

**Proposal for the Construction of
Postfocus Detectors for Solar Spectrograph for the
Astronomical Institute of the Slovak Academy of Sciences**

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Introduction

The High Altitude Observatory of the National Center for Atmospheric Research is proposing to design and build a visible/Infrared Postfocus Detectors for Solar Spectrograph (PDSS) for the CoMP-S instrument in operation on the 20cm Zeiss coronagraph at the Lomnický Štít Observatory. This effort follows the deployment of the original instrument in March of 2011 which utilized a single set of silicon focal plane arrays to image the corona between 540 and 1083nm. The new PDSS will provide newly available InGaAs focal plane arrays possessing high detection quantum efficiencies out to 1.7 microns.

This document is intended to provide a description of the PDSS and a Statement of Work to complete the design and construction of the PDSS. The remaining sections of this document discuss:

1. Description of the PDSS camera module concept
2. Estimate of cost and schedule
3. Detailed list of deliverables

The PDSS

The PDSS camera module is designed with quasi-simultaneous visible/infrared operation in mind. This leads us to propose an optical design incorporating a single dichroic mirror at the output of the Lyot Filter separating the optical system into a visible (VIS) channel (400-900nm) and a short wave infrared (SWIR) channel capable of operating between 700 and 1.7 microns (the Zeiss coronagraph O1 range of motion appears to be limited to achromatic operation between 400nm and 1.2 microns so this new system will completely cover any anticipated wavelengths within this range). The only latencies between observations in the visible region and the infrared regions will be the existing latencies associated with the rotation of the Andover filter wheel to select a specific narrowband prefilter.

S and P polarization states in each of the VIS and SWIR channels will be distinguished, as in CoMP-S, utilizing polarizing beam splitting cubes, and directed to one of four focal planes, each of which can be read out at 30 frames per second utilizing a global shutter which is synchronous with the polarimetric modulator state within the Lyot filter.

In the Zemax raytrace below, the Lyot filter is shown in the center of the frame. Immediately following the filter is an optical element designed to increase the focal distance of the existing ($f/20$) Zeiss re-imaging lens (the last surface of which is shown in the far left hand of the raytrace). This lens system is necessary to accommodate the mechanical packaging of four independent focal planes and their associated wavelength specific polarization beam splitters (PBS). Finally, the VIS and SWIR wavelengths are separated by a dichroic mirror placed just after the focal length extender. Each of the four cameras will possess its own computer controlled focus mechanism.

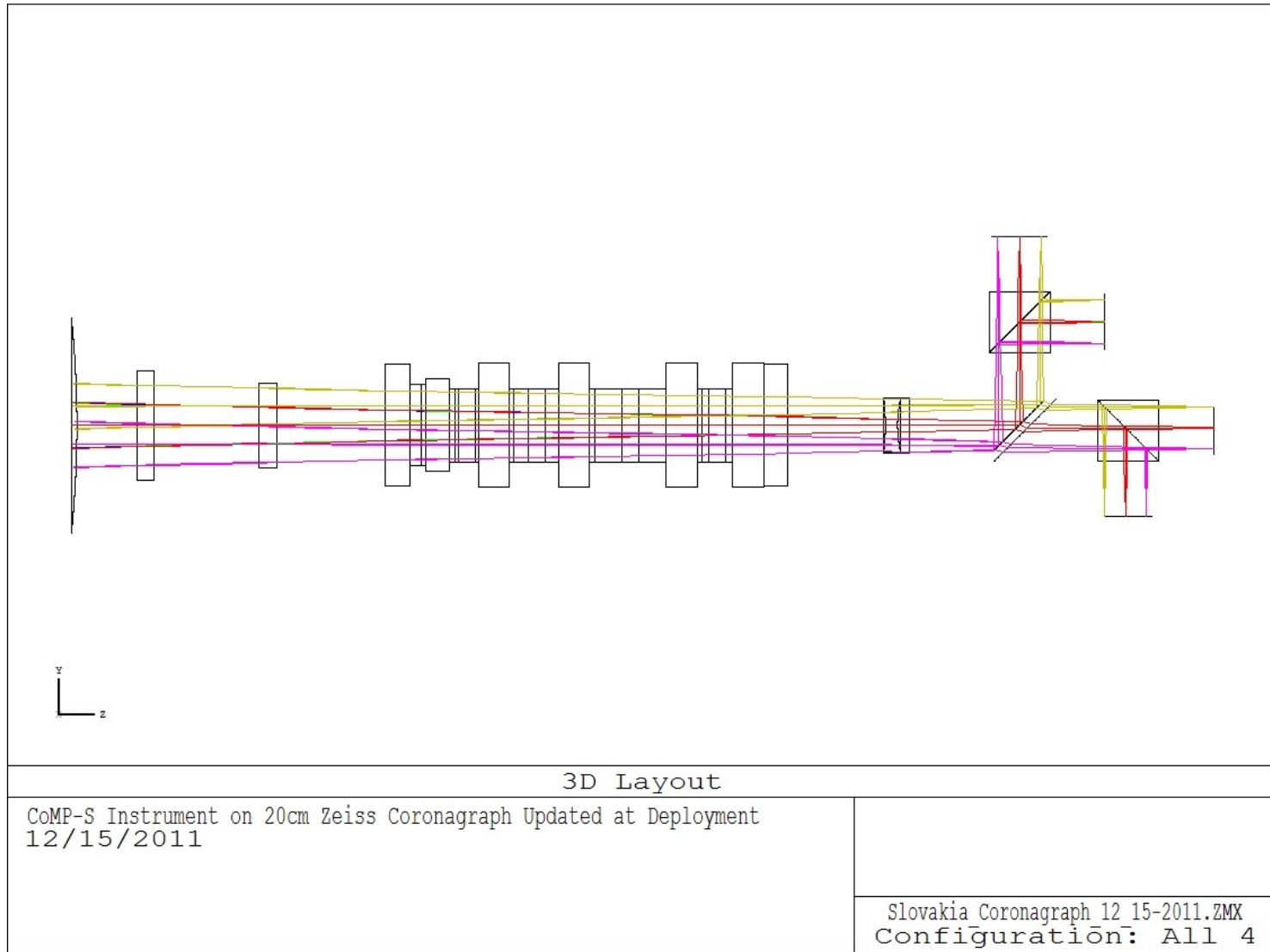


Figure Zemax ray trace of the PDSS instrument concept.

SWIR Camera Selection

The camera we propose to purchase for the system are the [Goodrich GA1280J](#). These are high sensitivity, 1280 x 1024 pixel, 15 μ m pitch, shortwave infrared cameras made from InGaAs, and sensitive to wavelengths between 0.7 and 1.7 μ m. The combination of the number of pixels and the pixel pitch produce an overall focal plane very closely matched in size (19.2 x 15.4mm) to the existing visible channel sCMOS cameras (pco.edge) from PCO Corporation (16.6 x 14.0 mm). These cameras consume <8 Watts of power. The operating case temperature range is -20C to +45C and they operate from +9 to +16 VDC so they will integrate into the existing thermal and electrical power environments with minimal changes.

Top Level Computing Architecture

It has been realized since the deployment of the original CoMP-S instrument that there are great advantages to be had by combining all of the camera link frame grabber hardware WITH the polarimetric modulator and wavelength tuning controller into a SINGLE chassis.

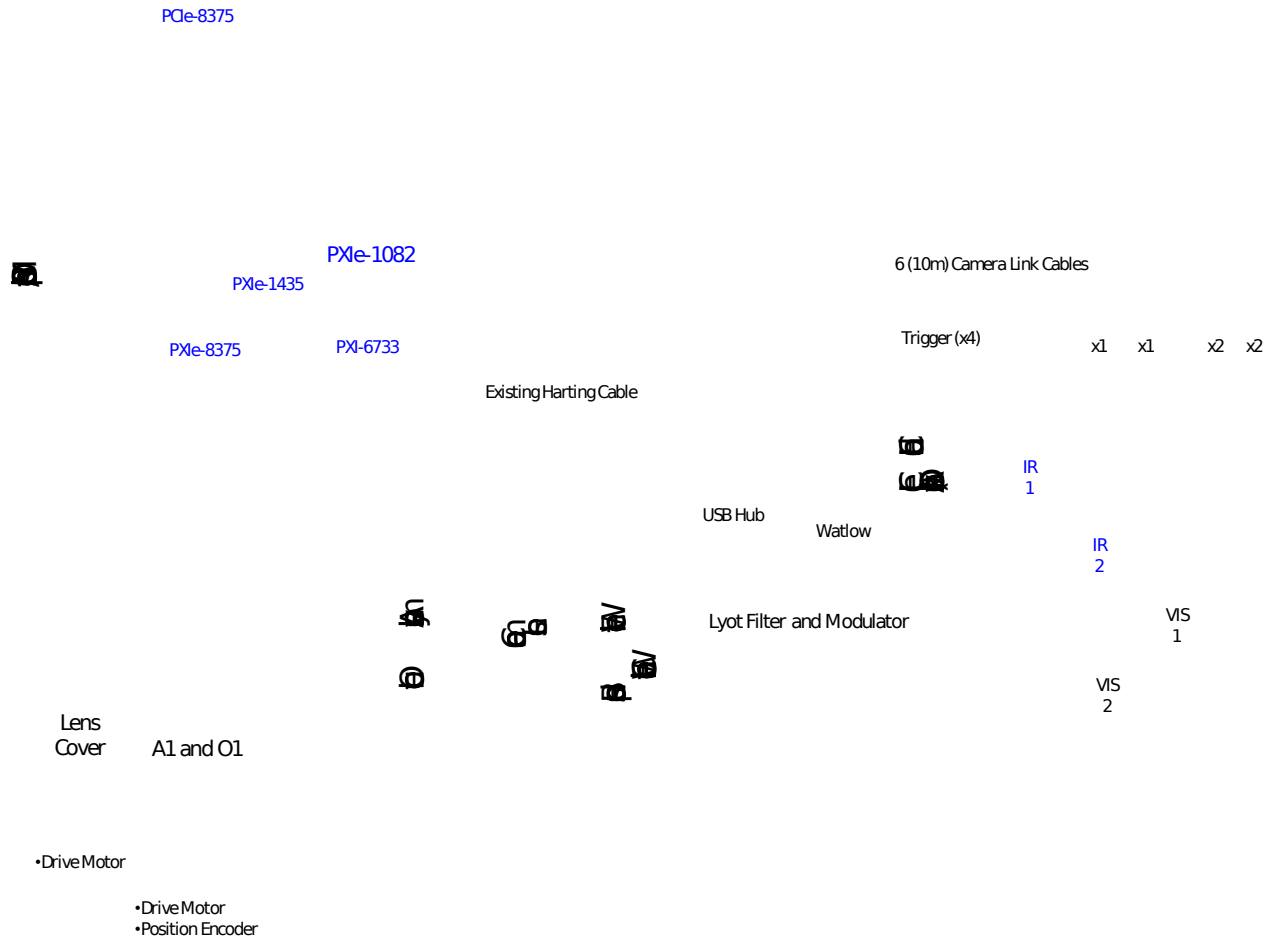
The PDSS proposal is to use four of the the newly available National Instruments [PXIe-1435](#) camera link frame grabbers in a very high system bandwidth [PXIe-1082](#) chassis. This chassis will replace the existing PXIe chassis in the Hammond electrical cabinet deployed with CoMP-S.

In this same chassis, (and tightly synchronized with the frame grabbers with a 10 MHz bus clock) will be the high speed analog output DAQ board used for wavelength tuning and polarimetric modulator state control. With this integration of cameras and filter controller, the new PDSS will be fully operable at 50fps in the visible and 30fps in the infrared.

The PXIe-1082 chassis will be viewed by the Host PC simply as an extension of the PCIe bus using the National Instruments [PCIe-PXIe 8375](#) fiber optic controller.

The connection between the PXIe chassis and the post-focal instrumentation package will be a custom, high-flexibility cable assembly comprising the six required camera link cables, power cables for each of the four cameras and four power/control lines for each of the four computer controlled focus stages. The cable assembly will terminate on both ends with a Harting style connector with levered removal arms for very quick removal by observatory personnel in the event of an electrical storm.

The figure on the next page depicts this top-level computing architecture



Mechanical Housing

Shown in the following pages are various mechanical models (Solidworks) showing the camera module assembly concept. To simplify alignment and operations, each camera will have only one (computer controlled) axis adjustment for focus. The cameras will be aligned to the PBS in the laboratory. In order to minimize the amount of space required for these new SWIR focal planes, the focal length extender optics and dichroic mirror (common to operations in both wavelength regions) will be mounted as close to the Lyot filter as possible. Shown below are 4 conceptual Solidworks models of the proposed PDSS.

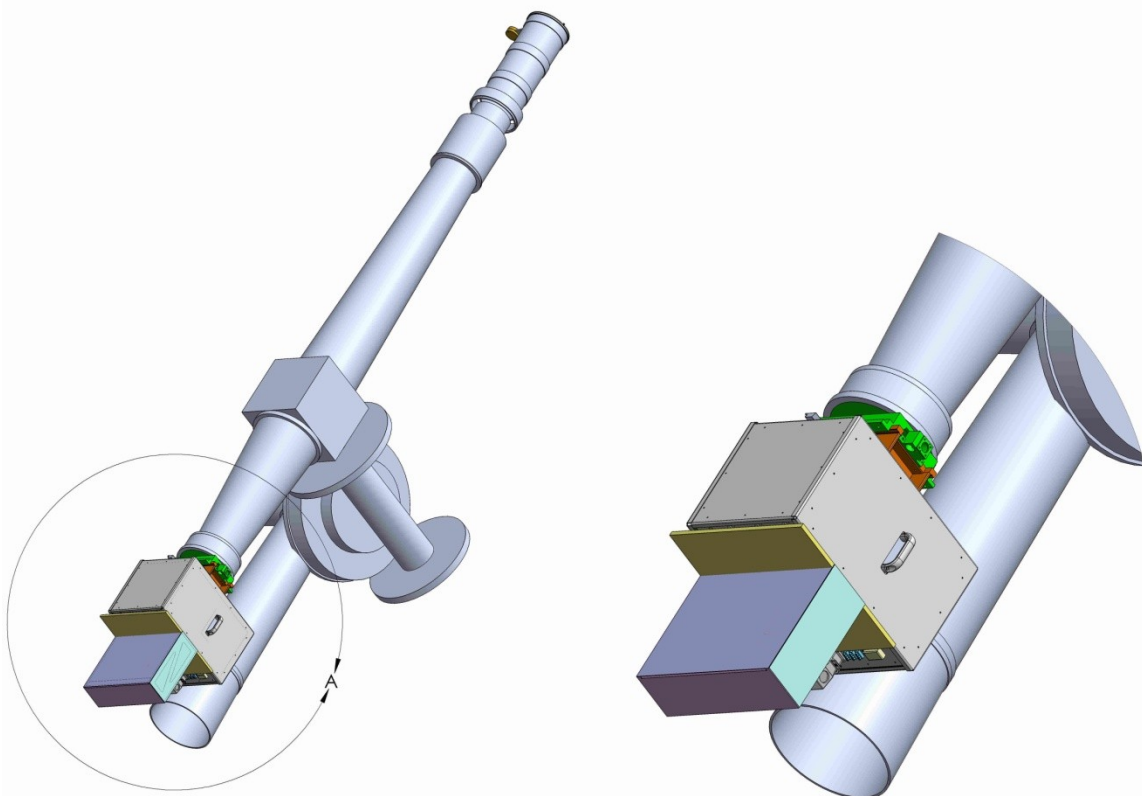


Figure The conceptual layout for the new post-focal instrumentation package attached to the larger Lyot filter module.

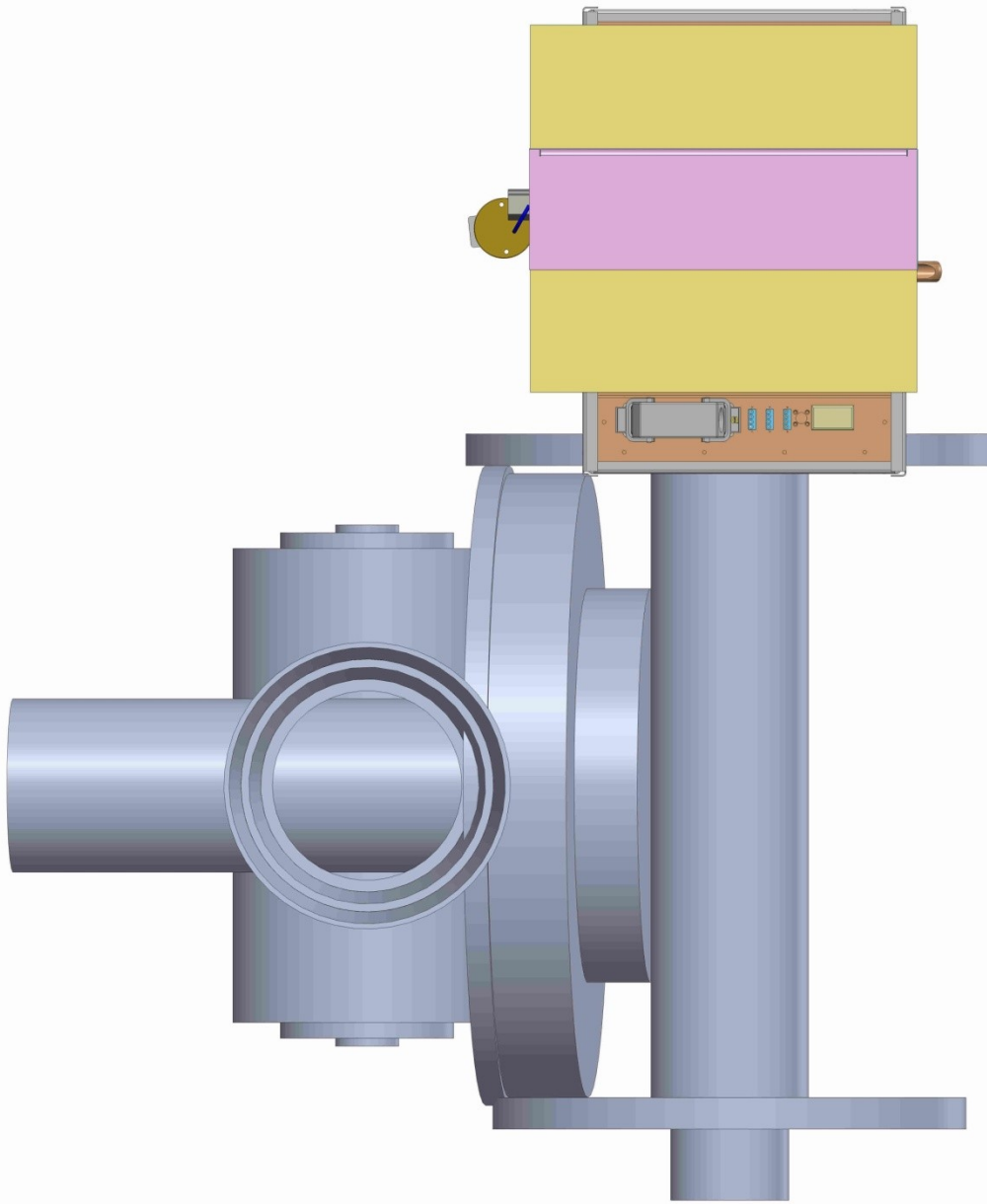


Figure "Bottom" view of instrument package showing relationship to existing Harting connector used for controlling the Lyot filter module. The post-focal package Harting connector is not shown but will be placed in a way so as to minimize interferences and to maximize accessibility and range of motion.

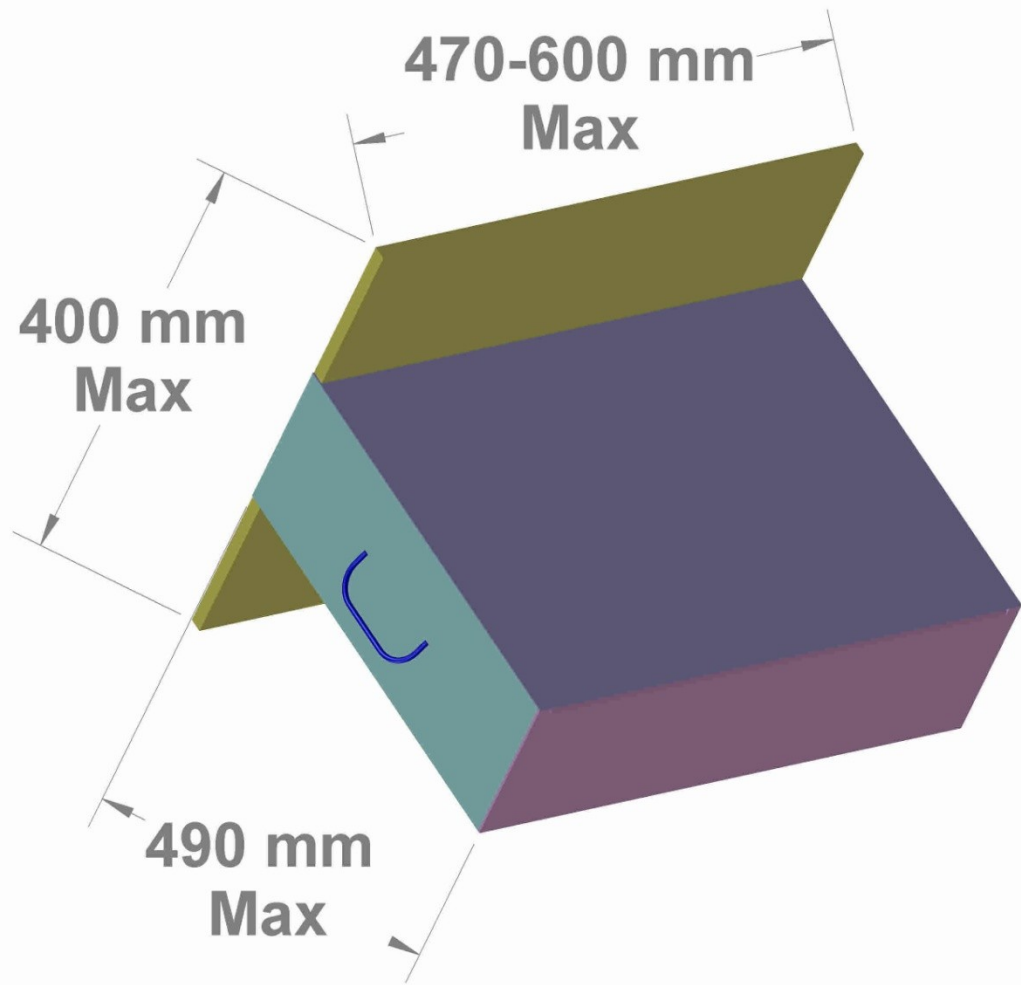


Figure Post-focal instrumentation package envelope dimensions.

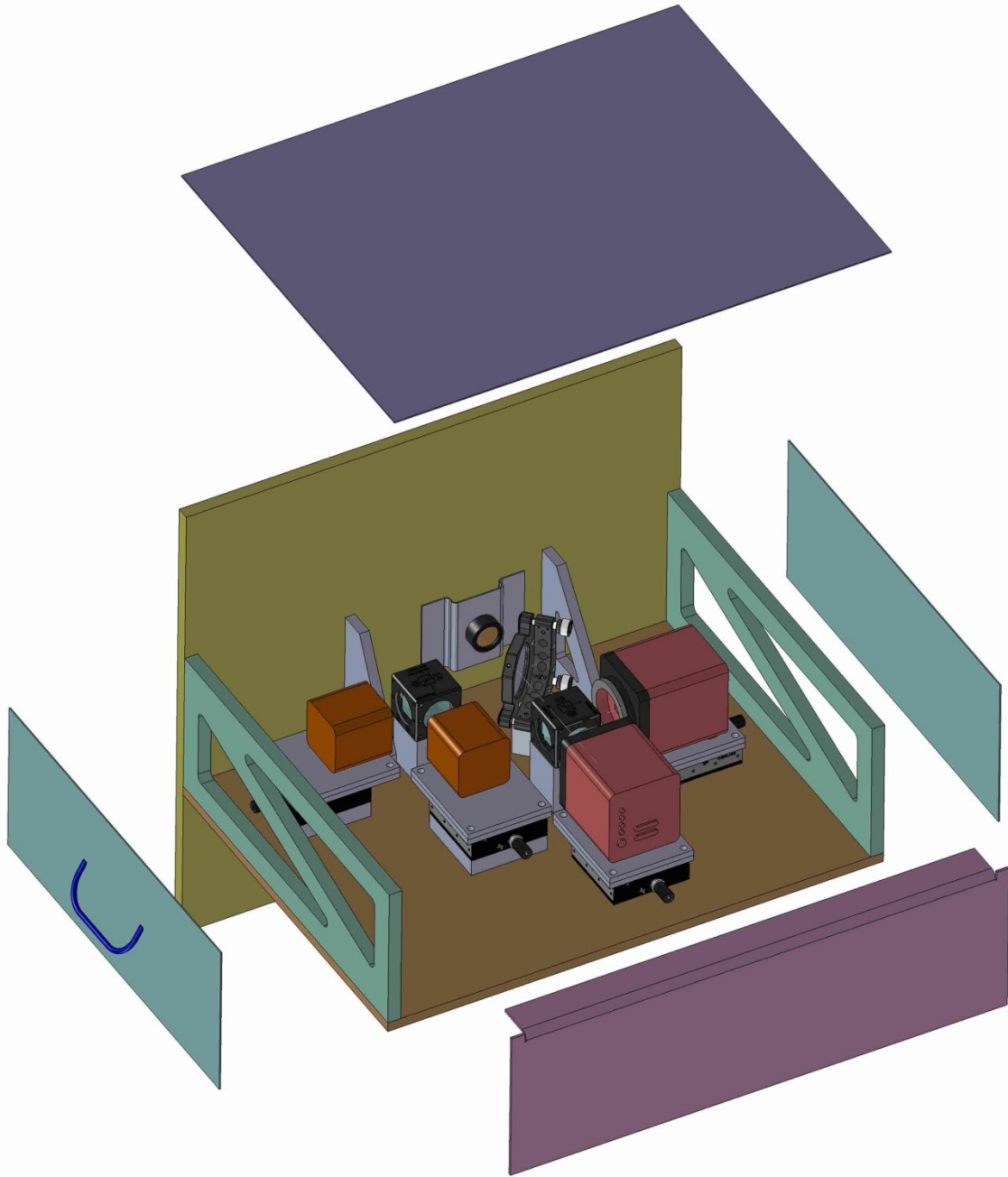


Figure Exploded view of interior of post-focal instrumentation package.

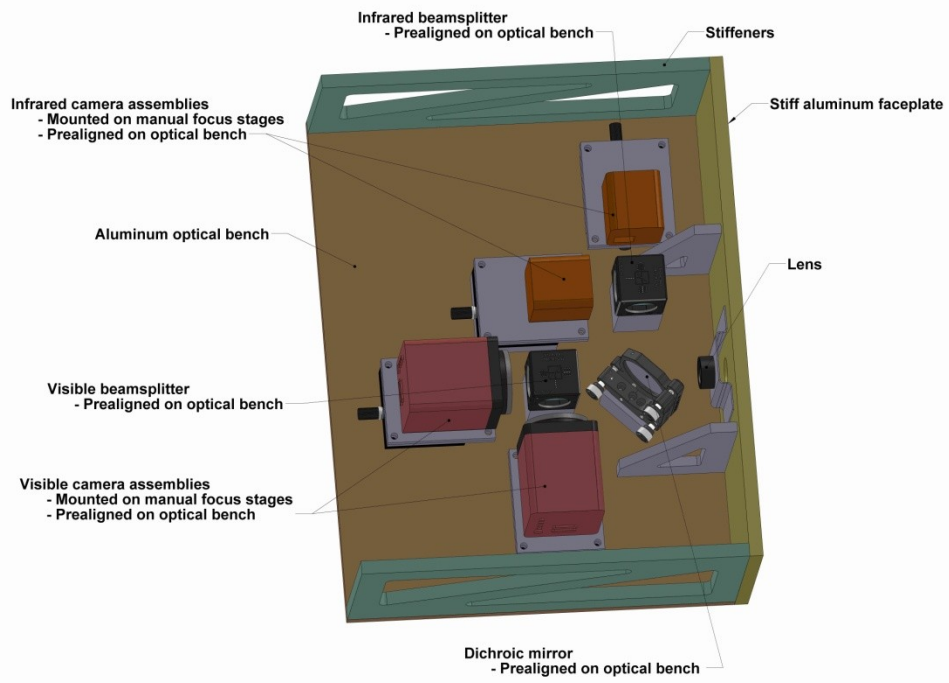


Figure Annotated view of PDSS.

Cost and Schedule

The cost drivers for the proposed instrument are the InGaAs cameras themselves. They are approximately twice as expensive as the visible cameras deployed with CoMP-S. The main schedule drivers for the PDSS camera module are twofold, a) the mechanical redesign and careful packaging of the cameras to ensure improved field alignment and access as well as a substantial software effort associated with the integration of all four cameras into a new LabVIEW program emphasizing high speed operation and low latency when moving from one wavelength to another.

A review of records shows that the complete cost of the CoMP-S instrument was 525,425 EUROS. This proposal does not have to produce a Lyot Filter or an interface to the Zeiss coronagraph. It's interface will simply be to the well defined filter module assembly. Finally, A tremendous amount was learned regarding international collaborations, logistics, field deployments, accessibility and system timing. All of this experience will be applied to the development of the PDSS camera module.

The cost of PDSS will be 252,500 EUROS.

The cost of the PDSS includes:

1. All materials and labor for construction
2. Shipping of the instrument and installation at Lomnický štít.
3. Local expenses for 2 Slovak colleagues to visit HAO during the instrument building and testing phases to learn operation and maintenance procedures.

The PDSS camera module will be delivered no later than 10 months after receipt of a signed contract.

Deliverables

Detectors: HAO will provide two InGaAs based detectors with approximately 1280x1024, 15 micron pixels. The detectors will communicate with the Instrument Control computer through a camera link interface residing in a PXIe chassis, fiber coupled to a host computer.

Camera Enclosure: HAO will provide a thermally insulated, light tight enclosure for housing the four camera systems and the associated post-Lyot optics. These consist of a dichroic mirror and two wavelength optimized polarizing beam splitters. The PDSS will be no more than 10 kg more massive than the CoMP-S camera module containing only visible detectors.

Computer System: The instrument control computer and software will be provided by HAO. It will include the aforementioned PXIe chassis and fiber optic coupling. The PXIe chassis will contain four camera link (full mode) frame grabbers. The computer will have at least 2 TB of RAID-6 storage and will be rack mountable in the AISAS

server room. It will be a single machine and incorporate into it, all the existing functions currently performed by the four separate chassis of CoMP-S (two PC's and two RAID storage systems). The computer system will run LabVIEW and contain all the necessary code for operating the instrument.

Documentation: HAO shall provide a complete set of documentation, drawings and software source code with the PDSS. This documentation will also include all manufacturer manuals, Solidworks engineering drawings (and associated E-Drawings files), an updated Zemax optical design file and updated wiring diagrams.