

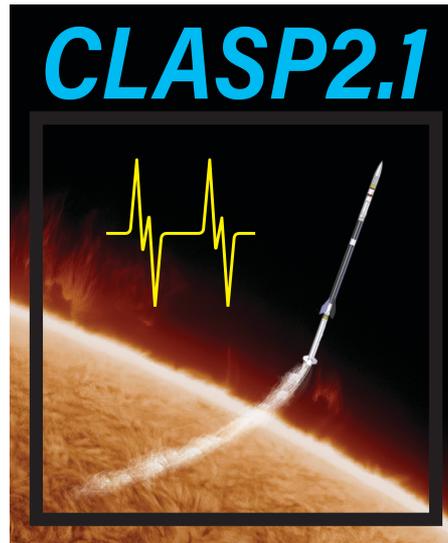


Demonstration of Chromospheric Magnetic Mapping with CLASP2.1



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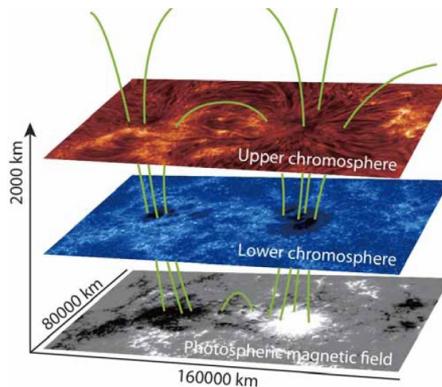
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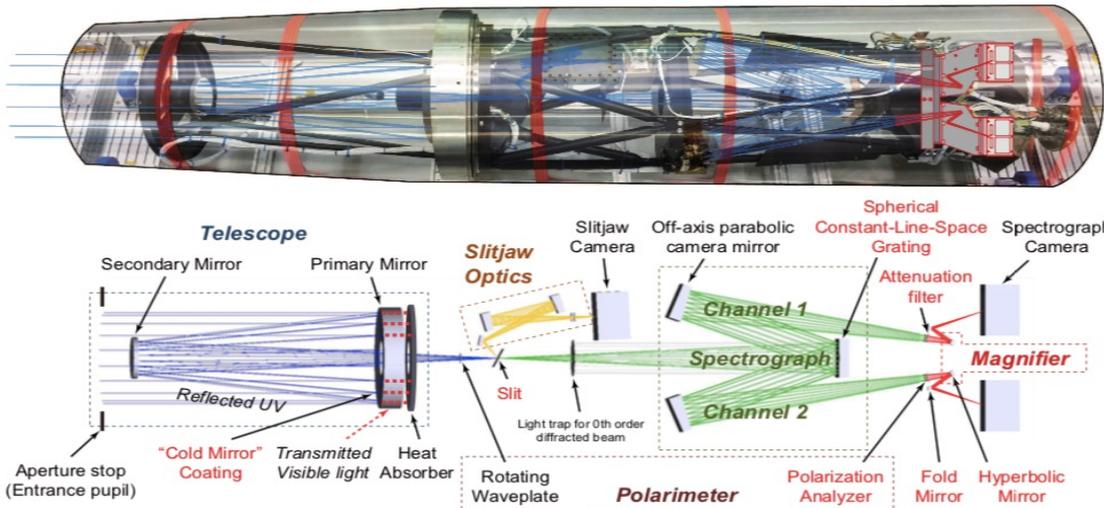
Goal of the CLASP missions

- The CLASP missions have one primary objective: enable mapping of the magnetic field in the Sun's chromosphere.
- Magnetic field is the source and storage medium of energy for solar flares, mass ejections, and space weather. *Magnetism is everything.*
- The chromosphere is a key layer of the Sun's atmosphere, and we do not have consistent measurements of the magnetic field there.
- CLASP, CLASP2, and now CLASP2.1 have developed and demonstrated a technique for making these measurements, as pathfinders for a future satellite chromospheric observatory.



How the CLASP instrument works

- The telescope feeds light of a narrow range of wavelengths into a spectrograph.
- At the front end of the spectrograph, a waveplate (the PMU) admits only light that is linearly polarized along a specified axis. As the waveplate rotates, the spectrograph gets to see all angles of polarization.
- At the detector-end of the spectrograph are polarization analyzers. We sample the intensity of the spectrum at 16 angles per rotation of the PMU. The spectrum images are then combined algebraically to yield the Stokes polarization parameters.

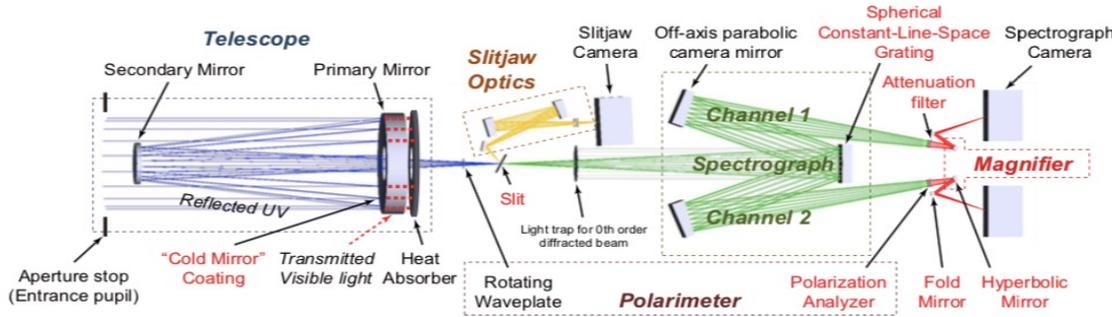


References:

- **Narukage et al.**, *Proc. SPIE*, vol 9905, id. 990508 12 pp. (2016).
- **Song et al.**, *Proc. SPIE*, vol 10699, id. 106992W 12 pp. (2018).
- **Yoshida et al.**, *Proc. SPIE*, vol 10699, id. 1069930 13 pp. (2018).

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$$\frac{Q}{I} = a^{-1} \frac{(D_{1,t_1} - D_{1,t_2} - D_{1,t_3} + D_{1,t_4} + D_{1,t_5} - D_{1,t_6} - D_{1,t_7} + D_{1,t_8}) + \dots}{(D_{1,t_1} + D_{1,t_2} + D_{1,t_3} + D_{1,t_4} + D_{1,t_5} + D_{1,t_6} + D_{1,t_7} + D_{1,t_8}) + \dots},$$

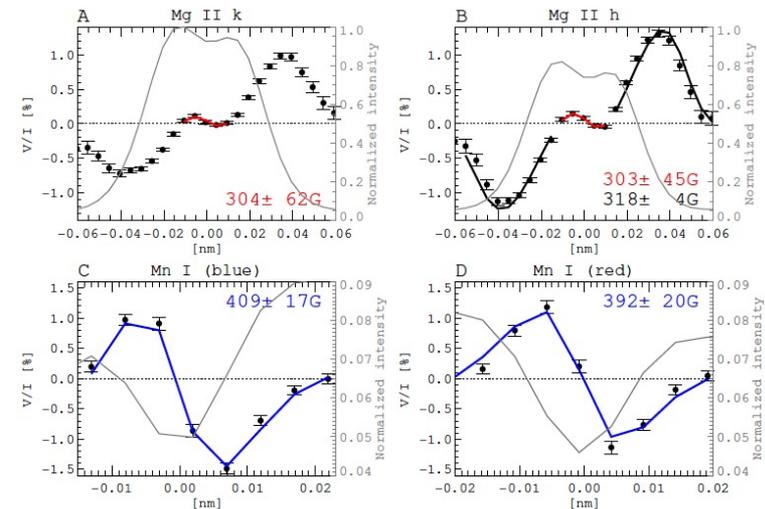
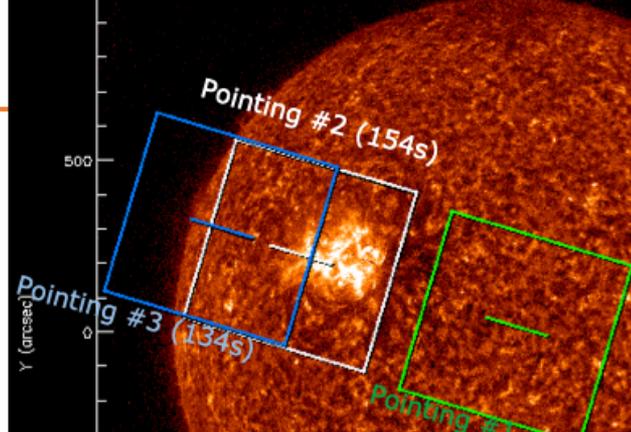
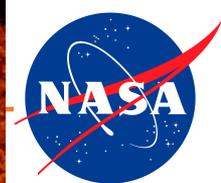
$$\frac{U}{I} = a^{-1} \frac{(D_{1,t_2} - D_{1,t_3} - D_{1,t_4} + D_{1,t_5} + D_{1,t_6} - D_{1,t_7} - D_{1,t_8} + D_{1,t_9}) + \dots}{(D_{1,t_2} + D_{1,t_3} + D_{1,t_4} + D_{1,t_5} + D_{1,t_6} + D_{1,t_7} + D_{1,t_8} + D_{1,t_9}) + \dots},$$

$$\frac{V}{I} = \left(\frac{b_1 + b_2}{2}\right)^{-1} \frac{(D_{1,t_3} + D_{1,t_4} - D_{1,t_5} - D_{1,t_6} - D_{1,t_7} - D_{1,t_8} + D_{1,t_9} + D_{1,t_{10}}) + \dots}{(D_{1,t_3} + D_{1,t_4} + D_{1,t_5} + D_{1,t_6} + D_{1,t_7} + D_{1,t_8} + D_{1,t_9} + D_{1,t_{10}}) + \dots},$$



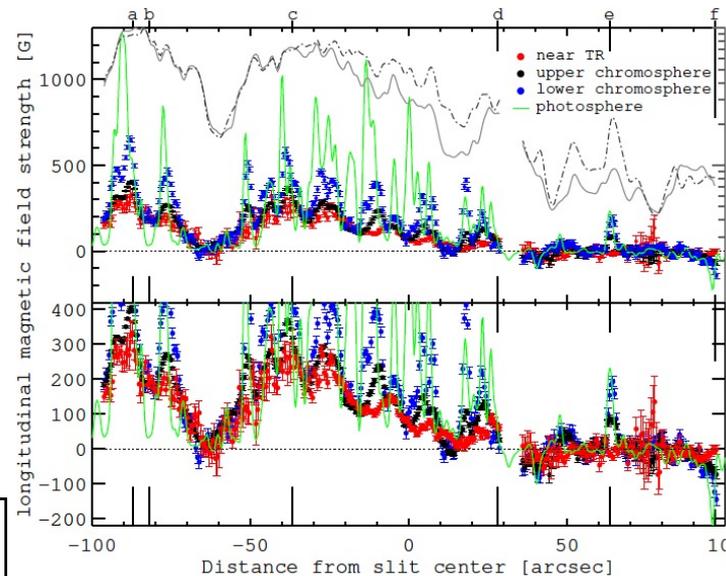
CLASP2 to CLASP2.1

What CLASP2 did: See
Ishikawa et al. 2021



Circular Stokes polarization from CLASP2

The result is a 1-dimensional *magnetogram*, a measure of magnetic field strength along a narrow track on the Sun.



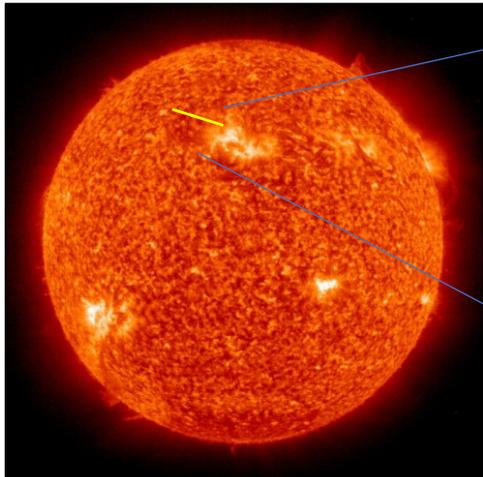


CLASP2 to CLASP2.1

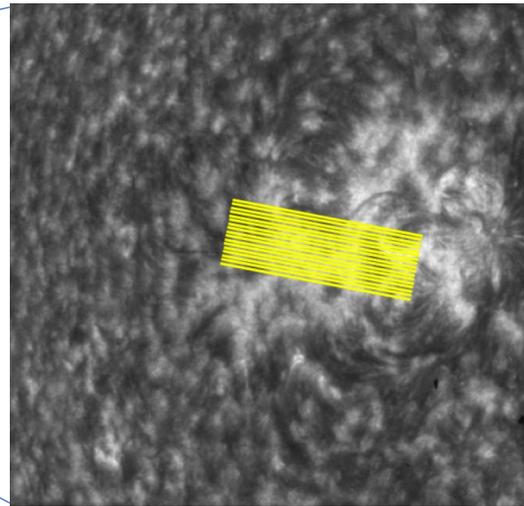


CLASP2.1 objective: Expand the 1-D “magnetogram” of CLASP2 over a 2-D area.

- Solution: Scan the spectrograph slit over the target.
 - For adequate signal/noise, we require at least 16 seconds “dwell” at each slit location
 - To make a useful/compelling data product, we require at least 8 pointings, approximately 2 arcsec apart



CLASP2



CLASP2.1 concept



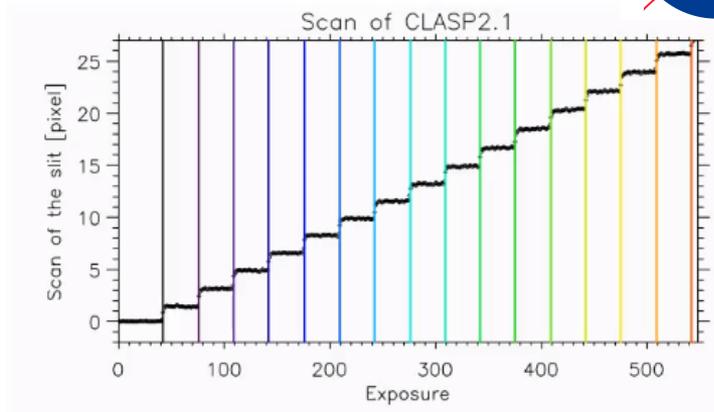
CLASP2.1 Preliminary results



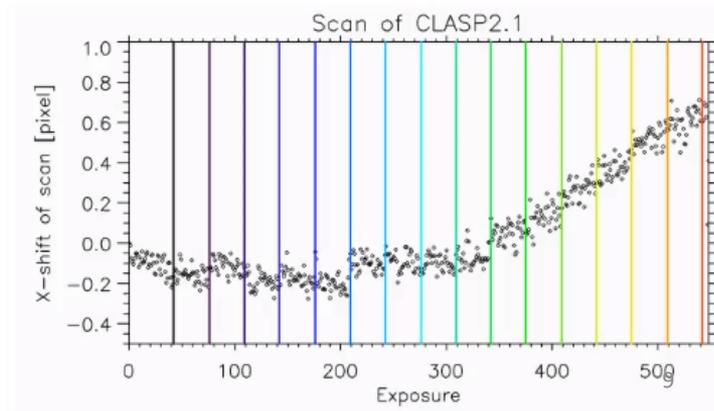
- Both the slitjaw (SJ) and spectro-polarimeter (SP) systems performed nominally.
- The pointing plan worked just like we'd hoped. We required at least 8 pointings, we actually got 16!
- Stability and resolution are consistent with the 2019 flight, and met expectations.
- The target region produced a flare and Earth-directed CME immediately after our observations, so we likely captured the magnetic field during the buildup.

12/17/2021

● Scanning of the slit (Y-direction)



● Shift of the slit (X-direction)

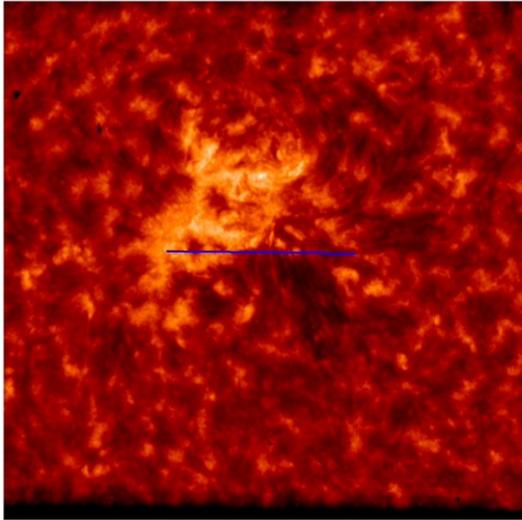




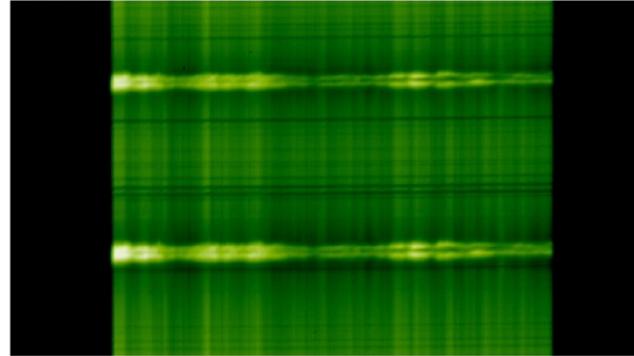
CLASP2.1 Preliminary results



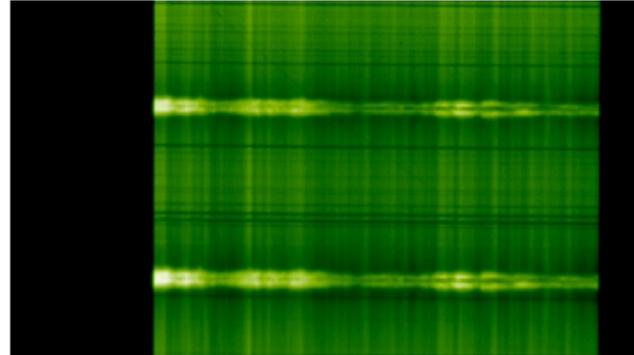
SJ ($\Delta t=158.1$ s)



SP1



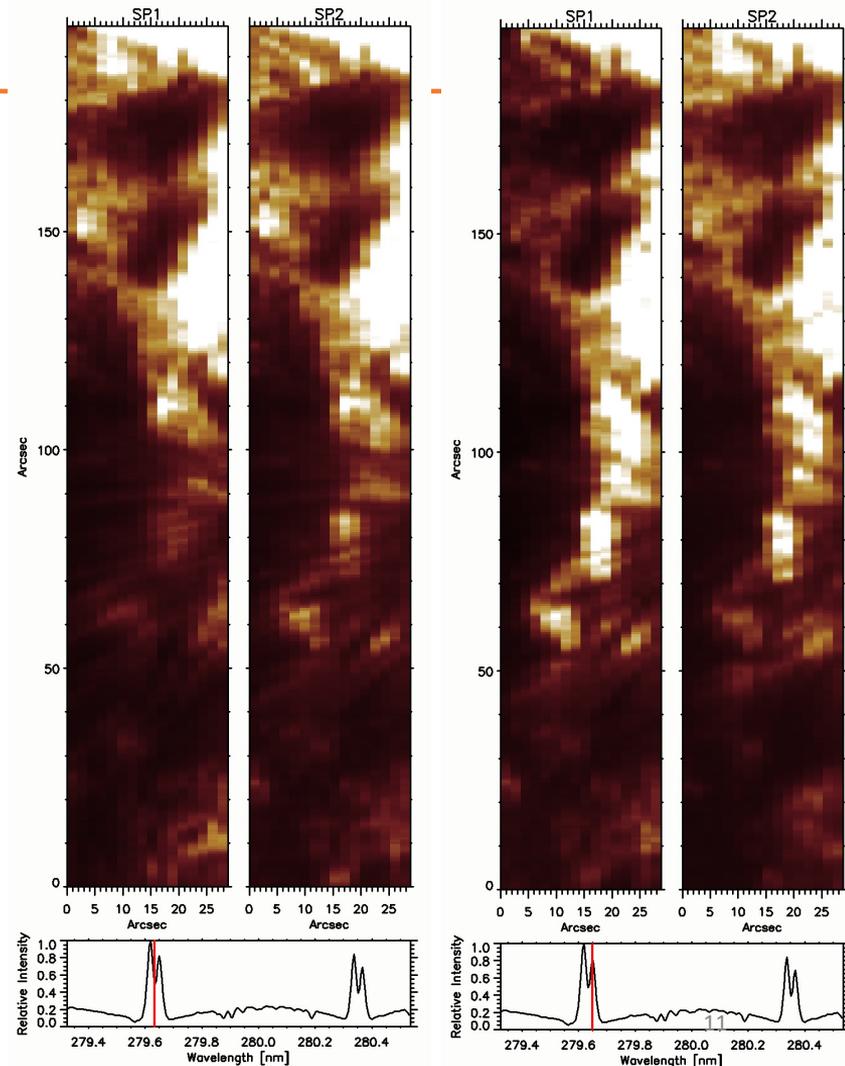
SP2





CLASP2.1 Preliminary results

- Stacking the exposures from 16 positions, side by side, creates a "raster image" of the target area.
- With a full spectrum at each location, we can select any wavelength to produce a raster map for the region, sampling a variety of heights.
 - Examples: Two different heights sampled by portions of the Mg II *k* line (K2R and K3).
- The polarization results, and the magnetic field strengths, will be shown in the same way. This will be the first-ever UV magnetogram of the chromosphere. Calibrations now in progress.





CLASP2.1 Status



- Payload recovered intact, all equipment returned to MSFC
- Nominal performance of all mechanisms & systems has been confirmed
- Now calibrating the data for science analysis and public release



12/17/2021