Hinode observation of the vector magnetic fields in a sunspot light bridge accompanied by chromospheric plasma ejections

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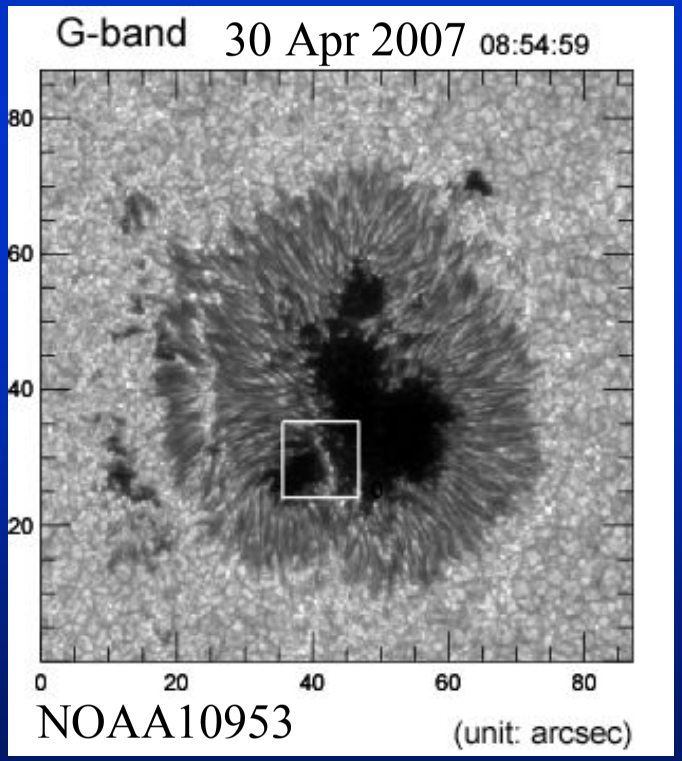
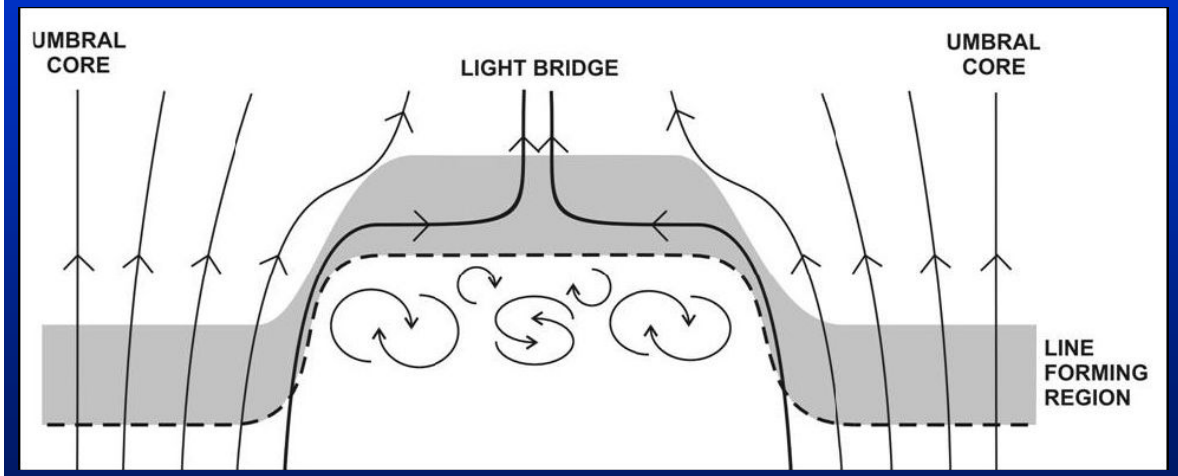
Sunspot light bridge and activities

- Light bridge (LB) – One of fundamental structures in sunspots
  - Penumbral (filamentary) structure or cell structures by convection
  - Lower field strength, more horizontal than in the neighboring umbrae
  - Field-free convection penetrates a strong magnetic field and forms a cusp-like magnetic field.



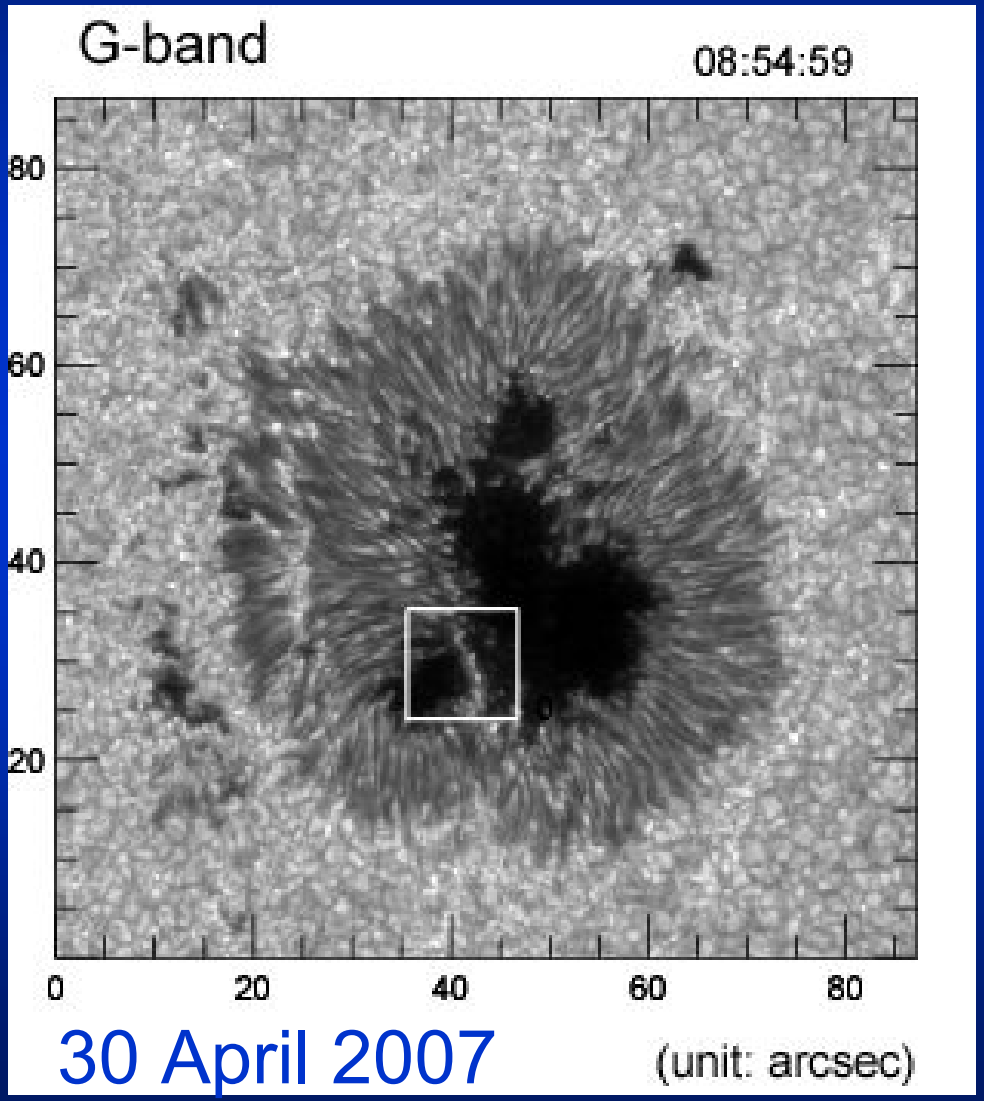
- Chromospheric activities
  - Long-lasting plasma ejections or surges (e.g., Asai et al. 2001, Bharti et al. 2007)
  - Brightness enhancement with TRACE1600A (Berger & Berdyugina 2003)



(Jurcak et al. 2006)

Observation : SOT SP + BFI

NOAA10953 : 29-30 April 2007



SP:
M-E inversion +
180 deg azimuth ambiguity resolution by AZAM

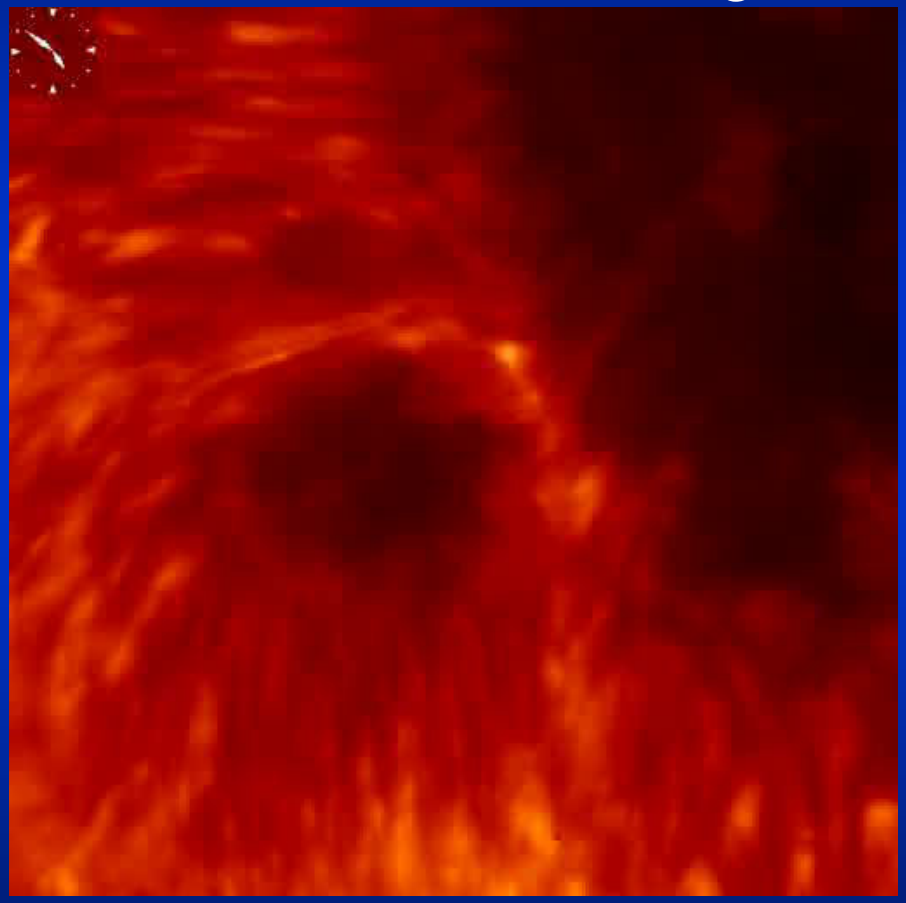
BFI（CaIIH, G）+
SP co-alignment:
shimizu et al. 2007 PASJ

Recurrent chromospheric plasma ejections

NOAA10953：30 April 2007

SOT/BFI - Ca II H filtergram

For reference： XRT – X-ray
（with different FOV size）



Loop brightenings (microflares) – One of their footpoints is located near the LB, but not exactly. They are not hot component of chromospheric ejections.

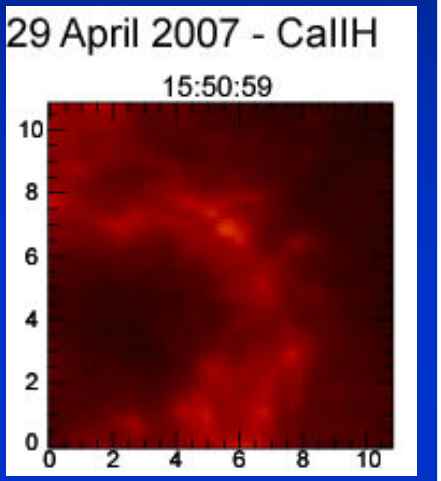
Recurrent chromospheric plasma ejections

- Recurrent ejections
  - 29 April　Nothing happened before 19:50UT.
  - 30 April　Occurred in almost all the periods. Continued until 1 May.

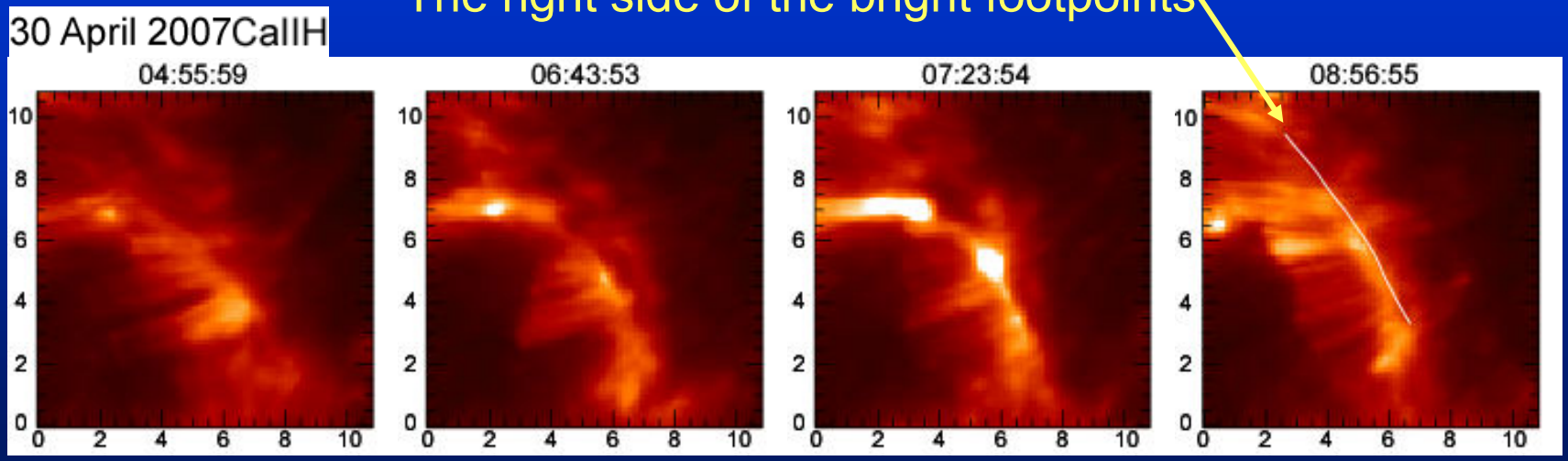
  ※ What changed magnetically from 29 April to 30 April?
- Physical parameters of ejections
  - Apparent　length: 1,500-3,000km, speed: 6-40km/s
  - Inclination of magnetic field at the footpoints (SP data)

    166.7deg from LOS direction
    - Estimated length　6,500-13,000km
    - Estimated upward speed　26-180km/s

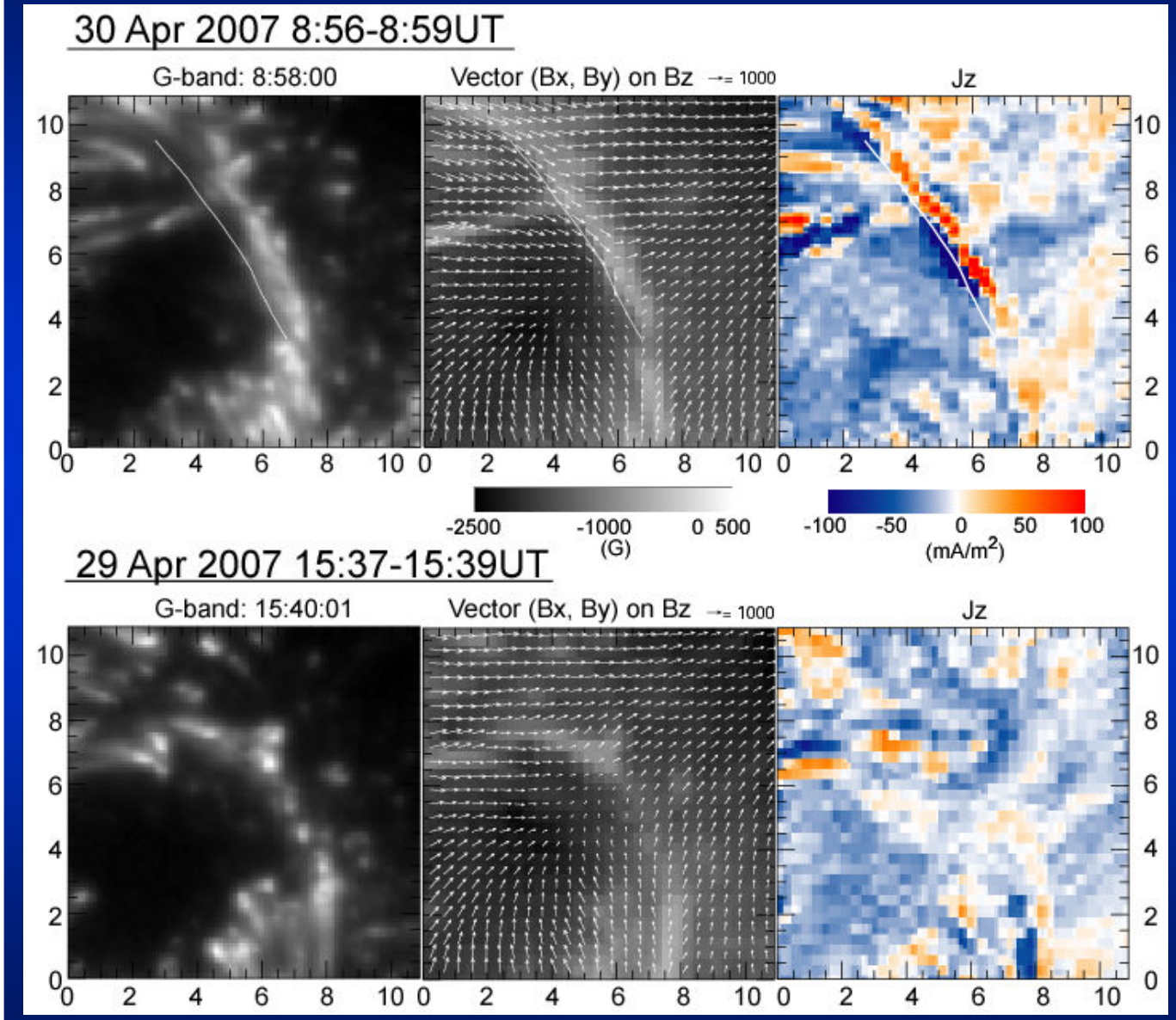
NOAA10953



The right side of the bright footpoints



Magnetic field and Vertical current at LB



Magnetic field at LB
B 700-1700G
γ 120-140deg
(90deg=horizontal, 180deg=vertical)

c.f. Umbral field
B 2000G

Current density (J_z)
Red: 60 - 175 mA/m^2
(along B,
J =80-230 mA/m^2)
Blue:100 - 220 mA/m^2

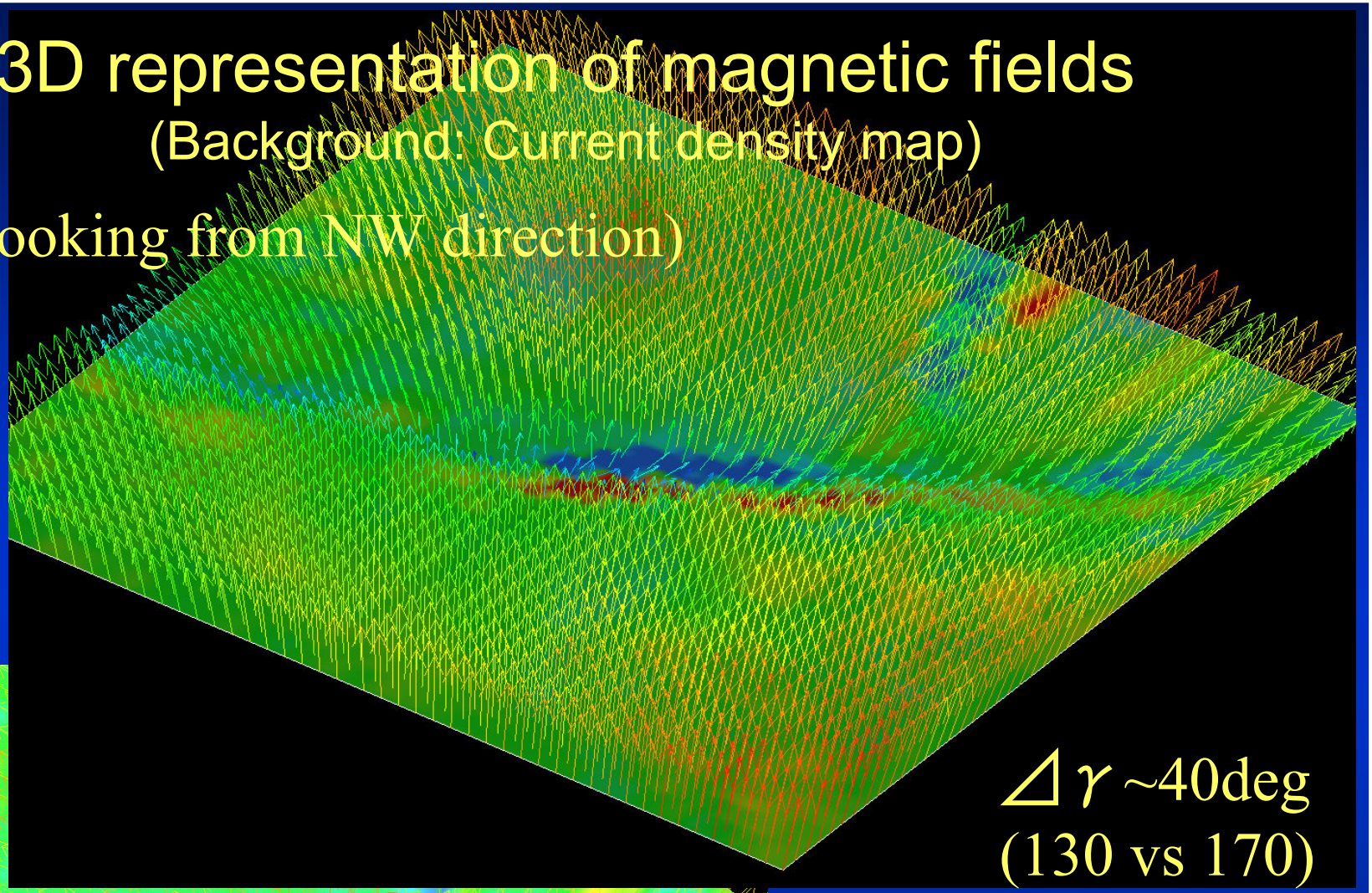
c.f. Blue in umbra
10-20 mA/m^2

Indicates a highly inclined and twisted magnetic tube.

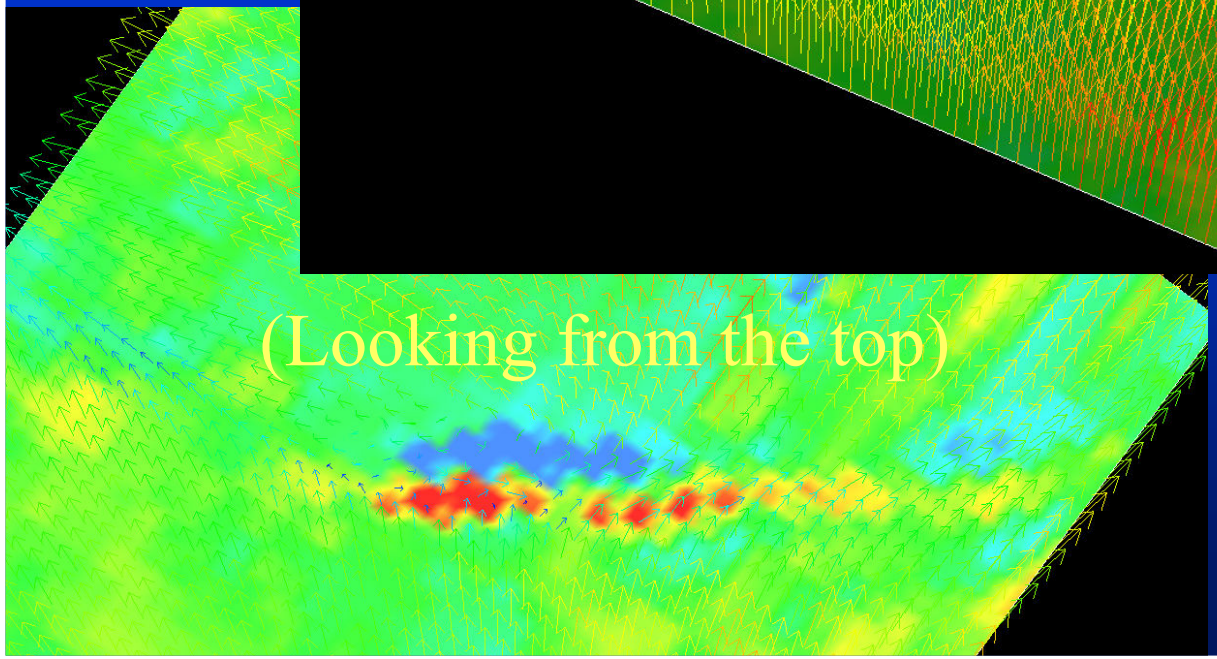
3D representation of magnetic fields

(Background: Current density map)

(Looking from NW direction)



$\Delta\gamma$ ~40deg
(130 vs 170)



(Looking from the top)

※Vectors' arrow is opposite to the actual direction.
(arrow direction = - to +)

Activities in the LB：Interpretation

- Long-lasting chromospheric plasma ejections
  - Indication of magnetic reconnections at the very low altitude
  - Close to the height where the magnetic fields are measured with SP
    - Providing the magnetic field structure near reconnection points

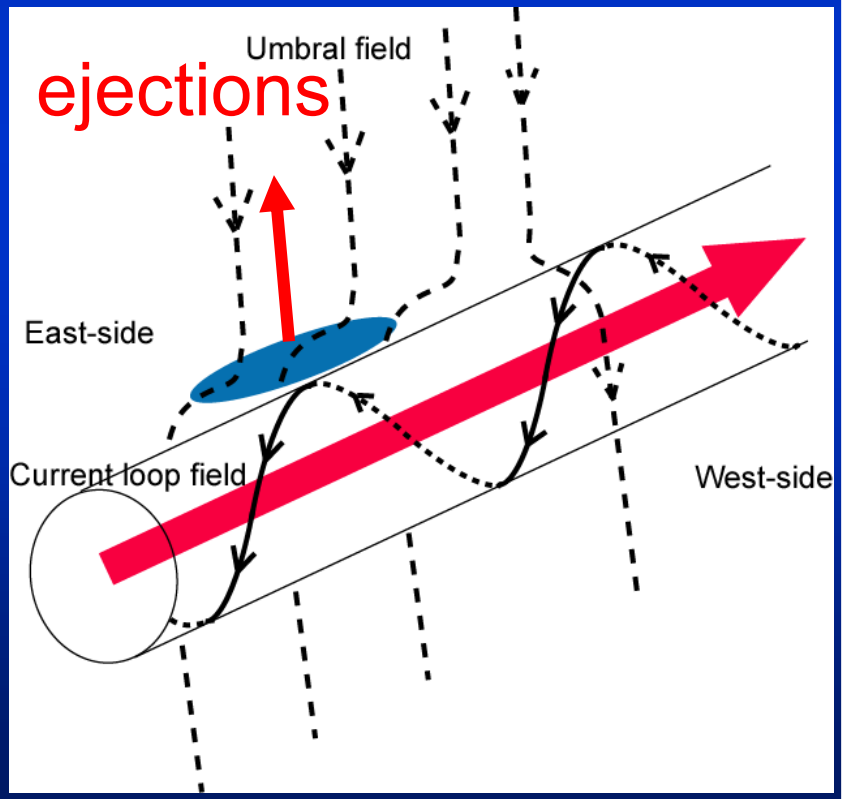
  c.f. Loop microflares

- Lying “twisted” magnetic flux （current carrying) loop
  - Red current “line” = Current loop
  - Upward current loop is trapped below the cusp-like magnetic field
  - Ejections were observed only at the east side of the current loop

  Formation of anti-parallel magnetic field lines

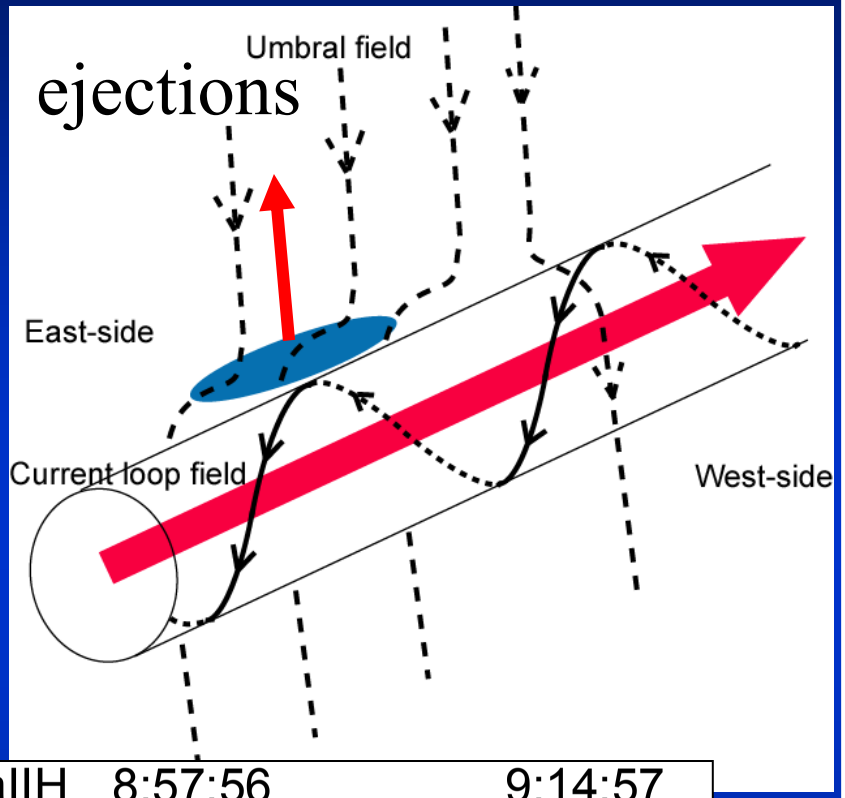
  → Magnetic reconnection

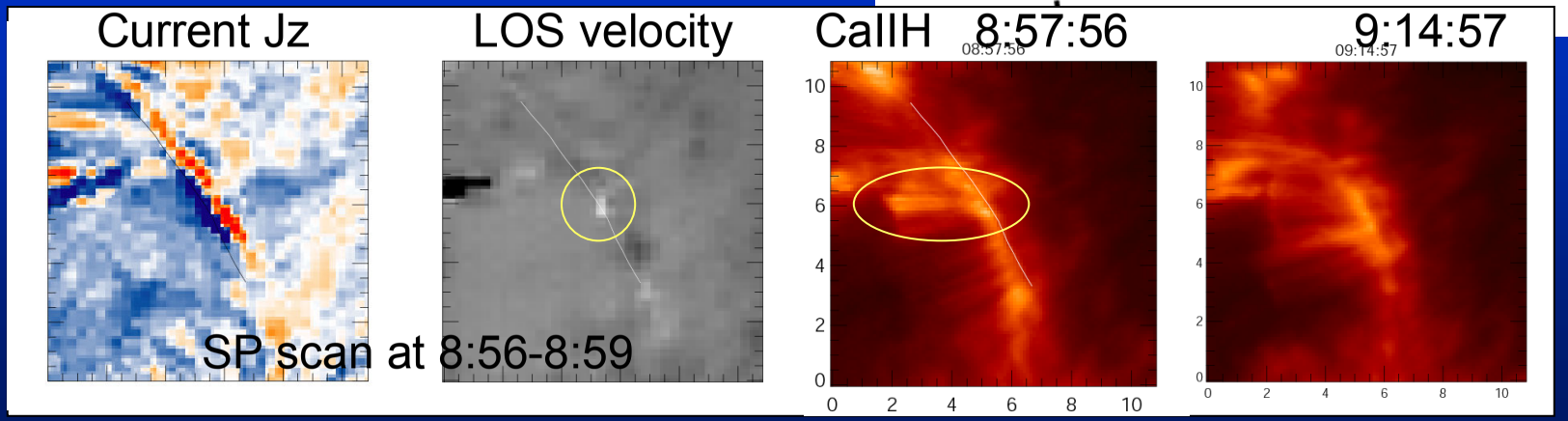
  → Chromospheric plasma ejections



Activities in the LB : Interpretation

- What is enhanced Blue current?
  - Direct detection of electric current sheet at reconnecting point?
  - Some series of intense ejections were launched from this site in a hour around the SP data.
  - SP measured just below reconnection point
    - A patch of downflow (0.7km/s) was observed with SP.
    - An intense plasma ejection was observed, which footpoint kernel is located there at the same time.





Summary

- Chromospheric activities at a LB well observed with SOT
  - Recurrent plasma ejections or surges
  - Vector magnetic field measurement at the height very close to reconnection points
- Remarkable electrical current (Iz= 60-175mA/m^2) along the LB
  - Clearly suggest a lying “twisted” magnetic flux (current carrying) loop
- Magnetic field structure for recurrent activities
  - Anti-parallel magnetic field lines are formed only at the east side between the lying “twisted” loop and vertically standing umbral field.
  - “Magnetic reconnections” are recurrently triggered there.
  - Also, direct detection of electric current sheet!
- Note that the similar magnetic field configuration can be found at penumbra, where recurrent chromospheric penumbral jets are found (Katsukawa et al. 2007).