Pbeam flux uncertainty

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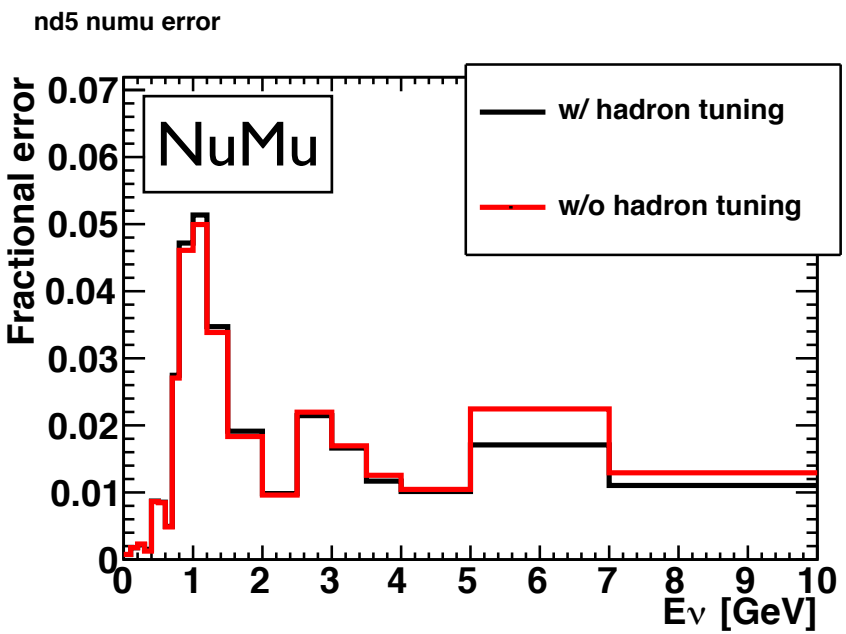
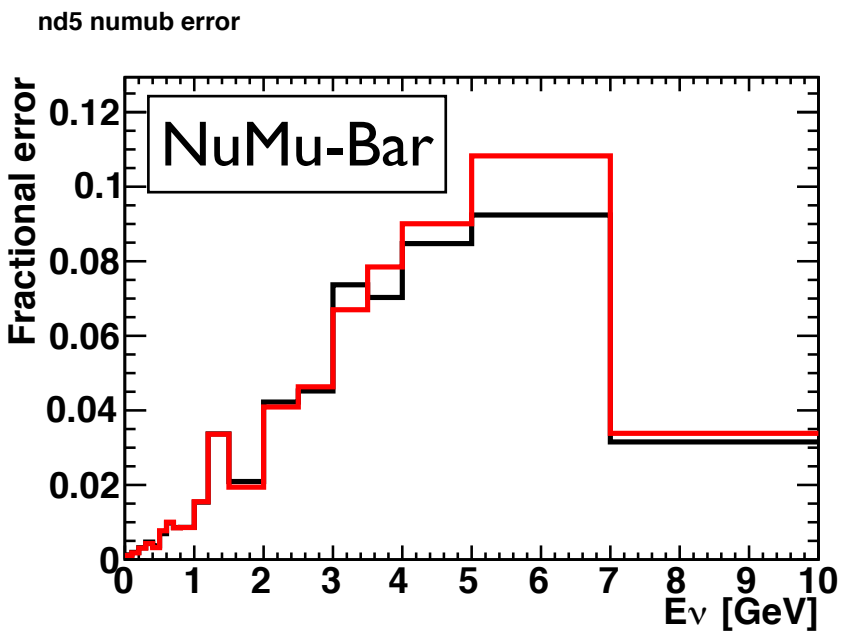
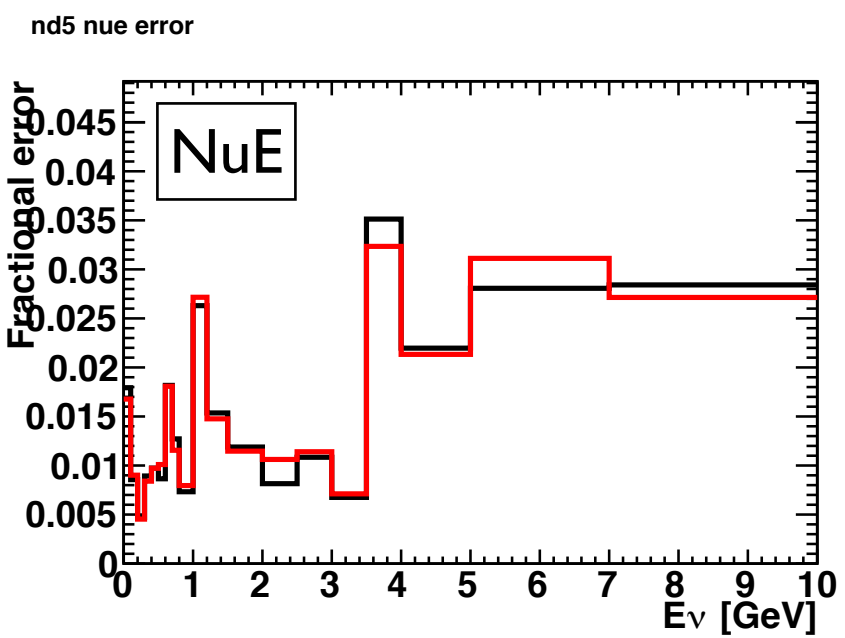
Effect of hadron tuning on proton beam flux uncertainty

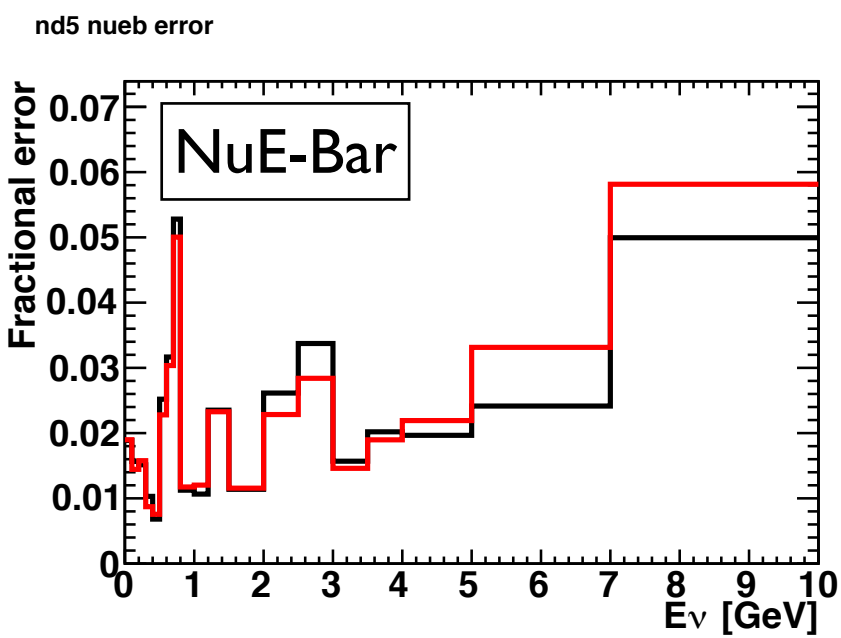
- Compare proton beam flux unc. w/ hadron tuning with one w/o hadron tuning
  - Compare flux unc. by using same 10d wide beam flux samples for two cases (w/ & w/o hadron tuning)
- If no the systematic difference, can use FLUKA2011 for this study
- Hadron tuning setting:
  - Pion : latest pion tuning
  - Kaon: latest kaon tuning
  - Other : no tuning

Flux unc. w/ & w/o hadron tuning (ND5)



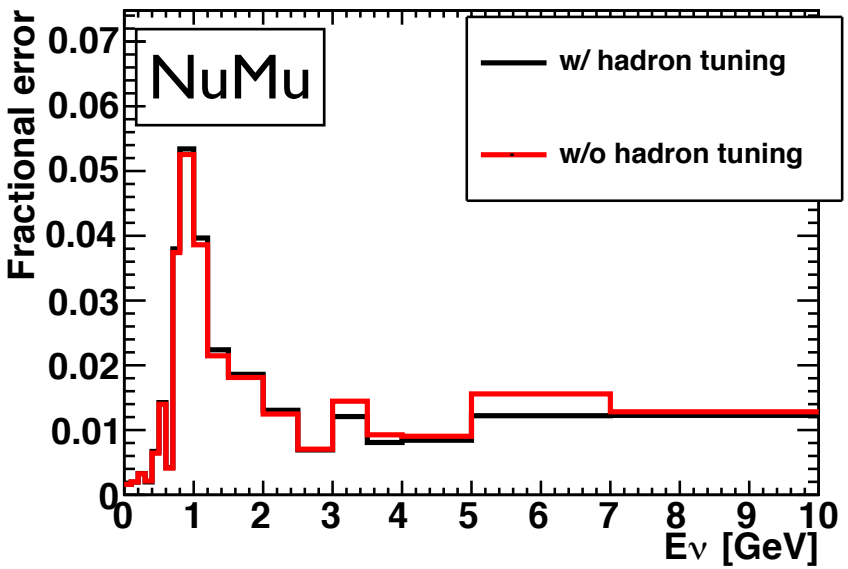




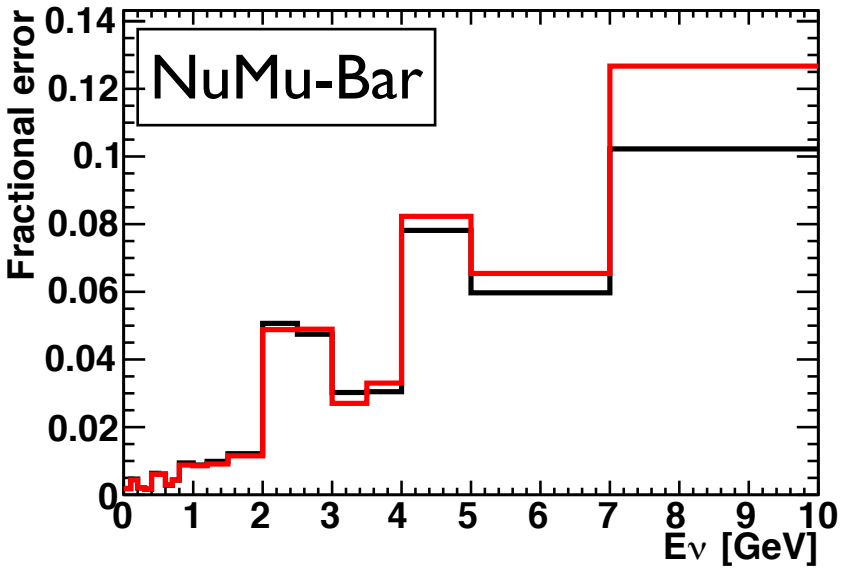


Flux unc. w/ & w/o hadron tuning (SK)

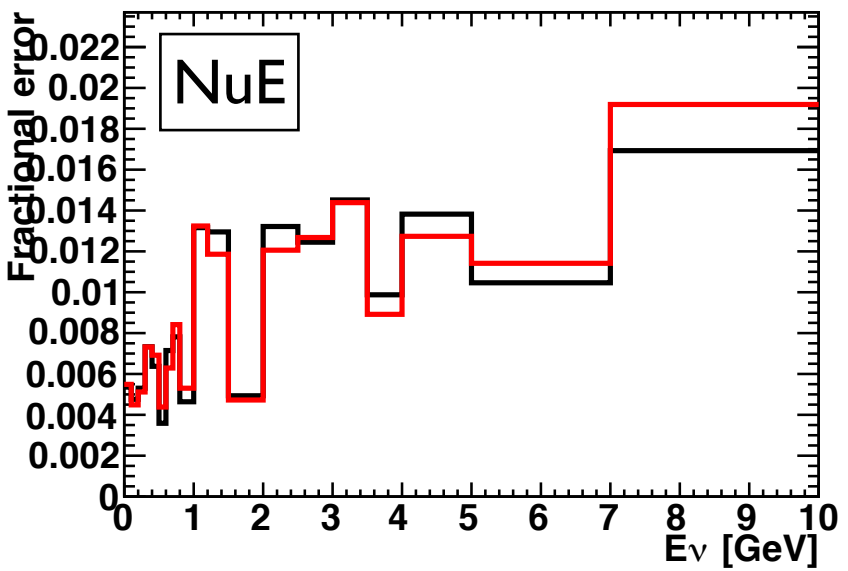
sk numu error



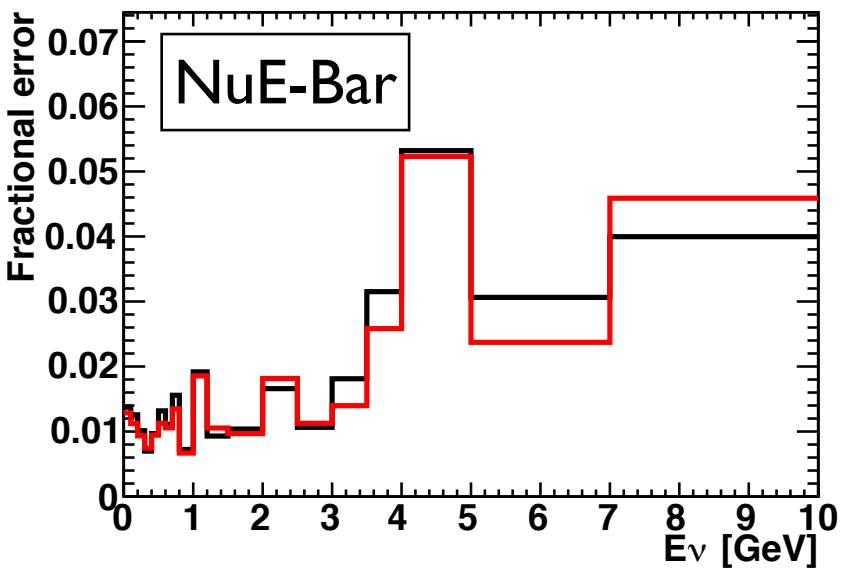
sk numub error



sk nue error



sk nueb error



- There is no large systematic difference b/w two cases → Small effect of hadron tuning
  - At a maximum, 1~2% difference for high energy region (except for NuMu).
- It is possible to use FLUKA2011 to estimate flux unc.
  - Can change proton beam parameters & increase MC stat.
- Now, generate new wide beam FLUKA inputs by FLUKA2011 and jnubeam flux with new wide flux.

New wide beam flux sample

- Make new wide beam flux sample whose emittance in Y is larger than previous wide beam flux sample.
  - Thanks for Suzuki-san to generate this FLUKA-input by FLUKA2011

The beam parameters to generate previous wide beam sample analysis

	center position (cm)	center angle (mrad)	profile width (RMS)(cm)	emittance (π mm.mrad)	Twiss parameter α
X	-0.037	0.044	0.4273	2.13	0.60
Y	0.084	0.004	0.42	5.04	0.0

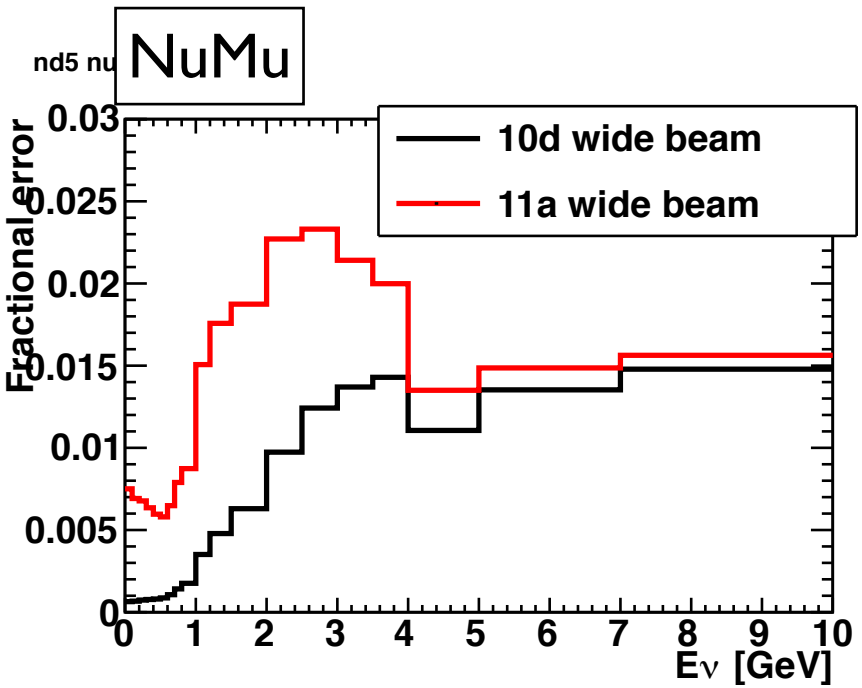
The beam parameters to generate new wide beam sample 11a analysis

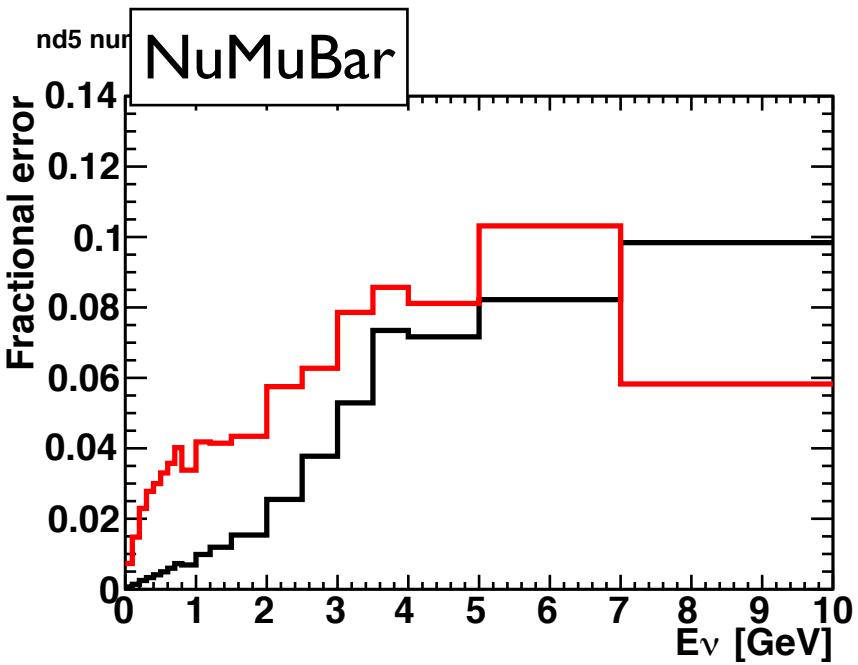
	center position (cm)	center angle (mrad)	profile width (RMS)(cm)	emittance (π mm.mrad)	Twiss parameter α
X	-0.037	0.044	0.4273	2.13	0.60
Y	0.084	0.004	0.42	15.12	0.0

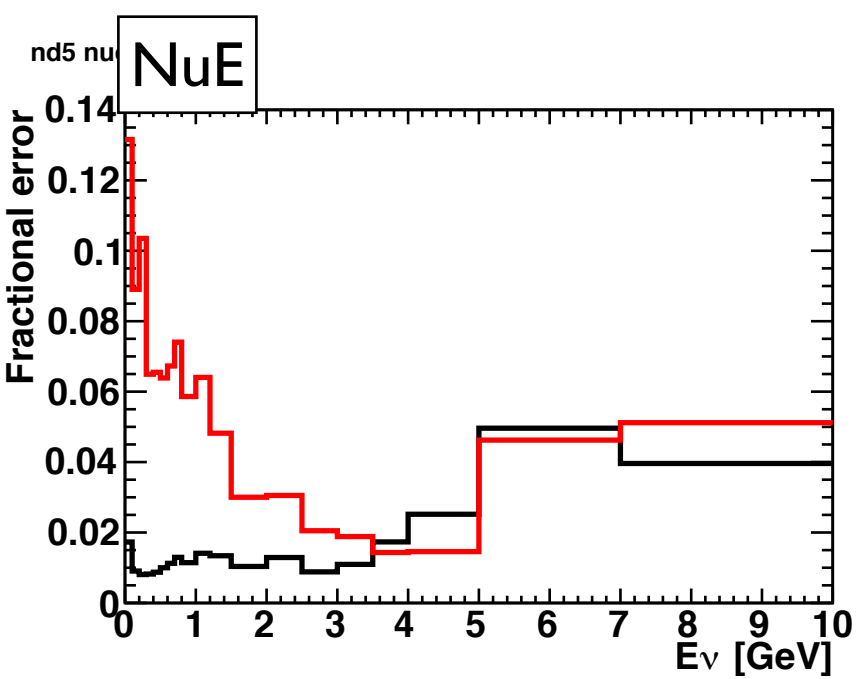
Checking MC stat. error

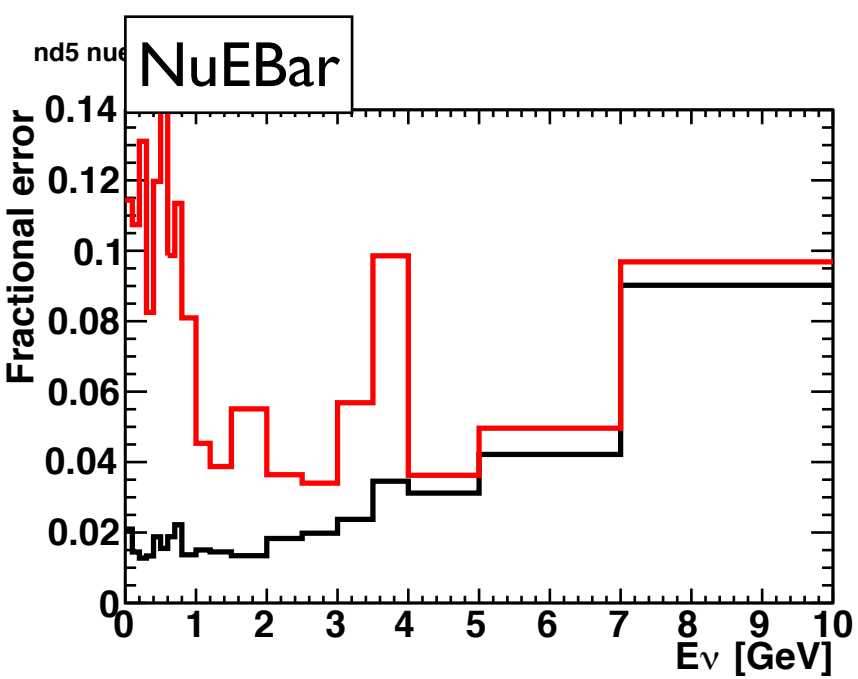
- Generate 1000 files (200k trigger/file) by FLUKA2011 inputs
  - When run JNUBEAM, low energy suppression turned on for all neutrino flavors (default setting)→ MC stat. at low energy large.
  - Will generate jnubeam flux with no low energy suppression excepted for numu.
- Check the error size of MC stat. and proton beam weighting (wide proton beam → actual proton beam)
  - Use 1000 wide beam flux files
  - Apply only proton beam weighting (for RunI/RunII).
  - No hadron tuning.

RunI : Fractional error (ND5)

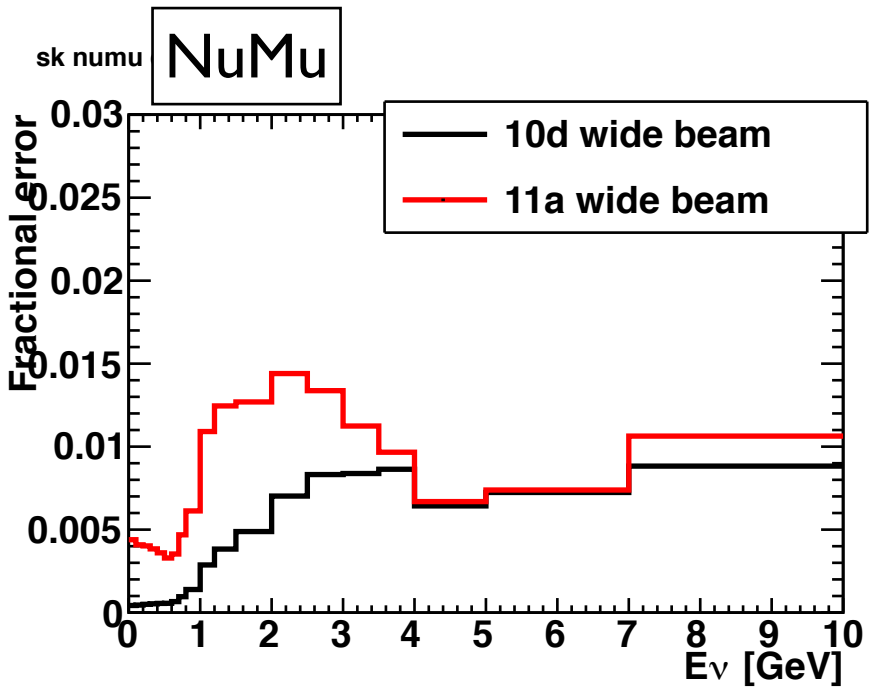


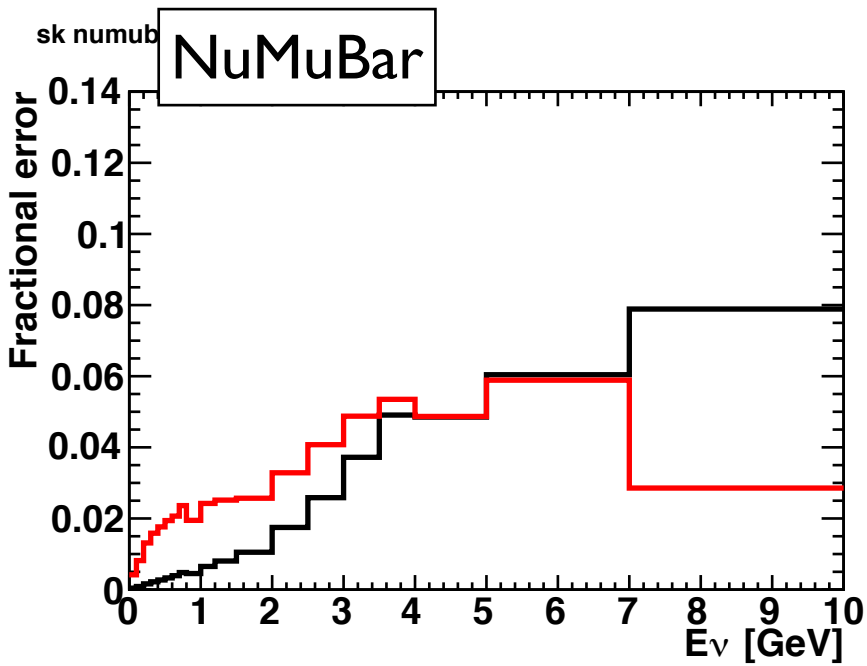


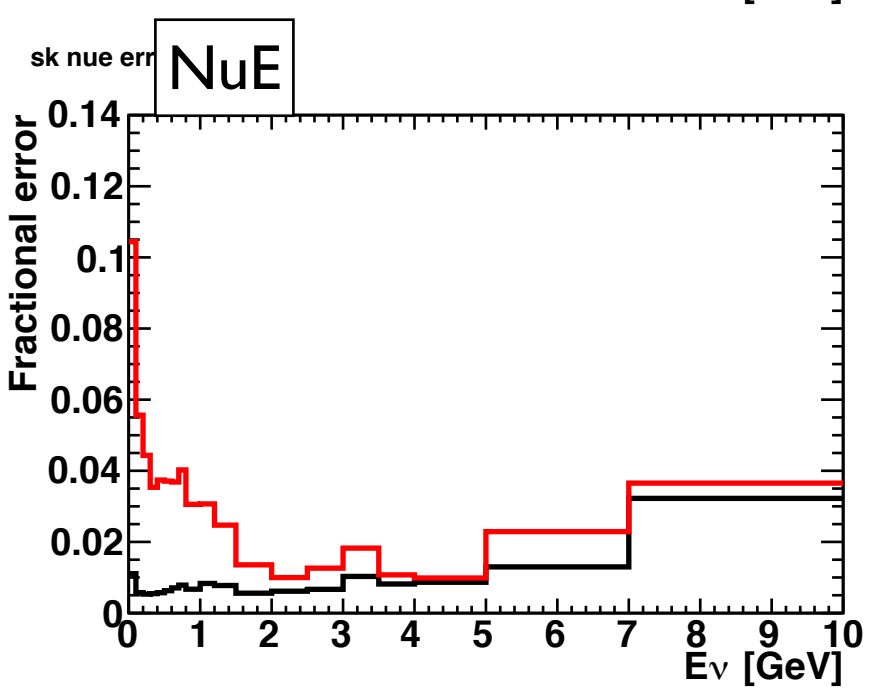


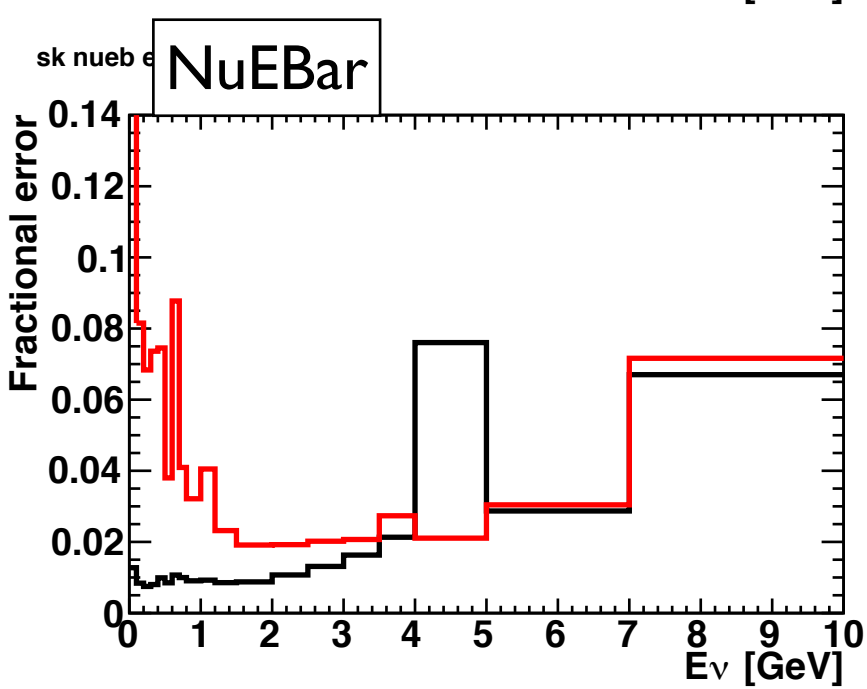


RunI : Fractional error (SK)

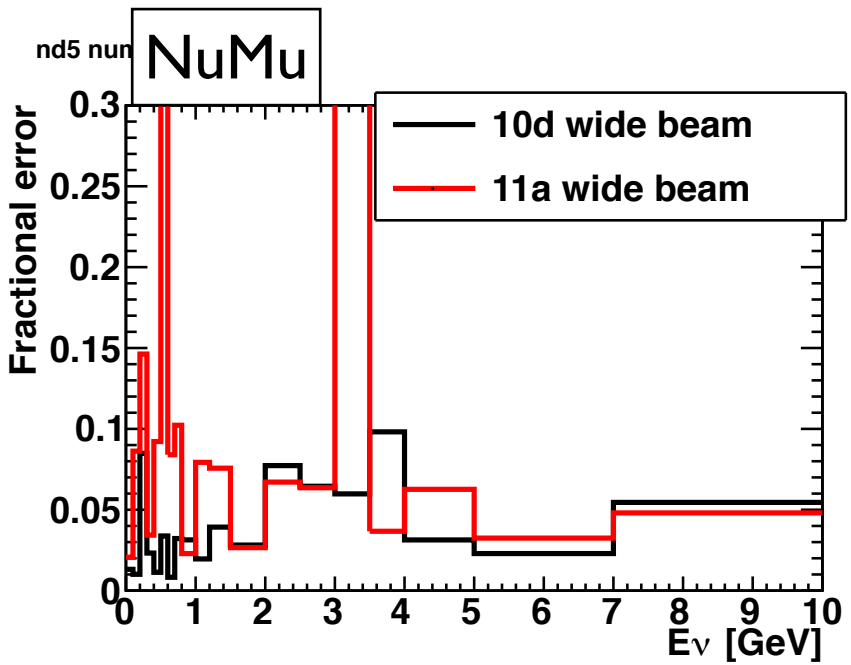


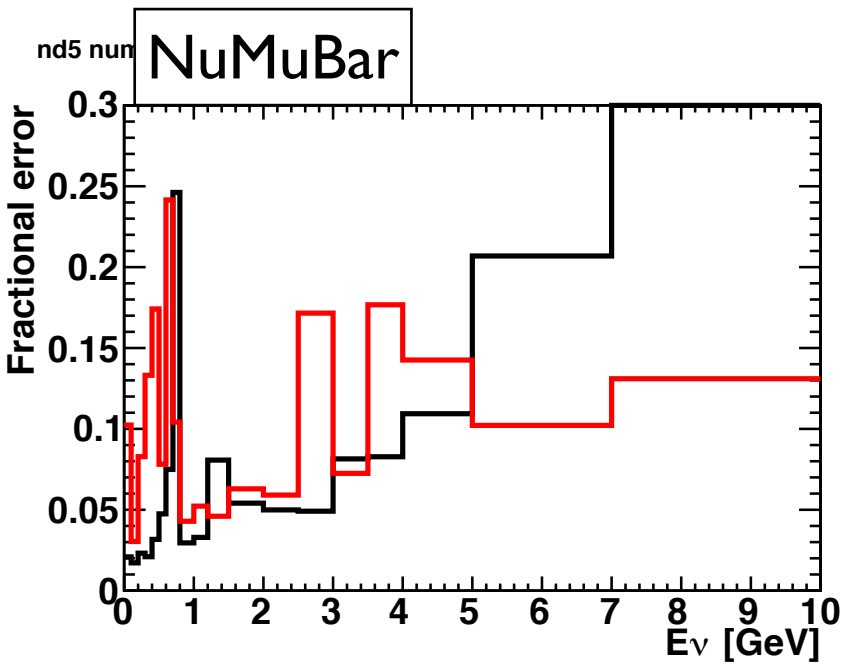


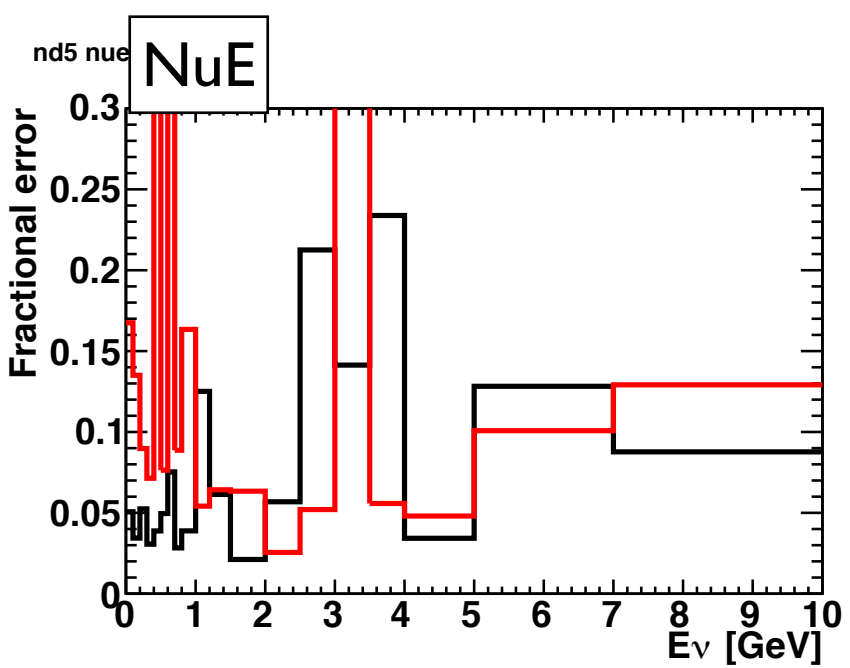


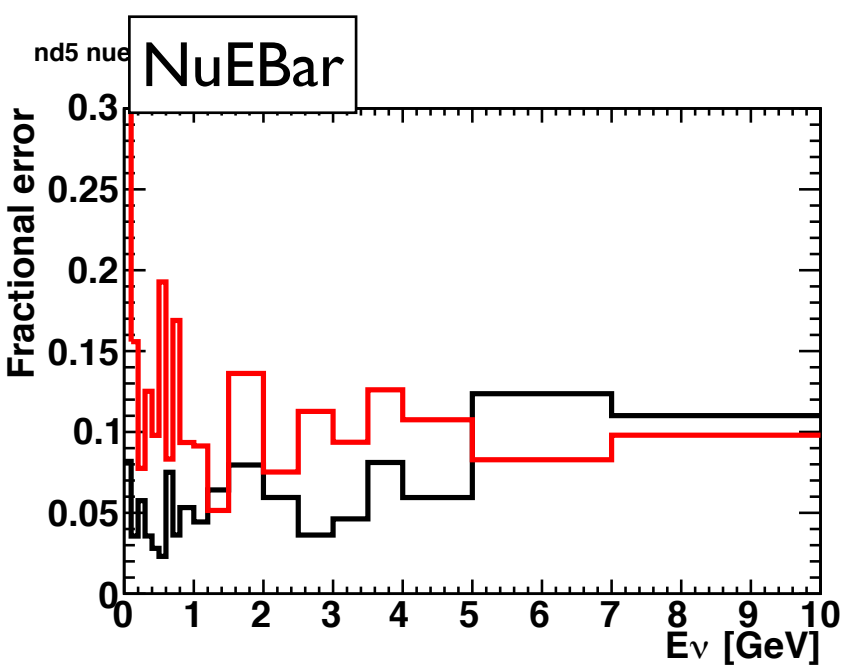


RunII : Fractional error (ND5)

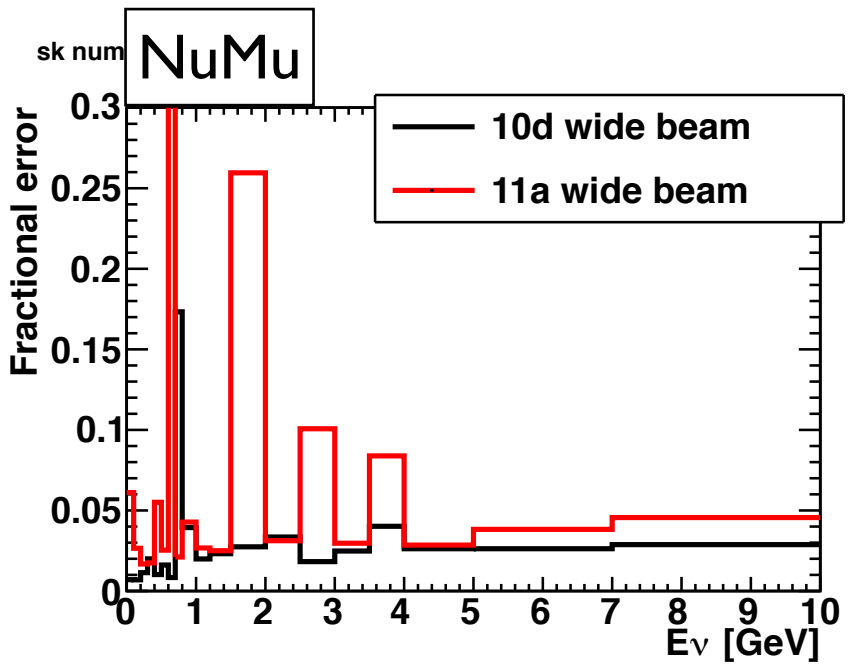


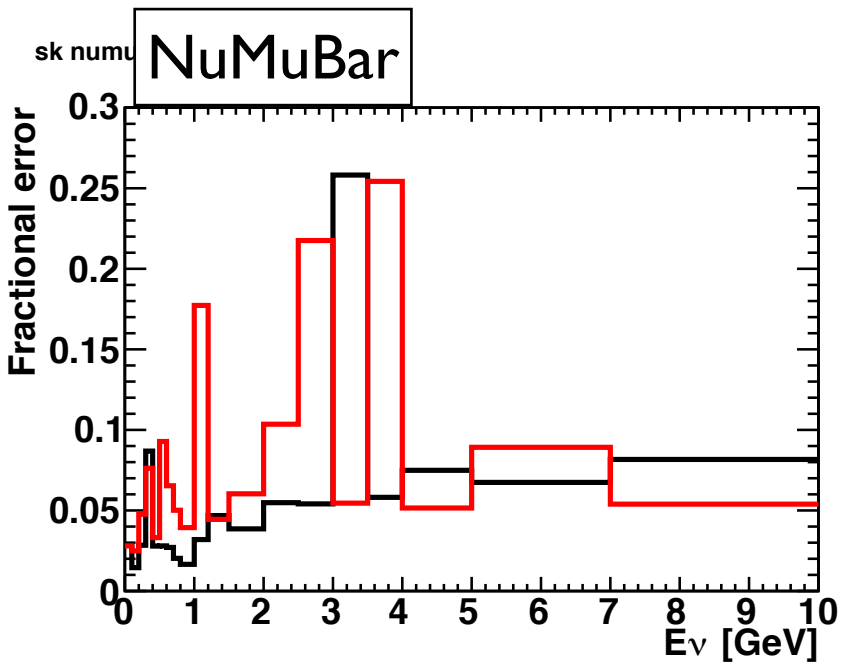


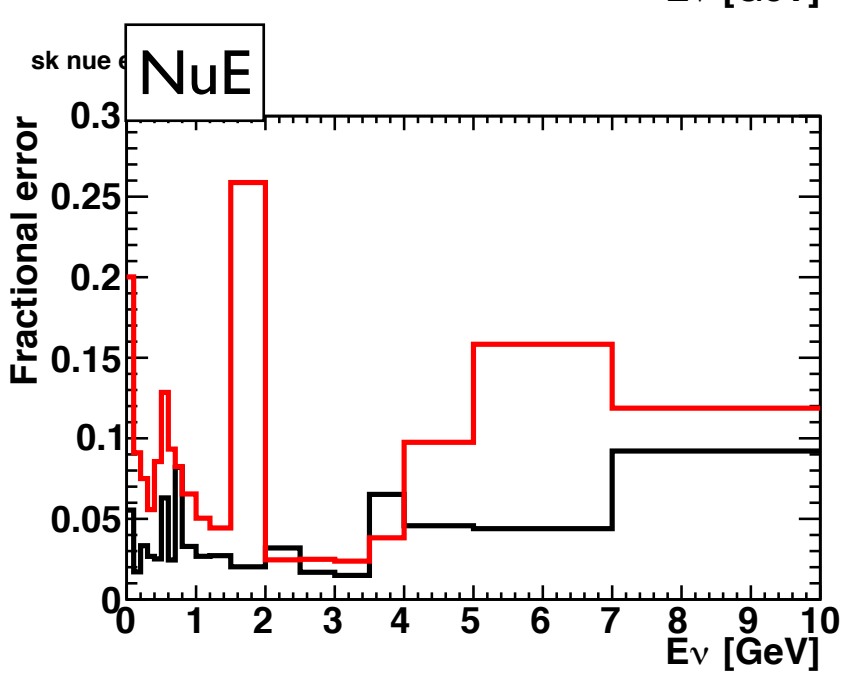


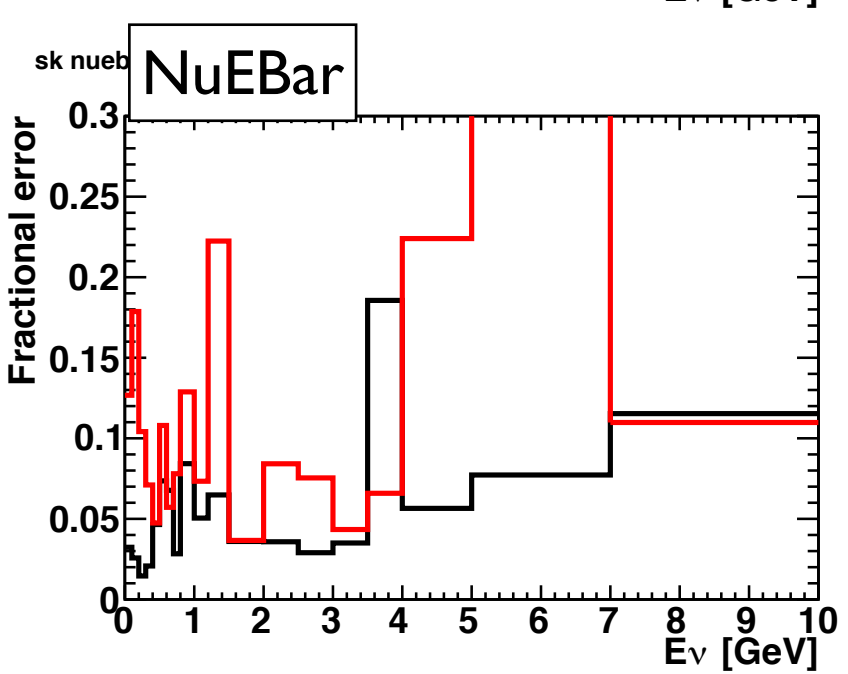


RunI : Fractional error (SK)









- Large fluctuation for Run II beam proton weighting
- Again, check the Run II proton beam parameter
  - Find that emittance in x-x' of Run II is larger than one of wide beam samples (next page).
  - Re-weighting from small emitt. to large emitt. can cause large fluctuation.

Emittance in X

- Take careful for only for the emittance in y-y', not in x-x'.
  - At proton beam weighting, emittance in x-x' also used.
- In T2K Run II, the emittance in x-x' also larger than in Run I.

Proton beam parameter (RunI) cs parameter for Run I

	center position (cm)	center angle (mrad)	profile width (RMS)(cm)	emittance (π mm.mrad)	Twiss parameter α
X	-0.037	0.044	0.4273	2.13	0.60
Y	0.084	0.004	0.4167	2.29	-0.09

Proton beam parameter (RunII) parameter for Run2.

	center position (cm)	center angle (mrad)	profile width (RMS)(cm)	emittance (π mm.mrad)	Twiss parameter α
X	-0.0149	0.080	0.4037	5.27	0.16
Y	-0.0052	-0.007	0.4083	5.17	0.14

Emittance in x-x' of wide beam flux = 2.13 → RunII is large!!

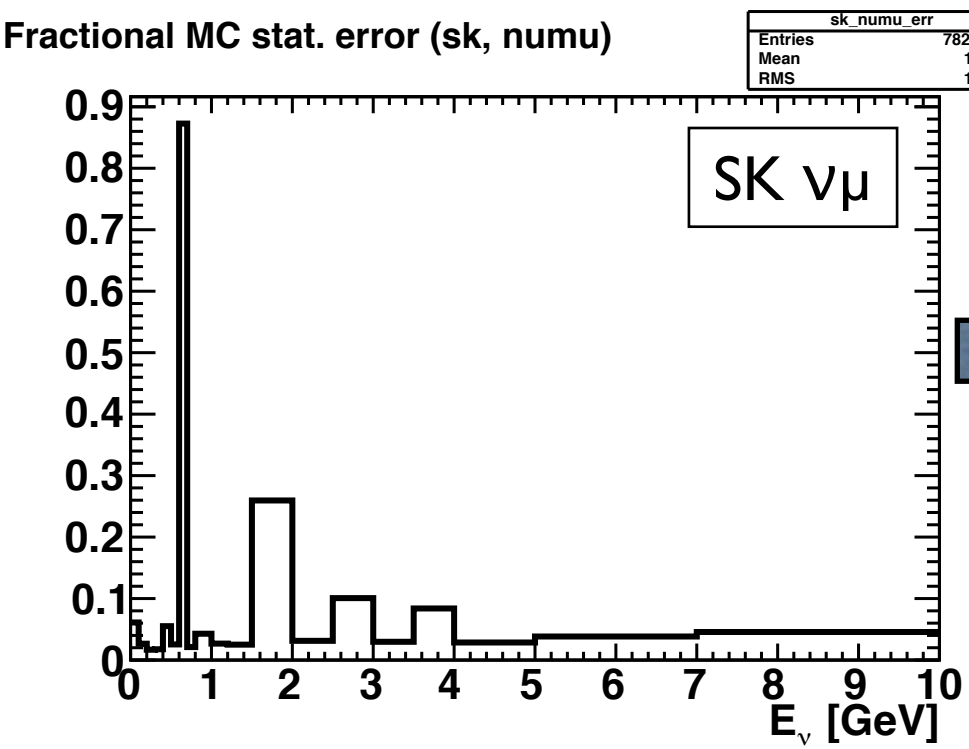
→ The proton weighting for x-x' may cause the high MC stat. error.

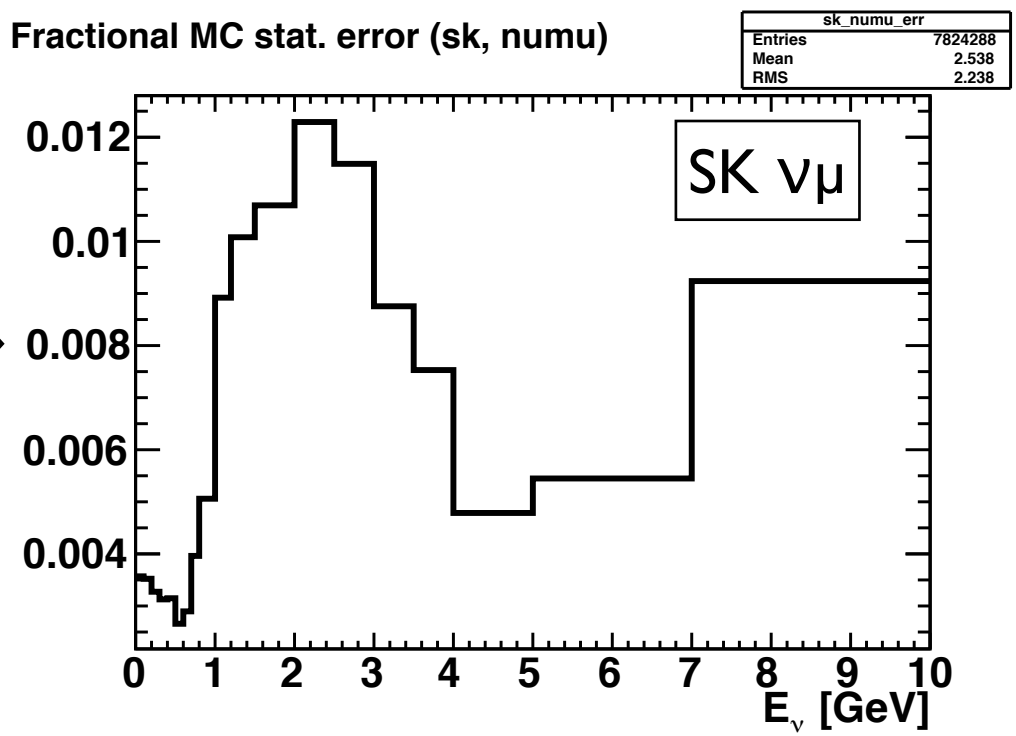
→ Check the MC stat. at small emittance in x-x'.

Small emittance in x-x' for RunII

- When proton beam weighting by using RunII beam parameters, use the emittance of Run I instead of RunII (5.27 → 2.13).
- Check the MC fluctuation by this weighting flux.

11a wide



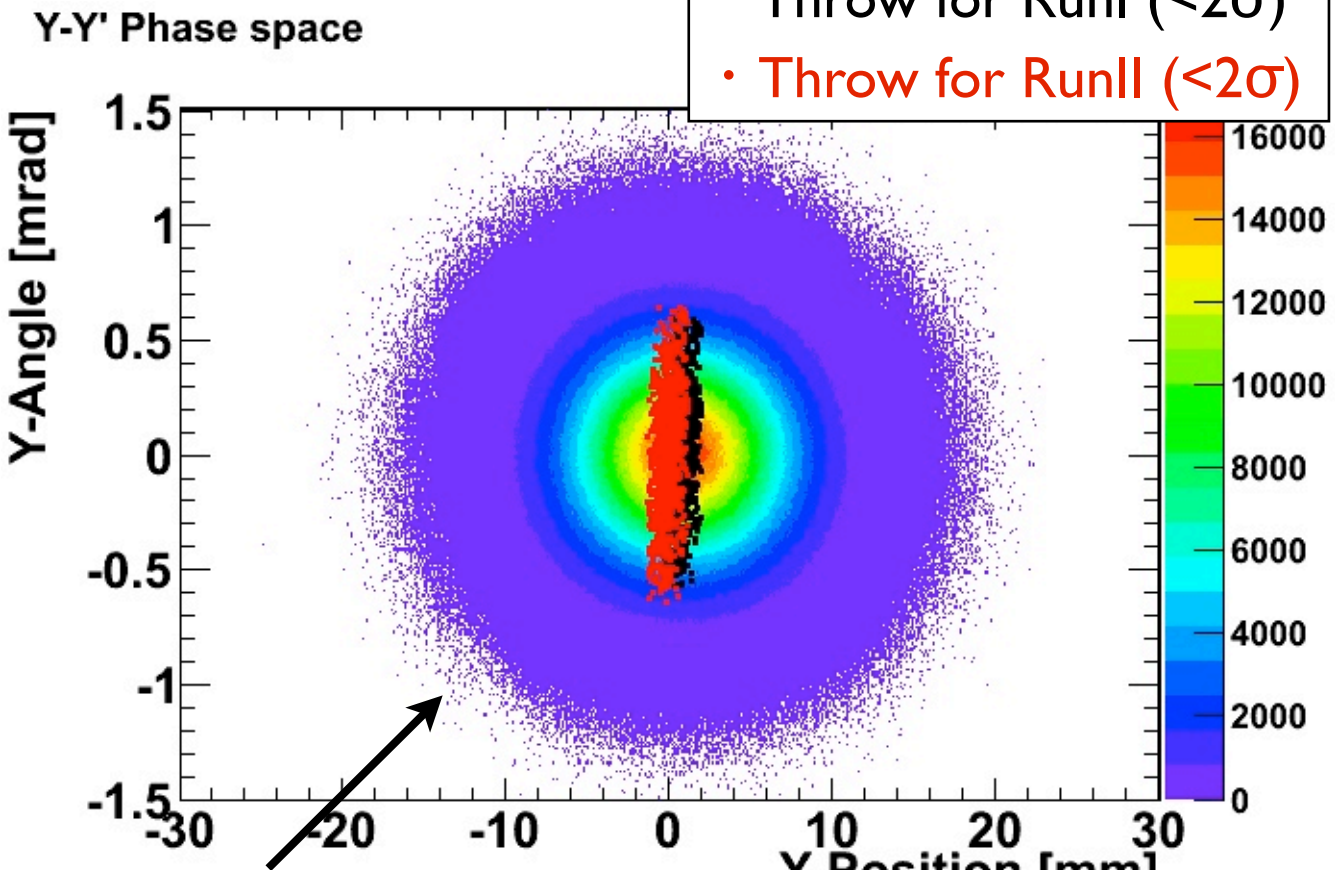


Proton beam flux uncertainty

- Back to estimation of the flux uncertainty. for RunII
  - Large flux uncertainty. in RunII seems to be due to larger emit. in x-x' in RunII.
  - Estimate flux uncertainty. for RunII by using emit. in x-x' in RunI
  - Postpone to estimate flux unc. with 11a wide beam samples for RunII.
- Estimation method is not changed
  - do 1000 throws for y-y'
  - Use throwing samples whose y&y' are within 2σ from mean value.
- Still MC stat. is not small (especially numubar&nue&nuebar)
  - Now generating more flux files by FLUKA2011

Y-Y' phase space

	r.m.s. of Y-Position [mm]	r.m.s. of Y-Angle [mrad]
RunI	0.589	0.292
Run2	0.613	0.321
wide beam flux	4.146	0.299

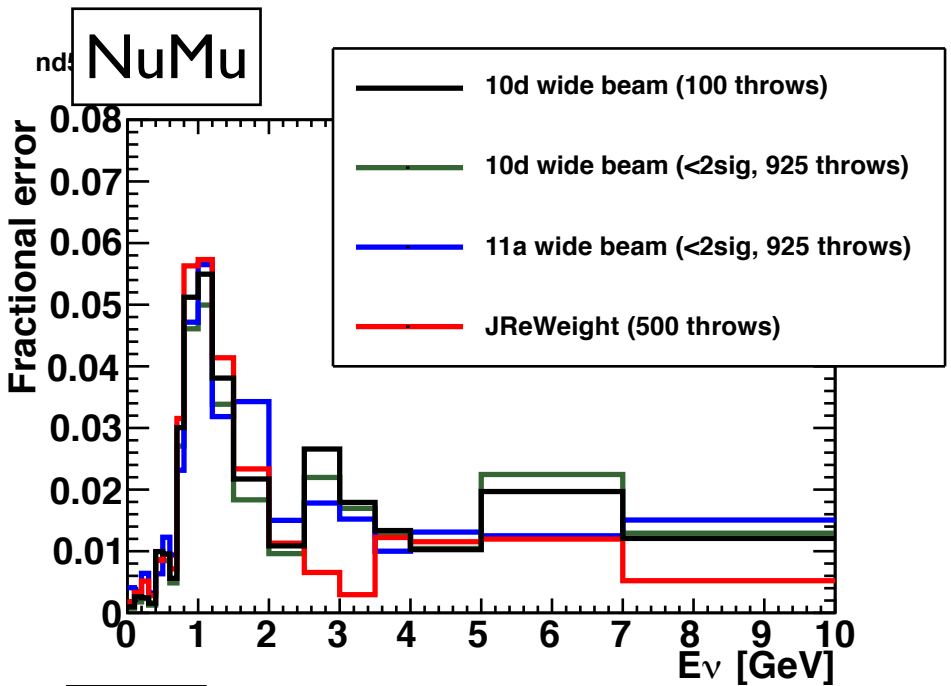


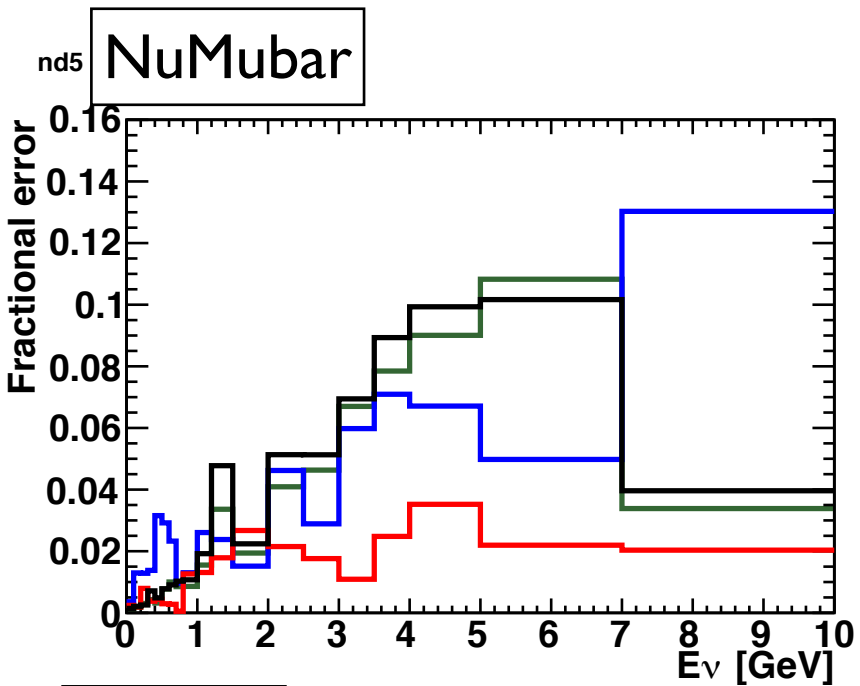
・Throw for RunI (<2σ)
・Throw for RunII (<2σ)

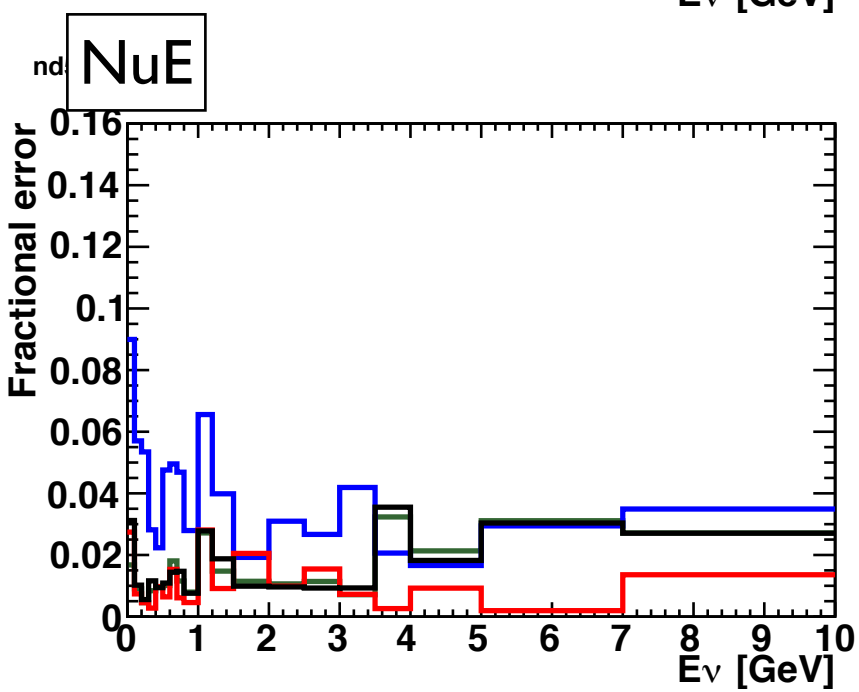
scatter :y-y' of wide beam samples

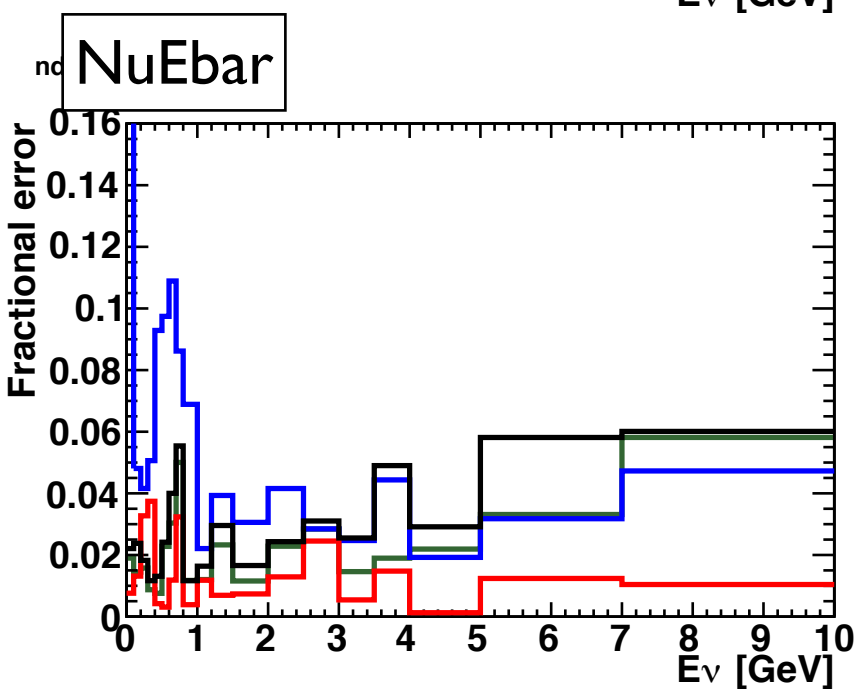
Use only throws whose y' difference from mean is within 2σ for estimation of flux uncertainty

RunI : ND5 Flux uncertainty

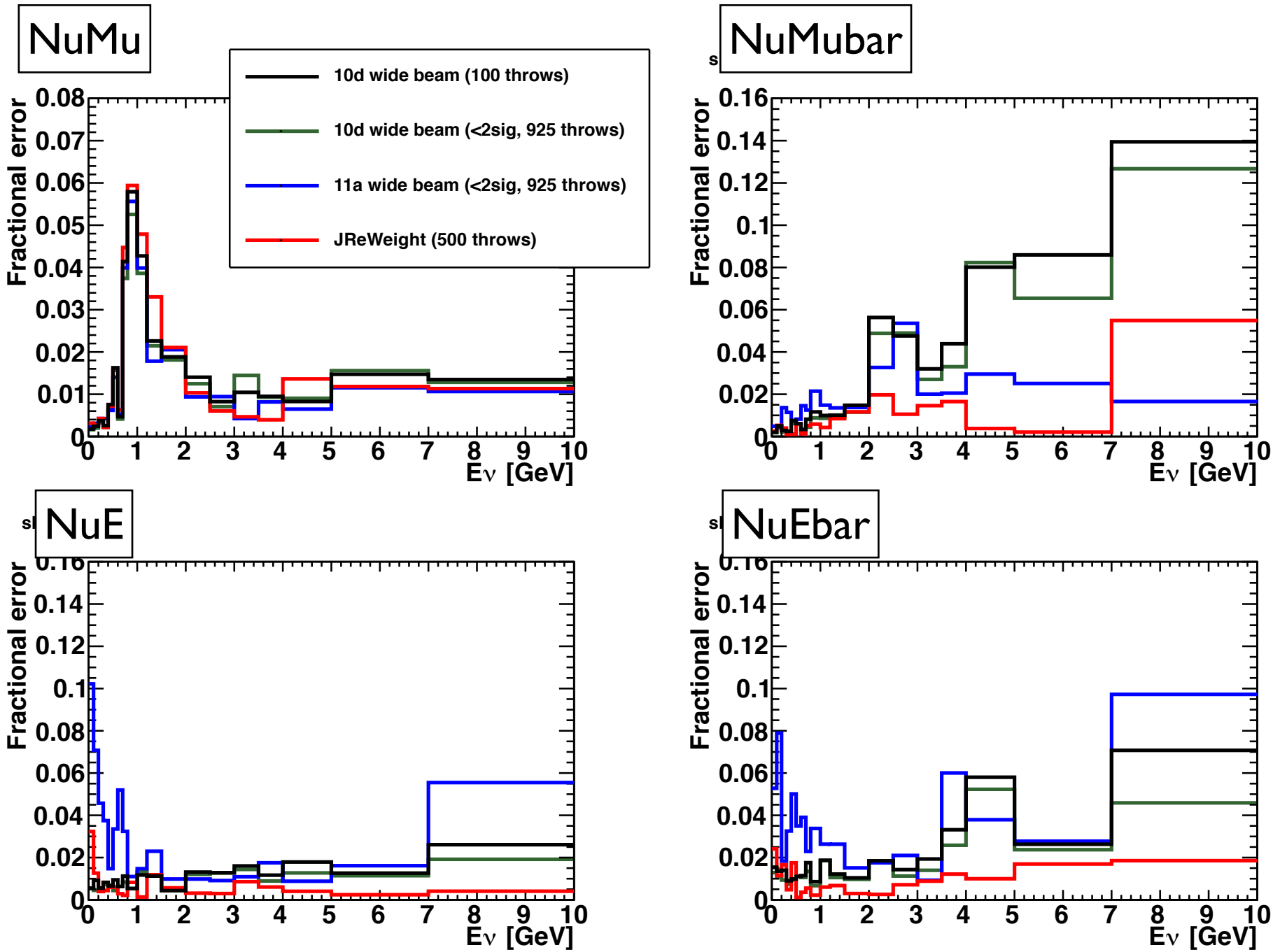






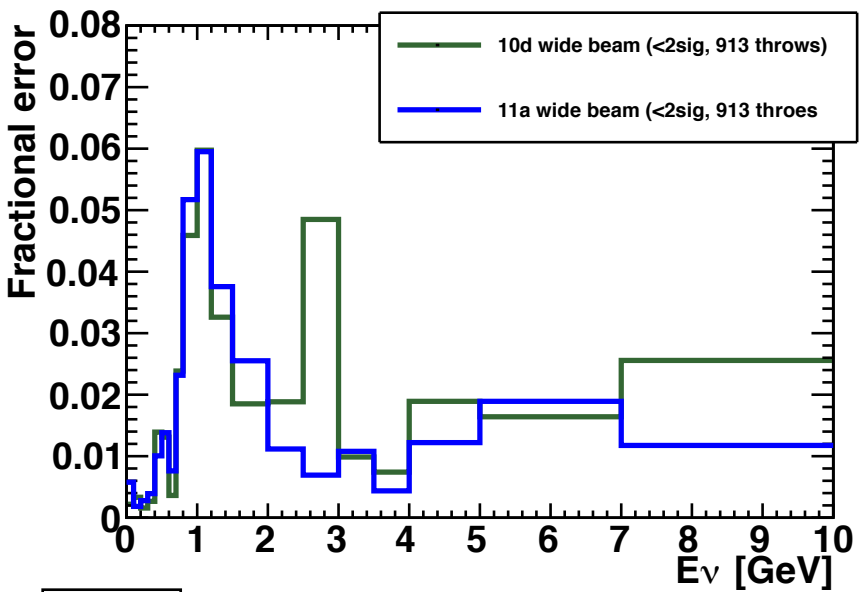


RunI : SK Flux uncertainty

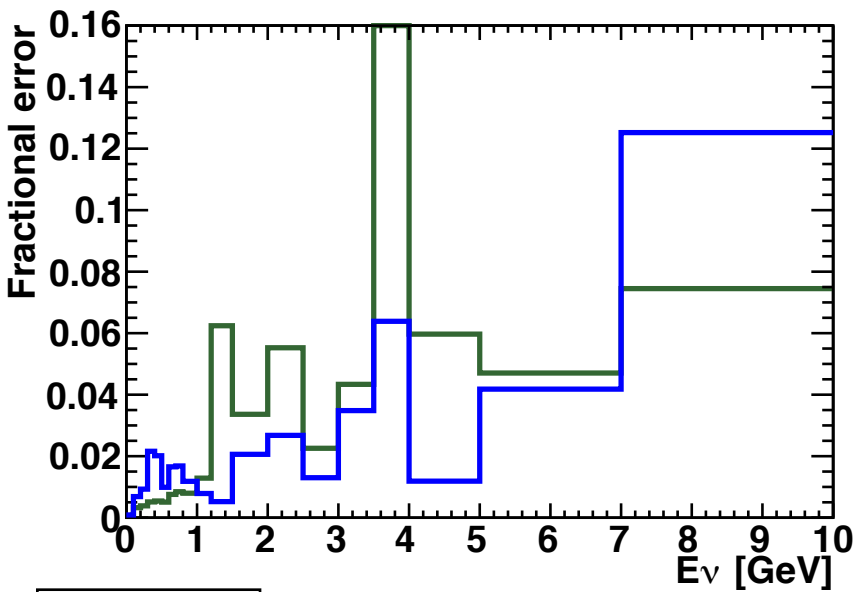


RunII : ND5 Flux uncertainty

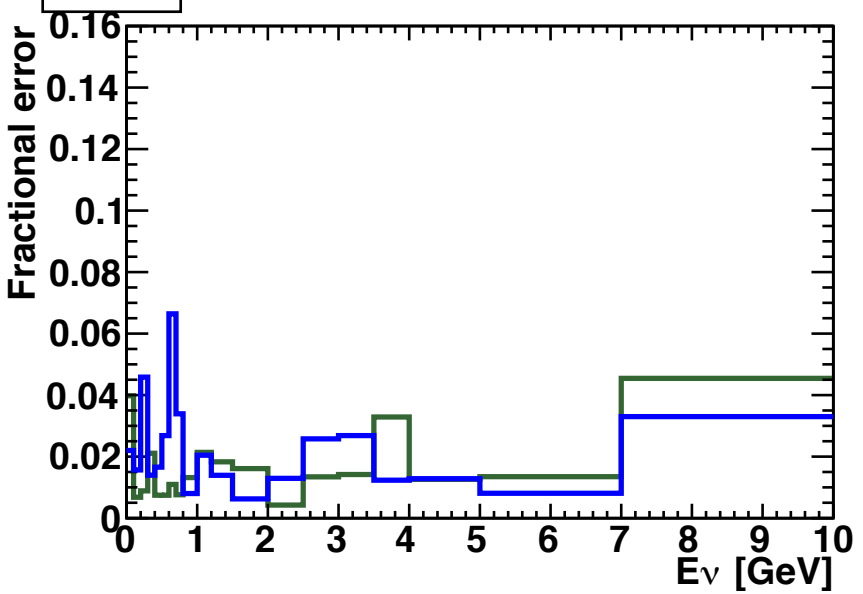
NuMu



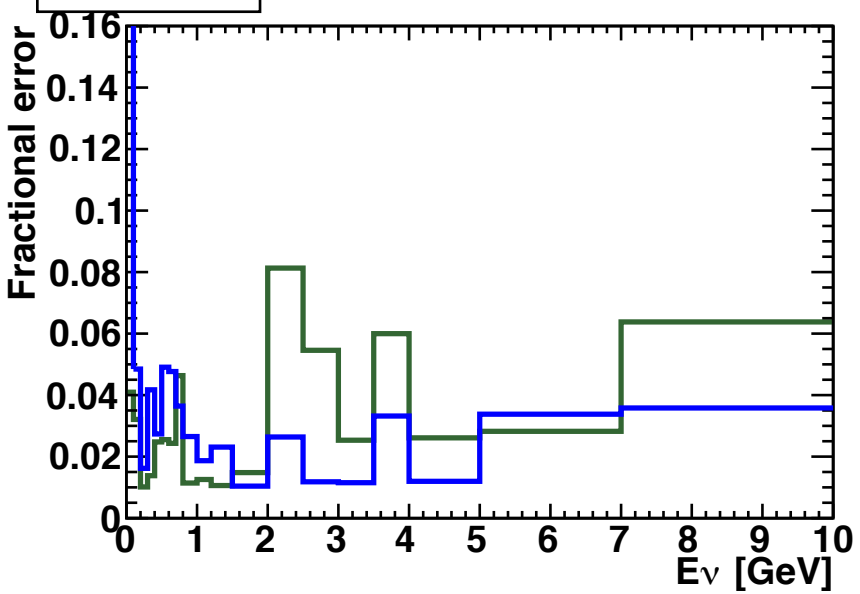
NuMubar



NuE

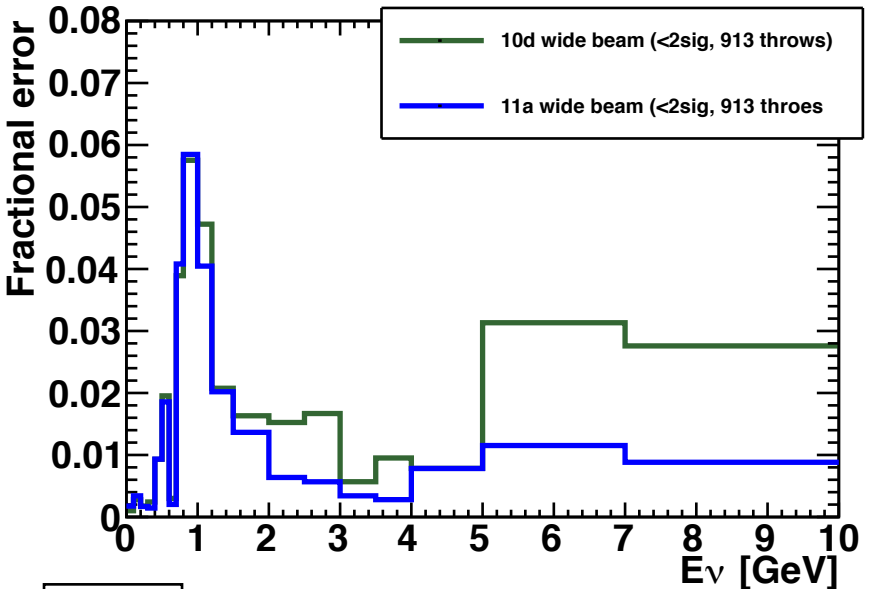


NuEbar

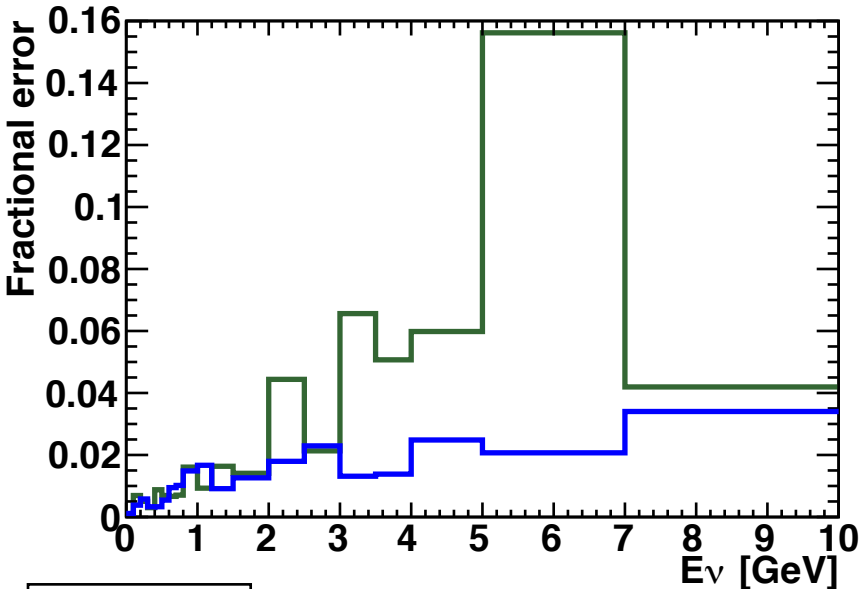


RunII : SK Flux uncertainty

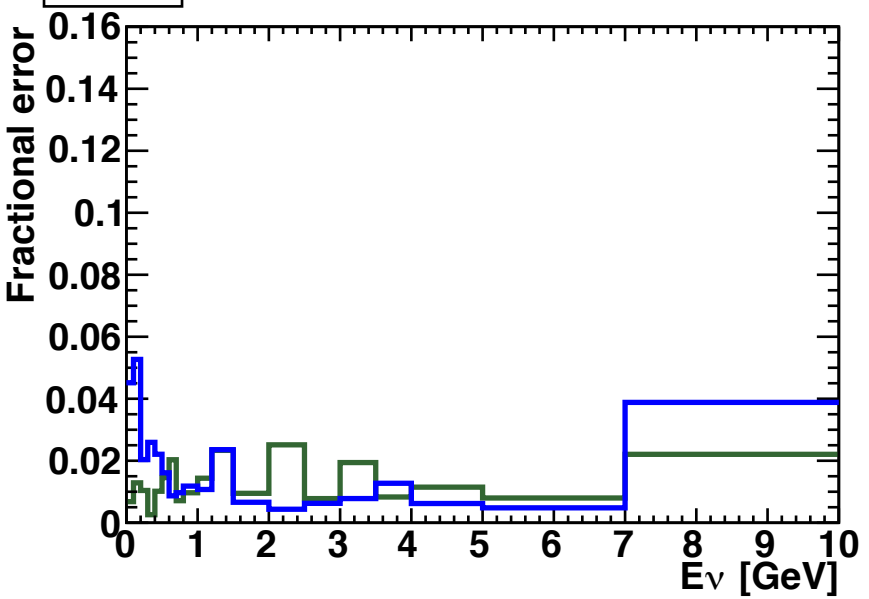
NuMu



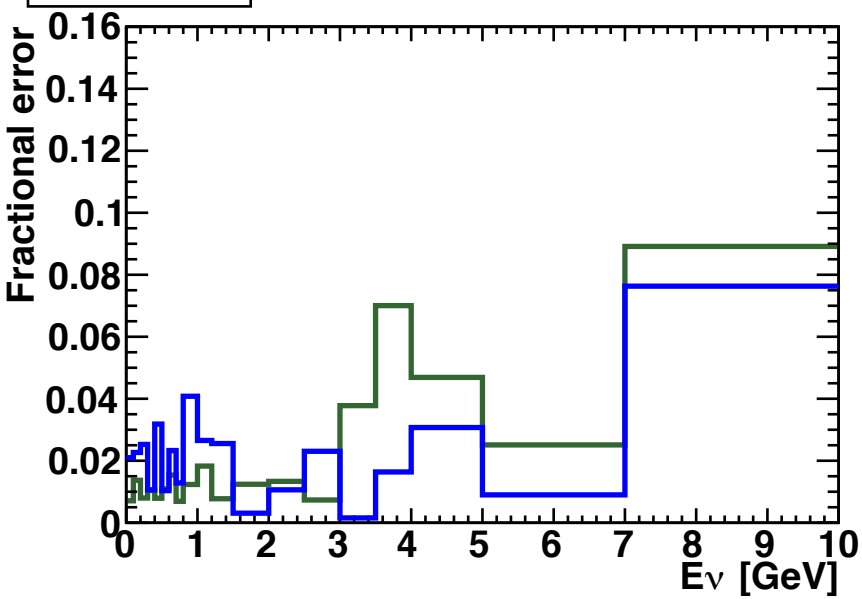
NuMubar



NuE



NuEbar



Summary

- Generate new wide beam flux sample with more larger the emittance in y-y' by using FLUKA2011
- Need larger emittance in x-x' for RunII proton beam weighting.
  - Tentatively, use RunI emittance in X instead of RunII value.
    - Need to generate larger emit. in x-x' in near future.
  - There are still some fluctuation.
- Plan to use the flux uncertainties estimated by 11a wide beam samples as updated flux uncertainties.
  - Now, re-generate JNUBEAM flux w/ 11a wide beam samples w/o low energy suppression for numubar/nue/nuebar → Expect to decrease fluctuation at low energy.
  - After this process, I estimate flux uncertainty (in near future).

back up