ING LA PALMA TECHNICAL NOTE NO. 137

Comparison of WEAVE and ISIS for single-target, point-source observations

Version 1.1

Marie Karjalainen (ING)
Marc Balcells (ING)
Chris Benn (ING)

23 Oct 2019

Contents

Figures

Tables

Comparison of WEAVE and ISIS for single-target, point-source observations

Version 1.1

Marie Karjalainen (ING)
Marc Balcells (ING)
Chris Benn (ING)

23 Oct 2019

Abstract

In this report we (1) compare the performance of WEAVE and ISIS for observation of a single stellar target, and (2) estimate the fraction of recent ISIS proposals which could be carried out using a single WEAVE MOS fibre.

(1) For most ISIS configurations, the estimated ISIS and WEAVE signal-to-noise ratios (SNR) per ISIS resolution element are similar, with the ratio SNR(WEAVE)/SNR(ISIS) having mean 0.94 in the blue, and 1.1 in the red. The SNR predicted for WEAVE by the WEAVE SNR calculator is in good agreement with values calculated in this report. The actual SNR for WEAVE might be lower due to fibre-positioning errors, which were not considered here, and also to sky-background-subtraction errors, which were assumed zero. Fibre-positioning errors of 0.4 arcsec would degrade the WEAVE SNR by 11% in seeing of 0.8 arcsec, and 8% in seeing of 1.3 arcsec.

(2) 35 ISIS proposals allocated observing time in semesters 2017 A and B were reviewed. Of these, 13 proposals (37%) could instead use WEAVE, assuming the following: individual exposure times can be used; one MOS fibre can be used for the time allocated; fibre acquisition does not take longer than long-slit acquisition; proposals requesting the ISIS H2400B grating can use WEAVE MOS high-resolution mode; and two fibres can be used simultaneously if required, without losing much time to field re-configuration. An additional 6 of the 35 proposals (17%), for observation of non-stellar targets, could in principle use WEAVE, but would suffer from the less accurate subtraction of the sky background. The remaining 16 of the 35 proposals (46%) are not suitable for WEAVE and require the particular strengths and versatility of ISIS to reach their science goals: polarimetry mode, spectral coverage below 3660 Å; long-slit for extended targets; or a wide slit to avoid light losses. Other ISIS functionality, not called on in this sample of proposals, includes the possibility of using electron-multiplying CCDs as detectors, and the possibility of choosing between various dichroics to optimise the spectral coverage.

1 Motivation

This report addresses the question of how much observing currently carried out with the Intermediate dispersion Spectrograph and Imaging System (ISIS) on the 4.2-m William Herschel Telescope (WHT) might be feasible with WEAVE. ISIS is the most demanded and most productive instrument on the WHT. In the years of the WEAVE surveys, access to ISIS, and consequently its scientific productivity, will be reduced because 70% of the telescope time will be devoted to the WEAVE surveys, and, given the expectation that ISIS will be mounted only every 9 to 12 months, large portions of the sky will become inaccessible to ISIS for long periods of time.

Two analyses are reported below. Firstly, a comparison is made between the SNRs achieved when observing a single stellar target with the low-resolution modes of WEAVE and ISIS. Secondly, an estimate is made of the fraction of ISIS proposals which could efficiently be observed with WEAVE, based on an analysis of projects actually carried out with ISIS during two recent semesters.

2 Overview of WEAVE and ISIS

2.1 WEAVE

WEAVE is a multi-fibre survey spectrograph expected to start operating on the WHT in 2020. Using a 2dF-like pick-and-place robot at the WHT f/2.8 prime focus, it delivers optical spectra of up to ∼1000 targets over a two-degree field of view in a single exposure (MOS), as well as integral-field spectroscopy using 20 deployable mini integral-field units (mIFUs) or one large fixed integral-field unit (LIFU). The diameters of WEAVE's fibres are 1.3 arcsec (MOS, mIFU) and 2.6 arcsec (LIFU).

WEAVE's fibre-fed spectrograph will be housed in the GHRIL Nasmyth enclosure of the WHT, and comprises two arms fed via a dichroic. One arm is optimised for the blue and one for the red. Observations are possible at two spectroscopic resolutions, $R = 5000$ over $\lambda = 3700 - 9500\,\text{Å}$, and $R = 20,000$ over one quarter of this spectral range.

2.2 ISIS

ISIS is mounted at the Cassegrain focus of the WHT, and is a high-efficiency, two-armed, medium-resolution spectrograph (R up to ∼10,000 with a 1-arcsec slit at 4000 Å and 7500 Å), capable of long-slit work with slit up to ∼4-arcmin long and ∼22-arcsec wide. Use of dichroic filters permits simultaneous observing in the blue and red arms, with a ∼200 Å wavelength range of reduced throughput at the dichroic crossover from reflection to transmission. Both arms of ISIS are optimised for their respective wavelength ranges. Most ISIS observations are carried out using one or more of the four low/medium-resolution gratings available for each arm. In the red arm, at 7000 Å with a 1-arcsec slit, grating R158R gives a spectral resolution $R = \lambda/\Delta\lambda = 909$, and gratings R316R, R600R and R1200R give $R = 1842$, 3867 and 9333 respectively. In the blue arm, at 4000 Å with a 1-arcec slit, gratings R158B, R300B, R600B and R1200B give $R = 512$, 976, 1980 and 4706 respectively. An additional grating for the ISIS blue arm, H2400B, has spectral resolution $R = 10250$ at 4000 Å with a 1-arcsec slit. This grating is not often used, and has a higher resolution than WEAVE MOS in low-resolution mode, so it is not considered in the comparison made here. Linear and circular spectro-polarimetry and imaging polarimetry modes are available. An image slicer can also be used, to limit the loss of light at the entrance slit of the spectrograph, allowing the maximum spectral resolution of the spectrograph to be attained with greater throughput in modest seeing conditions. Finally, two electron-multiplying CCDs (QUCAM2 and QUCAM3) are available as alternative detectors on both arms of ISIS for high-speed or faint-object spectroscopy with very little dead time and essentially zero read noise. Further details can be found on the ISIS web pages[1].

---

[1] http://www.ing.iac.es/Astronomy/instruments/isis/index.html

3 WEAVE versus ISIS for observations of single targets

Tables 1 (blue) and 2 (red) compare the SNR predicted for WEAVE MOS in low-resolution ($R = 5000$) mode with that achieved using ISIS long slit. For each ISIS grating a central wavelength $\lambda_{\rm c}$, and a slit width, have been chosen to match a resolution of WEAVE MOS in low-resolution mode, R=5000, or a resolution corresponding to 2–8 binned pixels, $\rm Pix_b$, for WEAVE. The diffusion of charge between pixels, which degrades resolution by $\sim$10% in ISIS blue arm, has been taken into account. The calculations assume a point source of mag 16 (at each $\lambda_{\rm c}$), integration time of 1800 s, airmass 1, and bright of moon. For each ISIS setting shown in tables 1 and 2, a SNR per pixel for ISIS, $\rm SNR_I$, was calculated using the following equation:

$$\mathrm{SNR_I} = \frac{N}{\sqrt{N + P(S + READ^2)}}, \tag{1}$$

where N is the number of detected object photons per pixel step in wavelength, S is the number of detected sky photons per pixel, P is the number of pixels over which integration was carried out in the spatial direction, and $READ$ is the CCD readout noise in electrons. N and S were calculated from the number of photons/Å from object, $\rm n_{obj}$, and the number of photons/Å/arcsec^2 from sky, $\rm n_{sky}$, both taken from the ING's exposure time calculator, `SIGNAL` version 14.5.

To calculate a SNR per ISIS wavelength resolution element for WEAVE, N and S as defined above were corrected for the relative throughput of ISIS and WEAVE, light losses due to vignetting by the ISIS slit or the WEAVE fibre aperture, ISIS CCD quantum efficiency QE (WEAVE CCD QE is taken into account in the WEAVE throughput values) and throughput of the atmosphere (which is not taken into account in the WEAVE throughput values). In addition, S for WEAVE was corrected to give the number of sky photons per pixel step in wavelength (not per pixel) for fibre spectroscopy. We used $P = 3.29$ for WEAVE, which is the number of illuminated pixels/fibre along the slit (this number was taken from `signal2noise.py v1.5` of Scott C. Trager; inter-fibre spacing = 6 pixels total). Finally, a SNR per ISIS resolution element for WEAVE, $\rm SNR_{W1}$, was calculated using the following equation:

$$\mathrm{SNR_{W1}} = \frac{N\,\mathrm{Pix_b}}{\sqrt{(N\,\mathrm{Pix_b}) + (S\,\mathrm{Pix_b}) + (P/\mathrm{Pix_b})\,READ^2}}, \tag{2}$$

where a resolution element corresponds to $\rm Pix_b$ binned pixels for WEAVE so that SNR estimates for ISIS and WEAVE can be directly compared. Tables 1 and 2 show the resulting SNR per ISIS wavelength resolution element for WEAVE when binning on the detector, $\rm SNR_{W1}$, and for WEAVE when binning during the data post-processing, $\rm SNR_{W2}$. The last column shows also the ratio of $\rm SNR_{W1}$ and $\rm SNR_I$. The comparison is made for several values of seeing, from 0.8 to 2.0 arcsec. The calculations account for differences in spectral sampling and detector noise between ISIS and WEAVE. The calculations assume that the average dispersion for WEAVE low-resolution mode is 0.259 and 0.420 Å/pixel for the blue and red arms respectively (numbers taken from `signal2noise.py v1.5` of Scott C. Trager). It was also assumed that the readout noise is 4.8 electrons for ISIS blue arm, 3.9 electrons for ISIS red arm and 3.0 electrons for WEAVE. No fibre offsets due to fibre positioning errors were considered in the above calculations, but if the requirement for positional accuracy of less than $\sim$0.2 arcsec rms is met, this will not have a large impact on the resulting SNR in tables 1 and 2.

The throughput for ISIS was taken from the ING's exposure time calculator, `SIGNAL` version 14.5. The throughput for WEAVE was extrapolated from the low-resolution blue and red throughputs given in WEAVE document WEAVE-SYS-007, version 1.8 (see Fig. 2). The curve for total 'essential' throughput from the above document was used; this is a conservative prediction, i.e. is expected to be a lower-limit on the actual instrument throughput. Light losses due to vignetting by the ISIS slit, as a function of seeing, were taken from `SIGNAL` version 14.5. Light light losses due to vignetting by the WEAVE MOS fibre aperture were estimated from Fig. 1.

Intermediate steps in the calculations leading to the results shown in Tables 1 and 2, can be seen in Tables 3 and 4 in the Appendix.

Tables 1 and 2 also show SNR calculated using the WEAVE SNR calculator (`signal2noise.py v1.5`), $\mathrm{SNR_{W3}}$. A Moffat profile with $\beta = 2.5$ was used. A Moffat profile gives lower SNR than a Gaussian profile, but is more realistic for La Palma. It was possible to match most of the data used in the above calculations (airmass, bright of Moon, seeing, readout noise, zero fibre offset, and band for the red arm). For the blue arm band B was used. In the above calculations, on the other hand, the resulting SNR values correspond to the λ_c as shown in tables 1 and 2 and therefore are more realistic. However, there is good agreement between the SNR calculated using WEAVE SNR calculator, $\mathrm{SNR_{W3}}$, and for WEAVE using the above calculations, $\mathrm{SNR_{W1}}$ and $\mathrm{SNR_{W2}}$.

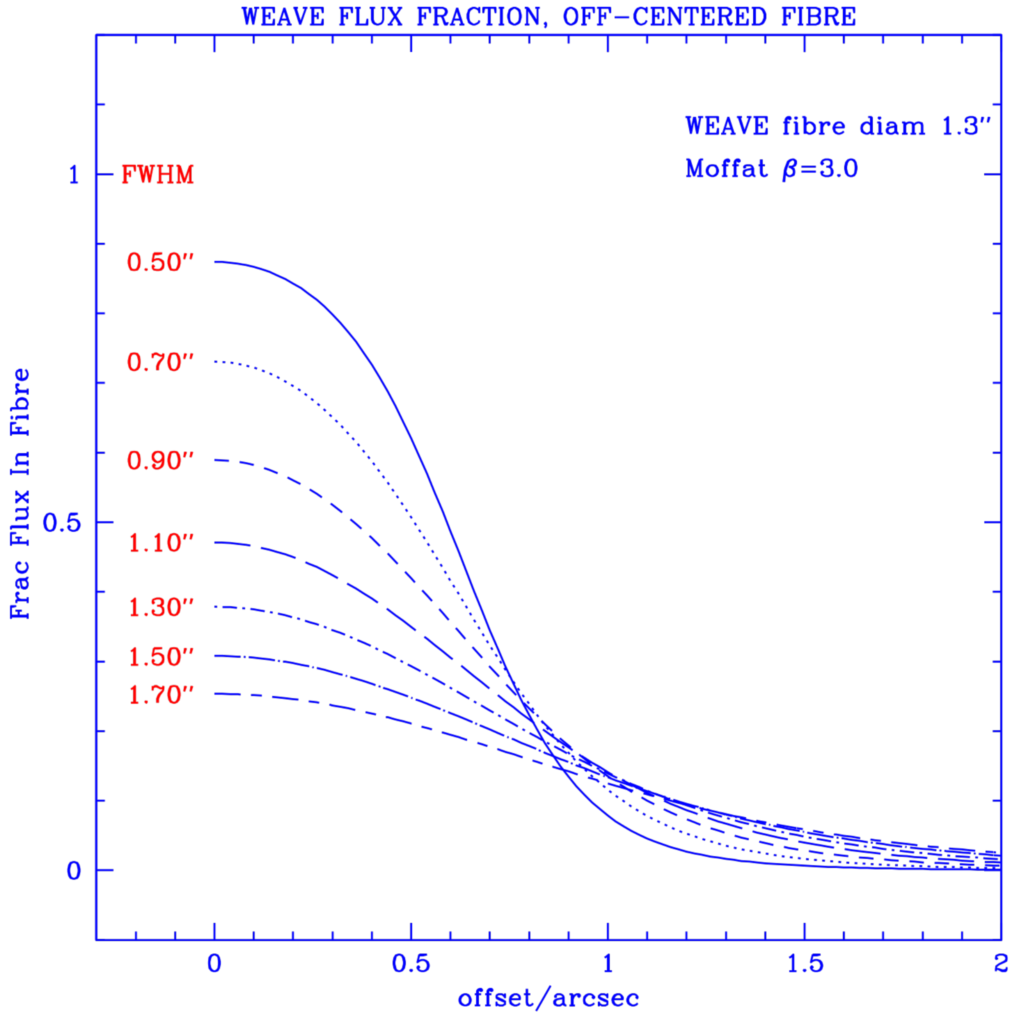

Figure 1: For seeing values ranging from 0.5 to 1.7 arcsec, the figure shows the fraction of flux from a point source that makes it into a WEAVE 1.3-arcsec fibre, as a function of the positional off-centering of the fibre. The accuracy with which WEAVE fibres can be centred is expected to be 0.2 arcsec rms. The PSF is modeled with a Moffat profile with $\beta = 3.0$. Clearly, WEAVE is optimised for good seeing.

Table 1: Signal-to-noise ratio (SNR) comparison between WEAVE and ISIS blue arm for ISIS resolution R. The result is given in column (11) as the ratio of predicted SNR for the two instruments. $\mathrm{Pix_b}$ is the number of binned pixels for WEAVE. An SNR per pixel for ISIS, $\mathrm{SNR_I}$, was calculated using Eq. (1), while a SNR per ISIS wavelength resolution element for WEAVE when binning on the detector, $\mathrm{SNR_{W1}}$, was calculated using Eq. (2). $\mathrm{SNR_{W2}}$ is a SNR per ISIS wavelength resolution element for WEAVE when binning during the data post-processing. $\mathrm{SNR_{W3}}$ was calculated using the WEAVE SNR calculator (`signal2noise.py v1.5`). Column (11) shows the ratio of $\mathrm{SNR_{W1}}$ and $\mathrm{SNR_I}$.

Grating (1)	λ_c Å (2)	R (3)	Slit arcsec (4)	Seeing arcsec (5)	$\mathrm{Pix_b}$ (6)	$\mathrm{SNR_I}$ (7)	$\mathrm{SNR_{W1}}$ (8)	$\mathrm{SNR_{W2}}$ (9)	$\mathrm{SNR_{W3}}$ (10)	$\frac{\mathrm{SNR_{W1}}}{\mathrm{SNR_I}}$ (11)
R1200B	4000	5000	0.85	0.8	1	53.0	47.3		57.7	0.9
R1200B	4000	5000	0.85	1.0	1	49.0	42.3		51.2	0.9
R1200B	4000	5000	0.85	1.3	1	41.9	35.5		42.7	0.8
R1200B	4000	5000	0.85	1.5	1	37.5	31.4		37.9	0.8
R1200B	4000	5000	0.85	1.7	1	33.9	28.5		33.8	0.8
R1200B	4000	5000	0.85	2.0	1	29.3	24.9		28.6	0.9
R1200B	4600	5000	1.00	0.8	1	55.4	54.2		57.7	1.0
R1200B	4600	5000	1.00	1.0	1	50.9	48.3		51.2	0.9
R1200B	4600	5000	1.00	1.3	1	46.0	41.0		42.7	0.9
R1200B	4600	5000	1.00	1.5	1	41.1	36.0		37.9	0.9
R1200B	4600	5000	1.00	1.7	1	37.1	32.6		33.8	0.9
R1200B	4600	5000	1.00	2.0	1	32.2	29.0		28.6	0.9
R600B	4500	2500	0.83	0.8	2	78.1	79.5	79.2	81.6	1.0
R600B	4500	2500	0.83	1.0	2	72.5	70.7	70.4	72.4	1.0
R600B	4500	2500	0.83	1.3	2	62.1	60.1	59.8	60.4	1.0
R600B	4500	2500	0.83	1.5	2	56.0	52.8	52.5	53.6	0.9
R600B	4500	2500	0.83	1.7	2	50.8	48.0	47.7	47.8	0.9
R600B	4500	2500	0.83	2.0	2	44.4	42.3	41.9	40.4	1.0
R600B	4300	1666	1.20	0.8	3	84.8	88.3	87.9	99.9	1.0
R600B	4300	1666	1.20	1.0	3	79.1	78.9	78.4	88.7	1.0
R600B	4300	1666	1.20	1.3	3	71.4	67.1	66.6	74.0	0.9
R600B	4300	1666	1.20	1.5	3	67.4	59.5	59.0	65.6	0.9
R600B	4300	1666	1.20	1.7	3	61.8	54.0	53.4	58.5	0.9
R600B	4300	1666	1.20	2.0	3	54.2	47.8	47.2	49.5	0.9
R300B	4500	1000	1.00	0.8	5	118.7	124.9	124.4	129.0	1.1
R300B	4500	1000	1.00	1.0	5	109.6	111.4	110.8	114.5	1.0
R300B	4500	1000	1.00	1.3	5	100.0	94.7	94.1	95.5	0.9
R300B	4500	1000	1.00	1.5	5	90.2	83.3	82.6	84.7	0.9
R300B	4500	1000	1.00	1.7	5	82.2	75.7	74.9	75.6	0.9
R300B	4500	1000	1.00	2.0	5	72.2	67.3	66.5	64.0	0.9
R158B	4500	625	0.85	0.8	8	143.9	152.4	151.7	163.2	1.1
R158B	4500	625	0.85	1.0	8	133.9	136.3	135.6	144.8	1.0
R158B	4500	625	0.85	1.3	8	116.2	114.8	114.0	120.8	1.0
R158B	4500	625	0.85	1.5	8	105.3	101.6	100.7	107.2	1.0
R158B	4500	625	0.85	1.7	8	96.0	92.3	91.4	95.6	1.0
R158B	4500	625	0.85	2.0	8	84.4	81.1	80.1	80.9	1.0

Table 2: SNR comparison between WEAVE and ISIS red arm for ISIS resolution R. The columns are as in Table 1.

Grating (1)	$\lambda_{\rm c}$ Å (2)	R (3)	Slit arcsec (4)	Seeing arcsec (5)	$\rm Pix_b$ (6)	$\rm SNR_I$ (7)	$\rm SNR_{W1}$ (8)	$\rm SNR_{W2}$ (9)	$\rm SNR_{W3}$ (10)	$\frac{\rm SNR_{W1}}{\rm SNR_I}$ (11)
R1200R	6500	5000	1.73	0.8	1	38.6	52.9		51.3	1.4
R1200R	6500	5000	1.73	1.0	1	36.4	46.9		45.1	1.3
R1200R	6500	5000	1.73	1.3	1	33.0	40.0		36.8	1.2
R1200R	6500	5000	1.73	1.5	1	30.2	35.1		32.2	1.2
R1200R	6500	5000	1.73	1.7	1	27.9	32.0		28.2	1.1
R1200R	6500	5000	1.73	2.0	1	25.1	28.3		23.3	1.1
R600R	8200	5000	0.90	0.8	1	34.8	33.2		36.5	1.0
R600R	8200	5000	0.90	1.0	1	30.6	29.1		31.4	1.0
R600R	8200	5000	0.90	1.3	1	24.9	23.9		24.9	1.0
R600R	8200	5000	0.90	1.5	1	21.2	20.6		21.3	1.0
R600R	8200	5000	0.90	1.7	1	18.4	18.2		18.3	1.0
R600R	8200	5000	0.90	2.0	1	15.1	15.7		14.7	1.0
R600R	6500	2500	1.40	0.8	2	58.7	75.6	75.4	72.5	1.3
R600R	6500	2500	1.40	1.0	2	55.9	67.4	67.1	63.8	1.2
R600R	6500	2500	1.40	1.3	2	48.5	57.0	56.8	52.0	1.2
R600R	6500	2500	1.40	1.5	2	44.7	50.1	49.8	45.5	1.1
R600R	6500	2500	1.40	1.7	2	41.6	45.7	45.4	39.9	1.1
R600R	6500	2500	1.40	2.0	2	36.2	40.1	39.8	33.0	1.1
R316R	8200	2500	0.85	0.8	2	45.3	50.8	50.6	51.6	1.1
R316R	8200	2500	0.85	1.0	2	40.0	44.7	44.5	44.4	1.1
R316R	8200	2500	0.85	1.3	2	31.9	36.4	36.2	35.2	1.1
R316R	8200	2500	0.85	1.5	2	27.3	31.5	31.3	30.1	1.2
R316R	8200	2500	0.85	1.7	2	23.6	28.0	27.8	25.9	1.2
R316R	8200	2500	0.85	2.0	2	19.4	23.9	23.7	20.8	1.2
R316R	6500	1666	1.00	0.8	3	85.5	91.6	91.2	88.9	1.1
R316R	6500	1666	1.00	1.0	3	77.5	81.2	80.8	78.1	1.0
R316R	6500	1666	1.00	1.3	3	68.8	68.6	68.2	63.7	1.0
R316R	6500	1666	1.00	1.5	3	60.5	59.8	59.4	55.8	1.0
R316R	6500	1666	1.00	1.7	3	53.9	53.9	53.5	48.8	1.0
R316R	6500	1666	1.00	2.0	3	45.8	47.4	47.0	40.4	1.0
R316R	6500	1250	1.30	0.8	4	87.9	106.4	106.0	102.6	1.2
R316R	6500	1250	1.30	1.0	4	82.2	94.7	94.3	90.2	1.2
R316R	6500	1250	1.30	1.3	4	71.8	80.1	79.7	73.6	1.1
R316R	6500	1250	1.30	1.5	4	66.5	70.6	70.1	64.4	1.1
R316R	6500	1250	1.30	1.7	4	62.1	64.1	63.6	56.4	1.0
R316R	6500	1250	1.30	2.0	4	52.4	56.5	55.9	46.6	1.1
R158R	6500	833	1.00	0.8	6	119.6	129.5	129.0	125.7	1.1
R158R	6500	833	1.00	1.0	6	108.5	114.8	114.3	110.5	1.1
R158R	6500	833	1.00	1.3	6	96.4	97.0	96.4	90.1	1.0
R158R	6500	833	1.00	1.5	6	84.9	84.6	84.0	78.9	1.0
R158R	6500	833	1.00	1.7	6	75.6	76.3	75.7	69.1	1.0
R158R	6500	833	1.00	2.0	6	64.4	67.1	66.5	57.1	1.0

Figure 2: Combined blue-arm + red-arm throughput of WEAVE in low-resolution mode. The figure is reproduced from the 'WEAVE Throughput Budget' (document WEAVE-SYS-007, version 1.8), by Kevin Middleton. The curves indicate the throughput requirement for WEAVE. The green curve indicates the 'essential' requirement, which *must* be exceeded by the instrument, while the brown curve indicates the 'optimal' requirement, to be met as long as doing so does not impact on the cost or schedule of the instrument. As-built optical coating data obtained after these curves were drawn gives confidence that the essential requirement will be amply met.

4 ISIS proposals in 2017a and 2017b

Proposals allocated observing time with ISIS during semesters 2017A and B were reviewed. Of the total of 35 proposals, 13 (37%) could use WEAVE, assuming the following:
1) All proposals can use individual exposure times, depending on the required SNR and target magnitude (rather than being executed as part of the WEAVE surveys with a fixed exposure time).
2) One fibre can be used throughout the night, or for the time allocated to the proposal.
3) Acquisition on the fibre does not take longer than acquisition on a slit.
4) Two ISIS proposals requested H2400B grating, which has a higher spectral resolution than WEAVE MOS in low-resolution mode, and it is assumed that WEAVE MOS in high-resolution mode could be used.
5) One ISIS proposal requested positioning of two targets on the slit (for more efficient observing). It is assumed that an equivalent observation could be made with WEAVE using two fibres simultaneously, although some time would be lost to field re-configuration after each pair of targets.

16 of the 35 proposals (46%) are not suitable for WEAVE for one of the following reasons:
1) WEAVE has no polarimetric mode (3 ISIS proposals).
2) WEAVE does not offer spectral coverage below 3660 Å (5 ISIS proposals).
3) WEAVE MOS does not provide the spatial resolution required to reach the science objectives, and WEAVE mIFU or LIFU modes are not suitable (7 ISIS proposals).
4) WEAVE does not allow use of a wide slit (up to 22.6 arcsec with ISIS), required for transmission spectroscopy of extrasolar planets (1 ISIS proposal), to minimise systematic errors due to slit losses.

Finally, 6 of the 35 proposals (17%), for observations of non-stellar targets, could in principle use WEAVE, but would suffer from the poorer sky subtraction. These include an ISIS proposal requesting simultaneous but independent observations at 6400 Å in the blue arm and 8400 Å in the red arm. With WEAVE, these observations would both have to be made with the red arm, so would take double the time.

No ISIS proposals in 2017A and B requested fast time-resolved spectroscopic observations with QUCAMs (there was one such proposal for semester 2018B).

5 Results and conclusions

5.1 Observations of single targets

For most ISIS configurations shown in Tables 1 and 2 for the blue and red arms, respectively, the estimated ISIS SNR per pixel, $\mathrm{SNR_I}$, and WEAVE SNR per ISIS resolution element, $\mathrm{SNR_{W1}}$, are similar, with the ratio $\mathrm{SNR_{W1}}/\mathrm{SNR_I}$ having mean 0.94 in the blue, and 1.1 in the red. In addition, the SNR calculated using the WEAVE SNR calculator (`signal2noise.py v1.5`), $\mathrm{SNR_{W3}}$, are in a good agreement with SNR calculations in this report, $\mathrm{SNR_{W1}}$ and $\mathrm{SNR_{W2}}$.

Several factors, noted below, affect differently the SNR obtained with ISIS and WEAVE, and the similarity in delivered SNR is fortuitous. Less of a star's light enters a WEAVE MOS fibre than enters a 1-arcsec ISIS long slit (the ratio WEAVE/ISIS is $\sim$ 76% for seeing 0.8", 67% for 1", 58% for 1.3", 52% for 1.5", 49% for 1.7" and 46% for 2.0"). In addition, more light will be lost due to fibre positioning errors, which were not considered here. WEAVE will also lose $\sim$25% of light in the fibres. On the other hand, the ISIS gratings are on average only $\sim$70% as efficient as the WEAVE blue and red low-resolution VPH gratings. Also the QE of the ISIS blue-arm CCD is $\sim$80%, compared with $\sim$92% for the WEAVE blue-arm CCD. The QEs of the CCDs on the red arms of ISIS an WEAVE are similar. The final performance of WEAVE will also depend on how well the rotator can track the field over an expected exposure duration of 1 hour, on optical misalignments, accuracy of sky-subtraction etc. In the calculations made in this note, no errors in the estimate of sky counts were considered as the accuracy of the sky subtracted spectra is expected to be limited by photon noise. On the other hand, fibre-positioning errors, which were not considered in the SNR calculations here, may degrade the SNR for WEAVE. Calculations for settings shown in tables 1 and 2 give $\sim$2% lower SNR for fibre positional offset of 0.2 arcsec with respect to the target's centroid, for seeing of 0.8 arcsec, and no SNR degradation for seeing worse than 1.5 arcsec. For fibre positional offset of 0.4 arcsec with respect to the target's centroid the SNR for WEAVE would be $\sim$11% lower than the values in tables 1 and 2 for seeing of 0.8 arcsec, $\sim$8% lower for seeing of 1.3 arcsec and $\sim$6% lower for seeing of 1.7 arcsec.

5.2 Proposals

A total of 35 ISIS proposals, for which observing time was allocated in semesters 2017 A and B, were reviewed. Of these, 13 proposals (37%) could use WEAVE, assuming the following: individual exposure times can be used, one fibre can be used for the time allocated, fibre acquisition does not take longer than long-slit acquisition, proposals requesting H2400B grating can use WEAVE MOS high-resolution mode and, if required, two fibres can be deployed at the same time without losing much time to field re-configuration. During the two semesters considered, 6 proposals (17%) for observation of non-stellar targets could in principle be done with WEAVE, but would most likely suffer from inaccurate sky subtraction. Finally, 16 proposals (46%) are not suitable for WEAVE and need the particular strengths and versatility of ISIS to reach their science goals. ISIS, unlike WEAVE, allows polarimetry, observation blueward of 3660 Å, long-slit observation for extended targets, and wide-slit observation to avoid light losses. It can also be used with electron-multiplying CCDs. Finally, ISIS also offers the possibility of choosing between different dichroics, to optimise the wavelength coverage and dichroic cut for a given observation.

Acknowledgment
The WHT's new multi-object spectrograph WEAVE is being designed and built by the international WEAVE Instrument Consortium.

Appendix. Input values for SNR calculations

Table 3: Input values for SNR calculations for ISIS blue arm and WEAVE. Columns (5), (6) and (7) show ISIS throughput, CCD quantum efficiency and in-slit fraction, respectively. Columns (8) and (9) show number of object photons per Å, n_{obj}, and number of sky photons per Å/arcsec^2, n_{sky}, respectively. Values were taken from the ING's exposure time calculator, `SIGNAL` v14.5. Column (10) shows ISIS throughput including CCD quantum efficiency. To make a direct comparison of throughputs between ISIS and WEAVE, throughput of WEAVE shown in column (12) is corrected for the atmospheric throughput (column (11)). The throughput for WEAVE was extrapolated from low resolution blue and red total essential throughputs of WEAVE-SYS-007 throughput document, v1.8. (see Fig. 2). Column (12) shows the fraction of light going into the fibre for WEAVE, which was estimated based on Fig. 1.

ISIS										WEAVE		
Grating	λ_c	Slit	Seeing	thr.	ccd	in-slit	n_{obj}	n_{sky}	thr.*ccd	thr.*atm	thr.	fibre flux
	Å	arcsec	arcsec				p/Å	p/Å/arcsec^2				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
R1200B	4000	0.85	0.8	0.14	0.78	0.79	13945	847	0.11	0.09	0.12	0.65
R1200B	4000	0.85	1.0	0.14	0.78	0.70	12466	847	0.11	0.09	0.12	0.52
R1200B	4000	0.85	1.3	0.14	0.78	0.57	10049	847	0.11	0.09	0.12	0.38
R1200B	4000	0.85	1.5	0.14	0.78	0.49	8709	847	0.11	0.09	0.12	0.30
R1200B	4000	0.85	1.7	0.14	0.78	0.43	7684	847	0.11	0.09	0.12	0.25
R1200B	4000	0.85	2.0	0.14	0.78	0.37	6532	847	0.11	0.09	0.12	0.20
R1200B	4600	1.00	0.8	0.19	0.83	0.86	15249	847	0.16	0.17	0.20	0.65
R1200B	4600	1.00	1.0	0.19	0.83	0.76	13510	847	0.16	0.17	0.20	0.52
R1200B	4600	1.00	1.3	0.19	0.83	0.67	11904	847	0.16	0.17	0.20	0.38
R1200B	4600	1.00	1.5	0.19	0.83	0.58	10246	847	0.16	0.17	0.20	0.30
R1200B	4600	1.00	1.7	0.19	0.83	0.51	9040	847	0.16	0.17	0.20	0.25
R1200B	4600	1.00	2.0	0.19	0.83	0.43	7684	847	0.16	0.17	0.20	0.20
R600B	4500	0.83	0.8	0.18	0.83	0.78	15022	924	0.15	0.16	0.19	0.65
R600B	4500	0.83	1.0	0.18	0.83	0.70	13447	924	0.15	0.16	0.19	0.52
R600B	4500	0.83	1.3	0.18	0.83	0.55	10704	924	0.15	0.16	0.19	0.38
R600B	4500	0.83	1.5	0.18	0.83	0.48	9277	924	0.15	0.16	0.19	0.30
R600B	4500	0.83	1.7	0.18	0.83	0.42	8186	924	0.15	0.16	0.19	0.25
R600B	4500	0.83	2.0	0.18	0.83	0.36	6958	924	0.15	0.16	0.19	0.20
R600B	4300	1.20	0.8	0.18	0.82	0.93	17940	924	0.15	0.13	0.16	0.65
R600B	4300	1.20	1.0	0.18	0.82	0.84	16256	924	0.15	0.13	0.16	0.52
R600B	4300	1.20	1.3	0.18	0.82	0.73	14154	924	0.15	0.13	0.16	0.38
R600B	4300	1.20	1.5	0.18	0.82	0.68	13220	924	0.15	0.13	0.16	0.30
R600B	4300	1.20	1.7	0.18	0.82	0.61	11835	924	0.15	0.13	0.16	0.25
R600B	4300	1.20	2.0	0.18	0.82	0.52	10060	924	0.15	0.13	0.16	0.20
R300B	4500	1.00	0.8	0.20	0.83	0.86	18022	1002	0.17	0.16	0.19	0.65
R300B	4500	1.00	1.0	0.20	0.83	0.76	15966	1002	0.17	0.16	0.19	0.52
R300B	4500	1.00	1.3	0.20	0.83	0.67	14068	1002	0.17	0.16	0.19	0.38
R300B	4500	1.00	1.5	0.20	0.83	0.58	12109	1002	0.17	0.16	0.19	0.30
R300B	4500	1.00	1.7	0.20	0.83	0.51	10684	1002	0.17	0.16	0.19	0.25
R300B	4500	1.00	2.0	0.20	0.83	0.43	9082	1002	0.17	0.16	0.19	0.20
R158B	4500	0.85	0.8	0.18	0.83	0.79	13945	847	0.15	0.16	0.19	0.65
R158B	4500	0.85	1.0	0.18	0.83	0.70	12466	847	0.15	0.16	0.19	0.52
R158B	4500	0.85	1.3	0.18	0.83	0.57	10049	847	0.15	0.16	0.19	0.38
R158B	4500	0.85	1.5	0.18	0.83	0.49	8709	847	0.15	0.16	0.19	0.30
R158B	4500	0.85	1.7	0.18	0.83	0.43	7684	847	0.15	0.16	0.19	0.25
R158B	4500	0.85	2.0	0.18	0.83	0.37	6532	847	0.15	0.16	0.19	0.20

Table 4: Input values for SNR calculations for ISIS red arm and WEAVE. The columns are as for Table 3.

ISIS										WEAVE		
Grating	λ_c Å	Slit arcsec	Seeing arcsec	thr.	ccd	in-slit	n_{obj} p/Å	n_{sky} p/Å/arcsec^2	thr.*ccd	thr.*atm	thr.	fibre flux
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
R1200R	6500	1.73	0.8	0.15	0.90	0.98	7938	969	0.13	0.19	0.21	0.65
R1200R	6500	1.73	1.0	0.15	0.90	0.95	7633	969	0.13	0.19	0.21	0.52
R1200R	6500	1.73	1.3	0.15	0.90	0.88	7128	969	0.13	0.19	0.21	0.38
R1200R	6500	1.73	1.5	0.15	0.90	0.82	6575	969	0.13	0.19	0.21	0.30
R1200R	6500	1.73	1.7	0.15	0.90	0.76	6153	969	0.13	0.19	0.21	0.25
R1200R	6500	1.73	2.0	0.15	0.90	0.70	5677	969	0.13	0.19	0.21	0.20
R600R	8200	0.90	0.8	0.17	0.80	0.81	3927	1460	0.14	0.17	0.18	0.65
R600R	8200	0.90	1.0	0.17	0.80	0.72	3500	1460	0.14	0.17	0.18	0.52
R600R	8200	0.90	1.3	0.17	0.80	0.60	2906	1460	0.14	0.17	0.18	0.38
R600R	8200	0.90	1.5	0.17	0.80	0.52	2518	1460	0.14	0.17	0.18	0.30
R600R	8200	0.90	1.7	0.17	0.80	0.46	2222	1460	0.14	0.17	0.18	0.25
R600R	8200	0.90	2.0	0.17	0.80	0.39	1889	1460	0.14	0.17	0.18	0.20
R600R	6500	1.40	0.8	0.17	0.90	0.95	9203	1163	0.15	0.19	0.21	0.65
R600R	6500	1.40	1.0	0.17	0.90	0.92	8901	1163	0.15	0.19	0.21	0.52
R600R	6500	1.40	1.3	0.17	0.90	0.79	7676	1163	0.15	0.19	0.21	0.38
R600R	6500	1.40	1.5	0.17	0.90	0.74	7130	1163	0.15	0.19	0.21	0.30
R600R	6500	1.40	1.7	0.17	0.90	0.69	6712	1163	0.15	0.19	0.21	0.25
R600R	6500	1.40	2.0	0.17	0.90	0.61	5879	1163	0.15	0.19	0.21	0.20
R316R	8200	0.85	0.8	0.13	0.80	0.79	3428	1314	0.10	0.17	0.18	0.65
R316R	8200	0.85	1.0	0.13	0.80	0.70	3064	1314	0.10	0.17	0.18	0.52
R316R	8200	0.85	1.3	0.13	0.80	0.57	2470	1314	0.10	0.17	0.18	0.38
R316R	8200	0.85	1.5	0.13	0.80	0.49	2141	1314	0.10	0.17	0.18	0.30
R316R	8200	0.85	1.7	0.13	0.80	0.43	1889	1314	0.10	0.17	0.18	0.25
R316R	8200	0.85	2.0	0.13	0.80	0.37	1606	1314	0.10	0.17	0.18	0.20
R316R	6500	1.00	0.8	0.20	0.90	0.86	9723	1357	0.18	0.19	0.21	0.65
R316R	6500	1.00	1.0	0.20	0.90	0.76	8614	1357	0.18	0.19	0.21	0.52
R316R	6500	1.00	1.3	0.20	0.90	0.67	7590	1357	0.18	0.19	0.21	0.38
R316R	6500	1.00	1.5	0.20	0.90	0.58	6533	1357	0.18	0.19	0.21	0.30
R316R	6500	1.00	1.7	0.20	0.90	0.51	5764	1357	0.18	0.19	0.21	0.25
R316R	6500	1.00	2.0	0.20	0.90	0.43	4899	1357	0.18	0.19	0.21	0.20
R316R	6500	1.30	0.8	0.20	0.90	0.94	10611	1357	0.18	0.19	0.21	0.65
R316R	6500	1.30	1.0	0.20	0.90	0.88	9945	1357	0.18	0.19	0.21	0.52
R316R	6500	1.30	1.3	0.20	0.90	0.76	8614	1357	0.18	0.19	0.21	0.38
R316R	6500	1.30	1.5	0.20	0.90	0.71	8022	1357	0.18	0.19	0.21	0.30
R316R	6500	1.30	1.7	0.20	0.90	0.67	7570	1357	0.18	0.19	0.21	0.25
R316R	6500	1.30	2.0	0.20	0.90	0.56	6369	1357	0.18	0.19	0.21	0.20
R158R	6500	1.00	0.8	0.20	0.90	0.86	9723	1357	0.18	0.19	0.21	0.65
R158R	6500	1.00	1.0	0.20	0.90	0.76	8614	1357	0.18	0.19	0.21	0.52
R158R	6500	1.00	1.3	0.20	0.90	0.67	7590	1357	0.18	0.19	0.21	0.38
R158R	6500	1.00	1.5	0.20	0.90	0.58	6533	1357	0.18	0.19	0.21	0.30
R158R	6500	1.00	1.7	0.20	0.90	0.51	5764	1357	0.18	0.19	0.21	0.25
R158R	6500	1.00	2.0	0.20	0.90	0.43	4899	1357	0.18	0.19	0.21	0.20