Solar coronal phenomenon: Imaging spectroscopy

Biswajit Mondal

NASA Postdoctoral Program

Marshall Space Flight Center

Email: biswajit.mondal@nasa.gov

TEAM:

Amy R. Winebarger (NASA MSFC)

P. S. Athiray (UAH/MSFC)

Sabrina L. Savage (NASA MSFC)

Ken Kobayashi (NASA MSFC)

Patrick R. Champey (NASA MSFC)

Adam Kobelski (NASA MSFC)

Genevieve D. Vigil (NASA MSFC)

MaGIXS team

Physical Research Laboratory

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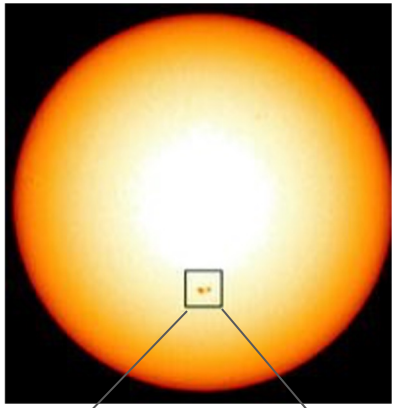
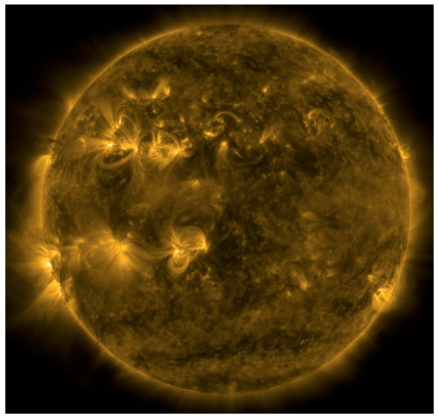
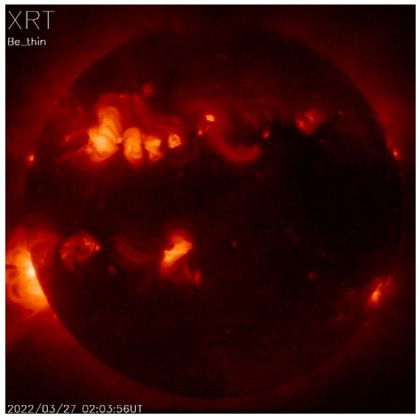
Introduction



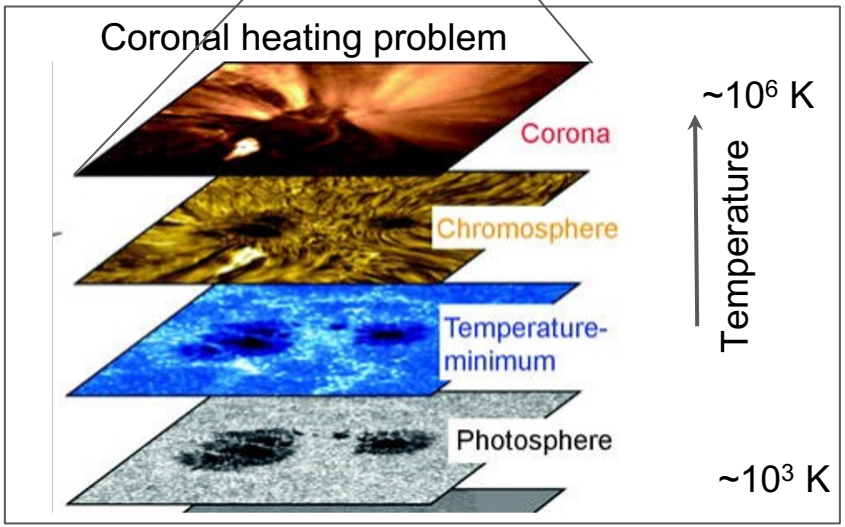
Visible wavelength

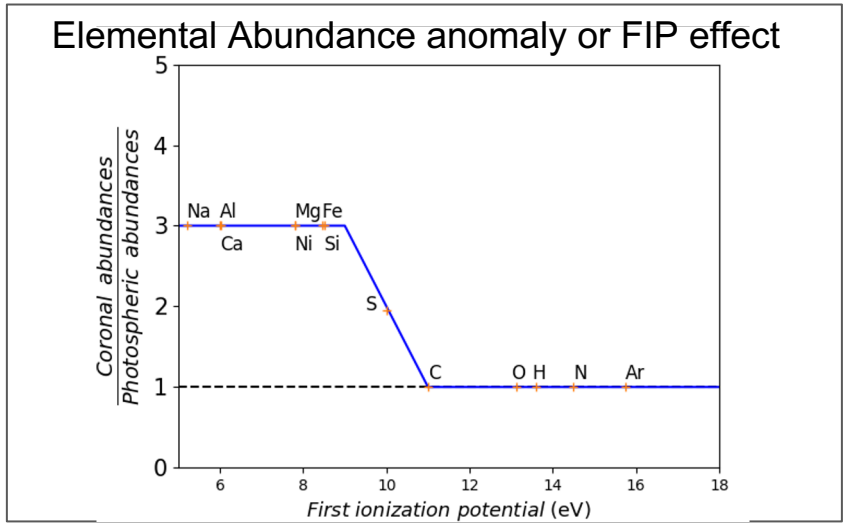


EUV



X-ray Credit: helioviewer.org

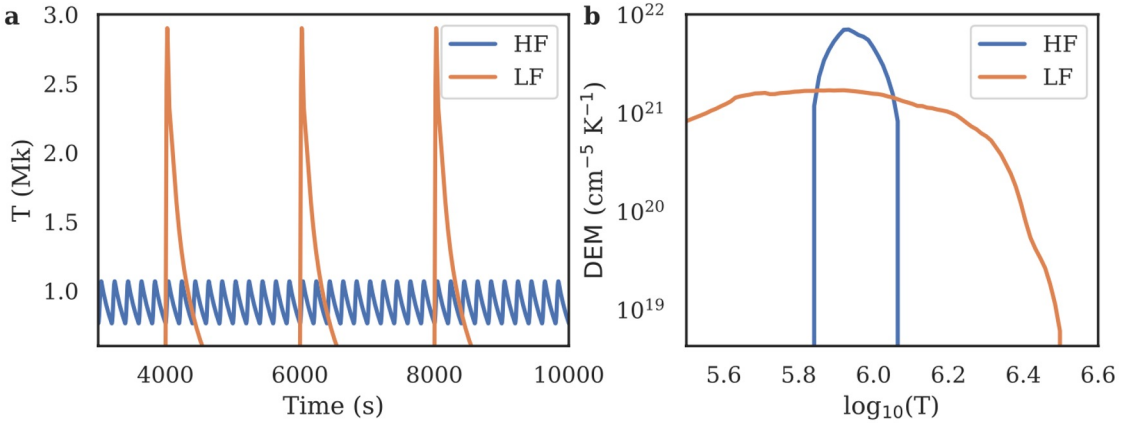


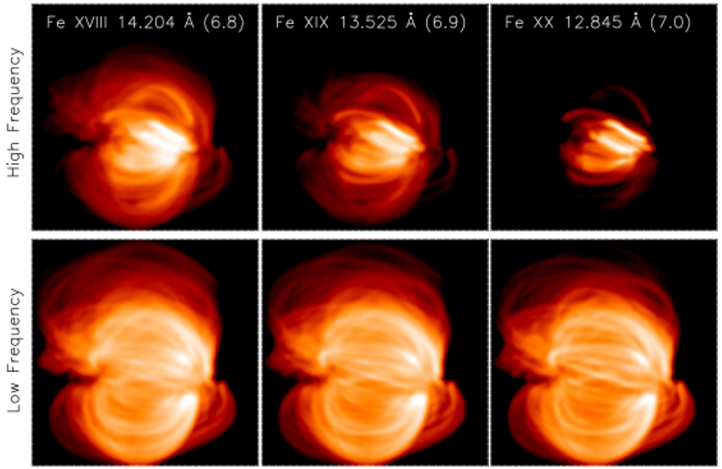


Supporting theories and how to probe them

Nanoflare heating

- In early 1980's, Parker suggested that the non-flaring solar corona could be heated by nanoflares.
- Direct detection of individual nanoflares are difficult.
- Used indirect methods, e.g., Differential Emission Measure (DEM) or existence of hot plasma etc.



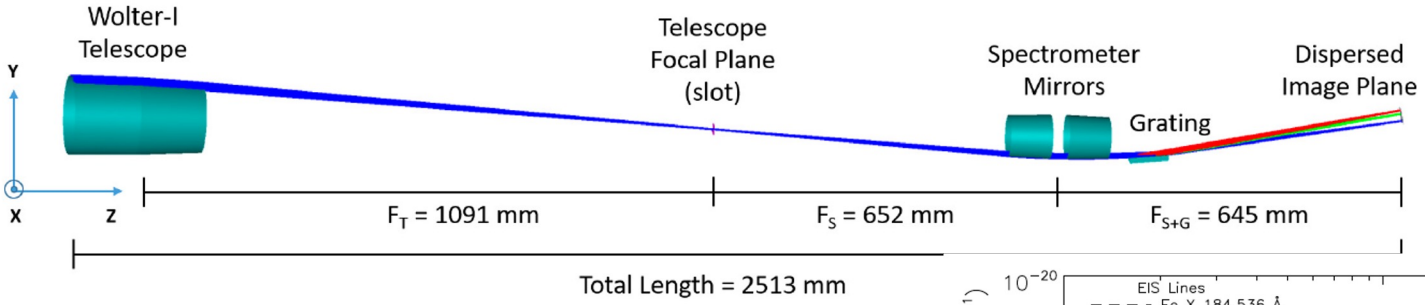


Klimchuk et al (2006, 2015)

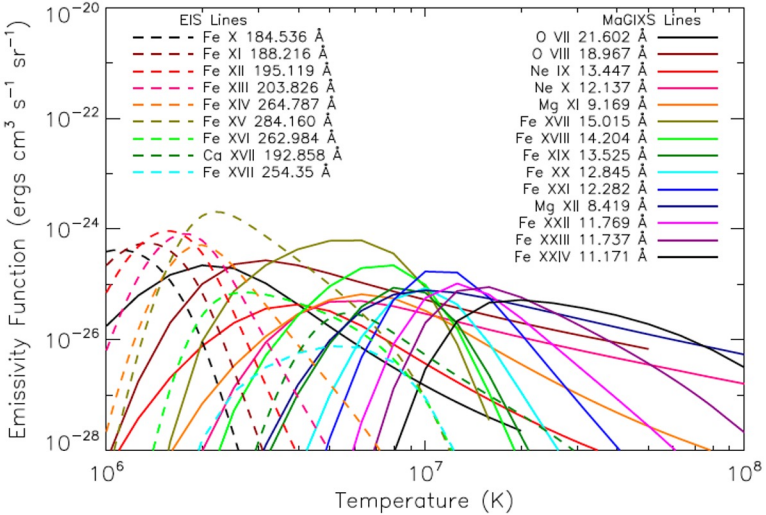
Imaging spectroscopy: Marshall Grazing Incident X-ray Spectrometer (MaGIXS)

- Different regions of the Sun are different in terms of emission structure

- To understand the special variation of the plasma parameters, imaging X-ray spectroscopic observation in soft X-ray energy range is essential.

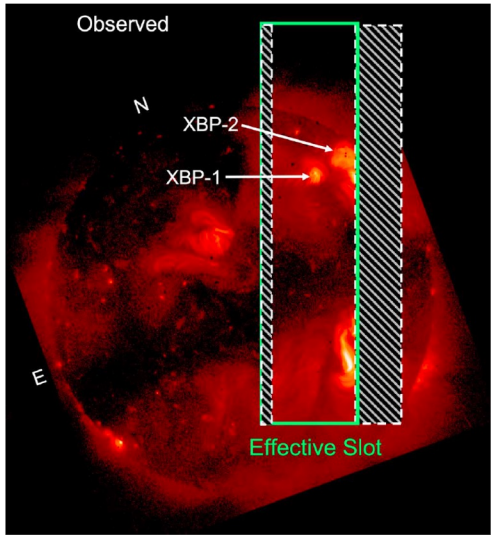


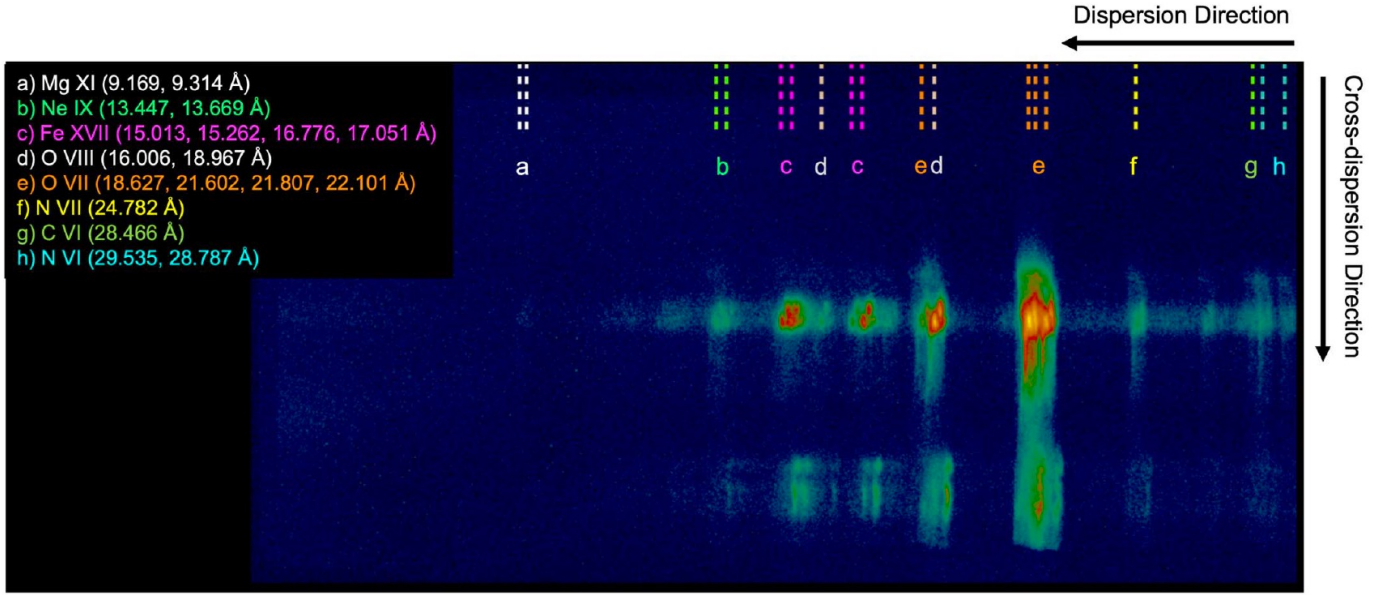
- MaGIXS is sensitive to hot plasma whereas most of the EUV instruments (e.g., EIS) is more sensitive to cool plasma.



Champey et al. 2022

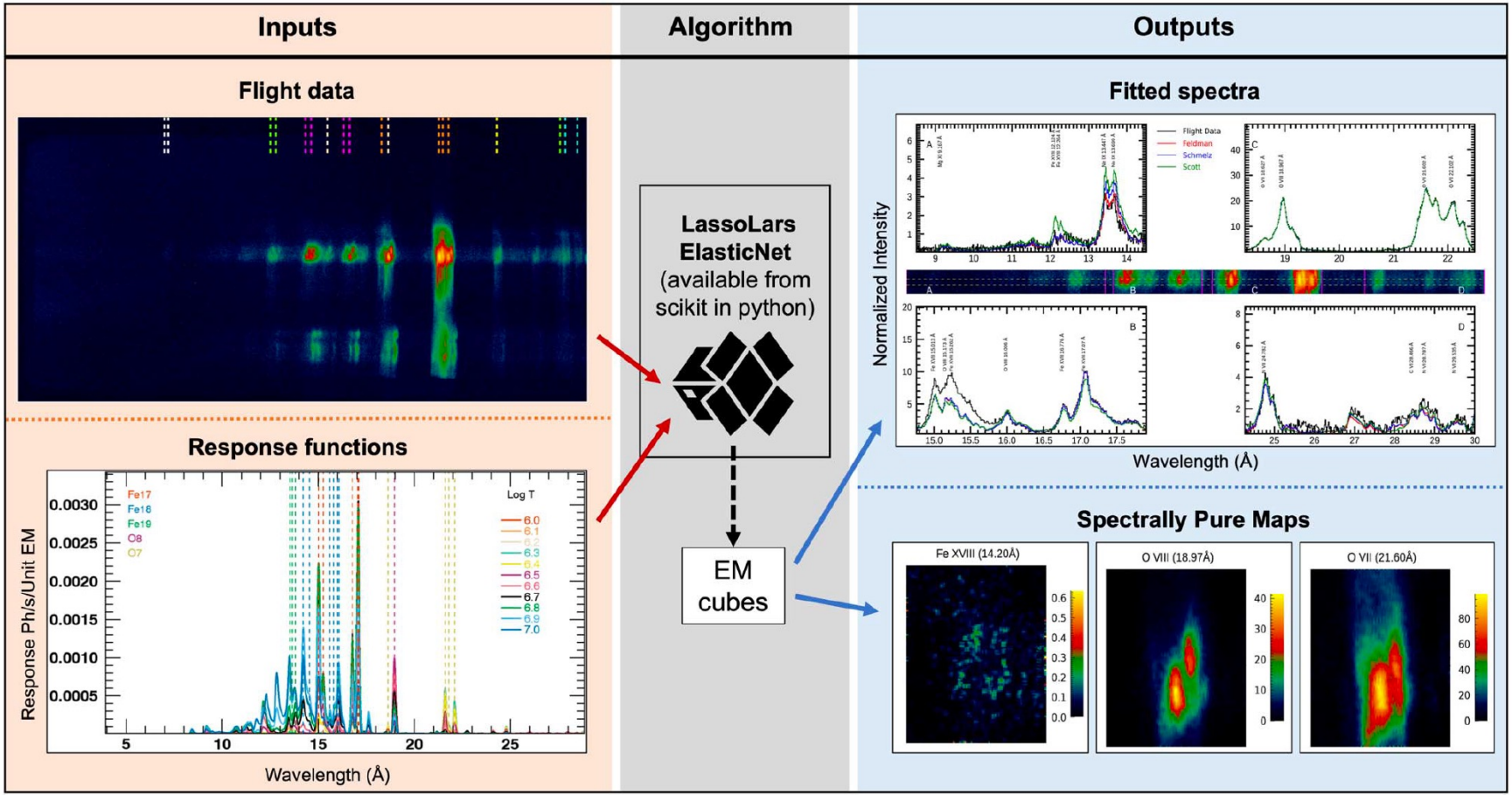
First flight of MaGIXS





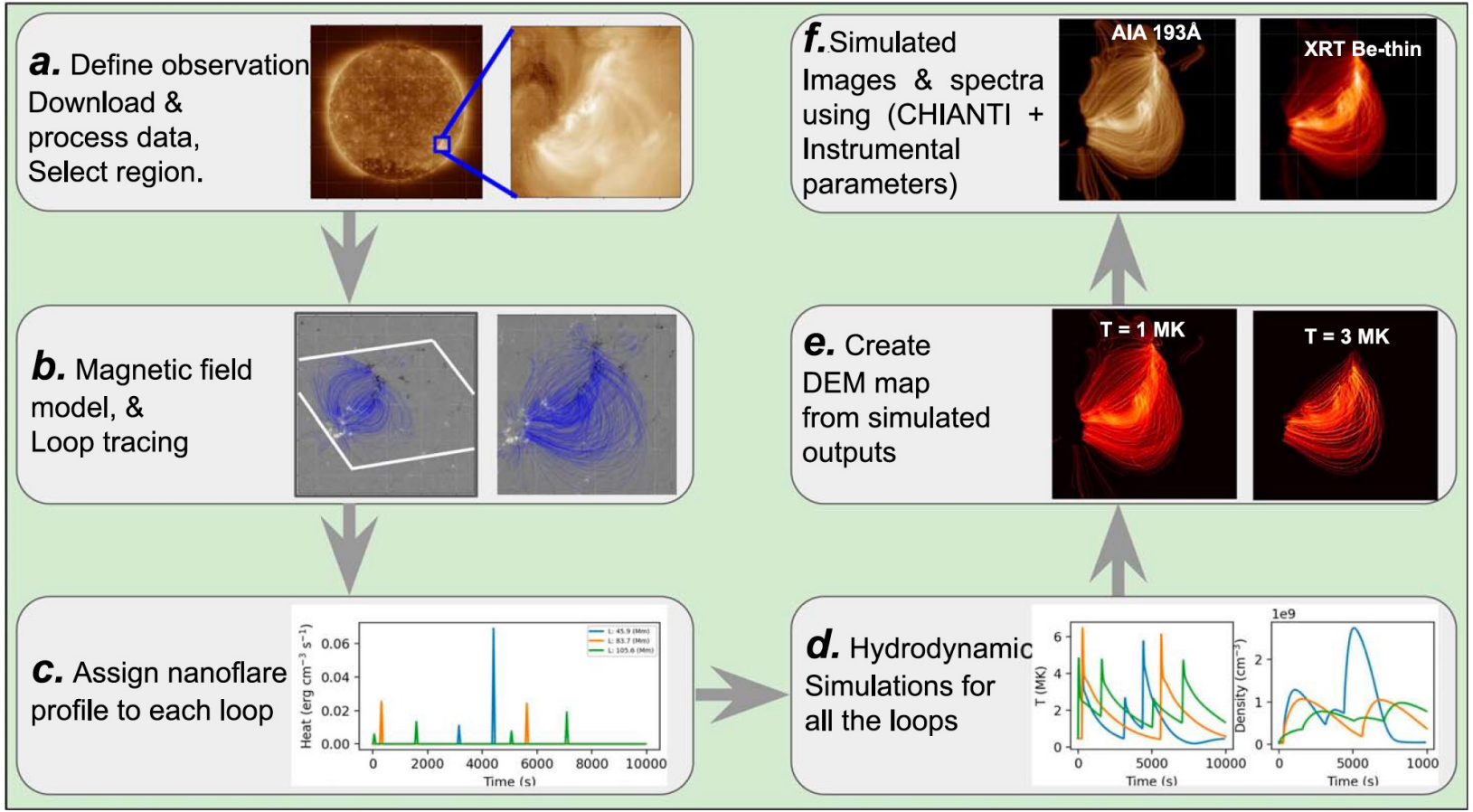
Savage et al (2023)

Spectrally Pure Maps

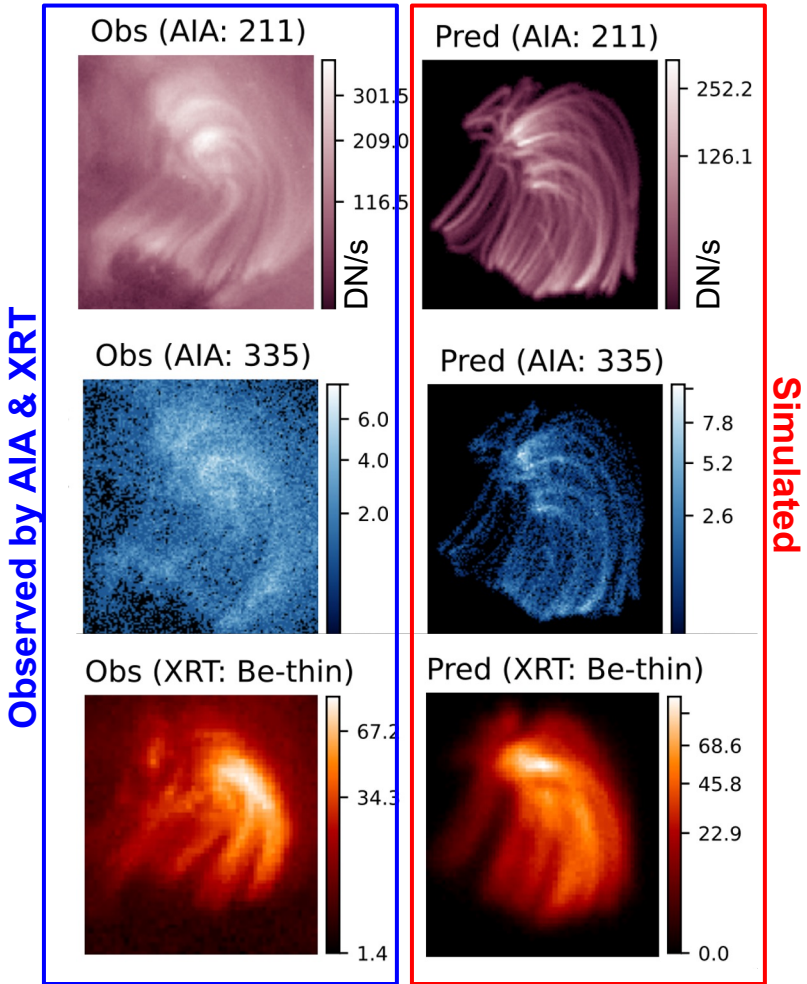


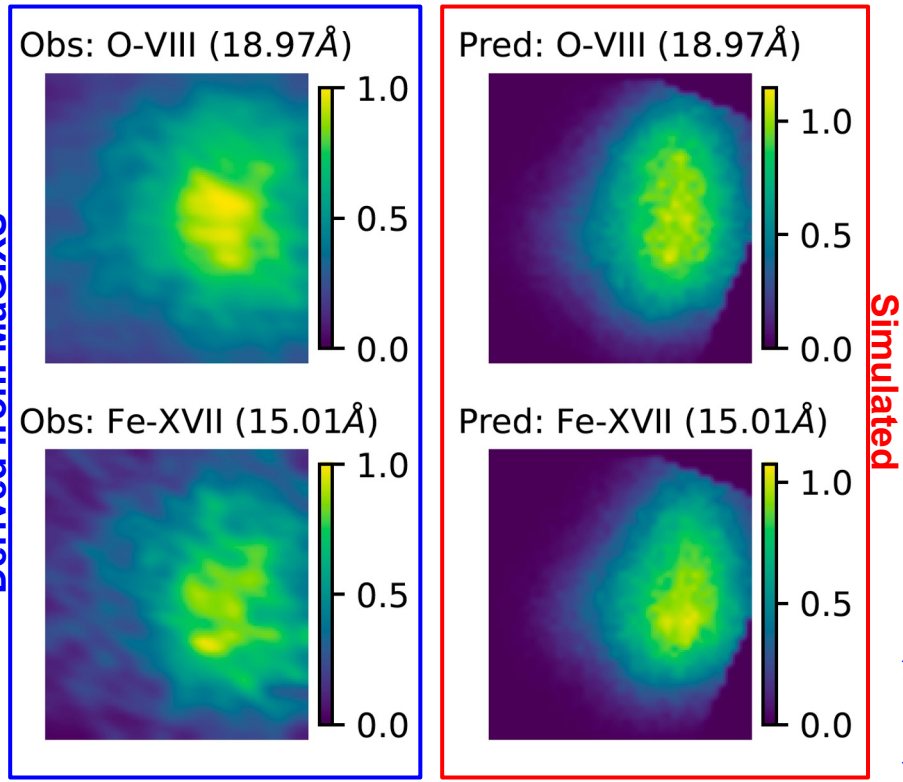
Savage et al (2023)

Combined observations with model



Nanoflare heating of an XBP observed by MaGIXS

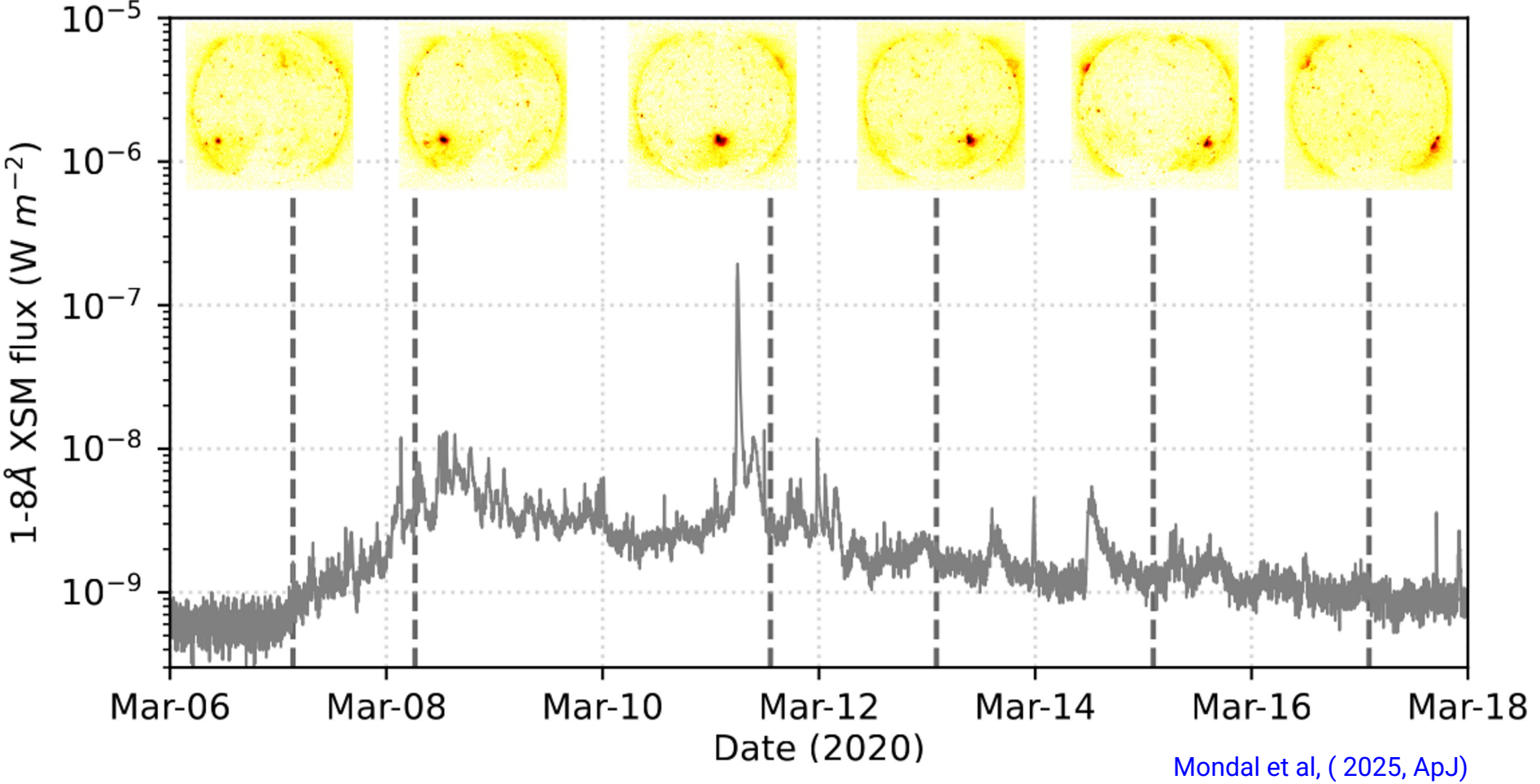




- Average delay = 1500 - 3000 s -> smaller than the cooling time.
- Average Poynting flux = ~5e5 erg/cm2/s
- MaGIXS and XRT are more sensitive.

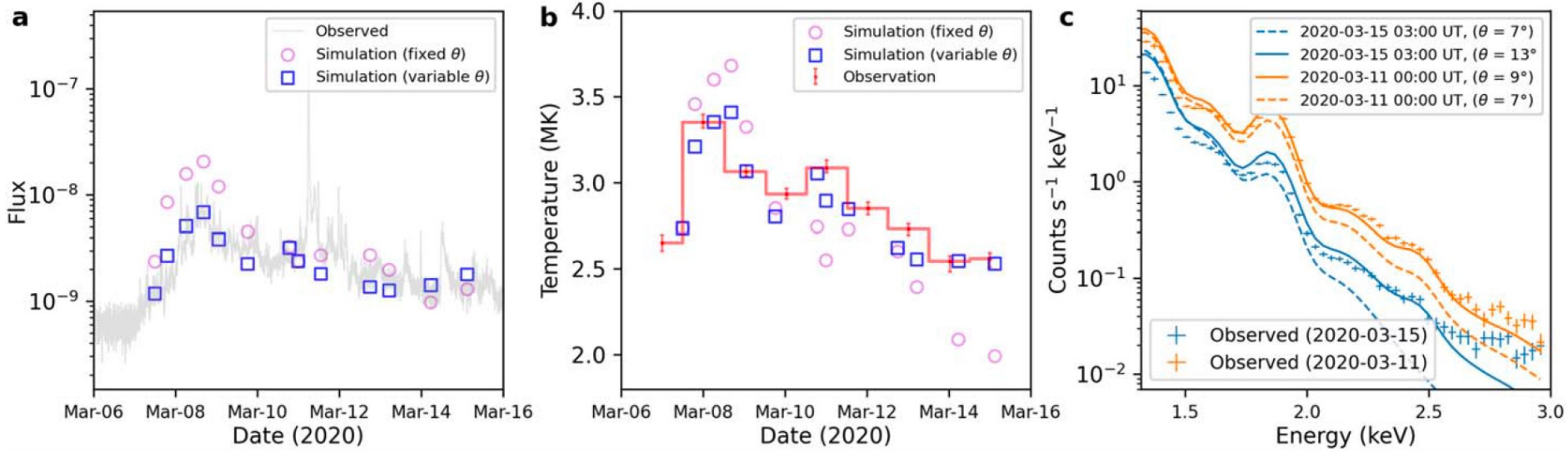
Mondal et al, (2024b)

Does nanoflare heating varies with space and time?

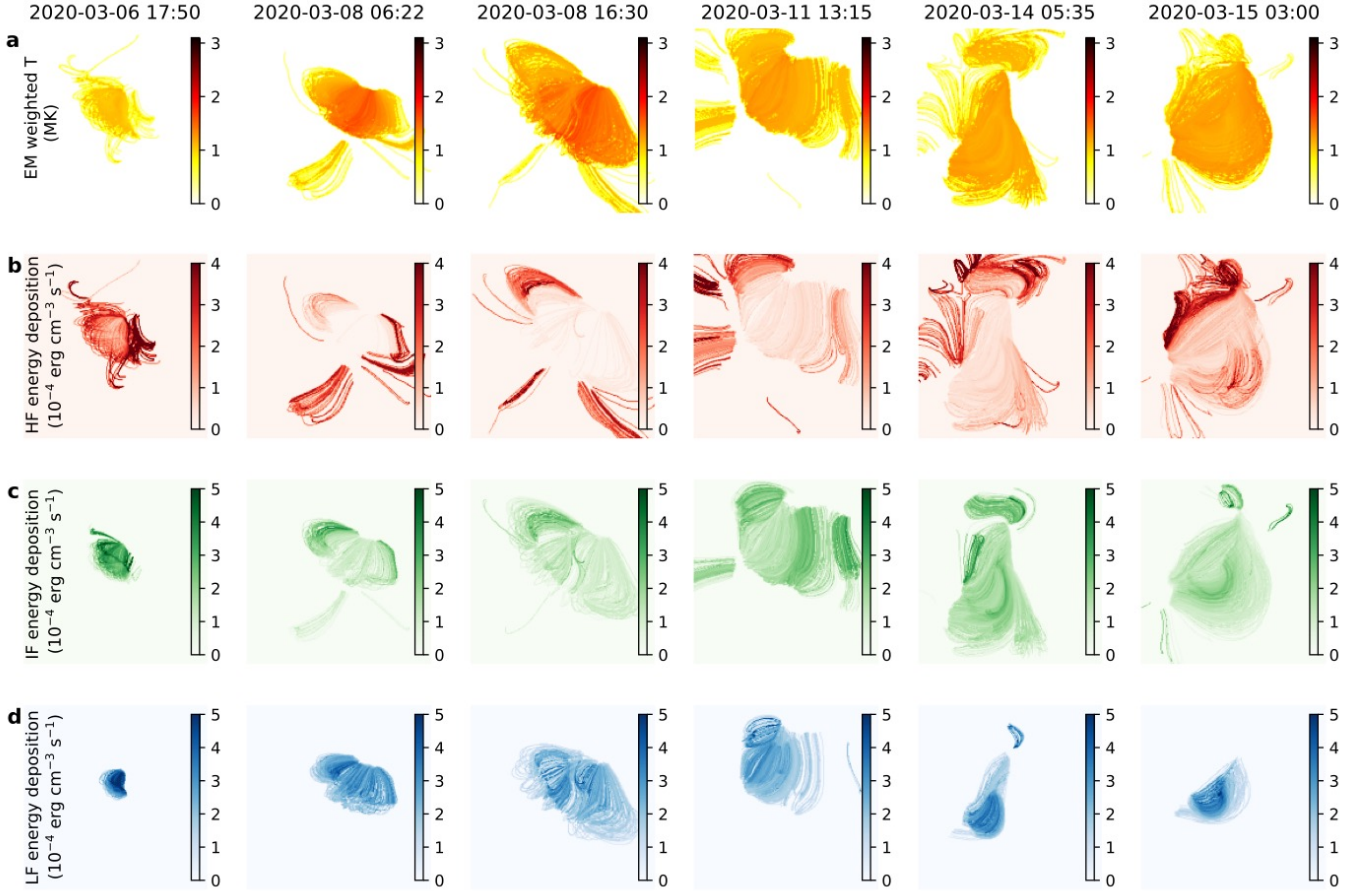


Mondal et al, (2025, ApJ)

Observed and predicted X-ray flux and temperature

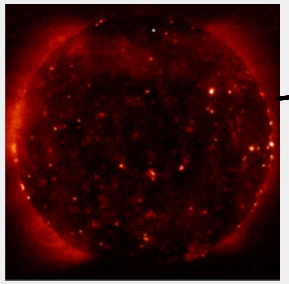


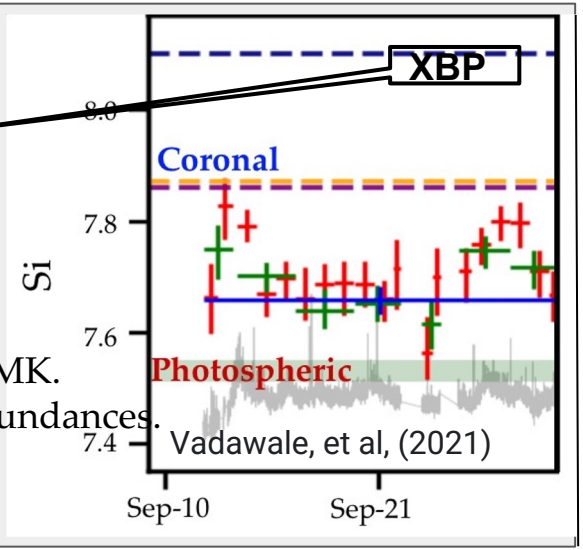
Heating is different over time and space: Long term imaging spectroscopic observation

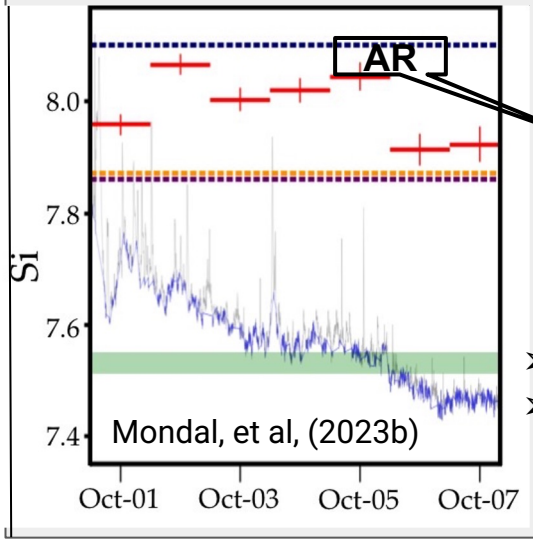


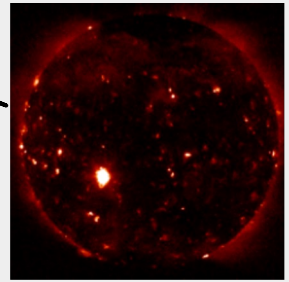
Mondal et al, (2025, ApJ)

Elemental abundances measured in X-ray wavelength





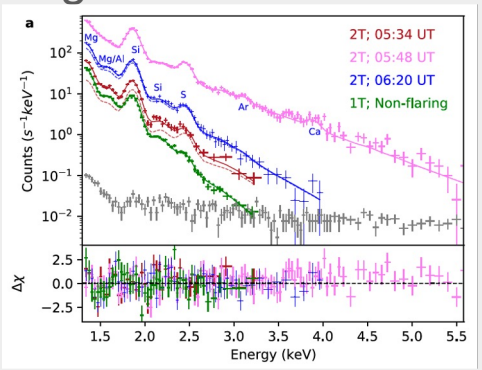


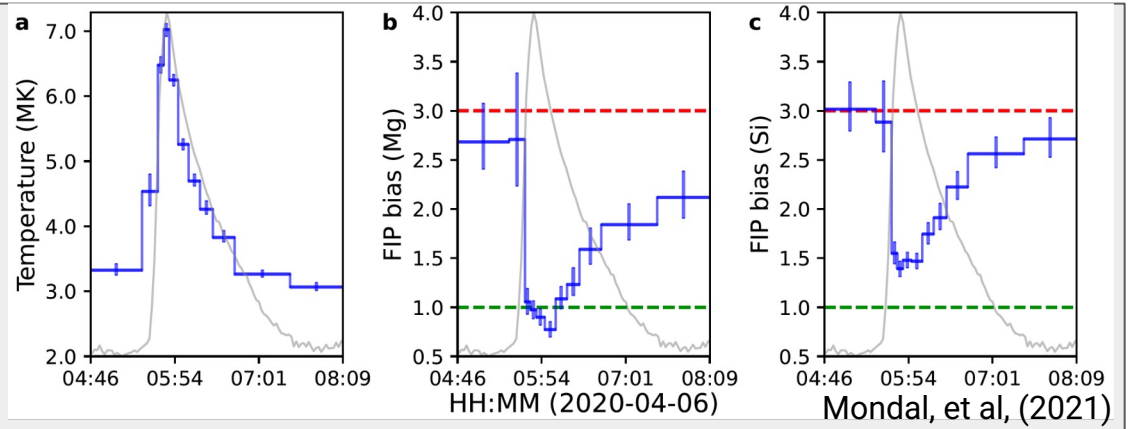


- Average T = ~2 MK.
- Intermediate abundances.

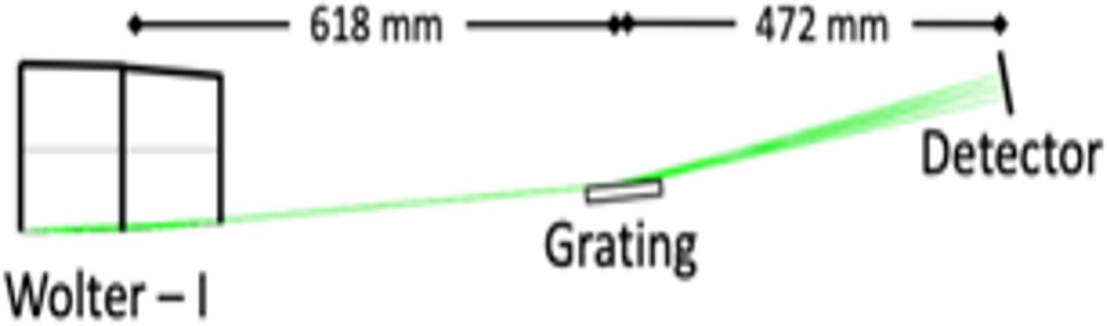
- Average T = ~3 MK.
- Coronal abundances

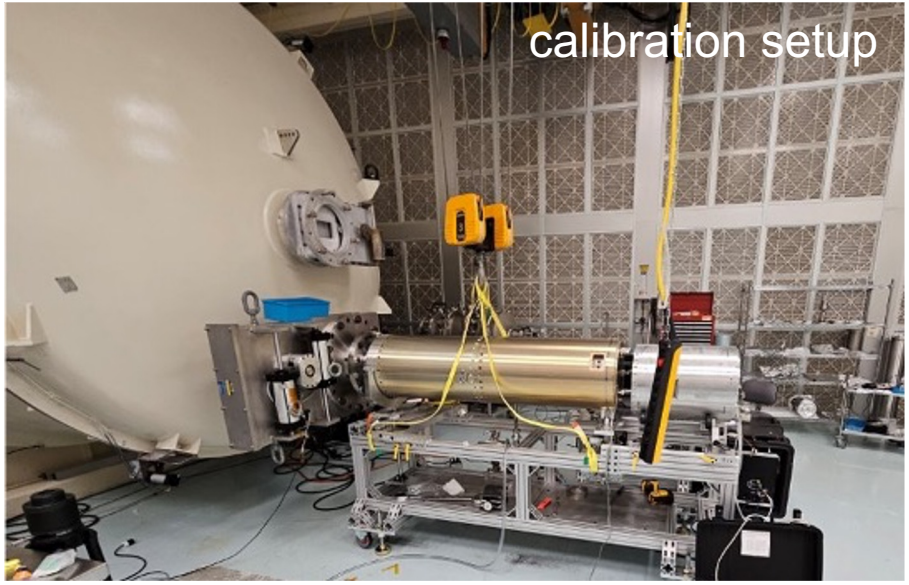
During Solar flares



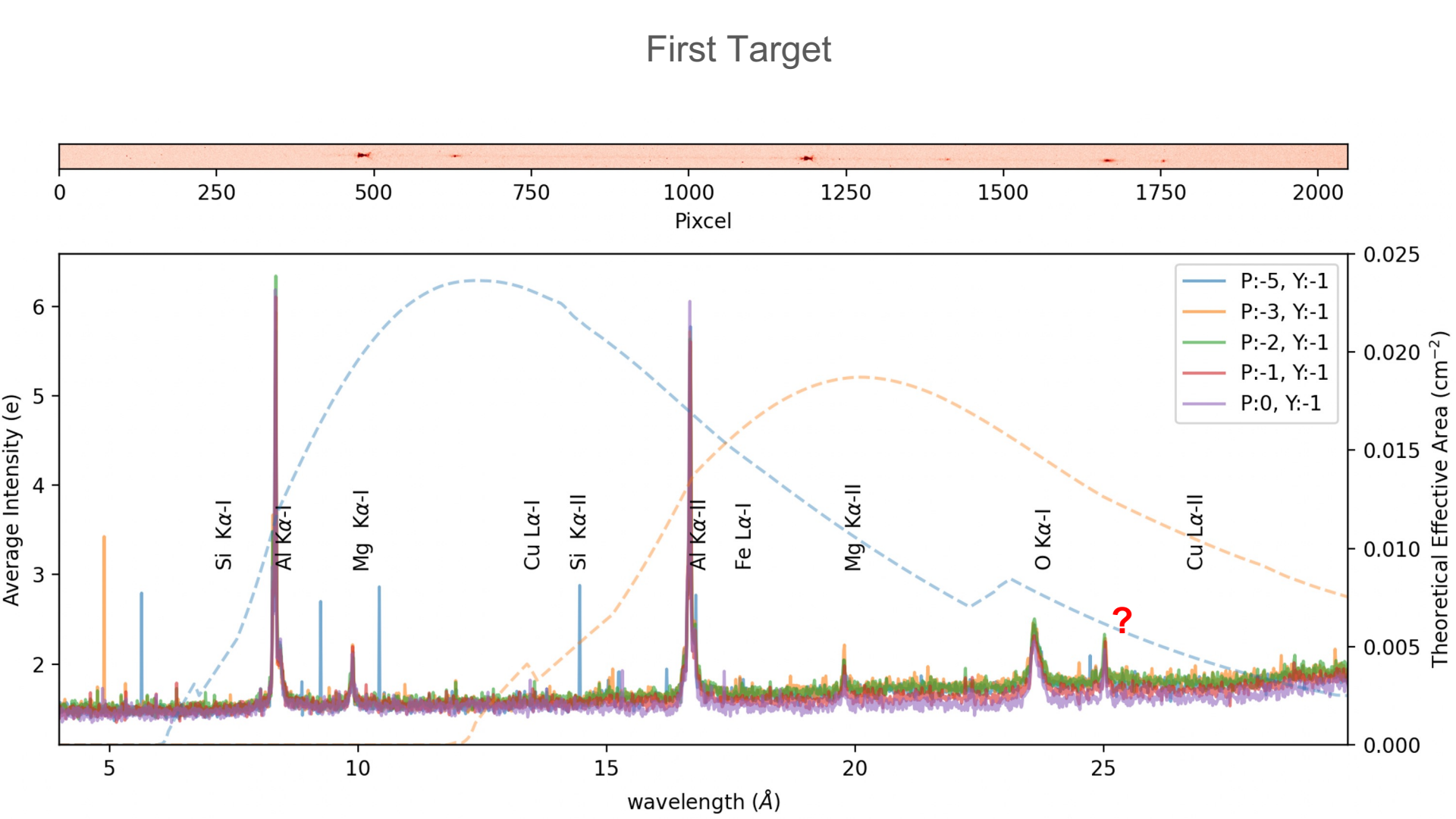


Second flight of Marshall Grazing Incidence X-ray Spectrometer (MaGIXS-2)

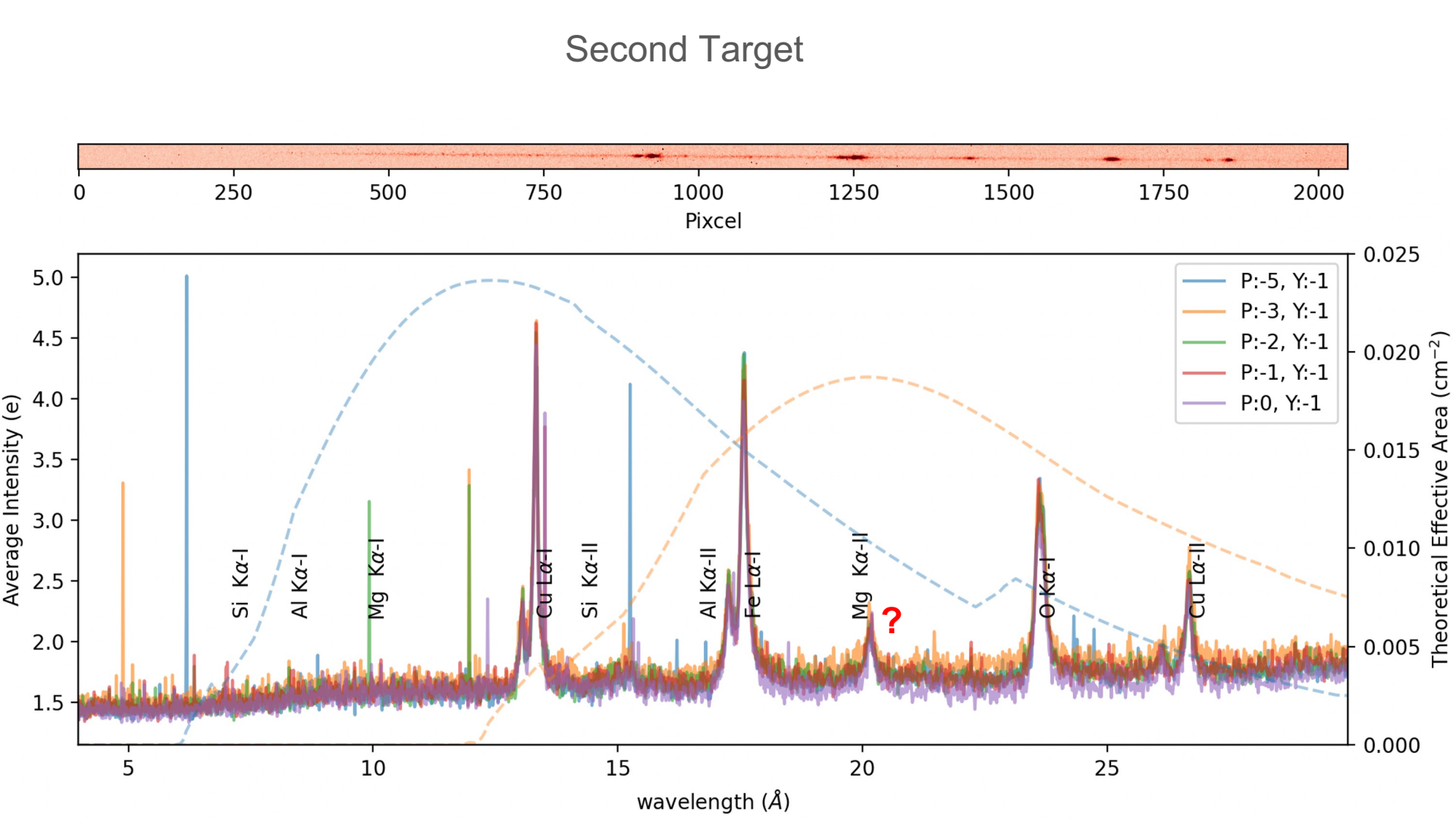




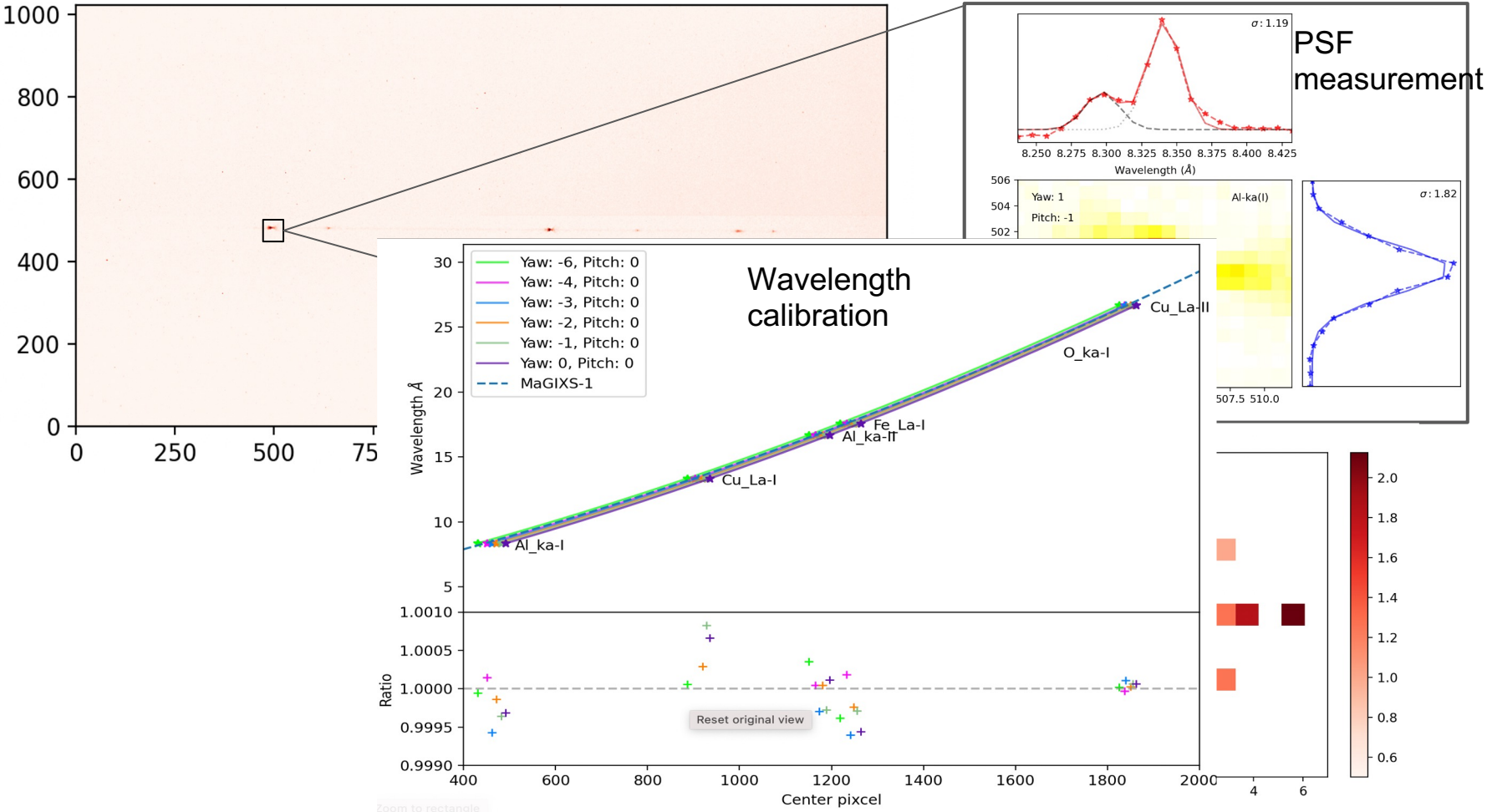
First Target



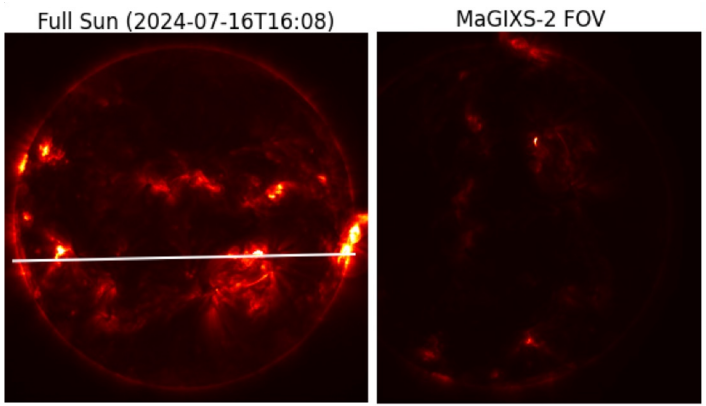
Second Target

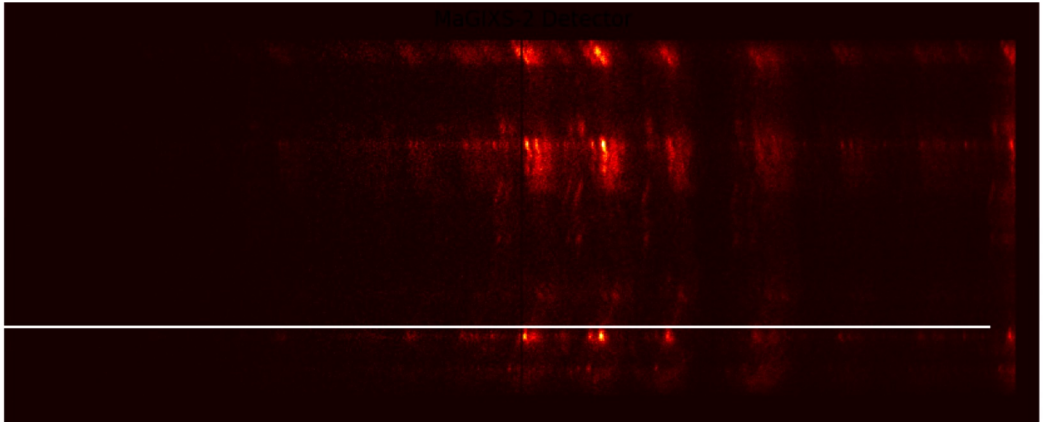


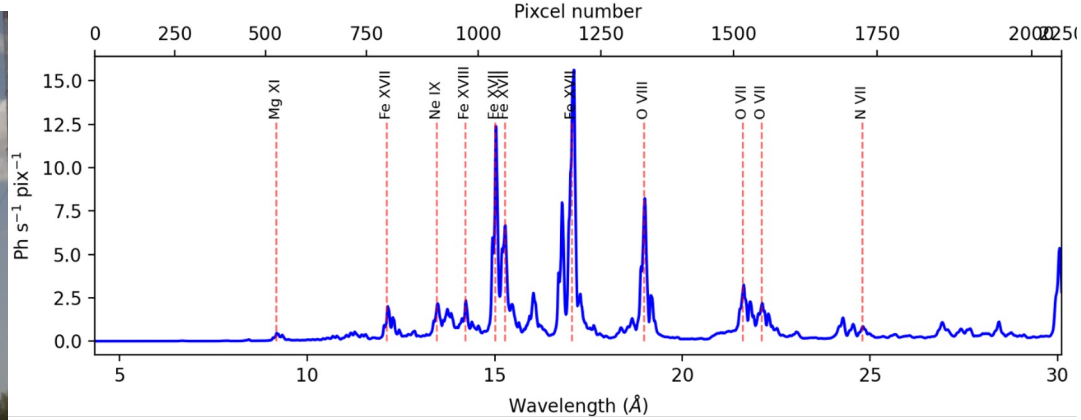
Calibration



MaGIXS-2 Launch preparation on July 16, 2024

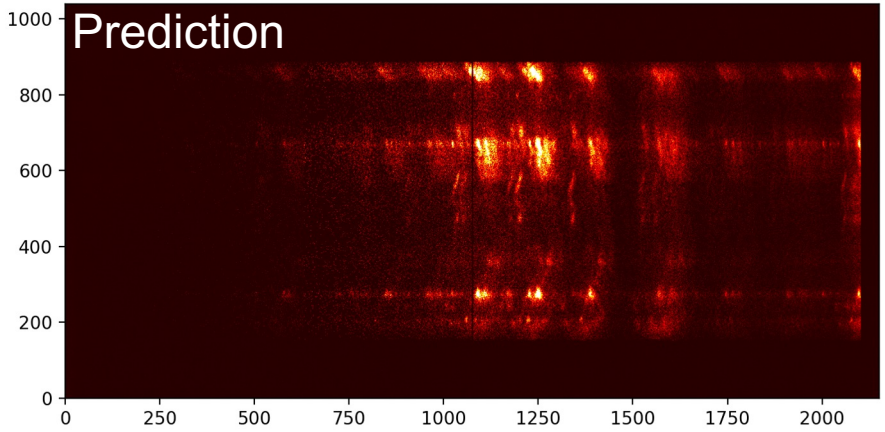


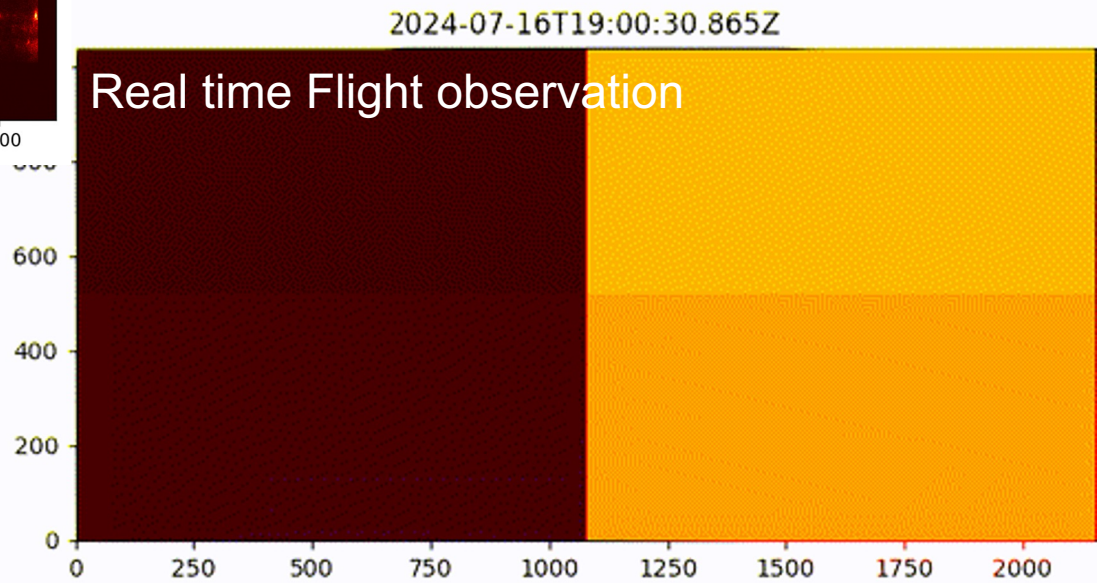




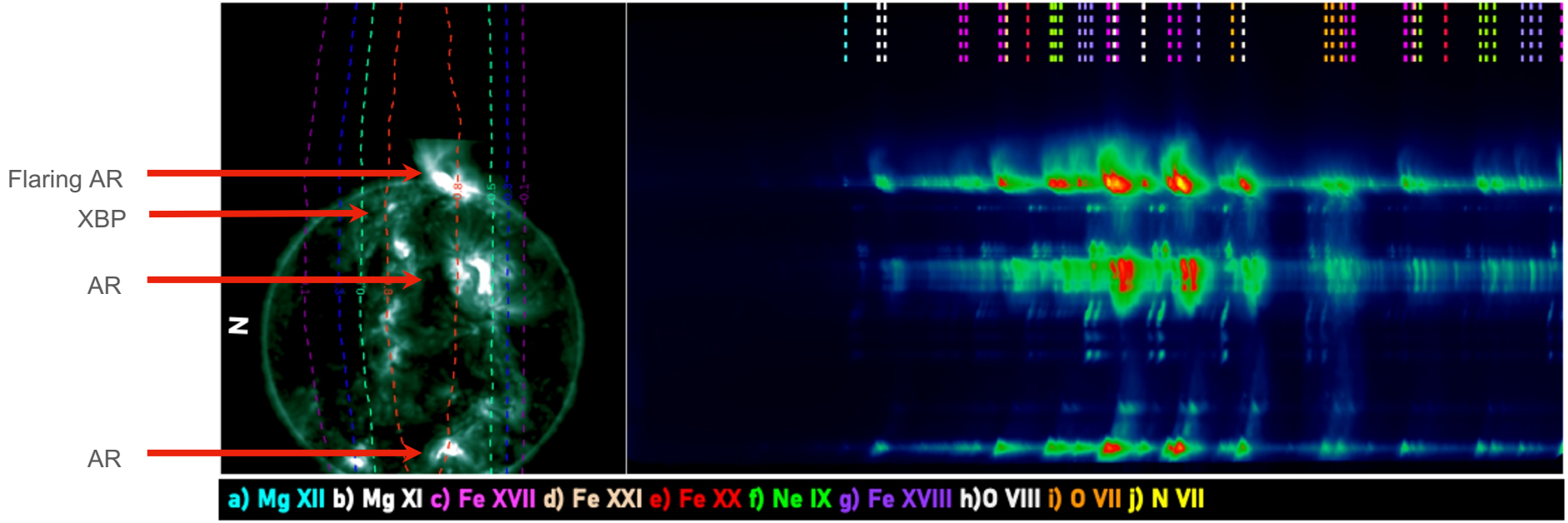
https://github.com/biswajitmb/SunX_overlappograms

MaGIXS-2 Launch preparation on July 16

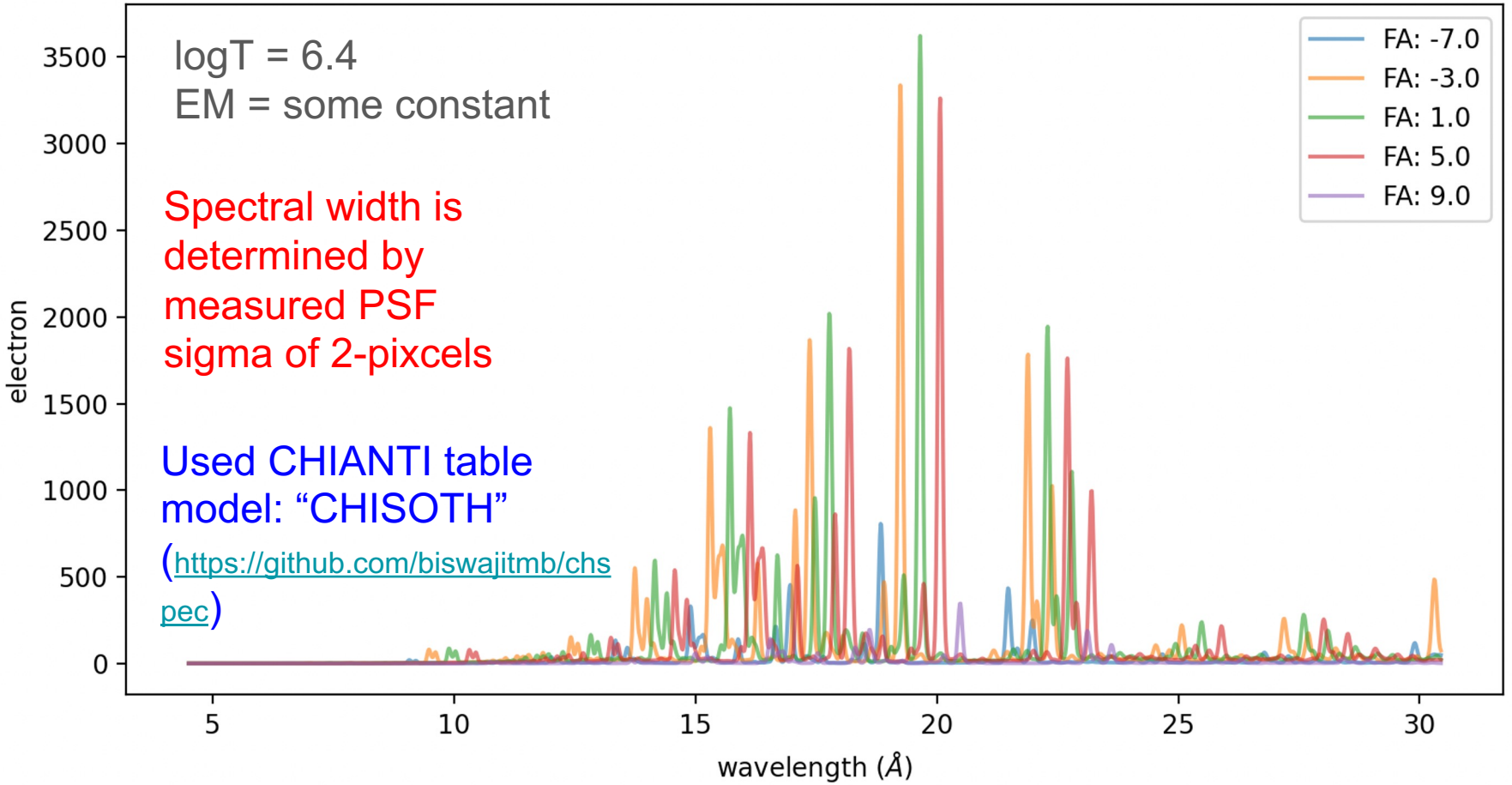




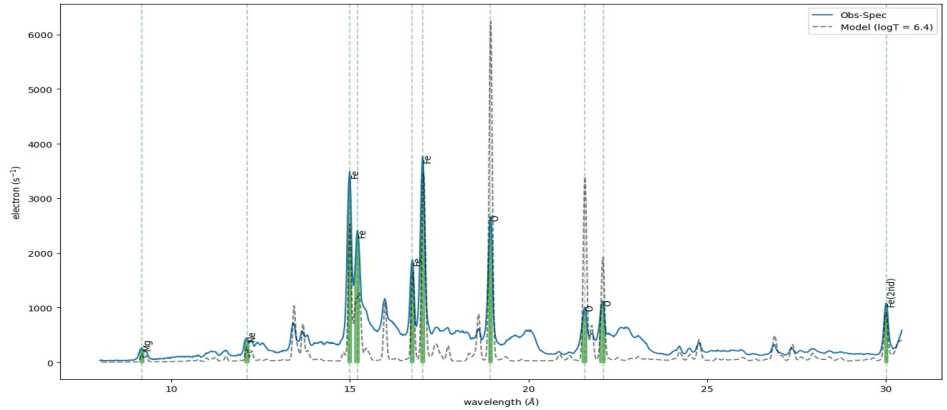
MaGIXS-2 data summary

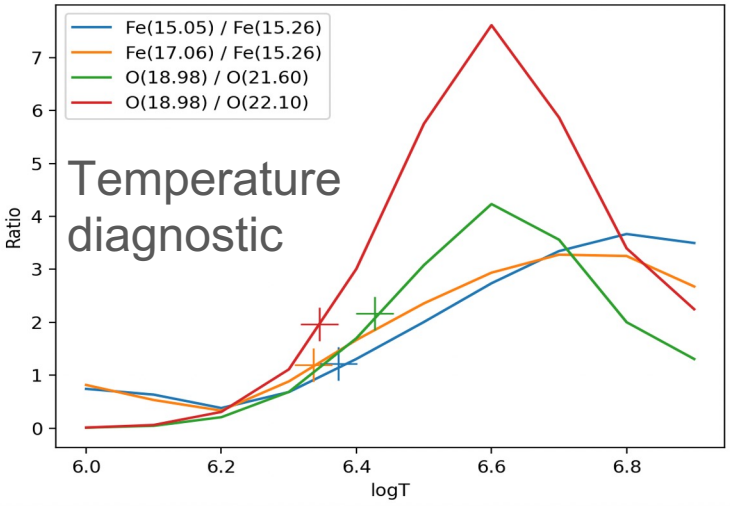


Convolved Spectra with Response for different FA

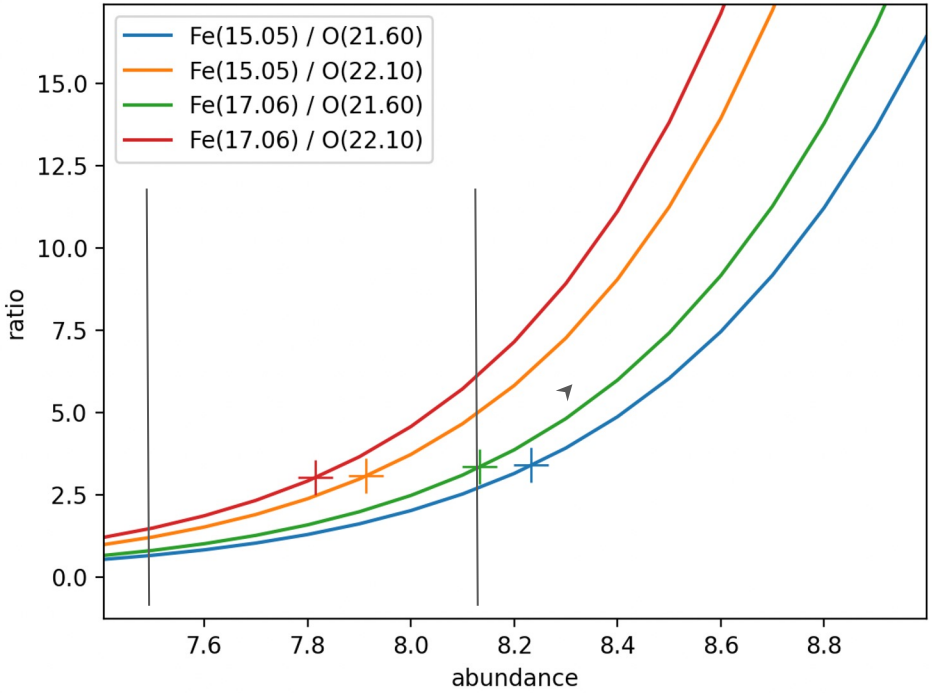


Simple approach to measure abundances

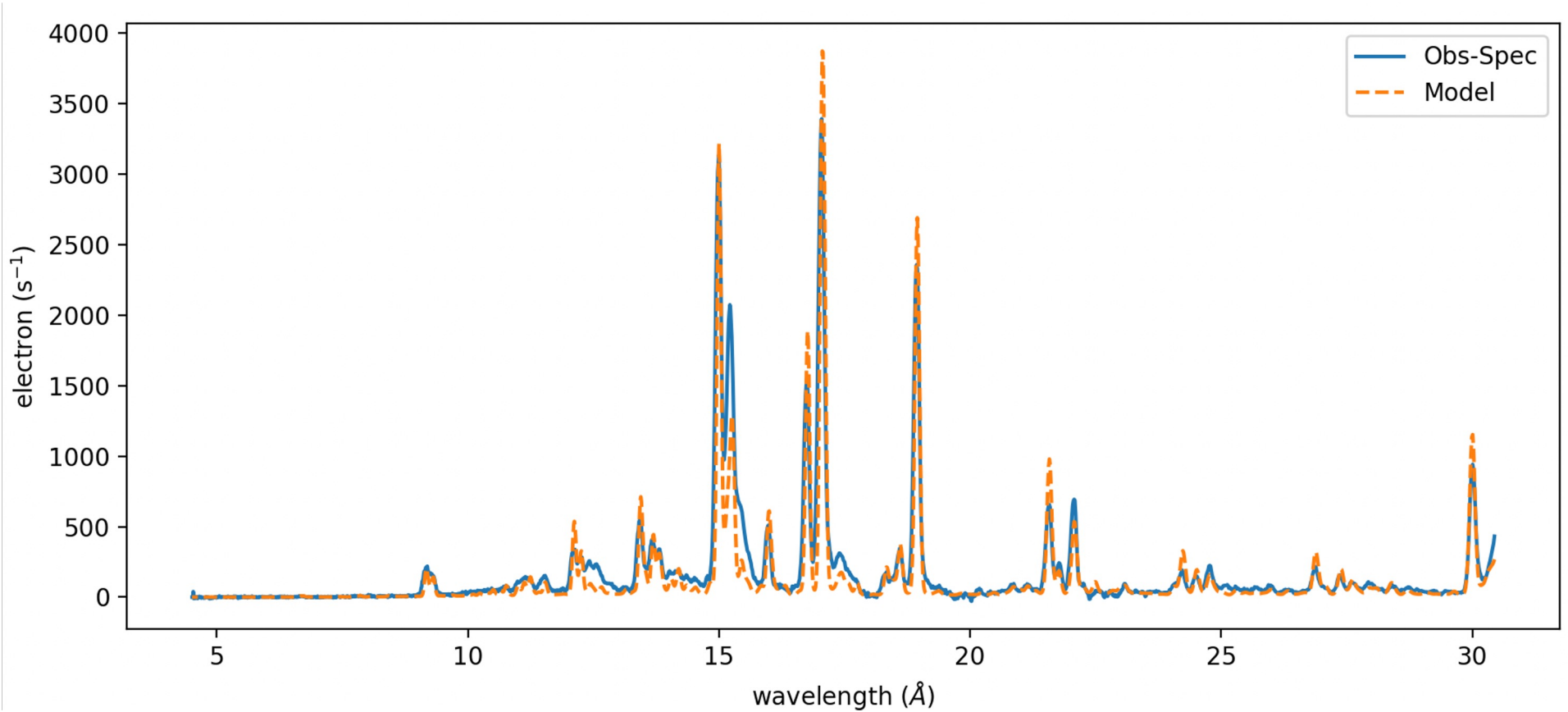




Fe Abundance (@logT = 6.45)



(very preliminary) Fit with 3 FA from the central FA



Thank You for your attention!