LYOT: LYman Orbiting Telescopes

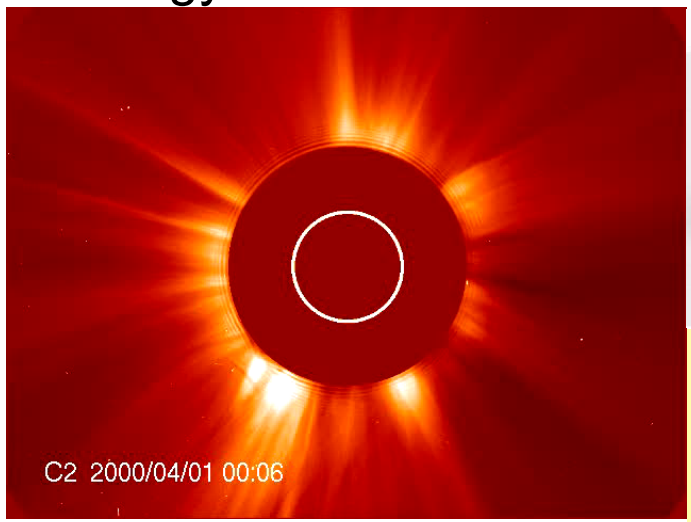
Jean-Claude Vial (PI) et Frédéric Auchère

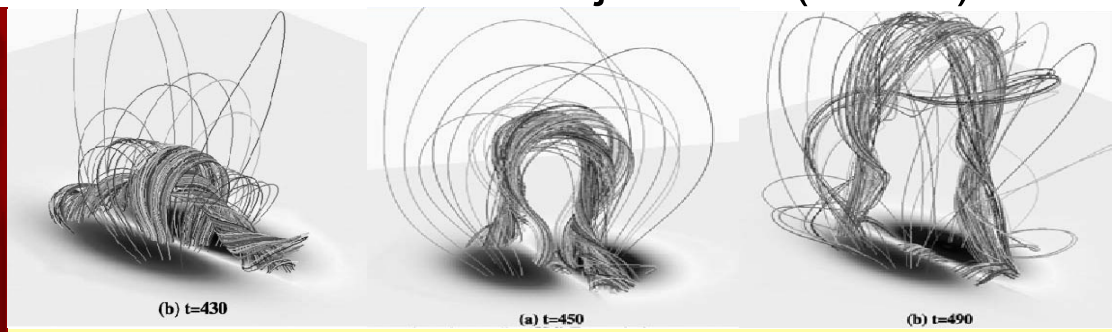
Institut d'Astrophysique Spatiale

and The LYOT Team Project:
Frédéric Rouesnel, Thierry Appourchaux, Michel Berthé, Bernard Cougrand, Catherine Cougrand, Cydalise Dumesnil, Philippe Duret, Jean-Jacques Fourmond, Jean-Christophe Le Clec'h, Benjamin Lustrement, Anne Millard, Gilles Morinaud, Guillaume Prévôt and Xueyan Song-Zhang

Main Scientific Objectives

- Energy release and the Initiation of Coronal Mass Ejections (CMEs)





Several models (e.g. flux rope, Amari et al. 2003, breakout Aulanier et al. 2001)

None are totally satisfactory

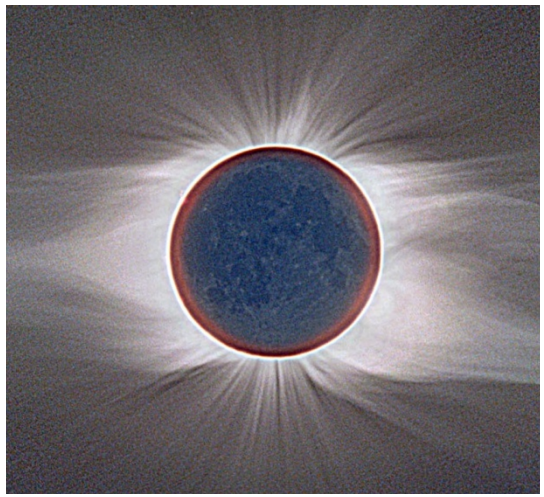
  - How is the magnetic energy stored ? Field topology ?
  - What triggers the instability ? Precursors ?
  - At what height does the magnetic reconnection occur ?

To answer these questions, one needs to observe the region, **unobserved today**, of CME initiation

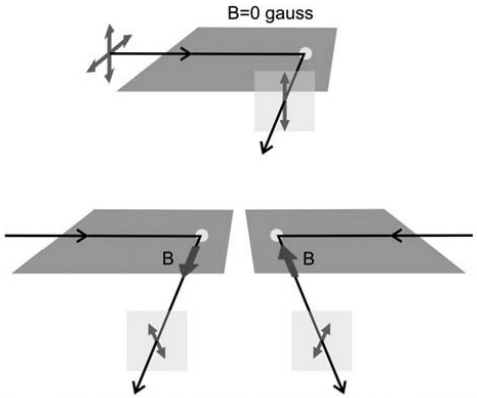
- Energy transport during flares
- Large-scale current sheets in the corona

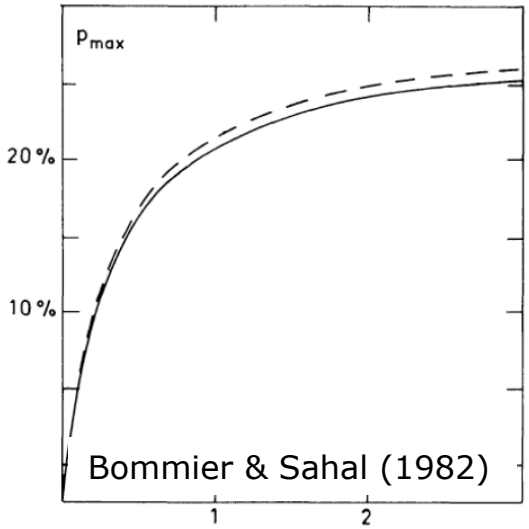
Complementary Scientific Objectives

- Measurements of the coronal magnetic field



Hanle effect





- The chromosphere-corona interface

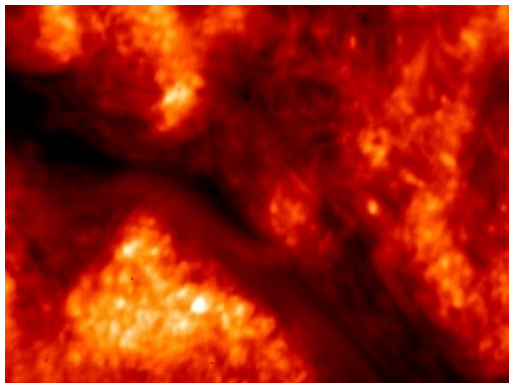
Further studies of interest

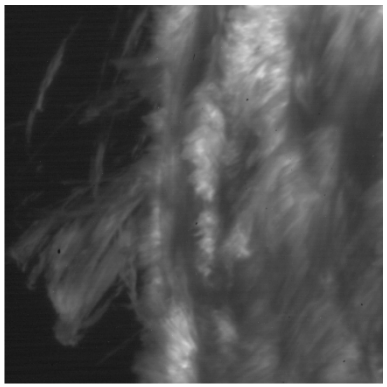
- Spatial and temporal variability of the Lyman α irradiance
- Origin of solar energetic particles

Why Lyman α ?

Chromo-sphere

cold



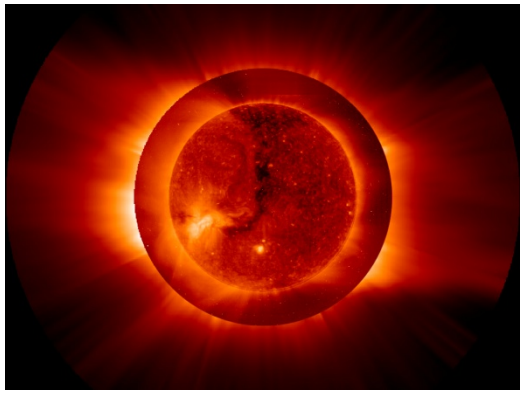


Filaments, prominences, spicules, **flares**, etc.

Chromosphere – corona coupling

Corona

hot



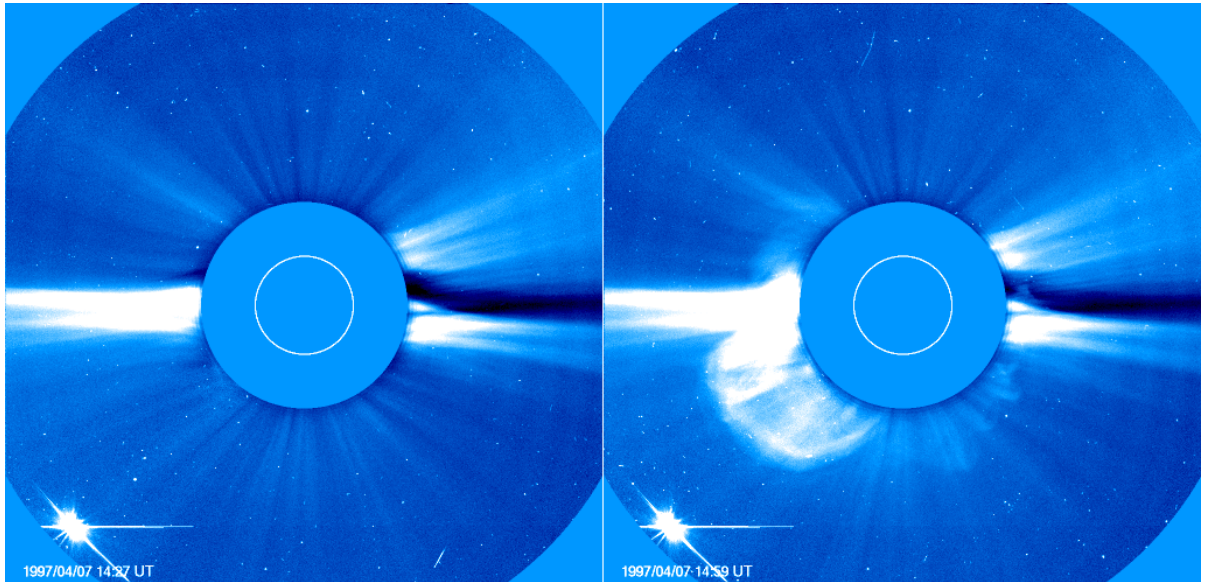
CMEs, prominence eruptions,

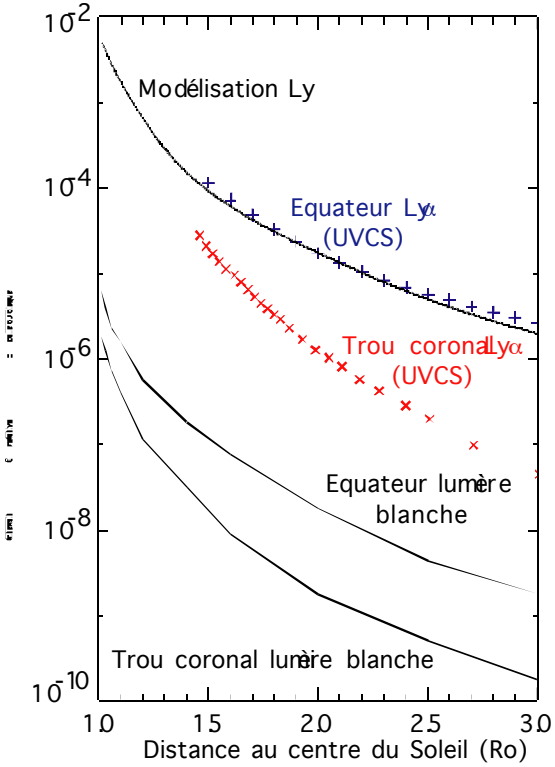
current sheets, plasmoids, etc.

B: Hanle effect

Other advantages of Lyman α

- **Factor 1000 gain** on the disk / corona contrast
- **Access to the inner corona** (1.15 $R_\odot$)
- **High resolution** imaging (low scattered light)
- **No F corona** (dust)





LYOT performances specifications

Specifications	LADI	LACI
Wavelength	121.6 nm	121.6 nm
FOV	1.2 Rs	1.15 Rs to 2.5 Rs
Spatial resolution	1.12 arcsec / pixel	2.35 arcsec / pixel
Dynamic range	$3\ 10^4$	$7\ 10^5$
Spectral purity	>95%	>90%
Cadence	0.2 s to 20 s	2 s to 120 s
Observing modes	Watching & event	Watching & event
SNR (photometry + electronics + compression)	>10	>1 at 2.5 Rs
Polarisation	N/A	• R_s min = 25% for photometry • Rp/Rs = $4.\ 10^{-3}$ • Possibility of total brightness images
Scattered light	< signal across the FOV	< signal across the FOV
Absolute calibration	10%	30%
Pointing accuracy	<29"	<29"
Pointing stability	0.4" over exposure time (1σ)	0.8" over exposure time (1σ)

LYOT OPTICAL DESIGN

LACI – DESIGN

Aperture size: 40 mm

Field of View: 1.15 to 2.5 Rs (0.307° to 0.668°)

Optical layout and focal length: 540 x 260 x 90 (mm^3) and 900 mm

Focal plane resolution: 2k x 2k with pixel size 10 µm x 10 µm

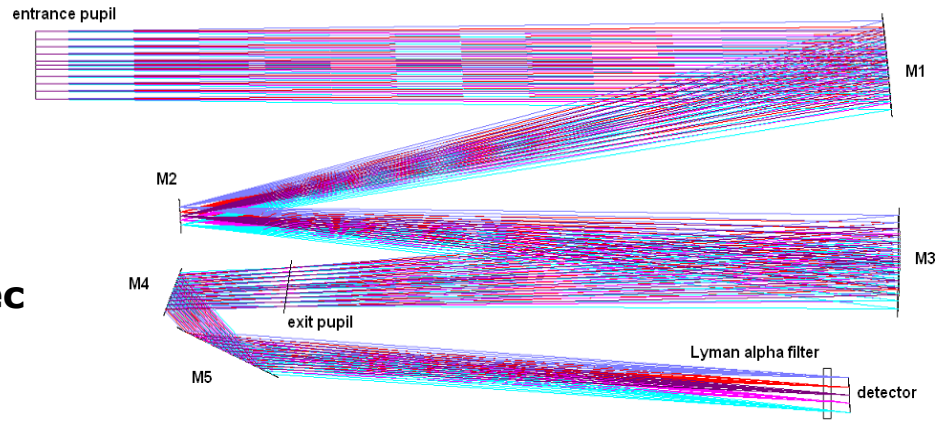
Pixel area equivalent FOV: 2.35 arcsec

Design constraints:

- **reflective optics**
- **superpolished first optics coated**
- **cleanliness**

Internally occulted coronagraph (Lyot)

- No loss of resolution
- More compact
- Stray-light



LACI Raytracing

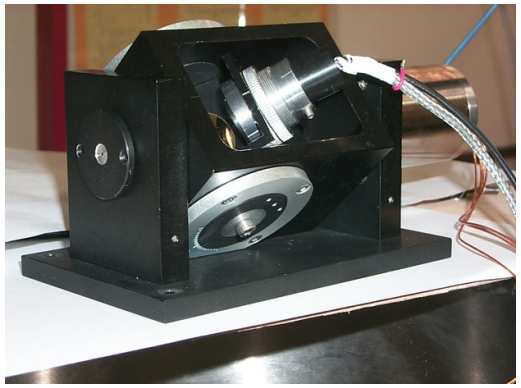
LYOT OPTICAL DESIGN
LACI / POLARIZER – DESIGN 1/2

Main drivers:

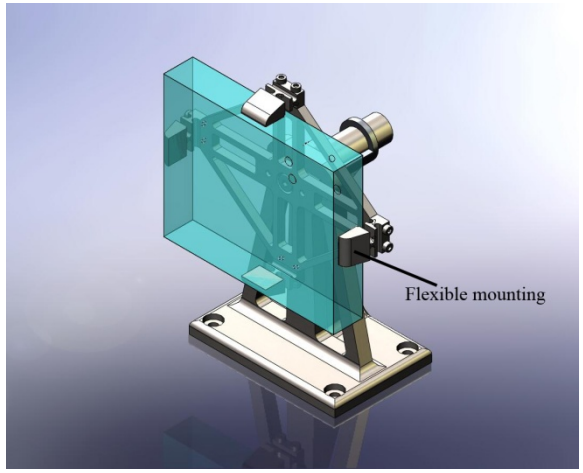
- **Rs min :** better than 25%
- **Rp/Rs:** better than 4 10^{-3}
- **Angle of acceptance:** Rs min & Rp/RS fulfilled on FOV
- **Capability to perform both polarized and unpolarized imagery**

Optical features:

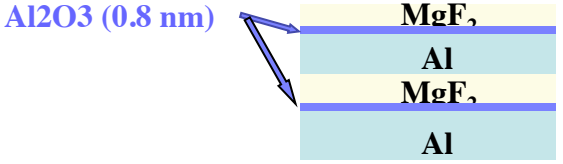
- M5 : flat mirror composed of two segments with different coatings (multilayers with MgF2/Al) for polarized/unpolarized imagery

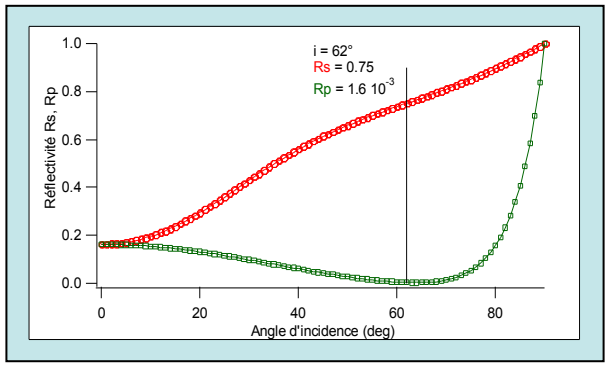


UV Polarizer Development
for test @ Fracasti



INSTITUT d'OPTIQUE GRADUATE SCHOOL





i = 62° Rs = 0.75 Rp = 1.6 10^{-3}

Rp/Rs = 2.13 10^{-3}

LYOT OPTICAL DESIGN

LADI - DESIGN

Aperture size: 40 mm

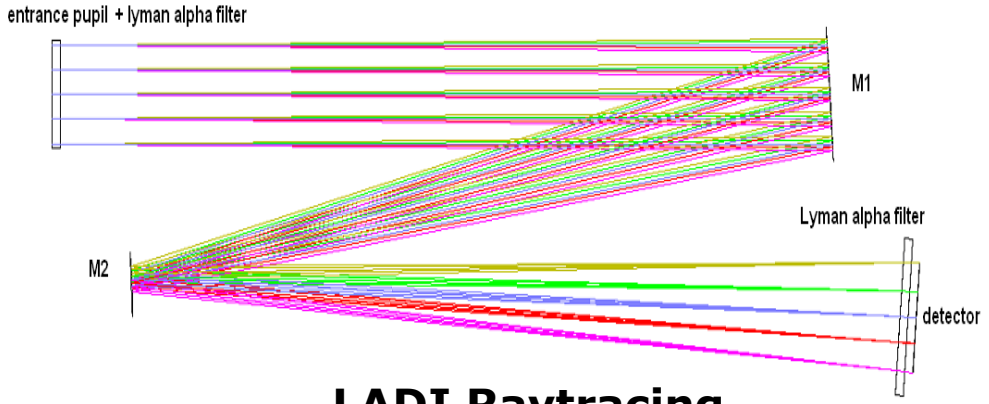
Field of View: 0 to 1.2 Rs (0° to 0.32°)

Optical layout and focal length: 500 x 90 x 40 (mm3) and 3960 mm

Focal plane resolution: 2k x 2k with pixel size 22µm x 22 µm

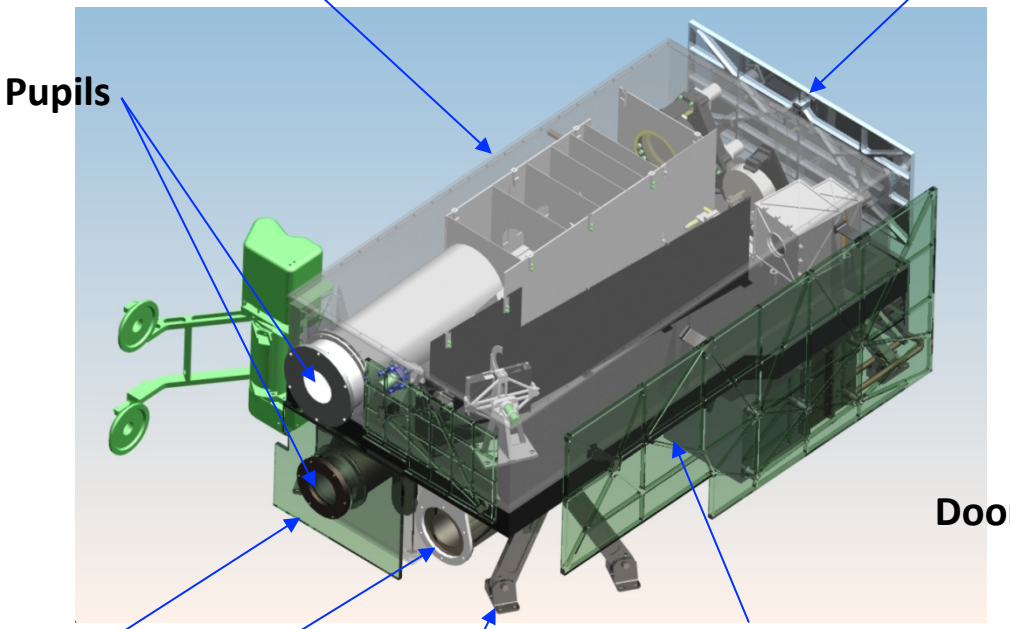
Pixel area equivalent FOV: 1.12 arcsec

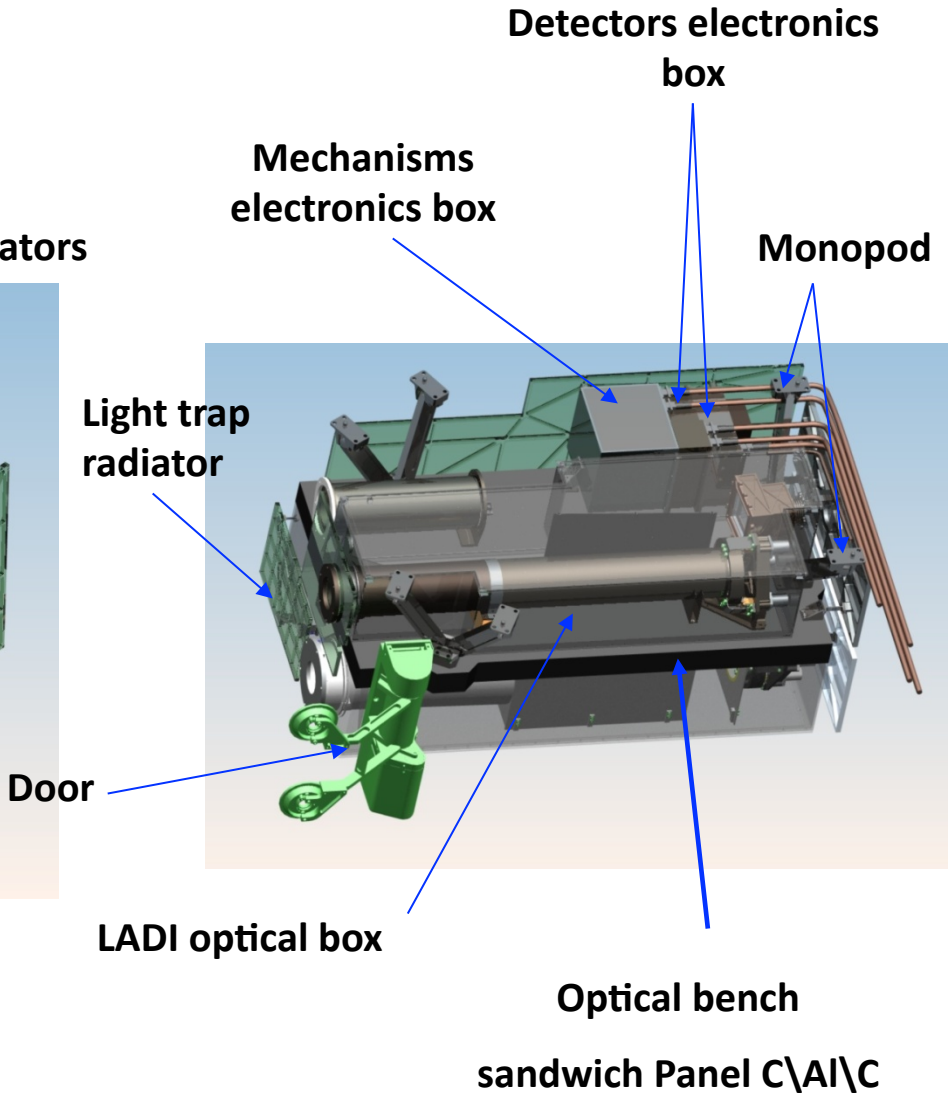
Spectral selection: obtained by using two Lyman α filters



LADI Raytracing

LYOT Overview





Conclusions

- **LYOT answers keys issues in solar physics**

  Initiation / propagation of CMEs

  Structuring role of the coronal magnetic field

  Chromosphere / corona coupling

- **Unique capabilities**

  First images of the Lyman α corona since 1970

  Continuous disk / corona observations at Lyman α

  First continuous measurement of the coronal magnetic field