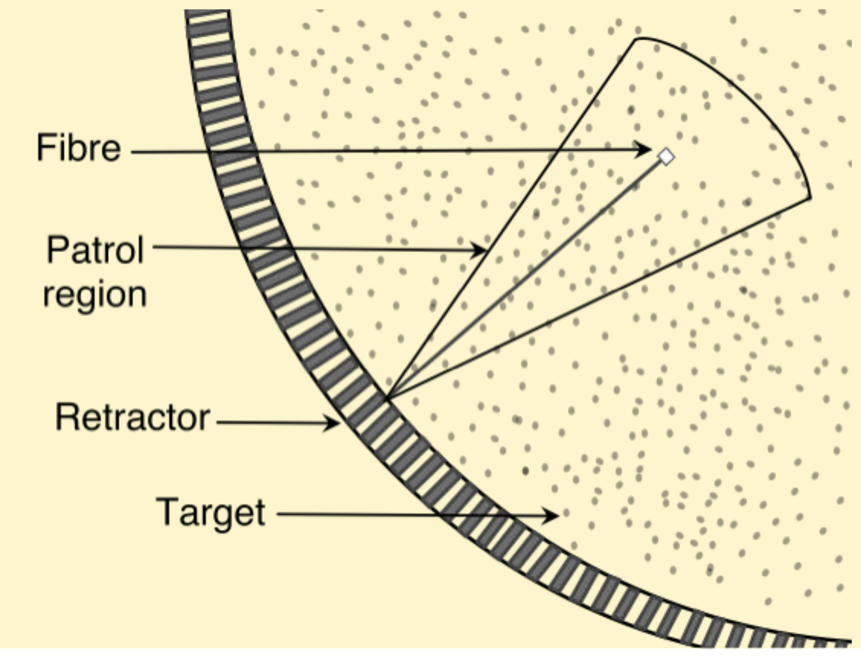
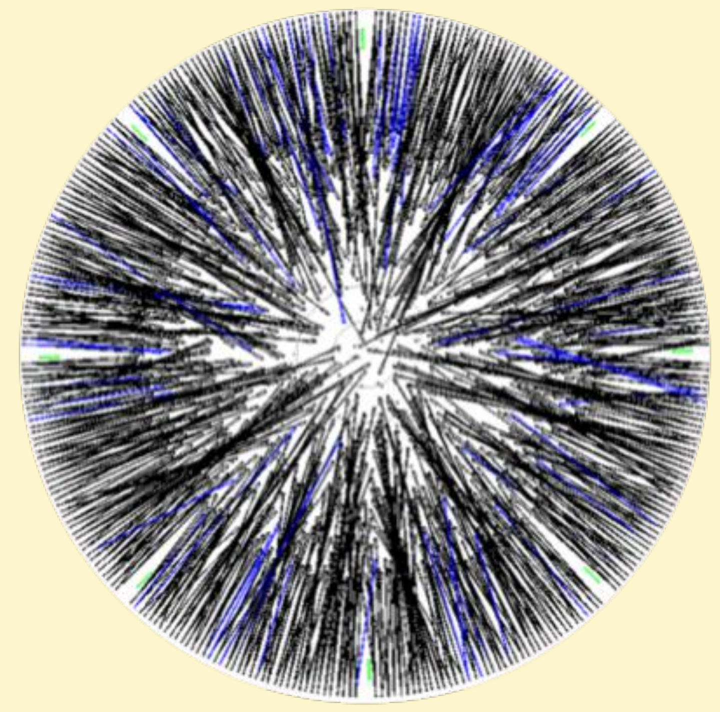
Optimisation of the WEAVE target assignment algorithm

Sarah Hughes*[1]
Gavin Dalton[1,2]
Daniel Smith[3]
Kenneth Duncan[4]
David Terrett[2]
Scott Trager[5]
Don Carlos Abrams[2]
Alfonso Aguerri[7]
Piercarlo Bonifacio[8]
Antonella Vallenari[9]
Esperanza Carrasco[10]
Georgia Bishop[2]
Ian Lewis[1]

*sarah.hughes@physics.ox.ac.uk [1]University of Oxford, UK [2]RAL Space, UK [3]University of Hertfordshire , UK [4]University of Edinburgh, UK
[5]University of Groningen, NL [6]ING, Spain [7]IAC, Spain [8]GEPI, France [9]INAF, Italy [10]INAOE, Mexico



WEAVE is the new wide-field spectroscopy facility[a] 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 assignment of its fibres to targets in the field of view is completed by a program called Configure[b], which uses simulated annealing as its basis. We have performed an in-depth analysis of Configure, by looking at its output using observational targets from the WEAVE-LOFAR (WL) mid-tier survey. This work optimises its performance both in the total number of fibres used per observation, and in the allocation of fibres to key science targets.

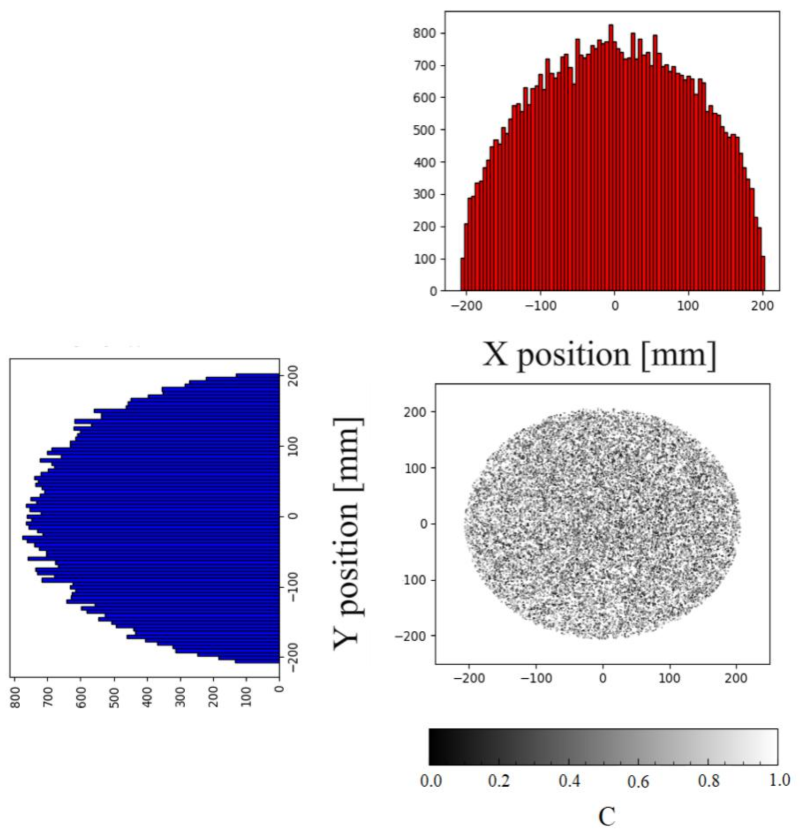


Completeness

We studied the target assignment distribution by dividing the field plate into 5x5 mm regions and calculating the fraction allocated within them, the completeness C:

$$C = \frac{n_a}{n_a + n_u},$$

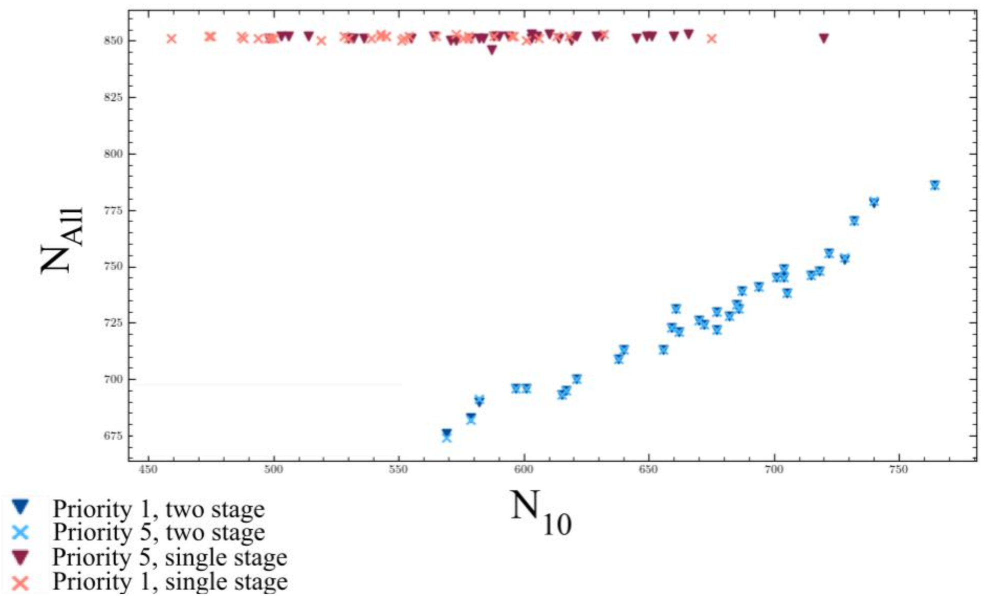
where n_a is the number of targets assigned in that region, and n_u is the number of unassigned targets. Shown below is the stack of all targets in the WL mid-tier survey, shaded according to their completeness. Darker areas of the field indicate low assignment in that region.



We see an even distribution of all targets for both plates, with no traces of the fibres' tiered structure. This means the algorithm has no inherent bias and does not need any modification.

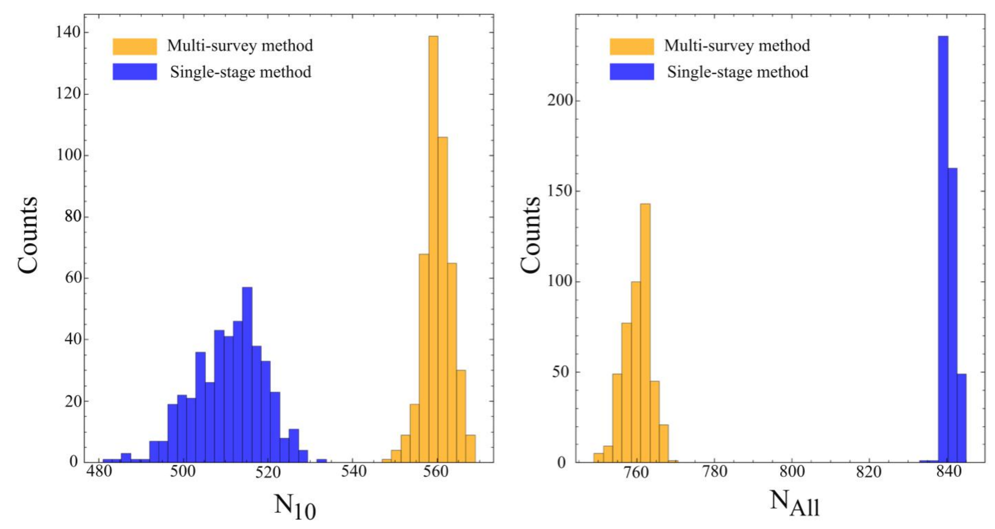
Allocation methods

We adjusted the process in which target fields are allocated through Configure, by altering its input field. We tested a two-stage method, where each field is passed through Configure twice, and compared this to a single round of allocations. In the first round, only the higher priority targets (priority 10) are assigned. In the second round, the other targets (either priority 1 or priority 5) are allocated.



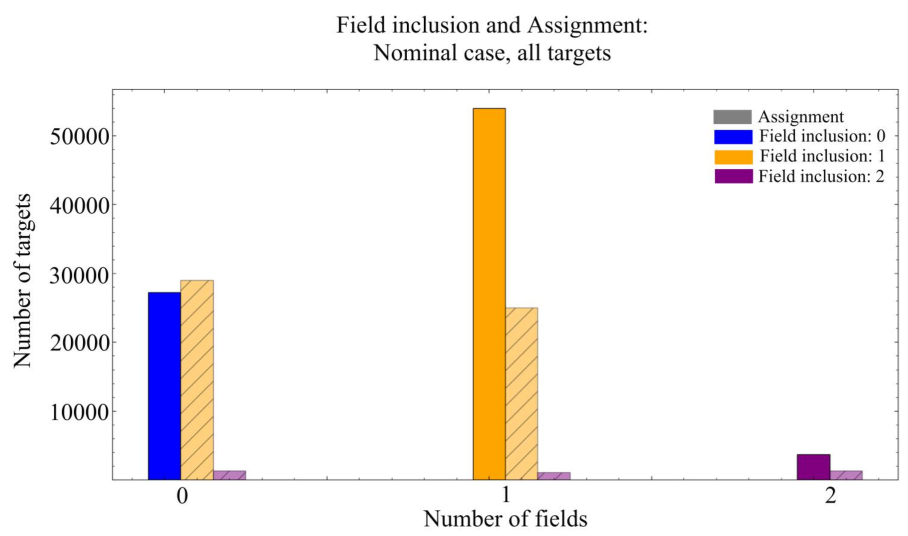
The two-stage method increases the proportion of high priority targets (N_{10}), but at great cost to the total number of fibres (N_{all}) compared to the single stage method.

An alternative method is to assign each priority under their own survey, capping the fibres available independently. The lower priority survey has a 200 fibre allowance.



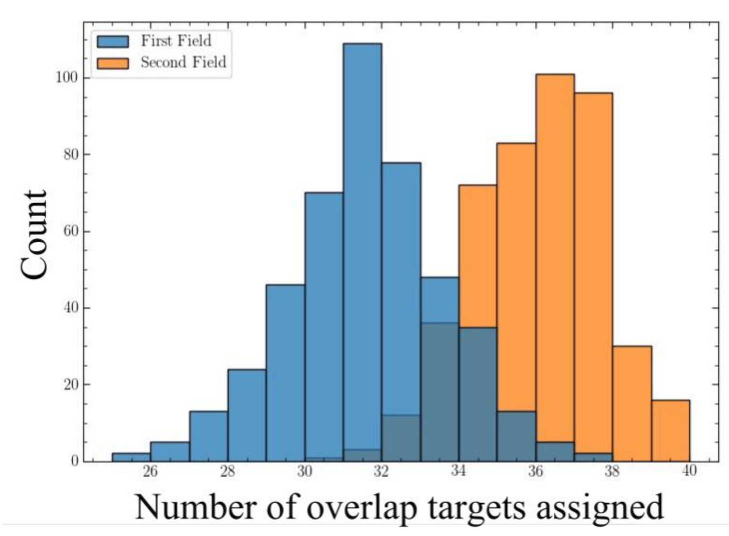
MC iterations show a consistently large assignment to the higher priority targets, at relatively small cost to the number of fibres that remain unallocated.

Overlapping fields



Many of WEAVE's science surveys have overlapping fields of view, and it is important to understand the allocation process in these areas. For all targets in the WL catalogue, we show above the proportion of targets that are included in multiple fields of view and how many times they are assigned once, twice or remain unallocated.

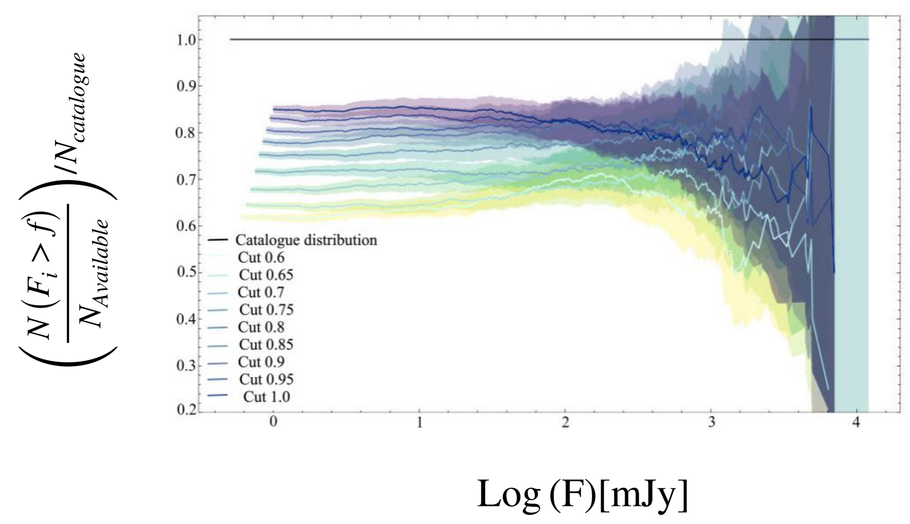
The largest proportion of targets are included in a single field of view and remain unassigned. For targets included in two fields, the field assignment numbers are quite close. However, there is greater number are either unassigned or assigned twice, compared to those allocated in only one of the fields that they are included in.



Shown above are MC iterations of two fields that overlap. The variation in the number of targets assigned is not consistent between fields of view. This is expected, as the overlap region is on the edge of the field. These regions have a reduced number of fibres that are accessible and are strongly affected by the location of targets towards the centre of the field.

Flux assignment

Every survey makes a flux selection from their catalogue to identify which targets are included in each field. We applied several flux thresholds to each WL observation to study the effect on the final number of assigned targets.
Below is the cumulative assignment of all targets above the threshold. This is normalised by the total number of catalogue targets and the number of MOS fibres available for assignment.



There is a regular and distinct separation between each of the selection cut in lower values of the flux distribution, which gradually merge together. The higher end is subject to large variations due to a decreasing number of catalogue targets available.

Configure is an effective method of assignment for WEAVE's fibre multiplex, using conventional computing power. It delivers an even distribution of targets without any systematic imprints.
There is also significant flexibility for survey teams to adjust their allocation procedure, to maximise the relevant parameters for observations.
In the near future, Configure should be compared to alternative optimisation algorithms, such as genetic algorithms, and studied with additional science surveys.

For further details on this work see 11447-164, "Optimisation of the WEAVE target assignment algorithm", Sarah Hughes et al. 2022
[a] 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
[b] "Fibre positioning algorithms for the WEAVE spectrograph", David L. Terrett, et al., Proc. SPIE 9152, 2014