CHARA TECHNICAL REPORT

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The AO Beam Splitters at the Telescopes

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ABSTRACT:

This report presents the available data about the beam splitters installed at the CHARA telescopes to send light to the telescope wave front sensor for the adaptive optics system. At each telescope there are three beam splitters to choose from, they are labeled: IR, VIS, BARE.

1. INTRODUCTION

When designing the adaptive optics (AO) system for CHARA, one of the driving idea was to increase the magnitude limit. One aspect in working toward this goal is to maximize the light used for acquisition and wave front sensing in all the spectral bands that is used for observations. For this reason one of the two wave front sensors serving a telescope was designed to work in the telescope domes taking light after only four reflections, the last one, M4, being a deformable mirror. The telescope wave front sensor works with a CCD camera, so all visible light could be directed to the telescope wave front sensor (TWFS) when using an infrared (IR) beam combiner in the laboratory. For beam combiners using visible light, an approximately 80-20 % split was decided between light going to the laboratory and to the TWFS. There are three beam splitters installed at each telescope of same dimensions and made of the same material, but coated differently: for IR, and VIS beam combiners, and one uncoated for engineering purposes. In order to prevent the light from secondary reflections entering the TWFS, the two surfaces of the beam splitter substrates make a wedge.

2. MATERIAL AND DIMENSIONS

2.1. Specifications

The order was placed in 2012 based on the following specifications.

Material:	IR grade low-OH fused silica
Spectral transmission:	The substrate must transmit at least 92% (10 mm thickness, reflective losses included) for all wavelengths between 400 to 2400 nm.
Homogeneity:	Bubble Grade 0, according to DIN 58927 Refractive index variation no more than 4×10^{-6} over the clear aperture.
Diameter:	6.25 +/- 0.01 inches
Clear Aperture:	90 %
Thickness:	0.75 +/- 0.01 inches
Edges :	Ground and safety beveled
Wedge angle:	0.05 deg = 3 arc minutes; +/- 0.5 arc minutes High point clearly marked
Surface Quality:	60/40 Scratch/Dig
Surface Accuracy:	We would prefer 1/20 λ peak to valley (at 632.8 nm) over clear aperture. 1/10 λ is also acceptable to cut the cost, if necessary.

2.2. The actual substrates

We purchased 18 substrates polished according to specifications from ESCO Products, 171 Oak Ridge Road, Oak Ridge, NJ 07438. The manufacturer along with the substrates provided Zygo test reports of all 36 surfaces in 2012.

The material is “12-IR FUSED SILICA”, ESCO Optics designation.

The flatness tolerance ended up being 1/10 λ.

3. THREE TYPES OF BEAM SPLITTERS

There are three beam splitters installed at each telescope on the AO board. These beam splitters work at 11 degree AOI. One of the three can be selected to be in the beam with a remotely controlled carousel. Figure 1.

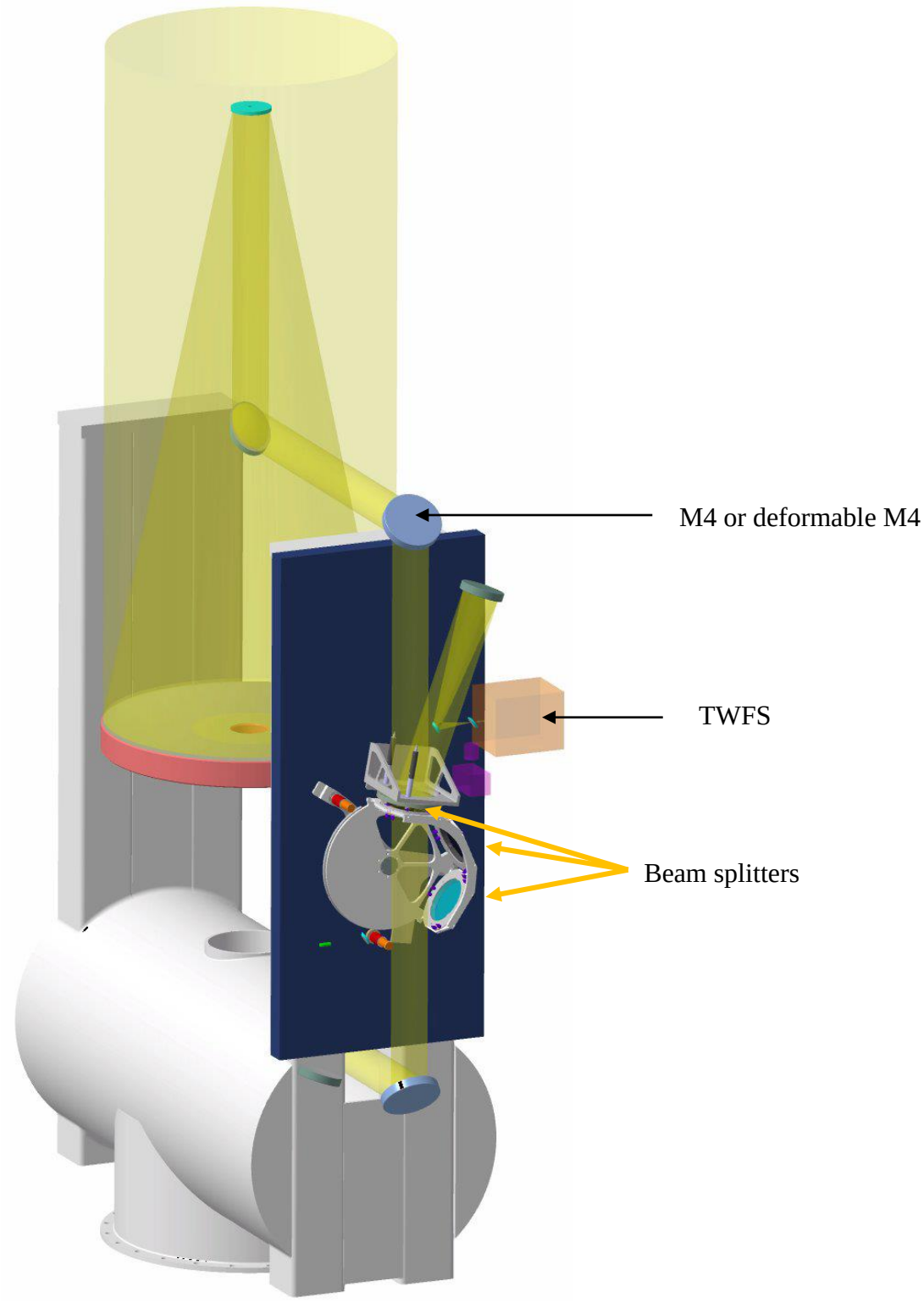

Figure 1. CHARA telescope beam path with the AO beam splitter changer and the TWFS.

The coatings of the telescope AO beam splitters was done by ISP Optics Corporation, 50 South Buckhout Street, Irvington, NY 10533 in 2013.

3.1. The VIS splitter

The VIS beam splitter, designed for use with the beam combiners working in the visible band, is installed in the first position of the carousel. In Figure 1, the VIS beam splitter is in the beam. One surface is coated to transmit approximately 80% of the star light toward the lab, and reflect ~20% toward the TWFS, as shown in Fig. 2 and Fig. 3.

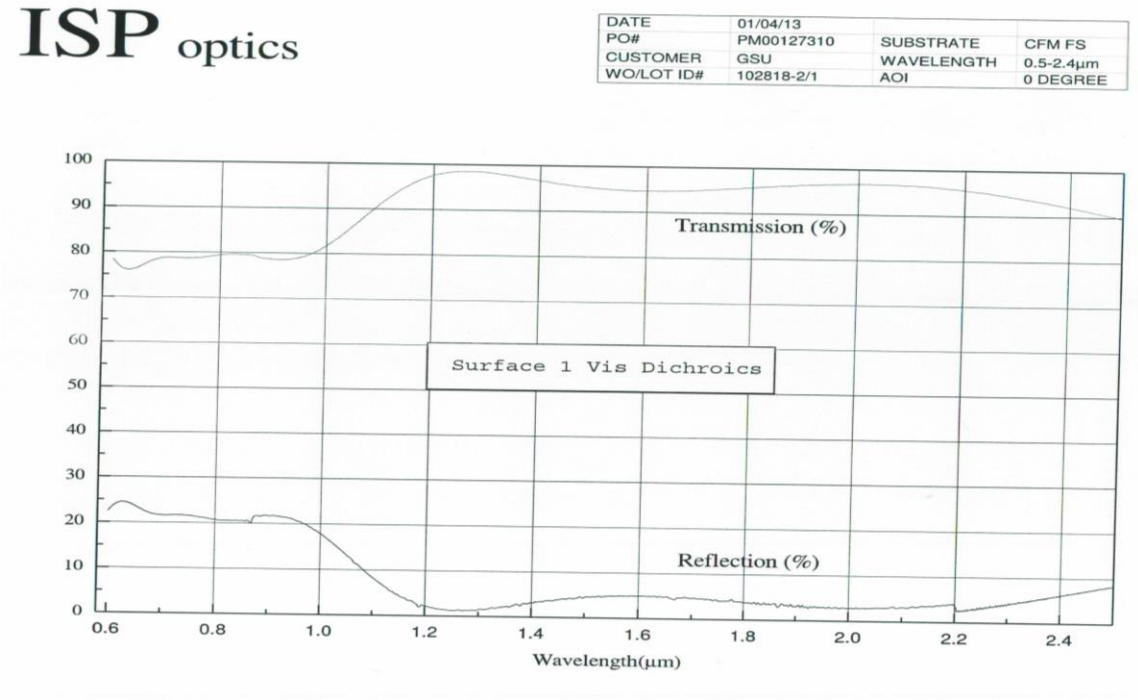

Figure 2. The spectral properties of the VIS splitter top surface, toward the star, measured by ISP Optics Co. at 0 degree AOI.

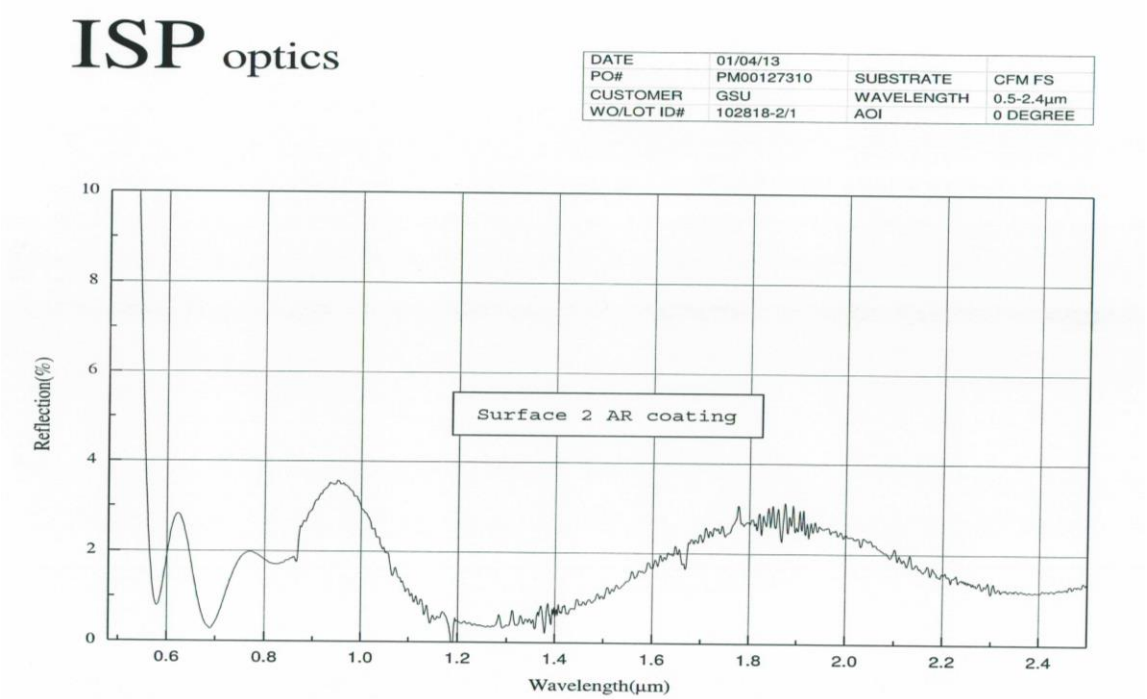

Figure 3. The spectral properties of the VIS splitter bottom surface, toward the lab, measured by ISP Optics Co. at 0 degree AOI.

3.2. The BARE splitter

One uncoated beam splitter is installed in the second, middle, position of the carousel. It is there for engineering purposes. This beam splitter is expected to have the best surface flatness, as it is not distorted by any coating. The uncoated surfaces reflect the usual 4% of visible light from each surface, so with negligible absorption one can expect approximately 92% transmission in the visible and also in the J, H, K infrared bands used at CHARA.

As full AO observations are becoming more routine, the BARE splitter is going to be mainly used when the telescope, M1-M2-M3-M4 alignments are checked after aluminizing, or for some calibration source alignment checks. The calibration source injects light in the direction of star light toward M4 and the laboratory.

This splitter could be used also in case there is a need for more visible starlight in the lab to check the full beam train alignment, or to use lab tiptilt detector as a backup in place of the TWFS system.

3.3. The IR splitter

The IR beam splitter, designed for use with the beam combiners working in the infrared, is installed in the third, right most, position of the carousel. This beam splitter transmits the maximum possible star light in J, H, K bands toward the lab, and reflects the maximum visible star light toward the TWFS for wave front sensing and AO control. The spectral characteristics of the IR splitter are shown in in Fig. 4 and Fig. 5.

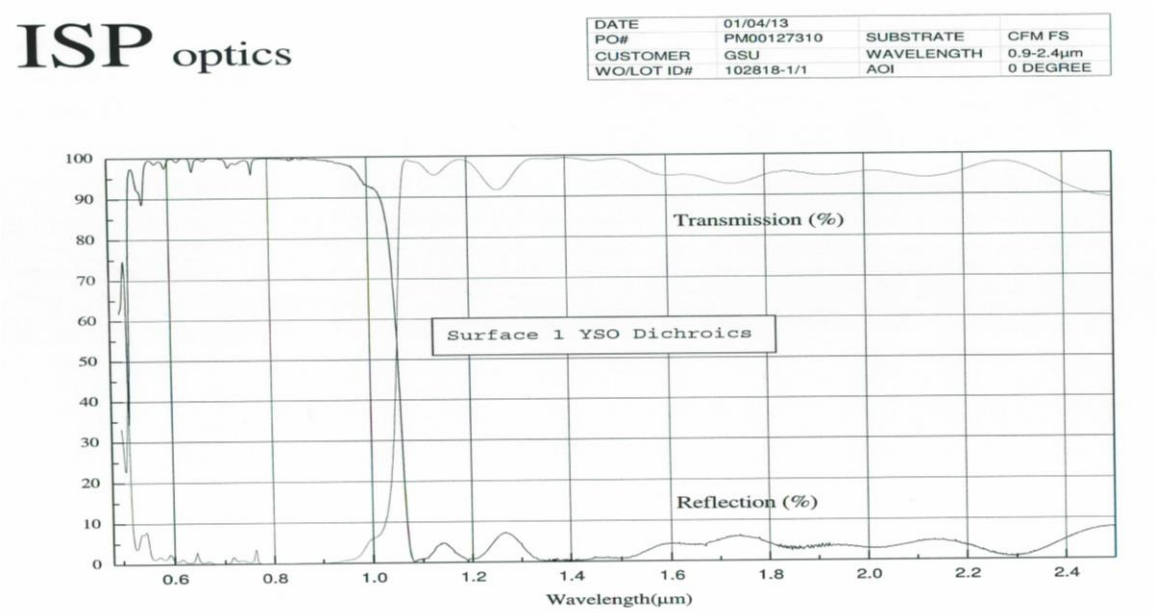

Figure 4. The spectral properties of the IR (originally called YSO) beam splitter top surface, toward the star, measured by ISP Optics Co. at 0 degree AOI.

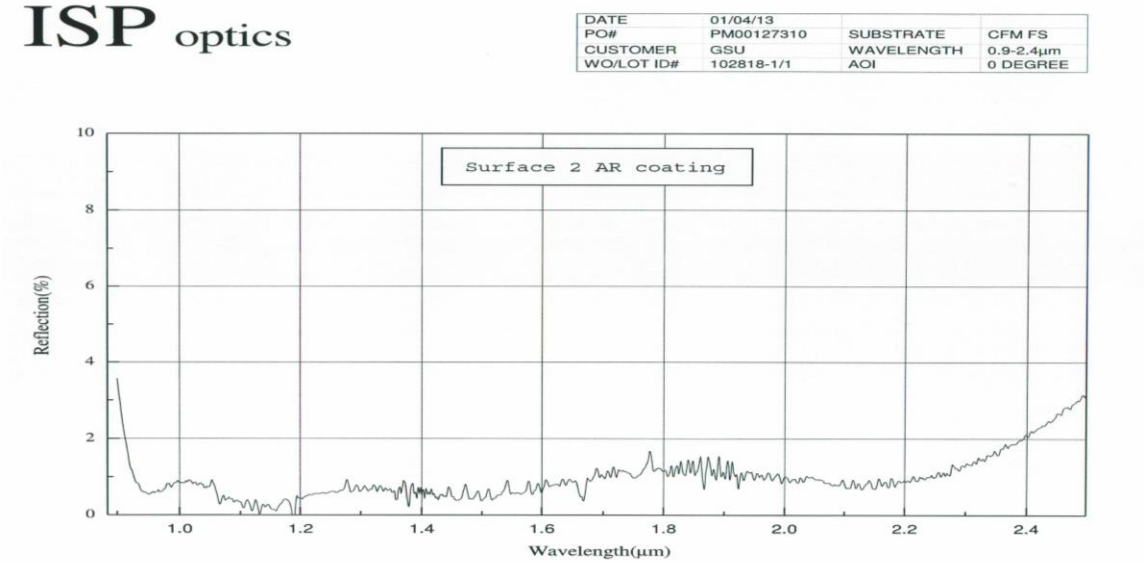

Figure 5. The spectral properties of the IR (originally called YSO) beam splitter bottom surface, toward the lab, measured by ISP Optics Co. at 0 degree AOI.