HAWC Overview

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Scientific/Technical Abstract

Many infrared sources are dusty. Absorption of starlight typically heats the dust grains to temperatures of tens or hundreds of degrees Kelvin where they radiate most of their energy in the far infrared, at wavelengths of 40-300 μm which are inaccessible from the ground. Imagery in this spectral range with the highest possible spatial resolution is the natural starting point from which to develop an understanding of source energetics and morphology. It is also a key to understanding the physics and chemistry of the interstellar medium.

When SOFIA enters operation, it will be the largest far-infrared telescope available, so it will have the best intrinsic angular resolution. HAWC (High-resolution Airborne Wideband Camera) is a far-infrared camera designed to cover the 40-300 μm spectral range at the highest possible angular resolution. Its purpose is to provide a sensitive, versatile, and reliable facility imaging capability for SOFIA's user community during its first operational years.

HAWC will utilize a 12x32 pixel array of bolometer detectors constructed using the silicon pop-up detector (SPUD) technology developed at Goddard Space Flight Center. The array will be cooled by an adiabatic demagnetization refrigerator and operated at a temperature of 0.2 K.

HAWC is being designed and constructed by a team of scientists and engineers at Goddard Space Flight Center, Rochester Institute of Technology, the Universities Space Research Association/SOFIA, and the University of Chicago.

Scientific Applications

- Energetics, morphology, and evolution of protostars and regions of star formation
- Formation and evolution of planetary systems
- Mass loss from evolved stars
- Evolution of galaxies
- History of galaxy formation in the early universe
- Physics and chemistry of the interstellar medium
- Properties of interstellar dust

HAWC Team and Heritage

- University of Chicago
- Goddard Space Flight Center
- Rochester Institute of Technology
- Universities Space Research Association/SOFIA

HAWC Requirements

- Sensitivity
  - High transmissivity
  - High detector quantum efficiency
  - Detectors capable of background-limited performance
  - Large array format
  - Software suppression of correlated noise
- Resolution
  - Take full advantage of the angular resolution of SOFIA
- Spectral range
  - Cover the 40-300 μm spectral range which is inaccessible to large ground-based telescopes

HAWC Requirements 2

- Spectral passbands
  - Efficiently characterize the emission from the "large-grain" component of the interstellar medium
- Efficiency
  - Observe with high efficiency on both bright and faint sources
- Accuracy
  - Efficient in-flight calibration and flat-fielding procedures
  - Effective self-calibration procedures which facilitate accurate photometric comparisons between measurements at different times within flights and between flights
  - Database of observations of astronomical standard sources which facilitates accurate photometric calibration while allowing maximal flexibility in flight planning

HAWC Requirements 3

- Readiness
  - Continuous availability in a flight-ready state, to facilitate a variety of GI investigations, large or long-duration projects, or support observations by other instruments
- Complementarity
  - HAWC observations should be easy to combine with data from other instruments to facilitate multi-spectral analysis projects
- Ease of use
  - For Guest Investigators
  - For SSMOC support scientists who operate the instrument and its data processing software
  - For SSMOC technicians who maintain the instrument

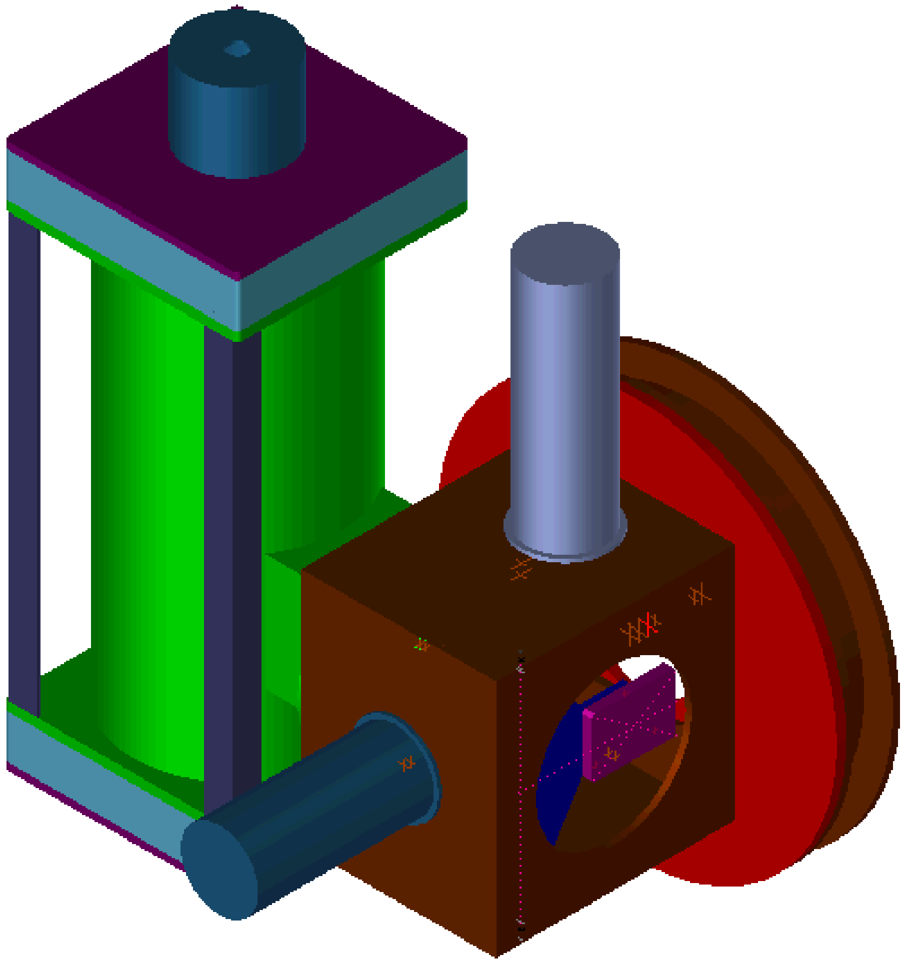
Optical Specifications

	Units	Band 1	Band 2	Band 3
Physical pixel size	mm	0.99	0.99	0.99
Projected pixel size	arcsec	2.8	5.1	9.3
Array size	pixels	12x32	12x32	12x32
Physical pixel spacing	mm	1.0	1.0	1.0
Projected pixel spacing	arcsec	2.8	5.2	9.4
Filling factor	%	0.98	0.98	0.98

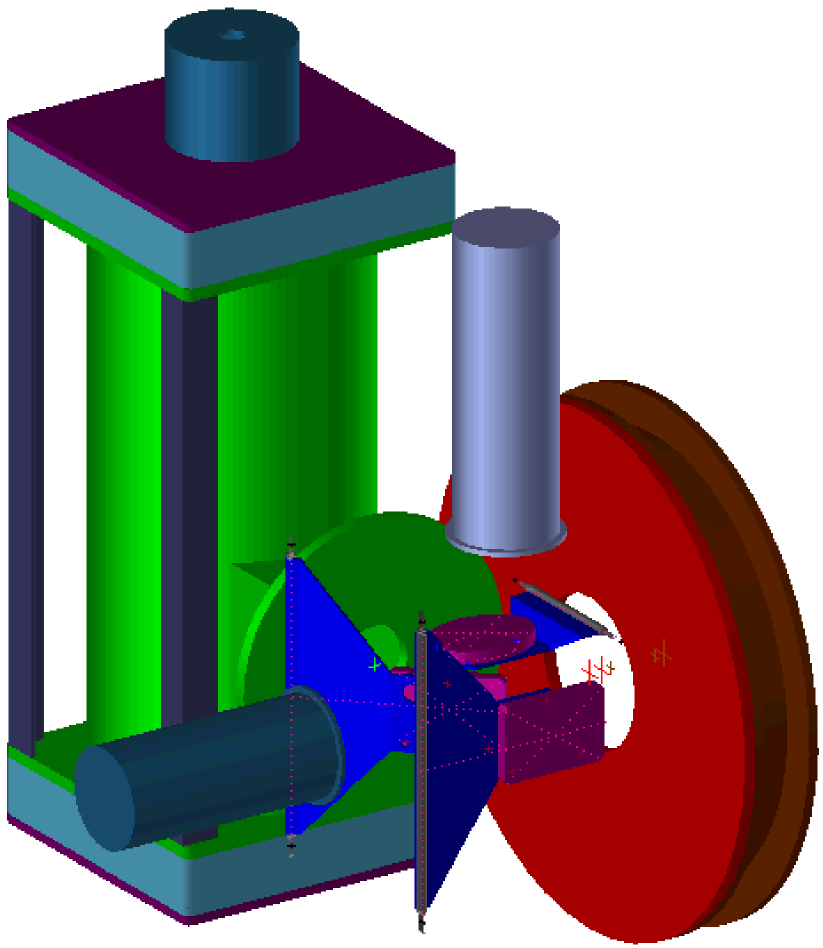
Photometric Specifications

	Units	Band 1	Band 2	Band 3
Central wavelength	μm	60	110	200
Short wavelength cutoff (50%)	μm	47	85	155
Long wavelength cutoff (50%)	μm	77	142	258
Bandwidth	$\Delta\lambda/\lambda$	0.5	0.5	0.5
Minimum mean in-band throughput (cold optics)	%	12	16	20
Background power per pixel	nW	0.08	0.09	0.06
NEP (thermal background limit, one pixel)	$fW/Hz^{1/2}$	0.76	0.59	0.36
NEFD (extended source, background limit, Airy disk fwhm)	$Jy/Hz^{1/2}$	0.35	0.45	0.28
NEFD (point source, background limit, Airy disk fwhm)	$Jy/Hz^{1/2}$	0.7	0.9	0.56
NEFD (point source, background limit, Airy disk fwhm)	mJy (1 hour)	4.1	5.3	3.4

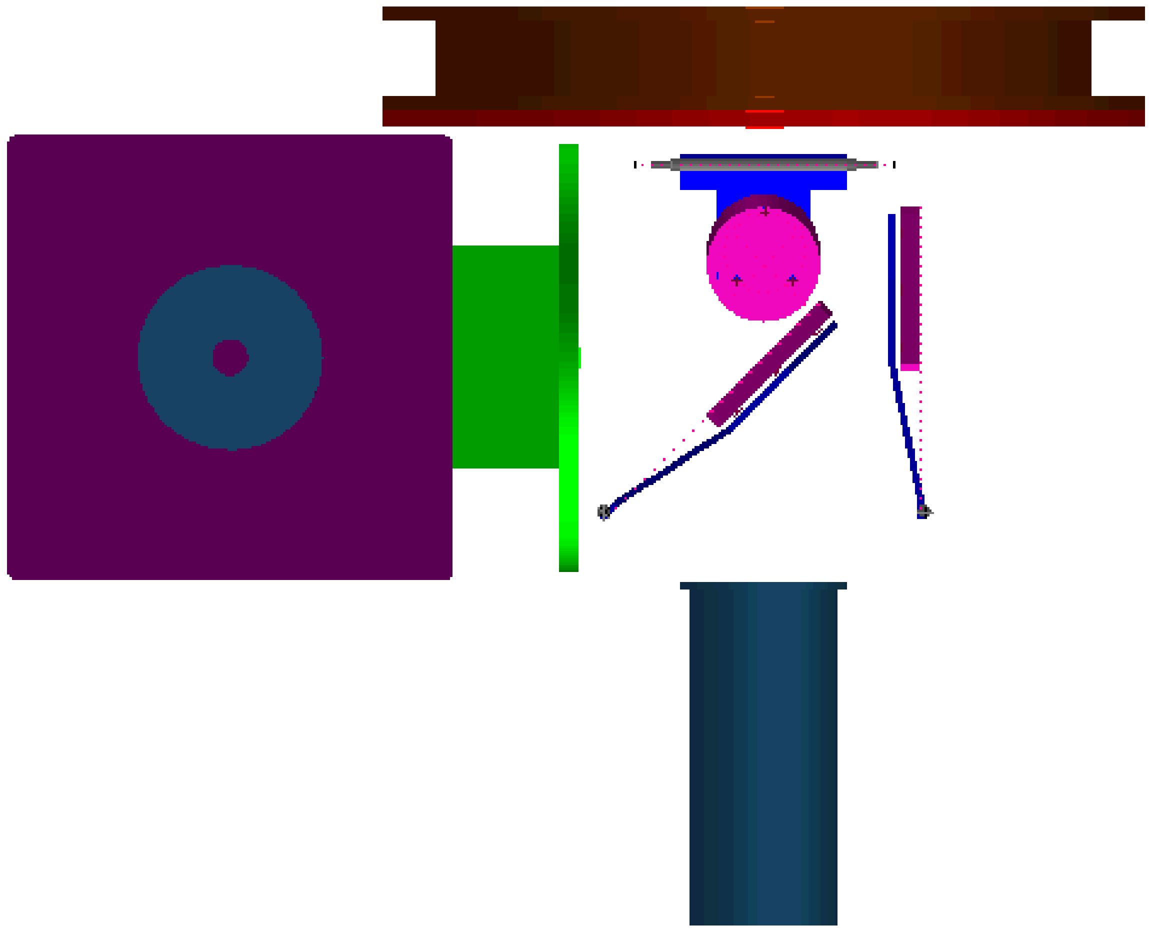
Instrument on Telescope



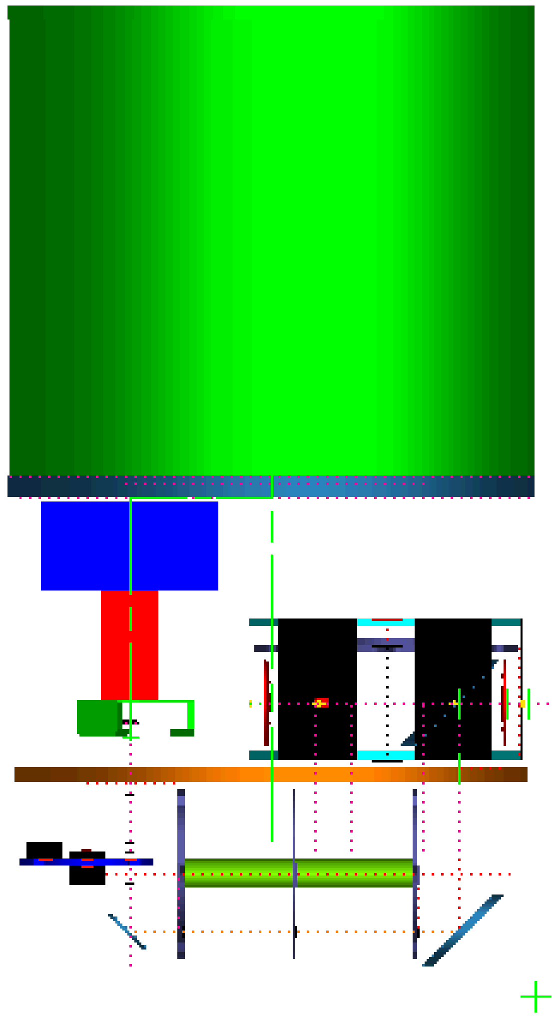
X-ray View of JIM



JIM Optics Layout



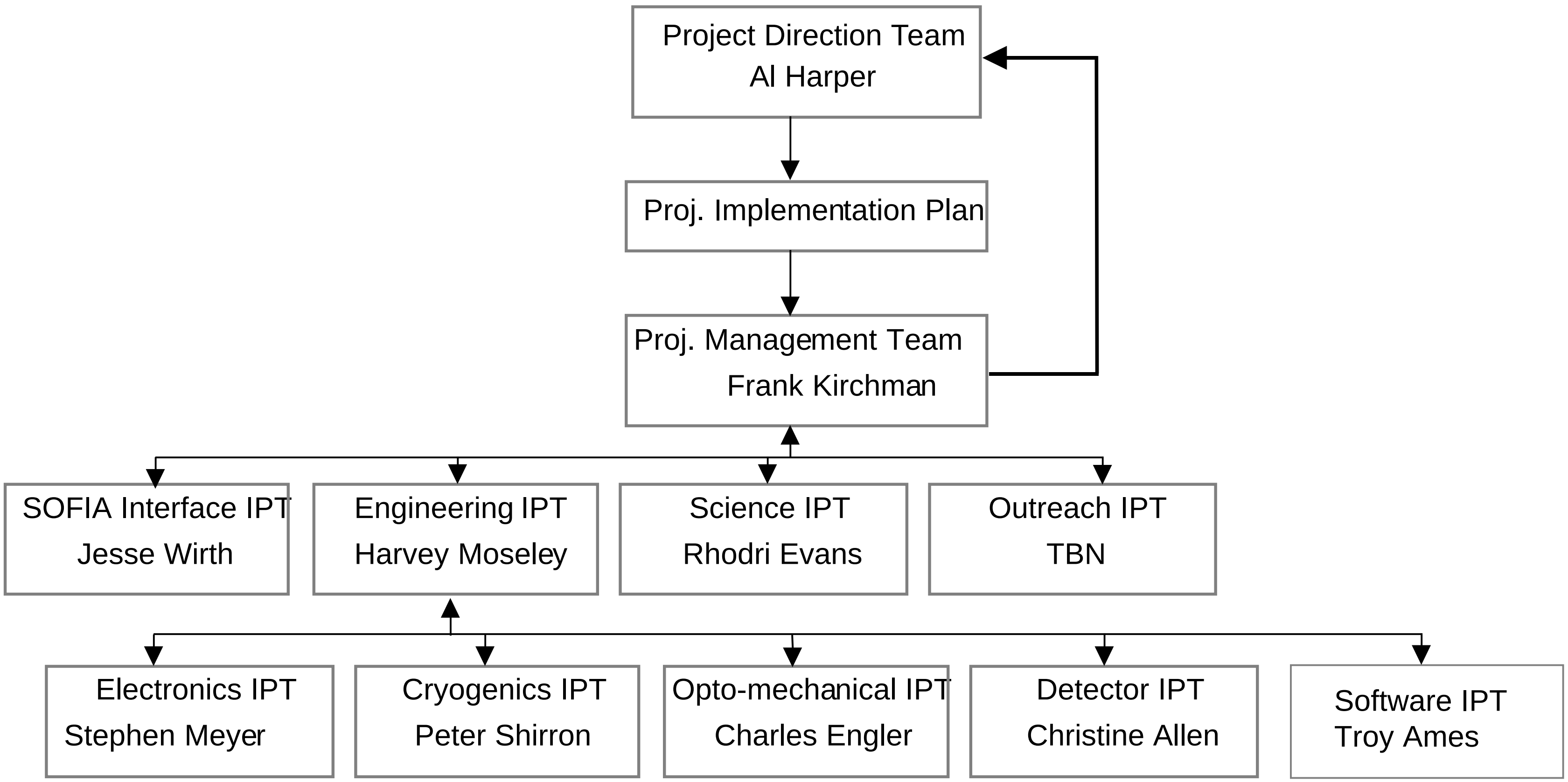
Cold Optics Layout



HAWC Project Organization and Management Plan

Al Harper
Frank Kirchman

HAWC
Project Organization



Project Direction Team

Responsibilities

- Conceptual design of the project
- Mission statement and project goals
- Recruiting/team development
- Resource development
- Project implementation plan (PIP)
- Review and approval of major changes in plan, staffing, resource allocations
- Internal project review
- Responding to external project reviews

Project Direction Team

Team Members

- Al Harper (University of Chicago)
  - Principal Investigator and PD/IPT Coordinator
- Sean Casey (SOFIA/USRA)
- Ian Gatley (Rochester Institute of Technology)
- Harvey Moseley (Goddard Space Flight Center)

Project Management Team
Responsibilities

- Project Work Plan (PWP)
  - Budget
  - Personnel and resource allocation
  - Schedule
- Progress and resource tracking
- Project scheduling and resource re-allocation planning
- Reporting to Project Direction Team
  - Project progress reporting
  - Recommendations for changes to schedule
  - Recommendations for resource re-allocation
  - Recommendations for changes to PIP
- Maintenance of Project Implementation Plan (PIP)

Project Management Team

Team Members

- Frank Kirchman/GSFC
  - Project Manager and PM-IPT coordinator
- Judy Bausch/UC
- Cristina Doria/GSFC
- Rhodri Evans/UC
- Nancy Odalen/UC
- Harvey Rhody/RIT
- Georgia Rothacker/RIT
- Jesse Wirth/UC

Project Work Plan

- Task list
- Schedule
- Resource allocations
  - Budget
  - Personnel
  - Space
  - Other resources
    - Equipment
    - Software
    - etc.

Project Manager

Responsibilities

- Manage project resources
- Coordinate work of the Project Management Team
- Schedule and conduct regular meetings with IPT leads
- Schedule and conduct monthly management meetings to review budget and schedule
- Management interface between University of Chicago and Goddard Space Flight Center
- Intra-project communications

IPT Responsibilities
General

- Design and delivery of IPT products as specified in the Project Implementation Plan (PIP)
- Conduct work according to Project Work Plan (PWP)
- Provide risk assessments and risk mitigation plans relevant to IPT tasks
- Provide documentation for IPT work products
- Alert Project Management IPT immediately upon identification of circumstances which may require modification of PIP or PWP

IPT Coordinators
Responsibilities

- Communications with Project Management IPT
- Scheduling and conducting team meetings
- Assembling and maintaining documentation
- Tracking progress of work on IPT tasks
- Tracking expenditure of IPT resources
- Alerting Project Manager to deviations (or potential deviations) from Project Work Plan
- Reporting to Project Manager any issues which cannot be resolved by consensus within the IPT
- Delivery of the IPT work product(s) to the Project

Science IPT

Responsibilities

- Science requirements maintenance and updates
- Data calibration plan
- Data analysis plan
- Data archiving plan
- Performance testing of instrument user interface
- Commissioning period observing plan
- HAWC team science observing plan
- Science user documentation
- Science community outreach
- Website

Science IPT
Team Members

- Rhodri Evans/UC
  - Science IPT coordinator
- Judy Bausch/UC
- Harold Butner/UA
- Sean Casey/USRA
- Ian Gatley/RIT
- Al Harper/UC
- Joel Kastner/MIT
- Robert Loewenstein/UC
- Harvey Moseley/GSFC
- Harvey Rhody/RIT
- Richard Shafer/GSFC
- Charles Telesco/UF
- Adolf Witt/UT

SOFIA Interface IPT

Responsibilities

- Performance testing of instrument and associated software after delivery by Engineering and Science IPTs
- Ground support equipment
- Interface with telescope simulator
- Interface with MCCS simulator
- Interface with SOFIA telescope and MCCS
- Operations plan
- Instrument hardware and software documentation
- Delivery of the instrument to the SSMOC
- Communications with SOFIA/USRA
- Packaging of telescope and aircraft-mounted instrumentation
- FAA certification

SOFIA Interface IPT

Team Members

- Jesse Wirth/UC
  - SOFIA Interface IPT coordinator
- Troy Ames/GSFC
- Judy Bausch/UC
- Sean Casey/USRA
- Rhodri Evans/UC
- Robert Loewenstein/UC
- Mark McGinnis/GSFC
- Fred Mrozek/UC
- Robert Pernic/UC
- Harvey Rhody/RIT
- Dale Sandford/UC
- Maureen Savage/USRA

Engineering IPT
Responsibilities

- Design and construction of HAWC camera and associated electronic systems
- Data acquisition software
- Structural analysis required to satisfy FAA certification requirements
- Integration and testing of camera subsystems and data acquisition software
- Support for re-engineering and modifications as required after delivery to SOFIA Interface IPT and prior to delivery to SOFIA/USRA

Engineering IPT
Team Members

- Harvey Moseley/GSFC
  - Engineering IPT coordinator
- Christine Allen/GSFC/Detector IPT
- Troy Ames/GSFC/Software IPT
- Charles Engler/GSFC/Opto-mechanical IPT
- Rhodri Evans/UC/Science IPT
- Robert Loewenstein/UC/Software IPT
- Stephen Meyer/GSFC/Electronics IPT
- Dale Sandford/UC/Electronics IPT
- Peter Shirron/GSFC/Cryogenics IPT
- Jesse Wirth/UC/SOFIA Interface IPT

Software IPT

Responsibilities

- Design and development of instrument software
  - Instrument control
  - Data acquisition: transforms output from data electronics (384 detector channels of chopper-modulated data, each sampled at a rate of ~1 KHz) into demodulated data corresponding to pixel intensities on the sky
  - Instrument graphical user interface and real-time data displays
- Design and development of data pipeline software
  - Data processing from raw pixel measurements to calibrated 2-dimensional images

System Electronics IPT

Responsibilities

- Data system electronics
- ADR control system
- Electronics for mechanisms
- Instrument health/safety/environmental monitors
- Power subsystem

Opto-Mechanical IPT

Responsibilities

- Optics
- Optical mechanisms
- Control of Optical Mechanisms

Detector IPT

Responsibilities

- Detectors
- JFETs
- Internal calibration sources

Cryogenics IPT

Responsibilities

- Thermal design and analysis of the He^4 dewar, ADR and Detector assembly (including the JFET amplifier housing)
- Mechanical design of the He^4 dewar and ADR
- Develop interface requirements for the electrical, detector and opto-mechanical subsystems
- Calibration of cryogenic sensors (thermometers)
- Fabrication and assembly of He^4 dewar and ADR
- Electrical and mechanical ground support equipment for cryostat assembly and testing

Cryostat IPT

Responsibilities (contd)

- Thermal performance testing of the He^4 dewar and ADR
- Cryogenic servicing and support during integration of the detectors, ADR and He^4 dewar