HETDEX

Illuminating the Darkness

Hobby-Eberly Telescope Dark Energy Experiment

Production-line Assembly of 150+ VIRUS Spectrographs

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ABSTRACT

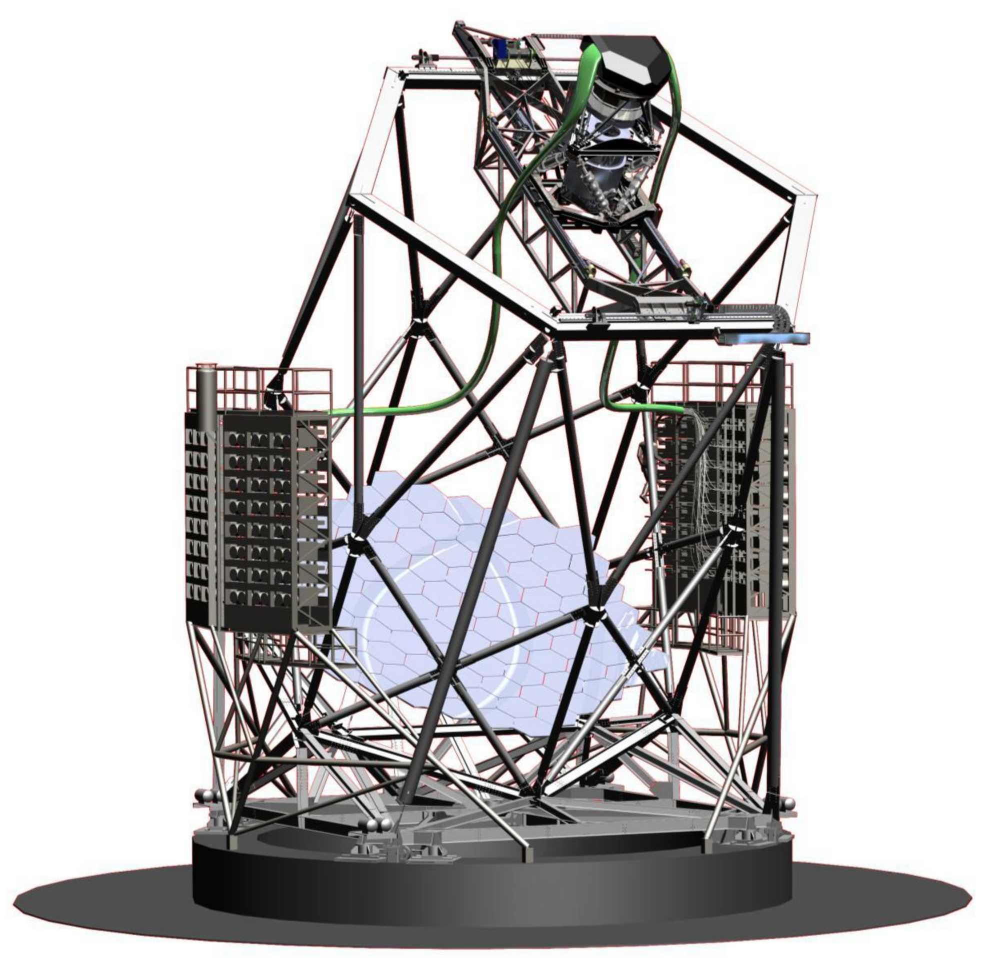
The Visual Integral-Field Replicable Unit Spectrograph (VIRUS) instrument is being built to support observations for the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) project. The instrument consists of 150+ identical fiber-fed integral field optical spectrographs. This instrument provides a unique challenge in astronomical instrumentation: each of the 150+ instruments must be identical and each component must be interchangeable amongst every other spectrograph in order to ease assembly and maintenance of the instrument. In this paper we describe plans for the production-line assembly of the spectrographs. In particular, we discuss the assembly procedures and design choices that will ensure uniformity of the spectrographs and support the project schedule.

Introduction

The Hobby Eberly Telescope Dark Energy Experiment (HETDEX) is a project aimed at looking for Dark Energy at high redshifts using the HET telescope. HETDEX consists of three main parts: a major telescope upgrade including replacing the top end of the telescope to allow for a larger focal plane, the construction of the Visual Integral-Field Replicable Unit Spectrograph (VIRUS) instrument, and the execution of a large area (5000 square degrees) blind survey for Lyman alpha emitting galaxies at redshifts z<3.5. The VIRUS instrument is currently nearing the end of the detailed design phase, and we have begun to prototype the VIRUS production design. We are now preparing for the production-line assembly of the instrument to be completed at Texas A&M University, while the fibers to feed the instrument are being designed and constructed at Astrophysical Institute Potsdam (AIP).

VIRUS is a project unlike other modern astronomical instruments. As opposed to the traditional spectroscopic instrument for a large telescope, i.e. a single spectrograph with large and expensive optics and mechanisms that observes the entire focal plane of the telescope in one instrument, VIRUS has been designed as an array of small, inexpensive spectrographs that each sample a small piece of the focal plane. VIRUS consists of between 150 and 192 simple fiber fed optical spectrographs. The final number of VIRUS units deployed will depend on project funding. The figure below shows a drawing of the upgraded telescope with VIRUS mounted on the telescope.

The planning process for constructing a large number of identical VIRUS spectrographs has led to specific design choices that will enable the instrument to be completed in a timely and affordable manner. Here we describe these design choices and plans for assembling this unique instrument.

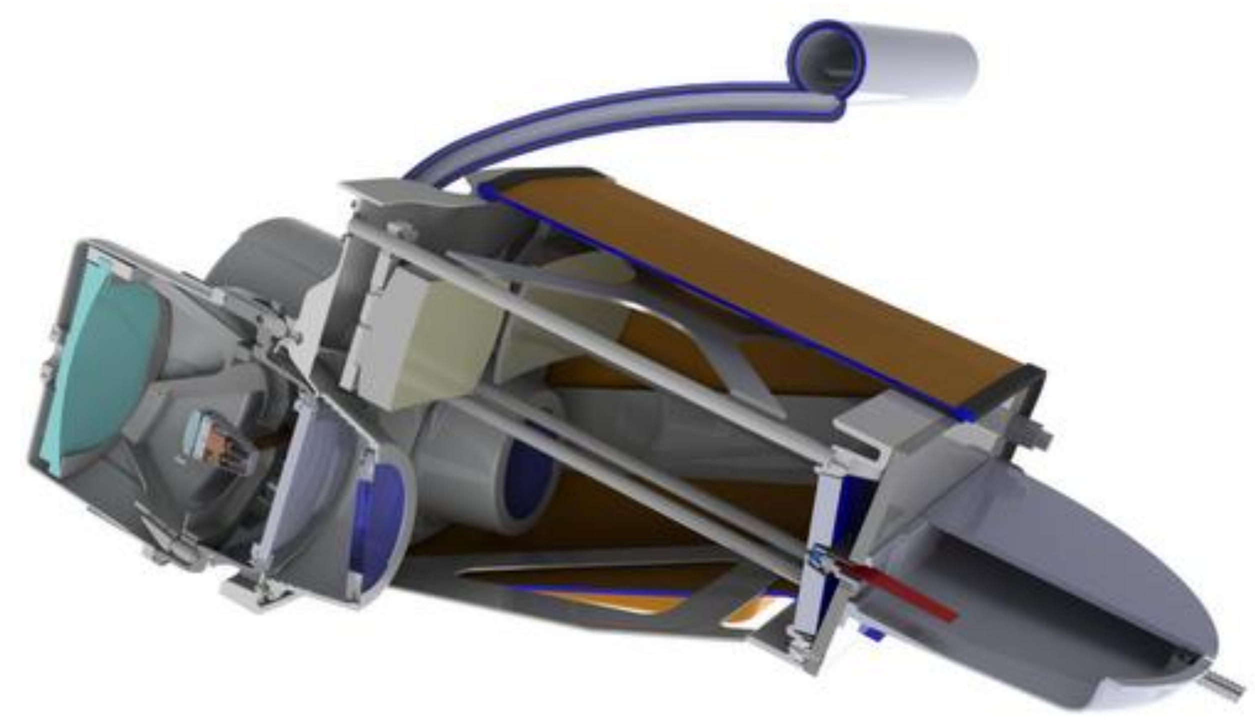


The 96 VIRUS spectrograph pairs will be mounted inside two climate-controlled enclosures located several meters above the base of the telescope.

Design philosophy

The VIRUS instrument consists of as many as 192 identical simple fiber-fed spectrographs mounted on the telescope structure. The VIRUS instruments are composed of a main spectrograph body (referred to as the "collimator") and a vacuum vessel which houses the Schmidt 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. Each spectrograph is fiber-fed from the focal plane of the HET via 224 fibers per spectrograph. The fibers are laid out in a grid pattern in the telescope focal plane. This instrument design allows large-scale spectroscopic mapping of the sky.

The spectrographs will be constructed in pairs; the completed VIRUS instrument will consist of up to 96 pairs of spectrographs.



Section-view drawing of a pair of VIRUS spectrographs.

The optical and mechanical designs of VIRUS have been carefully studied to make the instrument both affordable and able to be constructed in a reasonable amount of time. Several themes govern the instrument design overall:

Interchangeable subassemblies
It is a design requirement that the camera pairs be interchangeable amongst any collimator pair once the instrument is mounted on the telescope. This requirement will enable "hot-swapping" of cameras during operations and minimize down time of the instrument in the case of failures, vacuum pump downs, etc.

Minimize number of parts
We have made an effort to minimize the number of individual parts in each VIRUS unit spectrograph. While the total number of parts is not generally a large cost or assembly time driver in an average astronomical instrument, it certainly will be a consideration in the manufacture and assembly of 150+ instruments. With this factor in mind we have made efforts to minimize the total number of manufactured parts that compose the instrument. One way this is accomplished is through the use of several use of cast aluminum part pieces, discussed in more detail below.

Maximize ease of assembly
We have spent considerable design time thinking about how to assemble the unit spectrographs in the most straightforward way. In particular, we have made an effort to minimize difficult and complicated assembly tasks, time-consuming operations, and procedures that require more than one person to complete. Several key assembly fixtures have been designed that will align each individual optical element precisely within its mount. This practice will minimize the time required to align each spectrograph and camera. The VIRUS alignment and assembly fixtures are discussed in more detail elsewhere in these proceedings.

Optical tolerancing
The VIRUS optics have been carefully specified to produce optics that will be interchangeable amongst any VIRUS unit. Both the optical and mechanical properties of each optic have been carefully toleranced. This will enable quick assembly of the optical assemblies and spectrograph units, and make the optical alignment process of the subassemblies and the complete instrument more straightforward.

Instrument Design Choices

Simple optical design
The optical design of a VIRUS unit spectrograph is a simple off-axis Schmidt collimator coupled with a traditional Schmidt vacuum camera. This optical design has been carefully optimized with optics that can be easily and quickly provided by many different vendors.

Selection of vendors
The cost of the optics in VIRUS is a large fraction of the entire cost of the instrument. We have selected individual vendors for each of the categories of optics—this has minimized overall optics cost dramatically. Purchasing the optics in large quantities at one time reduces costs as well.

Fixed mechanical design
The VIRUS spectrographs have a simple, straightforward design with no moving parts in the instrument. Once optically aligned, the spectrographs will not need to be further adjusted.

Shared vacuums
The unit spectrographs are joined into pairs of spectrographs to allow the Schmidt cameras to share a single vacuum body. This minimizes pump down time of the dewars in the completed instrument and saves costs on vacuum fixturing on each instrument.

Castings
VIRUS has been designed with a minimum of parts in order to minimize costs and assembly time, largely through the use of cast aluminum units in several key subassemblies. The camera vacuum vessel, the grating housing, and the front and back plates of the collimator unit are cast aluminum. The spider that holds the CCD inside the Schmidt camera is cast Invar.

Integral Field Units

In the VIRUS project, the term Integral-Field-Units (IFUs) stands for the fiber bundles that connect the telescope focal plane with the spectrographs. The use of fibers and fiber bundles provides a simple method to split-up the focal plane and to feed the light from a high number (approximate 40,000) of spatial pixels (spaxels) into a set of modular spectrographs.

The development of the fiber bundle IFUs in this project is part of the work package of the AIP. Unlike most astronomical instruments, which are unique development efforts of an institute or university department, the design for all VIRUS components has industrial replication in mind.

While the serial production phase of fiber bundle IFUs is being outsourced, the final quality and acceptance testing is done at AIP and UT. In addition, the newly funded "center for innovation competence for fiber spectroscopy and sensing," innoFSPEC-Potsdam, is engaged in the system design and the development of a quality assurance process. Amongst others, the criteria include geometric accuracy, such as fiber-to-fiber pitch, tip-tilt alignment, telecentricity, surface flatness and roughness, scratch and dig, sub-surface damage, wavelength dependent transmission and flatfield characteristics, focal ratio degradation and any defects and breakages. The findings of these tests are being fed back into the production process to ensure a high quality and reproducibility of the IFUs. Currently, ten fiber-IFUs have been built, which is roughly 10% of the entire anticipated system (see Figure below). Thanks to the modular approach of VIRUS, these bundles can be brought either one-by-one or in batches into operation, once they have successfully passed manufacture item acceptance.

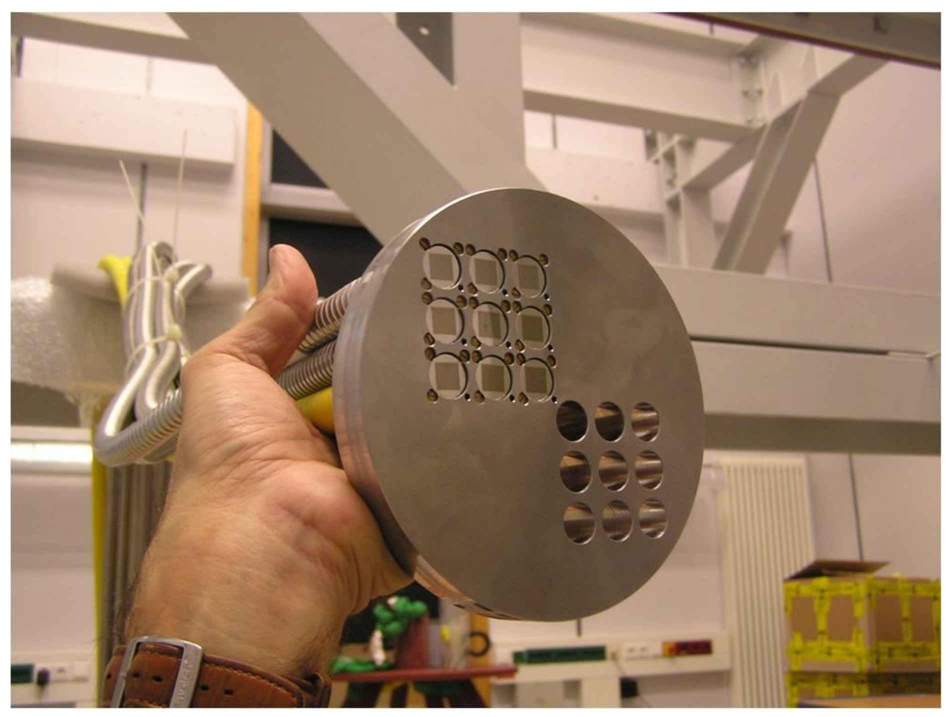


Figure 3: Picture of an IFU input head assembly in a preliminary plug plate using the first nine fiber bundles, featuring some 4000 individual fibers, which will feed 18 VIRUS-spectrographs.

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HOBBY-EBERLY TELESCOPE

The Hobby-Eberly Telescope is operated by McDonald Observatory on behalf of the University of Texas at Austin, the Pennsylvania State University, Stanford University, Ludwig-Maximillians-Universität München, and Georg-August-Universität, Göttingen

HETDEX COLLABORATION (http://hetdex.org)

VENDORS