Studies of Small-Scale and Large-Scale Solar Eruptions from Off-the-Sun-Earth-Line Missions

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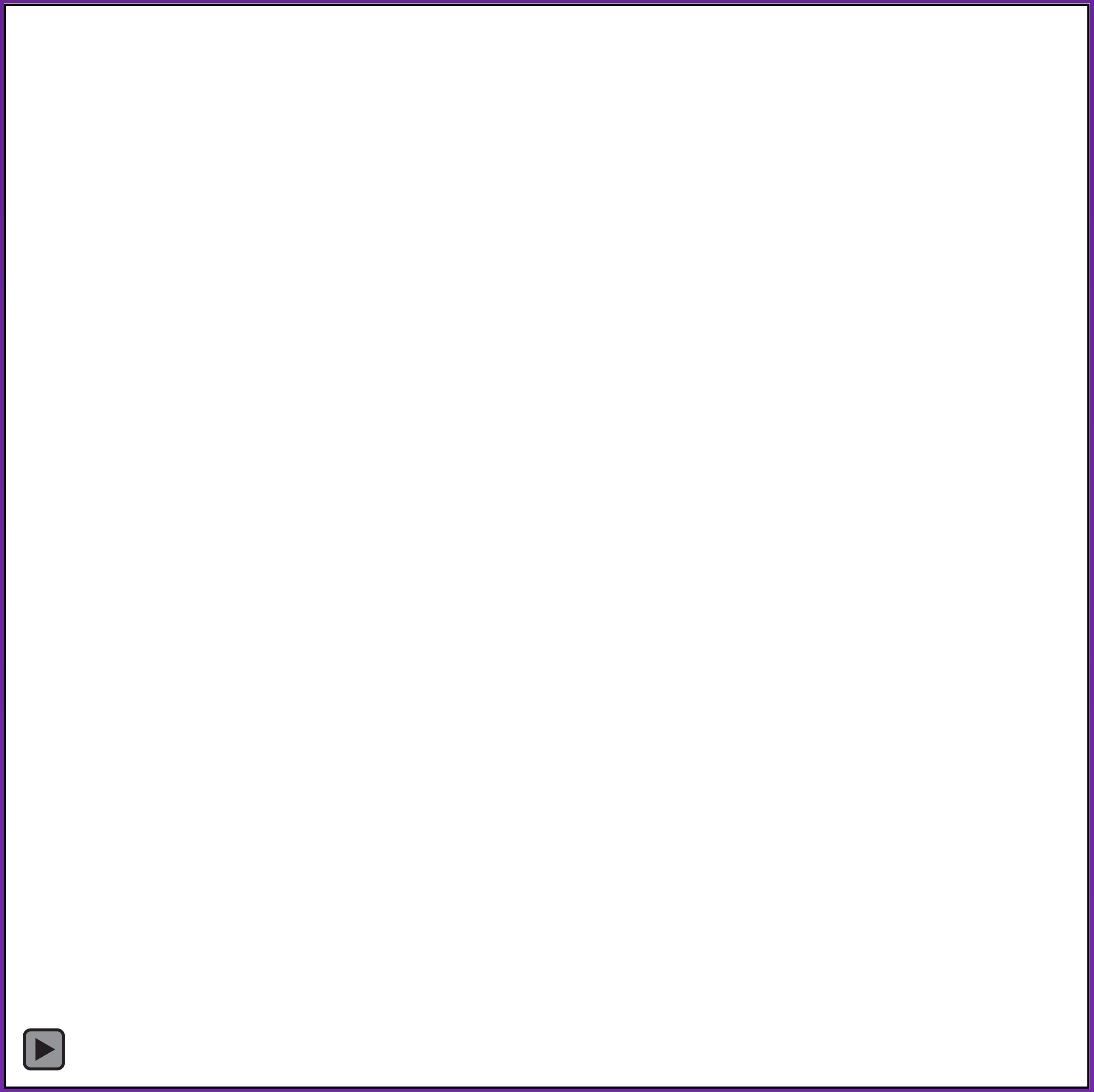
Cirtain et al. (2007)

Introduction: Solar X-Ray Jets

- Observed since the Yohkoh days (Shibata et al. 1992; also Shimojo et al. 1996, etc. Reviewed by Raouafi et al. 2016.)
- Yohkoh (SXT) saw them mainly in active regions.
- Hinode/XRT found them to be plentiful in polar coronal holes (Cirtain et al. 2007; also Savcheva et al. 2007, etc.)
- In polar coronal holes: size ~50,000 km x 8000 km; rate ~60/day (Savcheva et al. 2007).
- Often have a “hot loop” at the jet’s base.

Coronal Hole Jets: “Minifilament eruptions”

XRT



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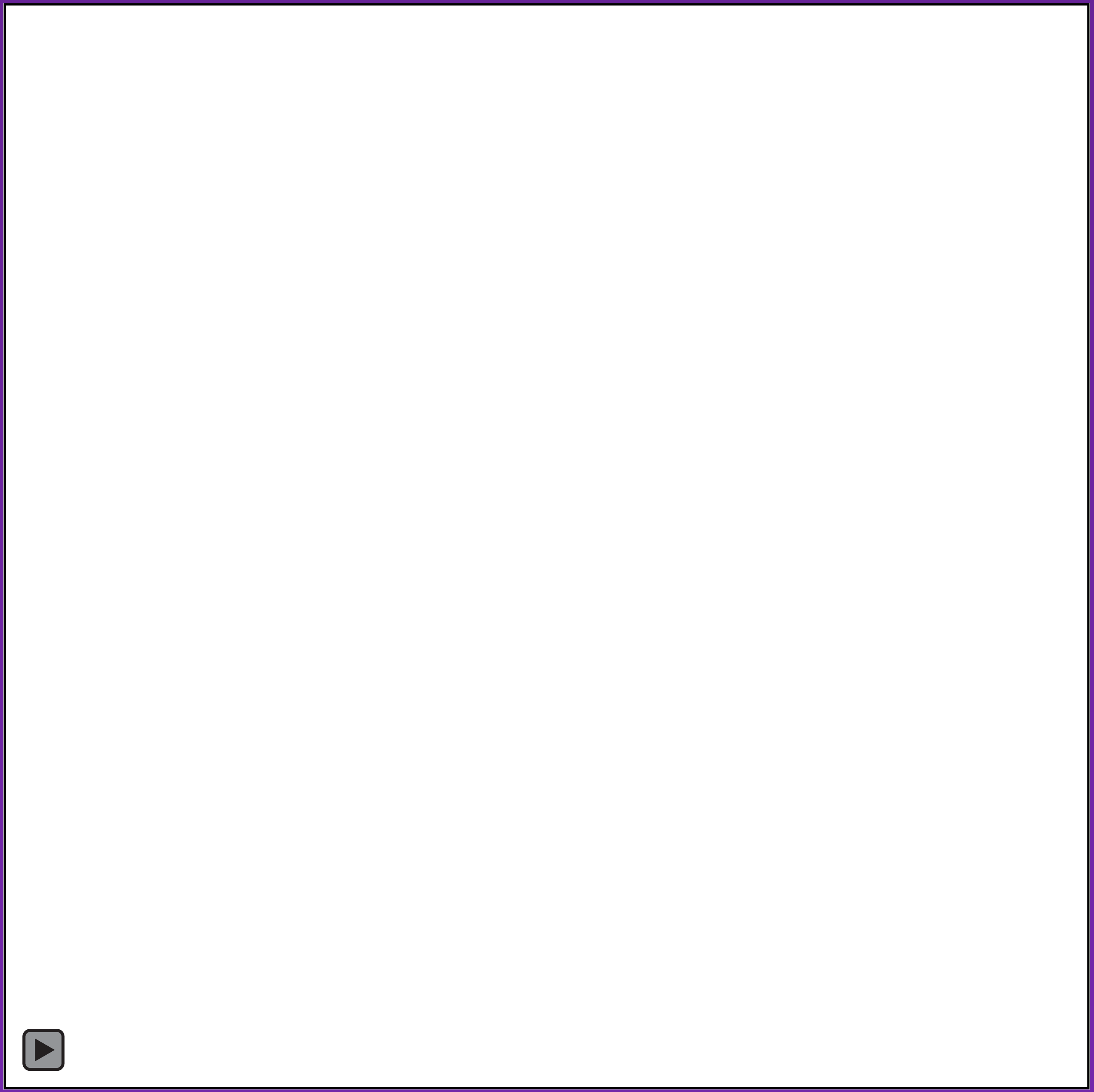
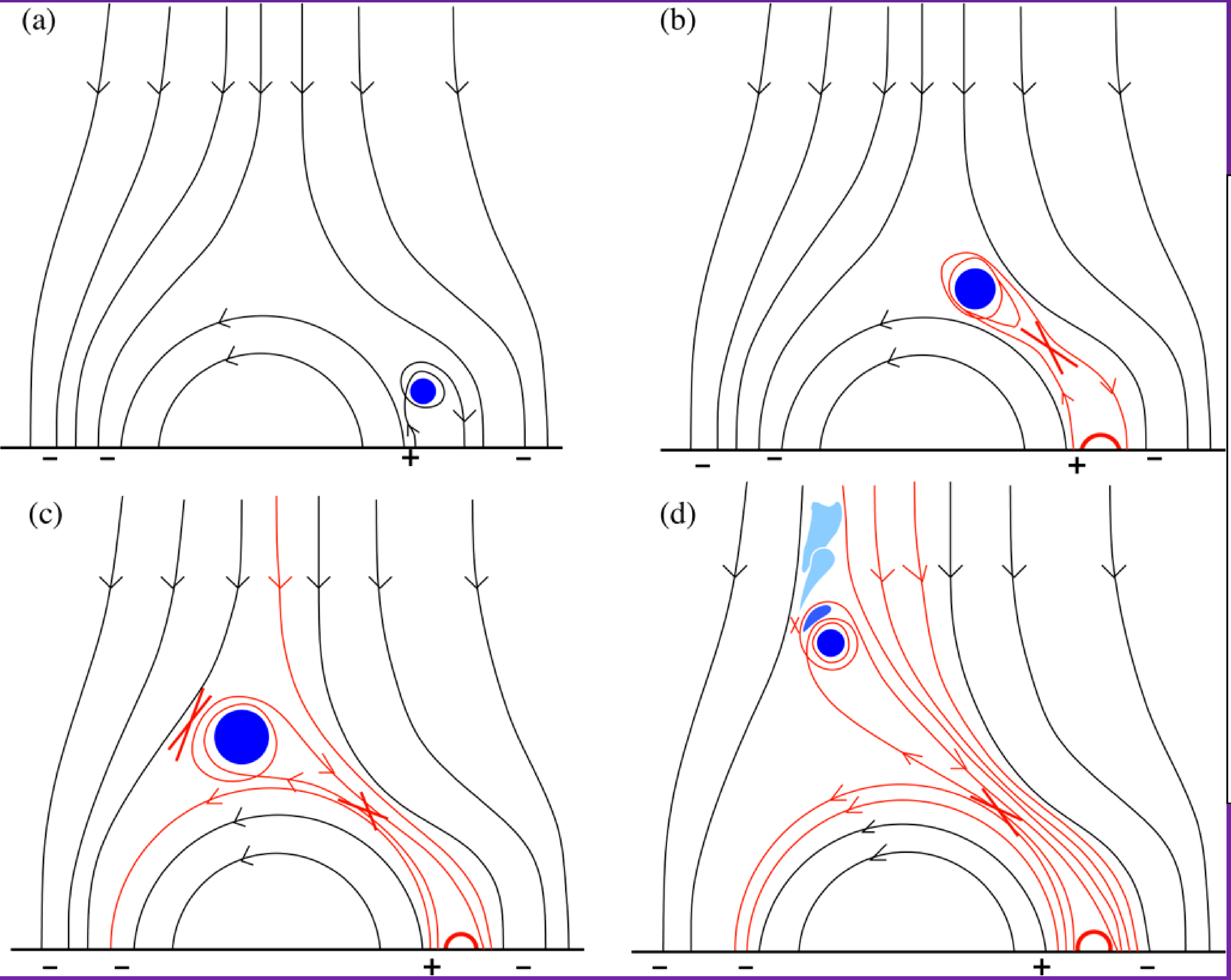
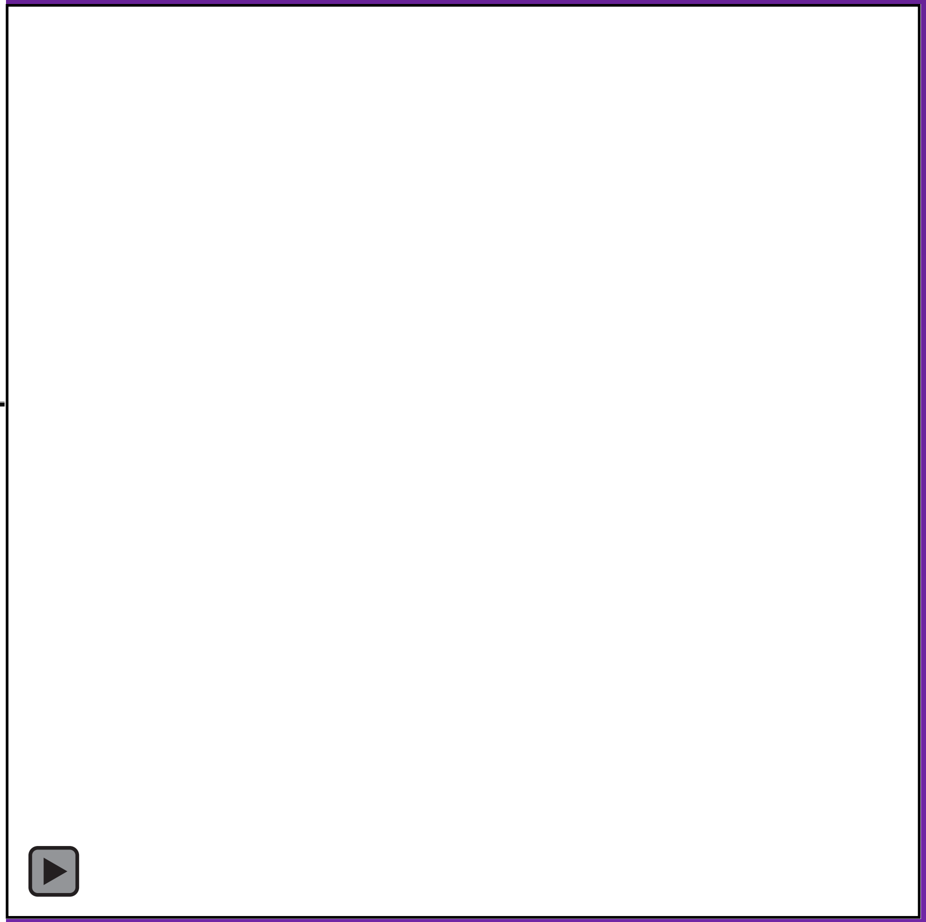


Sterling et al. (Nature, 2015): 20 Polar CH jets.

“Normal” Filament Eruption (TRACE)

Minifilament-Eruption Model for (X-Ray) Jets





Sterling et al. (2015, 2016, 2017)

Quite Sun jets work the same way (Panesar et al. 2016b)

Recently modeled by Wyper et al. 2017, 2018)

- Jet episodes appear to be miniature versions of large-scale eruptions.
- What triggers jets might also trigger large-scale eruptions.
- Since jets are more compact and shorter lived (and thus, “simpler”) than larger eruptions, understanding the trigger mechanism may be easier for jets than for large-scale eruptions.

- So, what triggers jets to occur??
- Study on-disk evolution of jets, using magnetograms.

Jet-Onset Mechanism

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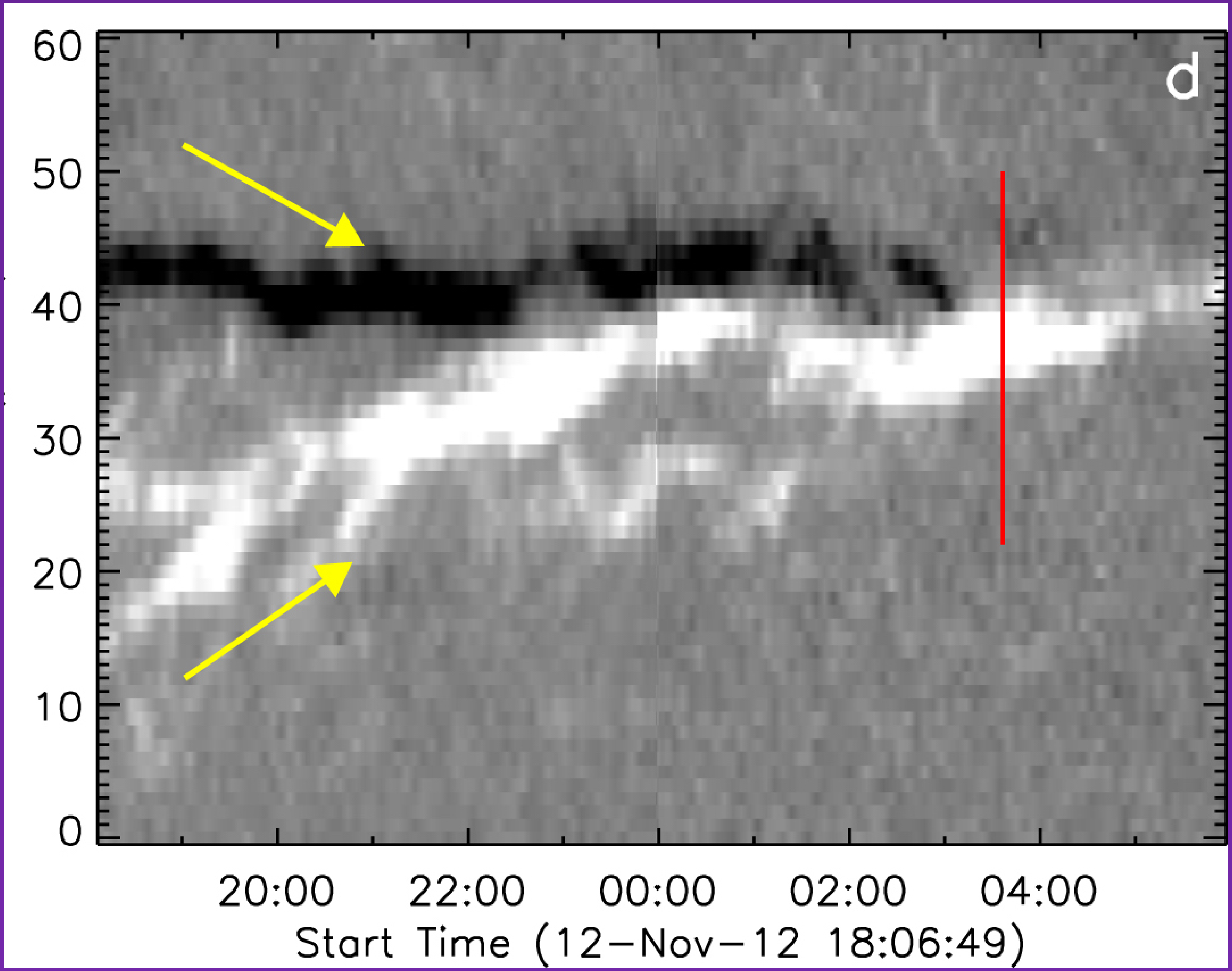
HMI

Panesar et al. (2016, ApJL)

Can Jets Tell Us About CME-Producing Eruptions?

Let's Check out the Onset Mechanism!



(Panesar et al. 2016, (2017a,b, 2018))

Jets frequently occur at sights where magnetic flux cancels (flux cancelation).

- Flux cancelation found in these cases:
  - Panesar et al. (2016): 10 QS jets.
  - Sterling et al. (2017): Series of AR jets.
  - Panesar et al. (2018): 13 CH jets.

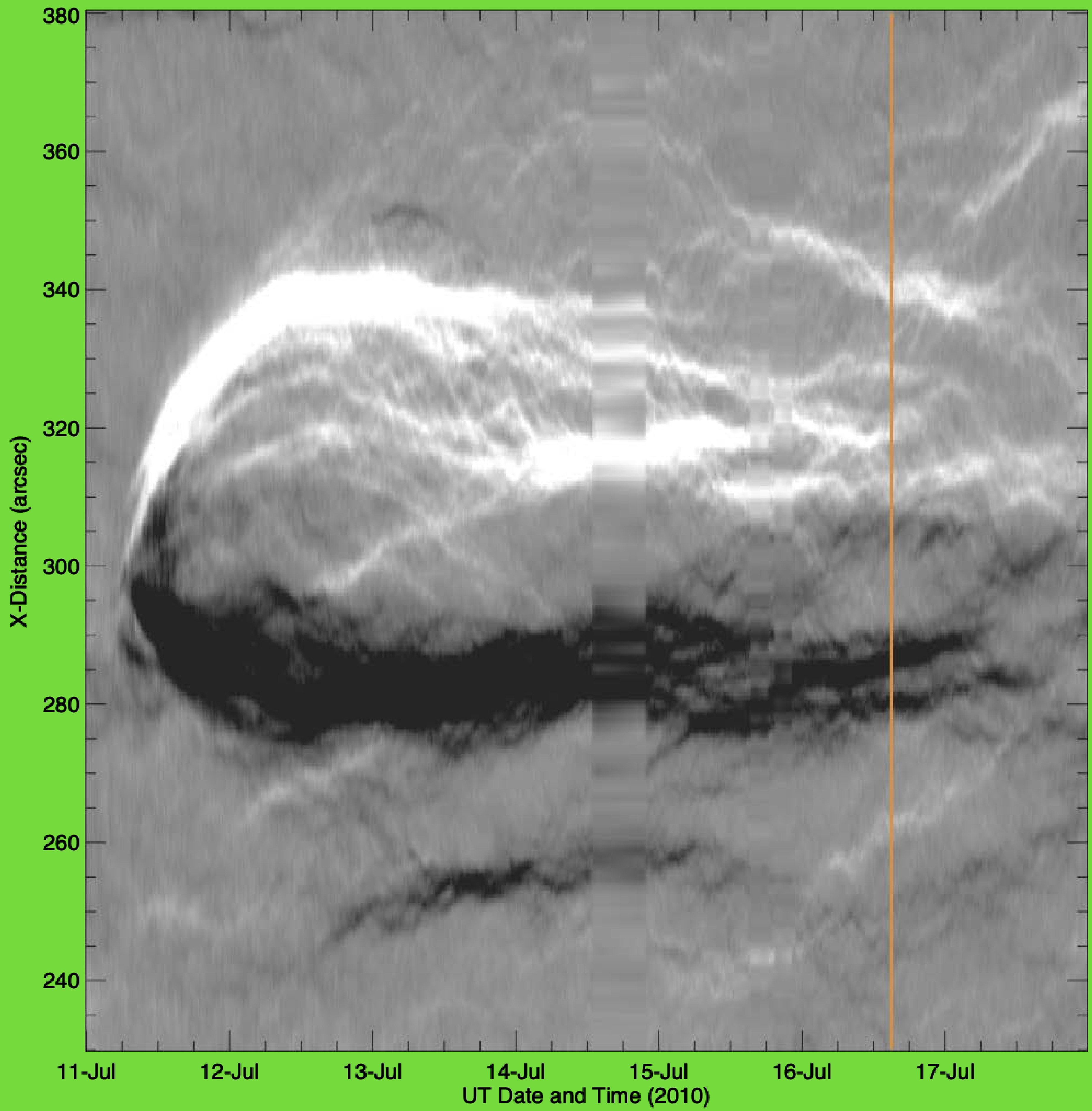
- McGlasson et al. (2019): 60 QS and CH jets, at least 85% of jets results from monofilament eruptions triggered by flux cancelation.
- In a small percentage of cases, mechanism not determinable or triggered by something else (e.g. Kumar et al. 2018).

- Several earlier studies found flux cancelation in single/few-event studies (e.g., Hong et al. 2011; Huang et al. 2012;

Does the same thing really happen for larger eruptions? Check it by looking at evolution of magnetically-isolated ARs

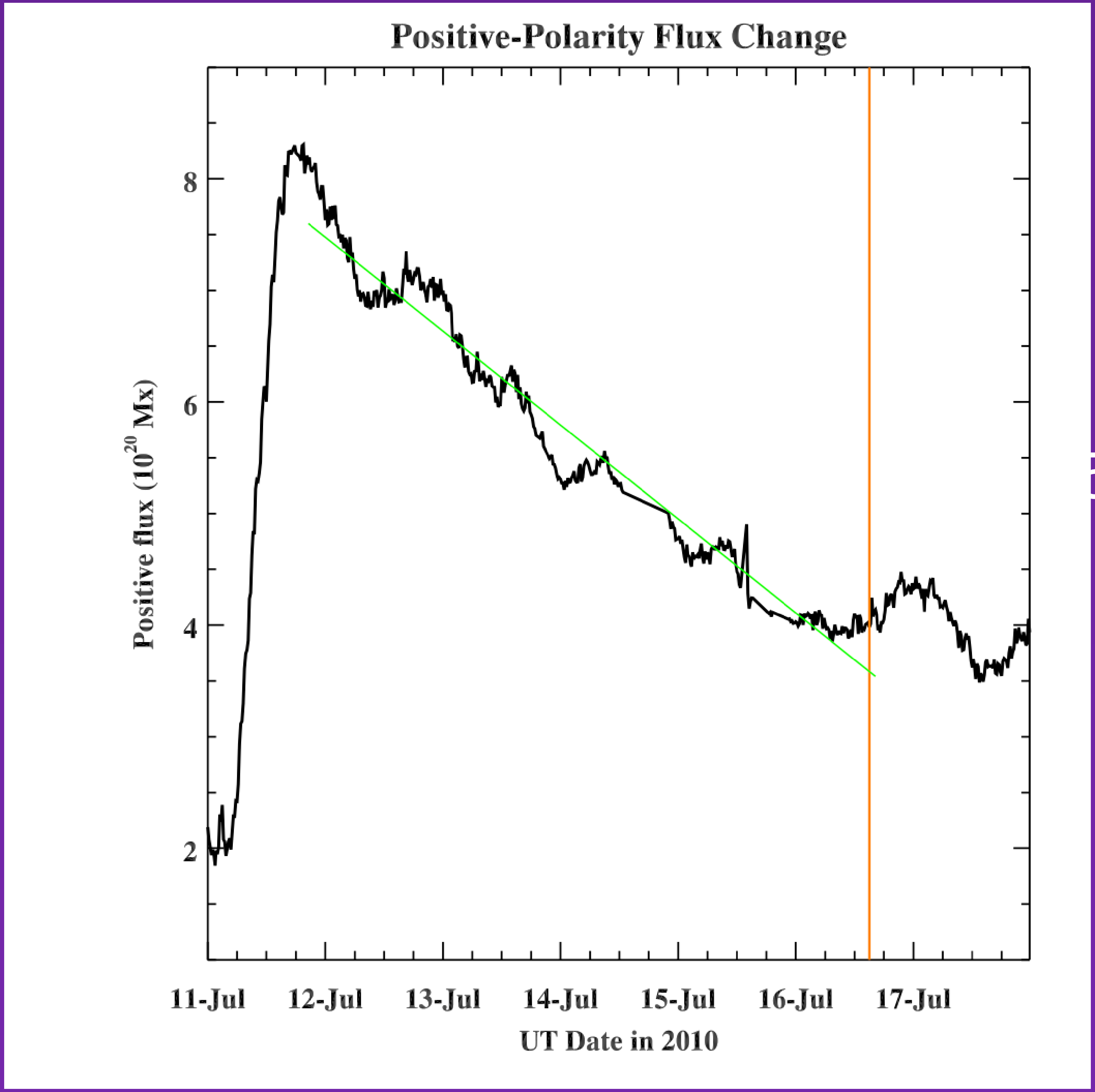
- Study CME-producing ARs.
- Use SDO/AIA and SDO/HMI (+STEREO COR).
- Follow the AR development from emergence to eruption.
  - Regions must be (largely) magnetically isolated;
  - Birth-to-eruption lifetime less than one-disk passage.

- Two small ARs: ~10^{21} Mx; lifetime ~5 days.

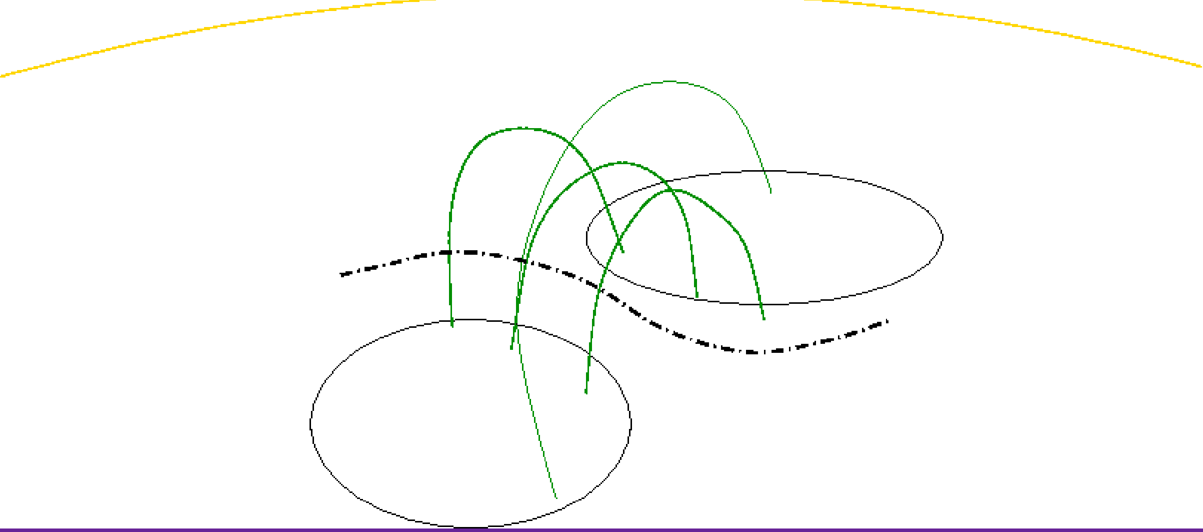


380
360
340
320
300
280
260
240
X-Distance (arcsec)
11-Jul
12-Jul
13-Jul
14-Jul
15-Jul
16-Jul
17-Jul
UT Date and Time (2010)

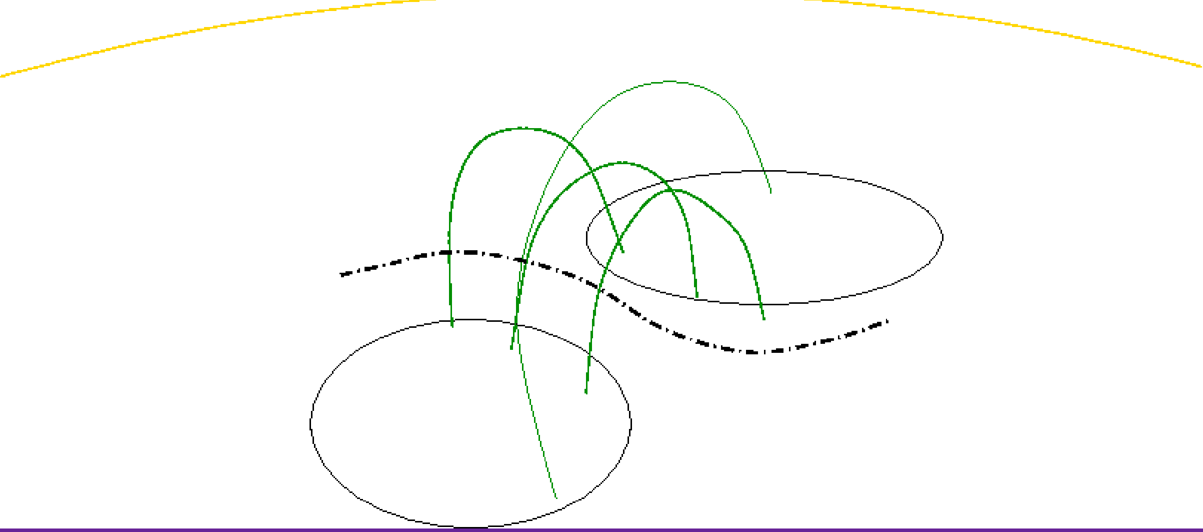
Positive-Polarity Flux Change



51% of max flux removed



(e.g., van Balleggoijen & Martens 1989, Moore & Roumeliotis 1992)



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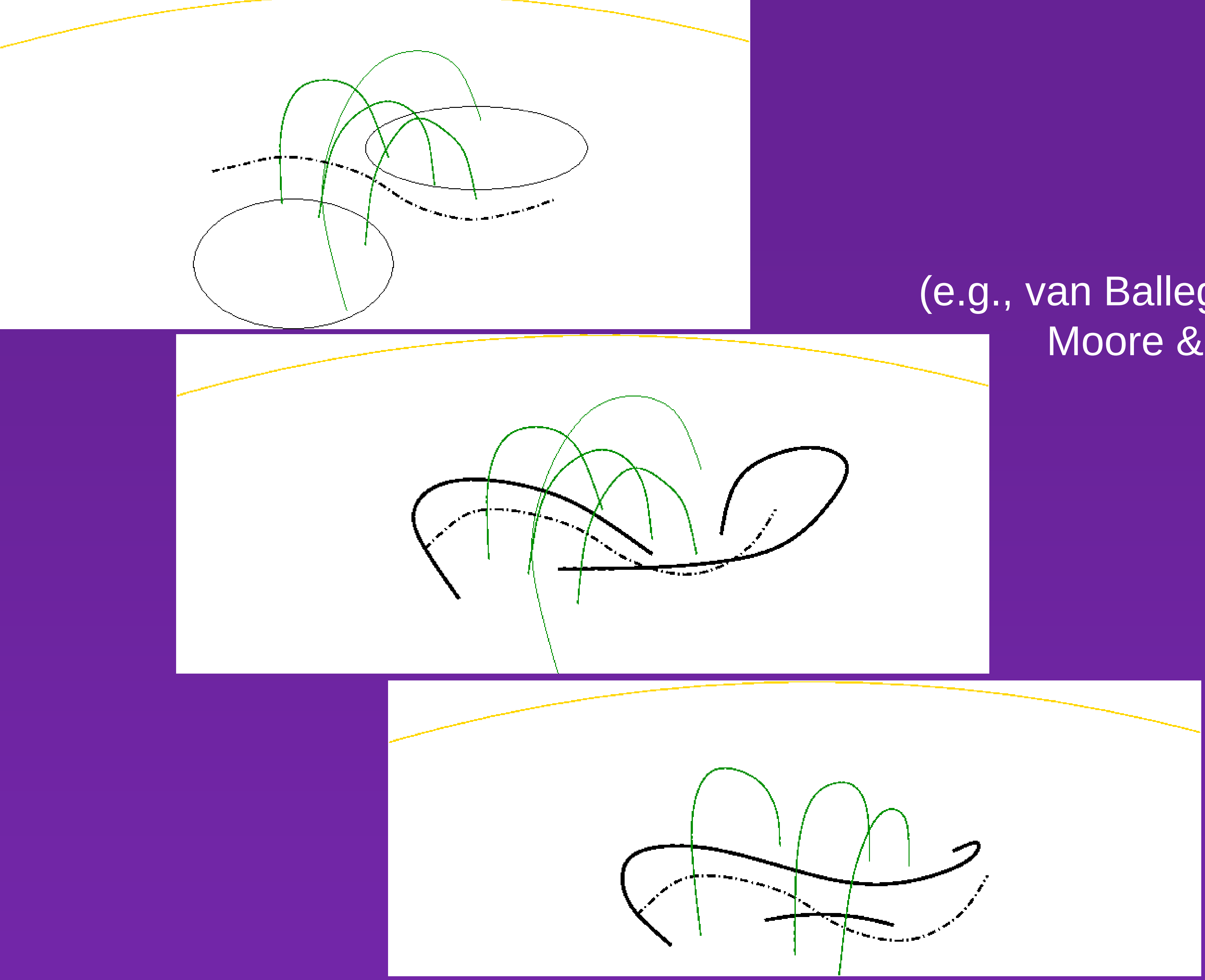

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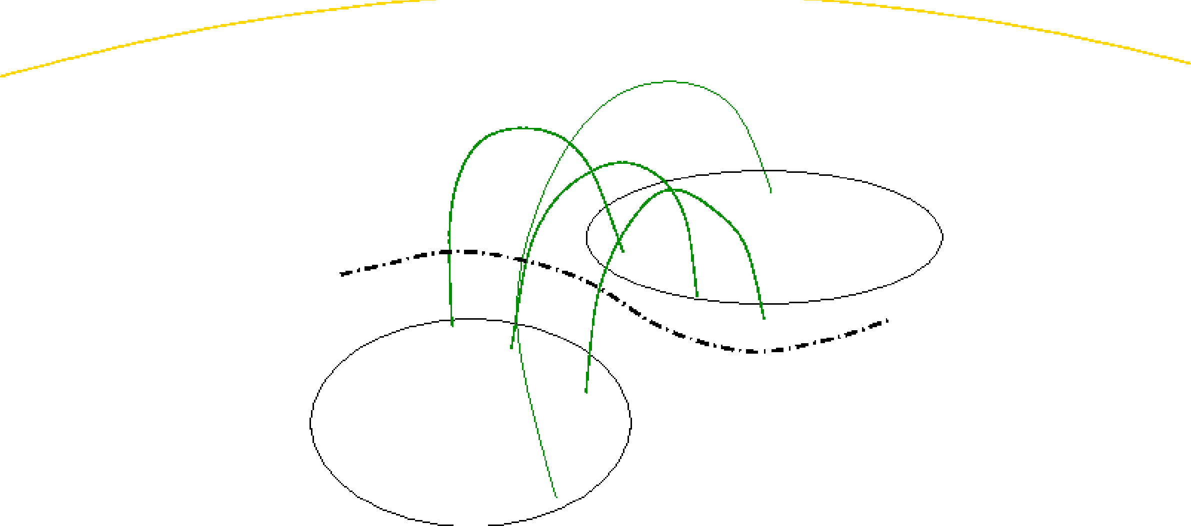

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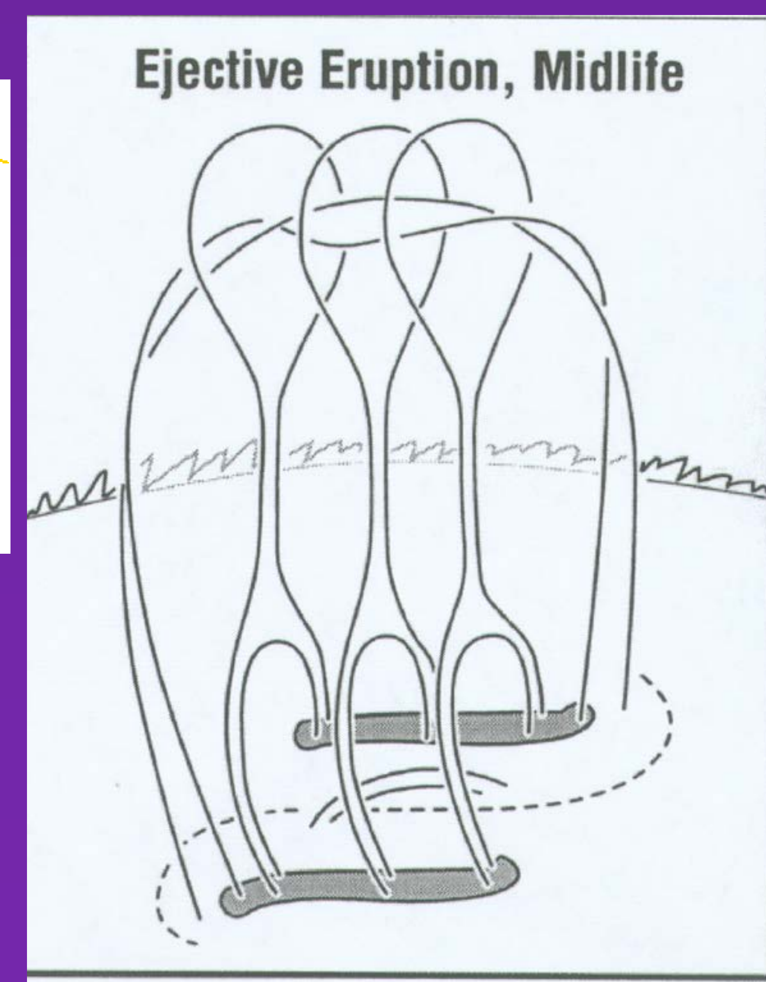


Flux Cancelation Rates and Percentages:

(Panesar et al. 2016, 2018; Sterling et al., 2018):

	(% flux canceled)
• For CH jets (~10 events):	45
• For QS jets (~10 events):	37
• Small AR Event 1:	51
• Small AR Event 2:	29

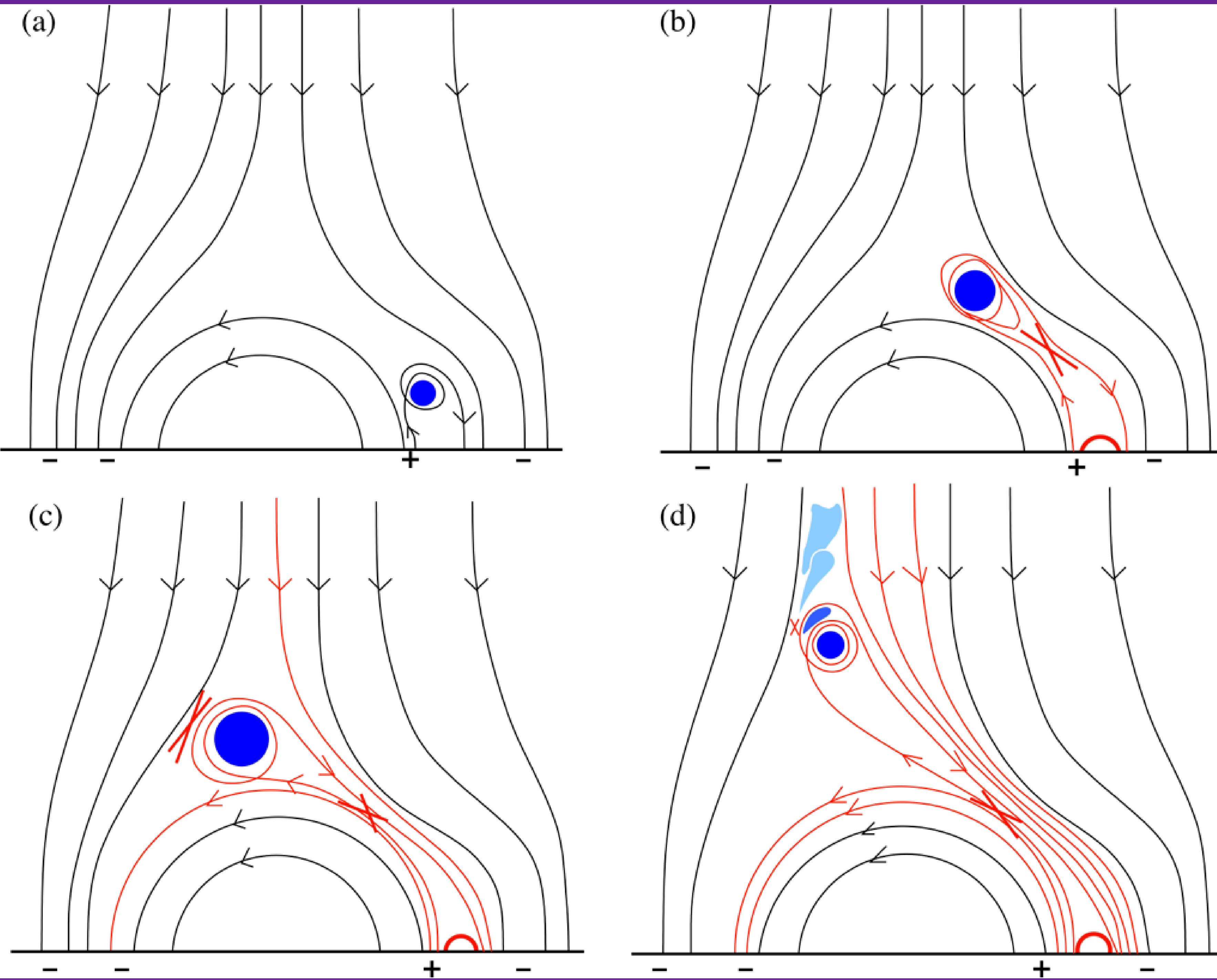
Details in Sterling et al. 2018 (also see Chintzoglou et al. 2019).

Summary

- Many/most coronal jets are like miniature CME-producing eruptions, resulting from minifilament eruptions, accompanied by a bright point/flare.
- Usually flux cancelation triggers eruption of the mini filaments causing the jets.
- When ARs are isolated and small enough to be followed, parts of the emerged flux will converge and cancel on the main neural line, and form a filament that erupts — this is similar to jets.
- There may be a threshold for amount of flux required to be canceled for eruption to occur.

What Can We Learn from L5?

- Stereo view will allow us to refine our understanding of jets, and of eruptions in general.
- Current study of isolated regions limited to relatively small ARs that we can track in a single passage on disk. Magnetograms from L5 will allow extensions to larger, longer-lived regions.
- Study of region magnetic evolution holds promise for predicting when eruptions will occur. Observations from L5 will potentially provide early warning for possible Earth-directed pernicious eruptions.



Sterling et al. (2015, 2016): “minifilament” eruptions.

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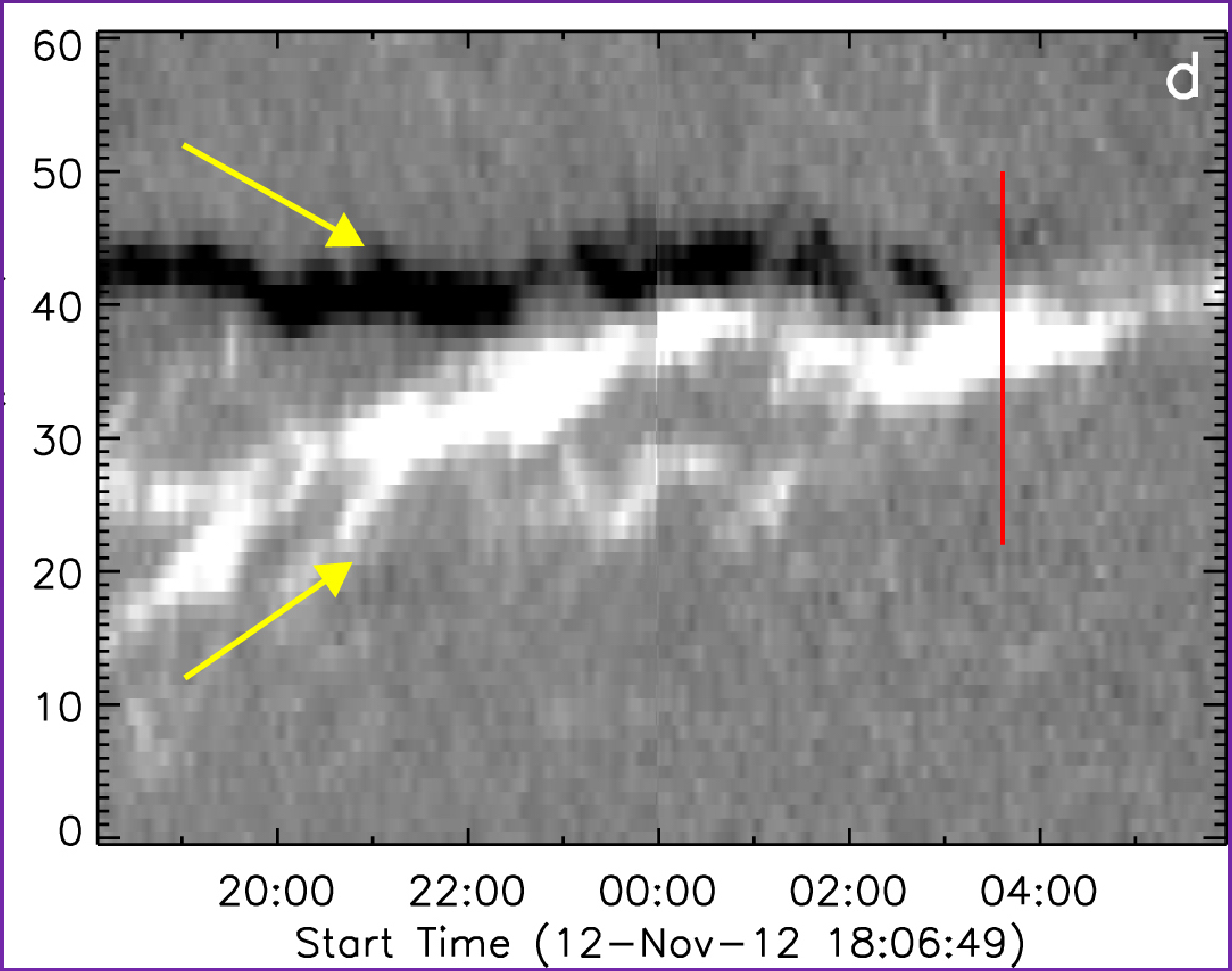

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