Testing the flare localization algorithm for Solar Ultraviolet Imaging Telescope (SUIT), using IRIS and AIA data

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Collaborators

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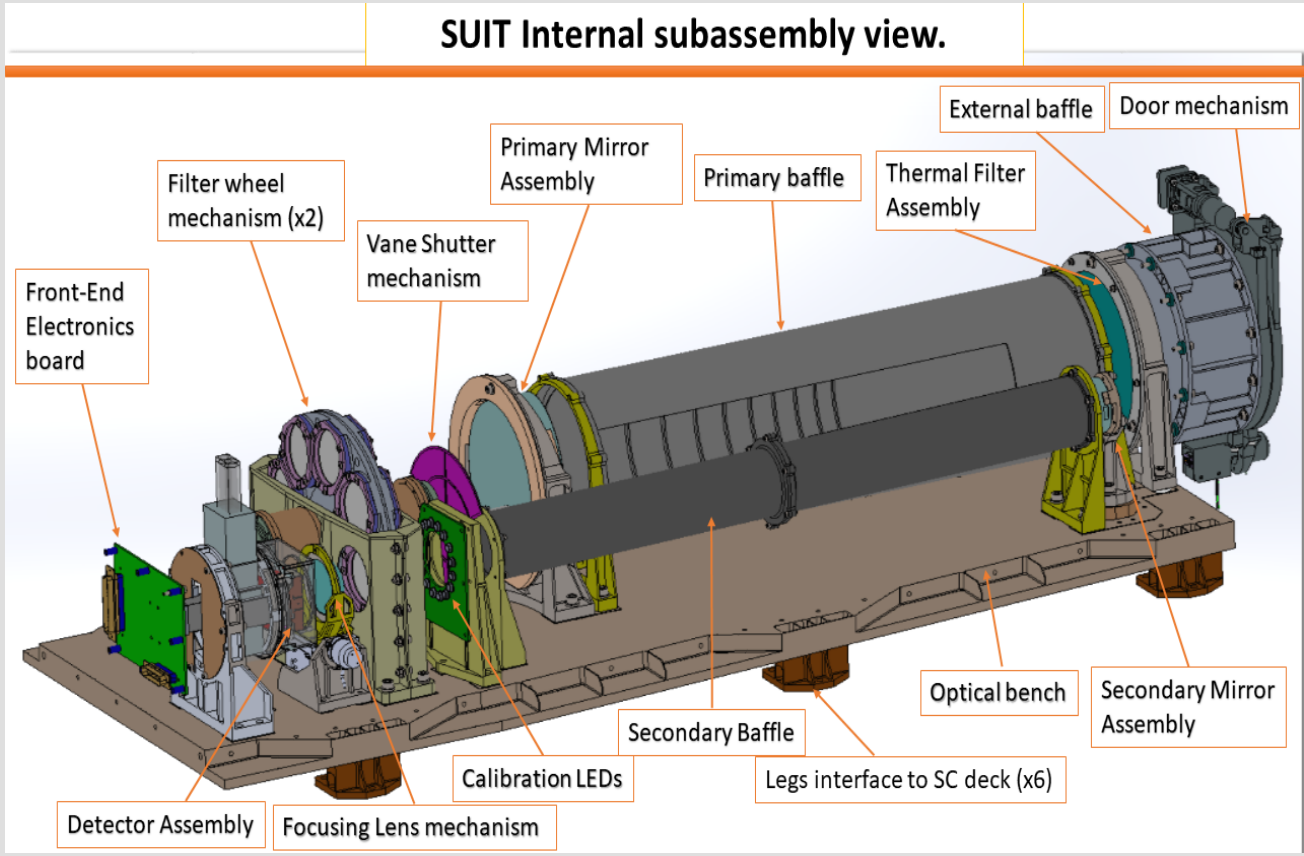
Solar Ultra-Violet Imaging Telescope (SUIT)

- A payload onboard Aditya-L1 mission, India's upcoming space mission to study the Sun.
- SUIT is one of the seven payloads onboard ADITYA-L1
- Observes the Sun in 11 spectral filters (8 narrow band and 3 broad band), in the spectral band of 200nm to 400nm.
- Option to observe the solar full disk images in lower cadence (best possible is ~16s per FD image) and smaller region of interest (RoI) in high cadence (best possible is ~ 3s per image).



Onboard decision making on SUIT

- One of the major science goal of SUIT is to catch early phase of flares, and observe in NUV spectral region, with high cadence.
- Hence, we have developed a module to find flaring region on the solar disk, in real time, and automatically go to a flare mode observation (smaller RoI, with high cadence)
- Also tracks the RoI to correct for solar rotation.

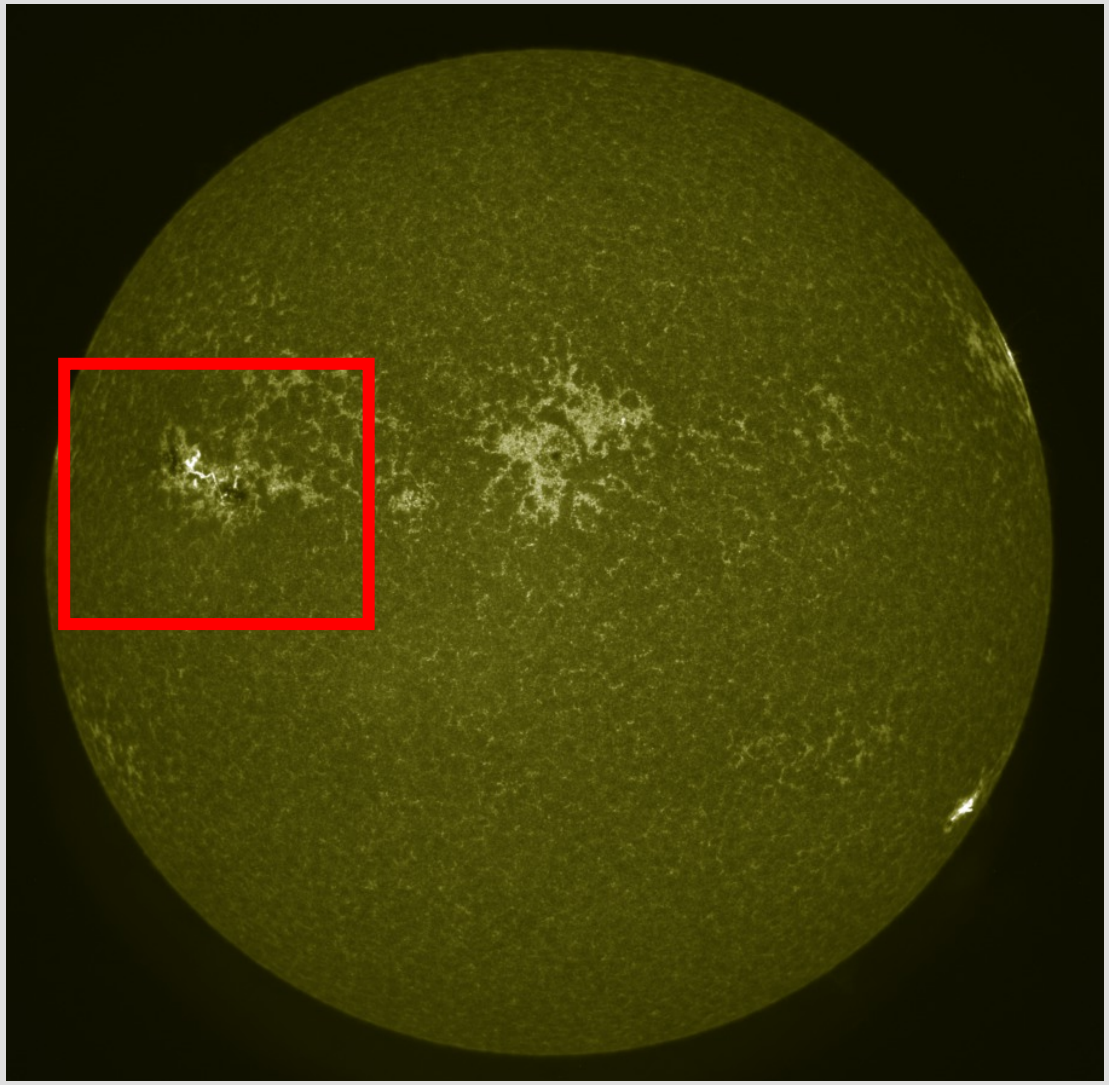
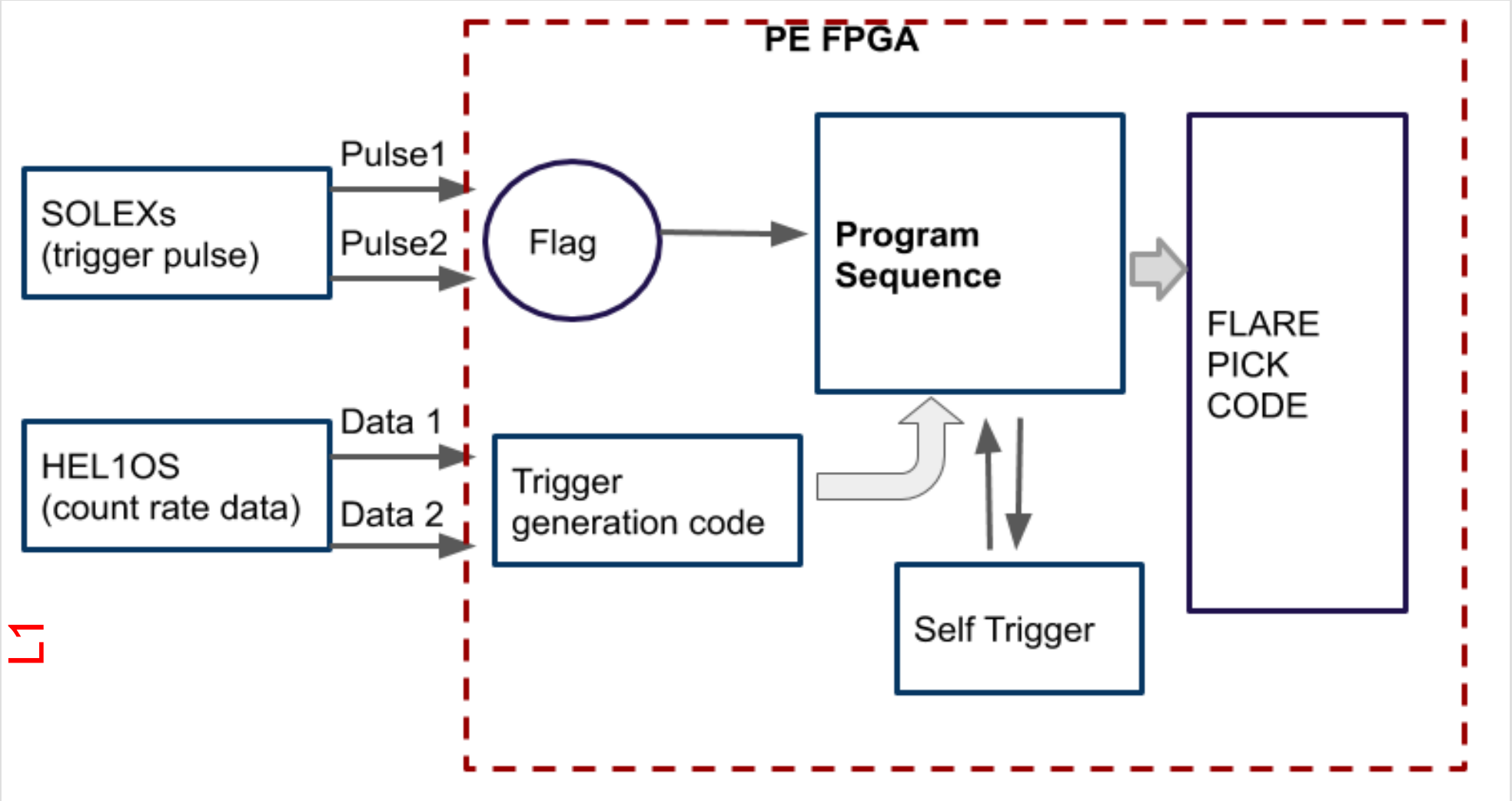


Image: SDO/AIA 1600

Overview of onboard intelligence

Hard and Soft -Xray spectrometers onboard Aditya - L1

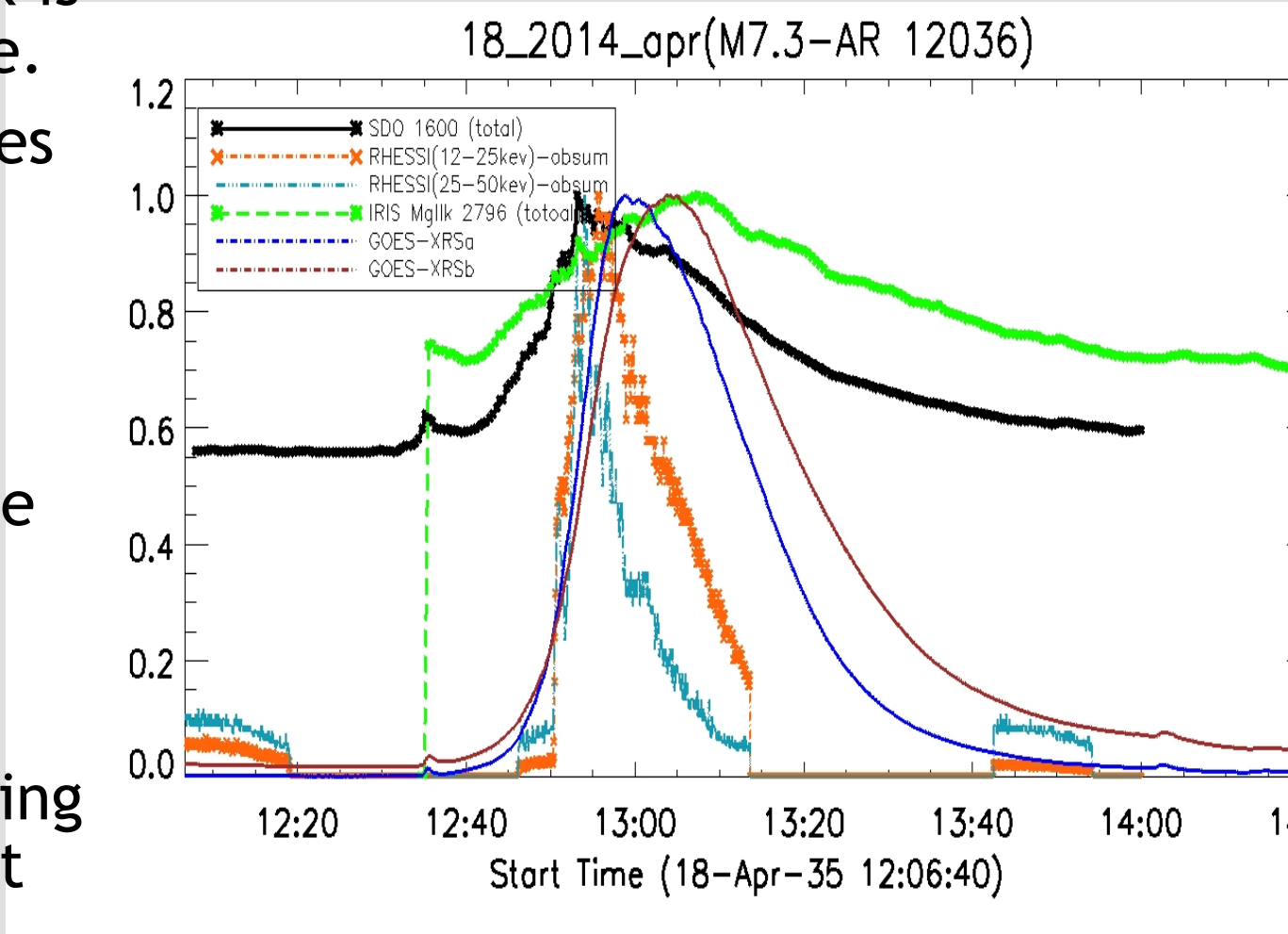


Flare localization algorithm – A quick overview

- Soft-X ray and Hard X-ray spectrometers onboard same satellite, Aditya-L1 monitor and inform SUIT about any increase in X-ray emission.
- When a flare trigger is generated by X-ray payloads, SUIT activates Flare Pick module.
- SUIT starts recording only in full disk Mg II h filter (cadence of about 16 sec) and use them to determine the location of flare.
- Flaring region is marked as RoI and starts observation of that RoI using multiple spectral filters.

Testing of the FlarePick Module.

- The flare light curve, and rise in flux is different for different spectral range.
- Since SUIT will be using Mg II h images to confirm the NUV flare, and to localize the flaring region, Ideally testing should be done using Mg II h full disk images.
- Since, such a data is not available we used AIA 1600 to test the module (localizing the flaring region on the disk)
- Also used IRIS slit-jaw images of flaring region to understand the flaring light curve and tune model parameters.

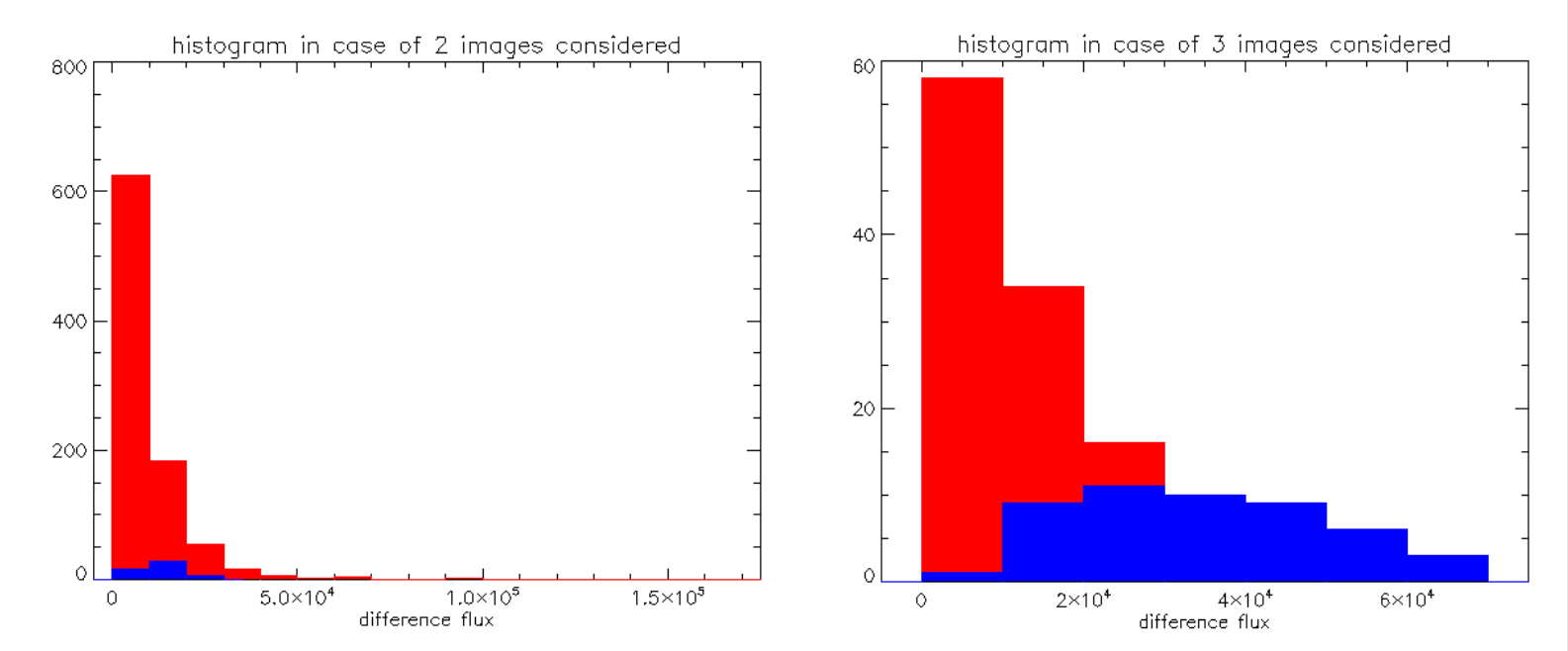


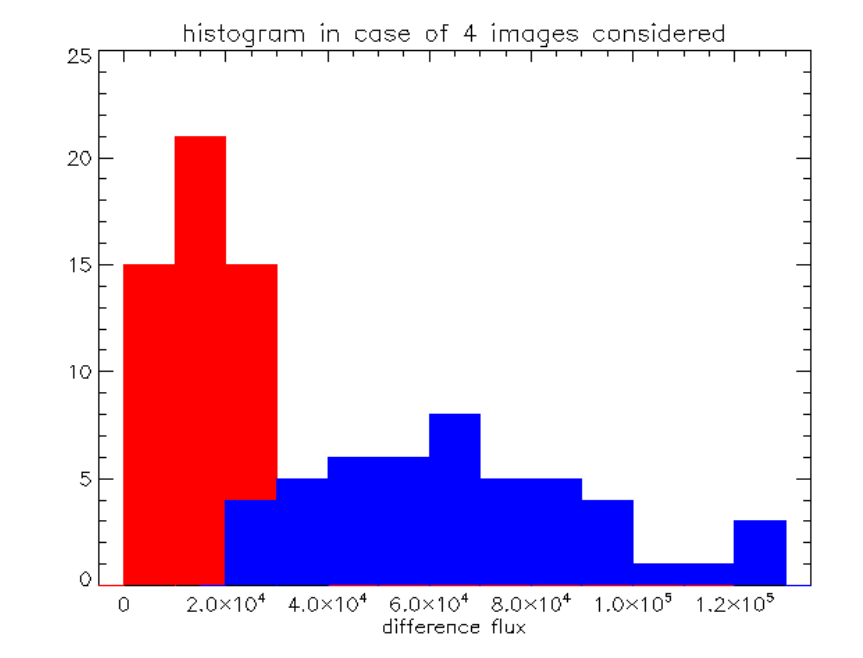
FlarePick module testing:
Flaring region localization using AIA 1600 data

- Dataset: AIA 1600, 4K X 4K images, cadence: 24 sec : 50 flares (35 C, 12 M and 3 C class) during the time period of 2013-2016.

- Difference images (Dn – D0) are found for n=1,2,3 and the corresponding maximum flux is calculated for flare and background images.
- This analysis is used to find what should be the value of ‘n’ in order to reduce the false positives and increase the chances of flare detection.

Result: Differential counts from the flaring regions



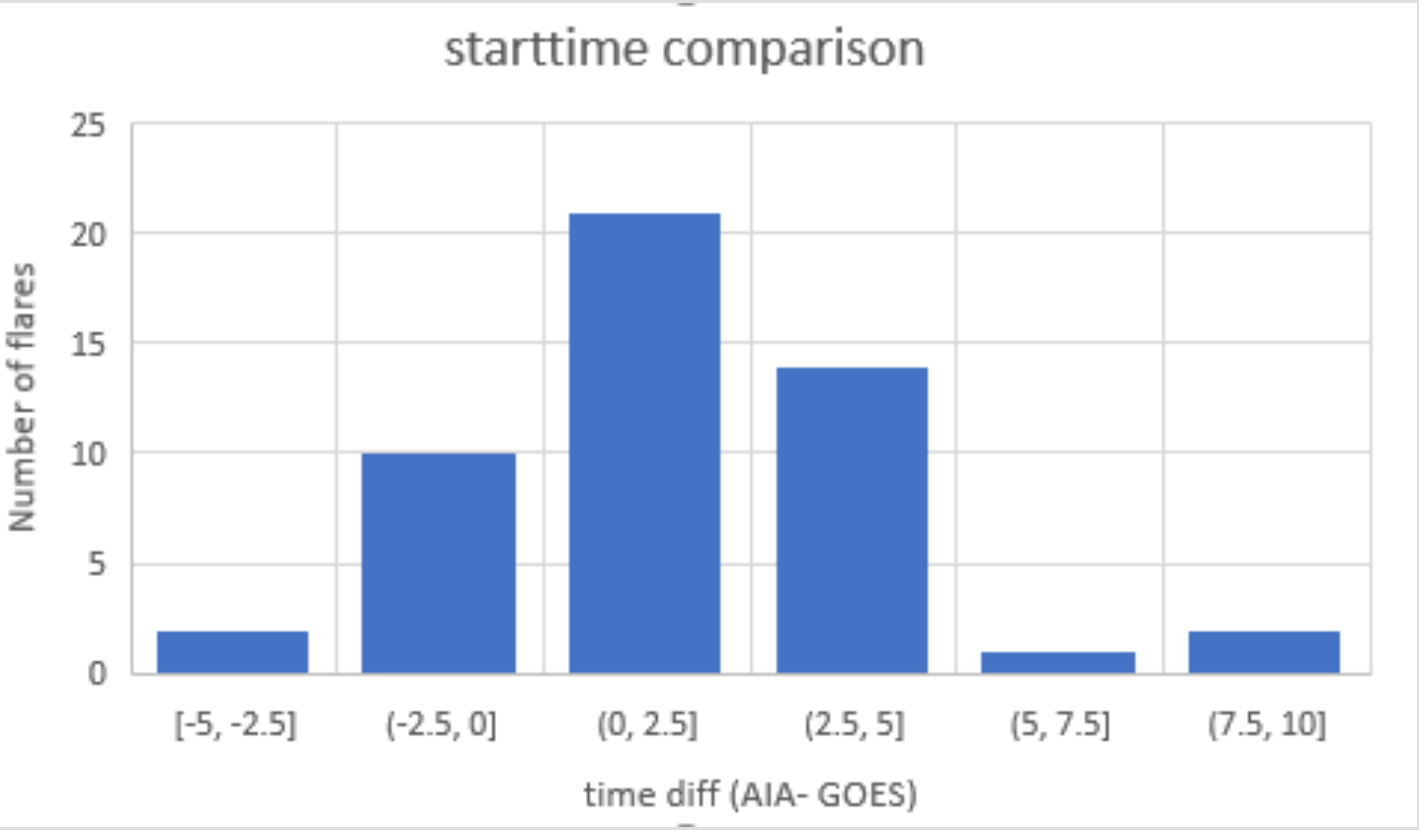


False detections

True Positives

So we decided to consider 4 images for the flare localization algorithm. The threshold values for each difference image is set based on the above results.

Detection time vs GOES start time (using AIA-1600)

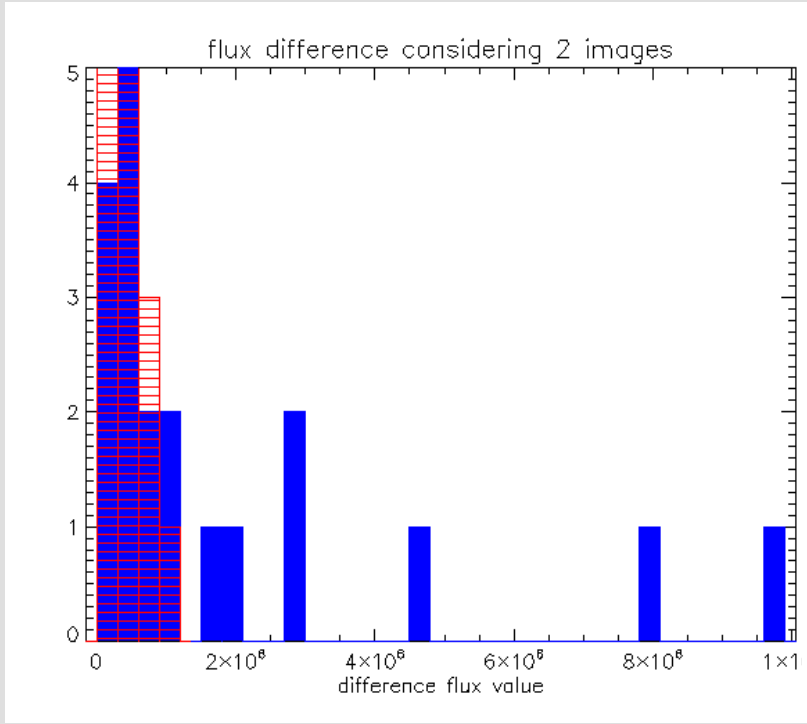


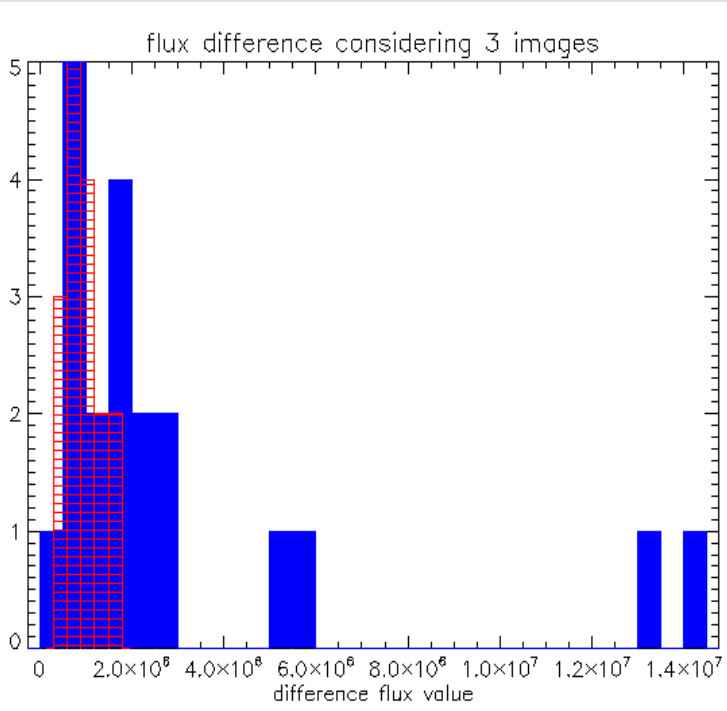
In majority cases the GOES start time is early than the detection time from AIA images. Note that in reality Mgll h images will be used to detect flares.

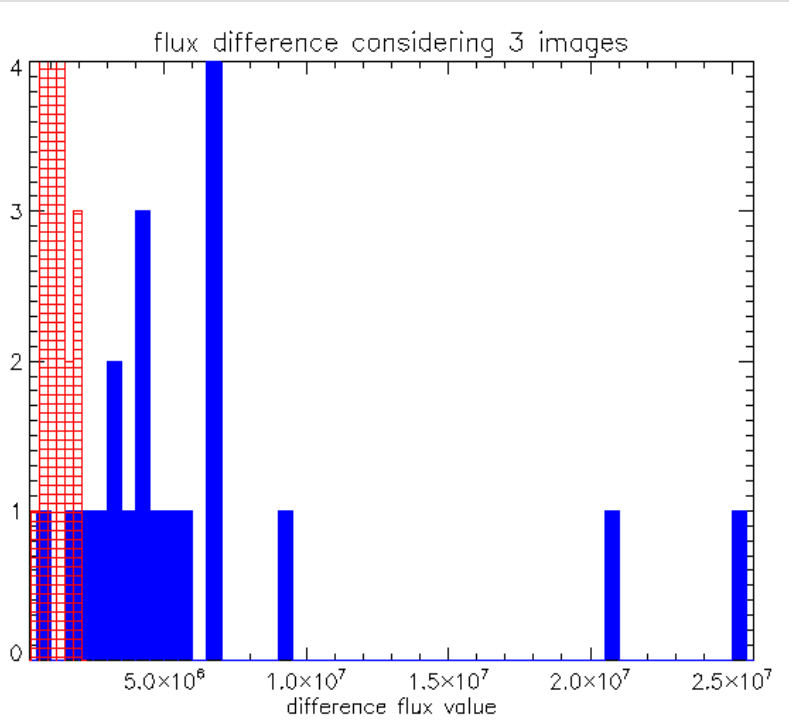
Analysis with IRIS Mg II data

- IRIS Mg II slit jaw images are used for the analysis.
- 20 flare image data with cadence ranging from 17 sec to 21 sec is used.
- Also active region data (without flare) is used to understand the non flaring background.
- A similar analysis like with AIA images is done to see the rate of change of flare intensity and background.

Result:







So we observed a similar trend as seen in AIA 1600 images.

Summary

- The Solar Ultraviolet Imaging Telescope (SUIT) on board upcoming ADITYA-L1 mission has an onboard flare detection and localization module.
- After obtaining the flare trigger from X-ray payloads on same satellite, this module uses self observed Mg II h full disk images to find the location of the flare.
- AIA 1600 and IRIS 2796 slit-jaw images are used to test the working of this module.
- The tuning parameters like the threshold will be fine tuned post mission launch from the original data.

Our Team

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8. Nagaraju K (IIA)
9. Manoj Varma (IIA)

And the entire SUIT team

Key Findings:

- The module successfully detected all 50 flares, and the correct location of the flare.
- The time of detection by the module, varies from case to case – This can be further improved by proper tuning of threshold values.