The π^0 Background

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- ## The π^0 Background

  - BooNE's sample of electron candidates will arise from
    - Charged current reactions
      - $\nu_e +^{12}C \rightarrow e^- + X$

        ν_e come from μ decay, K decay and possibly neutrino oscillations
      - $\nu_\mu +^{12}C \rightarrow \mu^- + X$

        μ^- misidentified as electron
    - Neutral current π^0 production

$$\nu_\mu +^{12}C \rightarrow \nu_\mu + \pi^0 + X$$

π^0 misidentified as electron

cd

- Charge current vs. neutral current
  - For the same visible energy the incident E_ν will be much higher for neutral current π^0 events than for the charged current events ($\nu_e +^{12}C \rightarrow e^- + X$ and $\nu_\mu +^{12}C \rightarrow \mu^- + X$)
  - The charged current converts a neutron to a proton

$$\nu_e + n \rightarrow e^- + p$$

or

$$\nu_e +^{12}C \rightarrow e^- + p +^{11}C^*$$

get proton and excited nucleus with $Z > N$

- For neutral current
  - $\nu_\mu + {}^{12}C_{g.s.} \rightarrow \nu_\mu + {}^{12}C_{g.s.} + \pi^0$ $\sim 15\%$
    coherent π^0 production, $\theta \approx 0^\circ$
  - $\nu_\mu + p \rightarrow \nu_\mu + p + \pi^0$ $\sim 15\%$
    off free protons, get energetic proton
  - $\nu_\mu + {}^{12}C \rightarrow \nu_\mu + \pi^0 + p + {}^{11}B^*$ $\sim 35\%$
    off bound protons, get energetic proton and excited nucleus with $N > Z$
  - $\nu_\mu + {}^{12}C \rightarrow \nu_\mu + \pi^0 + n + {}^{11}C^*$ $\sim 35\%$
    off bound neutrons, get energetic neutron
- Bill Louis has considered extra scintillation light from protons for distinguishing π^0 events
- Neutron detection would also be useful for distinguishing π^0 events. Energetic neutrons can create secondary neutrons and multiple correlated γ's (similar to the behavior of cosmic ray neutrons in LSND).

- **Procedure**

  - Approximately one ν event every 10 s
  - Look for γ's in 1ms interval after each neutrino event
  - Assign weights to γ's based on relative likelihood they are correlated or accidental (like R in LSND)
  - Measure distribution of γ weights for a sample of ν_μ charged current events (as a function of visible energy and muon direction)
  - Measure distribution of γ weights for a sample of identified π^0 events (as a function of visible energy and π^0 direction)
  - Measure distribution of γ weights for the sample of electron candidates
    - Should look like ν_μ sample if due to charged current interaction
    - Should look like π^0 sample if due to misidentified π^0 events

- **Comments**

  - Do not need as good a measurement of γ's as in LSND since only looking for statistical differences between samples
  - Multiple correlated γ's provide useful information
  - Measurements of γ's will not be as good as in LSND due to absence of scintillator light. However, bigger detector size will help and Čerenkov timing is better than scintillation timing

- **Conclusion**

  - Chance that γ information will be good enough to measure the neutral current π^0 contribution to our final sample of electron candidates
  - Need real data to know how well we can do
  - Only work required is to install γ trigger