# Real-time dose prediction for Artemis missions

National Aeronautics and Space Administration

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## *Introduction*

- Intense Solar Particle Events (SPEs) can cause Acute Radiation Sickness (ARS) that would manifest during the mission.
- Onboard dosimeters allows radiation exposure to be monitored directly in real-time and following the path of the spacecraft.
- An algorithm was recently developed for Artemis missions to use onboard dosimeter HERA measurement to estimate organ dosimetric quantities at crew locations for ARS risk projection inside Orion MPCV.

## *ARRT*

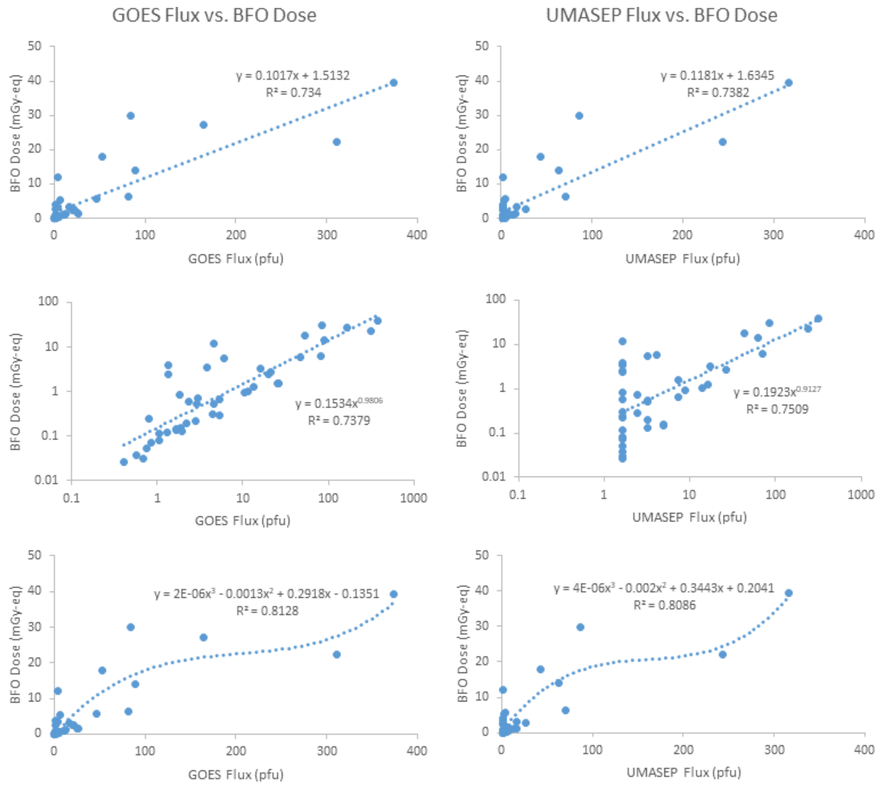
- Automatically plots the dosimeter readings and detects the onset and end of an event by linking with data streaming of onboard dosimeters.
- If threshold is reached, calculates and plots the relevant organ dose quantities, and triggers the ARS biological models to predict possible health risks.
- Automatically generates flight notes to facilitate communication of mitigation response within Flight Control Team (FCT).

## *UMASEP-100*

- Predicts the occurrence of >100 MeV energetic SPEs, the first three hours of the >100 MeV integral proton flux, and the fluence of 118 MeV.
- Based on the relationship between time series GOES SXR (soft X-ray) emissions and an increase in GOES differential proton flux.
- Validated with data from 1994 to 2013 with a POD of all >100 MeV SEP events of 80.85%, a FAR of 29.62%, and an average warning time of 1 hour and 6 minutes.

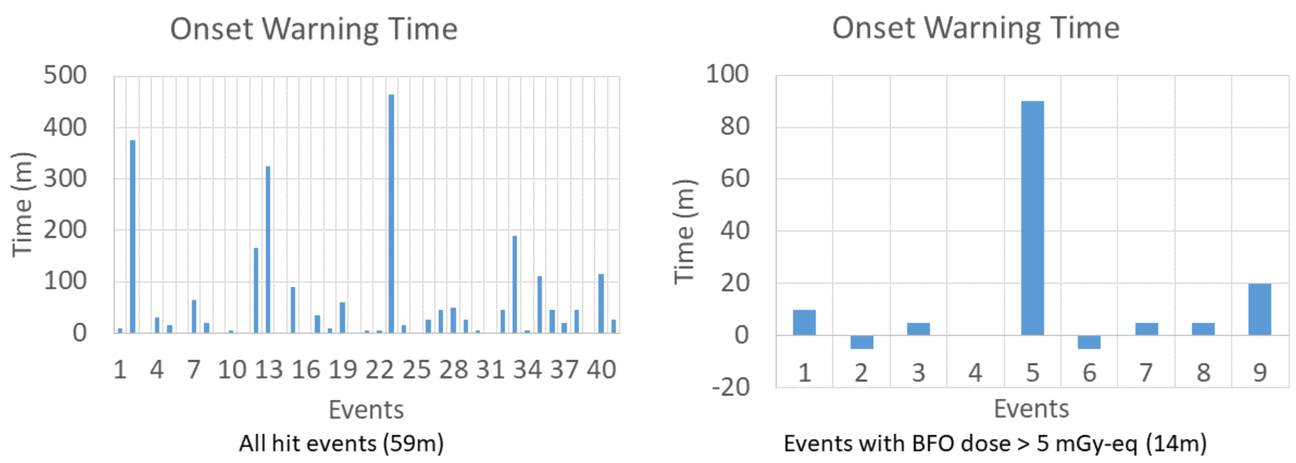
POD: Probability of Detection, FAR: False Alarm Ratio

## *Correlation between UMASEP-100 predicted fluxes and event BFO doses*

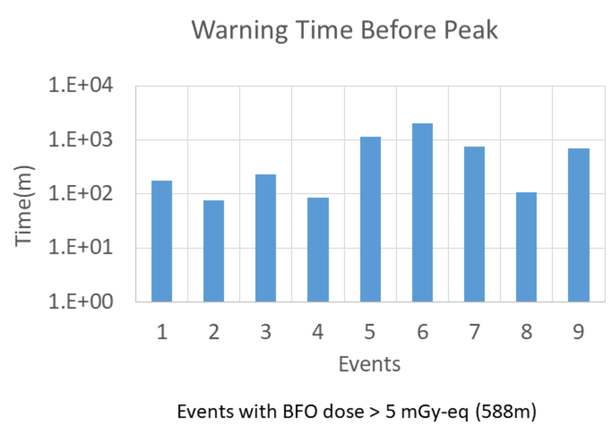



- Correlation formula between proton flux (ST + 3h) and BFO dose for 44 events observed with GOES (left) and for 40 events modeled with UMASEP-100 v3.4 (right), in the order of linear, power and cubic fitting from top to bottom.

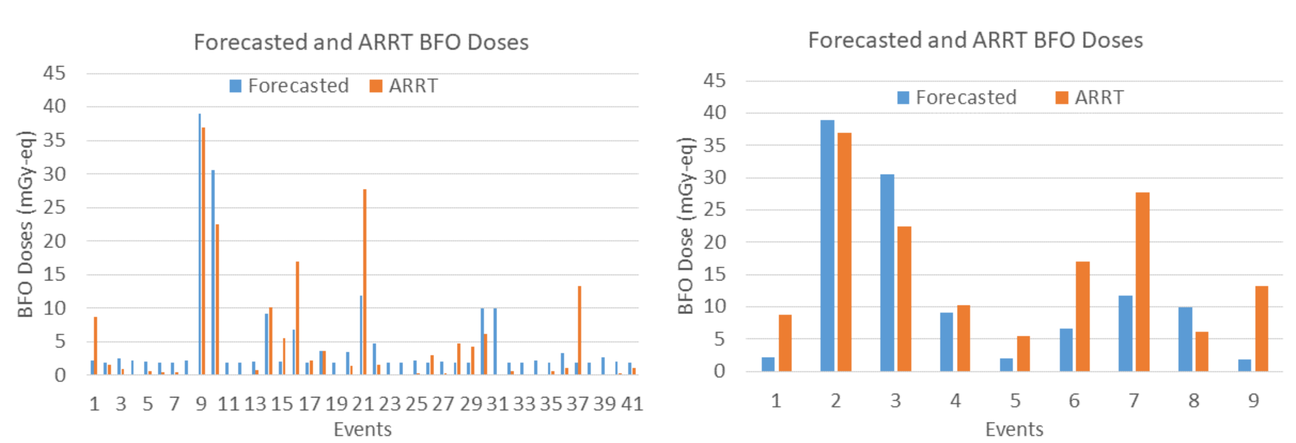
## *Advantages of UMASEP-100 dose projection in ARRT*




- Warning times by UMASEP-100 for the onsets of events as detected by ARRT. The average warning time for all hit events is 59 minutes (left), and for significant events is 14 minutes (right).




- Warning times by UMASEP-100 before the peaks of 9 significant events (BFO doses > 5 mGy-Eq), with an average 588 minutes and a minimum 75 minutes. .




- For the 32 hit insignificant events, ARRT correctly predicts 31 event doses in the range of the lower limit, with a success rate 97%.

## *Conclusions*

- A module is added to ARRT to link UMASEP-100 outputs for historical events and real-time forecasting, so that the total BFO dose of an event can be displayed whenever UMASEP-100 model issues a warning.
- The total BFO dose and warning time of the event will give the FCT important information to make timely decision in contingency scenarios to mitigate radiation exposure.
- ARRT 2.0 shows the capability to distinguish minor events from significant ones, which is important in space flight operation to avoid false alarms that will cause disruptions for space activities.