GENIE NC zero momentum nucleons

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GENIE zero momentum nucleons in NC

GENIE v3.0.6 G18_02b_02_11a

GENIE GHEP Event Record [print level: 3]

Idx	Name	Ist	PDG	Mother		Daughter		Px	Py	Pz	E	m	
0	nu_e	0	12	-1	-1	4	4	0.402	-0.415	0.122	0.591	0.000	
1	C12	0	1000060120	-1	-1	2	3	0.000	0.000	0.000	11.175	11.175	
2	neutron	11	2112	1	-1	5	5	-0.165	-0.101	-0.089	0.919	**0.940	M = 0.894
3	C11	2	1000060110	1	-1	10	10	0.165	0.101	0.089	10.256	10.254	
4	nu_e	1	12	0	-1	-1	-1	0.415	-0.027	-0.098	0.427	0.000	P = (-0.971,0.062,0.230)
5	neutron	14	2112	2	-1	6	7	-0.178	-0.489	0.131	1.082	0.940	FSI = 3
6	neutron	14	2112	5	-1	8	8	0.070	-0.023	-0.041	0.943	0.940	FSI = 1
7	proton	14	2212	5	-1	9	9	-0.020	-0.509	0.163	1.080	0.938	FSI = 1
8	neutron	1	2112	6	-1	-1	-1	0.000	-0.000	-0.000	0.940	0.940	
9	proton	1	2212	7	-1	-1	-1	-0.018	-0.459	0.147	1.055	0.938	
10	HadrBlob	15	2000000002	3	-1	-1	-1	-0.063	0.143	0.098	9.315	**0.000	M = 9.313
11	NucBindE	1	2000000101	-1	-1	-1	-1	0.070	-0.023	-0.041	0.025	**0.000	M = -0.081
12	NucBindE	1	2000000101	-1	-1	-1	-1	-0.002	-0.050	0.016	0.025	**0.000	M = -0.046
	Fin-Init:							-0.000	-0.000	0.000	0.021		

Vertex: nu_e @ (x = 0.00000 m, y = 0.00000 m, z = 0.00000 m, t = 3.566833e-09 s)

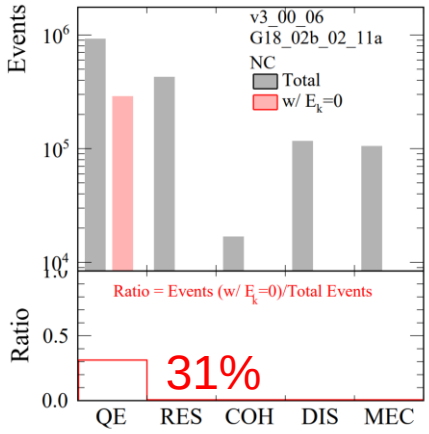
Err flag [bits:15->0] : 0000000000000000 | 1st set: none
Err mask [bits:15->0] : 1111111111111111 | Is unphysical: NO | Accepted: YES

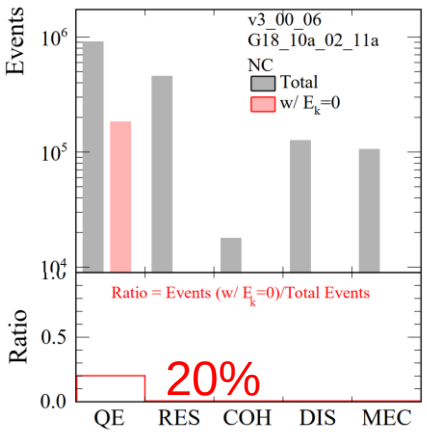
sig(Ev) = 8.30191e-39 cm^2 | dsig(Q2;E)/dQ2 = 3.08873e-39 cm^2/GeV^2 | Weight = 1.00000

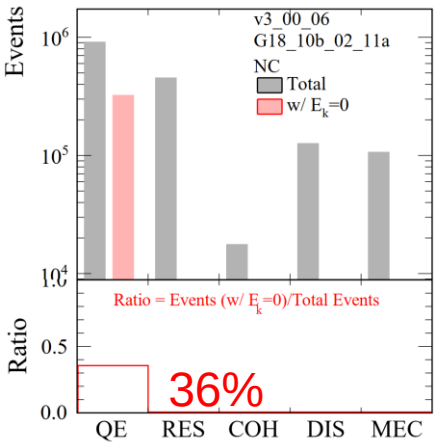
- **Check samples:**
  - Honda flux @ JUNO
    - Ev: 0.1-20 GeV
  - Target: C-12, including NC and CC interactions
  - Genie versions: v3.0.6, v3.2.0 and v3.4.0

Check-1: NC

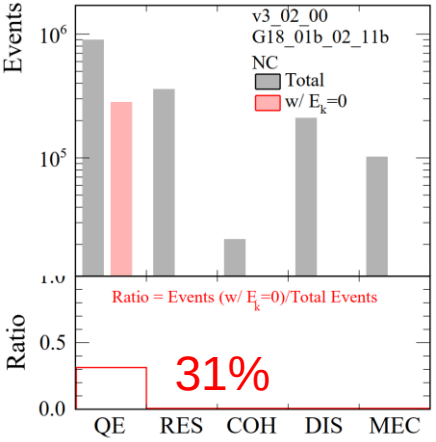
- **Check1: the fraction of events with Ek=0 nucleon in different cross section models and different genie versions**

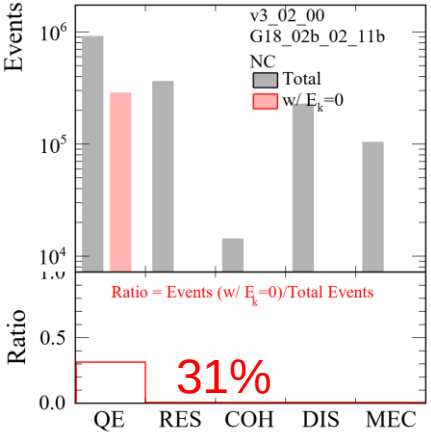


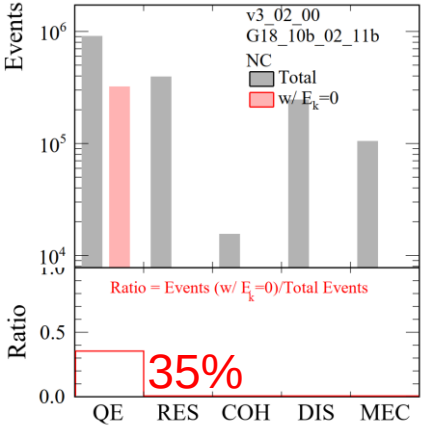


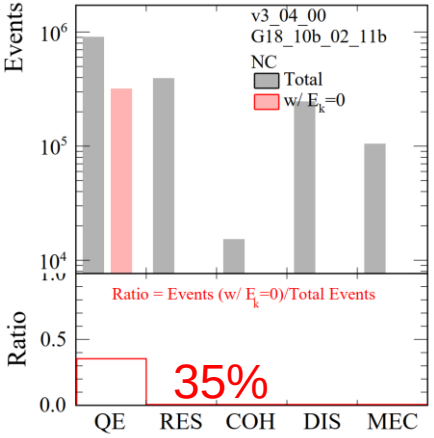


- ✓ Only exists in QE
- ✓ Fraction with hN FSI model > Fraction with hA FSI model



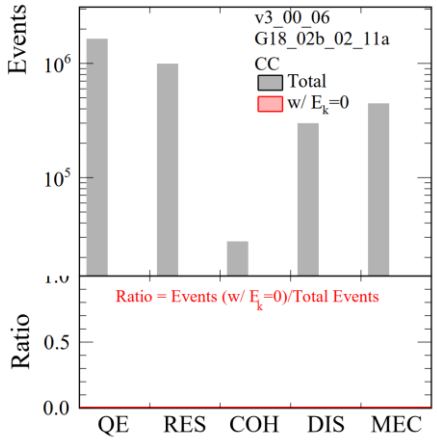






Check-1: CC

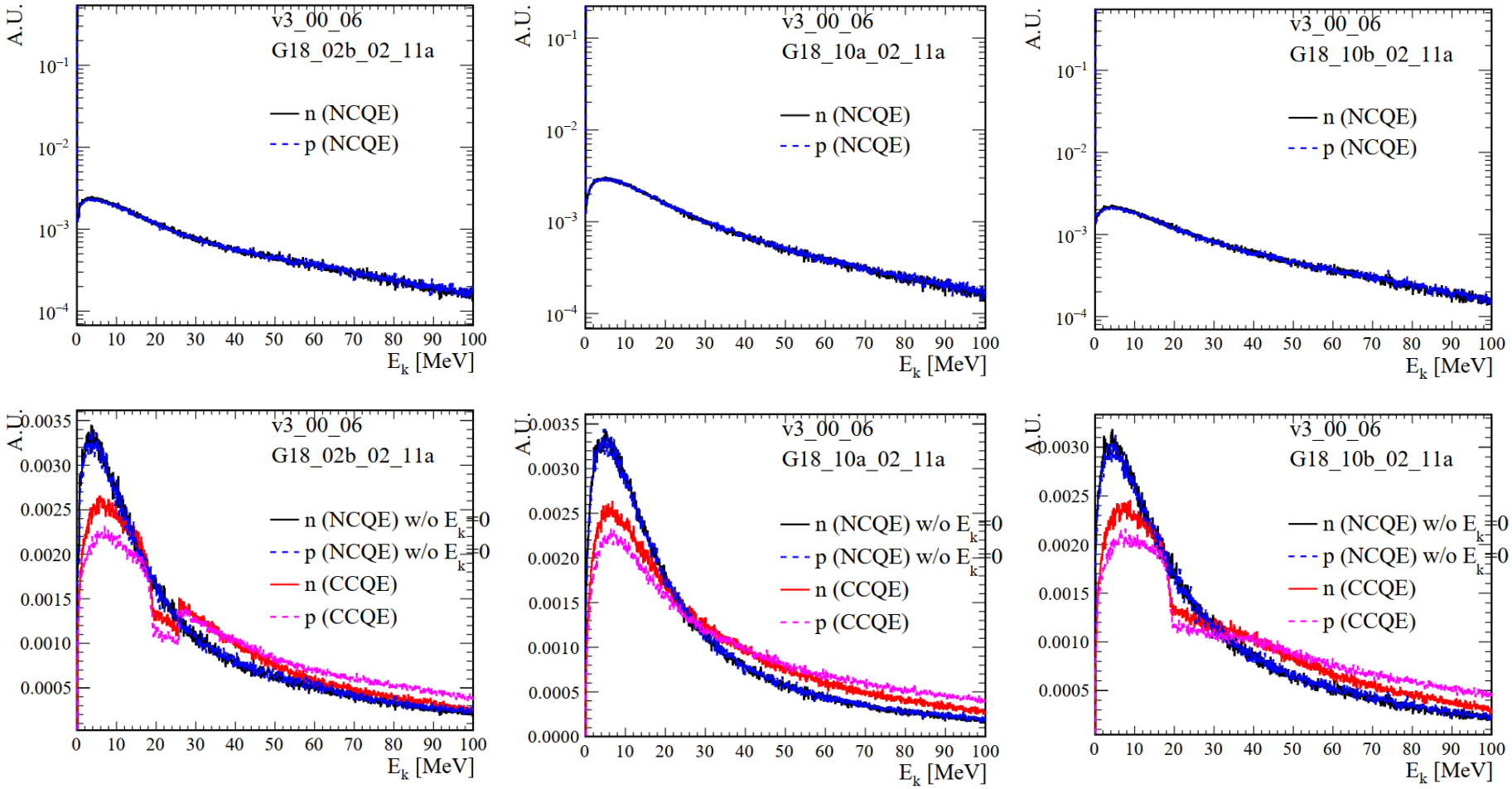
❖ **Check1: the fraction of events with Ek=0 nucleon in different cross section models and different genie versions**



- Check the same models and Genie versions as NC events
  - ✓ No CC events with Ek=0 nucleon production

Check-2

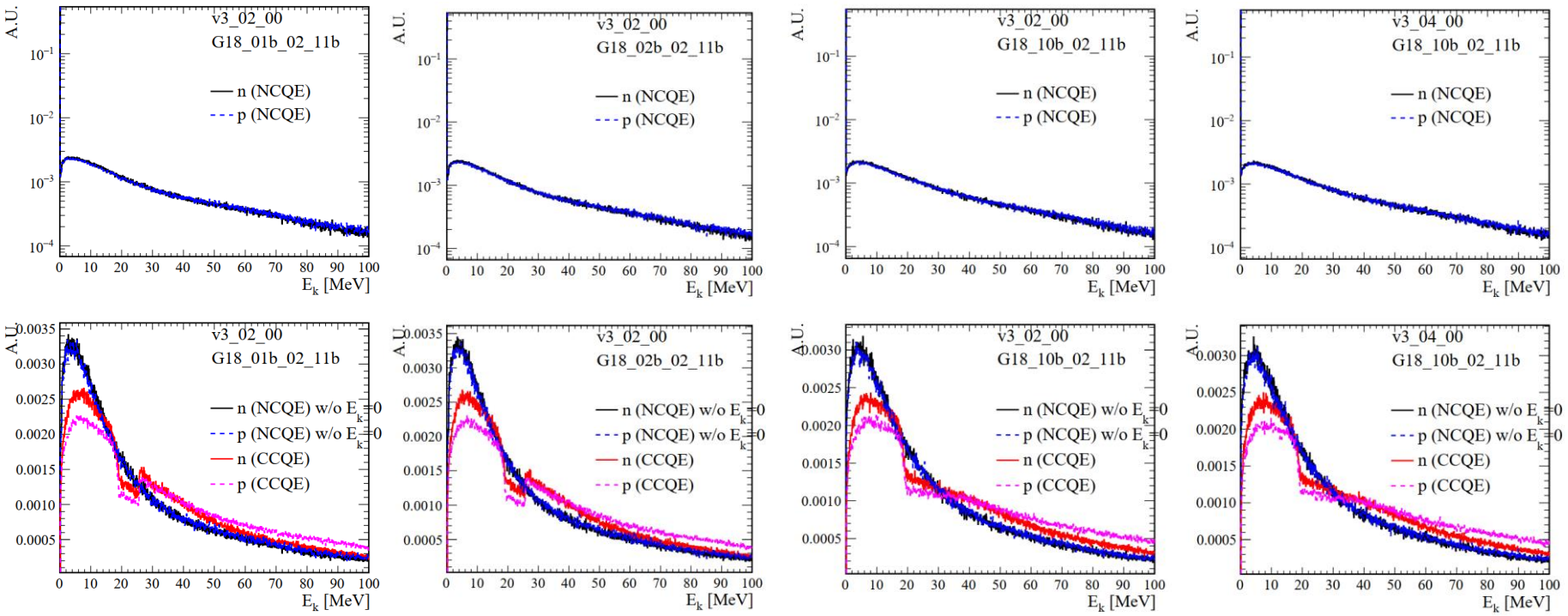
❖ **Check2: the distributions of kinetic energy of final-state nucleon in QE**



- In hN models, the fraction of nucleons w/ Ek=0 is about 25% in QE within [0, 100] MeV Ek range
- In hA model, the fraction is about 10%

Check-2

❖ Check2: the distributions of kinetic energy of final-state nucleon in QE

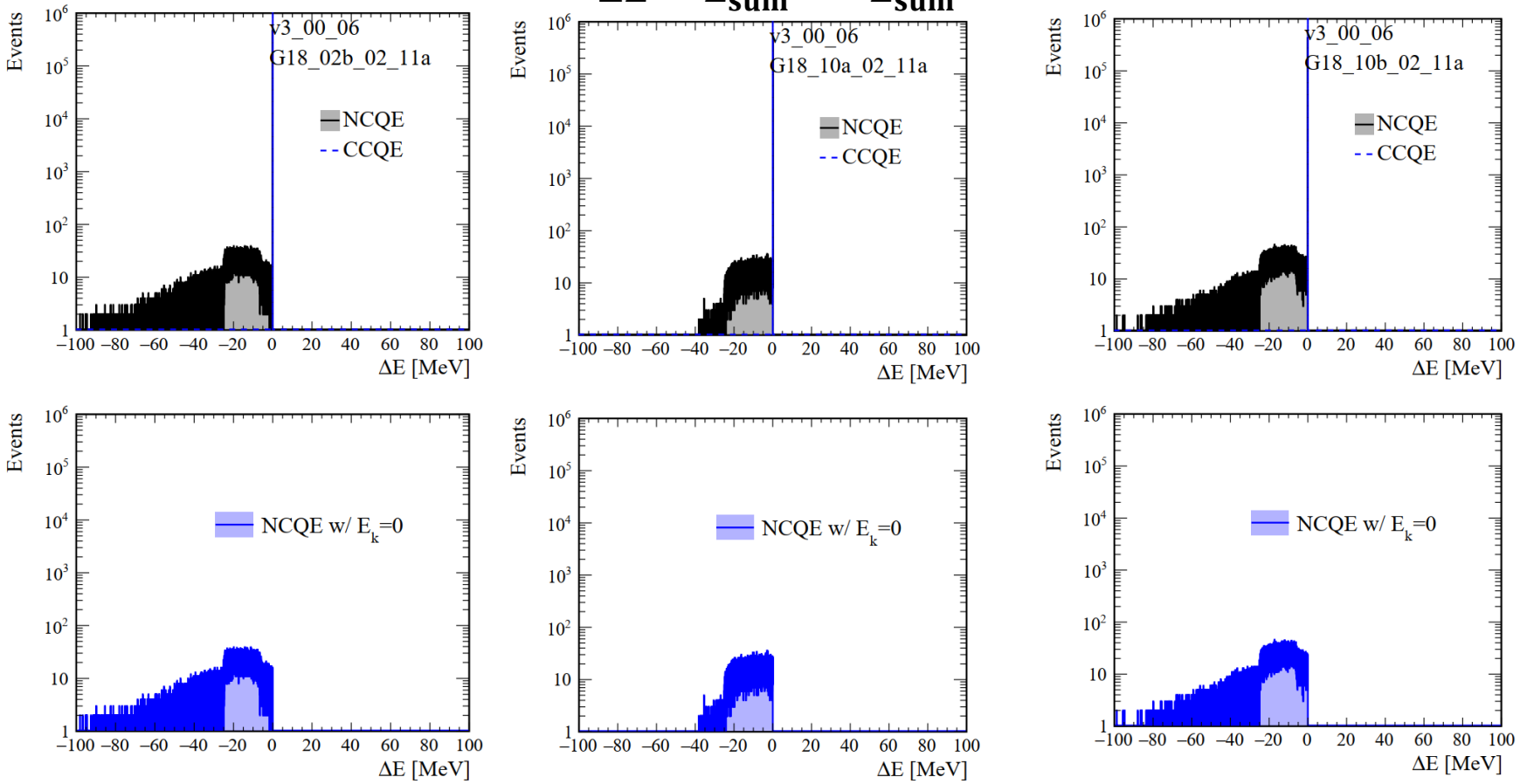


- Quite similar results in new versions of GENIE
- In hN models, the fraction of nucleons w/ Ek=0 is about 25% in QE within [0, 100] MeV Ek range
- In hA model, the fraction is about 10%

Check-3

❖ **Check3: check if energy is conserved before and after QE interactions**

$$\Delta E = E_{sum}^{initial} - E_{sum}^{final}$$

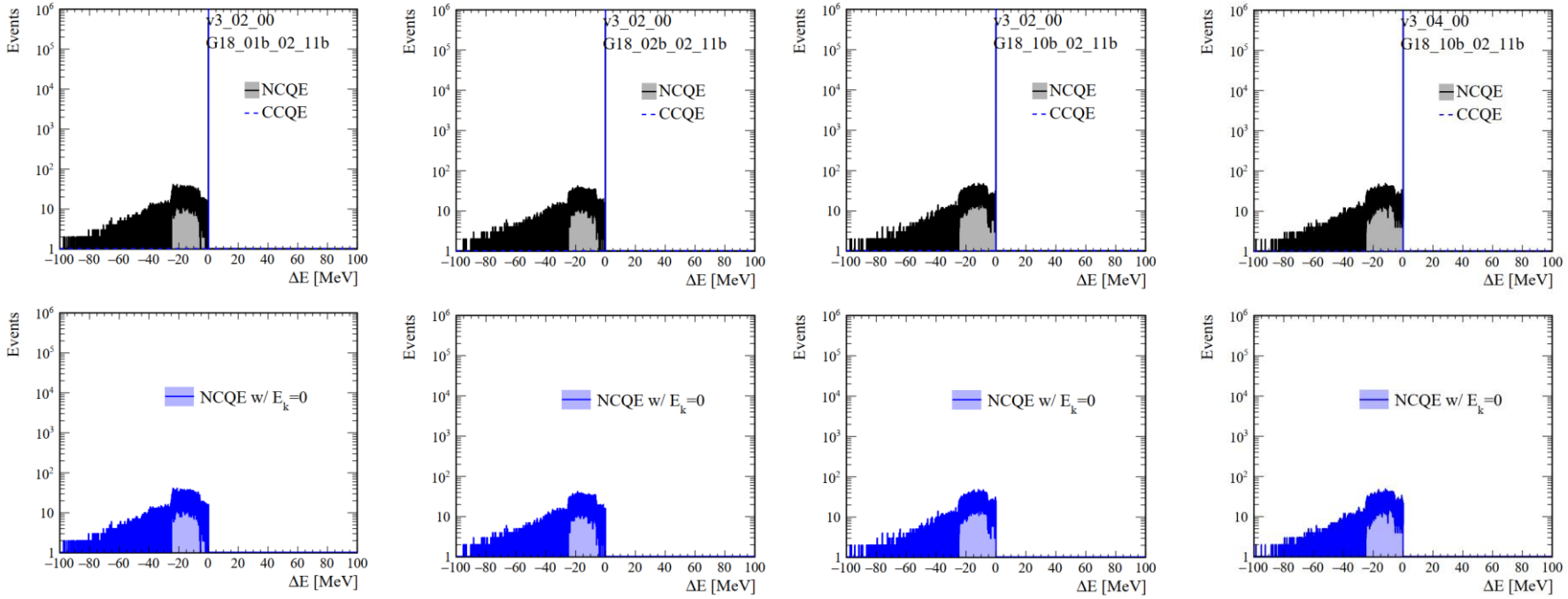


- Events with Ek=0 ← → energy is not conserved
- Other events: energy is conserved

Check-3

❖ **Check3: check if energy is conserved before and after QE interactions**

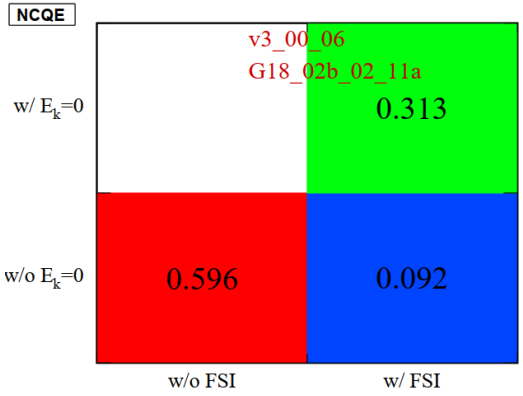
$$\Delta E = E_{sum}^{initial} - E_{sum}^{final}$$

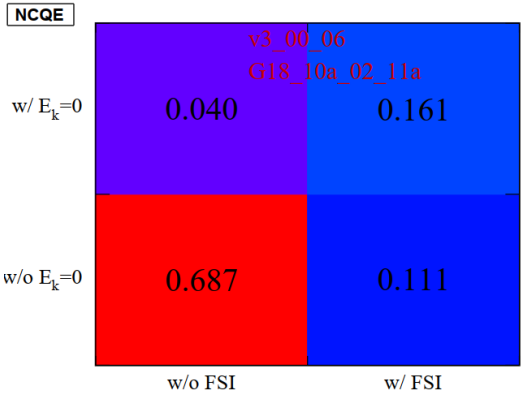


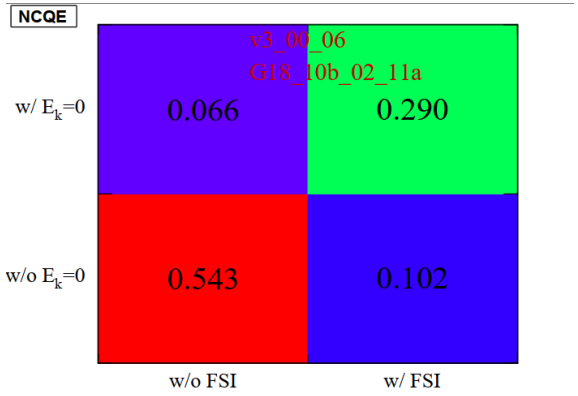
➢ Quite similar results in new versions of GENIE

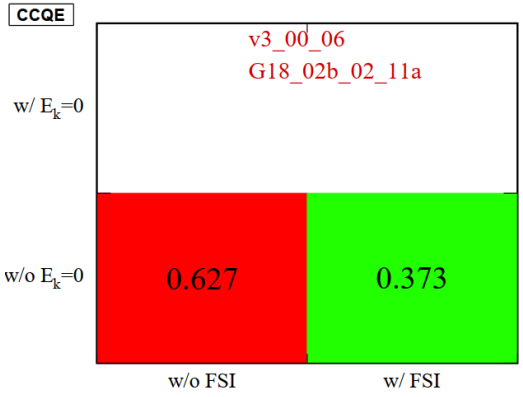
Check-4

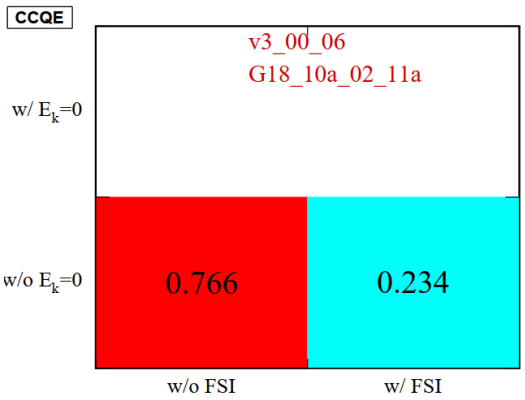
❖ Check4: check if the nucleon with Ek=0 is strongly correlated with FSI

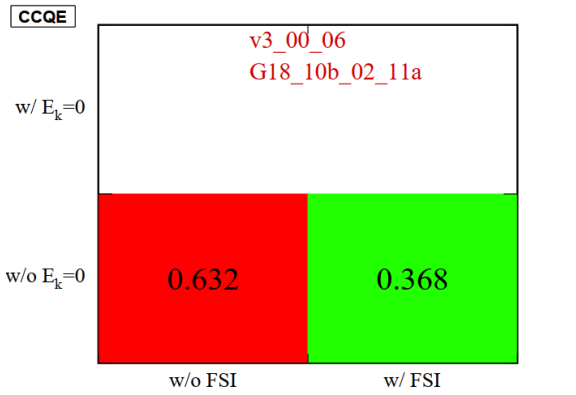








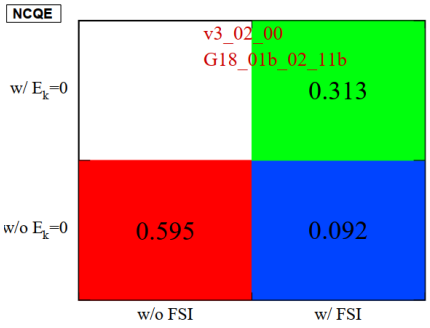


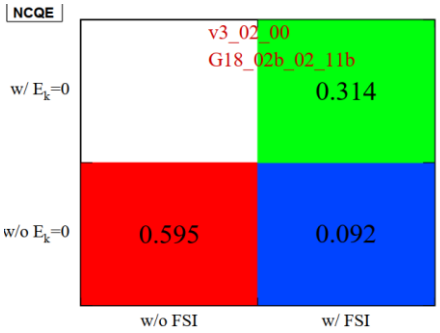


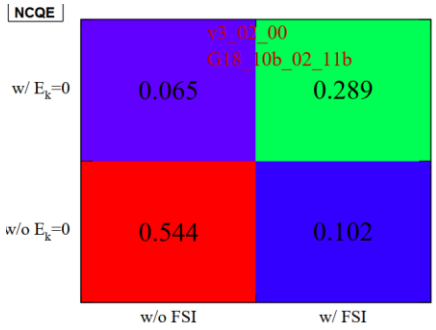
- Very strong correlation between nucleon (Ek=0) with FSI
- Why there is no nucleon production with Ek=0 in CCQE events?

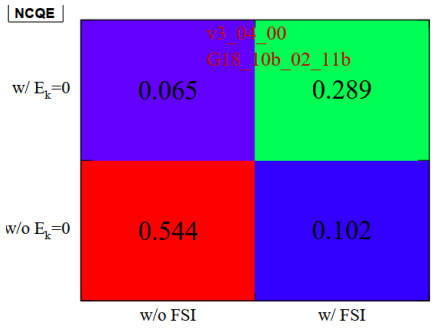
Check-4

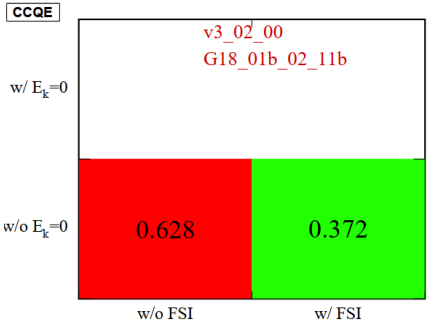
❖ Check4: check if the nucleon with Ek=0 is strongly correlated with FSI

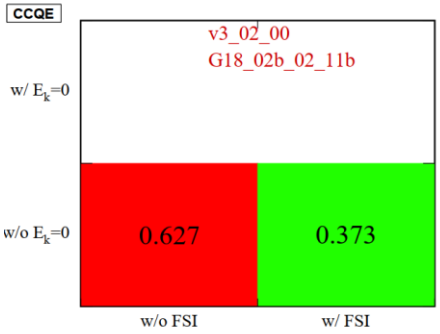


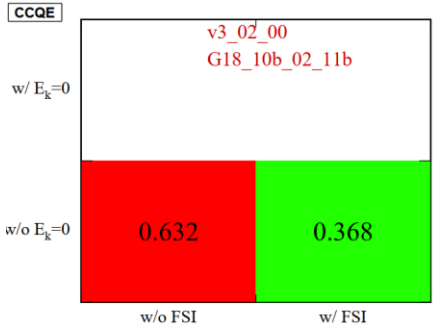


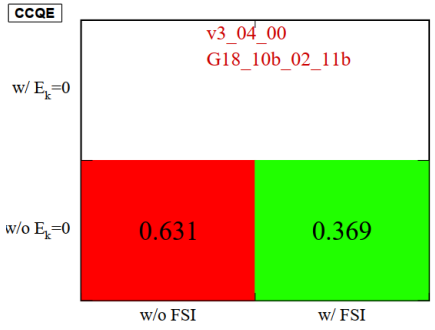








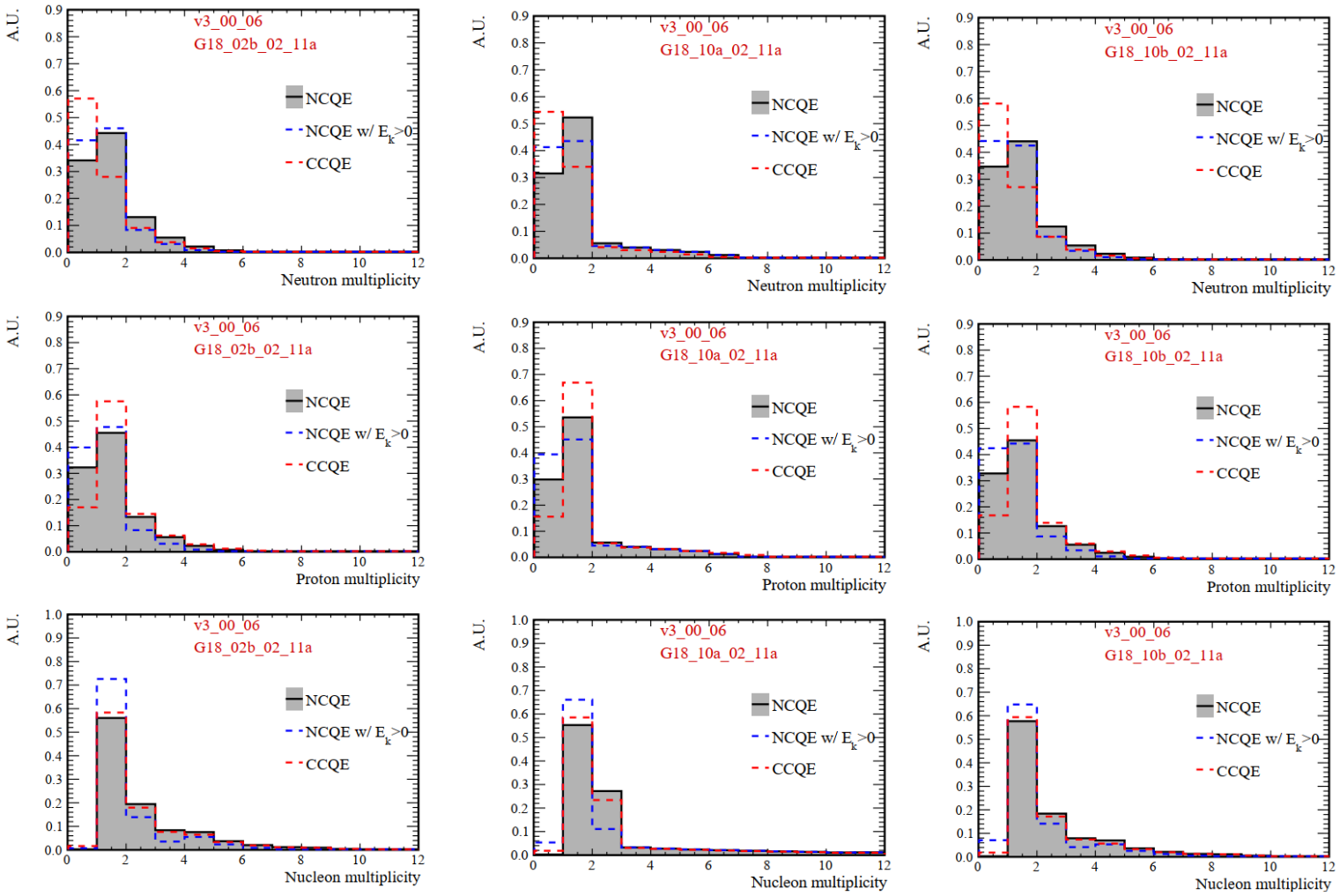




- Very strong correlation between nucleon (Ek=0) with FSI
- Why there is no nucleon production with Ek=0 in CCQE events?

Check-5

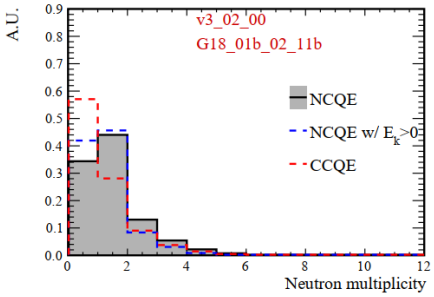
❖ Check5: nucleon multiplicity

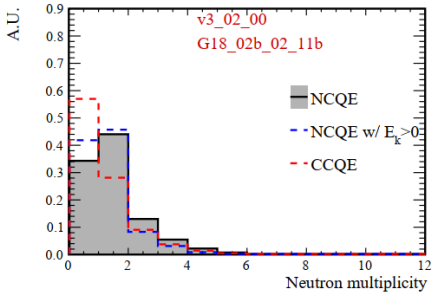


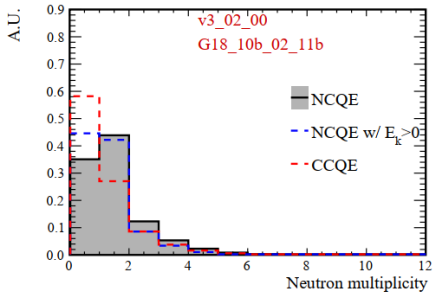
- ✓ **hN FSI model: effect all multiplicity**
- ✓ **hA FSI model: effect multiplicity <= 2**
- ✓ **For nucleon multiplicity, NCQE (including nucleon(Ek=0)) is more consistent with CCQE**

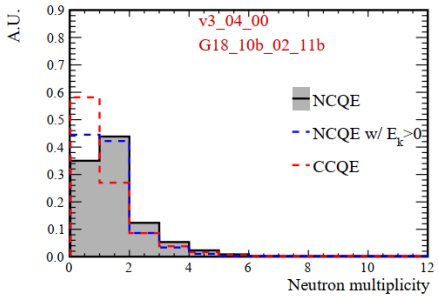
Check-5

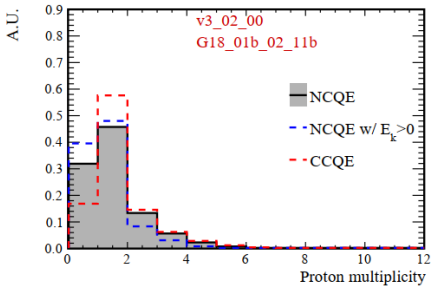
❖ Check5: nucleon multiplicity

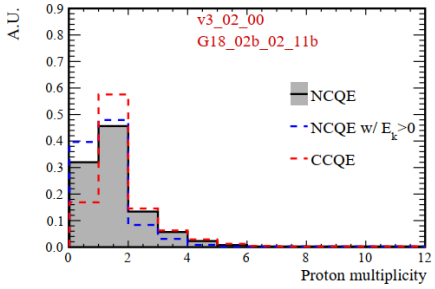


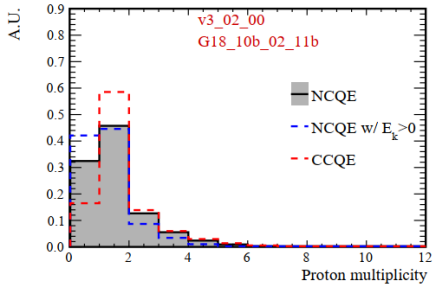


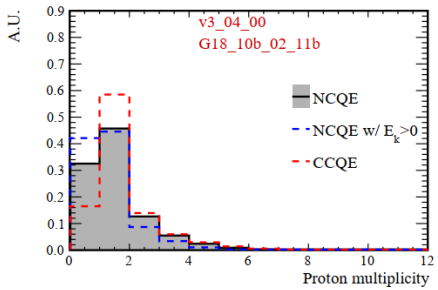


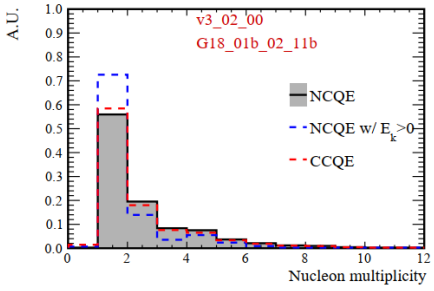


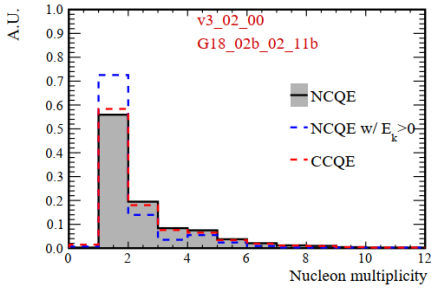


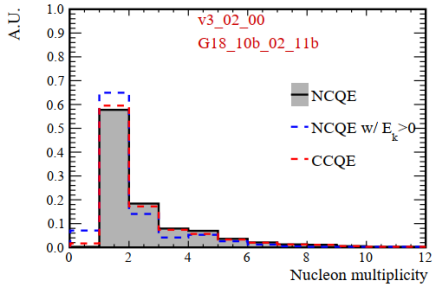


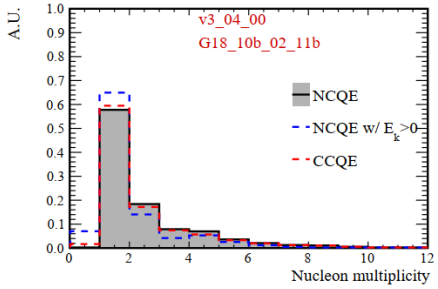












Summary

- Nucleon production with Ek=0: not be ignored
  - Only in NCQE process, about 20% (hA model) - 35% (hN model) NCQE events with nucleon production (Ek=0)
  - The fraction of nucleons (Ek=0) of the total nucleons in NCQE is about 25% and 10% for hA and hN, respectively
  - The kinetic energy distributions of nucleon (Ek>0) from NCQE is quite similar in hA and hN models (different in CCQE)
  - The events with nucleon production (Ek=0) :
    - energy is not conserved!
    - Strongly related to FSI
- For nucleon multiplicity, NCQE (including nucleon(Ek=0)) is more consistent with CCQE
- Any comments or suggestions for these nucleons?