HIDES quick observing recipe:

HIDES (HIgh Dispersion Echelle Spectrograph)

HIDES is a cross-dispersed echelle spectrograph, currently equipped with a 2Kx4K CCD from EEV, placed at the Coude focus of the 188cm reflector. It works at optical wavelengths from 3600Å～9000Å. Instantaneous wavelength coverage are currently 1100Å and 700Å with RED and BLUE cross-disperser gratings, respectively. RED is recommended for λ>4300Å and BLUE for λ<4300Å. The maximum spectral resolution (λ/Δλ) of 110,000 is achieved when the slit width is 0.38", while 0.76" slit width gives a spectral resolution of ~61,000. The typical seeing at the Coude focus is about 1.5". Read out noise of the CCD is 5.5 e- and the gain is 4.2 e-/ADU. Dark current is 3 e-/hr. Additional devices given below are also available for HIDES.

1. Iodine cell for high precision radial velocity measurements
2. Image rotator/de-rotator for extended objects
3. Off-set guider for extended or faint objects
4. Narrow band filters for single order long-slit observations
   [OIII]λ5007, [OI]λ6300, Hα, [NII]λ6583

For more details, please contact H.Izumiura (PI of HIDES, izumiura@oao.nao.ac.jp). Note that you cannot use the iodine cell and the image rotator simultaneously.

Planning observations

Ordinary multi-order observations:

1) Select wavelength range (-> this determines the choice of cross-disperser and order cutting filter)
2) Determine spectral resolution (slit width)
3) Determine binning factor
   (Note: On-chip binning is effective for improving the final S/N only where the CCD read noise is dominant. Otherwise, binning by software after read out gives almost the same results. On-chip binning is however convenient for reducing the read-out time and saving the space on hard disk drive)
4) Slit length (depending on the flat fielding method)
5) Determine necessary S/N or exposure time
6) Estimate total exposure time or final S/N using U, B, V, or R magnitudes
7) Estimate total observing time by adding overheads

Single-order long-slit spectroscopy:

1) Select observing line (-> this determines the choice of narrow band filter).
   Please see the transmission curves of the available filters given in the appendix
2) Determine spectral resolution (slit width)
3) Determine spatial coverage (slit length)
4) Determine slit position angle(s)
5) Determine binning factor
   (Note: On-chip binning is effective for improving the final S/N only where the CCD read noise is dominant. Otherwise, binning by software after read out gives almost the same results. On-chip binning is however convenient for reducing the read-out time and saving the space on hard disk drive)
6) Determine necessary S/N or exposure time
7) Estimate total exposure time or final S/N using expected flux density
8) Estimate total observing time by adding overheads

Slit width and Spectral Resolution

For the slit width wider than 100um, the reciprocal resolution is given by an empirical formula,

$$\mathbf{R = \lambda / \Delta\lambda = 68000 * 45 * [\,\{ 45 * W / (200 * \cos 20^\circ) \}^2 + 15^2\,]^{-0.5}},$$

where W is the slit width in microns.

Examples:					
	W	100 (0.38”)	200(0.76”)	250(0.95”)	300(1.13”)
	R	108,000	61,000	50,000	42,000

Binning factor

On-chip binning is available up to 4 (in spatial dir.) x 10 (in dispersion dir.) pixels.

Please visit the URL given below for details of the binning of HIDES CCD camera.

http://www.oao.nao.ac.jp/support/instruments/hides/hides_manual/binning/hides_binning.html

Order separation and maximum slit length

Order separation: Blue cross-disperser

Wavelength(Å)	3600	4300	5000
Separation(pixels)	58	85	110
Separation(arcsec)	9.6	14.0	18.1

Order separation: Red cross-disperser

Wavelength(Å)	4000	5000	6000	7000	8000	9000
Separation(pixels)	48	75	108	143	190	230
Separation(arcsec)	7.9	12.4	17.8	23.6	31.4	38.0

System efficiency:

Figure 1 presents the measured total efficiency of HIDES, including the influences of the atmospheric extinction at the zenith and the telescope mirror reflectance. Transmission efficiency at the entrance slit is not included. The final efficiency also depends on the sky condition and the zenith distance of the object. Users need to take these factors into consideration as well when they make their actual observations.

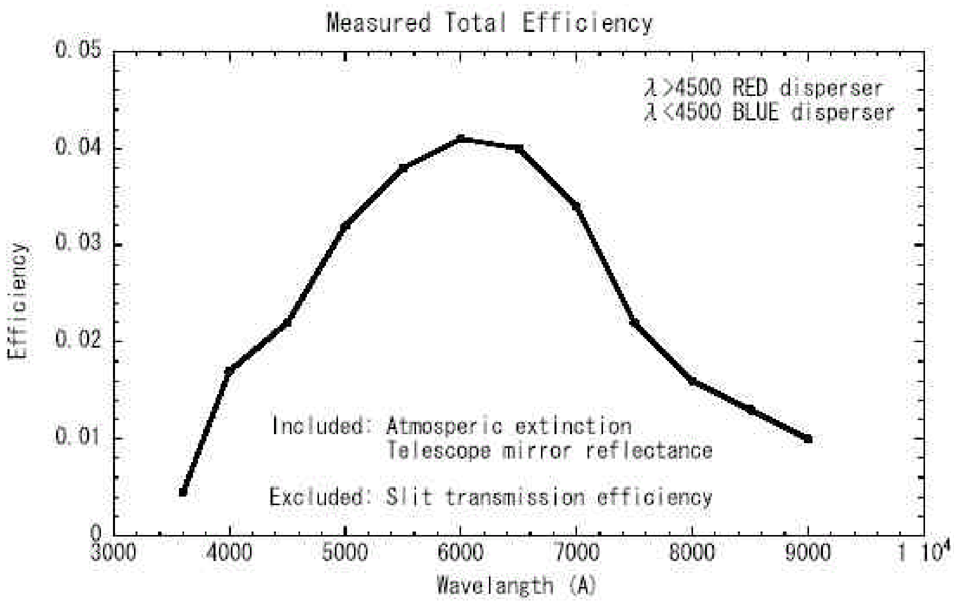


Figure 1: HIDES system efficiency

Exposure (S/N) calculation

The ratio of slit width to seeing size determines the transmission efficiency at the entrance slit (SE). It is given in the table below. Actual slit width is also given for the case of a seeing size (S) of 1.52” (typical value at OAO).

W	100um(0.38”)	200um(0.76”)	250um(0.95”)	300um(1.13”)
R	108,000	61,000	50,000	42,000
W/S	0.25	0.50	0.625	0.75
SE	0.23	0.44	0.54	0.62

(SE: Transmission efficiency at the entrance slit)

S/N in the finally extracted one-dimensional spectrum after the data reduction can be calculated with the following equation:

$$S/N = Nobj / \sqrt{(Nobj+Nsky+nNread^2)}$$

Nobj: the number of electrons given rise to by the photons from the object

Nsky: the number of electrons by the sky emission (usually negligible)

n: the number of pixels to sum up in slit length direction at the spectrum extraction, typically n~30

Nread: detector read out noise expressed in electrons, for HIDES 5.5e-

Then for an object of M-th magnitude at the observing wavelength, the resulting S/N can be calculated by

S/N ~ Nobj / √(Nobj+30*5.5*5.5)

Nobj=A * 10^(-M/2.5) * T * SE

A: read from the table below

T: total integration time in seconds

For the case of SE=0.54 (R=50,000), T=3600, M=10.0, A=24700(at 6000A), Nobj becomes 4802 and the final S/N is found to be 64. Inversely, the integration time to achieve a given S/N can be calculated by

T=Nobj/A/10^(-M/2.5)/SE

Nobj=(1/2)*(S/N)^2*(1+√{1+4*30*5.5*5.5/(S/N)^2}).

For example, in order to achieve a S/N of 100 Nobj should be 10837, which means that the integration time should be 8% longer than that for the case of photon noise alone.

Wavelangth(A)	A (electrons for 0 mag) (/s/pixel)
3600	1220
4000	14520
4500	17400
5000	23100
5500	24900
6000	24700
6500	21900
7000	16700
7500	10400
8000	6750
8500	5550
9000	4400

Necessary observing time also depends on the sky condition and the zenith distance of the object. Users need to take these factors into consideration as well when they make their final estimations. Correction factors for zenith distances are in preparation.

Auto guider

Stars as faint as 11-th magnitude can be used for auto guiding. The guider can cope with the following circumstances.

1) Normal guiding with or without the image rotator/de-rotator
2) Offset guiding with or without the image rotator/de-rotator

Sources within 1' from the slit position can be used for off-set guiding.

Wavelength calibration

Thorium-Argon hollow cathode lamp is used for the wavelength calibration. An atlas of the emission lines is available at the observatory site.

Sensitivity change

Total sensitivity varies with the time elapsed since the re-aluminization of telescope mirrors in June every year, due to the gradual degradation of the reflectance of the telescope mirrors. The degradation probably becomes more significant at shorter wavelengths. The total reflectance differs by a factor of 2 at around 6500A between just before and after the re-coating of mirrors. At shorter wavelengths the difference should be larger

Drift of the Spectrogram on the CCD

The spectrogram drifts on the CCD. It depends on the thermal stability inside the spectrograph room. The room is thermally controlled to a level better than 0.1℃. Usually the drift is only a fraction of a pixel per night. It is stable enough except for very high precision radial velocity measurements and high level de-fringing (see below).

Interference fringes

In the wavelength range long-ward of 6,500A, interference fringes become noticeable. The magnitudes are about 10% at 7,000A, 30% at 8,000A, and 50% at 9,000A. For very high S/N works in these wavelength ranges de-fringing is one of the most important issues. Under usual observing conditions, residual fringes are at most 5% of the continuum level even at 9000A. However, it has not been fully investigated how high S/N ratios can be achieved. In order to suppress residual fringes to 1% level, it is necessary to achieve a drift of spectrogram on the CCD as small as 0.1 pixels at 9,000A. Such stability is no longer warranted for observations separated by more than 2 hours. Thus, for high S/N works flat fielding data should be taken frequently at the expense of observing time.

It is also important to make the slit length as long as possible. This is because for de-fringing you need to divide the object frame by the flat frame directly. In those cases it is much convenient to employ a long slit length to provide sufficient sky regions, which will be used during data reduction, on both sides of each star spectrum.

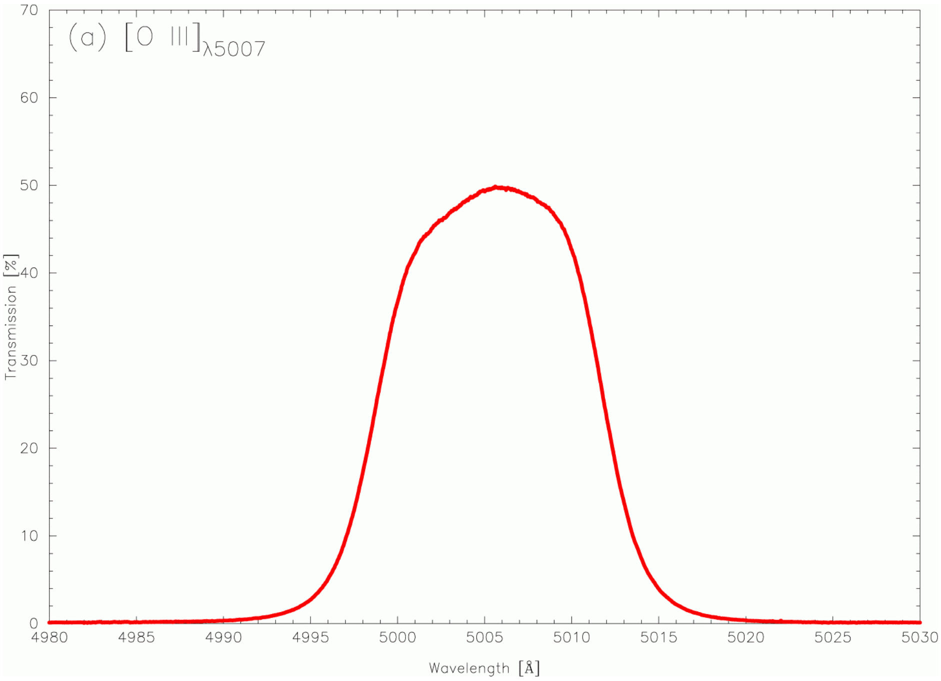
Facts table

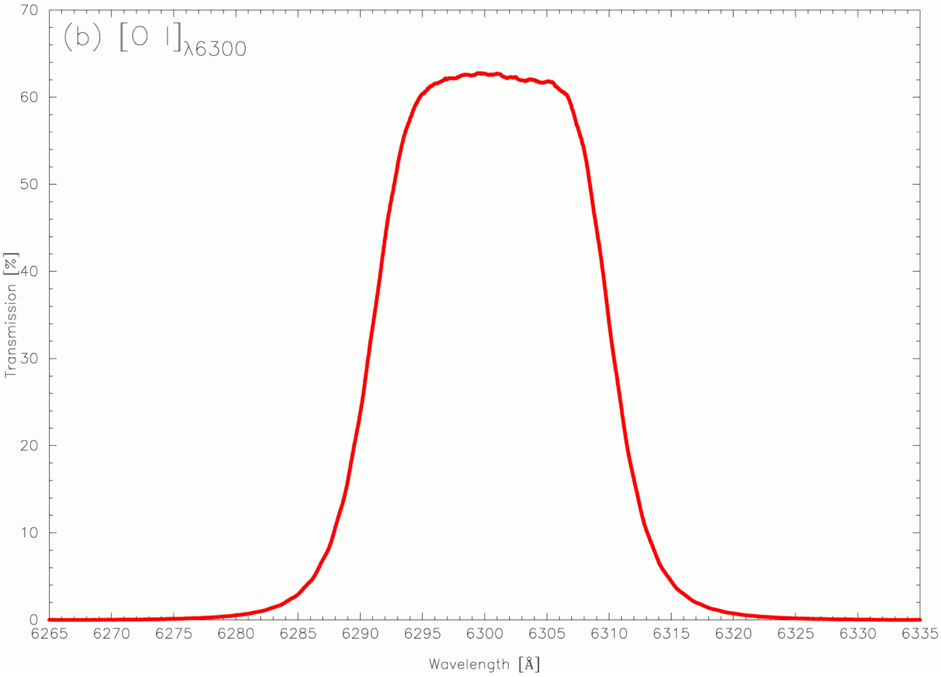
Detector: 2Kx4K CCD (EEV42-80)
Pixel: 2048x4100
Pixel size: 13.5 um square
Read noise: 5.5 e-
Dark current: 3 e- /hr
Gain: 4.2 e- /ADU
Saturation level: ~ 100,000 e-
Readout time: 110 sec for no binning

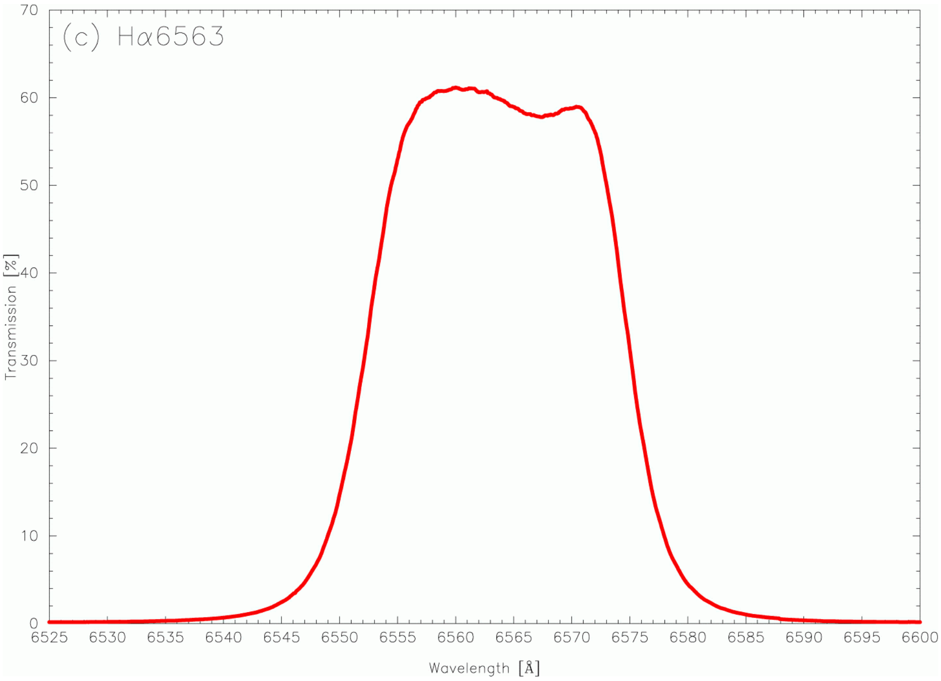
Fisrt uploaded: 2004-04-05 by H. Izumiura
Revised: 2004-04-06 by H. Izumiura
Revised: 2004-04-13 by H. Izumiura & M.Ohtsuka

Appendix

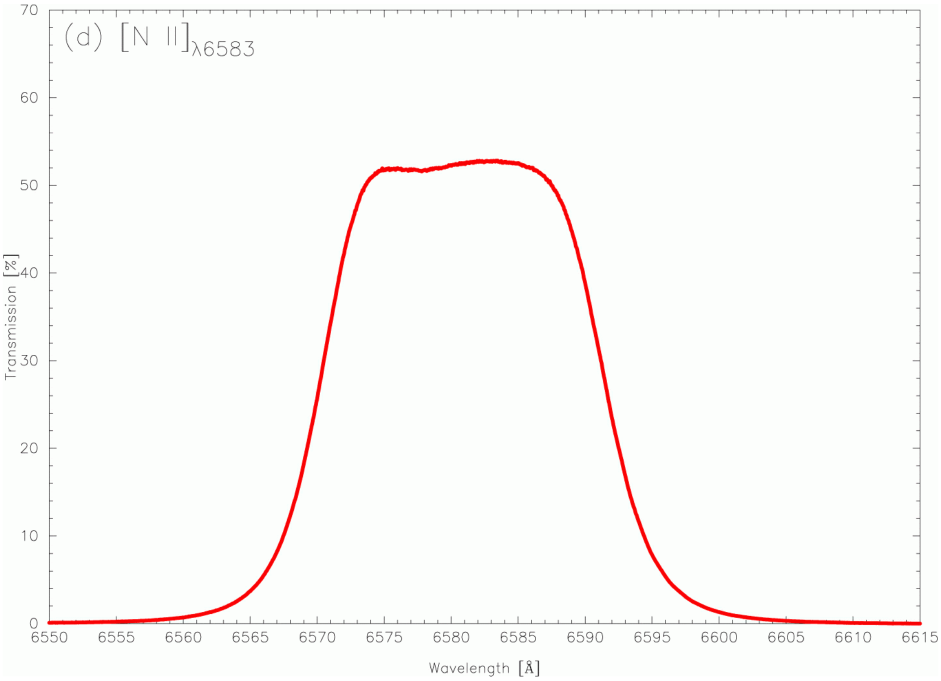
Given below are the transmission curves of the four available narrow band filters. Observers should carefully examine if these will do for their purposes.







(c) Hα6563
Transmission [%]
Wavelength [Å]



(d) [N II]λ6583
Transmission [%]
Wavelength [Å]