The detection of a line signal from dark matter annihilations over a background from conventional astronomical sources is one of the most important statistical problems faced by GLAST. The simplest approach is to divide the data into a signal region (where signal and background is supposed to be present) and a background region (where only background is supposed to be present), from which the contribution from the background to the signal region is subtracted. The estimated background is then a random variable which follows a Poisson distribution. 

In this simple approach, the likelihood model under the two hypothesis M1 and M0 for the measurement is given by:

\[ L(n_1, n_2, | S + B) = \frac{(S + B)^{n_1} e^{-S}}{n_1!} \frac{e^{n_2 - S}}{n_2!} \]

\[ L_0(n_1, n_2, | B) = \frac{e^{n_2}}{n_2!} \]

where \( n_{\text{bb}} \) is the observed number of counts in the signal region, \( n_1 \) is the estimated number of background counts in the signal region, \( S \) and \( B \) are the signal and background parameters in the Poisson process respectively. In this poster contribution we use this simple model as a benchmark to compare different methods for calculating upper limits and claim discovery.

### Bayesian approach

In Bayesian theory, a test statistic can be defined by taking the ratio of the posterior distribution over the likelihood function. Note that in this method it is possible to use the Likelihood function. The ratio measures the probability that a signal is present independent of the signal and background strength.

\[ \frac{L(n_1, n_2, | S + B)}{L_0(n_1, n_2, | B)} \]

Frequentist approach

To fit the model to the data we might wish to use the log-likelihood function, multiplied by a factor - 2 so that it behaves asymptotically like the chi-square. In this approach, the uncertainty in the nuisance parameter can be treated by maximizing the log likelihood over the nuisance parameter.

\[ n_{\text{bb}} = \sum (S + B) - B e^{-S} \]

and setting

\[ p(S) = L(B, \hat{S})(n_1, n_2, n_{\text{bb}}) \]

Feldman & Cousins

A popular technique to calculate confidence intervals in recent years is the technique suggested by Feldman & Cousins [2]. The method consists of constructing an acceptance region for each possible hypothesis (in the way as proposed by Neyman [3] and fixing the limits of the region by including experimental outcomes according to rank which is given by the likelihood ratio. Throughout this note we consider Poisson distributions with experimental outcome, hypothesis parameter 3 (and possibly not exactly) known background B. In this approach, the uncertainty in the hypothesis parameter is fixed, and the point which is given by the likelihood ratio is the hypothesis most compatible with \( n_{\text{bb}} \) and 1, the Likelihood function. Note that in this method it is assumed that the expected background (also called nuisance parameter) is perfectly known.

### Detection and Upper Limit

The question of presence of signal (detection) and calculation of confidence intervals are in general different topics in mathematical statistics (see e.g. [4]). The Bayesian method described above represents a hypothesis test, the frequentist methods represent confidence interval calculation methods. Also confidence intervals can be used for claiming detection in requiring that the null hypothesis (H0 in our case) is not contained in the calculated confidence interval.