The wide-field infrared transient explorer (WINTER)

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INTRODUCTION

The Wide-Field Infrared Transient Explorer (WINTER) is a new infrared time-domain survey instrument which will be deployed on a dedicated 1-meter robotic telescope at the Palomar Observatory. WINTER will perform a seeing-limited time domain survey of the infrared (IR) sky, with a particular emphasis on identifying *r*-process material in binary neutron star (BNS) merger remnants detected by LIGO. WINTER is expected to be commissioned during summer 2021 and will be on sky during the 4th LIGO-Virgo observing run (O4).

DETECTOR ARCHITECTURE

The custom camera for WINTER features six commercial large high-definition (HD) format (1920 x 1080 pixels) AP1020 Indium Gallium Arsenide (InGaAs) sensors currently being developed for our group by FLIR Electro-Optical Systems. These sensors are cooled to -50 C using a 2-stage thermo-electric cooler (TEC) mounted in a vacuum-sealed package with a 10 C base temperature.

CAMERA

The driving requirement of the WINTER camera design is to maintain a high fill-factor field of view (>90% over a 1° x 1° FoV) despite not being able to directly abut the sensor elements. The design approach makes use of a novel “fly's eye" approach built from a series of identical, replicated sensor channels. The layout is shown in Figure 2. In this replicated approach, the telescope focal plane is sliced into six individual channels, one per sensor, with a bonded array of plano-convex field lenses called the field lens array (FLA).

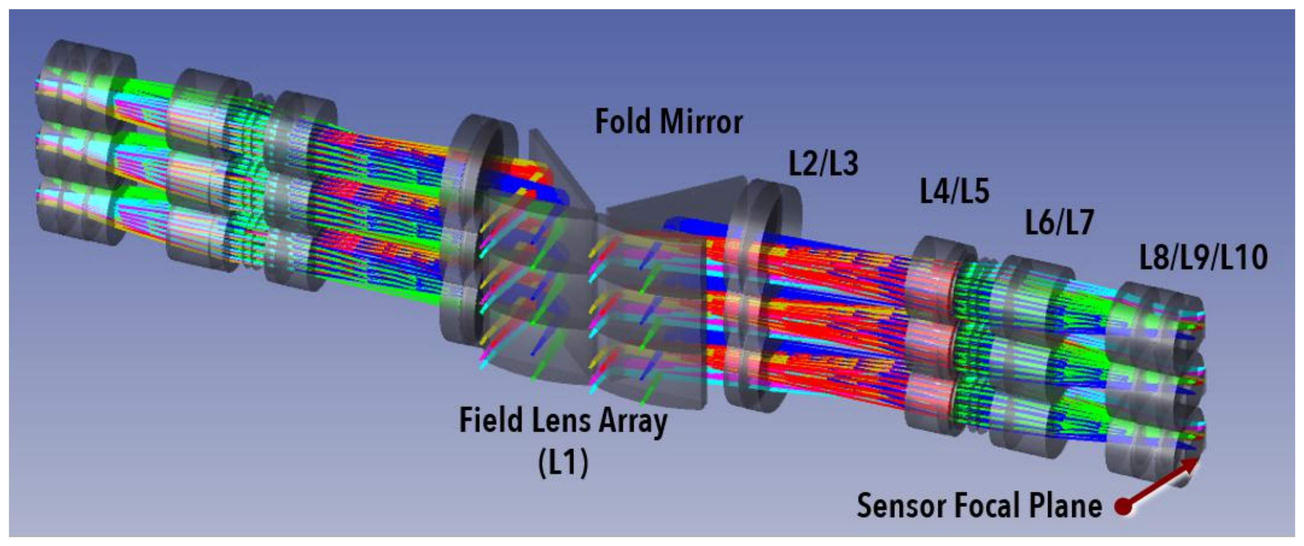

Fig. 2 Ray trace from Zemax of the WINTER camera, showing the FLA near the telescope focal plane, the fold mirror which splits the instrument into two arms, and the individual lens arrays.

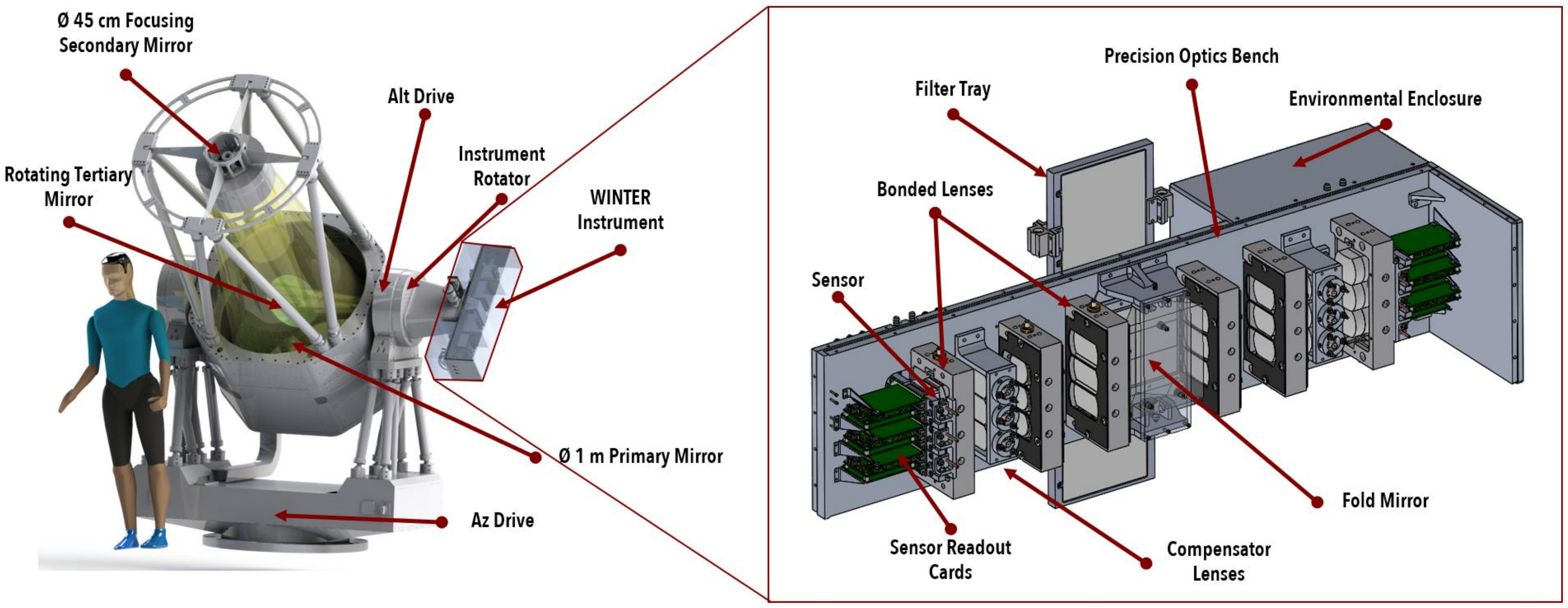

Fig. 1: CAD rendering showing an overview of the WINTER instrument mounted on its telescope. Inset shows a cutaway view of the instrument, with important subsystems and optical elements labeled.

OTHER WINTER REFS.

The following papers at this conference present information on individual WINTER subsystems:

1. Frostig, D. et al, “Design requirements for the wide-field infrared transient explorer (WINTER),” in [Proc. SPIE],**11447**(113) (2020)
2. Hinrichsen, E. et al, “Opto-mechanical mounting design of the wide-field infrared transient explorer (WINTER) “fly's eye” camera lenses,” in [Proc. SPIE],**11447**(115) (2020)
3. Malonis, A. et al, “Detector architecture of the wide-field infrared transient explorer (WINTER) InGaAs camera,” in [Proc. SPIE],**11454**(105) (2020)

FILTERS

The WINTER filters are based on the canonical Mauna Kea Observatory (MKO) filter set with a modified shortened H-band (Hs-band) with a long-wave cutoff tuned to the 1.7 μm InGaAs bandgap cutoff. A single 3-position filter tray sits 50 mm in front of the FLA in the converging, telecentric, F/6 beam of the telescope. The filters were built by Asahi Spectra, and the measured bandpass is shown below.

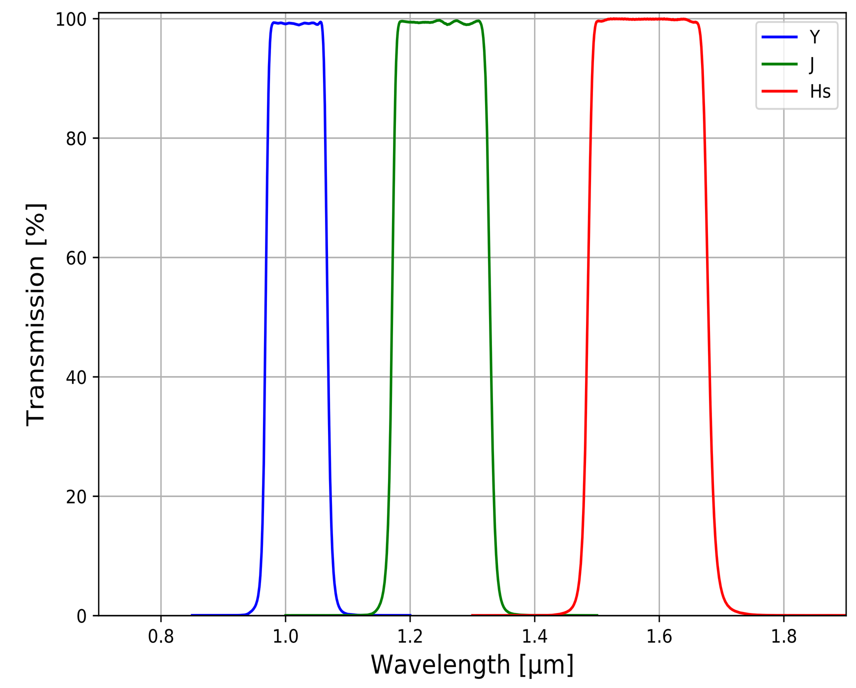

Fig. 3: Measured transmission of the WINTER Y, J, and Hs filters

λ (μm)	Center	Cut-On	Cut-Off
Y	1.02	0.97	1.07
J	1.25	1.17	1.33
Hs	1.60	1.49	1.68

Table 1. Bandpass specifications for the WINTER filters

OBSERVING

WINTER is designed to operate robotically without the need for an operator. An automated scheduler based on code developed for Zwicky Transient Facility (ZTF) and Palomar Gattini-IR (PGIR) optimizes nightly observations and prioritizes observing programs. A custom autonomous observatory control program ingests the schedule and makes decisions about whether to observe based on telemetry data from a dedicated weather station at the site.

The WINTER data processing approach draws on the heritage of the mature transient detection and analysis pipelines developed at Caltech for ZTF and PGIR. All raw images are processed in real time and candidate transient events are published to the GROWTH Target of Opportunity (ToO) Marshal (Kasliwa et. al, 2019) transient web server to coordinate follow-up by other observatories.

WINTER is made possible by the National Science Foundation under MRI grant number AST-182847. This work is also supported by the California Institute of Technology, the Caltech Optical Observatories, the Bruno Rossi Fund of the MIT Kavli Institute, and the MIT Department of Physics and School of Science.