The Helioseismic and Magnetic Imager

Stanford University

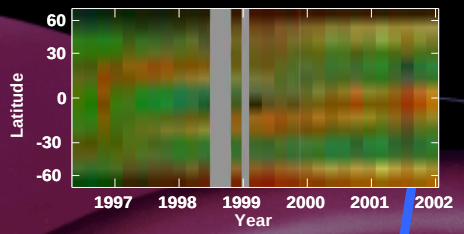
Lockheed Martin Solar and Astrophysics Laboratory

Science Co-Investigators

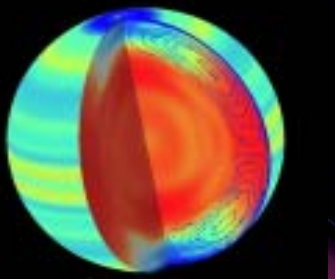
HMI Major Science Objectives

J – Sunspot Dynamics

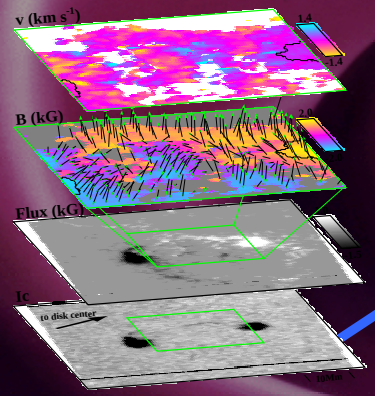
B – Solar Dynamo



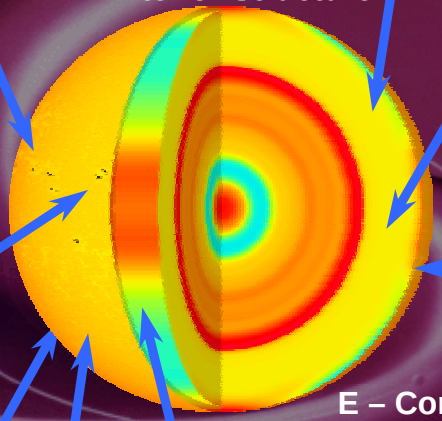
C – Global Circulation



I – Magnetic Connectivity

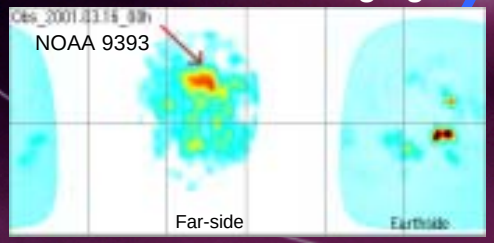


A – Interior Structure

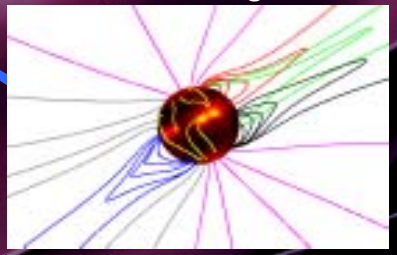


D – Irradiance Sources

H – Far-side Imaging

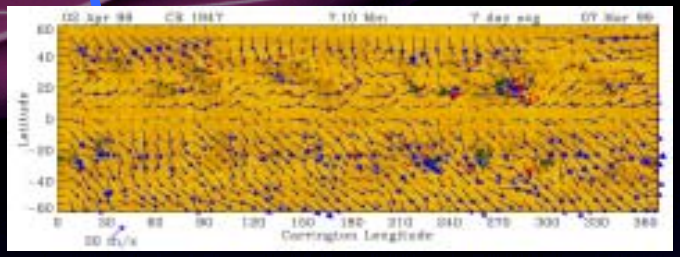


E – Coronal Magnetic Field



G – Magnetic Stresses

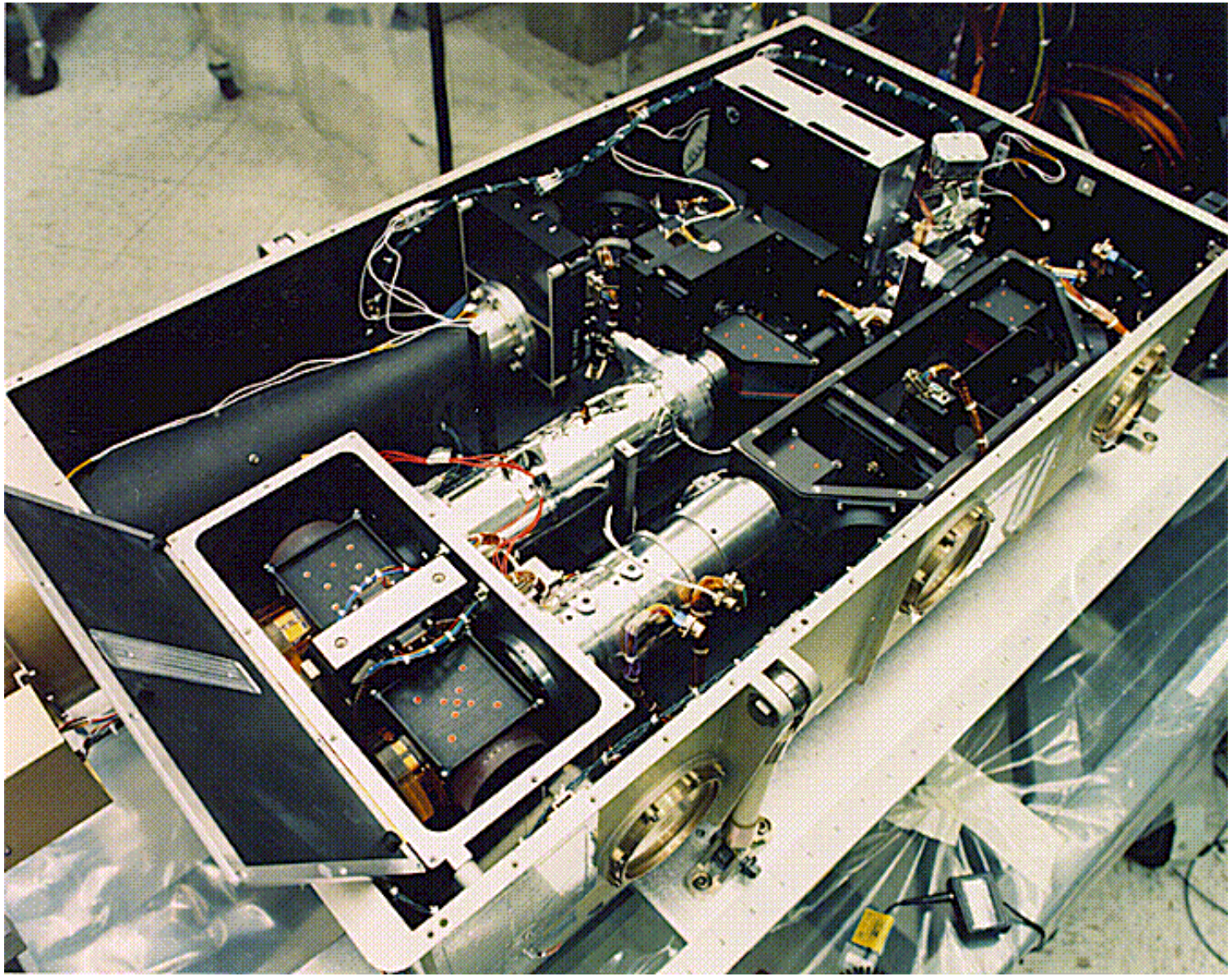
F – Solar Subsurface Weather



HMI Heritage

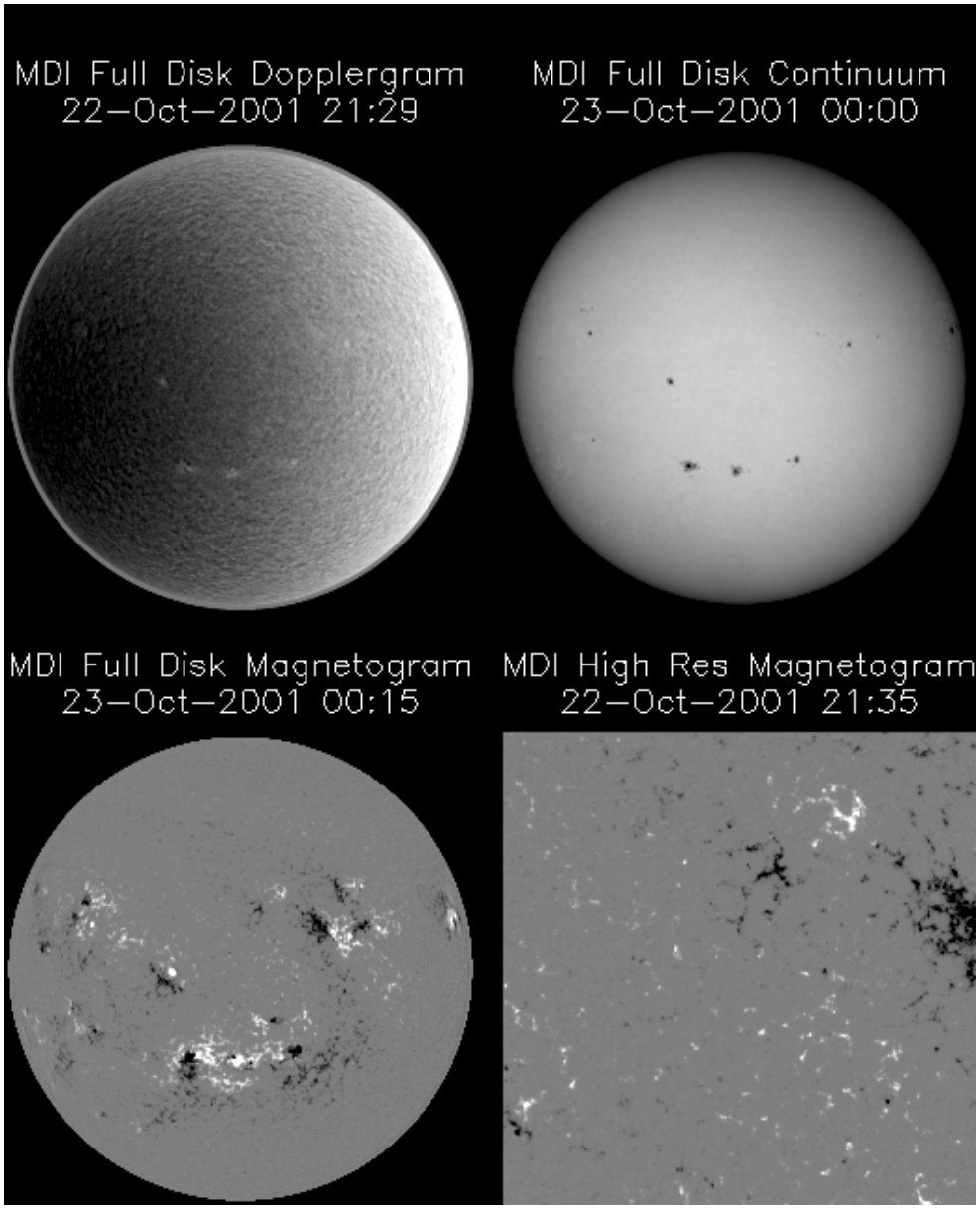
- The HMI instrument is an evolution of the successful Michelson Doppler Imager operating on the SOHO spacecraft.
- The primary differences are that HMI has no on-board image processing, and that two identical 4096x4096 pixel format CCD cameras are used to obtain both Doppler and vector magnetic field measurements.

Michelson Doppler Imager Flight Optics Package



HMI Observables

- Dopplergrams computed from filtergrams at 5 wavelengths across the Ni 6768 Å line.
- Longitudinal magnetograms generated from the LCP and RCP Dopplergrams.
- Vector magnetograms computed from filtergrams at 4 polarizations and 5 wavelengths.
- Continuum image filtergrams.

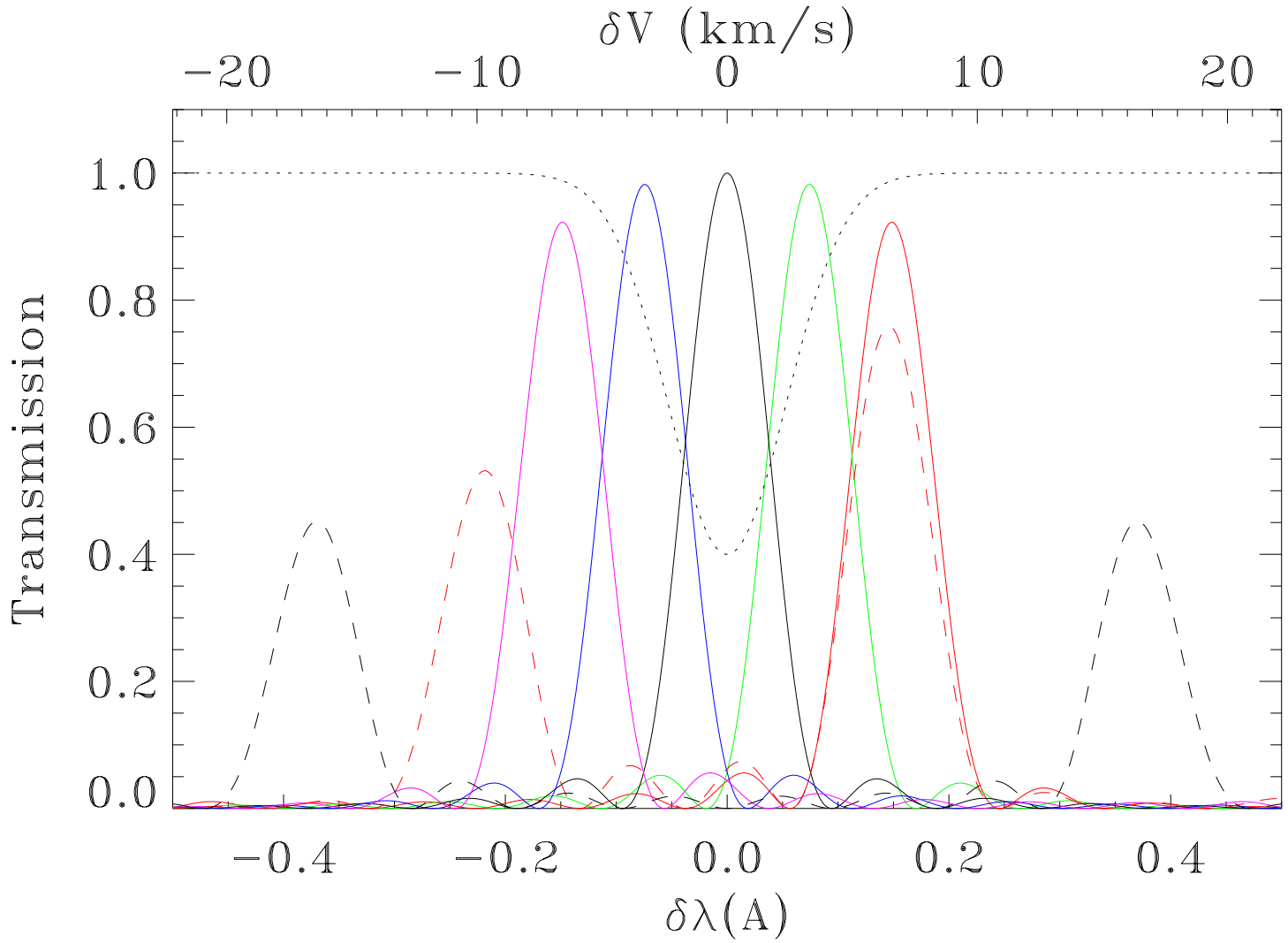


MDI observables similar to those expected from HMI

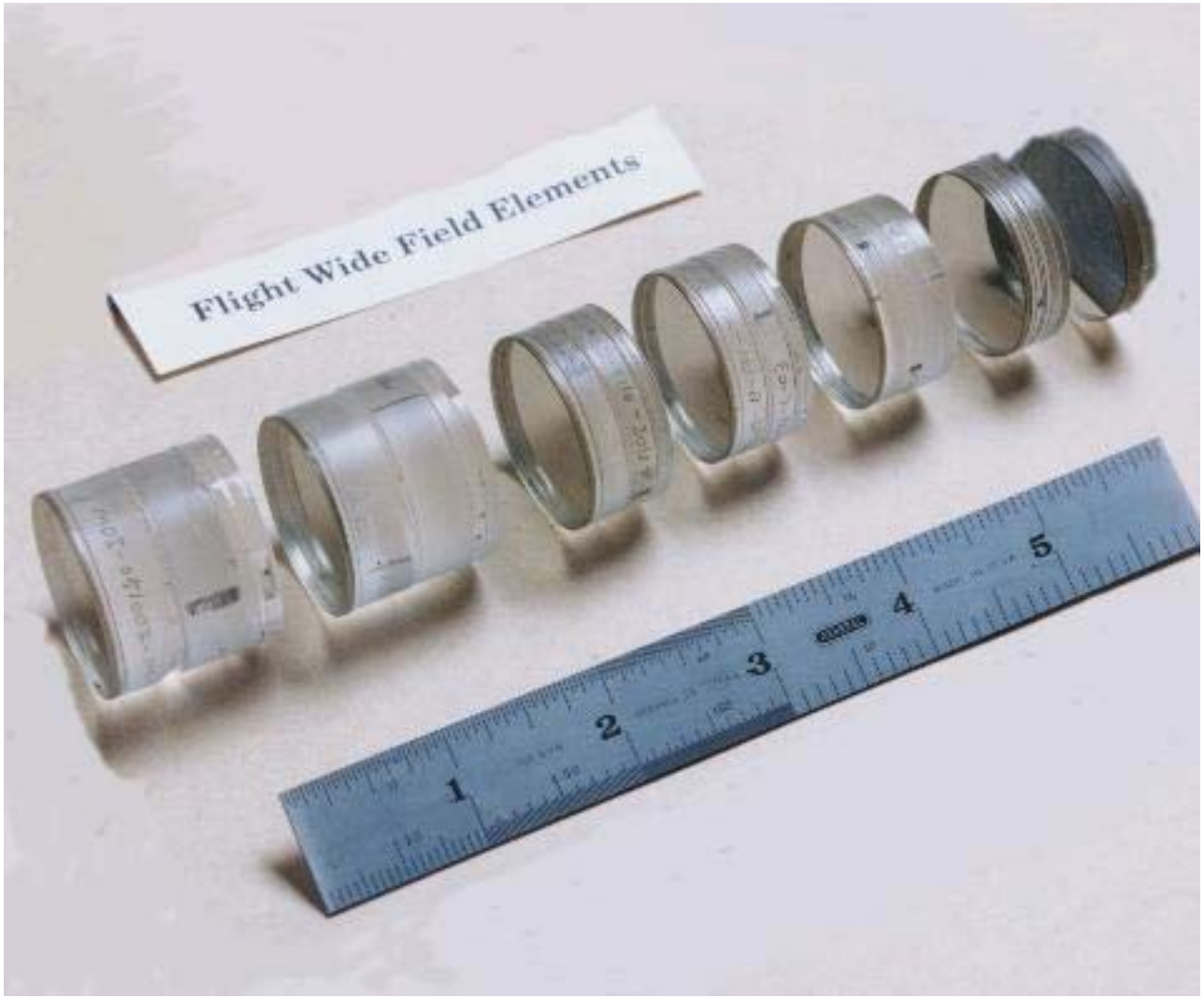
HMI Tunable Filter

- The HMI filter design has a Lyot filter with one tunable element and two tunable Michelson interferometers. The tuning is adjusted by rotating waveplates.
- The solid color lines on the next page show the HMI filter transmission profiles at 75 mÅ spacing. The dotted line shows the Ni line profile. The black dashed line shows the continuum filtergram tuning profile.

HMI Filter Profiles and Observing Line



MDI Lyot Filter Elements

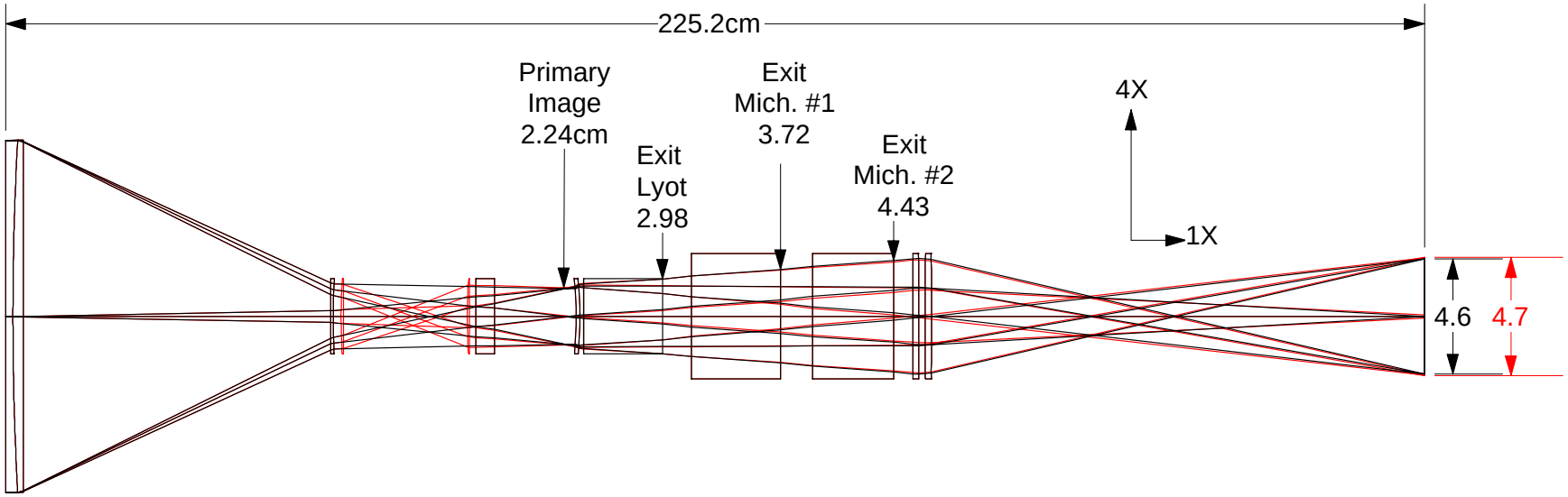


MDI Flight Michelsons

HMI Optical Design

Superimposed Calibration and Imaging Modes

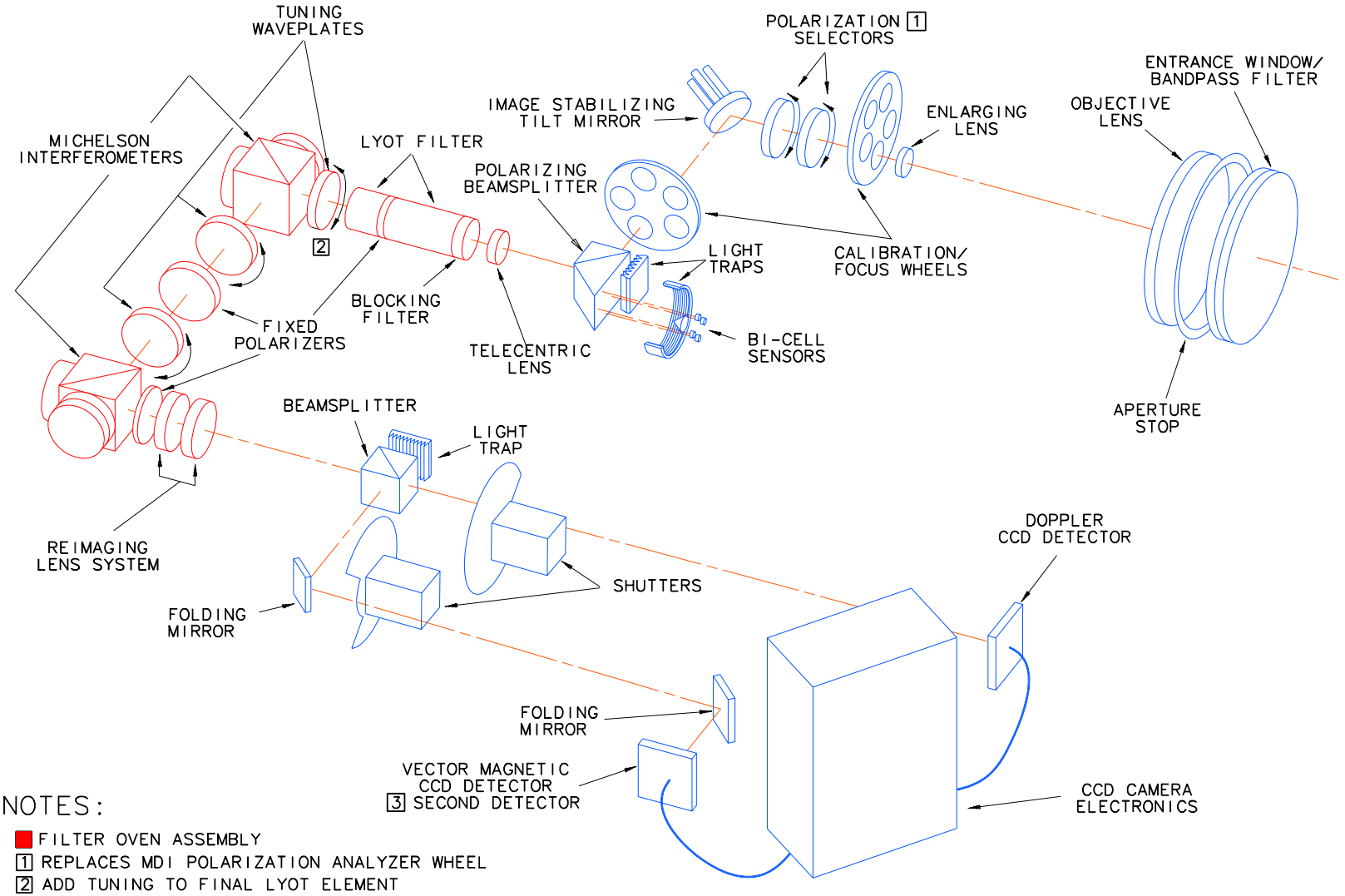
In calibration mode the path through filters for pupil image is similar to solar imaging path



Entrance pupil 14 cm diameter
EFL 485 cm, Total path 225 cm
Image size 4.60 cm for 32.64 arc-min

Beam is telecentric through filters
Focal ratio at final image 34.6
Focal ratio inside Lyot filter 30.3

HMI OPTICAL LAYOUT



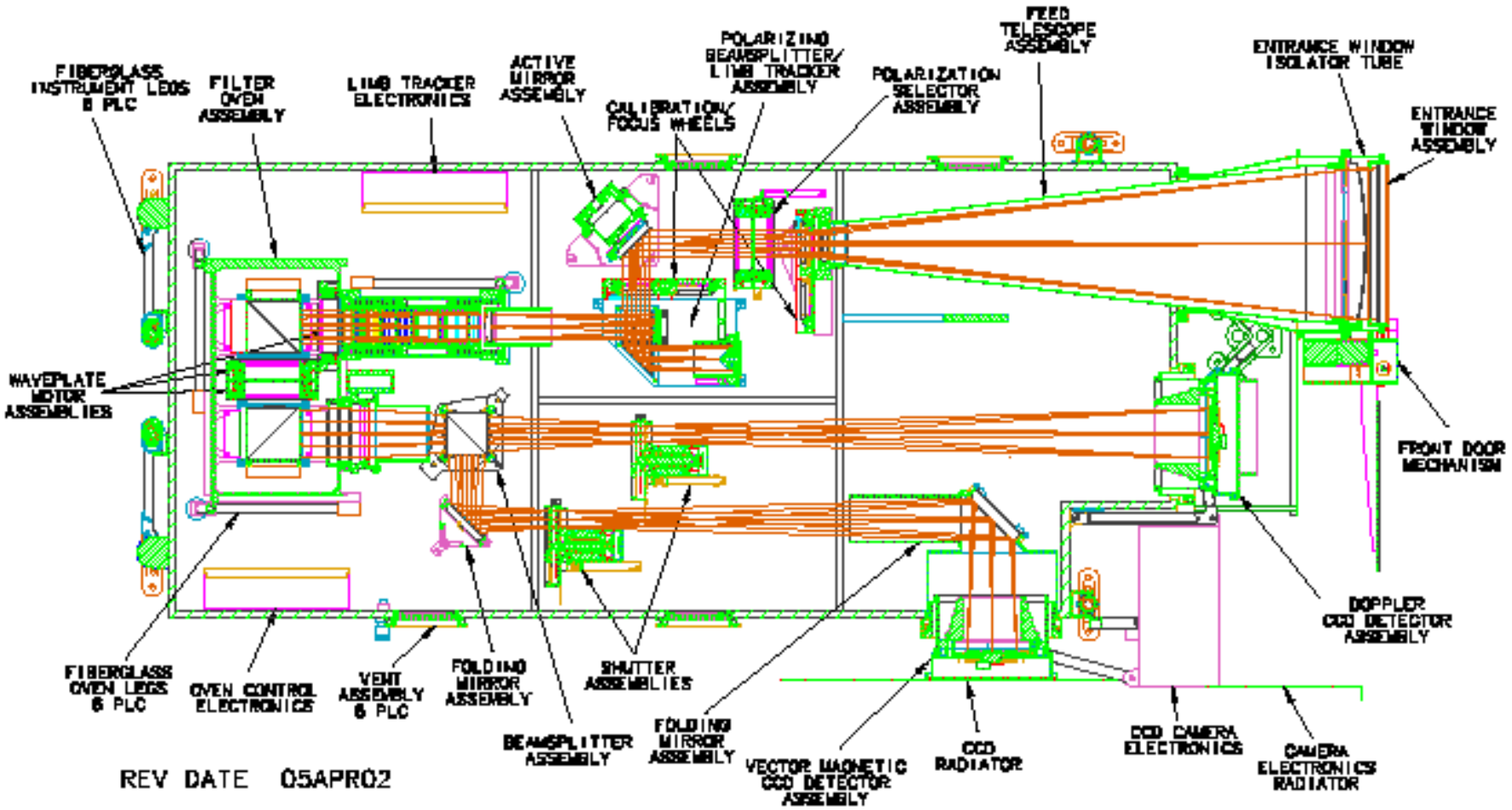
NOTES:

- FILTER OVEN ASSEMBLY
- [1] REPLACES MDI POLARIZATION ANALYZER WHEEL
- [2] ADD TUNING TO FINAL LYOT ELEMENT
- [3] SECOND DETECTOR

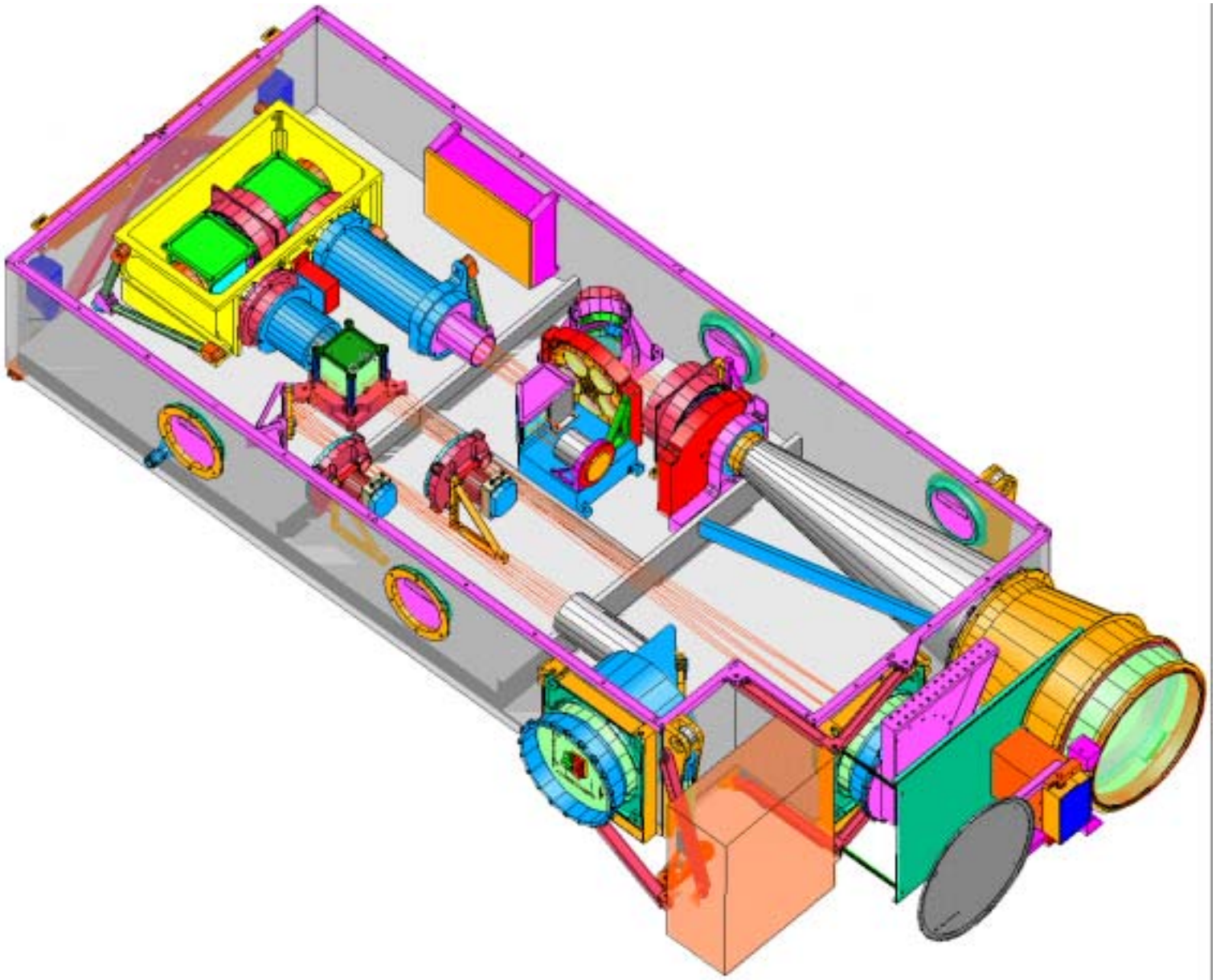
REV DATE 24MAR02

HMI OPTICS PACKAGE LAYOUT

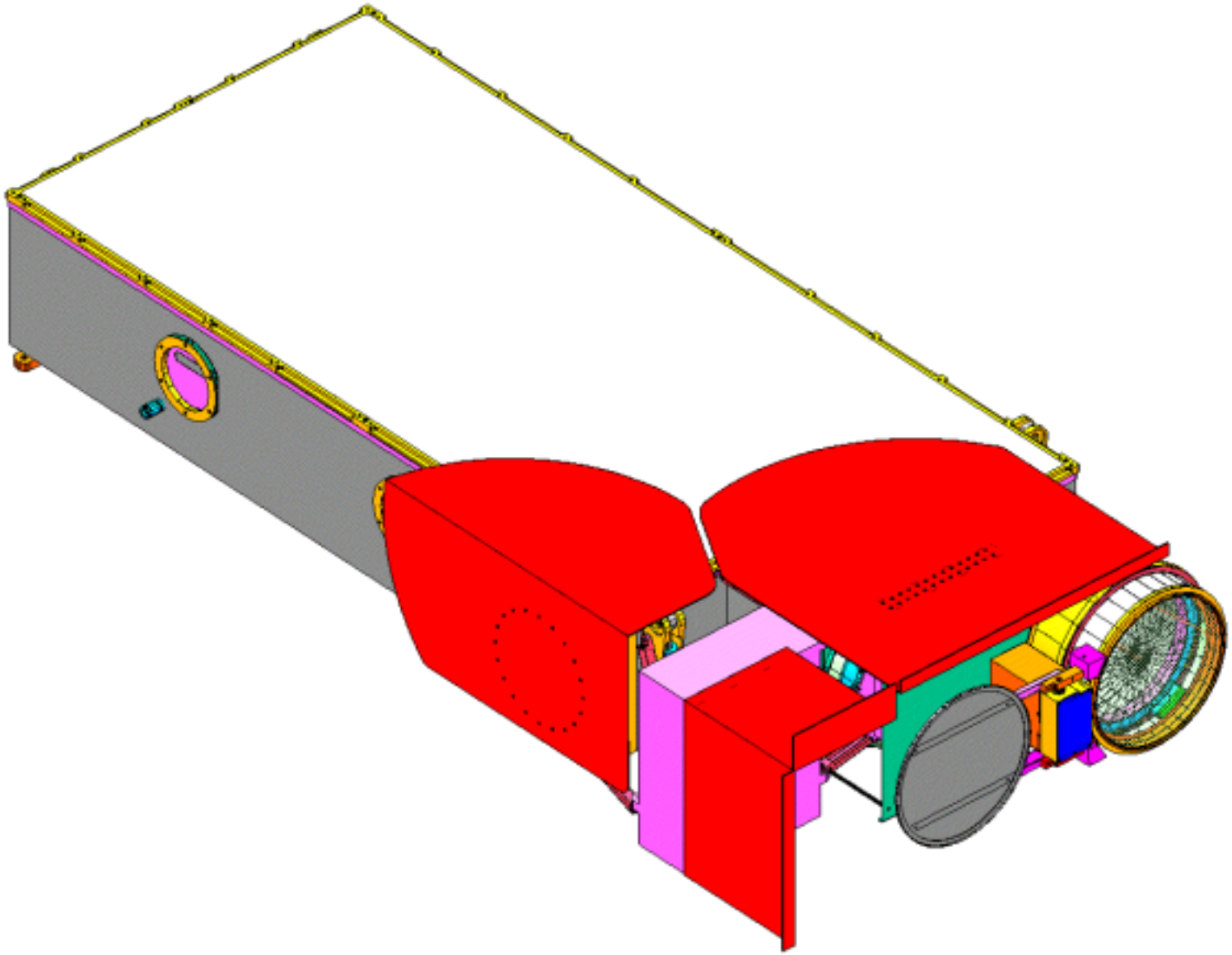
SECTION A-A (THROUGH OPTICAL CENTER PLANE)



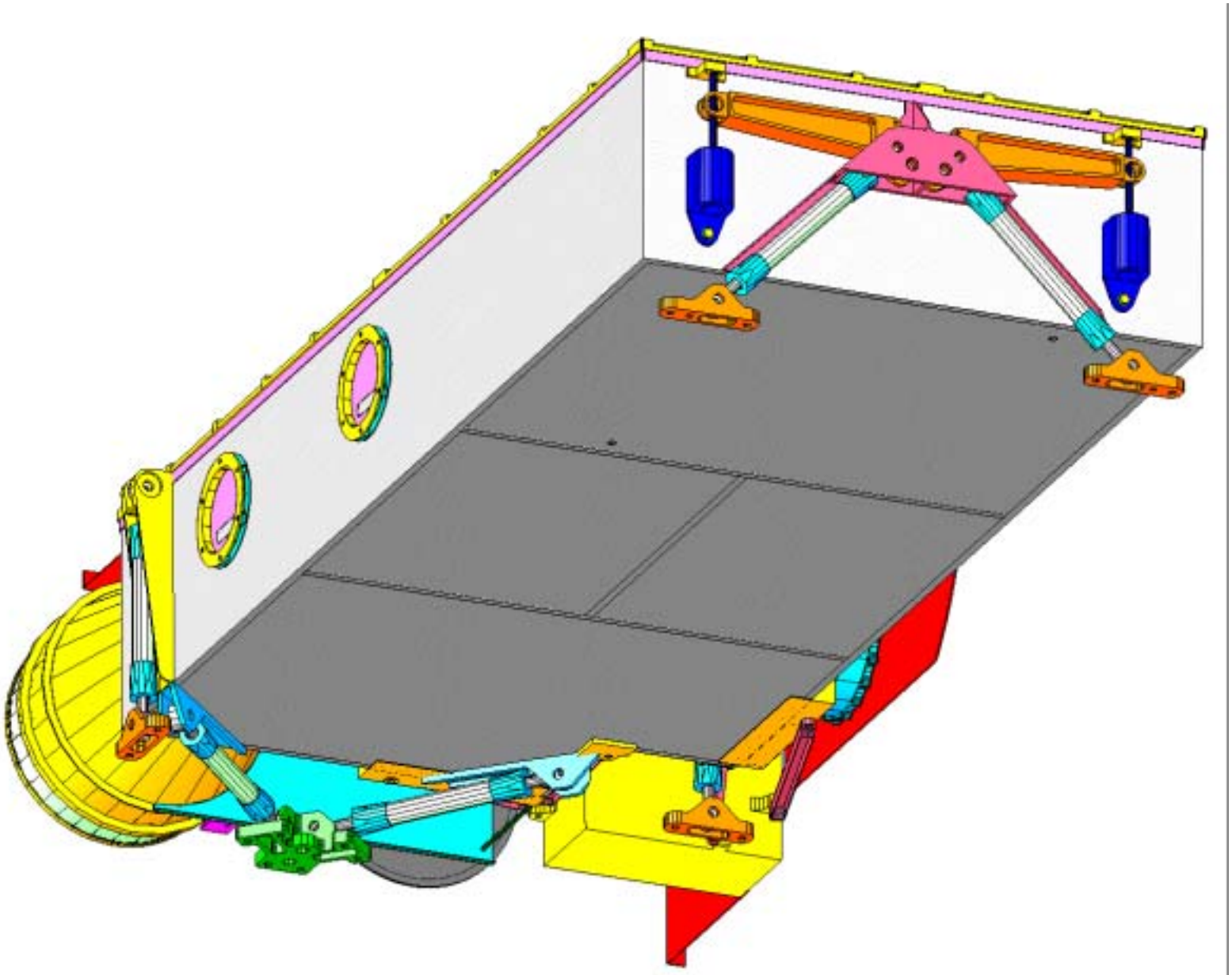
HMI Optics Package Layout

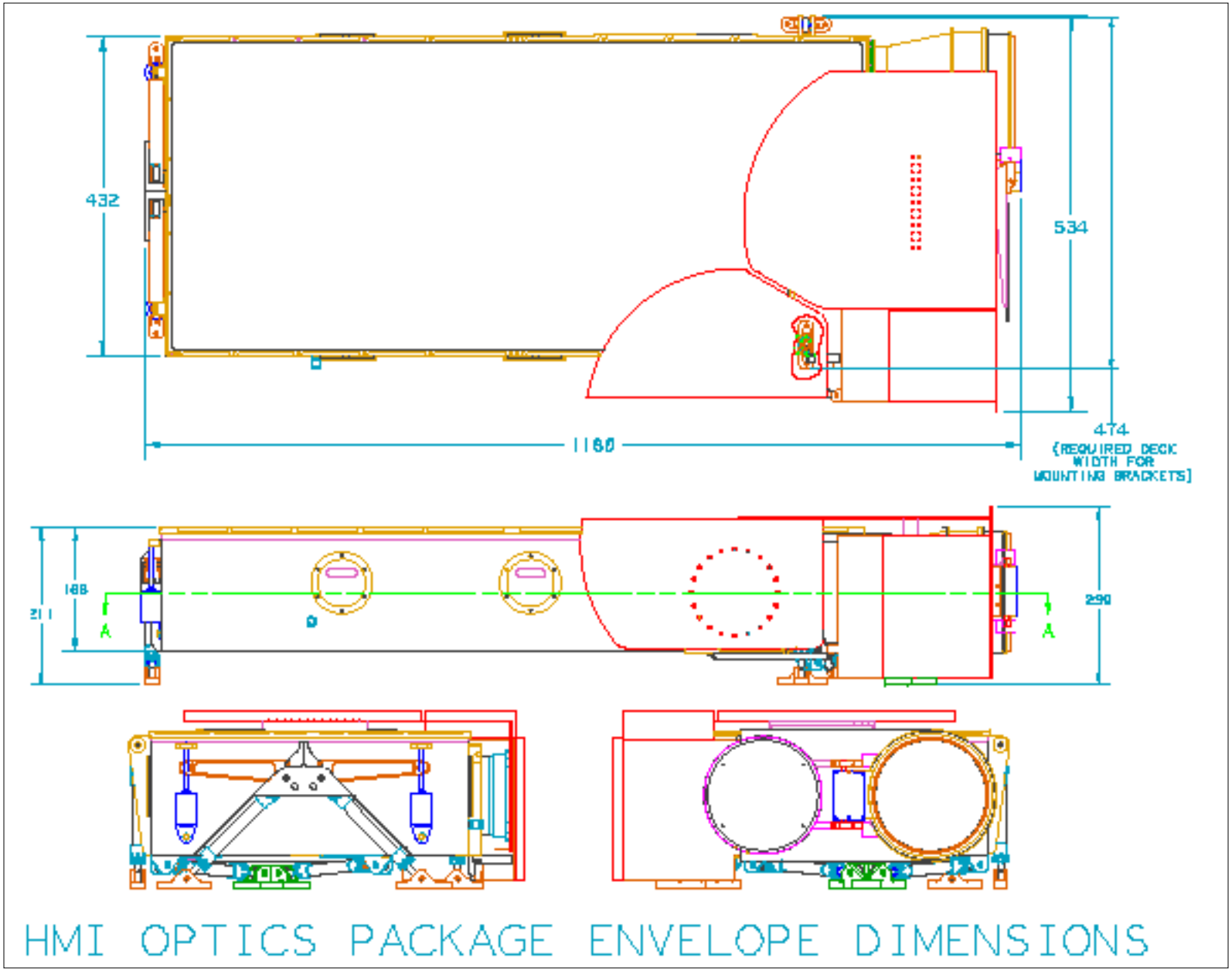


HMI Optics Package Top View

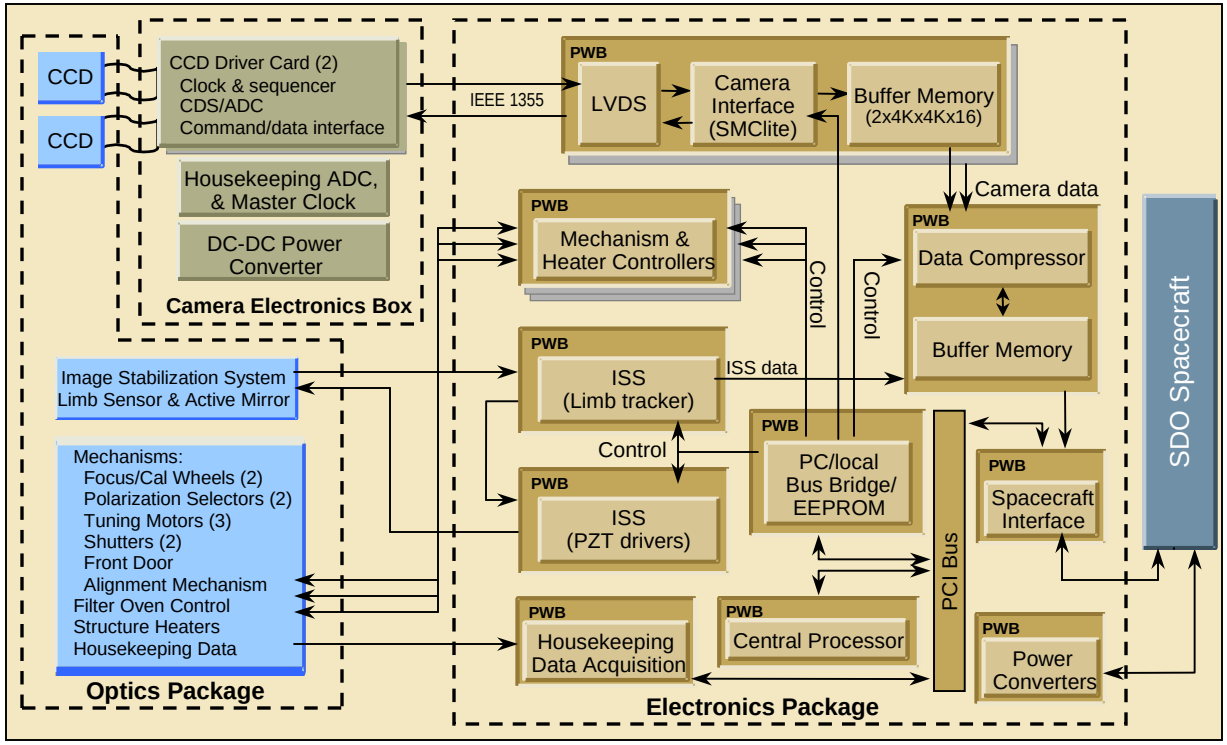


HMI Optics Package Bottom View




432
534
1180
474
(REQUIRED DECK WIDTH FOR MOUNTING BRACKETS)
211
168
290
A
A
HMI OPTICS PACKAGE ENVELOPE DIMENSIONS

HMI Functional Block Diagram



HMI Key Properties	
Field of view	34 arc-minutes
Spatial resolution	1.0 arc-seconds
Observing wavelength	Ni I – 6768 Å
CCD format	4096x4096 pixels
Cadence per camera	4.1 s
Exposure level	125 ke-
Exposure time	250 ms
Image Stabilization	0.1 arc-seconds (3 σ)

HMI Resources	
Optics Package	
Envelope	118 cm x 53 cm x 24 cm
Mass	28 kg
Electronics Package	
Envelope	32 cm x 28 cm x 21 cm
Mass	15 kg
Complete Instrument	
Mass (including cable harness)	46 kg
Power (including operational heater)	60 W
Telemetry	50 Mbit/s
Instrument Reserves	
Mass	9 kg
Power	12 W
Telemetry	5 Mbit/s

Major Implementation Drivers

- CCD Cameras are being provided by British science co-investigators.
- Michelson interferometers will be likely provided by foreign vendors.
- High speed data bus for the image data.

Major Concerns

- Phase A contract implementation and funding including ITAR issues.
- The Education and Public Outreach budget is uncertain, and the method of coordinating with the LWS office is not clear.
- There is not adequate funding for Phase E.

Constraints on SDO

- Data continuity for helioseismology requires 95% recovery of “observables”.
- Spacecraft accommodation is critical for thermal design (need cold CCD’s).
- Implementing “roll steering” and support of periodic offpoint and roll maneuvers puts constraints on spacecraft attitude control.

Possible Design Modifications

- Considering observing in the Fe 6173 Å line (g=2.5) instead of the Ni 6768 Å line (g=1.5) in order to increase magnetic field sensitivity.
- This change can be easily accommodated if incorporated before beginning the detailed instrument design.

Conclusions

- The HMI instrument will be designed and built by the same Stanford/LMSAL team that developed the MDI instrument.
- The MDI instrument has been successfully operating in space for over six years, and provides tremendous experience in the science requirements, instrument development and operations.