EVALUATION OF THE MINIFILAMENT-ERUPTION SCENARIO FOR SOLAR CORONAL JETS IN POLAR CORONAL HOLES

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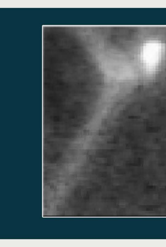
• All, bar one, located jets can be described using the mini-filament eruption model (Sterling et al 2015).
• 70% of jets chosen for further investigation had a clear pre-eruption filament.

• 80% of observed jets exhibited lateral movement of the spire away from the bright point.
• Except for one (questionable) case, the spire always moved away from the bright point.



• Jets are a lot more prevalent in the AIA data than the X-Ray data and exhibit great variation.
• In no jet did the spire form before the bright point. Although this was dificult to measure.

ABSTRACT

Solar coronal jets are suspected to result from magnetic reconnection low in the Sun's atmosphere. Sterling et al. (2015) looked at 20 jets in polar coronal holes, using X-ray images from the Hinode/X-Ray Telescope (XRT) and EUV images from the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA). They suggested that each jet was driven by the eruption of twisted closed magnetic field carrying a small-scale filament, which they call a "minifilatment", and that the jet was produced by reconnection of the erupting field with surrounding open field. In this study, we carry out a more extensive examination of polar coronal jets. From 180 hours of XRT polar coronal hole observations spread over two years (2014-2016), we identified 130 clearly-identifiable X-ray jet events and thus determined an event rate of over 17 jets per day per in the Hinode/XRT field of view. From the broader set, we selected 25 of the largest and brightest events for further study in AIA 171, 193, 211, and 304 Angstrom images.

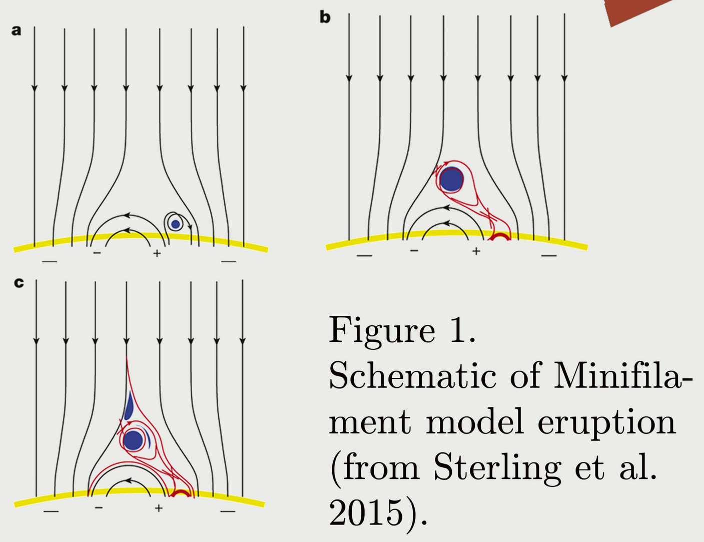


Figure 1. Schematic of Minifilament model eruption (from Sterling et al. 2015).

We find that at least the majority of the jets follow the minifilament-eruption scenario, although for some cases the evolution of the minifilament in the onset of its eruption is more complex then presented in the simplified schematic of Sterling et al. (2015). For all cases in which we could make a clear determination, the spire of the X-ray jet drifted laterally away from the jet-base-edge bright point; this spire drift away from the bright point is consistent with expectations of the minifilament-eruption scenario for coronal-jet production. This work was supported with funding from the NASA/MSFC Hinode Project Office, and from the NASA HGI program.

INTRODUCTION

• Solar X-Ray jets are explosive and short lived phenomena originating in the low atmosphere of the Sun (e.g., Shibata et al. 1992, Shimojo et al. 1996, Cirtain et al. 2007, Savcheva et al. 2007). These jets are easily identifiable near the solar limb and frequently observed in coronal regions by satellite telescopes in the 0.2-2.0 keV Range.

• These jets are traditionally thought to be best explained by emerging flux on the coronal surface with subsequent reconnection with the ambient field. More recently it is has been suggested that Solar X-Ray Jets are formed by a mini-filament eruption which induces magnetic reconnection, in a manner comparable to solar flare eruptions.

• We present observations of coronal jets observed in the coronal regions of the sun from 180 hours of observation spread over 2 years collected from the Hinode Space Satellite aggregating to 130 distinct jet events. Of these events 25 jets were selected for corroboration and further study by utilization of the Solar Dynamics Observatory / Atmosphere Imaging Assembly.

• Investigated elements of the mini filaments for each of the 25 jets selected for further study in the 171, 193, 211 and 304 Angstrom wavelengths.

• We shall look at 3 features of the jet to see if there exists a prejetting filament, spire movement and formation timeline.

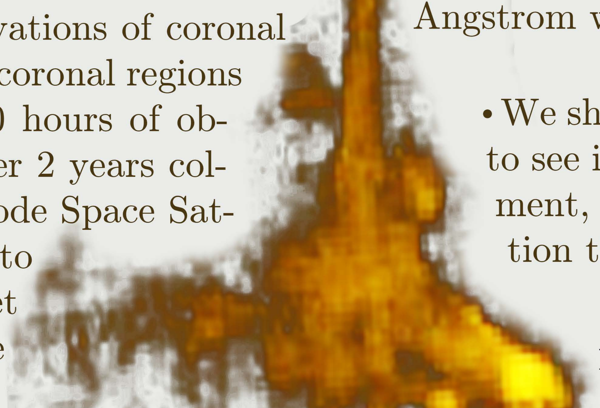


Figure 2 Standard form jet from data set, Event 10 in AIA 211.

METHODOLOGY

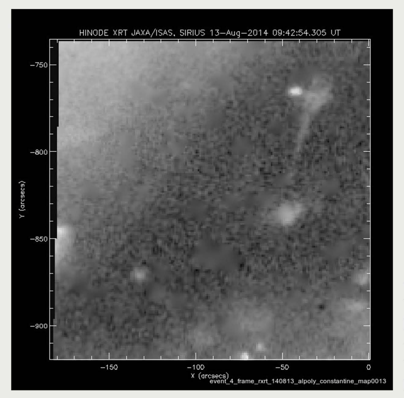
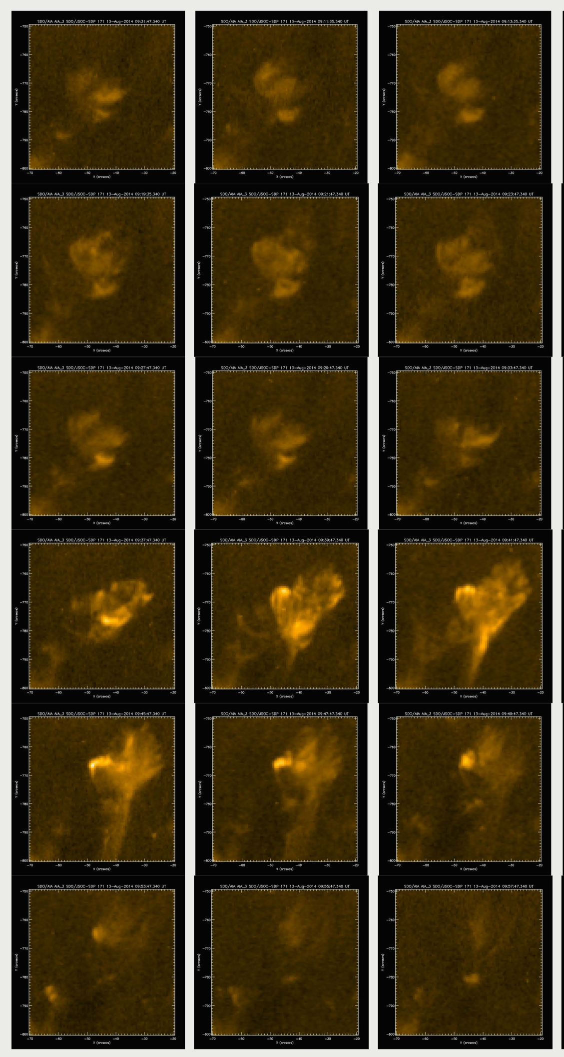


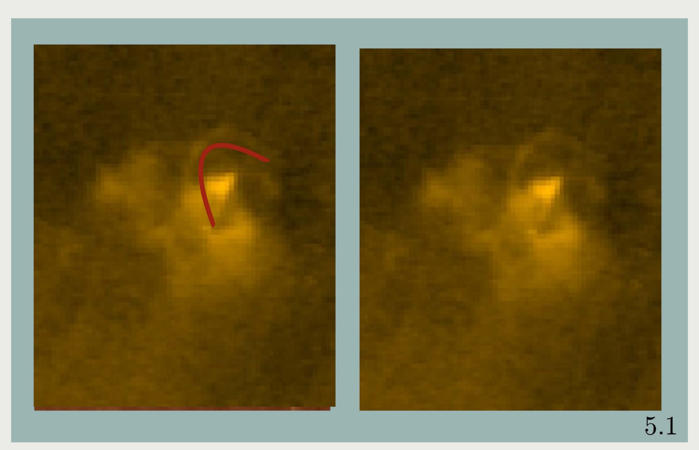
Figure 3 left - XRT image from Hinode for Event 2.
Figure 4 below - AIA images from same jet - 102s cadence.

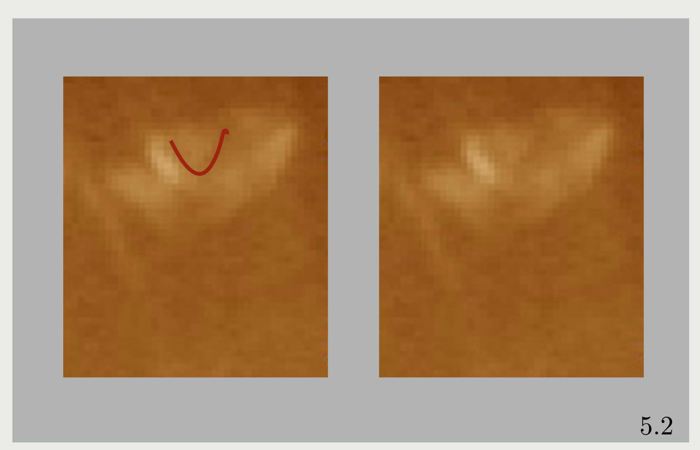


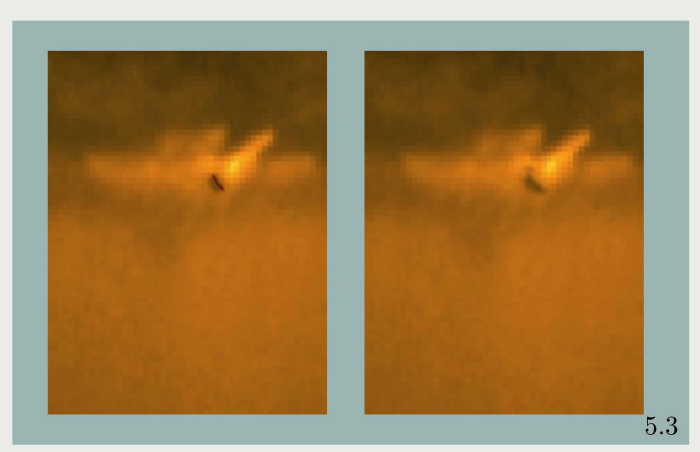
By using Solar Monitor we visually inspected the atmospheric conditions at the polar regions of the sun. Dates which exhibited clear conditions on these images were recorded.

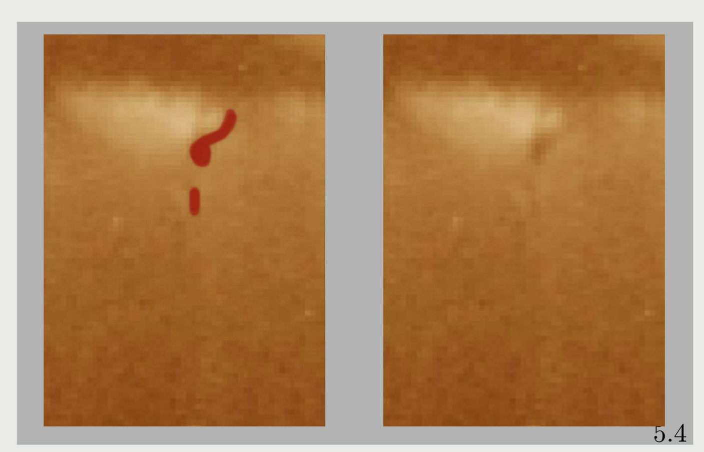
Using Hinode's Mission Operations Catalog we selected periods of observation at the polar regions of times of interest. The primary data for each time period was recovered using Hinode/XRT with 30-s cadence with the thin - AL filter.

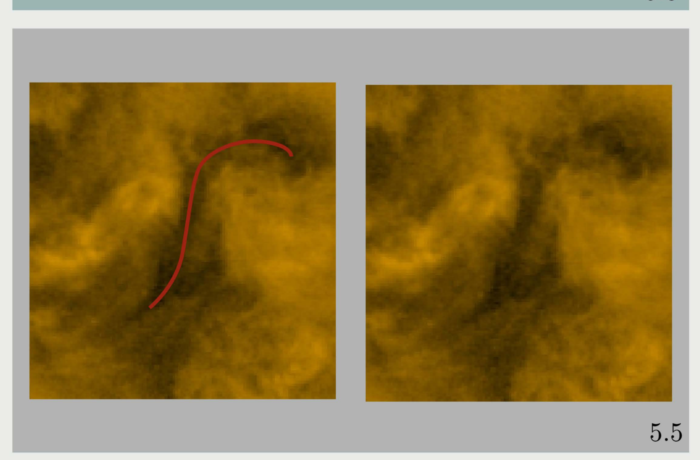
For jets carried forward for further investigation we used concurrent, images from SDO/AIA at 12 second cadence at 171A, 193A, 211A and 304A. These have strong responses to logarithmic temperatures of 5.8K, 6.2K, 6.3K, and 4.7K, respectively.

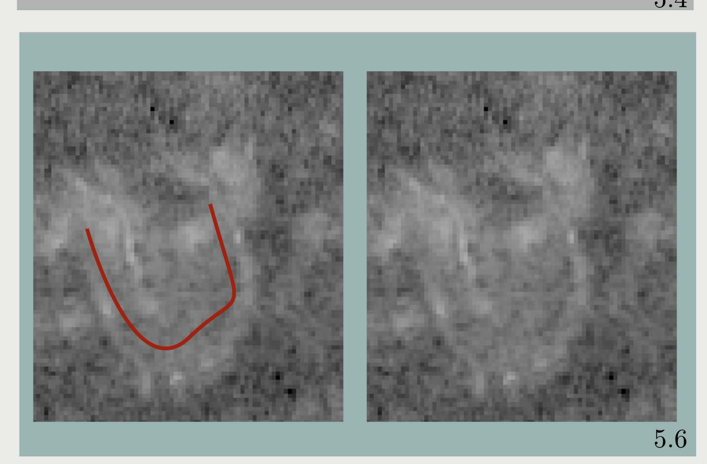




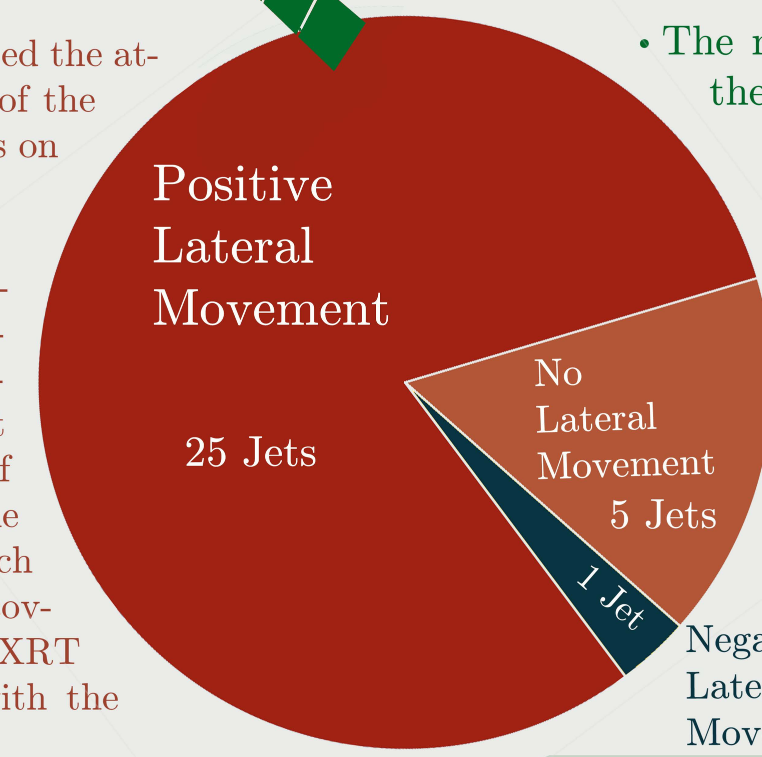








SPIRE MOVEMENT



• The movement of the spire is an indicator to the formation of the jet.

• Should the spire move laterally away from the bright point, i.e postive lateral movement relative to the bright point, this is an indicator of the mini-filament behaving as suggested by Sterling et al (2015).

• It was not practicable to recover data for 5 jets.

Figure 7, Right. Traditional "Blow Out" Jet. Figure 8, Left. Chart showing jets with specific spire movement characteristics.

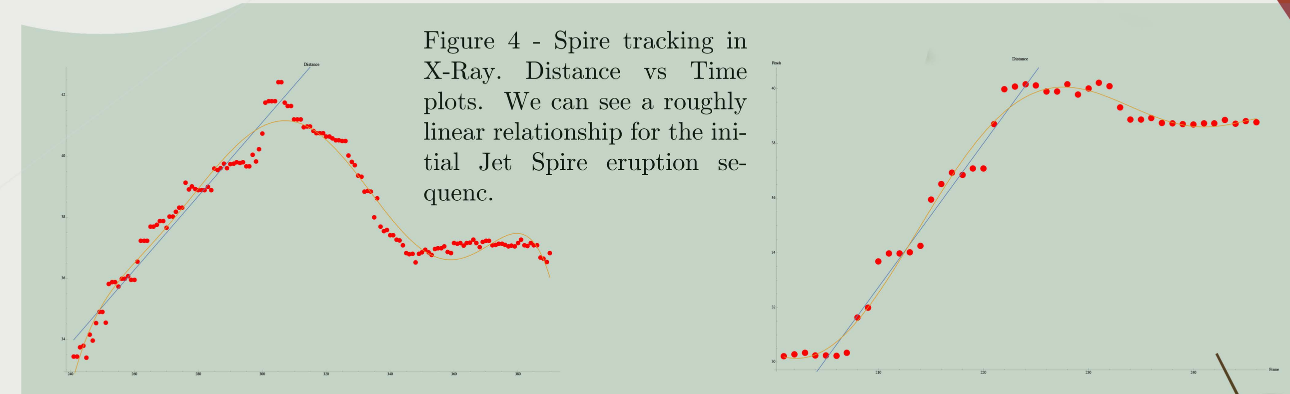
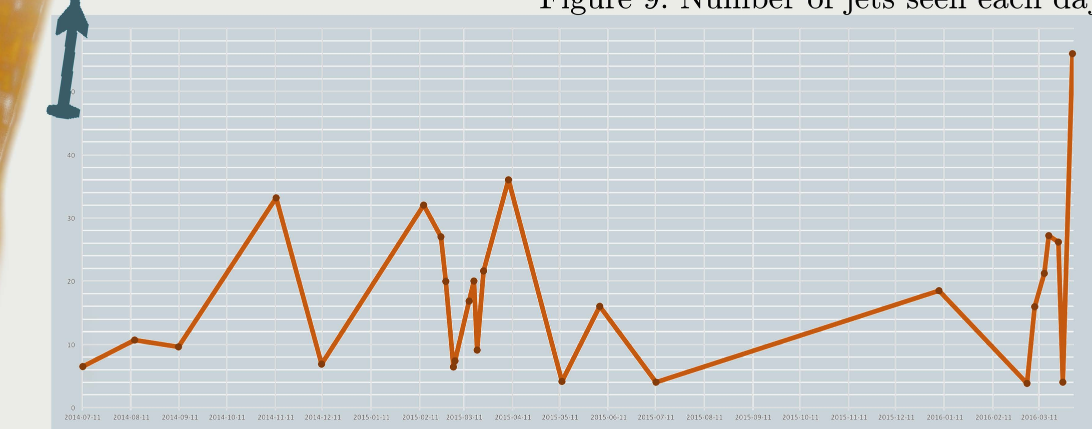


Figure 4 - Spire tracking in X-Ray. Distance vs Time plots. We can see a roughly linear relationship for the initial Jet Spire eruption sequenc.

PREVALENCE

• An average of 17.6 jets per day per Hinode field of view of 400 by 400 arc seconds.

Figure 9. Number of jets seen each day.



JBP FORMATION

• Jet Bright Point (JBP) formation difficult to determine due to the time resolution in the X-Ray wavelengths

• 11 jets exhibited bright points before spire. 18 were not clear. 3 occurred simultaneously as viewed by Hinode/XRT.

• No jet had a visible spire before the jet bright point.

• Potential further investigation in AIA wavelengths would be required for concrete statements.

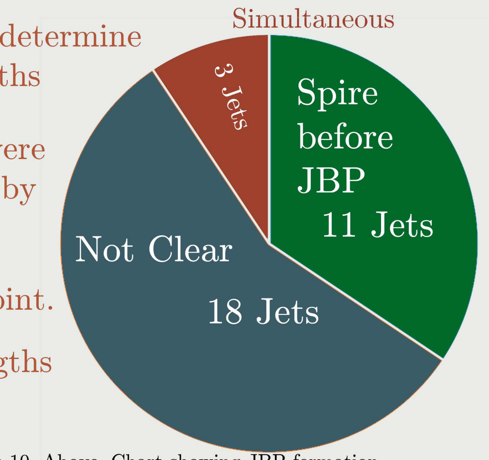


Figure 10, Above. Chart showing JBP formation.

MINIFILAMENT VISIBILITY

• Most jets had a visible mini-filament central to the eruption of the jet.

• A secondary number had a consistent eruption with a likely position for the minifilament, however, thiscould not be confirmed, often due to obscuring haze.

• Two events could not be observed clearly enough to make any conclusion and thus remain uncertain.

• One event which could be observed had no clear filament.

• The jets showed variety and diversity in their structure, however, the filament was critical in the eruption.

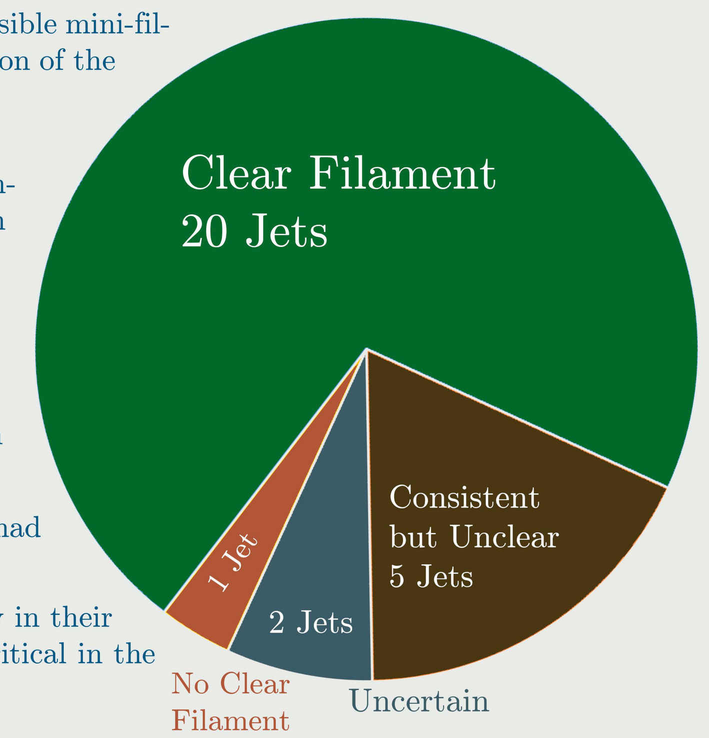


Figure 6, Above. Chart showing the relative populations of clear filaments within jets.

Figure 5 Left to Right, Top to Bottom

5.1 - Event 212. Filament rising before jet eruptions. 171A.

5.2 - Event 219. Pre-eruption filament moving upwards. 193A.

5.3 - Event 217. Jet on solarlimb with clear filament rising before eruption. 193A.

5.4 - Event 220. Jet on solar limb with clear erupting filament. 193A.

5.5 - Event 222. Sigmoid shape. Filament lifts off and peels apart to form jet. "Ron's elbows." (cf. Moore et al. 2001.)171A.

5.6 - Event 223 with erupting filament. 304A·

Jet	Filament
202	Clear Filament
203	Consistent But Unclear
204	Consistent But Unclear
205	Consistent But Unclear
206	Clear Filament
207	Clear Filament
208	Clear Filament
209	Clear Filament
210	Clear Filament
211	Clear Filament
212	Clear Filament
213	Consistent But Unclear
214	Uncertain
215	Clear Filament
216	Uncertain
217	Clear Filament
218	Consistent But Unclear
219	Clear Filament
220 a	Clear Filament
220 b	No Clear Filament
220 c	Clear Filament
221	Clear Filament
222	Clear Filament
223	Clear Filament
224 a	Clear Filament
224 b	Clear Filament
224 c	Clear Filament
226	Clear Filament

Table 1, Left. Showing each jet with filament determination.

CONCLUSION

• Cases where viewing conditions were favourable, the spire moved away from the bright point. 1 moved toward, however, this was dubious due to its position on the limb and the opportunity for geometries to exsist where the spire is only percieved to move away.

• For nearly all events observed with AIA we could see a clear minifilament moment to form jet and JBP. For some jets it was not possible to make out the minifilament, however, the minifilament location could be reasoned from the observation. These were marked as consistent. One eruption did not clearly fit the mini-filament eruption scenario.

• There exists a great variety of minifilament eruptions which follow the scenario suggested by Sterling et al. For instance the minifilament rolled over, split or teared. It may be impracticable to divide the jets into categories such as blow out or standard.

• Some jet events may be interconnected in such a way that an eruption induces another eruption.

• The results are most generally consistent with Sterling et al (2015) minifilament jet scenario. Most solar coronal jets follow the mini-filament eruption scenario in the solar coronal poles.

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ACKNOWLEDGEMENTS

This work was supported by the NASA Hinode programme. The author would also like to thank A. Sterling for his help and guidance, D. Falconer for his coding and trouble shooting, E. Priest for his support. Members of the Solar Physics REU and CSPAR at large for the experience.