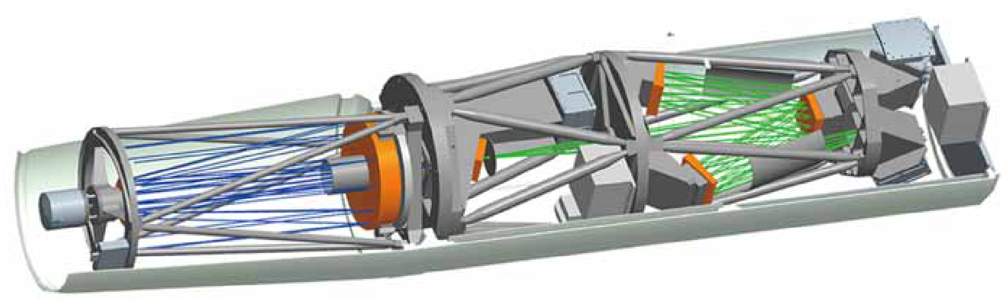
The Chromospheric Lyman-Alpha Spectro-Polarimeter (CLASP)



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and the CLASP team

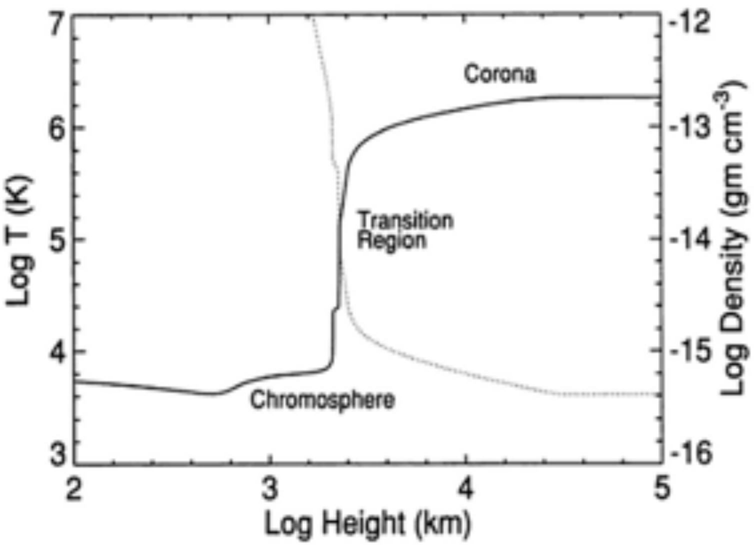
Introduction

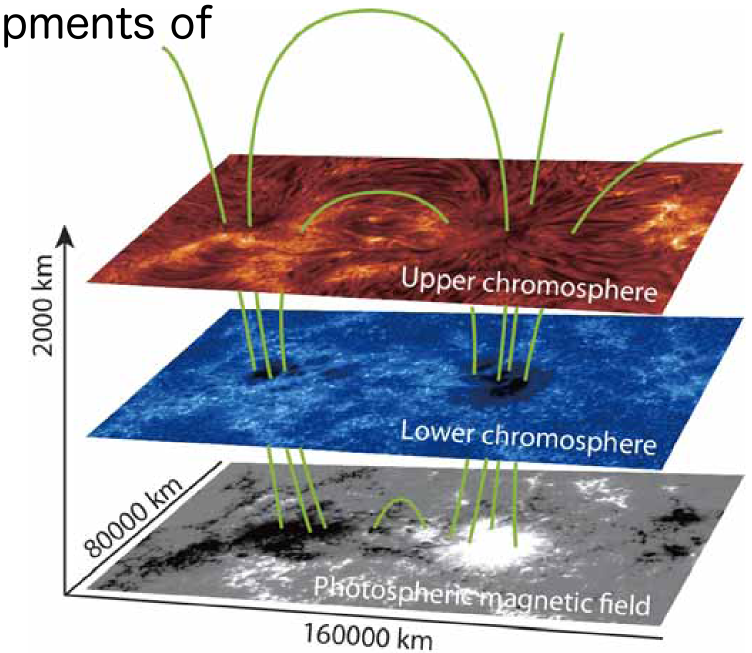
- To Understand energy release process in the Sun including solar flares, it is essentially important to measure the magnetic field of the atmosphere of the Sun

- Magnetic field measurement of the upper layers (upper chromosphere and above) was technically difficult and not well investigated yet

-> Upper chromosphere and transition region magnetic field measurement by Chromospheric Lyman-Alpha SpectroPolarimeter (CLASP) sounding rocket to be launched in 2015

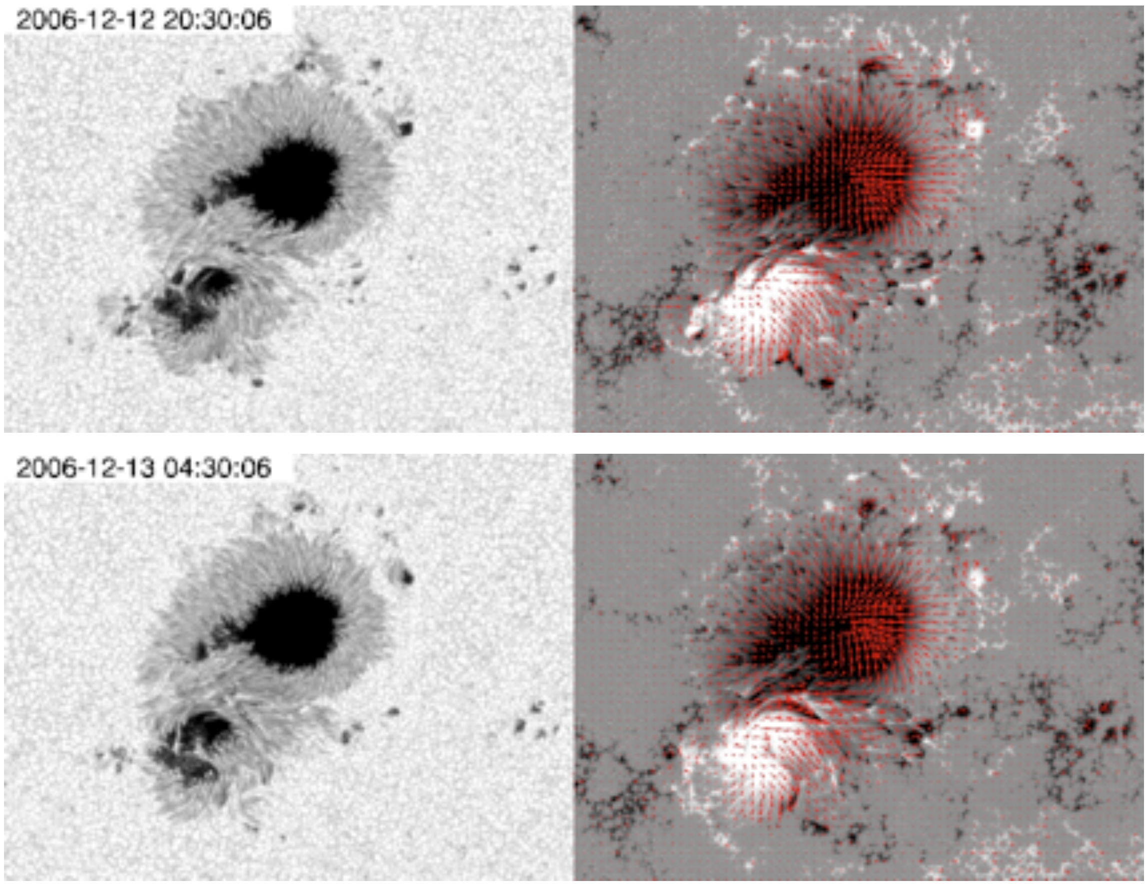
The proposal is already selected and developments of the flight components are going





Hinode/SOT Photospheric magnetic field observation

Hinode/SOT performed spectro-polarimetric observation of the optical light and vector magnetic fields are derived using the Zeeman effect

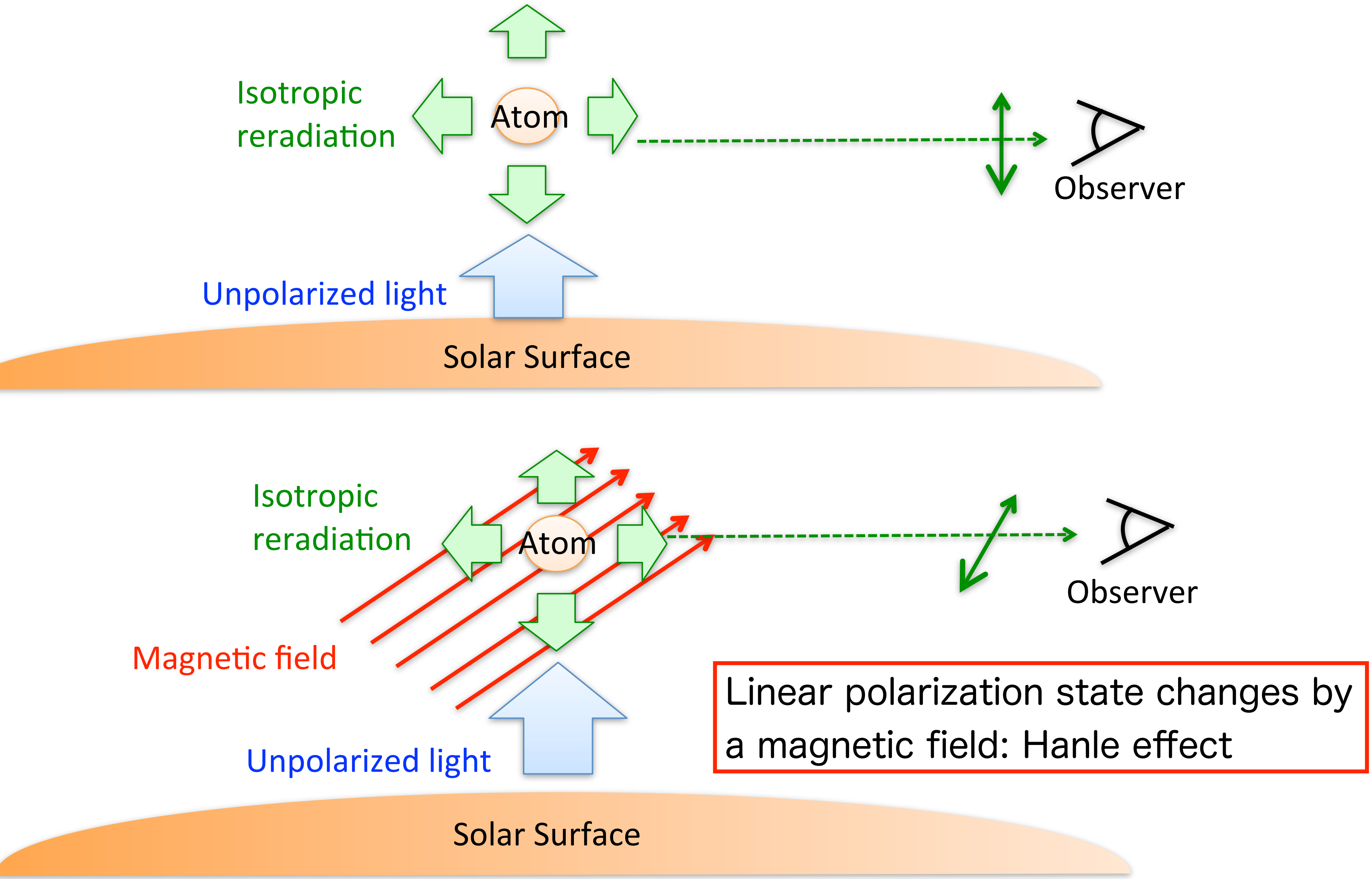


(preflare)

(postflare)

However, it is not possible to use the Zeeman effect for the magnetic field measurement of the upper layers because of weaker magnetic fields and shorter wavelengths

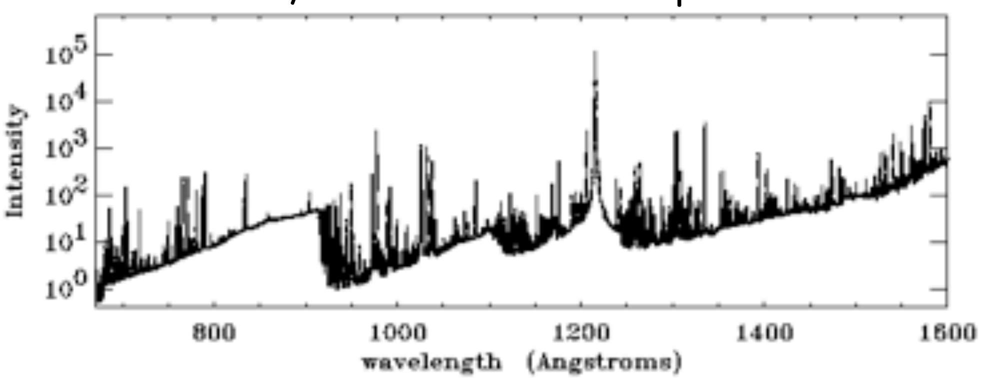
Magnetic field measurement of the upper layers: Hanle effect

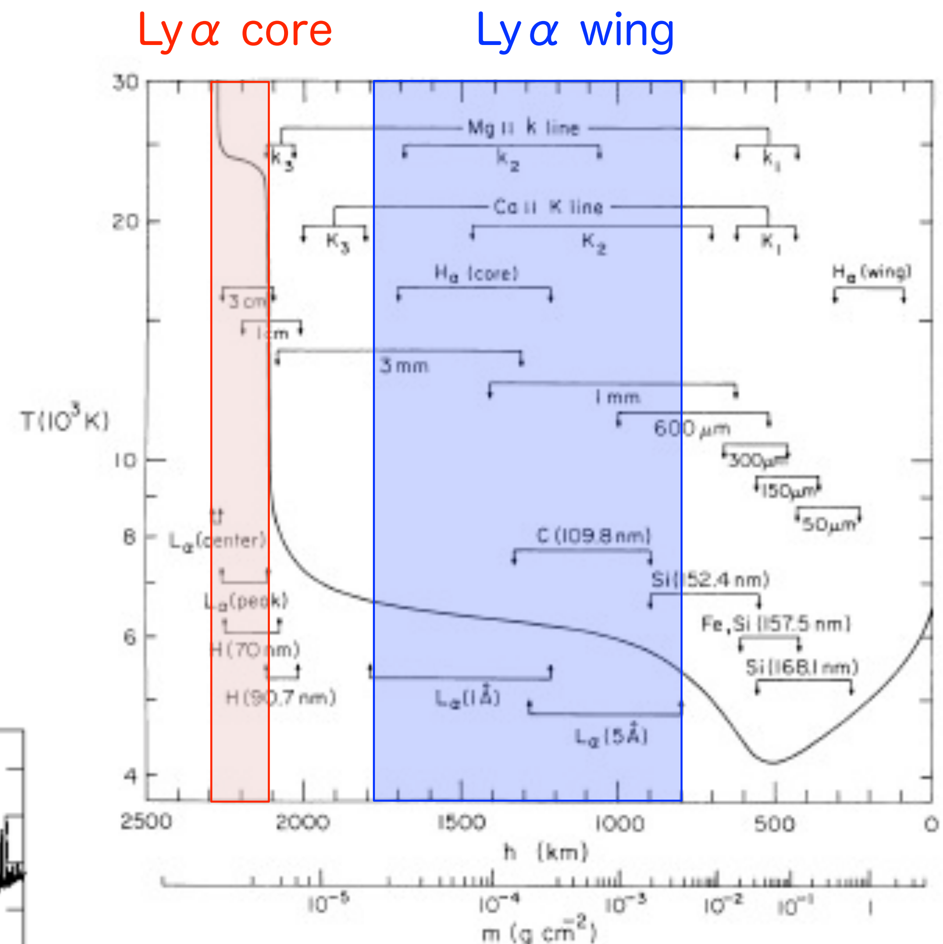


Lyman-alpha line as the magnetic field probe

Lyman alpha line:
Strongest upper chromosphere /transition region line
-> high sensitivity for
measuring vector magnetic fields
of these layers
using the Hanle effect

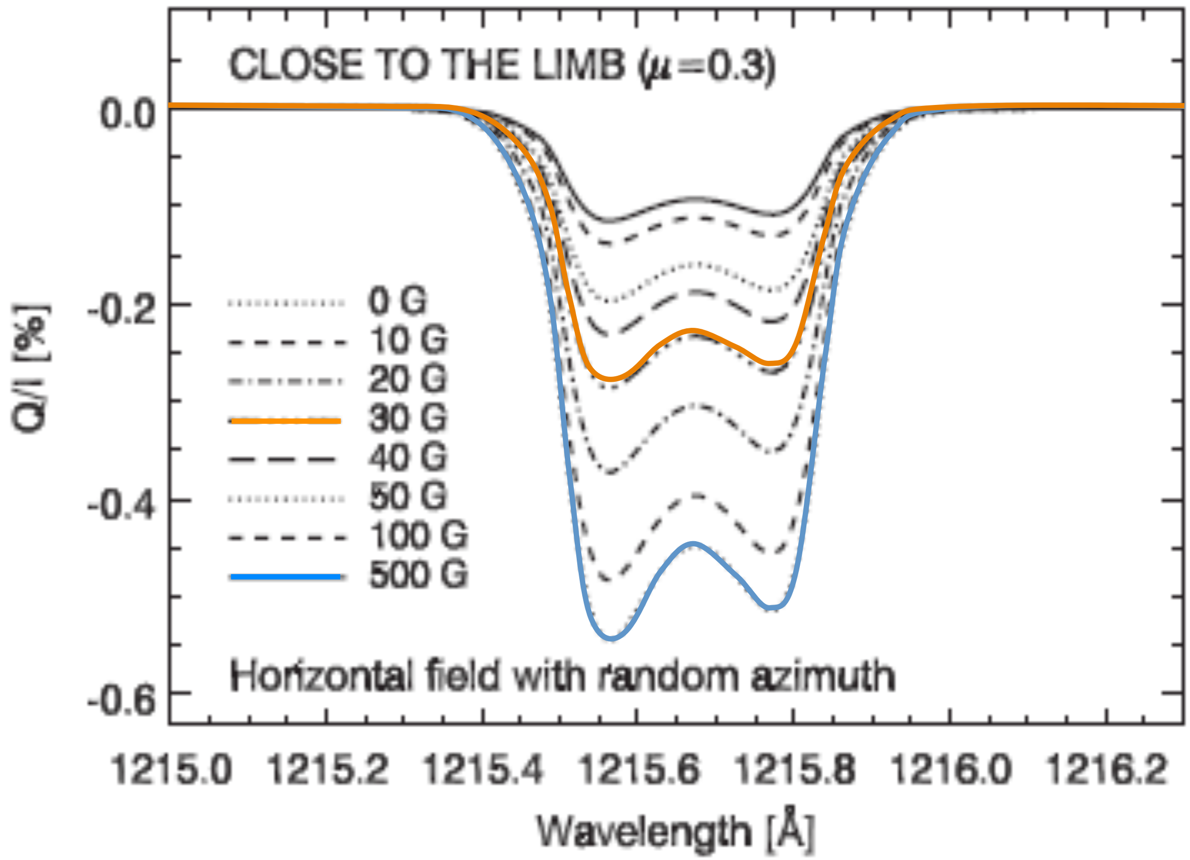
SOHO/SUMER on-disk spectrum





(Vernazza et al. 1981)

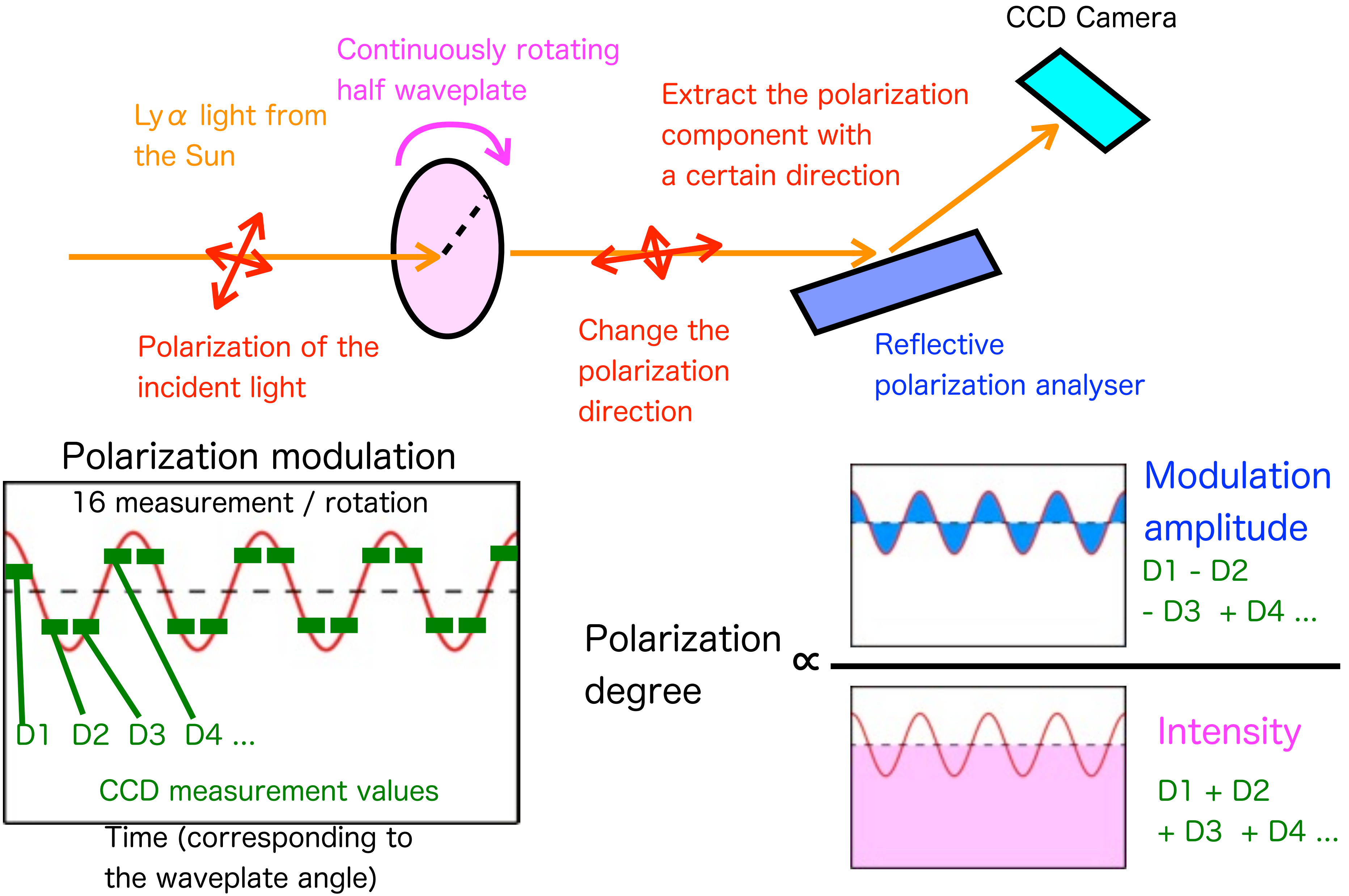
Expected polarization observation



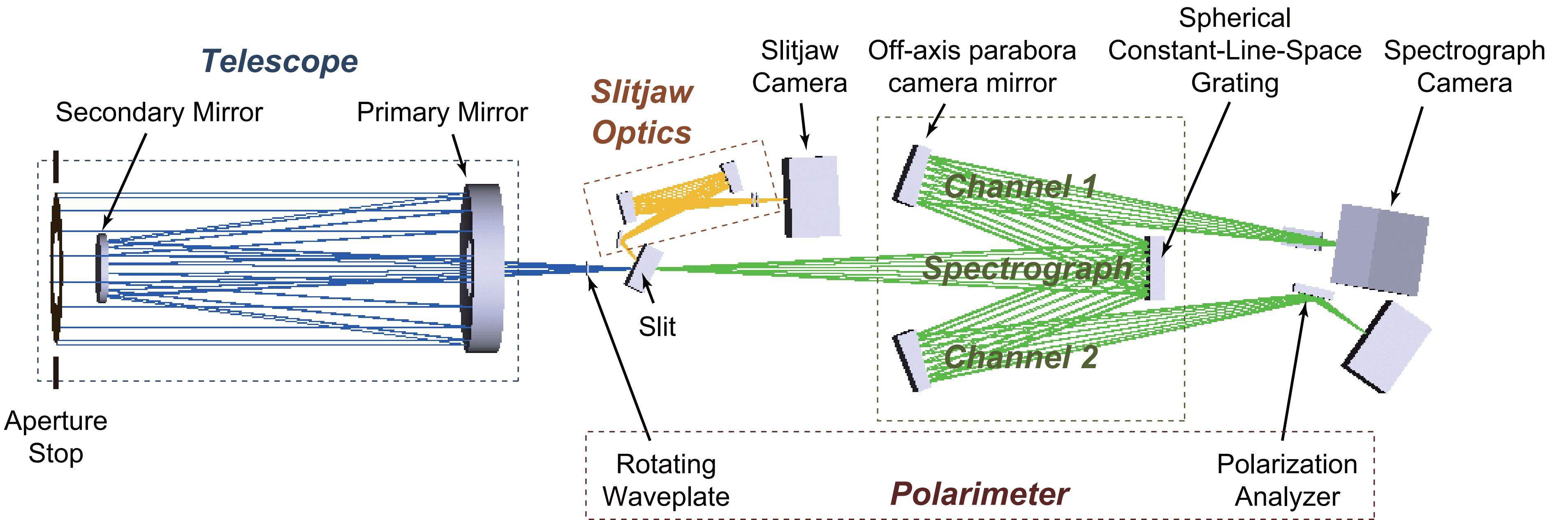
The expected deviation of the polarization degree caused by the magnetic field is only an order of 0.1% !

-> Spectropolarimetry with a precision of < 0.1% is required to measure the magnetic field

Polarization measurement by CLASP



CLASP instrumentation



CLASP consists of:

- Cassegrain telescope
- Spectropolarimeter with a rotating 1/2 waveplate, spherical grating, reflective polarization analyzers and CCD cameras (taking data along the slit)
- Slitjaw optics to take images of the surrounding part of the slit

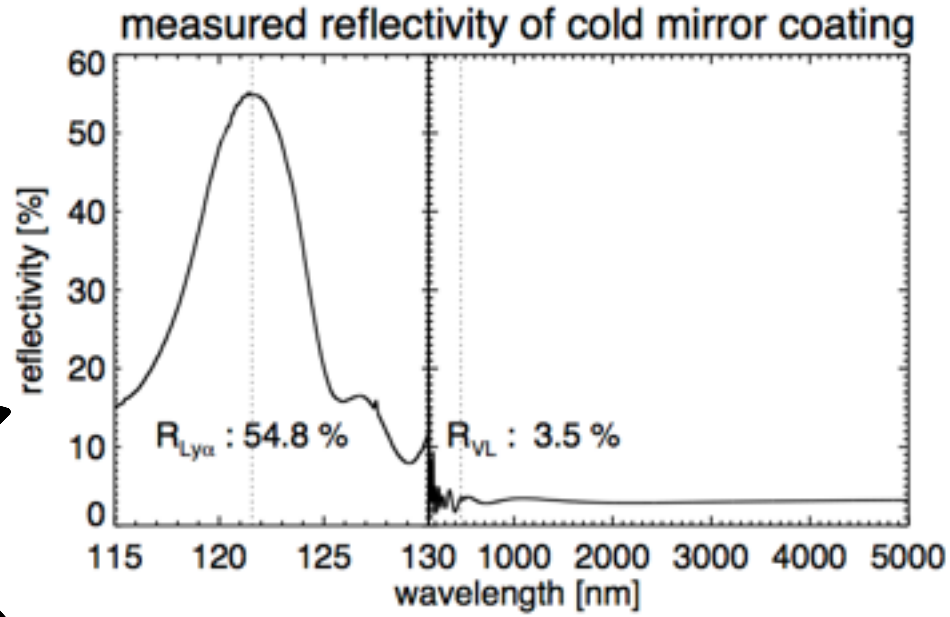
Error budget for spurious polarization

Cause of error	**error** (1σ)	
Photon noise at Ly-a center (*10”* along slit and *200s* obs. period)	*0.026%*	Random noise
Readout noise of CCD cameras	0.011%	Random noise
Fluctuation of exposure durations	5x10^{-5}%	Random noise
Time variation of source intensity	<0.018%† (~0%)	*dI/dt*
Intensity variation from pointing jitter	<0.018%† (~0%)	*dI/dt*
Image shift from waveplate rotation	~0%	*dI/dt*
Off-axis incidence with 200”	~10^{-4}%	Induced by telescope
Non-uniformity of coating on primary mirror	10^{-3}%	Induced by telescope
Error in polarization calibration	0.017%	
RSS	***<0.042% (~0.033%)***	

†: These values are the case for the single channel demodulation, and can be reduced by dual channel modulations.

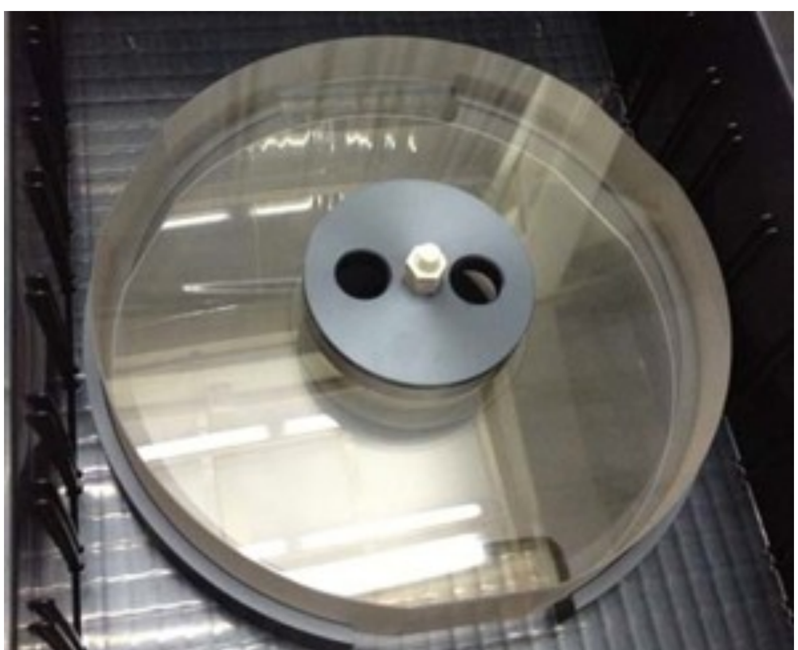
Telescope & cold mirror coating

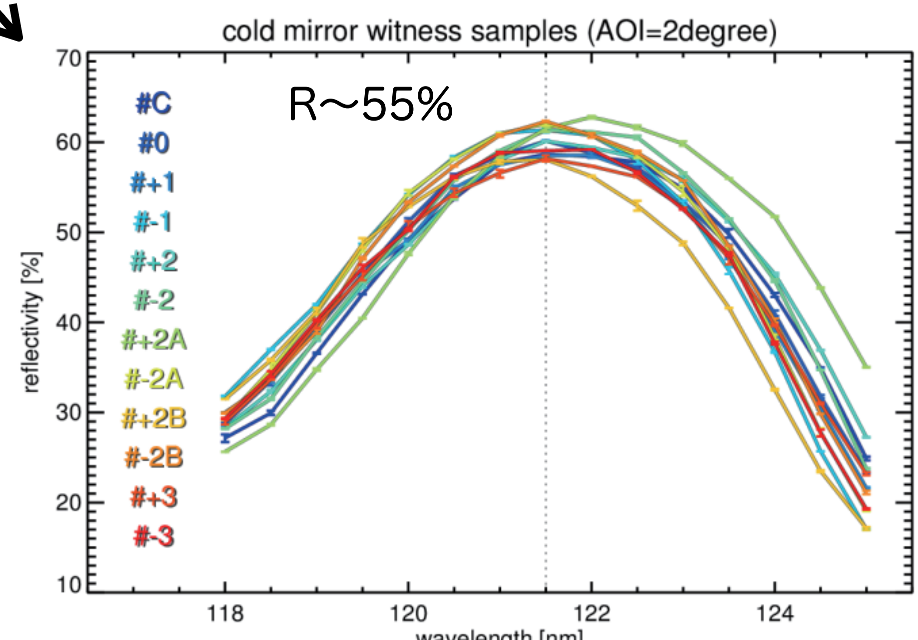
The primary mirror will be coated
to reflect the Lyα (>50%) and
not to reflect the visible light (<5%)



Test piece results

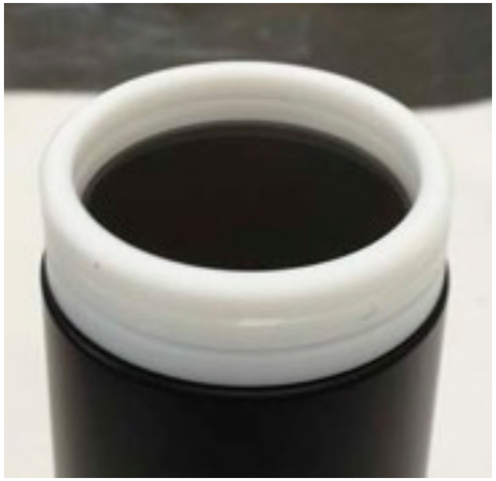
Flight primary mirror (not coated yet)





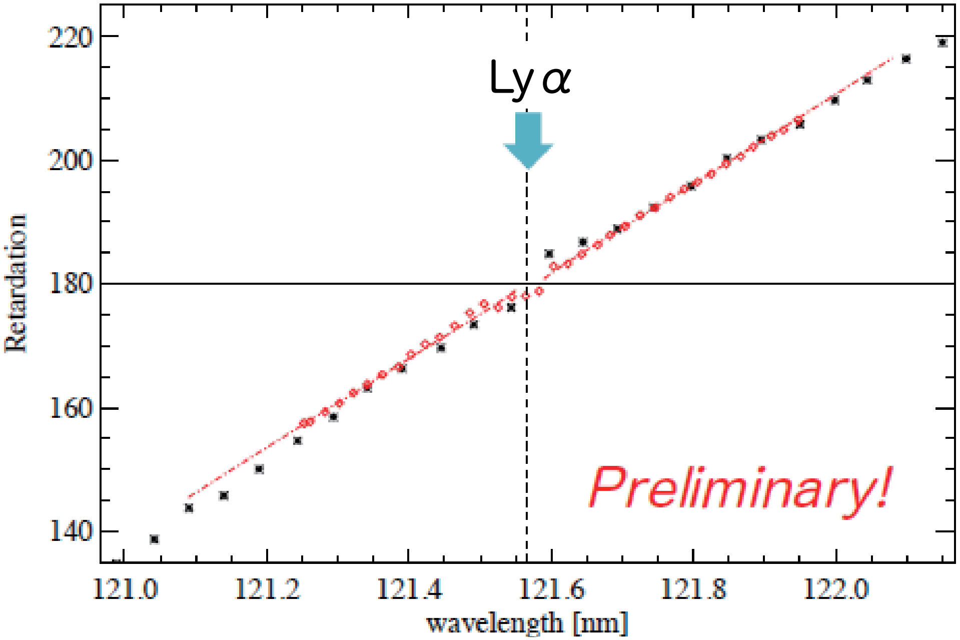
Waveplate

Flight waveplate



Flight waveplate is made of two MgF_2 plates

The difference between the extraordinary refractive index and ordinary refractive index (n_e-n_o) of MgF_2 is measured precisely by our group (R. Ishikawa et al. 2013) and the flight waveplate is fabricated for the retardation to be 180-degree at Lyα

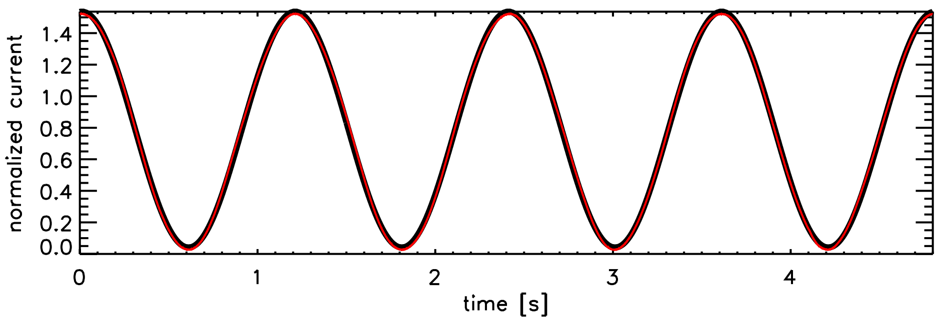


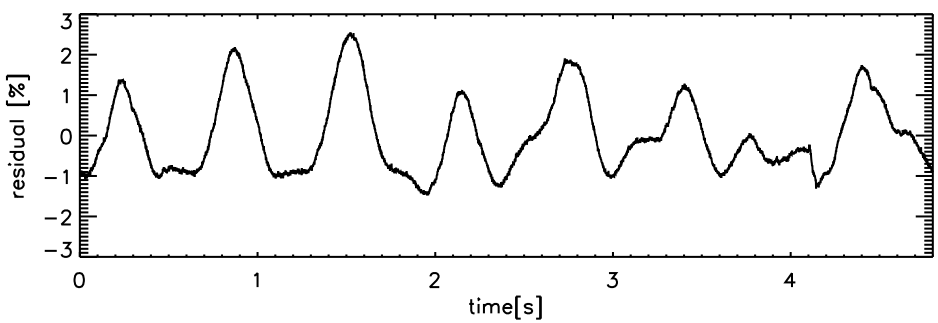
The retardation is measured to be very close to 180-degree at the Lyα wavelength

Waveplate motor

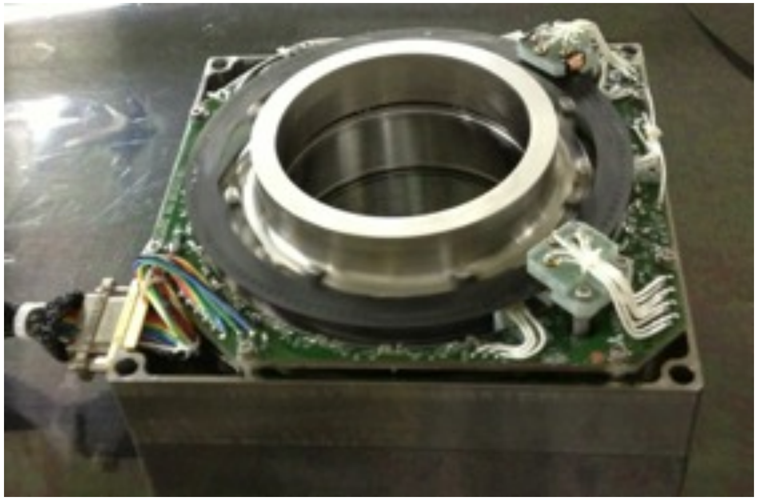
The continuously rotating motor
with the high rotation uniformity
to minimize the error of the polarization
degree measurement
(Rotation period: 4.8s)

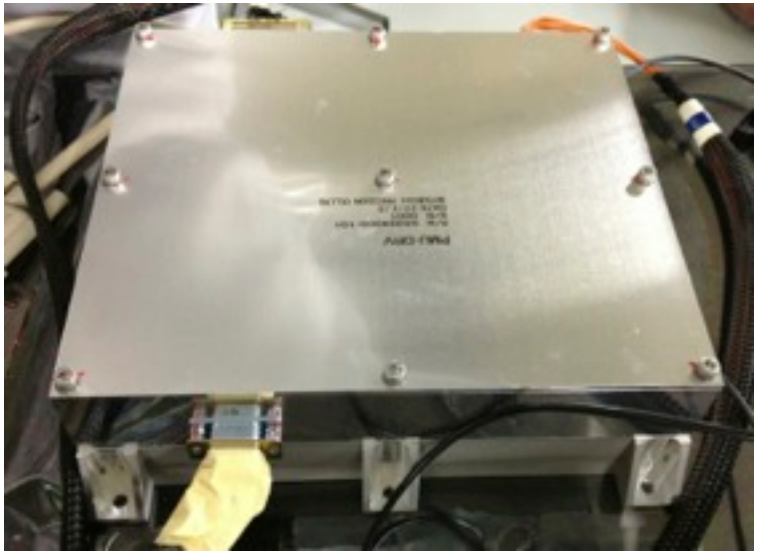
Error of the polarization degree measurement
is estimated to be <0.01%





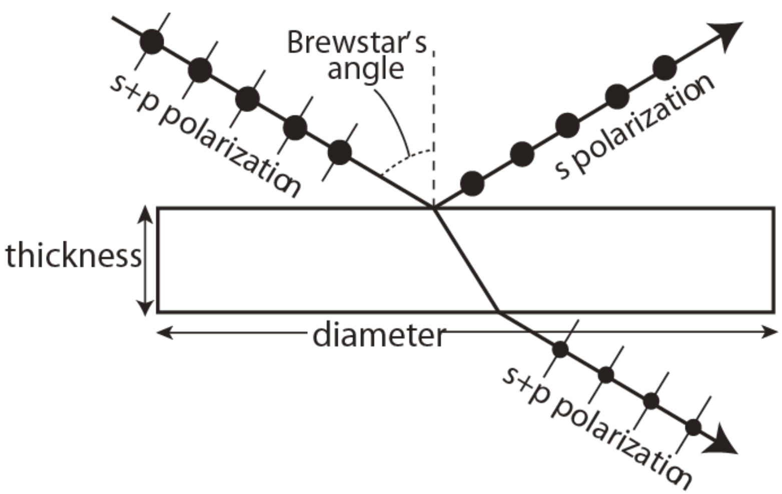
Flight motor & driver

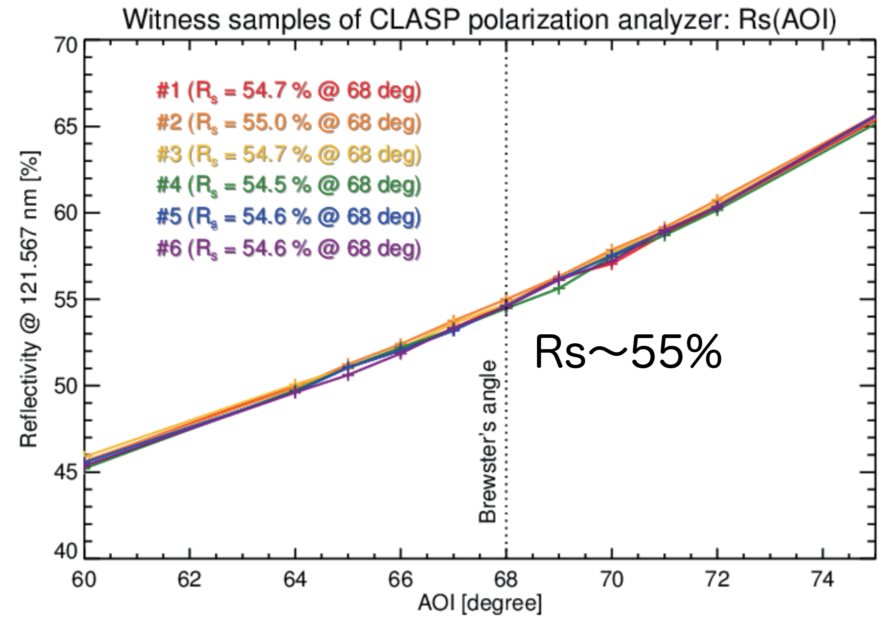


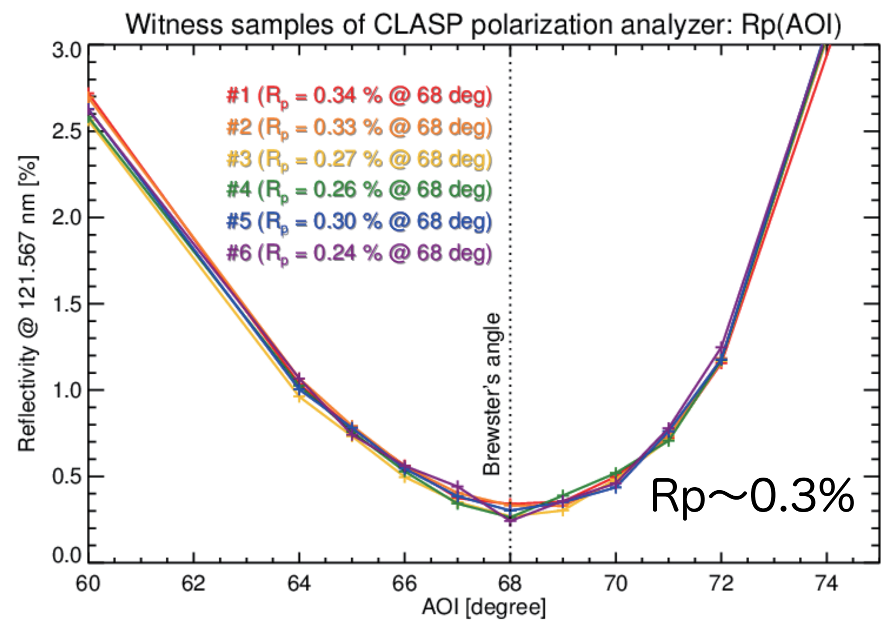


Reflective Polarization Analyzer

High polarization efficiency of ~99% and high uniformity are achieved by multi-layer coating proposed by Bridou et al. (2011)







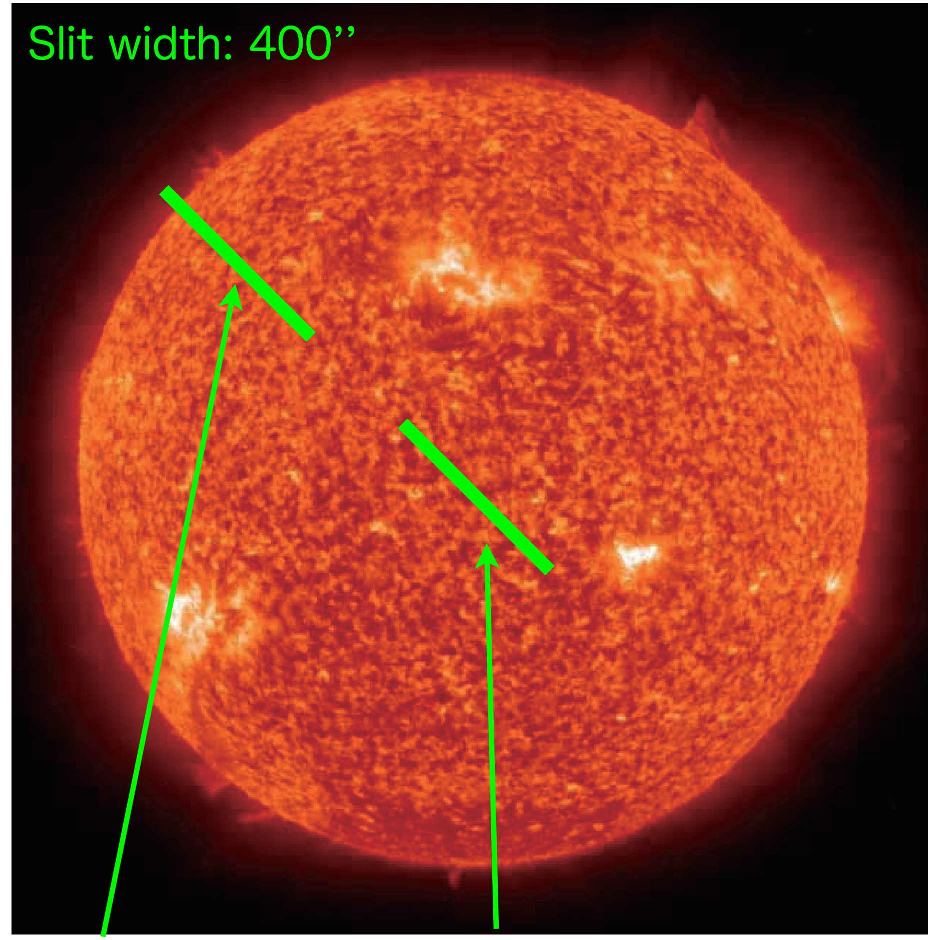
Operation

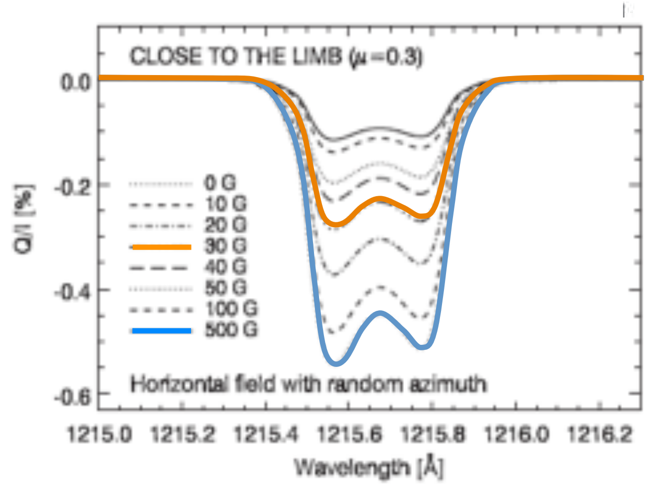
CLASP has an observation duration of only ~300s

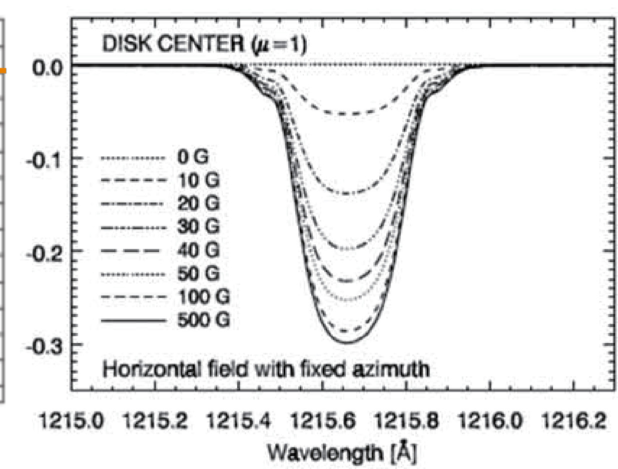
Target 1: disk center (10s)
- The polarization degree is expected to be significantly smaller than at the limb: checking the instrument is working well

Target 2: including limb (>220s)
- Scientific observation
  Data will be integrated for the whole duration (not considering a time variation during the pointing)

To be launched in summer 2015! (White Sands, New Mexico, USA)







Summary

- CLASP is a sounding rocket experiment to observe the linear polarization profile of the Lyα line from the Sun for the magnetic field measurement in the upper chromosphere and transition region

- CLASP estimates the magnetic field by the Hanle effect and it is necessary to measure the polarization with the precision of <0.1%

- The developments of the flight components are well going

- CLASP will be launched in summer 2015