Scanning law and short period spectroscopic binaries

How long before an orbit?

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Simulated data

Sample 1 (570 systems, 1710 simulations)

- 30 systems (w/α, δ, e, ω_A, T randomly generated, $K_A = 10$, $\sigma_V = 1$);
- $P_d \in [1, 10]$ (step: $0.5d$);
- Solution after 500, 1000, & 1500 days.

Sample 2 (2160 systems, 62640 simulations)

- 30 systems (w/α, δ, e, ω_A, T randomly generated, $K_A = 10$, $\sigma_V = 1$);
- $P_d \in [10, 730]$ (step: $10d$);
- Solution after 100, 150, $\ldots$, 1500 days.

Period determination

Among the several methods for period determination, even for unevenly sampled data (e.g. Stellingwerf 1978, Scargle 1982) we give preference to Horne & Baliunas (1986):

$$P_X(\omega) = \frac{1}{2\sigma^2} \left\{ \frac{\left[\sum_{j=1}^{N_o} (X(t_j) - \bar{X}) \cos(\omega(t_j - \tau))\right]^2}{\sum_{j=1}^{N_o} \cos^2(\omega(t_j - \tau))} + \frac{\left[\sum_{j=1}^{N_o} (X(t_j) - \bar{X}) \sin(\omega(t_j - \tau))\right]^2}{\sum_{j=1}^{N_o} \sin^2(\omega(t_j - \tau))} \right\}$$

where $\tan(2\omega\tau) = \left(\sum_{j=1}^{N_o} \sin(2\omega t_j)\right) / \left(\sum_{j=1}^{N_o} \cos(2\omega t_j)\right)$

Frequency range

$P_X(\omega)$ is evaluated at frequency $\nu(=\omega/2\pi)$ in $[\Delta T^{-1}, \nu_{Ny}]$ where ν_{Ny} is the Nyquist frequency (Eyer & Bartholdi 1999):

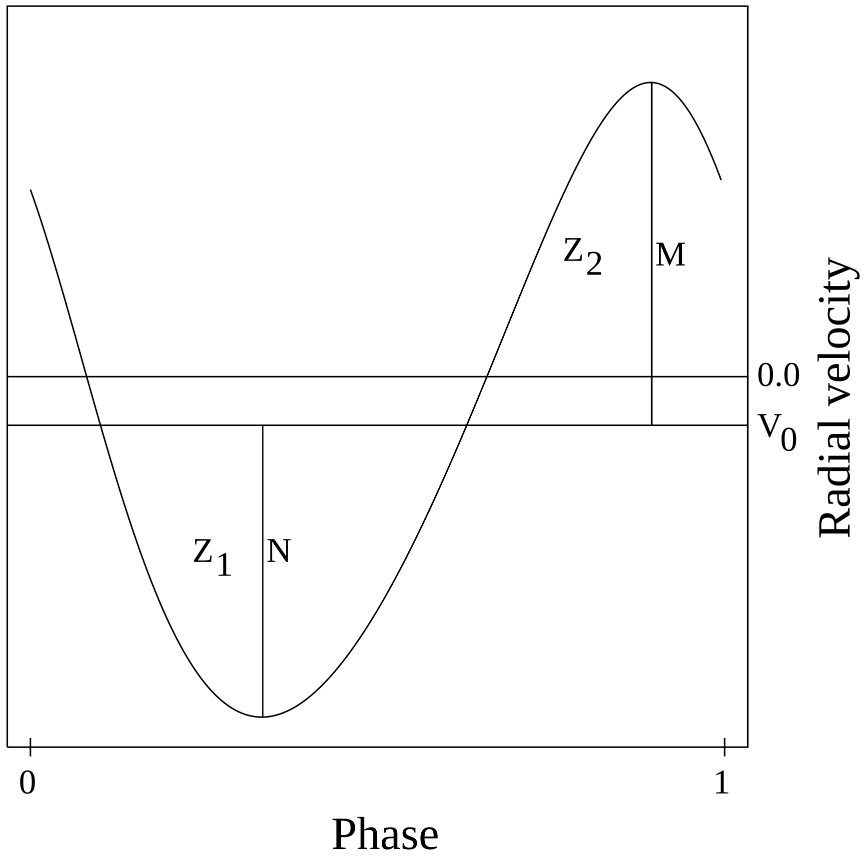
$$\nu_{Ny} = \frac{1}{2p}$$

where p is the largest value such that $\forall t_j$, $t_j = t_1 + n_j p$ with $n_j \in N$.

Step: $\frac{1}{\Delta T}$

Probability of false detection $F = 1 - [1 - e^{-z}]^{N_i}$ where $N_i \approx -6.4 + 1.2 N_o + 0.00098 N_o^2$

Initial solution: Lehmann-Filhés



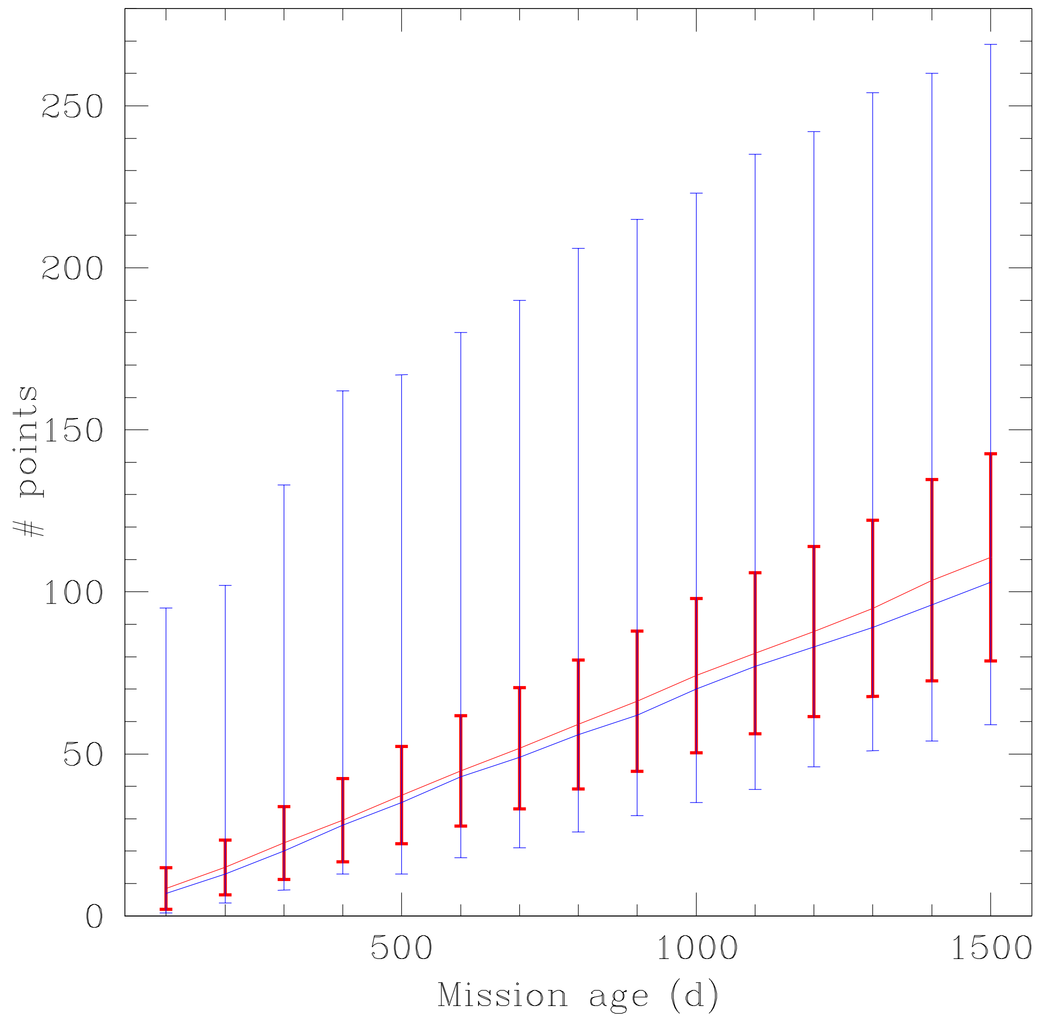
The curve is replaced by the polygonal contour of the data.
V_0 is such that the areas (trapezoidal rule) above and below $V = V_0$ are equal.

$$e\cos(\omega) = \frac{M-N}{M+N}$$

$$e\sin(\omega) = \frac{2\sqrt{MN}}{M+N}\frac{Z_2-Z_1}{Z_2+Z_1}$$

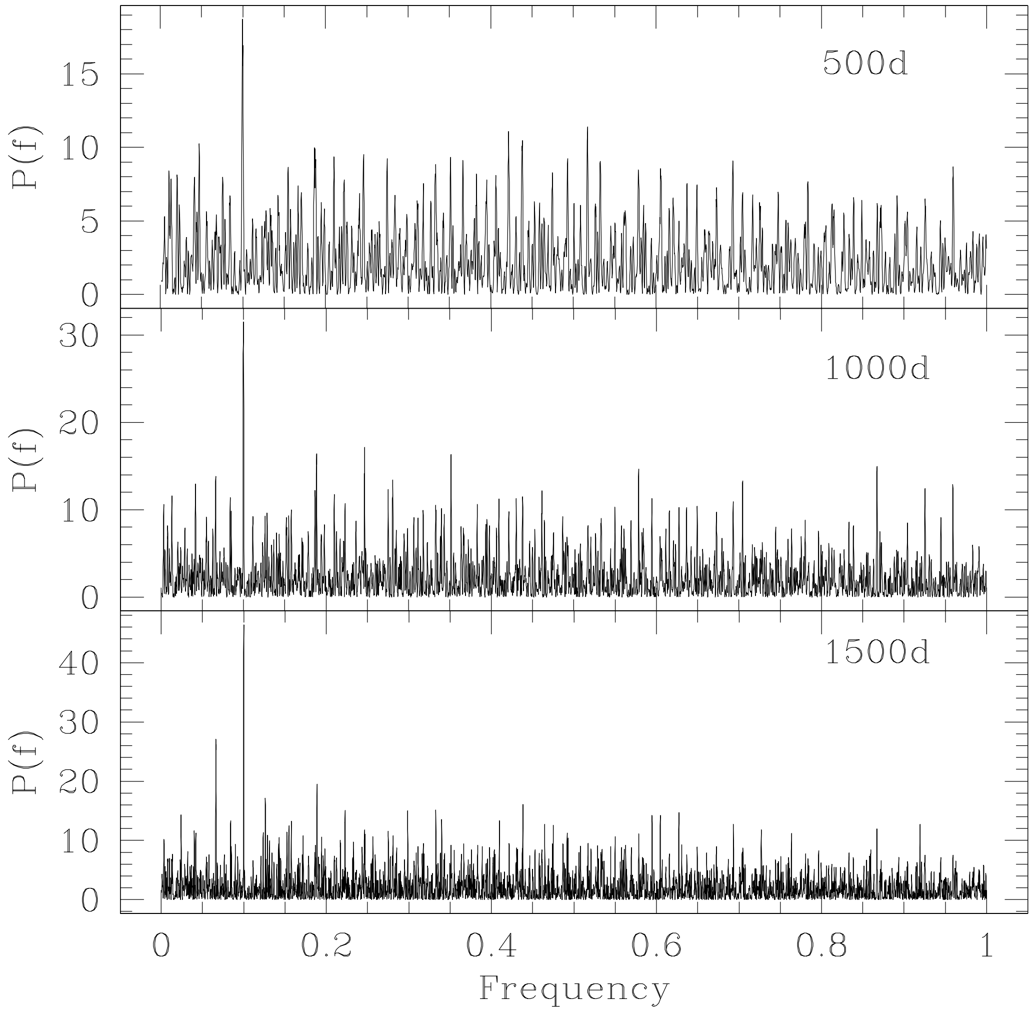
Sample size

From sample 2 (2160 systems)



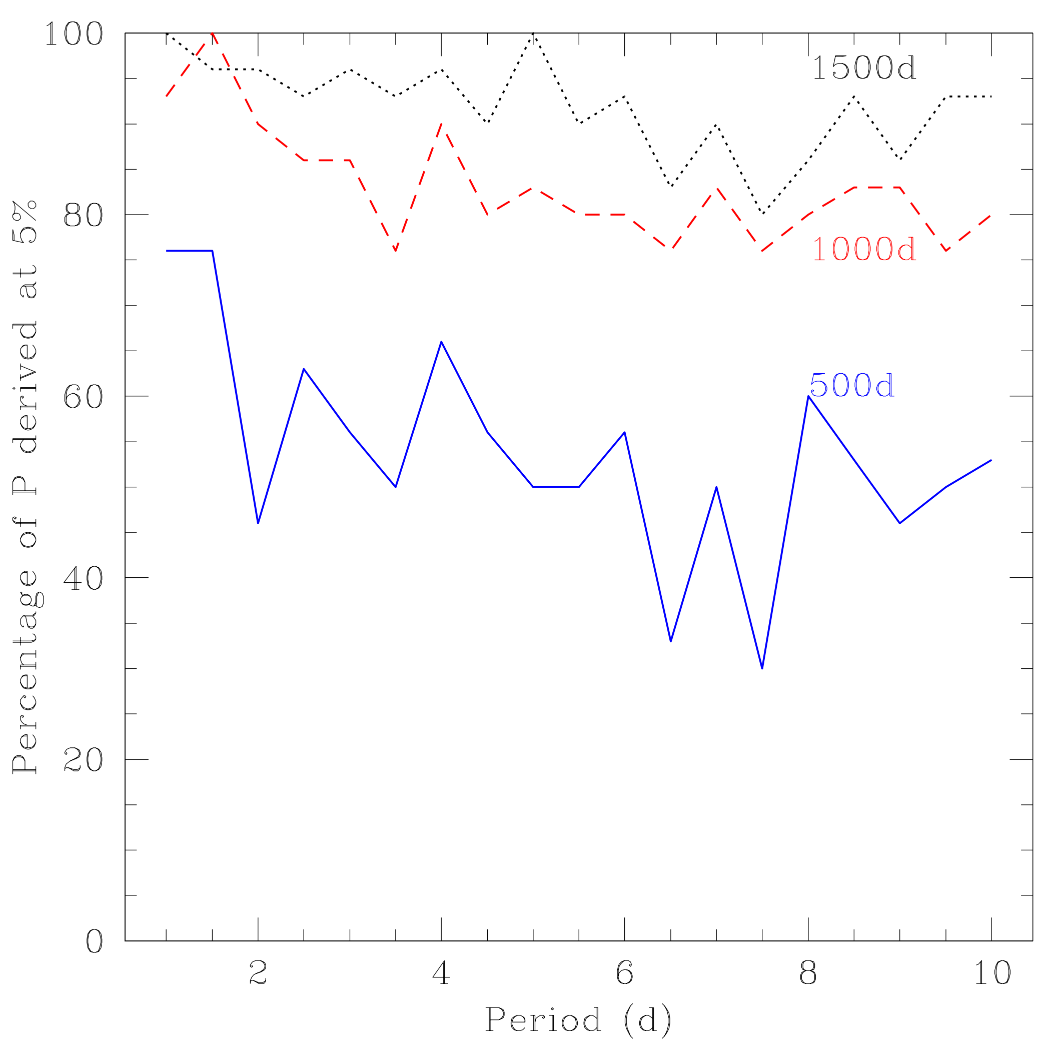
Power spectrum at 3 epochs

Sample 2



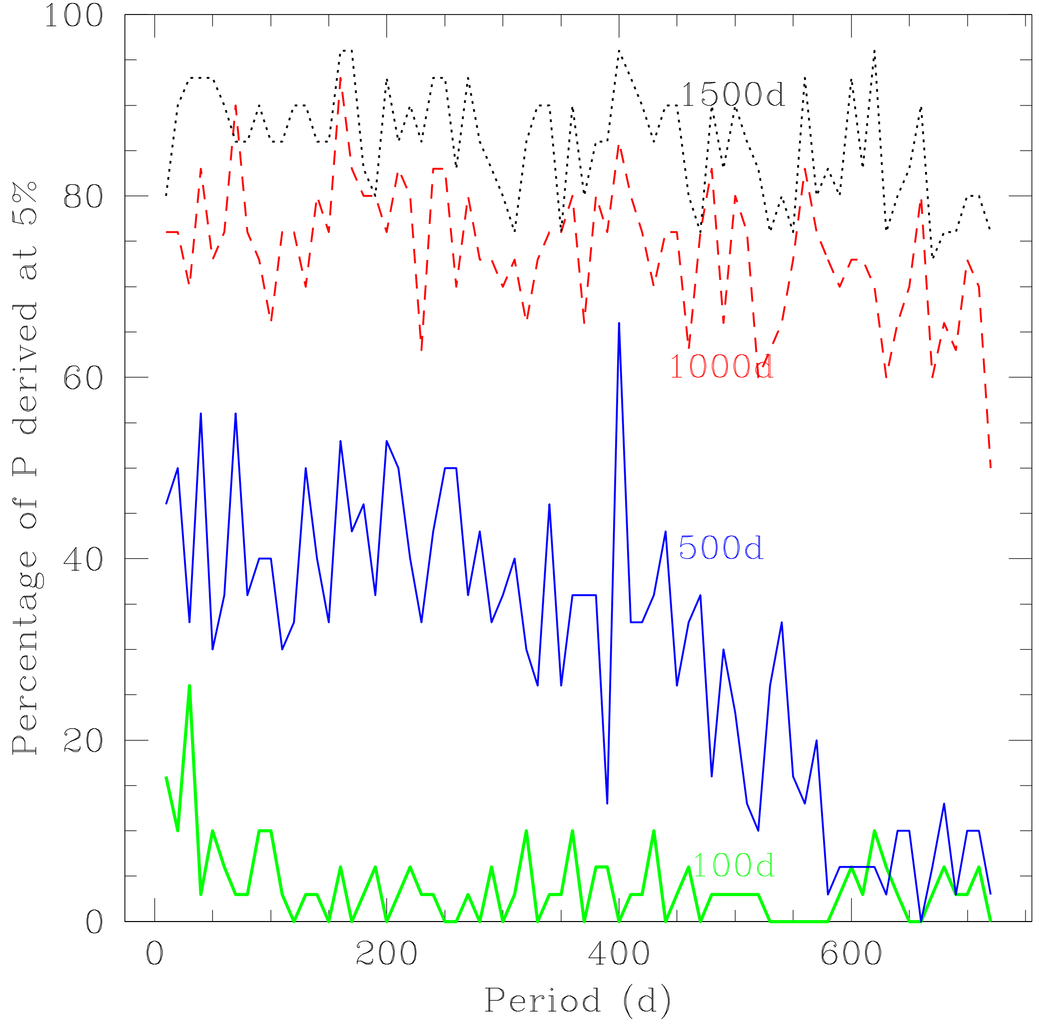
Derived period

Sample 1



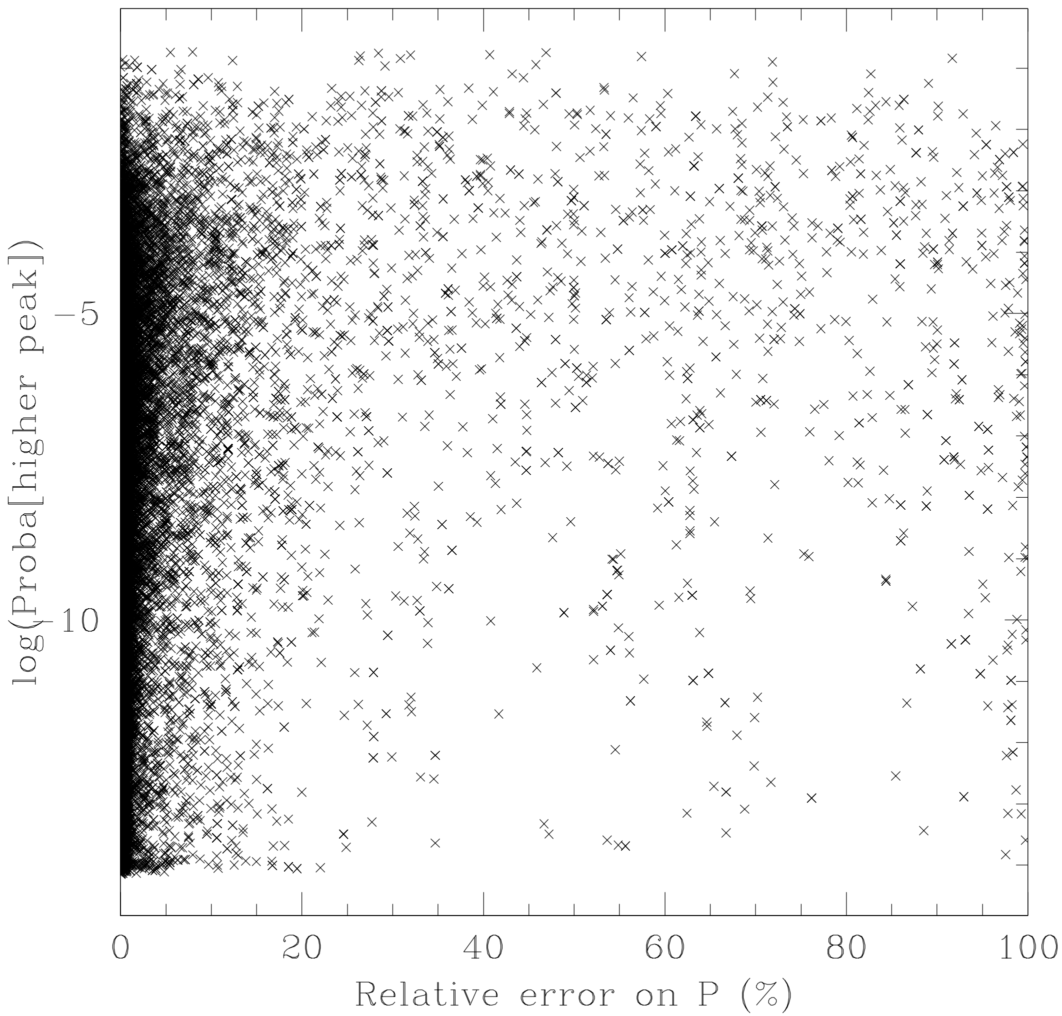
Derived period (cnt.)

Sample 2



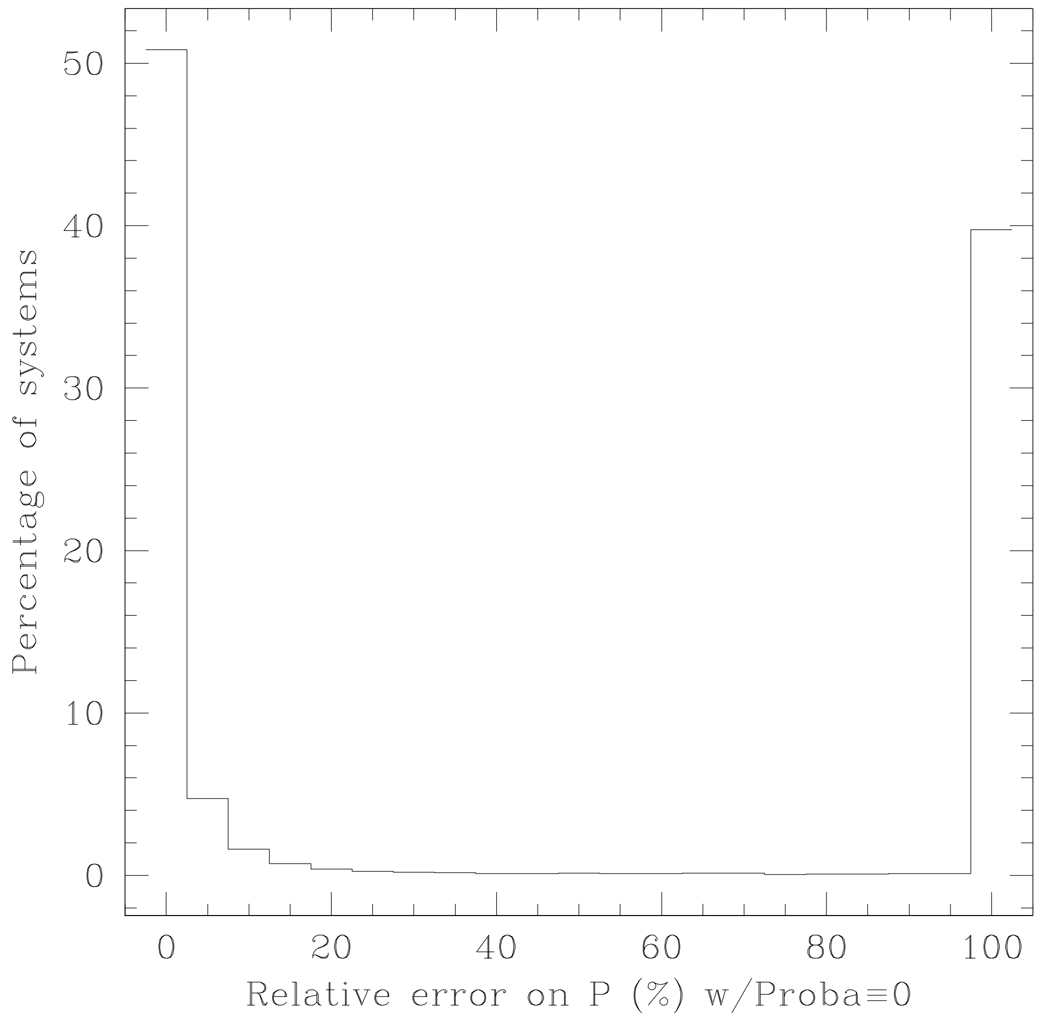
Period vs. F

Sample 2



Period when F=0

Sample 2



Conclusions

- Periodogram: quick and easy way to get *a* period. Faster implementation. Combination with other methods?
- Although $S/N = 10$, the relevance of highest peak looks questionable, F does not help!
- The scanning law often prevents the short periods (a few days) from being identified rapidly.
- The percentage of right orbits is even lower.

The coordinates should be left out of the simulation
$\Rightarrow$ percentage vs. location on the sky.