PHYS511L Lab 4: Radioactive Decay

Spring 2016

1 Introduction

In contrast to generating data via Monte Carlo simulation, in this lab we will investigate real physical phenomena: β^- decays from Strontium-90. If we were to measure the number of β^- decay reactions x occurring from our Sr-90 sample within a given time interval Δt, we know empirically that x follows a Poisson distribution as previously introduced:

$$P_{\text{Poisson}}(x; r\Delta t) = \frac{(r\Delta t)^x}{x!} e^{-r\Delta t} \tag{1}$$

where r is the detected-reaction rate and the mean number of events measured within the time interval is given by $r\Delta t = m$. As seen in the previous lab, the Poisson distribution is a limiting case of the binomial distribution when the mean is fixed and the sample size goes to infinity. Thus, if we think of the time interval Δt as a sequence of infinitesimally short moments in which a single β^- decay has infinitesimally small odds to occur, it seems reasonable to expect a Poisson distribution from β^- decay reactions.

2 Lab Tasks

- Retrieve previously collected Sr-90 decay data from `http://boson.physics.sc.edu/~gothe/511-S16/rootlab/Sr90-data.html`. The ROOT filenames are formatted as $\langle\Delta t\rangle$-$\langle T\rangle$.root where T is the measurement total run time (controls statistics). The data has already been converted into ROOT files from the raw data acquisition (DAQ) module formatting. Each file contains a TTree named "Sr90". Each branch of the TTree corresponds to a channel of a measured event. The DAQ module which took this data was configured to use channel 1 for the number of events measured; raw DAQ data files are also included on the webpage.
- For each data sample:
  1. Bin the Sr-90 data in a histogram.
  2. Fit the data with a Poisson distribution. You can use the Poisson TF1 object from last lab.
  3. Extract the detected event rate r.
- Plot r versus Δt and determine whether the rate seems constant.

- Determine whether or not you can calculate the activity a for this sample of Sr-90 from r. Are they the same? How is a related to r?
- Investigate for which Δt and T a Gaussian would work well for fitting the data and extracting the mean m and hence r. Use the χ^2 statistic to justify your claims.