CORMAG – CORONAL MAGNETOGRAPH FOR THE STRATOSPHERIC HEMERA MISSION

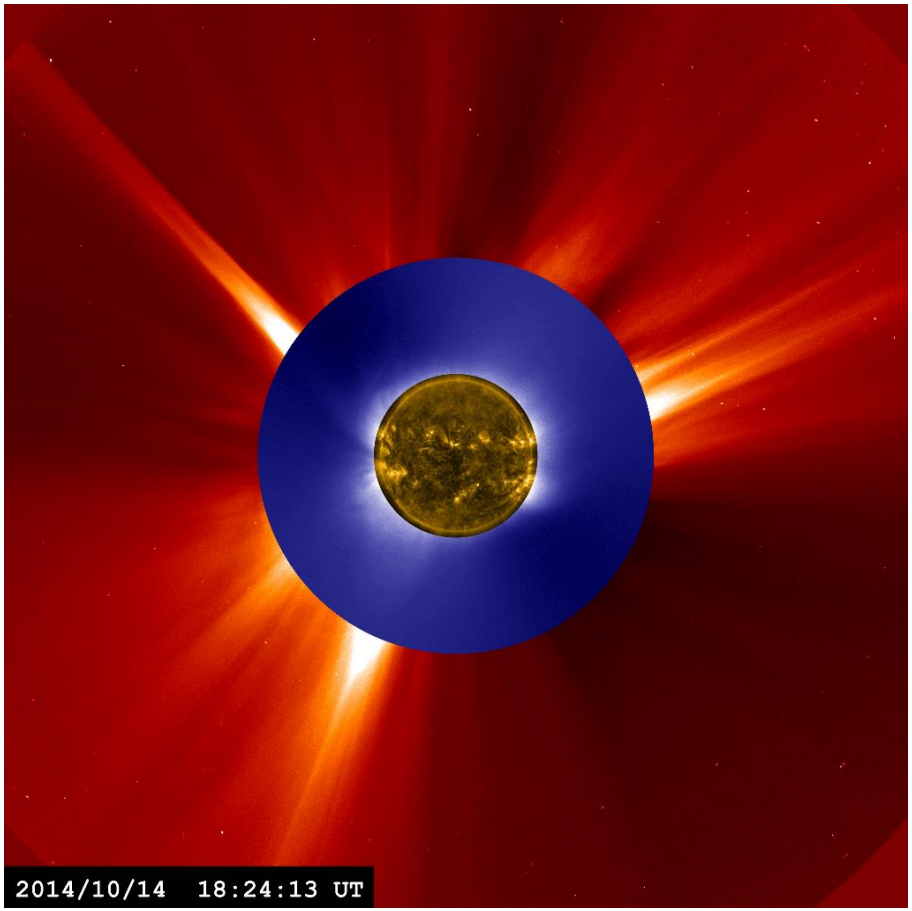
Silvano Fineschi
INAF – Astrophysical Observatory of Torino Italy
On behalf of the CorMag Team

Overview

- Science: Solar Corona & Space Weather
- Instrument: Coronal Magnetograph – CorMag
  - Optical Design
  - Polarization Camera
- Expected Science Performance
- Pointing and Tracking System: autonomous from gondola
- HEMERA: ZPB mission Timmins, Canada (August 2022)

Science Motivation

- Diagnostics of magnetic field topology and dynamics of the solar corona
- Detection and tracking of Coronal Mass Ejections

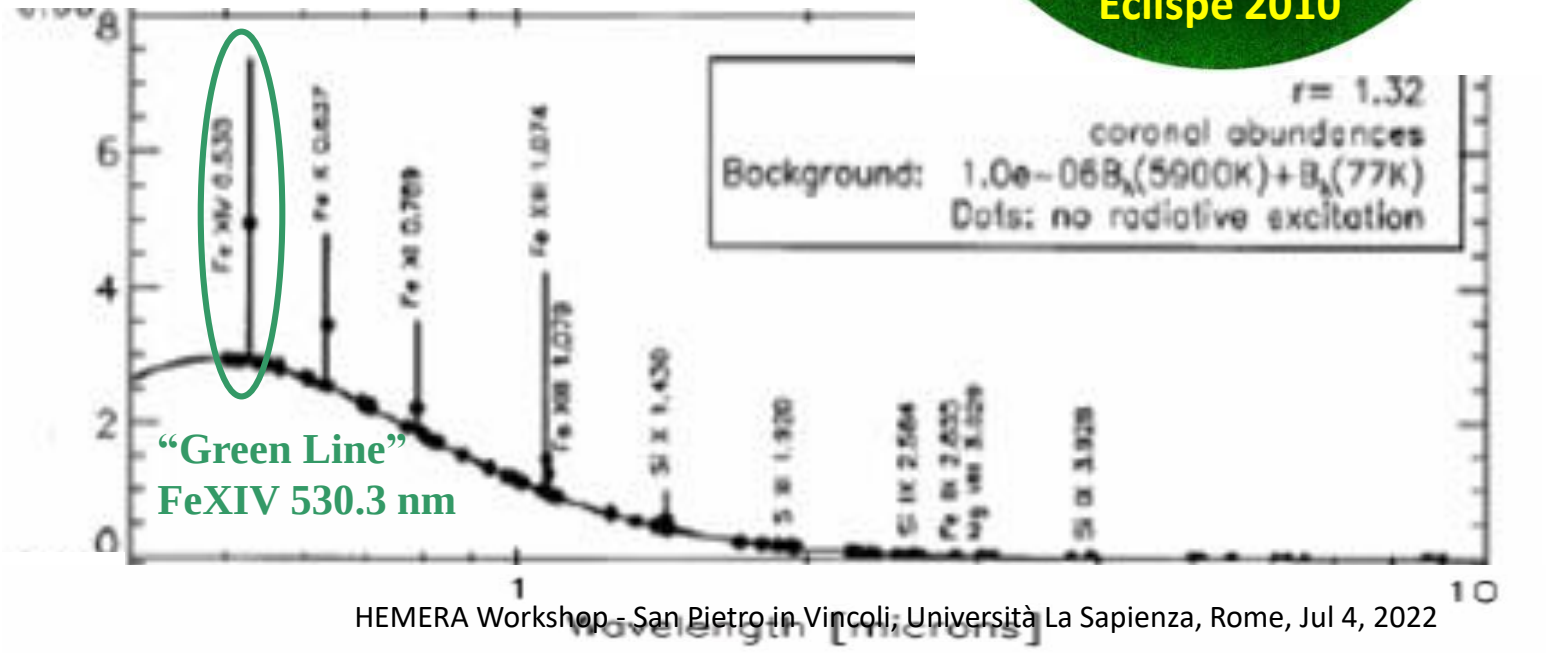


Coronal Magnetic Field Diagnostics

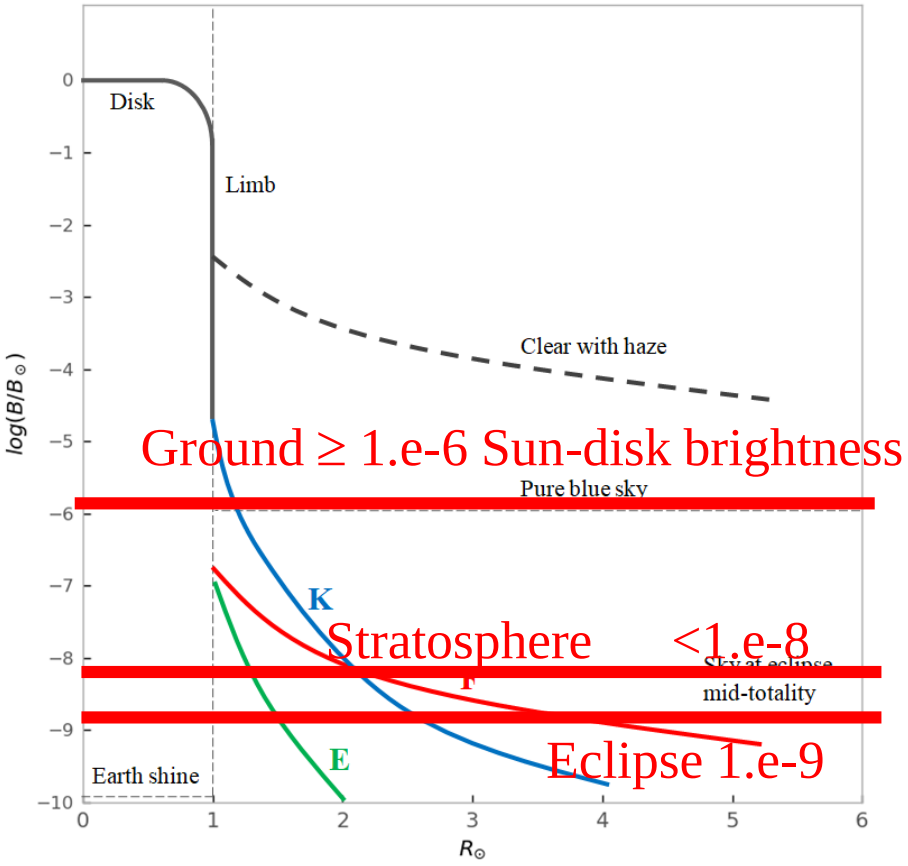
Coronal magnetic field ⇒

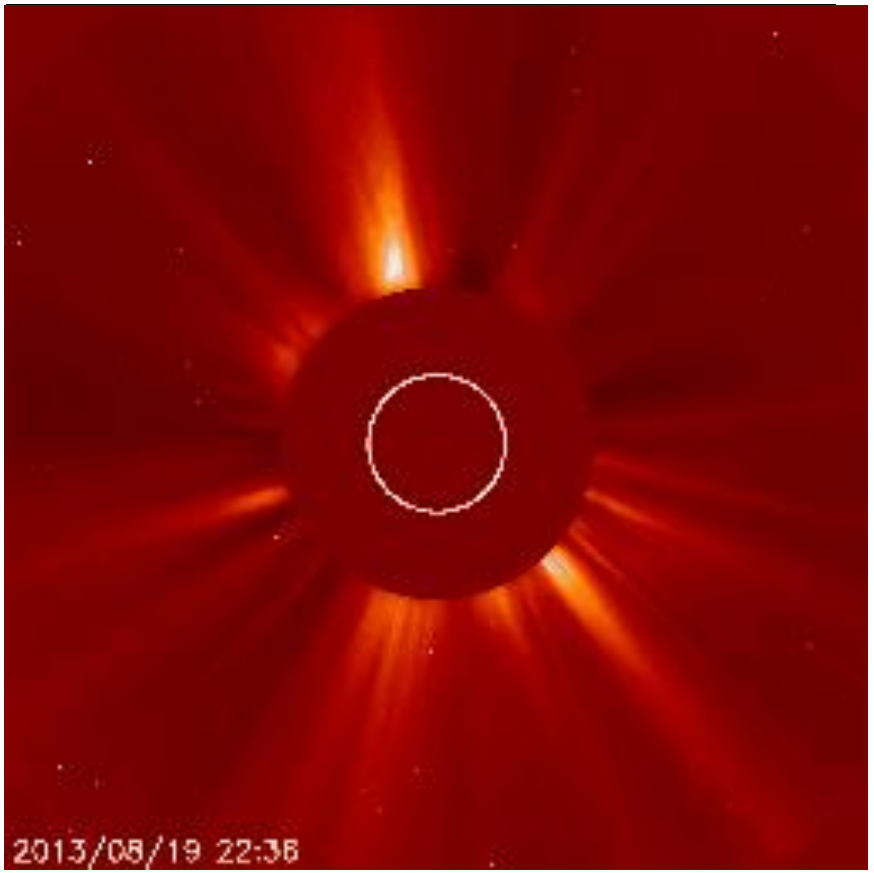
- coronal plasma heating
- acceleration solar wind
- solar storms (Coronal Mass Ejections)

Linear polarization of coronal emission lines ⇒
Topology of magnetic field lines (Hanle effect)



Observing the Corona: Ground-based vs Balloon-borne Coronagraphs





Italy's Heritage in Solar Coronagraphy

ASI funded Italian coronagraphs:

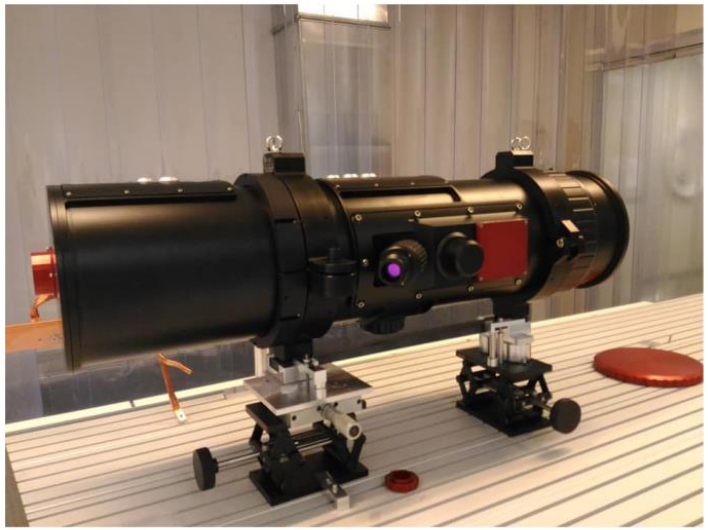
- UVCS on Solar and Heliospheric Observatory 1996 – 2012 (Italy Co-PI)
- Sounding-rocket Coronagraphic Experiment – SCORE on NASA HERSCHEL: 2009 1st launch; 2022 2nd launch (Italy PI)
- ASPIICS on PROBA-3 2020 (Italy Lead Co-I)
- Metis on Solar Orbiter 2020 (Italy PI)

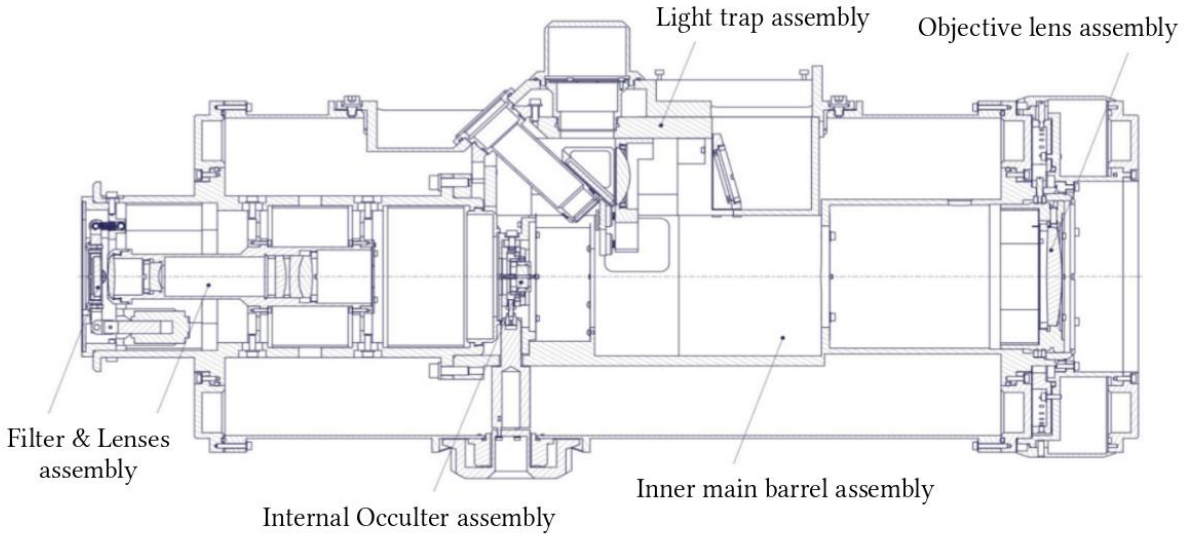
Ancillary heritage. In ALTEC - Turin:

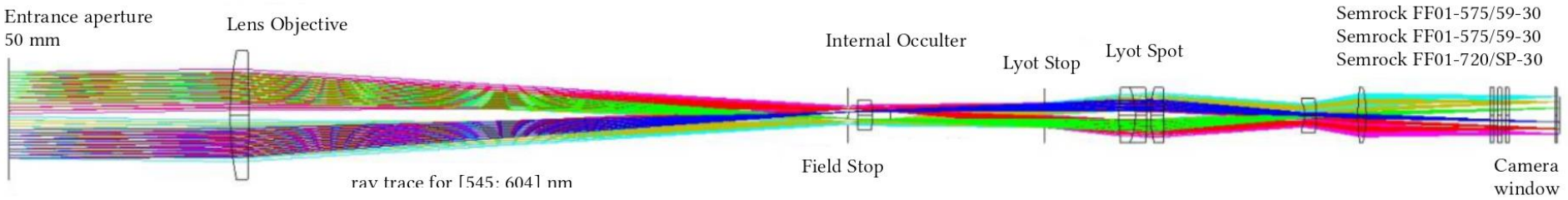
- INAF Optical Payload Systems (OPSys) facility - 2010 (Metis calibrations)
- ALTEC/INAF Heliospheric Center – SWx Data Center - 2017

CorMag Optical Design

Coronal Magnetograph



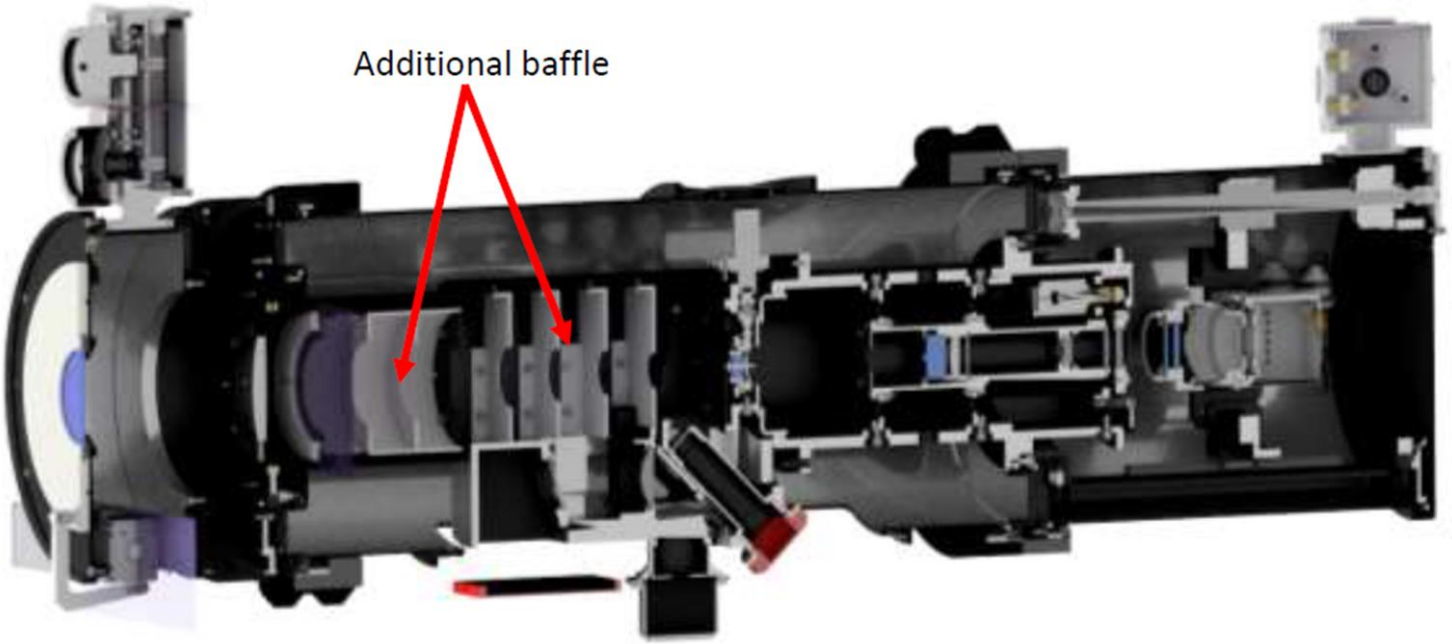




CorMag OptoMech Design

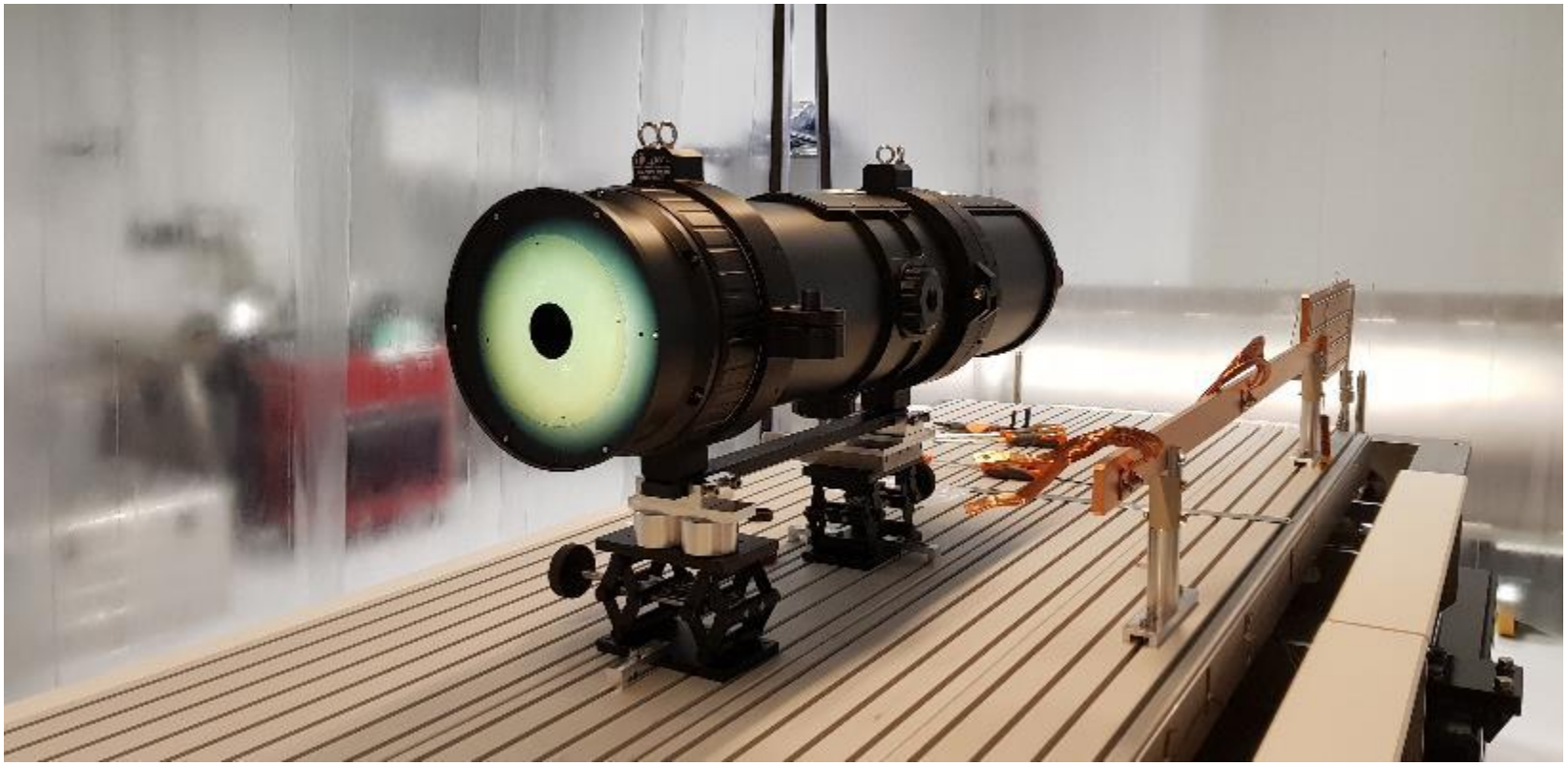
Coronal Magnetograph

Design: Classic internally occulted Lyot coronagraph
Aperture: 50mm
EFL: 700mm (F/14)
Plate scales: 4.3 arcsec (PolarCam with 2x2 binning) and 7.07 arcsec (CCD)
FoV: +/- 0.84° (3.14 Rsun) along diagonal and +/- 0.6° (2.24 Rsun) along X and Y axis for PolarCam
+/- 0.84° (3.14 Rsun) along diagonal and +/- 0.84° (3.14 Rsun) along X and Y axis for CCD



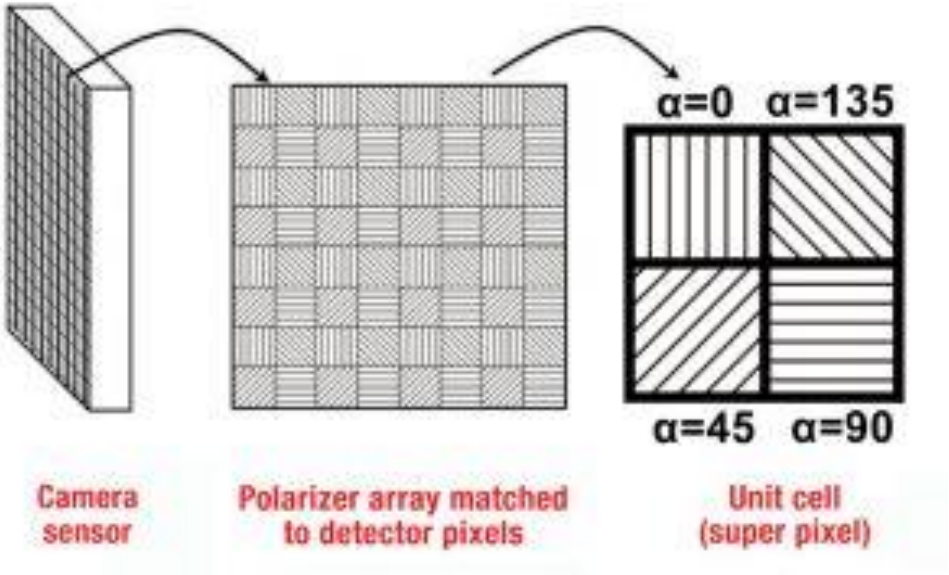
CorMag Ground Testings

INAF Optical Payload System (OPSys) facility with Sun simulator



CorMag Polarization Camera

- **Micro-Polarization Array (MPA)** mask and occulting disk
  - Manufacturer : 4D Technology
  - Pixelated Polarization Mask, aka Micro Polarization Array
  - Coating on the pixelated polarization mask



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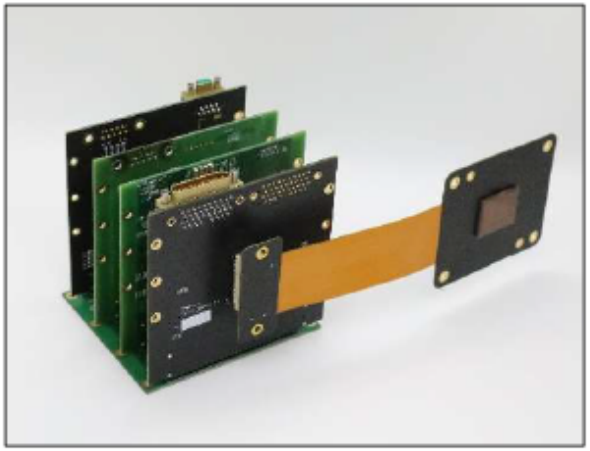
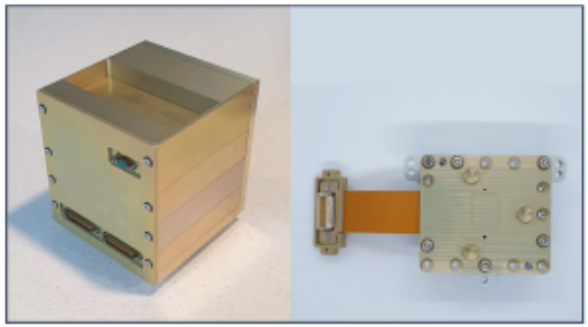
Sensor Type	Interline transfer CCD
Spectral Range	350 nm - 1060 nm
Pixel Size	7.4 µm
Min. Usable Pixels	1950 x 1950
Frame Rate	16 fps
Lens Mounting Type	F-Mount
Interface	GigE Ethernet
Physical Envelope	60 x 60 x 60 mm
	(2.4 x 2.4 x 2.4 in)
Power Requirement	5.5 W, 12 VDC
Weight	379 g (0.84 lbs)
PolarView option	Yes

On-chip image polarization analysis

CorMag Polarization Camera

Pixelated Polarization Camera
with Sony IMX253MZR CMOS Sensor

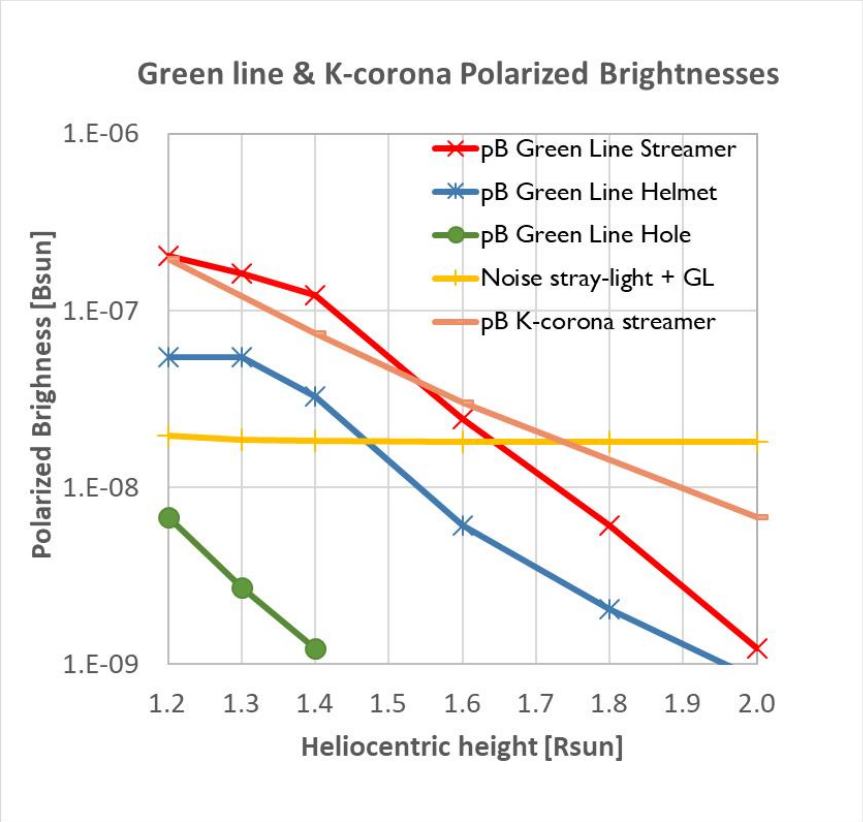


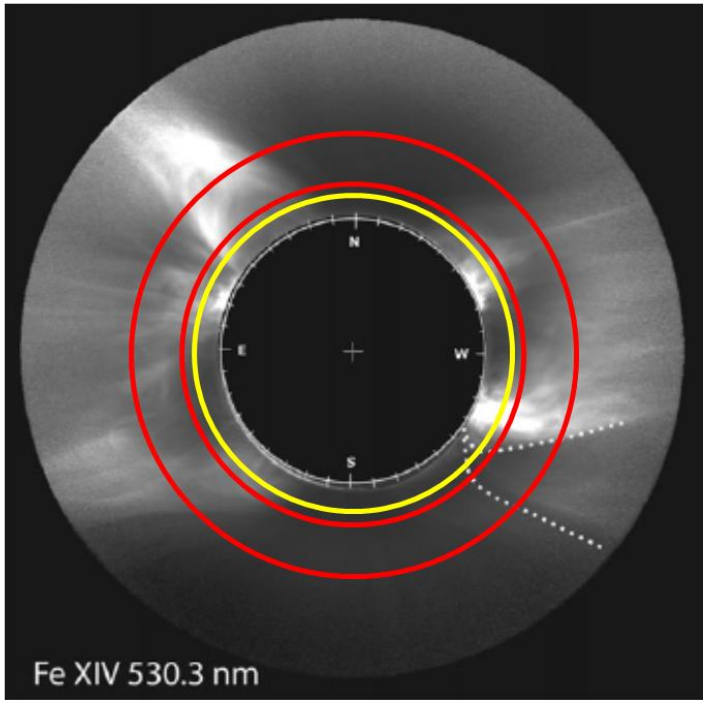


Specification	Description
Sensor Model	Sony IMX253MZR
Sensor Type	CMOS with Pixelated Polarization Mask
Pixel Size	3.45 x 3.45 µm
Pixel Resolution	4096 x 3000
Sensor Size	14.13 x 10.35 mm (Ø 17.52 mm)
Bits Per Pixel	12 bpp
Full Well Capacity	~ 8,800 e^- (10,000 e^- by Sony)
Frame Rate	5 fps (base, max), 10 fps (medium)
Exposure Time	1 ms to 2^{32} ms
Power Consumption	10 W
Input Voltage	26 to 30 VDC
Interface	CameraLink (Base/Medium Mode)
Dimension	100 x 100 x 110 mm
Weight	< 2,000 g

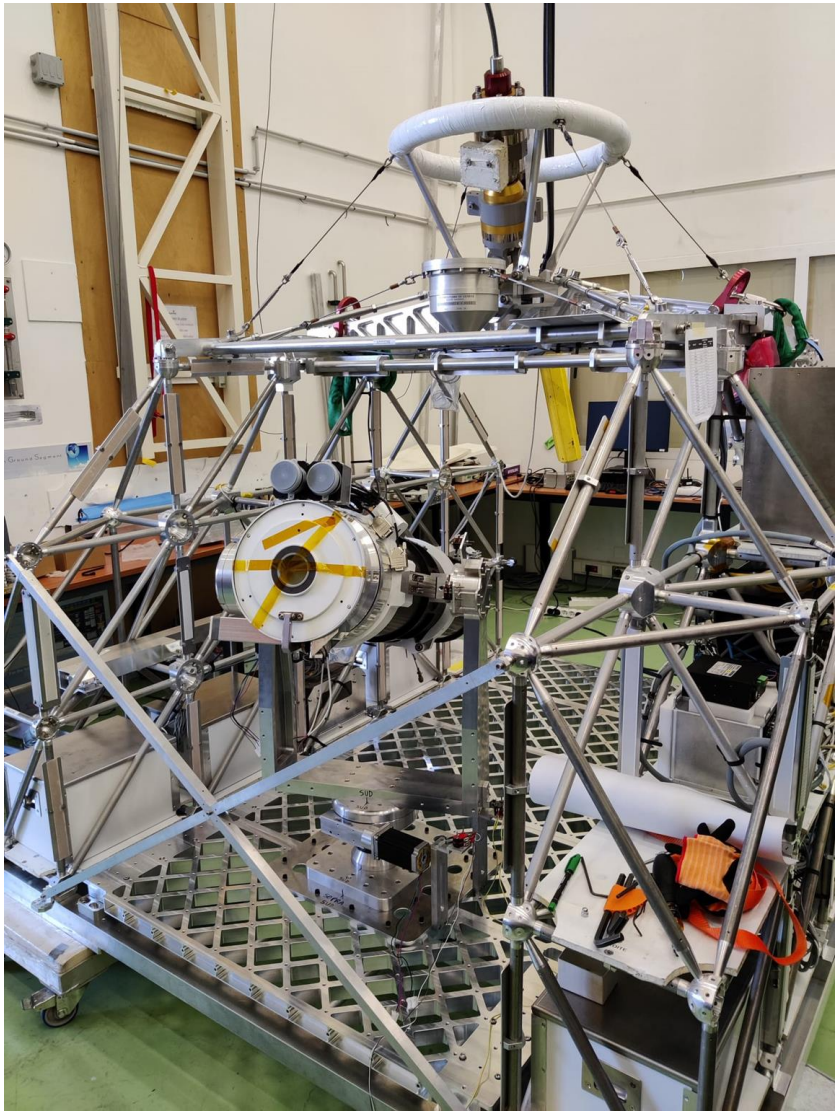
Expected Science Perfomance

Exposure time= 1.5 s
Summing 10 exposures





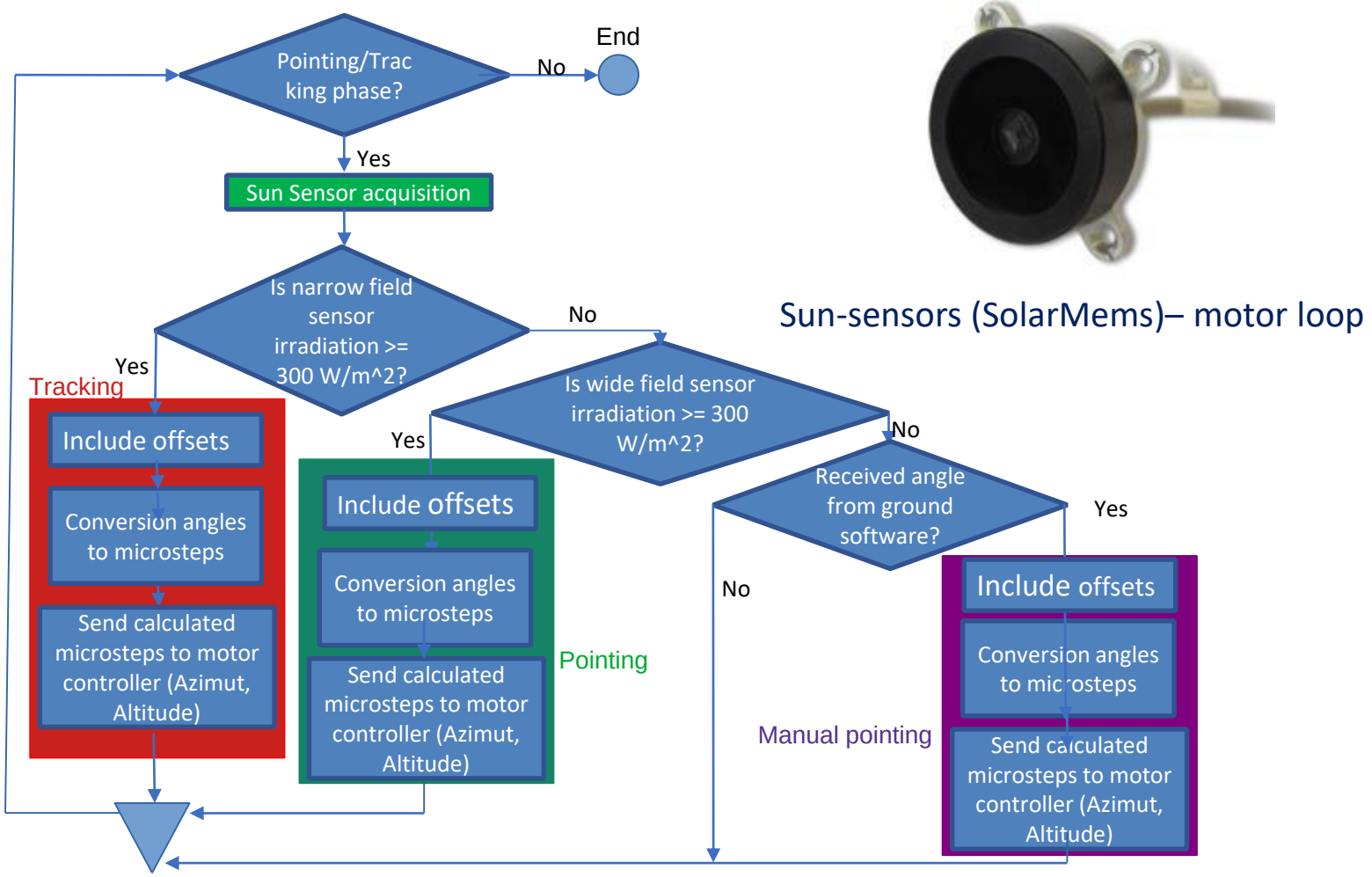
Pointing & Tracking



Pointing and Tracking System Requirements	
Sun-pointing accuracy	±1arcmin
Sun-tracking accuracy	< 10 arcsec/min
Sun-acquisition control system	Autonomous, with possibility of manual commanding: uplink bandwidth 50 kbps
Balloon gondola stability	
gondola rotation	less than 0.1 rpm
Conical pendulum motion of flight train	Frequency: 0.05 Hz Amplitude: < 0.1 deg
Wobbling/oscillation of the gondola around its centre of gravity below its attachment point at the flight train	Frequency: 0.5 Hz to 1.0 Hz Amplitude: 0.1° to 0.5°

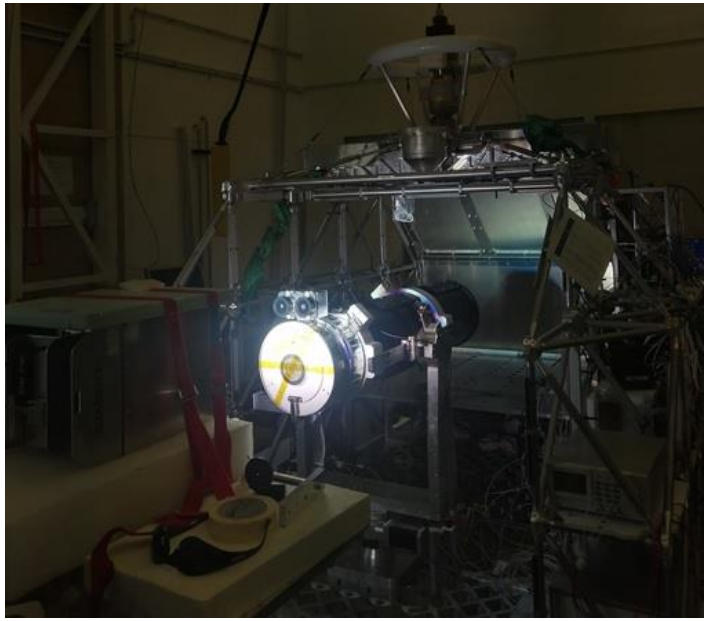
Pointing & tracking & gondola stability

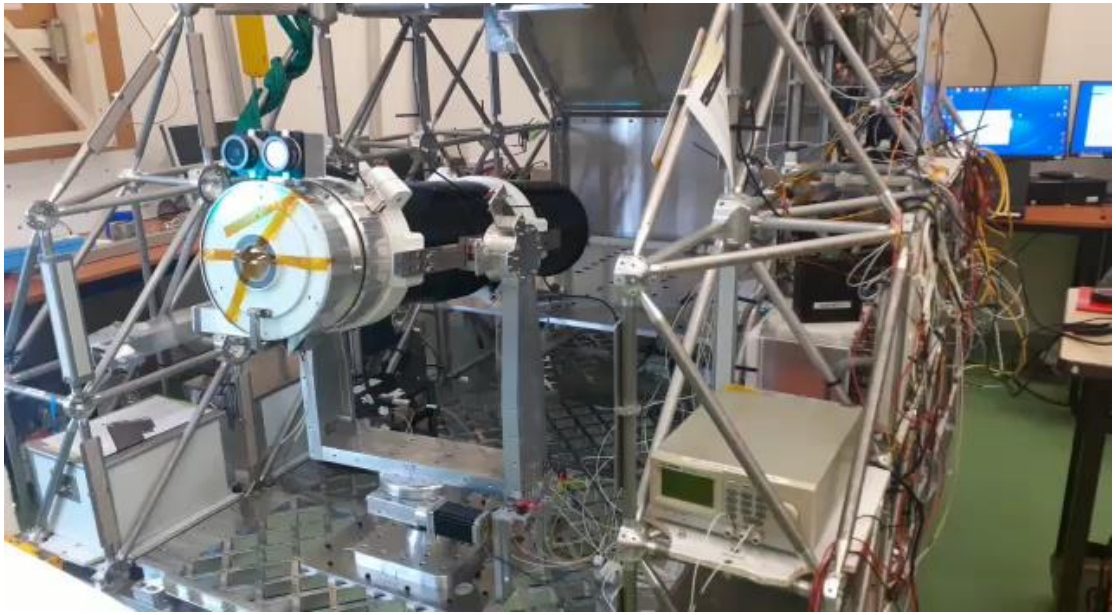
Pointing & Tracking Algo



Sun-sensors (SolarMems)– motor loop

Pointing & Tracking Tests





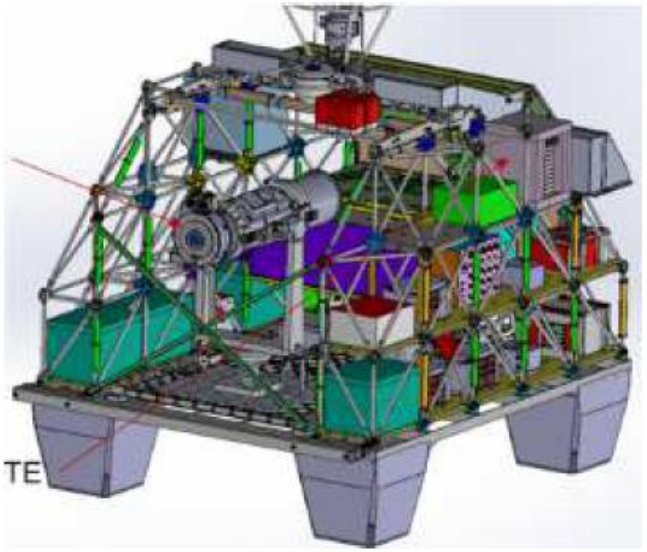
CorMag at CNES Toulouse on the suspended gondola with illumination system

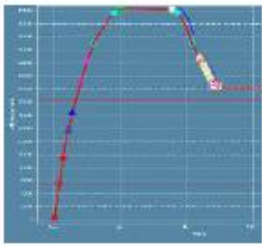
Campaign Schedule & Flight Profiles

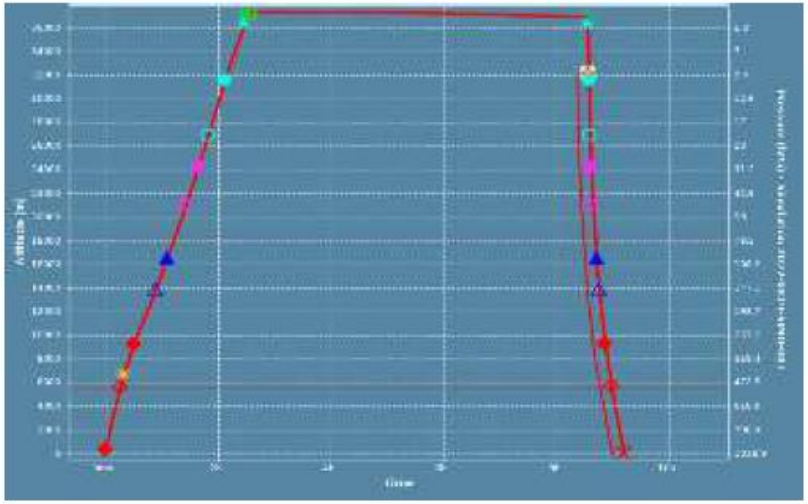
Aug.	1	2	3	4
TIM	✈	Integrati		

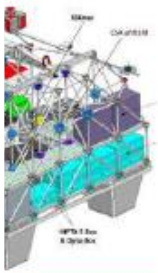
21	22	23	24	25	26	27	28	29	30	31	1	2
							Packing phase				✈	

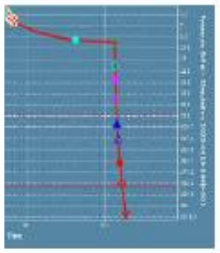
HEMERA 3

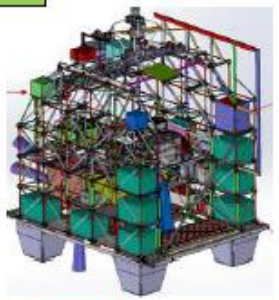


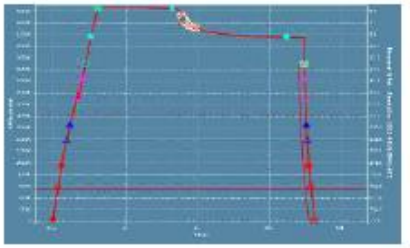












Summary

- **CorMag**: Coronal Magnetograph – Demonstration Model of future space-based coronagraphs for Space Weather.
- **Science Objectives:**
  - Diagnostics of the topology of the coronal magnetic field.
  - Target of Opportunity: Detection of Coronal Mass Ejections.
- **Instrument:** Internally-occulted, Lyot-coronagraph with
  - VL narrow and wide spectral bands alternatively switched by tilting mech.
  - On-chip image polarization analysis with micro-polarizer array.
- **Platform**: High-altitude (30-40 km) 4-6 hours duration, stratospheric zero-pressure balloon
- **HEMERA first launch campaign of CorMag**: summer 2022, Timmins (Canada)