Why S, Not X, Marks the Spot for CME/Flare Eruptions

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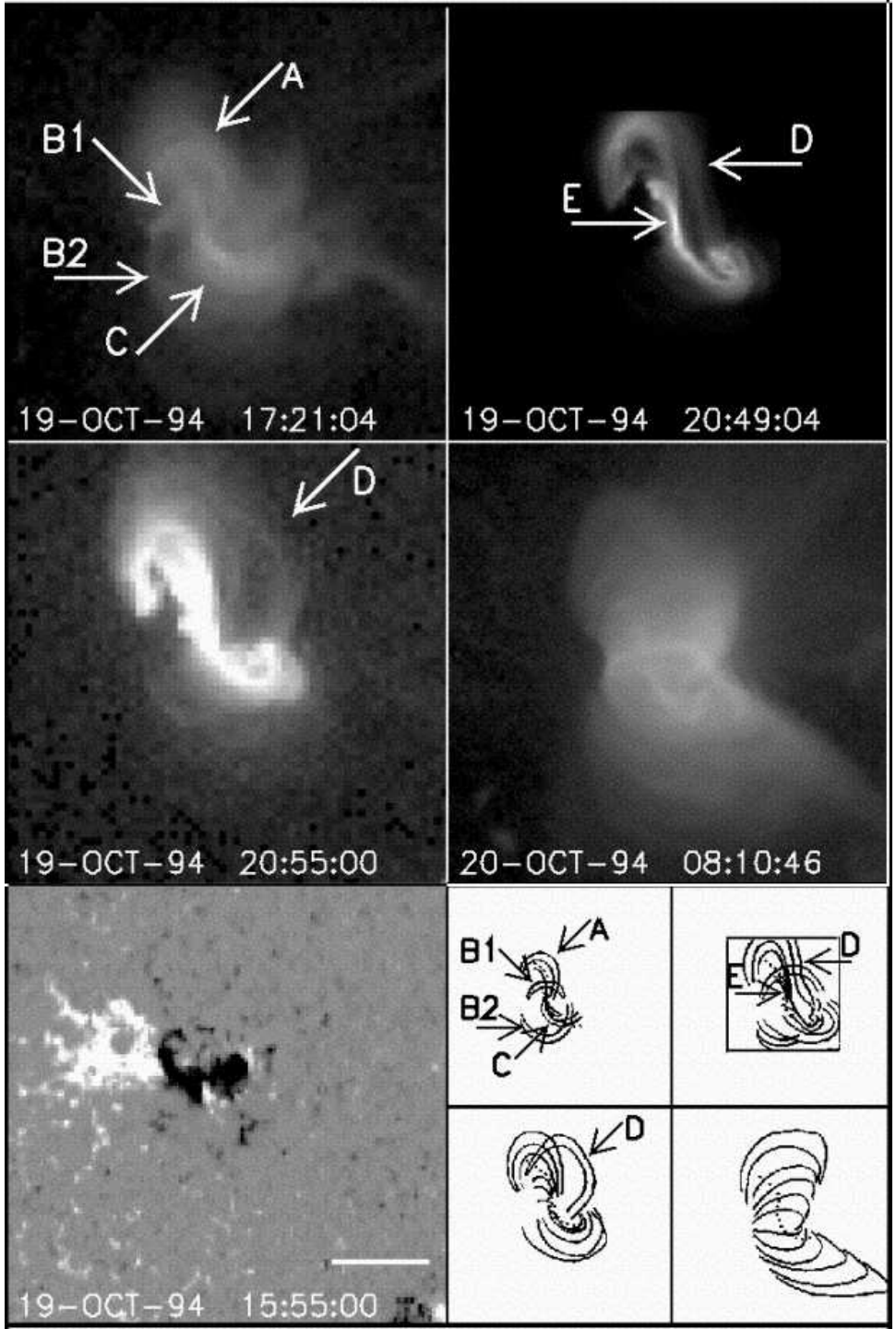
Isolated-Arcade CME/Flare Eruption

Observed by Yohkoh



Main Points

- For any major CME/flare eruption:
  - The field that erupts is an arcade in which the interior is greatly sheared and twisted.
  - Most of the free magnetic energy to be released:
    - Is in the shear and twist of the interior field.
    - Is Not due to a big current sheet.
  - The eruption is unleashed by reconnection at a growing current sheet.
  - The current sheet is still little when the reconnection turns on.
  - The unleashed eruption then makes the current sheet much bigger by building it up faster than the reconnection can tear it down.

- Most X-ray jets work the opposite way:
  - Tapped free energy is in the field of a pre-jet current sheet.
  - Current sheet built by small arcade emerging into ambient field.
  - Current sheet still much smaller than the arcade when reconnection turns on and tears it down, producing a jet.

- These rules reflect the low-beta condition in the eruptive magnetic field.

Outline

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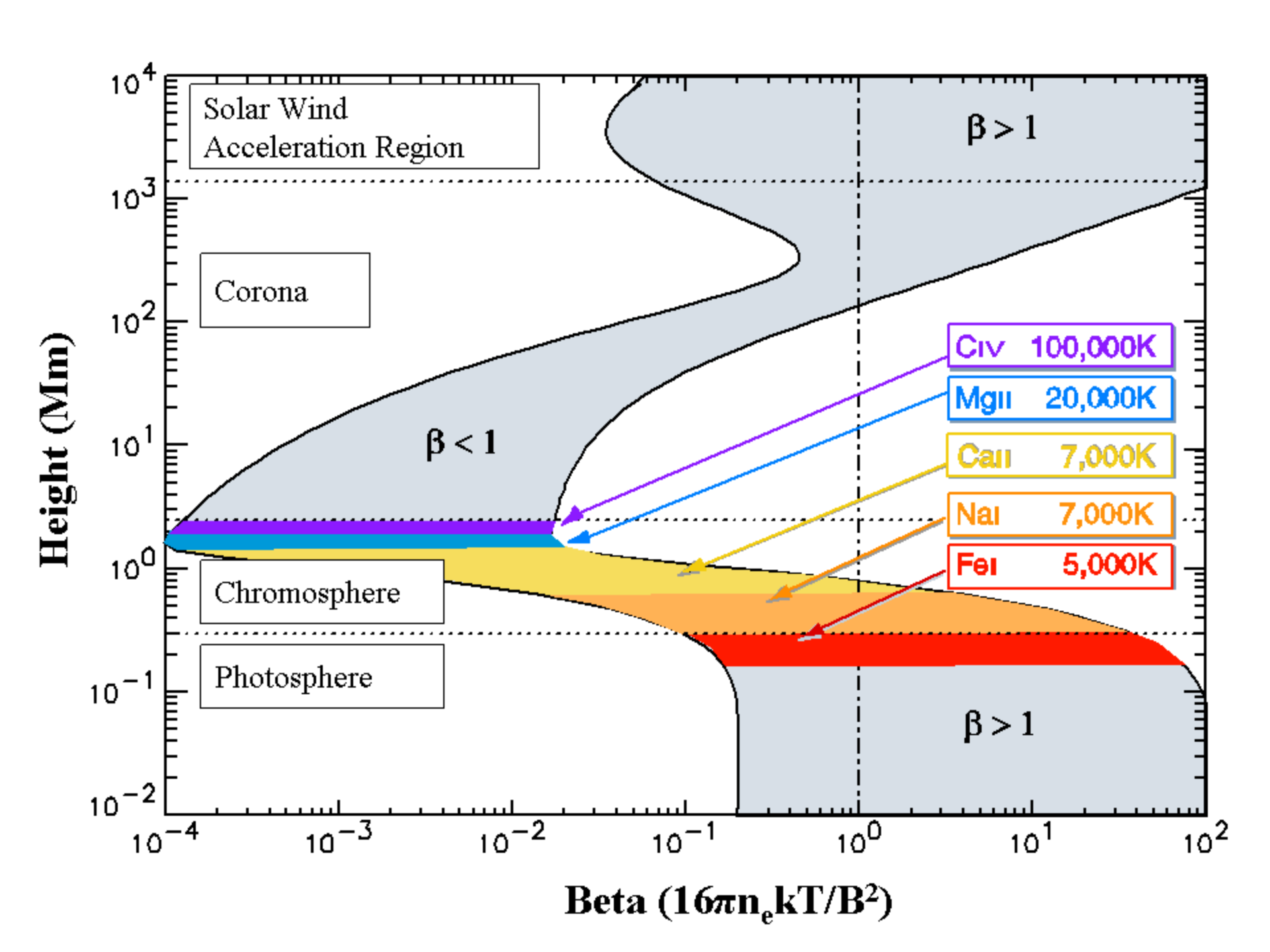
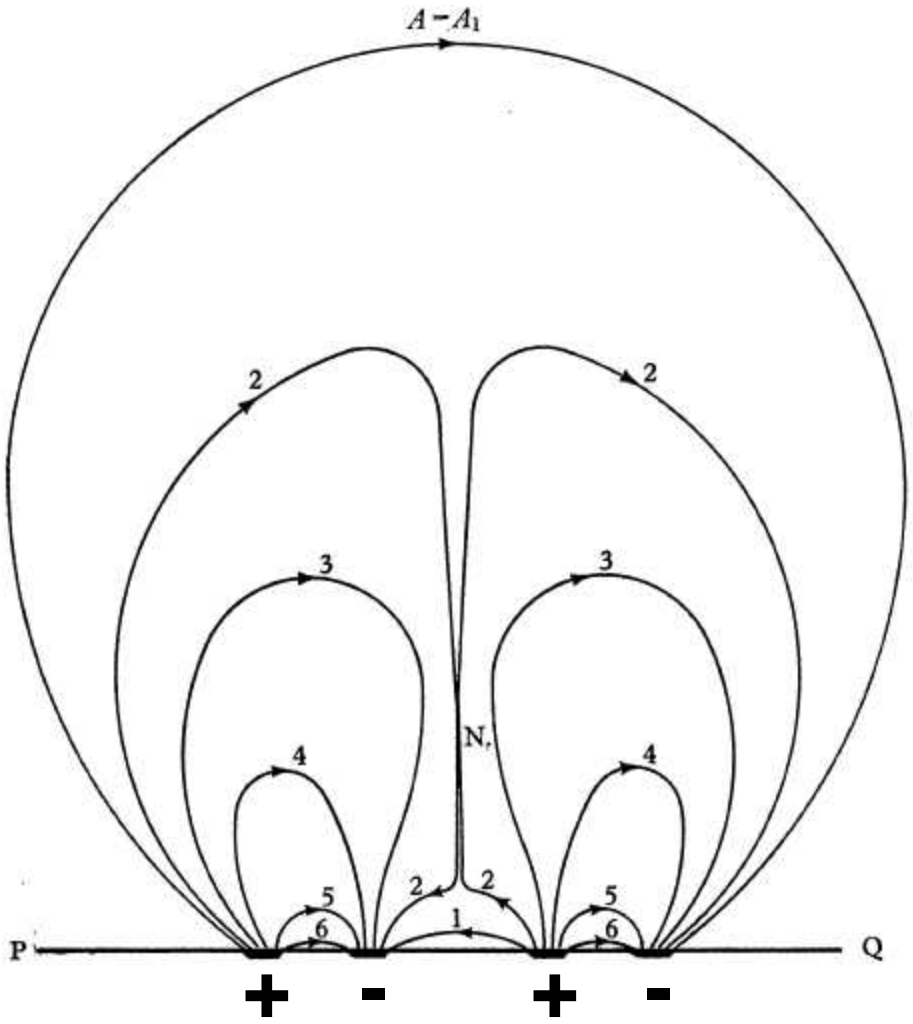
II. Physical Argument

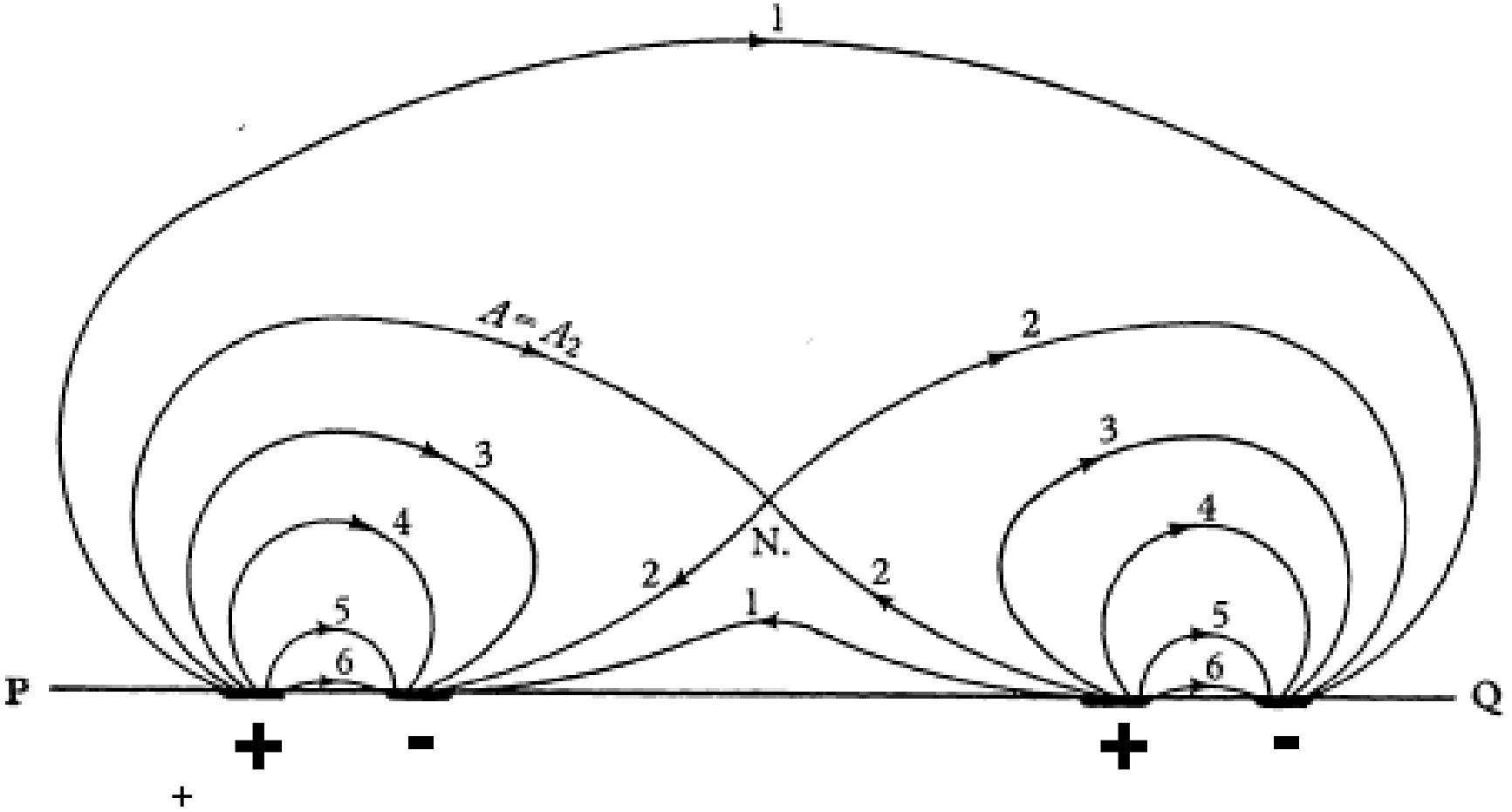
III. Observed Eruptions
   A. Isolated-Arcade CME/Flare Eruptions
   B. Embedded-Arcade CME/Flare Eruptions
   C. Standard X-Ray Jets

I. Conclusion


Solar Wind
Acceleration Region
β > 1
Corona
β < 1
CIV 100,000K
MgII 20,000K
CaII 7,000K
NaI 7,000K
FeI 5,000K
Chromosphere
Photosphere
β > 1
Height (Mm)
Beta (16πn_ekT/B²)

Peter Sweet, 1958

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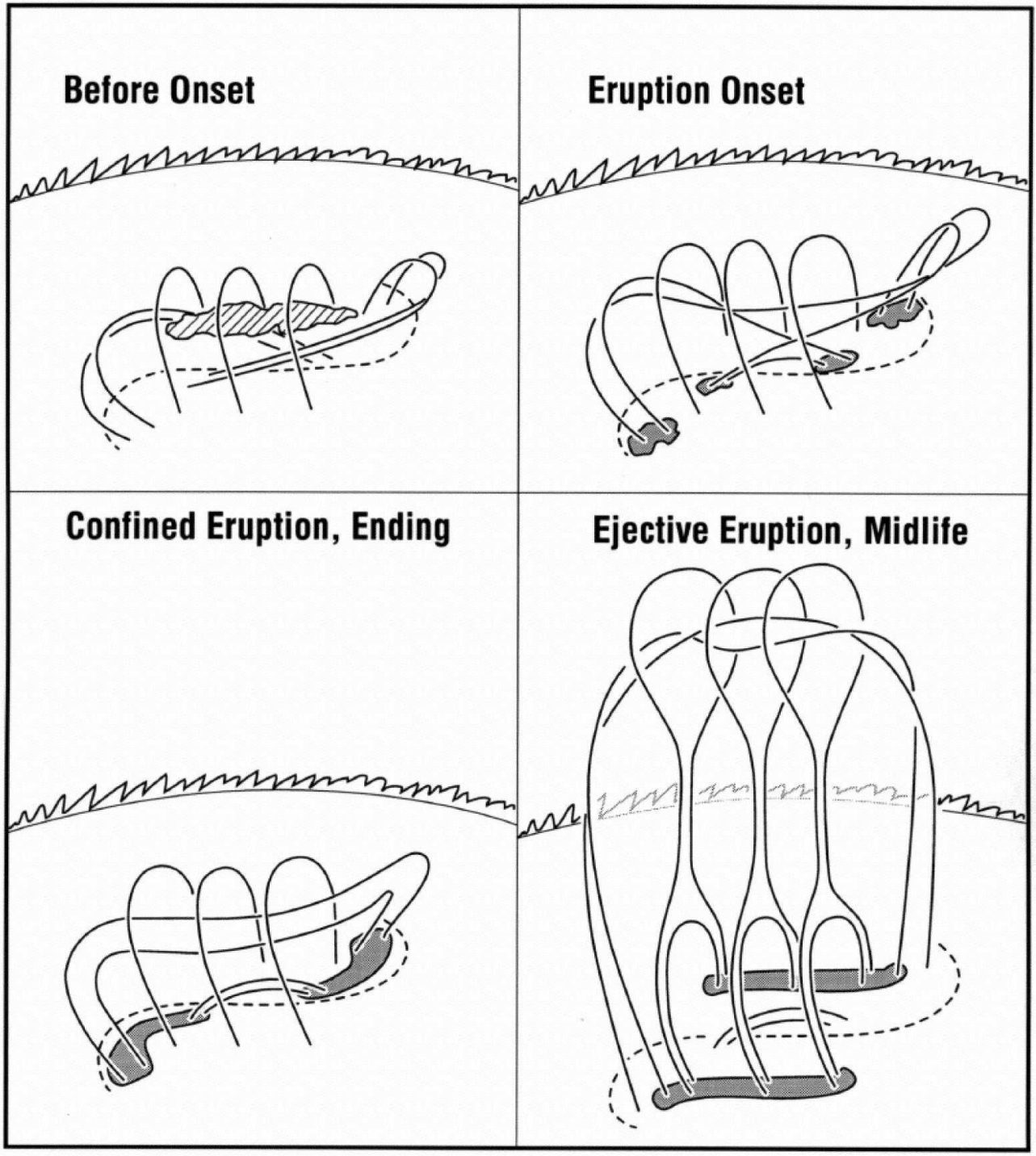
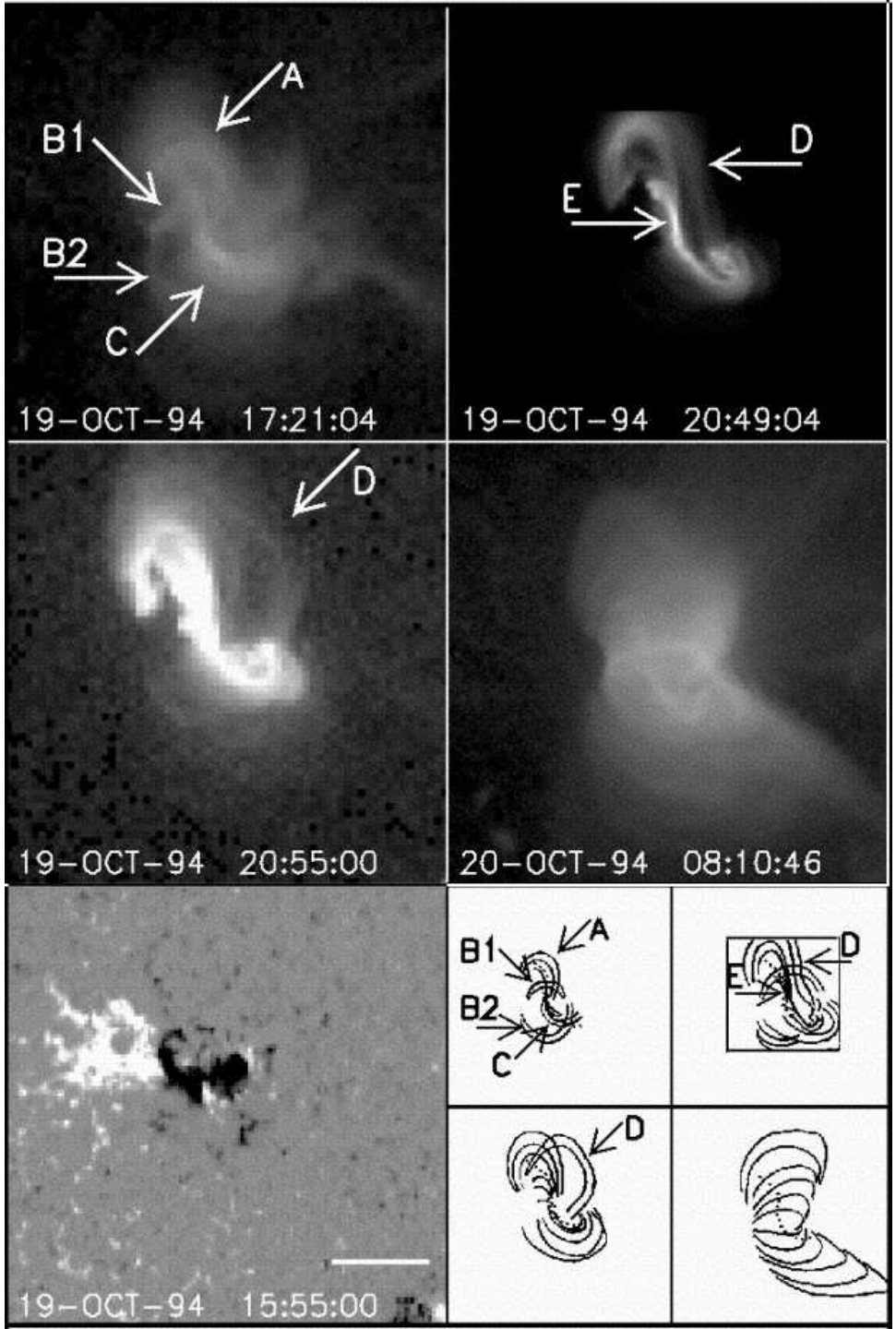
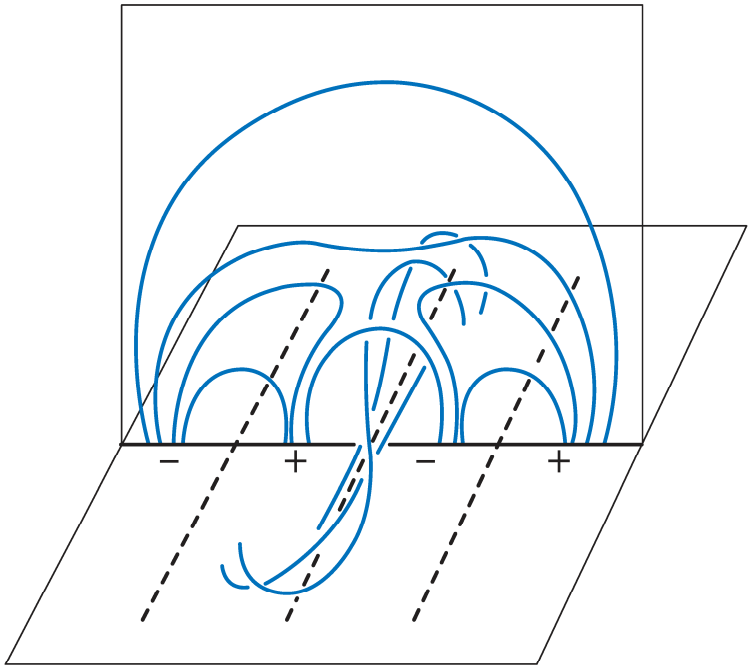
Standard Picture For Isolated-Arcade CME/Flare Eruptions



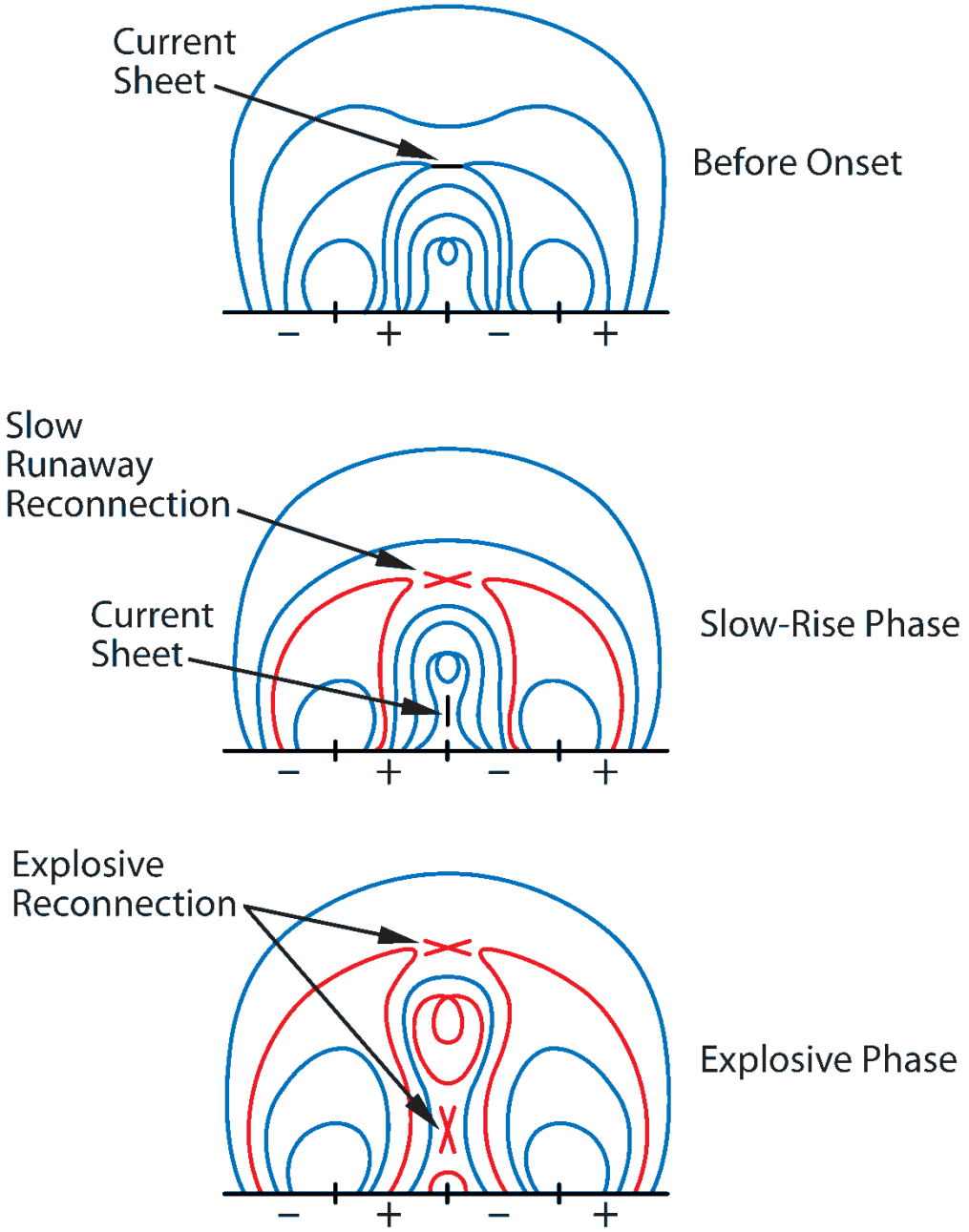
Isolated-Arcade CME/Flare Eruption

Observed by Yohkoh

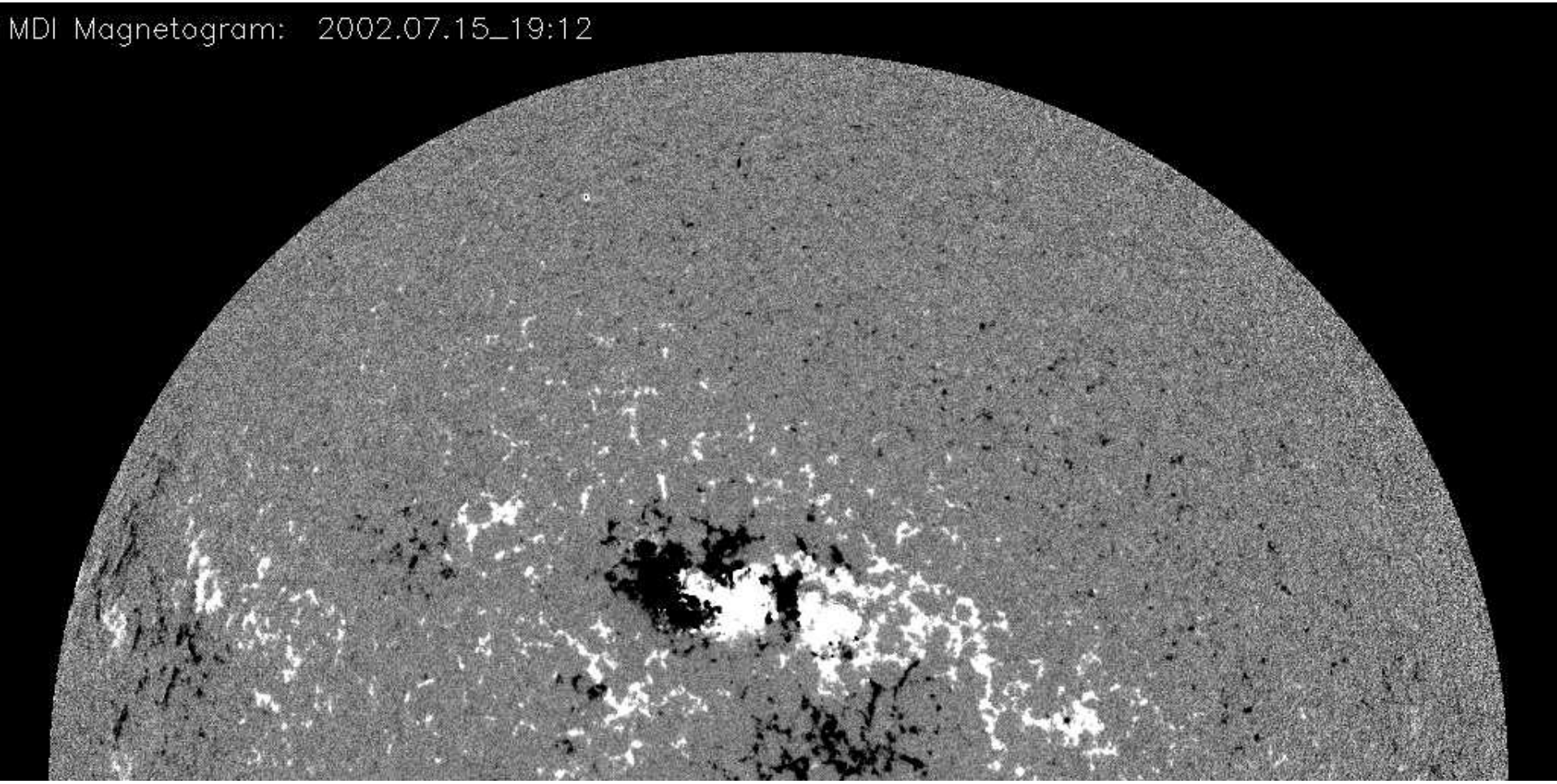




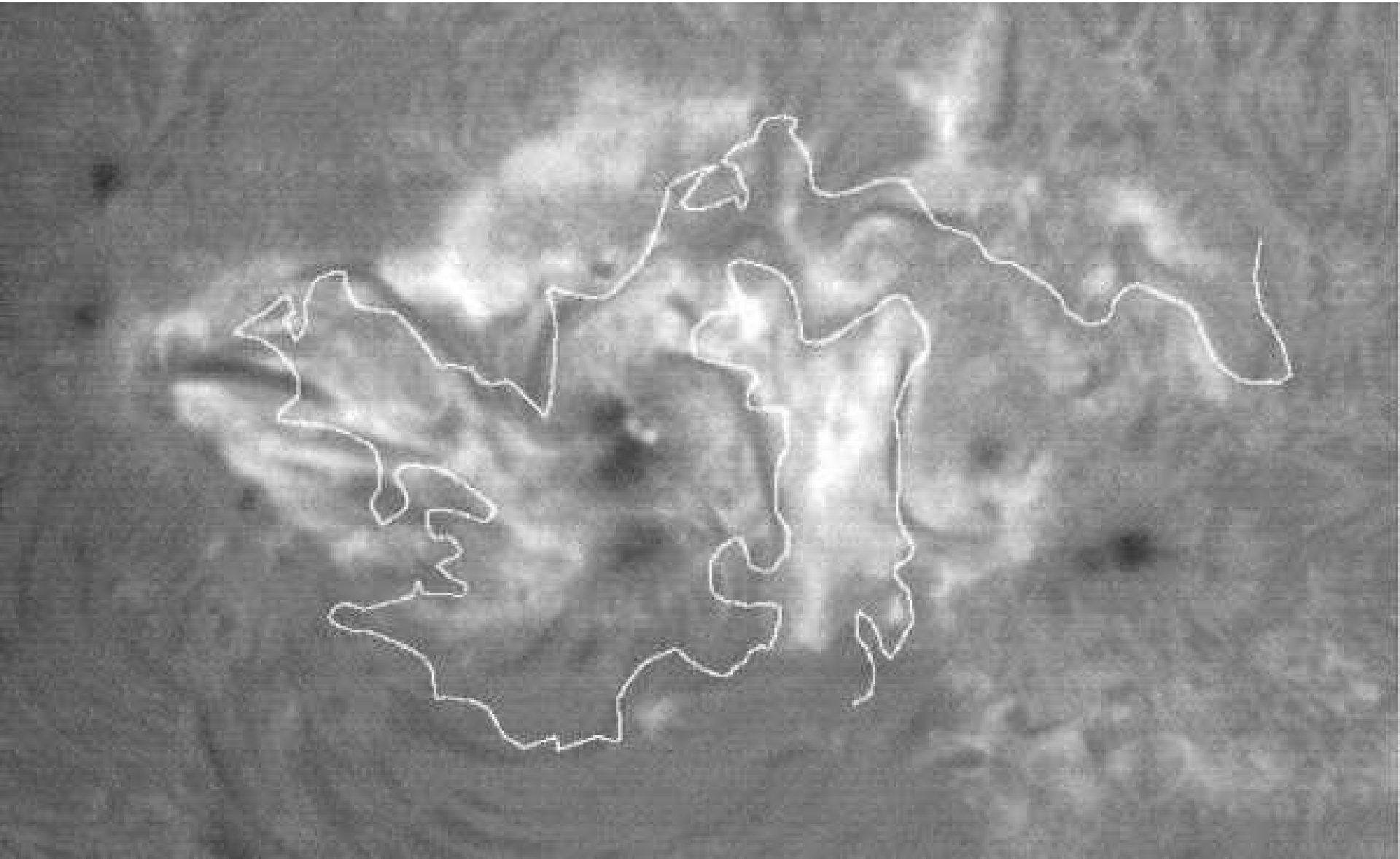
Standard Picture For Embedded-Arcade CME/Flare Eruptions



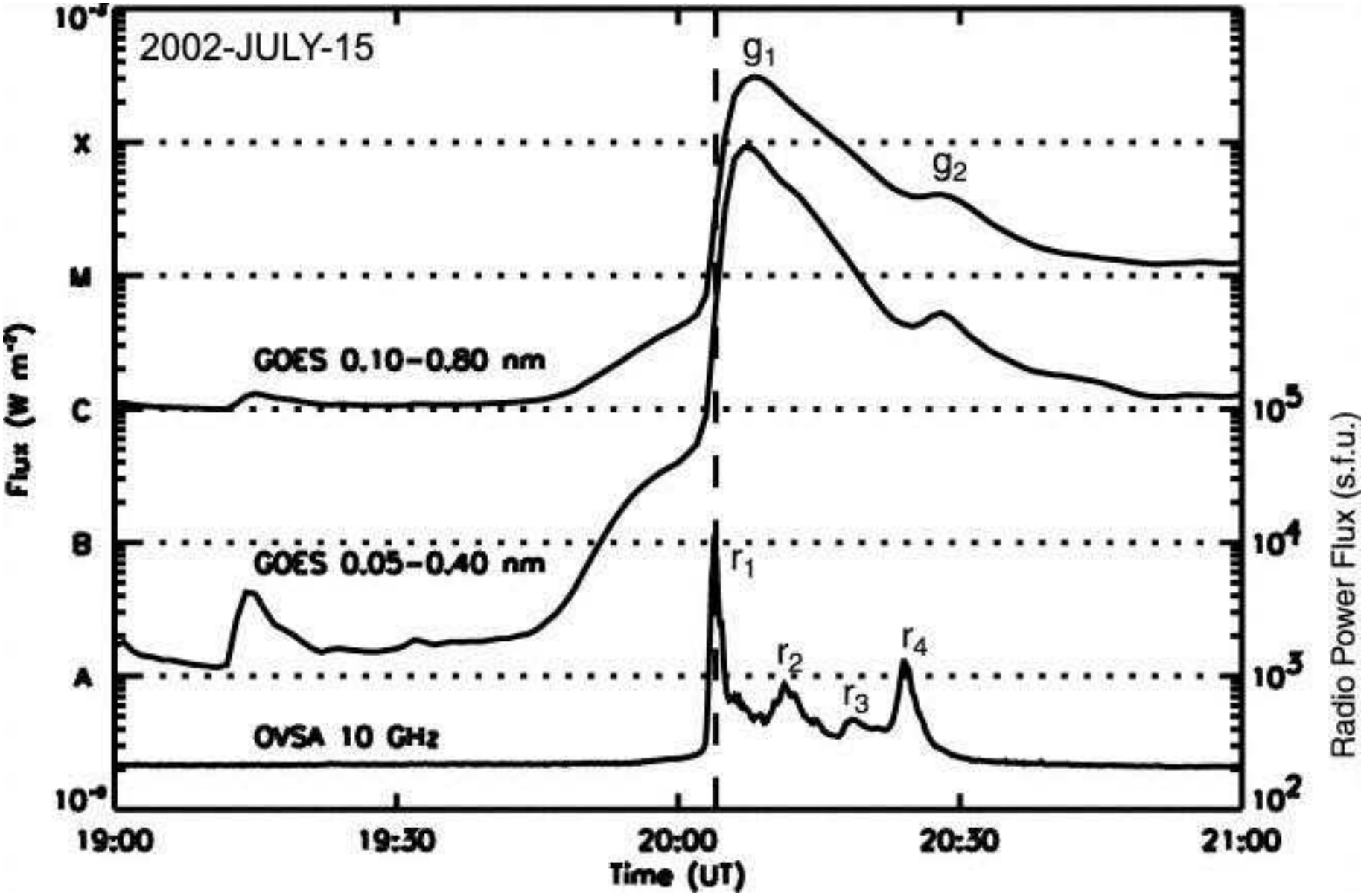
Quadrupolar Active Region 10030
on 15 July 2002
in SOHO/MDI magnetogram at 19:12 UT



AR 10030 Polarity Inversion Line on Hα Image

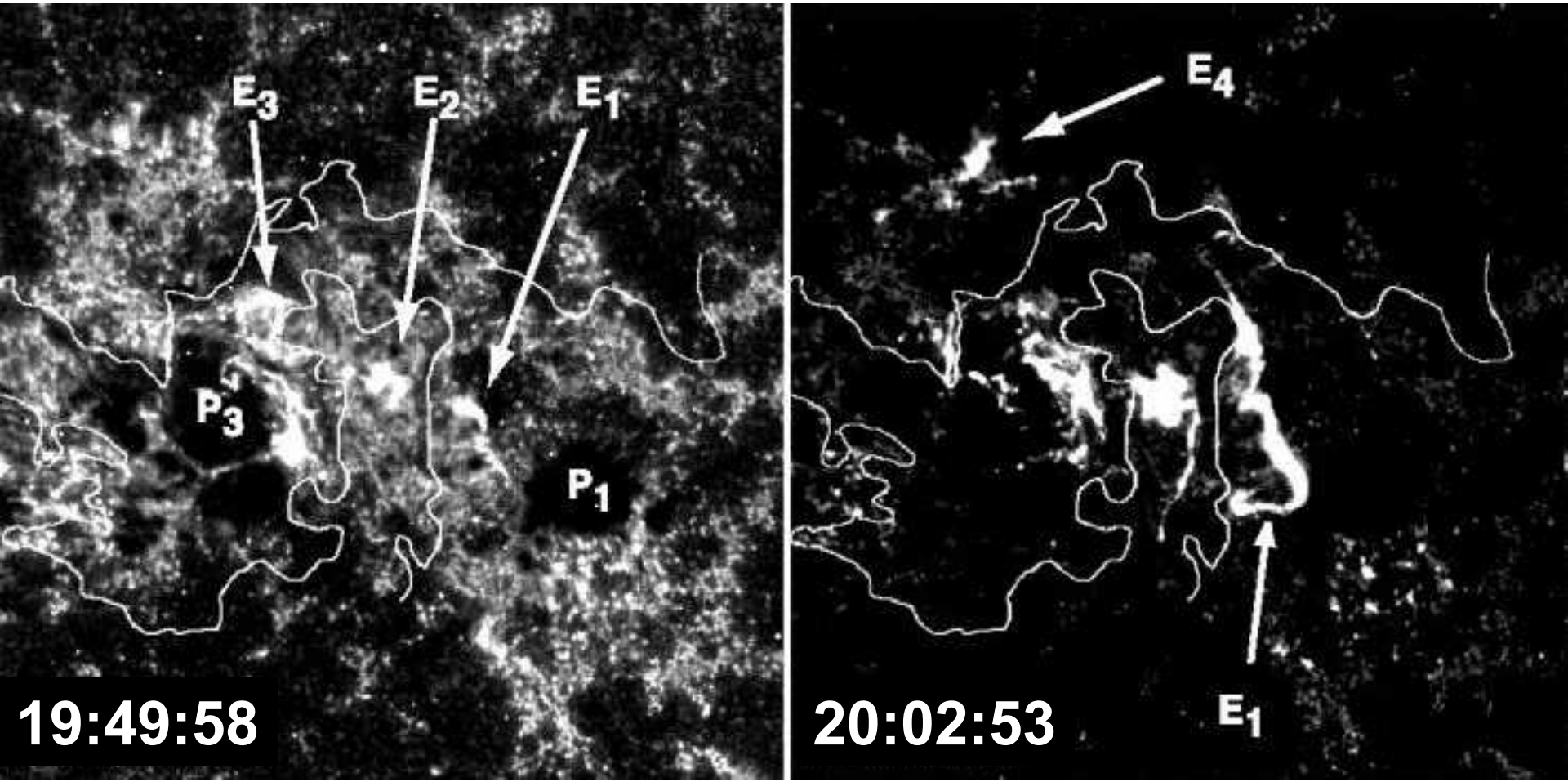


GOES Soft X-Ray Flux and OVSA Microwave Flux



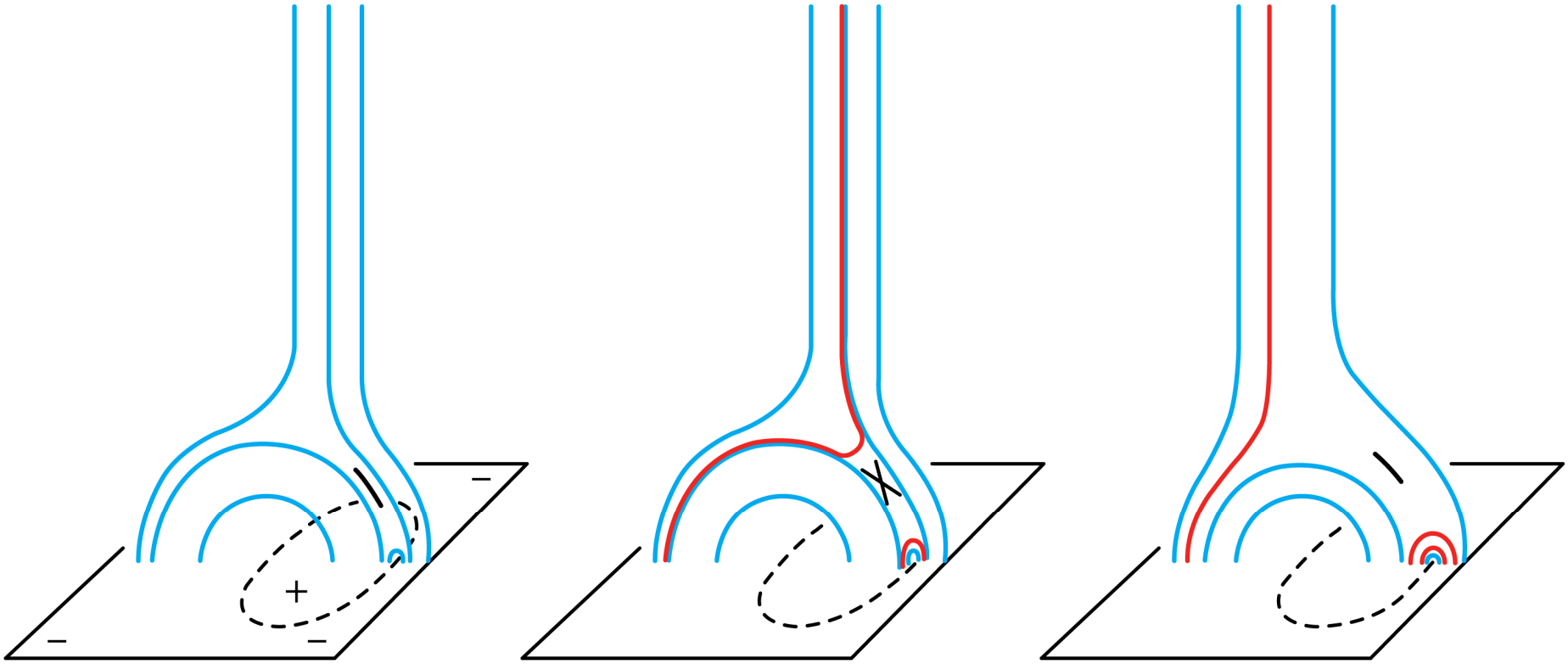
Breakout-Reconnection Flare Ribbons

in TRACE 1600 Å images



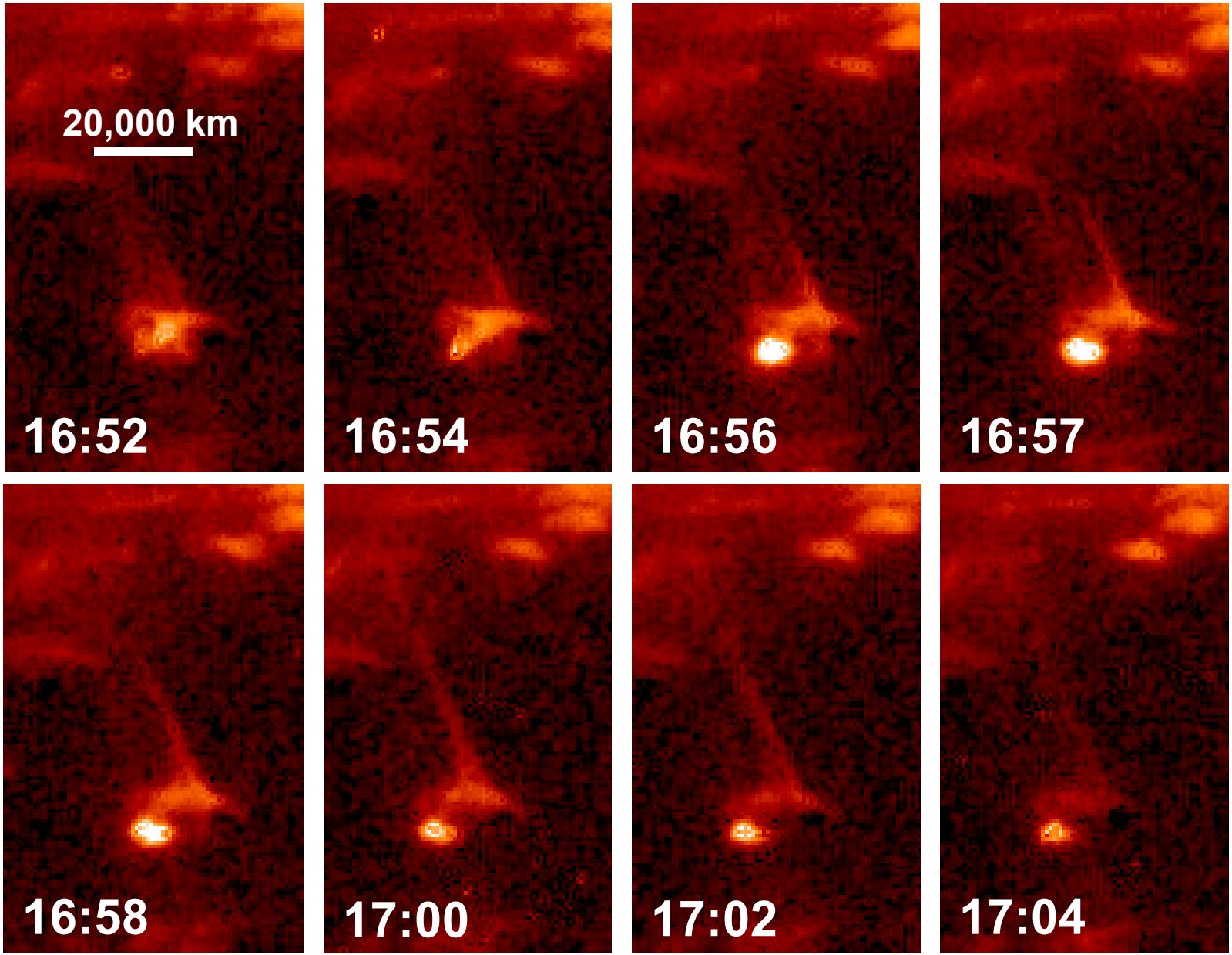
Reconnection Picture for Standard X-Ray Jets

a la Shibata et al



Standard Jet

observed by Hinode/XRT 2008 Sept 22



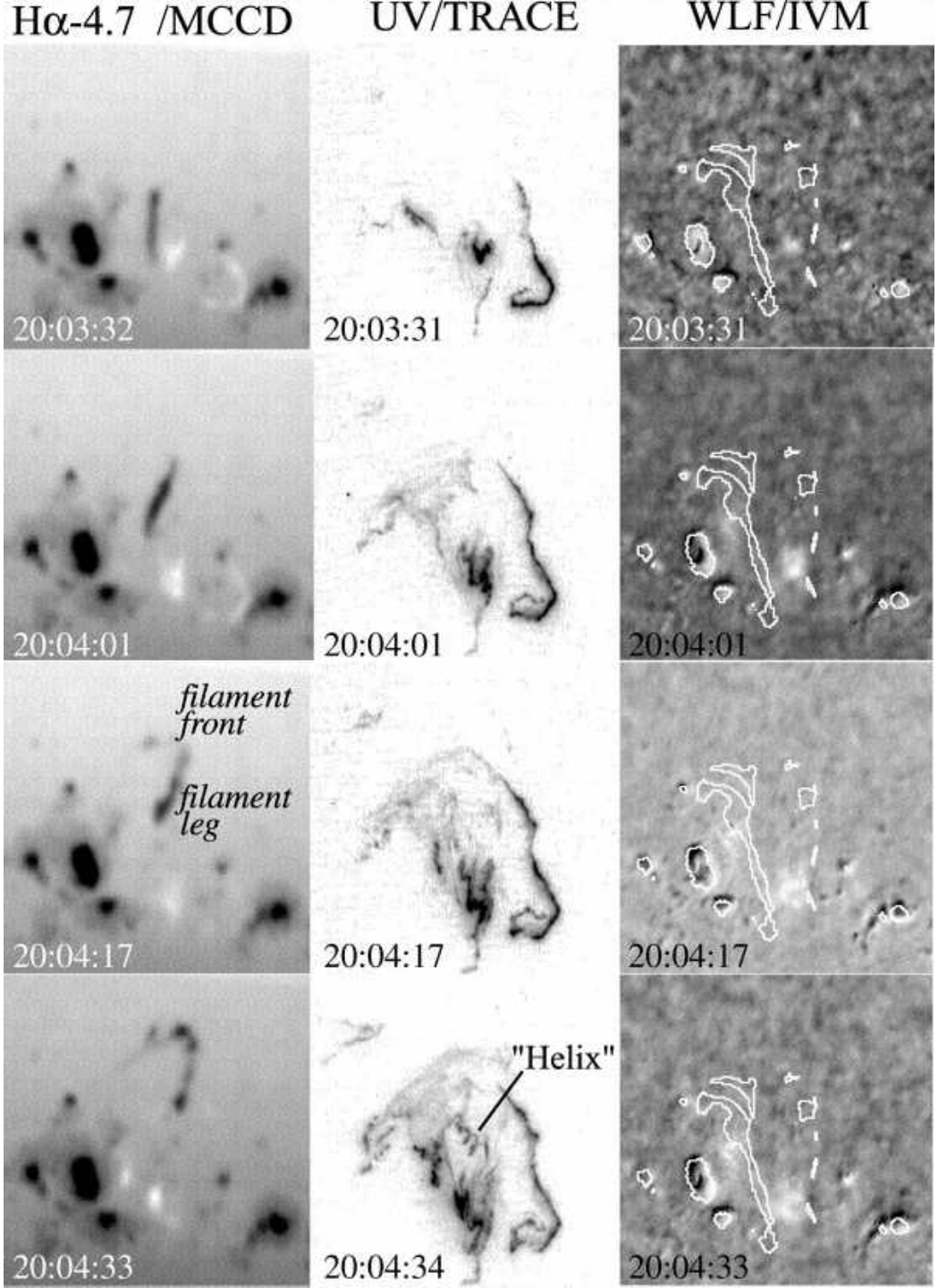
Conclusion

Because the pre-eruption magnetic field is much stronger than the plasma in it:

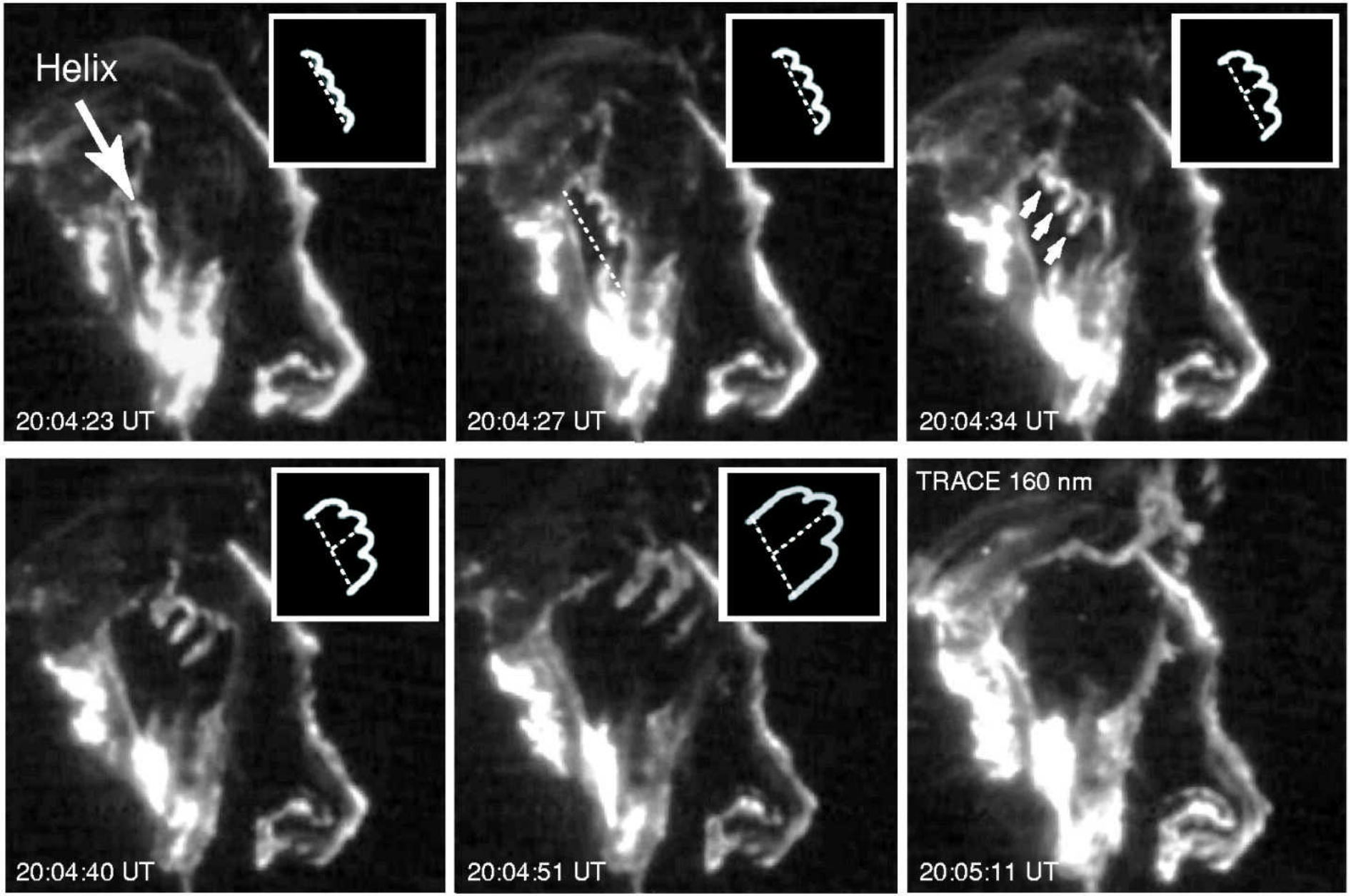
- **For a major CME/flare eruption:**
  - **Ample energy can be built up in (nearly-force-free) large-scale shear and twist in the field, but**
  - **Not nearly enough energy can be built up around a (non-force-free) current sheet in the field.**

- **$\Rightarrow$ S, not X, marks the spot for CME/flare eruptions.**

Hα Filament Eruption and Full Growth of Breakout-Reconnection Flare Ribbons Prior to Helix Eruption and Onset of Internal Tether-Cutting-Reconnection Flare Ribbons



Growth of Internal Flare Ribbons as Helix Erupts



Standard Jet

2008 Dec 20