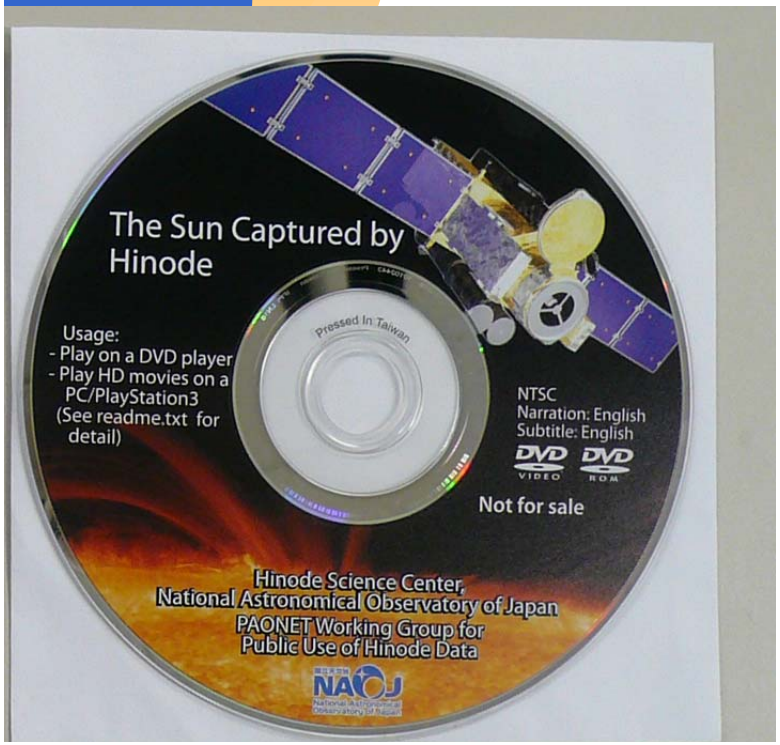
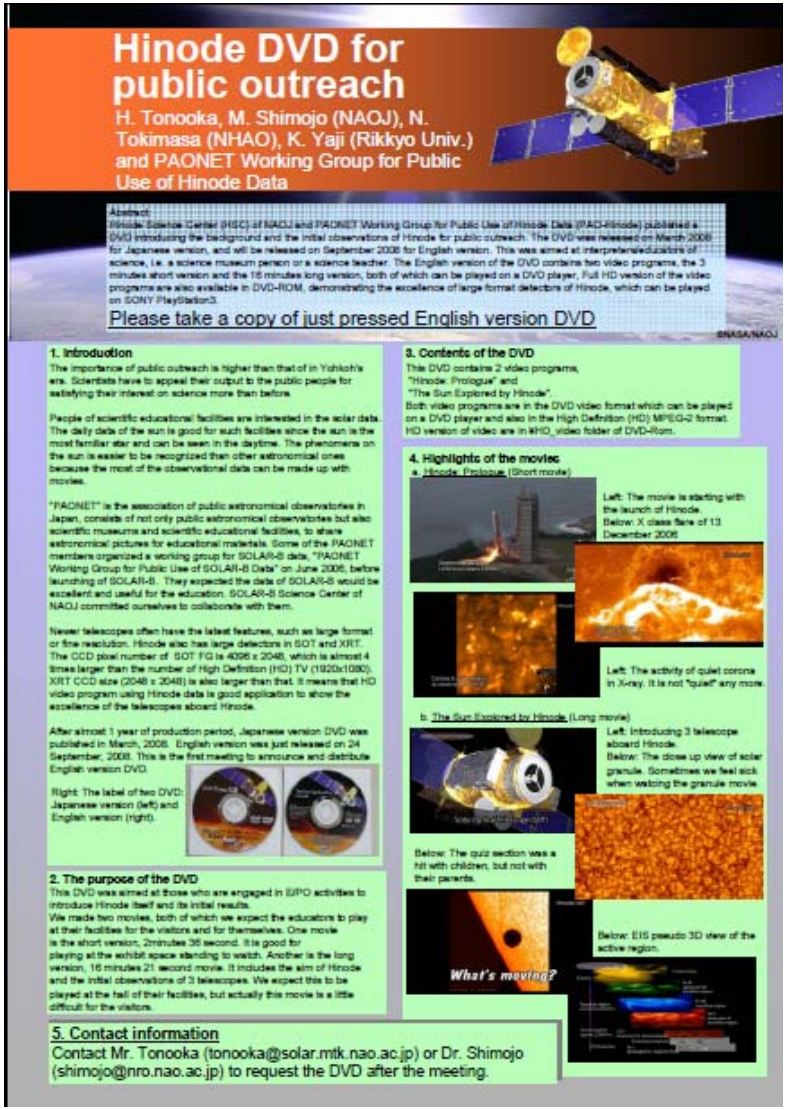
Hinode DVD (for Public Outreach)





T3-9: Solar Magnetic Activity
2nd Hinode Science Meeting “Beyond Discovery - Toward Understanding”
@HAO, Boulder, USA. 1 October, 2008

National Astronomical Observatory of Japan

THE RELATIONSHIP BETWEEN THE MAGNETIC FIELD AND THE CORONAL ACTIVITIES IN THE POLAR REGION

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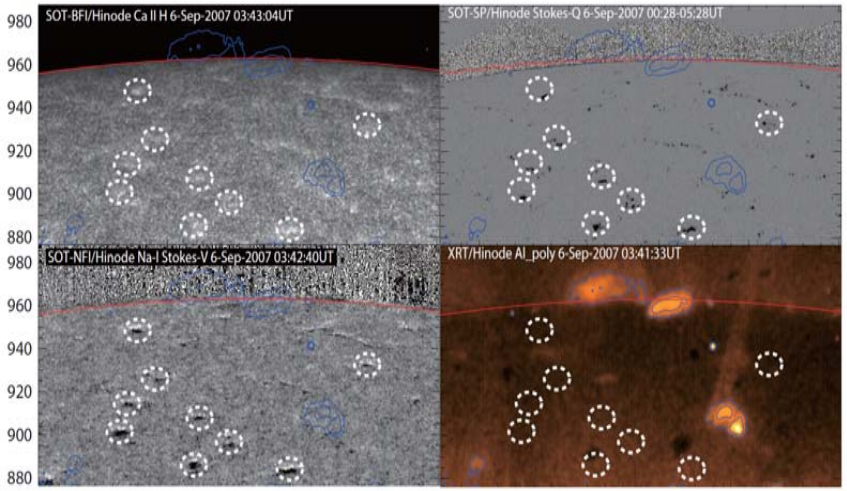

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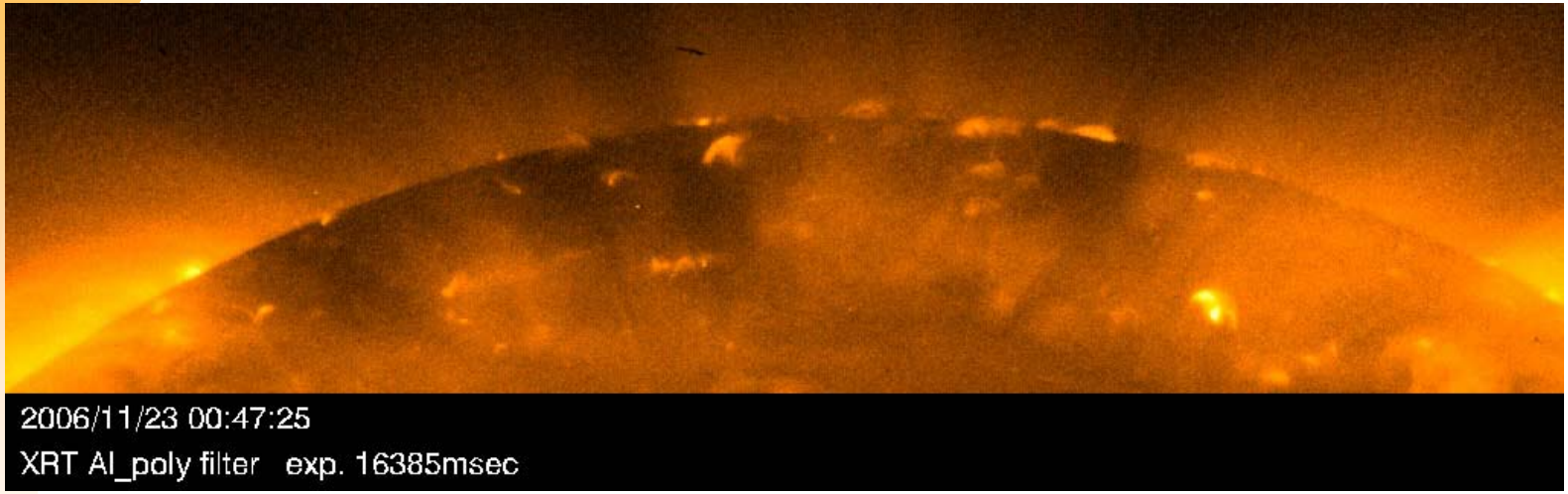
Introduction:1
Hinode shows the coronal activities around the pole.



- X-Ray Telescope (XRT) aboard *Hinode* showed us that numerous X-ray jets occur in the polar coronal hole.
- The occurrence rate of jets in the polar CH is **60 jets/day.**

(Savcheva et al., 2007 PASJ, 59, S771)

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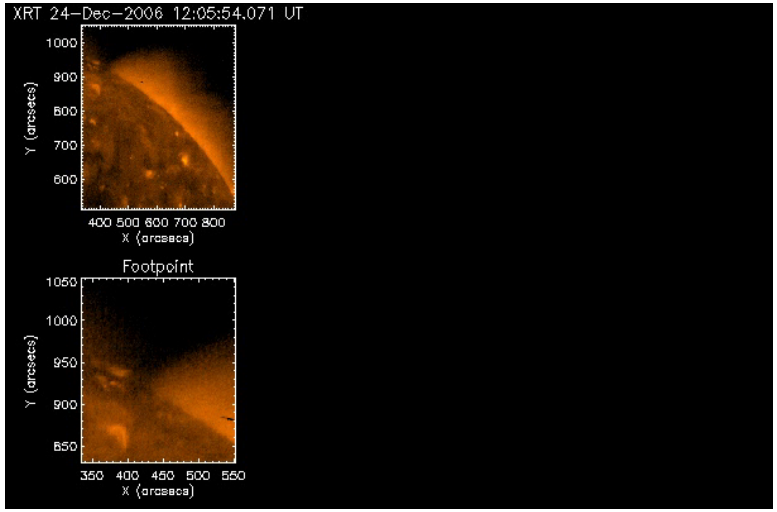
Introduction:2
Hinode observed waves in X-ray jets

- **Two velocity components in the X-ray jets.**
  - Slow component (Ave. 200km/s ≤ Sound speed)
  - Fast component (≥ 500km/s ~ Alfvén speed)

  X-ray jets produce Alfvén wave or/and Alfvénic jets.

  (Cirtain et al., 2007 Science, 318, 1580)
- **The thread structures in the X-ray jets**
  - The thread structures move across the jet's.

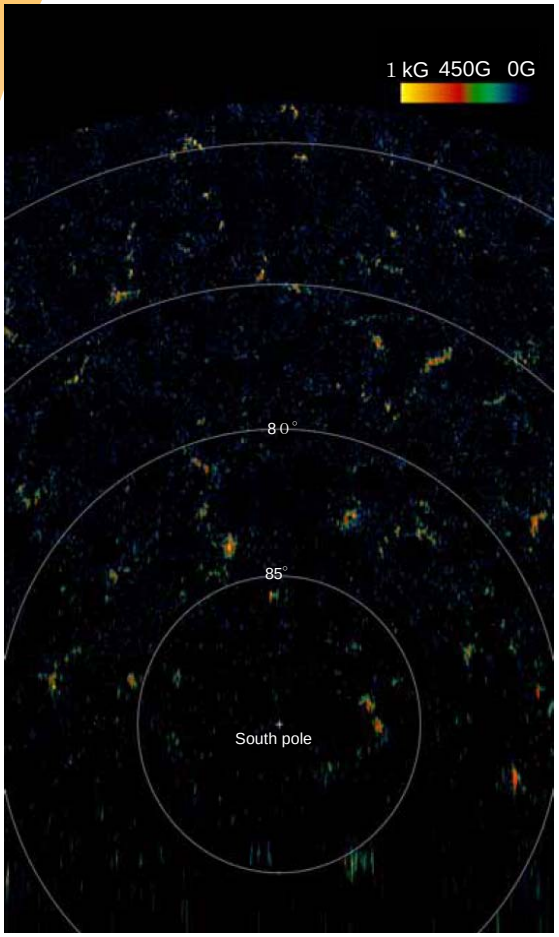
  (Shimojo, et al., 2007, PASJ, 59, S745)



The results suggest that waves are generated in X-ray jets.

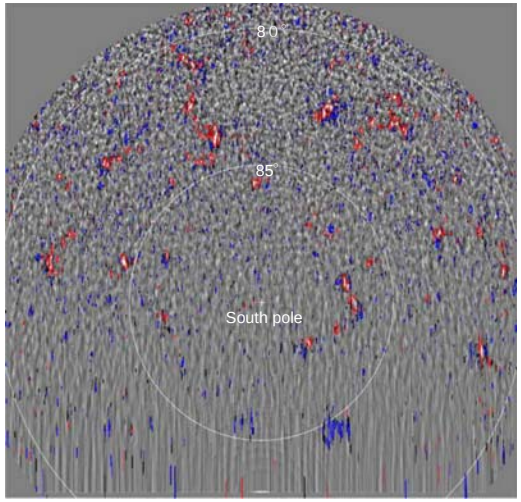
Introduction:3
The kG-patches and horizontal fields around the pole.

The south pole view of magnetic field strength



- There are intense (> 1 kG) vertical patchy magnetic fields (kG-patch) in the polar region.
  - Lifetime : 5~10 hours
- Weak horizontal fields covered the polar region.

(Tsuneta et al., 2008, in press)



Red contours:
Vertical field (>65°)

Blue contours:
Horizontal field (<25°)

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Introduction:4
Summary of previous *Hinode* obs.& Questions

- **Summary of the previous *Hinode* Observations**
  - X-ray observations of the polar region
    - Numerous X-ray jets occur in the polar CH. (60 jets/day)
    - X-ray jets generate the Alfvén waves.
      - The wave generation is very interesting from the point of view of the solar wind acceleration.
  - Magnetic field in the polar region
    - There are strong patchy-magnetic fields (kG-patches) in the polar region.
    - The polar region is covered with ubiquitous weak horizontal fields.

- **Questions**

Relationship between the strong patchy-magnetic fields (kG-patches) and the coronal structures/activities (XBP, X-ray Jets) in the polar region ?

Observation

- **HOP02:" Polar Region Observation Campaign**
  - North Pole Observations in September, 2007.
- **Data**
  - SOT Filtergram
    - G-band (Photosphere)
    - Ca II H (lower Chromosphere)
    - Stokes-V of Na I [5896 Å]
      (Indicate the line of sight magnetic field)
  - SOT Spectro-Polarimeter
    - Stoke-I, Q, U, V of Fe I (Photospheric Magntic field)
  - XRT
    - Al_poly filter image (> 2MK)
  - SOHO/EIT
    - 195Å band image (~1MK)

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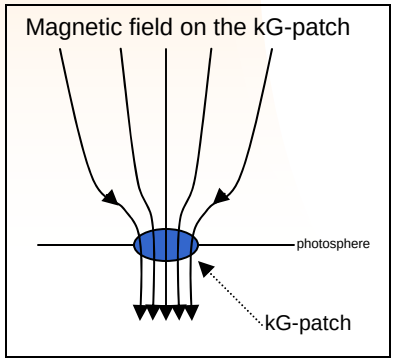
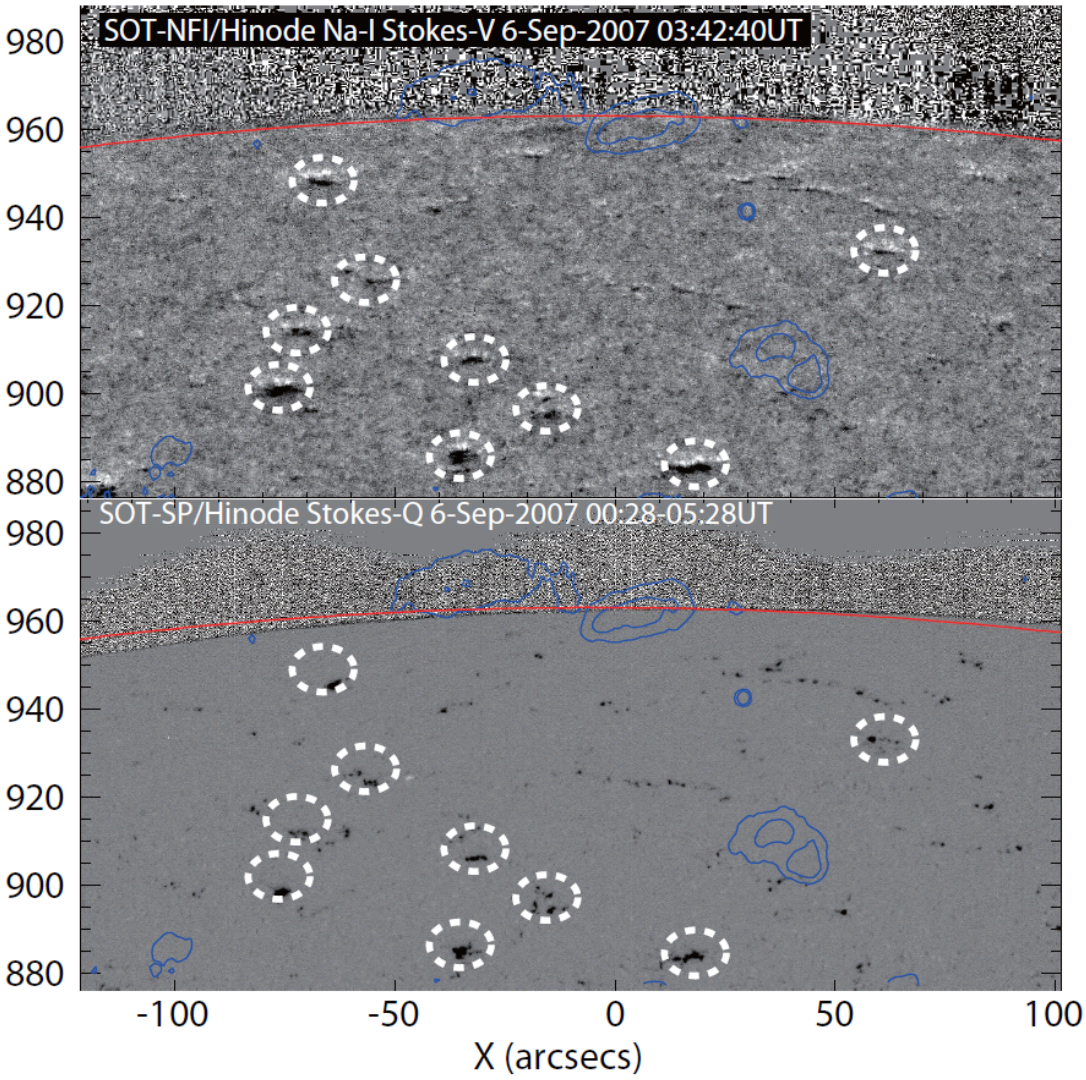
Result:1
Polar Magnetic Field and Coronal Structure

- **Stokes–V of Na I and Stokes-Q of Fe I**

The white dashed circles indicate the relatively large kG-patches.





White: ⊙ toward us

Black: ⊗ toward the screen

White: ↔

Black: ↕

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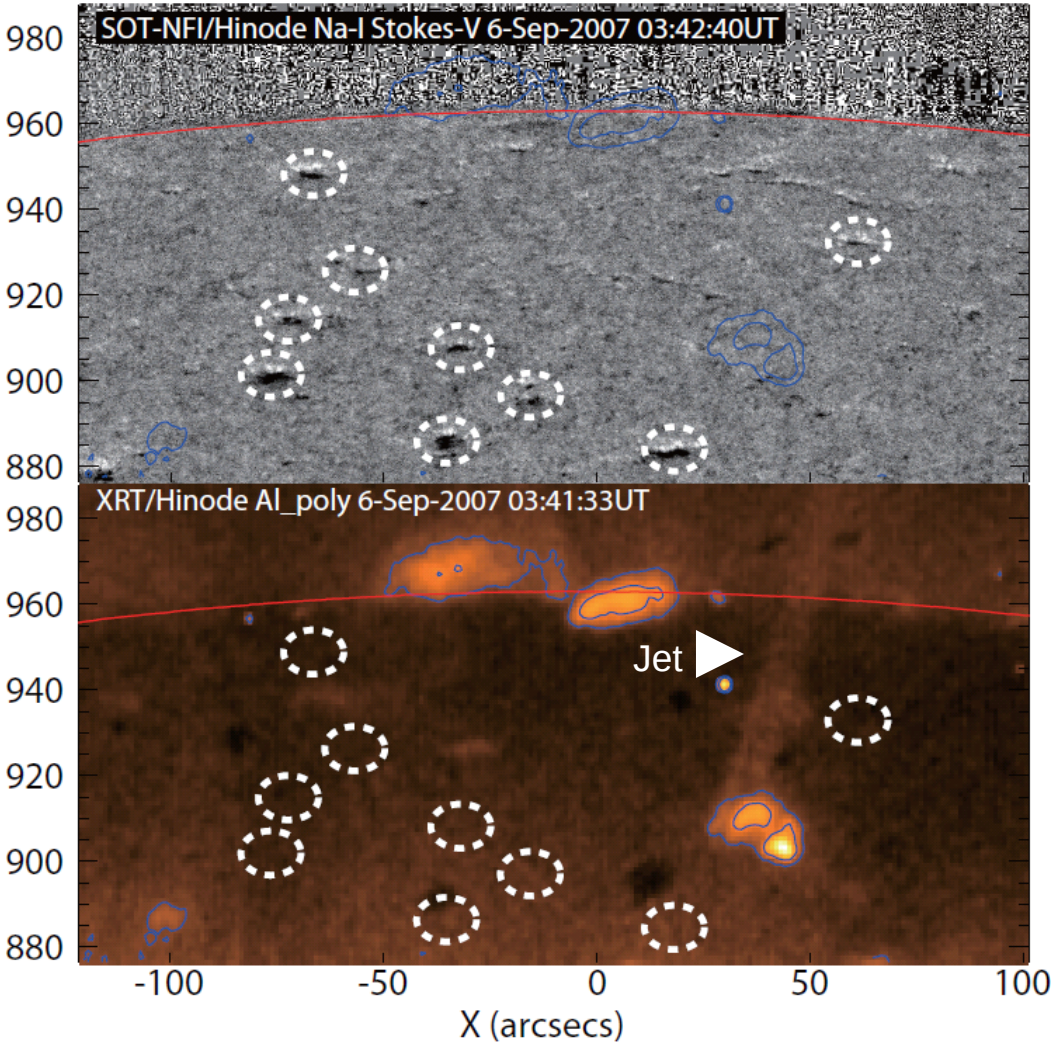
Result:1
Polar Magnetic Field and Coronal Structure

Stokes–V of Na I and X-ray (XRT/thin Al-poly)



White: ⊙ toward us

Black: ⊗ toward the screen

The white dashed circles indicate the relatively large kG-patches.

Co-align accuracy:
~ a few arcsec

The black dots in X-ray are not solar features. It is effect by the contamination.

The relatively large kG-patches do not always associate with the coronal structure.

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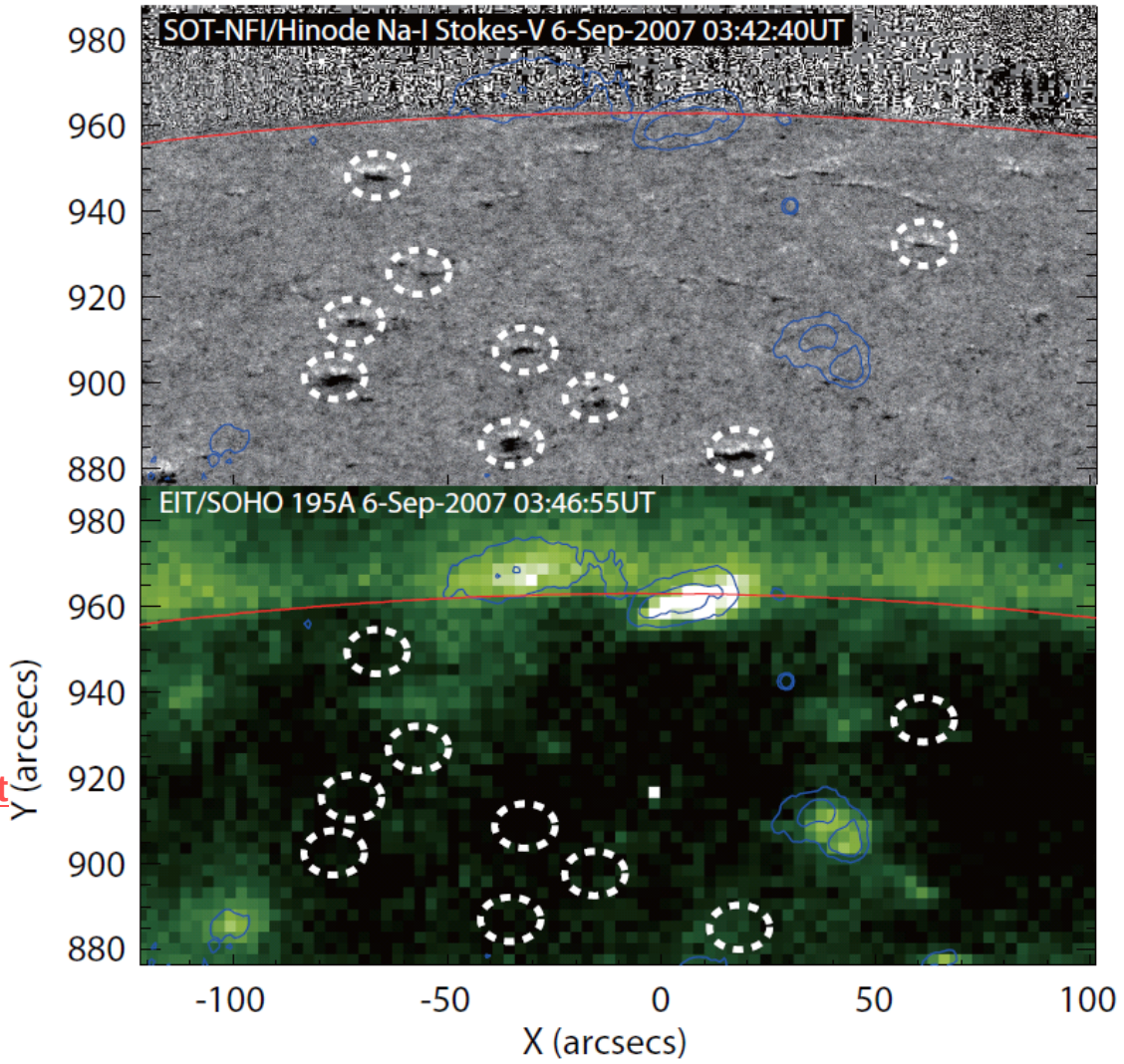
Result:1
Polar Magnetic Field and Coronal Structure

Stokes–V of Na I and EUV (EIT 195Å)

The white dashed circles indicate the relatively large kG-patches.



White: ⊙ toward us

Black: ⊗ toward the screen

In EUV (195 and 171) image, the relatively large kG-pathces do not always associate with the coronal structure, too.

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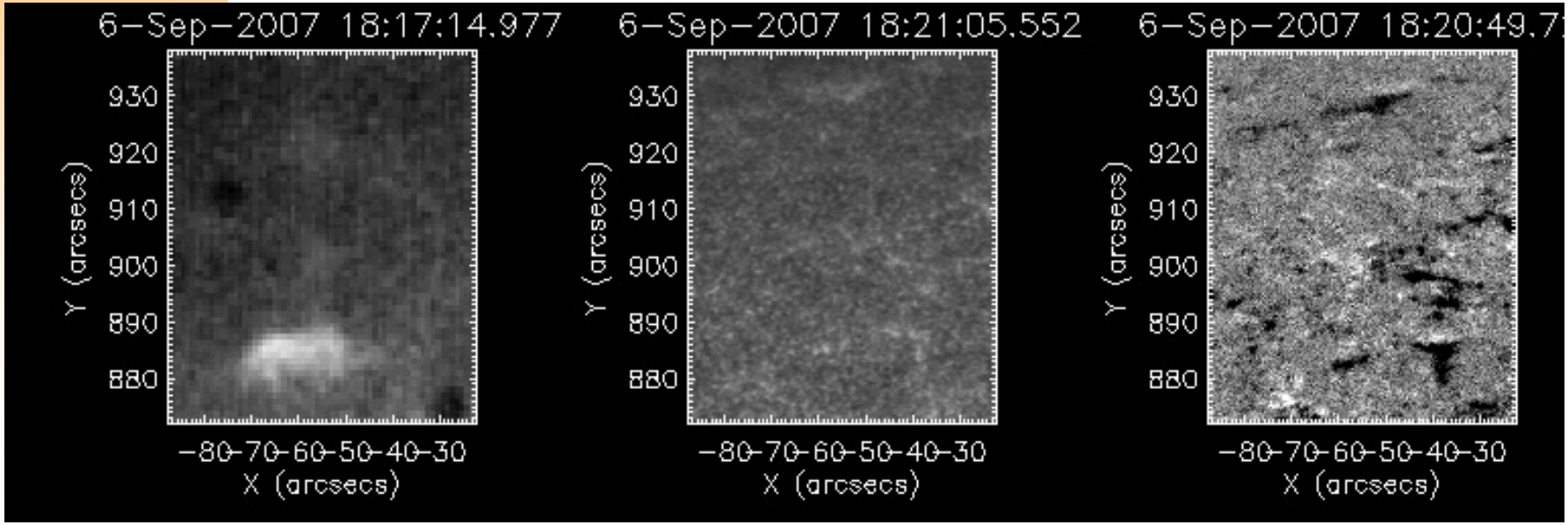
Result:2
The magnetic fields of the jet regions around the pole.

- **An X-ray jet associate with EFR in the polar region**

White: ⊙
toward us

Black: ⊗
toward the screen



X-ray　　Ca II H　　Stokes-V (Na)

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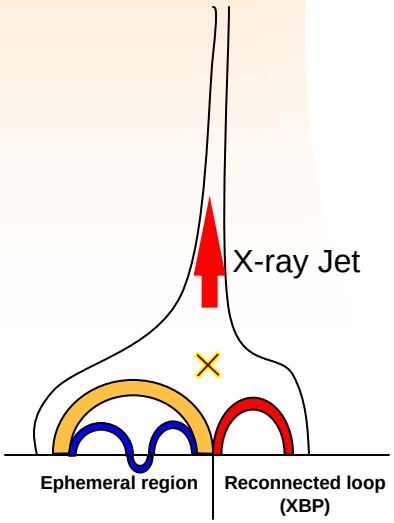
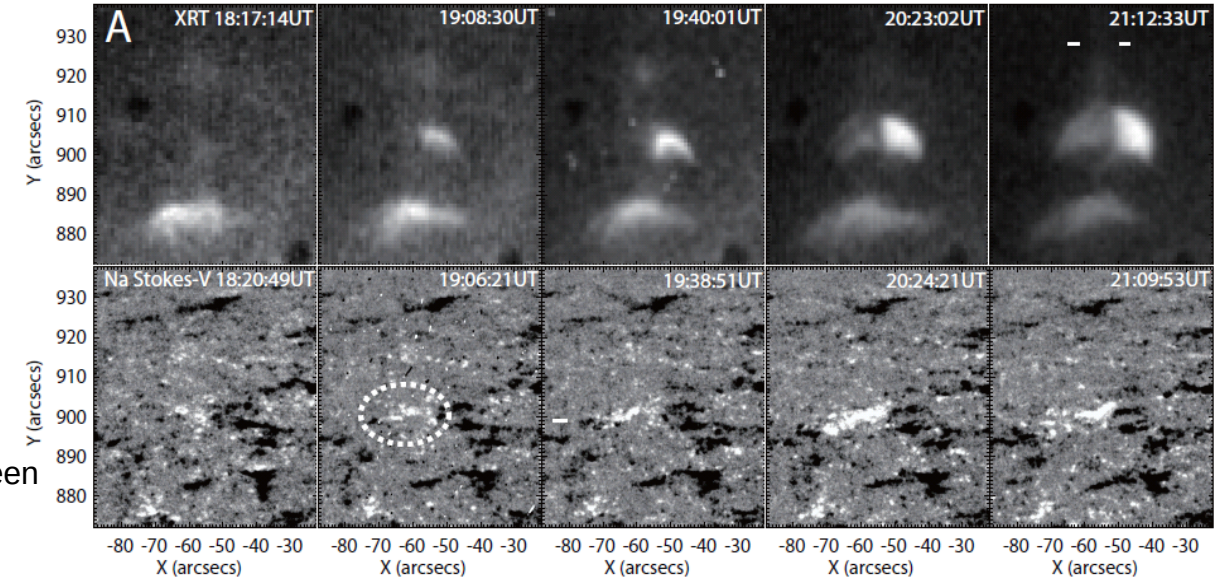
Result:2
The magnetic fields of the jet regions around the pole.

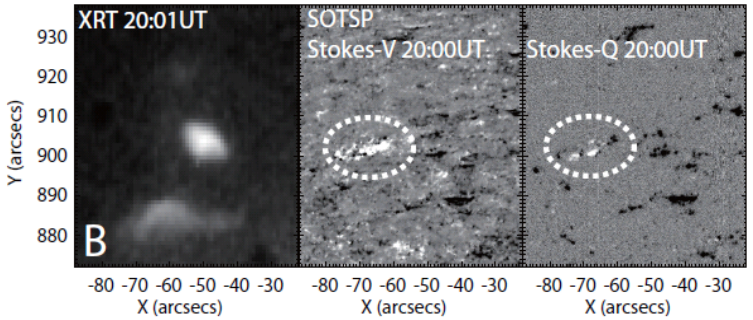
- **An ephemeral region in the polar region with an X-ray jet**

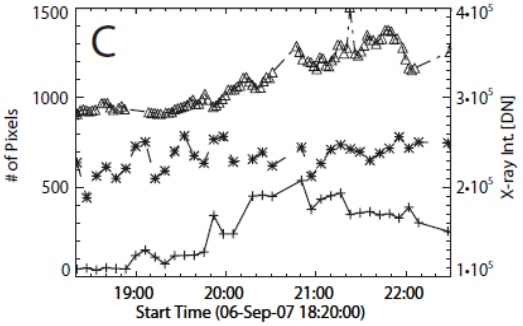
White: ⊙ toward us

Black: ⊗ toward the screen









White: ↔

Black: ↕

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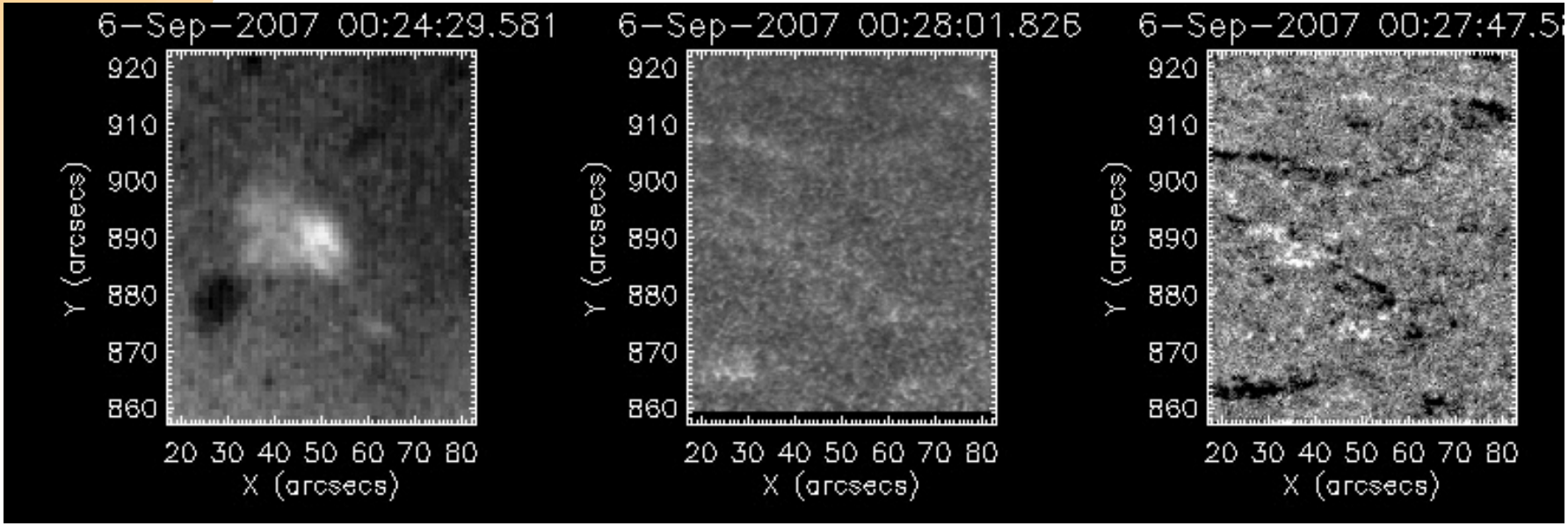
Result:2
The magnetic fields of the jet regions around the pole.

- **X-ray jets associate with cancelling flux in the polar region**

White: ⊙
toward us

Black: ⊗
toward the screen



X-ray　　Ca II H　　Stokes-V (Na)

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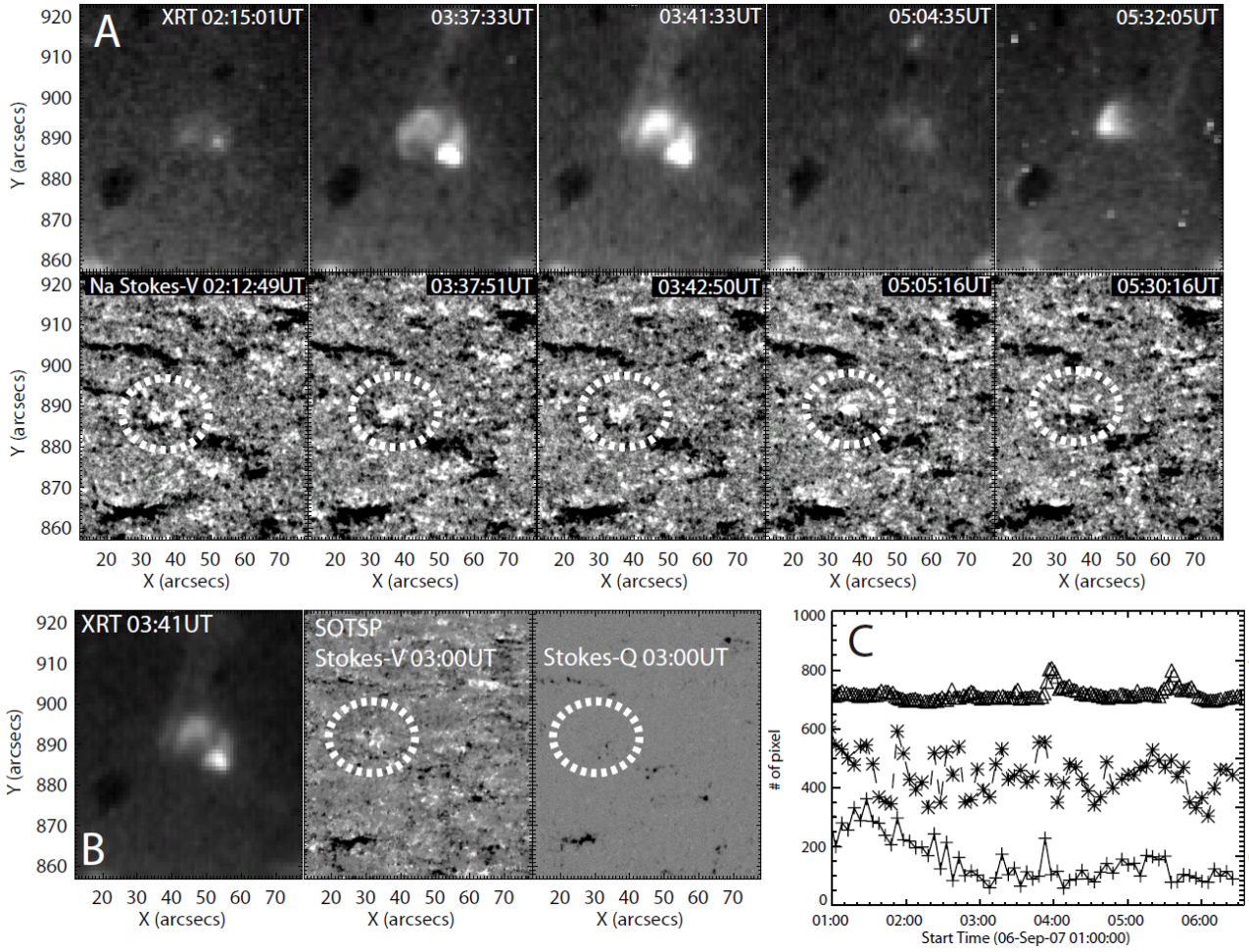
Result:2
The magnetic fields of the jet regions around the pole.

- **The X-ray jets associate with cancelling flux in the polar region.**

White: ⊙
toward us

Black: ⊗
toward the screen



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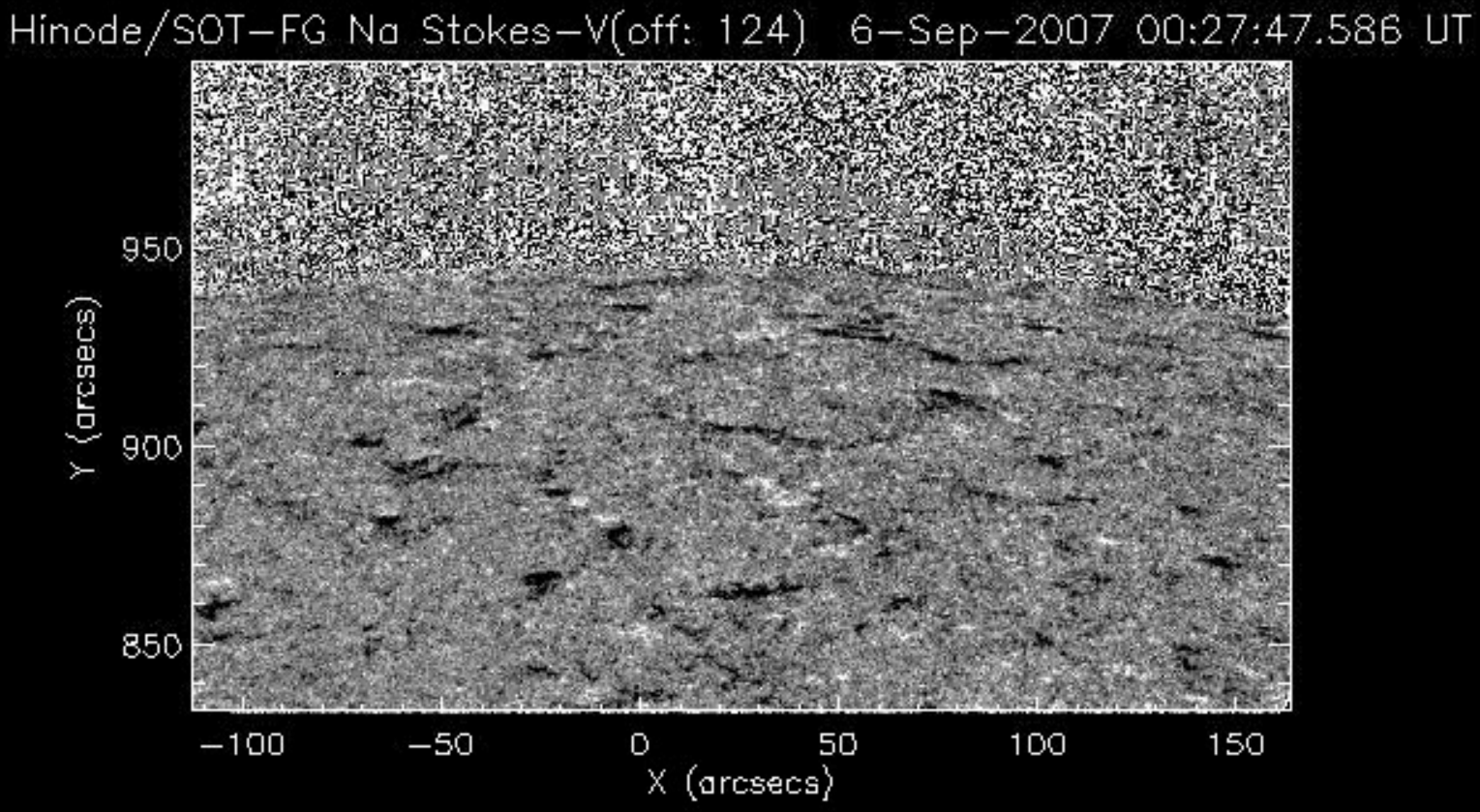
Result:3
Summary of Results

- **The relation between patchy magnetic fields and coronal structures.**
  - The coronal structures associated with the weak kG-patches. However, **the relatively large kG-patches does not always associate with the coronal structure/activities.**

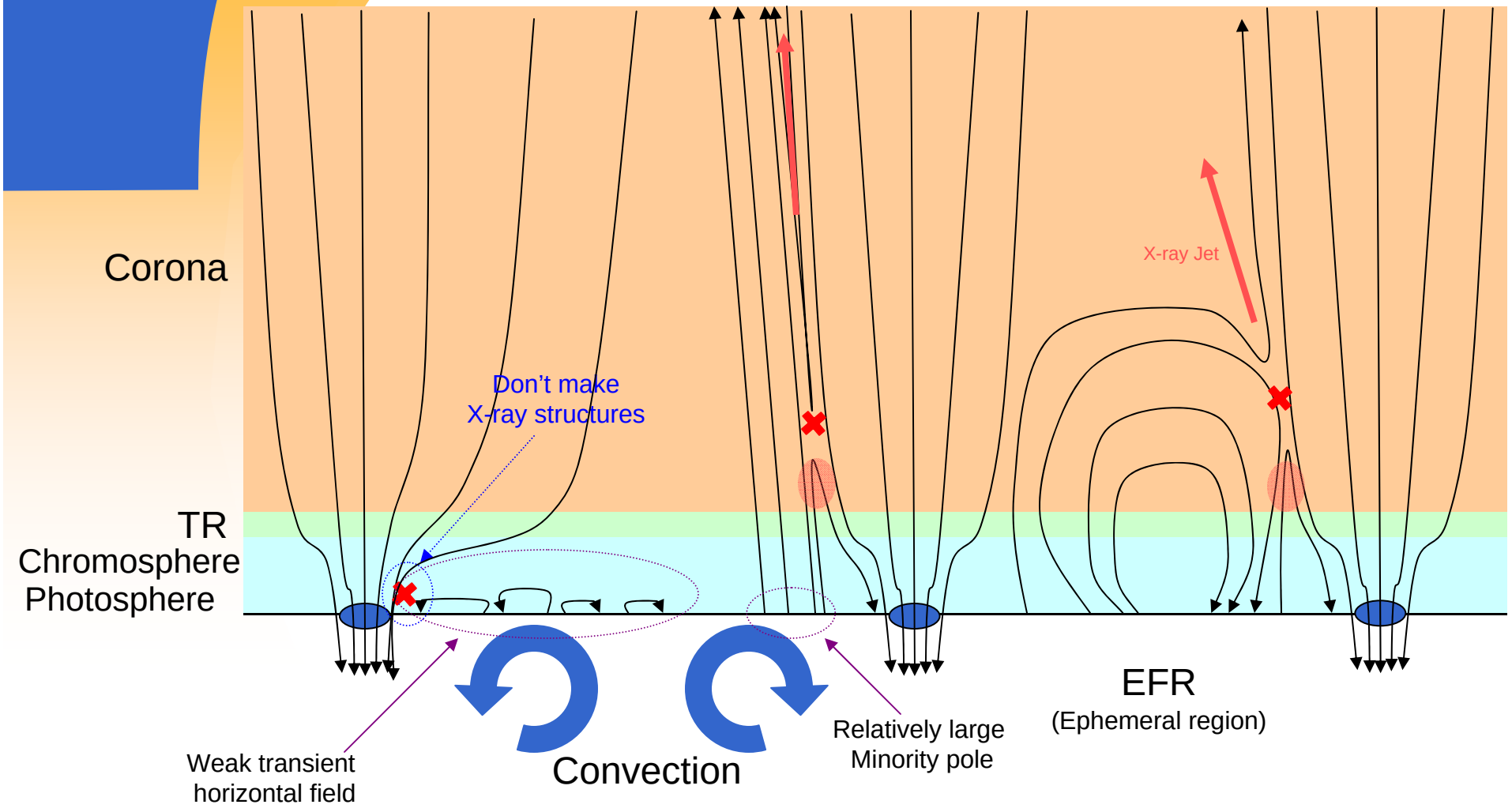
- **Magnetic environments of X-ray jets in the polar region**
  - The jets occur above the ephemeral region (EFR) and the cancelling flux region.
    - We investigated the 8 sites that produced the X-ray jets
      - 3 sites with the magnetic enhancement (EFR)
      - 4 sites with the cancelling flux
      - 1 site is unclassified.
    - The feature is same as that of the jets around ARs.
  - **The ephemeral region appear in the polar region !!**

Discussion

- **Wang et al., 1997, ApJ, 484, L75**
  - "polar plume occur where minority-polarity flux is in contact with flux of the dominant polarity"



The magnetic environments in the polar region



Conclusion

- **Observational results**
  - The coronal structures associated with the (weak) kG-patches. However, **the kG-patches does not always associate with the coronal structure/activities.**
  - The jets in the polar region occur above the ephemeral region (EFR) and the cancelling flux region. **The feature is same as that of the jets around ARs.**
  - **The ephemeral region appear in the polar region.**
- **Speculation**
  - Coronal activities in the polar region are produced from the interaction of the kG-patches with the relatively large minority-polarity fluxes (EFR, cancelling flux)
  - The weak transient horizontal fluxes also interact with the kG-patches, but they does not produce coronal plasma. However, the small interaction may be important from the energy input to kG patches. (Fast solar wind)
  - The magnetic fields in the polar region may have two components. One is the magnetic fields come from the active region. The other one is the EFR at the polar region.

Back Up Slides

Observation

- **HOP02 (old): Polar Region Observation Campaign**
  - One of the core Campaigns of the Hinode project.
  - North Pole Observations in September, 2007.
  - 2007/09/01 -- 28
- **Dataset**
  - SOT-FG (G-band, Ca II, Stokes-I and V of Na I [5896 Å])
  - SOT-SP (Stokes-I, Q, U and V of Fe I [6301.5 Å, 6302.5 Å])
  - XRT (thin Al-poly filter)
- **Requirements**
  - SOT : Large Field of View (> 200” x 100”)
  - XRT : include the synoptic Images
- **Selected Data**
  - #06 09/06 00:22 – 07:00 : 7 hours / X-ray Jet site : 1
  - #07 09/06 18:15 – 00:00 : 6 hours / X-ray Jet site : 1
  - #14 09/10 01:10 – 06:40 : 6 hours / X-ray Jet site : 1
  - #15 09/10 15:51 – 21:30 : 6 hours / X-ray Jet site : 2
  - #39 09/16 01:17 – 07:08 : 6 hours / X-ray Jet site : 3

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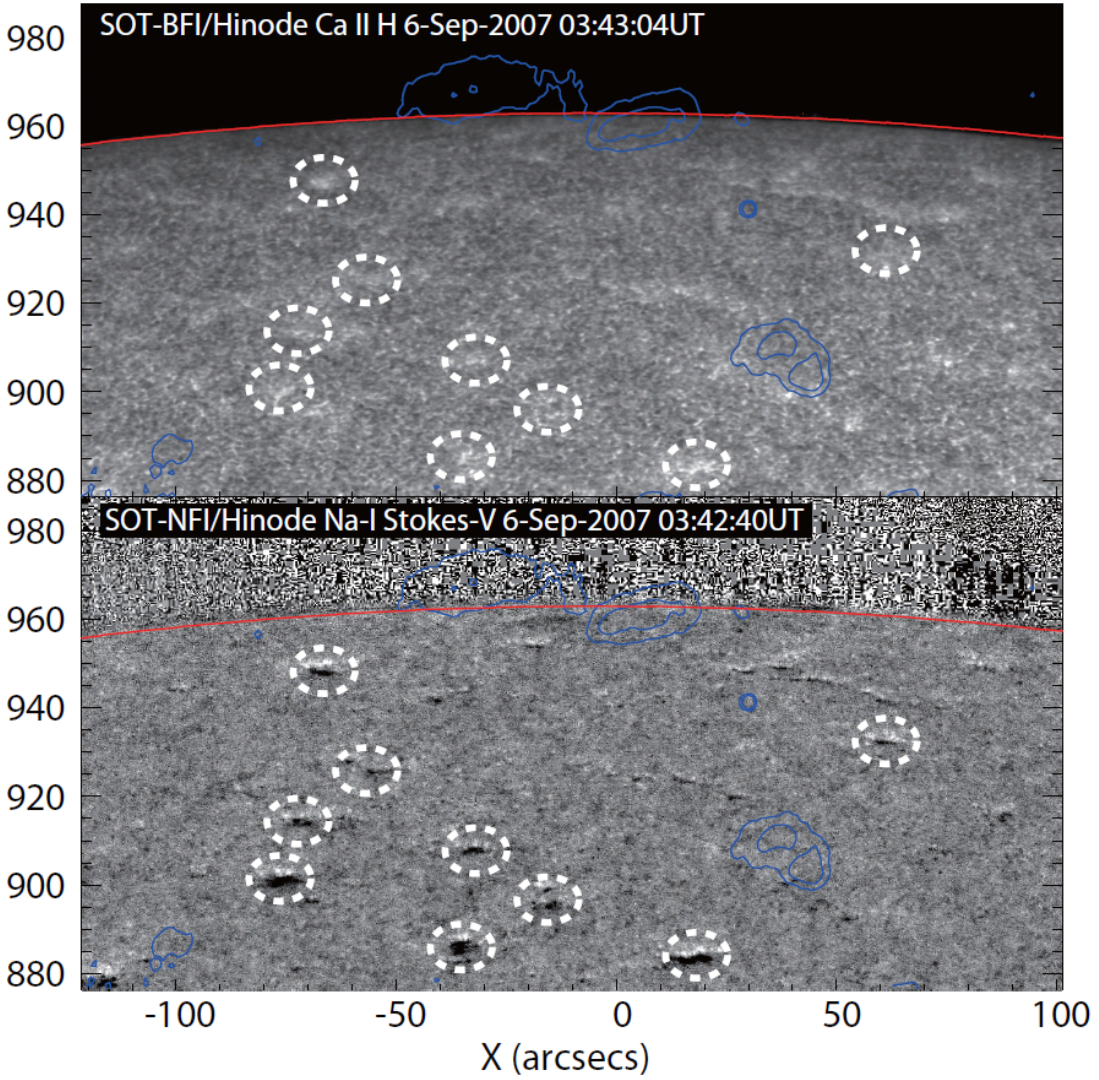
Result:1
Polar Magnetic Field and Coronal Structure

- **Ca II H Intensity and Stokes–V of Na I**

The white dashed circles indicate the relatively large kG-patches.

The kG-patches correspond with Ca bright points (and G-band BPs).



White: ⊙ toward us

Black: ⊗ toward the screen

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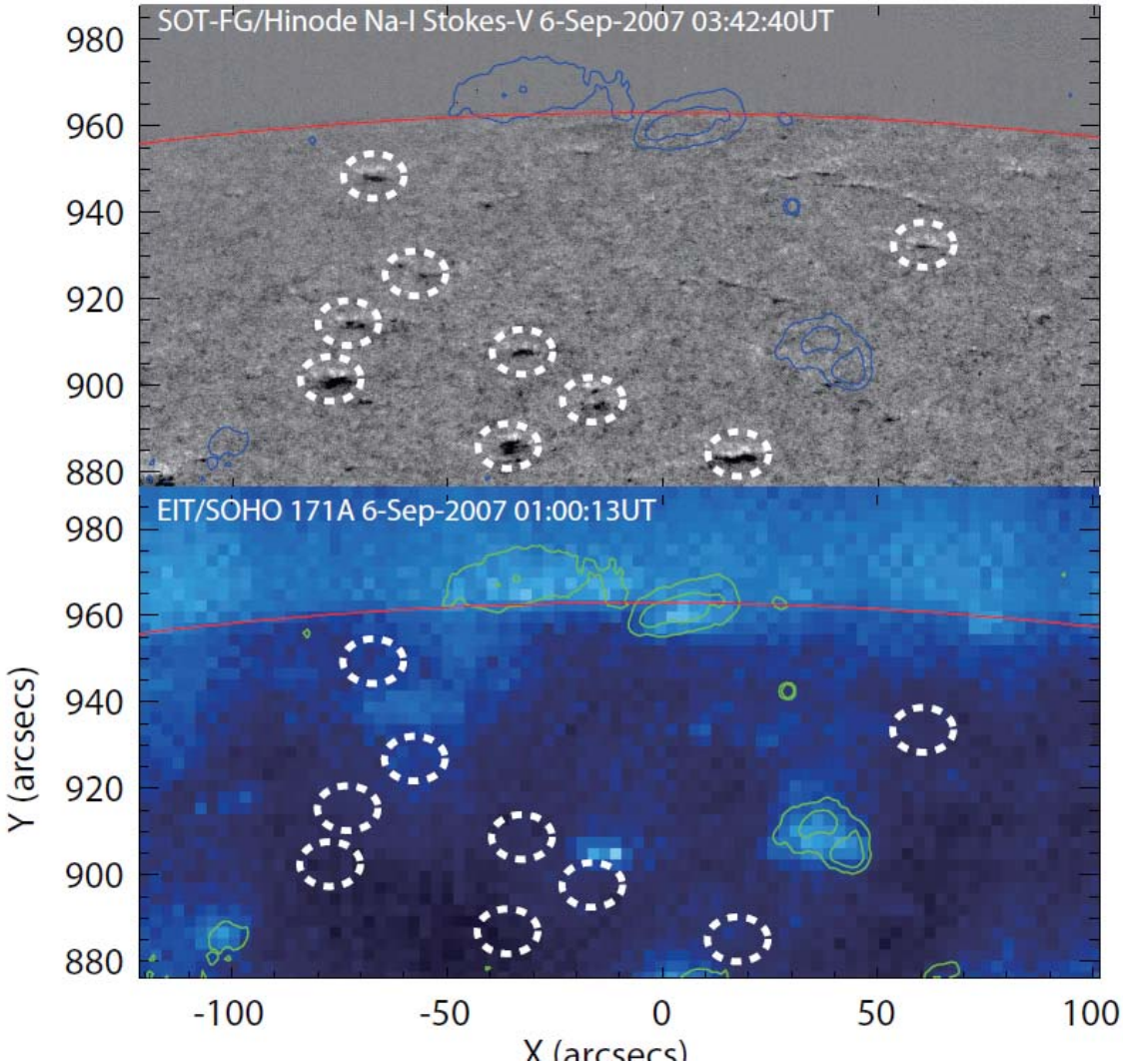
Result:1
Polar Magnetic Field and Coronal Structure

Stokes–V of Na I and EUV (EIT 171Å)

The white dashed circles indicate the relatively large kG-patches.

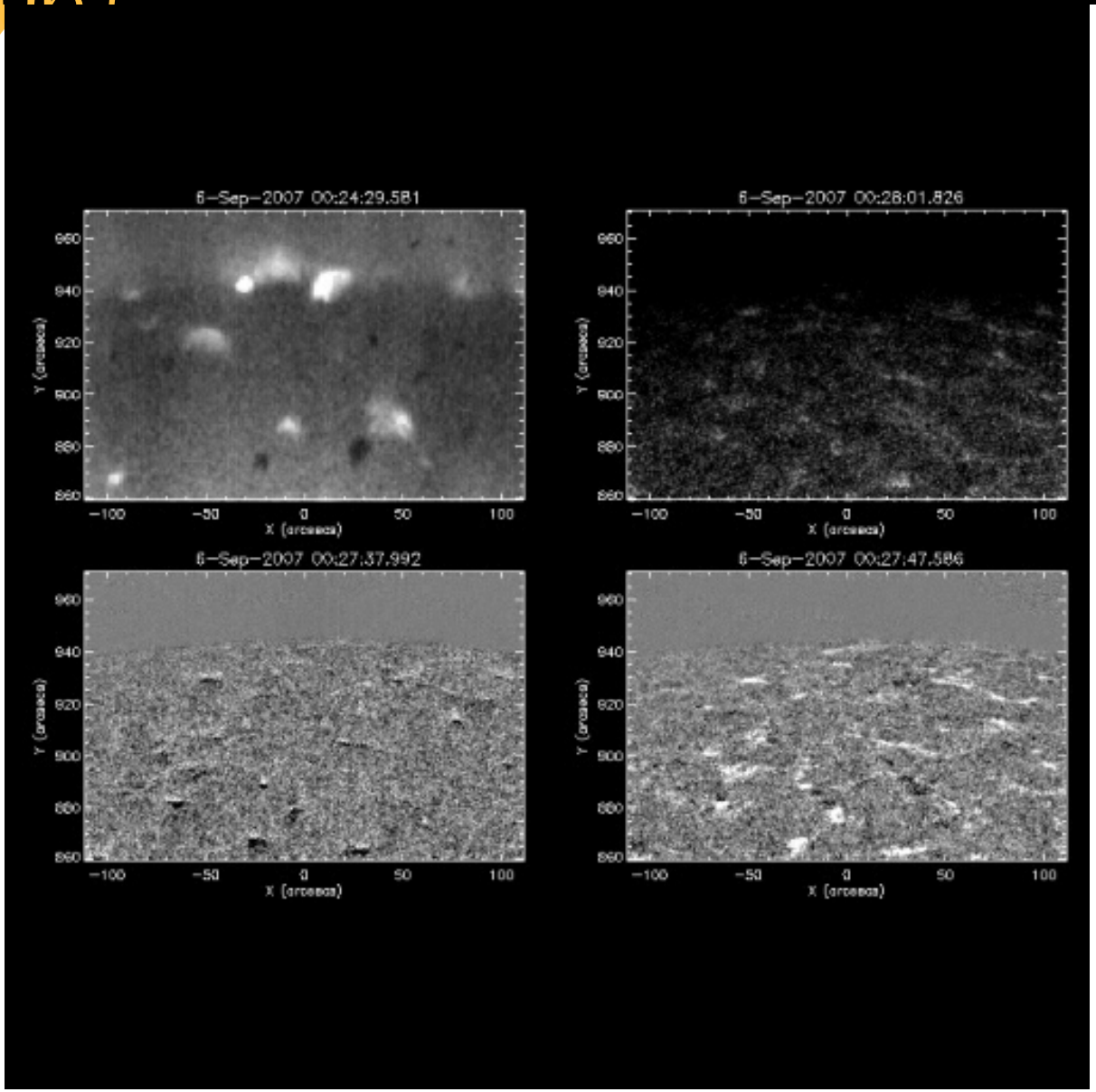


White: ⊙
toward us

Black: ⊗
toward the screen

In EUV (195 and 171) image, the relatively large kG-patches does not always associate with the coronal structure, too.

Wide Field of View Movies (#06)



Wide Field of View Movies (#07)