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Chromospheric magnetic fields of an active region filament measured using the He I triplet

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(Refer to: Xu, Z. et al. ApJ, 2012)

1. Background and purpose of the present work



- **QS filament --- high lying, above limb**

- **He I D3** (e.g. Rust 1967; Lopez Ariste & Casini 2002; reviewed by Paletou & Aulanier 2003; Bommier et al. 1994, 2005 etc.)
- **He I 1083.0 nm** (e.g. Merenda et al. 2006; etc.)

- **AR filament --- low lying, short-lived, on solar disk**

E.g. How strong is the field strength ?

- **Ca II IR** (e.g. Wiehr & Stellmacher, 1991) , Stokes *I* & *V* → 150 G
- **He I 1083.0 nm triplet**

e.g. Sasso et al. (2010) , Stokes *I*, *Q*, *U* & *V* → 100-250G **(filament eruption)**

Kuckein et al. (2009, 2012) , Stokes *I*, *Q*, *U* & *V* → 600-700G (uncommon or not ?)

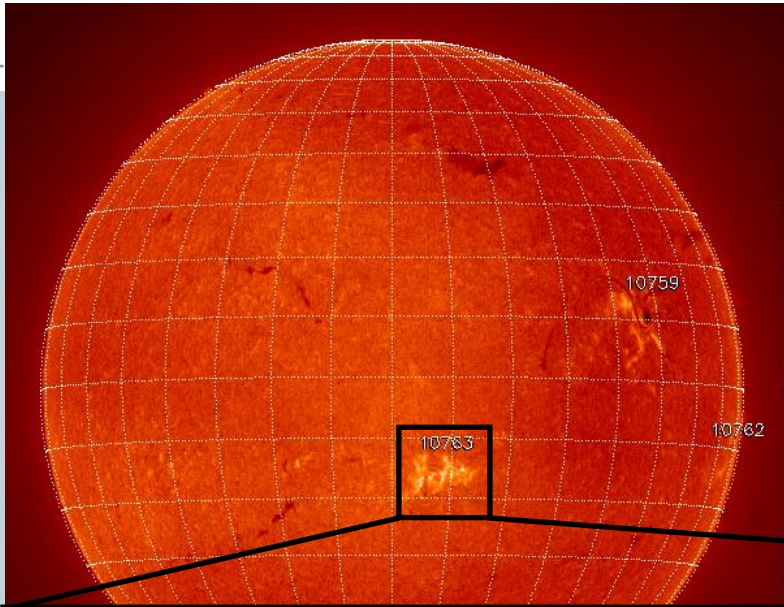
--- To investigate the magnetic field vectors (i.e., **full Stokes profiles**, →strength, direction, twist degree etc.) in **two atmosphere layers** (i.e. below and within the filament) of the **AR filament** in its **early and stable phase** (more reliable).

2. Outline

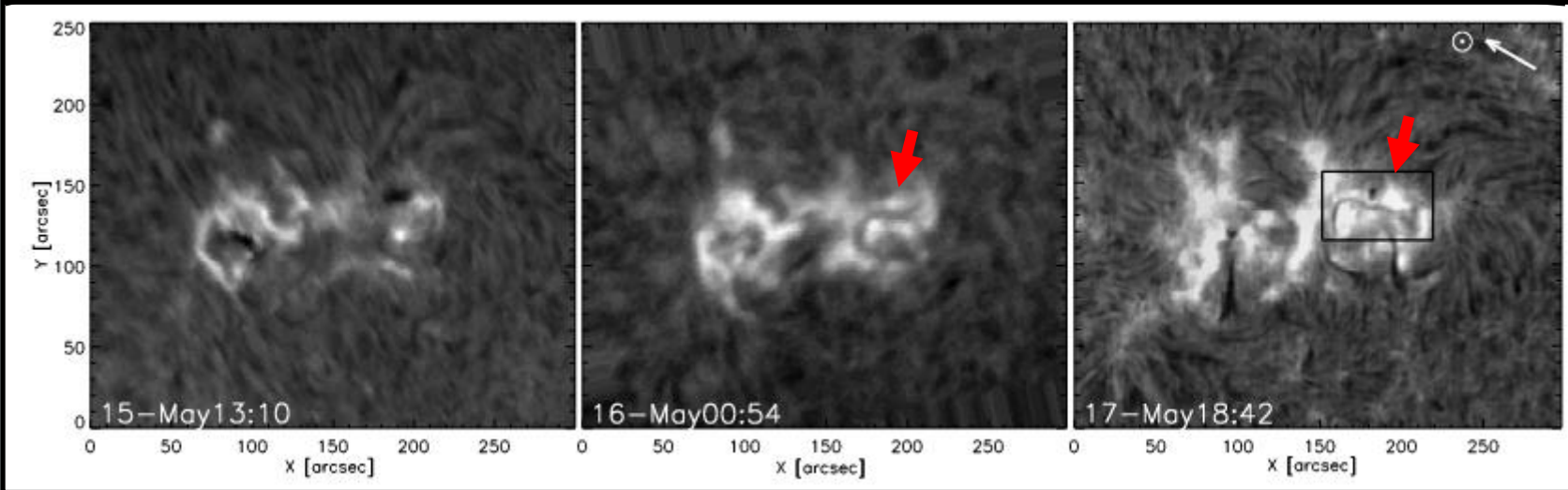


- Observations ---- Ha, MDI, TRACE & **Spectro-polarimetric observation**
- Retrieved physical parameters around filament (two layers)
 - Doppler Velocity map
 - Magnetic field strength/orientation in two layers
 - Discussion of the observation findings (emerging flux rope ?)
- Conclusion

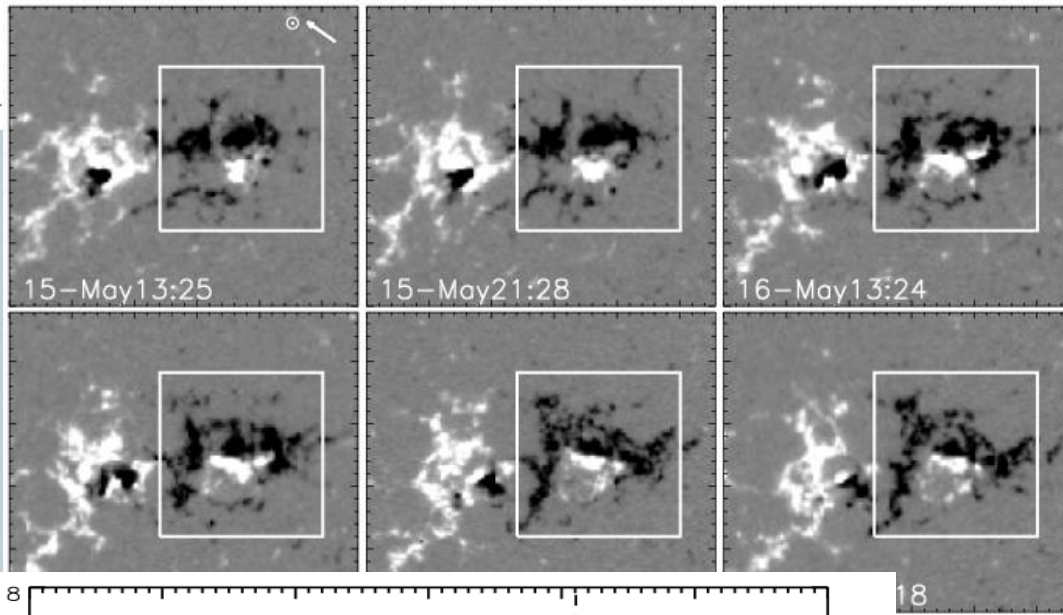
● Observations --- context



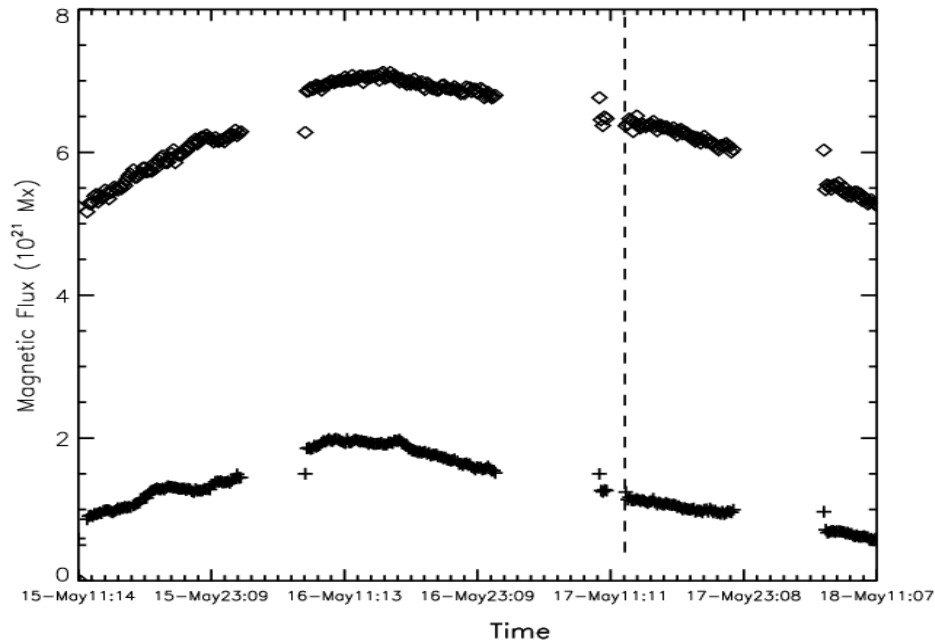
➤ Several H α filaments are visible in H α since May 16 (boxed area)



● Observations --- context



➤ MDI magnetogram :
opposite polarities **converge**
toward each other

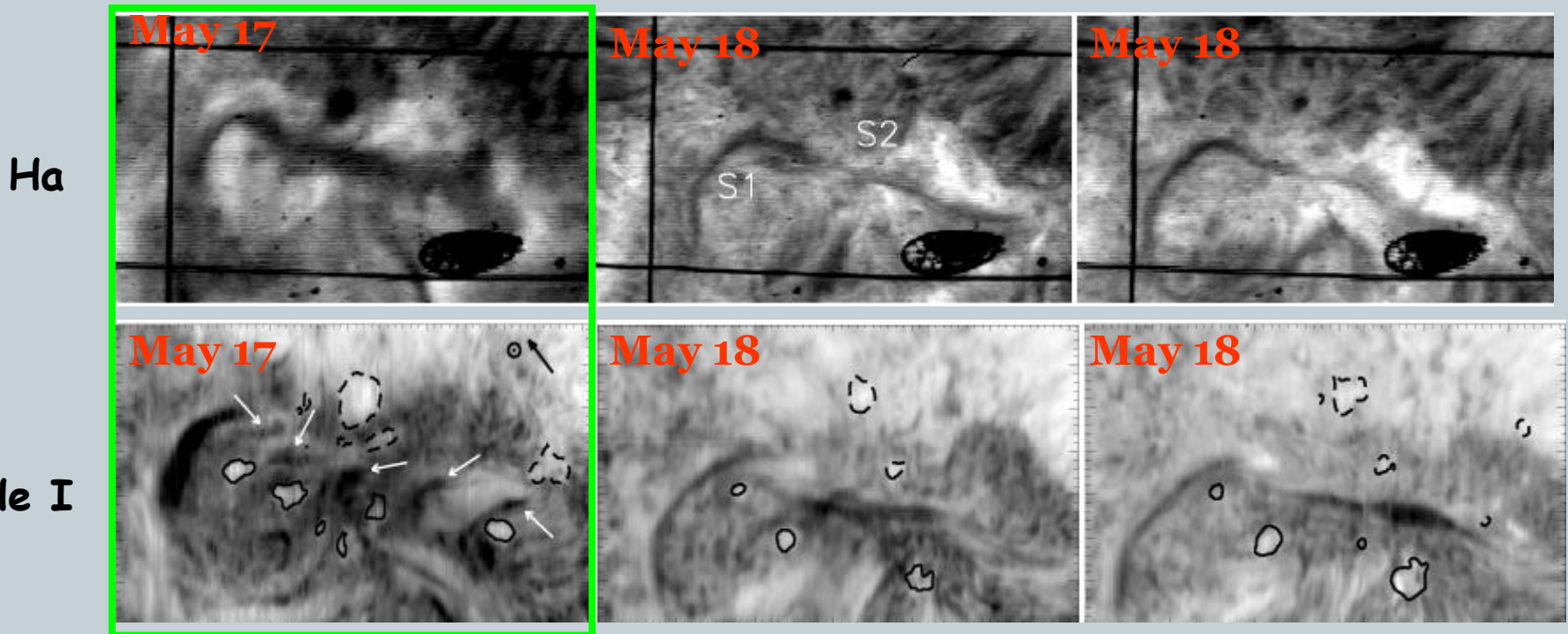


➤ MDI flux : positive and negative flux
increase and then decrease. The decrease
amount is almost the same.

Reminder: there is no Ha filament before
the fluxes increase

● Observations --- context

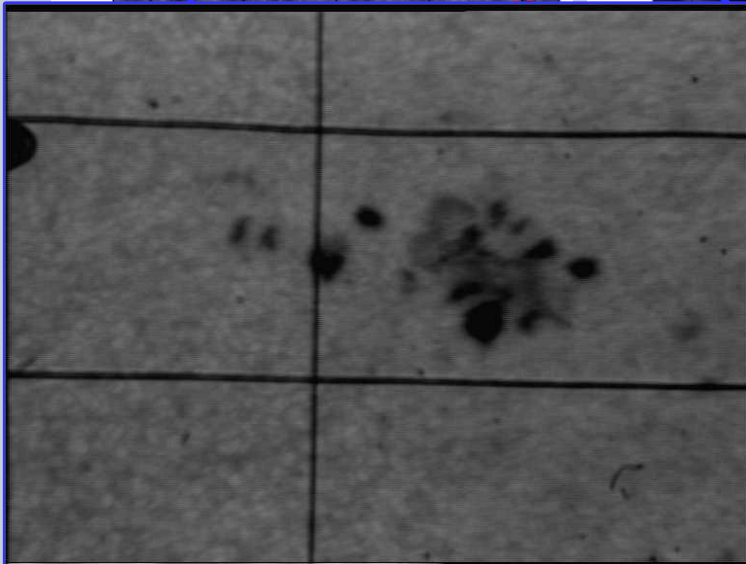
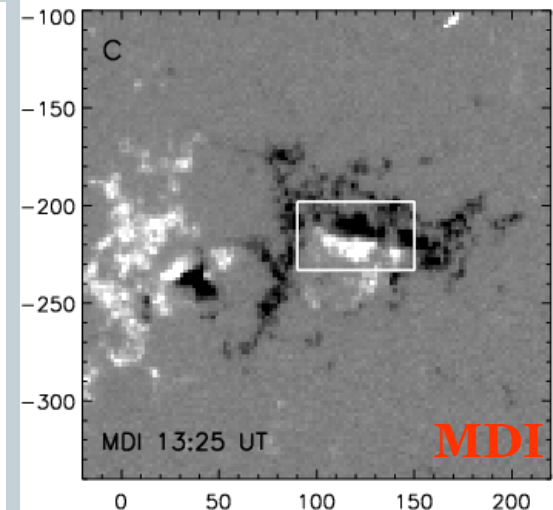
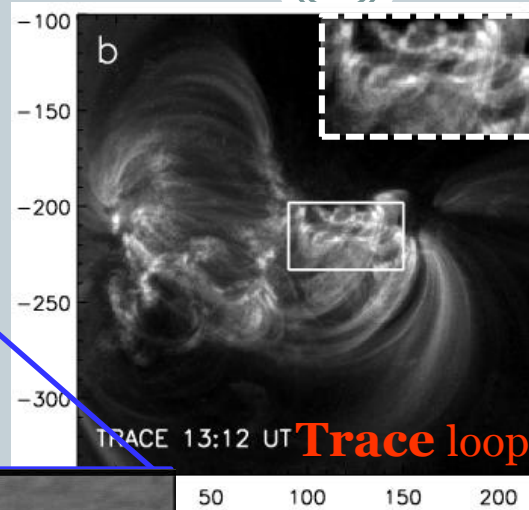
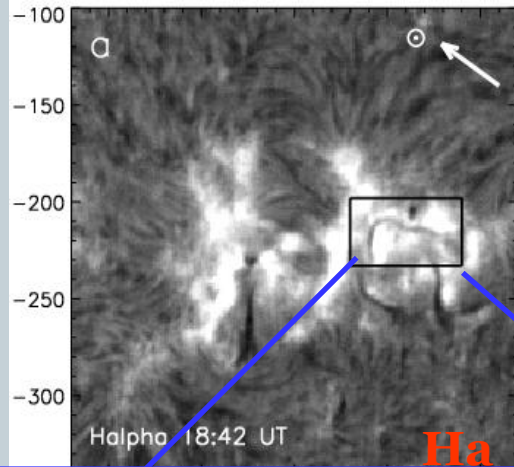
- Filament morphologies in Ha and He I line from May 17 to 18



- two sections of the filaments
- a complete filament was already present in Ha, only a partially formed one was present in the He I line (hint about the filament formation?)
- their morphologies became similar later

● Observations --- context

- Concentrate on the stable phase of the filament



- Spectro-polarimetric observation on May 17
 - Area of 35" * 60" was scanned by TIP II installed on VTT
 - At each scan position, full Stokes profiles of He I and Si I line are recorded.

● Observations --- spectro-polarimetric obs.

➤ Typical Stokes profiles in AR filament

➤ Strong He I line absorption (optically thick).

➤ Zeeman effect is dominant in linear Stokes profiles.

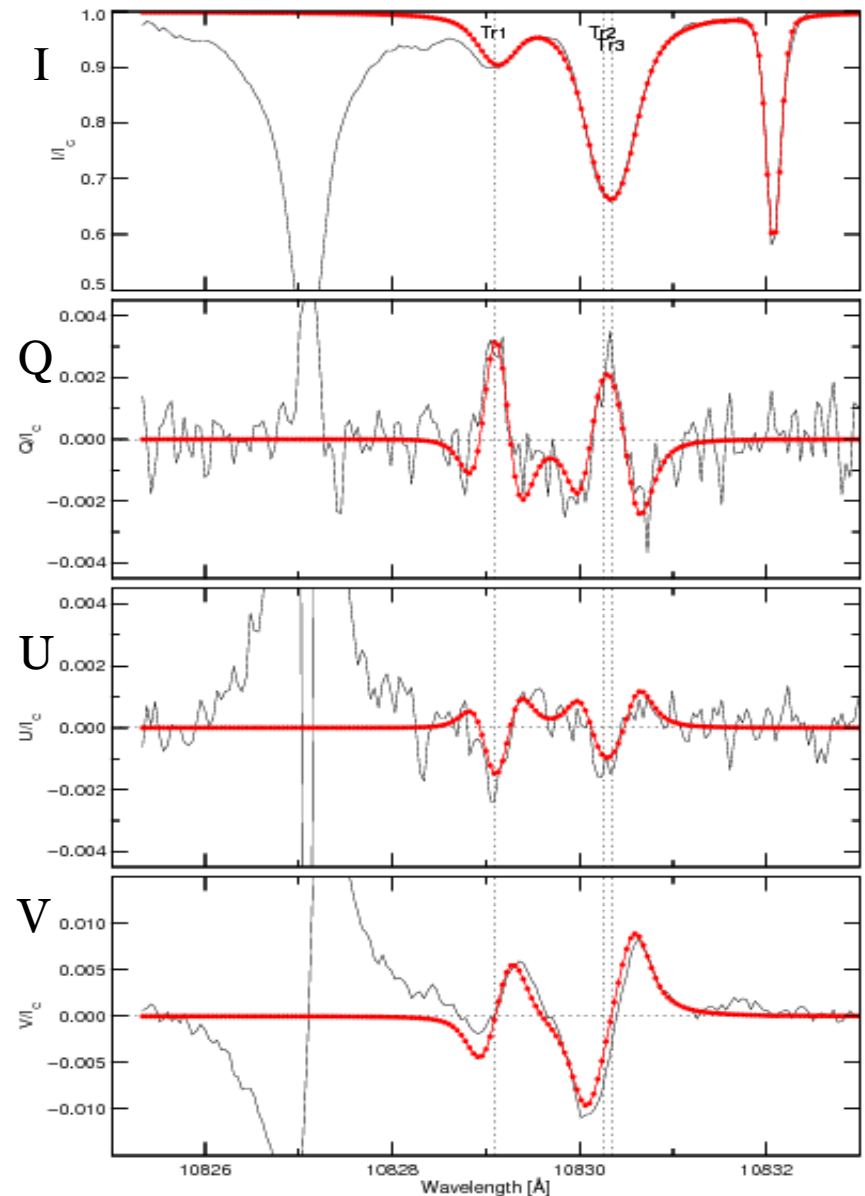
➤ 8 parameters are retrieved by HeLix (a ME approximation)

B, inc, azi, Vlos, Δλ, a, S1, ff

(atomic-level polarization is negligible)

➤ The full stokes profiles of He I and Si I lines are inversed, independently.

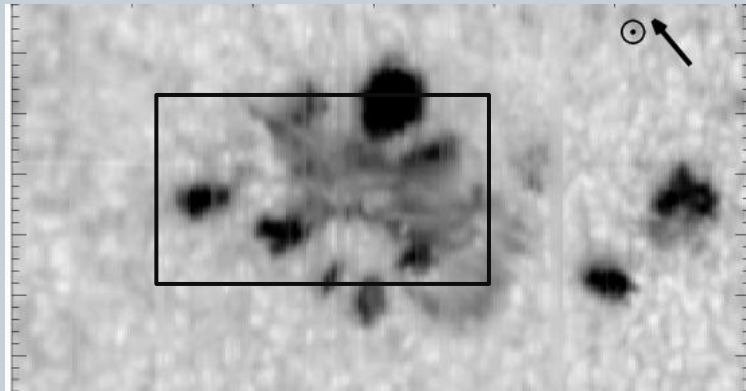
➤ Co-temporal and Co-spatial Doppler velocity map and magnetic fields at two layers are obtained.



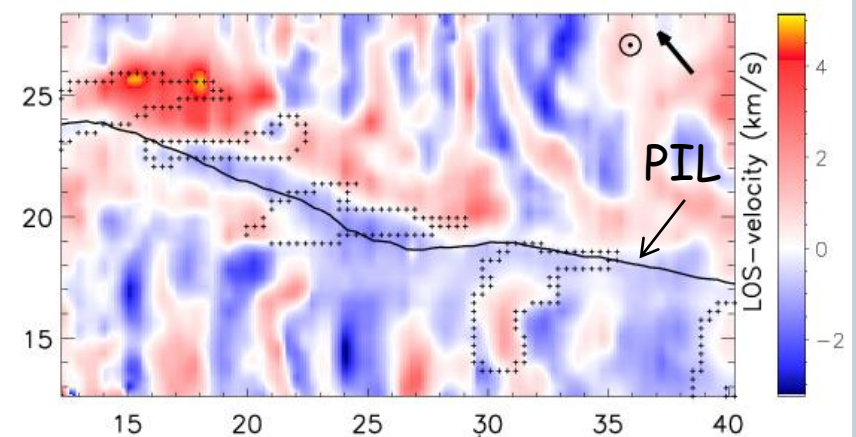
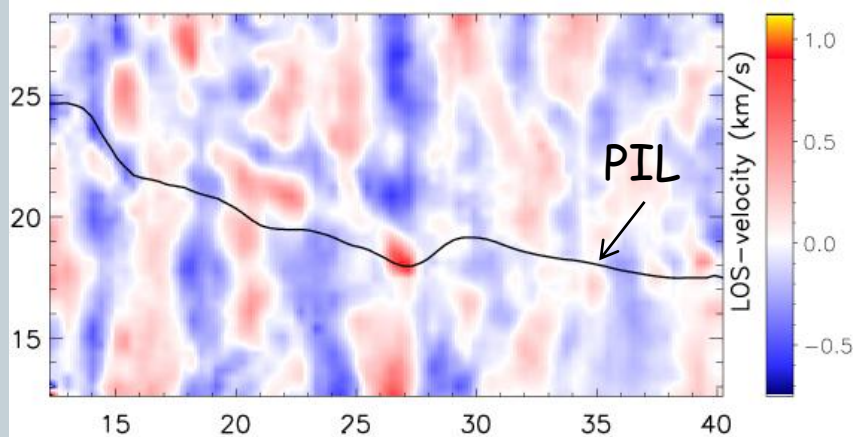
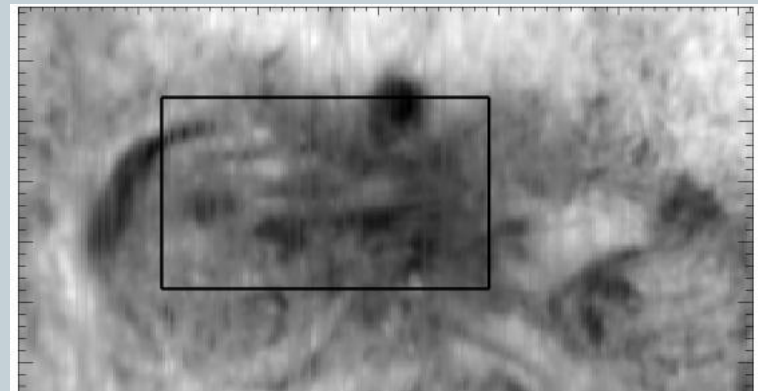
● Retrieved physical parameters around filament (two layers)

➤ Doppler velocity maps in two layers

Photosphere : *Con.*



Chromosphere : *He line center*



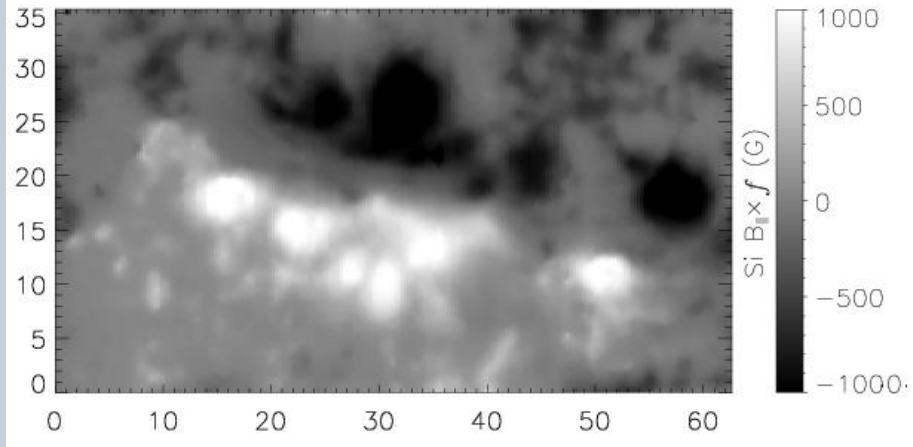
➤ Only in the chromosphere, consistent **upflows** are found along the **PIL** flanked by **downflows**.

Retrieved physical parameters around filament (two layers)

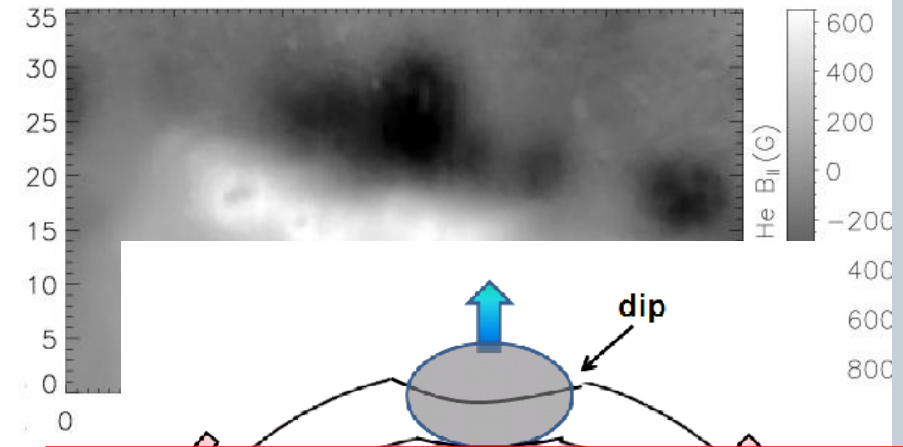
➤ Magnetic fields around the AR filament

LOS magnetic field component B_{los}

Photosphere : $B_{los} * f$

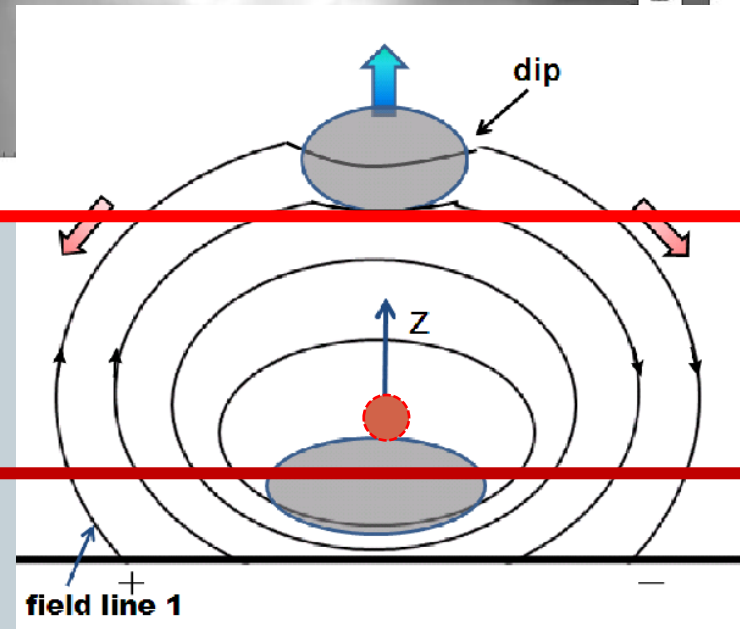


Chromosphere : B_{los}



➤ the chromospheric B_{los} is more diffuse

➤ +/- polarities are closer to each other in the chromosphere than in the photosphere

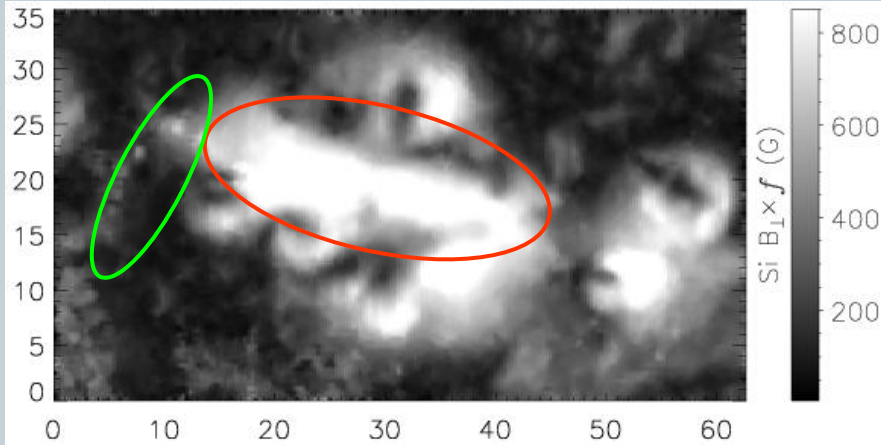


Retrieved physical parameters around filament (two layers)

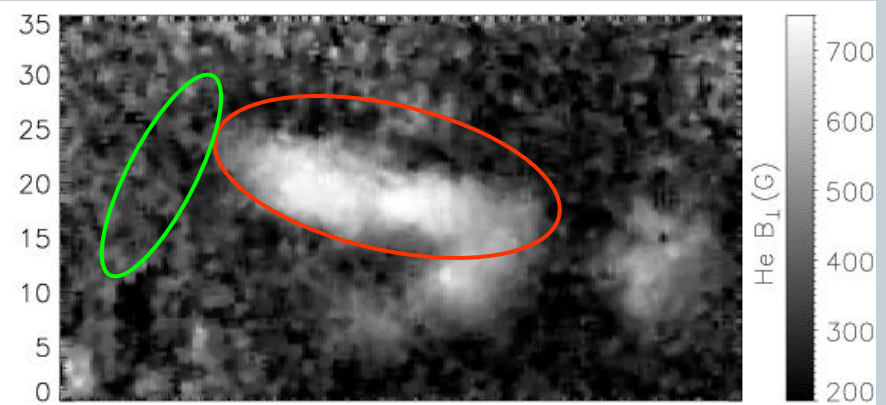
➤ Magnetic fields around the AR filament

Transversal magnetic field component B_{trans} .

Photosphere : $B_{\text{trans}} * f$

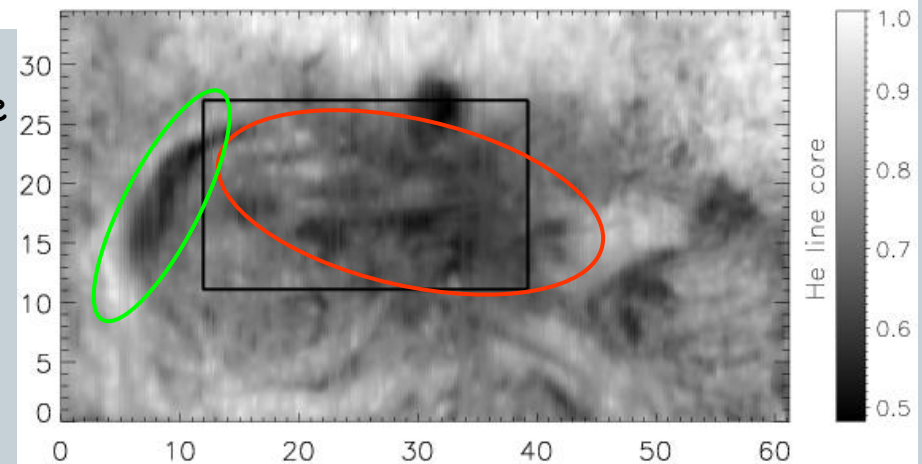


Chromosphere : B_{trans} .



- $B_{\text{trans}} * f \sim 600-800 \text{ G}$ in the photosphere
- $B_{\text{trans}} \sim 500-700 \text{ G}$ in the chromosphere

➤ Strong magnetic fields are only found around one filament section, no outstanding magnetic fields are found in another section.



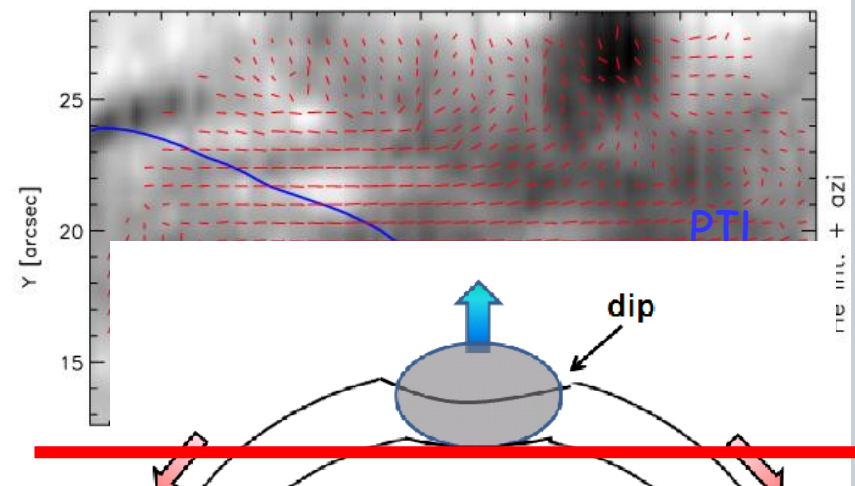
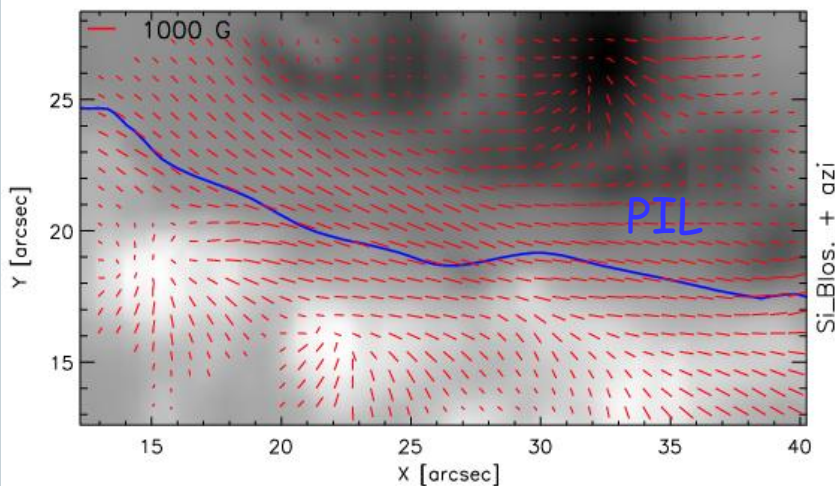
Retrieved physical parameters around filament (two layers)

➤ Magnetic fields around the AR filament

Transversal magnetic field orientation (*azi.*) vs. PIL

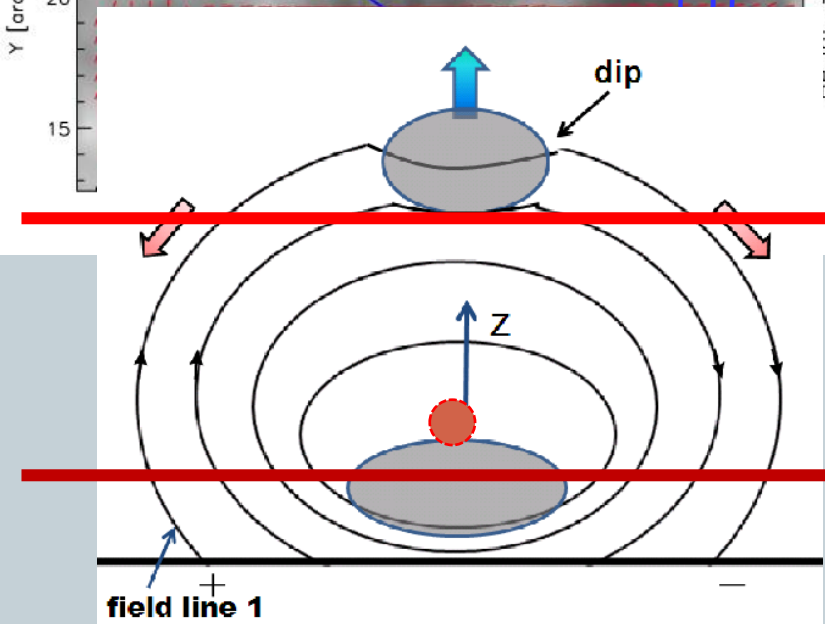
Photosphere : *Azi.* + *Blos*

Chromosphere : *Azi.* + *He I int.*



➤ *azi.* is nearly parallel to the PIL in the photosphere

➤ *azi.* is inclined at 20-30 degree to the PIL in the chromosphere, but aligned to the He segmented filaments.



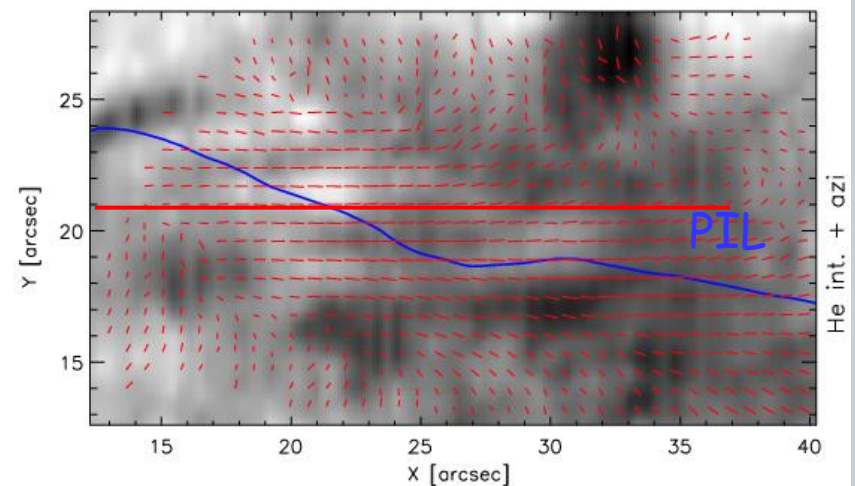
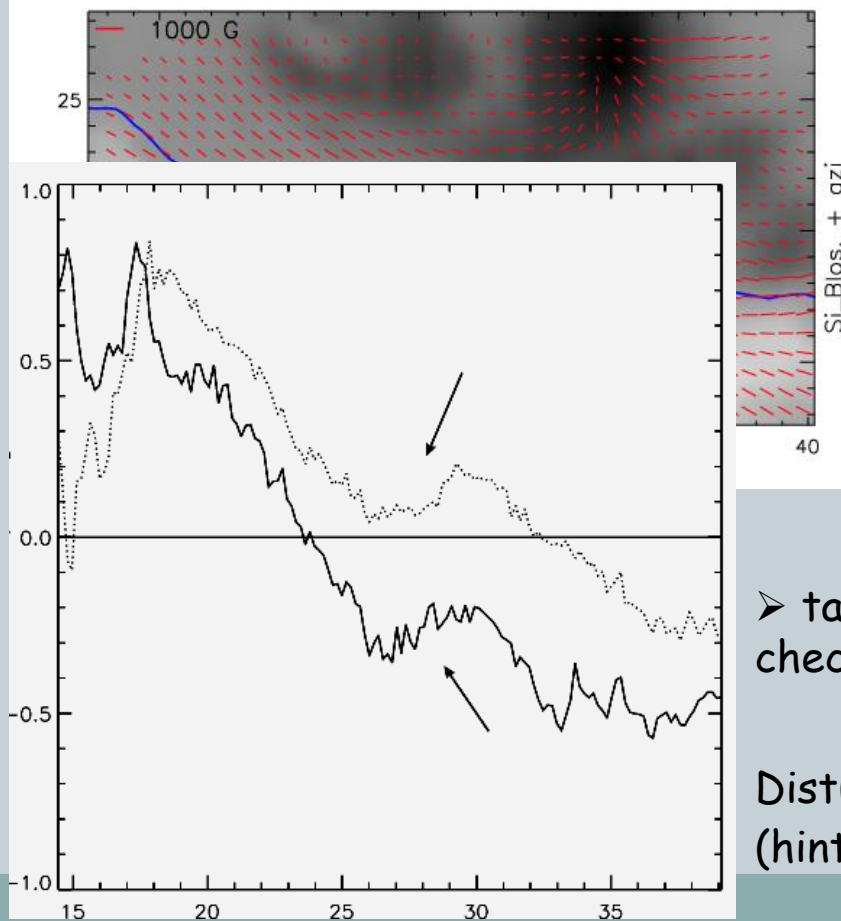
Retrieved physical parameters around filament (two layers)

➤ Magnetic fields around the AR filament

Transversal magnetic field orientation (azi.) vs. PIL

Photosphere : Azi. + Bloss

Chromosphere : Azi. + He I int.



➤ take several **cuts** along the field lines to check the *Stokes V* of the He I

Disturbance of the *Stokes V* close to the PIL (hint about a "dip" structure in the upper chro.?)

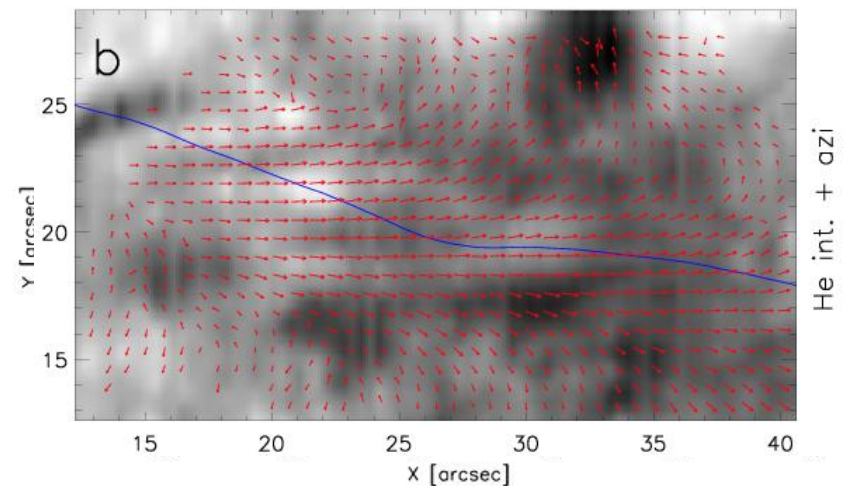
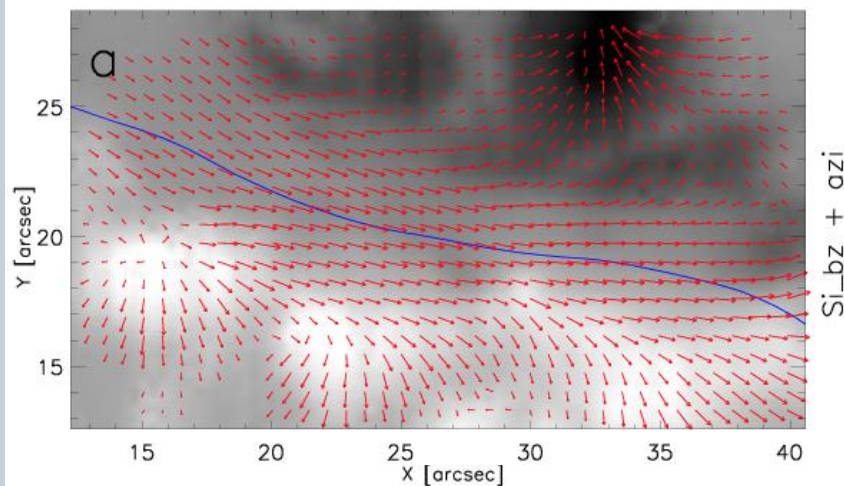
Retrieved physical parameters around filament (two layers)

➤ Magnetic fields around the AR filament

Transversal magnetic field orientation (azi.) vs. PIL

Photosphere : **Bh + Bz**

Chromosphere : **Bh+ He I int.**



- The 180-degree ambiguity of the azi. is resolved by a **NPFC** (Georgoulis, 2005) method
- The chromospheric magnetic field : **a normal polarity configuration**
- The photospheric magnetic field : **a concave structure**

● Conclusion

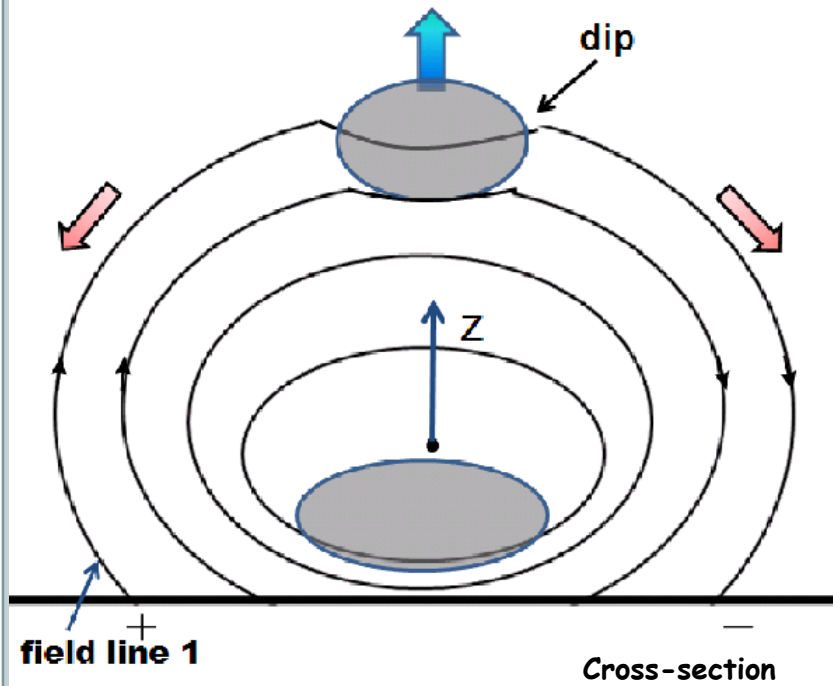
Summary of observations :



1. **MDI + Ha** : Ha filament is visible when the magnetic flux increase ;
Convergence movement of opposite polarities when the flux decreases
2. **TRACE + Ha** : the overlying EUV loops are close to potential configuration
3. **Ha vs. He I**: Ha filament is complete and He I filament is partially formed
4. **Doppler Velocity**: Only in the chromosphere, consistent upflows are found along PIL flanked by downflows.
5. **B_los**: the opposite polarities in chromosphere are close to each other than in photosphere. There is disturbance to the LOS component close to the PIL in the chromosphere.
6. **B_trans**.: the azi. in photosphere is nearly aligned with PIL, while in the chromosphere, the azi cross PIL on 20-30 degree.
7. **B_trans**.: after 180-degree dis-ambiguity on the azimuth angle. The chromospheric magnetic field are found to be in a normal polarity configuration. While, a concave structure is found in the photosphere.

● Conclusion

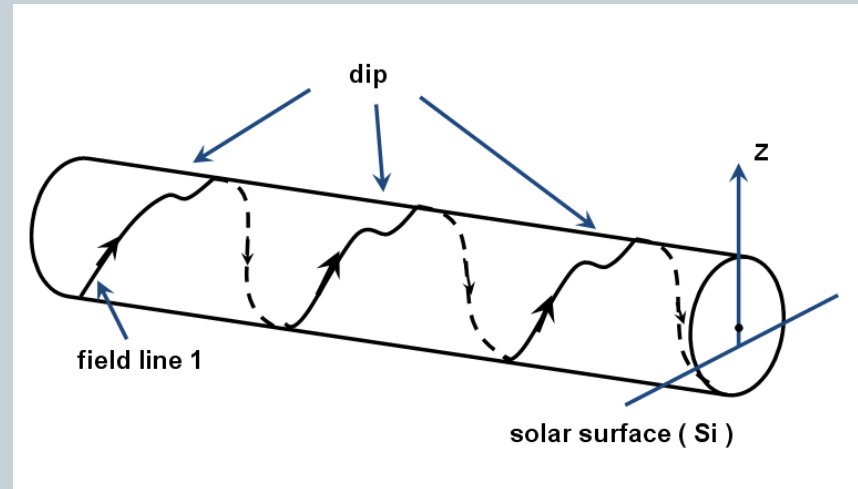
Summary of observations :



He I 10830

H α

Si I



Side-view

- Strong magnetic field strength (the horizontal component is up to 500-700G) in chromosphere is **not uncommon** for AR filaments.
- We are just observing the emergence of a flux rope that is producing a filament as it emergence.

The end . Thanks for you attention !