Interpretation of the UVS Noise Statistics

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This report provides a brief analysis of the noise statistics of the UVS raw data.

Holberg et al. (1987, see p. 180) note that, during the Uranus sigma Sgr occultation, each photon triggered about 2.5 UVS counts on average. Let us define parameter K as the number of UVS counts triggered by a single photon.

Let N be the number of UVS counts measured in a single time step. If K = 1, then we expect N to be distributed by Poisson statistics, in which case the standard deviation sigma(N) = sqrt(N).

For K not equal to 1, the standard deviation can be determined as follows. Let P = the number of photons counted = N / K. Since P obeys Poisson statistics, its standard deviation sigma(P) = sqrt(P). It follows that

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    sigma(N) = sigma(P*K)
             = K * sigma(P)
             = K * sqrt(P)
             = K * sqrt(N/K)
             = sqrt(K) * sqrt(N)                                    [1]
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Thus, we can determine K by studying the relationship between sigma(N) and sqrt(N).

Program SIGMA.FOR groups the data in runs of length "runsize" and evaluates the mean and sigma within each group. It then tabulates sigma as a function of the mean.

The files U**SIG01.TAB contain the results of running the program from input files EDITDATA/U**D01T.TAB. The run size is 10 and the tabulation uses a step size of 10 UVS counts. Figure 1 (NOISE001.PS) shows the results for all four occultations.

Files US1SIG01.TAB and UU1SIG01.TAB contain a number of measurements where the number of mean UVS counts is rather low. Here the relationship of standard deviation to mean counts is correspondingly less certain. These have been edited out of corresponding "version 02" files US1SIG02.TAB and UU1SIG02.TAB. File UU1SIG02.TAB also eliminates a few other outlying determinations of sigma. The eliminated points are shown in Figure 1. as open circles rather than filled circles.

The third column shows the ratio of sigma/sqrt(mean). This is an estimate of the value of sqrt(K) as demonstrated in Eq. [1]. Figure 2 (NOISE002.PS) plots these values, which appear to hover around 1.6.

Program FINDSCALE.FOR reads the tabulate files U**SIG0*.TAB and generates a weighted estimate of the actual scale factor. Running this program yields the following estimates of K:

File	K
US1SIG02.TAB	2.6809
UU1SIG02.TAB	2.3423
UU2SIG01.TAB	3.5216
UN1SIG01.TAB	2.2547

For three of the four files, the determination of K falls quite close to the value 2.5 as provided by Holberg et al. (1987). The Uranus beta Per result (from file UU2SIG01.TAB) is exceptional. The difference may have to do with the fact that beta Per data were dominated by the Uranian charged-particle background (Holberg et al. 1987. p. 179). It is quite possible that this background value does not obey such a simple model for Poisson statistics).

For simplicity in further analysis we adopt 2.5 as the number of UVS counts per photon in all further analysis. We recognize that this will result in slight underestimates of the noise properties in the Uranus beta Per data set.

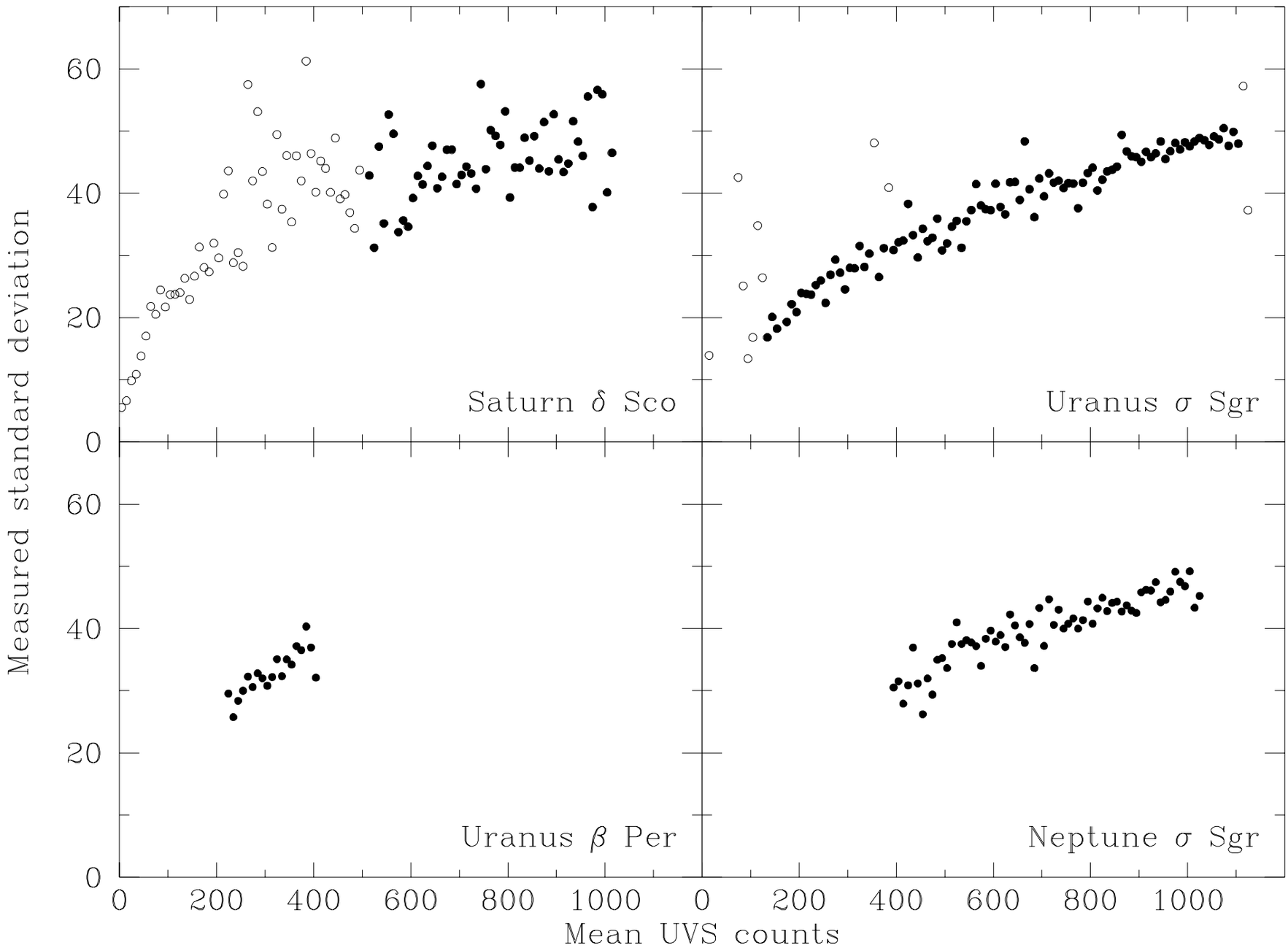
Measured standard deviation
Mean UVS counts
Saturn δ Sco
Uranus σ Sgr
Uranus β Per
Neptune σ Sgr
0
20
40
60
0
200
400
600
800
1000

Figure 1.

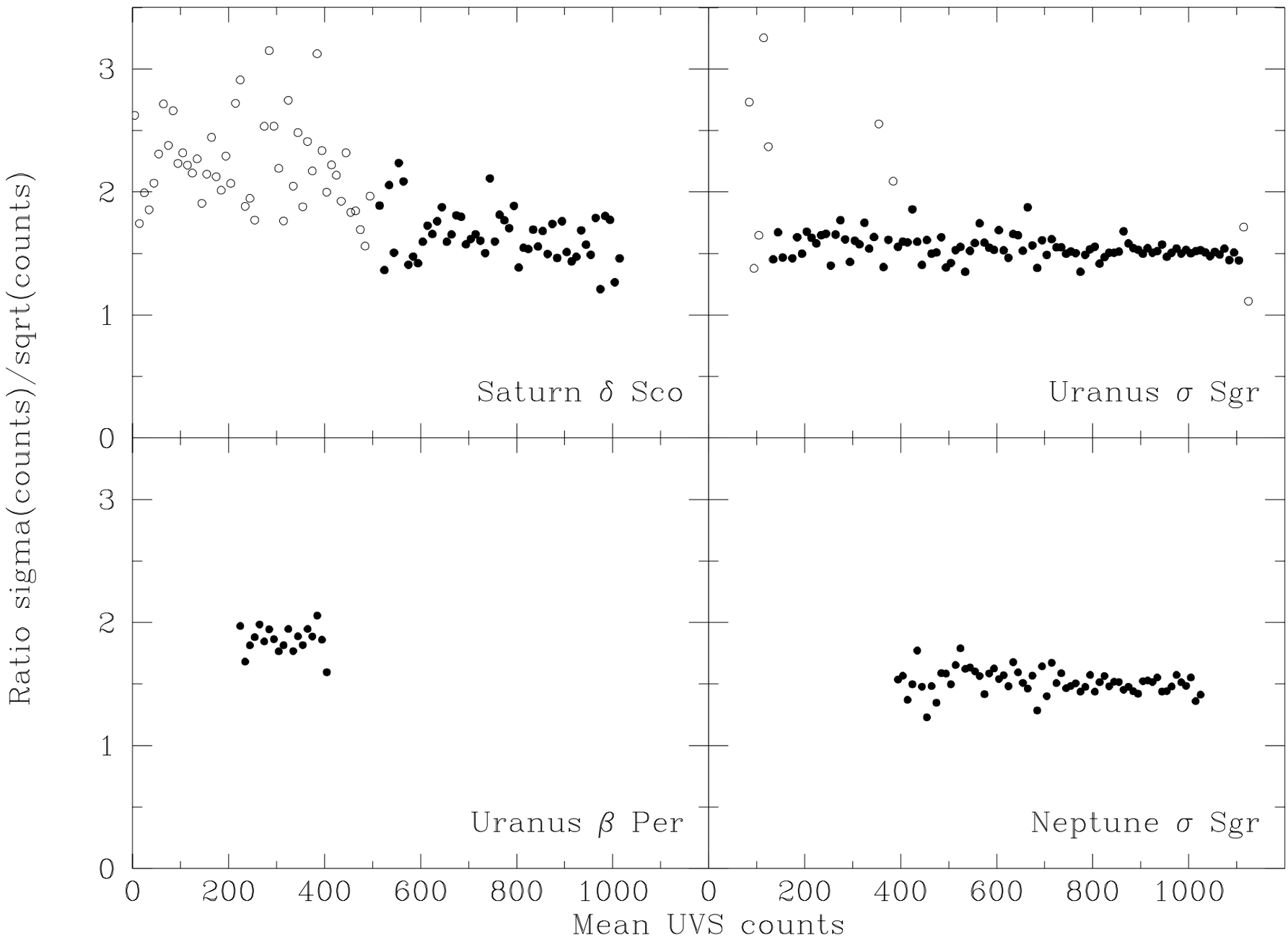
Ratio sigma(counts)/sqrt(counts)
Saturn δ Sco
Uranus σ Sgr
Uranus β Per
Neptune σ Sgr
0
1
2
3
0
200
400
600
800
1000
Mean UVS counts

Figure 2.