Exercise 12: A simple analysis

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Please send your solutions to nberger@physi.uni-heidelberg.de until 28. 1. 2013, 12:00. Put your answers in an email (subject line *SMIPP:Exercise12*).

The goal of this exercise is to perform a measurement of some properties of the π^0 meson. The π^0 almost exclusively decays to two photons, which are emitted back to back in the π^0 rest frame. Being a pseudoscalar meson, the π^0 does not have a polarisation and the decay is isotropic. We assume that also the π^0 production process is isotropic and the π^0 momentum spectrum is an exponential.

We assume that we have a nice calorimetric detector that measures the energy and position of the photons. From the knowledge of the interaction point, we can then reconstruct the 4-vectors of the photons. The detector has two holes for the beam pipe along the z-axis and covers a region from 0.2 to $\pi - 0.2$ radian in the polar angle θ. The energy resolution is 10%, with a Gaussian distribution. The absolute energy scale of the detector is known to 1% accuracy. Assume that angles are measured with arbitray precision. In the data selection, only events with both measured energies above 100 MeV and two photons in the detector acceptance are retained.

There are two root trees available on the course website, both with the components of the measured four-vectors (in GeV) of the two photons. One file (`no_pi0.root`) contains data from a channel where no π^0 are present, which can help you to determine the background shape. The second file (`pi0.root`) contains the data (with π^0 signal and background).

1. **Measure the π^0 mass** From the given data, determine the π^0 mass, give a statistical error.
   (Attach code and result)

2. **Systematic uncertainty** Estimate the systematic uncertainty of the mass measurement from the uncertainty of the energy scale.
   (Attach code and result)

3. **Measure the π^0 spectrum** Write a Monte Carlo to determine the acceptance and efficiency of your detector as a function of π^0 momentum, use this to correct the measured momentum spectrum. Present the measured number of π^0 as a function of the π^0 momentum with a suitable binning. Measure the slope parameter.
   (Attach code and result)

4. **Systematic uncertainty** Determine the systematic uncertainty on the counts per bin and the slope parameter. (Attach code and result)