PHYS 391, Homework #4
Due Tuesday, November 19th, start of class.

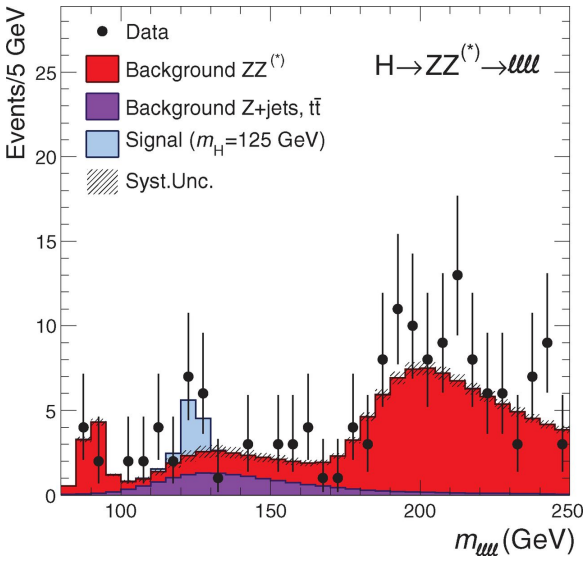
Key Concepts

- Binomial Distribution
- Poisson Distribution

Reading: Taylor Chapters 10-11

Homework Problems (taken from Taylor):

1. You want to measure the area of a rectangle. You are using a ruler that allows you to measure lengths to a precision of 0.05 cm. You measure lengths $a = 8.00 \pm 0.05$ cm and $b = 3.00 \pm 0.05$ cm, where the errors represent an estimate of the random errors associated to reading the scale. In addition, the length scale of the ruler has an overall accuracy quoted to be 1% (relative). We will solve this problem using covariance.
   (a) Write down the total covariance matrix for measurements a and b. In other words, find σ_a^2, σ_b^2 and σ_{ab} including both sources of uncertainty. You should assume the error on the length scale is fully correlated between a and b.
   (b) Using your variance and covariance from (a) calculate the area of the rectangle (ab) and the total uncertainty taking the correlations into account.
2. Problem 10.9
3. Problem 10.16 - Calculate this by hand or using python, which ever you prefer.
4. Problem 10.22 - I interpret this problem asking whether the observed performance is significantly better than the national average. As usual, you should set this up as a null hypothesis test.
5. Problem 11.3
6. Problem 11.8
7. Problem 11.10
8. Problem 11.20 - Answer the question "significant evidence" quantitatively both in terms of a number of standard deviations, as well as the probability that this was simply a statistical fluctuation in the background rate (P-value). This is another example of a null hypothesis test.
9. The mass plot below was included in the Higgs discovery paper by the ATLAS collaboration in 2012. The black points are observed numbers of real events, and the red histogram is the expectation from non-Higgs backgrounds. By comparing the black points in the two bins nearest to 125 GeV with the red histogram, is there significant evidence for the Higgs boson at this mass? Explain your reasoning. You can assume the background prediction has a relative uncertainty of 10% (this is the systematic uncertainty indicated by the grey hatching). As with the previous problem, answer this both in terms of some number of standard deviations and a probability. From: `https://science.sciencemag.org/content/338/6114/1576`


Data
Background ZZ(*)
Background Z+jets, tt̄
Signal (m_H=125 GeV)
Syst.Unc.
H→ZZ(*)→llll
Events/5 GeV
0
5
10
15
20
25
100
150
200
250
m_llll (GeV)