

Sample program of NEUT

```
neut_ntpl [ CARD FILE ] [ output NTUPLE file ]
```

The card file controls the energy distribution, direction, target etc..

In the following pages, there are some information how to control the program.

NEUT card file

```
C-----  
C Number of events ; EVCT-NEVT  
EVCT-NEVT 1000  
C-----  
C Particle Code ; EVCT-IDPT  
EVCT-IDPT 14  
C-----  
C fixed VERTEX ; EVCT-MPOS 1  
C random VERTEX ; EVCT-MPOS 2  
C  
C EVCT-MPOS 1  
C VECT-POS 100. 0. 0.  
C  
EVCT-MPOS 2  
EVCT-RAD 100.  
C-----  
C fixed DIRECTION ; EVCT-MDIR 1  
C random DIRECTION ; EVCT-MDIR 2  
C  
EVCT-MDIR 1  
EVCT-DIR 0. 0. 1.  
C-----  
C fixed MOMENTUM ; EVCT-MPV 1  
C random MOMENTUM ; EVCT-MPV 2  
C  
C EVCT-MPV 1  
C EVCT-PV 1000.  
EVCT-MPV 2  
EVCT-PV 0. 10000.
```

```
C **** TARGET INFORMATION ****  
C  
C NUMBNDN : total number of neutron  
C      (e.g. CH => 6, H2O => 8, Ar => 22, Fe => 30)  
C  
NEUT-NUMBNDN 8  
C  
C NUMBNDP : total number of bound proton  
C      (e.g. CH => 6, H2O => 8, Ar => 18, Fe => 26)  
C  
NEUT-NUMBNDP 8  
C  
C NUMFREP : total number of free proton  
C      (e.g. CH => 1, H2O => 2, Ar => 0, Fe => 0)  
C  
NEUT-NUMFREP 2  
C  
C NUMATOM : atomic number of atom heavier than hydrogen  
C      (e.g. CH => 12, H2O => 16, Ar => 40, Fe => 56)  
C  
NEUT-NUMATOM 16  
C  
NEUT-PFSURF 0.225  
NEUT-PFMAX 0.225  
C
```

NEUT card file

```
C **** NEUTRINO INTERACTION ****
C
C FERM : Fermi motion 0 : on ( default ) 1 : off
C
NEUT-FERM 0
C
C PAUL : Pauli blocking 0 : on ( default ) 1 : off
C
NEUT-PAUL 0
C
C NEFF : Nuclear effect in O16 0 : on ( default ) 1 : off
C
NEUT-NEFF 0
C
C IFORMLEN : Formation zone 1: on (default) 0: off
C
NEUT-IFORMLEN 1
C
C Nucleon rescattering
C
C NUCRES-RESCAT 1: on (default) 0: off
C
NUCRES-RESCAT 1
C
C NUCRES-XNUCFACT
C cross-section factor to study uncertainty default = 1.
C
NUCRES-FACT 1.
```

```
C
C PDF for DIS is set in this section
C (GRV94DI -> 7, GRV98_LO -> 12)
NEUT-PDF 12
C PDF Correction is used?
C ( original=0, modified=1)
NEUT-BODEK 1
C Select Coherent pion model
C Rein & Sehgal =0(default)
C Kartavtsev et al. =1
NEUT-COHEPI 0
C
C RAND : random seed
C 0 : Read RANDOM number from FILE
C 1 : Generating RANDOM SEED from the time
C
NEUT-RAND 1
```

NEUT card file

C MODE : Interaction mode

C 0 : normal (default)

C -1 : input cross section by NEUT-CRS / NEUT-CRSB

C n : select one mode (n > 0)

C

NEUT-MODE 0

C

C CRS : Multiplied factor to cross section on each mode. (neu)

C CSRB : Multiplied factor to cross section on each mode. (neu-bar)

C

C 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

NEUT-CRS 1.

NEUT-CRSB 1.

	NEUT-CRS	NEUT-CRSB		NEUT-CRS	NEUT-CRSB
CCQE	1	1			
CC 1pi	2,3,4	2,3,4			
CC DIS 1320	5	5			
NC 1pi	6,7,8,9	6,7,8,9			
NC DIS 1320	10	10			
NC elastic	11,12,13	11,12,13,14			
CC Coherent	14	15	CC 1 K	19	20
NC Coherent	15	16	NC 1 K	20,21	21,22
CC 1 eta	16	17	CC DIS	23	23
NC 1 eta	17,18	18,19	NC DIS	24	24
			CC 1 gamma	25	25
			NC 1 gamma	26,27	26,27

Interaction modes used in NEUT

NEUTRINO MODE

***** CHARGED CURRENT *****

-- ELASTIC --

1 : NEU,N --> LEPTON-,P

-- SINGLE PI FROM DELTA RESONANCE --

11 : NEU,P --> LEPTON-,P,PI+

12 : NEU,N --> LEPTON-,P,PI0

13 : NEU,N --> LEPTON-,N,PI+

16 : NEU,O(16) --> LEPTON-,O(16),PI+

-- SINGLE GAMMA FROM DELTA RESONANCE --

17 : NEU,N --> LEPTON-,P,GAMMA

-- MULTI PI (1.3 < W < 2.0 GeV) --

21 : NEU,(N OR P) --> LEPTON-,(N OR P),MULTI PI

-- SINGLE ETA FROM DELTA RESONANCE --

(added 97/12/01 J.Kameda)

22 : NEU,N --> LEPTON-,P,ETA0

-- SINGLE K FROM DELTA RESONANCE --

(added 98/02/25 J.Kameda)

23 : NEU,N --> LEPTON-,LAMBDA,K+

-- DEEP INELASTIC (2.0 GeV < W , JET set) --

26 : NEU,(N OR P) --> LEPTON-,(N OR P),MESONS

***** NEUTAL CURRENT *****

-- SINGLE PI FROM DELTA RESONANCE --

31 : NEU,N --> NEU,N,PI0

32 : NEU,P --> NEU,P,PI0

33 : NEU,N --> NEU,P,PI-

34 : NEU,P --> NEU,N,PI+

36 : NEU,O(16) --> NEU,O(16),PI0

-- SINGLE GAMMA FROM DELTA RESONANCE --

38 : NEU,N --> NEU,N,GAMMA

39 : NEU,P --> NEU,P,GAMMA

-- MULTI PI (1.3 GeV < W < 2.0 GeV) --

41 : NEU,(N OR P) --> NEU,(N OR P),MULTI PI

-- SINGLE ETA FROM DELTA RESONANCE --

(added 97/12/01 J.Kameda)

42 : NEU,N --> NEU,N,ETA0

43 : NEU,P --> NEU,P,ETA0

52 : NEU,N --> NEU,N

-- SINGLE K FROM DELTA RESONANCE --

(added 98/02/20 J.Kameda)

44 : NEU,N --> NEU,LAMBDA,K0

45 : NEU,P --> NEU,LAMBDA,K+

-- DEEP INELASTIC (2.0 GeV < W , JET set) --

46 : NEU,(N OR P) --> NEU,(N OR P),MESONS

-- ELASTIC --

51 : NEU,P --> NEU,P

Interaction modes used in NEUT

ANTI NEUTRINO MODE

***** CHARGED CURRENT *****

-- ELASTIC --
-1 : NEUBAR,P --> LEPTON+,N

-- SINGLE PI FROM DELTA RESONANCE --
-11 : NEUBAR,N --> LEPTON+,N,PI-
-12 : NEUBAR,P --> LEPTON+,N,PI0
-13 : NEUBAR,P --> LEPTON+,P,PI-

-16 : NEUBAR,O(16) --> LEPTON+,O(16),PI-

-- SINGLE GAMMA FROM DELTA RESONANCE --
-17 : NEUBAR,P --> LEPTON+,N,GAMMA

-- MULTI PI (W > 1.4 GEV) --
-21 : NEUBAR,(N OR P) --> LEPTON+,(N OR P),MULTI PI

-- SINGLE ETA FROM DELTA RESONANCE --
(added 97/12/01 J.Kameda)
-22 : NEUBAR,P --> LEPTON+,N,ETA0

-- SINGLE K FROM DELTA RESONANCE --
(added 98/02/25 J.Kameda)
-23 : NEUBAR,P --> LEPTON+,LAMBDA,K0

-- DEEP INELASTIC (2.0 GeV < W , JET set) --
-26 : NEUBAR,(N OR P) --> LEPTON+,(N OR P),MESONS

** NEUTAL CURRENT **

-- SINGLE PI FROM DELTA RESONANCE --
-31 : NEUBAR,N --> NEUBAR,N,PI0
-32 : NEUBAR,P --> NEUBAR,P,PI0
-33 : NEUBAR,N --> NEUBAR,P,PI-
-34 : NEUBAR,P --> NEUBAR,N,PI+

-36 : NEUBAR,O(16) --> NEUBAR,O(16),PI0

-- SINGLE GAMMA FROM DELTA RESONANCE --
-38 : NEUBAR,N --> NEUBAR,N,GAMMA
-39 : NEUBAR,P --> NEUBAR,P,GAMMA

-- MULTI PI (W > 1.4 GEV) --
-41 : NEUBAR,(N OR P) --> NEUBAR,(N OR P),MULTI PI

-- SINGLE ETA FROM DELTA RESONANCE --
(added 97/12/01 J.Kameda)
-42 : NEUBAR,N --> NEUBAR,N,ETA0
-43 : NEUBAR,P --> NEUBAR,P,ETA0

-- SINGLE K FROM DELTA RESONANCE --
(added 98/02/20 J.Kameda)
-44 : NEUBAR,N --> NEUBAR,LAMBDA,K0
-45 : NEUBAR,P --> NEUBAR,LAMBDA,K+

-- DEEP INELASTIC (2.0 GeV < W , JET set) --
-46 : NEUBAR,(N OR P) --> NEUBAR,(N OR P),MESONS

-- ELASTIC --
-51 : NEUBAR,P --> NEUBAR,P
-52 : NEUBAR,N --> NEUBAR,N

Meanings of the variables in ntuple

MODE : Interaction mode
NUMNU : Number of particles (including initial neutrino and nucleon)
IPNU : Particle Code
ABSPNU : Absolute momentum of particle (GeV / c)
PNU : Momentum of particle (GeV / c)

NPAR : Number of particles (after the final state interactions)
IPV : Particle code
IORGV : Parent particle
ICRNV : Tracking flag (set to 0 if the particle was interacted,
absorbed or disappeared)
IFLGV : Interaction code (If the particle already interacted with the others,
this flag is set.)

0	:	Not interacted yet.
1	:	Decayed to the other particles
2	:	N/A
3	:	Absorbed
4	:	Charge exchanged
5	:	Stopped
6	:	N/A
7	:	Particle production
8	:	Scattered

ABSPV : Absolute momentum of particle
PMOMV : Momentum of particle

Table 1. Proton and neutron Fermi momenta and binding energies (in MeV) for selected nuclei.

Nucleus	p_F^p	ϵ_b^p	p_F^n	ϵ_b^n
${}^{12}_6\text{C}$	221	25.6	221	25.6
${}^{14}_7\text{N}$	223	26.2	223	26.1
${}^{16}_8\text{O}$	225	26.6	225	26.6
${}^{19}_9\text{F}$	233	28.4	233	28.3
${}^{20}_{10}\text{Ne}$	230	27.8	230	27.8
${}^{27}_{13}\text{Al}$	239	29.5	239	29.4
${}^{40}_{18}\text{Ar}$	242	30.7	259	35.0
${}^{56}_{26}\text{Fe}$	251	33.0	263	36.1
${}^{80}_{35}\text{Br}$	245	31.5	270	38.1