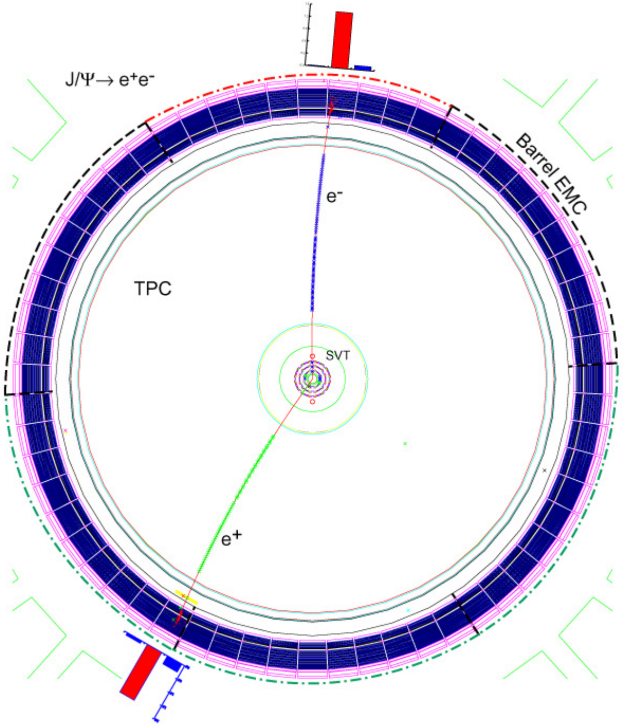
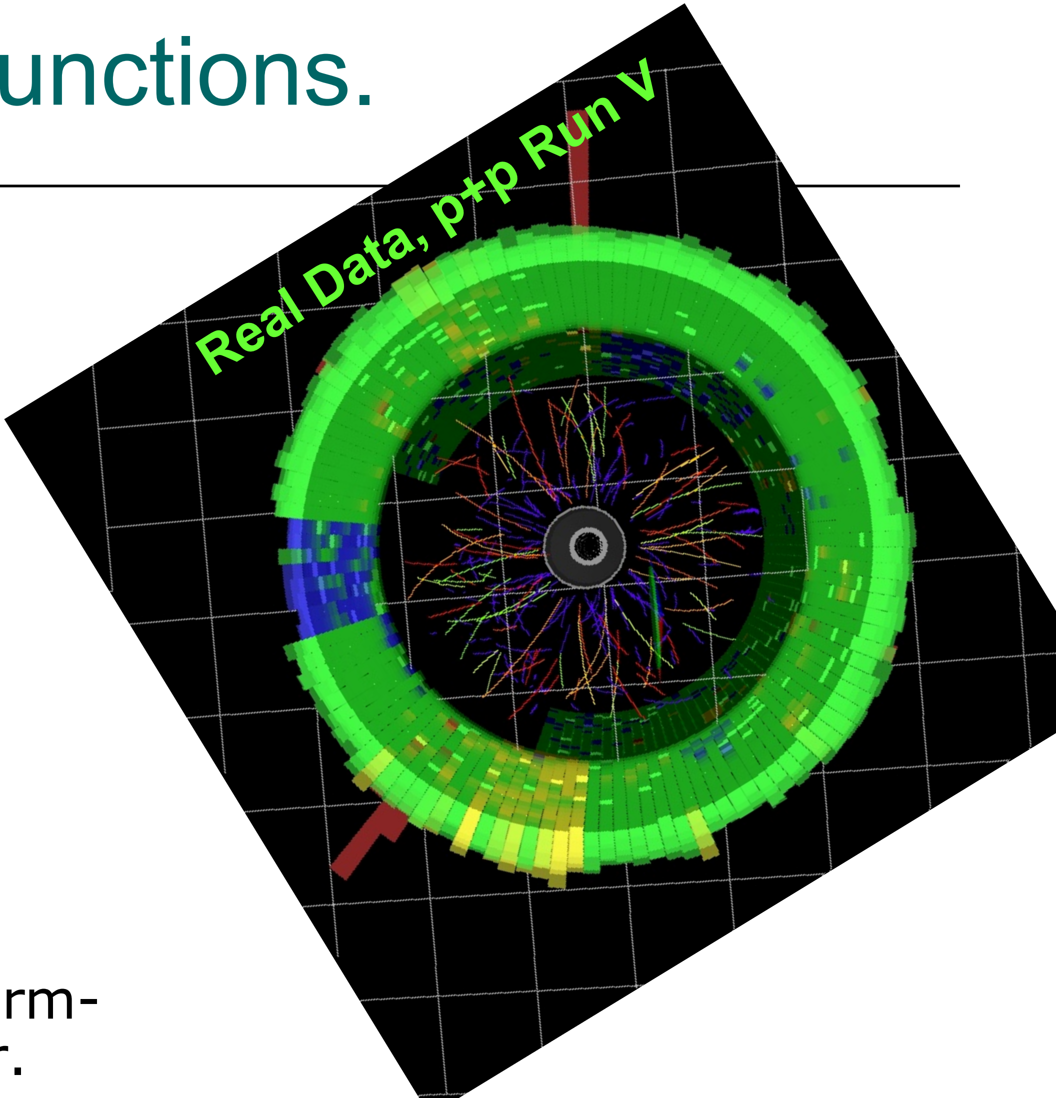
Computational Lab in Physics: Monte Carlo Evaluation of Distribution Functions.




Real Data, p+p Run V

Monte Carlo simulation of a decay of a J/ψ meson (charm-anticharm) into an e+e- pair.

Probability Distribution Functions: Stochastic Processes in Physics

- Stochastic variables:
  - Variables that fluctuate from one realization of a system to another.
    - Thermal effects.
    - Manufacturing uncertainties.
    - Quantum processes.
- Simple example: The 1-D Random Walk.

Random Walk and Stochastic Processes

  - RW: The particle will take N steps. At each step, there is a 50/50 chance for the particle to move right or left.
- Physical System is characterized by parameters that vary randomly.
  - RW: two discrete values: ±1 distance units
    - + is right, - is left
- Want to calculate a global parameter that can be evaluated or measured.
  - RW: Total initial displacement from the origin after N steps.
- General problem: Predict the probability that the global variables possess a specific value when averaged over all trial experiments.
  - RW: Probability that the walk terminates at a given displacement from the origin.

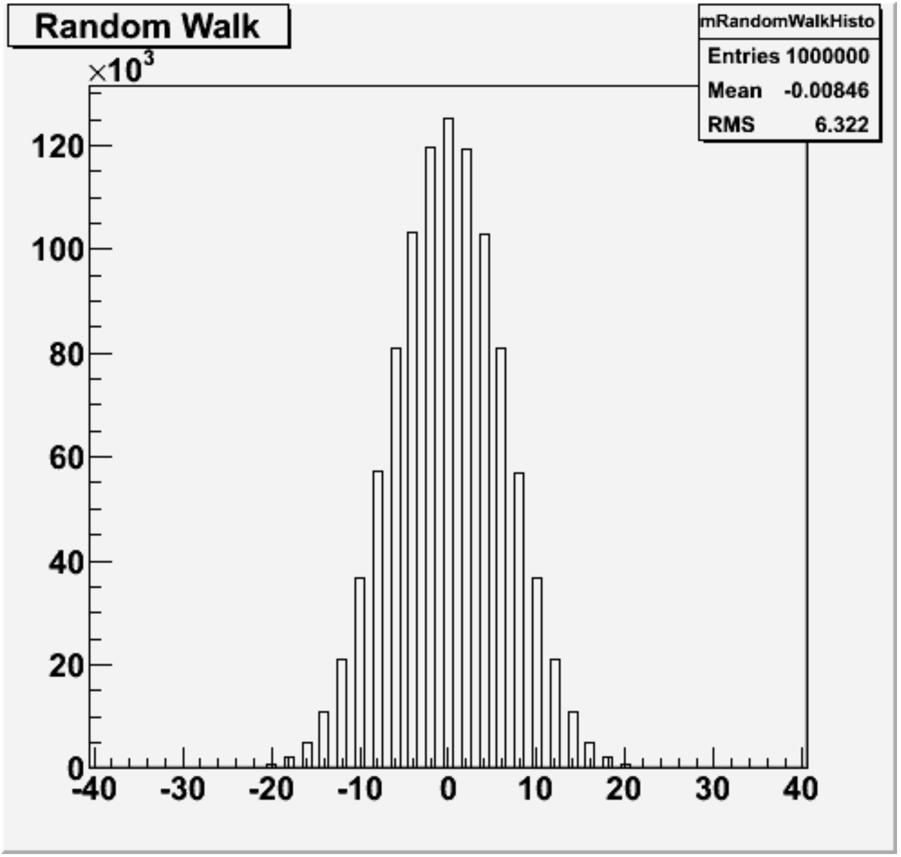
Making a random walk program in root:

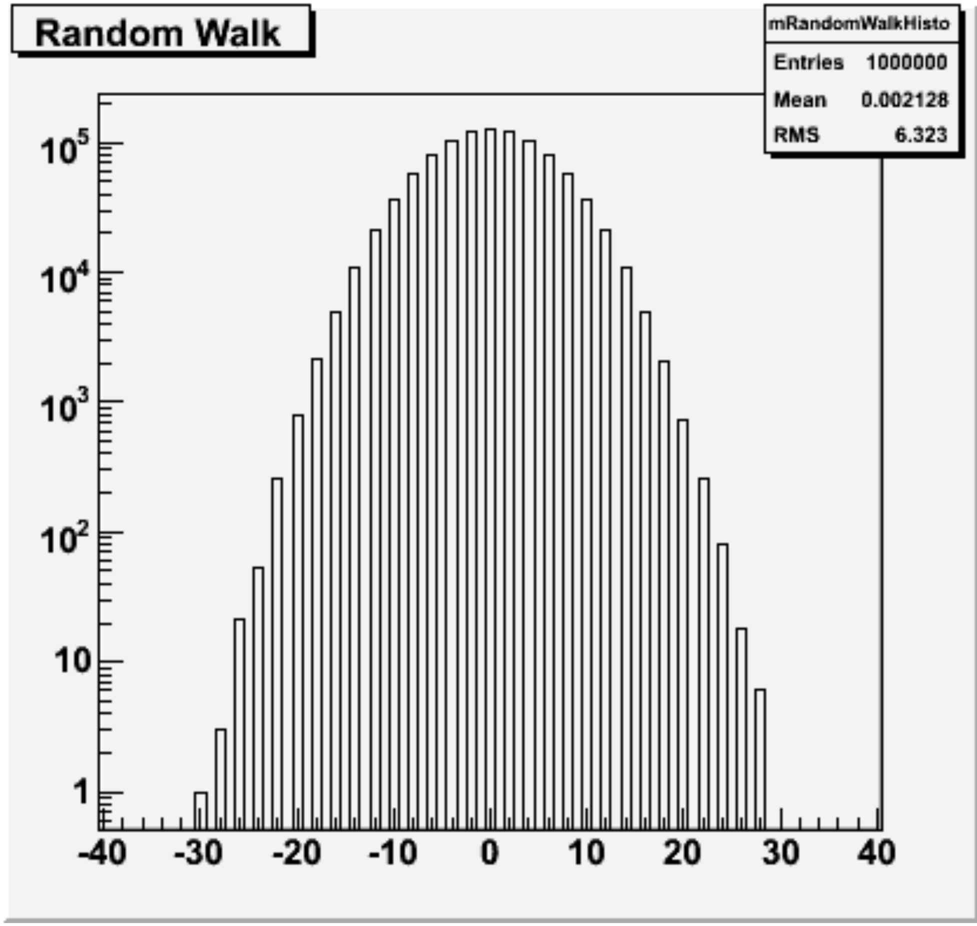
```
 int numberOfSteps = 40;
  int numberOfRealizations = 1e4;


TH1D* mRandomWalkHisto = new TH1D
    ("mRandomWalkHisto","Random
    Walk",2*numberOfSteps+1,-numberOfSteps-
    0.5,numberOfSteps+0.5)
```

Code for loop

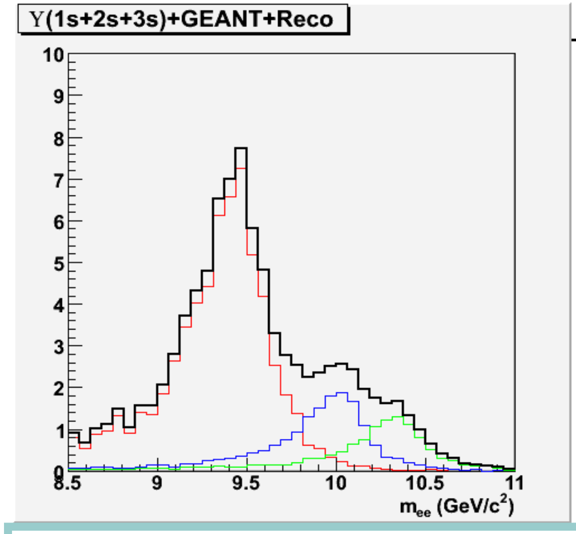
```
TRandom3 rnd3(0); // initialize random number generator with unique seed
 for (int iRealization = 0;
    iRealization<numberOfRealizations;
    ++iRealization) {
  int position = 0;
  for (int iStep = 0; iStep<numberOfSteps; ++iStep) {
   double a = rnd3.Rndm(); //random number between 0-1
   double step = 1;
   if (a<0.5) step=-1;
   // at this point, 50% of the time step will be 1
   // and 50% of the time step will be -1
   position += step;
  } // loop over steps
  //cout << "Realization " << iRealization << ", position " << position <<
   endl;
  mRandomWalkHisto.Fill(position);
 }// loop over realizations
```

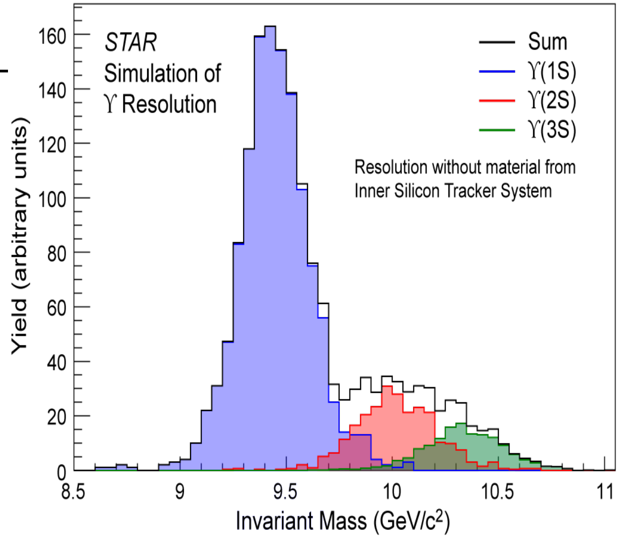
Result: Random Walk Histogram

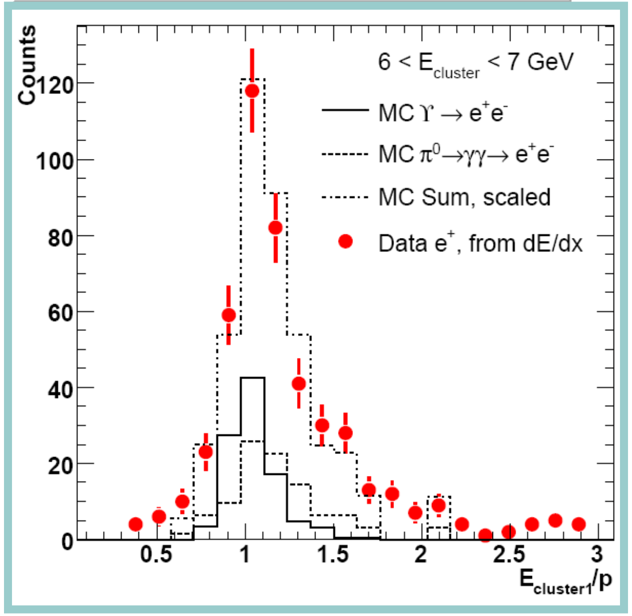


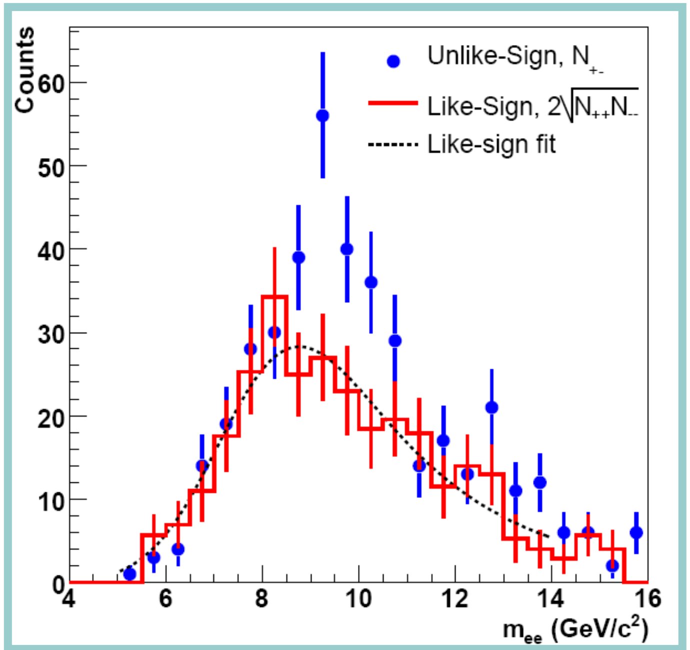


Examples of Histograms of Random Distributions









Homework 8, Random-Walk

- Code the Random Walk program in ROOT.

- Modify it to use a 2-D Histogram to do a 2-D random walk with unit length steps in which the angle that the walker describes with respect to any fixed axis is a uniformly distributed random variable on [0, 2π]. Use 40 steps, and also use unit width.