

Solar Activity from NOAA AR 10501 during November, 2003

**R. Chandra¹, B. Schmieder², E. Pariat², P. Démoulin², W.
Uddin³, T. Torok⁴, C.H. Mandrini⁵**

¹Department of Physics, DSB Campus, Kumaun University, Nainital, India

²Observatoire de Paris, LESIA, Meudon, France

³Aryabhata Research Institute of Observational Sciences, Nainital, India

⁴Predictive Science, Inc., 9990 Mesa Rim Road, San Diego, CA 92121, USA

⁵Instituto de Astronomia y Fisica del Espacio, Argentina

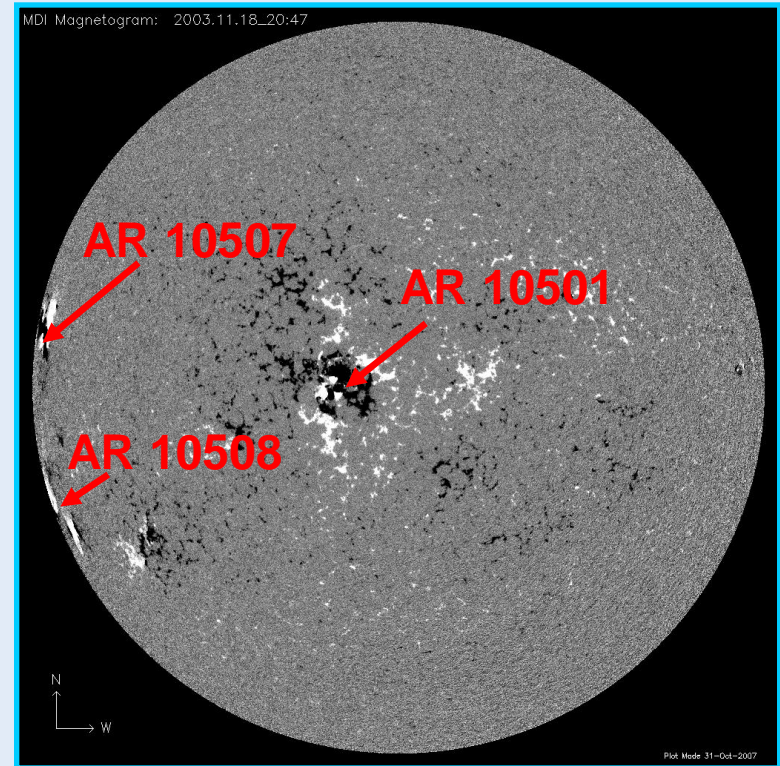


Outline

1. NOAA AR 10501 - An Introduction
2. Flare on 17 November, 2003
3. Flares and Geomagnetic storm from 18 November, 2003 event
4. Filaments Interaction/reconnection and flares on 20 November, 2003

Introduction

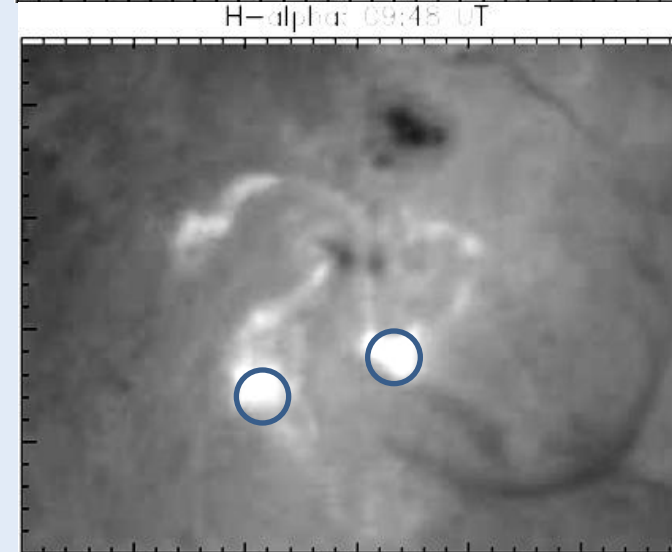
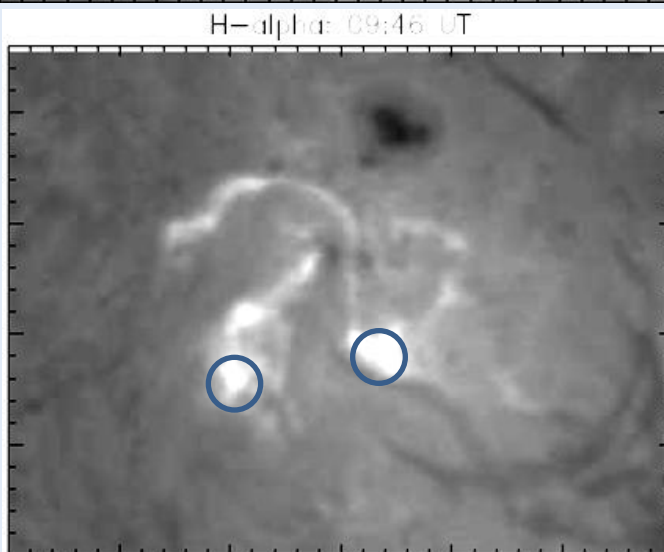
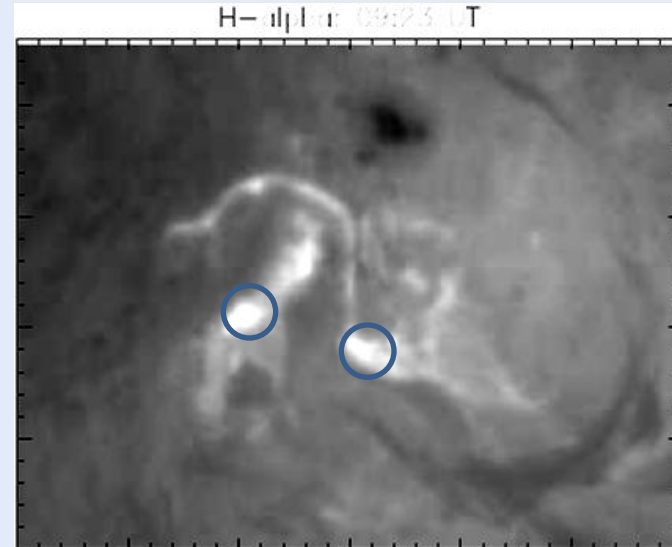
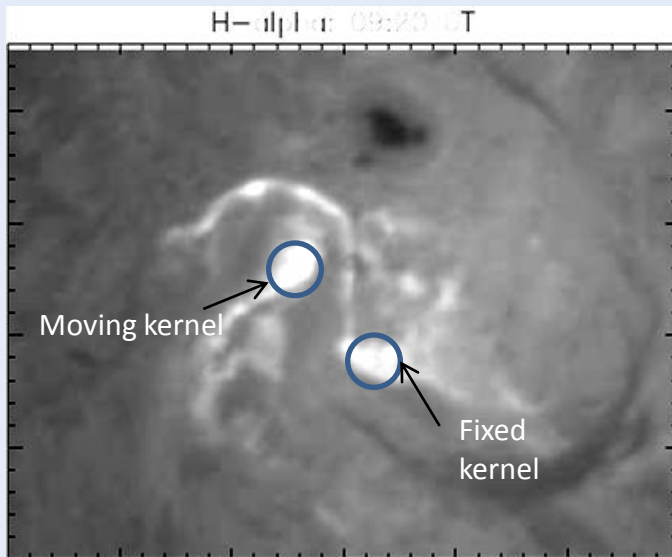
- In the decay phase of solar cycle 23rd during October-November, there was violent solar activity, which produced many geoeffective event.
- Active regions NOAA AR 10484, 10486, 10501, 10508, 10507 were the main centers of the activity.
- Activity from these active region are extensively studied by several authors (*Gopalswamy et al., 2005; Yurchyshyn, Hu, and Abramenko, 2005; Mostl et al., 2008; Srivastava et al., 2009; Chandra et al., 2010, 2011, Schmieder et al, 2011 and references therein*).
- In this talk, we will discuss about the activity from NOAA AR 10501.

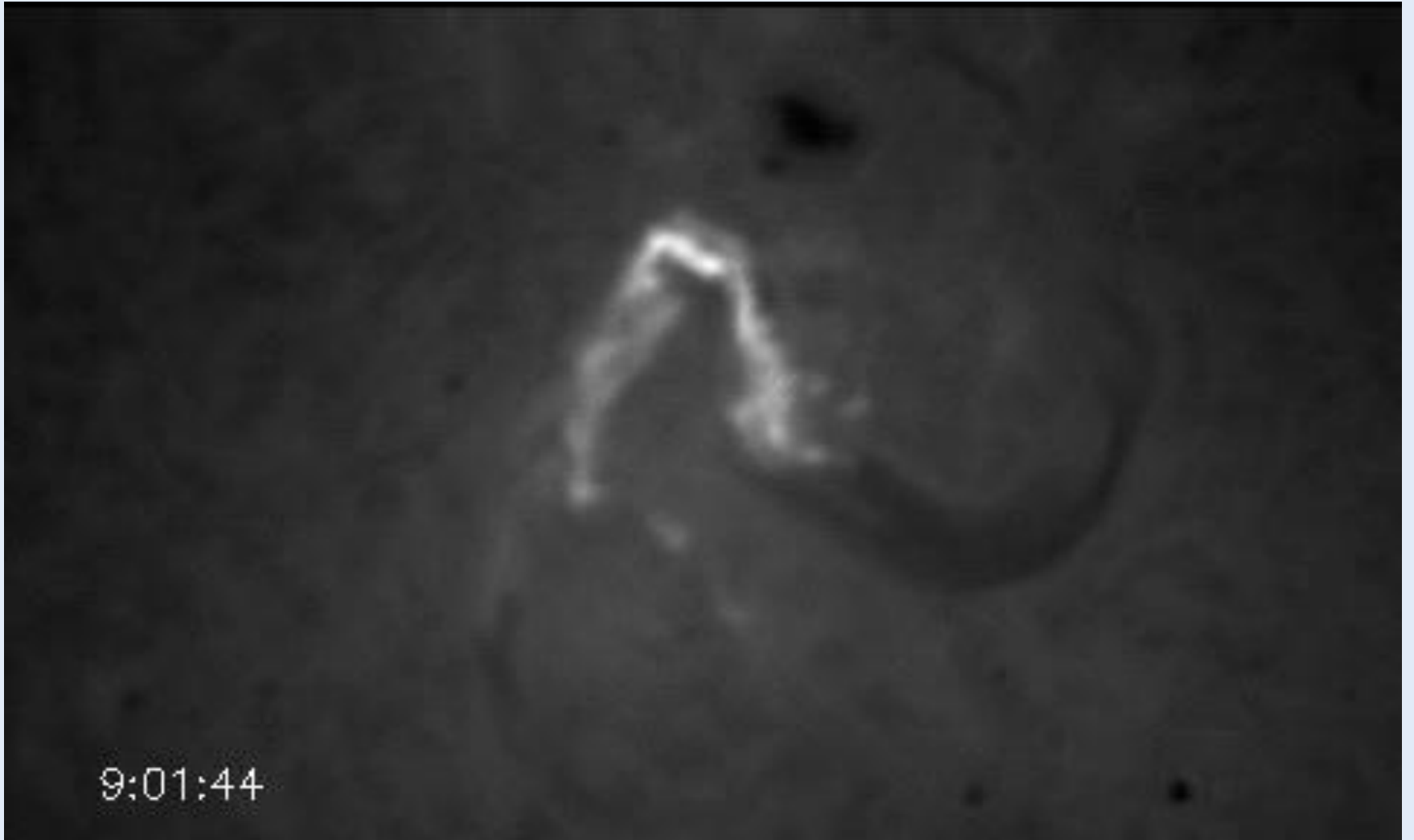


Evolution of active region (MDI Movie)



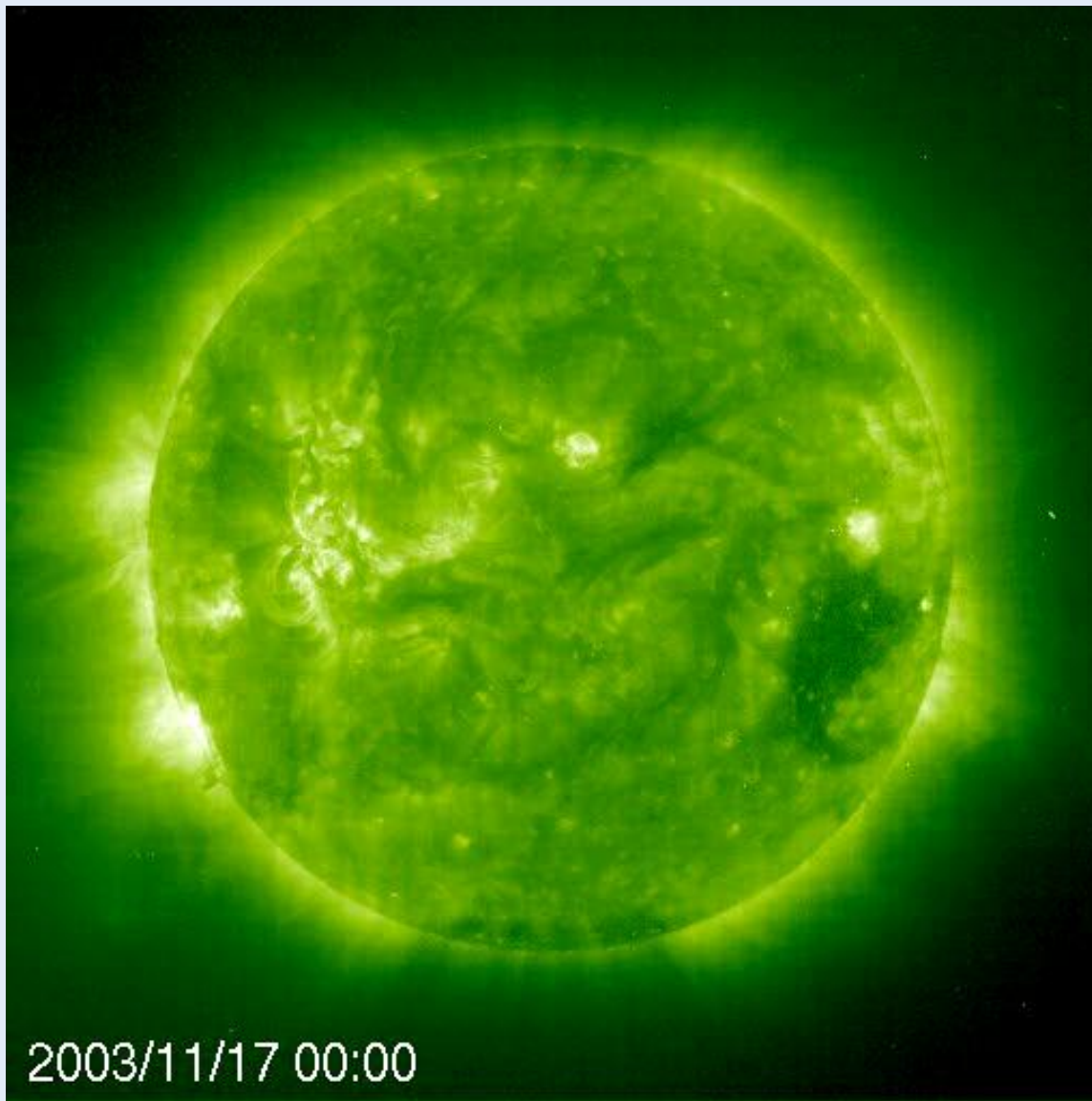
17 November, 2003 Flare in H-alpha (Slip-running Reconnection ?)



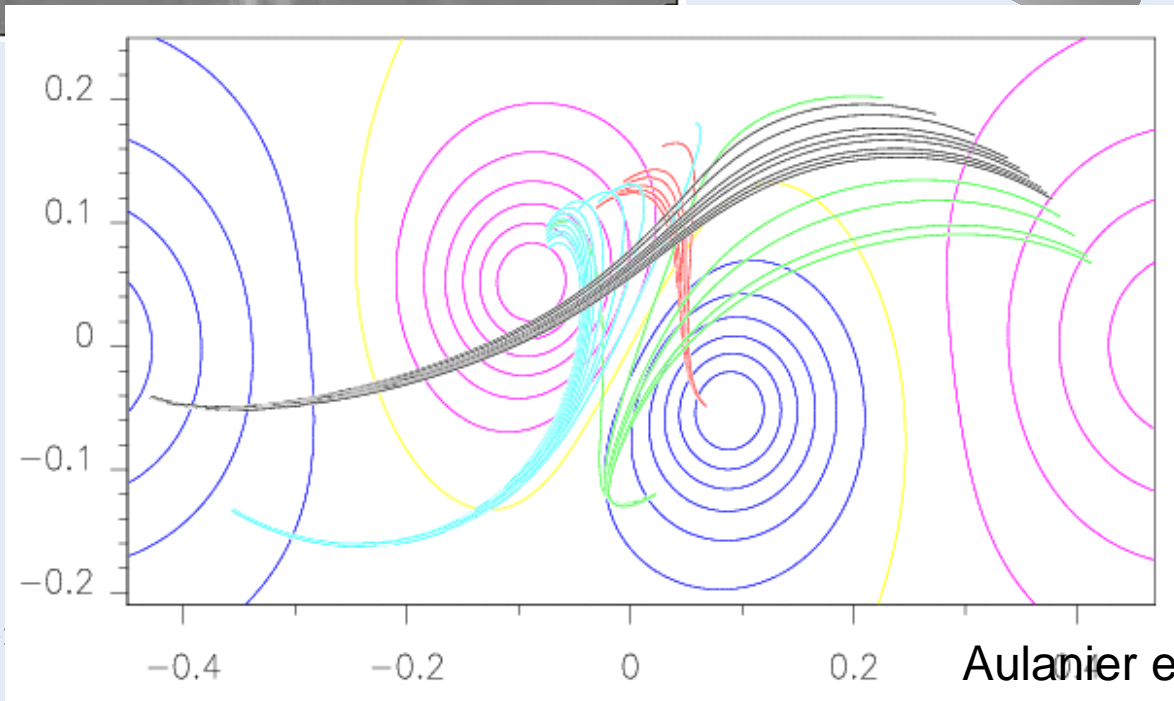
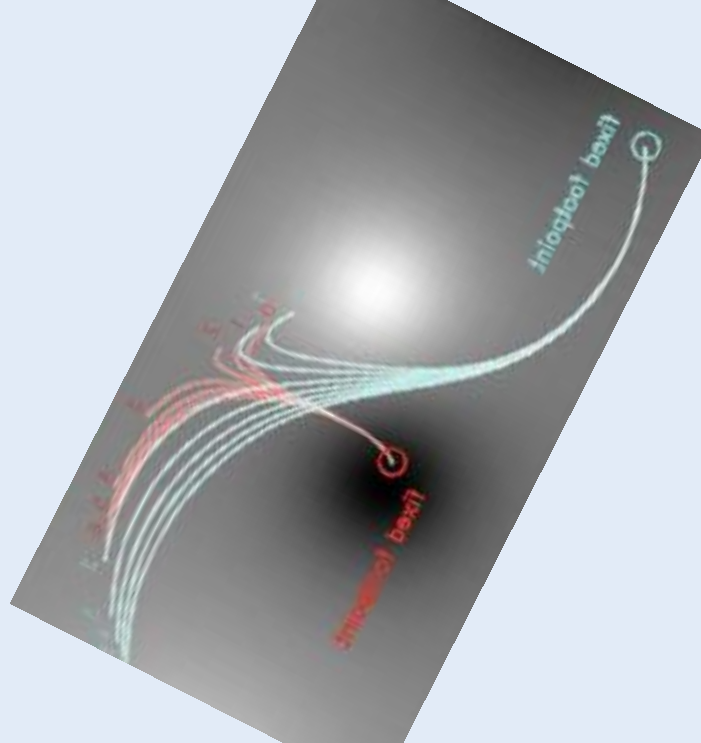
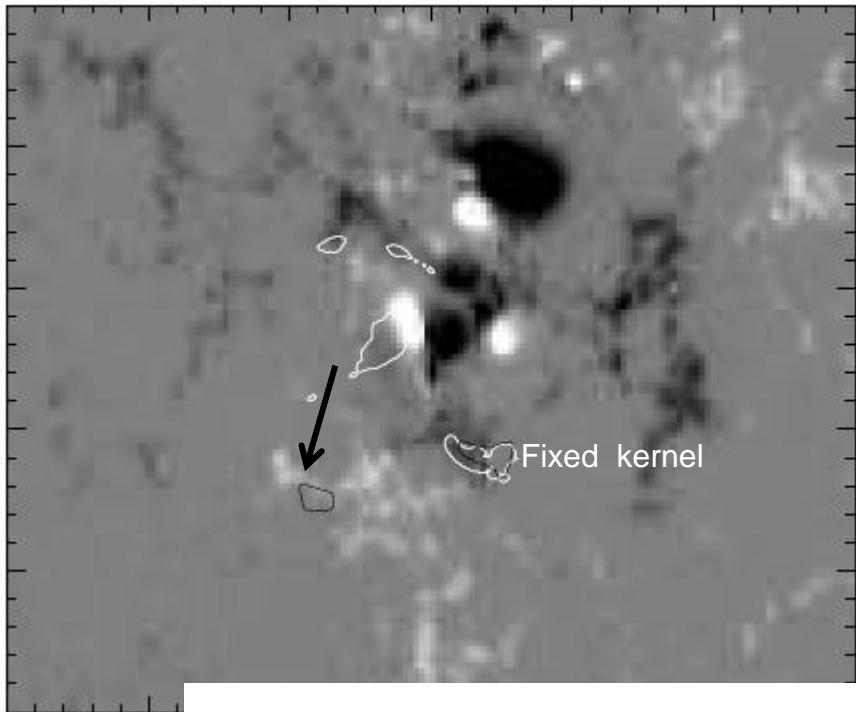


20-Sep-11

Workshop on Physics of the Transition
Region and Corona: 5-7 Sept, IUCAA, Pune



SOHO MDI 17-Nov-2003 09:35:02.657 UT



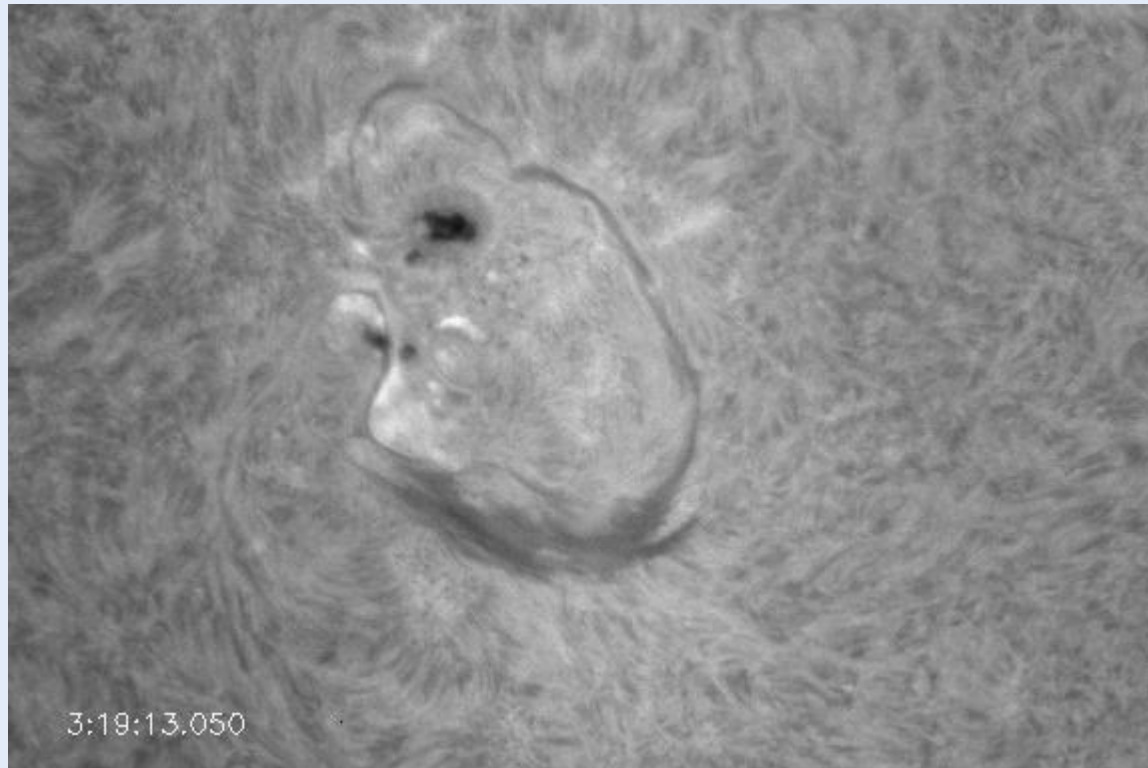
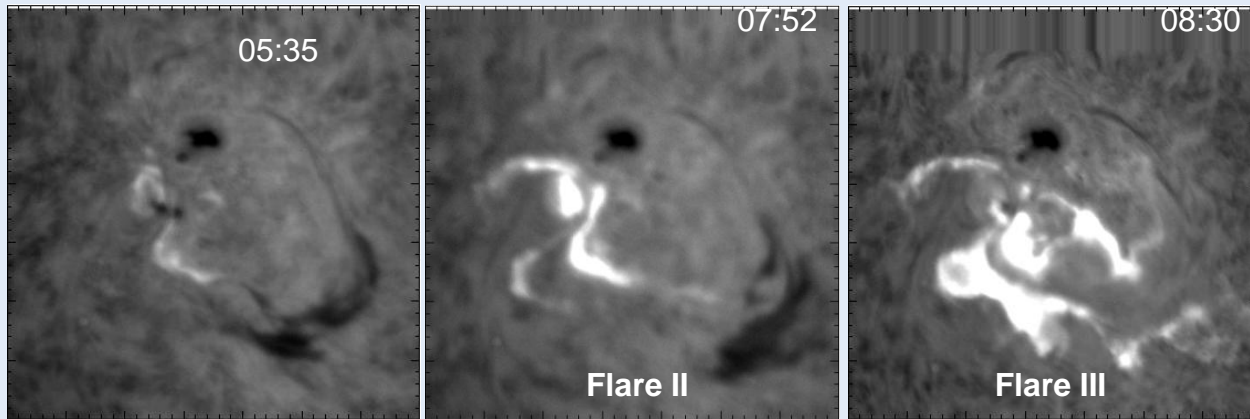
20-Sep-

Aulanier et al, 2006, Sol. Phys.

Another possibility for moving of kernels along the ribbons may be due to asymmetric eruption of filament i.e. one foot-point is fixed and other is erupting as explained by **Tripathi et al 2006** .

But due to our H α data limitations, very difficult to conclude , is it asymmetric eruption.

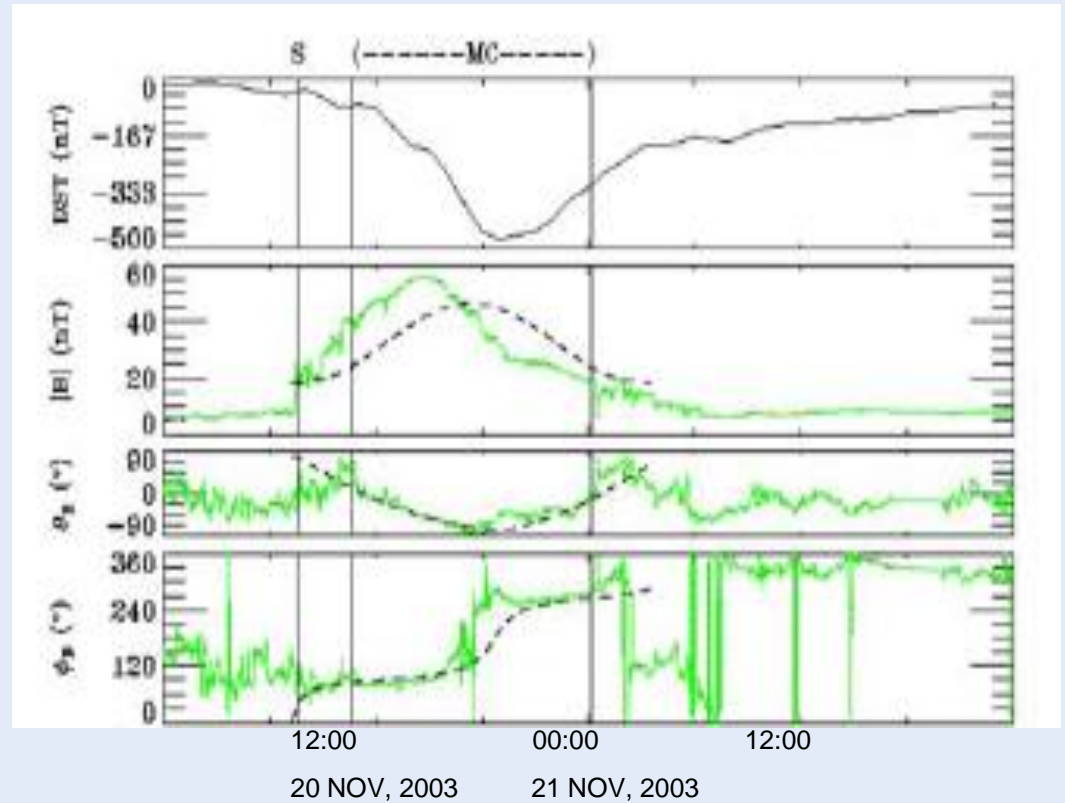
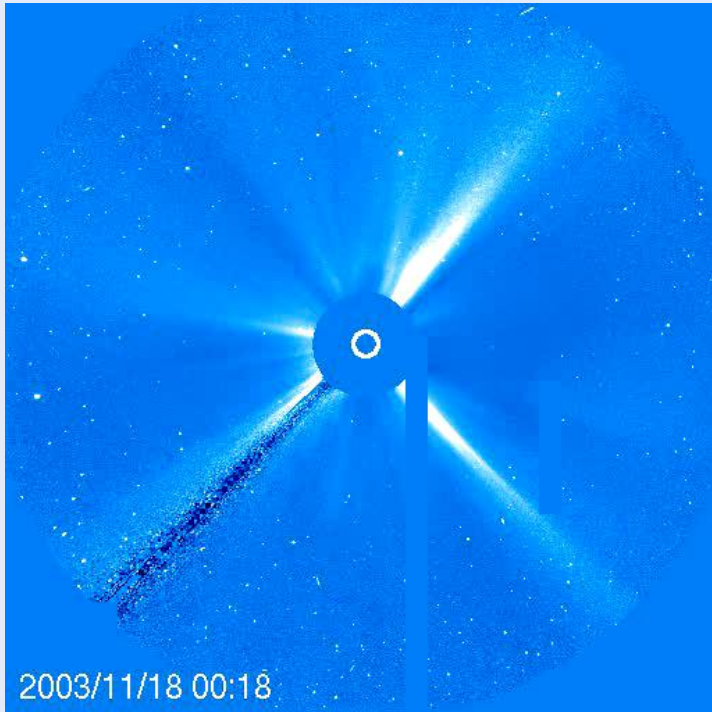
18 November, 2003



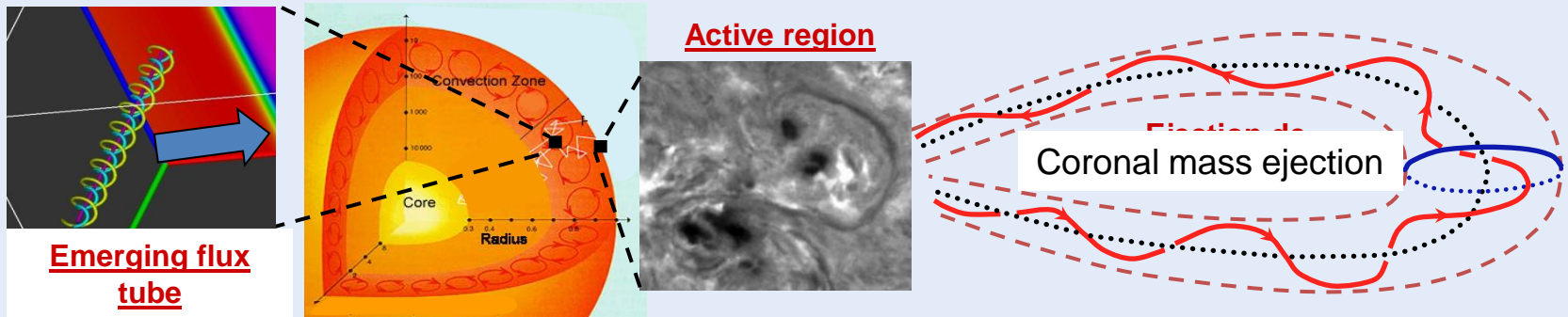
20-Sep-11

Workshop on Physics of the Transition
Region and Corona: 5-7 Sept, IUCAA, Pune Chandra et al, 2010, Solar Phys

Associated magnetic cloud



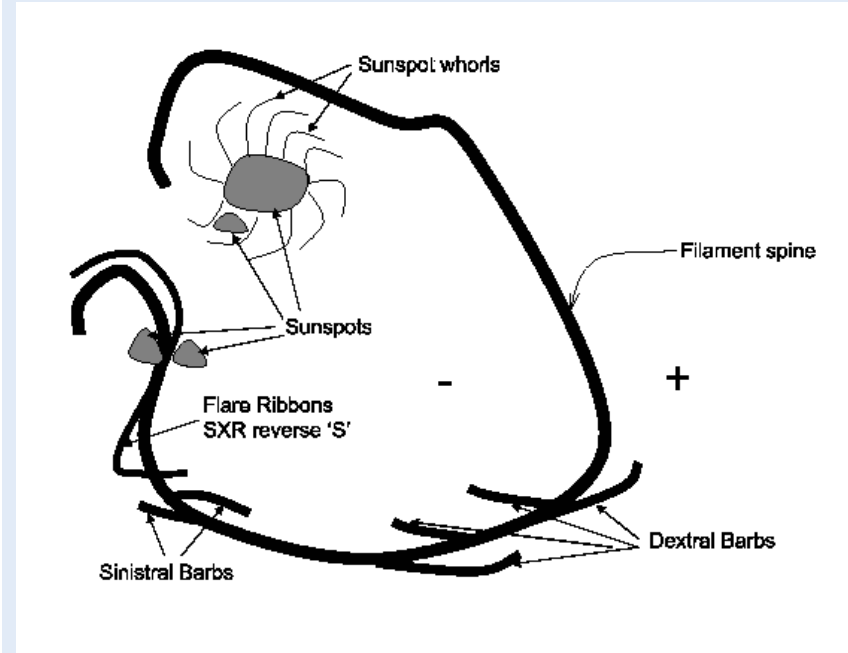
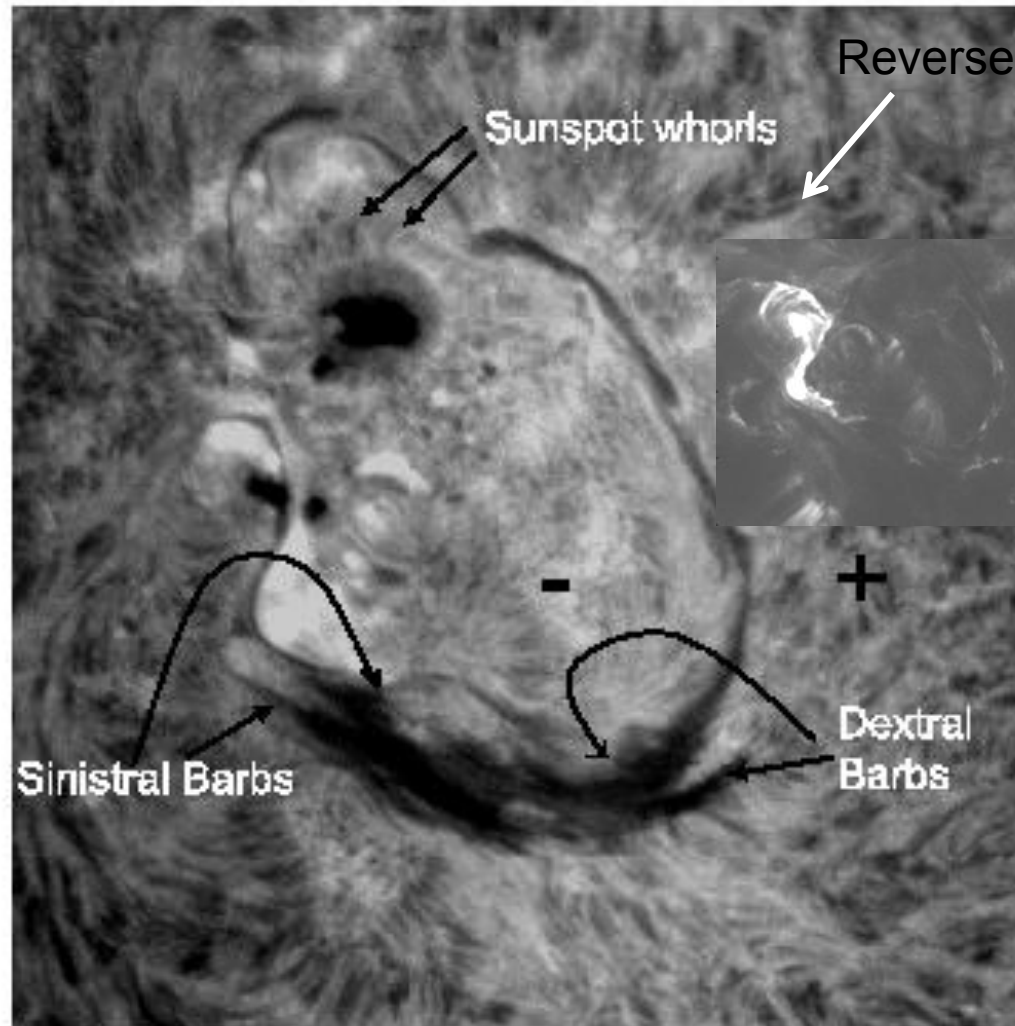
Magnetic Helicity



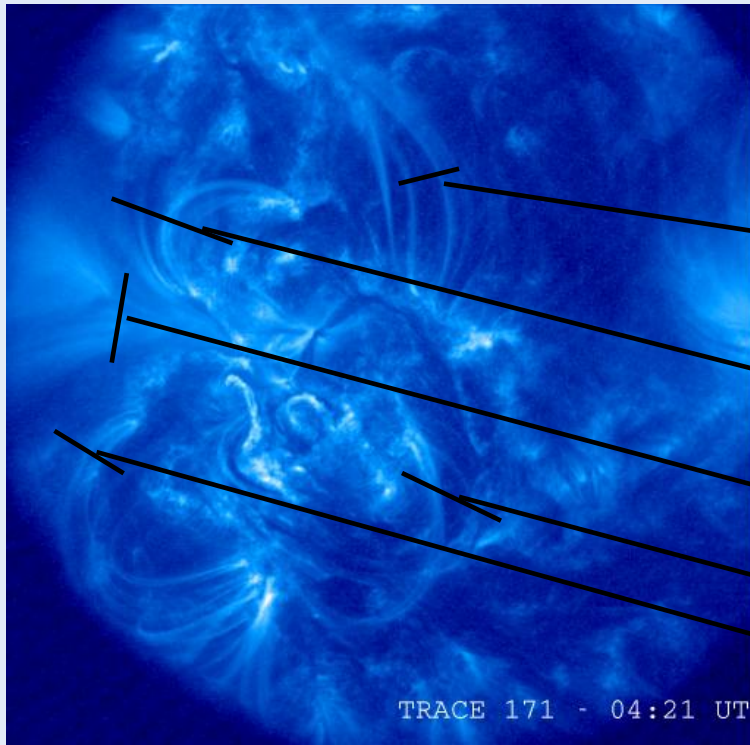
- MC and AR have the same magnetic helicity (Démoulin et 2007)
- Morphology signs of the helicity in AR
- Global : In the corona, using the LFFF extrapolations, alpha best fitting.
- Locally in the photosphere (maps from G_θ Pariat et al 2005)

$$G_\theta(\mathbf{x}) = -\frac{B_n}{2\pi} \int_{S_p} \frac{d\theta(\mathbf{x} - \mathbf{x}')}{dt} B'_n d^2x',$$

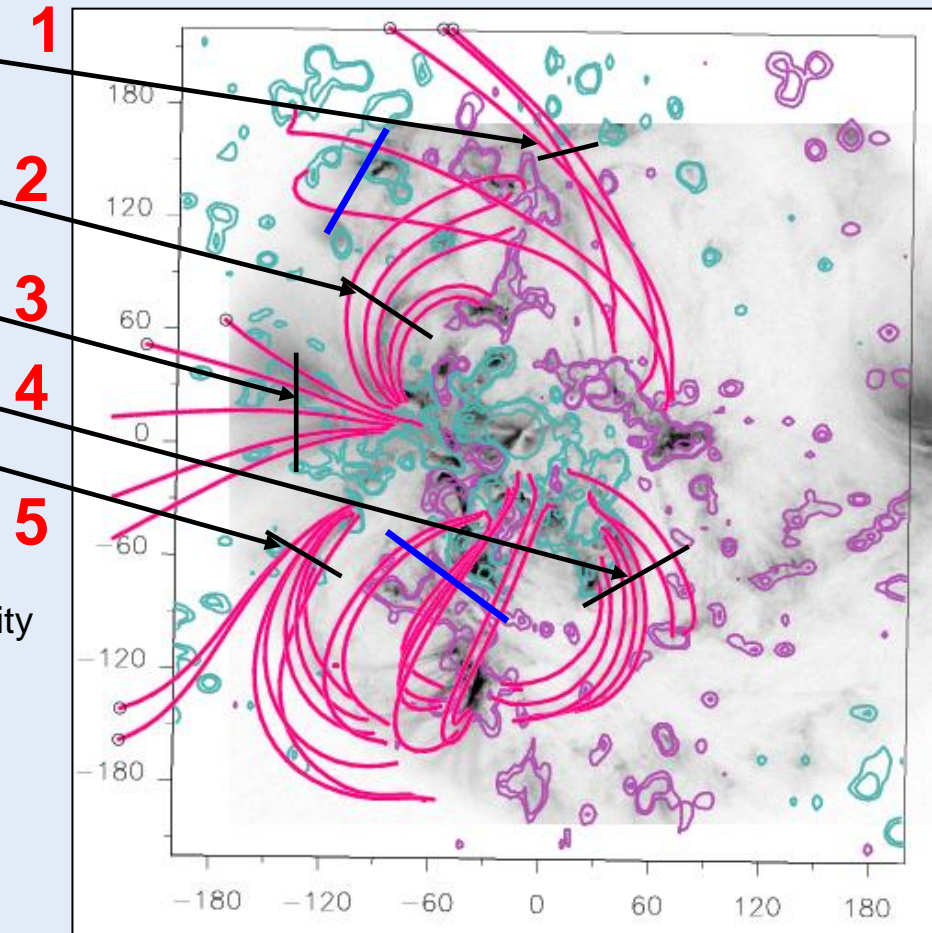
Signs of magnetic helicity of the AR 10501 on 18 Nov. , 2003



Lfff extrapolation: The α values: -1.2 to $-0.6 \times 10^{-2} \text{ Mm}^{-1}$



- Confirm again Negative twist/ negative helicity

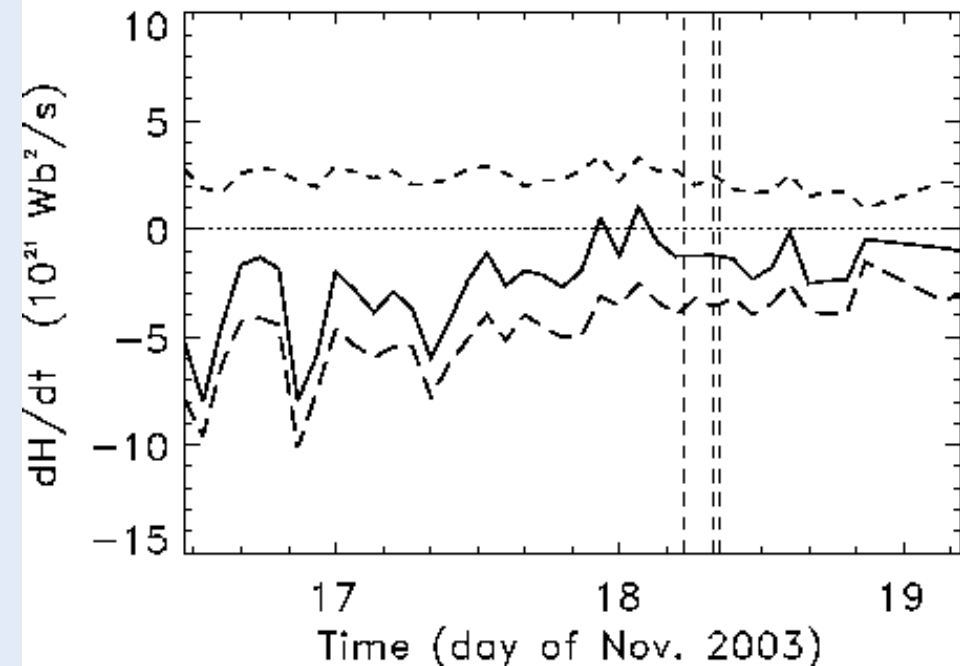


Morphological features \rightarrow Negative magnetic helicity

\neq

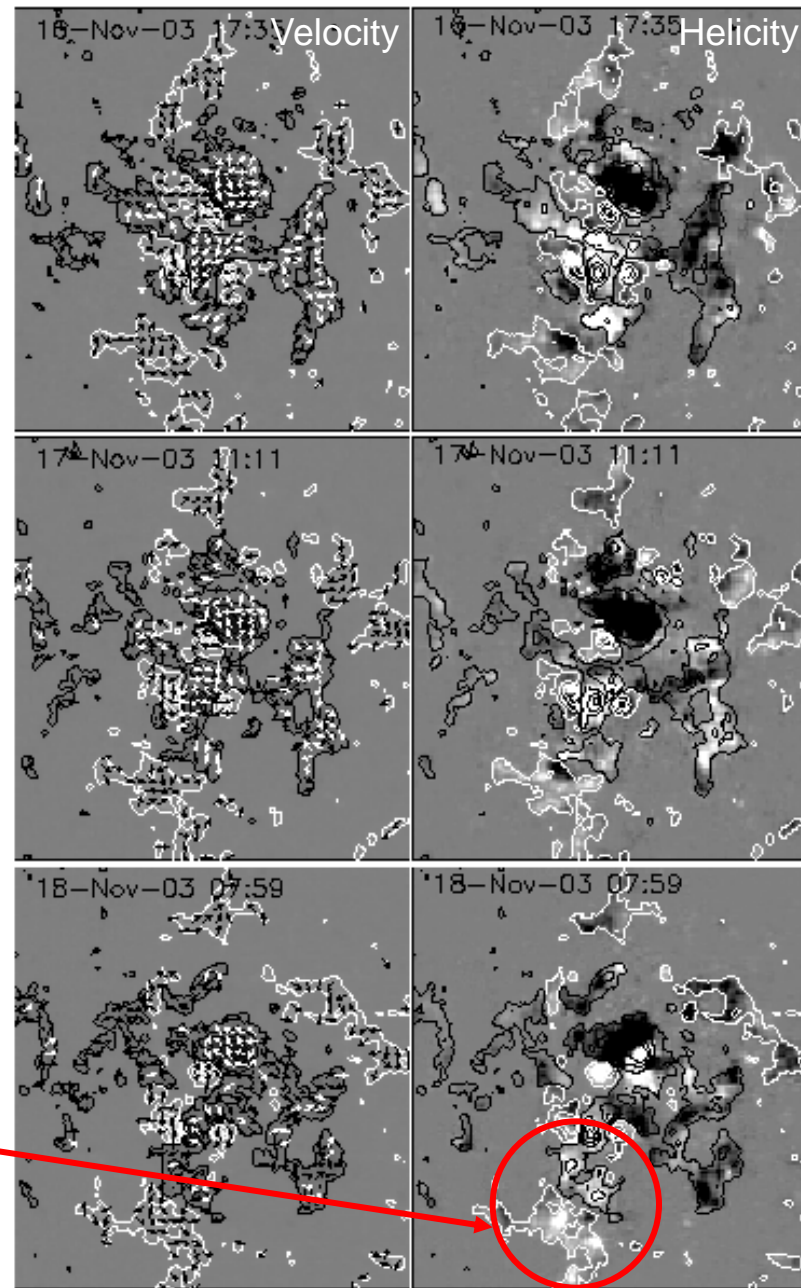
Associated MC \rightarrow Positive magnetic helicity
(Yurshyshyn et al 2005, Mostl et al. 2008)

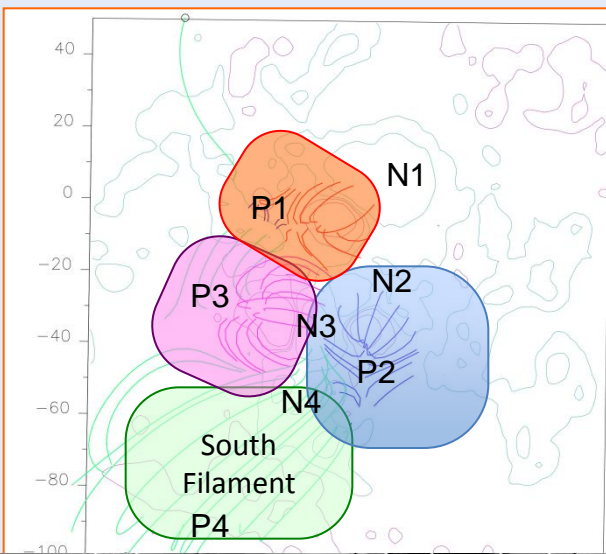
contradiction with the magnetic helicity conservations (?)



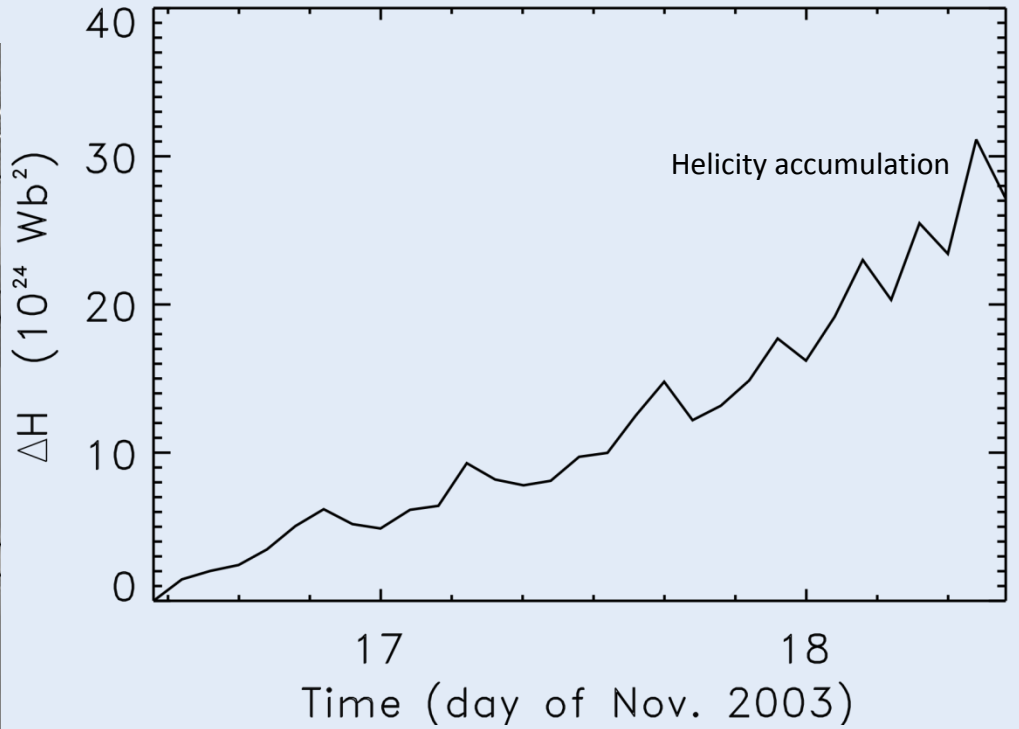
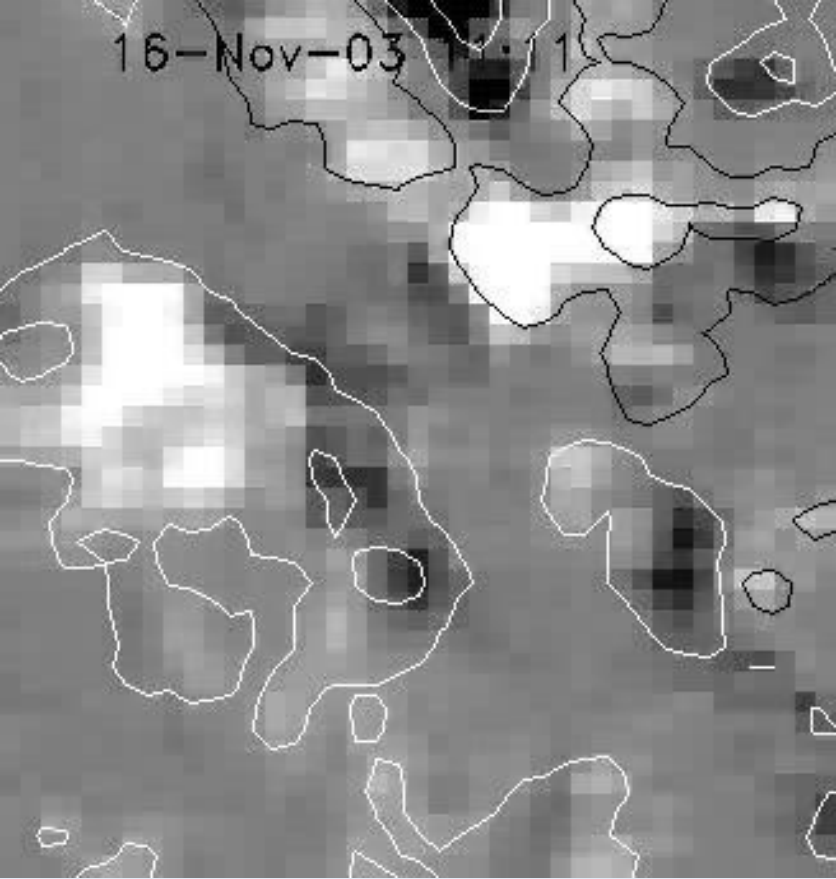
- The dominant negative injection comes from the main negative polarity: account for most of the AR helicity flux

Positive helicity ejection area, where the erupting filament rooted.





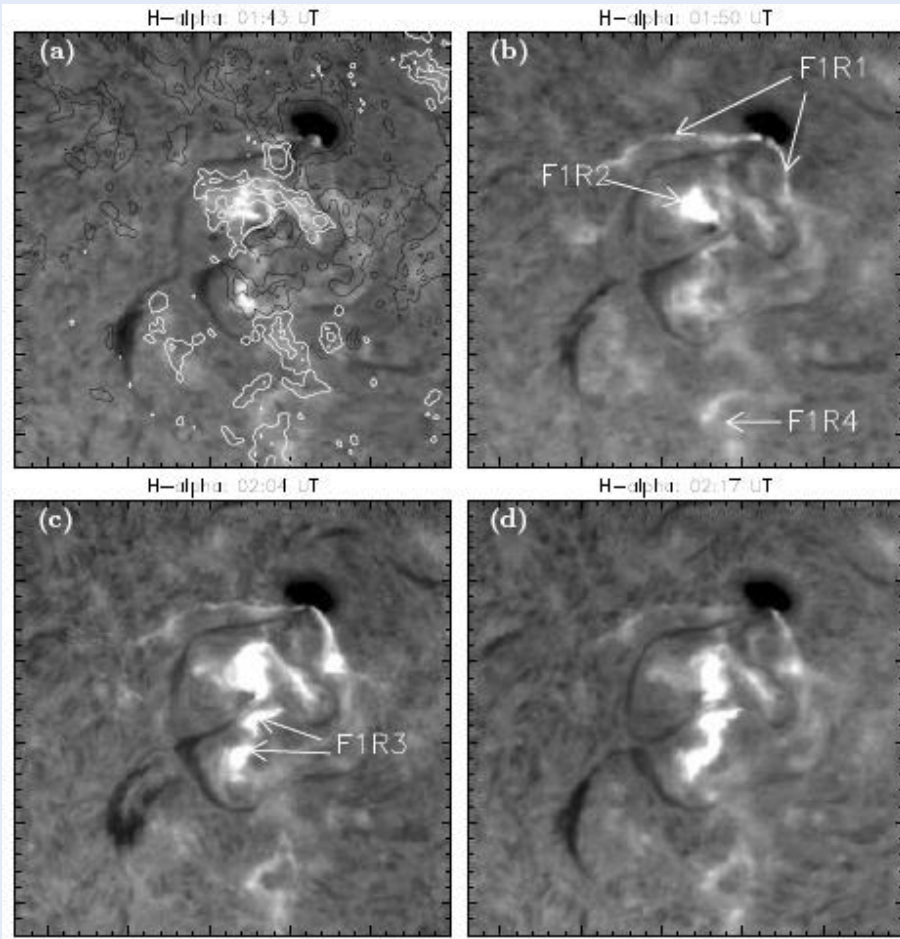
- Helicity maps: some negative patches but it is mostly positive.
- Helicity fluxes: It is constantly dominated by the positive flux. There is a net positive injection!
- The integrated flux is positive and much larger than in P2 & P3. More than 3×10^{41} Wb² are accumulated in 2 days here. So most of the positive injection comes directly here!



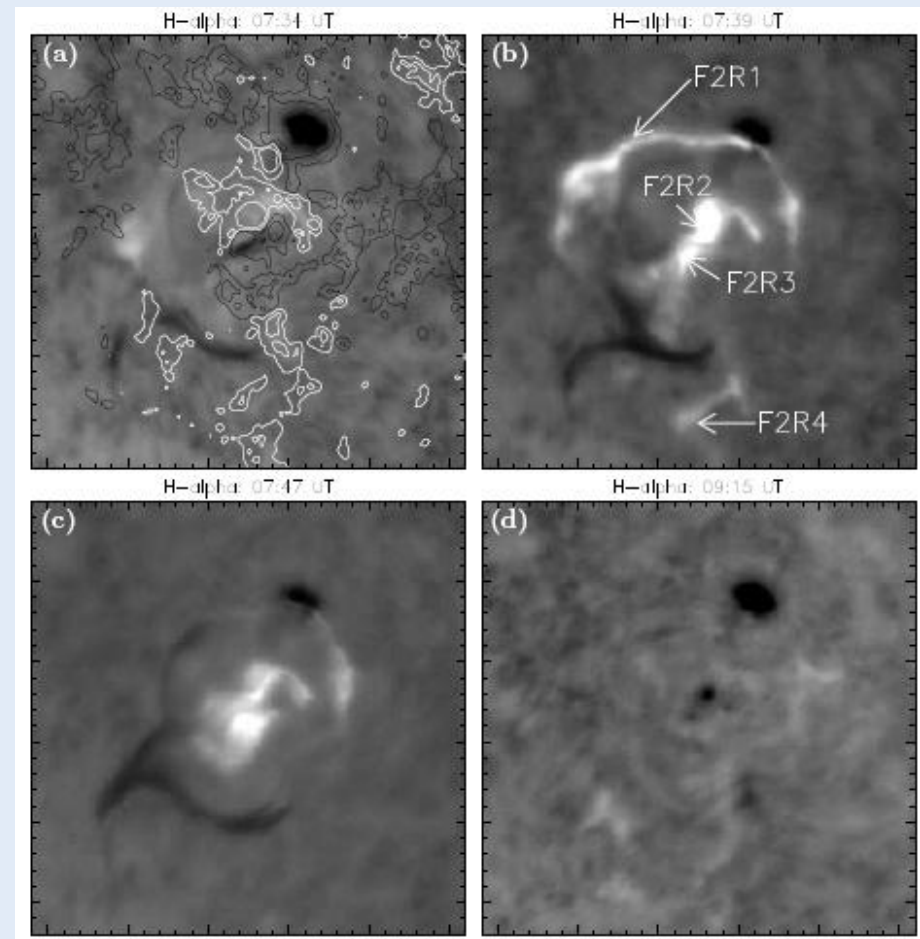
Chandra, Pariat, Schmieder et al 2010, Solar Phys.

Workshop on Physics of the Transition Region and Corona: 5-7 Sept, IUCAA, Pune

Homologous Flares from NOAA AR 10501 on 20 Nov, 2003

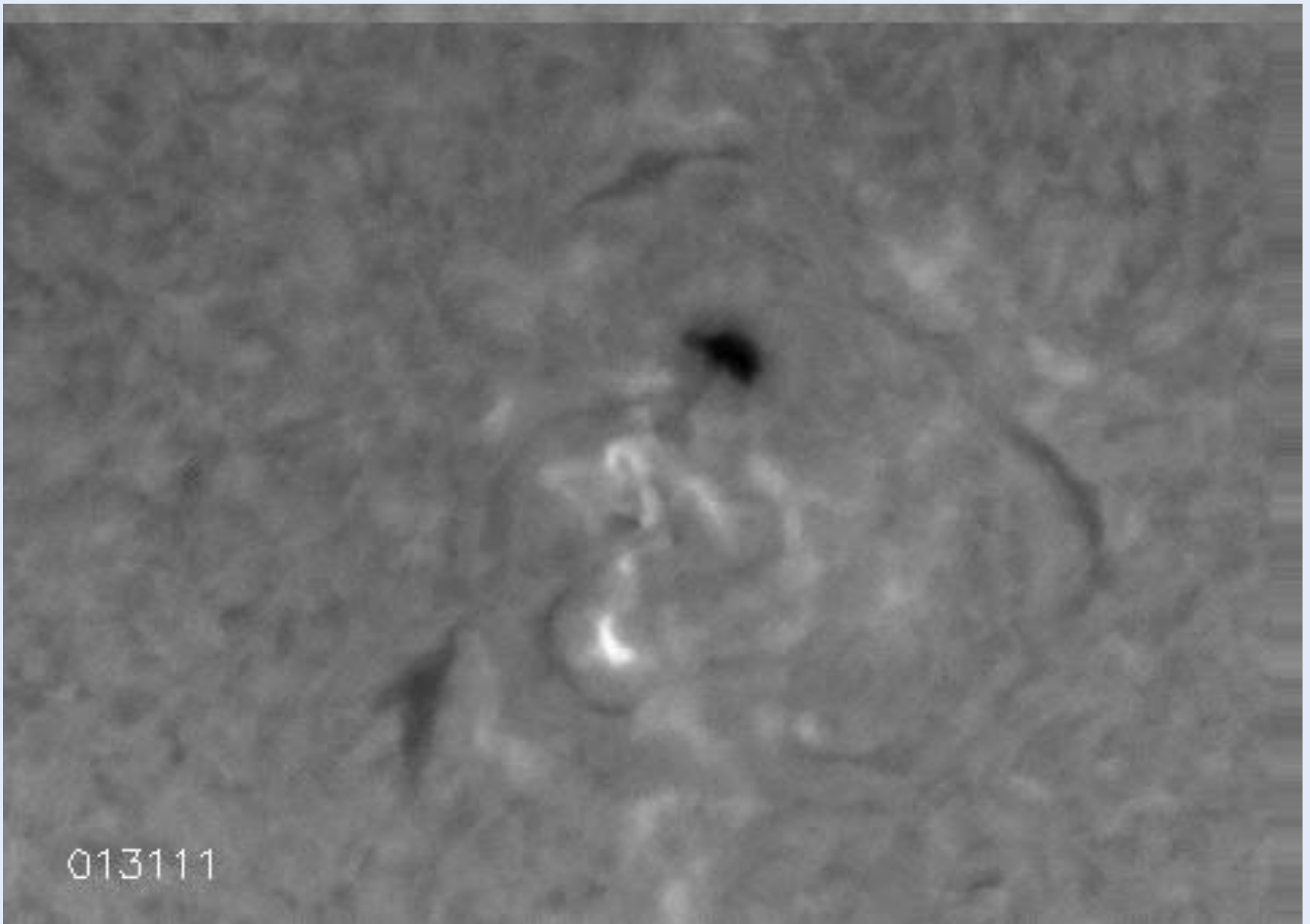


M1.4/ 1N Flare



M1.4/2B Flare

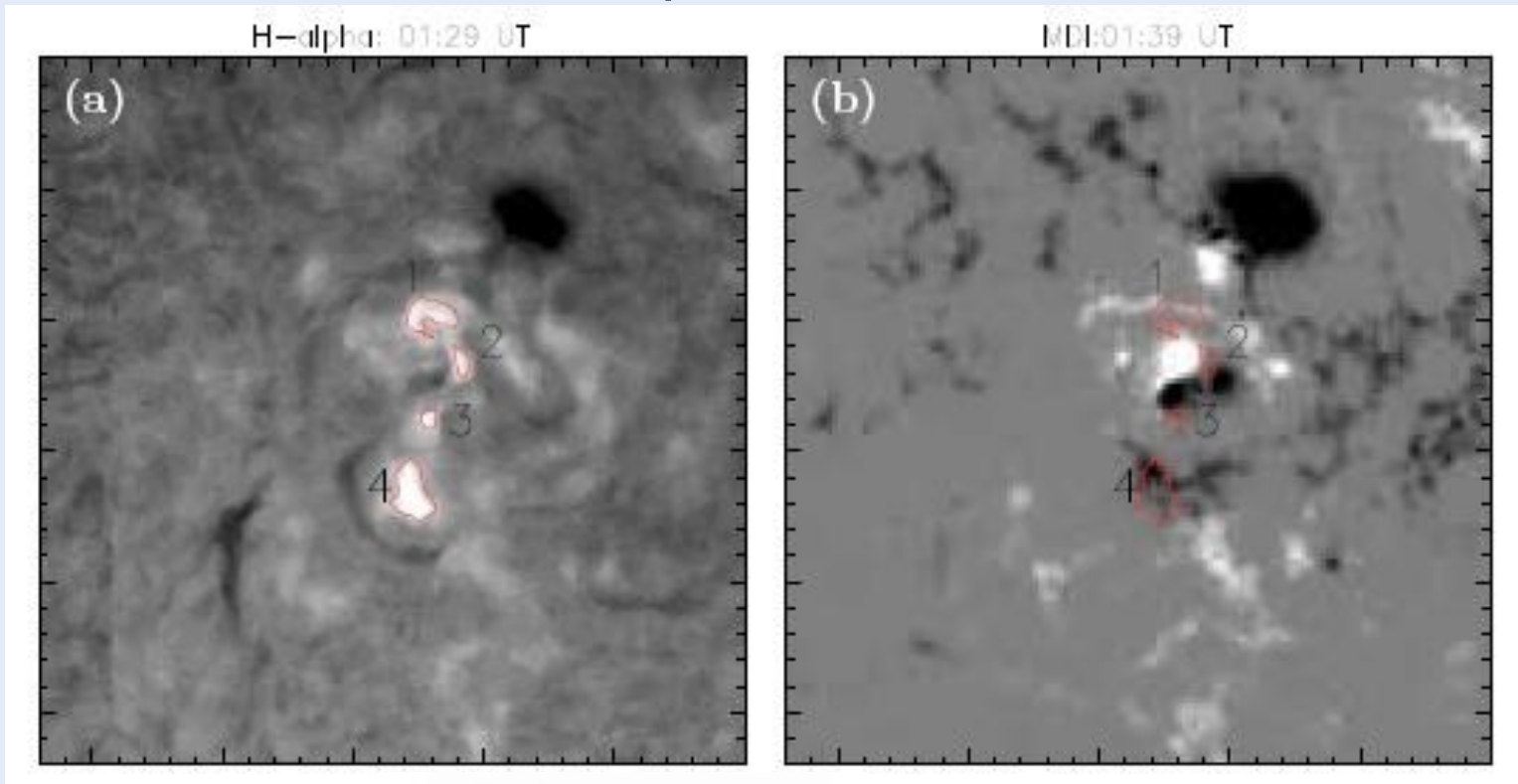
Chandra, Schmieder, Démoulin et al 2011, *Solar Physics*
Schmieder et al, 2011, *Adv. space Research*



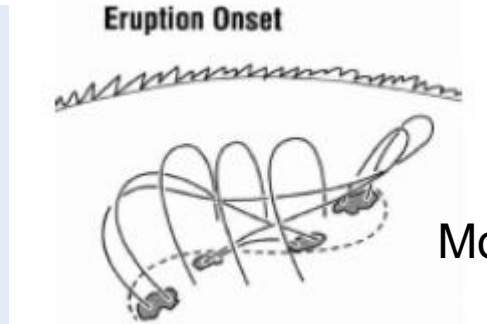
20-Sep-11

Workshop on Physics of the Transition
Region and Corona: 5-7 Sept, IUCAA, Pune

Possible interpretations of flares



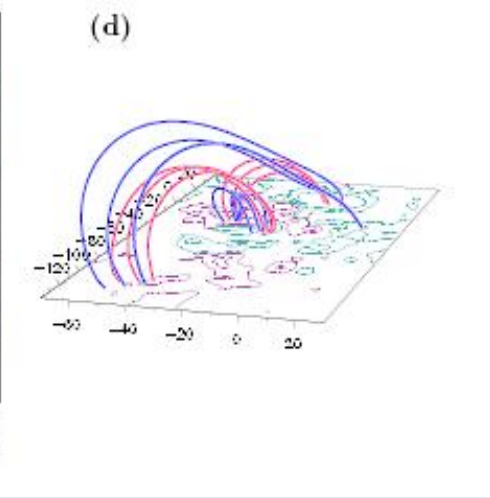
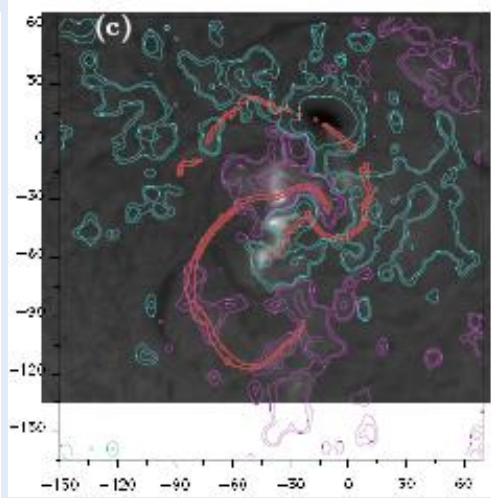
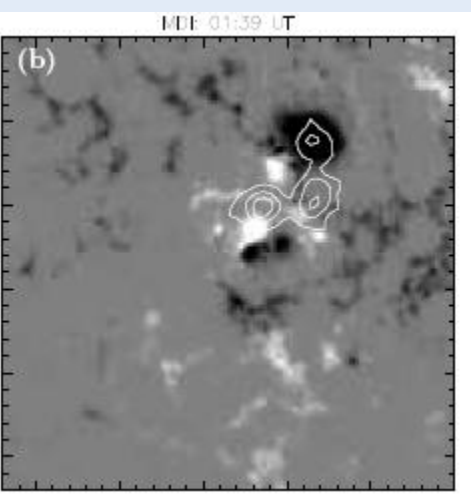
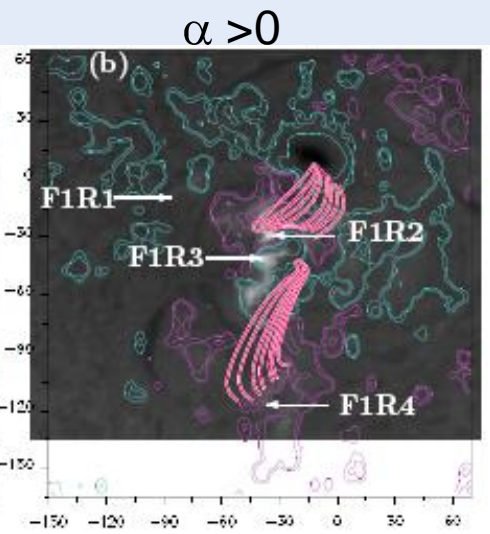
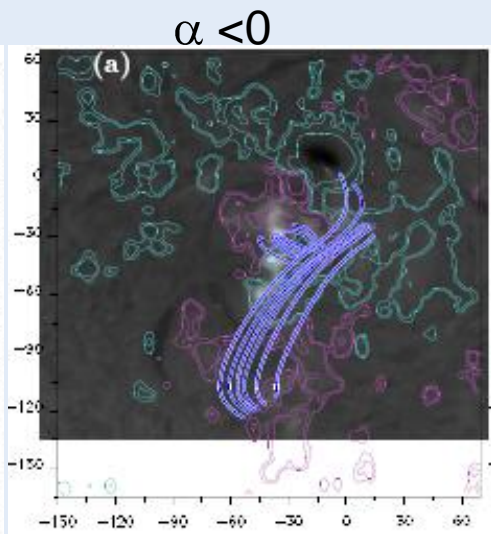
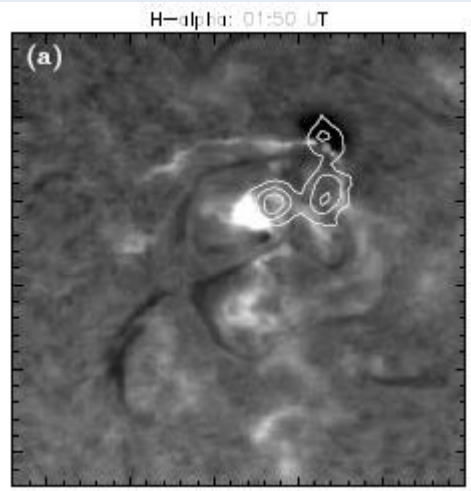
Eruption Onset



Moore et al, 2001

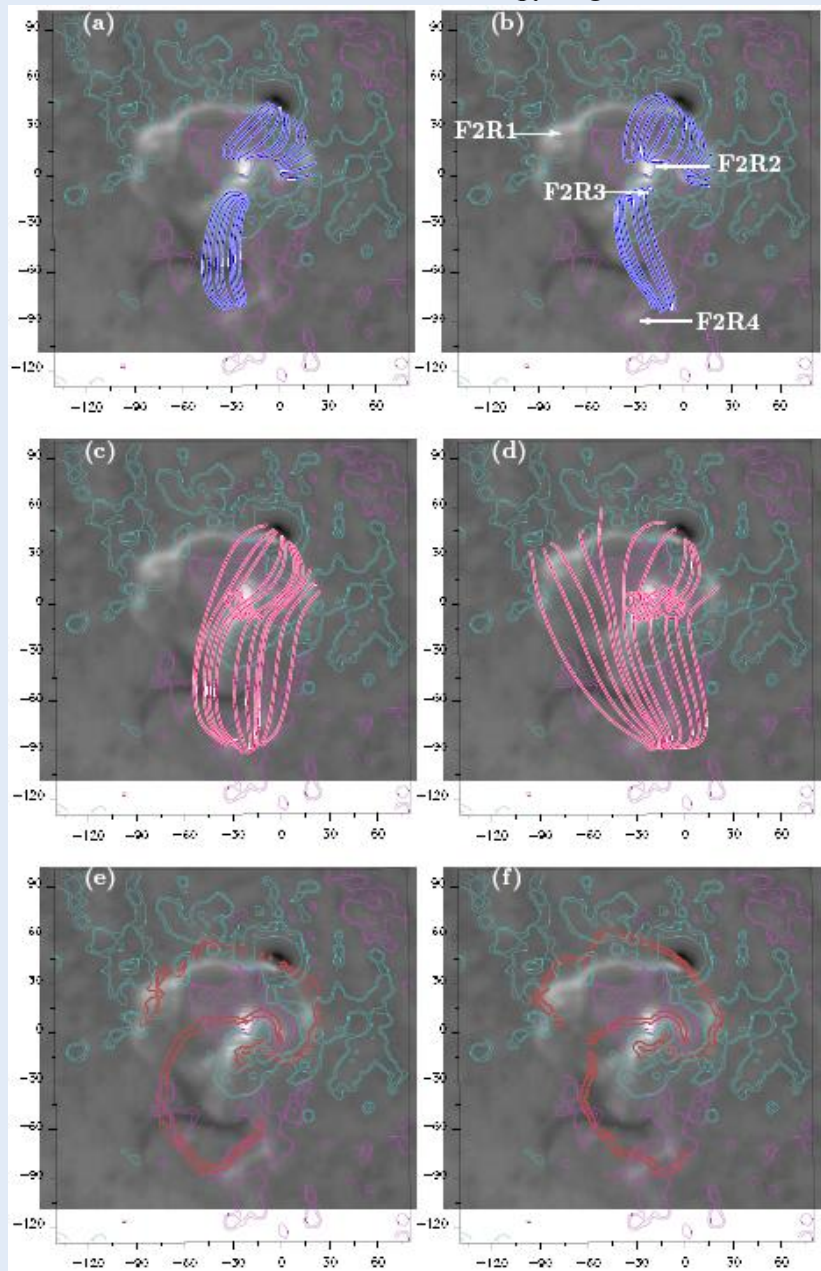
- During the pre-flare phase, we observed four ribbons in locally bipolar active region.
- This is the evidence of Tether cutting model.

However, looking at the RHESSI observations and magnetic field extrapolations



- Support the Magnetic breakout model. (from the RHESSI sources)

- Reconnection changed From F1R2-F1R3, F1R1 -F1R4 To F1R1-F1R2, F1R3-F1R4

$\alpha < 0$ $\alpha > 0$ 

- Also support the Magnetic breakout model. However, Reconnection changed (from the ribbon separation)

From :

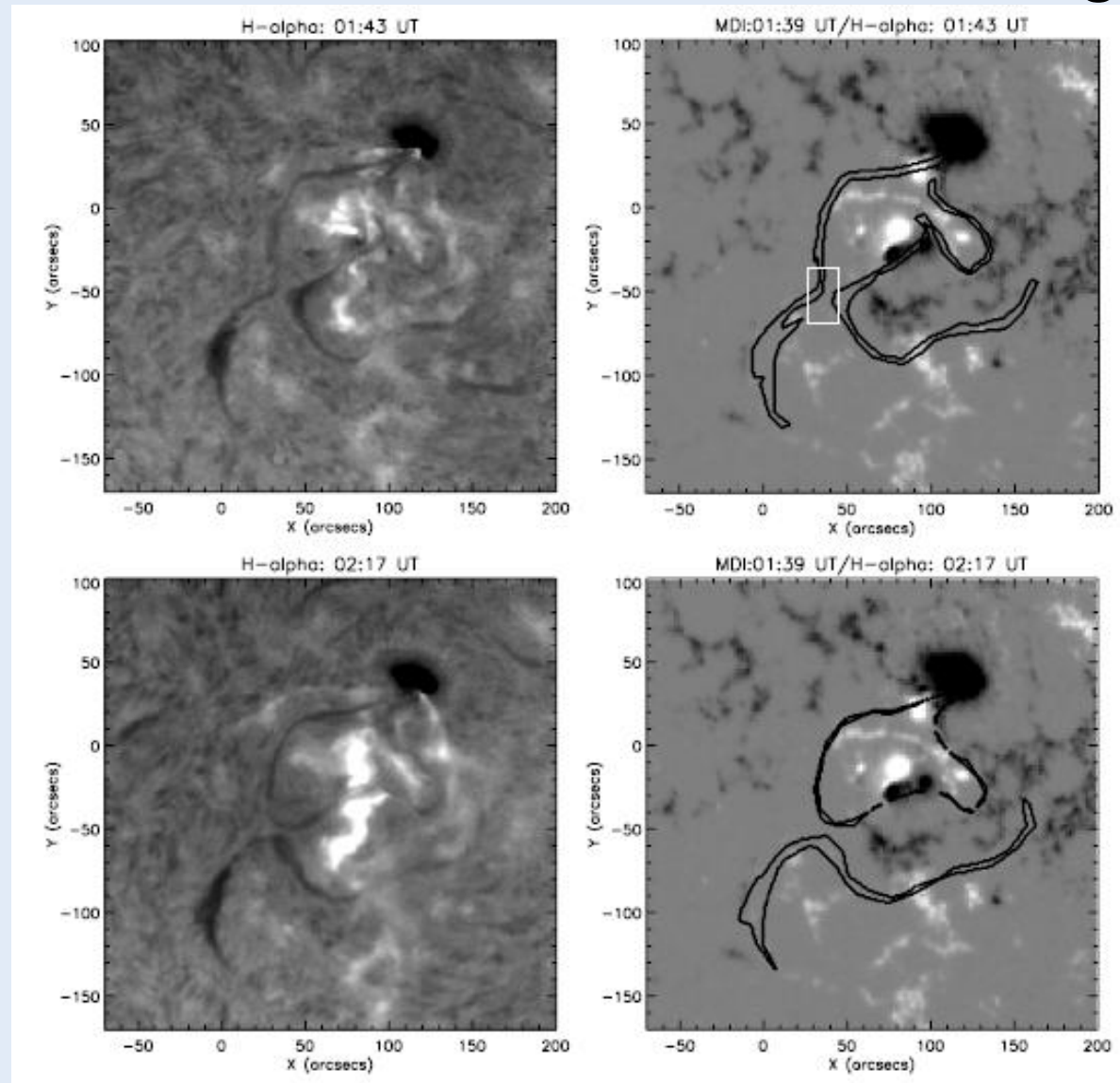
F2R1- F2R2 , F2R3-F2R4

To

F2R2 -F2R3, F2R1-F2R4

Which is contrary to first flare. Sometime this is called lateral magnetic breakout as reported by Goff et al. (2007) and by Karpen et al. (1998)

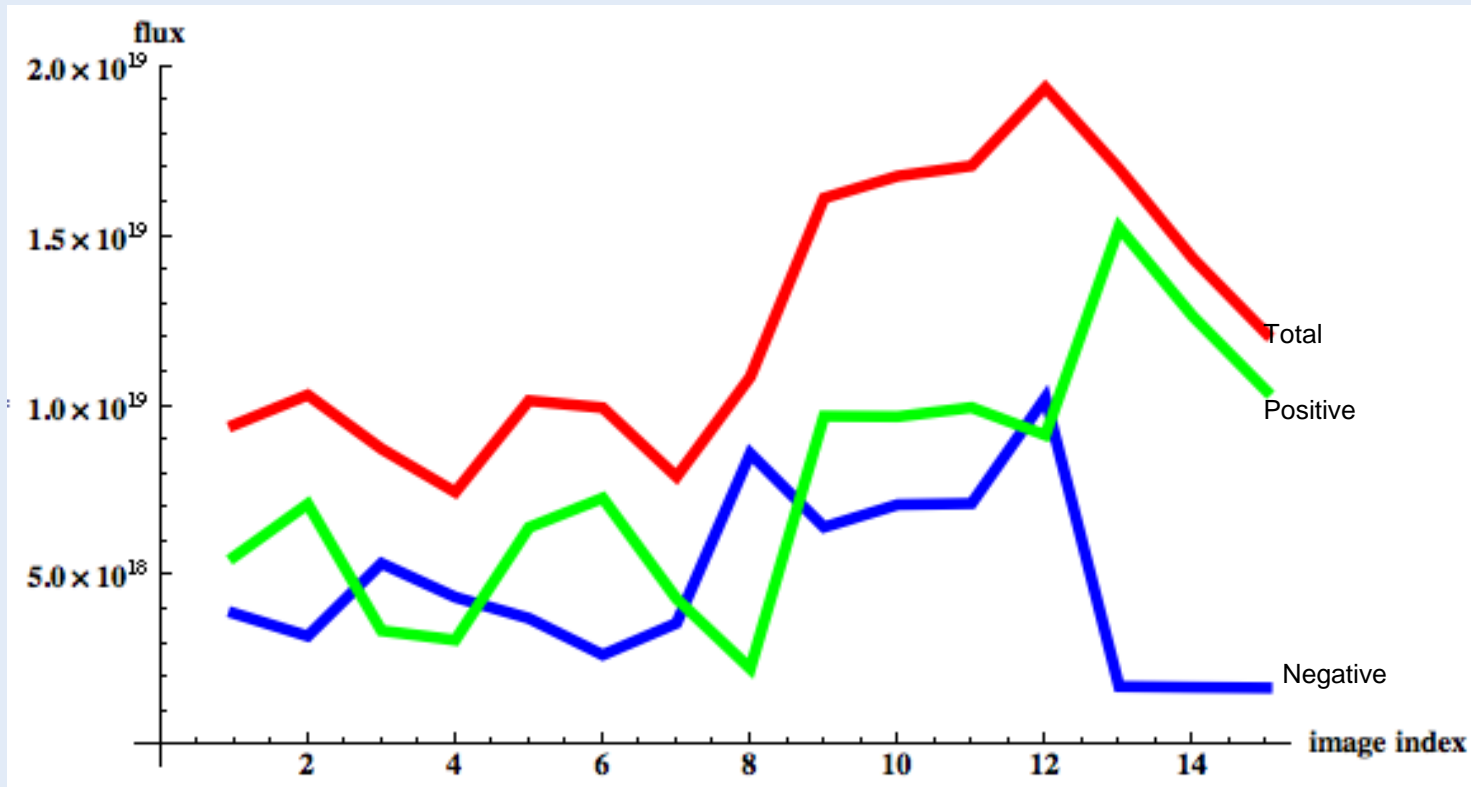
Filament reconnection in the active region

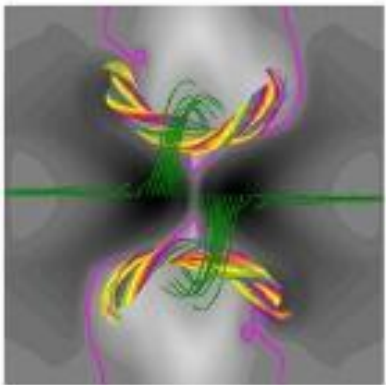
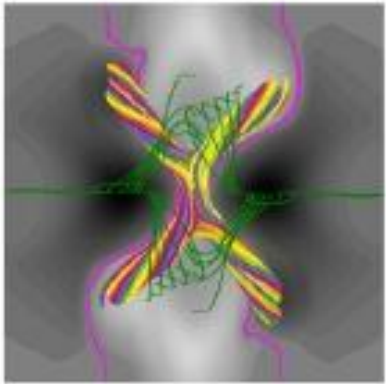
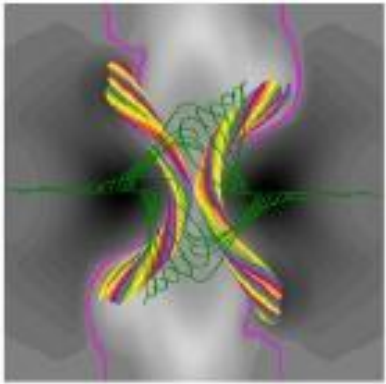


Torok, Chandra, Pariat et al 2011, ApJ

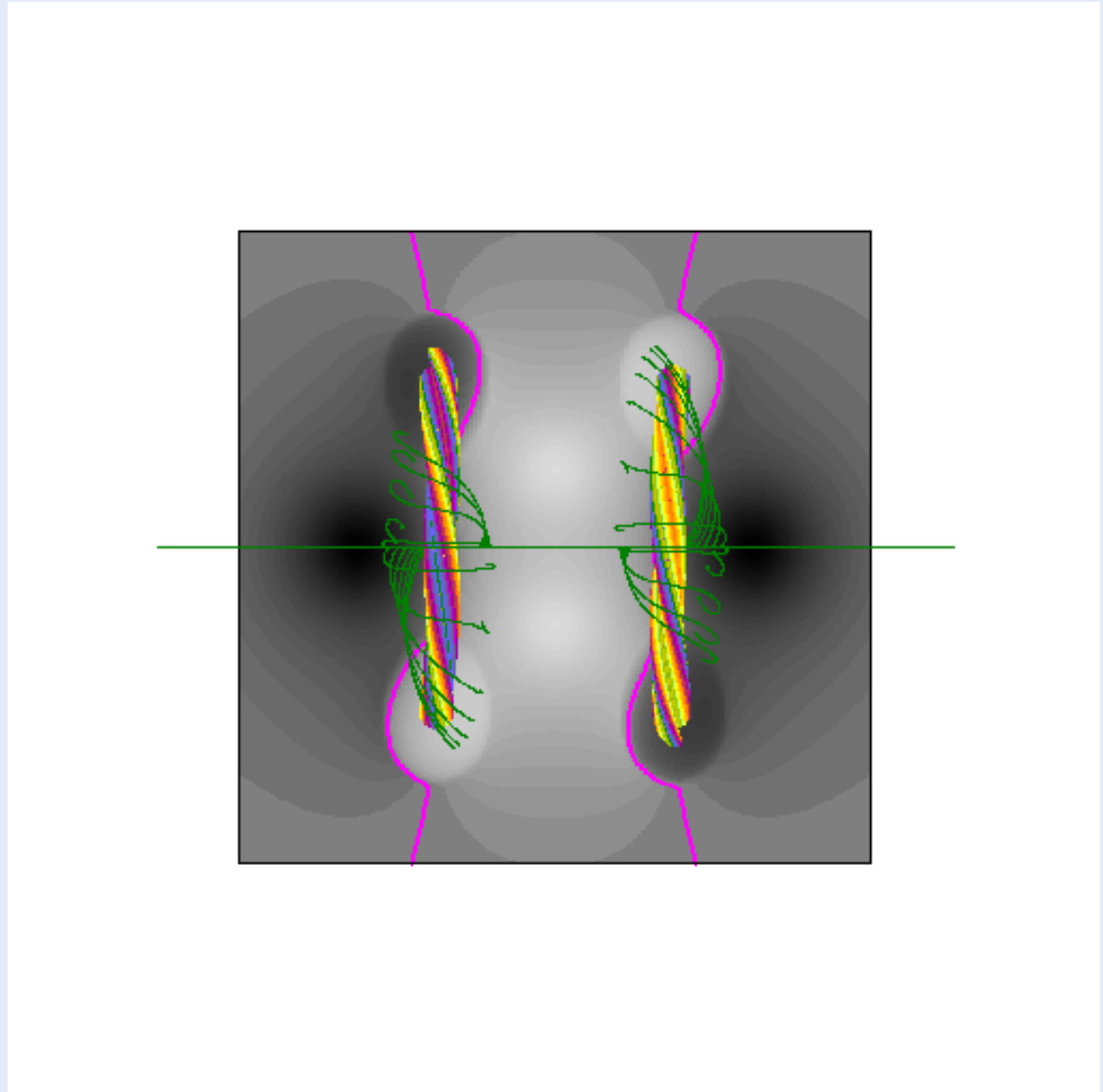
Simulation parameters are set by the observational parameters

- Before the reconnection of filaments (around 5 hrs), we observed decrease in positive flux.
- Based on the end point of filaments, the filaments are dextral (negative helicity) in nature.



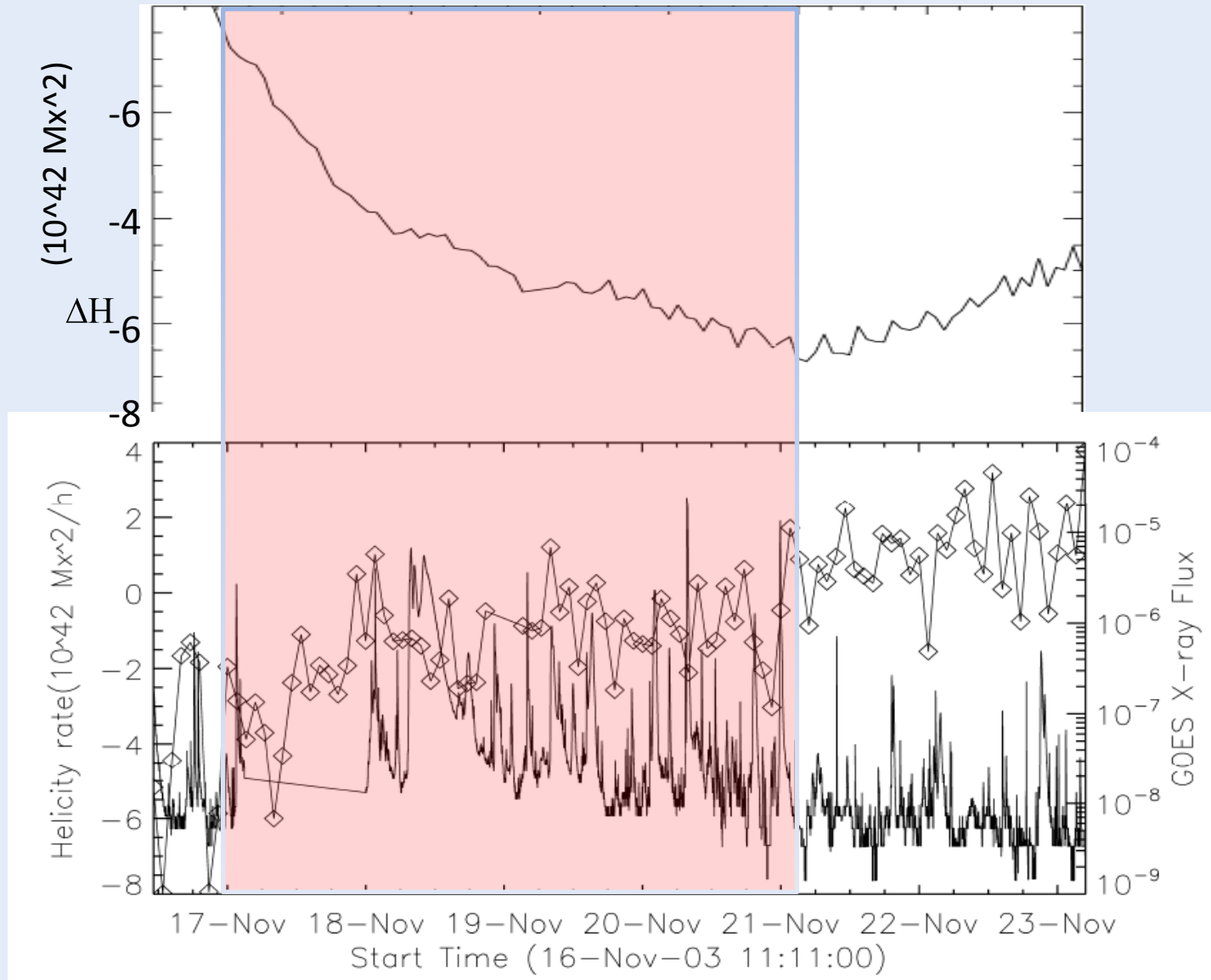


20-Sep-11



Workshop on Physics of the Transition
Region and Corona: 5-7 Sept, IUCAA, Pune

Helicity and flares in the active region NOAA 10501



Properties of active region NOAA AR 10501

- **Emerging active region**
- **Rotating sunspots**
- **Cancellation**
- **Mixed helicity sign**
- **Largest Geomagnetic storm of solar cycle 23rd**
- **Filaments reconnection**
- **Clear Evidence of tether cutting and breakout models**
- **Evidence of slip-running reconnection**

THANKS