HETDEX: Optical Alignment of the VIRUS Spectrographs

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Abstract

We present an optical alignment procedure for the Visible Integral-Field Replicable Unit Spectrograph (VIRUS) collimator. Texas A&M is helping to build the VIRUS spectrographs in collaboration with The University of Texas at Austin. The Hobby Eberly Telescope Dark Energy Experiment (HETDEX) will use as many as 192 of these spectrographs to search for answers regarding Dark Energy. Texas A&M is currently assembling the collimators for VIRUS and designing alignment fixtures to aid in the assembly. We used ZEMAX models of VIRUS optics made by UT engineers to analyze various alignment methods. Our current plan uses two steps to properly align the collimator within the tolerance of 0.1-degrees. This will permit interchangeability among the various VIRUS parts.

Introduction

The Visible Integral-Field Replicable Unit Spectrograph (VIRUS) instrument is a set of over 150 identical spectrographs to be used for the Hobby Eberly Telescope Dark Energy Experiment (HETDEX). The HETDEX collaboration will look for Dark Energy using a large area blind survey of Lyman Alpha Emitting galaxies of redshift z<3.5.

Texas A&M University is responsible for the production and assembly of the VIRUS spectrographs. Most of the design has been finalized, and we are moving into the production phase. In order for the instruments to function properly and collect accurate data, it is important that all of the optical components be well-aligned. In this paper, we present the design of the optical alignment procedure proposed for the collimator mirror. The design specifications require the mirror to be aligned to within 0.1-degrees.

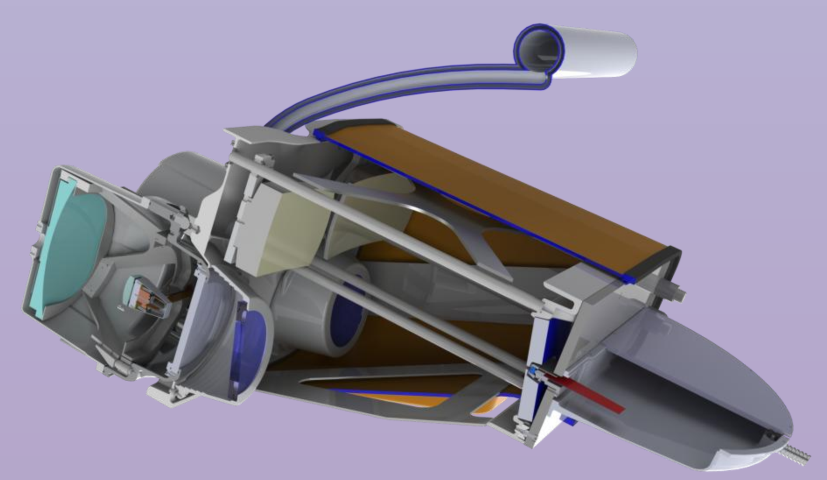


Figure 1: SolidWorks model of a pair of VIRUS Spectrographs. Light is fed from the telescope through the fiber bundle. It is collimated by the oblong shaped mirror in the upper left and reflected off a folding flat mirror in front of the fiber bundle. The light then passes through the volume phase holographic grating (in blue), and imaged by the camera to the left.

Collimator Alignment

The two-step process we developed to ensure the alignment of the collimator mirror begins with the auto-collimation of the mirror using a second fold flat mirror placed perpendicular to the light path so that the light is reflected back to its origin. The mirror was placed upon a mount capable of adjusting the tip and tilt with a resolution of 0.381 mm/rev. The mount was then secured to the frame of the VIRUS unit using clamps. We adjusted the mirror so that it would reflect directly back onto the VIRUS fold flat, allowing the collimated light to follow its path back to the fiber bundle. This acts as a first test for how well the light is collimated. If the light reflected back onto the fiber bundle does not have a circular shape of ~200 microns diameter, then the collimator will be adjusted until it does.

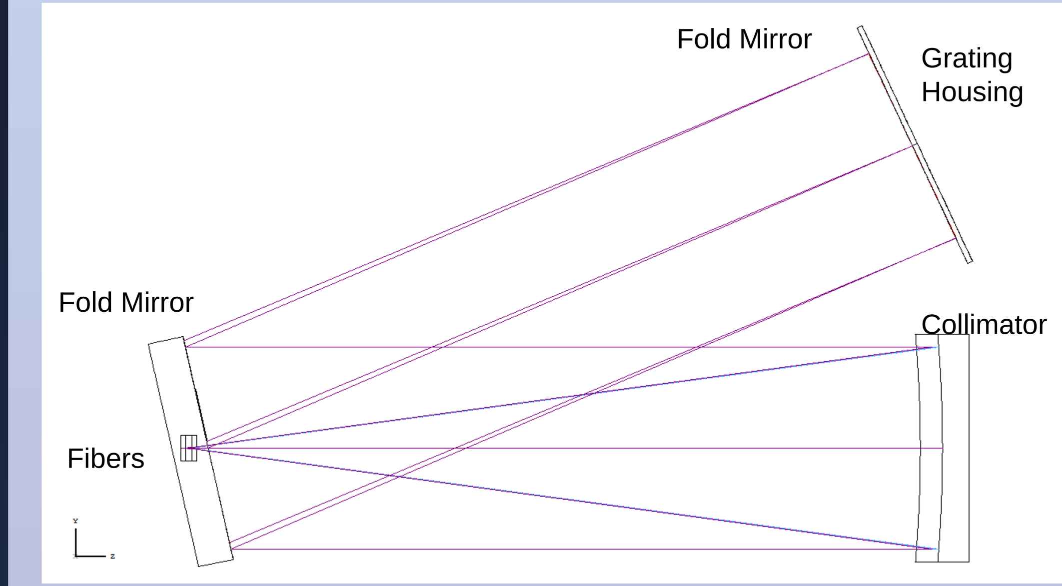


Figure 2: Optical Layout for the first alignment step

The second step for the alignment process uses a large lens (~4-5 inches in diameter) placed in the grating housing of the VIRUS mechanical frame. The lens will focus the incoming light onto a commercial CCD camera. The results from the CCD can then be analyzed to determine how the collimator should be adjusted to properly align it. The collimator is attached to the VIRUS spectrograph by a round puck which screws into a triangular plate that is clamped onto invar rods. There are 3 fine-adjustment screws that determine the orientation of the collimator plate.

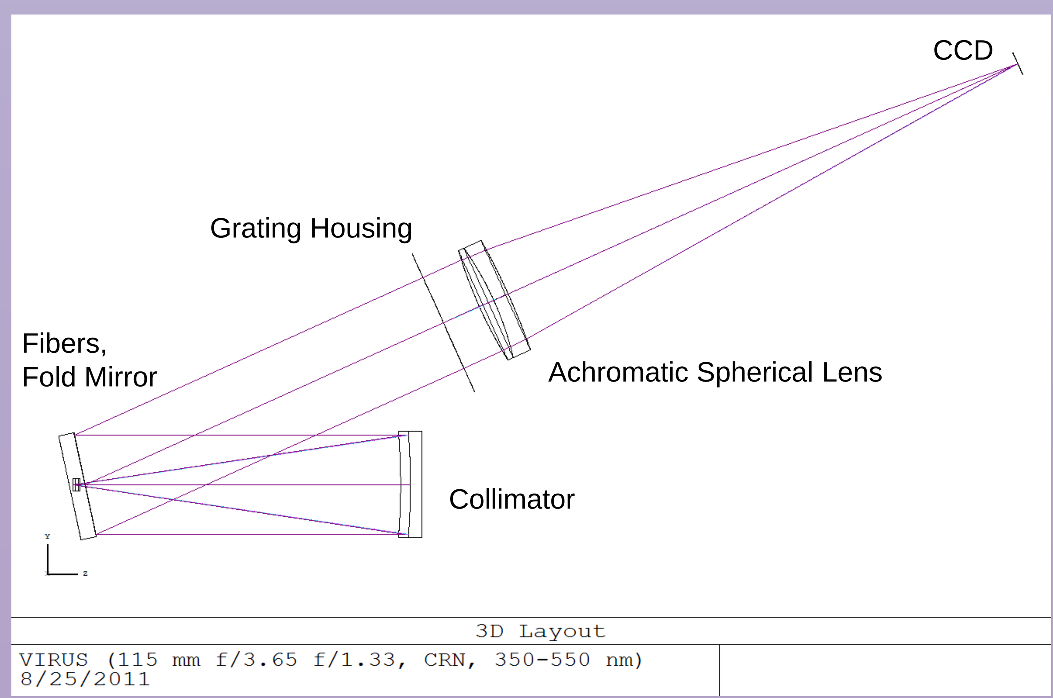


Figure 3: Optical Layout for the second alignment step

Results

At Texas A&M's Astronomical Instrumentation Laboratory, we have performed a proof-of-concept for the first step in the collimator alignment. We purchased a fold flat mirror and mount. We also assembled one side of a pair of VIRUS spectrographs. We used a FARO measuring arm to aid in gluing the fold flat mirror to the head plate, as well as the collimator and puck. We then did an initial alignment of the second folding flat and collimator mirrors using the FARO arm and our SolidWorks model. A small fiber bundle was clamped to the head plate of the VIRUS frame, as an actual fiber bundle was unavailable for use. We used a 532 nm green laser as our light source although in the final alignment we will use white light.

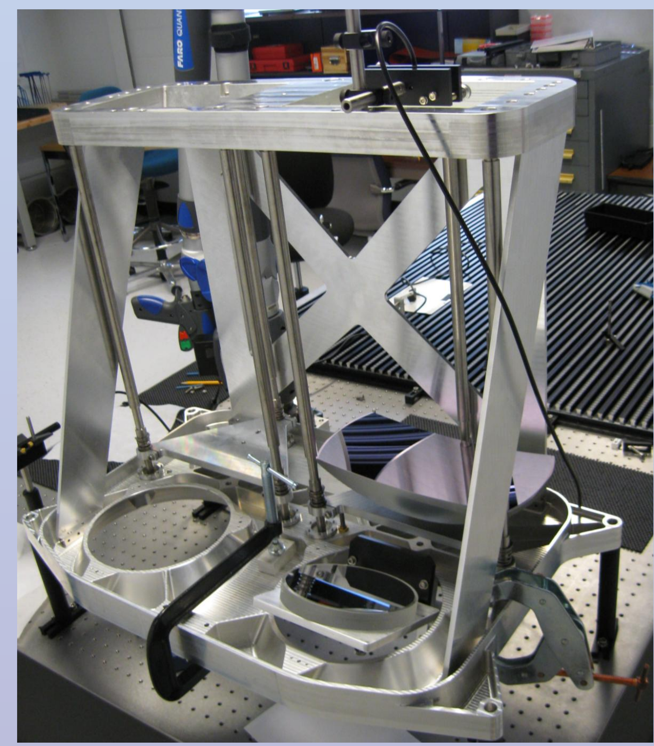
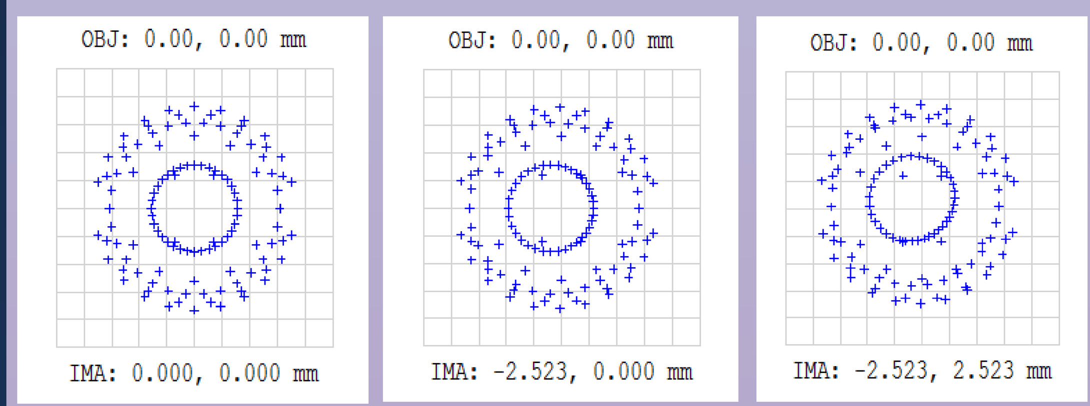


Figure 4: Proof-of-concept for first alignment procedure

For the second alignment procedure, we will be able to compare the ZEMAX model of the spot size diagrams to the CCD output to determine how the collimator needs to be adjusted.



Perfectly Aligned Spot Diagram | Collimator displaced by 0.1° on Y axis | Collimator displaced by 0.1° on X and Y axes

Figure 5: ZEMAX Spot diagrams for theoretical output on CCD

Conclusion

We present the optical alignment procedures designed for the collimator mirror for the VIRUS spectrographs. This process will ensure optical alignment to within 0.1-degrees, which meets the optical alignment tolerances set by the scientific goals of the HETDEX survey.

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