Week 12: Reading Assignment, Homework Assignment

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All lecture notes, homework, demos, references, *etc*. are available on the P598AEM website. Please spend some time checking these out!

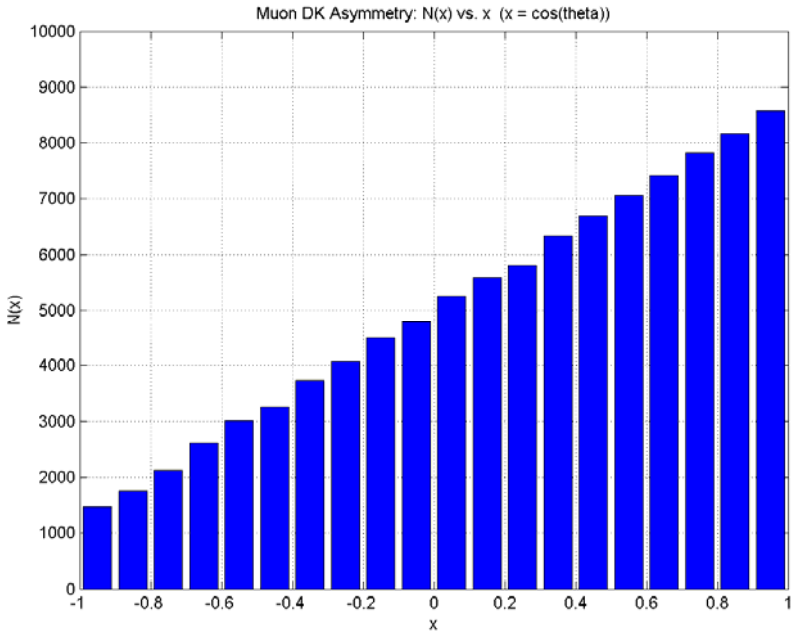
Course Organization:

A. Lectures: Tuesday & Thursday, 12:30-1:50 pm, in 136 Loomis.
B. Weekly Reading and Homework Assignments: HW due following Thursday, in class.
C. Take-Home Midterm Exam: Oct. 10th, due Oct. 17th (in lieu of P598AEM HW 7).
D. Take-Home Final Exam: Dec. 10th, due Dec. 17th.

Reading Assignment For Week 12: Please read/work through P598AEM Lect. Notes 21-23.
Homework Assignment For Week 12: See/do HW # 12 problems on following pages.

Physics 598AEM Week 12 Homework Assignment

Carry out a LSQ fit to a histogram of muon decay asymmetry events, $N(x_i;\alpha)$ *vs.* x (= $\cos\theta$) as shown in the figure below. The histogram has a total of 100,000 muon decay events associated with it.



The data contained in the $P = 20$ bins of the above histogram is summarized in the table below:

Bin Center $x_{ctr}(i)$	# Events/Bin $n_{expt}(x_i)$
0.95	1462
0.85	1757
0.75	2116
0.65	2606
0.55	3005
0.45	3251
0.35	3735
0.25	4078
0.15	4493
0.05	4778
0.05	5259
0.15	5585
0.25	5800
0.35	6342
0.45	6696
0.55	7060
0.65	7412
0.75	7821
0.85	8165
0.95	8579
Total:	100000

Recall that the theory P.D.F. associated with muon decay asymmetry is $f(x;\alpha) = \frac{1}{2}(1+\alpha x)$ where α is the asymmetry parameter, and that $\int_{-1}^{+1} f(x;\alpha)\,dx = \int_{-1}^{+1} \frac{1}{2}(1+\alpha x)\,dx = 1$.
The theoretical prediction for the number of events in the i^{th} bin of the above histogram is: $n_{thy}(x_i) = N_{tot}\int_{x_{lo}(i)}^{x_{hi}(i)} \frac{1}{2}(1+\alpha x)\,dx$ where N_{tot} is the total # of muon decay events (100,000), and $x_{lo}(i)$, $x_{hi}(i)$ are the low side bin edge and the high side bin edge of the i^{th} histogram bin, with bin centers $x_{ctr}(i)$ as given in the above table. Since the observed # of events in each bin is always $\gg 100$ events, the statistical fluctuations on the experimental data per bin are in the Gaussian (not Poisson) regime, hence the χ^2 test to be carried out here using the $P = 20$ bins of histogrammed muon decay asymmetry data is of the form:

$$\chi^2(\alpha) = \sum_{i=1}^{P} \frac{\left(n_{expt}(x_i) - n_{thy}(x_i)\right)^2}{\sigma^2_{n_{thy}(i)}} = \sum_{i=1}^{P} \frac{\left(n_{expt}(x_i) - N_{tot}\int_{x_{lo}(i)}^{x_{hi}(i)} \frac{1}{2}(1+\alpha x)\,dx\right)^2}{\sigma^2_{n_{thy}(i)}}$$

Where, due to Gaussian statistics, $\sigma_{n_{thy}(i)} = \sqrt{\sigma^2_{n_{thy}(i)}} = \sqrt{n_{thy}(x_i)}$. Hence, you will want to minimize $\chi^2(\alpha)$ via numerical computer methods in order to obtain your estimate α^* – *i.e.* step thru a range of α in tiny steps $d\alpha$. **Hint:** The above Monte Carlo muon decay asymmetry histogram data was generated with $\hat{\alpha} = 0.75$. Find/determine the $\pm 1\sigma$ uncertaint(ies) on your estimate of the muon decay asymmetry parameter α^*.