Solar Sounding Rocket Experiment CLASP2

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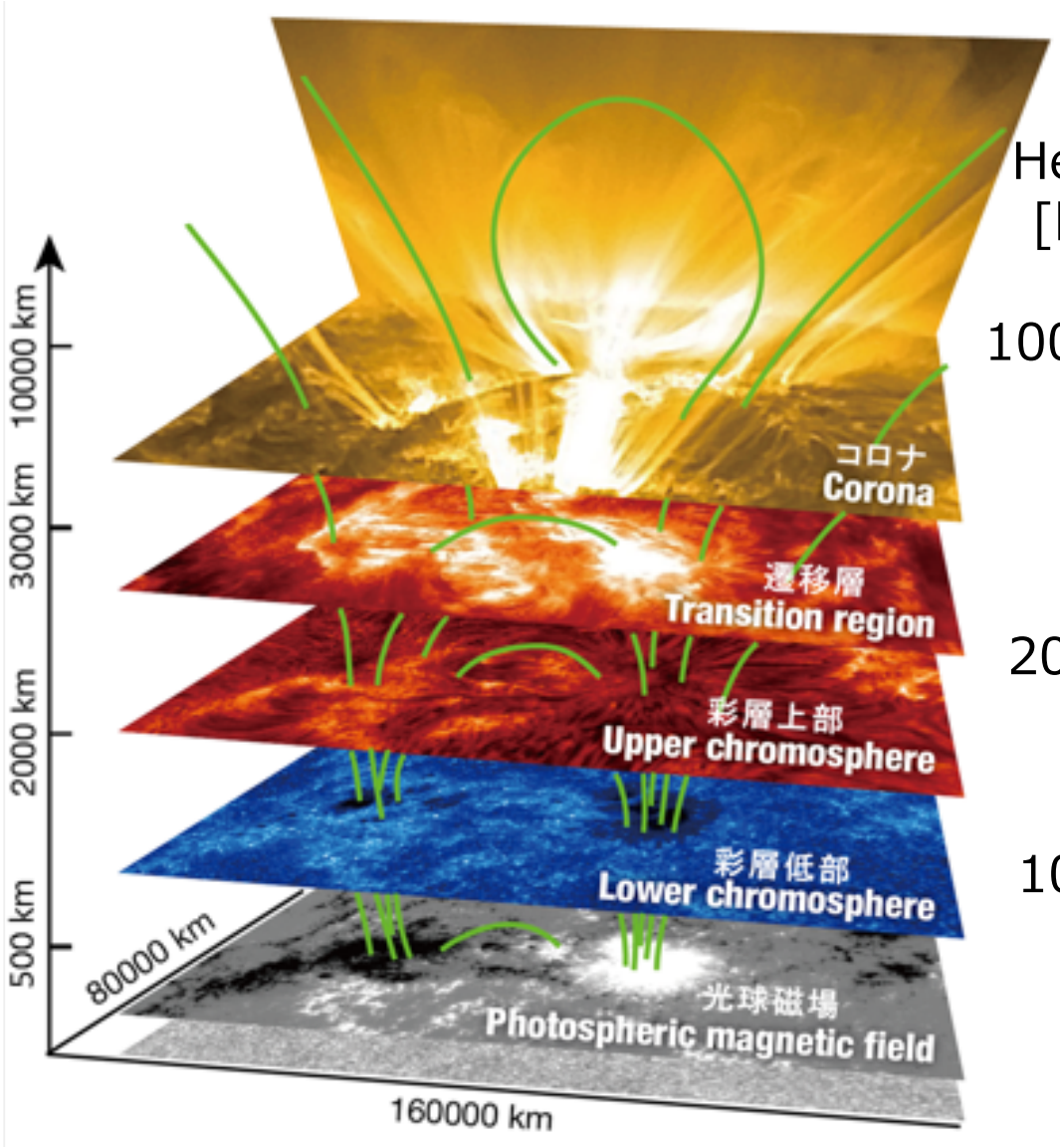
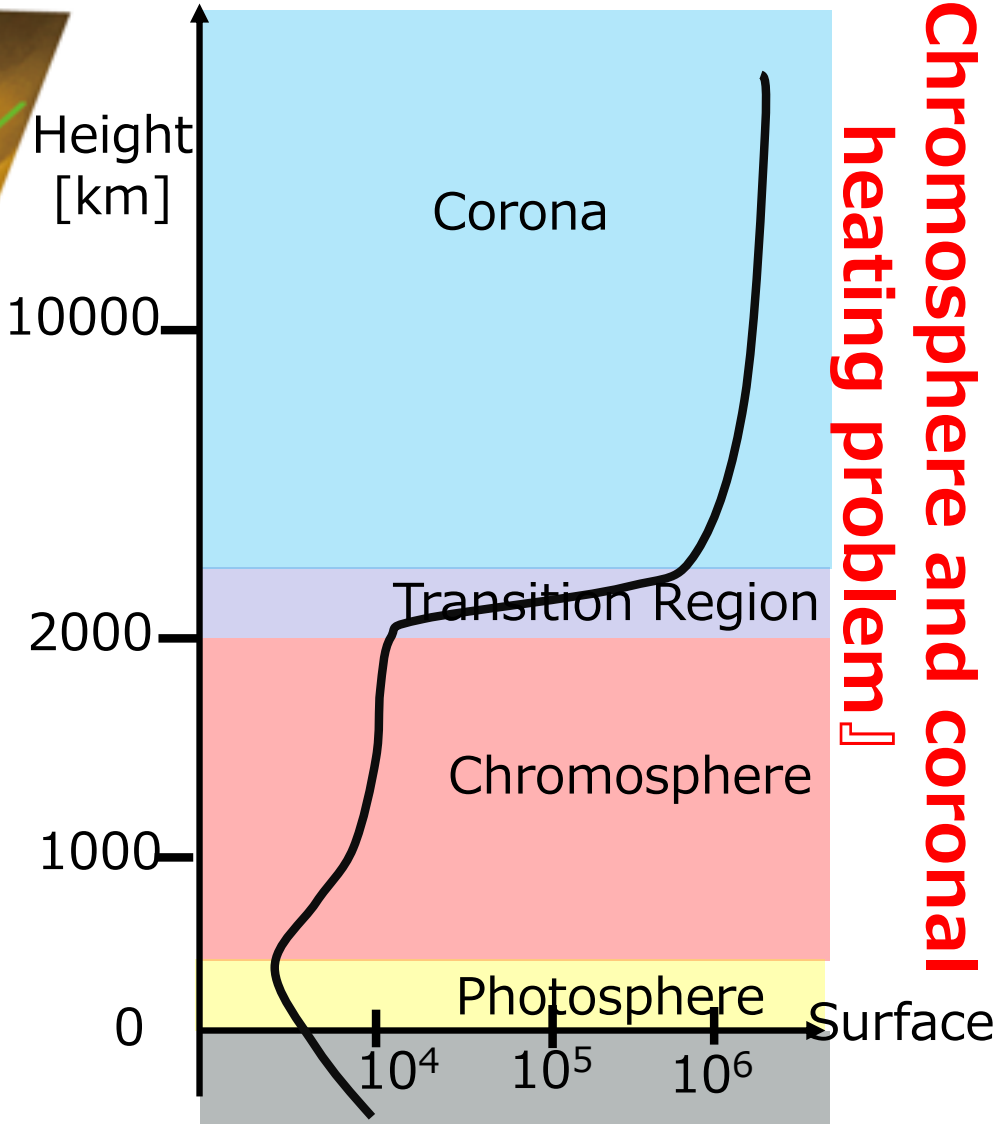
Credit: US Army photo, White Sands Missile Range

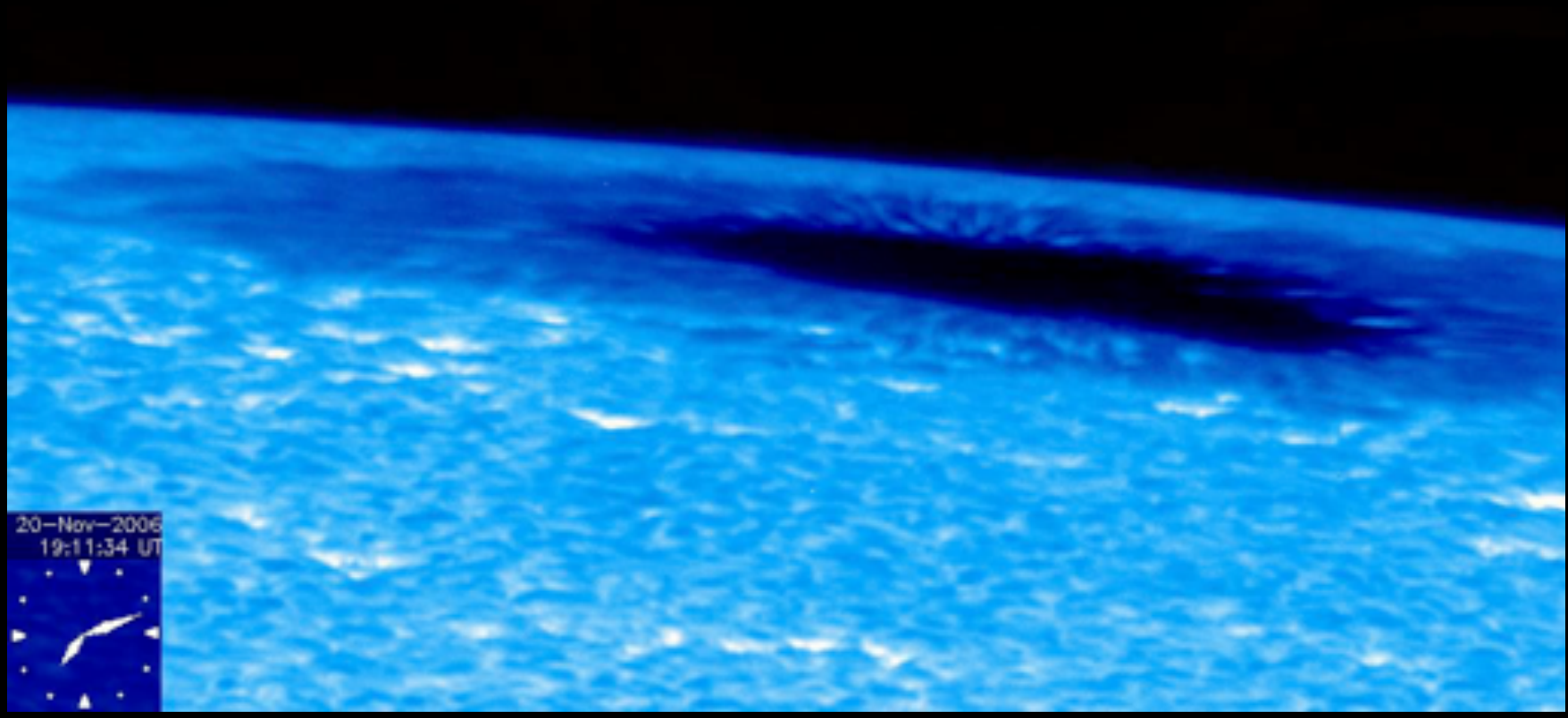
Solar atmosphere

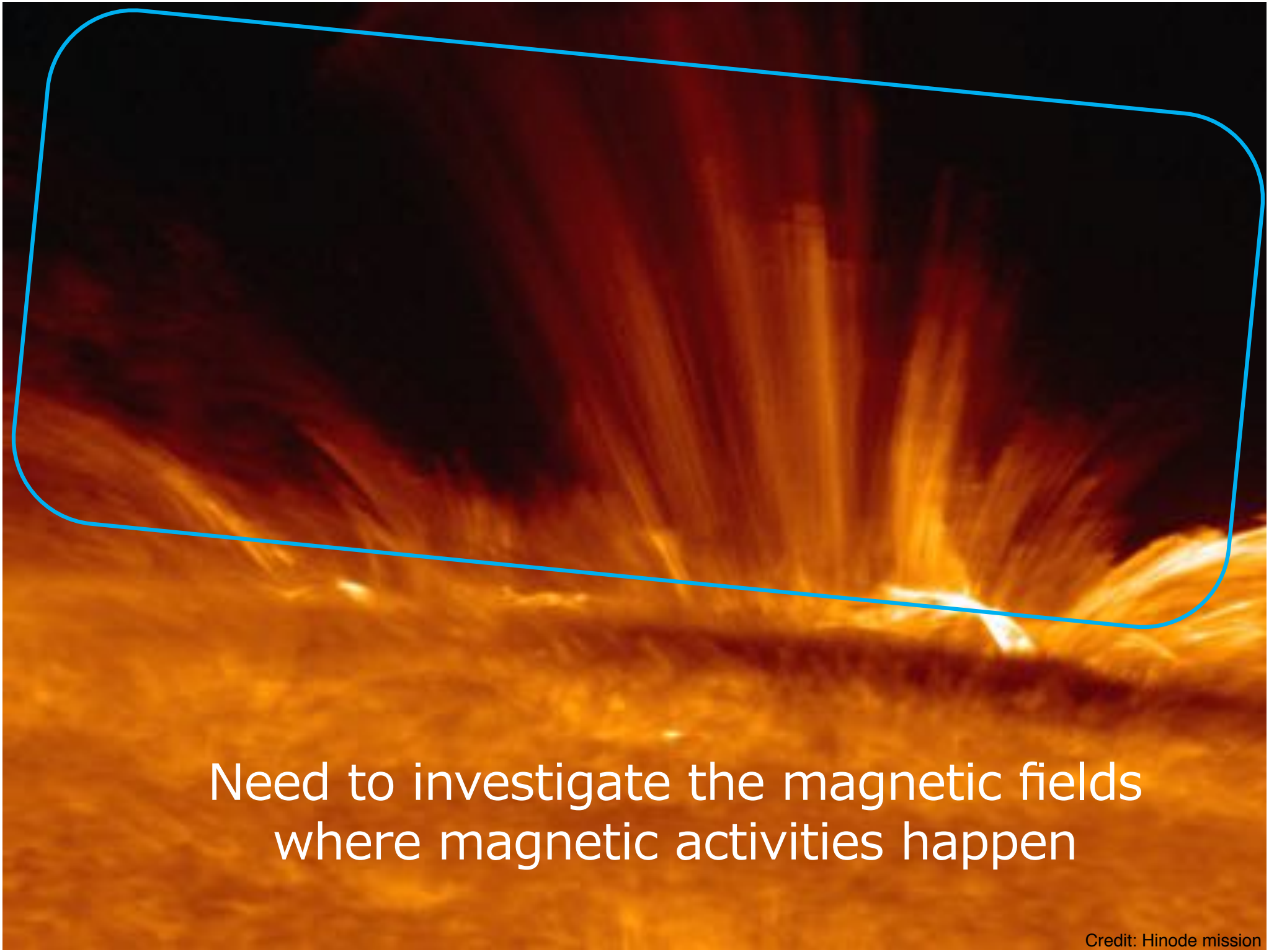




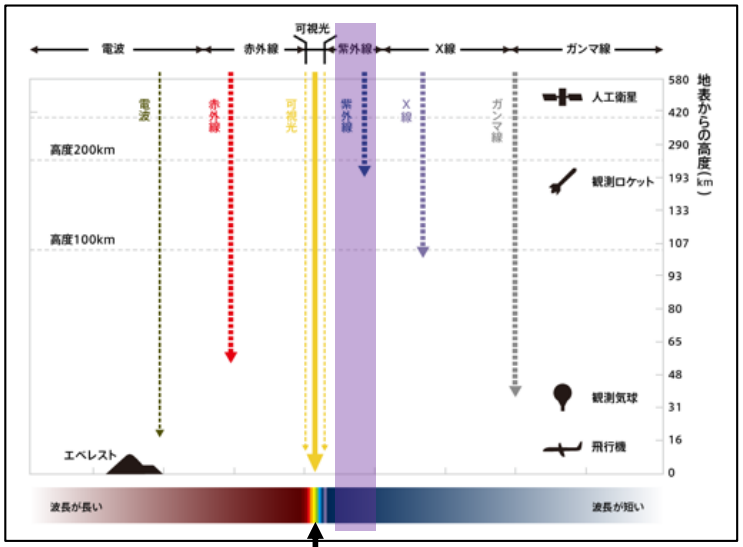
『Chromosphere and coronal heating problem』

Imaging observation by Hinode satellite :
Quiet solar surface（430nm）→ Active chromosphere（396nm）



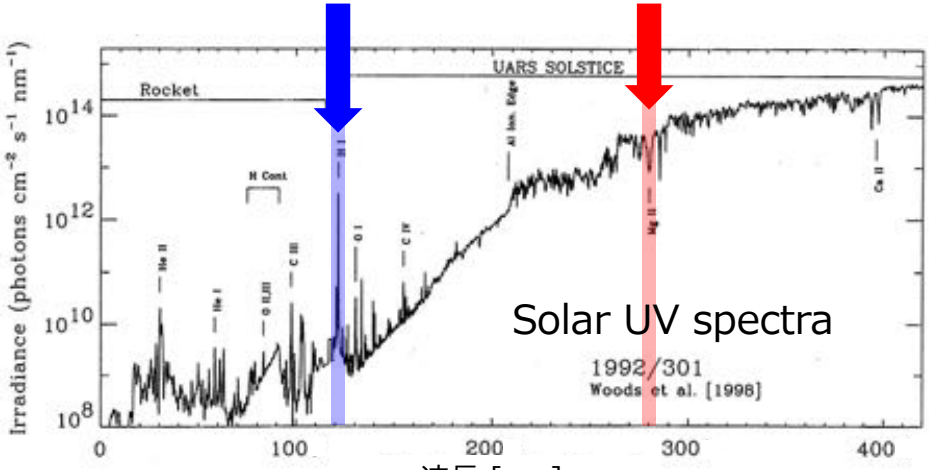

Need to investigate the magnetic fields
where magnetic activities happen
Credit: Hinode mission

New window: Polarization in UV

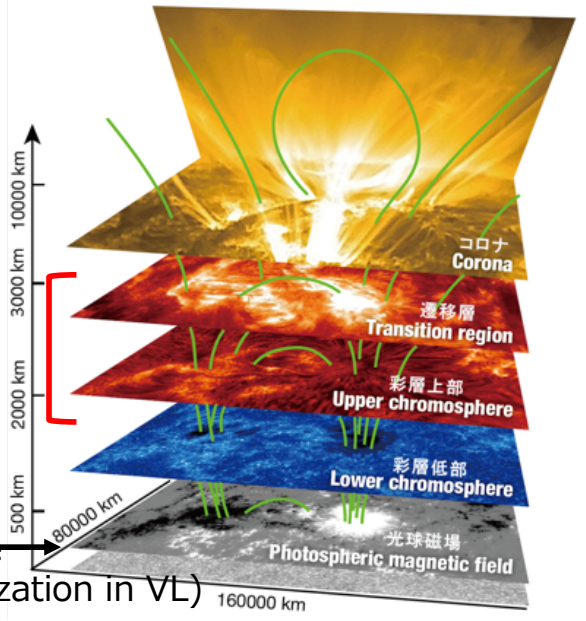


Hinode (SOT)

(Lyα) @122 nm (MgII) @280 nm



- UV spectra
  - Originate from the plasma with the temperature of 10^4～10^5 K. Access to the upper chromosphere and the transition layer
- Polarization in UV
  - There is no observation so far. Can we detect polarization? Can we extract magnetic field information from polarization?



Hinode (polarization in VL)

Sounding rocket experiment CLASP & CLASP2

CLASP: Chromospheric Lyman-Alpha Spectro-Polarimeter
CLASP2: Chromospheric LAyer Spectro-Polarimeter

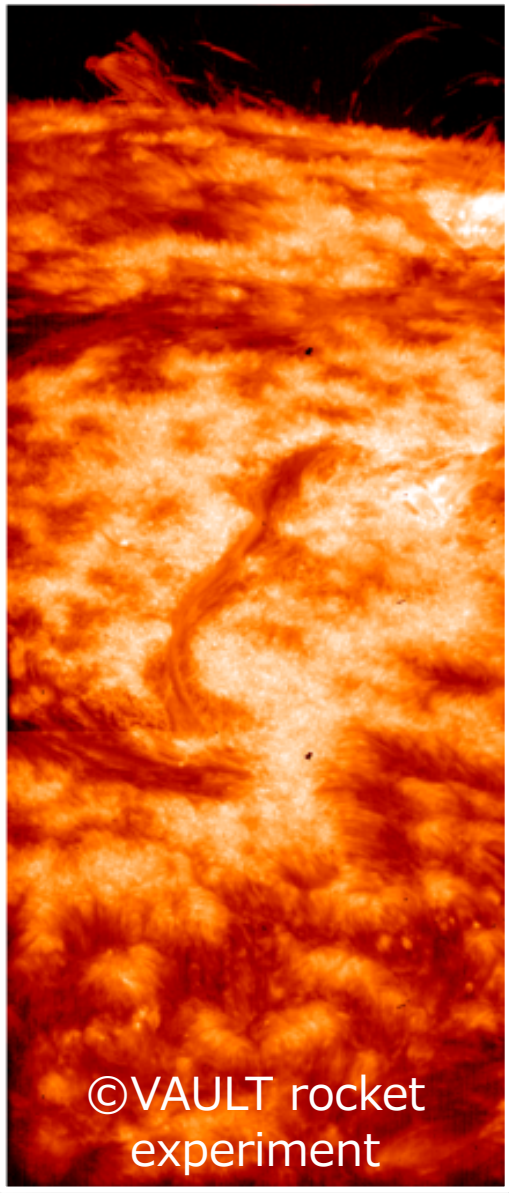
International cooperation experiment by Japan, the US and Europe using NASA's rocket

- [Technical verification] Realization of high precision polarization measurement with ultraviolet light
- [Science verification] Development of magnetic field measurement method using ultraviolet polarization spectrum

Developed from 2009. Flight 2 times

- 2015.9: CLASP@Lyα, 122nm
- 2019.4: CLASP2@MgII, 280nm

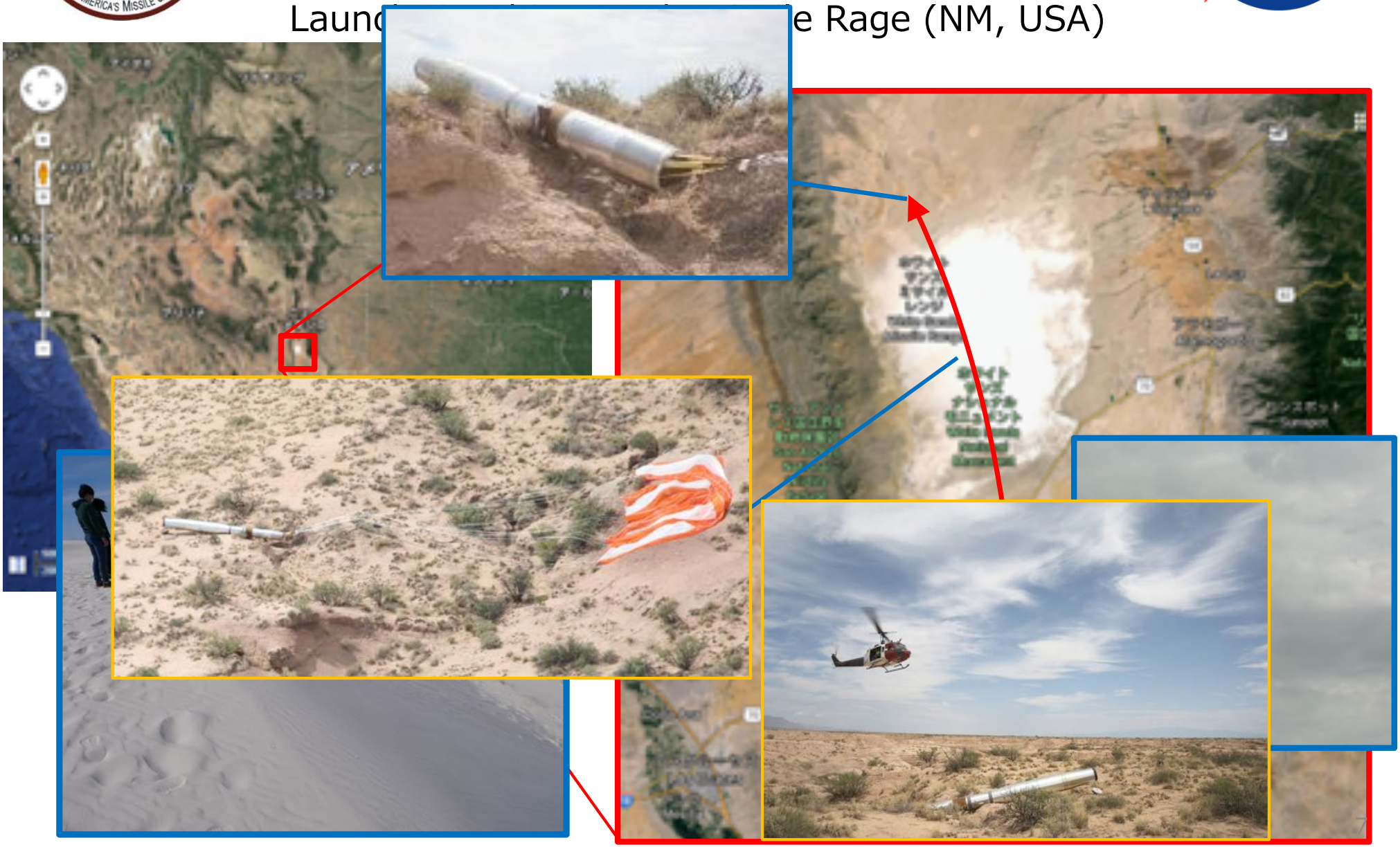
CLASP2 adopted as JAXA small-scale plan from 2017 (JAXA solar observation small-scale program)



Imaging obs. of transition region (Lyα)

Beginning of CLASP2: Returning from the first flight (2015/9/3)

Launc e Rage (NM, USA)



Credit: US Army photo, White Sands Missile Range

Soundness check in CLASP2

- November 2015: Optical test conducted at NASA/MSFC to confirm that there is no problem with alignment

  [December 2016: NASA proposal adopted]

- March 2017: Returning the observation device to Japan, full-scale start-up
  - Reusable parts: torque check of all accessible screws and visual check of adhesion.
  - New parts (structure & adhesion): vibration test with single body @ JAXA Tsukuba

  [November 2018: Shipment of observation equipment NAOJ → NASA / MSFC]

- March 2019: Vibration test combined with rocket @ WSMR
  - X / Y / Z random (new rocket also needs Z sine sweep)

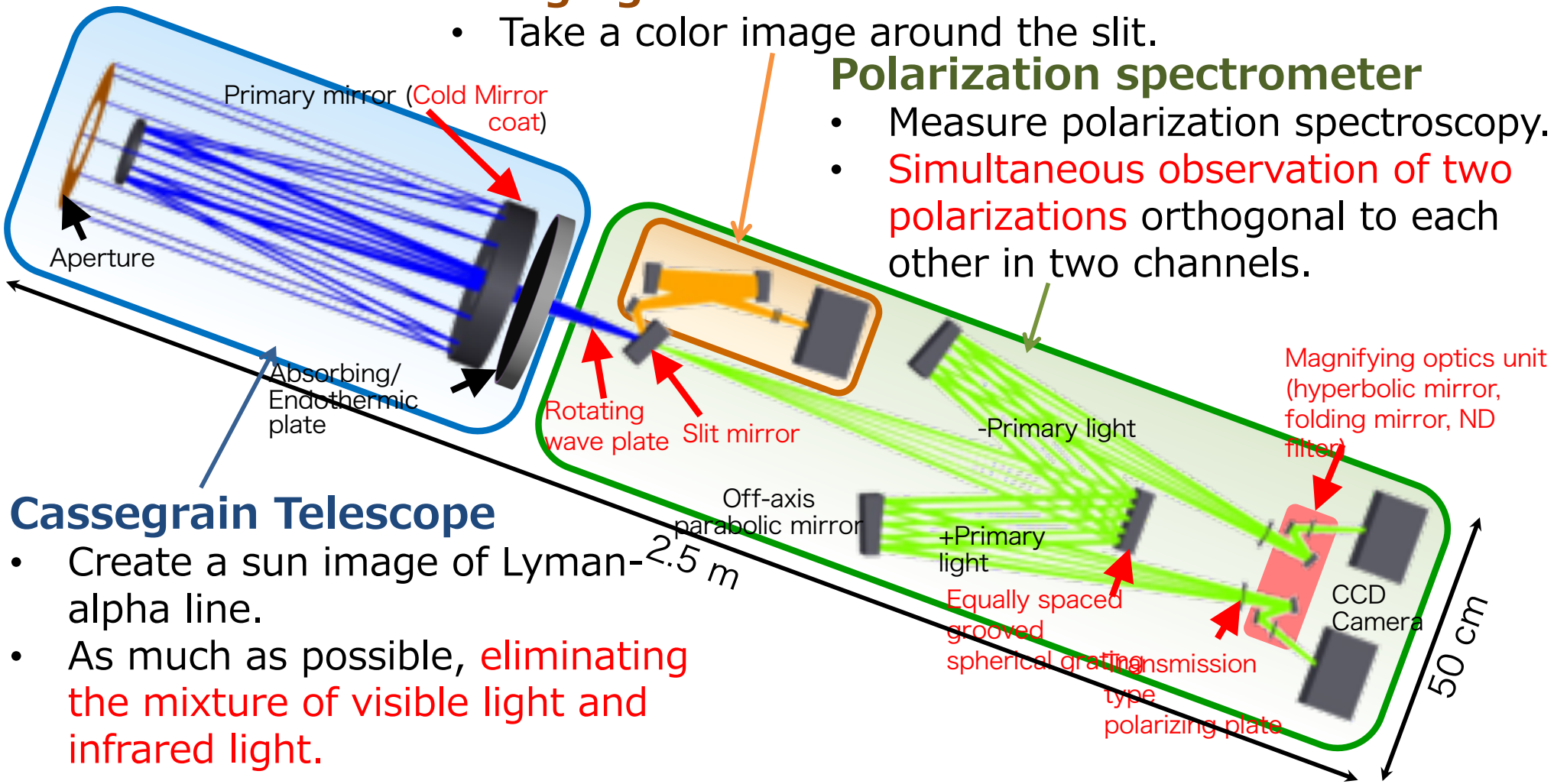
CLASP & CLASP2: The world's first high-precision polarization spectroscopy instrument for UV

Imaging device for monitor

- Take a color image around the slit.

Polarization spectrometer

- Measure polarization spectroscopy.
- Simultaneous observation of two polarizations orthogonal to each other in two channels.



Cassegrain Telescope

- Create a sun image of Lyman-alpha line.
- As much as possible, eliminating the mixture of visible light and infrared light.

All mirrors have a special coating for UV light.

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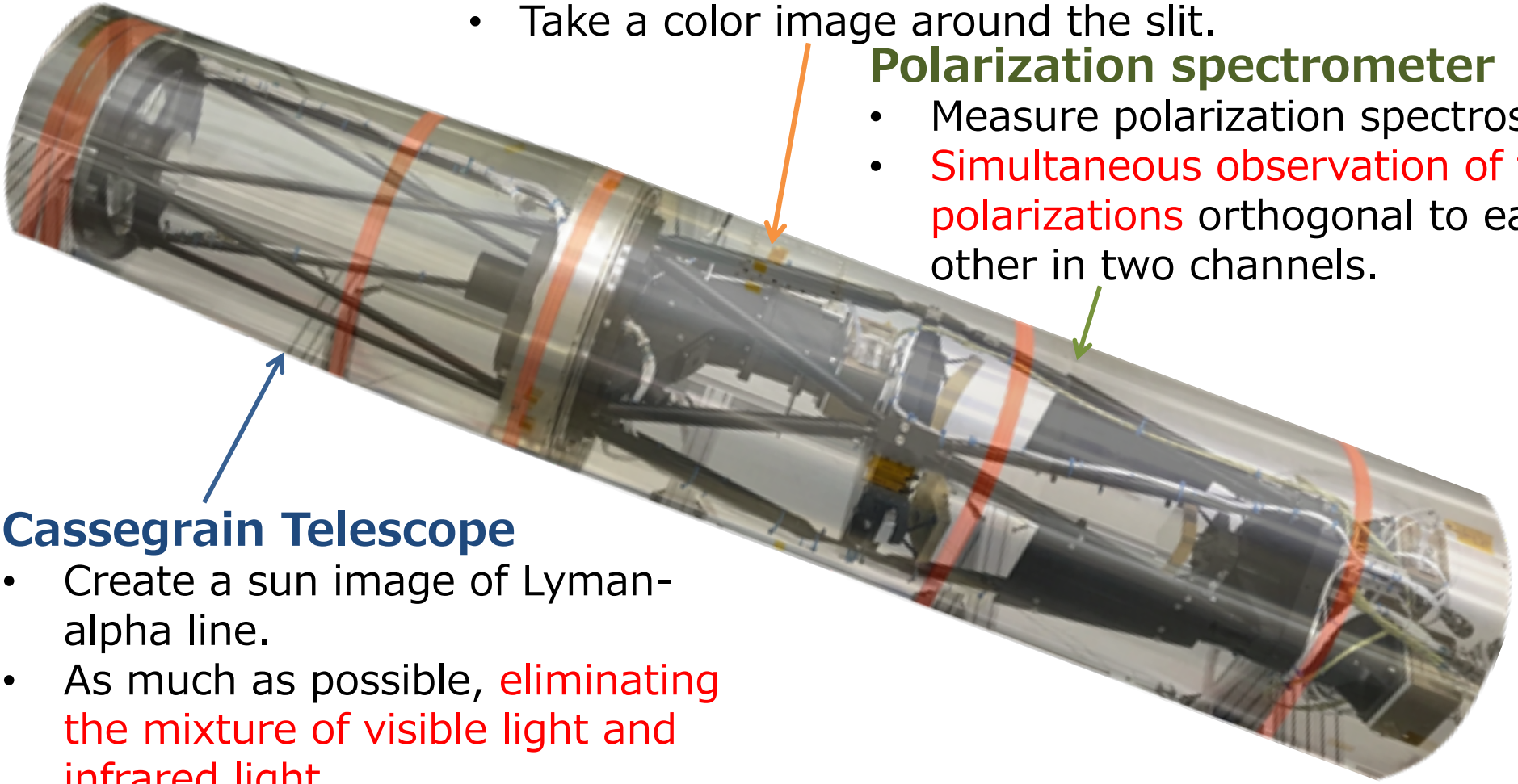


Cassegrain Telescope

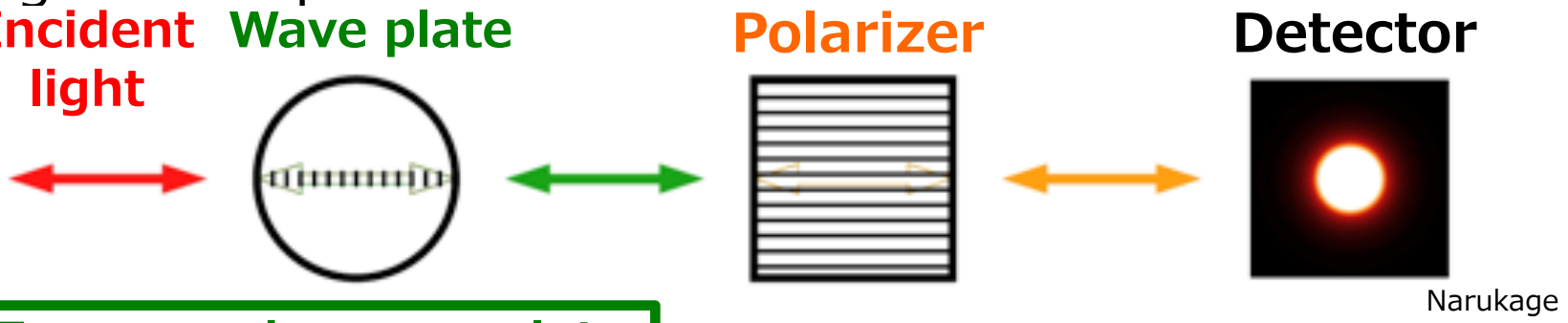
- Create a sun image of Lyman-alpha line.
- As much as possible, eliminating the mixture of visible light and infrared light.

Slender (φ 50 cm x 2.5 m) to fit into the rocket cylinder!

Key to high precision polarization measurements: rocket attitude stability

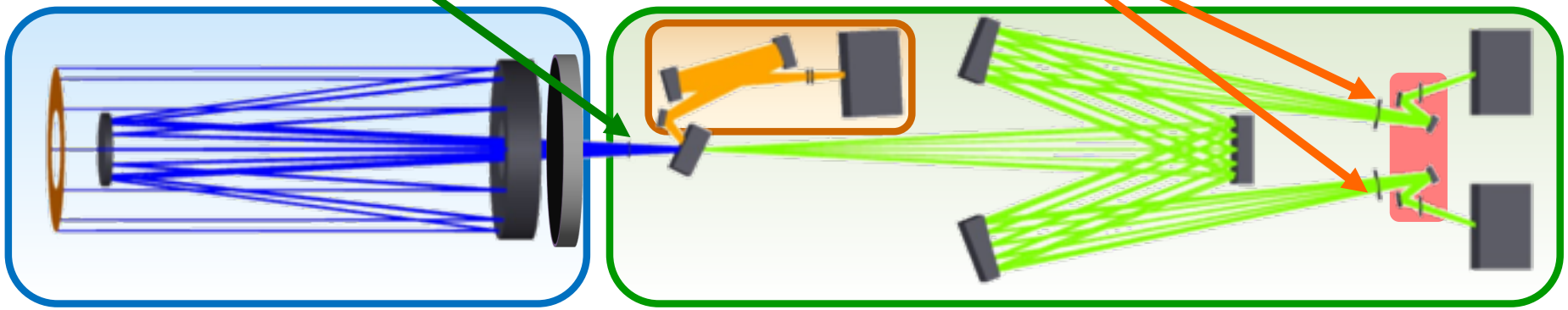
- Polarization measurement: Modulate and obtain the degree of polarization and direction according to the degree and phase.

※ CLASP2 must detect 0.1% level modulation!



MgF_2 zero order wave plate
+
rotary drive mechanism

UV wire grid polarizer

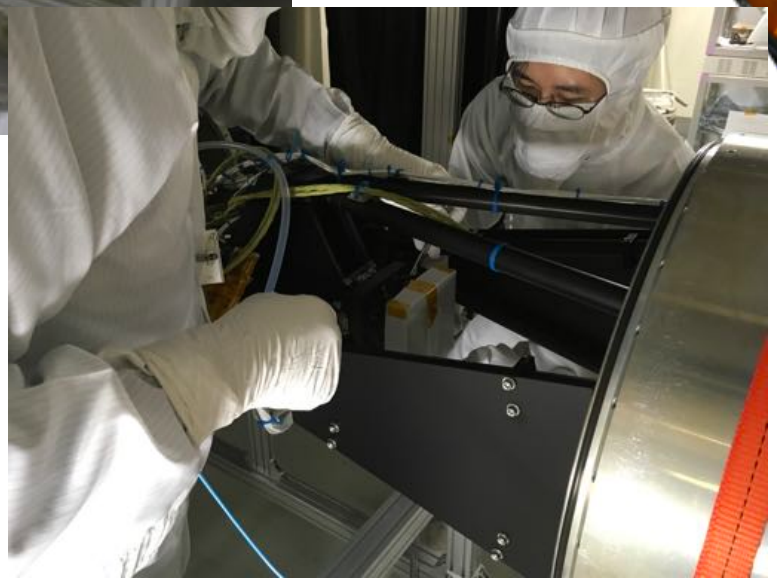


Device development @NAOJ

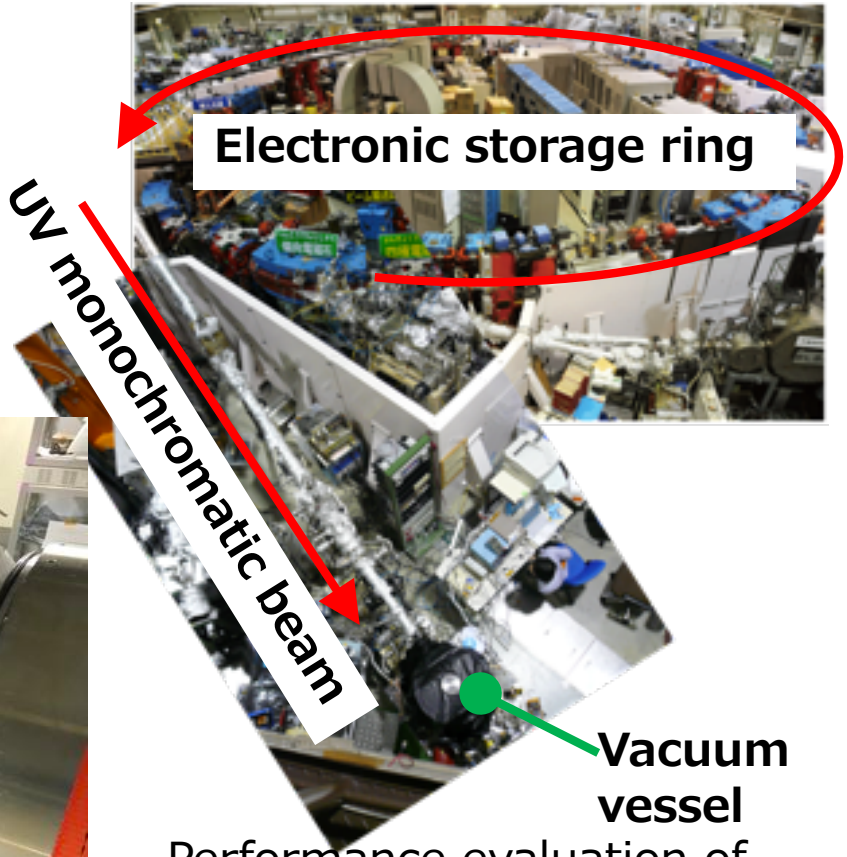
- Design of observation equipment, device development, assembly of flight model, performance confirmation by their hands!

Optical adjustment work of telescope

NAOJ Advanced Technology Center
Clean room



Flight grating installation



Performance evaluation of coatings and polarizers at a synchrotron radiation facility at IMS (Okazaki, Aichi Prefecture)

Shipment of observation equipment

To NASA Marshall Space Flight Center (NASA / MSFC) @ Huntsville, Alabama.

- Combined with flight computer

Combine with rocket
To launch

Ishikawa: CLASP 2 Japan Representative (Assistant Professor)

Structural design engineer

Project Assistant Professor

Project Research Staff

Kano: CLASP 1 Japan Representative (Associate Professor)

SOKENDAI student (D3)

Credit: US Army Photo, White Sands Missile Range

CLASP2 Launched 10:51 am (local time) on April 11, 2019

Credit: US Army Photo, White Sands Missile Range

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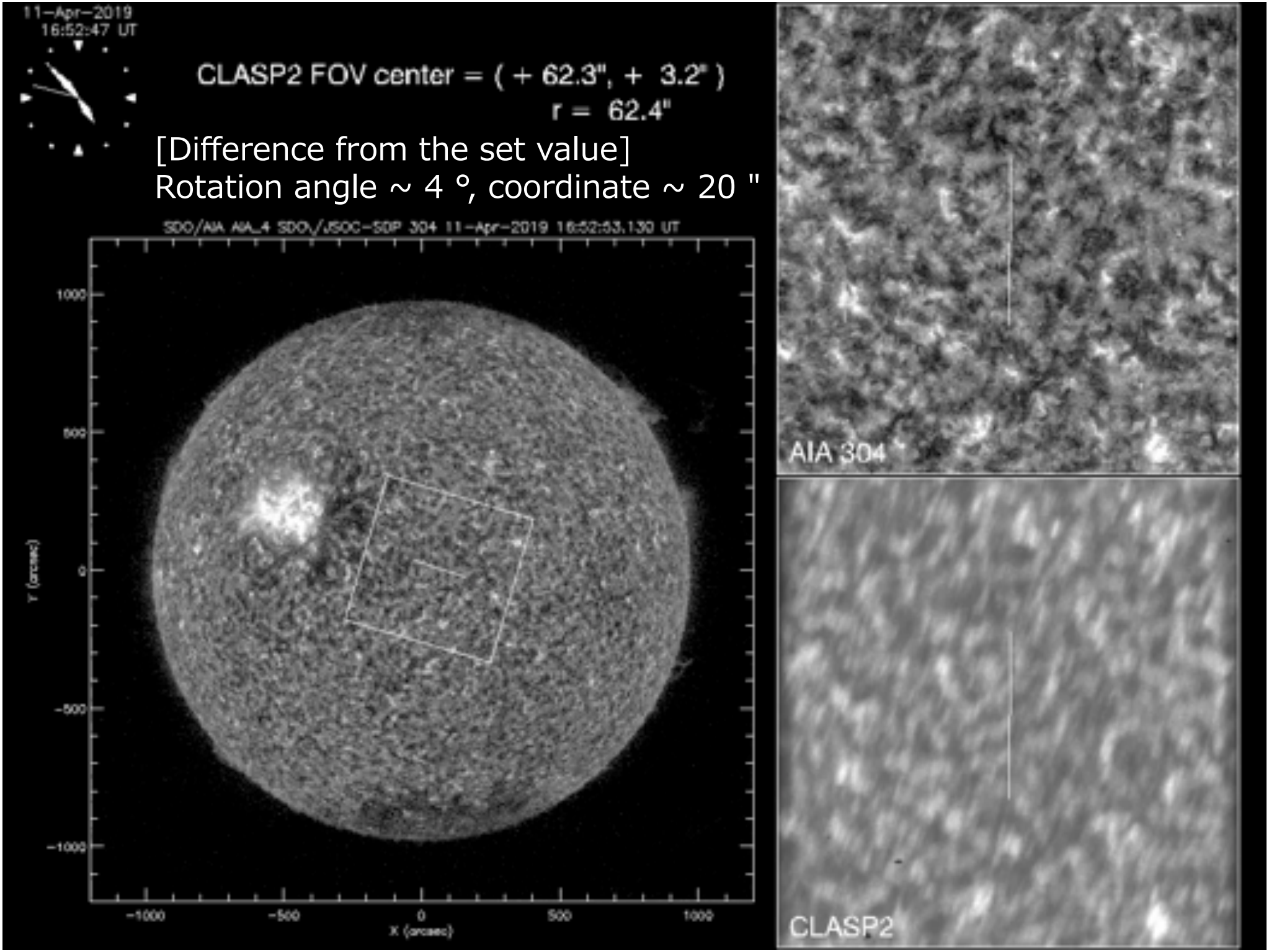
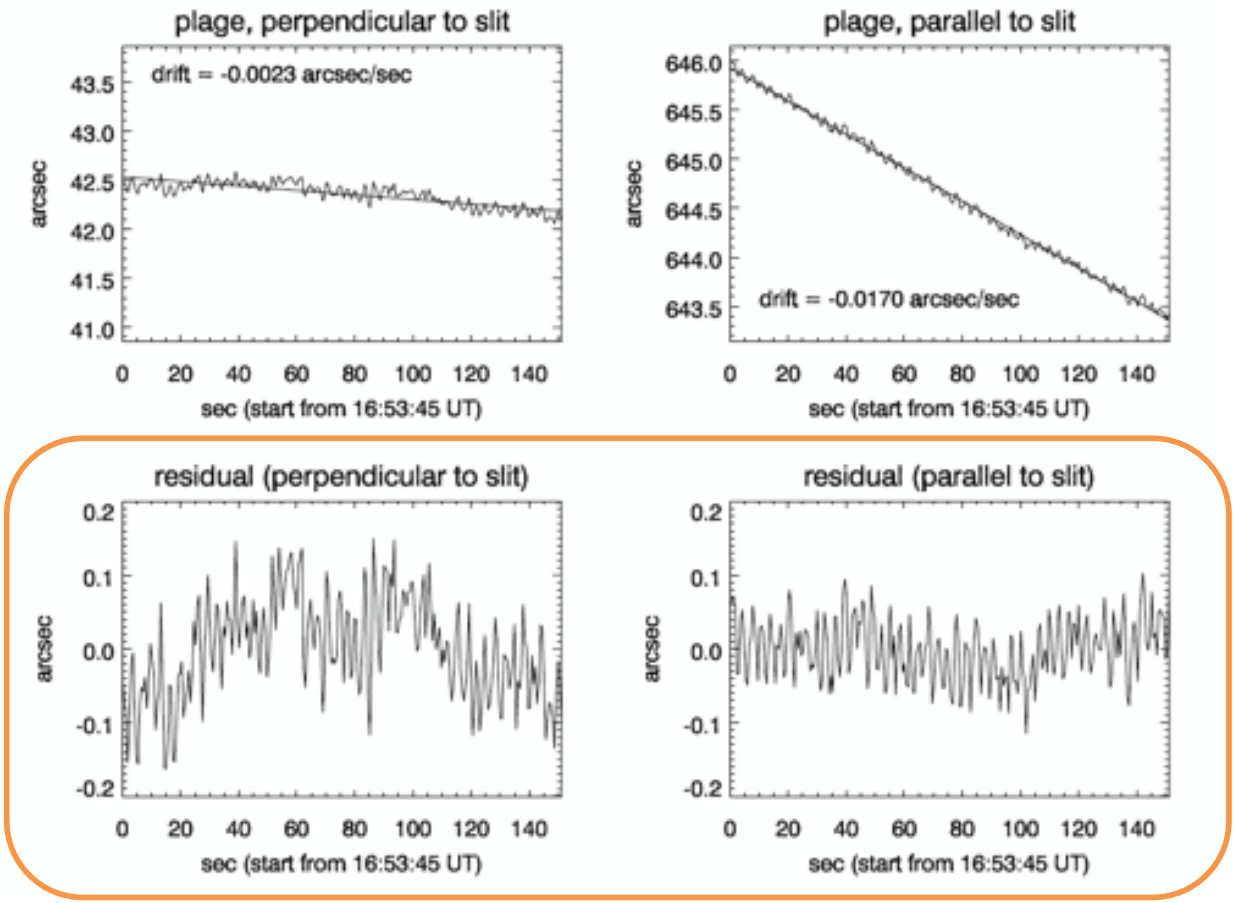
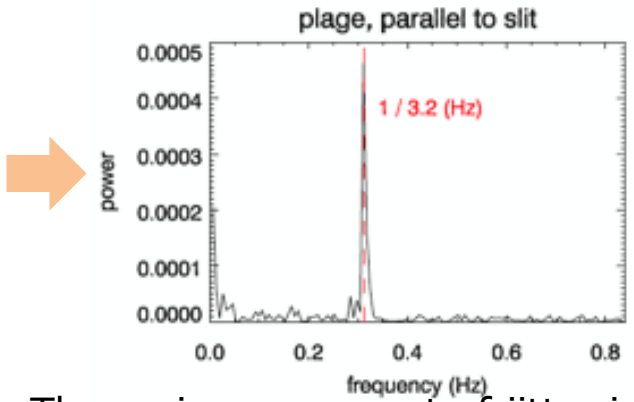

11-Apr-2019
16:52:47 UT
CLASP2 FOV center = (+ 62.3", + 3.2")
r = 62.4"
[Difference from the set value]
Rotation angle ~ 4 °, coordinate ~ 20 "
SDO/AIA AIA_4 SDO/JSOC-SDP 304 11-Apr-2019 16:52:53.130 UT
1000
500
0
-500
-1000
Y (arcsec)
-1000
-500
0
500
1000
X (arcsec)
AIA 304
CLASP2

Flight performance seen from observation data

Observation time: 6 minutes (highest altitude: 274 km)



- Drift ~ 1″/min
- Jitter << 0.2″ (P-P)



The main component of jitter is the fluctuation of the sun image by the rotating waveplate (from the observation device)

CLASP2 summary

- Both the observation rocket and observation equipment work perfectly.
- Acquisition time longer than expected is acquired. Observations were conducted at 3 pointings.
- Succeeded in the world's first high-precision polarization spectroscopy of ionized magnesium radiation!
  - Polarization data consistent with theoretical predictions obtained
  - Further analysis is underway to derive the magnetic field from there