



JUNO Report

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GENIE Forum 2023/11/15



GENIE v3.0.6 G18_02b_02_11a

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GENIE GHEP Event Record [print level:  3]
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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
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- **Check samples:**

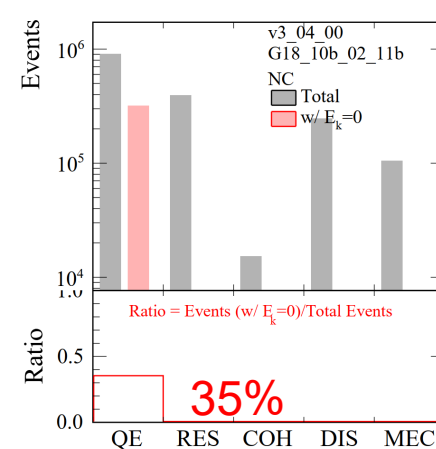
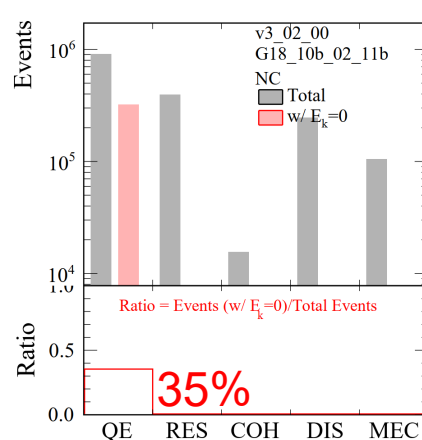
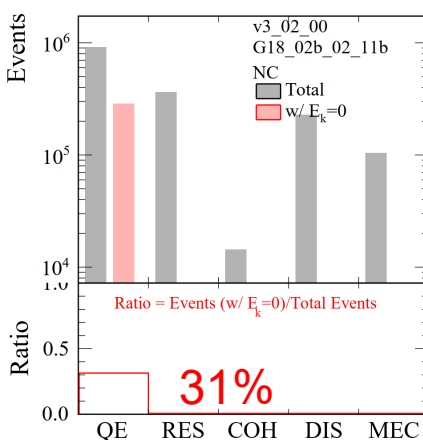
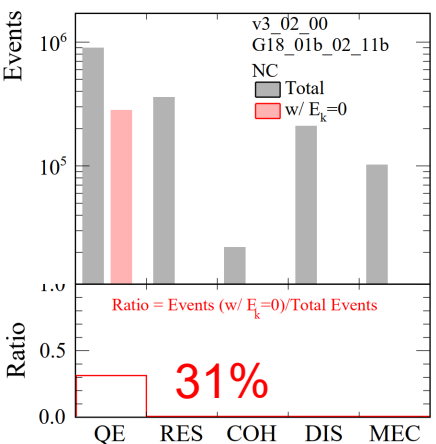
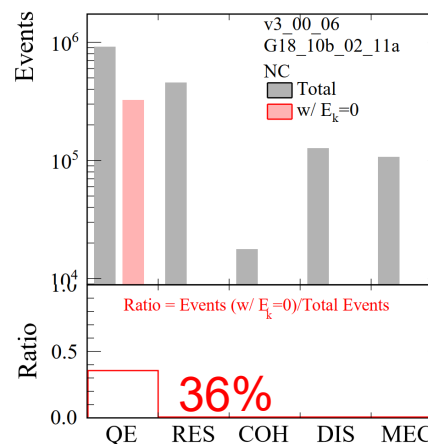
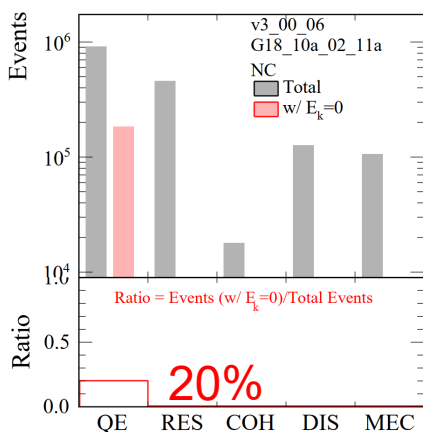
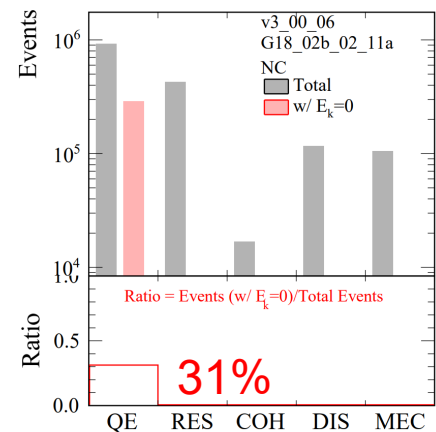
- Honda flux @ JUNO
 - Ev: 0.1-20 GeV
- Target: C-12, including NC and CC interactions
- Genie versions: v3.0.6, v3.2.0 and v3.4.0

Check-1: NC



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

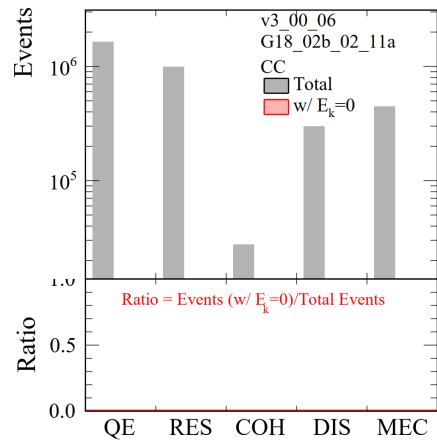
- ✓ Only exists in QE
- ✓ Fraction with hN FSI model > Fraction with hA FSI model



Check-1: CC



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

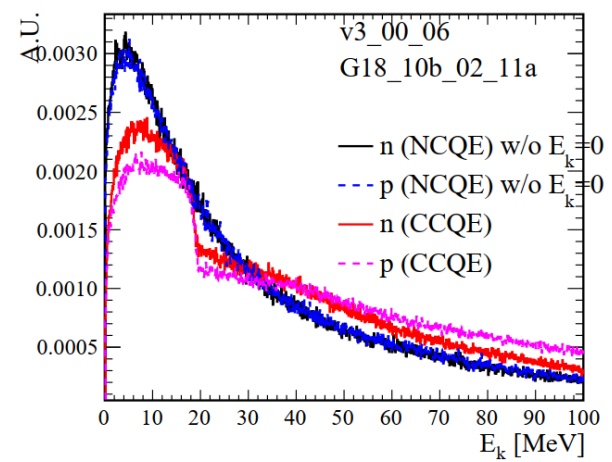
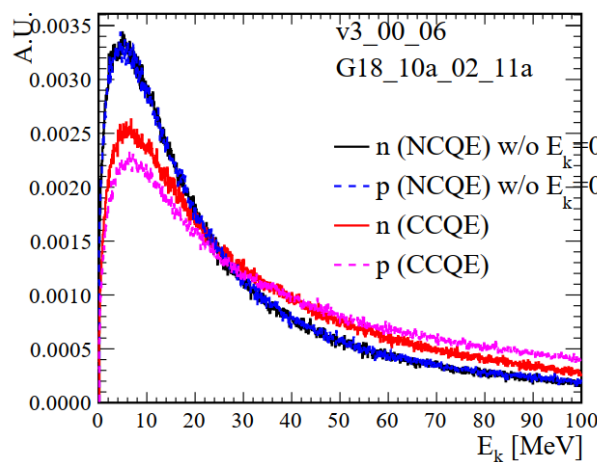
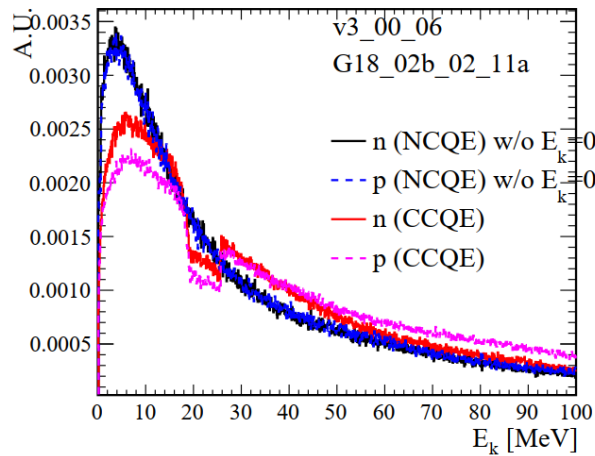
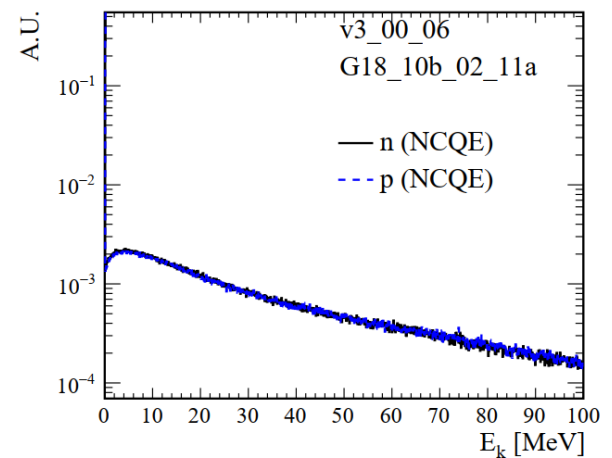
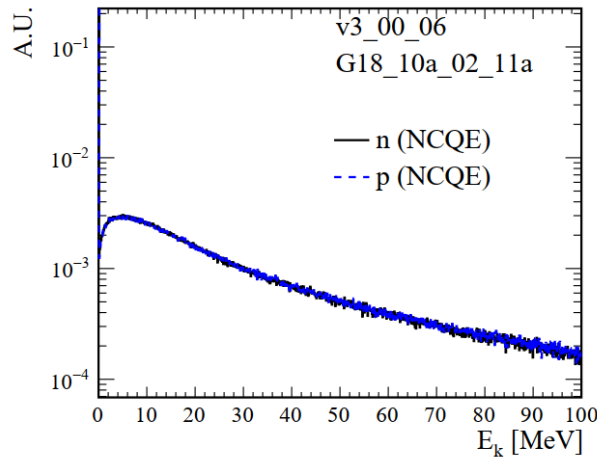
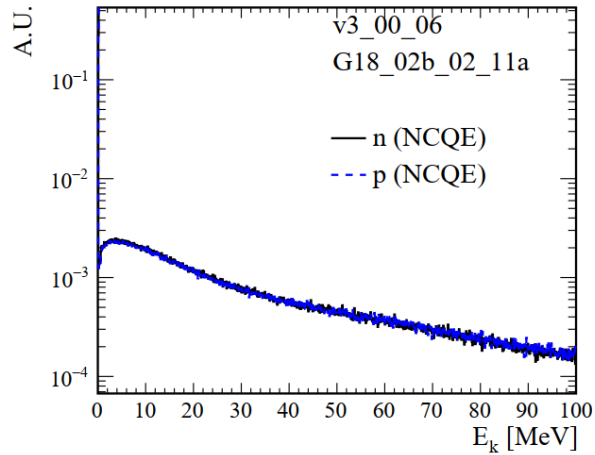


- Check the same models and Genie versions as NC events
 - ✓ No CC events with $E_k=0$ nucleon production

Check-2



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

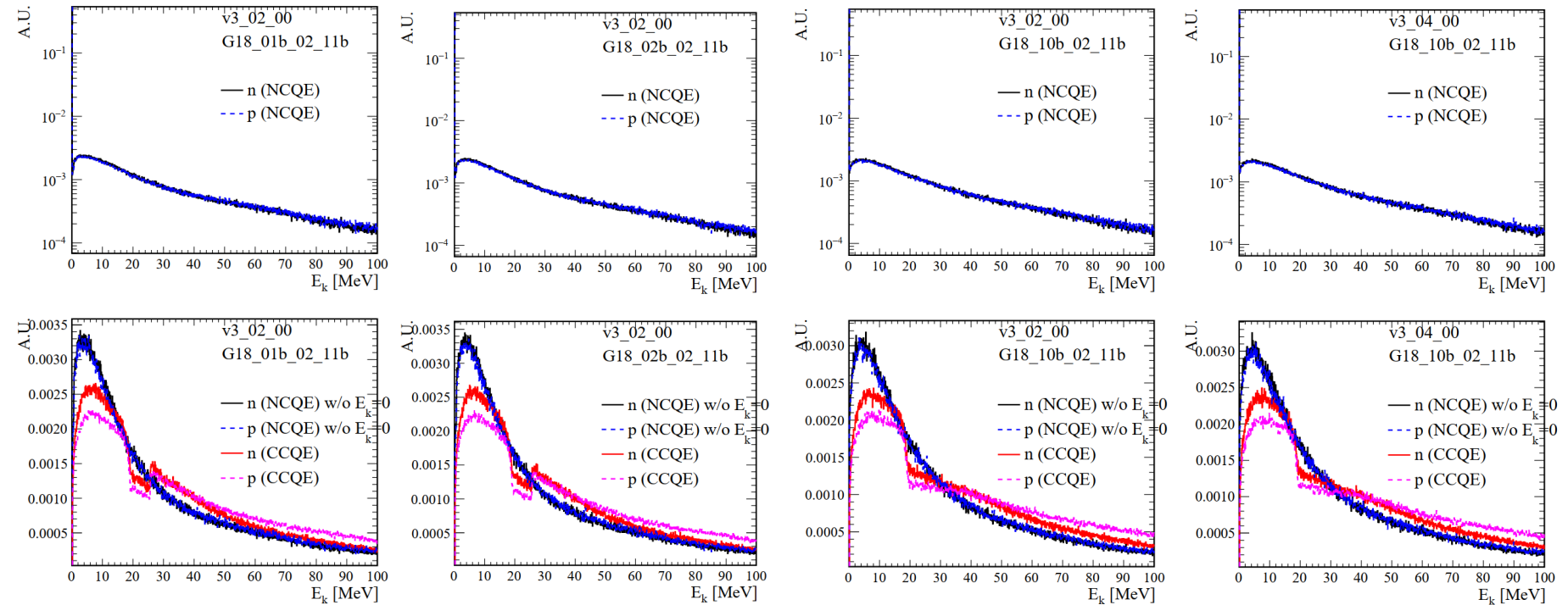


- In hN models, the fraction of nucleons w/ $E_k=0$ is about 25% in QE within [0, 100] MeV E_k range
- In hA model, the fraction is about 10%

Check-2



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

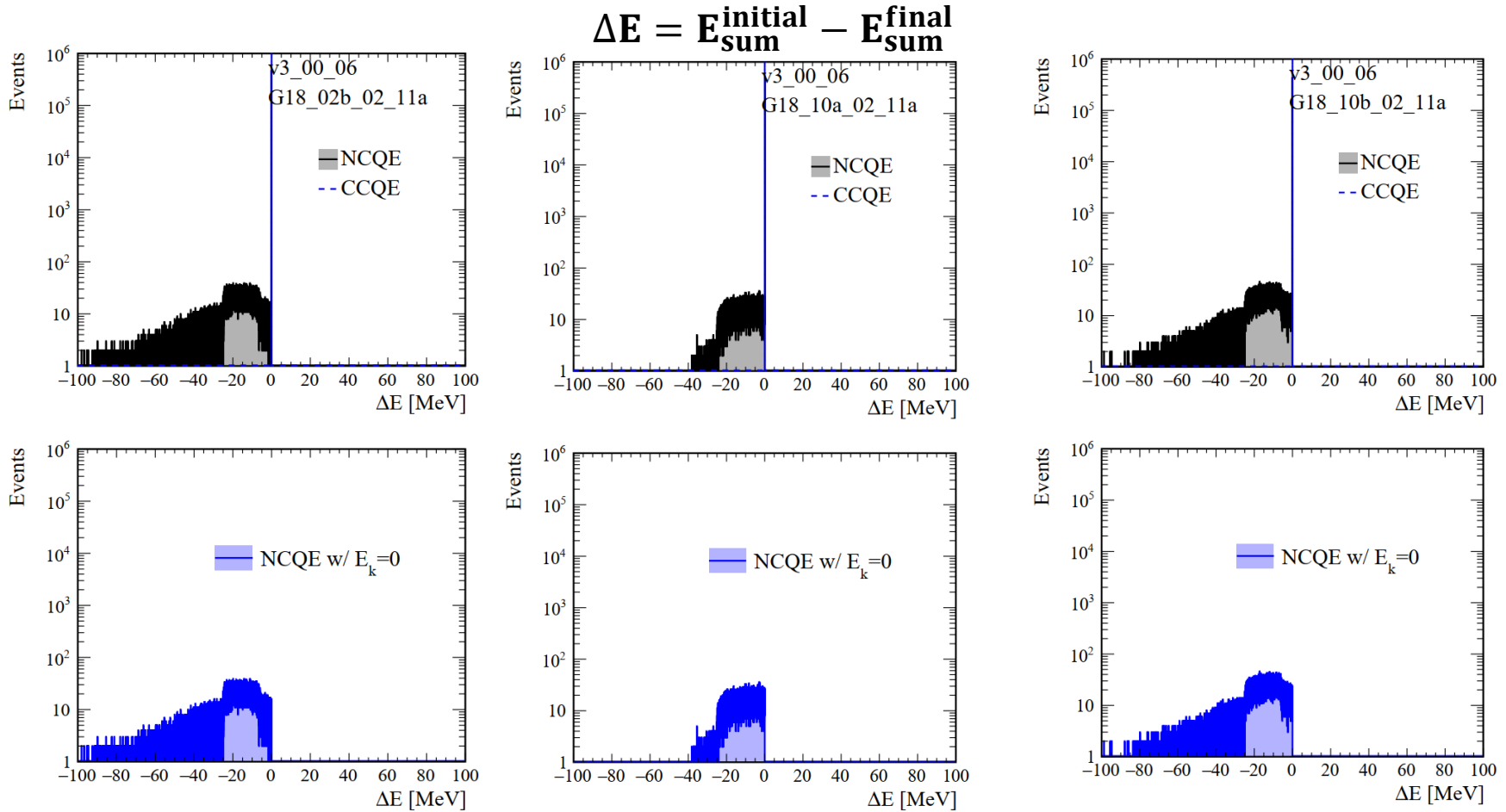


- Quite similar results in new versions of GENIE
- In hN models, the fraction of nucleons w/ $E_k=0$ is about 25% in QE within [0, 100] MeV E_k range
- In hA model, the fraction is about 10%

Check-3



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



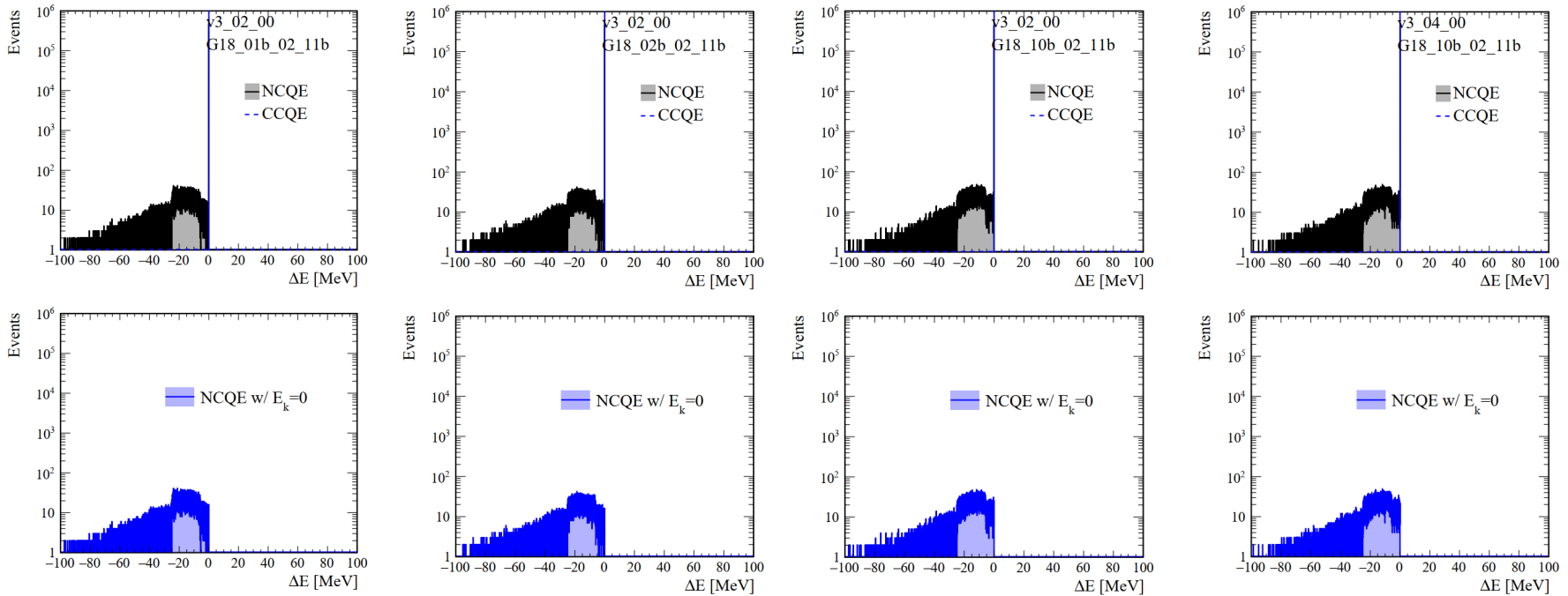
- Events with $E_k=0$ $\leftarrow \rightarrow$ energy is not conserved
- Other events: energy is conserved

Check-3



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

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

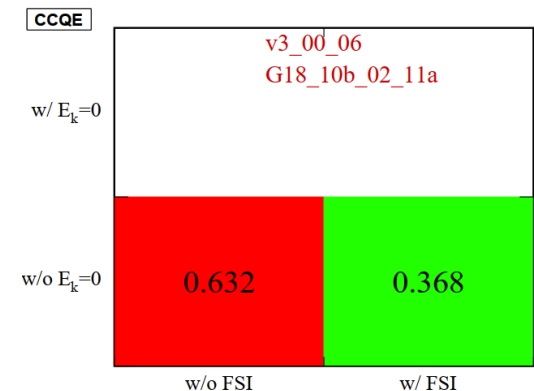
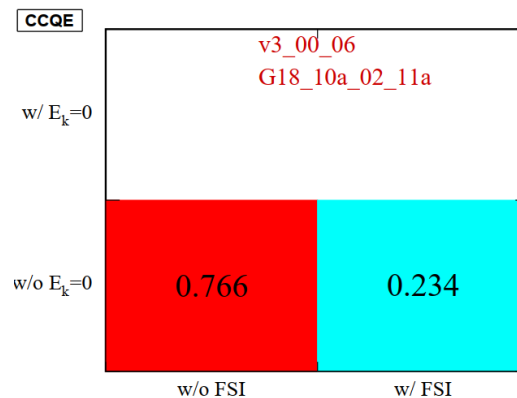
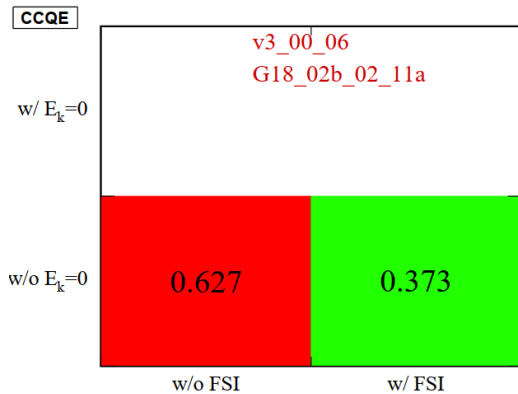
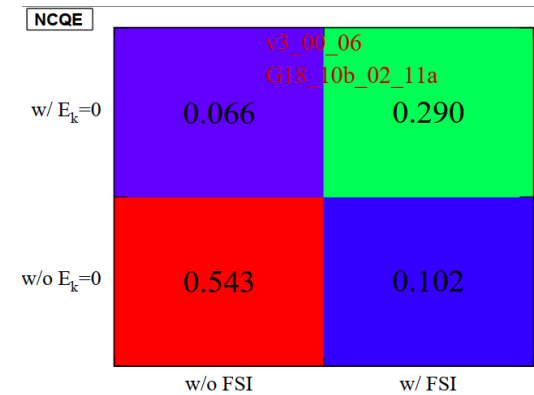
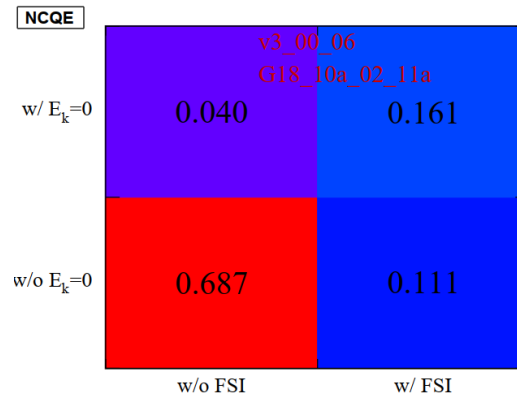
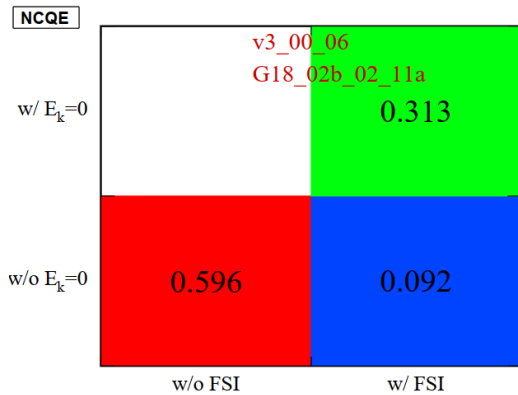


➤ Quite similar results in new versions of GENIE

Check-4



❖ **Check4: check if the nucleon with $E_k=0$ is strongly correlated with FSI**

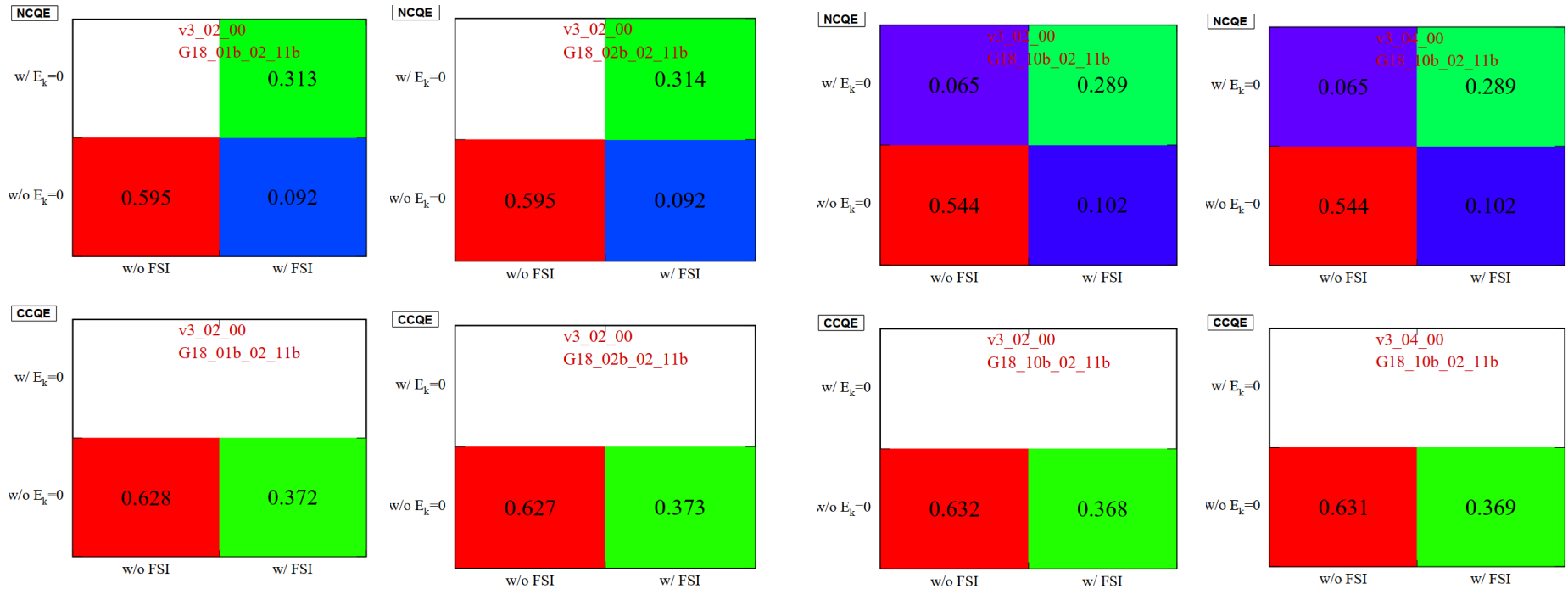


- **Very strong correlation between nucleon ($E_k=0$) with FSI**
- **Why there is no nucleon production with $E_k=0$ in CCQE events?**

Check-4



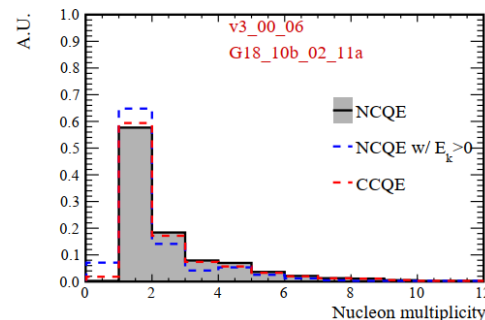
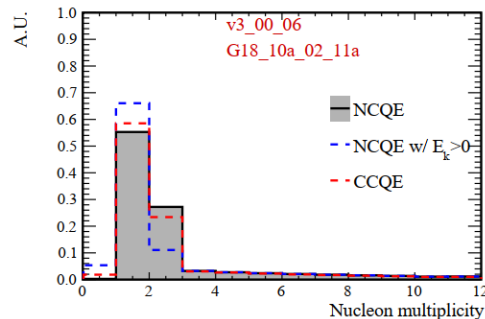
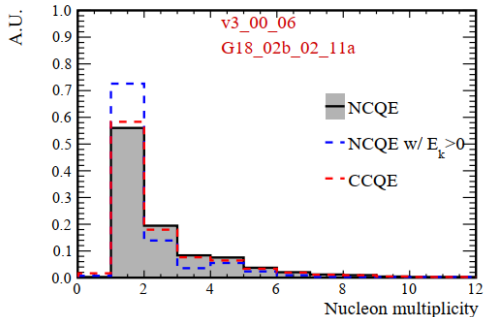
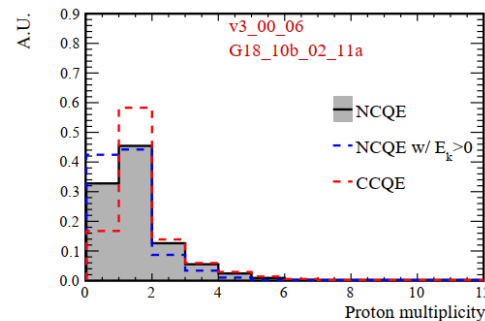
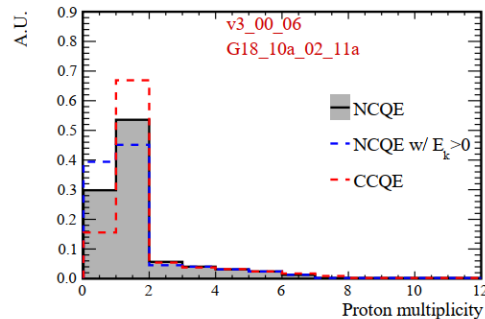
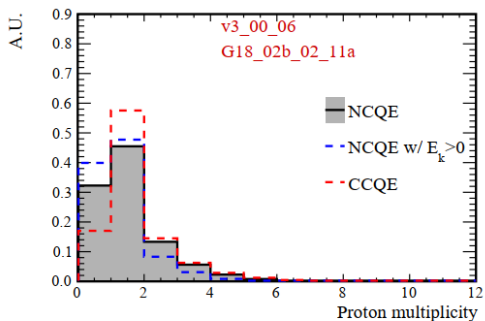
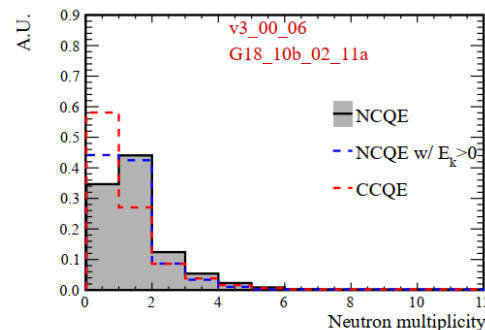
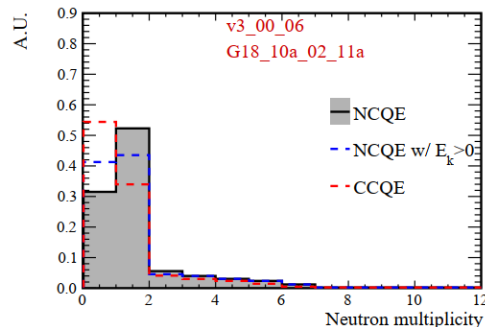
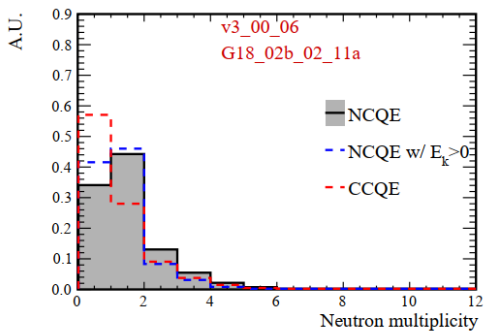
❖ Check4: check if the nucleon with $E_k=0$ is strongly correlated with FSI



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

❖ Check5: nucleon multiplicity

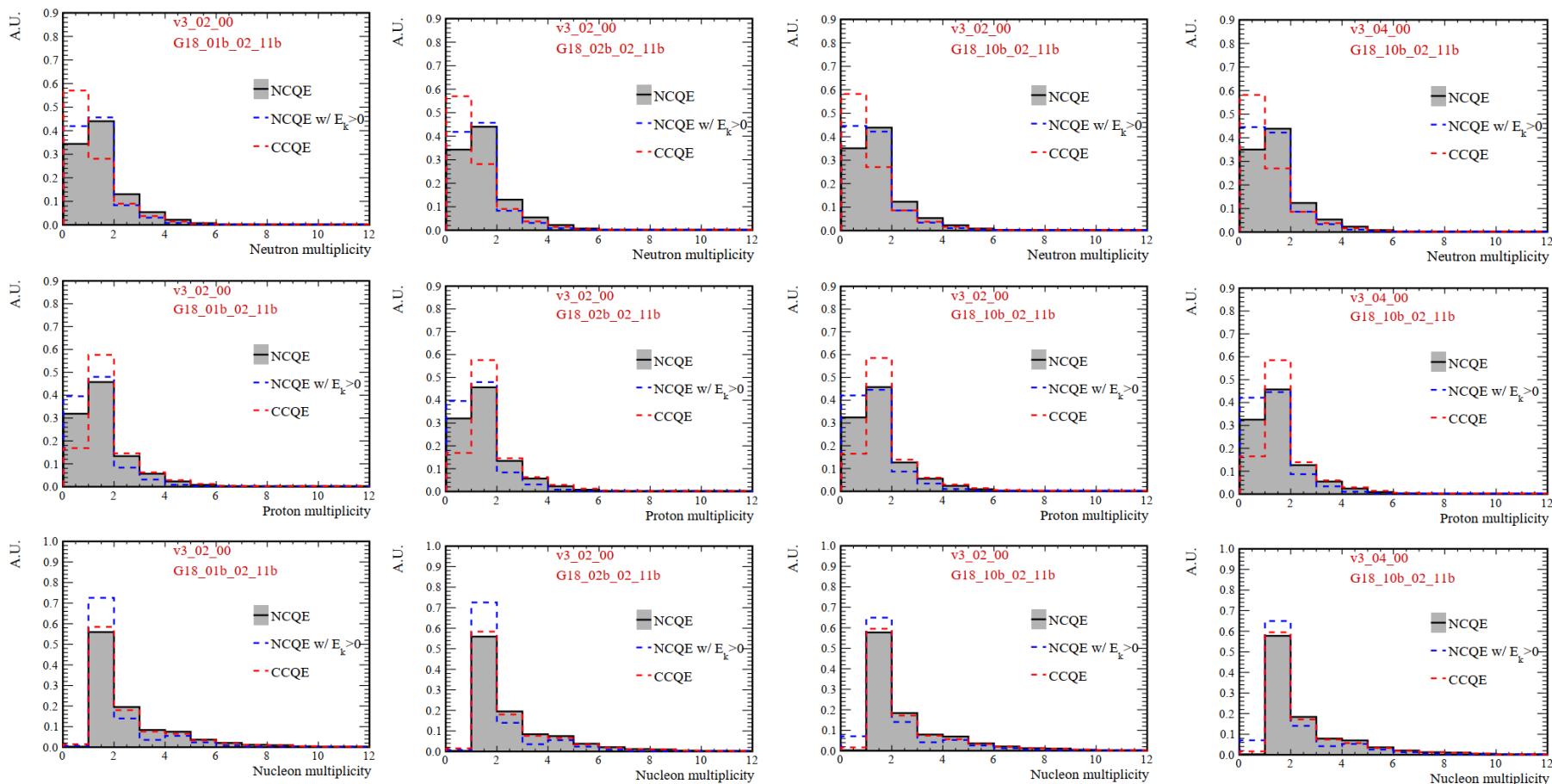
- ✓ hN FSI model: effect all multiplicity
- ✓ hA FSI model: effect multiplicity ≤ 2
- ✓ For nucleon multiplicity, NCQE (including nucleon($E_k=0$)) is more consistent with CCQE



Check-5



❖ Check5: nucleon multiplicity



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