Hard X-ray spectrometer STIX
Status report from July 7, 2021

University of Applied Sciences
Northwestern Switzerland

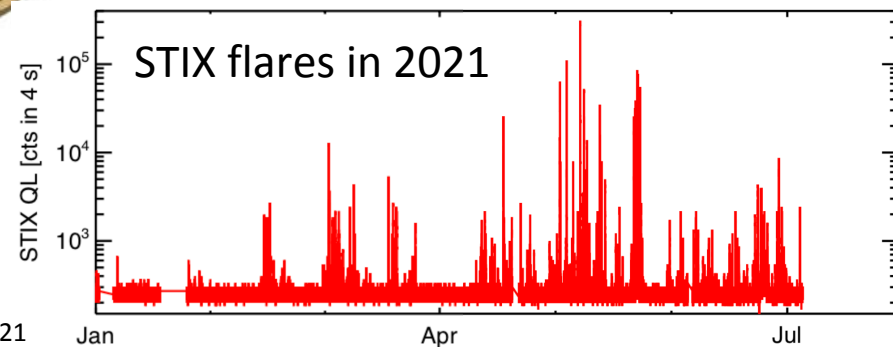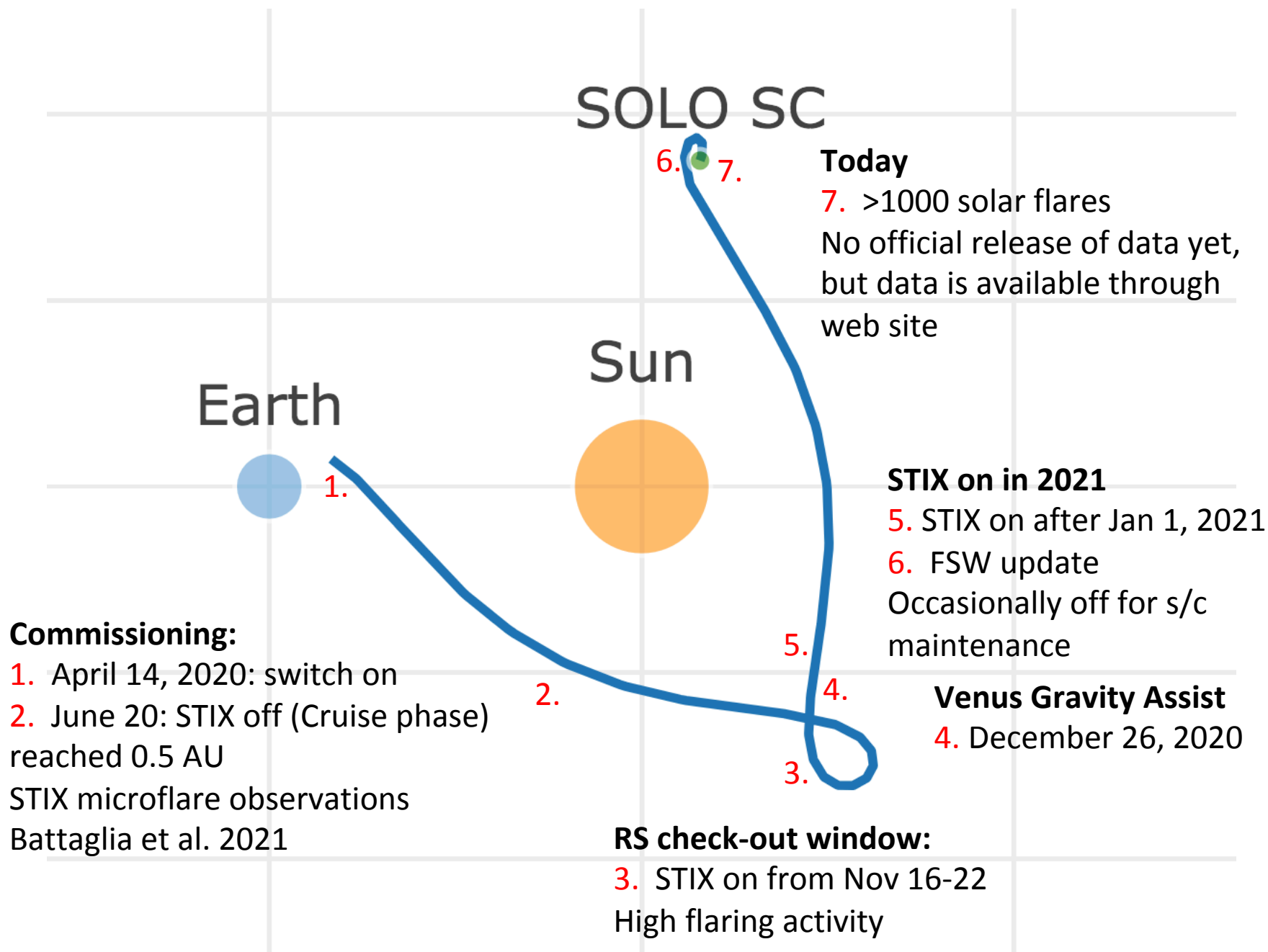**Imager**

DEM
Detector
Electronics
Module

X-ray window

STIX flares in 2021

STIX QL [cts in 4 s]

2021   Jan   Apr   Jul

SOLO SC

6. 7.

Today
7. >1000 solar flares
No official release of data yet, but data is available through web site

Sun

Earth

1.

STIX on in 2021
5. STIX on after Jan 1, 2021
6. FSW update
Occasionally off for s/c maintenance

5.

4.

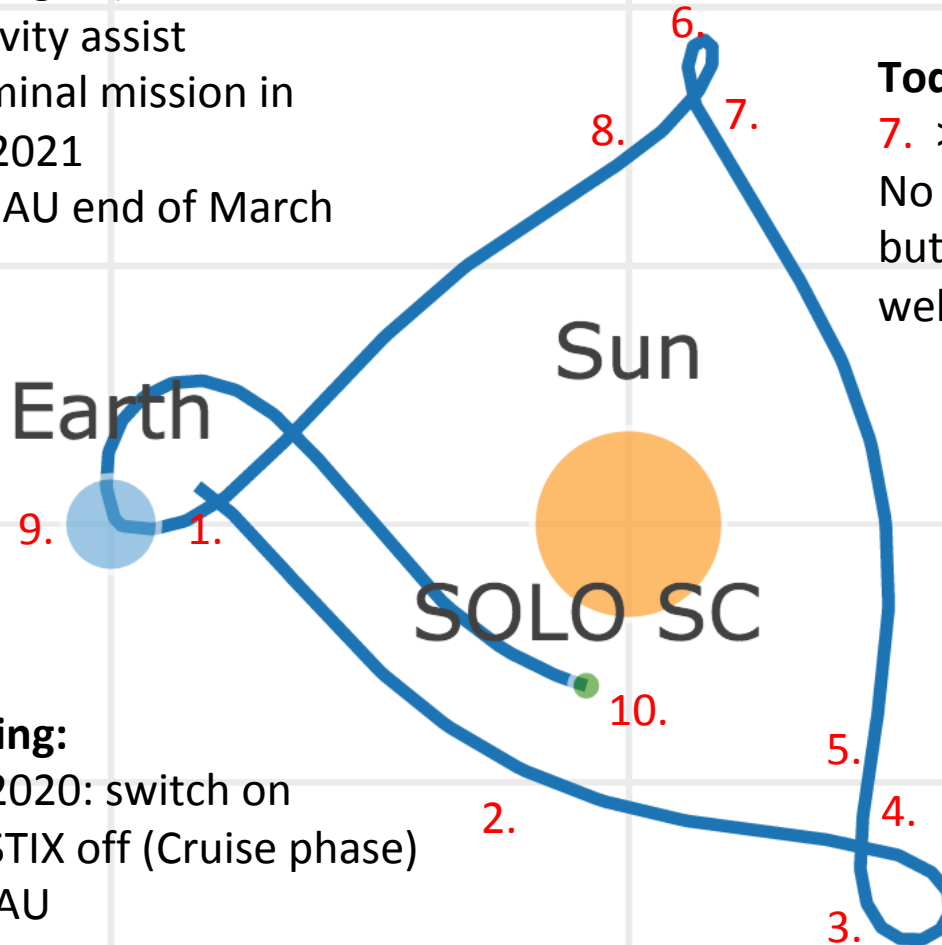**Venus Gravity Assist**
4. December 26, 2020

Commissioning:
1. April 14, 2020: switch on
2. June 20: STIX off (Cruise phase) reached 0.5 AU
STIX microflare observations
Battaglia et al. 2021

2.

3.

RS check-out window:
3. STIX on from Nov 16-22
High flaring activity

Coming months
8. VGA 2 (August)
9. Earth gravity assist
Start of nominal mission in December 2021
10. at 0.32 AU end of March 2022

Today
7. >1000 solar flares
No official release of data yet, but data is available through web site

Sun

Earth

SOLO SC

STIX on in 2021
5. STIX on after Jan 1, 2021
6. FSW update
Occasionally off for s/c maintenance

Venus Gravity Assist
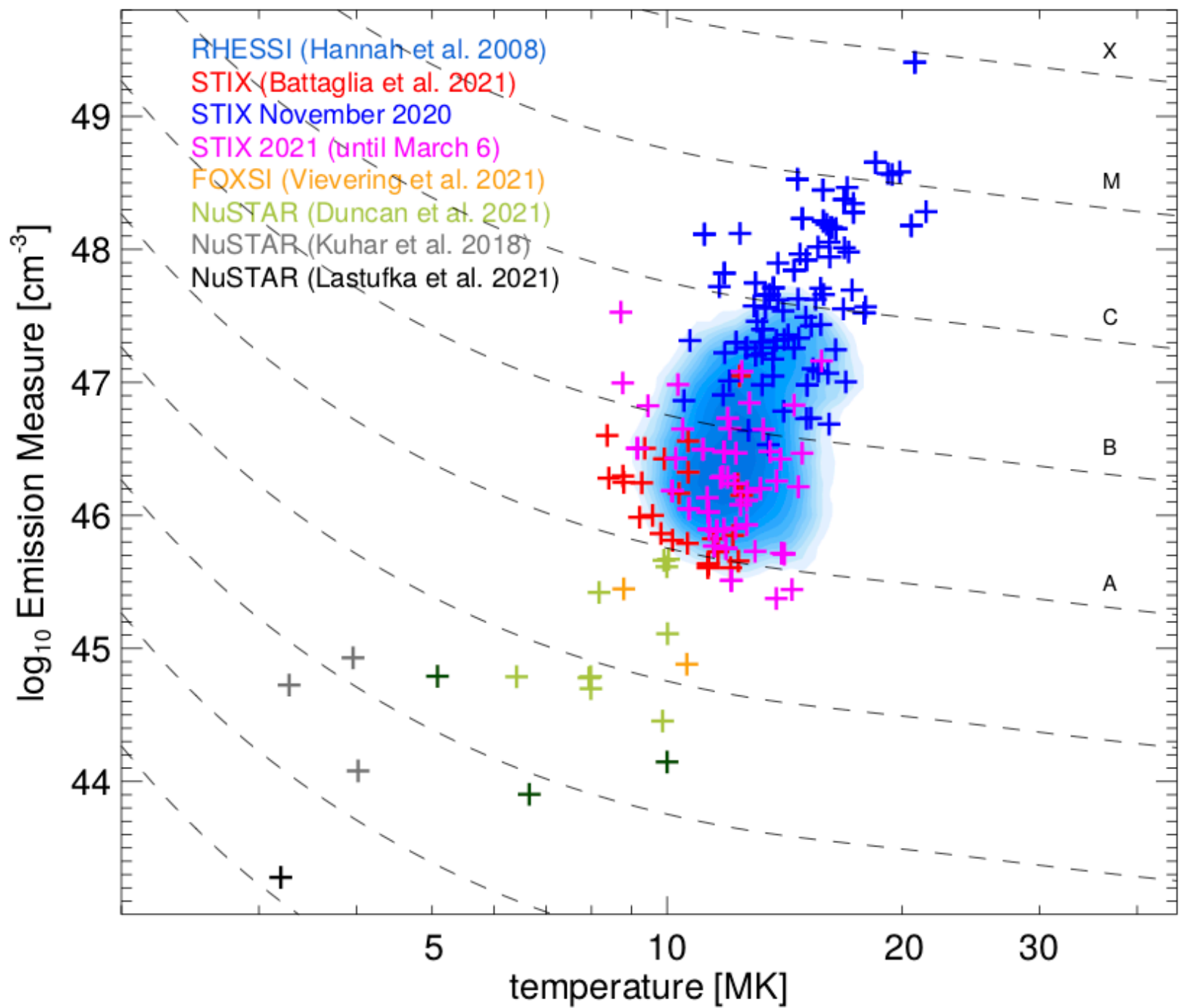4. December 26, 2020

Commissioning:
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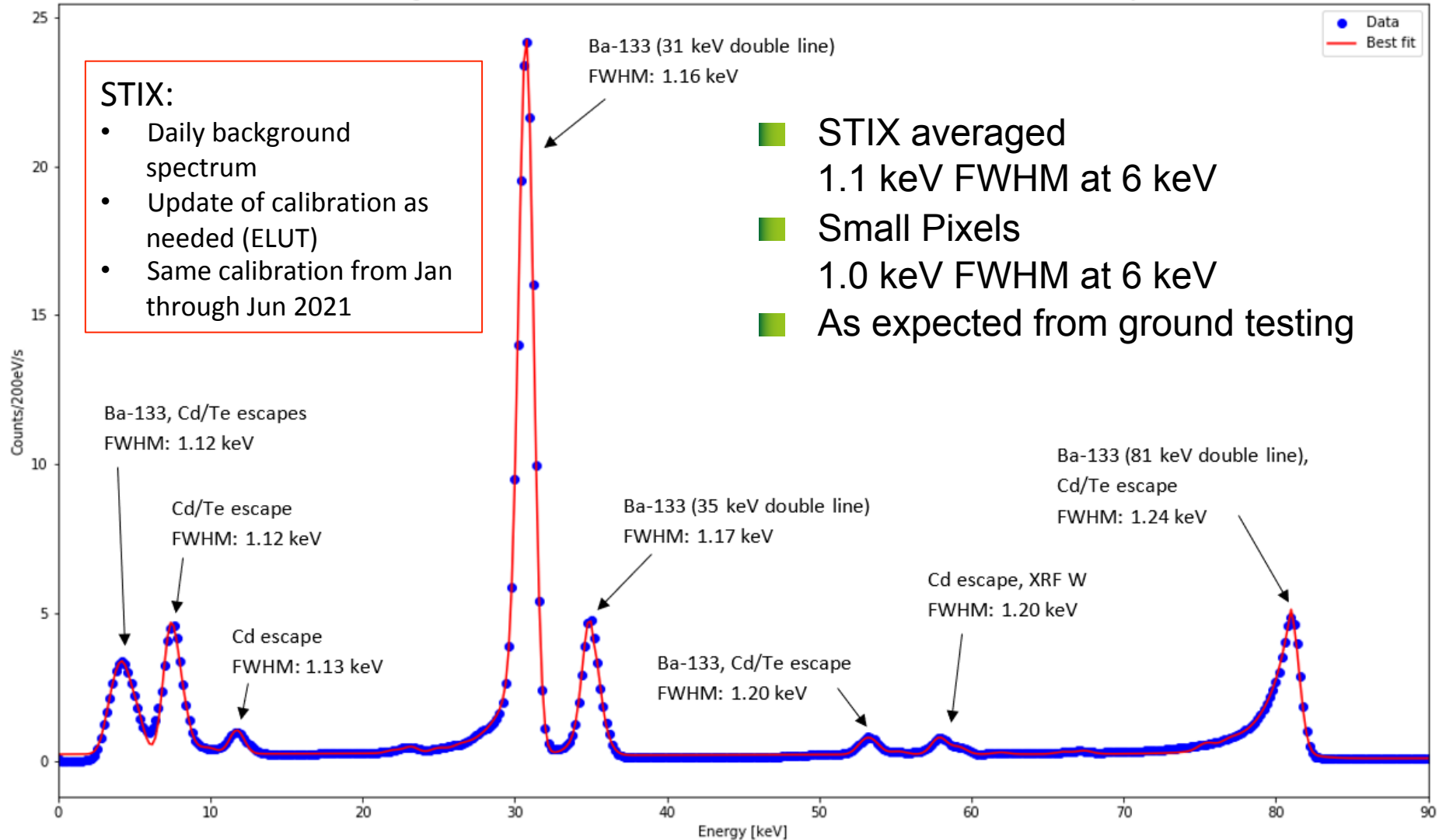STIX microflare observations
Battaglia et al. 2021

RS check-out window:
3. STIX on from Nov 16-22
High flaring activity

RHESSI (Hannah et al. 2008)
STIX (Battaglia et al. 2021)
STIX November 2020
STIX 2021 (until March 6)
FOXSI (Vievering et al. 2021)
NuSTAR (Duncan et al. 2021)
NuSTAR (Kuhar et al. 2018)
NuSTAR (Lastufka et al. 2021)

RHESSI (Hannah et al. 2008)
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NuSTAR (Duncan et al. 2021)
NuSTAR (Kuhar et al. 2018)
NuSTAR (Lastufka et al. 2021)

STIX:
- Detection of flares above GOES A class
- Detailed analysis for GOES B and larger

$\log_{10}$ Emission Measure [cm^{-3}]

temperature [MK]
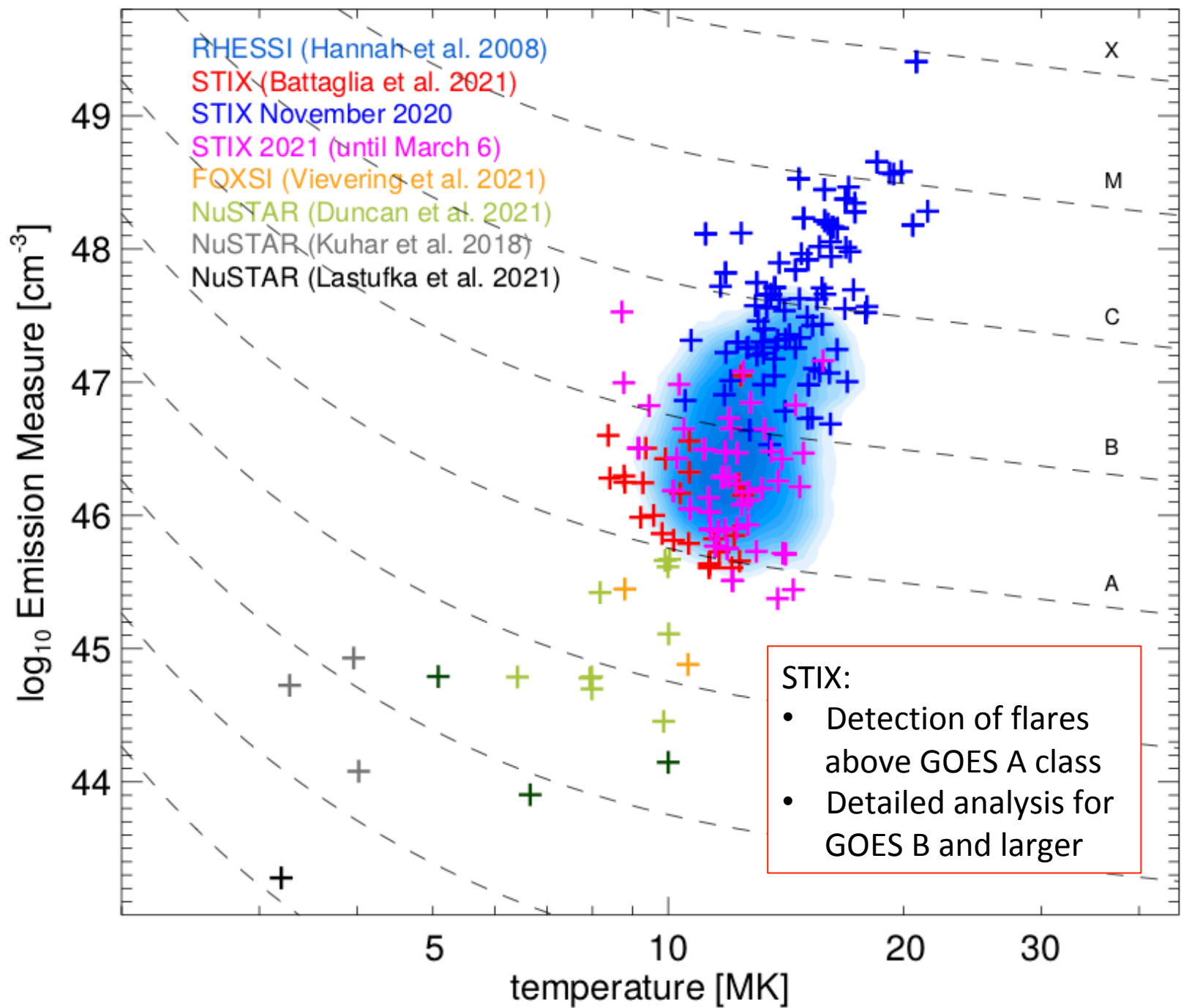
Counts are binned in energy and time

- Binning is required to stay within allocated telemetry budget
- Energies are binned on board to 30 science energy bins (1 keV at lower energies)
- Time resolution: dynamic
  - 20 second during non-flaring times
  - down to 1 second during flares (higher cadence under testing)
  - Adjustable through parameters
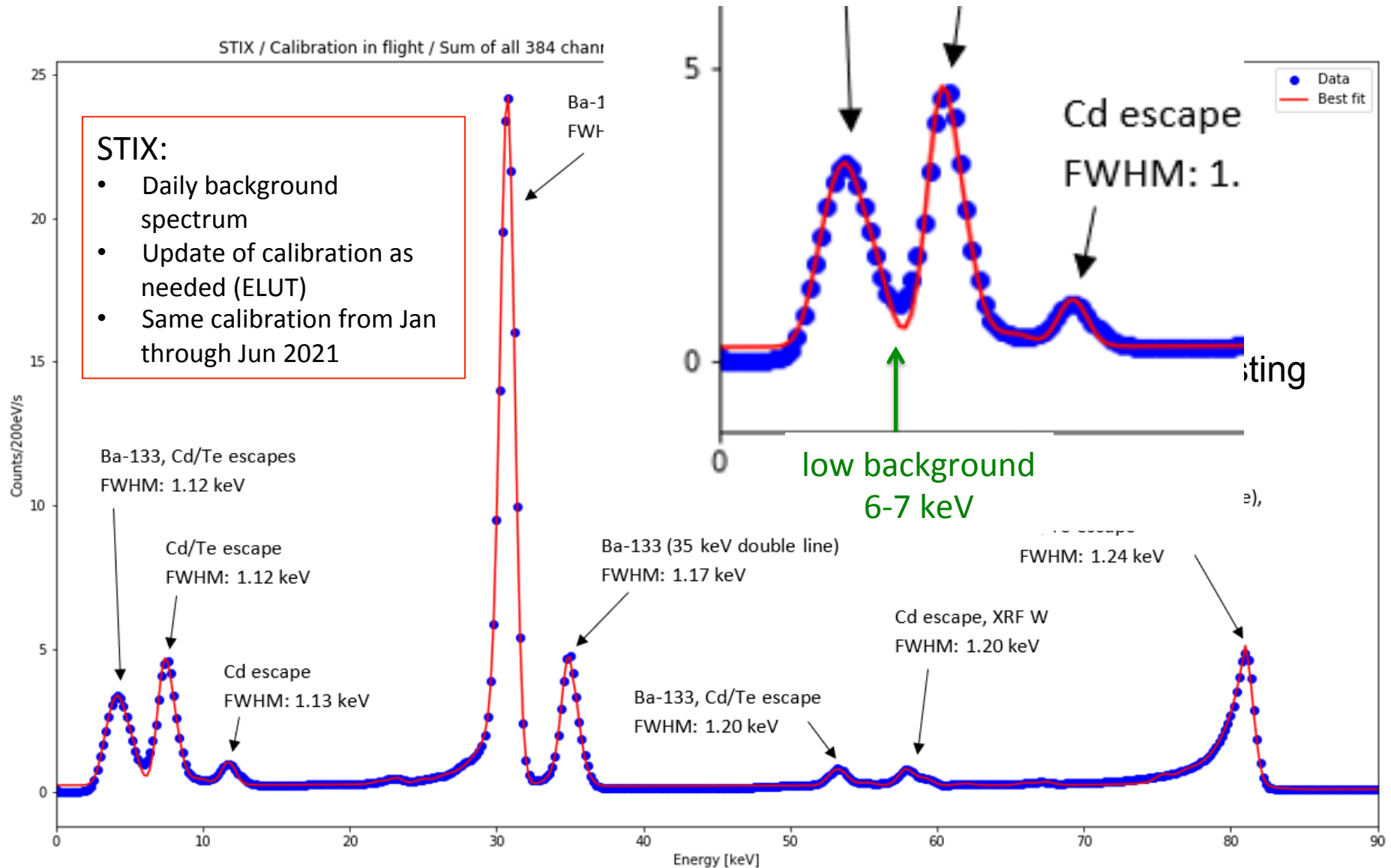- Onboard storage of flares for about 6 months
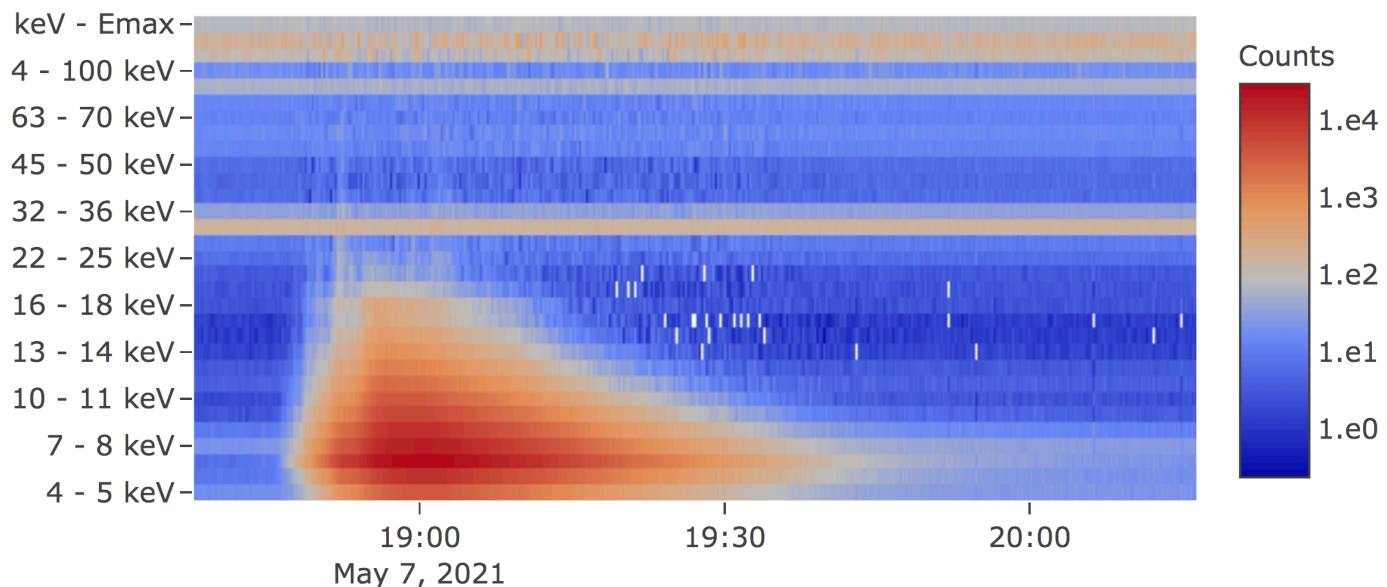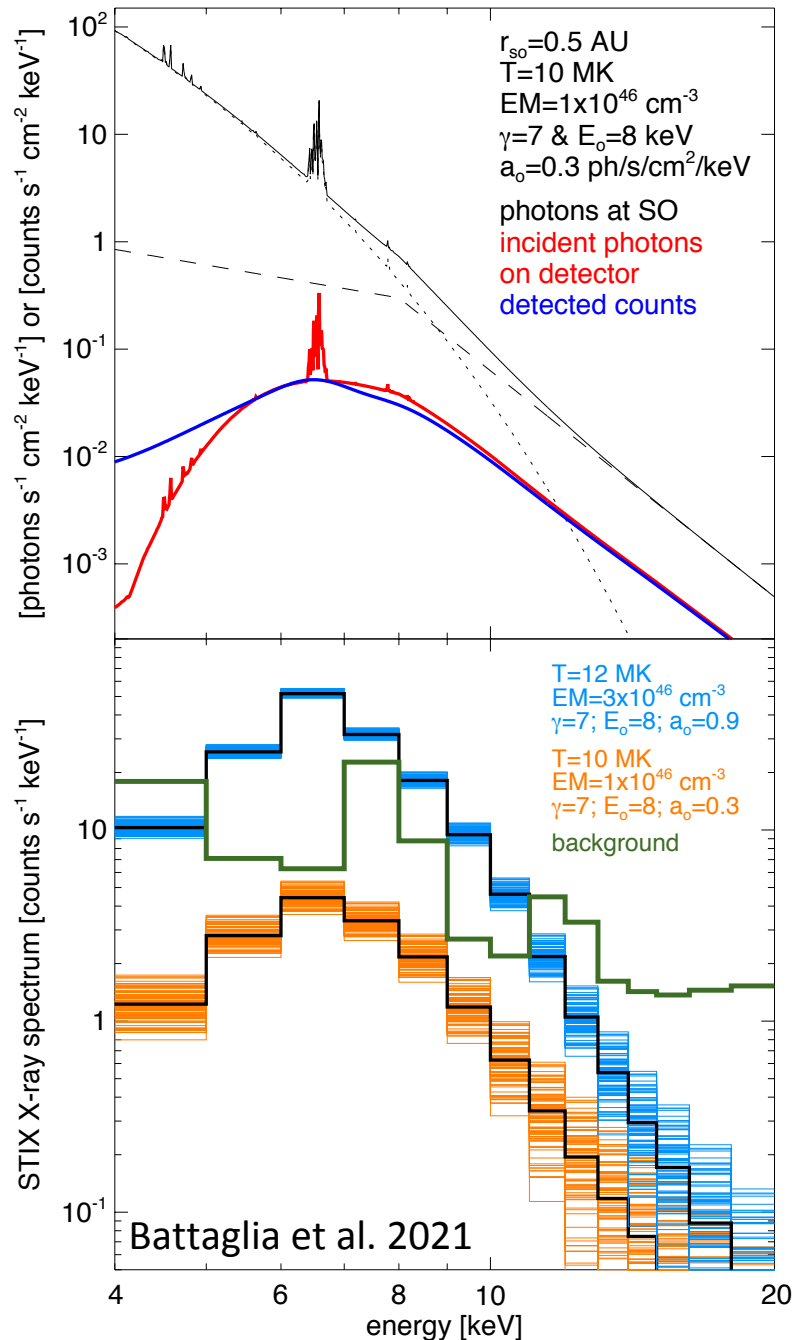
Spectrum of on-board Calibration source

STIX / Calibration in flight / Sum of all 384 channels / Run #964 (HV 300V, TP2, Gain 3, TH11, BLH ON, Rdelay 0, LT 37999s)
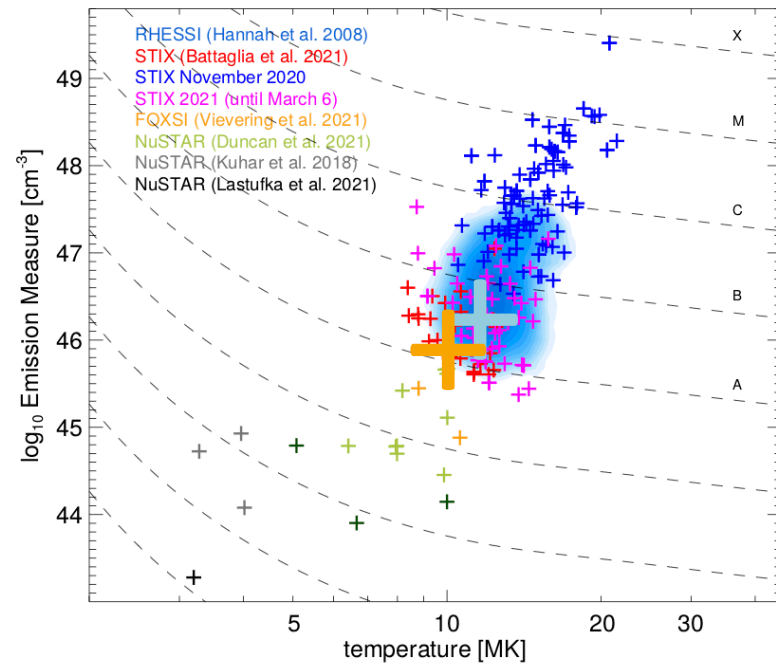
STIX:
- Daily background spectrum
- Update of calibration as needed (ELUT)
- Same calibration from Jan through Jun 2021

Ba-133 (31 keV double line)
FWHM: 1.16 keV

Ba-133, Cd/Te escapes
FWHM: 1.12 keV

Cd/Te escape
FWHM: 1.12 keV

Cd escape
FWHM: 1.13 keV

Ba-133 (35 keV double line)
FWHM: 1.17 keV

Ba-133, Cd/Te escape
FWHM: 1.20 keV

Cd escape, XRF W
FWHM: 1.20 keV

Ba-133 (81 keV double line),
Cd/Te escape
FWHM: 1.24 keV

■ STIX averaged 1.1 keV FWHM at 6 keV
■ Small Pixels 1.0 keV FWHM at 6 keV
■ As expected from ground testing

Olivier Limousin, Aline Meuris, Hugo Allaire (CEA)

Spectrum of on-board Calibration source

STIX / Calibration in flight / Sum of all 384 chan...

STIX:
- Daily background spectrum
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Ba-133, Cd/Te escapes
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Cd/Te escape
FWHM: 1.12 keV

Cd escape
FWHM: 1.13 keV

Ba-1...
FWH...

Ba-133 (35 keV double line)
FWHM: 1.17 keV

Ba-133, Cd/Te escape
FWHM: 1.20 keV

Cd escape, XRF W
FWHM: 1.20 keV

FWHM: 1.24 keV

Cd escape
FWHM: 1.

low background
6-7 keV

Data
Best fit

Counts/200eV/s

Energy [keV]

Olivier Limousin, Aline Meuris, Hugo Allaire (CEA)

STIX response

r_so=0.5 AU
T=10 MK
EM=1x10^46 cm^-3
γ=7 & E_o=8 keV
a_o=0.3 ph/s/cm^2/keV

photons at SO
incident photons on detector
detected counts

$r_{so}=0.5$ AU
$T=10$ MK
$EM=1\times10^{46}$ cm^{-3}
$\gamma=7$ & $E_o=8$ keV
$a_o=0.3$ ph/s/cm^2/keV

photons at SO
incident photons on detector
detected counts

T=12 MK
EM=3x10^46 cm^-3
γ=7; E_o=8; a_o=0.9

T=10 MK
EM=1x10^46 cm^-3
γ=7; E_o=8; a_o=0.3
background

Battaglia et al. 2021

- black: microflare spectrum (GOES A1)
- red: transmission through windows, grids, MLI
- blue: recorded counts (1 keV resolution)
- Lower panel: resulting STIX count spectra for 30 second integration time

Main STIX data products

- Quicklook (low latency)
    - Lightcurves
    - Flare locations (after June 28, 2021, TBC)

- Science
    - Spectrograms (L4): spectroscopy
        - Summed on board over detectors
    - Pixel data (L1): imaging spectroscopy
        - Individual pixels are downloaded

https://pub023.cs.technik.fhnw.ch/
For details see:
Krucker et al. 2020, A&A (instrument paper)
Battaglia et al. 2021, A&A

STIX QL data: lightcurves

- Low latency (one per day during nominal mission)
  - 5 energy channels at 4 second cadence
  - https://pub023.cs.technik.fhnw.ch/view/plot/lightcurves

STIX QL data: lightcurves

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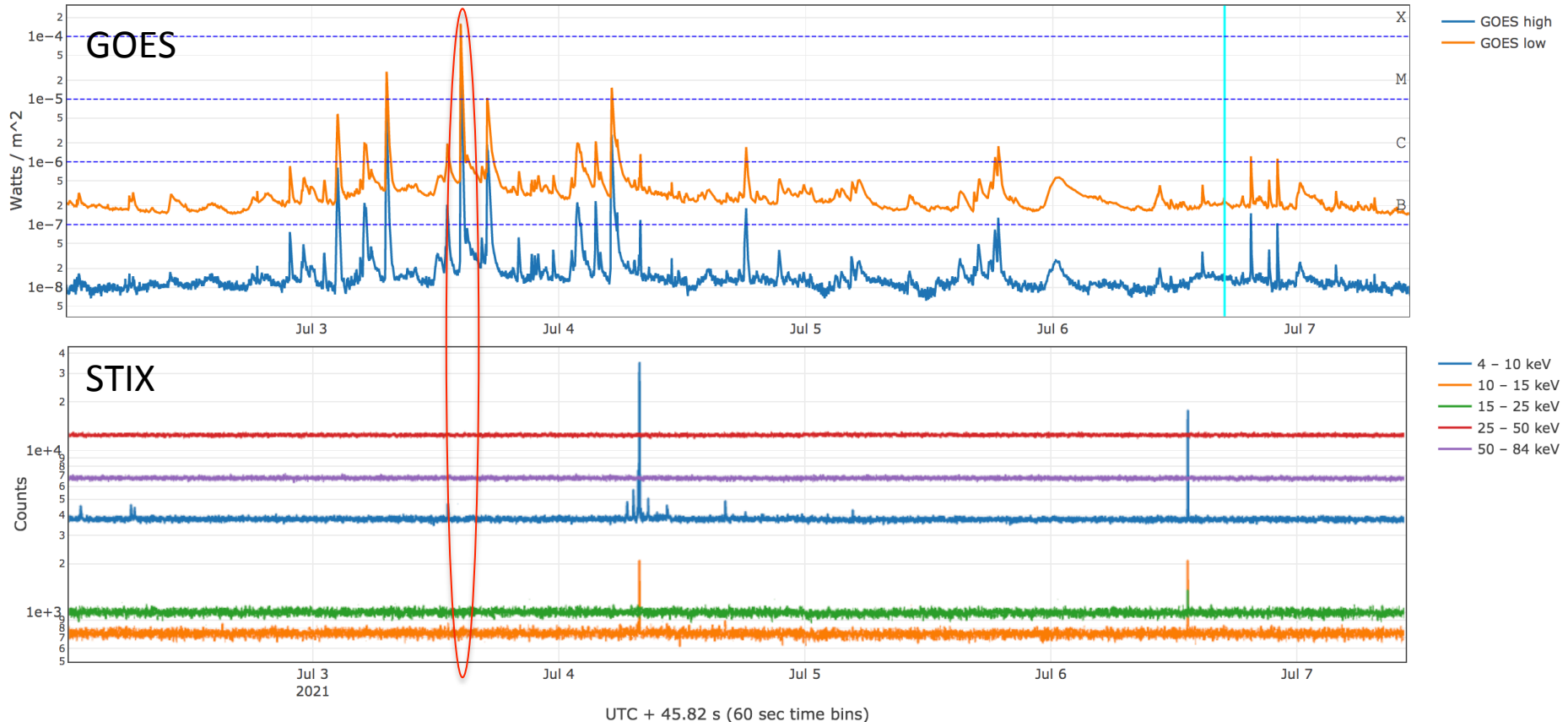
STIX QL data: lightcurves

- Low latency (one per day during nominal mission)
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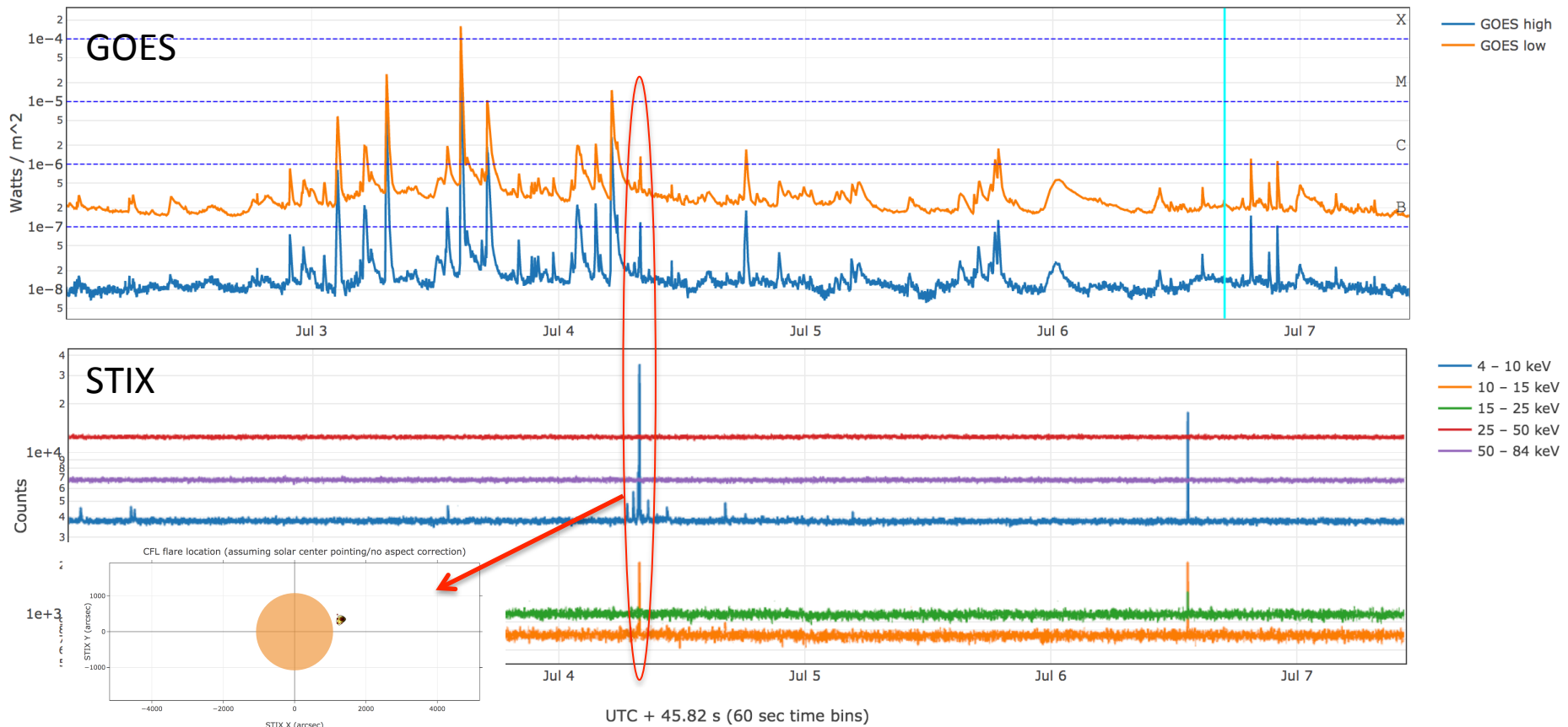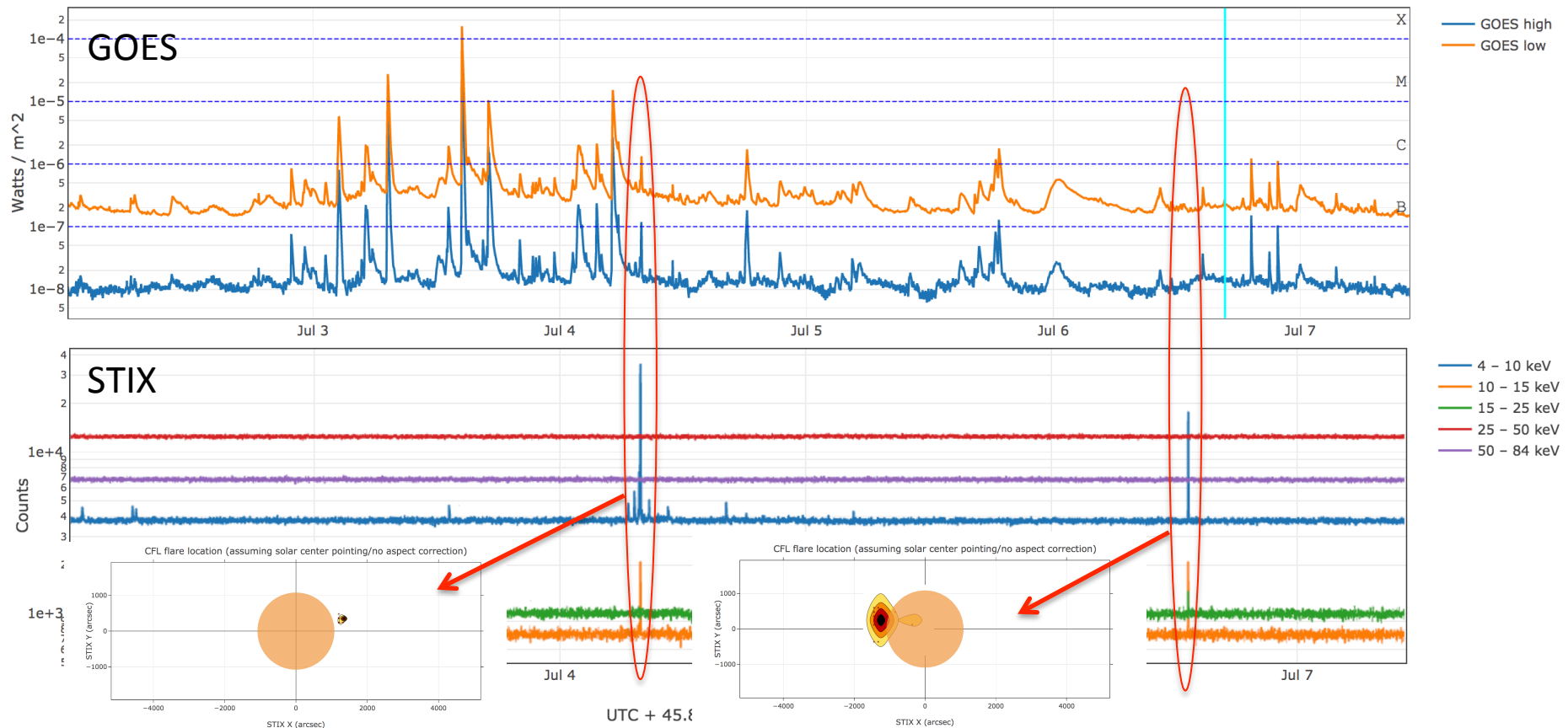
STIX science data: Spectrograms (L4)

- Spectrogram (onboard summing of pixels)
  - Count rates as a function of time and energy
- efficient use of telemetry, but no imaging
- Spectral fitting: Temperature, EM, nonthermal fit (OSPEX idl, contact Ewan Dickson for test version of OSPEX).
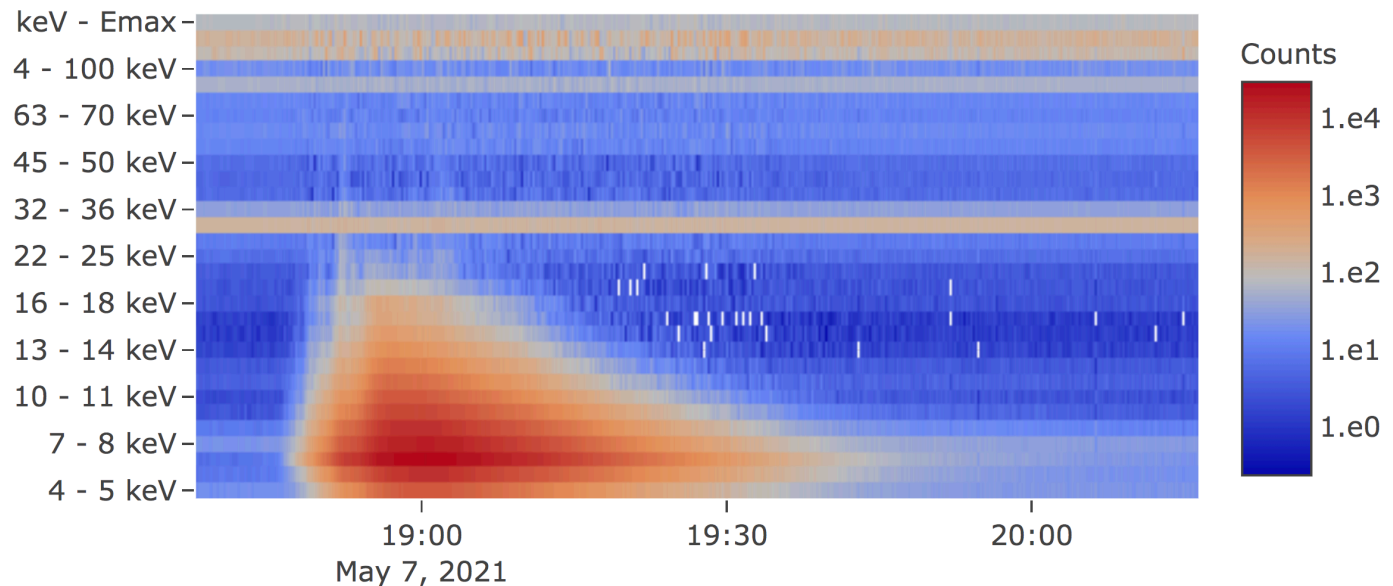
STIX science data: pixel data (L1)

- Count rates in individual pixels:
  - Count rates as function of time, energy, detector, and pixel
  - Much higher telemetry

- Imaging and imaging spectroscopy
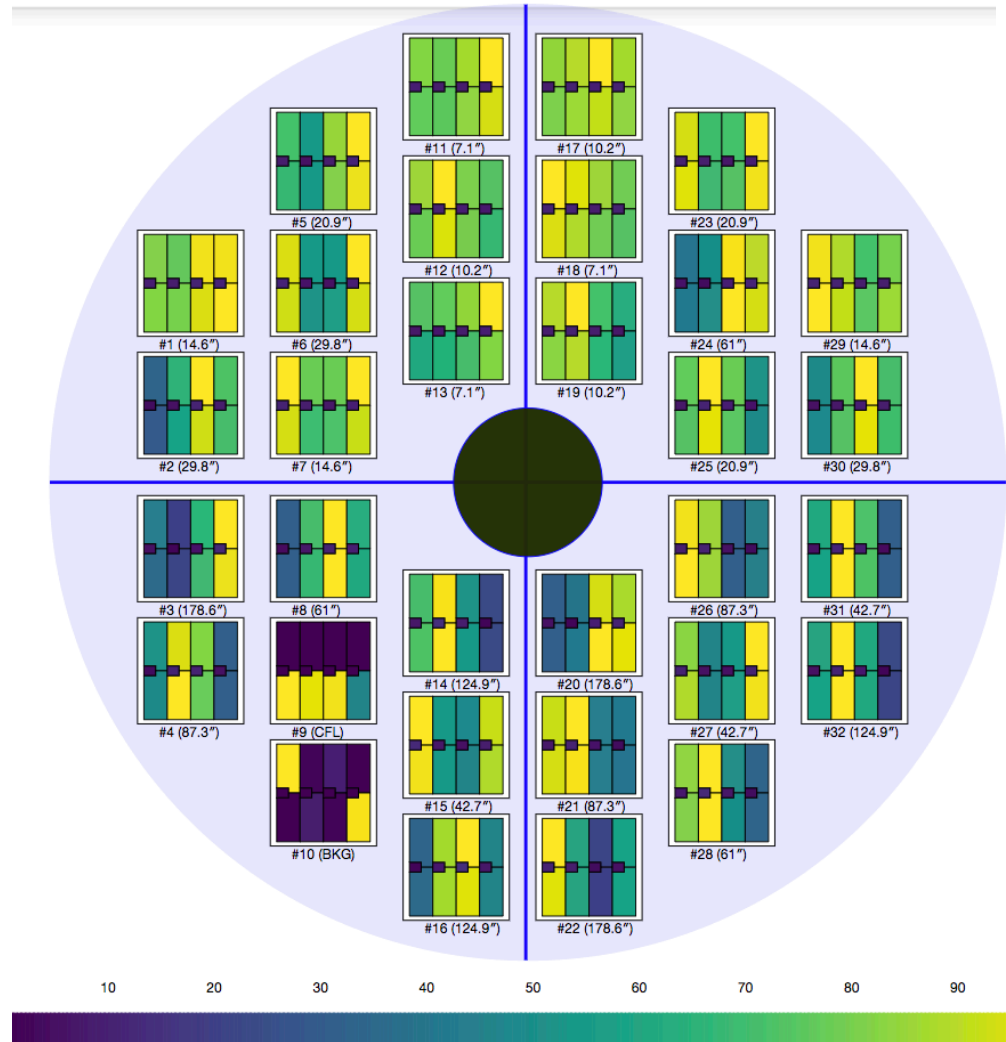
Mode of operation

- **STIX observes continuously,** but only QL data is sent down
- From QL data, we select flares (automatically selected, manually checked)
  - **All flares are downloaded as spectrograms (L4)**
    - Full time resolution, energy range restricted depending on flare size
    - Used for spectroscopy
  - **Larger flares are downloaded as pixel data (L1)**
    - Generally at reduced time resolution, and restricted energy/time range
    - Used for imaging and imaging spectroscopy
- Science data is available 1 to 3 months delayed
- Flares are stored up to 6 months onboard STIX
- Input from community on joint observations

☰ STIX science data request

Home

Raw data

Housekeeping data

Quick-Look data ▶

Science data

Calibration data

STIX flare list

L1 data products

Data archive

Packet browser

Science data request

Operations event calendar

Where is Solar Orbiter

Operations ▶

Miscellaneous ▶

External links ▶

Create a request for STIX data

Need help? Click here!

Your name *

[Please enter your name *]

Institution*

[Please enter your institution]

Email *

[Please enter your email *]

Co-observation instrument

[Co-observation instrument]

Links to the co-observation instrument data

[Links to the data observed by the co-observation instrument]

Science motivation *

[Science motivation]

Data time range *

[Start UTC]   [End UTC]

Click here to check if the data already exists

Message

[Additional message]

Most valuable input:
- Jointly observed flares recorded by other observatories
- reporting up to a few months after flare occurred is generally ok

Example: microflare on May 4, 2021
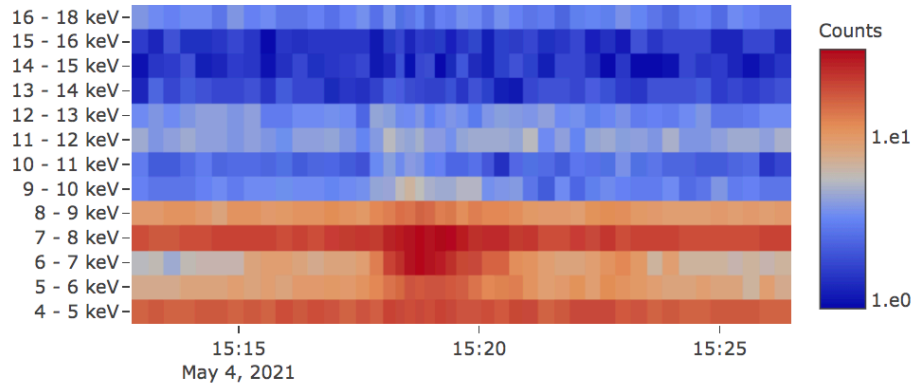
L4 (spectrogram) request
Full time resolution
Energy range limited to 4-18 keV

Required telemetry: 0.002 M
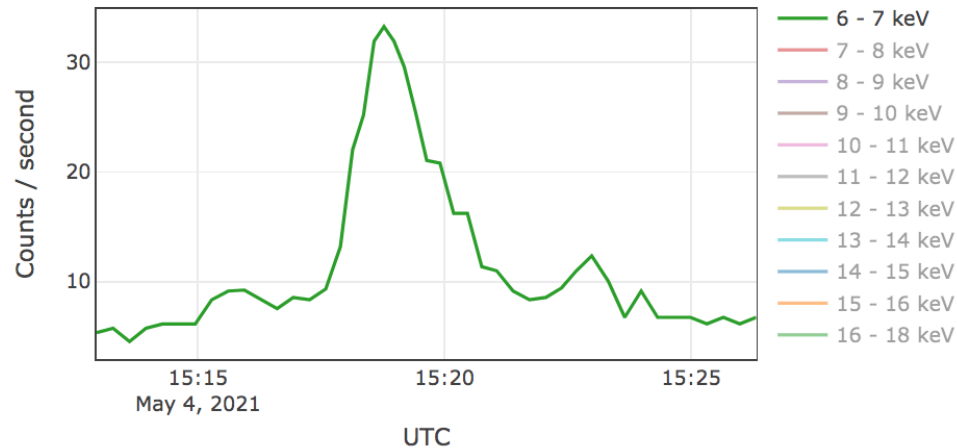
No L1 (pixel) request)

Example: B5 flare on Mar 3, 2021

Count rate spectrogram
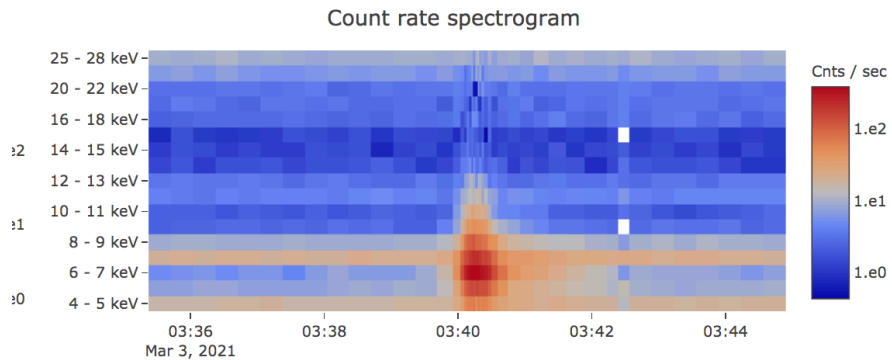
L4 (spectrogram) request
Full time resolution
Energy range limited to 4-28 keV

Required telemetry: 0.002 M

Count rate spectrogram
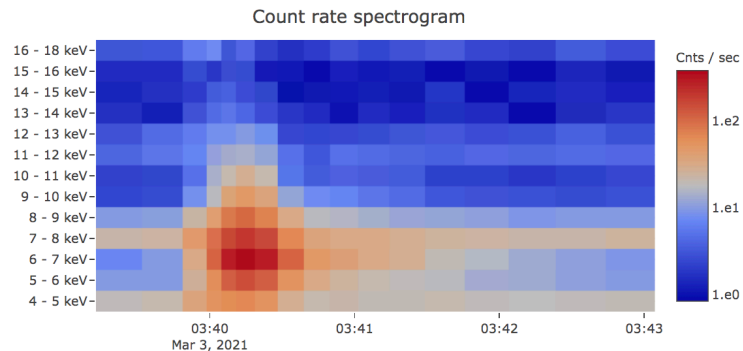
L1 (pixel) request
At 8 second resolution
Energy range limited to 4-18 keV
shorter time range

Required telemetry: 0.2 M

Example: M4 flare on May 7, 2021
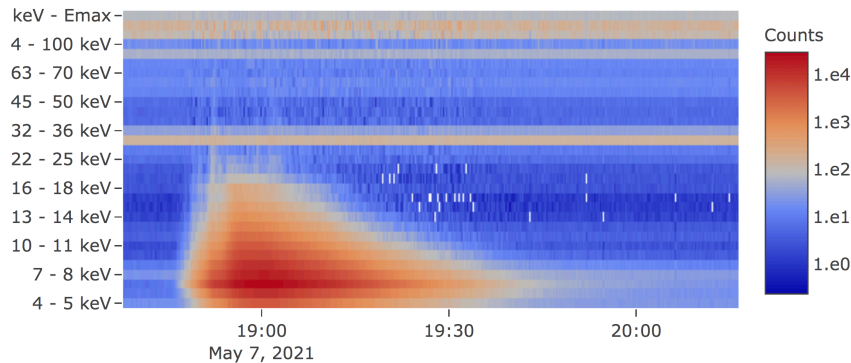
L4 (spectrogram) request
Full time and energy resolution
for entire flare

Required telemetry: 0.1 M
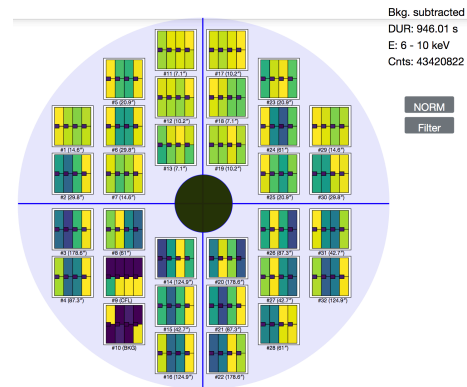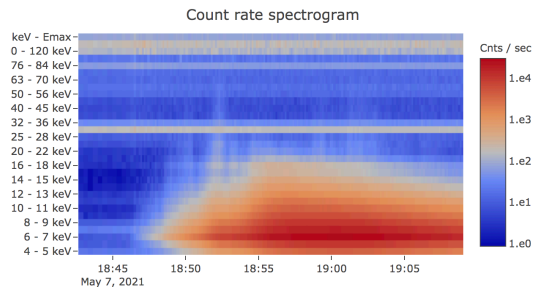
L1 (pixel) request
- 8 second resolution during impulsive phase, all energies
  - Required telemetry =2.8 M
- 30 second during decay and only up to 28 keV
  - Required telemetry =1.1 M
- Individual hard X-ray peak at full resolution (~1 M per min)
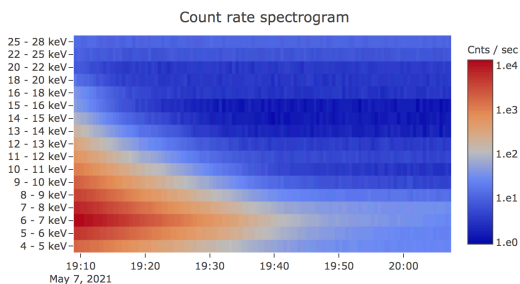
Full resolution would be 80 M
(few months of nominal allocation!)

Spectroscopy & Imaging status

- Spectroscopy
  - OSPEX works, but not yet fully implemented in SSWIDL (Contact Ewan Dickson for test version)
  - Python effort well underway
- Imaging
  - Amplitudes are calibrated
  - Phase calibration is ongoing
  - First images: forward fit to STIX amplitudes (Massa et al. 2021)

Forward fitting of STIX amplitudes

May 7, 2021 – 18:51:20, 18:53:00 – 5-10 keV
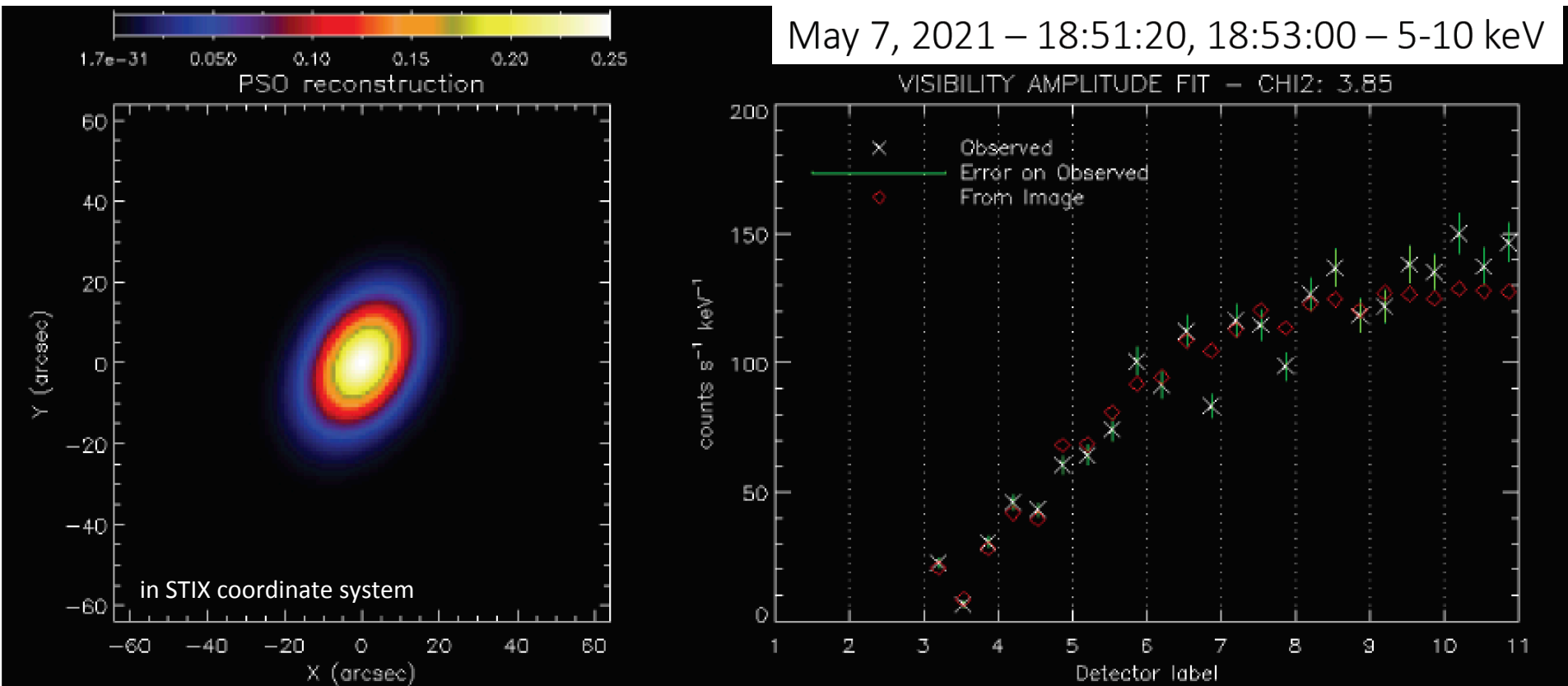
Massa et al. 2021

Flux (counts/s/keV)	FWHM max (arcsec)	FWHM min (arcsec)	Orientation angle (degrees)	chi2
129.7 ± 1.85	25.6 ± 0.4	17.7 ± 0.5	57.2 ± 2.3	3.85

Known issues

- Occasionally, too short (1s) time bins are created onboard (under investigation)
  - Does not influence science, but requires a correction on ground
- Time bin sizes are shifted by one time stamp
  - Will be corrected in next FSW update
  - Correction for already recorded flares is in progress
- Background above 80 keV is slightly contaminated (under investigation)
- Jan/Feb 2021: detector masks were set wrong, no CFL/BKG data saved
- Onboard flare location (CFL): was not working before June 28, 2021; now hopefully ok.
- STIX turned itself off twice; all nominal after STIX was turned on again. SEU?

Access to STIX data

- **Data release**
  - Open data policy: fits files are available on STIX website, but they are not yet final.
  - Work together with STIX team members to make sure that everything is ok
- **Software**
  - IDL and python
  - We are using some routines from RHESSI that are currently only available in IDL
- **Publication policy**
  - Co-authorship: only add STIX team members that actually worked on your paper.
  - Mention STIX in acknowledgement:
    - The STIX instrument is an international collaboration between Switzerland, Poland, France, Czech Republic, Germany, Austria, Ireland, and Italy.

STIX coverage in 2021
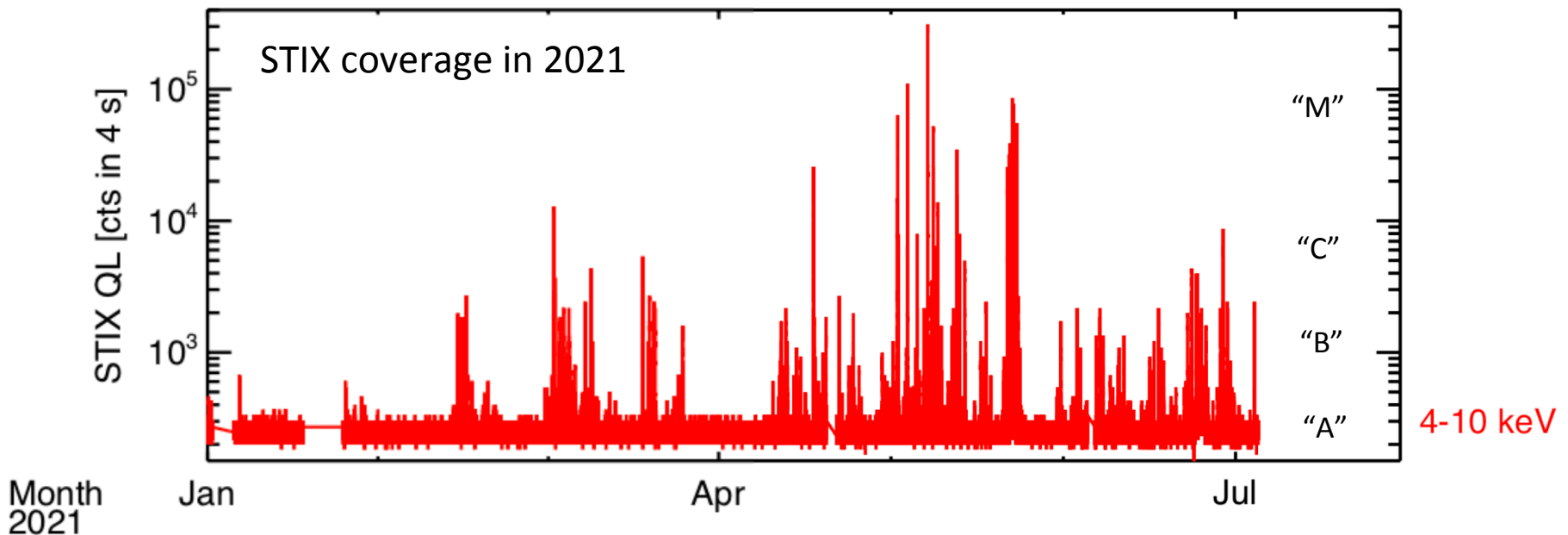
Next milestones

- First version of phase calibration
- Test of attenuator and RCR with real flares
- FSW update this fall
- Release of FITS files and associated software before start of nominal mission
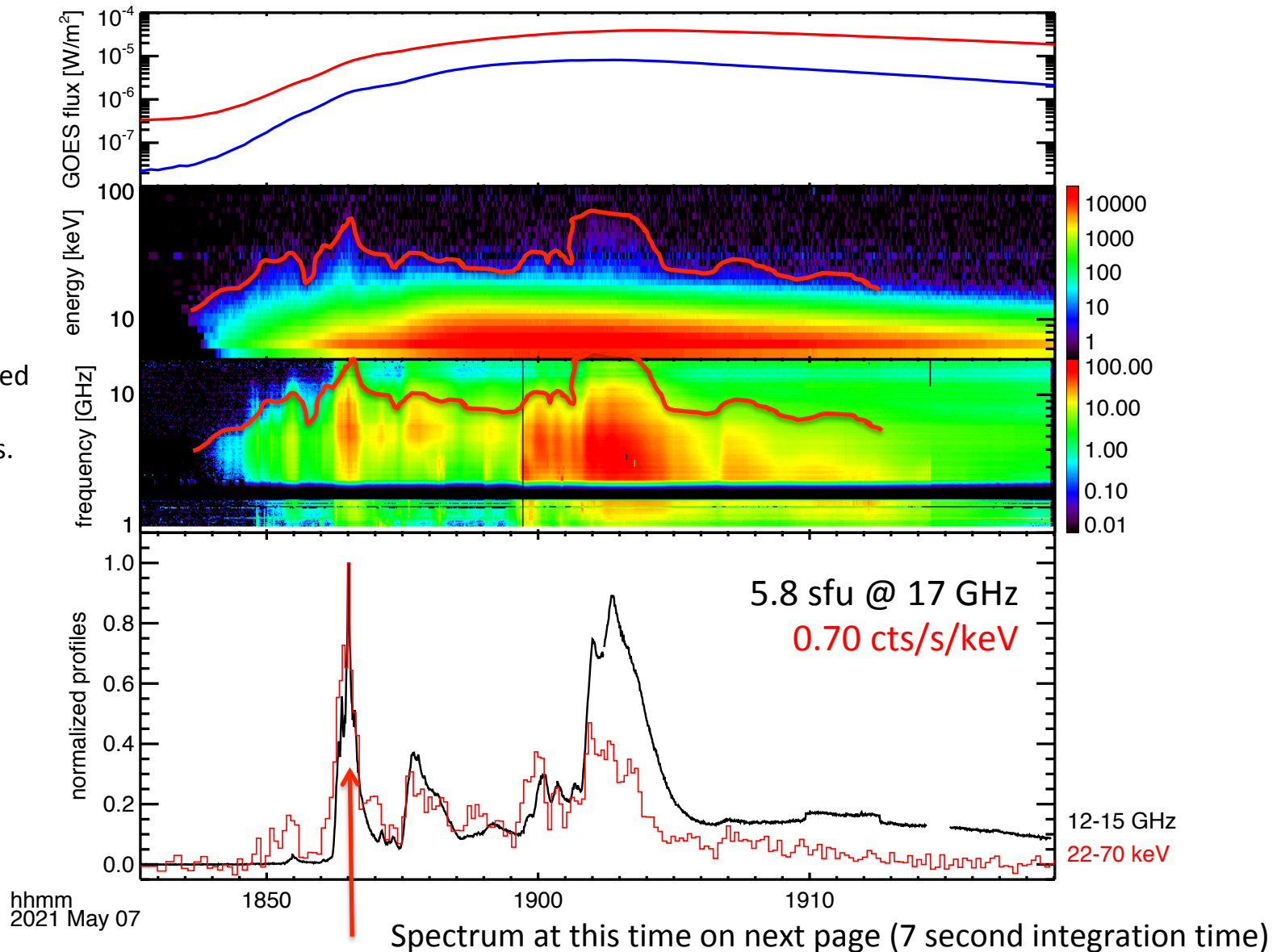- Science paper!

the May 7 flare (M4)
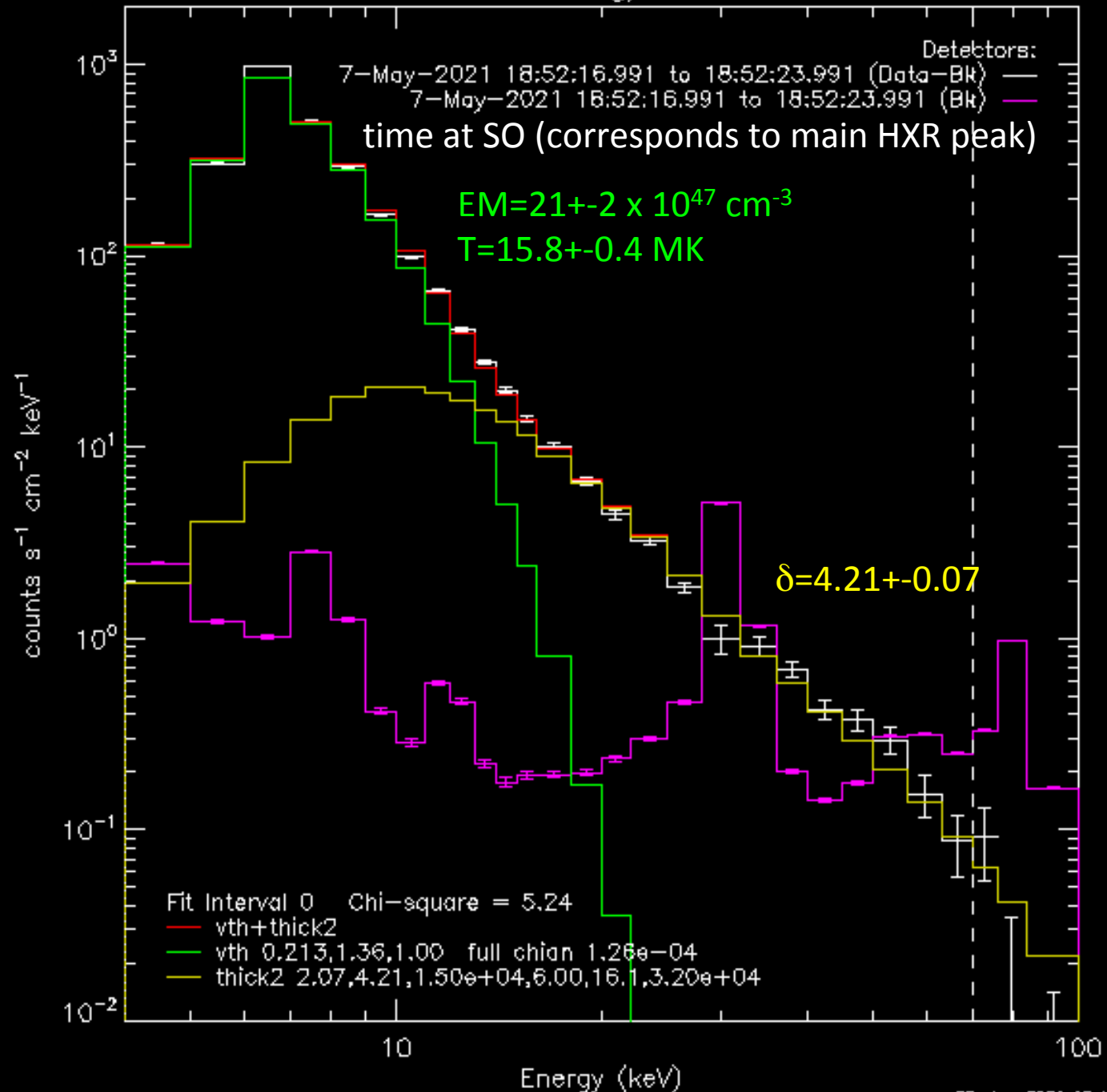
May 7, 2021 (GOES M4)
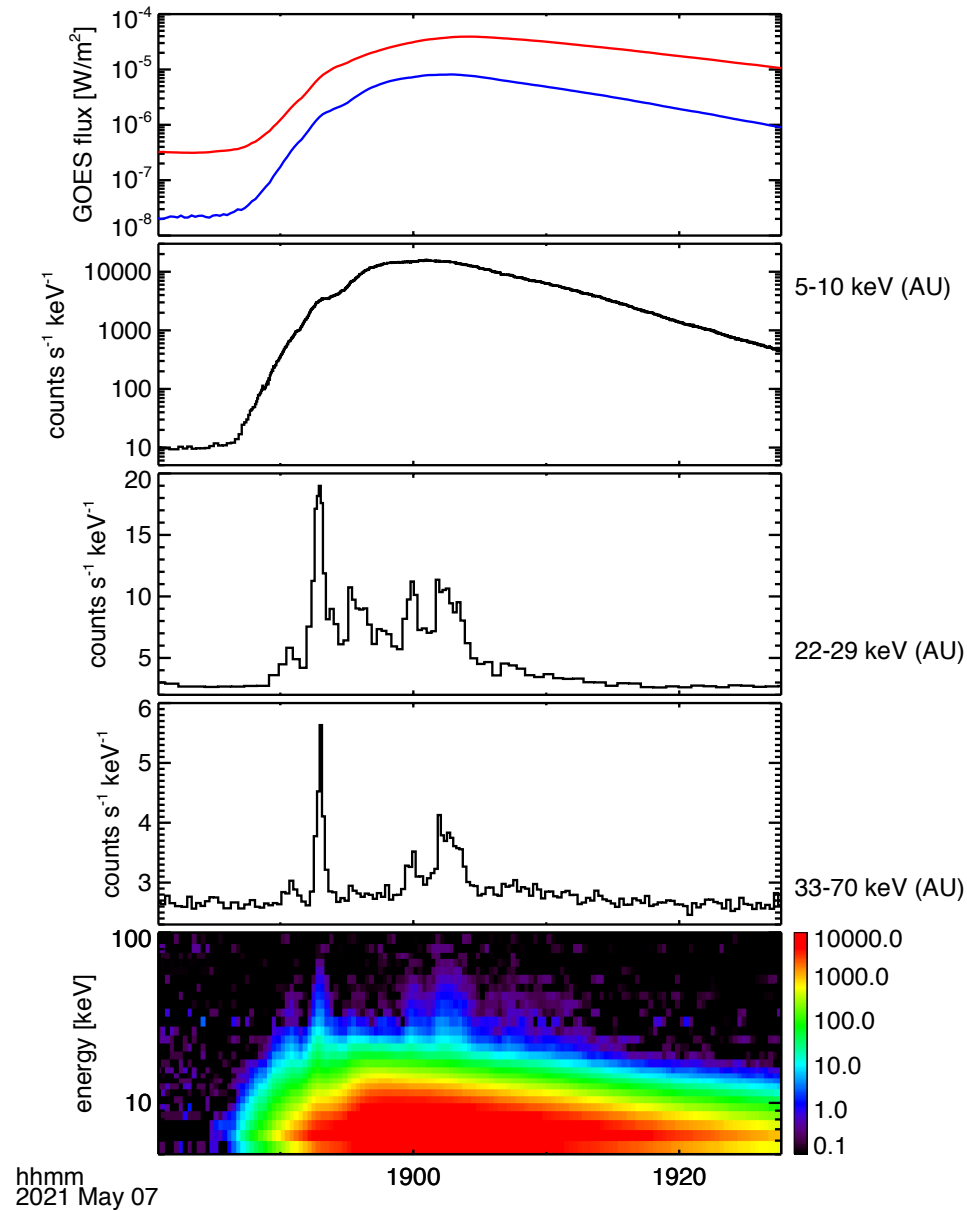
May 7, 2021 (GOES M4)
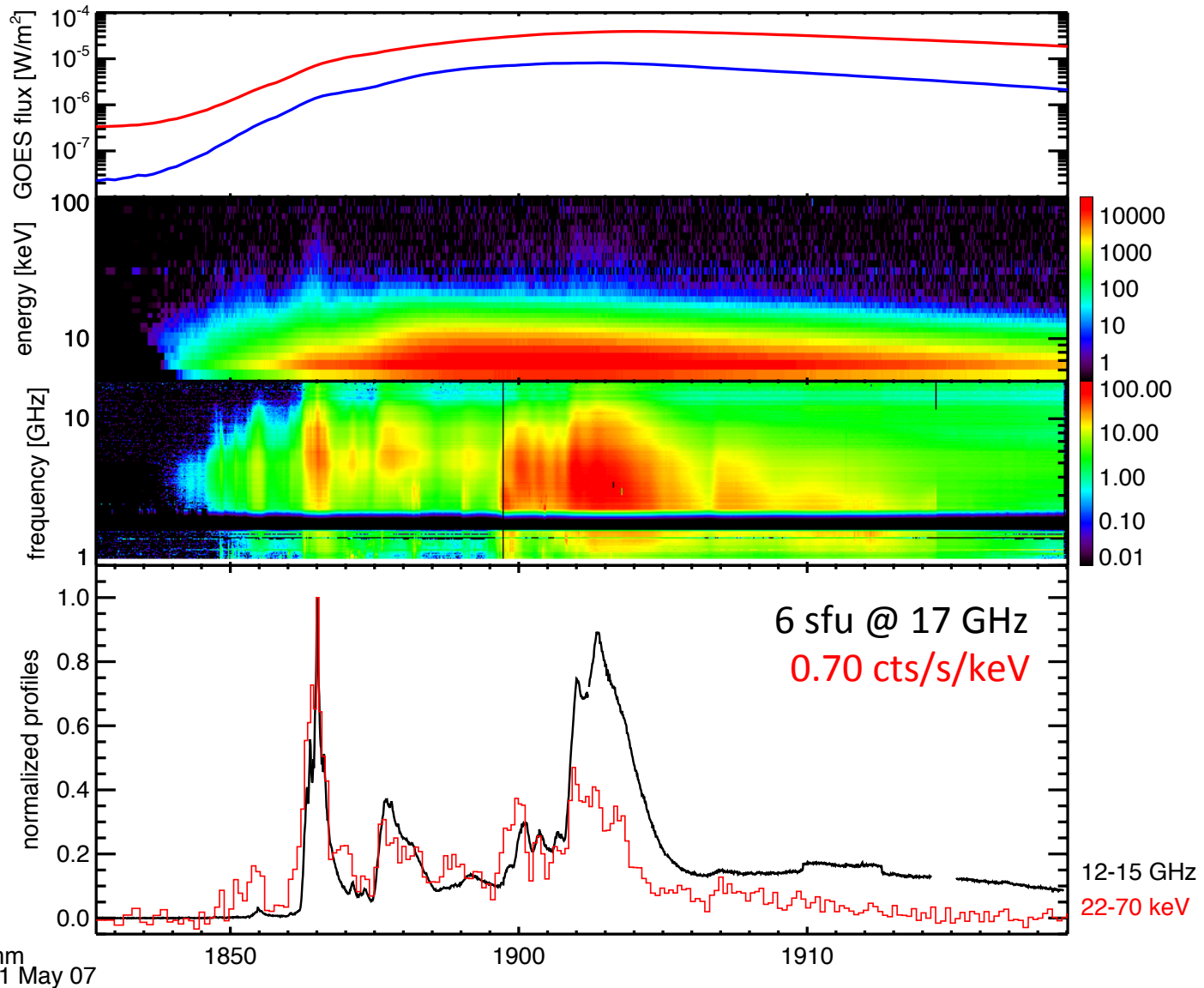
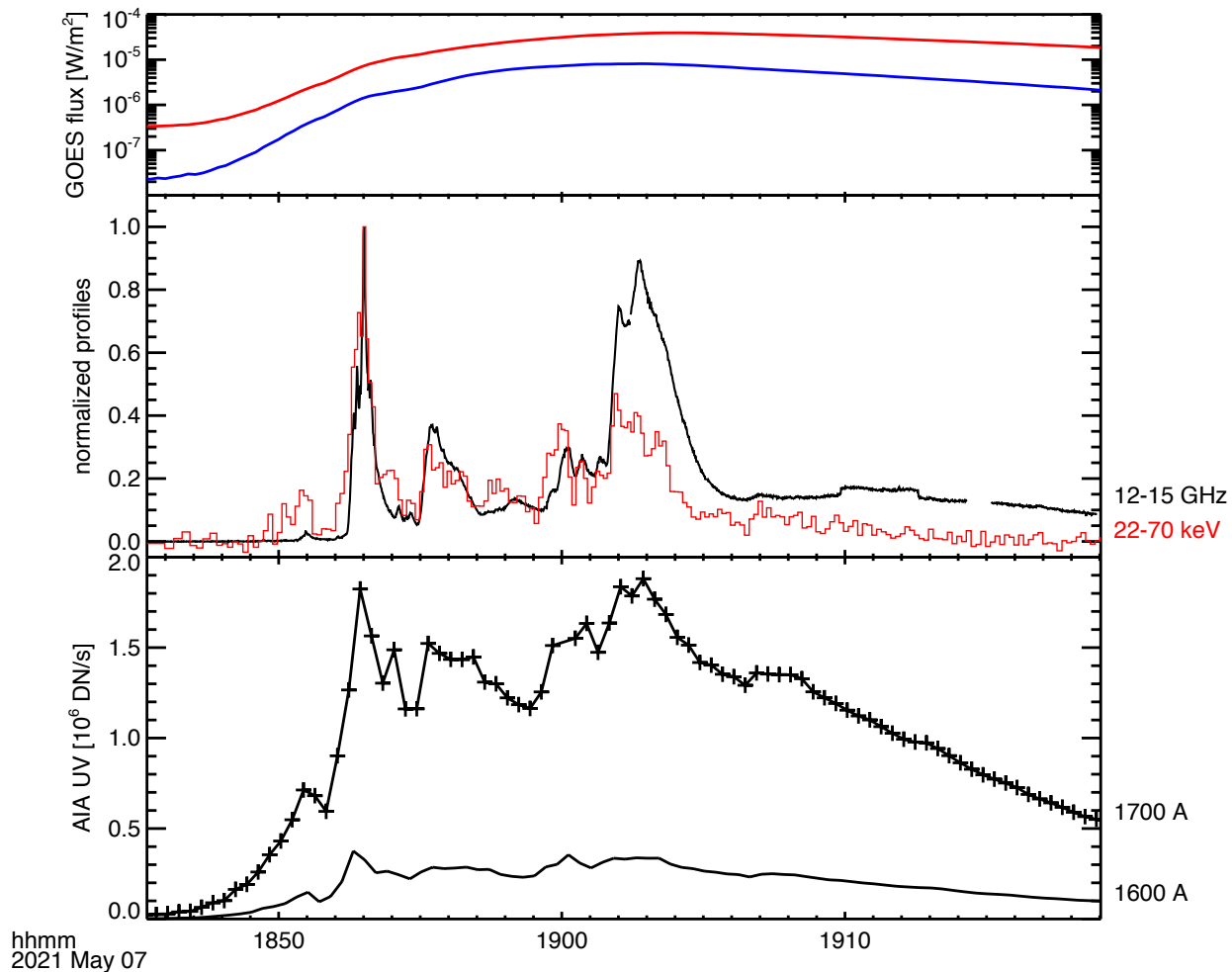Small radio peak fluxes (6 sfu @ 17 GHz), but clear temporal correlation.

6 sfu @ 17 GHz
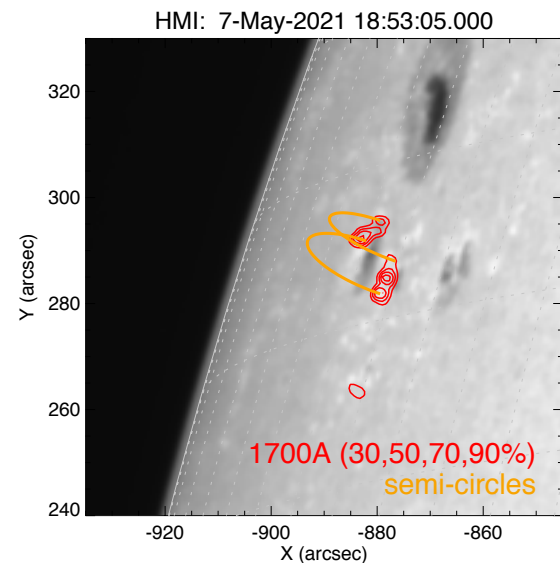0.70 cts/s/keV

12-15 GHz
22-70 keV

hhmm
2021 May 07

May 7, 2021 (GOES M4)

Envelope of highest emissions is closely related at both wavelengths.

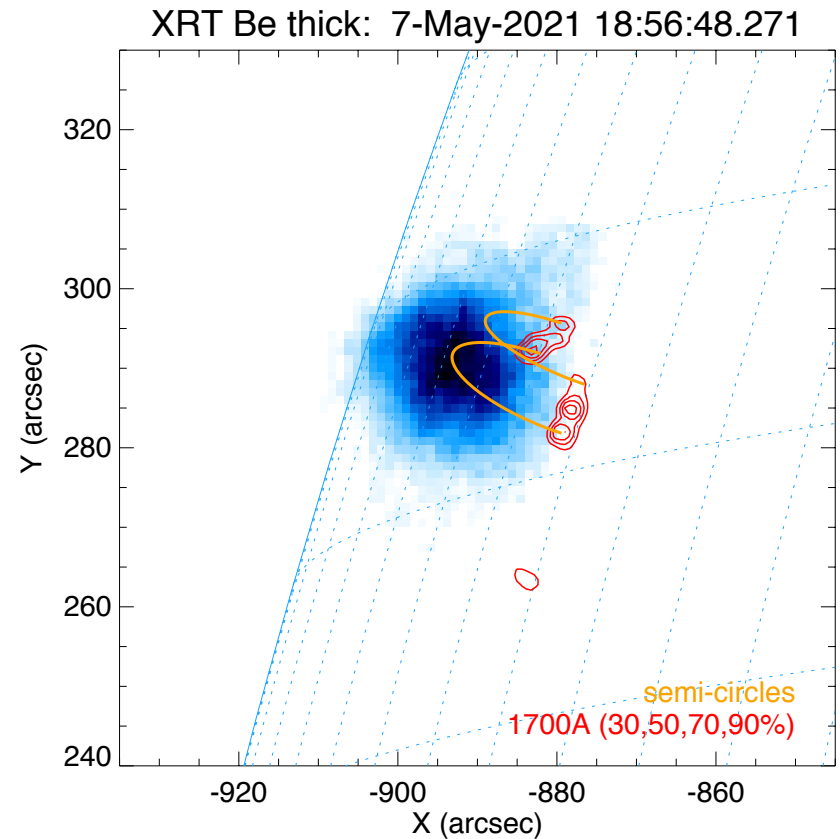5.8 sfu @ 17 GHz
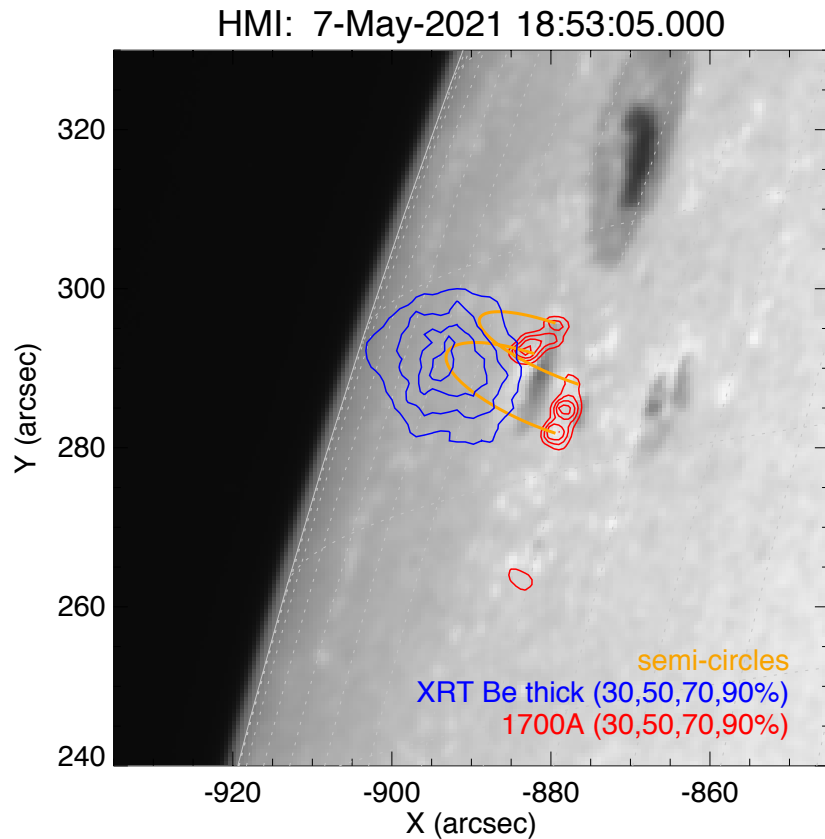0.70 cts/s/keV

12-15 GHz
22-70 keV

hhmm
2021 May 07

Spectrum at this time on next page (7 second integration time)

UV flare ribbons

HMI: 7-May-2021 18:53:05.000

1700A (30,50,70,90%)
semi-circles

1700 A: : 7-May-2021 18:53:16.717

12-15 GHz
22-70 keV

1700 A

1600 A

hhmm
2021 May 07

UV ribbons and SXR loops

HMI: 7-May-2021 18:53:05.000

XRT Be thick: 7-May-2021 18:56:48.271
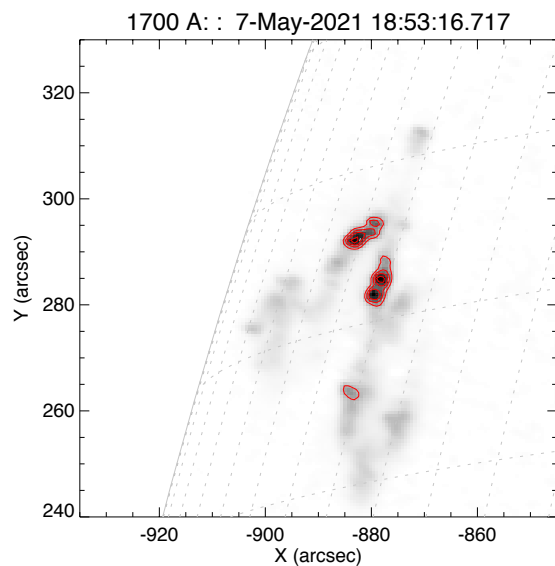
Soft X-ray emission in rough agreement with flare ribbon and semi-circles
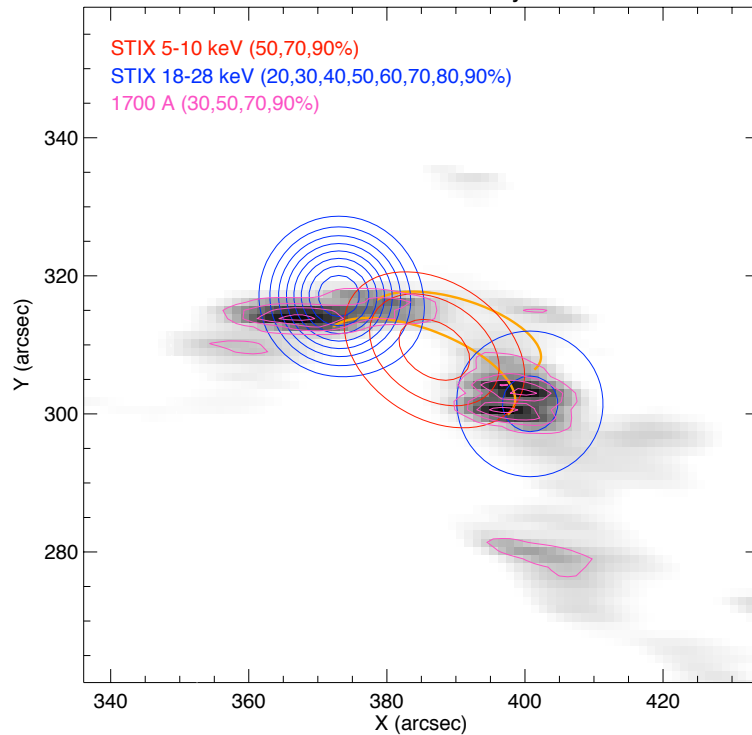
AIA is saturated, but in rough agreement.
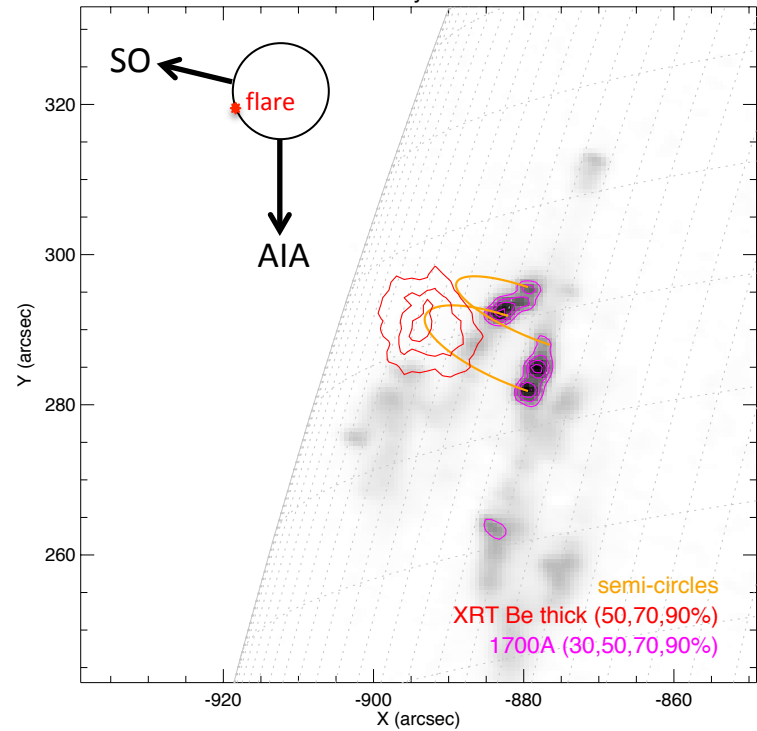
STIX imaging

Fitting STIX amplitudes only provides source sizes, orientation, and separation. STIX images have been positioned by eye to match the UV flare ribbons.
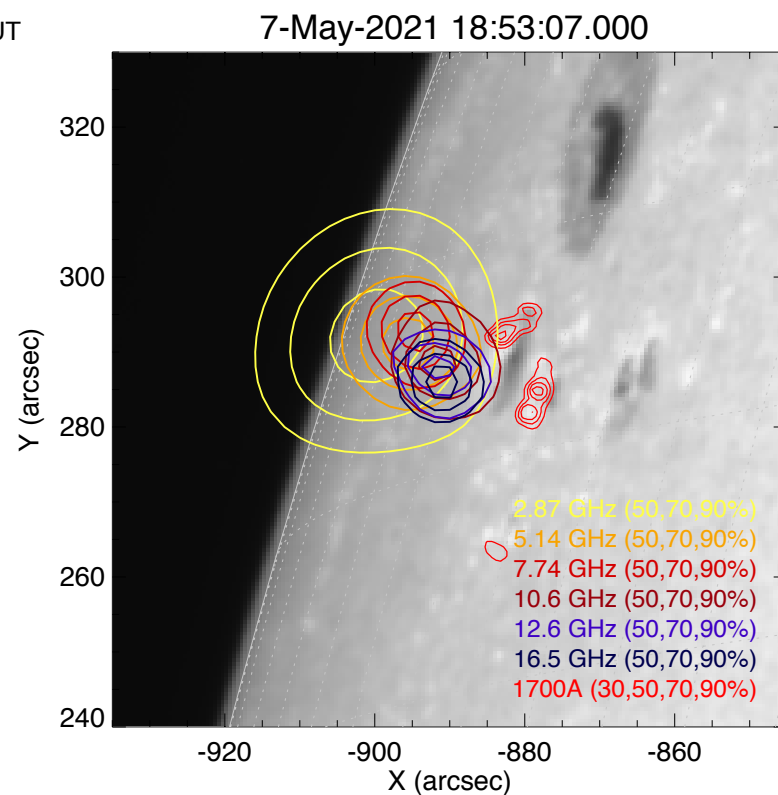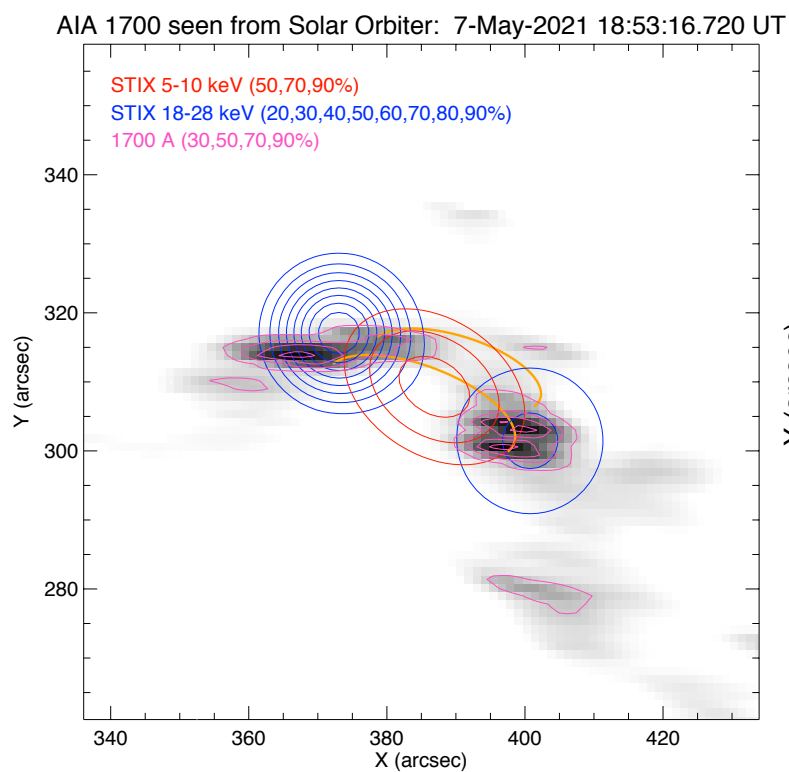
EOVSA MWs and STIX HXRs

AIA 1700 seen from Solar Orbiter: 7-May-2021 18:53:16.720 UT

STIX 5-10 keV (50,70,90%)
STIX 18-28 keV (20,30,40,50,60,70,80,90%)
1700 A (30,50,70,90%)

7-May-2021 18:53:07.000

2.87 GHz (50,70,90%)
5.14 GHz (50,70,90%)
7.74 GHz (50,70,90%)
10.6 GHz (50,70,90%)
12.6 GHz (50,70,90%)
16.5 GHz (50,70,90%)
1700A (30,50,70,90%)

Thanks to everybody
who made STIX a success!