



Monitoring Space Weather for Mars Science Laboratory, on approach to Mars

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SWx for MSL, on approach to Mars

Assertion 1: Operations during bad space weather carry an increased risk of Safe-mode entry (or worse).

Assertion 2: Only near Earth do we know the space weather well enough to set quantitative criteria for including SWx in operations decisions.



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Assertion 3: For locations not near Earth, we can, at best, infer the space weather conditions and the forecast well enough to **qualitatively** factor SWx into operations decisions.

This is appropriate only at certain times in some missions, when the benefit might overcome the drawbacks of subjective criteria and SWx false alarms.



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When do we need to monitor SWx?

MSL's Entry, Descent, and Landing (EDL) sequence is completely autonomous, and orbital mechanics dictates when it will happen, so
no need to look at SWx for EDL . . .



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...except for EDL anomaly resolution
(but that wasn't needed either).



<http://www.youtube.com/watch?v=wnG-rFFpP8A>



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SWx monitoring at launch?

YES;

LV and S/C need to perform critical operations
in a timely manner, so...

**Don't launch into a large
solar energetic particle event.**



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SWx monitoring during cruise?

No need;

S/C is designed to handle a lot of radiation,
and handle it autonomously.

If it sees more than it can handle, Safe mode
helps it ride out the storm.



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But it takes time to recover from Safe mode,
and time is precious when a critical
operation such as EDL is imminent...



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Hence we want to avoid operations that carry a relatively higher risk of taking the s/c into safe mode.

Remember Assertion 1: Operations during bad space weather carry an increased risk of Safe-mode entry (or worse).



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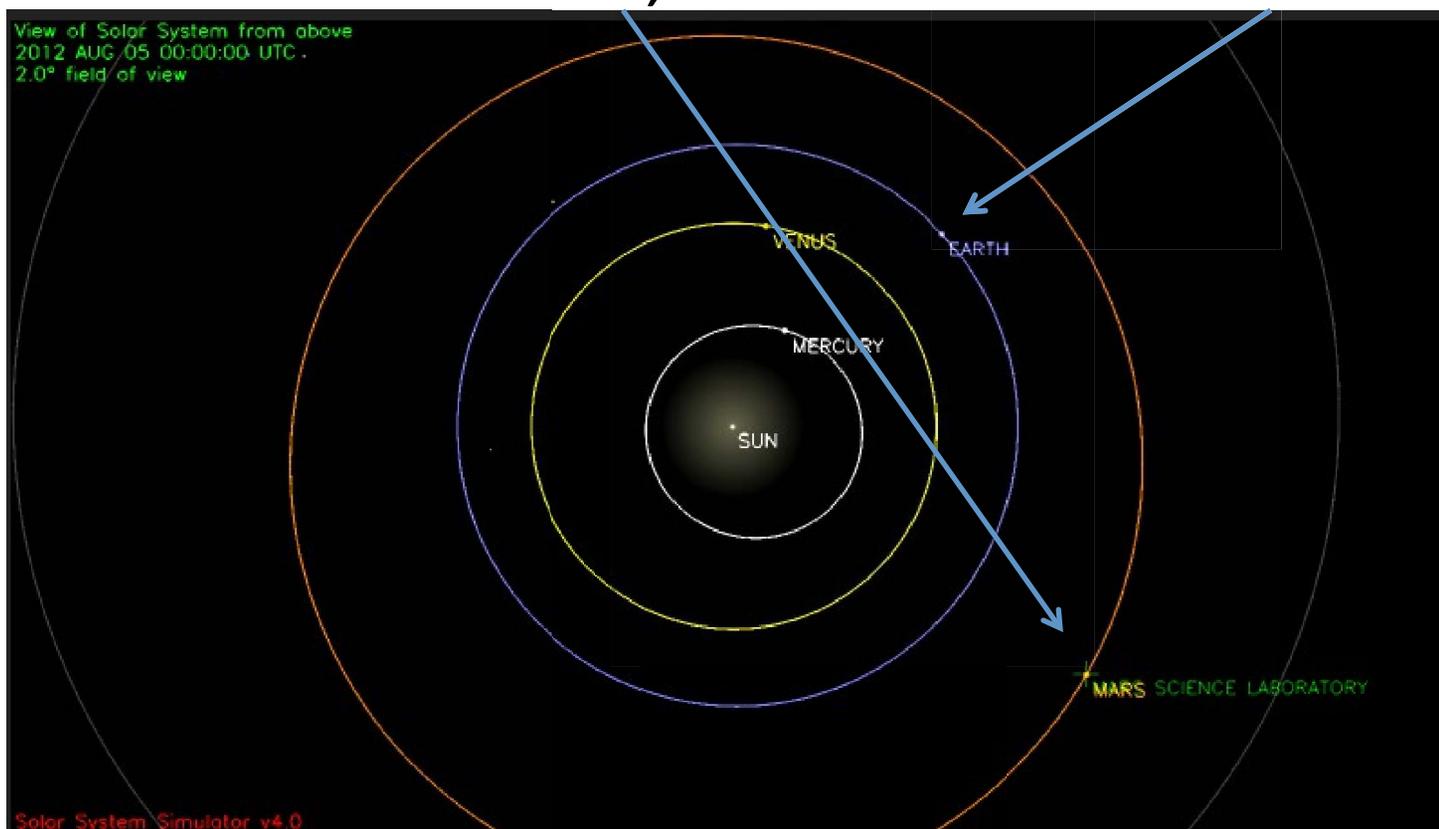
SWx monitoring began about 2 weeks prior
to EDL.

For maneuvers and data uploads
just prior to EDL,
solar energetic particle (SEP) events will
increase the risk of safe-mode entry.



SWx for MSL, on approach to Mars

How do we determine and forecast SWx there at Mars, when we are here?



Simulation from <http://space.jpl.nasa.gov/>



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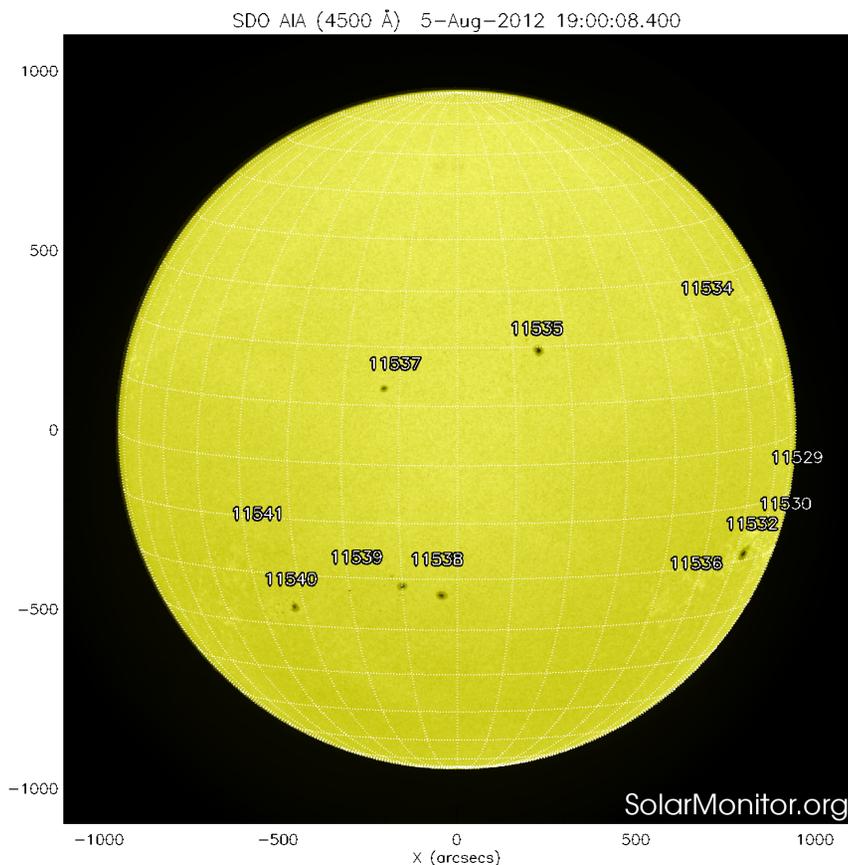
Fuzzy criteria for postponing flight ops and data uploads due to weather:

- a SEP event at Mars may be imminent (look at flare probability);
- a SEP event may be in progress at Mars (flare and CME sightings);
- a SEP event of unknown severity is in progress (un-calibrated HEND in-situ data).



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Use regions' flare probabilities to get flare probability relevant to Mars. (SWPC solar synoptic analysis; off-menu product)



NOAA/SWPC gives a low probability of X-class flares from regions we can see from Earth (which is also what happens to matter most for Mars right now).

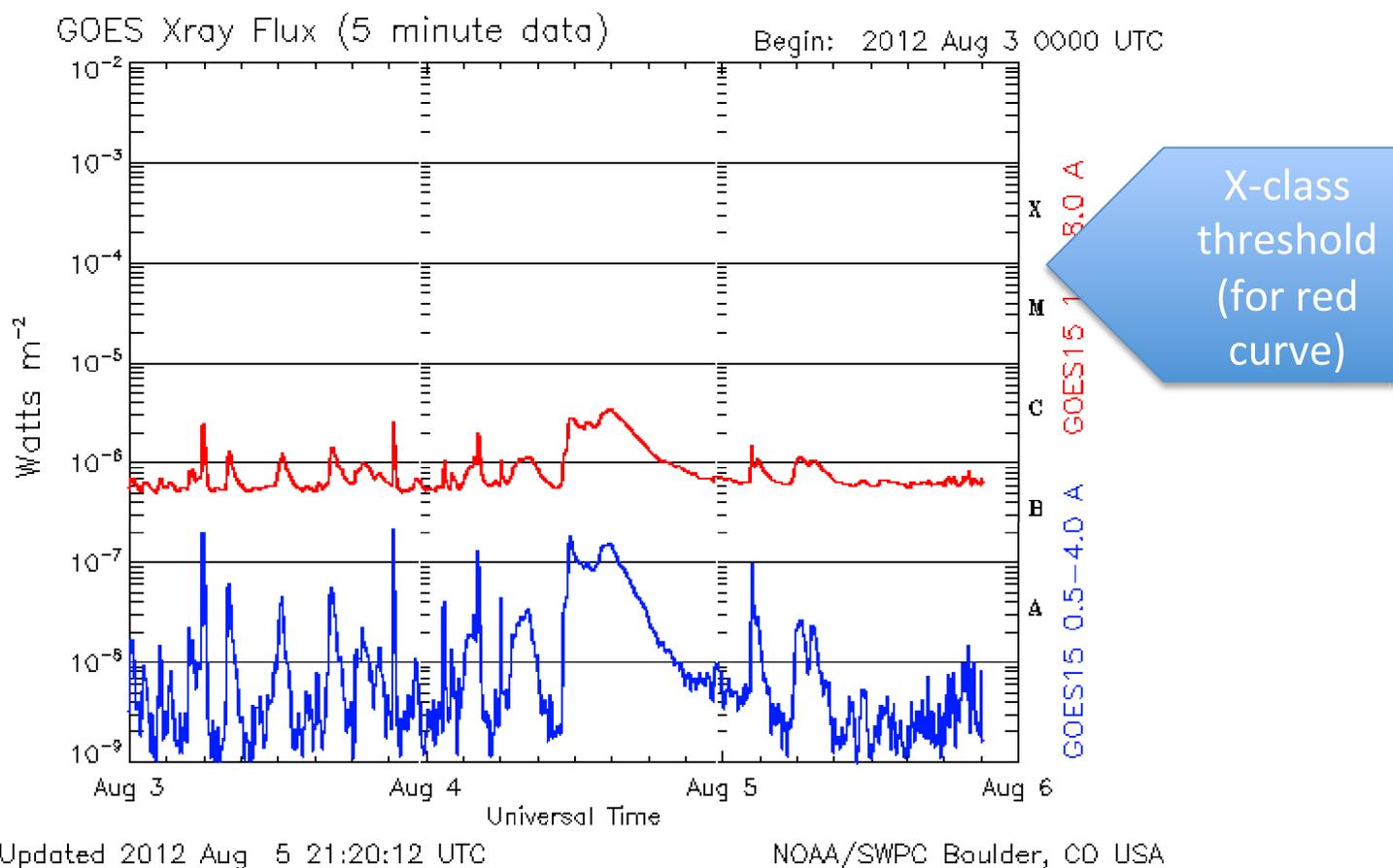
Flare Event Probabilities for next 24 hrs:

Class M 15%
Class X 1%



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Watch for flare alerts, note peak values and locations.

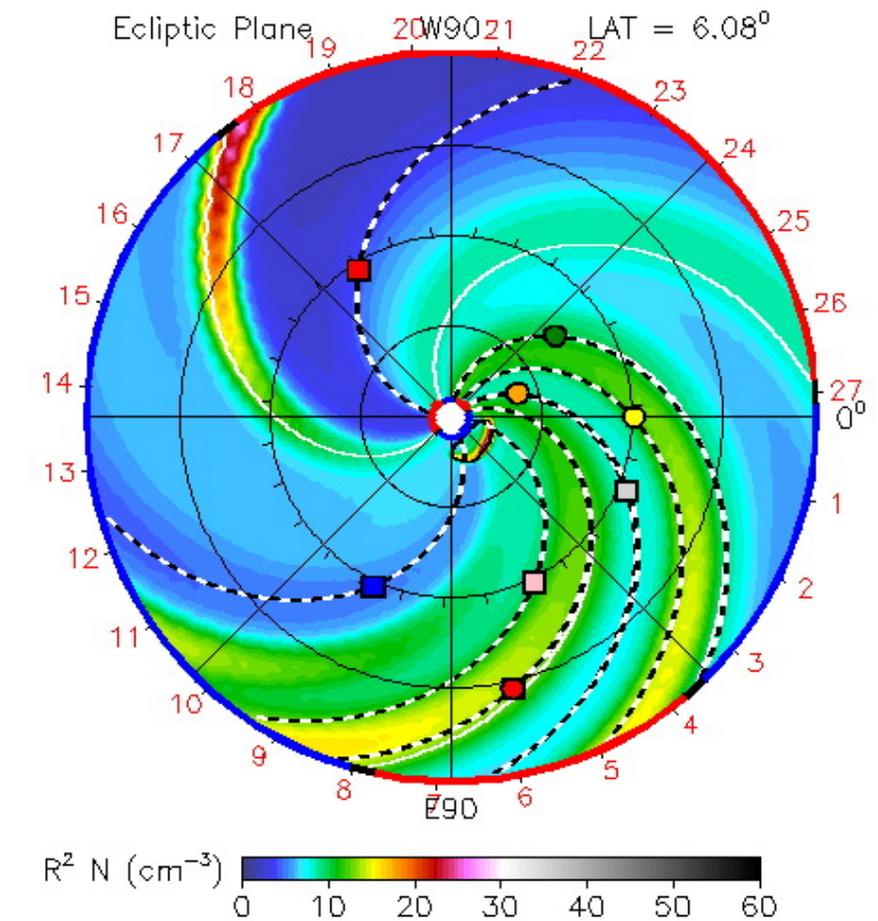




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2012-08-05T06:00

- Earth
- Mars
- Mercury
- Venus
- Stereo_B



ENUL-2.7 lowres-2126-a3b1f WSA_V2.2 GONG-2126 [ccmc/wsafr-ld/256x](http://ccmc.gsfc.nasa.gov)

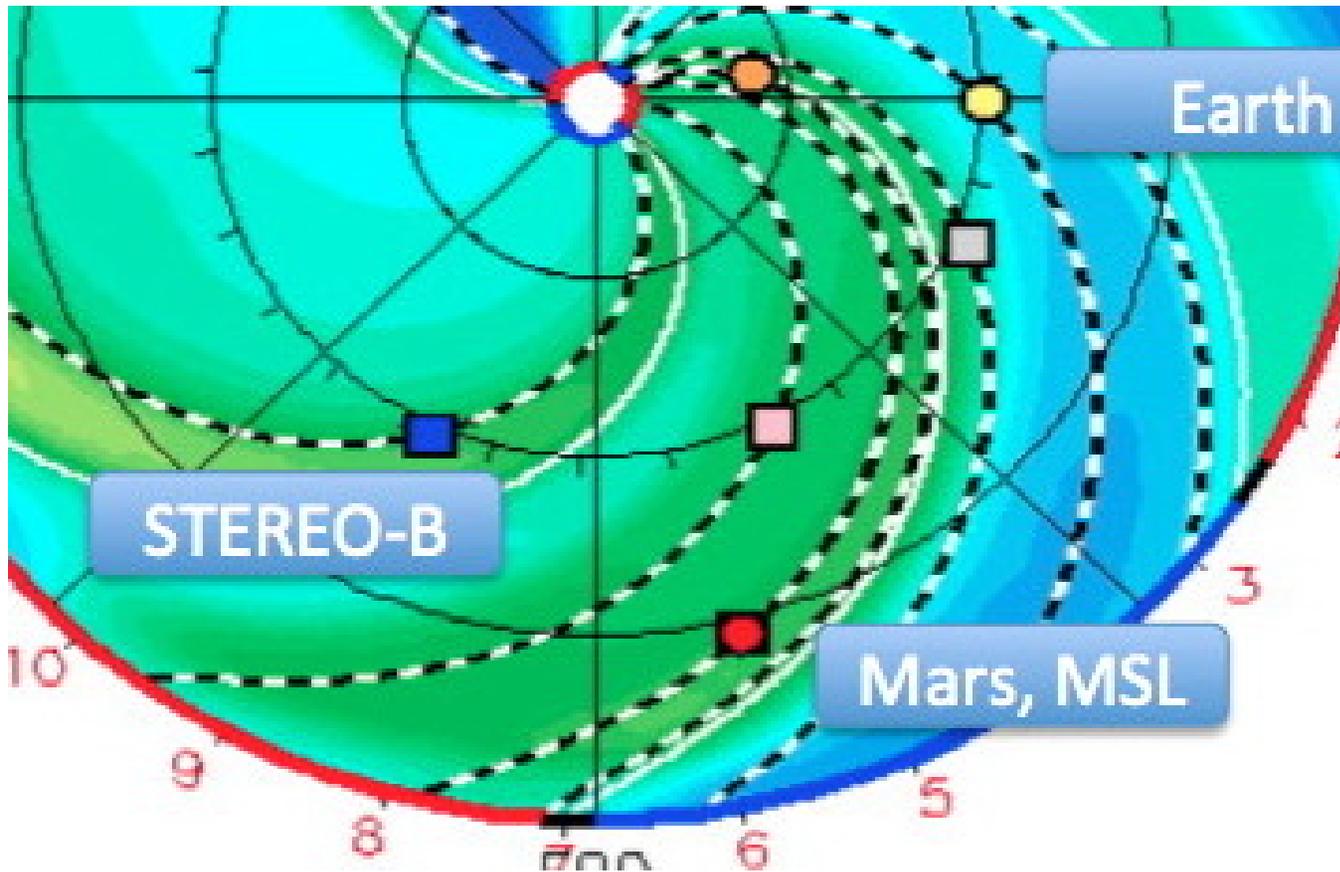
Watch for CME sightings.

<http://swrc.gsfc.nasa.gov/main/iSWACygnStream-CME-03-Aug.gif>



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“Interpolate” from SEP conditions at Earth and Stereo-B.

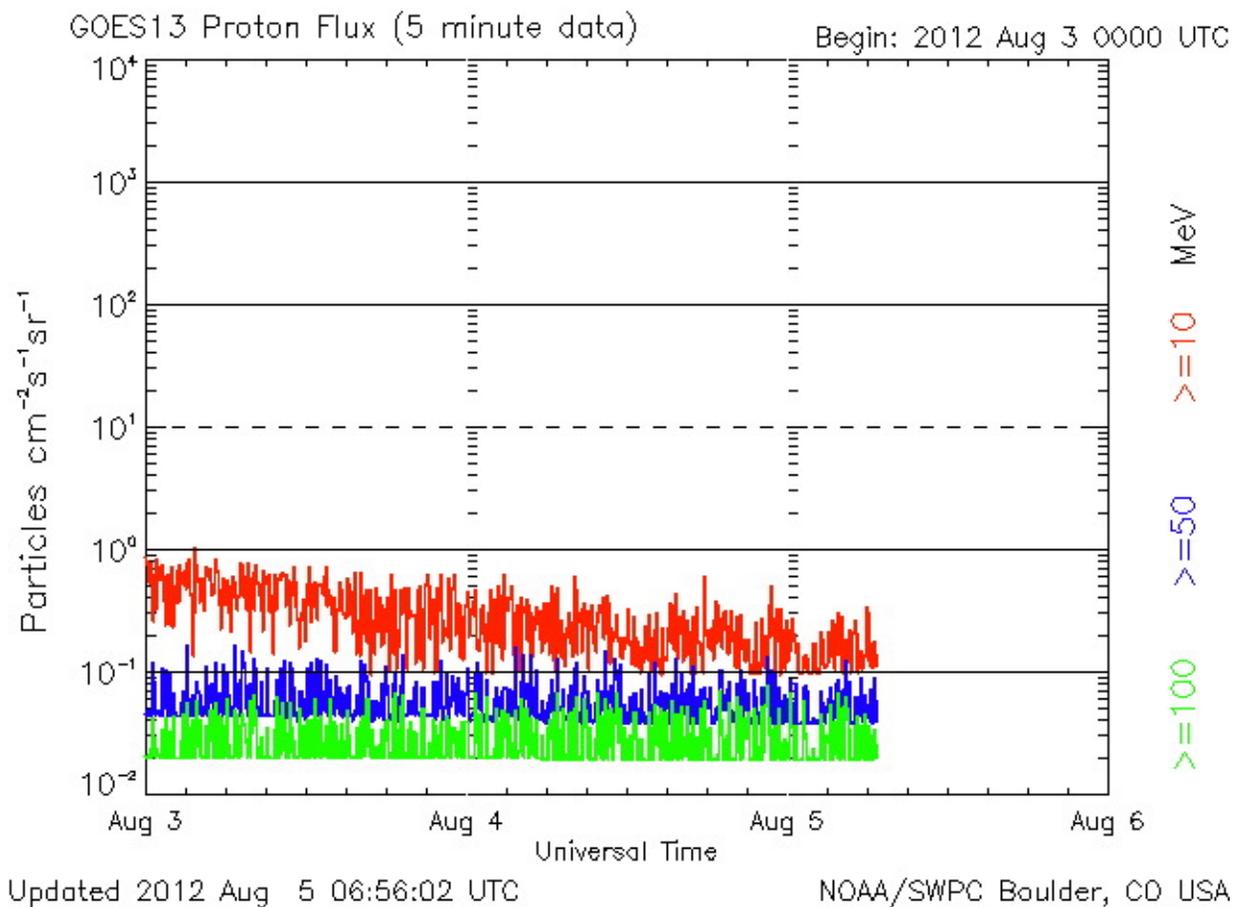


http://www.swpc.noaa.gov/rt_plots/pro_3d.html



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SEP conditions at Earth, from GOES.

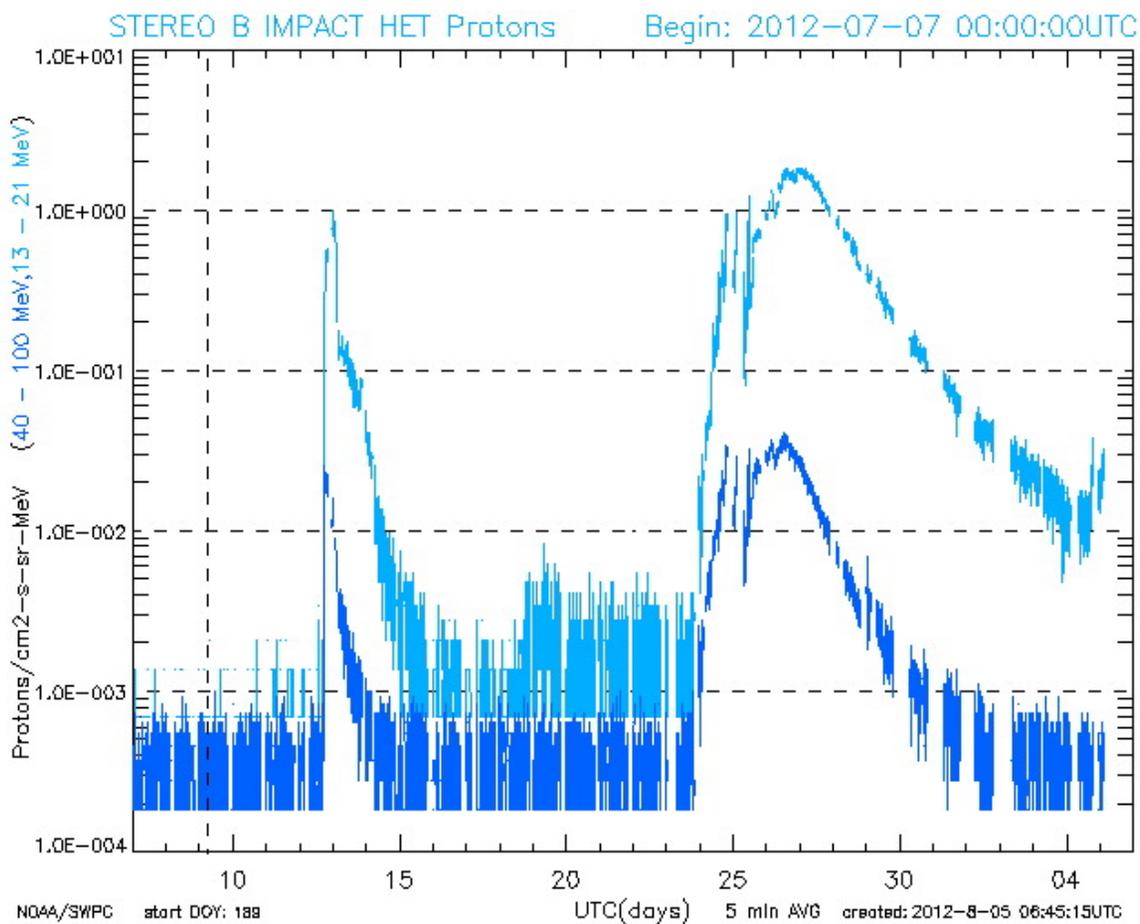


http://www.swpc.noaa.gov/rt_plots/pro_3d.html



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SEP conditions from STEREO-B.



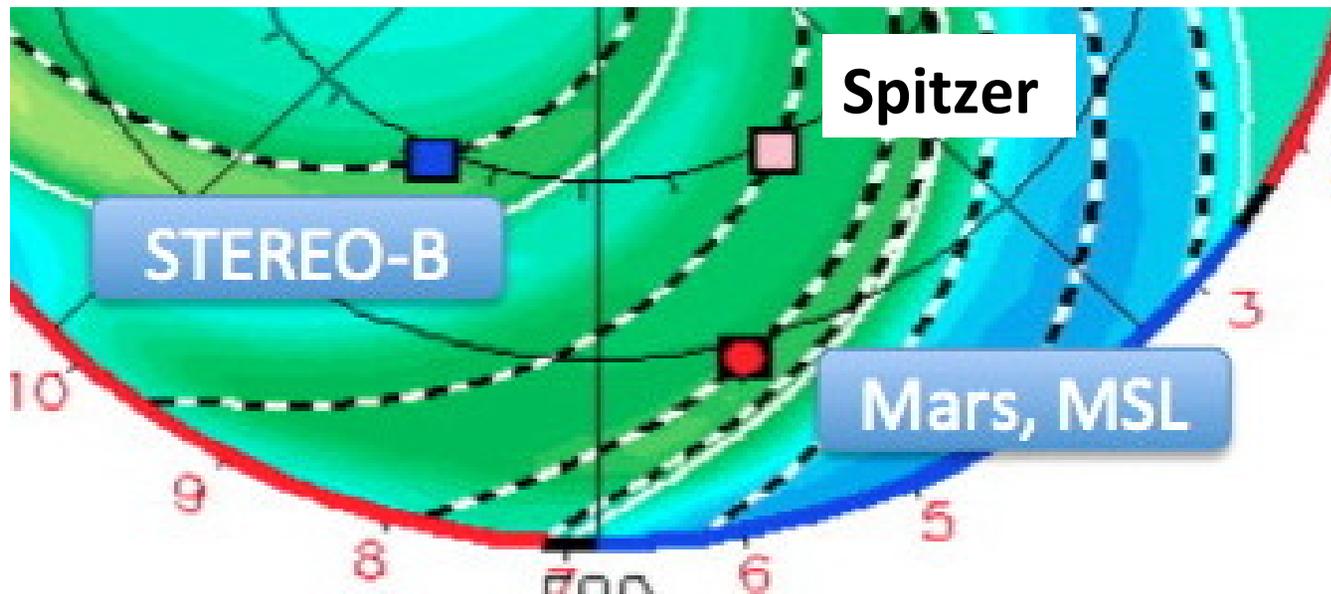
http://www.swpc.noaa.gov/stereo/impact_het_B_30d_w.html



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On one occasion, I requested and received housekeeping telemetry from Spitzer, showing memory SEU counts.

**No change in count-rate,
so
no evidence of SEP flux.**





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In-situ monitor of high-energy protons: High Energy Neutron Detector (HEND) on Odyssey s/c orbiting Mars.



<http://mars.jpl.nasa.gov/odyssey/mission/overview/>



SWx for MSL, on approach to Mars

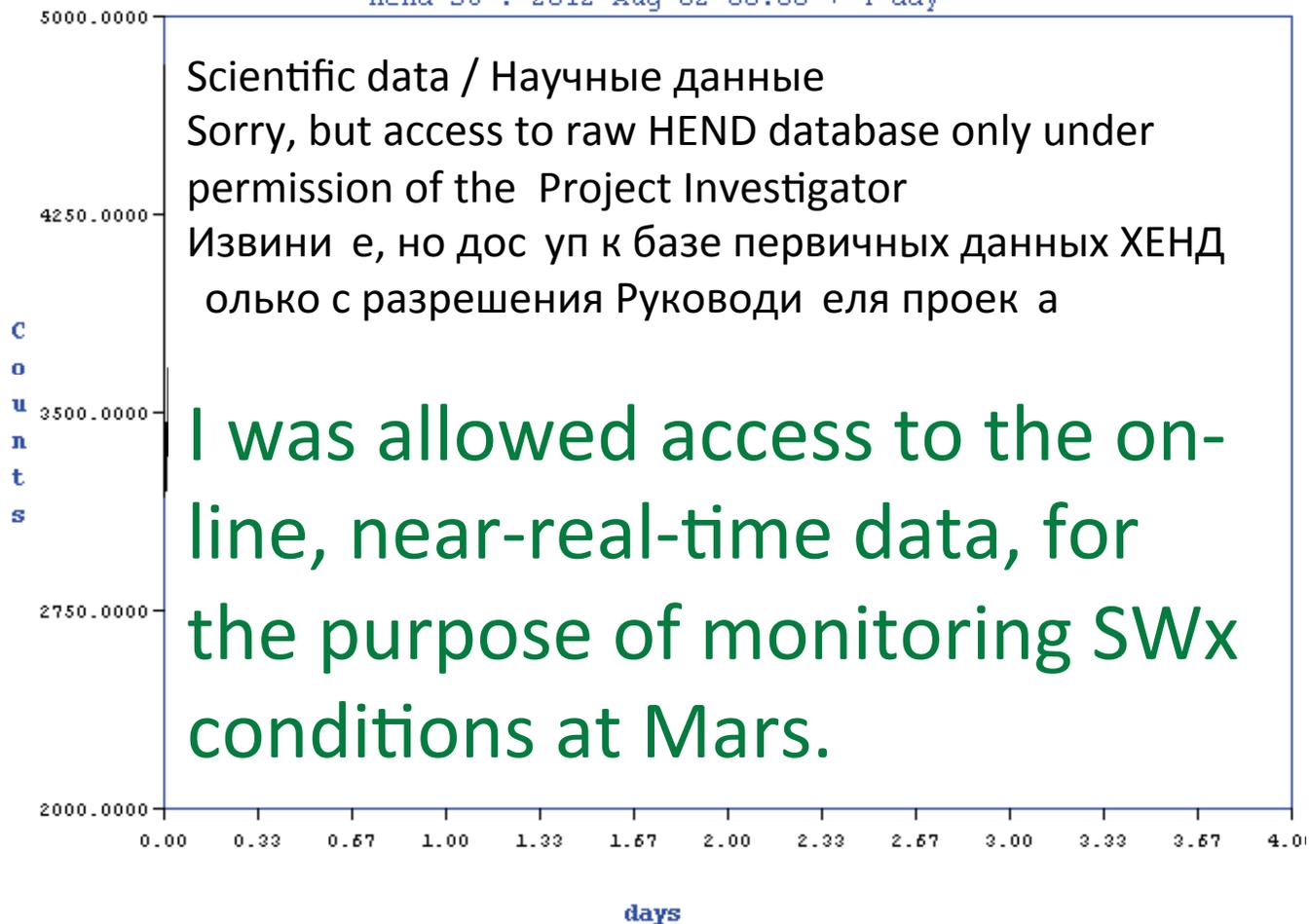
HEND:

- developed at the Institute for Space Research (ИКИ, anglicized to IKI) in Moscow, Russia. (Dr. Igor Mitrofanov);
- detects epithermal, resonance, and fast neutrons;
- sees high-energy protons, but is **NOT CALIBRATED FOR THEM!**



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hend s6 : 2012 Aug 02 00:00 + 4 day



Energetic particle flux at Mars is at background level.
(This is what MSL wanted to see.)



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Sample: Last slide of the last MSL SWx report, at
EDL minus 8 hrs:

SUMMARY:

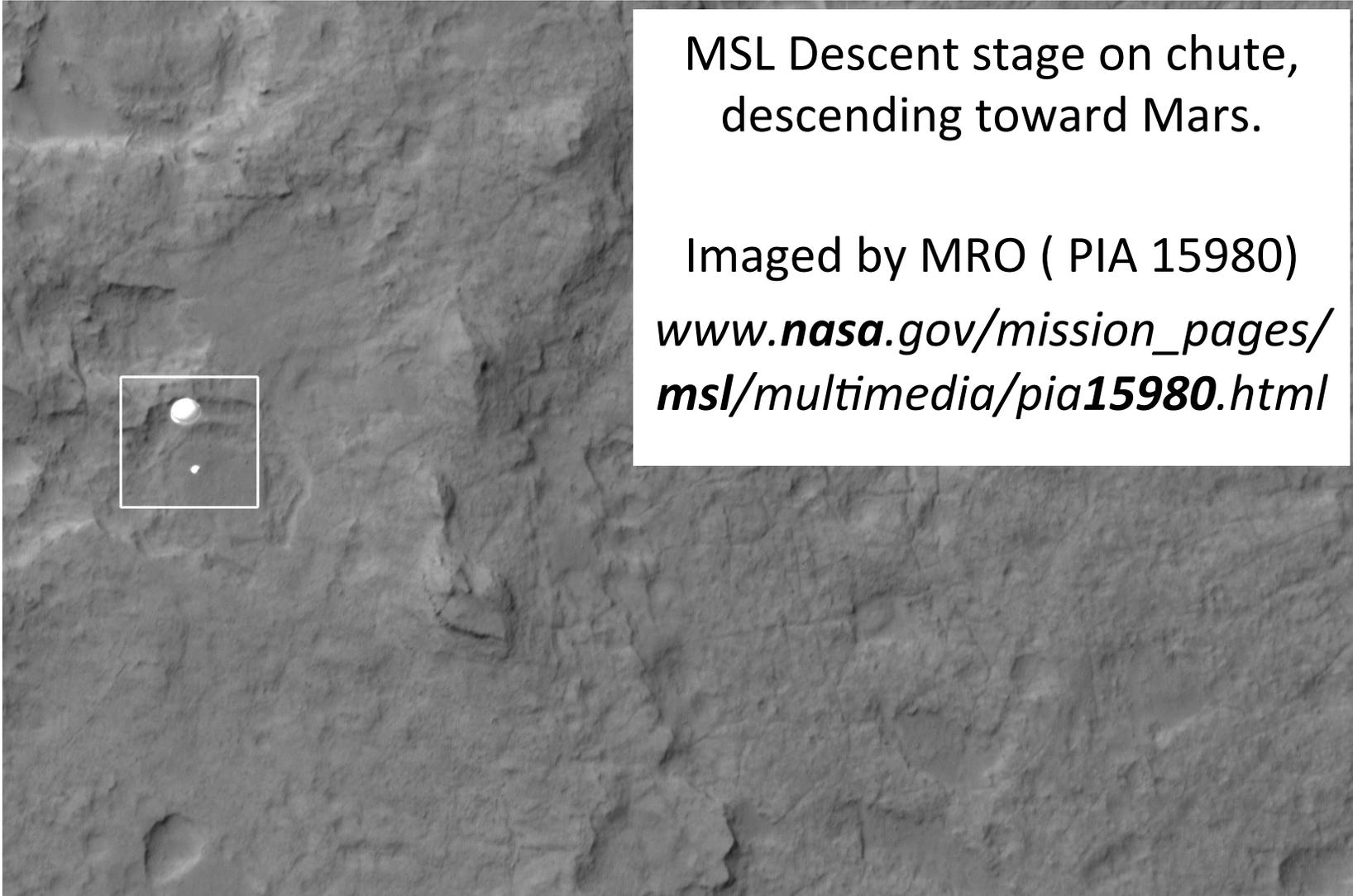
We currently have a background radiation level at Mars.

Some chance of a small to moderate Solar Energetic Particle event (SEP event) at Mars, through EDL.

Low (near zero) chance of a large SEP event.



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MSL Descent stage on chute,
descending toward Mars.

Imaged by MRO (PIA 15980)
[www.nasa.gov/mission_pages/
msl/multimedia/pia15980.html](http://www.nasa.gov/mission_pages/msl/multimedia/pia15980.html)



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First MSL image
from Mars.

[http://
photojournal.jpl.nasa.gov/
catalog/?
IDNumber=PIA15971](http://photojournal.jpl.nasa.gov/catalog/?IDNumber=PIA15971)



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Summit of Mt.
Sharp, 16 km
distant.
(telephoto
camera on MSL)

[http://www.nasa.gov/
681384main_PIA16104r_ma
lin03m100focus_raw.png](http://www.nasa.gov/681384main_PIA16104r_malin03m100focus_raw.png)