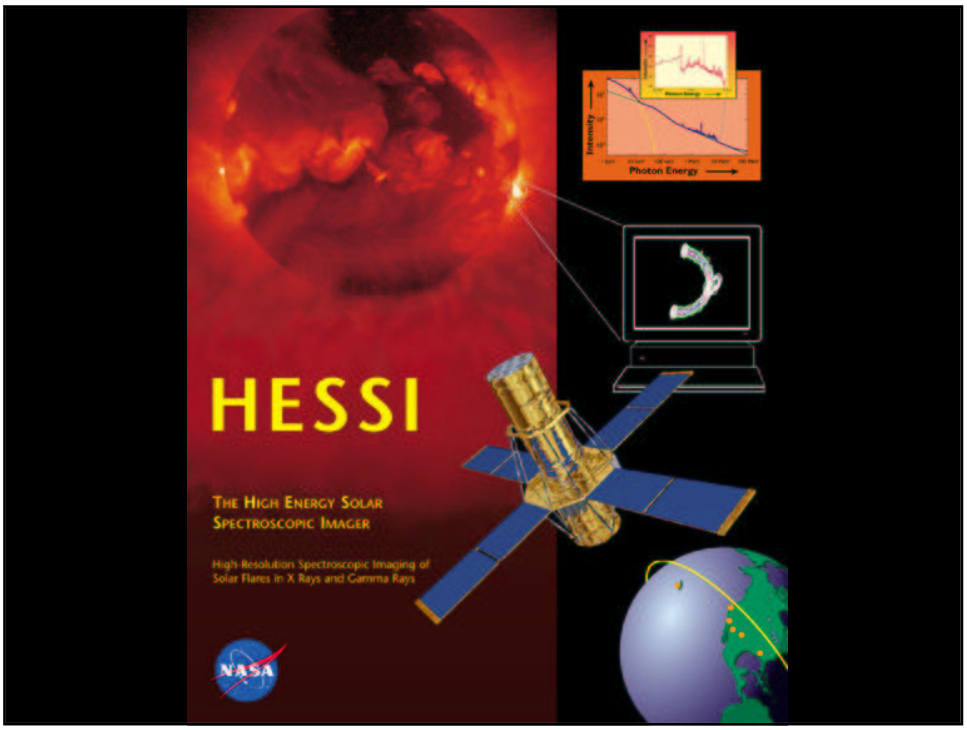


* ***The Sun is the most powerful particle accelerator in the solar system***

  Ions up to ~ 10s of GeV

  Electrons up to ~100s of MeV

* ***Solar Flares – the most powerful explosions in the solar system***

  Releases up to ~ 1032 - 1033 ergs in ~ 10 – 103 seconds

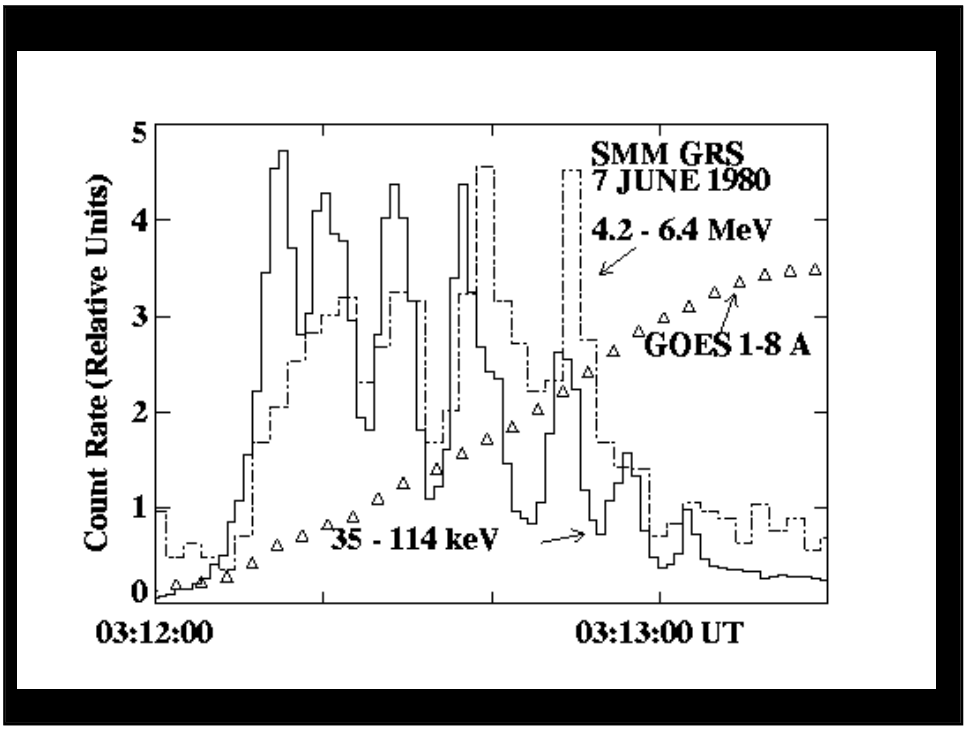
  Flare-accelerated ~10-100 keV electrons contain ~10-50% of energy released, and >~1MeV ions may contain comparable energy

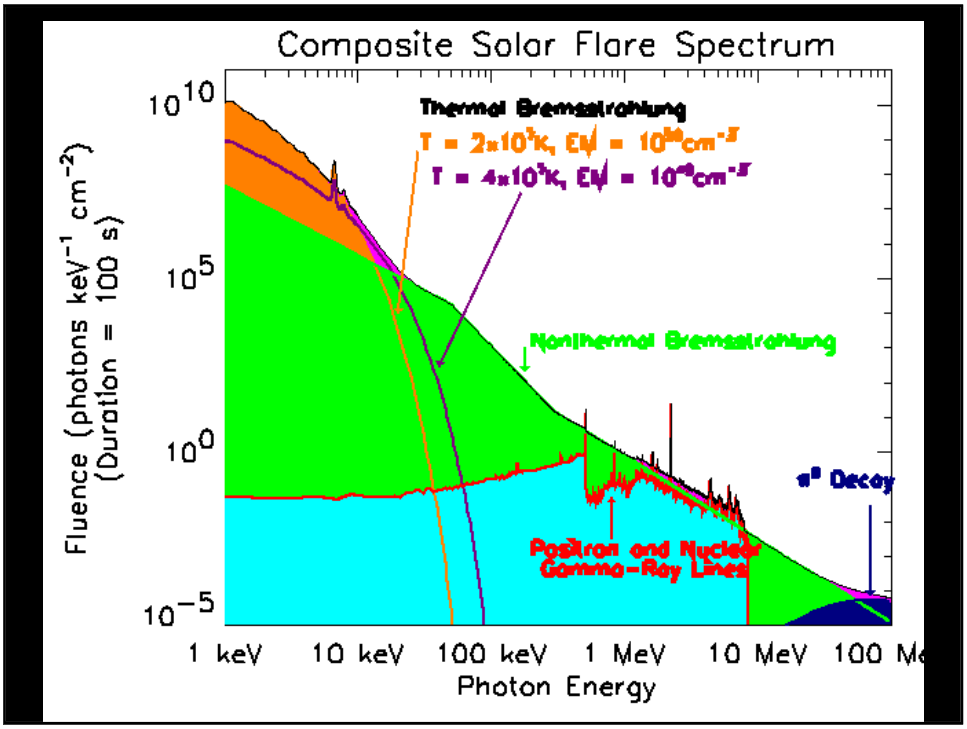
  => Acceleration is intimately related to flare energy release

* ***Fast (>~700 km/s) Coronal Mass Ejections (CMEs)***

  CMEs eject ~ 1015 –1016 g from Sun

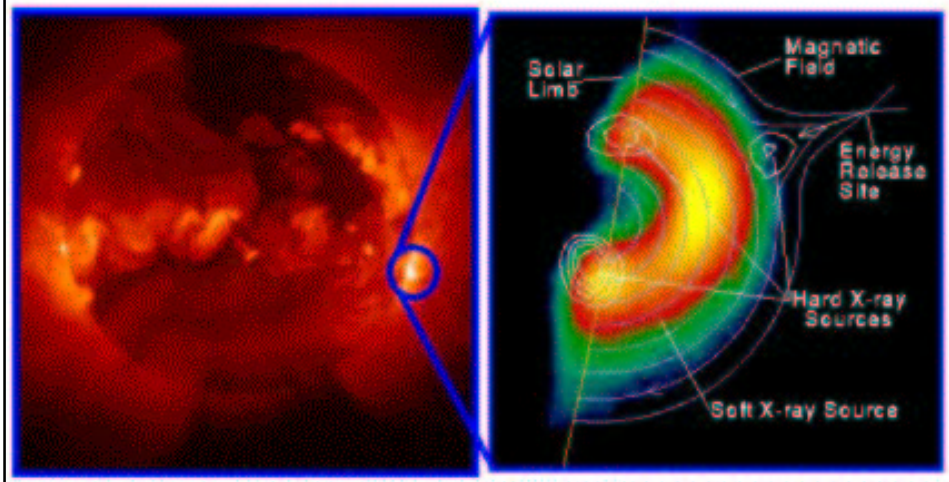
  CME shocks appear to accelerate particles in large solar energetic particle L(SEP) events observed in the interplanetary medium


SMM GRS
7 JUNE 1980
4.2 - 6.4 MeV
GOES 1-8 A
35 - 114 keV
Count Rate (Relative Units)
0
1
2
3
4
5
03:12:00
03:13:00 UT


Composite Solar Flare Spectrum
Thermal Bremsstrahlung
Nonthermal Bremsstrahlung
π⁰ Decay
Positron and Nuclear Gamma-Ray Lines
Fluence (photons keV⁻¹ cm⁻²)
(Duration = 100 s)
10¹⁰
10⁵
10⁰
10⁻⁵
1 keV
10 keV
100 keV
1 MeV
10 MeV
Photon Energy

- ~ 10^{32} ergs in ~ 10^{3} seconds = ~10^{29} ergs/s
- => ~10^{36} electrons/s!! => empty entire flare loop
- => ~10^{17} amps!!

What about thermal emission from confined ~10^{8} K plasma?



Yohkoh X-ray Image of a Solar Flare. Combined Image in Soft X-rays (left) and Soft X-rays with Hard X-ray Contours (right). Jan 13, 1992.

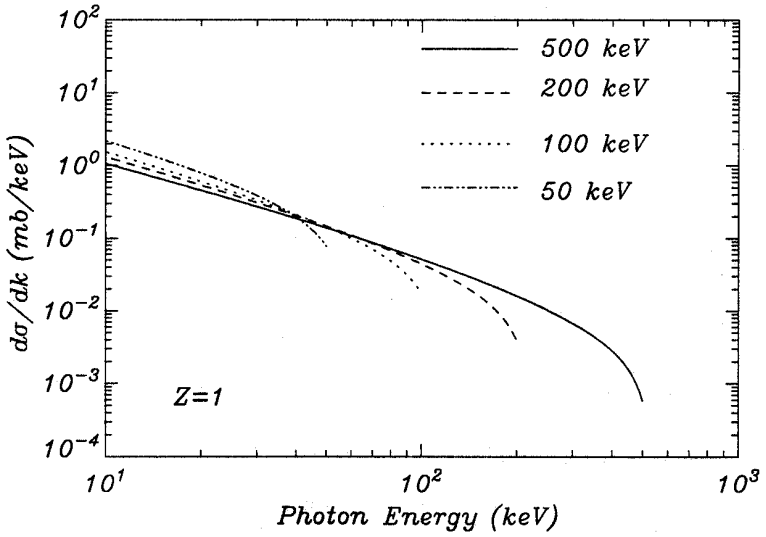
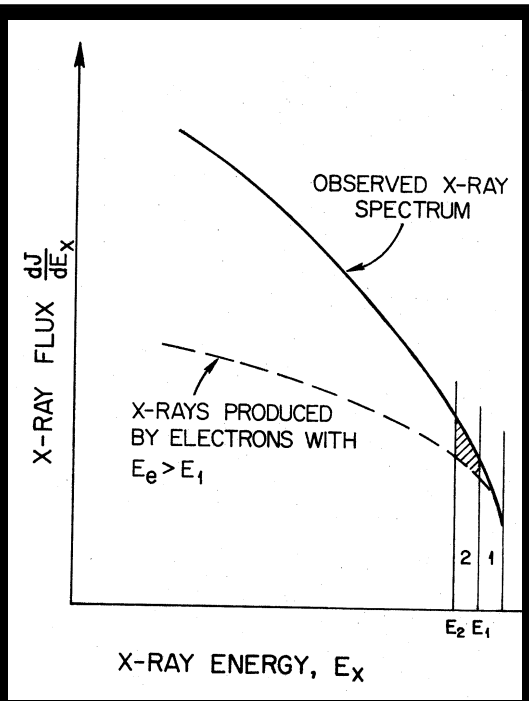


Fig. 2. Differential bremsstrahlung cross sections $d\sigma/dk$ for incident electron energies of 50, 100, 200, and 500 keV. Equations (16) through (19) have been used with the extrapolation at photon energies near the electron energy.



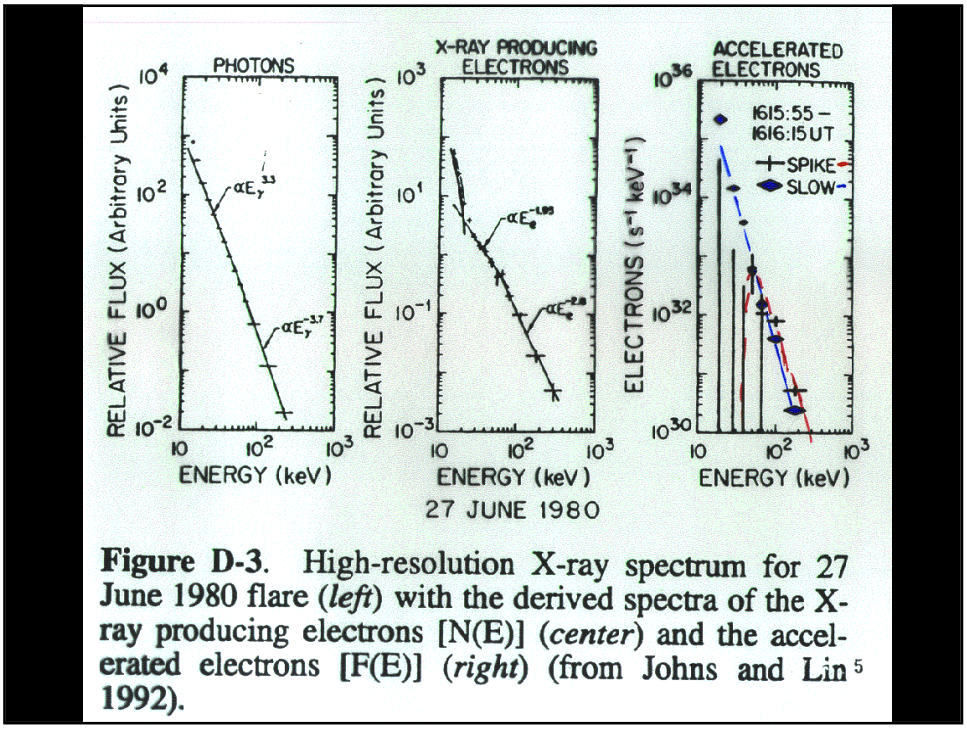
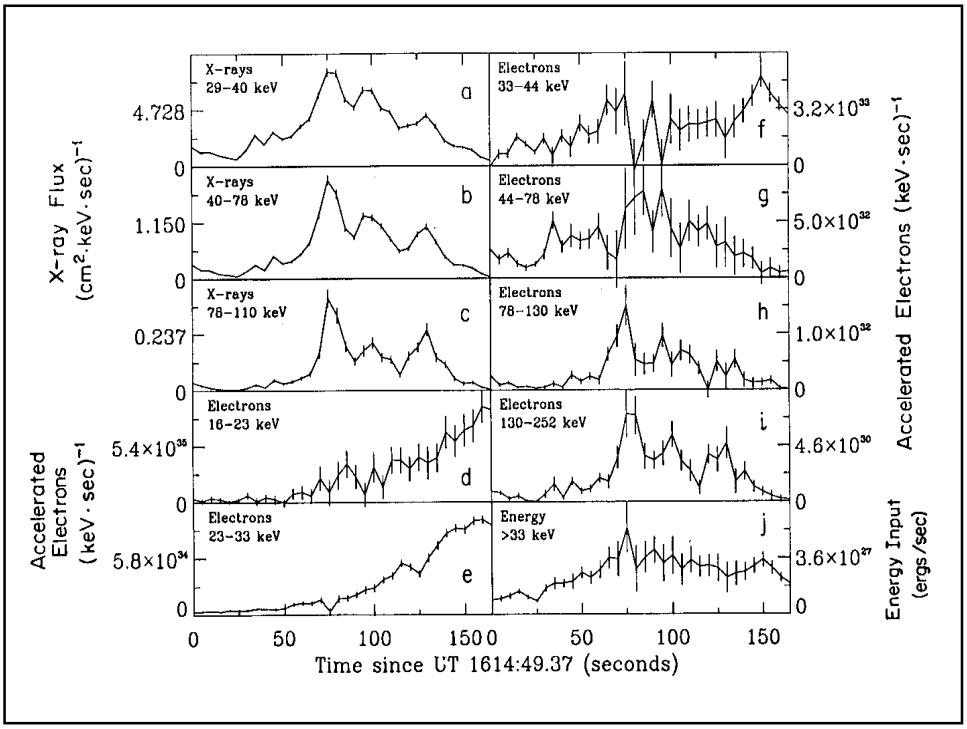
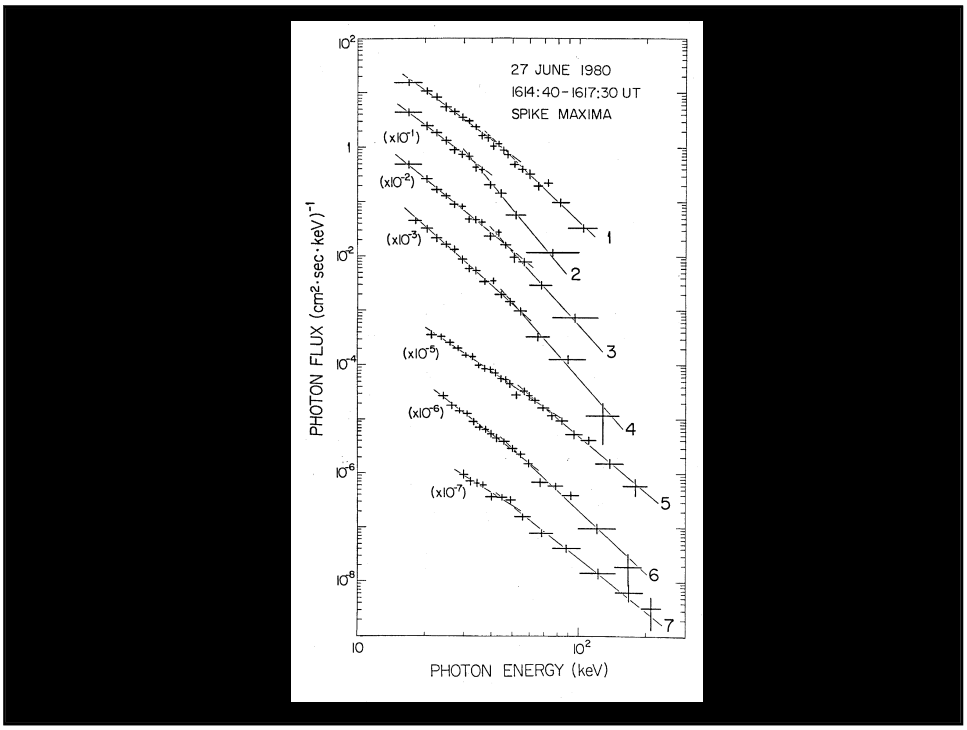
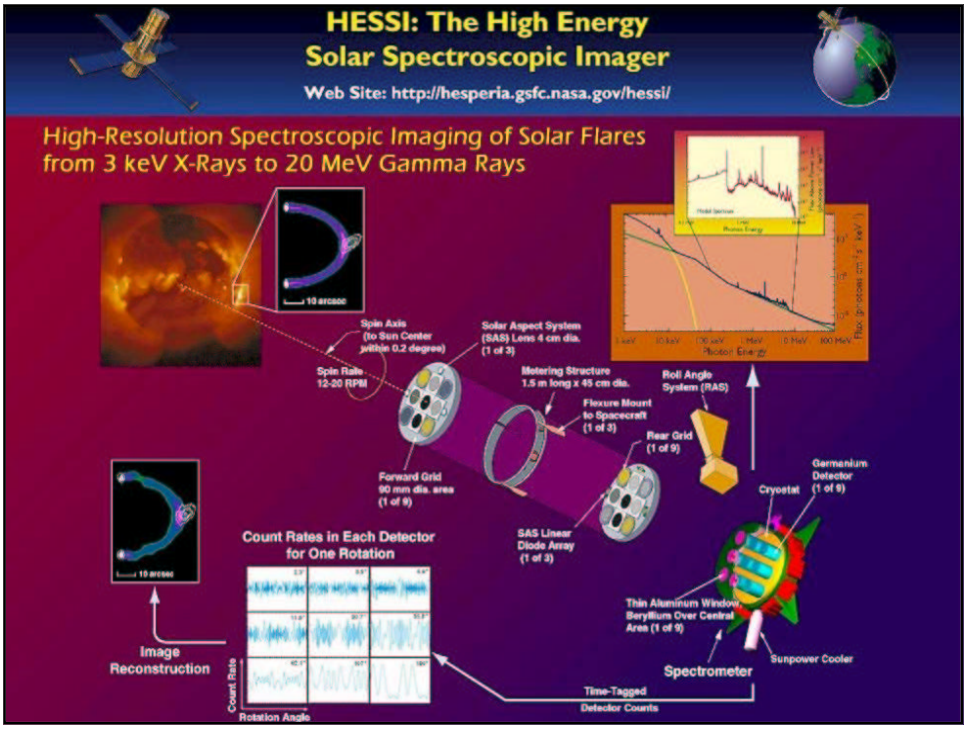
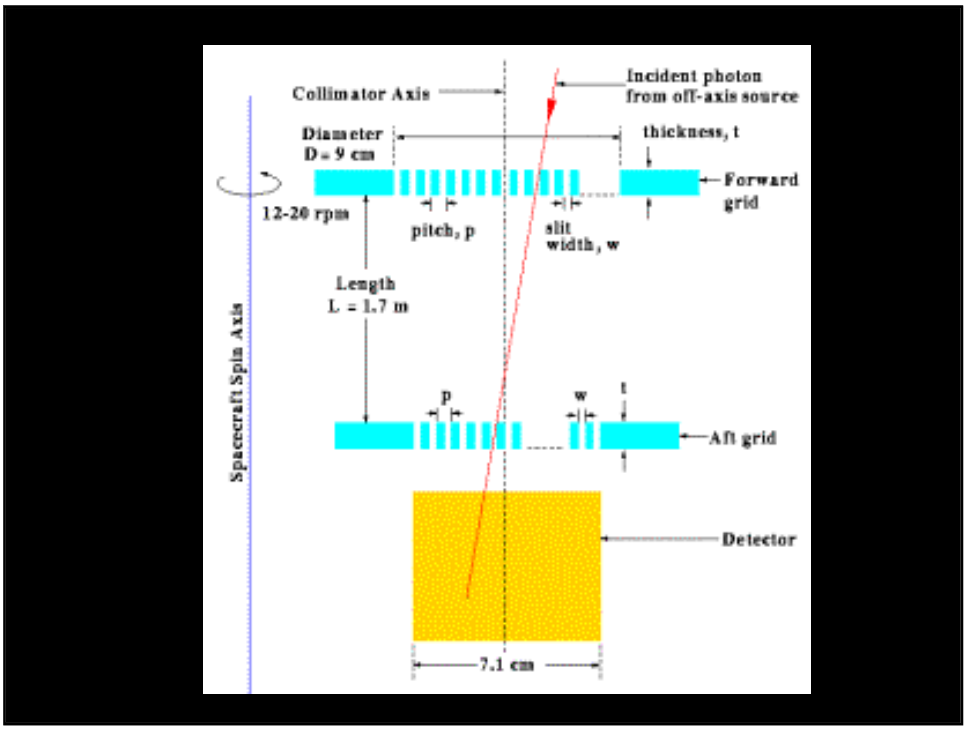


Figure D-3. High-resolution X-ray spectrum for 27 June 1980 flare (*left*) with the derived spectra of the X-ray producing electrons [N(E)] (*center*) and the accelerated electrons [F(E)] (*right*) (from Johns and Lin 1992).[5]

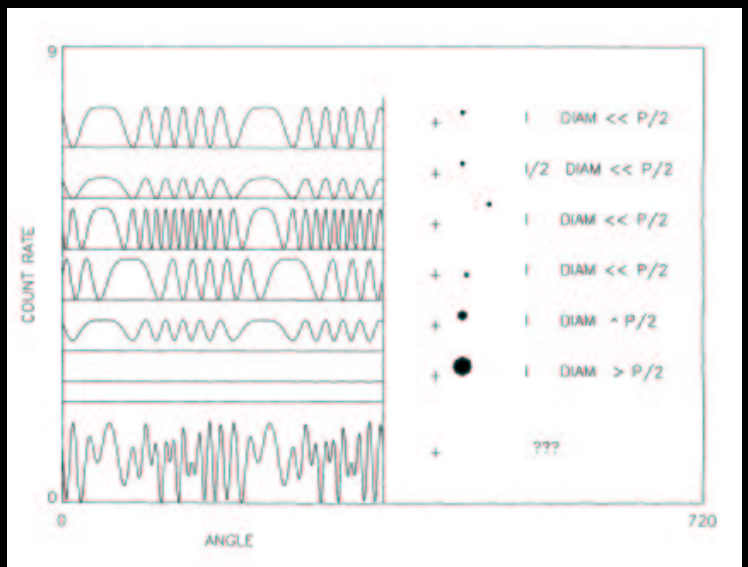


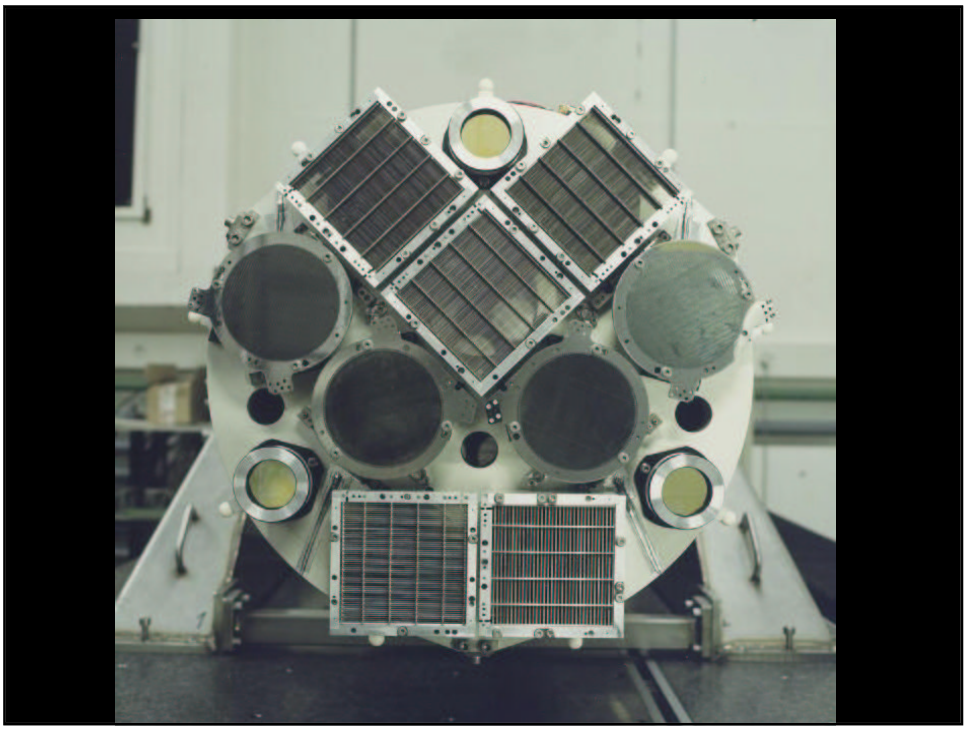

27 JUNE 1980
1614:40 - 1617:30 UT
SPIKE MAXIMA
PHOTON FLUX (cm²·sec·keV)⁻¹
PHOTON ENERGY (keV)
(x10⁻¹)
(x10⁻²)
(x10⁻³)
(x10⁻⁵)
(x10⁻⁶)
(x10⁻⁷)
1
2
3
4
5
6
7


HESSI: The High Energy
Solar Spectroscopic Imager
Web Site: http://hesperia.gsfc.nasa.gov/hessi/
High-Resolution Spectroscopic Imaging of Solar Flares
from 3 keV X-Rays to 20 MeV Gamma Rays
10 arcsec
Spin Axis
(to Sun Center
within 0.2 degree)
Spin Rate
12-20 RPM
Solar Aspect System
(SAS) Lens 4 cm dia.
(1 of 3)
Metering Structure
1.5 m long x 45 cm dia.
Flexure Mount
to Spacecraft
(1 of 3)
Roll Angle
System (RAS)
Rear Grid
(1 of 9)
Forward Grid
90 mm dia. area
(1 of 9)
Germanium
Detector
(1 of 9)
Cryostat
SAS Linear
Diode Array
(1 of 3)
Count Rates in Each Detector
for One Rotation
Count Rate
Rotation Angle
Image
Reconstruction
Thin Aluminum Window
Beryllium Over Central
Area (1 of 9)
Sunpower Cooler
Spectrometer
Time-Tagged
Detector Counts

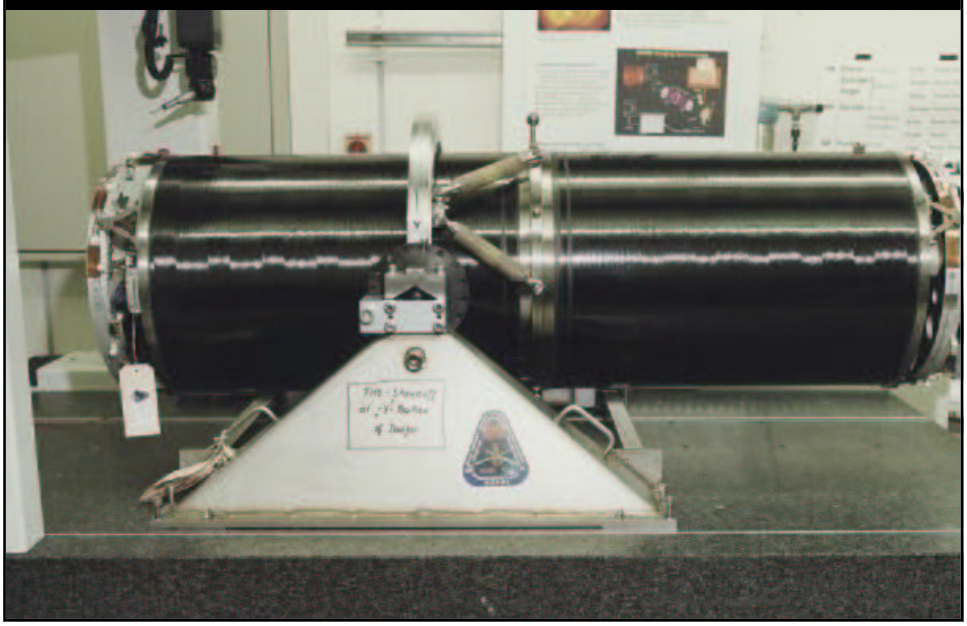


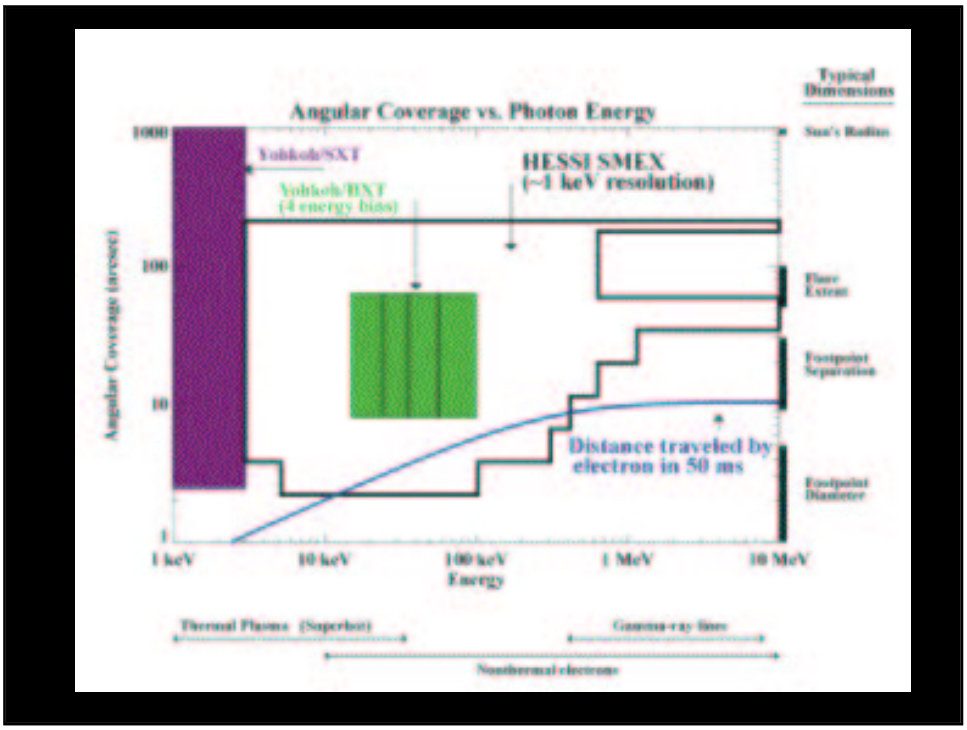
Modulation Patterns

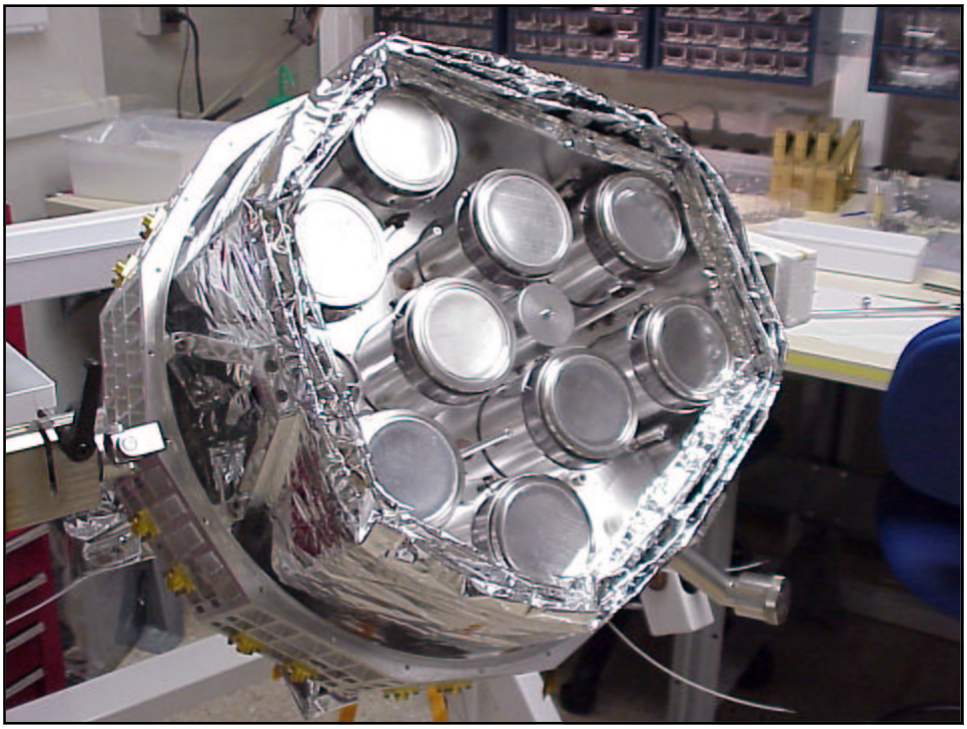


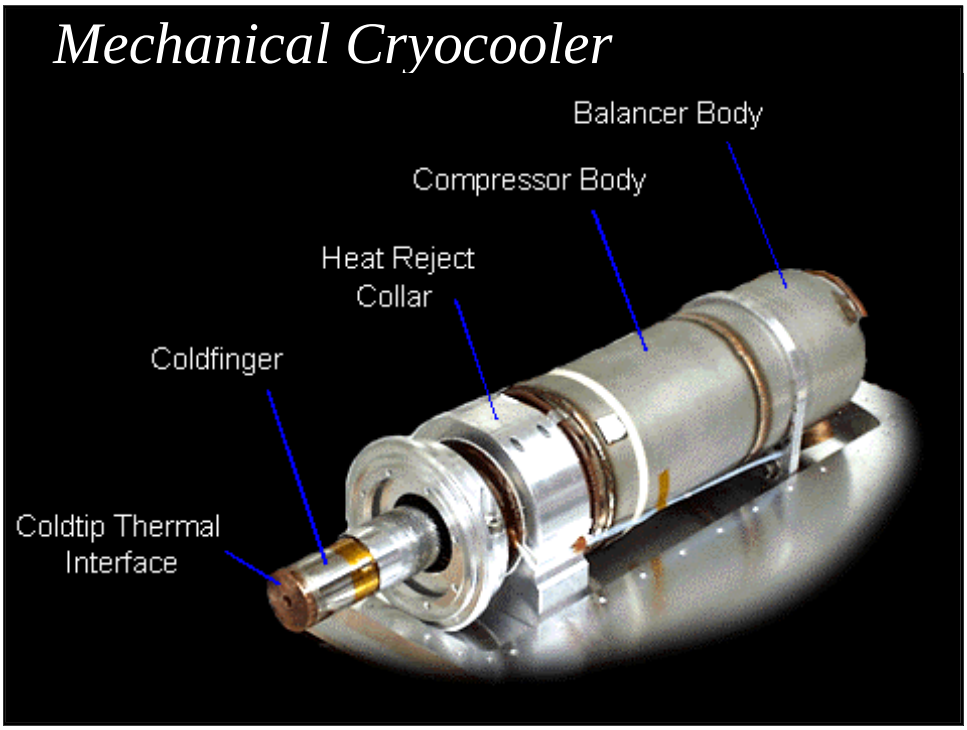


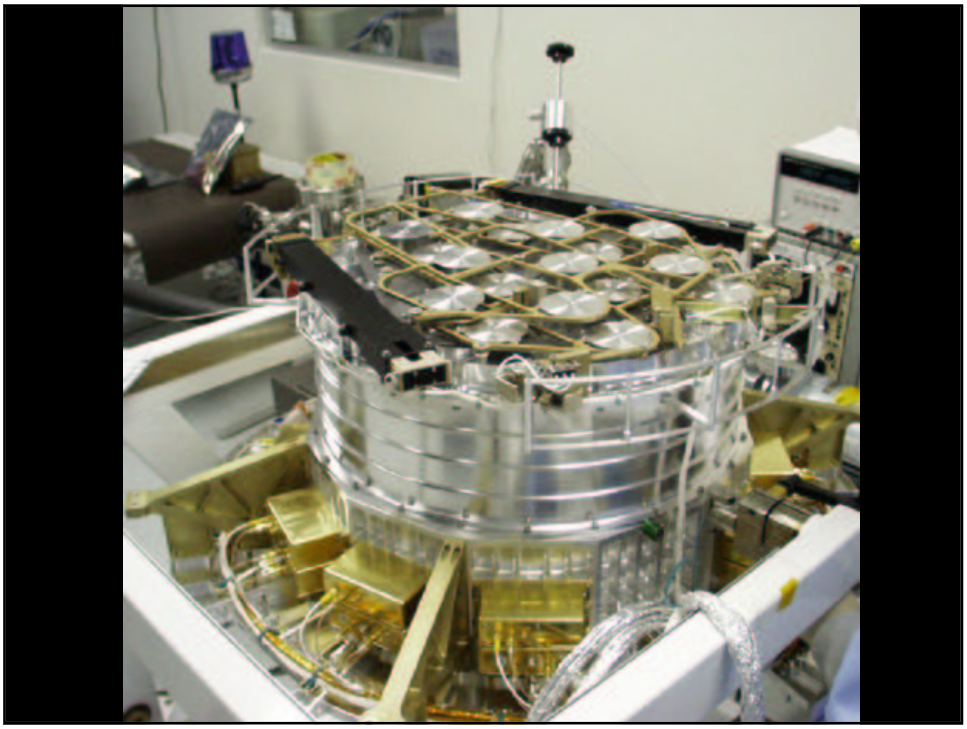
Imager – side view

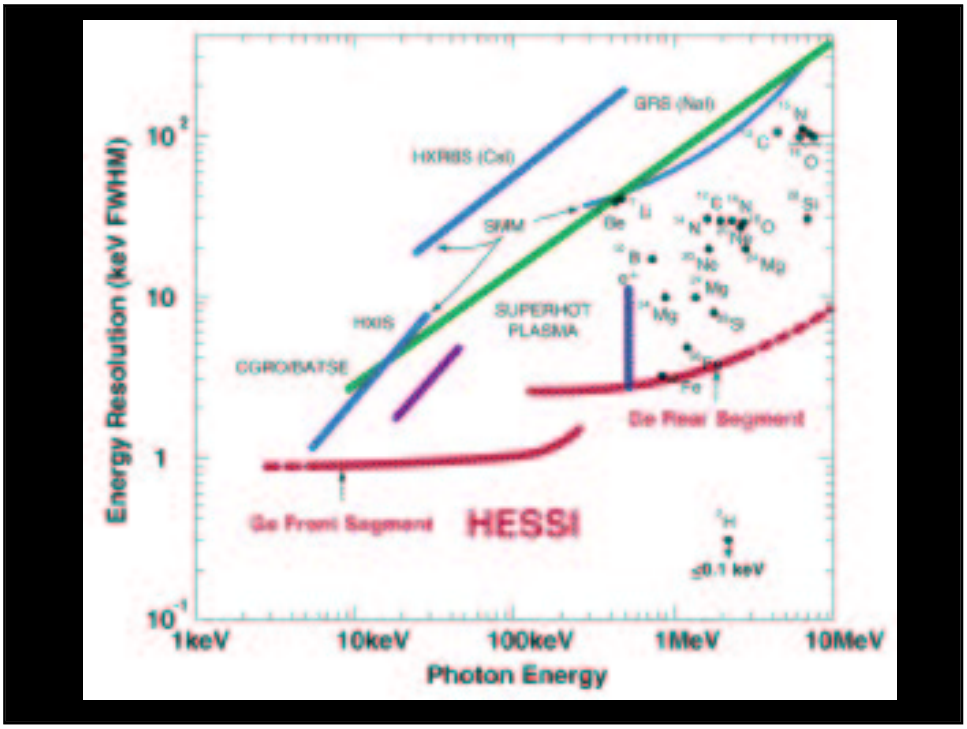


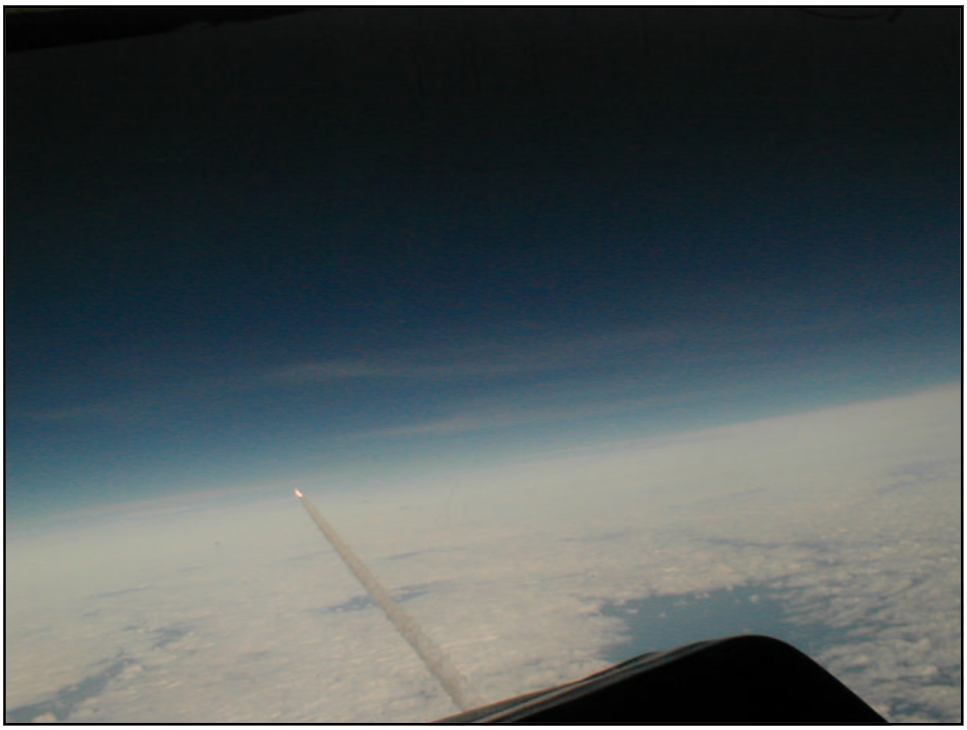

Angular Coverage vs. Photon Energy
Typical Dimensions
Sun's Radius
Yohkoh/SXT
Yohkoh/HXT
(4 energy bins)
HESSI SMEX
(~1 keV resolution)
Flare Extent
Footpoint Separation
Distance traveled by electron in 50 ms
Footpoint Diameter
Angular Coverage (arcsec)
1000
100
10
1
1 keV
10 keV
100 keV
1 MeV
10 MeV
Energy
Thermal Plasma (Superhot)
Gamma-ray lines
Nonthermal electrons

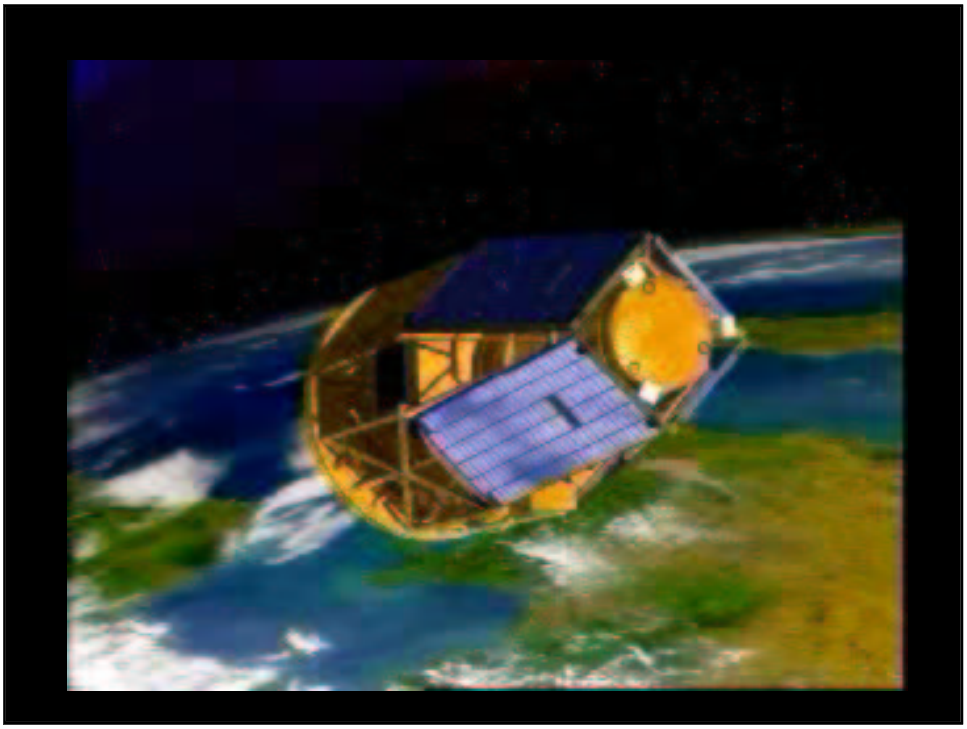


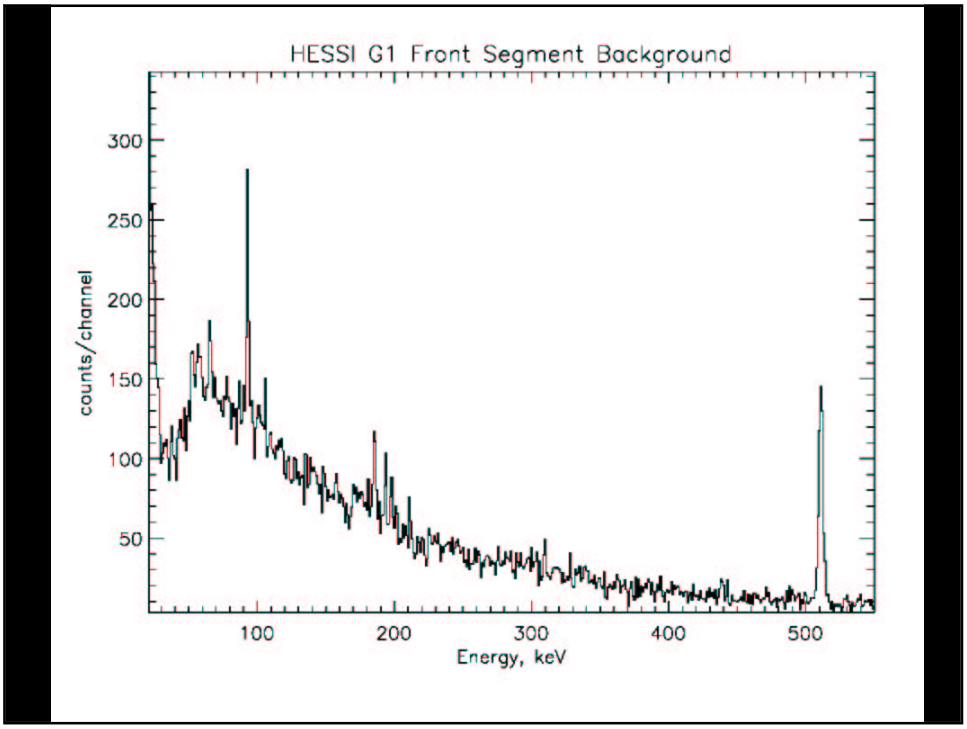

Mechanical Cryocooler
Balancer Body
Compressor Body
Heat Reject
Collar
Coldfinger
Coldtip Thermal
Interface

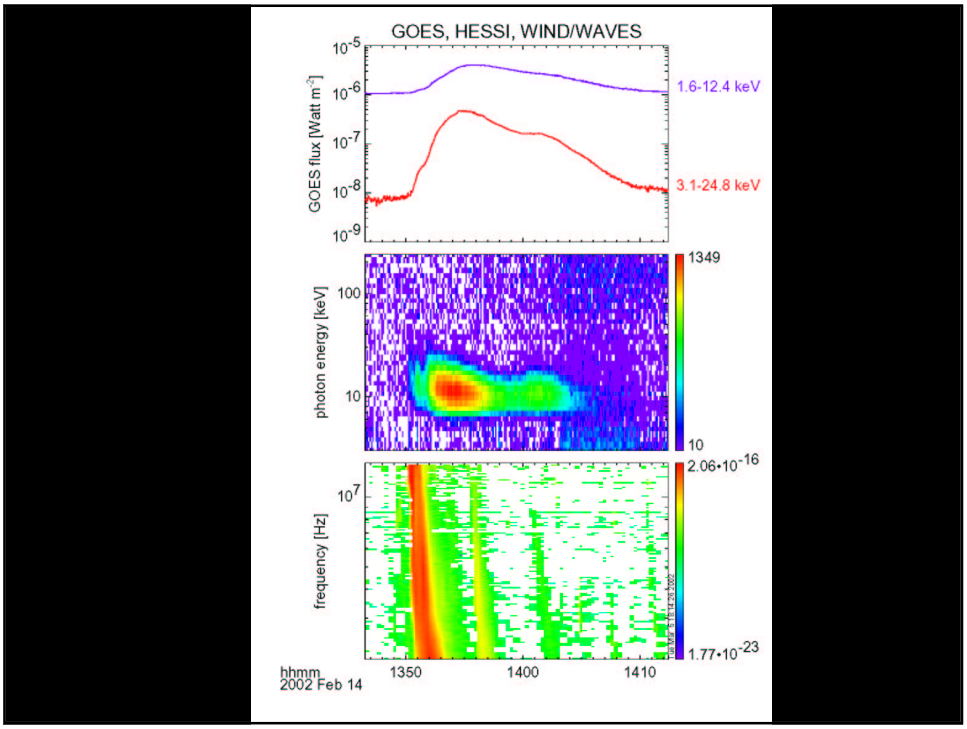


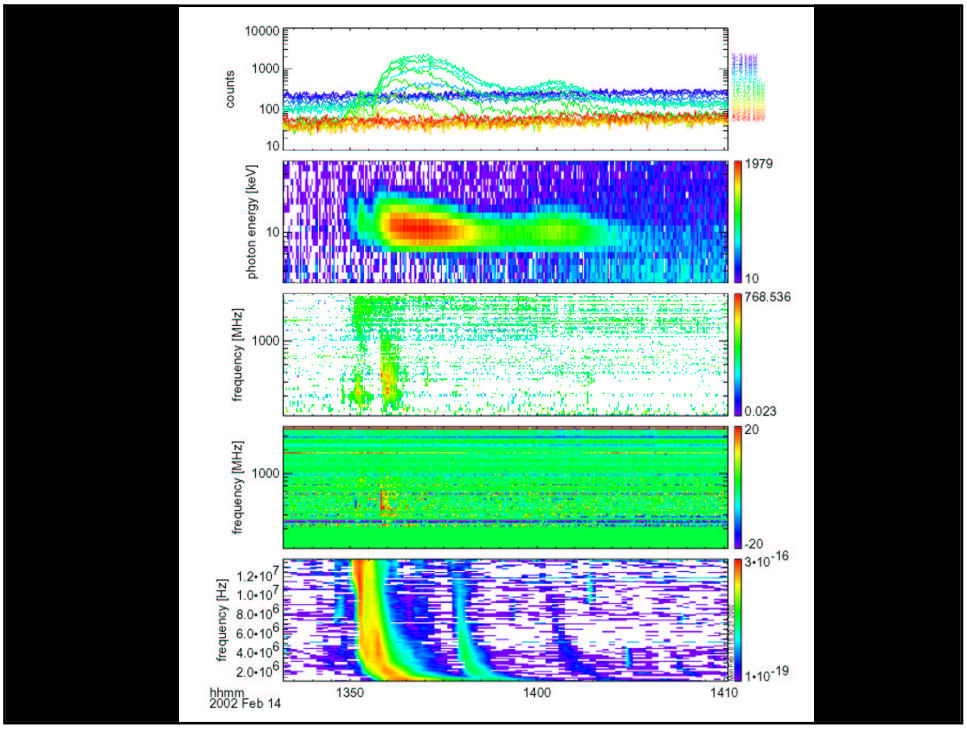

Energy Resolution (keV FWHM)
10^2
10
1
10^{-1}
1keV
10keV
100keV
1MeV
10MeV
Photon Energy
GRS (NaI)
HXRBS (CsI)
SMM
HXIS
CGRO/BATSE
SUPERHOT PLASMA
Ge Rear Segment
Ge Front Segment
HESSI
≤0.1 keV

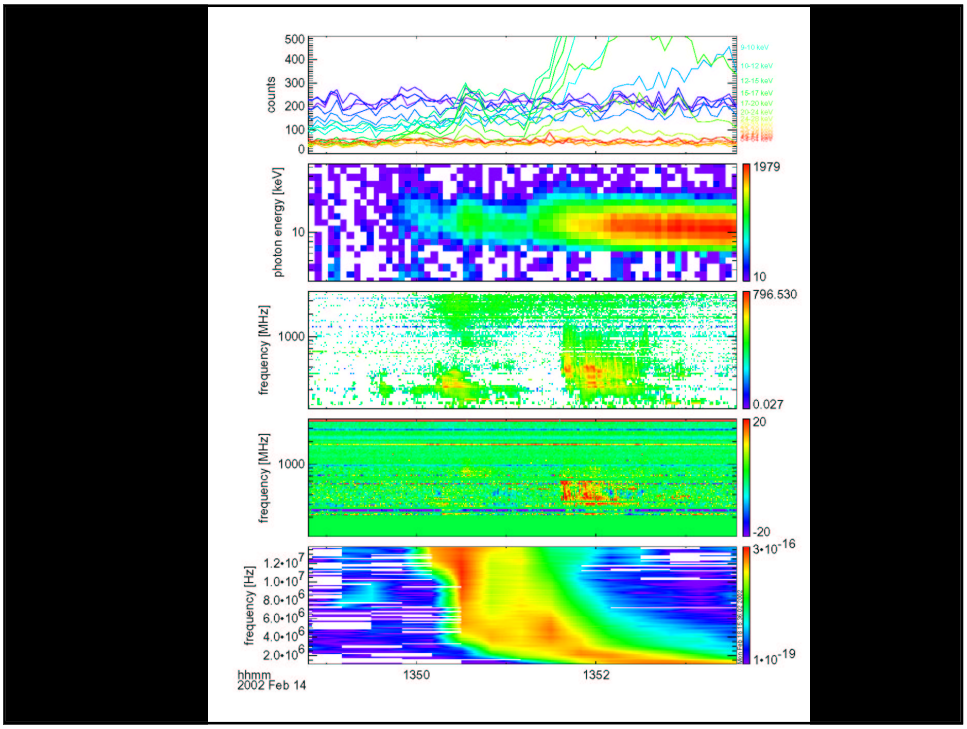


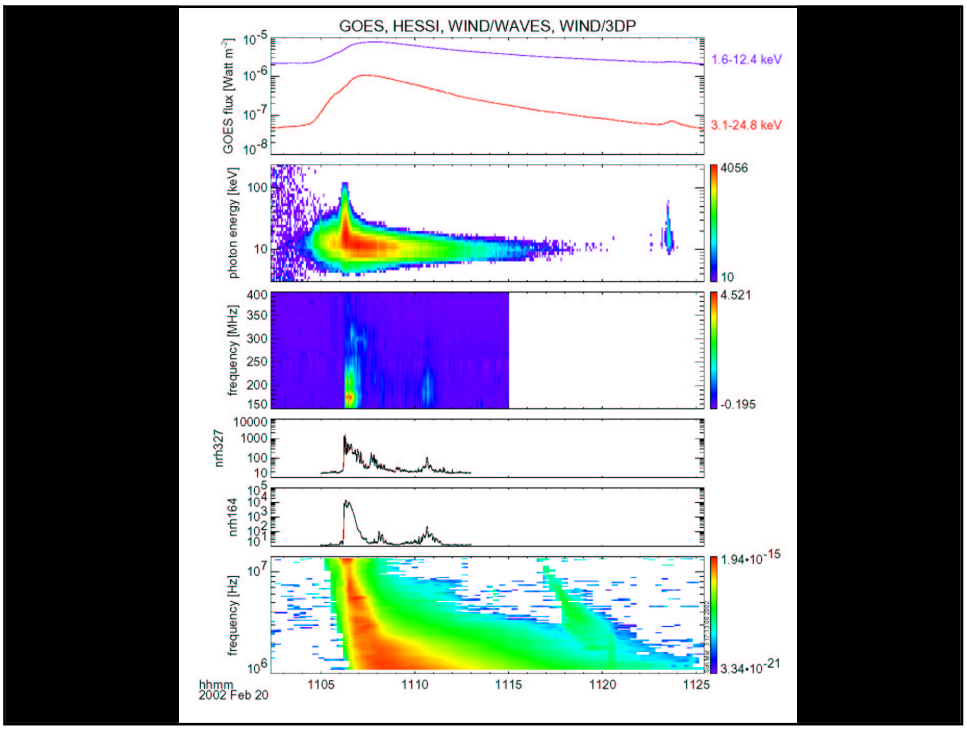


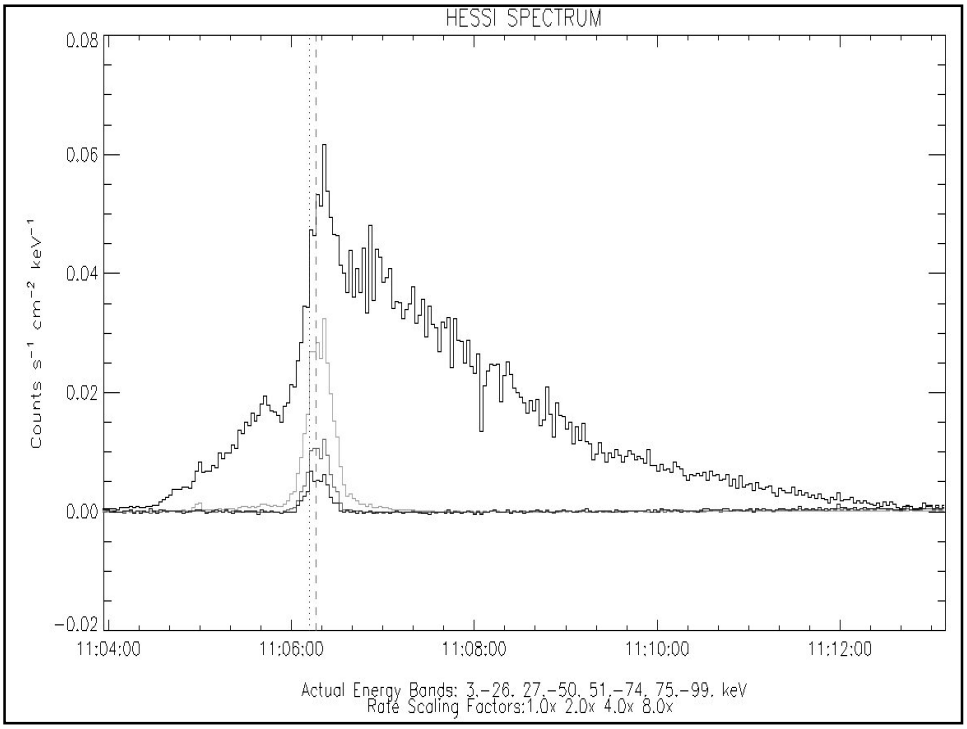

HESSI G1 Front Segment Background
counts/channel
300
250
200
150
100
50
100
200
300
400
500
Energy, keV

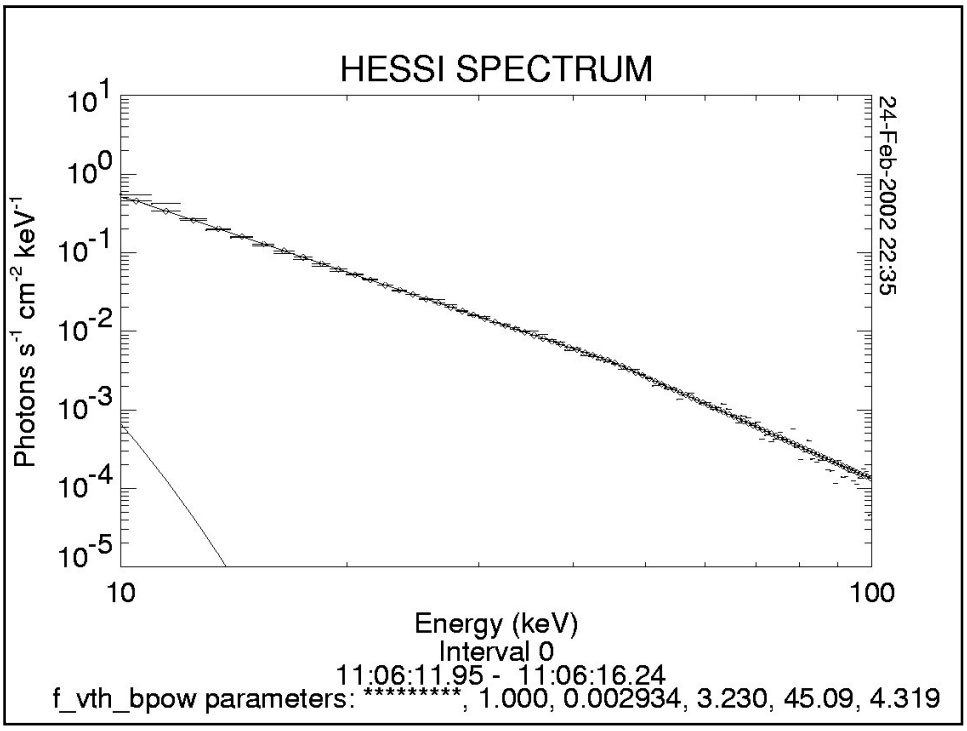

GOES, HESSI, WIND/WAVES
GOES flux [Watt m⁻²]
1.6-12.4 keV
3.1-24.8 keV
photon energy [keV]
1349
10
frequency [Hz]
2.06•10⁻¹⁶
1.77•10⁻²³
hhmm
2002 Feb 14
1350
1400
1410

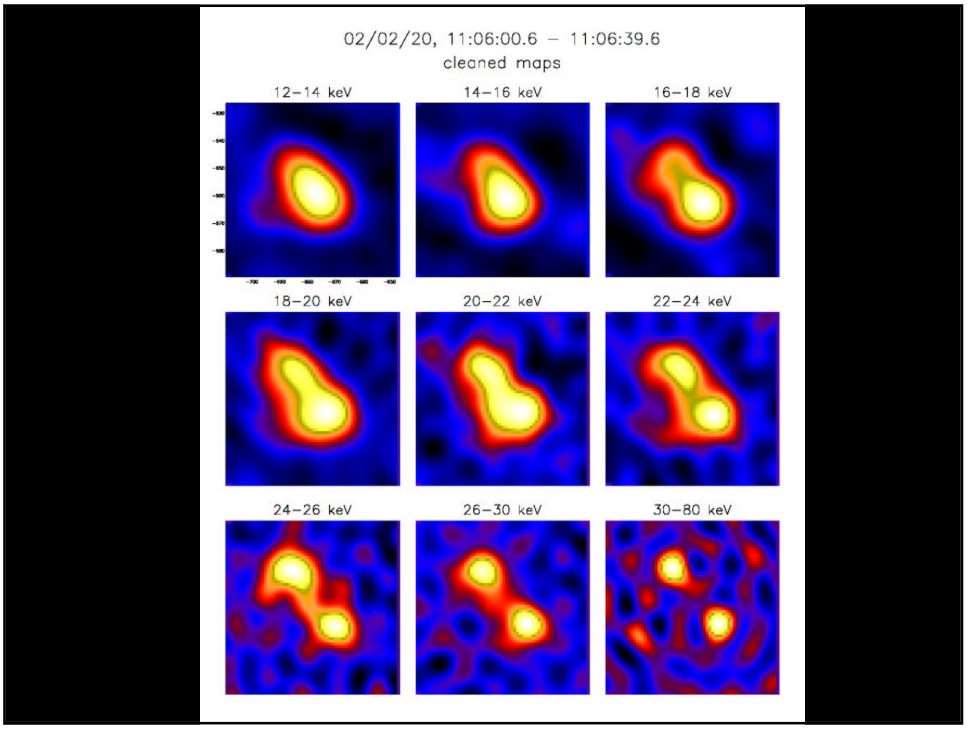

counts
10000
1000
100
10
photon energy [keV]
1979
10
frequency [MHz]
768.536
0.023
20
-20
3•10-16
1•10-19
frequency [Hz]
1.2•10^7
1.0•10^7
8.0•10^6
6.0•10^6
4.0•10^6
2.0•10^6
hhmm
2002 Feb 14
1350
1400
1410

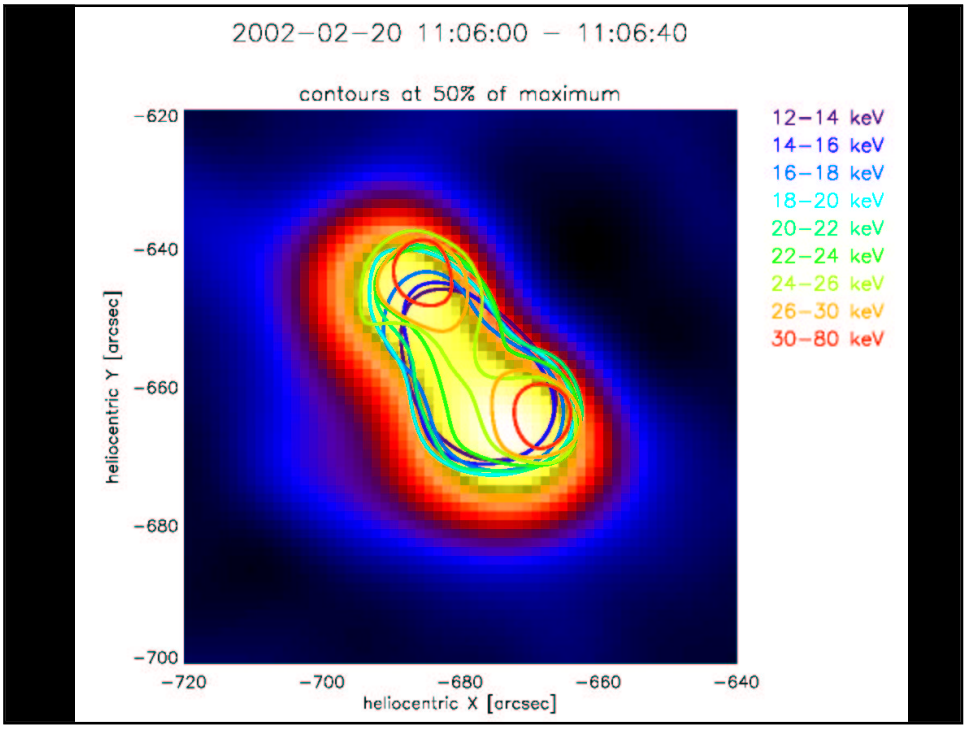

counts
500
400
300
200
100
0
photon energy [keV]
1979
10
frequency [MHz]
796.530
0.027
20
-20
3•10-16
1•10-19
frequency [Hz]
1.2•10^7
1.0•10^7
8.0•10^6
6.0•10^6
4.0•10^6
2.0•10^6
hhmm
2002 Feb 14
1350
1352

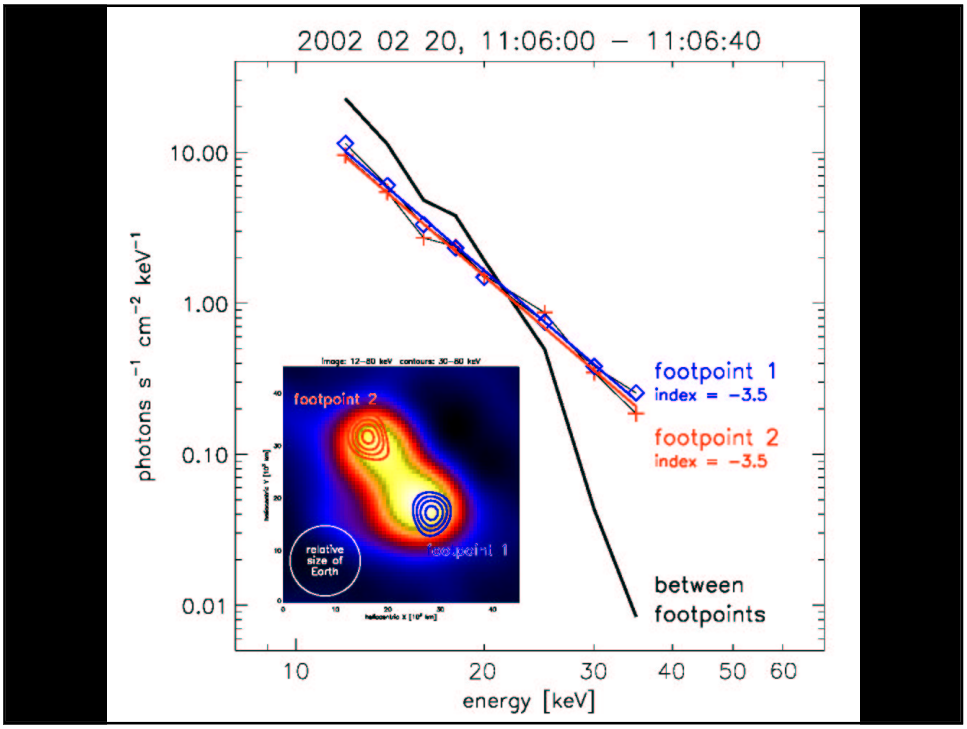

GOES, HESSI, WIND/WAVES, WIND/3DP
GOES flux [Watt m⁻²]
1.6-12.4 keV
3.1-24.8 keV
photon energy [keV]
4056
10
frequency [MHz]
4.521
-0.195
nrh327
nrh164
frequency [Hz]
1.94•10⁻¹⁵
3.34•10⁻²¹
hhmm
2002 Feb 20
1105
1110
1115
1120
1125

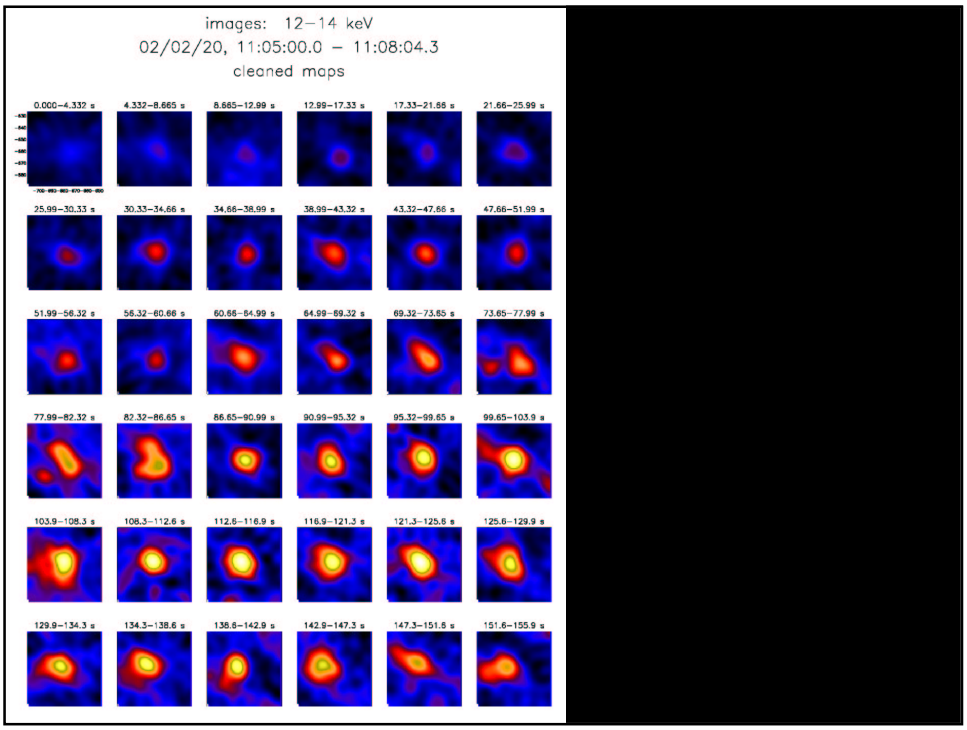

HESSI SPECTRUM
Counts s⁻¹ cm⁻² keV⁻¹
0.08
0.06
0.04
0.02
0.00
-0.02
11:04:00
11:06:00
11:08:00
11:10:00
11:12:00
Actual Energy Bands: 3.-26. 27.-50. 51.-74. 75.-99. keV
Rate Scaling Factors:1.0x 2.0x 4.0x 8.0x

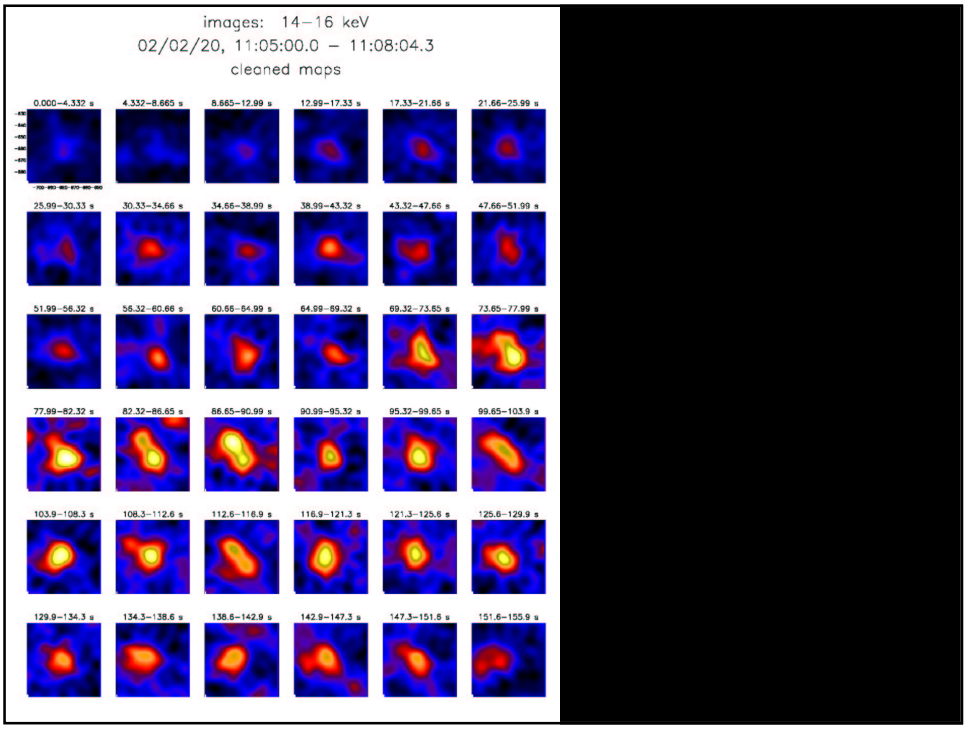

HESSI SPECTRUM
Photons s^{-1} cm^{-2} keV^{-1}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
Energy (keV)
24-Feb-2002 22:35
Interval 0
11:06:11.95 - 11:06:16.24
f_vth_bpow parameters: *********, 1.000, 0.002934, 3.230, 45.09, 4.319

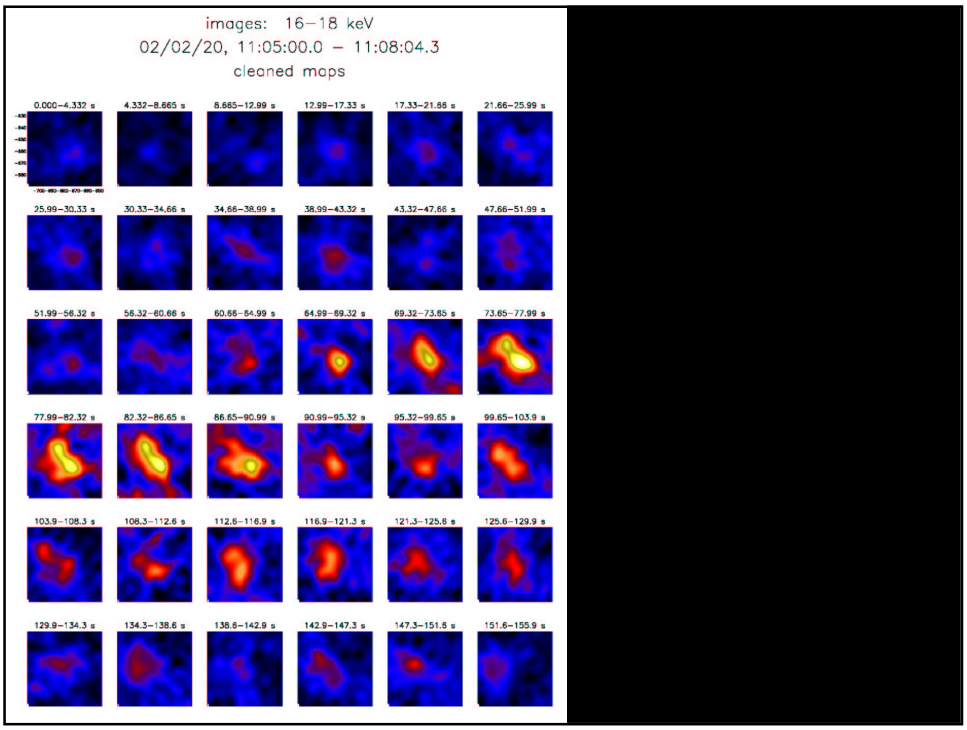

02/02/20, 11:06:00.6 – 11:06:39.6
cleaned maps
12–14 keV
14–16 keV
16–18 keV
18–20 keV
20–22 keV
22–24 keV
24–26 keV
26–30 keV
30–80 keV

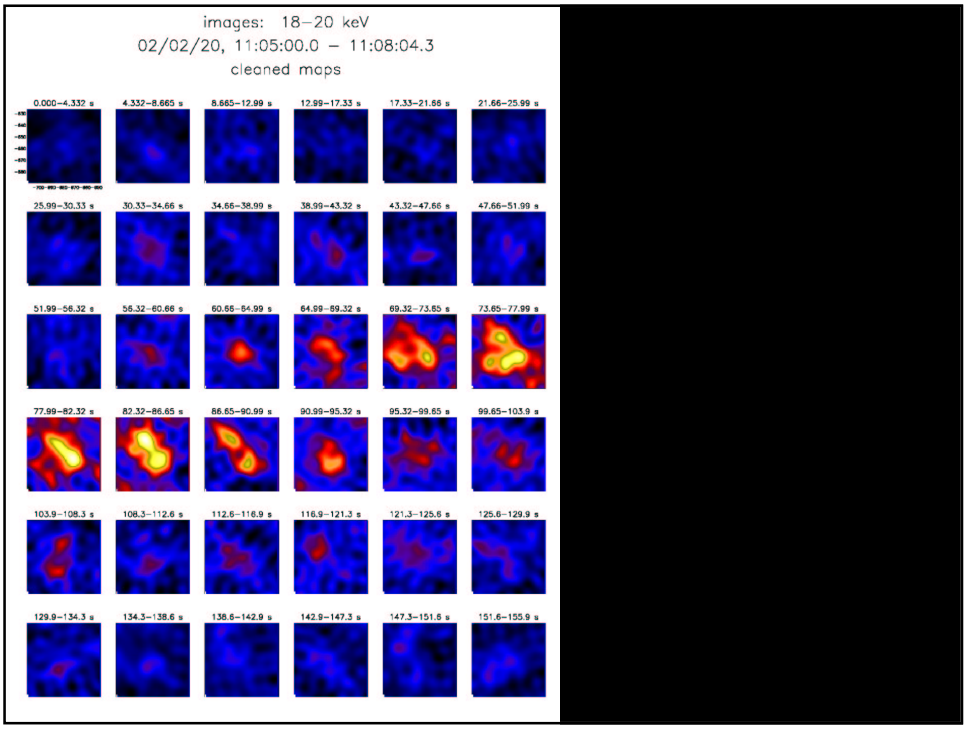

2002−02−20 11:06:00 − 11:06:40
contours at 50% of maximum
12−14 keV
14−16 keV
16−18 keV
18−20 keV
20−22 keV
22−24 keV
24−26 keV
26−30 keV
30−80 keV
heliocentric Y [arcsec]
heliocentric X [arcsec]
−620
−640
−660
−680
−700
−720
−700
−680
−660
−640

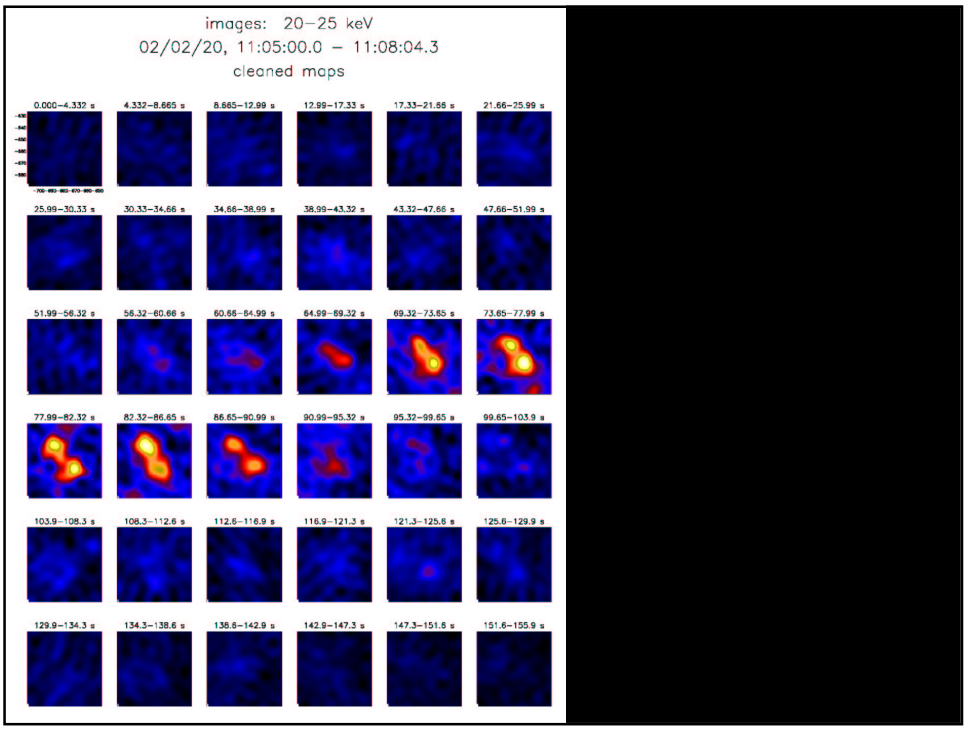

2002 02 20, 11:06:00 − 11:06:40
photons s^{-1} cm^{-2} keV^{-1}
energy [keV]
10.00
1.00
0.10
0.01
10
20
30
40
50
60
footpoint 1
index = −3.5
footpoint 2
index = −3.5
between
footpoints
footpoint 2
footpoint 1
relative
size of
Earth

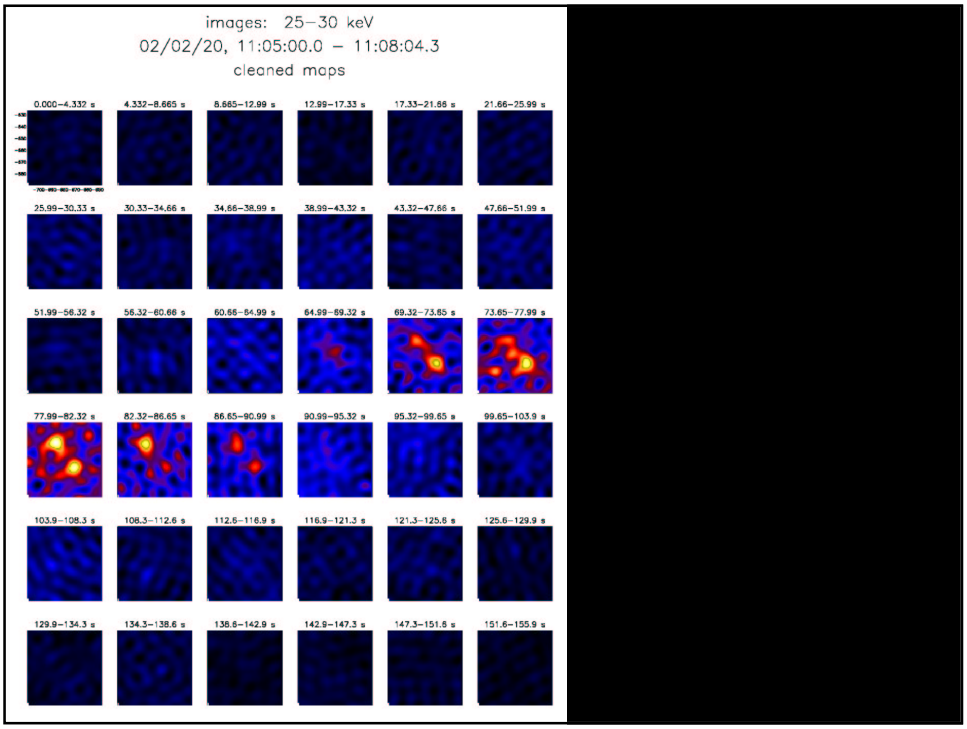

images: 12–14 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps

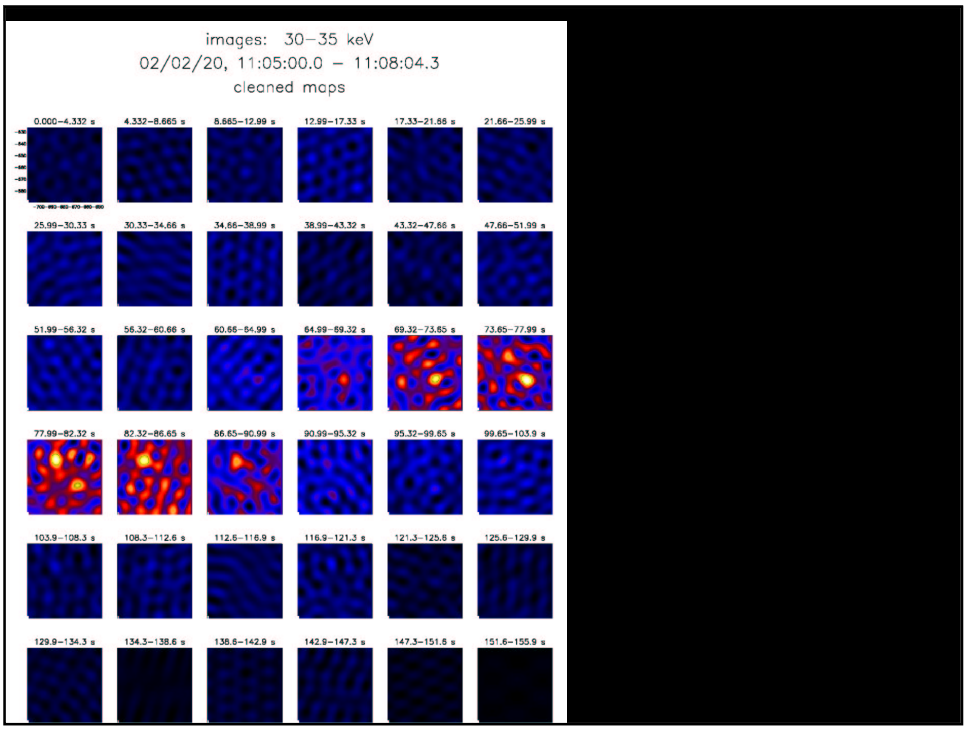

images: 14–16 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps

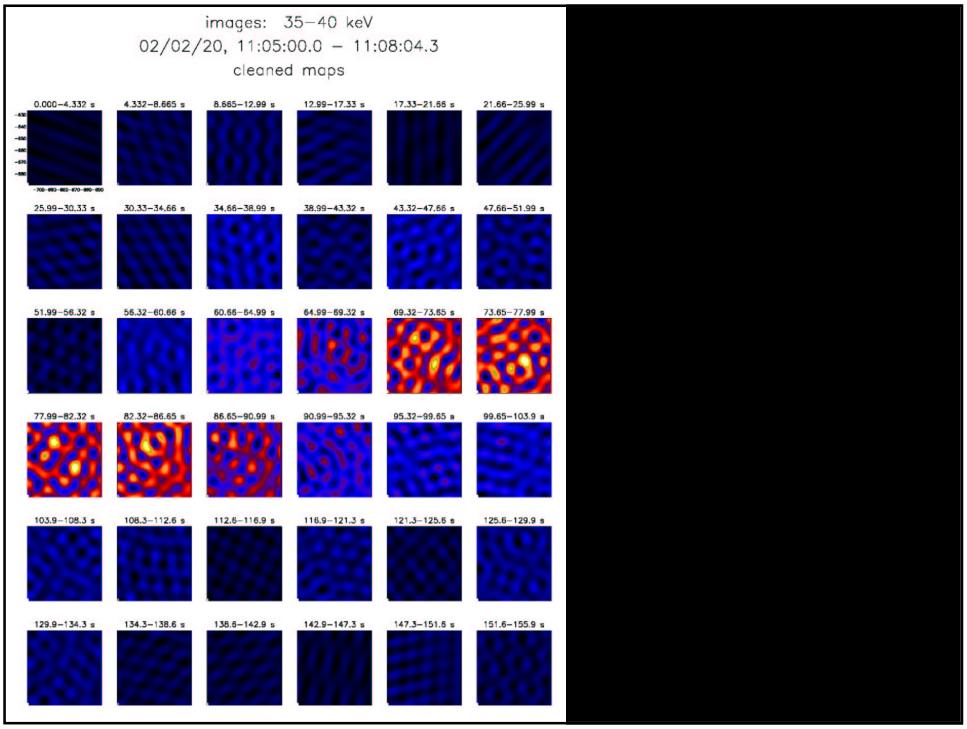

images: 16–18 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

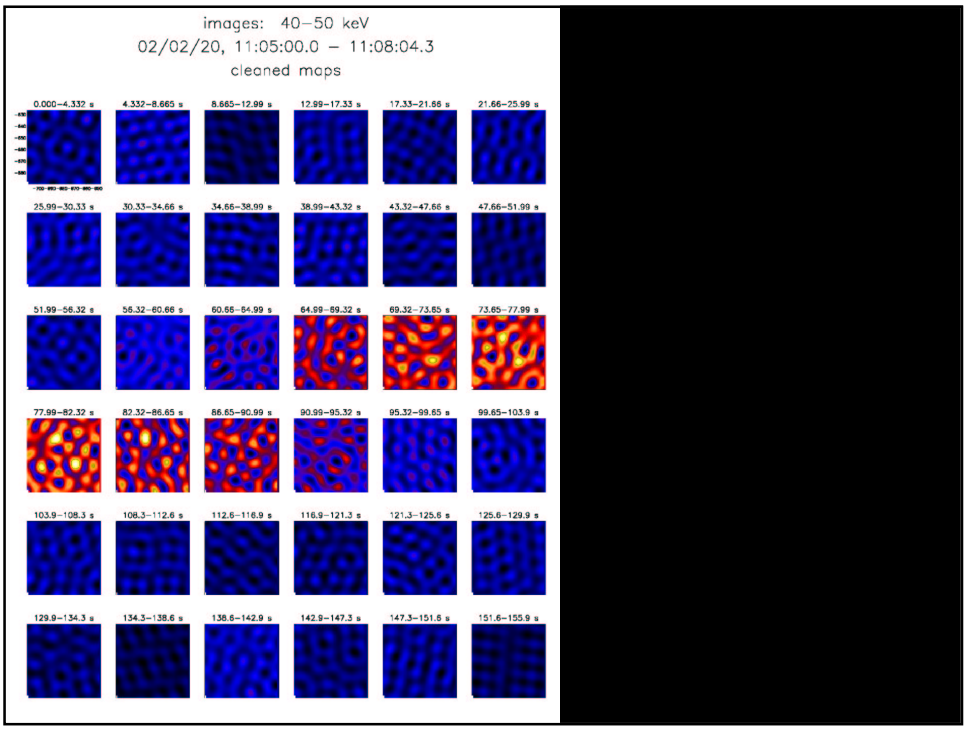

images: 18–20 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

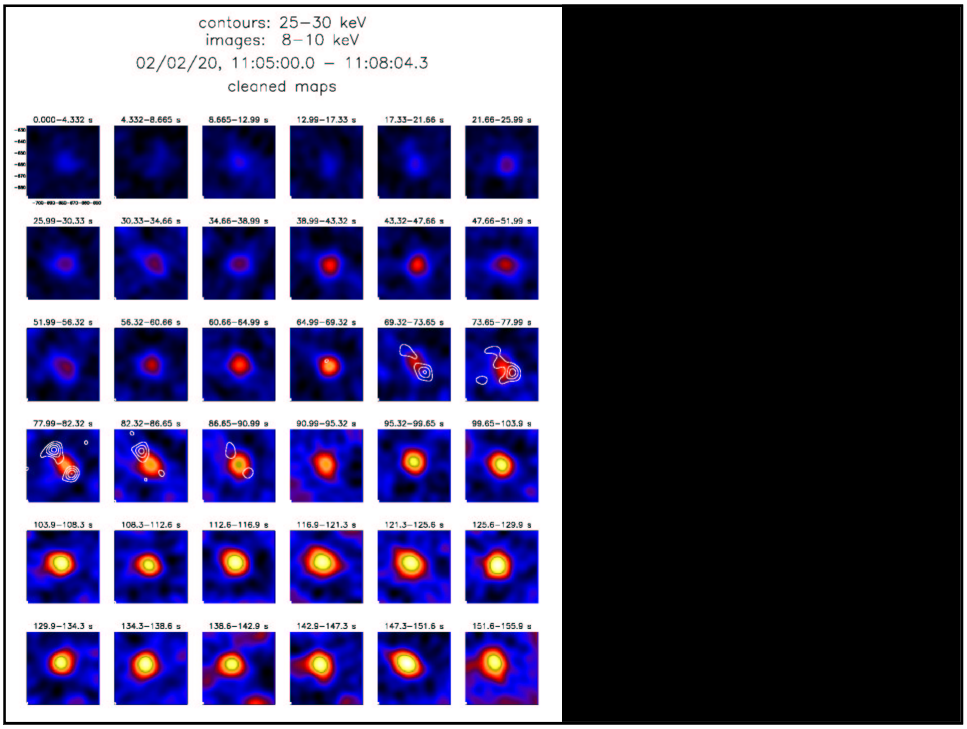

images: 20–25 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

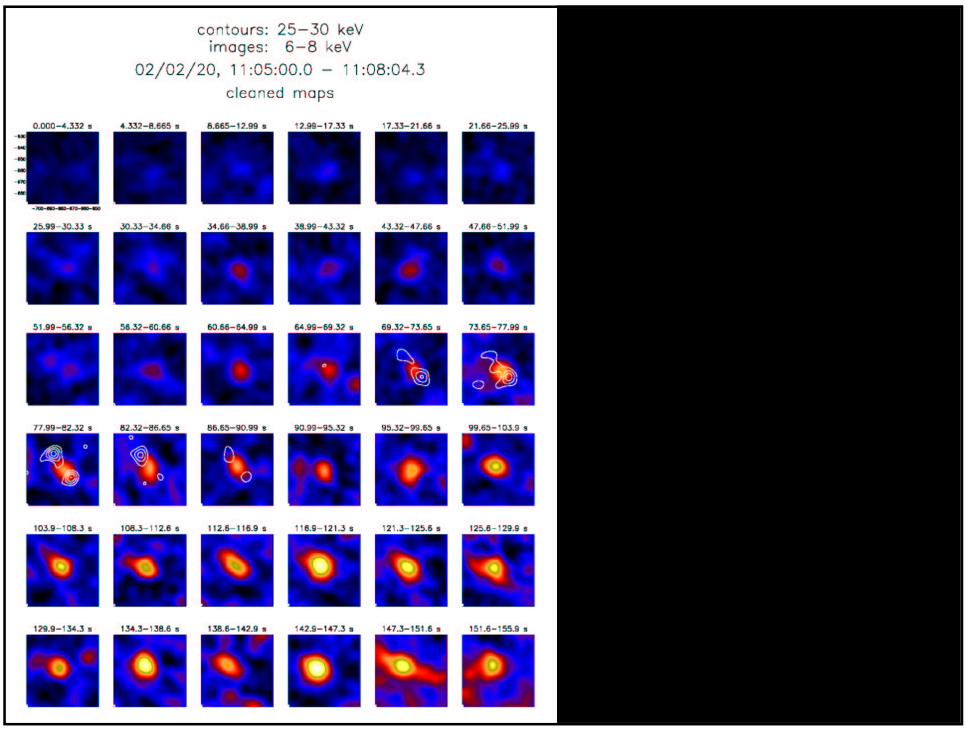

images: 25–30 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

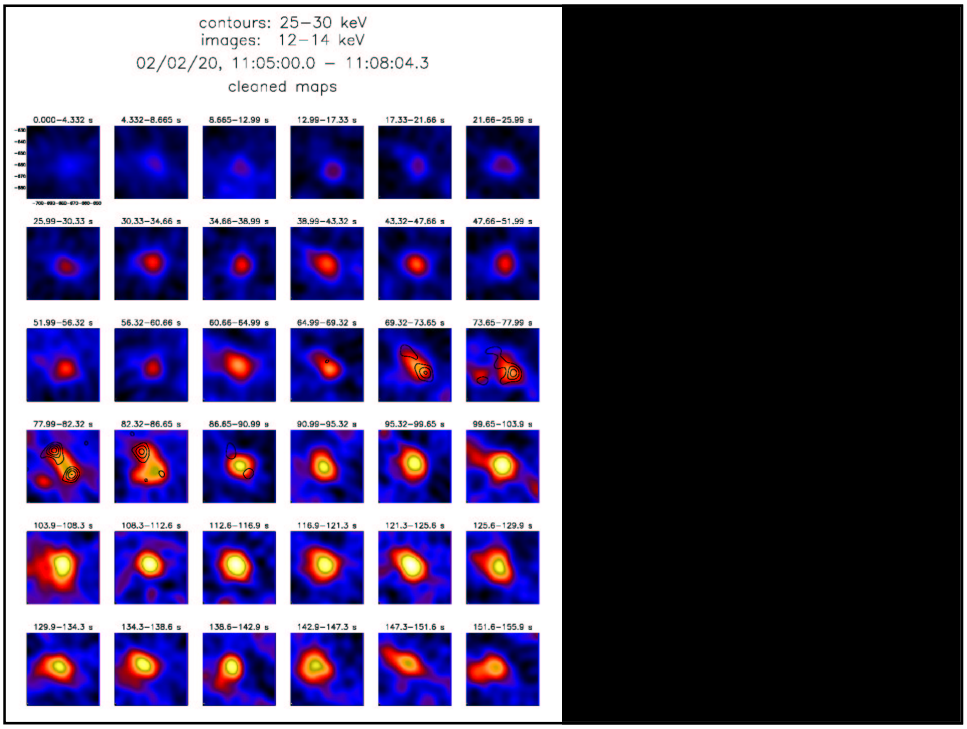

images: 30–35 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps

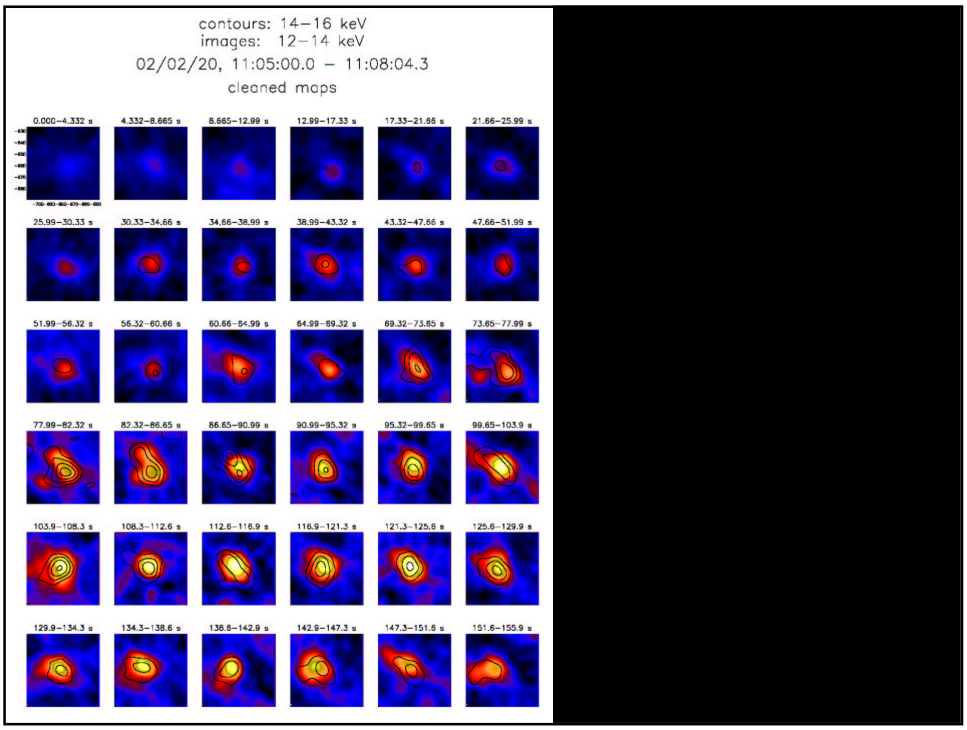

images: 35–40 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps

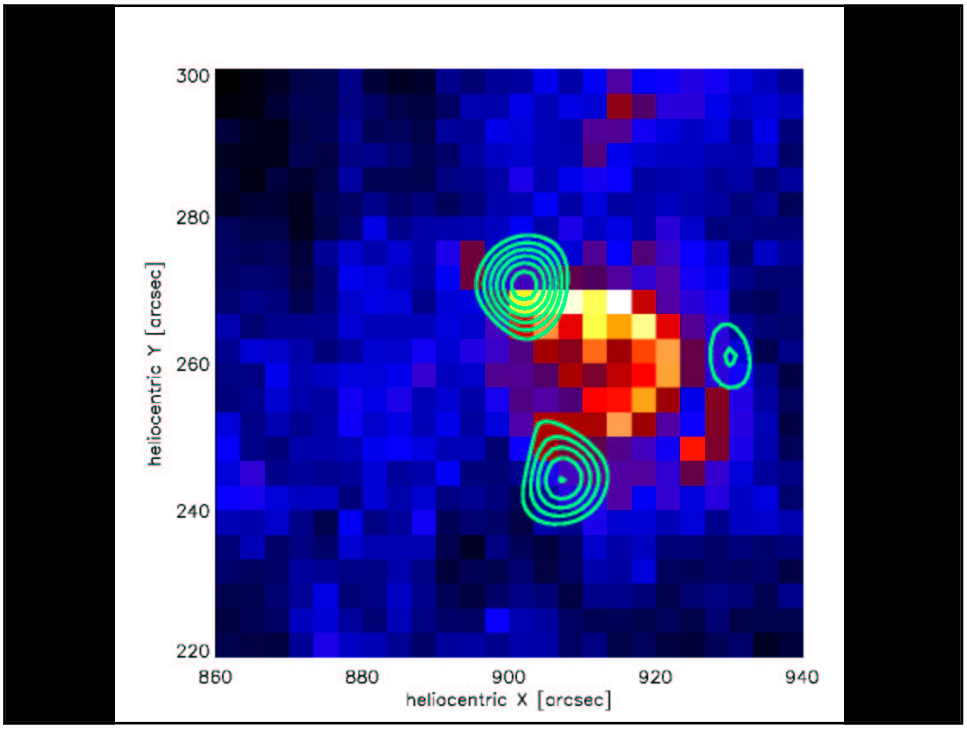

images: 40–50 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

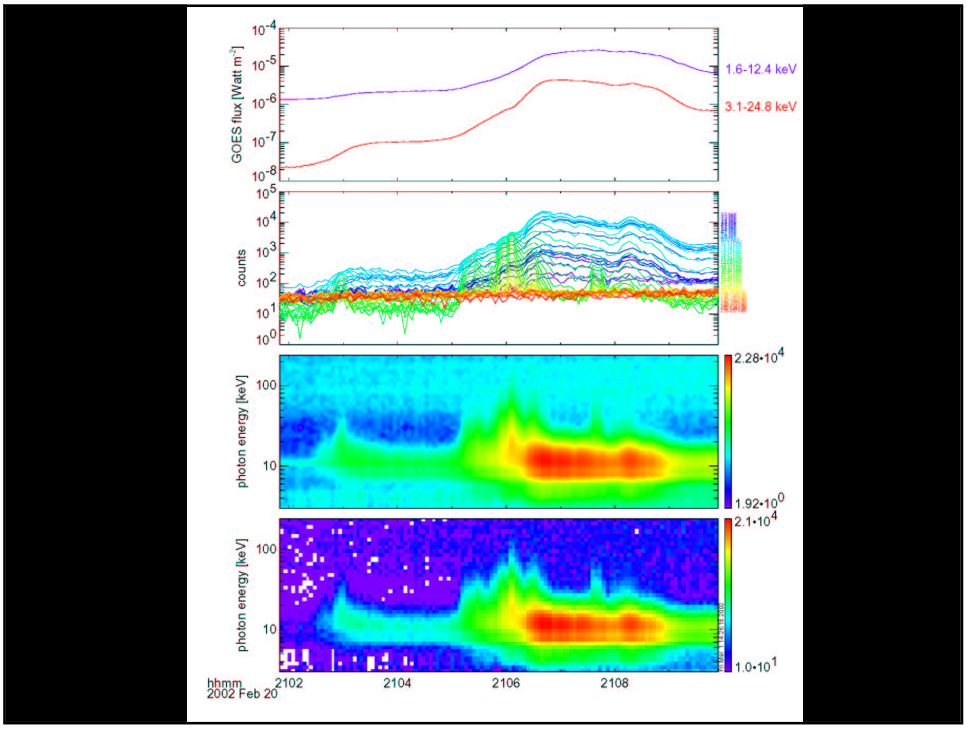

contours: 25–30 keV
images: 8–10 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

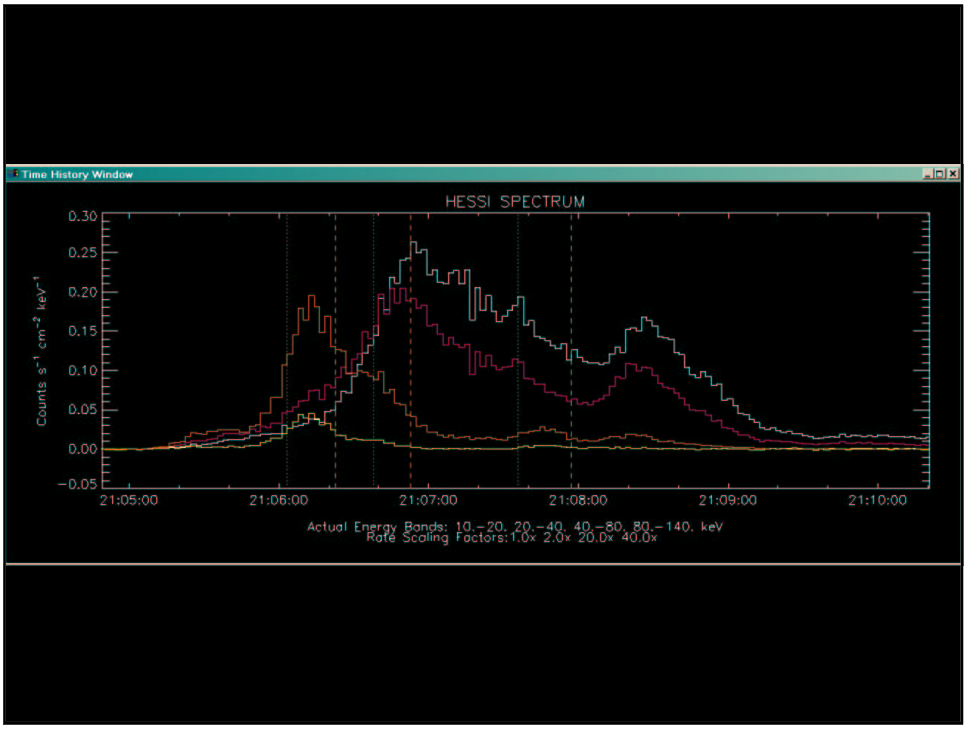

contours: 25–30 keV
images: 6–8 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

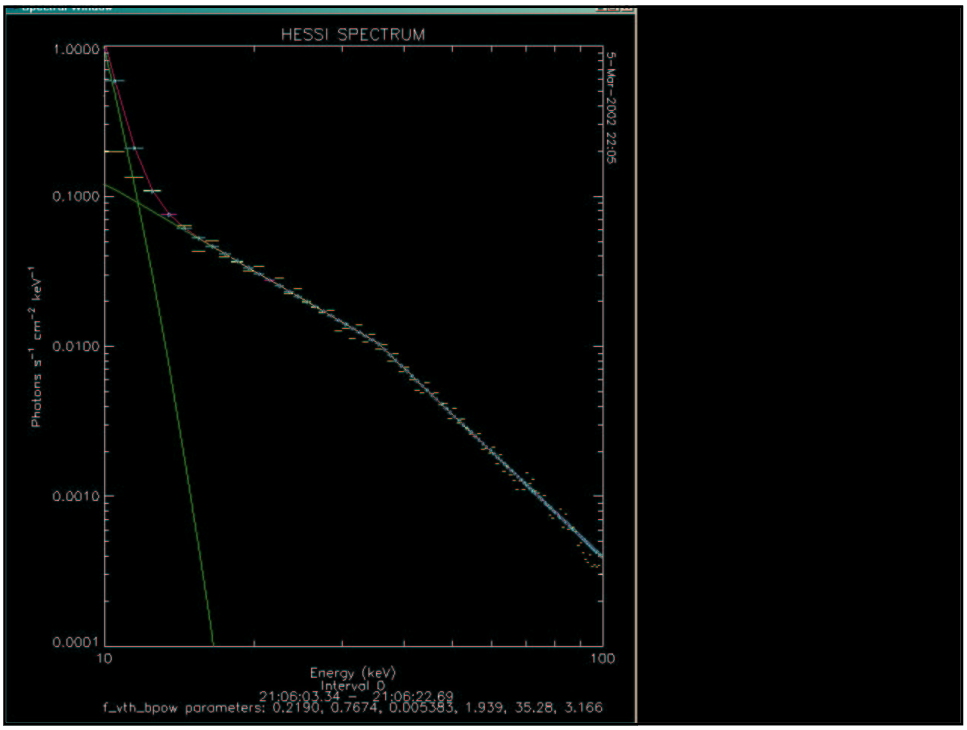

contours: 25–30 keV
images: 12–14 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps
0.000–4.332 s
4.332–8.665 s
8.665–12.99 s
12.99–17.33 s
17.33–21.66 s
21.66–25.99 s
25.99–30.33 s
30.33–34.66 s
34.66–38.99 s
38.99–43.32 s
43.32–47.66 s
47.66–51.99 s
51.99–56.32 s
56.32–60.66 s
60.66–64.99 s
64.99–69.32 s
69.32–73.65 s
73.65–77.99 s
77.99–82.32 s
82.32–86.65 s
86.65–90.99 s
90.99–95.32 s
95.32–99.65 s
99.65–103.9 s
103.9–108.3 s
108.3–112.6 s
112.6–116.9 s
116.9–121.3 s
121.3–125.6 s
125.6–129.9 s
129.9–134.3 s
134.3–138.6 s
138.6–142.9 s
142.9–147.3 s
147.3–151.6 s
151.6–155.9 s

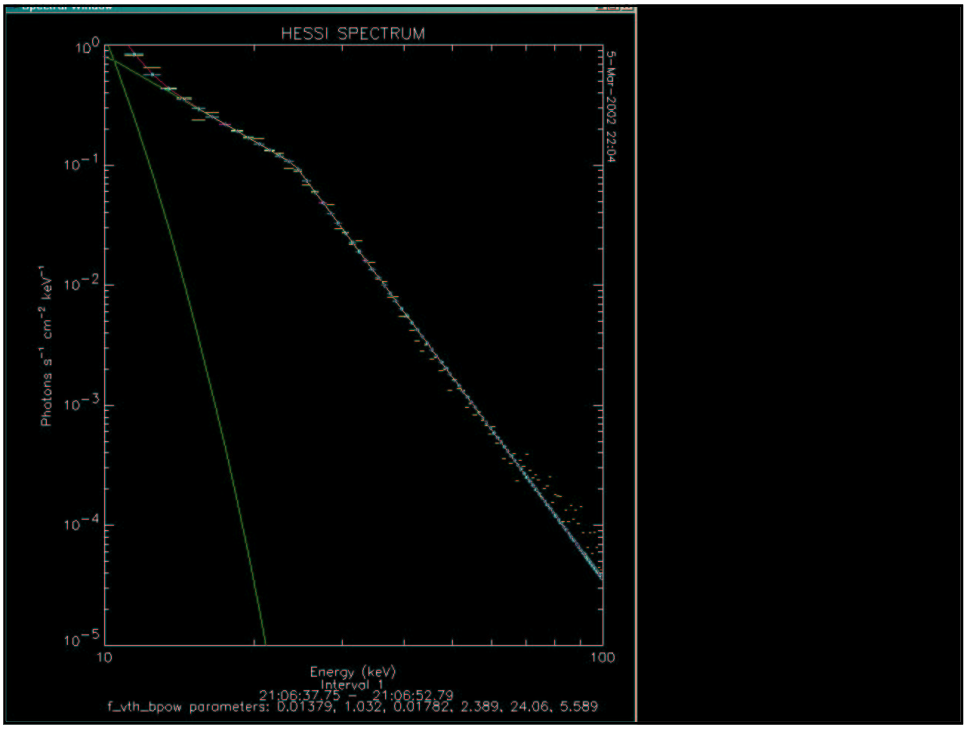

contours: 14–16 keV
images: 12–14 keV
02/02/20, 11:05:00.0 – 11:08:04.3
cleaned maps

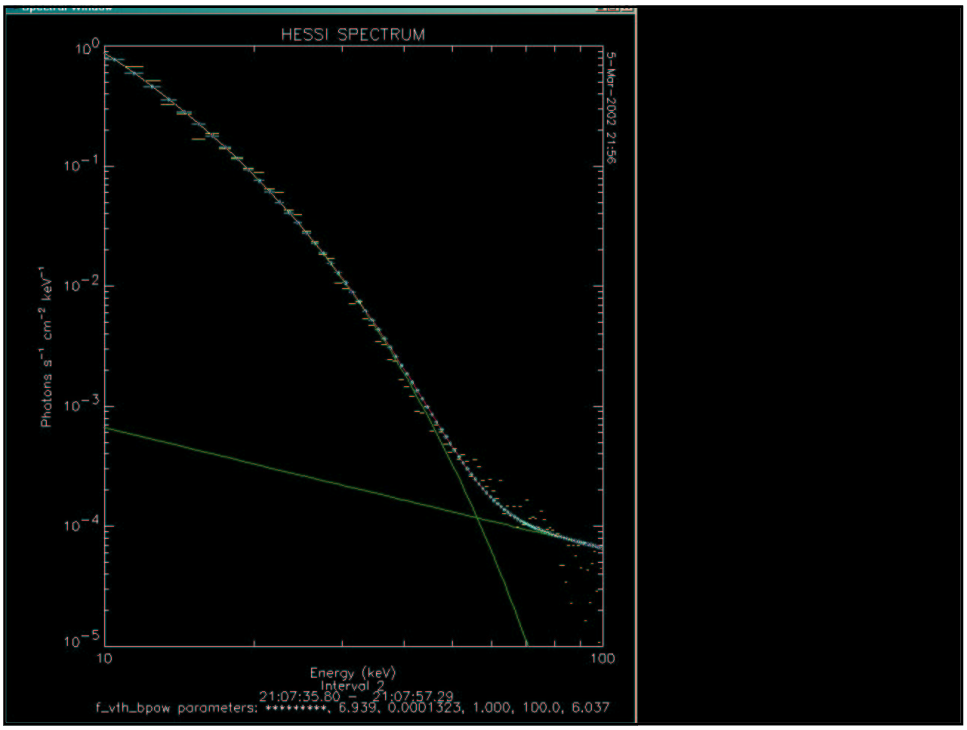

300
280
260
240
220
860
880
900
920
940
heliocentric Y [arcsec]
heliocentric X [arcsec]

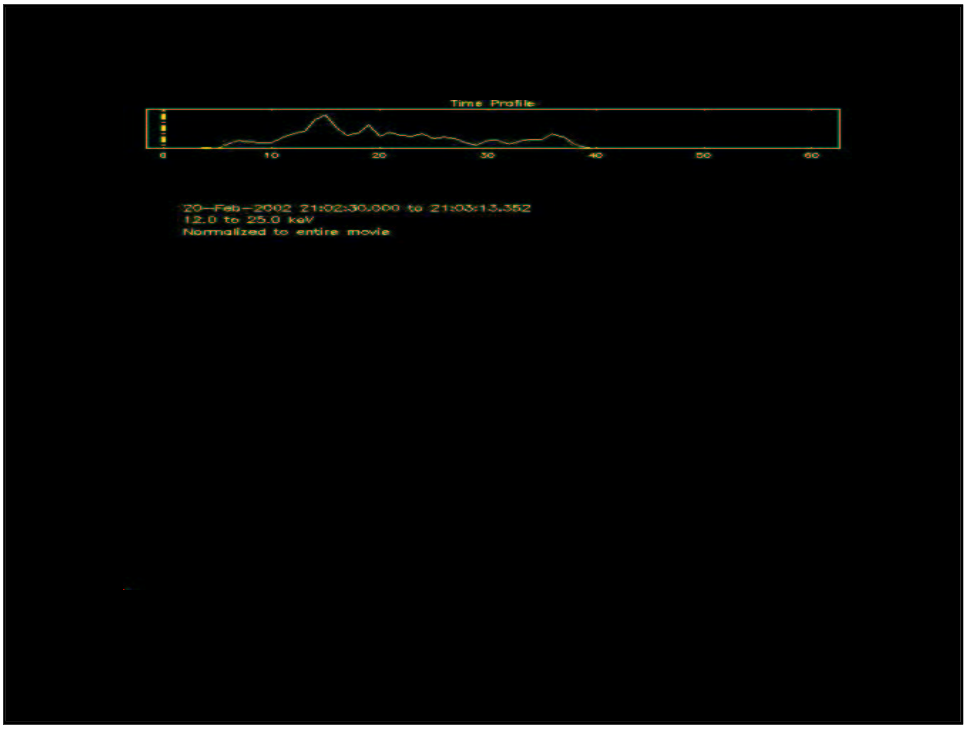

GOES flux [Watt m^{-2}]
1.6-12.4 keV
3.1-24.8 keV
counts
photon energy [keV]
$2.28 \cdot 10^4$
$1.92 \cdot 10^0$
$2.1 \cdot 10^4$
$1.0 \cdot 10^1$
hhmm
2002 Feb 20
2102
2104
2106
2108


Time History Window
HESSI SPECTRUM
Counts s^{-1} cm^{-2} keV^{-1}
21:05:00
21:06:00
21:07:00
21:08:00
21:09:00
21:10:00
Actual Energy Bands: 10.-20. 20.-40. 40.-80. 80.-140. keV
Rate Scaling Factors: 1.0x 2.0x 20.0x 40.0x

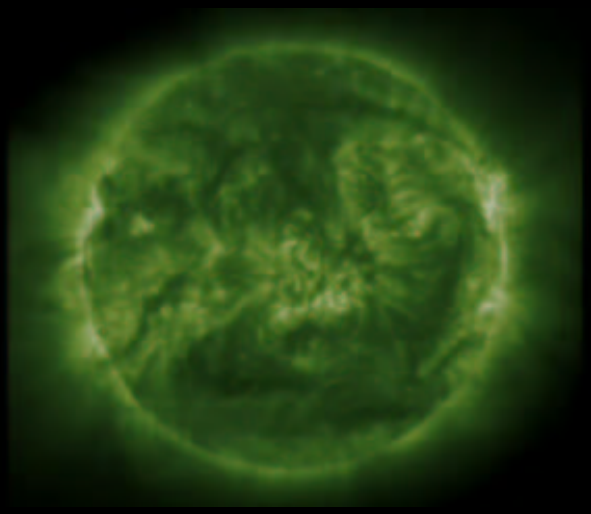

HESSI SPECTRUM
5-Mar-2002 22:05
1.0000
0.1000
0.0100
0.0010
0.0001
Photons s^{-1} cm^{-2} keV^{-1}
10
100
Energy (keV)
Interval 0
21:06:03.34 - 21:06:22.69
f_vth_bpow parameters: 0.2190, 0.7674, 0.005383, 1.939, 35.28, 3.166


HESSI SPECTRUM
5-Mar-2002 22:04
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Photons s^{-1} cm^{-2} keV^{-1}
10
100
Energy (keV)
Interval 1
21:06:37.75 - 21:06:52.79
f_vth_bpow parameters: 0.01379, 1.032, 0.01782, 2.389, 24.06, 5.589


HESSI SPECTRUM
5-Mar-2002 21:56
Photons s^{-1} cm^{-2} keV^{-1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
Energy (keV)
Interval 2
21:07:35.80 - 21:07:57.29
f_vth_bpow parameters: **********, 6.939, 0.0001323, 1.000, 100.0, 6.037

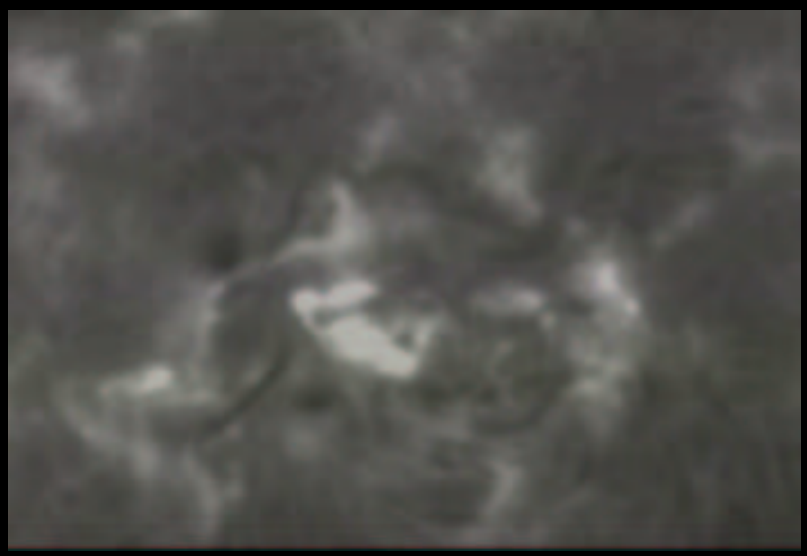

Time Profile
0
10
20
30
40
50
60
20-Feb-2002 21:02:30.000 to 21:03:13.352
12.0 to 25.0 keV
Normalized to entire movie

First Flare movie for the HESSI instrument (speed 105X normal)



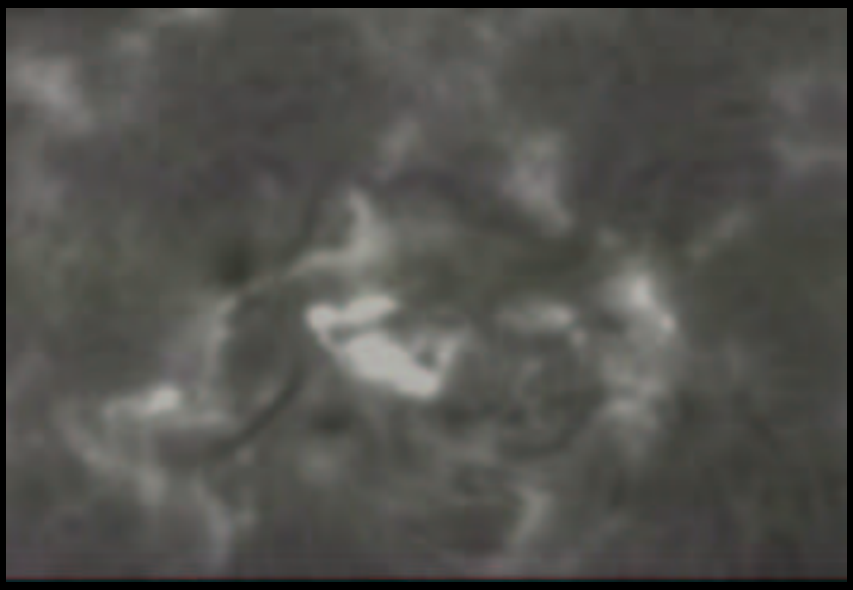
Movie from NASA/GSFC online Scientific Visualization Studio

First Flare movie for the HESSI instrument (speed 52x normal)



Movie from NASA/GSFC online Scientific Visualization Studio

First Flare movie for the HESSI instrument (speed 26x normal)



Movie from NASA/GSFC online Scientific Visualization Studio

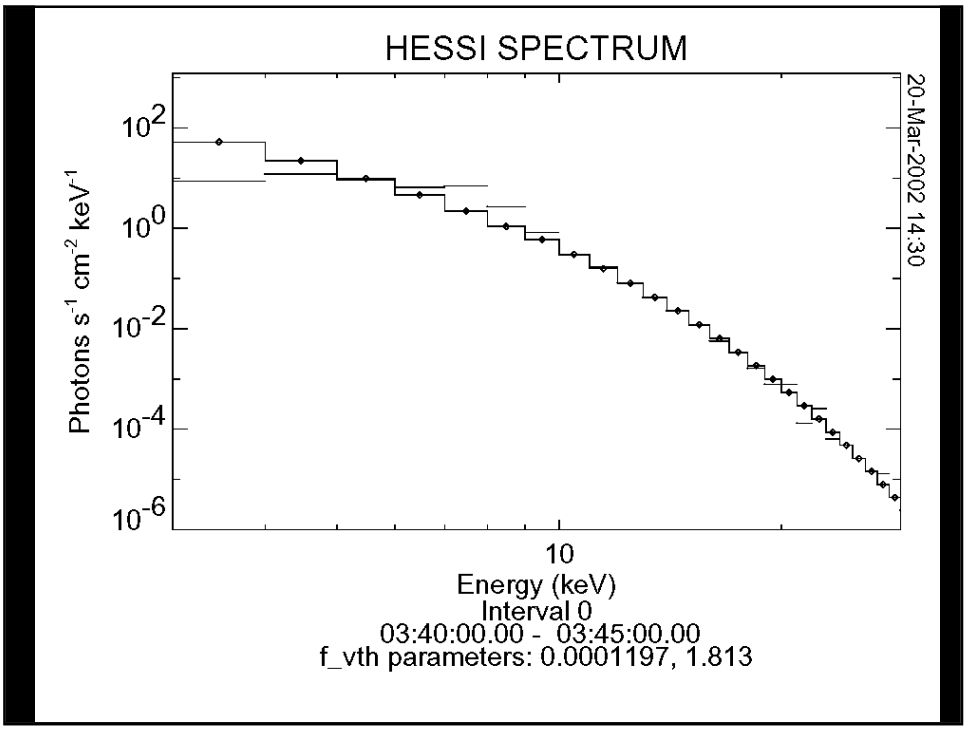
HESSI DATA ANALYSIS AND DISTRIBUTION

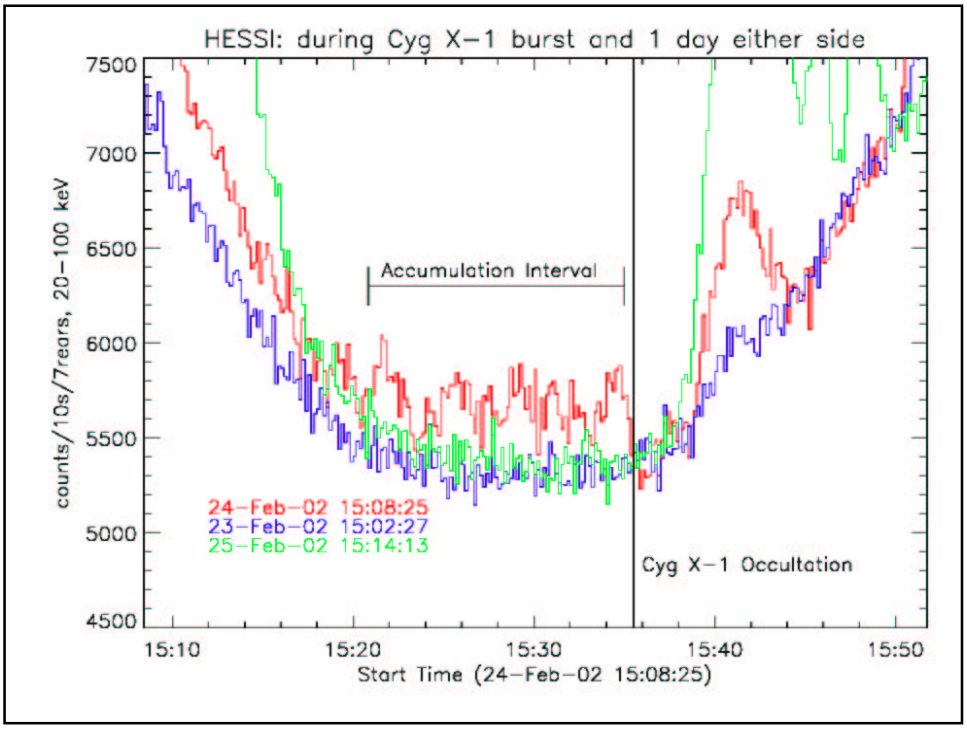
DATA ACCESS

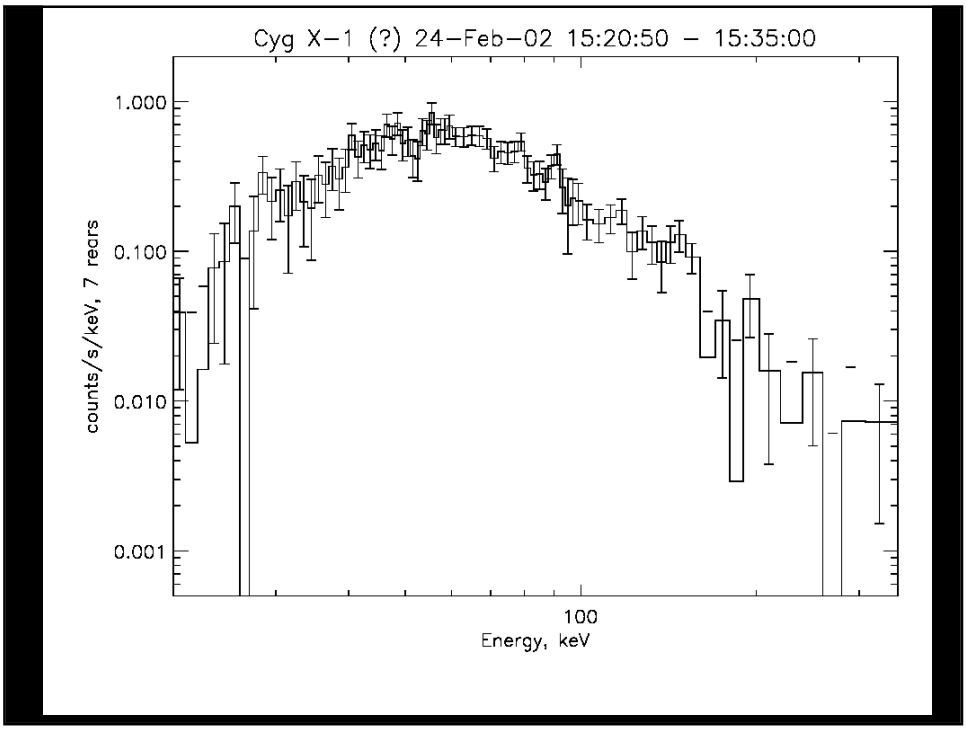
- Science data to be available on-line to the community without restrictions within 6 to 48 hours of acquisition.
- PI team and community will have equal access to on-line software tools required for scientific analysis.

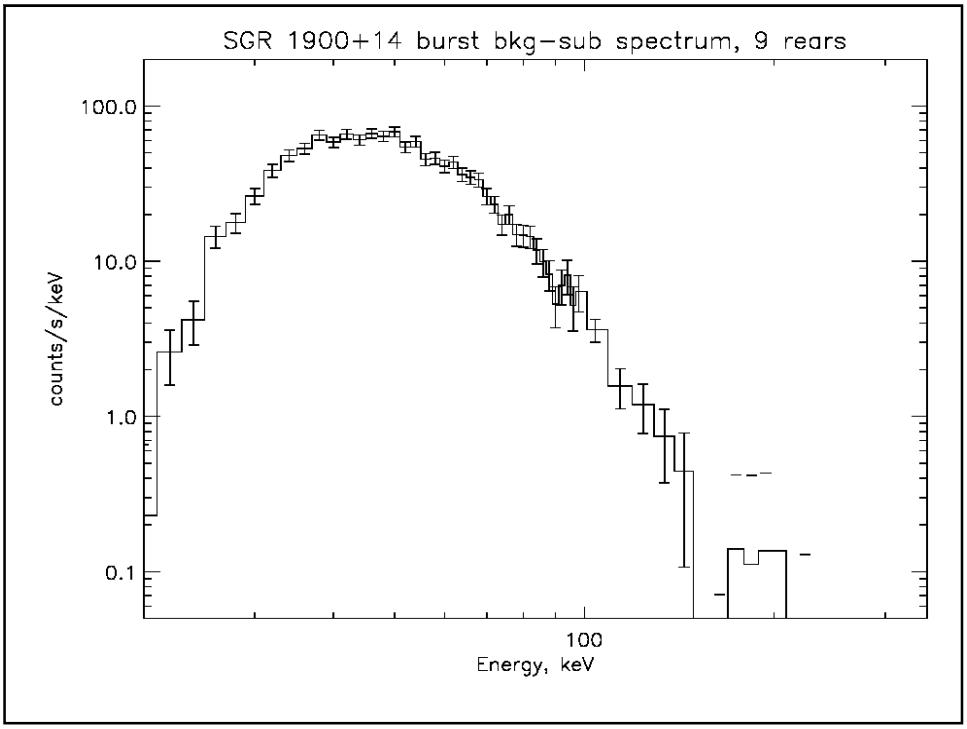
PHOTON-BASED IMAGING

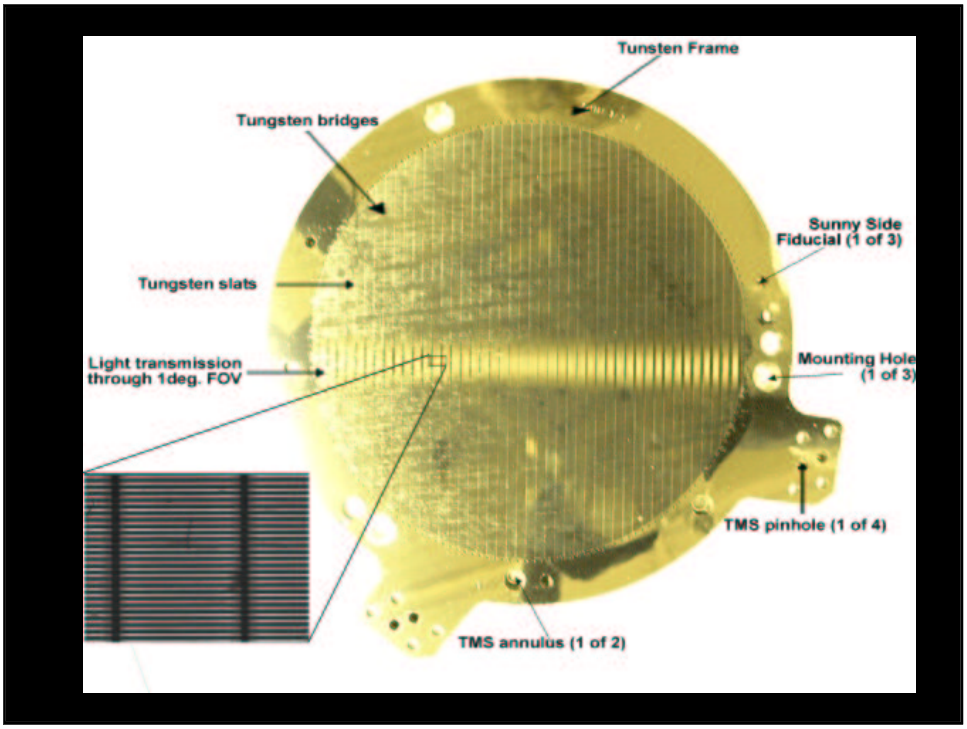
- HESSI science data contains time- and energy-tagged photons.
- Wide range of science-driven tradeoffs possible among:
  - Time resolution
  - Spatial resolution
  - Energy resolution;
  - Image field of view
  - Image quality
  - Imaging speed
- Key strategy is to defer these tradeoffs to data analysis phase (not mission-planning phase).


HESSI SPECTRUM
20-Mar-2002 14:30
Photons s-1 cm-2 keV-1
10^2
10^0
10^-2
10^-4
10^-6
10
Energy (keV)
Interval 0
03:40:00.00 - 03:45:00.00
f_vth parameters: 0.0001197, 1.813

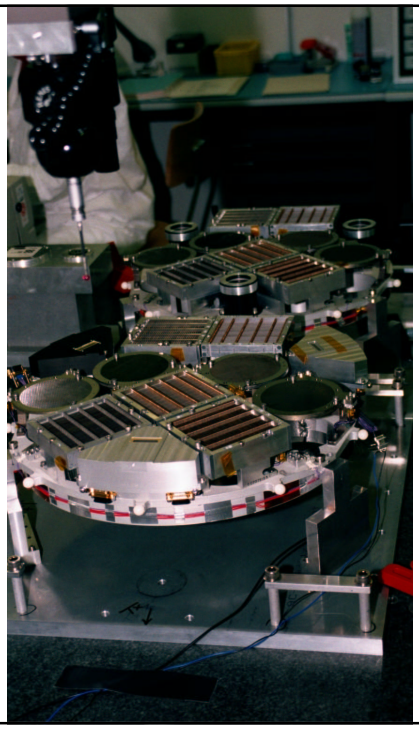

HESSI: during Cyg X-1 burst and 1 day either side
counts/10s/7rears, 20-100 keV
7500
7000
6500
6000
5500
5000
4500
Accumulation Interval
24-Feb-02 15:08:25
23-Feb-02 15:02:27
25-Feb-02 15:14:13
Cyg X-1 Occultation
15:10
15:20
15:30
15:40
15:50
Start Time (24-Feb-02 15:08:25)

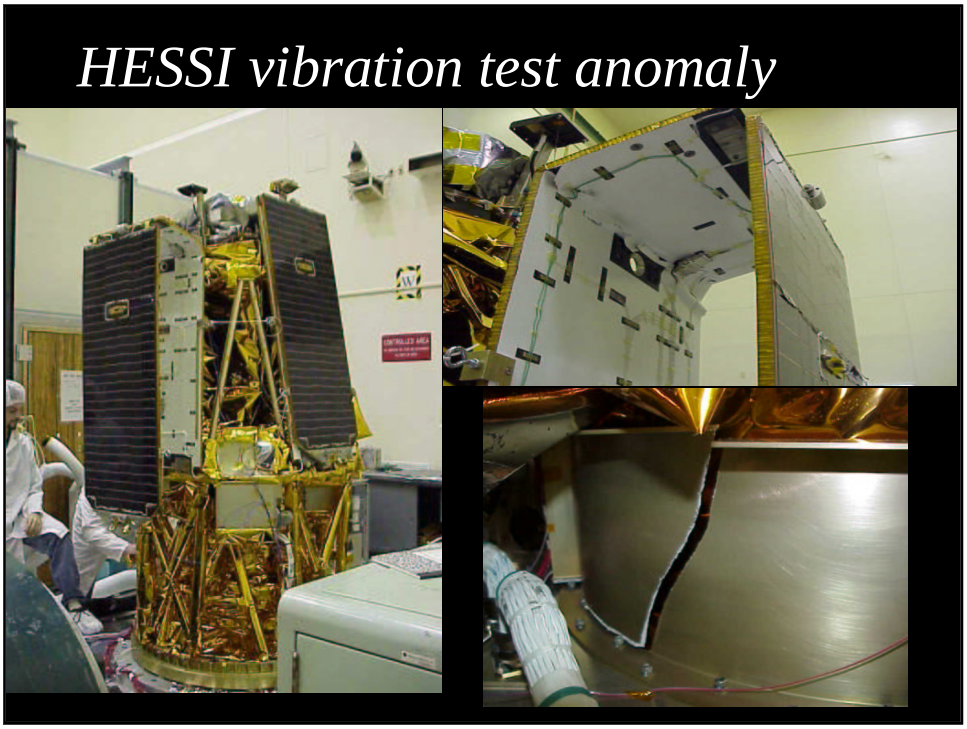

Cyg X-1 (?) 24-Feb-02 15:20:50 - 15:35:00
1.000
0.100
0.010
0.001
counts/s/keV, 7 rears
100
Energy, keV


SGR 1900+14 burst bkg-sub spectrum, 9 rears
100.0
10.0
1.0
0.1
counts/s/keV
100
Energy, keV


Tunsten Frame
Tungsten bridges
Sunny Side
Fiducial (1 of 3)
Tungsten slats
Light transmission
through 1deg. FOV
Mounting Hole
(1 of 3)
TMS pinhole (1 of 4)
TMS annulus (1 of 2)

Front and rear grid trays on measuring machine




HESSI vibration test anomaly


Orbital
Pegasus


MARSHALL
Pegasus

SPACEFLIGHT NOW

Posted: June 4, 2001

X-43A launch failure

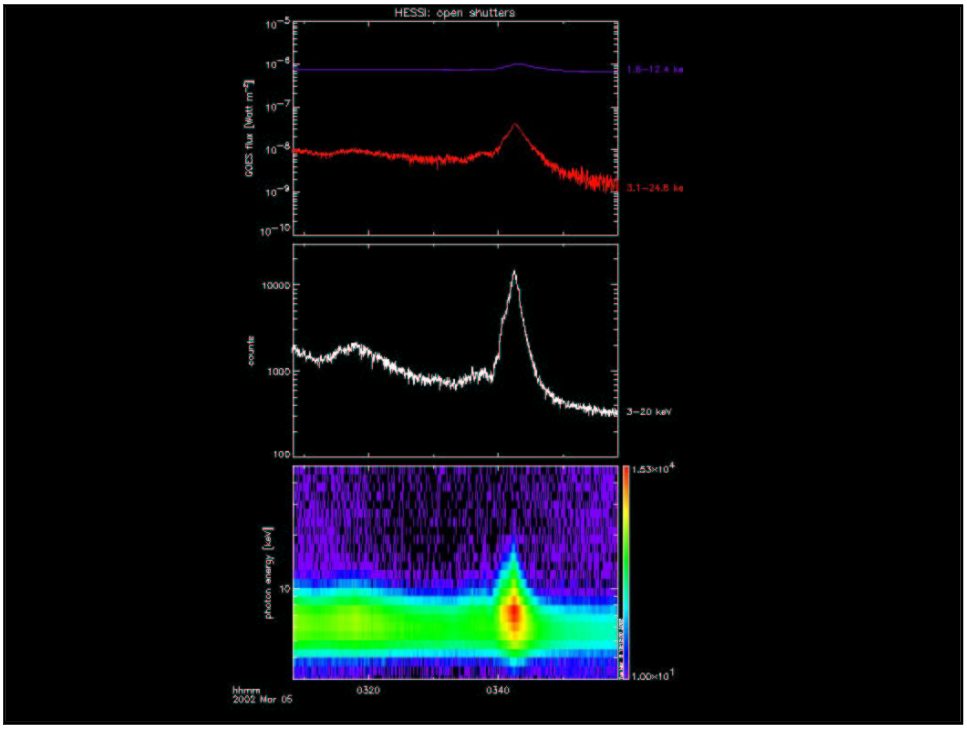
Next Pegasus rocket launch delayed in X-43A aftermath

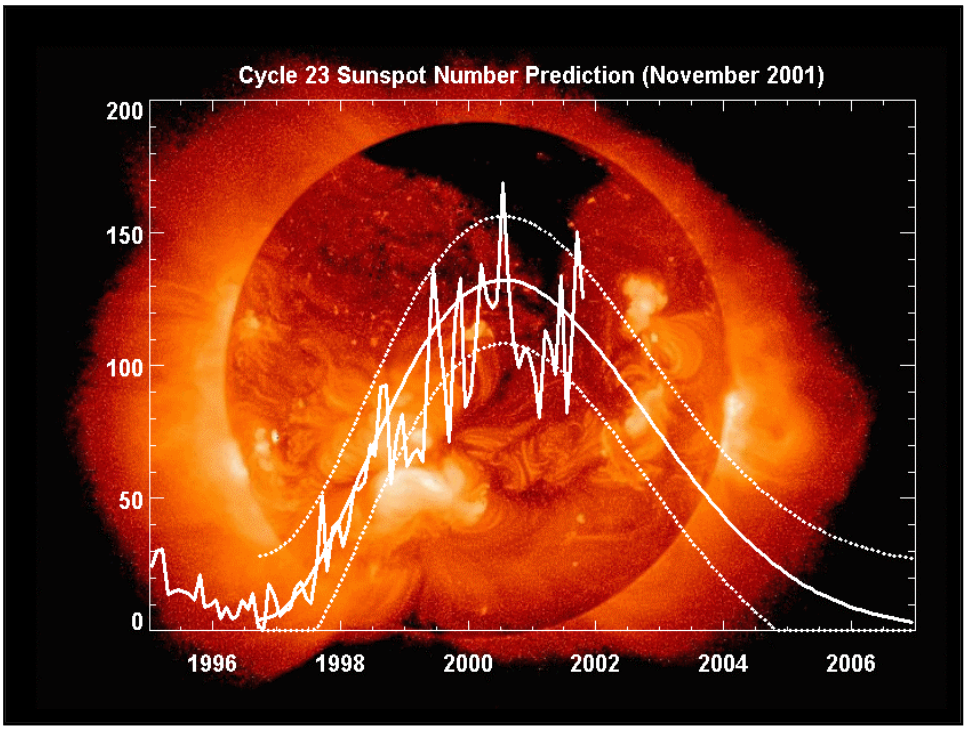
The High Energy Solar Spectroscopic Imager, or HESSI satellite, was scheduled to rocket into space on Thursday aboard an air-launched Orbital Sciences Pegasus XL booster.

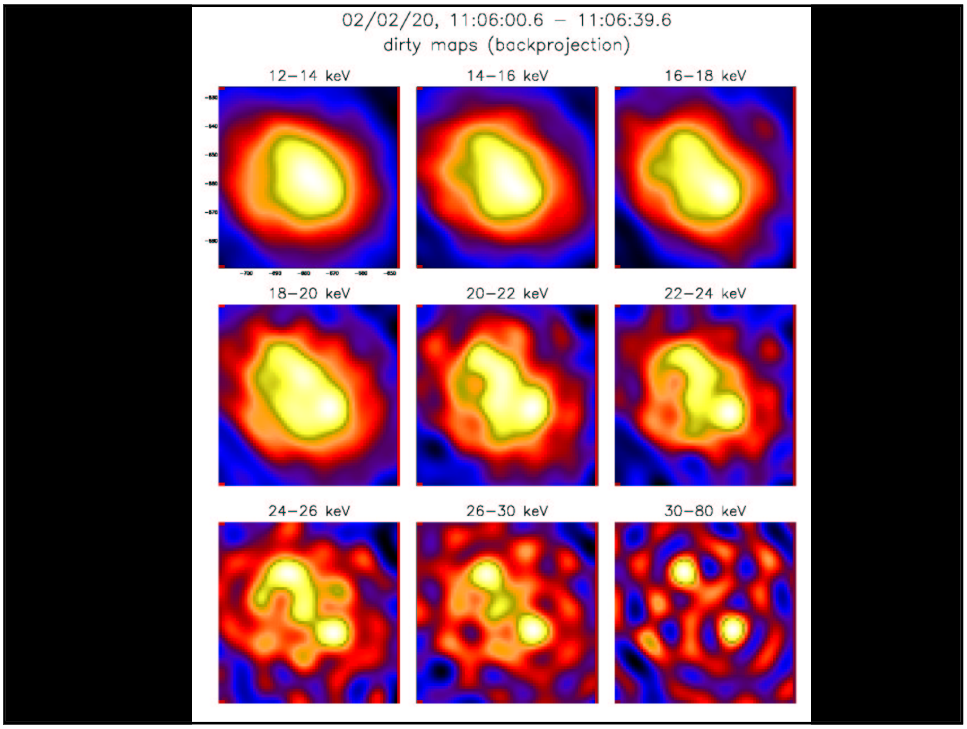
Star-Crossed HESSI Mission Delayed Again

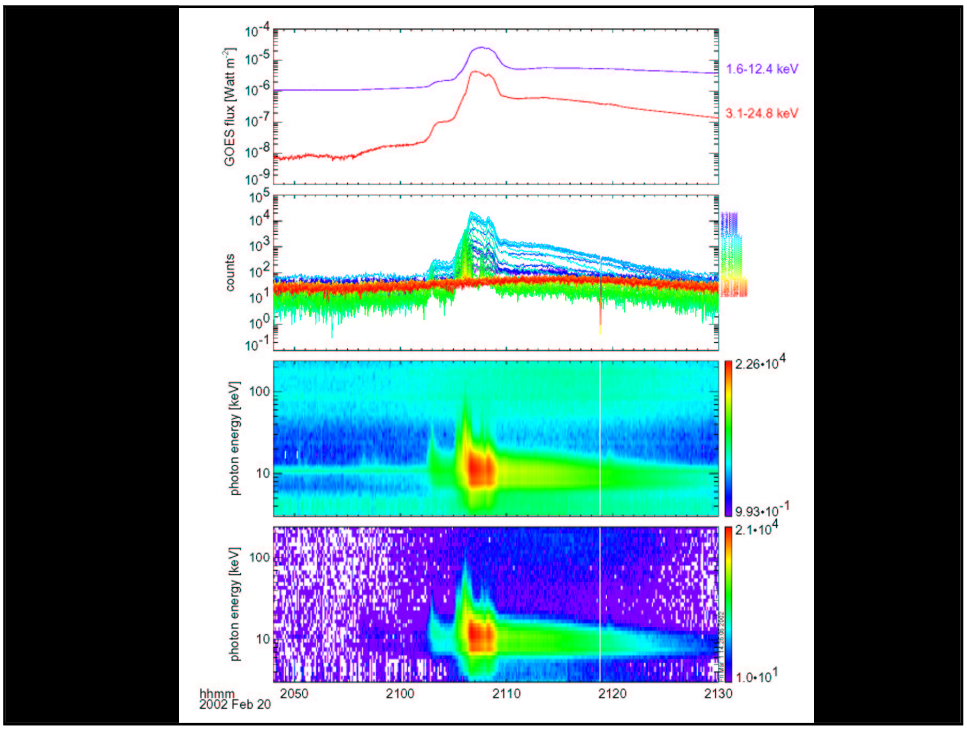
The eight-day slip until at least Feb. 1 represents a fourth delay for NASA's High Energy Solar Spectroscopic Imager, or HESSI, spacecraft, which originally had been slated for launch in July 2000.

Mission managers want to make certain that the satellite's launcher -- an Orbital Sciences Corp. Pegasus rocket -- will not suffer the same fate as a prototype missile defense booster that veered off course and was destroyed shortly after a Dec. 13 launch.


HESSI: open shutters
GOES flux [Watt m⁻²]
1.6–12.4 ke
3.1–24.8 ke
counts
3–20 keV
photon energy [keV]
1.53×10⁴
1.00×10¹
hhmm
2002 Mar 05
0320
0340


Cycle 23 Sunspot Number Prediction (November 2001)
200
150
100
50
0
1996
1998
2000
2002
2004
2006


02/02/20, 11:06:00.6 – 11:06:39.6
dirty maps (backprojection)
12–14 keV
14–16 keV
16–18 keV
18–20 keV
20–22 keV
22–24 keV
24–26 keV
26–30 keV
30–80 keV


GOES flux [Watt m^{-2}]
1.6-12.4 keV
3.1-24.8 keV
counts
photon energy [keV]
2.26•10^4
9.93•10^{-1}
2.1•10^4
1.0•10^1
hhmm
2002 Feb 20
2050
2100
2110
2120
2130