INGRID update

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1. Monte Carlo simulation
2. Summary of 10a beam DATA
3. Comparison of DATA and MC
4. Syst. error study

Overview of MC

- Component
  - Jnubeam -> Estimate Neutrino Flux to INGRID
  - NEUT -> Simulate neutrino interaction
  - GEANT4 -> Detector MC

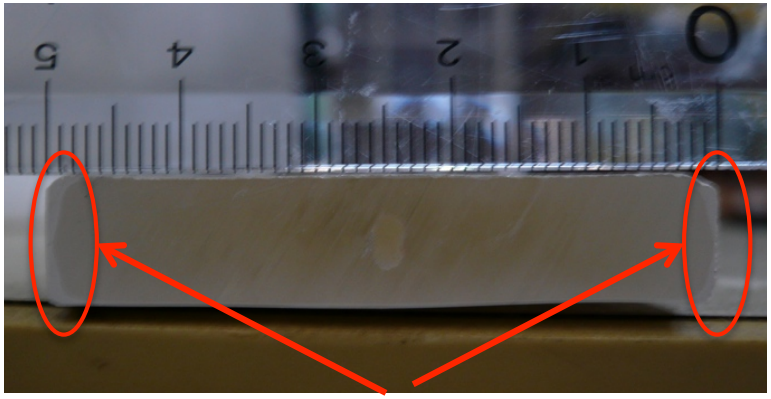
Updates from last collabo. meeting

- Implement Real scintillator dimension
  - Before : box shape -> octagon shape (from measurement)
- Consider interaction vertex in scintillator
  - Ratio of scintillator target to Fe is about ~4%
    - Simulate neutrino interaction at Fe target (preparing about scintillator target).
- Add MPPC noise on MC data
- Install bad channels
- Use Jnubeam 10c (nominal beam) -> weighting with FLUKA2008 (real beam).

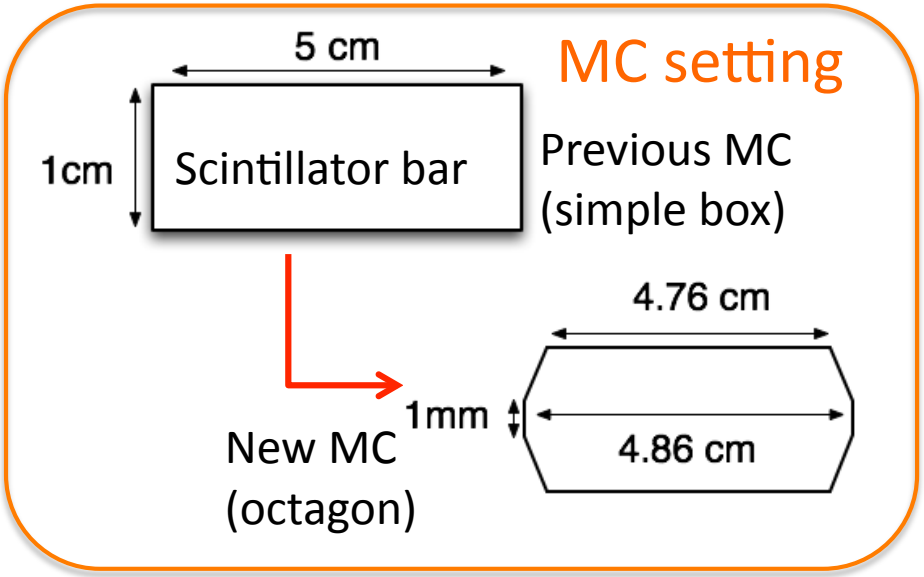
Dimension of scintillator bar of MC

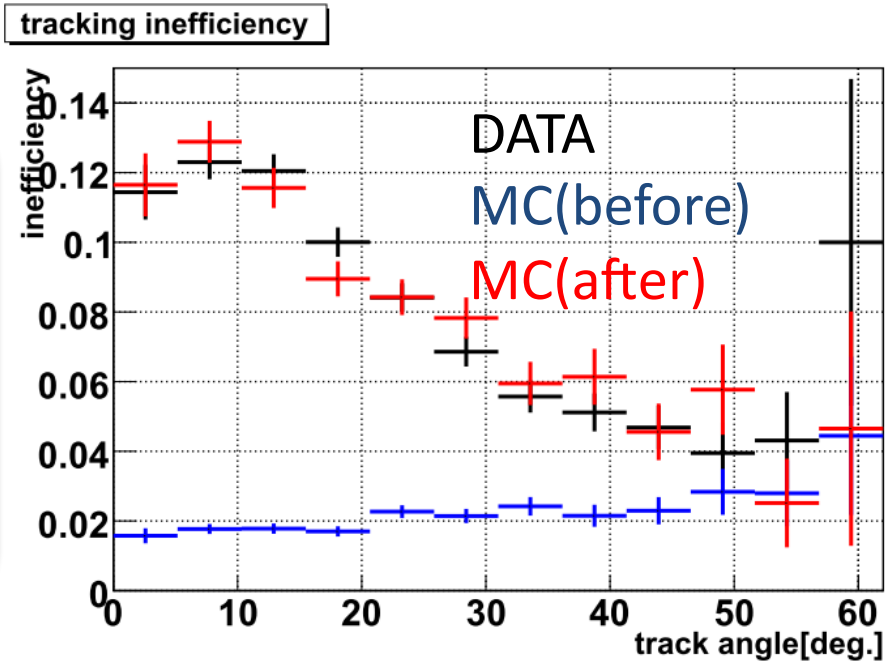
- The edge area is reflective material. So the area is not efficient.
- Due to this inefficient area, the hit efficiency is dependent on track angle (studied by Christophe, Matsumura-san, Otani-san).
- After change MC, reproduce the angle dependency.

Photo : surface of scintillator bar



white area : the reflective material.



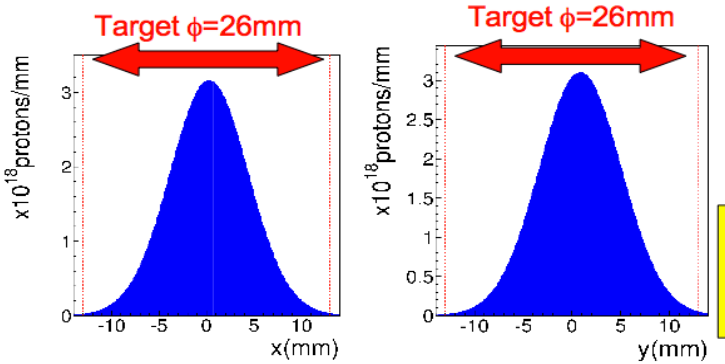


Weighting method

- Weighting from Jnubeam10c (nominal beam) to FLUKA2008 (real beam) with energy spectrum ratio
  - Φ(FLUKA2008 with real beam) / Φ(Jnubeam 10c with nominal beam)
- Including diff. of hadron production model and diff. of beam profile
  - Diff. between GCALOR/GFLUKA and FLUKA2008
  - Diff. between nominal beam (σ=4.343 mm) and real beam

Accumulated beam profile @ target

- gaussian assumption for shot-by-shot beam profile
-integrate shot-by-shot beam profile on target
-number of protons from CT05



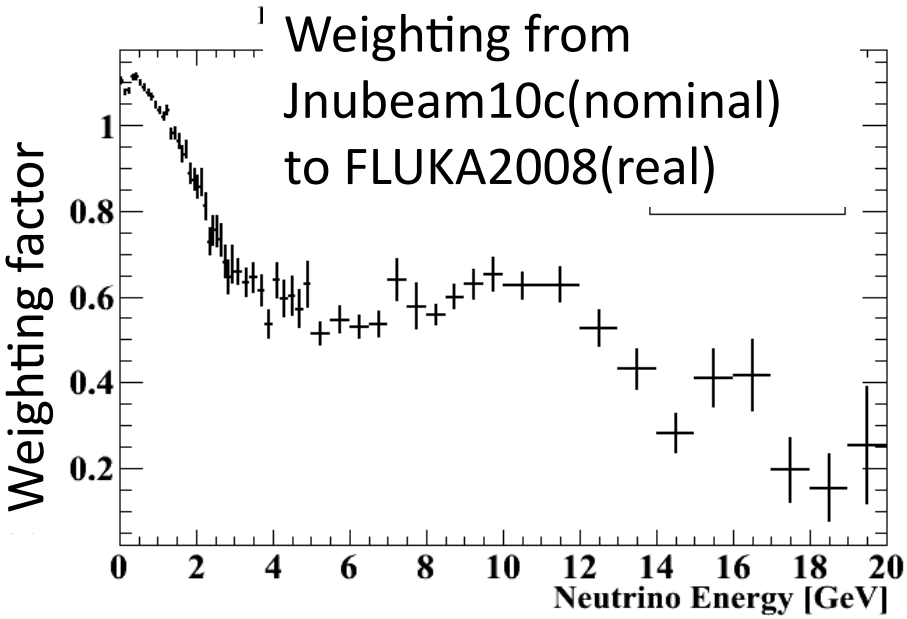
run29-34

Real beam parameters

Fit w/ single gaussian
μx=0.27mm
σx=4.133mm
μy=0.85mm
σy=4.192mm

cf. simple targeting efficiency = 99.1%

Reported by Kakuno-san



Event selection

Make timing cluster(more than 4 hits within 100nsec)

↓

# of active planes > 2 && p.e./active layer > 6.5

↓

Tracking

↓

Track matching

↓

On time

↓

Upstream VETO

↓

Fiducial volume

↓

neutrino event

Summary of 10a beam DATA

DATA taking efficiency

Summary of # of good spills and protons

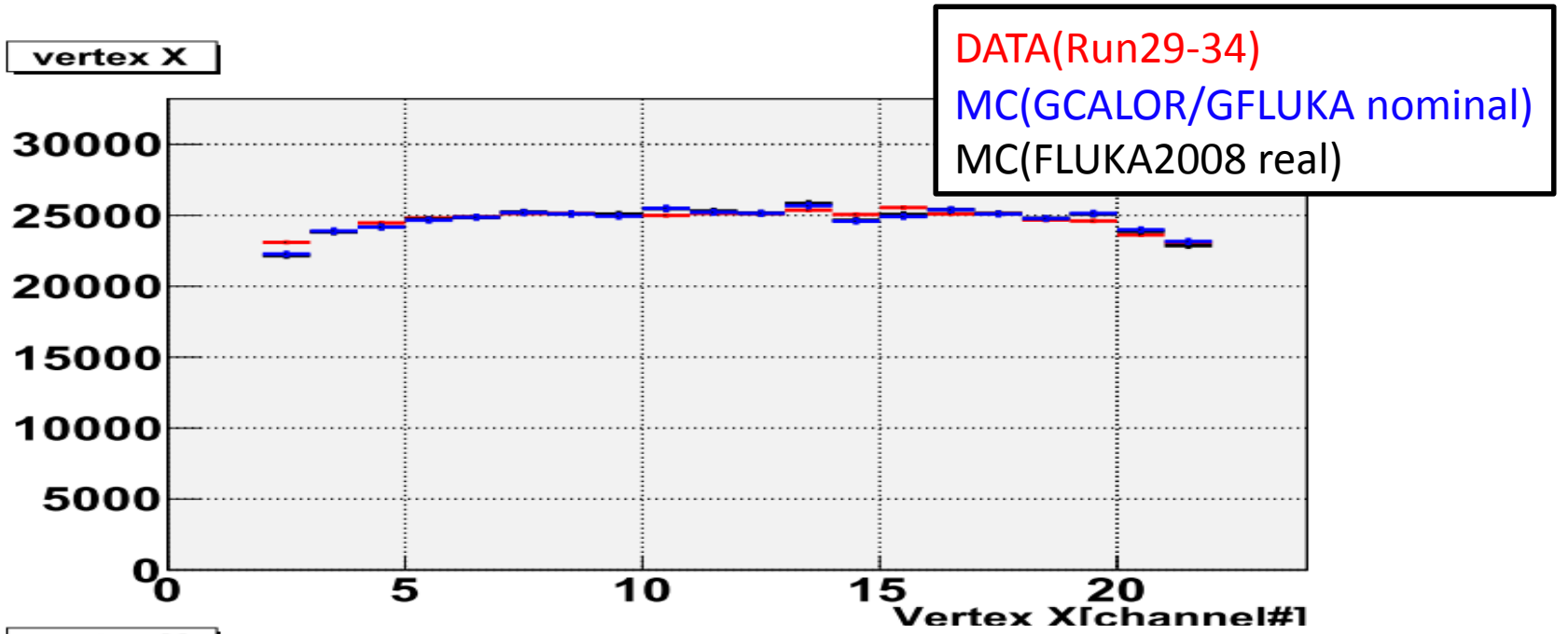
run	period	all goos spills	INGRID good spills	total protons at CT05
29	Jan.23rd Feb. 5th	26813	26813	0.32×10^{18}
30	Feb.24th 28th	59256	59070	1.12×10^{18}
31	Mar.19th 25th	86980	86935	1.97×10^{18}
32	Apr.14th May.1st	237350	236647	7.64×10^{18}
33	May.9th Jun.1st	350079	350012	1.22×10^{19}
34	Jun.7th Jun.26th	246504	246410	9.30×10^{18}

99.9% data taking efficiency
(# of good spills = 1005887 / 1006982)
Total delivered protons 3.26 x 10^{19}

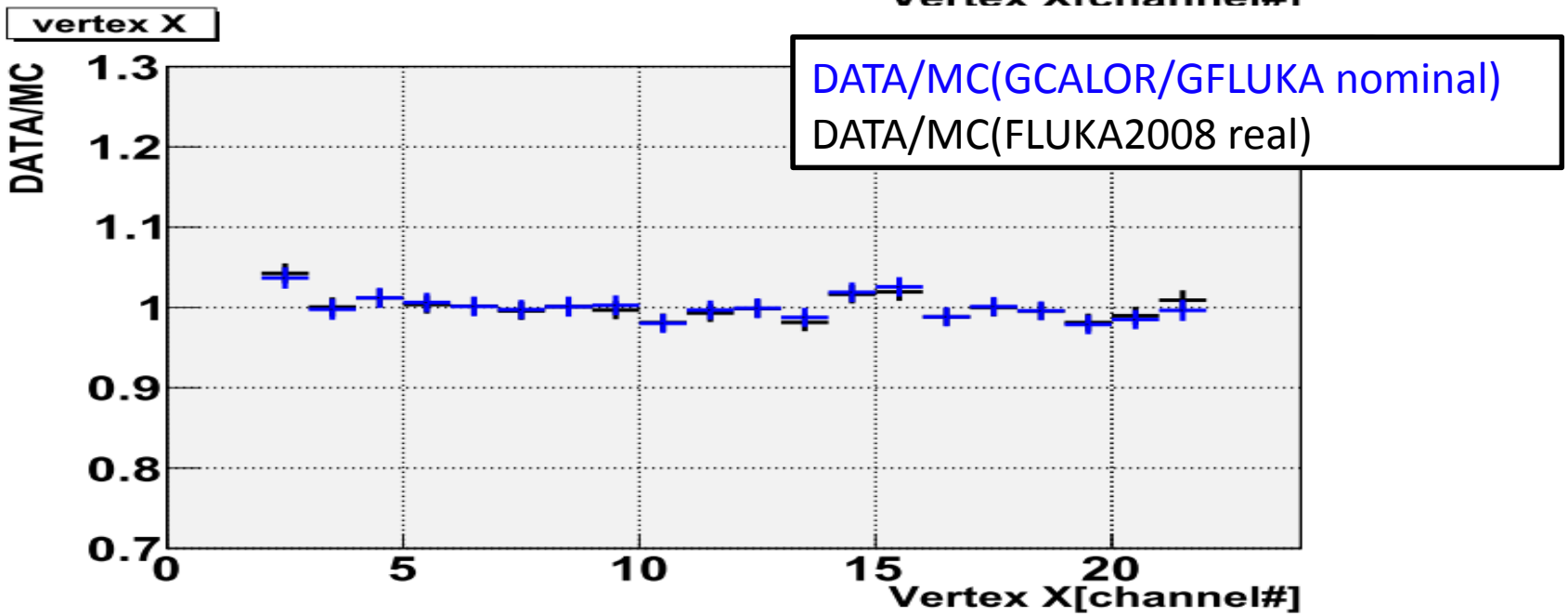
Comparison Data vs MC

- Comparison at some distribution after neutrino selection
  - Reconstructed vertex
  - # of active plane
  - Reconstructed track angle
- Data set
  - Data : Run 29-34
  - MC Data : Jnubeam10c with nominal beam and FLUKA2008 with real beam (weighted from Jnubeam 10c with nominal beam).
- Normalize each distribution at # of events

Vertex X

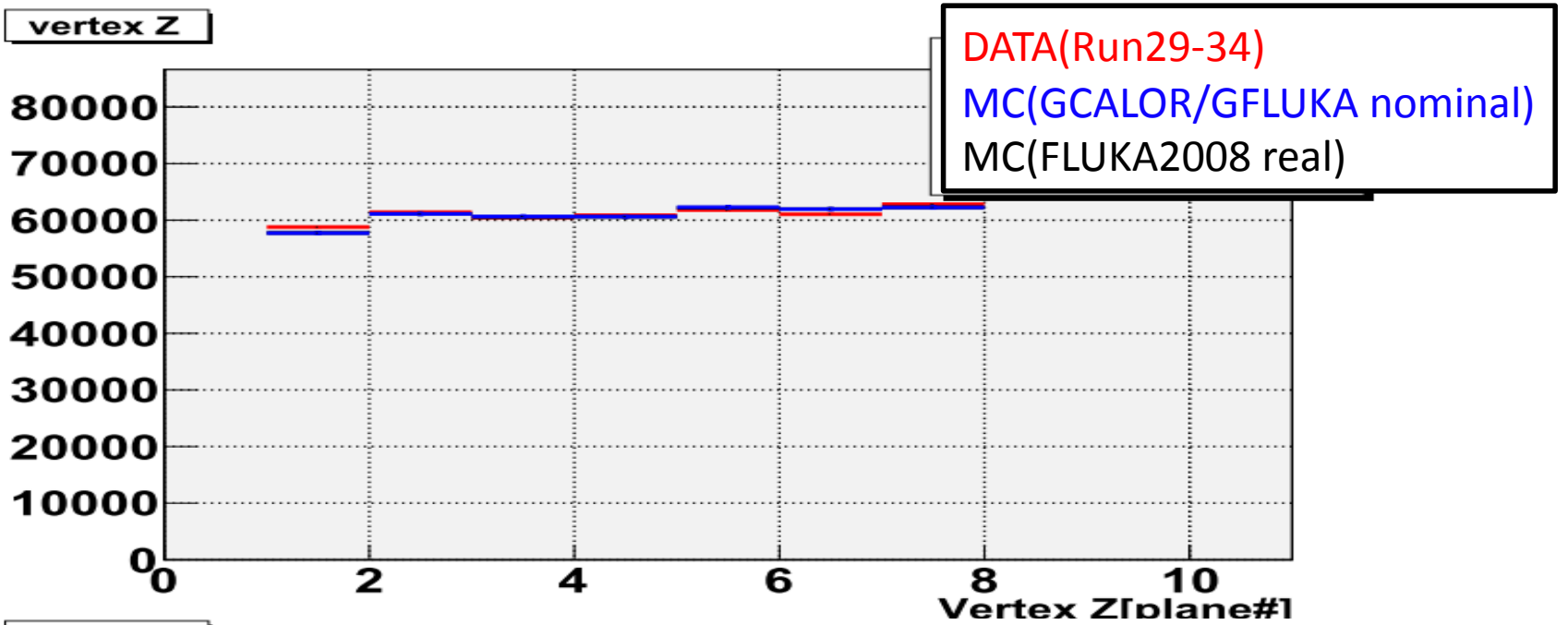


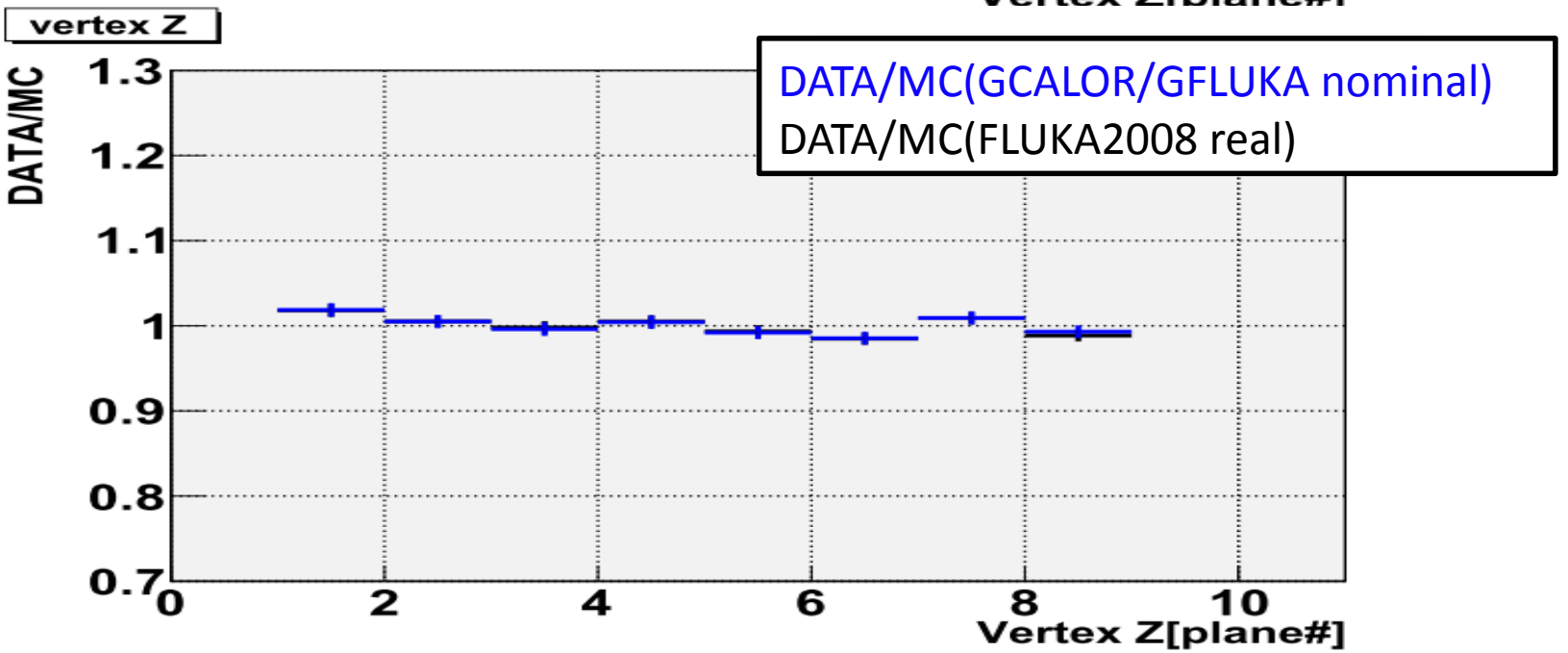
DATA(Run29-34)
MC(GCALOR/GFLUKA nominal)
MC(FLUKA2008 real)



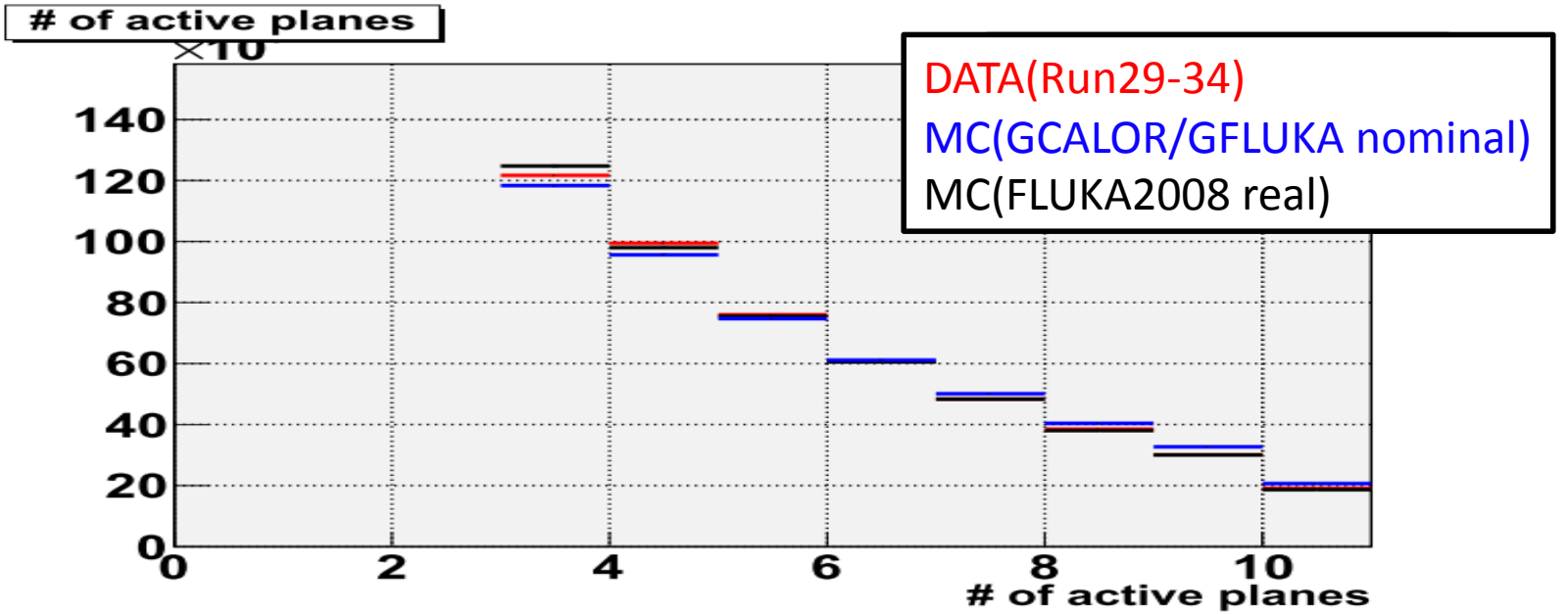
DATA/MC(GCALOR/GFLUKA nominal)
DATA/MC(FLUKA2008 real)

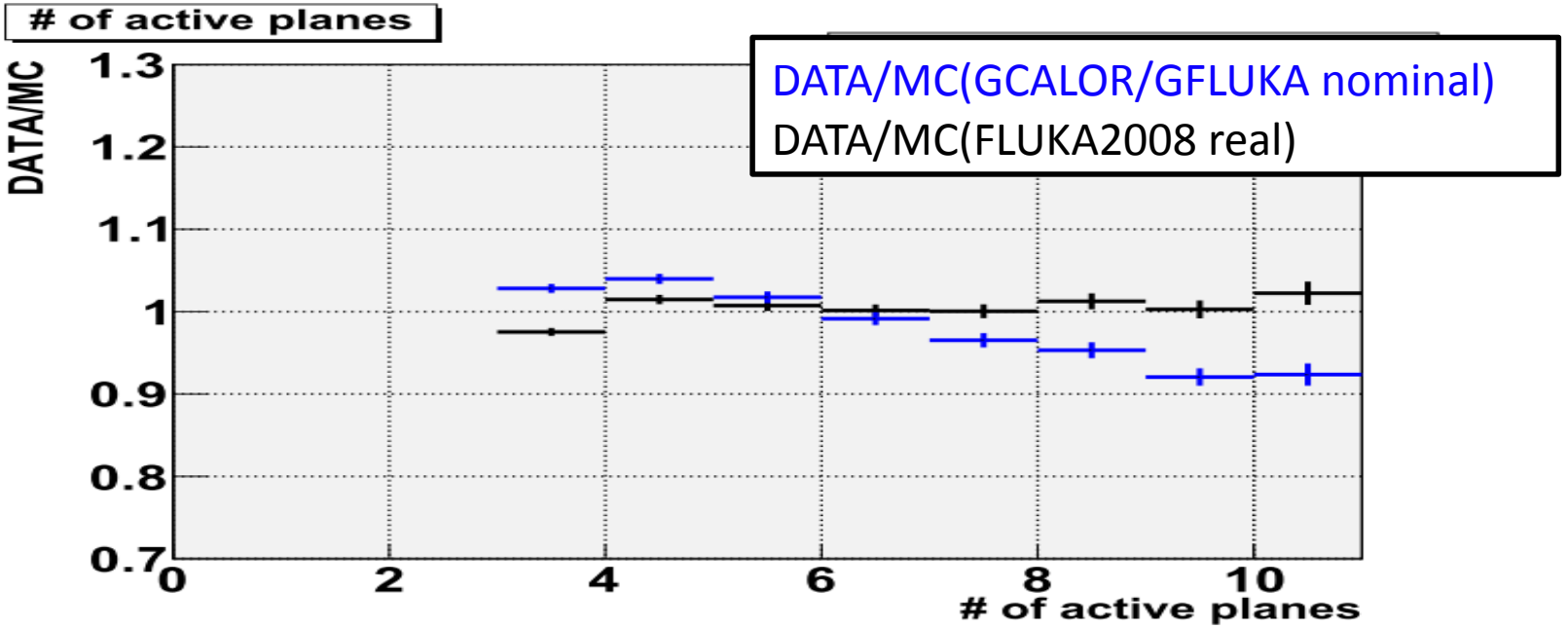
Vertex Z


vertex Z
80000
70000
60000
50000
40000
30000
20000
10000
0
0
2
4
6
8
10
Vertex Z[plane#]
DATA(Run29-34)
MC(GCALOR/GFLUKA nominal)
MC(FLUKA2008 real)

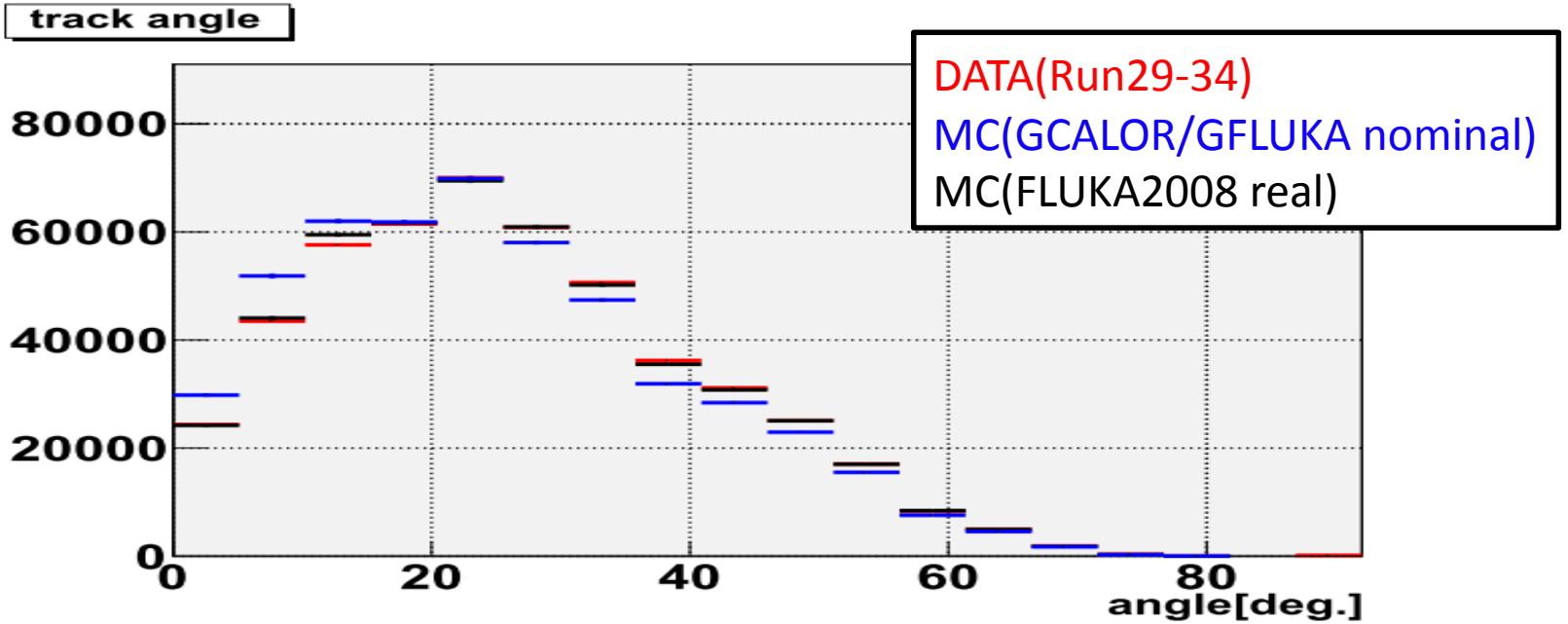

vertex Z
DATA/MC
1.3
1.2
1.1
1
0.9
0.8
0.7
0
2
4
6
8
10
Vertex Z[plane#]
DATA/MC(GCALOR/GFLUKA nominal)
DATA/MC(FLUKA2008 real)

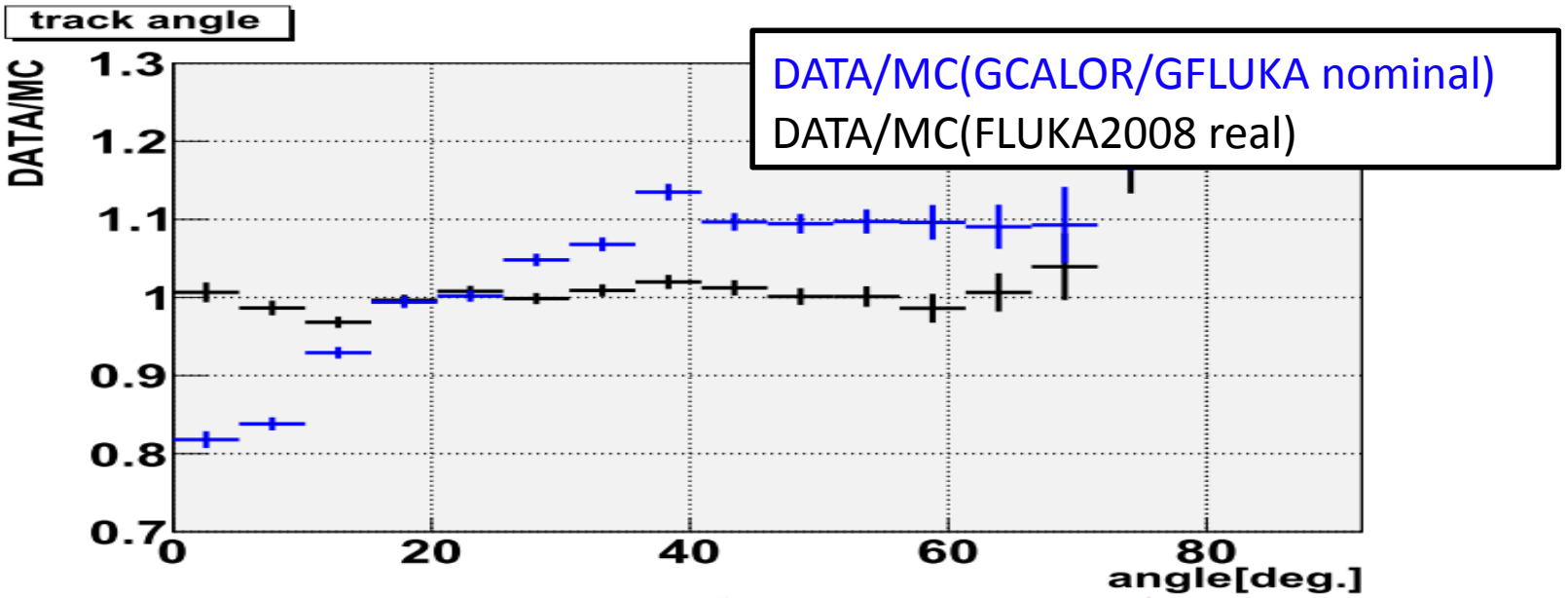
of active planes





Track angle





FLUKA2008 is in good agreement with DATA

Selection efficiency

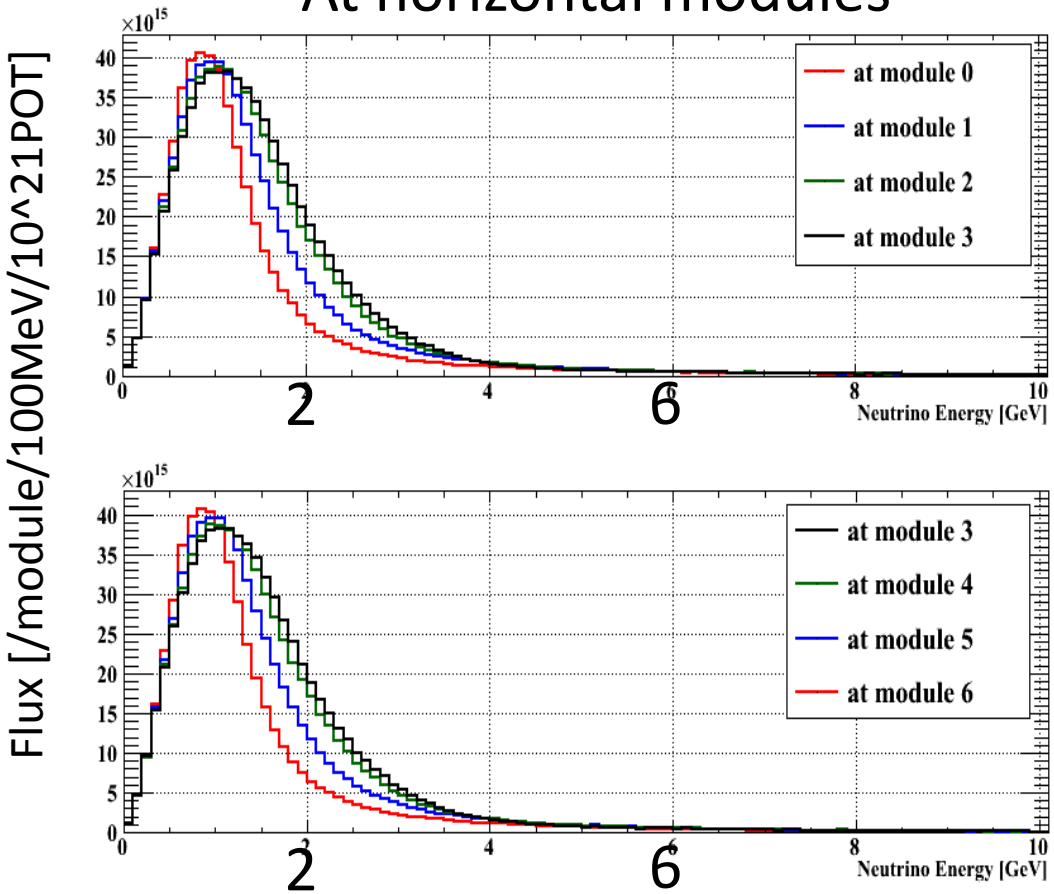
- Calculate the efficiency of this neutrino selection with INGRID MC.

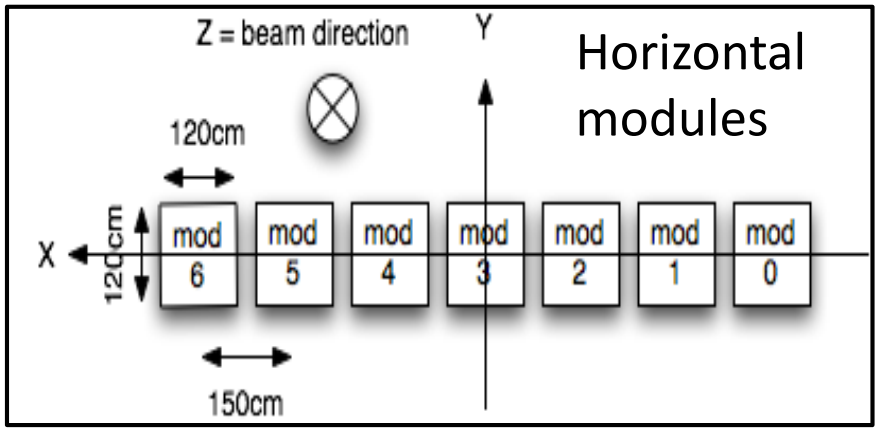
- Efficiency = (# of events after neutrino selection) / (# of generated interaction in Fiducial volume).

Energy spectrum of ν into INGRID

Jnubeam 10c (nominal beam) Flux
Only numu energy spectrum.

At horizontal modules

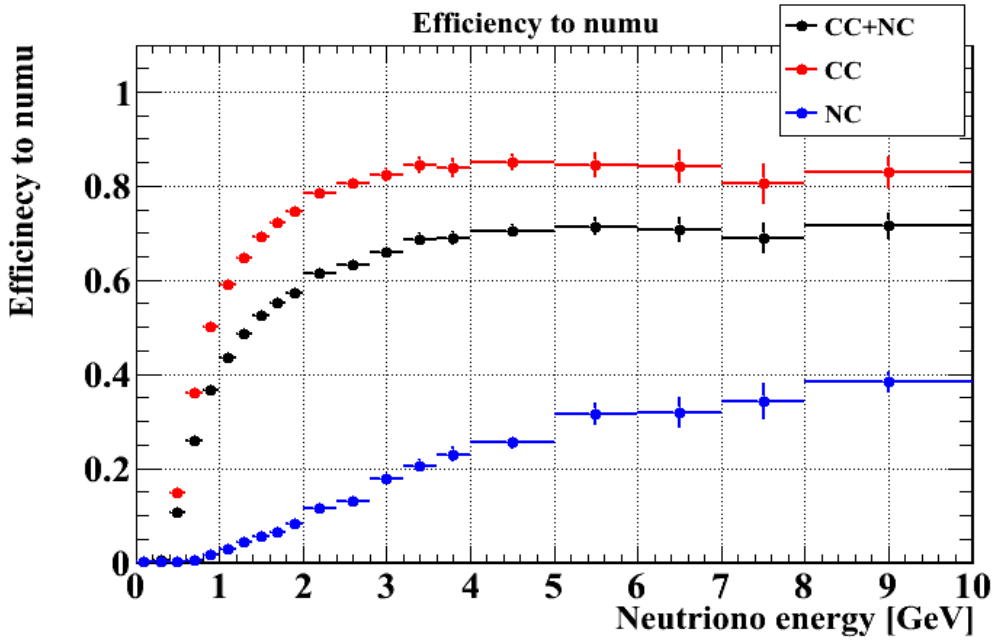


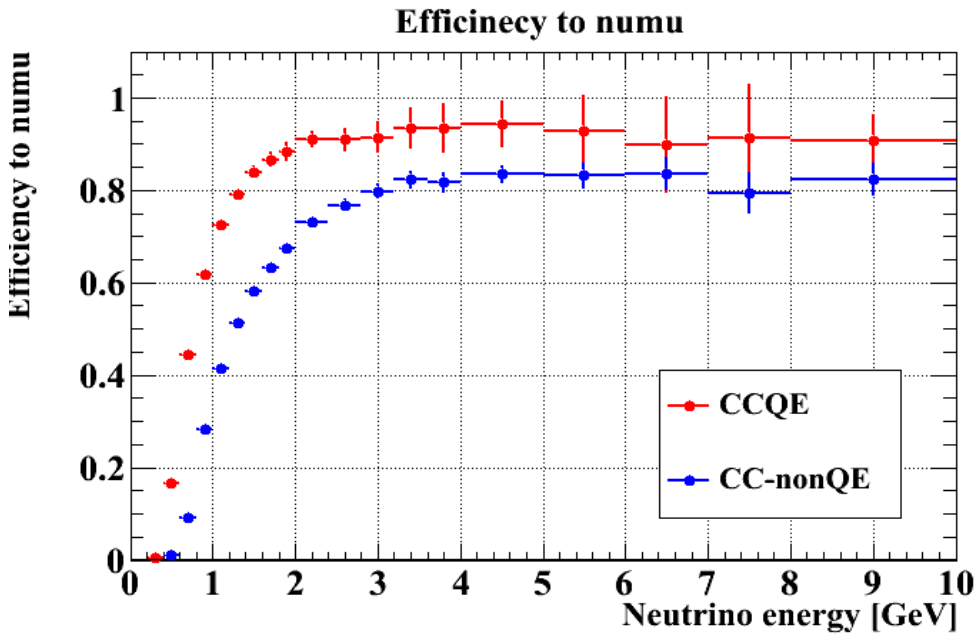


From the edge to center module, the peak energy region is shifted higher and wider.

Selection efficiency

Efficiency curve to numu at each interaction mode

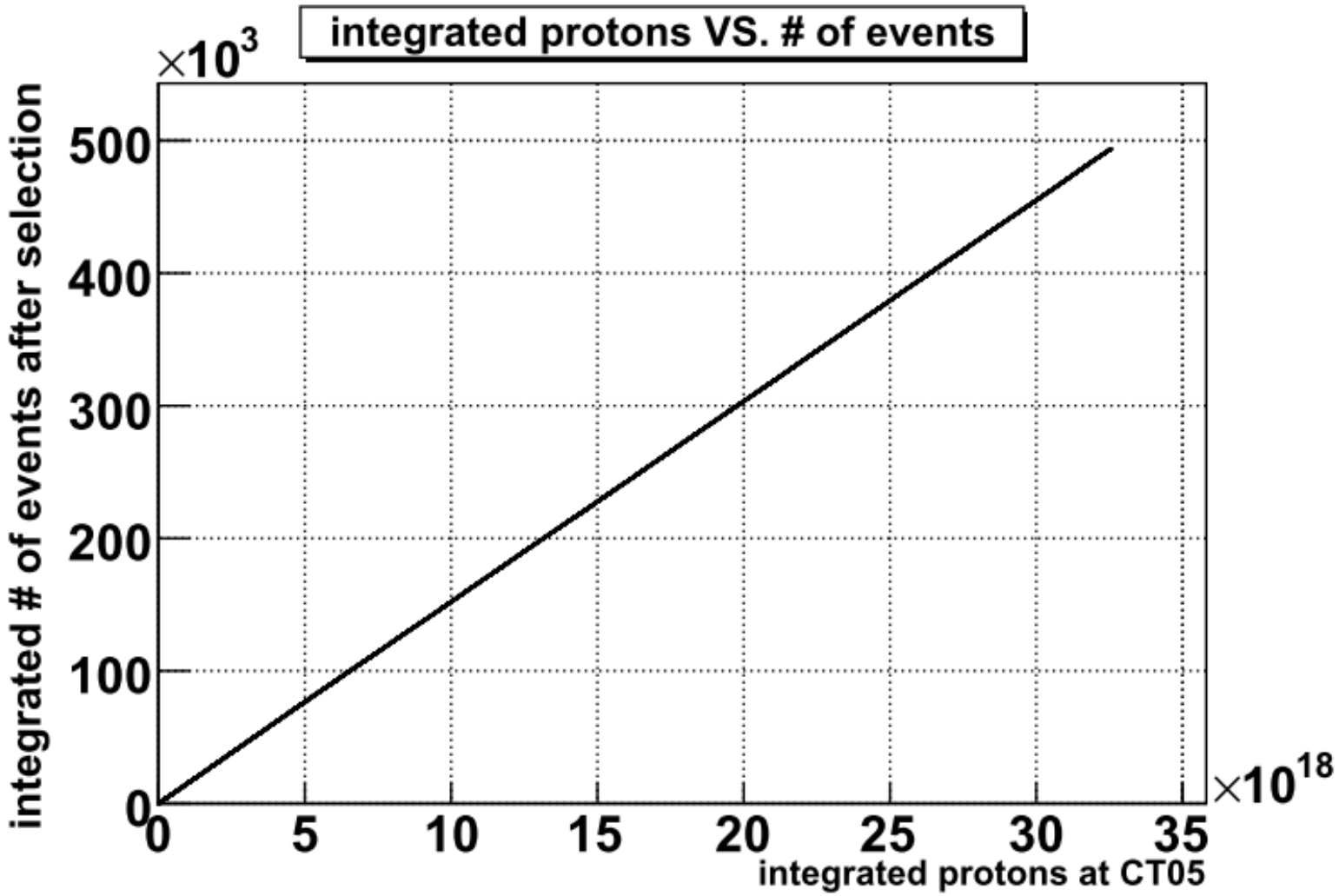




Module#	0	1	2	3	4	5	6
Mean efficiency [%]	51.7	54.0	55.1	55.1	55.0	54.2	51.2
Module#	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Mean efficiency [%]	52.6	54.4	55.1	55.0	54.6	54.1	51.8

Diff. of mean efficiency is due to diff. of energy spectrum

Accumulated protons and $N_{obs.}$



Delivered protons ~ 3 x 10^{19}, Total $N_{obs.}$ ~ 5 x 10^5