Temporal evolution of arch filaments as seen in He I 10830 Å

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AISAS, AIP, UP, IAC, MPS, and SSR

EST SCIENCE MEETING, Giardini Naxos. 12 June 2018

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 739500"

Observations

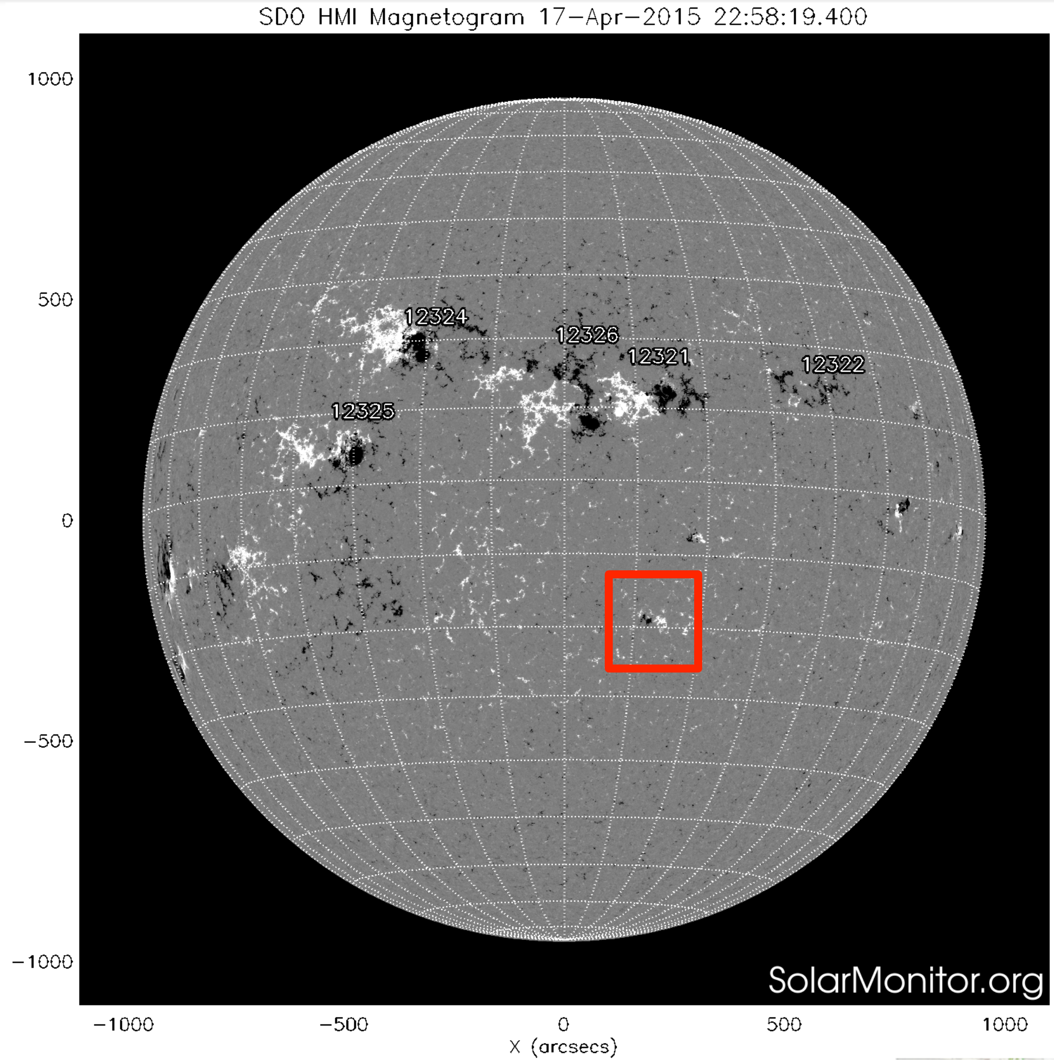
- 8:16 UT on 17 April 2015
- Two small pores
- Coordinates:
  x = 64” y = - 232”
- μ = 0.97
- Observed spectral lines:

GRIS:

Si I 1082.7 nm

He I 1083.0 nm

Ca I 1083.9 nm



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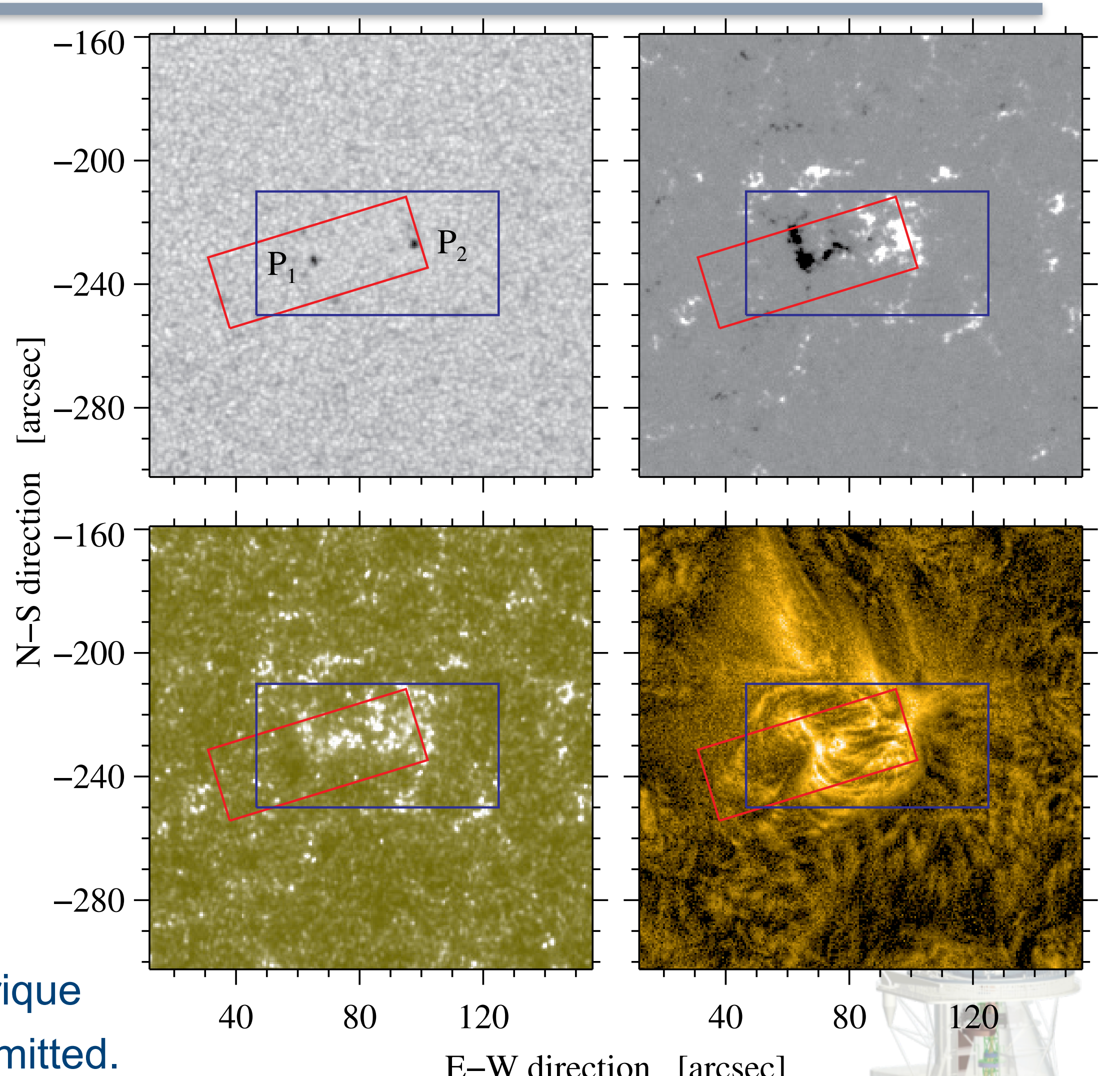

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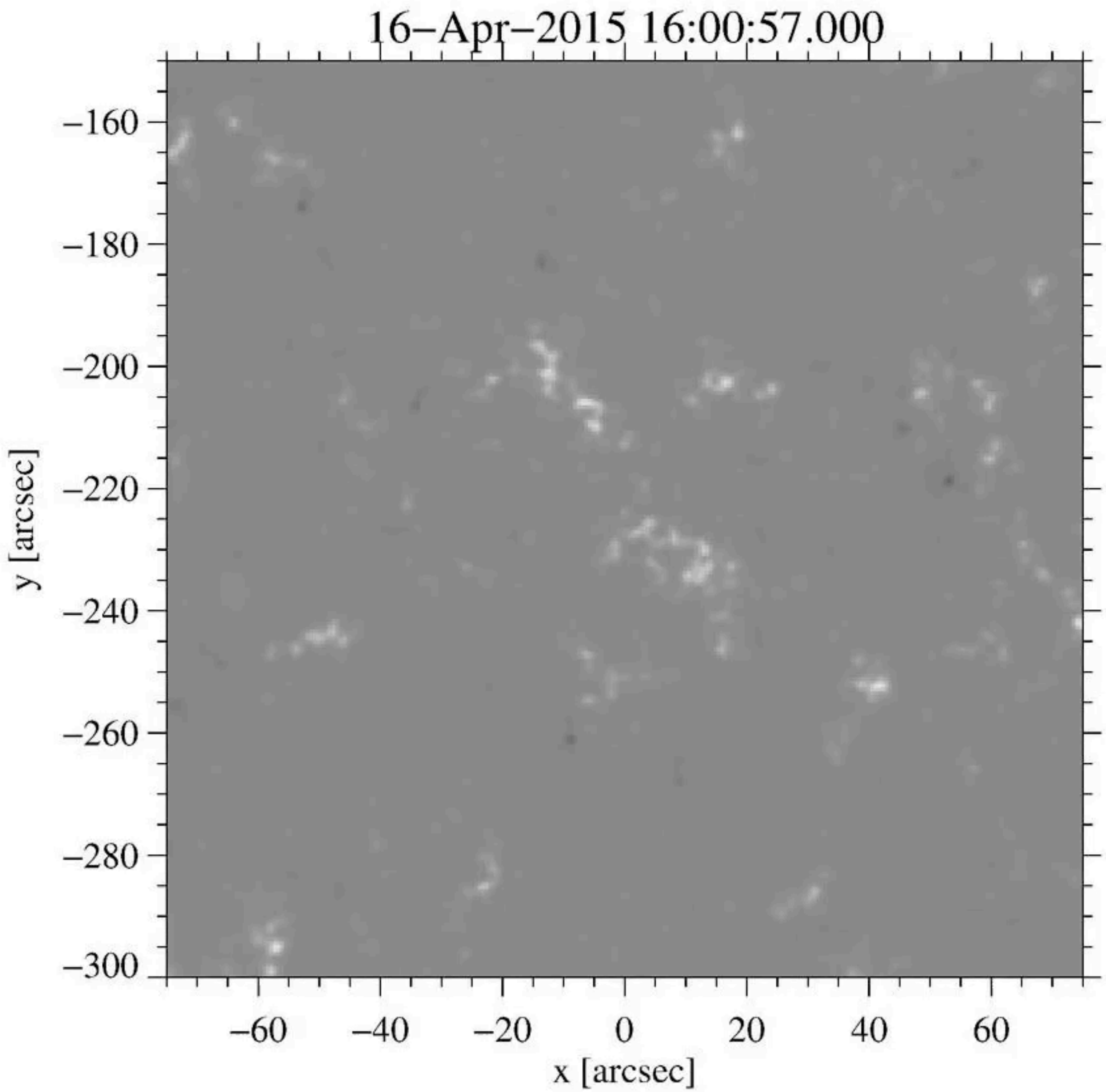

Line-of-sight magnetograms SDO/HMI

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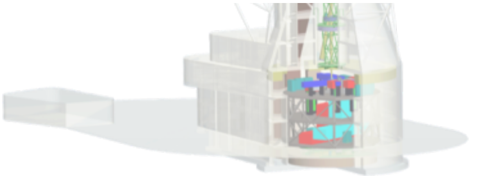

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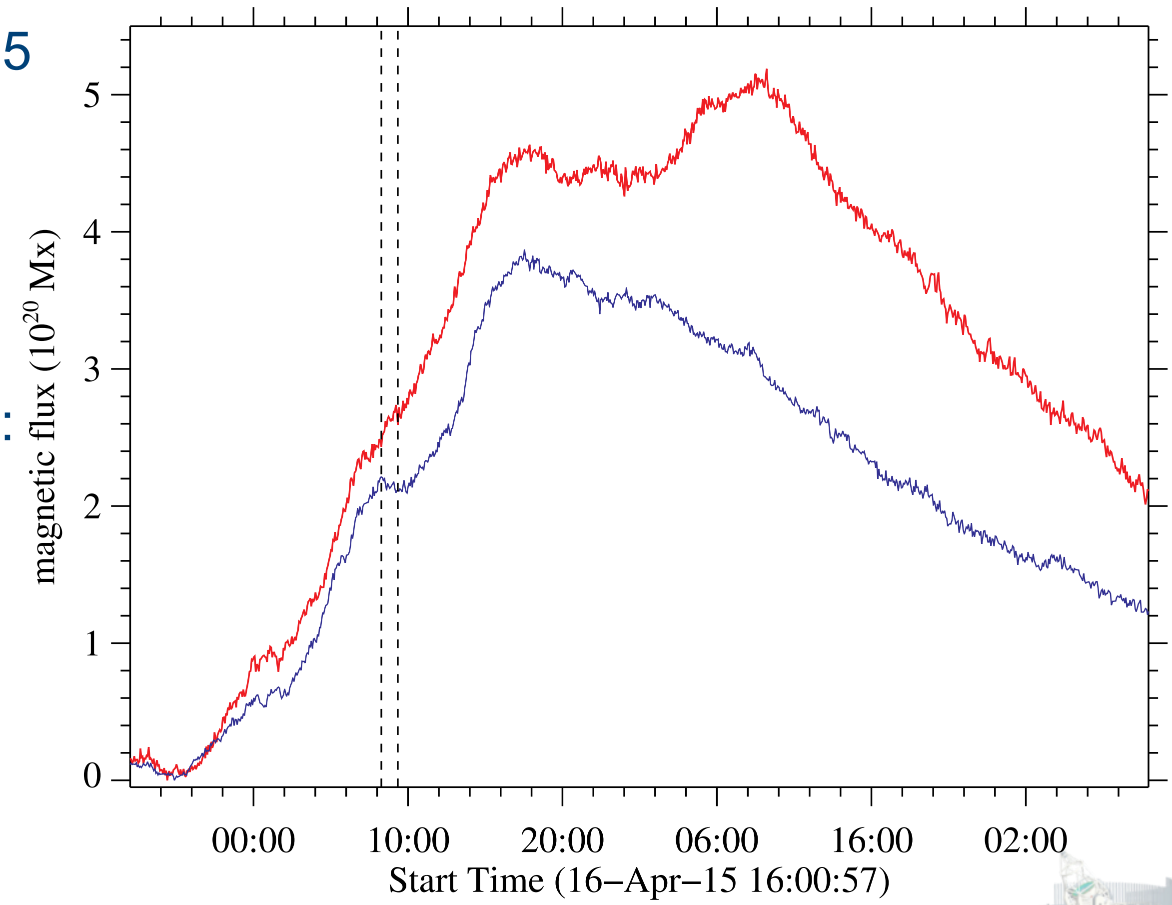

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- Start observations:
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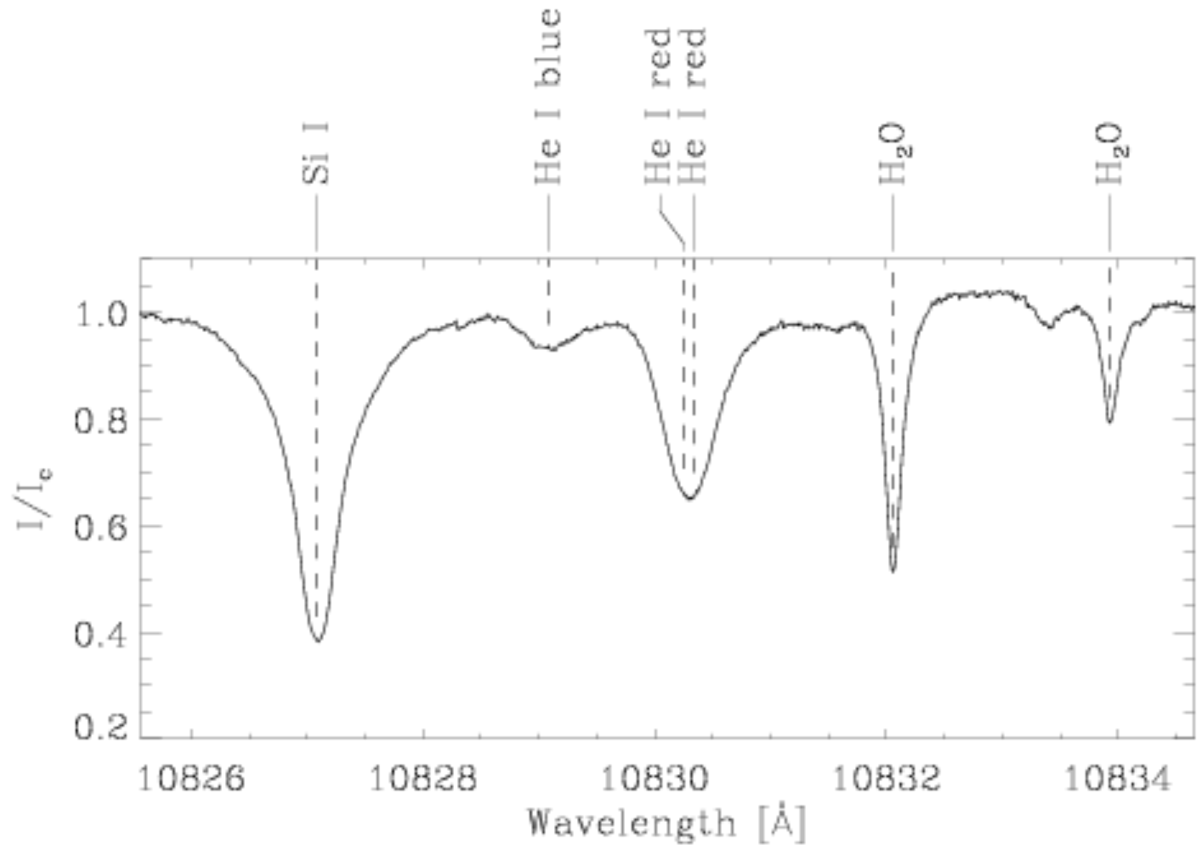
- **Very fast spectroscopic mode**
- Spectral region: 1083.0 nm
- Photospheric Si I and chromospheric He I spectra among others
- Steps: 180
- Stepsize: 0.134”
- Pixel size: 0.137” along the slit
- Integration time: 100 ms
- 65 maps
- Cadence: 58 s



Kuckein et al. (2012b)

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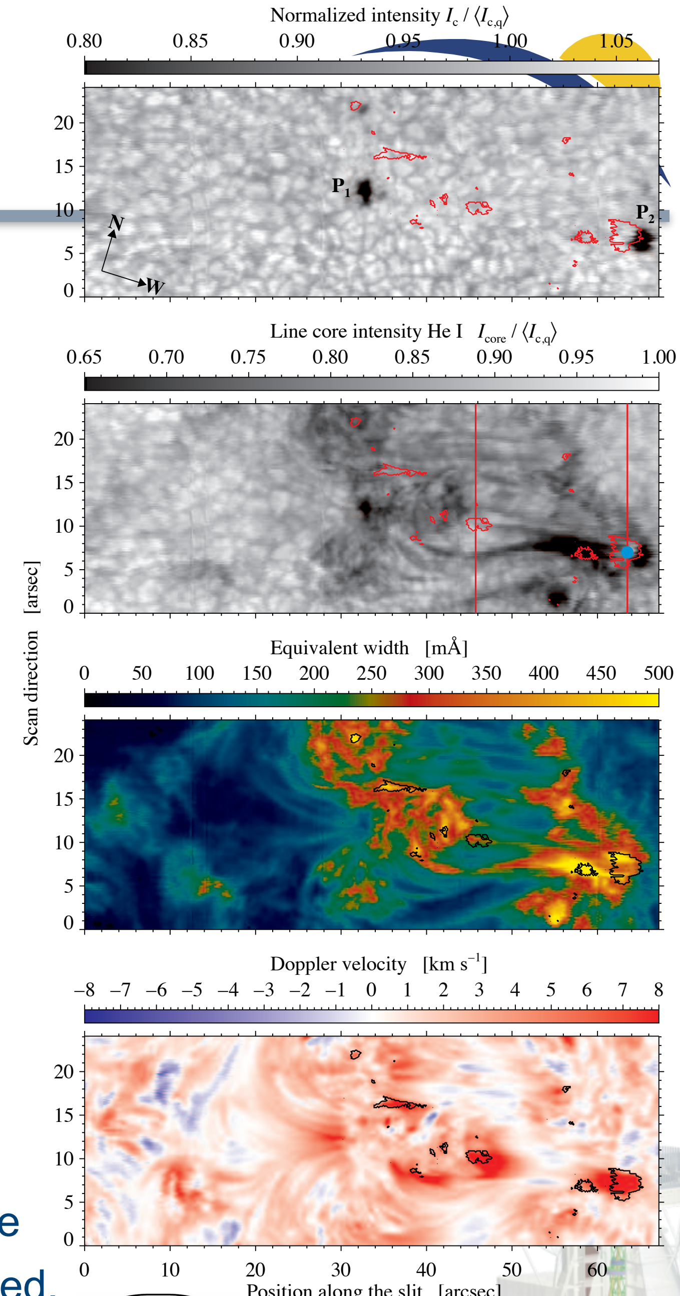

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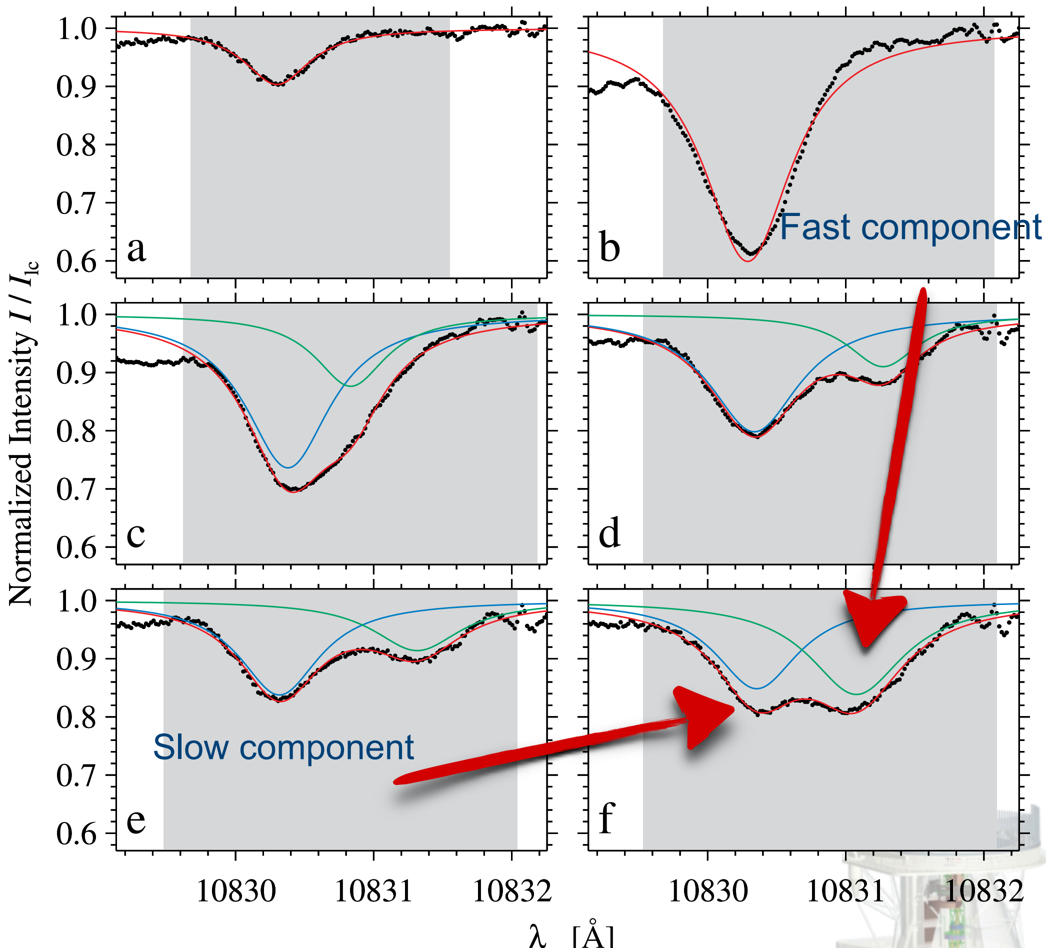
Fitting spectral profiles in He I 1083.0 nm

- Two atmospheric components located within the same resolution element (Lagg et al., 2007)
- Two or more peaks next to the red component of He I (e.g., Sasso et al., 2011, 2007)
- Slow component often subsonic
- Fast component reaches supersonic velocities
- Dual-flow components reported in different phenomena. For example, flares (Teriaca et al., 2003), (Sasso et al., 2011, 2007), emerging flux process (Lagg et al., 2007), pores, etc.
- Typical velocity range 40 – 90 km/s

González Manrique et al. (2016)



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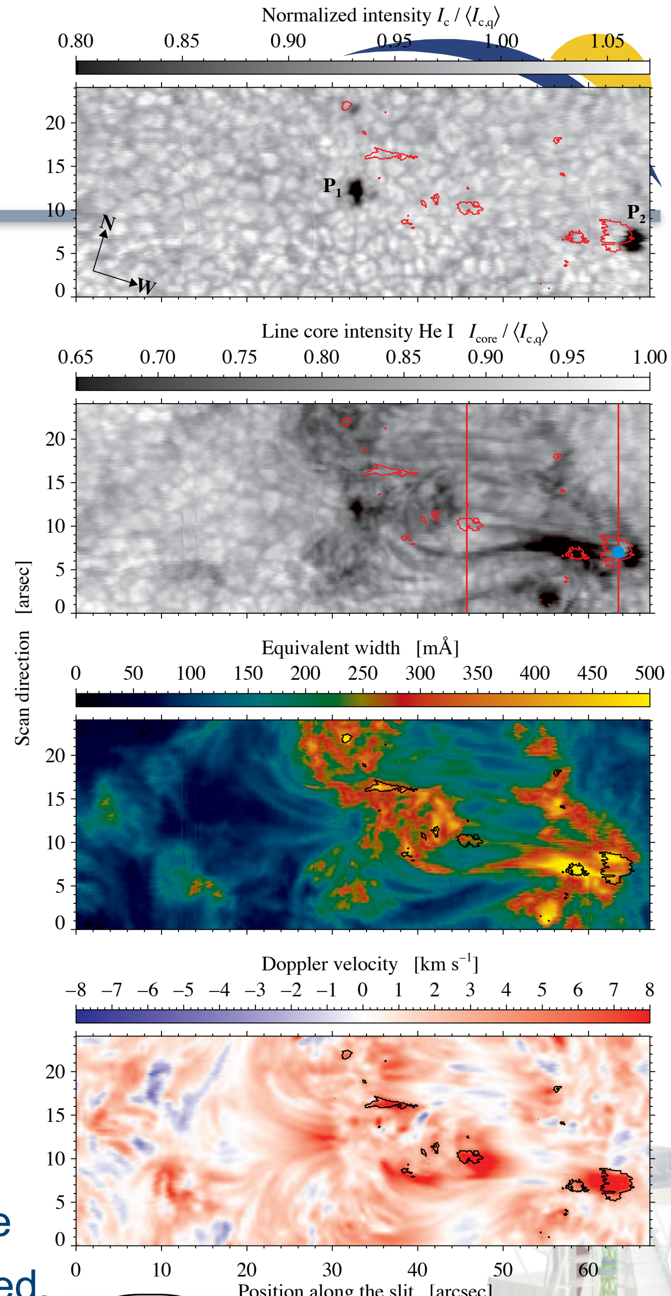
Supersonic downflows near the leading pore

- The blue filled circle near the leading pore (second panel from top) refers to the location of strong downflows
- It is used to calculate average profiles and LOS velocities
- 69 spectra located inside the blue circle with a diameter of 1.4”



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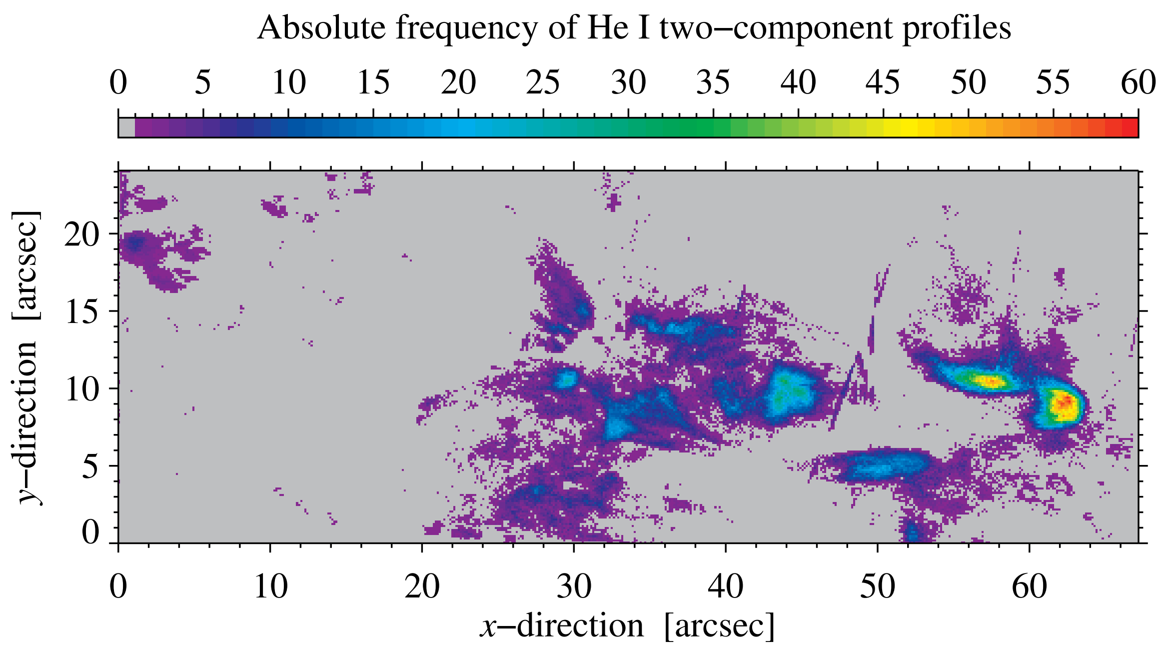
Supersonic downflows near the leading pore

- Frequency of occurrence of dual-flow profiles during the observing period
- The colour bar represents the number of maps in which dual flows are present at a particular location
- Gray areas refer to regions where dual-flow profiles are absent
- Red colours indicate that in more than 60 maps the dual-flow profiles are present at the same location throughout the time-series



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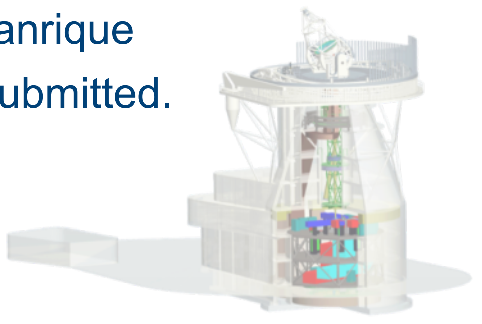

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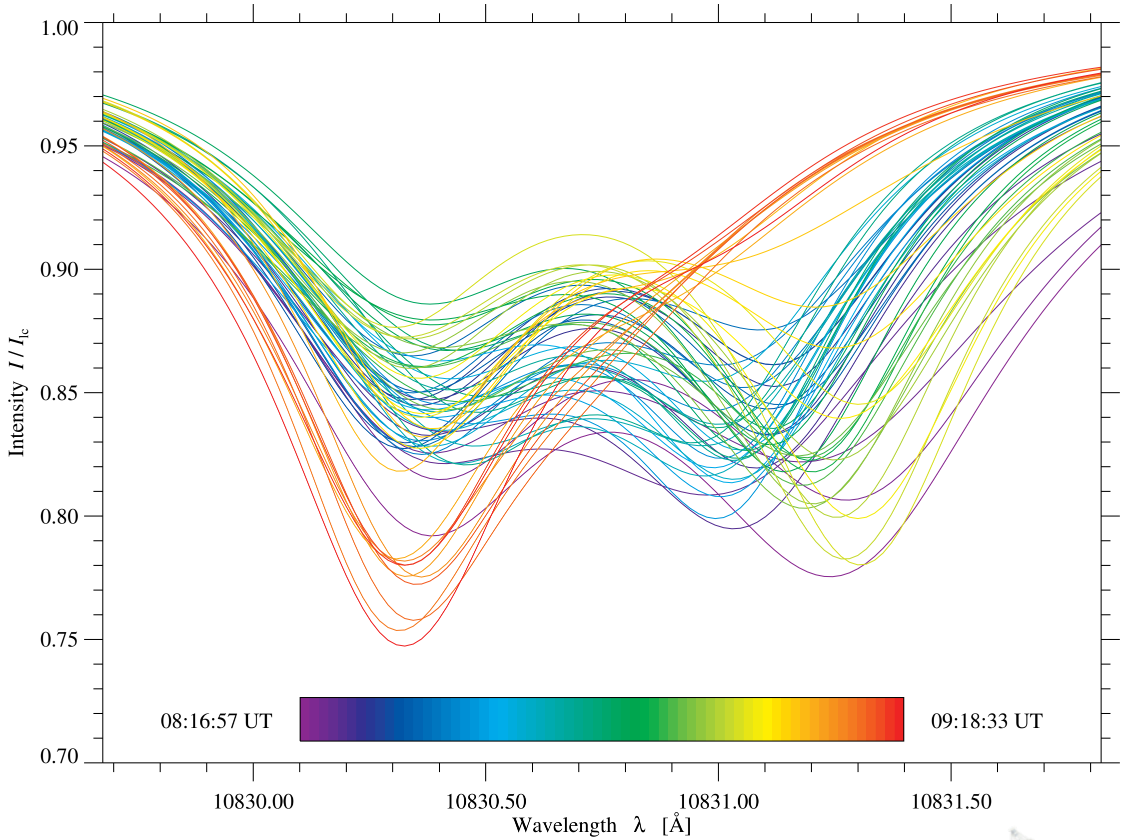
Supersonic downflows near the leading pore

- The profiles correspond to an average of 69 which are located inside the blue
- At the beginning of the time series, the slow and fast components had their minima well separated
- In the first 25 minutes of the times series the average values of the Doppler velocities fluctuated in the range of 7 – 17 km s^{-1}
- After 25 minutes, the minima of the two components are no longer well separated and the intensity profile of the fast component becomes deeper
- 08:41 UT the mean Doppler velocities increased, reaching a maximum of about 23 km s^{-1}
- The profiles change suddenly into single-component profiles. Doppler velocities drop drastically to 2 – 4 kms^{-1}



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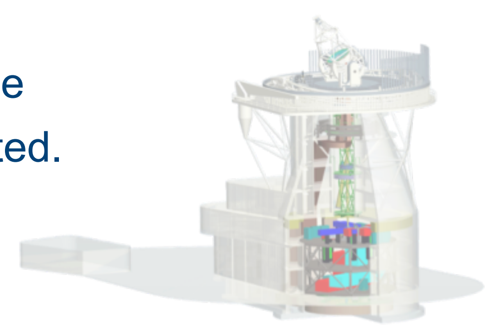

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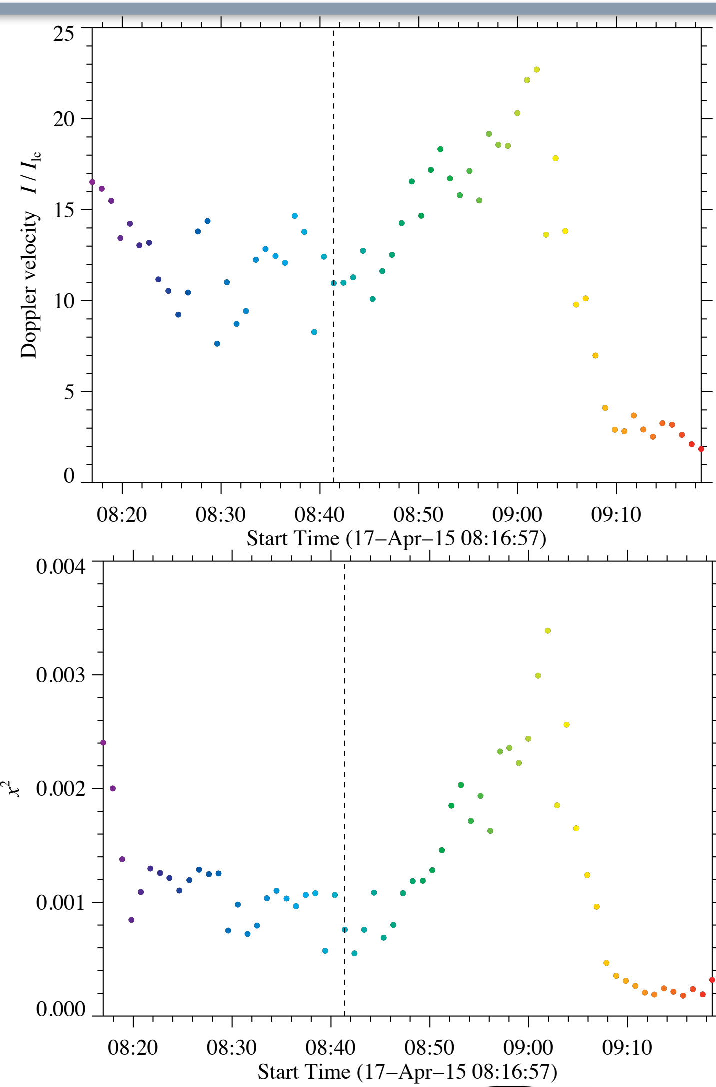

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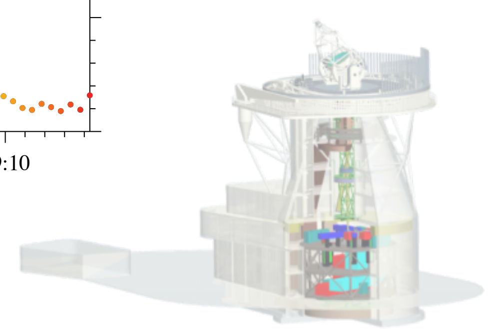

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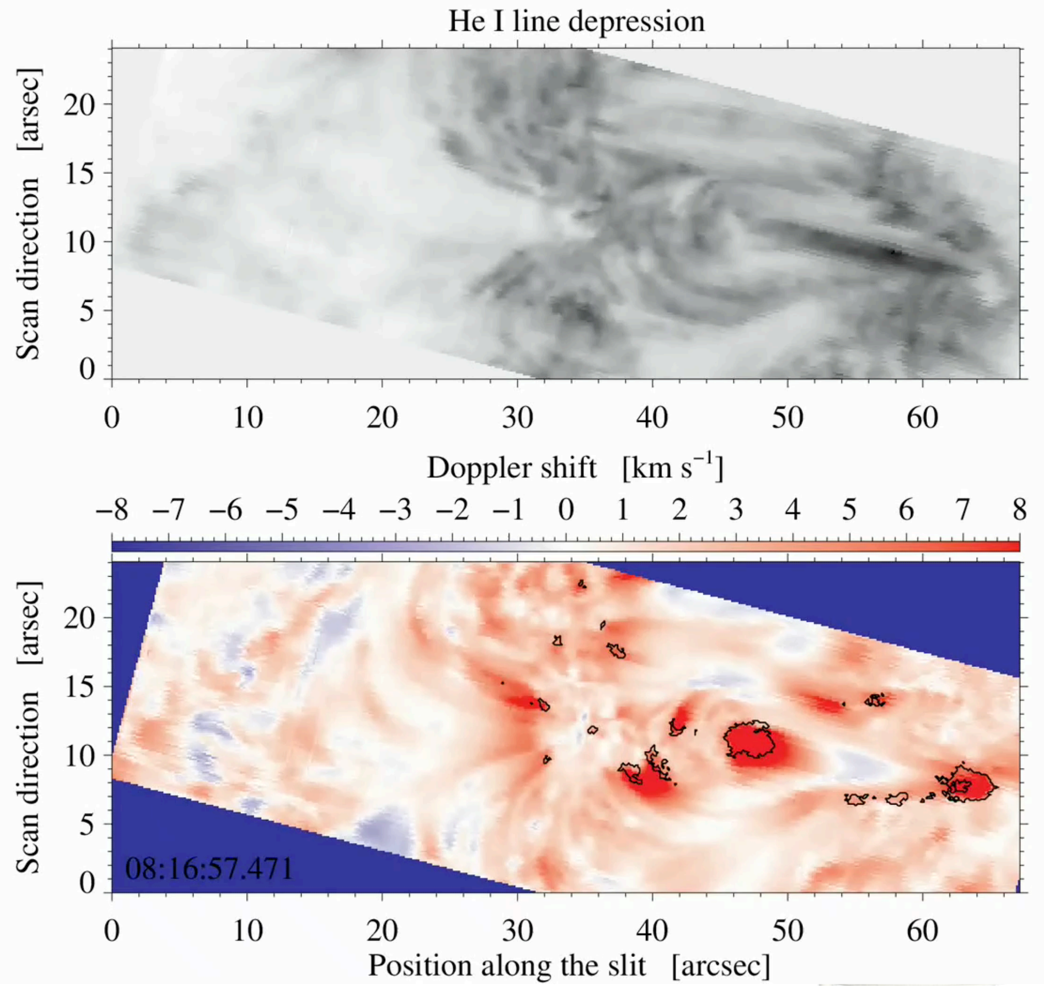
Temporal evolution of an arch filament system

- One-hour evolution of the EFR
- The He I line-core intensity maps show an AFS connecting two opposite polarities.
- The contours encompass only clearly discernible dual-flow components in the He I profiles.



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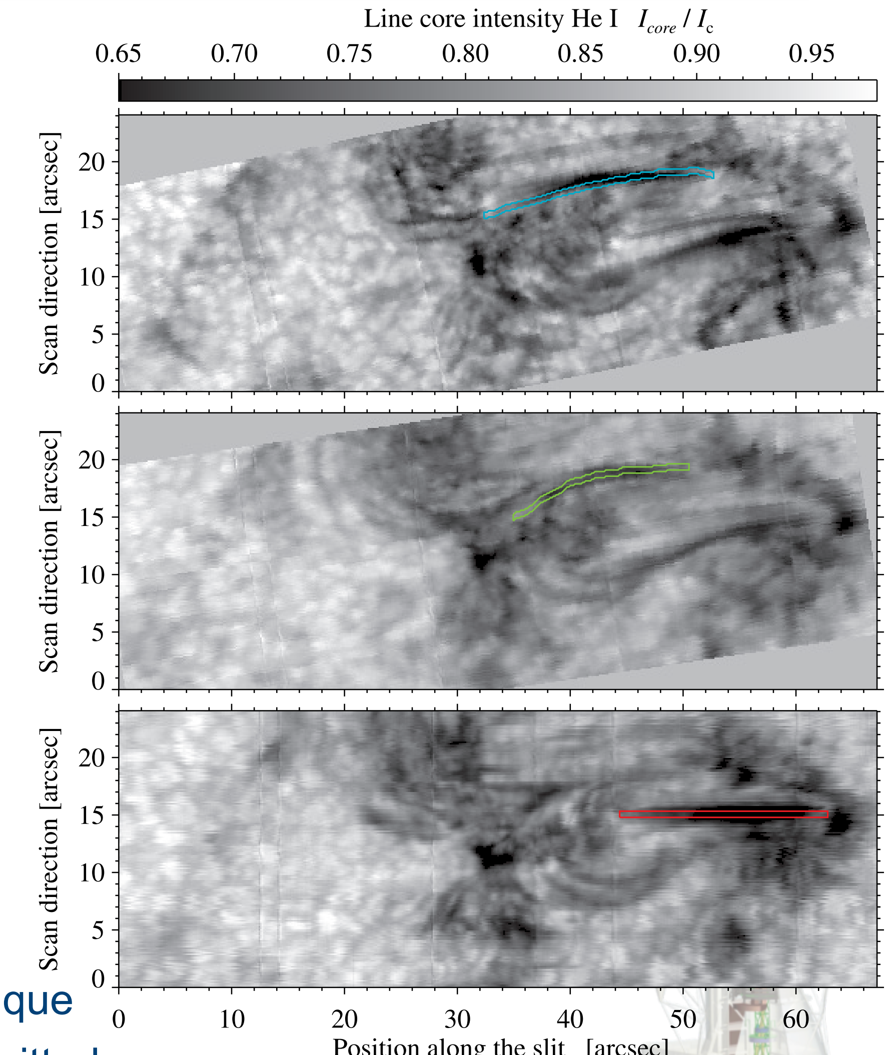
Temporal evolution of an arch filament system

- Mean velocities of arch filaments
- Mean velocities of five pixels within a column
- Upflows at the loop-tops of the arch filaments
- Reaching chromospheric heights, the magnetic loops become visible in Hα, He I, and Ca II. Material gradually drains from the loops to the footpoints
- Supersonic downflows at the footpoints



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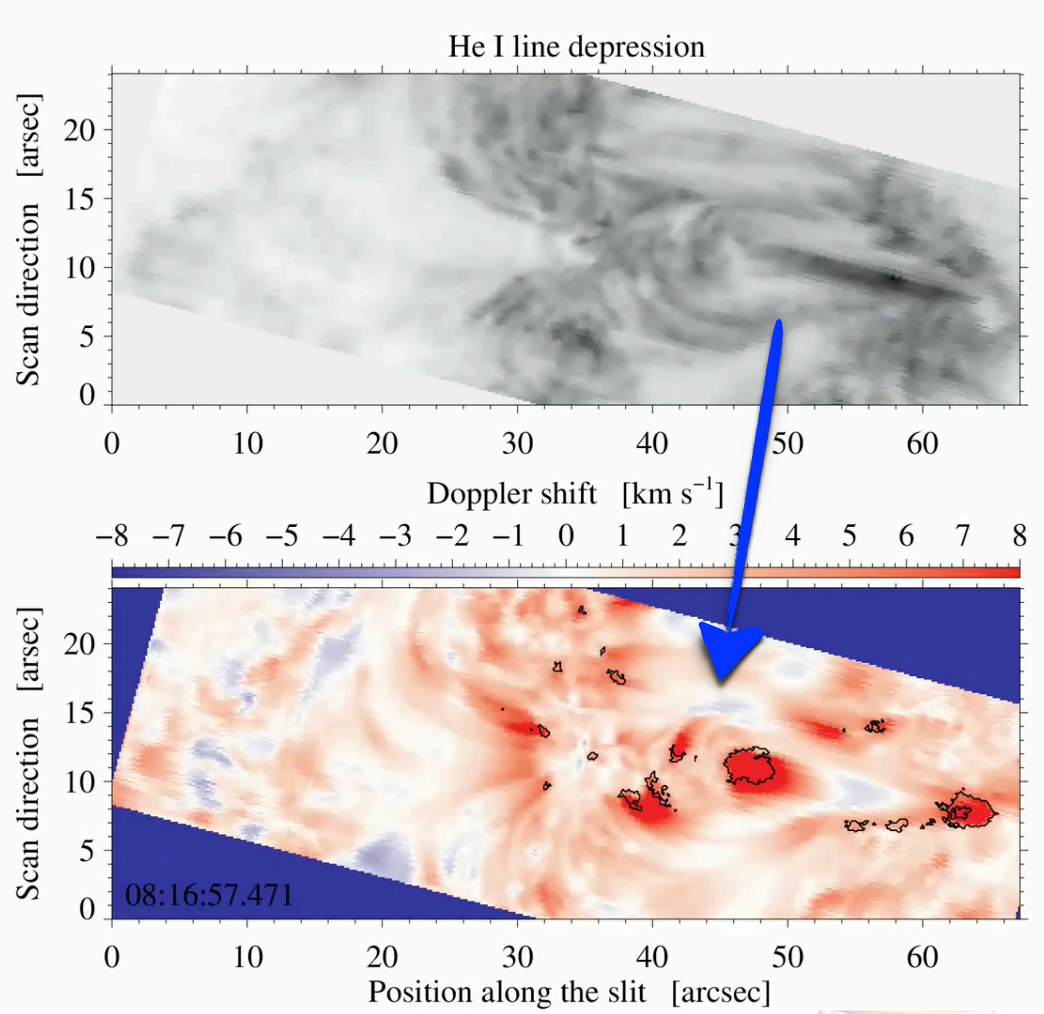
Temporal evolution of an arch filament system

- Temporal evolution of one arch filament
- Life-time of the arch filament is about 25-30 min
- Initially the velocities are near 0 km/s at the loop-tops and there are small downflows at the footpoints.
- With time the loop-tops present high upflows and supersonic downflows at the footpoints.
- The distance increase with time
- Near the end the velocities approach zero in the whole arch filament



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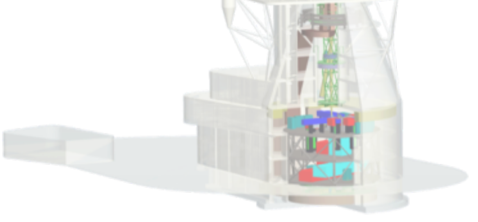

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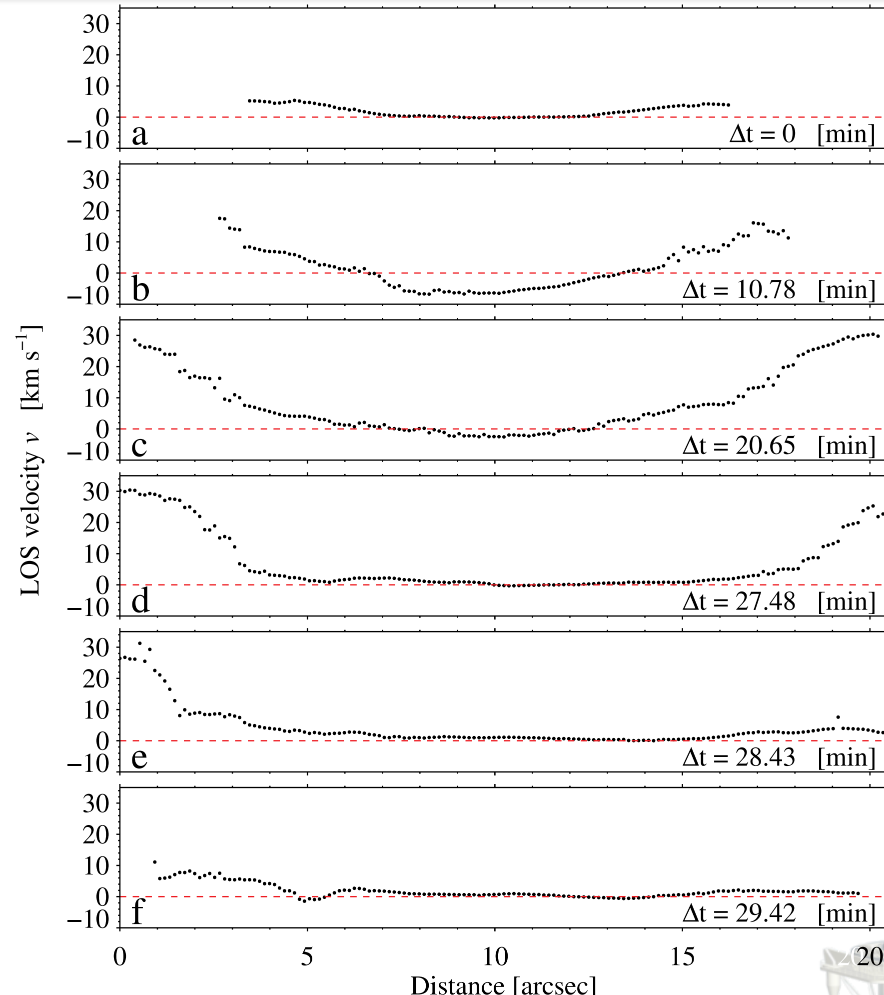

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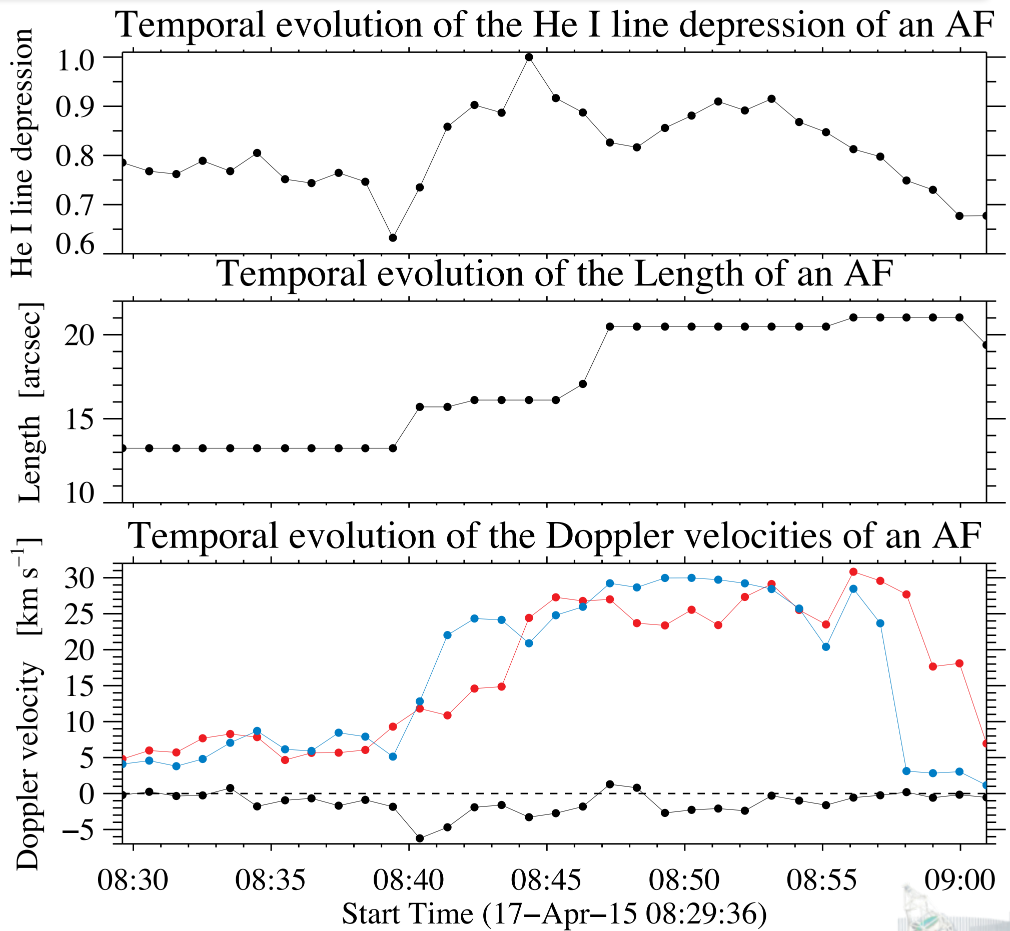
Temporal evolution of an arch filament system

- Temporal evolution of the normalized mean He I line depression of the whole arch filament (upper panel).
- Temporal evolution of the length of the individual arch filament (middle panel).
- Temporal evolution of the mean Doppler velocities of the individual arch filament (lower panel).
- The Doppler velocities were calculated based on either single- or dual-flow components. The black bullets represent the mean Doppler velocities at the loop top and the blue and red bullets indicate the mean Doppler velocities at the left and right footpoints, respectively.



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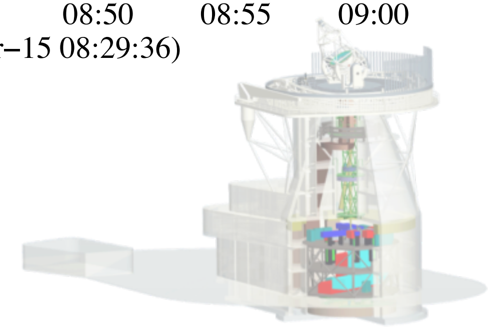

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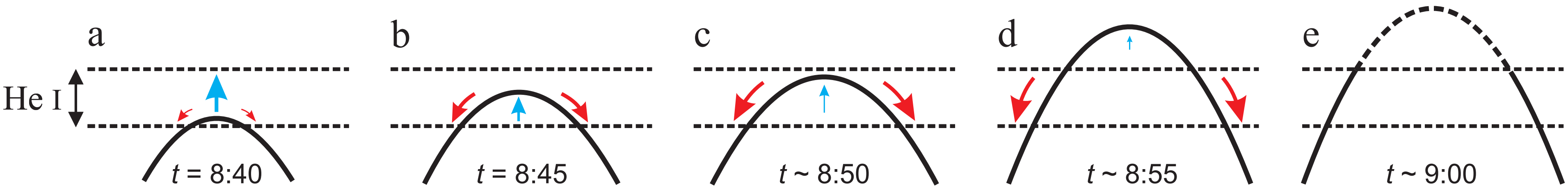
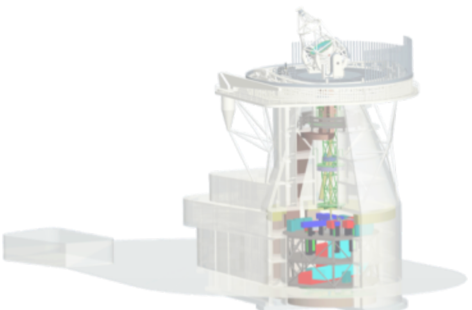


- Cartoon of the evolution of an individual arch filament (from “a” to “e”)
- The cartoon only represents the evolution seen in the He ı
- Arrows in blue and red mark the direction of the plasma flows as observed in the He ı triplet, respectively. The stronger the downflows (red), the thicker the arrow. The He i layer lies between the two dashed lines



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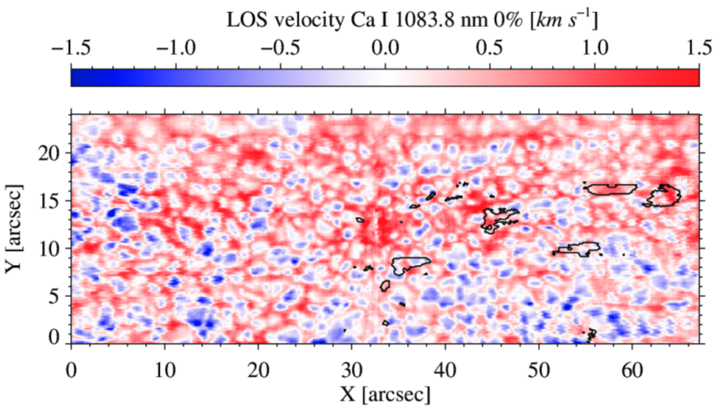
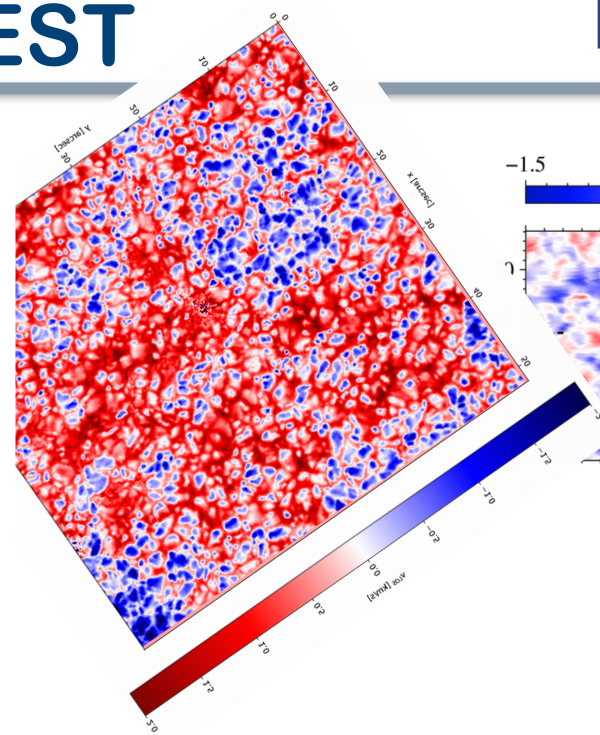
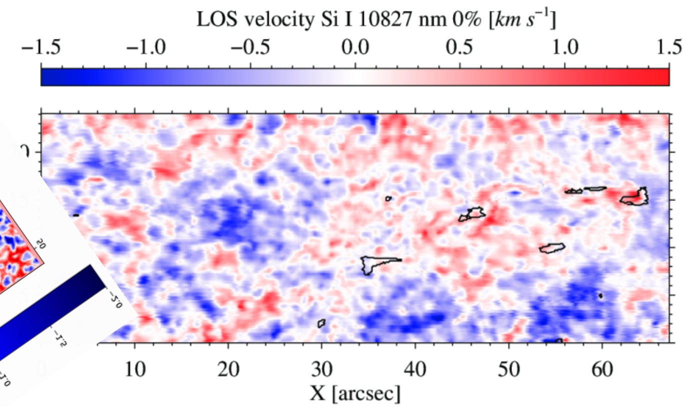
Consequences of observations such as AFS for EST







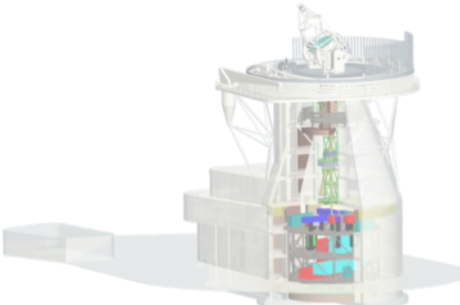
Ca I 10838 Å

Si I 10827 Å

Fe I 6173 Å

González Manrique, Kuckein, Pastor Yabar et al. 2018 (in preparation)

Phothosperic Lines



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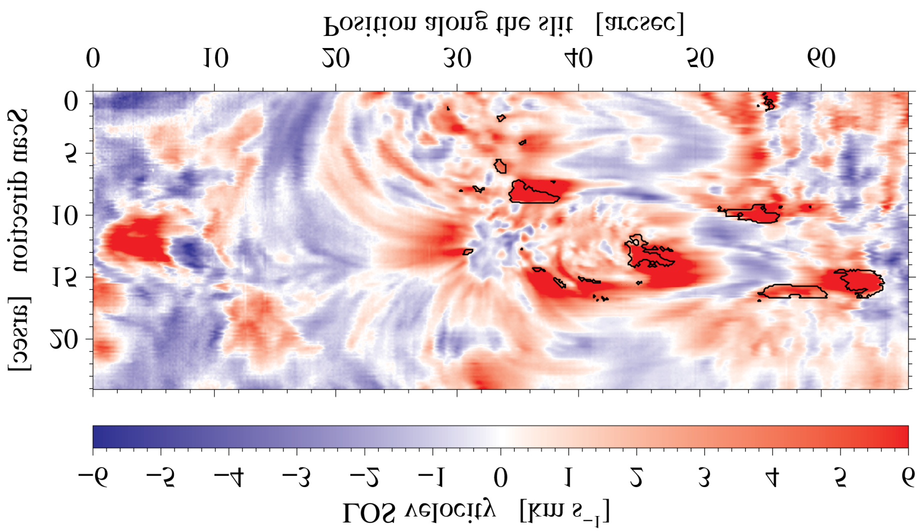
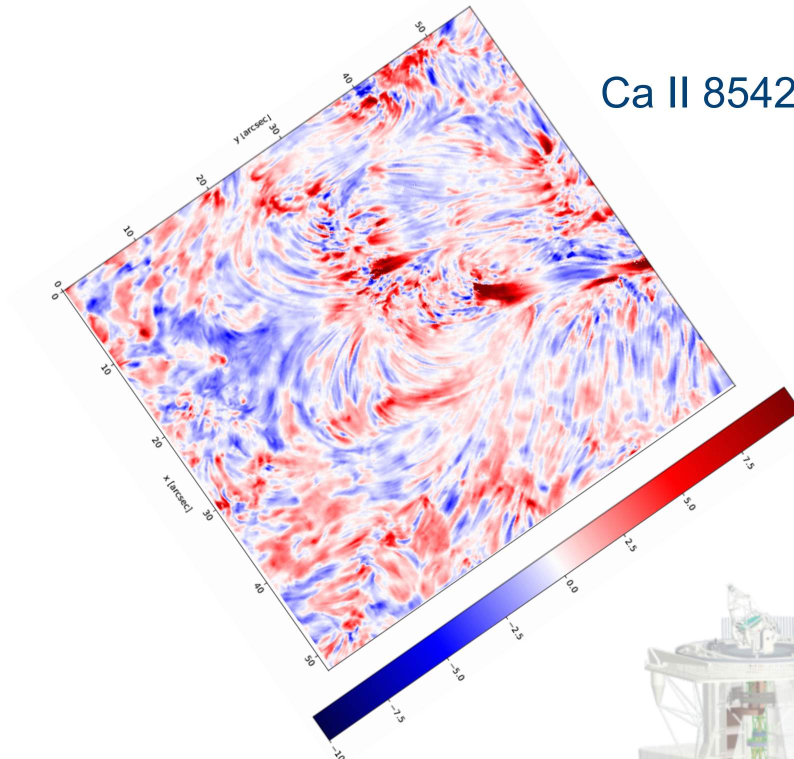
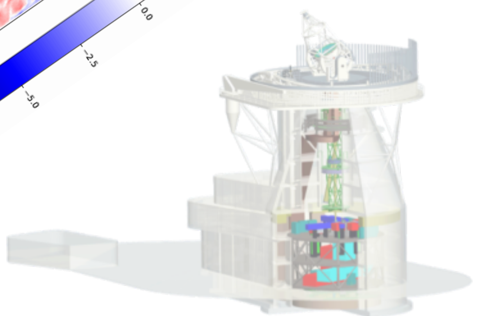
Chromospheric Lines

He I 10830 Å



Ca II 8542 Å





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Conclusions and Outlook

PRE-EST

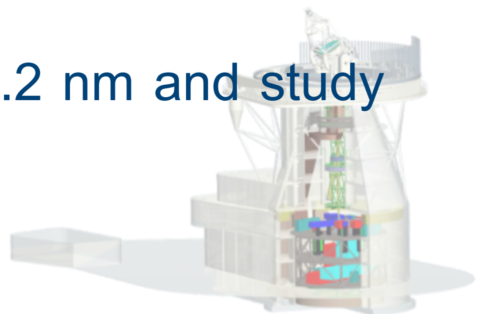
- We used a simple and fast technique for determining the velocity of multiple atmospheric components within a single spatial pixel. Good fits and reasonable velocity values.

- With the available data we are able to follow during one hour the dynamics and temporal evolution of chromospheric structures.

- We can confirm the lifetime of arch filaments presented in other studies. We presented the evolution of the He I velocities within a single arch filament. We confirm supersonic LOS velocities at the footpoints.

- We are studying the link between the chromospheric filamentary structures and the underlaying photosphere structures.

- Inversions at a footpoint with the Ca II NIR line at 854.2 nm and study the chromospheric velocities.



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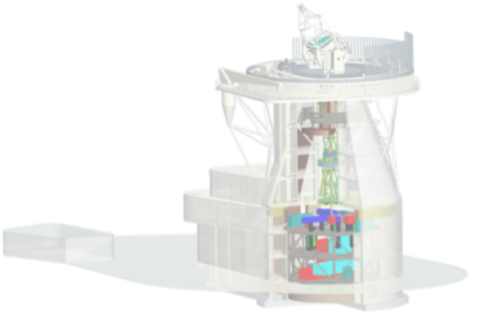

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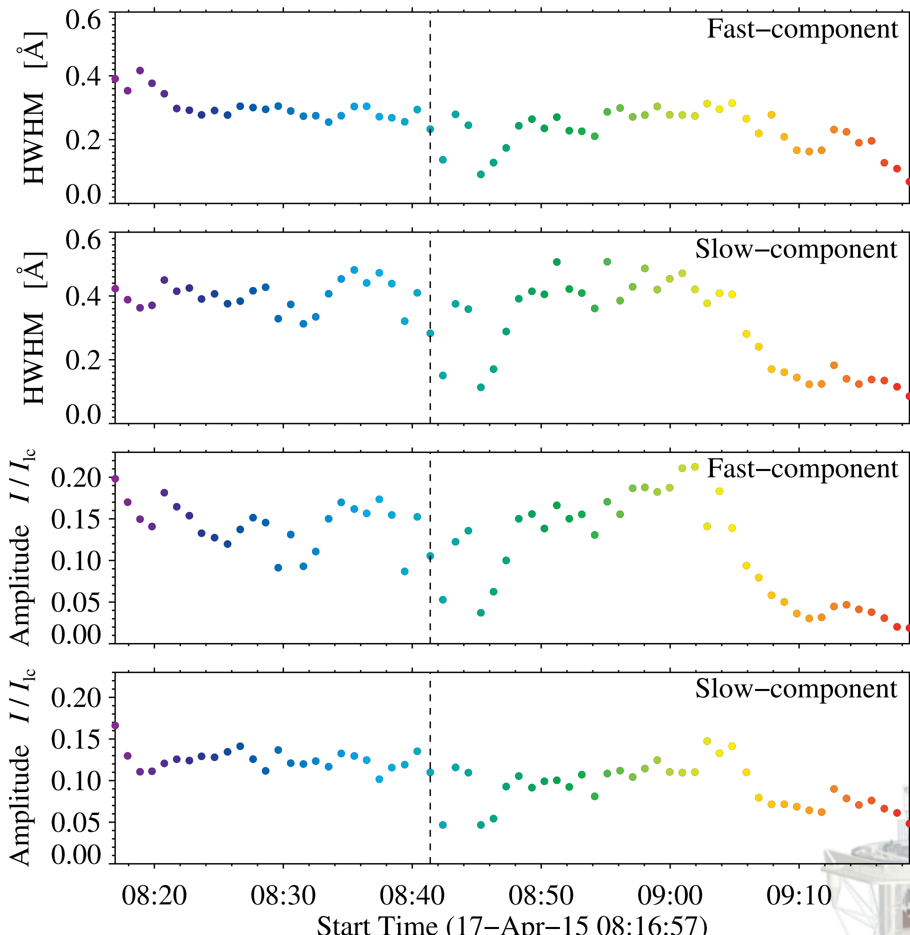

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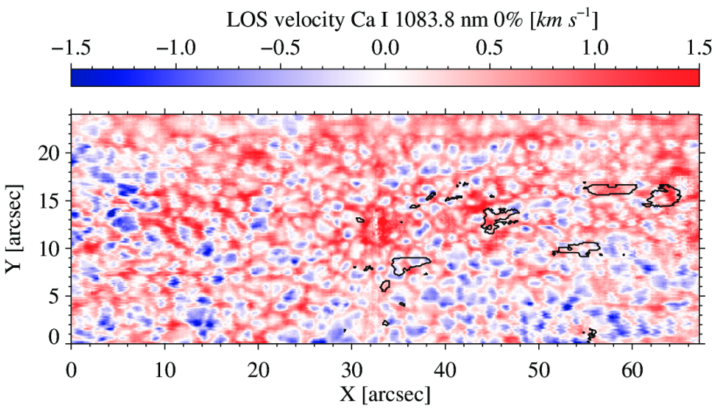

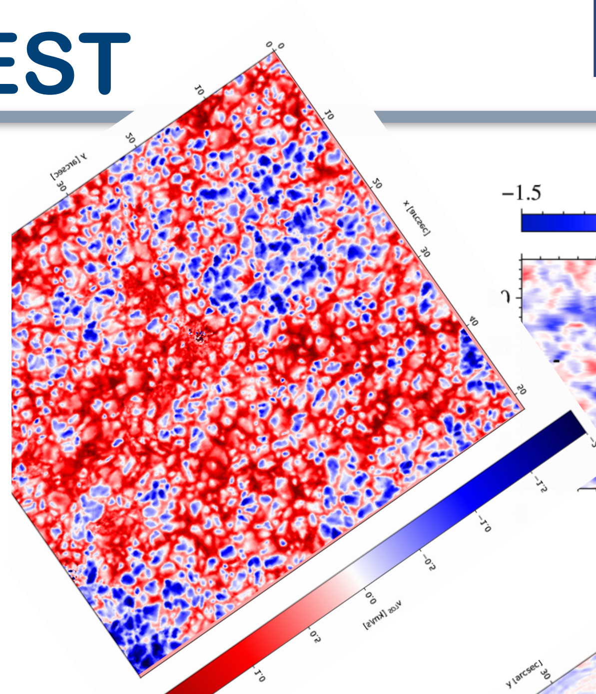

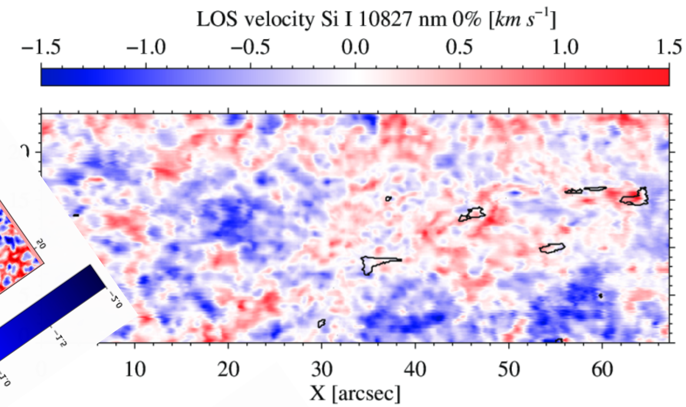

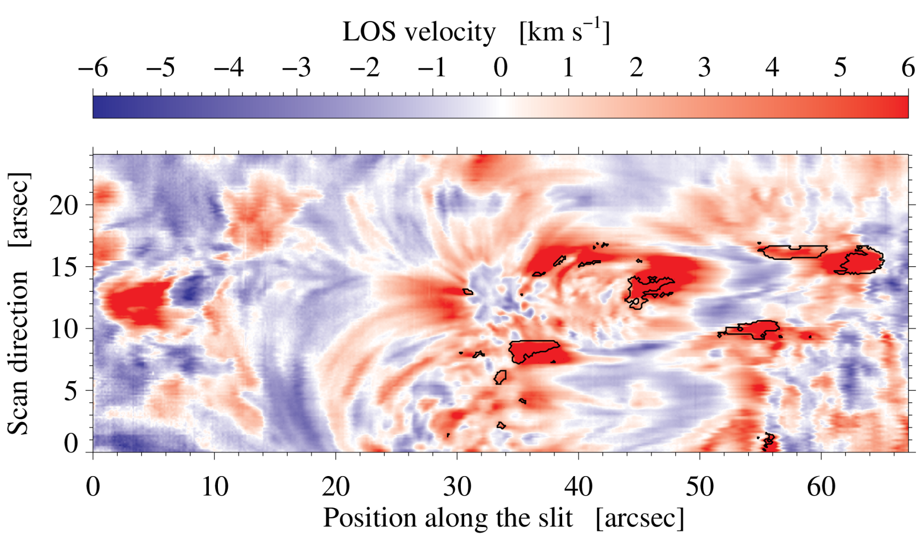

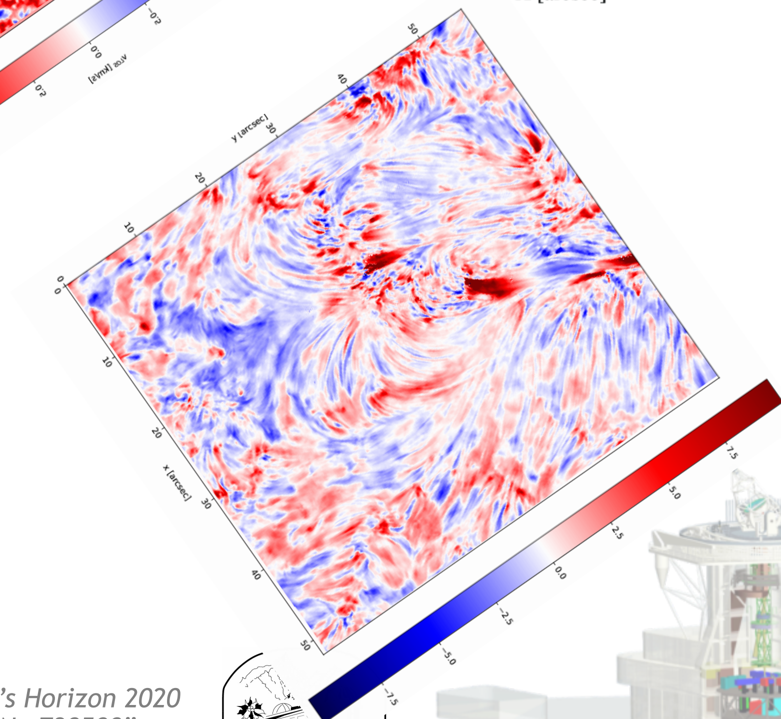

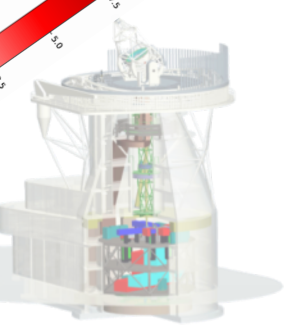

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Method

- Most of the He I intensity profiles show the expected two spectral lines.
- Around 3% show a clear signature of a fast component
- Assume all the profiles have only the slow component
- We use single Lorentzian profile to fit the He I profiles
- Equation set to unity to normalize the synthetic intensity continuum
- Levenberg-Marquardt least-squares minimization
- Upper and lower bounding limit
- Spectral range depending of the amplitude
- Zero reference 10830.30 Å

$$F = 1 - \frac{A_0}{u^2+1}$$

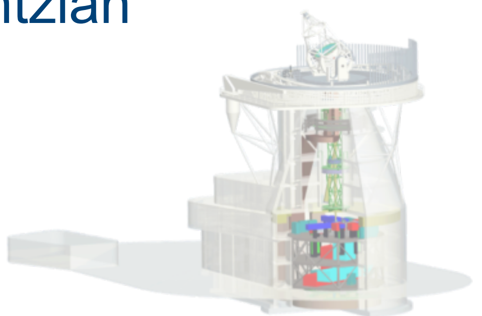
$$u = \frac{x - A_1}{A_2}$$

A_0 = Amplitude

A_1 = Peak centroid

A_2 = Half-width-at-half-minimum

Single-Lorentzian



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Method

- Fitting all profiles double-Lorentzian profile
- Two different wavelengths ranges depending of the position of the line core
- Below 10830.49 Å the range is [-0.83, +1.73] Å respect to the line core
- Above 10830.49 Å the range is [-1.37, +1.73] Å respect to the line core
- Initial estimates of the fit parameters A_0-A_5 were based on the single-Lorentzian fits
- To localize the dual-flow profiles different types of these profiles were selected and correlated with all the profiles of the map.
- Threshold 98% of the mean of the correlation

$$F = 1 - \frac{A_0}{u_1^2+1} - \frac{A_3}{u_2^2+1}$$

$$u_1 = \frac{x - A_1}{A_2}$$

$$u_2 = \frac{x - A_4}{A_5}$$

$A_{0,3}$ = Amplitude

$A_{1,4}$ = Peak centroid

$A_{2,5}$ = Half-width-at-half-minimum

double-Lorentzian

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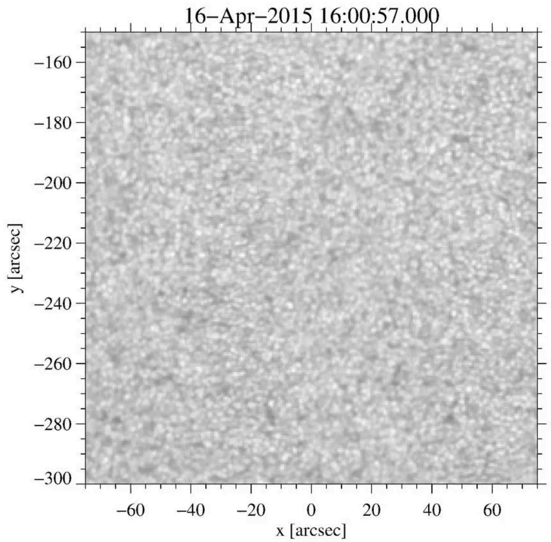
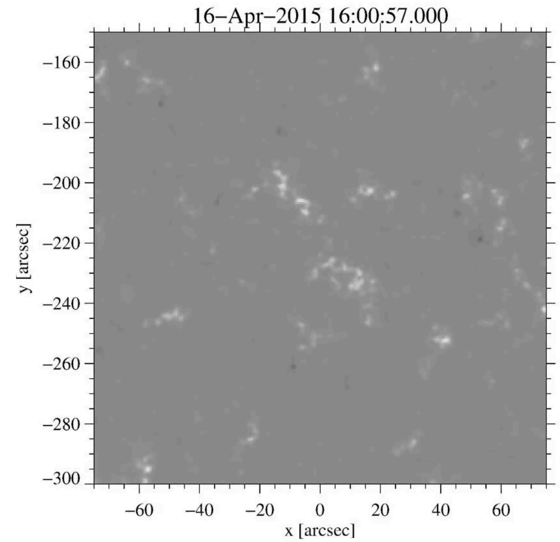
Complement data with SDO (HMI, AIA)

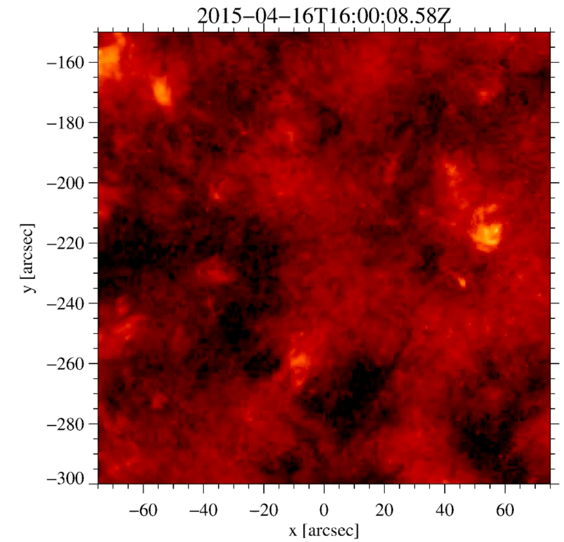
HMI: Continuum



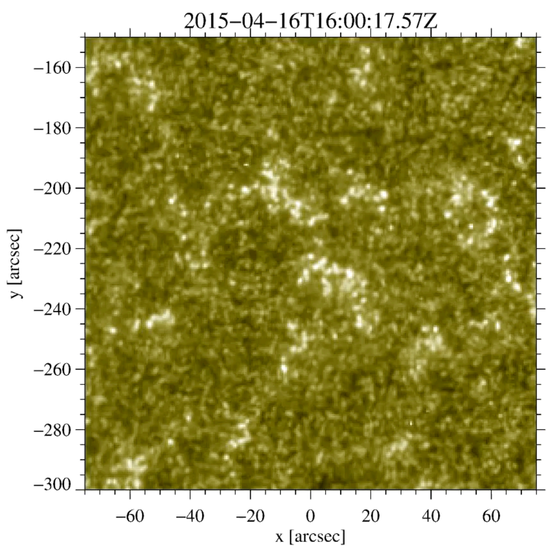
HMI: Magnetograms



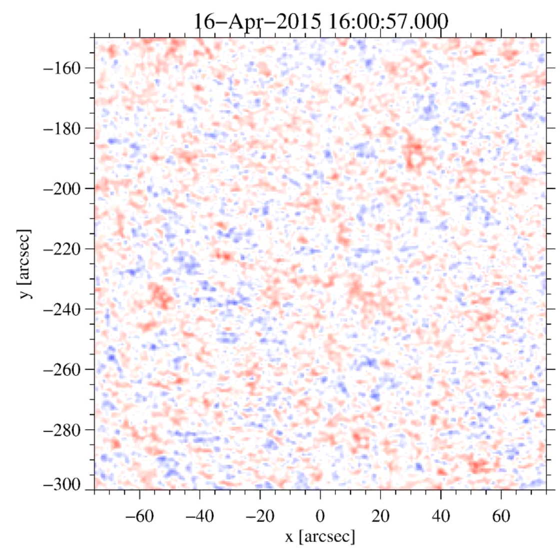
AIA: 304 Å

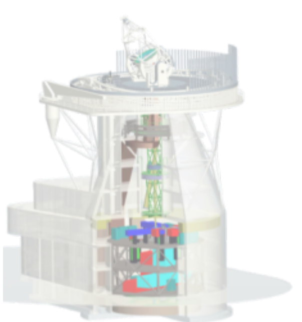


AIA: 1600 Å Continuum



HMI: LOS Velocity





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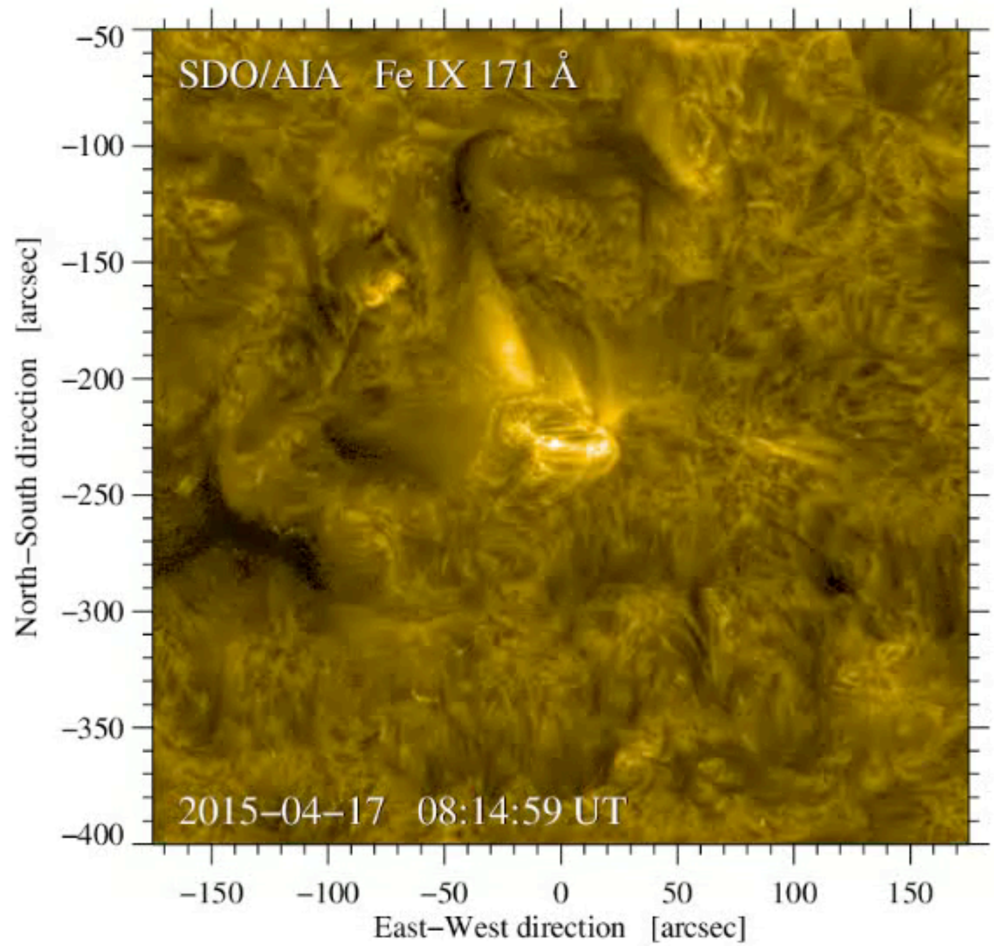
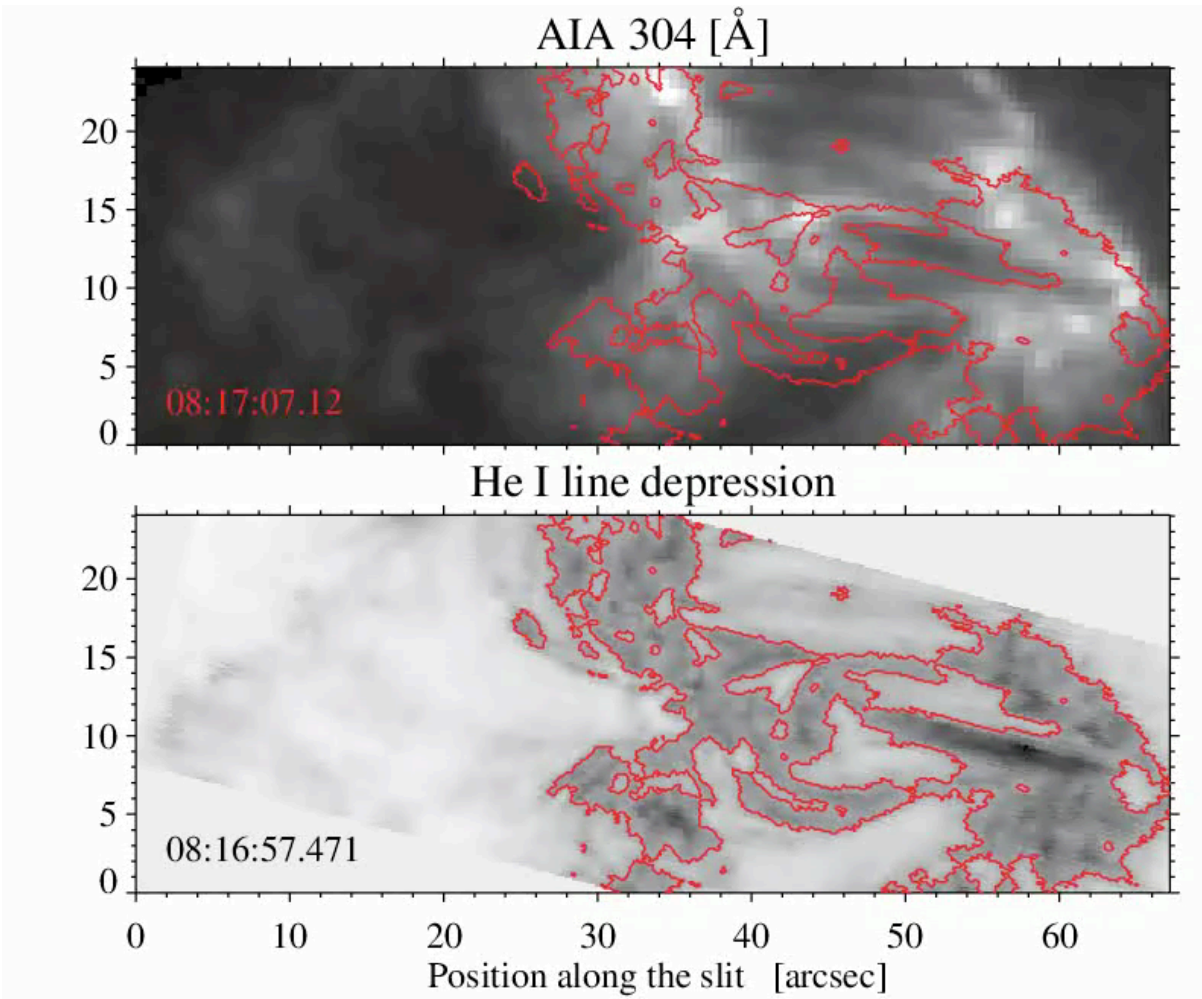
Complement data with SDO (HMI, AIA)

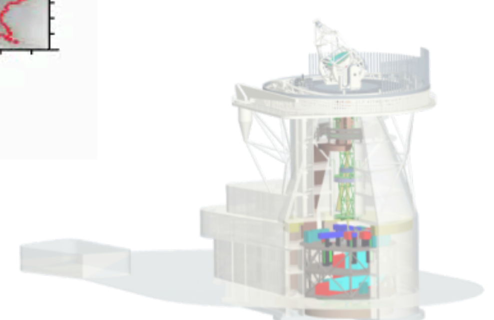
- Start: 17 April 2015 8:15 UT
- Finish: 17 April 2015 9:20 UT
- Same time range as observations
- Image enhancement using NAFE
- AIA: 171 Å
- Microflare at the end of the movie?



"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 739500"

Complement data with SDO (HMI, AIA)





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