

Hogehoge

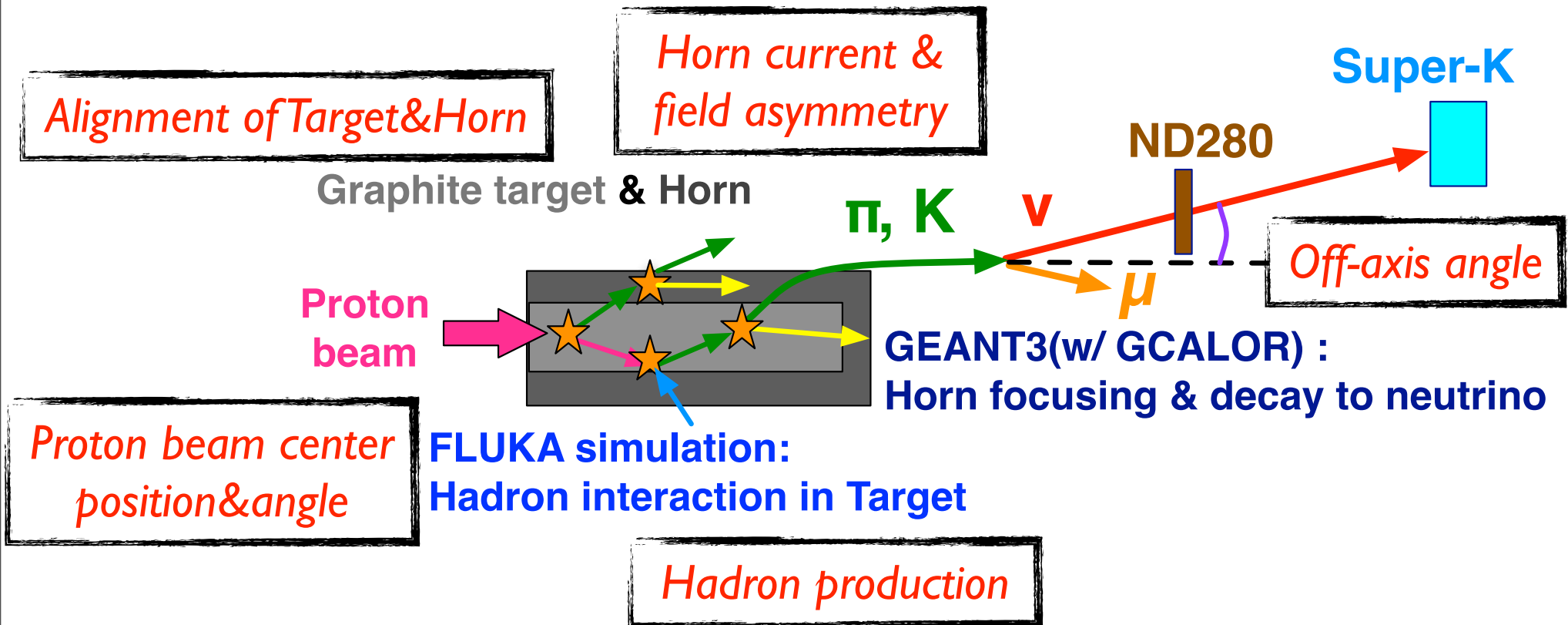
Beam group

Contents

- Review of current flux uncertainty
- Update of flux uncertainty in Dec. analysis meeting at Tokai
- Current study status

Flux uncertainty components

Overview of flux simulation and components of flux uncertainty



Current beam uncertainty in 2010a nue analysis

$\sin^2 2\theta_{23} = 1$, $\Delta m^2_{23} = 2.4 \times 10^{-3} \text{ eV}^2$ and $\sin^2 2\theta_{13} = 0.1(0.0)$ for $\nu_e (\bar{\nu}_\mu)$

Hadron production		Percent Errors of expected number of events			
Source	N_{ND}	$N_{SK}(1 \text{ Ring } \mu)$	$N_{SK}(\nu_e \text{ Sig.})$	$N_{SK}(\nu_e \text{ Bgnd.})$	$N_{SK}(\nu_e \text{ Tot.})$
Pion Multiplicity	5.53	5.47	6.86	6.04	6.06
Tertiary Pion scaling	1.39	1.76	1.32	1.12	1.27
Kaon Multiplicity	10.01	10.63	1.76	11.71	4.21
Prod. Cross Sections	7.65	7.12	11.61	6.66	10.39
Sec. Nucleon Multiplicity	5.87	6.35	6.76	6.55	6.69
Proton Beam	2.22	1.78	1.05	0.04	0.80
Off-axis Angle	2.65	3.19	2.07	2.09	2.08
Target Alignment	0.26	0.34	0.08	0.05	0.05
Horn Alignment	0.57	0.52	0.41	0.47	0.42
Horn Abs. Current	0.47	0.08	1.23	0.71	1.11
Total	15.43	15.83	15.48	16.35	14.92

Already update : I lav2.x (as reported Collabo. or ASG meeting)

Investigate to update for the Dec. analysis meeting or near future.

Make the flux covariance matrix for the global analysis by using flux uncertainty.

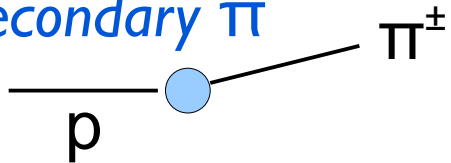
Hadron production

Production Type

$\frac{v_\mu}{\mu}$ Fraction
for SK

$\frac{v_e}{e}$ Fraction
for SK

Secondary π

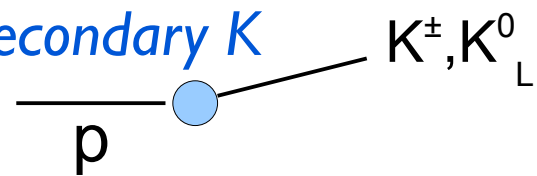


70%

40%

- FLUKA is compared with NA61 Pion/Kaon data.

Secondary K

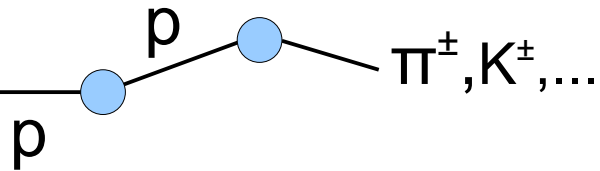


8%

39%

- About not covered by NA61, use interpolated data of other experiment (Eichten, Allaby).

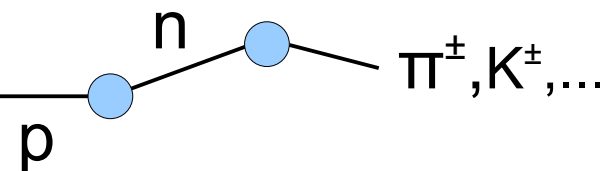
Secondary nucleon $\rightarrow$ Tertiary π, K



16%

14%

- For secondary nucleon production, FLUKA is compared with the experiment data.



5%

5%

- For tertiary pion/kaon production, the same error as secondary pion/kaon by scaling method (w/ scaling uncertainty)

Proton beam center

- Consider only RunI proton beam position/angle uncertainty for current flux uncertainty.
- Uncertainties of beam center position/angle (especially in Y) during RunII period are larger than RunI period

RunI beam parameters

	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

RunII beam parameters

	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

TN054(v2.3)

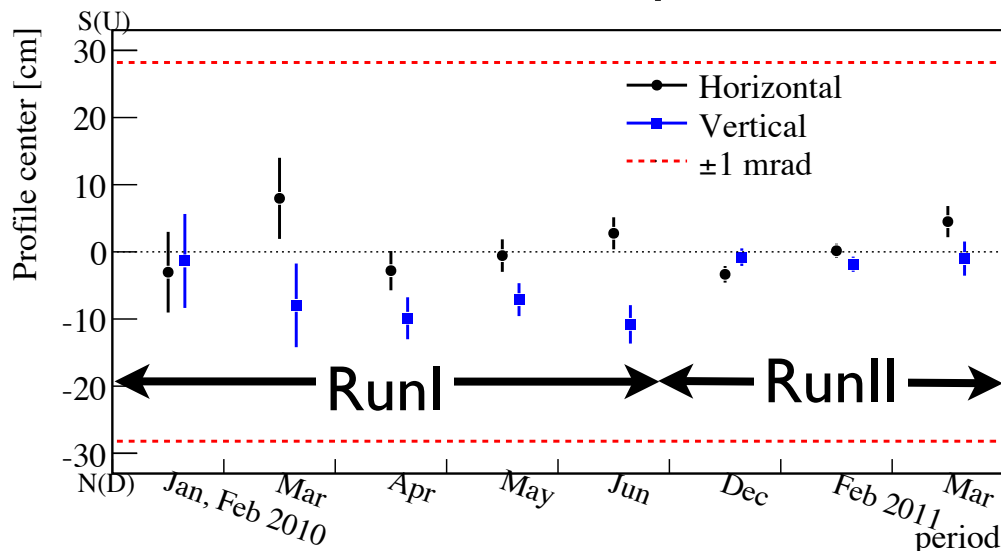
Proton beam uncertainty

	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

Off-axis angle

- The following factors cause flux uncertainty
 - The deviation of the beam direction from the beam-axis.
 - Statistic error of the beam direction measurement.
 - Beam direction uncertainty from INGRID detector systematic error
- Current error estimated by only RunI data.
 - We controlled neutrino beam better in RunII than RunI → Flux uncertainty to be small every T2K-Run period.

ν Beam measurement by INGRID



ν Beam summary in INGRID

Beam center from the INGRID center	X center[cm]	Y center[cm]
RUN1 + RUN2	$-0.4 \pm 0.7 \pm 9.2$	$-3.0 \pm 0.7 \pm 10.4$
RUN1 only	$0.4 \pm 1.4 \pm 9.2$	-8.6 ± 1.5
RUN2 only	$-0.7 \pm 0.8 \pm 10.4$	-1.4 ± 0.8

Toward Dec. analysis meeting

- Already release I lav2.1 flux uncertainty
- Release flux uncertainty I lav2.2 around Dec. analysis meeting.
 - (At least) Establish the format of flux covariance matrix for 2011a analysis.
- Many studies for 2011a/near future analysis investigated
 - Proton beam & off-axis angle uncertainty by using RunII data and same method as for 2010a analysis
 - Compare FLUKA2011/2008
 - Horn field & angular alignment uncertainty
 - Consider MUMON measurement for off-axis uncertainty
 - And so on...

Note of I l av2.1, v2.2 uncertainty

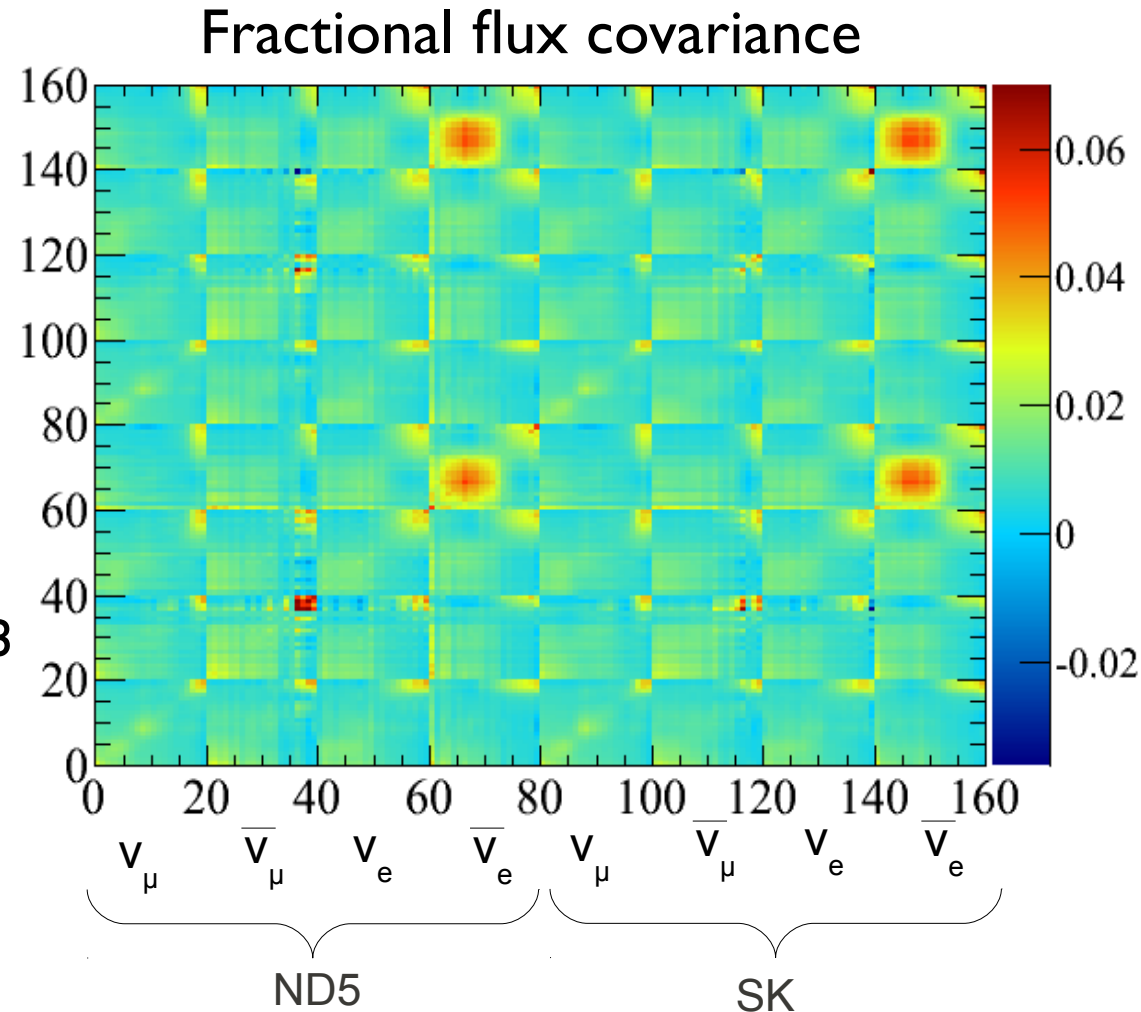
- I l av2.1 uncertainty: already released (<http://www.t2k.org/beam/NuFlux/FluxRelease/I l arelease/I l av2p l covariance>)
 - Include Kaon flux uncertainty by using NA61 Kaon data.
 - Release with coarse binning only for flux covariance matrix
 - Include $\nu_{\bar{e}}$ uncertainty for sources where it has been evaluated
 - Update the proton beam error with Run 2 y - y' variations (tentatively use the different method (JReWeight) from evaluation for 2010a).
 - Include horn/target alignment and horn absolute current using variations evaluated for 2010a
- I l av2.2 uncertainty:
 - Include finely binned covariance that can be used for binning studies
 - Include missing $\nu_{\bar{e}}$ uncertainties at I l av2.1
 - Include results of some studies about flux uncertainties if ready
 - Define to include which results in Dec. meeting ?

Flux covariance matrix (11av2.1)

Flux covariance for ν_μ , anti- ν_μ , ν_e and anti- ν_e at ND5 and SK detector planes

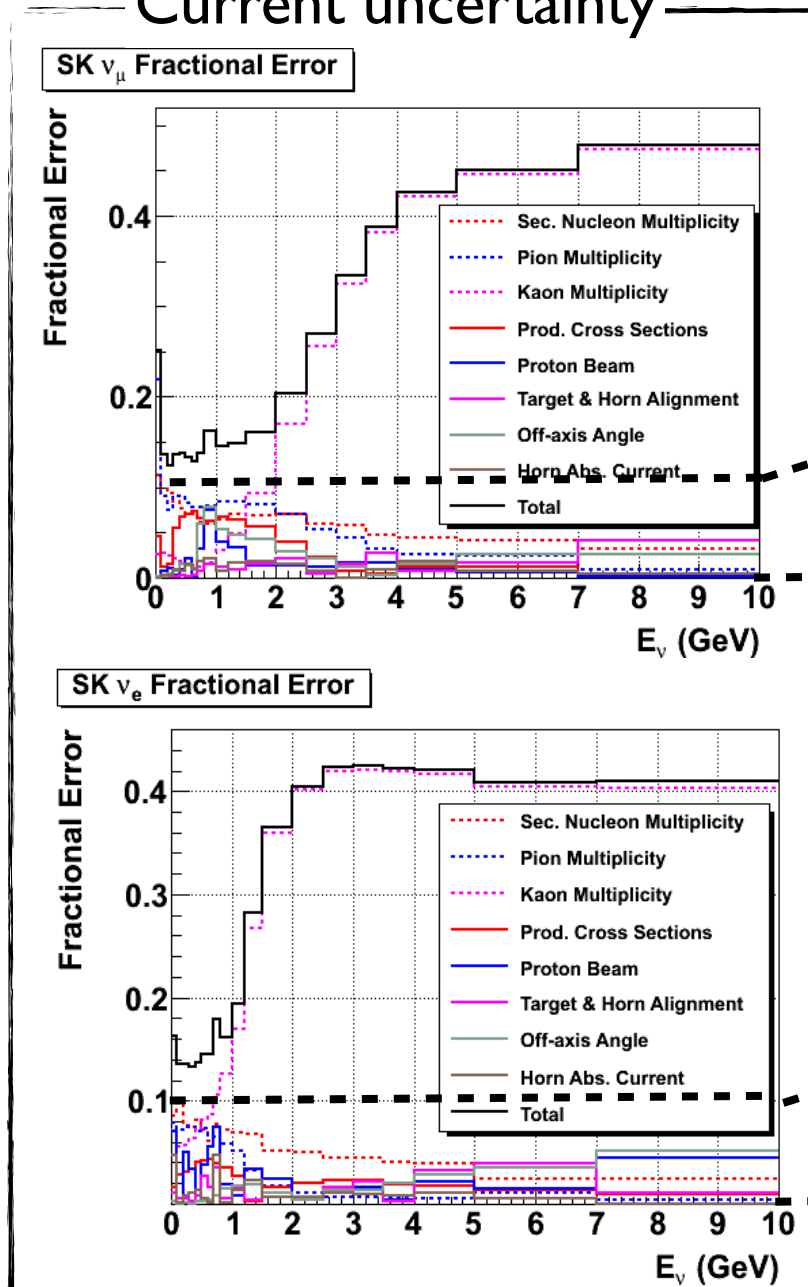
Error Sources:

- Pion production – updated for 11av2 tuning
- Kaon production – updated for 11av2 tuning
- Secondary nucleon production – same as 10dv3
- Production cross sections – same as 10dv3
- Off-axis angle – no ν_e -bar errors at this time (10dv3 errors)
- Proton beam errors – y - y' errors calculated with JReWeight
- Horn&Target alignment – no ν_e -bar errors at this time (10dv3 errors)
- Horn absolute current – same as 10dv3

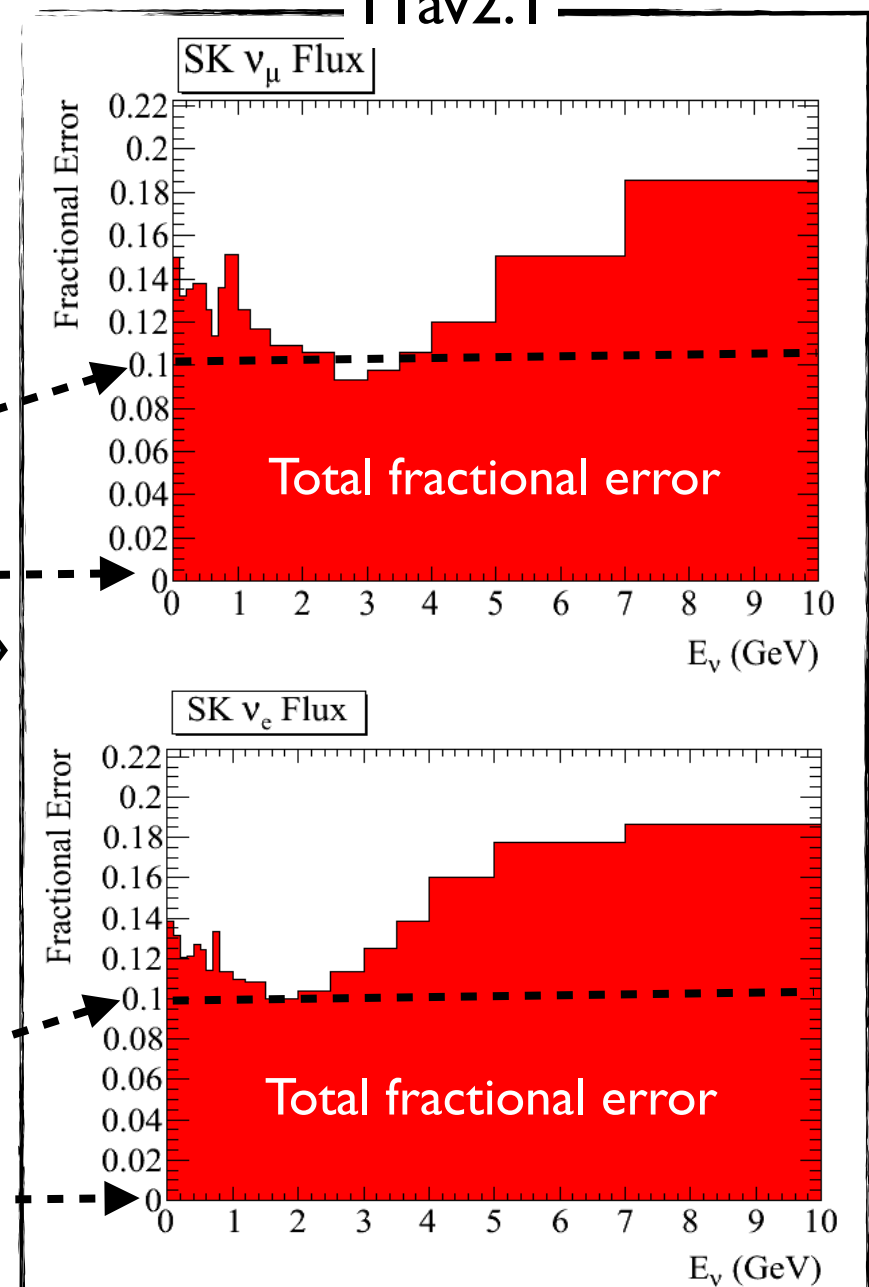


Update flux uncertainty (11av2.1)

Current uncertainty



11av2.1

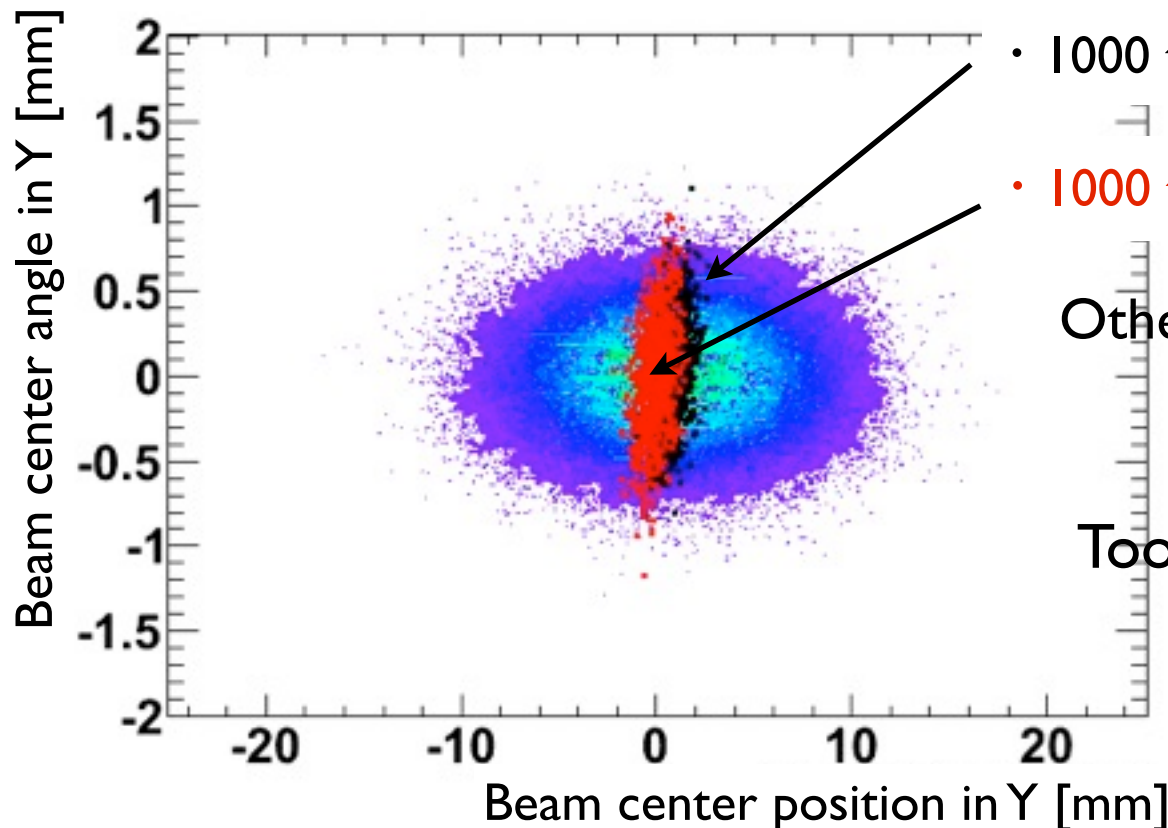


→ Flux uncertainty at the high energy region reduce drastically

Update of proton beam uncertainty

- Estimate flux uncertainty from proton beam by using RunII data and the same method as 2010a

Y-Y' phase space



- 1000 throwing by Run I p-beam parameters.

- 1000 throwing by RunII p-beam parameters

Other dots : using flux made with wide p-beam parameter

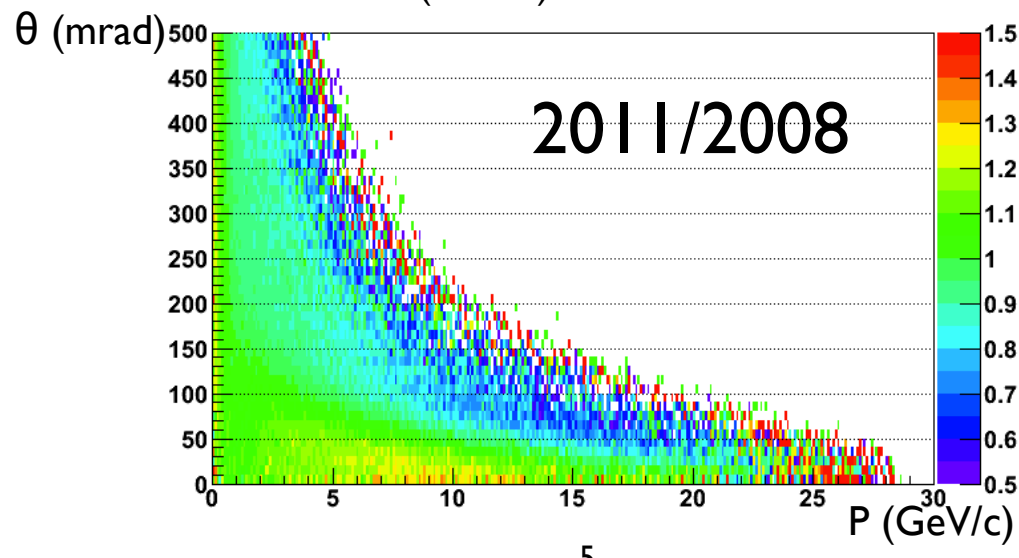
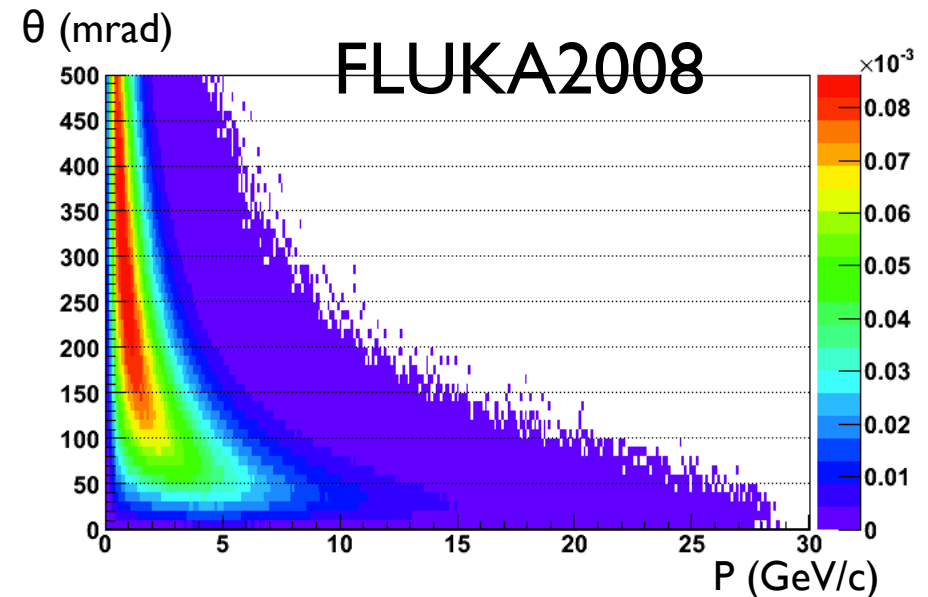
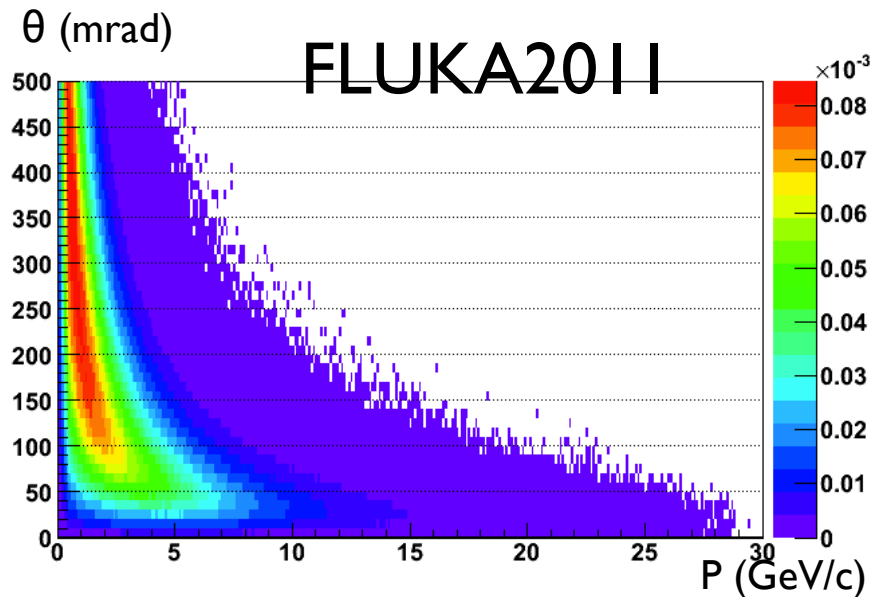
Too large Y-angle variation compared to used wide p-beam flux.

Discard throw samples with too large Y-angle to estimate uncertainty or more wider p-beam flux samples

FLUKA2011/2008

Multiplicity (p - θ) distribution (π^+)

K.suzuki



Now investigate
comparison with
FLUKA2011 to
FLUKA2008