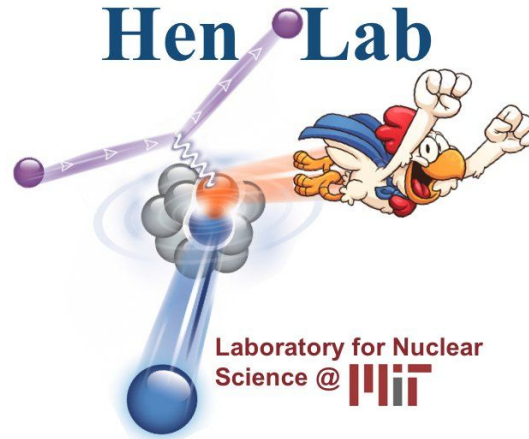


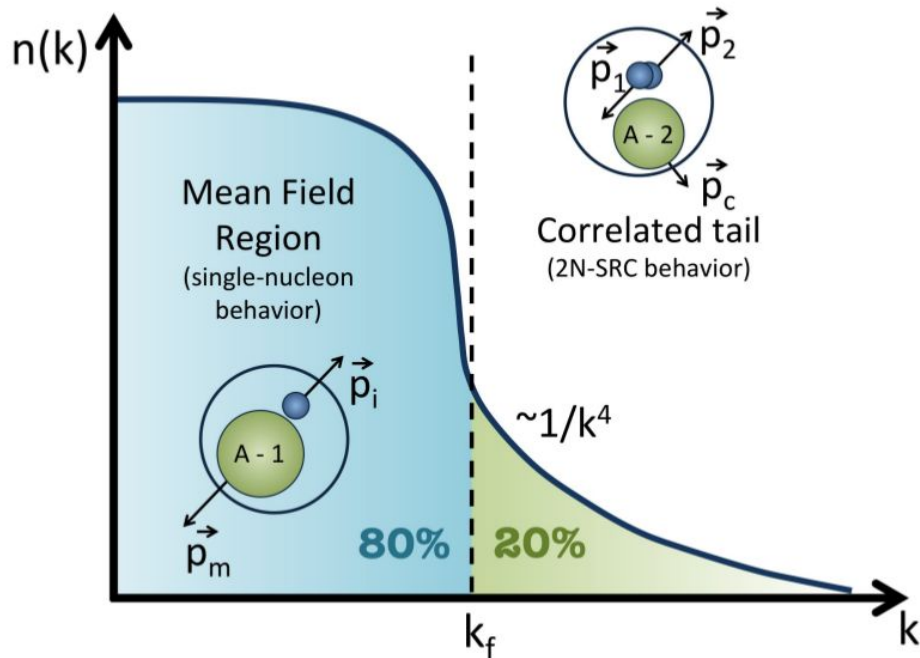
# Correlated Fermi Gas GENIE Implementation

Sept 16, 2020



# Physics Motivation

$\sim 20\%$  of nucleons form short range correlated (SRC) pairs



Electron scattering experiments revealed the existence of a high momentum tail beyond Fermi momentum  $k_F$  accounting for  $\sim 20\%$  of the nucleons in the form of correlated pairs

However...

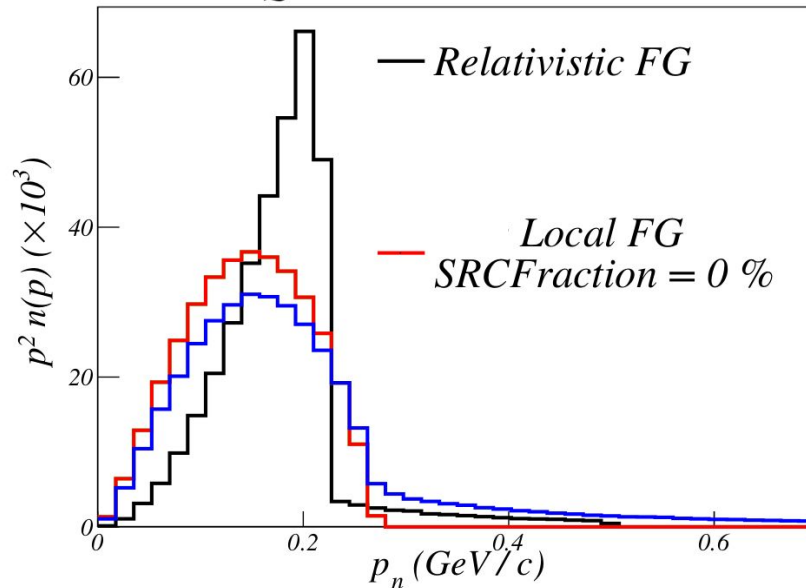
Correlated Fermi Gas (CFG) Model  
not available in GENIE until recently

Missing physics knowledge that has to be incorporated  
before future neutrino experiments start  
making high precision measurements (accuracy < 3%)

However...

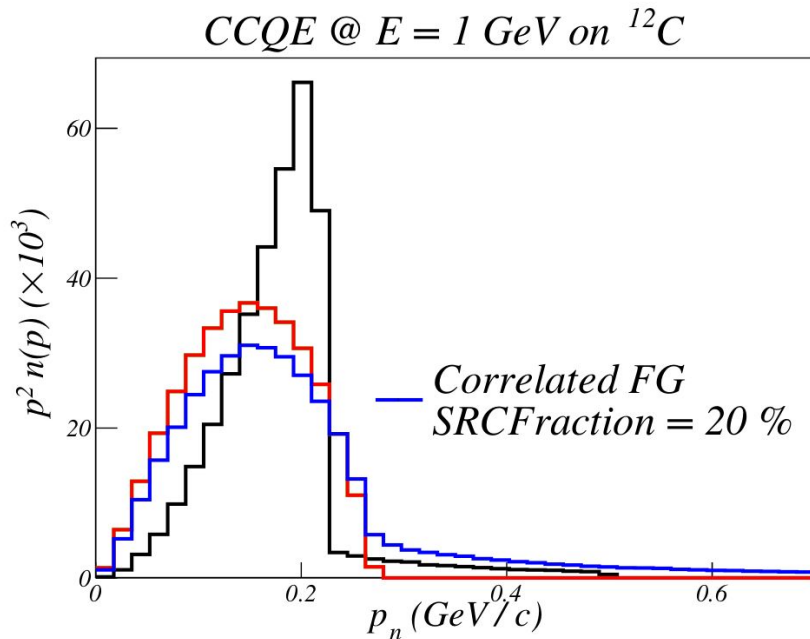
Correlated Fermi Gas (CFG) Model  
not available in GENIE until recently  
(instead Relativistic, Local et al)

*CCQE @  $E = 1 \text{ GeV}$  on  $^{12}\text{C}$*



# Objective

## Overview of CFG implementation in GENIE How-to-do's



# Correlated Fermi Gas Model

For the implementation of the CFGM, the introduction of two parameters is necessary:

- $SRC_{Fraction} = 0.2$ , percentage of nucleons with a momentum greater than  $k_F$ .
- $k_{CutOff} = 0.7$  GeV, the point where the momentum distribution becomes zero.

A description of the CFGM is included below.

- Uses a local Fermi gas when  $k < k_F$ .
- Uses a high-momentum tail when  $k_F \leq p \leq k_{CutOff}$ .
- Becomes zero when  $p > k_{CutOff}$ .

The exact functions that will be included into GENIE can be seen in expression 1.

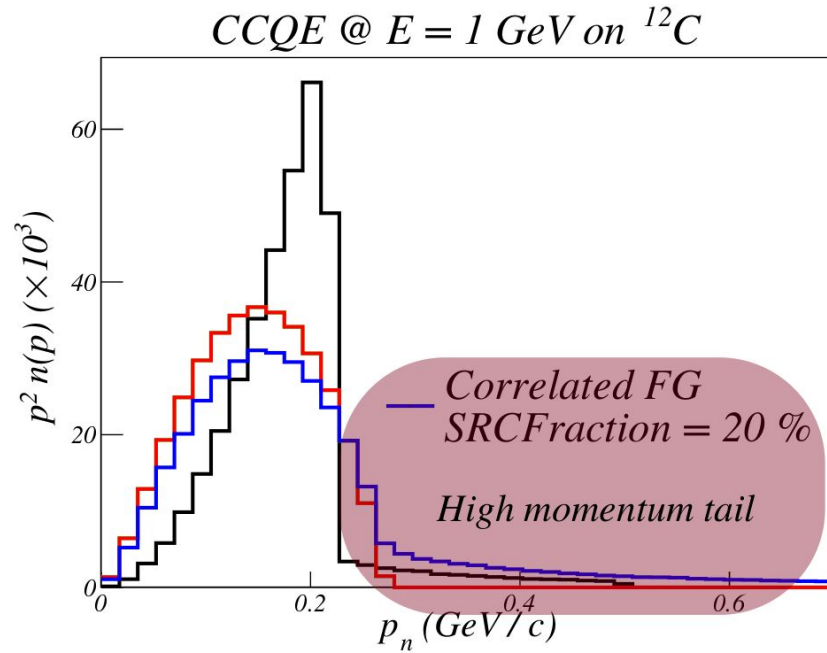
$$n(p, r) = \begin{cases} \frac{1}{4 \cdot \pi} \cdot \frac{3}{k_F^3} \cdot (1 - SRC_{Fraction}) & \text{if } p \leq k_F(r) \\ \frac{1}{4 \cdot \pi} \cdot \frac{SRC_{Fraction}}{1/k_F - 1/k_{CutOff}} \frac{1}{p^4} & \text{if } k_F(r) \leq p \leq k_{CutOff} \\ 0 & \text{if } p > k_{CutOff} \end{cases} \quad (1)$$

# SRC Fraction

Controls fraction of high momentum tail ( $\sim 20\%$ )

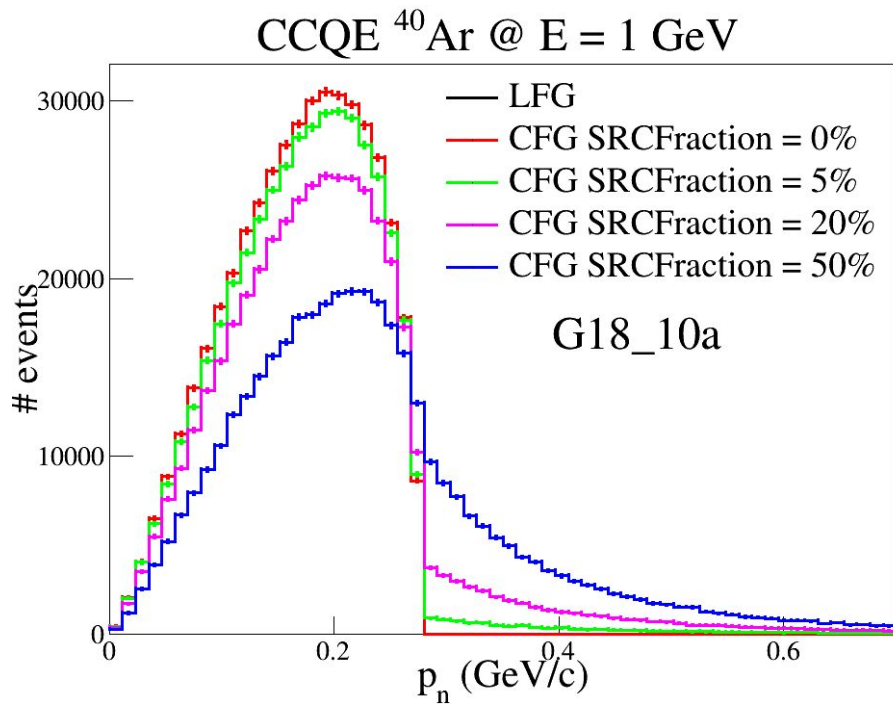
Future experiments might make more accurate measurements

Thus must provide the flexibility to easily modify it



# SRC Fraction

Illustration of the effect when changing the fraction



Sanity check

LFG = CFG with  
SRCFraction 0%



# How to ...

## Activate the Correlated Fermi Gas ?

### config/GXY\_AB/ModelConfiguration.xml

```
<!--  
-----  
Nuclear model selection.  
Options:  
- genie::FGMBodekRitchie/Default  
- genie::LocalFGM/Default  
- genie::LocalFGM/Correlated  
- genie::SpectralFunc1d/Default  
- genie::EffectiveSF/Default <- See http://arxiv.org/abs/1405.0583  
The 'NuclearModel' option defines the default basic model which should work for any nuclei  
(typically a Fermi Gas model with the Bodek-Ritchie NN corellatin tail). Refinements for specific  
nuclei are possible, by specifying the 'NuclearModel@Pdg=10LZZZAAAI' option.  
Currently the same nuclear model is forced for all isotopes.  
-->
```

```
<!-- <param type="alg" name="NuclearModel">                genie::EffectiveSF/Default </param> -->  
<!-- <param type="alg" name="NuclearModel">                genie::FGMBodekRitchie/Default </param> -->  
<param type="alg" name="NuclearModel">                    genie::LocalFGM/Default </param>  
<!-- <param type="alg" name="NuclearModel">                genie::LocalFGM/Correlated </param>-->
```

Comment in the  
last line

# How to ...

## Modify the SRCFraction / Momentum CutOff

### config/LocalFGM.xml

```
<param_set name="Default">
  <param type="string" name="CommonParam"> FermiGas </param>
  <!-- CutOff known from electron scattering experiments
  Short range correlations and the isospin dependence of nuclear correlation functions (arXiv:1710.07966)-->
  <param type="double" name = "LFG-MomentumCutOff"> 0.7 </param>
</param_set>

<param_set name="Correlated">
  <!--Correlated Fermi Gas Model
  - Percentage of high momentum / SRC tail
  In the Correlated Fermi Gas Model, 20% of our nucleons live under the high momentum tail
  (K. S. Egiyan et al., Phys. Rev. C 68 (2003) 014313 and Phys. Rev. Lett. 96 (2006) 082501.)
  - Short range correlations and the isospin dependence of nuclear correlation functions (arXiv:1710.07966)
  -->
  <param type="double" name = "SRC-Fraction"> 0.2 </param>
</param_set>
```

Modify in order to  
change momentum cut  
off

Modify in order to  
change fraction of high  
momentum tail

## Next Steps

Addition of emitted recoil particles  
and choice of kinematics



NOT MEC INTERACTION!

Available Options

- Back-to-back with respect to leading nucleon
- Gaussian center-of-mass motion (not in master yet)

## Next Steps

Part of the functionality already  
available in the GENIE master branch



However not enabled by default!

On top of that,  
ongoing discussion on how  
to handle energy conservation

But working on that, so stay tuned !

Thank you !

