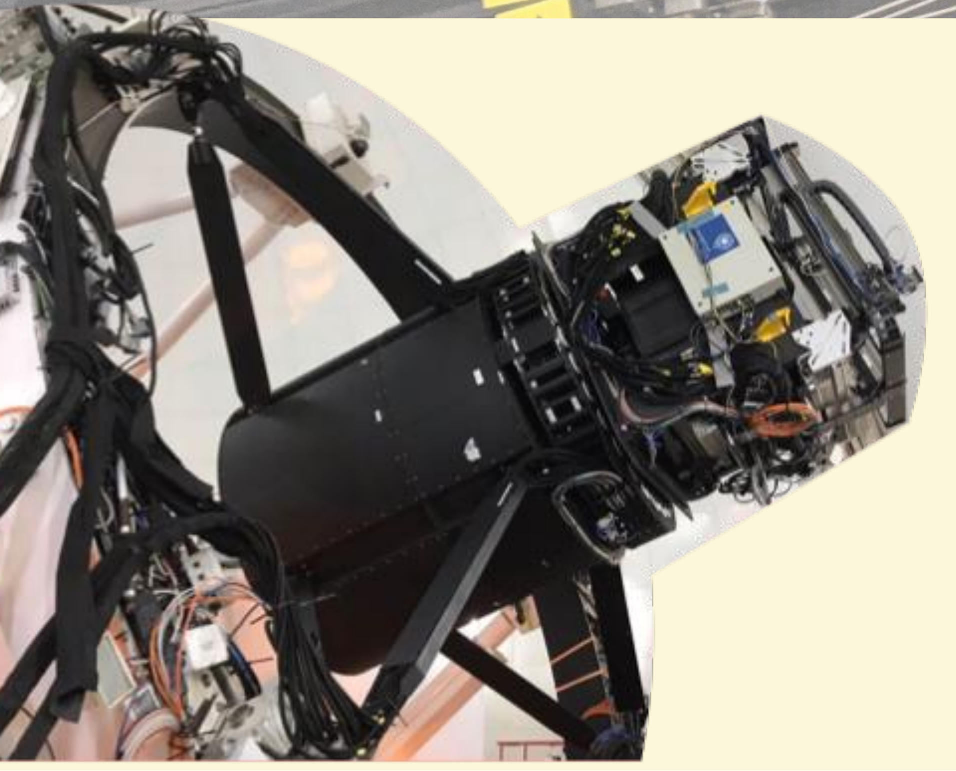
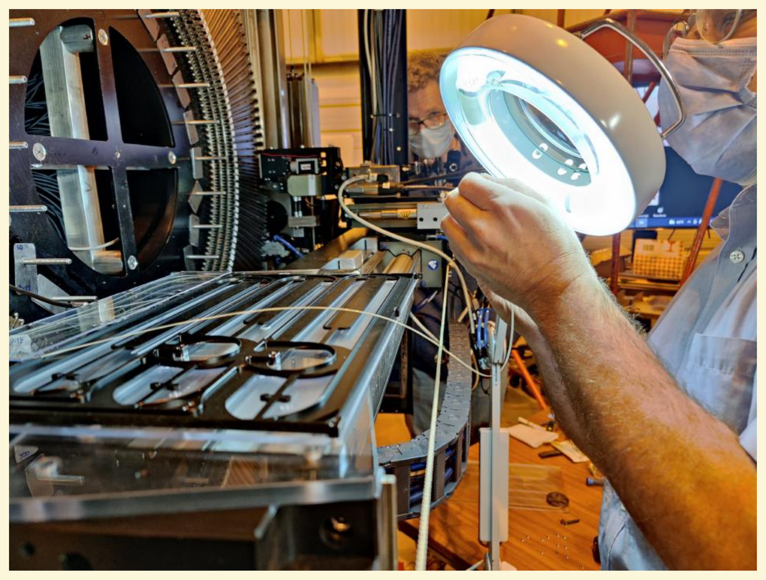


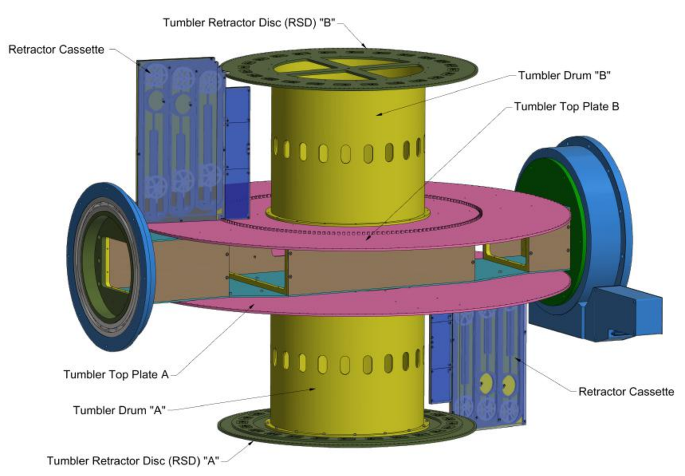
WEAVE is the new wide-field spectroscopy facility[b] for the prime focus of the William Herschel Telescope on La Palma, Spain. Its fibre positioner is essential for the accurate placement of the spectrograph's 960 fibre multiplex. The positioner arrived at the WHT in La Palma, Spain by January 2021. Unfortunately, the positioner was damaged during its journey to the observatory when it experienced a large shock. After extensive maintenance work, we have completed the calibrations required to conduct full field configurations.



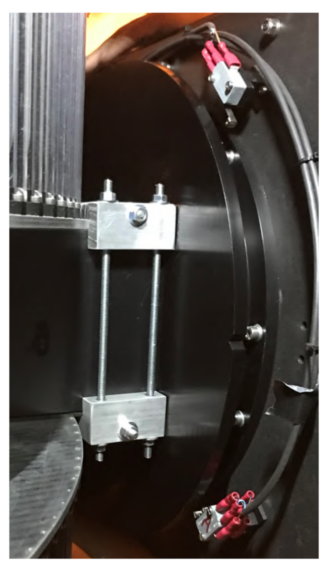
It took ~5 weeks to remove, inspect, repair, and reinstall all 336 retractors in the positioner. No systematic affects were seen, and the process proved that these repairs can be conducted on the telescope as required.

Tumbler flexure adjustments

Significant flexure movement was found when the positioner was mounted to the rotator system. This meant that the field plates would not remain within the required focal distance tolerances. The relative tilt of the field plates to the rotator interference exaggerated this affect.

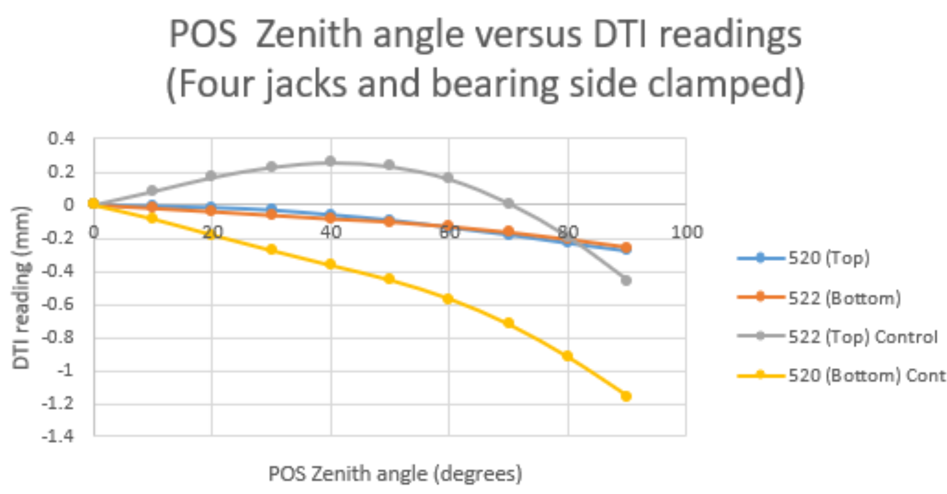


The source of the flexure was from the central tumbler beam that the fibres fed through. To minimise the flexure affects, a clamp and two jacks were inserted to stiffen the structure, and to prevent it from twisting relative to the the motor bearing. This is shown below.



To reduce the plate tilt affect, the previous shims were replaced and the tumbler rotation angle was adjusted to set the calibrated focal distance at ZD 40°. New shims were placed symmetrically under the field plate remove the remaining tilt.

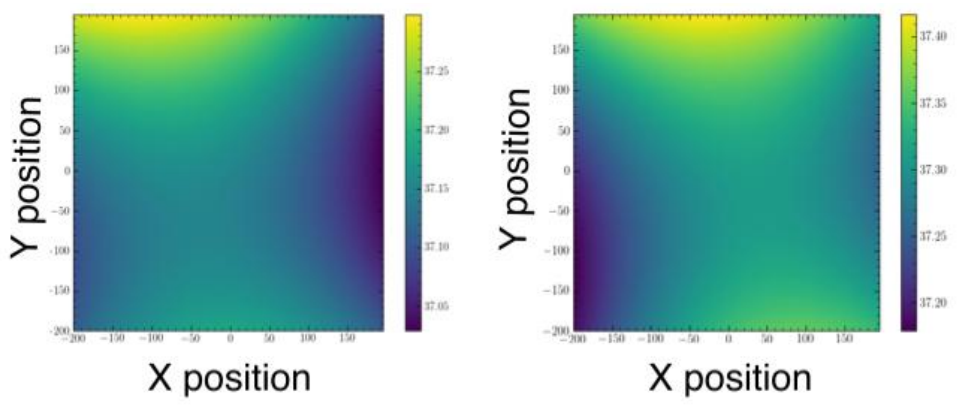
Shown below are the DTI measurements of the tumbler relative to the interface plate, where the top and bottom indicate the opposite side to the motor and bearing positions. We see that the stiffening measures significantly reduce the movement across the full range of elevation angles.



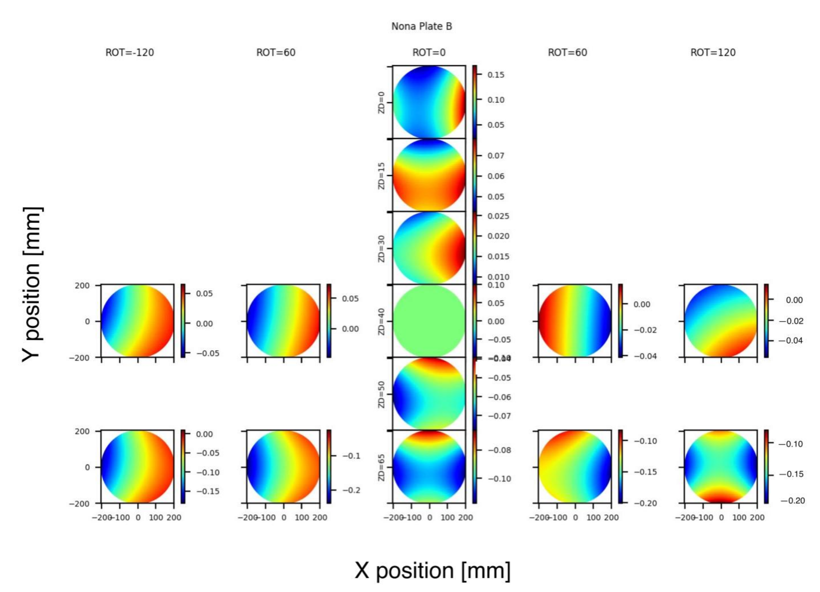
Field plate mapping

The height variation of the field plates must be mapped to meet the 8 μm accuracy limit. A DTI gauge was mounted to the back of the robot's gripper unit. The robot is positioned at (0,0,37) mm and the DTI is zeroed (displayed below). The robot is lifted to 33 mm and driven to the desired coordinates, where the is gauge read. Every map uses the same coordinate positions. The base map was measured at ZD 40° to match tumbler reassembly orientation.

The final base maps for plate A are shown below, with Nona (left) and Morta (right). There is a maximum tilt of ~200 microns across the plate, flipped for both robots. This process is repeated for plate B and the affect is accounted for during fibre placement.

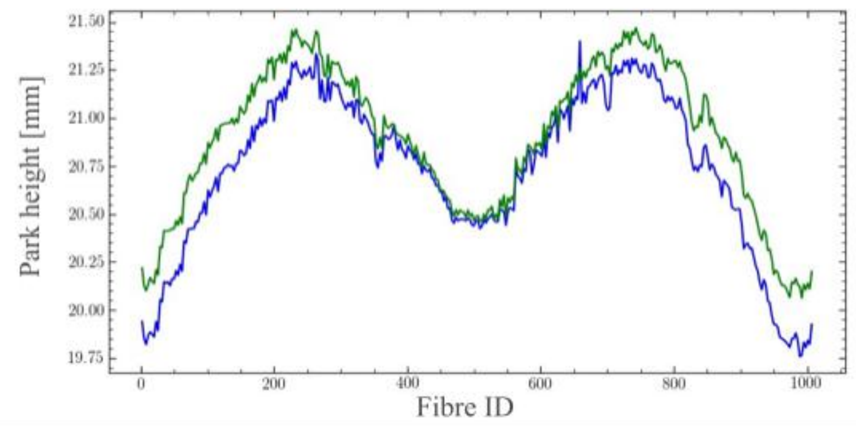


Maps were measured at elevation angles of ZD 15°, 30°, 50°, and 65°, as well as rotator angles of -120°, -60°, 60°, and 120° to cover the full range that will be used during observations. These measurements relative to the base map are shown below.



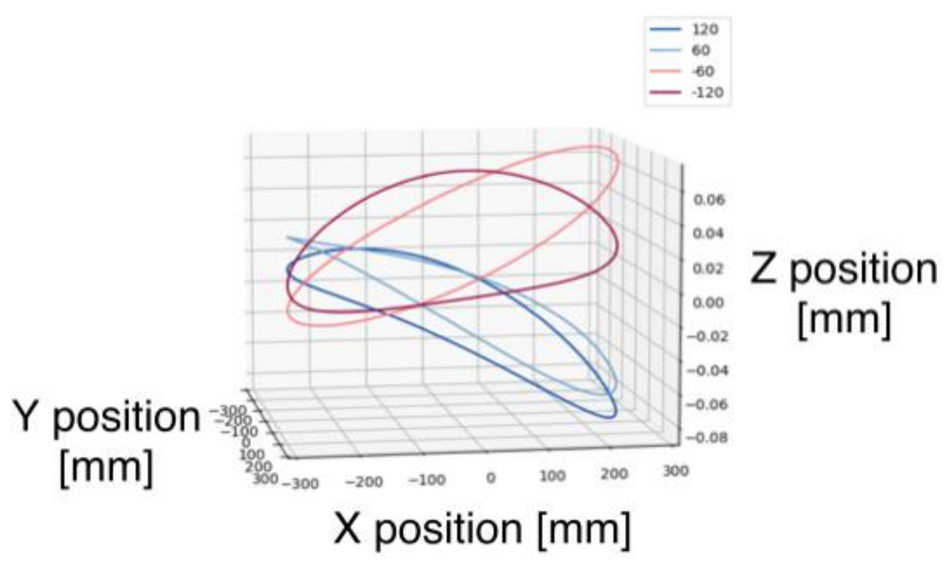
Park height modelling

An incorrectly parked fibre can introduce additional offsets when it is picked up, potentially causing collisions that damage nearby fibres. Therefore, we must measure the height of every fibre's porch, and it's change with the positioner's orientation.



The heights at ZD 40° are shown above. The park heights are measured by moving a series of tier 3 fibres onto the field plate at a 14° degree angle so that the fibre is clear of the porch . The robot gripper unit is lowered by hand onto the retractor, with the height read from the encoders while the jaws are closed. The lower tiers cannot be directly measured and are extrapolated from the recorded values.

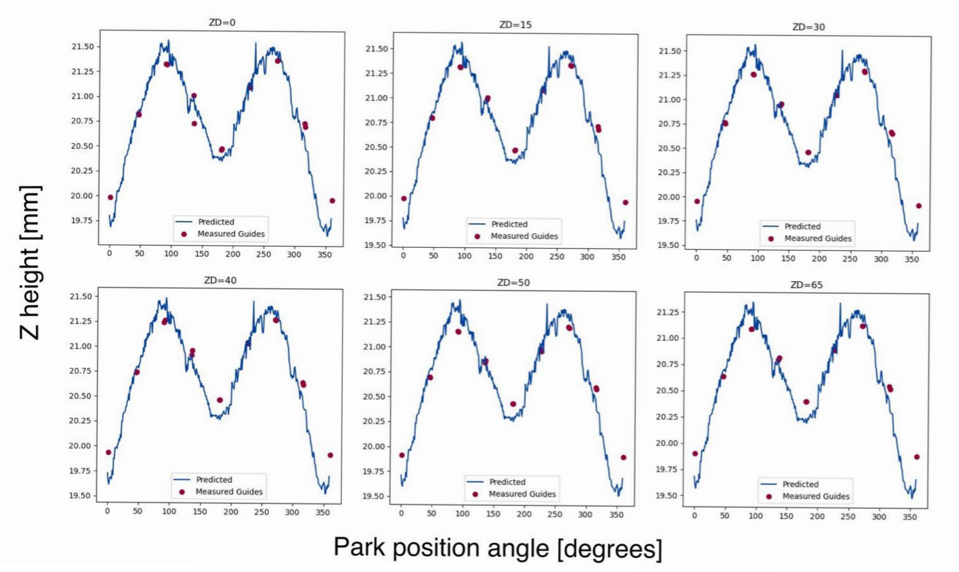
The measurements are consistent for both robots, and the gradual shift is due to the flexure relative to the gantries.



The guide fibre retractors on plate A are arranged symmetrically around the edge of each plate, and are not populated. Therefore, it is relatively easy to measure their height for each orientation. We use them as a comparison for our models. Shown above is the difference in guide retractor height at each rotation angle, relative to ZD 40, and fitted to the park radius. There is a maximum change of 0.15 mm, which the models must account for.

To develop the models, we extrapolate the base field plate map to the radius of the park positions. The offset between this estimation and the full set of measurements is the calculated and applied to the plate map at the new orientation. This gives a complete set of predictive heights for every orientation.

The plot of the park height models for each elevation are shown below. The red points represent the guide fibre heights, for an estimation of the models accuracy. Some residuals still remain. These are large enough that further corrections are still needed, however they are consistent and periodic so they can be removed in easily in software.



Significant progress has been made on the maintenance and calibration of the positioner over the last year. This work will continue for the remainder of the commissioning period and by the time you are standing in front of this poster, we will most likely have first light!

[a] For further details on this work see 11447-164, "Calibration at elevation of the WEAVE fibre positioner", Sarah Hughes et al. 2022
[b] SPIE 11447-164, "Final integration and early testing of WEAVE: the next generation wide-field spectroscopy facility for the William Herschel Telescope", Gavin Dalton et al. 2020
[c] SPIE 114477R "Final assembly, metrology, and testing of the WEAVE fibre positioner", Sarah Hughes et al. 2020