P0D $\nu_e$ analysis systematics

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Introduction

- Energy scale
- Selection efficiency/background rejection
- Background cross-sections
Energy scale

- **Simulation:**
  - Vary amount of high Z material in P0D MC (TODO)

- **Calibration:**
  - Per channel variation not modelled
Simulating channel-to-channel variations

- Multiply each channel’s response by $X \sim N(0, \sigma)$
- Find $\sigma$ to make MC width match data in stopping and $\mu$
- Apply same smearing to simulated $\nu$ interactions
- (Not done quite right: smear charges of hits after readout, instead of deposited energy in bar)
Effect on reco $e$ energy

- Truly fiducial CC $\nu_e$ events with one EM-like (median width $> 1$), reco fiducial
- Fit width is 2.3% (mean $-0.18\%$)
- TODO: Effect on selection efficiency (prob. negligible)
Selection efficiency/background rejection

- MC with varied high $Z$ material can address selection eff.
- Background rejection systematic from sand muons:
  - Compare fraction of stopping sand $\mu$ selected in data and (particle gun) MC
    1. Select sand $\mu$ which stop in P0D
    2. Require $N_{\text{track}} = 1$ and $N_{\text{shower}} = 0$ to veto non-$\mu$ activity
    3. Count fraction passing Median width $\geq 1$ cut in data and (my own particle gun) MC
Median width

- Excess in data at nonzero median width values
- Translates to selected fractions:
  - data=1.4%, mc=1.2%, data/mc=1.18
- For want of something better:
  - correct $\mu$ BG in analysis by 1.18
  - take 100% of correction as systematic (i.e., $1.18 \pm 0.18$)
- Not ideal, but $\mu$ BG small in analysis
Digression: Understanding hit widths

- Distribution of widths of all nodes agrees well, except:
  - Data excess around 5
  - Data population between 0 and 1, not present in MC

- Hypothesis:
  1. Higher noise rate in data
  2. Low pe noise hit adjacent to track included in track
  3. Produces small but nonzero width

Production 4, Runs 1 and 2. Particle gun MC
Digression: Noise

- Look at hits in empty spills
- Noise rate off in data
- Charge threshold not sharp in data
Digression: Increase noise

- Generated stopping sand $\mu$ MC with noise rate $\times 9$
- Change in hit widths is in right place for data excess
- Also investigated charge cut, triplet nodes (backup slides)
Background cross section

Error on NC $1\pi^0 / \text{CCQE Ratio}$

- Use NIWG number for NC$\pi^0$
Conclusions

- Progress on systematics for $\nu_e$ analysis
- Understand main $e/\mu$ discrimination variable
- Ideas welcome, especially for selection efficiency systematic
Backup slides
Triplet nodes and noise

From stopping muons

- Right: **Nominal** Noise $\times$ 9
- Effect of increased noise goes in right direction
Hit widths after charge cut

Cut at 6pe

Cut at 10pe

Agreement much improved after cut
Node $n$ hits after charge cut

- Charge cuts massively reduce doublet efficiency
- Don’t improve data/MC so much