Experiment 8

Poisson Statistics

8.1 Preface

This simple experiment will help you gain familiarity with the second most important statistical distribution in physics, the Poisson distribution. It describes the results of experiments where one counts events that occur at random, but at a definite average rate (example: radioactive decays). It is of paramount importance in all of atomic, and, in particular, subatomic physics.

8.2 Method

You will use the same setup as for the electron rest mass experiment. No source will be needed as you will simply measure the background count rate in our NaI detector. In addition, you will use our multichannel analyzer (MCA) in *multichannel scaling* mode (MCS) instead of pulse height analysis mode (PHA). In MCS function, the MCA no longer acts as a pulse height selector, but as a multichannel scaler with each channel acting as an independent scaler. At the start of operation, the MCA counts the incident pulse signals (regardless of amplitude) for a certain *dwell time*, and stores this number in the first channel. It then jumps to the next channel and counts for another dwell time period, after which it jumps to the next channel and so on. In MCS mode, therefore, the channels represent bins in time. Typical dwell times will be in the milliseconds range.

Suggested starting values:

HV of 1000V for the NaI, minimum gain (both fine and coarse) for the preamp/amp/discriminator (PAD) module, no radioactive source.

MCA setup: To put the MCA into MCS mode, we need to connect two pins on the MCA input connector. This is done with a “hydra” break-out cable. Find a break-out cable, and connect the cable labeled MCS/REJ to the one labeled SCA. With the **computer off**, attach the break-out connector to the MCA card.

Setup the software with 256 channels. (Note: this means the computer will effectively perform this simple counting experiment 256 times for you!), MCS mode of operation with 1 pass. Make sure sync is set to internal and presets on (or the number of passes doesn't work correctly). And now the important part: adjust the dwell time such that the average count rate per channel is around 1-2 counts. Save the resulting spectrum as an ASCII file to a floppy. Repeat this procedure for two other dwell times such that the average count rate per channel is around 5 counts and around 10 counts, respectively.

8.3 Analysis

Plot your three resulting distributions (with MATLAB). Notice the significant asymmetry of the distribution for the lowest average count rate (Poisson at work!). Calculate mean and standard deviation in each case. How closely do your results follow the expectation for Poisson distributions, i.e. that the standard deviation is equal to the square root of the mean? Also notice how your highest average count rate case is rather symmetric, i.e. already for an average count rate of around 10 the Poisson distribution is virtually indistinguishable from a Gaussian.

Compare your three count rate distributions with the expected Poisson distributions graphically (with statistical error bars), and calculate the chisquare per degree of freedom. For the highest average count rate case, repeat with a Gaussian distribution.

8.4 References

[1] Melissinos and Napolitano, Chapter 10.