INGRID MC Work

A.Murakami

New Jnubeam Flux

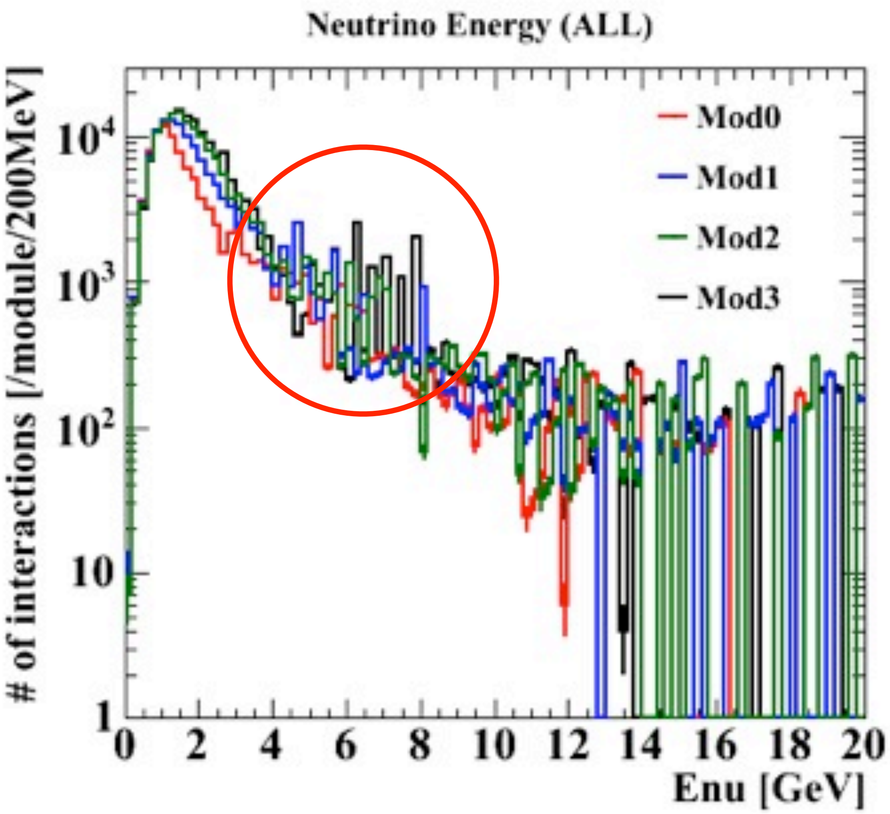
- Again INGRID MC by using the new Jnubeam Flux file (jnubeam 10b)
  - improve the problem that the same jnubeam flux entry is used some times.
- The check the neutrino energy spectrum.

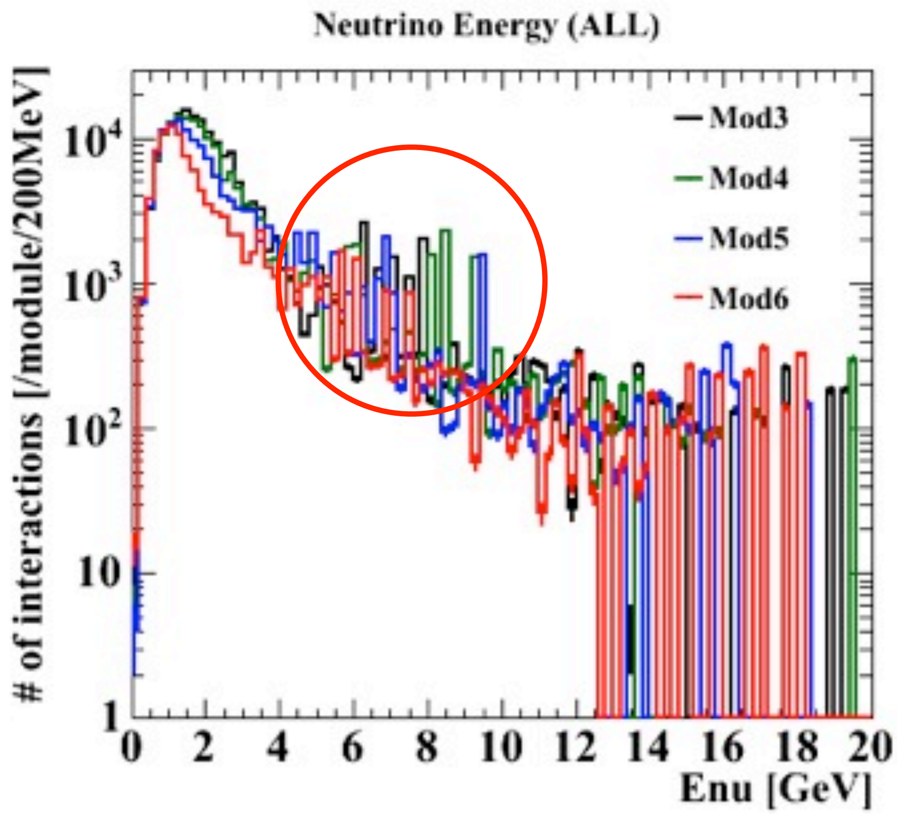
Data set

- Jnubeam 10b(by kubo-san) × 1000 file ~ 1.5×10^7
- NEUT 80entries/file × 1000 file = 8e4 entries
- Only numu interactions

Neutrino energy spectrum

previous neutrino Flux (jnubeam10a)

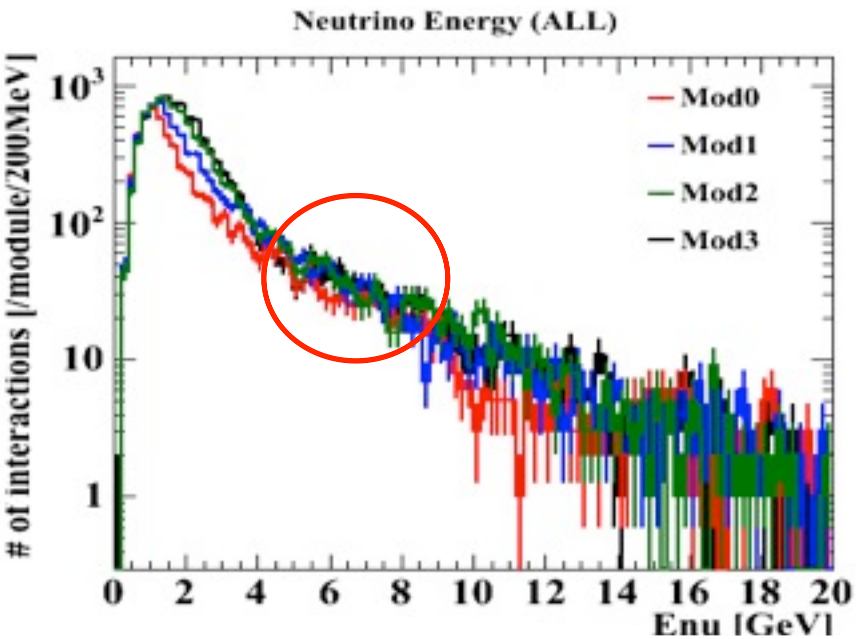


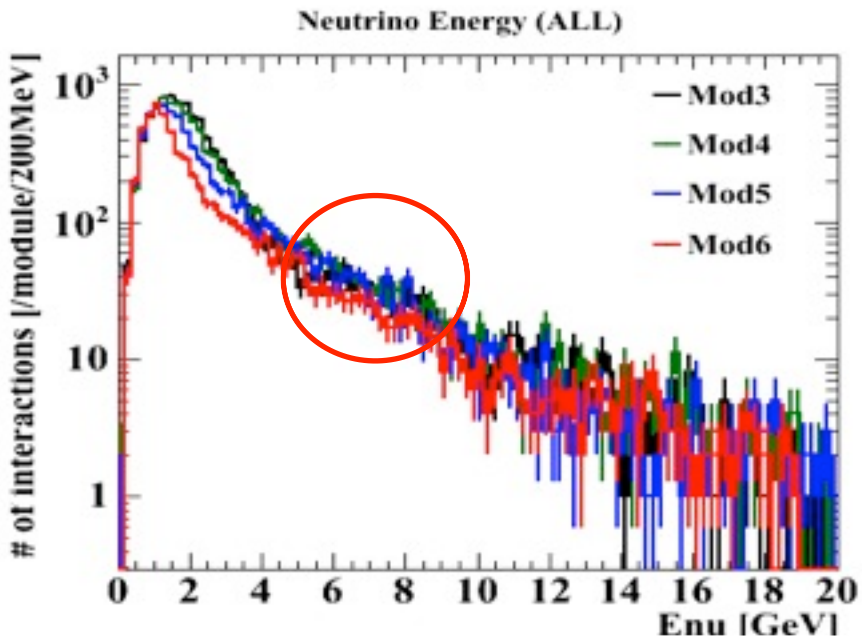


At high energy region, these are some peaks
(because, same entries of one Flux file are used some times.)

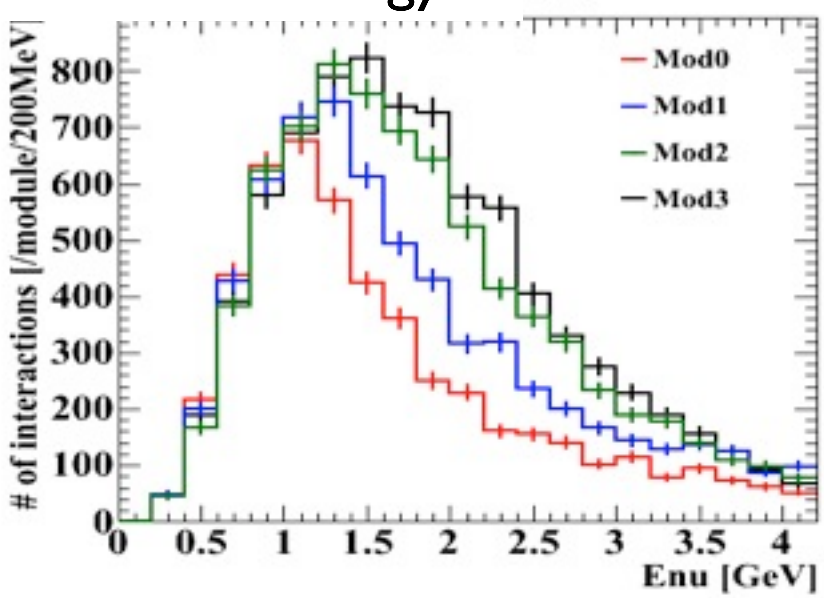
After improved Flux(jnubeam10b)

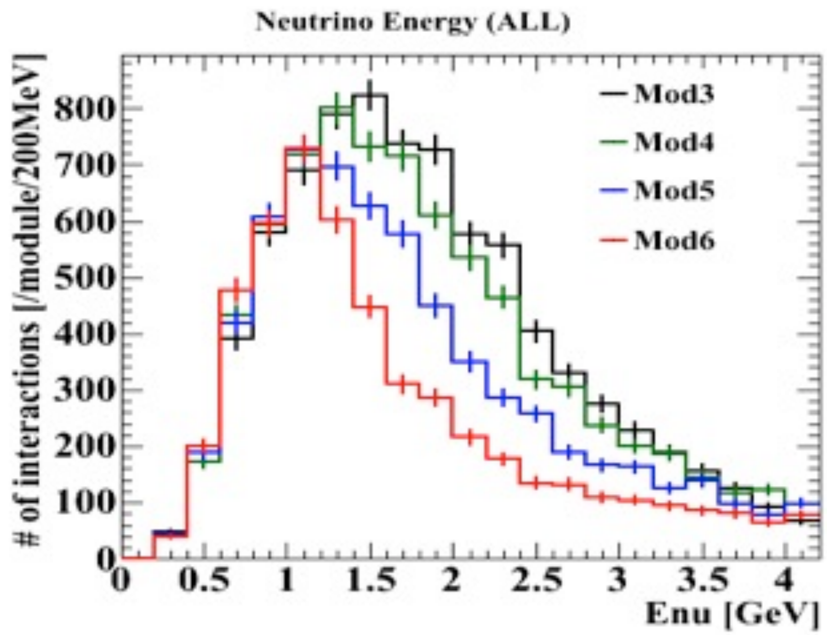
MC True neutrino energy (horizontals)





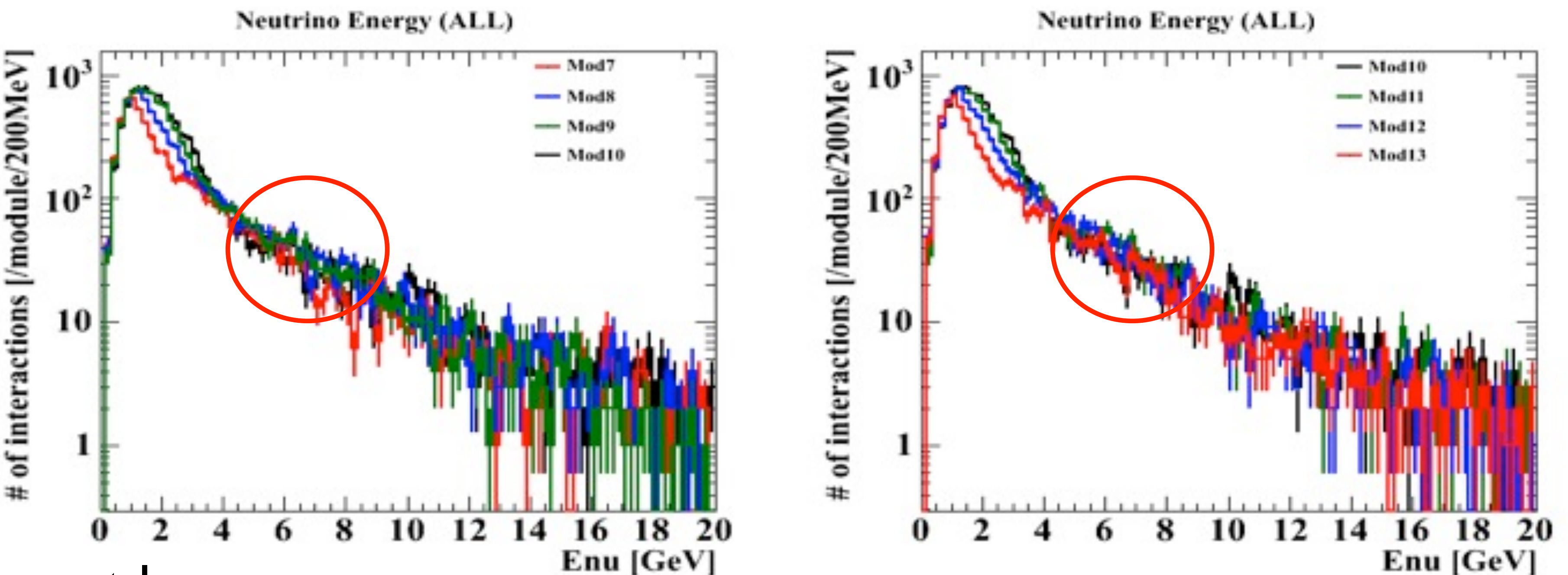
Zoom at low energy



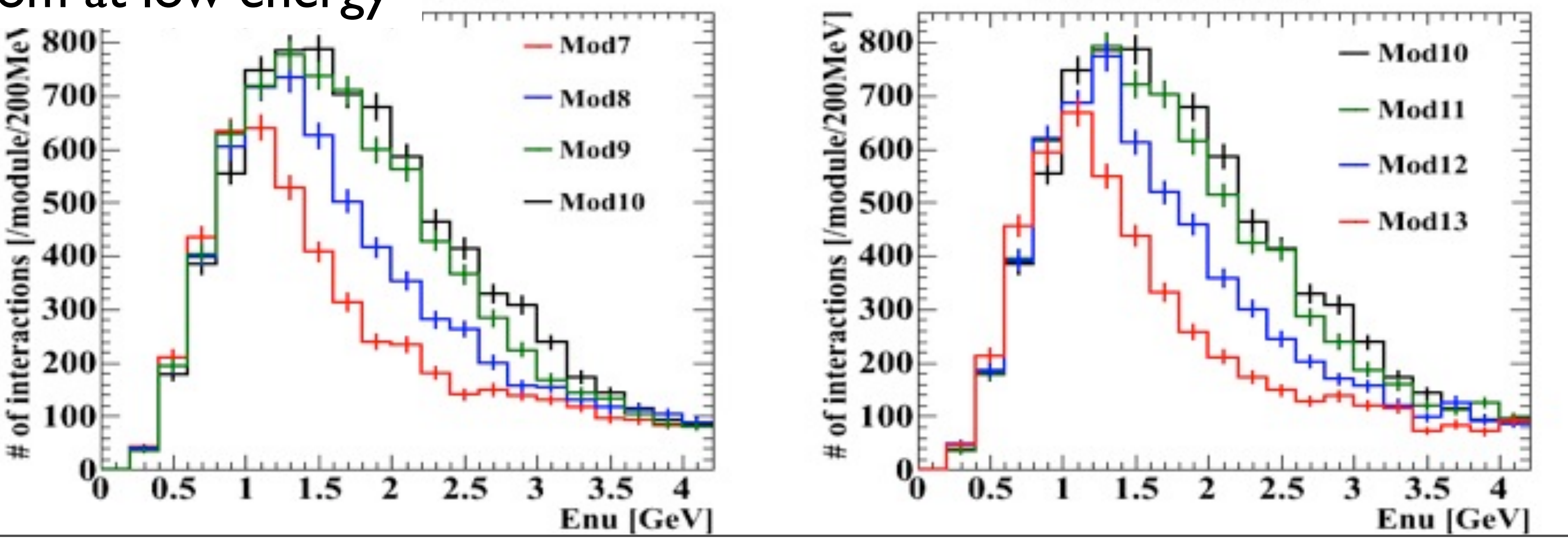


After improved Flux(jnubeam10b)

MC True neutrino energy (verticals)



Zoom at low energy

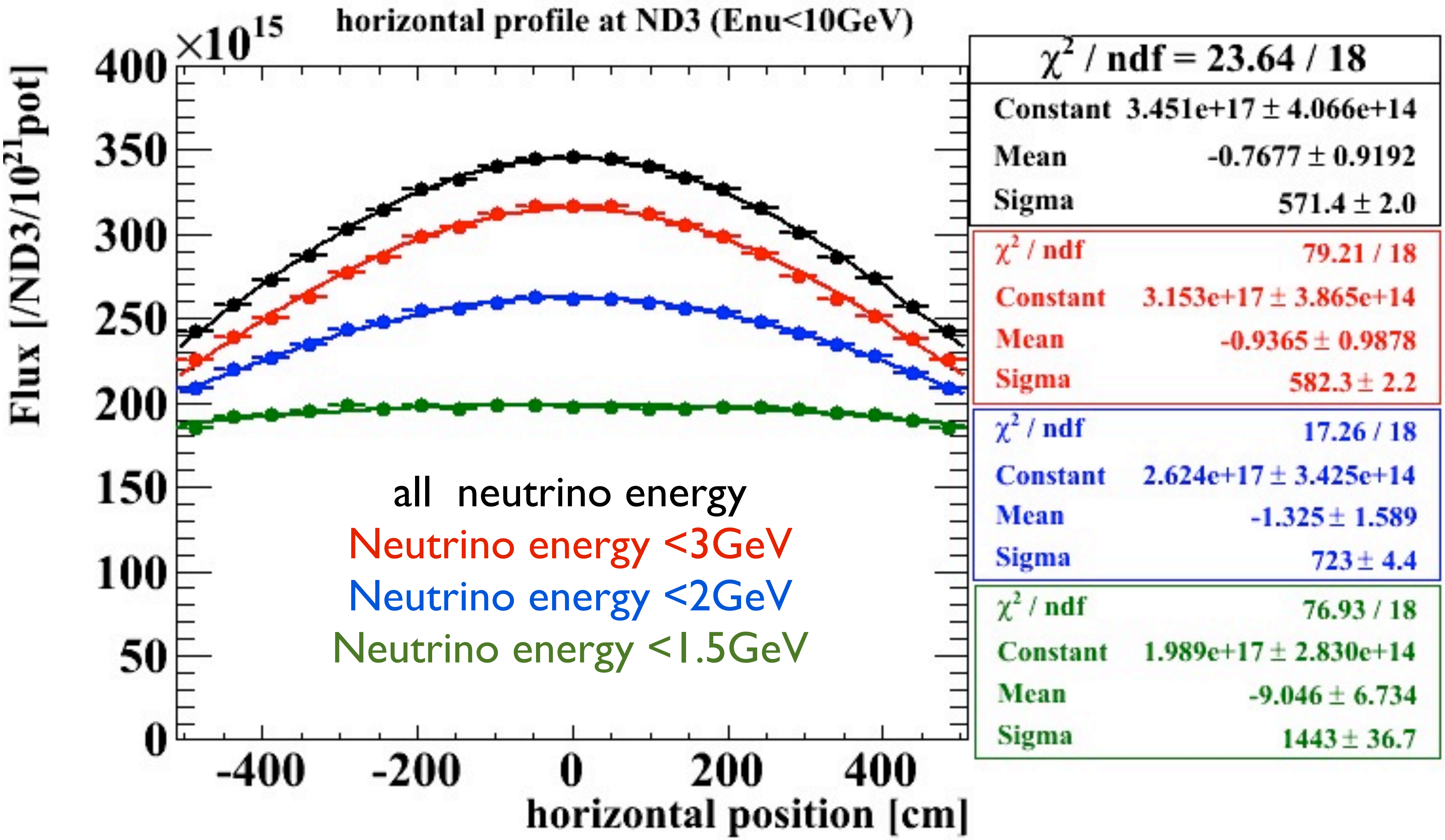


- The peak at high energy region disappeared.
  - Improve the problem.

Beam Profile

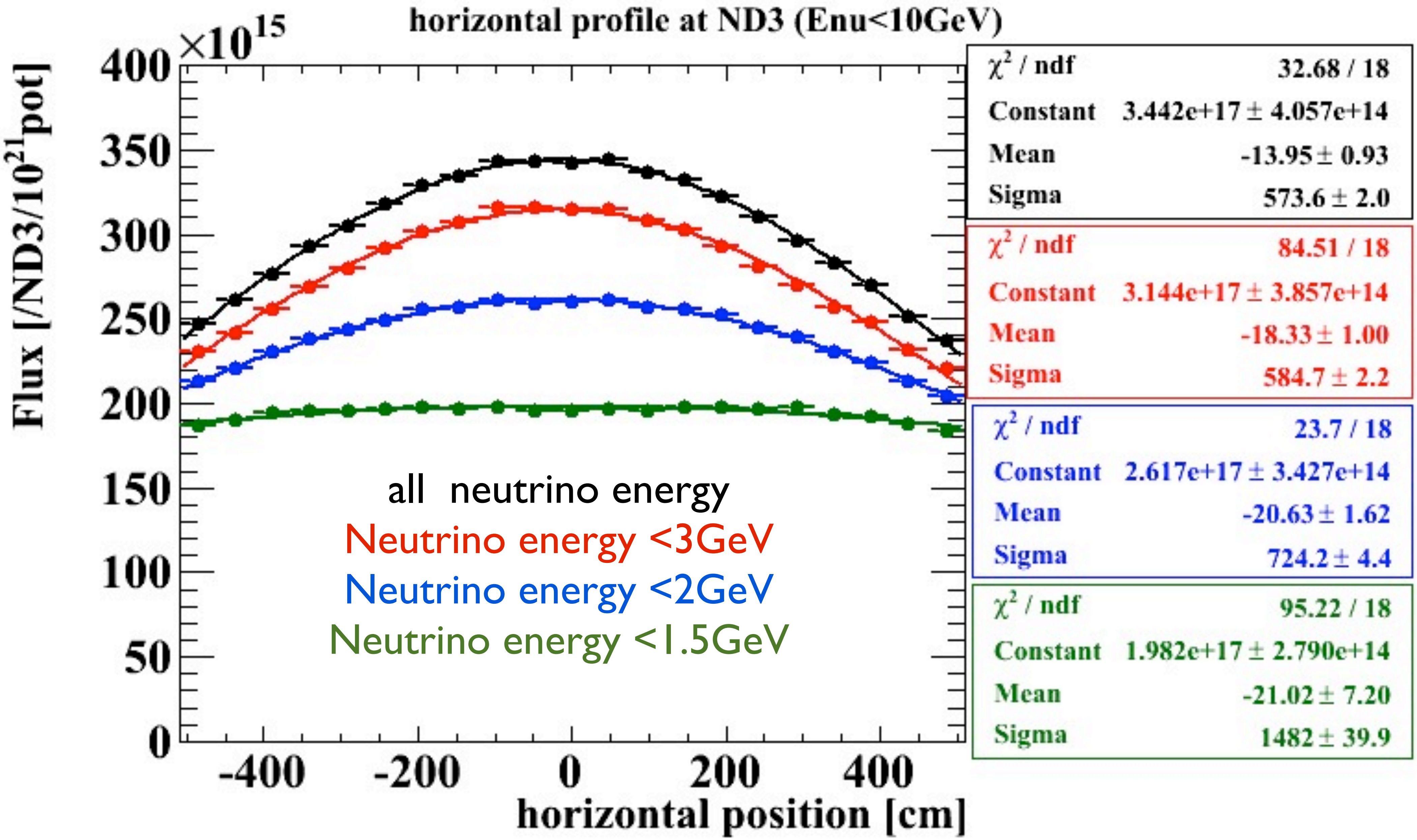
- Check beam profile at each step (two primary proton beam condition).
  - Flux (nominal , x+2mm shifted) : Flux into INGRID area.
  - Interact (nominal, x+2mm shifted) : interact in modules
  - Observe (after "neutrino event selection", nominal, x+2mm shifted) : observe the events after "neutrino event selection".
- I want to check whether INGRID can measure the shift of beam profile when the primary proton beam is shifted from the center of the target.
- Now, consider only statistics error.

Beam Profile (horizontal)
(Flux,nominal)

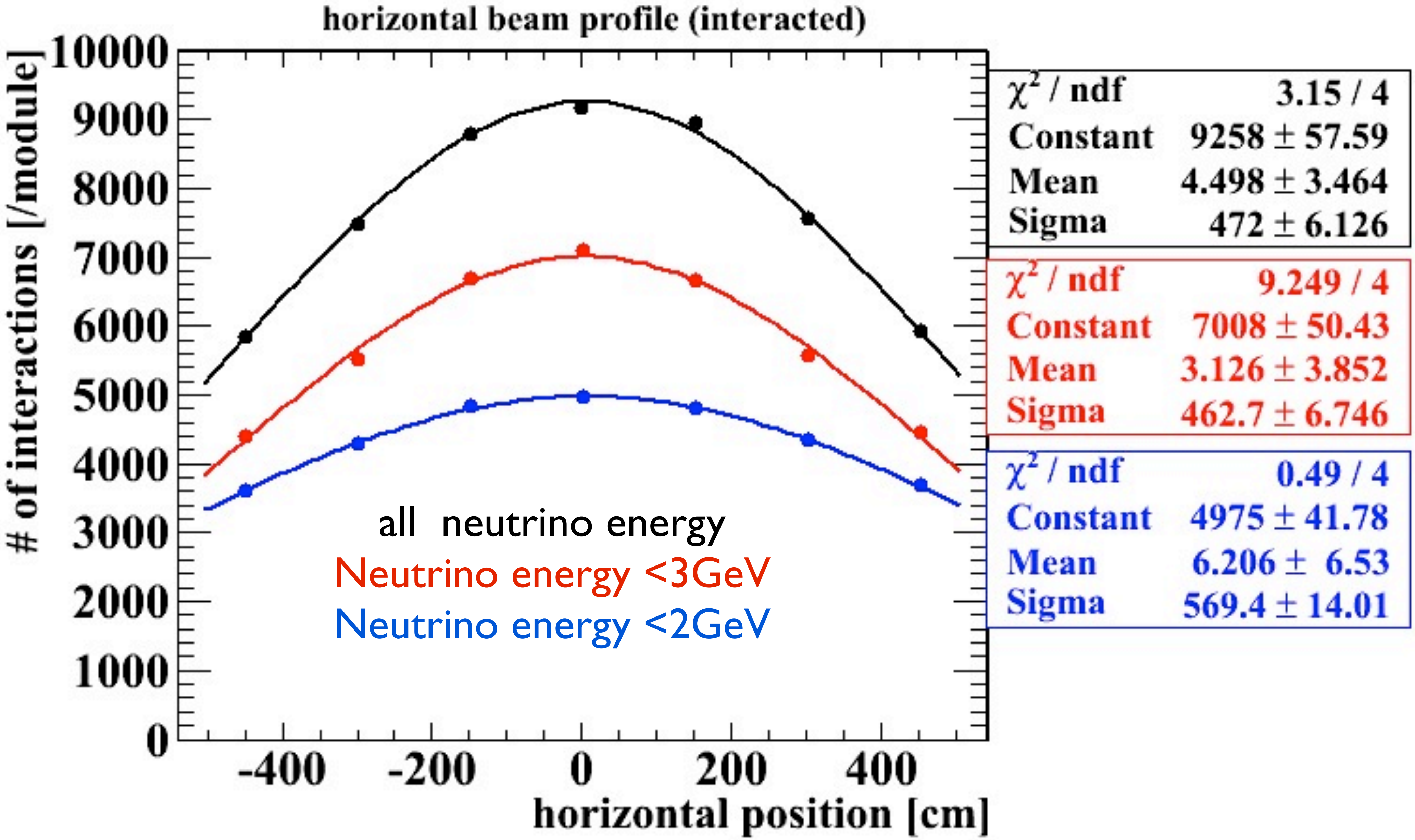


Beam Profile (horizontal)

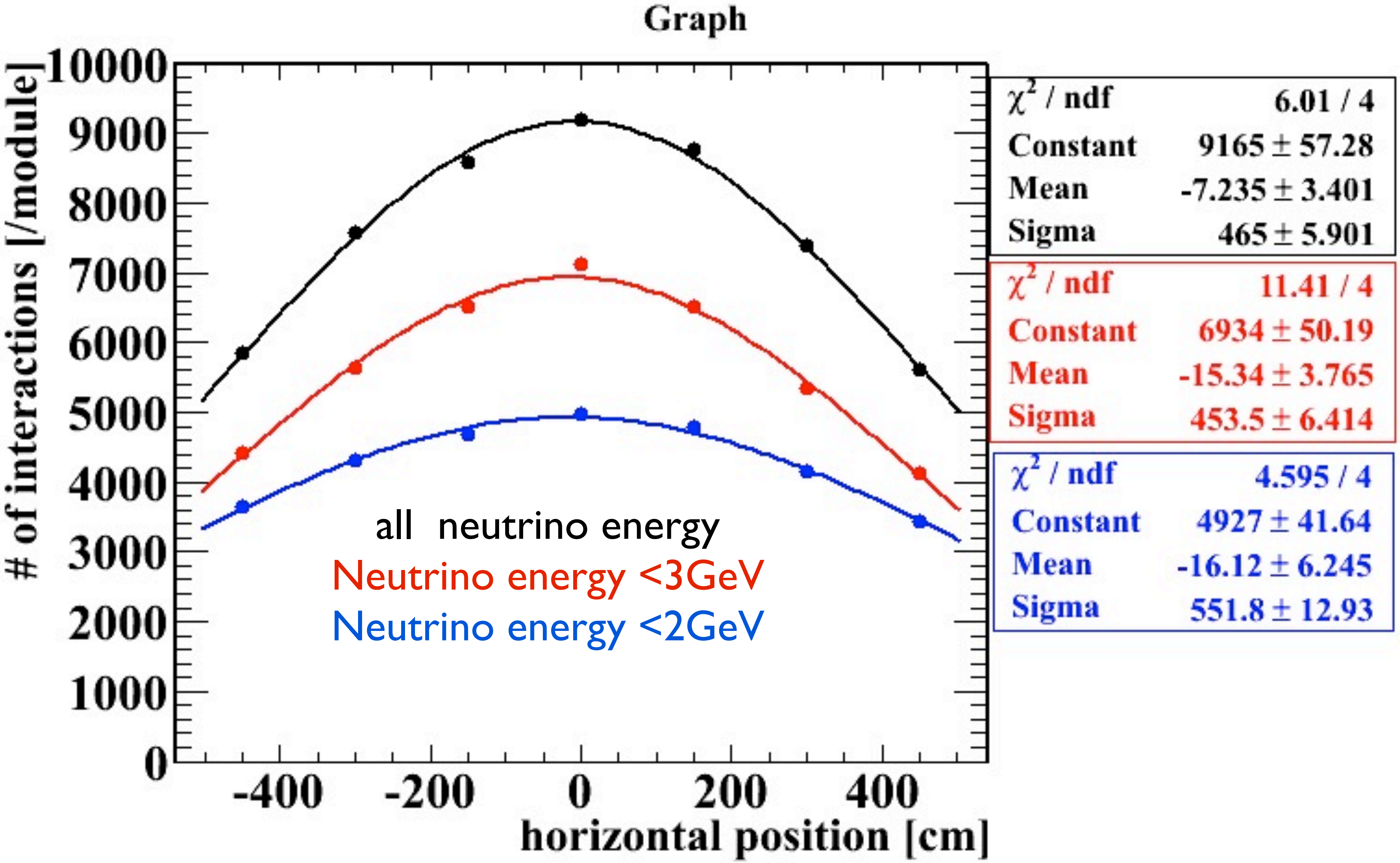
(Flux,x+2mm)



Beam Profile (horizontal)
(interaction, nominal)

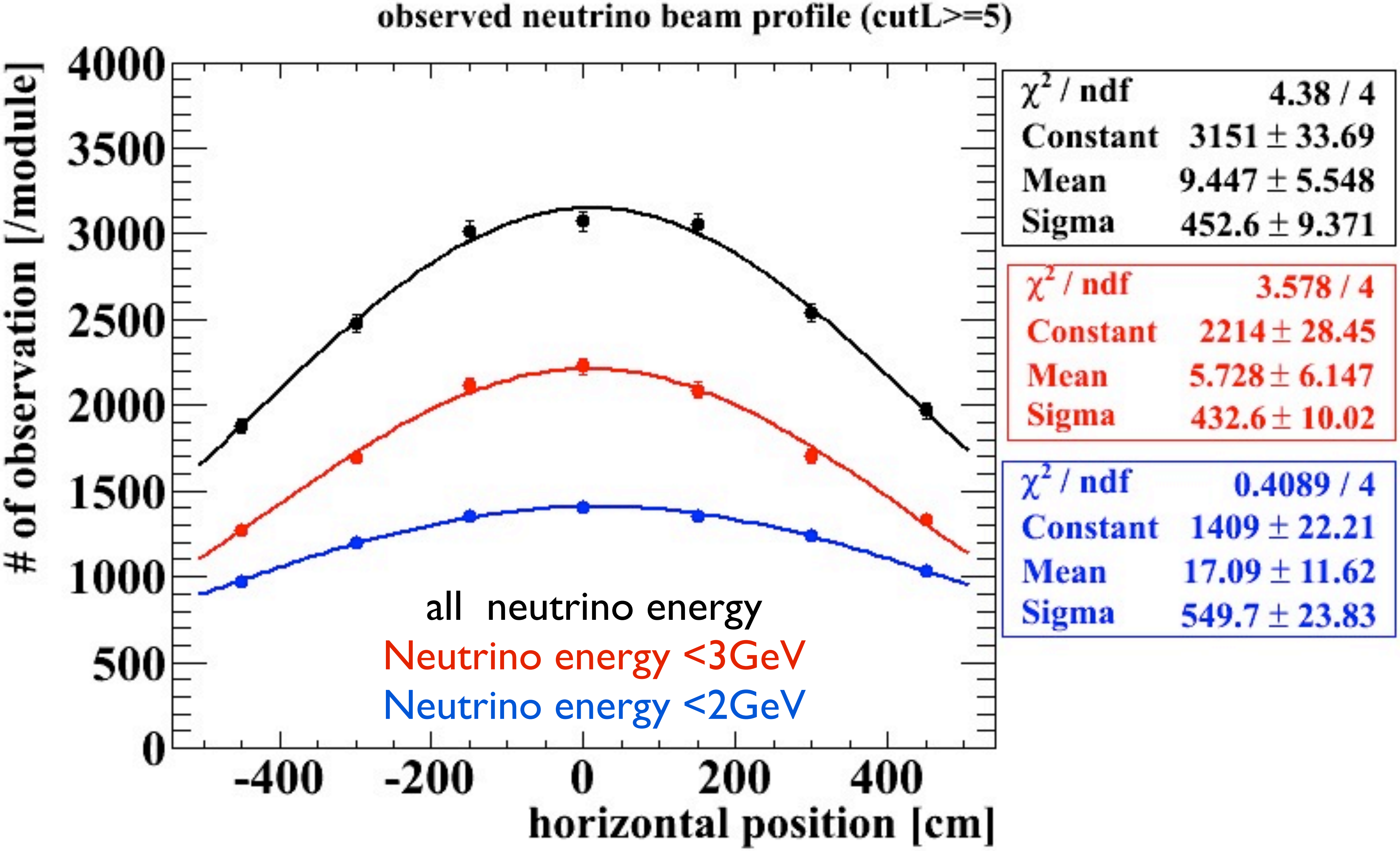


Beam Profile (horizontal)
(interaction, x+2mm)

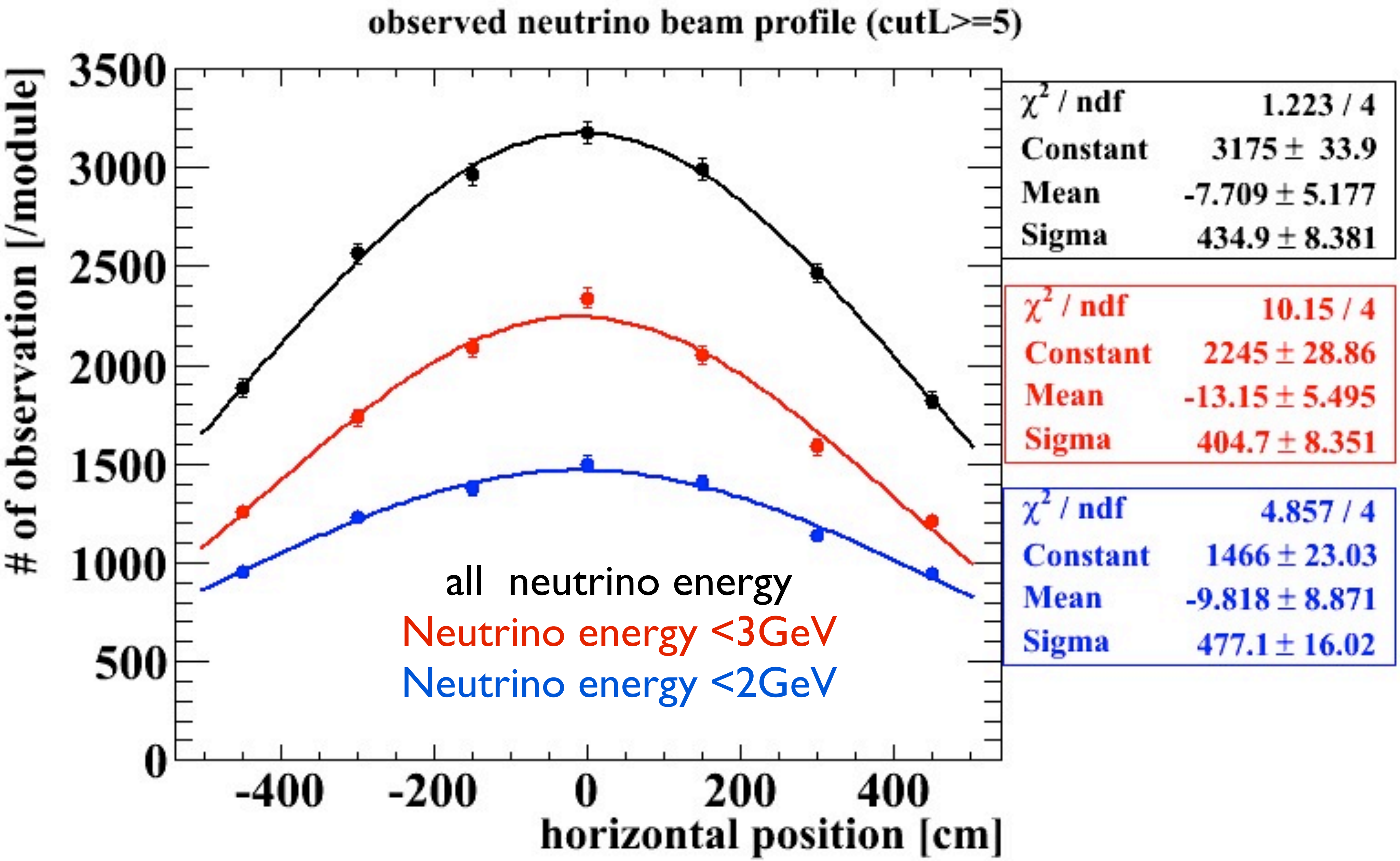


Beam Profile (horizontal)

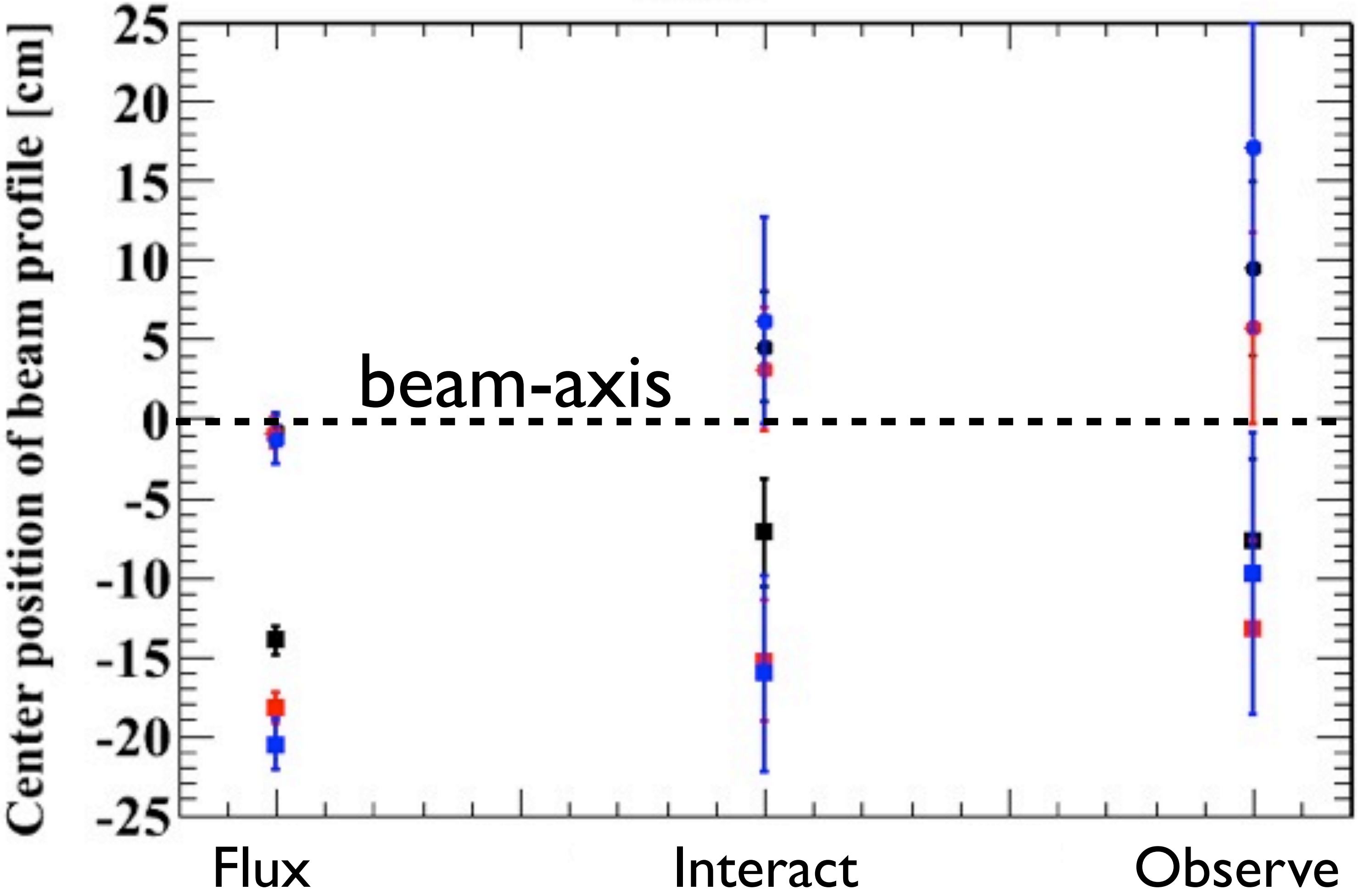
(observation, nominal)



Beam Profile (horizontal)
(observation, x+2mm)



Center of Beam Profile (horizontal)



Black : all energy
Red : Energy < 3GeV
Bule : Energy < 2GeV

● : nominal beam
■ : x+2mm

1mrad diff. = 28cm
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More sensitive to the diff. of beam center from beam-axis by energy cut.
→ But fitting error is large, need more statistics

Efficiency(E) of "neutrino selection"

- Calc. efficiency of event selection, which is same as beam data analysis.

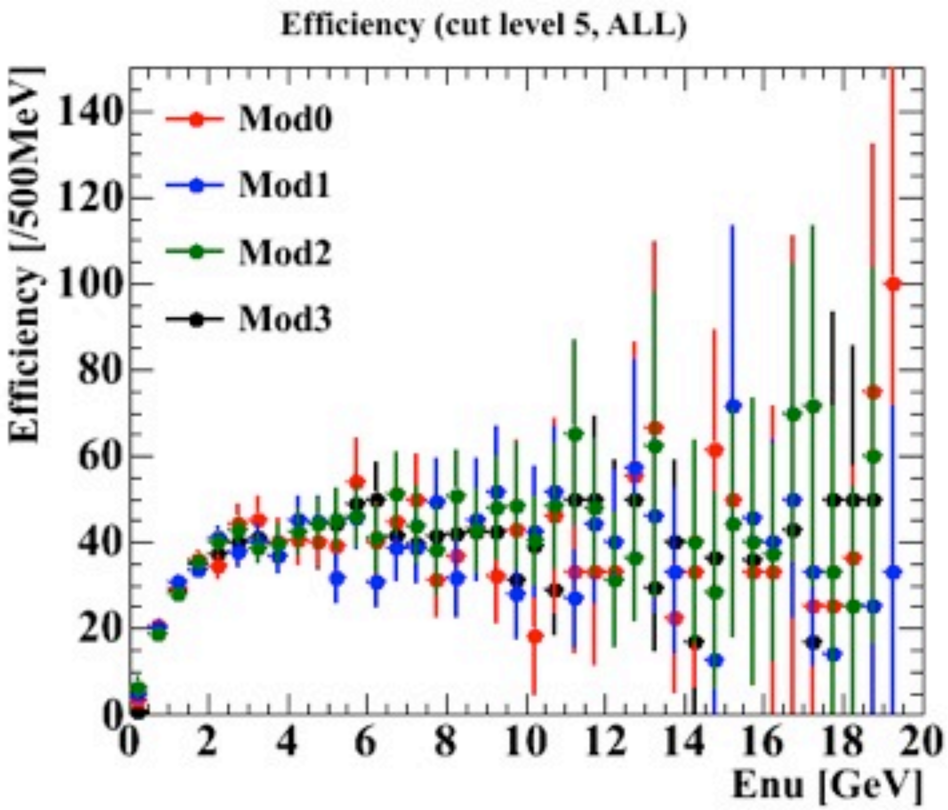
$$\text{Efficiency}(E) = \Phi_{obs}(E) / \Phi_{int}(E) \times 100\ [\%]$$
Φ_{obs} = # of events after event selection
Φ_{int} = # of interactions in a module

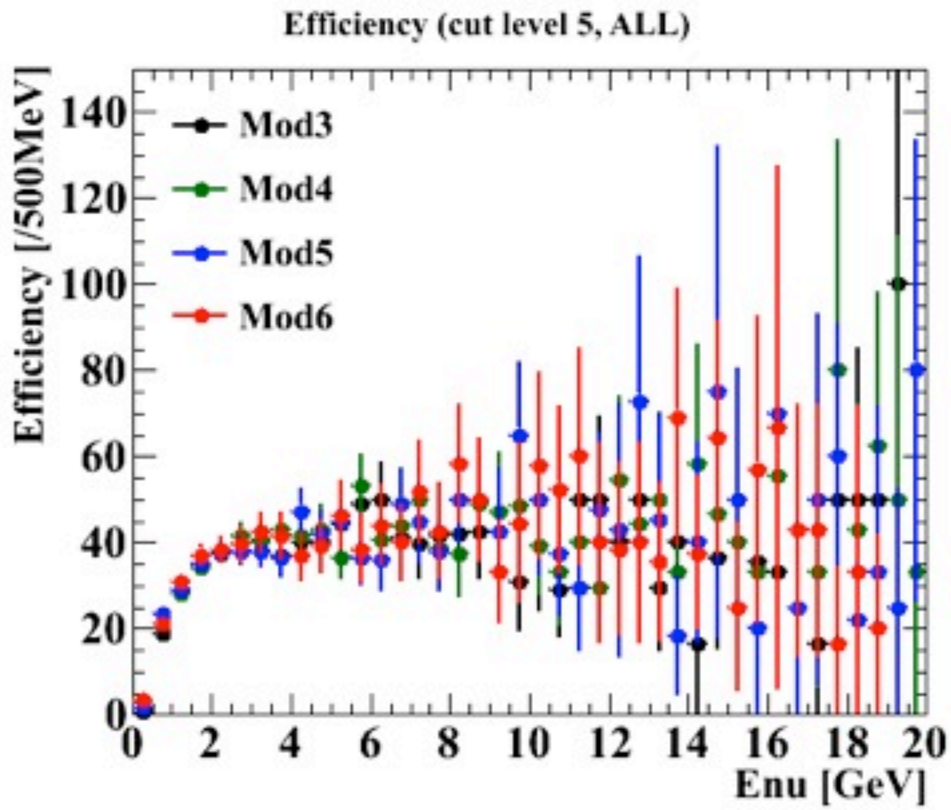
- I also check the efficiency at each neutrino interaction mode (CC, CCQE, CC-nonQE, NC)

$$\text{Efficiency}(E) = \Phi^{mode}{}_{obs}(E) / \Phi^{mode}{}_{int}(E) \times 100\ [\%]$$
$\Phi^{mode}{}_{obs}$ = # of events after event selection at each interaction mode
$\Phi^{mode}{}_{int}$ = # of interactions in a module at each interaction mode

Efficiency(E) of "neutrino selection"

All neutrino interaction, at horizontal modules



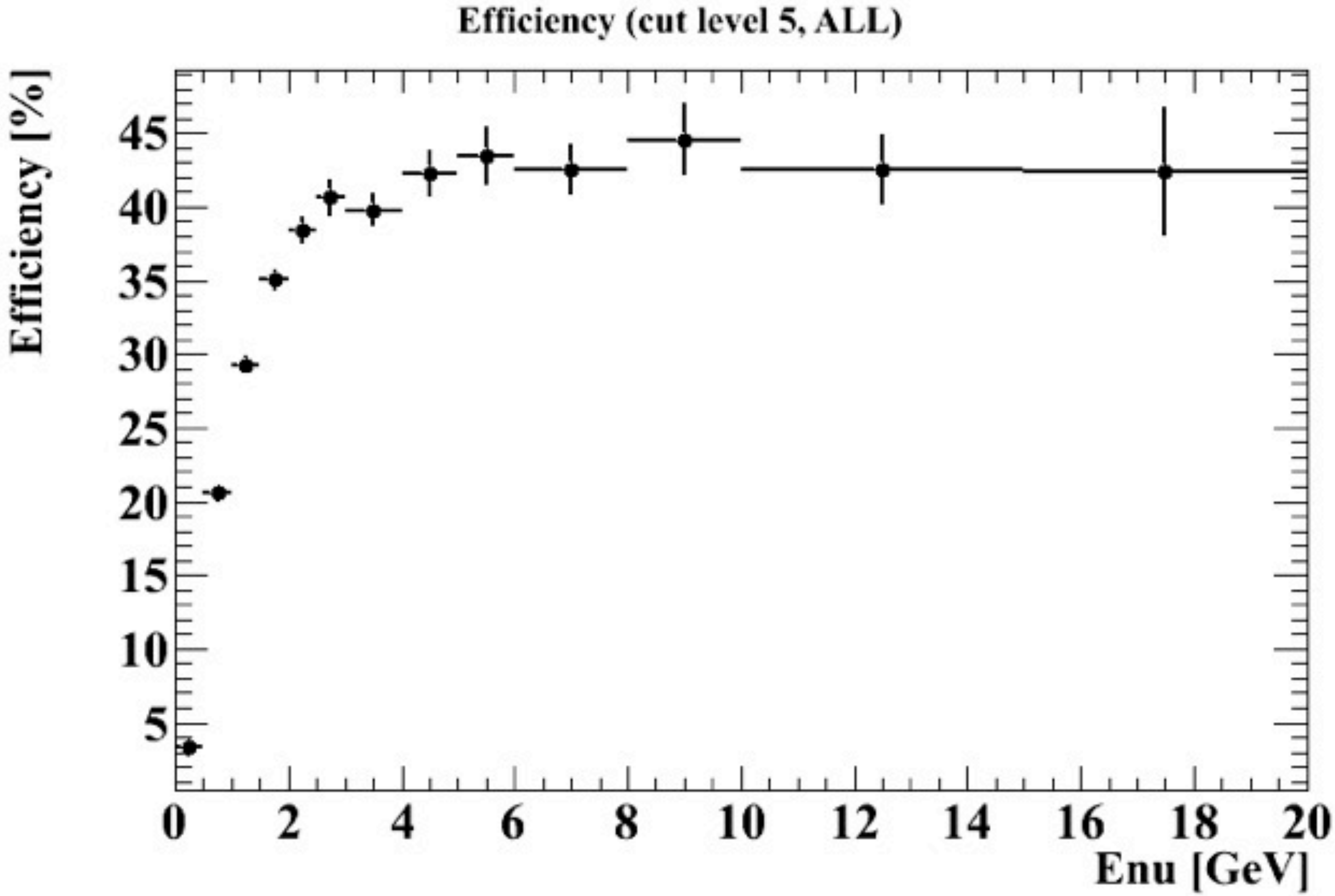


Fluctuation of efficiency is large (consider only statistic error) .

→ Mean efficiency of horizontal modules (7modules).

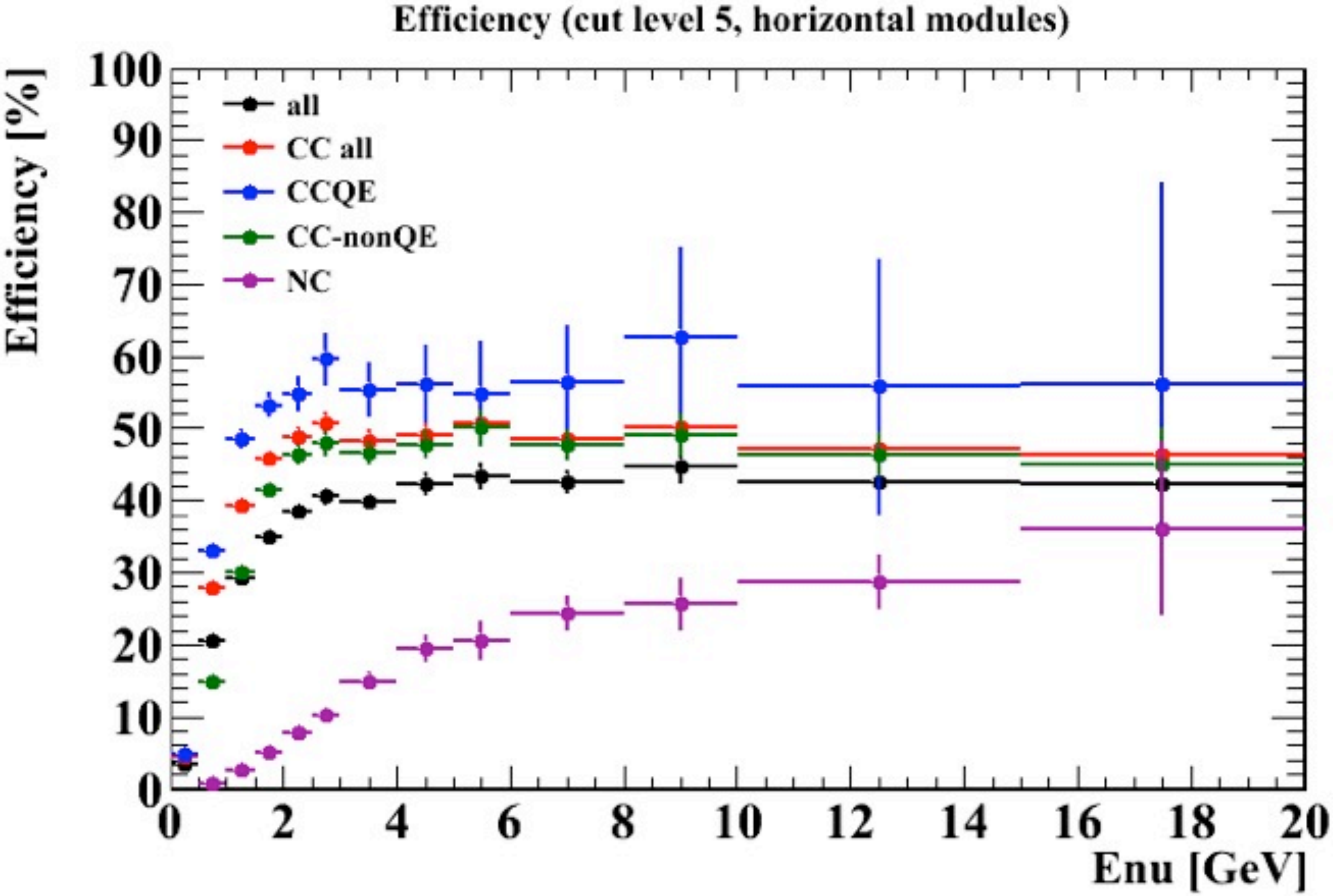
And I change the energy bin size (to make the error lower).

Mean of efficiency(E) of horizontal modules



About other interaction mode (CC, CCQE, CC-nonQE, NC), I also calc mean of efficiency.

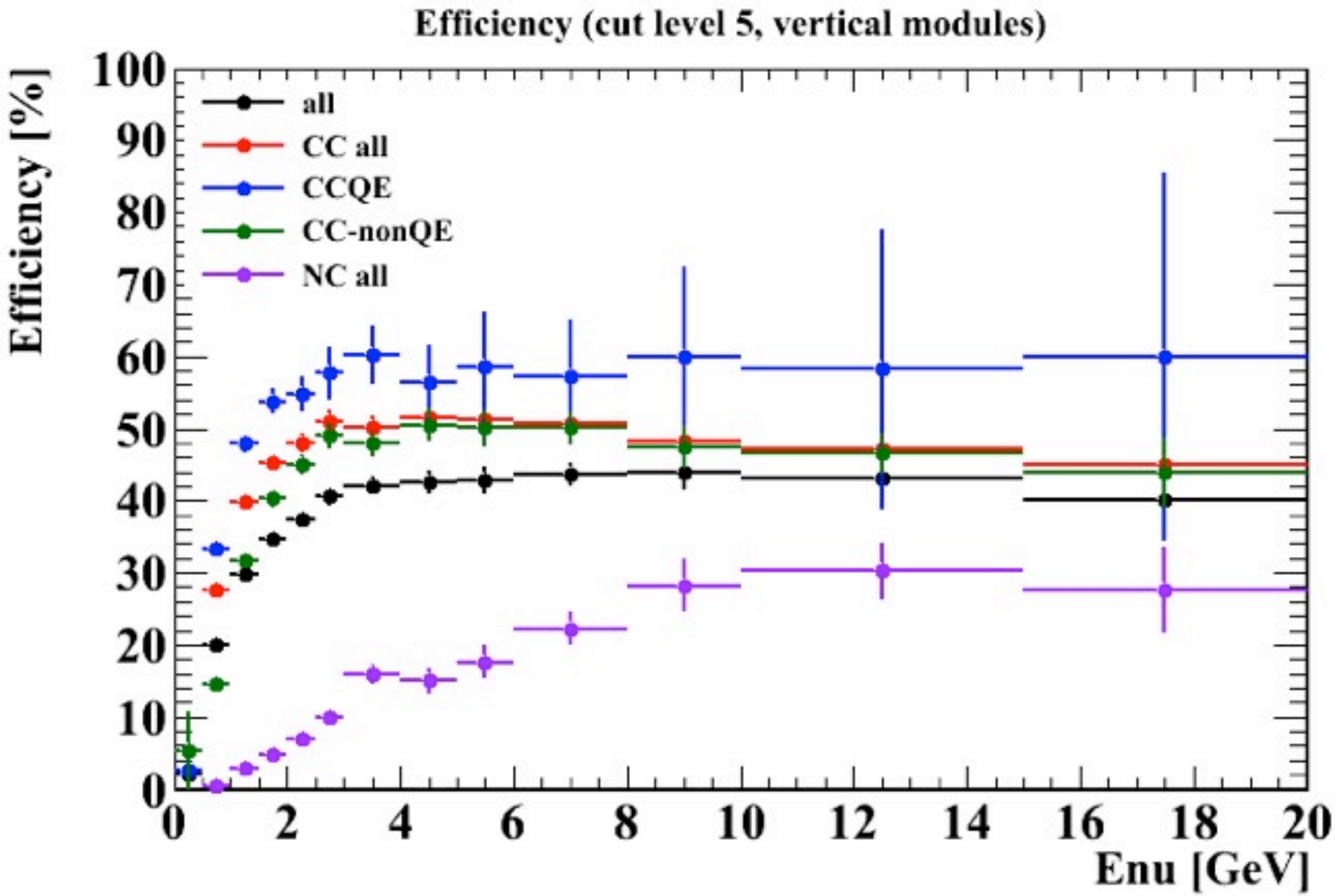
Mean of efficiency(E) of horizontal modules



The detail table of each bin value is on

ingrid_efficiency_20100622.xls

Mean of efficiency(E) of vertical modules



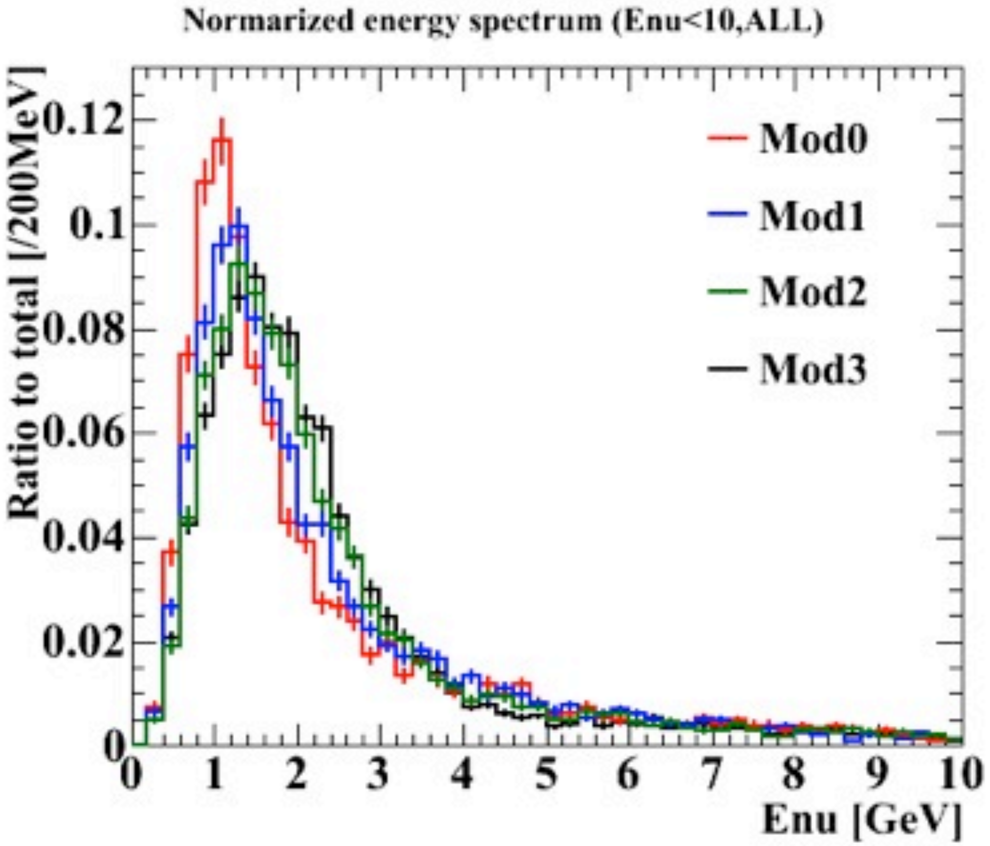
The detail table of each bin value is on
ingrid_efficiency_20100622.xls

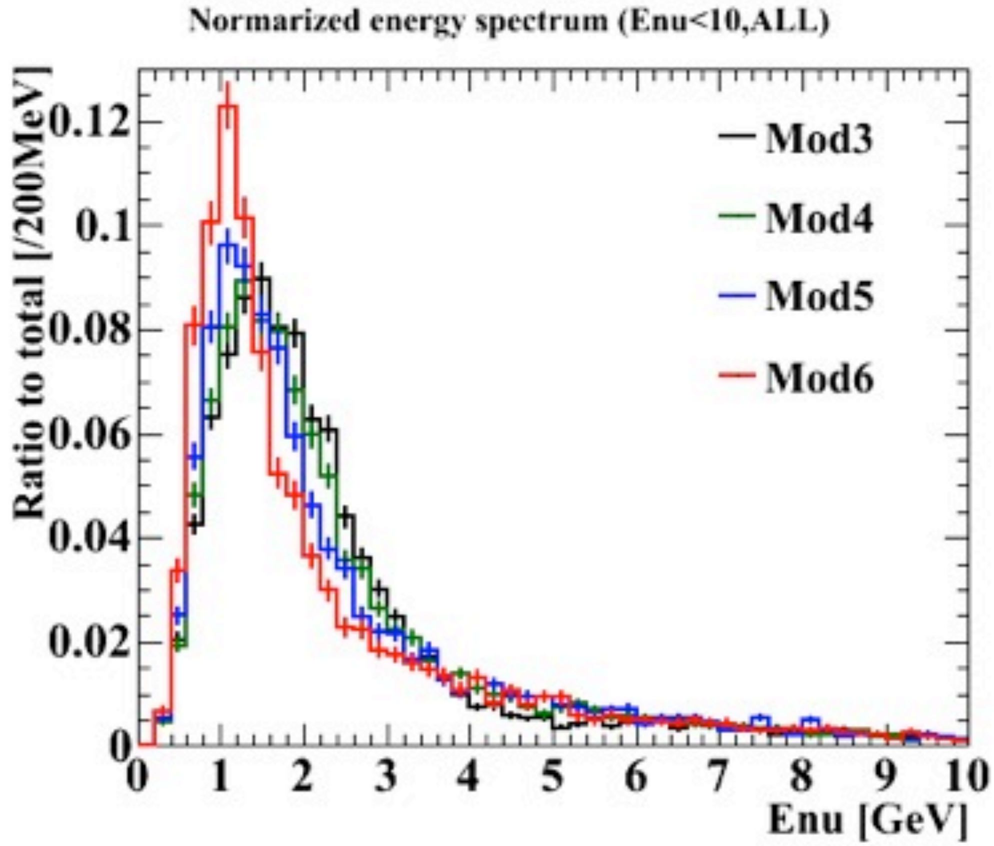
Total Efficiency at each module

Total Efficiency = $\int \Phi_{obs}(E)dE \,/\, \int \Phi_{int}(E)dE \times 100$ [%]

- Diff. of total efficiency between modules is mainly due to the diff. of normalized neutrino energy (MC true information) spectrum.
- Show normalized spectrum by area at each modules (about all interaction mode).
  - Need check spectrum at each interaction mode.

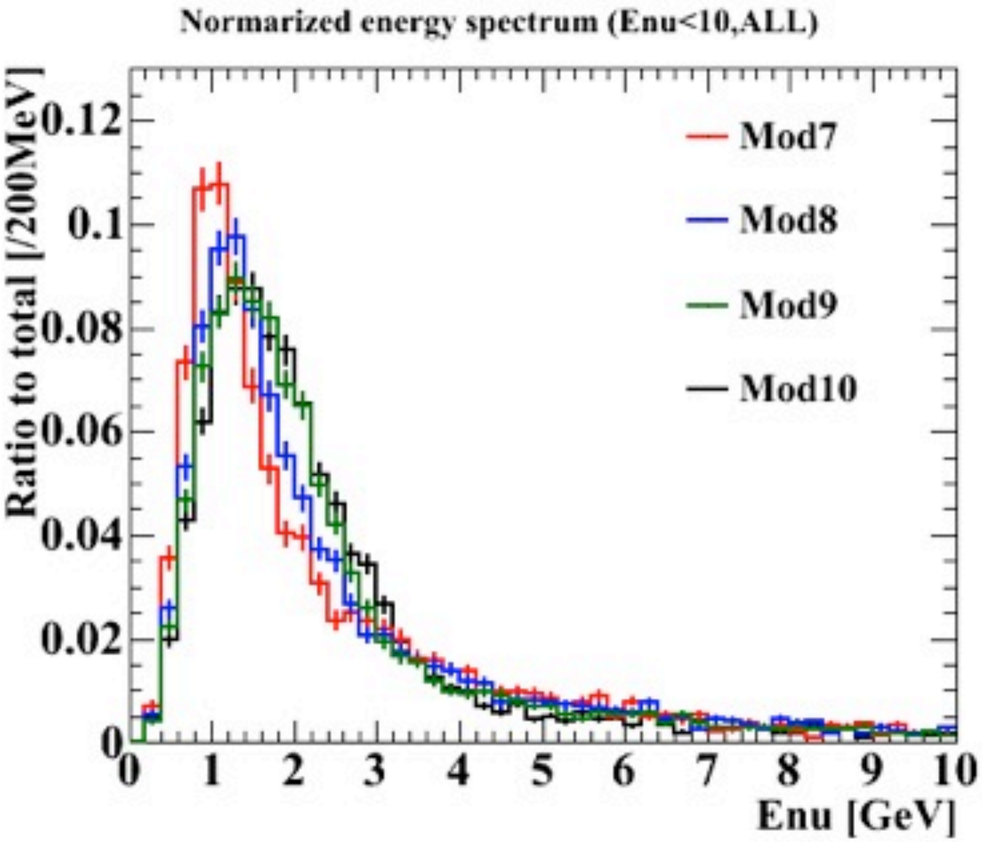
Normalized neutrino energy spectrum (horizontal)

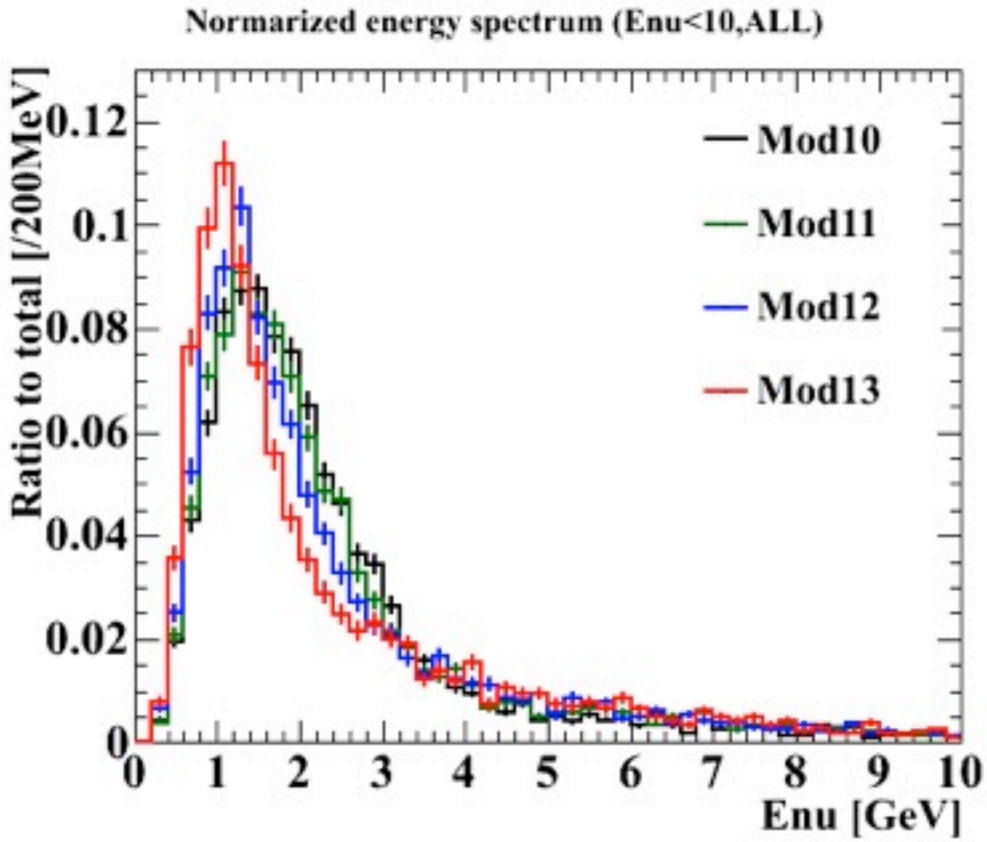




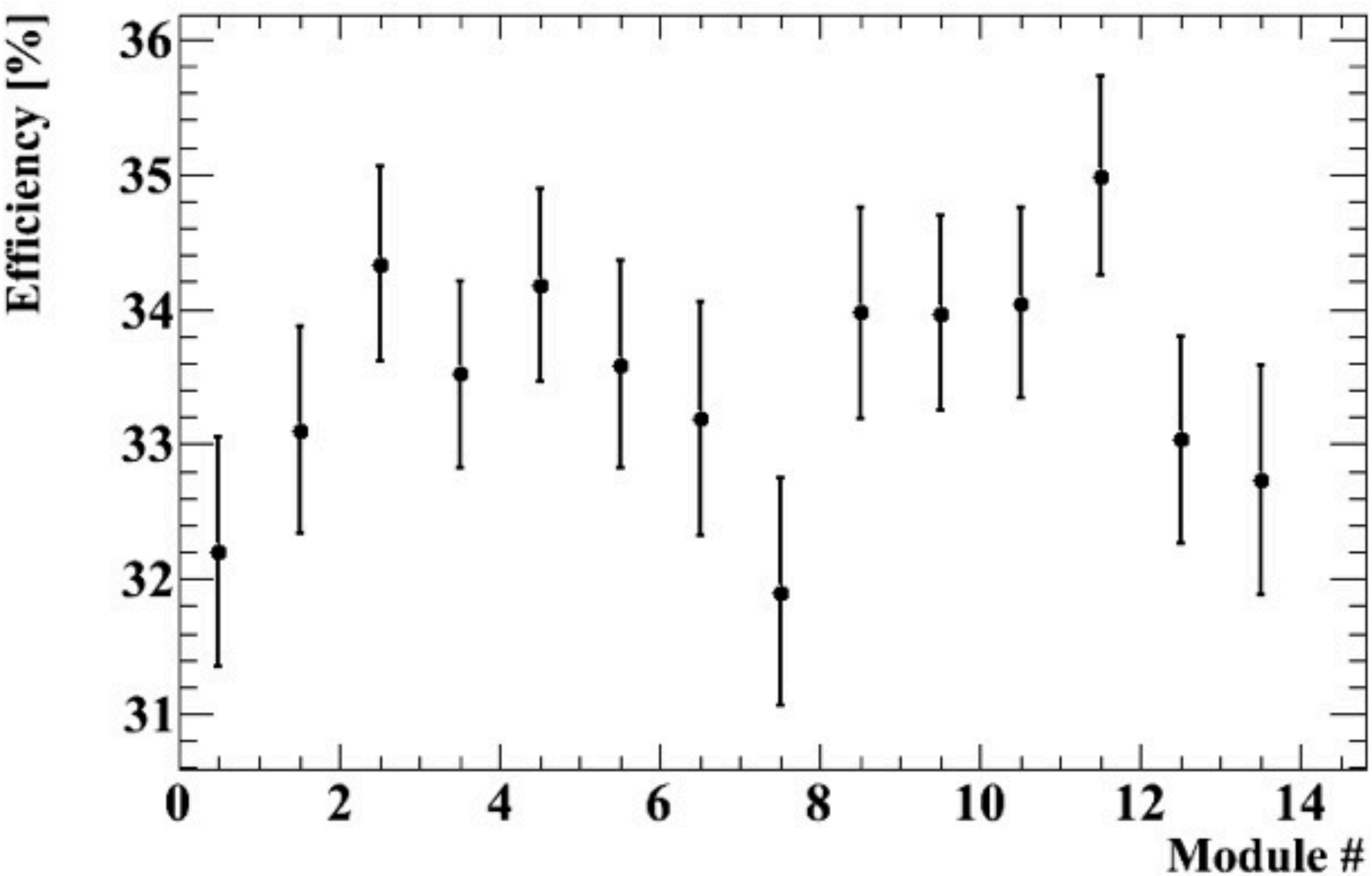
Normalized by area (energy<10GeV)
(→ almost of entries is at low energy region)

Normalized neutrino energy spectrum (vertical)





Total Efficiency at each module



Consider only MC statistics error.

→ Need more statistics.

Total Efficiency at each module

module#	0	1	2	3	4	5	6
Total Efficiency (mean value)	32.2	33.1	34.3	33.5	34.2	33.6	33.2

module#	7	8	9	10	11	12	13
Total Efficiency (mean value)	31.9	34	34	34	35	33	32.7

- When the proton beam is shifted from the center of the target, the center of reconstructed beam profile by INGRID is also shifted large than the fitting error.
  - By selection of low neutrino energy (Energy < 3GeV), the shift of the profile by INGRID is larger (-8cm shift → -13cm shift).
- Try "reconstructed angle cut" to enhance low energy neutrino.