PHY310: Lecture 22

Characterizing a Signal

Road Map

- Figures associated with the lecture
  - The $\pi^0$ mass peak
  - Reconstructed Momentum
  - Definition of Efficiency
Recap: Event Selection

- **Preselection:**
  - The event must have two fitted tracks.

- **Selection:**
  - The event must not have an associated muon decay signal
    - $\text{decay time } \leq 0$ (the time is negative when no signal is found)
  - The event must not have a muon like ring
    - Electron likelihood for first track $> 0$
    - Electron likelihood for second track $> 0$
  - The two tracks in the event must have similar momentum
    - Fraction of visible energy in low energy track $> 10\%$
  - The invariant mass of the two tracks must be between $110 \text{ MeV/c}^2$ and $170 \text{ MeV/c}^2$
Invariant Mass of Data Events

Offset in mean implies there is an energy calibration systematic!

Need to verify the widths are “the same”

(more when we talk about systematic error.)
Closer Look at Peak Shape

Fix the normalization to data exposure
Use TH1:Sumw2() for correct uncertainty on points

Fit to the sum of two Gaussians
Overall fit probability is “OK”
Tries to get tails right.

This tells us the distribution is not really a Gaussian...
Closer Look at the Expected Signal

Fix the normalization to data exposure

Fit to the sum of a Gaussian and a Line
Overall fit probability is awful
Ignore low probability and just look at “centroid” position.

This tells us the distribution is not really a Gaussian, but proceed anyway.
Closer Look at the Expected Signal

Notice that with lower statistics, the fit is GOOD. Not enough events to support an extra 3 parameters.

Compare fit values:
- Mean: $141.4 \pm 0.2$ (MC) vs $143.5 \pm 0.9$
  2.3 sigma difference
- Sigma: $17.7 \pm 0.2$ (MC) vs $15.6 \pm 0.7$
  2.9 sigma difference
- Bck: $7.1 \pm 0.3$ vs $3.8 \pm 1$
  3.2 sigma difference

There are real differences between the MC and the data. Will need to consider systematic error.
Momentum of Selected $\pi^0$ events

Pearson's $\chi^2$ is $53/39$ dof the P-Value is $6.7\%$
Momentum of Selected $\pi^0$ events

Momentum for All $\pi^0$ from $\nu N \rightarrow \nu N \pi^0$

Entries: 5885
Mean: 303.7
RMS: 181.5
Underflow: 0
Overflow: 48

Translate into an efficiency by dividing selected histogram by the histogram with all events.

Momentum (MeV/c)
Momentum of Selected $\pi^0$ events

Efficiency to Select $\pi^0$ Events

Translate into an efficiency by dividing selected histogram by the histogram with all events.

Be careful and calculate the binomial uncertainty by hand.

Notice that we have relatively good efficiency above 100 MeV/c
About 75% at 200 MeV/c
About 60% at 600 MeV/c
Found Momentum vs True Momentum for $\pi^0$ Events

Reconstructed vs True Momentum

Entries: 4056
Mean: 300.8
Mean y: 290
RMS: 165.7
RMS y: 164.6
Underflow: 0
Overflow: 900.7

Good correspondence between reconstructed and true $\pi^0$ momentum
Found Momentum vs True Momentum for $\pi^0$ Events

Between 200 MeV/c and 600 MeV/c
Momentum resolution is $\sim$5%
At 400 MeV/c that is 20 MeV/c

Will be combined with Fermi
Momentum “resolution”
of $\sim$75 MeV/c
The End