Dilution Analysis

Toby Badman

- 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 radiation lengths (including packing fraction – all data in this talk assumes f ~ 0.55)
  - → Scaling factor to scale carbon yield to nitrogen yield

Adding in radiation 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 radiation 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 scaling factor a(k)

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

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

Kinematic independent!

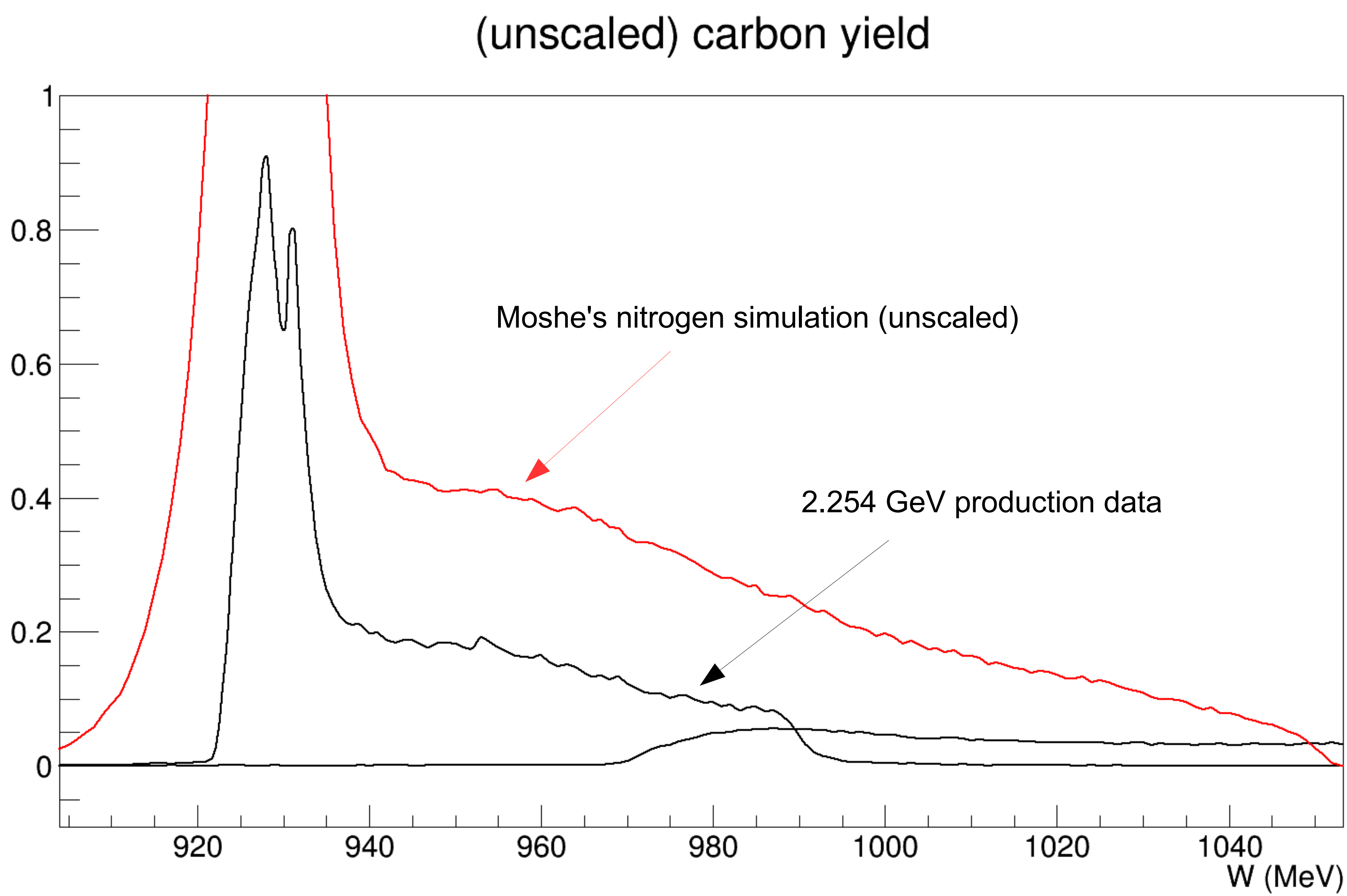
$$N_o \frac{\rho_N\, f\, l_N}{m_N} \sigma_N = Y_N = f\,a(k)\left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_C - f\,a(k)\left(1 - \frac{l_C}{l_{total}}\right)\left(\frac{\rho_N\, l_{tg}\, m_C}{\rho_C\, l_C\, m_N}\right) Y_{empty}$$

Energy dependent scaling factor

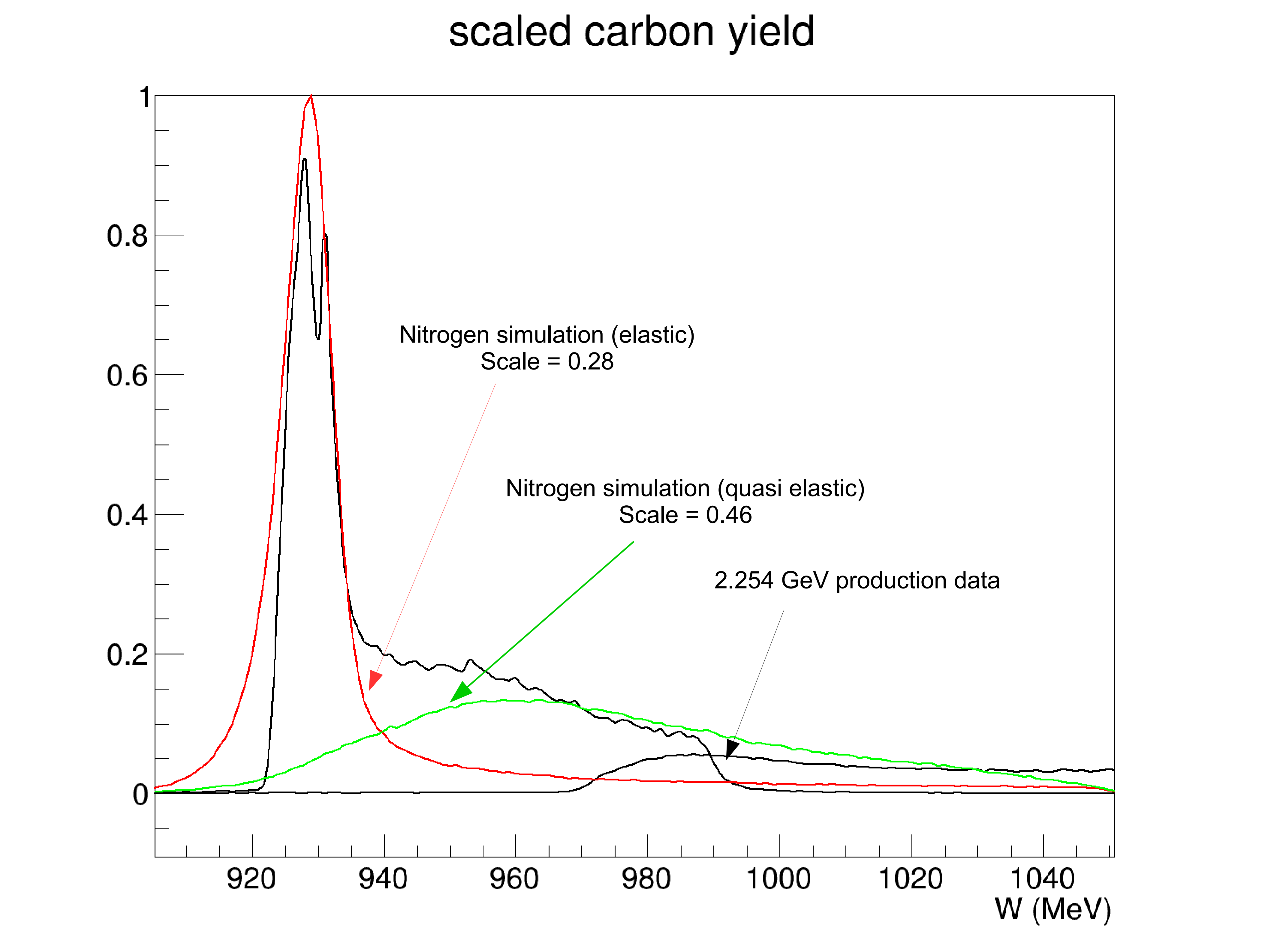
Finding the scaling factor a(k)

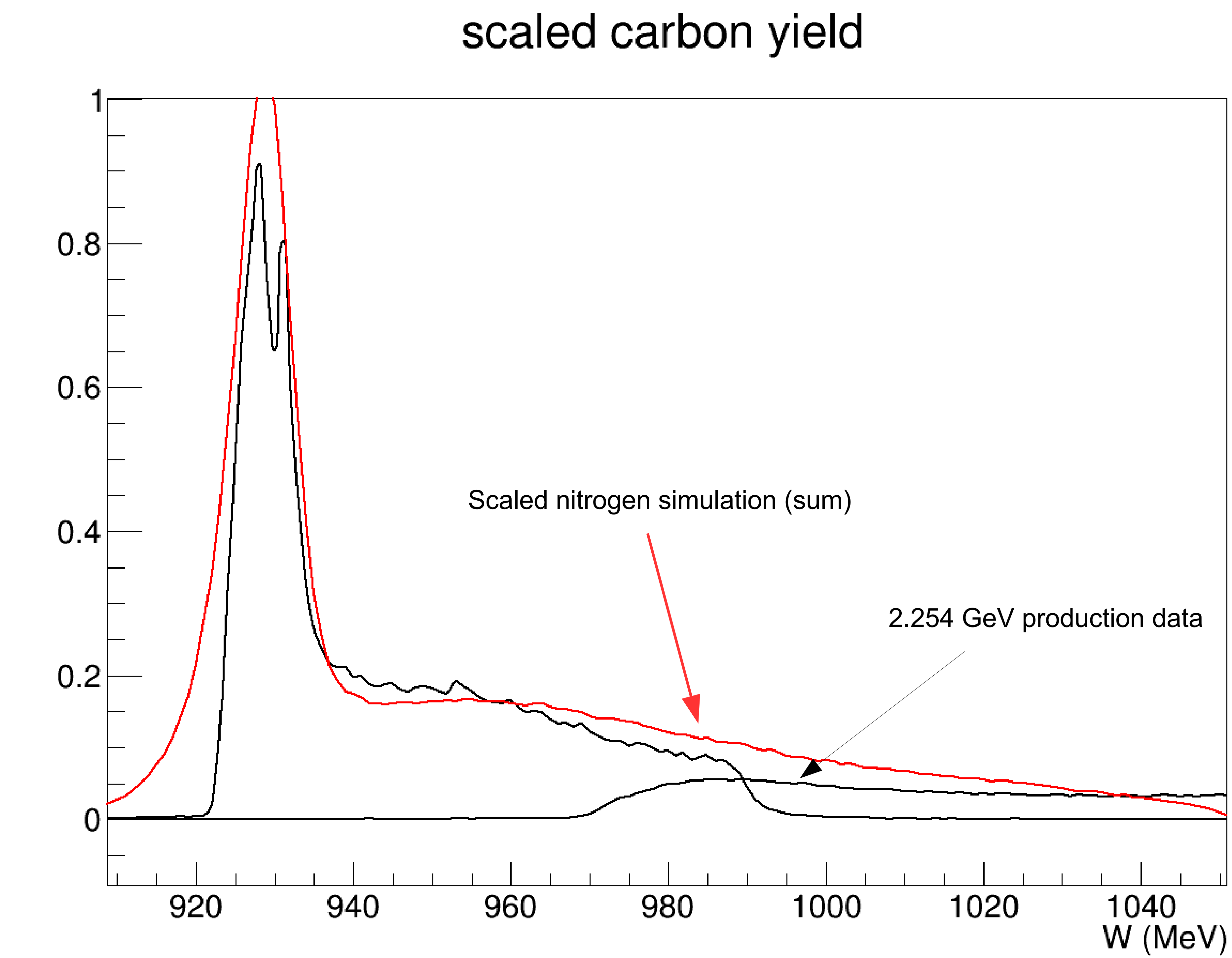
- Initial assumption:
  - ➔ $\sigma_C = 12$
  - ➔ $\sigma_N = 14$
  - ➔ $a = \frac{\sigma_N}{\sigma_C} = \frac{14}{12} = 1.17$
- Nitrogen simulation needed for more accurate scaling factor
  - ➔ $Y_{N(simulation)} = a(k)\left(f\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_C - f\left(1 - \frac{l_C}{l_{total}}\right)\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_{empty}\right)$

    $= a(k) Y'_C$
  - ➔ $a(k) = \frac{Y_{N(simulation)}}{Y'_C}$



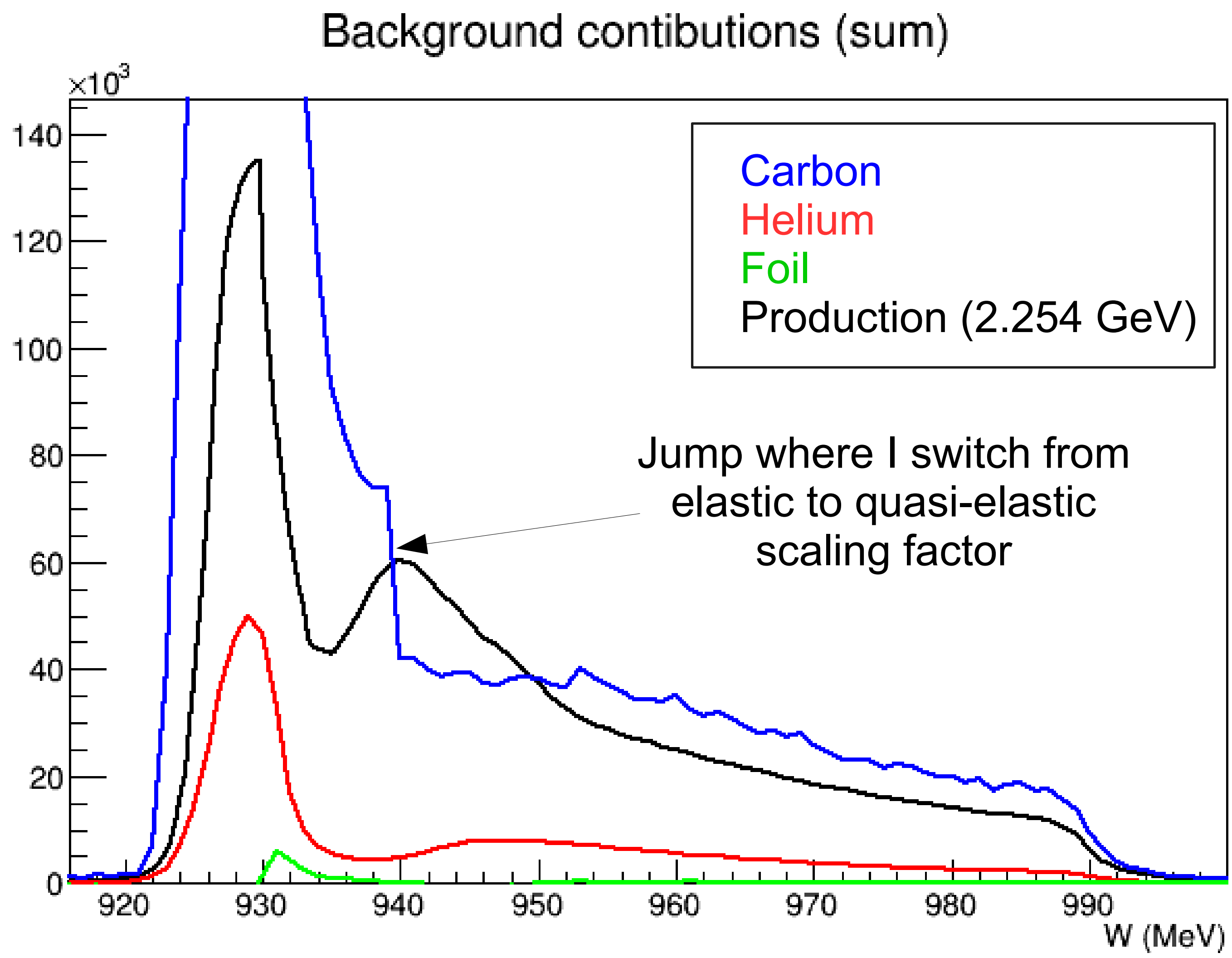
(unscaled) carbon yield
Moshe's nitrogen simulation (unscaled)
2.254 GeV production data
1
0.8
0.6
0.4
0.2
0
920
940
960
980
1000
1020
1040
W (MeV)


scaled carbon yield
Nitrogen simulation (elastic)
Scale = 0.28
Nitrogen simulation (quasi elastic)
Scale = 0.46
2.254 GeV production data
0
0.2
0.4
0.6
0.8
1
920
940
960
980
1000
1020
1040
W (MeV)

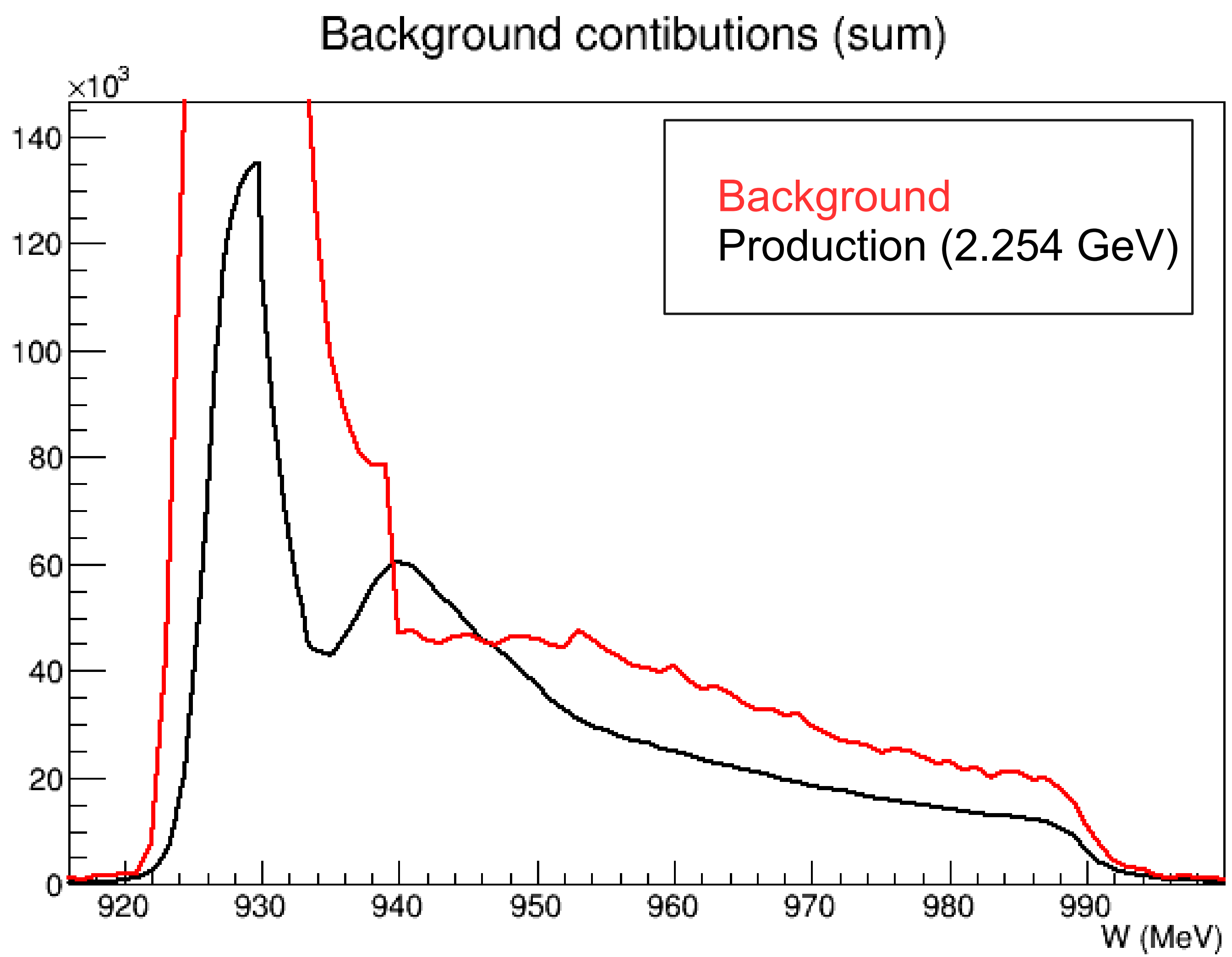


scaled carbon yield
Scaled nitrogen simulation (sum)
2.254 GeV production data
1
0.8
0.6
0.4
0.2
0
920
940
960
980
1000
1020
1040
W (MeV)

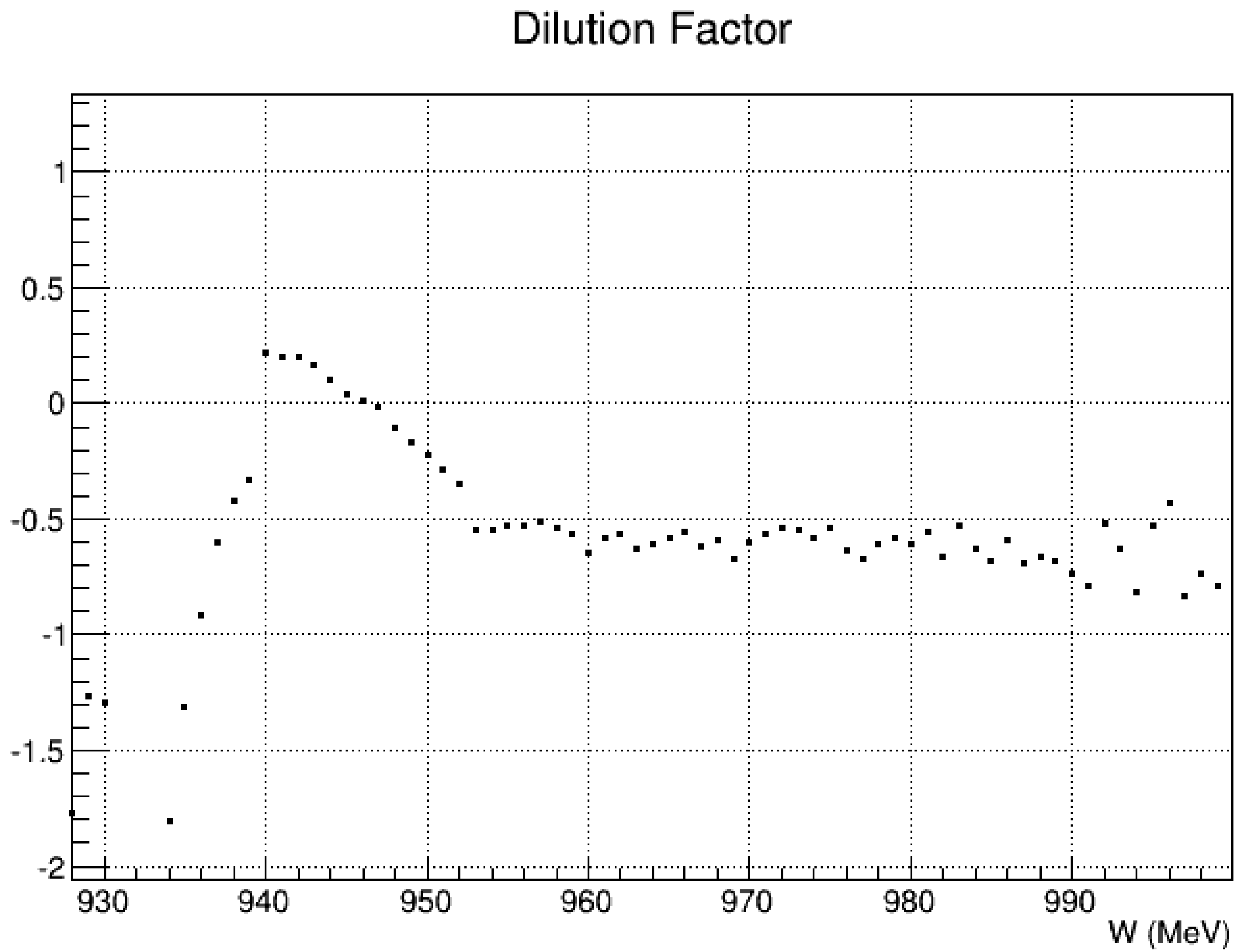
Background contribution using a(k) from simulation



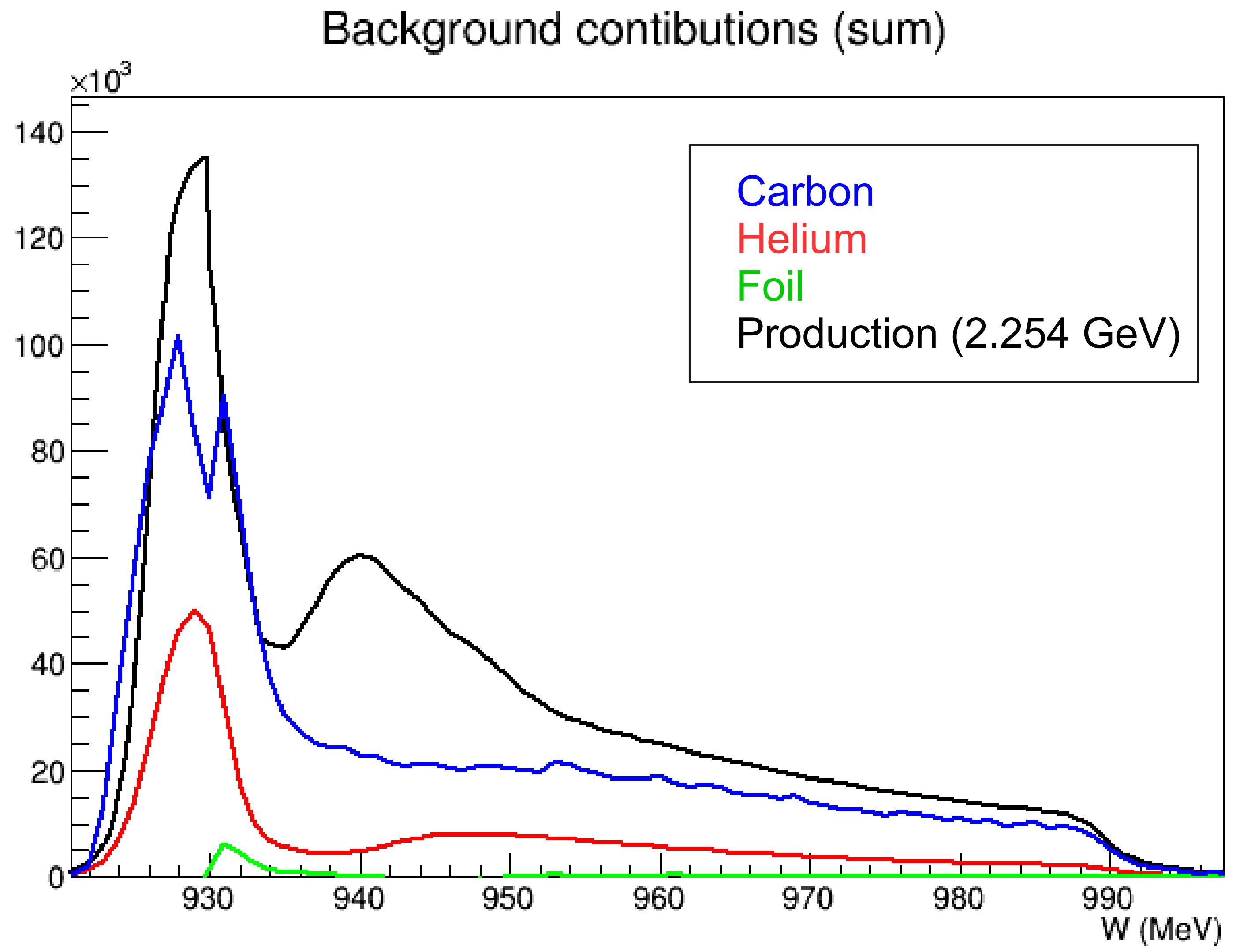
Background contribution using a(k) from simulation



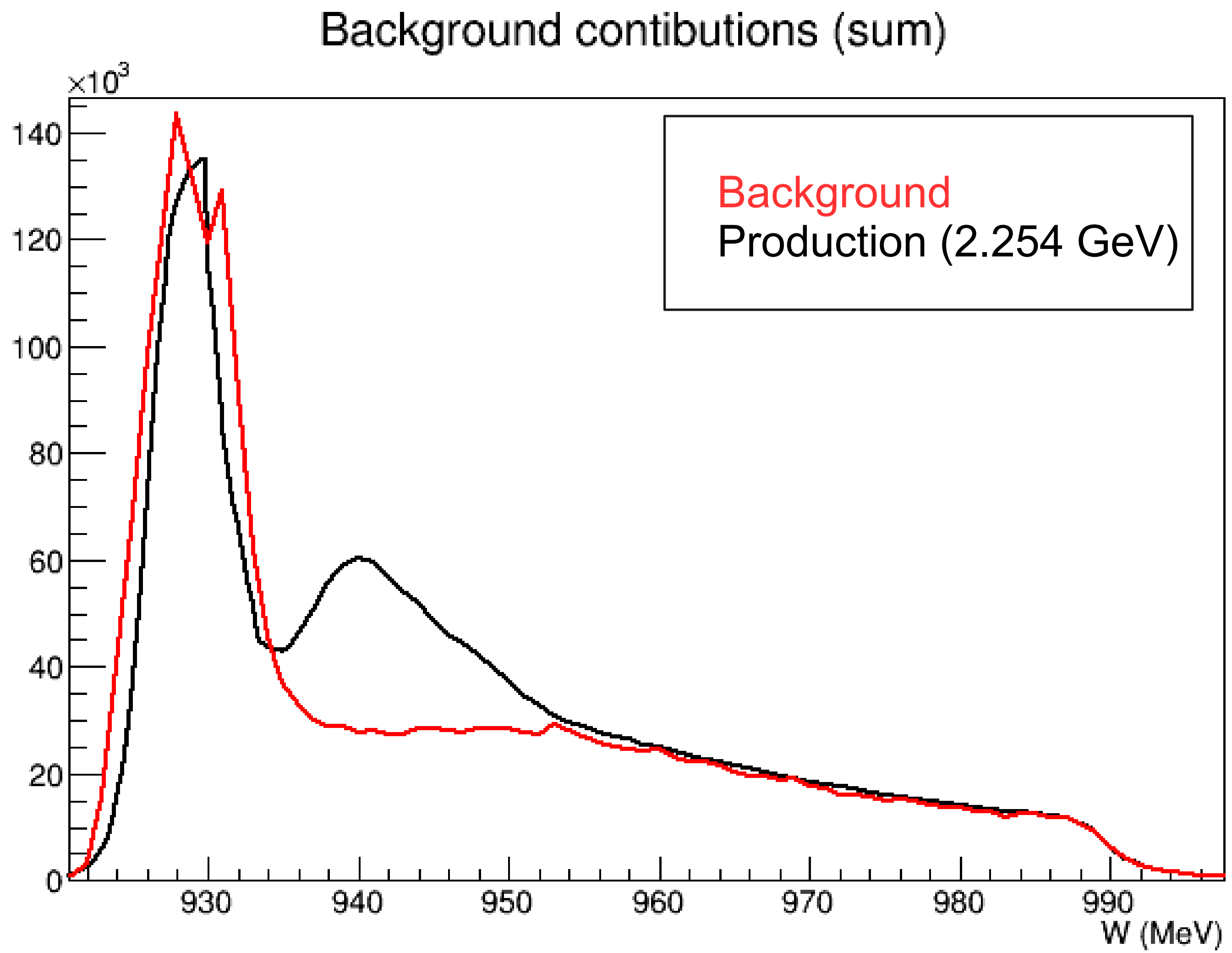
Dilution using a(k) from simulation



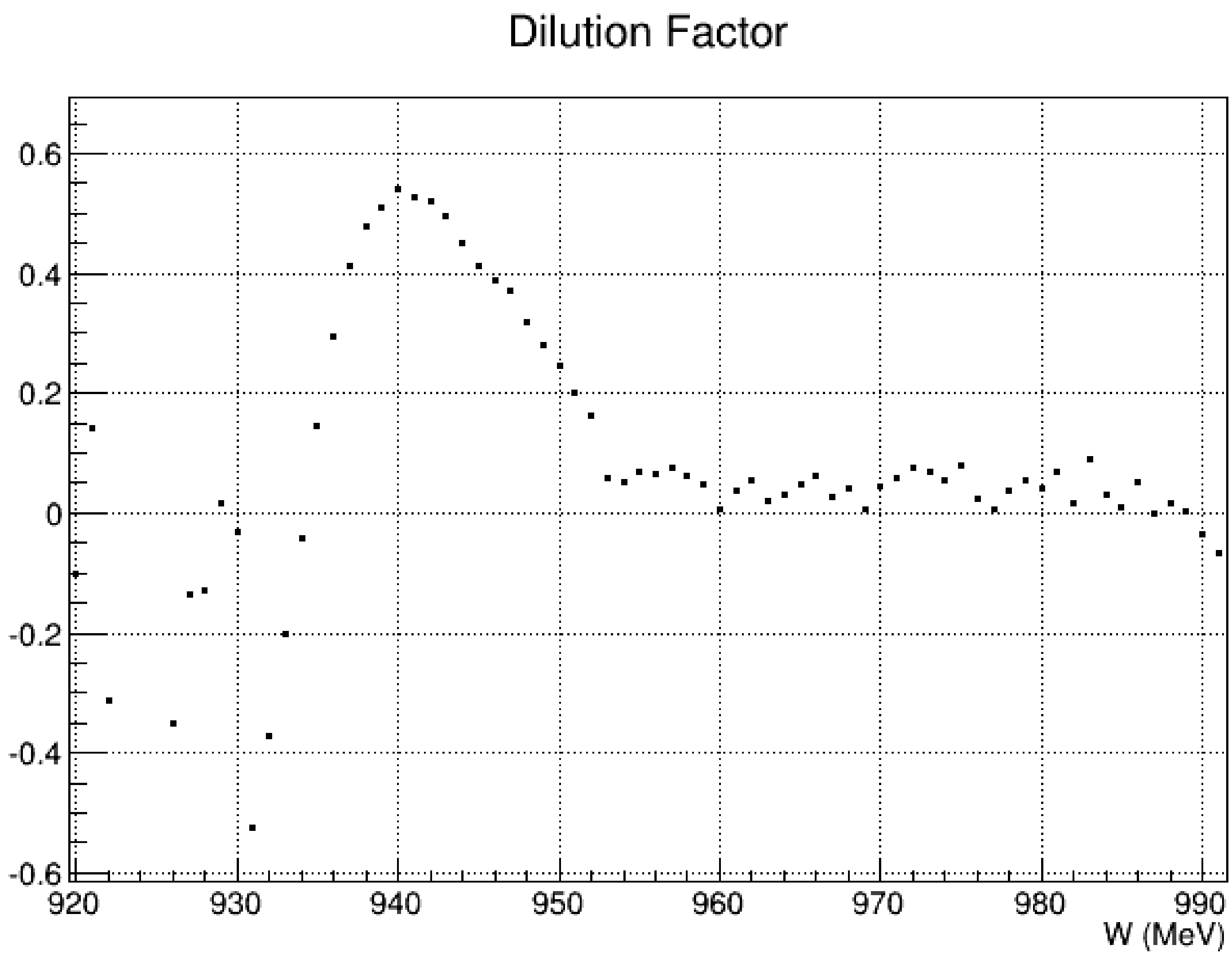
Background contribution using a=1.17 (constant)



Background contribution using a=1.176 (constant)

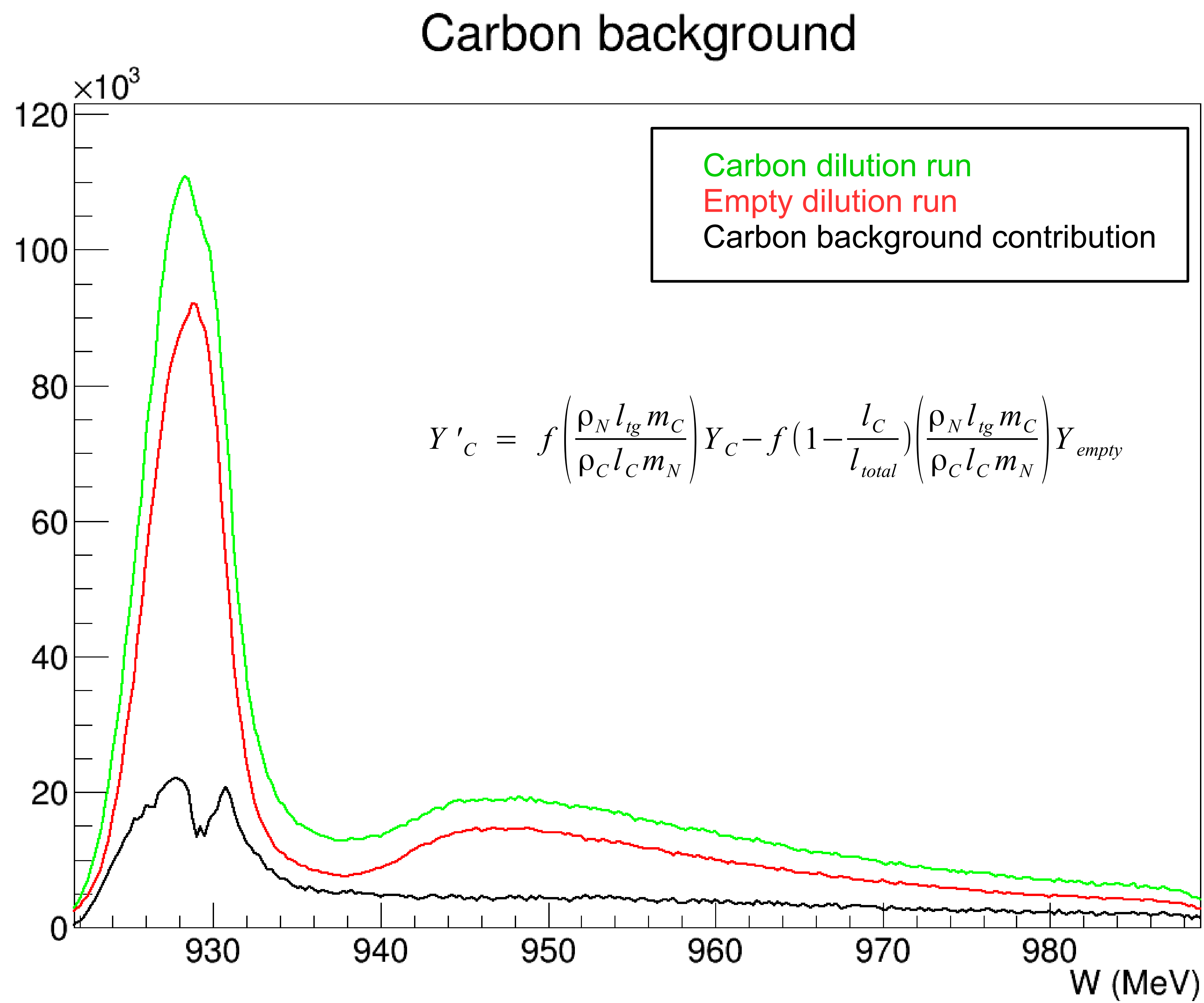


Dilution using a=1.17 (constant)



To do

- Apply cuts to dilution runs
- Look at other kinematic settings (same problem?)
- 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
$Y'_C = f\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_C - f\left(1-\frac{l_C}{l_{total}}\right)\left(\frac{\rho_N l_{tg} m_C}{\rho_C l_C m_N}\right) Y_{empty}$