Update of proton beam flux uncertainty

Contents

- Flux uncertainty due to Run2 proton beam uncertainty
- Investigate large flux error at 3.5~4GeV due to proton beam uncertainty.
  - MC stat. error for SK flux with wide proton beam.
  - Normalization factor vs neutrino energy

Change the method of running throwing jobs

- Currently, in one process, 1000 (or 2000) throwings are processed because I think loop of throwing is quick.
  - Processes of 1000 throwings for SK and ND5 are done separately with the same initial seed.
  - But, takes much time! (few days).
- Change the method : 1000 throwings are processed separately.
  - One set of proton beam parameter should be applied for SK and ND5 at the same time. Initial seed should be same for SK and ND5 every throwings.
  - Initial seeds of all throwings should be different for each throwings.
    - Init seed = 4357 + throw#*100 (tentative)
    - The period of TRandom3 used in the process is 2**19937-1.
- One throwing process takes 1~2 hours. So quick!

Run2 proton beam parameter

- Use primary beam optics parameter and uncertainty for Run2
  - Use only y-y′ uncertainties for throwing.

Table 1. Primary beam optics 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

Table 2. Primary beam optics parameter for Run2.

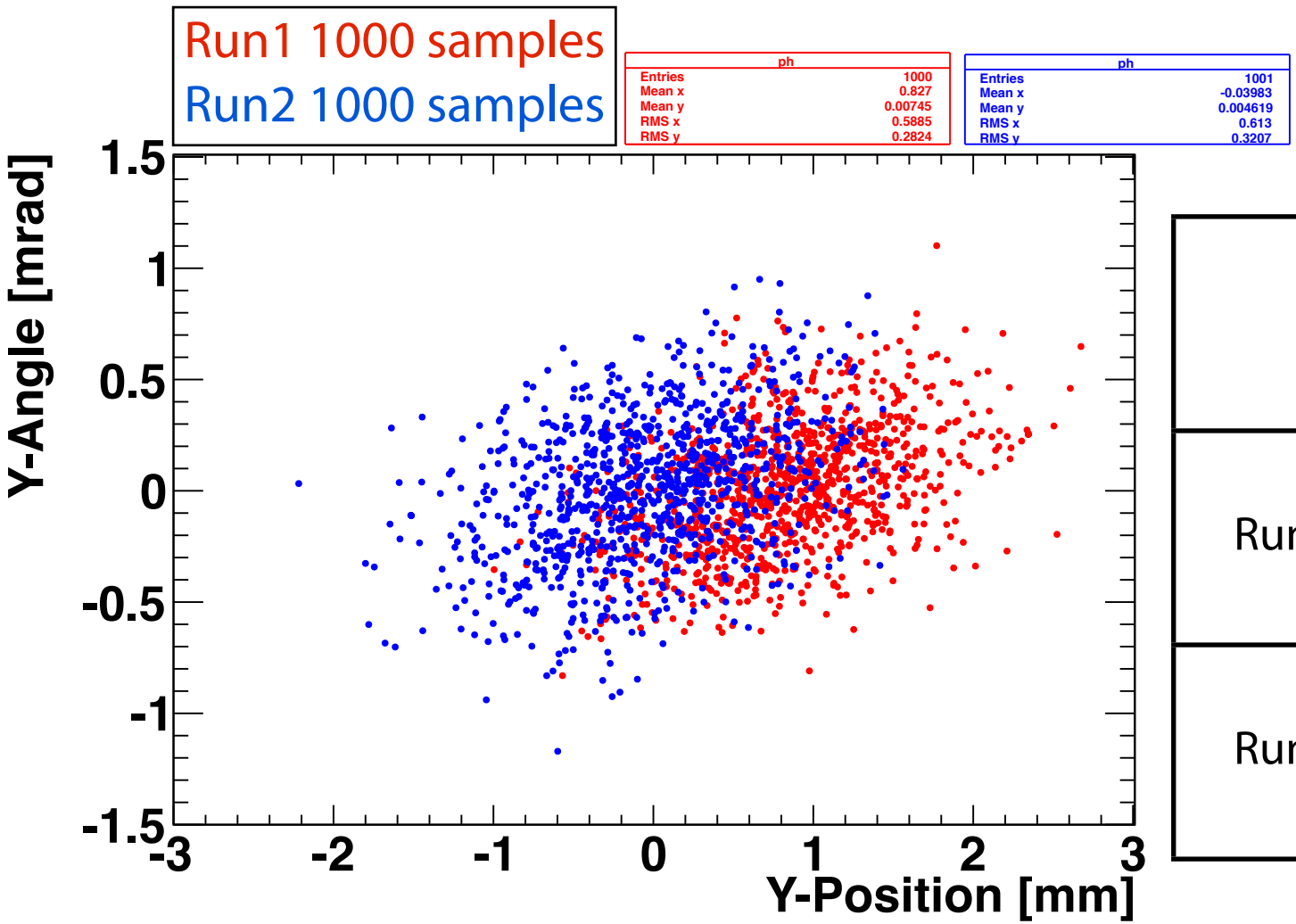
	center position (cm)	center angle (mrad)	profile width (RMS)(cm)	emittance (π mm.mrad)	Twiss parameter α
X	-0.0149	0.080	0.4037	5.27	0.16
Y	-0.0052	-0.007	0.4083	5.17	0.14

Uncertainty

	Run I	Run II
width in X (mm)	0.11	0.26
width in Y (mm)	0.97	0.82
Twiss α in X	0.32	0.26
Twiss α in Y	1.68	0.49
position in X(mm) (x)	0.38	0.27
position in Y(mm) (y)	0.58	0.62
angle in X (mrad) (x')	0.056	0.064
angle in Y (mrad) (y')	0.286	0.320
cov(x, x')	0.011	0.013
cov(y, y')	0.065	0.079

TN054(v2.3)

Thrown Y-Y' distribution

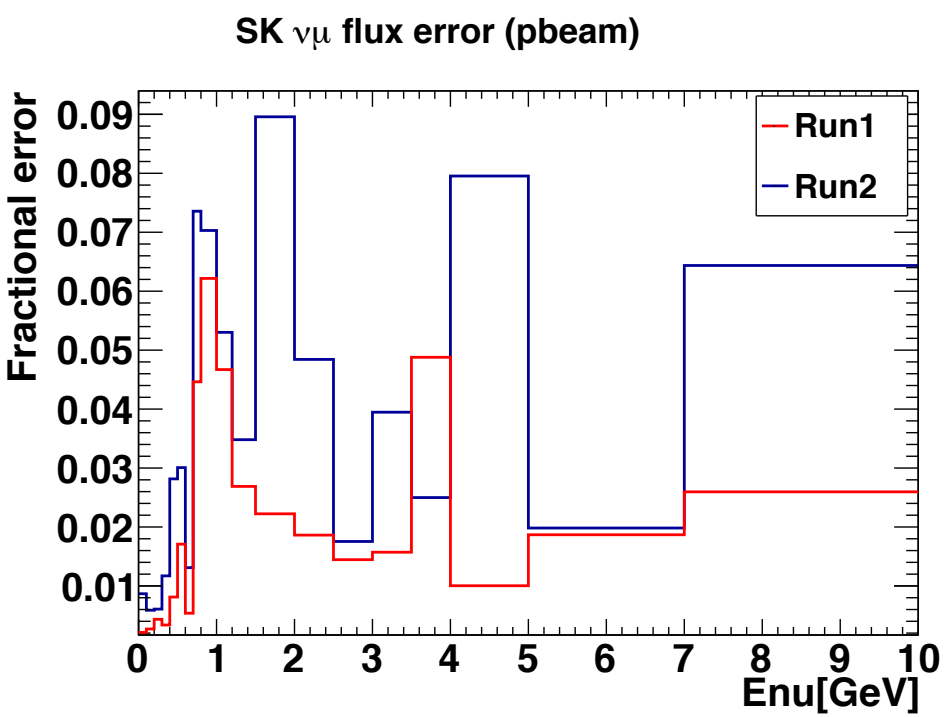


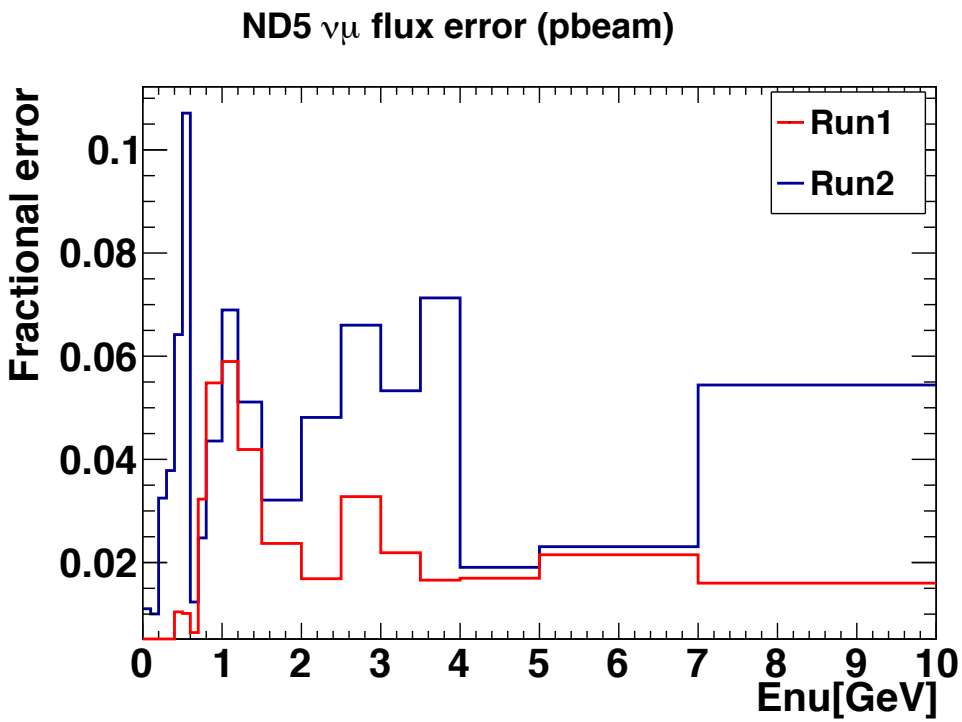
	r.m.s. of Y-Position [mm]	r.m.s. of Y-Angle [mrad]
Run1	0.589	0.292
Run2	0.613	0.321

- r.m.s. of thrown distribution is consistent with input uncertainties.
- There are some throwing samples with >3σ diff.

SK/ND5 flux uncertainty

Run1 : 1000 samples by previous throwing method
Run2 : 1000 samples by new throwing method





Large error than one of Run1 (by previous throwings meshod). Proton beam uncertainties of run2 is not so much different from one of run1

→ Some bugs with new throwing method ? (Treatment of initial seed, etc)

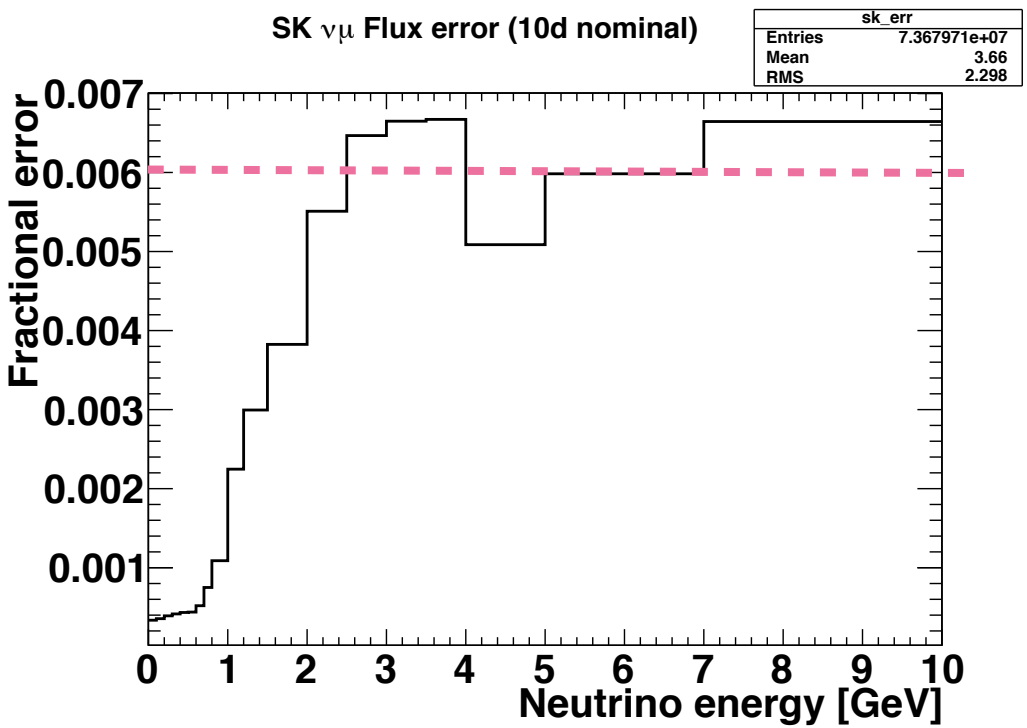
Summary of this topic

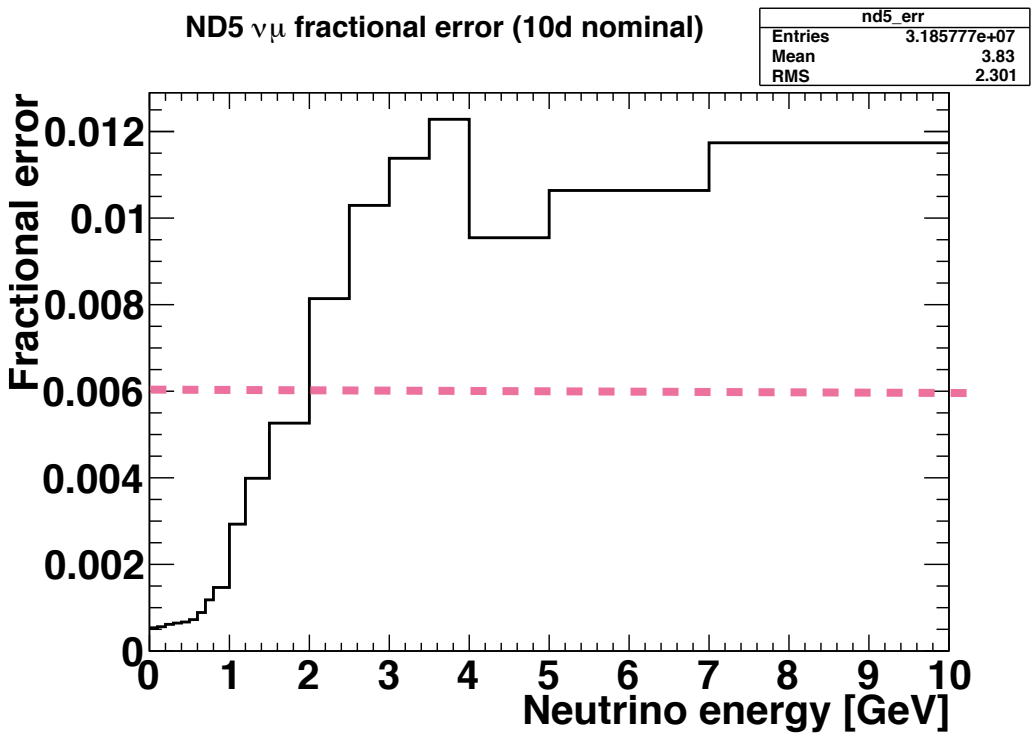
- Calculate SK and ND5 flux error due to Run2 proton beam uncertainties with same method to calculate Run1 error.
- The error of run2 is larger than expectation.
- Will calculate Run1 error with new throwing method and compare the effect of throwing method difference.

MC stat. of wide beam flux

- Used flux files made w/ wide proton beam
  - Jnubeam 10d with fluka2008 input.
    - # of triggers / file = 2e5
  - SK : 371 files (a certain file has 338958 entries)
  - ND5 : 483 files (a certain file has 338620 entries)
- By comparison, 10d nominal flux files
  - SK: 275 files (a certain file has 12591 entries)
  - ND5: 515 files (a certain file has 12796 entries)
- I calculate the quadratic sum of "norm" of each entry as MC stat. error.

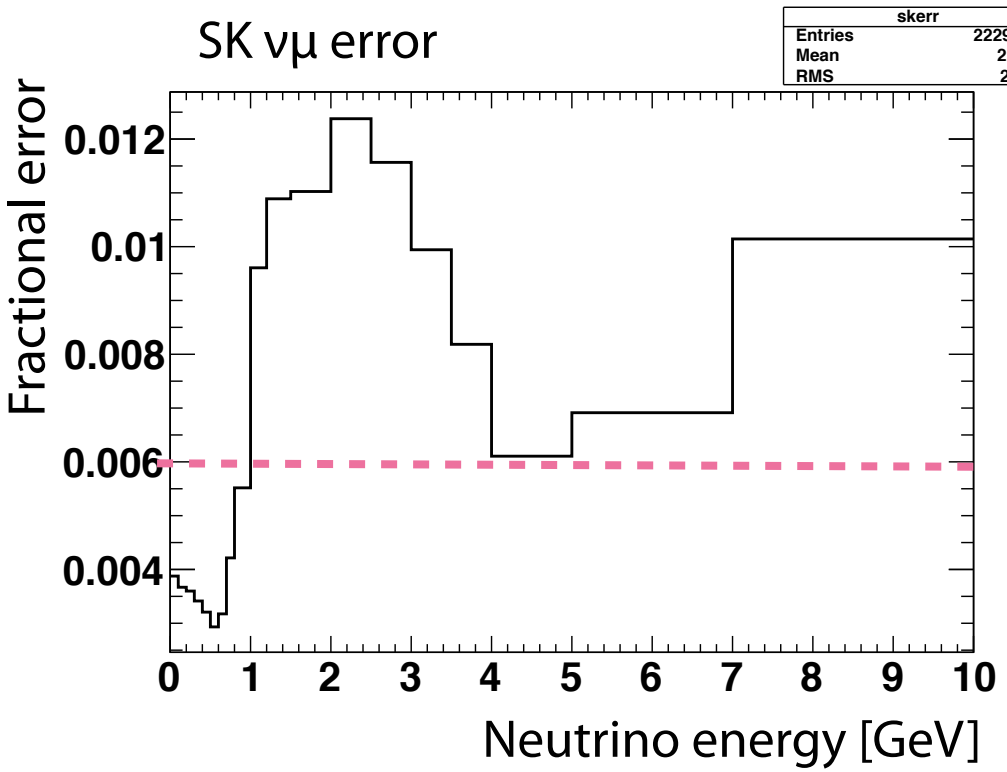
Flux fractional error (wide beam)

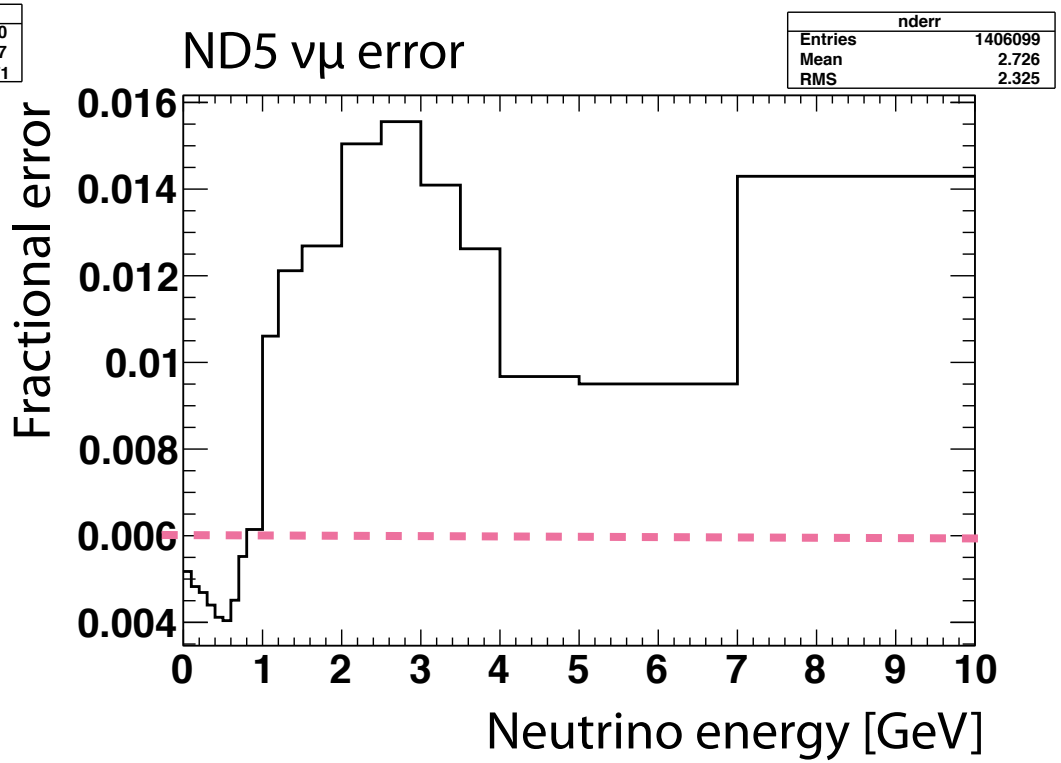




- SK flux error is small (less than 1%.) and ND5 flux error is also small (~1%).
- There is no drastic change around 3.5-4GeV energy bin (where large flux fractional error due to proton beam uncertainty, which I reported)

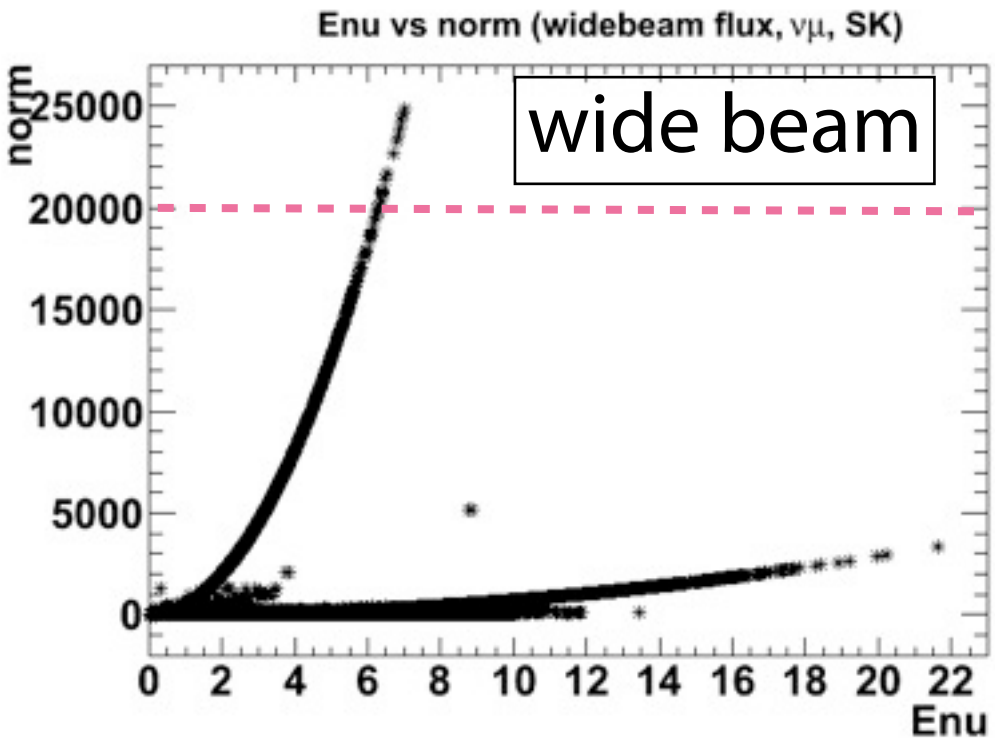
Fractional error (10d nominal)

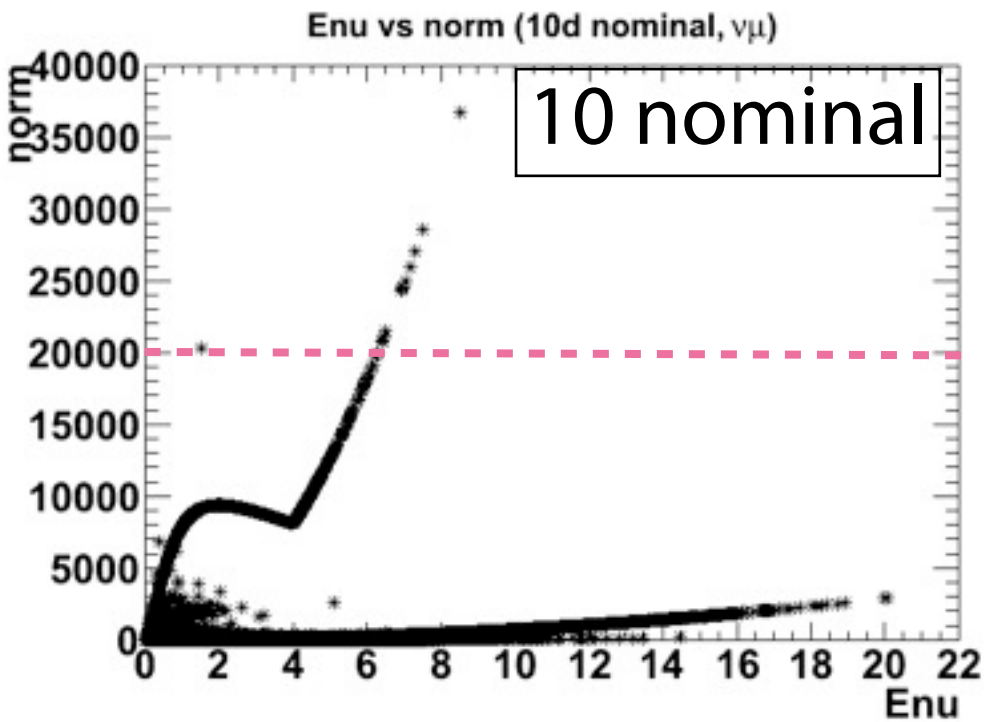




- SK&ND5 flux errors are ~1% level (a little larger than at the case of wide beam)
- The shape of flux error is also diff. due to diff. of energy dependence of "norm" (→ next page)

Enu vs norm about SK νμ flux





- There is a peak of norm around 2GeV in 10d nominal → A peak of flux MC error.
- There is no peak in wide beam (smoothly increase).
- I think a remarkable peak of norm around 3.5-4GeV causes the large flux error due to proton beam unc., but it seems to be wrong guess ?
  - I'm trying to do throwings excluding large norm (>2000) w/ wide beam flux.

Summary of this topic

- I check MC stat. error and norm factor to investigate the large flux uncertainty at 3.5~4GeV.
- I don't find remarkable reason for the large flux error at 3.5-4GeV due to proton beam.
  - I'm trying to estimate flux error w/o large norm entries now to check the effect of large norm.

Enu vs norm about SK νμ flux

- Enu vs norm about ND5 νμ flux (wide proton beam)