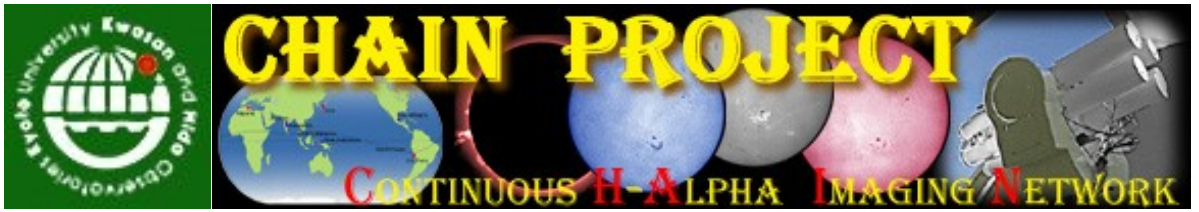
CHAIN-Project: Investigation of Solar Active Phenomena Obtained with Flare Monitoring Telescope (FMT)

(*"Dandelion" Filament Eruption and Coronal Wave*)



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Outline

- Flare Monitoring Telescope (FMT).
- Study of “Dandelion” Filament Eruption.
  - Observation and Data.
  - Side view of the filament eruption.
  - Velocity map, line of sight velocity, 3-dimensional velocity.
- Investigation of Extreme Ultra-Violet (EUV) waves and Filaments Oscillation.
- Summary and conclusion.

Ica University Solar Station, Peru

The Flare Monitoring Telescope (FMT)

- The FMT is a system of six (6.4cm) refracting telescopes, that provide us continuous and simultaneous observation of solar full-disk image at different wavelength around the H-alpha line center.

- By using FMT data, we can quantitatively investigate the solar activity and explosive events on the chromosphere.

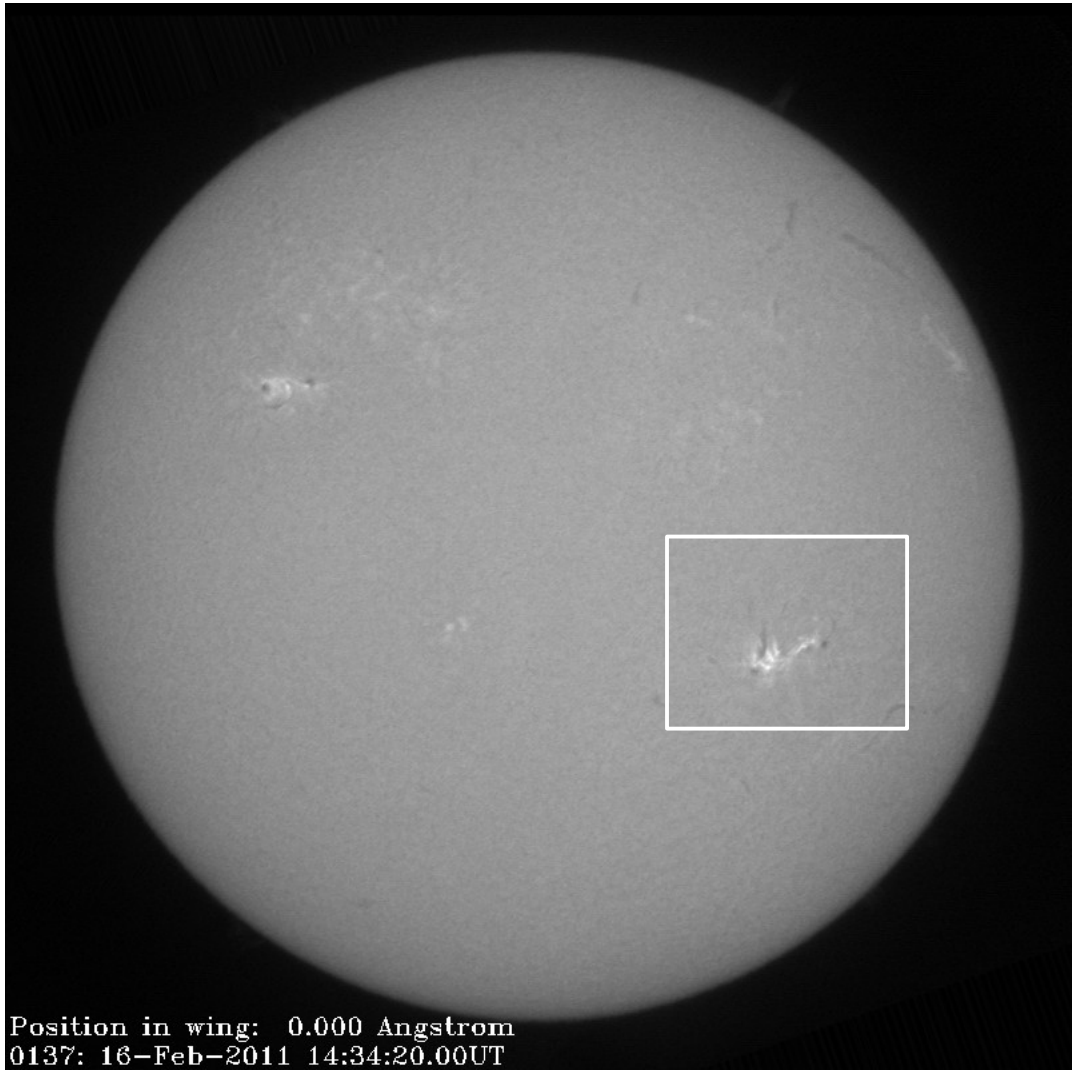
- Allow us to derive physical parameter applying Becker's cloud model.

Study of “Dandelion” Erupting Filament

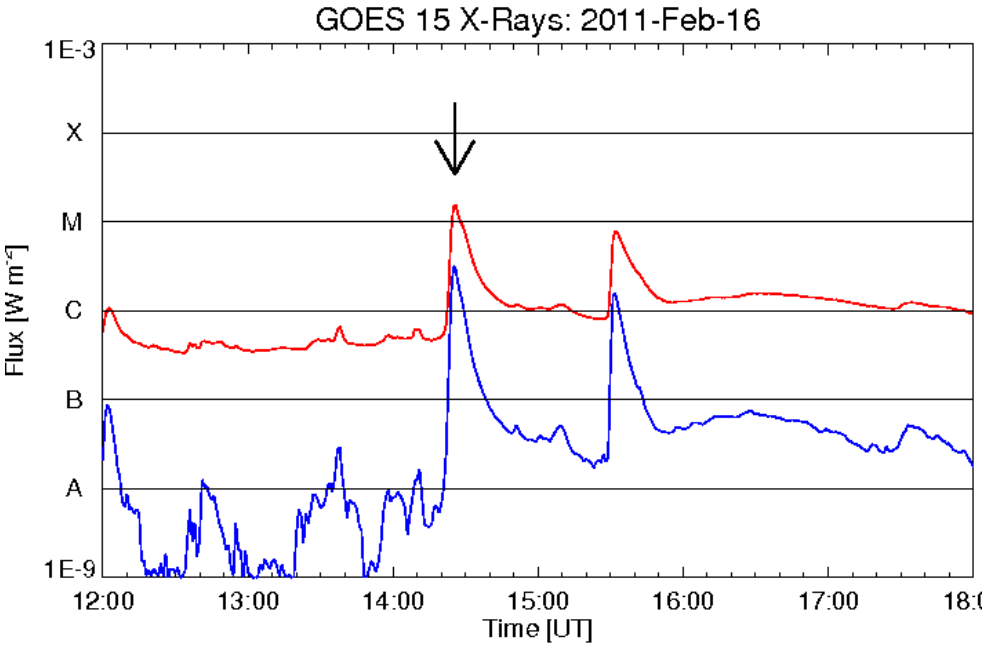
(2011 Feb. 16th Flare)

Observation and Data

(2011 February M1.6 Flare)



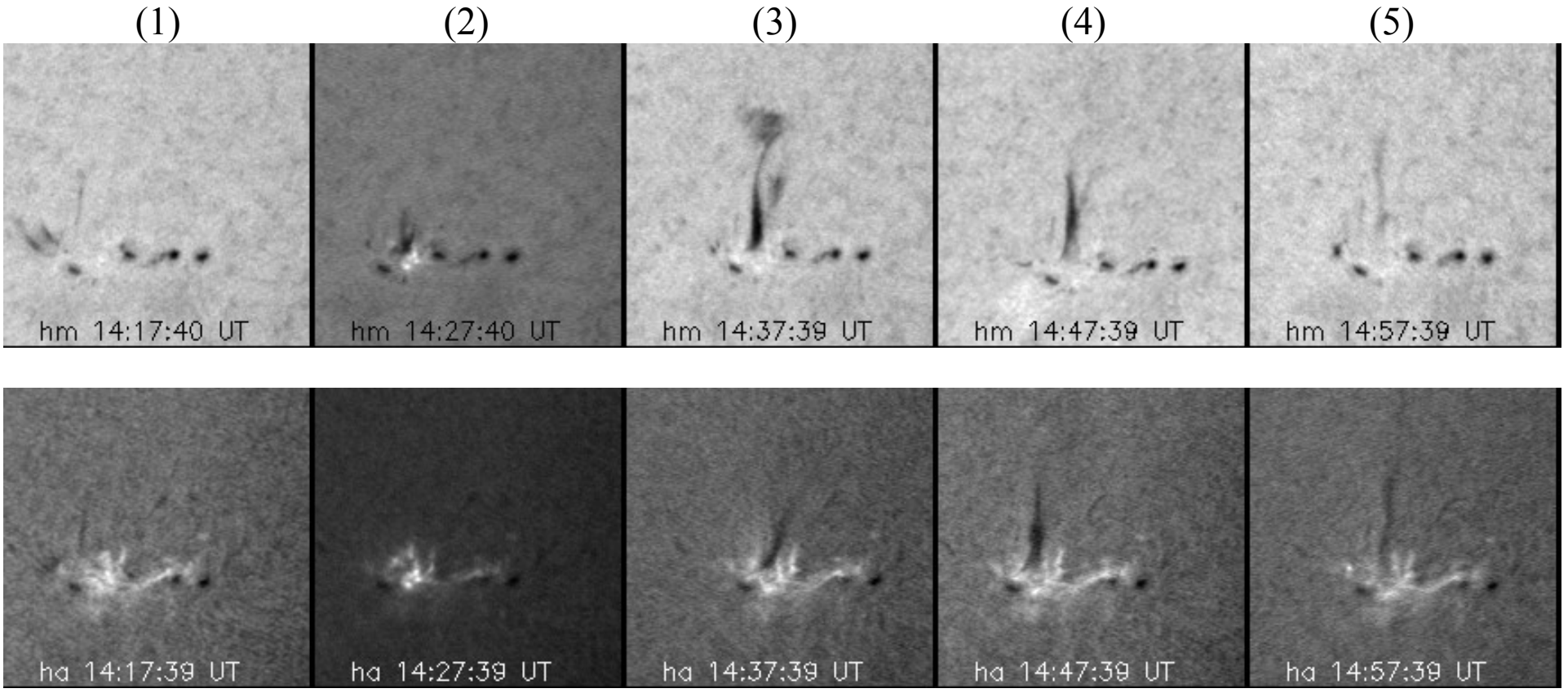
H-alpha full-disk solar image, taken by FMT at Ica, Peru.



- Date: 2011 Feb. 16th
- Start: 14:19 UT
- Peak: 14:27 UT
- Flare GOES class: M1.6
- Active region: NOAA 11158
- Full disk obs. by
  - FMT: Hα center, ± 0.8Å (20s cadence)
  - SDO/AIA: EUV 193Å, 171Å (12s cadence)
  - STEREO/EUVI: EUV 195Å(5min cadence)
  - HINODE: XRT

Dandelion Filament Eruption

(Time Evolution of 2011 Feb. 16th Flare)

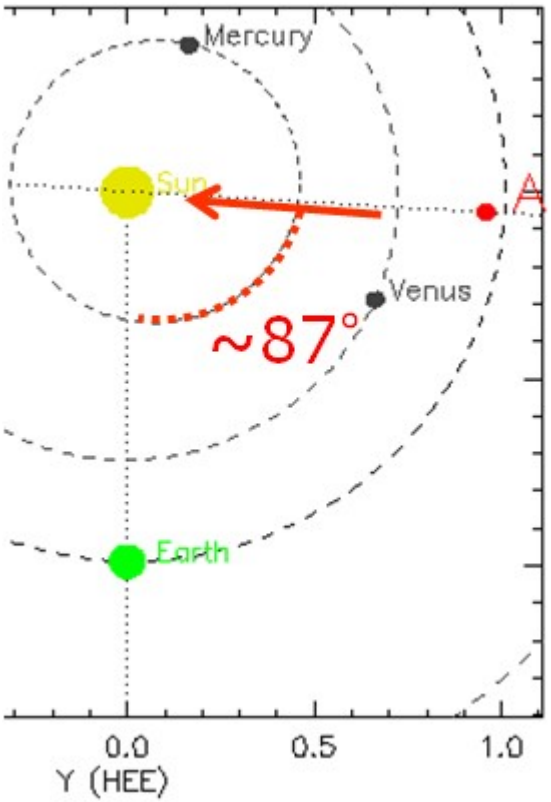


Process of flare generation and the erupting filament observed by the FMT, at Ica University, Peru.

Jsm ->

The Side View of the Filament Eruption

(STEREO-Ahead Satellite)



• The STEREO-Ahead satellite was located 87 degree ahead of the Earth at the time of the flare.

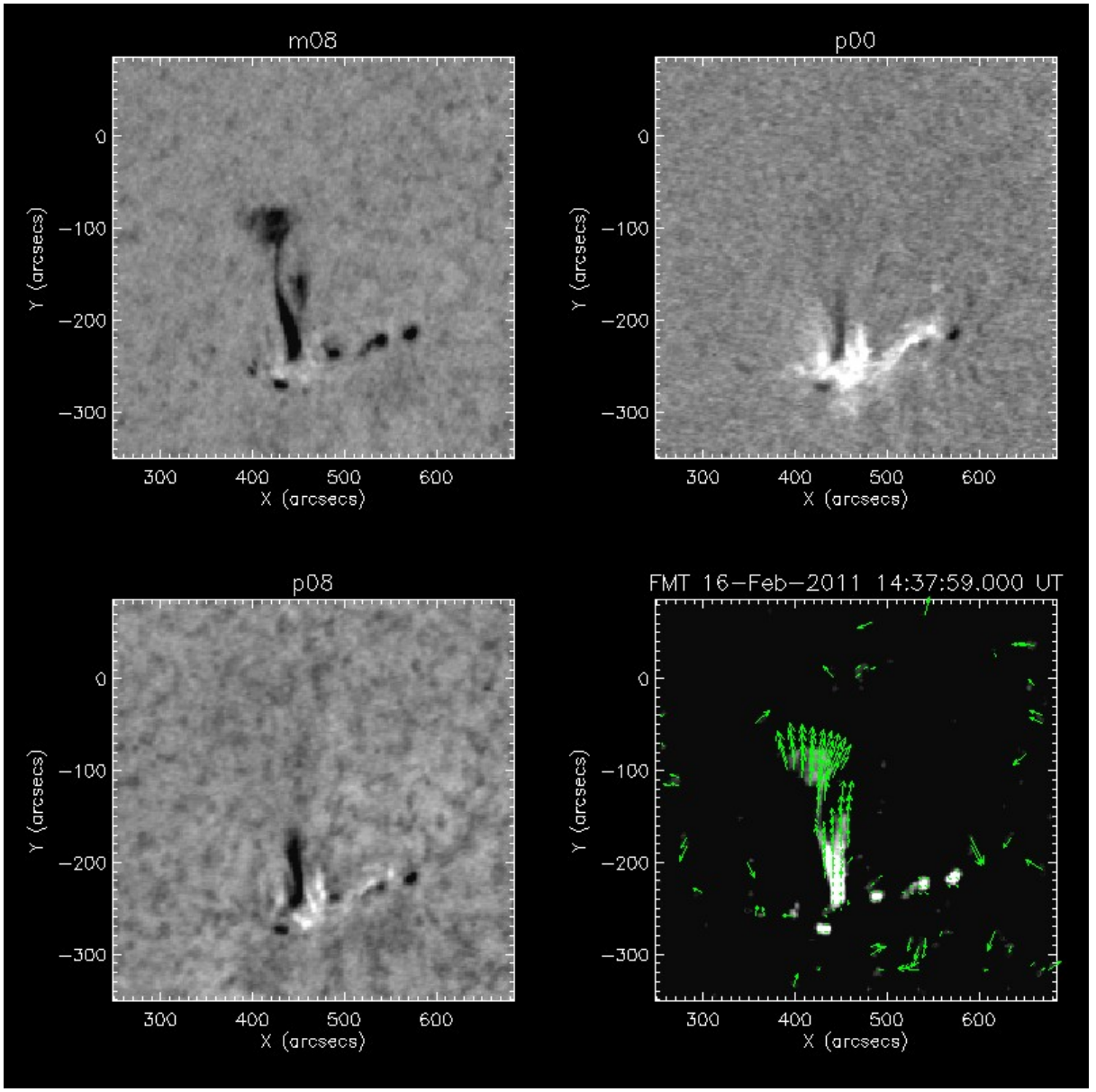
• The velocity of the erupting filament is about ~250km/s

STEREO_A SECCHI EUVI 195Å / FEB. 16, 2011

Velocity Map

(Study of the characteristics of filament eruption)

Hα - 0.8Å



Hα + 0.0Å

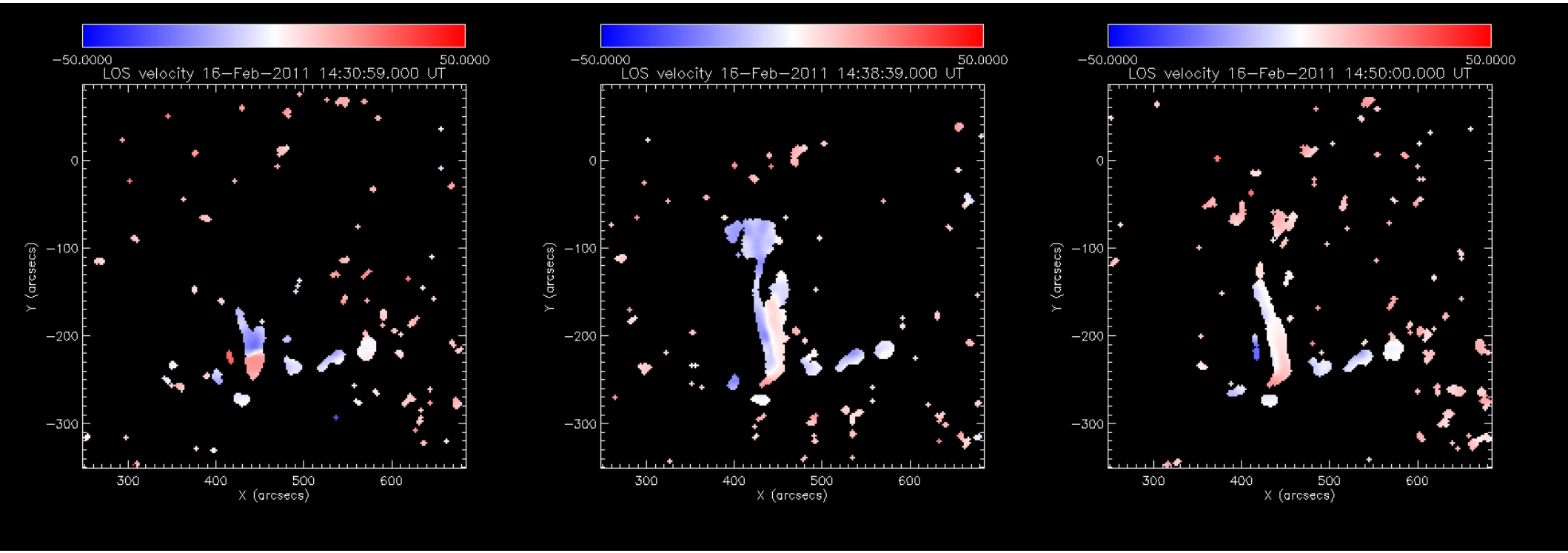
Hα + 0.8Å

Velocity vectors

The tangential velocity is obtained by tracing the motion of the internal structures on the successive images.

Line of Sight Velocity

(Study of the characteristics of filament eruption)

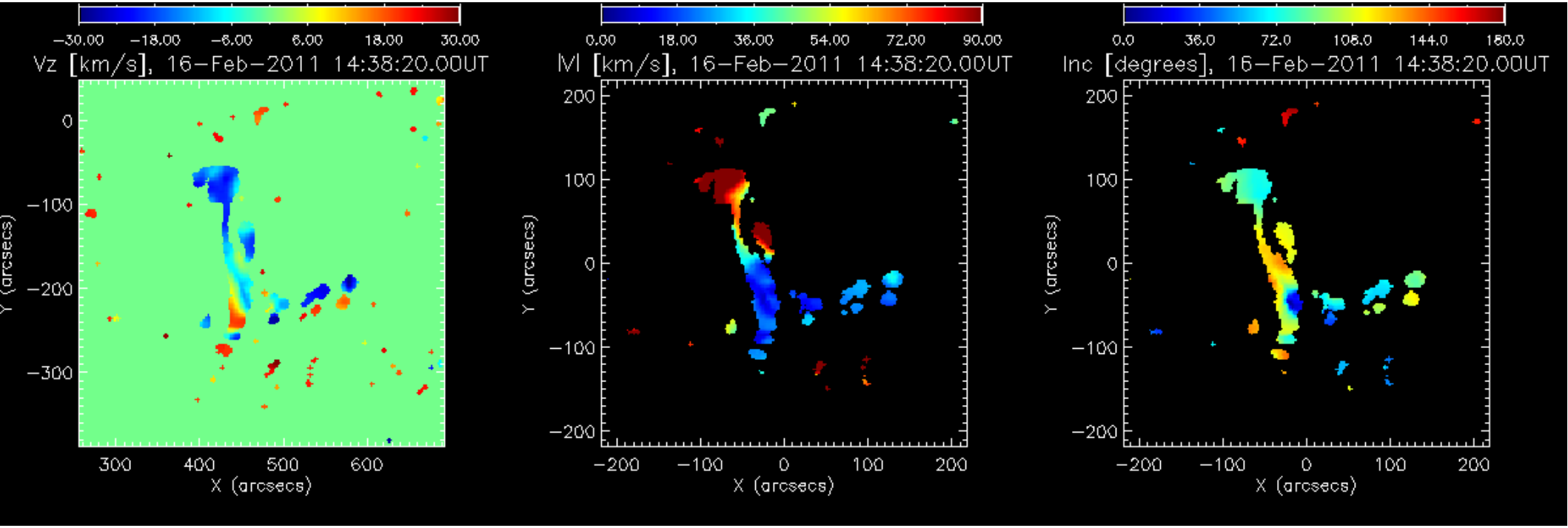


14:30:59UT 14:38:39UT 14:50:00UT

- The line of sight velocity was obtained by calculating the H-alpha profile of the filament.
- By measuring the Doppler shift considering the temporal variation of the contrast.

3 Dimensional Velocity

(Study of the characteristics of filament eruption)



Velocity field (Vz)
(Doppler Velocity)
[Km/sec]

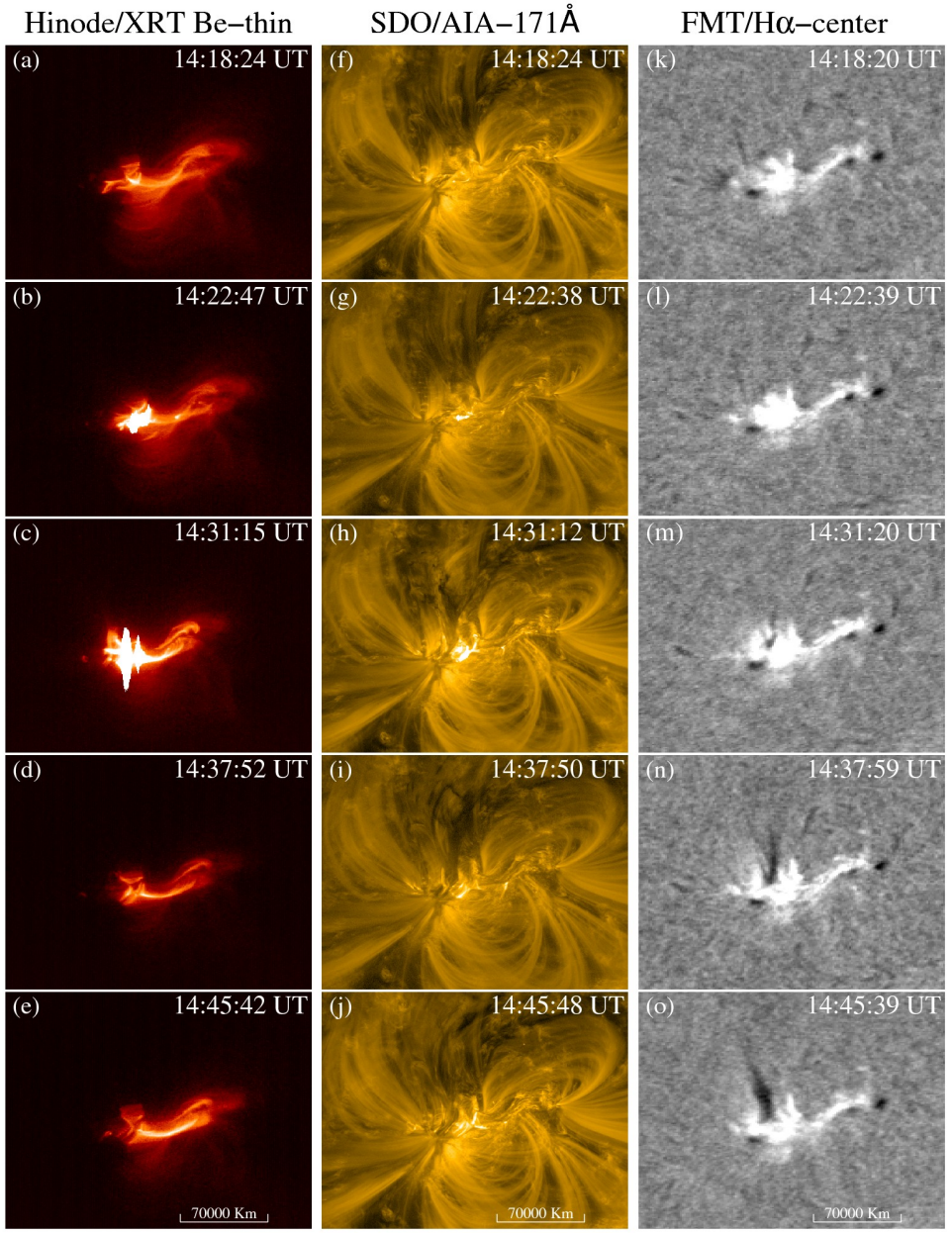
Absolute velocity |V|
[Km/sec]

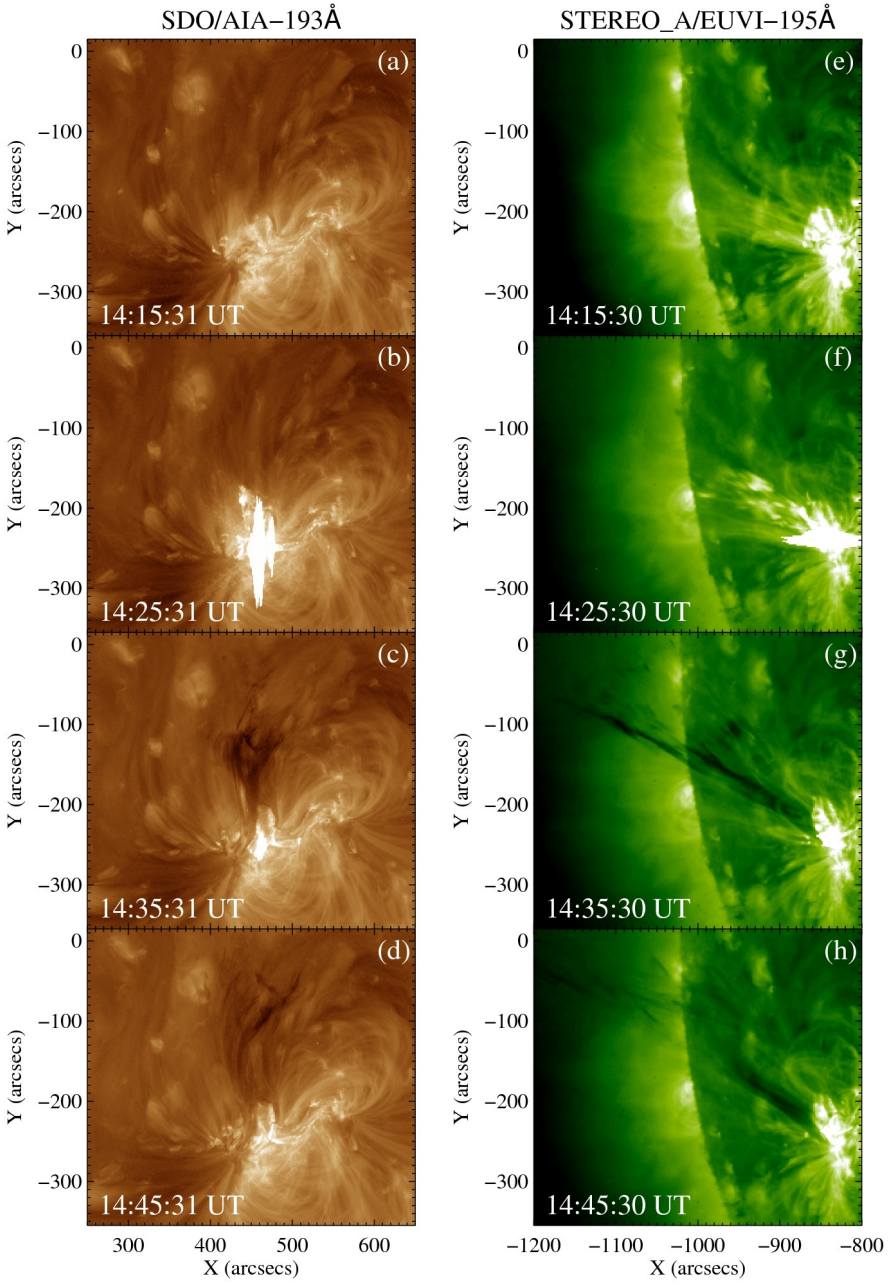
Inclination
(0 – 180 degrees)
0^0 is to observer

- The angle of the eruption is ~ 32 degree. In this case, possibly the Moreton wave appearance is not so large.

Temporal Evolution of Ejecta and Filament

(HINODE:XRT, FMT:H-alpha, SDO/AIA:EUV, STEREO/SECCHI: EUVI)



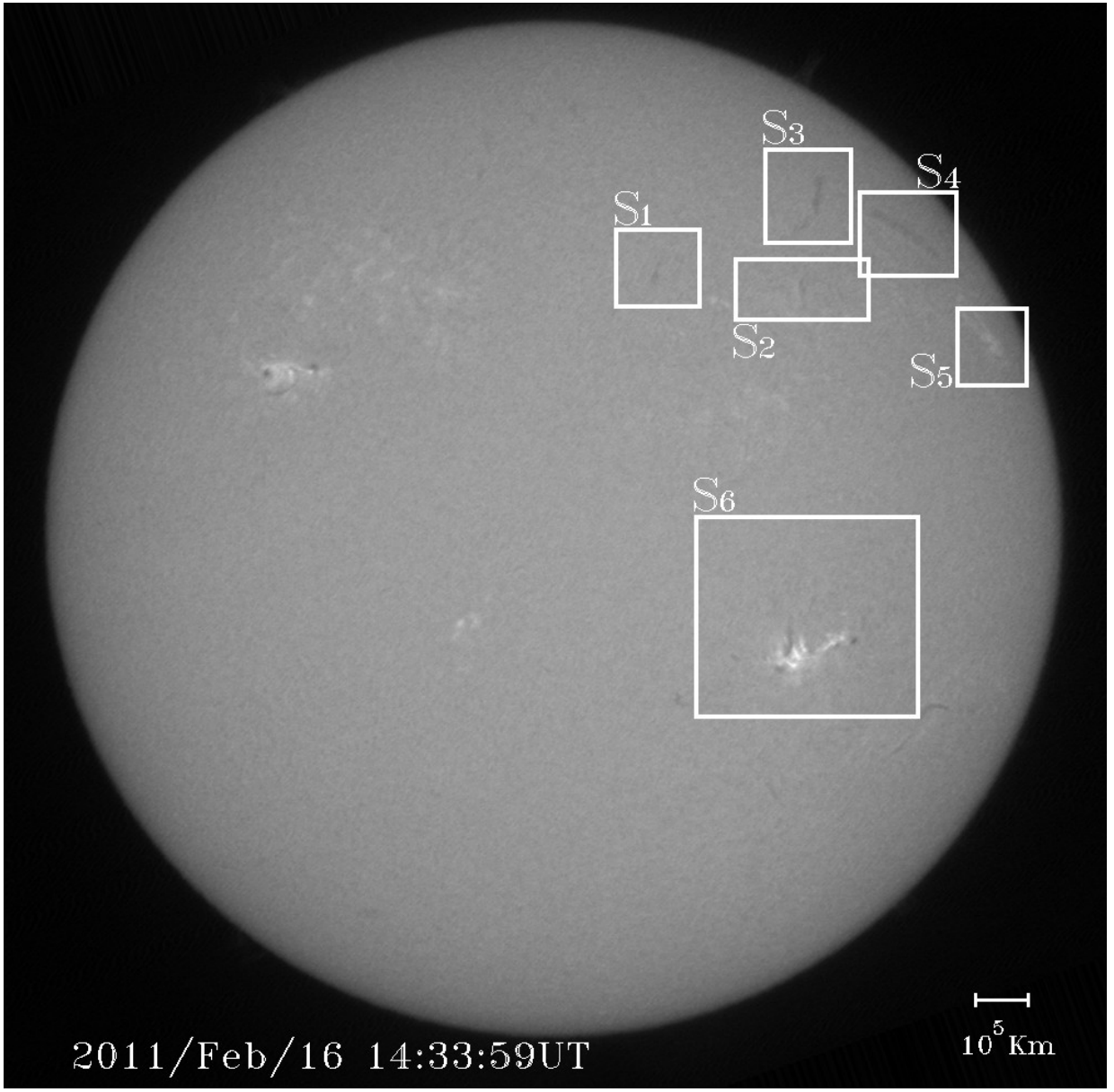


Investigation of Extreme Ultra-Violet (EUV) Wave and Filaments Oscillation

(2011 Feb. 16th Flare)

Filaments Oscillation

Area Map (S1~S5: Dark Filaments, S6:Flare site)



- Solar flares are sometimes associated with Moreton waves and we often observe “winking” filaments triggered by the wave fronts.
- We observed that only the dark filaments in S2 and S5 had a “winking” motion.
- In the 2011 Feb. 16 flare, we did not observe Moreton waves but wave-like features observed in EUV would have a relation with the “winking” filaments.

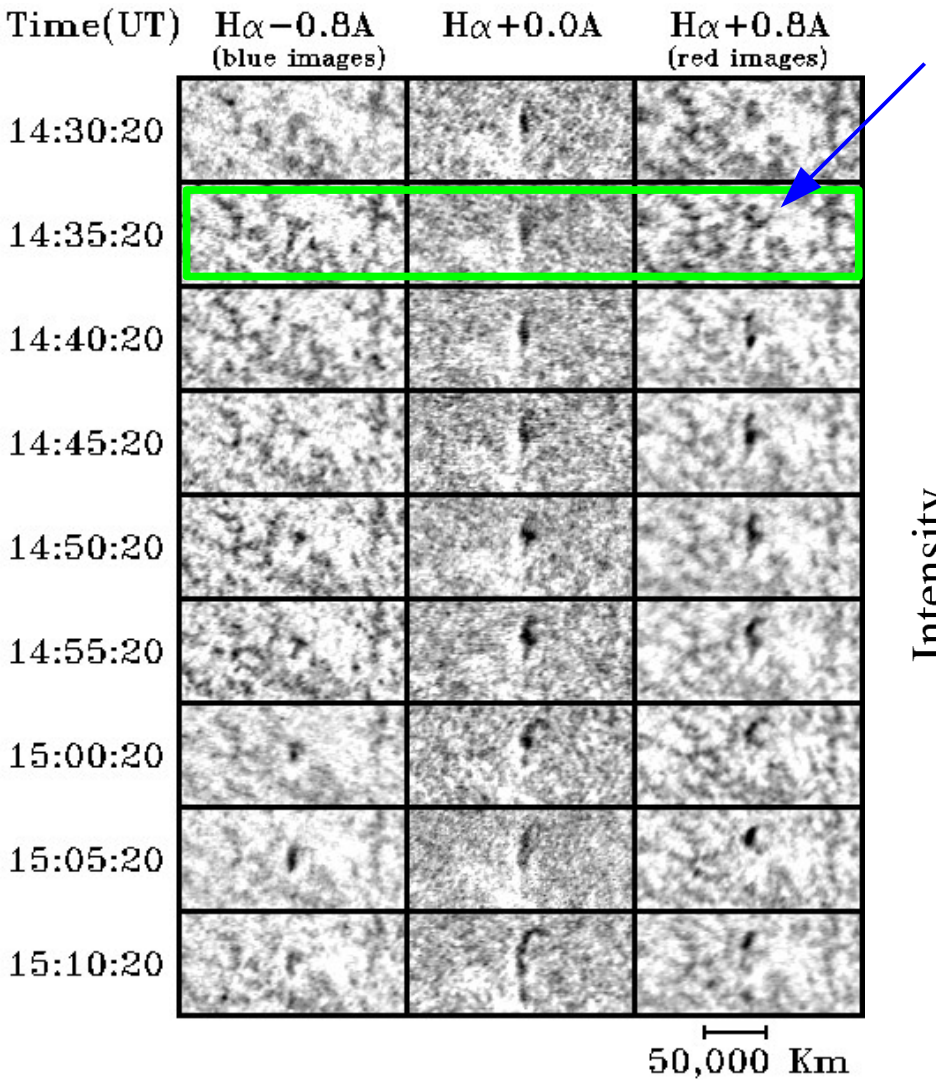
Winking Filament

(2011 Feb. 16 Flare)

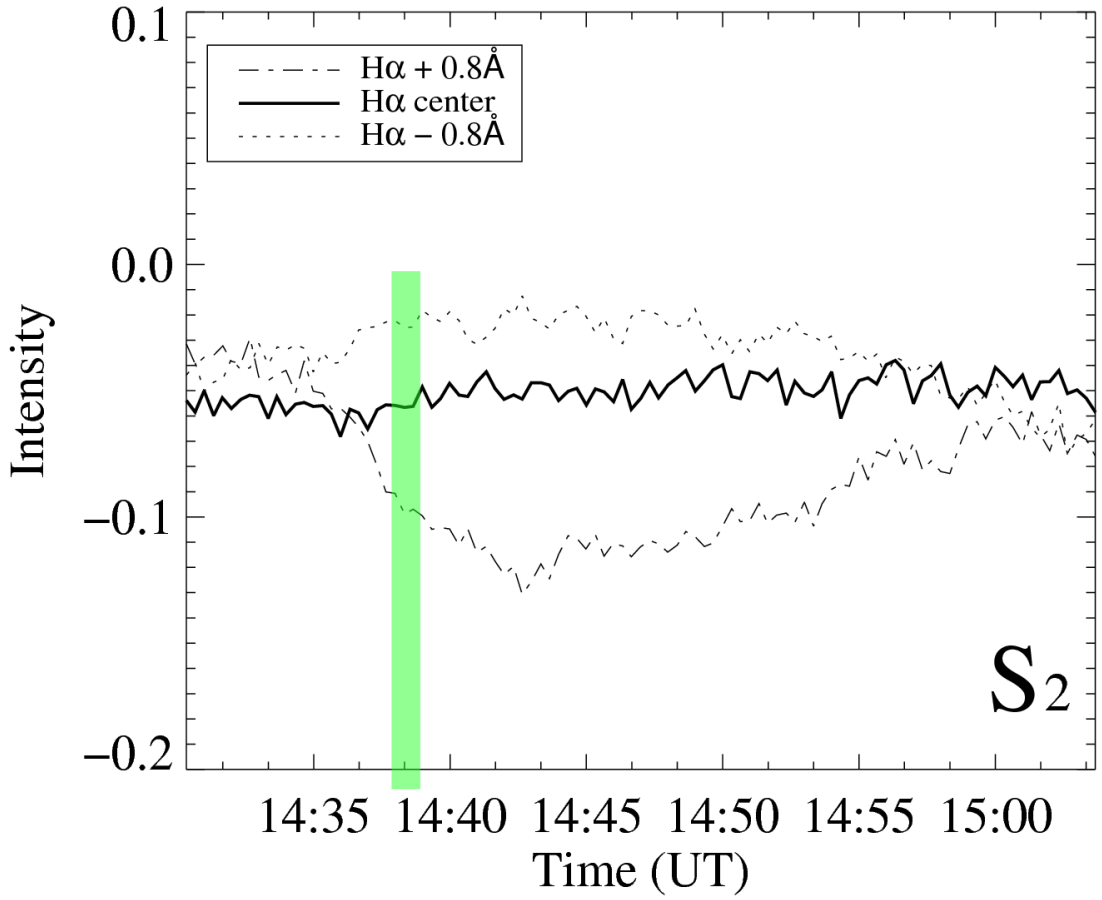
Blue wing (Hα – 0.8Å) Hα + 0.0Å Red wing (Hα + 0.8Å)

Winking Motion of the Filament in "S2" Region

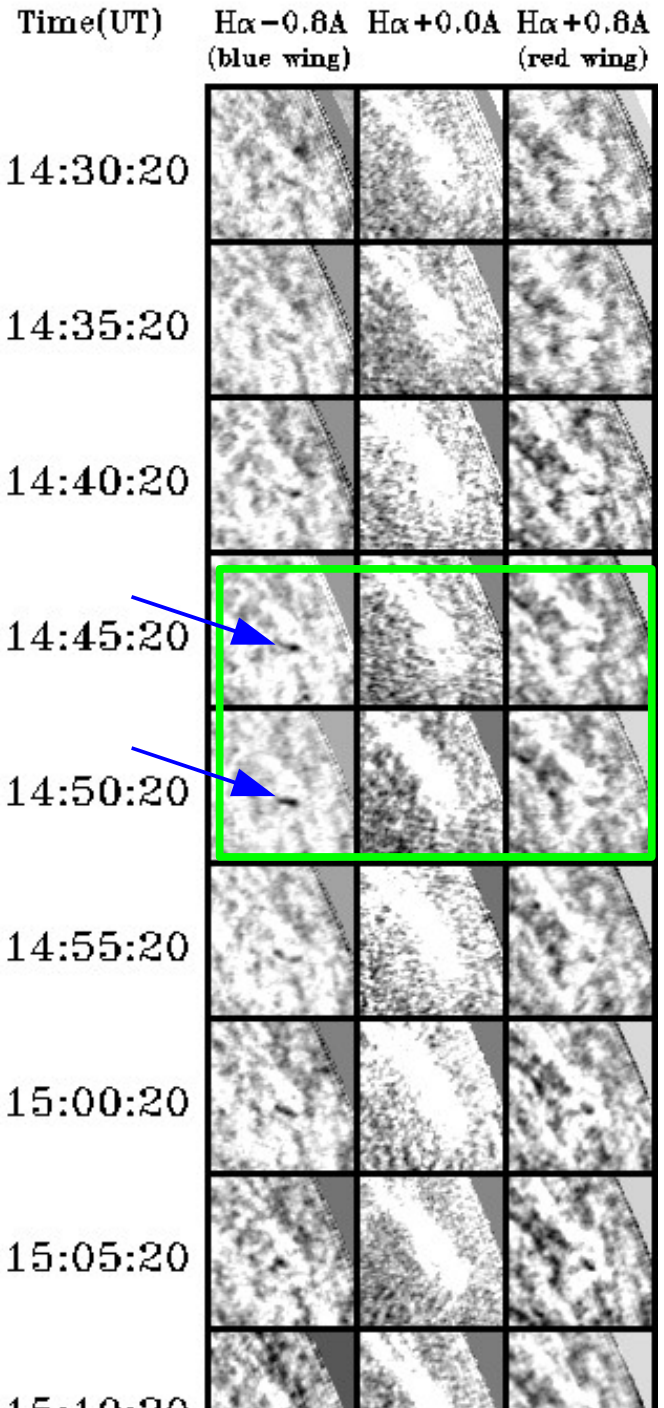
- ***Left panel***: temporal evolution of the filament (S2) in the three wavelengths.
- ***Right panel***: light curve of the filament in the three wavelengths.



➧ At 14:35:20UT the filament starts to appear in red wing.

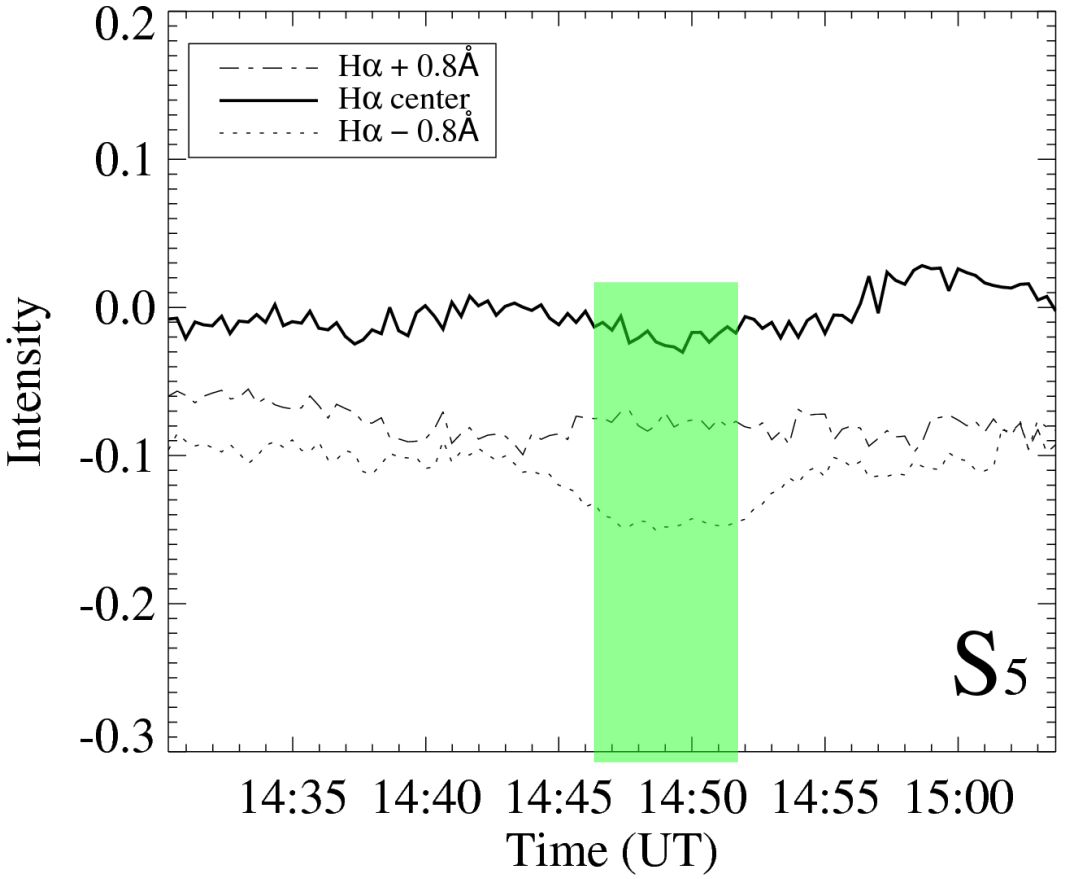


Winking Motion of the Filament in “S5” Region



- ***Left panel***: temporal evolution of the filament (S5) in the three wavelengths.
- ***Right panel***: light curve of the filament in the three wavelengths.

➧ From 14:45UT to 14:50UT the dark feature is evident.



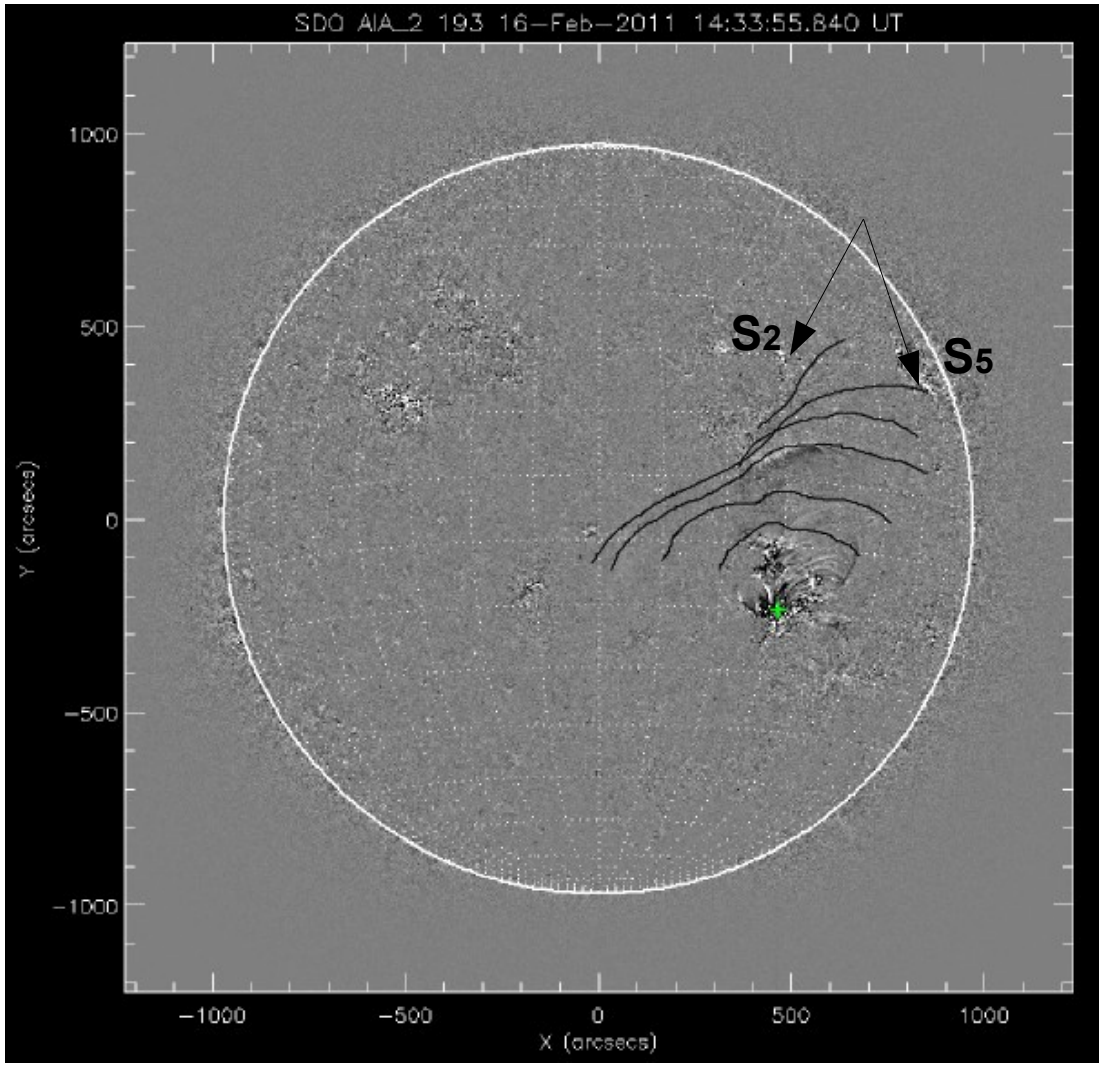
Running Difference Movie SDO/AIA

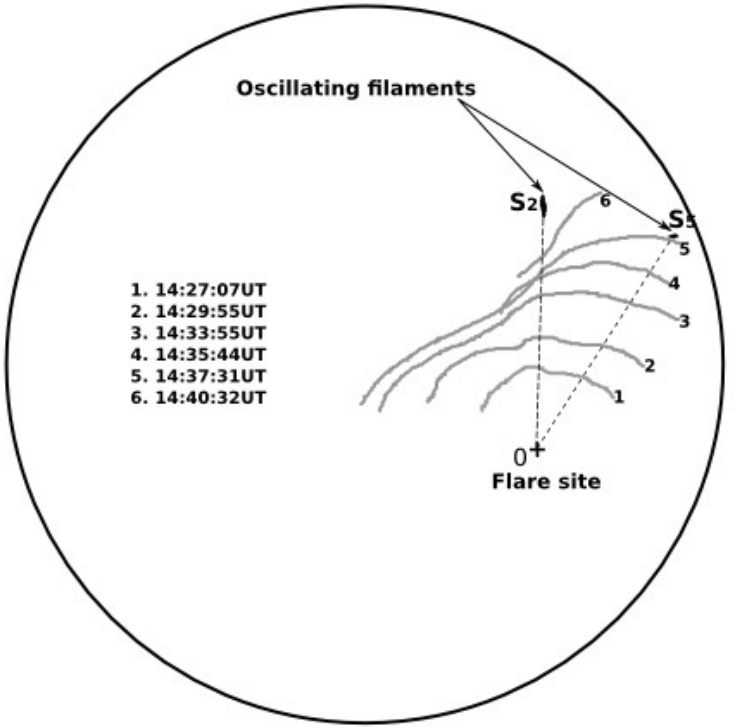
- Propagation of the EUV wave observed by SDO/AIA 193Å on **2011 February 16**. Solar north is up and the west to the right.
- We derive the propagation speed by following the wave fronts. The *mean* propagating speed is about ~ 600 km s^{-1}.

EUV Wave Fronts

• ***Left panel:*** SDO/AIA-193Å difference image. ***Right panel:*** The light gray solid lines are the wave-fronts propagating in north direction.

• According the wave-front sequences, first a weak wave reach to the 'S5' region at 14:37UT, and later a refracted wave reach to the 'S2' region around 14:40UT.

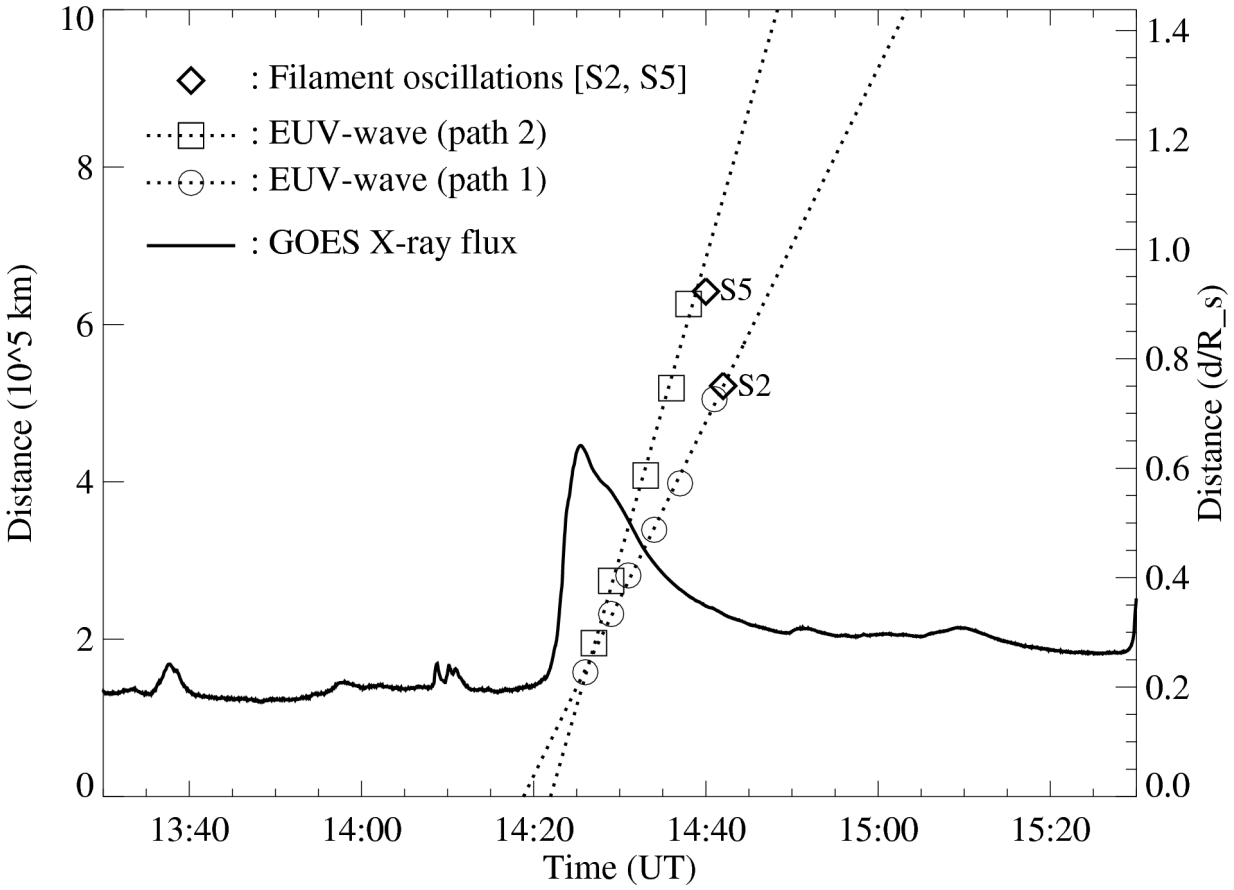




Time-Distance Plot

(EUV Waves and Oscillating Filaments)

- Time evolution of the distance of the EUV, oscillating filaments (S2, S5) and GOES X-ray flux data at the 1 – 8Å channel (solid line). 'R_s' is the solar radius (~695 800Km).
- According the plot-figure the distance of 'S5' is greater than the distance 'S2' from the flare site, moreover the filament in 'S5' starts to oscillate before than in the 'S2'. In both cases the speed EUV waves is about ~640 km s^{-1} and ~380 km s^{-1} respectively.



Summary and Conclusion

- We investigated 3D velocity field of the filament eruption of the 2011 Feb. 16th flare. The angle of the eruption from the solar surface was about ~ 32 degree.
- We did not observe a Moreton wave, but EUV waves were observed by SDO/AIA 193Å. Moreover we identify oscillation of the two dark filaments far from the flare site in H-alpha data taken by the FMT.
- The activation/oscillation of the filaments and the EUV wave fronts are consistent at the time. We expect a coronal wave with the velocity about 600 - 800km s^{-1} to trigger the filaments.

Acknowledgement

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- Quito Astronomical Observatory, National Polytechnic School of Ecuador.
- Kwasan and Hida Observatories, Kyoto University, Japan.