5.2.3 Master Catalogue Template FITS File

The WASP and WAS will hold the master list of all permitted catalogue columns in FITS format such that all standards relating to the columns and their definitions are fixed to the WEAVE Data Model [AD20]. The list of all columns is given in Table 31.

The filename is Master_CatalogueTemplate.fits.

Each WEAVE TARGSRVY catalogue, and each Open Time proposal catalogue, will contain some approved subset of these columns. The approved set of columns will be issued as an empty FITS Template that must be filled in and submitted to the WASP as the associated input catalogue.

5.2.4 Catalogue Template FITS File

The WASP will test compliance of each submitted catalogue FITS file against the catalogue template associated with the respective TARGSVY (and Open Time proposal). For Open Time proposals, the WASP provides a web-form for PIs to select desired columns from the Master Catalogue FITS template. The catalogue template is then stored on their WASP account and also provided as a download. Changes to this template are permitted up to the point the WASP opens for FITS submissions.

Each catalogue template is therefore held in the WASP as a FITS file in which all the columns of the catalogue are fully specified following the standards described in the following sections. The structure of these templates adheres to the WEAVE data model standard as defined by the DATAMVER FITS Primary Header keyword, which has the form 'X.xx' to represent the version number. In the case of WEAVE science teams, the catalogue template file is also change controlled under the data model itself: any changes to the template must be made through an official change request.

Each TARGSRVY and Open Time proposal is issued the respective catalogue FITS template to use as the basis for input catalogue FITS files that are submitted to the WASP.

The filename for the catalogue template for both WEAVE TARGSRVY and WEAVE Open Time is defined as: <TARGSRVY>_CatalogueTemplate.fits

5.3 Catalogue FITS File: Extension 0 Primary Header

The Primary Header should contain the keywords in Table 6 which are additional to the standard header keywords that are generated automatically when a FITS file is created.

Table 6 WEAVE-specific keywords for the Catalogue Primary Header

Keyword	Description in FITS file	Contains
COMMENT		<TARGSRVY> Catalogue
DATAMVER	WEAVE Data Model Version	'X.xx'
TRIMESTE	Observing Trimester	Fill in with current trimester i.e. 2023B1. *Note that Maximum keyword character length is 8*

Keyword	Description in FITS file	Contains
TACALLOC	Proposal identifier	TAC allocation code (only filled for SV/Open Time programmes). See Section 5.2.2.1
TACID	TAC identifiers	Identifier the TAC used for the proposal (only filled for SV/Open Time programmes). If there are multiple sources then use "|" to delimit them.
MAG_G_CM	Survey-Specific magnitude column(s) used to fill MAG_G	Provide list of which **Survey-Specific** photometric columns have been used to fill the MAG_G columns. These need to be uncorrected for extinction SDSS-like on the AB system. FYI: Useful colour transformations http://www.ast.cam.ac.uk/~mike/wfcsur/technical/photom/colours/ If there is more than one source columns then use '|' to delimit the column names.
MAG_R_CM	Survey-Specific magnitude column(s) used to fill MAG_R	Provide list of which **Survey-Specific** photometric columns have been used to fill the MAG_R columns. These need to be uncorrected for extinction SDSS-like on the AB system. If there is more than one source column then use '|' to delimit the column names.
MAG_I_CM	Survey-Specific magnitude column(s) used to fill MAG_I	Provide list of which **Survey-Specific** photometric columns have been used to fill the MAG_I columns. These need to be uncorrected for extinction SDSS-like on the AB system. If there is more than one source column then use '|' to delimit the column names.
STL_NME1	Science Team Lead (or PI) forename	Fill with the STL/PI's first name
STL_NME2	Science Team Lead (or PI) surname(s)	Fill with the STL/PI's second name(s)
STL_MAIL	Science Team Lead (or PI) email	Fill with the STL/PI's email address
CAT_NME1	Catalogue submitter forename	Fill with the first name of the person submitting this file to the WASP.
CAT_NME2	Catalogue submitter surname(s)	Fill with the second name(s) of the person submitting this file to the WASP.
CAT_MAIL	Catalogue submitter email	Fill with the email address of the person submitting this file to the WASP.
CAT_CC	Catalogue report cc list	Optionally fill with email addresses (CSV with no spaces) for the WASP validation FITS report to be sent to. *Please note the report is always sent to STL_MAIL and CAT_MAIL*. Please be careful not to exceed the string length (<60A) and truncate email addresses. Two should be possible, or three short addresses.
DATETIME	Datetime file created	
CHECKSUM		
DATASUM		

There should be **NO DATA** in Extension 0. The WASP will test that this is an empty extension and will reject the catalogue submission if the extension is found to be non-empty.

5.4 Catalogue FITS File: Extension 1

The TARGSRVY and Open Time catalogue values are provided in Extension 1 as a binary table. The column properties of the binary table are fully specified by keywords in the extension header.

5.4.1 Extension 1 Header Keywords

The keywords in Table 7 are required to fully specify the columns in the catalogue binary table. The conventions used to define these are explained also.

Table 7 Catalogue FITS File Extension 1 Header Keywords

Keyword	Value	Keyword Comment	Notes
TTYPE	Name of column - Survey-specific column names should follow standard scheme with these rules: • Upper case names only • Delimiter if needed is the underscore '_' • Photometry names constructed as 'CAT_MAG_X' & 'CAT_EMAG_X', where CAT is general or a specific catalogue name, and X is the letter or number of specific pass band as per mandatory column scheme for SDSS and Gaia above.	Description of column value	Please keep to 47 characters or less
TFORM	A=string, E=floating point, D= double precision, I=integer	Data format of field: *(standard description)*	See example files below
TDISP	Xx.x	Display format for column	Recommended print format for the binary data and to be used to check data precision for WASP and for display in the archive by WAS. See legal values in above table.
TUCD	string.string	UCD for column	A UCD does not define the units nor the name of a quantity, but rather "*what sort of quantity is this?*"; for example **phys.temperature** represents a temperature, without implying a particular unit. Select from the list in WD-UCDlist-1.3-20170502.pdf. Build and Validate the UCD at http://cdsweb.u-strasbg.fr/UCD/
TUNIT	Measurement unit of column value	physical unit of field	Do not provide if measurement is unitless.

Keyword	Value	Keyword Comment	Notes
TNULL	Value which FITS interprets as NULL. FITS Default: Empty string {‘’} for strings, floating point NULL for real (default) Recommended Default for positive integers is -1.	NULL value for field	Only include if specifying different TNULL from the FITS default for float and string. Needs to be specified for integer columns.
TPROP	0 1	Public column Proprietary column	If Value=0 then the column contains public data. If Value=1 then the column contains proprietary data and so will have restricted access in WAS.
TLMIN	min(Data)	Minimum value expected for field	This will be used in quality control tests to ensure columns are filled in correctly. Do not include if limits are infinity or string.
TLMAX	max(Data)	Maximum value expected for field	This will be used in quality control tests to ensure columns are filled in correctly. Do not include if limits are infinity or string.

Further information for using these keywords is provided in the following sections.

5.4.1.1 TTYPE

This keyword provides the name of the column in the binary table. The FITS Standard[2] recommends that only letters, digits, and the underscore character be used in column names with no embedded spaces. It is recommended that all the column names in a given table be unique within the first 8 characters. This recommendation has not proven possible for naming the WEAVE catalogue columns but great effort has been made to group sets of columns to be logically displayed and in an easily searchable way.

5.4.1.2 TFORM

This keyword specifies the data type for the column in the binary table. The legal formats for TFORM for BINARY TABLES are given in Table 8 where r=vector length and the default is r =1.

Table 8 Legal formats for TFORM and entries for TFORM comment

TFORM	Description	TFORM comment
rA	character string	data format of field: ASCII Character
rAw	array of strings, each of length w	data format of field: ASCII Character
rL	logical	
rX	bit	
rB	unsigned byte	
rI	signed 16-bit integer	data format of field: 2-byte INTEGER

[2] https://fits.gsfc.nasa.gov/fits_standard.html

TFORM	Description	TFORM comment
rJ	signed 32-bit integer	data format of field: 4-byte INTEGER
rK	signed 64-bit integer	data format of field: 8-byte INTEGER
rE	32-bit floating point	data format of field: 4-byte REAL
rD	64-bit floating point	data format of field: 8-byte DOUBLE
rC	32-bit complex pair	
rM	64-bit complex pair	

https://heasarc.gsfc.nasa.gov/docs/software/fitsio/quick/node10.html

If TFORM specifies a character string (A) then the number of characters in the string (if r>1) should also be specified.

5.4.1.3 **TUNIT**

This keyword specifies the physical units for the values in the column. Please inspect the entries for the SPA columns to understand the appropriate usage. Usage has been standardised across the Survey-Specific catalogue columns. Please consult the FITS standard (https://fits.gsfc.nasa.gov/fits_standard.html) to revise best practice.

5.4.1.4 **TNULL**

This keyword specifies the value used to indicate a NULL value. A common mistake is to create a vector which defines 0 as the NULL by default, but 0 is actually a valid entry for the column e.g. Metallicity. A floating point NULL is available in most computing languages and should be used for floating point data formats, in which case TNULL is not required. Please consult the FITS standard to ensure best practice. (https://fits.gsfc.nasa.gov/fits_standard.html)

Similarly the default NULL value for string columns is the empty string ‘’. This does not need to be specified by TNULL.

There is no equivalent NULL for integer columns. Thus a default value has been specified using TNULL such that it can be interpreted as NULL. It lies outside the expected range of values, e.g. if the expected range of values is positive real, then using -1 is the recommended choice for TNULL.

5.4.1.5 **TPROP**

This is a WEAVE specific keyword designed to provide information on the proprietary nature of the data in a column. On a per column basis, data that is provided within an MOU may have restrictions on who can have access to it in WAS. This keyword defines that proprietary nature per column. There are no targets that are proprietary, thus no per object proprietary definition.

The Master Catalogue template specifies all columns as public so TPROP=0. WEAVE surveys had the option to specify a column as proprietary so TPROP=1. Open Time proposals cannot specify TPROP=1 – all columns will have TPROP=0. By default, all Open Time proposal catalogues, observations and data products are proprietary within WAS for 1 year: only the Open Time proposal team will have access to these observations within this one-year period.

5.4.1.6 **TLMIN, TLMAX**

These keywords specify the minimum and maximum allowed value for a numeric column. Please consult the FITS standard (https://fits.gsfc.nasa.gov/fits_standard.html) to ensure best practice. If the data limits are +/- infinity, or the data type is string, then these are not included.

5.4.1.7 **TDISP**

This keyword provides a recommended print format for the binary data and may be used to check data precision for WASP@CPS and for display in the archive by WAS. Please consult the FITS standard (https://fits.gsfc.nasa.gov/fits_standard.html) to ensure best practice.

TDISP should be consistent with the data type in TFORM. Two exceptions are:

- For double precision, the CFITSIO fitsverifier seems to have issues with the Dw.dEe format. Thus for TFORM=D please use TDISP=FXX.X instead. The WASP allows for this.
- If TFORM is E then the equivalent floating point TDISP is F. The WASP allows for this.

Table 9 Legal formats for TDISP

Legal format	Description		Legal format	Description
Aw	character string		Zw.m	Hexadecimal integers
Lw	logical (T, F or U (undefined))		Fw.d	Floating-points
Iw.m	integers		Ew.dEe, ENw.d, ESw.d	Exponential form
Bw.m	Binary integers		Gw.dEe	Floating-points form or exponential form
Ow.m	Octal integers		Dw.dEe	Double precision

Here “w” is the width of the displayed value in characters, “m” is the minimum number of digits to display (filled with leading 0s), “d” is the number of digits after the decimal point, and “e” is the number of digits in the exponent. See https://heasarc.gsfc.nasa.gov/ftools/fv/doc/displayFormat.html

5.4.1.8 **TUCD**

UCD stands for Unified Content Descriptor and is a convention used by CDS and governed by the IAU. A UCD does not define the units nor the name of a quantity, but rather "*what sort of quantity is this?*"; for example *phot.mag* represents a *photometric magnitude*, without implying a particular unit.
See http://www.ivoa.net/documents/UCD1+/20170502/index.html and http://wiki.ivoa.net/bin/view/IVOA/IvoaSemantics for more information. There are tools available which can be used to build and validate UCDs under ‘**UCD Tools**’ on this website: http://cdsweb.u-strasbg.fr/UCD/.

The UCDs used in the WEAVE catalogue columns have been reviewed to meet the IAU standards and to be consistent between source catalogues.

5.4.2 Extension 1 Binary Table

The target information comprising the catalogue is contained in a binary table in Extension 1. The binary table has two sections:

1. SPA Columns: these are the same for all catalogues and contains the information essential for observation and processing by OCS, CPS and APS.
2. Survey-Specific Columns: these contain supplementary information per target that the survey wants to be included in the WEAVE Archive System (WAS).

These are described in the following sections.

5.4.3 SPA Columns

The SPA columns must be included in all TARGSRVY catalogues. The data for some of these columns will not be available for some or many of the targets of particular surveys and so they will necessarily be NULL. In this context these are designated as 'desirable' by SPA. However they are 'mandatory' in the sense that if these data are available, even if just for a subset of targets, then each survey must report them.

The categories of the SPA columns and which team uses them are listed in Table 10.

Table 10 SPA Column Categories

Categories	Used by
Naming & Priority	SWG, OCS, WAS, OR
Observing Mode and Conditions	SWG, OCS
Coordinates in the Gaia Reference Frame	SWG, OCS, WAS
IFU Specific	SWG, OCS
Photometry for Spectral Reduction	CPS
General APS Settings	APS
PPXF Settings	APS
GANDALF Settings	APS
Line Strength Settings	APS
SSP Settings	APS
IFU Settings	APS
CS/CDP Settings	APS

The SPA columns are listed in the following table:

Table 11 SPA Columns

SPA Columns	Column Name (TTYPE)	TTYPE Comment (*additional information*)	Maps to FIBINFO[3]
Naming & Priority			
Mandatory	CNAME	WEAVE object name from coordinates *(assigned by WASP)*	CNAME
Mandatory	TARGSRVY	The Survey where the target belongs *(See authorised list in Table 4)*	TARGSRVY

[3] These are passed through to OCS/CPS/APS data products (see [RD04], [AD09]), or in some cases only the XML files (see [AD18], in which case we indicate via the nomenclature element:attribute).

SPA Columns	Column Name (TTYPE)	TTYPE Comment *(additional information)*	Maps to FIBINFO[3]
Mandatory	TARGPROG	Optional description of (sub-) survey/programme. To delimit sub-descriptions please `|'. The full description cannot exceed 40 characters. *(See Section 5.4.3.1 below)*	TARGPROG
Mandatory	TARGCAT	Catalogue filename *(See Section 5.2 above)*	TARGCAT
Mandatory	TARGID	The identifier of the target assigned by survey *(For IFU usage, see Section 5.4.3.2 below)*	TARGID
Mandatory for IFU	TARGNAME	The target name *(Optional for MOS, Mandatory for LIFU and mIFU. See Section 5.4.3.2 below)*	TARGNAME
Mandatory	TARGPRIO	Target relative priority within a survey *(MOS/mIFU: 1.0= lowest, 10.0=highest; LIFU: 10.0*	TARGPRIO
Mandatory	TARGUSE	T=target, S=sky, G=guide, C=calib., R=random.	TARGUSE
Mandatory	TARGCLASS	Classification of the target assigned by survey *(See Table 12 for authorised list)*	TARGCLASS
Observing Mode and Observing Constraints			
Mandatory	PROGTEMP	Observing Programme Template *(see Section 5.4.3.6)*	configure input
Mandatory	OBSTEMP	Observing Conditions Template *(see Section 5.4.3.7)*	configure input
Coordinates in Gaia Reference Frame			
Mandatory if available	GAIA_ID	Gaia Source Identifier	
Mandatory	GAIA_DR	Gaia Data Release *(Gaia Reference Frame. Permitted data releases are Gaia DR2 and Gaia (e)DR3. Please specify here as '2' and '3'. Do not use 'DR'.)*	
Mandatory	GAIA_RA	Gaia RA of target in decimal degrees *(in Gaia Reference Frame specified in GAIA_DR)*	TARGRA (need for CNAME assignment)
Mandatory	GAIA_DEC	Gaia Dec of target in decimal degrees *(in Gaia Reference Frame specified in GAIA_DR)*	TARGDEC (need for CNAME assignment)
Mandatory	GAIA_EPOCH	Gaia Epoch of target in (Julian) decimal years *(2015.5 for Gaia DR2, 2016.0 for Gaia (e)DR3)*	TARGEPOCH (need for CNAME assignment)
Mandatory if available	GAIA_PMRA	Gaia Proper Motion of target in mas/yr in RA	TARGPMRA (need for CNAME assignment)
Desirable	GAIA_PMRA_ERR	Error on GAIA_PMRA	
Mandatory if available	GAIA_PMDEC	Gaia Proper Motion of target in mas/yr in Dec	TARGPMDEC (need for CNAME assignment)
Desirable	GAIA_PMDEC_ERR	Error on GAIA_PMDEC	
Mandatory if available	GAIA_PARAL	Gaia Parallax of target in mas	TARGPARAL
Desirable	GAIA_PARAL_ERR	Error on GAIA_PARAL	
Mandatory	HEALPIX	ID for res=19 nested HEALPix scheme *(leave empty for submission, values are assigned by WASP)*	
IFU Specific Mandatory Columns			
Mandatory	IFU_SPAXEL	Identifier for spaxel within IFU *(assigned by configure – see Section 5.4.3.9, MOS = '' for all targets)*	IFU_SPAXEL [XML only, target:ifu_spaxel]
Mandatory	IFU_PA	Position Angle of IFU bundle *(mIFu - Assigned by configure LIFU - Assigned based on Guide star position - see IFU workflow, Section 9 MOS=0.0 for all targets)*	IFU_PA [XML only, observation:pa, target:ifu_pa]
Mandatory	IFU_DITHER	IFU dither pattern code (-1,0,-3,3,4,5,6) *(MOS/TNULL=0. Assigned by TARGSRVY team)*	IFU_DITHER [XML only dithering:apply__dither]
Photometry - Ideal set for CPS (see Section 5.4.3.11)			
Mandatory if available	MAG_G	Magnitude for target in SDSS-like g band (AB) *(Note: must be uncorrected for extinction)*	MAG_G
Mandatory if available	MAG_G_ERR	Error on MAG_G	EMAG_G
Mandatory if available	MAG_R	Magnitude for target in SDSS-like r band (AB) *(Note: must be uncorrected for extinction*	MAG_R
Mandatory if available	MAG_R_ERR	Error on MAG_R	EMAG_R

SPA Columns	Column Name (TTYPE)	TTYPE Comment (*additional information*)	Maps to FIBINFO[3]
Mandatory if available	MAG_I	Magnitude for target in SDSS-like i band (AB) *(Note: must be uncorrected for extinction)*	MAG_I
Mandatory if available	MAG_I_ERR	Error on MAG_I	EMAG_I
Mandatory if available	GAIA_MAG_G	Magnitude for target in Gaia G band (Vega) *Provide Gaia Vega magnitudes as-supplied by Gaia archive*	MAG_GG
Mandatory if available	GAIA_MAG_G_ERR	Error on MAG_G	EMAG_GG
Mandatory if available	GAIA_MAG_BP	Magnitude for target in Gaia BP band (Vega) *Provide Gaia Vega magnitudes as-supplied by Gaia archive*	MAG_BP
Mandatory if available	GAIA_MAG_BP_ERR	Error on GAIA_MAG_BP	EMAG_BP
Mandatory if available	GAIA_MAG_RP	Magnitude for target in Gaia RP band (Vega) *Provide Gaia Vega magnitudes as-supplied by Gaia archive*	MAG_RP
Mandatory if available	GAIA_MAG_RP_ERR	Error on GAIA_MAG_RP	EMAG_RP

5.4.3.1 **TARGPROG**

TARGPROG is an optional column, to be filled out at the discretion of the catalogue creator (typically in coordination with SPA). If this column includes the entry "|BW", however, then the target is assumed to be *filler* (bad-weather) target. In this case, any XML generated with this target will given an overall priority of 0.1 rather than the default priority of 1.0, significantly reducing the probability of this OB being observed unless no other OB is available in the conditions specified by the OBSTEMP (Section 5.4.3.7) of the observation.

5.4.3.2 **TARGNAME and TARGID**

Whilst for MOS observations, these values have no operational / CPS implications, this is not the case for IFU modes. Care should therefore be taken by IFU users to ensure that their use of these values reflects the desired outcomes from CPS. *No retrospective re-processing of data can occur due to incorrect use of TARGNAME and TARGID.*

See also Section 5.4.4 for how Target Uniqueness is defined for MOS and IFU observations.

TARGNAME is optional for MOS observations so it can be left as an empty string (''). TARGID is mandatory for MOS and must be the unique identifier for that object within a TARGSRVY.

TARGNAME is mandatory for IFU observations. This parameter is used to group IFU observations of the same target, in cases where stacks are required. This helps CPS identify cases where the same astrophysical target is observed but the OBs executed were not related (via for example the "chained" directive - see Section 7 and [AD18]).

We refer readers to [AD19] for specifics, but an example would be LIFU observations of the core of M33. If a user requires 3 OBs, each with different dither positions, then the CPS could not ordinarily stack these data, because they do not share the same Central

CNAME (CCNAME). We illustrate this here, with red, blue and yellow signifying each OB starting position:

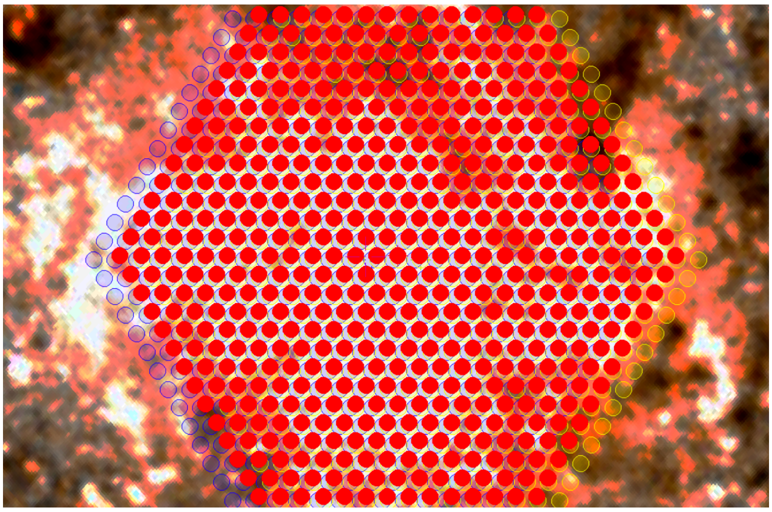


Figure 2 - Three LIFU dither positions centred on a putative target. This information must be encoded in the input FITS catalogue, but grouped by common TARGNAME.

In the input FITS catalogue, these observations are represented by 5,427 rows: 603 fibres, dithered 3 times for 3 OBs (for readers baulking at this, please consider it an advertisement for the IFU workflow package described in Section 9).

Each of these rows must be tied together by a common TARGNAME, e.g. "M33bulge". This indicates to the CPS that these observations should be evaluated for stacking. It is not always true that IFU observations with common TARGNAME will be stacked – the below example, with a TARGNAME="M33" would not be stacked, as this is in effect a mosaic. Only common TARGNAMEs with sufficient overlap will be stacked by the CPS. However, if Contributed Data Products exist to create larger mosaics from these data, then they should use the common TARGNAME to group L1 products.

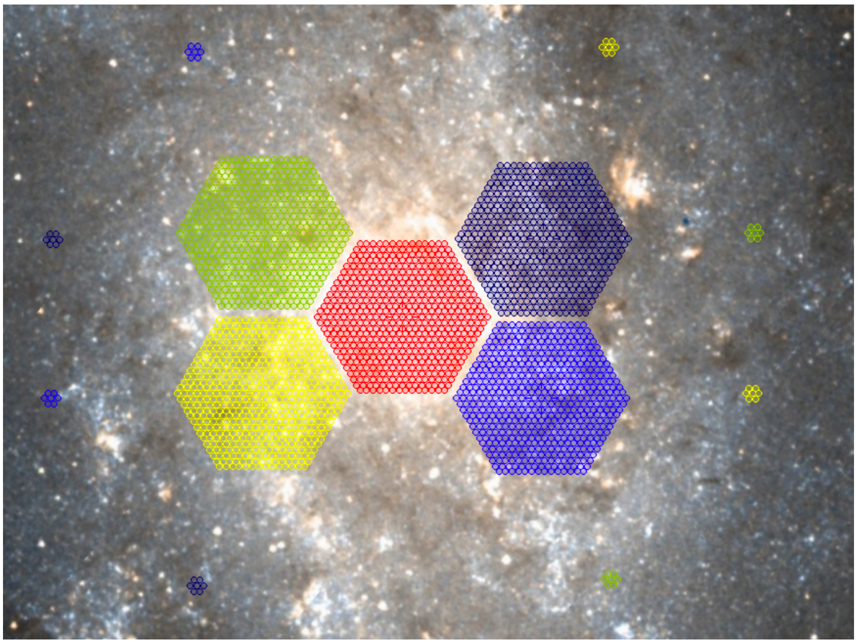


Figure 3 - Example LIFU coverage of an extended source. Each colour here represents an OB. Within each pointing there would be a series of dithers (as per previous Figure). Whilst these pointings might share the same TARGNAME ("M33"), the CPS would recognise these as a mosaic and not stack them into a single LIFU data cube.

This principle similarly applies to individual mIFU bundles.

The TARGID is the target identifier assigned by the survey. It is mandatory that this column is filled in.

For MOS this is unique within the TARGSRVY for the object.

For IFU fields, this is the OB-specific descriptor of the field. In the first example above, this could be a simple numerical identifier for each OB:

- OB1: TARGNAME = "M33bulge" TARGID = "M33bulge1"
- OB2: TARGNAME = "M33bulge" TARGID = "M33bulge2"
- OB3: TARGNAME = "M33bulge" TARGID = "M33bulge3"

For the second example, TARGID could be more descriptive:

- OB1: TARGNAME = "M33" TARGID = "M33 bulge"
- OB2: TARGNAME = "M33" TARGID = "M33 disc NE"
- OB3: TARGNAME = "M33" TARGID = "M33 disc NW"
- etc

For MOS, the same TARGID (object) may get observed multiple times with different observing conditions. See Section 5.4.4 for further details on how this is defined.

5.4.3.3 TARGPRIO

TARGPRIO is used to provide a weight to the target for priority of observation selection for MOS targets. 1.0 is the lowest priority, 10.0 is highest priority. This corresponds to a positive weighting in Configure [See ICD-025]. The data type for TARGPRIO is float. The precision of TARGPRIO is to 1 decimal place (X.x) as defined in the TDISP keyword (F4.1) for this column in the FITS binary table.

For LIFU fibres within a single exposure, all have equal (and redundant) priority so this column should be filled with value 10.0.

For mIFU targets, all fibres within the same bundle should have the same TARGPRIO. Bundles within the same (putative) mIFU field (i.e. a WEAVE FOV) can have different priorities, and this should be used as a guide for deciding which bundles should be placed down onto the field during the Configure stage. Because mIFU bundle allocation within a field is an interactive and manual process, it is for the end-user to use TARGPRIO as an indicator of the relevance of a putative target within the field.

We urge users to take care in choosing values for TARGPRIO, particularly for MOS targets. These values cannot be changed at point of fibre allocation, meaning (for example) an inappropriately low TARGPRIO could result in a target never being allocated a fibre. We refer readers to Section 7.1.7.1.1 for further discussion on this.

5.4.3.4 **TARGUSE**

There are five uses for TARGUSE: T=target, S=sky, G=guide, C=calibration standard, R=random. G, C and R are reserved for SWG/operational use only. These will not be accepted within a TARGSRVY catalogue (see exception in Section 5.4.3.4.2).

5.4.3.4.1 Skies

Specific sky positions (S) can be provided in a TARGSRVY catalogue. Please consult with the SWG for best practice on this. The same conditions as to what is filled or not of the SPA column still apply with these specifics:

1. TARGSRVY and TARGCAT match the rest of the targets
2. TARGCLASS can be any within the accepted list (Section 5.4.3.5), and APS modules can be added. TARGCLASS=SKY has a particular set of APS modules activated (See Section 5.4.3.10.1).
3. For MOS and mIFU Sky targets: GAIA_PMRA, GAIA_PMRA_ERR, GAIA_PMDEC, GAIA_PMDEC_ERR, GAIA_PARAL and GAIA_PARAL_ERR must all be set to 0.0. Do not use floating point(NULL).
4. For LIFU Sky targets: GAIA_EPOCH, GAIA_PMRA, GAIA_PMRA_ERR, GAIA_PMDEC, GAIA_PMDEC_ERR, GAIA_PARAL and GAIA_PARAL_ERR must inherit the corresponding values from the central fibre. Do not use floating point(NULL).

5.4.3.4.2 IFU White Dwarfs

The only exception when TARGUSE = ‘C’ or ‘R’ is permitted is when white dwarfs are extracted from the White Dwarf operational catalogue (WD.fits) as part of the construction of mIFU or LIFU bundles.

The TARGSRVY, TARGCAT and TARGCLASS must match that in the WD.fits. The user can specify TARGUSE=‘C’ or ‘R’. This is an outcome of using the IFU Workflow whereby the user wishes to adopt within their catalogue some of the additional output from configure run within the workflow.

IFU users are strongly encouraged to use the IFU Workflow, as considerable work has been undertaken to ensure that configure, the IFU Workflow and the WASP are consistent.

5.4.3.5 TARGCLASS

This is the classification of the target as assigned by the survey. The valid values provide for both general classification (e.g. "STAR") and more granular assignment ("STAR_FGK"). We list these values in Table 12.

Table 12 List of TARGCLASS Categories

TARGCLASS	Definition
GALAXY	Galaxy
MASK	Mask
NEBULA	Nebula
QSO	Quasar
SKY	Sky
STAR	Star
STAR_BHB	Blue Horizontal Branch
STAR_CEP	Cepheids
STAR_EM	Emission Line star
STAR_EMP	Extremely Metal Poor
STAR_FGK	FGK Spectral Type
STAR_IB	Interacting Binary
STAR_MLT	MLT Spectral Type
STAR_MLUM	Luminous M Star
STAR_OB	OB Spectral Type
STAR_BA	BA Spectral Type
STAR_RRL	RR Lyrae
STAR_VAR	Variable
STAR_WD	White Dwarf
STAR_YSO	Young Stellar Object
UNKNOWN	Unknown

APS will use this list to direct how targets are analysed, via a mapping between TARGCLASS and the APS_FLAG described in Section 5.4.3.10.1. Please note that it is possible to specify preferred sky positions in the input FITS catalogue. In this instance, we recommend setting the TARGCLASS to “SKY”, but please consult the APS_FLAG section to understand the processing implications of doing so.

5.4.3.6 **PROGTEMP**

The PROGTEMP code is an integral part of describing a WEAVE target. This parameter encodes the requested instrument configuration, OB length, exposure time, spectral binning, cloning requirements and probabilistic connection between these clones. We describe the PROGTEMP code fully here, but we also refer registered WEAVE users to the PROGTEMP form in WASP.

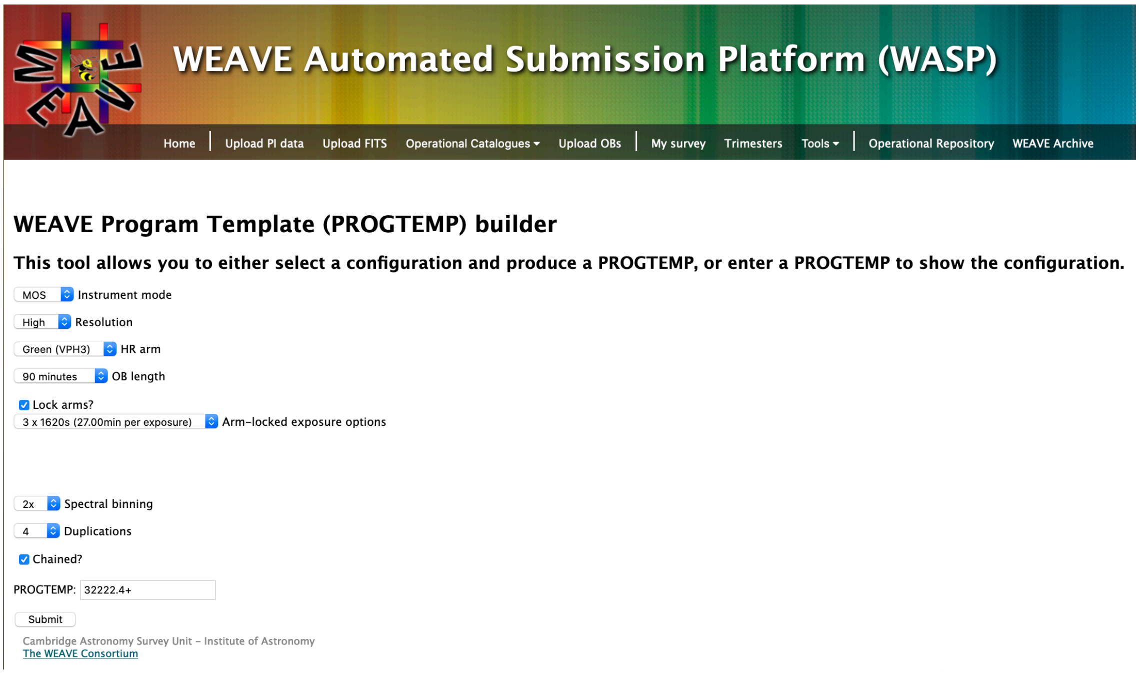


Figure 4 - The WASP's PROGTEMP tool. Users can select the desired instrument configuration and the tool will output the associated PROGTEMP code. Alternatively, users may enter a code and the form will be updated to reflect the configuration associated to this code.

This tool allows users to generate the correct PROGTEMP code for their desired observation. The WEAVE Data Model [AD20] also provides a lookup table (*progtemp.dat*) to permit scripted use of the PROGTEMP scheme – a tool to build a PROGTEMP is in the WASP (http://wasp.ast.cam.ac.uk/progtemp).

NB: whilst this description of PROGTEMP is complete, be aware that only limited functionality described within this system is available to WEAVE Science Teams. In constructing a PROGTEMP code, it is useful to think of the mnemonic “NORBI.X”:

PROGTEMP = "NORBI.X(+)"

- **N** = i(**N**)strument configuration
- **O** = (**O**)B length
- **R** = (**R**)ed arm exposure code
- **B** = (**B**)lue arm exposure code
- **I** = B(**I**)nning in the spectral direction
- **X** = Clone this Observing Block (**X**) times

If "X" is used, it may be followed with a "+" to "chain" these cloned OBs so that completion of one in the chain boosts the weights (within a survey) of the remaining OBs.

Because WEAVE can only observe one instrument configuration at a time, ***only targets with the exact same PROGTEMP can be observed within the same OB***. We now detail the individual components described above.

5.4.3.6.1 i(N)strument configuration:

This initial integer (1–9) sets the configuration of the spectrograph, according to the following table

Table 13 The available WEAVE instrument modes under the PROGTEMP scheme

N	Type	Resolution	Red arm	Blue arm
1****.*	MOS	LR	Red (VPH1)	Blue (VPH1)
2****.*	MOS	HR	Red (VPH2)	Blue (VPH2)
3****.*	MOS	HR	Red (VPH2)	Green (VPH3)
4****.*	LIFU	LR	Red (VPH1)	Blue (VPH1)
5****.*	LIFU	HR	Red (VPH2)	Blue (VPH2)
6****.*	LIFU	HR	Red (VPH2)	Green (VPH3)
7****.*	mIFU	LR	Red (VPH1)	Blue (VPH1)
8****.*	mIFU	HR	Red (VPH2)	Blue (VPH2)
9****.*	mIFU	HR	Red (VPH2)	Green (VPH3)

5.4.3.6.2 (O)B length specifier

This PROGTEMP component specifies the overall OB length (inclusive of overheads). Whilst we provide the option of setting the following OB lengths, please be aware that not all OB lengths are available to WEAVE science teams.

Table 14 Options for total OB length under the PROGTEMP scheme

O	OB length (mins)
*0***.*	30
*1***.*	60
*2***.*	90
*3***.*	120
*9***.*	custom

Where O=9, then the RB component of PROGTEMP (below) is ignored, and the user sets exposure times manually. This mode is not available to WEAVE science teams.

5.4.3.6.3 (R)ed or (B)lue arm exposure code

The RB component of PROGTEMP's NO**RB**I.X defines how the time within the OB that you wish to observe the target is divided up, by specifying the number of exposures within the OB length stipulated above.

In principle, it is possible to provide different codes for the different arms. It is WEAVE policy to "lock" the arms: i.e., the Red and Blue arms must be observed with the same exposures within an OB. No such restriction is placed on Open Time, beyond cases where it adversely affects instrument efficiency (for example, requesting one exposure in Red, and 12 in Blue would cause a significant mismatch in overheads between the two arms).

The T_{exp} column in the below table is for approximate guidance only (and is approximately 60 minutes / exposure code). T_{exp} includes overheads, meaning actual time on-target will be less. Similarly, the exposure times provided for each OB length are inclusive of overheads, meaning on-target time will be less.

WEAVE science teams are permitted a limited subset of the below exposure options for MOS / IFU (coloured green), or IFU-mode only for options coloured orange. Exposure options for which fixed dither patterns are available in IFU modes are indicated in ***bold-italic***.

Open time surveys may use other combinations at their own risk, notwithstanding forbidden combinations arising from mixing different exposure codes for the two arms. The exception here is OB length O=0 (30 minutes) options *cannot* be used for MOS observations. We advise users to check their desired combination in the WASP PROGTEMP tool.

Table 15 The number and length of exposures within an OB for different OB lengths and exposure codes. Exposure codes may be specified on a per-arm basis, subject to comparable overhead penalties.

Exposure code	Typical T_{exp}	(O)B length specifier			
R , B (or union)	(min)	O = 0	O = 1	O = 2	O = 3
0.* , ***0*.*, **00*.*	-	1x30m	1x60m	1x90m	1x120m
1.* , ***1*.*, **11*.*	60	--	--	--	2x60m
2.* , ***2*.*, **22*.*	30	--	2x30m	***3x30m***	***4x30m***
3.* , ***3*.*, **33*.*	20	--	***3x20m***	***4x20m***	***6x20m***
4.* , ***4*.*, **44*.*	15	2x15m	***4x15m***	***6x15m***	8x15m
5.* , ***5*.*, **55*.*	12	--	***5x12m***	--	10x12m
6.* , ***6*.*, **66*.*	10	***3x10m***	***6x10m***	9x10m	12x10m
7.* , ***7*.*, **77*.*	8.55	--	7x8.55m	10x8.55m	14x8.55m
8.* , ***8*.*, **88*.*	7.5	***4x7.5m***	8x7.5m	12x7.5m	16x7.5m
9.* , ***9*.*, **99*.*	6	***5x6m***	9x6m	15x6m	20x6m

5.4.3.6.4 B(I)nning in the spectral direction

To request spectral binning, users can use the following codes within PROGTEMP:

Table 16 Spectral binning options available under the PROGTEMP scheme

I	Spectral binning
****1.*	1x
****2.*	2x
****4.*	4x
****9.*	custom

All other values are forbidden. Custom (9) spectral binning is not available to WEAVE science teams, and for all other cases must be agreed with ING in advance.

As an aside, we note that there is no facility to request spatial binning in WEAVE. Such a mode would compromise the spectral extraction performance and crosstalk characterisation within the L1 pipeline.

5.4.3.6.5 Duplicate this OB (X) times

This component is entirely optional – validation checks will not fail if there is no X value in the PROGTEMP. If a survey wishes to duplicate the observations of this target, then they can add the .X directive onto the end of the PROGTEMP code. This would result in the OB this target lives in being duplicated X times.

Furthermore, if users want to "chain" these cloned OBs together, such that the observation of one of these clones increases the chance that the remaining OBs in this group are observed, then a "+" can be added to the end of PROGTEMP.

The "+" instructs the WEAVE Scheduler to increase the (internal, survey-specific) weight of all OBs in this group. This provides a mechanism to ensure that once a series of observations are started, completion of the chain becomes a progressively higher priority above other OBs from this survey.

5.4.3.6.6 PROGTEMP examples

PROGTEMP = **11331**: MOS, LR, Red arm: 3x20mins, Blue arm: 3x20mins
PROGTEMP = **23331**: MOS, HR-Blue, Red arm: 6x20mins, Blue arm: 6x20mins
PROGTEMP = **32332**: MOS, HR-Green, Red arm: 5x18mins, Blue arm: 5x18mins, x2 spectral binning
PROGTEMP = **11331.4**: Observe this target in 4 identical OBs.
PROGTEMP = **11331.4+**: As above, but probabilistically link the OBs to maximise the chance this target is fully observed if started.
PROGTEMP = **23601**: MOS, HR-Blue, R:12x10mins, B:1x120m - FORBIDDEN
The red arm would incur a significant overhead readout penalty. The blue arm would complete long before the red arm.

5.4.3.7 OBSTEMP

Whilst PROGTEMP deals with "how" a target is observed, OBSTEMP deals with "when" a target is observed – namely setting the observational constraints required to optimally extract scientific information from the observation. We note that these constraints represent "worst-case" observing parameters – targets will be observed under these conditions or better. Observers should note that the probability of observing targets with highly restrictive OBSTEMP codes (e.g. "A***A") may be quite low.

We describe the OBSTEMP code fully here, but again we refer registered users to the OBSTEMP form in WASP.

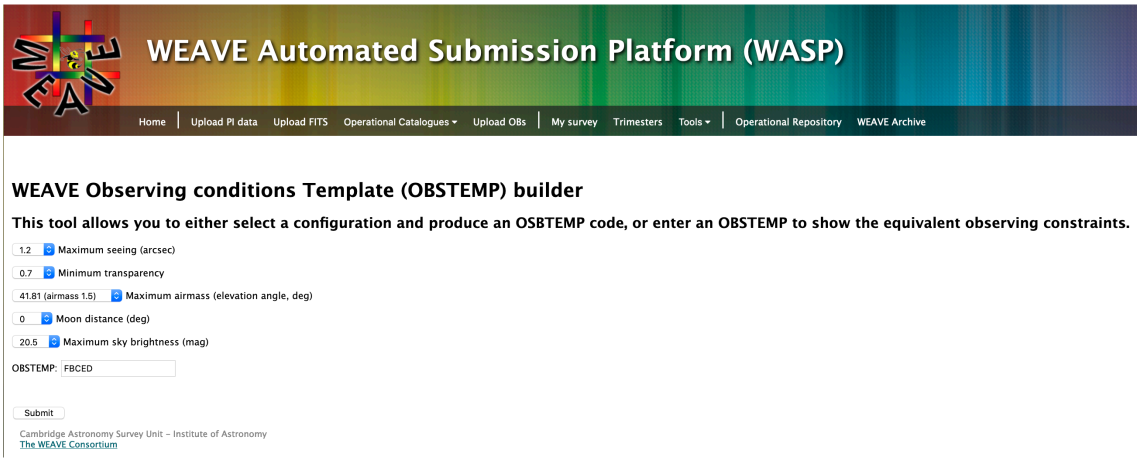


Figure 5 - The WASP's OBSTEMP tool. Users can select their desired observing constraints, and the tool will generate the corect OBSTEMP code. Alternatively, if users supply a code, the form will update to the corresponding constraints.

Within this form, users are able to select their desired observing conditions, and these will be translated into an OBSTEMP code. The mnemonic WEAVE uses for the OBSTEMP code is “STAMB”:

OBSTEMP = “STAMB”

- **S** = (**S**)eeing
- **T** = (**T**)ransparency
- **A** = Elevation (**A**)ngle [(**A**)irmass]
- **M** = (**M**)oon distance
- **B** = Sky (**B**)rightness

Each of these components are divided into grades (“A”, “B”, “C”, “D”, “E”...) with "A" being the best. For input FITS catalogues, we require that the OBSTEMP be valid, as per the options detailed below. For the construction of XML OBs, the values entered into the [AD18] <obsconstraints> element must:

1. Match the values derived from the following tables for each OBSTEMP component.
2. Correspond to the OBSTEMP code written into the [AD18] <observation> element.

As per [AD20], the discrete values for each component are provided in digital form via the *obstemp.dat* lookup table. A tool to build an OBSTEMP is in the WASP (http://wasp.ast.cam.ac.uk/obstemp).

In some instances, there are potential clashes between competing constraints (e.g. selecting a small moon-distance, but also stipulating a dark sky). WASP will warn users of these clashes.

Unlike PROGTEMP, targets with different OBSTEMP can in principle share the same OB. However, the constraints of the most stringent observation must be applied (permitting, for example, observation of a bright-time target in dark-time, but not vice-versa).

We now detail the individual components of the OBSTEMP code.

5.4.3.7.1 (S)eeing

This grade sets the maximum seeing (as evaluated by the ING) required to successfully observe the target.

Table 17 Seeing options available under the OBSTEMP scheme

S	Max seeing (arcsec)		S	Max seeing (arcsec)
A____	0.7		M____	1.9
B____	0.8		N____	2.0
C____	0.9		O____	2.1
D____	1.0		P____	2.2
E____	1.1		Q____	2.3
F____	1.2		R____	2.4
G____	1.3		S____	2.5
H____	1.4		T____	2.6
I____	1.5		U____	2.7
J____	1.6		V____	2.8
K____	1.7		W____	2.9
L____	1.8		X____	3.0

General guidance for MOS observers is to request seeing not much worse than the diameter of the fibres (1.3”). mIFU and LIFU observations are more tolerant of poorer seeing. During winter nights, the seeing is worse than 1.3” on a substantial fraction of the nights[4]. An instrument-level limit of seeing <3” is adopted due to degradation of guiding quality in poorer seeing.

5.4.3.7.2 Sky (T)ransparency

This component defines the minimum transparency (as defined by ING) required for the observation.

Table 18 Sky transparency options available under the OBSTEMP scheme

T	Minimum Transparency
_A___	0.8
_B___	0.7
_C___	0.6
_D___	0.5
_E___	0.4

[4] http://www.ing.iac.es/astronomy/observing/conditions/#seeing

In the absence of cloud and Saharan dust, the V-band transparency (i.e. the fraction of top-of-the-atmosphere light reaching the WHT) is ~ 0.88, and likely scales as (0.88)^airmass (i.e. T ~ 0.83 at airmass 1.5, T~ 0.77 at airmass 2).

Extinction due to Saharan dust rarely exceeds a few tenths of a magnitude (i.e. reduces transparency by <~ a few tenths) and varies little with position on the sky. Thin cloud, reducing transparency by a few tenths, can be patchy, so only an all-sky average can be predicted (based on the guide-star signal from previous observations).

A survey-wide limit on transparency (T > 0.4) is adopted to avoid various performance degradations such as guidance on attenuated guide stars, delivery of science data with significantly reduced SNR and increased risk of precipitation on the telescope optics.

5.4.3.7.3 Elevation (A)ngle [(A)irmass]

Users may set the minimum elevation angle (and thus airmass) that their targets should be observed with.

Table 19 Elevation angle / airmass options available under the OBSTEMP scheme

A	Minimum Elevation (deg)	Airmass
__A__	50.28	1.3
__B__	45.58	1.4
__C__	41.81	1.5
__D__	35.68	1.6
__E__	33.75	1.8
__F__	25.00	2.4

An instrument-wide limit of airmass < 3 will be set due to several effects degrading the quality of data at higher airmass: increasing differential refraction; higher extinction; worse light pollution.

5.4.3.7.4 (M)oon distance

Users may specify the minimum angular distance between the moon and the target. Observations under low moon distance may suffer from sky background light gradients across the field, as well as higher levels of reflected light causing spurious signals within the focal plane.

Table 20 Moon distance options available under the OBSTEMP scheme

M	Moon Distance (deg)
___A_	90
___B_	70
___C_	50
___D_	30
___E_	0 (no constraint)

An instrument-wide lower limit of 30 degrees ensures sky brightness gradients and scattered light effects are kept to a minimum. This limit applies to any observations set with “no constraint” (M=“E”).

5.4.3.7.5 Sky (B)rightness

The maximum V-band surface brightness of the sky (mag / sq. arcsec) required to observe the target.

Table 21 Sky brightness options available under the OBSTEMP scheme

B	Sky Brightness (V mag / sq arcsec)	
____A	21.7	
____B	21.5	Dark
____C	21.0	
____D	20.5	
____E	19.6	Grey
____F	18.5	Bright
____G	17.7	

The dark-of-moon sky brightness varies by a few tenths of a mag depending on ecliptic and galactic latitude and phase of the solar cycle.

With the moon up, the sky can be up to ~4 mag brighter than dark-of-moon, depending on lunar phase, elevation and angular distance from the target: these are therefore only rough characterisations in the above table.

The sky brightness for any phase of the moon, and anywhere on the sky, can be predicted with accuracy ~20%.

Science observations are carried out mainly during astronomical night, but those OBs tolerating moonlit skies can also use the latest bit of evening twilight, or the earliest bit of morning twilight – the only relevant criterion is sky surface brightness. No observations will be carried out when the sky brightness exceeds that at full moon.

5.4.3.8 Gaia Specific Columns

All input targets must be on the Gaia Reference Frame. WEAVE currently accepts either Gaia DR2 or DR3 data with reference epoch as 2015.5 or 2016.0 respectively[5]. Thus in the catalogue binary table, GAIA_DR= ‘2’ or ‘3’ (do not include ‘DR’ in the string) and GAIA_EPOCH= 2015.5 or 2016.0 respectively. These two columns MUST be filled regardless of whether or not the object has been detected by Gaia..

We note that, with the release of Gaia DR3 before the start of WEAVE commissioning, we strongly urge observers to use the DR3 reference epoch for WEAVE targets.

5 See https://www.cosmos.esa.int/web/gaia/earlydr3#datamodel

Objects that are NOT detected by Gaia MUST have their coordinates converted onto the Gaia Reference Frame (DR2 or DR3) to ensure all fibres are placed correctly. It is the responsibility of the observer to verify that their provided coordinates are both consistent with the ICRS and internally consistent within a configured field to within a few mas. Further details can be found in [AD18], as well as the Gaia DR2 astrometric paper[6].

If any Gaia information relating to parallax, proper motion and photometry in the G, BP and RP bands is available for a target then it must be included. This is because the more information the better for successful and optimal observations and spectral processing. Parallax and proper motions are particularly important for construction of the WEAVE CNAME, to ensure that successive observations (with varying separation in time) of the same target are correctly attributed to the same CNAME.

Information from Gaia is expected to be provided exactly as it is retrieved from the Gaia archive, so parameter definitions, data formats and units remain the same. Please consult the Gaia webpages[7] to further understand their data model.

The Gaia magnitudes are currently provided on the Vega system. Please report them in the GAIA_MAG columns as Vega. All other photometry sources must be reported on the AB system.

5.4.3.9 **IFU Specific Columns**

There are three columns used to specify IFU observations. Due to the complex nature of the IFU observation preparation workflow[8], we refer users to the documentation therein, but summarise the parameters here. MOS users should set IFU_SPAXEL to an empty string (‘’), IFU_PA to 0.0 and IFU_DITHER to 0 for all MOS targets.

IFU_SPAXEL provides an identifier that allows identification of the fibre within the IFU array, and consequently where it contributes to the construction of the data cube. The mapping between fibre and IFU_SPAXEL is determined by two lookup tables within the WEAVE Data model. In the case of the mIFU, IFU_SPAXEL also describes which bundle the fibre belongs to. These values are typically filled out by the IFU workflow software. Users wishing to populate these manually are referred to the *LIFUfibreTable.dat* and *mIFUfibreTable.dat* files under the WEAVE Data model hosted at the Operational Repository.

IFU_PA allows the catalogue provider to specify a rotation angle of the LIFU (not mIFU) if required. The default value is zero. Rotation is generally used in cases where the default PA results in no viable guide stars falling within the autoguider FOV or when the rotation during an exposure is likely to exceed the angular limits of the rotator. Any dithering requested for the field is applied to the rotated LIFU frame. During the IFU observation preparation workflow, an analysis is performed on putative LIFU pointings to determine if a rotation is required and provides the optimal value IFU_PA should take. Fibres within the same LIFU pointing must have the same IFU_PA.

[6] https://ui.adsabs.harvard.edu/abs/2018A%26A...616A...2L%2F
[7] https://gea.esac.esa.int/archive/documentation/GDR2/Gaia_archive/chap_datamodel/sec_dm_main_tables/ssec_dm_gaia_source.html
[8] https://ingbitbucket.ing.iac.es/projects/WVSWG/repos/ifu/browse/workflow

IFU_DITHER allows the user to specify the dithering strategy for their observations. LIFU observations may use a custom dither pattern. This should be reflected in the positions of LIFU fibres sharing common TARGNAME and TARGID within the input FITS catalogue, as described in Section 5.4.3.2. This mode is not available for mIFU observations. IFU users may alternatively request not to dither their observations, with the understanding that this will not provide full spatial coverage of their requested field. Finally, users may request the preset 3,4,5 and 6-dither patterns. We refer users to the *configure.cfg* file that is used by the Configure fibre allocation tool for the dither patterns adopted under these presets. A copy of this file is available under the WEAVE Data Model hosted at the Operational Repository.

Table 22 Dither modes available for IFU observations

Dither code	Description	Allowed modes		Dither pattern (coordinates given in arcsec)						
-1	Custom dither	LIFU		Defined by users via the RA and Dec of each position, as described in the OB <field> element (Section)						
0	No dither	MOS	LIFU	x	0.0000					
				y	0.0000					
			mIFU	x	0.0000					
				y	0.0000					
3	3-dither preset	LIFU		x	0.0000	-1.9494	-0.9747			
				y	0.0000	0.0000	-1.6882			
		mIFU		x	0.0000	0.0000	-0.9208			
				y	0.0000	1.0632	0.5316			
4	4-dither preset	LIFU		x	0.0000	-1.9494	-0.9747	-0.9747		
				y	0.0000	0.0000	-1.6882	1.6882		
		mIFU		x	0.0000	0.0000	-0.9208	0.9208		
				y	0.0000	1.0632	0.5316	0.5316		
5	5-dither preset	LIFU		x	0.0000	-1.9494	-0.9747	-0.9747	0.9747	
				y	0.0000	0.0000	-1.6882	1.6882	1.6882	
		mIFU		x	0.0000	0.0000	-0.9208	0.9208	0.9208	
				y	0.0000	1.0632	0.5316	0.5316	-0.5316	
6	6-dither (3 and -3 combined)	LIFU		x	0.0000	-1.9494	-0.9747	-0.9747	0.9747	-2.9240
				y	0.0000	0.0000	-1.6882	1.6882	1.6882	1.6882
		mIFU		x	0.0000	0.0000	-0.9208	0.9208	0.9208	0.0000
				y	0.0000	1.0632	0.5316	0.5316	-0.5316	-1.0632
-3	3-dither alt preset	LIFU		x	-0.9747	0.9747	-2.9240			
				y	1.6882	1.6882	1.6882			
		mIFU		x	0.9208	0.9208	0.0000			
				y	0.5316	-0.5316	-1.0632			

For custom dither patterns, constraints on the dither step size are imposed by the WASP to ensure that the guide star remains within the GuideCam field of view.

From the perspective of IFU users, careful consideration of the dithering options should be made.

This is especially true of mIFU observations, where the bundle rotation angle (which cannot be set by the user) impacts the filling factor of the reconstructed image. Furthermore, selection of certain dither patterns with the mIFU implies in some cases the White Dwarf calibration star will not lie within any of the fibres of the calibration bundle fibres. Whilst the 4-dither pattern is safe from this effect, other carefully constructed custom dither patterns should be check to ensure the WD can be observed.

It is worth noting that the -3 dither modes do not contain a null offset exposure, which means that the calibration bundles will not contain any exposure with a calibration star centred in its central fibre.

One important difference between LIFU and mIFU observations is the following: The LIFU preset patterns will be properly rotated according to the position angle of the observation; nevertheless, this will not happen in the mIFU observations (because in this case there will be a different position angle for each mIFU bundel and so makes no sense).

In Appendix C, we represent the pre-set patterns and their weight maps.

5.4.3.10 APS Specific Columns

The keywords with prefix APS_ are input parameters that APS will automatically read and adjust the values of corresponding modules in the APS processing. NULL values for any column correspond to the default values for the APS processing. If the default APS processing is preferred, then the TARGSRVY should leave these columns alone.

Table 23 Default Parameters for APS inputs

TTYPE	TTYPE comment	Default value	Options	TUCD	TUNIT	TLMIN	TLMAX
APS_WL_MIN	Min observed wavelength considered	Minimum available		em.wl	Angstrom	0	--
APS_WL_MAX	Max observed wavelength considered	Maximum available		em.wl	Angstrom	0	--
APS_Z	Redshift of system (heliocentric corrected)	0.0		src.redshift	--	--	--
APS_SIGMA	Initial guess of velocity dispersion	200.0		phys.veloc.dispersion	km/s	0	--
APS_TEMPL_LIB	Library of spectral templates	"XSL"		stat.fit.param	--	--	--
APS_TEMPL_LIB_NORM	Normalise spectral template library	0	0="LIGHT" 1="MASS"	meta.code	--	0	1
APS_PPXF_WL_MIN	Min rest-frame wavelength for use by pPXF	Minimum available		em.wl	Angstrom	0	--
APS_PPXF_WL_MAX	Max rest-frame wavelength for use by pPXF	Maximum available		em.wl	Angstrom	0	--
APS_PPXF_MOM	No. of kinematic moments to be extracted	4		stat.fit.dof	--	0	--
APS_PPXF_DEG_ADD	Deg. of additive Legendre polynomial Set to -1 not to include any additive polynomial	-1		stat.fit.dof	--	0	--
APS_PPXF_DEG_MULT	Deg. of multiplicative Legendre polynomial	4		stat.fit.dof	--	0	--
APS_PPXF_NUM_MC	No. of MC simulations to extract pPXF errors	0		meta.code.multip	--	0	--
APS_GAND_MODE	Run GANDALF to extract emission-line kinematics	1	0=skip GANDALF 1=run normal procedure; 2=run other procedure	meta.code	--	0	2
APS_GAND_ERR	Derive errors on emission-line analysis	1	0= no error; 1=normal procedure	meta.code	--	0	1
APS_GAND_RED1	Initial estimate for reddening by dust	0.0		meta.code	--	0	1
APS_GAND_RED2	Second estimate for reddening by dust	0.0		meta.code	--	0	1
APS_GAND_EBV	De-redden spectra for galactic extinction	0	0=do not de-redden; 1=deredden using RED1, RED2 above	meta.code	--	0	1
APS_LS_MODE	Extract indices and convert them to SSP prop. Note: mode 2 is only available as an extra feature (e.g. for CS developers), not available for the main APS analysis	1	1=perform normal extraction; 2=perform extra process (CS only)	meta.code	--	0	1
APS_LS_RES	Spectral resolution (FWHM) of index measrmnt	Nominal spectral resolution		spect.resolution	Angstrom	0	1000

TTYPE	TTYPE comment	Default value	Options	TUCD	TUNIT	TLMIN	TLMAX
APS_LS_NUM_MC	No. of MC simulations to extract errors	30		meta.code.multip	--	0	--
APS_SSP_NUM_WLKR	No. of walkers for the SP MCMC algorithm	100		meta.code.multip	--	0	--
APS_SSP_NUM_CHAIN	No. of iterations in the SP MCMC algorithm	1000		meta.code.multip	--	0	--
APS_IFU_MASK	Mask this fibre in IFU analysis	0	0=no mask; 1=mask	meta.code	--	0	1
APS_IFU_TSSL_TYPE	Type of spatial binning for data	"VORONOI"		meta.code	--	--	--
APS_IFU_TSSL_TARG_SNR	Target SNR per pix for spat. bin.	40.0		stat.snr	--	--	--
APS_IFU_TSSL_MIN_SNR	Min SNR per pix for spat. bin.	2.0		stat.snr	--	--	--
APS_IFU_TSSL_COVAR	Correct for spatial correlations	0	0=don't correct; 1=correct	meta.code	--	0	1
APS_IFU_SRC_ID	Identifier for sources within IFU mosaic	Null		meta.code	--	--	--
APS_IFU_SRC_RA	RA of centre of its IFU source	Null		pos.eq.ra	deg	0	360
APS_IFU_SRC_DEC	Dec of centre of its IFU source	Null		pos.eq.dec	deg	-90	90
APS_FLAG	Bit mask activating APS-CS-CDP modules	See Section 5.4.3.10.1		meta.code	--	--	--

5.4.3.10.1 APS_FLAG

APS_FLAG will be used to trigger the analysis of a target using a specific APS module or Contributed Software (CS) code. The flag will be as a bit mask where the length of the bit mask, N, is the number of core APS modules + CS modules. Each bit corresponds to a single APS module or CS module. When filling in APS_FLAG, for every position in the bitmask that is the digit 0, the corresponding APS/CS module is *not* activated. For every position in the bit mask that is the digit 1, the corresponding module is activated.

Users can “supplement” the default APS_FLAG for any TARGCLASS they specify by converting a 0 to 1. Users will not, however, be permitted to alter modules within the APS_FLAG from 1 to 0. In other words, where an APS_FLAG value is provided, it will override the TARGCLASS (though an APS_FLAG should be "additive" with respect to the TARGCLASS).

If the requested APS_FLAGs are inconsistent with the prediction of APS classifier (STAR/GALAXY/QSO) all APS/CS modules set by APS_FLAGs, as well as the default set of modules for that specific class of target (evaluated by APS classifier) will be activated as a precautionary measure. For Unknown sources (e.g. community surveys), APS will only run the default basic core APS modules.

In some cases, some modifications will be applied to the final APS_FLAG by the core APS system:

1. If running a CS module depends on an APS (main) module, APS will run that specific APS module regardless of the status of its APS_FLAG set by the user.

2. If a target is shared among two or more surveys, APS will apply the union of APS FLAGs set by different surveys.

Table 24 provides the default bitmask for each APS/CS module under the different TARGCLASS values. In case no APS_FLAG is provided, the APS core system will adopt the bit mask associated with the TARGCLASS value provided in this table.

Table 24 APS_FLAG Bitmask Definition

TARGCLASS	Definition	Classifier				APS stellar modules								APS extragalactic modules								Contributed Software							
		REDROCK	RESV1	RESV2	RESV3	RVSPECFIT (RV)	RVSPECFIT (ATMOS)	FERRE	RESV4	RESV5	RESV6	RESV7	RESV8	AT	PPXF	GANDALF	LS (LINE INDICES)	RESV9	RESV10	RESV11	RESV12	ALFA-NEAT	FESWI	SPAce	SQUEEZE	AMY	SAPP	RRLGV	RRLEW
GALAXY	Galaxy	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MASK	Mask	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEBULA	Nebula	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
QSO	Quasar	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0
SKY	Sky	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
STAR	Star	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
STAR_BHB	Blue Horizontal Branch	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
STAR_CEP	Cepheids	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
STAR_EM	Emission line star	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAR_EMP	Extremely Metal Poor	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
STAR_FGK	FGK Spectral Type	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
STAR_IB	Interacting Binary	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAR_MLT	MLT Spectral Types	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
STAR_MLUM	Luminous M star	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
STAR_OB	OB Spectral Type	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAR_BA	BA Spectral Type	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
STAR_RRL	RR Lyrae	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
STAR_VAR	Variable star	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAR_WD	White Dwarf	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAR_YSO	Young Stellar Object	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
UNKNOWN	Unknown	1	0	0	0	1	1	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

5.4.3.11 MAG_G, MAG_R, and MAG_I

These columns were originally designed to report the SDSS *g*, *r* and *i* band photometry for CPS to use in the spectral processing and quality control checks.

However, SDSS photometry is either not necessarily available for every target or is not the preferred photometry for all surveys. Therefore these can be filled with alternate photometry provided they meet the following conditions:

1. UNCORRECTED for extinction
2. SDSS-like on the AB system
    a. Equivalent to the Gunn filters (e.g. PS1 filters, CFHT MegaPrime or MegaCam filters) but not the SDSS Fiber Magnitudes (wrong size fibres).
    b. Assumed below atmosphere at airmass of ~1.3 (canonical SDSS)
3. Also specified in TARGSRVY catalogue as **Survey-Specific columns** (see Section 5.4.5).

Ideally this is the photometry used as the basis for target selection, but this is not a formal requirement.

Therefore the preferred photometry that is reported in MAG_G, MAG_R and MAG_I should be included also as Survey-Specific columns where SDSS-like on the AB System is the main column.

Warning 1: if photometry is calibrated to Vega and/or corrected for extinction, and then passed into the MAG_G, MAG_I or MAG_R columns, the fibre throughput estimates in Quick-Look and L1 processing will be incorrectly reported. This may impact WEAVE observations during the night, as the On-Island Survey Management Team may waste time assessing the scientific viability of an OB based on incorrect assumptions.

Warning 2: If you are only using Gaia photometry (G, BP, RP) please only fill the GAIA_MAG_GG, GAIA_MAG_BP, GAIA_MAG_RP columns. Do not convert the Gaia photometry to then also fill MAG_G, MAG_R, MAG_I. The Gaia columns are not Survey-Specific columns. Please provide all three Gaia magnitudes where possible. G+BP+RP is optimal, BP+RP is better than only G, but only G is better than nothing.

Warning 3: The WASP will report warnings if you do not fill any of the mandatory photometry columns (MAG_G, MAG_R, MAG_I, GAIA_MAG_GG, GAIA_MAG_BP, GAIA_MAG_RP). Your catalogue will not be rejected by the WASP but you will be warned that your data will not be processed optimally. Please make all effort to provide useful photometry as specified above in some or all of these columns.

5.4.4 Target Uniqueness

The PROGTEMP and OBSTEMP columns in the binary table provide the observing programme and the observing conditions respectively per target.

WASP validation prevents the submission of multiple instances of the same target in the same catalogue, where the definition of "same" is defined below. This does not prevent users from using the same row entry in the FITS catalogue and passing through multiple OBs. To observe the same target in the same fibre configuration multiple times please change the PROGTEMP ".X(+)" component as per Section 5.4.3.6.

The same target within a catalogue can be observed with a different PROGTEMP and OBSTEMP, e.g. as Low Resolution (LR) and High Resolution (HR), and so the same target can appear multiple times within a single catalogue.

For MOS targets, the uniqueness of a row in the catalogue is set by a combination of:

- TARGID+PROGTEMP+OBSTEMP.

For IFU targets, this depends also on whether it is LIFU or mIFU. For the LIFU, the uniqueness combination is

- PROGTEMP+OBSTEMP+TARGNAME+TARGID+IFU_PA+IFU_SPAXEL+IFU_DITHER

For mIFU it is

- PROGTEMP+OBSTEMP+TARGID+IFU_PA+IFU_SPAXEL+IFU_DITHER

See also Section 5.4.3.1 for usage of TARGID and TARGNAME for MOS and IFU.

5.4.5 Survey-Specific Columns

These columns will generally vary between the surveys. In compiling the list of Survey-Specific columns the following guidelines were considered:

1. Columns used for target selection of the survey targets, such that the selection function can be reproduced in WAS;
2. Columns providing photometry by default must the AB system.
3. Columns of ancillary data for use within the limits and tools provided by WAS.

The catalogue template per survey is defined and fixed within this ICD as part of the version controlled WEAVE Data Model. Changes to the catalogue templates can only be made via a format change request (see [AD20] for further details).

For PI Surveys we provide a tool through the WASP (see Section 8) to generate fits catalogue templates from the predefined list of Survey-Specific columns (see appendix)

The requirements of the surveys and the archive teams were balanced in each case.

5.4.5.1 FITS Binary Table Keywords per Survey -Specific Column

Key information per column is needed for that column to be included in the Binary Table of the FITS template. The standard use of these is described in Section 5.4.1 but in summary the information is as shown in Table 25.

Table 25 Binary Table Keywords – Survey -Specific Columns

Keyword	Description/Usage

TTYPE	Name of column. See Section 5.4.1.1. Survey-Specific column names should follow standard scheme with these rules: • Upper case names only • Delimiter if needed is the underscore '_' • Photometry names constructed as 'CAT_MAG_X' & 'CAT_MAG_X_ERR', where CAT is general or a specific catalogue name, and X is the letter or number of specific pass band as per SPA column scheme for SDSS and Gaia above.
TFORM	Data format – A=string, E=floating point, D=double precision, I=integer. See Section 5.4.1.2.
TUNIT	Measurement unit of column value. Not present if no units needed. See Section 5.4.1.3.
TNULL	Value which FITS interprets as NULL. Empty string {''} for strings, floating point NULL (NaN) for real, and -1 for positive integer. See Section 5.4.1.4.
TLMIN, TLMAX (Data Range)	Range of expected values: alphanumeric, real, positive real, integer, positive integer. Assumes (-inf,inf) or (0,inf). If range is more restricted than infinity then include (min:max) for restrictions. See Section 5.4.1.6.
TPROP (Proprietary)	If column should be restricted access in WAS due to MOU with external organisation use '1', otherwise '0'. See Section 5.4.1.5.
TDISP	Precision of value for checking and display. See Section 5.4.1.7.
TUCD	Unified content descriptor. See summary in Section 5.4.1.8.

As an example, key information for the SPA columns is provided Table 31.

5.4.5.2 Column Naming Scheme

Columns from photometric catalogues other than SDSS and Gaia that are included by a TARGSRVY should be correctly referenced in the FITS file. The full list of available columns is provided in (Appendix A - Table 31).

There are two schemes to include these data, each of which needs to use a specific format for column naming:

1. Single catalogue named explicitly in the column name as for Gaia.

   This table provides the generic set of four columns, where <> is replaced by the catalogue name and X is the associated pass band(s).

Table 26 Column Name Set for specific Photometric Source Catalogue

TTYPE	TTYPE Comment	Notes
<>_ID	Target Identifier of the X,Y,Z bands	For example, for Pan-STARRS the naming used already is PS_ID etc
<>_DR	Data release of <>_ID	
<>_MAG_X	<> magnitude in X band.	Repeat for each associated band.
<>_MAG_X_ERR	Error on <>_MAG_X	Repeat for each associated band.

   Examples used so far include: Pan-STARRS = PS, JPAS=JPAS, IGAPS=IGAPS, VPHAS=VPHAS. Please consult the full list in Table 31.

2. Multiple catalogues are used for the same photometric bands

This table provides the generic set of five column where == refers to the type of photometry e.g. NIR, OPT ..., and X is the associated pass band(s).

Table 27 Column Name Set for generic Photometric Source Catalogue

TTYPE	TTYPE Comment	Notes
==CAT	Catalogue associated with the X,Y,Z bands	For instance, if using the J,H,K bands of either 2MASS or UKIDSS, then the column name would be NIRCAT for Near Infra-Red Catalogues.
==CAT_ID	Target Identifier associated with ==CAT	
==CAT_DR	Data release of ==CAT_ID	
==CAT_MAG_X	Magnitude in the X band for ==CAT_ID	Repeat for each associated band
==CAT_MAG_X_ERR	Error on ==CAT_MAG_X	Repeat for each associated band

Examples used so far are IRCAT for IRAC1, IRAC2, IRAC3, IRAC4; NIRCAT for Y, J, H, K, Ks bands; OPTCAT for U, B, V, R, I, u, g, i, r, z, y bands.

For OPTCAT, this means that U can be either U or u, R can be R or r, I can be I or i.

The current set of all Survey-Specific columns based on the current versions of the TARGSRVY catalogue templates are listed in Table 31. Open-time observers can inspect a thematically grouped list of columns under the WASP's Template Builder tool (Section 8.1).

All column names have been consolidated and made consistent between surveys.

3. Additional columns that may also be present are:

- _FLAG for flag columns,
- _MAG_X_AX for photometry in the X band corrected for extinction

5.4.5.3 Which Photometric System can I use: AB or Vega?

All the photometric columns are assumed by default to be on the AB-system.

The only exceptions are the Gaia magnitudes in the SPA columns (GAIA_MAG_G, GAIA_MAG_BP, GAIA_MAG_RP) as these are provided in the Gaia Archive as calibrated to Vega. Do NOT convert the Gaia magnitudes to the AB-system.

The final set of photometric columns as defined by the TARGSRVYs does not include any photometric columns specifically for Vega. Please convert all photometry to the AB-system.

5.4.5.4 Tracking the source data for MAG_G, MAG_R, MAG_I

To record which **Survey-Specific** columns were used to fill MAG_G, MAG_R and/or MAG_I, three keywords are required in the Primary Header (MAG_G_CM, MAG_R_CM, MAG_I_CM). See the Primary Header section above for further instructions.

The columns listed in the Primary Header keywords much be entered with these two criteria:

1. Must match a **Survey-Specific** column present in the catalogue AND
2. Must be an SDSS-like on the AB system column

If multiple source columns are listed then used the pipe '|' as the delimiter.

If the source photometry in the **Survey-Specific** column that you want used by SPA is corrected for extinction and you have provided the extinction correction in the EBVCAT columns, you can combine these in the MAG_<G,R,I>_CM keyword to indicate that the two are applied together to supply the SPA-required extinction UNCORRECTED photometry.

For example, if you've put extinction-corrected photometry in OPTCAT_MAG_G and you've put the extinction correction in EBVCAT, then MAG_G_CM = `OPTCAT_MAG_G|EBVCAT_EBV' and MAG_G must then contain the extinction UNCORRECTED G band magnitude in the SDSS-like AB system.

5.4.5.5 Why provide these MAG_G, MAG_R, MAG_I columns?

Why is it important to do this?

1. MAG_G, MAG_R and MAG_I values will be used by CPS to monitor the throughput of the fibres, i.e. to test that the signal received is the signal expected.
2. MAG_G, MAG_R and MAG_I values are necessary to perform the best possible flux calibration
3. MAG_G, MAG_R and MAG_I values will be used to monitor positioning of the fibres to test they are being accurately placed.

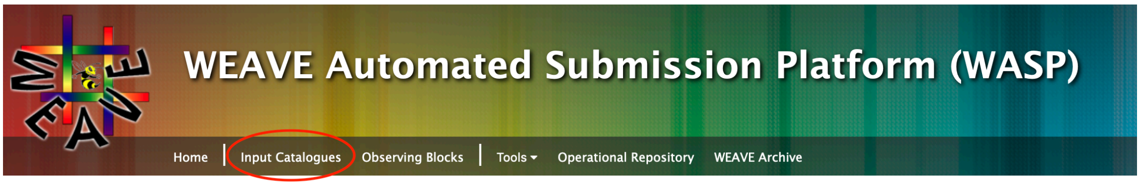
In summary, MAG_G, MAG_R and MAG_I values are critical within the data flow to carry out quality control and optimal spectral extraction. This will ensure that surveys get the best observations and data products possible of their targets. Without these values properly set on the SDSS-like AB system, the quality of the reduced data cannot be guaranteed.

5.5 Submission of catalogues to WASP

One of the primary roles of the WASP is to act as a validation platform for users to submit FITS catalogues that will be checked against the WEAVE data model. Users must have a user account in WASP to permit upload of their test products to the platform.

WASP accounts operate on a per-TARGSRVY basis. If users have been delegated responsibility within their WEAVE science team for the submission of FITS catalogues, then they should request WASP access from their STL. Open-time PI surveys will have accounts automatically generated once time allocation information is sent from the ING to CASU – an email will be sent providing authentication details.

Once logged in, users can select "Input Catalogues" from the top menu bar:



This provides them with a form that allows for the upload of a FITS file:

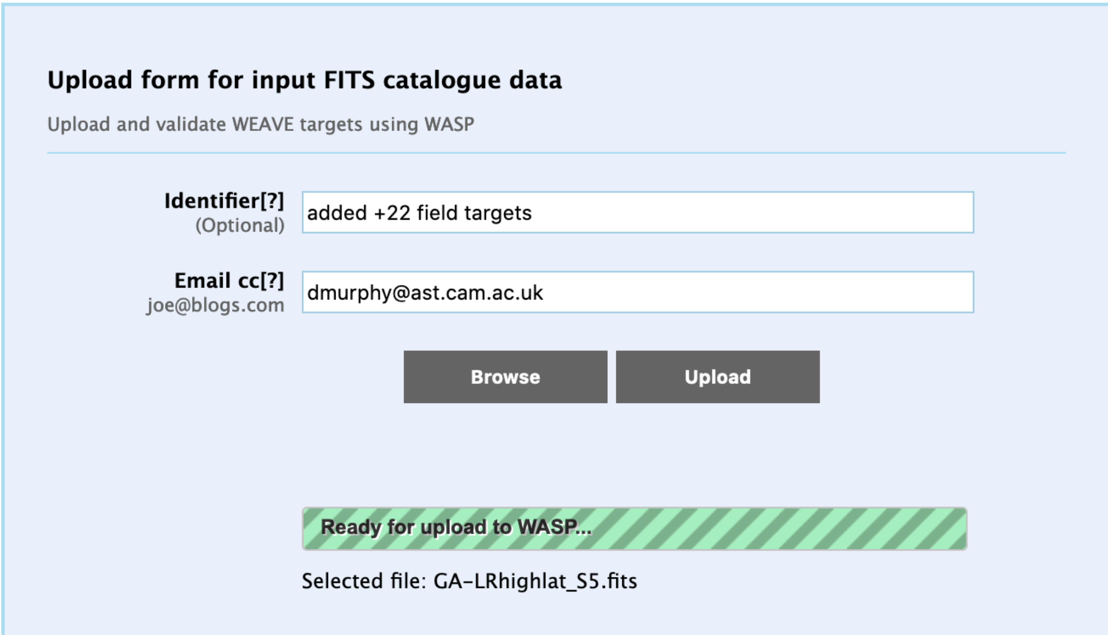


Figure 6 - The WASP FITS catalogue upload form.

Users can add a short optional description for their submission, as well as provide an additional email address where the validation report will be sent.

Click "Browse" to choose the file, and then Upload. Users will then be taken to the processing screen, where they can see the status of their submission.

There are two modes of operation for FITS catalogue submission. At all times, the WASP will provide a "test channel" that allows users to submit putative WEAVE catalogues for validation. These will not be stored in the system but will allow users to build catalogues and test them periodically to ensure they still conform to the required standards. The test channel allows users to select the observing trimester they want to test against.

Once validation is complete, if successful, users can download the validated catalogue with CNAMES added to the targets. This catalogue can be used as the basis for the creation of XML Observing Blocks based on the specification laid out in [AD18] and using the base XML template available from the Data Model hosted on the Operational Repository.

5.5.1 Irregularly submitted catalogues

In the case of Operational Catalogues (ASTRO-CALIB, WD, WG, ING-SYSCAT), the WASP does not expect submissions for each trimester. This is because these catalogues provide a static list of targets that are used in calibration, guidance and WHT observing routines.

Within the WASP, we identify the TARGSRVYs associated with these catalogues as *irregular* surveys. The assigned owners of these catalogues will therefore not receive the regular notifications and emails from WASP to prepare materials leading up to observation of an upcoming trimester.

When irregular surveys need to be updated, the owners should contact CASU to arrange for submission of new data products. Depending on the case, this may involve validation outside of the WASP environment, so sufficient lead time should be provided to ensure updates can be made in good time. Furthermore, these updates should consider the community use of these catalogues to ensure end-users are best served with the appropriate data.

5.5.2 Carryover Open-Time catalogues

In some instances, open-time proposals are awarded time spanning multiple observing trimesters. Within WASP, we define these as *carryover* surveys. Carryover surveys are assigned a TARGSRVY in the same manner as before (5.2.2), and this TARGSRVY remains with them throughout the programme. The trimester identifier in a carryover survey's TARSRVY *refers to the first trimester they will observe in*, not the current trimester.

Carryover surveys must define their FITS catalogue template in their first trimester. This template *cannot* be changed for subsequent trimesters. When the WASP switches operations to the next trimester, PIs of carryover surveys will receive a notification that their FITS catalogue template has been carried over from the previous trimester.

Carryover survey PIs will then upload targets for the new trimester using the same catalogue filename as

For example, a survey has been awarded time extending over semester 2024A (ie. Trimesters 2024A1, 2024A2). WASP expects the following:

Trimester 2024A1
TARGSRVY: WS2024A1-001
FITS catalogue template: WS2024A1-001_CatalogueTemplate.fits
Target FITS catalogue: WS2024A1-001.fits
XML files: user-defined

Trimester 2024A2
TARGSRVY: WS2024A1-001
FITS catalogue template: WS2024A1-001_CatalogueTemplate.fits (carried over from 2024A1)
Target FITS catalogue: WS2024A1-001.fits (the same filename as for 2024A1)
XML files: user-defined

Carryover surveys may use the WASP test channel for validation in the same way other users do, meaning the above survey can test validation of their 2024A2 targets during 2024A1.