STIX hard X-ray signatures from erupting filaments

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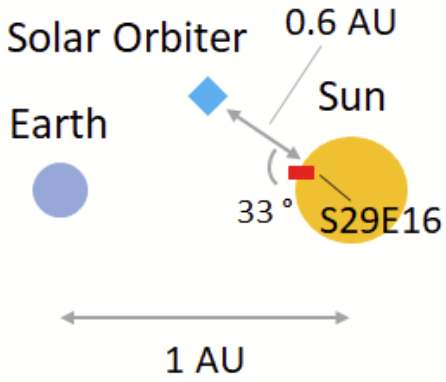
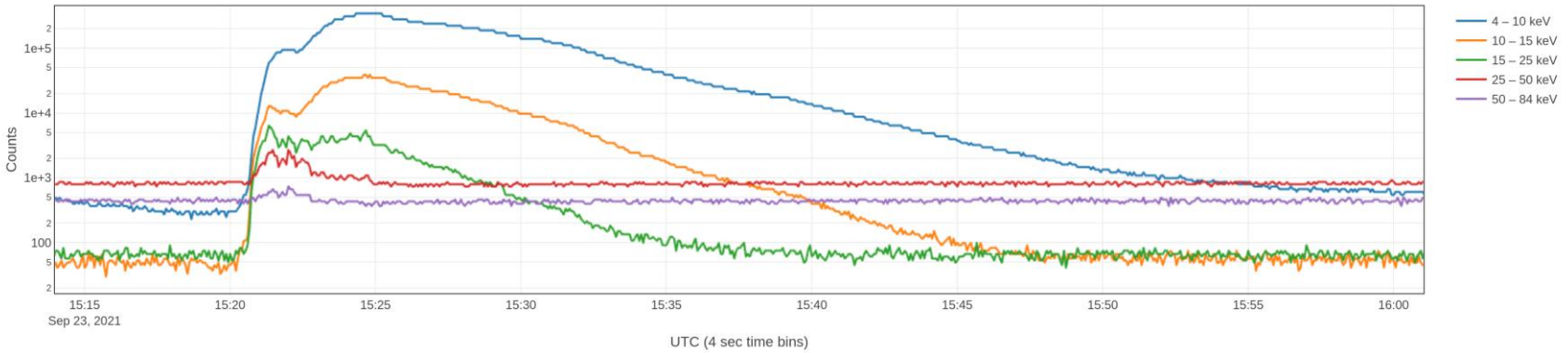
Content

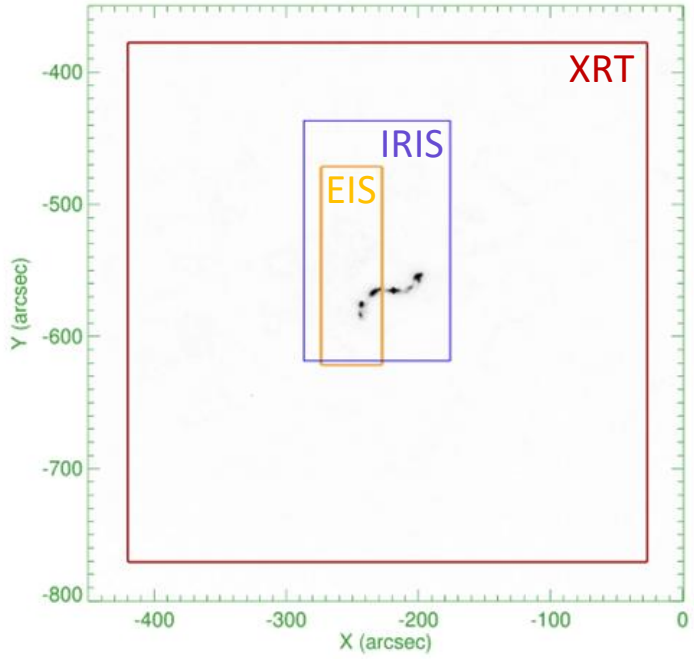
- Starting Point: SOL210923
  - Outline project
  - Analysis/Results
  - Interpretation
- Science Questions
- Approaches
  - Statistical Survey
  - Simulations for STIX

Starting Point: SOL210923

- Flare on the 23.09.2021, 15:20 UTC
- M1.8-GOES class
- Observed by:
  - STIX/SO
  - EIS & XRT /Hinode
  - IRIS
  - AIA/SDO







SOL210923: Four distinct, nonthermal footpoints

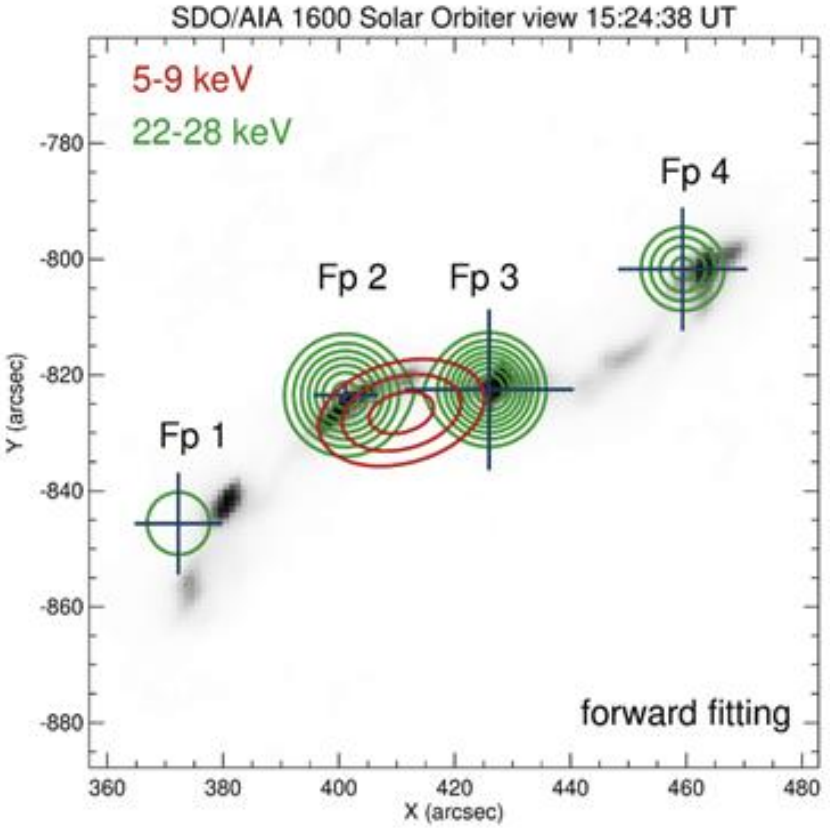
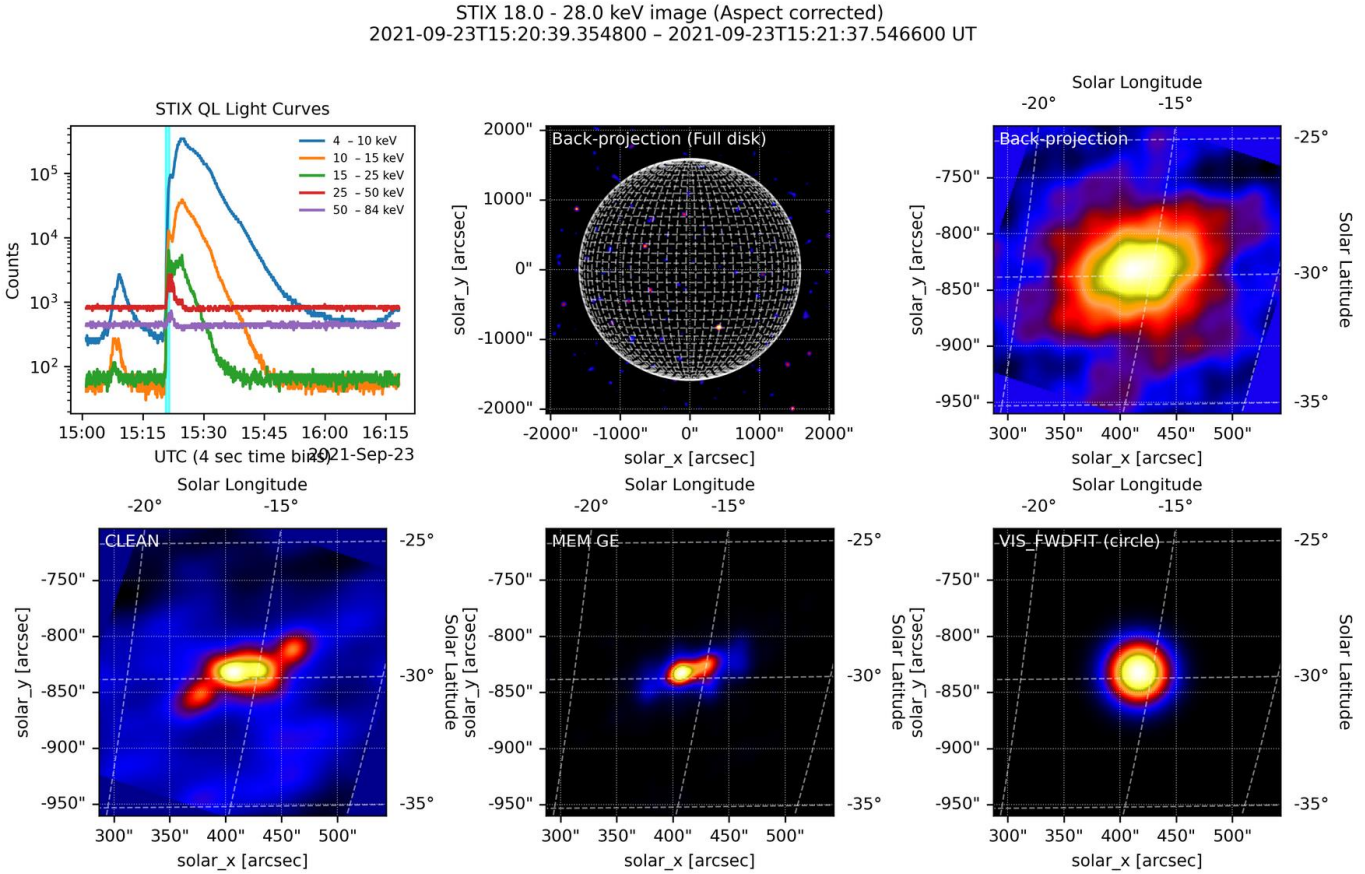
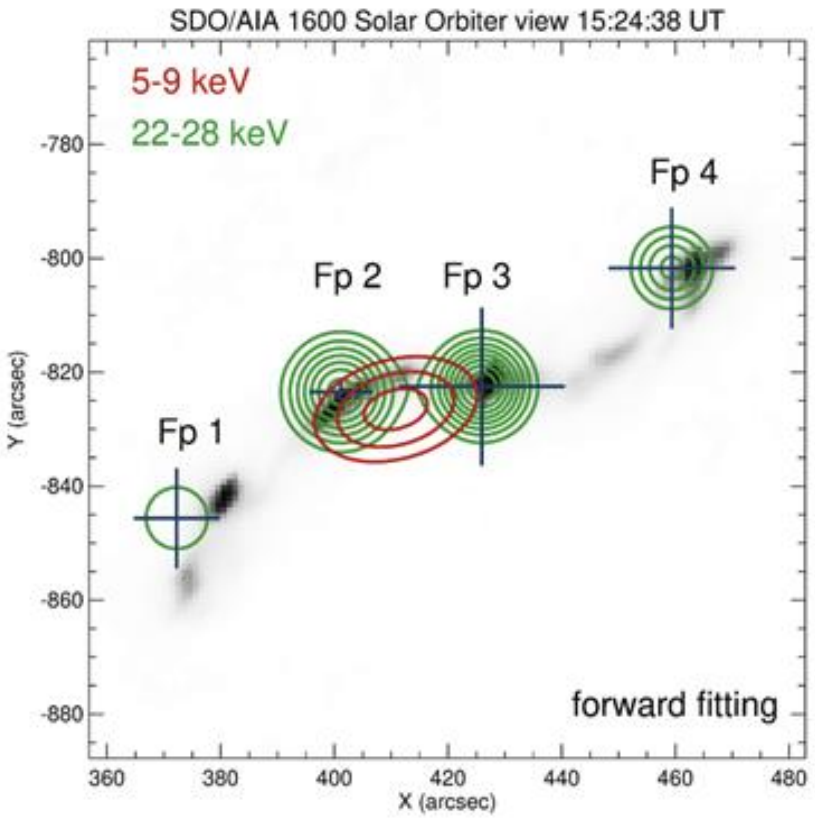


Image from Stiefel et al. (2023)

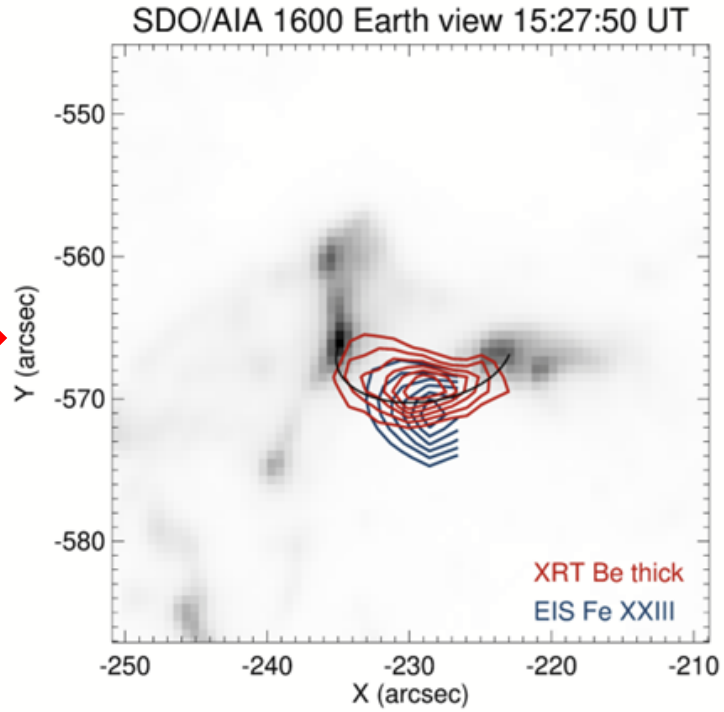


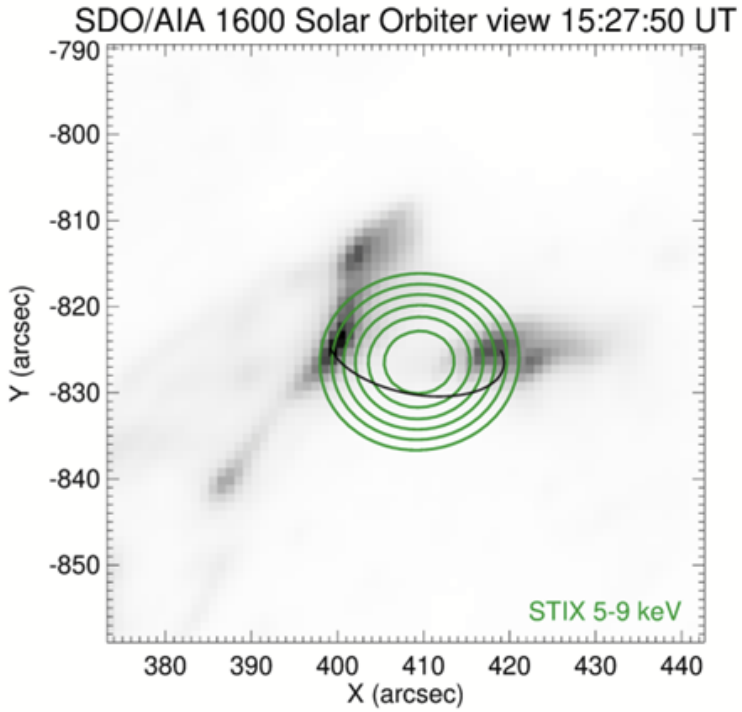
SOL210923: Four distinct, nonthermal footpoints

Impulsive Phase



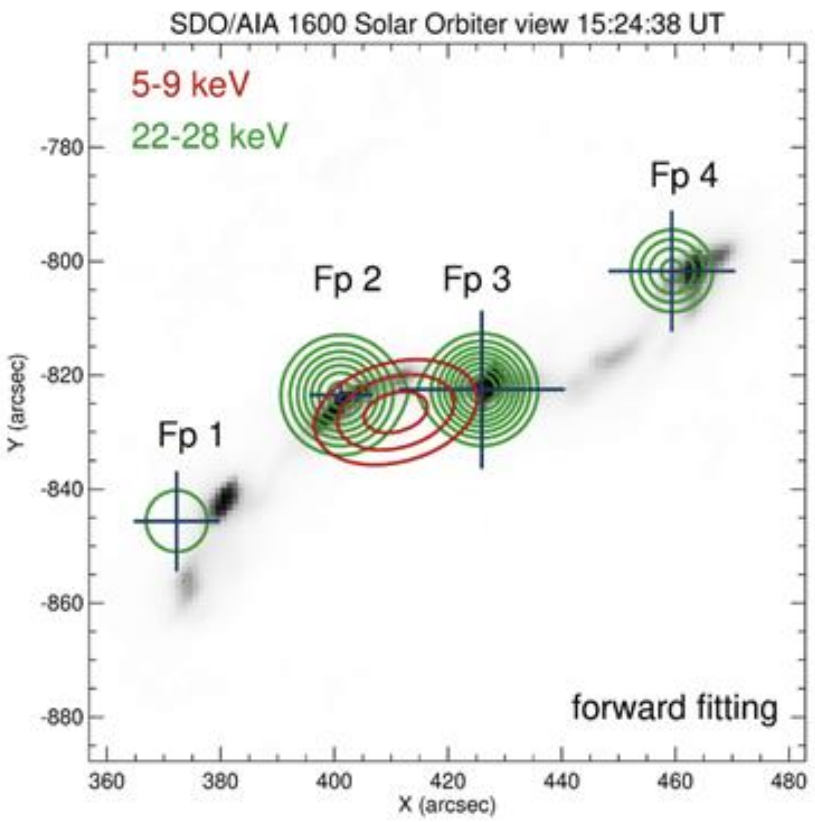
Thermal Peak



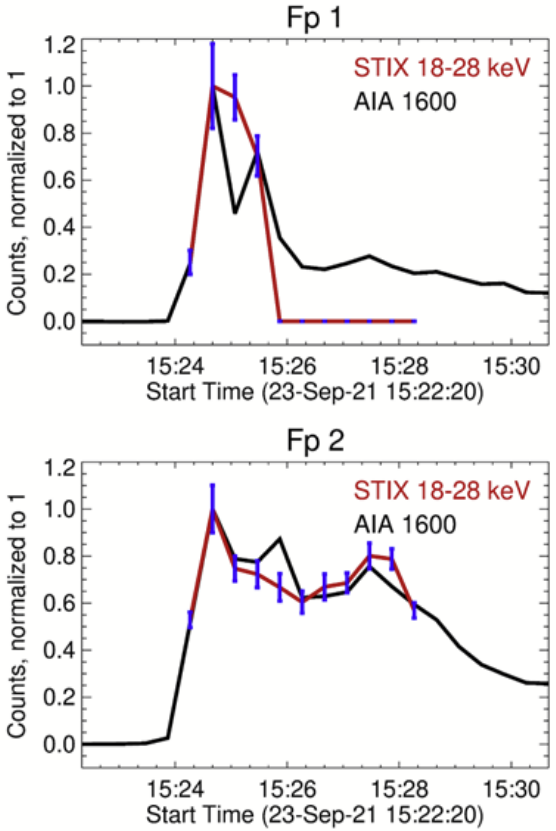


Images from Stiefel et al. (2023)

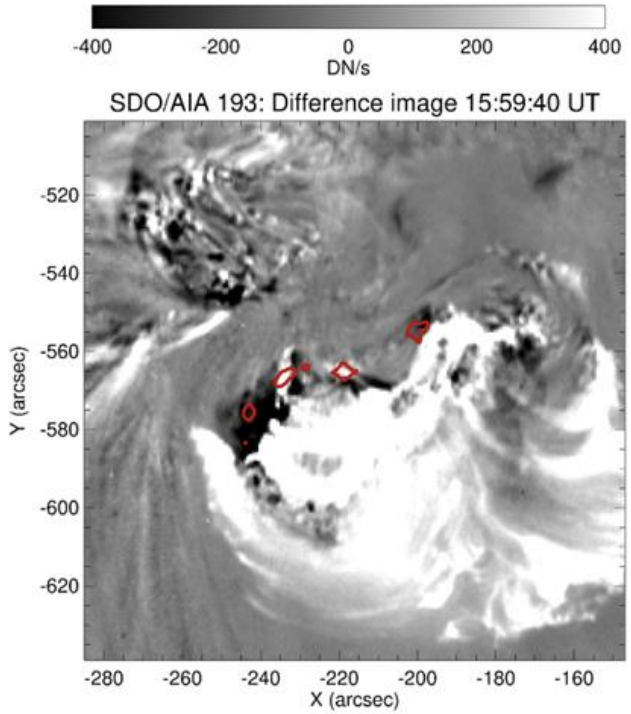
SOL210923: Four distinct, nonthermal footpoints



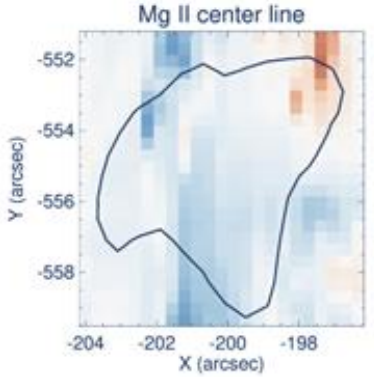
Time evolution



CME Study



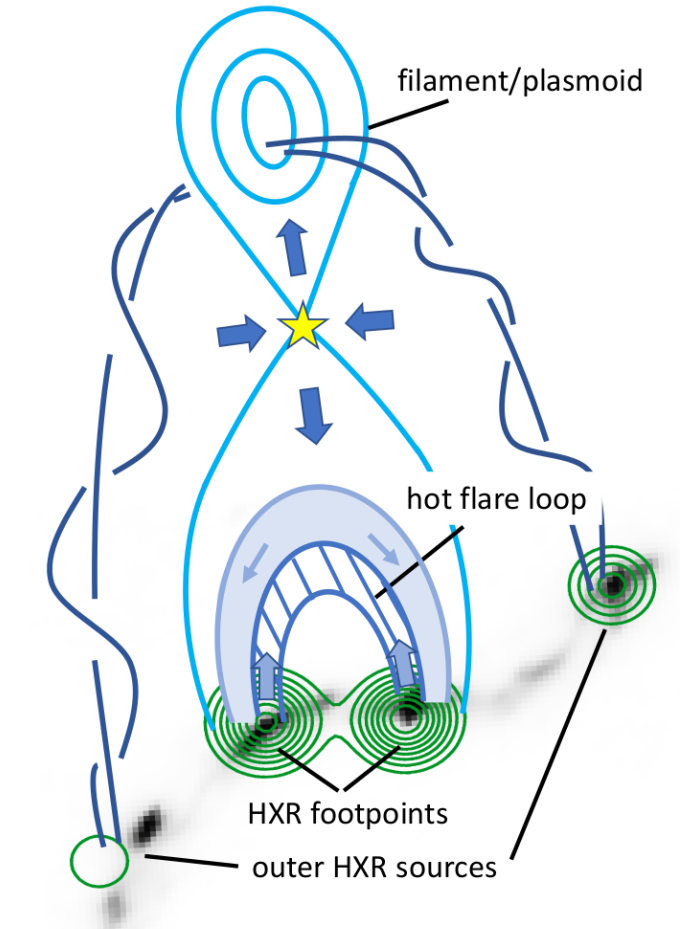
Doppler velocity



IRIS around Fp 4
Contours: UV

Images from Stiefel et al. (2023)

SOL210923: Interpretation



Stiefel et al. (2023)

Electrons moving along flux rope legs and emitting Bremsstrahlung at anchor points

Can this be observed more frequently in filament eruptions?

Science Questions

- Can we measure accelerated electrons precipitating along legs of filaments ?
- What is their energetic contribution compared to electrons in flare loops?
- Where do the electrons lose their energy?

- Imaging Spectroscopy: comparison spectral index filament anchor points vs. flare loop footpoints

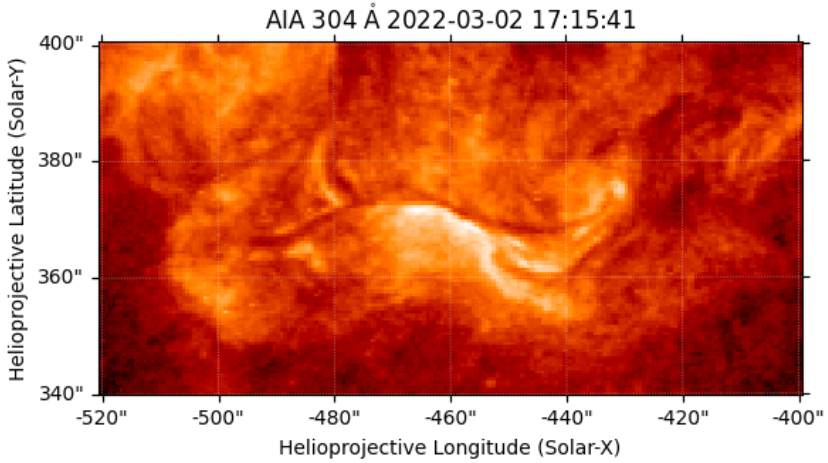
- Where are the boundaries of STIX imaging capability?

Statistical study of hard X-rays at anchor points of filaments

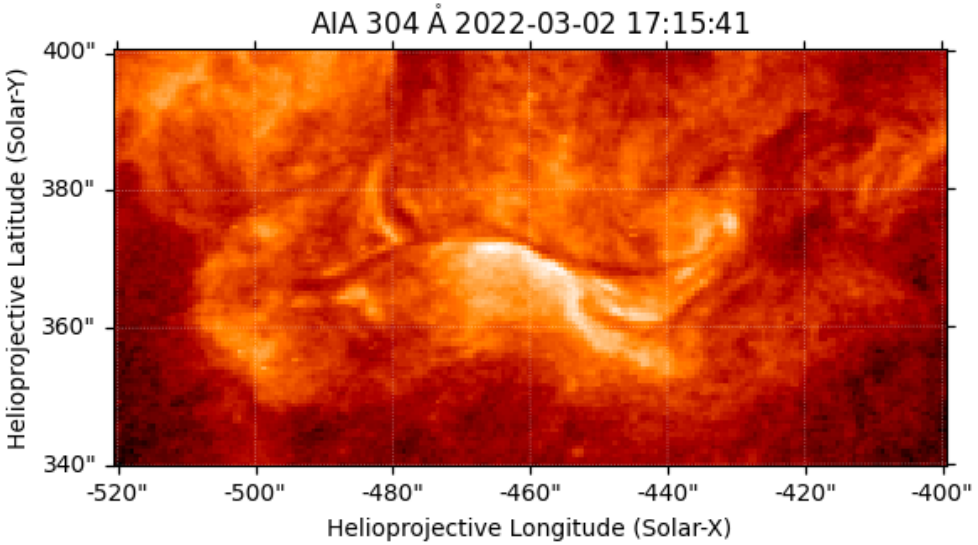
Method Systematic search of filament eruptions observed by STIX and AIA:

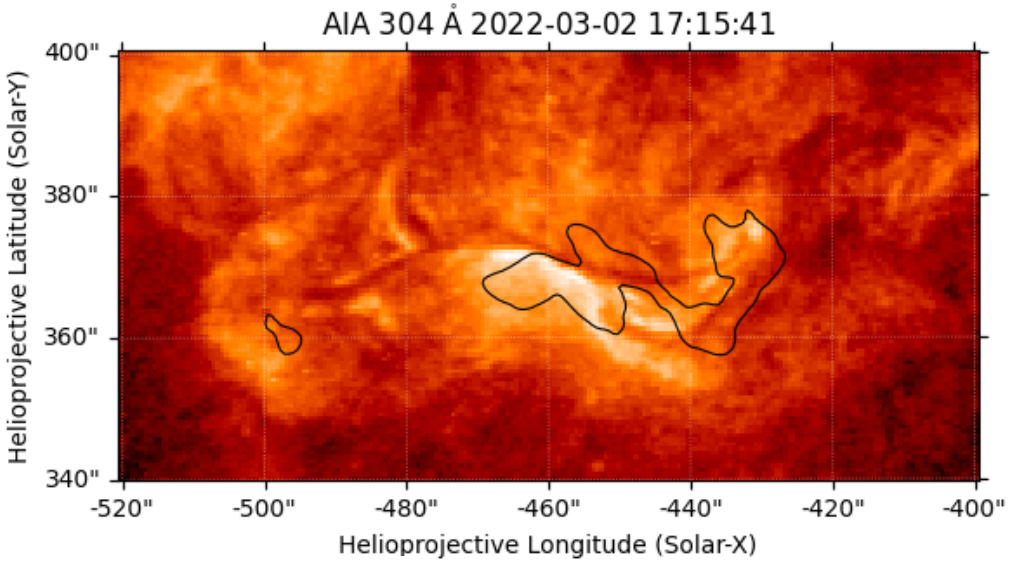
- STIX flare list -> filter for flares observed by Earth
- Sort list by high energy counts (25-50 keV)
- JHelioviewer: check flares for filament eruption & signs in UV
- For promising flares: look at STIX images
- Analysis of the flares

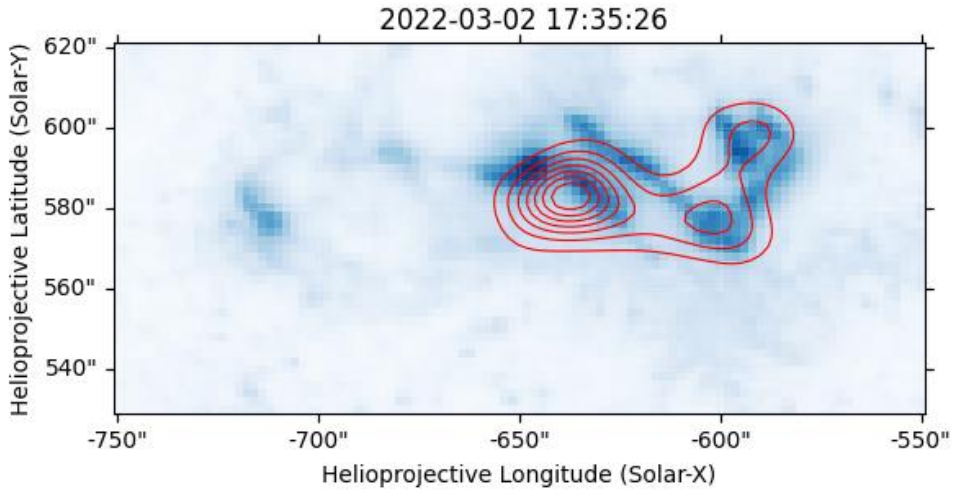
Example



Statistical study of hard X-rays at anchor points of filaments

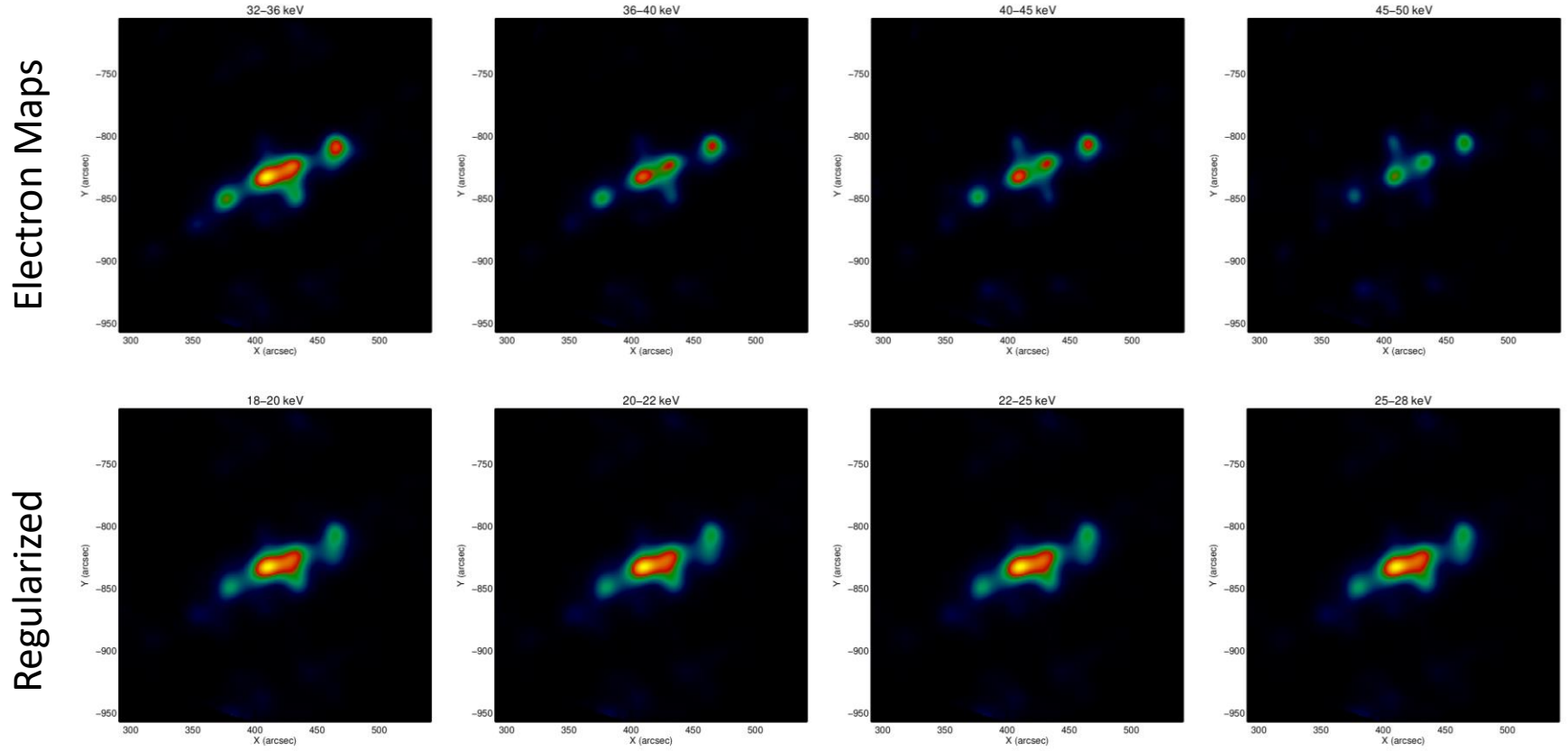






Imaging Spectroscopy

- Electron maps: electron visibilities and regularized visibilities
- STIX imaging spectroscopy[1]



[1] https://github.com/afbattaglia/STIX-GSW_test-imaging-spectroscopy

Boundaries of STIX imaging: Simulations

From Stiefel et al. (2023): rule of thumb 10'000 counts are needed to be able to reconstruct four sources (with similar flux)

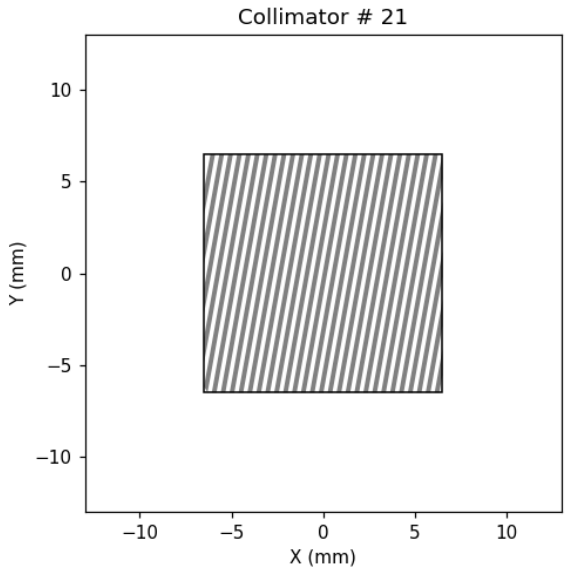
But where are the boundaries really?

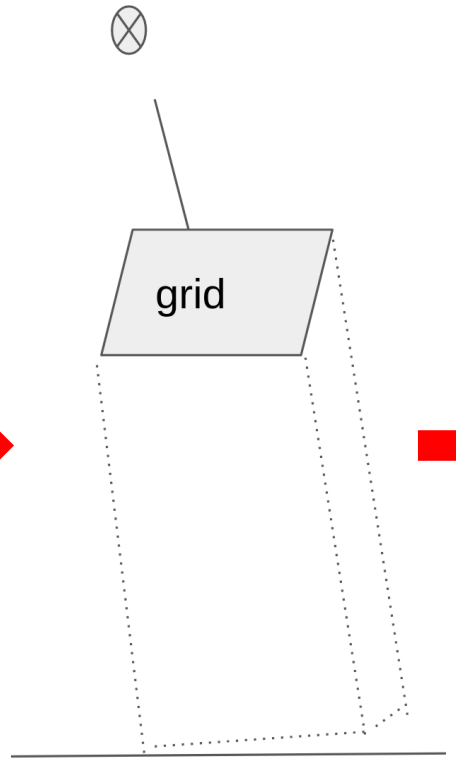
Goal: from position, size & flux of sources -> simulate image
Method:

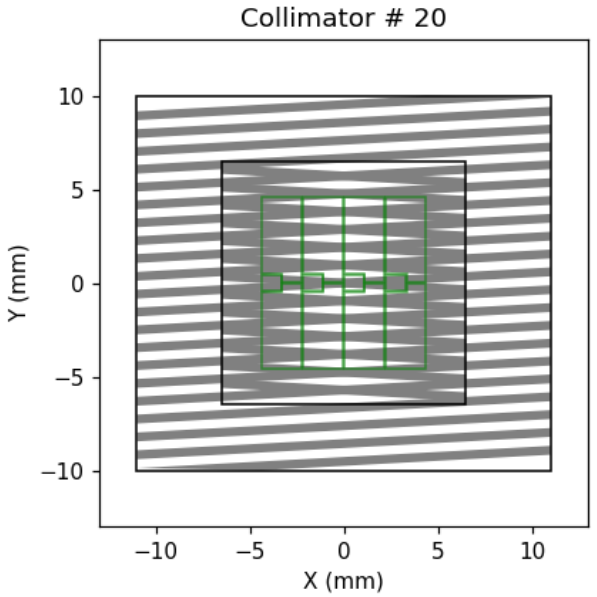
- Python Calculation Tool[1] "pystixsim" -> under development & testing
- Moiré pattern -> visibilities -> Imaging
- Make systematic tests for flares with multiple sources

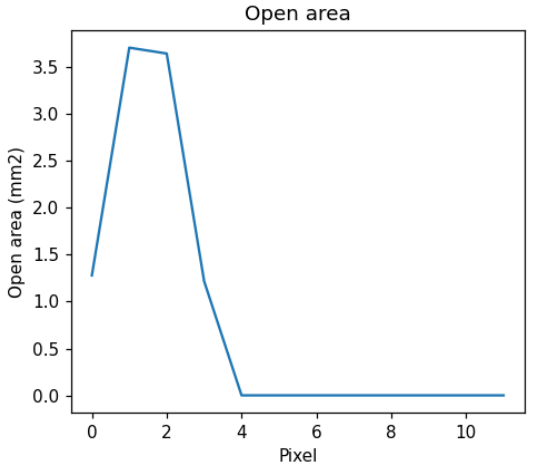
[1] https://github.com/drhlxiao/pystixsim

pystixsim: Graphical Projection







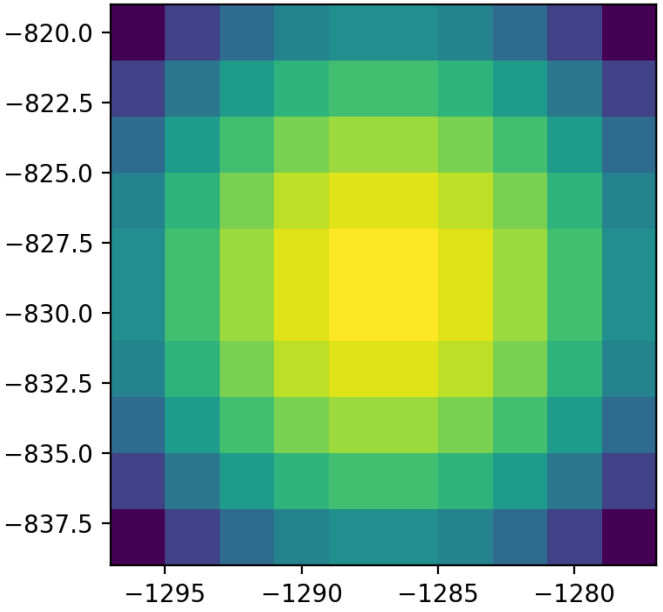


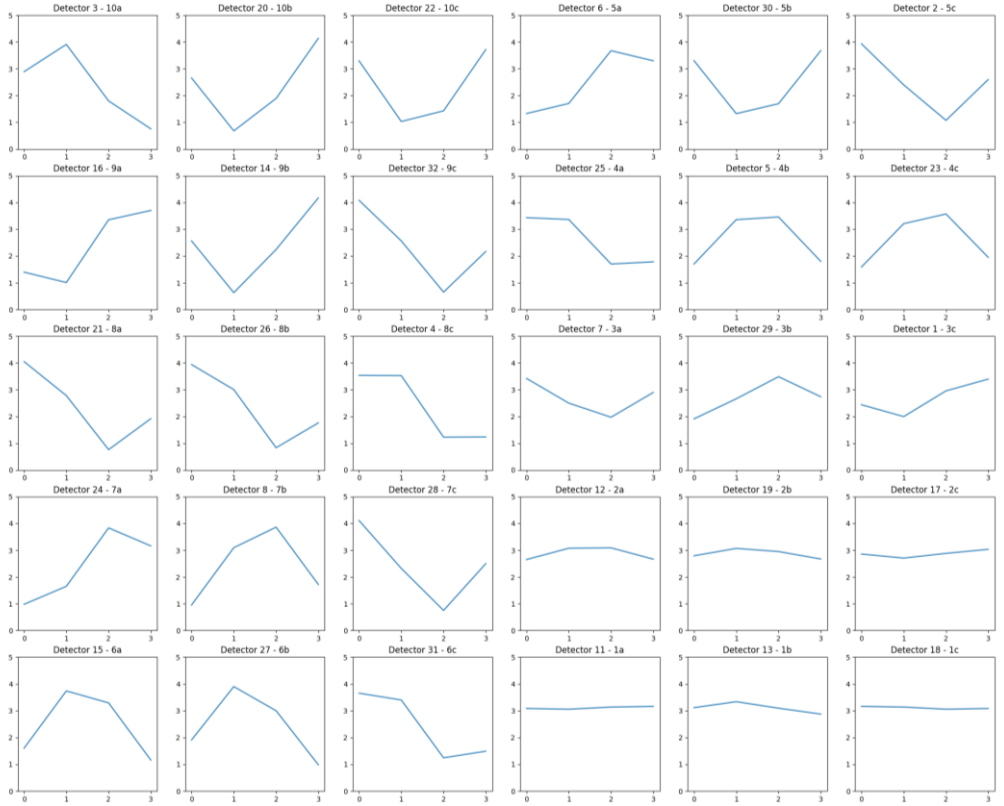
Each grid and each detector is described by a 2D polygon

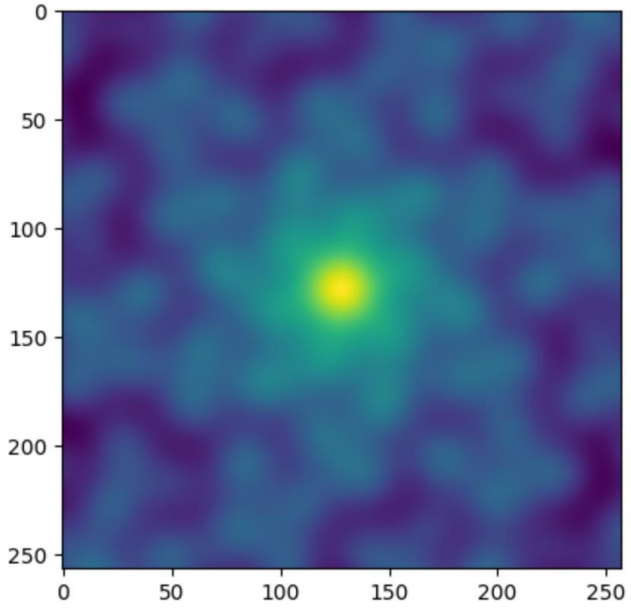
Calculate shadows

Illuminated area = pixel_area - Union(front_grid_shadow, rear_grid_shadow)

Current Pipeline on Simulations







Input: Source Size and Location

Moiré Pattern (Illuminated Area)

Backprojection

Questions?

Questions

- Difference Flux Rope vs. Filament? Could electrons be detected for both?
- What do we really expect to see at anchor points of filament?

SOL210923: Nonthermal image with three imaging methods