

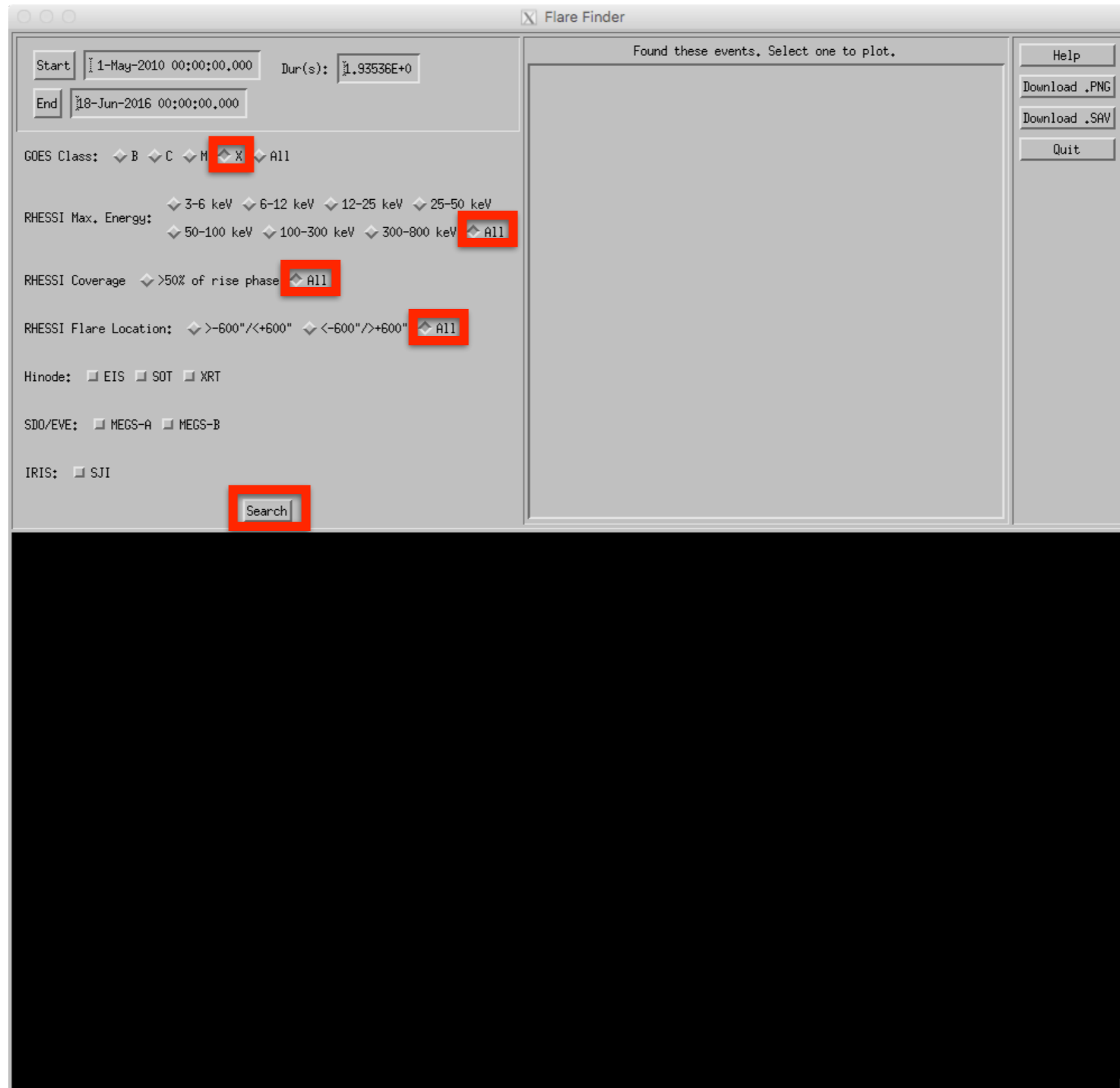
A Method to Search for Solar Flares Jointly Observed by RHESSI and Other Instruments

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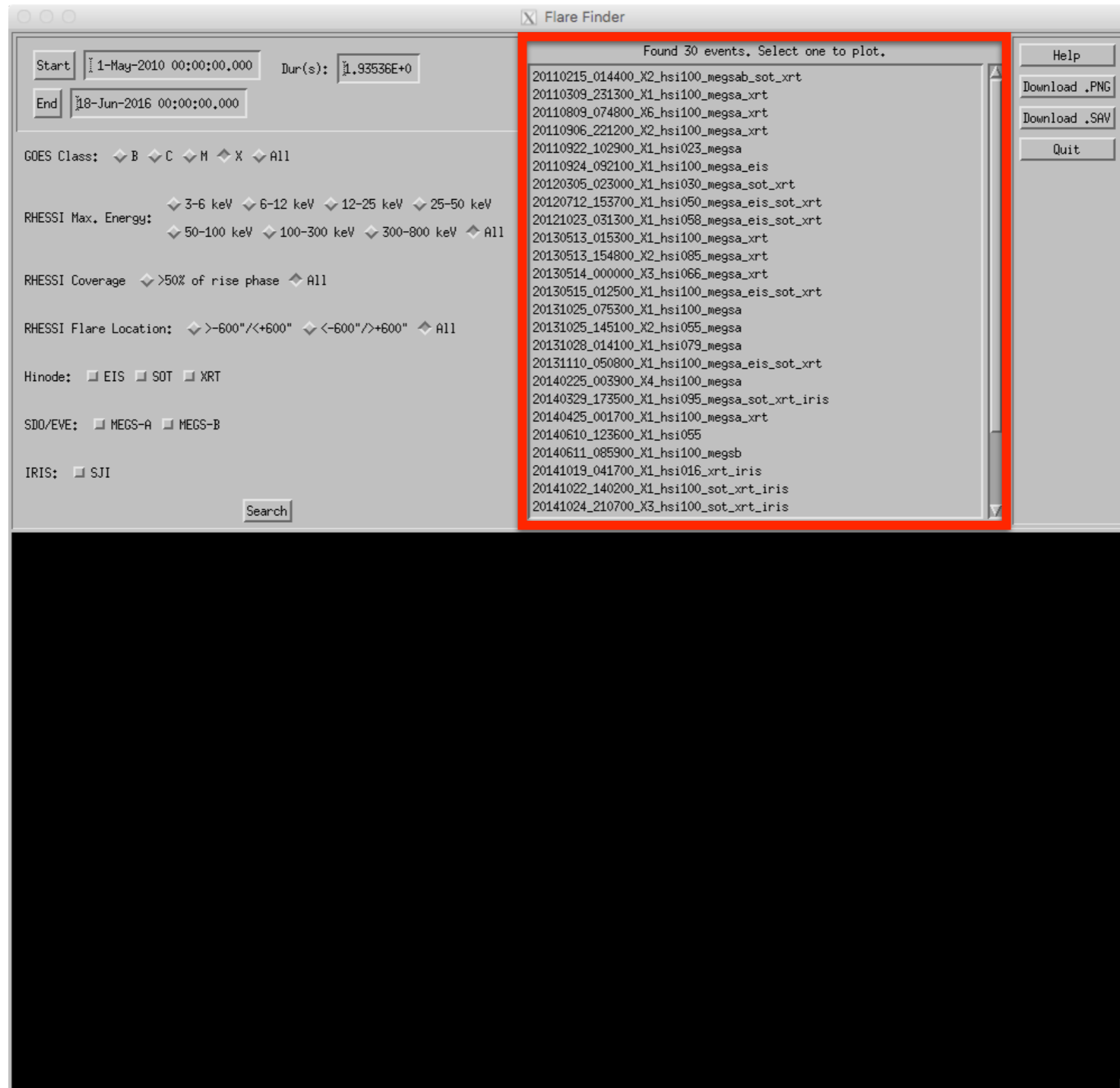
Acknowledgements: thanks to Kim Tolbert for help with the GUI, Albert Shih for help with the RHESSI browser and Dominic Zarro for help with the Hinode/EIS software.

This work was supported by NASA LWS/SDO Data Analysis grant NNX14AE07G.

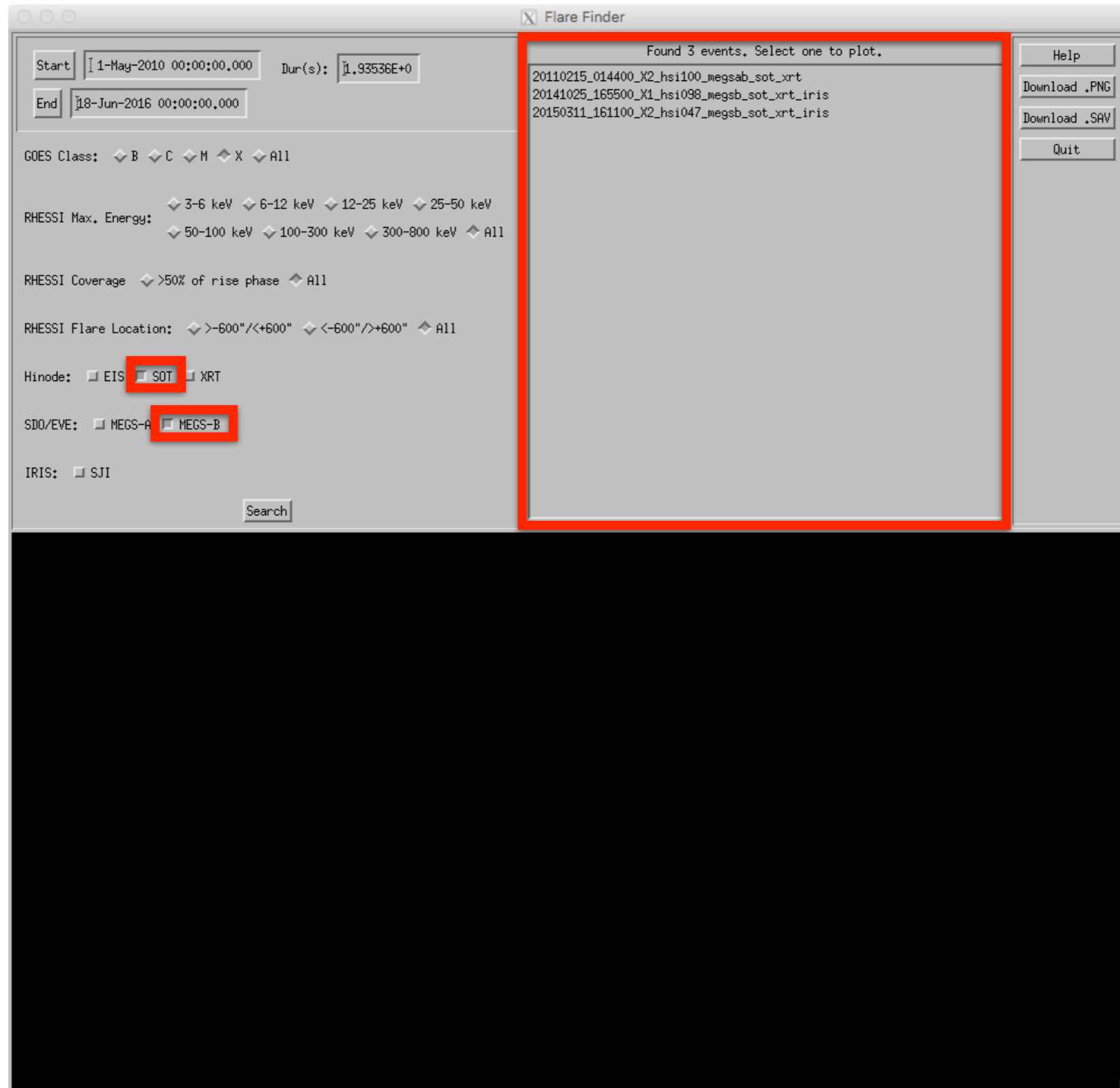
Widget-based search tool now in SSWIDL (IDL>solar_flare_finder).



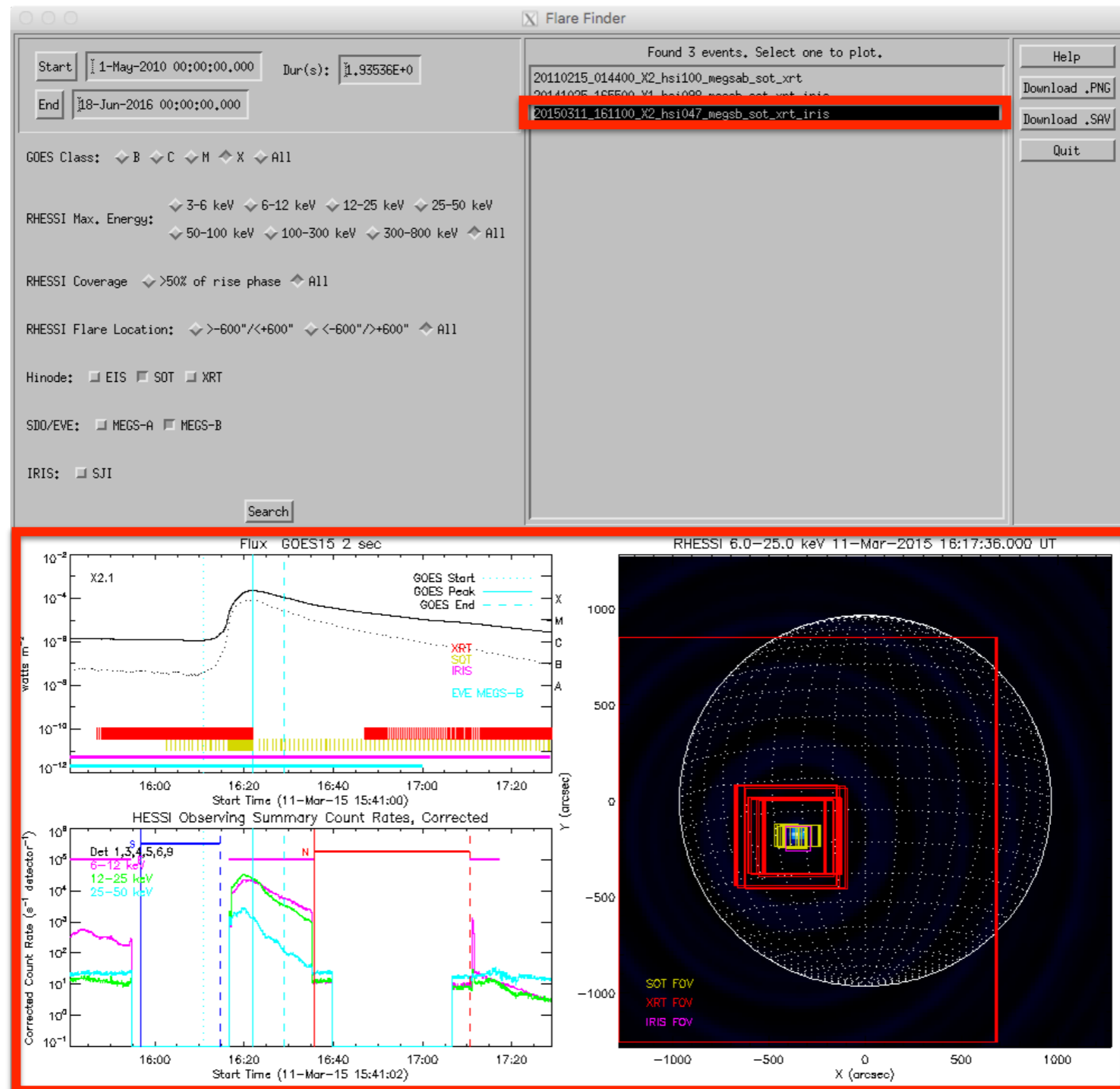
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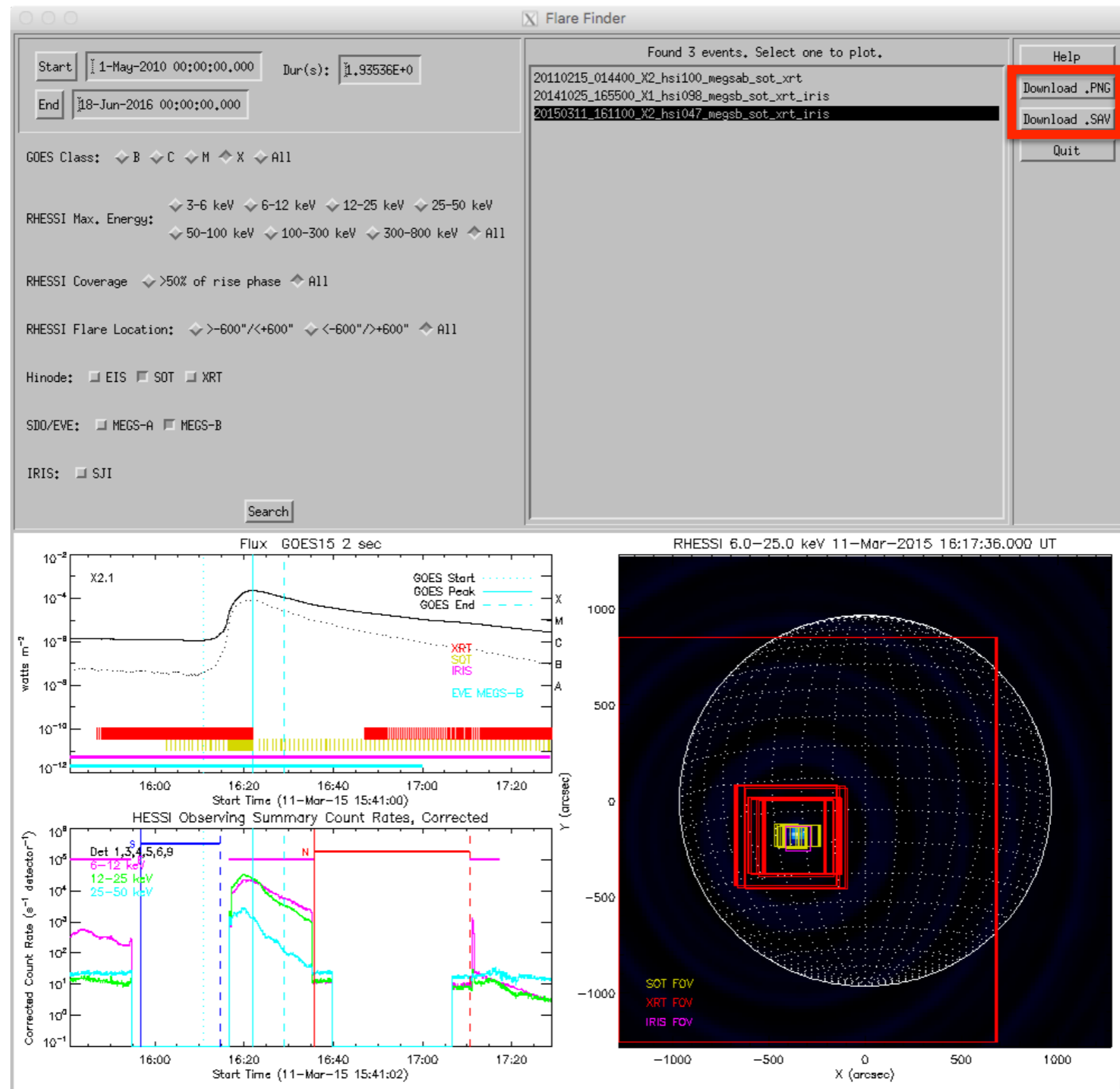
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Browser 2.0

- GOES w/ RHESSI Times
- Time-Based Quicklook
- Flare-Based Quicklook
- Cross-Mission Synoptic
 - w/ Hinode/EVE/IRIS
 - w/ WIND [Type A]
 - w/ WIND [Type B]
- RHESSI Monitor Rates
- Fermi (GBM and LAT)
- Radio Monitoring



02:39:07



2002	Jan	01
2003	Feb	02
2004	Mar	03
2005	Apr	04
2006	May	05
2007	Jun	06
2008	Jul	07
2009	Aug	08
2010	Sep	09
2011	Oct	10
2012	Nov	11
2013	Dec	12
2014		13
2015		14
2016		15

Reset Date

Latest Flare

Flare #

Direct URL

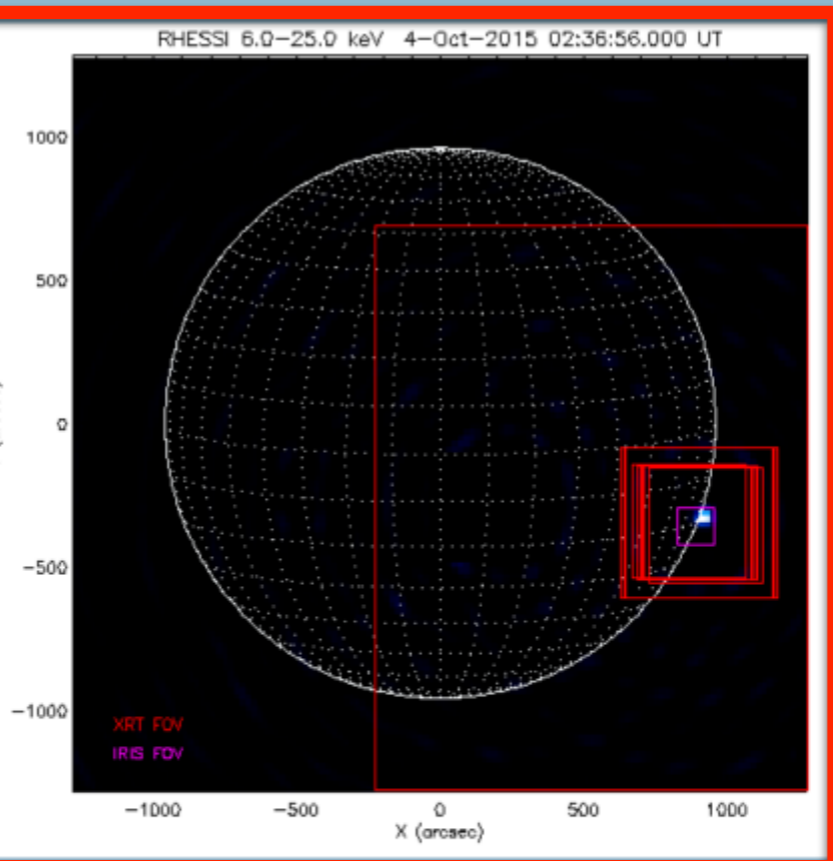
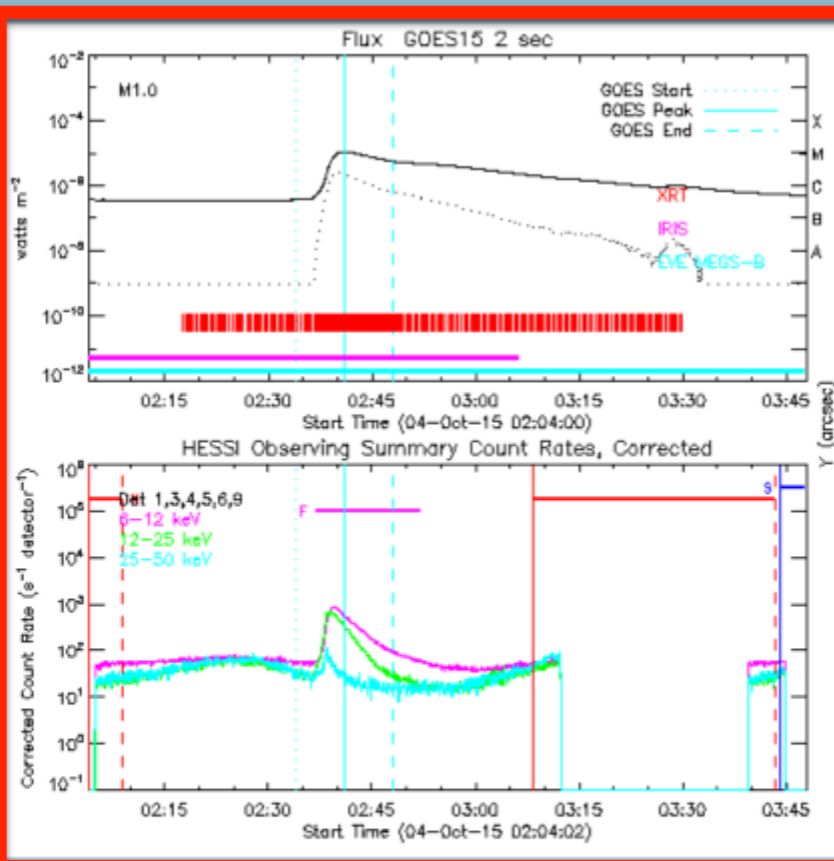
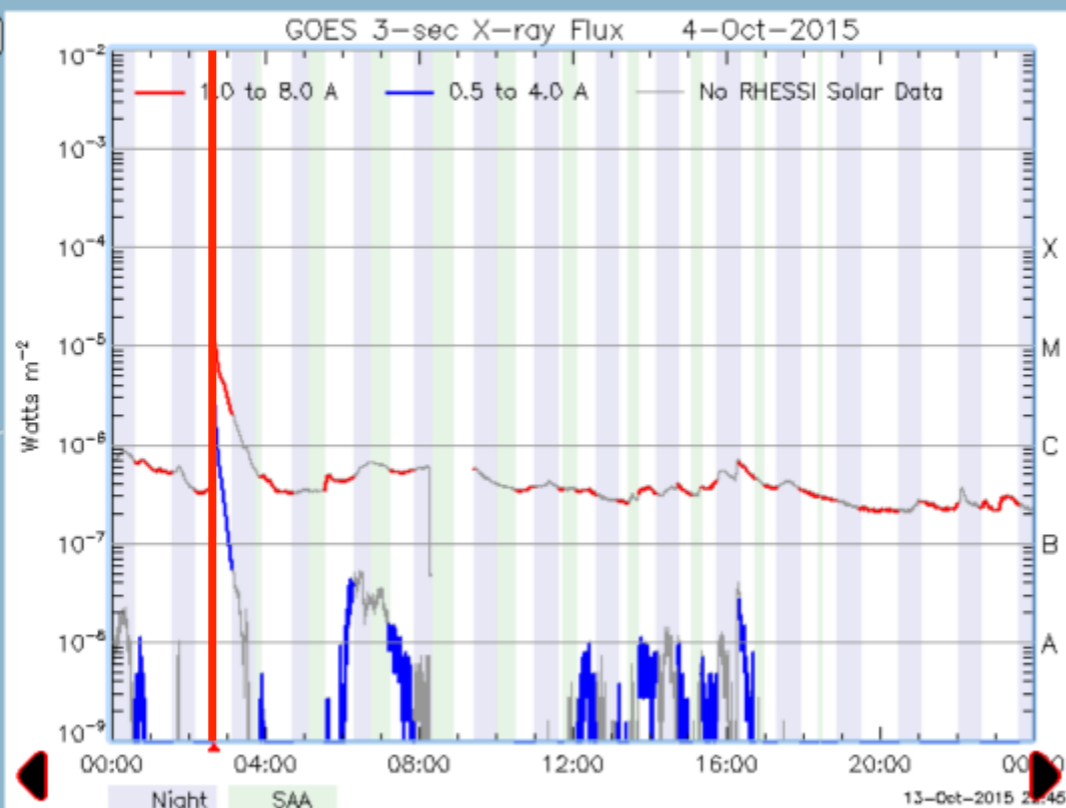
01

Other data for this time:

- [SolarMonitor](#)
(includes MDI and EIT data)
- [Heliviewer](#)
(includes AIA and LASCO data)
- [Radio Monitoring](#)
(includes WAVES and NRH data)
- [STEREO Daily Images](#)
- [SDO/EVE Daily Plots \(SAM\)](#)
- [MDI Farside Image \(old\)](#)
- [GOES/SXI Data](#)
- [RHESSI State-of-Health](#)
(password required) (gaps)
- [AIA Flare Cutout \[SSW\]](#)

Plot sources for this time:

- GOES w/ RHESSI Times:
 - [24-hour](#)
 - [2x12-hour orbit](#)
 - [Quicklook Lightcurves](#)
- Flare Quicklook:
 - [Images](#)
 - [Detector spectra](#)
 - [Quicklook Spectra \(beta\)](#)
 - [Cross-Mission Synoptic](#)
- RHESSI Monitor Rates [PS]:
 - Fronts: [slow](#) [livetime](#)
 - [ULD](#) [reset](#) [fast](#)
 - Rears: [slow](#) [livetime](#)
 - [ULD](#) [reset](#) [fast](#)
- Fermi/GBM: [day orbit](#)



NEW PLOTS: In addition to the quicklook images produced for each flare, there is a new plot with per-detector count spectra and semi-calibrated photon spectra at the flare peak. Check out "Detector spectra" under "Flare Quicklook".

TIP: Click the "Latest Flare" button to go to the most recent event in the RHESSI flare list that could be (automatically) imaged.

TIP: The events in the RHESSI flare list for the current day are selectable from a drop-down list. Events prefixed with a "n" are contiguous and cospatial with the preceding RHESSI flare.

Motivation

- Multi-wavelength flare observations are often greater than the sum of their parts.
- Finding specific combinations of flare datasets are useful for answering specific science questions...
- ...or to know what other instruments might have observed a specific RHESSI flare.
- Modeling flare plasma parameters may require certain combinations of datasets for comparison.
- “Planning” coordinated observations is almost impossible. “Easier” to retrospectively search archives.
- RHESSI XV Workshop working groups are predominantly mission-centric (RHESSI+Fermi, RHESSI+IRIS, RHESSI+SDO).
- Useful to have identified specific events to include in grant proposals.

Instruments

- **GOES**: full disk; multiple satellites ([get_gev.pro](#))
- **RHESSI**: full disk; suffers from eclipse and SAA passes ([hsi_whichflare.pro](#))
- **SDO/EVE MEGS-A**: full disk; no longer operating as of 26 May 2014
- **SDO/EVE MEGS-B**: full disk; limited duty cycle; now responding to flare trigger (http://lasp.colorado.edu/eve/data_access/evewebdata/interactive/megsb_daily_exposure_hours.html)
- **Hinode/EIS**: Rastering instrument; limited FOV; eclipses; planning schedules ([eis_list_raster.pro](#))
- **Hinode/SOT**: Limited FOV; eclipses; planning schedules ([sot_cat.pro](#))
- **Hinode/XRT**: Limited FOV (sometimes); eclipses; planning schedules ([xrt_cat.pro](#))
- **IRIS**: Rastering instrument; limited FOV; eclipses; planning schedules ([iris_obs2hcr.pro](#))


Flare Finder Criteria

- Search for all GOES flares since SDO was launched
- RHESSI flare flag must lie between GOES start and end times, and must have been “on” during the rise phase (GOES start->peak)
- Determine if SDO/EVE MEGS-A and/or MEGS-B were exposed (AIA and HMI are assumed to have been)
- Determine if EIS/SOT/XRT/IRIS were observing within GOES start/end time (if so, return all data within -30/+60 minutes)
- Determine if RHESSI flare location lies within +/- 20” of EIS/SOT/XRT/IRIS FOV (to allow for pointing uncertainties)

Limitations/Caveats

- EIS/IRIS slit may not have been over footpoints/ribbons
- <C5 flares may not show up in EVE data
- MEGS-A and IRIS were only observing together for 11 months
- Some flares may not have produced hard X-rays
- Some arbitrary search criteria may bias sample size
- Data dropouts/bad data may be possible

This NASA press release highlighted just how rare coordinated observations of solar flares really are.

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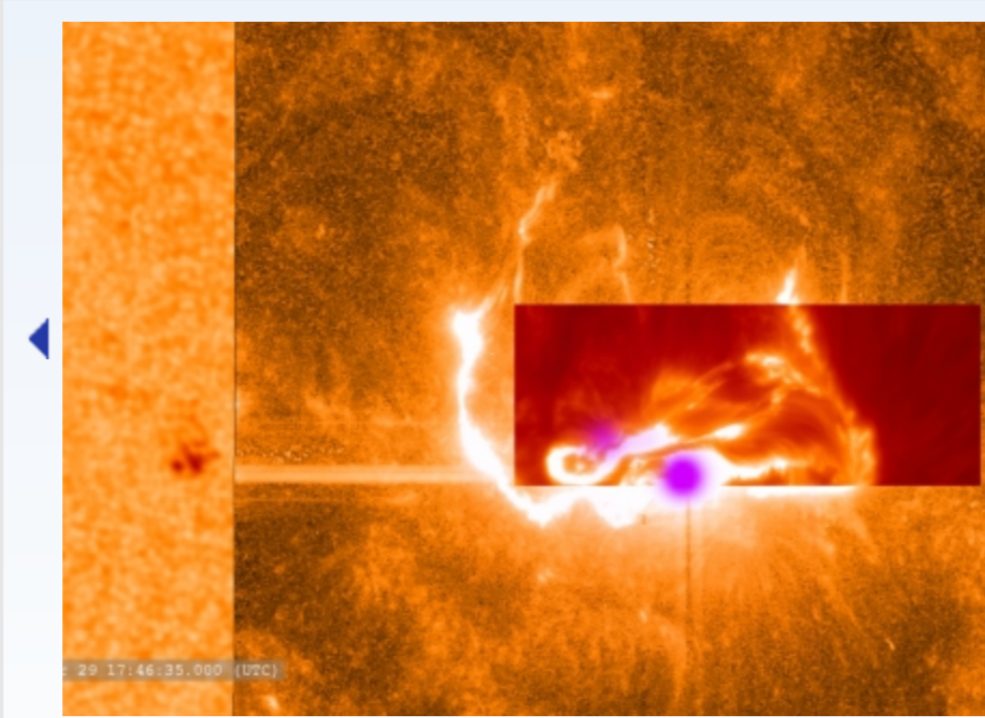
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NASA Telescopes Coordinate Best-Ever Flare Observations May 7, 2014

On March 29, 2014, an X-class flare erupted from the right side of the sun... and vaulted into history as the best-observed flare of all time. The flare was witnessed by four different NASA spacecraft and one ground-based observatory – three of which had been fortuitously focused in on the correct spot as programmed into their viewing schedule a full day in advance.

To have a record of such an intense flare from so many observatories is unprecedented. Such research can help scientists better understand what catalyst sets off these large explosions on the sun. Perhaps we may even some day be able to predict their onset and forewarn of the radio blackouts solar flares can cause near Earth – blackouts that can interfere with airplane, ship and military communications.



March 29 X-class Flare - 1

This combined image shows the March 29, 2014, X-class flare as seen through the eyes of different observatories. SDO is on the bottom/left, which helps show the position of the flare on the sun. The darker orange square is IRIS data. The red rectangular inset is from Sacramento Peak. The violet spots show the flare's footpoints from RHESSI.

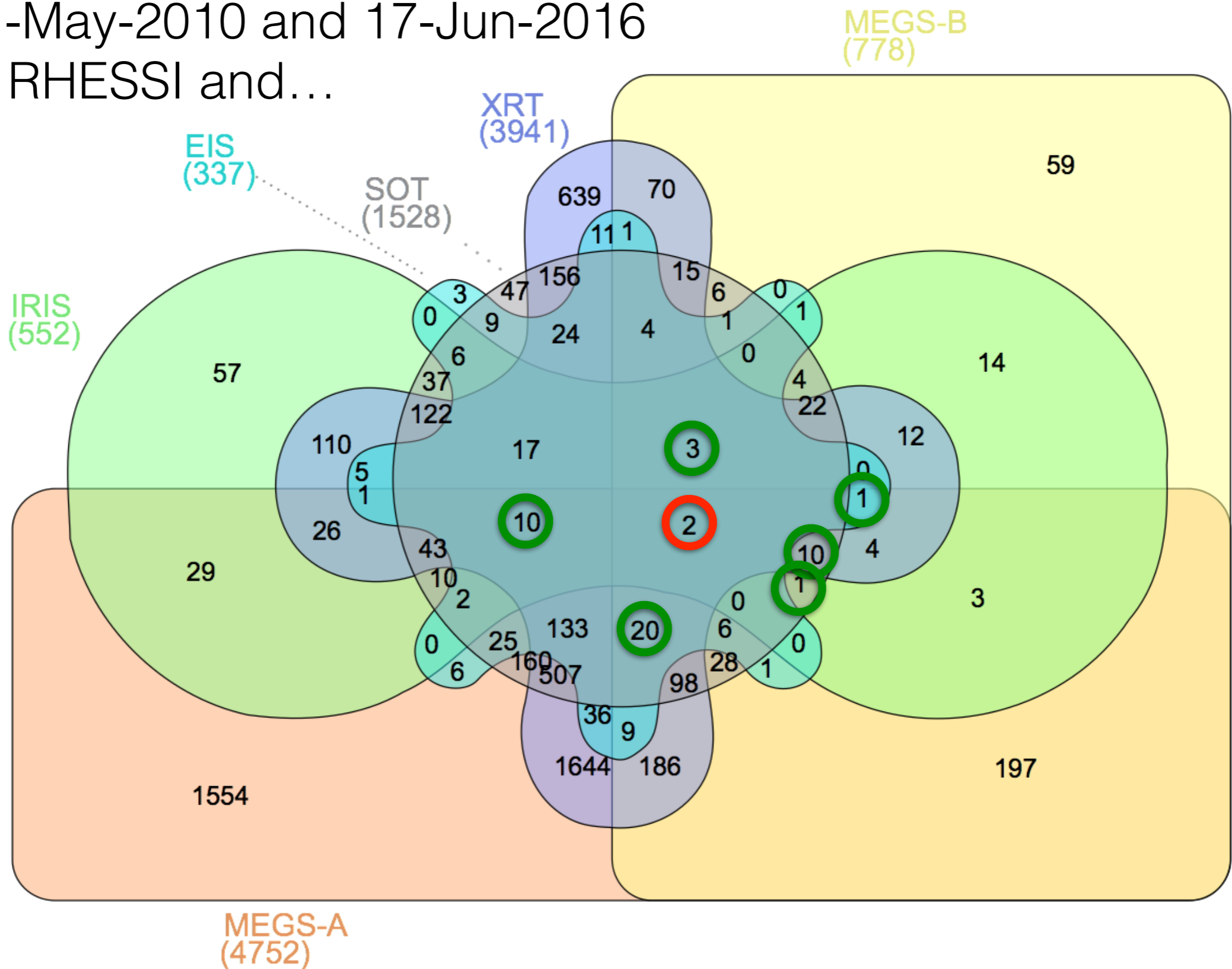
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But it shouldn't be!

Number of flares jointly observed
between 1-May-2010 and 17-Jun-2016
by GOES, RHESSI and...



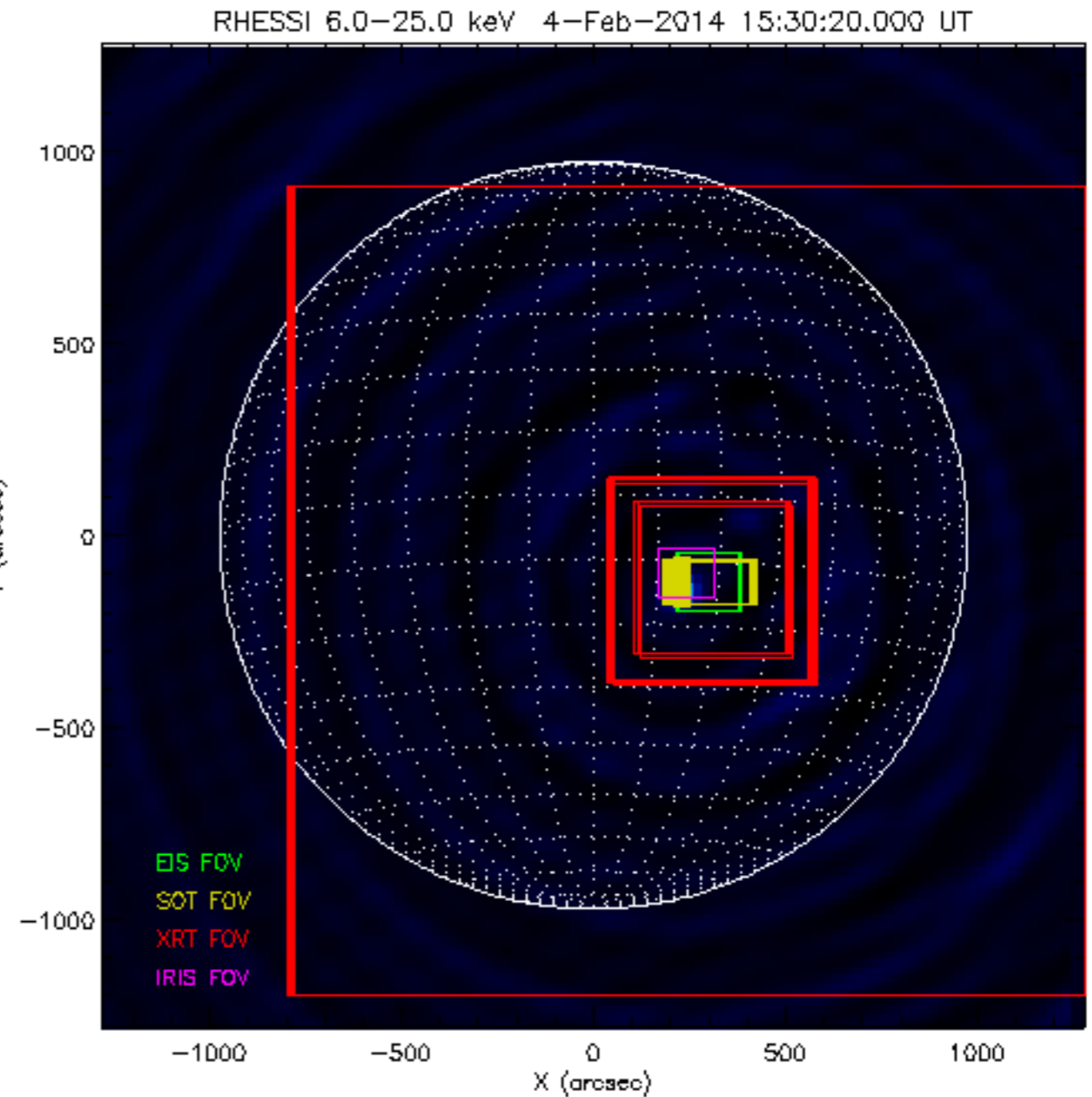
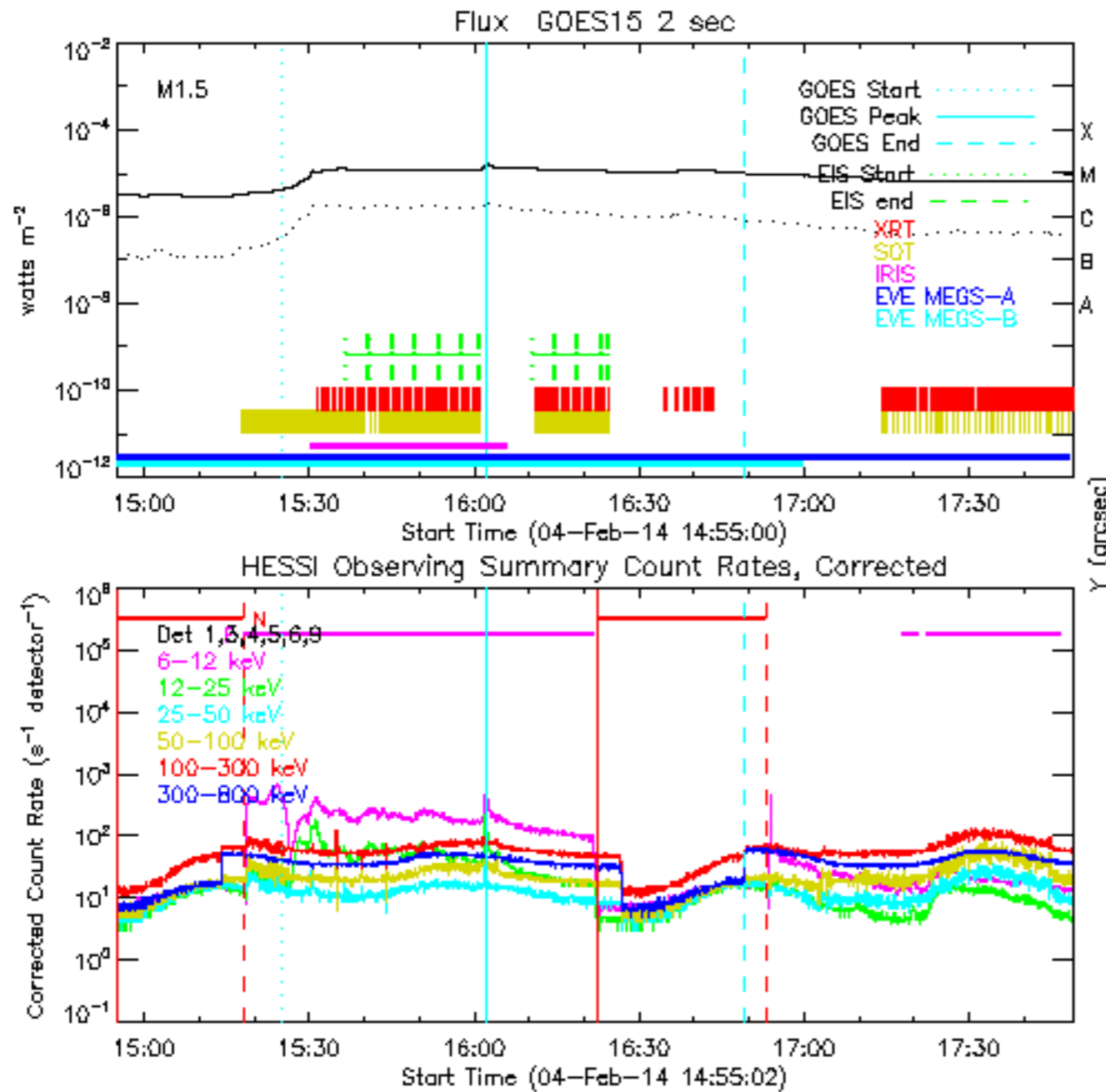
Total number of GOES flares = 12,254
 Total number of RHESSI flares = 6,761

○ = all 8 instruments
○ = any 7 instruments

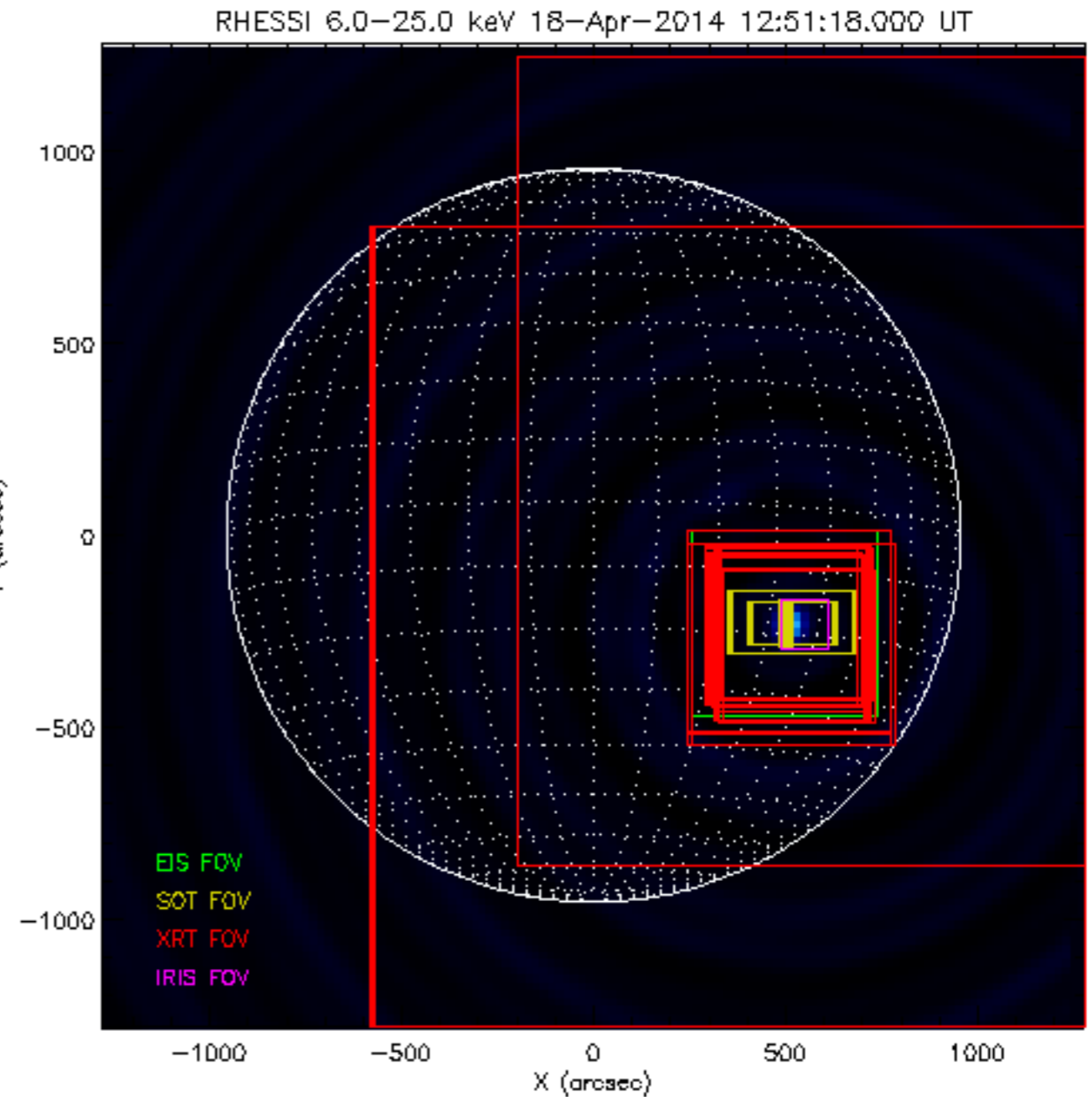
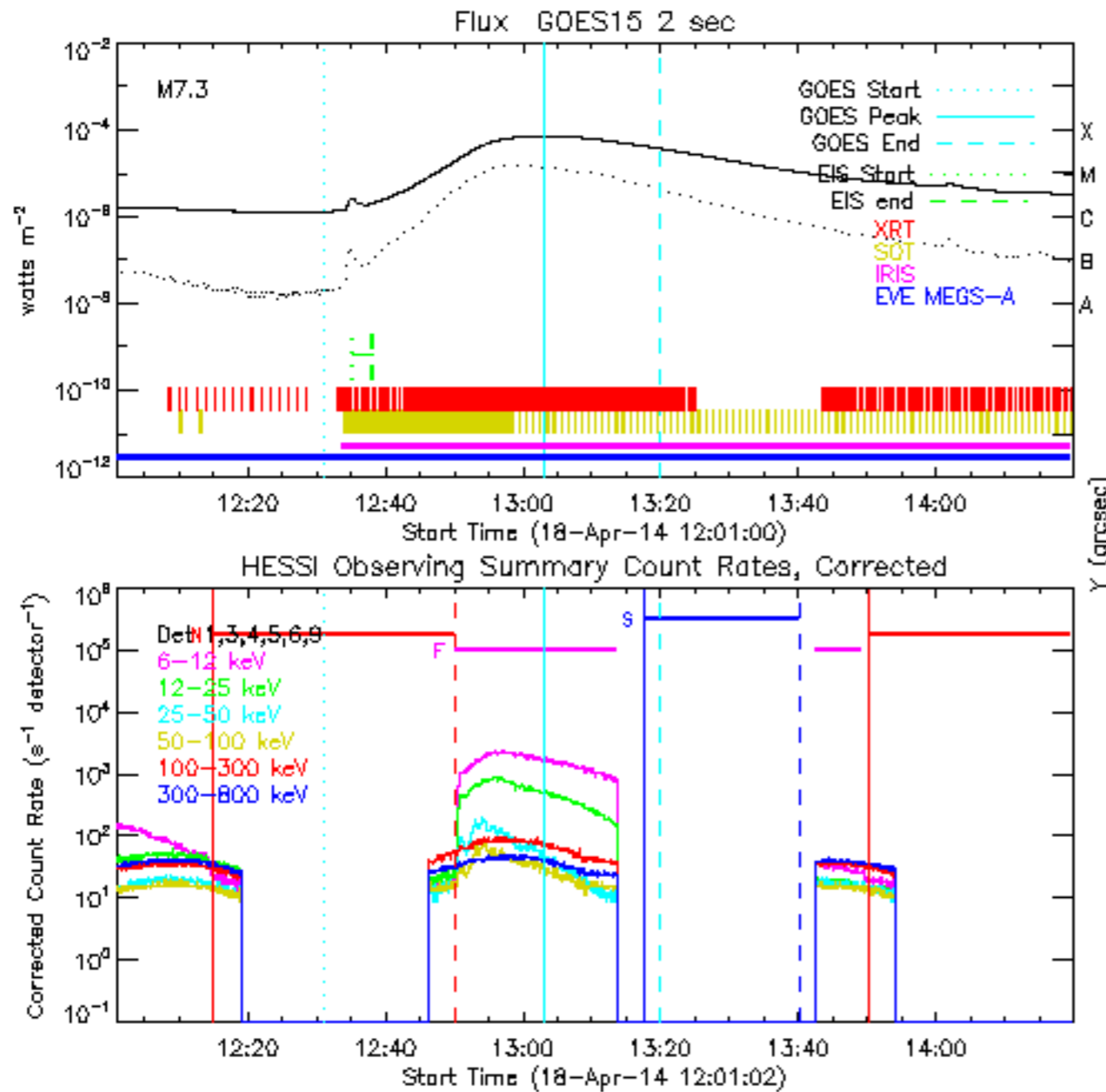
Statistics (out of 12,254 flares)

- RHESSI+MEGS-A+MEGS-B+EIS+SOT+XRT+IRIS = 2
- RHESSI+MEGS-A+EIS+SOT+XRT+IRIS = 10
- RHESSI+MEGS-A+MEGS-B+EIS+SOT+XRT = 20
- RHESSI+MEGS-A+MEGS-B+EIS+SOT+IRIS = 1
- RHESSI+MEGS-A+MEGS-B+EIS+XRT+IRIS = 1
- RHESSI+MEGS-A+MEGS-B+SOT+XRT+IRIS = 10
- RHESSI+MEGS-B+EIS+SOT+XRT+IRIS = 3

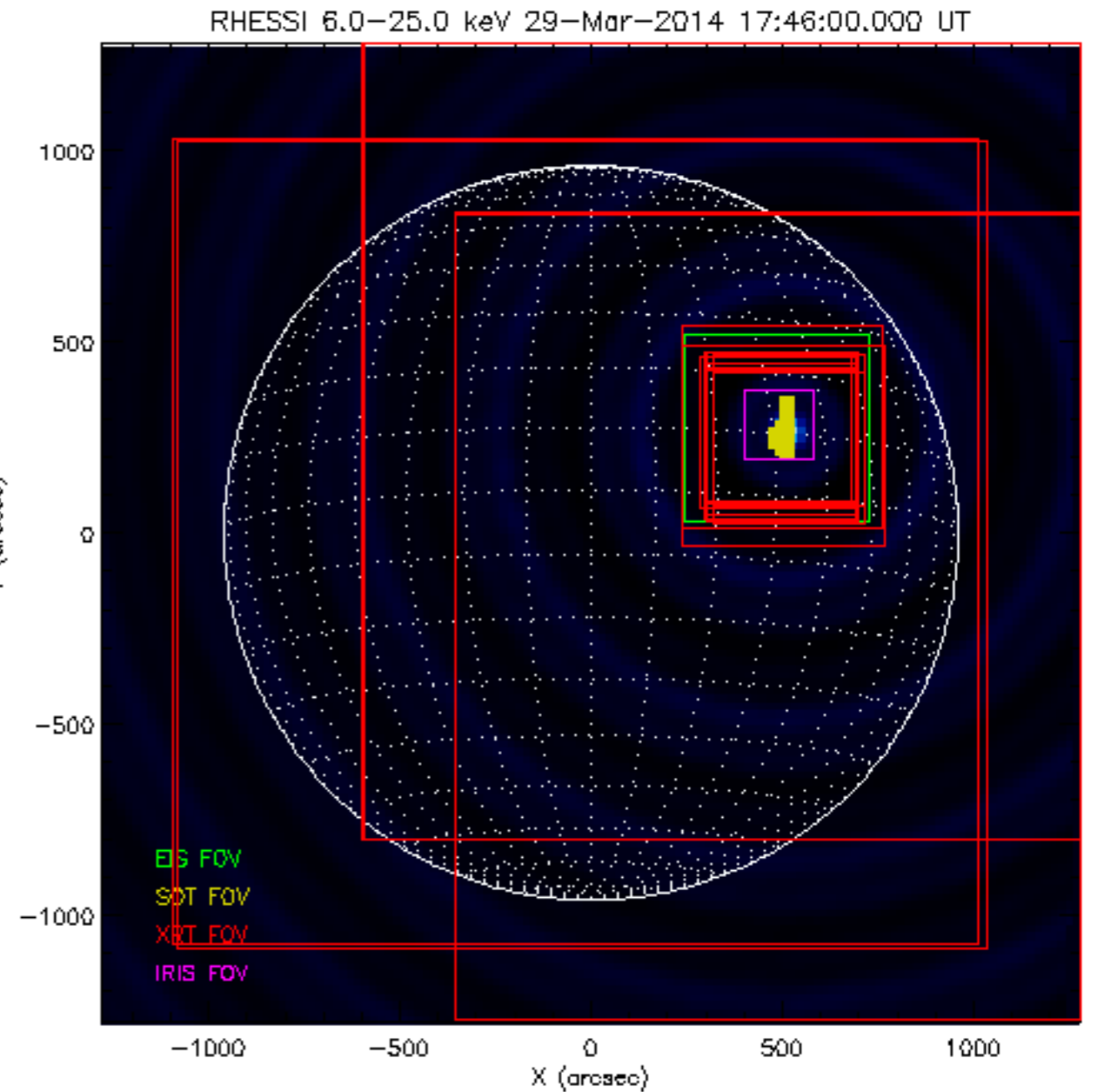
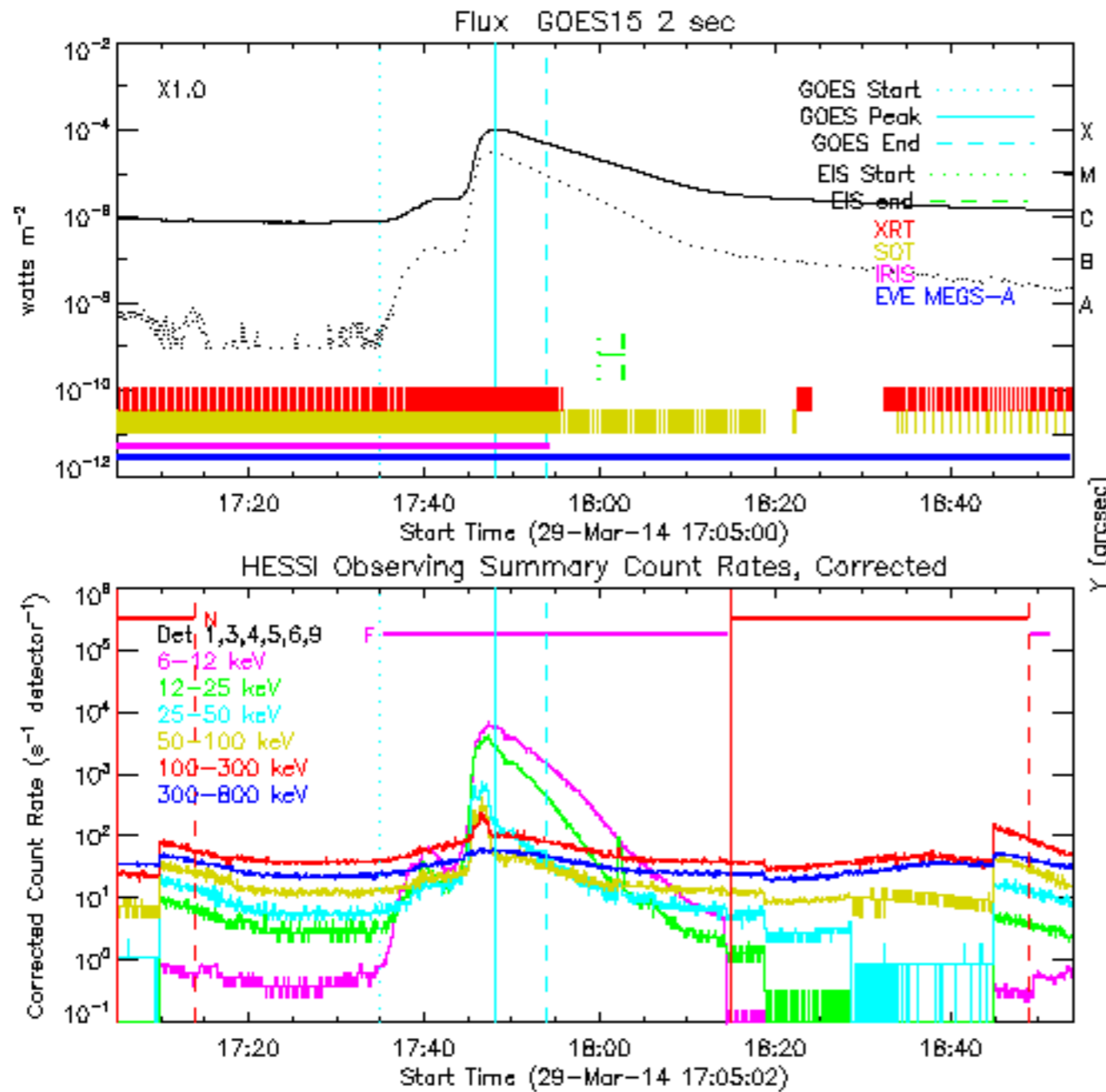
Example 1: An M1.5 flare observed by all instruments



Example 2: An M7.3 flare observed by all instruments except EIS raster only at flare onset.



Example 3: The famous 29 March 2014 X1.0 flare.



Future Directions

- Search by SOL or RHESSI flare number
- What lines/filters were EIS/SOT/XRT/IRIS observing?
- Include A-class flares
- Provide direct access to data (via VSO)
- SDO/AIA flare locations (for flares without RHESSI data)
- Add GOES/EUVS, Fermi, NoRH, MAVEN, GBO, etc...
- Other suggestions welcome... (email: r.milligan@qub.ac.uk)

Search for all commonly observed flares
between 1-May-2010 and 17-June-2016

