Eclipse 2012 Nov 13 flash spectrum experiment

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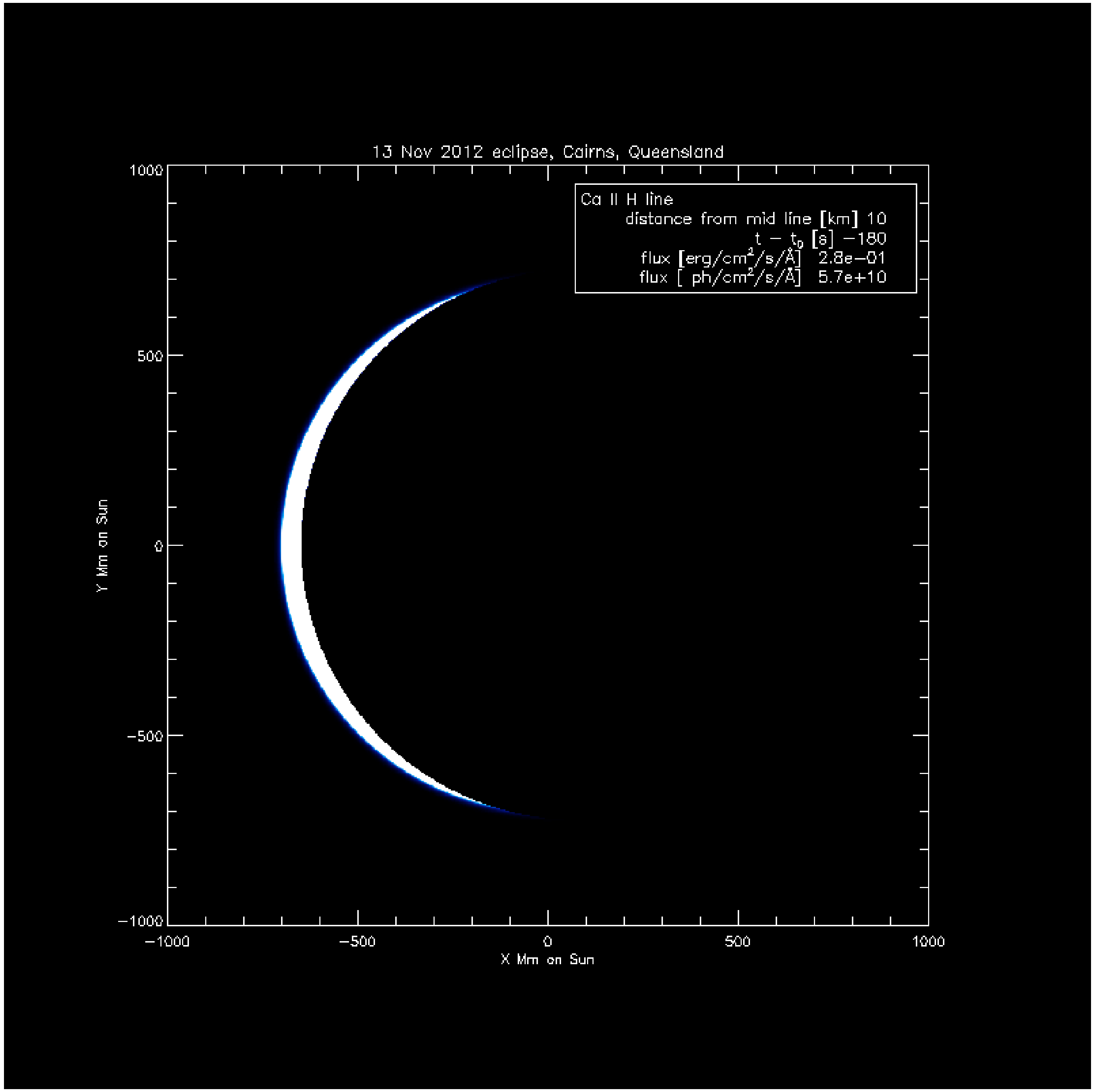
Science case

Eclipse circumstances

Possible approach

Risks

Deadline: March 2010 for NASA/ NSF proposals through U. Hawaii, S. Habbal PI



science case

- Importance of spicules- mass energy transport

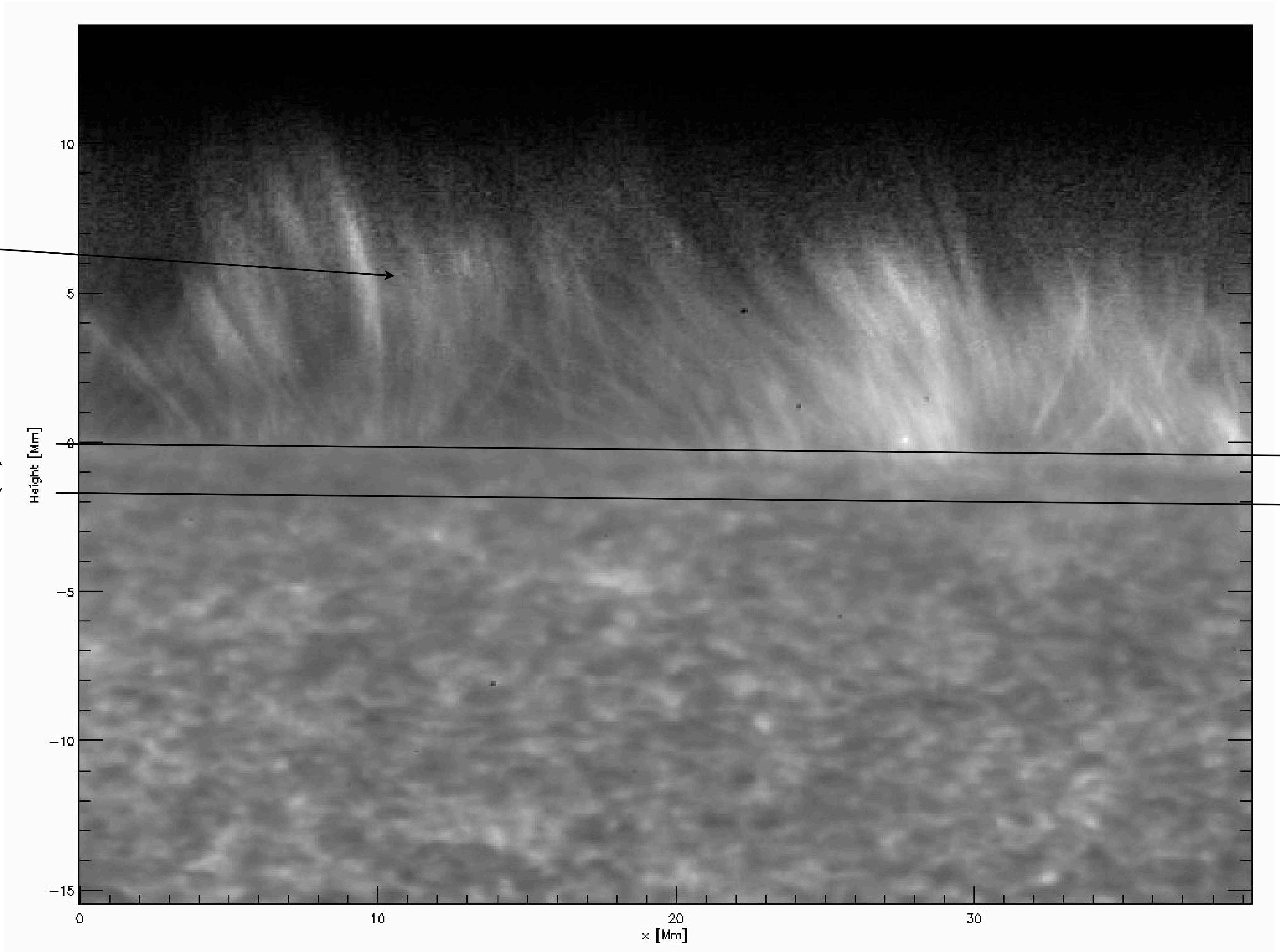
- Hinode Ca II H line, type I, II spicules
- MHD from photosphere-chromosphere
- A different picture (warped sheets vs tubes)
- GOALS:
  - measure change in dynamics accurately as a function of radius
  - use this to understand basic MHD of coupling to corona

Hinode spicules

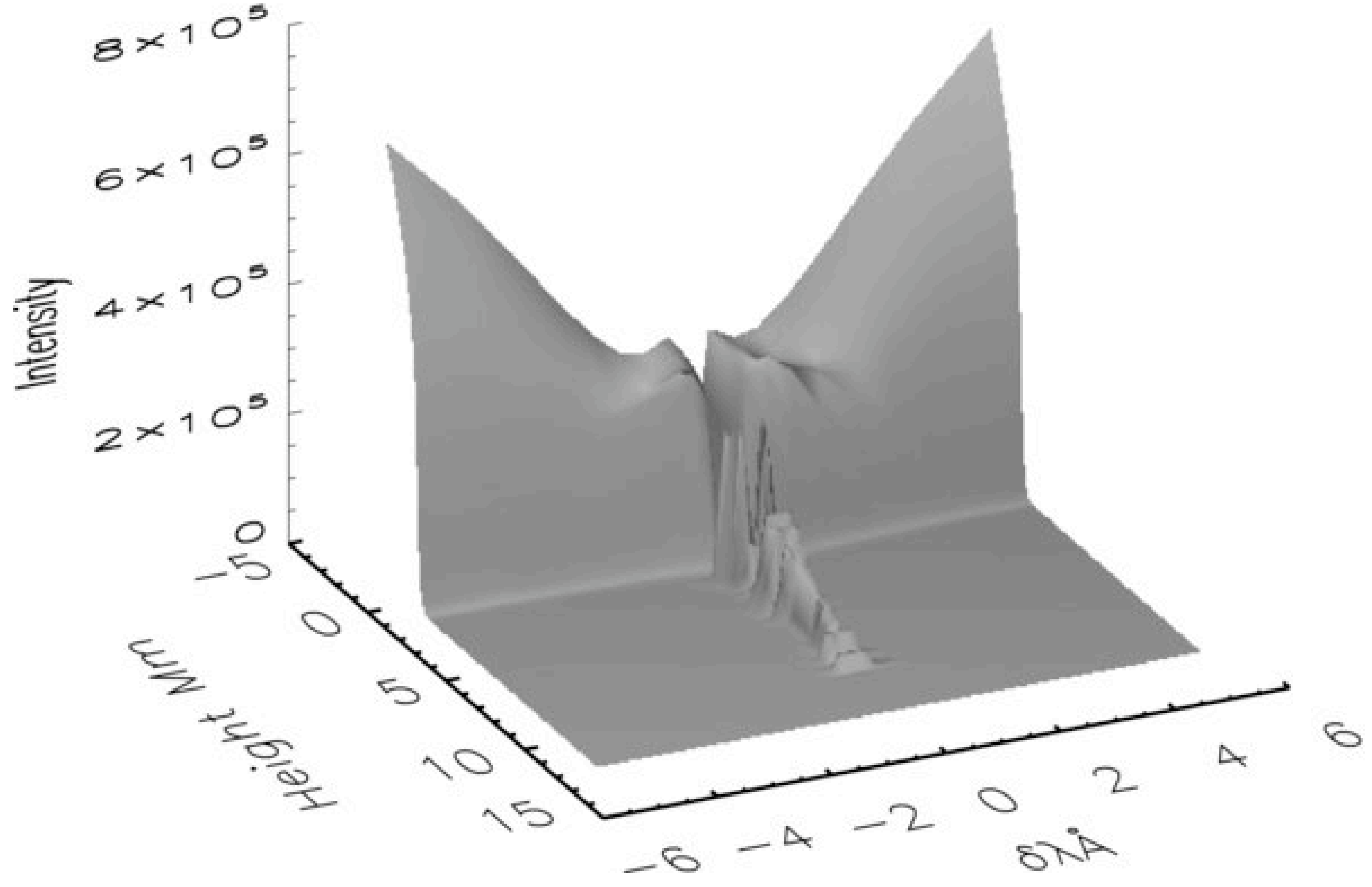
- Ca II (radial filter to enhance spicules, M. Carlsson)

spicules *arise from within* the chromo-sphere

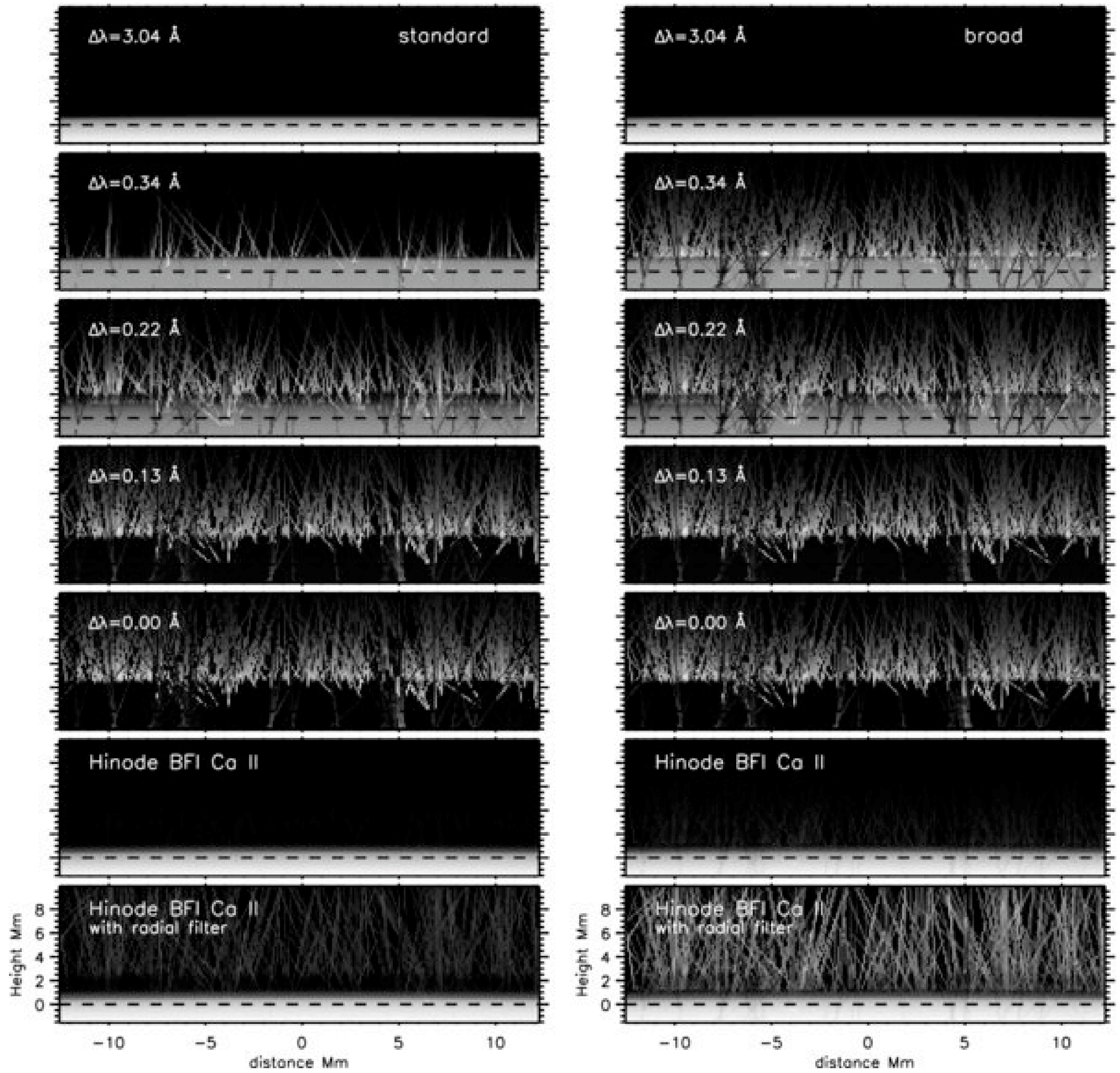
stratified VAL chromosphere 1.5Mm only



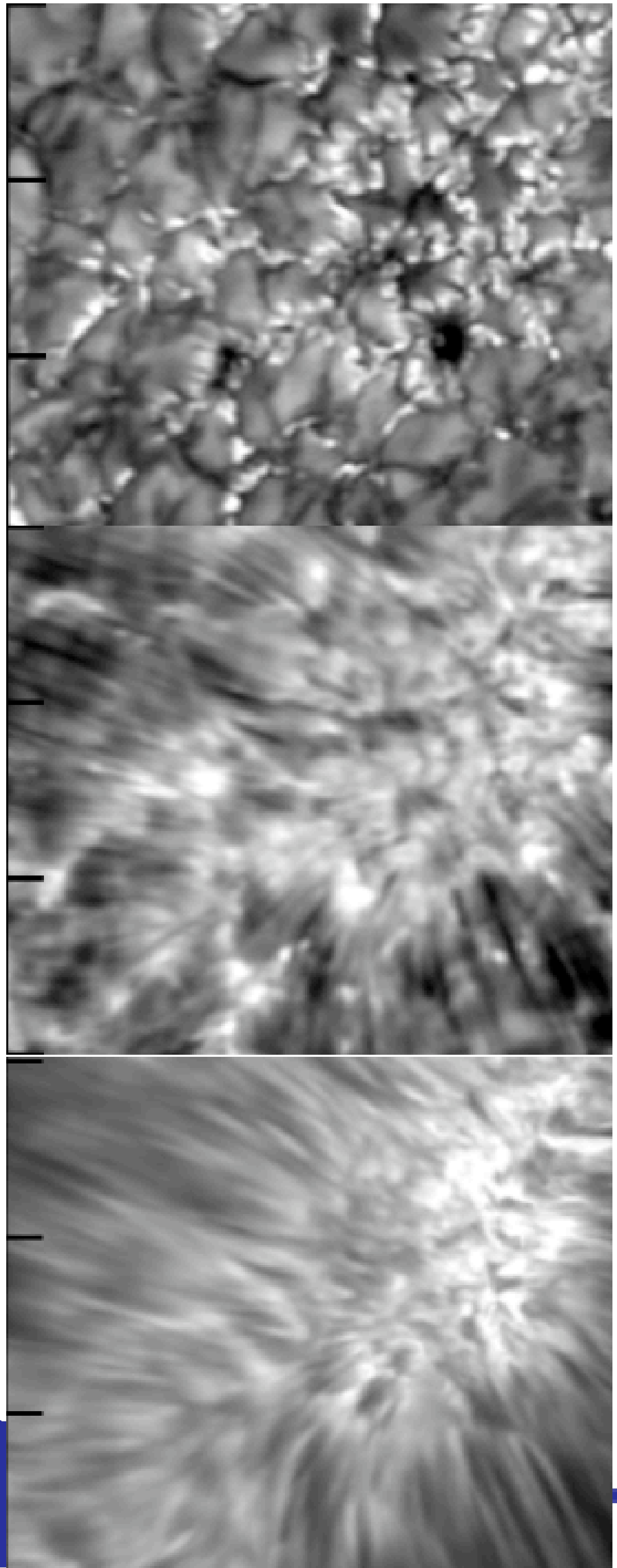
Judge-Carlsson 2010

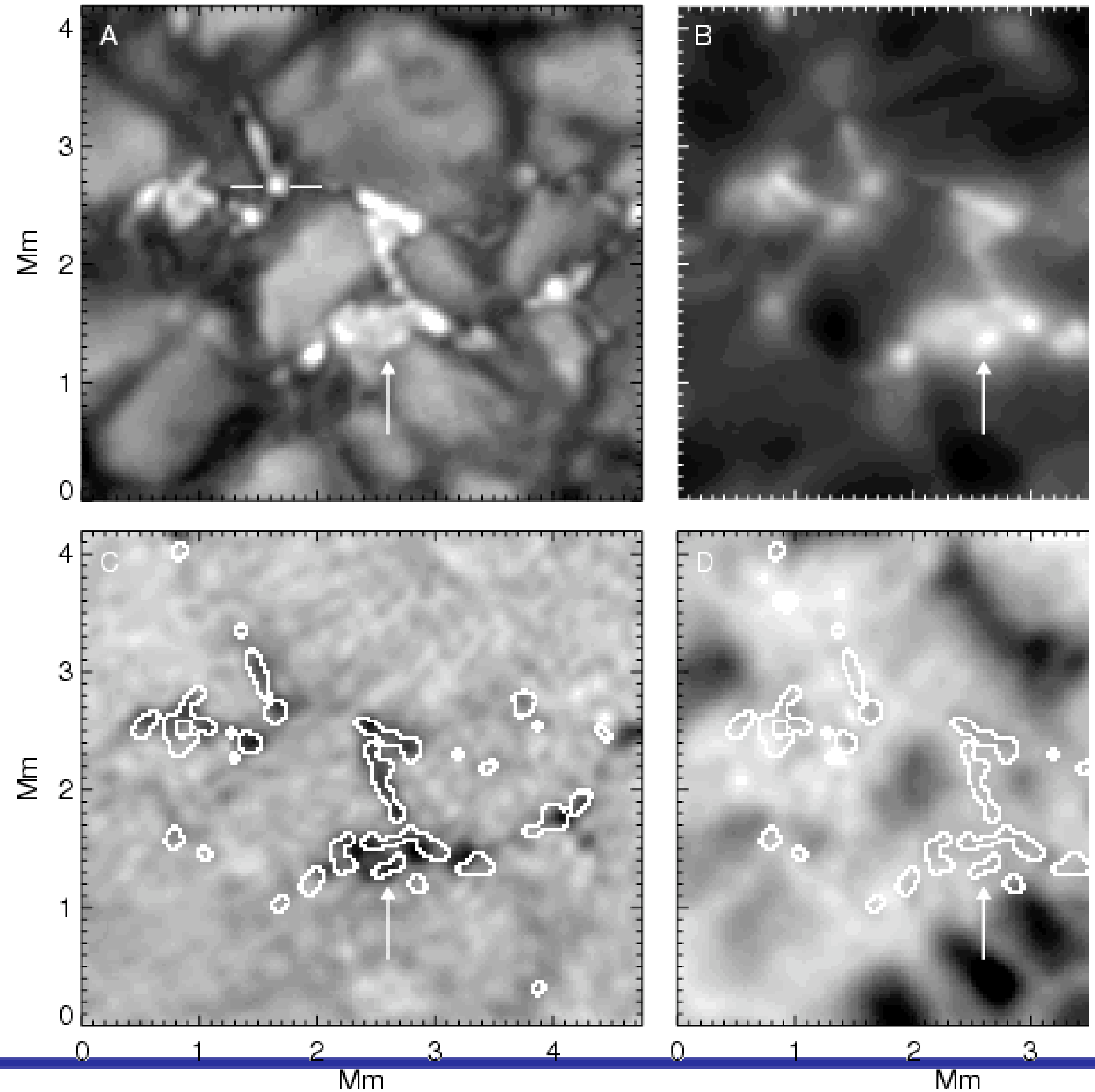


Judge-Carlsson 2010



Judge-Tritschler 2011
warps not tubes?





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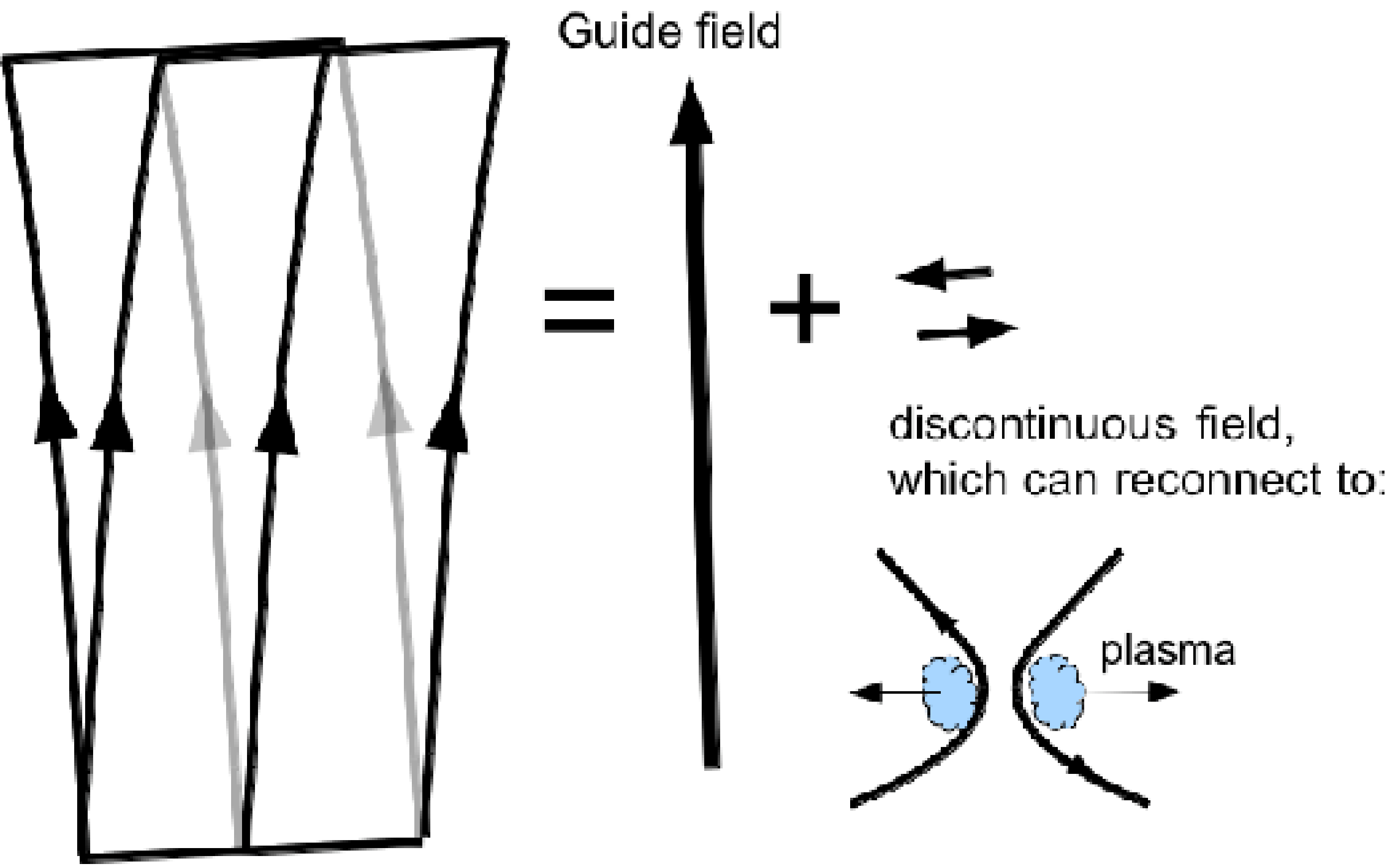
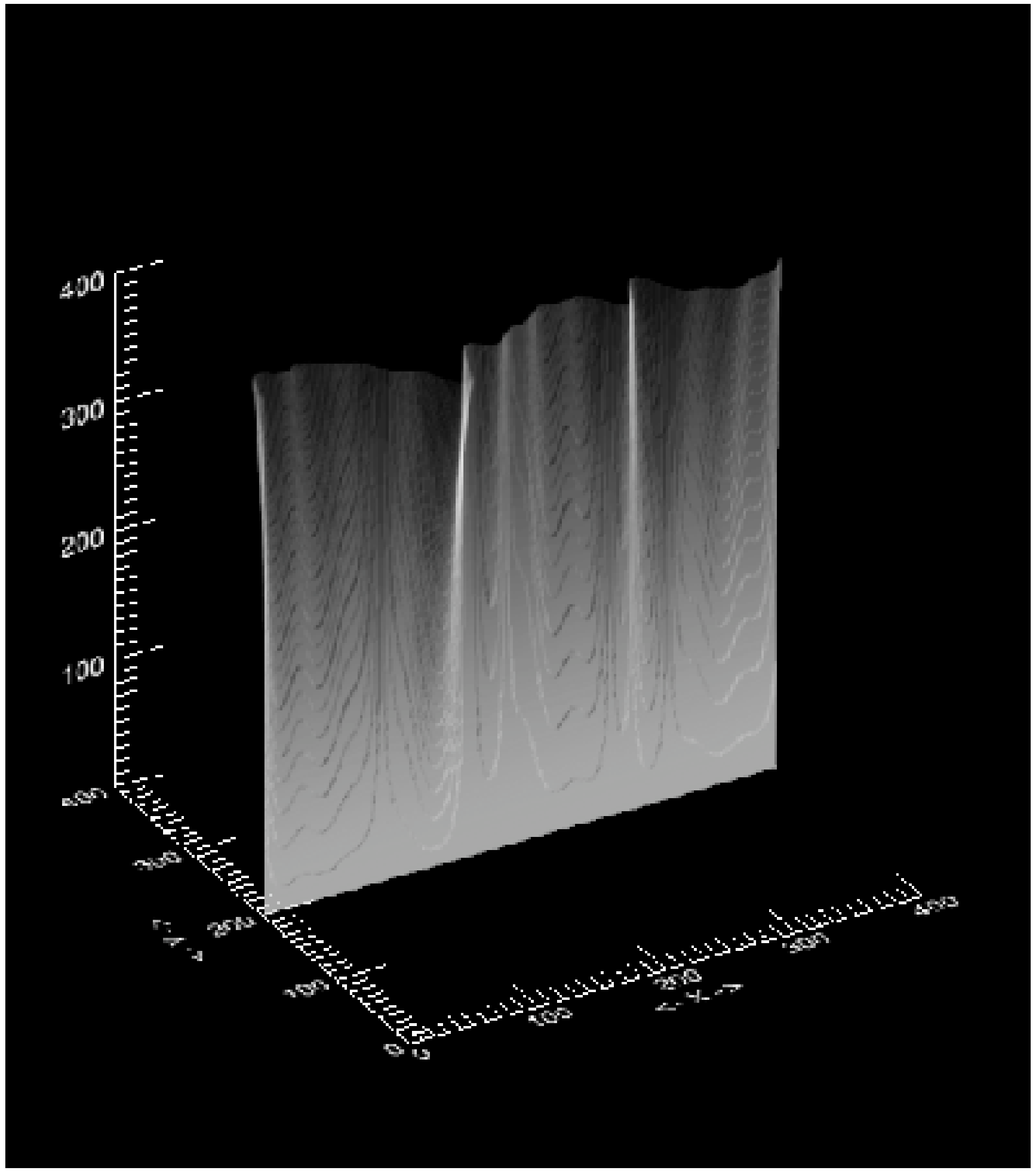




circumstances

*Cairns location.
Coordinates: 16°55′32″S 145°46′31″E / 16.92556°S 145.77528°E

Universal Time	Northern Limit Latitude (° ′)	Northern Limit Longitude (° ′)	Southern Limit Latitude (° ′)	Southern Limit Longitude (° ′)	Central Line Latitude (° ′)	Central Line Longitude (° ′)	M:S Diam. Ratio	Sun Alt (°)	Sun Azm (°)	Path Width (km)	Central Line Durat.
Limits	11 26.7S	133 22.4E	12 27.3S	132 47.5E	11 56.9S	133 05.1E	1.033	0	-	126	01m40.9s
20:37	14 29.7S	141 58.1E	14 06.6S	137 28.1E	14 24.2S	139 59.4E	1.035	7	107	136	01m53.4s
20:38	15 29.0S	144 29.2E	15 32.5S	141 12.2E	15 33.0S	142 56.2E	1.036	11	106	140	01m59.5s
*20:39	16 17.5S	146 28.2E	16 32.2S	143 39.8E	16 26.3S	145 07.2E	1.037	13	105	143	02m04.2s
*20:40	16 59.8S	148 09.1E	17 21.4S	145 36.9E	17 11.7S	146 55.2E	1.038	15	105	146	02m08.2s
20:41	17 38.0S	149 37.8E	18 04.5S	147 16.4E	17 52.1S	148 28.8E	1.038	17	104	148	02m11.9s

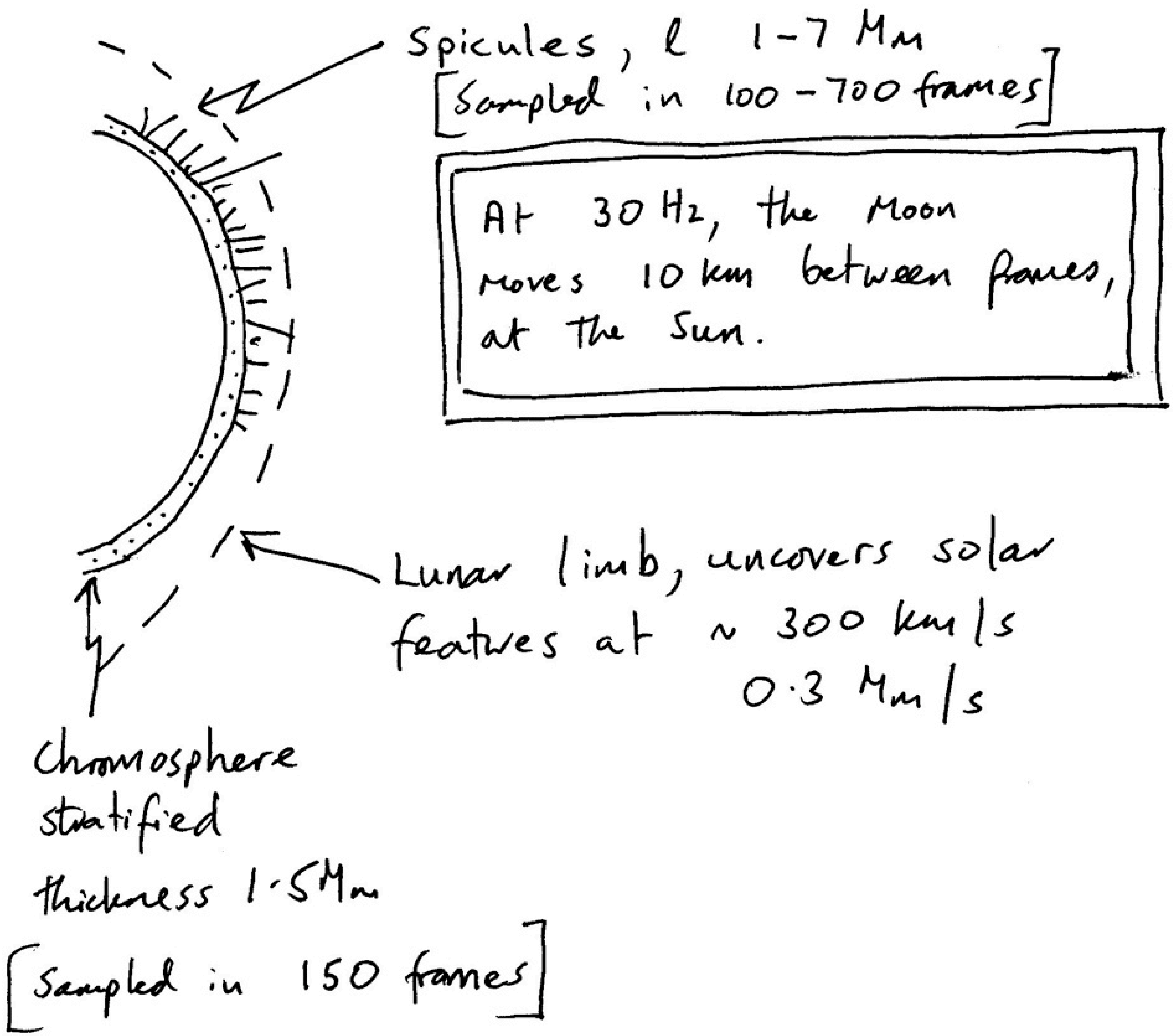
lunar radius is 1.038 Rsun, with R=6.96e2 Mm, or 26 Mm larger, 3.8%.

Solar Oblateness (semi-diameter difference eq-pole: .05", .03 Mm, 0.004% Allen 1973)

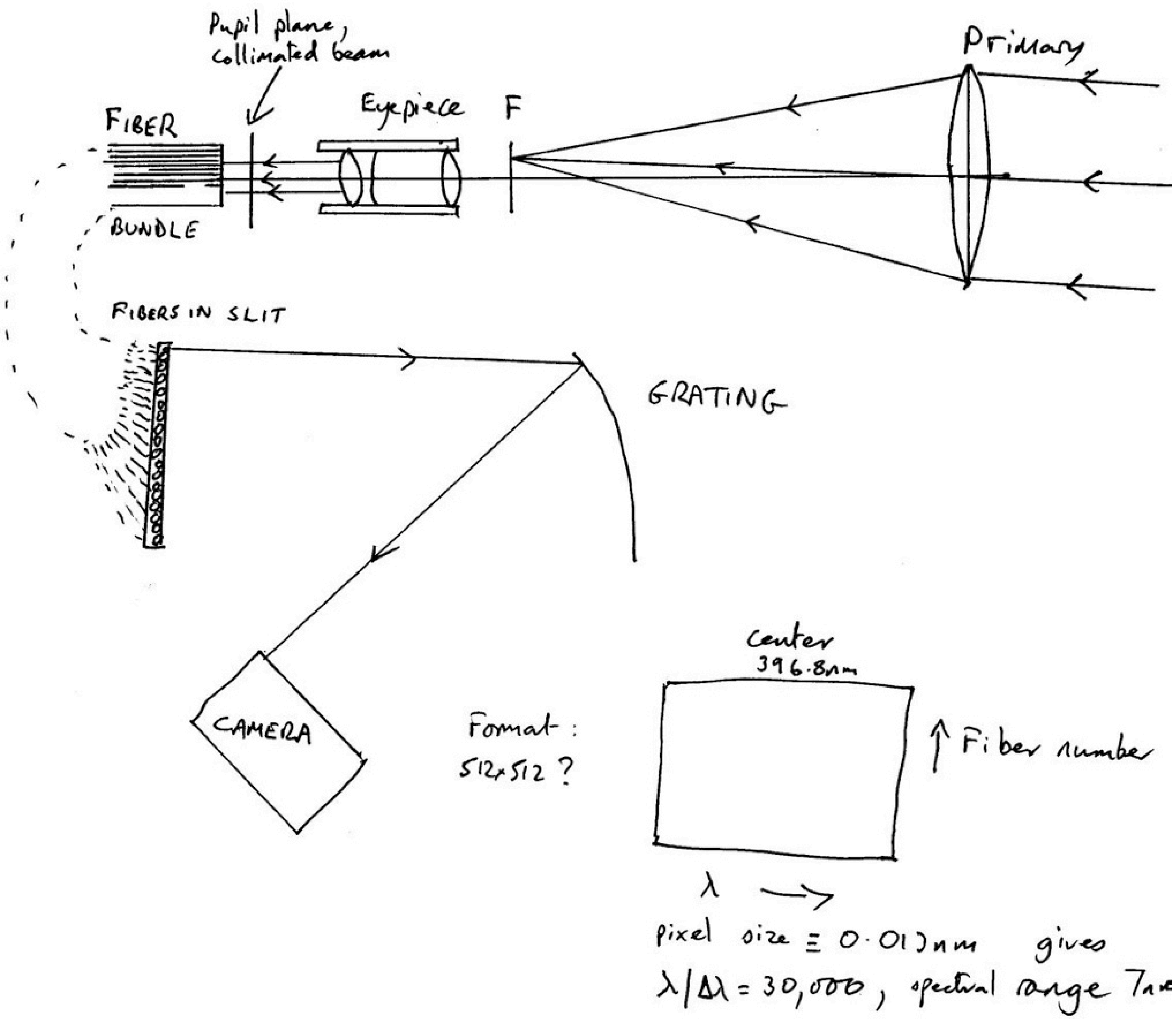
Lunar oblateness= .78km/1738.2 km = 0.00044, .04%

Lunar surface topography has variance of at most 5km (bailey's beads & much later measurements) 0.29%.

Concept

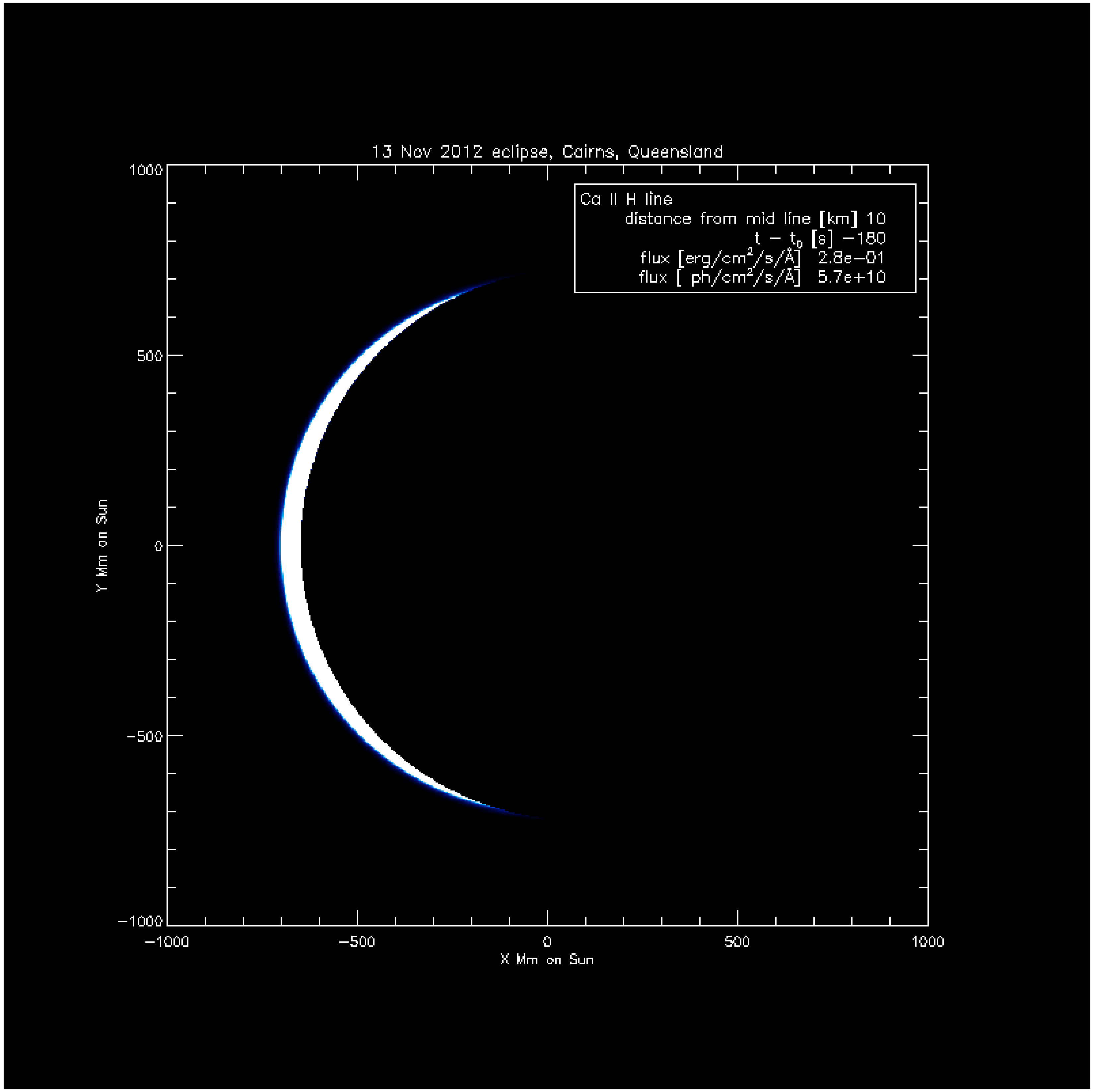

Spicules, l 1-7 Mm
[Sampled in 100-700 frames]
At 30 Hz, the Moon moves 10 km between frames, at the Sun.
Lunar limb, uncovers solar features at ~ 300 km/s
0.3 Mm/s
Chromosphere stratified
thickness 1.5 Mm
[Sampled in 150 frames]

Concept

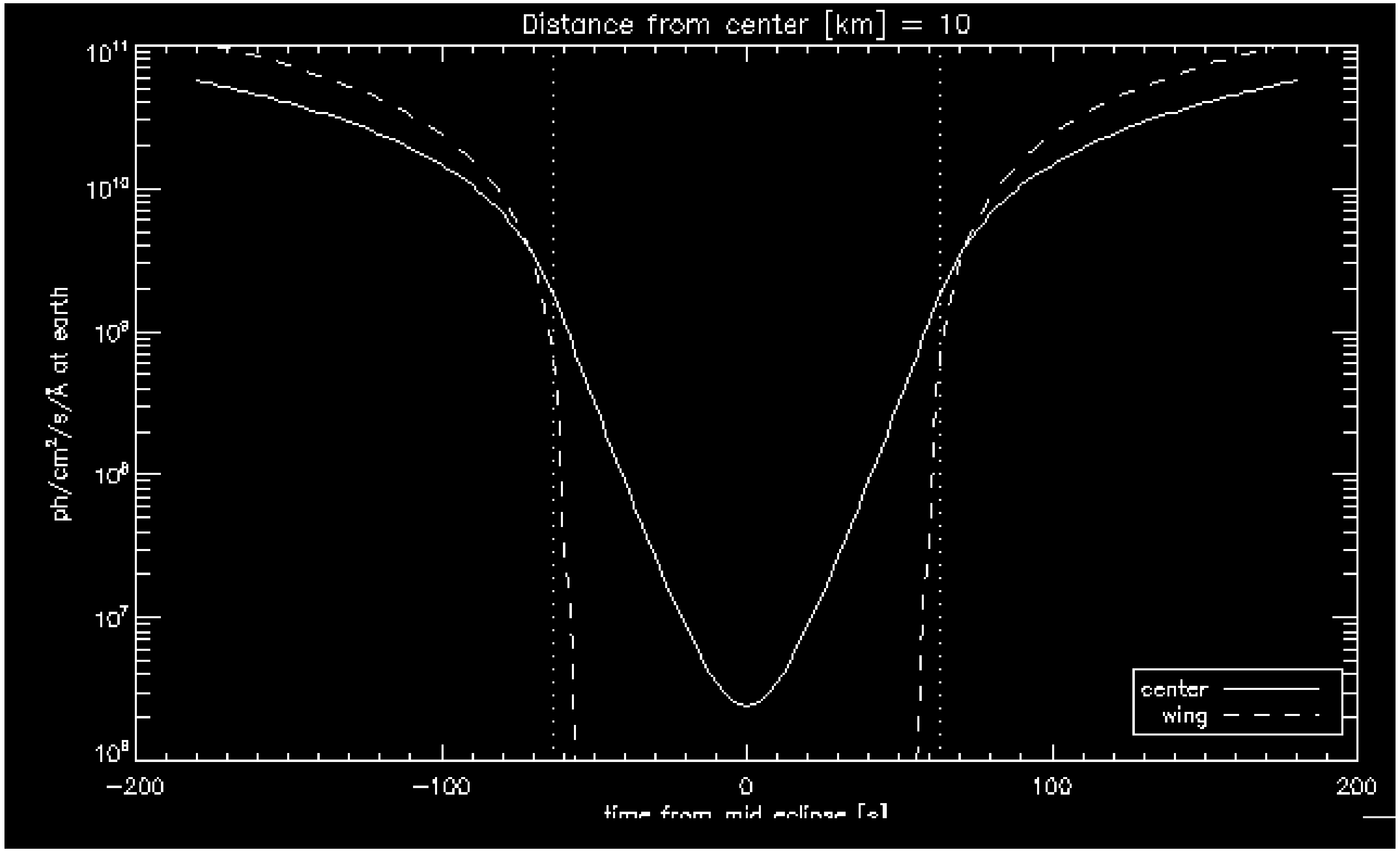


measure spectrum as a function of time => azimuthally averaged $I_\lambda(r)$ with r resolution of 13 km

time variations
2nd 3rd contacts -/+60s



time series (simulated)



The chromospheric component of the line is about 1 Å wide. The following table lists the azimuthally averaged intensities within 1 Å of line center, used to make the time series calculations above:

cos θ	μ=1	μ=0.2	-	-	-
distance above limb Mm	-700	-14	4	6	8
I erg/cm^2/s/sr/Å	3x10^5	1.5x10^5	6x10^4	3x10^4	1x10^4

Looking at Figure 2, we see that $> 10^6$ photons would arrive, unattenuated, per square cm at the earth, per Å, in 1 second. The time series of primary interest is within about 20s after/before second/third contact, respectively, where unattenuated photon fluxes are $> 10^8$. If we assume that the overall efficiency of the combined effects of earth atmospheric absorption/ telescope/ fiber bundle/ spectrograph/ camera is on the order of 1%, then there are 10^6 photons/cm^2/s/Å. With an aperture of 10cm, the collecting area is 80 cm^2. For a spectrograph of resolution 15,000, camera pixels would need to span just 3968/30,000=0.13 Å. With an exit pupil sampled by say 100 fibers, we have the total number of photons incident on the camera, per pixel (actually per column of pixels from each fiber), of

$$N \sim 10^6 \,.\, 80.\ 0.13 /100 \sim 10^5 \quad \text{photons per second}$$

If the exposure time is say 20 ms, each such "pixel" will acquire

$$n \sim 2000 \ \text{photons},$$

so shot noise $\sigma \sim$ 44 photons, and the noise is 2.2%. There are 100 such fiber images dispersed across the 2D detector, leading to a final noise estimate, per 20 ms exposure, of just 0.2%. This exceeds the requirement of 0.8% for a radial resolution of about 80 km. Flat fields and gain corrections must of course be known to a better precision than the above estimates.

known risks

- clouds, variable atmospheric transmission (timescales < 20s)
- lunar topography
- prominences
- lack of azimuthal information- important?
- instrumental issues