Hinode/SOT Observations of Prominence Dynamics

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and the rest of the SOT Team

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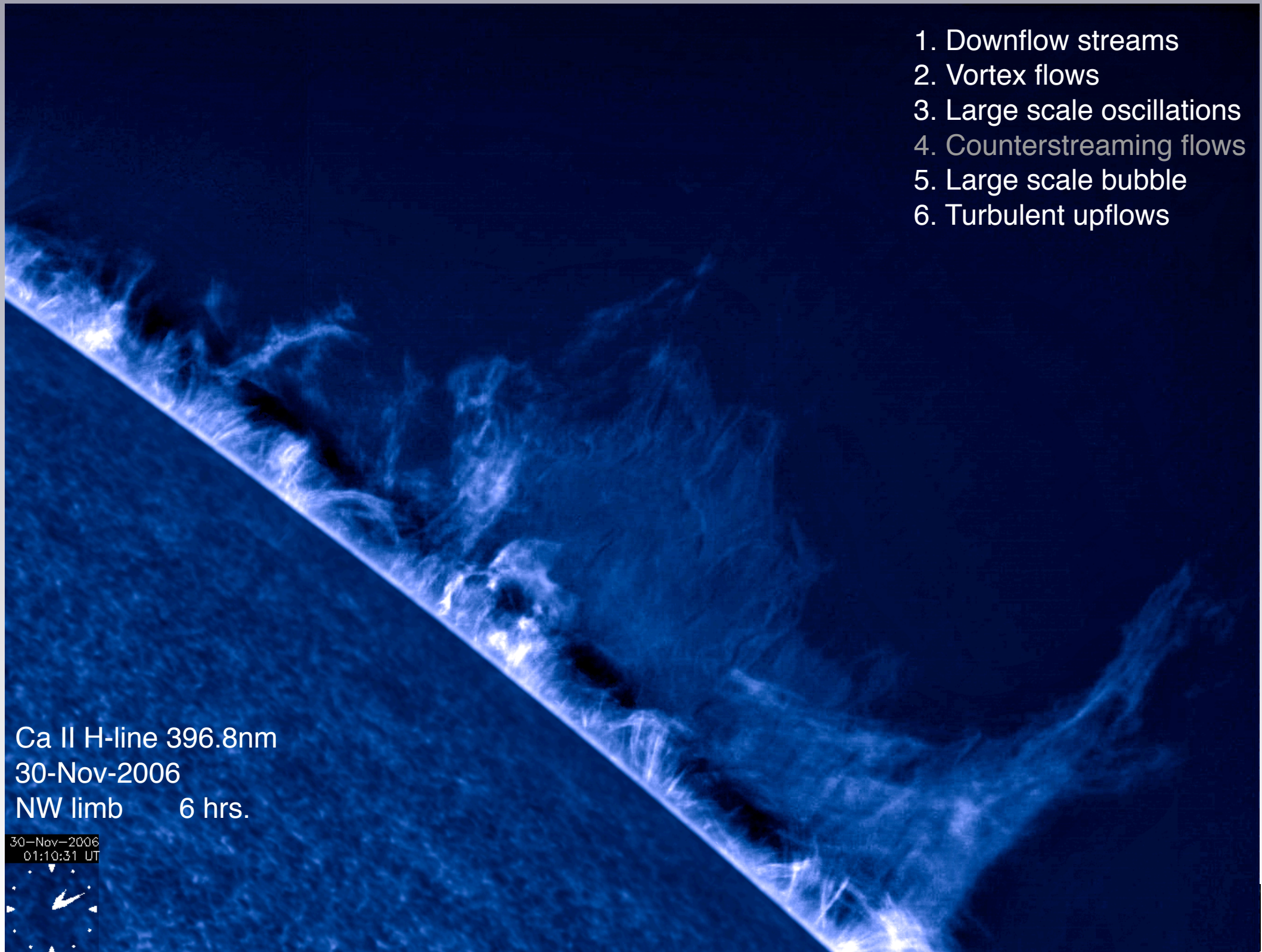
Prominences Dynamics

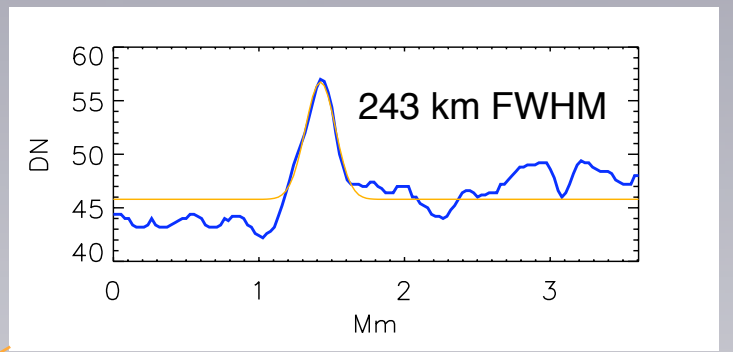
Font size indicates relative novelty

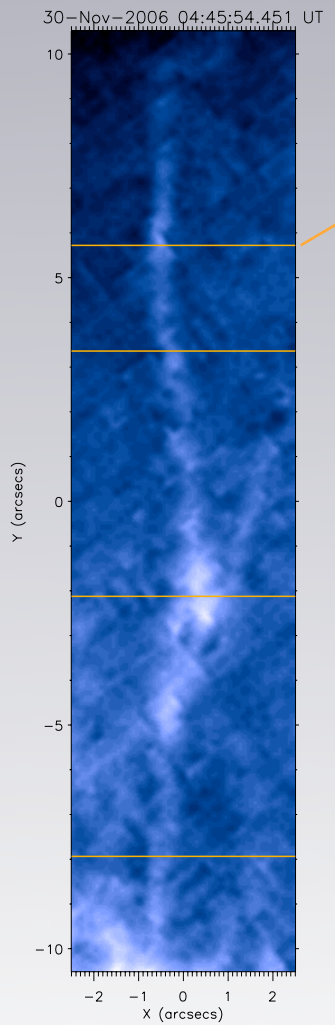
1. Downflow streams
2. Vortex flows
3. Large-scale oscillations (distinct from Alfvenic oscillations in AR filaments)
4. Counterstreaming flows
5. Large-scale “bubbles”
6. Turbulent upflow plumes


1. Downflow streams
2. Vortex flows
3. Large scale oscillations
4. Counterstreaming flows
5. Large scale bubble
6. Turbulent upflows
Ca II H-line 396.8nm
30-Nov-2006
NW limb 6 hrs.
30-Nov-2006
01:10:31 UT

Downflow Stream

Grid = 2”



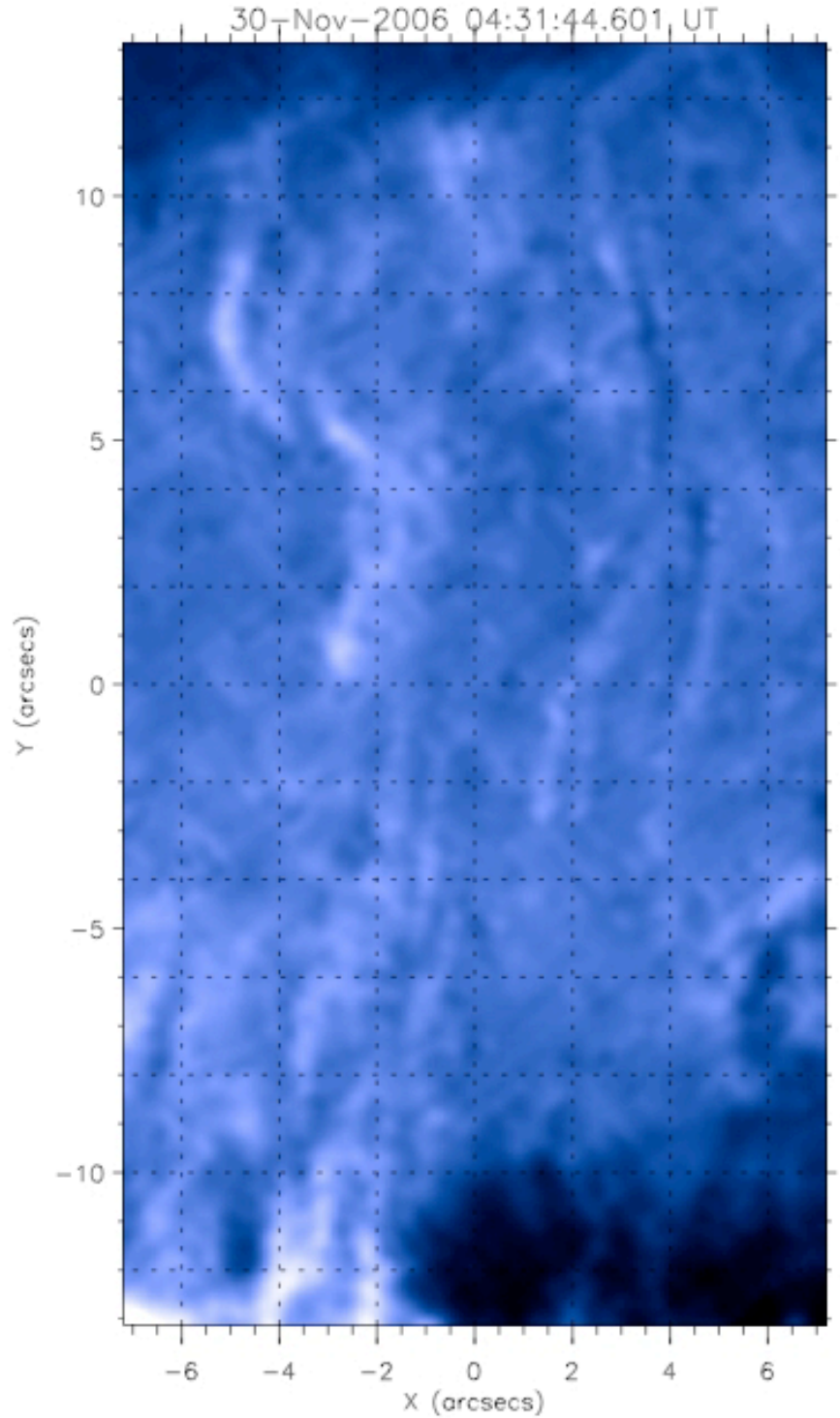


Speed ~ 10 km s^{-1}
Distance ~ 20—30 Mm
Duration ~ 10 min
Width ~ 200—700 Mm

Ubiquitous in most QPs

Note: $V_{freefall(20\ Mm)}$ ~ 100 km s^{-1}.
$V << V_{freefall}$, like waterfalls...

Theories that neglect drag force are not applicable to this problem.



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Vortex Flow

Grid = 2”

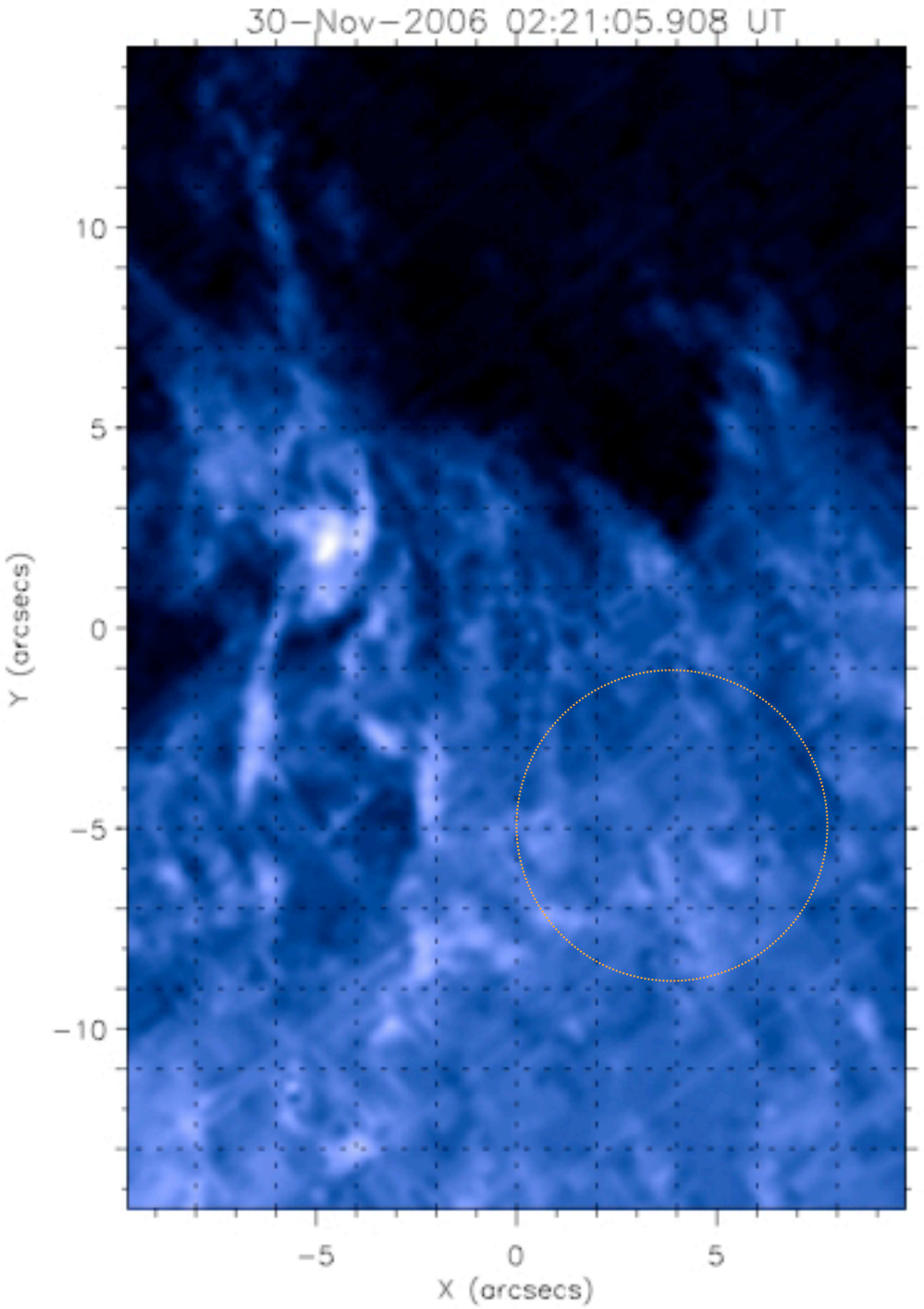
2.5 Rotations
Rate = 3.27 x 10^{-3} rad/sec

~3000 km diameter

Assume:
- T = 7000 K
- $n_e = 10^{11}$ cm^{-3}
- f = 0.3
- B = 10 G

Then:
- P = 0.042 Pa
- β ~ 0.1

Must explain vortex motion in low-β environment. Are the field lines doing this?



Upflow Plumes

Grid = 2”

Speed ~ 20 km s^{-1}
Distance ~ 10—20 Mm
Duration ~ 10 min
Width ~ 400—2000 Mm

Intermittent

Assume:
- T = 7000 K
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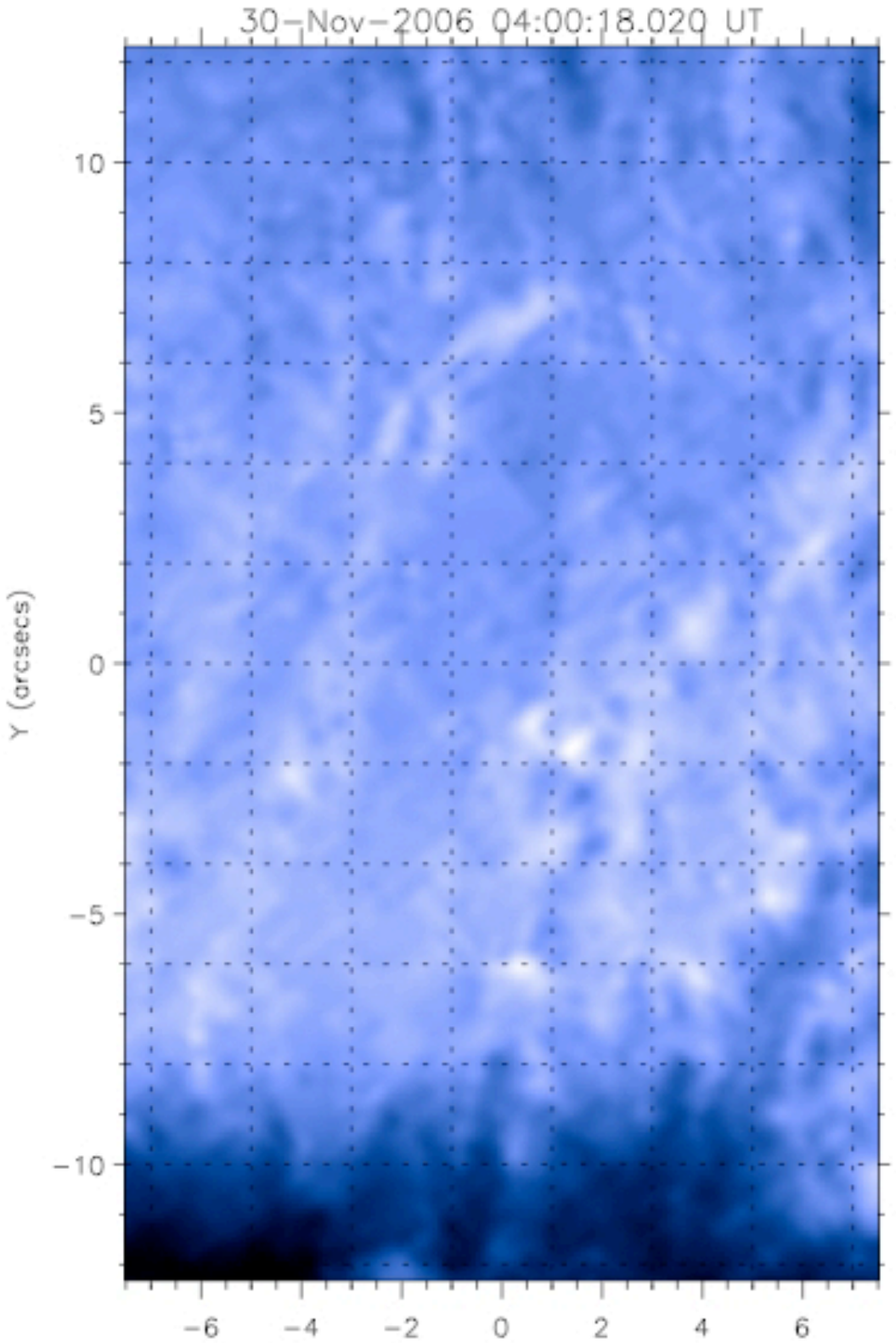
- f = 0.3
- B = 10 G

Then:
- Re ~ 400,000
- but...
- P = 0.042 Pa
- β ~ 0.1



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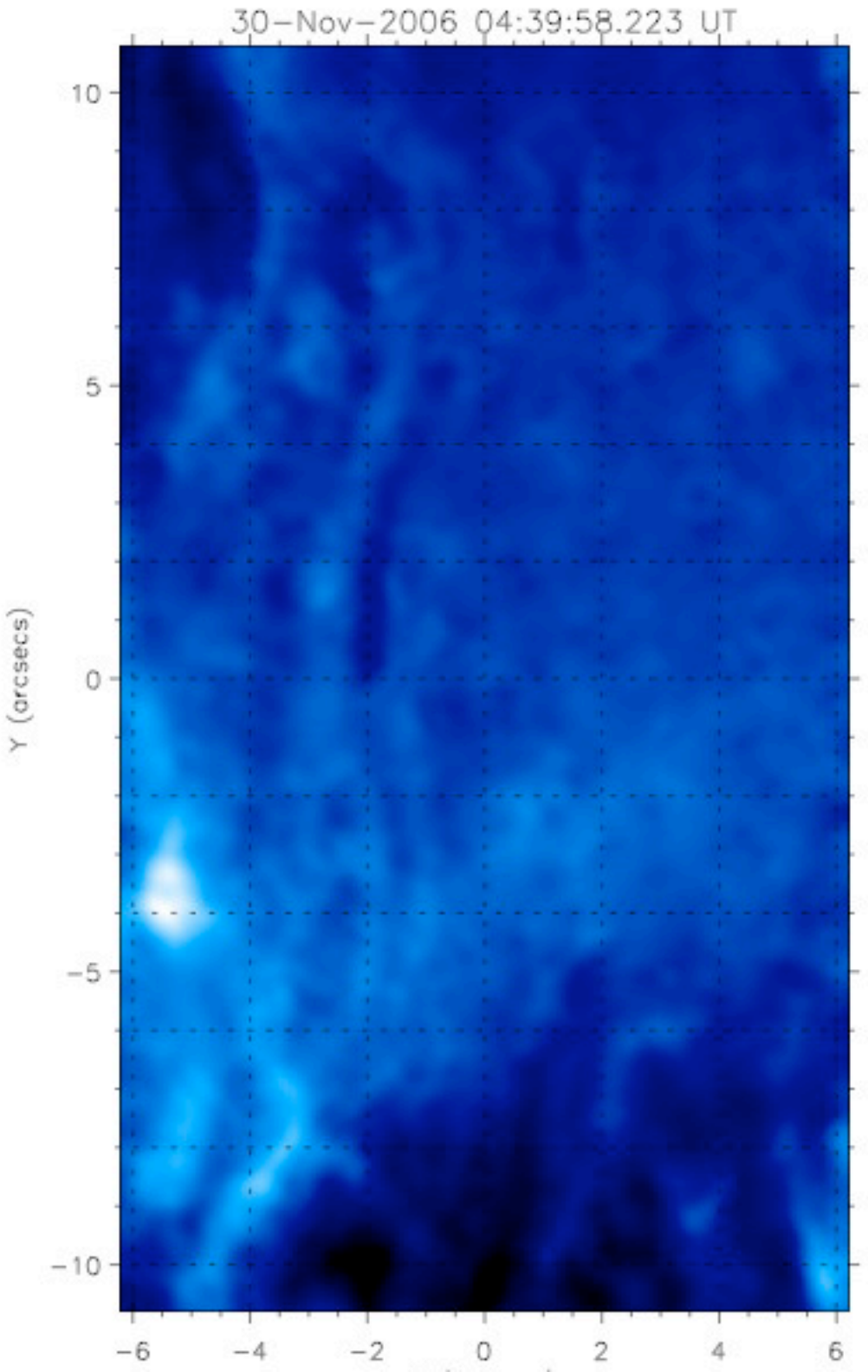

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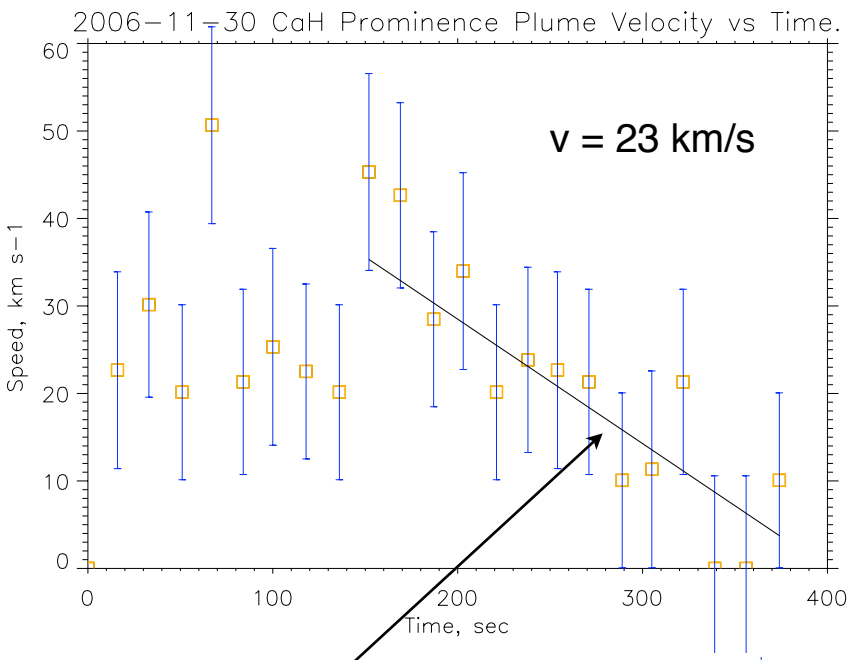
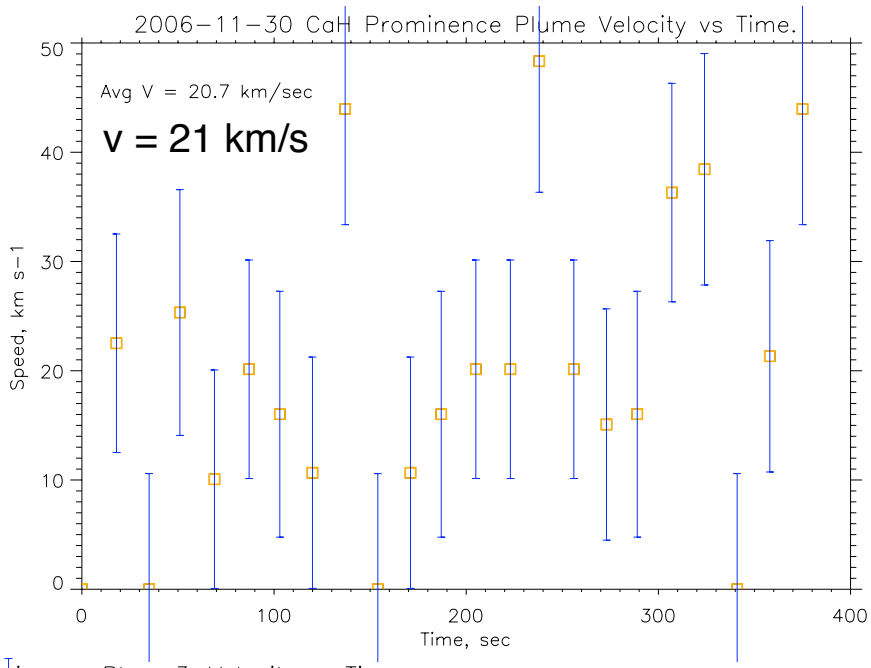
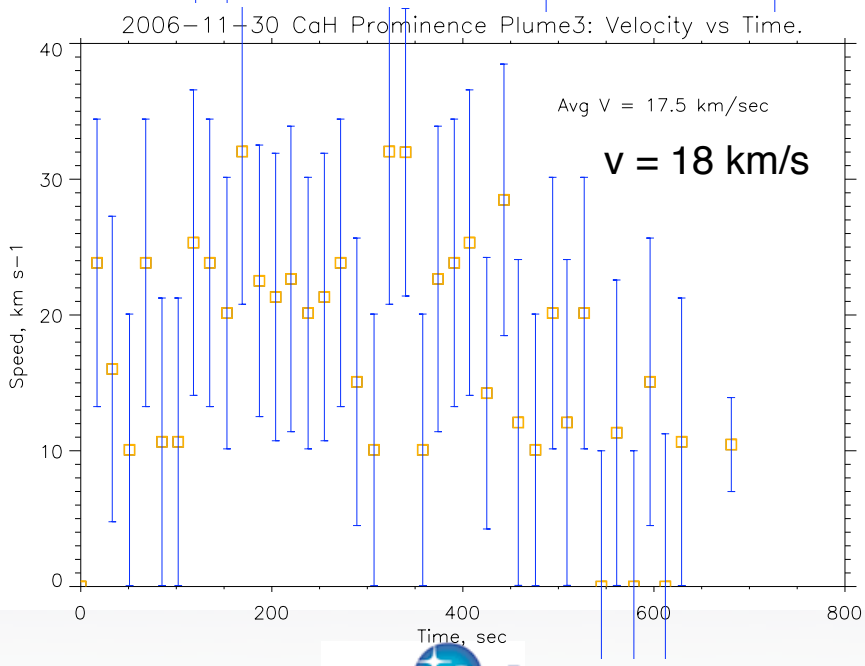
Upflow Plume Velocity Measurements

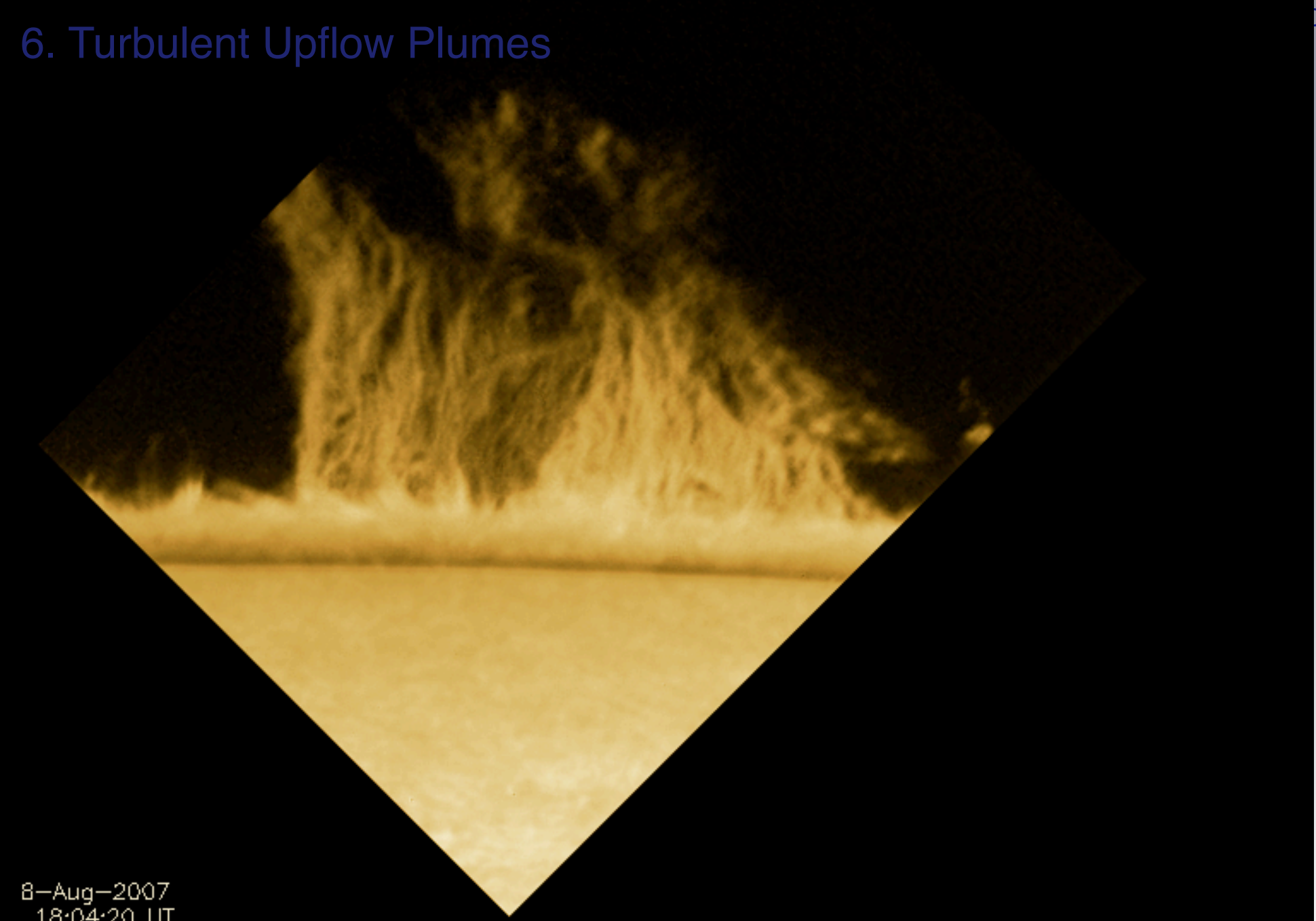




a = -0.18 km/s^2



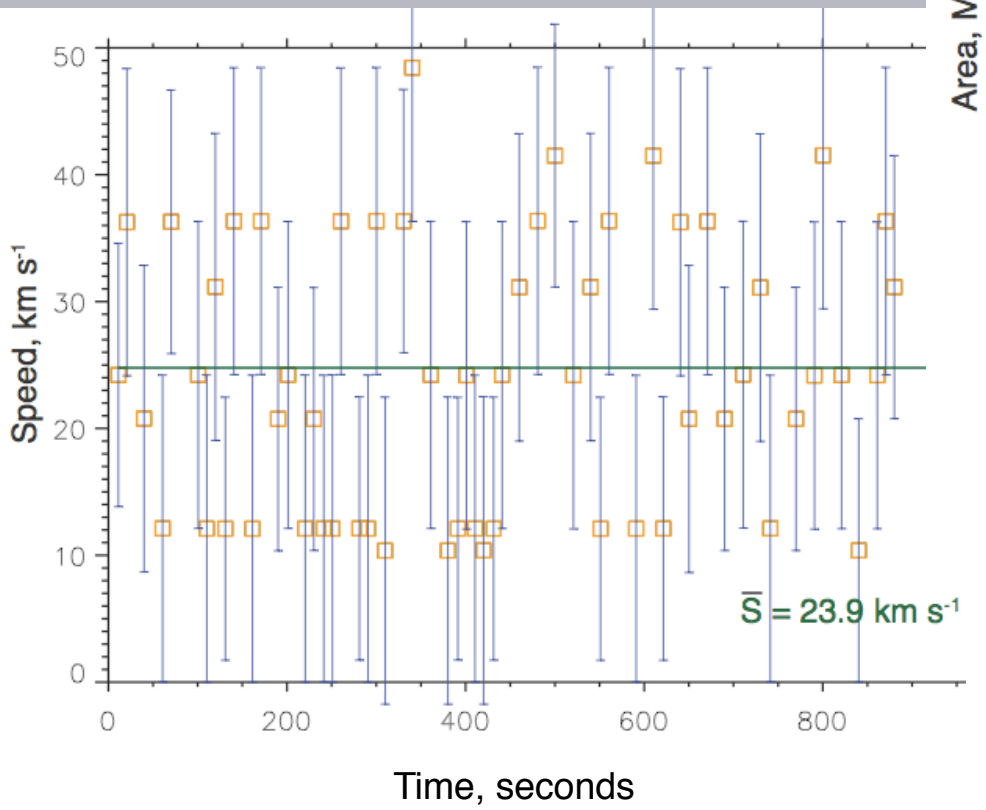
6. Turbulent Upflow Plumes

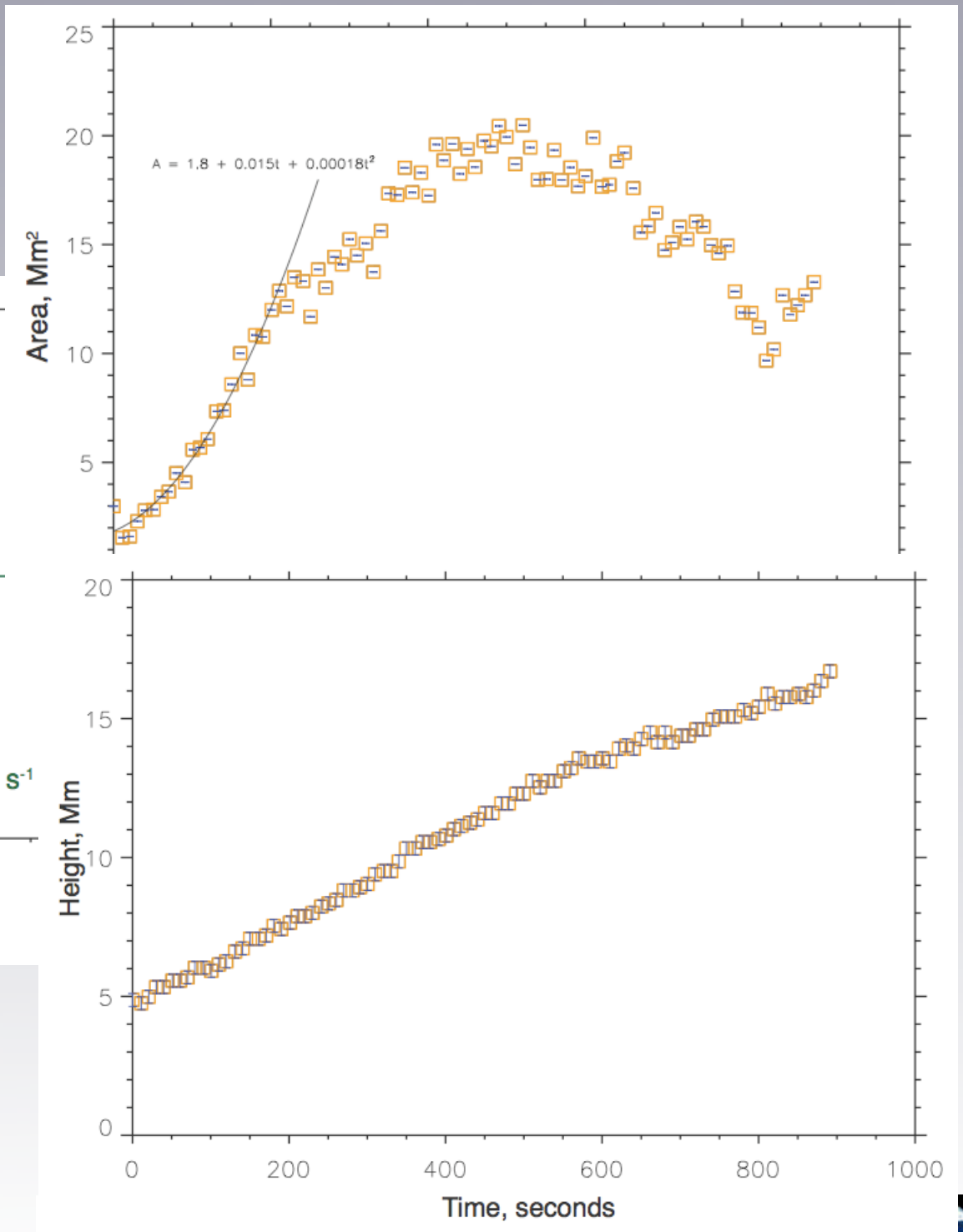


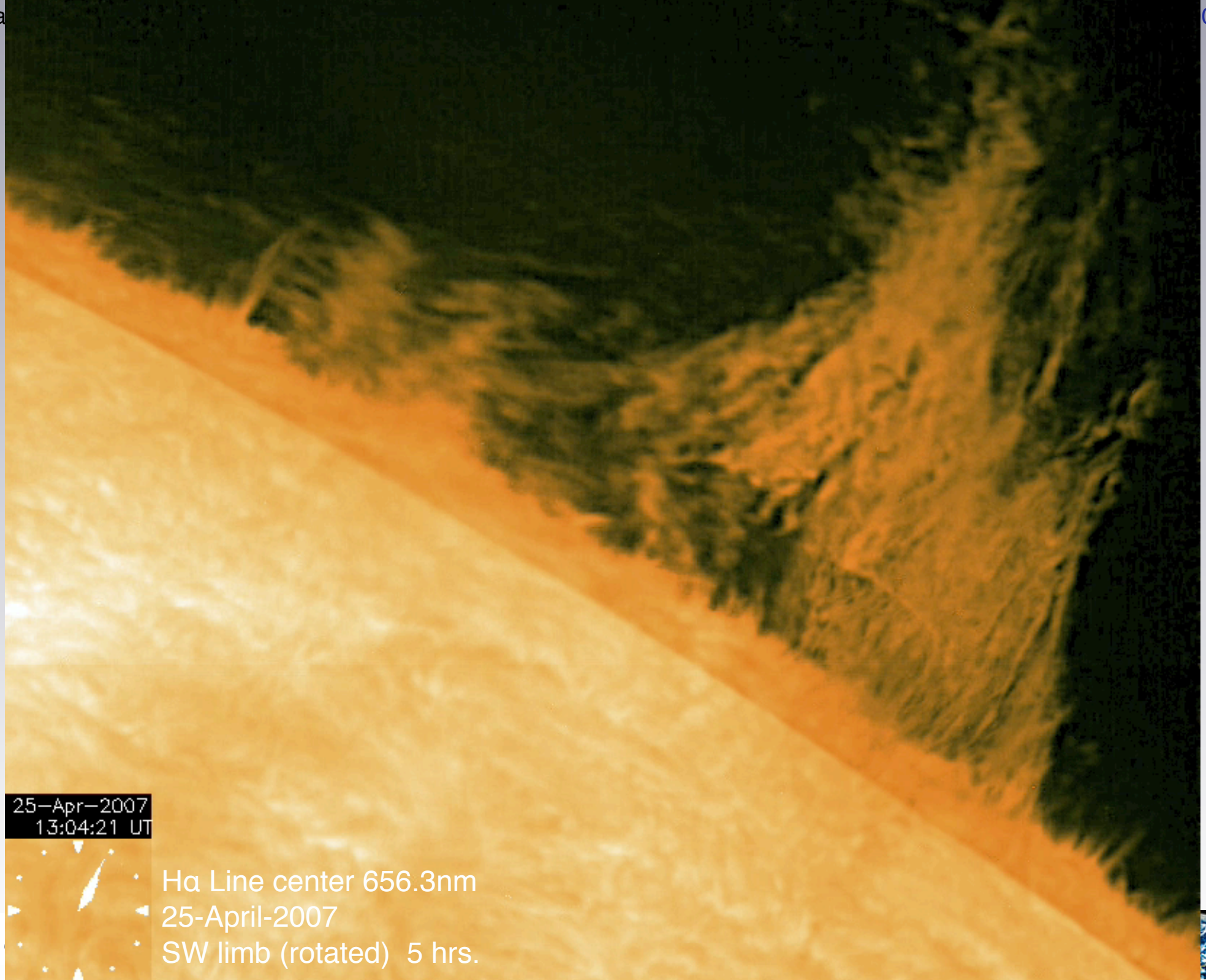
H-alpha 656.3nm
8-Aug-2007
NE limb 4 hrs.


A

Upflow Plume Growth Rate

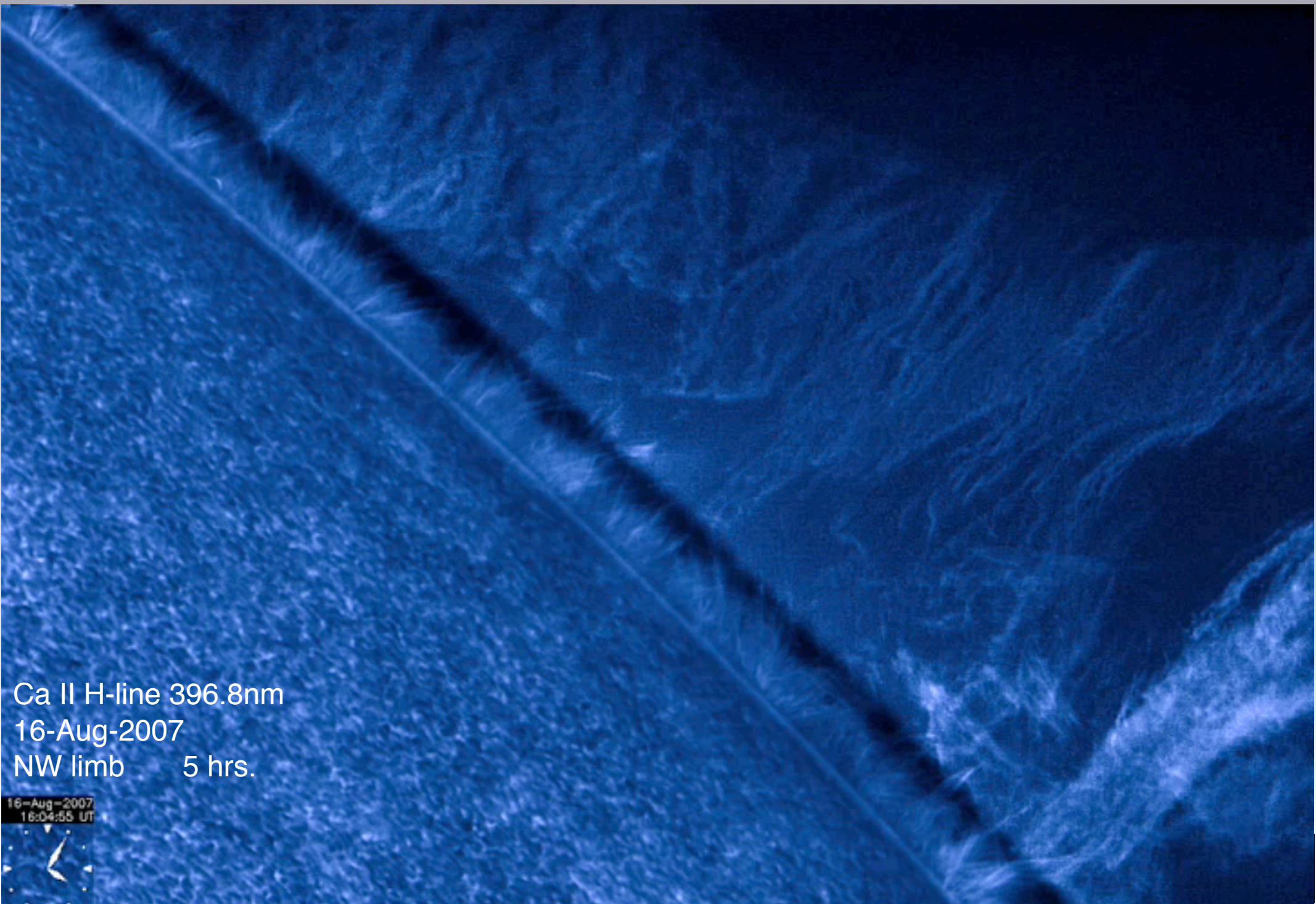






Hα Line center 656.3nm
25-April-2007
SW limb (rotated) 5 hrs.

5. Large-scale Bubbles



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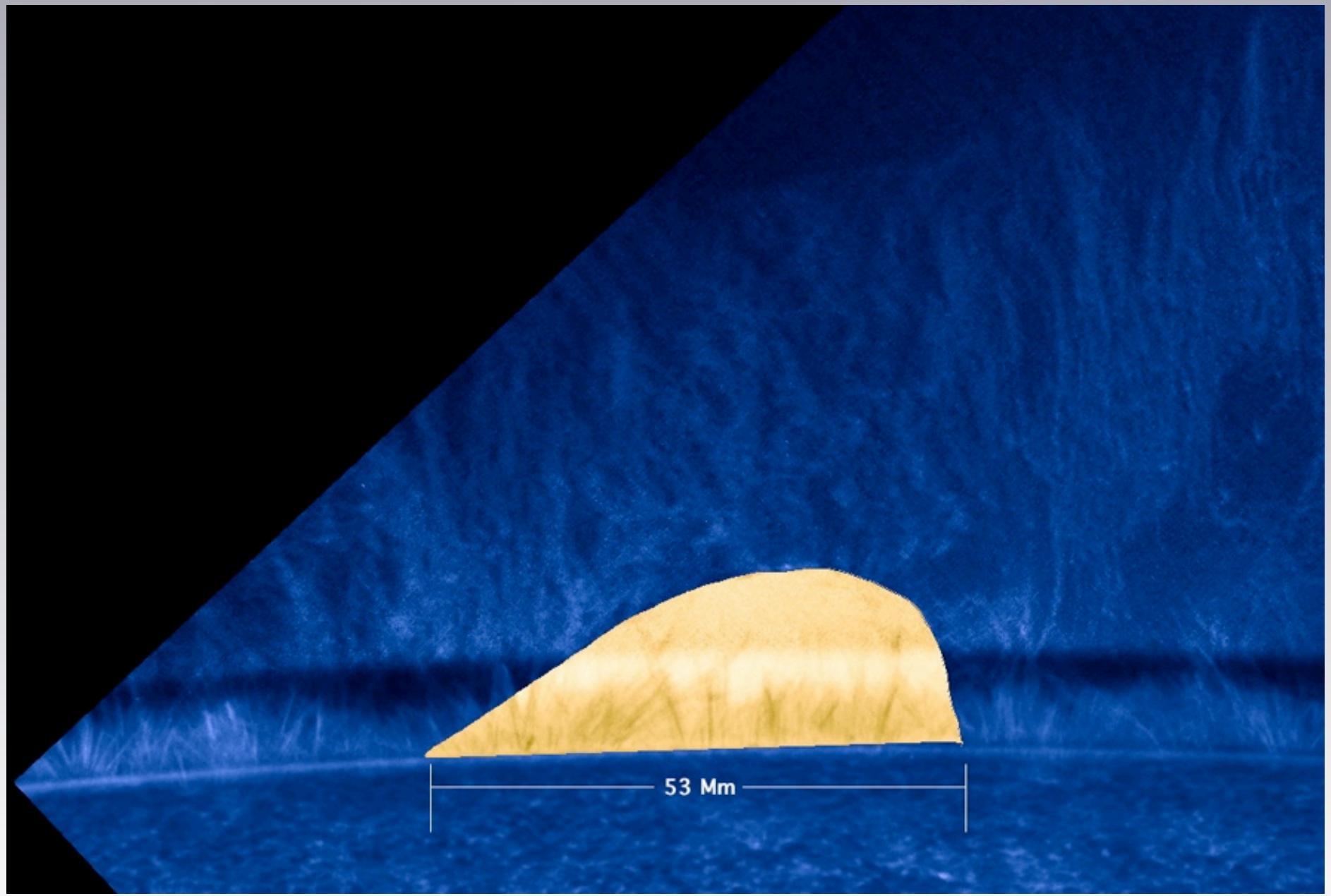

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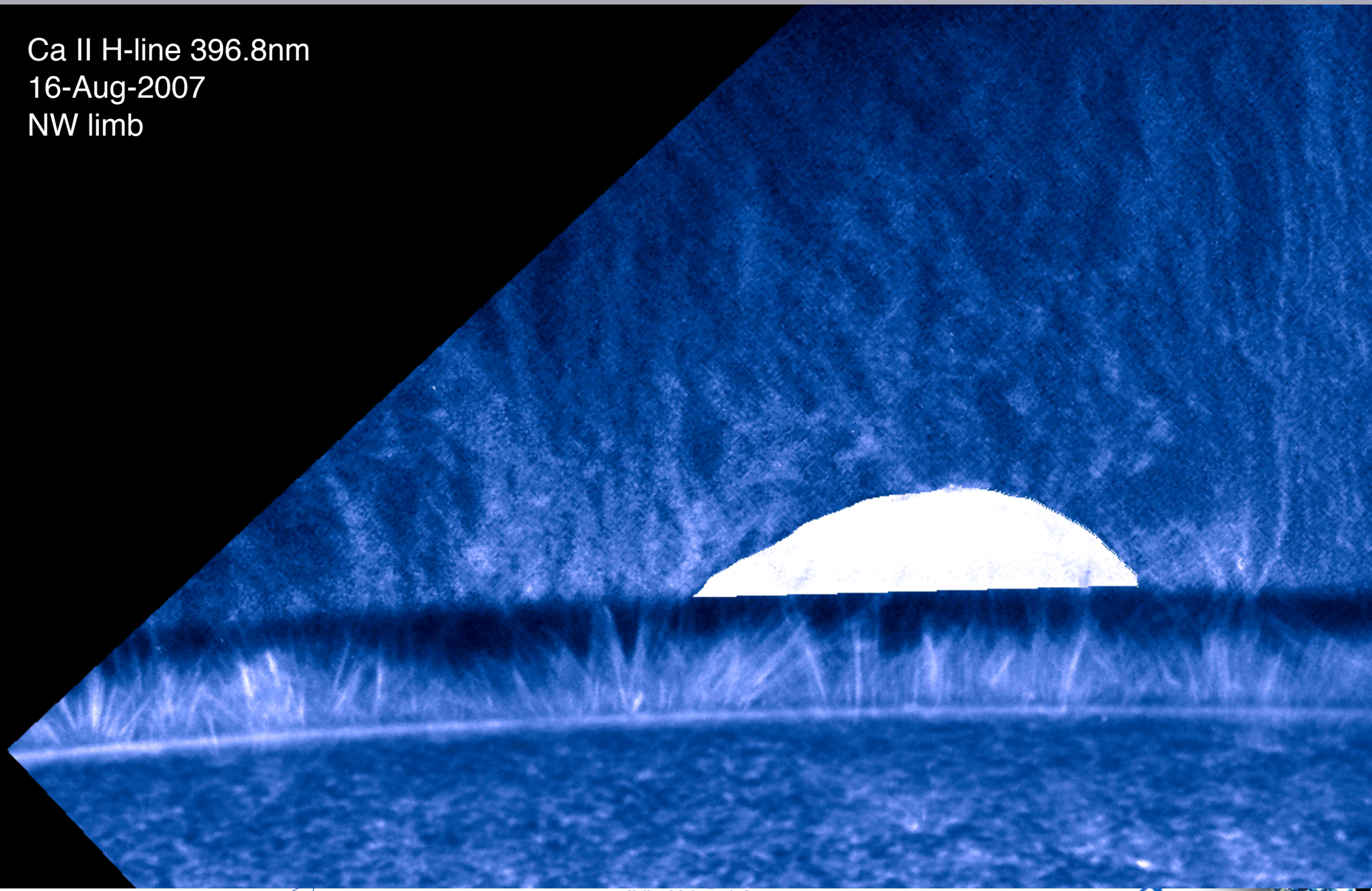
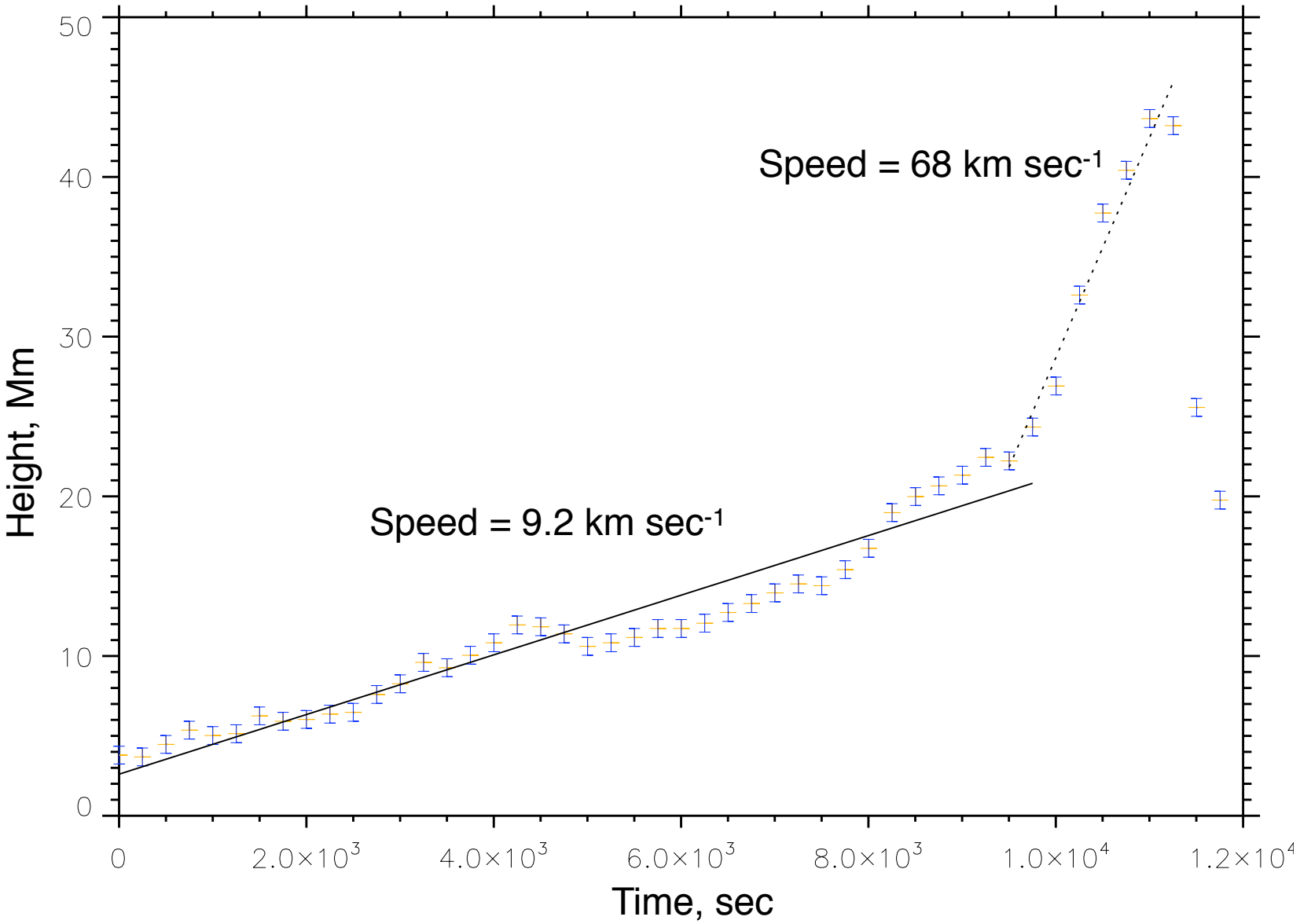
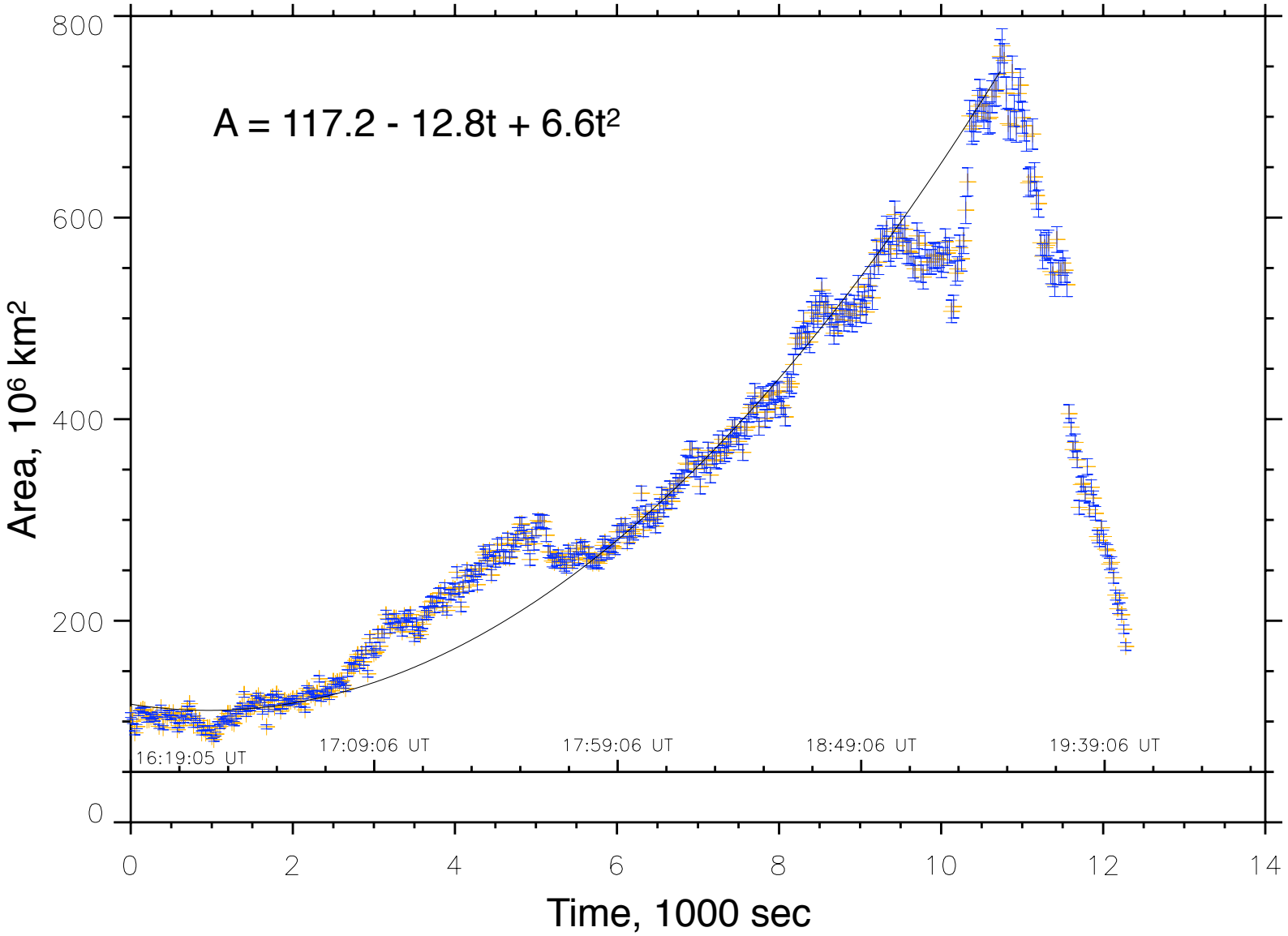


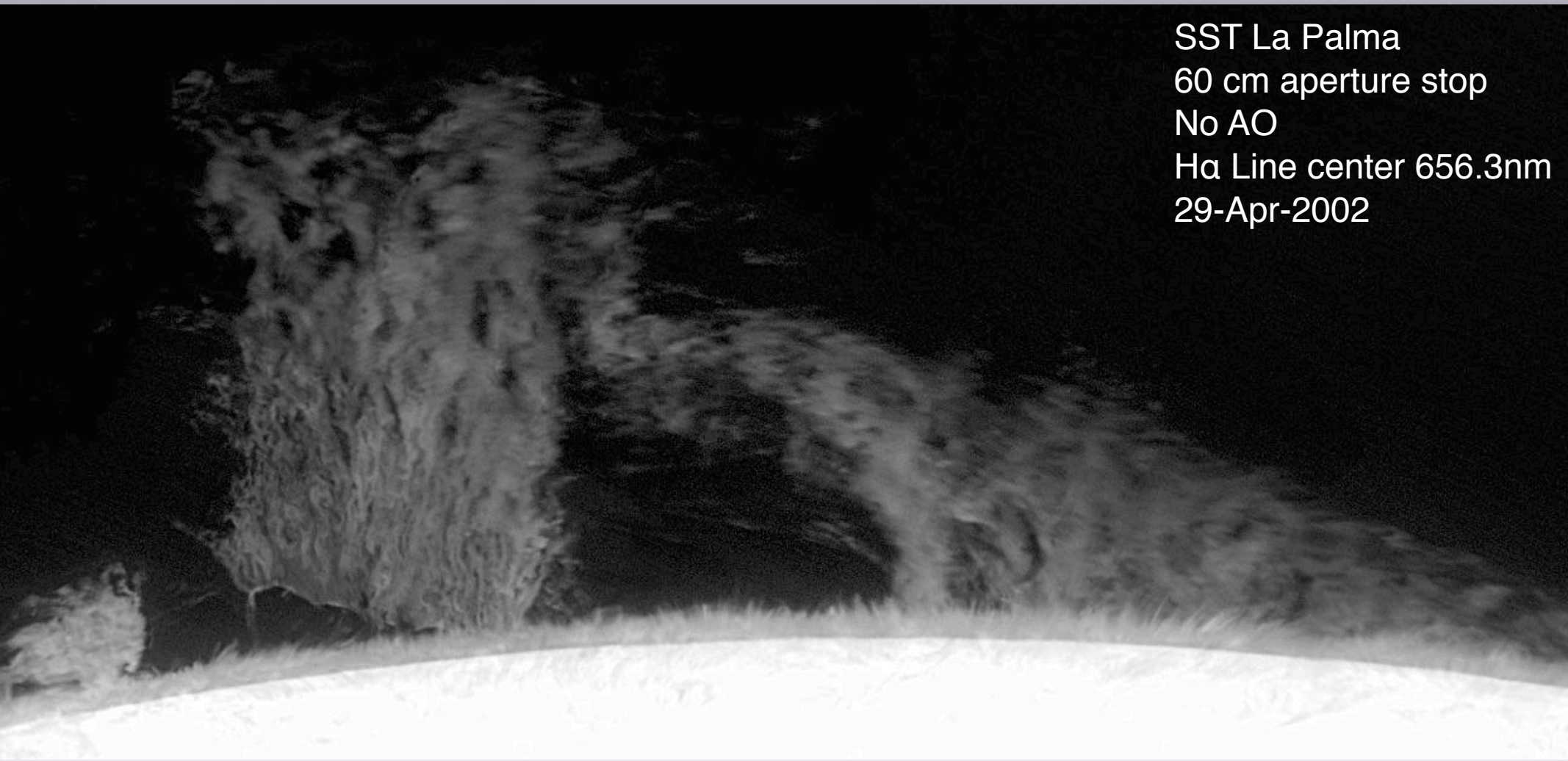
Large Bubble Growth Rate



Large Bubble Growth Rate



Why we need optical instruments in space AND on the ground



Much larger FOV, comparable resolution

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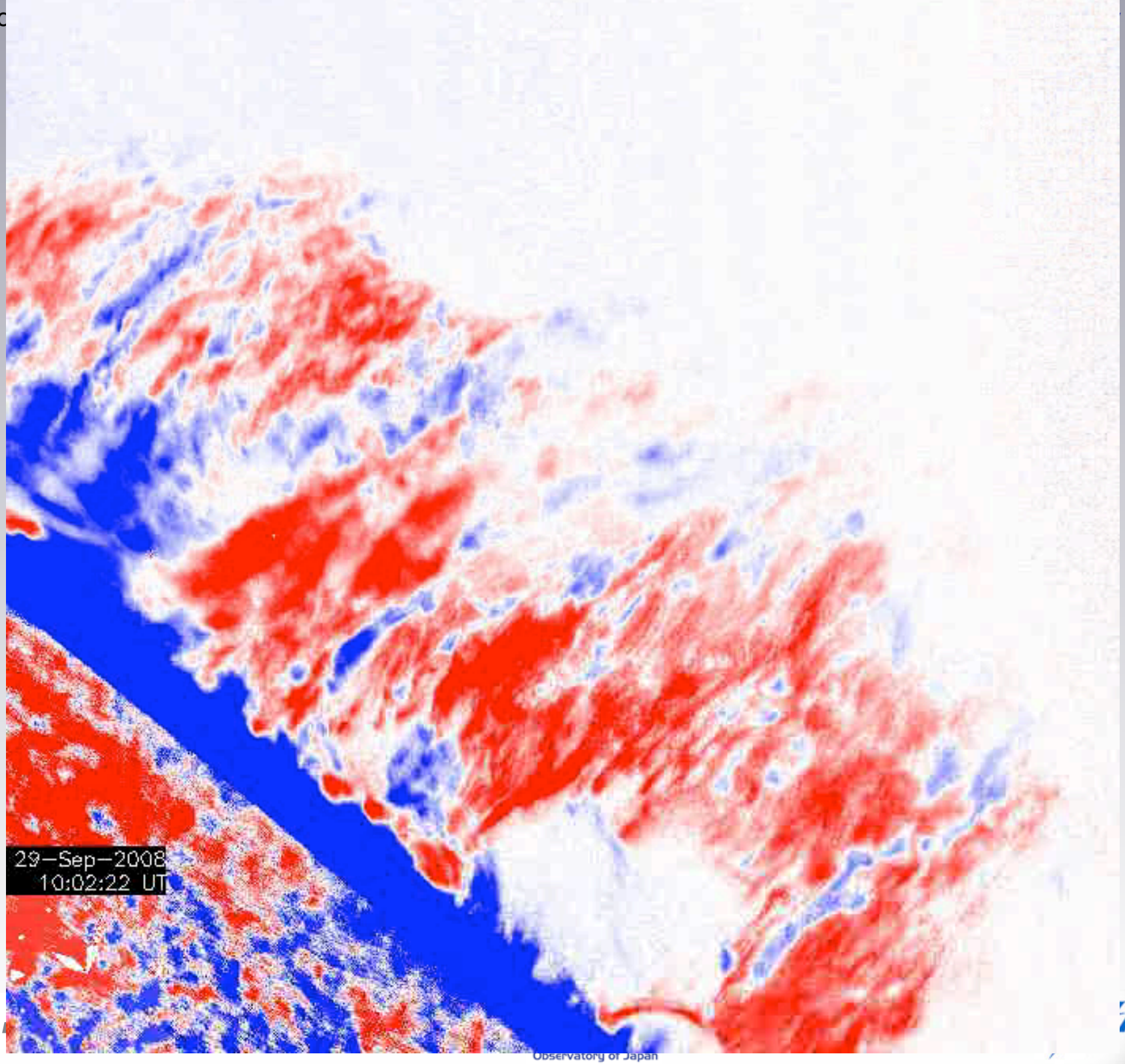
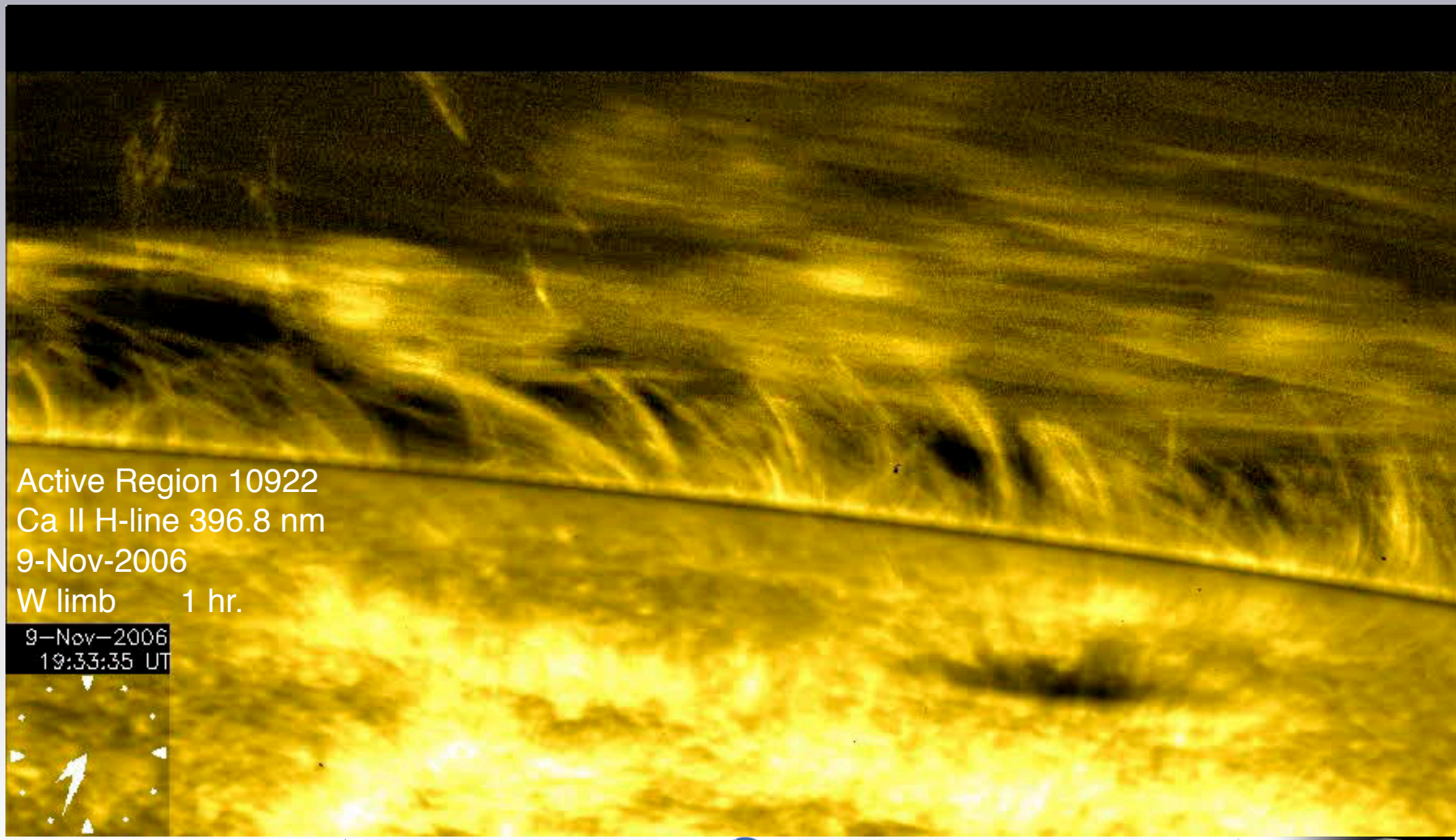
Hα wing 656.31nm
29-Sep-2008
NW limb 4 hrs.
30 sec cadence
29−Sep−2008
10:02:02 UT


29-Sep-2008
10:02:22 UT

Active Region Filaments

primarily counterstreaming on horizontal filaments



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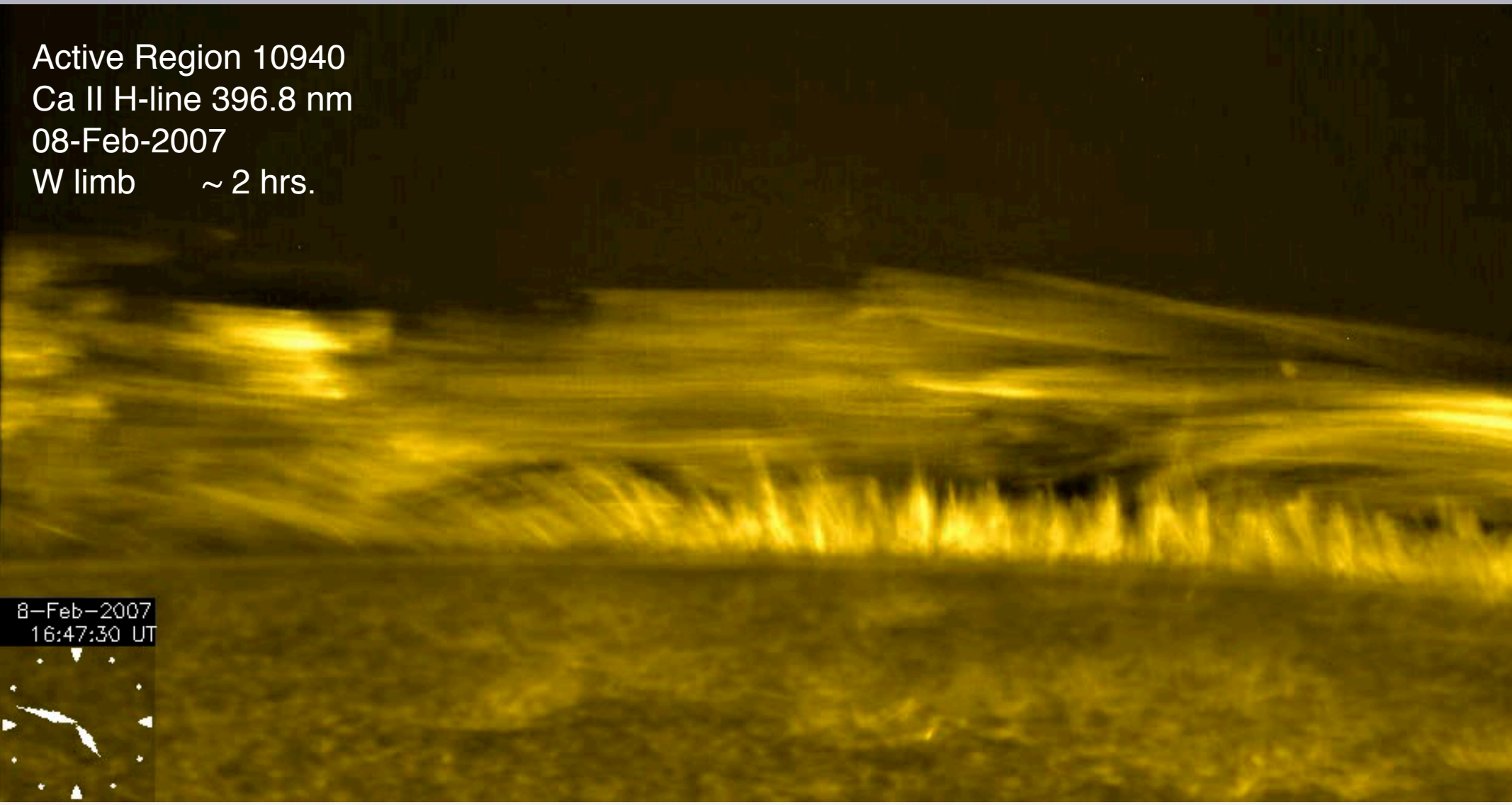

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Conclusions

Quiescent Prominences always show one or more of the 6 dynamics.

- Bright downflow “streams”, $< V > \sim 10$ km/sec, 10 min characteristic lifetime, 250 - 700 km width.
- Vortices, characteristic scale 10^3 km, 3×10^{-3} rad/sec
- Large scale bubble events “inflate” at ~ 10 km/sec. Bursting can be > 50 km/sec.
- Dark upflow “plumes” are intermittent, $< V > \sim 20$ km/sec, 10 minute characteristic lifetime, 400 — 2000 km width.

There is no such thing as a static prominence.

There is no need to “suspend gas against gravity”

Active Region prominences are **always** are horizontally structured.

Very little or no vertical motions - “vertically static” - counterstreaming is dominant dynamic.

- No plume or bubble formation.
- Alfven wave propagation on horizontal filaments.
- Evidence of rotation of groups of filaments.