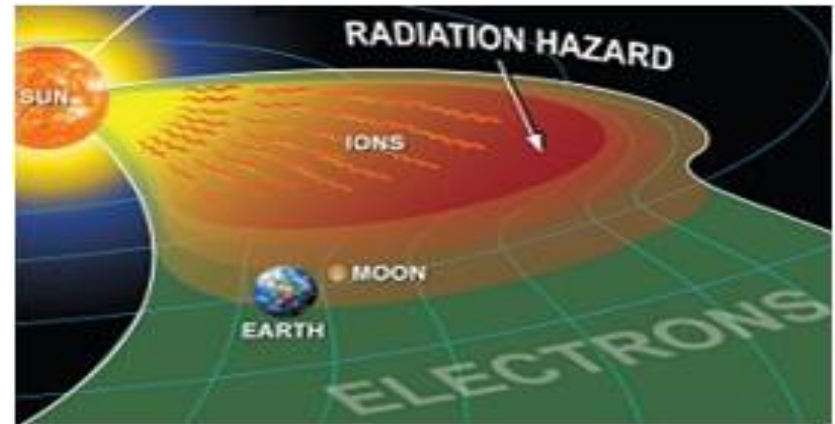
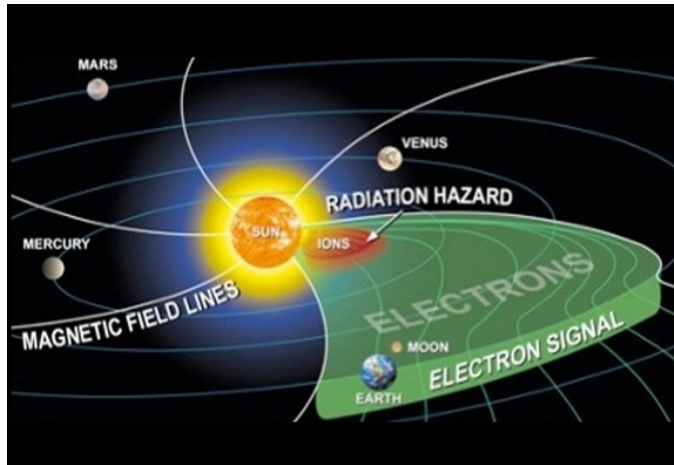


# HESPERIA REleASE

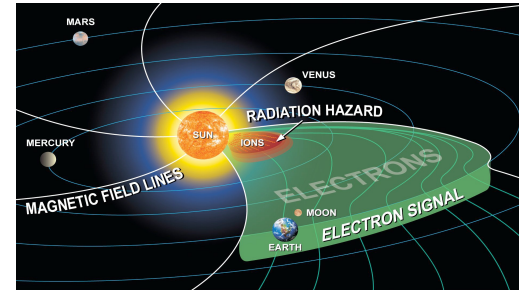
## Predicting 30-50 MeV SEP events by using the Relativistic Electron Alert System for Exploration (REleASE) scheme



- This tool has been implemented and evaluated a real-time SEP predictor by using the REleASE scheme (Posner, 2007)
- The implemented model infers the maximum proton intensity and onset at 30-50 MeV based on near relativistic and relativistic electron intensity time profiles measured by SOHO/EPHIN and **ACE/EPAM**
- The tool provides advanced nowcasting/forecasting methods
- Validation: POD, FAR, and average warning time.

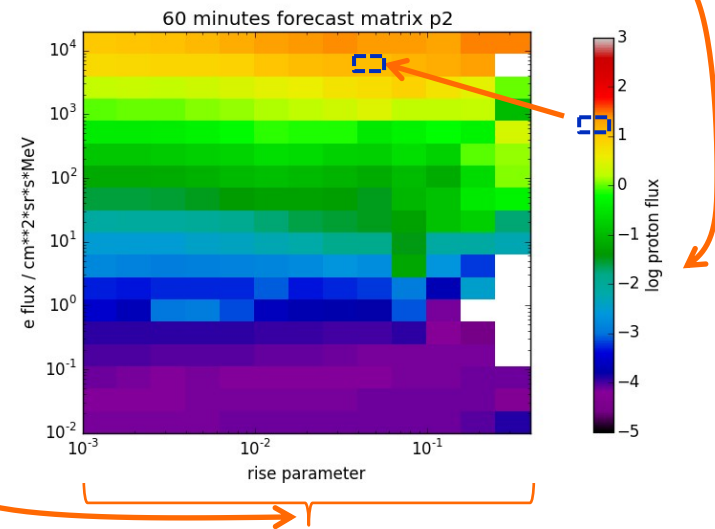
## The REleASE scheme (Posner 2007)

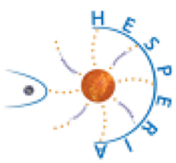
- Near relativistic electrons travel faster than ions and are present in SEP events. The faster electrons arrive at L1 30-90 min before the slower protons.



- The REleASE scheme uses this effect to predict the proton flux by utilizing:

- the actual electron flux
- the increase of the electron flux in the last 60 minutes





# HESPERIA RELeASE

## Developments

- RELeASE utilizes an empirical matrix to predict the proton intensity (30, 60, 90 min)
- Real-time SOHO/EPHIN electron data (0.25-1.0 MeV) are available:

### Advantage

- 1-min resolution

### Disadvantages

- limited time data coverage (less than 4 hours per day)
- if no real-time data are available → no forecast produced

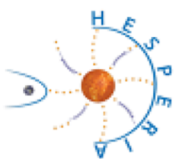
- **HESPERIA Innovation:** Real-time electron intensities by ACE/EPAM in a comparable energy range (0.175-0.315 MeV) adapted to the existing RELeASE forecasting matrix.

### Advantage

- Good data coverage

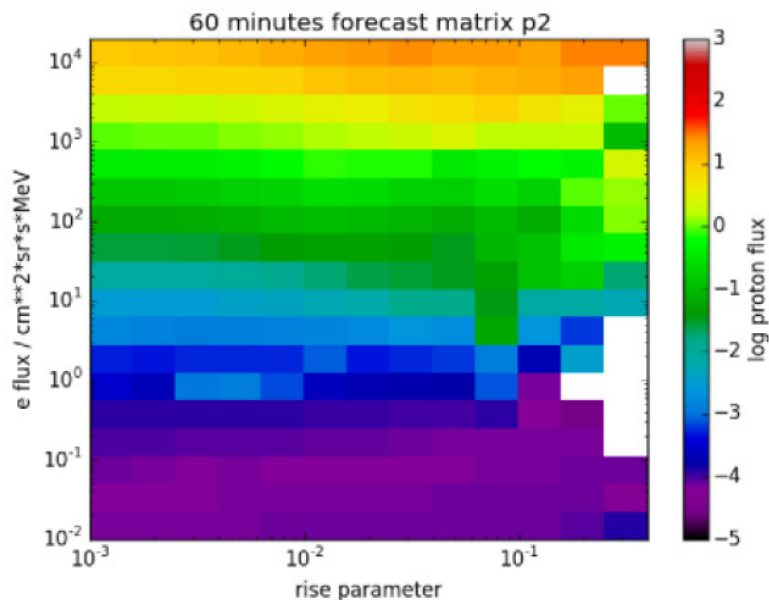
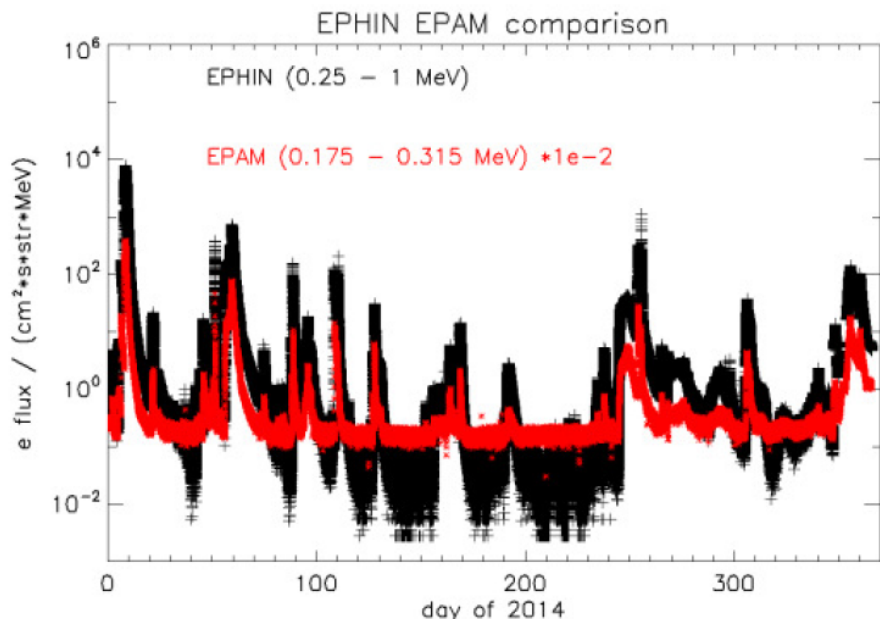
### Disadvantages

- 5-min resolution

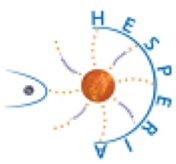


# HESPERIA REleASE

- The forecast depends on the measured electron intensities and their increase. A comparison of electron intensity time series between SOHO/EPHIN (**black**) and ACE/EPAM (**red**) shows good correlation. If there is an increase in EPHIN electron intensity there is also one in EPAM.

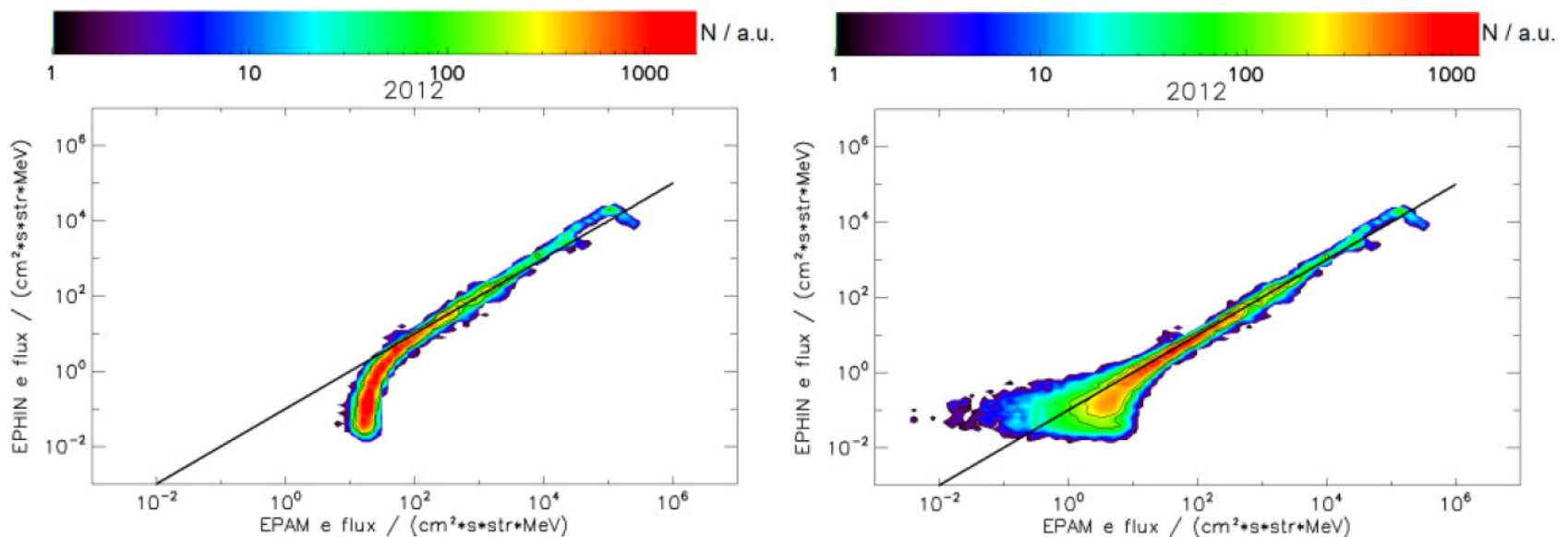


The Matrix shows the predicted intensity of protons in one hour as function of the measured absolute electron intensities and the intensity rise parameters.

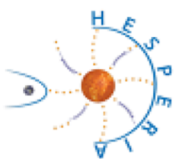


# HESPERIA RELeASE

- To quantify this correlation, we show the EPHIN electron intensity against the corresponding EPAM intensities. The higher background level of EPAM reflects itself by the nearly vertical line at low EPAM intensities. Background subtraction correction was implemented in ACE/EPAM.

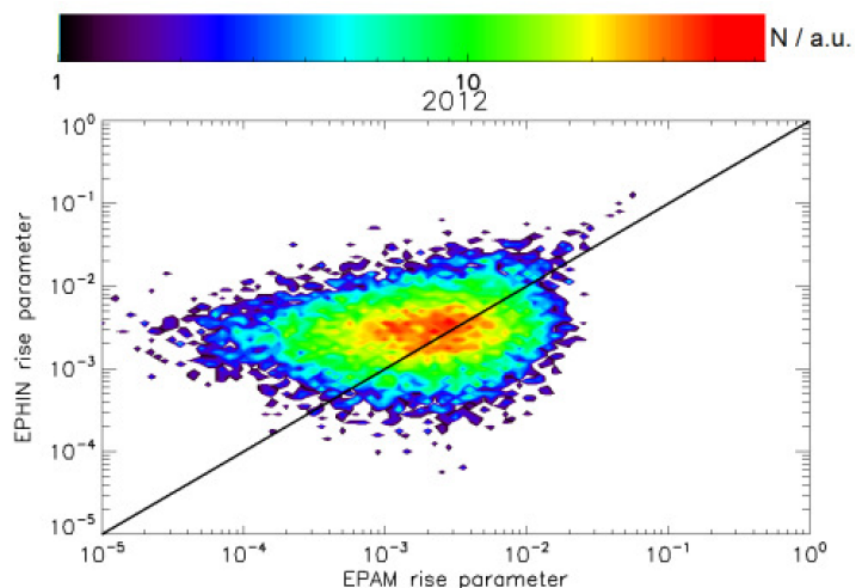
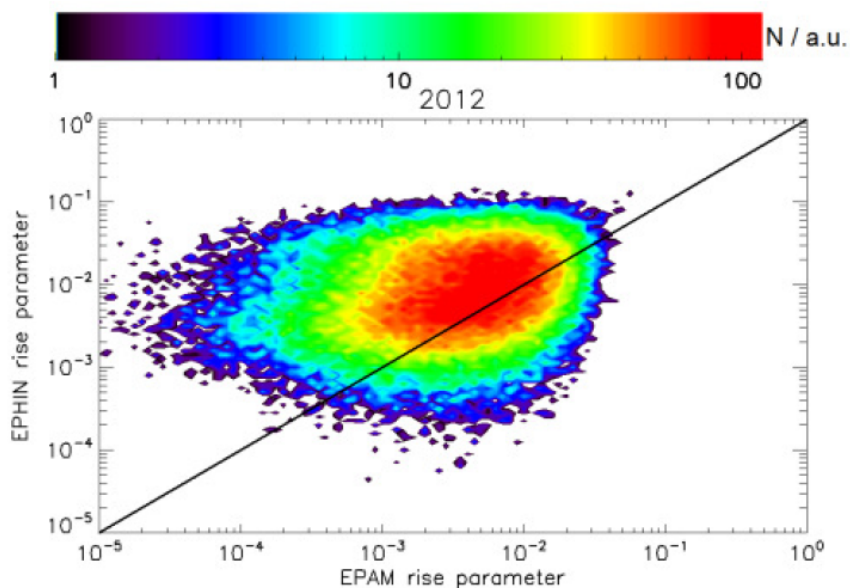


The direct comparison of SOHO/EPHIN and ACE/EPAM electron intensities shows good correlation above 20 (cm<sup>2</sup> sec sr Mev)<sup>-1</sup>.



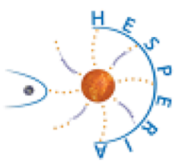
# HESPERIA REleASE

- The second parameter used in the REleASE forecast matrices is the intensity rise parameter. Calculated by linear fits through the logarithmic electron intensities of the last 5 to 60 minutes.



The right panel displays all data from 2012 while the left panel shows only rise-parameters for strong enhanced electron fluxes.

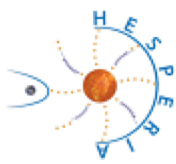
We found that if we only take electron fluxes  $>100$  into account, the correlation gets stronger.



# HESPERIA REleASE

## Validation

- The performance was tested by using all historic EPAM and EPHIN data from 2009 until 2016. The following results for events are possible:
  - True forecast (Alarm and Event): T
  - Missed event (No / late Alarm and Event): M
  - False alarm (Alarm and no Event): F
- By using the total number of true forecasts, missed events and false alarms of the analyzed time period, it is possible to calculate the **Probability of Detection (POD) and False Alarm Ratio (FAR)**:
  - False Alarm Ratio:  $FAR = F / (T+F)$
  - Probability of Detection:  $POD = T / (T+M)$



# HESPERIA REleASE

## CONCLUSIONS (Cntd.)

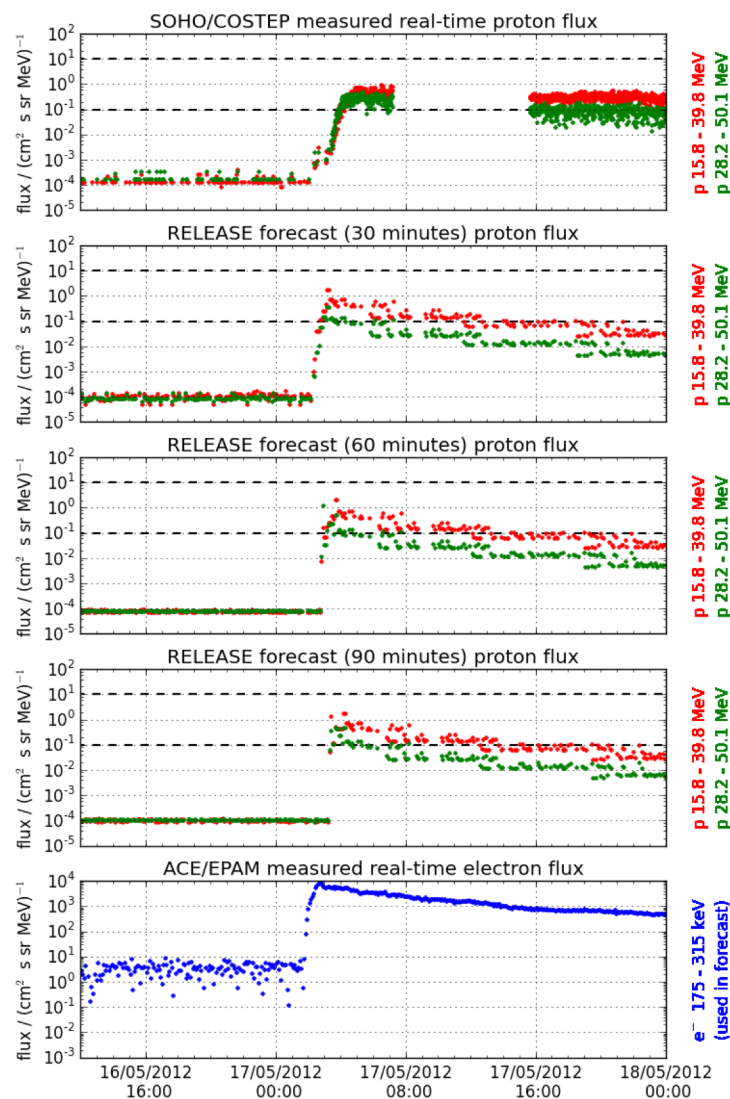
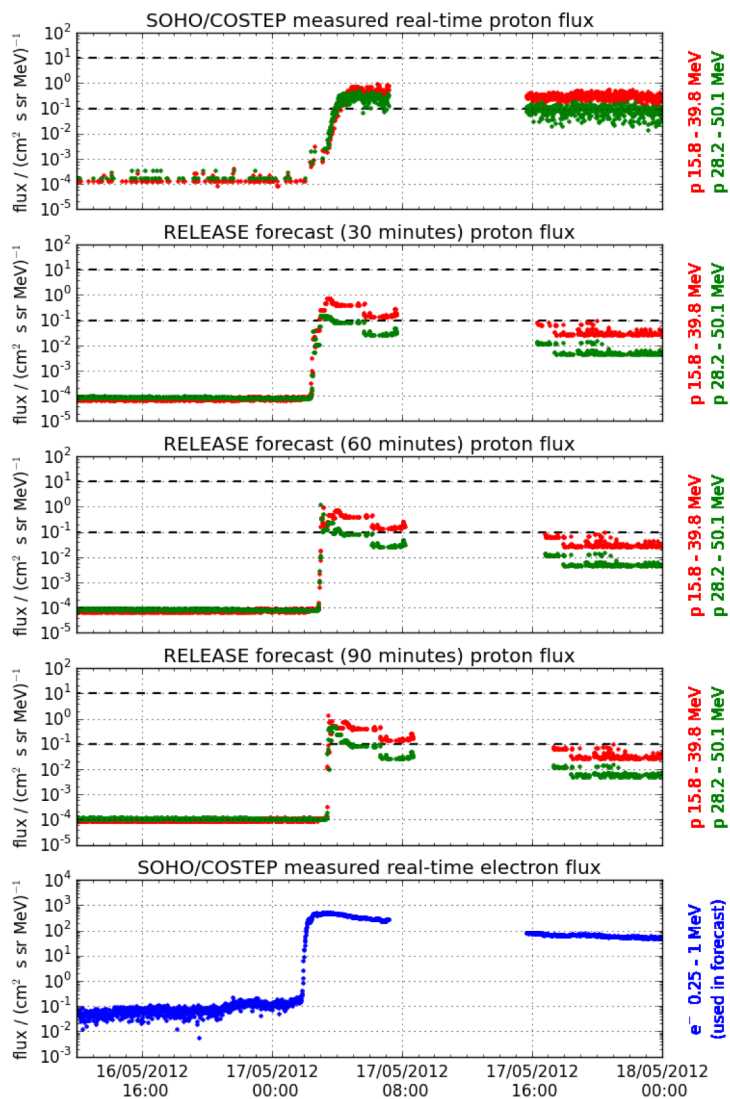
- The largest interval (that is possible with EPHIN) was selected 2009-2016 to calculate POD, FAR, and AWT.
  - The obtained **POD** using both data sources (EPHIN/EPAM) was 63.2%.
  - The **FAR** using EPHIN and EPAM were 29.4%, and 35.1% , respectively.
  - The **AWT (Advanced Warning Time)** using EPHIN and EPAM were 107 and 123 min, respectively.
- The results are satisfactory (low FAR, high POD, high AWT).
- We conclude that the REleASE forecasting scheme can be used with ACE/EPAM data, and can probably be used with other near relativistic electron flux measurements.
- The HESPERIA REleASE system can generate alerts which are distributed to registered users:

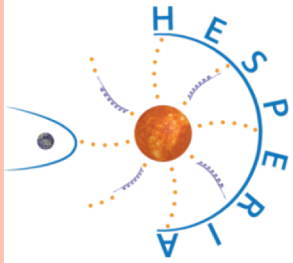
<https://www.hesperia.astro.noa.gr/webform/ReleaseAlert/contact.php>



- Real-time SEP predictions are publicly available via the HESPERIA project website at the National Observatory of Athens:

<https://www.hesperia.astro.noa.gr/index.php/results/real-time-prediction-tools/release>



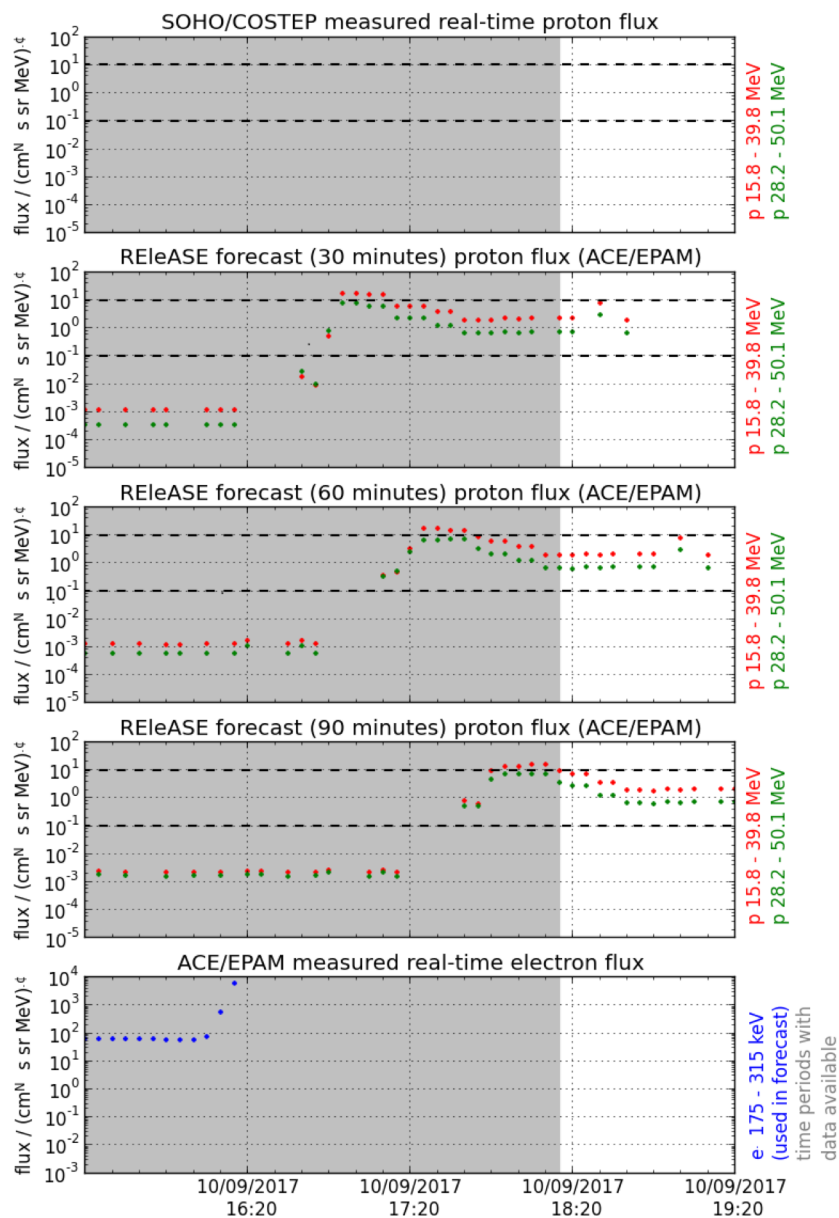
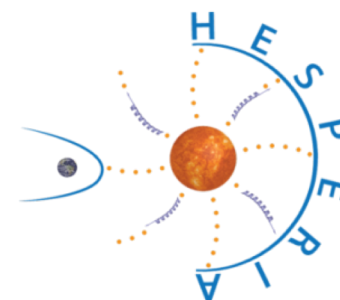


# ASSETS OF HESPERIA RELEASE

- No need for any prior solar flare (soft X-ray observations) to issue forecasts
- Providing forecasts also in the case of backside flares which other schemes cannot provide
- 30% of the SEP events observed at Earth's orbit are due to backside solar events (Richardson et al., 2014)

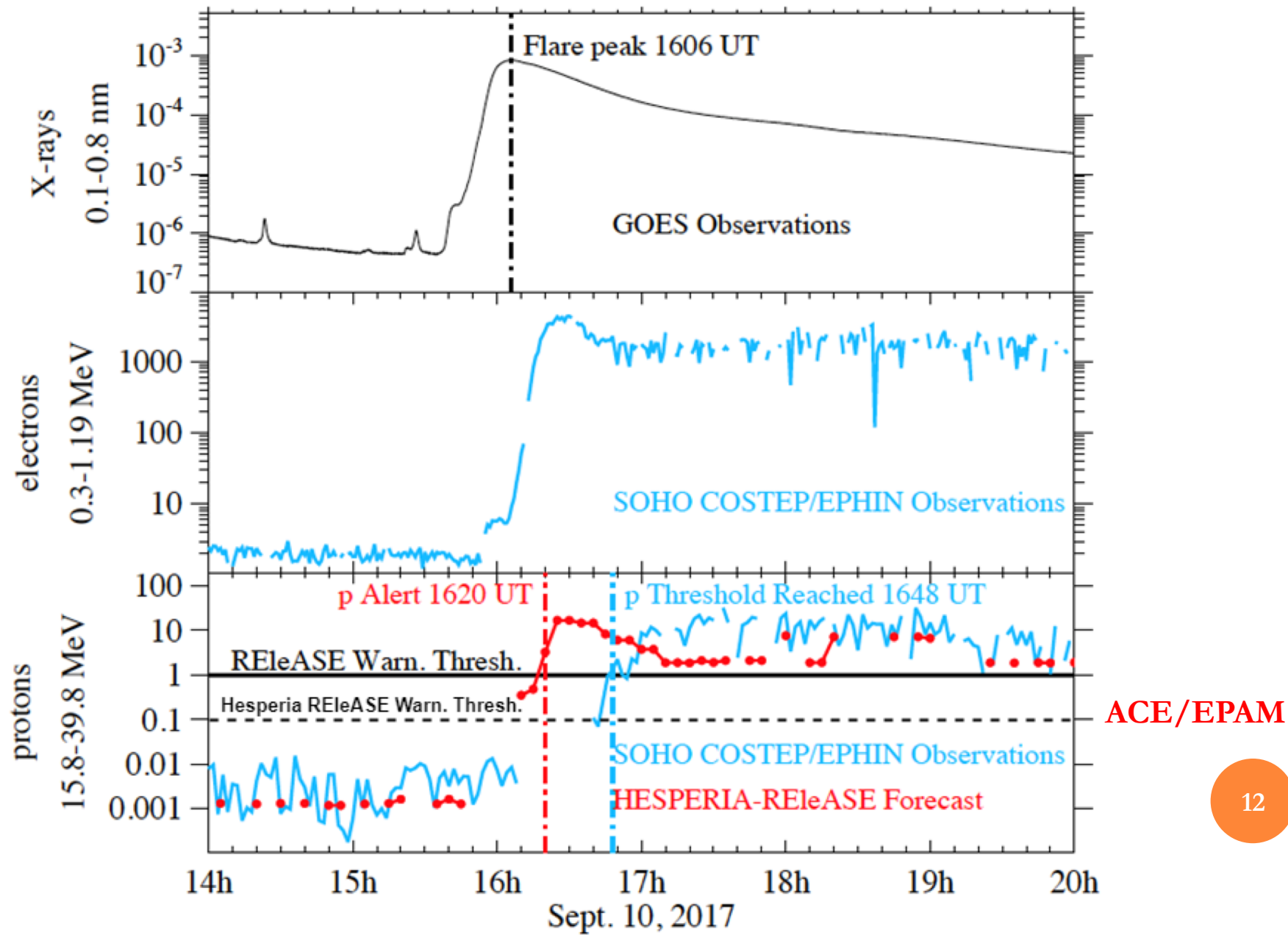
# SEPT 10, 2017 SHINE CAMPAIGN EVENT

## HESPERIA RELeASE FORECAST



# SEPT 10, 2017 SHINE CAMPAIGN EVENT

## HESPERIA REleASE FORECAST



# Chapter 7

## HESPERIA Forecasting Tools: Real-Time and Post-Event

Marlon Núñez, Karl-Ludwig Klein, Bernd Heber, Olga E. Malandraki, Pietro Zucca, Johannes Labrens, Pedro Reyes-Santiago, Patrick Kuehl, and Evgenios Pavlos

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