INGRID MC Work

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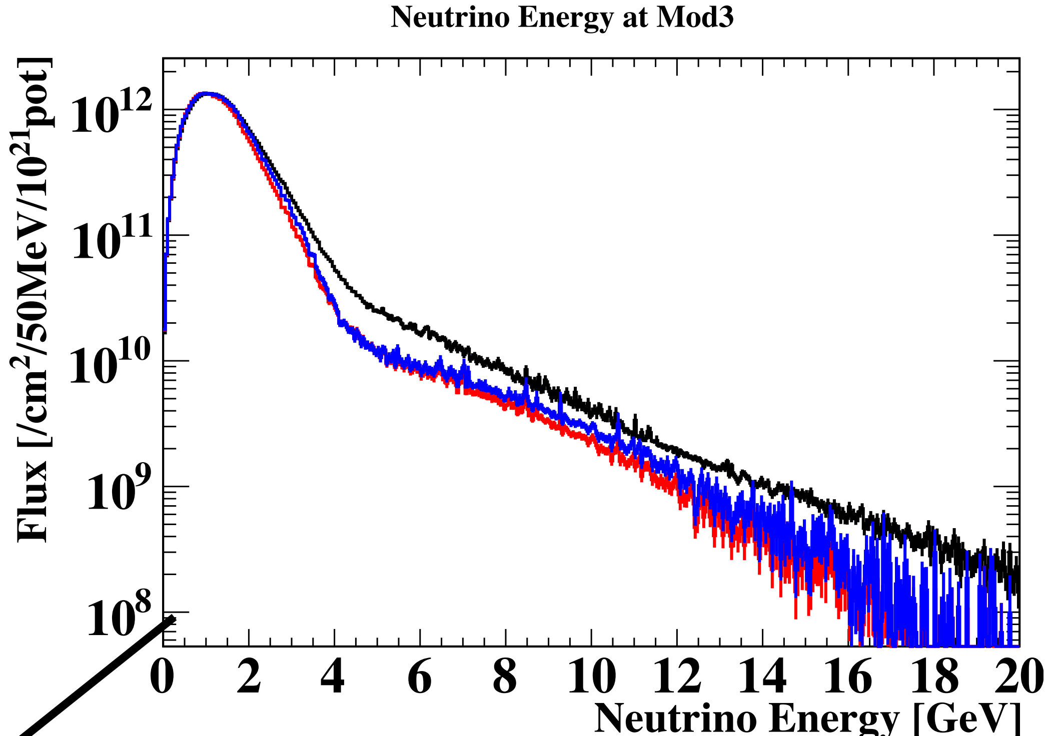
- Check the effect of flux tuning (tuned-v1) on INGIRD observation.
  - Comparison of 10c nominal, of 10d (no tune) to 10d tuned flux.

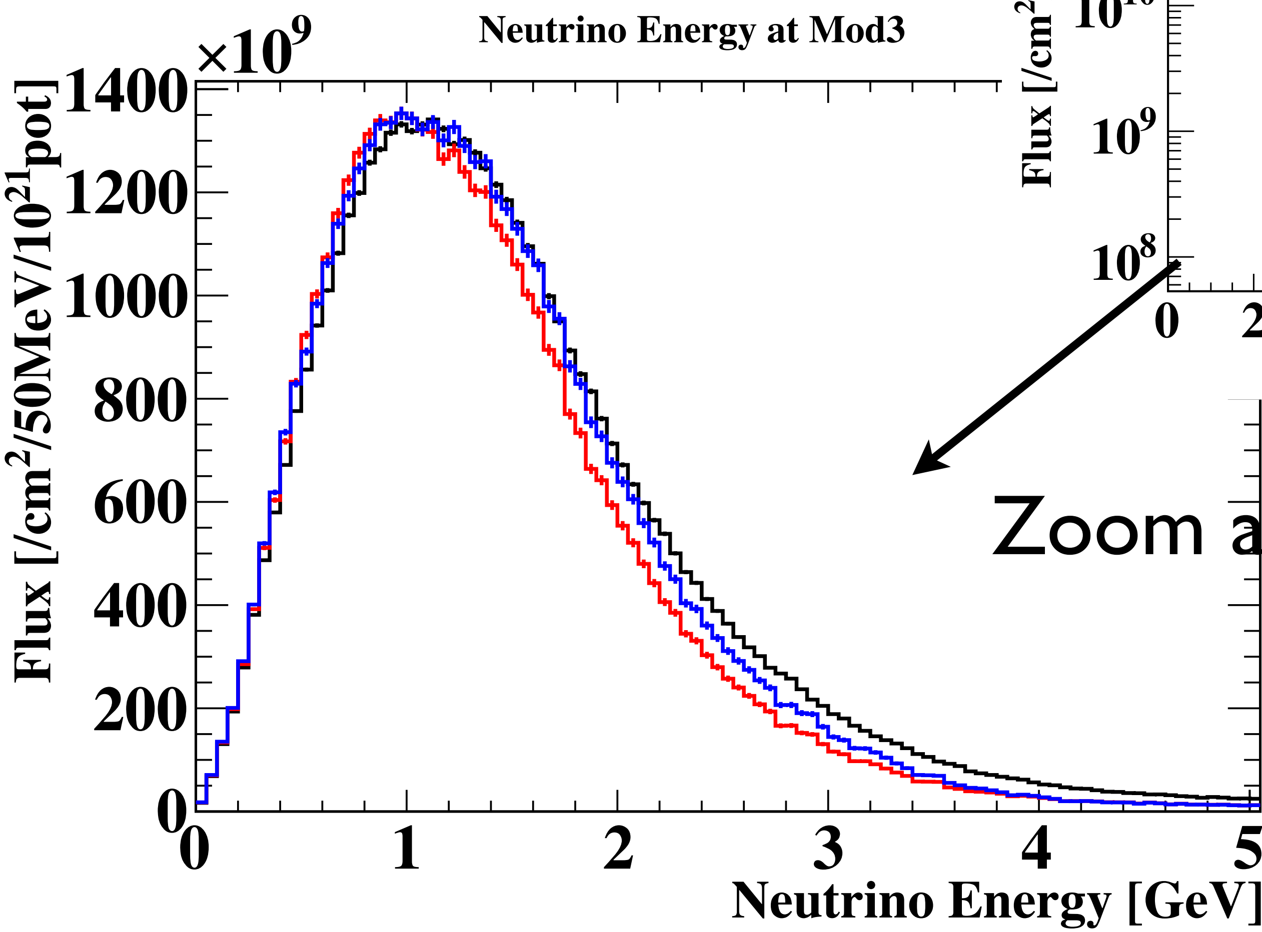
10d flux (no tune & tuned-v1)

- The slavic's report of 10d flux (no tuned) is here : http://www.t2k.org/beam/NuFlux/FluxRelease/10d/sumplot10d/view.
  - Main component : 10d use FLUKA model and has the history of hadrons. → Hadron production mechanism is almost same as FLUKA10b flux.
- The slavic's report of 10d tuned flux is here : http://www.t2k.org/beam/NuFlux/FluxRelease/10d/10dtunev1/sumplots/view
  - Main tune : parameta of hadron production, etc...
- Check 10d flux at INGRID.

νμ Flux at module 3

10c nominal
10d nominal
10d tune-v1

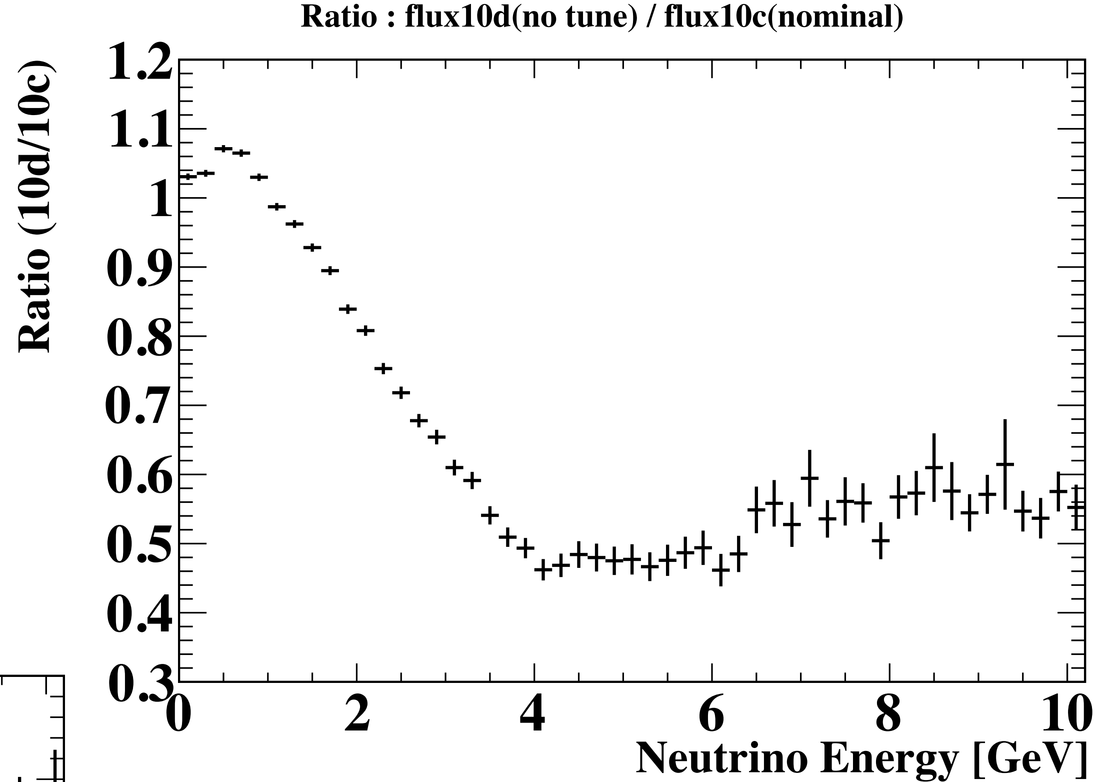


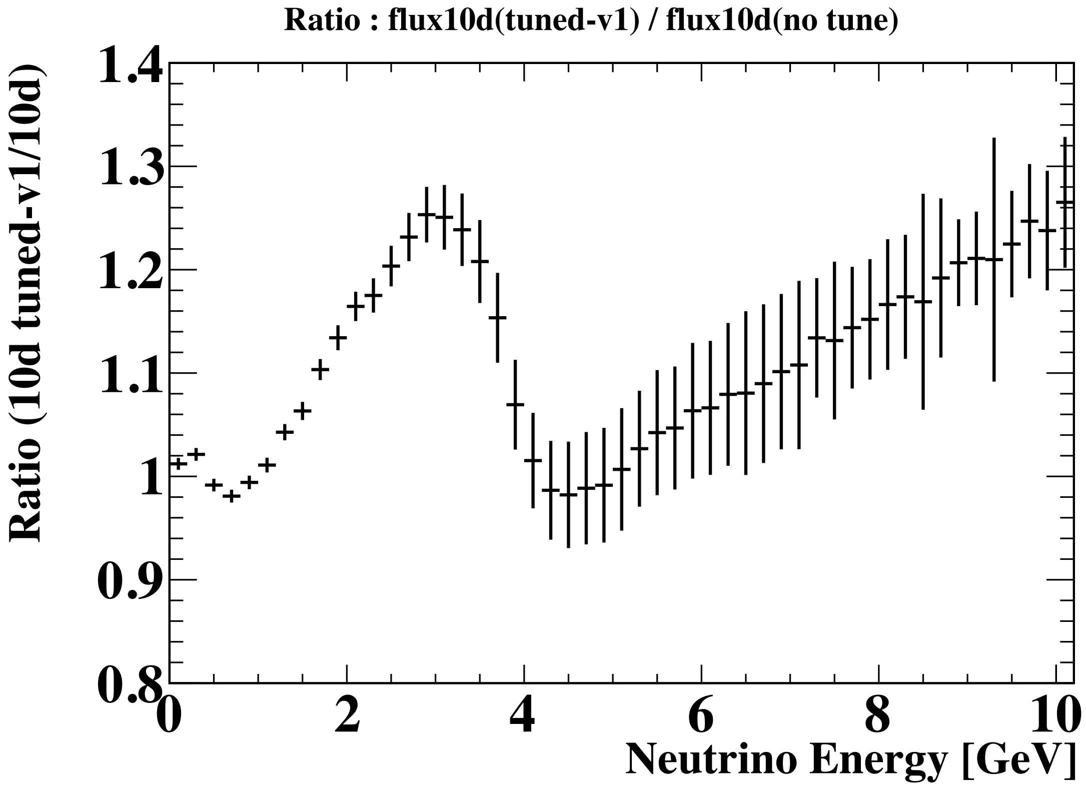


Zoom at low energy ration

The ratio νμ Flux at module 3

flux10d no tune /
flux10c nominal →

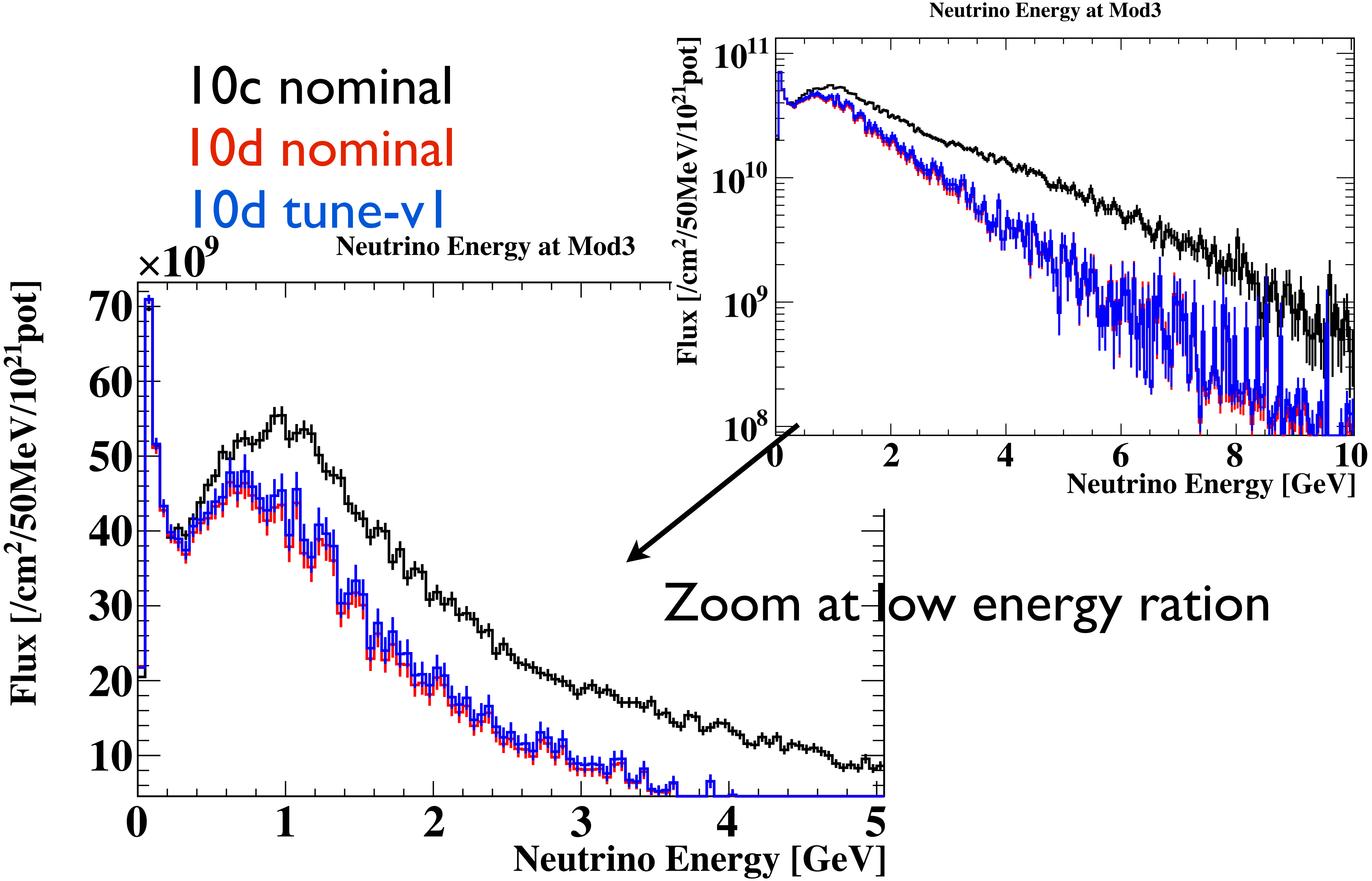




← flux10d tune-v1 /
flux10d no tune

anti-νμ Flux at module 3

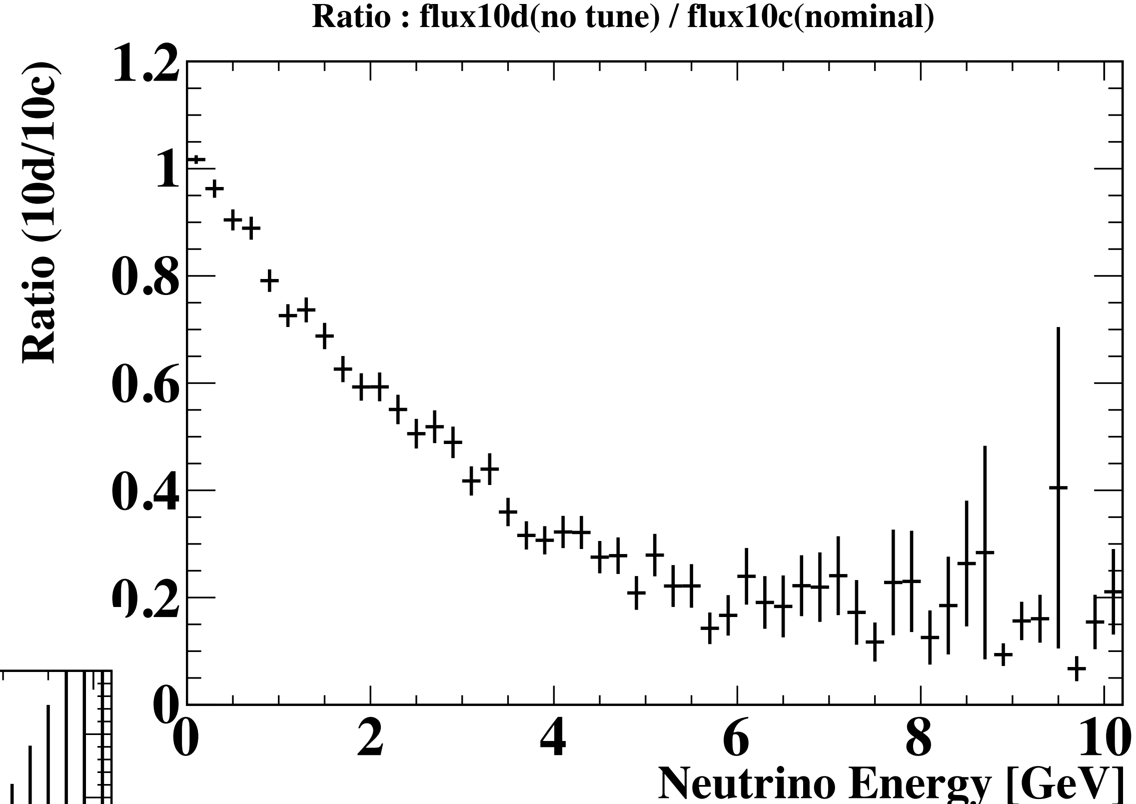
10c nominal
10d nominal
10d tune-v1

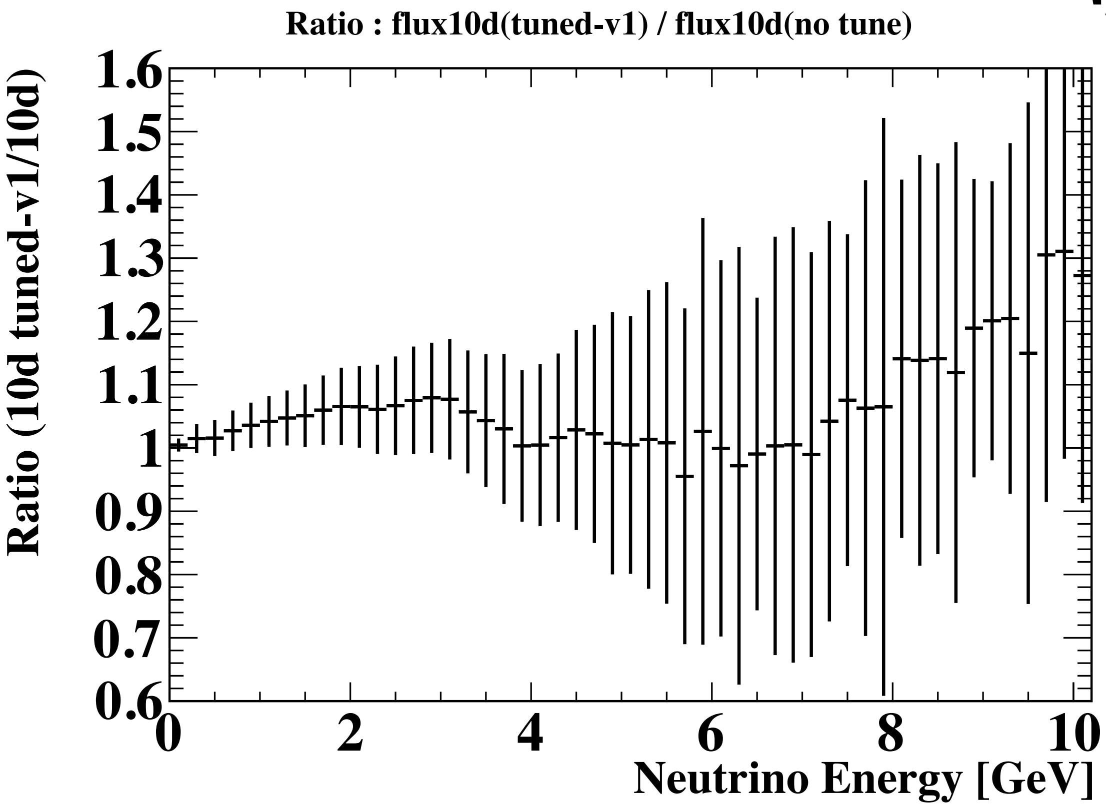


Zoom at low energy ration

The ratio anti-νμ Flux at module 3

flux10d no tune / flux10c nominal →





← flux10d tune-v1 / flux10d no tune

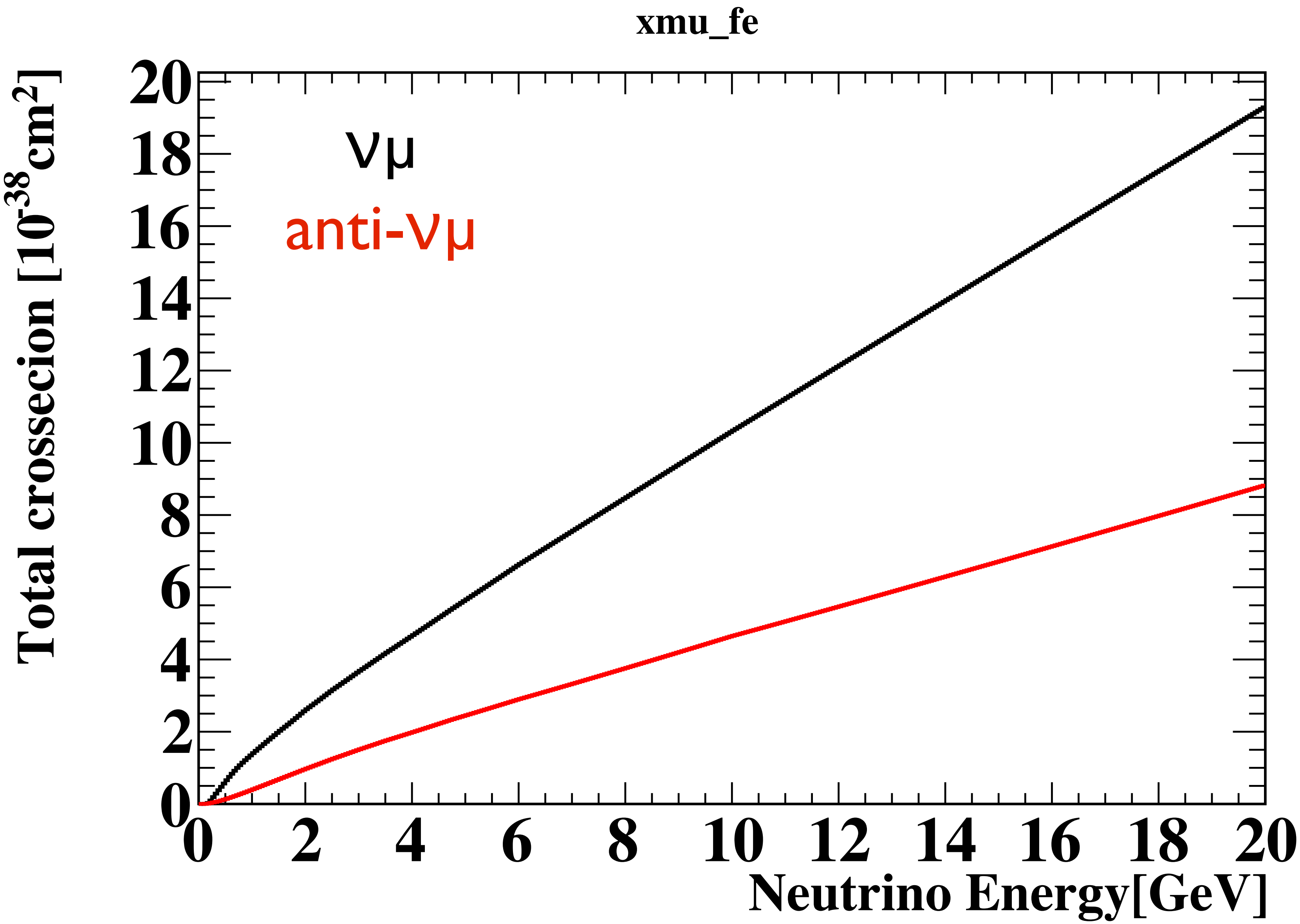
The histogram ratio

- The histogram ratio is put at scbn00:/export/scraid0/data/akira/jnubeam/enuweight/10d_tune-v1/
  - "fRatio_10c_10d_mu_3" means "The $\nu\mu$ ratio (10d no tune)/(10c nominal) at module 3.
  - "fRatio_10d_10dv1_mu_3" means "The $\nu\mu$ ratio (10d tune-v1)/(10d no tune) at module 3.
- These histogram have fine binning (bin width is 50MeV) → Big MC stat. error at high energy region.
  - Change the bin size of the histogram yourself for lower stat. error.

The expect # of events observed at INGRID

- Calculate the expect event rate at the fiducial module of INGRID.
  - Flux × cross-section of Fe × efficiency to ν interacted in the module.
  - Use Flux 10d and 10d tuned-v1.
  - Use νμ and anti-νμ MC sample.

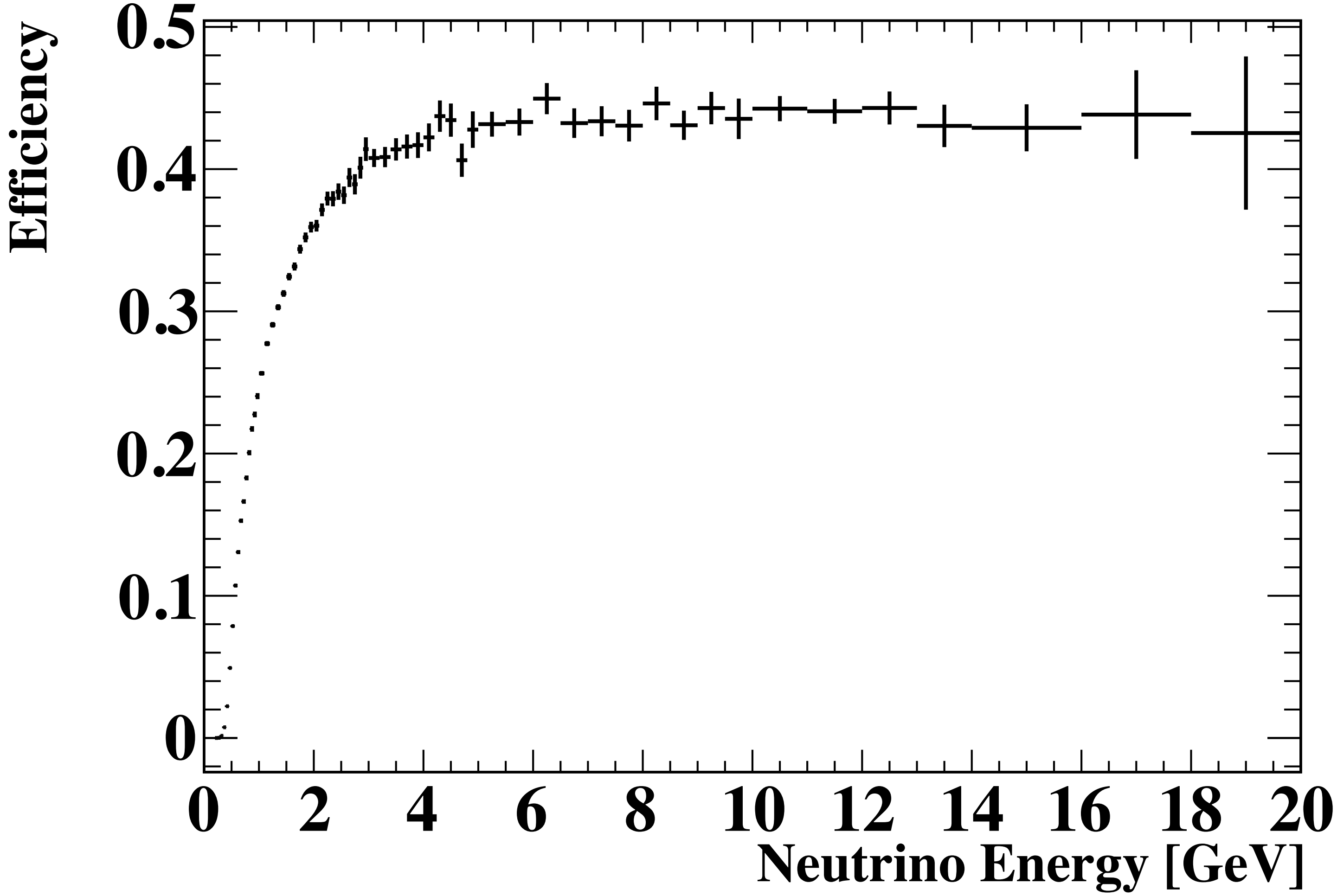
Cross-section of ν+Fe



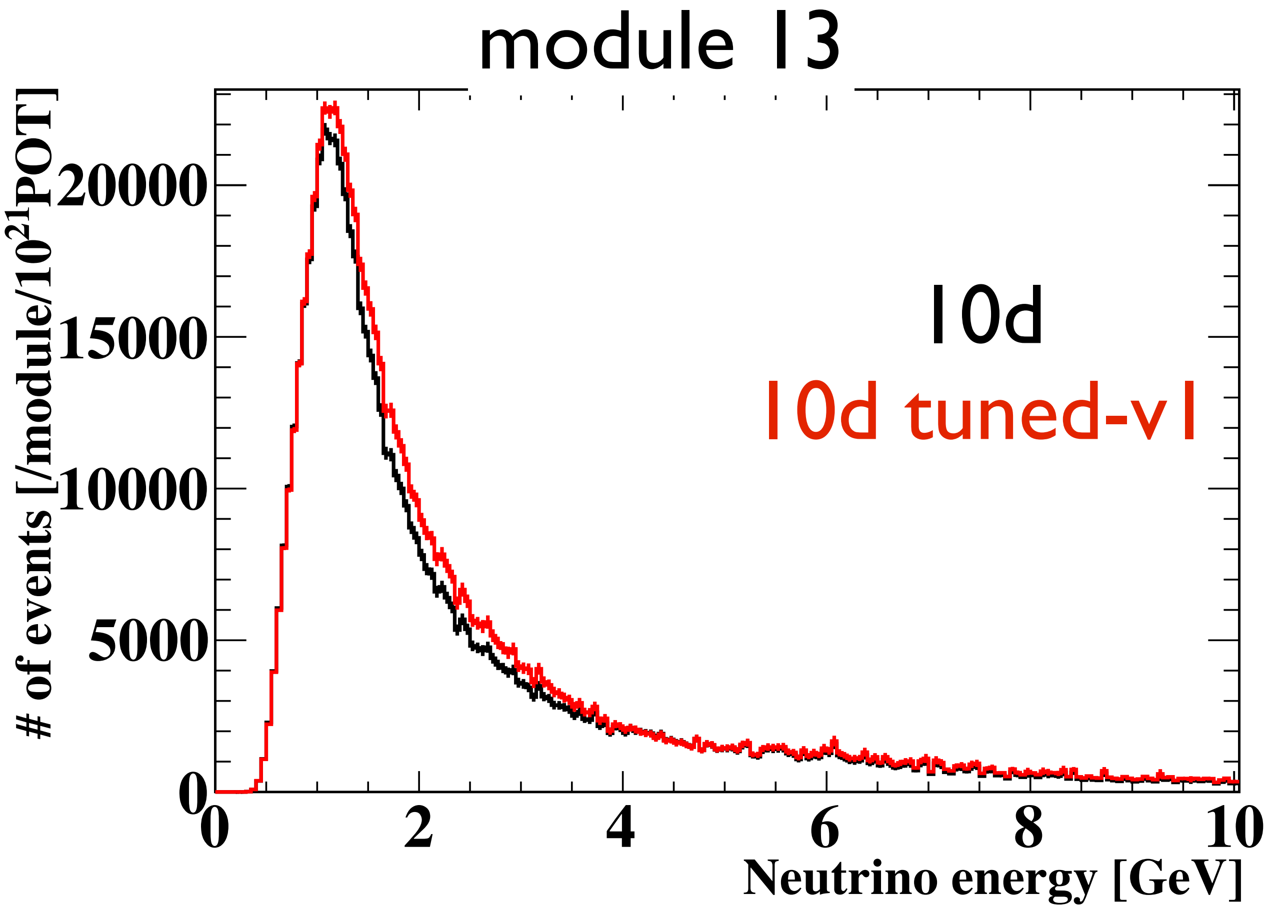
Used efficiency of ingrid

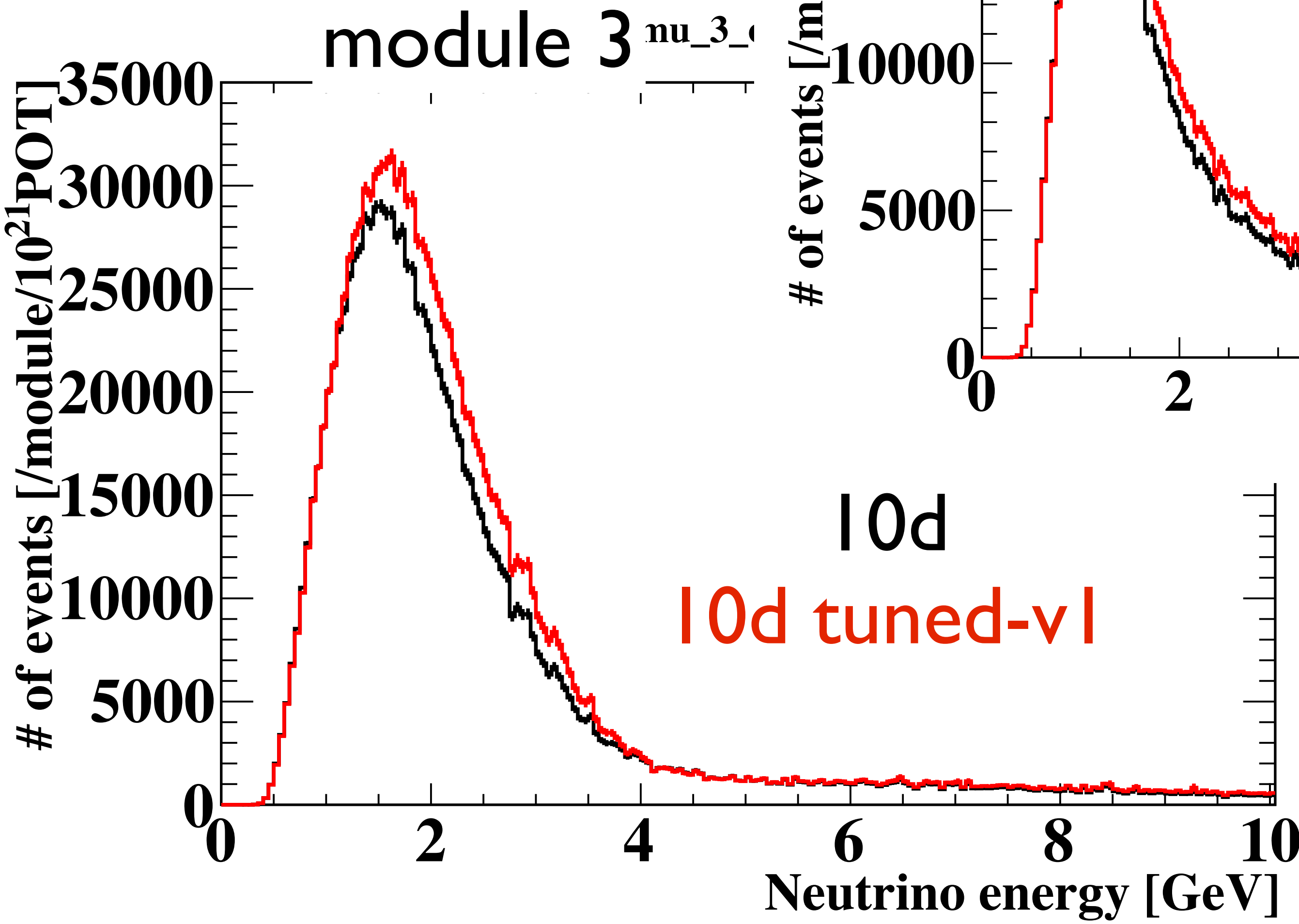
The used efficiency in this study :
(# of events after cut)/(# of interacts in a whole module)

efficiency to $\nu\mu$



νμ Energy spectrum after cut



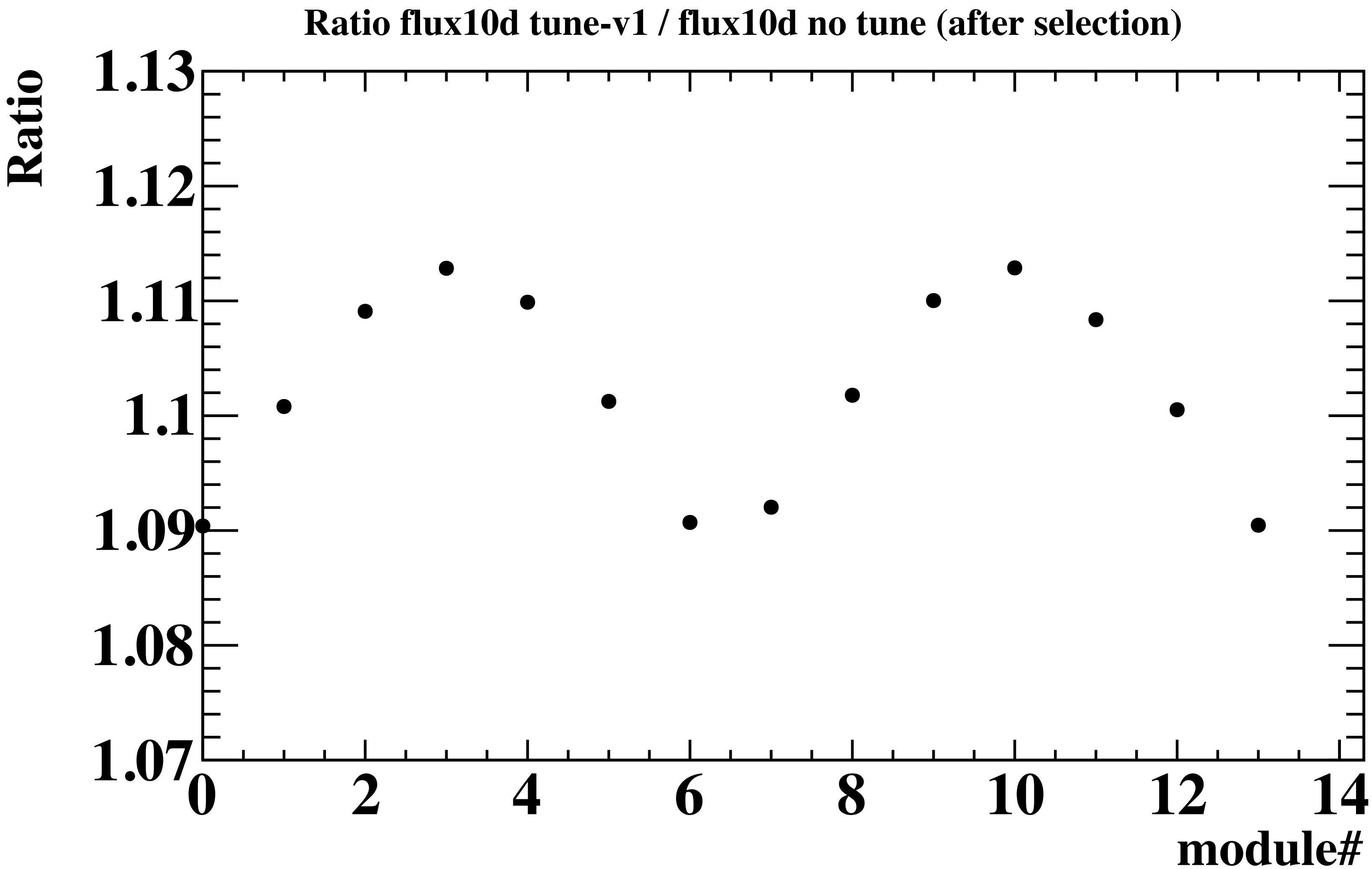


of observed νμ [/10^{21}POT]

module#	0	1	2	3	4	5	6
10d	6.59E+05	8.78E+05	1.05E+06	1.12E+06	1.06E+06	8.88E+05	6.67E+05
10d tune-v1	7.18E+05	9.67E+05	1.17E+06	1.25E+06	1.18E+06	9.78E+05	7.27E+05

module#	7	8	9	10	11	12	13
10d	7.20E+05	9.30E+05	1.10E+06	1.16E+06	1.09E+06	9.22E+05	7.08E+05
10d tune-v1	7.87E+05	1.03E+06	1.22E+06	1.29E+06	1.21E+06	1.01E+06	7.72E+05

Ratio of $\nu\mu$ Nobs (10d tuned-v1 / 10d)



The difference between modules is due to

- Energy spectrum difference of each module
- Energy dependence of weight factor (no tune → tuned-v1)

Nobs of all modules

	ν_μ [/10^{14}pot]	anti-ν_μ [/10^{14}pot]	ν_μ+anti-ν_μ [/10^{14}pot]
10d	1.30	0.0251	1.32
10d tune-v1	1.43	0.0264	1.46
(10d tuned-v1) /10d	1.10	1.05	1.11

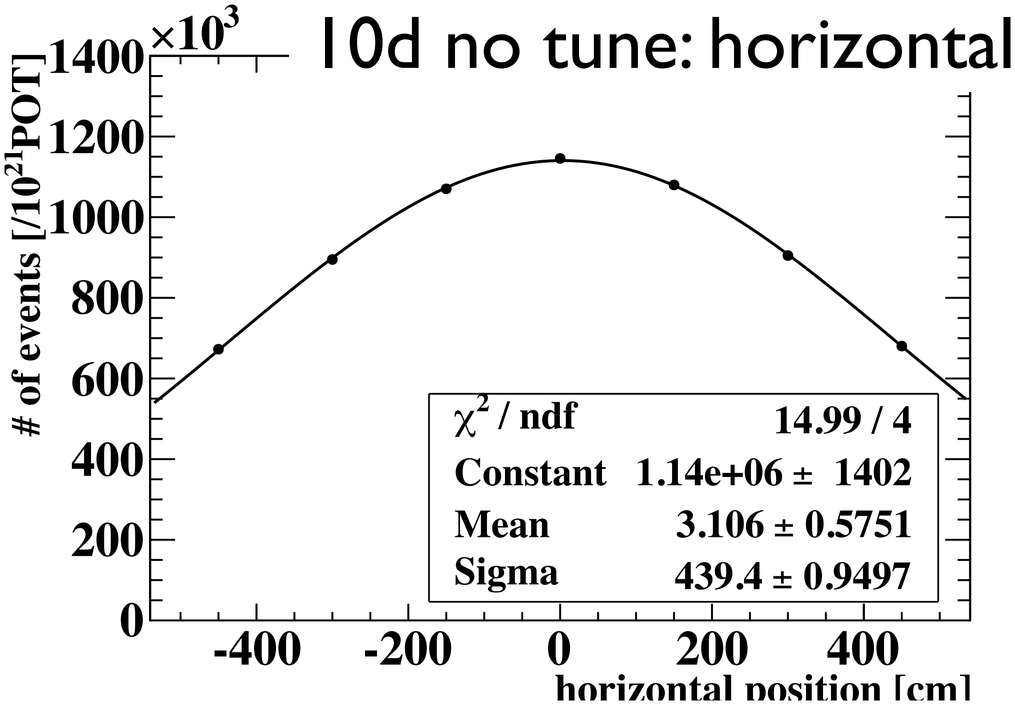
Tuned-v1 effect to Nobs of INGRID : **+11%**

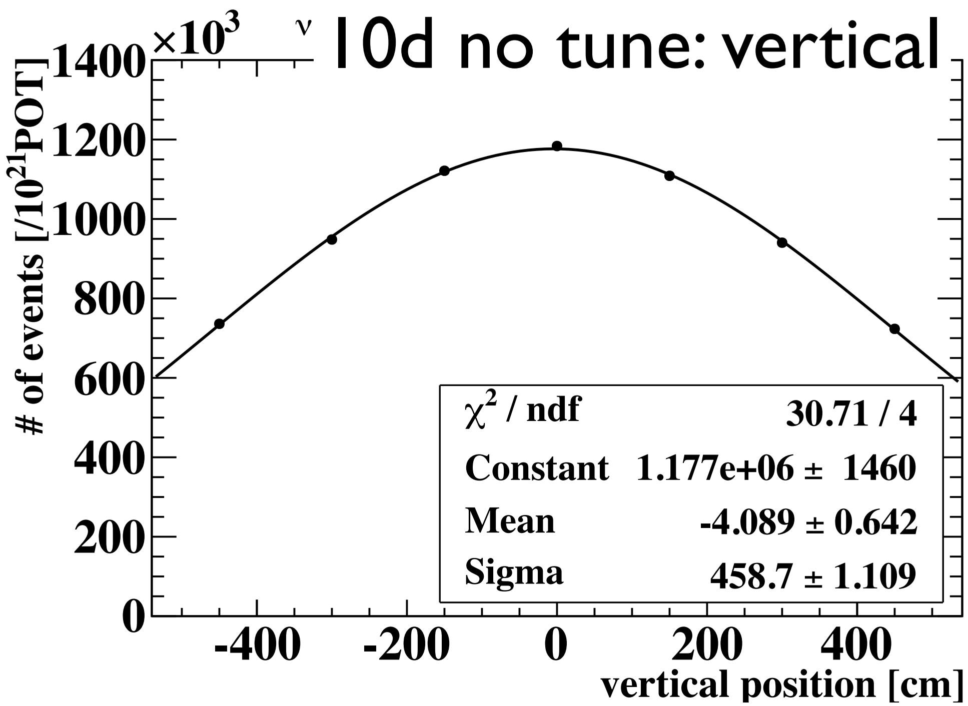
The event rate of beam data (run2010a) = 1.52
→ the ratio (10d tuned-v1) / data (run2010a) = 0.96

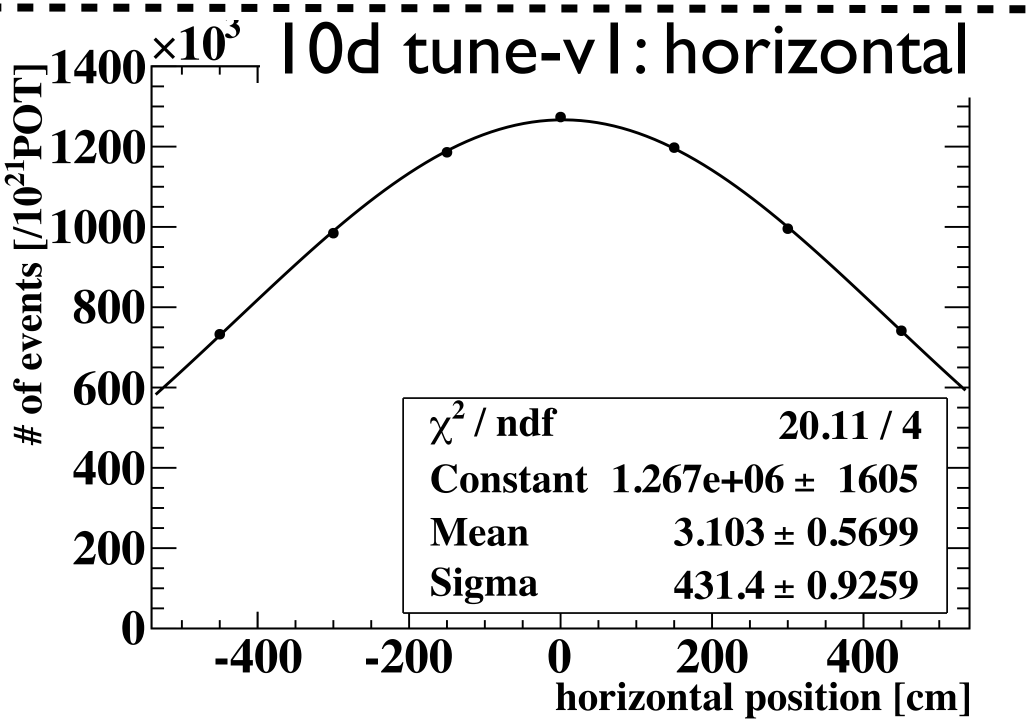
Beam profile

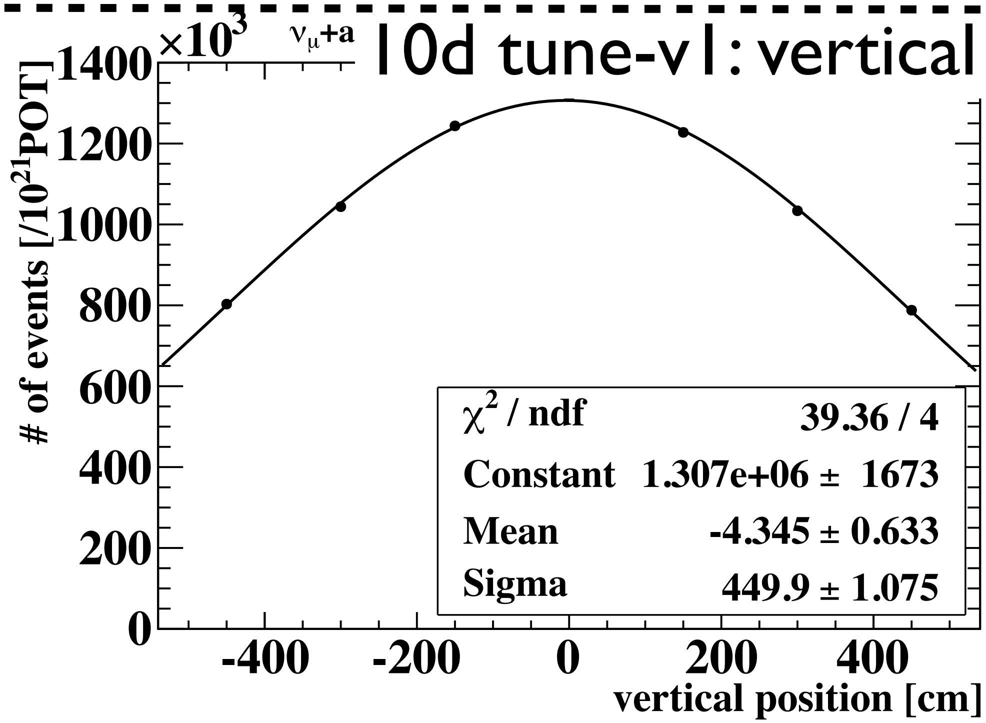
- Reconstruct beam profile with # of events after neutrino selection.
- Use ν_μ + anti-ν_μ MC samples and run2010a data.
  - Only stat error.
- Fit the profile with Gaussian.

MC Beam profile (after selection)









MC Beam profile (after selection)

Beam width different between no-tune and tuned-v1.
(Beam center is same in stat error)

width (MC)	σ horizontal [cm]	σ vertical [cm]	horizontal / vertical
10d	439±1	459±1	0.96
10d tune-v1	431±1	450±1	0.96
(10d tuned-v1)/(10d)	0.98	0.98	

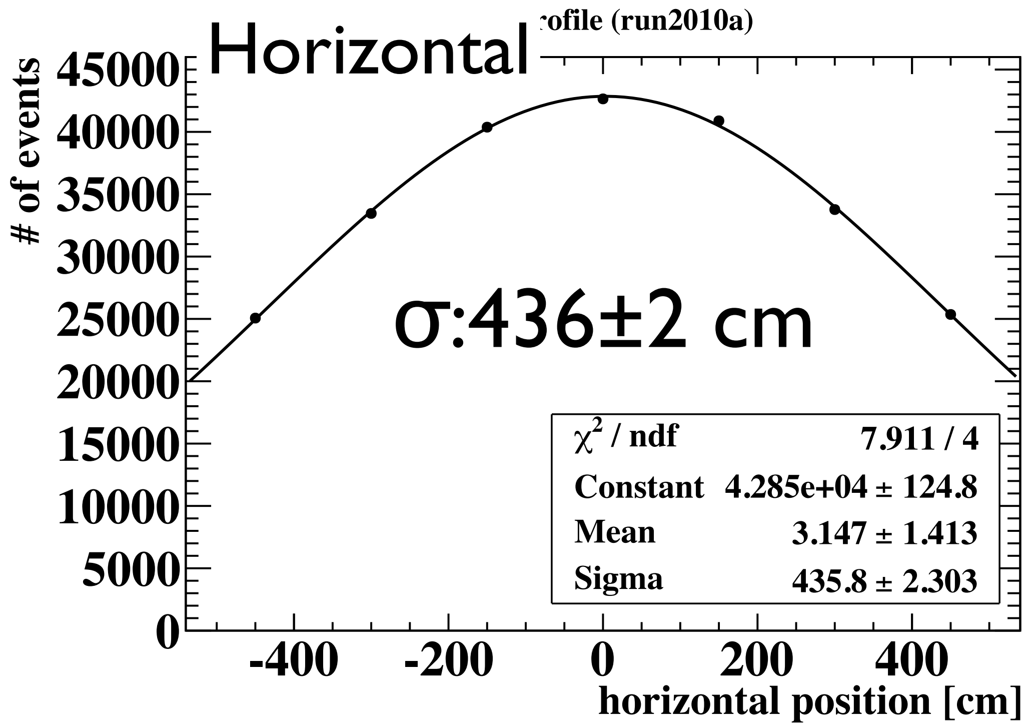
→ Tuned effect : -2% beam width

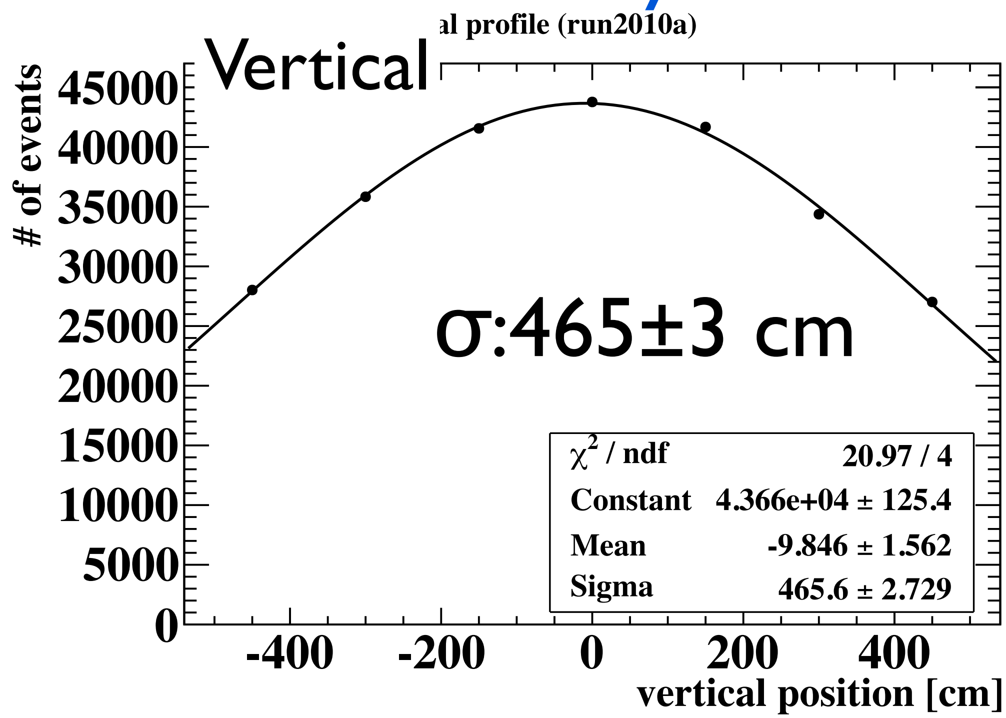
→ Beam width is not so much changed.

Beam profile of run2010a Data

Reconstruct beam profile after neutrino selection with all run2010a data.

Only stat error





	σ horizontal [cm]	σ veretical [cm]
run2010a	436±2	465±3
10d tuned-v1 (νμ+anti-νμ)	431±1	450±1
MC/Data	0.99	0.97