HETDEX

Illuminating the Darkness

Hobby-Eberly Telescope Dark Energy Experiment

Development of VIRUS Alignment and Assembly Fixtures

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ABSTRACT

The Visible Integral-Field Replicable Unit Spectrograph (VIRUS) Instrument is a set of 150+ optical spectrographs to support observations for the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX). We plan to use a production line assembly process to construct the large number of VIRUS units. This allows each sub-assembly of a VIRUS unit to be interchangeable amongst all other VIRUS units. A production line manufacturing procedure will enable various sub-assemblies to be built and tested in parallel. Examples of alignment and assembly fixtures required for the VIRUS manufacturing process include a camera mirror alignment system, a collimator structure assembly device, a collimator mirror mounting tool, and a grating alignment system. In this paper we describe the design of these fixtures and their importance in the VIRUS assembly process.

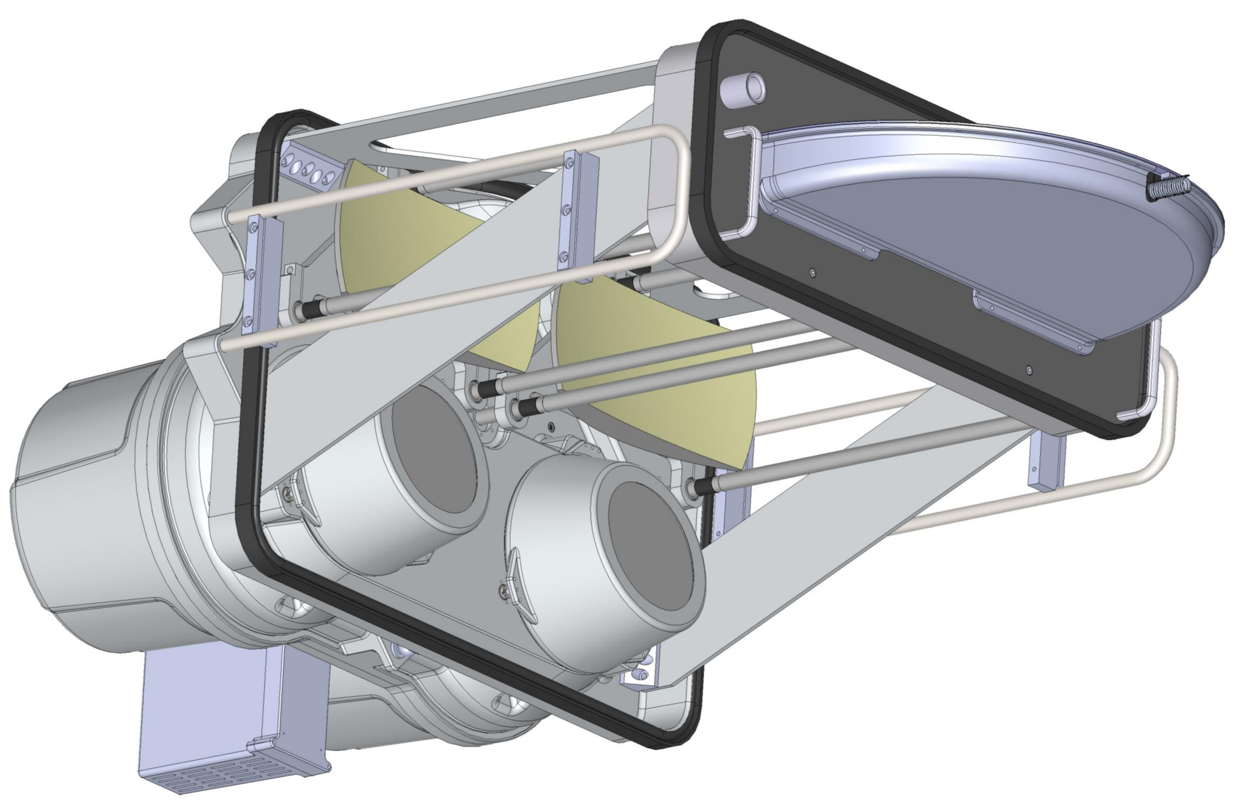
Introduction

The VIRUS instrument is a set of at least 150 optical spectrographs that will support observations for the HETDEX project. The HETDEX project is aimed at looking for Dark Energy at high redshifts using the Hobby-Eberly (HET) telescope. As members of HETDEX, Texas A&M University is responsible for the manufacture, assembly, and testing of the 150+ VIRUS spectrographs.

This paper describes conceptual designs of the alignment fixtures that will be used to precisely and repeatably mount the optics in the instrument and assemble the structure of the instrument. These alignment fixtures are necessary to allow the 150+ unit spectrographs to be assembled in a timely fashion and in such a way as to maximize the throughput of the instrument and therefore produce the most science possible. The assembly procedure and plans for building the 150+ unit spectrographs are described elsewhere in these proceedings.

Instrument Overview

The VIRUS instrument consists of between 150 and 192 simple fiber fed optical spectrographs. The unit spectrographs are assembled in pairs, and consist of a simple Schmidt spectrograph (referred to as the "collimator") with an on-axis Schmidt vacuum camera. A volume phase holographic (VPH) grating provides a wavelength range of 350-550 nm. The detailed optical and mechanical designs of the instrument are described in more detail elsewhere in these proceedings. The VIRUS unit spectrographs will be mounted on the sides of the telescope structure; each spectrograph is fiber-fed from the focal plane of the HET. The figure below shows a drawing of a pair of VIRUS unit spectrographs.



Drawing of a pair of VIRUS spectrographs. The cover for the fiber feed is shown on the top right. Light from the fibers enters the instrument and is collimated by the oblong spherical collimator mirrors (top center). The light is reflected by a folding flat located behind the fiber feed (not shown), and into the grating (lower center) which is mounted in front of the vacuum Schmidt cameras (lower left).

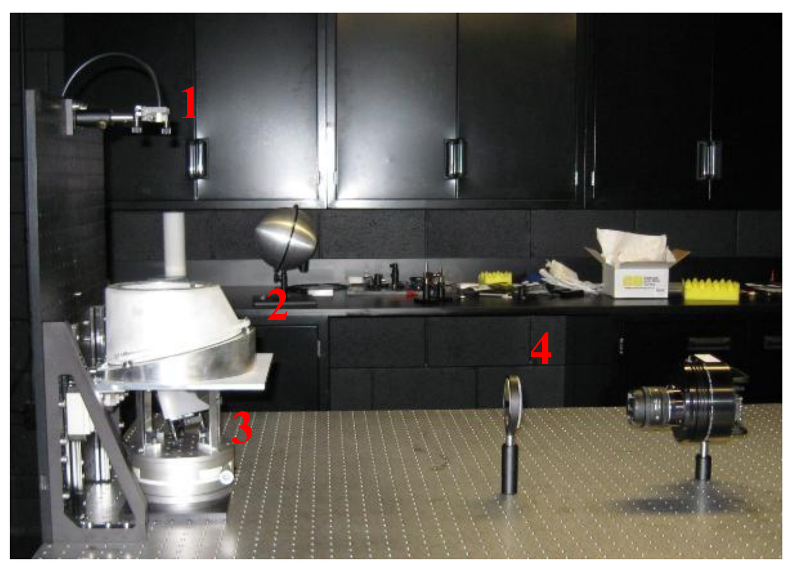
Grating Alignment Fixture

Design Requirements

The grating alignment fixture allows for the installation of the VIRUS grating substrate into the grating housing. It is necessary for the rotation of the grating substrate to be aligned within 0.1 degrees of the center plane of the grating housing. The tip and tilt of the grating substrate is machined into three mounting pads on the grating housing. The alignment device should allow the grating to conform to the tip and tilt of the mounting pads on the housing. The substrate must be epoxied into the grating housing after it is aligned.

Design Solution

The overall design solution for the grating alignment device utilizes a concept which includes one structure used to align the grating rotationally, and a separate structure to lower the housing onto the grating to epoxy them together. The design features the use of a custom fiber optics to transmit a light source, an off-the-shelf CCD camera, and a precision rotary platform to adjust the grating. A fiber bundle has been designed to simulate the actual VIRUS light source as closely as possible. The alignment fixture and VIRUS optics both utilize 200 μm diameter fibers. In the grating alignment setup, the fibers are fed by an integrating sphere illuminated with white light. The precision rotary stage features a locking mechanism that will hold the grating substrate in place while is is being attached to the grating housing. We have chosen to use a system that utilizes gravity to hold the grating substrate onto three spring plungers. This would avoid having any objects interfere in the gluing process between the substrate and housing, as well as, limit the chances of touching the grating surface. The spring plungers would also allow the grating substrate to flex and conform to the mounting pads of the grating housing. The separate structure that holds the grating housing rests on a shelf attached to linear precision bearings that vertically lower the grating housing onto the substrate.



Picture of the grating alignment assembly with features indicated as follows: (1) Fiber head (note that the collimator lens is not seen in this photo). (2) Grating cell holding grating substrate mounted on alignment bracket. (3) Rotary stage. (4) Focusing mirror and CCD.

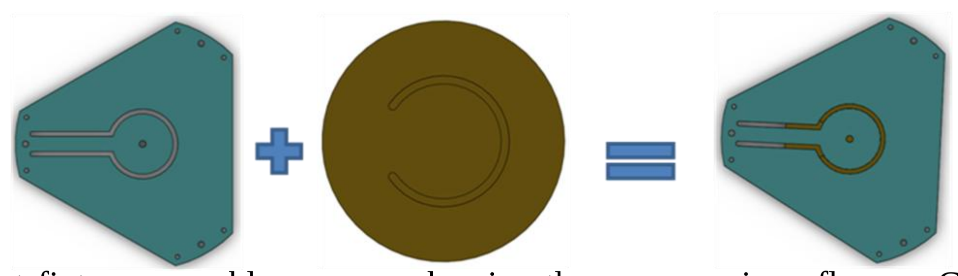
Camera Mirror Alignment Device

Design Requirements

The VIRUS camera primary mirror is attached to a camera mirror alignment (CMA) flexure (referred to as the "lollipop") which allows for the adjustment of the tip and tilt of the camera mirror. It is essential to center the camera mirror onto the CMA lollipop within ± 1 mm in order to dial the correct tip and tilt into the mirror. The design is required to allow for the added thickness of the epoxy between the camera mirror and the CMA lollipop during the alignment process.

Design Solution

The design concept utilizes a guide made from machined aluminum. The CMA lollipop is placed in the alignment piece (note that the guide has a flatness specification so the CMA lollipop rests flat against the surface of the guide). The raised edge of the camera mirror is then placed into the alignment tool, centering both pieces within the specified tolerance. This simple alignment device can be built multiple times to allow for several camera mirrors and CMA lollipops to be assembled at once.



CMA alignment fixture assembly process, showing the camera mirror flexure, CMA alignment device, and completed assembly.

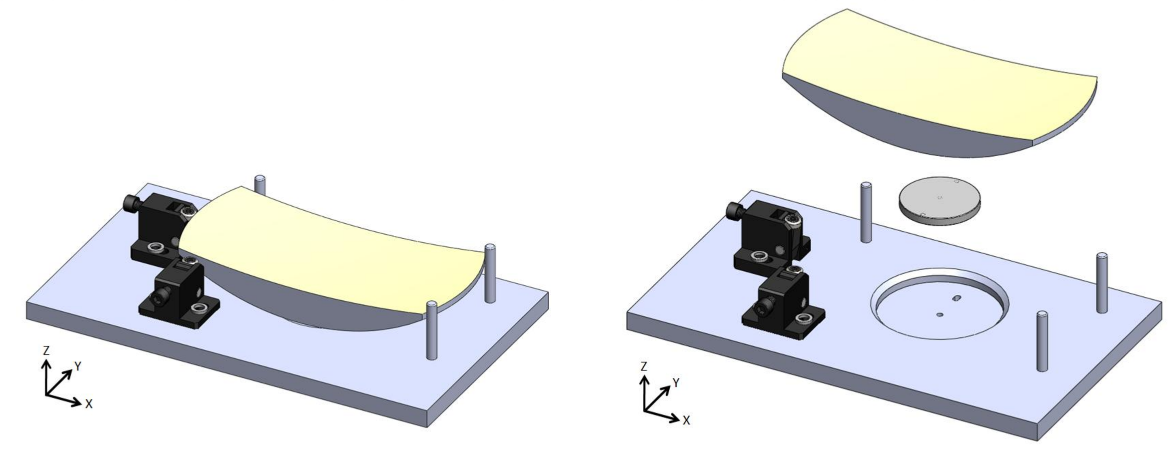
Collimator Mirror Mounting System

Design Requirements

The collimator mirror reflects and collimates light from the fiber optics into the folding flat mirrors of the VIRUS unit. The collimator mirror will be glued to an aluminum puck which will allow it to be mechanically fastened to the collimator adjustment plate. The collimator mirror must be attached to the puck to within 0.5 mm concentricity and ±0.1° rotation.

Design Solution

To meet all rotational and translational requirements, the cylindrical and flat surfaces of the mirror will be used as the reference surfaces in the alignment fixture. As seen in the figure below, two pins will be used along one cylindrical surface to define the mirror's X and Y position and a third pin is used along one of the flat sides to define the rotation. Clamps are also used on the other sides of the mirror to hold its position and rotation as defined by the pins. In the fixture assembly's current configuration the mirror's radius would have to deviate more than 0.46 mm from 147.5 mm to make the position out of tolerance. Likewise, the Y position of the referenced flat surface would have to deviate more than 0.20 mm from 65 mm to make the rotation out of tolerance.



Left: Collimator mirror and puck alignment fixture, assembled view. Right: Exploded view of the collimator mirror and puck alignment fixture.

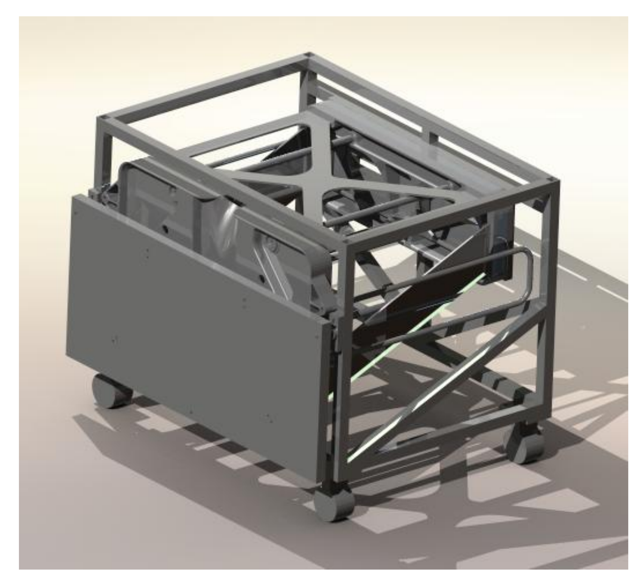
Collimator Assembly Structure

Design Requirements

The collimator assembly fixture allows for the assembly of the collimator shell. The collimator shell is the frame on which the VIRUS optical components are mounted. The collimator shell assembly device must be able to support the load of a completed collimator assembly.

Design Solution

A proposed solution for constructing the collimator shell in a repeatable and precise manner is to use a tubular steel to build a custom frame to amass the collimator, as shown in the figure below. The steel frame will be built in such a way as to allow the placement of the top and side collimator plates. Attached to the steel frame will be 4 swivel casters, 2 of which will be total locking. This will allow for mobilization of the fixture. A custom guide rail will be used on each side of the collimator to allow for an ease of removal from the frame. An IFU reference will be welded to the frame to prevent movement of the collimator head plate. With the collimator head plate fixed in place, the base plate can be translated until it is aligned to within 10 μm of the correct location from the base plate. Below is a picture of a completed collimator shell inside the assembly structure.



Collimator shell assembly fixture showing the collimator base plate (left, behind structure), collimator head plate (upper right), and side plates (connecting the two) mounted inside the assembly fixture. Once the head and base plate are positioned precisely using the assembly fixture, the remaining structure is attached to them.

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HOBBY-EBERLY TELESCOPE

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HETDEX COLLABORATION (http://hetdex.org)

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