The Cause of Faint Coronal Jets from Emerging-Flux Regions in Solar Coronal Holes

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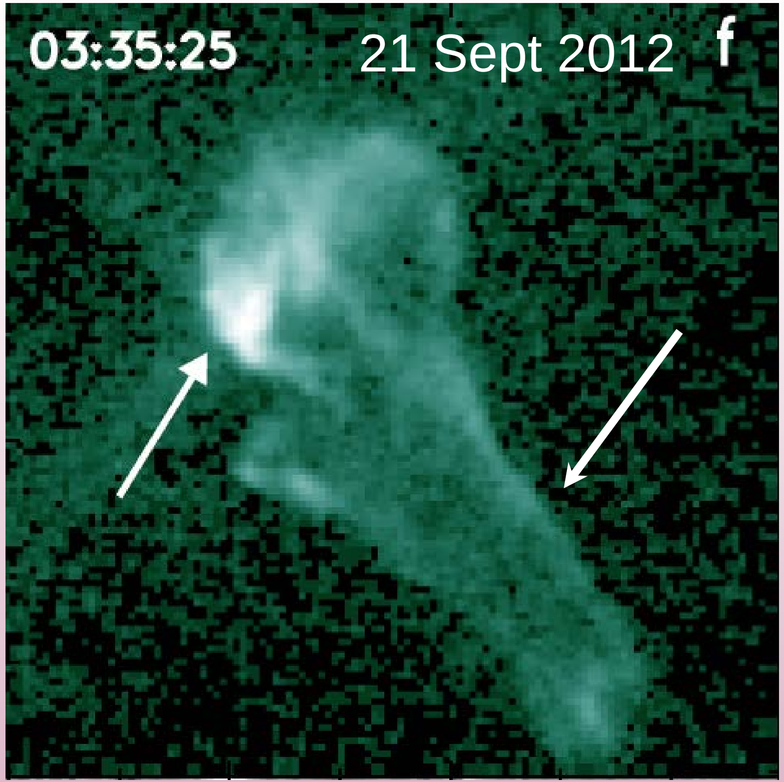
Coronal Jets

SDO/AIA 94A



Panesar et al 2016

•Coronal jets are transient, thin bursts of magnetically channeled solar material from the surface into the corona.

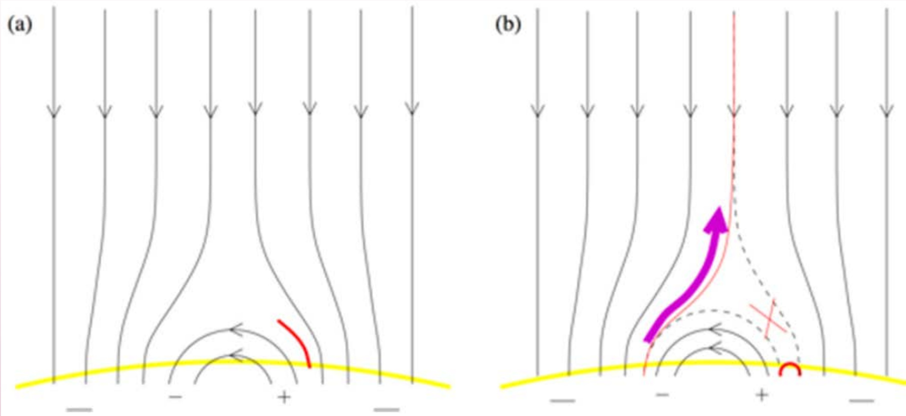
•Found in coronal holes, active regions, and quiet regions.

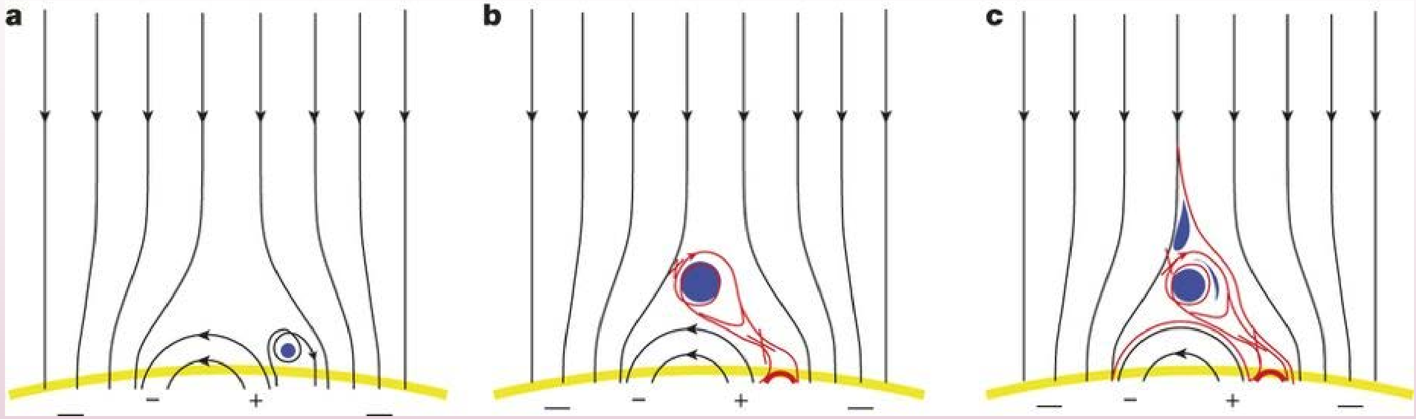
•They are relatively short-lived features (of about 10 minutes; *Shimojo et al 1996, Savcheva et al 2007*) occur at a rate of ~60 per day in polar coronal holes (*Savcheva et al 2007*).

•They show a base brightening (*Shibata et al 2007, Sterling et al 2015*), sometimes called a jet bright point (JBP).

•The average speeds are 200 km s^{-1} in X-rays (*Cirtain et al 2007*).

What Causes Coronal Jets?





Sterling et al 2015

<u>Emerging-Flux Mechanism (Shibata et al 1992)</u>

(a) Emerging bipole in a unipolar ambient field & plasma current sheet forms at null region (red line).

(b) Flux emergence triggers reconnection (red cross). New closed loop, JBP (small red loop) & connection with ambient field allows plasma (purple arrow) flows.

<u>According to recent AIA and XRT observations:</u>

(a) Two bipoles, with the smaller (right) bipole has a highly sheared magnetic field that holds a minifilament.

(b) Field becomes unstable, causing minifilament to erupt and reconnection to occur at red crosses.

(c) JBP forms where the minifilament was rooted, external reconnection results in jet spire.

Motivations

- Recent studies (e.g. Panesar et al. 2016) show that most pre-jet minifilament eruptions are triggered by flux cancelation at the neutral line underneath the minifilament.
- We wanted to find if any jets are driven by flux emergence (as in Shibata et al. 1992).

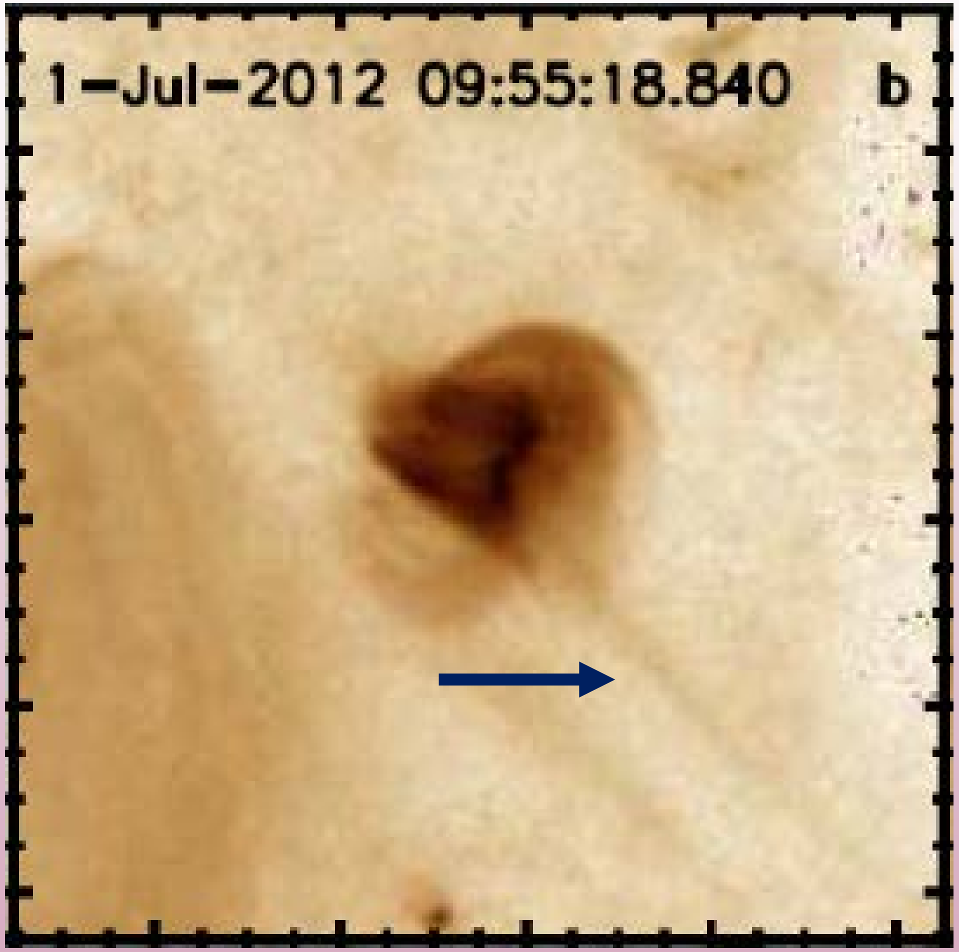
Methodology

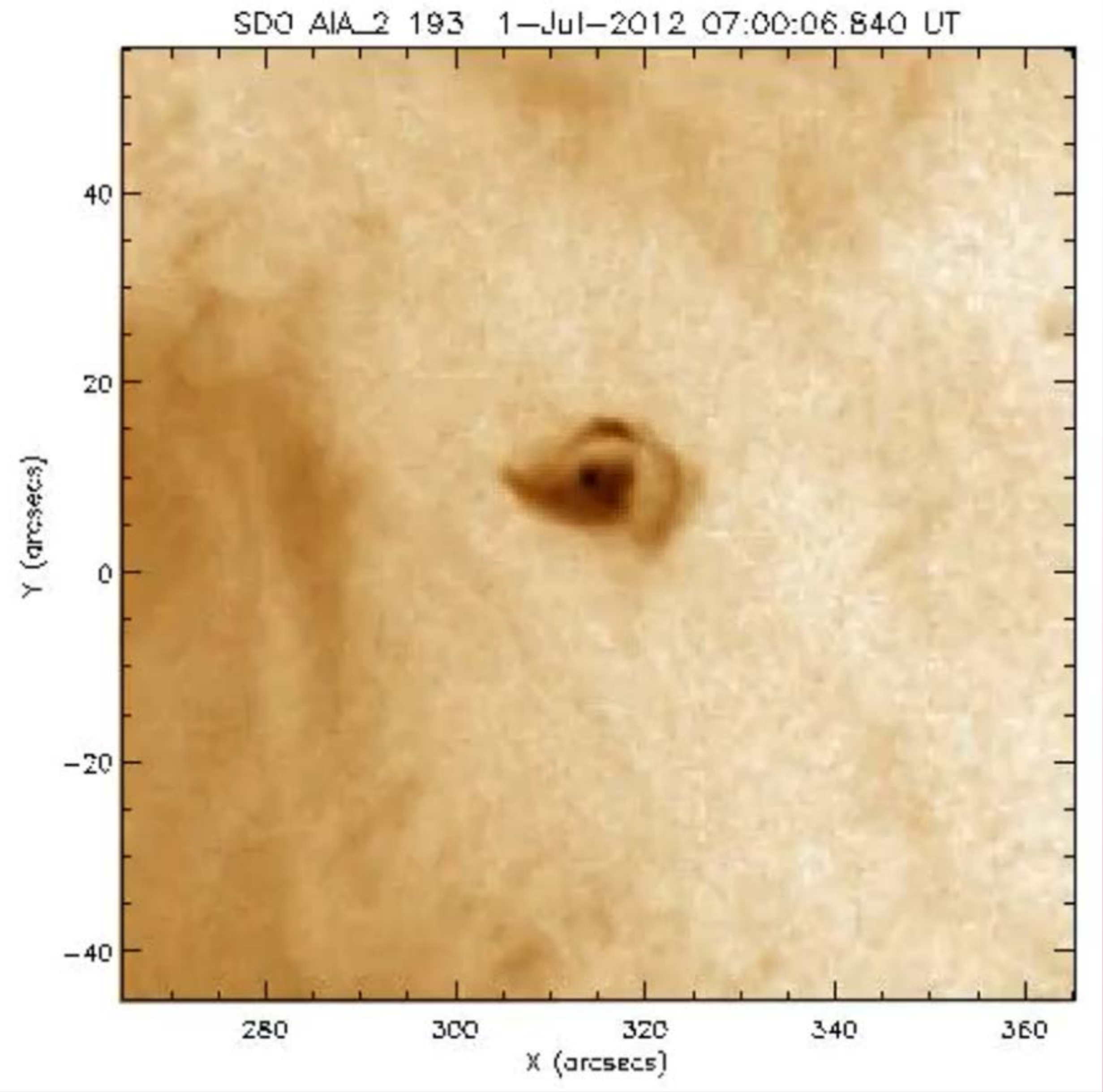
- Studied 8 emerging flux regions over their emergence period using SDO/AIA/HMI movies and data.
- We used SDO/AIA 193 Å images and SDO/HMI line of sight magnetograms to study the 8 emerging flux regions.
- Tracked the photospheric magnetic field evolution of emerging regions to see whether they led to any coronal jets.
- We studied candidate faint jets. Using AIA 193 Å images we measured physical parameters of these faint jets.

Physical Parameters of Observed Faint Jets

Emerging Flux Region No.	Start Time (UT)	End Time (UT)	No. of Faint Jets	Jet No.	Time (UT)	Duration (min.)	Triggered by Flux Emergence?	Speed (km s^{-1})
E1	21:00 June 30 2012	10:00 July 1 2012	1	J1	21:30	2 ± 1	Ambiguous	90 ± 30
E2	04:00 July 1 2012	20:00 July 1 2012	2	J2	09:48	15 ± 5	N	90 ± 5
				J3	10:52	13 ± 4	N	90 ± 10
E3	15:00 July 1 2012	08:00 July 2 2012	2	J4	18:17[1]	9 ± 2	N	-
				J5	18:41[1]	4 ± 1	N	-
E4	20:00 January 9 2015	18:00 January 11 2015	3	J6	12:45	7 ± 5	N	180 ± 65 [6]
				J7	19:08	16 ± 10	N	80 ± 25 [6]
				J8	20:46	32 ± 6	N	175 ± 45 [6]
E5	20:00 January 9 2015	18:00 January 11 2015	10	J9	10:19[2]	9 ± 2	N	235 ± 70
				J10	10:31[2]	6 ± 3	N	200 ± 10
				J11	10:40[3]	2 ± 1	N	120 ± 30
				J12	10:42[3]	9 ± 2	N	160 ± 10
				J13	10:58[4]	11 ± 3	N	115 ± 10
				J14	11:10[4]	8 ± 3	N	100 ± 10
				J15	11:23	13 ± 3	N	110 ± 10
				J16	12:09[5]	8 ± 2	N	130 ± 10
				J17	12:20[5]	8 ± 1	N	120 ± 10
				J18	17:24	10 ± 4	N	35 ± 10 [6]
E6	06:00 January 31 2017	06:00 February 1 2017	3	J19	08:16	4 ± 2	N	85 ± 10
				J20	08:26	10 ± 3	N	145 ± 5
				J21	09:04	7 ± 1	N	135 ± 10
E7	03:30 February 27 2011	10:30 February 27 2011	1	J22	04:31	11 ± 5	N	80 ± 20
E8	22:00 May 12 2012	02:00 May 13 2012	3	J23	22:24	3 ± 1	Y	90 ± 10
				J24	22:33[7]	3 ± 1	Y[8]	90 ± 10
				J25	22:38[7]	2± 1	Y[8]	100 ± 10

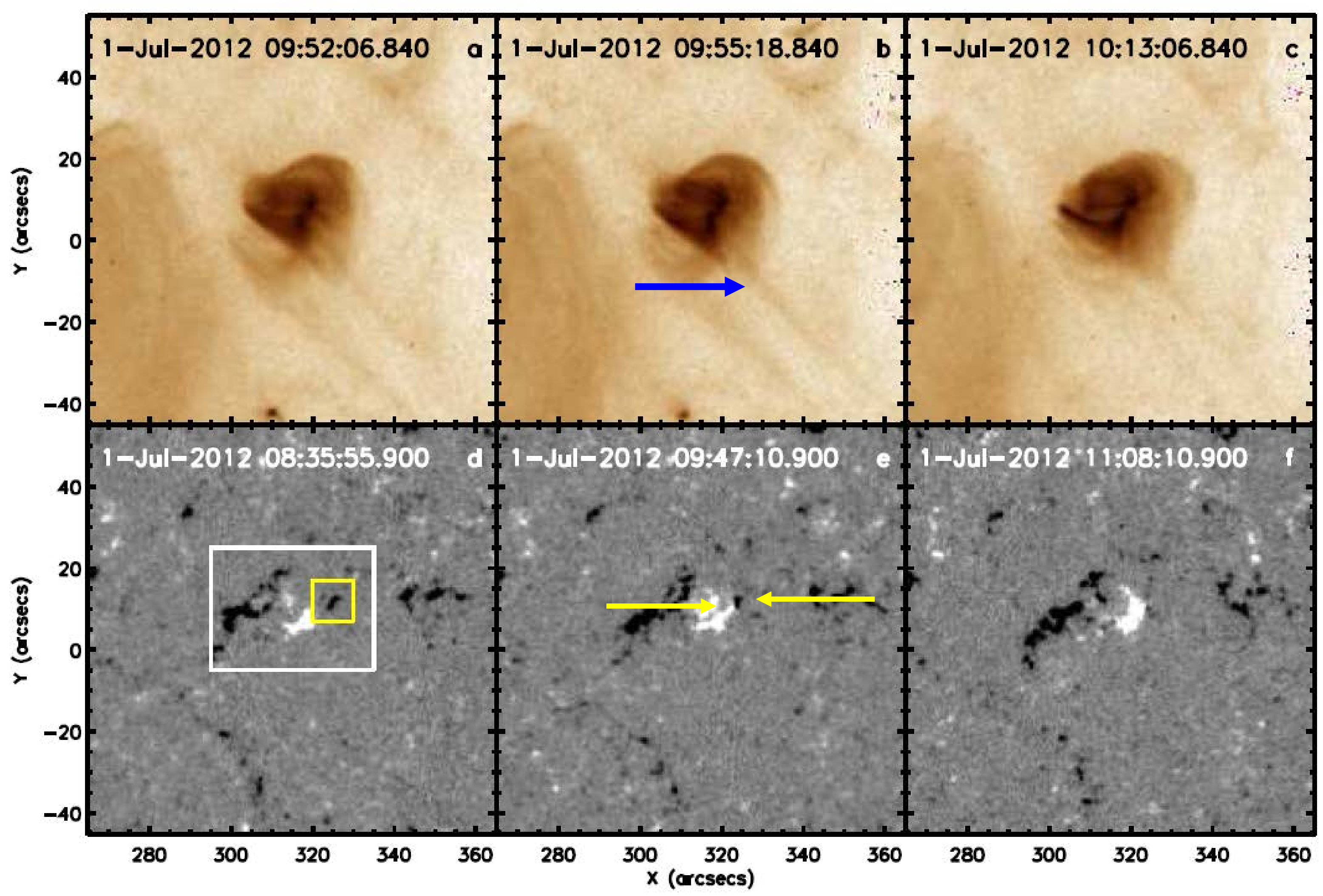
First Example (emerging region E2) in 193 Å

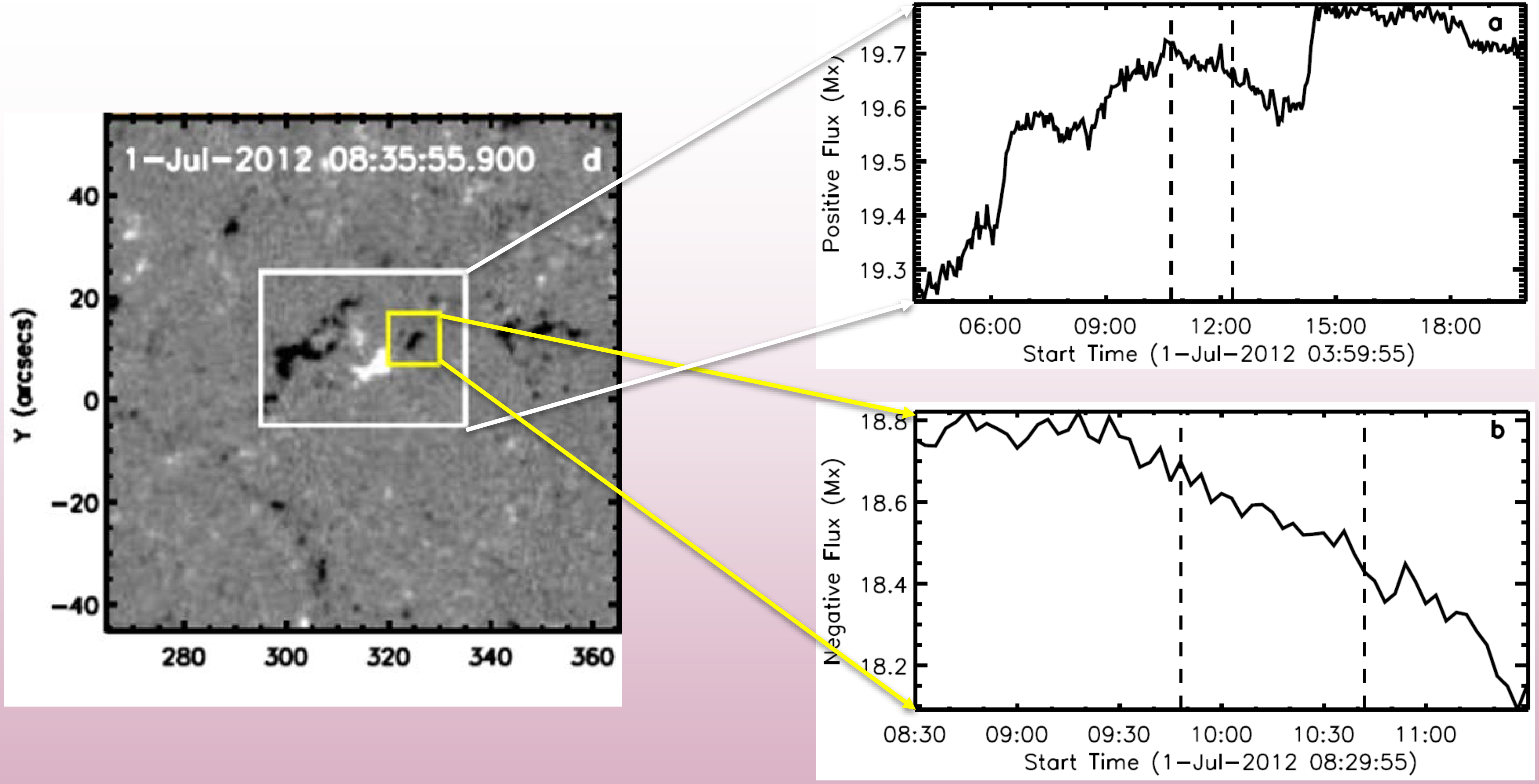




First Example (emerging region E2)

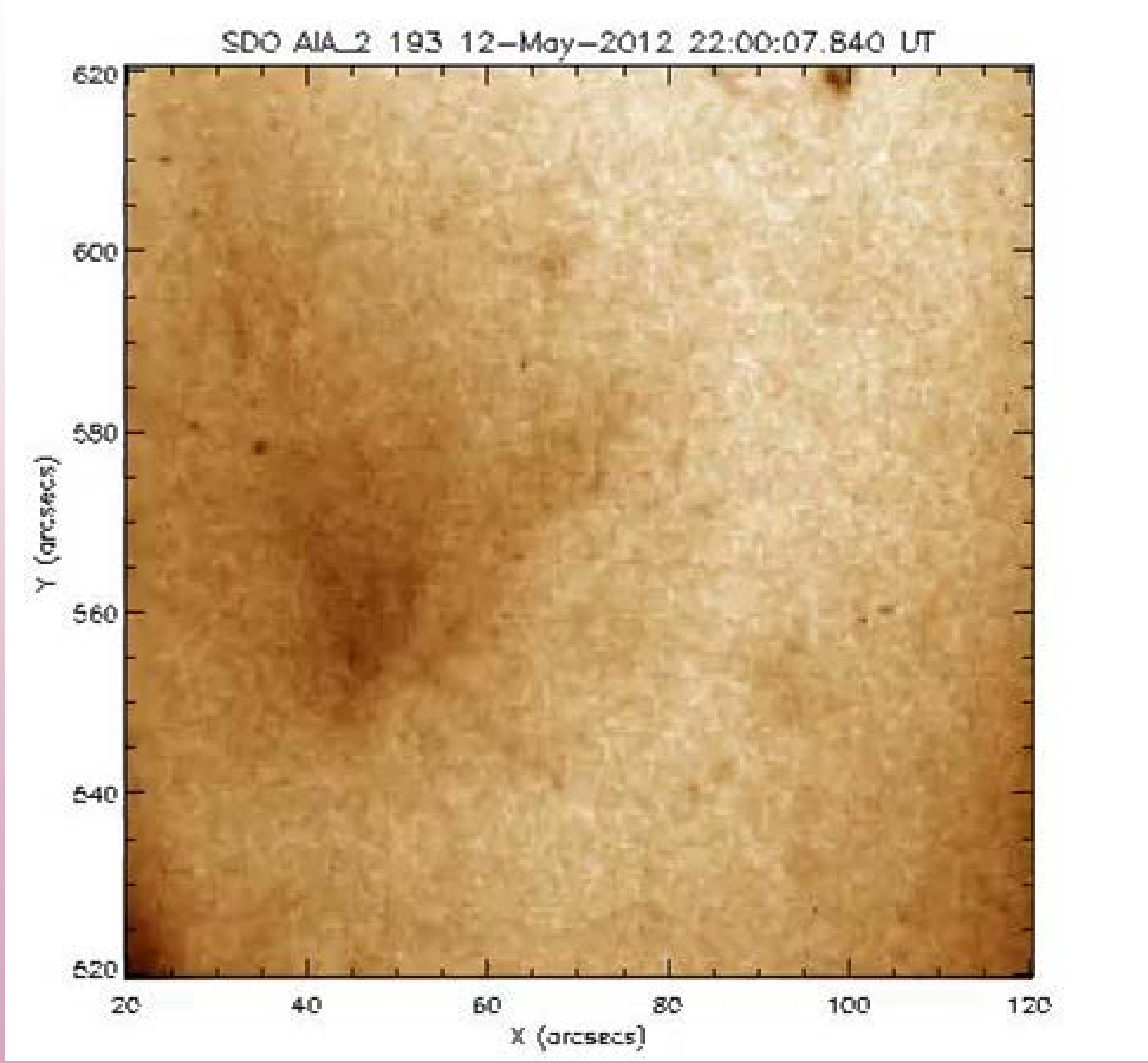
- J2 in 193 Å (reversed color)
- HMI magnetogram ± 75 G





These results are consistent with on-disk coronal jet observations (e.g. *Panesar et al 2018*) that are also seen to erupt due to flux cancelation at a neutral line.

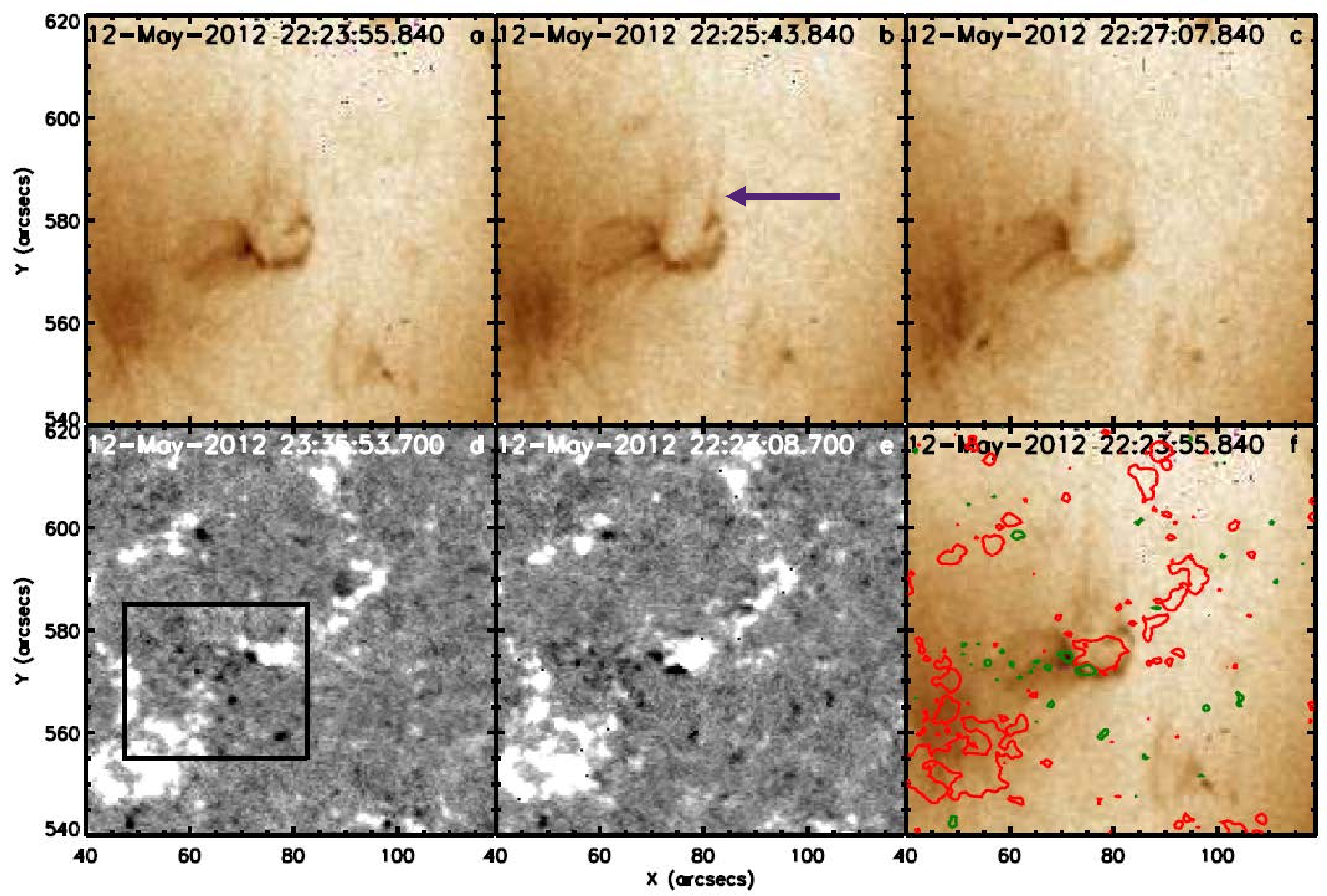
Second Example (emerging region E8) in 193 Å

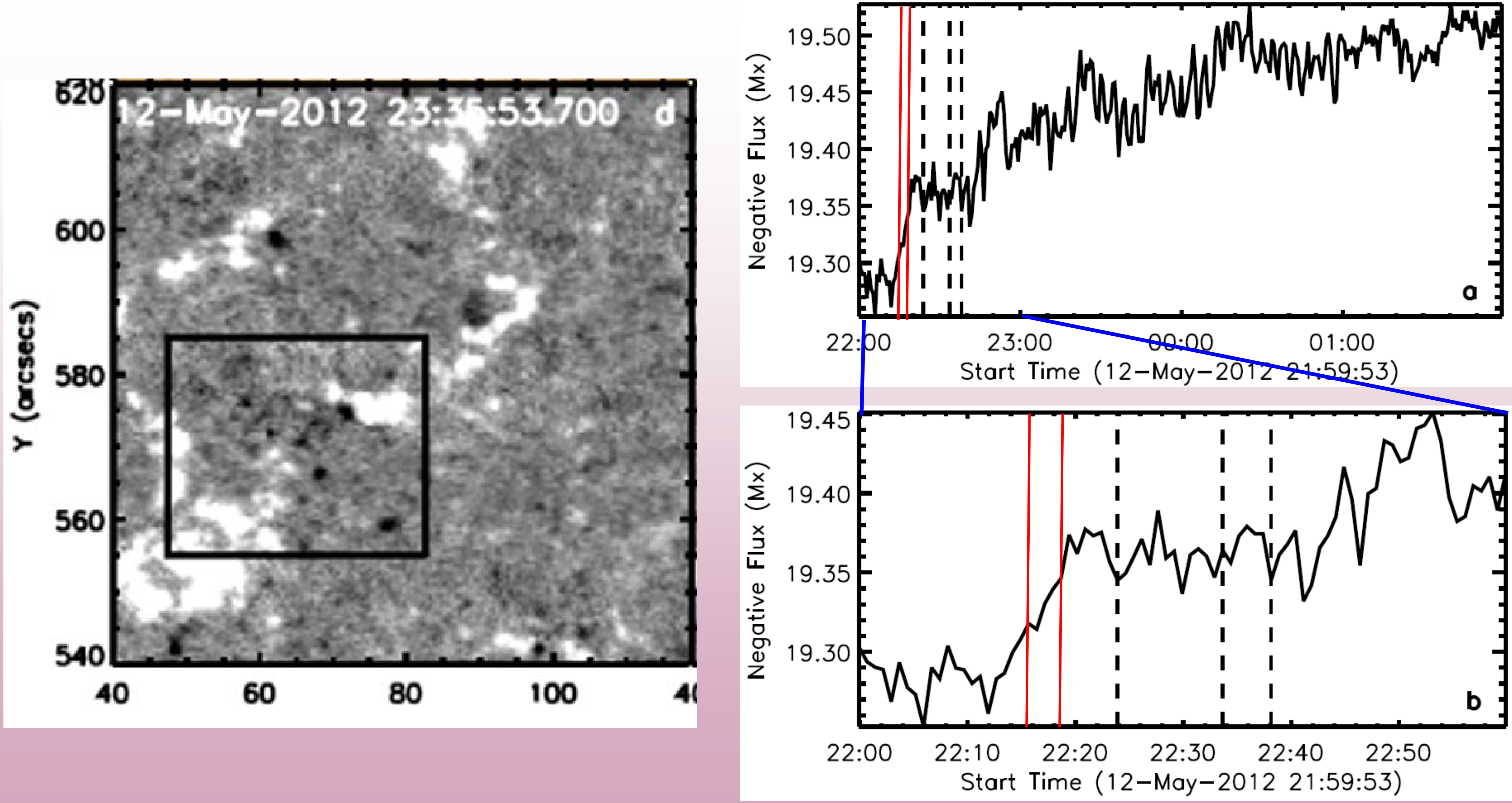


Second Example (emerging region E8)

- J23 in 193 Å (reversed color)

- HMI magnetogram ± 75 G; contour level ± 50 G





12-May-2012 23:35:53.700 d
Y (arcsecs)
620
600
580
560
540
40
60
80
100
Negative Flux (Mx)
19.50
19.45
19.40
19.35
19.30
a
22:00
23:00
00:00
01:00
Start Time (12-May-2012 21:59:53)
Negative Flux (Mx)
19.45
19.40
19.35
19.30
b
22:00
22:10
22:20
22:30
22:40
22:50
Start Time (12-May-2012 21:59:53)

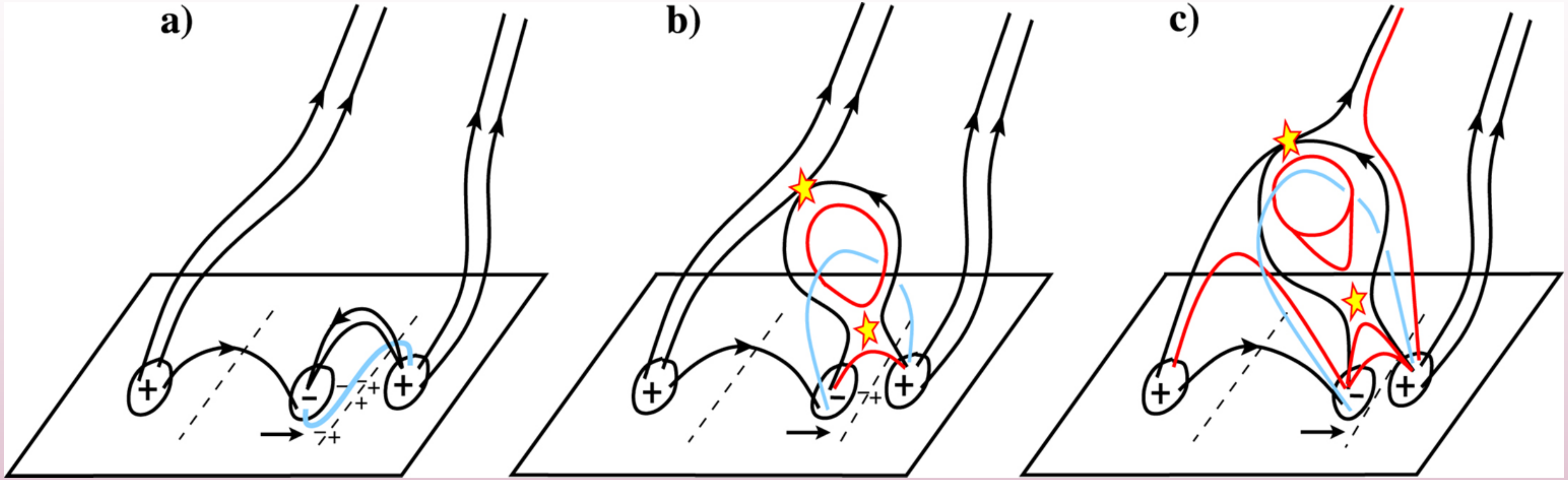
Conclusions

- Investigated 8 emerging flux regions in solar coronal holes, to determine if emerging flux caused jets.
- Found faint jets in all eight emerging flux regions. In all cases these jets were much fainter than typical coronal jets.
- In 7 of these regions the faint jets came from where one foot of the emerging flux clearly canceled with pre-existing opposite-polarity field (in agreement with recent results).
- In one case a weak jet formed with flux emergence but without clear flux cancelation (consistent with flux emergence idea). This region had the fastest flux-emergence rate among the 8 regions.
- Average speed of all 25 faint jets: 125 km s^{-1}.
- Average faint-jet duration among 25 faint jets: 10 minutes.

Backup

What Triggers Minifilament Eruptions?

Panesar et al. 2018



<u>According to recent AIA and HMI observations:</u>

(a) Highly sheared minifilament field (blue) over neutral line, opposite polarity flux patches are moving toward and canceling at neutral line.

(b) Minifilament erupts due to continuous flux cancelation, triggering internal reconnection (lower star) forming JBP.

(c) External/interchange reconnection with ambient field creates two new connections, leading to external brightenings and jet spire.