Mizuche MC neutrino interaction study

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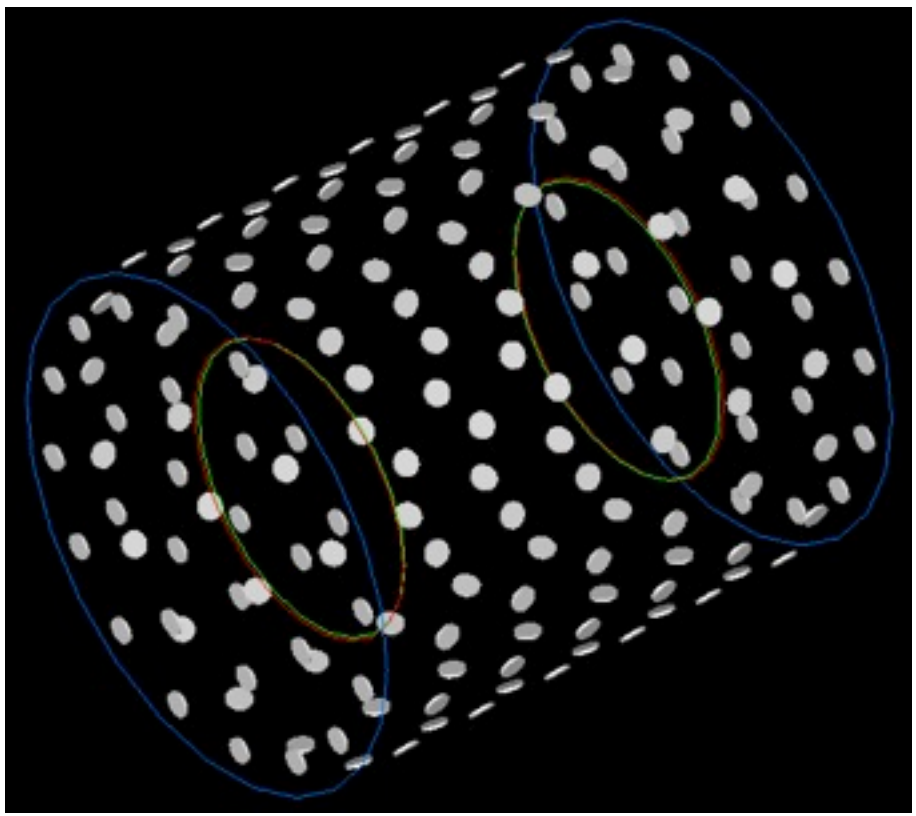
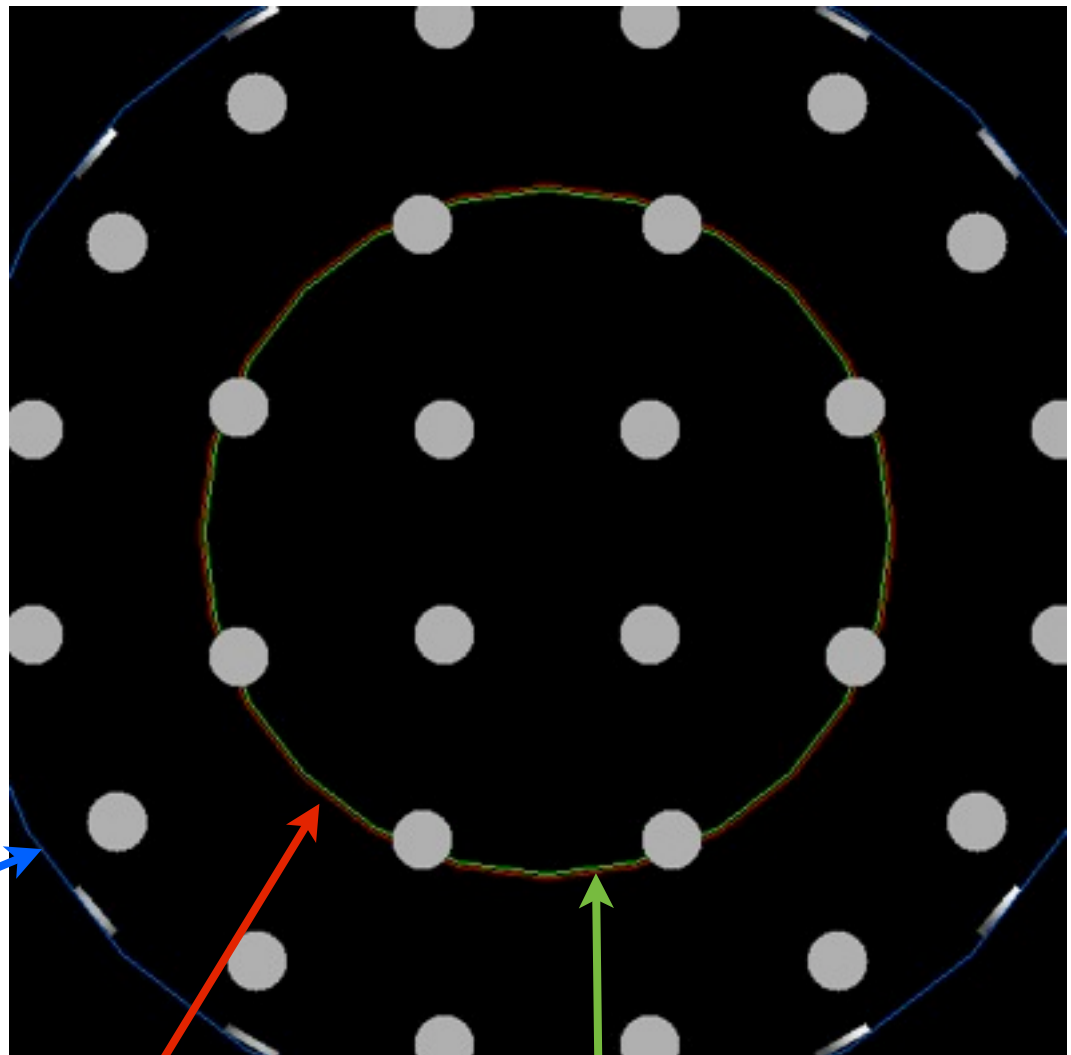
Contents

- Update & check the boundary process around acrylic area.
  - Re-Check cosmic muon MC.
- Neutrino interaction MC (w/ water in FV, w/ o water in FV).

MC geometry





Surface of Tank

Surface of Acrylic area (5mm)

Surface of FV area

Boundary condition

- アクリル層・FVの表面(Skin)に同じ単純な境界条件.
  - 境界面は鏡面状態(理想的なつるつる)
    - 乱反射・表面での吸収はなし.
  - 反射・屈折は Snell's law, Fresnel's equations に従う.
    - Physics process : Total internal reflection, Fresnel reflection-refraction.
  - 各領域での屈折率を元に計算.

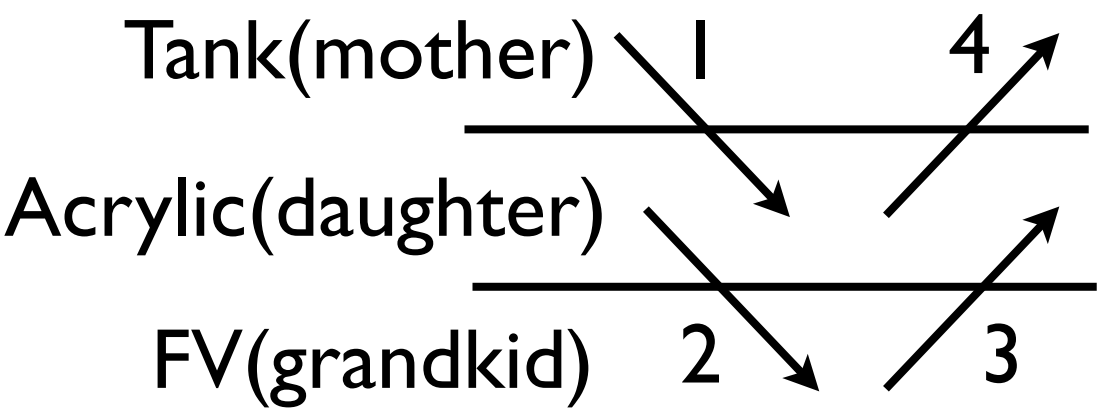
Boundary condition

Tank : water

Acrylic area : acrylic

FV : water

- Refractive index
  - water : n(energy) = 1.34~1.36
  - acrylic : n = 1.49 (temporary)
- Attenuation length
  - water : 3~50m
  - acrylic : 3m (temporary)



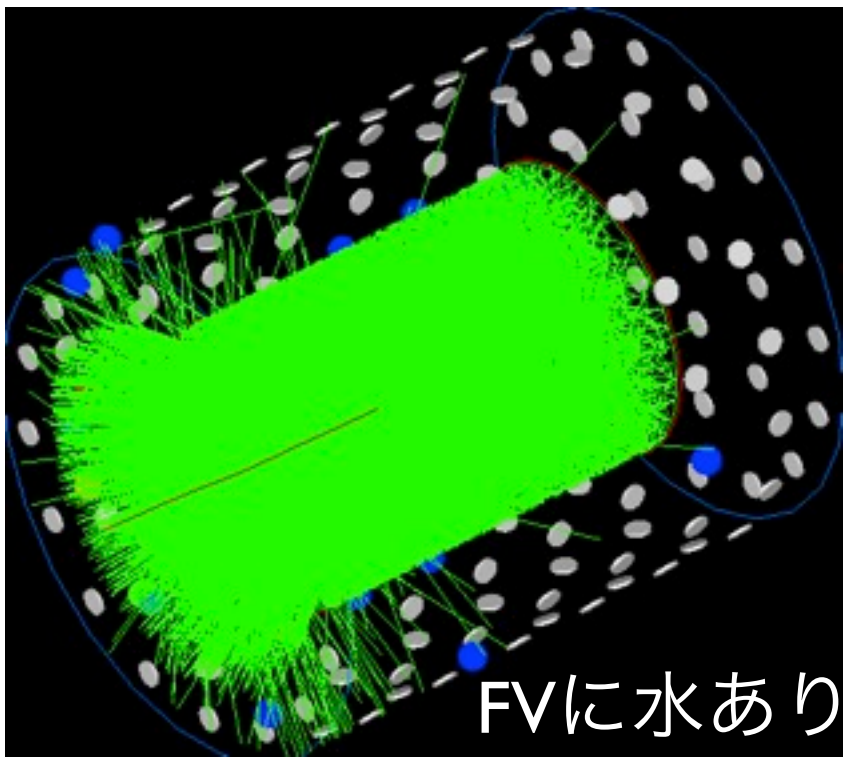
mother → daughter : daughter skin
daughter → mother : daughter skin.

Which skin used ?

1. acrylic skin
2. FV skin
3. FV skin
4. acrylic skin

Check boundary process

Single μ (300MeV/c, center)



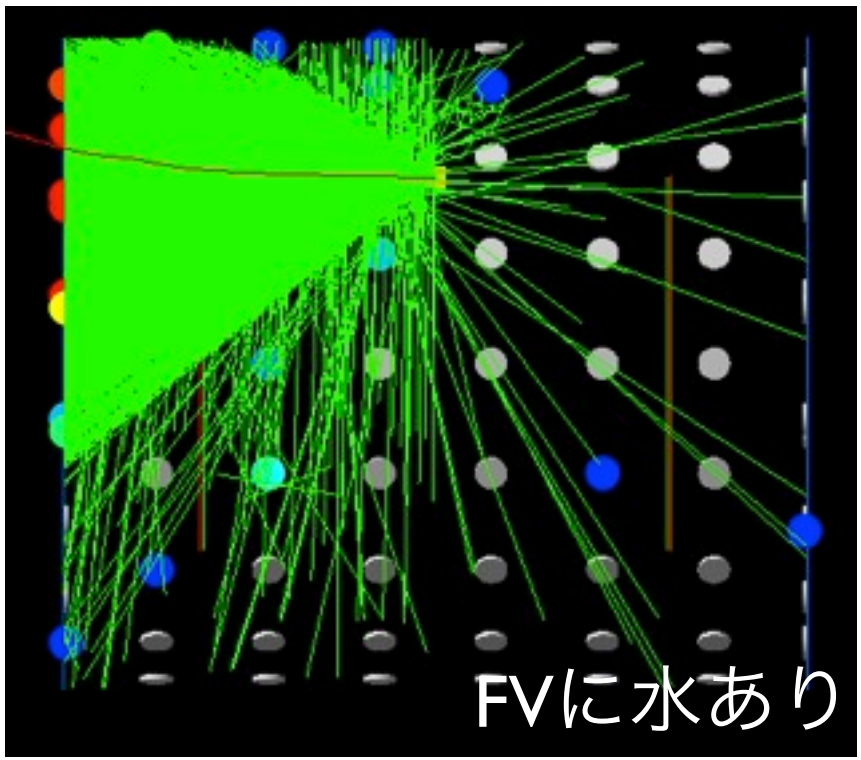
ログを目で見てみると...

- Generate in FV or Acrylic area → few FresnelRefraction → outside
- Generate in Acrylic area → Many FresnelReflection → Absorption or FresnelRefraction
- Generate in FV → Many FresnelReflection → Many Total Internal Reflection → Absorption

大量のOptical Photon がトラップされているようなトラックに見えるが、Optical Photonの一部が(吸収されるまで)たくさん反射しているためにこのように見える (疑似Optical fiber).

Check boundary process

Single μ (300MeV/c, out of FV)



今度はFVの外でミューオンを発生.

“Tank → acrylic → FV → acrylic → Tank“と Optical Photonが伝搬している様子がわかる.

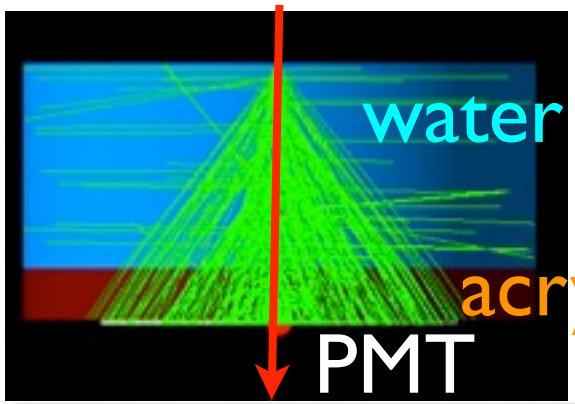
→ とりあえず、境界条件はこれを使用することに.

Cosmic MC

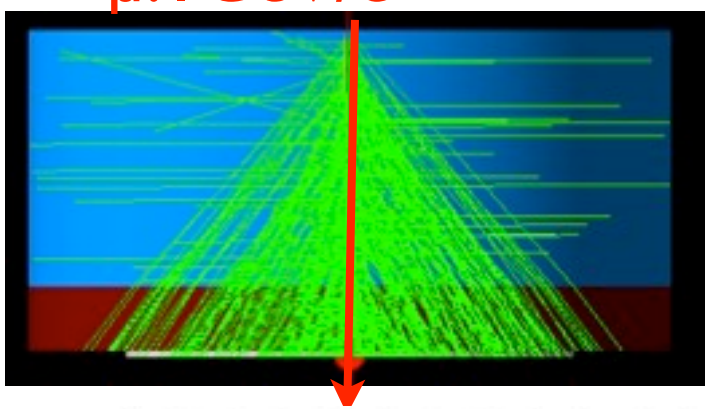
μ : 300MeV/c, 1GeV/c

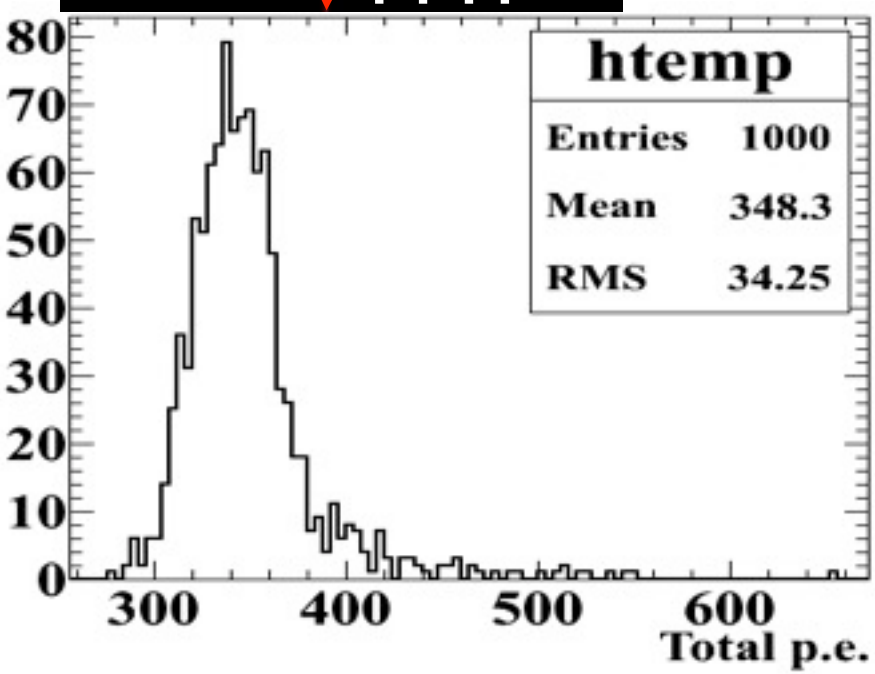
water(4cm) acrylic(1cm) radius of tank : 5cm

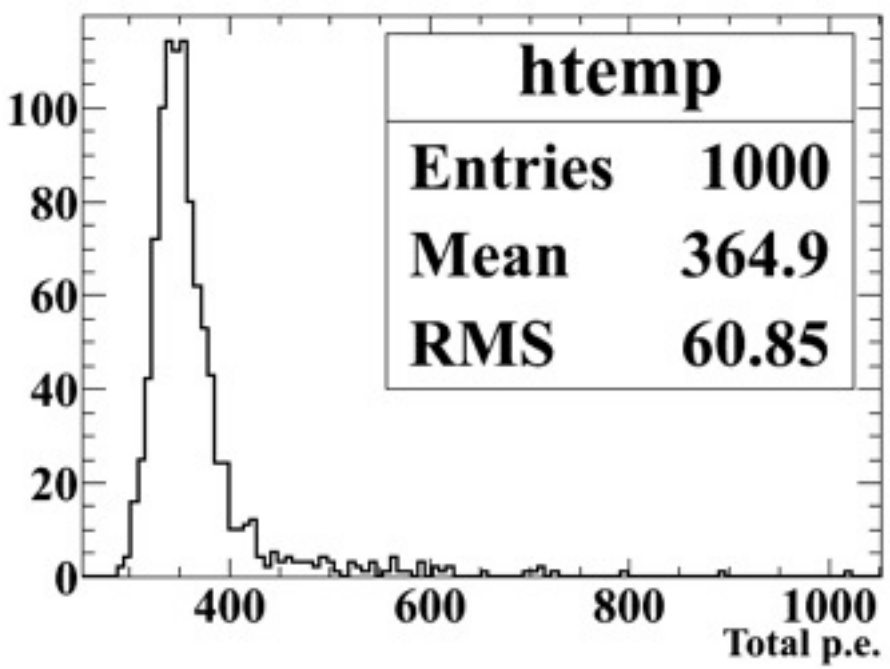
μ:300MeV/c



μ:1GeV/c







Neutrino interaction MC

- Flux setting
  - Jnubeam 10c (GCALOR) : 1e5 trigger × 10 file. → Low MC stat.
  - at ND5 (→ temporary used. In near future use flux at Mizuche-Tank placement)
- Neutrino interaction
  - NEUT 5.0.6.
  - Vertex is uniformed in Tank. If without water in FV, vertex is uniformed outside FV.
- Simulate two times with same NEUT file. (with water in FV, without water in FV).

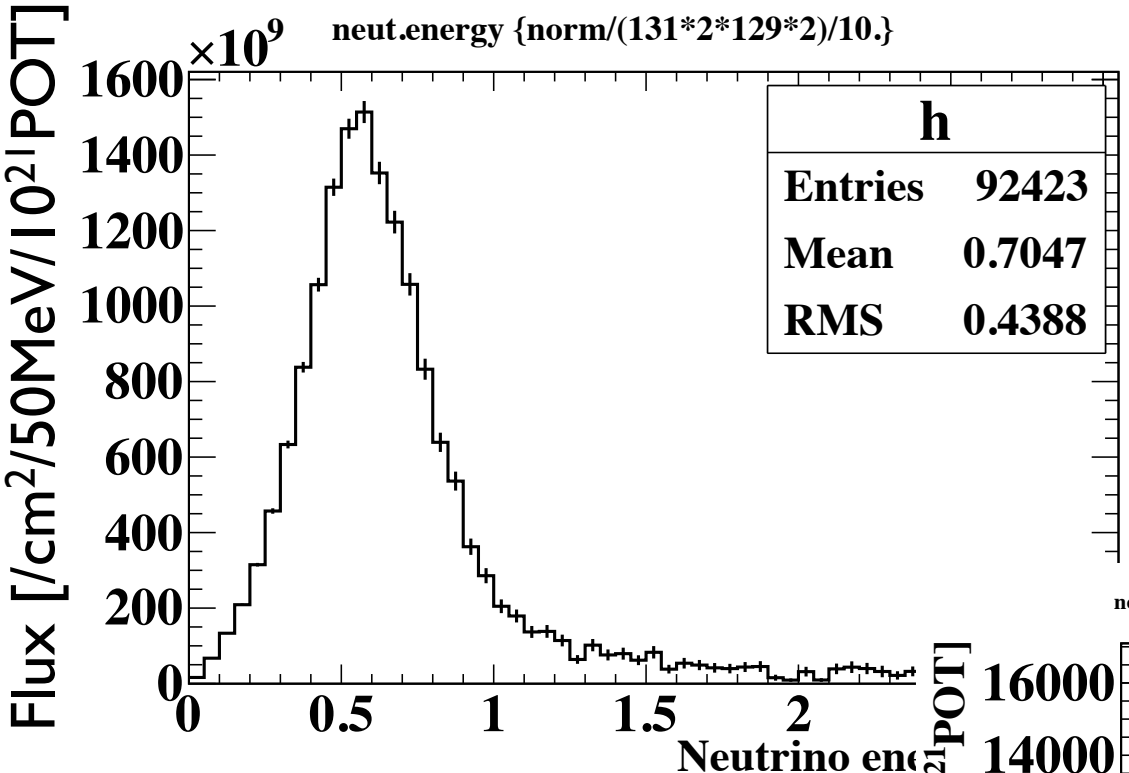
MC normalization

- Mass of water in Tank
  - 2.5 ton (water with FV)
  - 2.0 ton (water without FV)
- Molar mass of water : 18.02 g/mol
- Nucleon number of water : 18
- Avogadro's number : $6.02e^{23}$

# of interaction in Tank (water with FV)
= Flux [/cm^2/10^{21}POT] × 2.5 ton × 18/18.02 [mol/g] × $6.02e^{23}$ × σ [cm^2]

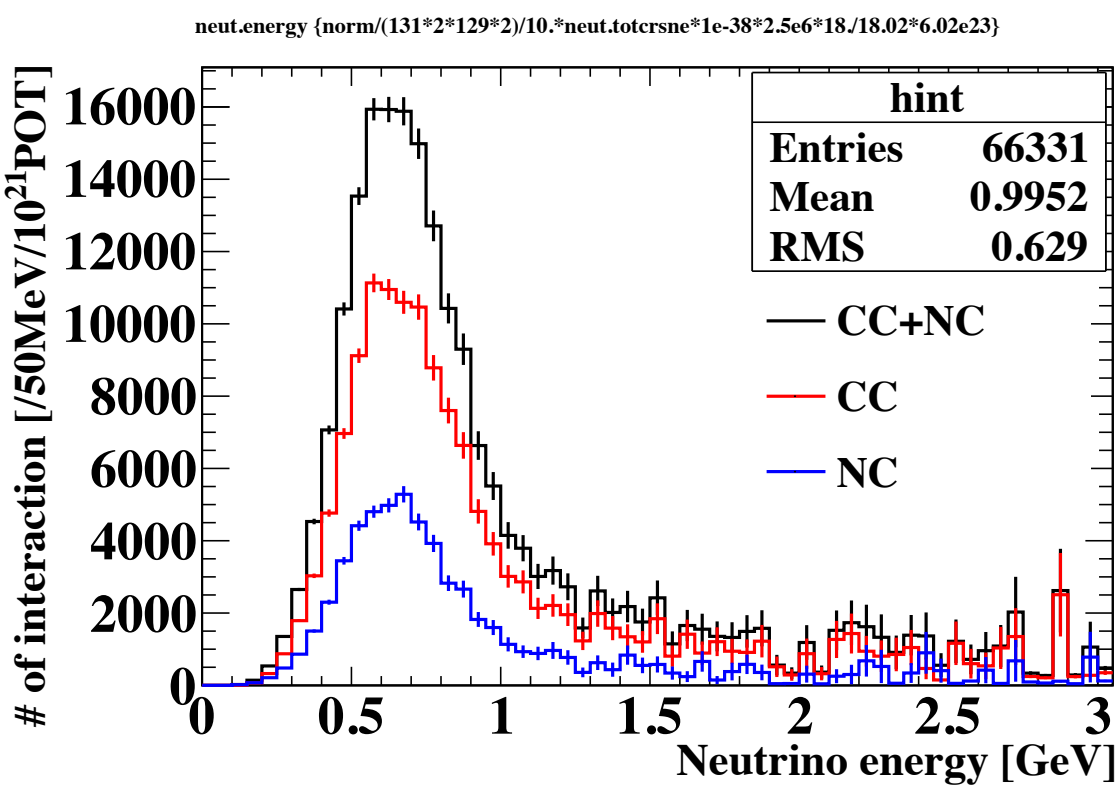
Energy spectrum

Error : Only MC stat

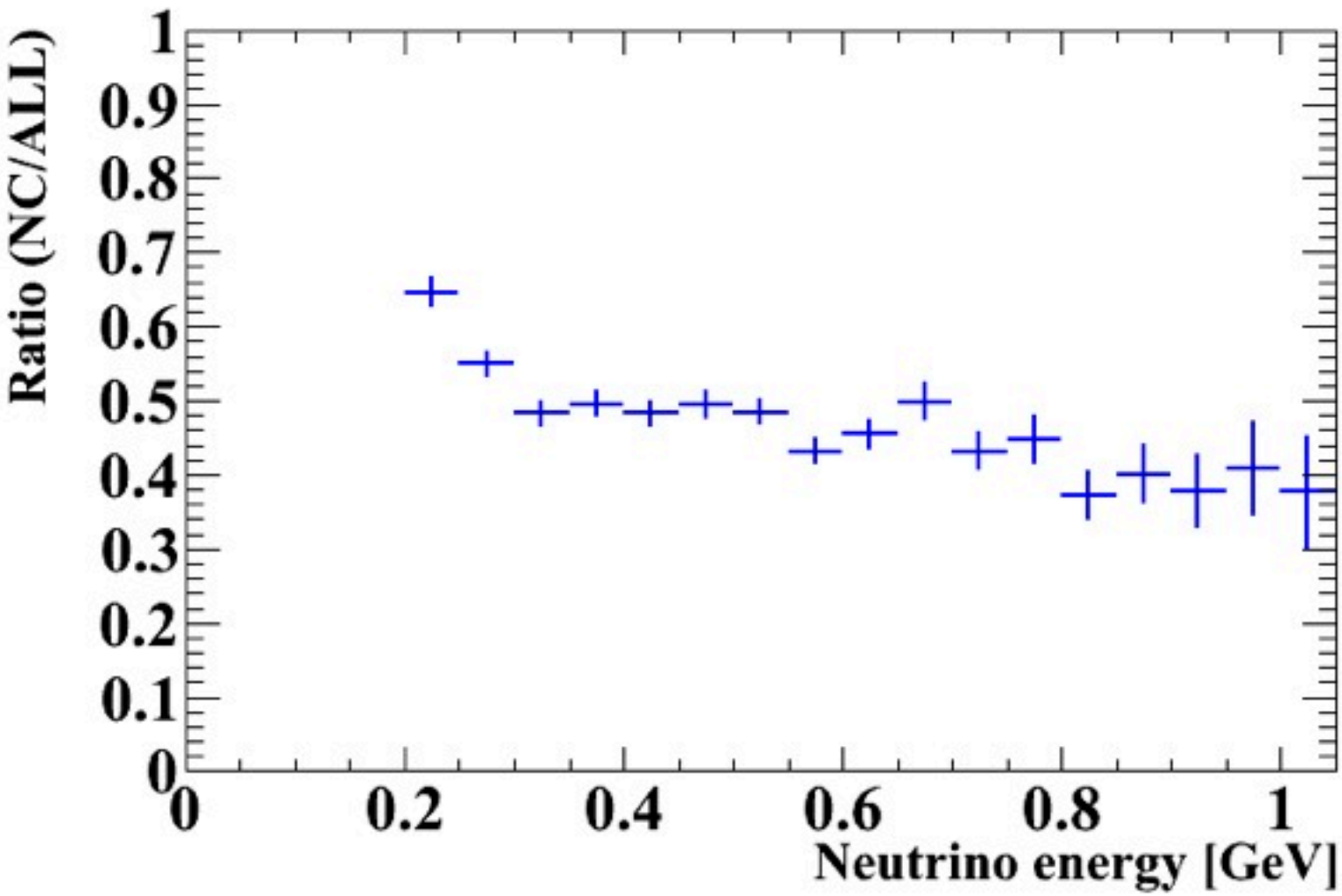


← νμ Flux @ ND5

νμ interacted in Tank →
(water with FV)



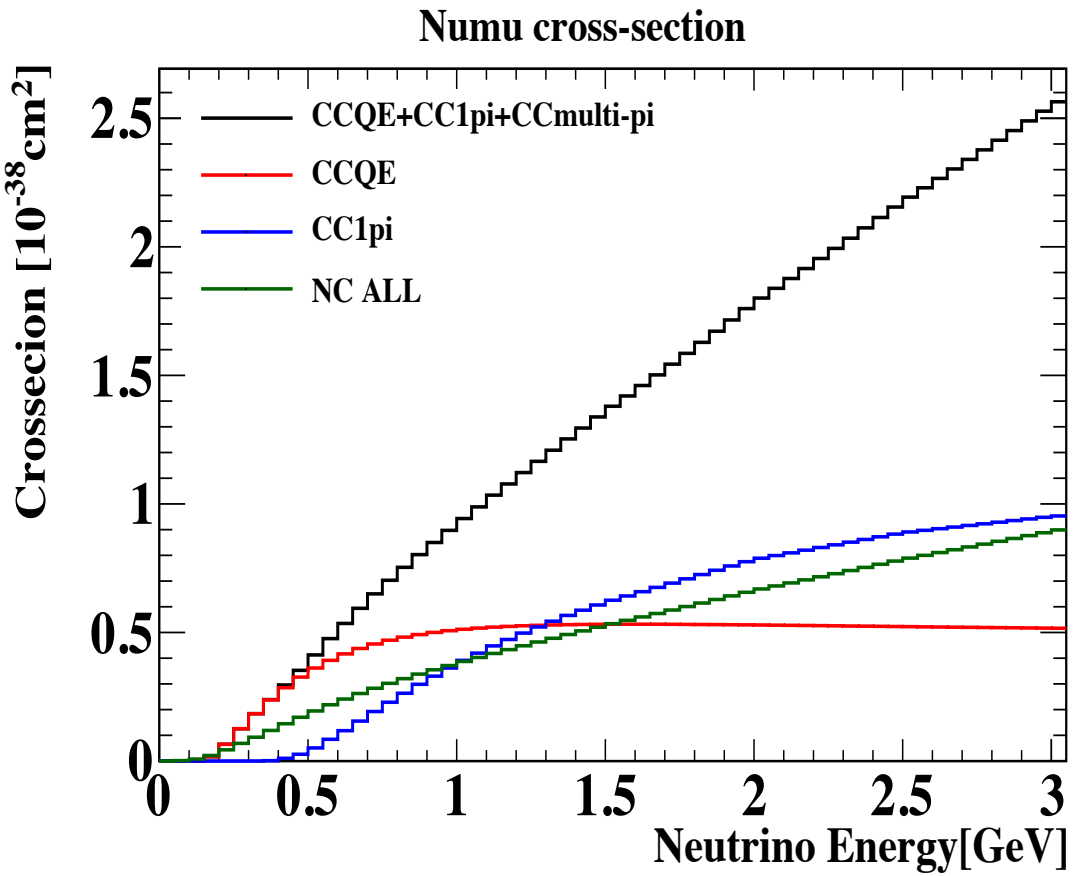
Ratio NC/CC around peak energy region

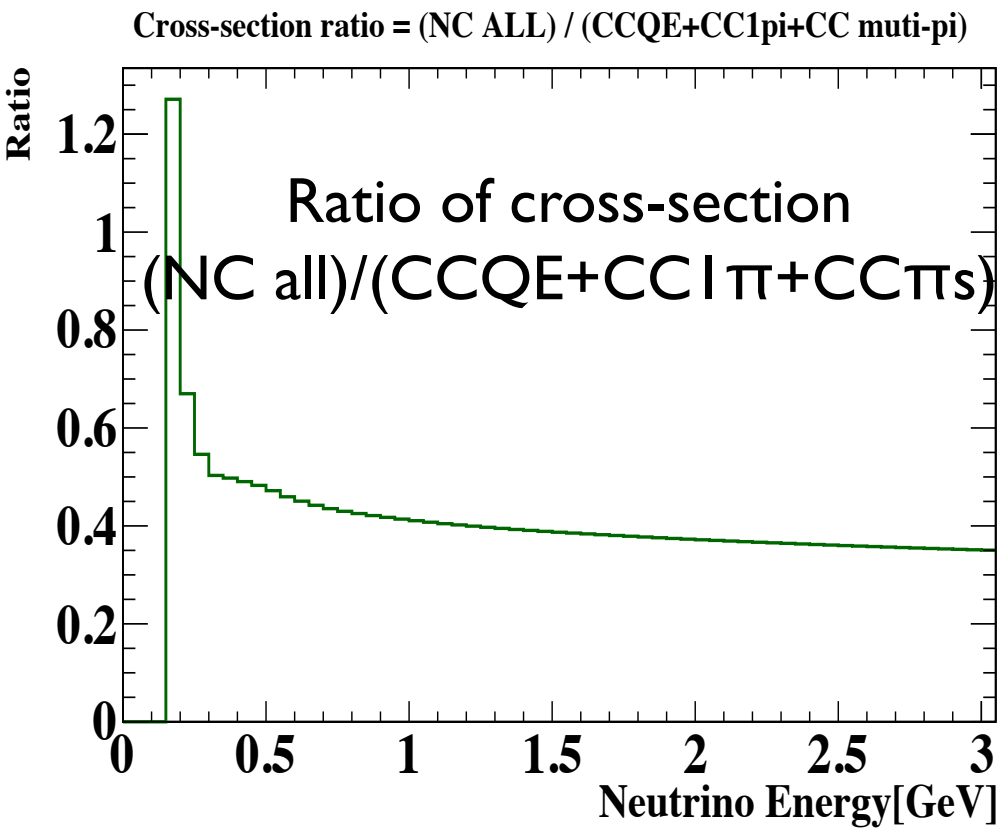


→ Compare with cross-section table

Neutrino cross-section

This cross-section table for water-target was made by Hayato-san (for INGRID study).





Around 0.6GeV, ratio of interactions : NC/CC ~ 0.5

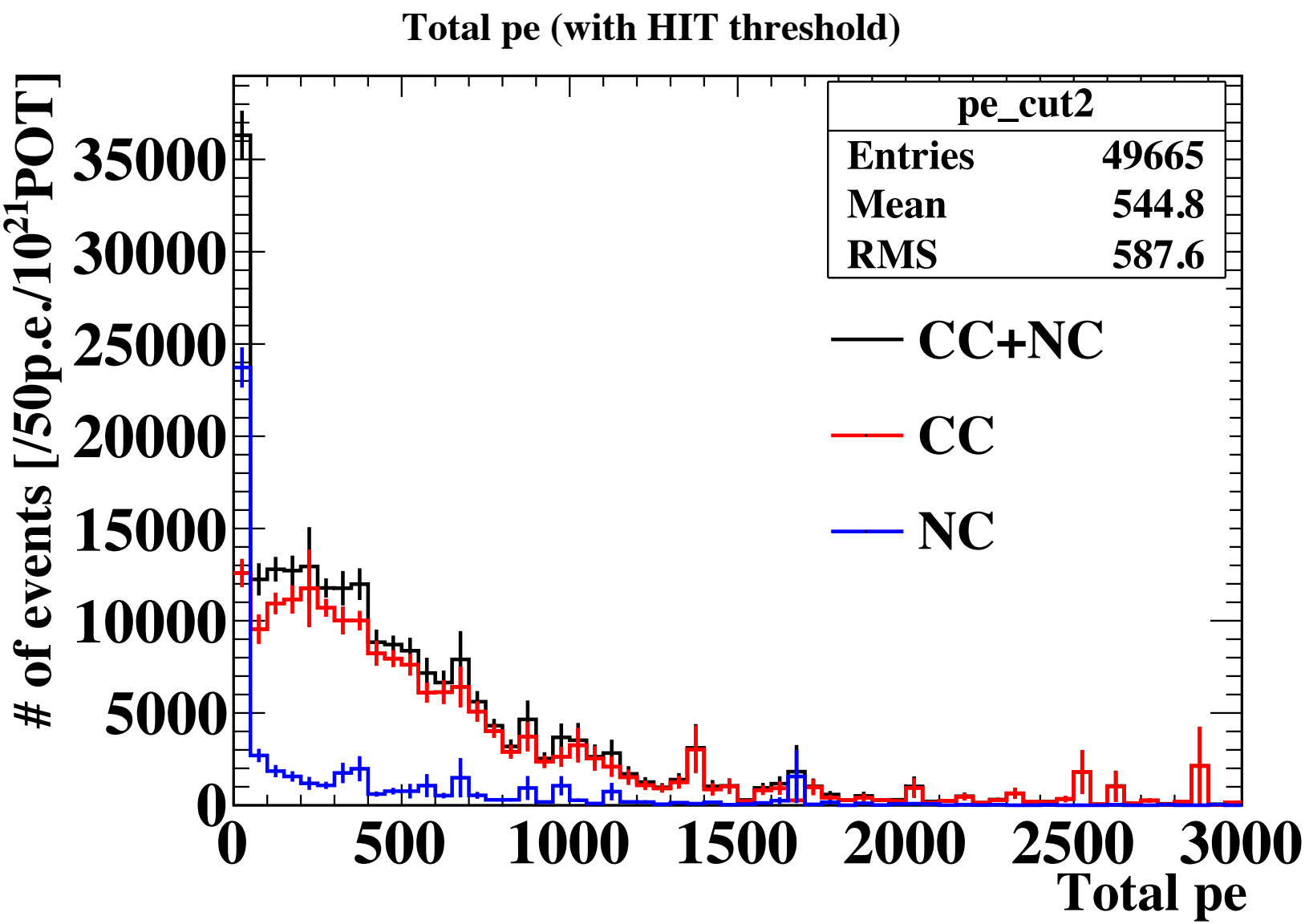
→ Consistency check is OK

Event selection

- Use Only HIT PMT = p.e. >= 2 p.e.
- Simple analysis cut : Total p.e. > 150
  - Total p.e. = Sum of p.e. of HIT PMT.

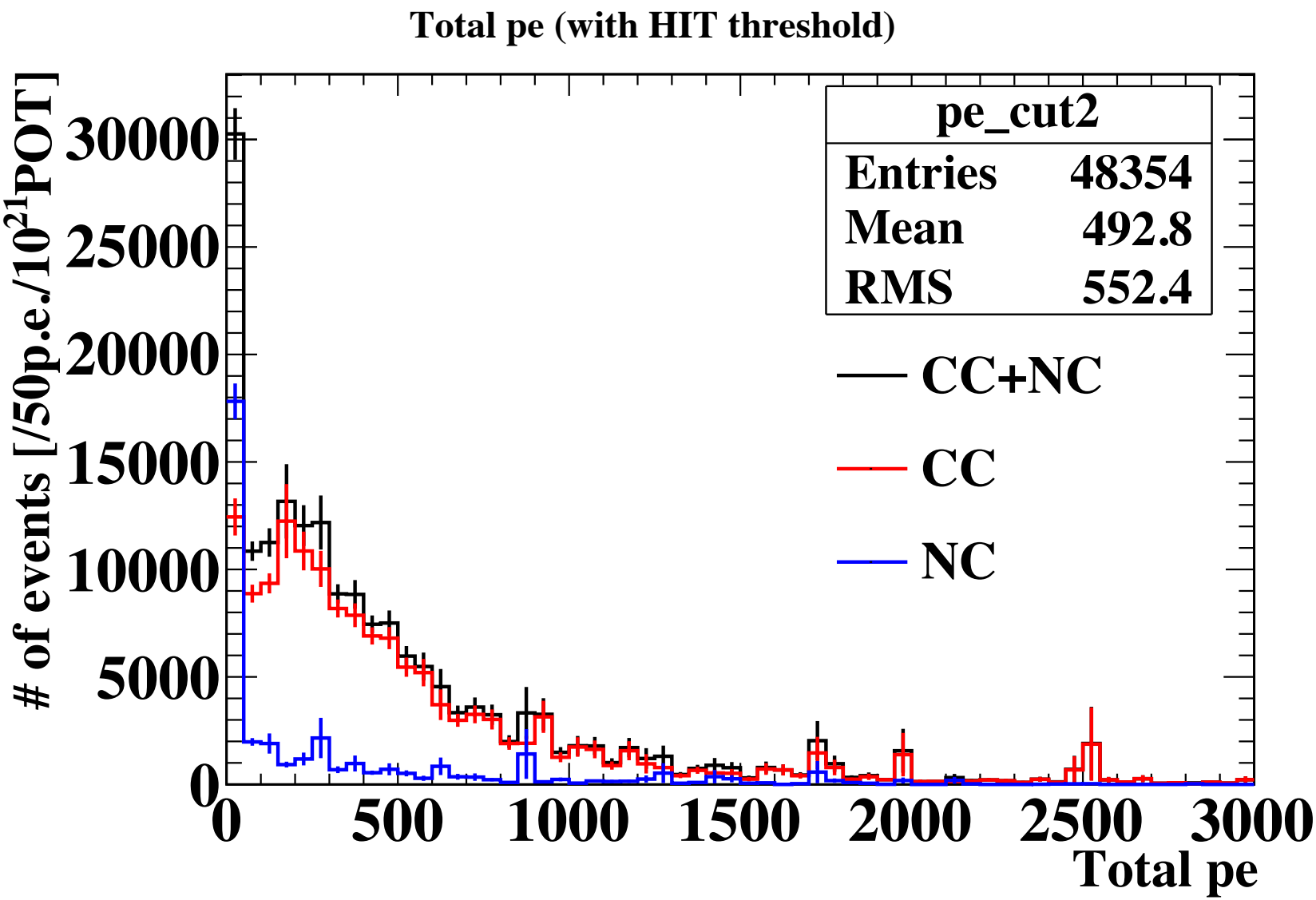
Total p.e. distribution

Vertex in whole Tank, water with FV.



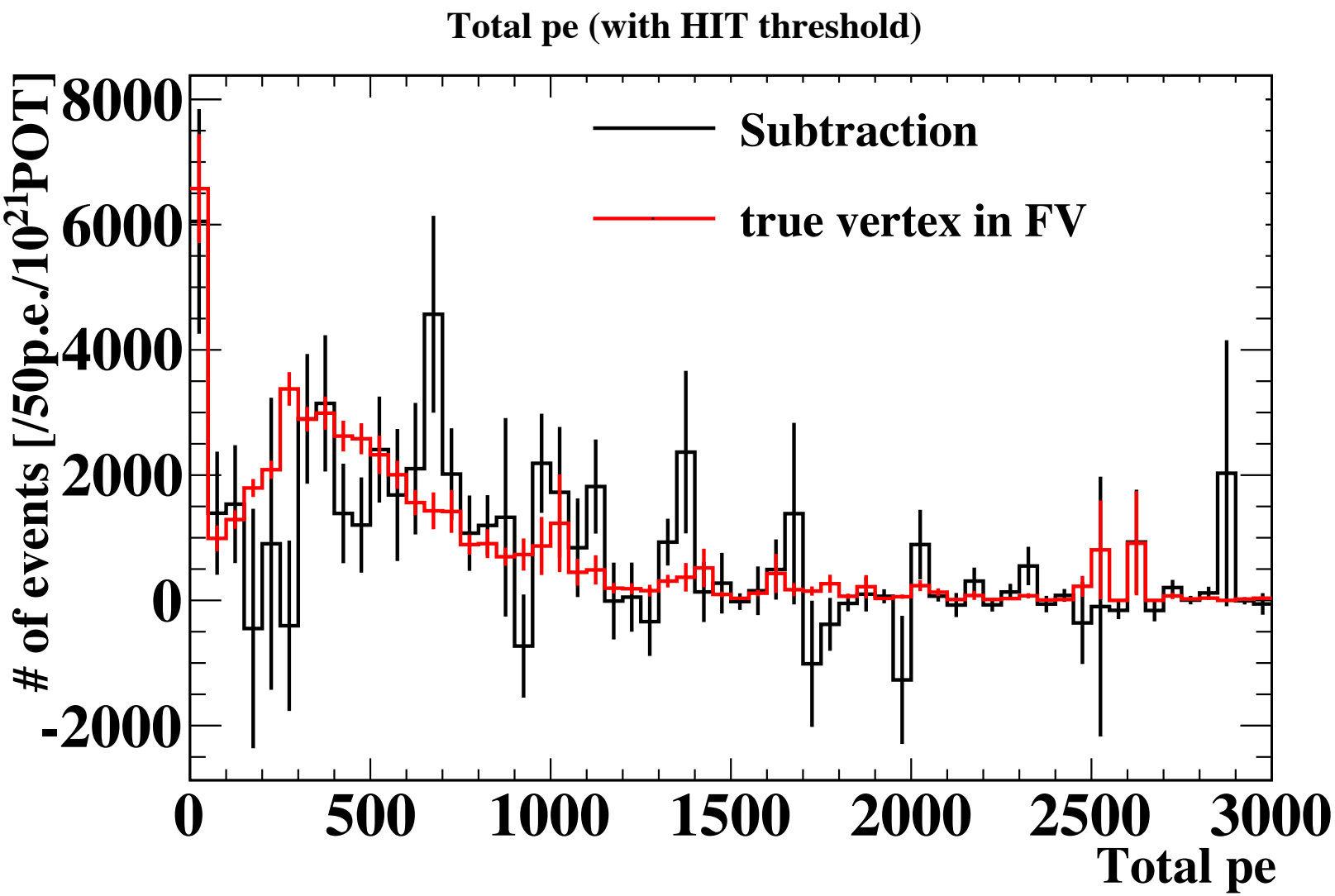
Total p.e. distribution

Vertex in outside FV, water without FV.



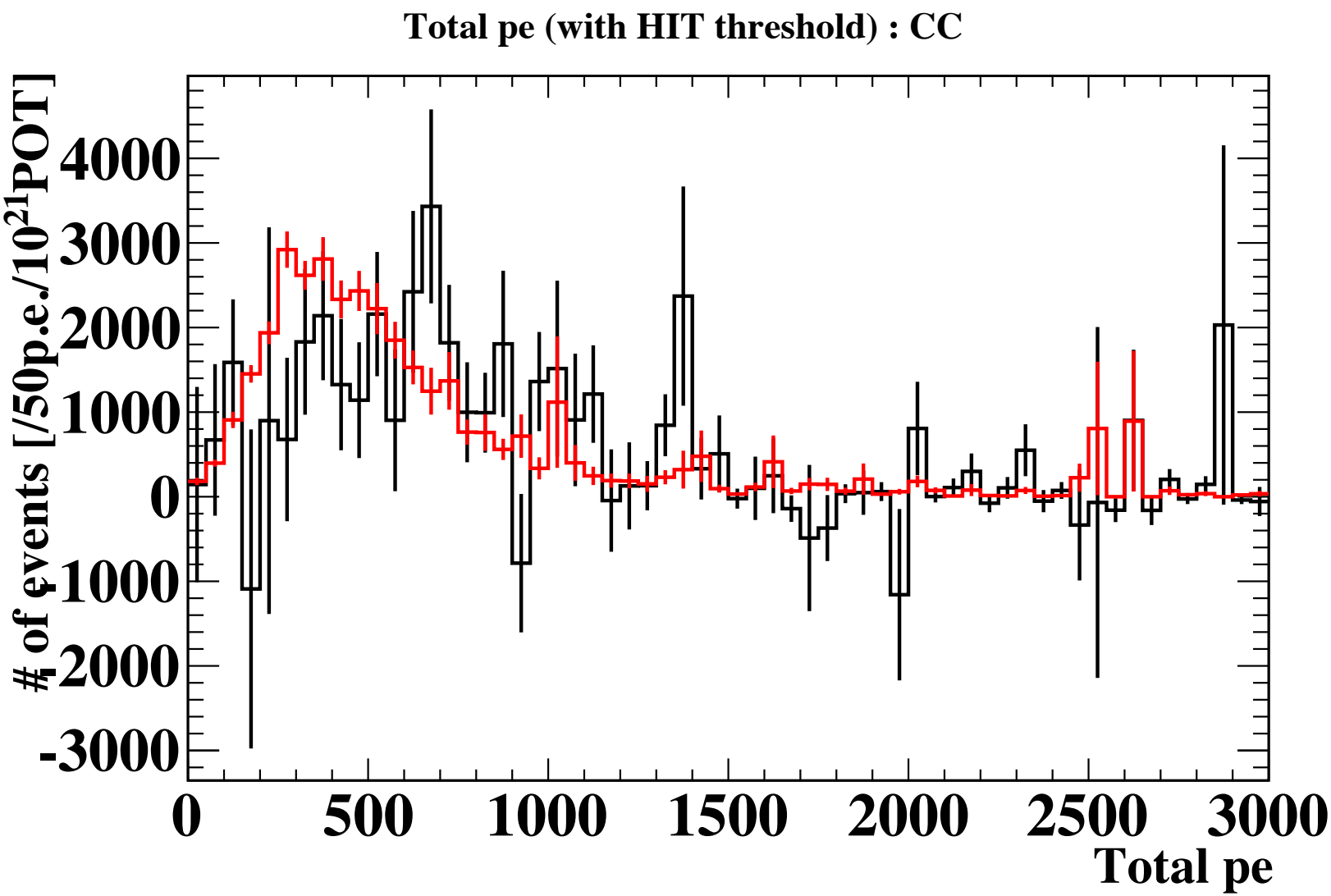
Sub. of total p.e. dist. (CC+NC)

Subtraction of total p.e. : (water w/ FV) - (water w/o FV)
Total p.e. distribution of true vertex in FV.



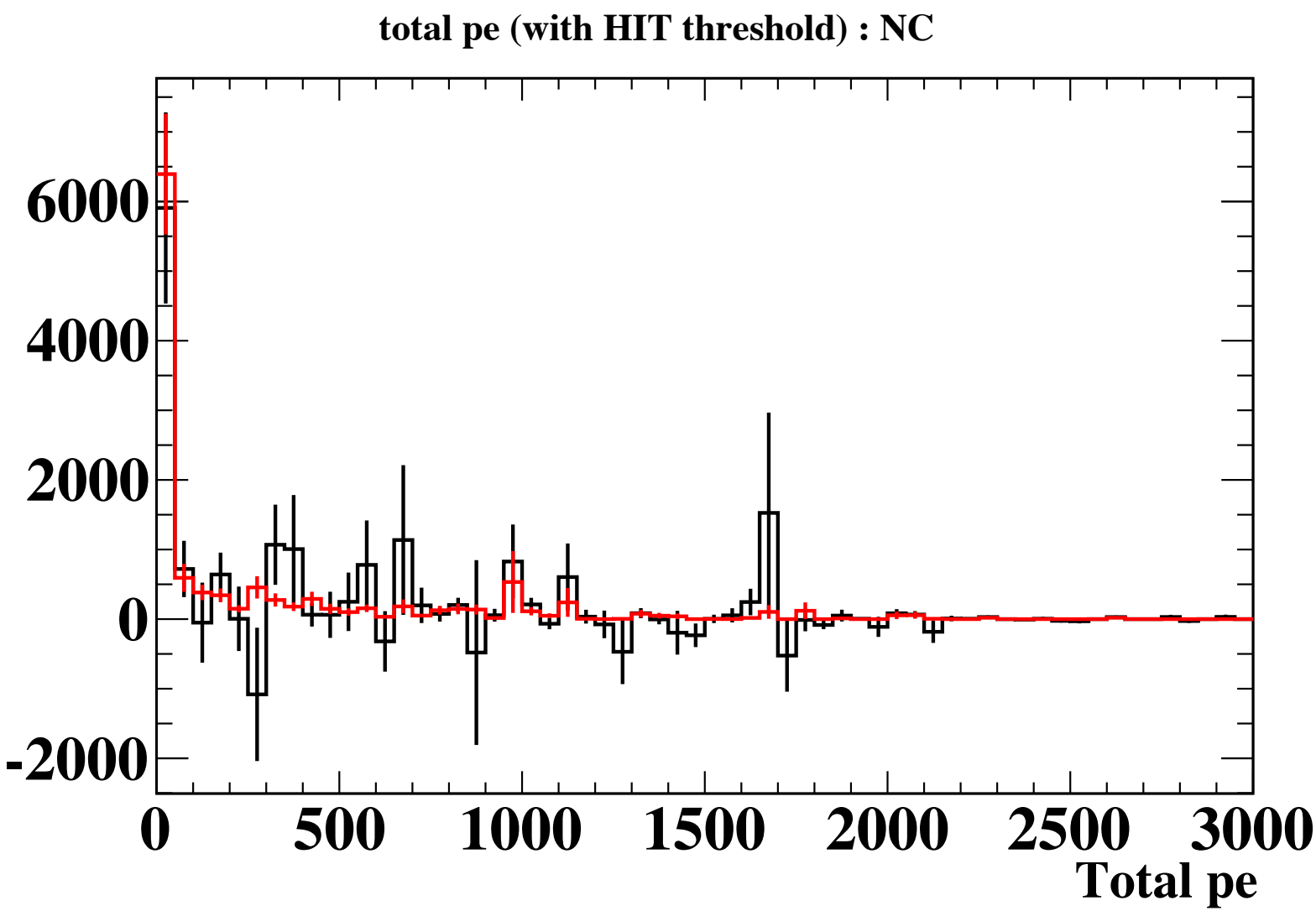
Sub. of total p.e. dist. (CC)

Subtraction of total p.e. : (water w/ FV) - (water w/o FV)
Total p.e. distribution of true vertex in FV.

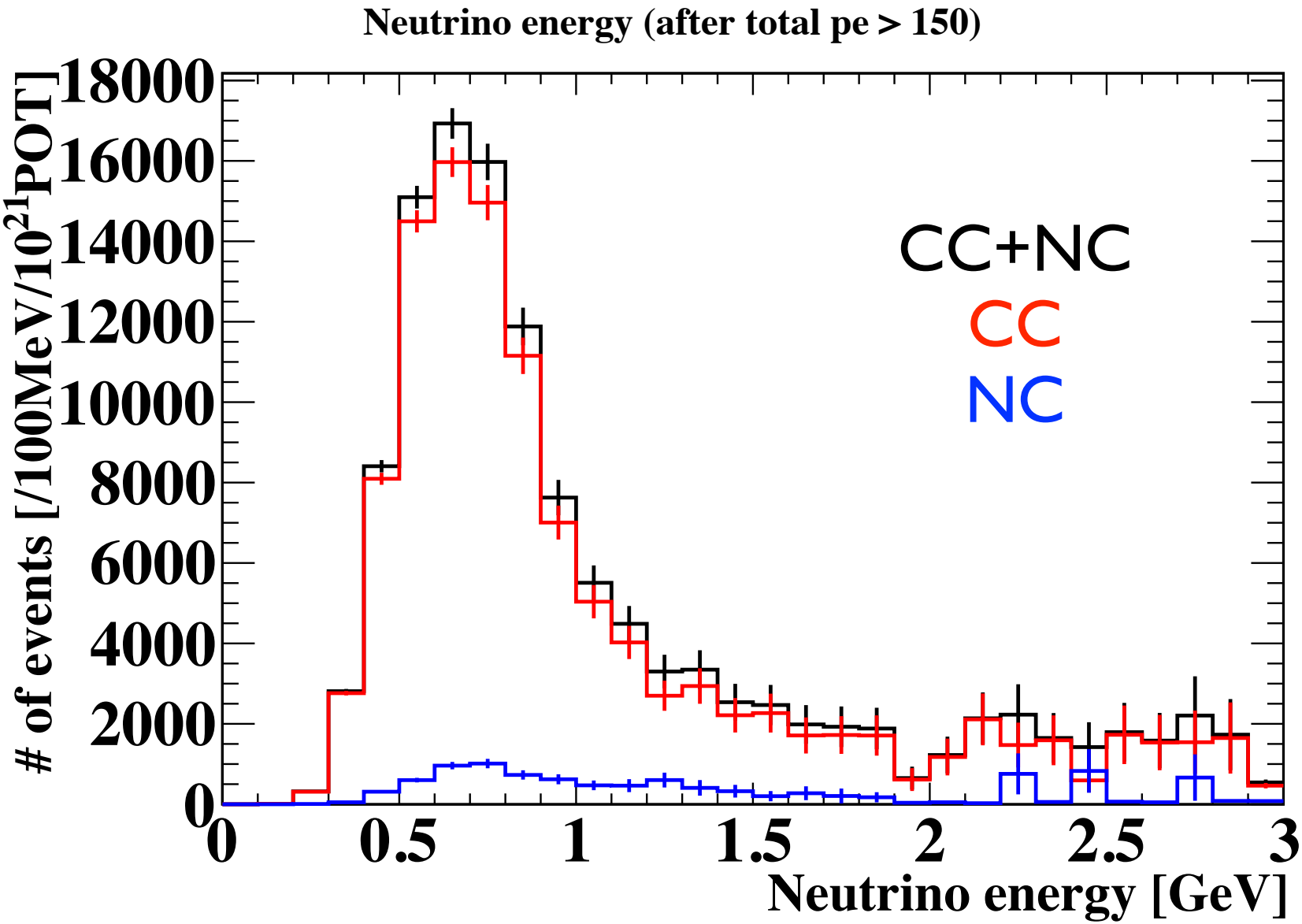


Sub. of total p.e. dist. (CC)

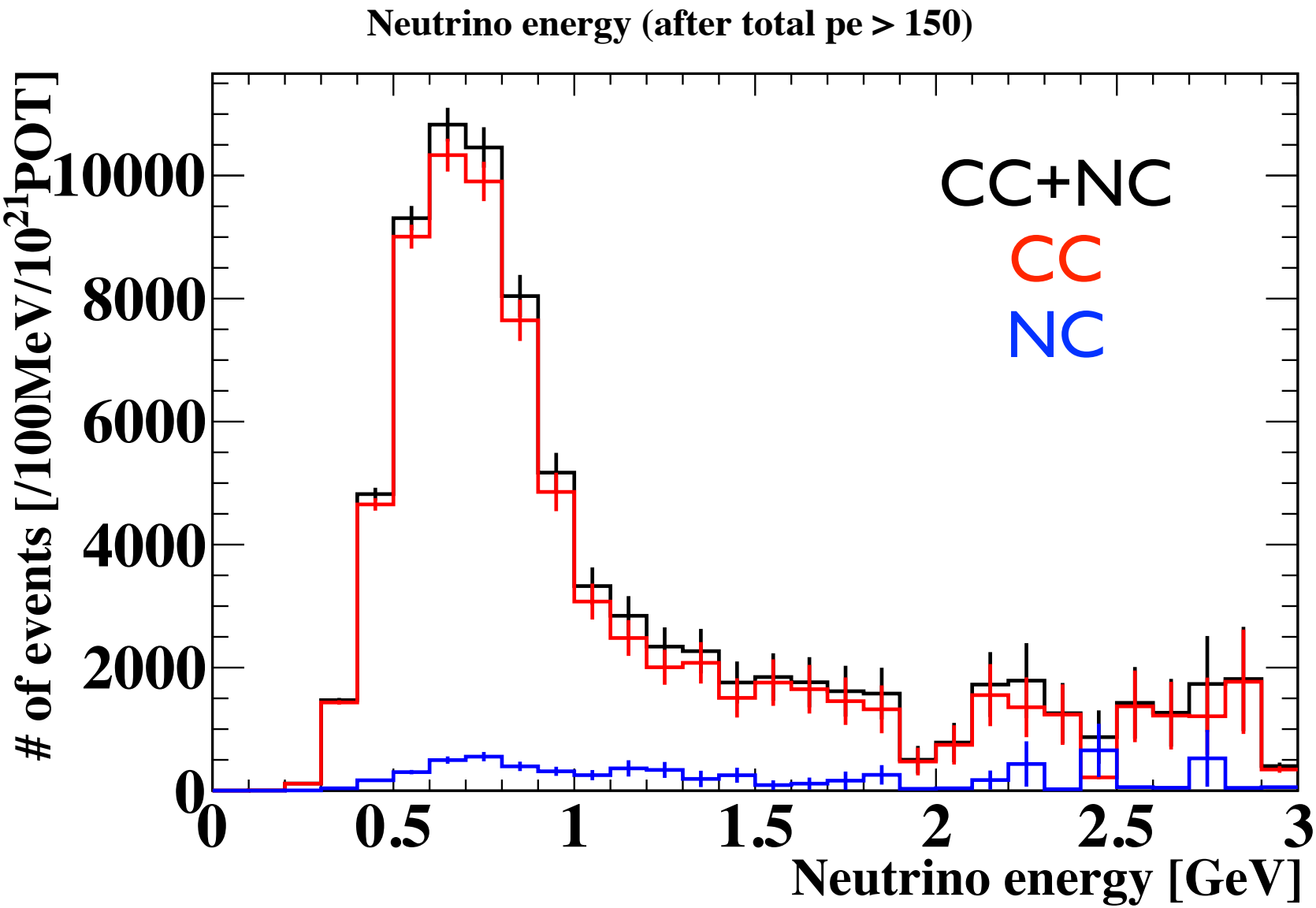
Subtraction of total p.e. : (water w/ FV) - (water w/o FV)
Total p.e. distribution of true vertex in FV.



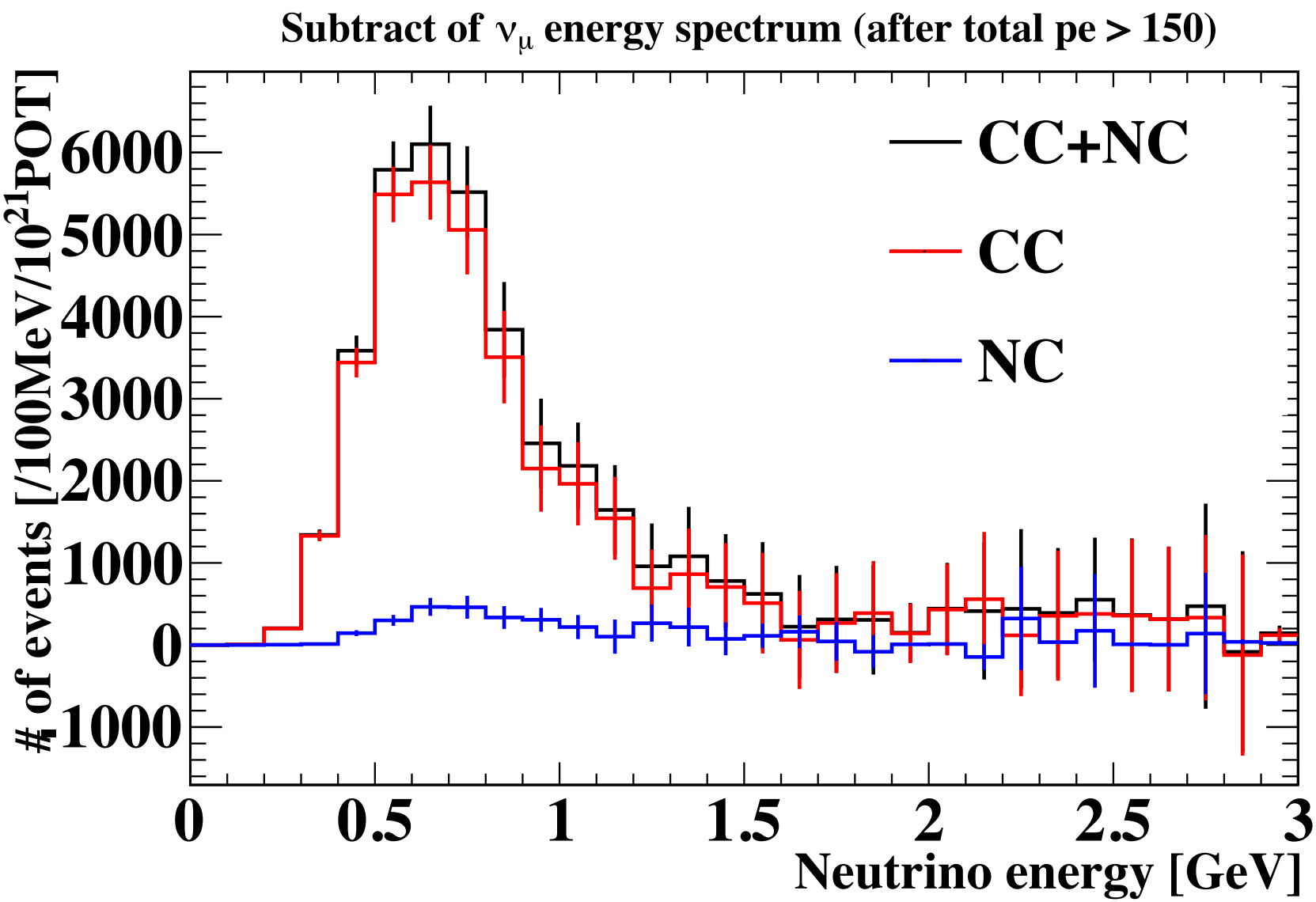
νμ energy w/ water in FV after total p.e. > 150 cut



νμ energy w/o water in FV after total p.e. > 150 cut

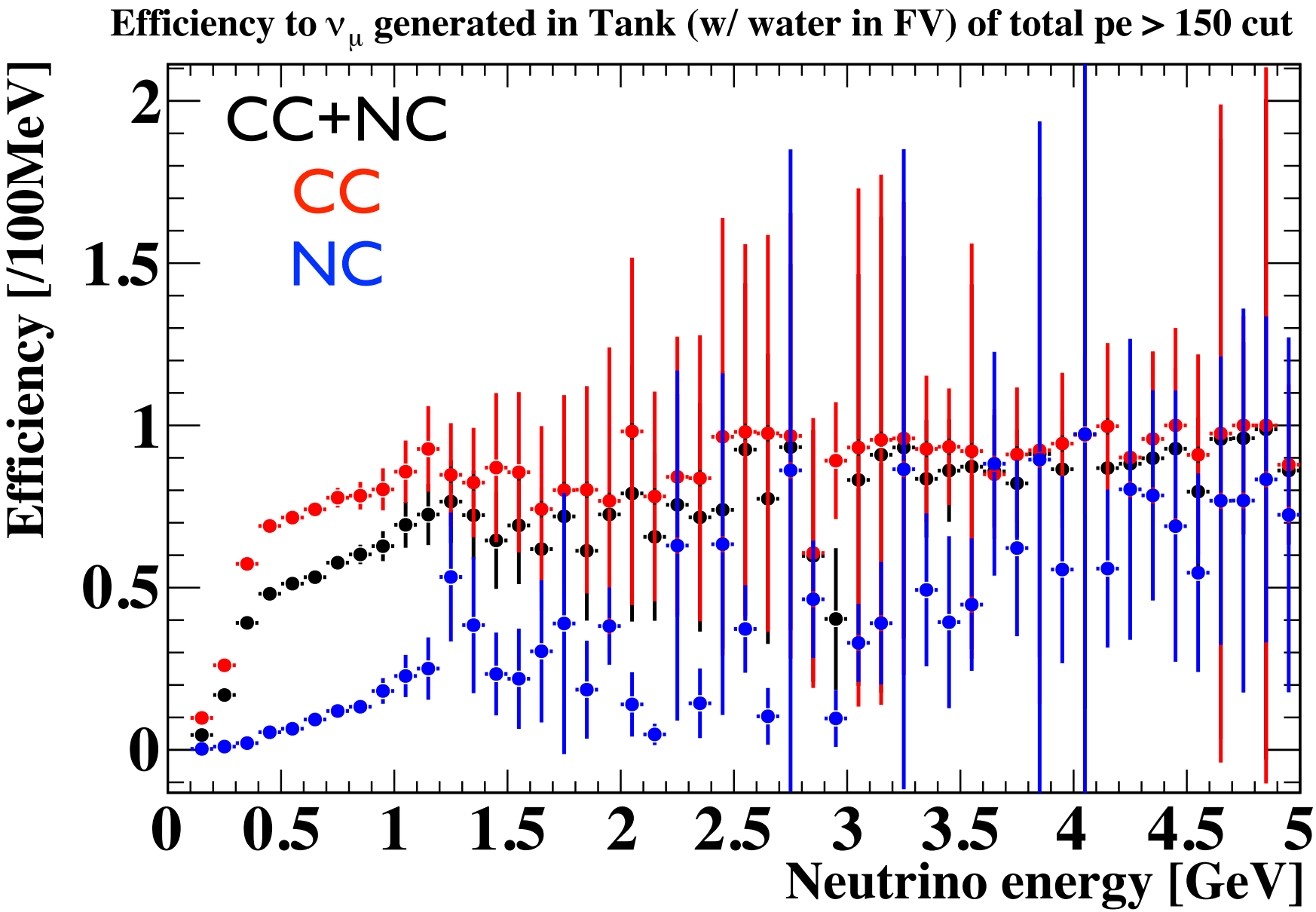


Subtract of νμ energy after total p.e. > 150 cut



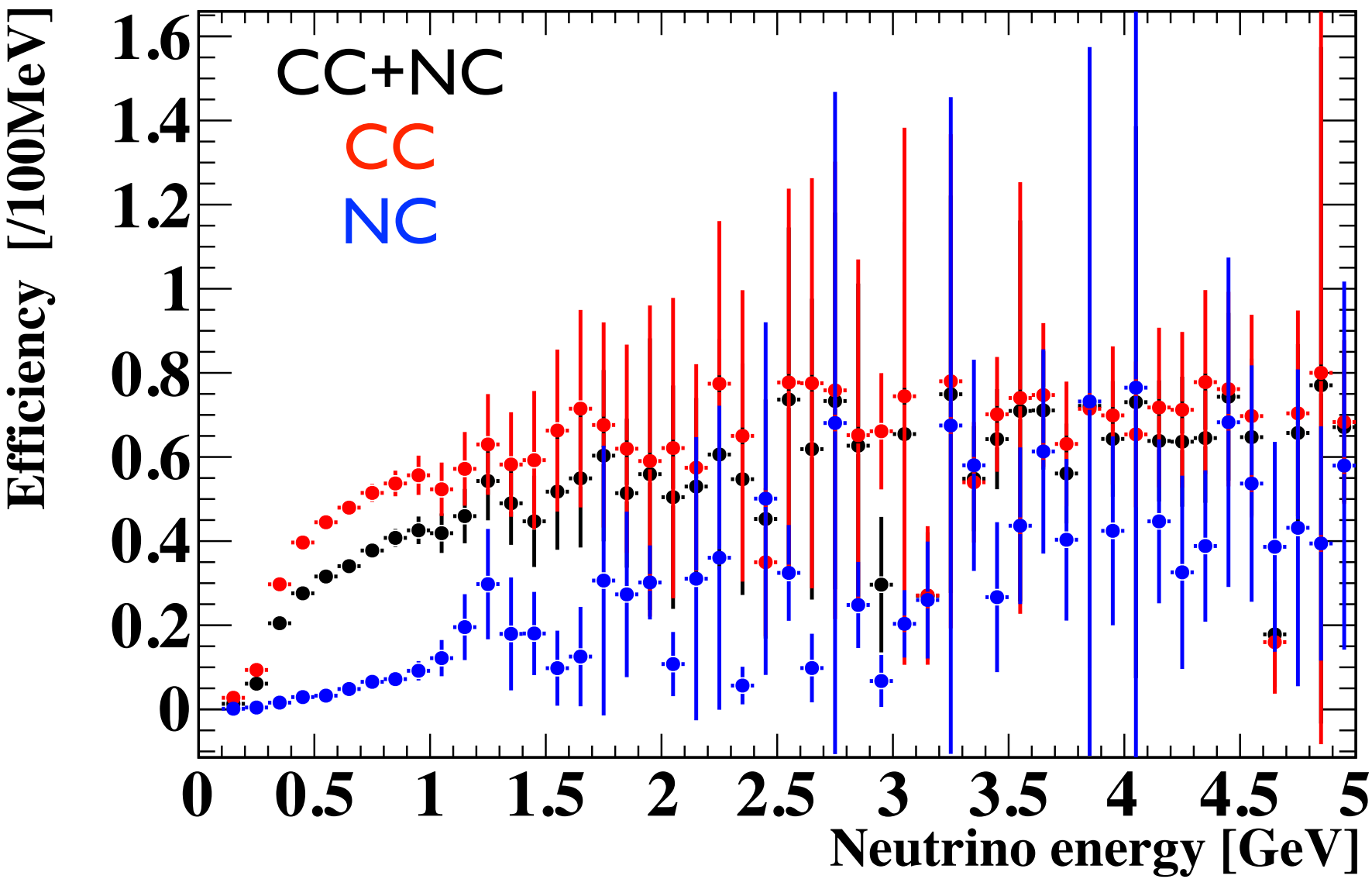
Efficiency (w/ water in FV)

(# of events after total pe>150)/(# of interactions in whole of Tank)



Efficiency (w/o water in FV)

(# of events after total pe>150)/(# of interactions out FV)



Efficiency
(w/ water in FV, true vertex in FV)

(# of events after total pe>150 in FV) / (# of interactions in FV)