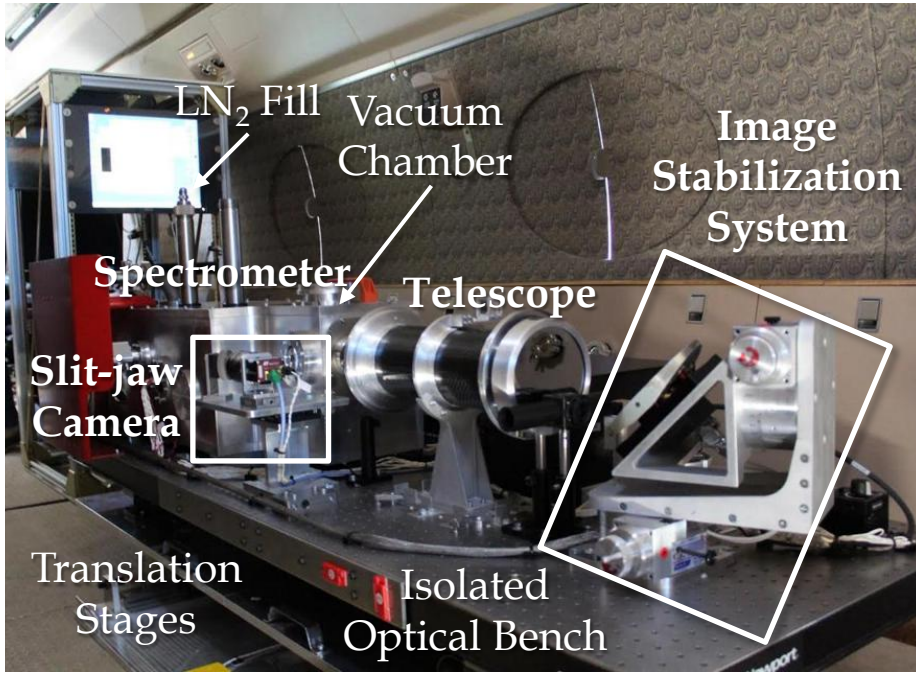
Infrared Eclipse Observations: Implications for DKIST

Jenna Samra, Shadia Habbal, Philip Judge, Adi Ding

DKIST CSP Workshop
28 June 2018

The Airborne IR Spectrometer

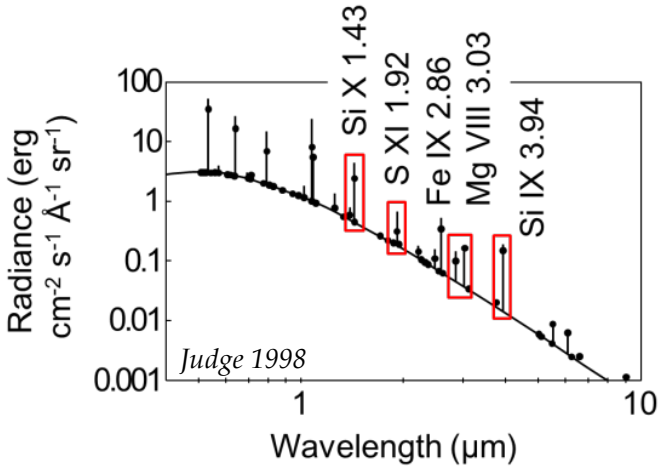
Airborne **I**nfra**R**ed **Spec**trometer (**AIR-Spec**)



NSF/NCAR **G**ulfstream-**V** **H**igh-performance **I**nstrumented **A**irborne **P**latform for **E**nvironmental **R**esearch (**GV HIAPER**)

https://www.eol.ucar.edu/content/about-hippo

Target Lines

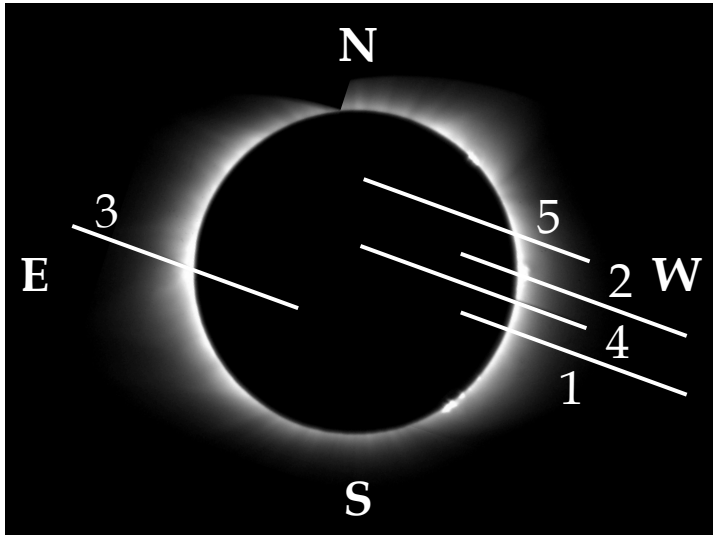


Ion	λ (μm)	Transition	Level (cm^{-1})
Si X	1.43	[He] $2s^2 2p\ {}^2P^\circ_{3/2 \rightarrow 1/2}$	6,990.6 → 0.0
S XI	1.92	[He] $2s^2 2p^2\ {}^3P_{1 \rightarrow 0}$	5,208.0 → 0
Fe IX	2.84	[Ne] $3s^2 3p^5 3d\ {}^3F^\circ_{3 \rightarrow 4}$	429,310.9 → 425,809.8
Mg VIII	3.03	[He] $2s^2 2p\ {}^2P^\circ_{3/2 \rightarrow ½}$	3,302 → 0
Si IX	3.94	[He] $2s^2 2p^2\ {}^3P_{1 \rightarrow 0}$	2,545.0 → 0.0

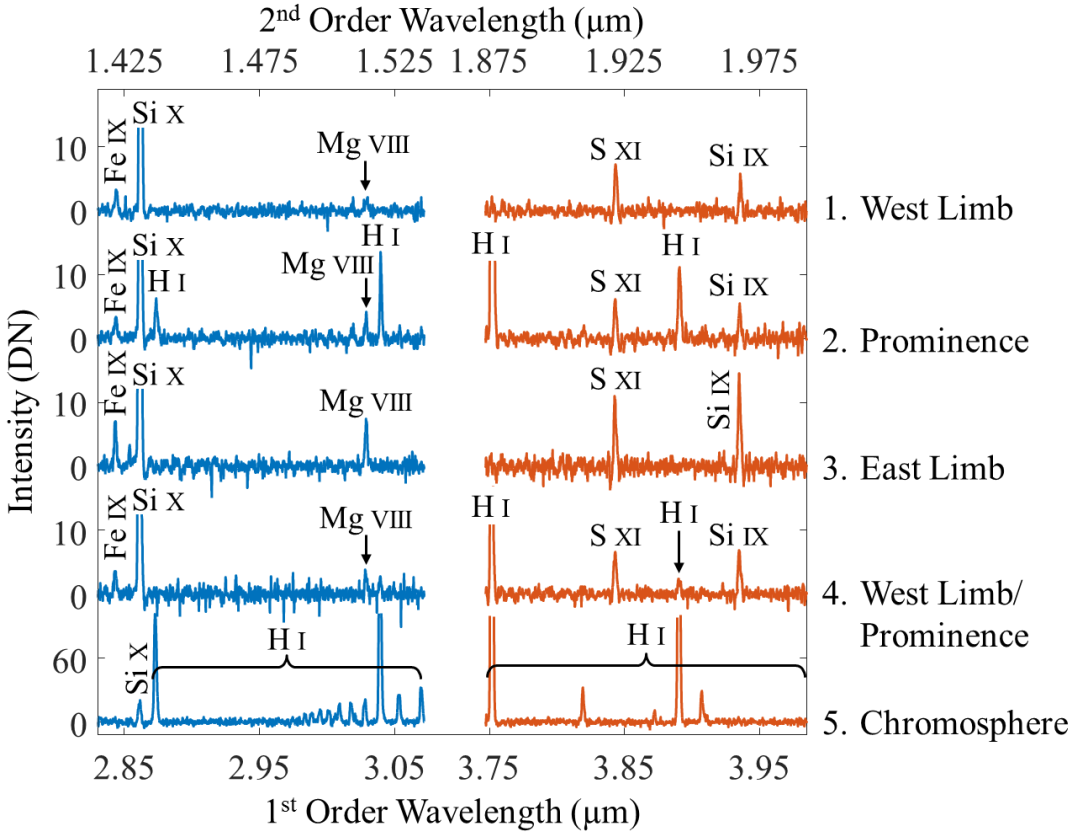
Goals

1. Measure line wavelengths and intensities in different regions of the corona.
2. Measure intensity gradient as a function of distance from the limb.
   Information on line excitation processes
3. Search for time-varying Doppler velocities.
   Signatures of waves or flows

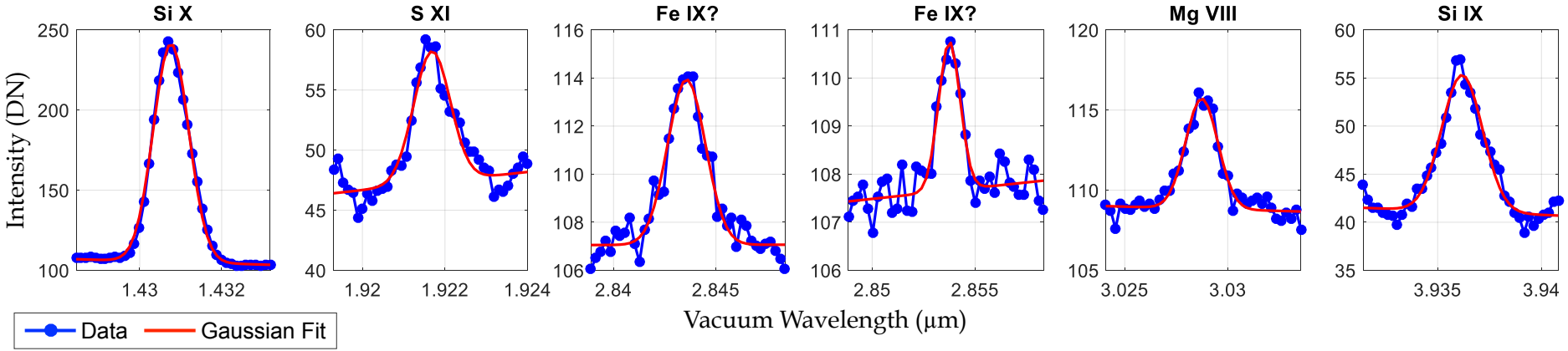
Eclipse Data Summary



1. West Limb	63.5 sec	953 frames
2. Prominence	41.5 sec	622 frames
3. East Limb	35.7 sec	536 frames
4. Prom./West Limb	82.4 sec	1236 frames
5. Chromosphere	5 sec	75 frames

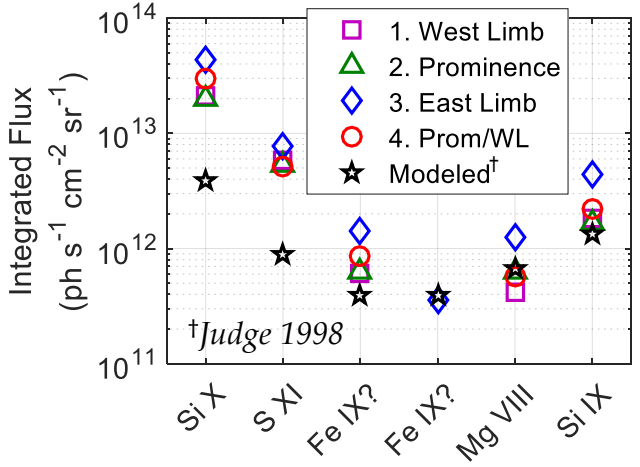


Emission Line Parameters



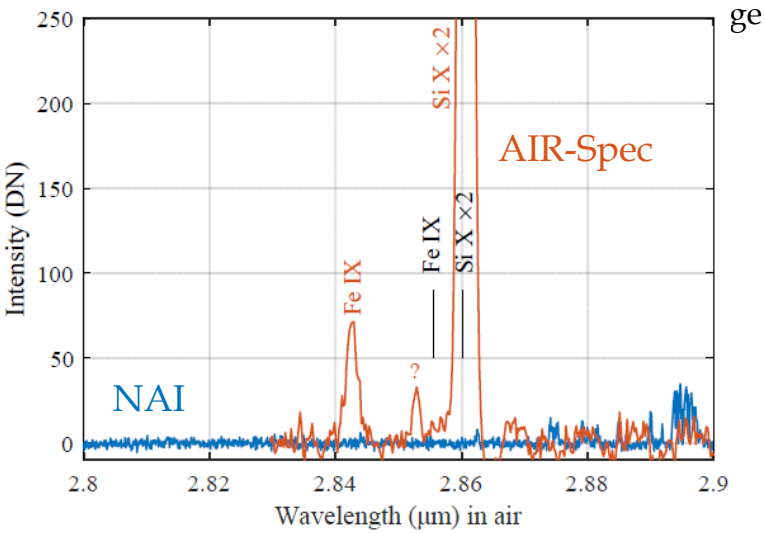
Obs. 3, East Limb

	Vacuum Wavelength (μm)	FWHM (Å)	Amplitude (σ)	Integrated Flux (10^{12} ph s^{-1} cm^{-2} sr^{-1})
Si X	1.4308	10.1	185	44
S XI	1.9217	10.8	13	7.8
Fe IX?	2.8436	21.8	9.3	1.4
Fe IX?	2.8537	12.3	4.2	0.36
Mg VIII	3.0287	18.4	9.3	1.3
Si IX	3.9362	23.1	17	4.4



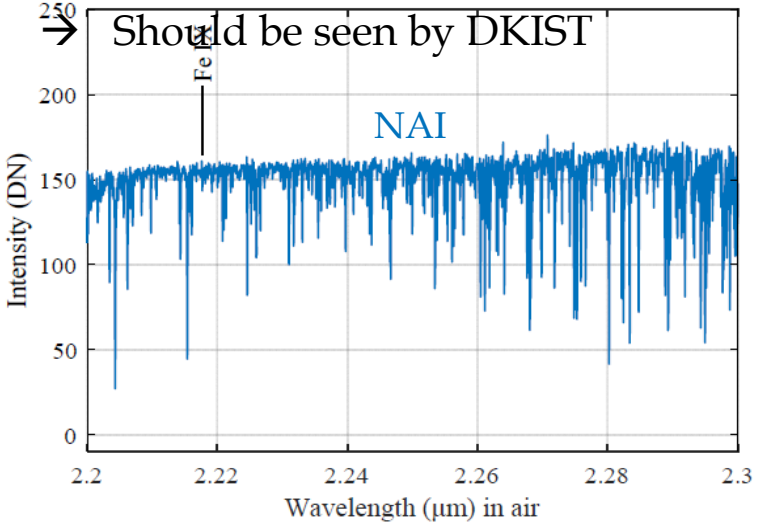
Fe IX 2.84 μm, First Observation

- **2.844 μm**, *3s23p53d 3F↓3 → 4↑o*
- First observation by AIR-Spec
- Total atmospheric absorption



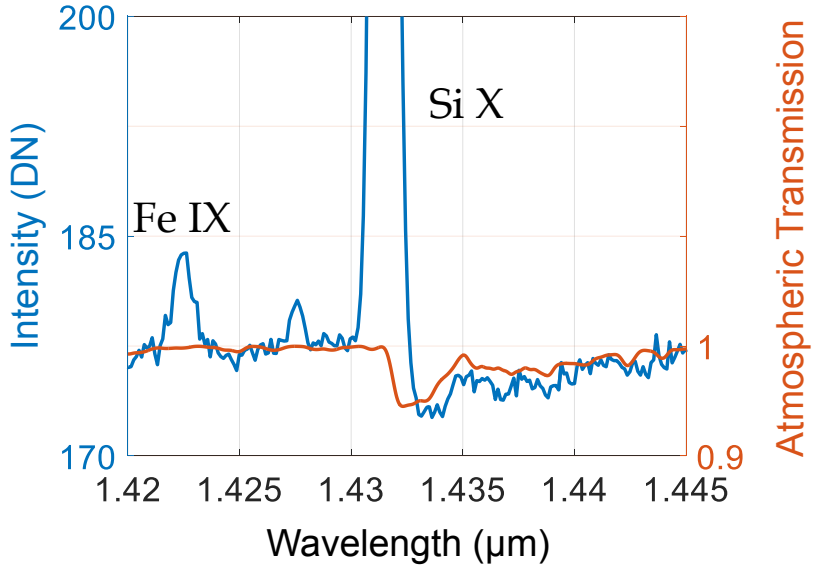
- **2.218 μm**, *3s23p53d 3F↓2 → 3↑o*
- Similar branching ratio to 2.844 μm
- Transmitted to the ground

→ Should be seen by DKIST

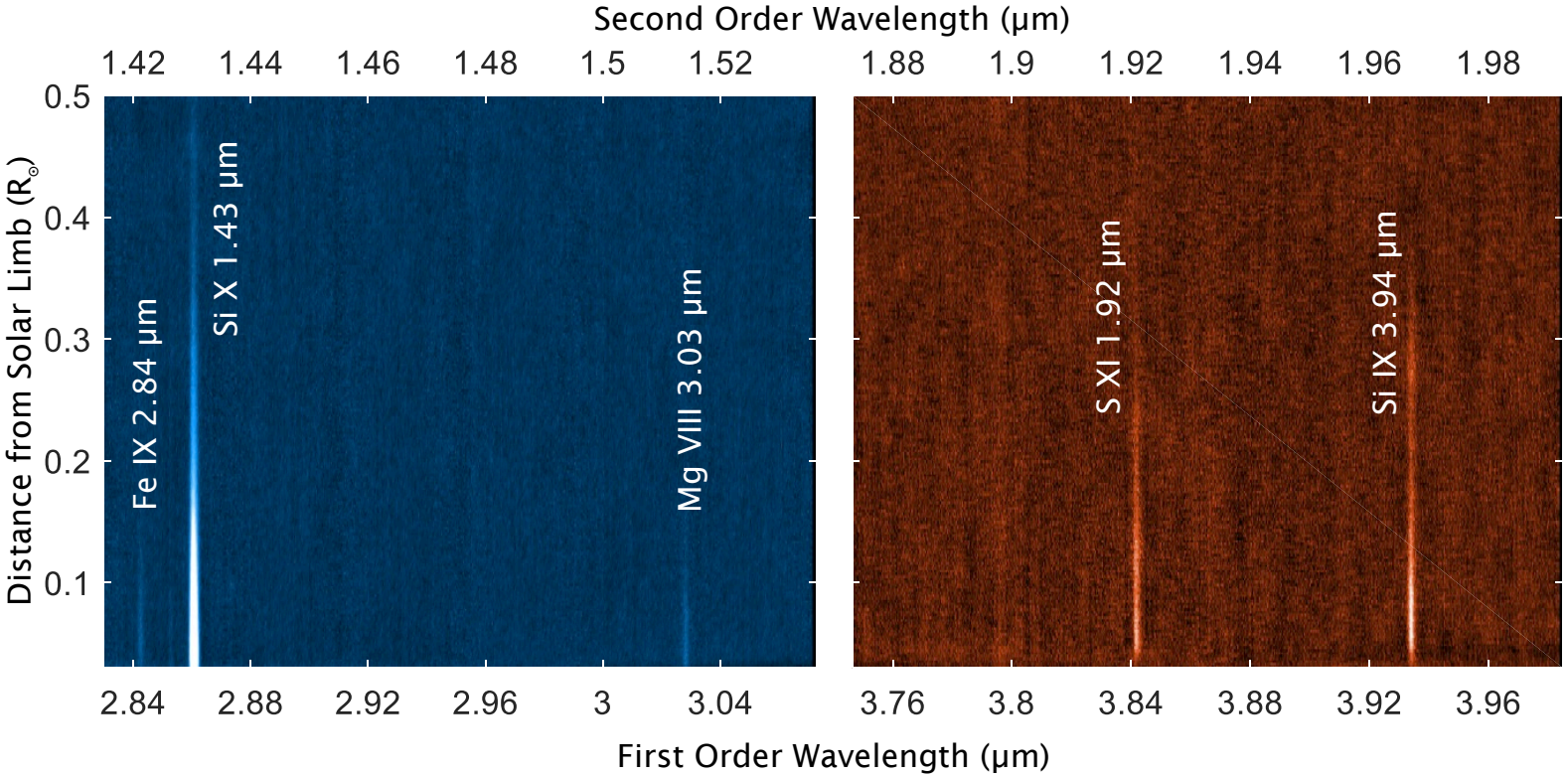


Telluric Absorption, 14 km

- Atmospheric absorption band overlaps Si X
- At **14 km**, affects baseline but not Si X line shape
- At **3 km**? Implications for ground-based observatories
  - Is simultaneous atmospheric monitoring required to achieve the necessary spectro-polarimetric precision?
  - How precisely do we need to know the rest wavelengths of the emission lines?

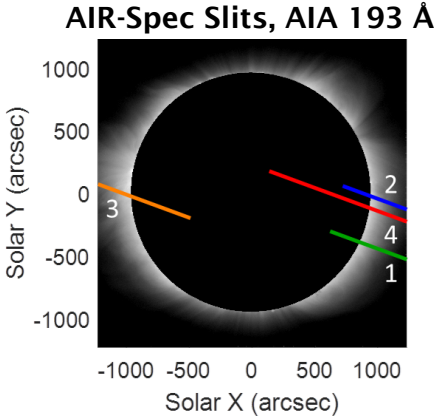


Intensity Gradient, East Limb

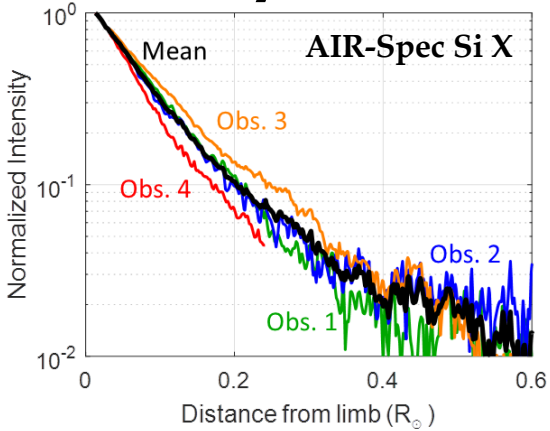


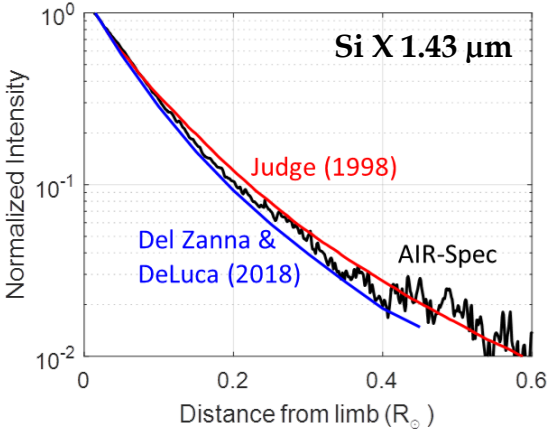
Si X Intensity Gradient

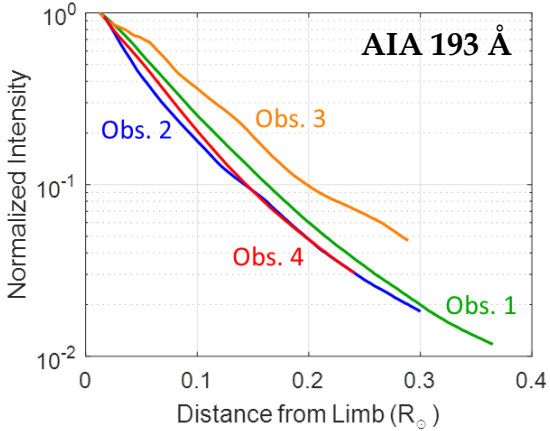
- **EUV lines** expected to be collisionally dominated ($\sim n_e^2$)
- **Visible lines** have radiative contributions
  - Compare with EUV to find relative importance (Habbal et al. 2011)
- **IR lines**? Compare with AIA.

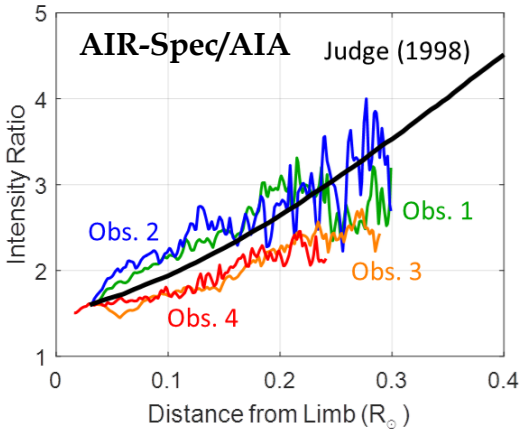


AIA	AIR-Spec
193 Å	1.43 μm
Fe XII, Fe XXIV	Si X
$10^{6.1}$ K, $10^{7.3}$ K	$10^{6.1}$ K

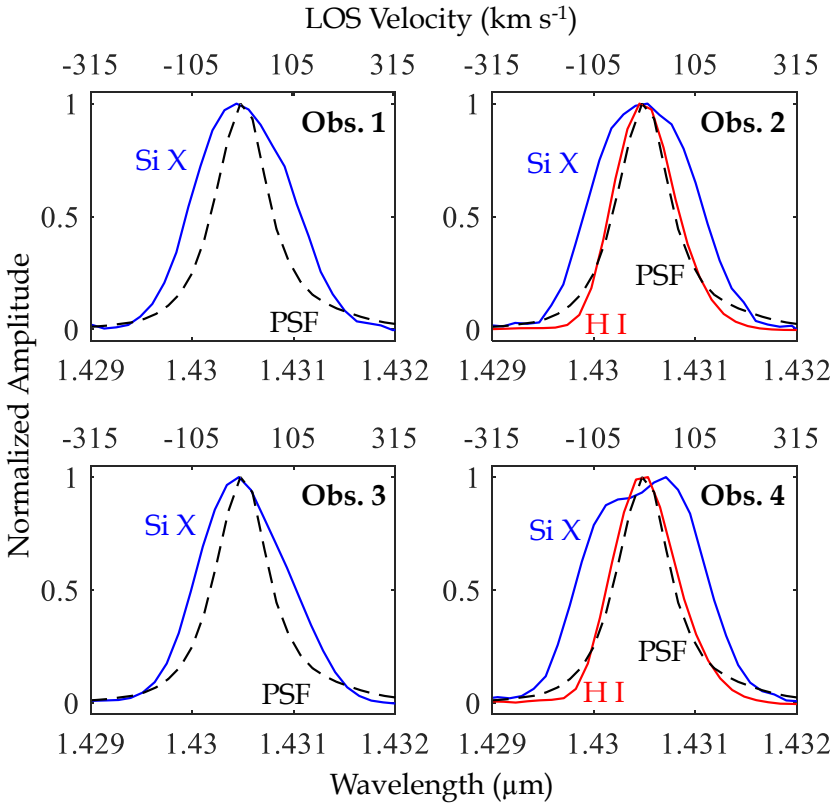








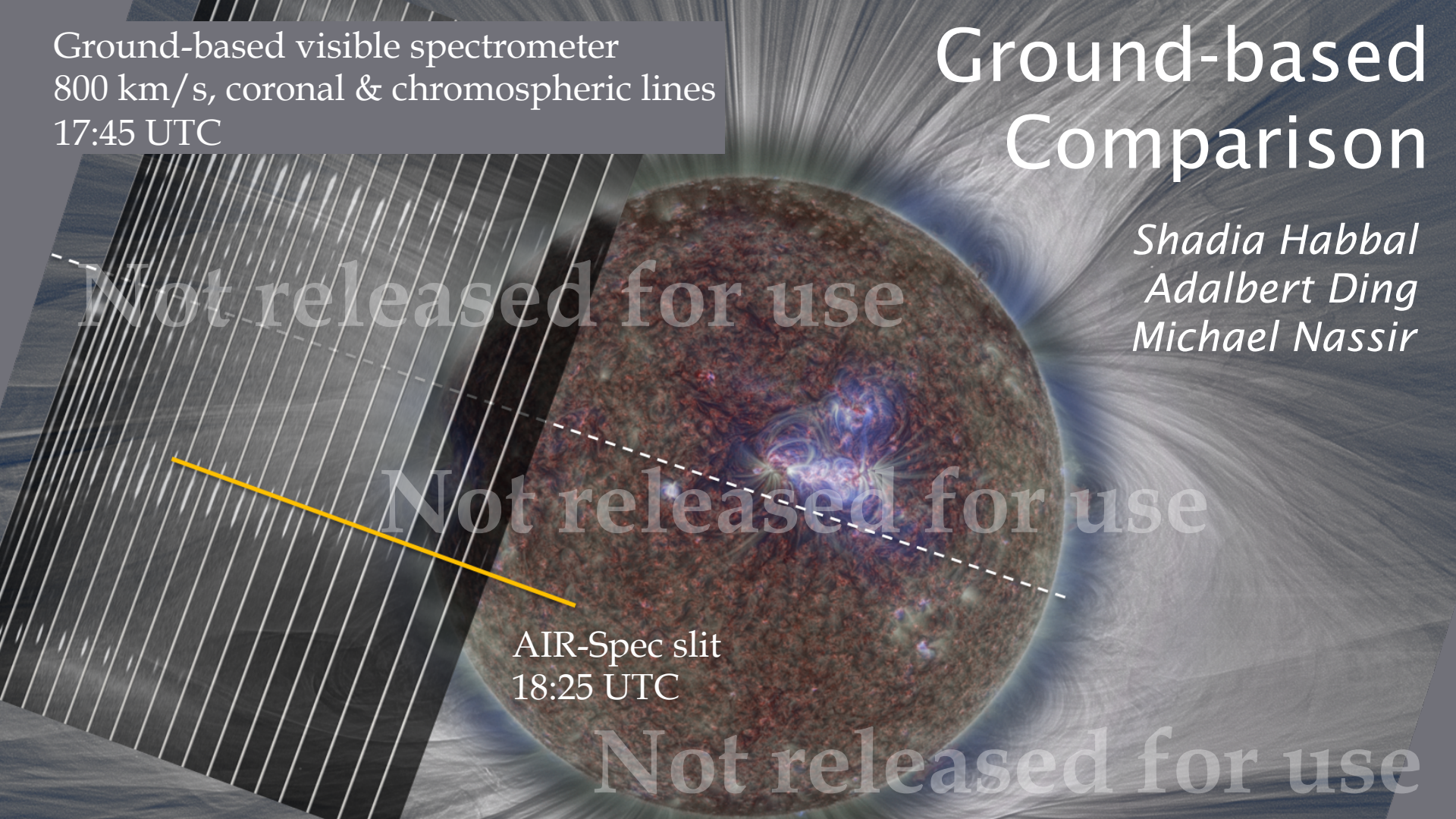
Si X Velocities

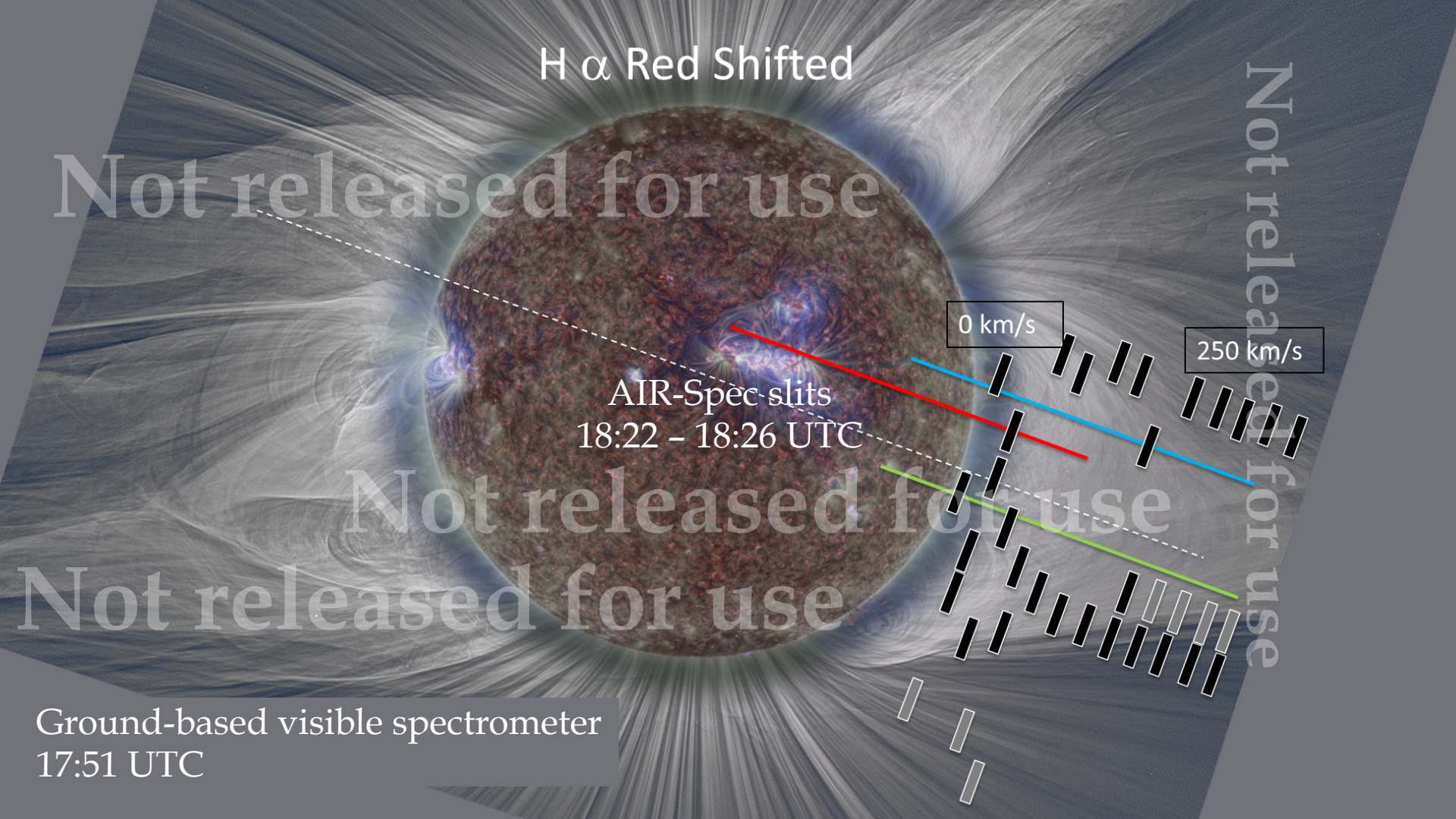


- Two measurements of instrument PSF
  - 3rd contact spatial PSF (black)
  - H I Paschen line, 1.875 μm (red)
  - Both have 7.5 Å FWHM
- Si X 1.43 μm profiles
  - At least 40% wider than PSF
  - 150 km/s non-thermal width
  - Double Gaussian needed to fit obs. 2 and 4
  - Velocity separation > 100 km/s
- Hypothesis: Distinct flows superimposed along the line of sight

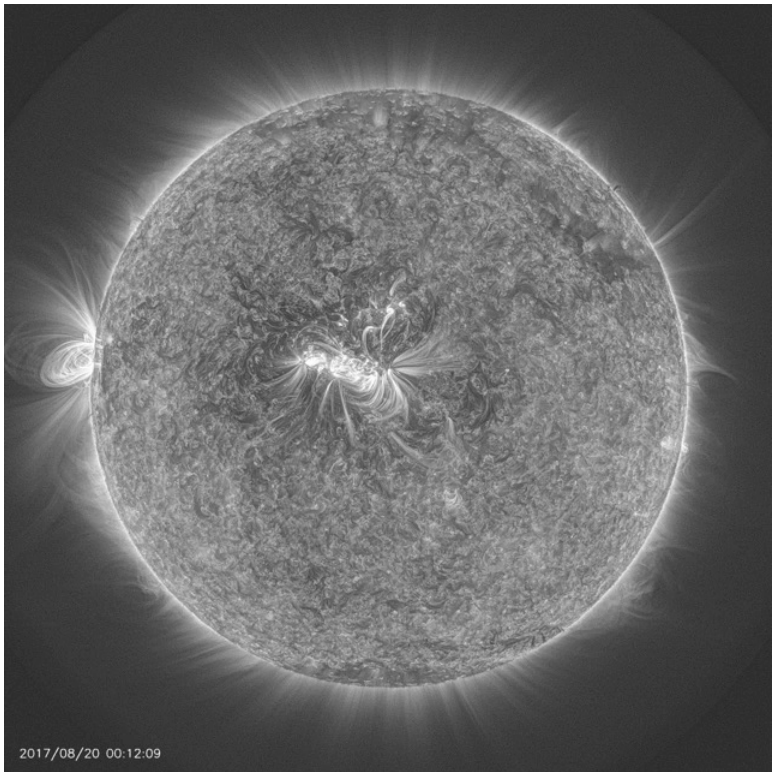
Ground-based Comparison

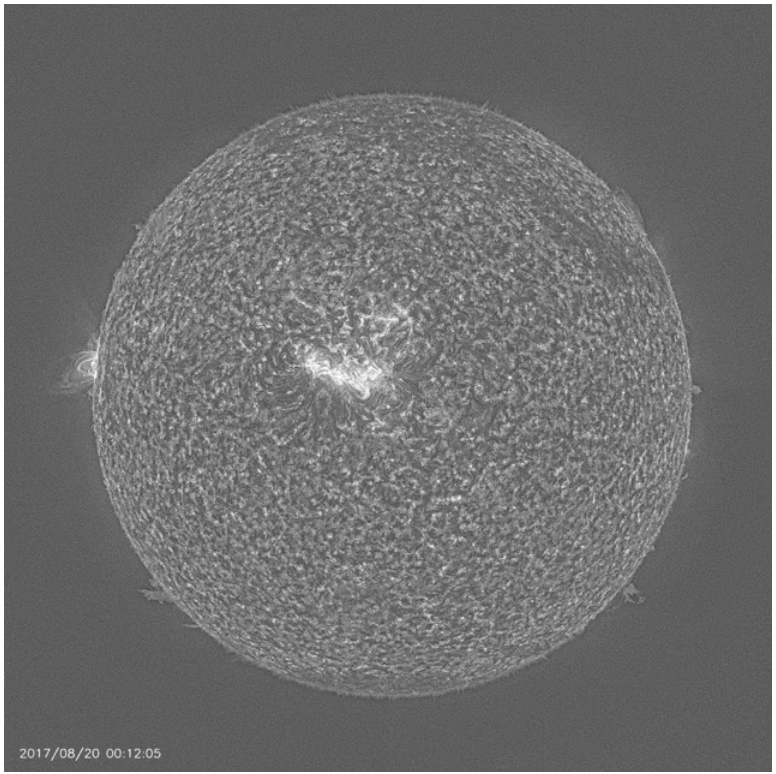
Shadia Habbal
Adalbert Ding
Michael Nassir




H α Red Shifted
Not released for use
Not released for use
Not released for use
Not released for use
0 km/s
250 km/s
AIR-Spec slits
18:22 – 18:26 UTC
Ground-based visible spectrometer
17:51 UTC

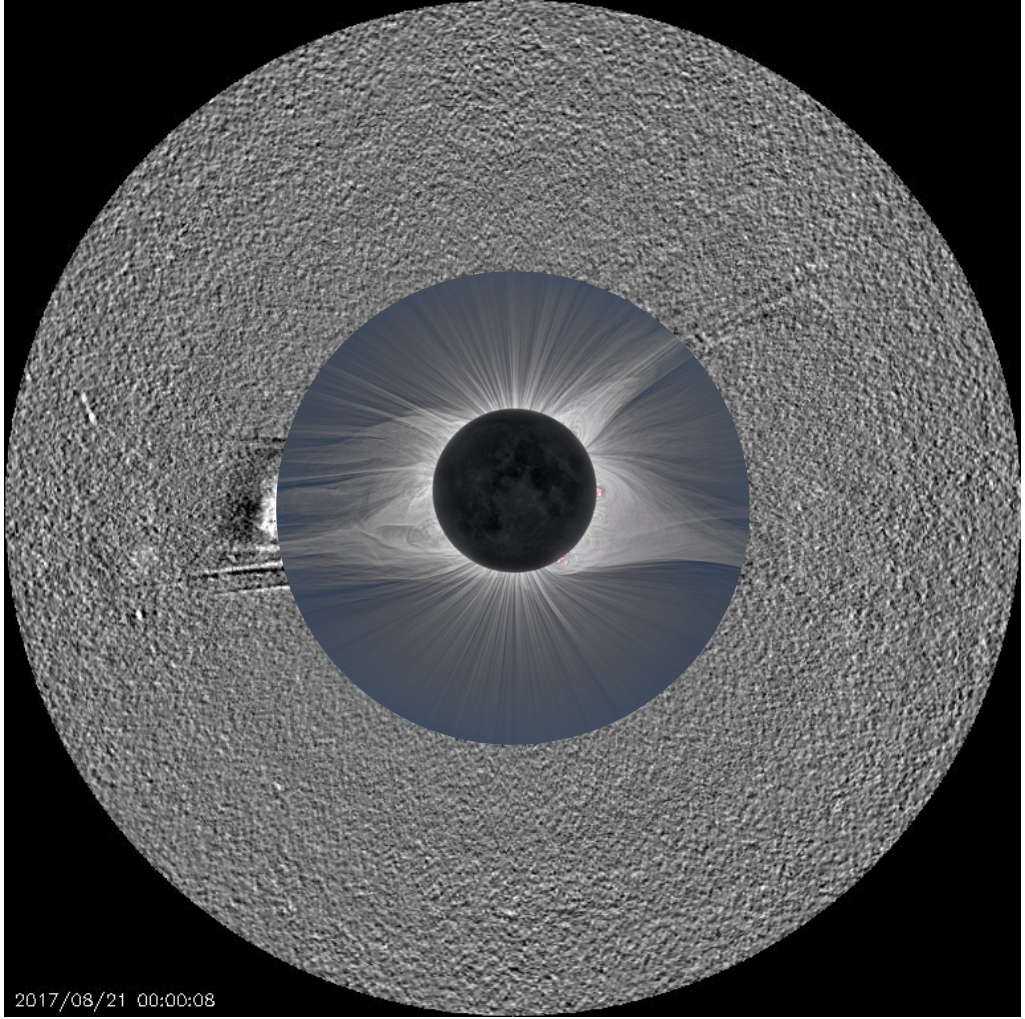
Off-Limb Activity in AIA 171 & 304





Processed by Nathalia Alzate

DST-processed LASCO/C2 images with white light eclipse image



Conclusions

- IR lines are visible throughout the corona
  - Fe IX 2.218 μm should be visible based on AIR-Spec detection of the 2.844 μm line
- Line intensity and radial fall-off similar to model predictions (Judge 1998, Del Zanna & Deluca 2018)
  - Significant radiative contributions to Cryo-NIRSP lines Si X 1.43 μm and Si IX 3.93 μm
- Faster than expected flows in coronal plasma, due to off-limb activity during the eclipse
- Telluric absorption may be important