Electron and Photon like Backgrounds, Low Energy Event Rates

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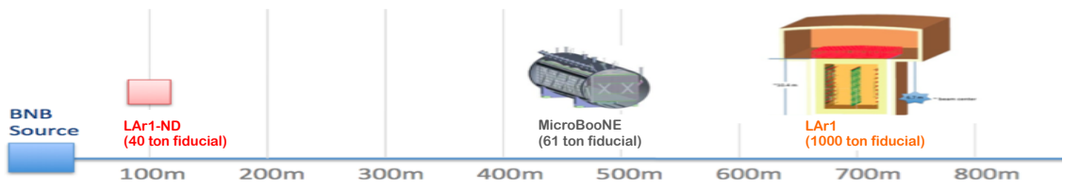
Topic

- Recently, for LAr-1 we've been simulating several oscillation signals in a multiple detector scenario for the BNB.

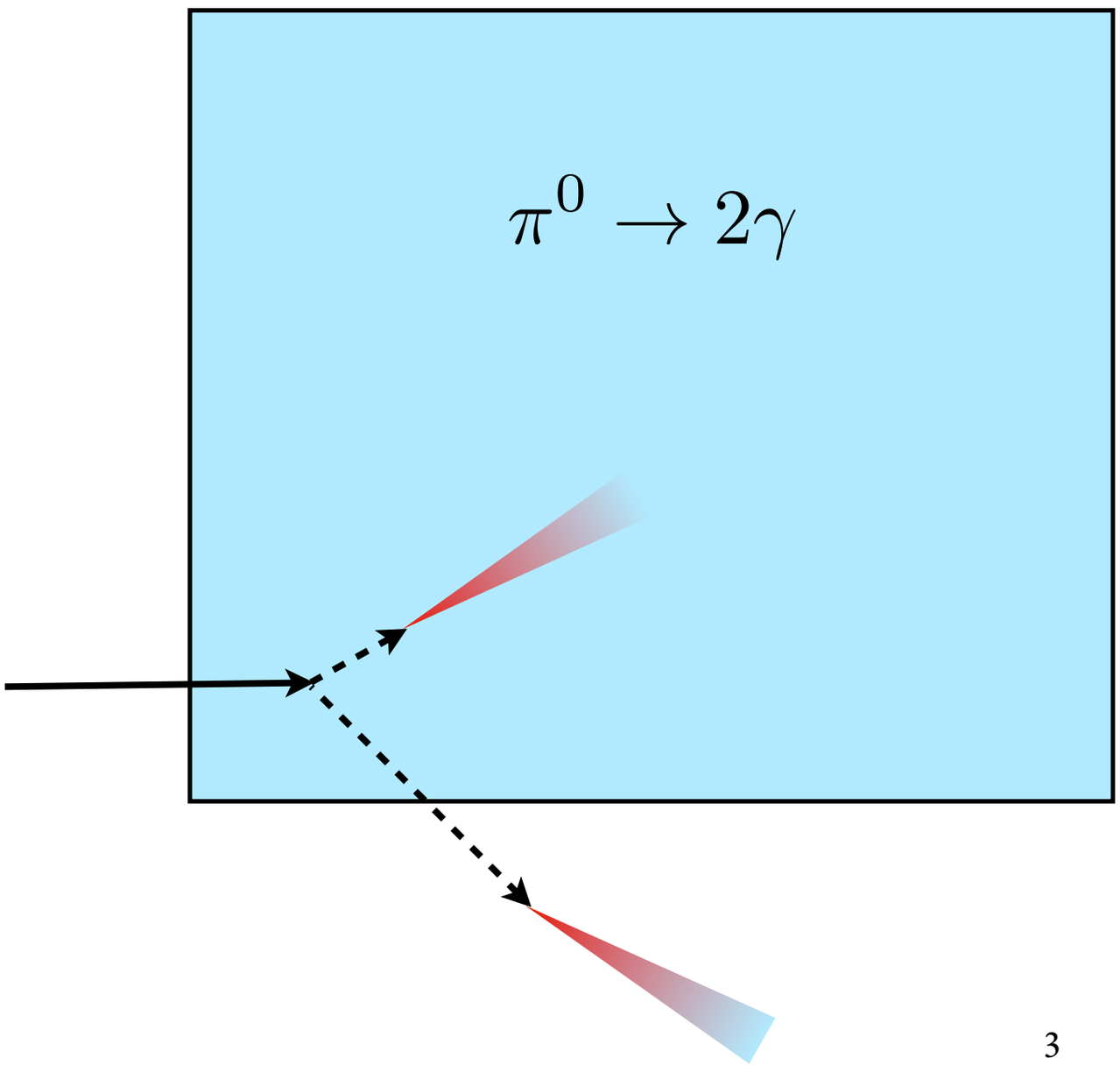


I've pulled out the results for MicroBooNE that are relevant for the oscillations group:

-energy reconstruction
-misID rates
-containment
-LowE background rates

Electron Neutrino Backgrounds

What can get accepted into our "electron neutrino" sample?



-Intrinsic Electron Neutrinos
-NuMu CC MisID
-Single Photons from pio

We assume we reject fully events with both photons contained, and reject 94% of events with only 1 photon converting in the volume.

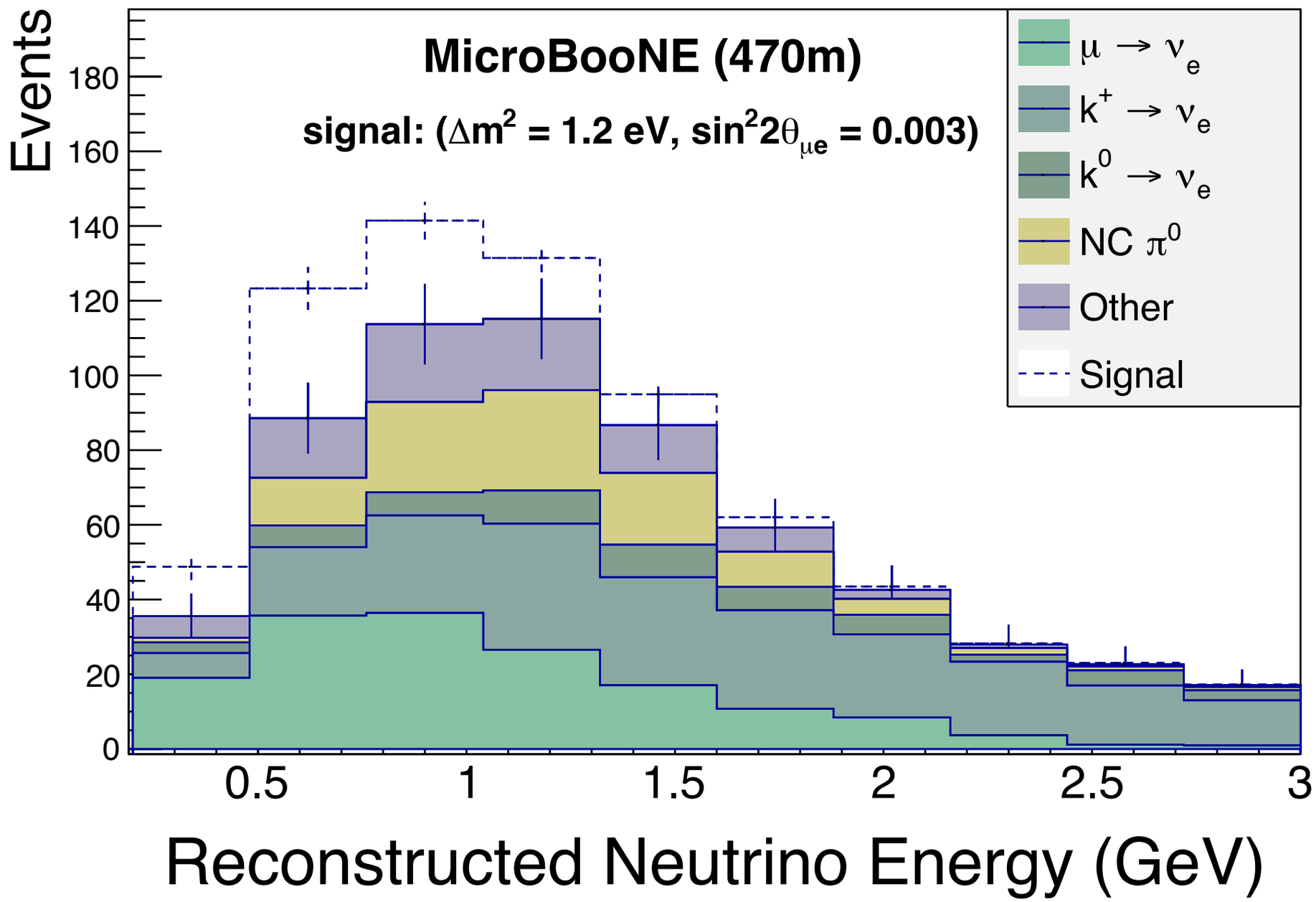
Energy Reconstruction

True: MC truth neutrino energy

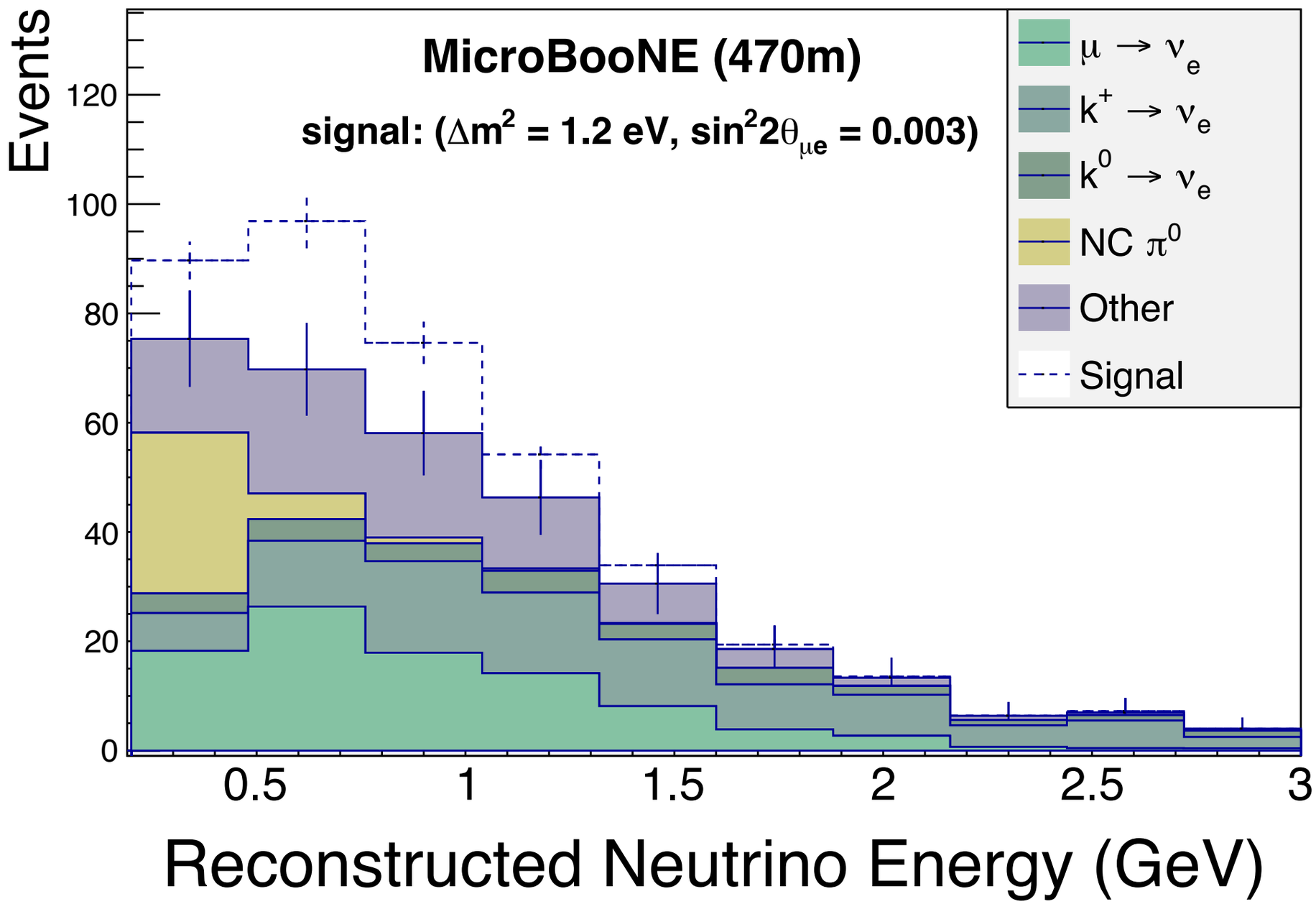
CCQE: Ccqe formula using the electron or single photon as the electron

Calorimetric: lepton energy (or lepton candidate) + sum of visible kinetic energy
-> What's visible? Used charge particles and also the case where neutrons are "visible"

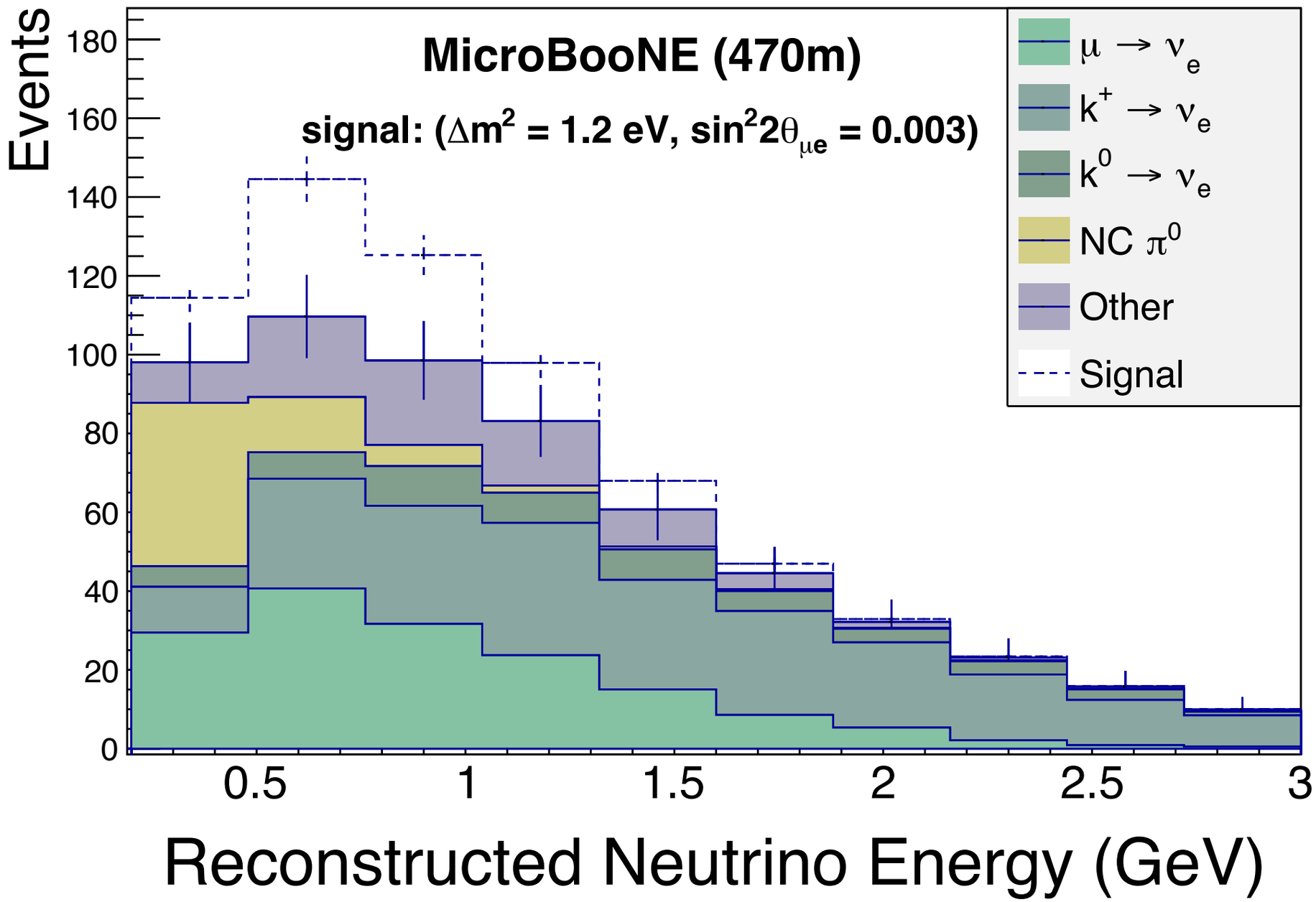
True Neutrino Energy



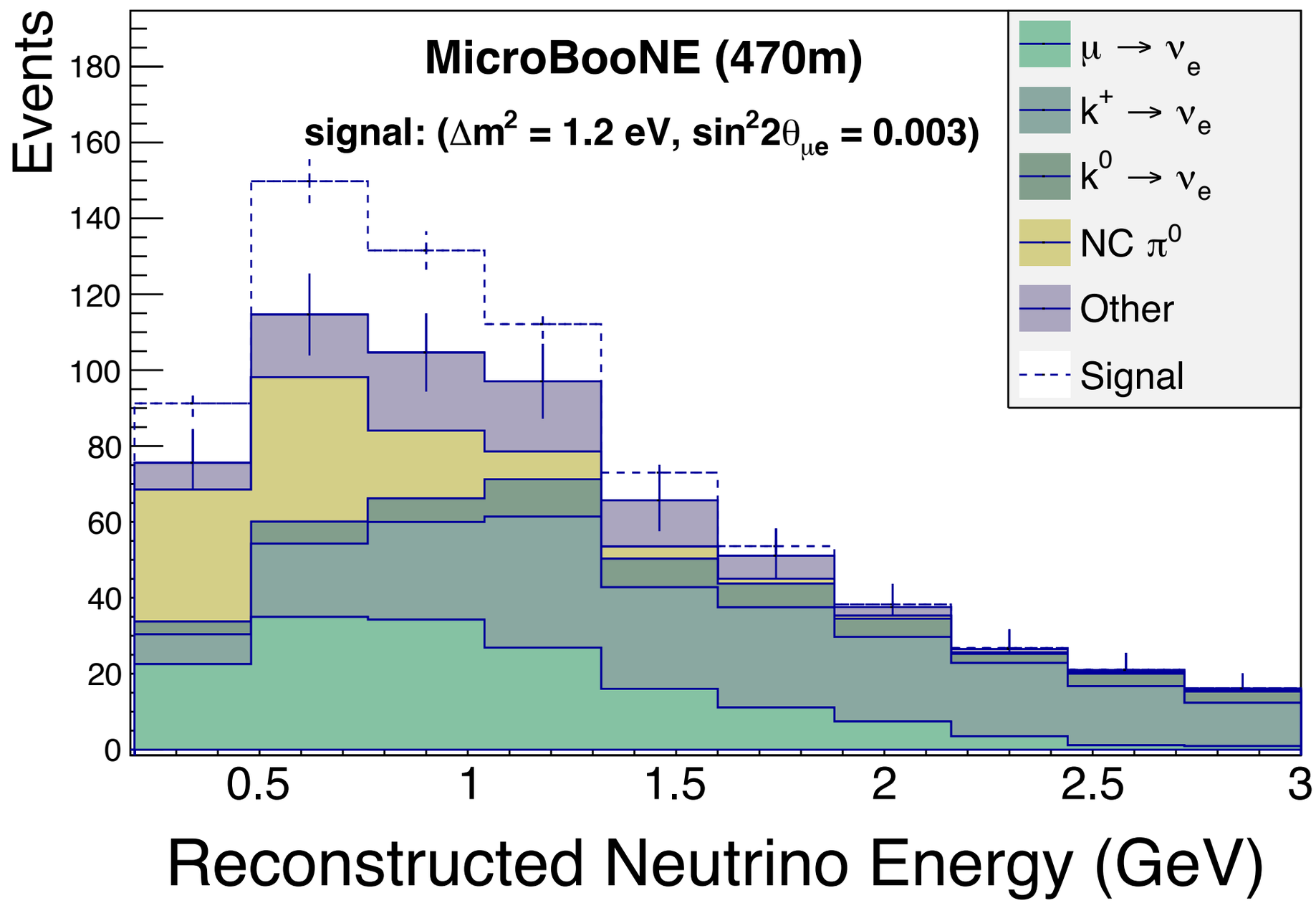
CCQE Events


MicroBooNE (470m)
signal: (Δm^2 = 1.2 eV, $\sin^2 2\theta_{\mu e}$ = 0.003)
Events
0
20
40
60
80
100
120
0.5
1
1.5
2
2.5
3
Reconstructed Neutrino Energy (GeV)
$\mu \rightarrow \nu_e$
$k^+ \rightarrow \nu_e$
$k^0 \rightarrow \nu_e$
NC π^0
Other
Signal

Calorimetric Energy (no neutrons)



Calorimetric Energy (with neutrons)



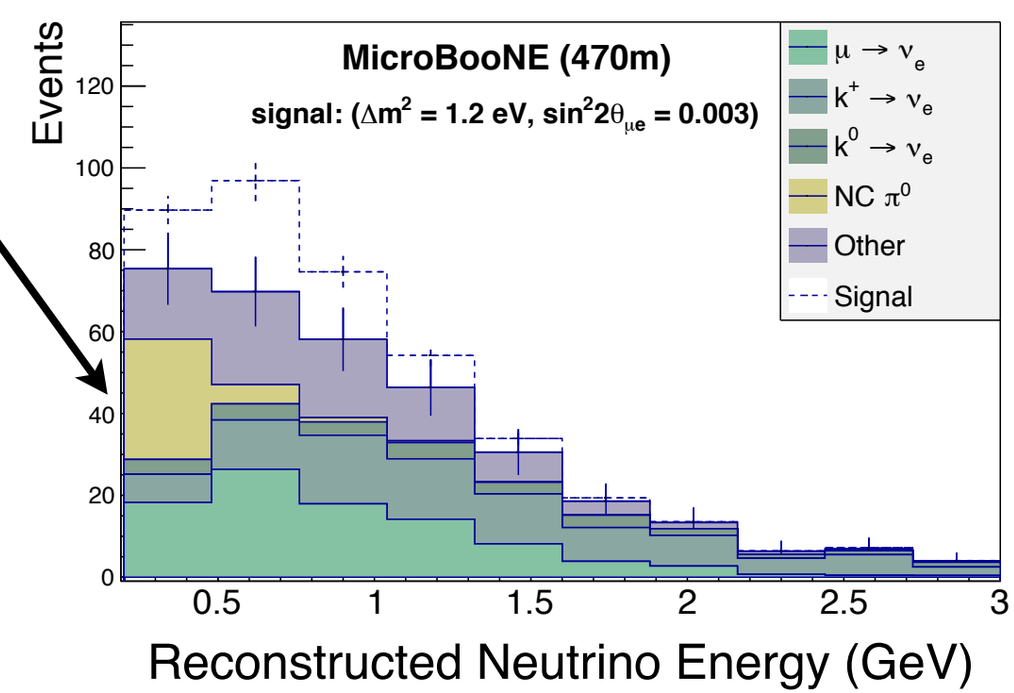
CCQE events scaled from MiniBooNE, a la uBoone proposal

Process	200 - 300 MeV (mB)	300 - 475 MeV (mB)	Total (mB)	Scaling (μB)	Total (μB)
Background from intrinsic ν_e					
$\mu \to \nu_e$	13.6	44.5	58.1	.369	21.5
$K^+ \to \nu_e$	3.6	13.8	17.4	.369	6.4
$K^0 \to \nu_e$	1.6	3.4	5.0	.369	1.8
Background from ν_μ misidentification					
ν_μ CC	9.0	17.4	26.4	.185	4.9
$\nu_\mu e \to \nu_\mu e$	6.1	4.3	10.4	.369	3.8
NC π^0	103.5	77.8	181.3	.037	6.7
Dirt	11.5	12.3	23.5	.037	0.9
$\Delta \to N\gamma$	19.5	47.5	67.0	.037	2.5
Other	18.4	7.3	25.7	.037	0.9
Background	187	228	415		**49.4**
Excess	45.2	83.7	128.9	.369	**47.6**

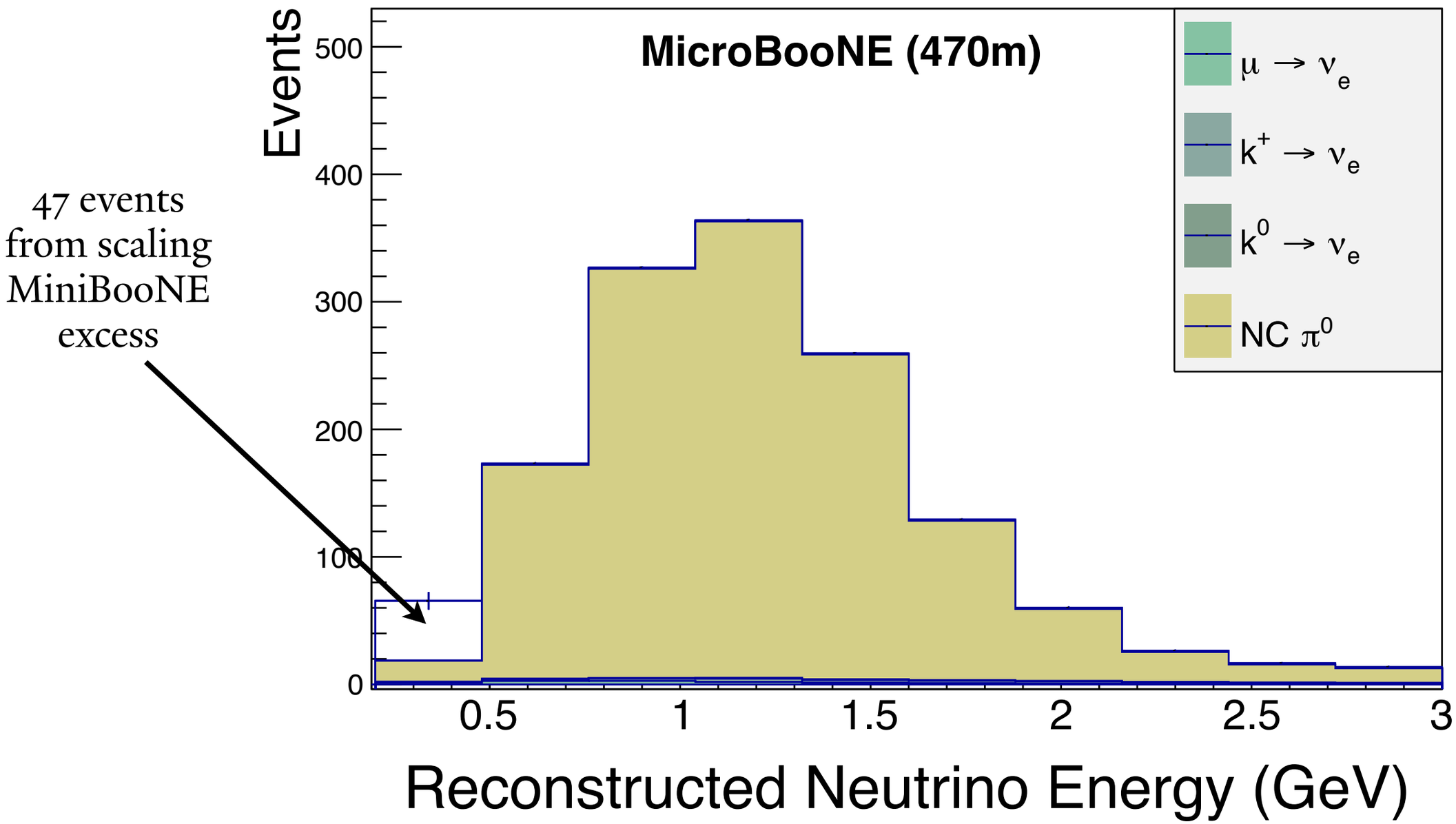
LAr1 Snowmass White Paper, Table 2

This yellow segment is ~30 events!

Neutral pions are very important for the single photon background, so this discrepancy is interesting...

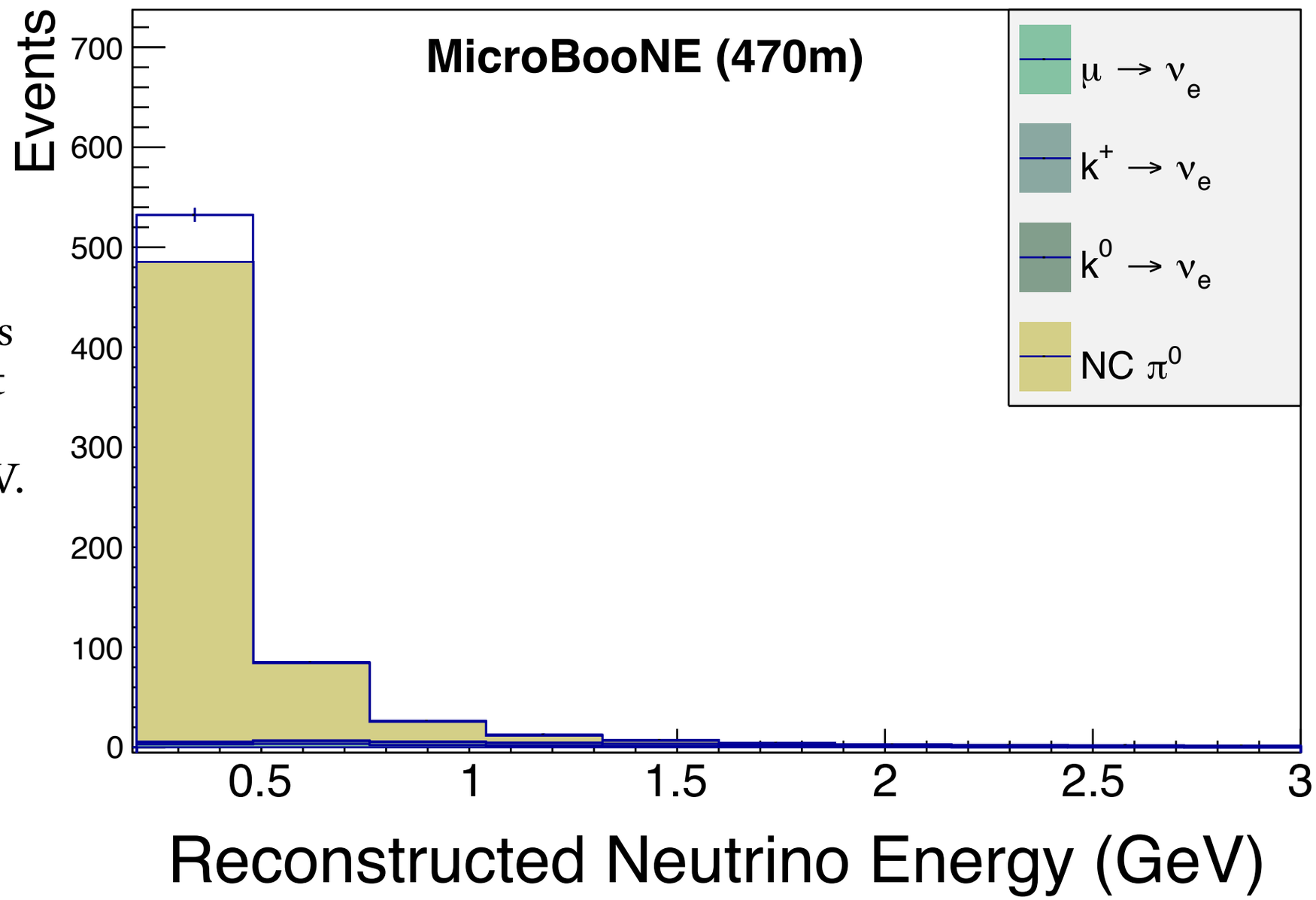


Single photons (True Neutrino Energy)

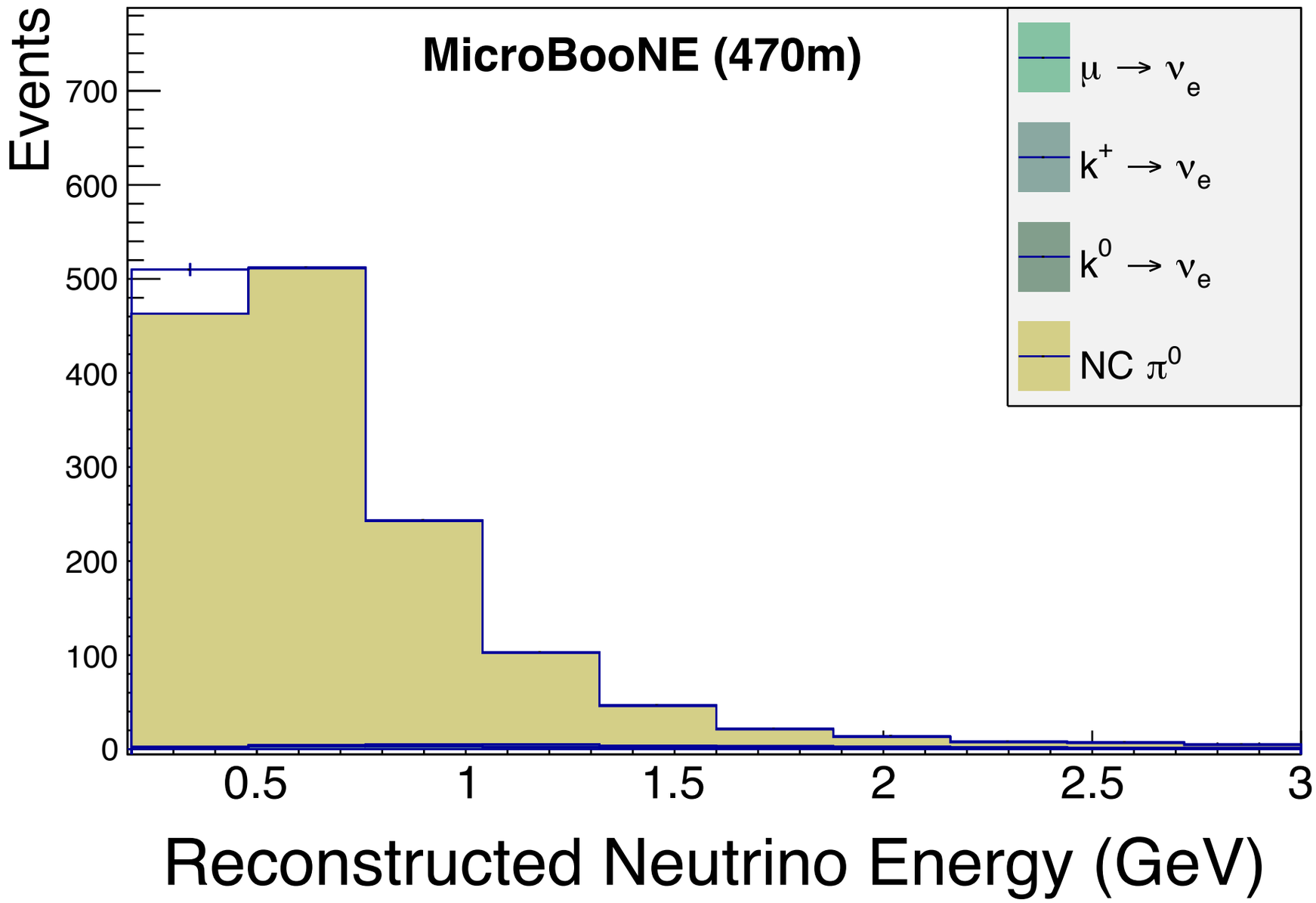


Single photons (CCQE as if photon is electron)

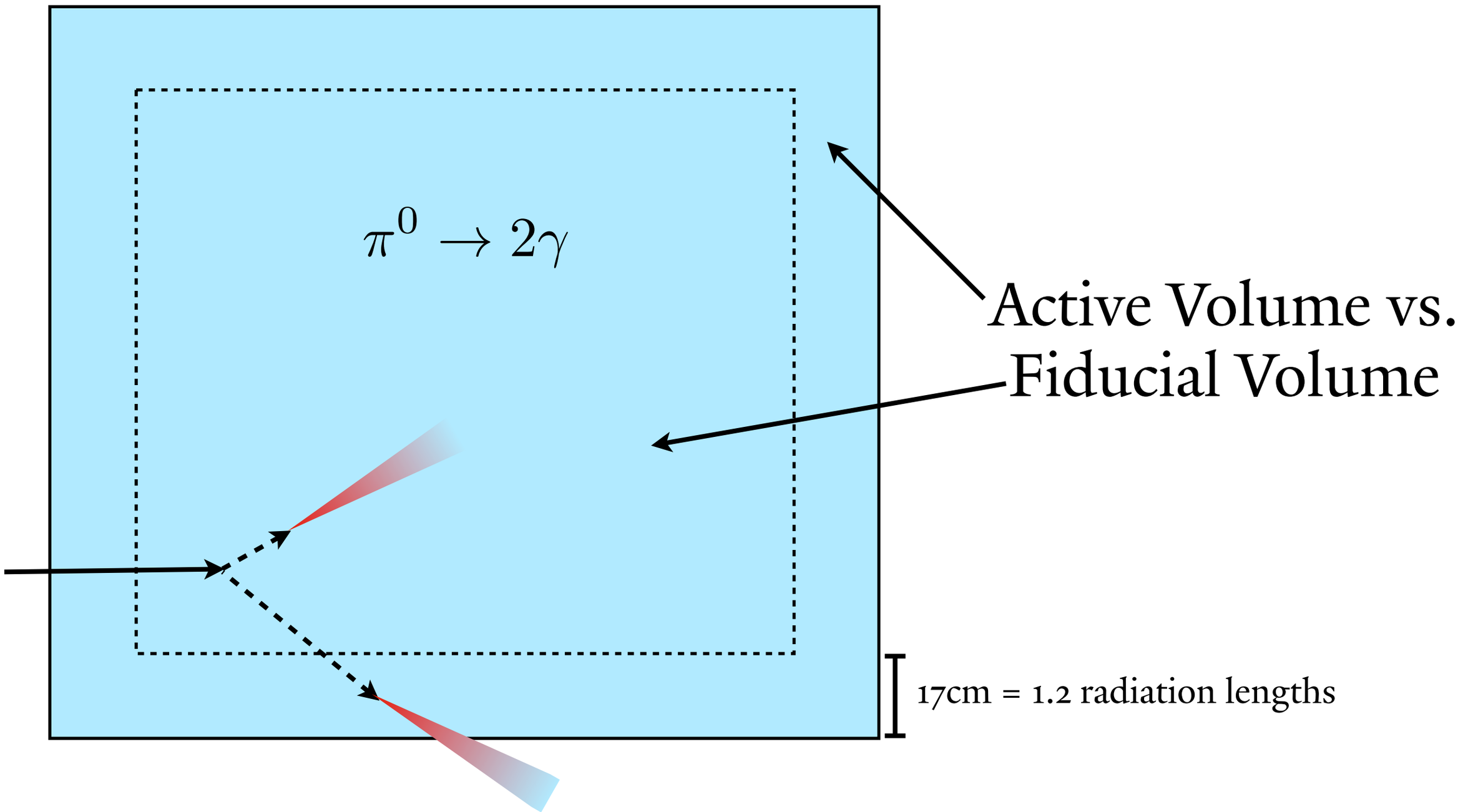
CCQE appears to reconstruct many events below 200 MeV.



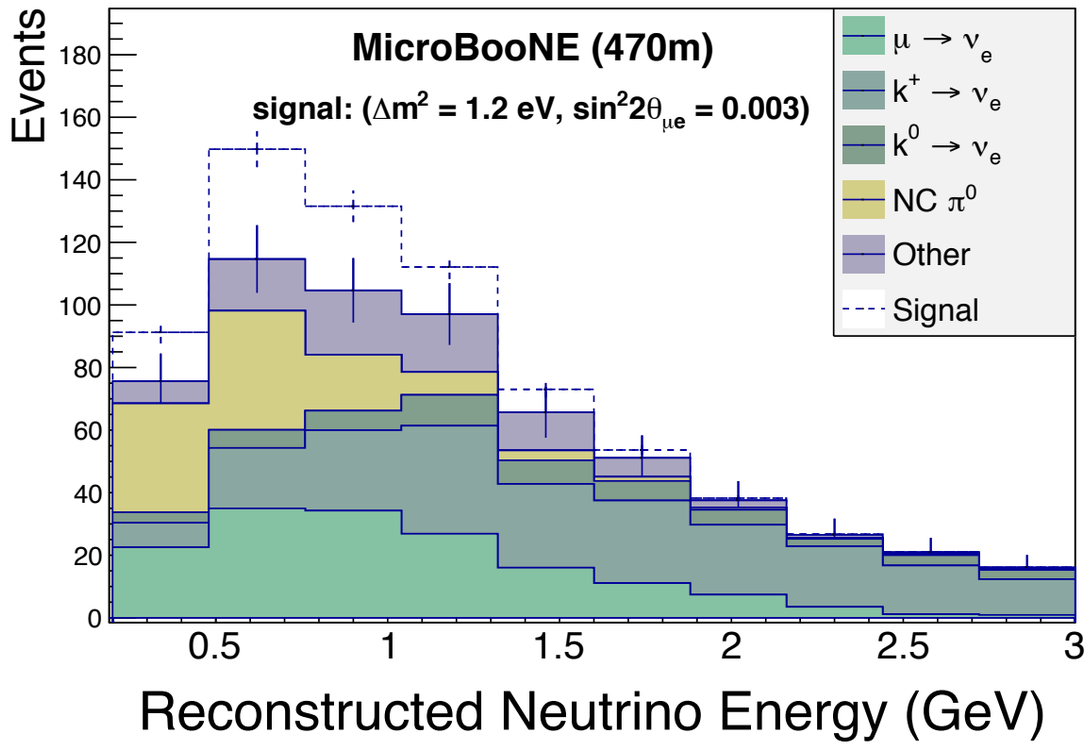
Single photons (Visible energy: photon + charged)



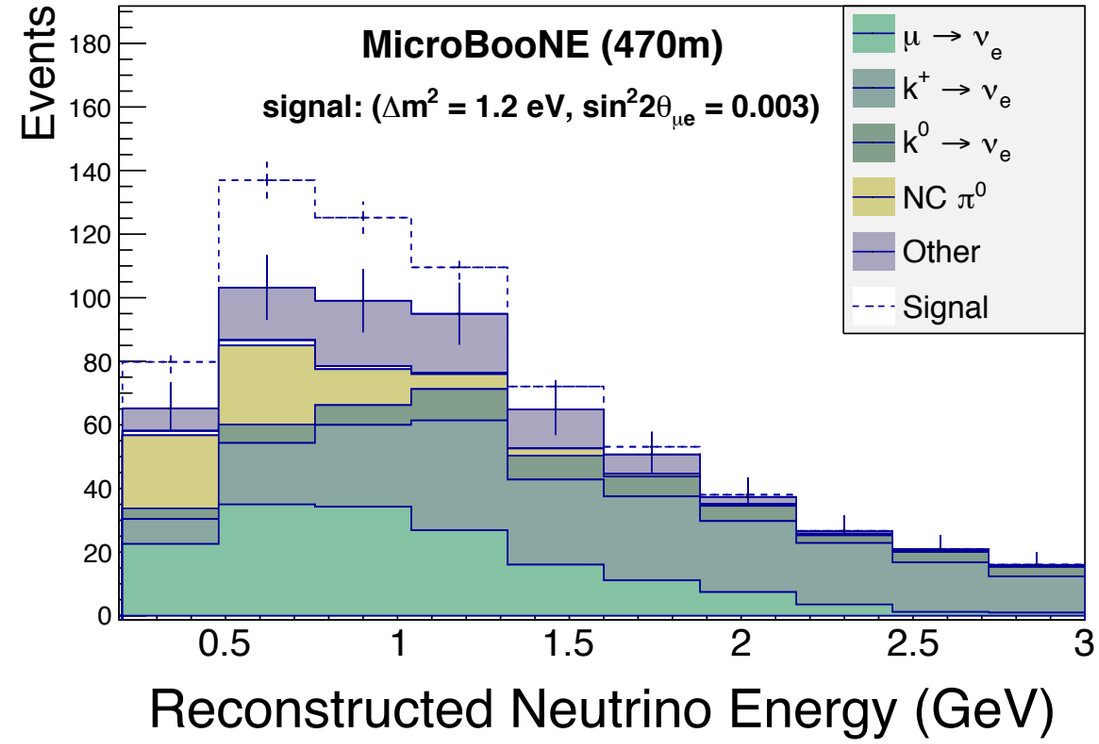
Photon Containment

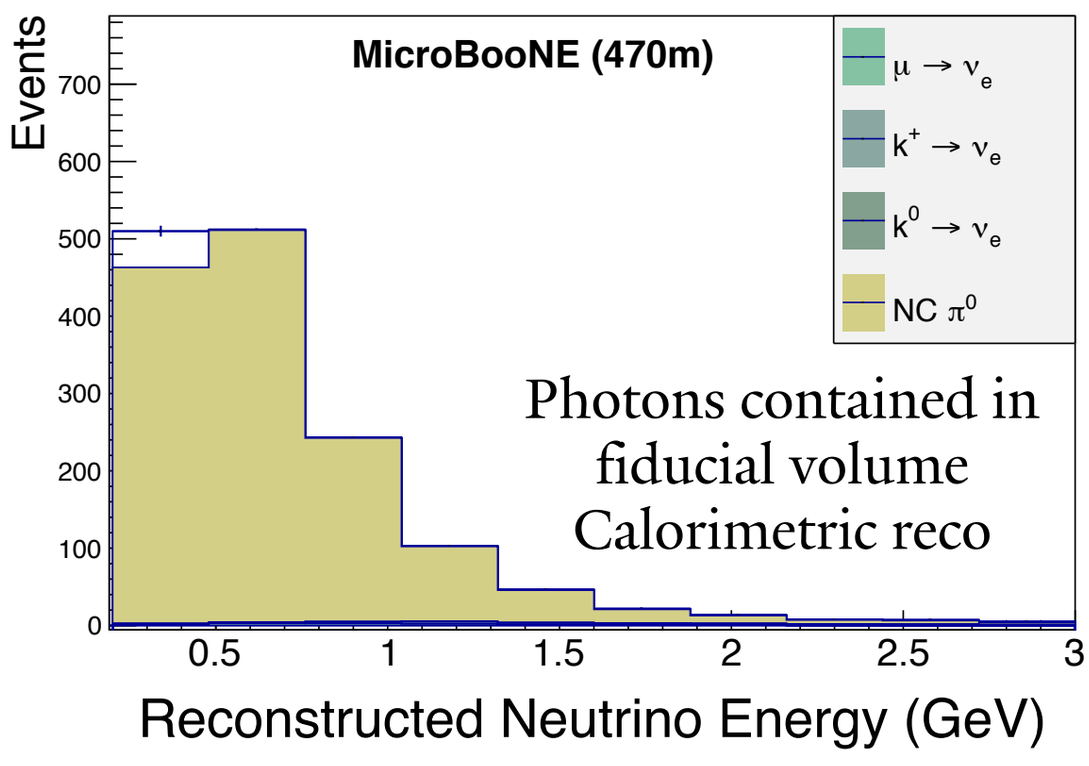


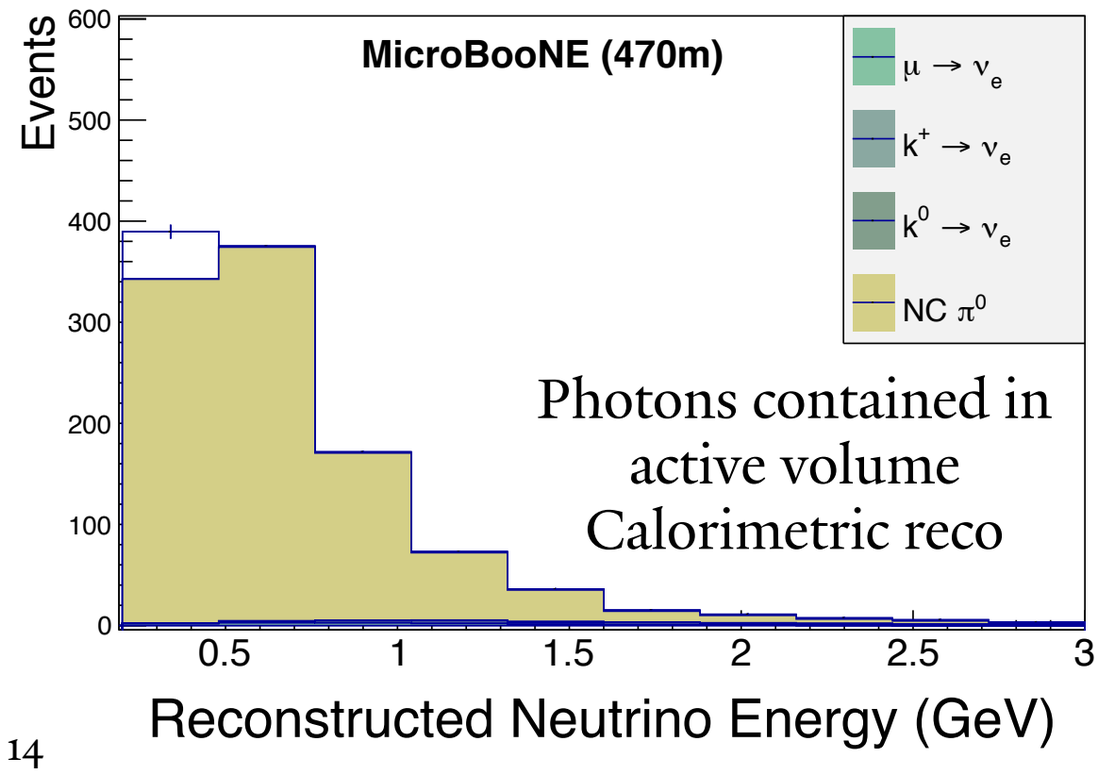
Photons contained in fiducial volume
Calorimetric + neutrons



Photons contained in active volume
Calorimetric + neutrons







Pi Zero Photon Containment

NC PiZero	Fiducial	Active
Total Events	9819	9819
Both Photons	5886 (60%)	8179 (83%)
One Photon	1899 (19%)	1398 (14%)
No Photons	2034 (21%)	241 (3%)
Multi Pi Zero	460	460

Other possible sources of discrepancy with MB scaling: nuance vs. genie, detector shape (sphere vs. rectangle)

Event Rates / Photon Containment

Asking for fiducial volume vertex events (equal event rates), but can look for photons that convert in fiducial volume or active volume.
Using visible energy + neutrons

Low Energy Region (200 - 475 MeV)

	Fid.	Act.	Scaling
$\mu \rightarrow \nu_e$	29	29	29
$K^+ \rightarrow \nu_e$	11	11	9
$K^0 \rightarrow \nu_e$	5	5	2
ν_μ CC	10	10	5
$\nu_\mu + e \rightarrow \nu_\mu + e$	1.9	1.9	5
NC π^0	36	19	7
NC γ	1.7	2.2	3
TOTAL	94	77	60

All Nue Events (200 - 3000 MeV)

	Fiducial	Active
ν_e CC	453	453
ν_μ CC	88	88
NC π^0	74	92

These two columns (fiducial, active) correspond to the top two charts on slide 14

More complete event rates (ν_μ, NC) from the same calculations at docdb 2876

Conclusions

- The energy reconstruction has a noticeable effect on the shape of the intrinsic backgrounds
- The containment of photons depends strongly on the definition of fiducial volume.
- We found a few anomalies in the various ways to calculate event rate backgrounds, probably due to a number of different sources.
- This is the best logo