Event selection efficiency, N_{INGRIDexpected} w/ systematic errors

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Content

- INGRID MC component
- Compare Data vs MC
- Efficiency of neutrino observation
- # of expected observation
- Simple study of systematic error of INGRID
  - study about neutrino cross-section uncertainty

INGRID MC

- Component
  - Jnubeam 10ab → Neutrino Flux to ND3, ND4
  - NEUT → simulate neutrino interaction
  - GEANT4 → Detector simulation
- Not consider MPPC noise and hit efficiency of scintillator (no MPPC noise and 100% hit efficiency)
- Beam related backgrounds (rock-muon, neutron and gamma) not be simulate in this MC.

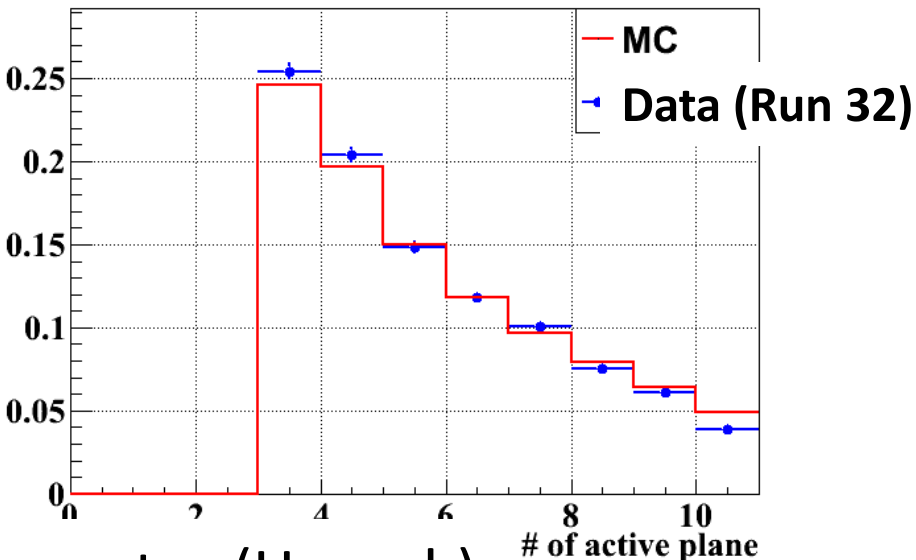
Comparison between Data and MC

- Compare MC with Beam data after "neutrino event selection"
  - this selection is same analysis method as INGRID beam analysis.
  - Check diff. of MC from real data.
- Beam data set : Run 32 (Horn = 250kA&250kA)
- All distributions are normalized by area.
  - Will be normalized by # of protons.
- Consider only statistics error now.

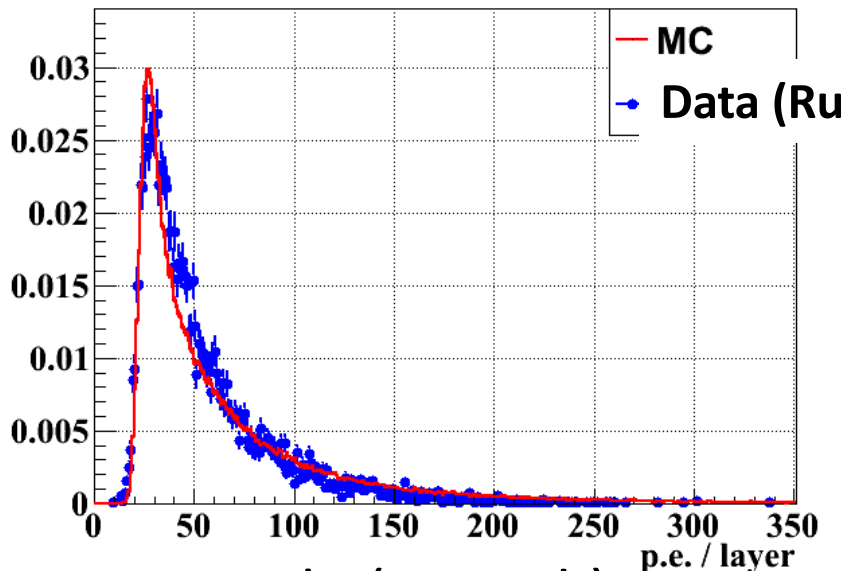
Comparison between Data and MC

After neutrino event selection

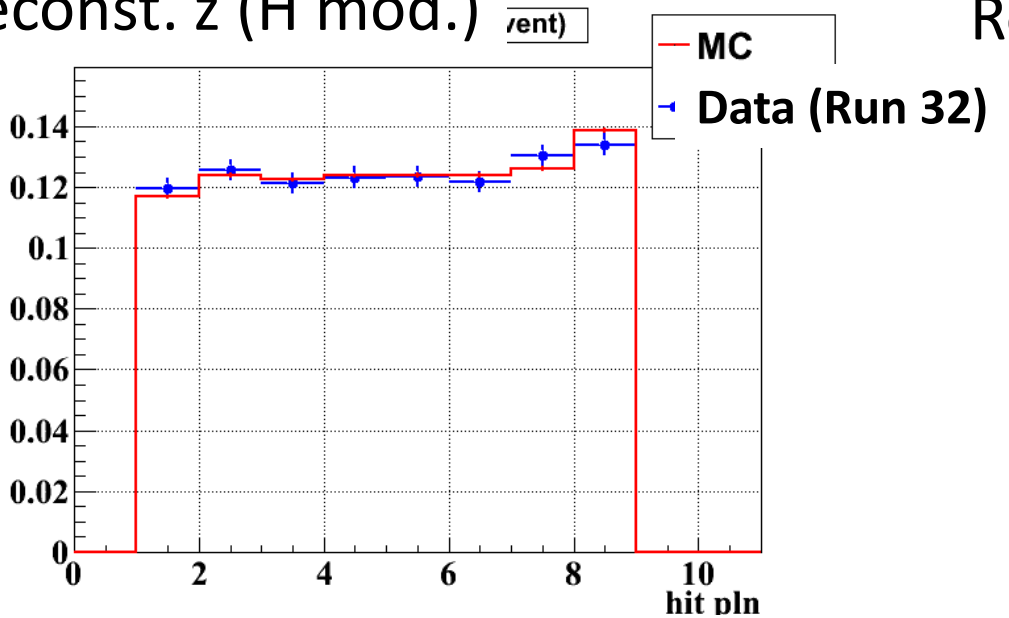
of active planes (H mod.)



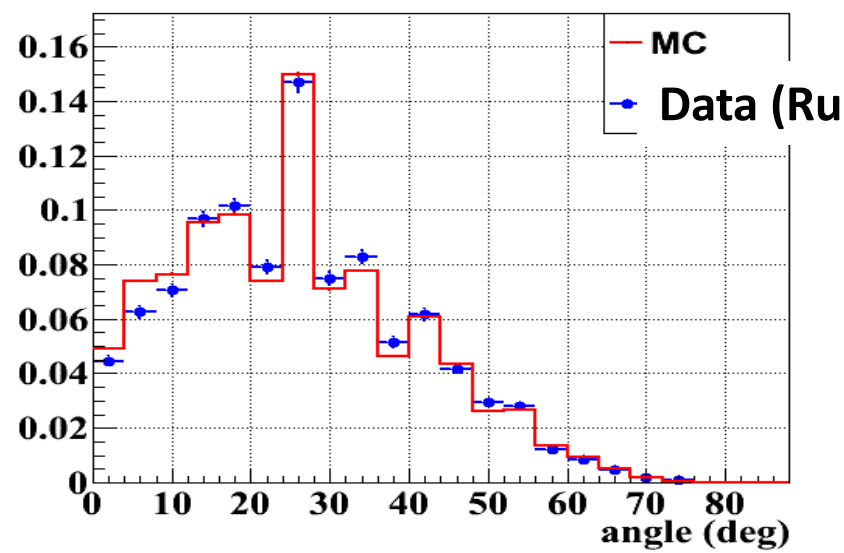
p.e./layer (H mod.)



Reconst. z (H mod.)



Reconst. angle (H mod.)



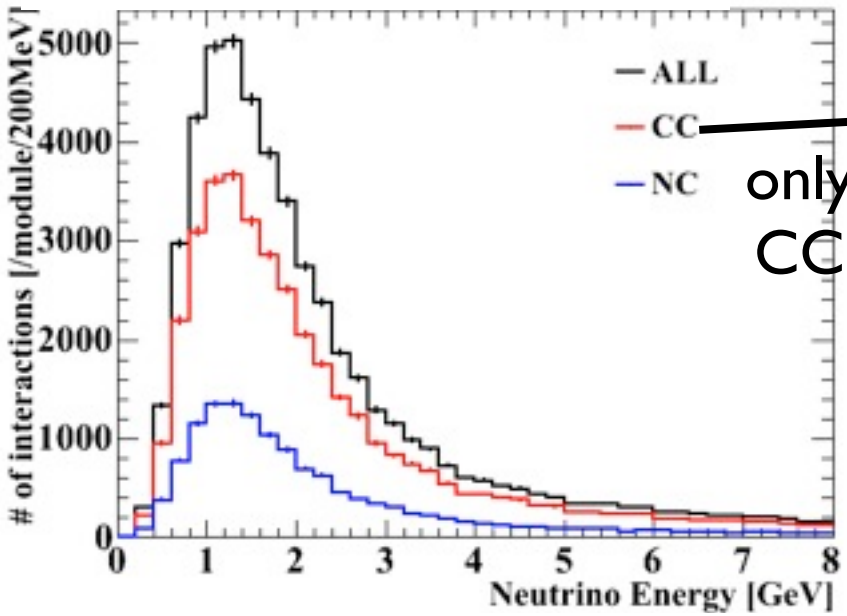
Neutrino selection efficiency as a function of neutrino energy

- Calculate neutrino selection efficiency for each interaction mode (CCQE, CC1Pi, CC other mode and NC).
- Use same efficiency curve for all modules.
  - The efficiency curves of modules is same within statistics error from MC study.

$$
\begin{aligned}
Efficiency(E) &= N_{obs}^{mode}(E)/N_{int}^{mode}(E) \times 100[\%] \\
N_{obs}^{mode} &= \#\ of\ events\ after\ neutrino\ event\ selection \\
N_{int}^{mode} &= \#\ of\ interactions\ in\ the\ modules
\end{aligned}
$$

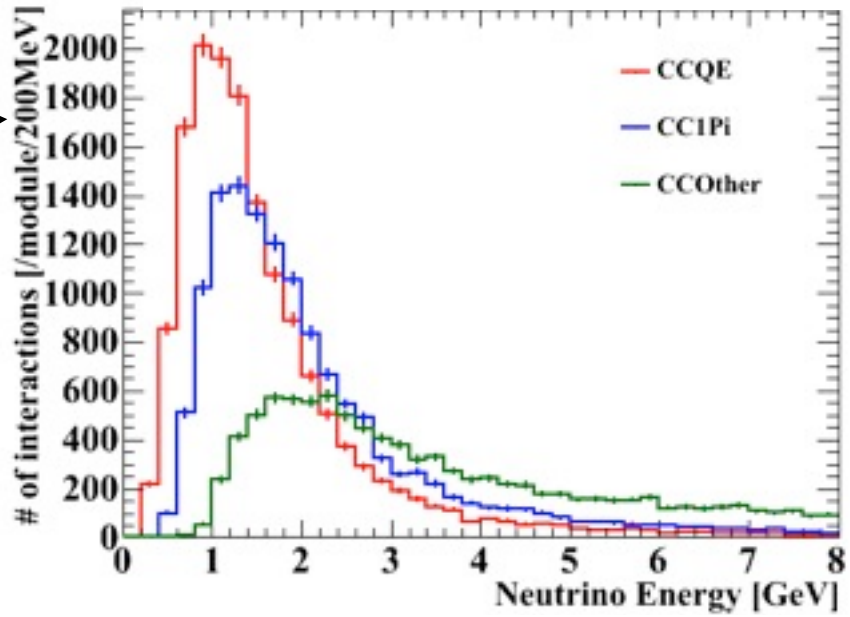
Neutrino energy spectrum (numu, ~2.41e18 pot)

of interaction in H.mods

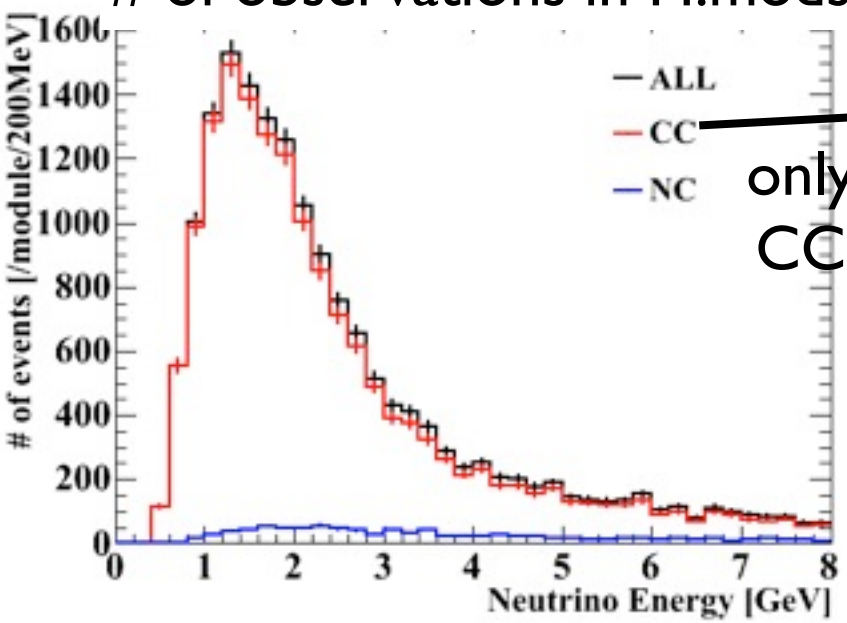


only CC

# of interaction in H.mods

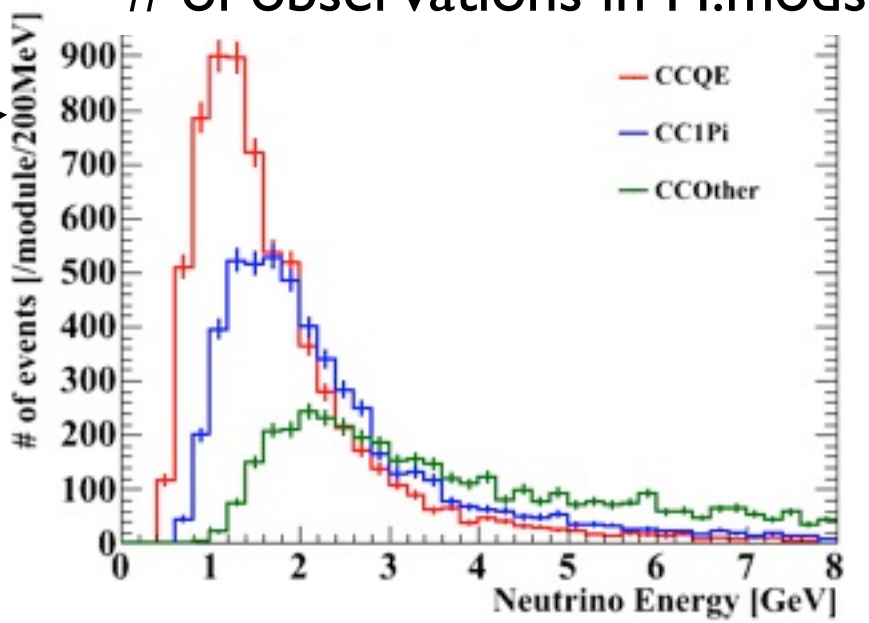


# of observations in H.mods



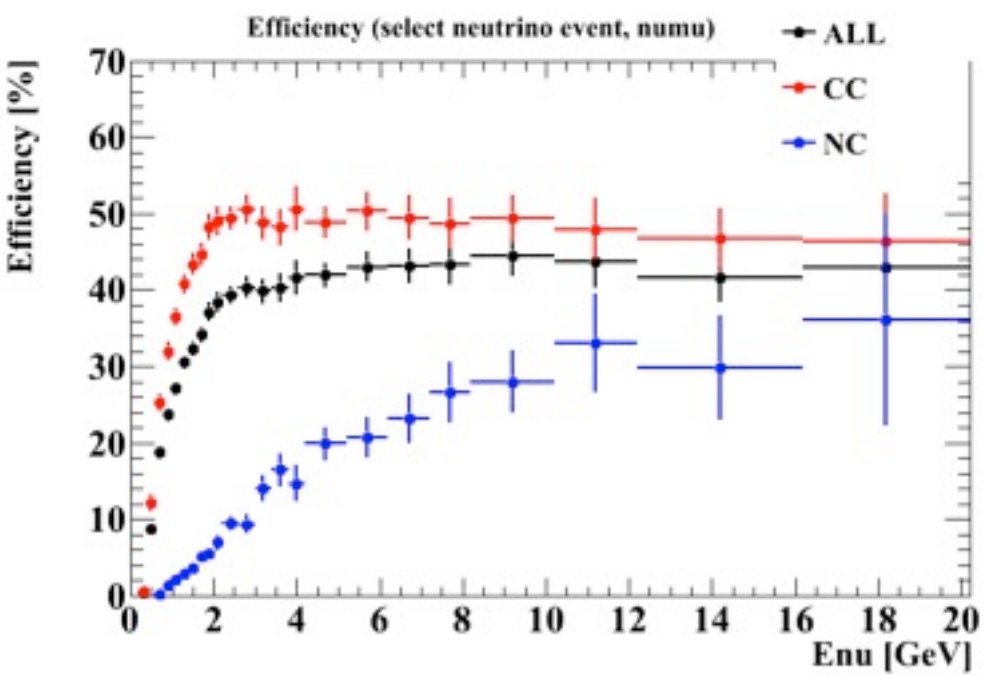
only CC

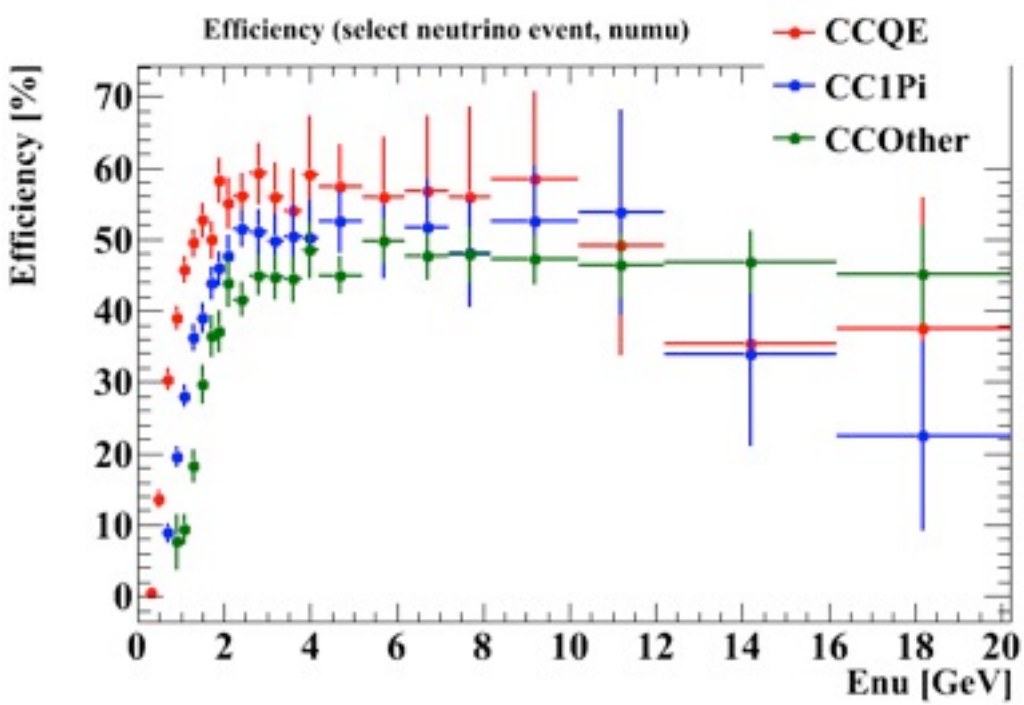
# of observations in H.mods



Neutrino selection efficiency (numu)

calc mean of efficiency of horizontal modules for
reduction of the statistics error.





(only statistics error)
Calculate the efficiency curve about numubar, nue, nuebar interation.

Comparison between Data and MC (250kA)

- Beam data : all physic run data
- MC data : Jnubeam flux 10ab, Cross-section(NEUT), INGRID neutrino selection efficiency
  - Sum # of numu, numubar, nue, nuebar event.
  - Consider scintillator mass (×1.038)

	Data	MC
# of events after neutrino event selection [/10^14pot]	1.52±0.0	1.66

No systematic error is included.

Study of systematic error of INGRID

- Study of the effect from neutrino interaction uncertainties.
- Check the difference of # of neutrino observations of INGRID when change # of interactions in module of each interaction.
  - ex) # of CCQE interactions $\times$ 1.1 $\rightarrow$ # of observations ?
- For check the effect from neutrino interaction uncertainties, not consider the uncertainties of the efficiency of neutrino event selection of INGRID.
- This study is about horizontal modules.
  - About vertical modules, we will study in future.

Result of this study

MC:jnubeam 10ab(250kA), NEUT, INGRID MC
including numu, numubar, nue, nuebar MC data.
Ex) If CCQE+10% → # of CCQE of numu, numubar, nue, nuebar is increased by 10%.

	# of observations [/10^14pot]	diff. from original value
CCQE + 10%	0.813	+3.7%
CC1Pi + 20%	0.829	+5.7%
CC other + 20%	0.829	+5.7%
NC + 30%	0.798	+1.8%

only about horizontal modules
Original of observations is 0.784 / 10^14 pot

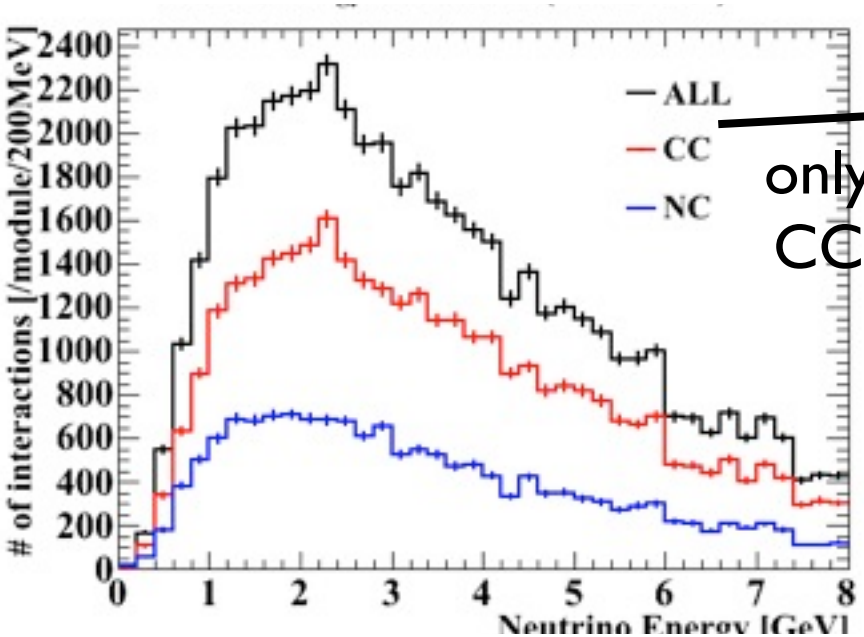
Summary

- Compare MC with Beam data after neutrino event selection.
  - Compare at some basic plots. There is not so much difference.
- Calculate the efficiency curve of each interaction mode at numu, numubar, nue, nuebar.
- Estimate the expected # of neutrino observation at INGRID when horn 250kA.
- Estimate the effect from neutrino cross-section uncertainty on # of observation at INGRID.
  - This is first step. Start to collaborate closely with others (Neutrino working group, etc).
- Now, progress in study of beam profile of INGRID at some beam condition (when beam position shifted, etc).

Back up

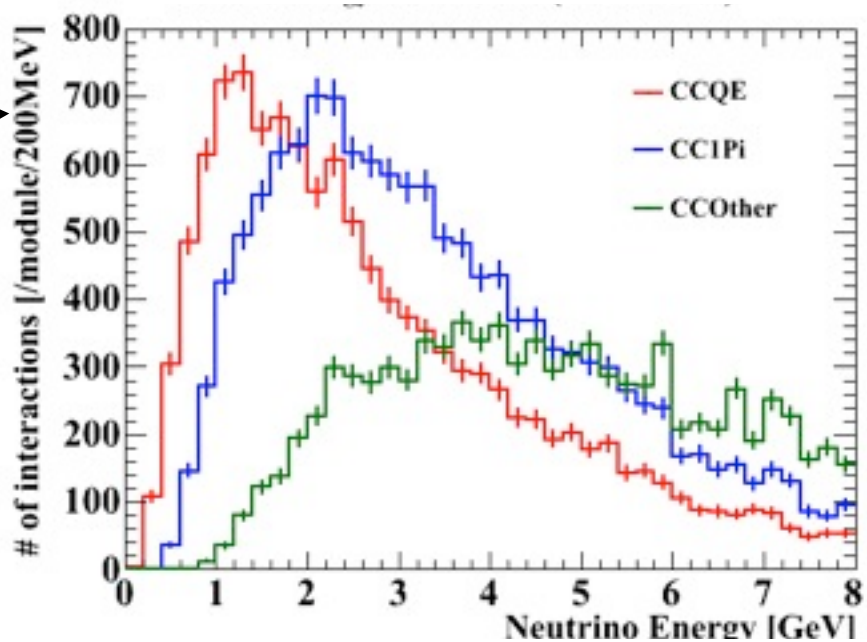
Neutrino selection efficiency (numubar, ~6.64e19pot)

of interaction in H.mods

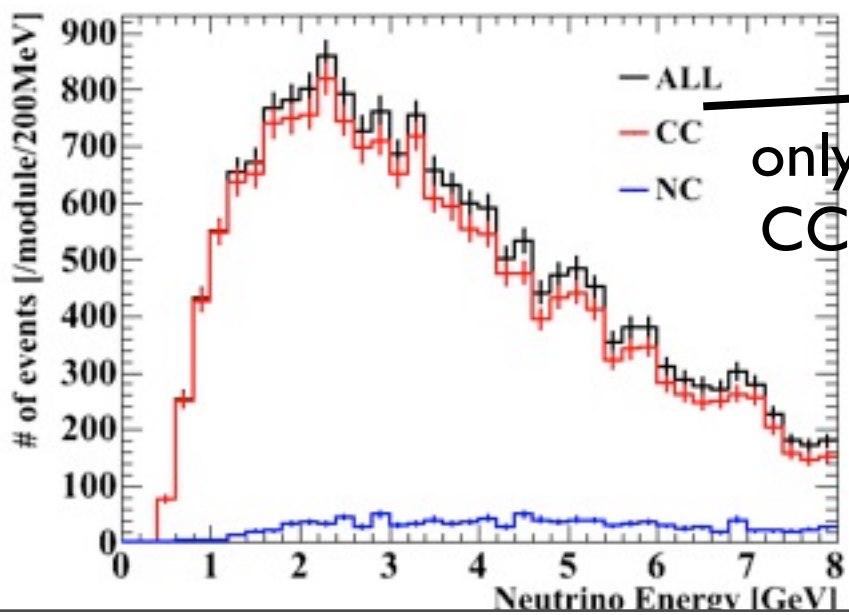


only CC

# of interaction in H.mods

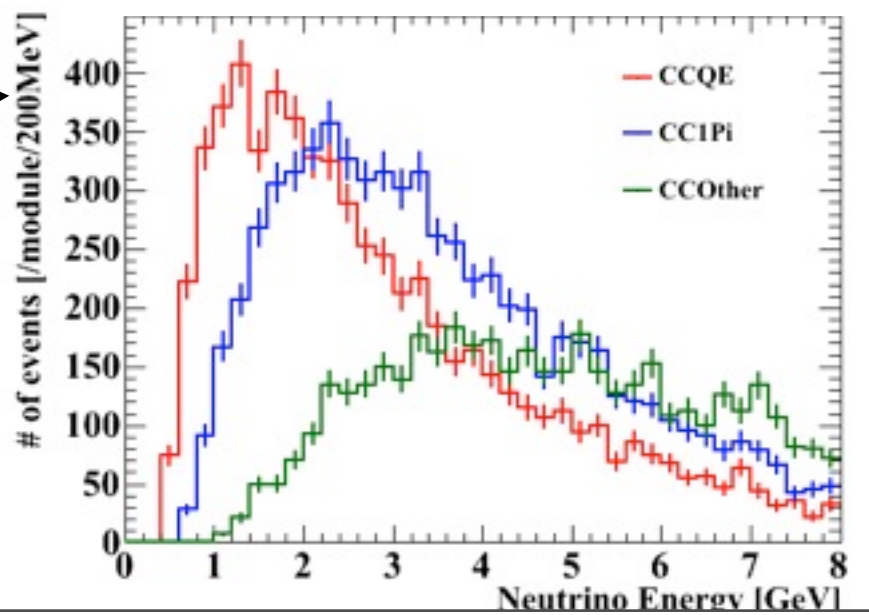


# of observations in H.mods



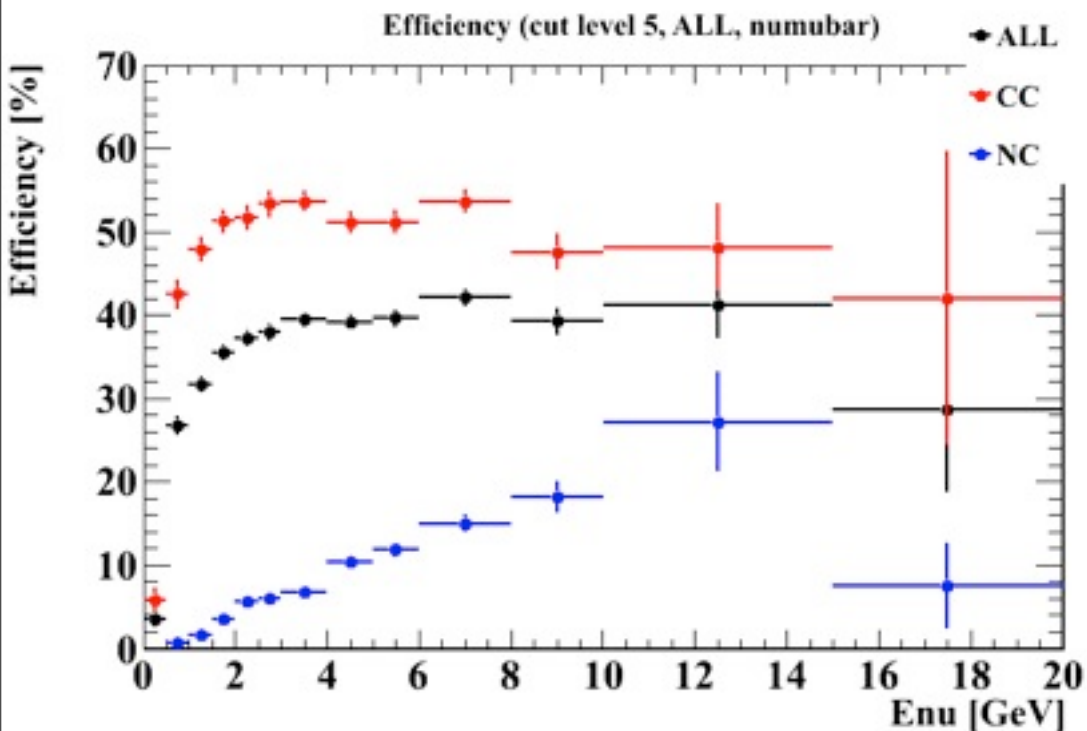
only CC

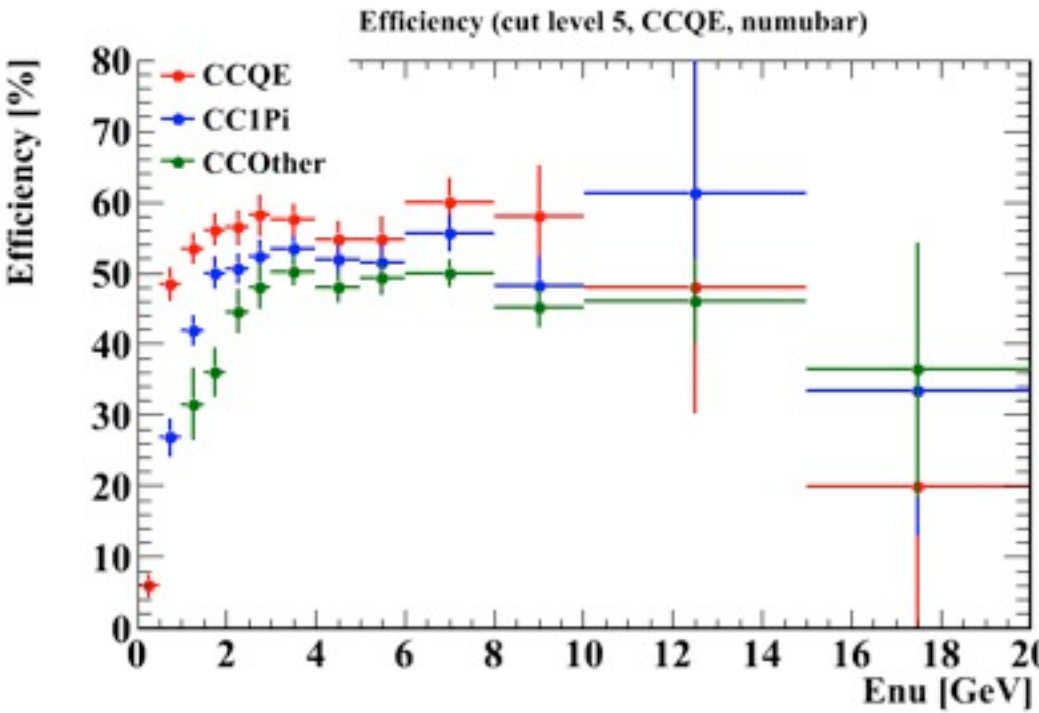
# of observations in H.mods



Neutrino selection efficiency (numubar)

calc mean of efficiency of horizontal modules for reduction of the statistics error.

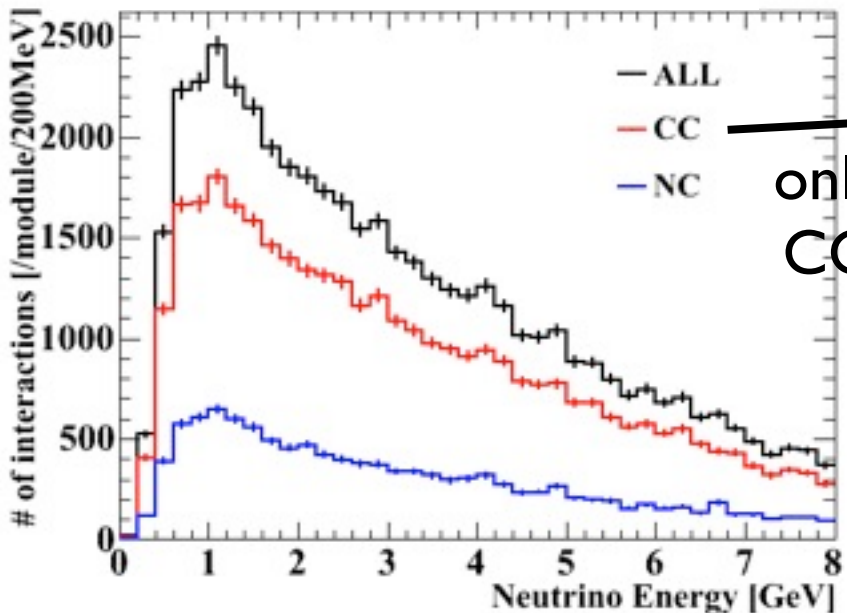




(only statistics error)

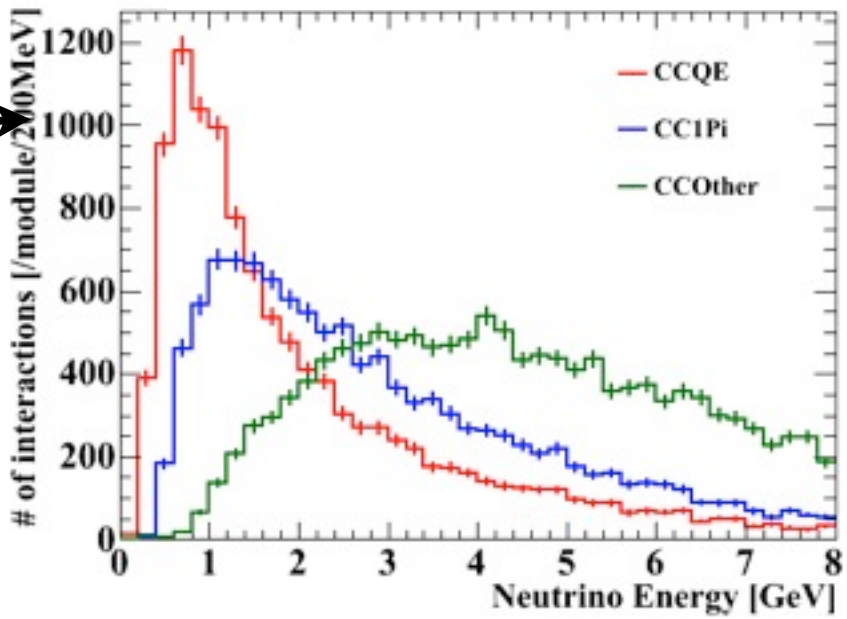
Neutrino selection efficiency (nue,~2.42e20pot)

of interaction in H.mods

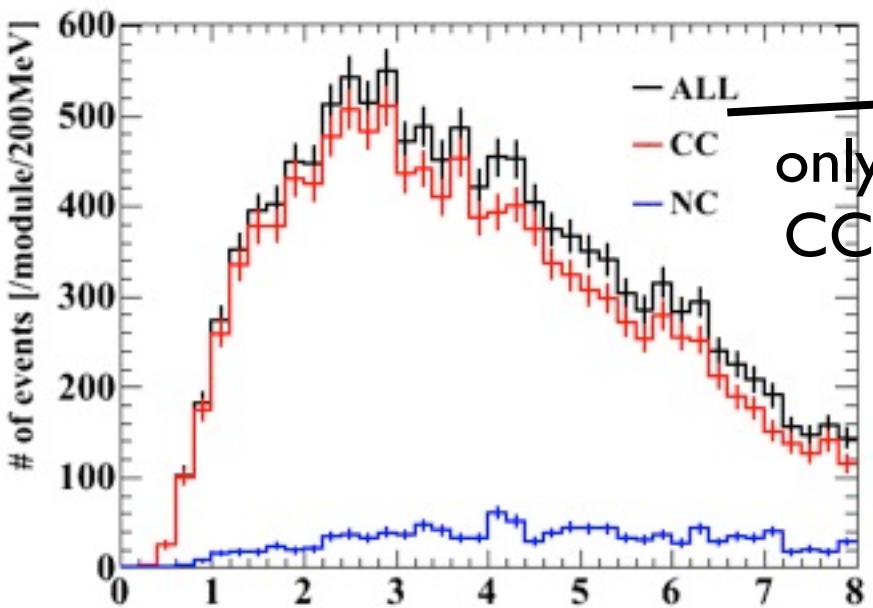


only CC

# of interaction in H.mods



# of observations in H.mods



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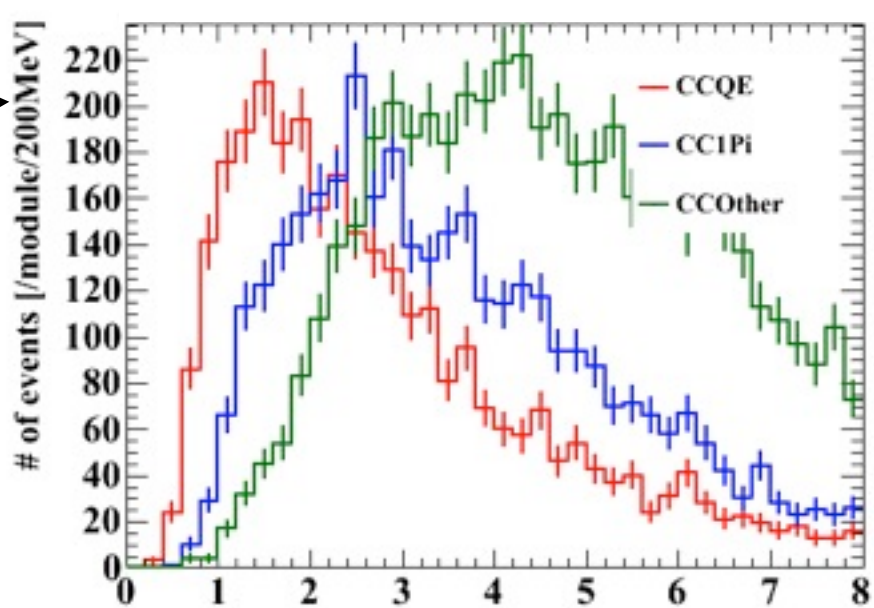
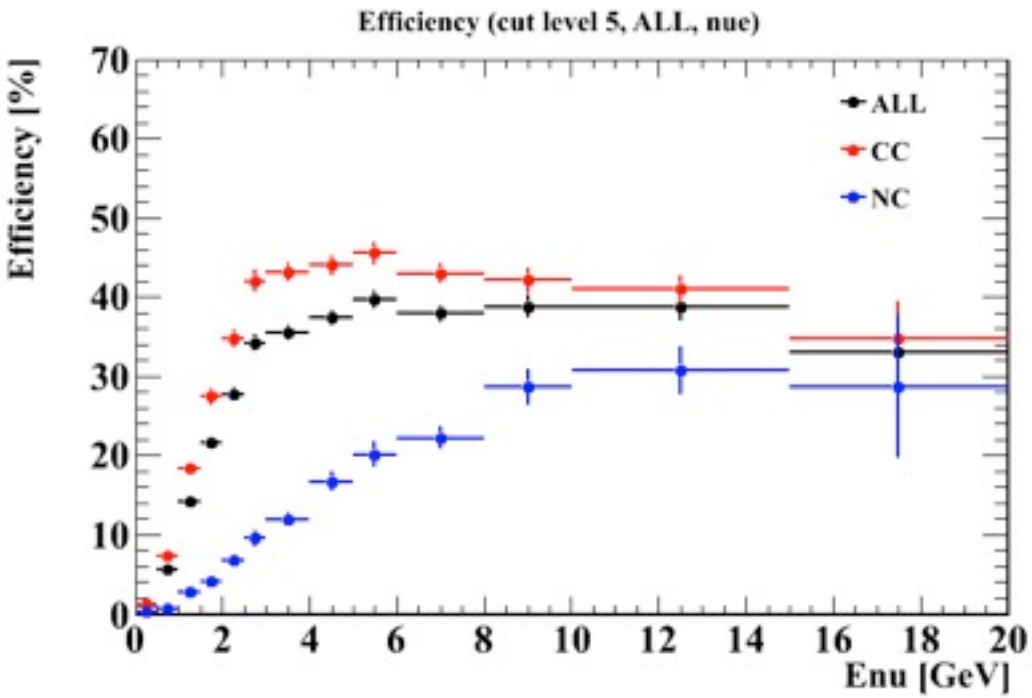
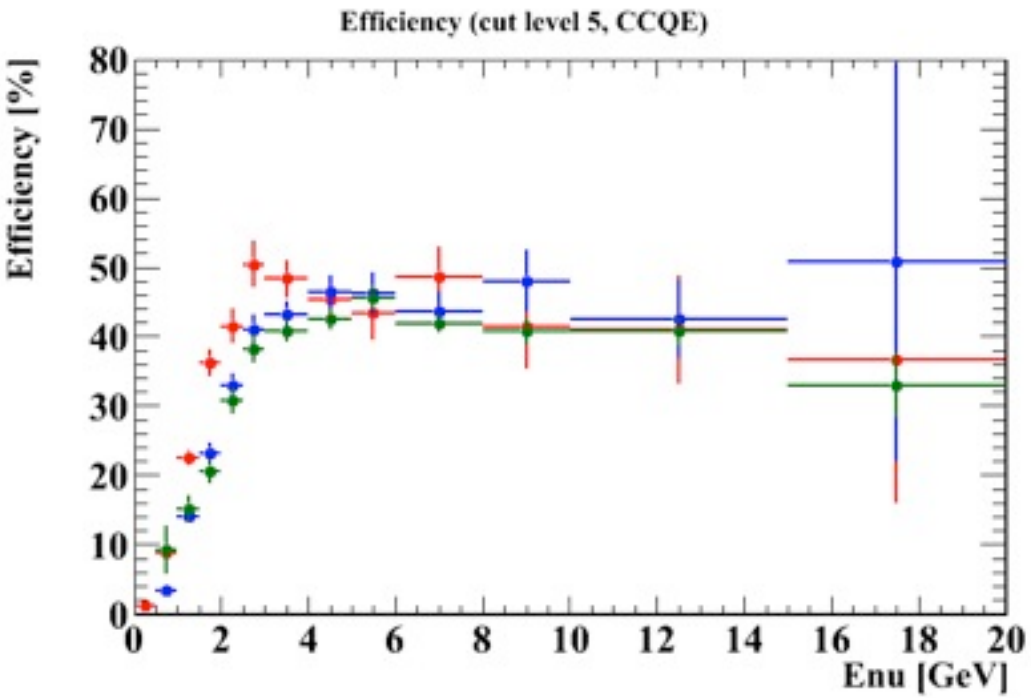
# of observations in H.mods



Neutrino selection efficiency (nue)

calc mean of efficiency of horizontal modules for reduction of the statistics error.

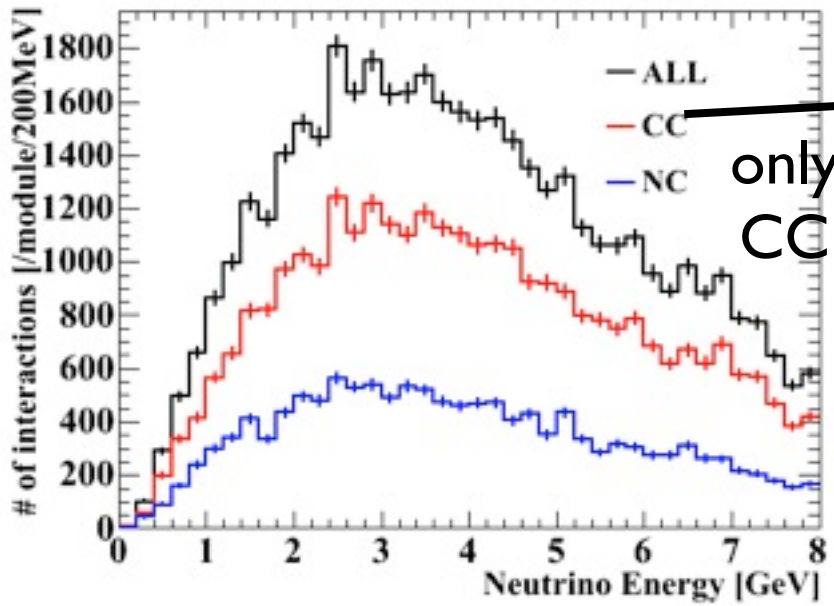




(only statistics error)

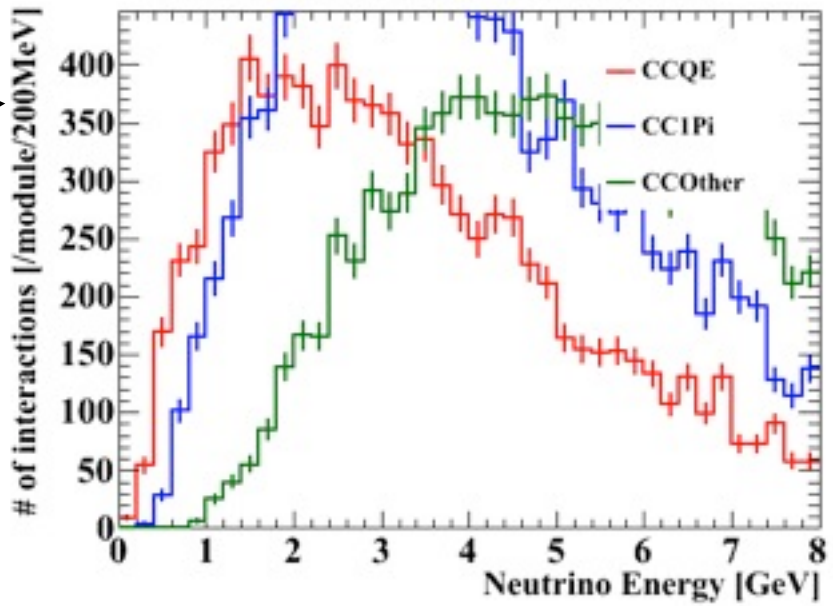
Neutrino selection efficiency (nuebar, ~2.9e21pot)

of interaction in H.mods

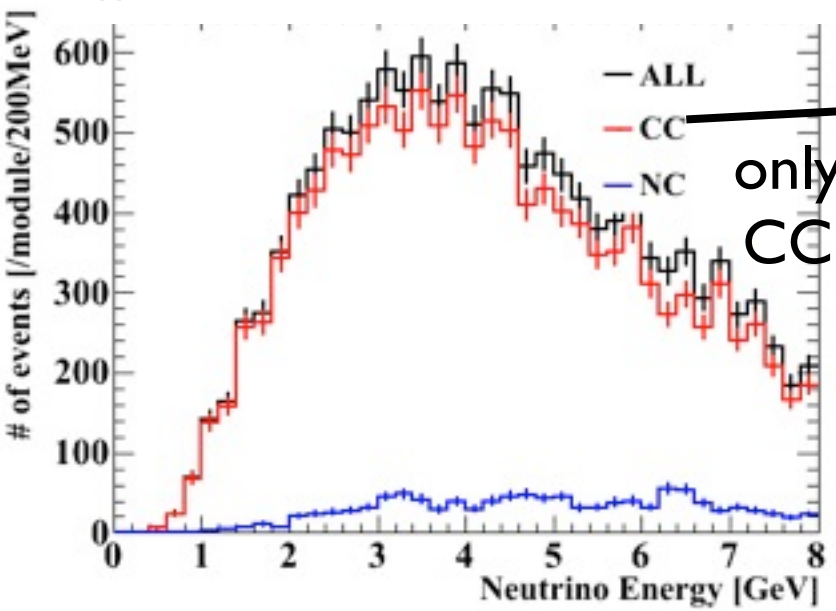


only CC

# of interaction in H.mods



# of observations in H.mods



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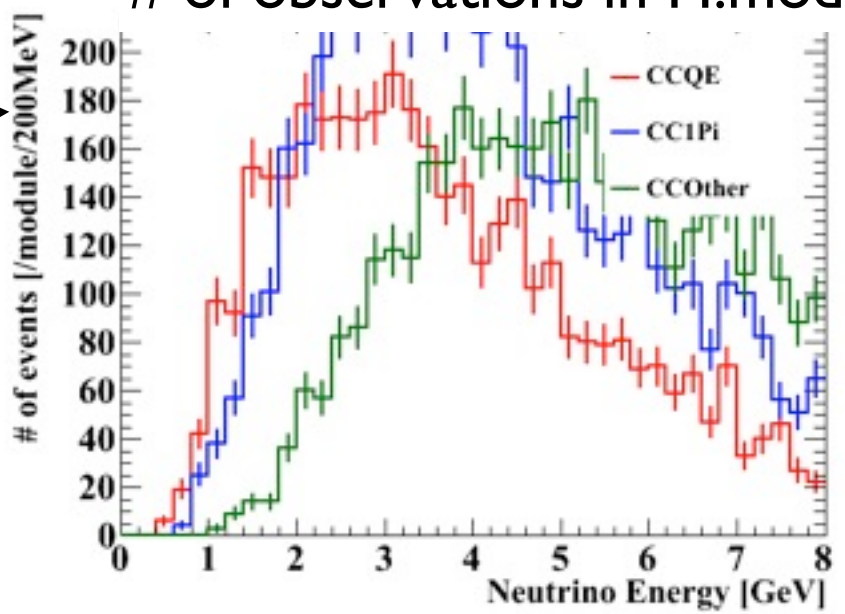
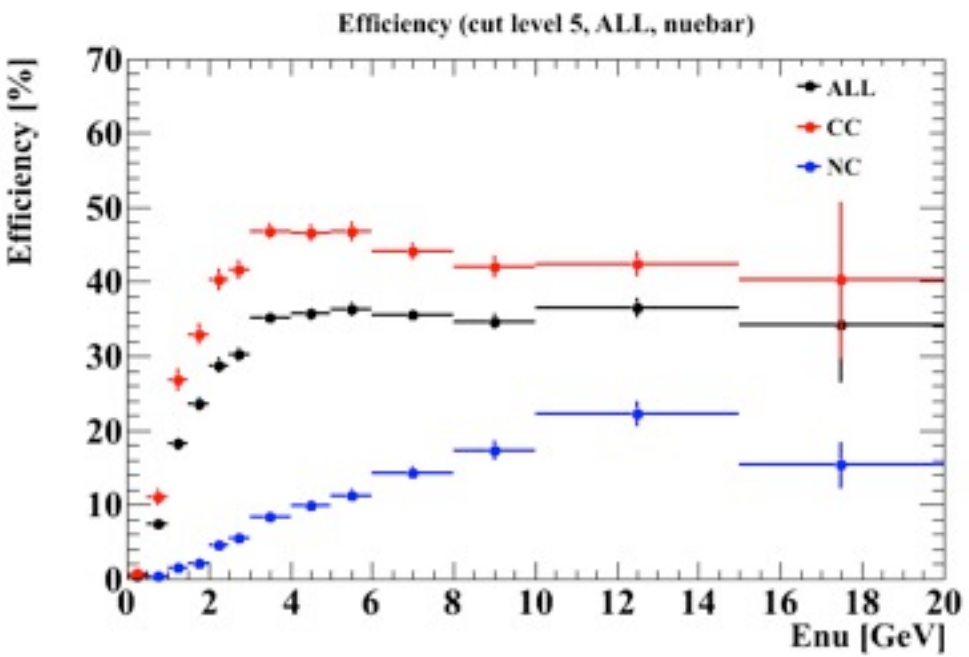
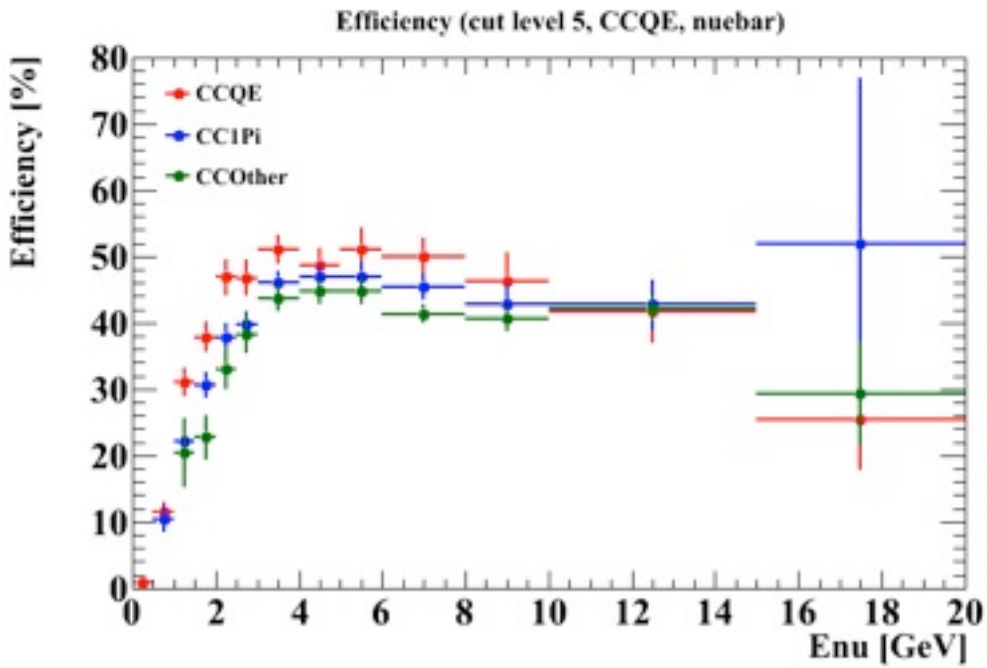
# of observations in H.mods



Neutrino selection efficiency (nue)

calc mean of efficiency of horizontal modules for reduction of the statistics error.





(only statistics error)