PHZ4151C: Exercise 10
Computational Physics Lab
Due Friday April 19

For each problem you will write one or more python programs. These programs should follow the Python 2.7.x coding and formatting conventions outlined for our course.   <u>You must hand in copies of the programs and outputs as prescribed in each problem.</u>

In addition, you must submit all Python programs as an archive tgz file via email to phz4151c@hadron.physics.fsu.edu.   Place copies of **only your Python program(s) and the pdf exercise document** in a directory called <last_name>-exercise9/where <last_name> is your last name. Below are the commands for creating, checking, and submitting archive files.

Creating archive file:
    tar   -zcvf   last_name-exercise9.tgz   last_name-exercise9/
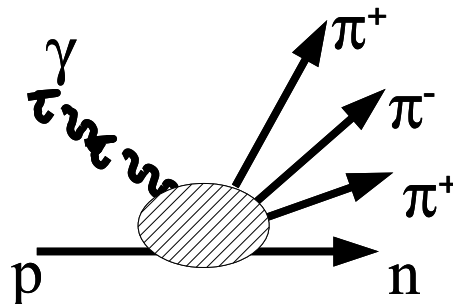
Checking archive contents:
    tar -ztvf   last_name-exercise9.tgz

Submitting via email:
    mail -s "exercise 9"   -c <your-email> -a last_name-exercise9.tgz phz4151c@hadron.physics.fsu.edu

Analysis of Large Data Sets

Studies of hadronic spectra via strong decays of hadrons provide insight regarding the Strong Force (*i.e.* QCD) at the confinement scale. These studies have led to phenomenological models for QCD such as the constituent quark model. Data from studies of γp -> n $\pi^+\pi^+\pi^-$ are located at ~eugenio/data/n3pi.dat. This file contains over 1 million events of the reaction depicted above. The information for each reaction is given in a simple ascii format. An example of one such event is given below:

        4

        1 0 0.000000e+00 0.000000e+00 5.000000e+00 5.000000e+00

        8 1 -7.692400e-02 1.210350e-01 3.835767e+00 3.841000e+00

        9 -1 -1.182520e-01 -1.387120e-01 3.485660e-01 4.175200e-01

8 1 2.804500e-02 -3.515470e-01 4.627850e-01 5.984500e-01

The first line of the event corresponds to the number of observed event particles which follow. After that, the next line corresponds to the first particle which is the photon beam. Following the beam are three charged pion mesons(two positively and 1 negatively charged). The format of each particle line is: {particle id} {charge} {p.x} {p.y} {p.z} {E}. The charge is given in units of the electron charge (+1,-1, or 0), and the momentum and energy are given in GeV/c and GeV, respectively. Particle id=1 represents the photon beam whereas id=8 is a π+ and id=9 is a π-. The two baryons(*i.e.* the target proton and the recoil neutron) particles of the event are not given. The proton target interacts at rest with a rest mass m_p=0.938 GeV/c^2. Conservation of four-momentum (energy and momentum) can be readily employed to provide the neutron four-momentum information.

1. Choose an event from the data file and calculate by hand (or calculator) the magnitude of the four-vector for each particle listed in the event. Given your event and the fact the target proton four-momentum (p.x, p.y,p.z, E) is (0,0,0,0.938), calculate the magnitude of the missing particle four-momentum. Recall that the missing_4vec = beam_4vec + target_4vec -(piplus1_4vec + piplus2_4vec + piminus_4vec). Note, this does not require the use of a computer.

2. Get a copy of the program dumpData.py which reads the *n3pi.dat* data file one event at a time (wget http://hadron.physics.fsu.edu/~eugenio/comphy/examples/dumpData.py). Use this program to create a new program which uses the ROOT TLorentzVector objects to represent the four-momentum vectors of the particles in an interaction event. For each event, calculate the four-momentum of the missing neutron. For the first 5 events print the invariant mass of missing neutron and check that the mass is consistent with the rest mass of a neutron (937 - 941 MeV/c^2). After the first 5 events, your program should continue and count the number of events in the data file print out the total.

3. Use your program to make a new program that uses either the ROOT TH1F histograms or a ROOT TNtuple data container. In either case use the ROOT TFile object to save your ROOT Objects to a ROOT file with the filename extension ".root". For each particle in the event, calculate the invariant four-momenta mass for the following 8 four-momenta combinations: $n \pi_1^+\pi_2^+\pi^-$, $\pi_1^+\pi_2^+\pi^-$, $\pi_1^+\pi^-$, $\pi_2^+\pi^-$, $\pi_1^+\pi_2^+$, $n\pi_1^+$, $n\pi_2^+$, $n\pi^-$. Fill histograms or a TNtuple with the 8 invariant mass values over all events in the data file. After processing all events, draw histograms or TNtuple projections of each invariant mass quantity using 8 plots on one ROOT TCanvas in a 2x4 division. Save the histograms or NTuple to a ROOT TFile. Using the results, describe and explain the features in the invariant mass spectra.

For full credit turn in a printout of your finished programs and a print out of the discussion from part 3..