solar orbiter

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Probing hot X-ray onsets and Mg II flare precursors for predictive insights

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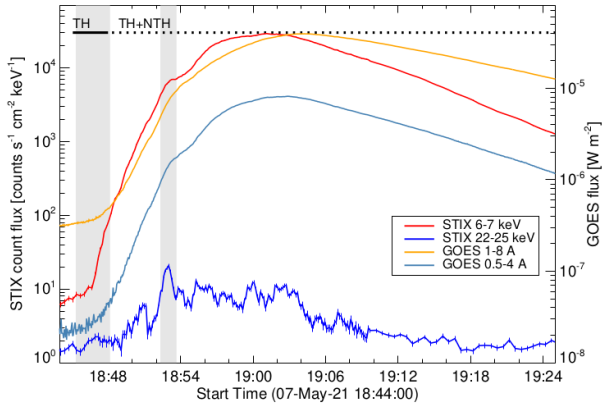
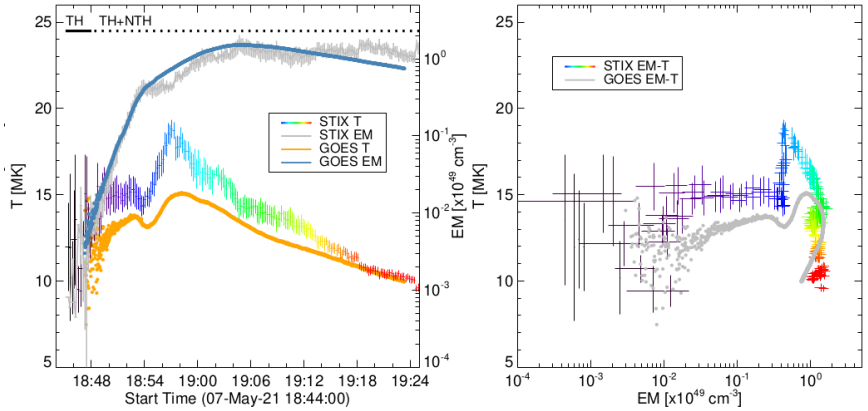
Credits: ESA

Introduction

Hot X-ray onsets, where were we?

Battaglia et al. (2023)





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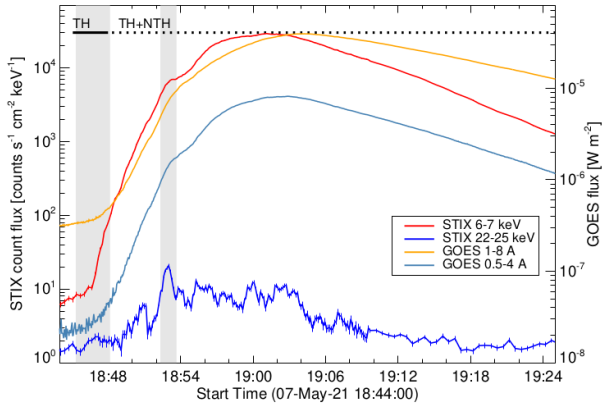
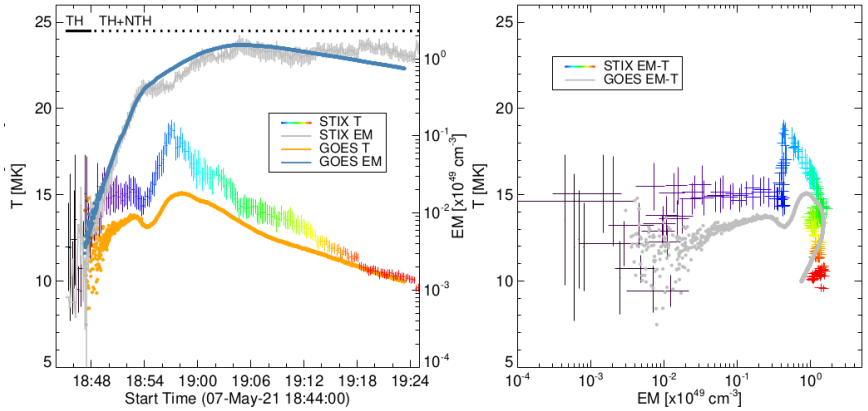
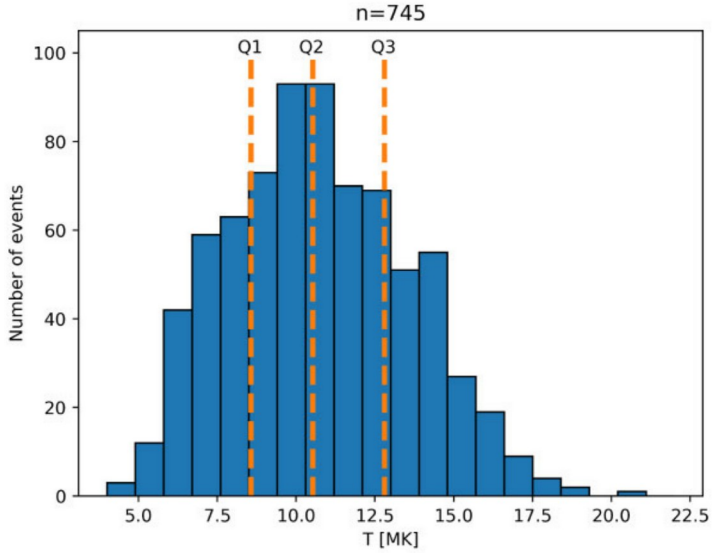




NEW

Statistical analysis of GOES/XRS flares

Da Silva et al. (2023)



75% of the analyzed events:
onset T > 8.6 MK

Introduction

Panos & Kleint (2020)

- Despite ML increased model complexity:
  → imaging and photospheric magnetic field data may not be sufficient for short-term flare prediction.

- For the first time, they extended the study of flare prediction to spectral data
  (*Deep Neural Networks*: pre-flare activity in Mg II h and k observations by IRIS)

Spectral data alone can lead to good predictive models:
→ identify pre-flare spectra ~35 minutes before the start of the flare

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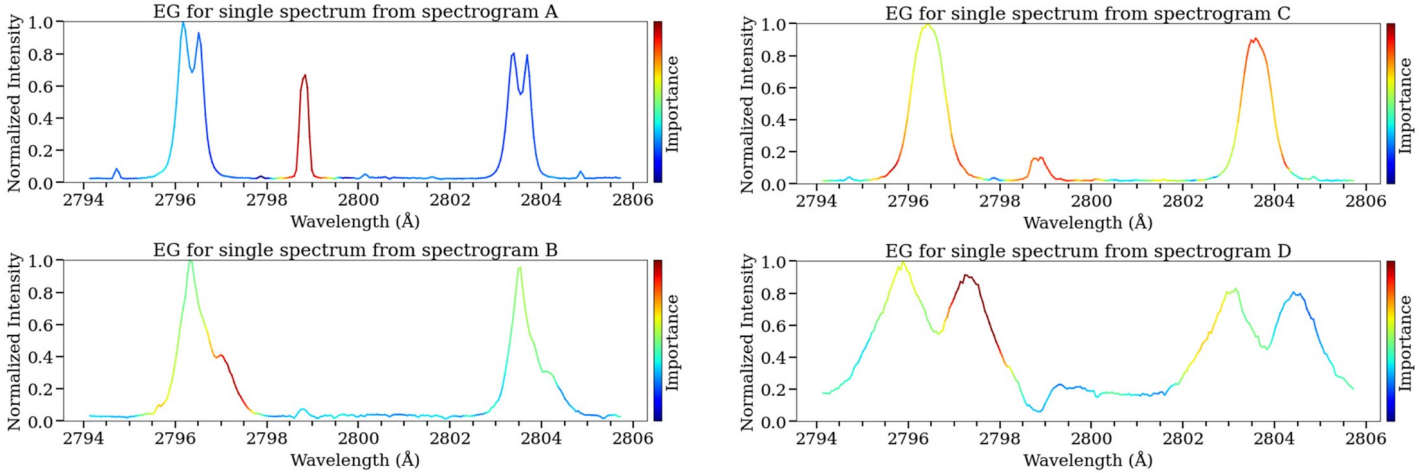

Triplet emission, downflows, broad line cores, and highly asymmetric spectra, are indicative of forthcoming flares

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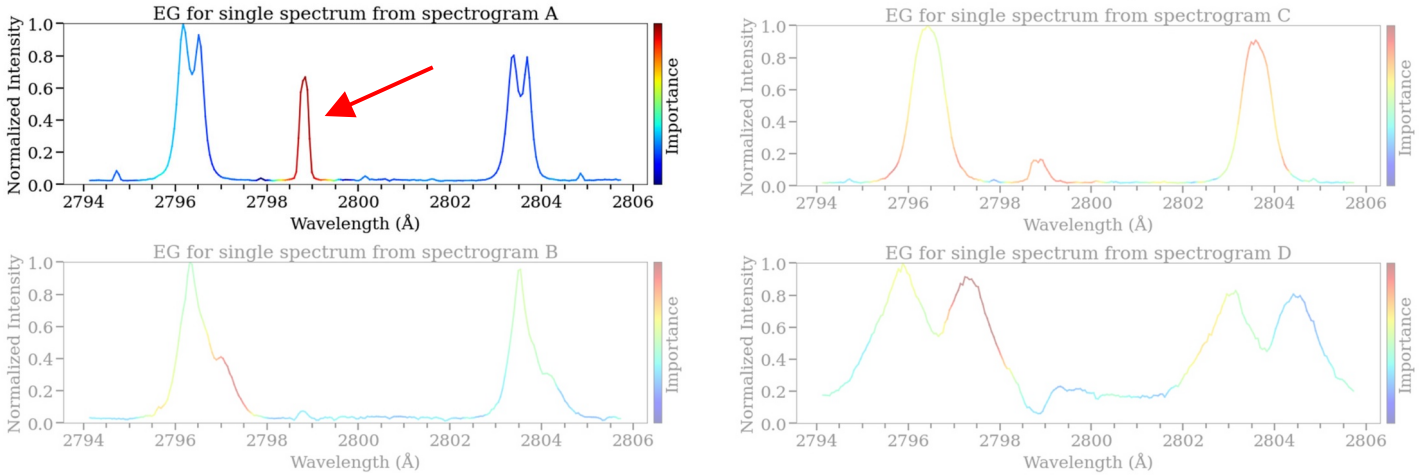

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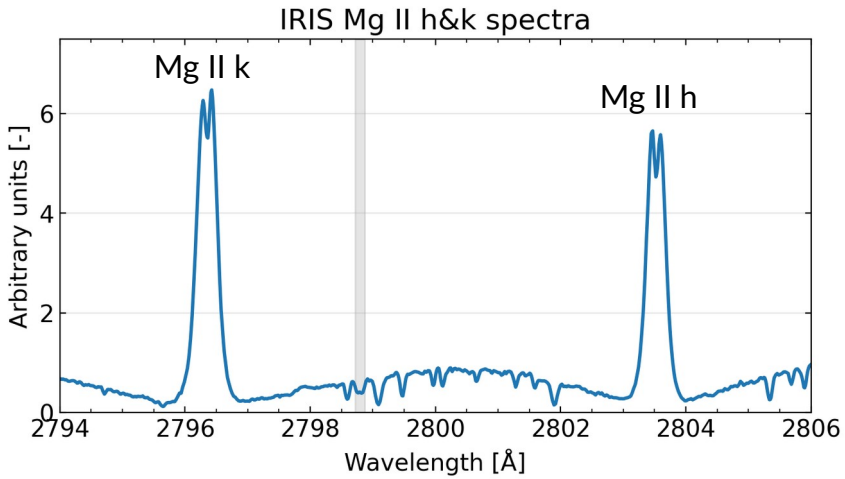
- Mg II h&k lines are among the strongest in the solar spectrum



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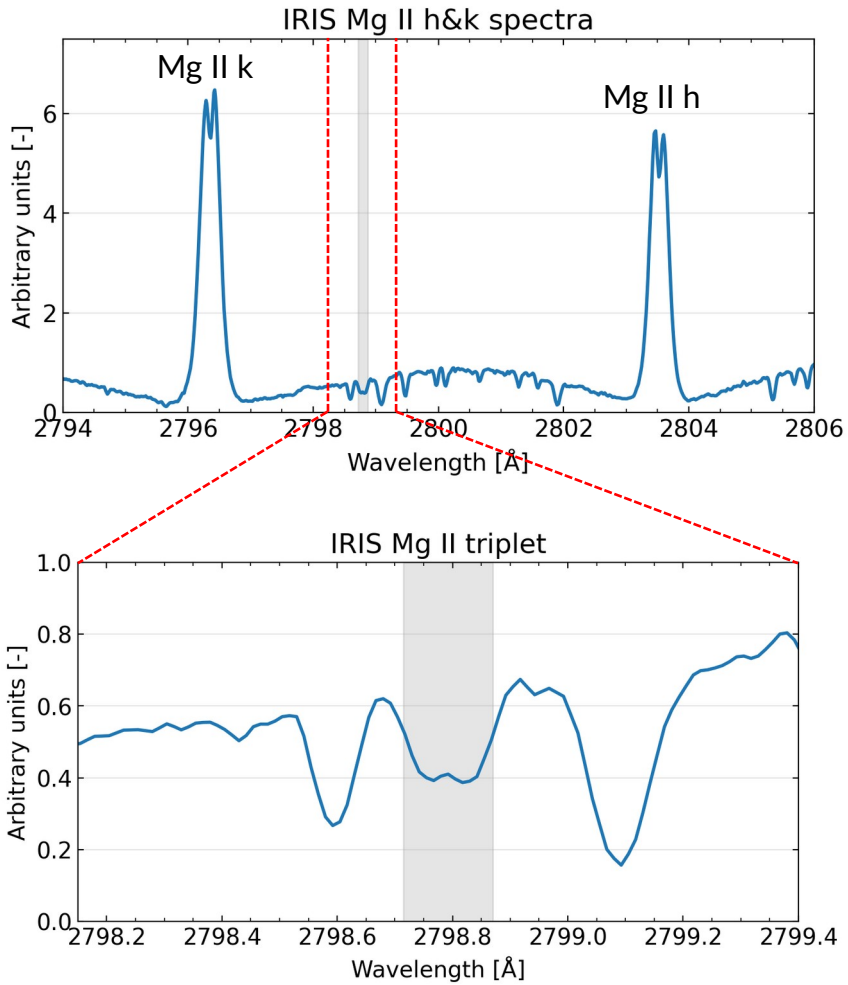

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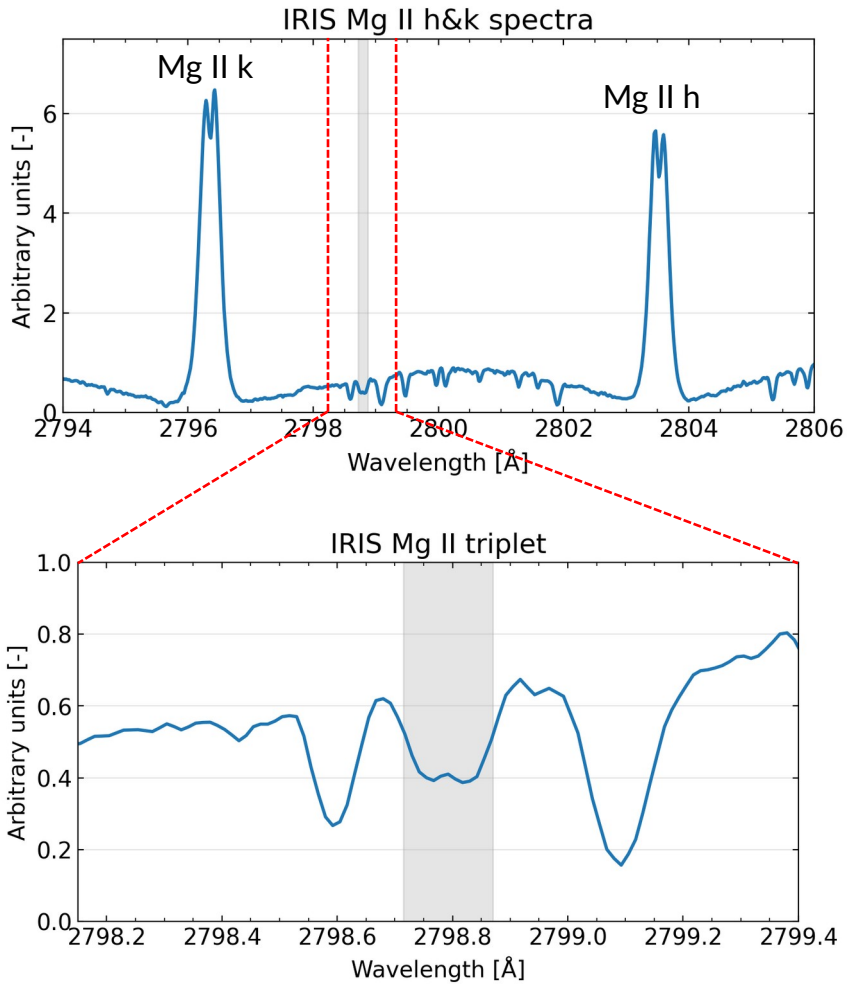
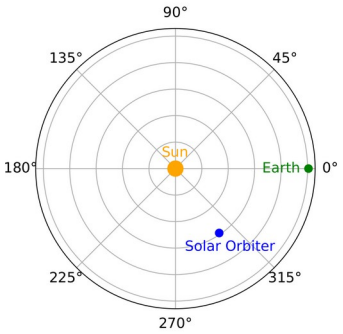
Pereira et al. (2015)

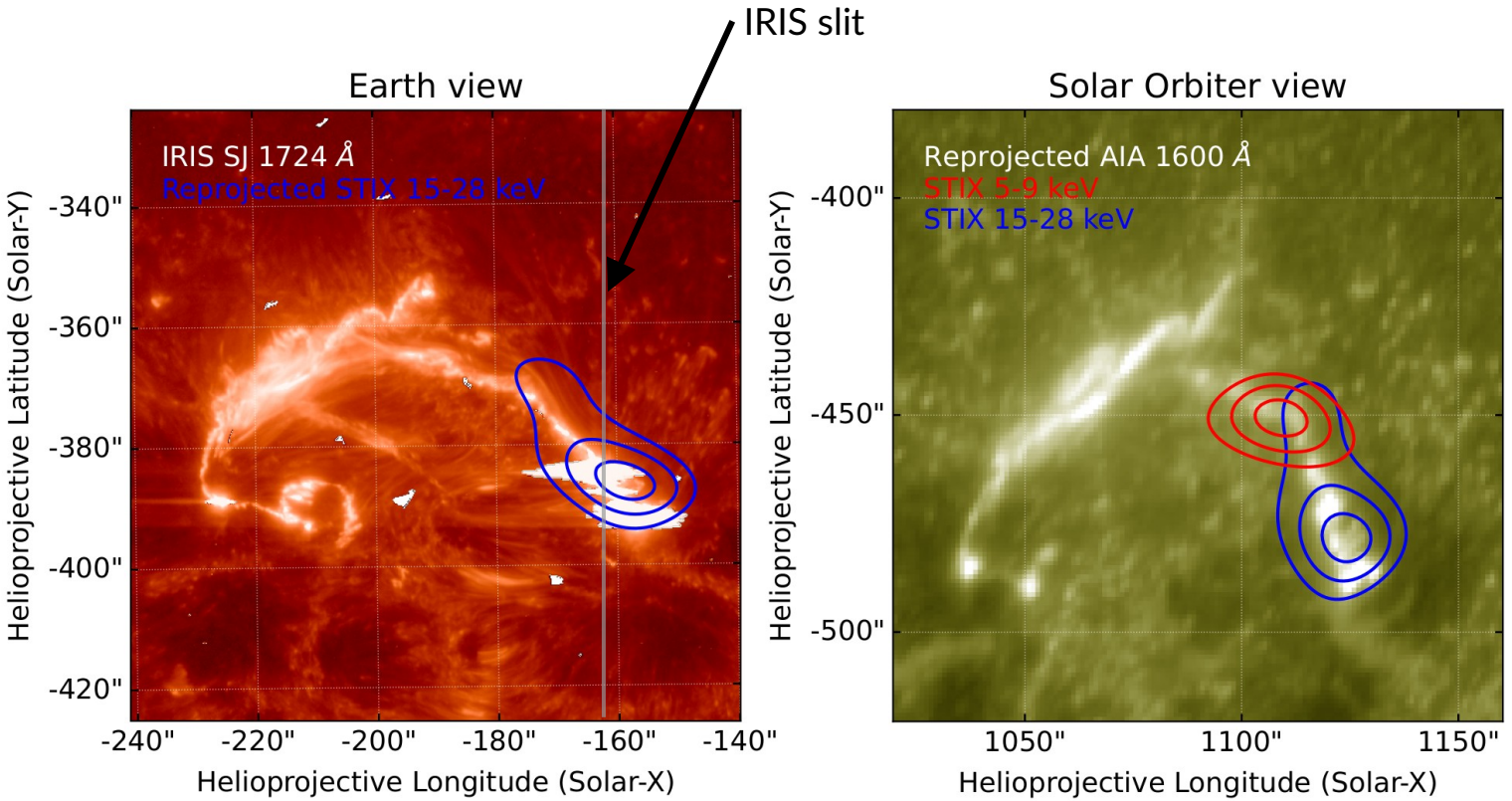
- Using 3D radiative MHD simulations → how the spectral features respond to the atmosphere

Triplet goes in emission when there is an increase in temperature in the (lower) chromosphere



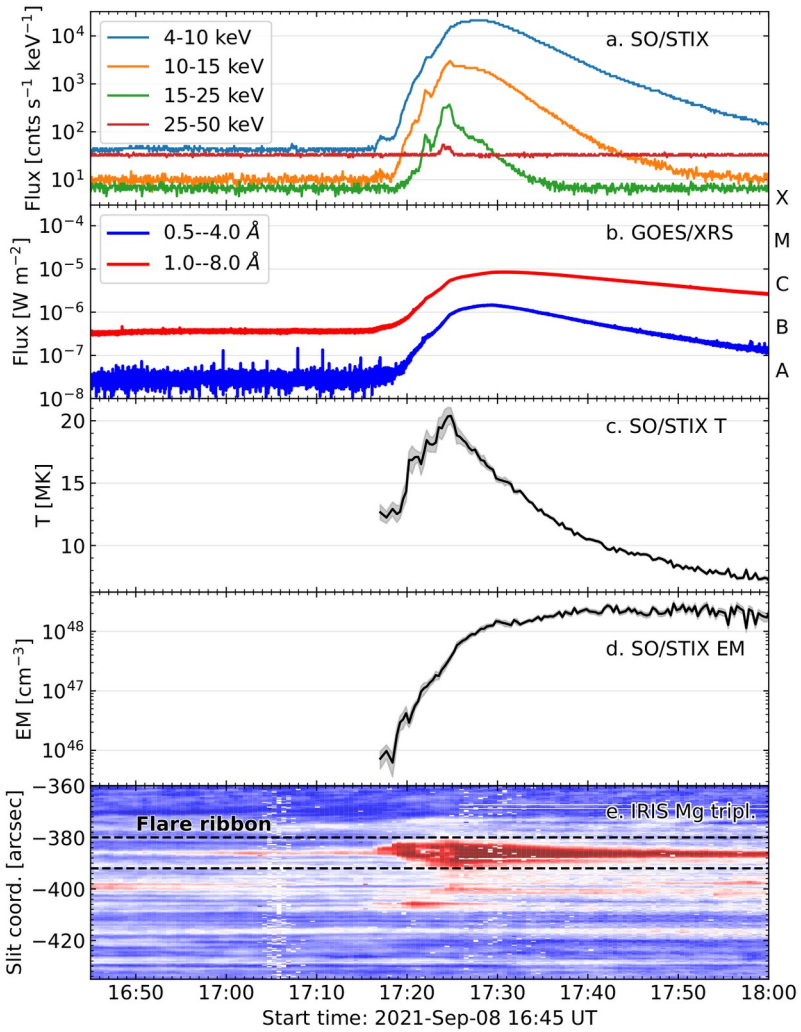
SOL2021-09-08 Flare – X-ray and UV Images





- **IRIS**
  - slit crossing the brightest part of the UV ribbon as well as the nonthermal STIX source
  - high cadence sit and stare mode, already one hour before the flare

SOL2021-09-08 Flare – Time Histories



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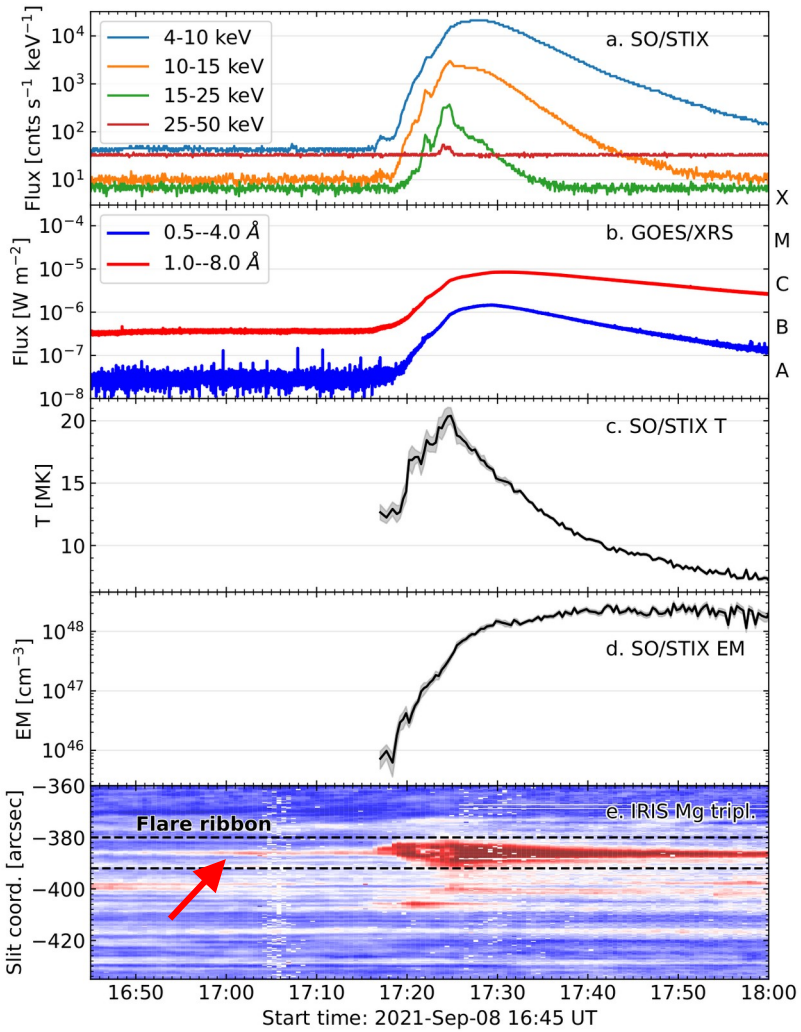

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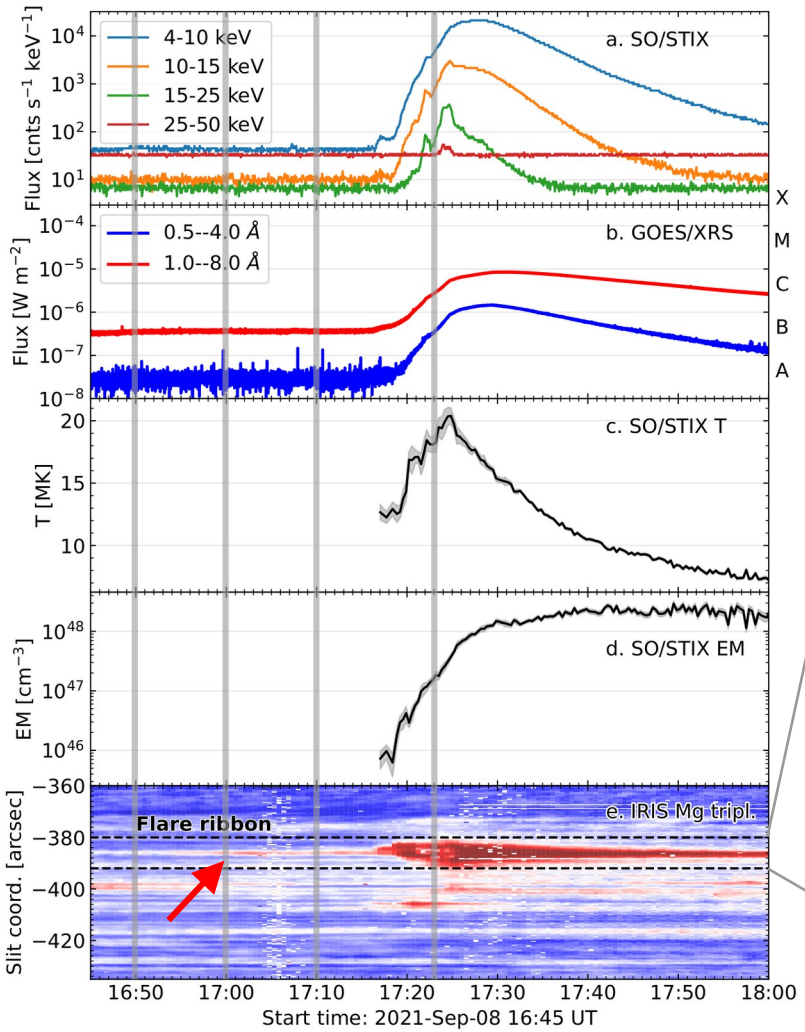

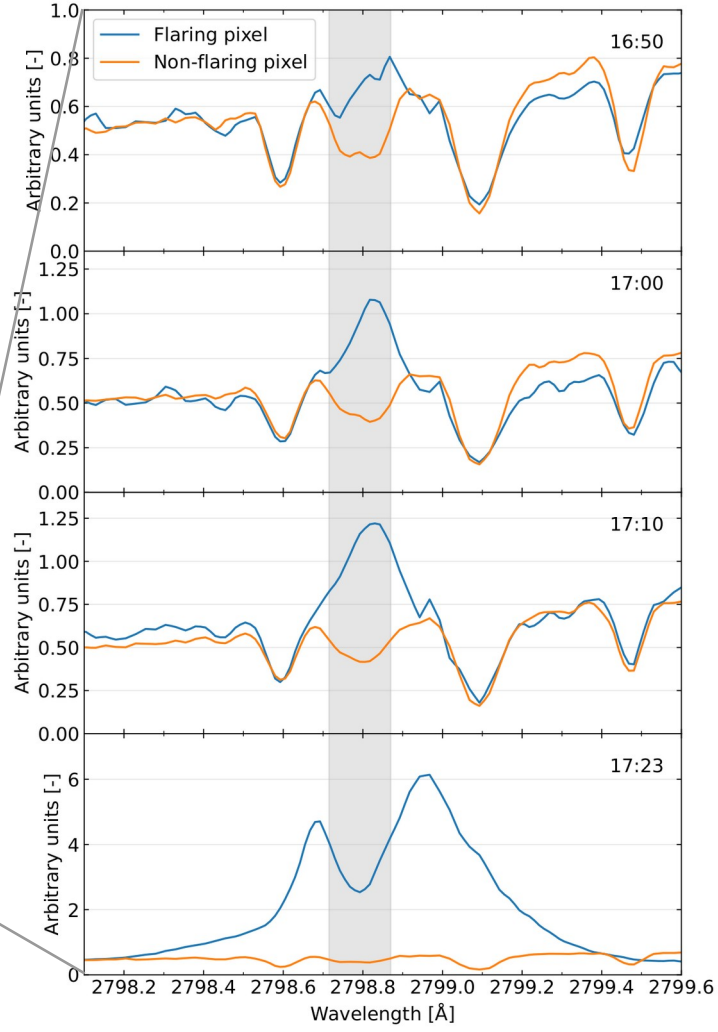

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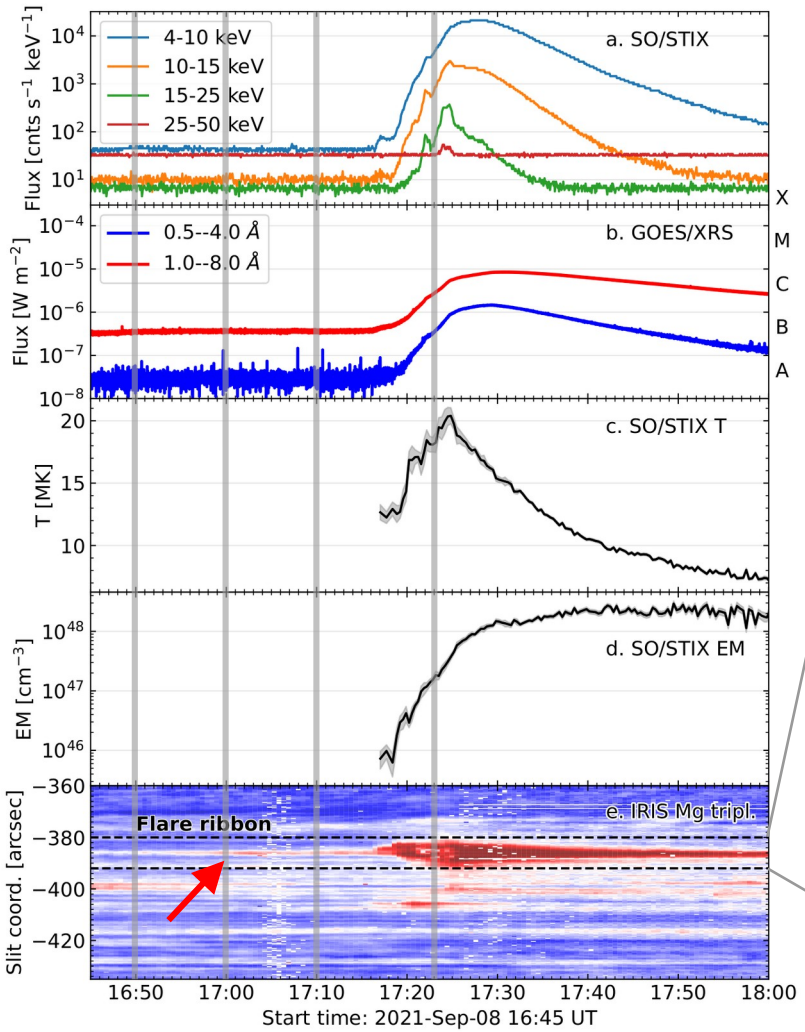

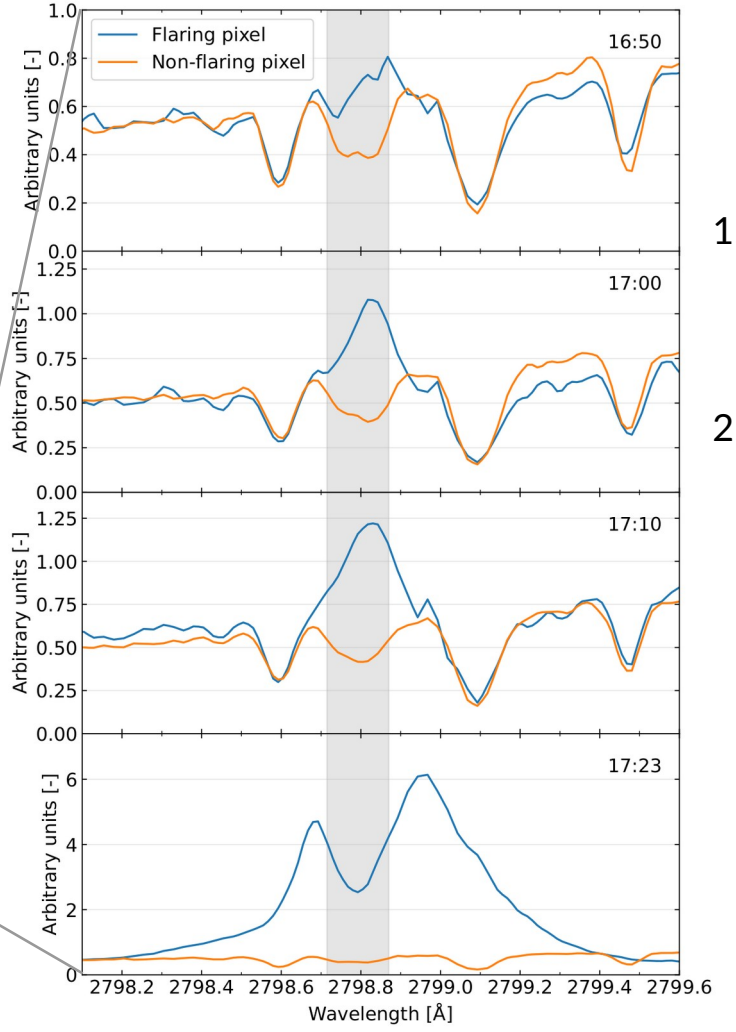

1. Elevated (> 11 MK) X-ray temperature from the very beginning

2. Mg II triplet increase **25 minutes** prior to the flare

Heating prior to main energy release

Is this just a lucky case?

1. Model results + STIX/RHESSI case studies (work in progress)

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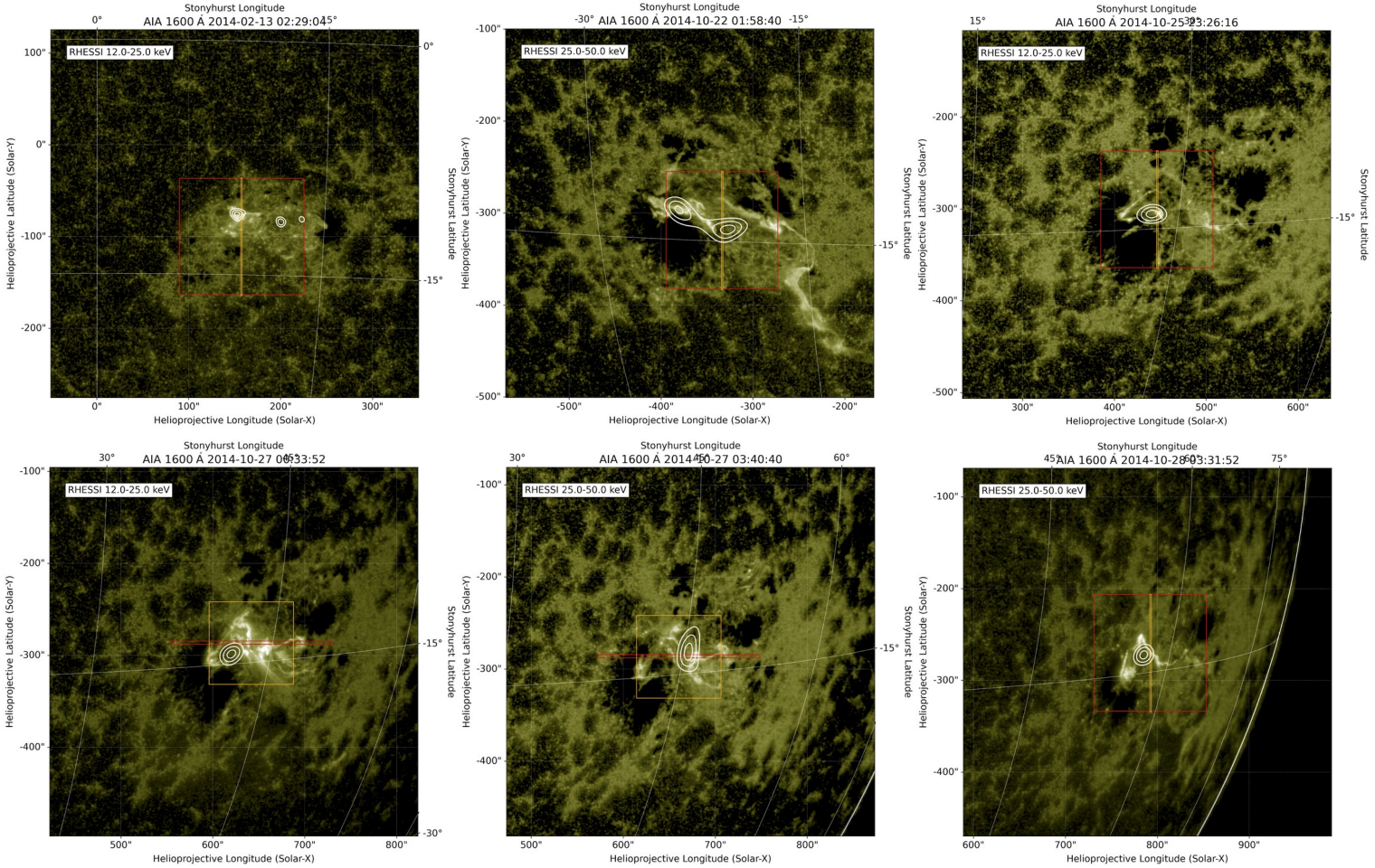
Model results
+
1. STIX/RHESSI case studies (work in progress)



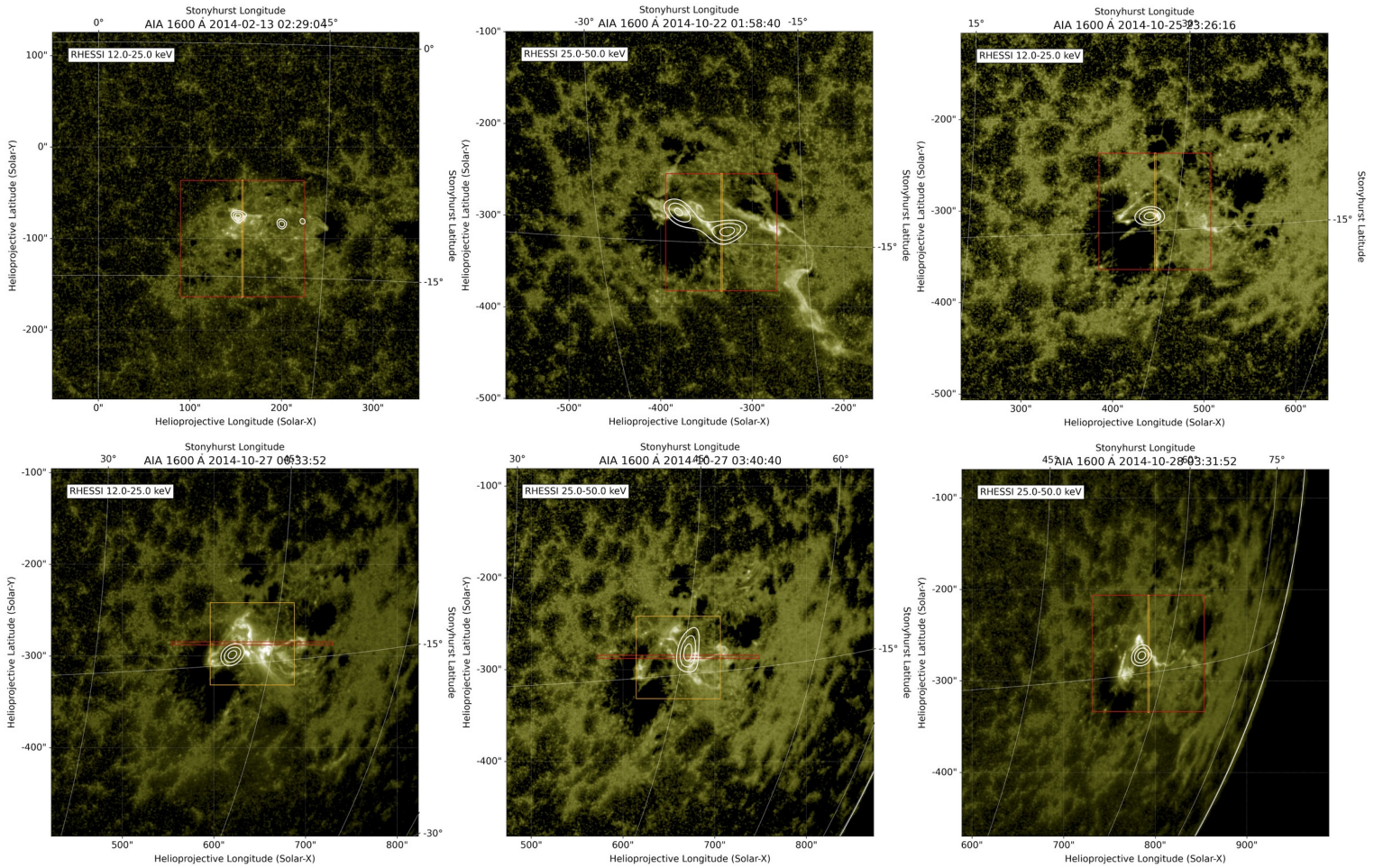
… and others

Is this just a lucky case?

1. Model results + STIX/RHESSI case studies (work in progress)

2. Quiescent ARs: Model → "No-flare„ Zbinden et al., in prep.

This is not a lucky case!



… and others

How to get rid of the “slit„ bias?

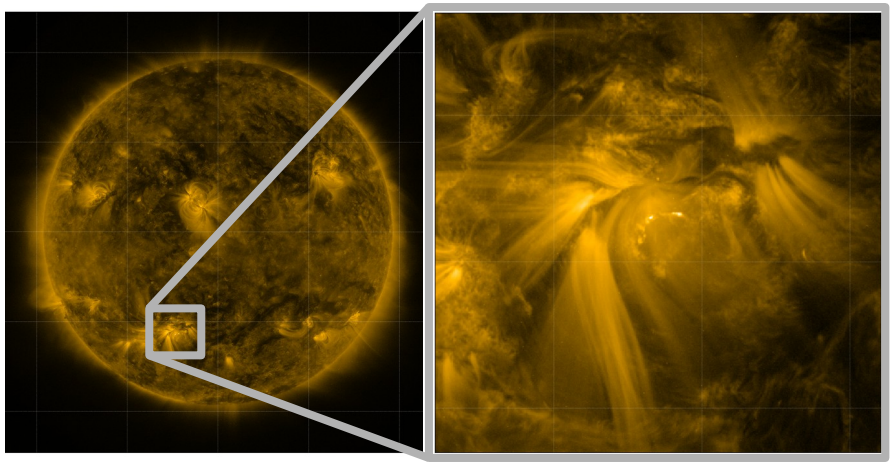
How to study this in a more systematic way?

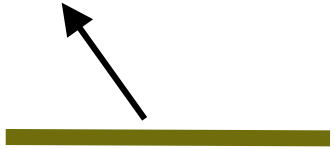
… with **MagnIIFICuS**, of course!

Mg II pre-Flare Investigation CubeSat

MagnIIFICuS: Mg II pre-Flare Investigation CubeSat

FoV: AR size

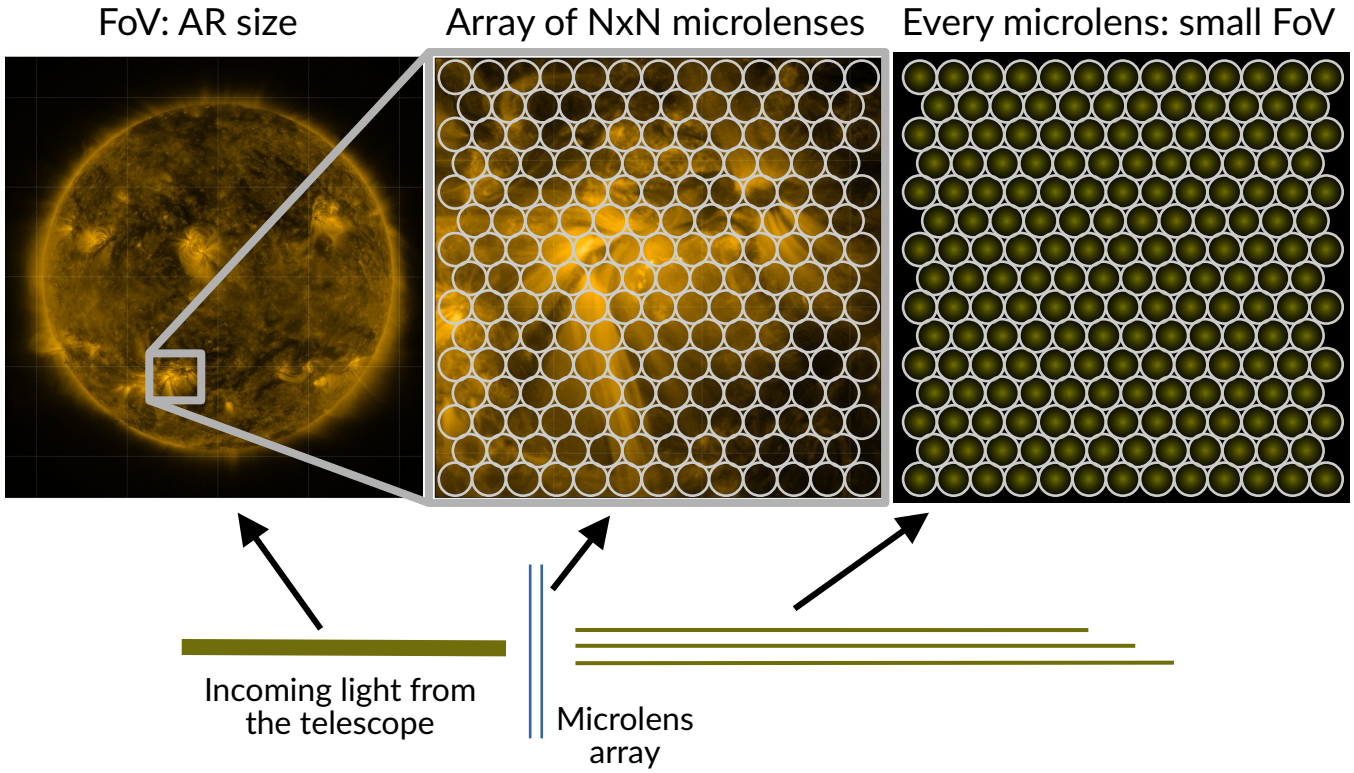




Incoming light from the telescope

Adapted from SolarCube (R. Casini et al., HAO/NCAR)

MagnIIFICuS: Mg II pre-Flare Investigation CubeSat



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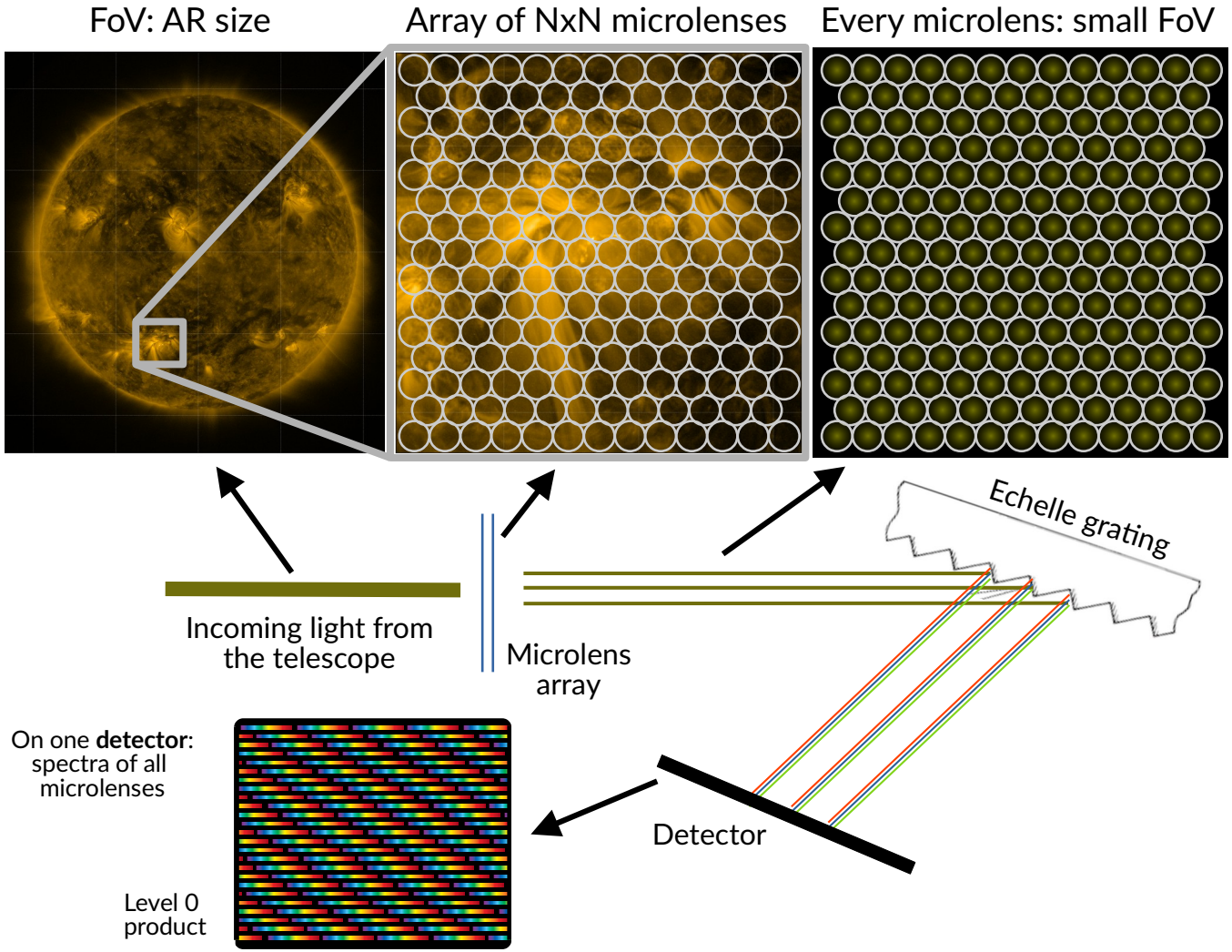

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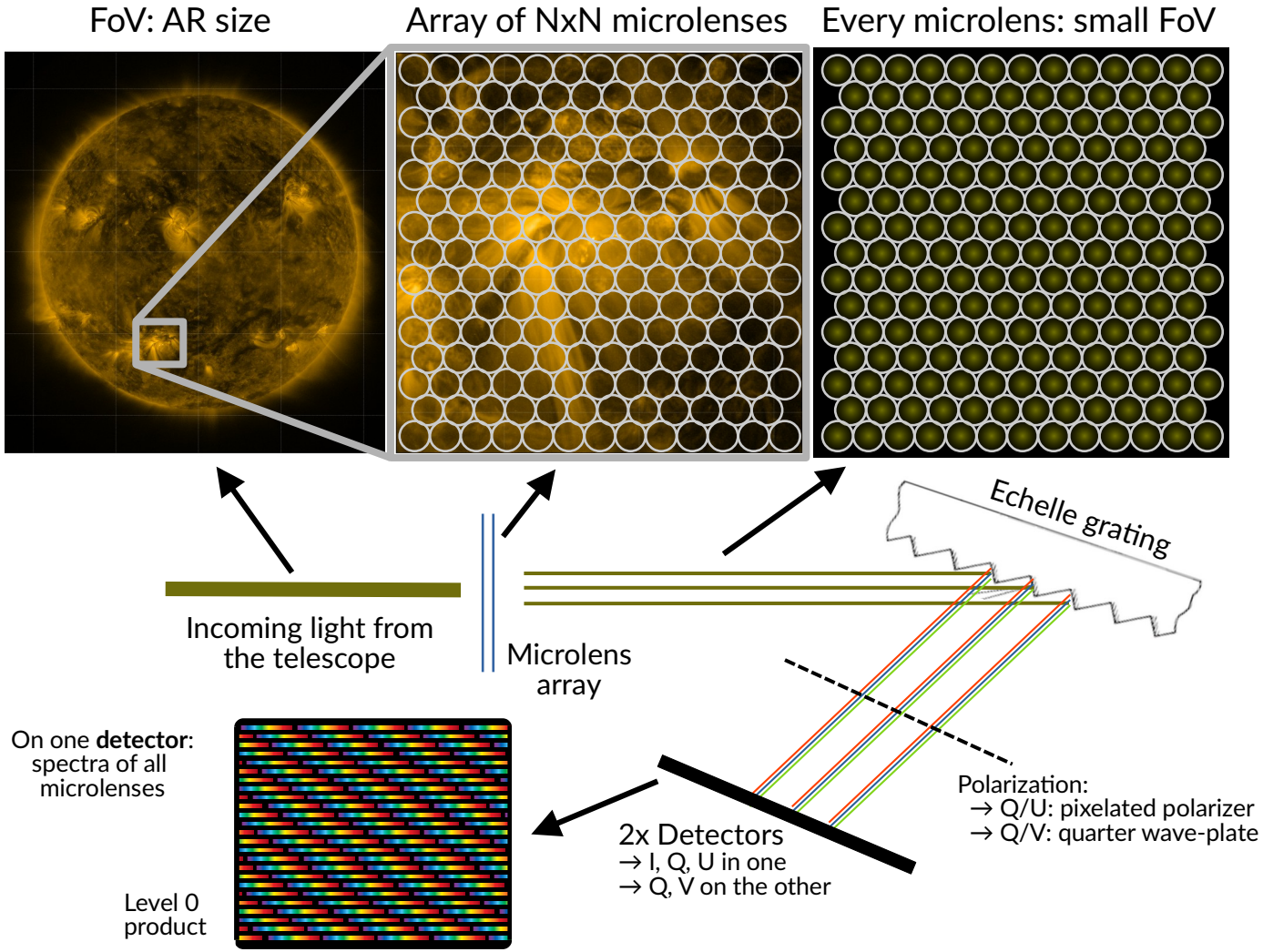

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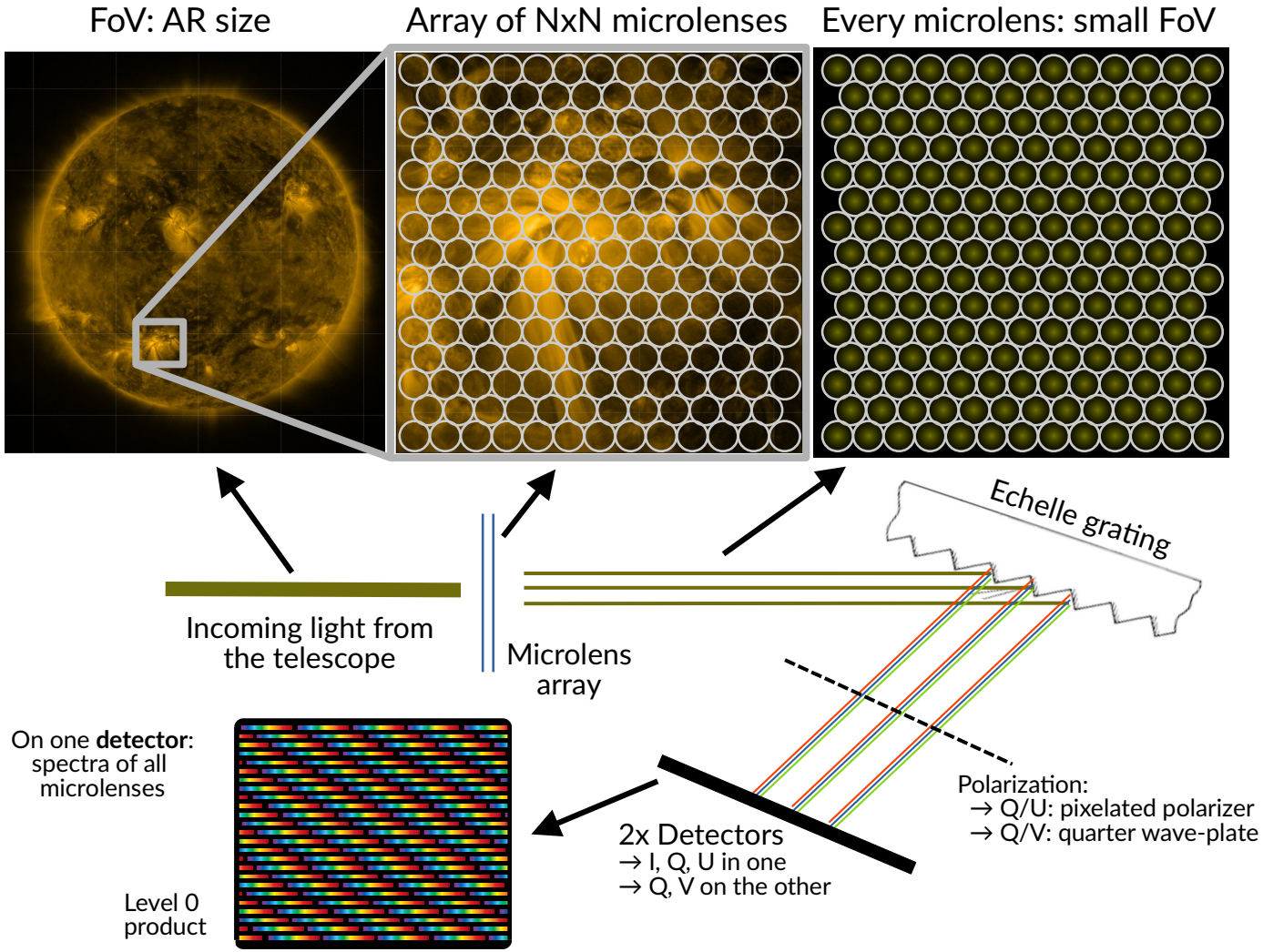

- 12 U CubeSat
- D primary mirror: **10-12 cm**
- Spatial resolution: **~3-5 arcsec**
- Wavelength band: **2794 – 2806 Å (Mg II h & k, triplet)**
- Field of view: **~ Active region size**
- Polarimetry: **Mg II k, Mn I, Fe II**

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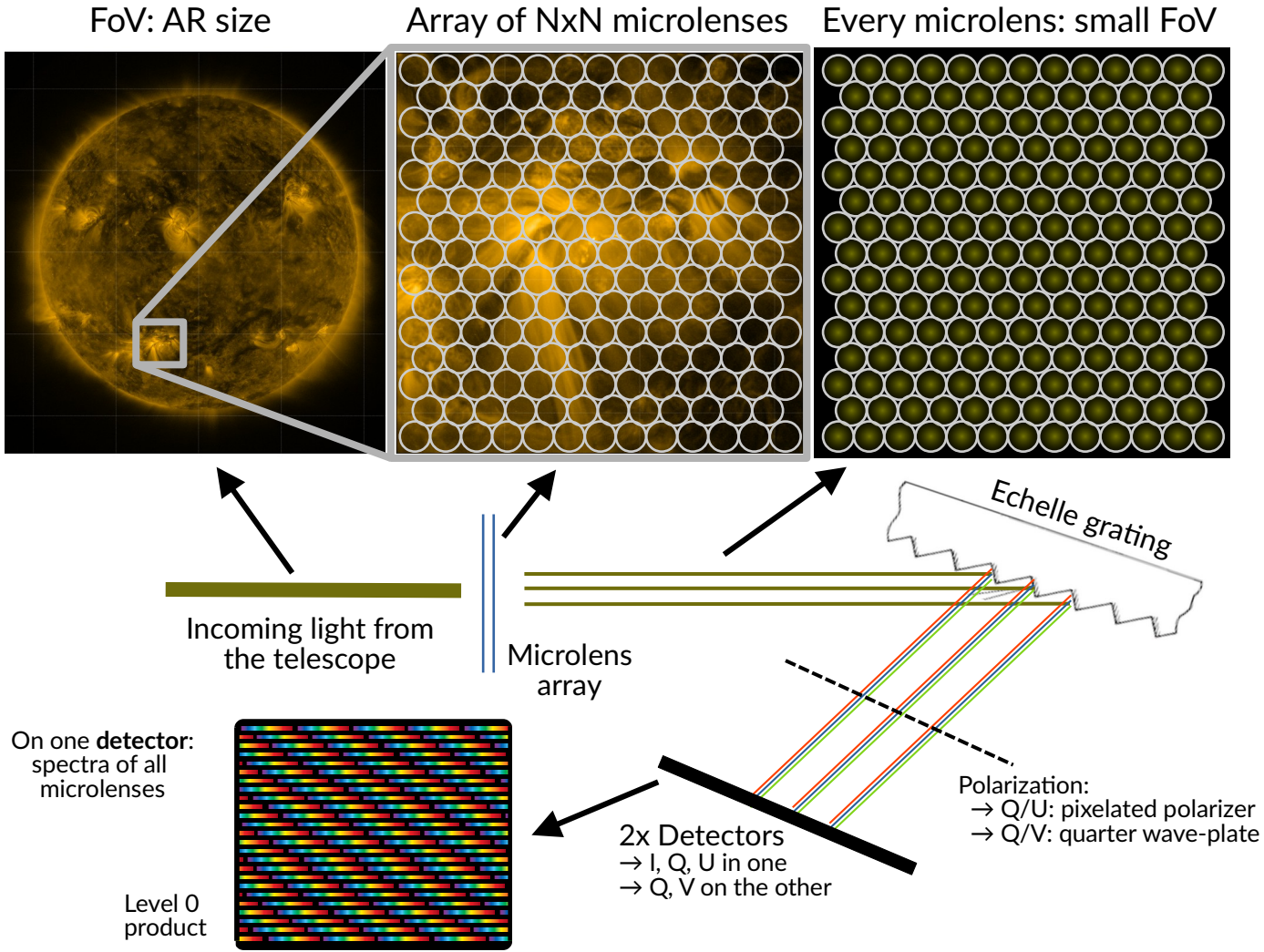

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- Simultaneous imaging, spectral and polarization information over a 2D FoV;
- **No rastering: Full AR in the FoV removes pointing selection bias;**
- No movable mechanisms.

Adapted from SolarCube (R. Casini et al., HAO/NCAR)

Conclusions

- **Hot X-ray onset + Mg II precursors**
  - → Heating prior to the main energy release
  - → We are missing the real flare-onset!
  - → Potential impact on short-term flare (or, main energy release) prediction (with the right instrument...)

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FOXSI (and NuSTAR?)

MagnIIFICuS, MUSE, CMEx

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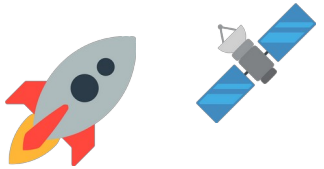
FOXSI (and NuSTAR?)

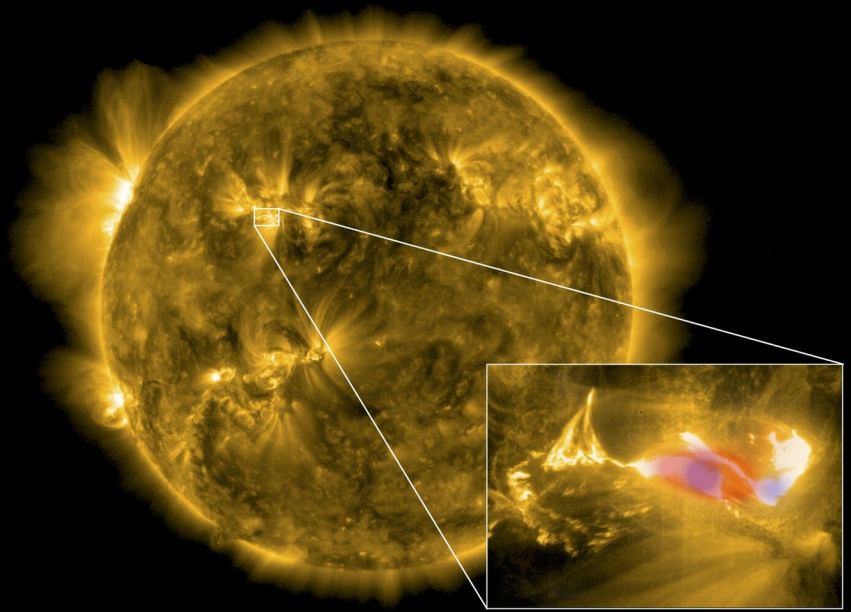
MagnIIFICuS, MUSE, CMEx

- **MagnIIFICuS: Mg II pre-Flare Investigation CubeSat**
  - → Cubesat for observing flares and flare precursors with Mg II
  - → Simultaneous imaging, spectral and polarimetric information of the whole AR
  - → Apply for funding: next year!
  - → **Please contact us if you want to be part! We are looking for international partners!**



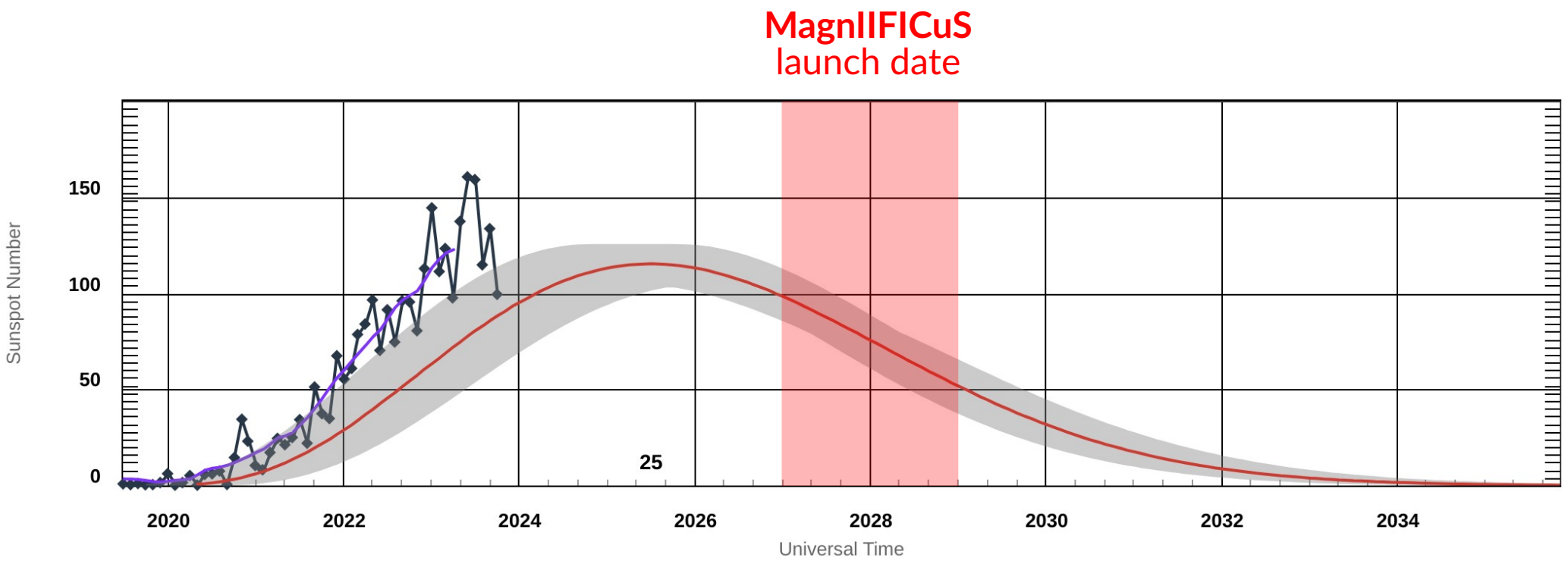
THANKS FOR LISTENING!

Happy to answer any questions!



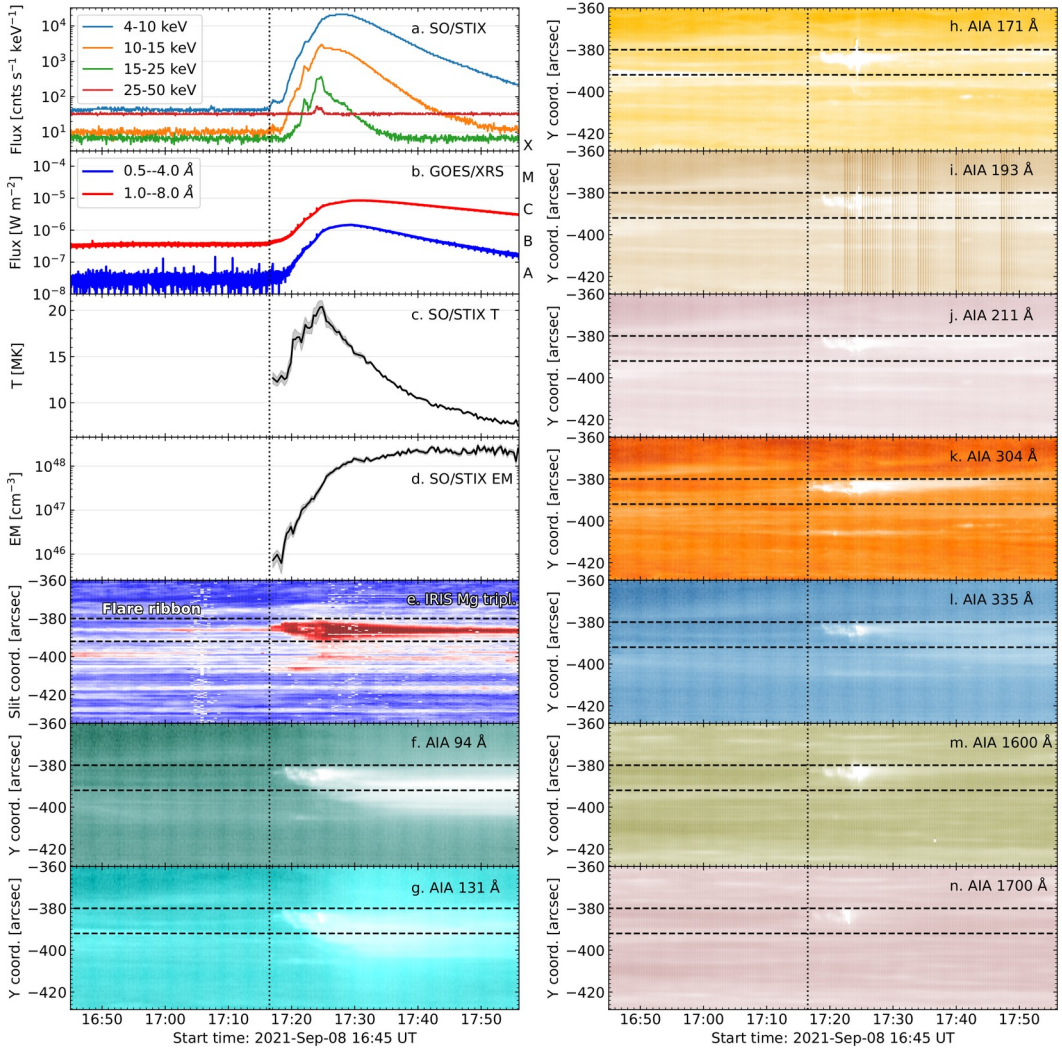
BACK-UP

Solar Cycle Sunspot Number Progression



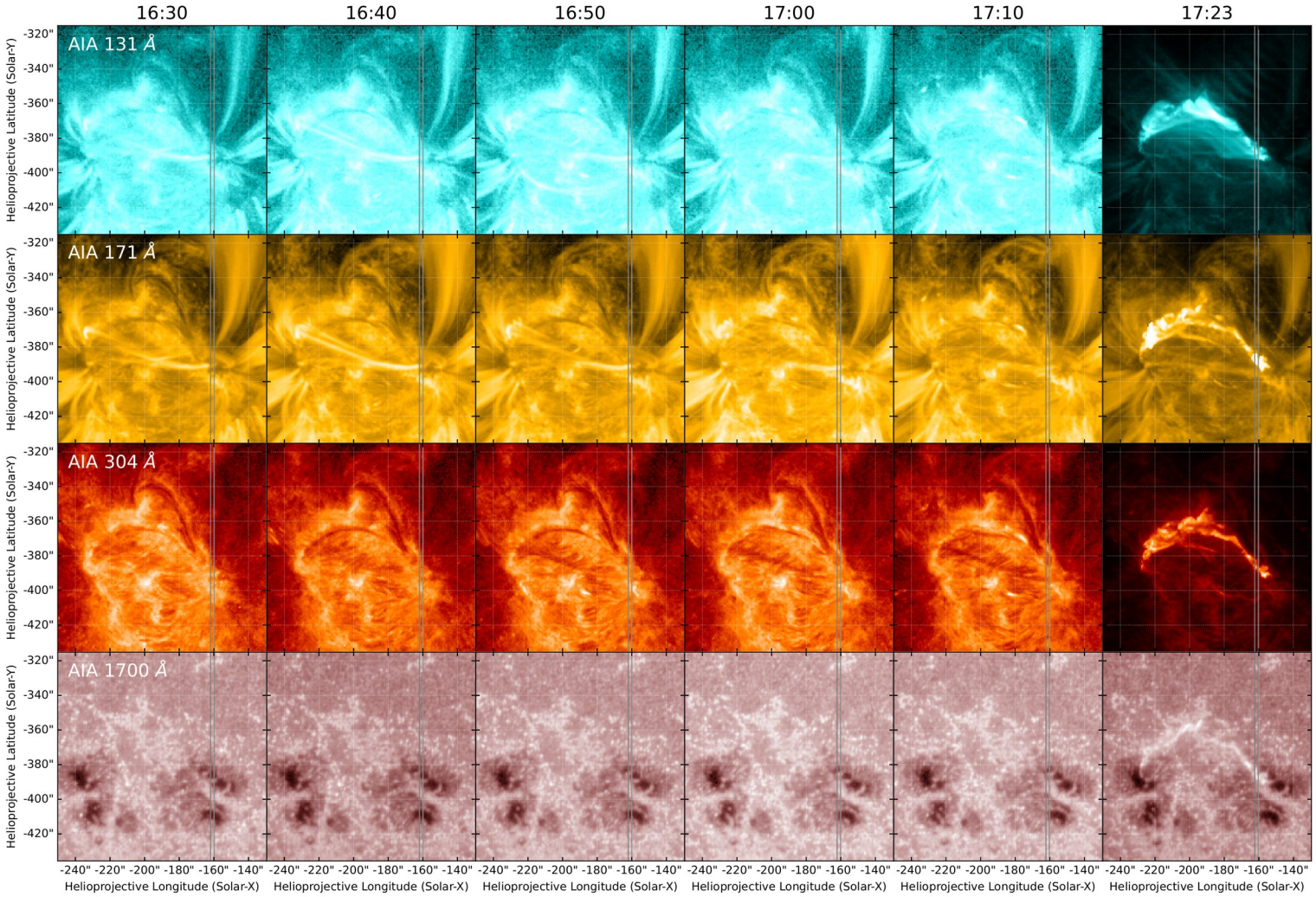
From NOAA

SOL2021-09-08 Flare – AIA Time Histories



No activity in AIA, prior to the main energy release, at the same location as the IRIS slit

SOL2021-09-08 Flare – AIA Images



SOL2021-09-08 Flare – AIA Running Differences