MODS1 Instrumental Sensitivity

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The values below are based on measurements of the MODS1 instrumental efficiency described in the *MODS1 Instrument Commissioning Report*. These are intended as guidance for observing planning.

Imaging Mode

Table 1 summarizes the zero-color photometric zero point magnitudes ($m_{f,0}$) for each SDSS filter, corrected to outside the atmosphere using the estimated extinction coefficients (K_f).

Table 1: MODS1 ugriz Photometric Zero Point Magnitudes

Filter	Nstars	$m_{f,0}$ (mag)	K_f
SDSS u	19	25.68±0.12	0.47
SDSS g	48	27.38±0.03	0.17
SDSS r	56	27.24±0.03	0.10
SDSS i	44	27.21±0.04	0.05
SDSS z	40	26.41±0.04	0.03

The photometric conversion formula is

$$m_f = m_{f,0} - 2.5\log S_f + 2.5\log t_{\text{exp}} - K_f X$$

where:

m_f = SDSS magnitude in filter f in AB units
$m_{f,0}$ = photometric zero point magnitude in filter f in AB units (Table 1)
S_f = Measured total counts in ADU in exposure time t_{exp} seconds
K_f = extinction coefficient for filter f
X = airmass at the time of the observation

Turning the formula around, the predicted integrated counts in ADU in a filter given its SDSS AB magnitude in the filter band is given by:

$$\log S_f = \log S_{f,0} - 0.4 m_f + \log t_{\text{exp}} - 0.4 K_f X$$

where:

log S_f = log counts in ADU for filter f
log $S_{f,0}$ = ADU zero point (counts for $m_f = 0.0^{\text{mag}}$ in 1 second, see Table 2)
m_f = SDSS magnitude in filter f in AB units
t_{exp} = exposure time in seconds

Table 2 lists the ADU zero points (log $S_{f,0}$) for the five MODS1 imaging mode filters.

Table 2: MODS1 ugriz Photometry ADU Zero Points

Filter	log $S_{f,0}$
SDSS u	10.25
SDSS g	10.94
SDSS r	10.90
SDSS i	10.91
SDSS z	10.58

Taking account of pixel sampling and the typical PSF shape, as a rule of thumb an r=15^{mag} star will just saturate the central pixel on the red CCD in 30sec in 0.6-arcsec seeing. This is most useful as guidance for selecting alignment stars for MOS masks or setting target acquisition image exposure times, since currently we do not use MODS1 as a science imager due to the problems of stray light due to the undersized adaptive secondary mirrors.

Grating and Prism Spectroscopic Modes

The estimated counts per wavelength, S_λ, in ADU Å^{-1} is given by:

$$\log S_\lambda = \log S_{\lambda,0} + \log F_\lambda + \log t_{\rm exp} - 0.4 K_\lambda X$$

where:

- $\log S_\lambda$ = log counts in ADU Å^{-1} at wavelength λ
- $\log S_{\lambda,0}$ = Spectroscopic zero point in ADU/Å at wavelength (see Tables 3 and 4 below)
- F_λ = flux in units of erg/sec/cm^2/Å
- t_{exp} = exposure time in seconds
- K_λ = atmospheric extinction coefficient at wavelength λ (see Table 5 below)
- X = airmass at the time of the observation

If you have AB magnitudes instead of F_λ, the conversion formula is:

$$\log F_\lambda = -0.9608 - 0.4 AB - 2 \log \lambda$$

where: AB = Spectral AB magnitude and λ is the wavelength in Ångstroms.

The coefficients for selected wavelengths on 500Å intervals for the MODS red and blue grating and prism modes are listed in Table 3 and Table 4. These estimates are mostly valid for the 5-arcsec wide spectrophotometric slit (LS60x5), and do not include slit losses.

Some of the wavelengths in Tables 3 and 4 are chosen to avoid strong telluric or stellar absorption features in the standard stars spectra, and hence are not on a regular grid.

For prism spectra, the flux calibration does not extend below 3600Å (due to lack of a good wavelength solution below 3500Å in the blue because the lower dispersion at the blue end of the prism range smeared out the wavelength calibration lines below our sensitivity limits.

Table 3: MODS1 Grating Mode Spectroscopic Zero Points

Red Grating			Blue Grating		
	log $S_{\lambda,0}$			log $S_{\lambda,0}$	
λ (Å)	Direct	Dichroic	λ (Å)	Direct	Dichroic
5000	15.978	...	3200	15.721	15.597
5500	16.381	14.922	3500	15.934	15.865
6000	16.465	16.453	4000	16.226	16.179
6500	16.487	16.473	4500	16.270	16.257
7000	16.488	16.462	5000	16.239	16.237
7500	16.456	16.433	5500	16.167	16.162
8000	16.391	16.341	5800	16.109	14.811
8500	16.310	16.242	6000	16.063	...
9000	16.229	16.151	6450	15.940	...
9500	15.963	15.893			
10000	15.802	15.396			

Nominal pixel sizes for grating mode are 0.85Å pix^{-1} for the red grating and 0.50Å pix^{-1} for the blue grating.

Table 4: MODS1 Prism Mode Spectroscopic Zero Points

Red Prism				Blue Prism			
	log $S_{\lambda,0}$		Pixel		log $S_{\lambda,0}$		Pixel
λ (Å)	Direct	Dichroic	δλ (Å)	λ (Å)	Direct	Dichroic	δλ (Å)
5000	15.722	...	2.6	3600	15.663	15.640	3.4
5500	16.178	14.978	3.4	3850	15.886	15.858	4.4
6000	16.268	16.265	4.6	4030	15.978	15.927	5.1
6450	16.301	16.293	5.9	4500	16.121	16.096	7.1
7000	16.357	16.348	7.6	5000	16.162	16.138	9.8
7450	16.365	16.368	9.1	5500	16.172	16.112	12.7
8000	16.342	16.350	11.2	6000	16.143	15.478	15.8
8500	16.307	16.297	13.3	6450	16.082	...	18.5
8800	16.264	16.252	14.6	7000	15.964	...	21.8
9750	15.740	15.692	18.9				
10000	15.396	15.333	20.1				

Because the dispersion in prism mode is a strong function of wavelength, columns 4 and 8 in Table 4 list the nominal pixel sizes for each wavelength.

A short version of the adopted LBT model atmospheric extinction curve is given in Table 5 for the wavelengths used in Tables 3 and 4. The full model extinction curve is available in electronic form (ASCII text) on the MODS Calibration webpage.

Table 5: Model LBT Atmospheric Extinction

λ (Å)	K_λ
3200	0.866
3500	0.511
4000	0.311
4500	0.207
5000	0.153
5500	0.128
6000	0.113
6450	0.088
6500	0.085
7000	0.063
7500	0.053
8000	0.044
8210	0.043
8260	0.042
8370	0.041
8708	0.026
10256	0.020

Estimating Signal-to-Noise Ratio (SNR)

Excluding second-order effects like flat field uncertainty, the signal to noise ratio (*SNR*) you expect for a given ADU signal *S* is given by the standard formula:

$$SNR = \frac{gS}{\sqrt{gS + \sigma_{RO}^2}}$$

For MODS1, the nominal conversion gain (g) and readout noise (σ_{RO}) are

MODS1 Blue:	g=2.5 e^-/ADU	σ_{RO}=2.5 e^-
MODS1 Red:	g=2.6 e^-/ADU	σ_{RO}=2.5 e^-

These are good estimates to adopt for purposes of estimating SNR in a given exposure time from the imaging and spectrophotometric sensitivity data described above.