New parameters for systematic analysis in GENIE

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Genie

Introduction

In this talk I will talk about two pull requests in the GENIE generator:

- QvalueShift:
  `https://github.com/GENIE-MC/Generator/tree/QvalueShift`
- Switch:
  `https://github.com/GENIE-MC/Generator/tree/Switch`

Pending the discussion of today, this will be merged and released with version 3.2

Qvalue Shift

- The Q_{value} is an effective modification of the removal energy used for the Nieves and Susav2 models.
- In GENIE, this is implemented as a shift in the q^0 value as: $q'_0 = q_0 - Q_{value}$
- The Q_{value} is calculated as $M(A_{Z+1}) - M(A_Z)$
- The implementation is similar for *NievesSimoVacasMECPXSec2016* and *SuSAv2MECPXSec*.

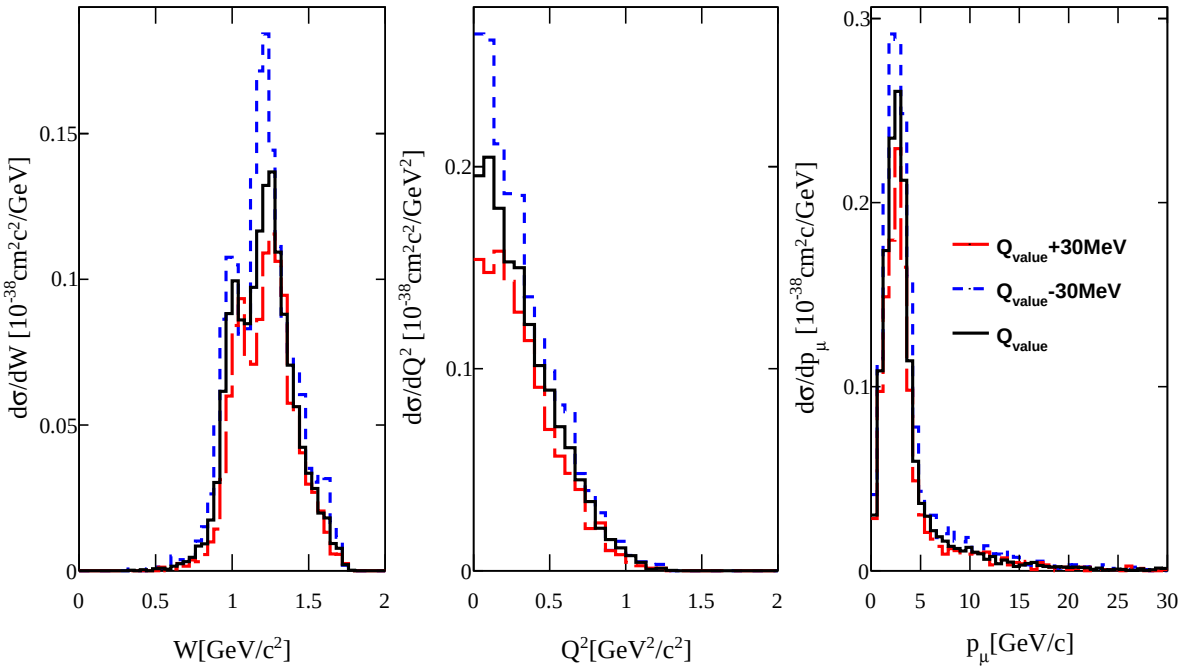
Qvalue Shift

- Two new parameters are added to shift the $Q_{value} \rightarrow Q_{value} + Q_{value}^{shift}$:
  - **"MEC-Qvalue1p1hShift"**: only for Susav2
  - **"MEC-Qvalue2p2hShift"**: Nieves and Susav2
- The shift can be > 0 and < 0. The Q_{value}^{shift} default is set to 0.
- You can modify the parameter in the corresponding xml files.
- Recomended shift: 0-20 MeV (1p1h) 0-40 MeV (2p2h)
- The final shift to q_0 is: $q_0' = q_0 - (Q_{value} + Q_{value}^{shift})$.

Possible changes in the implementation

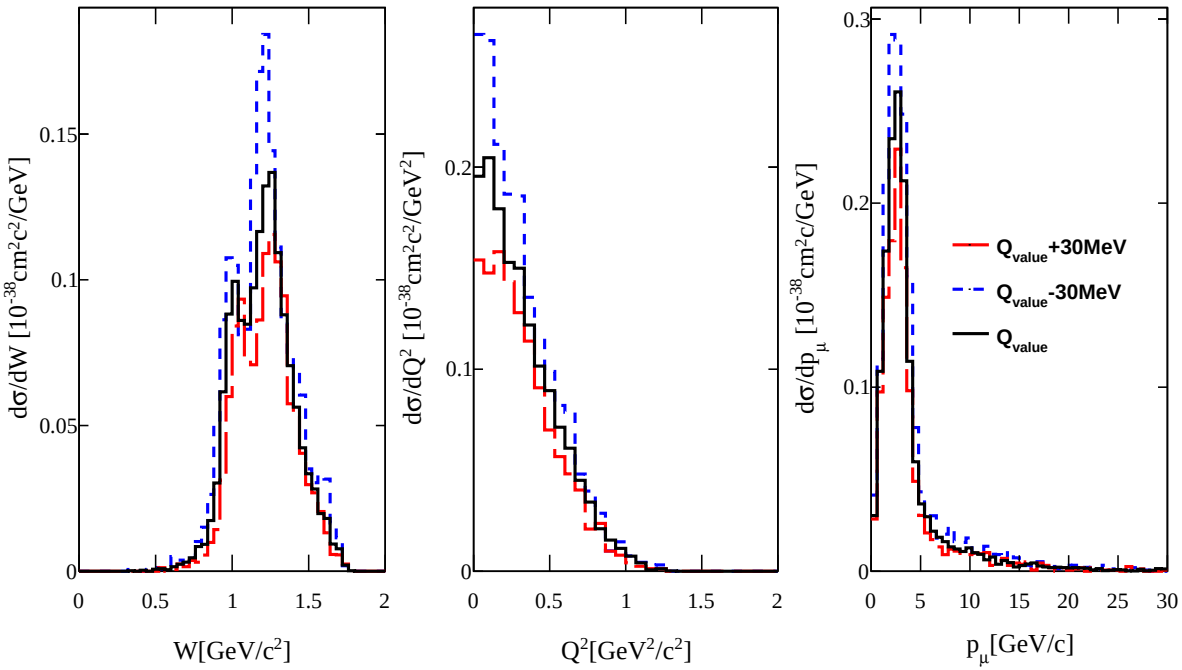
- Would we prefer a relative shift rather than an absolute one?
- There are plans to add a $Q_{value}^{shift}(A)$

Impact on kinematic distributions - NievesSimoVacas



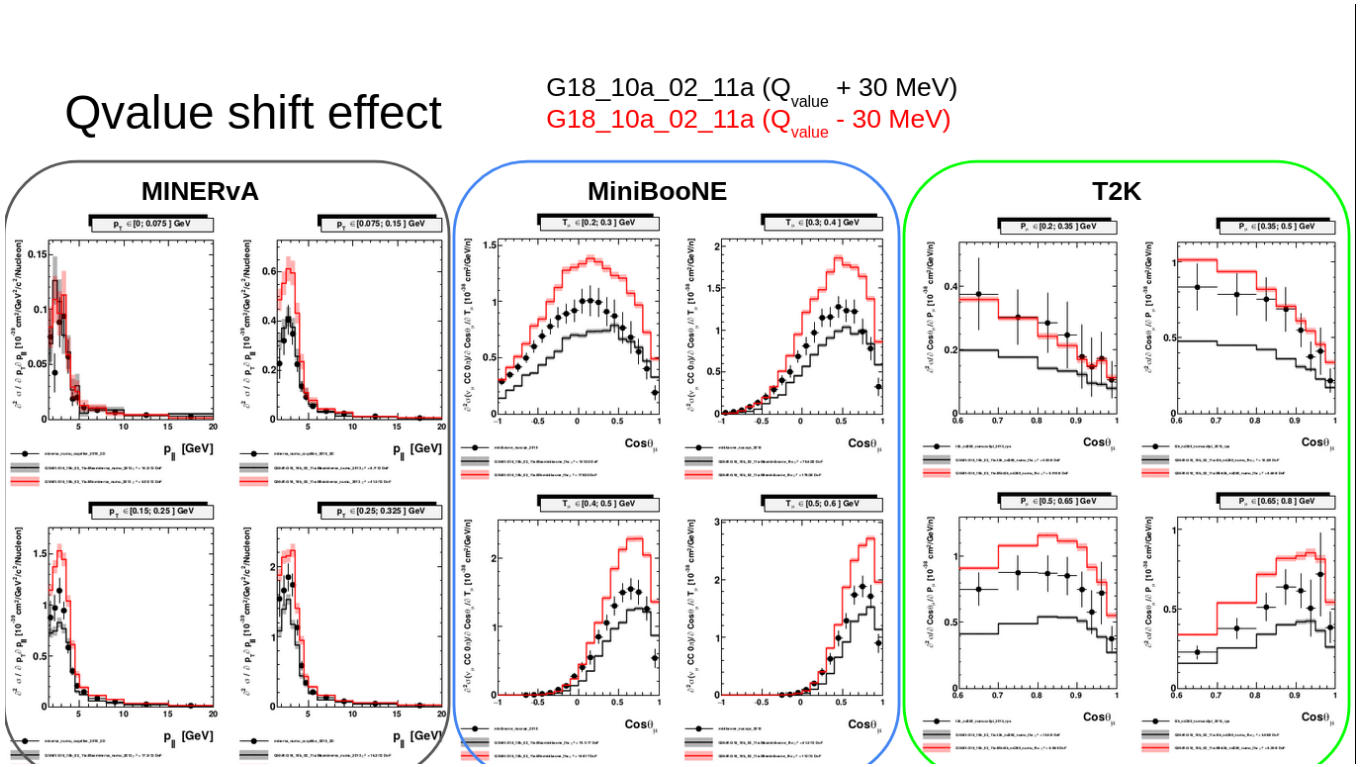
- GENIE, master version
- Tune: G18_10a_02_11a
- ν_μ CC MEC interaction on ^{12}C, $\langle E_\nu \rangle = 3.5$ GeV (MINERvA flux).
- Modifying "MEC-Qvalue2p2hShift" by 30 MeV for Nieves.

Impact on kinematic distributions - NievesSimoVacas



- The effect is to change the intensity and shift the peaks in W.

Impact on predictions



- The effect is bigger for T2K and MiniBooNE ($\langle E_\nu \rangle \sim 1$ GeV)

New XSecAlgorithmI: XSecLinearCombinations

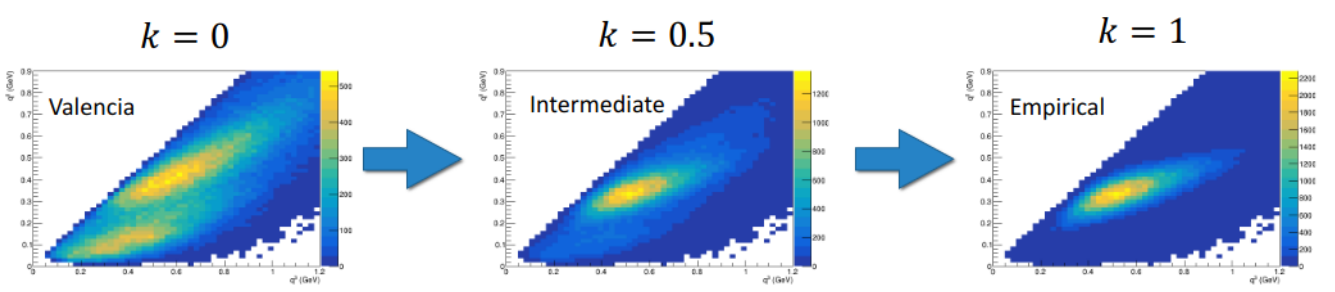
- I added a new XSecAlgorithmI, see link here.
- It computes the cross section as a linear combination of different XSecAlgorithmI
- The vector of algorithms and the weight associated to each is specified in XSecLinearCombinations.xml.
- An extra configurable parameter is added to give the option to normalize the weights to 1. The default is set to false.
- Examples are given in the xml file. New configurations can be added by the user.
- The only limitation is that the XSecAlgorithms should have a valid cross section for the phase space of interest.

XSecLinearCombinations.xml file

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<alg_conf>
<!--
Configuration for the XSec LinearCombination
Configurable Parameters:
.....................................................................................................
Name                  Type     Optional   Comment                                  Default
.....................................................................................................
CrossSection          vec-alg    No         List of xsec algorithms
LinearCoefficients    vec-double No         Linear coefficient values
Normalise             bool       No         Sum of coefficients = 1                  false
-->

  <param_set name="Default">
    <param type="bool"  name="Normalise"> false </param>
  </param_set>

  <param_set name="QuasiElastic1p1h">
    <param type="vec-alg"  name="CrossSection" delim=";"> genie::LwlynSmithQELCCPXSec/Dipole ; genie::NievesQELCCPXSec/Dipole </param>
    <param type="vec-double"  name="LinearCoefficients" delim=";"> 1. ; 1. </param>
  </param_set>

  <param_set name="RESXSec">
    <param type="vec-alg"  name="CrossSection" delim=";"> genie::ReinSehgalRESPXSec/NoPauliBlock ; genie::BergerSehgalRESPXSec2014/NoPauliBlock </param>
    <param type="vec-double"  name="LinearCoefficients" delim=";"> 1. ; 1. </param>
  </param_set>

  <param_set name="MECXSec">
    <param type="vec-alg"  name="CrossSection" delim=";"> genie::EmpiricalMECPXSec2015/Default ; genie::NievesSimoVacasMECPXSec2016/Default ; genie::SuSAv2MECPXsec/Default </param>
    <param type="vec-double"  name="LinearCoefficients" delim=";"> 1. ; 1. ; 1. </param>
  </param_set>

  <param_set name="NievesQELCCPXSecNoRPA">
    <param type="vec-alg"  name="CrossSection" delim=";"> genie::NievesQELCCPXSec/Dipole ; genie::NievesQELCCPXSec/DipoleNoRPA </param>
    <param type="vec-double"  name="LinearCoefficients" delim=";"> 1. ; 1. </param>
  </param_set>
```

Possible usage of XSecLinearCombinations

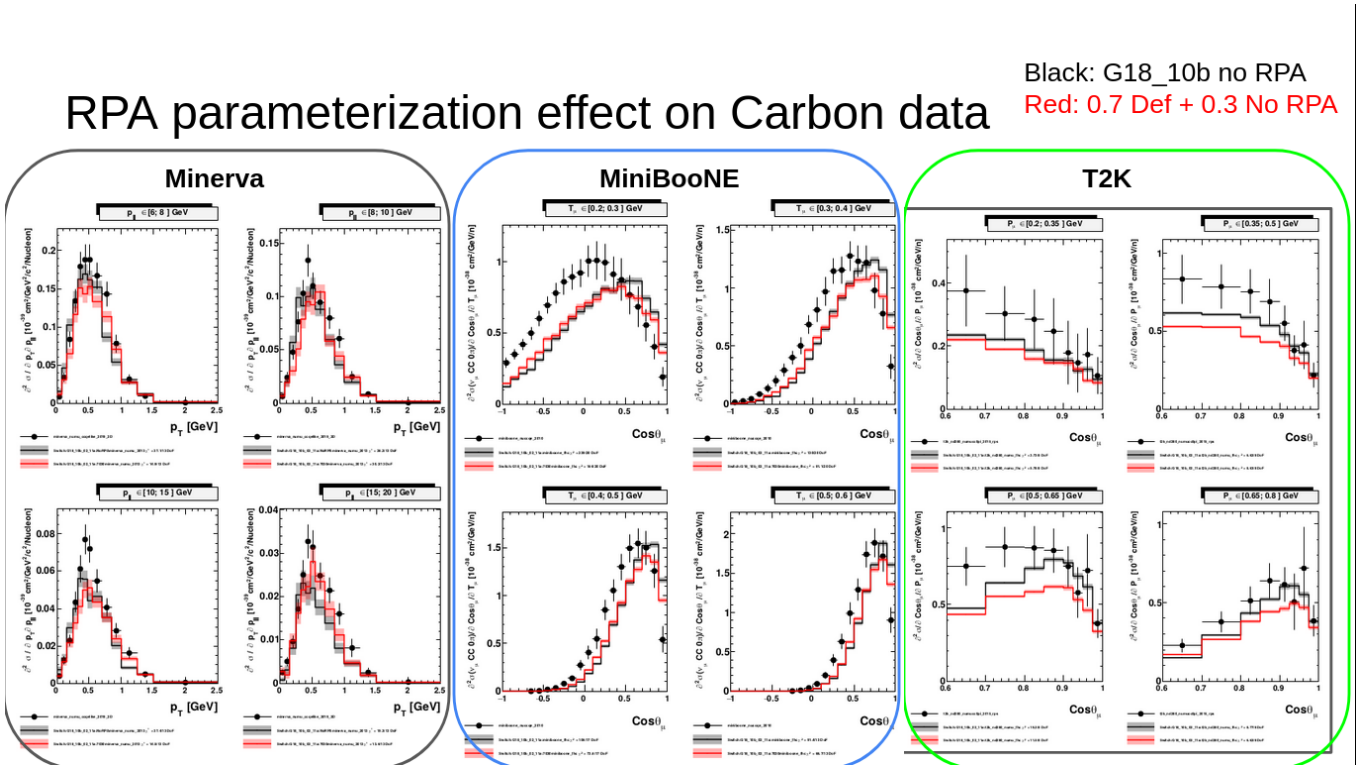
- The MicroBooNE collaboration recently gave a talk on a carbon tune: see Talk here.
- They reweight between Empirical and Nieves MEC using a parameter k:



- With the new class, this can be directly implemented in the generator using the *MECXSec* configuration and setting the adequate weights.

Possible usage of XSecLinearCombinations

- Another possibility would be to parameterise the 1p1h Nieves prediction with and without RPA
- See *NievesQELCCPXSecNoRPA* configuration.



Conclusions

- Two pull requests on the GENIE generator are on the way.
- One of them offers the possibility to shift the Q_{value} in the Nieves and Susav2 model implementation in GENIE.
- The other one allows the user to linearly mix XSecAlgorithmI.
- Both will be available in the master version and released with GENIE v3.2

Thank you for your attention!

Backup slides

Qvalue Shift

- Inclusive reaction: $\nu_\mu + A_Z \rightarrow l^- + X$
- The Qvalue is introduced to ensure the correct energy balance in the hadron tensor.
- Without the Qvalue, the energy balance condition is writen as $\delta(q^0 + E(\mathbf{p}) - E(\mathbf{p}+\mathbf{q}))$, where $E(\mathbf{p})$ and $E(\mathbf{p}+\mathbf{q})$ refer to the LFG of the initial and final nucleons
- In the Fermi sea, there is no energy gap to transition from occupied to unoccupied states

  $\rightarrow$ ph excitations can be produced with a small energy $Q^{LFG}(r) = E_F^p(r) - E_F^n(r)$
- However, in a nuclei, the minimum excitation energy is: $Q = M(A_{Z+1}) - M(A_Z)$
- This is taken into account with $q^0 \rightarrow q^0 - (Q - Q^{LFG}(r))$
- See details in Nieves paper.