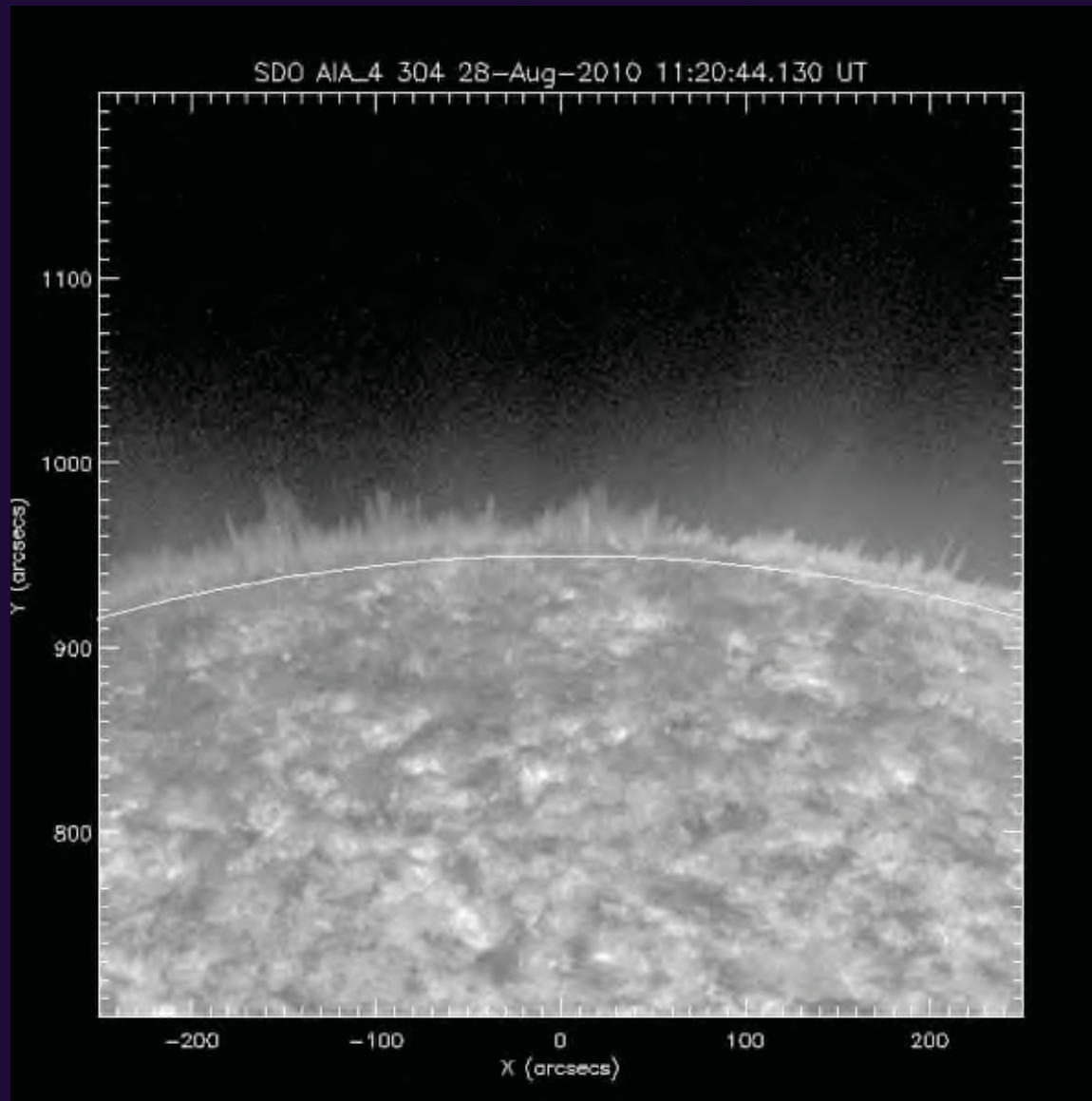


# Exploring He II 304 Å Spicules and Macrospicules at the Solar Limb

Alphonse C. Sterling<sup>1</sup>, Ian R. Snyder<sup>2,3,4</sup>,  
David A. Falconer<sup>5,1</sup>, & Ronald L. Moore<sup>5,1</sup>

1. NASA/MSFC
2. Vassar College
3. NASA/MSFC Research Experience for Undergraduates (REU) Student
4. Companion poster: SH51C-4179
5. U of Alabama Huntsville



Macrospicules (in  $304 \text{ \AA}$  He II): Bohlin et al. (1975), Withbroe et al. (1976).  
EUV Spicules: e.g., Xia et al. (2005).

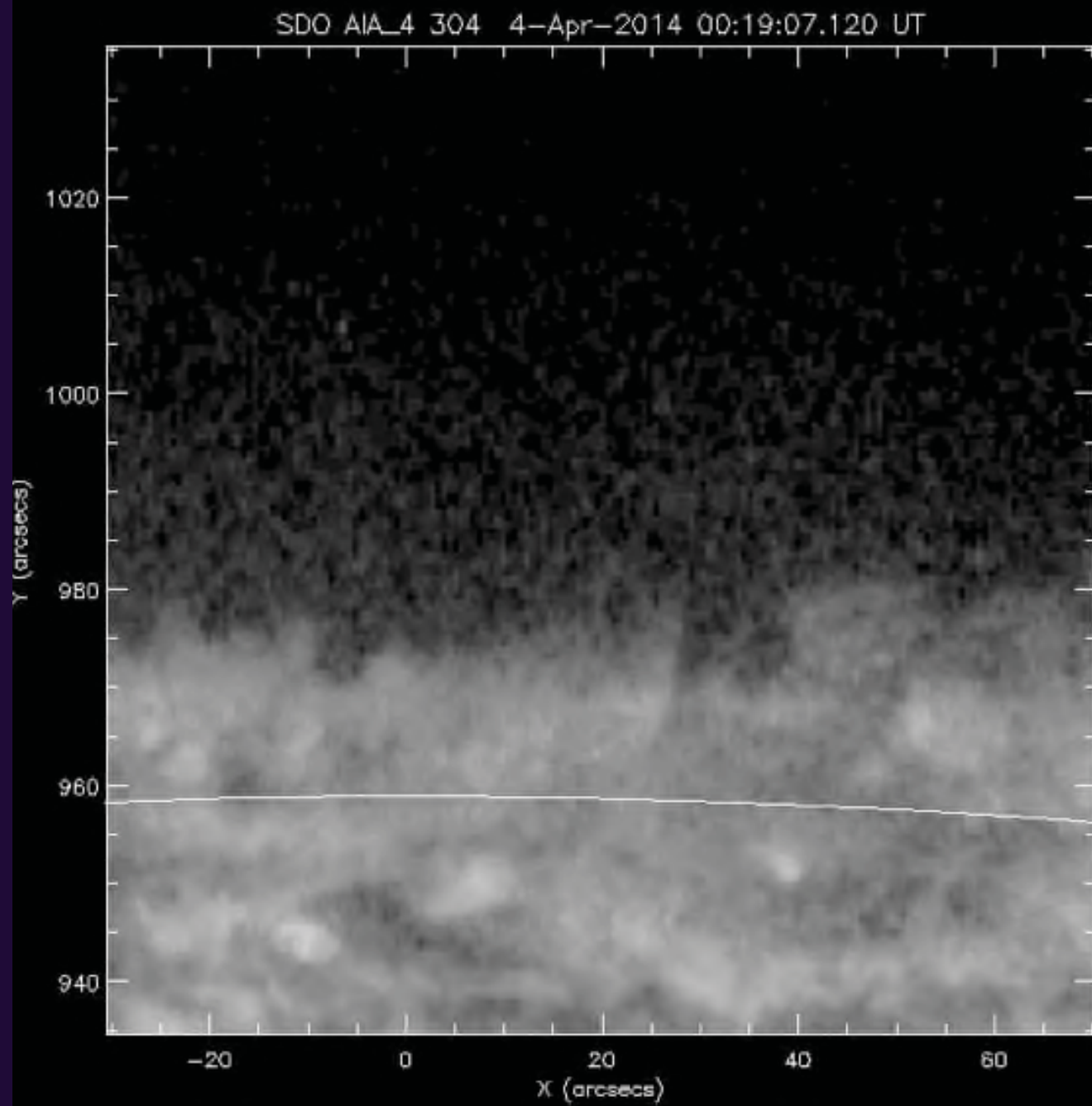
- There is a “sea” of EUV spicules at  $\sim 30''$  above white-light limb ( $\equiv$  “EUV spicules”).
- Occasionally there are very tall ejections ( $\equiv$  “macrospicules”). Our macrospicules have hotter “coronal jet” counterparts.
- Main Question: Are the macrospicules larger versions of the EUV spicules?
- Explore this by studying properties of both features.

# Data Sets

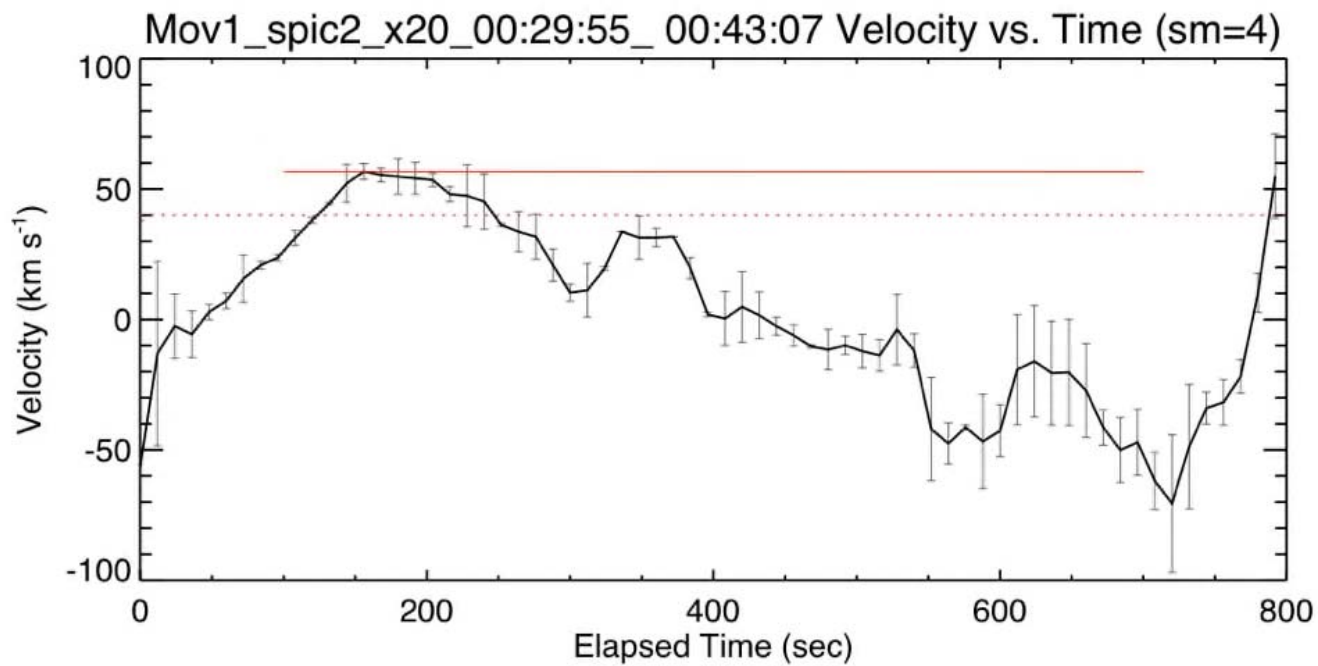
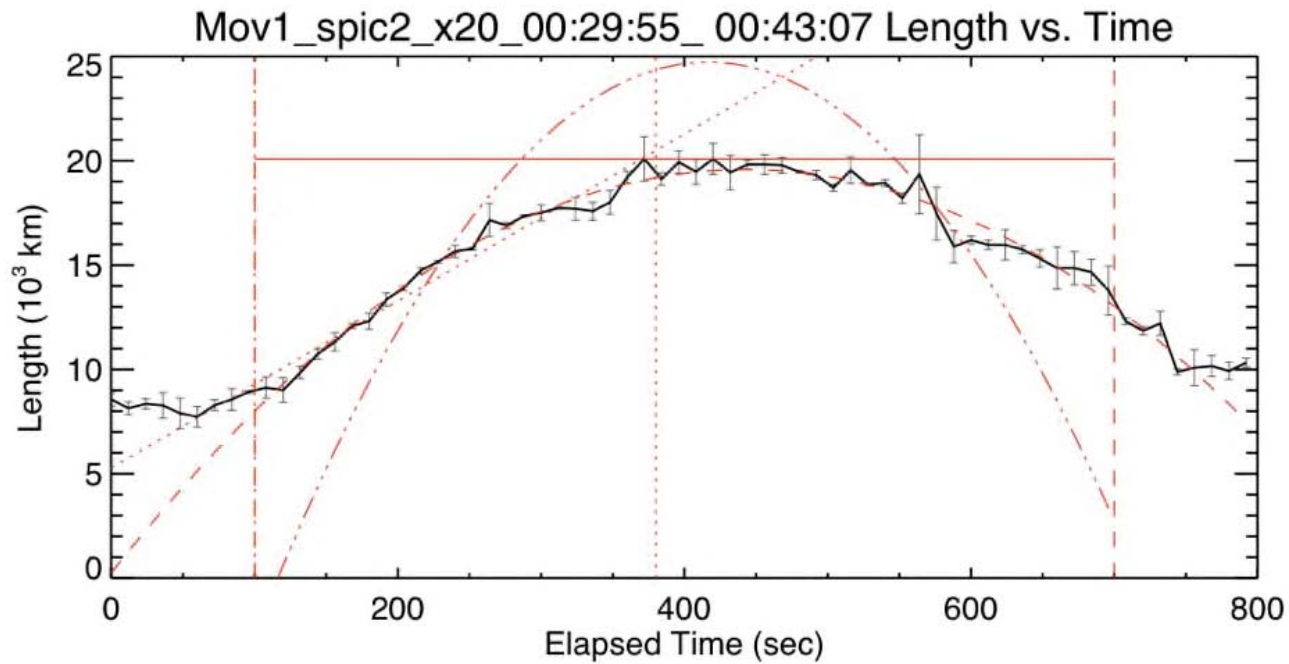
- AIA 304 Å He II. Movies of polar regions.
- 12 sec cadence (EUV spicules), 36 sec cadence (macrospicules).
- For EUV spicules (33 in total). Each movie covered periods of ~90 min, concurrent with Hinode HOP runs.
  - Three periods during 2014; no coronal holes. (Movies 1-3.)
  - One period during 2011, when there was a small coronal hole. (Movie 4.)
  - Selection not totally random, but included some “minor” events.
- Macrospicules; five in total:
  - One occurred during Movie 3.

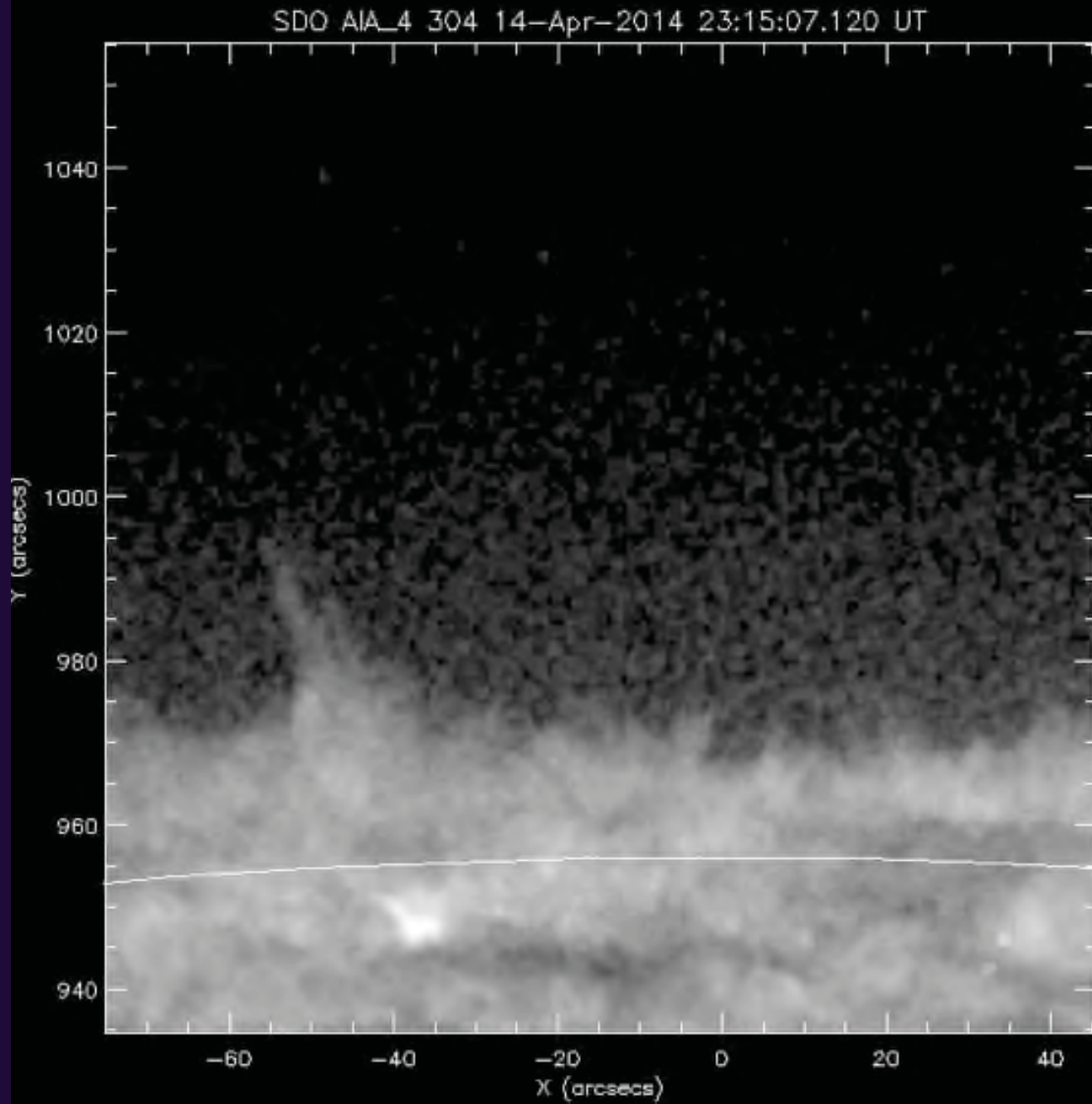
# Analysis

- Determined length-with-time trajectory of each feature.
- Three measurements,  $1\sigma$  error bars.
- Determined lifetime, from “committed” start, until fall or fade.
- Determined velocities from the length measurements (some smoothing applied).
$$h(t) = h(0) - at^2$$
- Fit with second-order polynomial, to determine best-fit acceleration:
- Compare obtained acceleration with that of solar gravity.



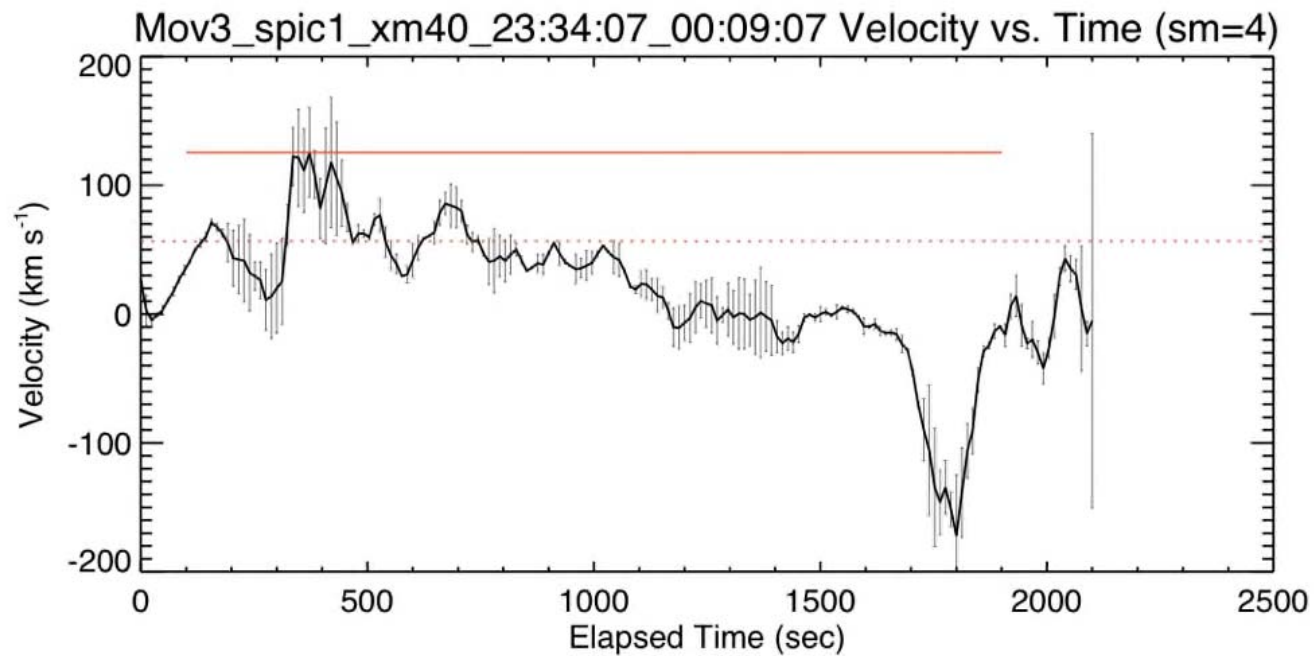
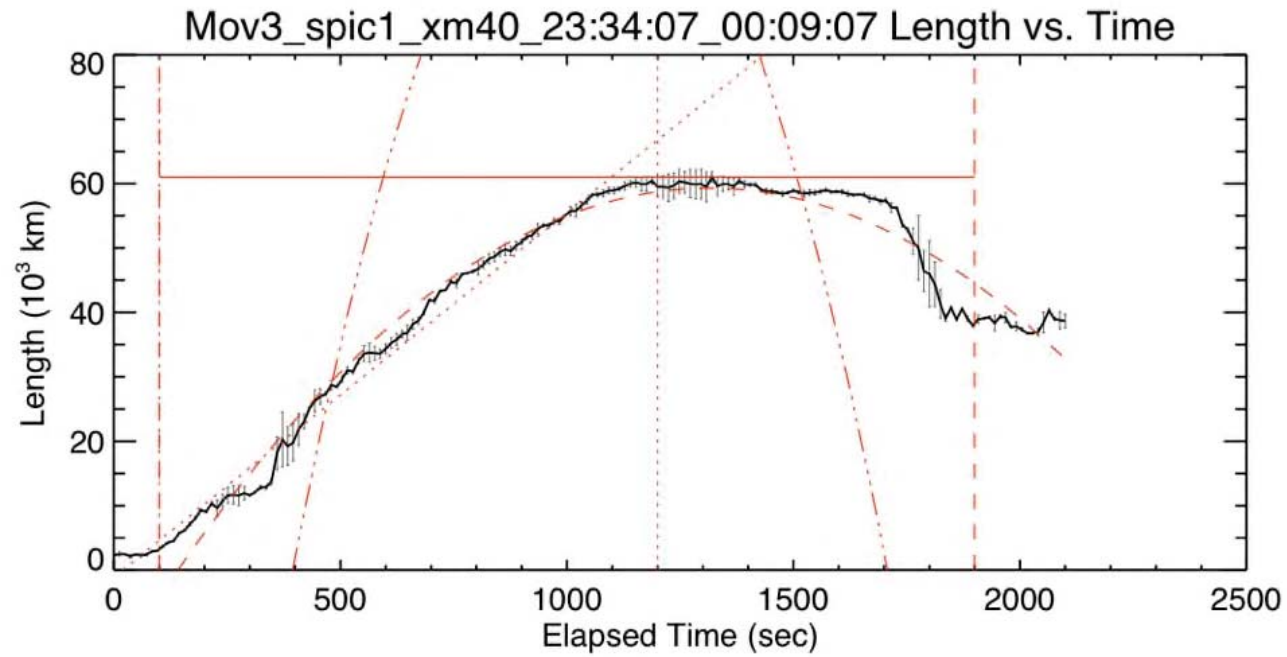
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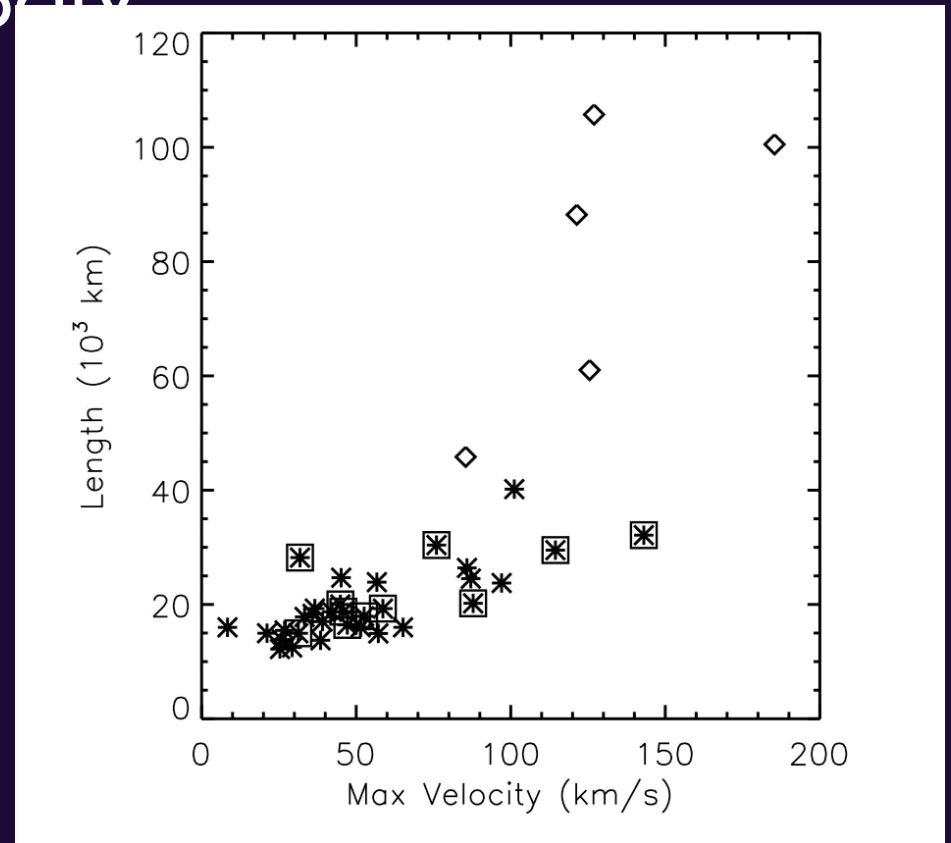
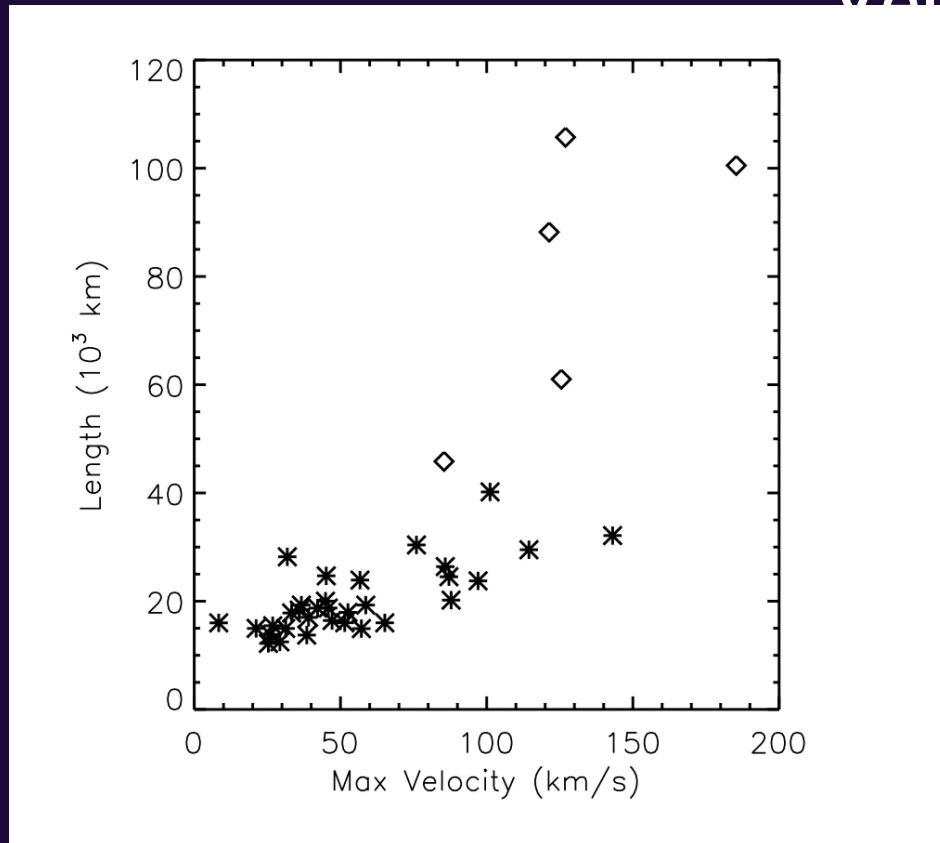


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# Length vs. Maximum Velocity



- Velocities:

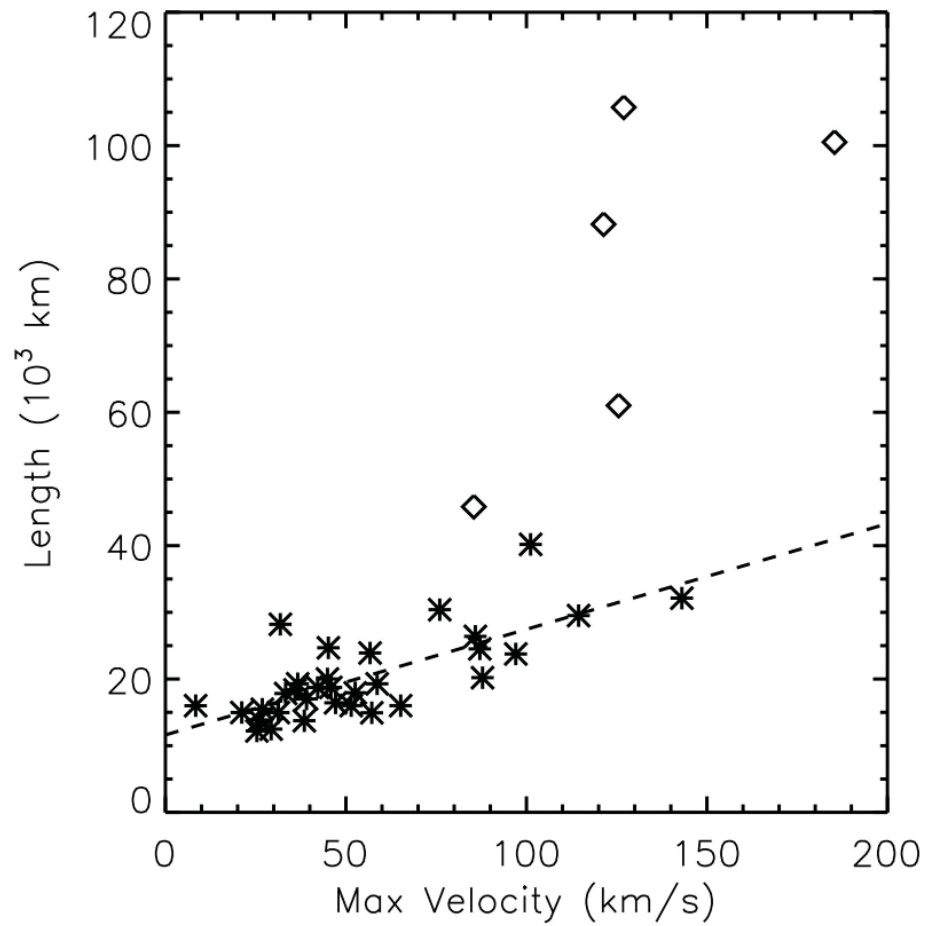
- EUV Spicules: 20 ~ 70, 150 km/s

- Macrospicules: ~100---200 km/

- Lengths:

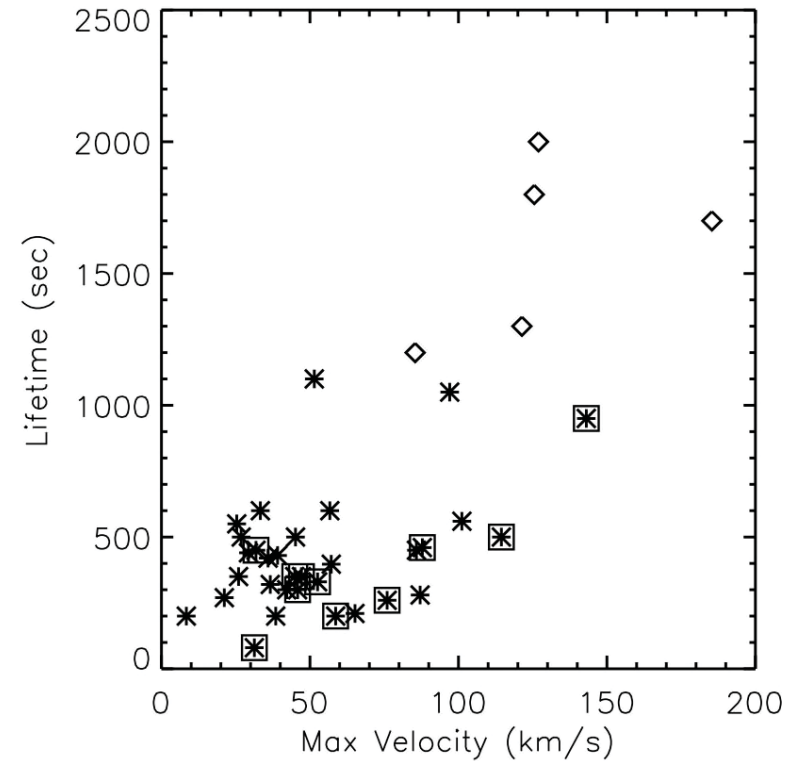
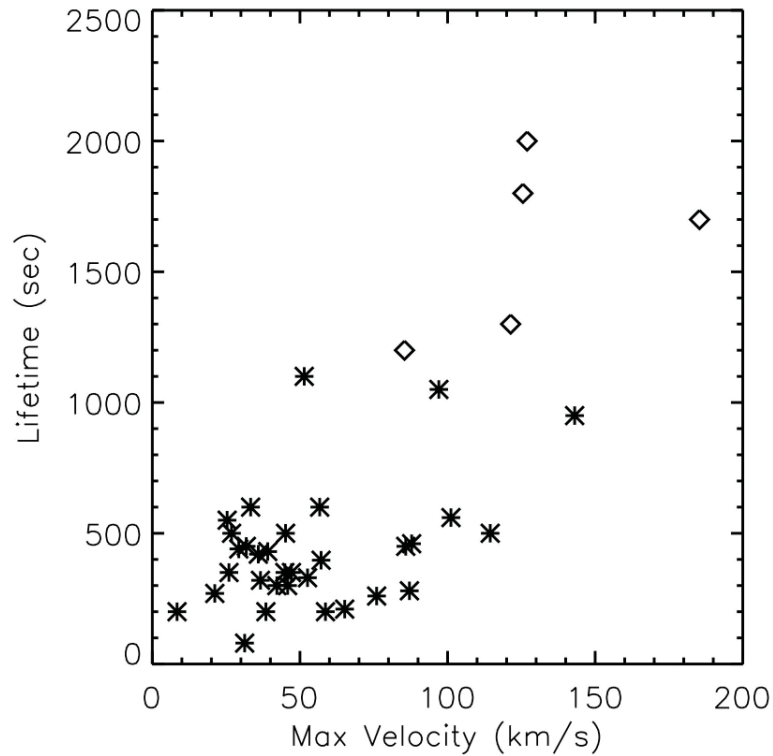
- EUV Spicules: 10K ~ 20K, ~30K km

- Macrospicules: ~40K---100K km

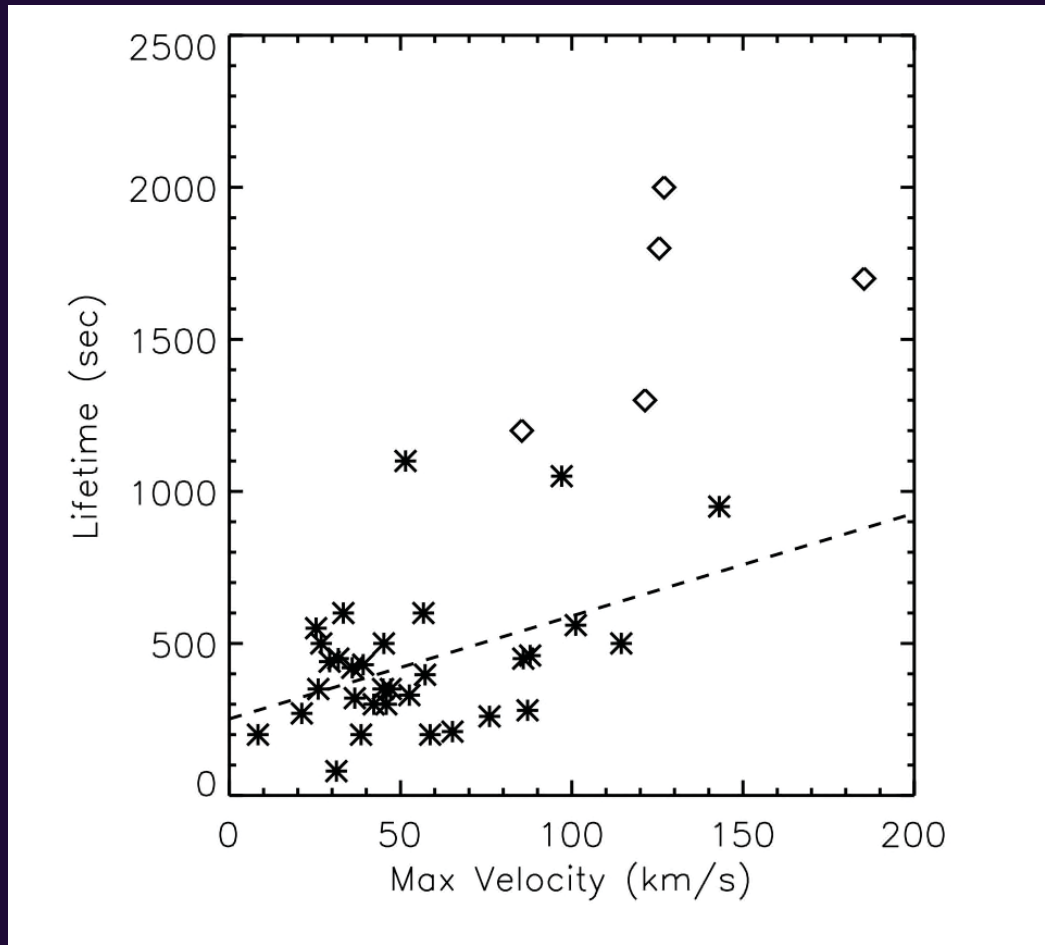


Slope:  $0.16 \pm 0.03$

# Lifetime vs. Maximum Velocity

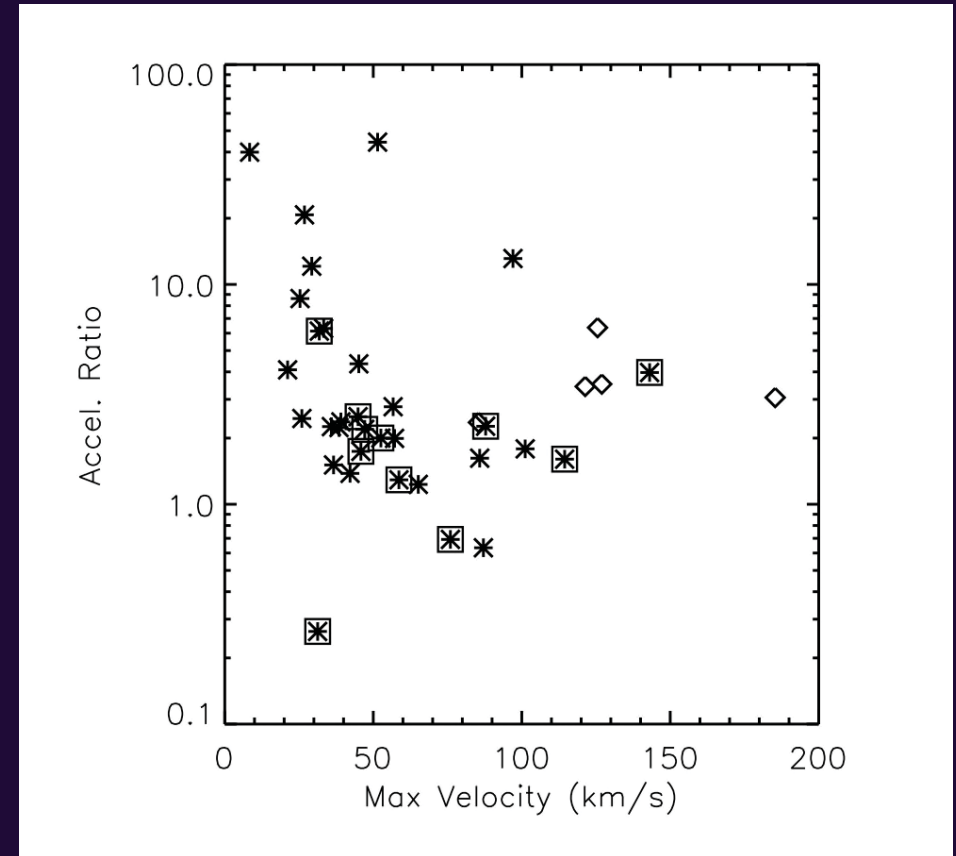
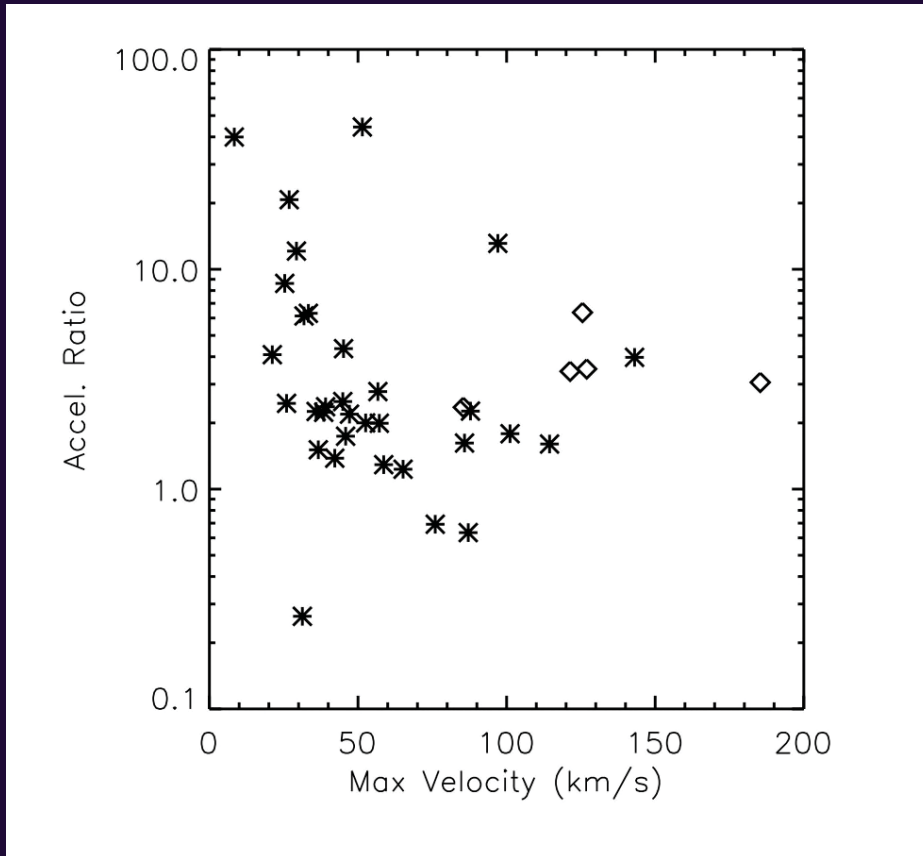


- Lifetimes:
  - EUV Spicules: 100 ~ 1000 sec
  - Macrospicules: ~1000 --- 2000 sec



Slope:  $3.4 \pm 1.3$

# Acceleration Ratio vs. Maximum Velocity Plots

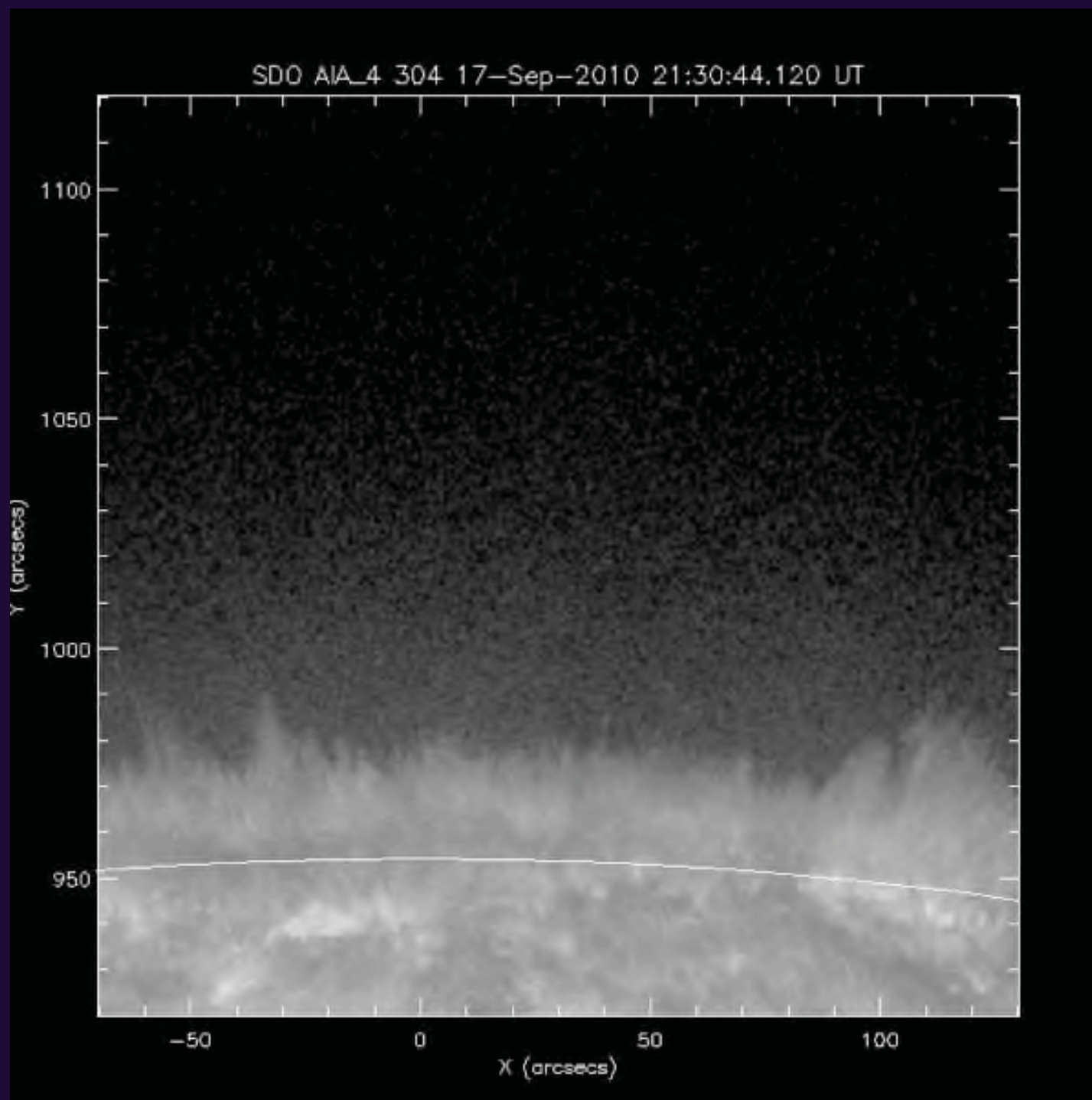


$$\text{ratio } [=g/a] < 1 \Rightarrow F = -mg + F_{\text{extra}}$$

$F_{\text{extra}}$  could be due to, e.g., thermal energy

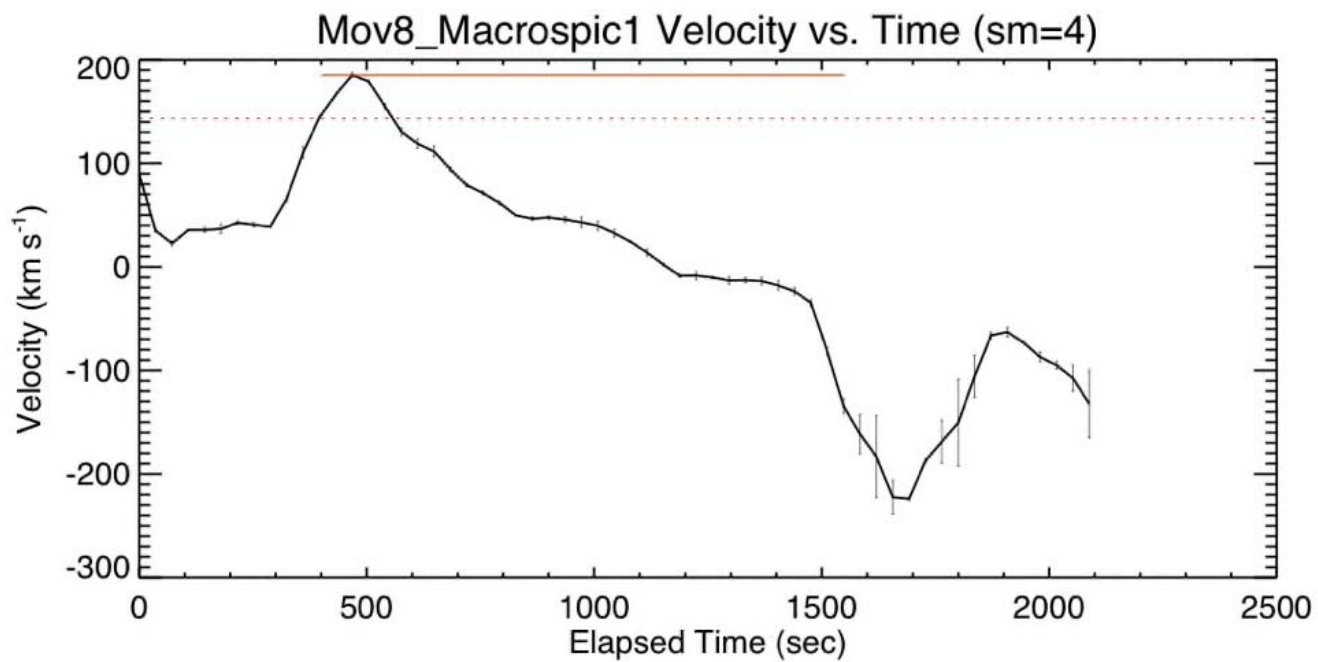
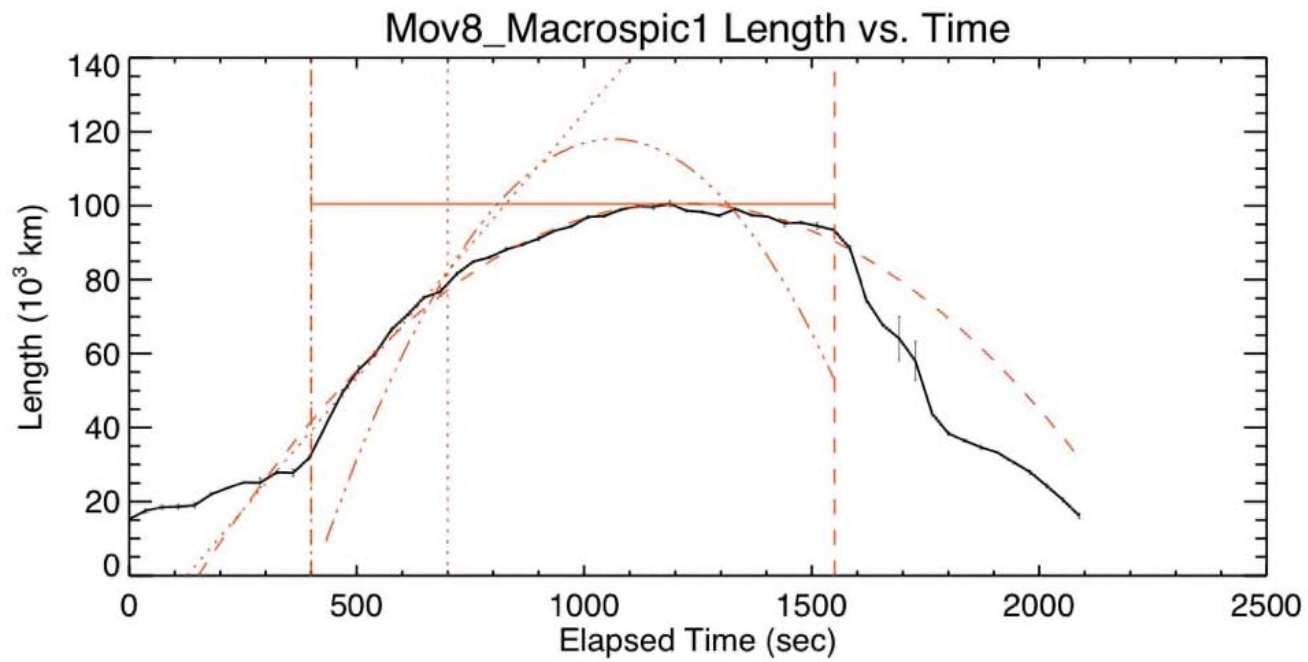
(pressure)

The above suggests that there are quantitative differences between EUV spicules and macrospicules. There is also an important morphological difference between the two features: Brightenings (or lack thereof) at their respective bases at onset time...



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# Summary of Results

- Indications are that macrospicules (as defined here) and EUV spicules have some differences in behavior (especially length vs. max velocity), and appearance (base brightenings in macrospicules).
- From De Pontieu et al. (2011) and Pereira et al. (2014), “EUV spicules” are almost certainly “spicules” in many cases. Our macrospicules are “coronal jets.” So our results suggest that spicules and coronal jets have different driving mechanisms. (Still preliminary.)
- Among EUV spicules themselves, those in polar coronal holes tend to be longer and faster than those in quiet-Sun polar regions.
- Both EUV spicules and macrospicules follow largely parabolic profiles. Macrospicules tend to fade in EUV 304 Å more often than do the EUV spicules.
- Both EUV spicules and macrospicules tend to have  $g/a > 1$ , suggesting an auxiliary force besides gravity is acting on the material. (Agrees with Moschou et al. 2013.)







# Length vs. Lifetime

