Variables

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1 Defining the Signal Time Series

The Signal Time Series is the predicted time-dependent particle event rate of Heavy Neutral Leptons (HNLs), N, decay. This predicted signal should be at its minimum at Mid-day and its max at midnight due to the rotation of the Earth. This modulation, for our purposes, can be represented as a sinusoidal wave whose amplitude is dictated by the HNLs mass, M_N, and its dipole coupling strength, d_N.

2 Defining the Background Time Series

The Background Time Series is the total resulting time-independent event rate of the different nuclear reactions, beta decays, and others producing neutrinos. This background should be relatively constant throughout time.

3 Computing Expected Background Rate

To compute the Expected Background rate, it is the sum of the different background events per day per a 100T per a N_h. Representing the different backgrounds as $Bkg_0(N_h)$, $Bkg_1(N_h)$, $Bkg_2(N_h)$, ... $Bkg_n(N_h)$. For instance the predicted events per day for polonium 210 at 200 Hits can be $Bkg_0(200)$. By setting a max and min number of hits, H_{min} and H_{max} this background rate can be represented as

$$\lambda_{bkg} = \sum_{i=0}^{n} \int_{H_{min}}^{H_{max}} Bkg_i(N_h) dN_h \tag{1}$$

where n is the number of backgrounds. Then we can generate samples using a Poisson Distribution with the mean of λ_{bkg}.

4 Computing Expected Signal Rate in the Off and On Bin

We can set up a sine wave with the formula

$$sig(t) = A\sin\left(\frac{\pi}{12}(t+6)\right) + A \tag{2}$$

where A is the amplitude determined by d_N and M_N. In this formula, the time is measured in hours and it will give us the expected event rate. We can represent the expected signal event rate in the 12 hour off-bin as

$$\lambda_{off} = \int_0^{12} [A\sin\left(\frac{\pi}{12}(t+6)\right) + A]dt \tag{3}$$

and the expected number of events in the 12 hour on-bin as

$$\lambda_{on} = \int_{12}^{24} [A\sin\left(\frac{\pi}{12}(t+6)\right) + A]dt \tag{4}$$

5 Generating Observable

These computed values can allow us to generate observable. For the off-bin, the observable number of events can be calculated as

$$P_{off} = Pois(\lambda_{bkg}) + Pois(\lambda_{off}) \tag{5}$$

Similarly, the observable number of events in the on-bin can be calculated as

$$P_{on} = Pois(\lambda_{bkg}) + Pois(\lambda_{on}) \tag{6}$$