CC Hyperon Production for MicroBooNE

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Methodology

Use BNB/NuMI flux files found in /uboone/data/flux/bnb(numi)/current/ histograms, along with x-sec files to generate 10k nu(bar), cherry pick out CC hyperon, and convert to a root file with various histograms.

Count how many Λ0 ,Σ+ ,Σ-, Σ0 occur in the final state, and come up with some expected rate as a percentage of total events.

This allows 8 combinations in nu and nubar mode, producing nu and nubars, for both BNB and NuMI. While uB may only get 3 years in neutrino mode and so only the 4 neutrino mode combinations may be relevant, I'll give numbers assuming 3 years in antineutrino mode after. Knowledge is power.

BNB was simulated over 0-7 GeV, NuMI from 0-10 GeV

How this works (I think), How this fails

Using the gevgen (not gevgen_fnal) command with the flux files from the previous slide, GENIE uses the flux as a probability distribution to decide what energy to give a neutrino, then fires it at an Ar40 atom, using the cross section to decide whether it interacts and if so, what interaction route it takes. Do that as many times as is necessary to give me 10k interactions.

The pro/con is that this simulation is completely independent of experiment. That means I can't tell you how this translates in terms of POT or time for MicroBooNE, I think purely in terms of number of actual interactions. However, according to various people, we expect on the order of ~150k CC interactions over 6E20 POT.

So while the flux files are in weird units in terms of area and POT, which means the ratio of tries/10k events is not correct, I should be able to use this 150k/6E20POT to shortcut any problem. With a properly normalized flux file I can get the ratio of tries/10k correct, but that is merely a constant correction and not energy or interaction channel dependent, so my hyperon count should scale directly by multiplying by 15, or whatever number you like if 150k isn't correct.

Another pro/con: GENIE only does CC hyperon production. Con: There are NC channels for hyperon production, and I'm going to miss those events entirely in this talk. Pro: That means we should expect even more hyperon events from the NC channels in MicroBooNE.

Processes that occur

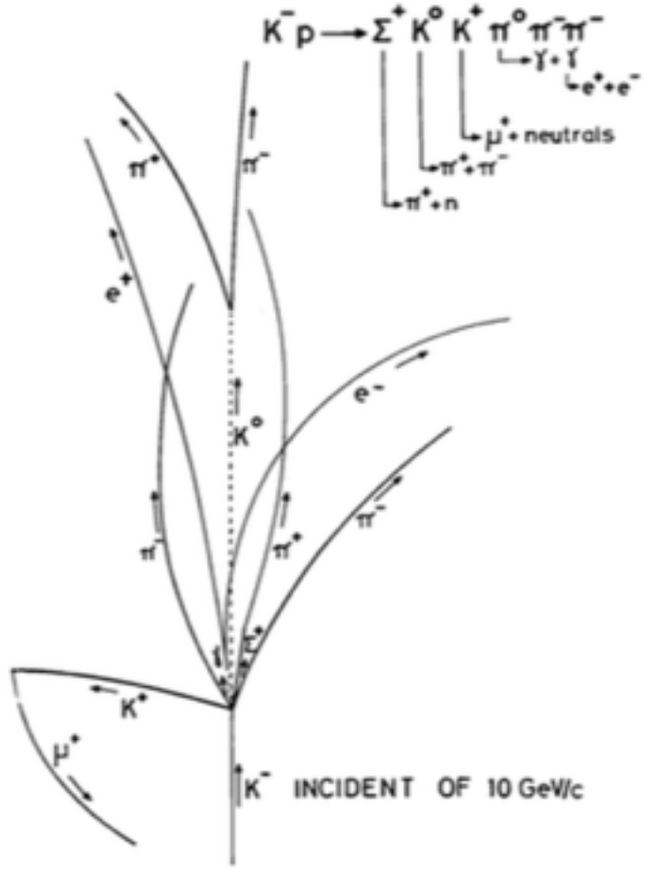
In neutrino interactions, all hyperon processes are associated production with a Kaon and Muon. Ex:

$$\nu_\mu + n \rightarrow \mu^- + \Lambda^0 + K^+$$
$$\nu_\mu + p \rightarrow \mu^- + \Sigma^+ + K^+$$

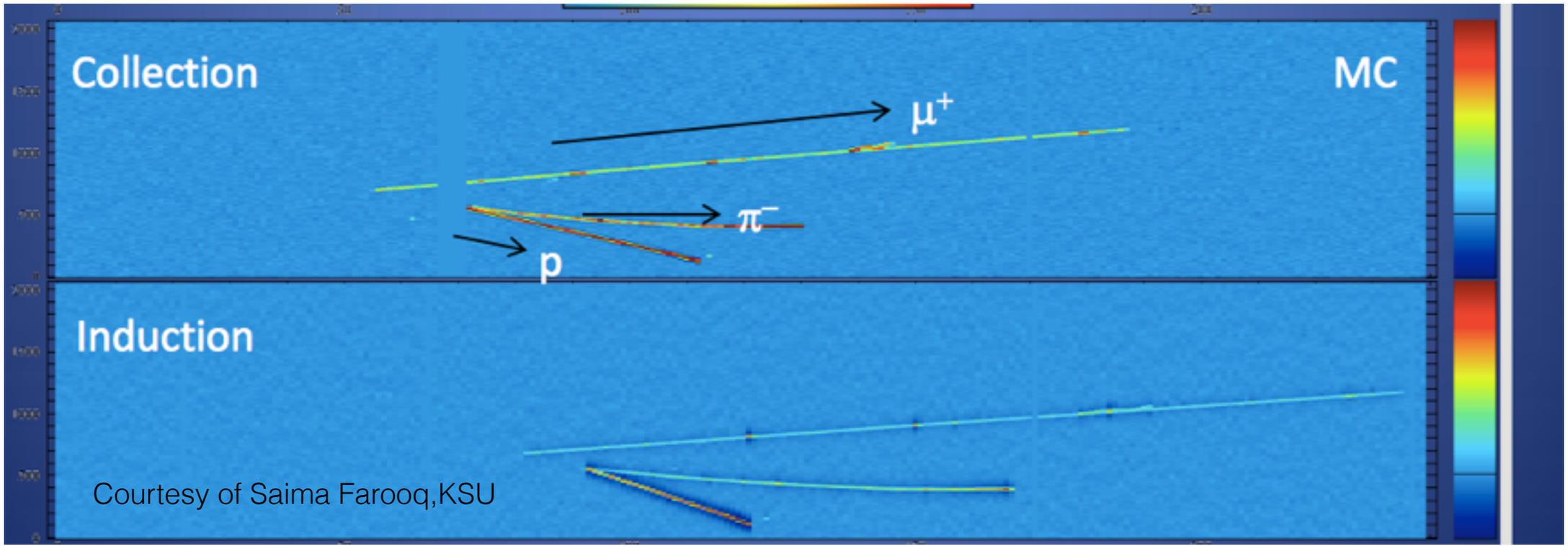
In anti-neutrino interactions, we can directly produce hyperons. Ex:

$$\overline{\nu}_\mu + p \rightarrow \mu^+ + \Lambda^0(\Sigma^0)$$

Σ+ event from CERN 2m Bubble Chamber experiment



Argoneut MC EVD



BNB Results: per 10k neutrino interactions

Vert:Hyperon Horiz:mode/ interacting neutrino	ν ν	ν $\bar{\nu}$	$\bar{\nu}$ ν	$\bar{\nu}$ $\bar{\nu}$
Λ	12	2	28	0
Σ+	5	0	12	0
Σ0	0	0	0	0
Σ-	0	2	0	0

NuMI Results: per 10k neutrino interactions

Hyperon mode/ interacting neutrino	$\nu\ \nu$	$\nu\ \bar{\nu}$	$\bar{\nu}\ \nu$	$\bar{\nu}\ \bar{\nu}$
Λ	13	15	24	8
Σ+	8	0	19	0
Σ0	0	0	0	0
Σ-	0	5	0	7

Event Rates

Categorizing into each beam in neutrino or anti neutrino mode:

BNB-neutrino: .21%
BNB-antineutrino: .40%
NuMI-neutrino: .41%
NuMI-antineutrino: .58%

What this means for MicroBooNE:

Assuming we get 150k events in neutrino-mode from BNB, and just to ballpark, assuming NuMI provides150k events as well, the chart below shows how many events each mode should provide:

	neutrino	anti-neutrino
BNB	315	600
NuMI	615	870