SECCHI-EUVI Status and First Observations

Jean-Pierre Wuelser
Lockheed Martin Solar and Astrophysics Lab
And
The SECCHI Team

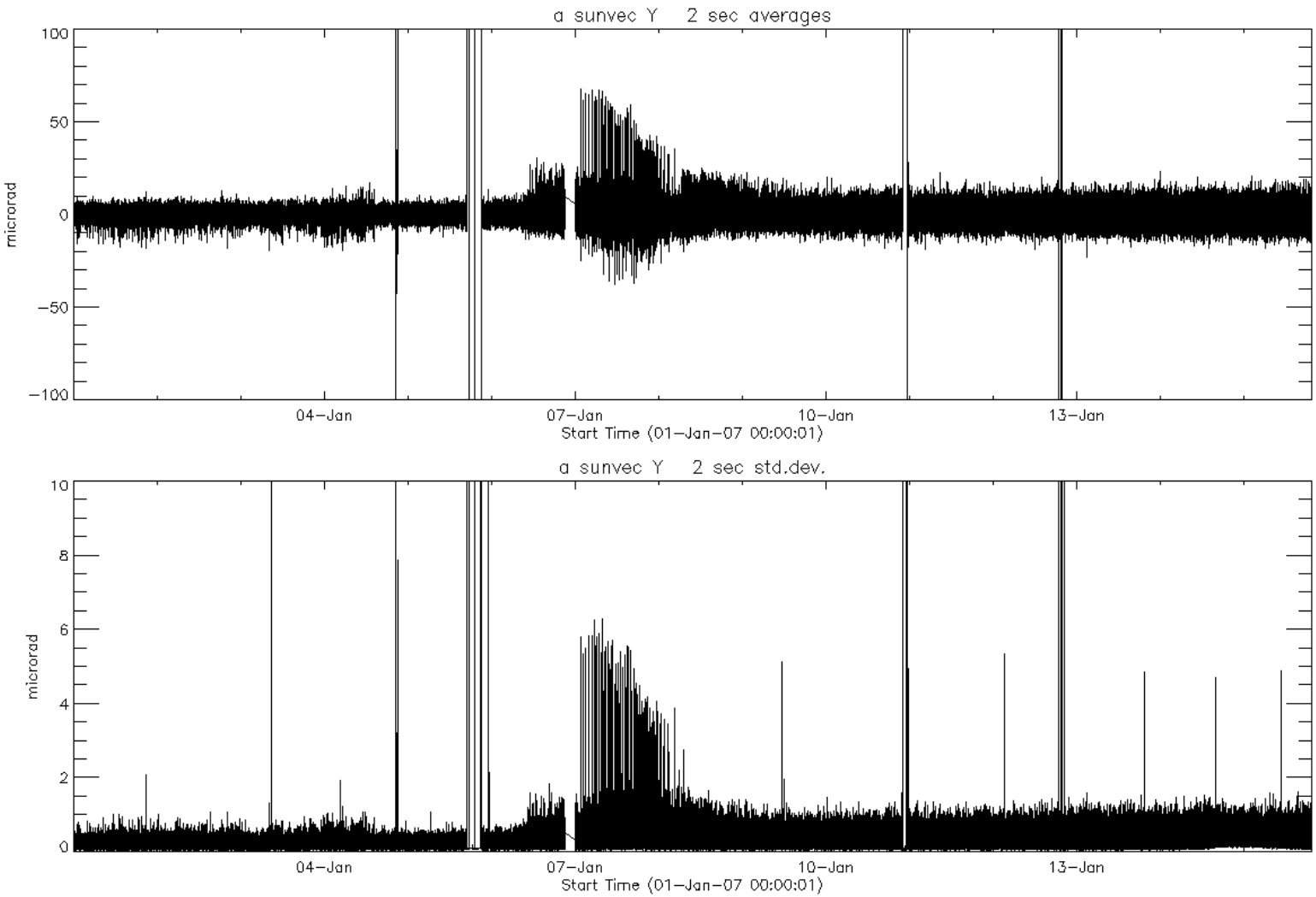
Outline

- Commissioning activities
- First light images
- Performance
  - Entrance Filters
  - Fine pointing system
- Flat fielding
- Pointing and roll
- Lunar transit
- Image compression
- Observing strategies
- SECCHI campaigns
- First 3D

Commissioning Activities (1)

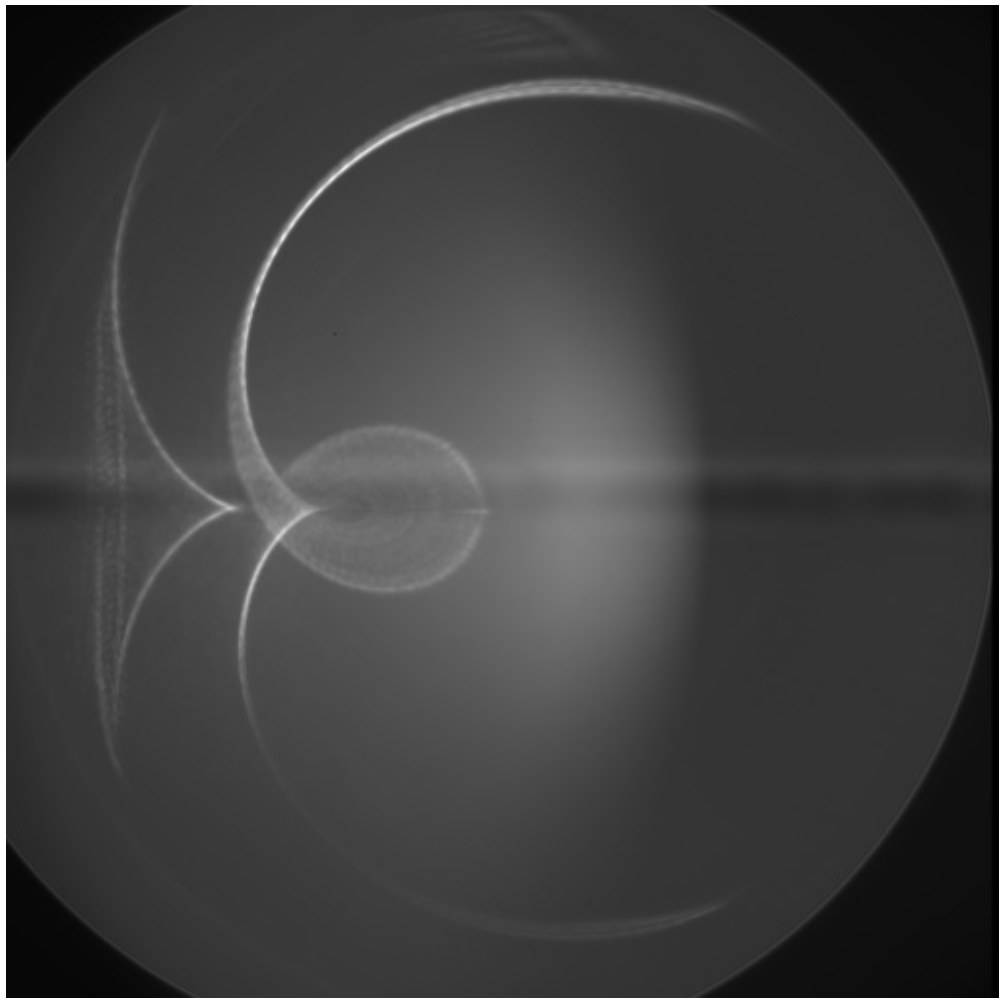
- Commissioning activities still ongoing
  - Much of the calibration data still need to be analyzed
- Guide Telescope commissioning
  - Initial GT gain calibration based on intensities
    - Still used on orbit, absolute accuracy about 10 percent
  - First use of GT as S/C fine sun sensor went smoothly
  - GT fine calibration: compare GT signal with sun center in EUVI during offpoints
    - Results implemented in software for updating EUVI FITS keywords
    - Plan to provide software for updating FITS header of CORs
  - GT signal is very low noise
    - Signal fluctuations reflect true S/C attitude motions
    - S/C jitter decreased substantially over course of S/C commissioning

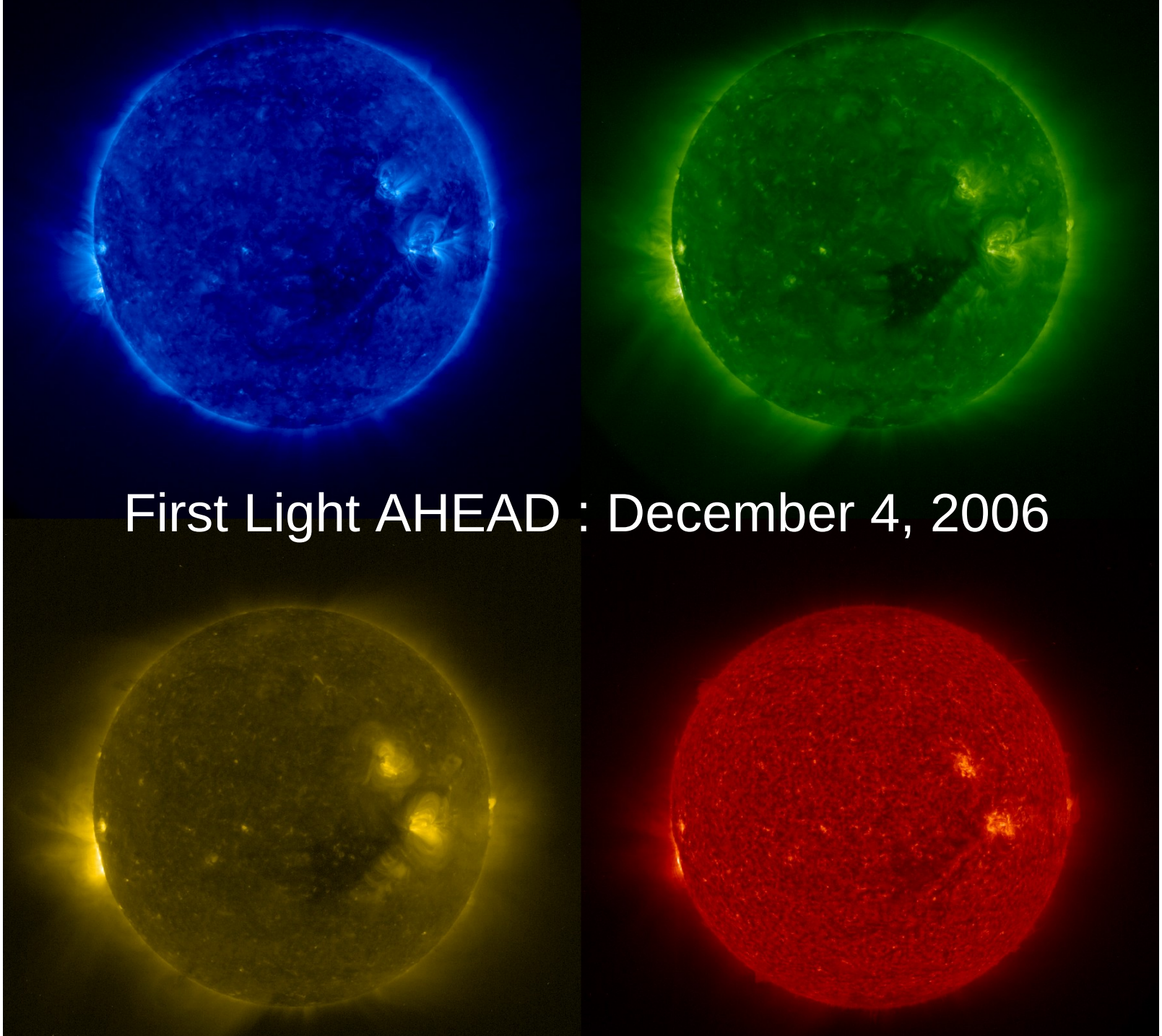
GT-A Signal Example: 2 Sec Ave/StdDev

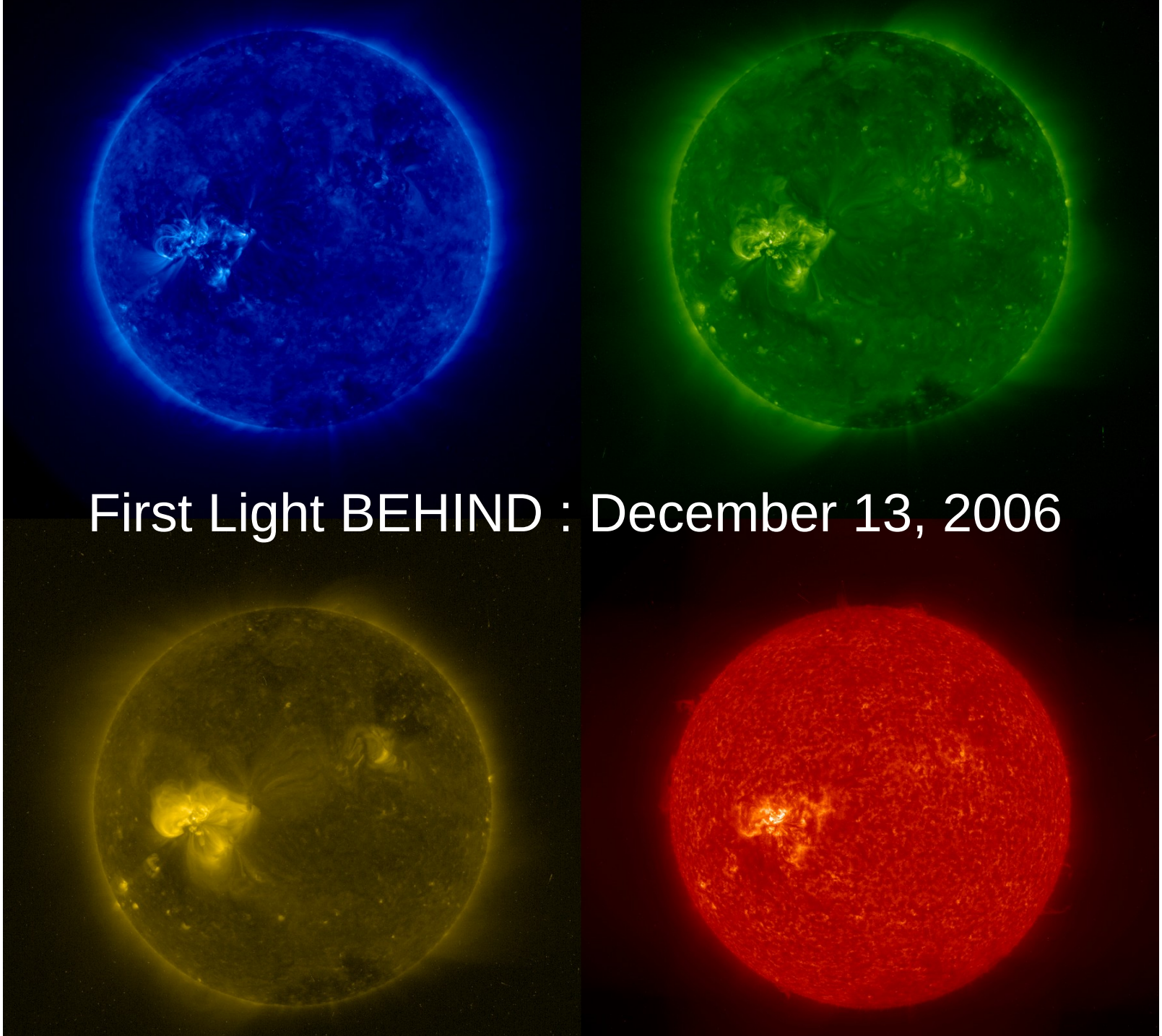


Commissioning Activities (2)

- EUVI closed door commissioning
  - Darks
  - LED images
    - 2 LEDs in spider:
    - Blue (470 nm)
    - Purple (400 nm)
    - 1 LED in FPA
  - Primarily a performance baseline




First Light AHEAD : December 4, 2006

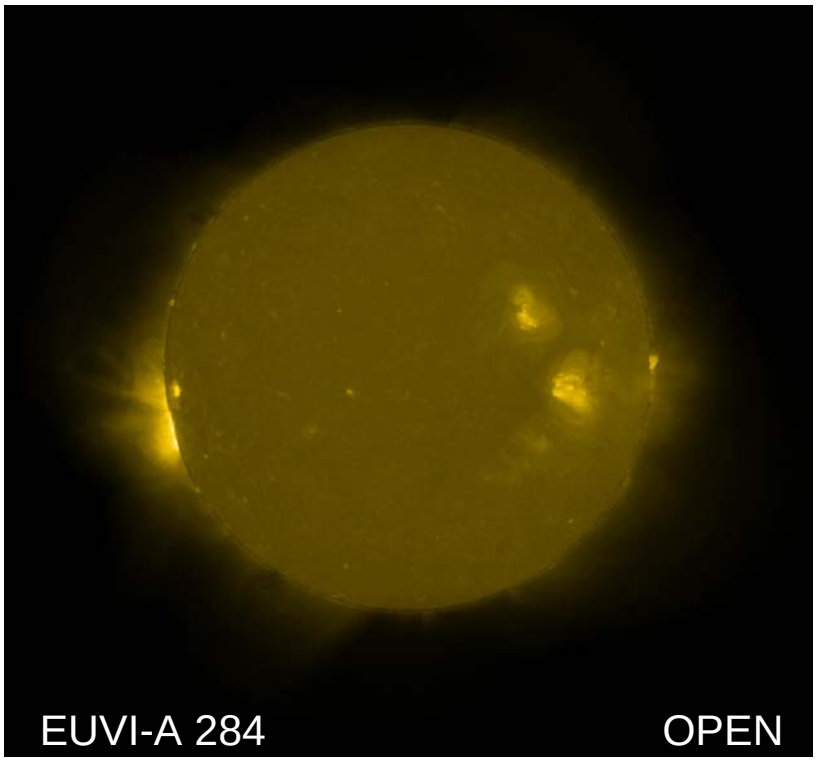

First Light BEHIND : December 13, 2006

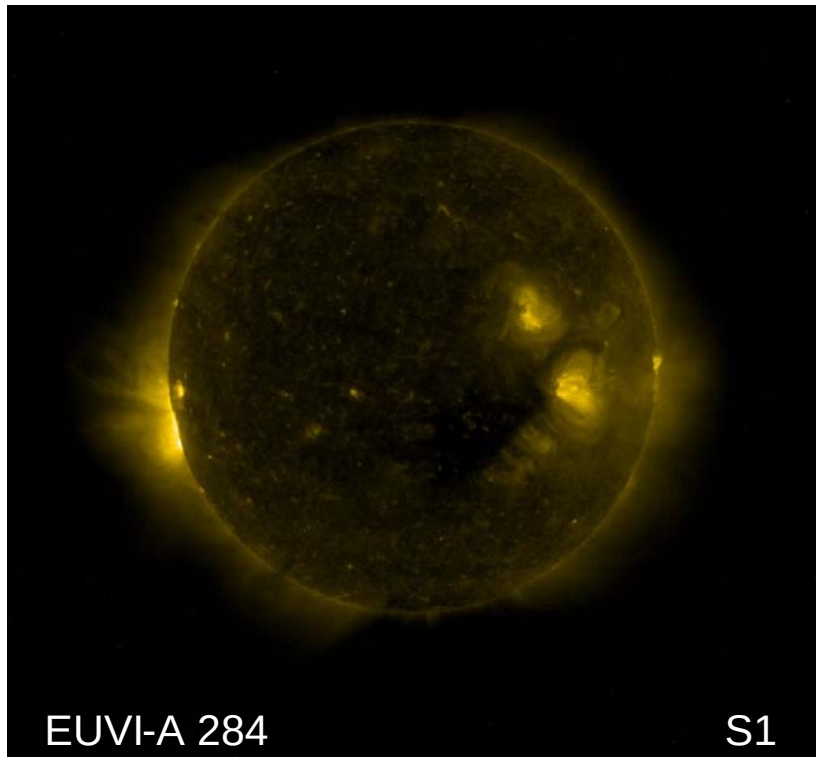
First Light

- First Light went smoothly on both S/C
  - Initial images with open filter wheel at all 4 wavelengths
  - Comprehensive set of images at all filter wheel / wavelength combinations with lossless compression
  - Images to test tip/tilt mirror Fine Pointing System (FPS)
- Open filter wheel images showed that entrance filters survived launch in pristine condition
- Image intensity levels within factor 2 of expectations
- Images well in focus
- FPS performed very well without any tuning

Entrance Filters

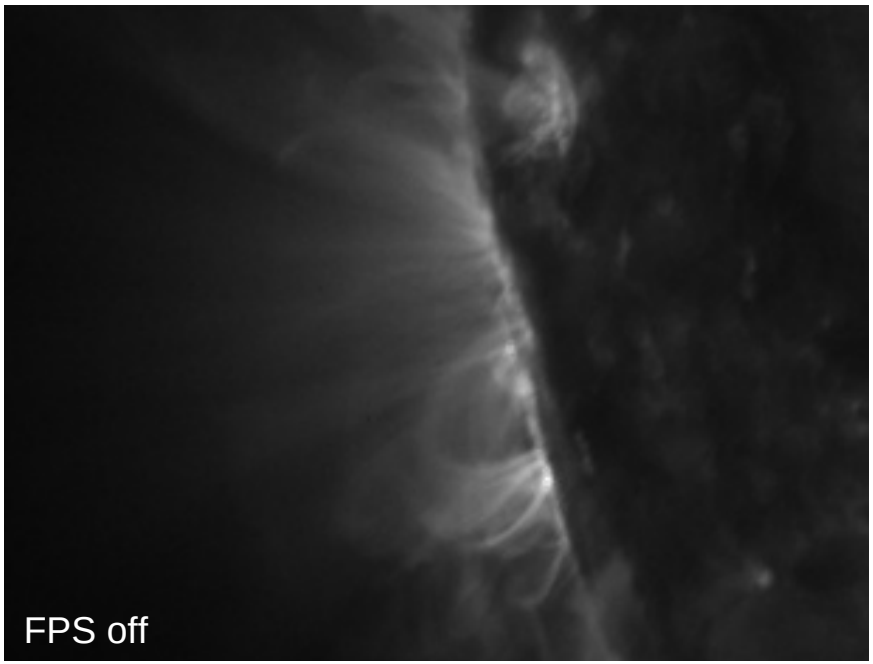
- Entrance filters have a very small bulk transmission (less than 1e-8)
- Images in the filter wheel “open” position show a small visible light component, in particular at the (fainter) 284 wavelength

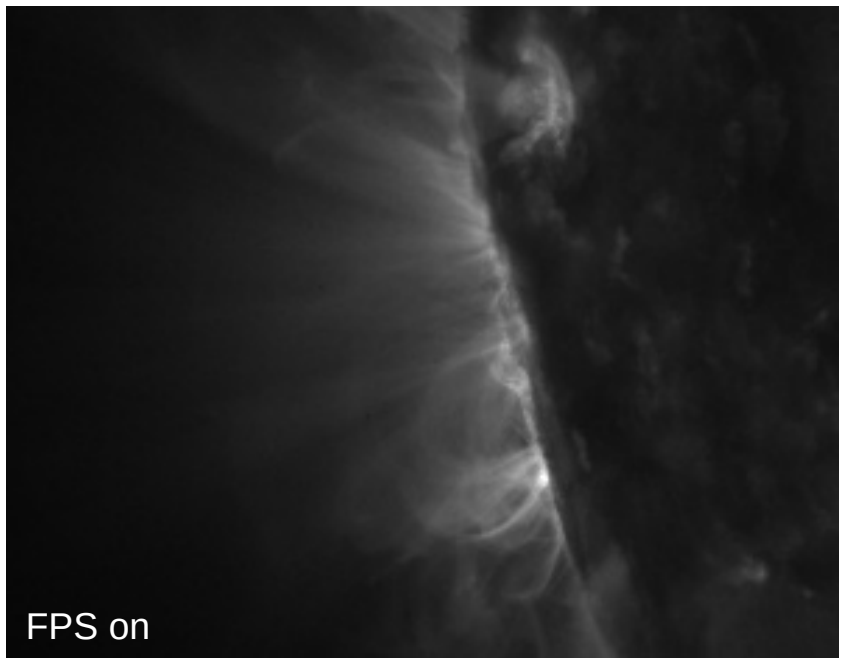




Fine Pointing System

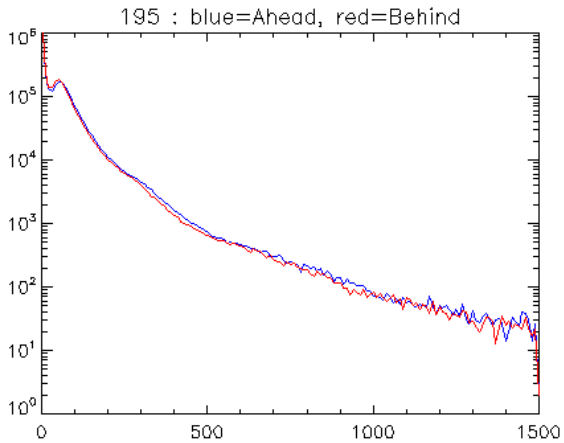
- Early in the commissioning phase, the FPS dramatically improved the quality of the EUVI images
  - Images below were taken during EUVI-A first light
- S/C jitter performance has substantially improved since, making the effect more subtle

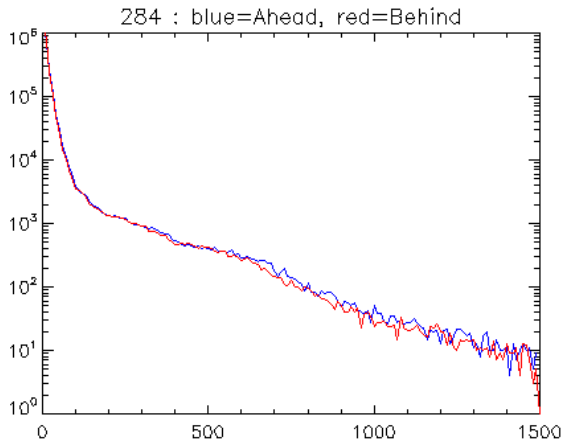


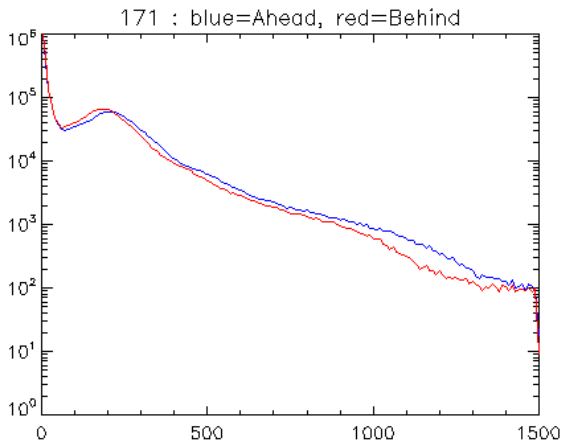


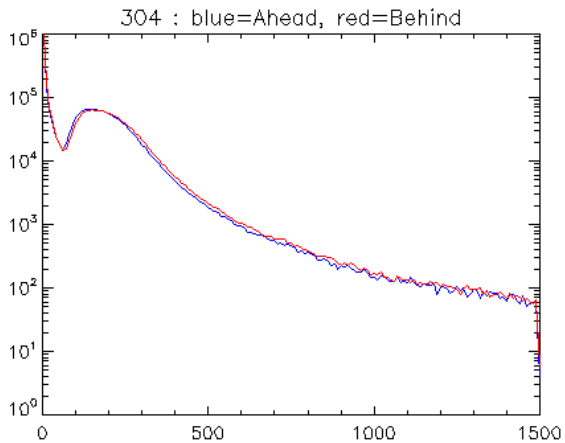
Response Comparison Ahead vs. Behind

- Histograms of simultaneous images in A/B
  - Blue: Ahead
  - Red: Behind
- Response very similar
- Largest difference in 171:
  - Approx. 10 %
  - EUVI A & B have slightly different response ratio 171 / 175

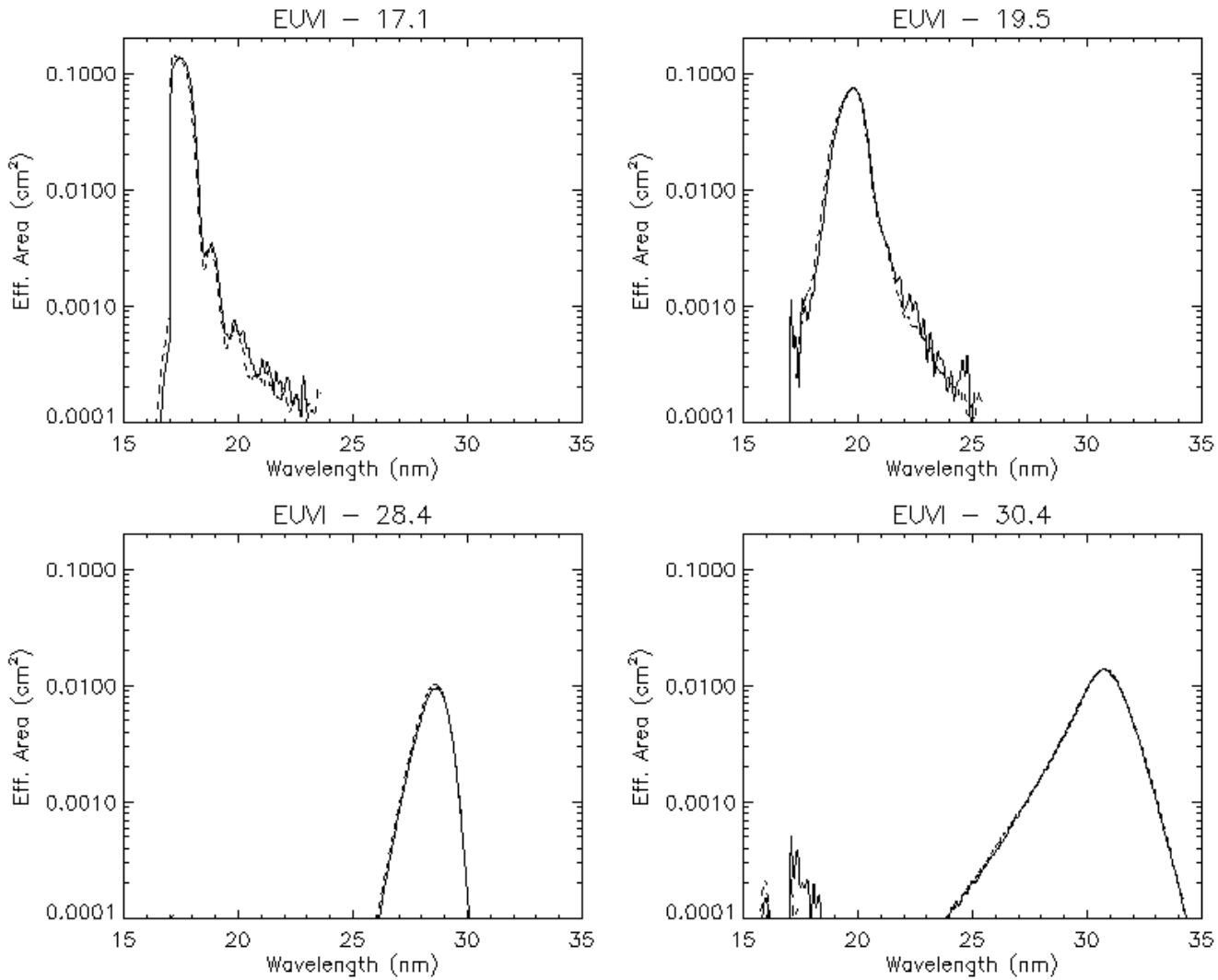








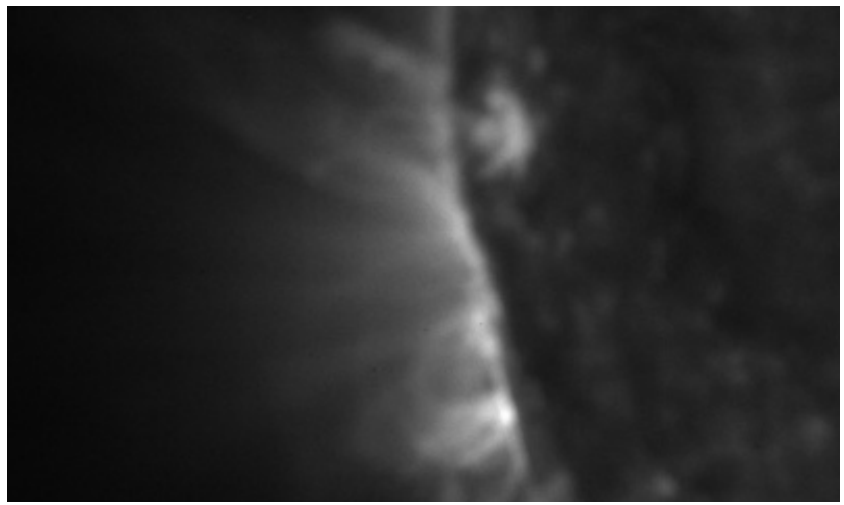
EUVI A / B Spectral Response (Prelaunch)



Flat Fielding

Approach:

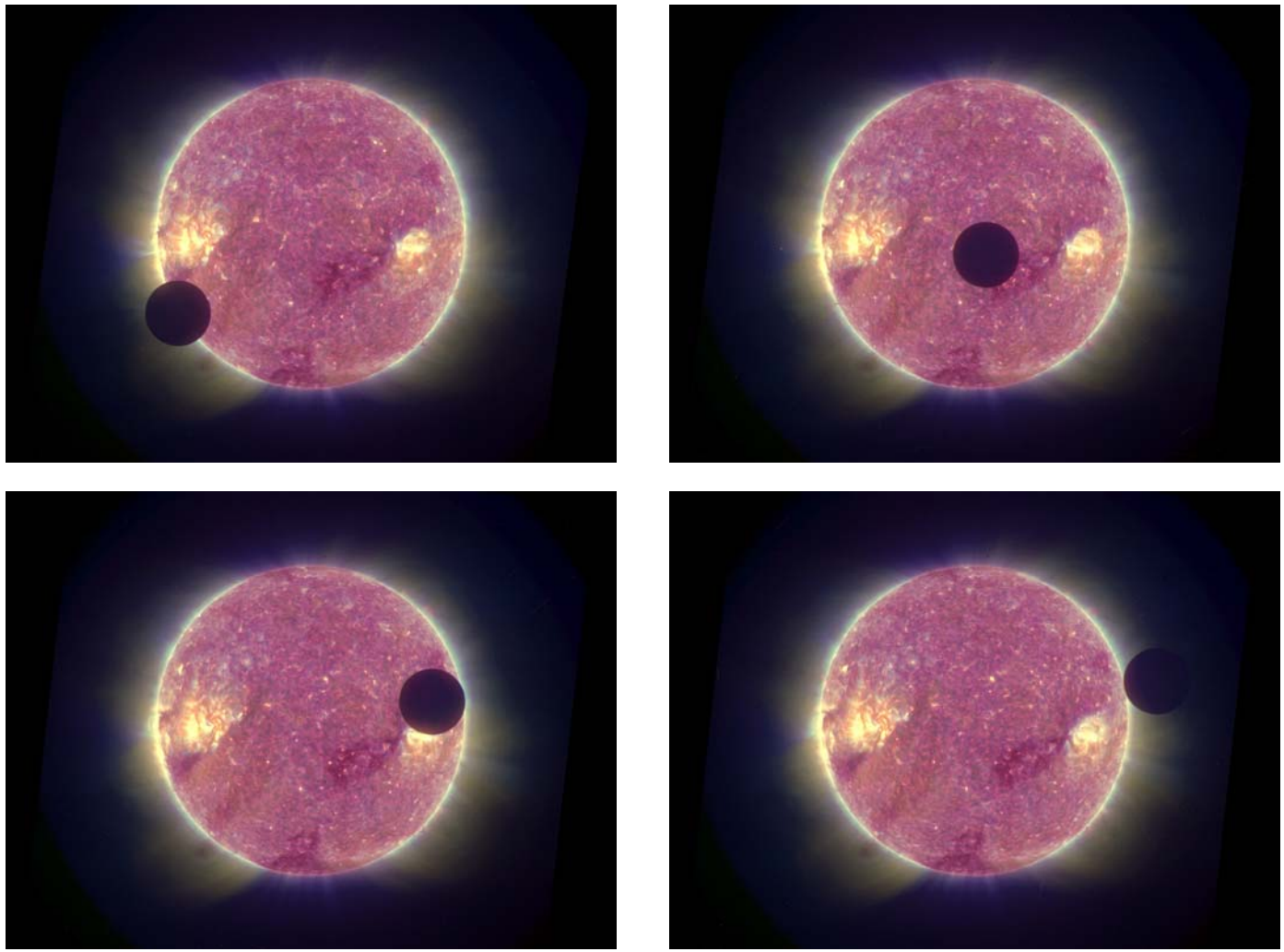
- Large scale (S/C controlled) offpoints for vignetting function
  - 6 positions
  - Up to +/- 12 arcmin
- Small (SECCHI controlled) offpoints for flat field
  - 14 random positions
  - Up to +/- 1.5 arcmin
- All observations use tip/tilt mirror to artificially blur images



EUVI Pointing and Roll Calibration

- Determined relative roll between EUVI-A and EUVI-B (1.245 degrees)
- Absolute roll calibration for EUVI-B (offset from S/C roll) based on lunar transit (pending analysis)
- Pointing (pitch and yaw) based on GT data
- Absolute sun center currently accurate to a few arcsec
  - Subarcsec accuracy expected from improved modeling of GT nonlinearities
- Relative pointing (jitter) accurate to subarcsecond level
- Determined plate scale difference between EUVI-A and EUVI-B (approx. factor 0.9986)
- Absolute plate scale for Behind based lunar transit (pending analysis)
- FITS files for data up to 2007-03-19 have generic pointing information, update via SolarSoft routine (euvi_point)

Lunar Transit 2007 February 25



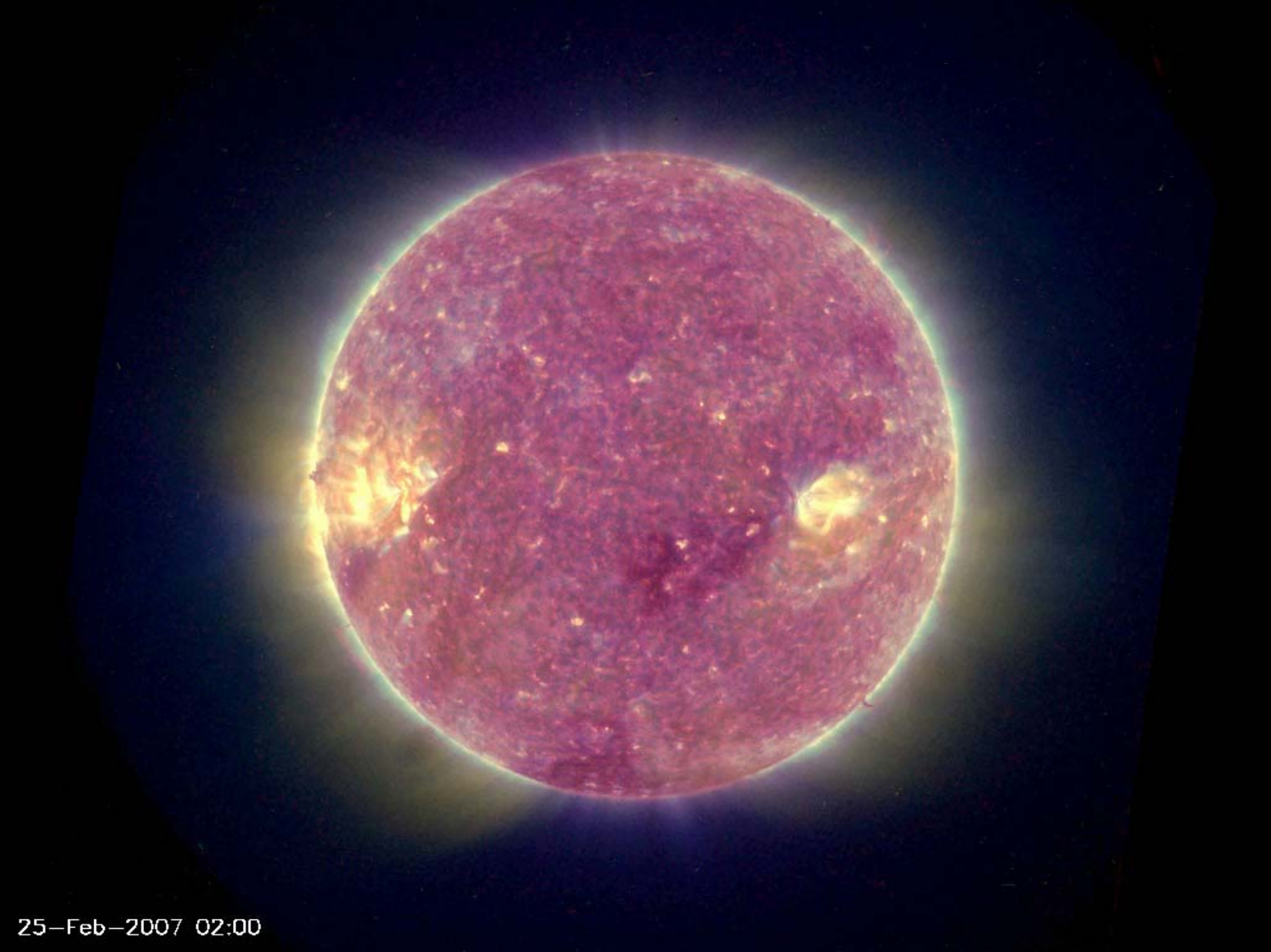

25-Feb-2007 02:00

Image Compression - ICER

- Almost all EUVI images are ICER compressed on-board
  - ICER was developed at JPL and used on the Mars Rovers
- Main ICER parameter: desired size of compressed image
  - SECCHI uses 12 sets of compression parameters, including
    - ICER0 : 2 MByte (usually lossless for EUVI images)
    - ICER4 : 400 kByte
    - ICER5 : 300 kByte
    - ICER6 : 200 kByte
- Choosing compression level essentially involves trading image quality versus image cadence
  - ICER4 instead of ICER6 means half the image cadence
  - We are using a mix of different compression factors, depending on observing objectives, and wavelength
    - To date, most images were compressed with ICER6

Observing Strategies - General Concept

- Synoptic program
  - Continuous coverage to catch all events
  - 85 - 90 % of available telemetry
  - Moderate cadence
- Event buffer program
  - Observes into ring buffer (“SSR2”)
  - On-board event detection algorithm on Cor2 images stops observations when triggered by CME
  - Ring buffer has 3-4 hour capacity of high cadence observations
  - Allows for some “well observed” events

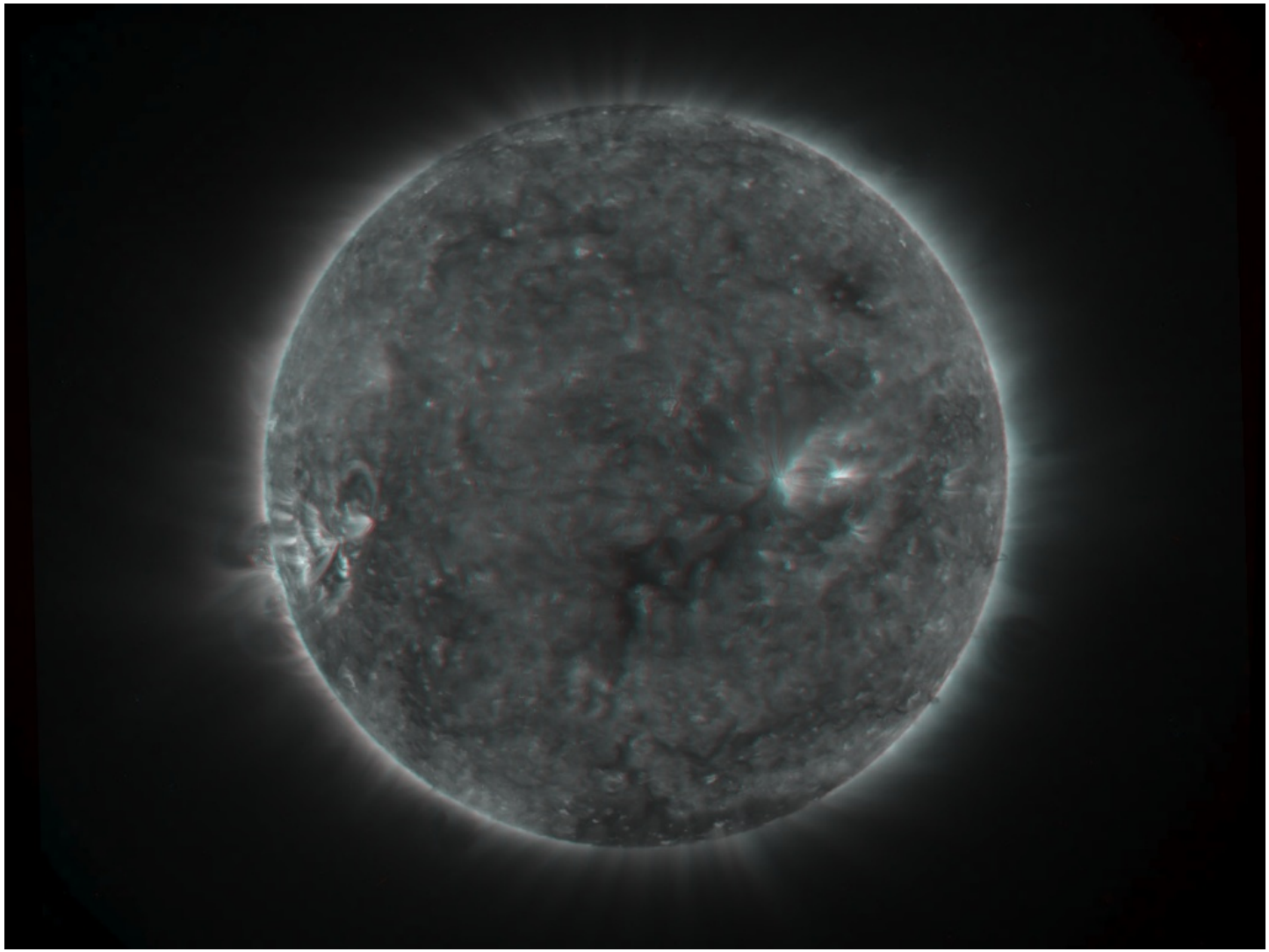
SECCHI Campaigns

- SECCHI Campaigns are designated periods of time where
  - Each STEREO observatory receives two DSN downlinks per day
  - SECCHI receives twice the daily telemetry volume, i.e., approx. 9.3 Gbit/day/observatory instead of 4.65
- SECCHI gets a total of 4 weeks of campaign time during the primary science mission
  - SECCHI plans to have 2 campaigns of two weeks each
- SECCHI Campaigns must be scheduled long in advance
  - The campaign dates cannot be adjusted based on solar activity

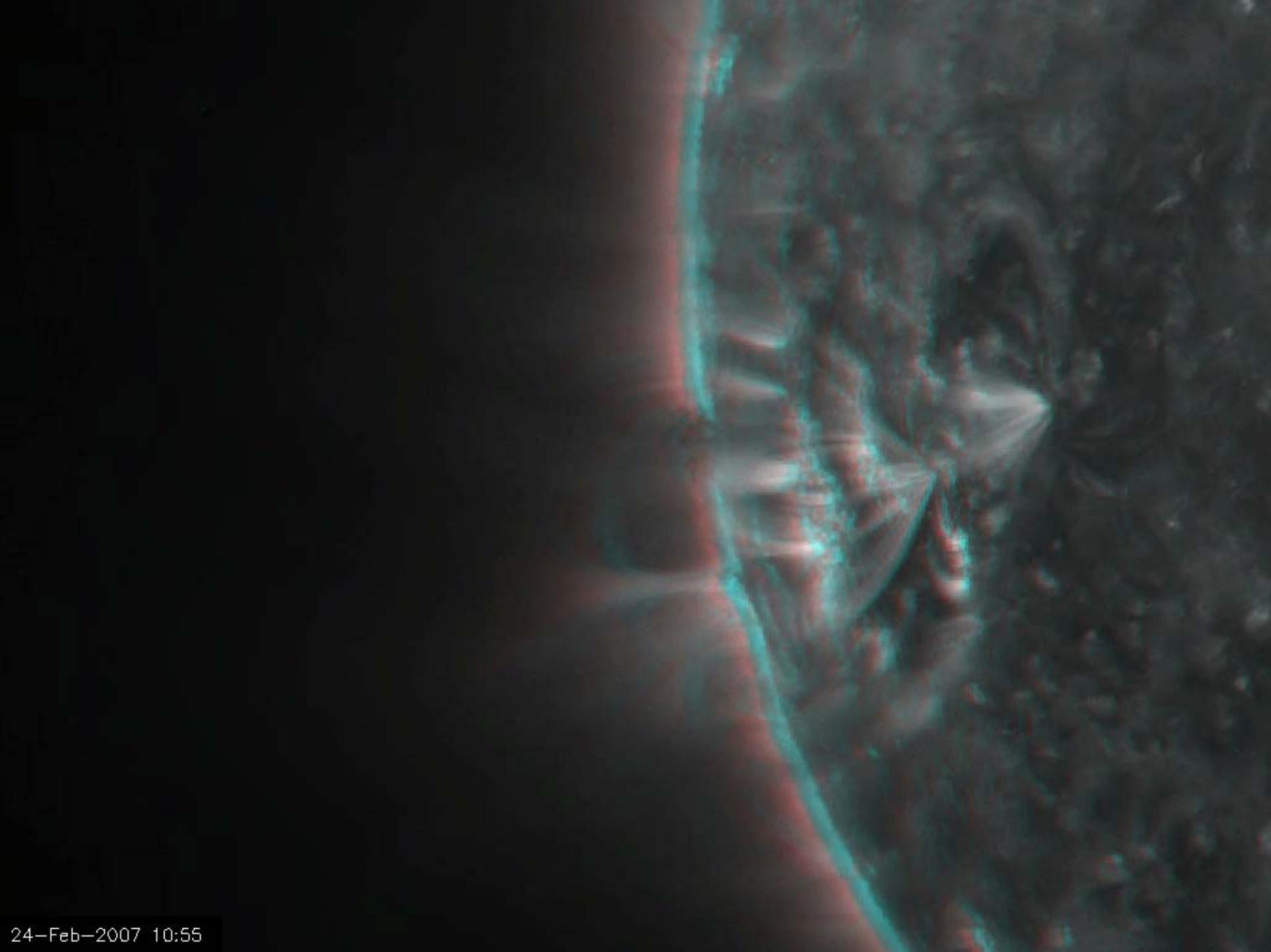
The First SECCHI Campaign

- The focus of the first SECCHI Campaign are observations at an observatory separation angle best suited for
  - Stereoscopic observations in the classical sense
  - 3D reconstruction using tie point methods with visual interaction
- Primary science objective: Investigate CME initiation in the low corona
- The first SECCHI Campaign:
  - Starts on May 4 and ends on May 17
  - Observatory separation: approx. 7 degrees
  - Ends just before the beginning of the SOHO keyhole period
  - Unfortunately during the Hinode eclipse season
    - May impact the availability of data from the optical telescope in particular

First 3D in 171



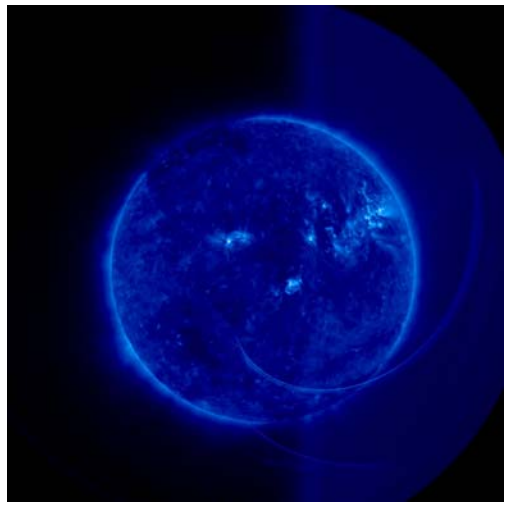

21-Feb-2007 21:05

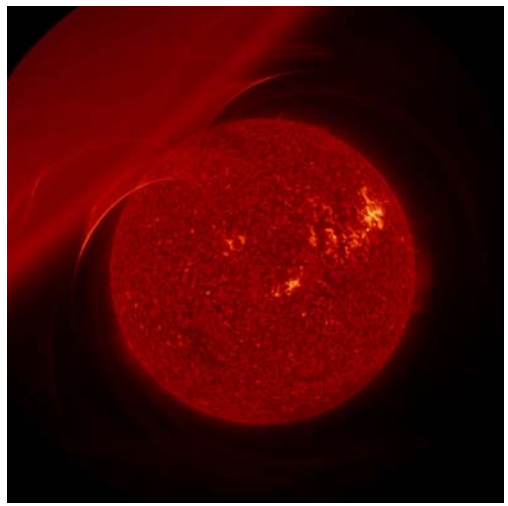

24-Feb-2007 10:55

Backup

Entrance Filters (2)

- A few weeks after launch, two entrance filters on the EUVI-A developed a small pinhole
- Pinholes are tiny, imaging in the “open” position is still possible
- No practical impact as we always planned to observe with additional filter in the filter wheel.
- The filters continue to meet light and heat rejection requirements
- Affected quadrants: 171 & 304 on Ahead
- All other quadrants, including all quadrants on EUVI-B continue to be in pristine condition as of mid January 2007

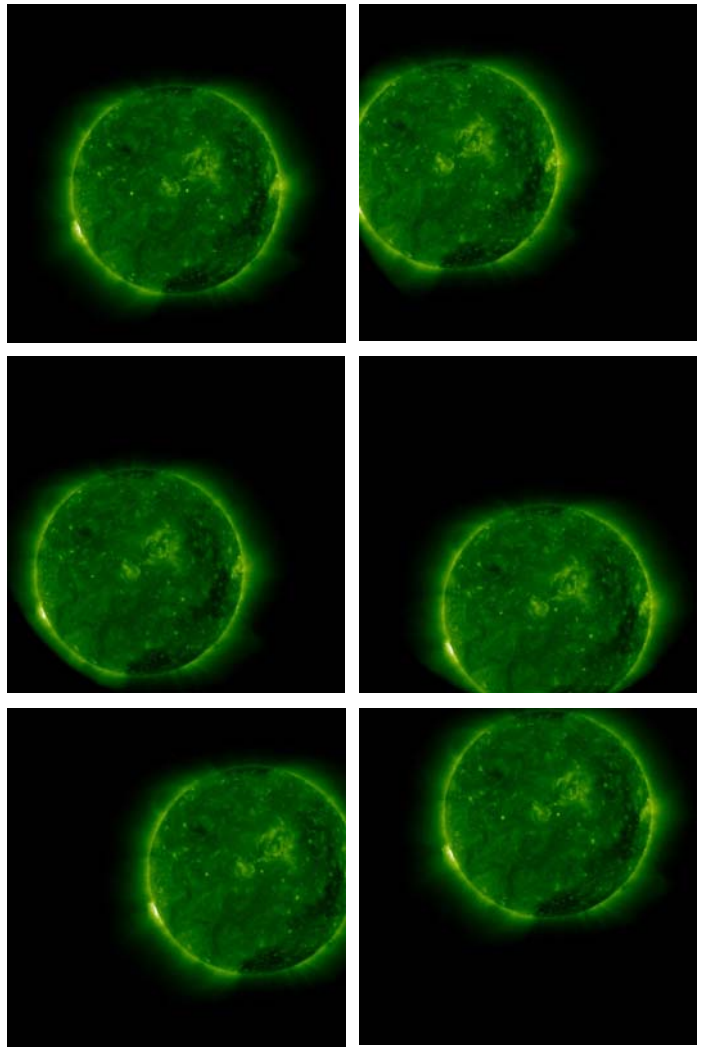




Flat Fielding (2)

Status

- Large scale offpoints complete
  - A: 2007-02-15, B: 2007-02-05
  - See Figures on the right
- Small scale offpoints:
  - A-171 & 304: 2007-02-21
  - B-171 & 304: 2007-02-04
  - 195 & 284 not done yet
- Data analysis pending

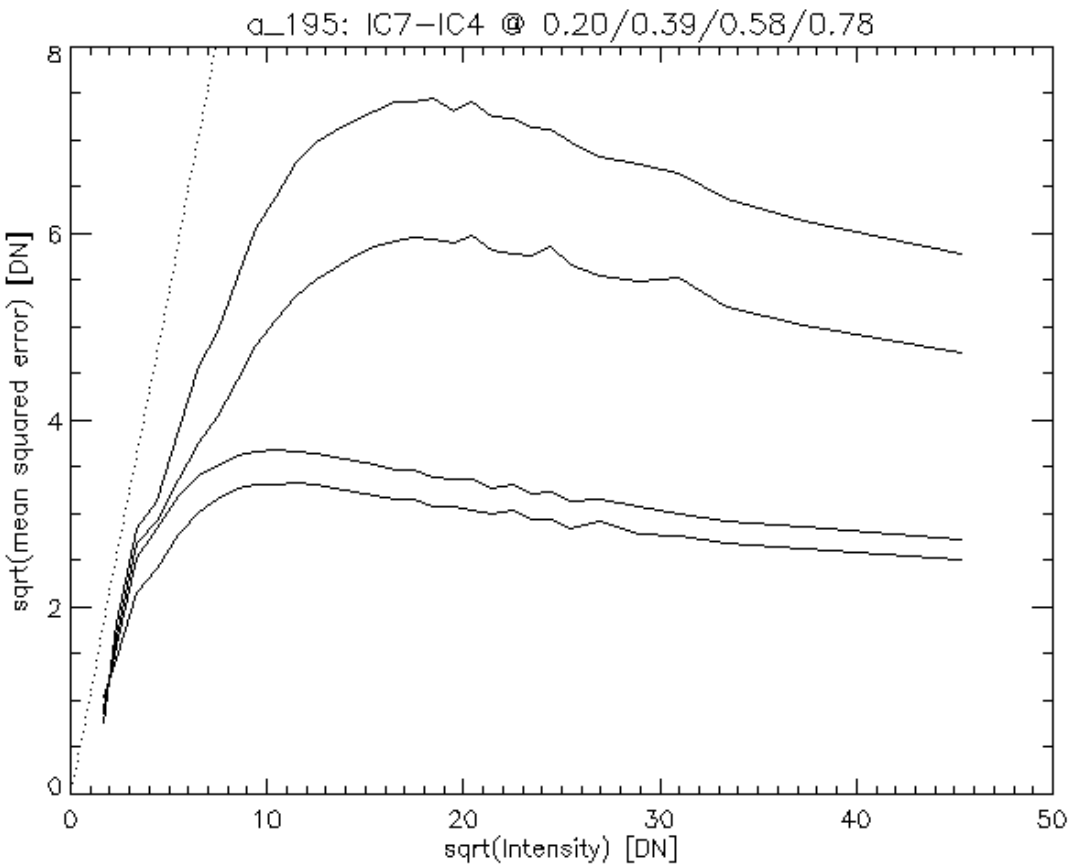


EUVI Pointing and Roll - The FPS and Jitter

- FPS mode of operation:
  - The FPS is turned on/off for each image
  - At the beginning of the exposure, an offset is added to the GT signal to minimize the motion of the tip/tilt mirror
  - The offset is chosen in integer increments of the EUVI pixel size
- Effect on EUVI raw images
  - The sun center location may jump around from image to image
  - The amplitude of the jumps is in full pixel increments
    - The exact amplitude may be a few percent off a full pixel increment
    - The exact amplitude is given in the (corrected) $CRPIX_i$ values
  - Movies, overlays, or difference images can be made with images that are shifted in full pixel increments
    - Sub-pixel interpolation is not necessary

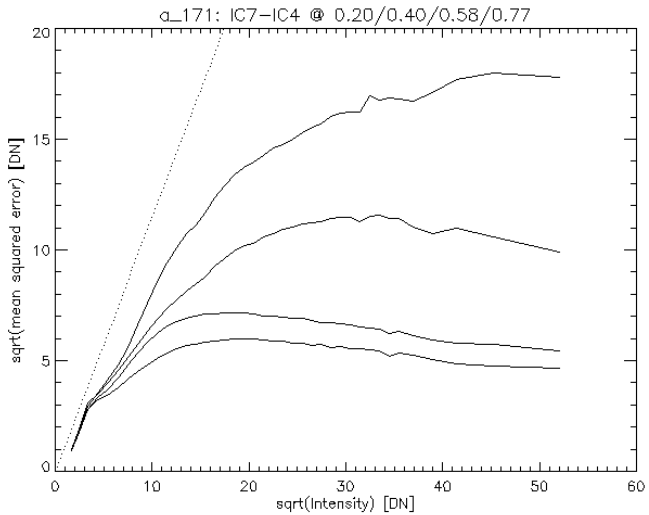
ICER Performance - EUVI 195

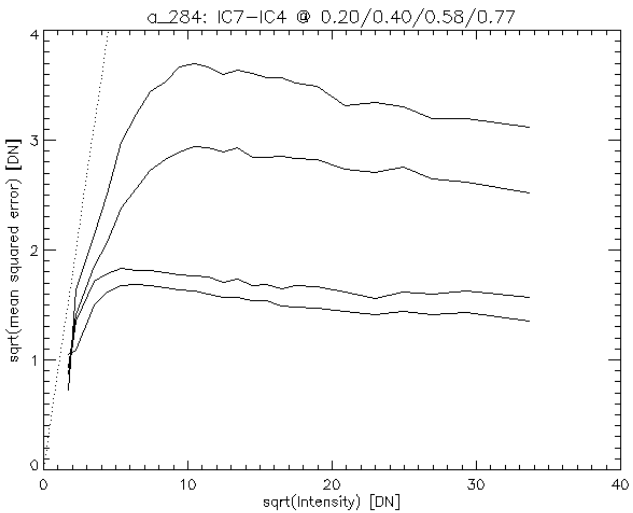
- Analysis of an EUVI image with various levels of ICER
- Plot shows average compression error as a function of intensity
- Horizontal axis is square root scaled
  - Poisson noise limit is a straight line (dotted)
  - Top: ICER7
  - Bottom: ICER4
- All curves are below the single pixel Poisson noise limit

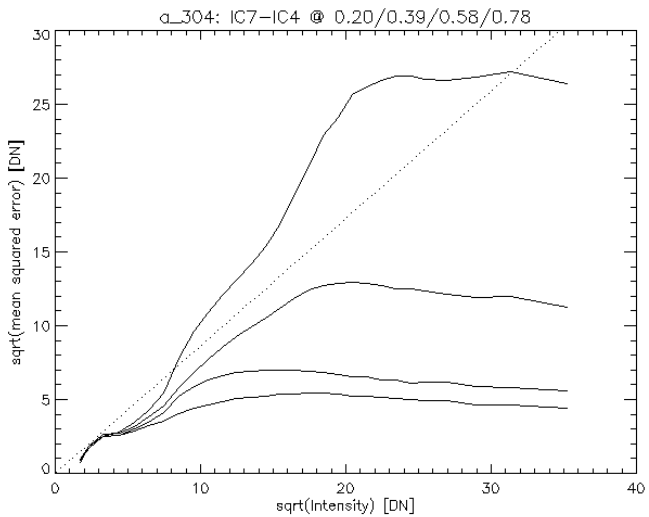


ICER Performance - EUVI 171, 284, 304

- 284 compresses very well
- 304 compresses the least, with ICER7 exceeding the Poisson limit
- All wavelengths compress below the Poisson limit for up to ICER6
- Most EUVI observations to date use ICER6







ICER

Faint areas:

- ICER adjusts spatial resolution to match the noise level by summing faint areas into superpixels
- Areas at the noise level show “blocky” appearance
- Loss of true information is small
- Left to right:
  - ICER6
  - ICER4
  - Lossless