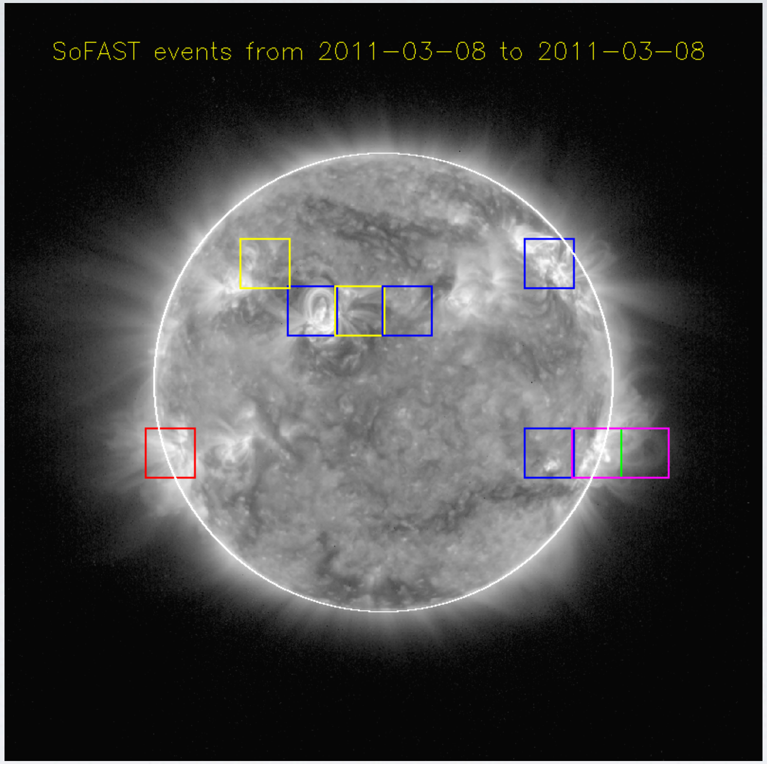

SoFAST: AUTOMATED FLARE DETECTION WITH THE PROBA2/SWAP EUV IMAGER

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ESWW9, 5 November 2012

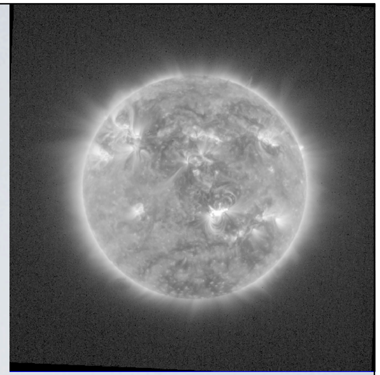
EUV FLARE DETECTION

- SoFAST: Solar Flare Automated Search Tool
- Aim
- Input: PROBA2/SWAP EUV images
- Detection
- Output
- Conclusions & Applications

AIM

- Automated detection of EUV-flares
- EUV ≠ X-rays
- Towards Space Weather monitoring tool
- Towards SoFAST SWAP catalogue
- Towards onboard intelligence for data selection (robust) Solar Orbiter EUI

PROBA2/SWAP



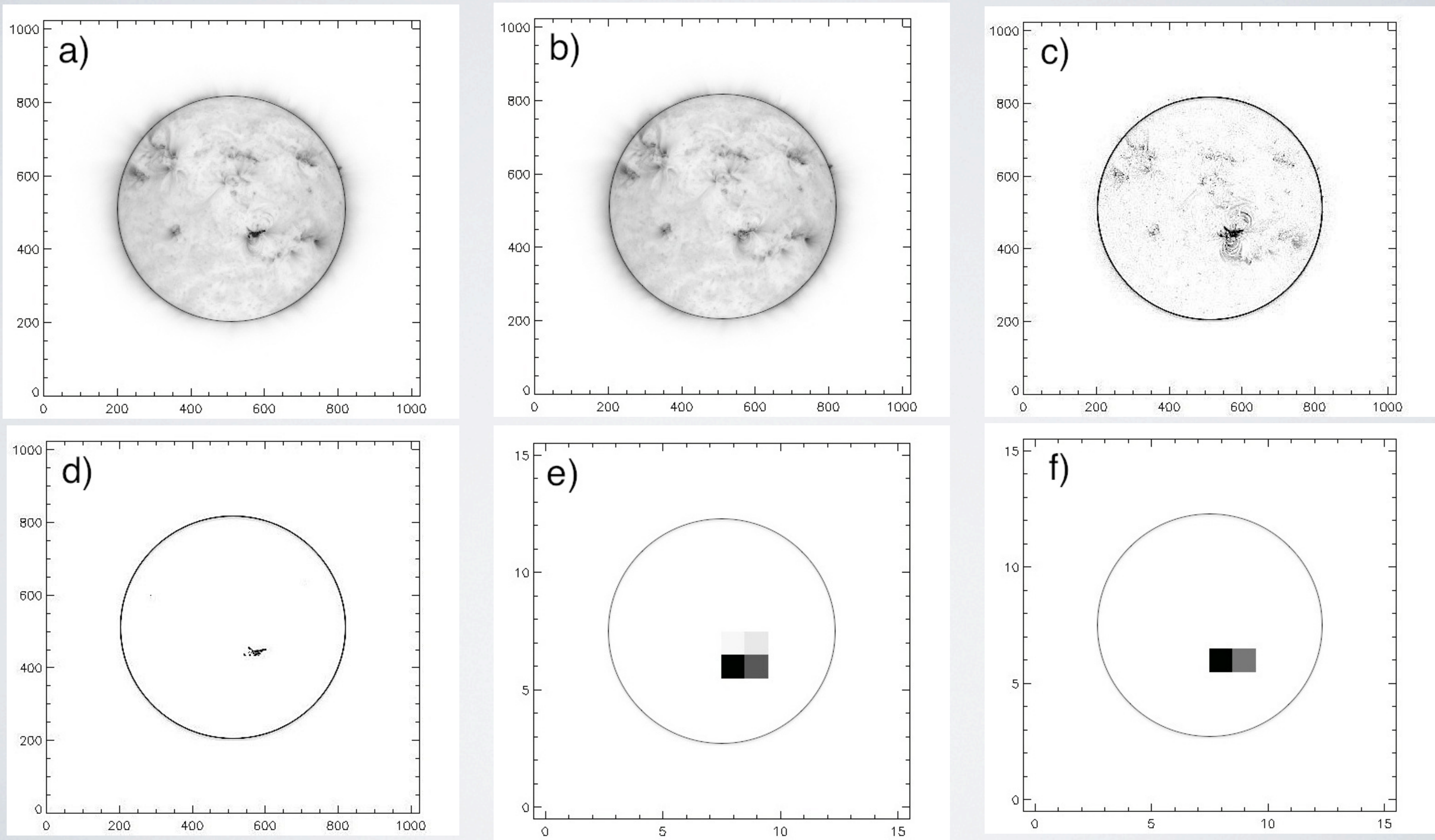
EUI/FSI

- Sun Watcher with Active Pixels and Image processing
- EUV imager ✓
- bandpass peaking at 17.4 nm (1 million Kelvin plasma) ✓ +30.4
- 1024x1024 pixels (nominal mode) ✓
- resolution of 3.17 arcseconds (nominal mode) ✓
- cadence around 130s ✓

LEVEL-0 → LEVEL-1

- Level-1 images are....
    - dark subtracted
    - corrected for bad pixels
    - corrected for instrumental and spacecraft effects
    - normalized to exposure time
    - in DN per second per pixel (FITS file format)

DETECTION METHOD



CLUSTERING

- Clustering operations to mark out different events
  - in space
  - in time

OUTPUT

```
#   EUV FLARE:            FLARE number
#   date:                 Day of observation
#   start:                Start time, earliest indication of detection (hh:mm UT)
#   end:                  End time, last indication of detection (hh:mm UT)
#   pos:                  Derived position (Heliographic coordinates)
#   size:                 Spatial size of event in number of macropixels
#   #images:              Duration of event in number of images (dt)
#   EUV-significance:     EUV relative variability, in %.
#                         Flare-related activity typically shows EUV-significance >8%
#
# EUV FLARE |    date    | start |  end  |    pos     | size | #images | EUV-significance
  016       | 2011-03-08 | 23:37 | 23:55 |   N28W56   | 001  |   006   |      008 %
```

TYPICAL ONE-DAY

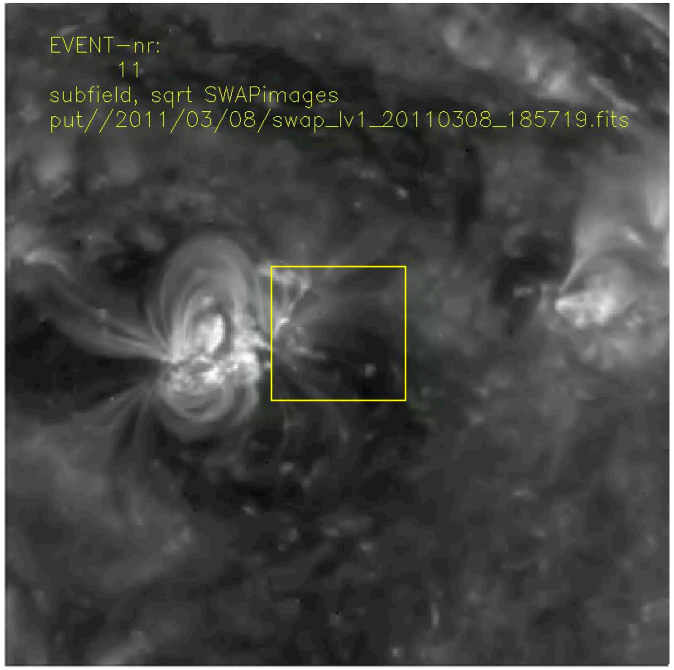
# EUV FLARE	date	start	end	pos	size	#images	EUV-significance	
016	2011-03-08	23:37	23:55	N28W56	001	006	008 %	non-GOES
015	2011-03-08	22:32	23:55	S19W85	002	026	005 %	GOES C8.8
014	2011-03-08	22:07	22:42	N28W56	001	011	008 %	non-GOES
013	2011-03-08	21:55	22:17	N26E35	001	008	005 %	non-GOES
012	2011-03-08	20:27	21:18	S19W85	001	027	020 %	GOES M1.4
011	2011-03-08	18:57	19:22	N11W06	001	013	049 %	non-GOES
010	2011-03-08	18:50	19:12	N28W56	001	011	005 %	non-GOES
009	2011-03-08	18:12	18:20	S19W85	001	004	003 %	GOES M4.4
008	2011-03-08	16:47	17:02	N11E06	001	006	004 %	non-GOES
007	2011-03-08	10:38	11:03	S19W85	001	014	008 %	GOES M5.3
006	2011-03-08	09:32	09:37	S23W52	001	004	009 %	GOES C4.7
005	2011-03-08	06:15	06:22	S23W52	001	004	002 %	non-GOES
004	2011-03-08	05:32	05:52	S19E85	001	008	004 %	non-GOES
003	2011-03-08	03:37	05:27	S19E85	001	039	031 %	GOES M1.5
002	2011-03-08	02:12	02:32	S19W85	001	007	011 %	GOES M1.3
001	2011-03-08	00:12	00:27	N11E19	001	005	010 %	non-GOES

EVENT DETAILS

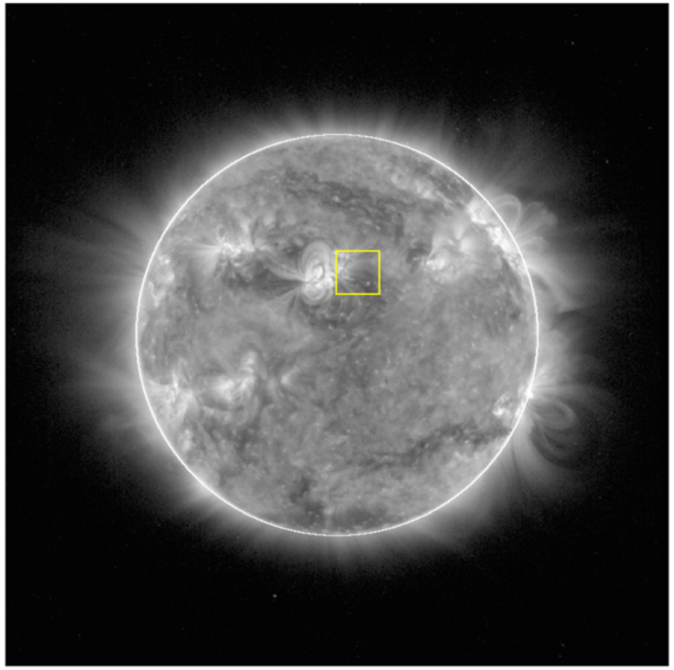
Details and graphs for EUVflare_011

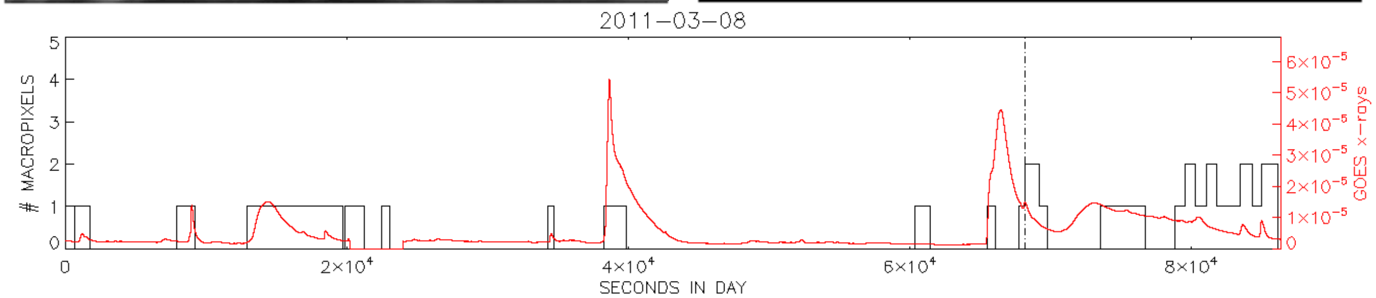
# EUV FLARE	date	start	end	pos	size	#images	EUV-significance
011	2011-03-08	18:57	19:22	N11W06	001	013	049 %

EUV flare Movie :: Enlarge and/or Download ::

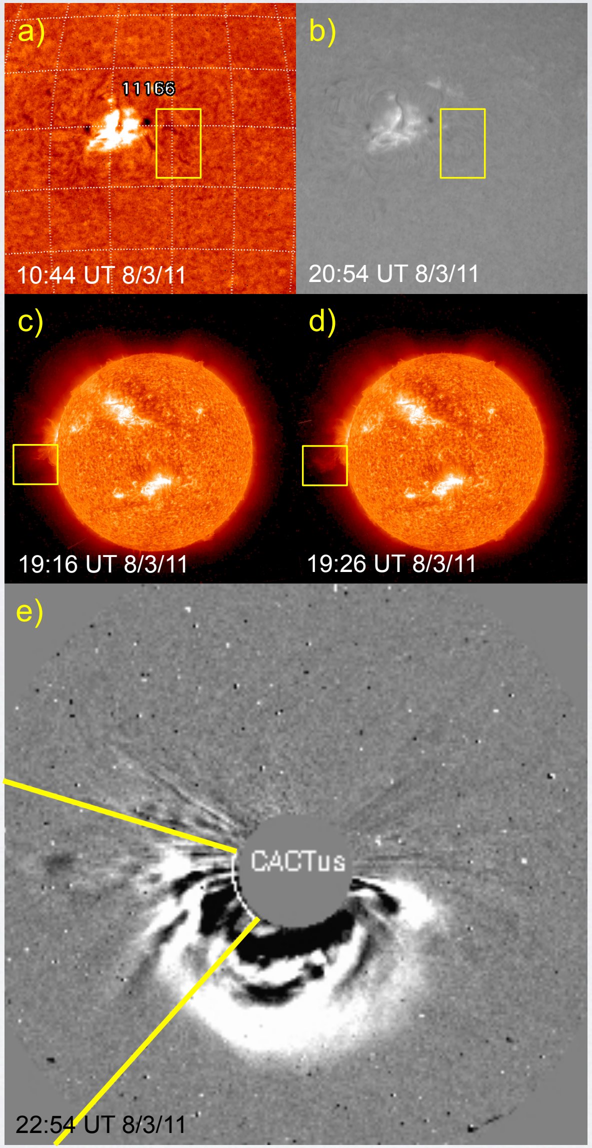


Sample Image





"NON-GOES" EVENT



CONCLUSIONS

- Detection validated
  - High energy flares on one hand
  - EUV dynamic events on the other hand
- Clear strengths
  - Robustness; Insensitivity to particle noise
  - EUV-significance quantifying the EUV relative variability

APPLICATIONS

- PROBA2 SWAP+LYRA joint Space Weather monitoring
  [See poster Bonte et al, “Space Situational Awareness Services offered by PROBA2”]
- SoFAST SWAP catalogue
- Solar Orbiter EUI: onboard intelligence for data selection. Taking into account limited telemetry quota.

SoFAST IS / WILL BE USED..

- ..as a prototype for aEUI/FSI event trigger
- ..by Space-Weather forecasters @ROB
- ..as input for Heliophysics Event Knowledgedatabase (HEK)
- ..as input for the Coronal Mass Ejections and Solar Energetic Particles (COMESEP) alert system
- ..as input for the HELIO virtual observatory
- ..to build a complete SoFAST SWAP catalogue (future work)
- ..for investigation of stealth CMEs (future work, collaboration with E. D'Huys)
- ..for investigation of thermal evolution of flares, Neupert effect (future work, collaboration with M. Dominique)
- ..to better interpret Lyra data
- ....

REAL TIME ONLINE

www.sidc.be/sofast

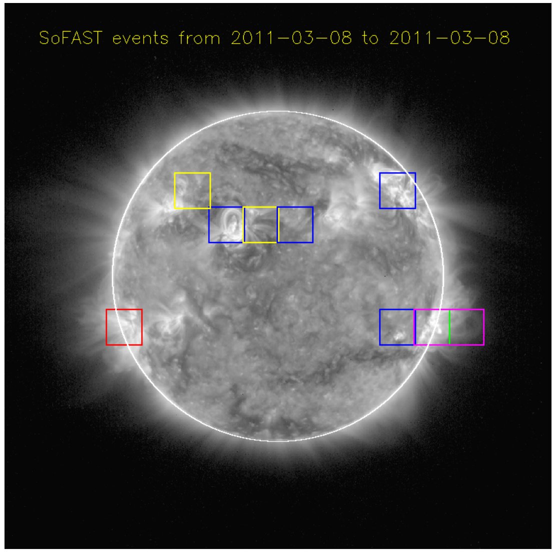
SoFAST 1.2.0

The 'Solar Flare Automated Search Tool'

EUV-flares detected by SoFAST

```
:Issued: Mon Oct 22 21:38:08 2012
:Product: SoFAST catalogue (http://www.sidc.be/sofast)
#----------------------------------------------------------------------
# Instrument: SWAP| Detector: CMOS APS 1024 x 1024
# Flare-threshold : 2 | Rebinsize : 16 | Maxhits : 4 | Offset : 65
# Modus : (1) SW service
#
  first SWAP image this run: swap_lvl_20110308_000038.fits
  last  SWAP image this run: swap_lvl_20110308_235720.fits
#
#
#----------------------------------------------------------------------
# Output: Detected EUV-flare list with the following characteristics:
#
#   EUV FLARE:          FLARE number
#   date:               Day of observation
#   start:              Start time, earliest indication of detection (hh:mm UT)
#   end:                End time, last indication of detection (hh:mm UT)
#   pos:                Derived position (Heliographic coordinates)
#   size:               Spatial size of event in number of macropixels
#   #images:            Duration of event in number of images (dt)
#   EUV-significance:   EUV relative variability, in %.
#                       Flare-related activity typically shows EUV-significance >8%
#
```

# EUV FLARE	date	start	end	pos	size	#images	EUV-significance
016	2011-03-08	23:37	23:55	N28W56	001	006	008 %
015	2011-03-08	22:32	23:55	S19W85	002	026	005 %
014	2011-03-08	22:07	22:42	N28W56	001	011	008 %
013	2011-03-08	21:55	22:17	N26E35	001	008	005 %
012	2011-03-08	20:27	21:18	S19W85	001	027	020 %
011	2011-03-08	18:57	19:22	N11W06	001	013	049 %
010	2011-03-08	18:50	19:12	N28W56	001	011	005 %
009	2011-03-08	18:12	18:20	S19W85	001	004	003 %
008	2011-03-08	16:47	17:02	N11E06	001	006	004 %
007	2011-03-08	10:38	11:03	S19W85	001	014	008 %
006	2011-03-08	09:32	09:37	S23W52	001	004	009 %
005	2011-03-08	06:15	06:22	S23W52	001	004	002 %
004	2011-03-08	05:32	05:52	S19E85	001	008	004 %
003	2011-03-08	03:37	05:27	S19E85	001	039	031 %
002	2011-03-08	02:12	02:32	S19W85	001	007	011 %
001	2011-03-08	00:12	00:27	N11E19	001	005	010 %



CLICK IMAGE
to see the complete SWAP movie during this run (with indication of detected events)

THANKS