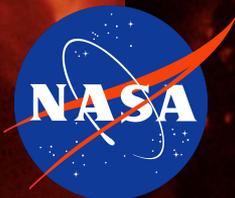# Nanoflare heating of an X-ray Bright Point observed by MaGIXS

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Amy R. Winebarger[1] , P. S. Athiray[2], Sabrina L. Savage[1], Ken Kobayashi[1], Leon Golub[3], Robert W. Walsh[4],Stephen Bradshaw[5], Patrick R. Champey[1], Peter Cheimets[3], Christopher S. Moore[3], Giulio Del Zanna[6], Jaroslav Dudík[7], Chad Madsen[3], Helen Mason[6], David E. McKenzie[1], Katharine K. Reeves[3], Paola Testa[3], Genevieve D[1]. Vigil, Harry P. Warren[8]

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Introduction

- In early 1980's, Parker suggested that the non-flaring solar corona is heated impulsively by small scale reconnection events, termed as nanoflares.

- Direct detection of individual nanoflares are difficult, with present generation instruments.

- Used indirect methods, e.g., DEM or existence of hot plasma etc. (e.g., Tripathi et al. 2011; Winebarger et al. 2011; Brosius et al. 2014; Caspi et al. 2015; Del Zanna et al. 2015; Ishikawa et al. 2017, Barnes et al. 2016, 2021)
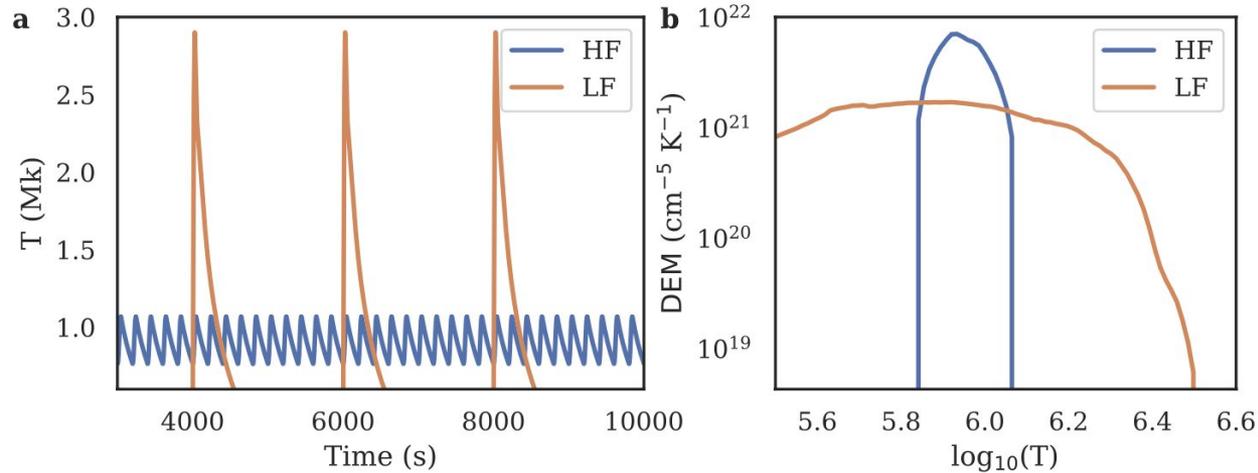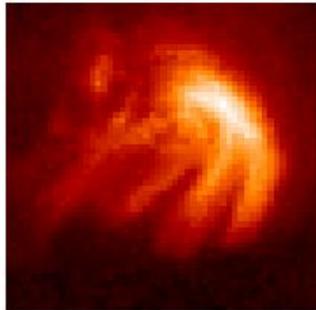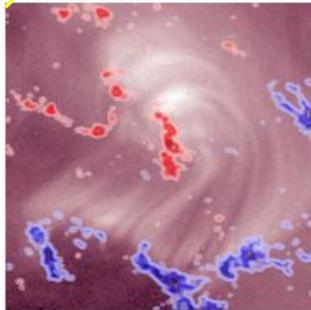

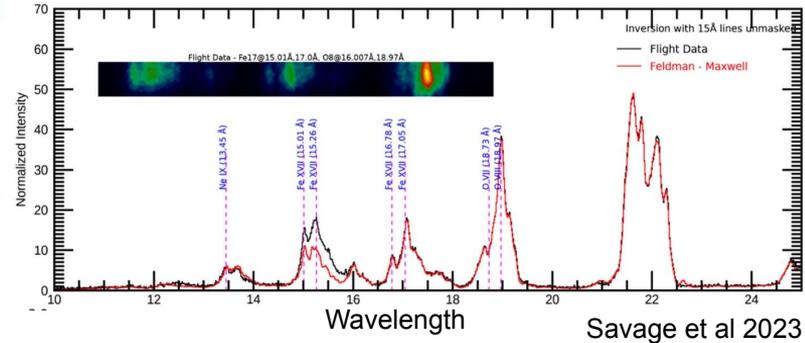See Klimchuk et al 2006, 2015 for more details.
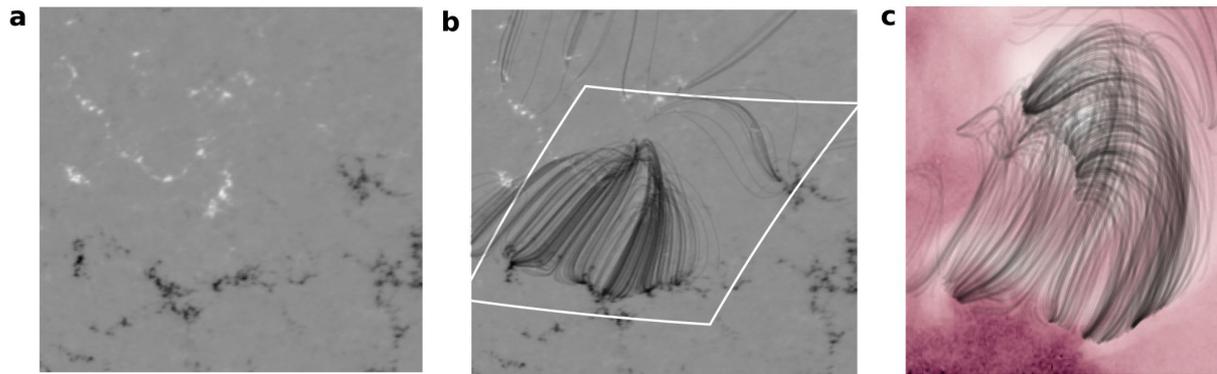
Observation of the XBP by *MaGIXS, AIA, and XRT*
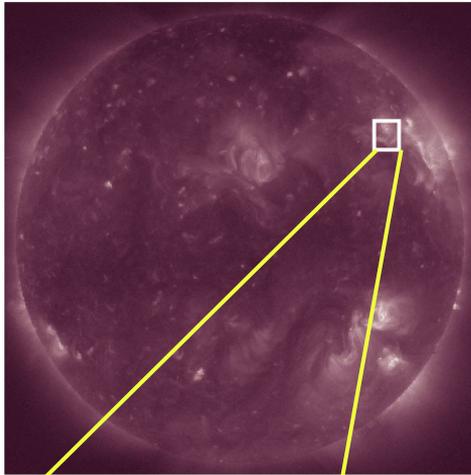
- MaGIXS observed two XBPs.

- Morphology of these XBPs are similar to ARs but consist with cool plasma.

- MaGIXS and XRT are more sensitive to hot plasma whereas AIA is more sensitive to cool plasma.

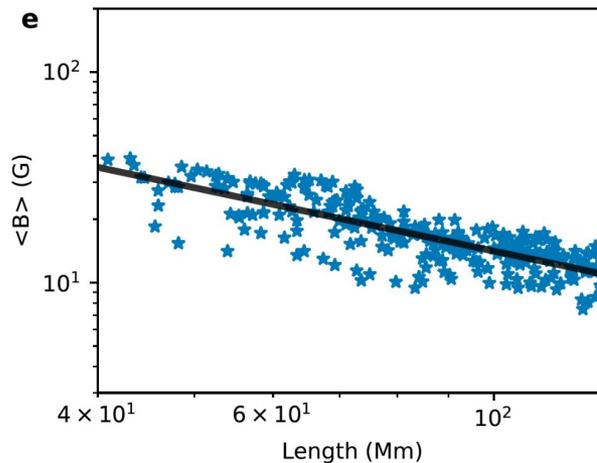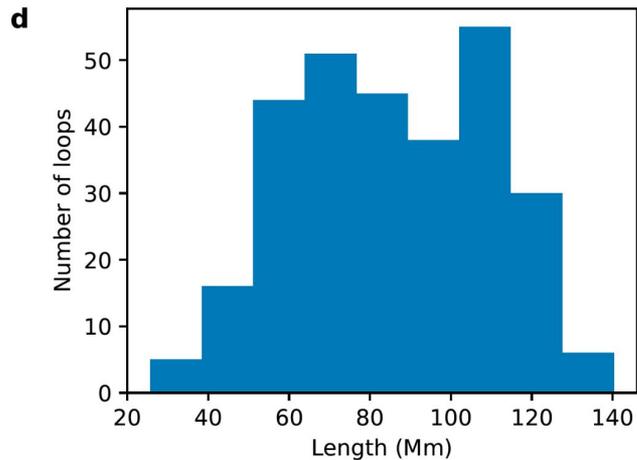July-30-2021, 18:20 UT

Savage et al 2023

Hydrodynamic simulation of XBP-1

➢ Determine Magnetic skeleton using potential field extrapolation.

➢ XBP-1 located away from the disk-centre.

➢ Required projection corrections.

➢ Use field-aligned hydrodynamic codes, HYDRAD.
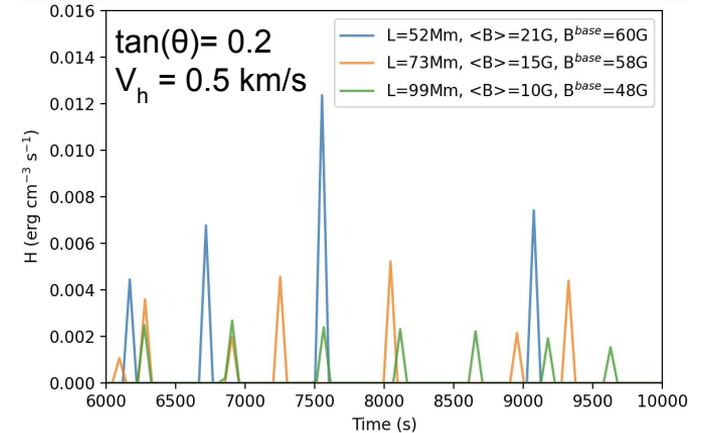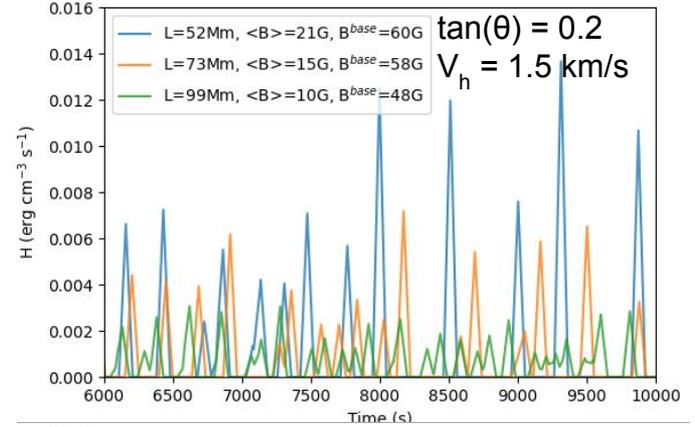
Nanoflare heating sequence

- Consider triangular heating profiles having a duration, τ = 100 s.

- The peak heating rate during an event is randomly chosen between minimum (H_0^{min}) and maximum (H_0^{max}) values that are loop dependent.

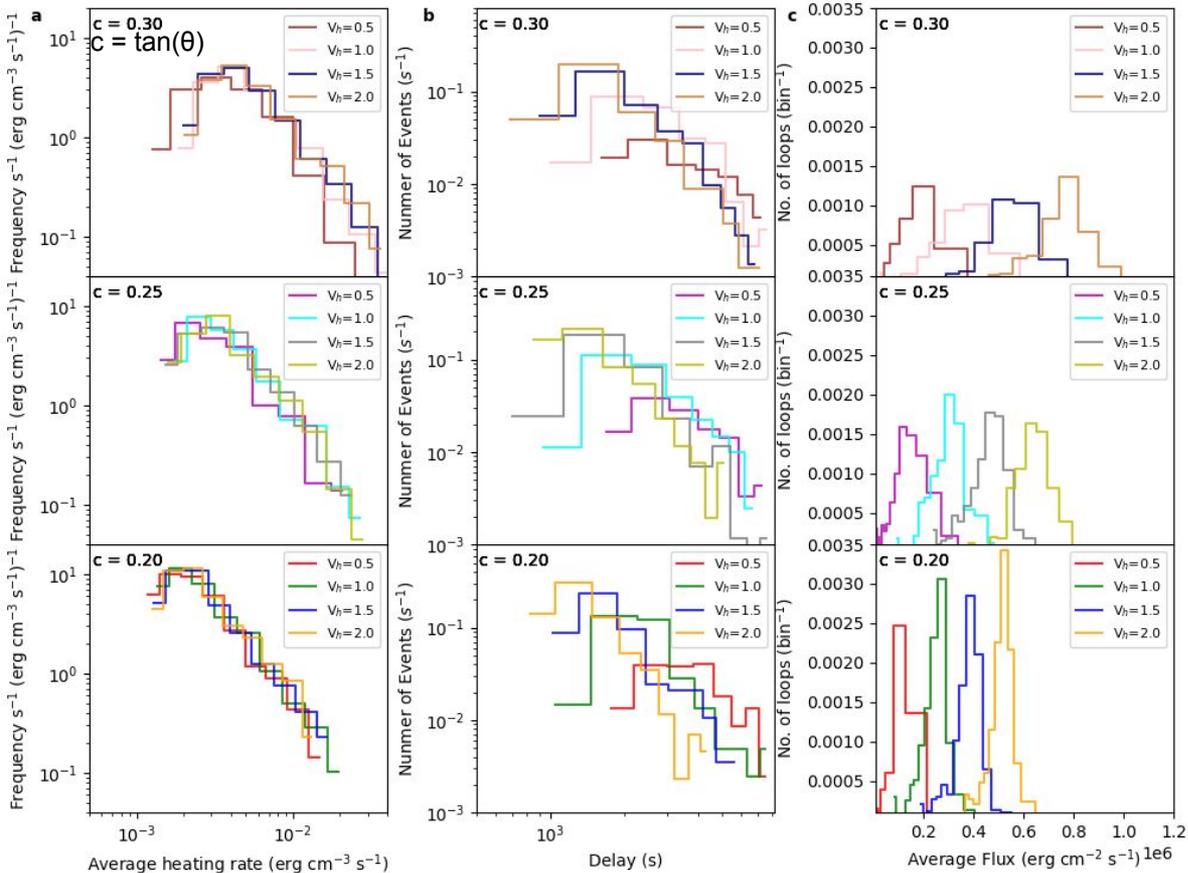$$H_{0_i}^{max} = \frac{1}{\tau} \frac{(tan(\theta) <B>_i)^2}{8\pi} (erg\ cm^{-3}\ s^{-1})$$

$$d_i^l = \frac{\tau L}{F_i} \times H_i^{l-1}$$

$$F = -\frac{1}{4\pi} V_h tan(\theta) B^{base} <B>$$

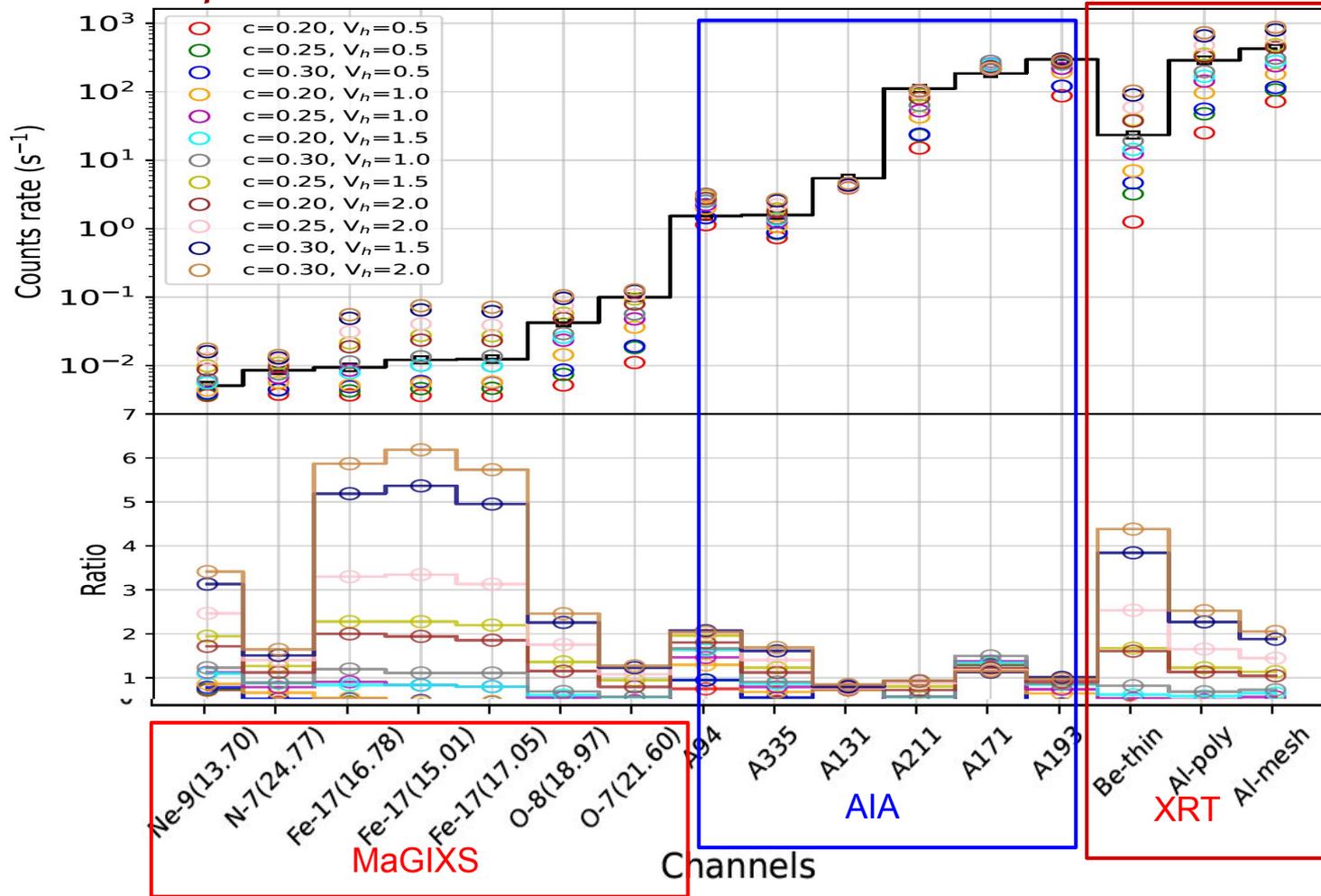See appendix: Mondal, Klimchuk et al 2023

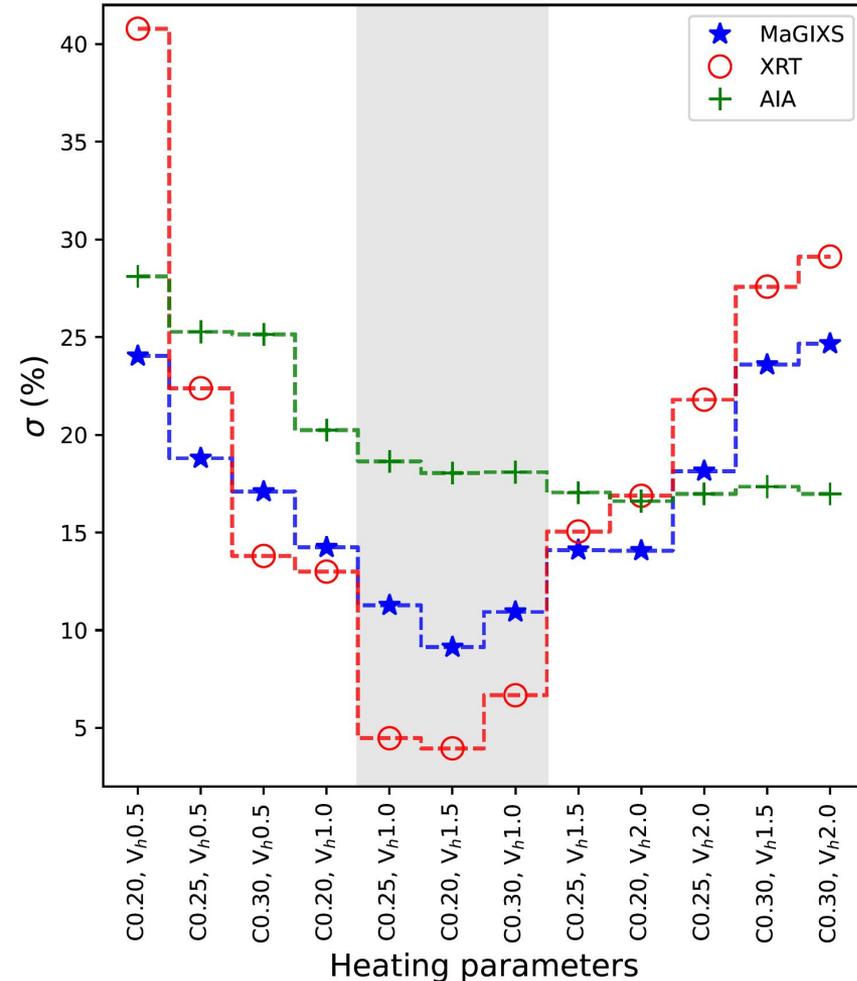# Distribution of nanoflare events for different heating parameters

- Run the simulation setup for various combination of $\tan(\theta)$ and V_h.

- For each combination, we create the DEM map for the XBP.

- Convolving instrument response with the DEM map provides the images.

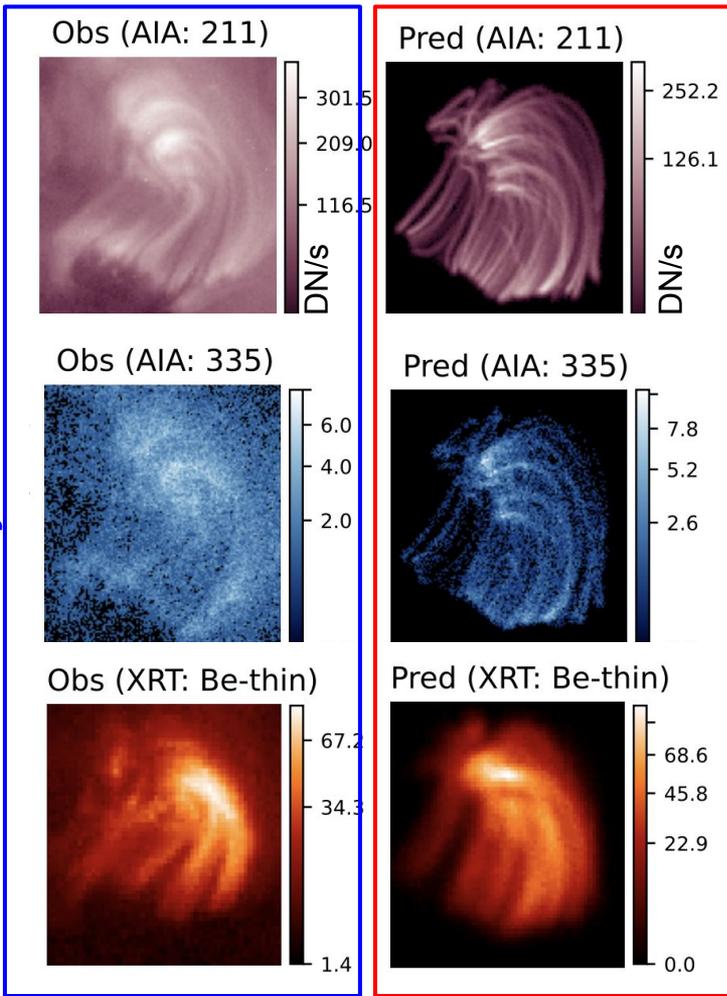# Comparison between simulations and observations

Results & Discussions

➢ HF nanoflare -> average delay = 1500 - 3000 s (Which is smaller than the cooling time of the loops derived from the formula by Cargill et al 2014).

➢ Average Poynting flux = ~5e5 erg/cm2/s

➢ MaGIXS and XRT are more sensitive.

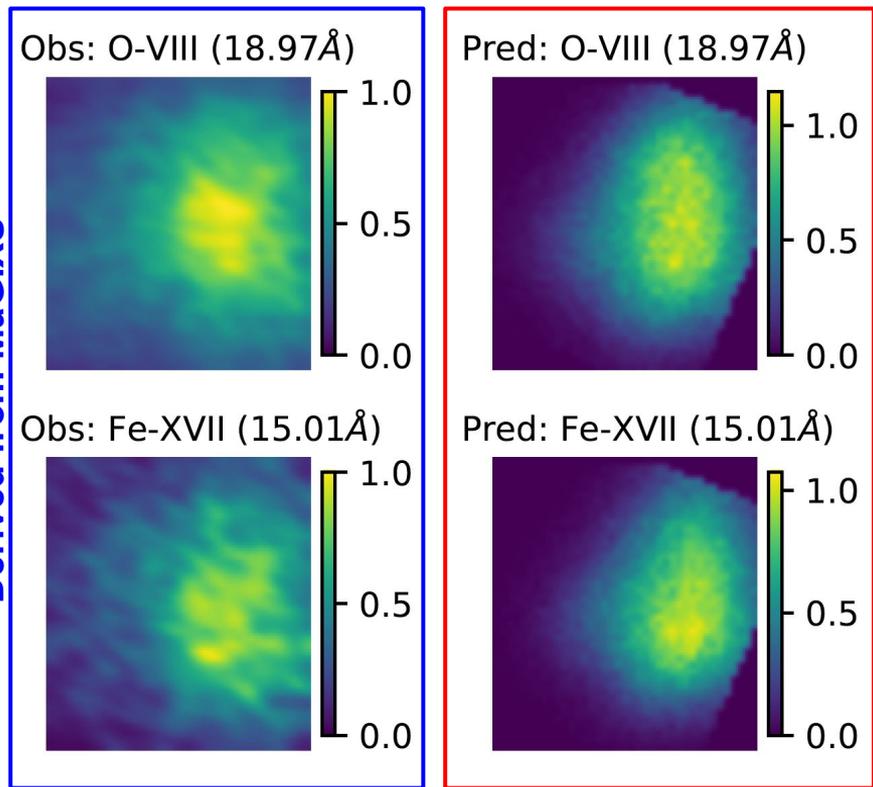# Observed and Predicted images of XBP-1

Mondal et al, (under review)

Summary

➢ Investigated the nanoflare heating of an XBP observed by MaGIXS, AIA and XRT

➢ Nanoflare heating can reproduce the observed intensity of the XBP with an average nanoflare delay time in the order of 1500-3000 s, which is likely to be high-frequency.

➢ The average poynting flux is found to be in the range of 3-4 $\times$ 10^5 erg cm^{-2} s^{-1}, which is intermediate between the total coronal loss of quiet-Sun and ARs, as predicted by Withbroe et al 1977.

➢ MaGIXS and XRT are more sensitive to diagnose the heating frequency, whereas only AIA channels are less sensitive.

➢ Future MaGIXS observations will be useful to determine the contributions of LF and HF nanoflare to heat the AR.

MaGIXS-2 (This year)

Credit: MaGIXS team

Thank You for your attention!