



Configure User Manual

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TABLE OF CONTENTS

1 INTRODUCTION.....	5
1.1 Abbreviations	5
1.2 Purpose.....	5
1.3 References	5
2 TERMINOLOGY	6
3 INPUTS.....	6
3.1 Files.....	6
3.2 Command line options	7
3.2.1 configure	7
3.2.2 lifu_configure	8
3.2.1 dither.....	8
4 BASIC INTERACTIVE USE	8
5 INTERACTIVE EDITING.....	11
6 CONTROL PARAMETERS	11
7 BATCH MODE.....	12
8 ALGORITHMS.....	13
8.1 Annealing.....	13
8.2 Field position angle.....	13
8.3 Finding guide stars	14
8.4 Finding sky background.....	14
8.5 Target attributes	14

1 INTRODUCTION

WEAVE is a new wide-field spectroscopy facility proposed for the prime focus of the 4.2m William Herschel Telescope. The facility comprises a new 2 degree field of view prime focus corrector with a 1000-multiplex fibre positioner, a small number of individually deployable integral field units, and a large single integral field unit. The IFUs and the MOS fibres can be used to feed a dual-beam spectrograph that will provide full coverage of the majority of the visible spectrum in a single exposure at a spectral resolution of ~ 5000 or modest wavelength coverage in both arms at a resolution ~ 20000 . The instrument is expected to be on-sky by 2017 to provide spectroscopic sampling of the fainter end of the GAIA astrometric catalogue, chemical labelling of stars to $V \sim 17$, and dedicated follow up of substantial numbers of sources from the medium deep LOFAR surveys.

1.1 Abbreviations

The abbreviations and acronyms used in this document can be found in [WEAVE-MAN-001](#).

1.2 Purpose

“configure” is a program for finding an optimal set of assignments of fibre to positions on the sky for field containing a set of science and calibration objects and guide stars. It has two modes of operation, an interactive one with a graphical display of the objects and fibres with some limited facilities for manual edit of the fibre layout, and a non-interactive mode suitable for processing multiple fields in a “batch job” fashion.

“lif_u configure” is an analogue to configure for the large IFU. Given a single target and the fibre that it is assigned to, it generates targets for all the other fibres. There is no GUI mode.

“dither” is another, command line only, program that takes a configured mini-IFU or LIFU field and applies a standard dither pattern.

This document describes how to install and use the field configuration programs.

1.3 References

- [1] [WEAVE-MAN-001](#) Abbreviations and Definitions

2 TERMINOLOGY

This manual uses a number of terms with very particular (maybe even peculiar) meanings. This section attempts to describe exactly what each term means in the context of this document.

A **configuration** is a field plus target to fibre assignments. The purpose of “configure” is therefore to configure a field.

A **field** is a collection of targets, the celestial position of the field centre and, optionally, a list positions and radii of places that are not suitable for background sky sampling.

A **program** is a set of fields that share the same spectrograph configuration, exposure time etc.. Every field belongs to one, and only one, program.

A **survey** is a collection of targets that are to be observed to achieve some scientific goal. A single target can belong to more than one survey and field can (and usually will) contain targets from more than one survey.

A **target** is just a position in the sky. It may be the location of an object of scientific interest, a calibration star, a guide star or just a piece of sky suitable for measuring the sky background. Fibres can only be positioned on targets (unless they are parked). Under some circumstances “configure” will create targets automatically. “configure” recognises **science**, **guide**, **calibration**, **sky** and **mIFU** targets.

3 INPUTS

3.1 Files

“configure” reads two user supplied input files; the field to be configured (the field centre and a list of targets) is an XML file, the contents and format of which are described in WEAVE-ICD-025.

The, optional, “source list” describes which parts of the sky are not suitable for positioning sky background fibres. It is in XML format and is, essentially, a list of all the objects in the field (with an optional radius for extended objects) each one of which describes an “exclusion zone” for the automatic sky background searching algorithm. This file is not needed if locations that are suitable for sky fibres are included in the field description.

Five configuration files are also required and are distributed with configure. A configuration file (`configure.xml`) defines the location of the telescope and the pre-defined dither patterns; the focal plane map file (`focal_plane_map.xml`) defines the

telescope optics and the three plate files (PLATE_A.xml, PLATE_B.xml and LIFU.xml) describe the fibre geometry of the two field plates and the large IFU. The current versions of the files contain the nominal layout and will be updated once the instrument has been commissioned. They will also need to be updated if the availability of individual fibres changes (i.e. get broken or are repaired).

3.2 Command line options

3.2.1 configure

“configure --help” produces the following output:

```
Allowed options:
-a [ --avoid_list ] arg          avoidance list file name
-c [ --config_file ] arg (=/configure.cfg) name of configuration file
--delta_temp arg (=0.01)        "temperature" step
--epoch arg                      estimated epoch of observation (yr)
--fibre_swaps arg (=200000)     number of fibre swaps per temperature
                                step
-f [ --field ] arg              field definition file name
-g [ --gui ] arg (=1)           enable GUI
--ha arg                          estimated hour angle of observation
                                (hr)
-h [ --help ]                   display all the command arguments
--horizon_limit arg (=25)       horizon limit (deg)
-o [ --output ] arg             output configuration file name
--margin arg (=0.25)            margin for refraction adjustments
                                (fraction of button width)
--plate arg                      plate name
--preallocate_guide arg (=1)    pre-allocate guide targets
--pressure arg                   estimated pressure at time of
                                observation (mBar)
--seed arg (=0)                 random number generation seed
--sky_search arg (=1)           search for places to put sky fibres
--start_temp arg (=200)         start "temperature"
--stop_temp arg (=50)           stop "temperature"
--threads arg (=0)              print version number
-v [ --version ]
```

The command line options fall into the following categories:

--help and --version just print information and the program then exits.

--gui controls whether the program runs interactively or in batch mode.

--config_file specifies the name of the positioner configuration file which, in turn, specifies where the focal plane map and plate definition files are located. This option is not usually needed as, by default, configure will use copies of these files embedded in the executable image file.

--preallocate_guide and --sky_search only apply to batch mode and determine whether guide fibres are allocated before annealing starts and sky positions are searched for after annealing respectively.

`--seed` *only when run in batch mode* sets the seed for the random number generator used by the annealing. If set to zero (the default) a random seed is chosen. The seed value used is written into the configure element of the output XML.

The remaining options define the values of various parameters in batch mode and in interactive mode set the defaults that are preset in the corresponding data entry widgets.

3.2.2 lifu_configure

`lif_configure --help` produces the following output:

```
Allowed options:
-c [ --config_file ] arg (=/configure.cfg)  name of configuration file
--epoch arg                                estimated epoch of observation (yr)
-h [ --help ]                               display all the command arguments
--horizon_limit arg (=25)                  horizon limit (deg)
--ha arg                                    estimated hour angle of observation
                                           (hr)
-i [ --input ] arg                          input configuration file name
-o [ --output ] arg                          output configuration file name
--pressure arg                              estimated pressure at time of
                                           observation (mBar)
-v [ --version ]                            print version number
```

3.2.1 dither

`dither --help` produces the following output:

```
Allowed options:
-c [ --config_file ] arg (=/configure.cfg)  name of configuration file
-h [ --help ]                               display all the command arguments
-i [ --input ] arg                          input configuration file name
-o [ --output ] arg                          output configuration file name
-v [ --version ]                            print version number
```

4 BASIC INTERACTIVE USE

This section walks through the basic steps needed to configure a field using “configure” in its interactive mode. When “configure” is run without any command line options a control window like this appears

The screenshot shows the 'configure' application window with the following settings:

- Field:** An empty text box with a browse button (...).
- Plate:** Radio buttons for 'get from input field' (selected), 'PLATE A', and 'PLATE B'.
- Avoidance list:** An empty text box with a browse button (...).
- epoch of obs (yr):** 0
- start T:** 200
- cycle length:** 200000
- HA (hr):** 0
- end T:** 50
- threads:** 0
- Pressure (mBar):** 773
- dT:** 0.01
- margin:** 0.25
- Display Fibres:**
 - Calibration
 - Guide
 - Science
 - Sky
- Display Targets:**
 - Calibration
 - Guide
 - Science
 - Sky
 - Display avoidance masks
- Buttons:** Open, Optimize, Freeze, Find Sky, Save, Stop, Unfreeze, Find guide, Park, Re-map, Check, Uncollide.

Type a suitable epoch (e.g. 2021.0) into the “epoch of observation” box and the name of your field definition file into the widget labelled “Field” (or click on the button next to it to browse for the file). Do the same for the avoidance list file if you have one. Then click on the “open” button and a window with a representation of the field with all the fibres in their park positions will appear.

The thick dotted circle marks the edge of the field, the inner thin dotted circle shows the area that can only be reached by fibres on the innermost ring and the outer one the area

that fibres on the middle ring cannot reach. The remaining buttons in the control window will also be enabled.

The display can be zoomed with a mouse wheel, track pad gesture or the buttons labelled “-“ and “+” on the main window, and then the visible area dragged around a trackpad or with the left mouse button held down. The visibility of the various types of targets and fibres can be toggled with the check-buttons immediately below the parameter entry widgets. Display of the avoidance masks is disabled by default.

A second smaller window also appears with a zoomed in view of the plate around the position of the mouse pointer. This is to help with the fine positioning of fibres when editing the field interactively.

Pressing the “Find guide” button allocates all the guide fibres to guide targets. Although the guide fibres participate in the annealing process, because they have to be allocated to a different set of targets from all the other fibres they tend to get “frozen out” if they are not allocated before annealing starts. Note that the guide fibres and the guide targets are coloured green.

Pressing “Optimise” starts the annealing. The first steps are to calculate which targets each fibre can reach and to build a map of which of all the possible combinations of fibre to target assignment are valid – i.e. don’t cause a collision between buttons or between buttons or fibres. This process typically takes several minutes during which time the busy cursor will be displayed, although it is still possible to zoom and pan the display. By default, all available cpu’s are used (these steps are “embarrassingly parallel” and cpu intensive) which may make interacting with other applications very sluggish.

Once the collision analysis is complete, the annealing starts and the display shows the configuration at each step. The number of fibres allocated to each type of target and the number still parked is displayed in the control window. If the annealing stops making any useful progress it can be halted by pressing the “Stop” button – the resulting configuration will still be a valid one.

When the annealing finishes there may be fibres still parked. These can be allocated to sky background by pressing the “Find sky” button. This involves searching for positions on the plate where fibres can be placed without a collision and not overlapping any of the sources in the source list file and can take a while for a crowded field. Fibres allocated to the sky are coloured blue.

Pressing the “Save” button brings up the usual open file dialogue for saving the completed configuration to a file. There may be a pause before the “save file” dialogue box appears while the valid hour angle range is calculated. Any fibres that are deployed on the plate but do not have a target assigned (e.g. they have been placed by the find sky

function) have a sky background target will be created for them. If the configuration contains any errors, a warning dialogue appears.

5 INTERACTIVE EDITING

A fibre configuration can be explored and manipulated in various ways:

- Pressing “Park” puts all the fibres back to their park positions.
- “Freeze” locks all the current fibre to target assignments so that annealing won’t change them. This is useful if you have manually assigned some fibres and want to use annealing to allocate the rest.
- “Unfreeze” reverses the effect of “Freeze” and makes all fibres available for annealing.
- “Remap” recalculates the effects of refraction and proper motions on the positions of all the targets. Any fibres that collide after the re-calculation are coloured red. This can be used to explore the effect of attempting to observe the field at a different hour angle, on a different date or with a different atmospheric pressure.
- “Uncollide” attempts to resolve any collisions by making small adjustments to the positions of fibres assigned to sky background (it assumes that the exact positions of these fibres is not important).
- “Check” checks the configuration for fibre collisions and that all fibres can reach their assigned targets. Any “bad” fibres will be coloured red.

If the mouse pointer is “hovered” over a button, a popup window appears containing the fibre number and the “tier” or ring that comes from. Tier 1 is the inner ring and tier 3 the outer. Similarly, hovering over a target display its identifier, type and priority.

If the right hand mouse button is clicked on a button, all the targets that that fibre can reach are re-coloured orange and similarly all fibres that can reach a target are re-coloured orange if a target is clicked. The right hand button is held down while over a button, the fibre can be dragged to another position on the plate. If released over a target it will “snap” onto the target (even if the target and fibre types are incompatible) otherwise it will just remain where it has been dropped. If dropped outside the field it will jump to its park position.

The diagram of the configuration can be printed by selecting “Print” from the File menu. If your operating system has a software printer that creates pdf’s you can use it to create a pdf. The resolution can be controlled by selecting different paper sizes – the larger the paper, the higher the resolution of the picture.

6 CONTROL PARAMETERS

The following control parameters can be set via controls in the command window:

- “epoch” sets the date of the observation and is needed to calculate target positions (if they have proper motions), precession etc. The effects of changing the date by a few months is small so only an approximate value is needed.
- “hour angle” sets the hour angle of the observation. Of course, during survey preparation this will not be known so should normally be left at zero but is useful for exploring the effect of changing the hour angle on a configured field.
- “horizon limit” sets the horizon limit. If the elevation of the field at the specified hour angle is less than this limit, the observation is rejected. The default is 25 degrees which is the minimum elevation the atmospheric dispersion corrector is designed for.
- The “plate” radio-buttons can be used to override the plate name in the input field definition. Note that the plate must be selected *before* the field is read in with the “View” button.
- “Pressure” sets the atmospheric pressure used in the refraction calculation. The effect is small so can be left at the default of 770 mBar which is typical for the WHT.
- “threads” sets the number of threads used in the collision analysis phase (the annealing itself is single threaded). A value of zero means use as many threads as cpus are available. You may want to use fewer threads if configure is interfering with some other use of the computer.
- “startT”, “endT”, “dT” and “cycle length” control the annealing process – see section 8.1 for more information.
- “margin” is a parameter that sets how much clearance is left around each button in order to make the configuration more resilient to hour angle and refraction changes at the expense of making allocating all fibres more difficult. The actual margin scales with distance from the field centre and is zero at the centre.

7 BATCH MODE

For batch processing of many fields, configure can be run without a GUI by specifying “--gui 0” on the command line; the --field and --output options must be present. The program will process the field as described in Section 4, write an output file and exit.

The automatic guide star and sky search steps can be suppressed with the --preallocate_guide and --sky_search options respectively.

If --plate is used to override the plate defined in the input field, the value must be either “PLATE_A” or “PLATE_B”.

8 ALGORITHMS

8.1 Annealing

The optimisation of the fibre configuration is done using “simulated annealing” – see https://en.wikipedia.org/wiki/Simulated_annealing for an introduction to the technique.

The “energy” of each fibre with a target assigned to it is:

$$(1.0 + s)/(target\ priority)$$

where “s” is a measure of how straight the fibre is – it is always a good deal less than 1.

Fibres without a target (i.e. parked) have energy 10 so targets should have priorities greater than 0.1 if they are to have any chance of having a fibre assigned to them and the priority *must* be greater than zero. Targets without an explicit priority in the input file are assigned a priority of 1.

The algorithm searches for the configuration with the lowest energy. If a proposed change to the configuration causes the total energy to be reduced it is always accepted; if not, the probability that the change is accepted is:

$$e^{\frac{i_2 - i_1}{T} \times 1000}$$

i_1 and i_2 are the energies before and after the transition and T is the “temperature”. So, as the temperature is lowered, the probability that a change to a less good configuration is accepted reduced.

T starts at startT and is reduced by $dT \times T$ at step until it reaches endT.

At each step “cycle length” configuration changes are attempted.

After each step, the temperature, total energy and the numbers of fibres allocated to each category of target is displayed in the command window.

8.2 Field position angle

Preliminary measurements of the flatness and tilt of the WEAVE field plates suggests that the best image quality will be achieved if the rotator is at an angle between 120 and +30 degrees for plate A and -30 and +120 degrees for plate B. Therefore, if no position angle is specified in the input observation element (which should normally be the case) configure will set the field position angle such that the rotator is at approximately -25 (plate A) or +25 (plate B) degrees at the hour angle specified for the observation. The actual angle is rounded to the nearest 5 degrees.

If the angle is specified in the input XML, `configure` and `lifu_configure` checks that the resulting rotator angle is within the operating range of the rotator (-135 to +135 degrees).

All these angles are subject to change as further measurements are made as WEAVE is commissioned on the telescope.

8.3 Finding guide stars

The algorithm for finding targets for the guide fibres is to select the guide star closest to the centre of the field for one of the guide fibres and then allocate the remaining guide fibres to the guide star closest to the edge of the field reachable by the fibre.

8.4 Finding sky background

The algorithm for finding locations for sky fibres is a straight-forward brute force search. It starts with the fibre fully extended with a gate angle of zero and attempts to locate a free space with progressively shortening the fibre. If this fails it tries again with progressively larger gate angles.

8.5 Target attributes

When a MOS or mIFU is dropped and does not land on an existing target, a target element is created with XML attributes:

attribute	value
<code>targsrvy</code>	
<code>targpmra</code>	0
<code>targpmdec</code>	0
<code>targprio</code>	1
<code>targuse</code>	S
<code>targclass</code>	
<code>targparal</code>	0
<code>automatic</code>	1
<code>targprog</code>	
<code>targx</code>	<i>x position on plate in mm</i>
<code>ifu_spaxel</code>	
<code>config_id</code>	<i>unique id chosen by configure</i>
<code>targdec</code>	<i>target declination in degrees</i>
<code>targname</code>	auto generated sky
<code>targcat</code>	
<code>targy</code>	<i>y position on plate in mm</i>
<code>cname</code>	%%%
<code>fibroid</code>	<i>id of assigned fibre</i>

ifu_pa	
targra	<i>target RA in degrees</i>
targid	

When configure or lifu_configure creates a target for an LIFU or mIFU fibre other than the central fibre, the new target is a copy of the central fibre's target with targuse changed as follows:

- For miniIFU fibres:
 - If the central fibre target is targuse "S" all new targets are targuse type "S"
 - If the central fibre target is targuse "C" the targets for the six fibres that make up the innermost ring are targuse "R" and the rest are targuse "S"
 - For all other target types the new targets have the same targuse as the central fibre target.
- for Large IFU fibres:
 - All targets are targuse "T" except those for the sky fibres which are targuse "S".

When dither creates a new field for a dither position with non-zero offsets each target is a copy of the target in the field input field and:

- For targets with targuse "C", targuse is changed to "R".
- Any photometry element is removed
- automatic is set to "1"
- targra, targdec, tarx and targy are updated to match the fibre position
- targparal, targpmra and targpmdec are all set to "0.0"
- For targets of targuse "S"
 - cname is set to "%%%"
 - targclass is set to ""
- For targets of targuse "C"
 - cname is set to "%%%"
 - targclass is set to "%%%"