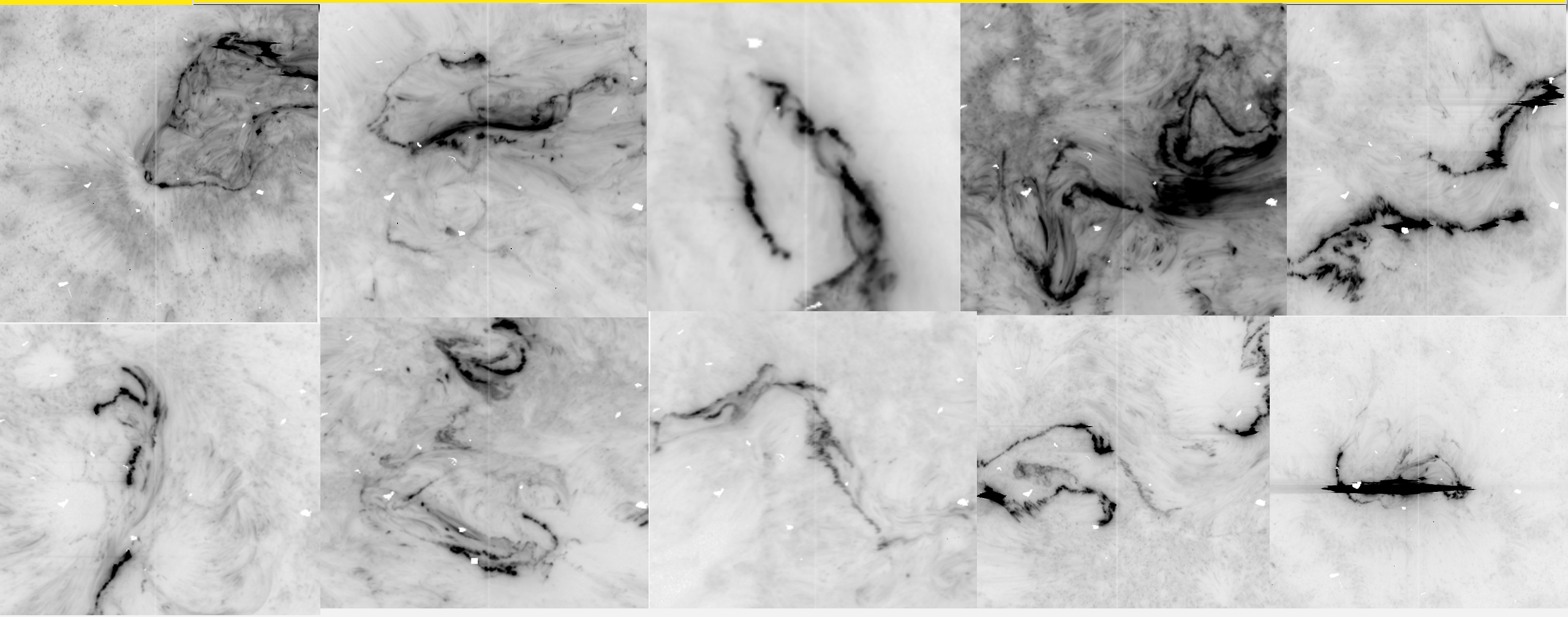
DO ALL FLARES SHARE THE SAME CHROMOSPHERIC PHYSICS?



Brandon Panos, brandon.panos@fhnw.ch, RHESSI Workshop 2018, Dublin

IRIS-9, Göttingen, 25-29 June 2018

Contributed Talk

4. Eruptions in the solar atmosphere

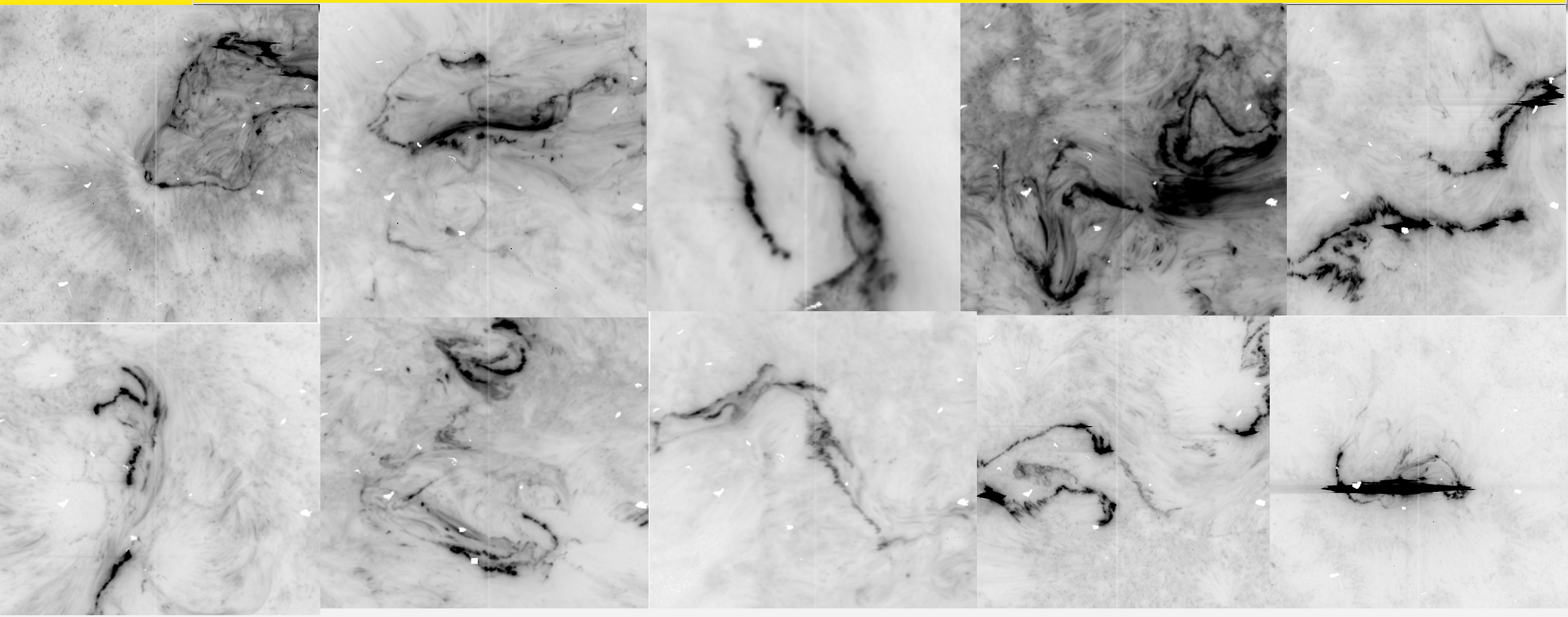
Do all flares share the same chromospheric physics?

Brandon Panos[1,2], Lucia Kleint[1], Cedric Huwyler[1], Säm Krucker[1], Martin Melchior[1], Denis Ullmann[2], Sviatoslav Voloshynovskiy[2]

[1] *Fachhochschule Nordwestschweiz*
[2] *University of Geneva*

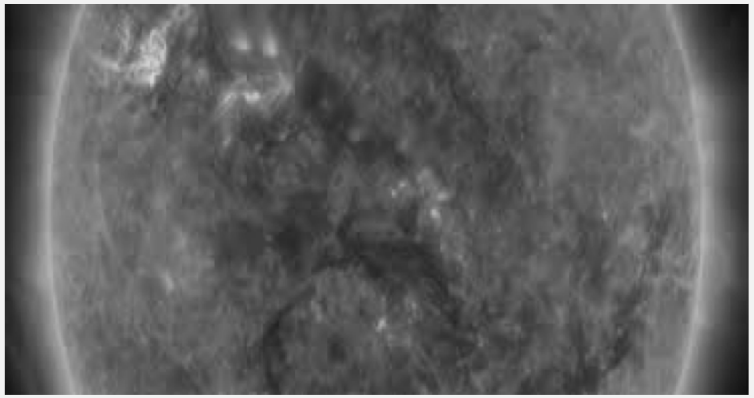
IRIS observes over a large range of atmospheric heights including the chromosphere where the majority of flare energy is dissipated. The strong Mg II h&k spectral lines are capable of providing excellent atmospheric diagnostics but have not been fully utilized for flaring atmospheres. We aim to investigate whether the physics of the chromosphere is identical for all flare observations and if there are certain spectra that occur in all flares. To achieve this, we automatically analyze hundreds of thousands of Mg II h&k line profiles from a set of 33 flares and use a machine learning technique known as k-means to classify all profile shapes. We identify a single peaked Mg II profile, in contrast to the double-peaked quiet Sun profiles, appearing in every flare. Additionally, we find extremely broad profiles with characteristic blue shifted central reversals occurring at the front of fast moving flare ribbons. We present strong evidence that these profiles are correlated both temporally and spatially with X-ray signatures. The ratio of the integrated Mg II h&k lines can also serve as an opacity diagnostic and we find higher opacities during each flare maximum. Our study shows that machine learning is a powerful tool for large scale statistical solar analyses. We plan to extend our methods to include additional spectral lines, and use the diagnostics available for each line to further understand the dynamic flaring atmosphere.

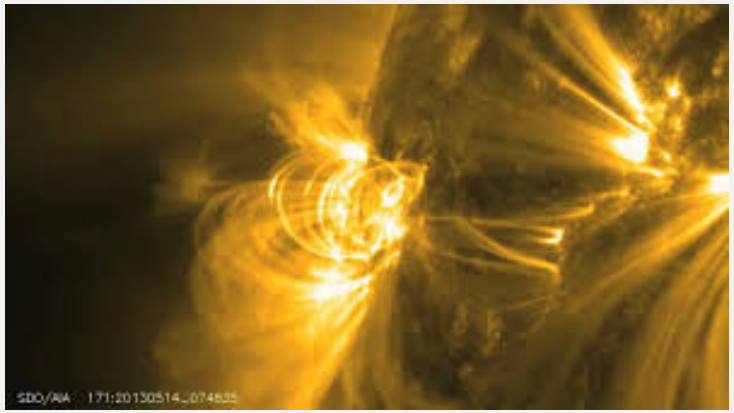
DO ALL FLARES SHARE THE SAME CHROMOSPHERIC PHYSICS?

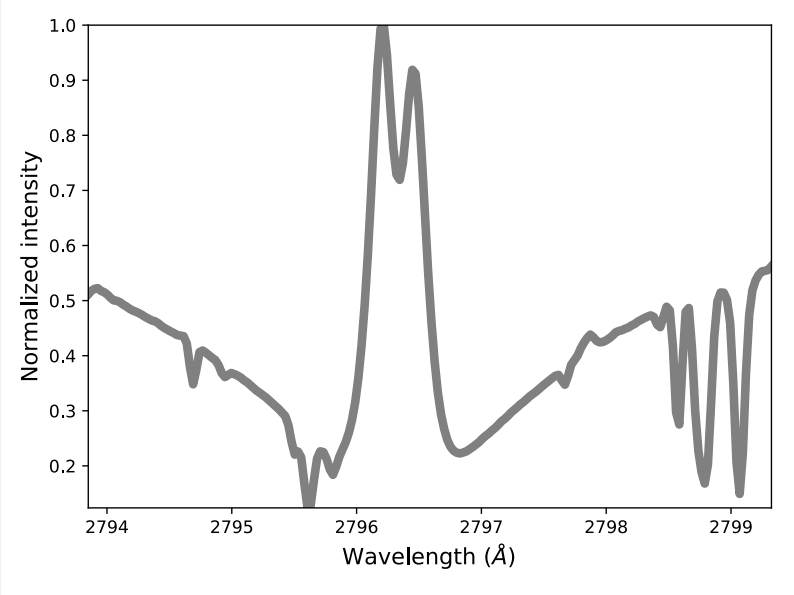


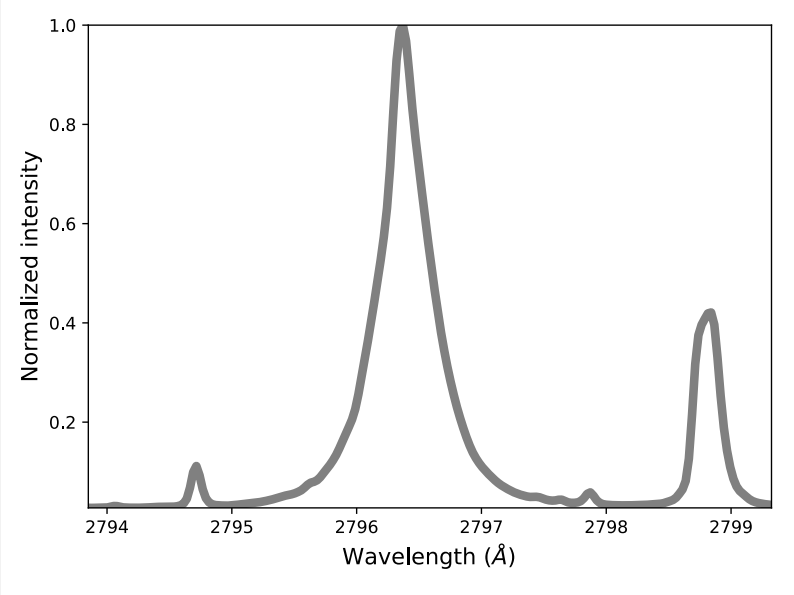
Brandon Panos, brandon.panos@fhnw.ch, RHESSI Workshop 2018, Dublin

Mg II k line: quiet sun vs. flare









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RESEARCH QUESTIONS

- What Mg II profiles are produced in solar flares?
- Where are these profiles located in relation to the flare morphology?
- Are there special profiles that occur in all flares and at the front of flare ribbons?
- Is the physics of the chromosphere the same in all flares?

MACHINE LEARNING: THE K-MEANS ALGORITHM

1. Initiate centroids

$$\mu_j \in X$$

2. Assign points

$$c_i = \arg\min_{1 \leq j \leq k} ||x_i - \mu_j||^2$$

3. Upgrade centroids

$$\mu_j = \frac{1}{n_j} \sum_{i=1}^{n} \delta_{c_i,j} \; x_i$$

4. Cost

$$\mathcal{L} = \sum_{i=1}^{n} \sum_{j=1}^{k} \delta_{c_i,j} ||x_i - \mu_j||^2$$

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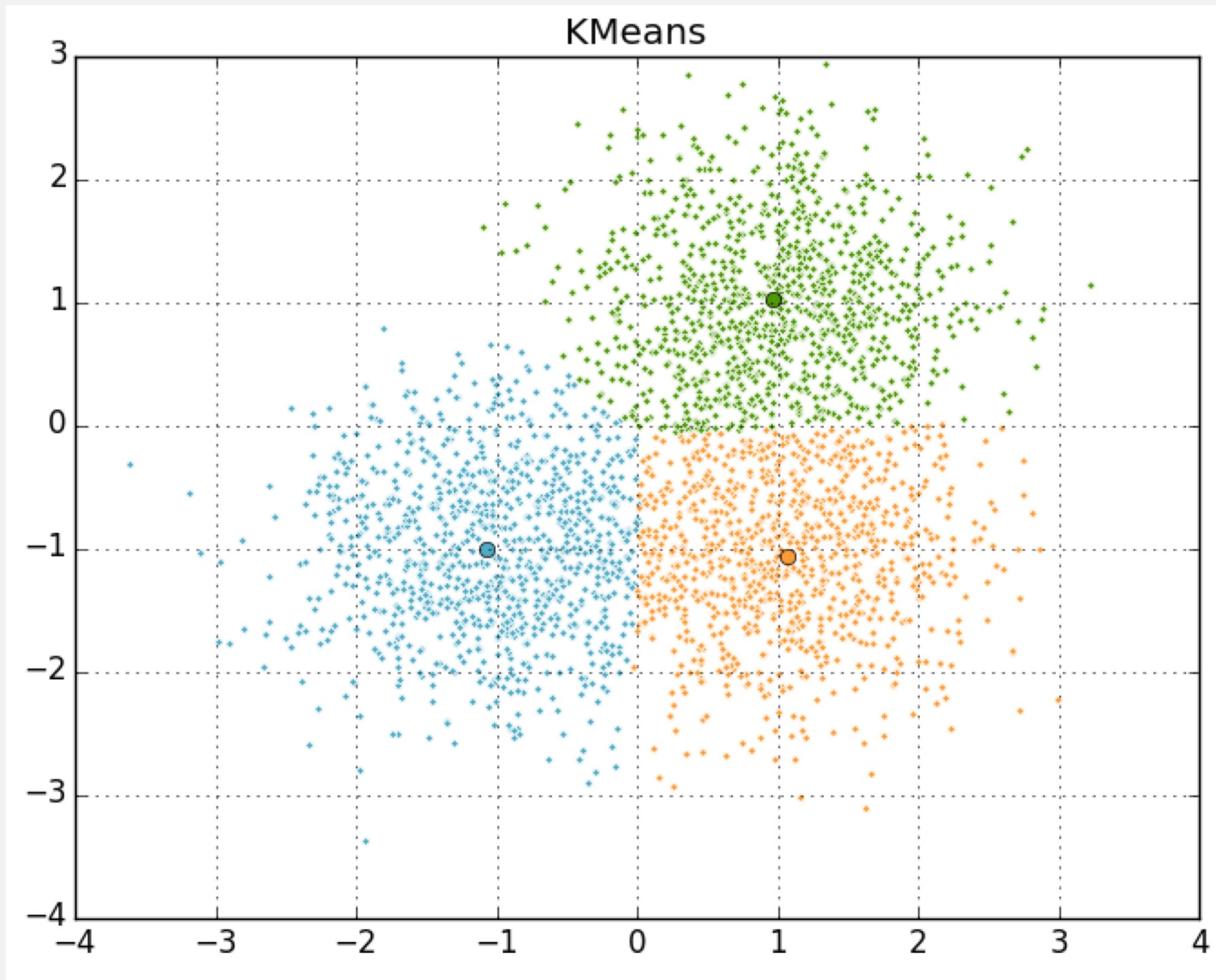

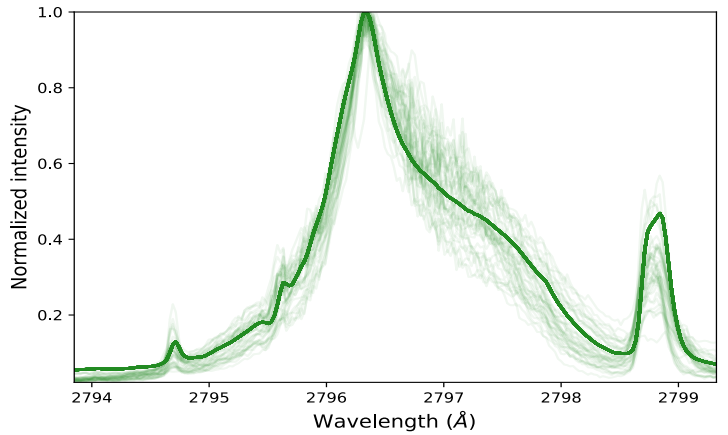

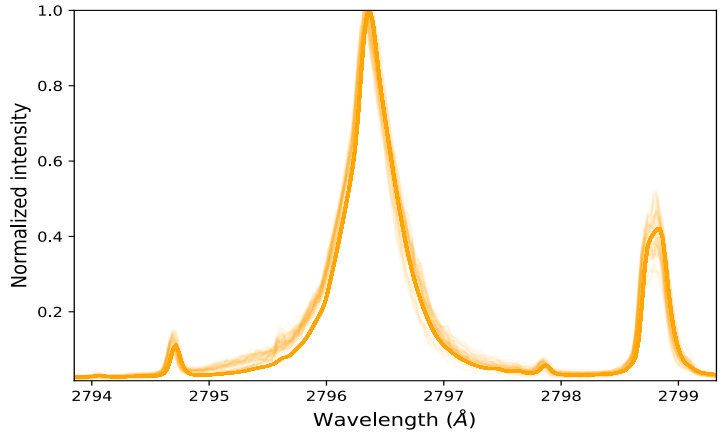

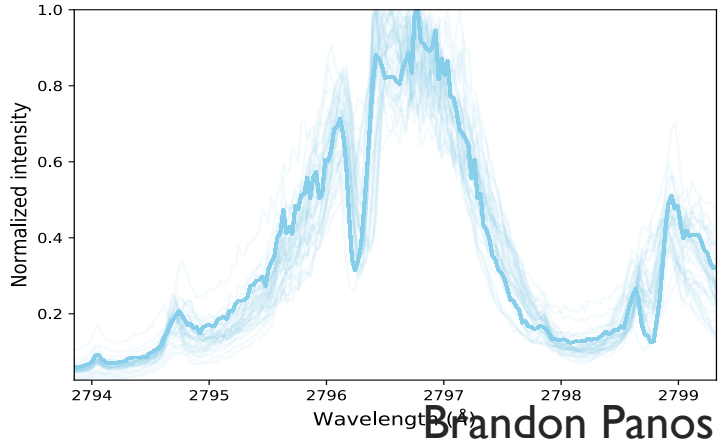

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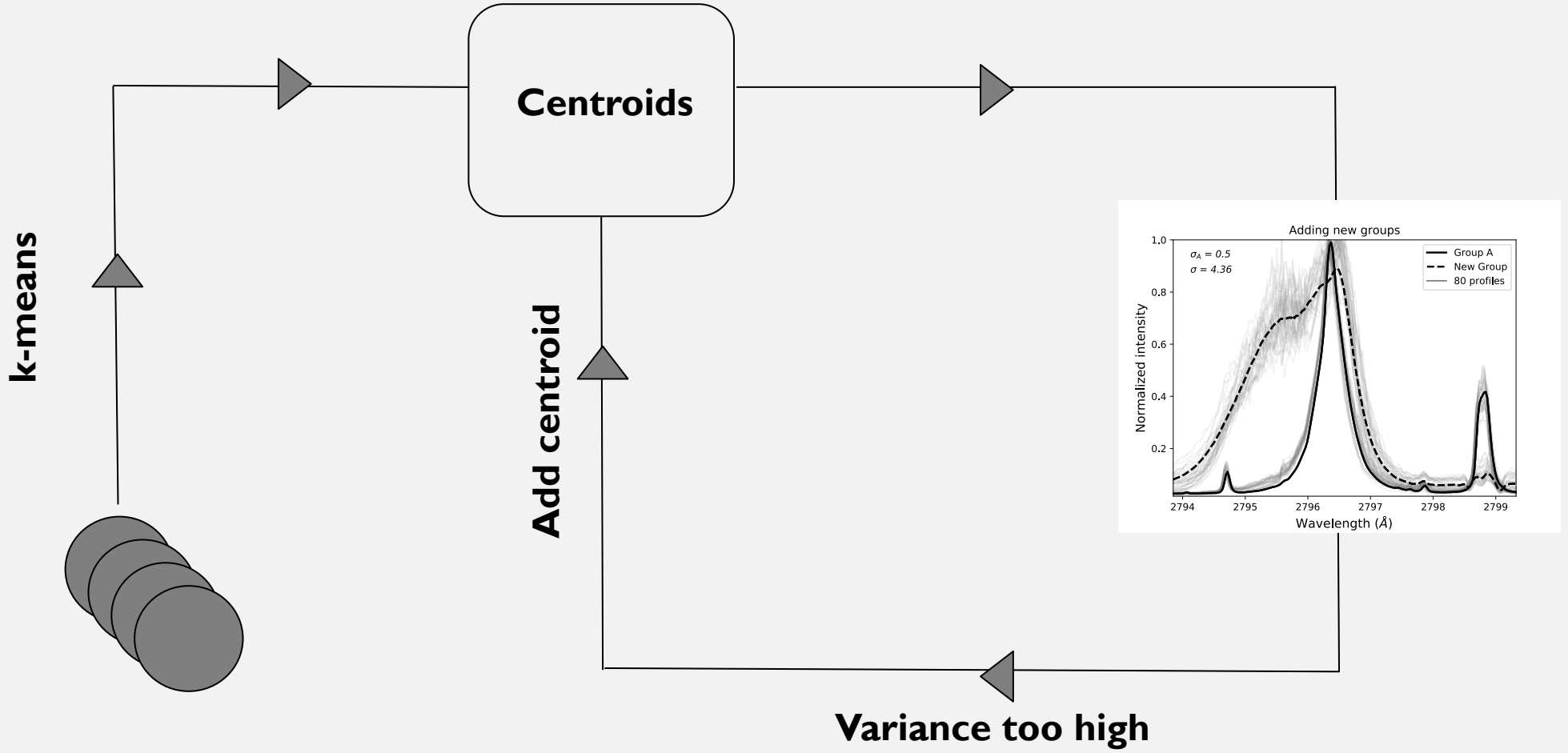
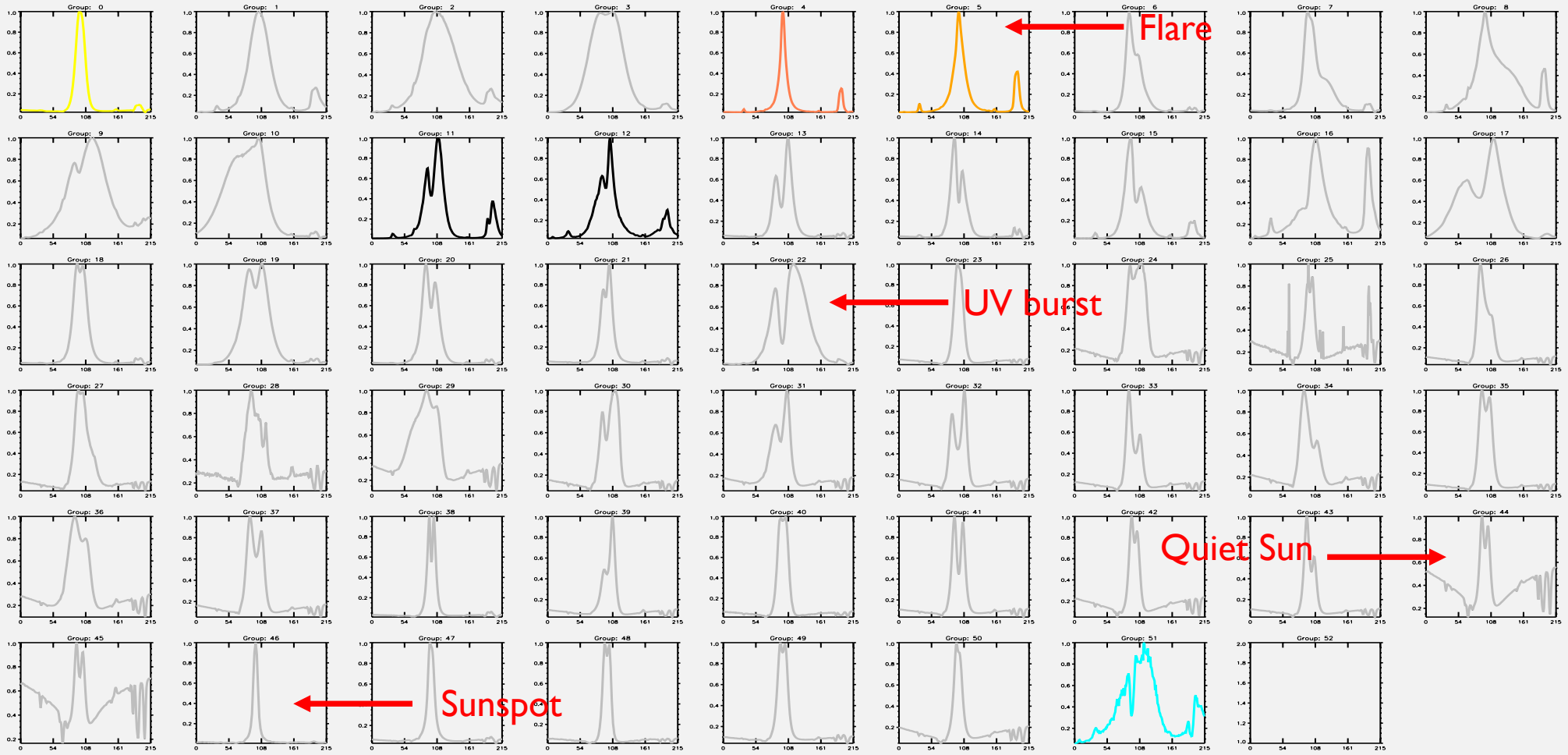
METHOD


Centroids
k-means
Add centroid
Variance too high
Adding new groups
$\sigma_A = 0.5$
$\sigma = 4.36$
Group A
New Group
80 profiles
Normalized intensity
Wavelength (Å)
1.0
0.8
0.6
0.4
0.2
2794
2795
2796
2797
2798
2799



Millions of spectra organized into 53 groups by k-means

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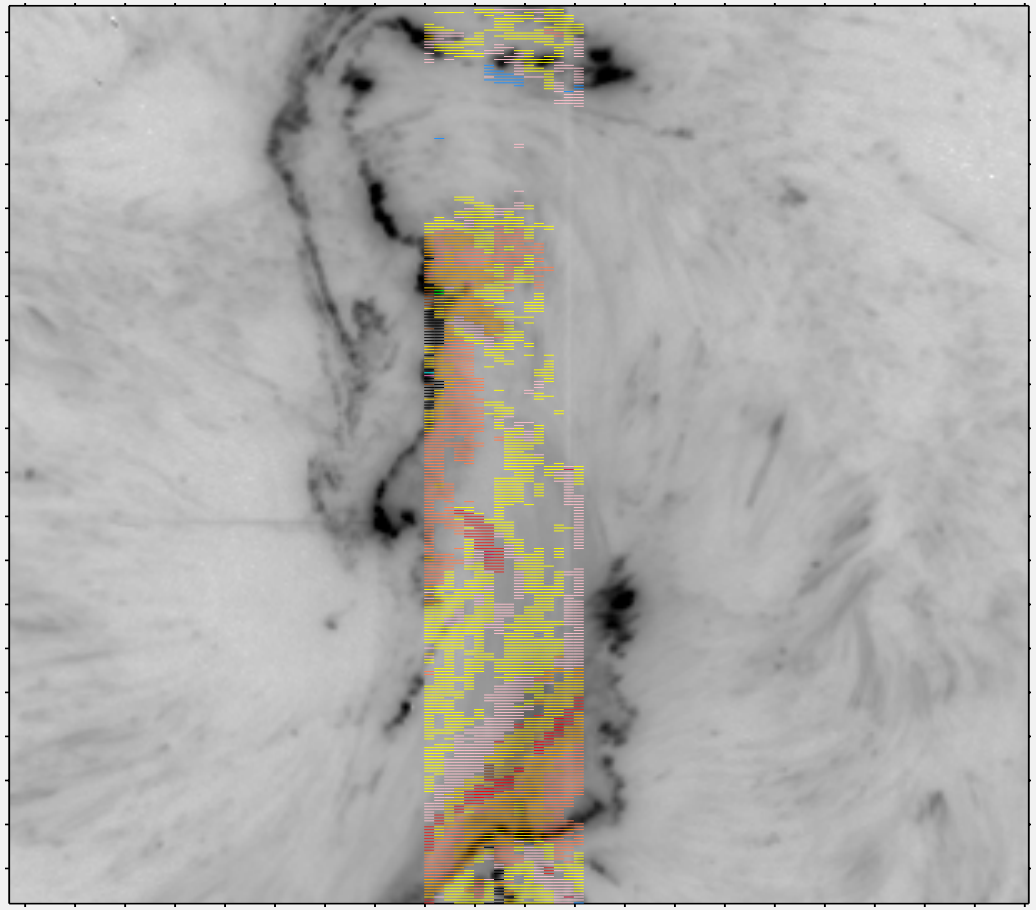
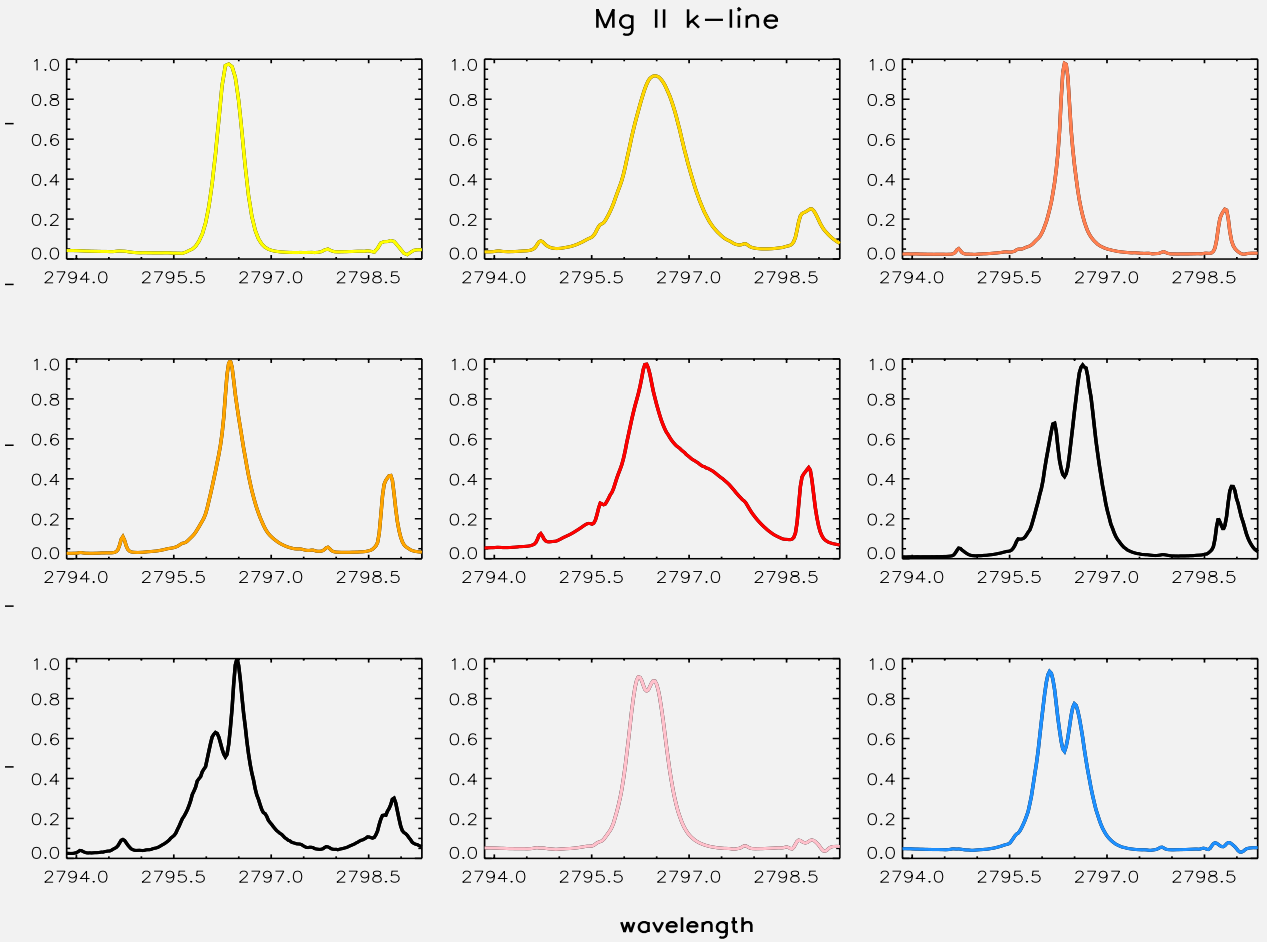
PROJECTION ONTO SJI'S





K-means groups projected onto a single SJI

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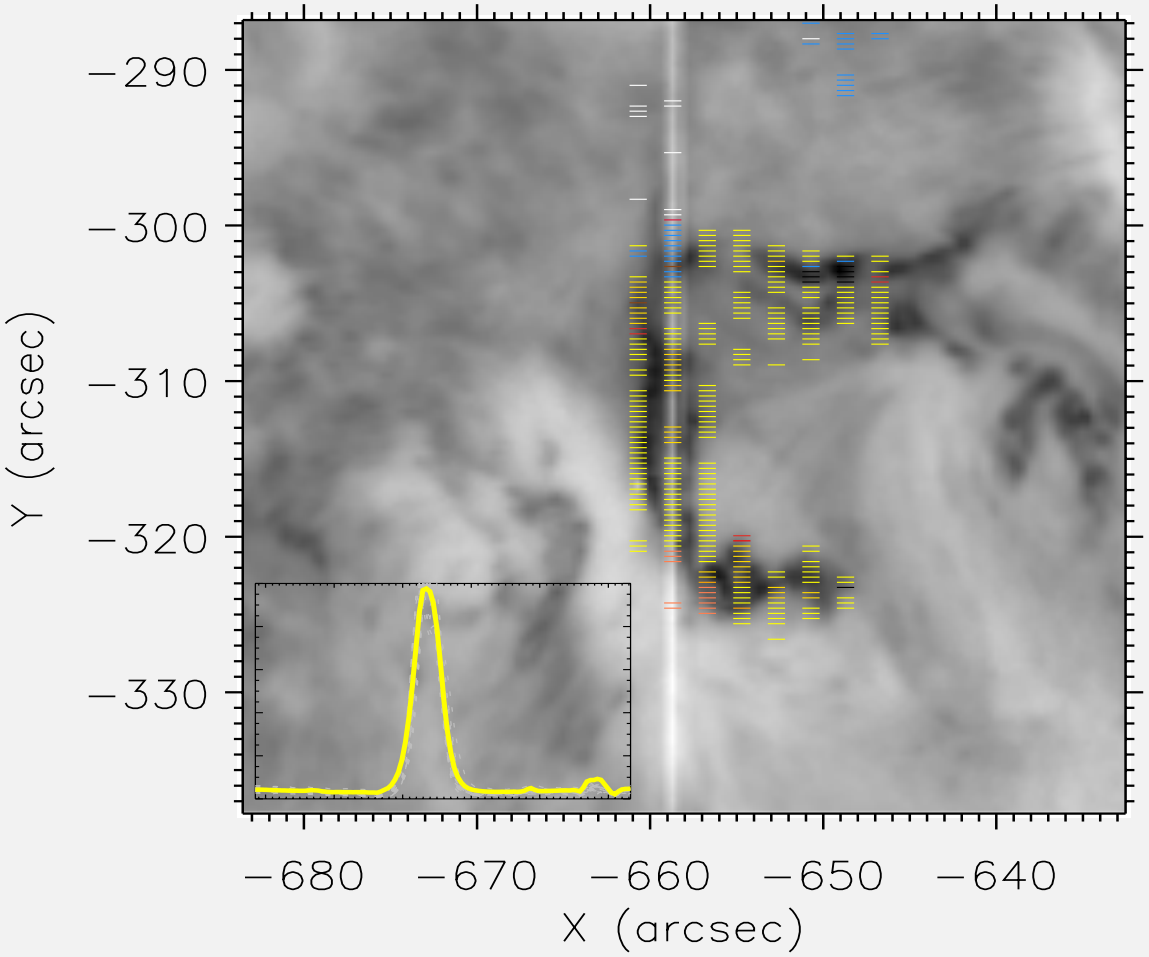
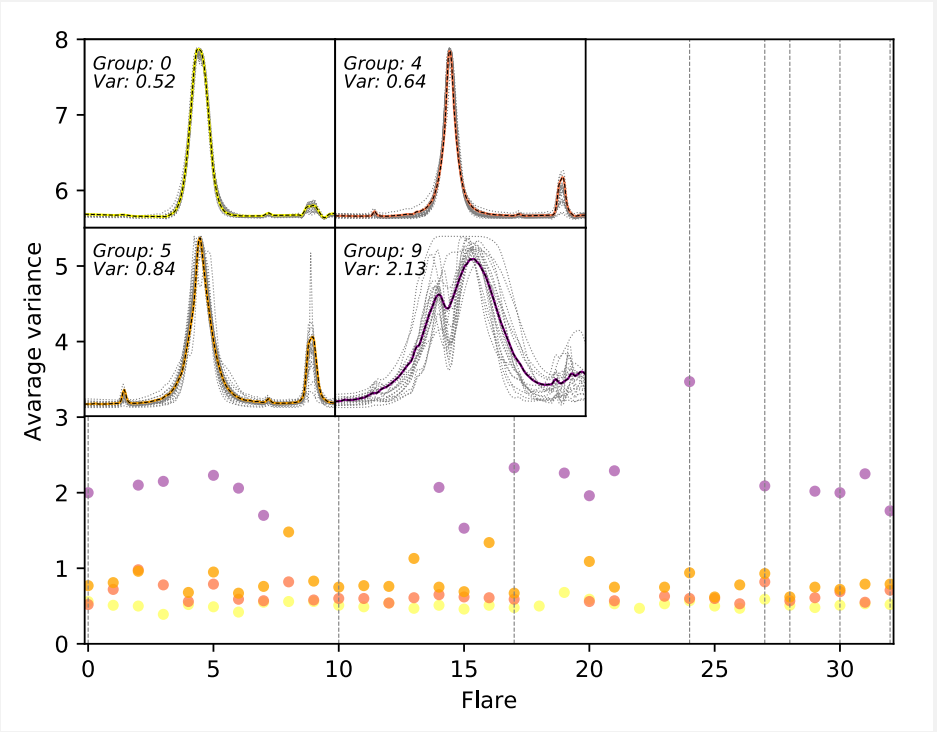
UNIVERSAL FLARING PROFILE: SINGLE PEAKED





1. Often appear over the flare ribbon
2. They exist in every flare
3. Extremely low variance
4. Also appear in lower energy energetic events

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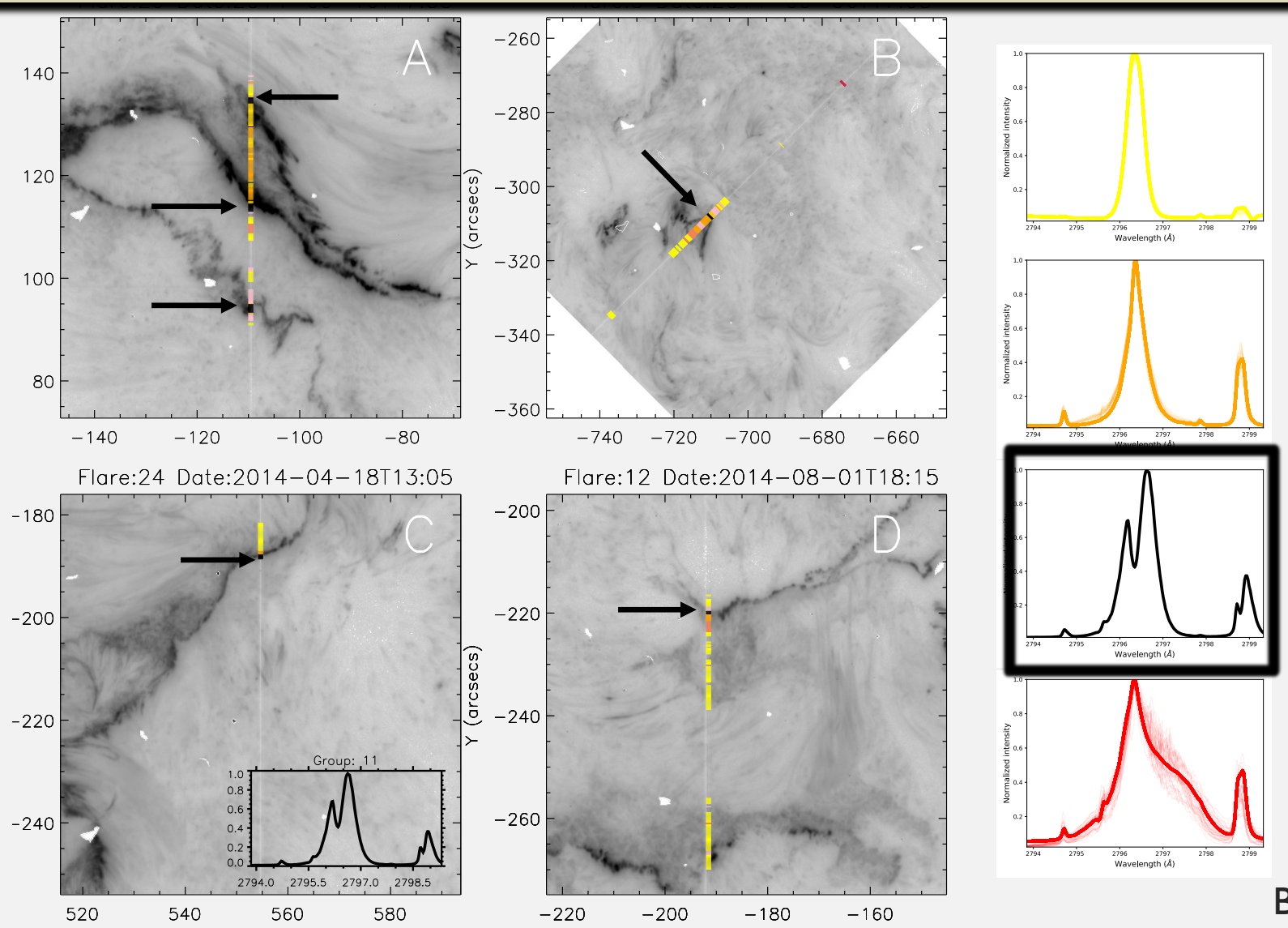
RIBBON-FRONT IRIS PROFILES

Unique profiles at the ribbon front



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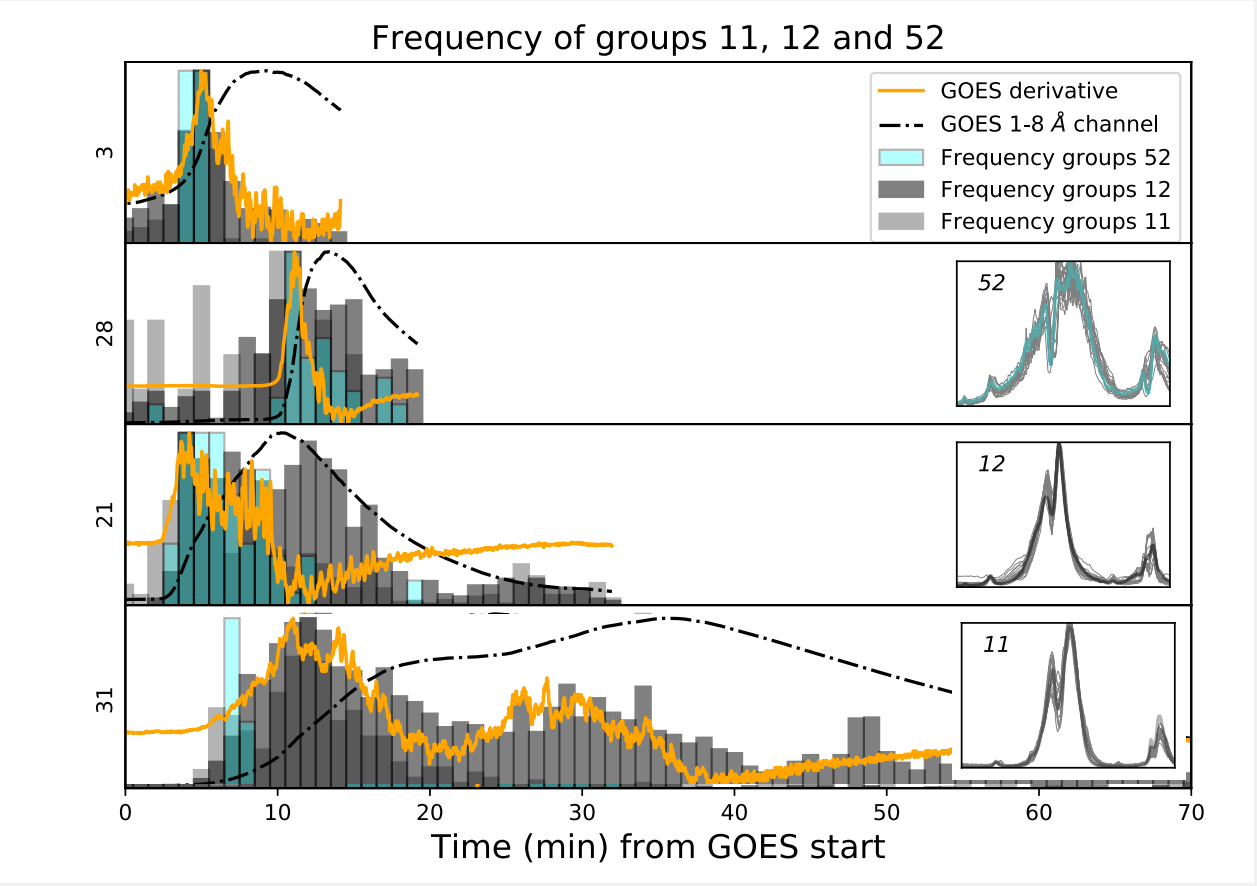
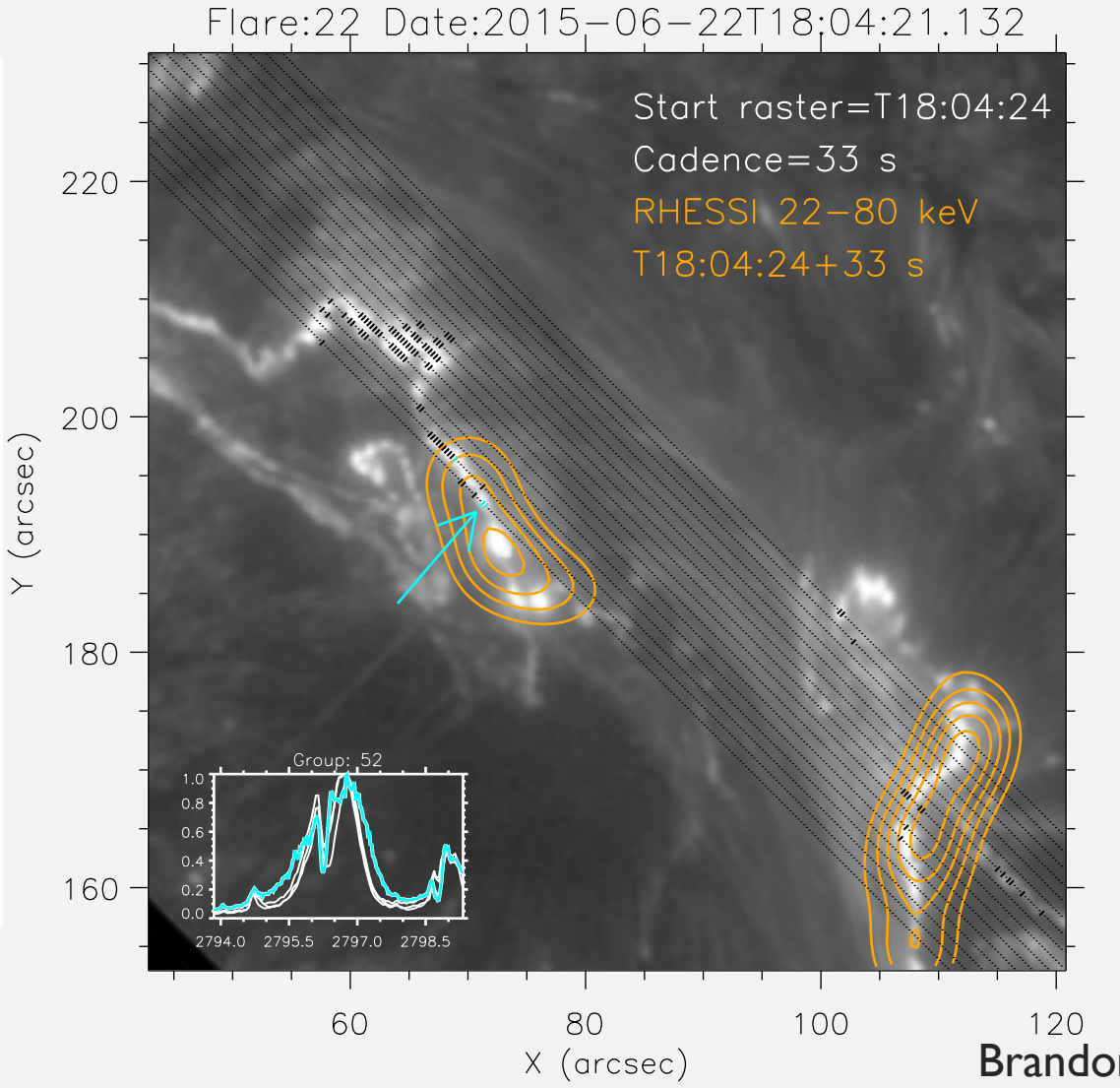
TEMPORAL AND SPATIAL CORRELATION WITH X-RAY SIGNATURES





Correlated with GOES and within RHESSI contours

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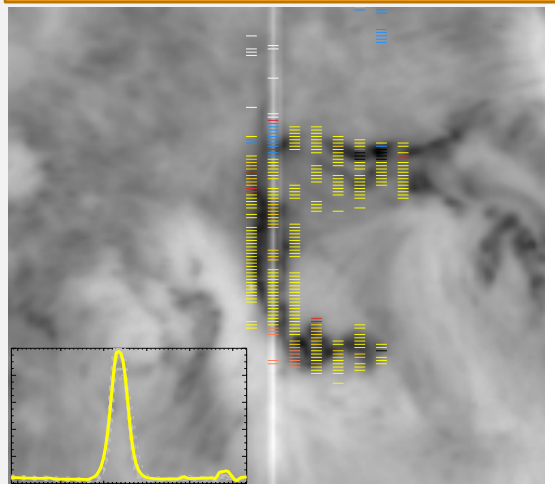
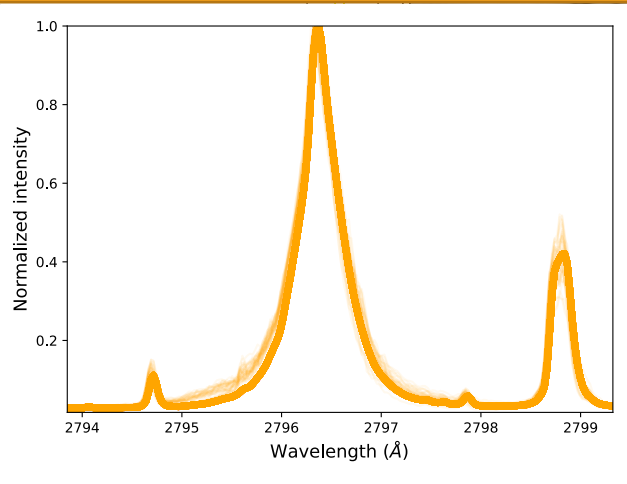
RESEARCH QUESTIONS

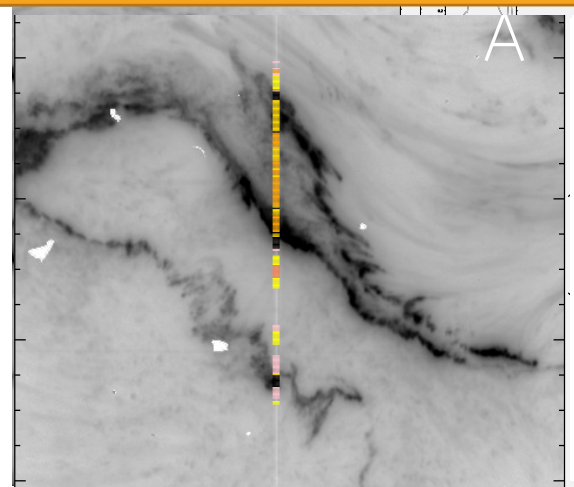
We found all the fundamental flaring profiles using the k-means algorithm

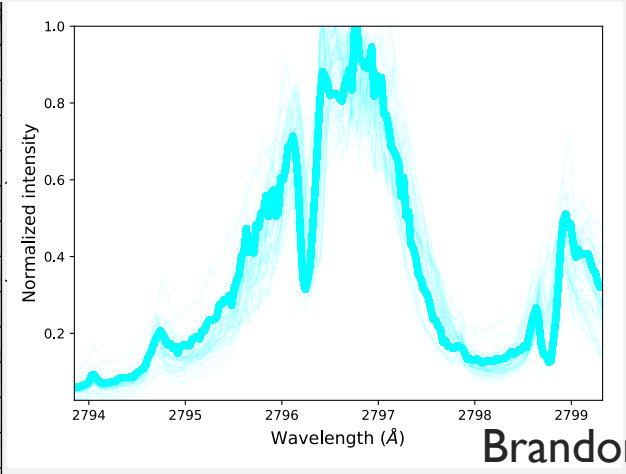
We can pinpoint the location of all the profiles by projecting the k-means results onto SJI's

Universal triangular profiles + IRIS-ribbon front profiles









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THE END

Thank you for your attention