Dilution Analysis

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- Dilution factor (df) defined as $df = 1 - \frac{Y_{bg}}{Y_p}$
  - ➔ $Y_{bg} = Y_{foil} + Y_{helium} + Y_{nitrogen}$
- 'Dilution runs' performed at each kinematic setting so we can reconstruct Y_{bg}
  - ➔ "Empty" run: $Y_{empty} = Y'_{helium}$
  - ➔ "Dummy" run: $Y_{dummy} = Y_{empty} + Y_{foil}$
  - ➔ "Carbon" run: $Y_{carbon} = Y'_{carbon} + Y''_{helium}$
- To relate dilution runs to the production background we need
  - ➔ Dilution run yields
  - ➔ Material lengths (including packing fraction – all data in this talk assumes f ~ 0.55)
  - ➔ Scaling factor to scale carbon yield to nitrogen yield

Adding in material lengths

$$Y_{bg} = N_o \frac{\rho_f l_f}{m_f}\sigma_f + N_o \frac{\rho_{He}(1-f) l_{tg}}{m_{He}}\sigma_{He} + N_o \frac{\rho_N f\, l_{tg}}{m_N}\sigma_N + N_o \frac{\rho_{He} l_{out}}{m_{He}}\sigma_{He}$$

$$Y_{empty} = N_o \frac{\rho_{He} l_{total}}{m_{He}}\sigma_{He} \longrightarrow l_{total} = l_{tg} + l_{out}$$

$$Y_{dummy} = N_o \frac{\rho_{He} l_{total}}{m_{He}}\sigma_{He} + N_o \frac{\rho_f l_f}{m_f}\sigma_f$$

$$= Y_{empty} + N_o \frac{\rho_f l_f}{m_f}\sigma_f$$

$$Y_{carbon} = N_o \frac{\rho_c l_c}{m_c}\sigma_c + N_o \frac{\rho_{He}(l_{tg} - l_c)}{m_{He}}\sigma_{He} + N_o \frac{\rho_{He} l_{out}}{m_{He}}\sigma_{He}$$

Now we can express each background material yield in terms of dilution runs...

Adding in material lengths

$$N_o \frac{\rho_{He}(1-f)\, l_{tg}}{m_{He}} \sigma_{He} = Y_{He} = Y_{empty}\left(1 - f\frac{l_{tg}}{l_{total}}\right)$$

$$N_o \frac{\rho_f\, l_f}{m_f} \sigma_f = Y_f = Y_{dummy} - Y_{empty}$$

$$N_o \frac{\rho_N\, f\, l_N}{m_N} \sigma_N = Y_N = f\, a(k)\left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_C - f\, a(k)\left(1 - \frac{l_C}{l_{total}}\right)\left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_{empty}$$

Finding the carbon scaling factor

$$N_o \frac{\rho_{He}(1-f)\, l_{tg}}{m_{He}} \sigma_{He} = Y_{He} = Y_{empty}\left(1 - f\frac{l_{tg}}{l_{total}}\right)$$

$$N_o \frac{\rho_f\, l_f}{m_f} \sigma_f = Y_f = Y_{dummy} - Y_{empty}$$

Kinematic independent!

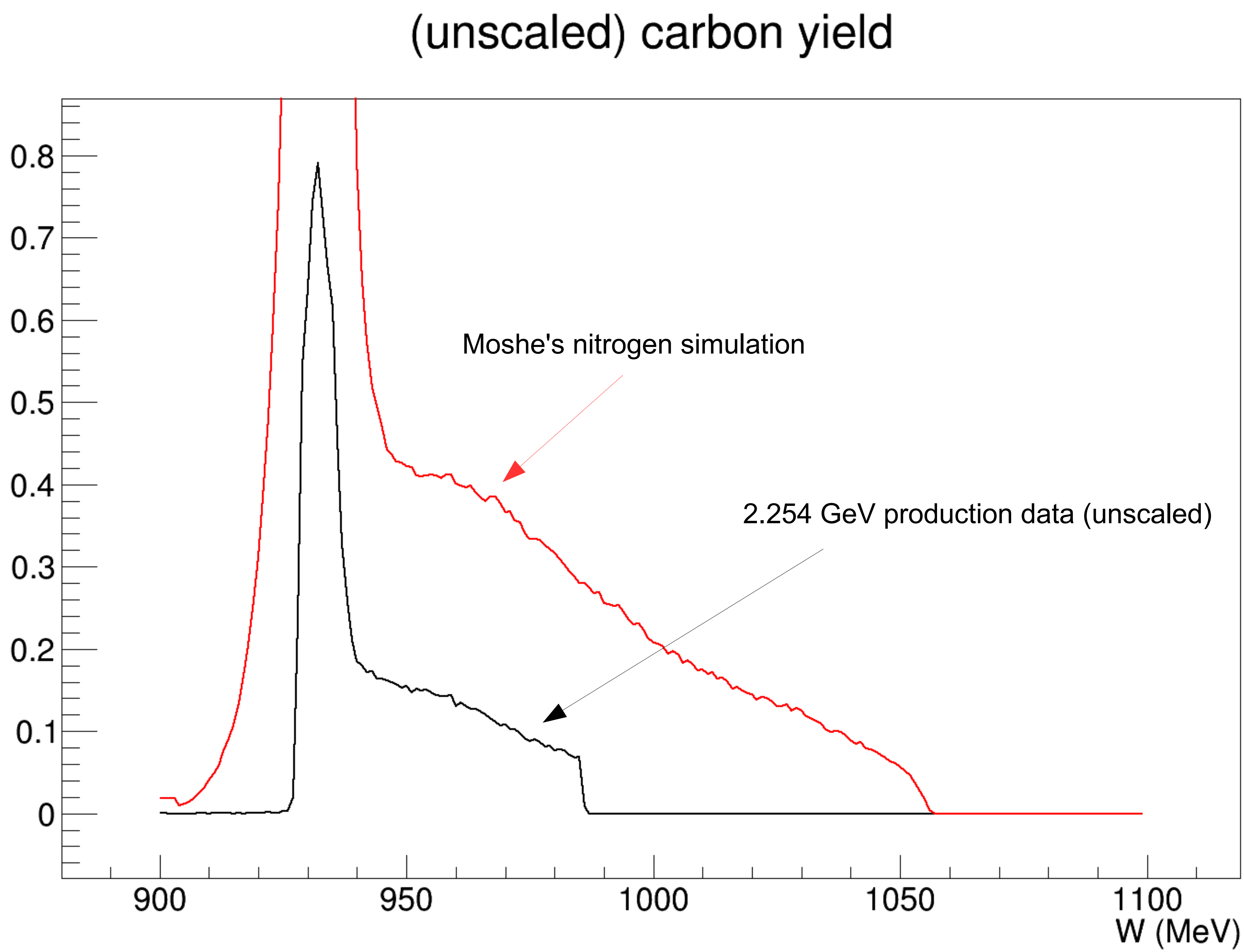
$$N_o \frac{\rho_N\, f\, l_N}{m_N} \sigma_N = Y_N = f\, a(k) \left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_C - f\, a(k)\left(1 - \frac{l_C}{l_{total}}\right)\left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_{empty}$$

Energy dependent scaling factor

Finding the carbon scaling factor

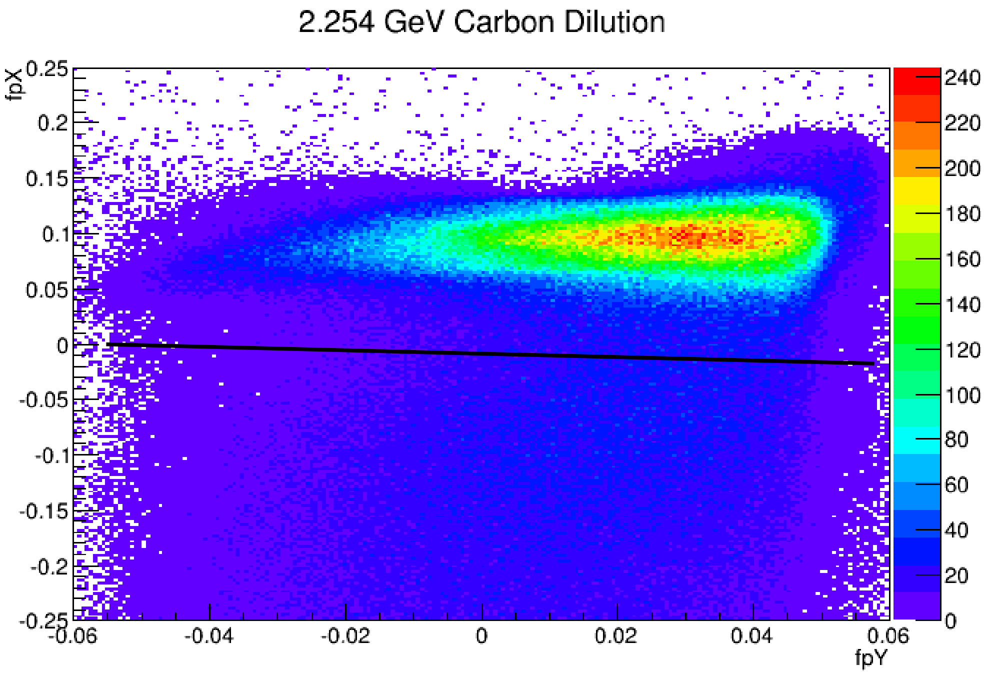
- Initial assumption:
  - ➔ $\sigma_C = 12$
  - ➔ $\sigma_N = 14$
  - ➔ $a = \frac{\sigma_N}{\sigma_C} = \frac{14}{12} = 1.17$

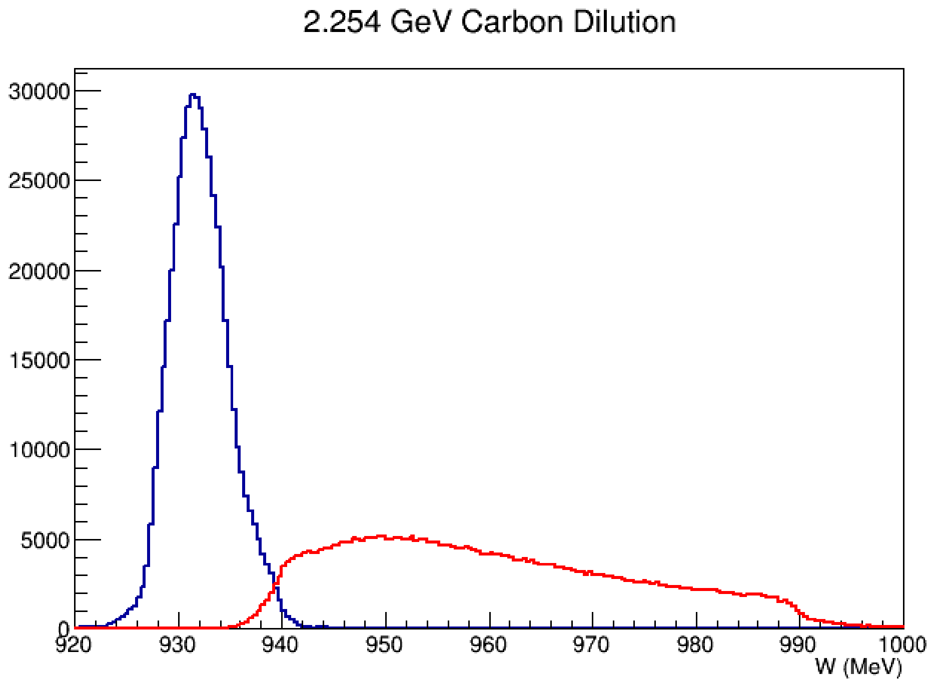
- Nitrogen simulation needed for more accurate scaling factor
  - ➔ $$Y_{N(simulation)} = a(k)\left(f\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right)Y_C - f\left(1-\frac{l_C}{l_{total}}\right)\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right)Y_{empty}\right)$$
    $$= a(k)Y'_C$$
  - ➔ $$a(k) = \frac{Y_{N(simulation)}}{Y'_C}$$



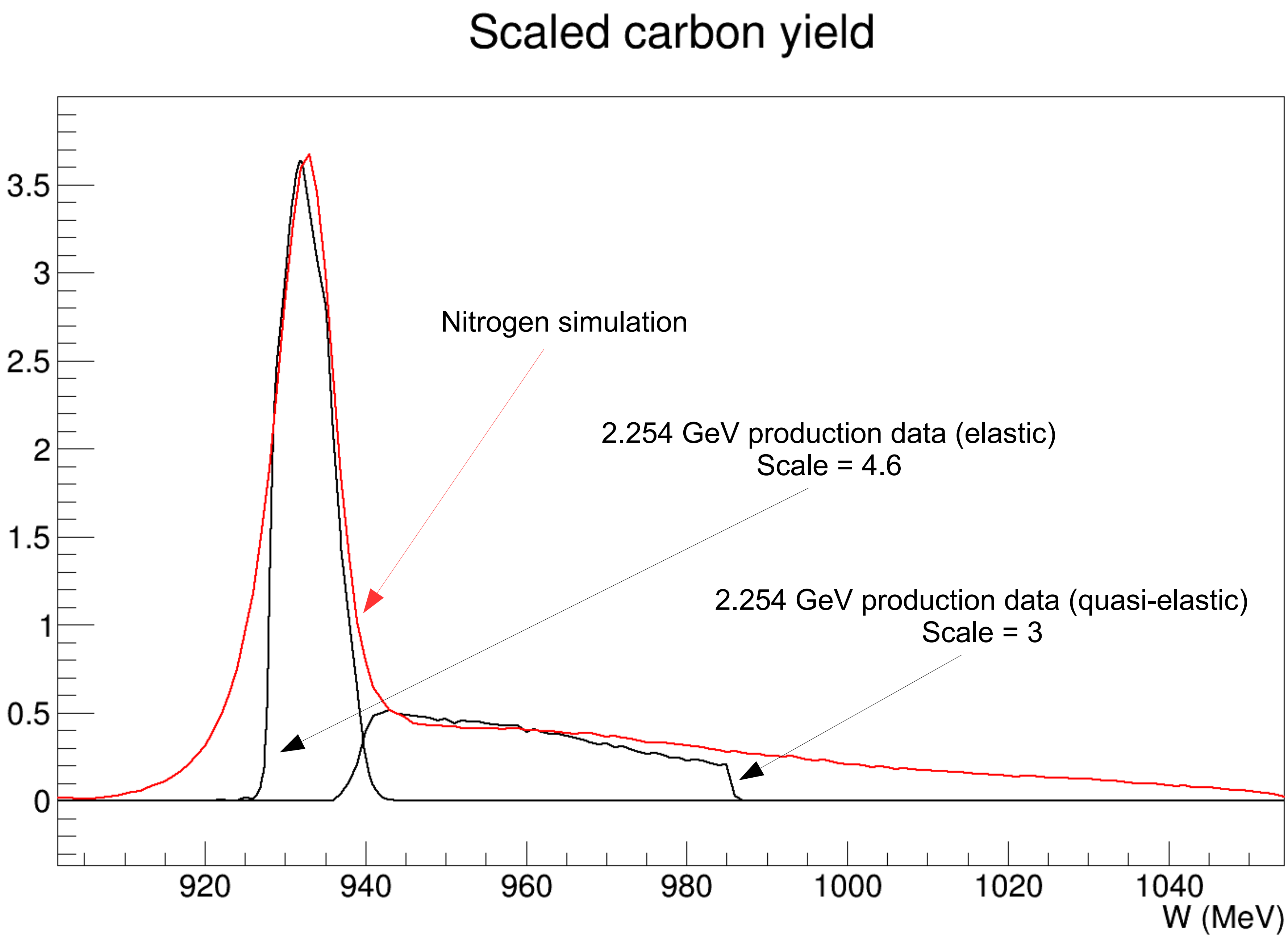
(unscaled) carbon yield
Moshe's nitrogen simulation
2.254 GeV production data (unscaled)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
900
950
1000
1050
1100
W (MeV)

Isolating elastic/qelastic channels

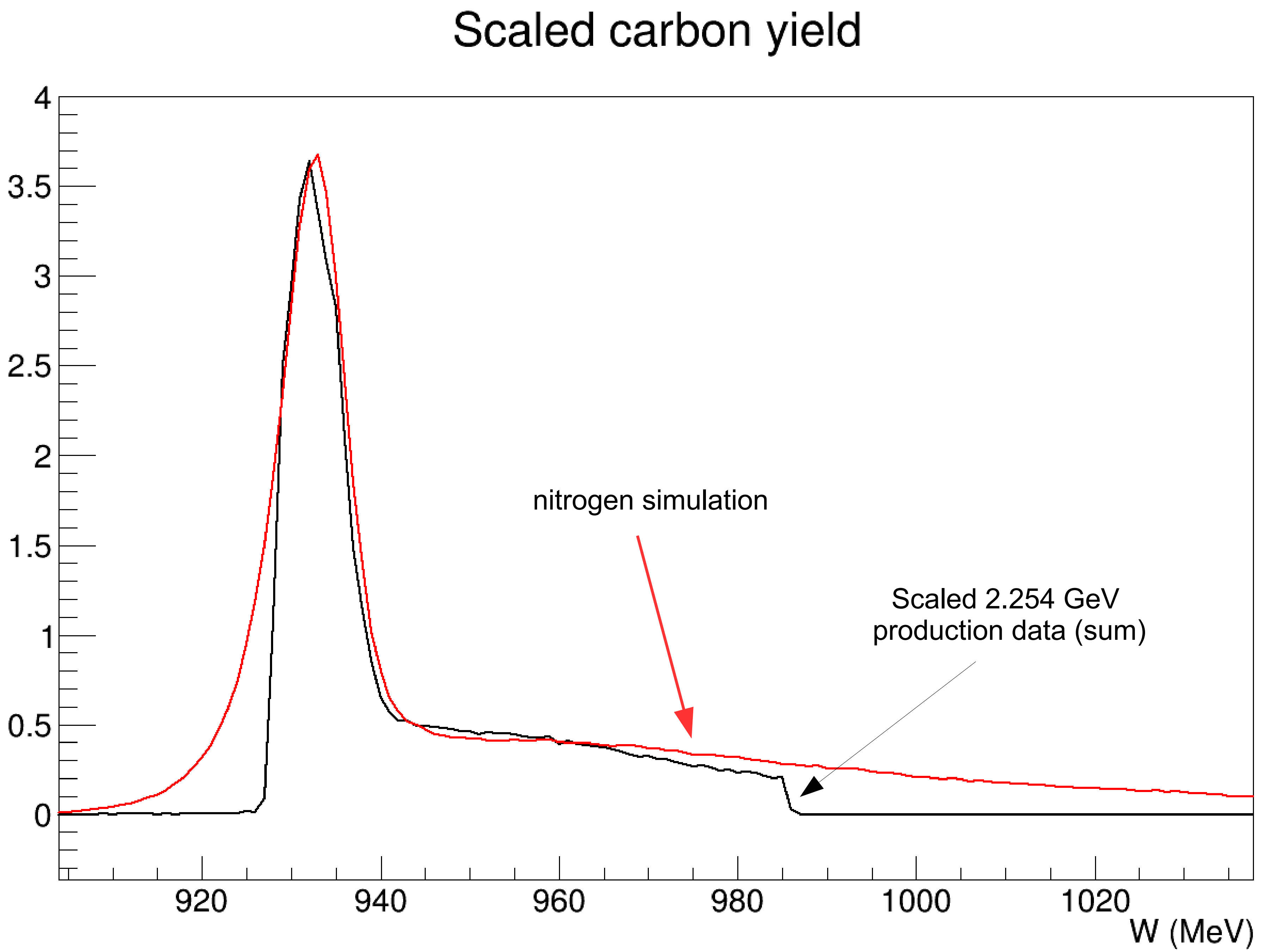




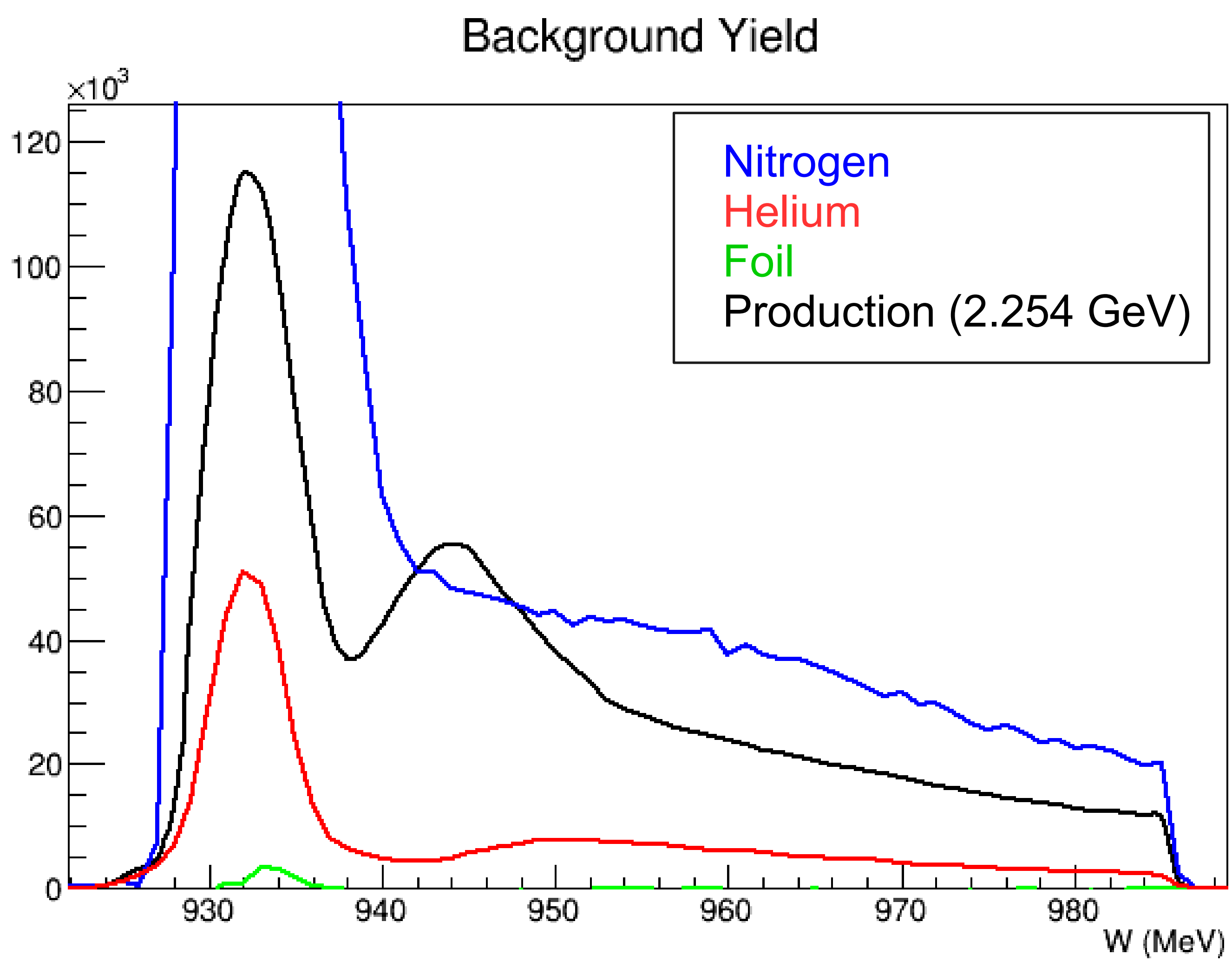
Graphical cut done for both carbon and empty dilution runs so individual channels could be scaled to match simulation.



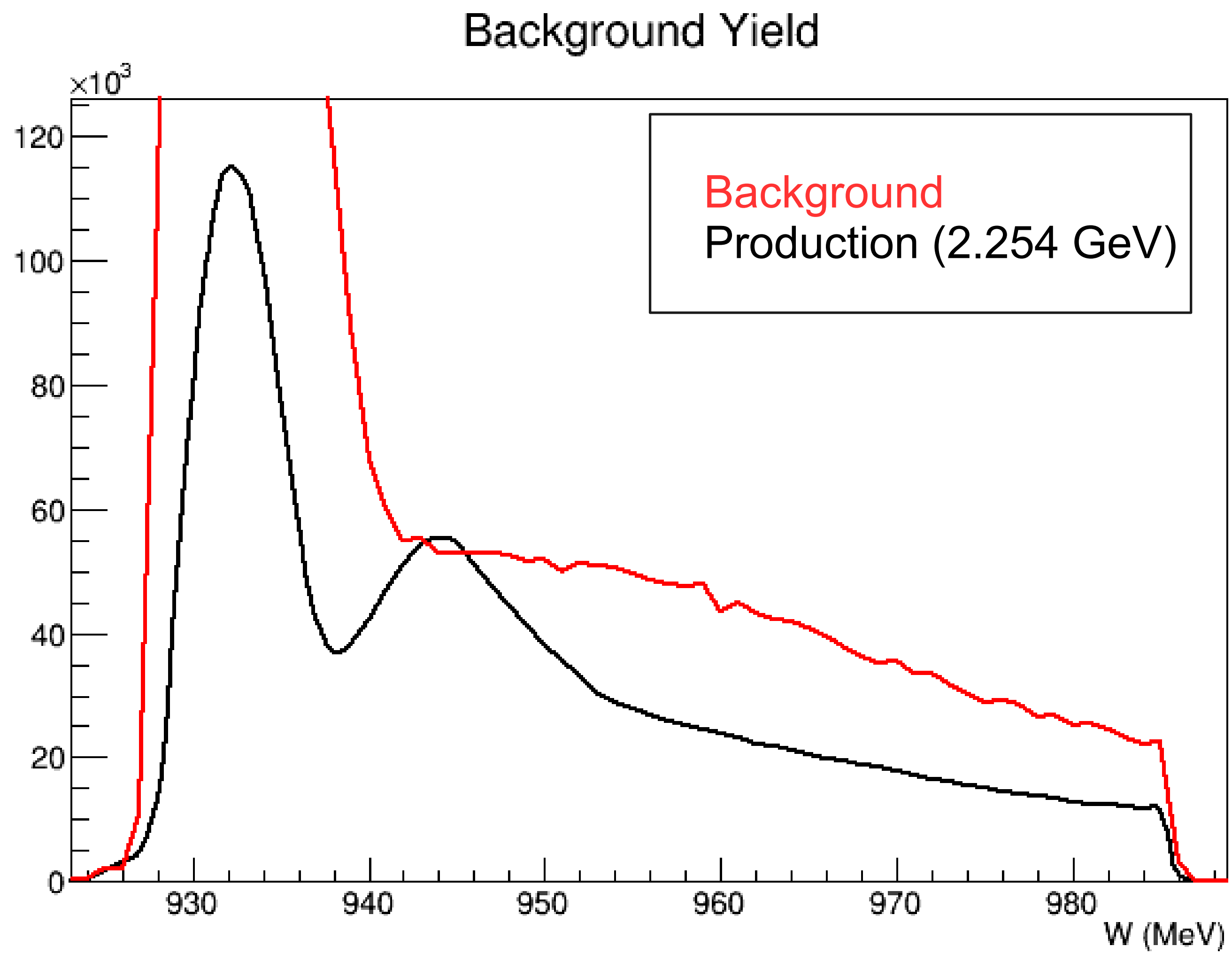
Scaled carbon yield
Nitrogen simulation
2.254 GeV production data (elastic)
Scale = 4.6
2.254 GeV production data (quasi-elastic)
Scale = 3
3.5
3
2.5
2
1.5
1
0.5
0
920
940
960
980
1000
1020
1040
W (MeV)


Scaled carbon yield
nitrogen simulation
Scaled 2.254 GeV
production data (sum)
W (MeV)
0
0.5
1
1.5
2
2.5
3
3.5
4
920
940
960
980
1000
1020

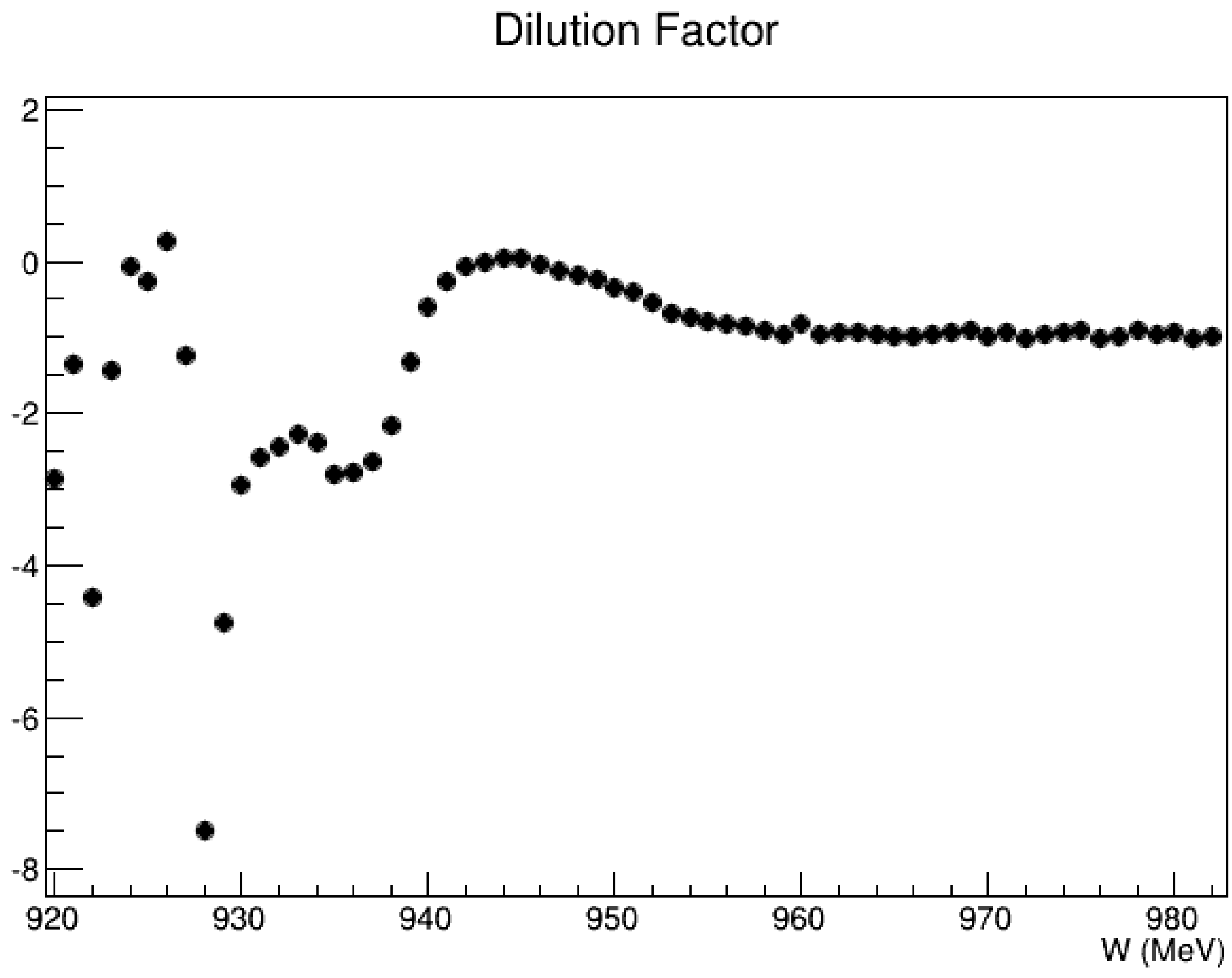
Background contribution using scaling factor from simulation



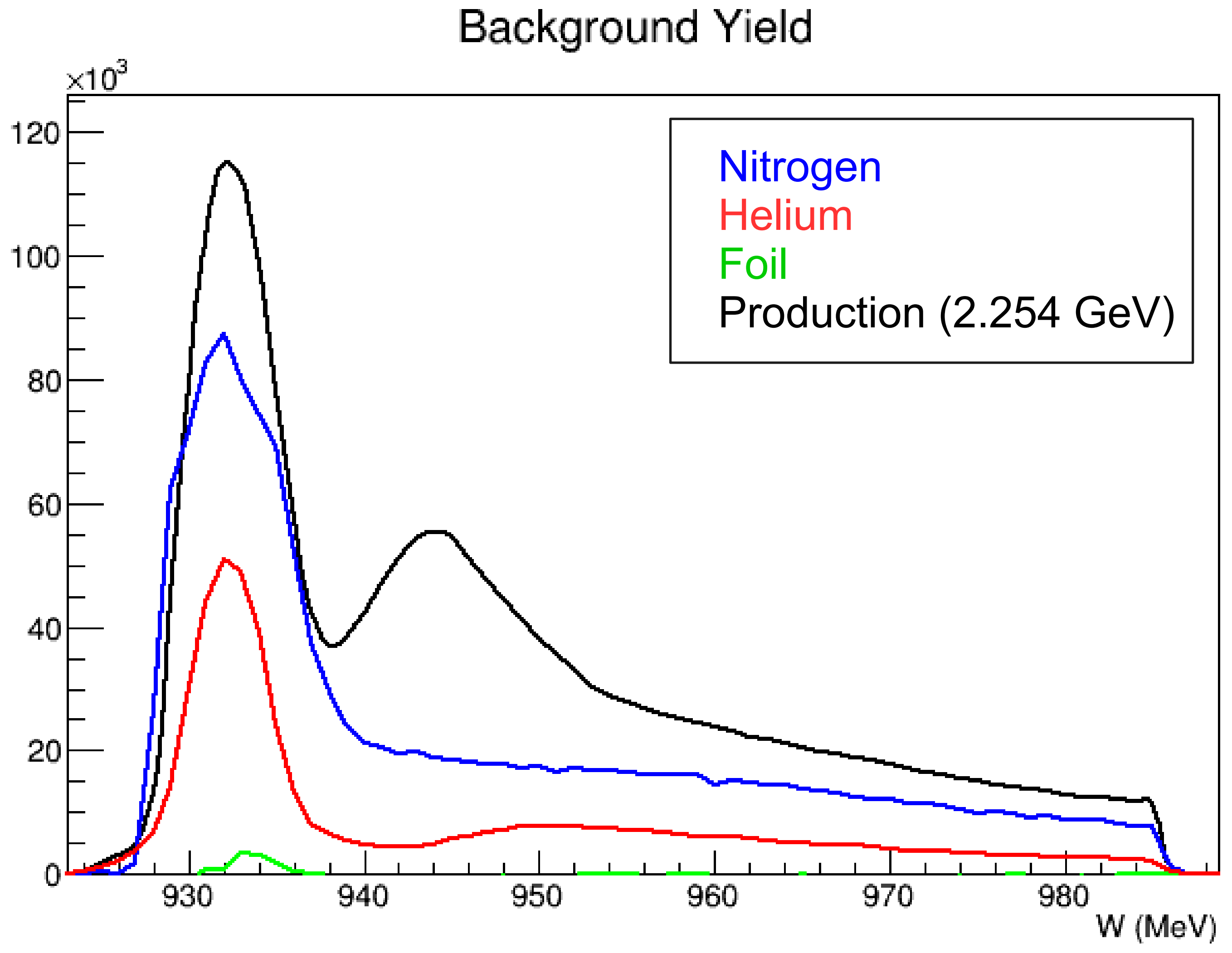
Background contribution using scaling factor from simulation



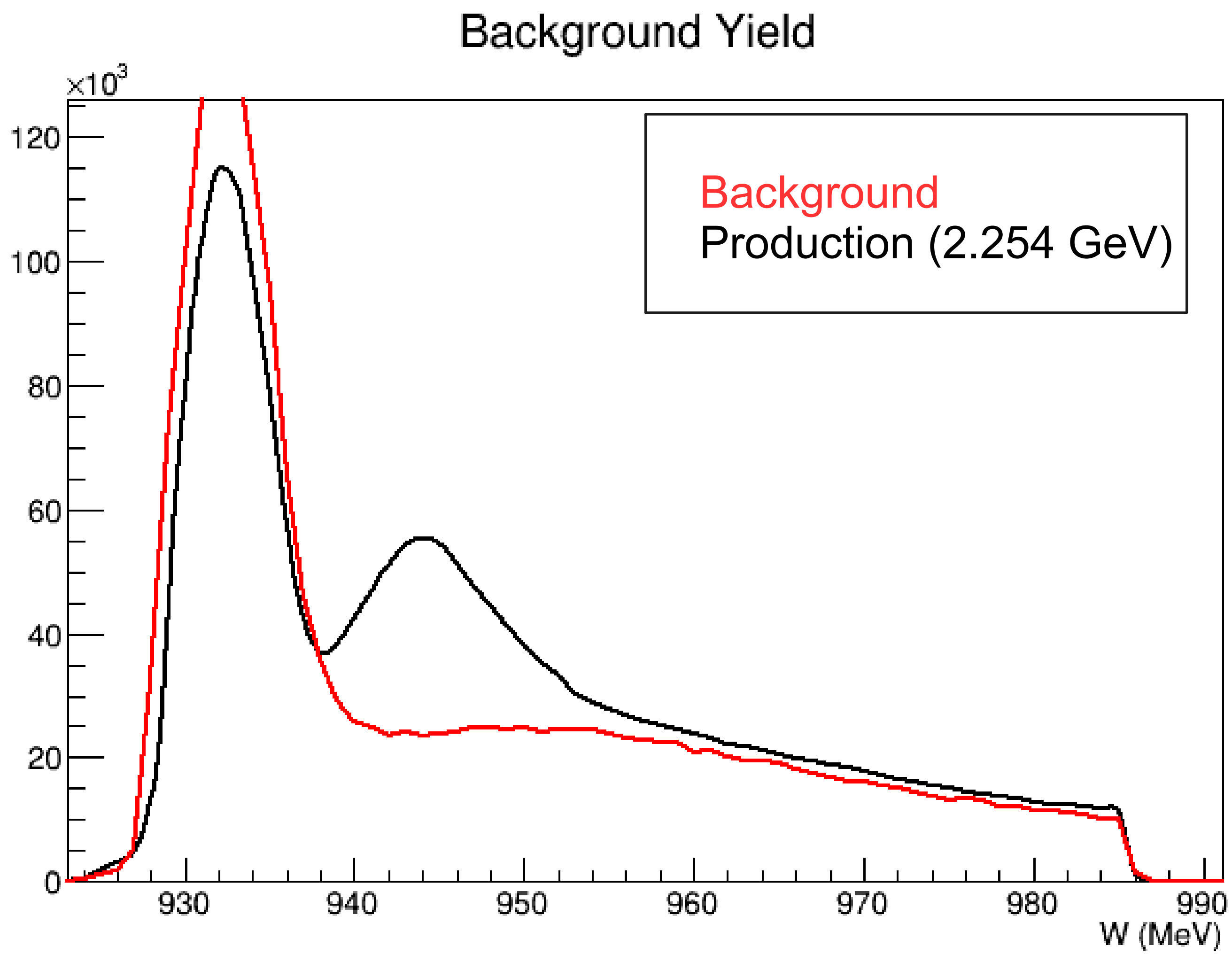
Dilution using scaling factor from simulation



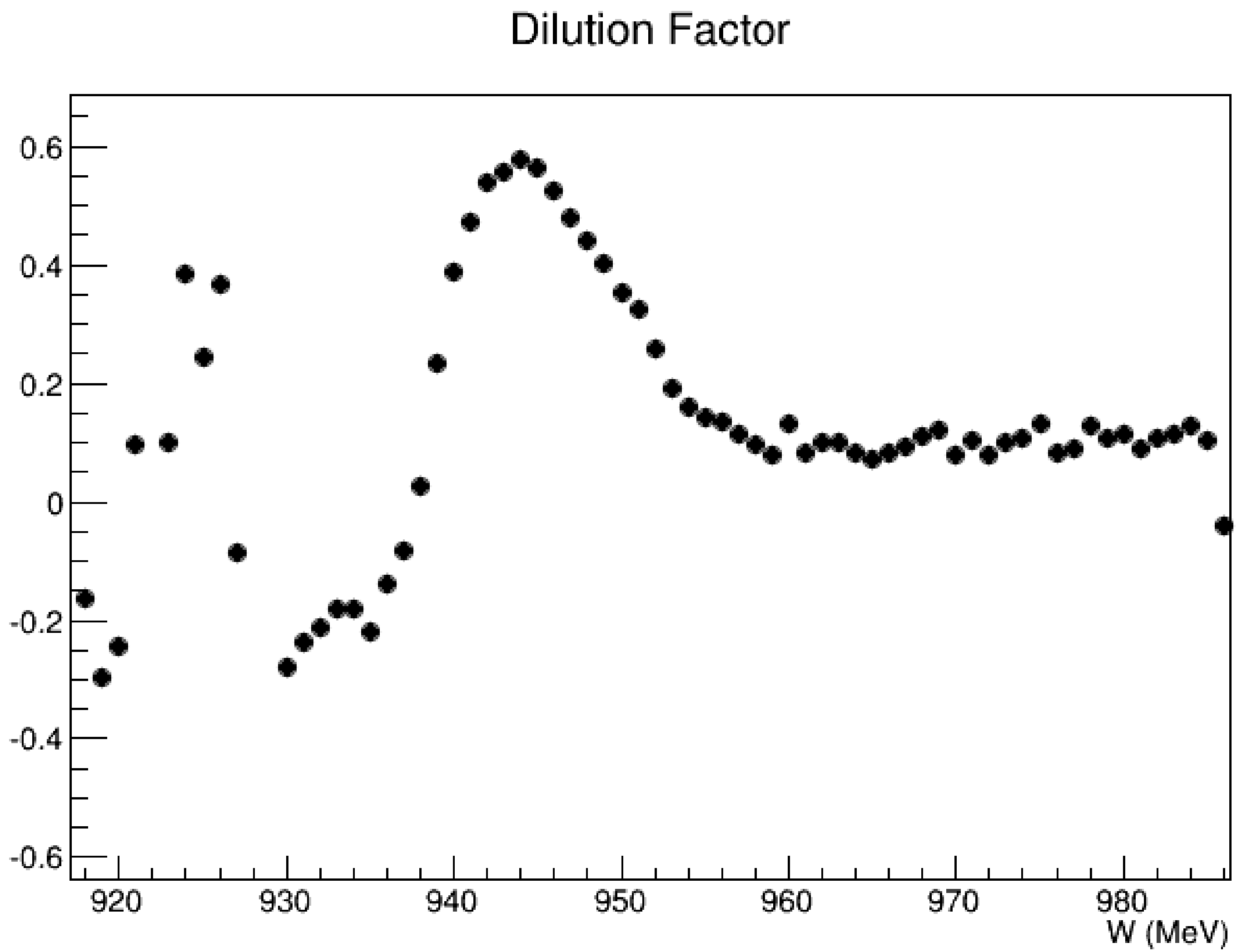
Background contribution using a=1.17 (constant)



Background contribution using a=1.176 (constant)

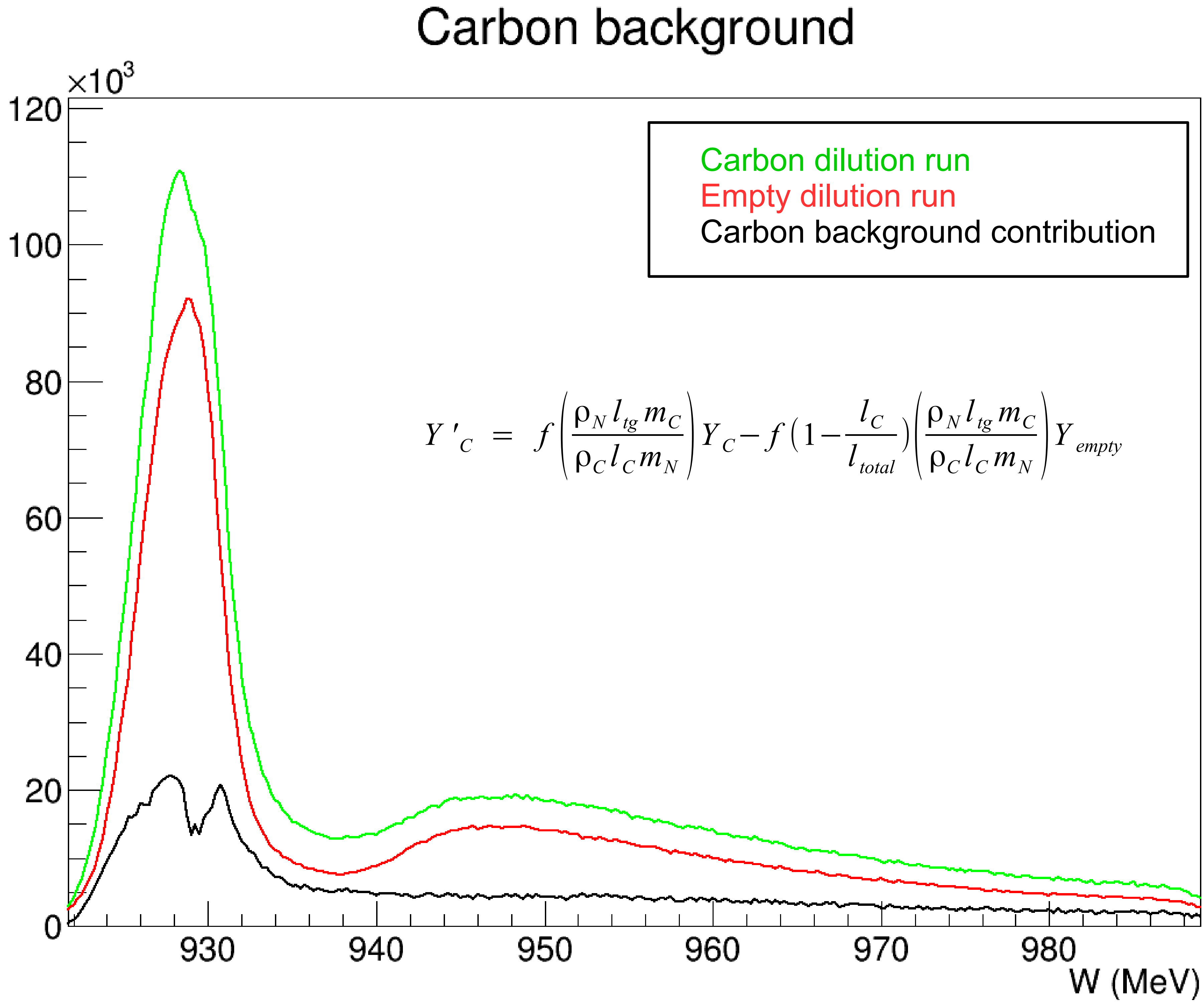


Dilution using a=1.17 (constant)



To do

- Look at other kinematic settings (split peak problem for carbon)
- Suggestions?


Carbon background
×10^3
120
100
80
60
40
20
0
930
940
950
960
970
980
W (MeV)
Carbon dilution run
Empty dilution run
Carbon background contribution
$Y'_C = f\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_C - f\left(1 - \frac{l_C}{l_{total}}\right)\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_{empty}$