MRS Direct Feed
7 October 2004

The Direct Feed Description: The direct feed is so named as the fibers are positioned at the prime focus of the collimator and the fiber core defines the entrance aperture of the spectrograph. The direct feed (DF) is the first of the fiber feeds to be commissioned. It is described in the context of the other modes in the ***MRS Configuration Definition*** document. Briefly the DF consists of four options, two 1.5 arc-sec (300 micron) object/sky pairs and two single 2 arc-sec (400 micron) fibers). The object/sky pairs are separated by about 10 arc-seconds in the telescope focal plane. Figure 1 is an image of the fibers on the DF probe backlit. The fiber properties are detailed in Table 1. The resolutions given in Table 1 are derived from measured FWHM of emission lines in Th-Ar comparison spectra. The higher measured resolving powers as compared to predictions in design documents are a result conservative predictions where the resultant resolution is passed on the diameter of the fiber core. In reality the image widths are consistent with the average cord of the fiber core as opposed to the diameters. It should be noted that only the in the DF mode is the resolving power defined by the fiber itself. In all other MRS configurations, an intermediate slit defines the resolution. These are designated indirect feed (IDF) modes.

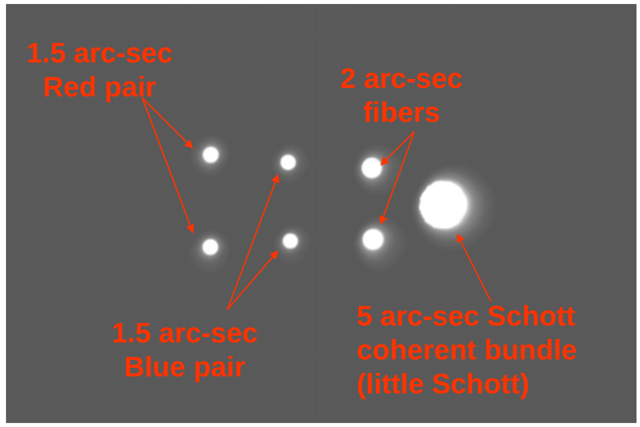

Figure 1 Backlit DF probe

Table 1: Direct Feed Fibers

	Core diameter	Fiber #	Slit height	Fiber separation (at CCD)		Effective Resolution ($\lambda/\Delta\lambda$)
	microns		microns	microns	Pixels	VISCAM
FIP Dual						
object	300	1	624	156	10.4	9200
sky	300	2				
FVP Dual						
object	300	3	624	156	10.4	9200
sky	300	4				
FIP Single						
object	400	5	312	-	-	6800
FVP Single						
object	400	6	312	-	-	6800

The FIP and FVP fibers are red and blue optimized respectively. Fibers made from the FI material (called FIP in Table 1 due to the polyimide buffer) has a lower OH content and are best from 600 nm redward. Fibers drawn from the FV material (or FVP with the polyimide buffers we use) have a higher OH content and large absorption in the near IR but are much better shortward of 550 nm. In Figure 1 we compare laboratory measurements of 35 meter sample fibers made from the FI and FV material. All MRS fibers are approximately 35 meters total length. Only in the DF configuration do

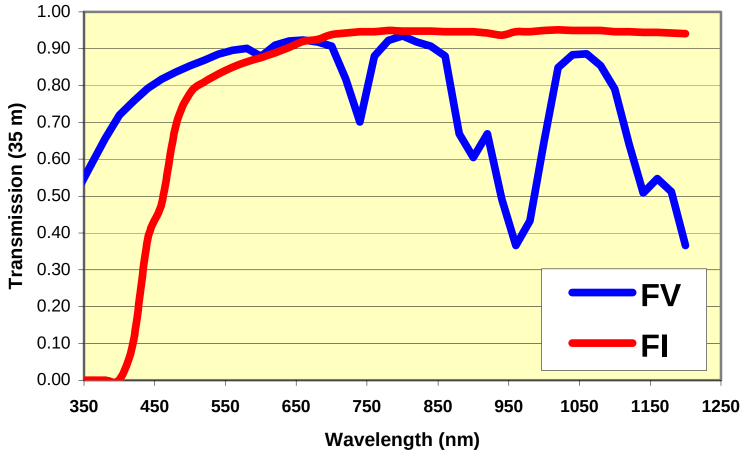

Figure 1: Transmission of 35-meter lengths of FV and FI fibers used in DF

we have both blue and red optimized fibers. In all other configurations so called STU fibers are available which have better transmission properties across the visible spectrum. These described more completely in the MRS Indirect Feed document which is in progress.

The FI inputs have a GG455 filter so the spectral coverage in a single exposure is 4550- 9000 Angstroms with the current 220 line/mm cross disperser (XD). The FV fibers have a WG305 filter thus the spectral coverage is only uncontaminated by XD order overlap to ~7500 Angstroms.

Measured Performance of DF: In April 1993 we finally had the combination of (mostly) clear skies and reasonable seeing needed to assess the instrument throughput with the HET. Figure 2 presents those results. The solid green line represents a model of the MRS DF in the ***R*** band on the HET which yields a maximum expected throughput of ~5% in 1.5 arc-second seeing assuming 50% of the light gets into the 1.5 arc-second (300 micron) fiber. The red symbols are for what we have designated fiber #1 and the blue for fiber #2 in the FIP pair. We were not able to obtain at that time an adequate data set on the FVP pair or the single fibers. In theory the 2 arc-second fibers should have ~1.4 times the throughput of the 1.5 arc-second fibers. From the sample it is clear that the #1 fiber is typically better. We expect this is because we have better offset coordinates for this fiber from the acquisition coherent bundle but this must be verified. From sky and calibration data there is no reason to expect the difference is due to intrinsic transmission differences although a few percent difference is to be expected due to details in terminations and bonding. A few observations in the #1 fiber lie on the model line. These are when the tracker X,Y was near center and when the image quality was < 2 arc-seconds although we do not know the instantaneous values. Integration times were between 120 and 600 seconds. The average value of the # 1 fiber observations is 67% of the model value; this is perhaps the best number to use in an exposure time estimator based on this data set. Figure 2 gives the observed and modeled number of photons integrated in one pixel across the order. There are ~6

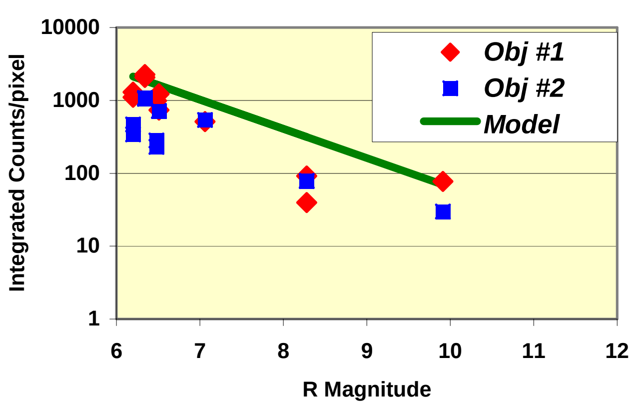

Figure 2: MRS DF mode throughput

pixels per resolution element when the CCD is binned 2x2 as was the case here. The Y-axis is the counts per pixel in the dispersion direction where the data had been summed across the order perpendicular to dispersion. The CCD gain used in the above was 2.3 e-/ADU with a pupil diameter of 9 meters.

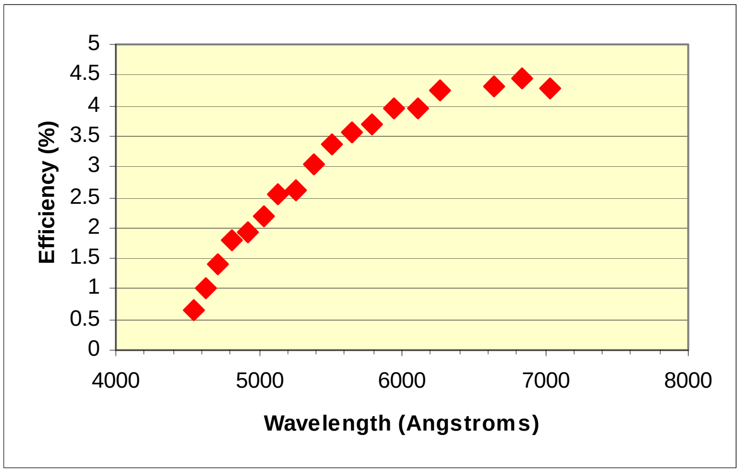

Figure 3: Measured efficiency for the DF 1.5R mode.

An independent approach to the efficiency measurement was out by George Trammel this last summer under the guidance of Drs. Ciardullo and Schneider. He uses the data taken in Spring and early summer 2004. This data was obtained after the CCD bias voltages were adjusted in February 2004 and thus the gain has changed to 2.5 e-/ADU. The only data taken explicitly for the purpose of throughput measurements was on 11 June 2004 with a pre-exposure seeing of 1.3 arc-seconds with photometric conditions and a nearly centered track. The target was BD+17 4708, a flux standard. The measure efficiency for the peak of each echelle order using the 1.5R fiber is presented in Figure 3. These June 11 results, while broadly consistent with the April 2003 measurements, should be considered superior and more useful given the better image quality and more in depth analysis with wavelength dependence.

We do not have well controlled observations for comparison with the 1.5B and 2.0 arc-second fibers. However, George Trammel did reduce observations of the same star taken on 11 May 2004 as a spectroscopic standard. The seeing was poor with the pre-exposure image quality at ~2.3 arc-seconds. There is no reason from either the fiber properties (see Figure 1) or the spectrograph implementation to expect the efficiency behavior of the 1.5R and 1.5B fibers to differ at 6250 Angstroms, which is near the peak of the 1.5B measure efficiency. and thus I have normalized the 1.5B measurements to be equal to the 1.5R at that wavelength so as to get an idea on the relative merit of these fibers with wavelength. This is presented in Figure 4.

We have results for the 2.0B fiber but again in poor seeing. If we make a crude correction for the seeing difference the results are consistent with the expected 1.4 times increase in throughput of the 2.0 arc-second fibers over the 1.5 arc-second fibers. This guideline should be followed until better data is obtained.

Phase II: The MRS phase II definitions are on the RA web page. The configuration that has been characterized above is ***MRS_DF_Vis_79_220_7000_1.5RS_2_0_0_0_2x2_none***. Other configurations that are available and whose performance could be easily extrapolated from the above information are:

MRS_DF_Vis_79_220_7000_1.5BS_2_0_0_0_2x2_none
MRS_DF_Vis_79_220_7000_2.0R_1_0_0_0_2x2_none
MRS_DF_Vis_79_220_7000_2.0B_1_0_0_0_2x2_none.

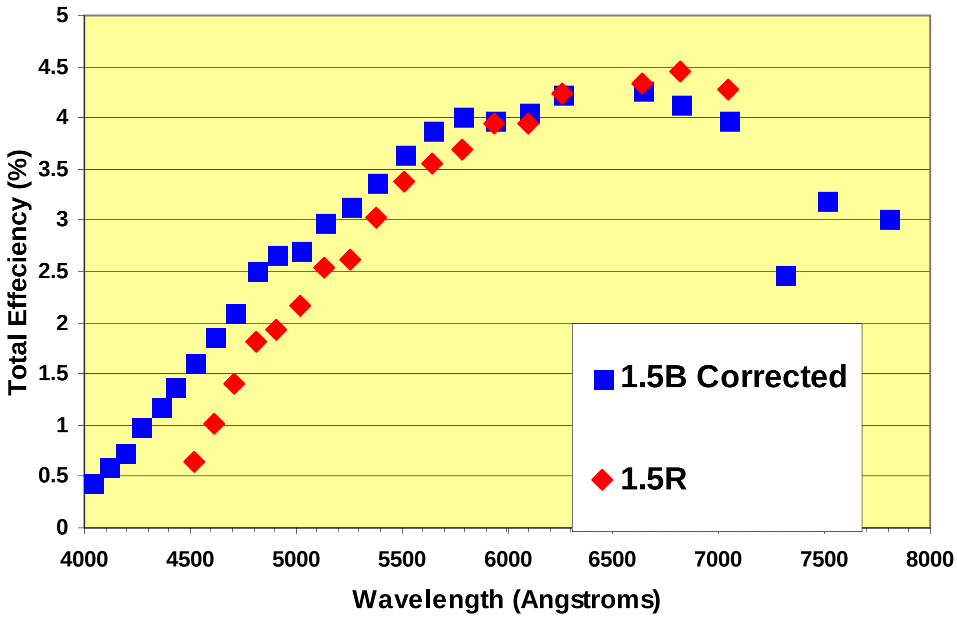

Figure 4: This plot compares the 1.5B and 1.5R efficiencies.