

Preliminary $\text{NC}\pi^0$ selection

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Introduction

- Have started looking at a $\text{NC}\pi^0$ selection.
- Clear motivations for this sample in SBND.
 - Background for $\text{CC}\nu_e$ and other LEE samples.
 - Events with 0 protons will face the same reconstruction problems as other isolated shower events (lack of vertex information). Worth identifying areas of possible improvement.
 - π^0 mass peak is a good test of energy reconstruction.

Selections

Sample

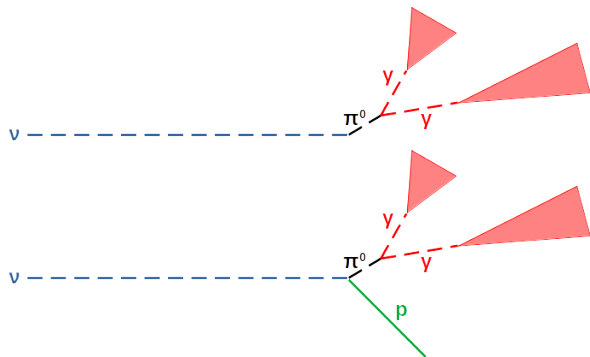
Sample of 458 BNB ν + Cosmic Overlay files (45,800 events) with the plots scaled to $1e20$ POT (~ 6 months of SBND exposure).

No in-time cosmics or dirt samples.

This sample is affected by the refactored LArG4 bug, making truth matching for electrons & photons \sim impossible. Looking forward to using the new samples being simulated for MCP2021C to do more in depth digging with truth matching working.

Signal

- 0 μ^\pm
- 0 e^\pm
- 0 π^\pm
- 1 π^0
- N p
- In FV*

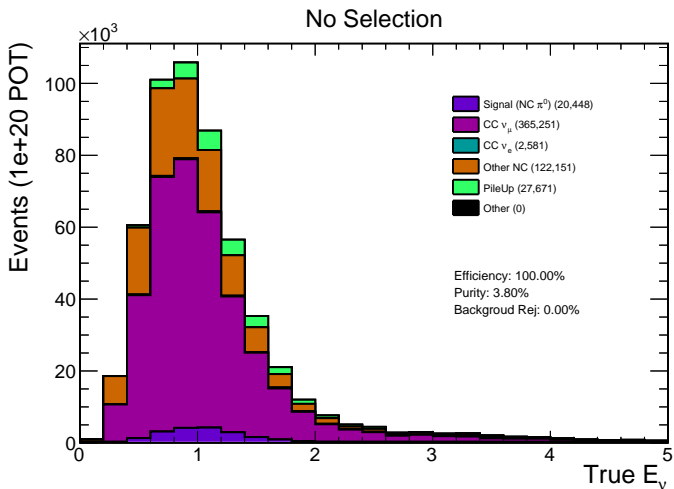


Not to scale!

$$\text{BR}(\pi^0 \rightarrow \gamma\gamma) = 98.823\%$$

* 25cm from x & y walls, 30cm from front wall, 50cm from end wall.

Initial Sample



Selections

Have attempted three first passes at selections, just using the tools already available in SBND.

- Box Cut Selection
- R-D Selection (RazzleDazzle PID to select showers & reject tracks)
- “Half” R-D Selection (RazzleDazzle PID to reject tracks)

Common Cuts

All three selections start with two common cuts

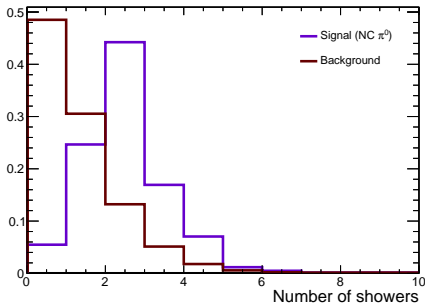
There is at least one slice identified by pandora to be a neutrino candidate. If there are multiple neutrino slices I chose the one with the largest slice score (most neutrino-like).

The reconstructed vertex is within the fiducial volume definition (debatably not a cut as the same requirement is made in the signal definition).

Box Cut Selection

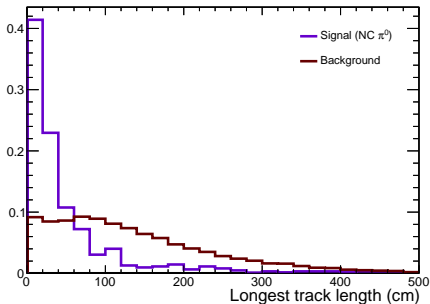
Box Cut Selection - Cuts

- Slice has 2 or more showers
- Longest track is shorter than 1m
- Neither shower is within 10cm of a cosmic muon track
- The 2 shower invariant mass $W > 40 \text{ MeV}/c^2$
($W^2 = 2E_1E_2(1 - \cos\theta)$)



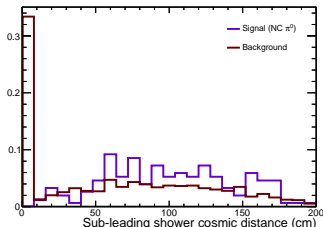
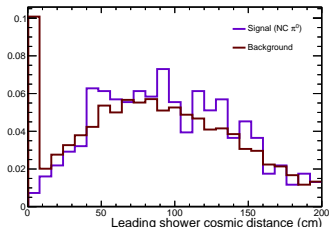
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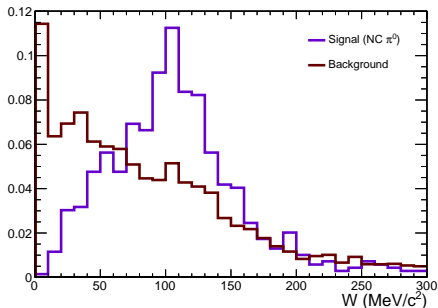
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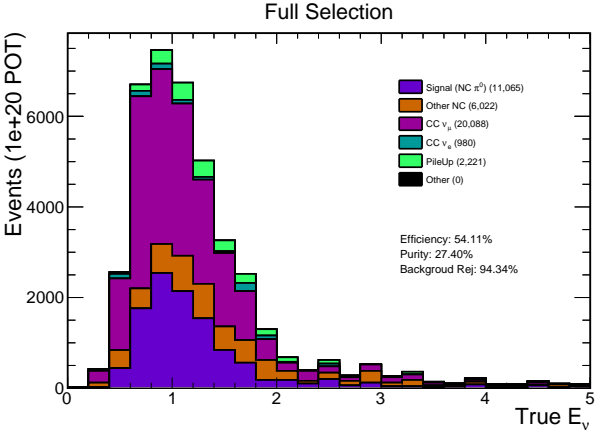


Box Cut Selection - Cuts

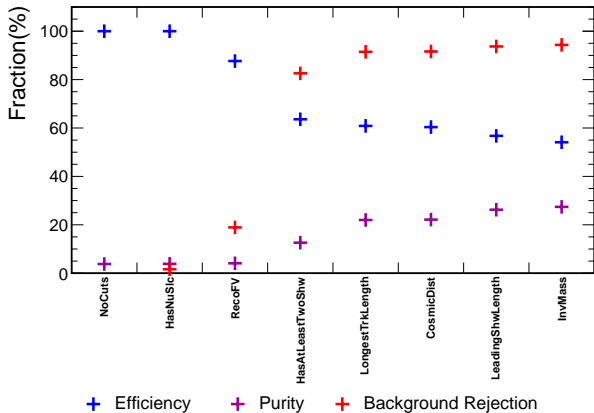
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Box Cut Selection



Box Cut Selection - Metrics



RazzleDazzle Selection

Razzle Dazzle PID

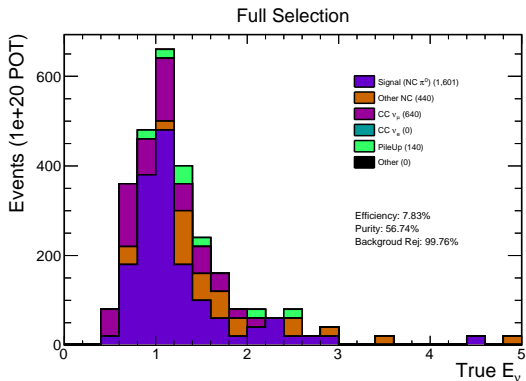
Ed Tyley has developed a set of MVA PIDs for SBND.

- Razzle identifies showers as Electron/Photon/Other
- Dazzle identifies tracks as Muon/Pion/Proton/Other

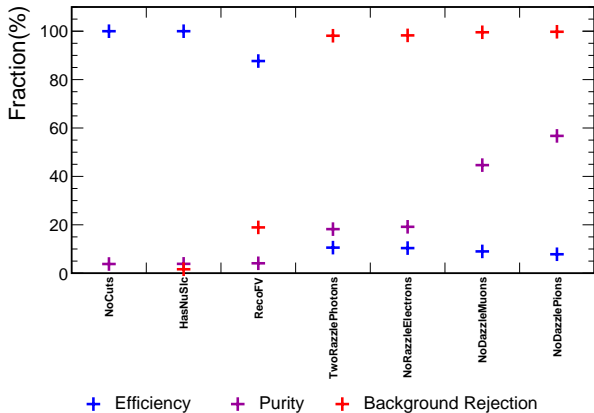
R-D Selection - Cuts

- Using Razzle shower PID there are 2 photons and no electrons
- Using Dazzle track PID there are no muons or pions

As you might have expected this ended up being a little drastic...



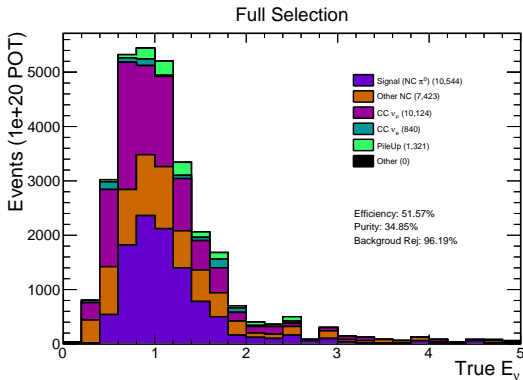
R-D Selection - Metrics



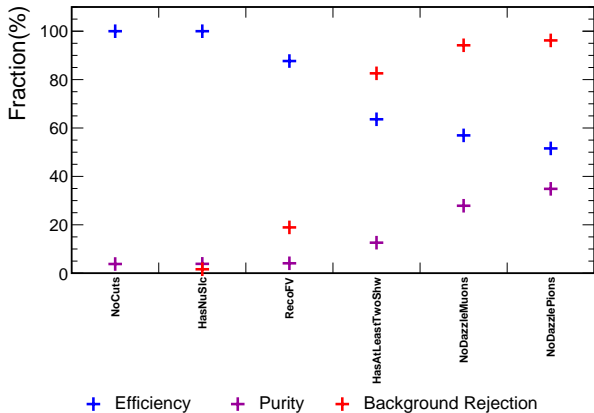
Half RazzleDazzle Selection

Half R-D Selection - Cuts

- There are 2 or more showers
- Using Dazzle track PID there are no muons or pions



Half R-D Selection - Metrics

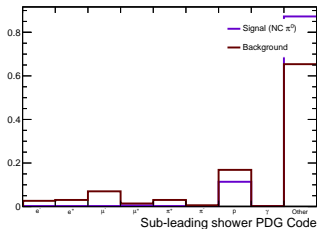
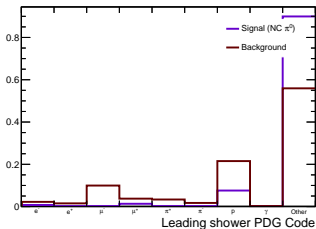


Diagnosing issues

Diagnosis

Obvious next step is to look at the backgrounds being accepted and the signal being thrown away in order to identify what metrics could be used to improve rejection and what reconstruction improvements could aid acceptance.

My first attempt would be to look what the leading & sub-leading true showers actually truth match to...



Requires being able to truth match showers *cry*

Diagnosis 2

Another way of trying to approach the same problem is, what the background categories break down into:

Selected Events

Signal (NC π^0) (10,544)

NC $n\pi^0$ (660)

NC π^\pm (1,080)

NC $n\pi^\pm$ (340)

NC $\pi^\pm\pi^0$ (880)

NC 0π (3,221)

Inv NC (1,241)

CC $\nu_\mu\pi^0$ (3,201)

CC $\nu_\mu n\pi^0$ (280)

CC $\nu_\mu\pi^\pm$ (1,761)

CC $\nu_\mu n\pi^\pm$ (260)

CC $\nu_\mu\pi^0\pi^\pm$ (680)

CC 0π (3,942)

CC ν_e (840)

PileUp (1,321)

Need to deal better
with labelling when
I've selected the
cosmic slice in an
event.

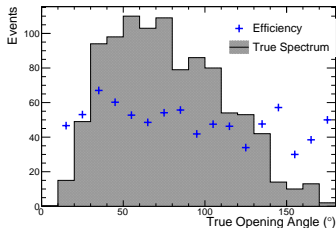
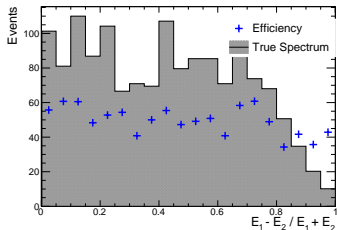
Diagnosis 3

Finally, we can look at the reconstruction of rejected signal events. I have begun scanning through pandora event displays with a set of files containing purely rejected signal. Due to these events containing overlay picking out the neutrino part becomes more difficult. I set it up to only plot neutrino induced hits but guess what, you need roll-up working to do that...

Easy to see themes like merged showers but I think that's partly because they're the easier ones to pick out when there's a lot going on in the event (I'm seeing what I want to see).

Diagnosis 4

Tried to see if I could find any true variables that described the fundamental reconstruction issues via selection efficiency.



Conclusions

- Have developed a simple $NC\pi^0$ selection using the tools already available in SBND.
- Best version gets 51.6% efficiency and 34.9% purity without any tuning.
- Idea is to use this as a grounding for identifying good spots for reconstruction improvements.
- Have lots of diagnosis-y tools set-up that will work much better on the upcoming production.