Early ALMA Science with Big Bear Solar Observatory's New Solar Telescope

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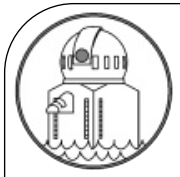

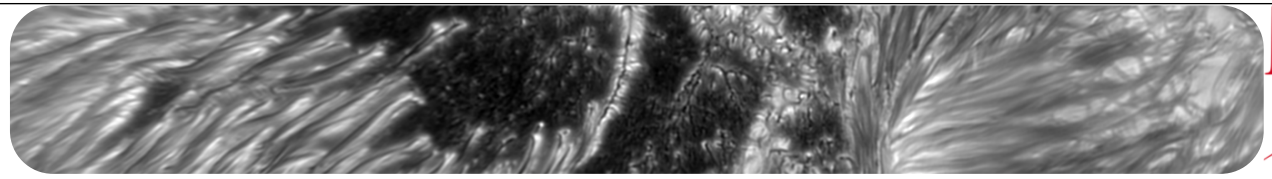

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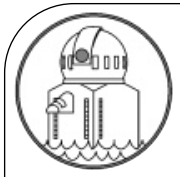
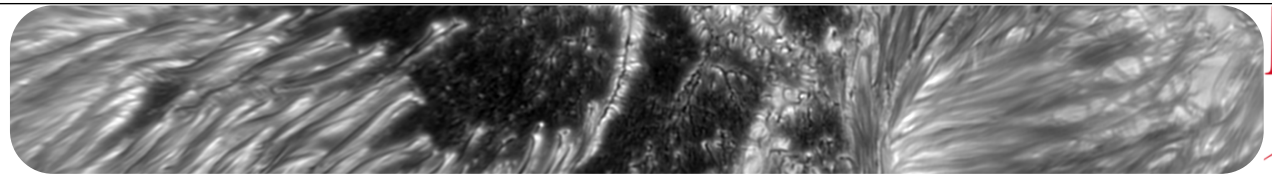
Outline

- Goal of the talk is to convince you to coordinate your ALMA (and IRIS) observations with NST.
- Description of NST and its instruments
- Joint science possible with ALMA and NST
- Ways to coordinate your observations
  - Outside proposal for NST time
  - Specific collaboration with NJIT or one of its partners
  - Simple request for observing support
  - Getting data with/without arranging for collaboration





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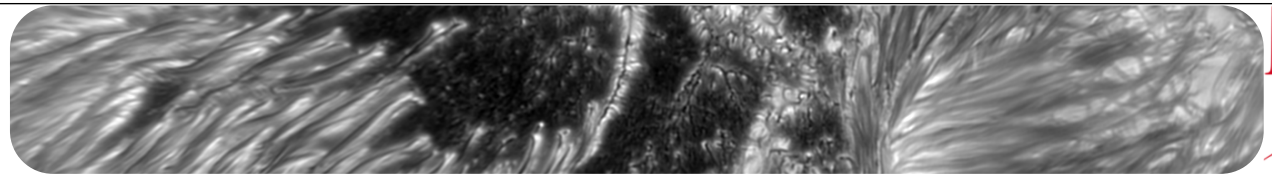
Why use NST for ALMA science?

- Synergies for joint ALMA/NST studies
  - Unprecedented spatial resolution (<0.1")
  - Targets similar, but distinct layers of the solar atmosphere
  - High cadence (~seconds) for dynamic changes
- Decent overlap of sky coverage
  - Longitude difference is 49.2 degrees (3.28 h). *c.f.* 107 degrees (7.13 h) for DKIST.
  - NST sky coverage roughly ±3.5 hours from meridian, year-round => 1630-2330 UT.
  - 1630 UT is when the Sun is on the meridian at ALMA, so time overlap is 3-4 hours depending on ALMA altitude limit (morning at BBSO, afternoon in Chile).
- NST instrumentation can provide important additional information for interpreting ALMA data.



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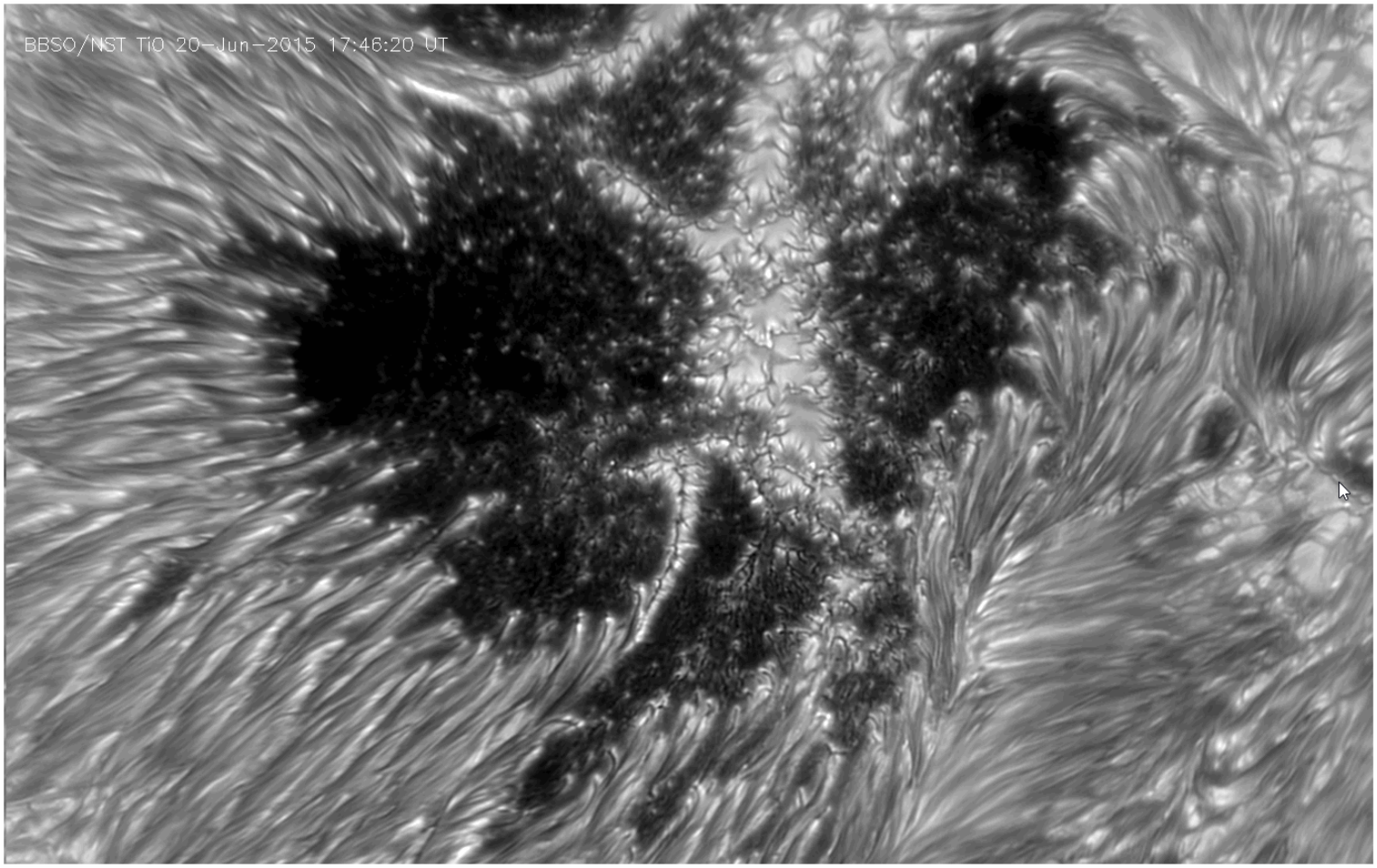
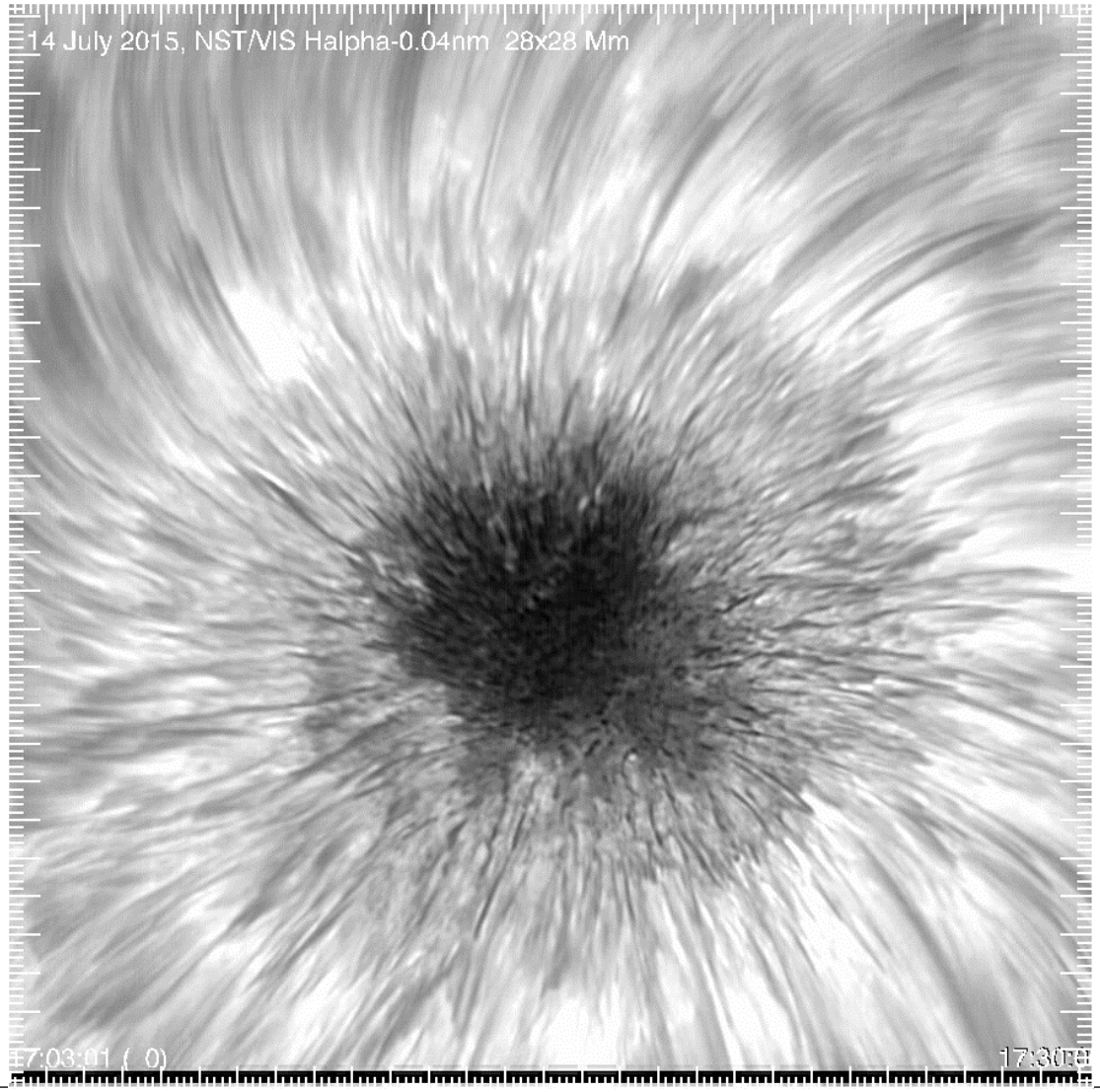
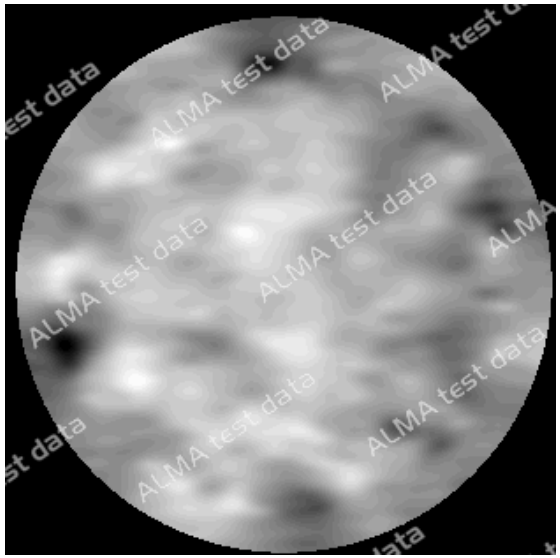
Diffraction-Limited Images



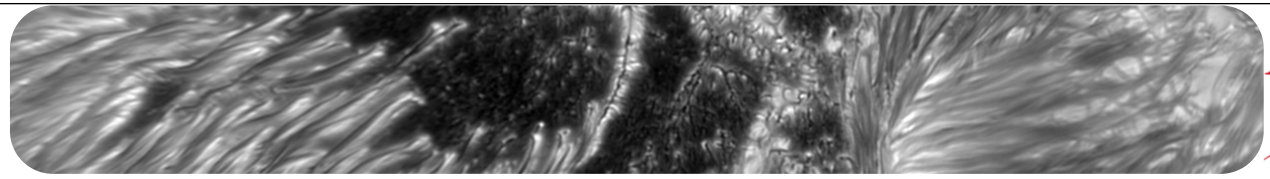
Science highlights—umbral waves





Example ALMA movie
Dec. 2016 campaign (2 s)
(Yi Chai)

Yurchyshyn et al., in preparation



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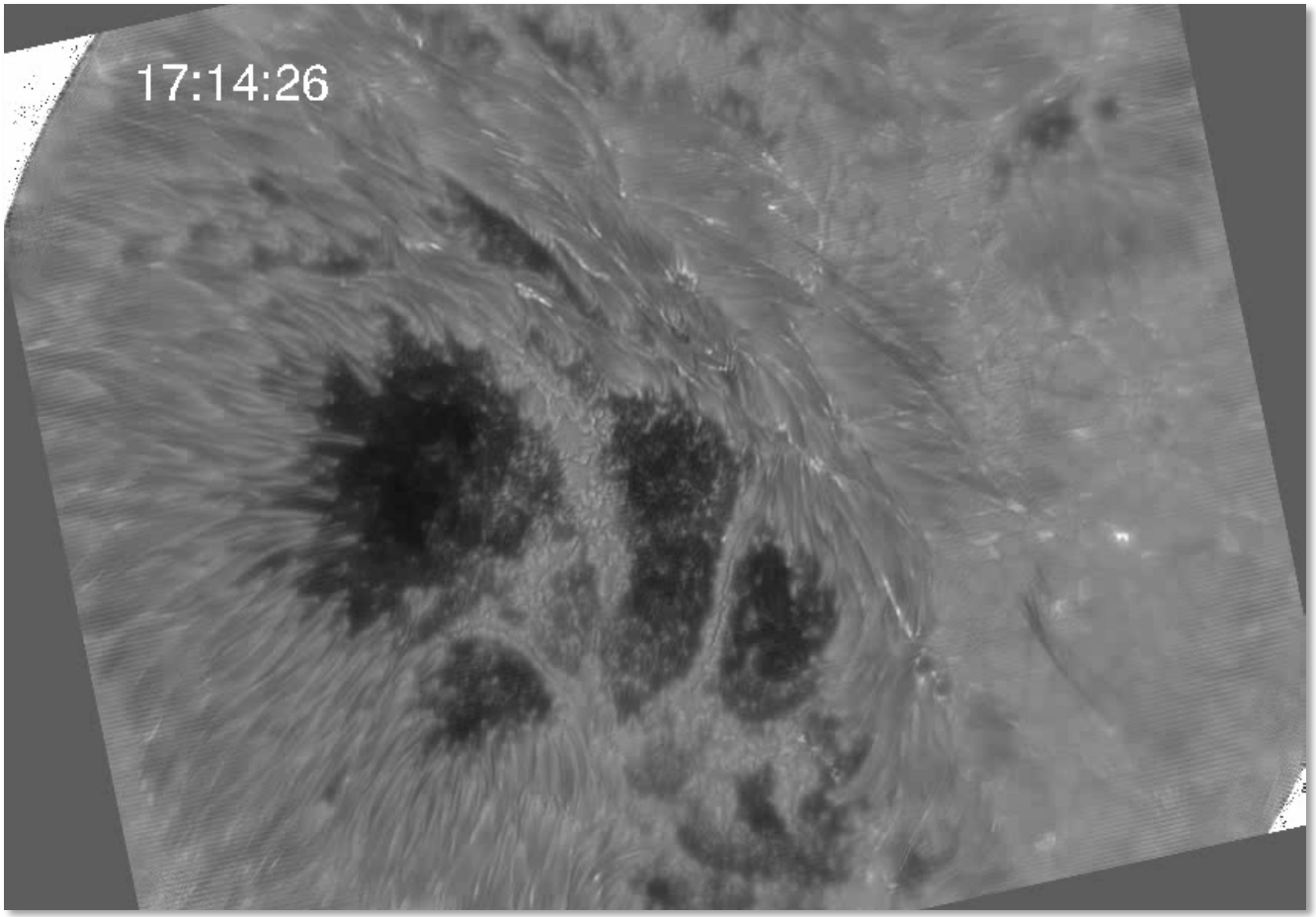
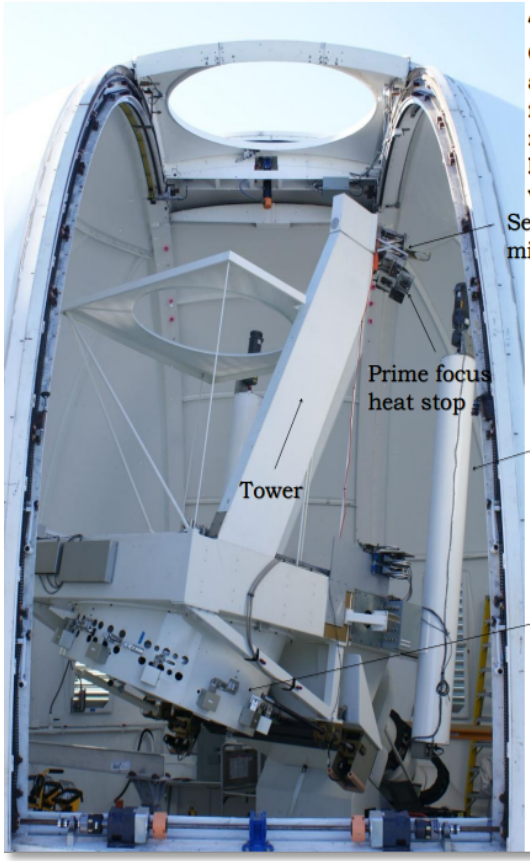
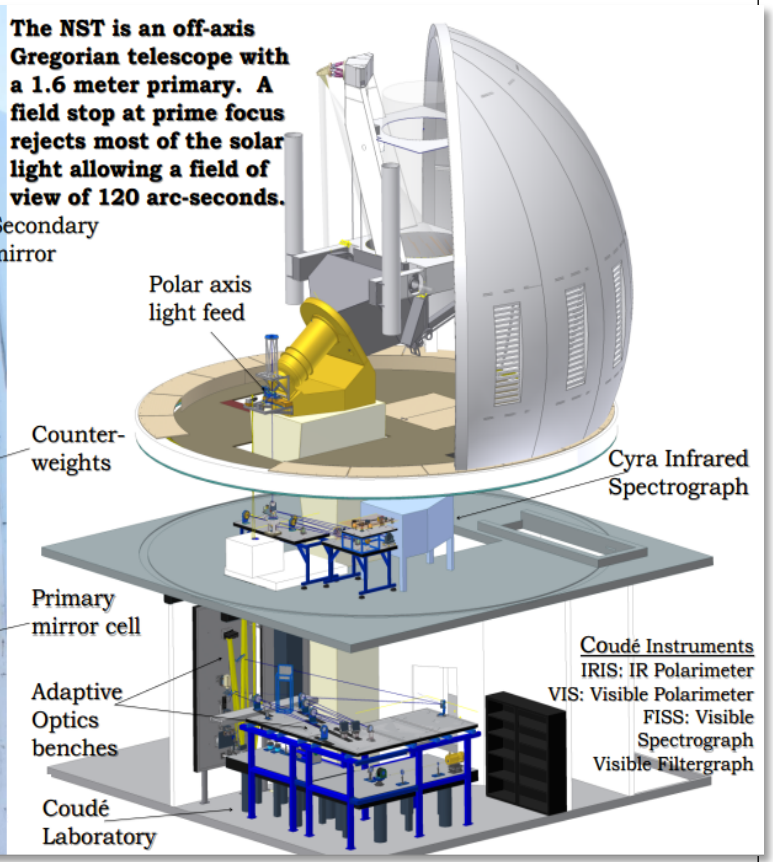
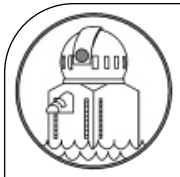
2015 June 22 solar Flare

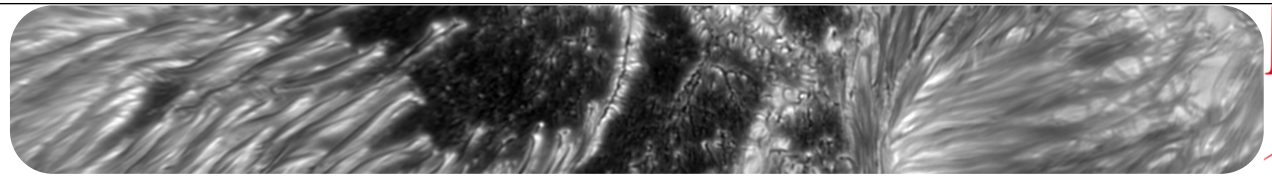


The New Solar Telescope









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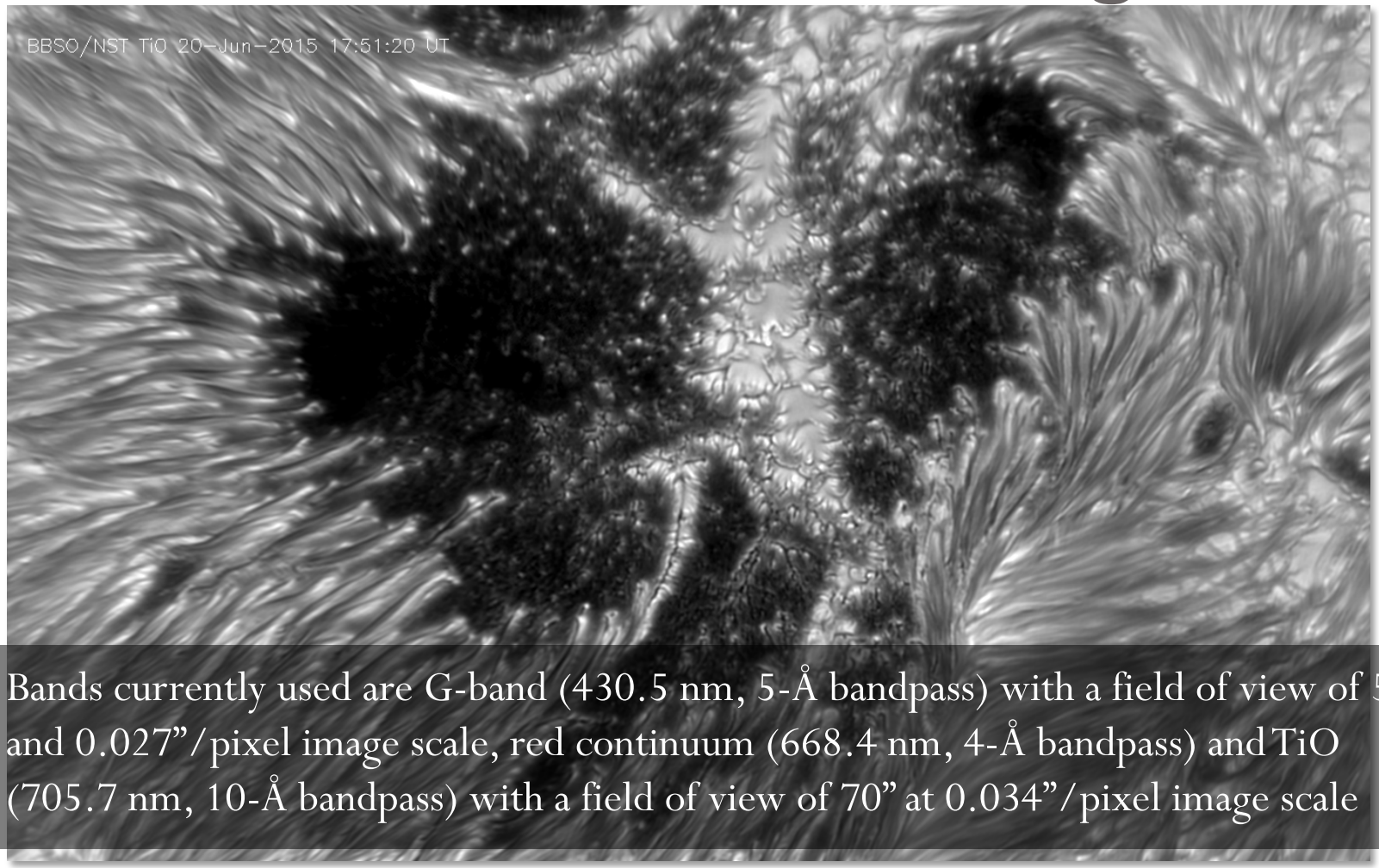
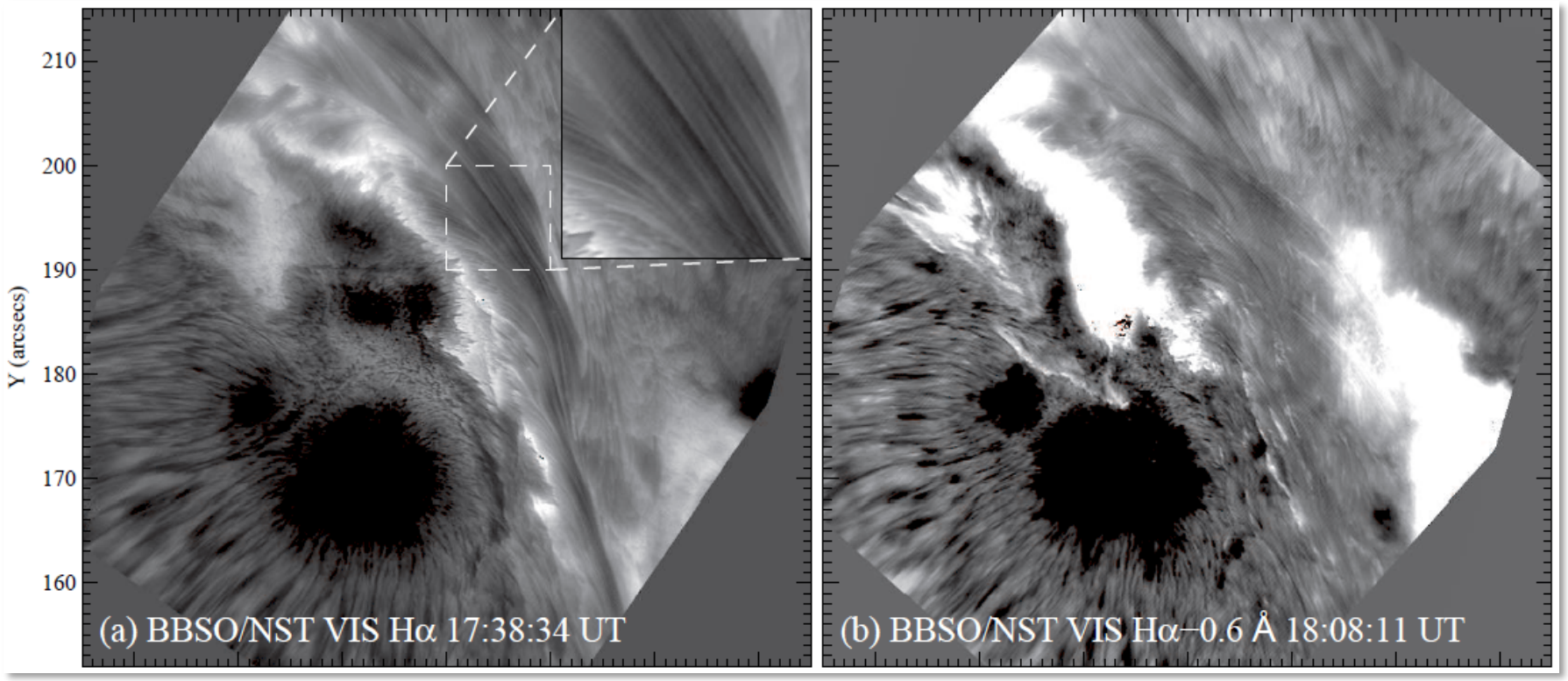
BFI—broadband filter imager



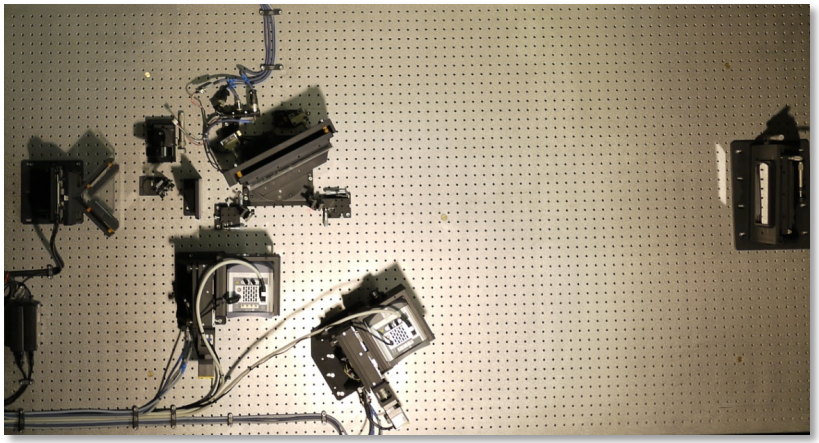
- Bands currently used are G-band (430.5 nm, 5-Å bandpass) with a field of view of 55" and 0.027"/pixel image scale, red continuum (668.4 nm, 4-Å bandpass) and TiO (705.7 nm, 10-Å bandpass) with a field of view of 70" at 0.034"/pixel image scale

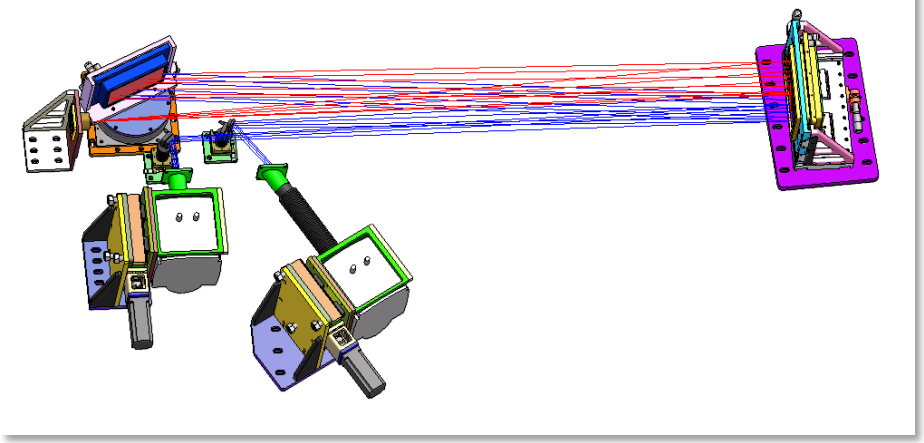
Vis—visible imaging spectrograph

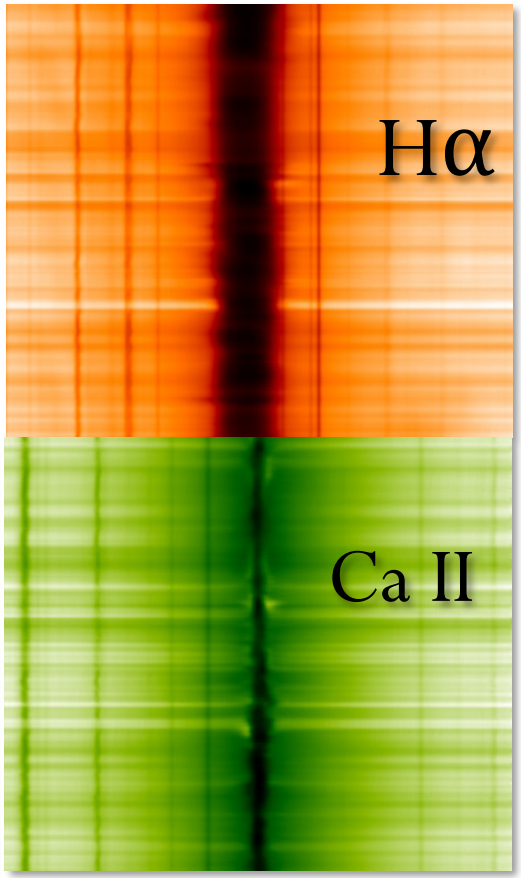


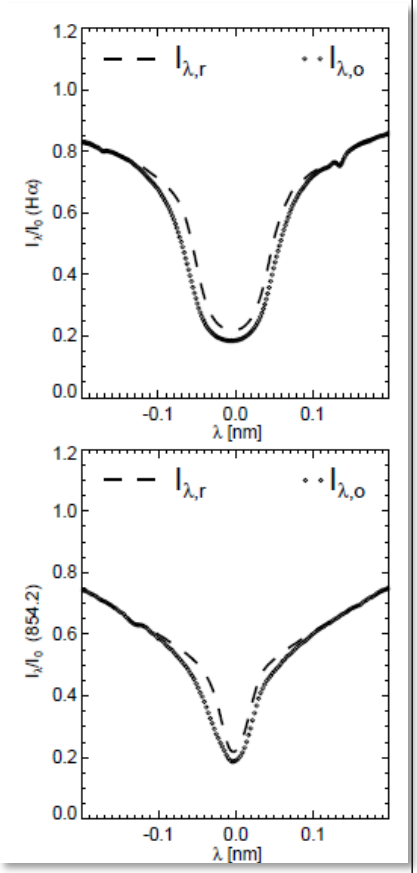
- Can tune to spectral lines Ha, Fe I 630 nm, Na I D2, 589 nm, He I D3, 588 nm, resolution 0.07Å, and scan line quickly.
- Typical wavelengths are Ha±1.0Å, Ha±0.6Å, Ha 0.0Å (25 s cadence)

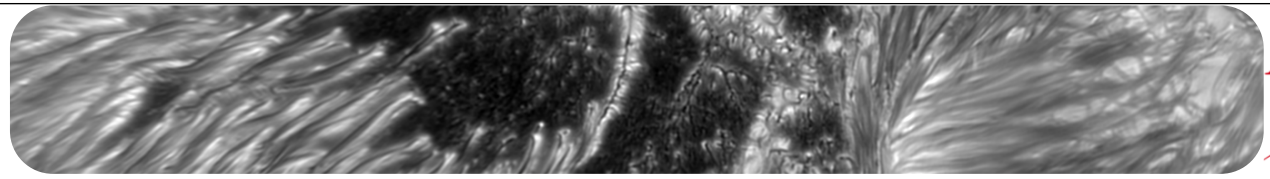
Korean Spectrometer—FISS











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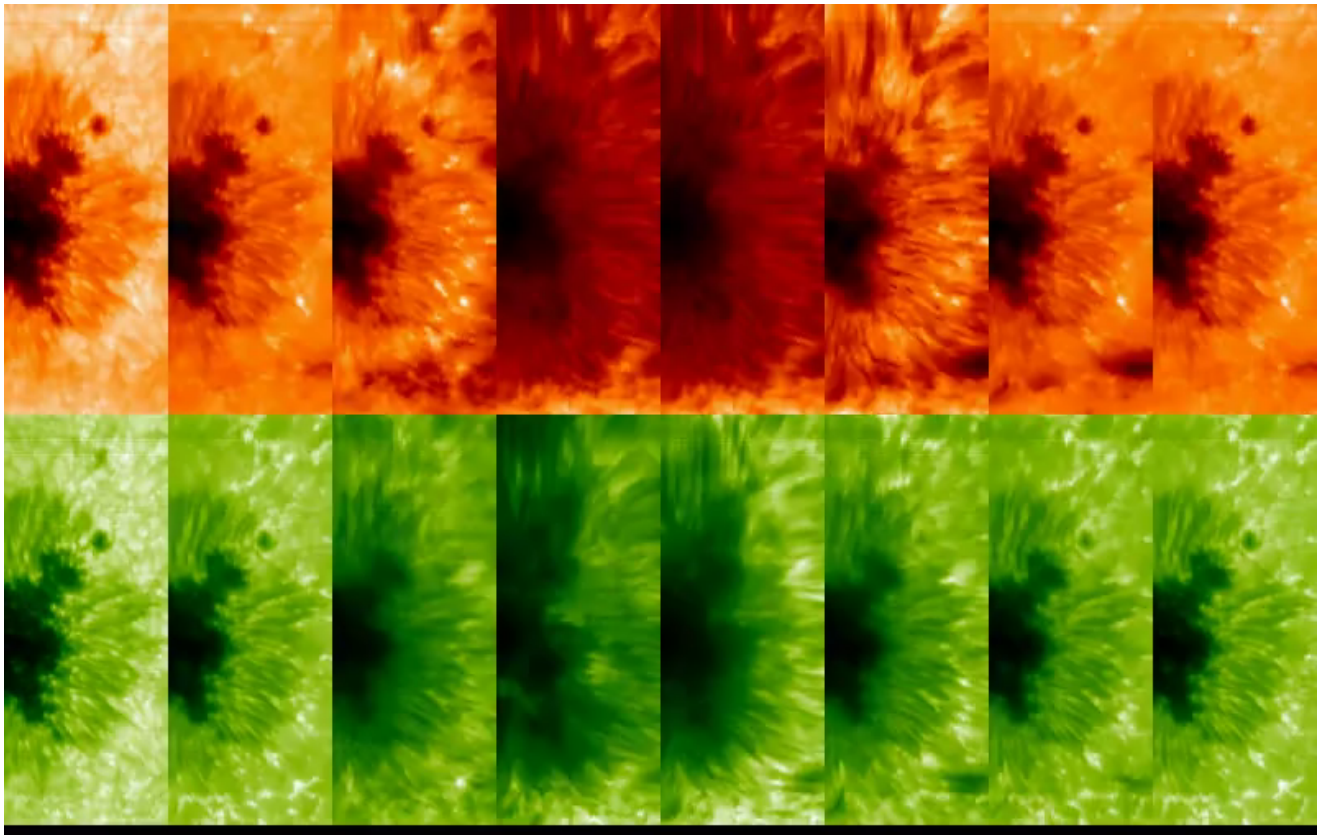
Fast-imaging solar spectrograph♪

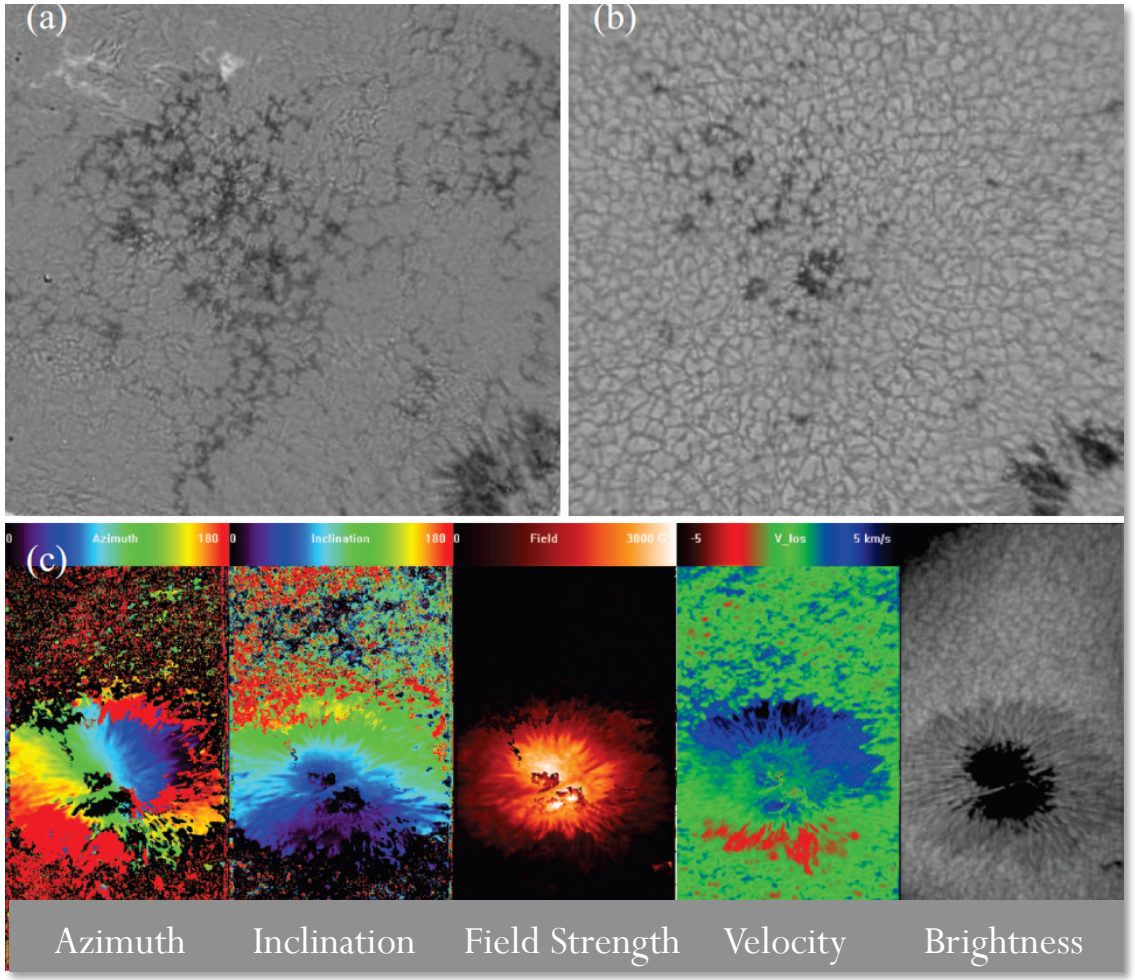
Hα

Ca II

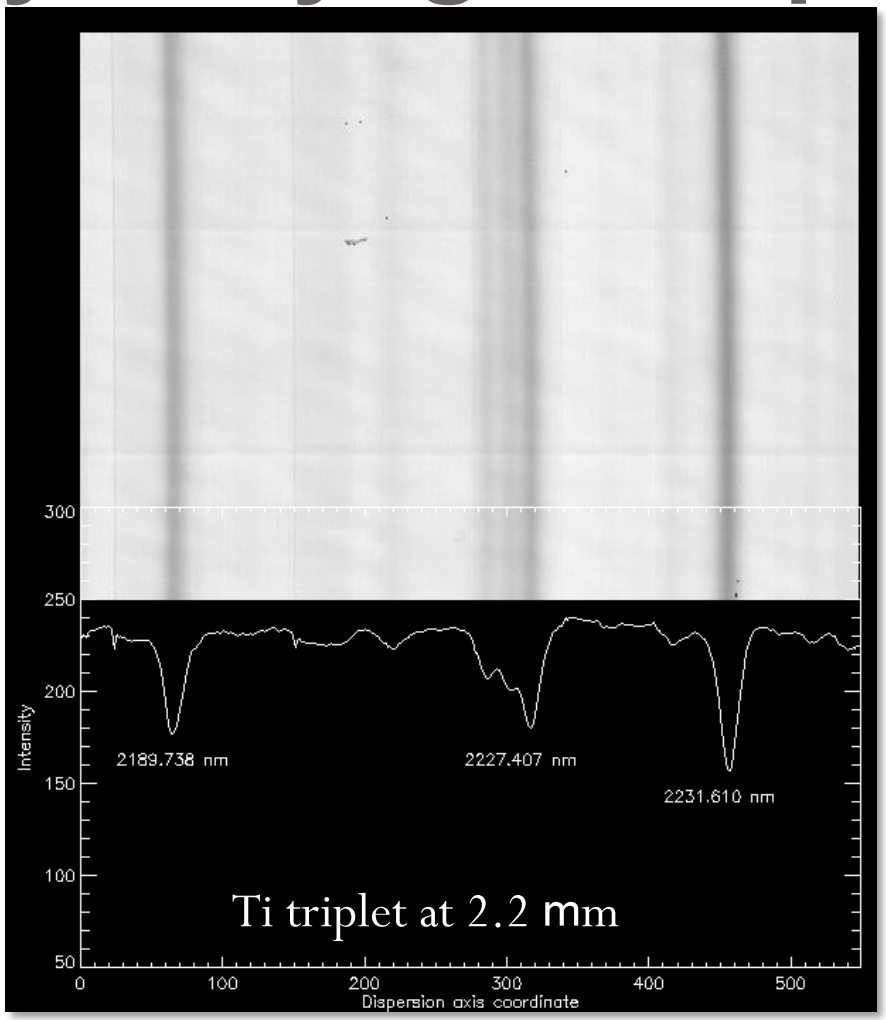


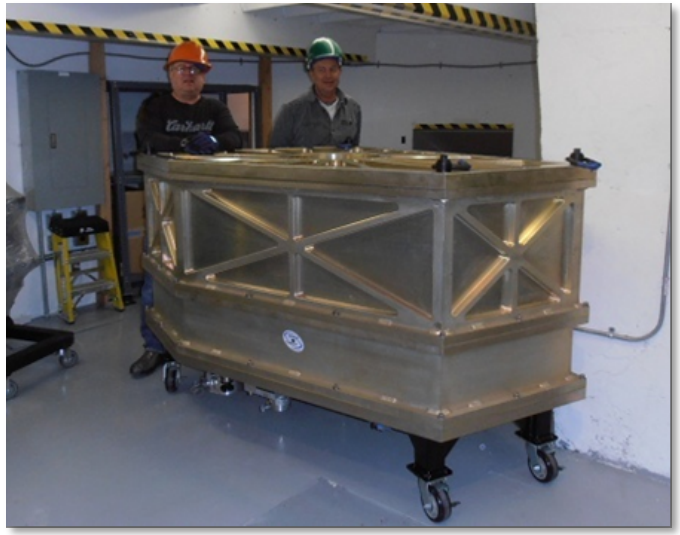
NIRIS—near IR imaging spectrograph

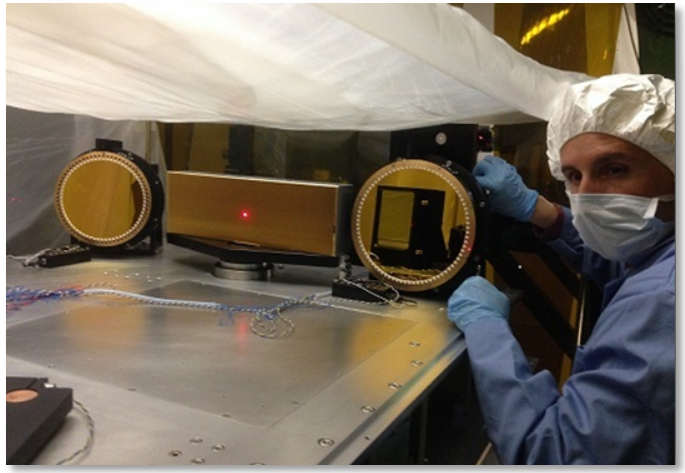
- Measures >100 l positions in 16 polarizations in magnetically sensitive iron line.
- Used to make measurements of magnetic field at high resolution.
- Now implementing He I 10830 Å for the 2016 observing season.

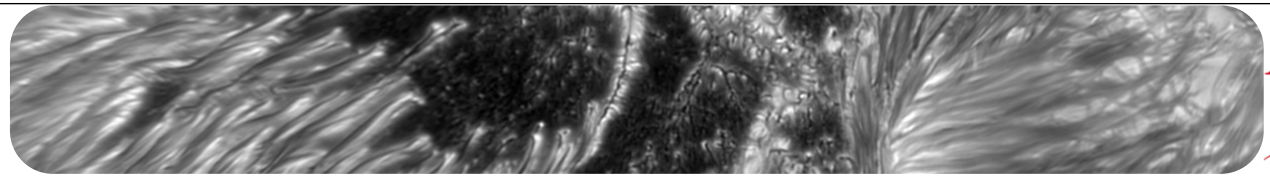


Cyra cryogenic spectrograph









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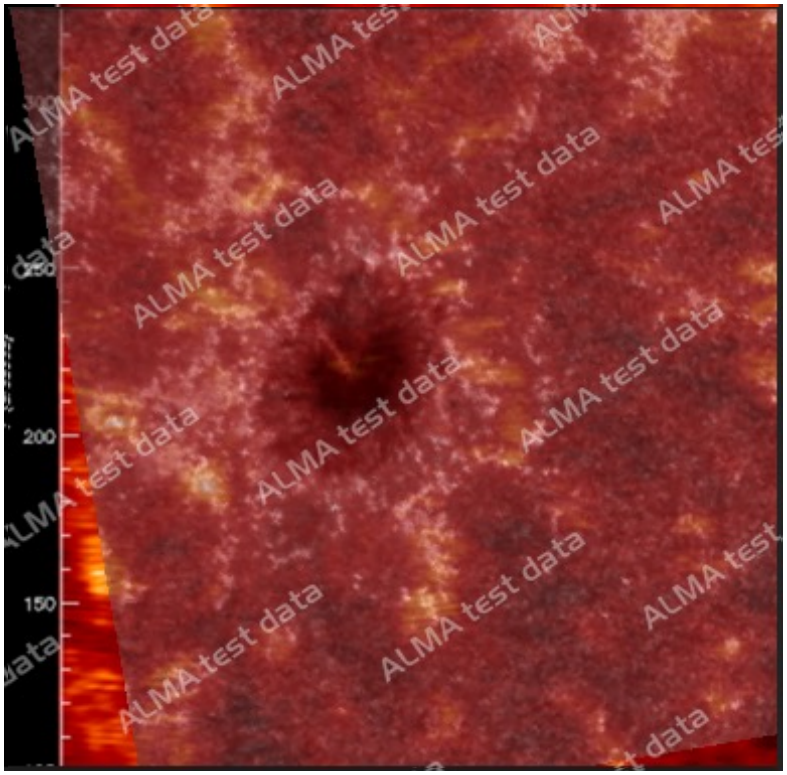
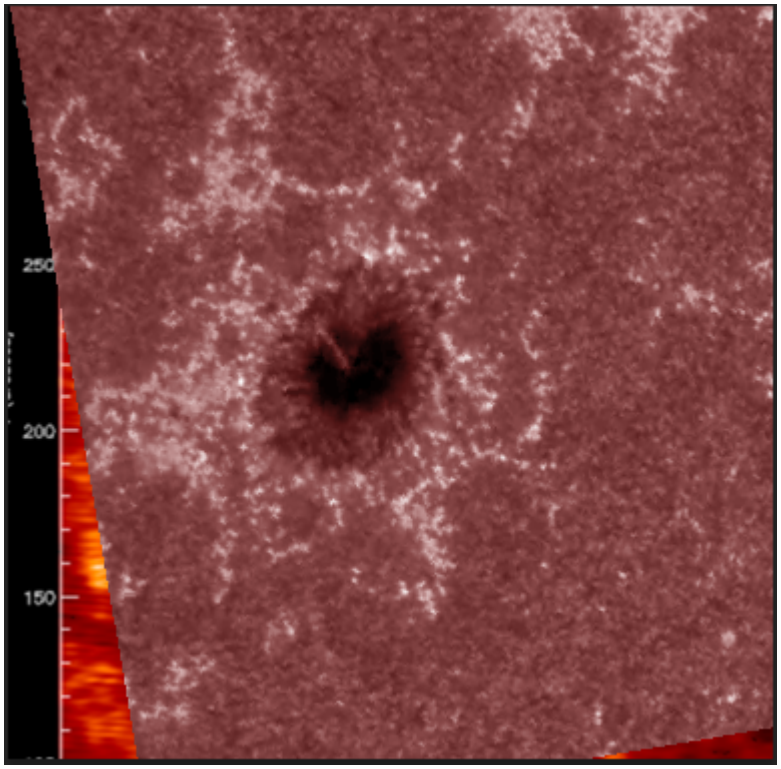
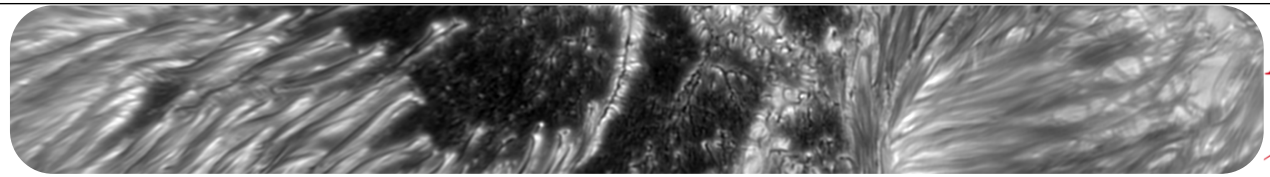
ALMA/AIA 1700 Comparison







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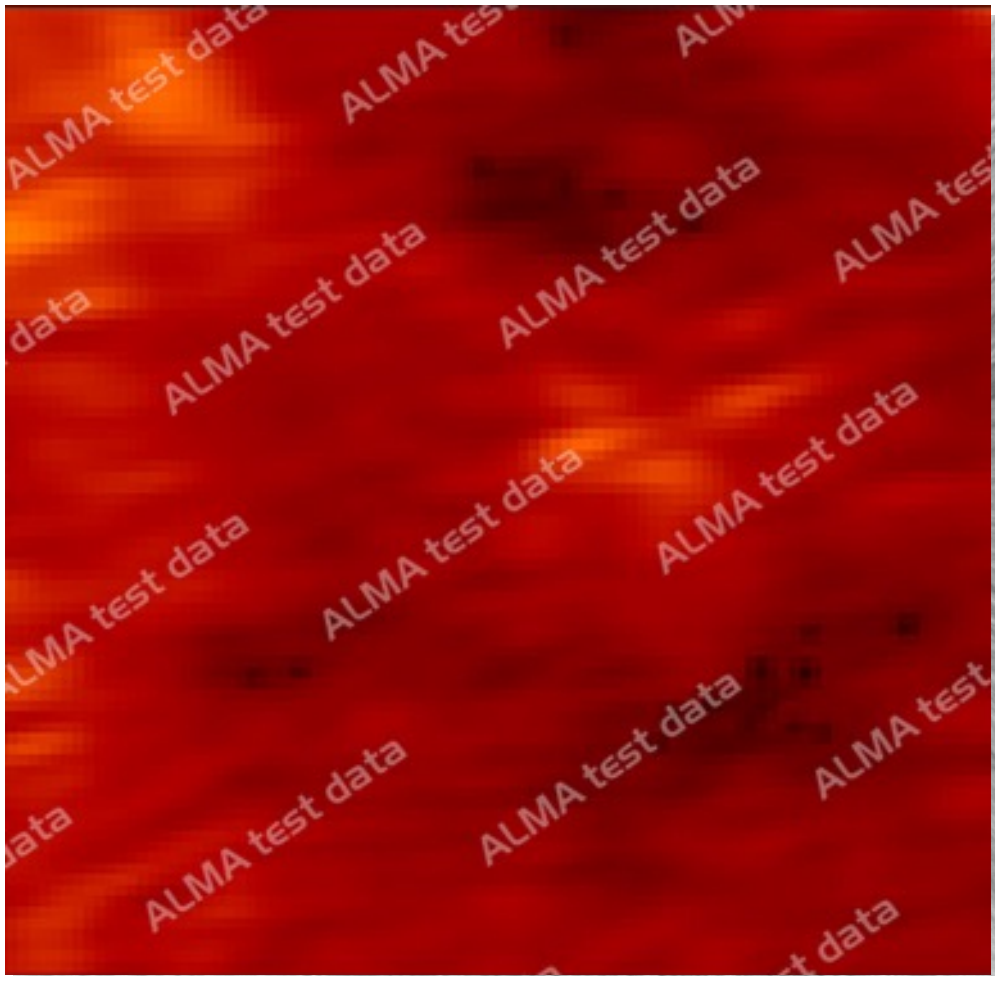
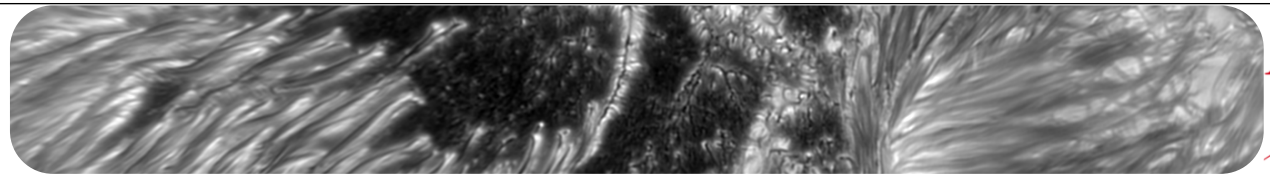
Data from Dec 2015 Campaign



- ALMA resolution during the campaign (~1.2" for this band 3 image).
- Longer baselines and more ALMA antennas are available—to rival BBSO resolution.



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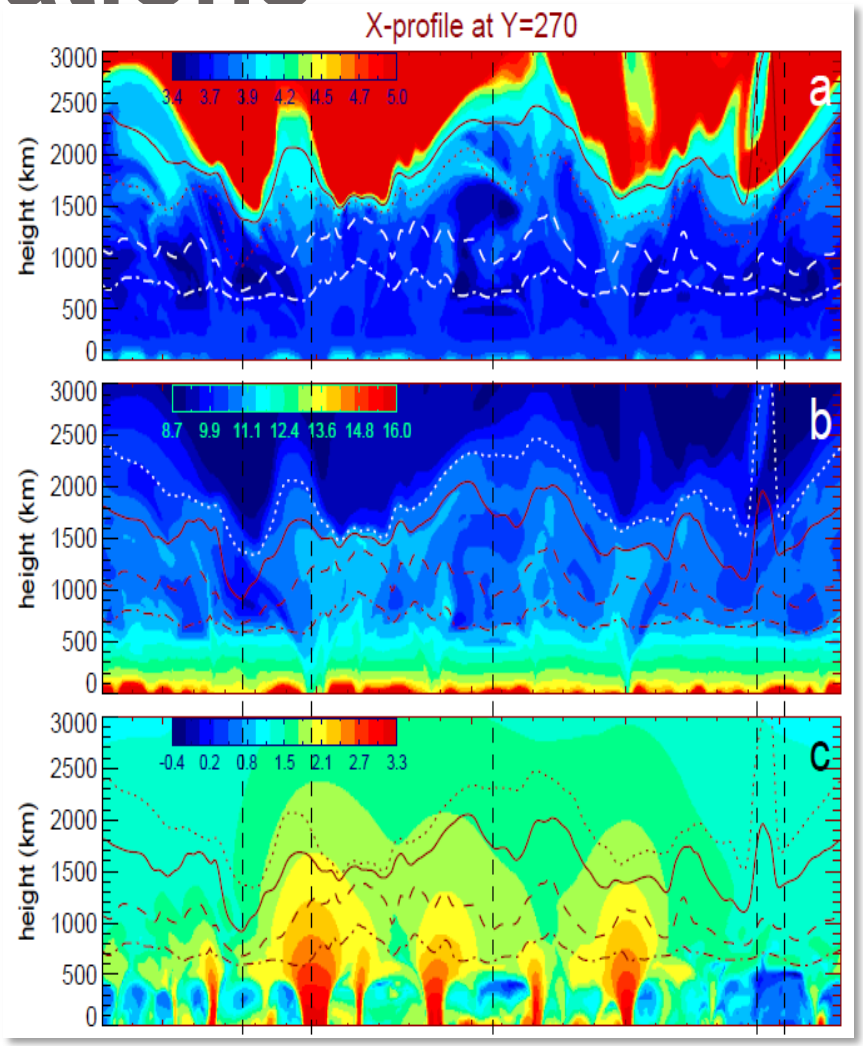
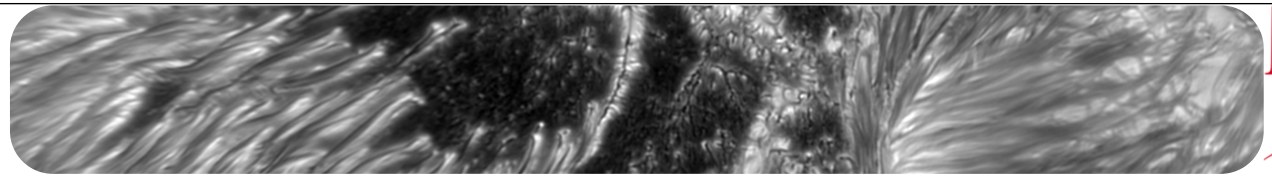
Alma solar simulations

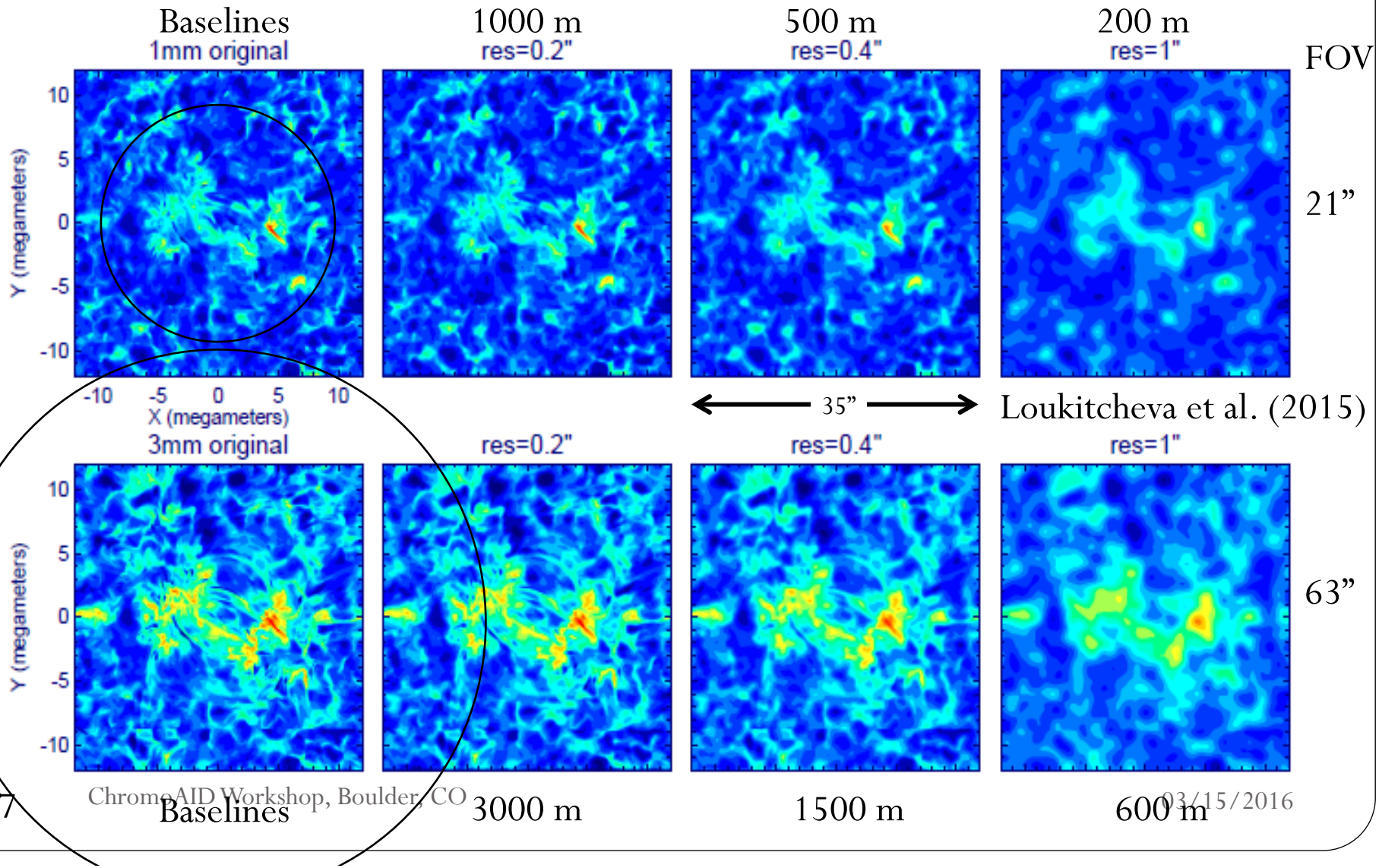
- Height of emission at different wavelengths (0.4, 1, 3, 6 and 10 mm), along a single cut across the image, showing the part of the solar chromosphere that can be studied by ALMA.
- This is highly complementary to NST observations, which are sampling heights near 500 km with roughly the same spatial resolution.
- Movies at high cadence at multiple frequencies can show dynamics.

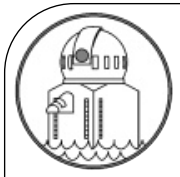


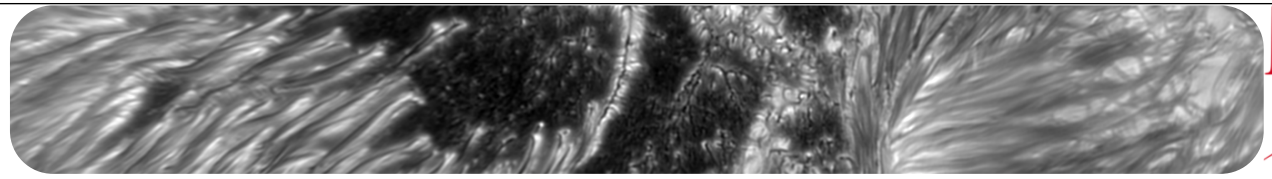
Loukitcheva et al. (2015)



Alma solar simulations







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Coordinating with NST

- Outside proposal for NST time (limited, about 2 weeks/year)
  - Submit proposals at http://www.bbso.njit.edu/cgi-bin/NSTObsForm
  - Deadline 1 June for session II (through Oct. 31)
  - Time between Nov. 1, 2016 and May 1, 2017 (off-season) much less formal.
- Specific collaboration with NJIT or one of its partners
  - Contact one of our scientists (e.g. Haimin Wang, Vasyl Yurchyshyn, Chang Liu, Na Deng, Ju Jing, Yan Xu, Dale Gary, Wenda Cao) and ask them to collaborate on a proposal.
- Simple request for observing support
  - Contact Haimin Wang or Vasyl Yurchyshyn for general observing support (ToO)
- Getting data with/without arranging for collaboration
  - Check the NST data catalog (http://www.bbso.njit.edu/~vayur/NST_catalog/)
  - Fill out data request (http://www.bbso.njit.edu/~vayur/nst_requests/)