The Current Solar Maximum and Its Effects on IUE

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The current extreme solar maximum has had its effects on many satellites, and IUE is no exception. IUE's orbit is too high for atmospheric drag to be a problem, but the satellite is exposed to electrons trapped in the Van Allen belts and to solar protons. Fortunately the negative effects on IUE have not been major, and there are some beneficial results. This short report summarizes these effects.

1. US2 Radiation Background

A beneficial effect of the current solar maximum, which has been noted by many Guest Observers, is that the radiation during the US2 shift is generally lower than it has been for several years. This effect was noted during the last solar maximum (e.g. Imhoff, 1985, NASA IUE Newsletter No. 27, 9). This is thought to occur because of the slight compression of the upper Van Allen belts in conjunction with higher solar activity. IUE's orbit generally lies above the belts but dips down into the upper portion at perigee, which occurs during US2. Then electrons trapped in the belts produce Cerenkov emission as they pass through the camera faceplate and are detected during an exposure, producing a "fogging" effect. Any compression of the belts will therefore reduce the radiation background experienced by IUE. The variations in the Flux Particle Monitor (FPM) readings can be seen to follow the solar rotation cycle when one active region is dominating solar activity levels (see Loomis and Arquilla, this issue).

2. Effects of Protons on the Cameras

In the last year, the extreme solar maximum has produced some very large proton storms. Last fall it was recognized that these large proton fluxes were affecting the cameras. The effects that are seen are two-fold. First, there is a fogging effect which is produced by Cerenkov radiation from protons passing through the camera faceplate, similar to the fogging produced by electrons during US2. Second, there are discrete "hits" in the image as protons strike the camera target. Images obtained during severe proton storms can be thoroughly "peppered" with proton hits and have substantially higher backgrounds.

The IUE Observatory is notified of large proton events by the Space Environment Services Center in Boulder, Colorado. This center collects and distributes a wealth of solar-geophysical data (radio, magnetic, particle, X-ray) to many groups concerned with the near-earth space environment, including various satellites, communications companies, commercial aviation, and the military. Through the center we are now able to obtain detailed information on proton fluxes in near real-time, as measured by detectors on board the Geostationary Operational Environmental Satellites (GOES 6 and 7).

An analysis was performed using IUE's FPM readings, the DN levels measured from images obtained during the proton storms, and the proton fluxes obtained from the SESC. The results are summarized here.

First, the FPM readings during proton storms are generally low despite significant effects on the IUE cameras. This appears to be due to the FPM's low end sensitivity cutoff of 15 Mev for protons. A significant flux of protons at lower energies are not detected by the FPM but can affect the cameras. Thus an FPM reading of 1 volt normally signifies a radiation background on the cameras of about 10 DN/hour, but during a proton storm may indicate a fogging rate of roughly 100 DN/hr or more. Aside from this difference in the "calibration", the FPM readings are reasonably well correlated with the actual proton fluxes (see Figure 1).

Second, the proton fluxes and camera fogging rate (in DN/hour) are well correlated (Figures 2 and 3). This appears to confirm that in fact the protons are responsible for the effects on the camera, not some indirect aspect of the solar activity. Together with the correlation of FPM and proton flux, the FPM reading can be used as an indication of the background affecting the cameras - that is, if it is known that a proton event is occurring.

Finally, the LWP camera was found to be 3 times as sensitive to the proton flux as the SWP (see again Figures 2 and 3). The reason for this is unknown, but it may be that the SWP camera is mounted in a somewhat shielded position in the spacecraft.

It should be noted that the effects of a proton storm can be felt during any shift since this is a direct effect from the Sun, not due to particles trapped in the Earth's magnetic field. High backgrounds were experienced during several VILSPA and US1 shifts last October when three large proton events occurred within a few days of each other.

Fortunately the occurrence of such very large proton events has been rare (see report by Fireman, this issue). Aside from the cluster of events in October, there have been only a few proton storms which have affected IUE observations during the last year, usually for less than a day. In fact numerous proton events go on all the time with no measurable effects on IUE (except perhaps reducing the US2 radiation background, see Fireman); only the very largest proton storms are detected by IUE's FPM and camera.

3. Solar Array Degradation

The potentially most serious effect of the solar maximum on IUE is the decreased rate at which the solar arrays provide power to the spacecraft. For the last several years, the array output has degraded at a rate of 2 to 3 percent per year. For several months this fall and winter, this rate rose to over 10 percent per year. Since the array degradation is thought to be due to radiation damage, the increased particle flux due to solar maximum is thought to be responsible.

The decreased solar array output affects IUE in limiting the power positive beta range at which we can operate the spacecraft. This is responsible for the slowly shrinking range of betas (currently about 34 to 105) in which we normally operate IUE. If the larger degradation rate were to be in affect over the long term, the expected lifetime of IUE of about 5 more years could be cut short substantially. Fortunately the proton storms have decreased in frequency and the solar array degradation rate appears to have leveled off again. Some decrease in IUE's lifetime due to the solar maximum has undoubtedly occurred, perhaps from 5 to 4 years. The full effects of solar maximum will not be known until well past the peak of the maximum.

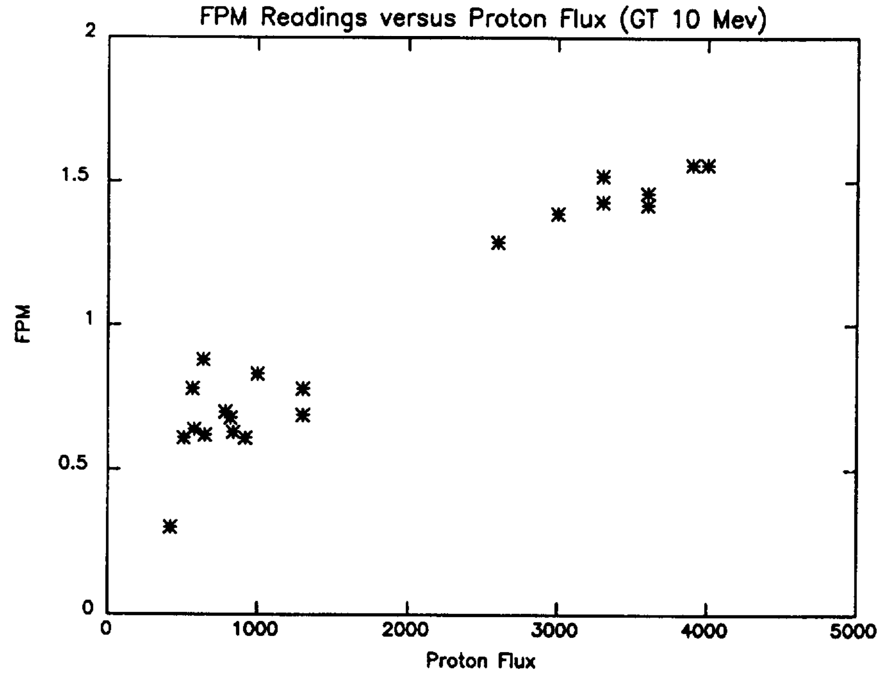

Figure 1. Correlation of FPM readings (volts) with proton flux (particles/cm/cm/ster/sec) for protons with energies in excess of 10 Mev.

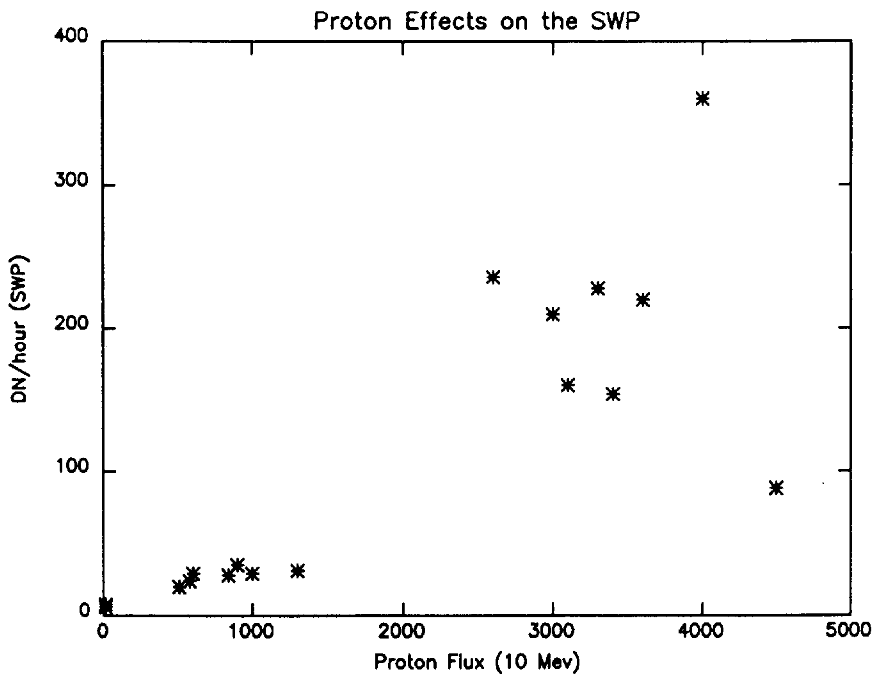

Figure 2. "Fogging" of the SWP camera, in DN/hour, due to protons. The proton flux, for protons with energies in excess of 10 Mev, is in units of particles/cm/cm/ster/sec. The proton flux and fogging rate are fairly well correlated, but there is a large scatter apparently due to variable amounts of shielding depending on the orientation of the spacecraft with respect to the incoming proton storm. The data are from the October sequence of proton storms.

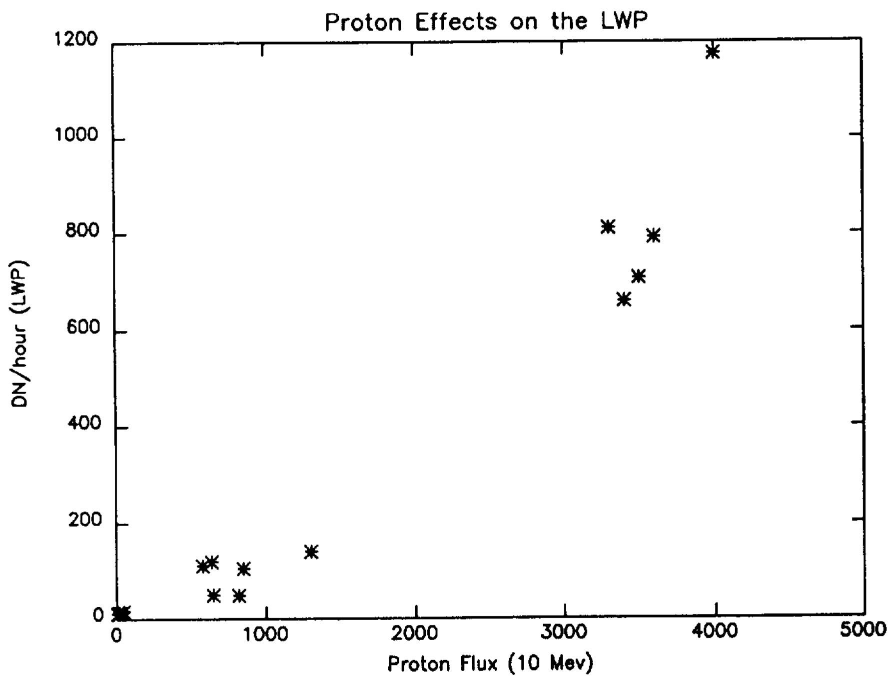

Figure 3. "Fogging" of the LWP camera, in DN/hour, due to protons. The units are the same as in Figure 2. Note that the LWP is 3 times as sensitive as the SWP to protons.