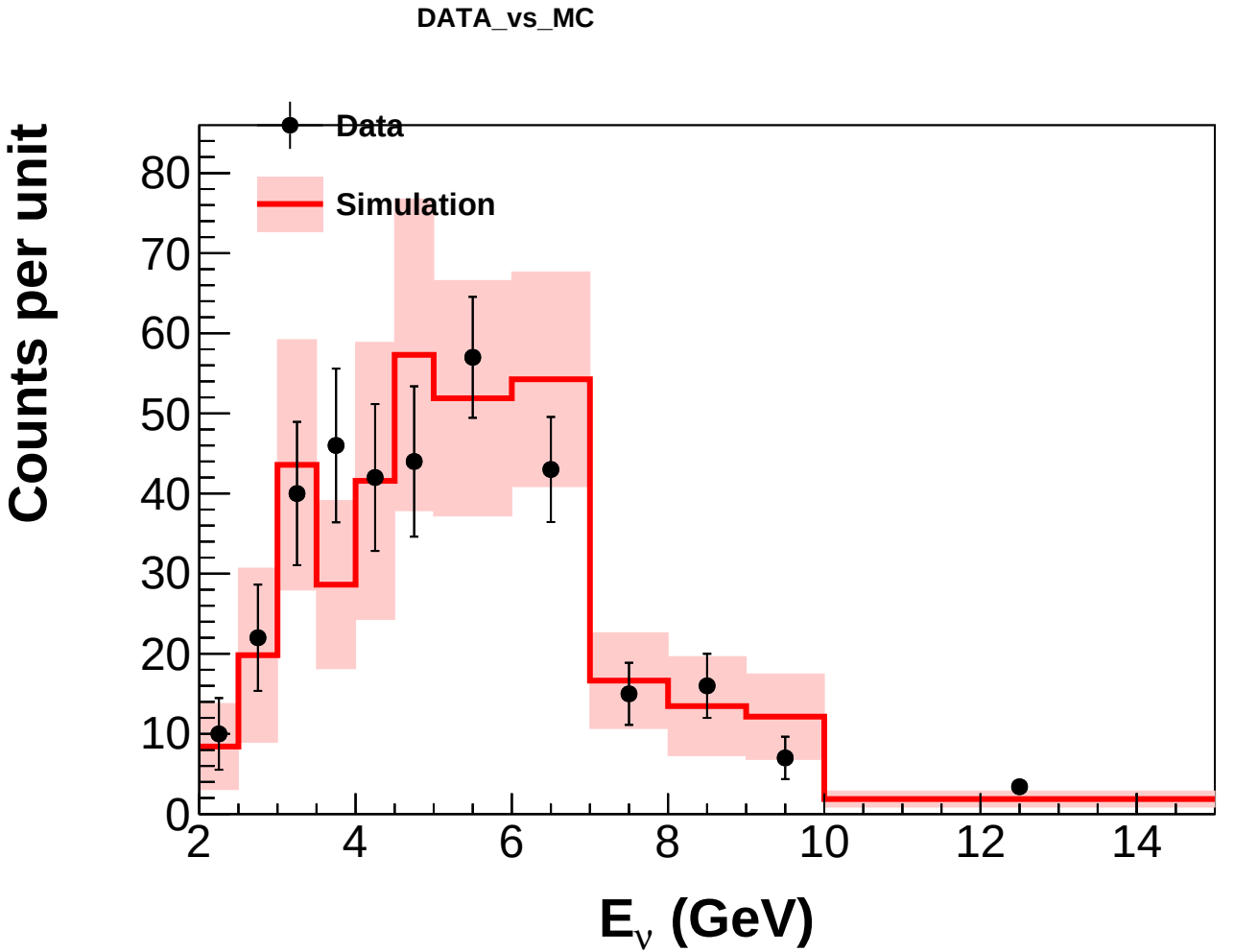
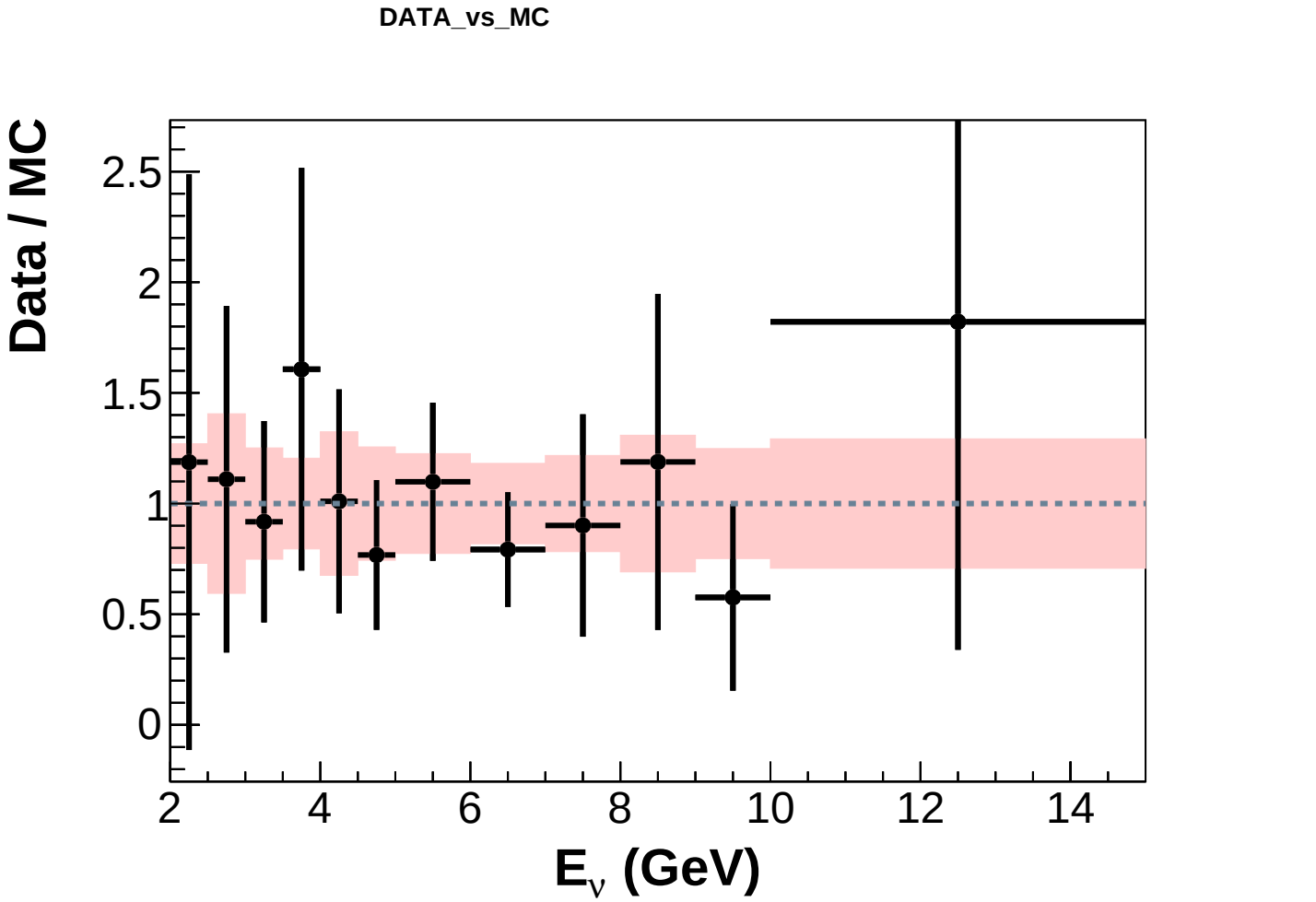
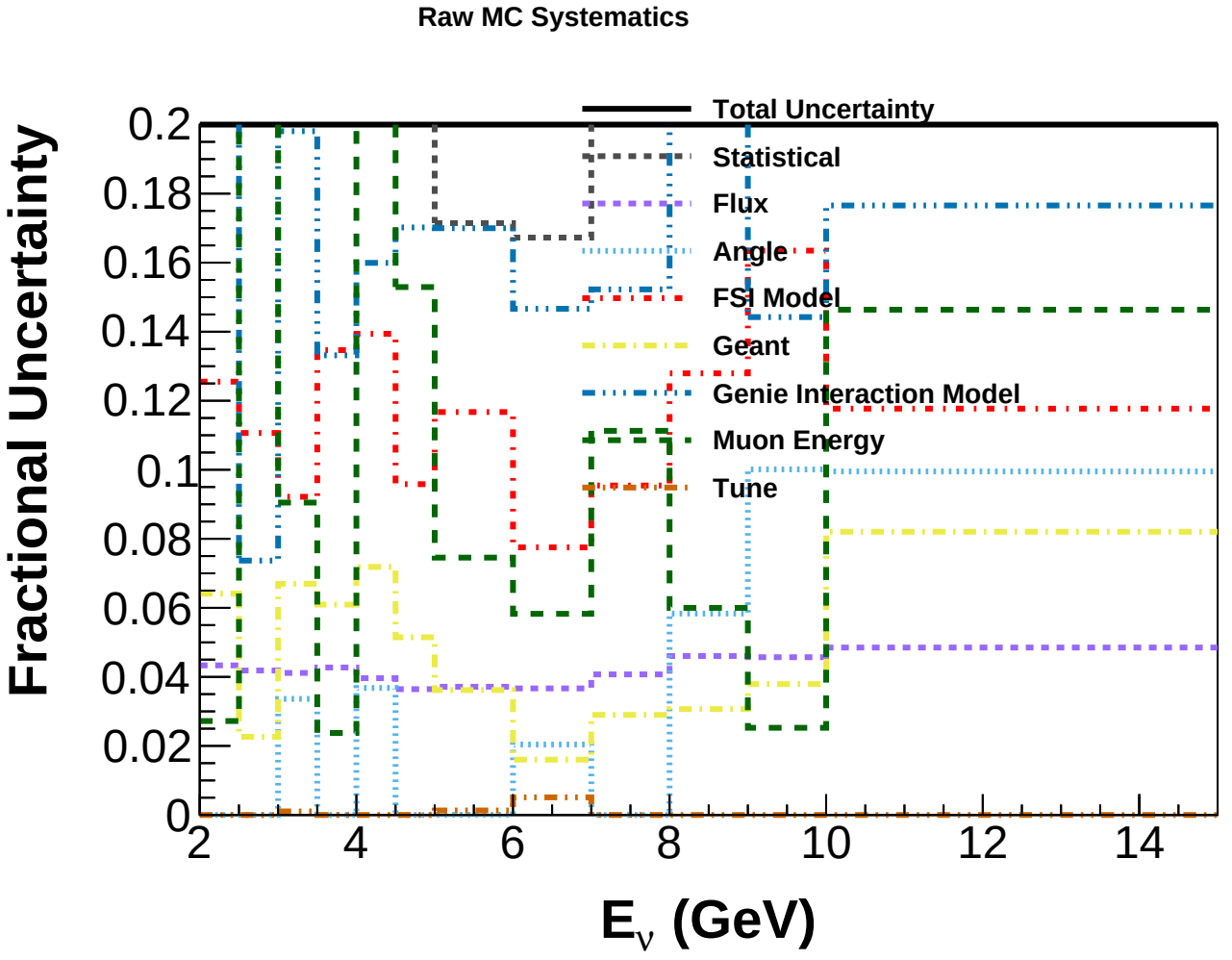
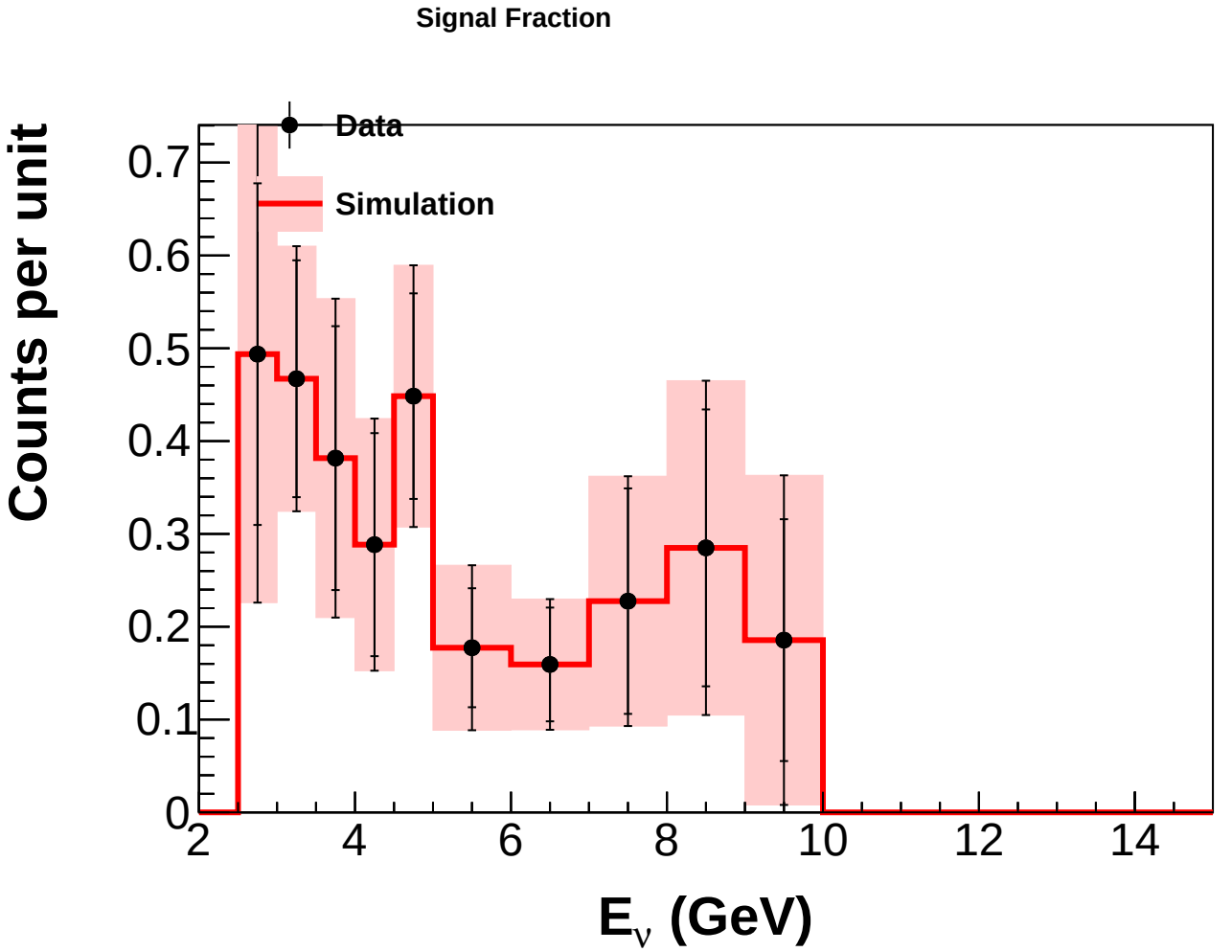
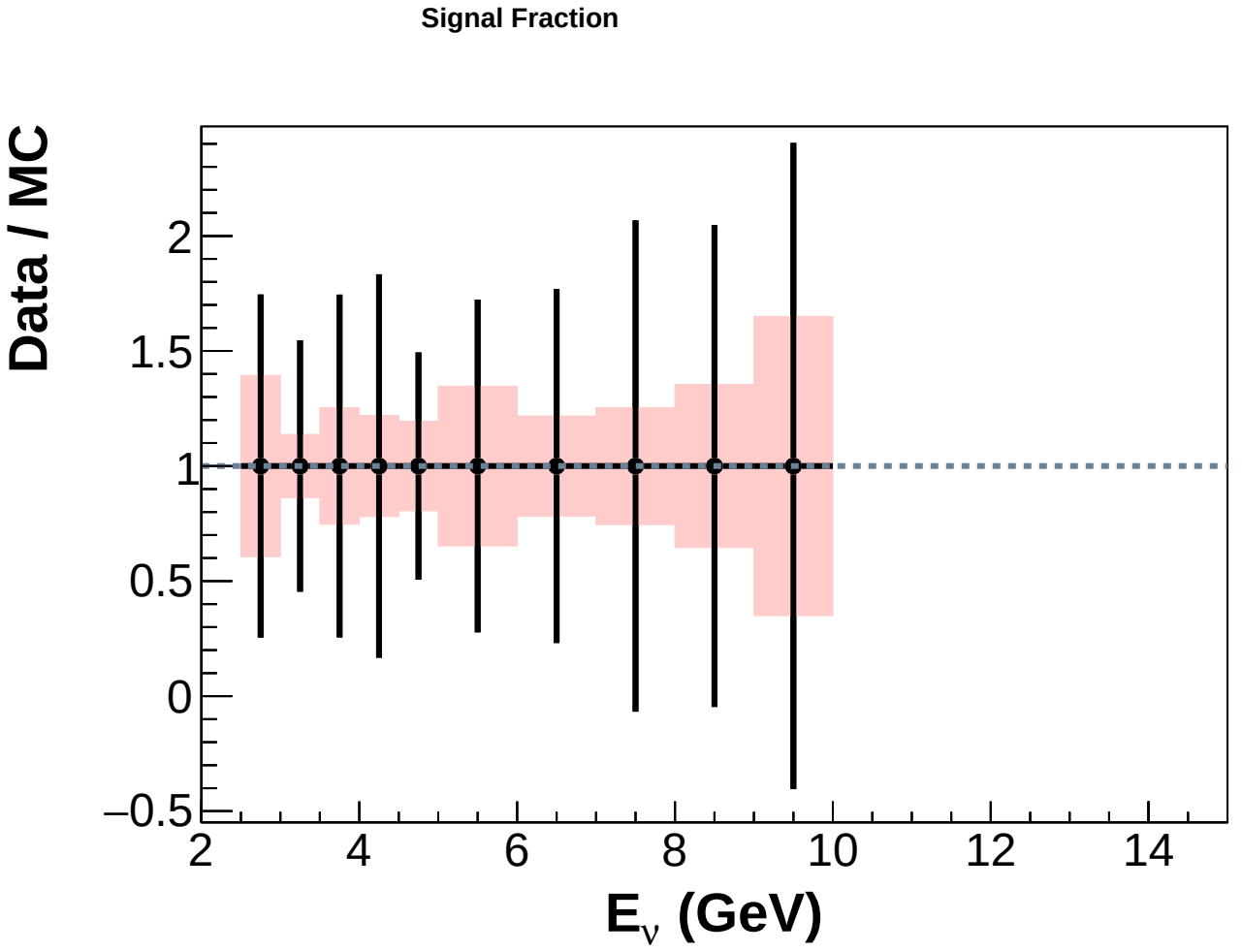
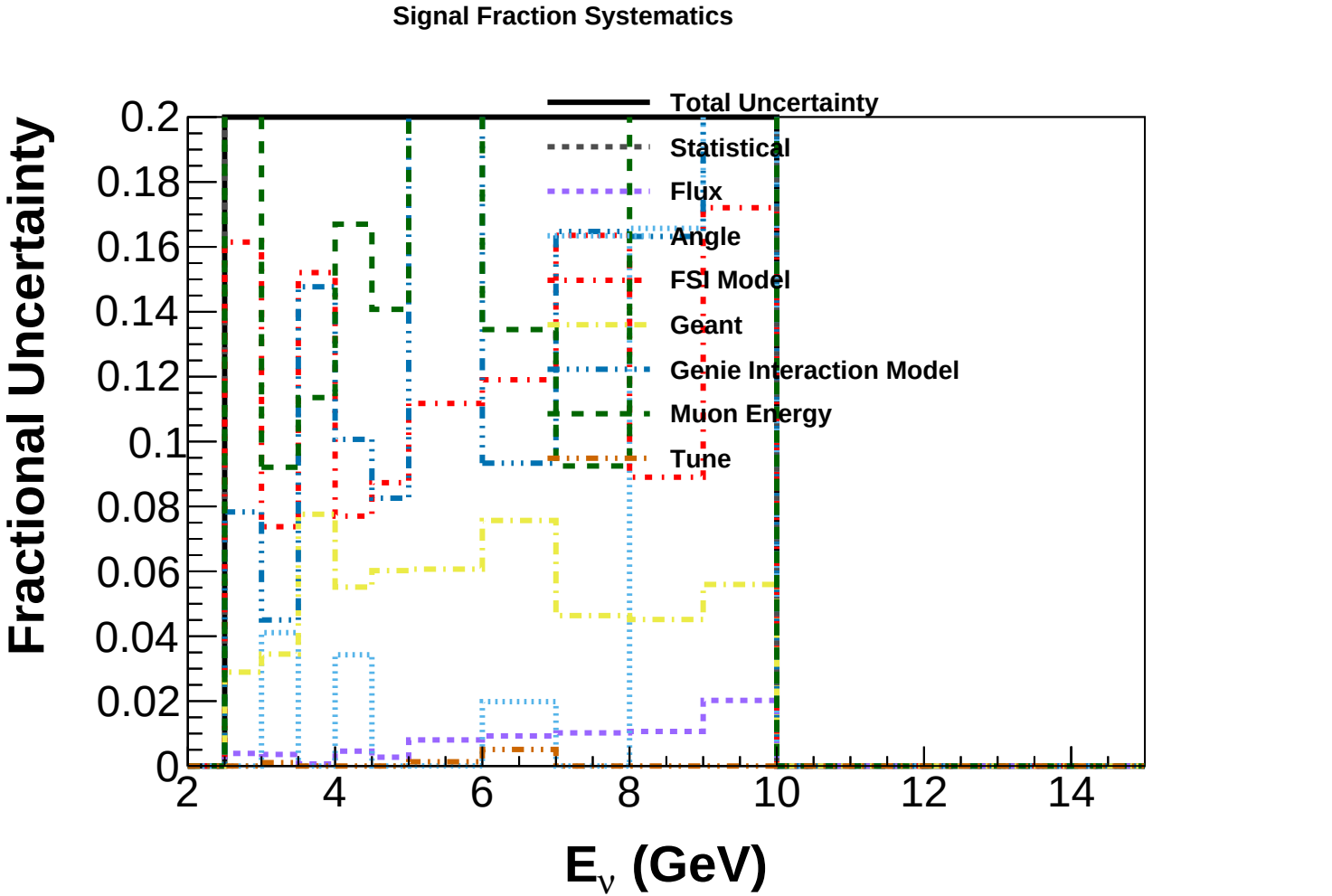

DATA_vs_MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
E_ν (GeV)

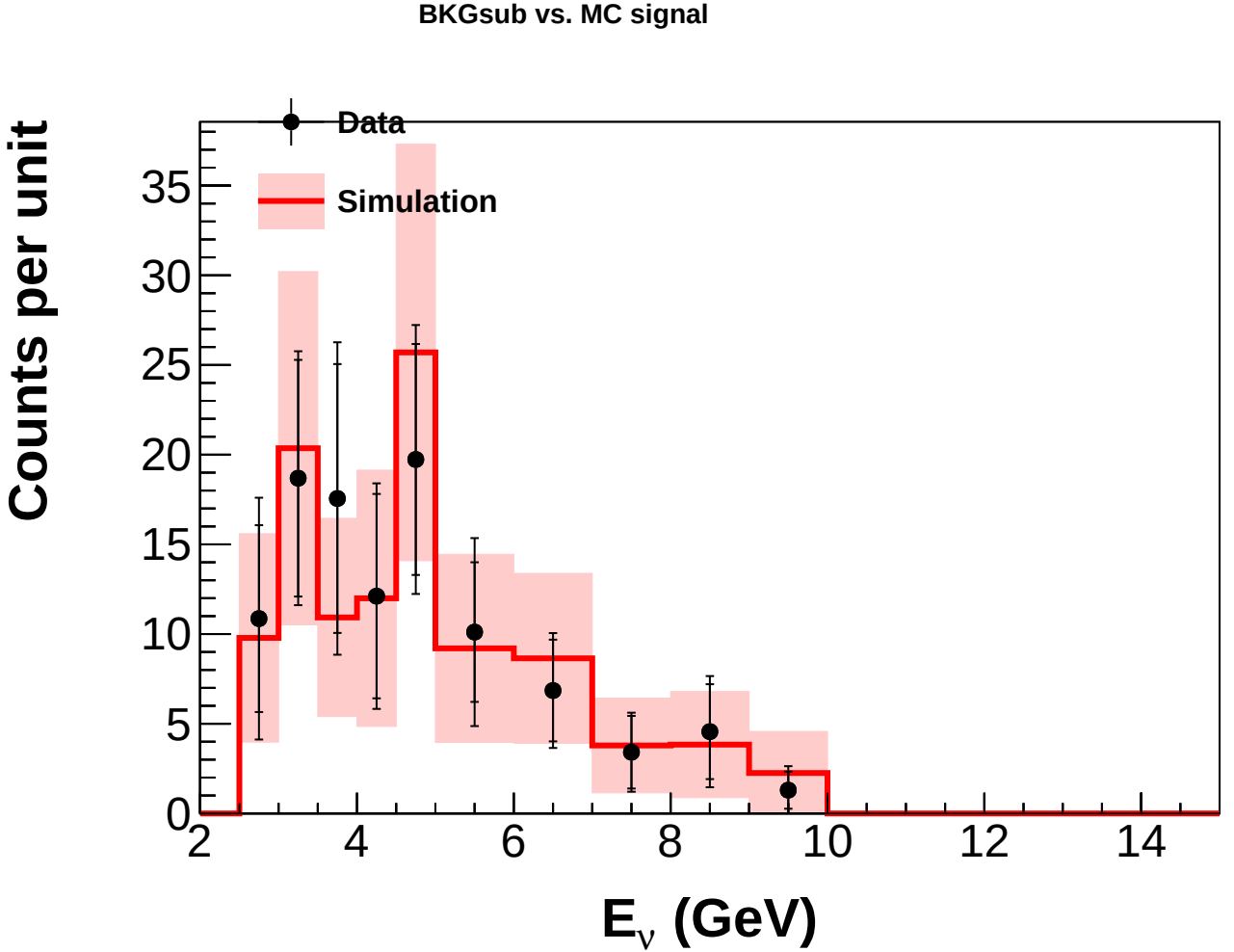

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

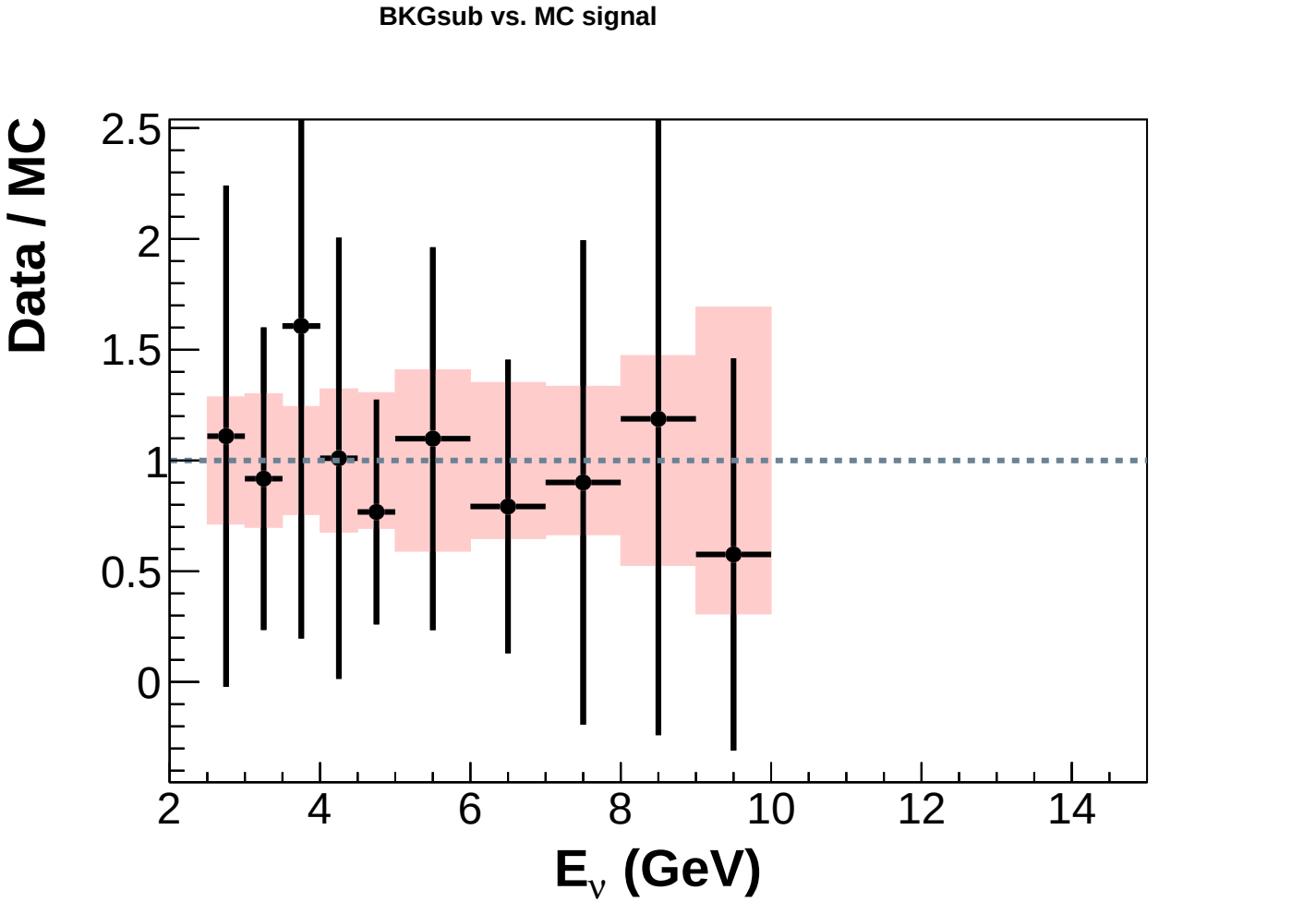

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

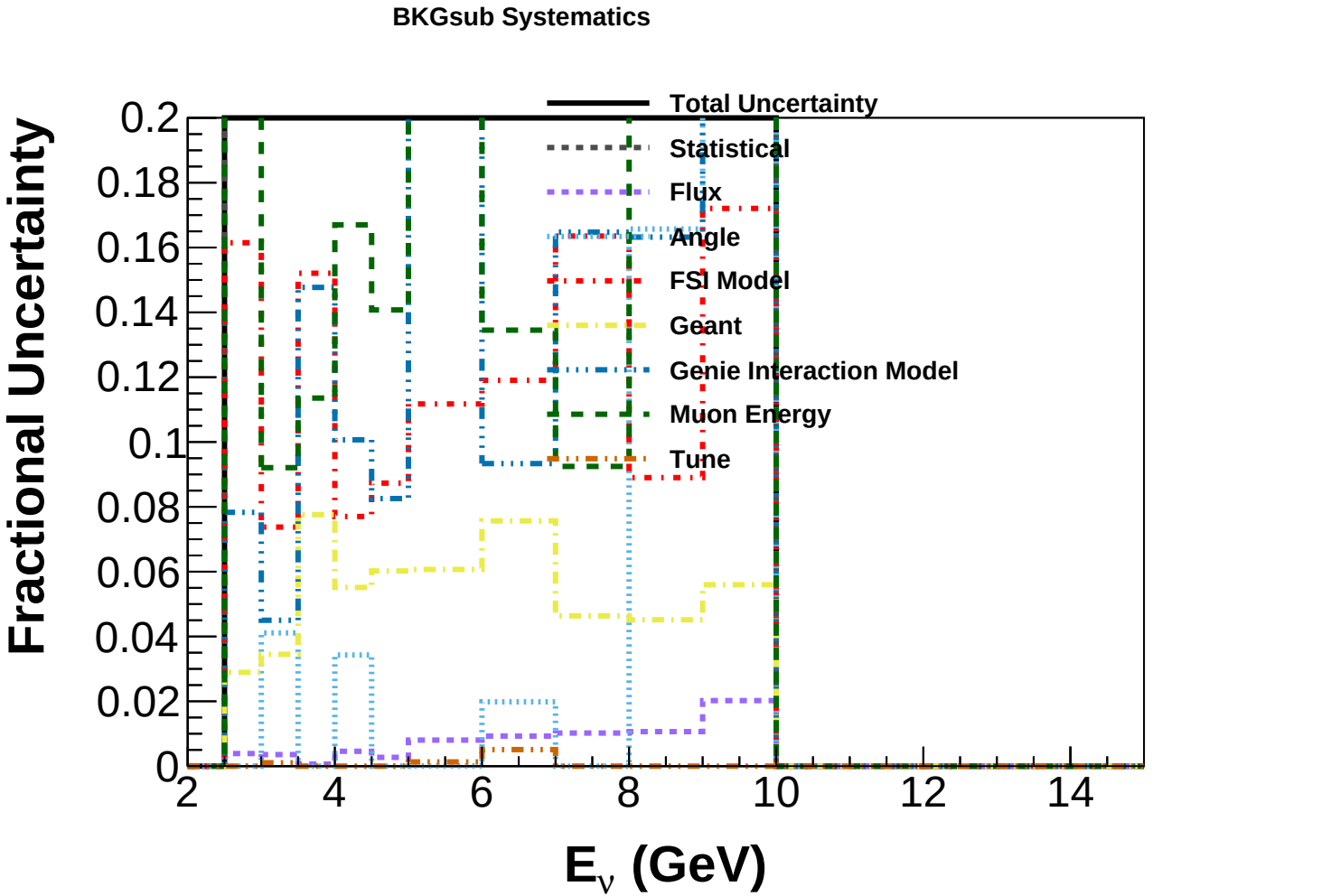

Signal Fraction
Data
Simulation
Counts per unit
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2
4
6
8
10
12
14
E_ν (GeV)

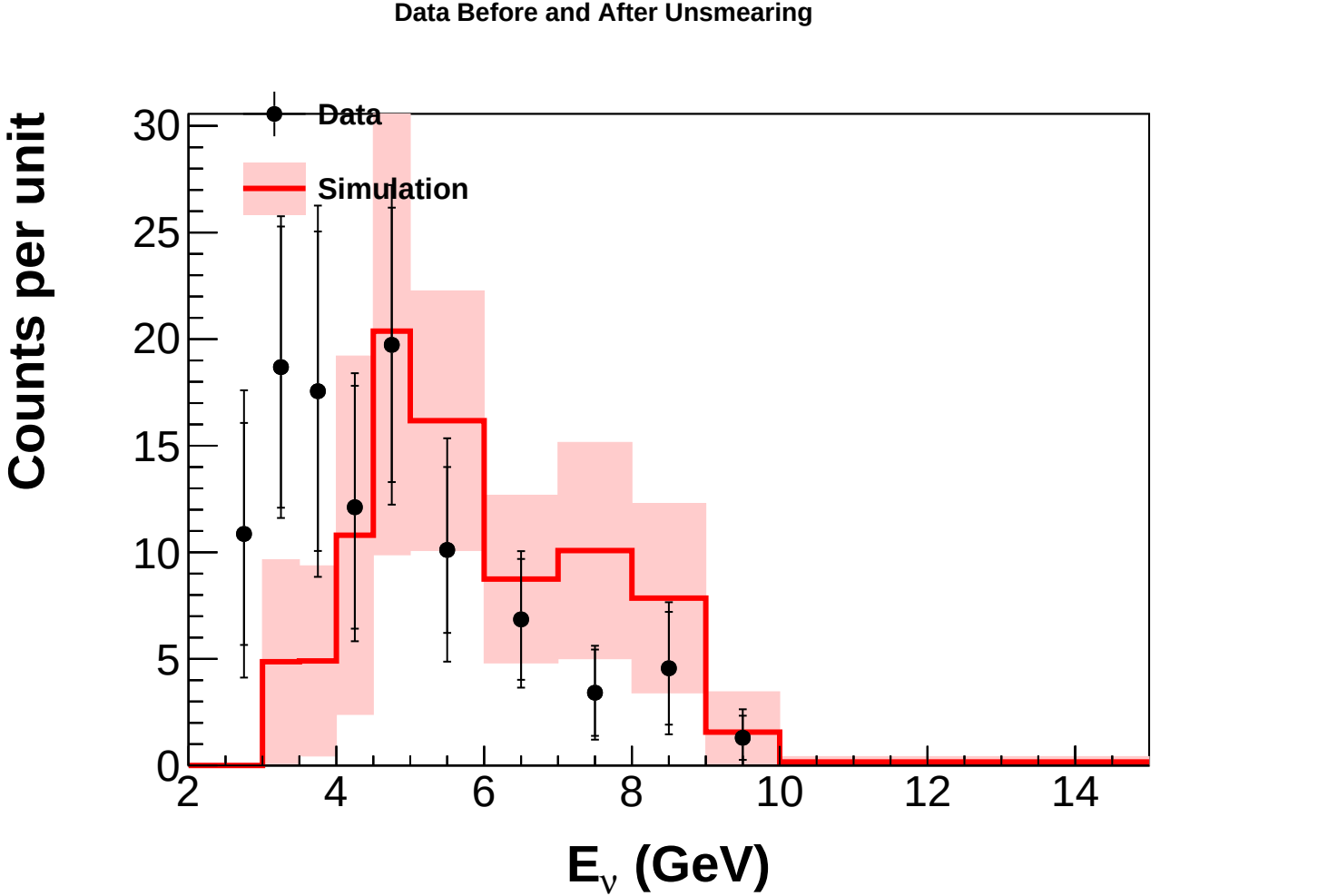

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

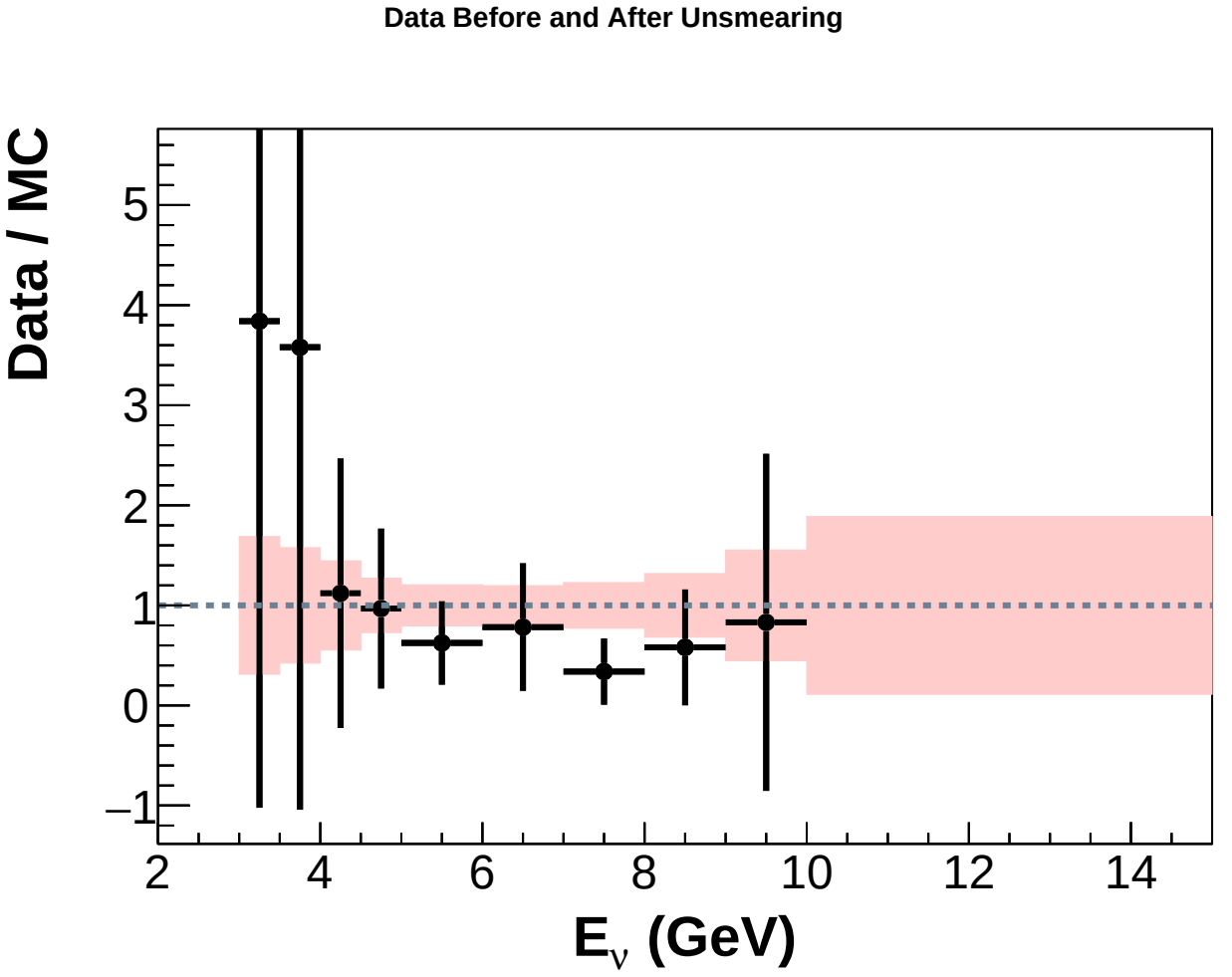

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

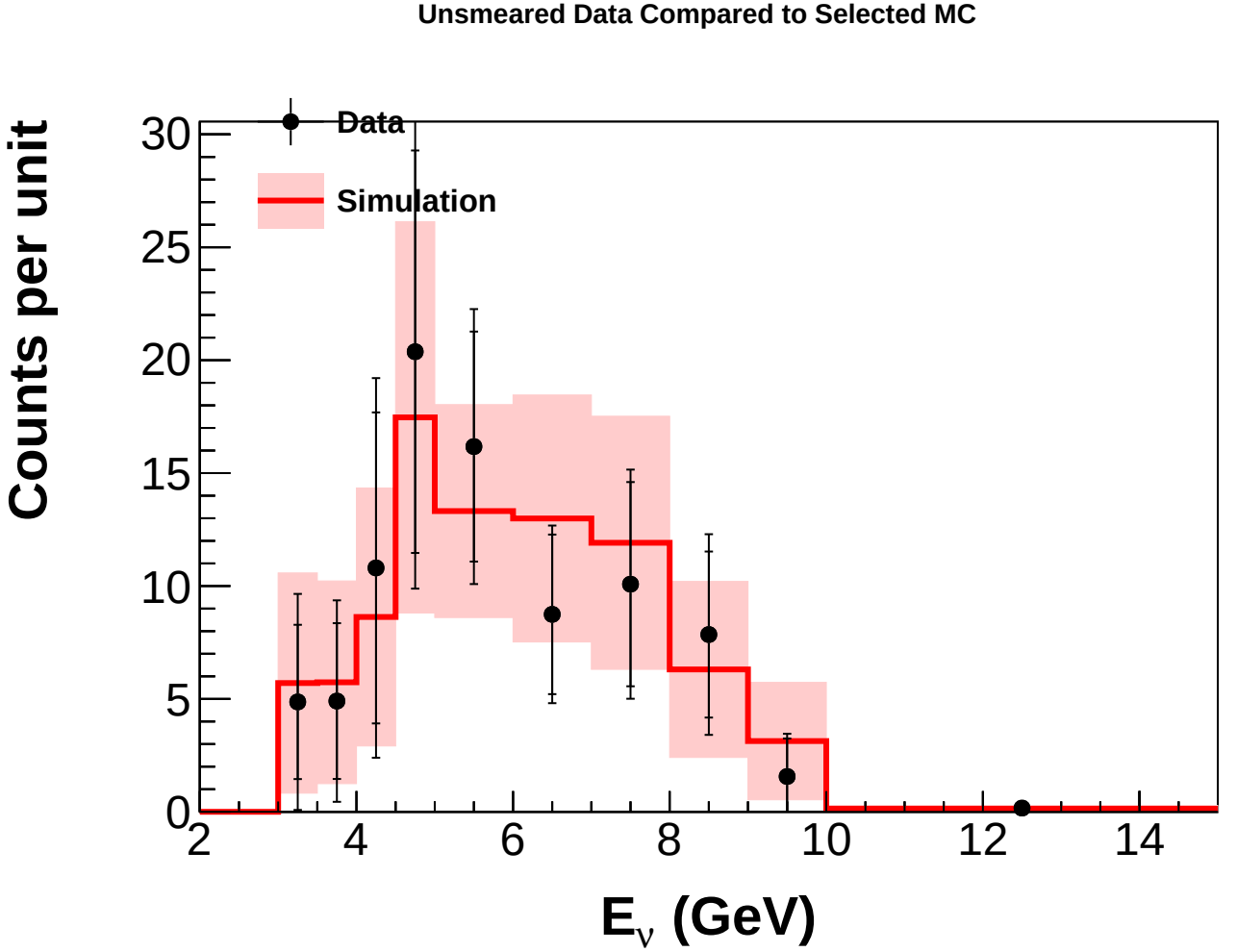

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
E_ν (GeV)

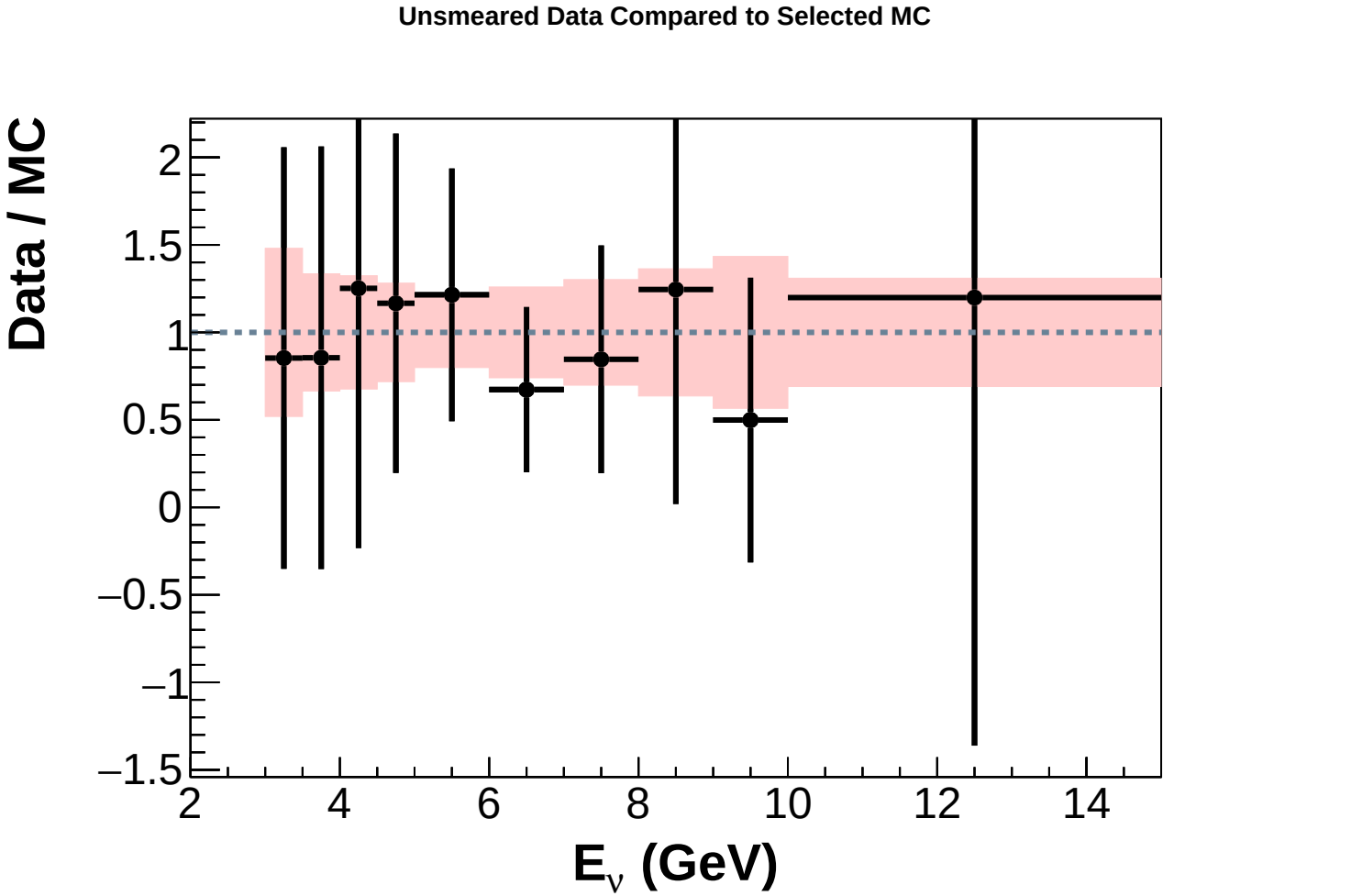

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

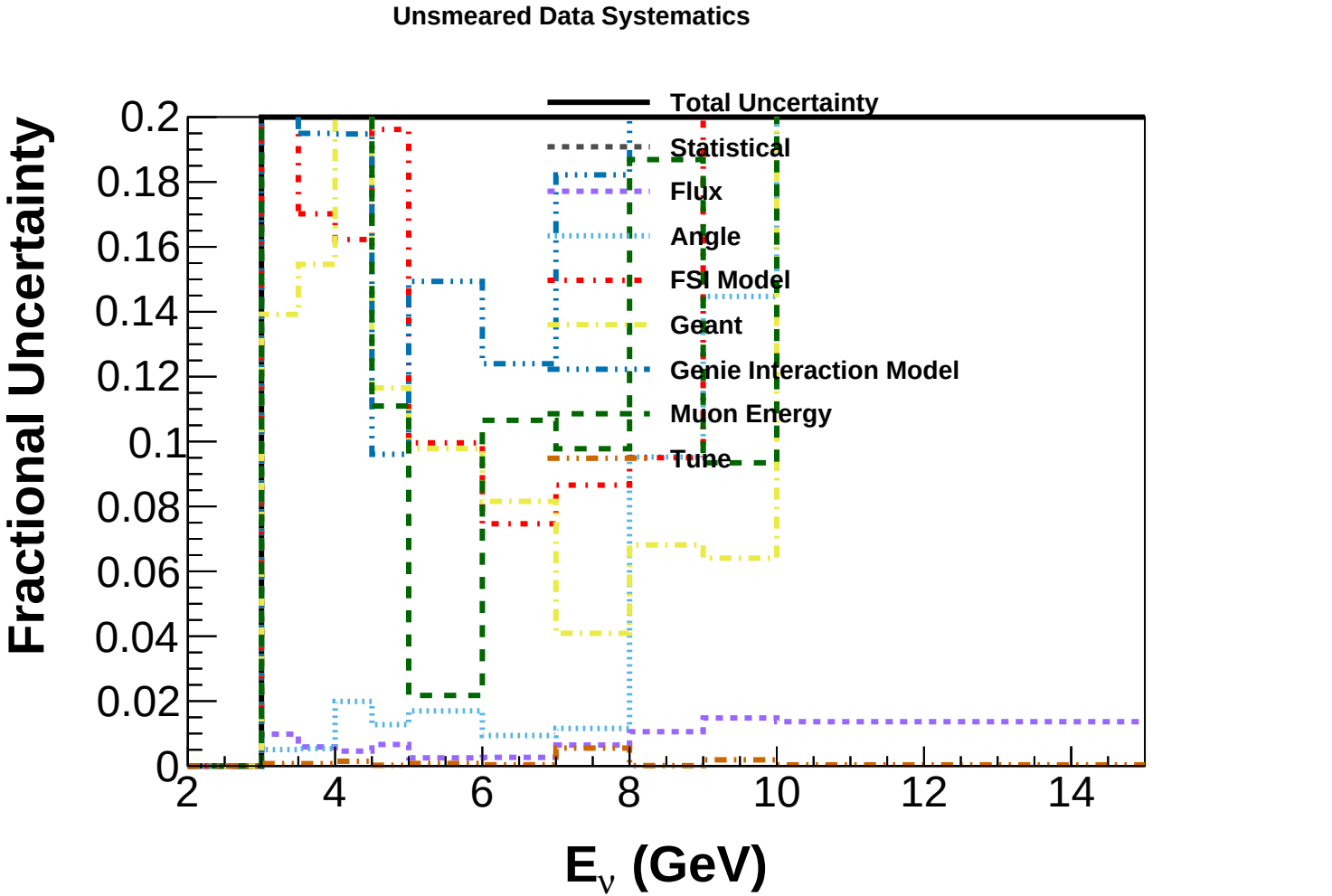

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

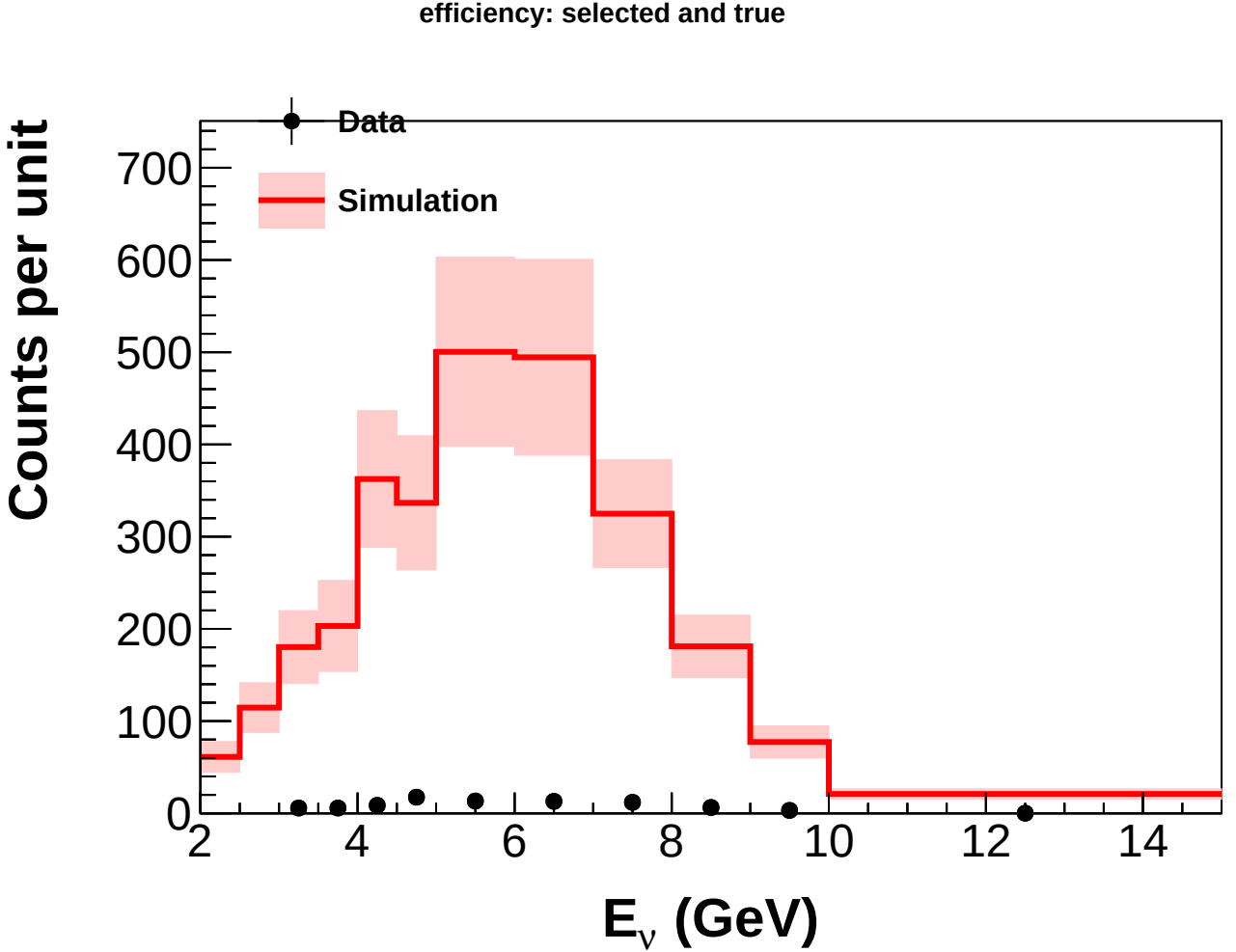

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
2
4
6
8
10
12
14
E_ν (GeV)


Data Before and After Unsmearing
Data / MC
5
4
3
2
1
0
−1
2
4
6
8
10
12
14
E_ν (GeV)

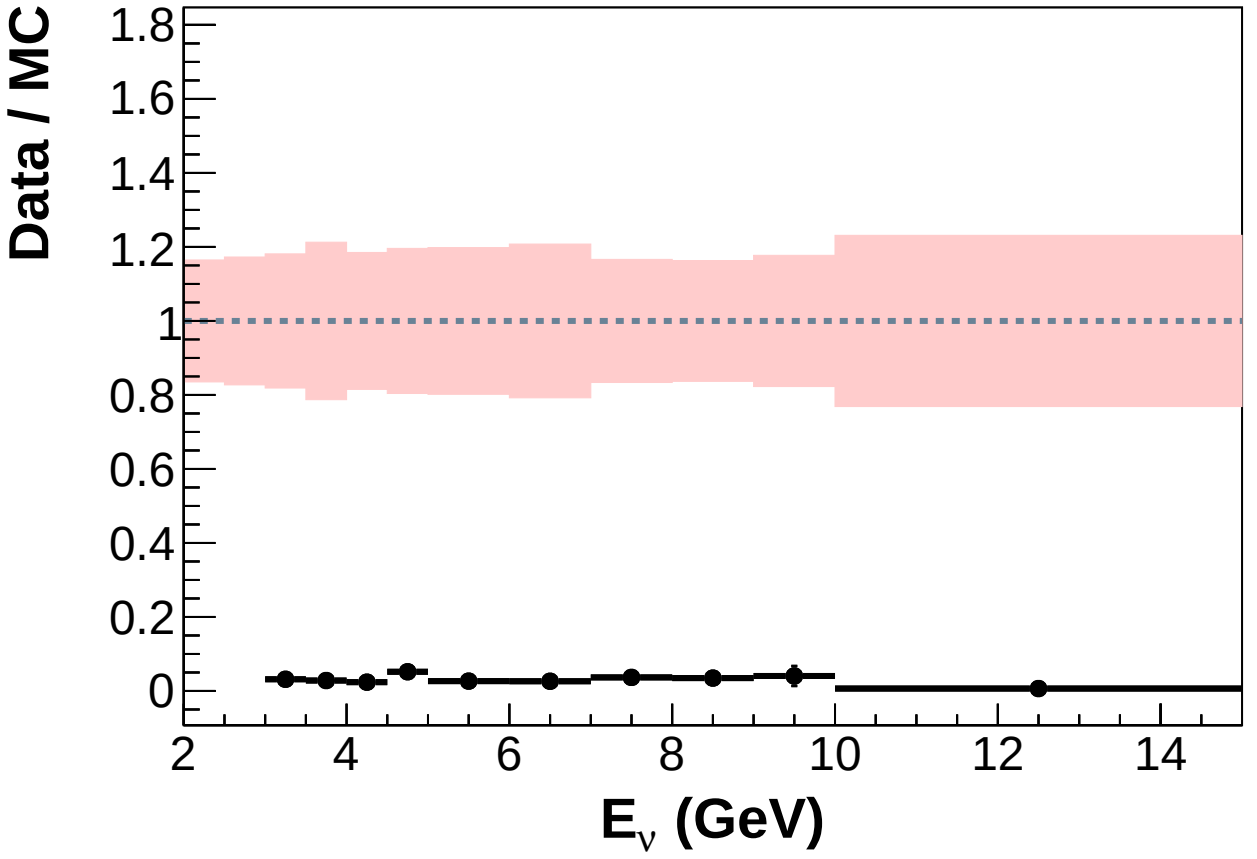

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
2
4
6
8
10
12
14
E_ν (GeV)

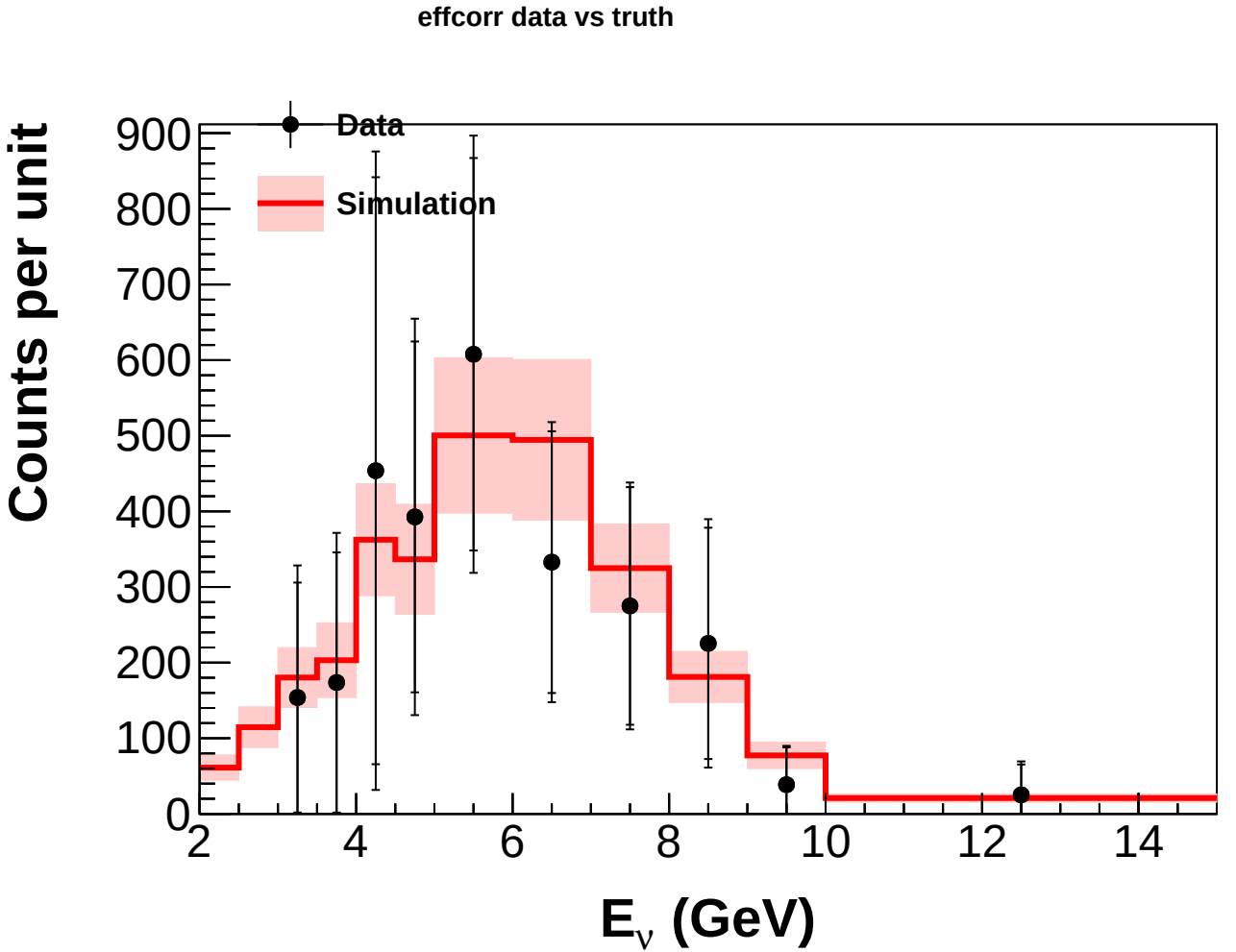

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
−1.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

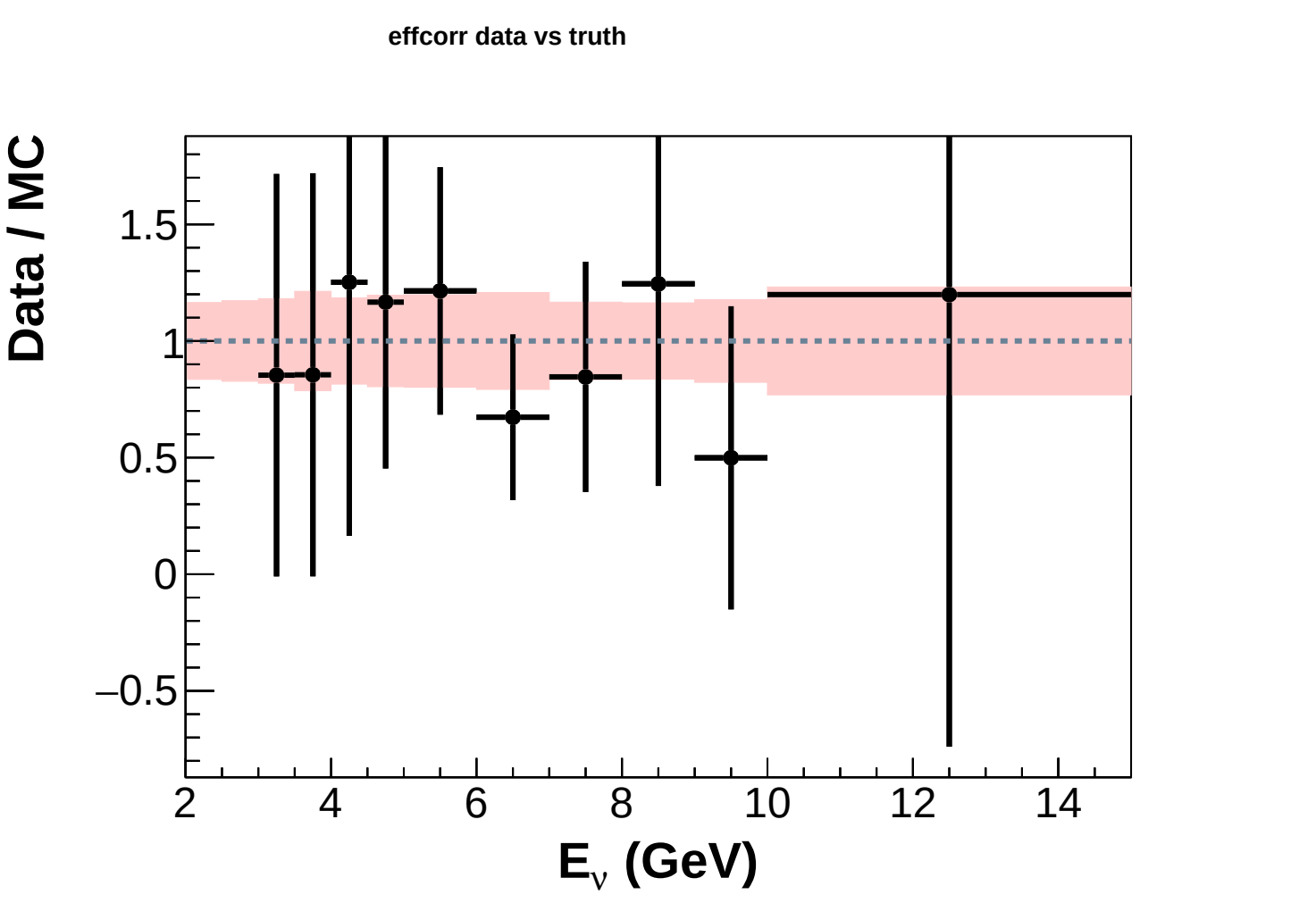

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

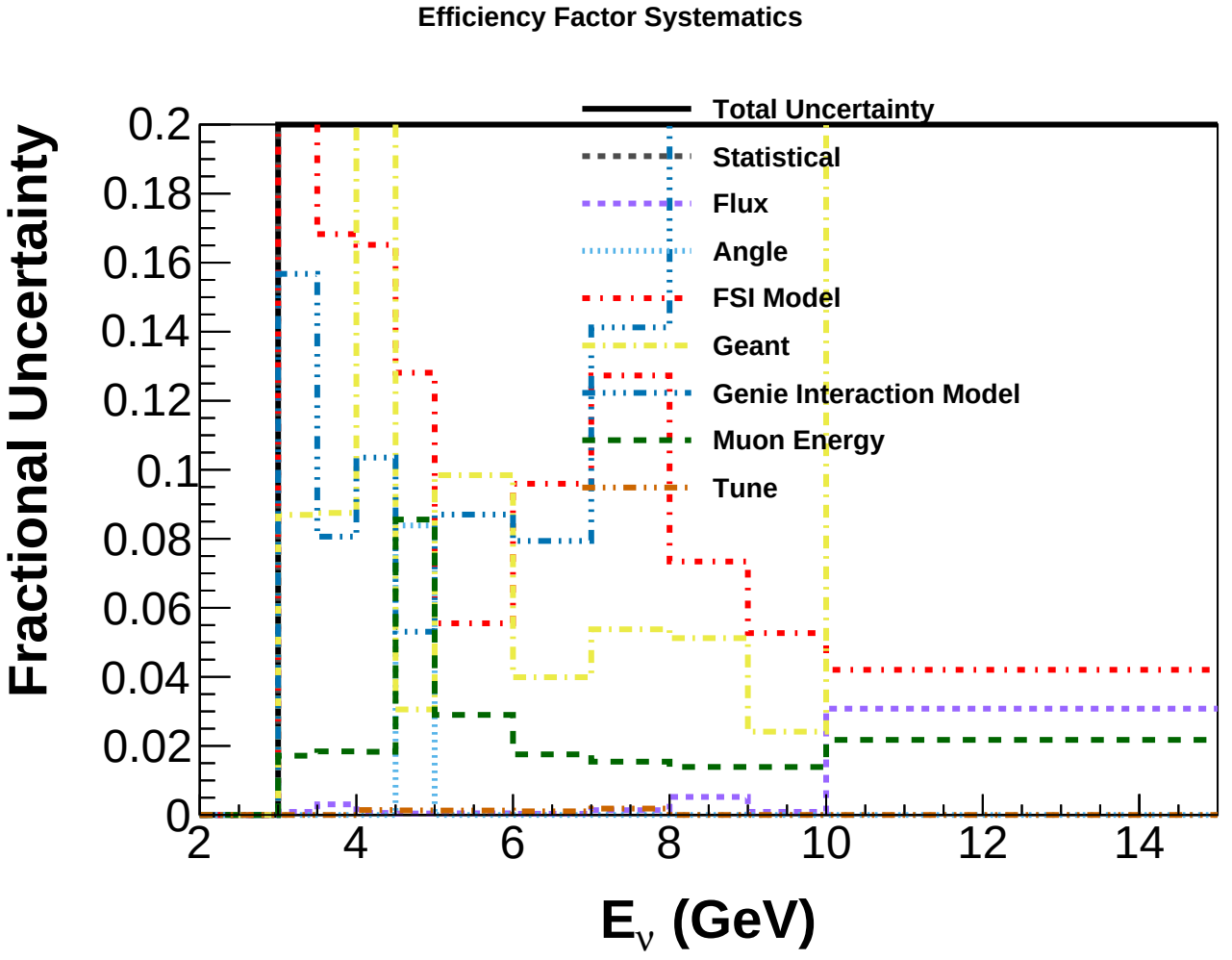

efficiency: selected and true
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
2
4
6
8
10
12
14
E_ν (GeV)

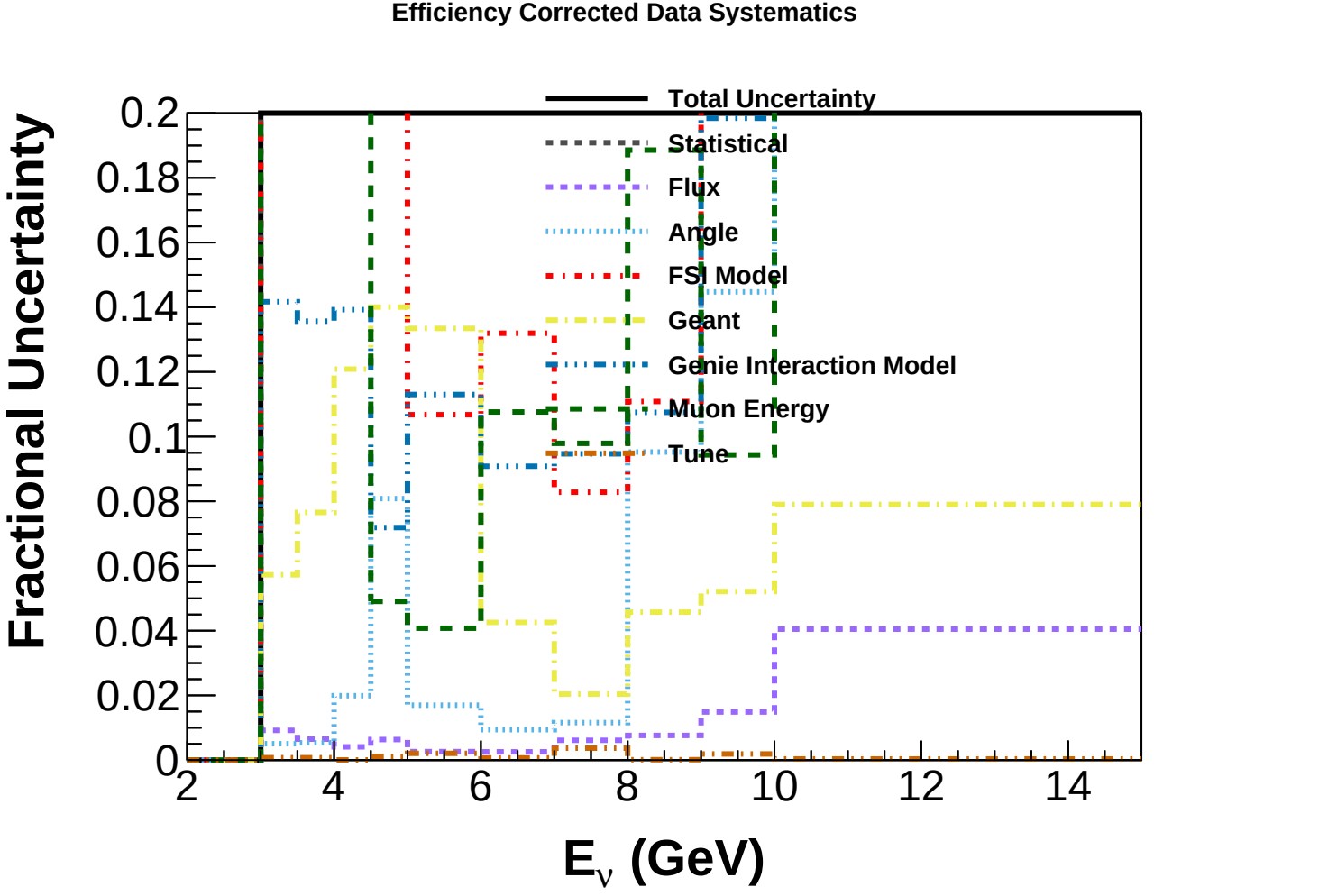
efficiency: selected and true

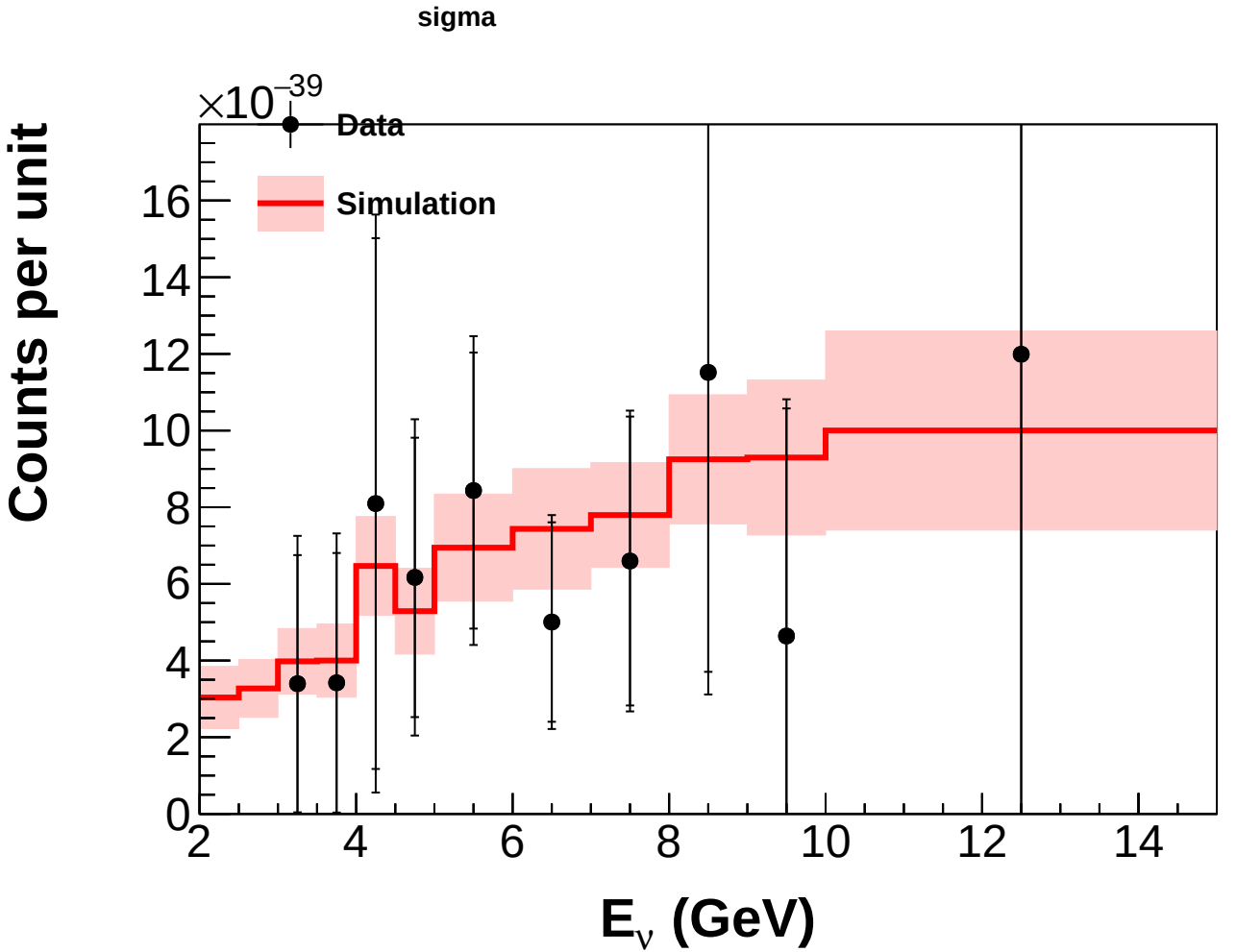


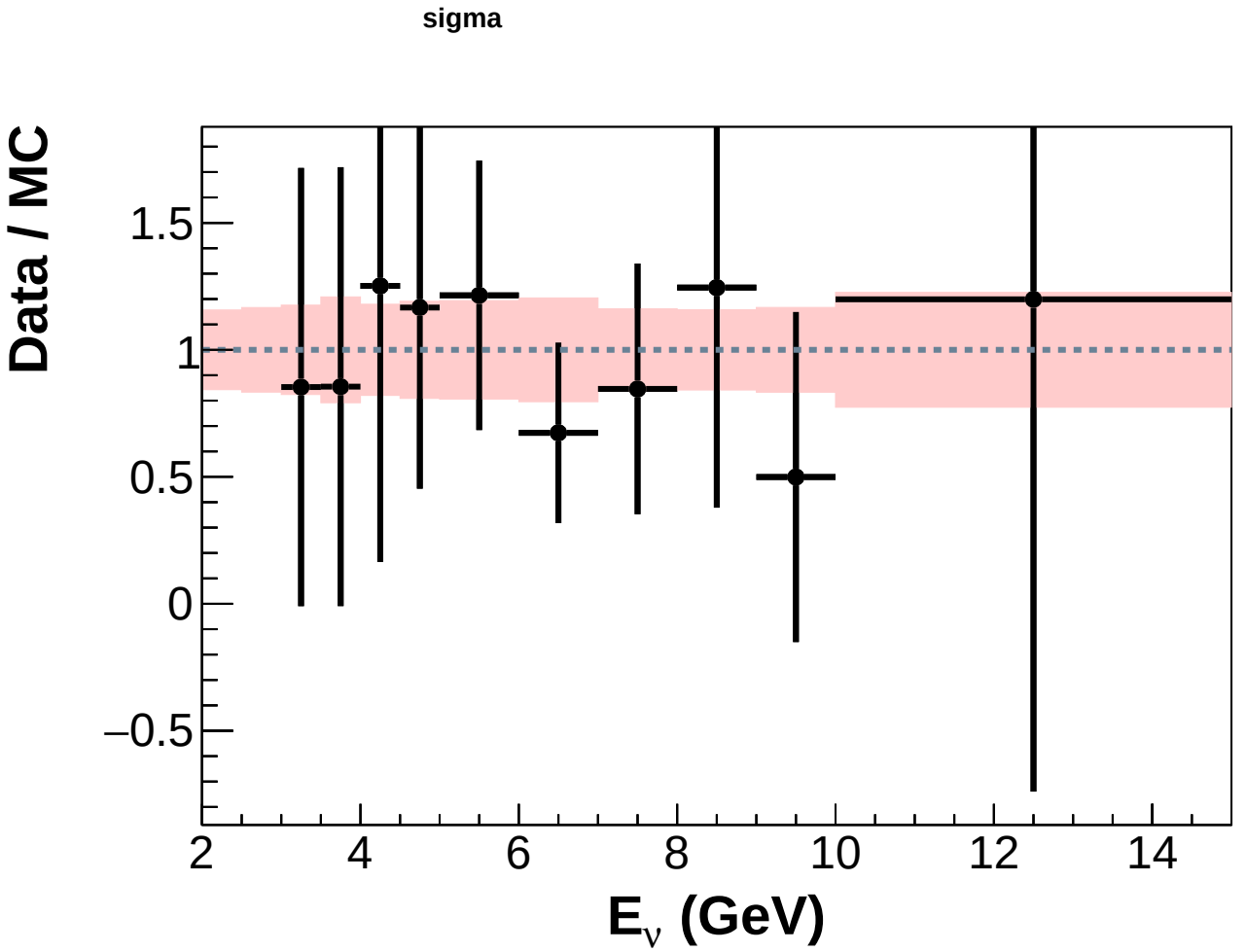

effcorr data vs truth
Data
Simulation
Counts per unit
900
800
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
E_ν (GeV)

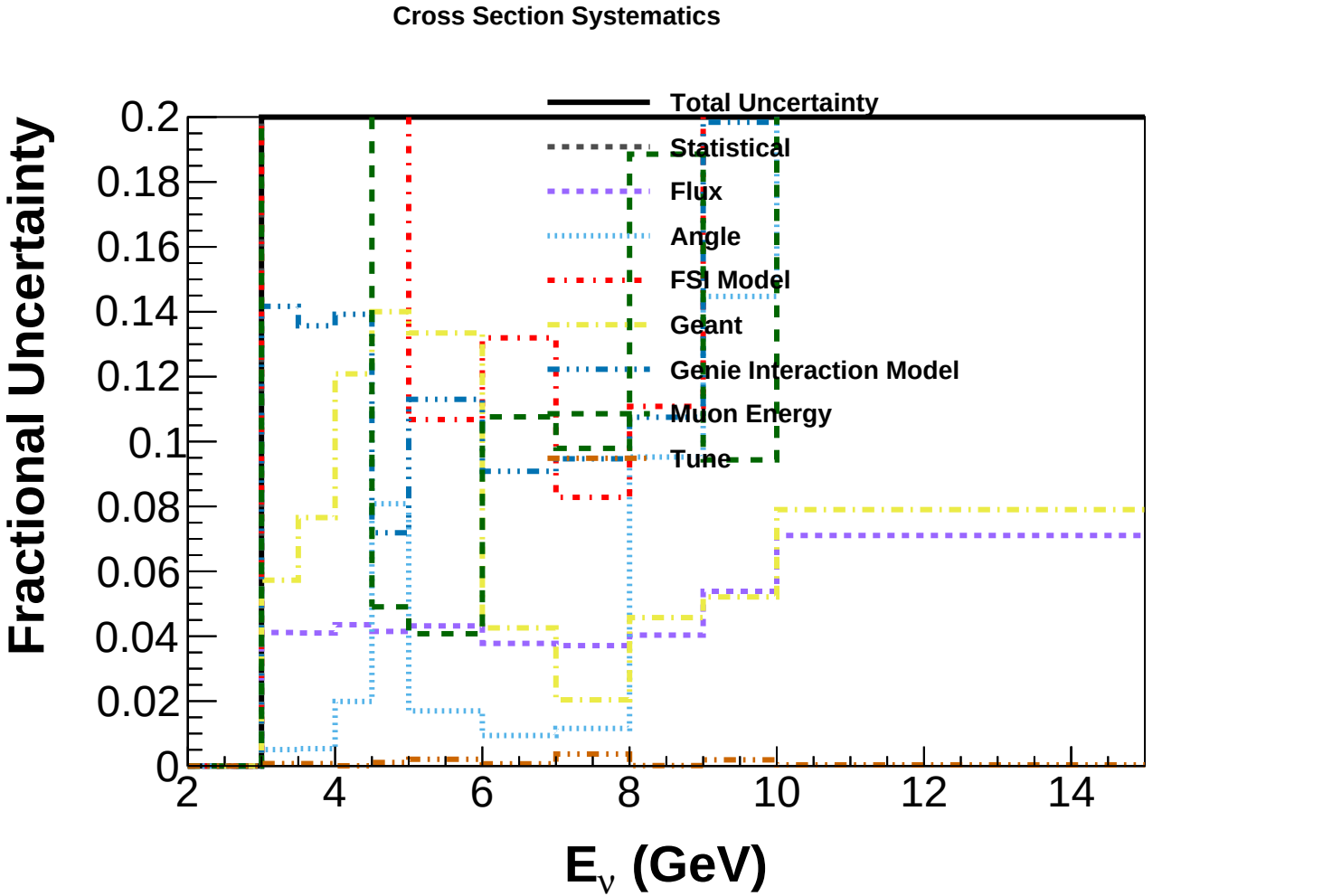

effcorr data vs truth
Data / MC
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E_ν (GeV)

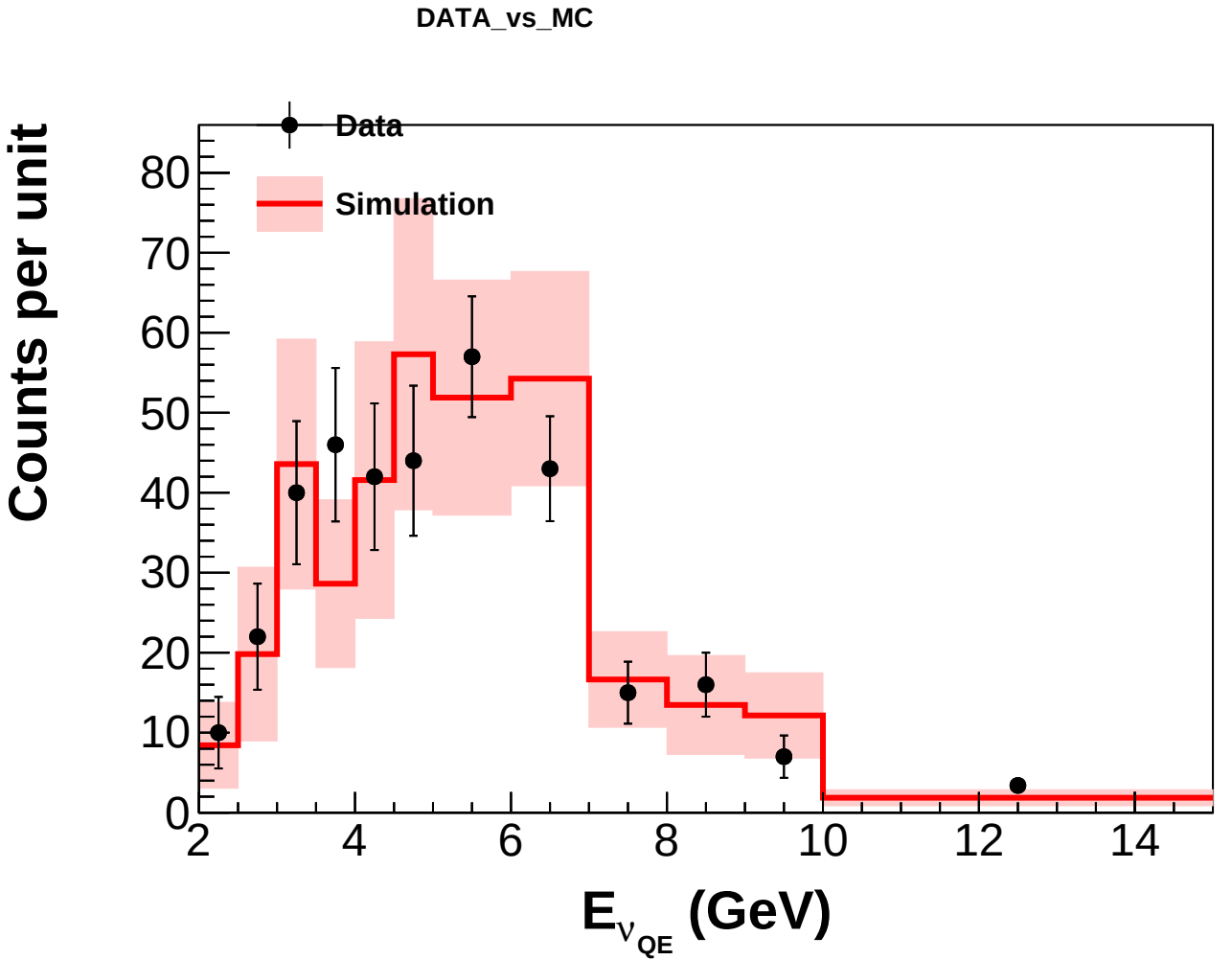

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

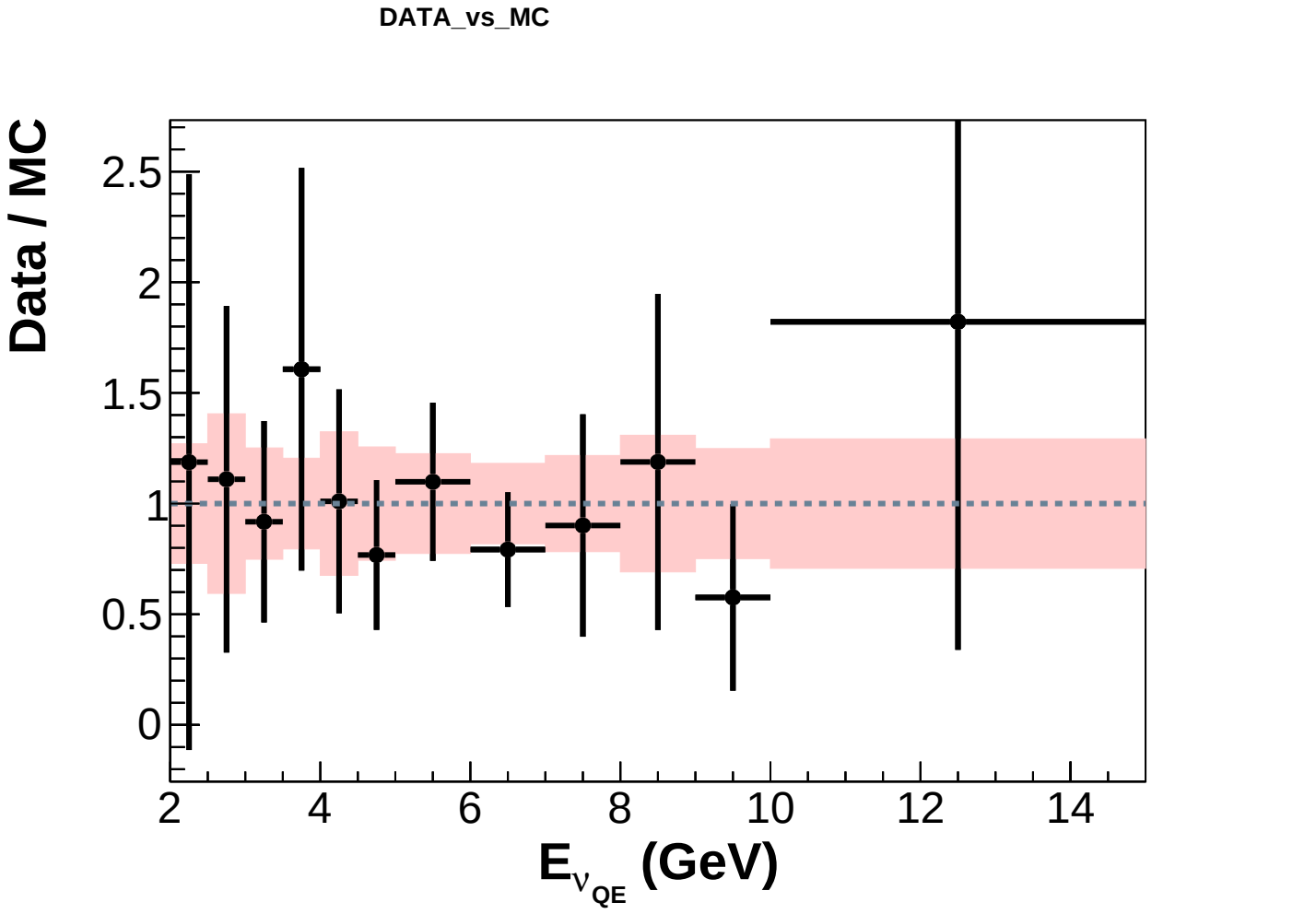

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

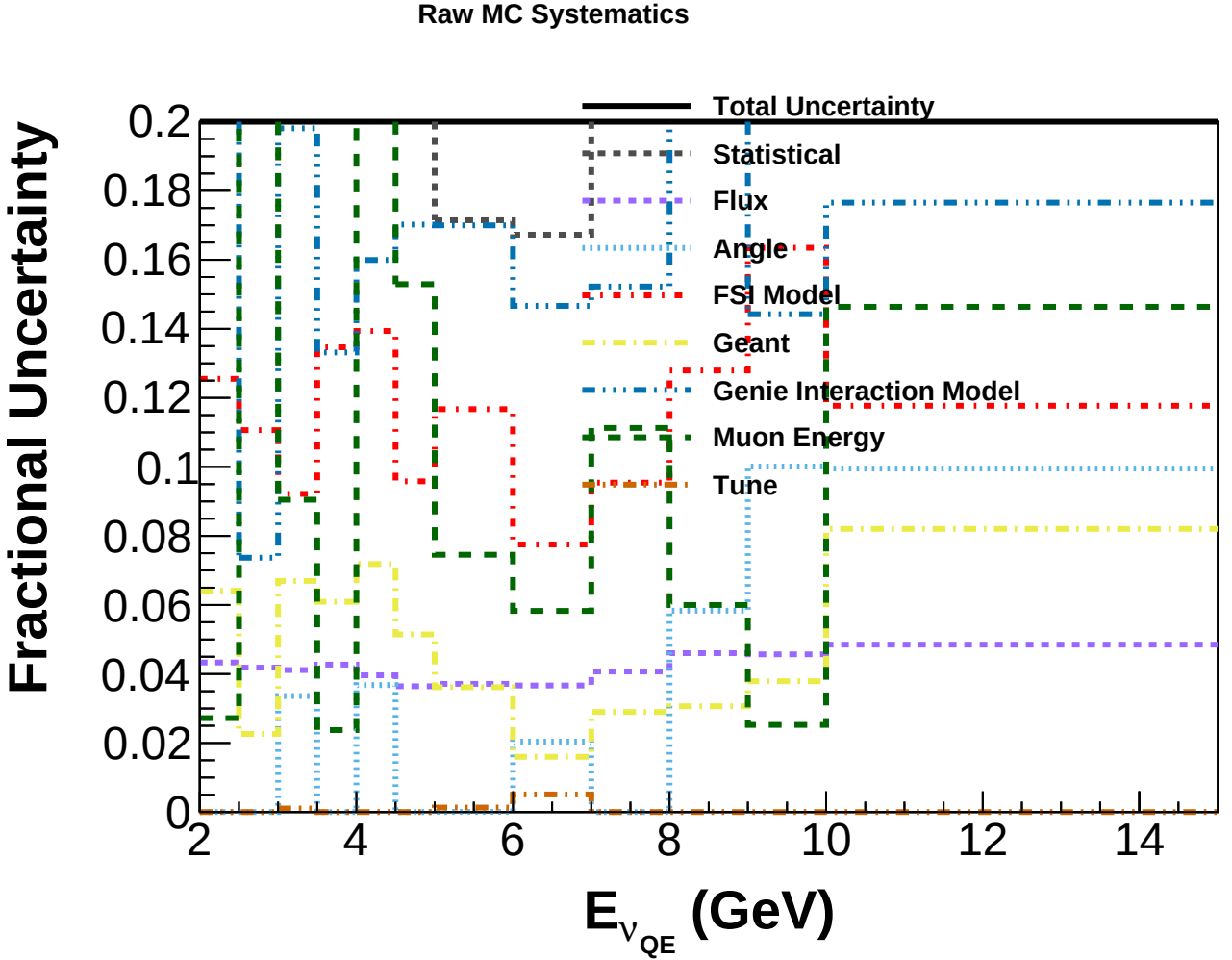

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
0
2
4
6
8
10
12
14
16
2
4
6
8
10
12
14
E_ν (GeV)

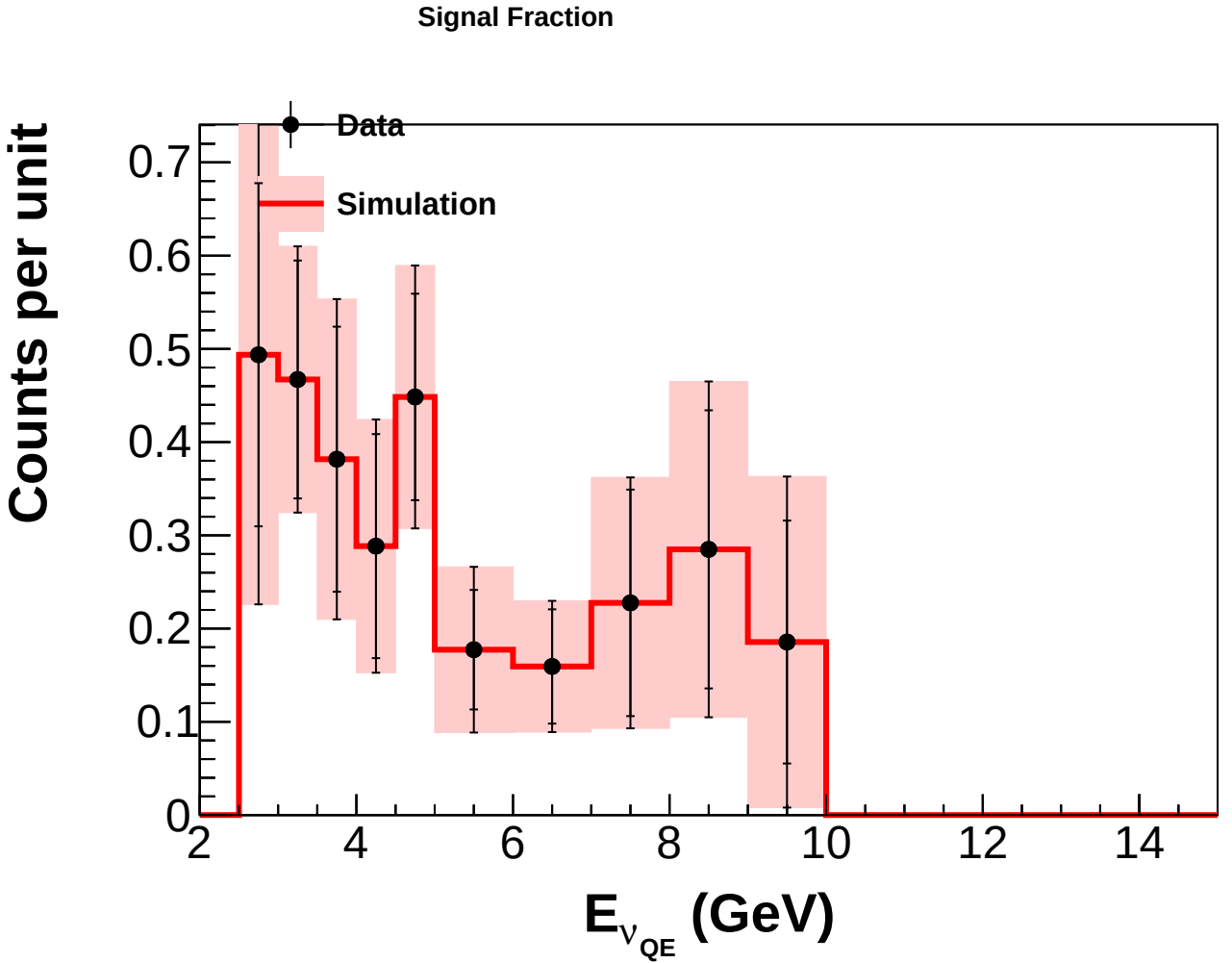

sigma
Data / MC
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

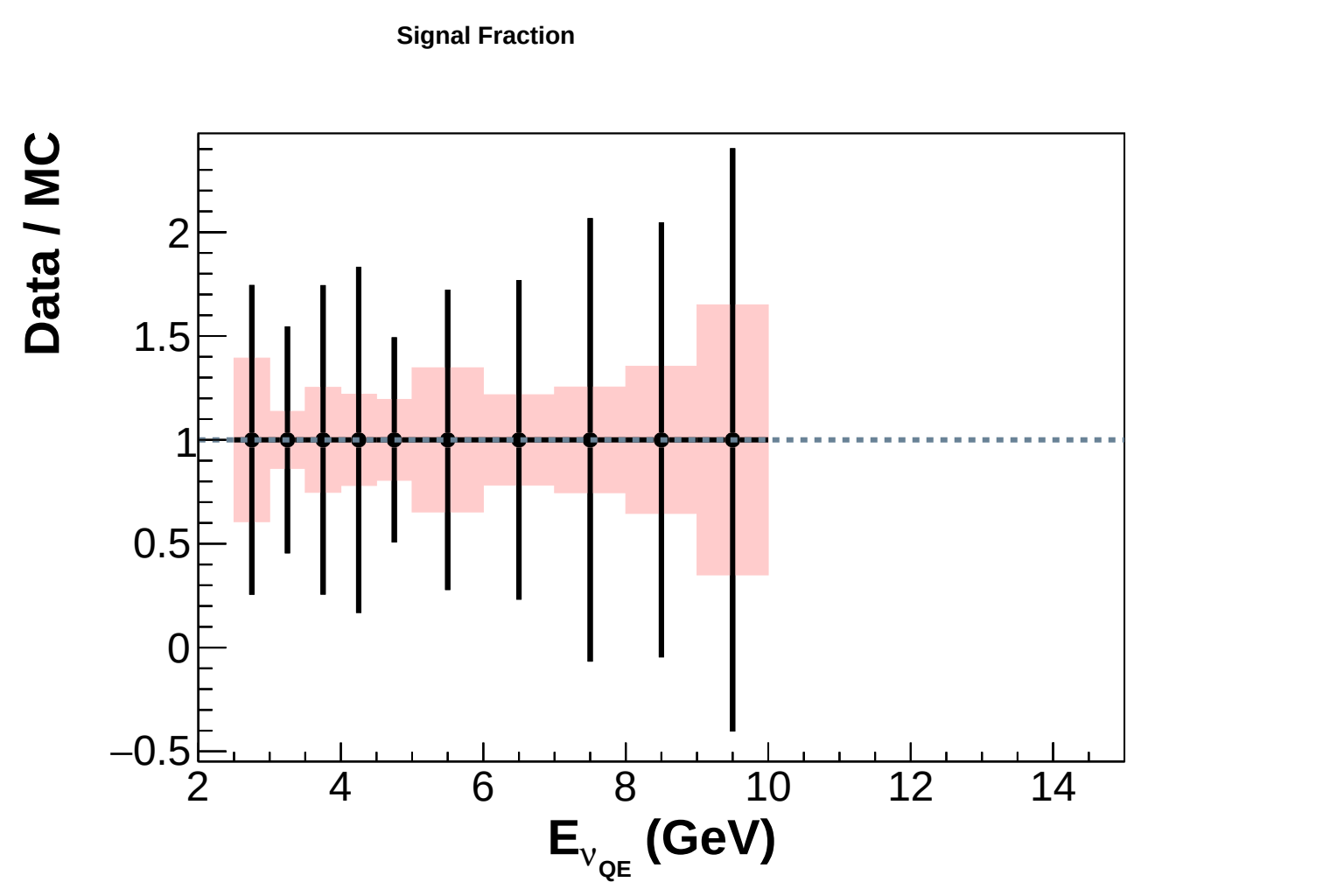

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

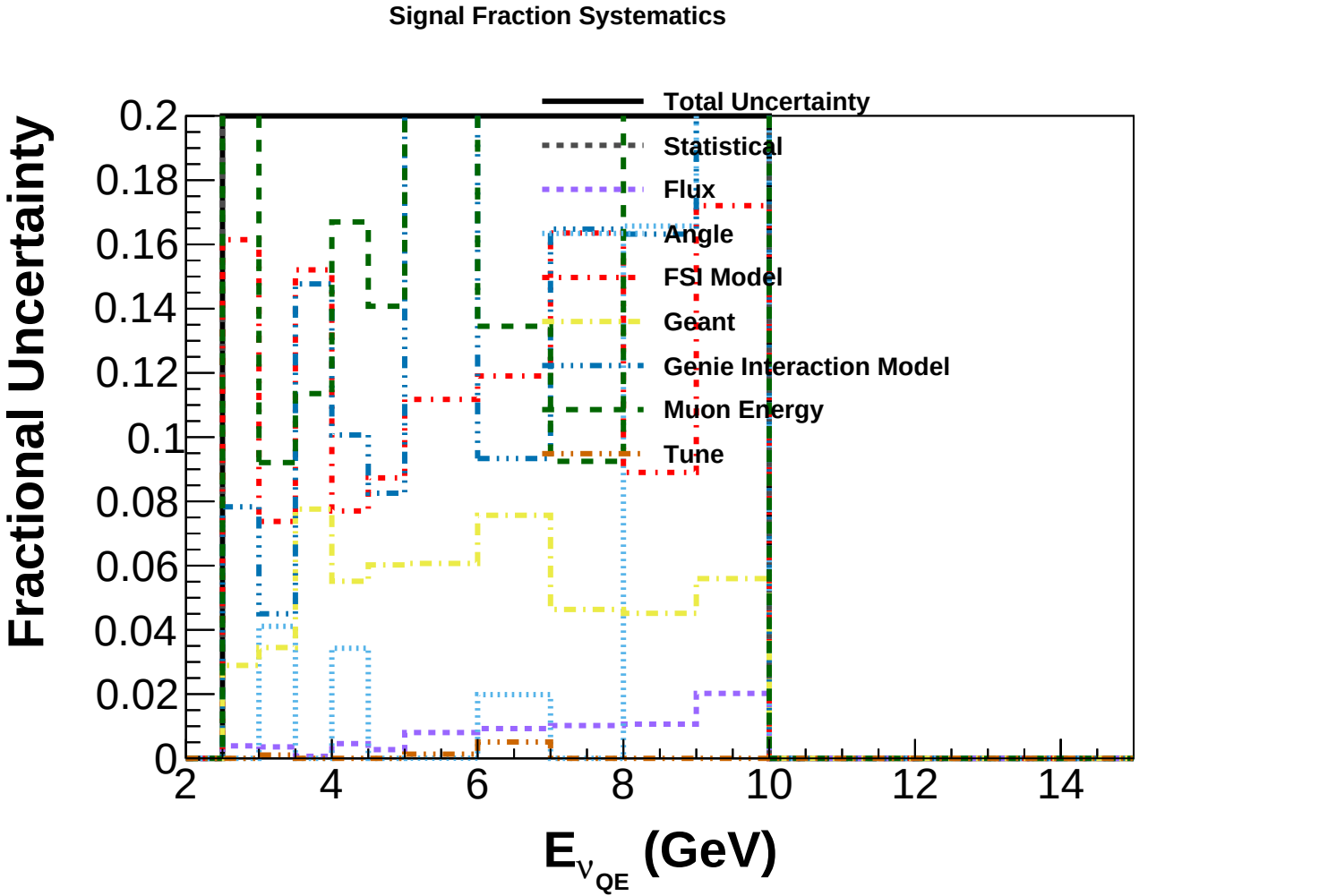

DATA_vs_MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

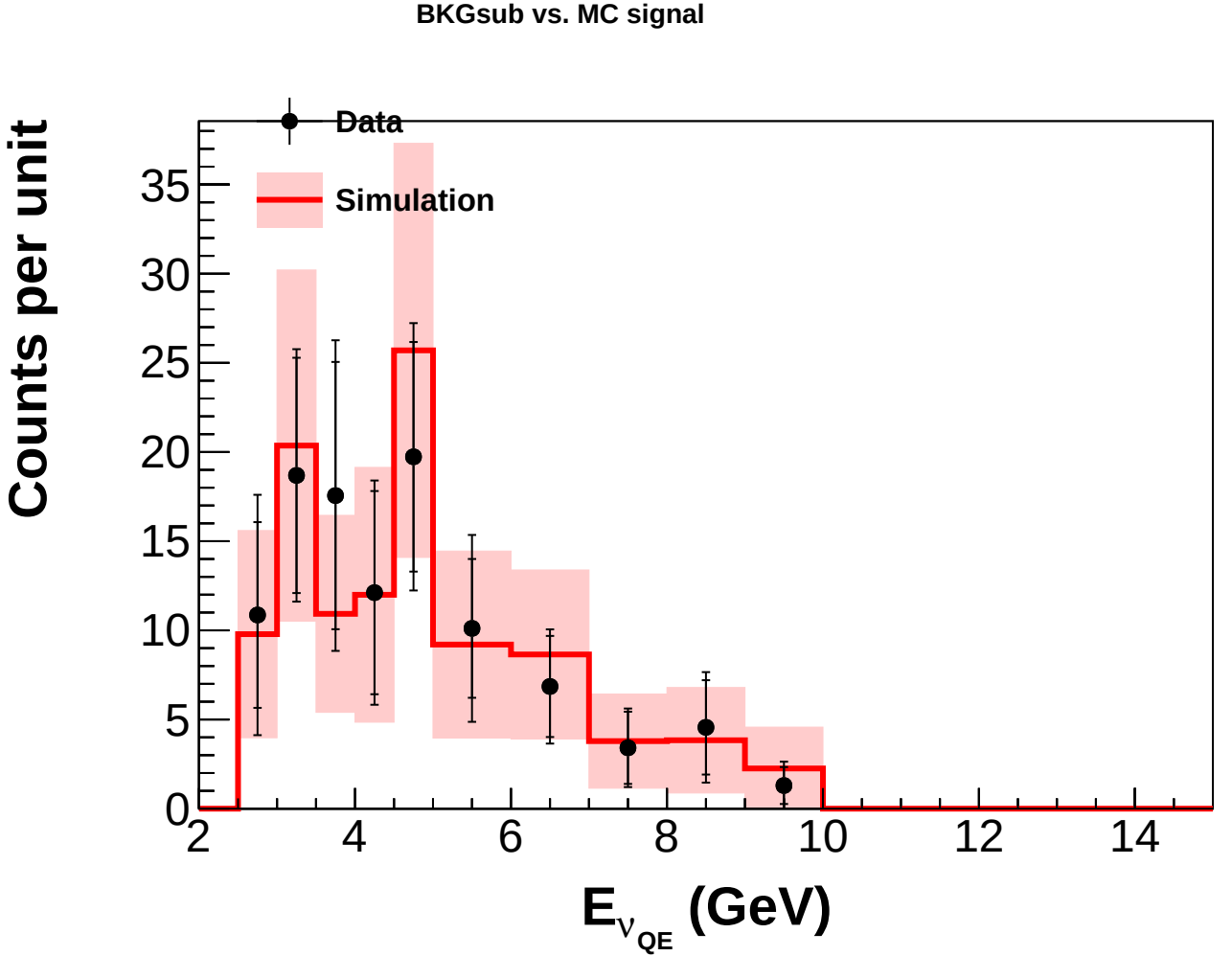

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

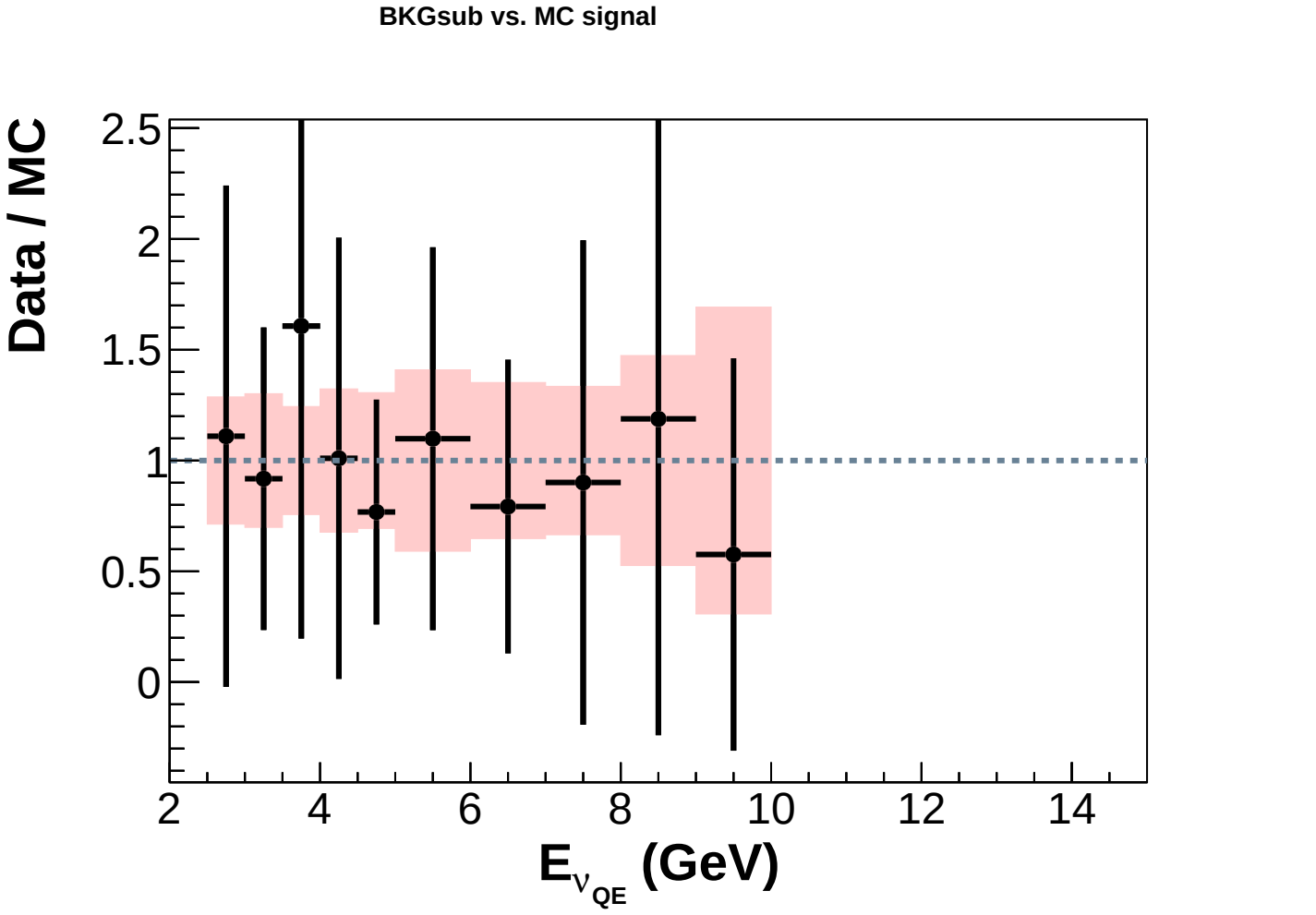

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

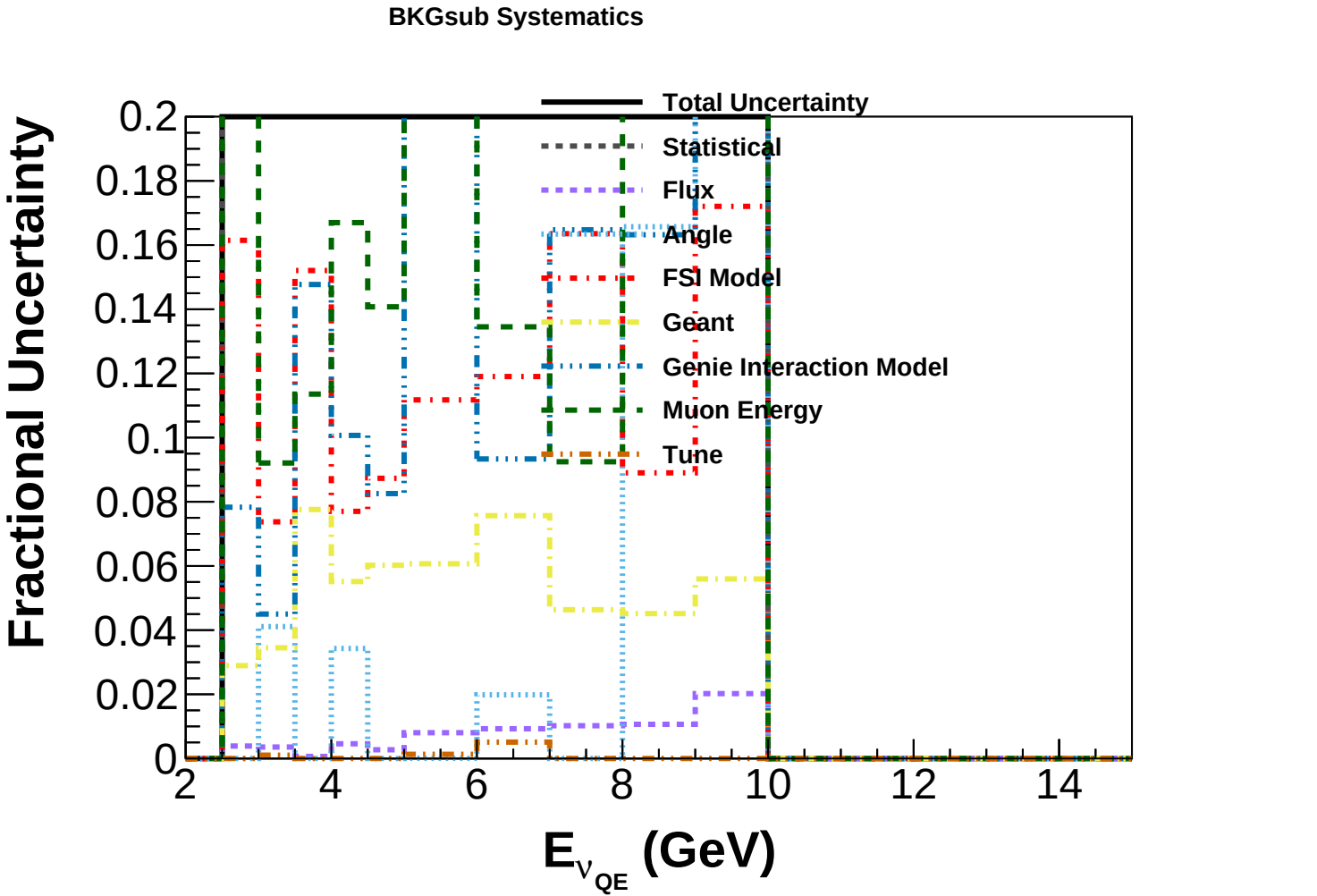

Signal Fraction
Data
Simulation
Counts per unit
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

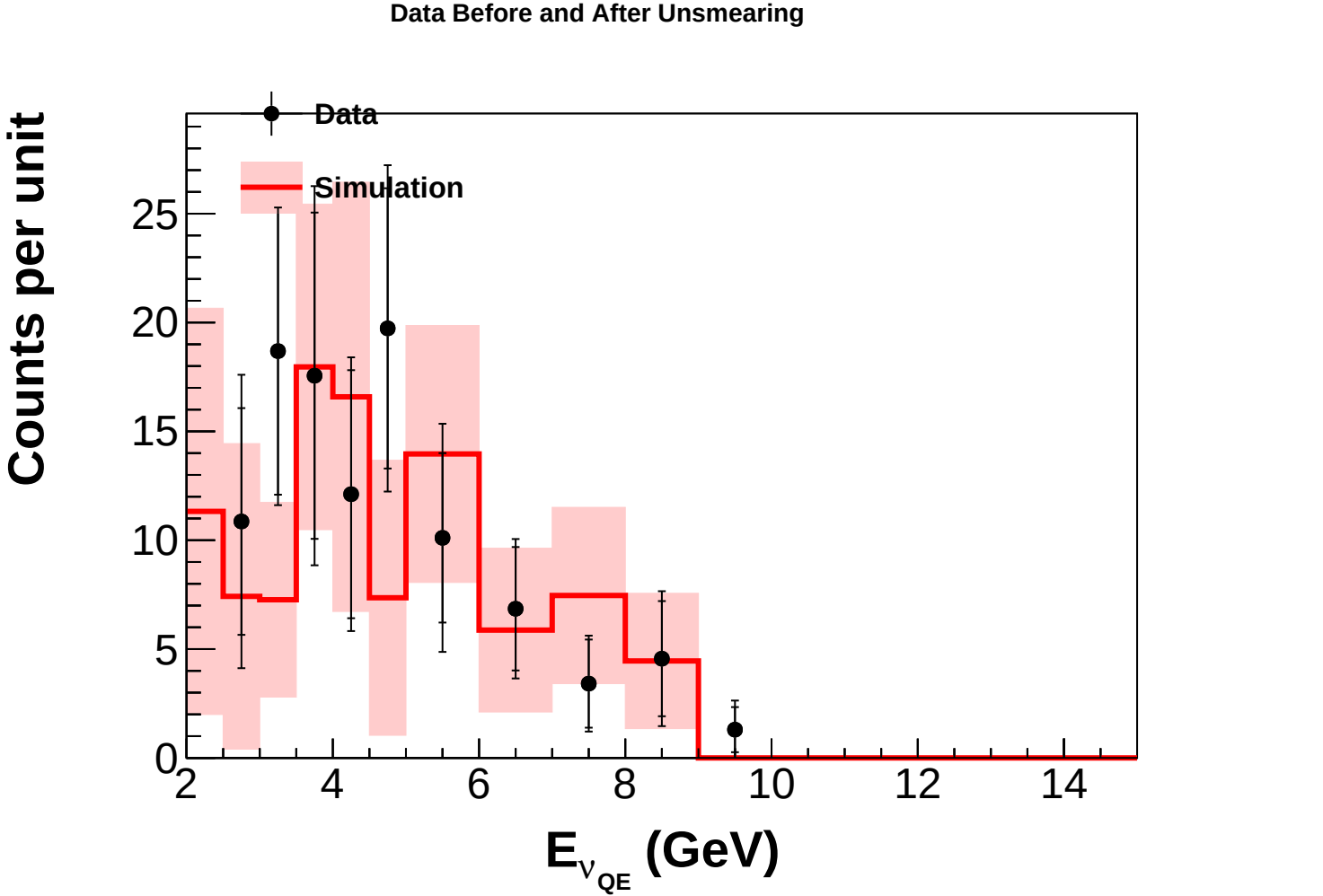

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

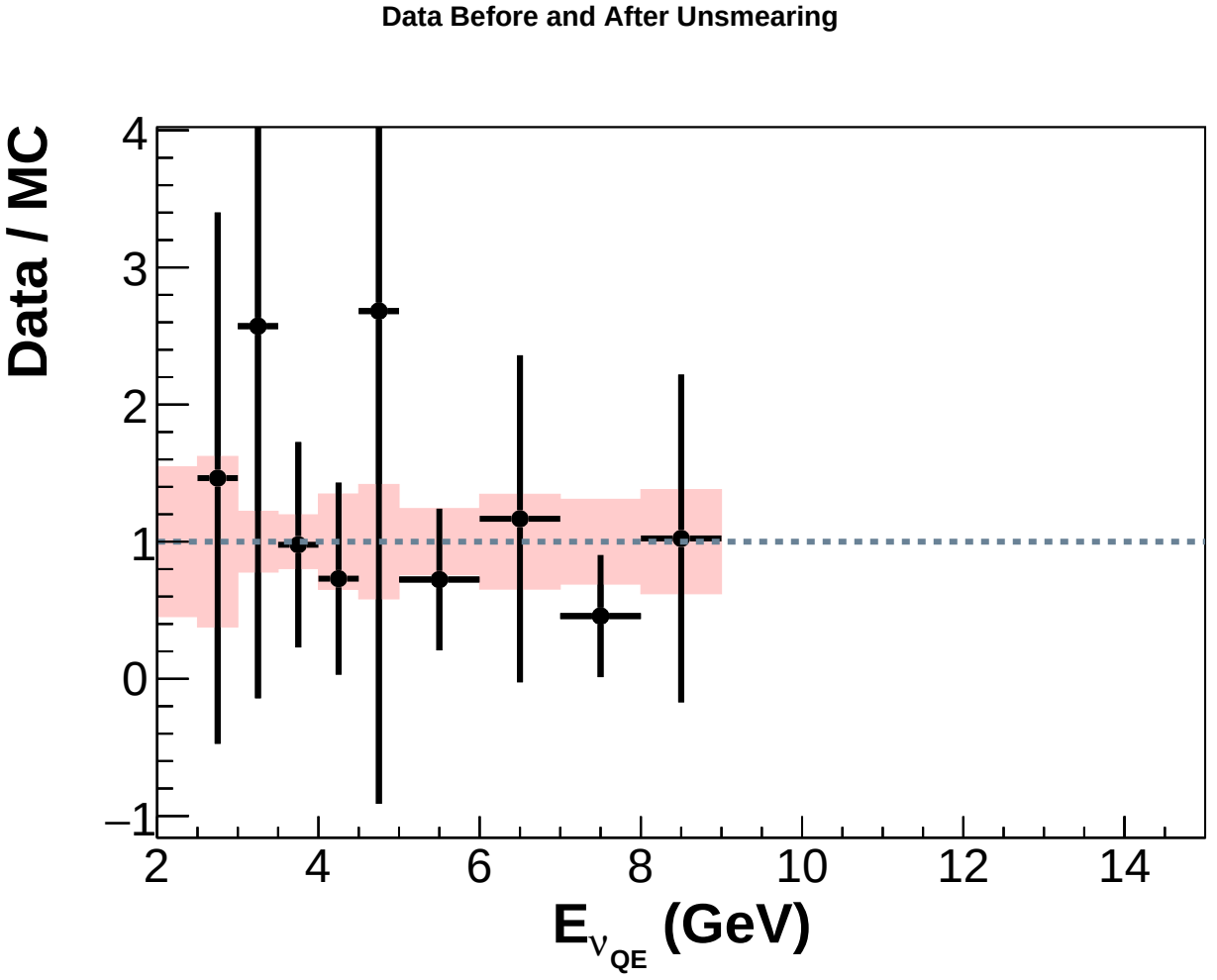

Signal Fraction Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

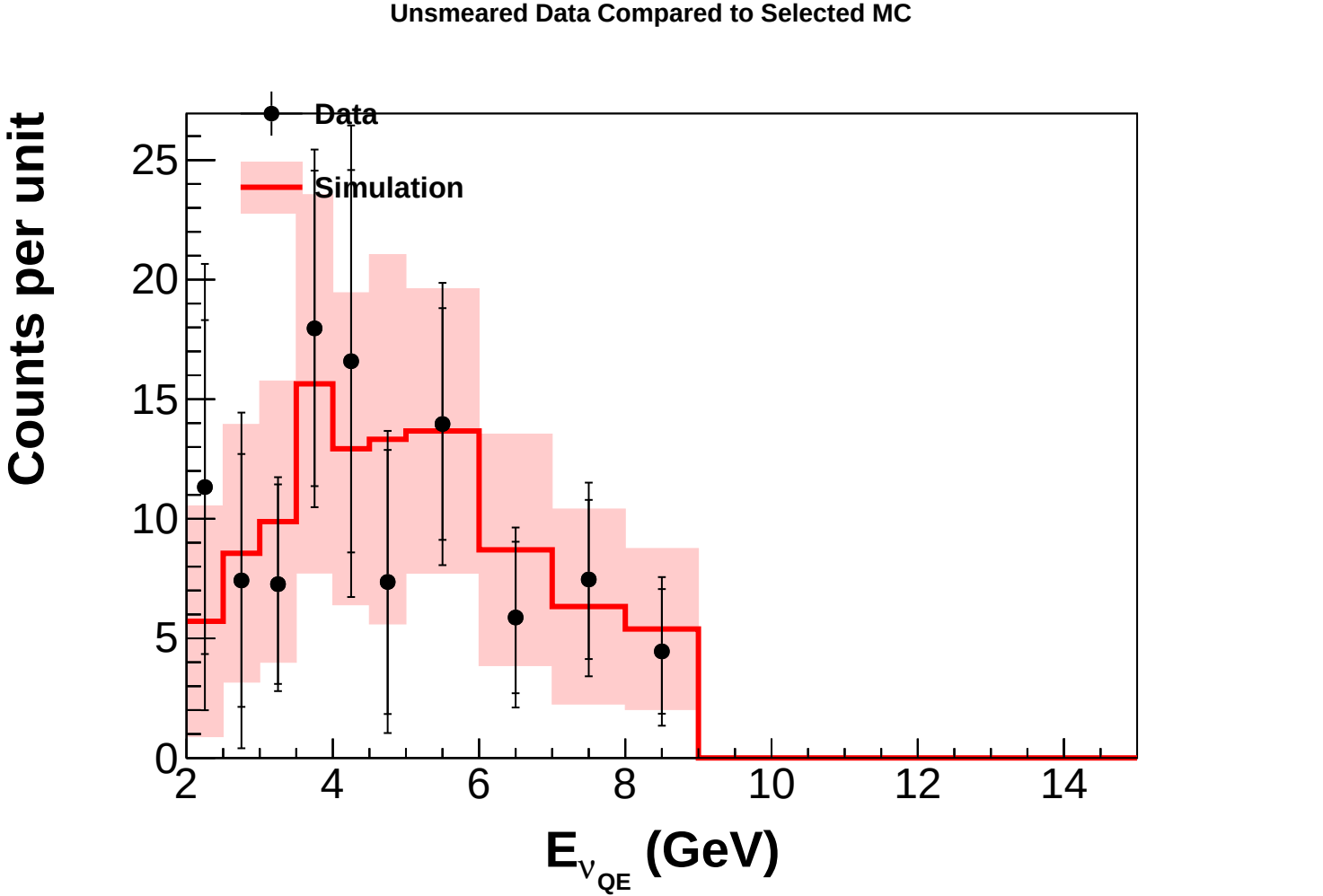

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

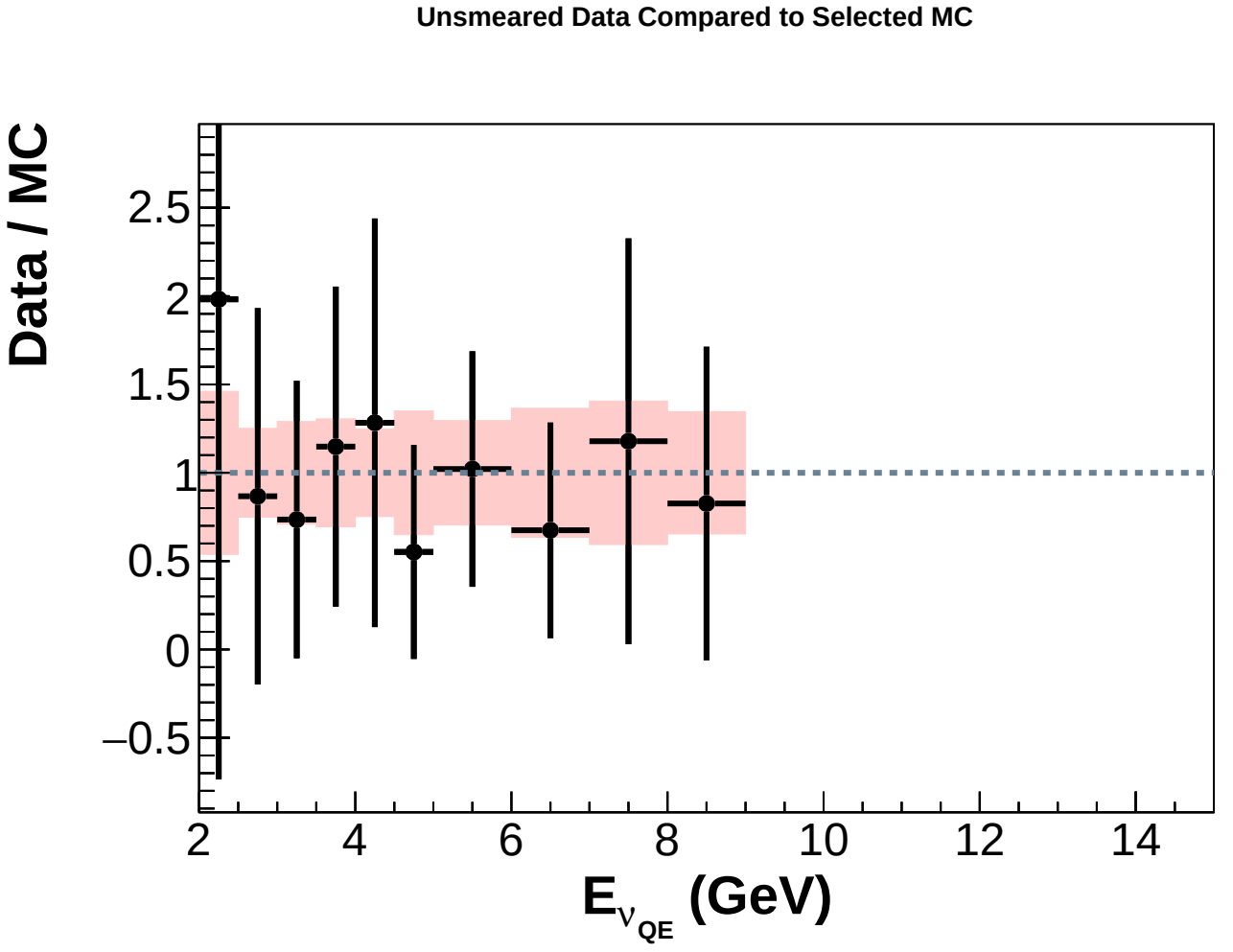

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

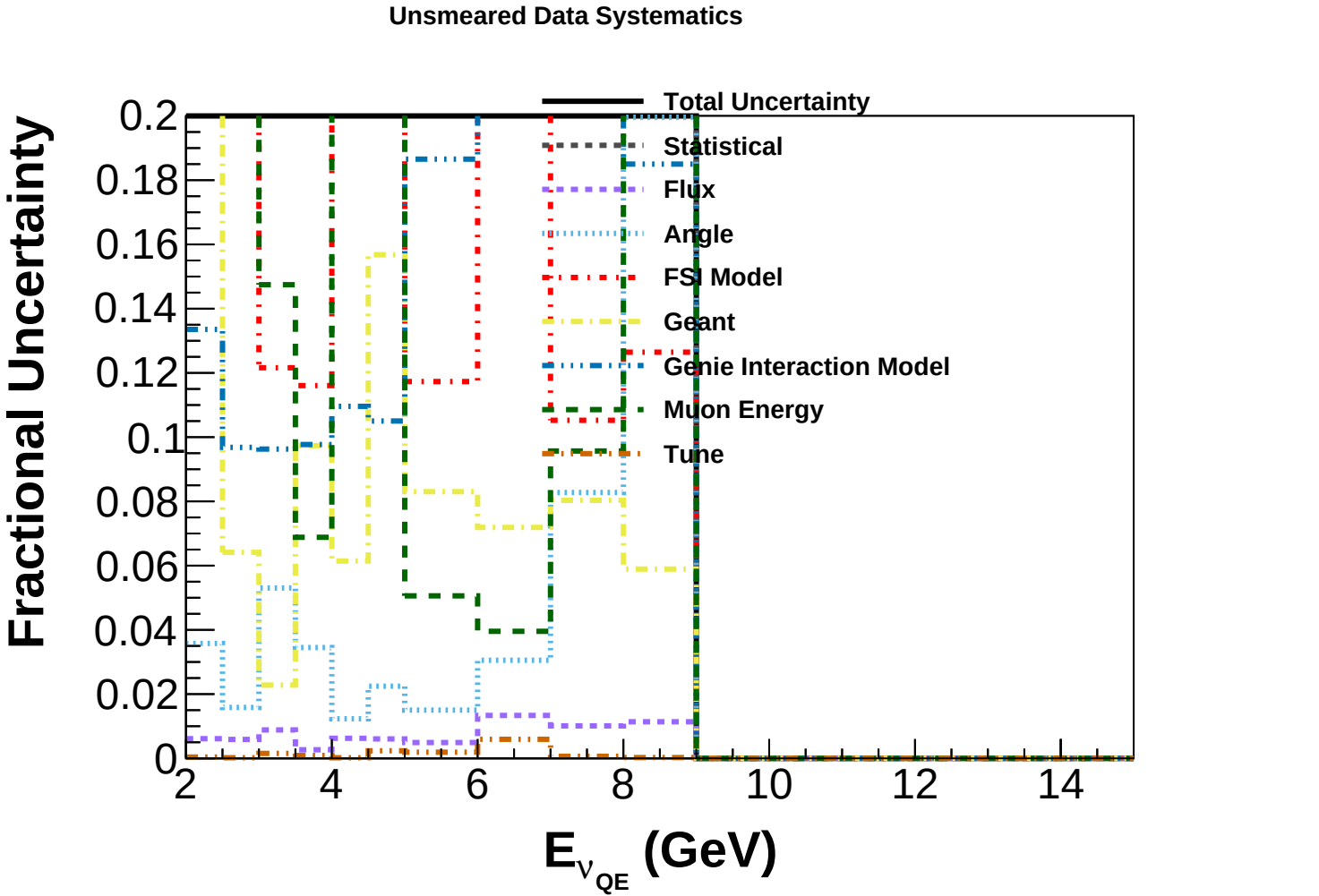

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν QE (GeV)

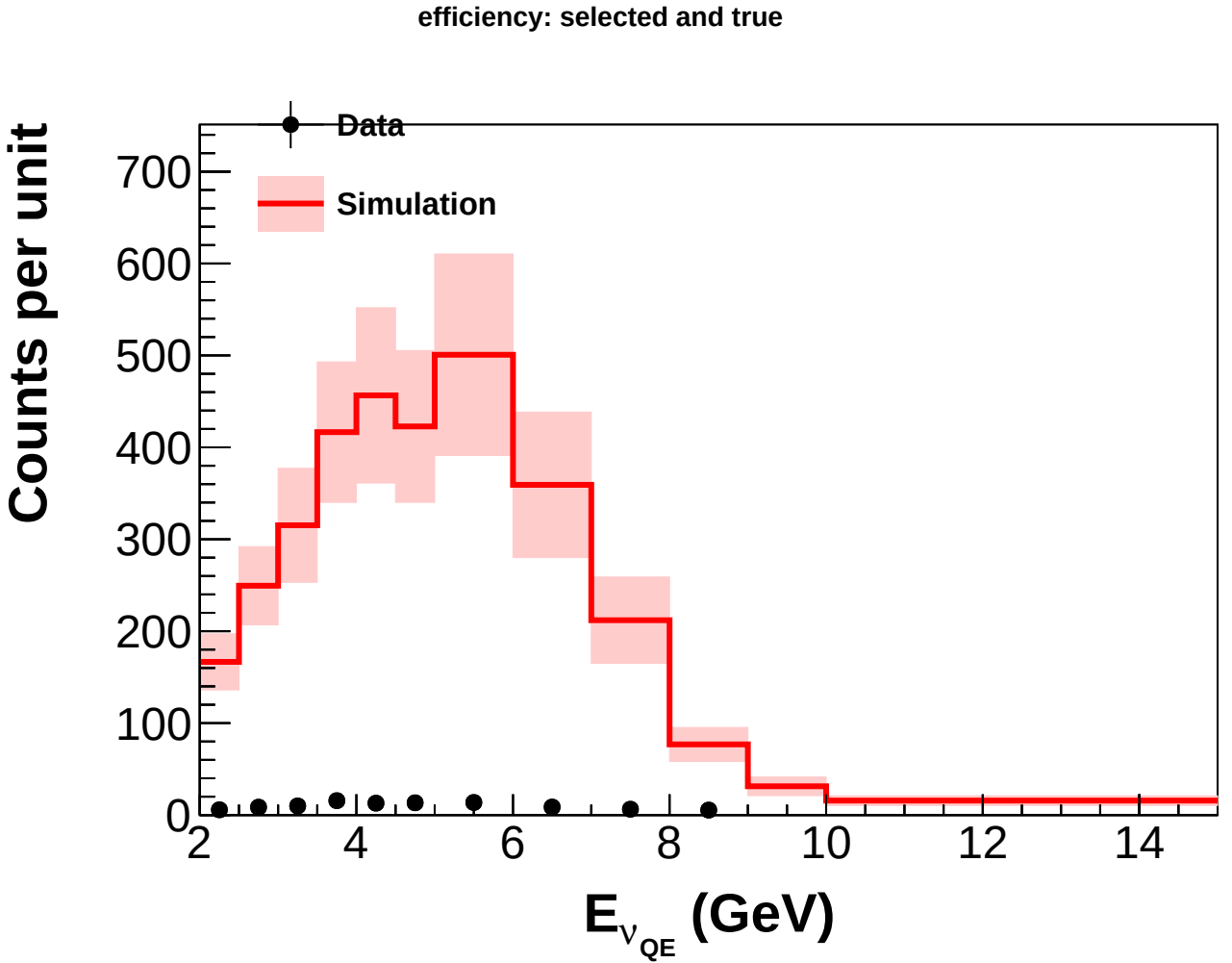

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
5
10
15
20
25
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)


Data Before and After Unsmearing
Data / MC
4
3
2
1
0
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

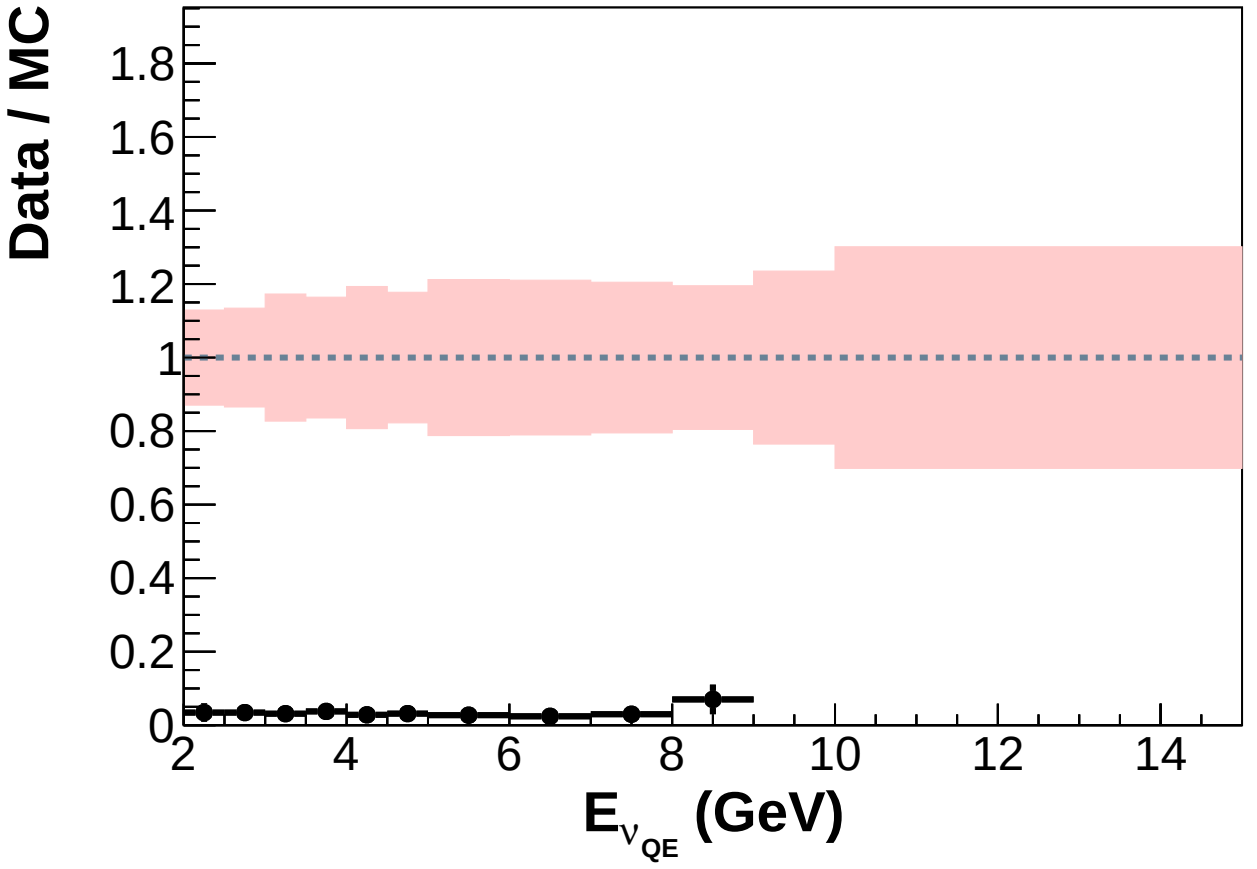

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

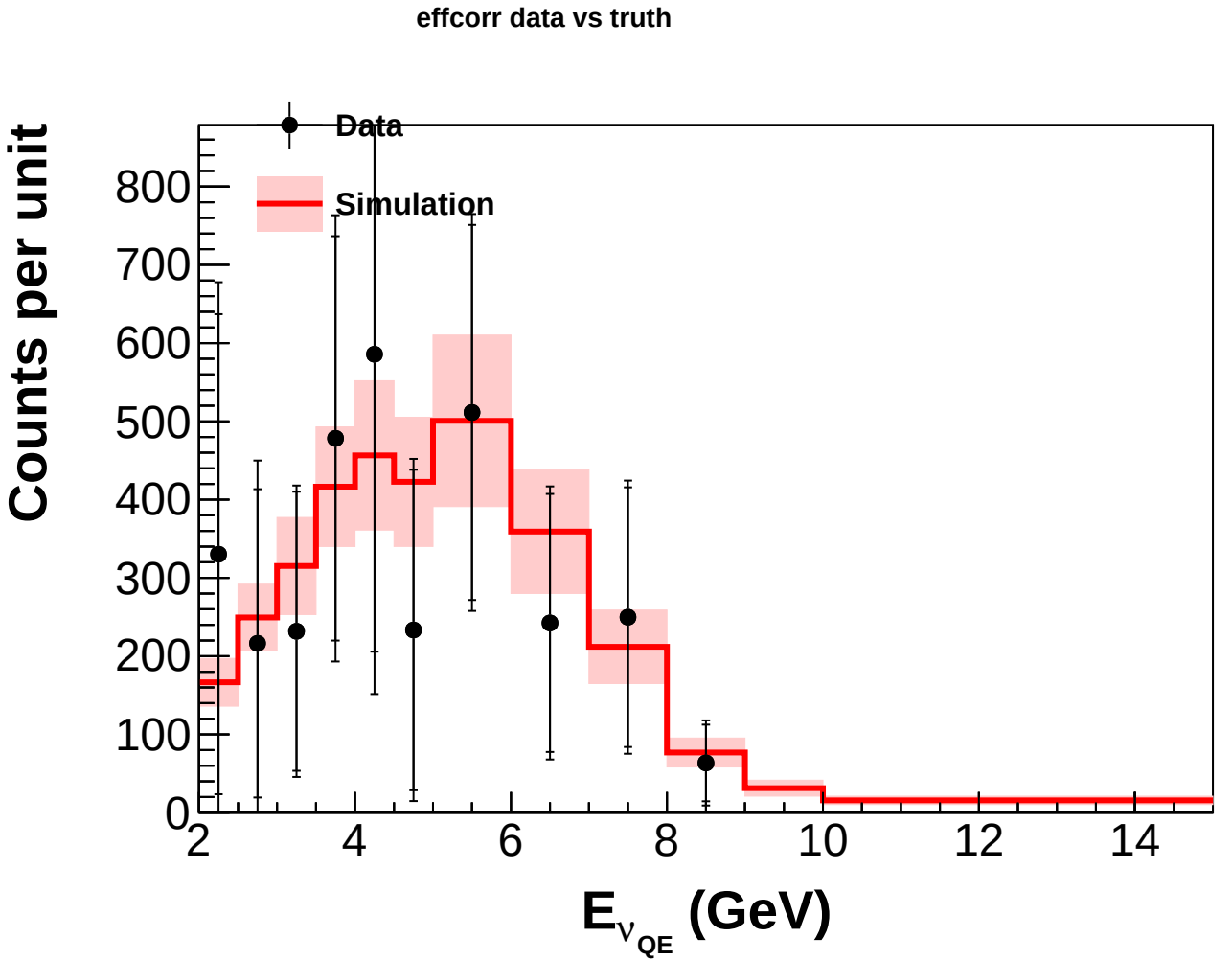

Unsmeared Data Compared to Selected MC
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

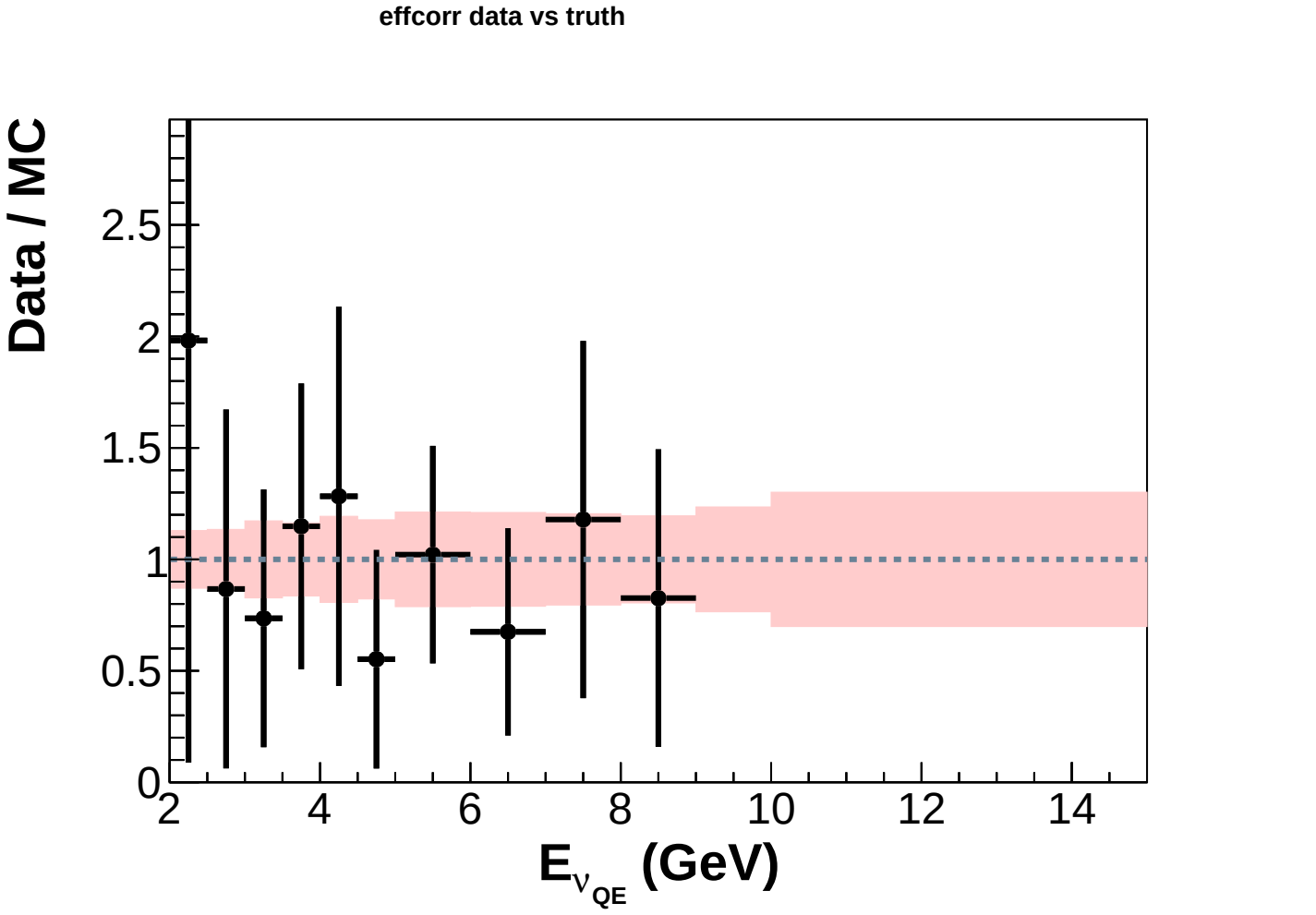

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

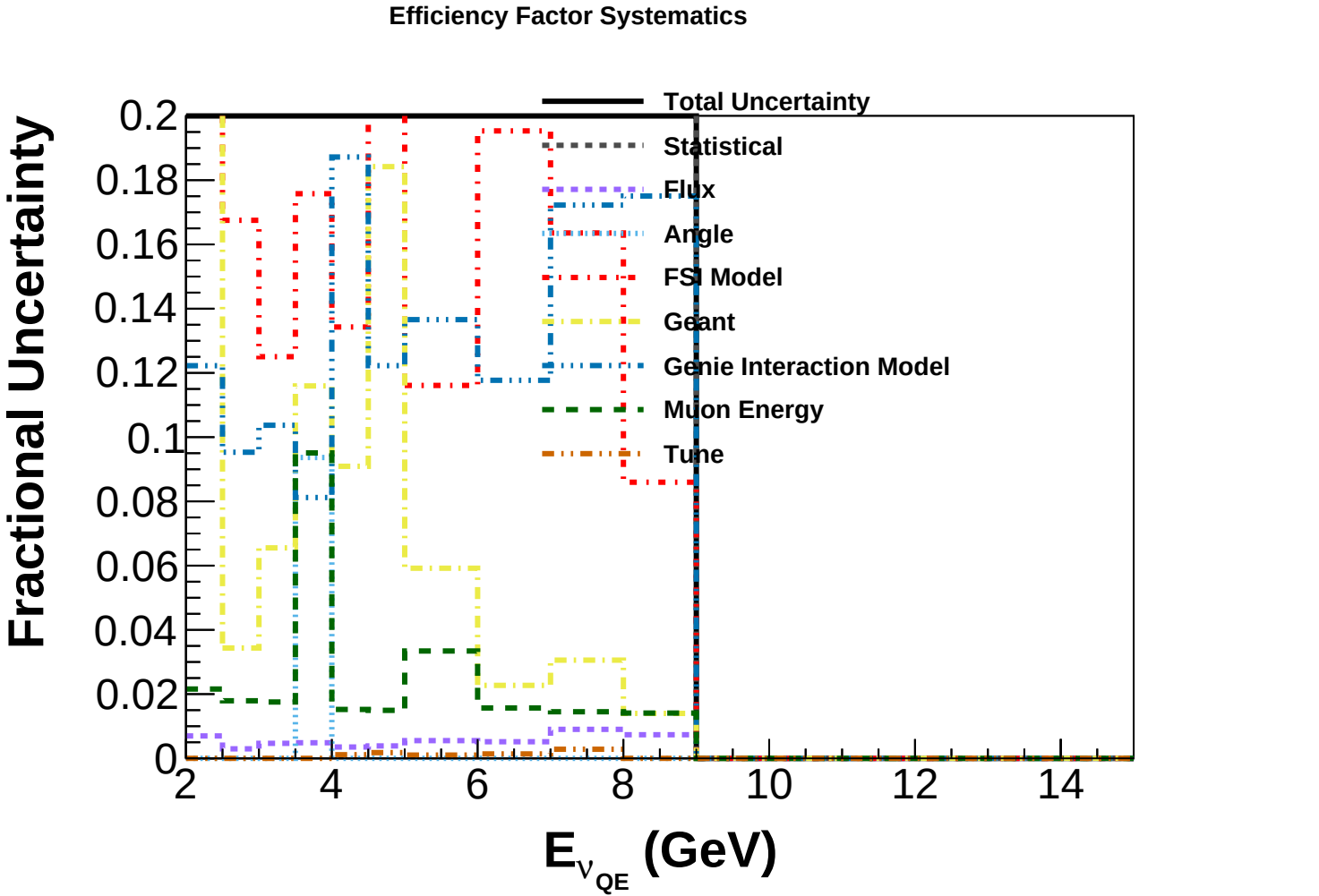

efficiency: selected and true
Data
Simulation
Counts per unit
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

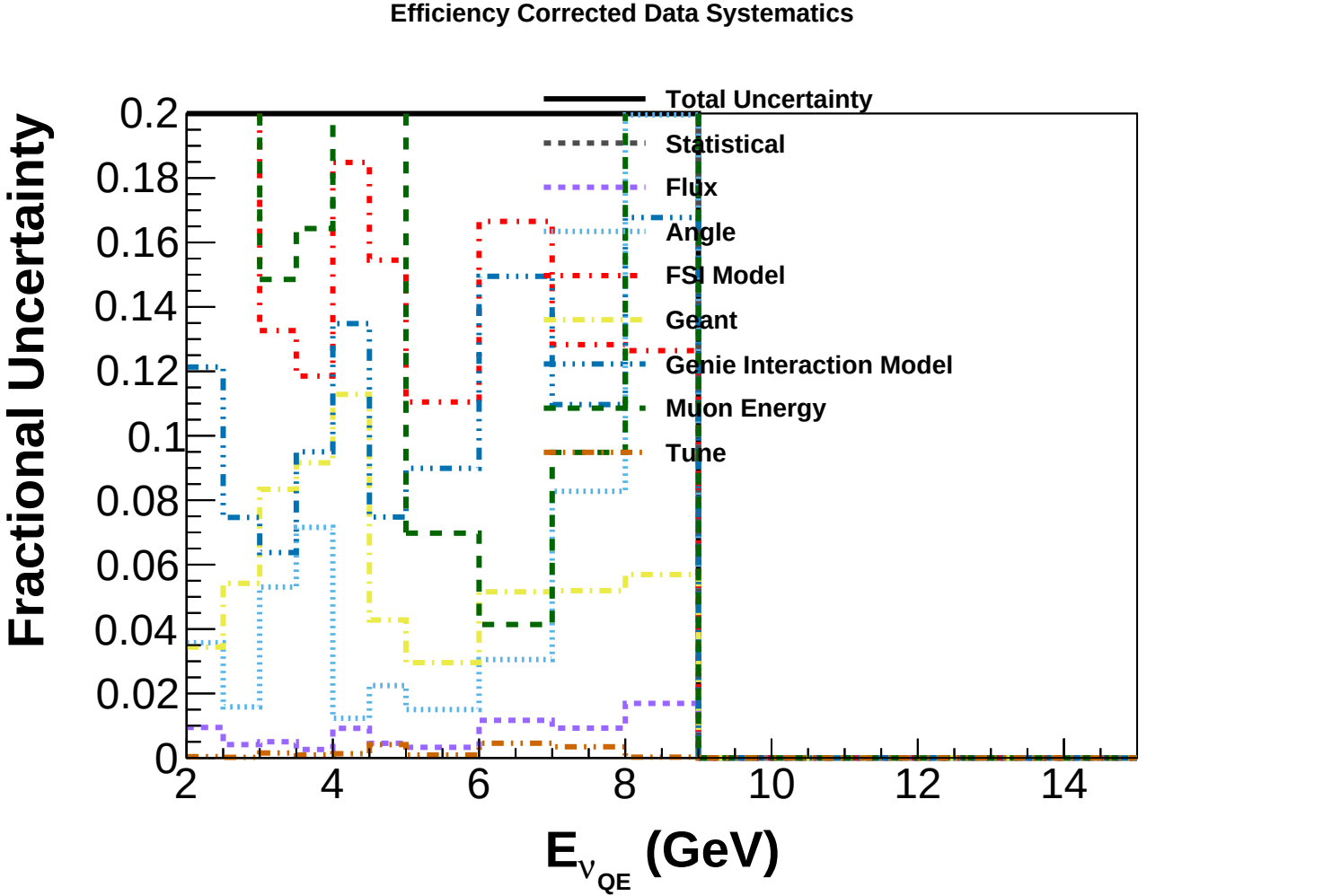
efficiency: selected and true

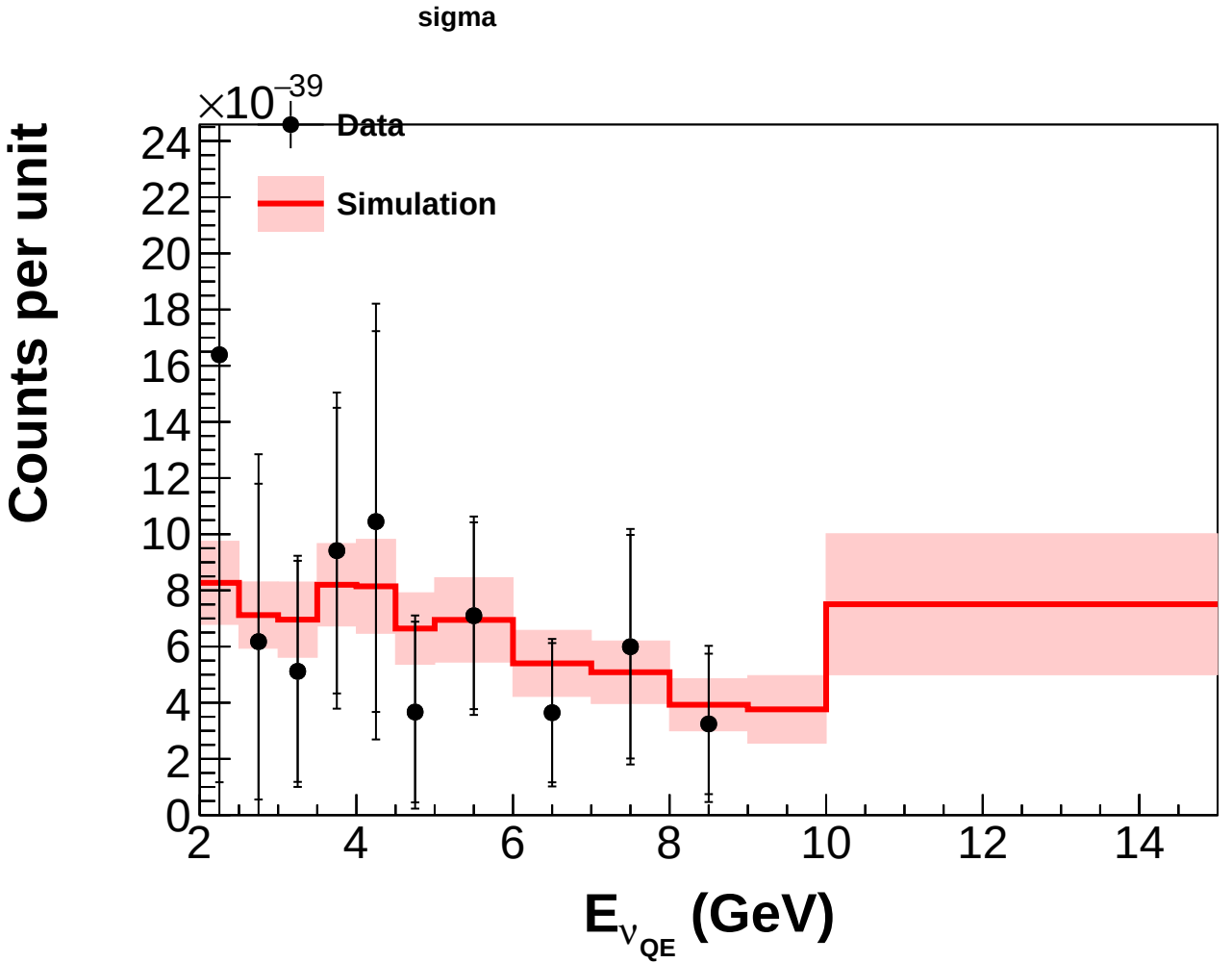


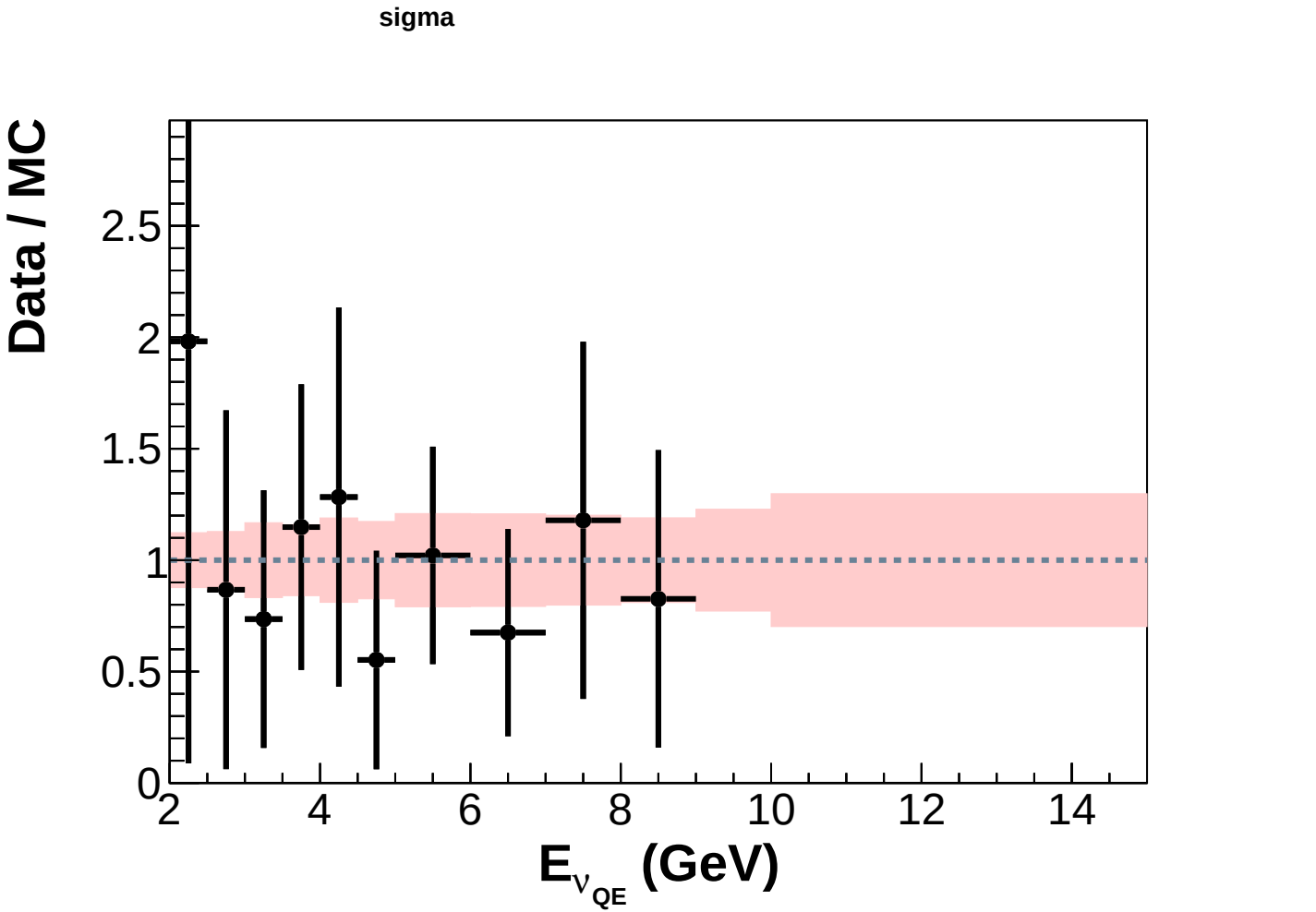

effcorr data vs truth
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
800
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

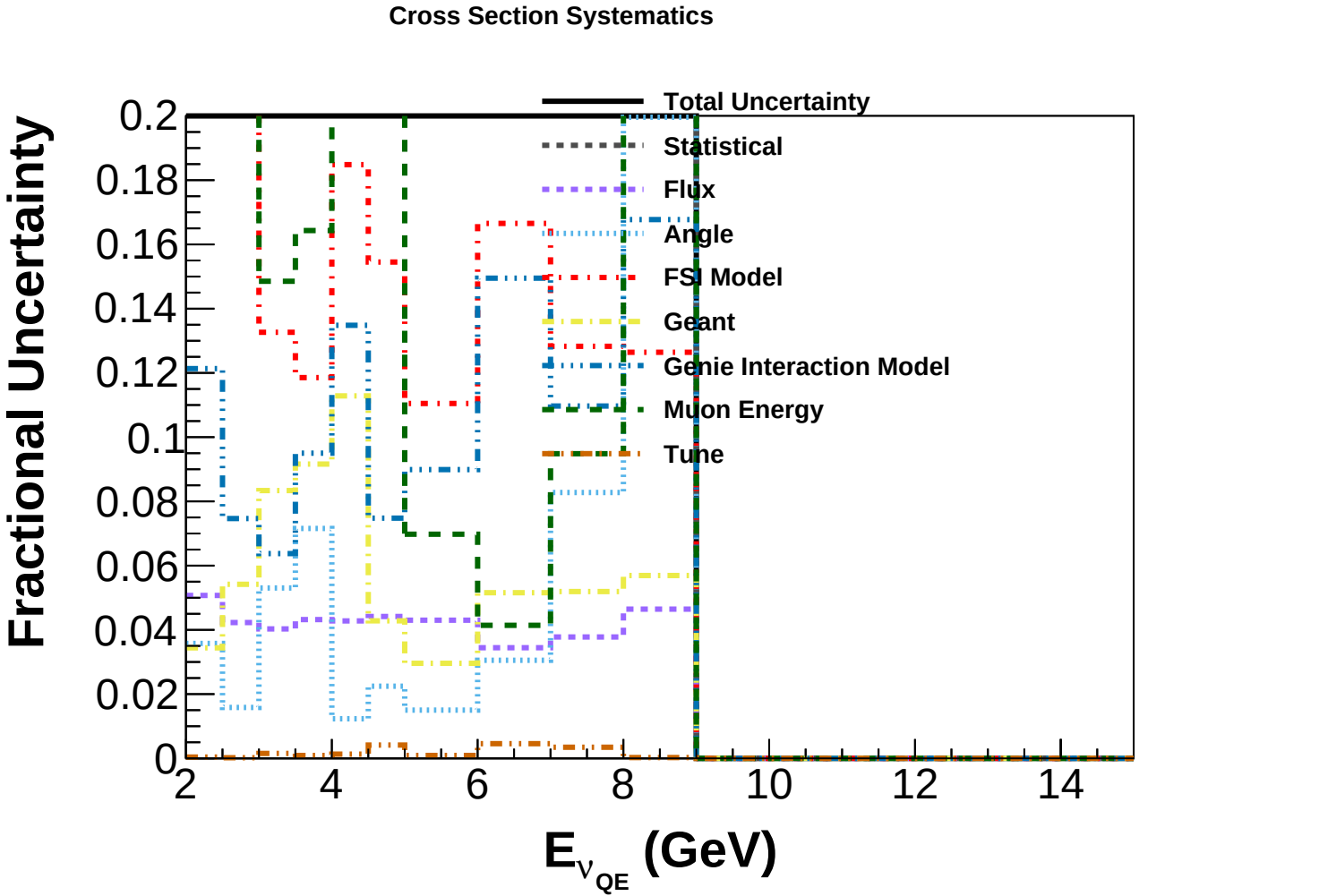

effcorr data vs truth
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

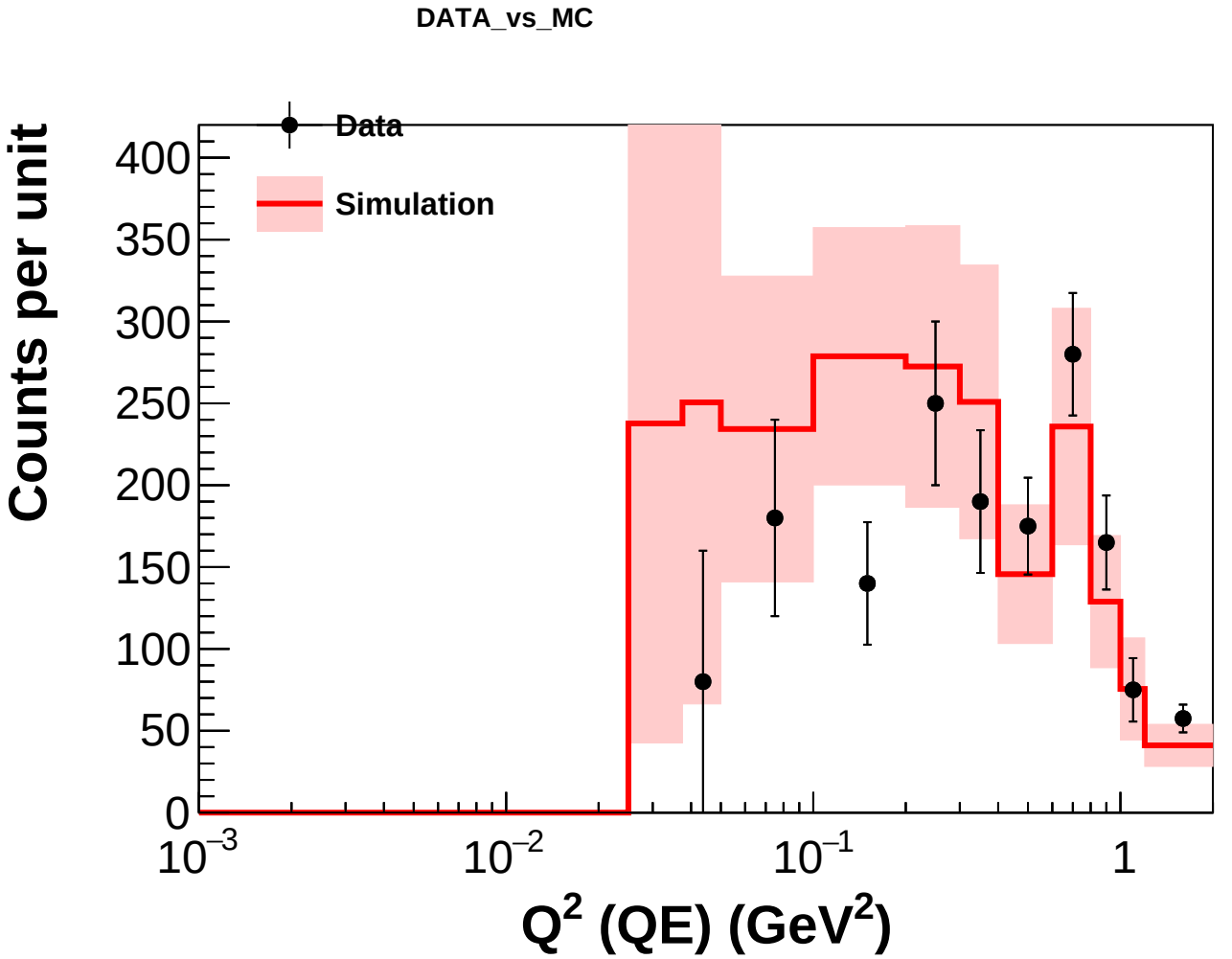

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_νQE (GeV)

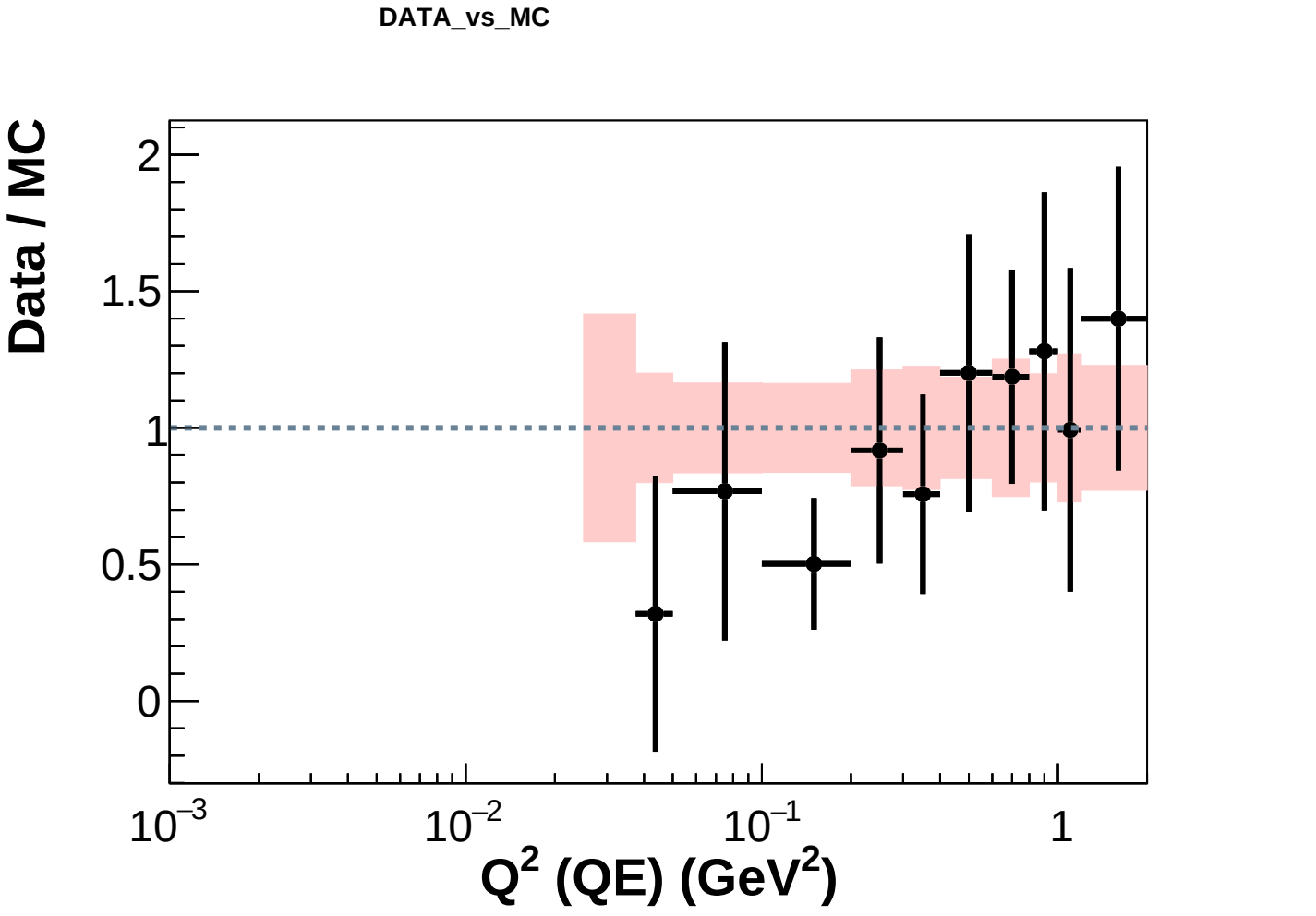

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

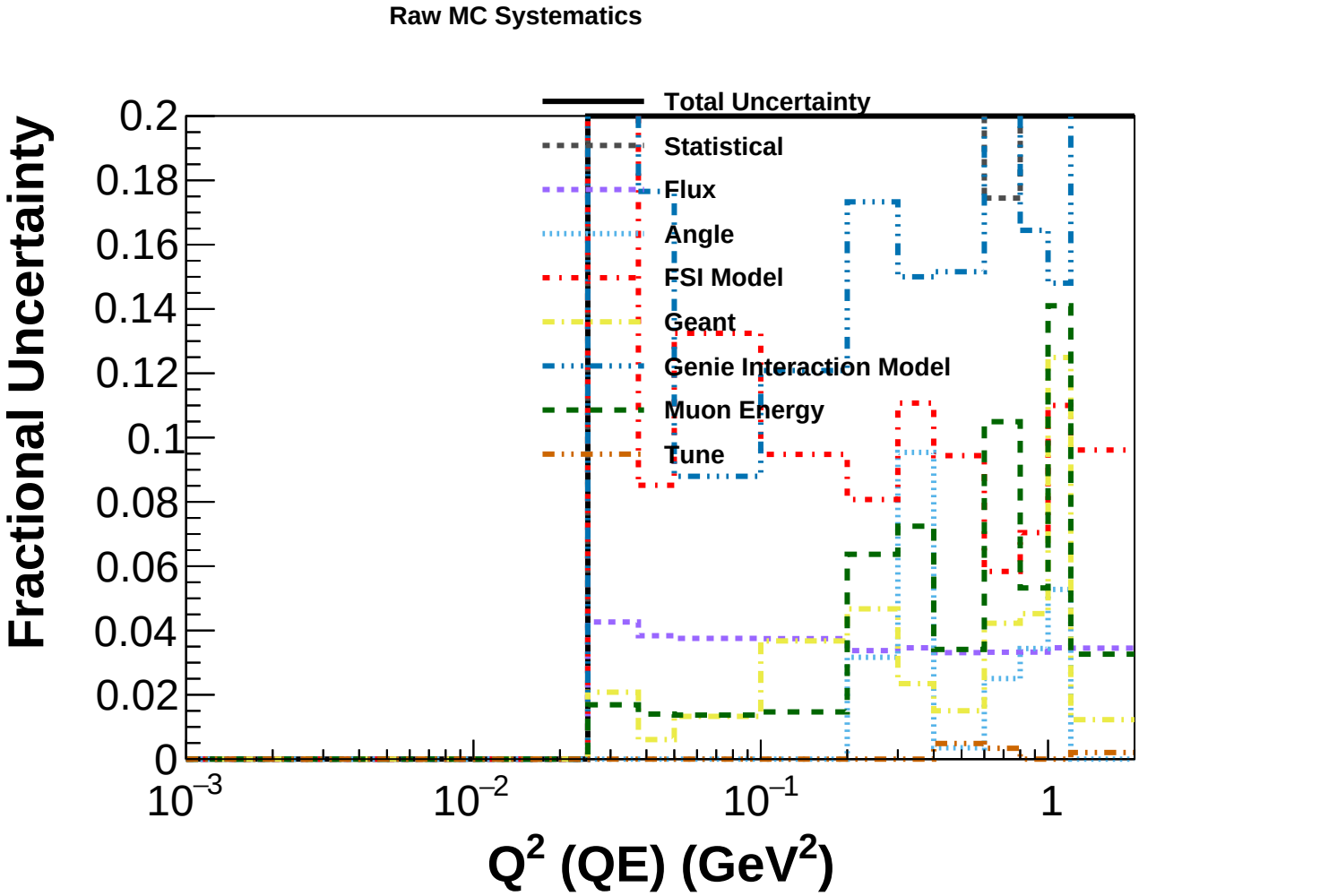

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
24
22
20
18
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
E_νQE (GeV)

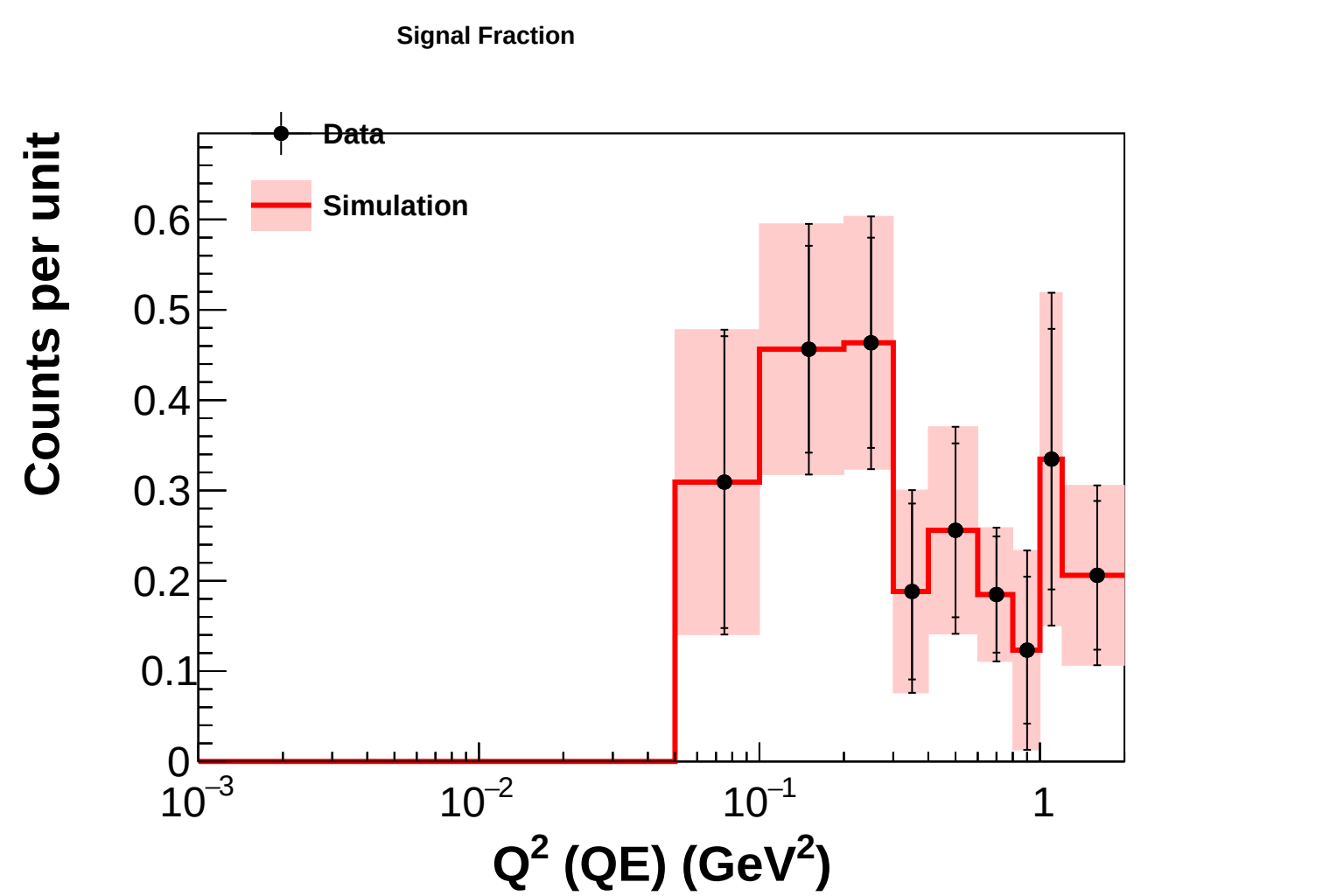

sigma
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

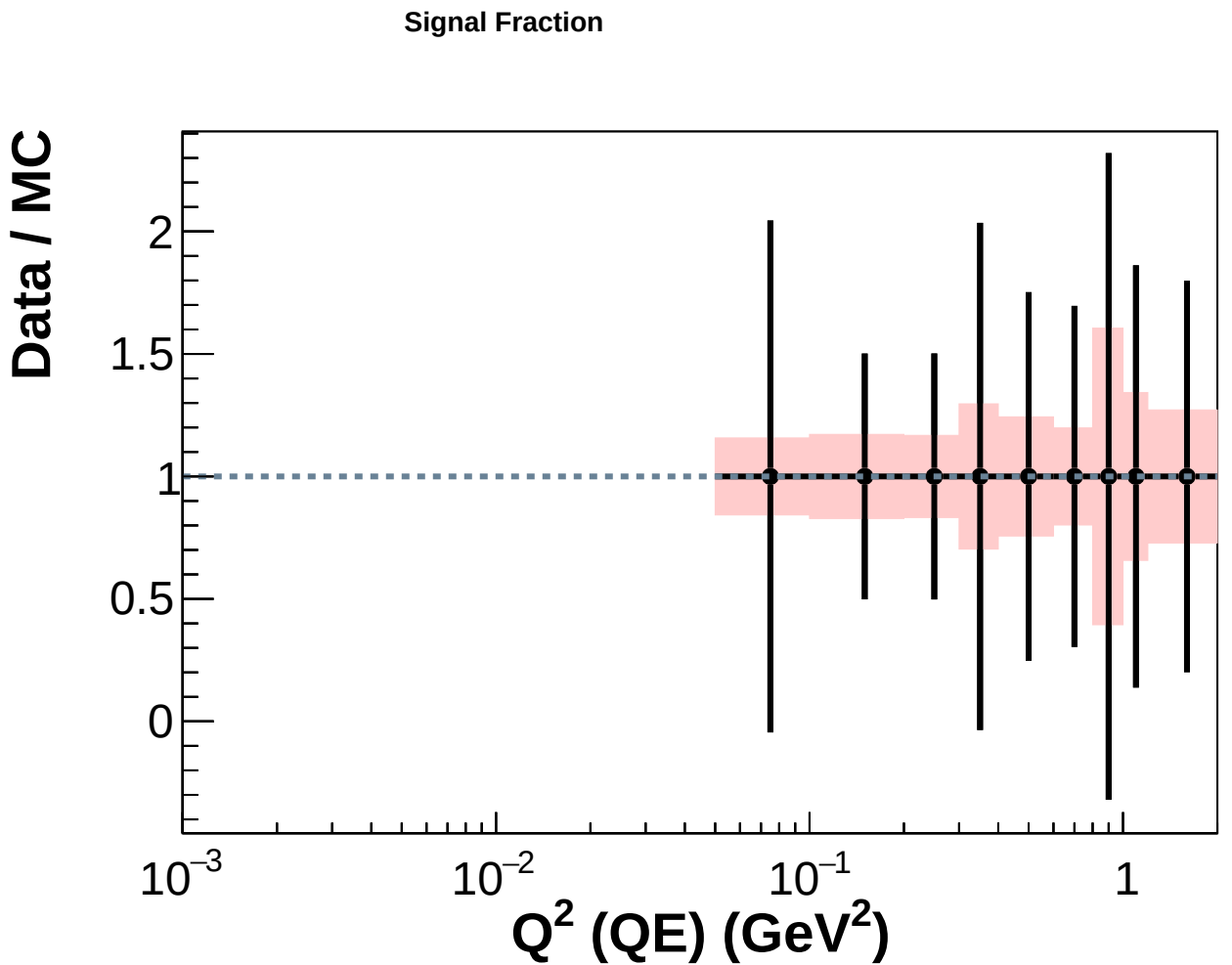

Cross Section Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

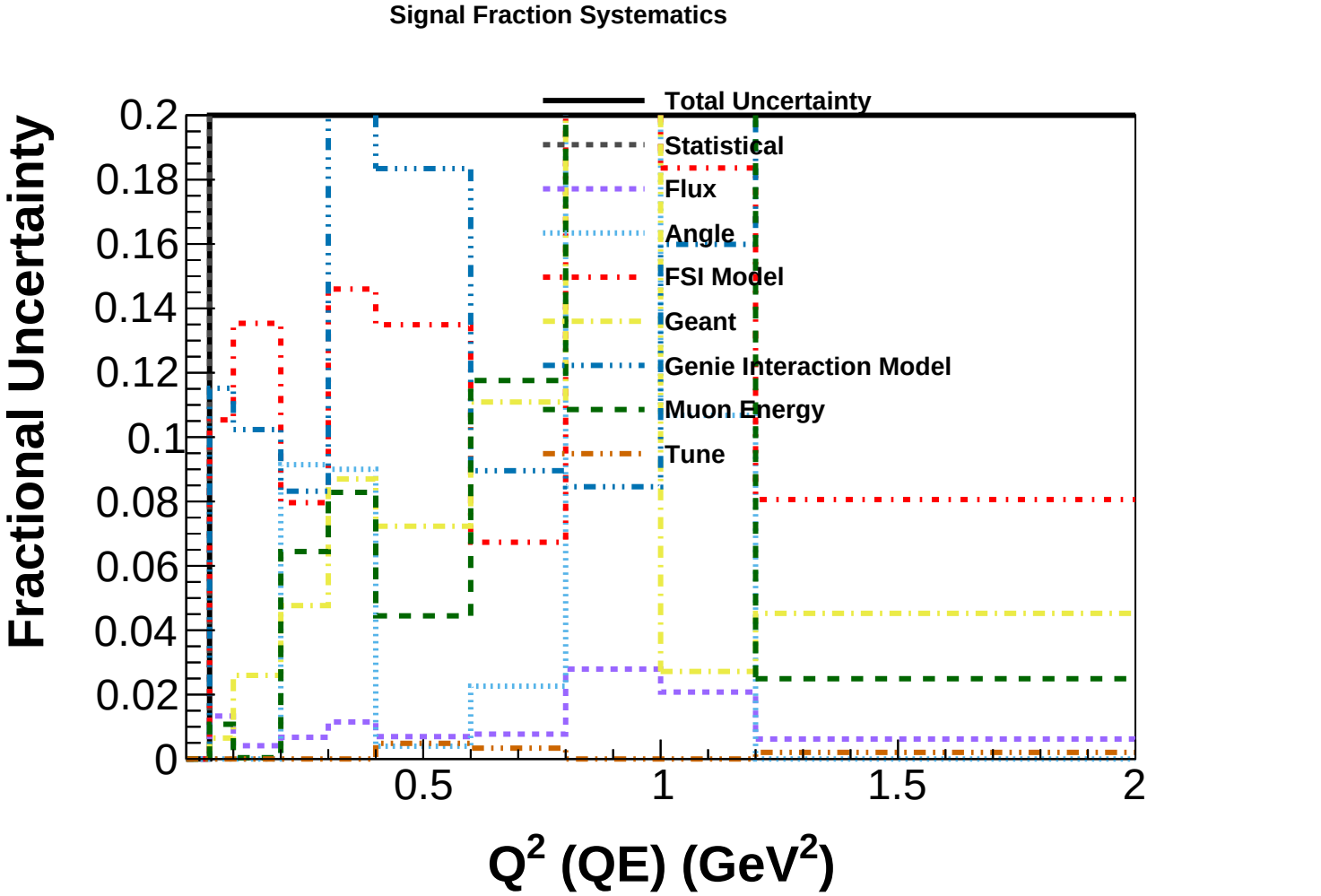

DATA_vs_MC
Data
Simulation
Counts per unit
400
350
300
250
200
150
100
50
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

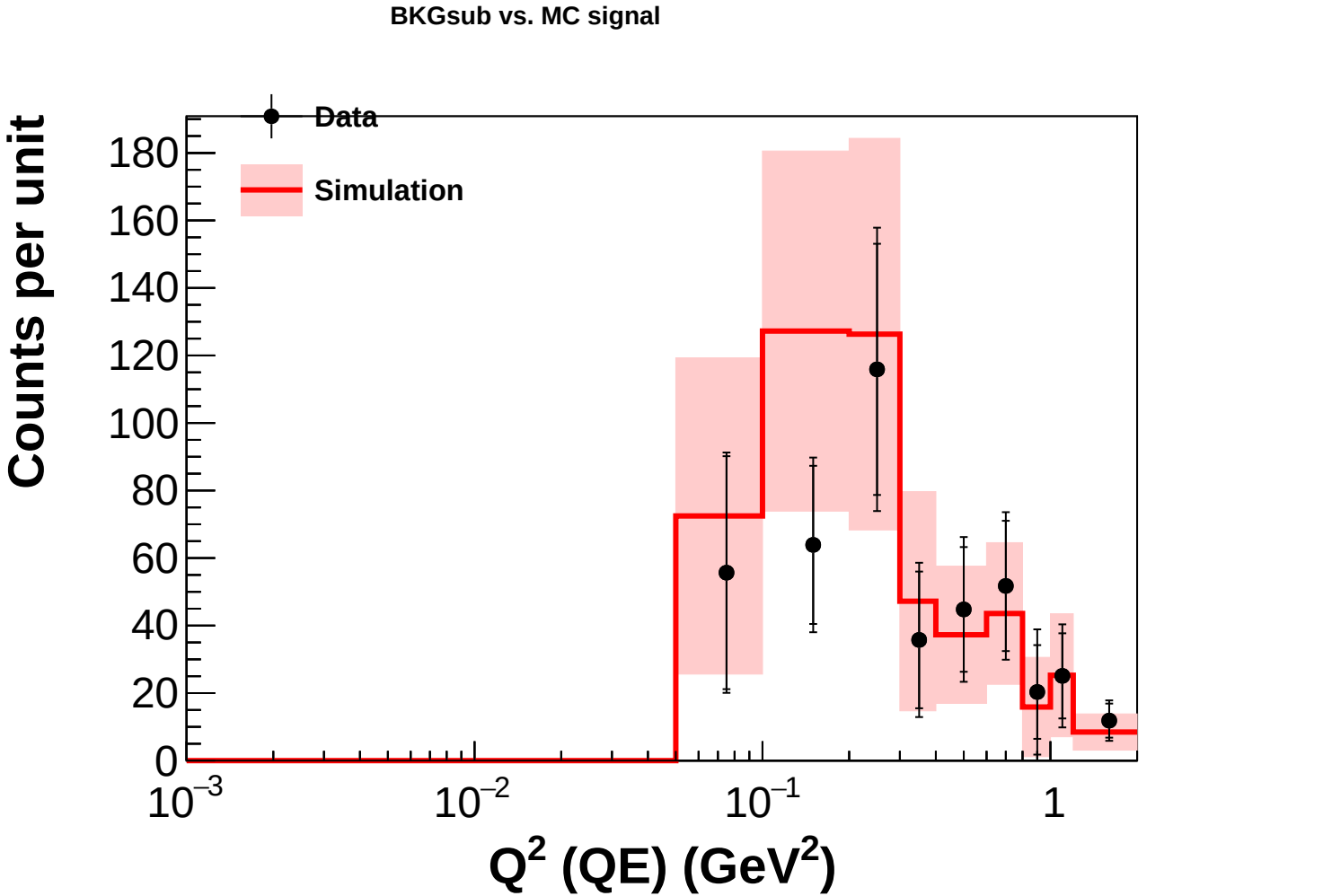

DATA_vs_MC
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

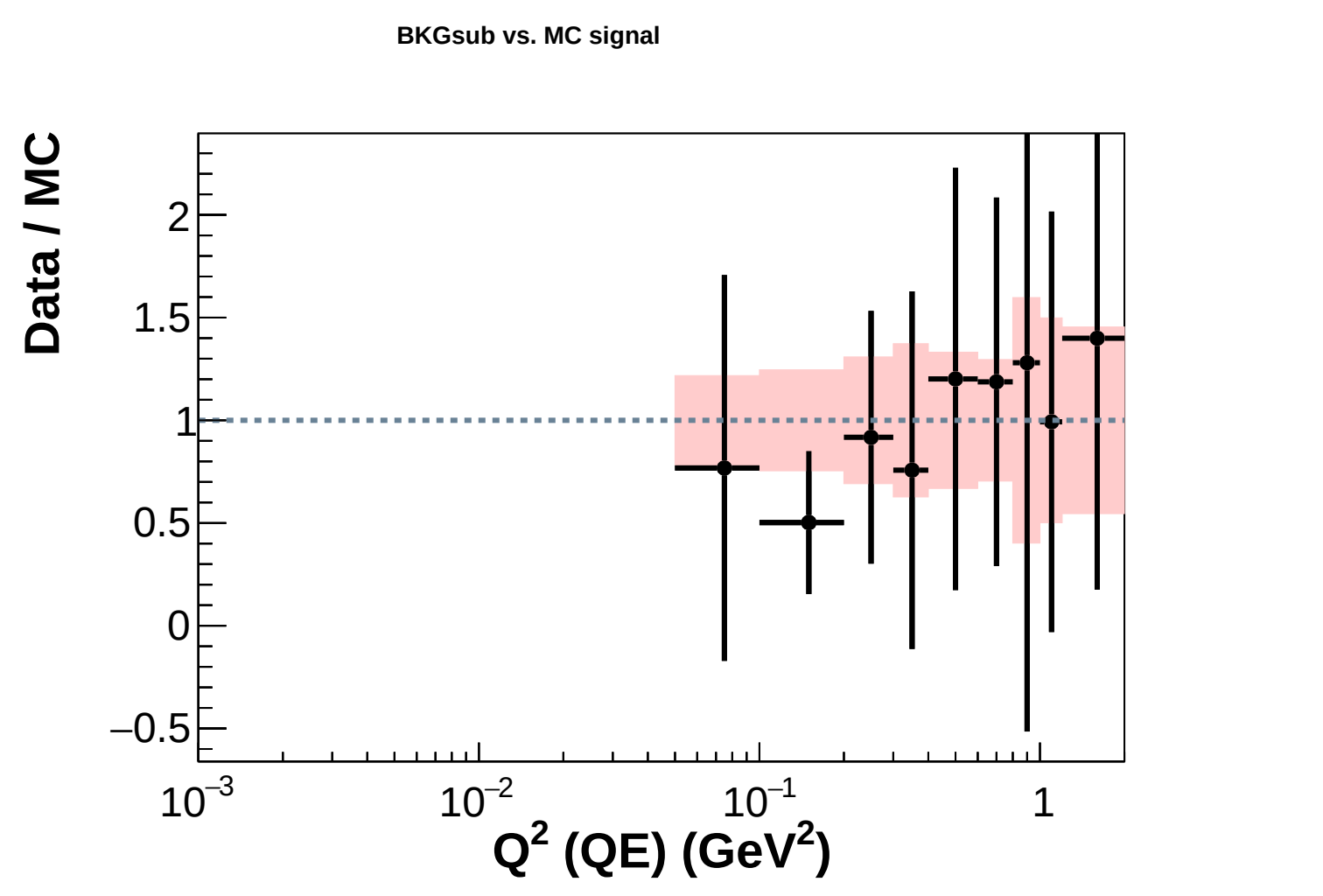

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

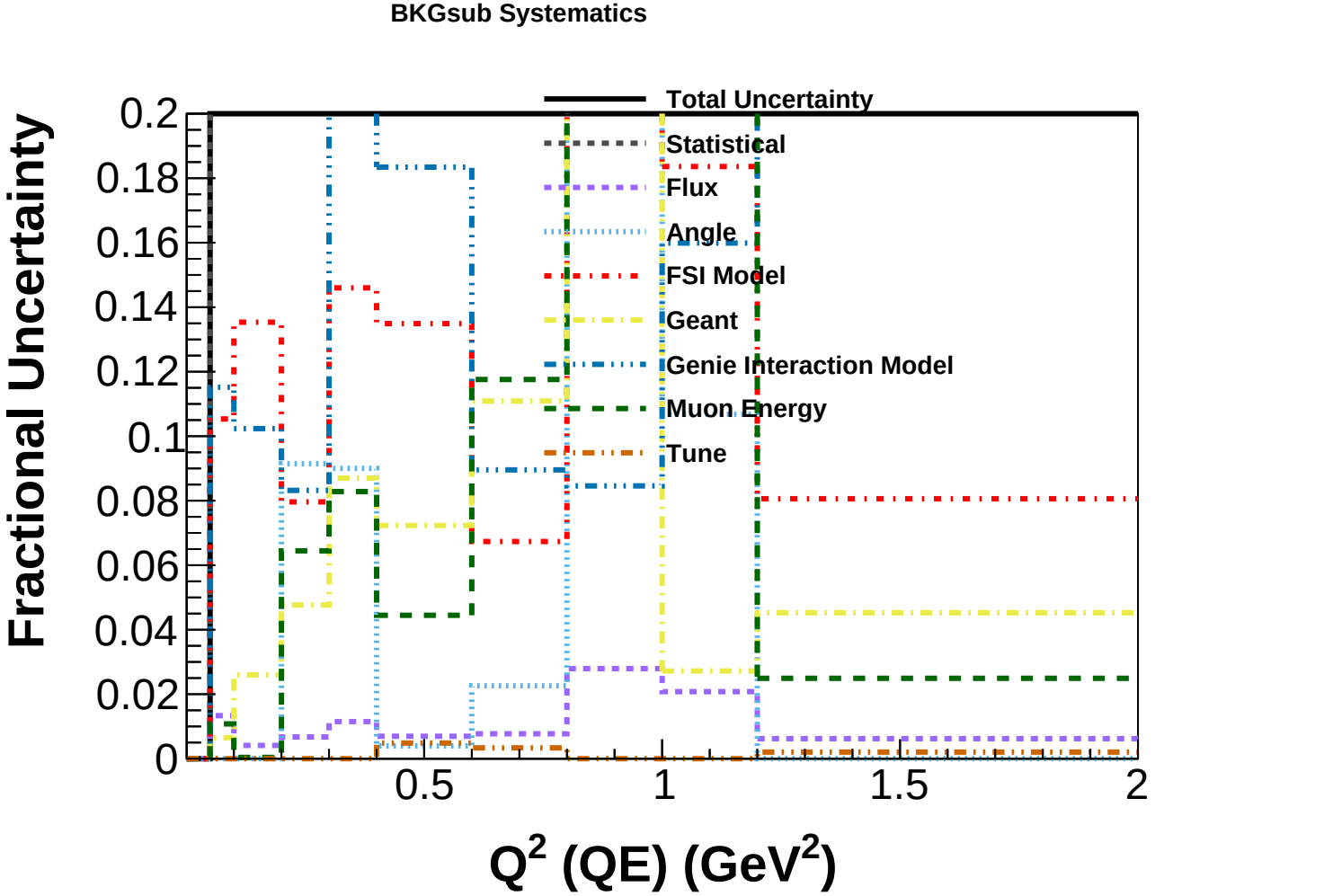

Signal Fraction
Data
Simulation
Counts per unit
0
0.1
0.2
0.3
0.4
0.5
0.6
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

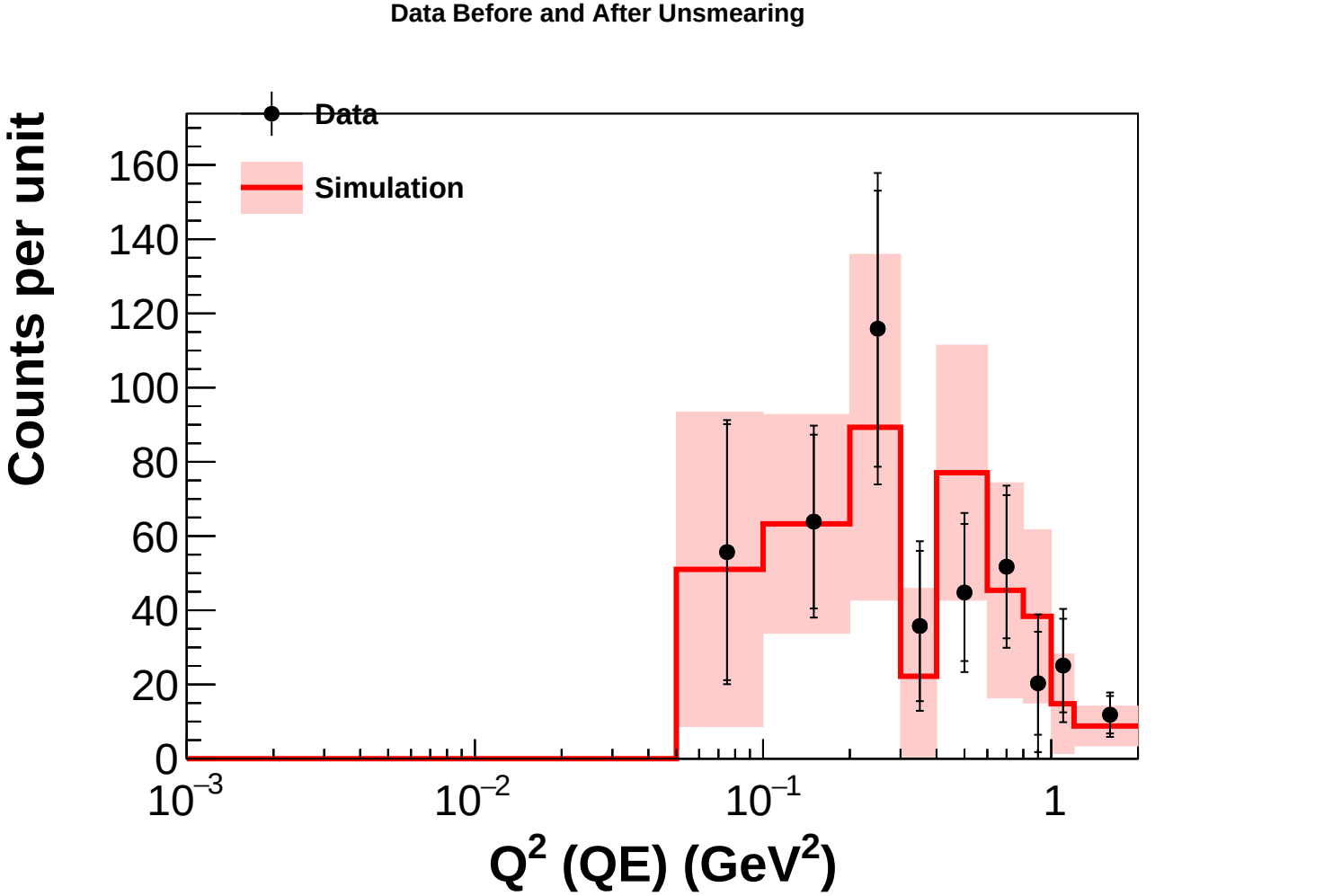

Signal Fraction
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

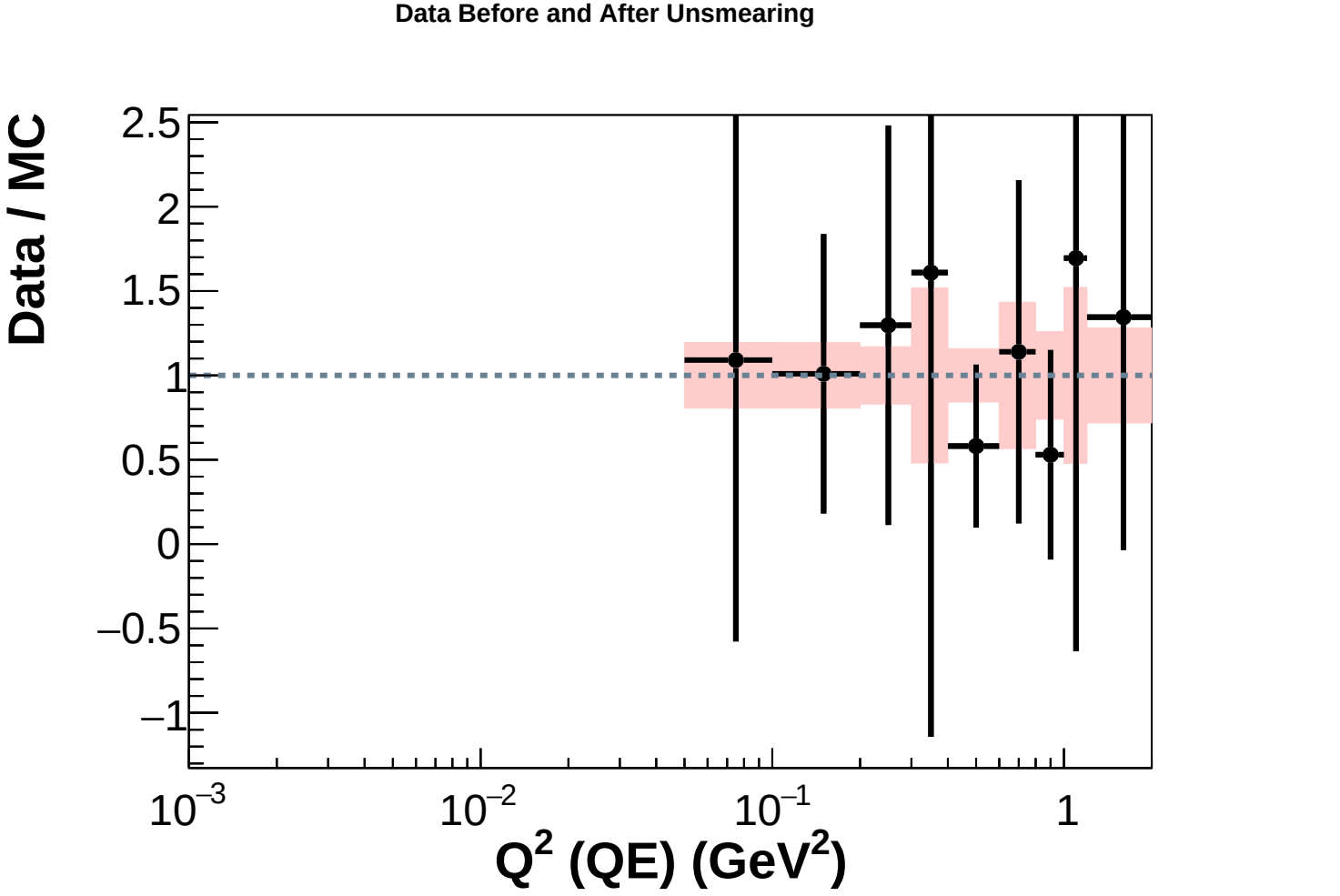

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

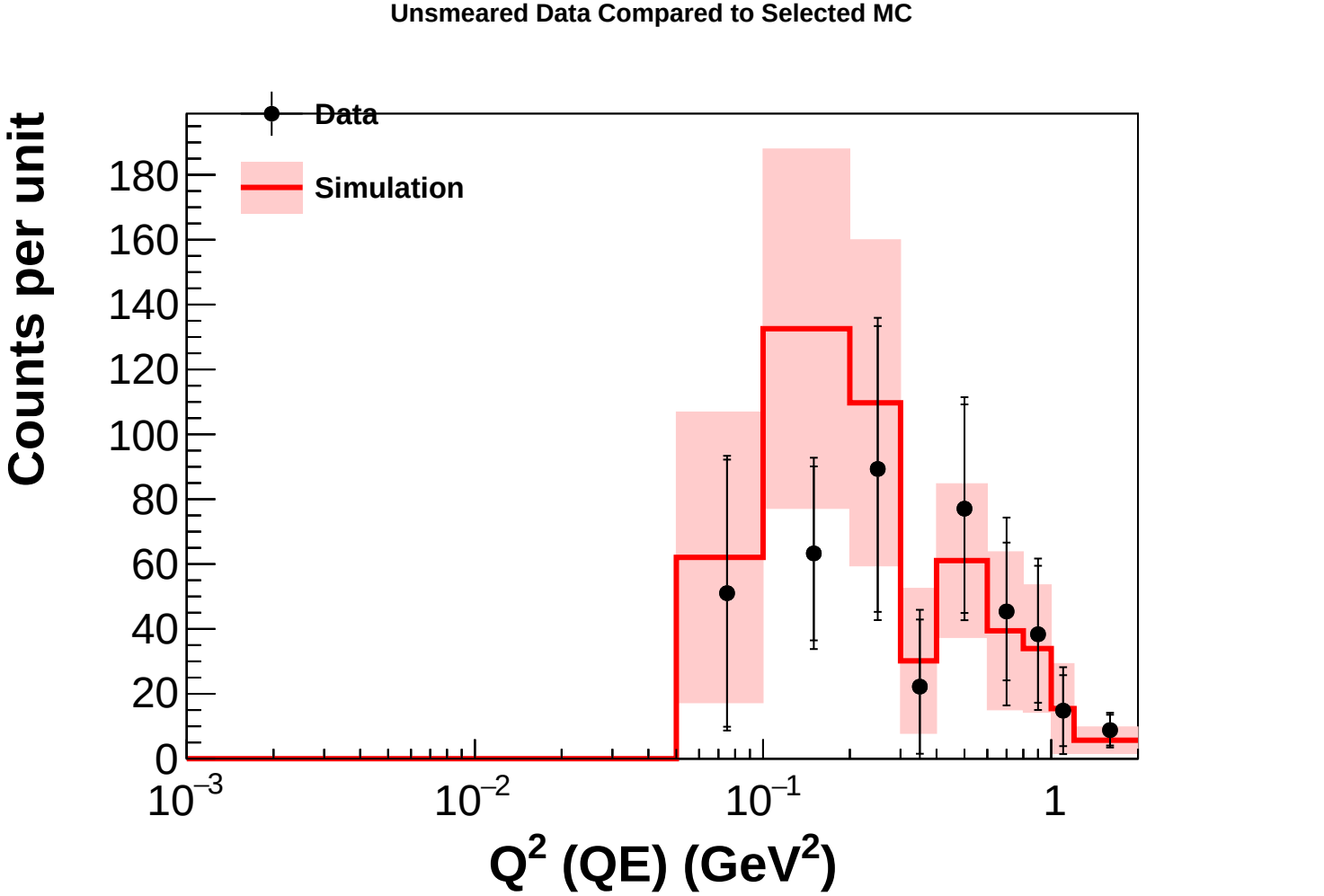

BKGsub vs. MC signal
Data
Simulation
Counts per unit
180
160
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

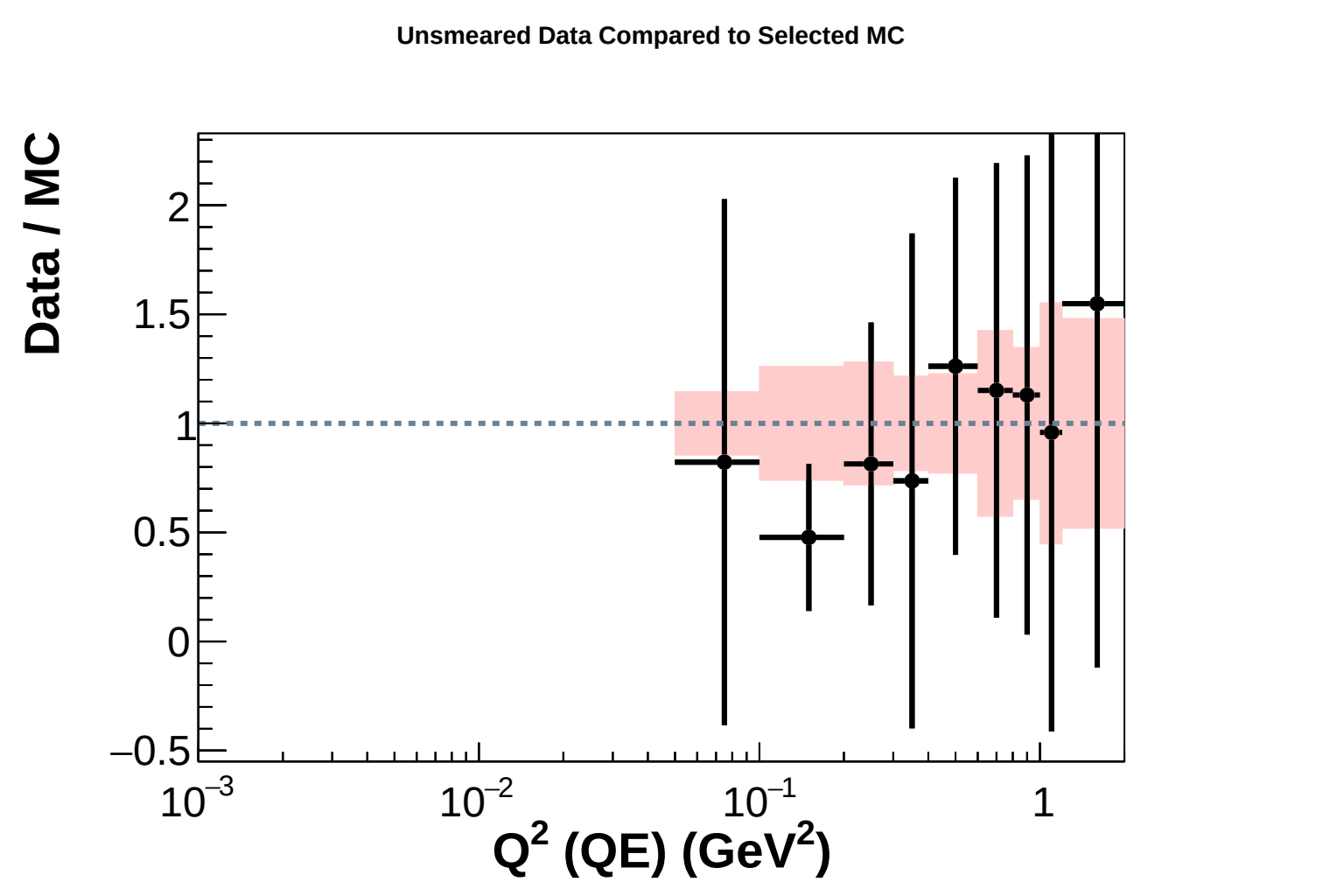

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

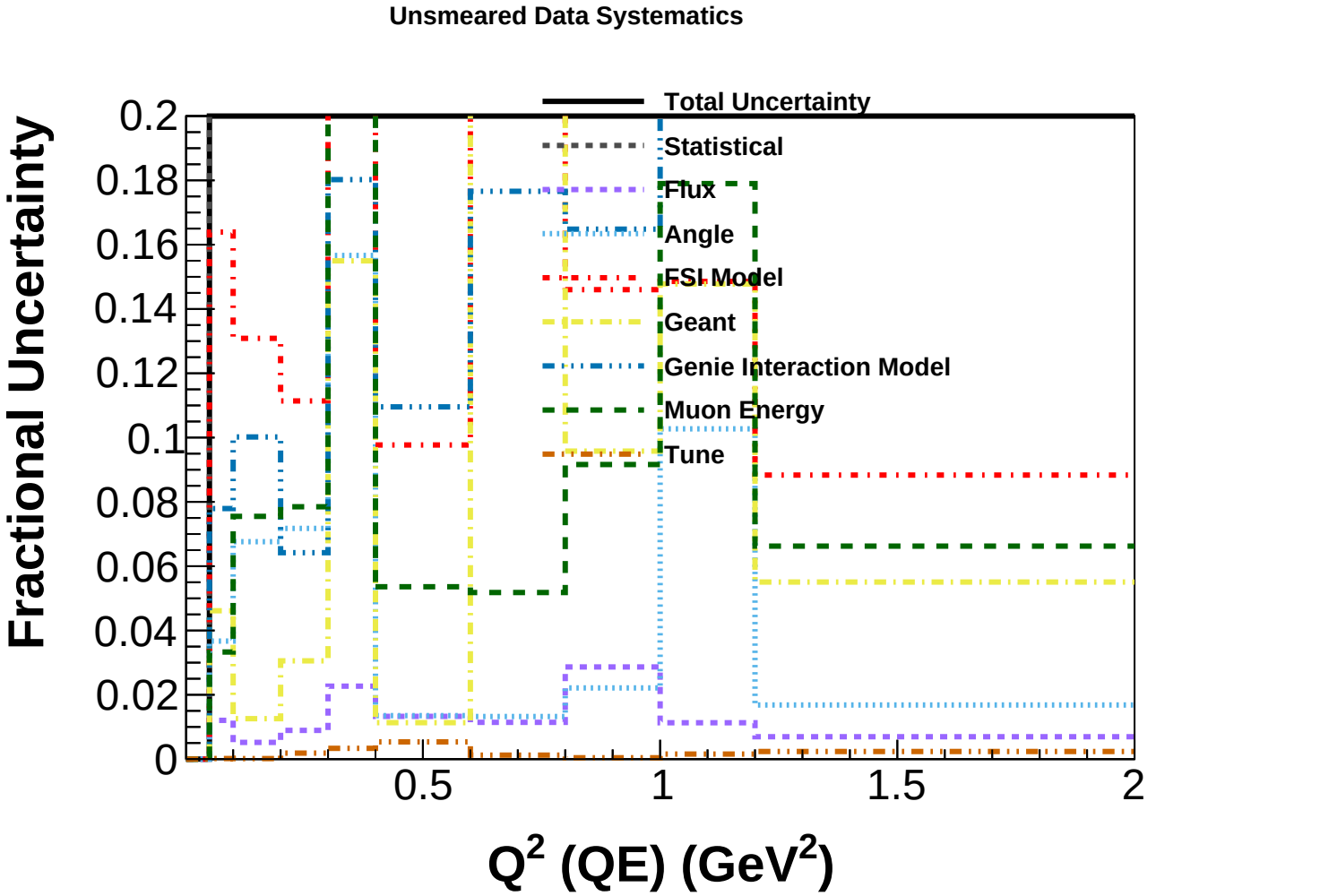

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

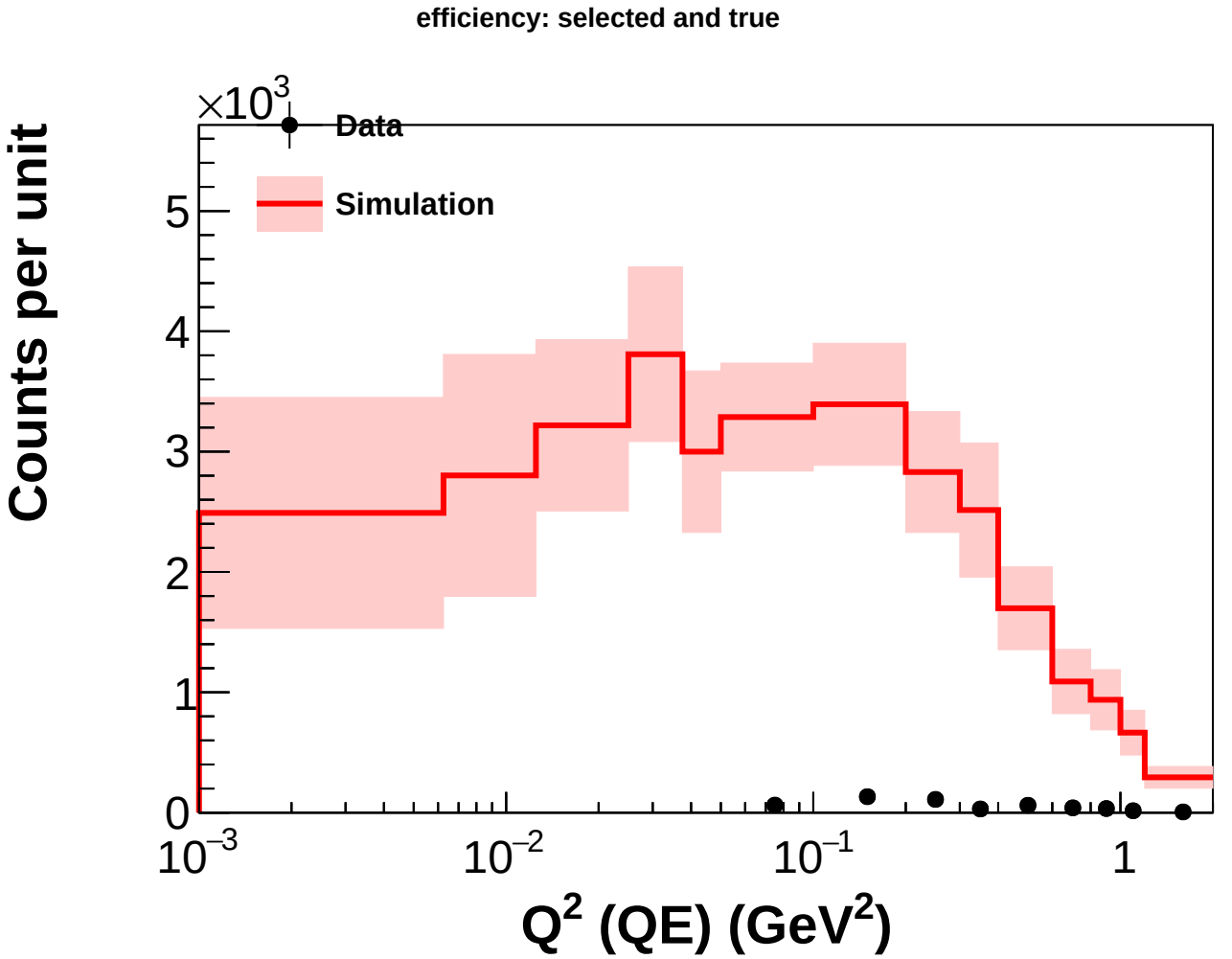

Data Before and After Unsmearing
Data
Simulation
Counts per unit
160
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)


Data Before and After Unsmearing
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

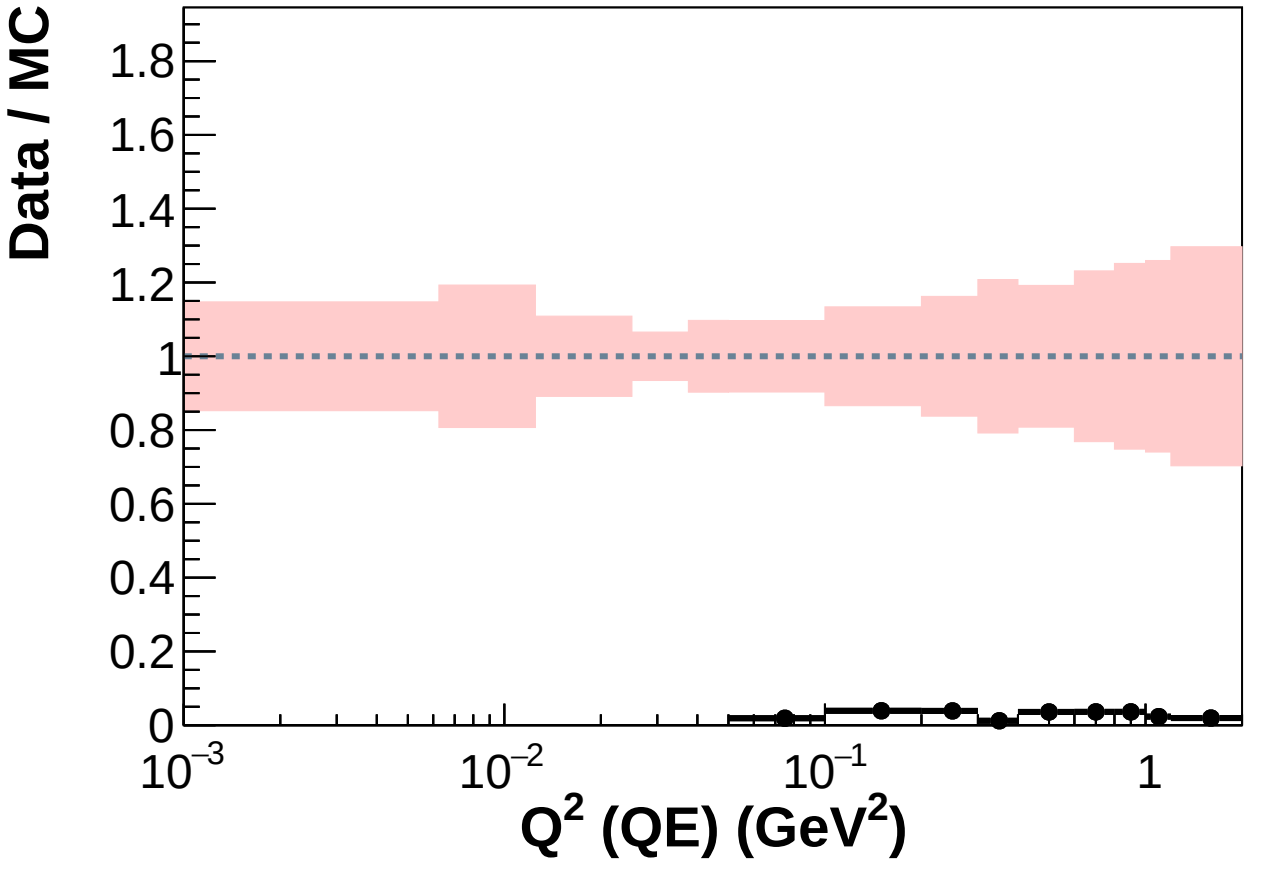

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
180
160
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

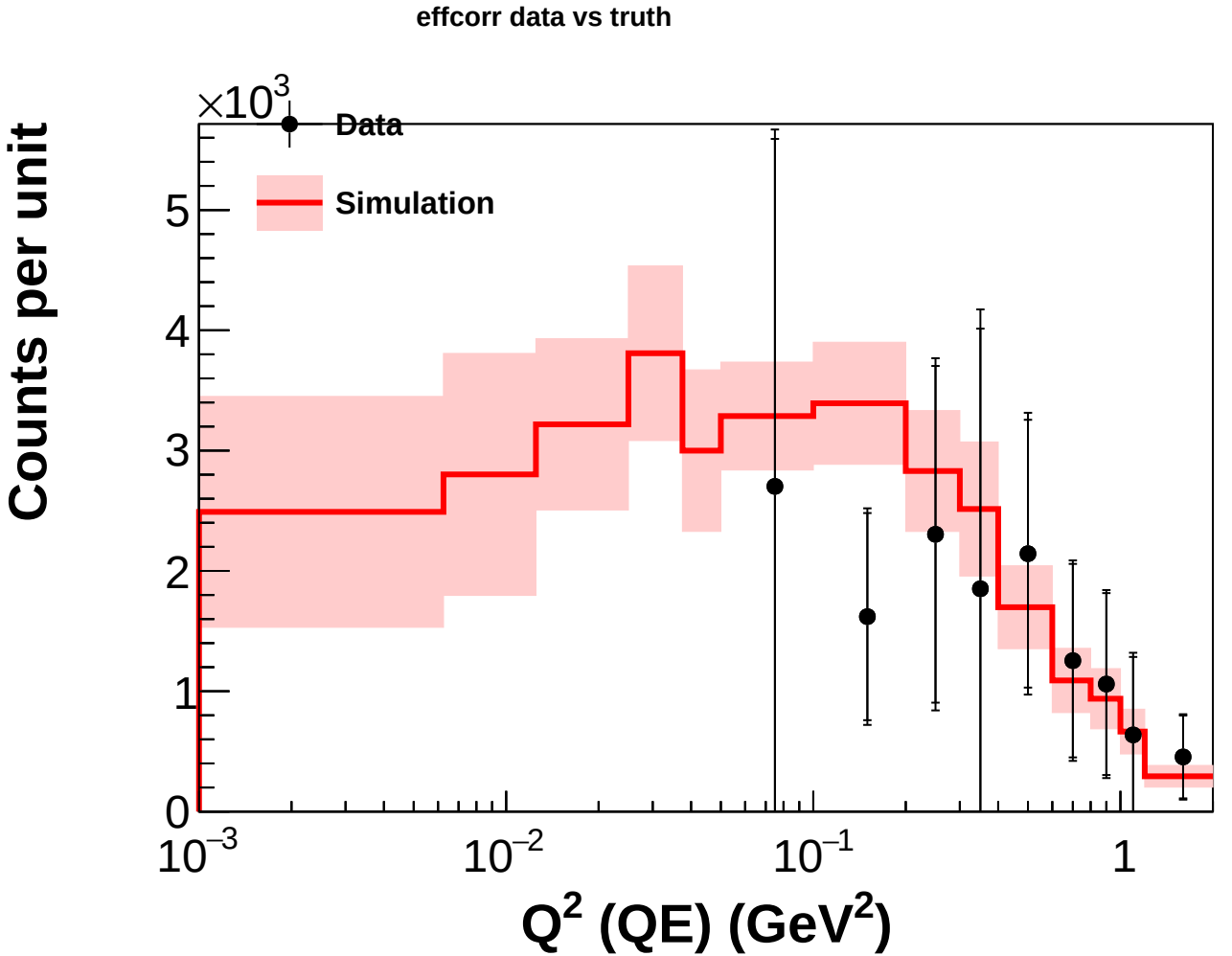

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

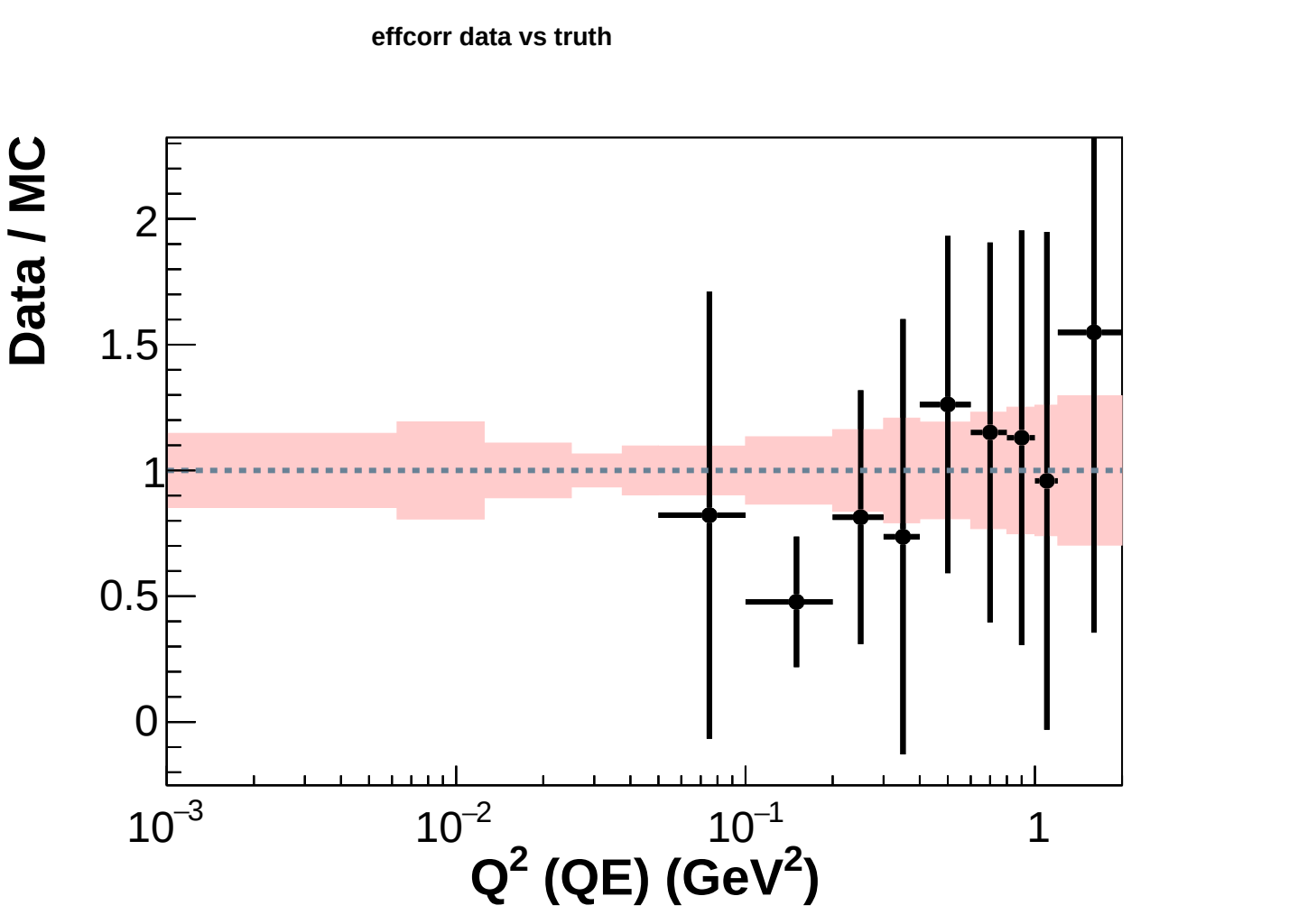

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

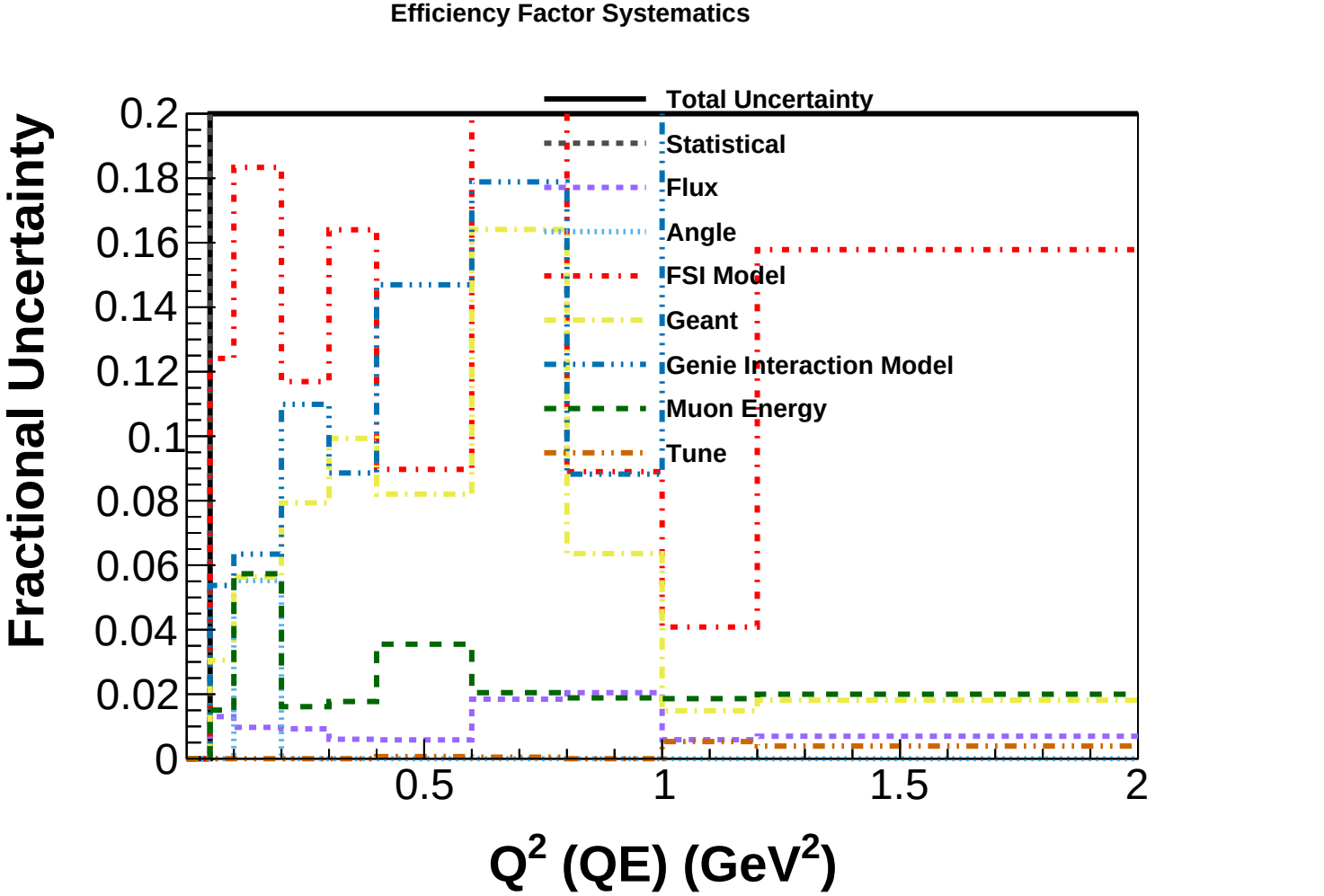

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
5
4
3
2
1
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

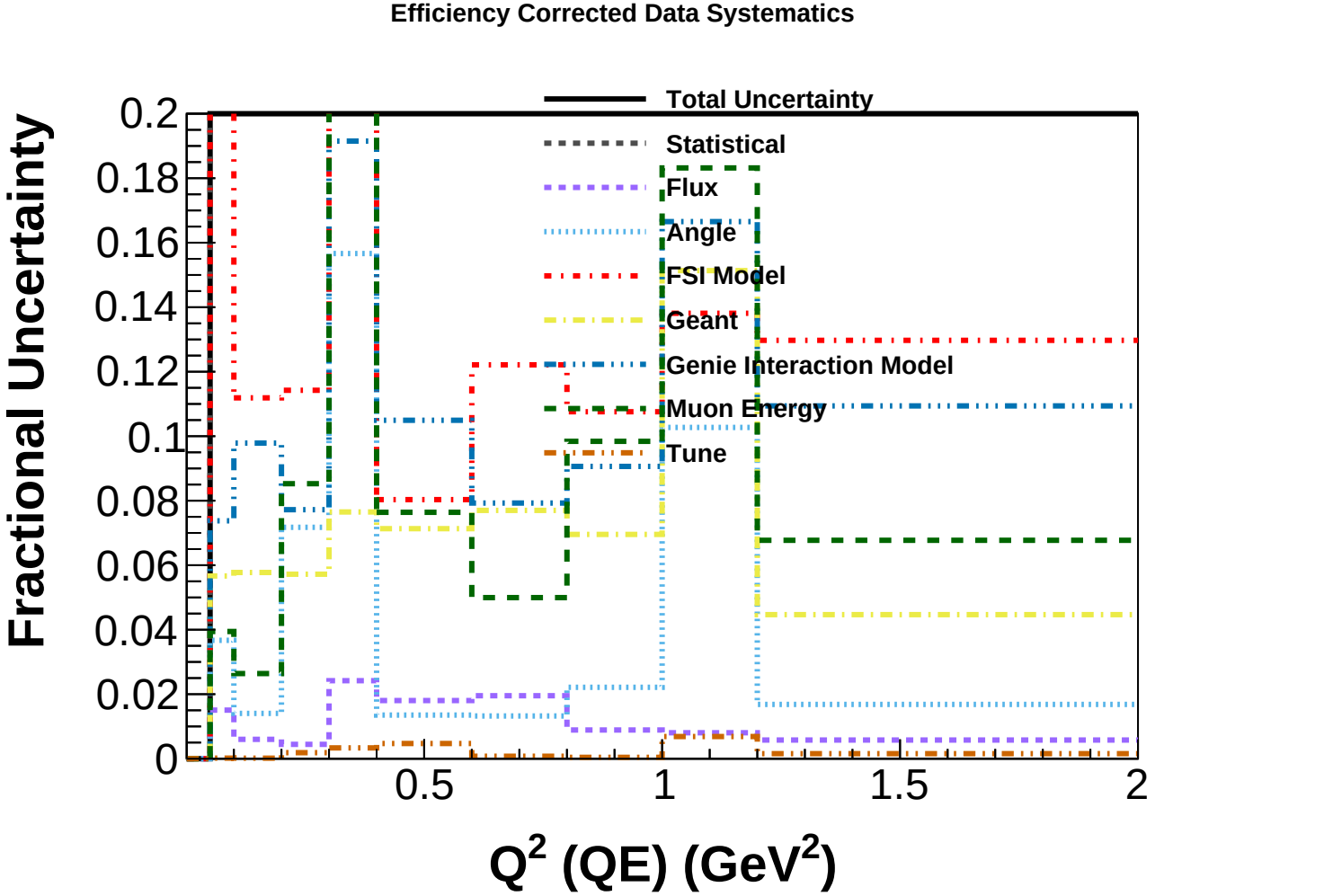
efficiency: selected and true

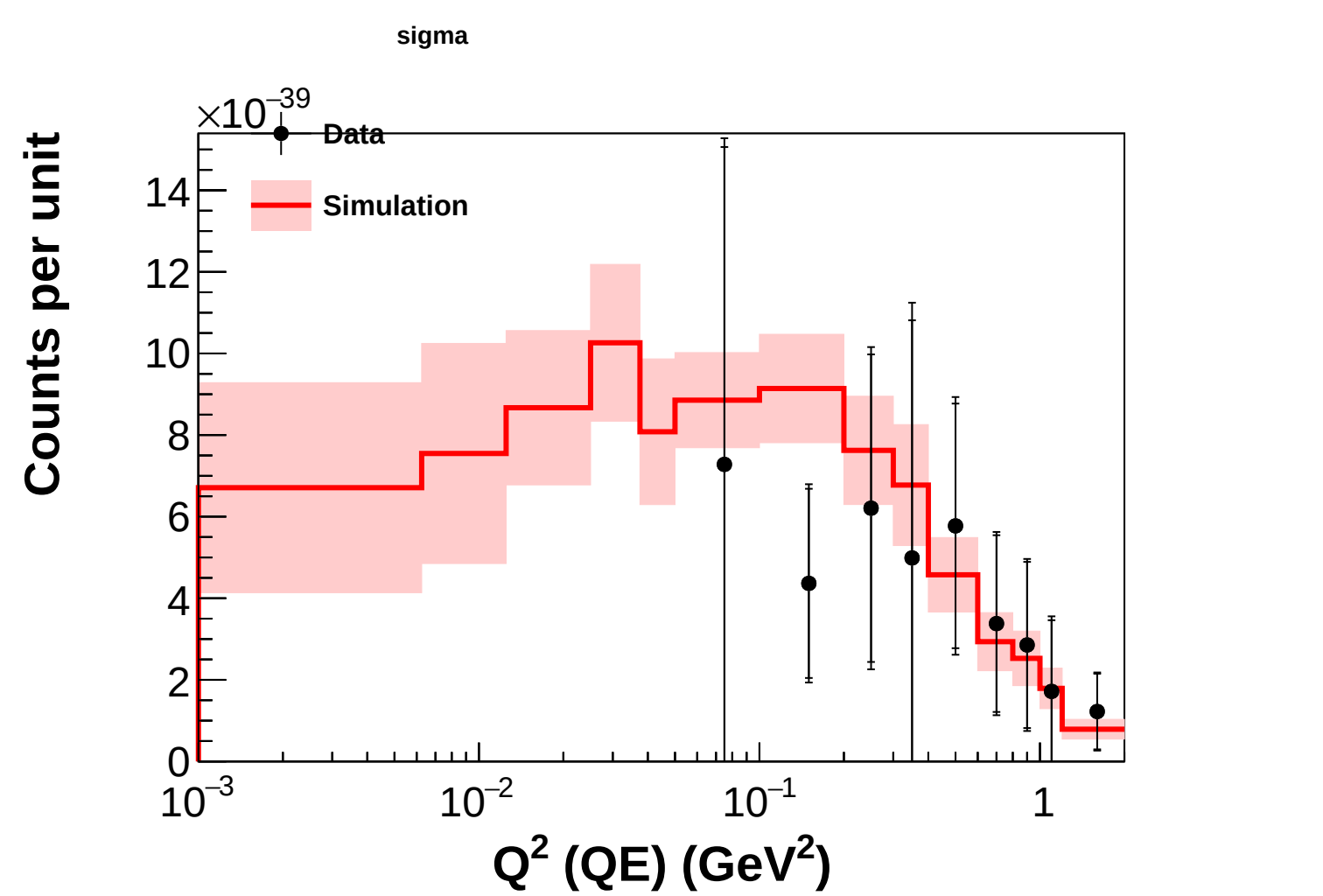


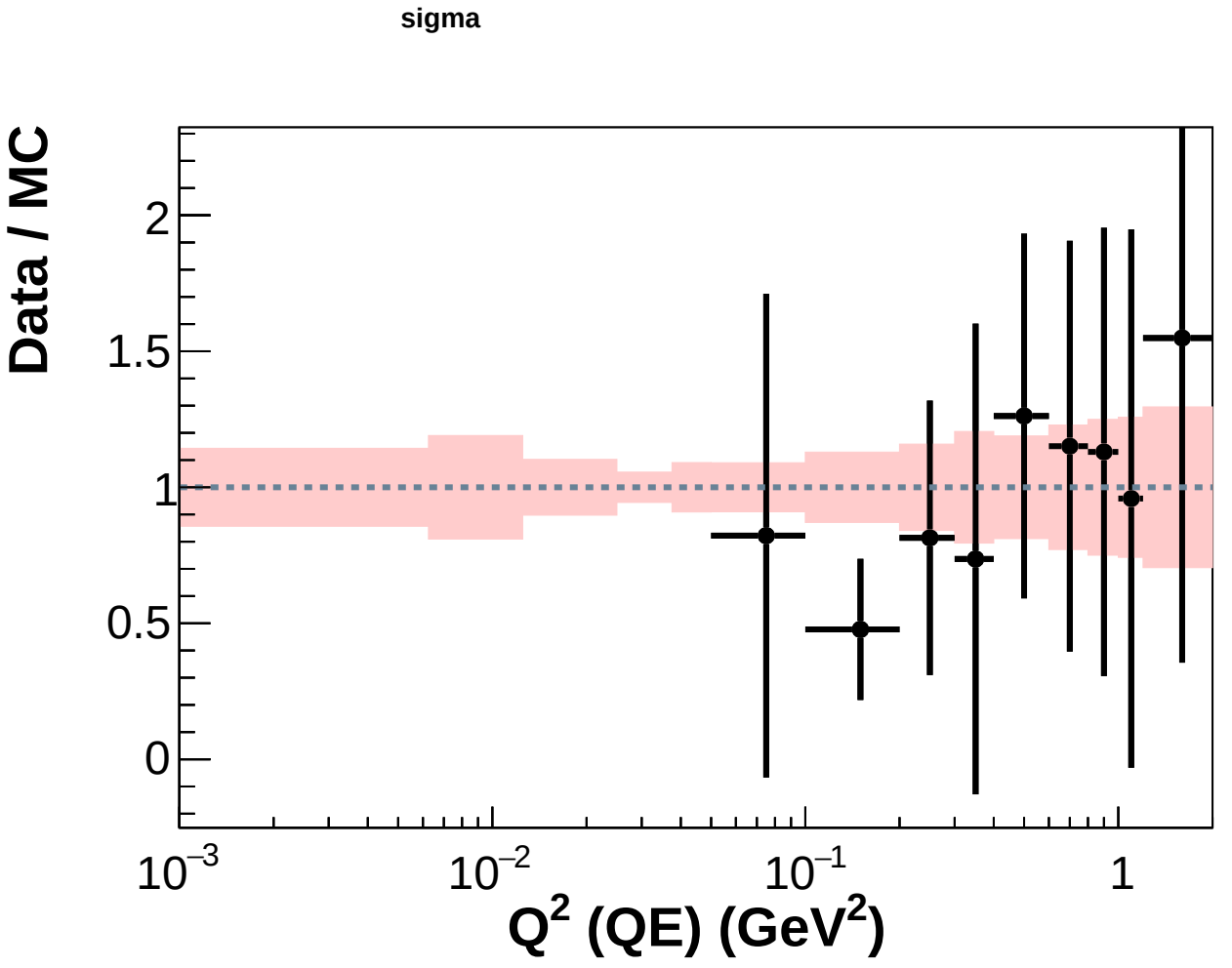

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
5
4
3
2
1
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

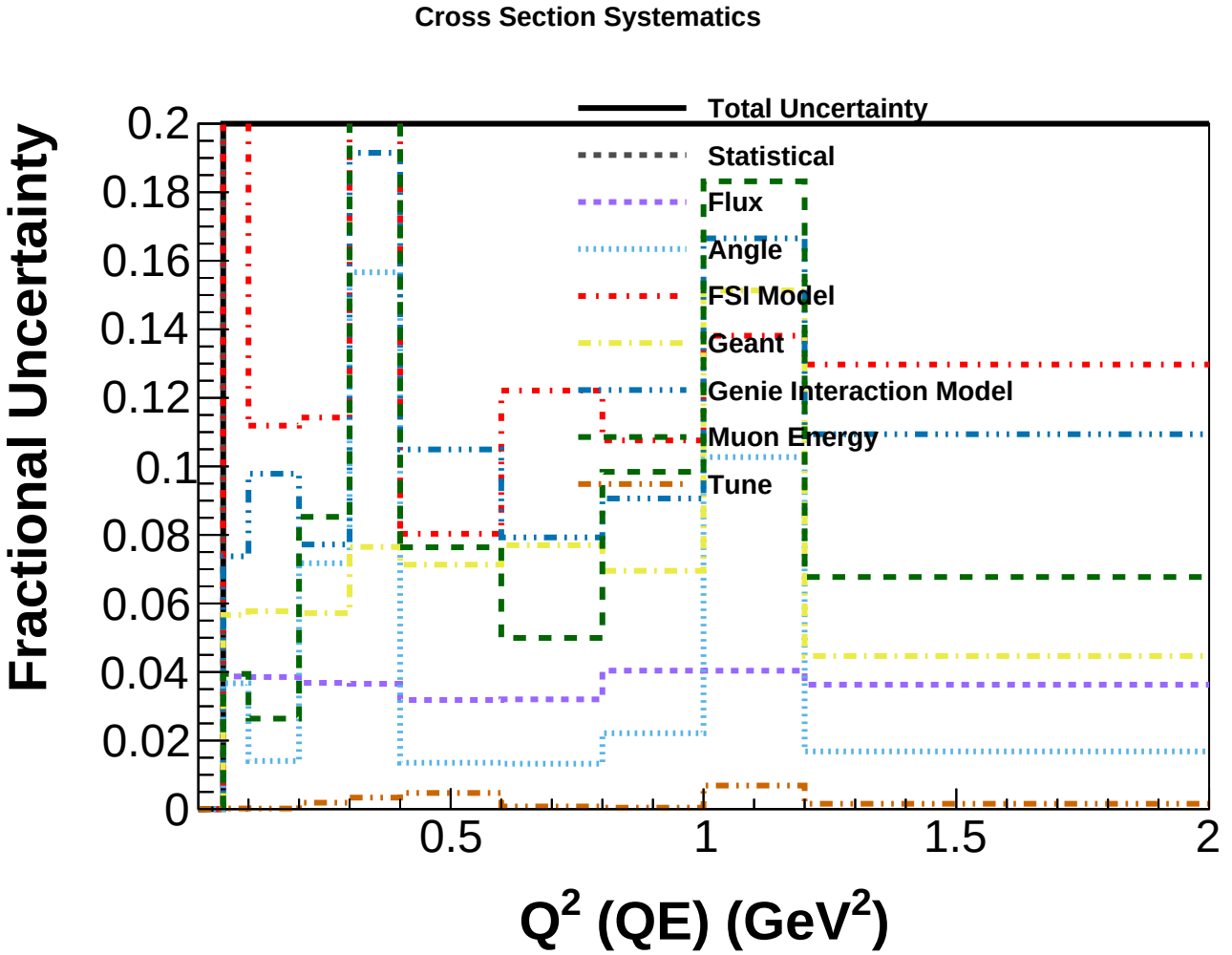

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

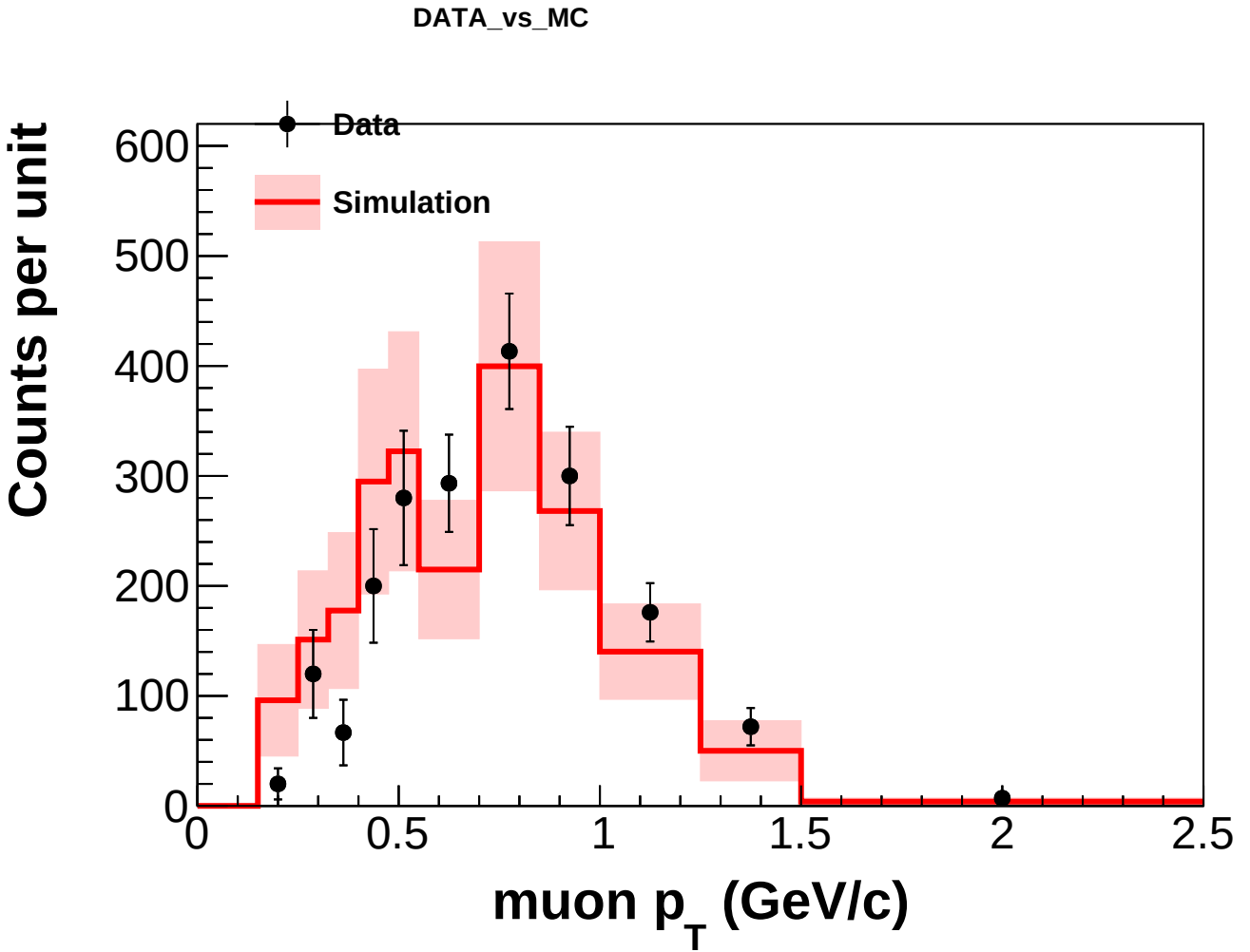

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

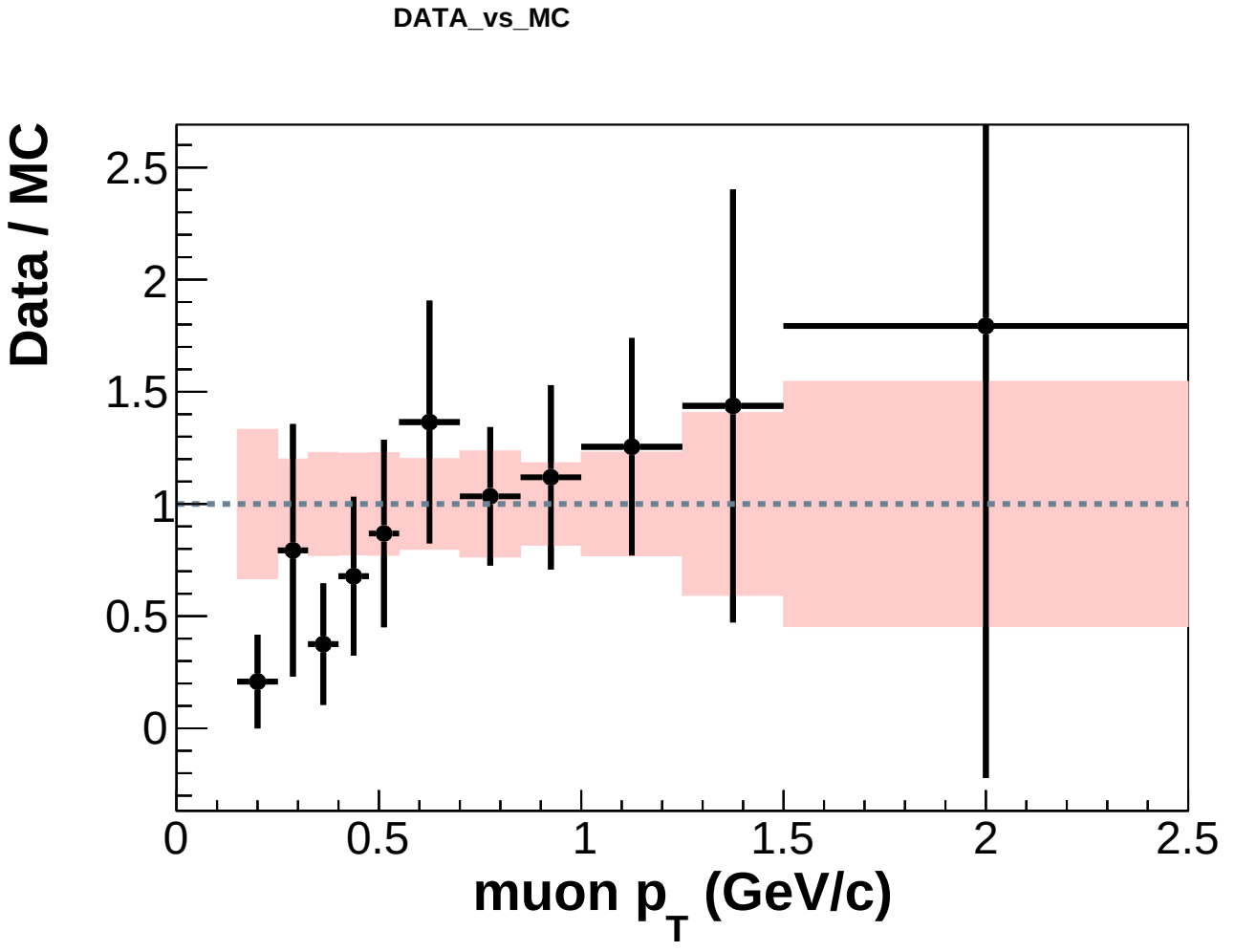

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

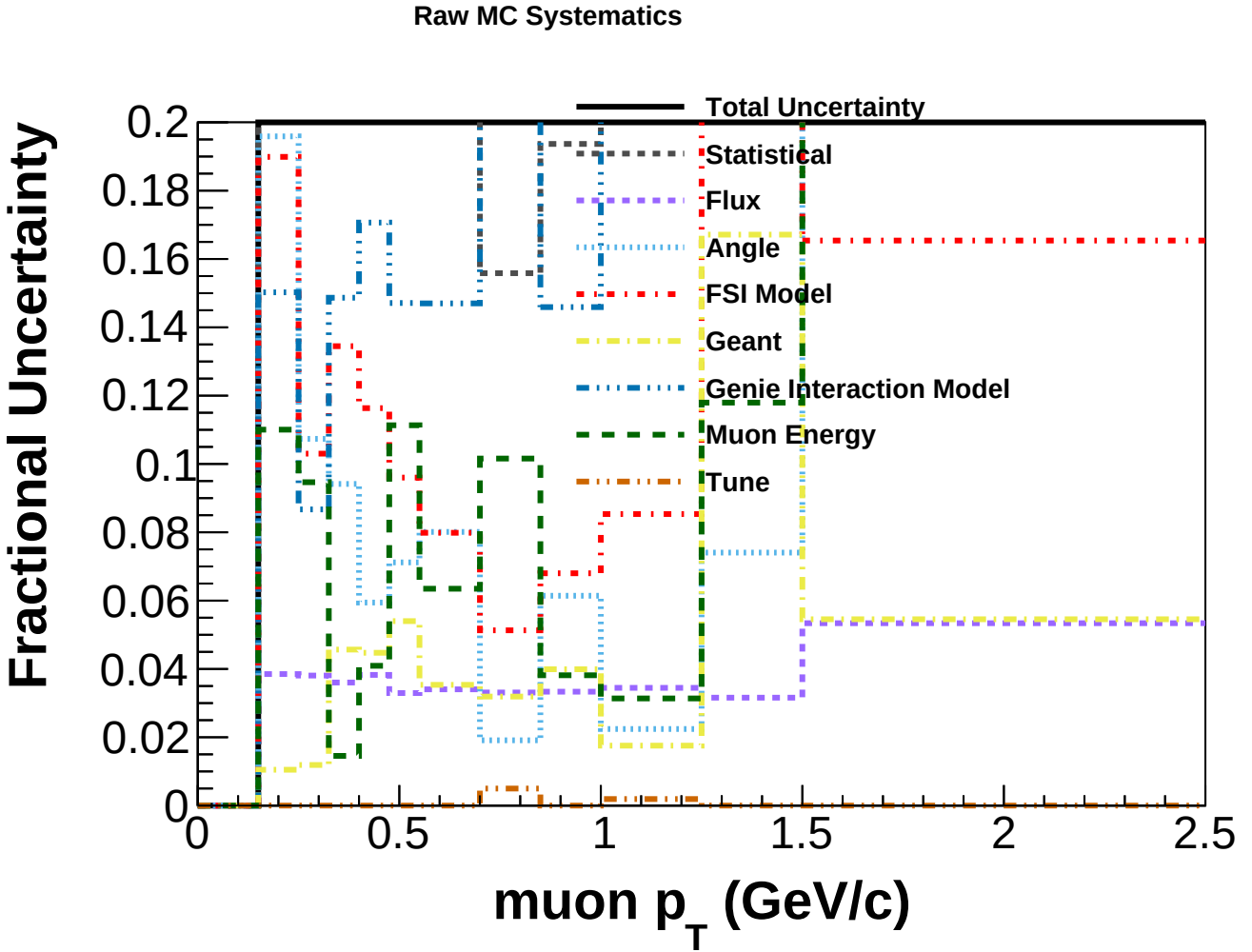

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
14
12
10
8
6
4
2
0
10⁻³
10⁻²
10⁻¹
1
Q² (QE) (GeV²)

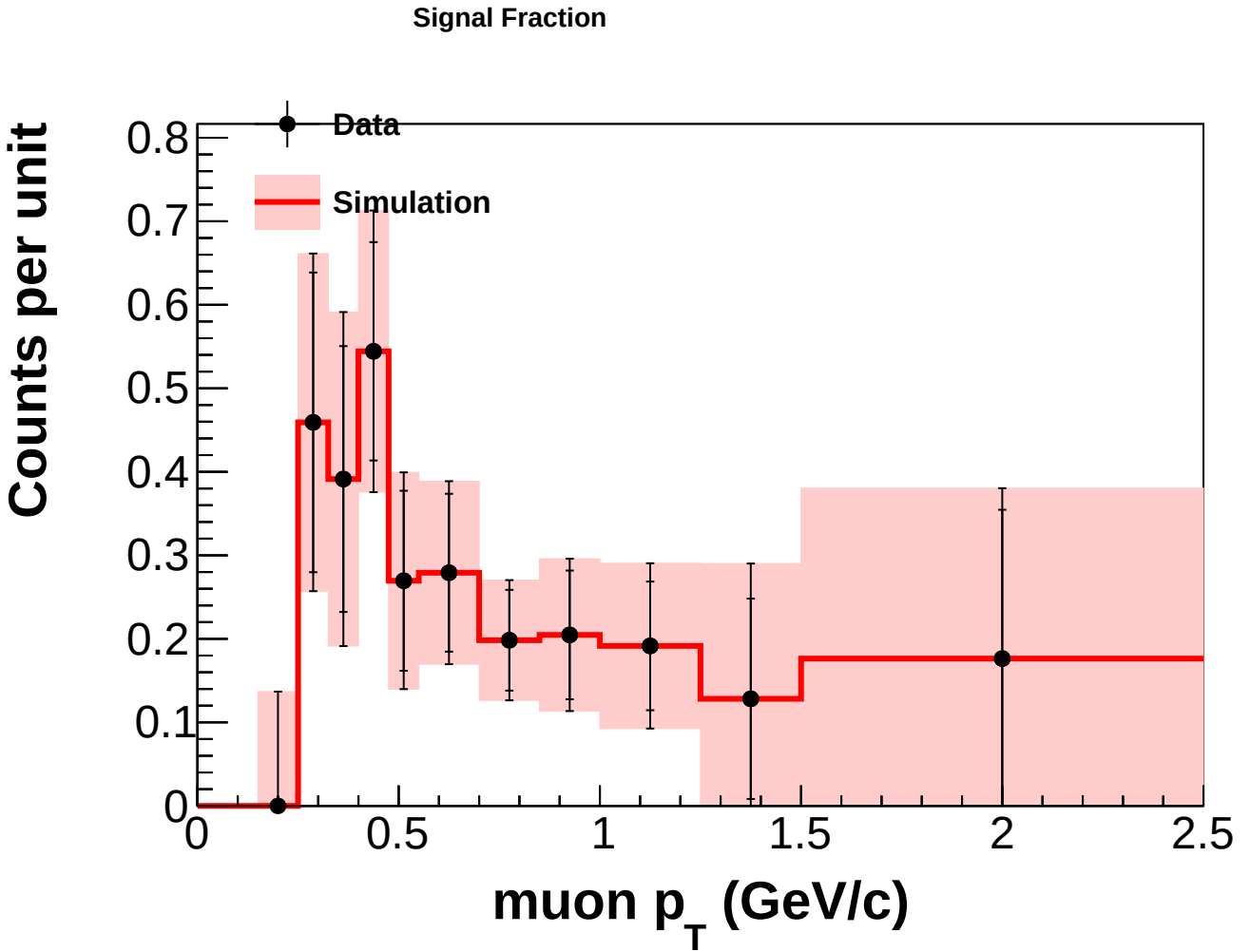

sigma
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

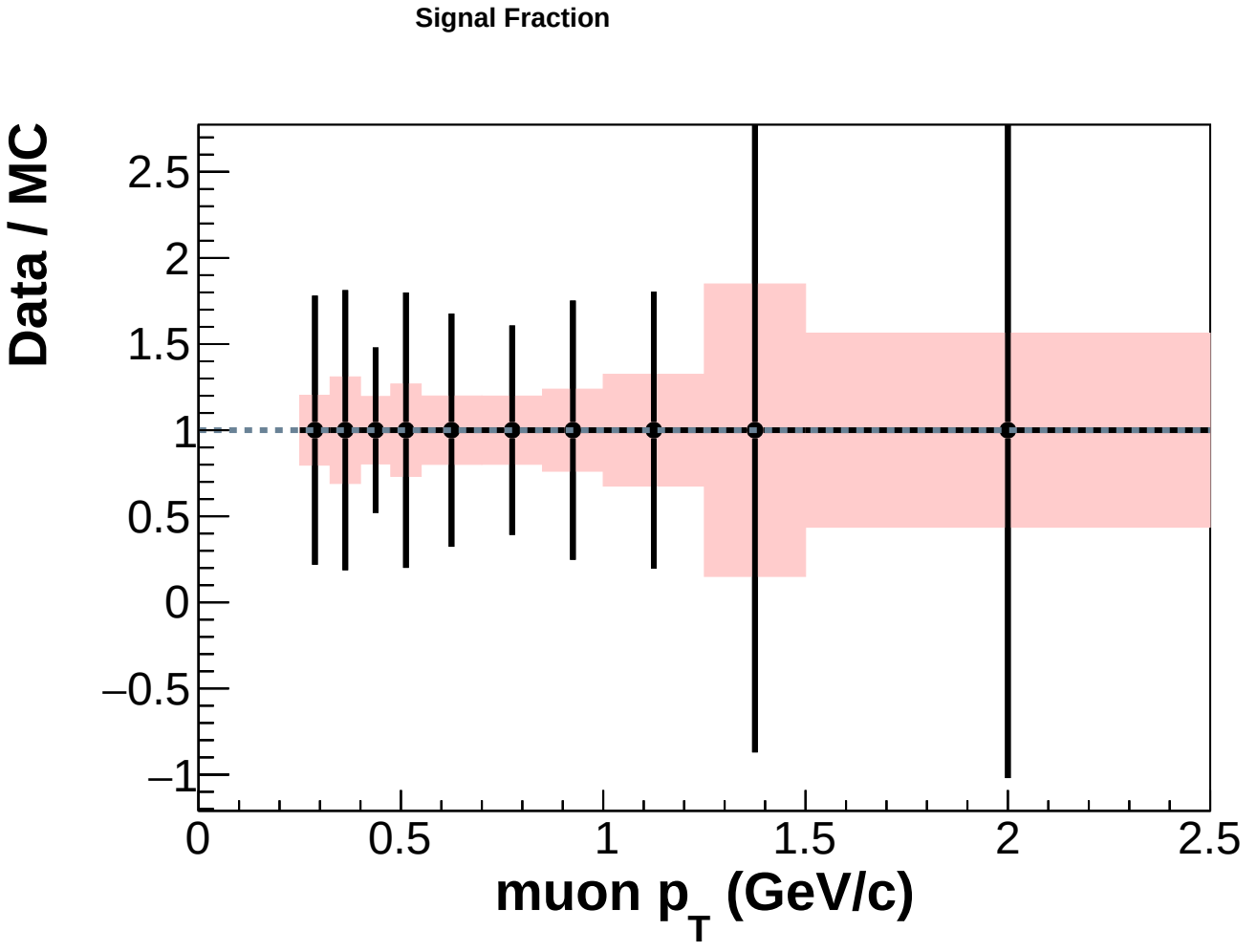

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

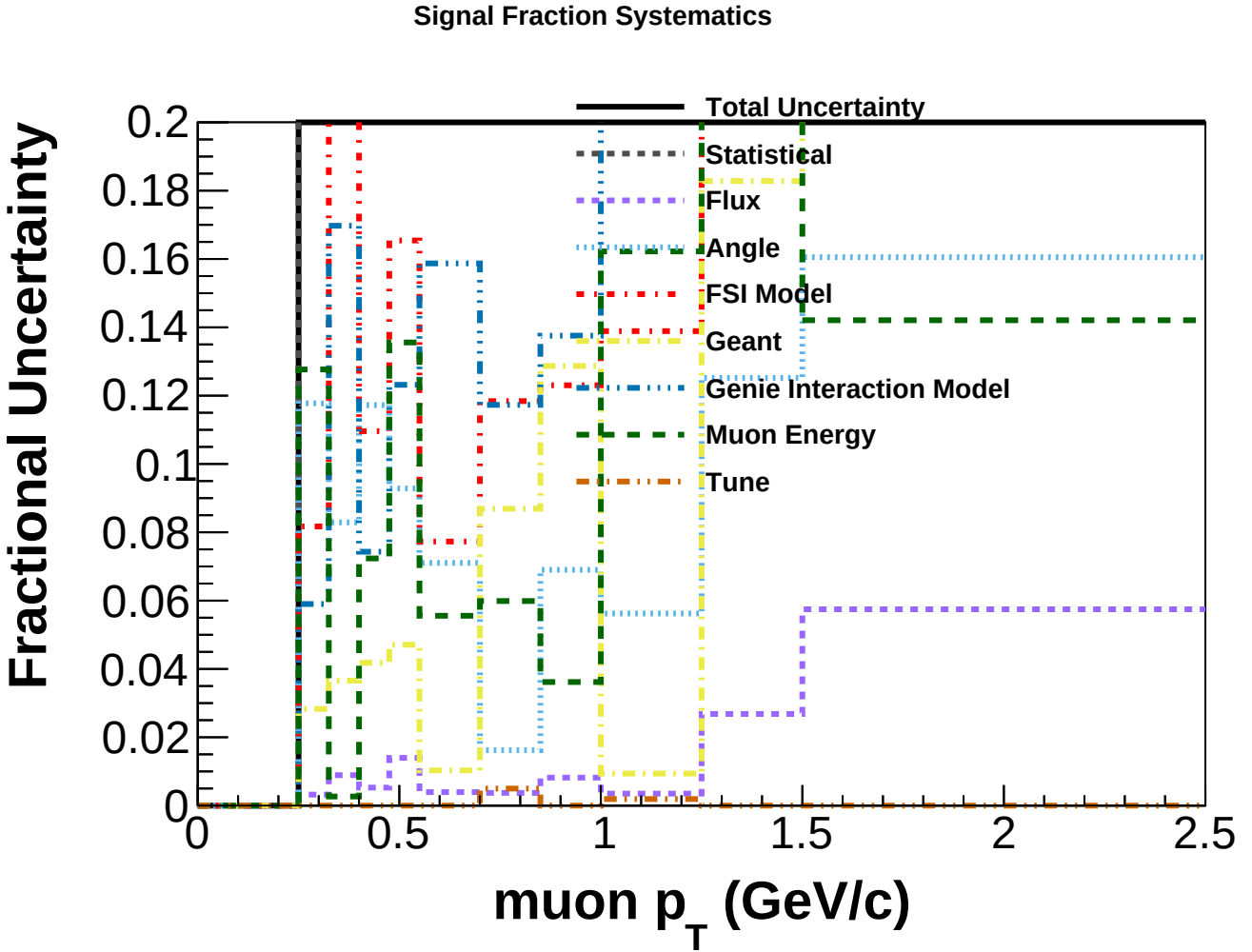

DATA_vs_MC
Data
Simulation
Counts per unit
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

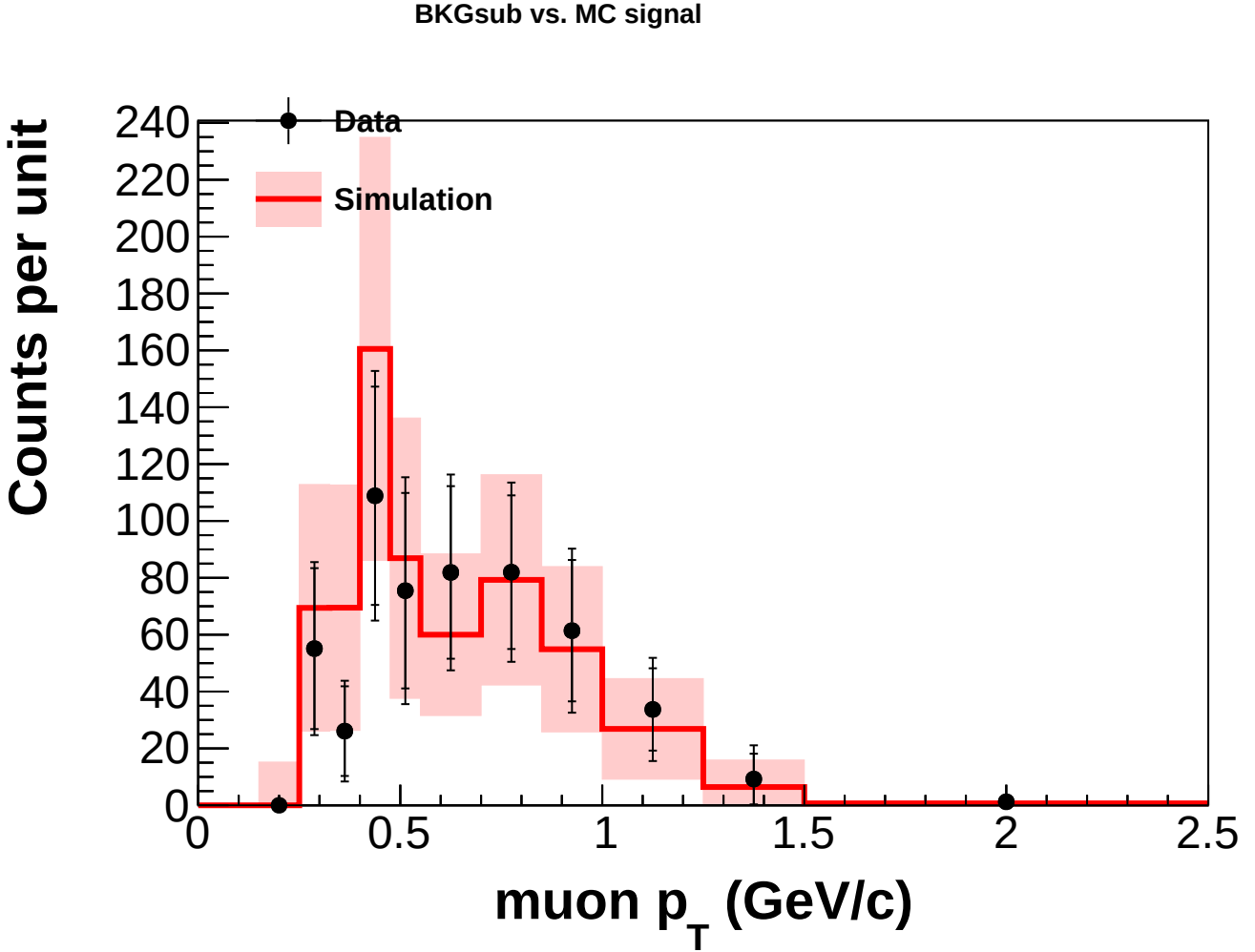

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

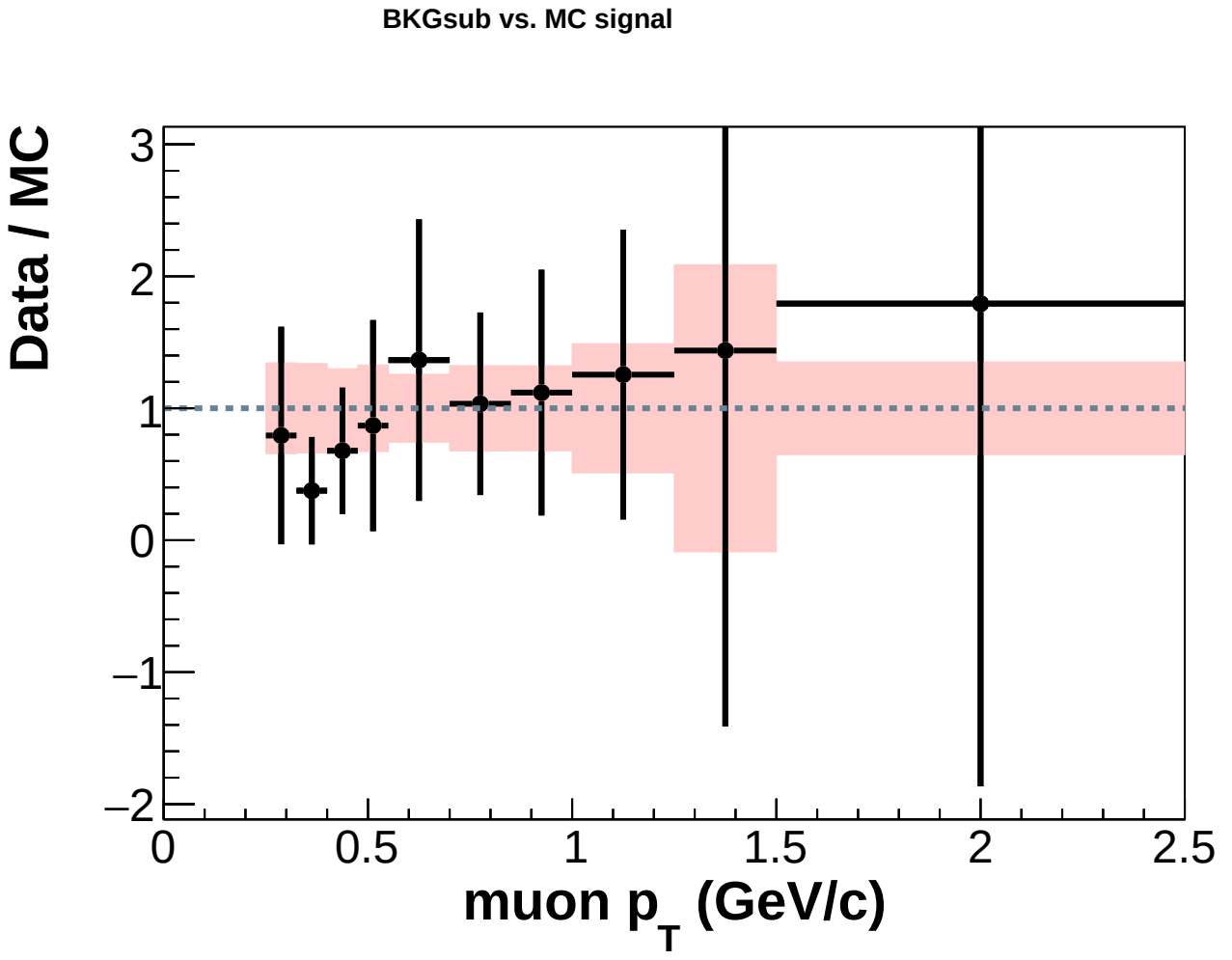

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

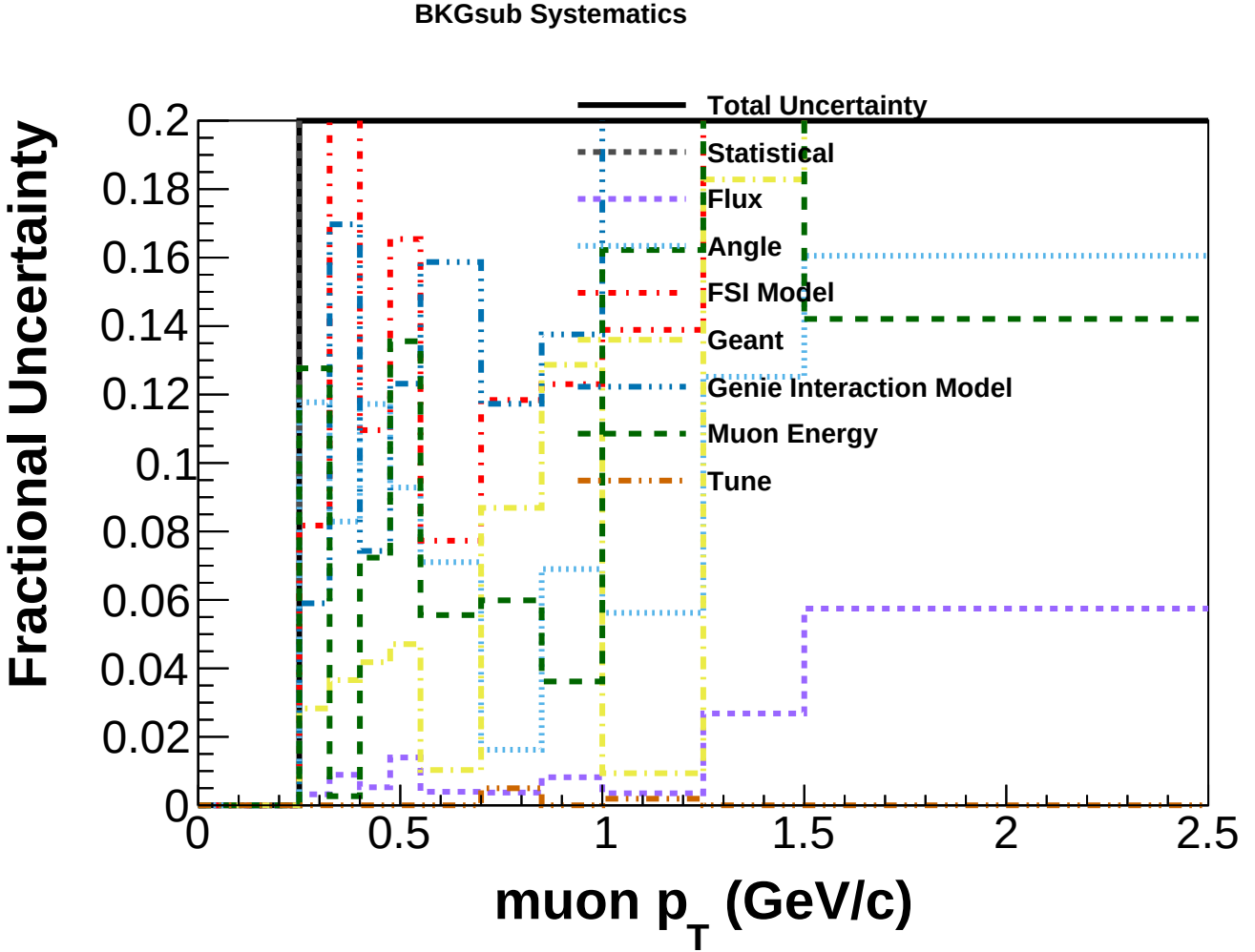

Signal Fraction
Data
Simulation
Counts per unit
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

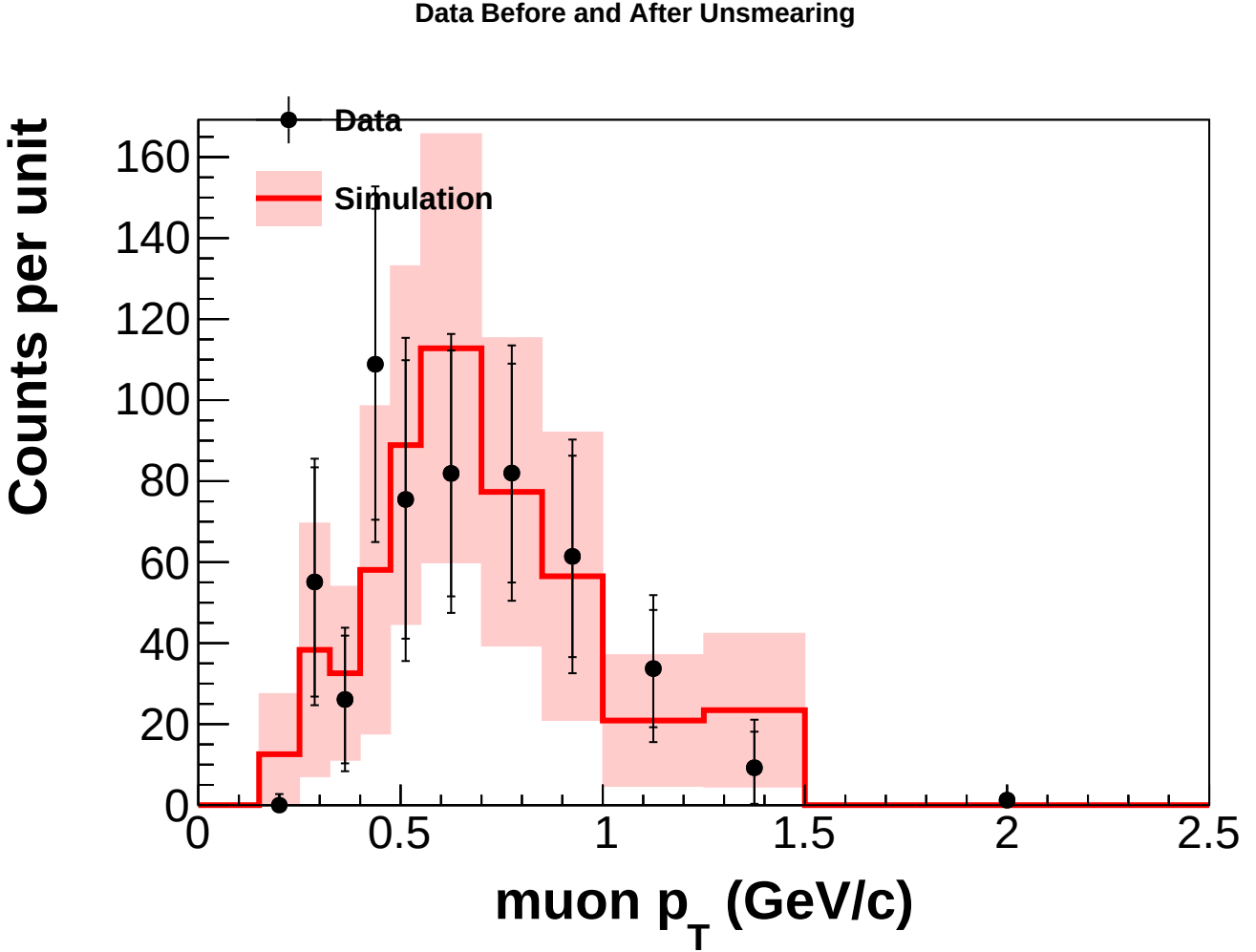

Signal Fraction
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

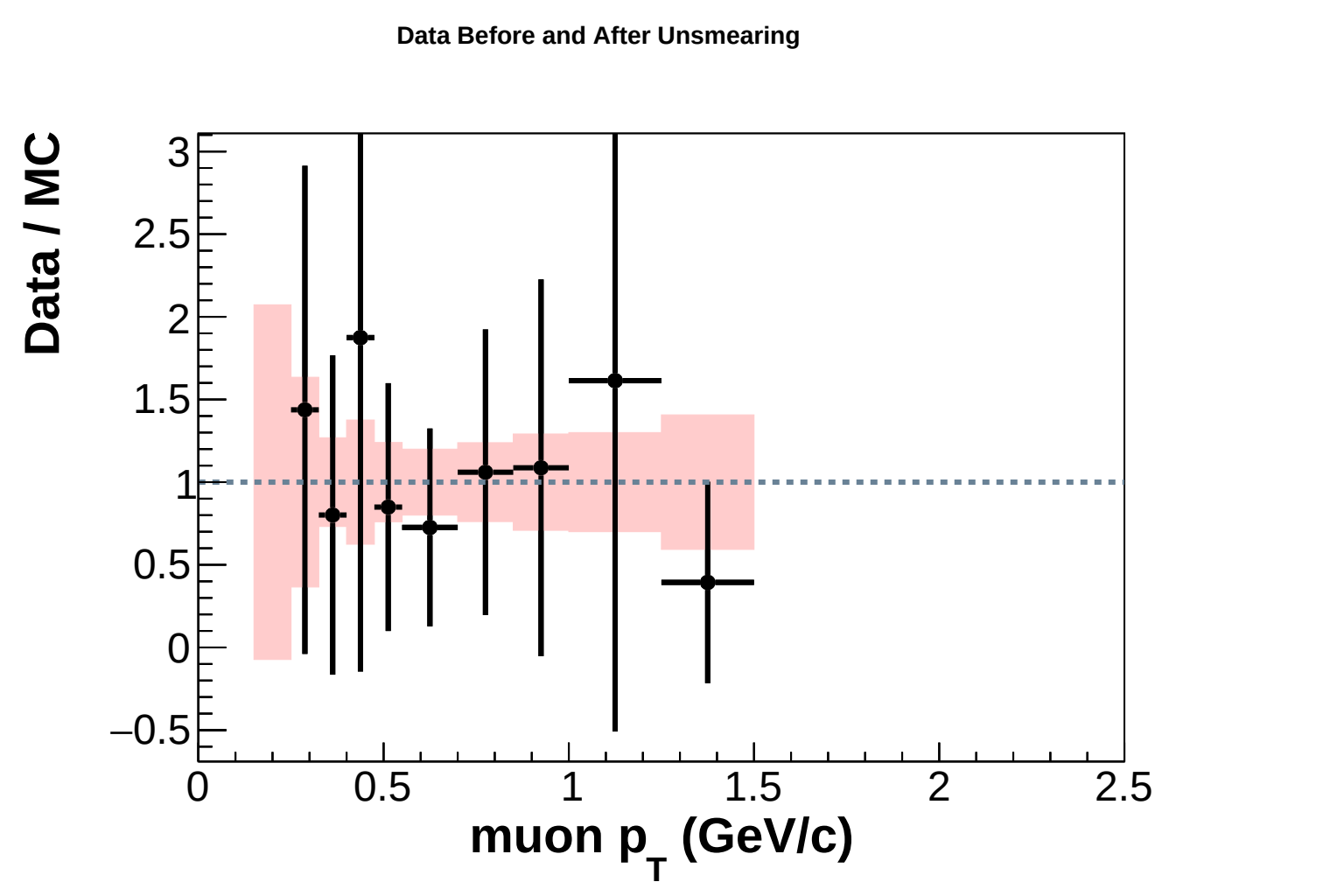

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

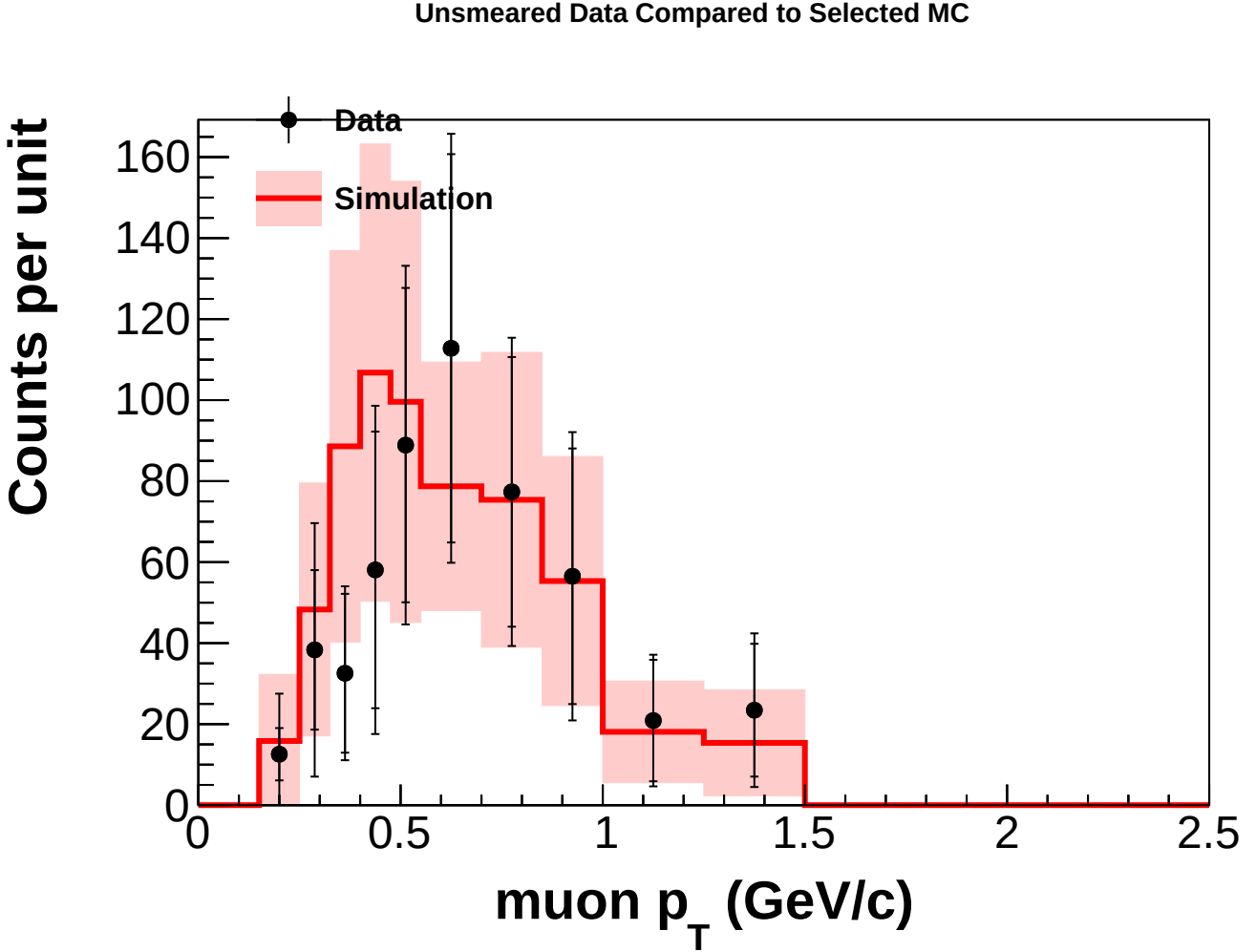

BKGsub vs. MC signal
Data
Simulation
Counts per unit
muon p_T (GeV/c)
0
20
40
60
80
100
120
140
160
180
200
220
240
0
0.5
1
1.5
2
2.5

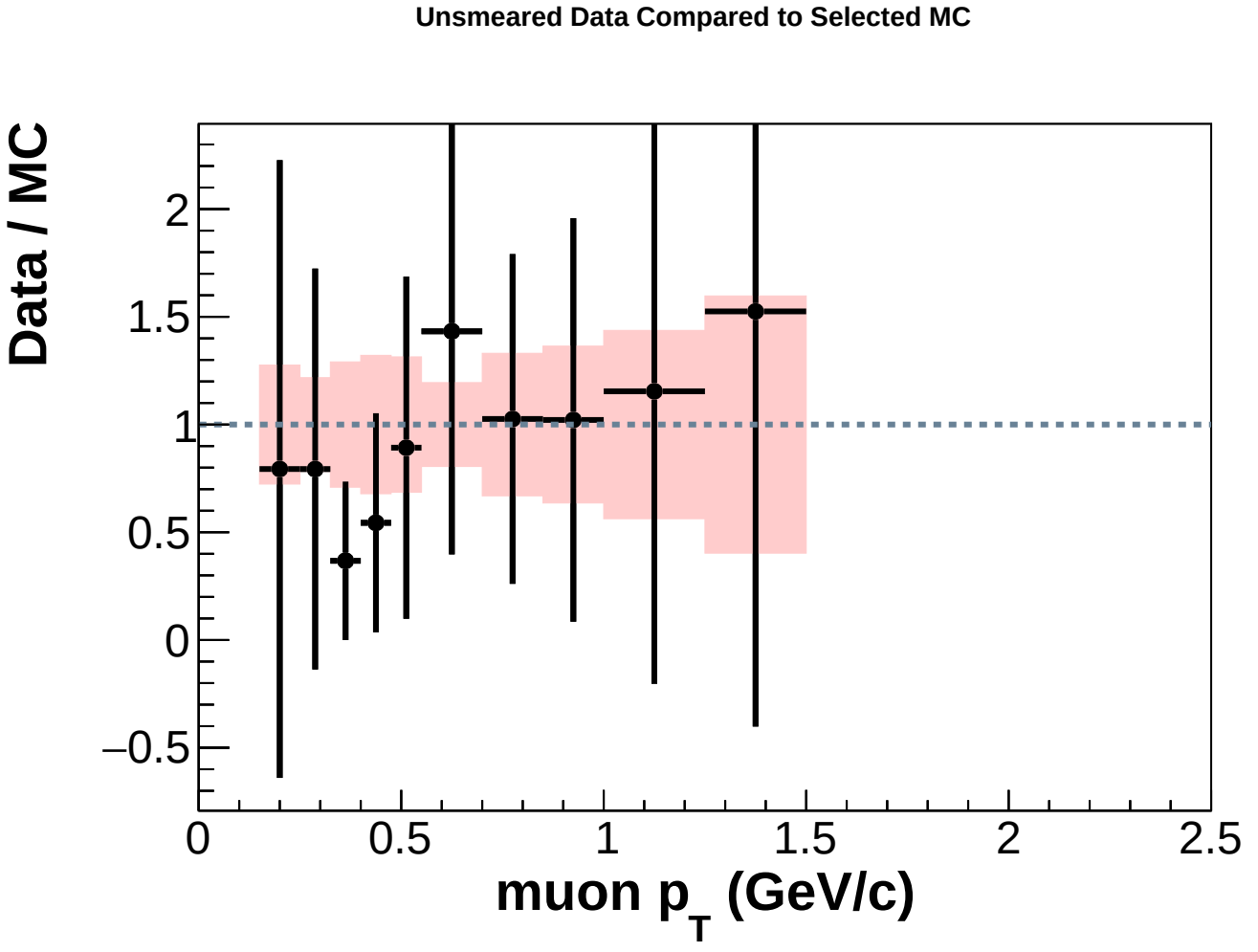

BKGsub vs. MC signal
Data / MC
3
2
1
0
−1
−2
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

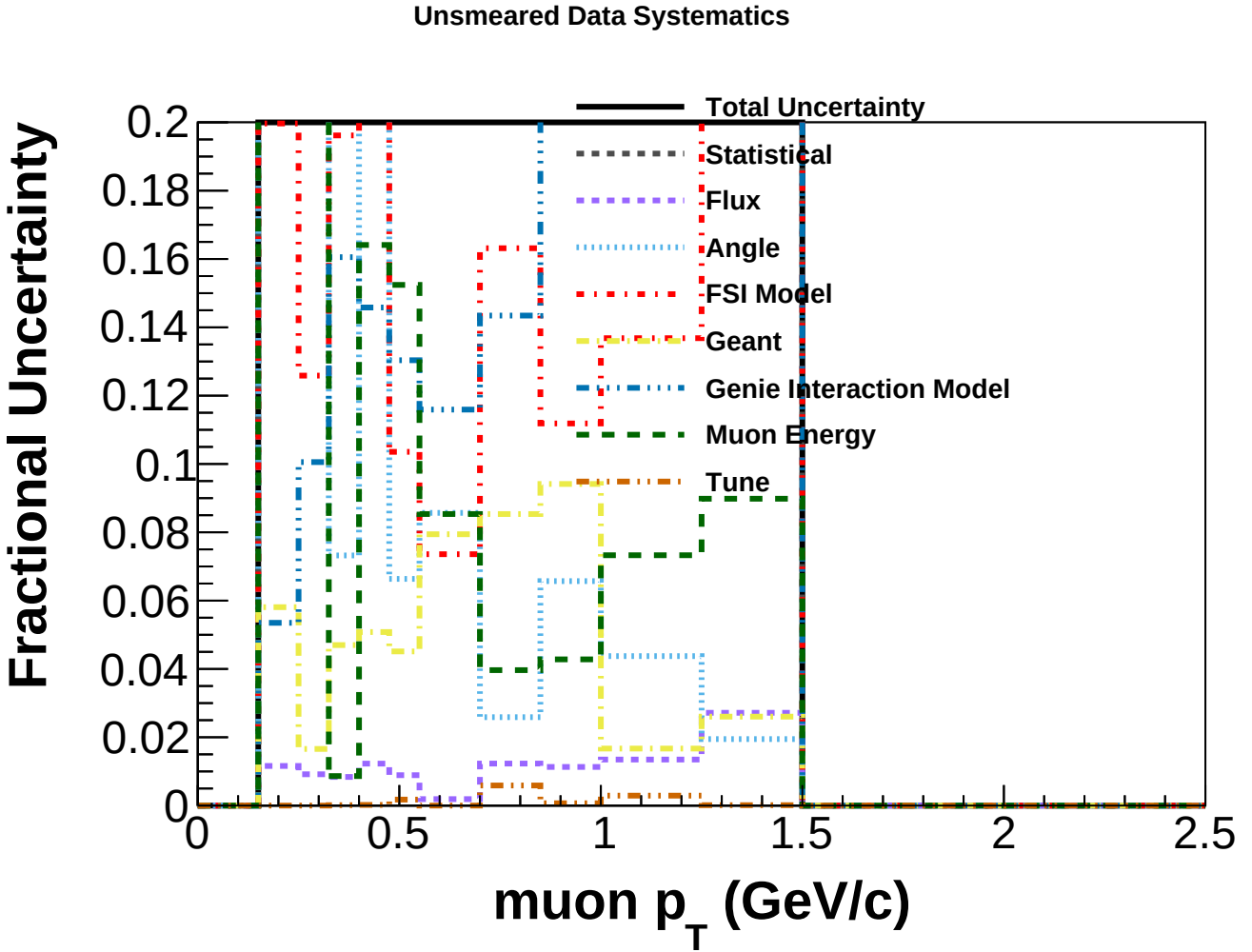

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

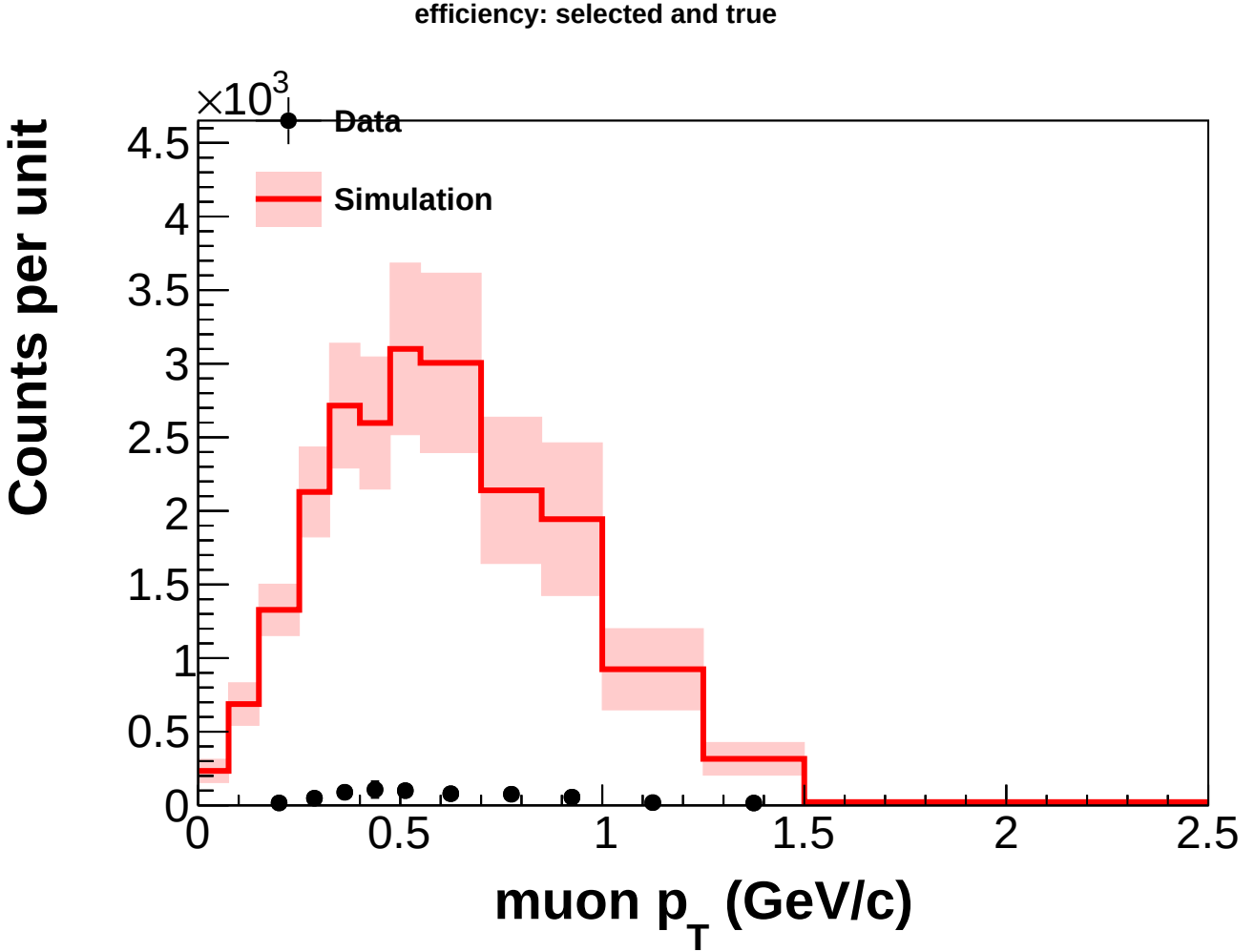

Data Before and After Unsmearing
Data
Simulation
Counts per unit
160
140
120
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

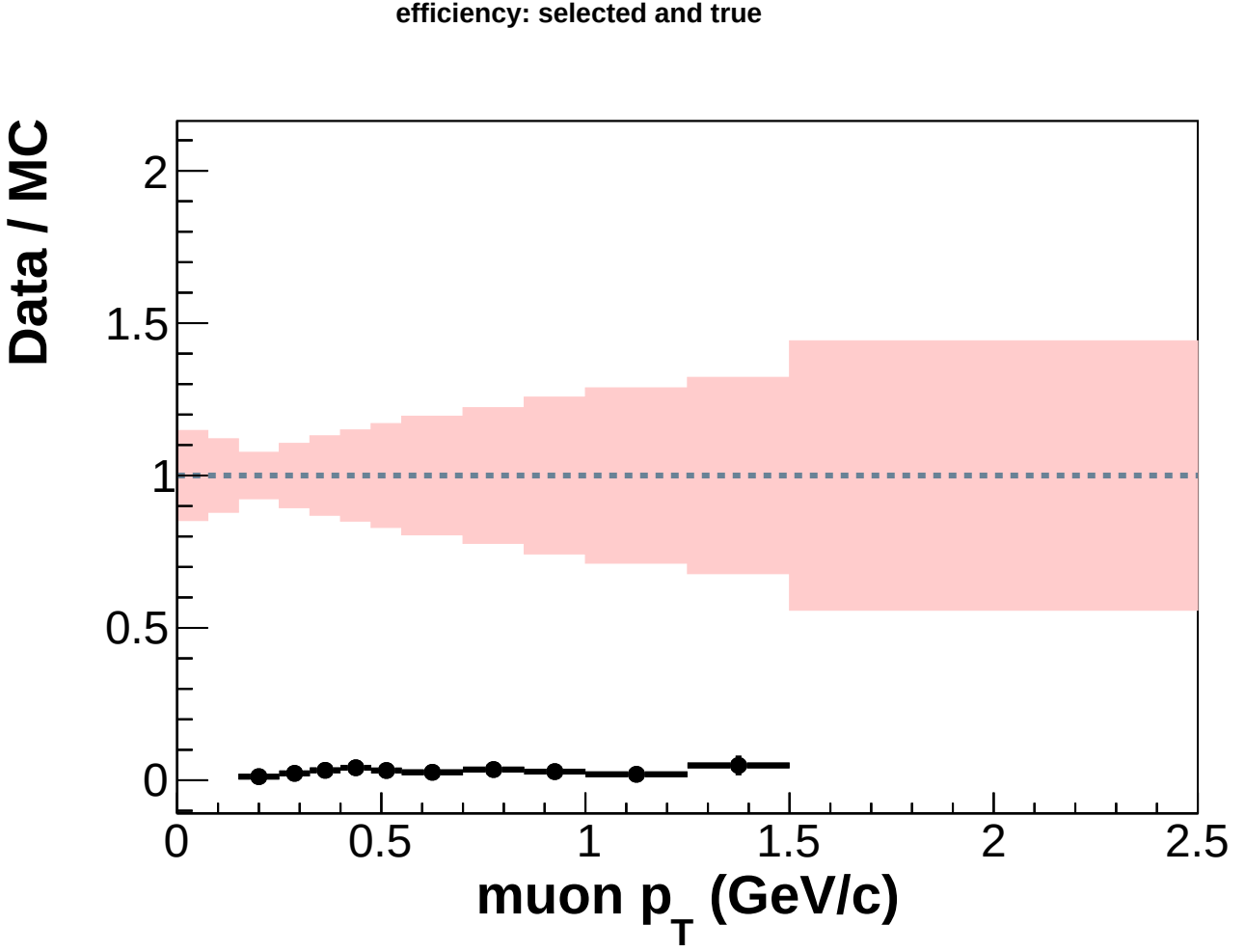

Data Before and After Unsmearing
Data / MC
3
2.5
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

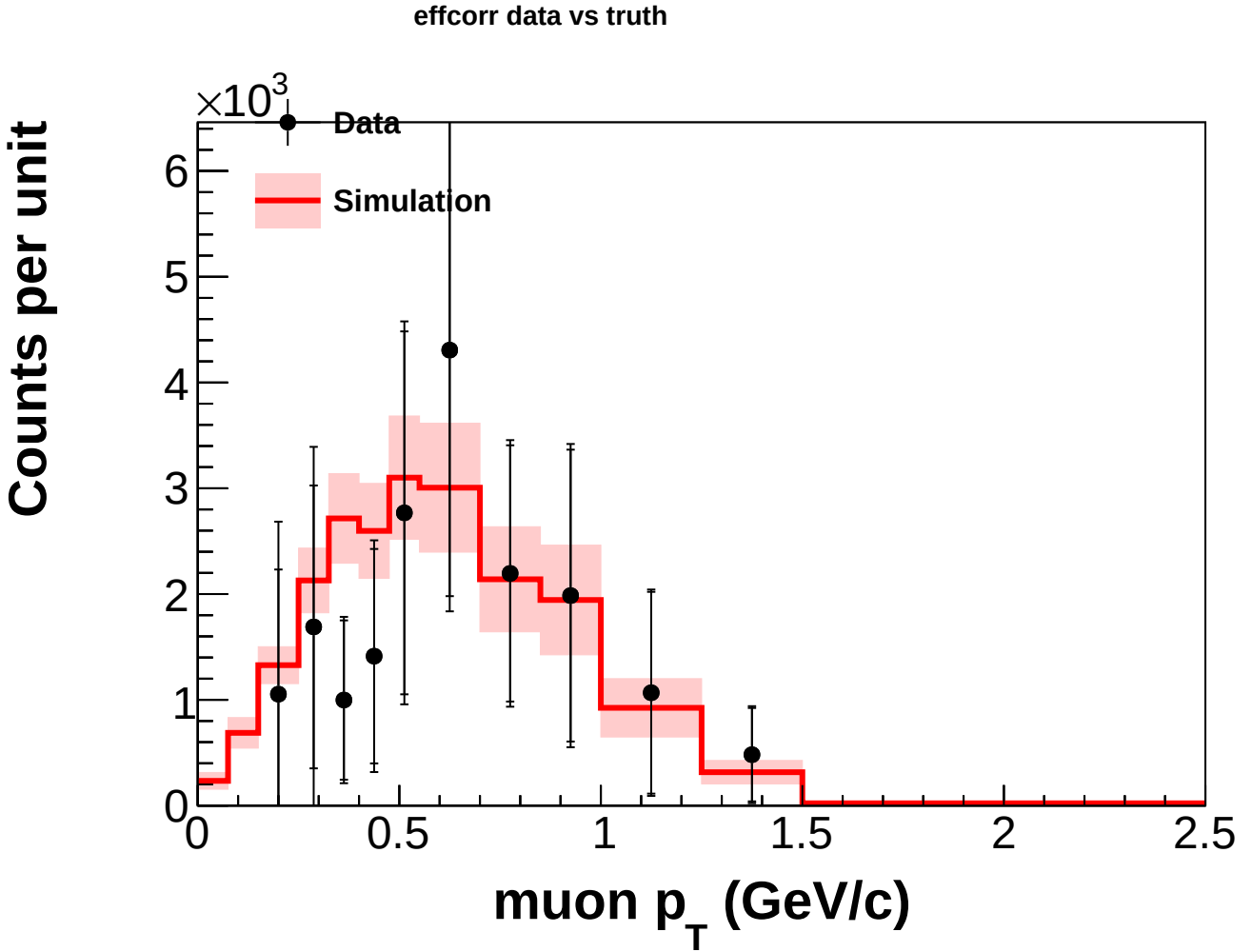

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

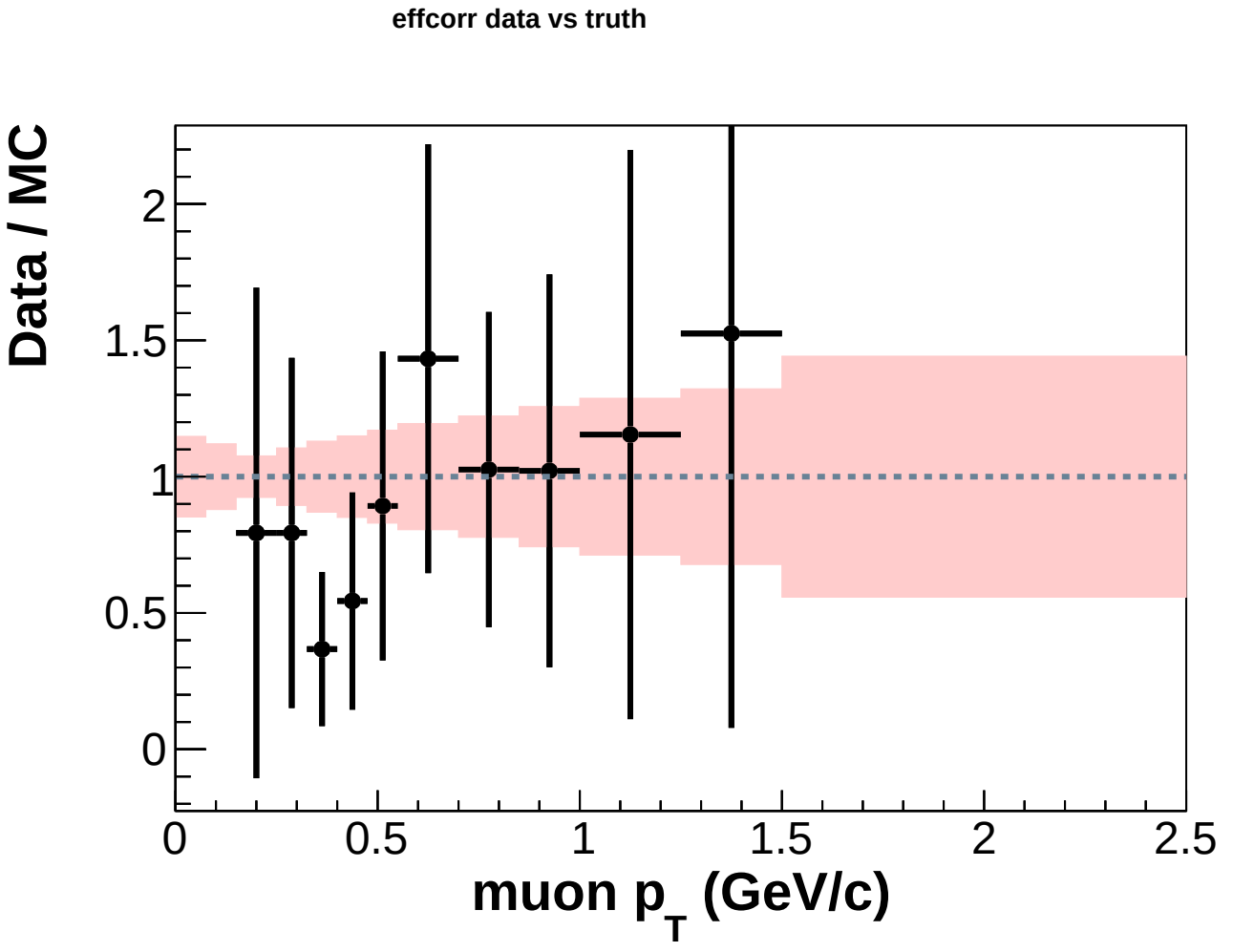

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

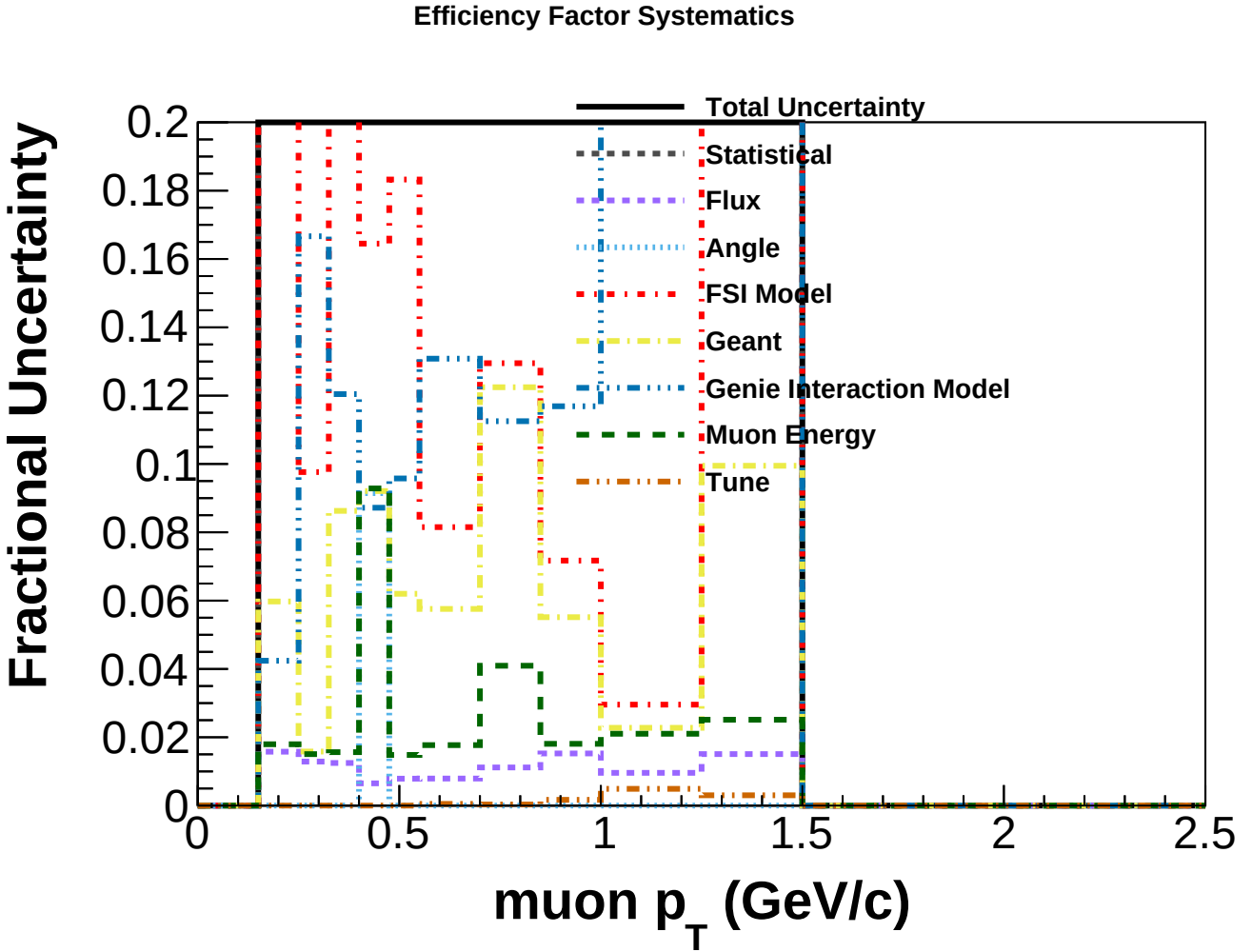

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

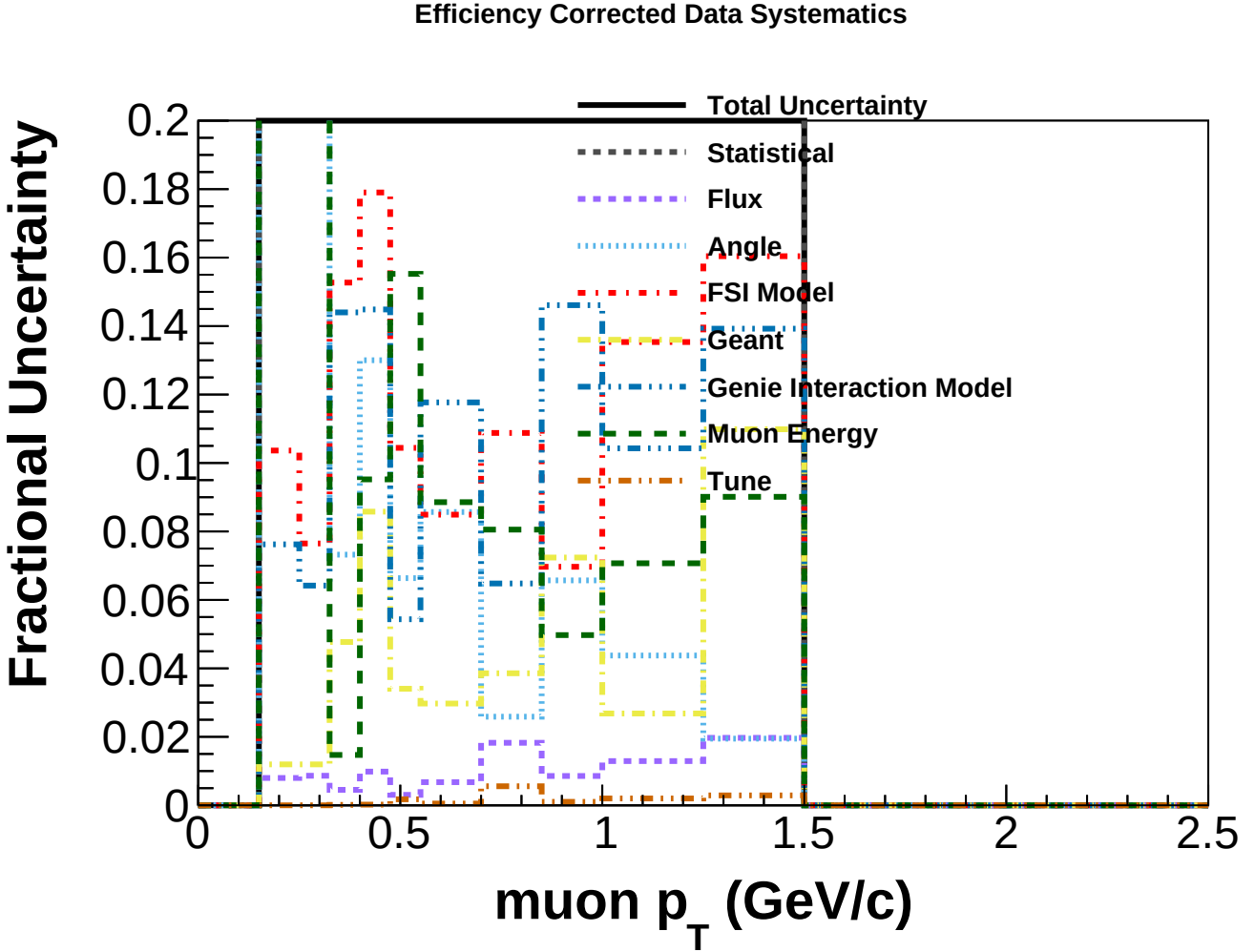

efficiency: selected and true
Counts per unit
×10^3
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Data
Simulation
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

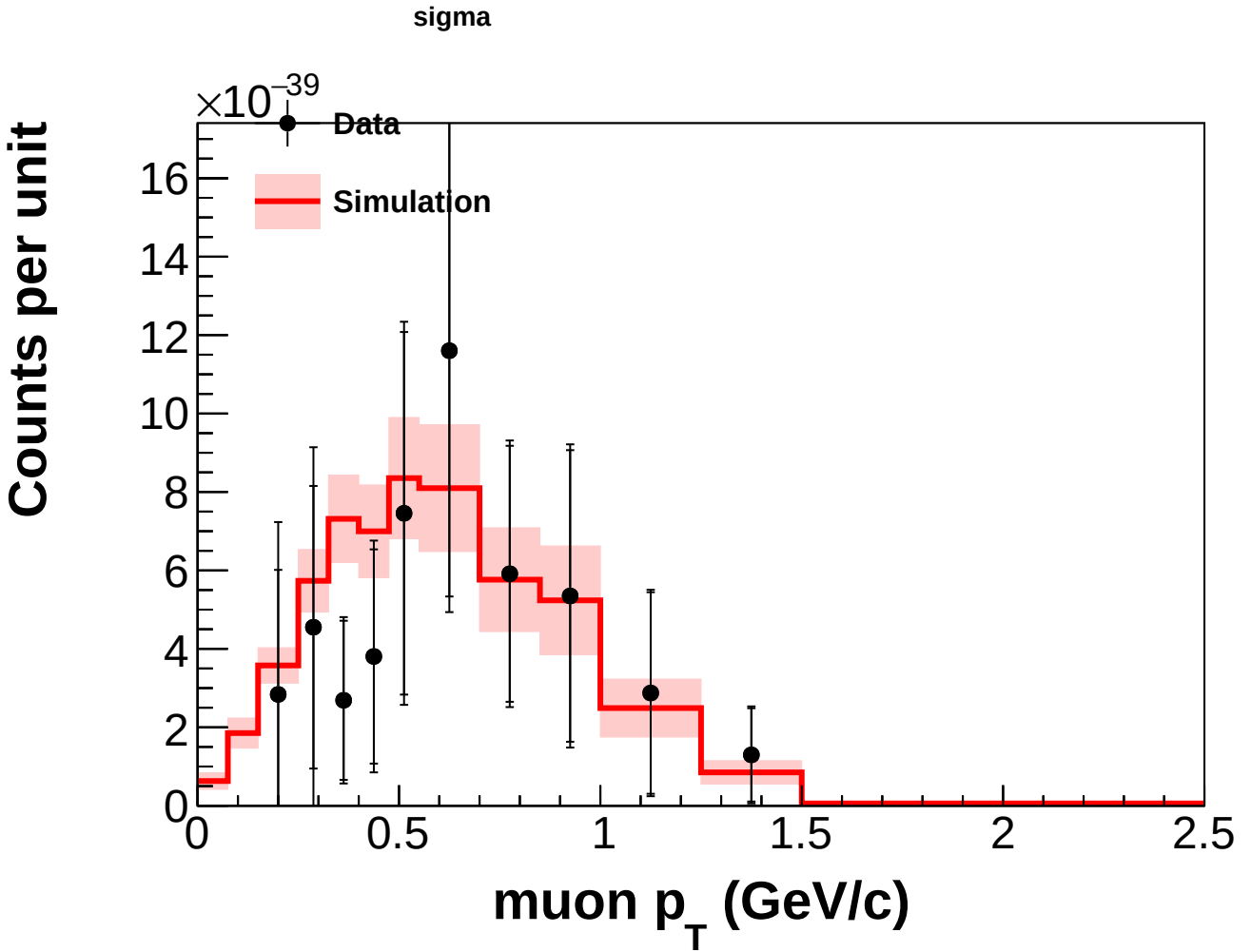

efficiency: selected and true
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

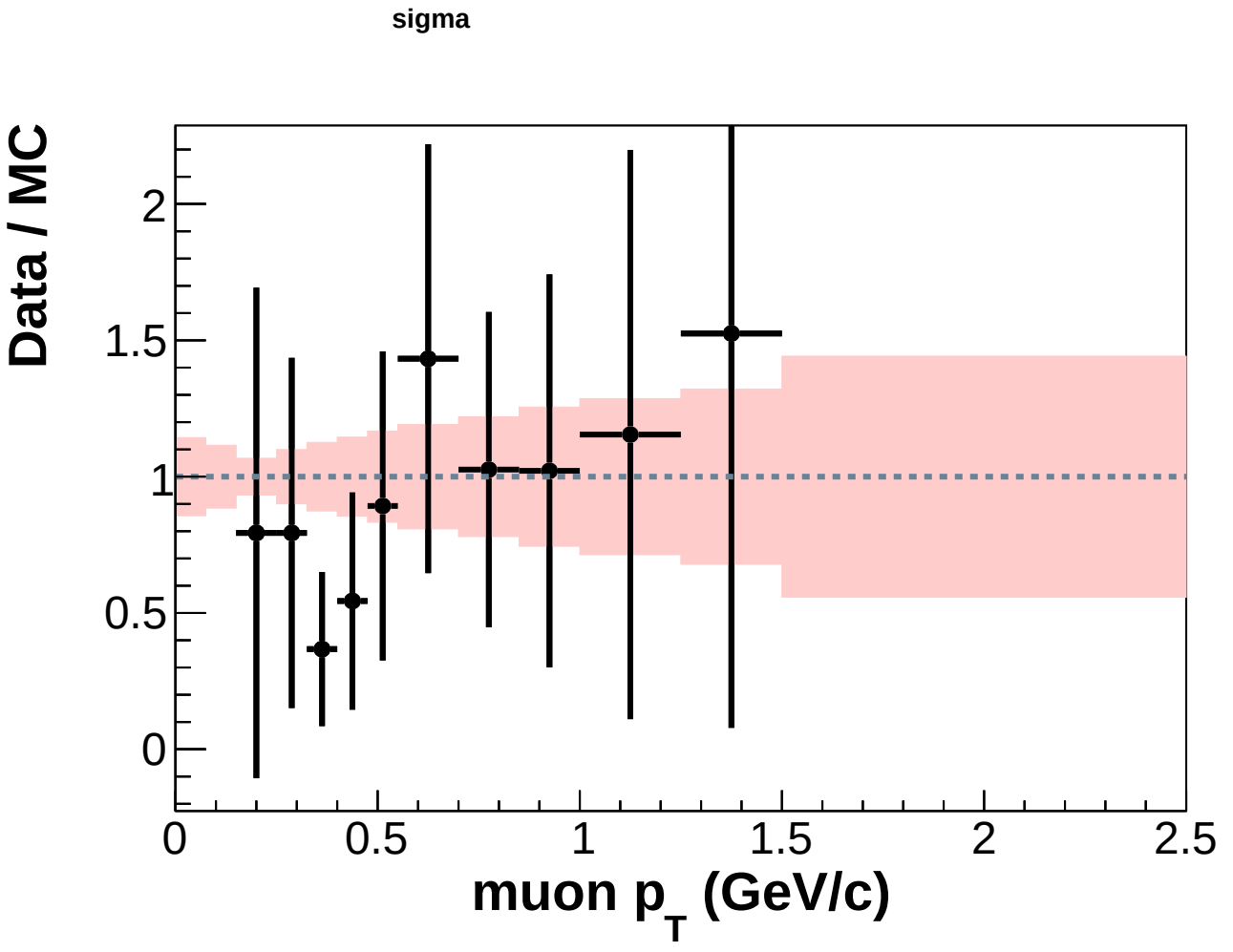

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

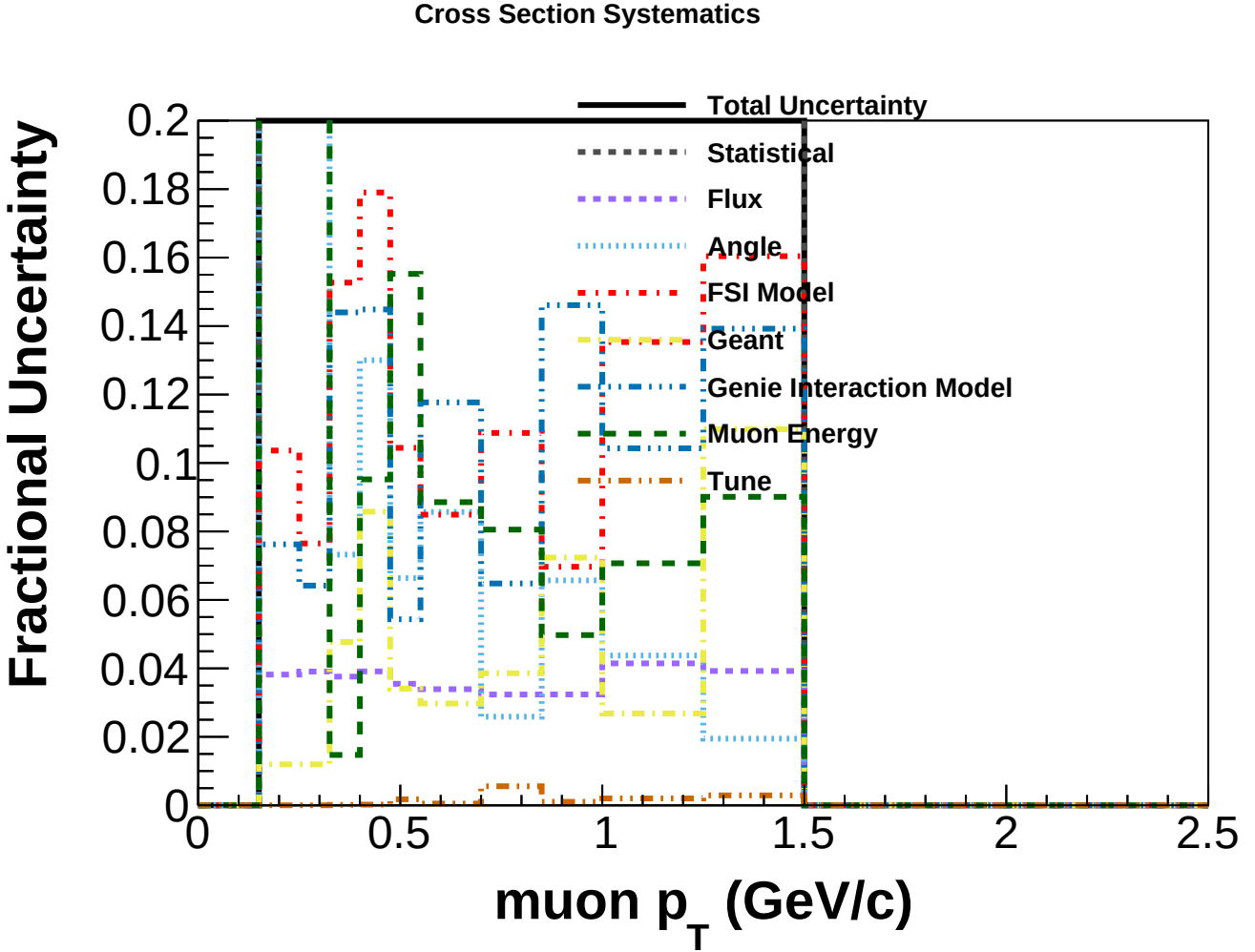

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

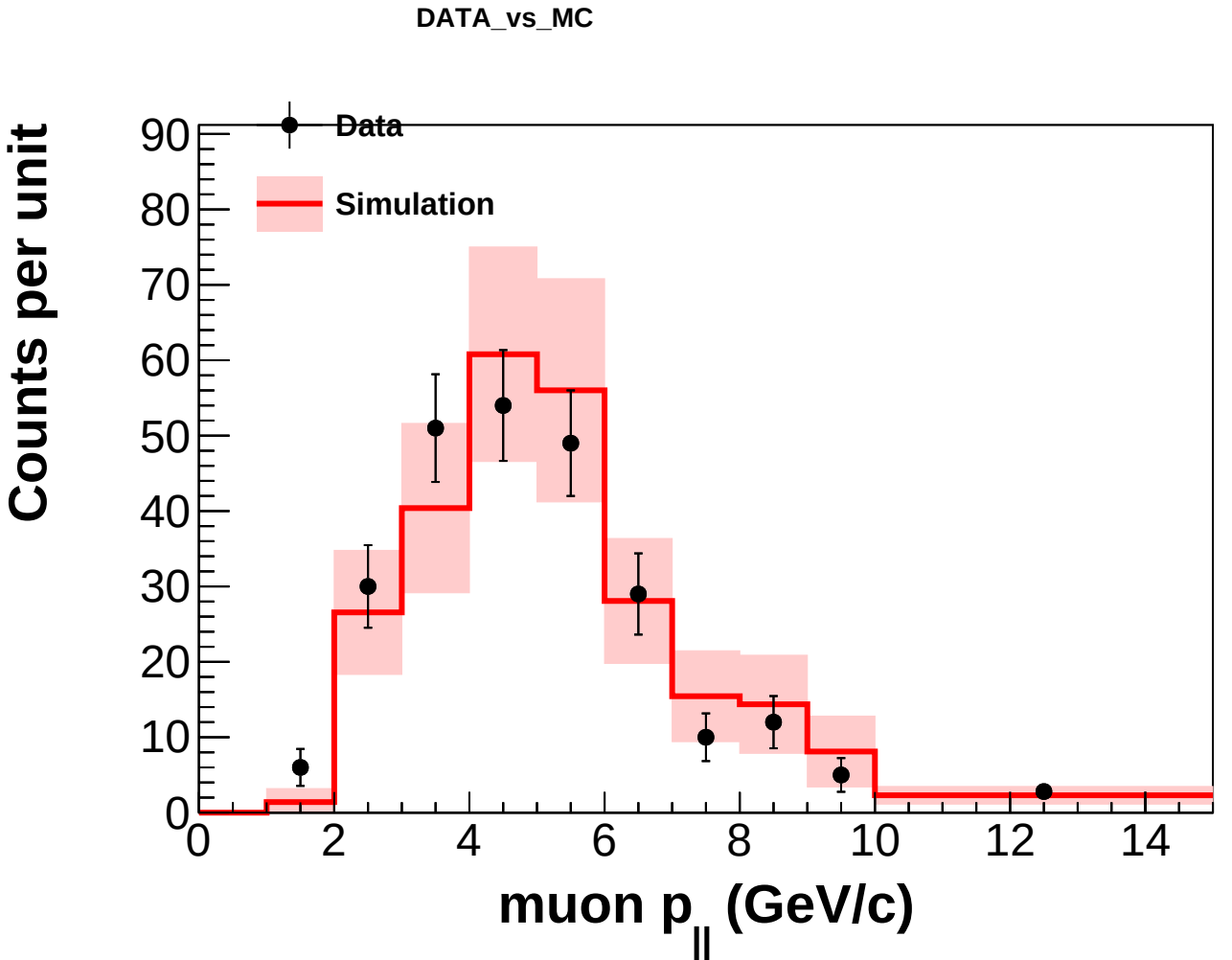

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

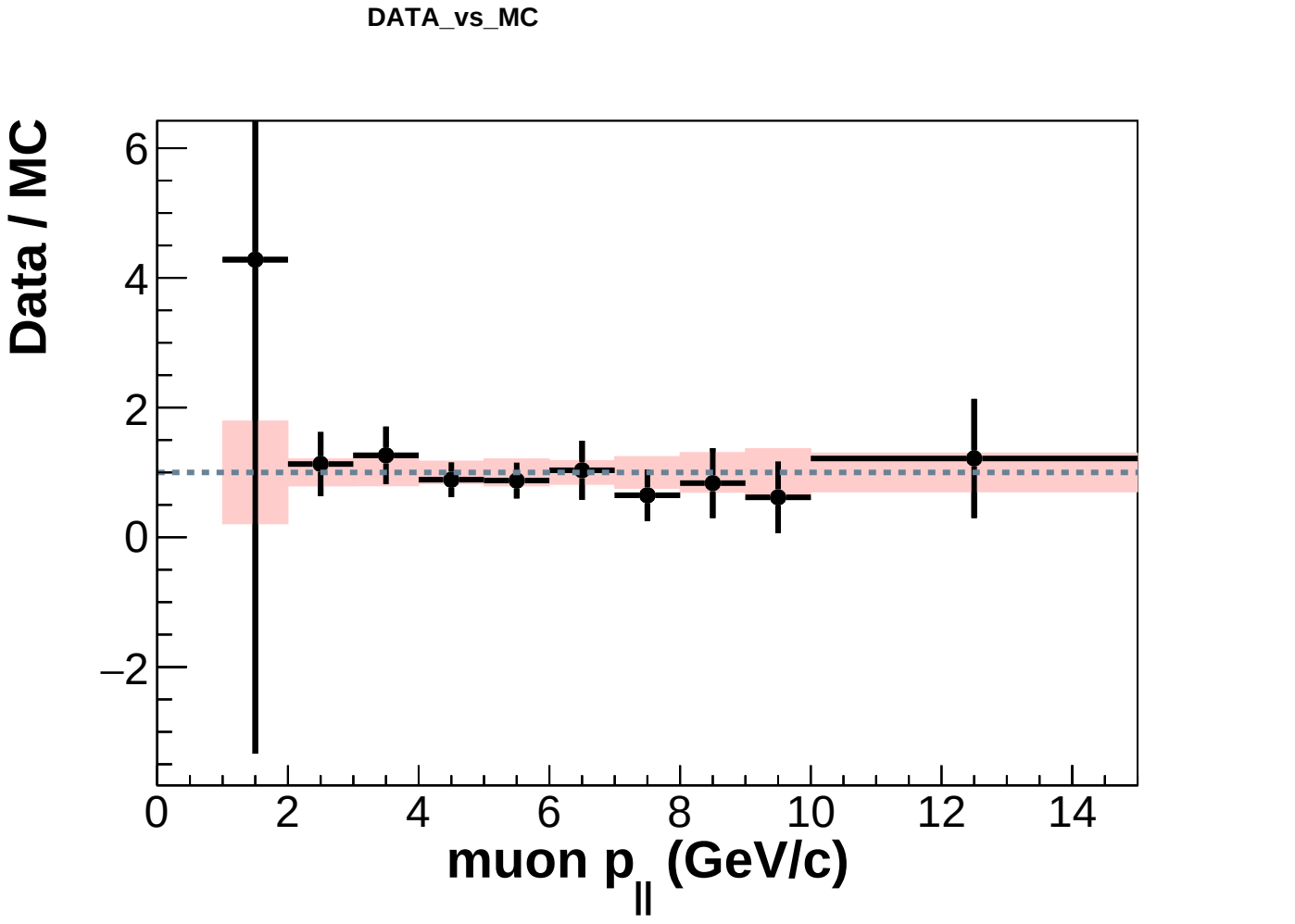

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

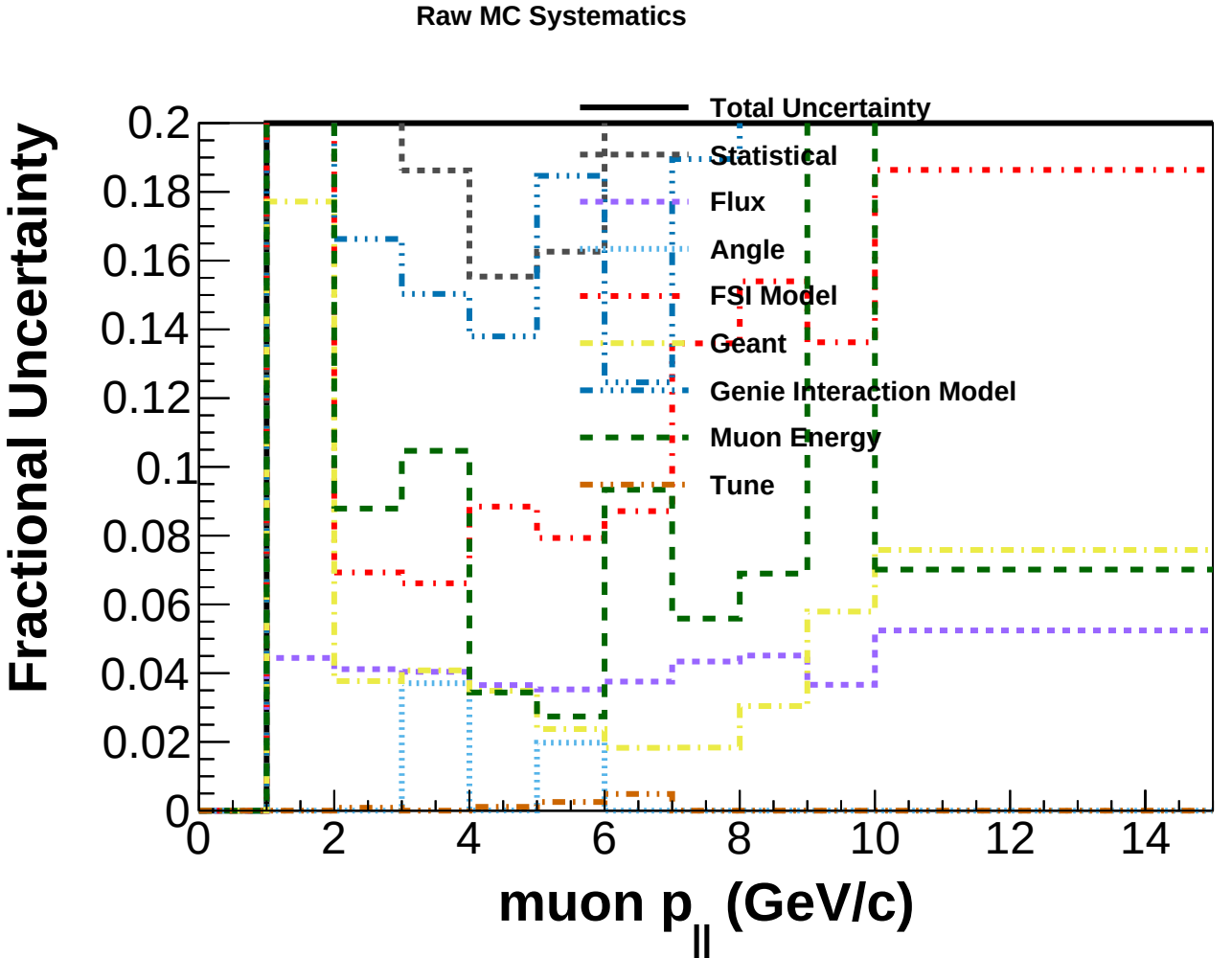

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

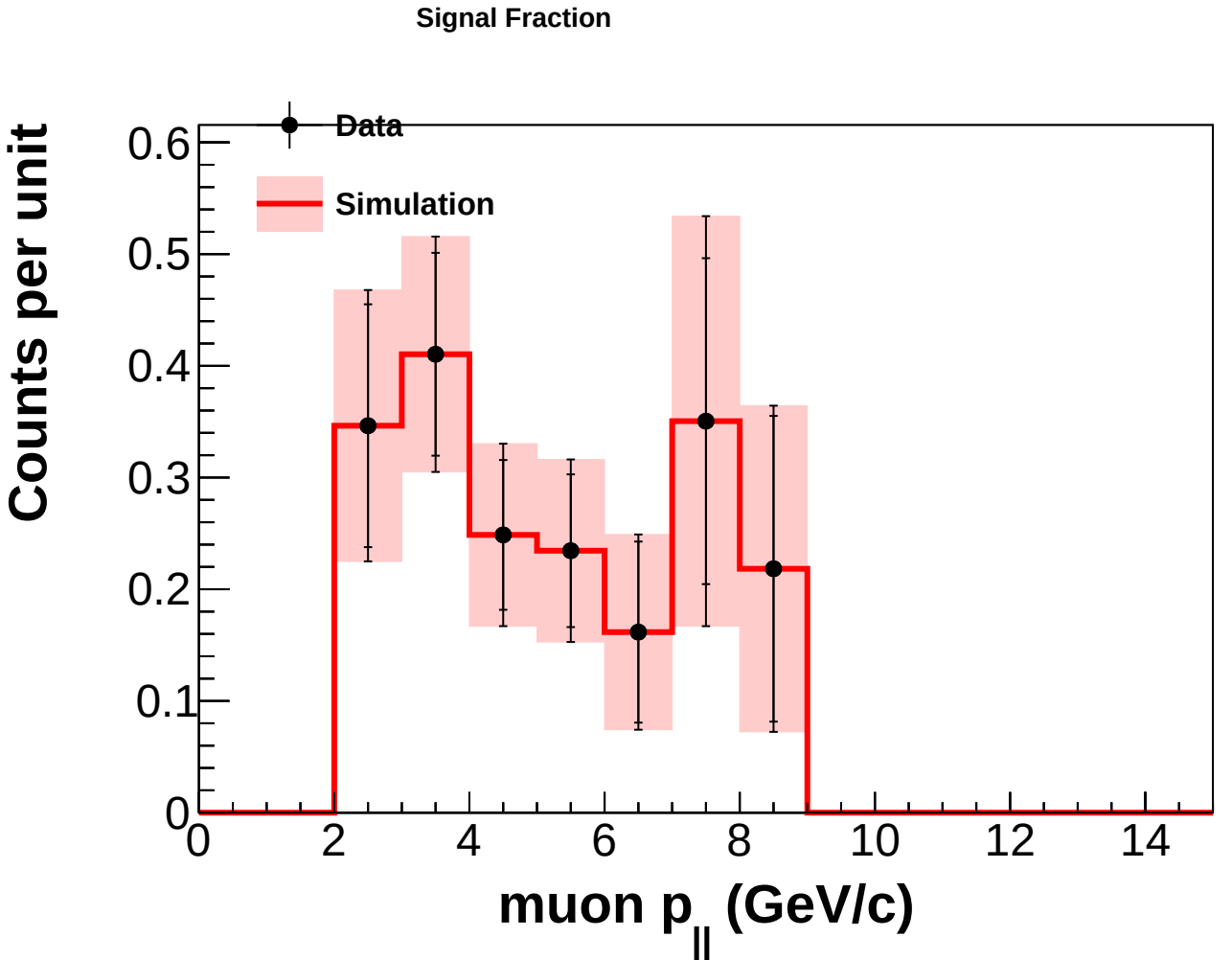

sigma
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

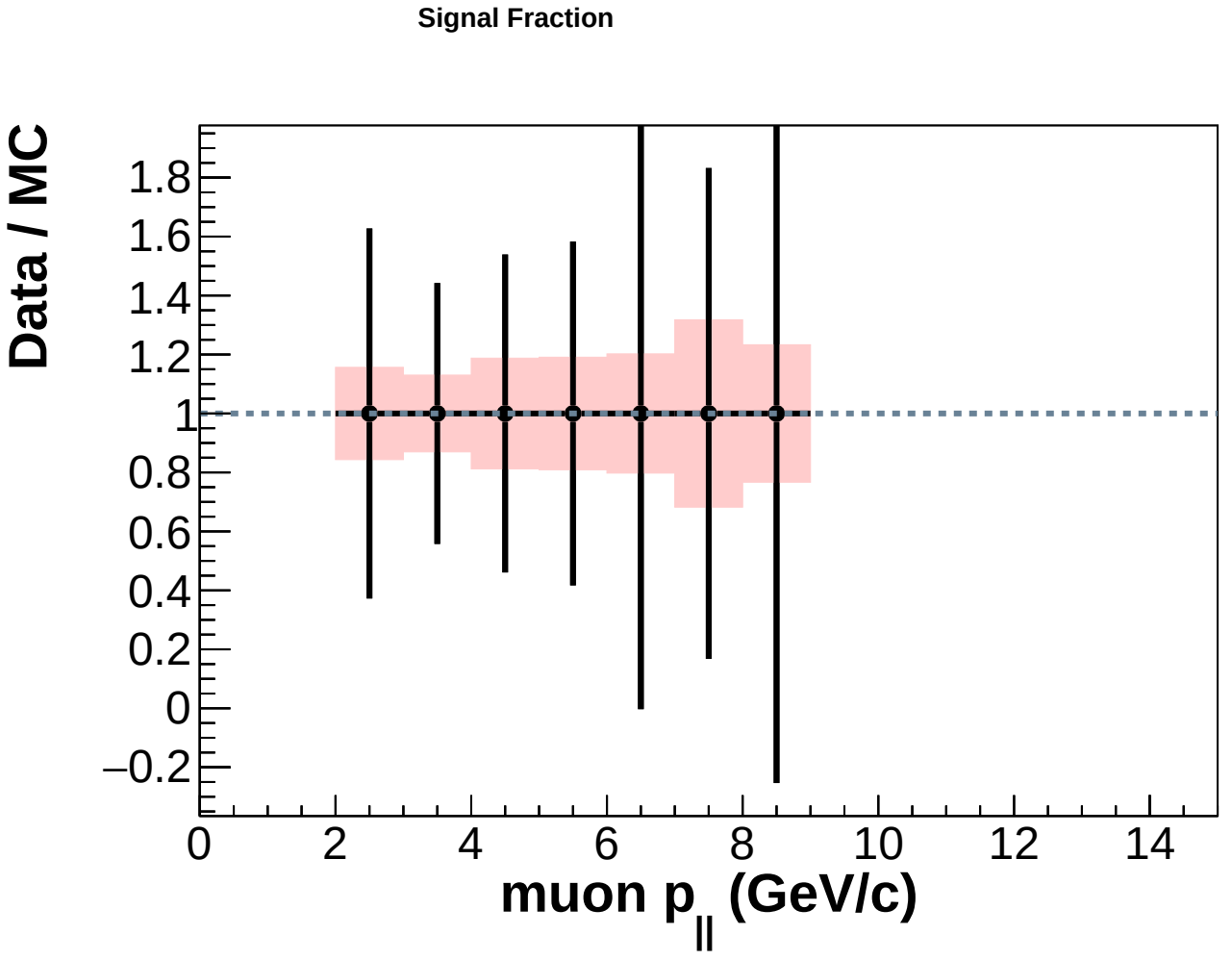

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

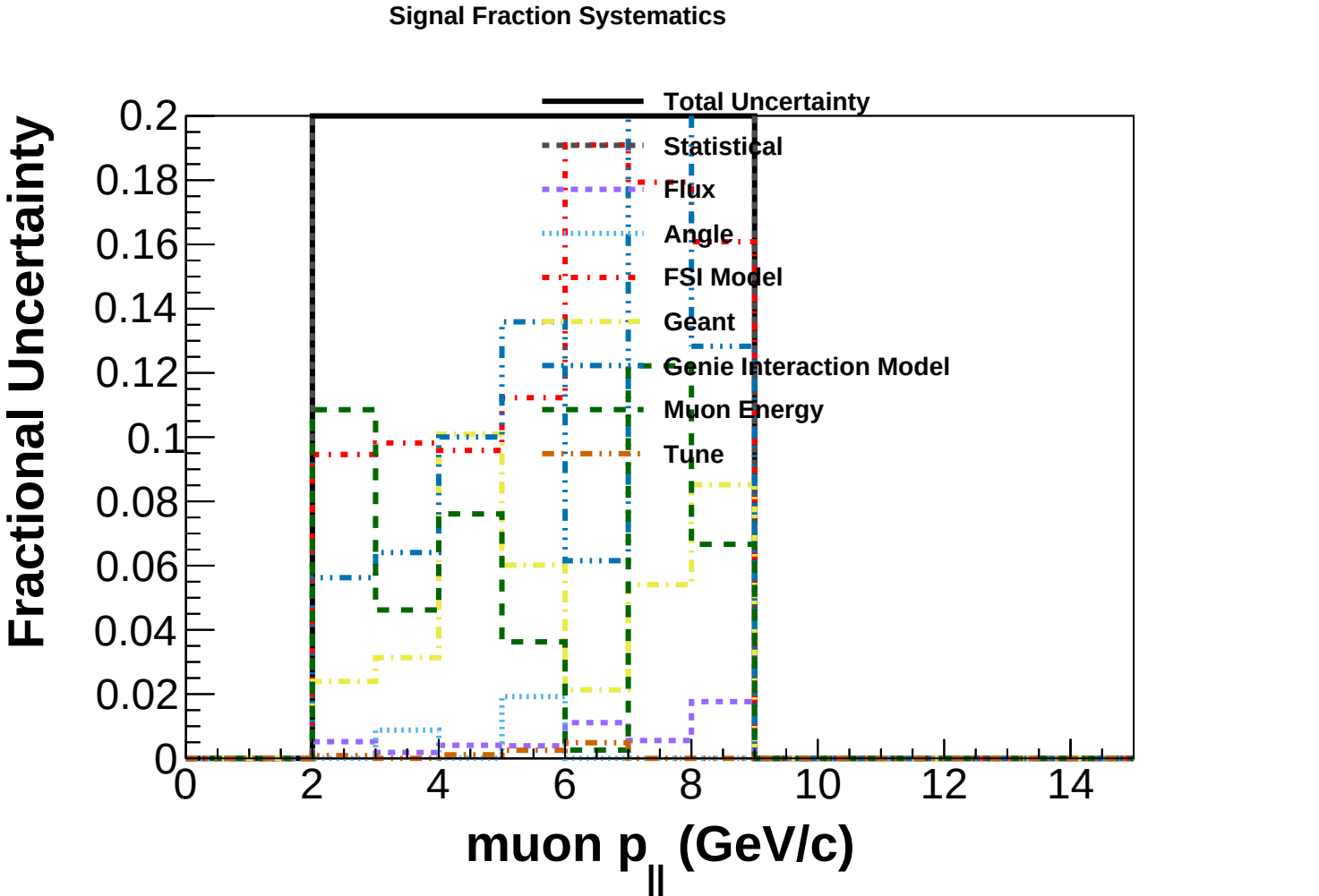

DATA_vs_MC
Data
Simulation
Counts per unit
muon p_ll (GeV/c)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14

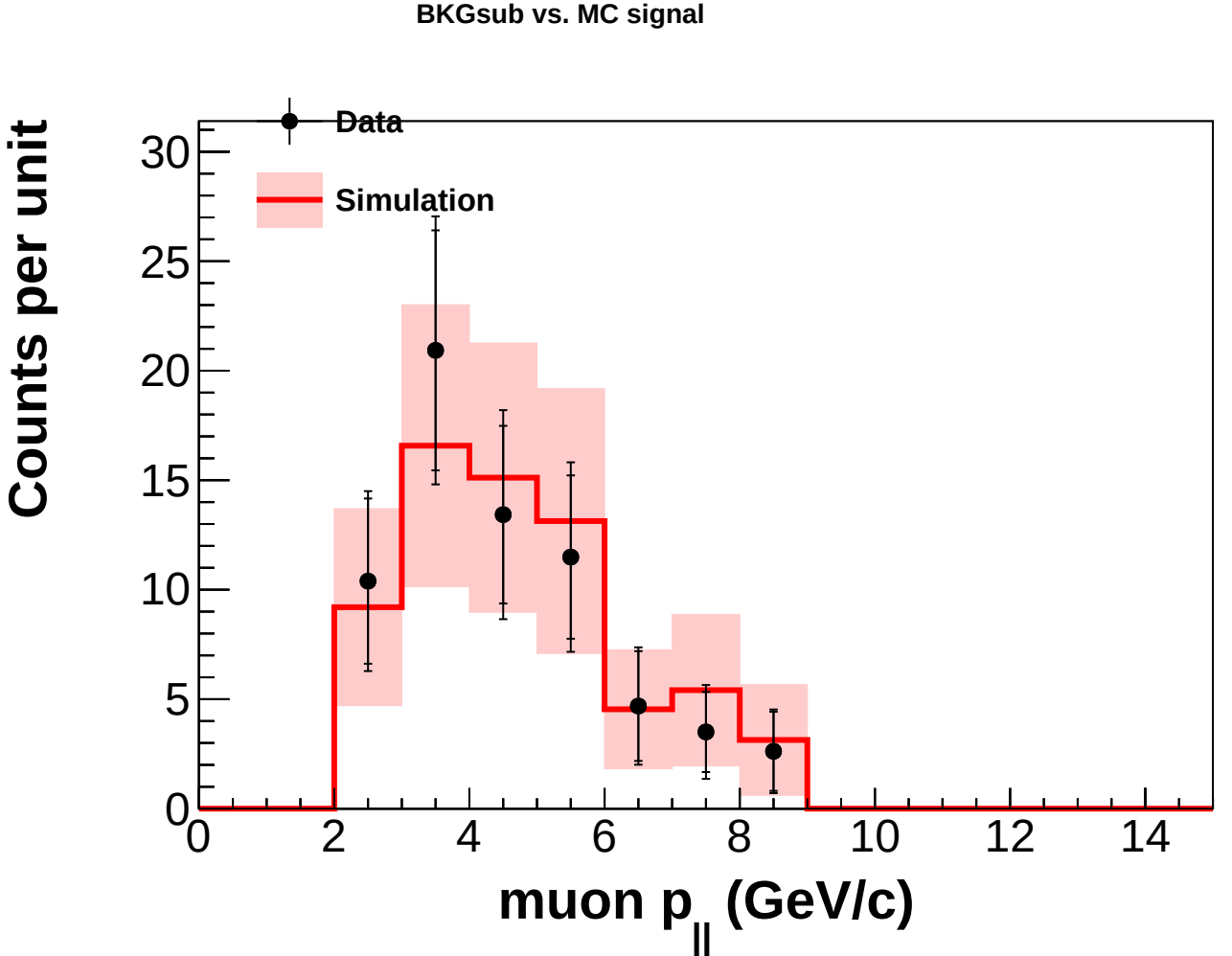

DATA_vs_MC
Data / MC
6
4
2
0
−2
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

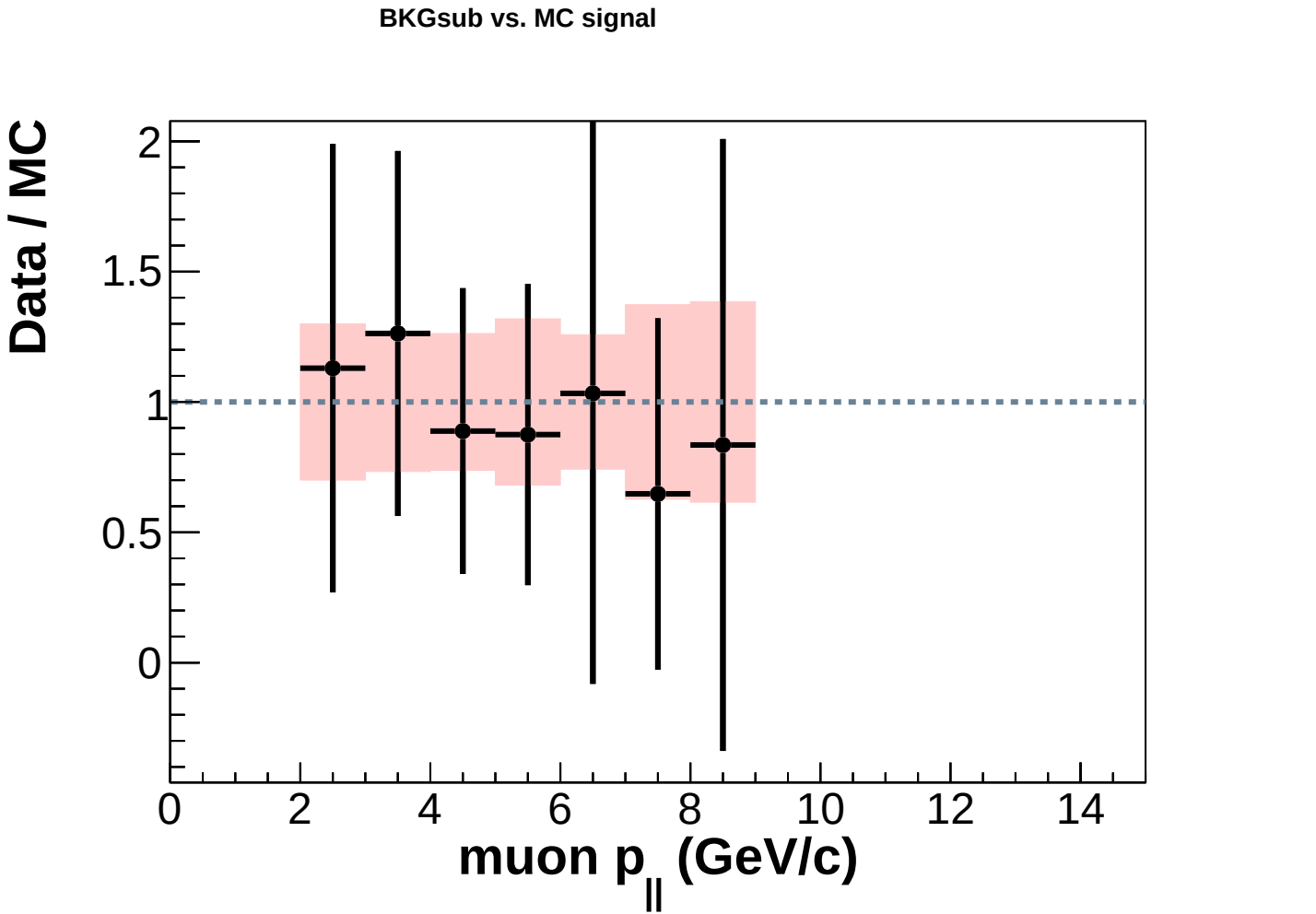

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

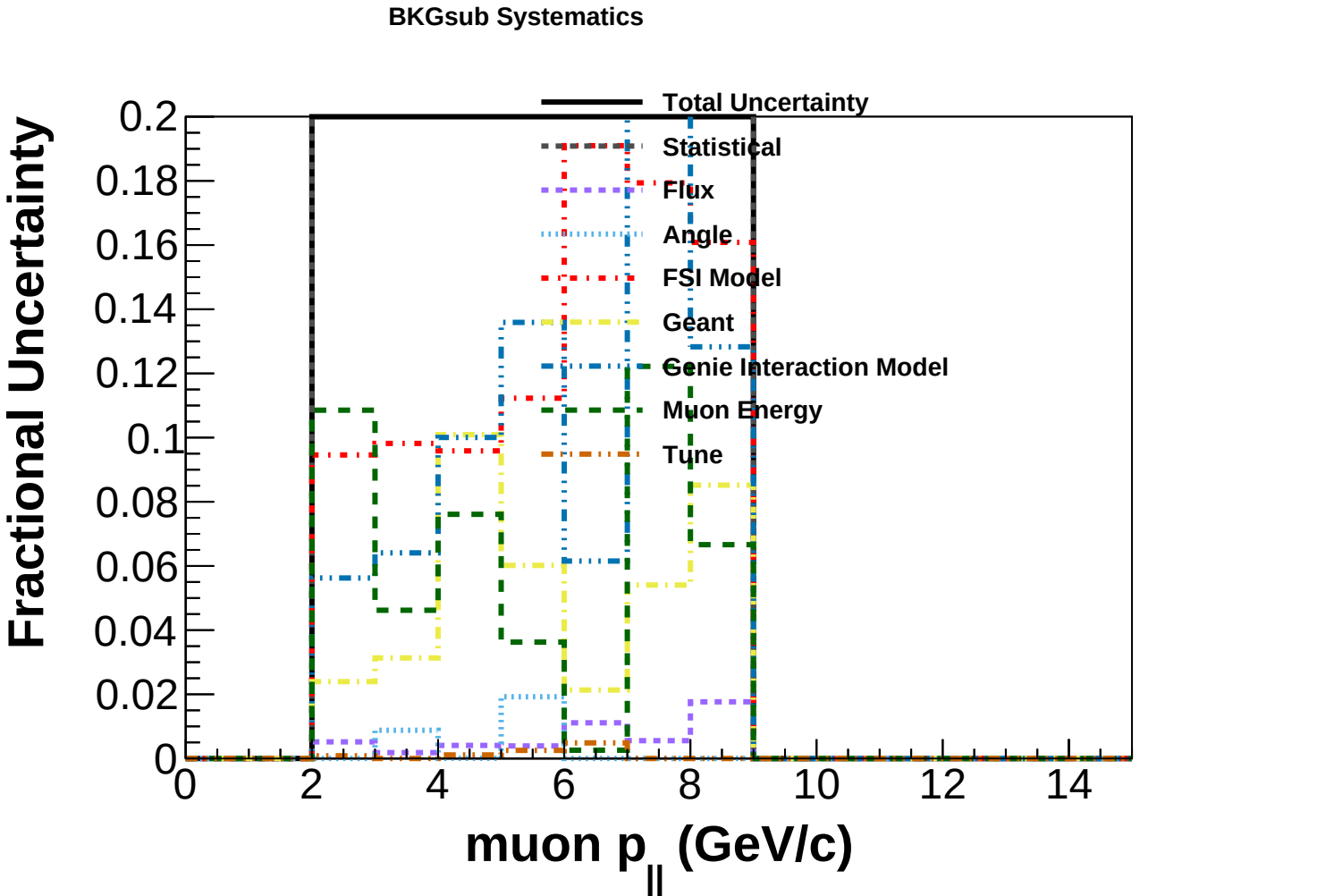

Signal Fraction
Data
Simulation
Counts per unit
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

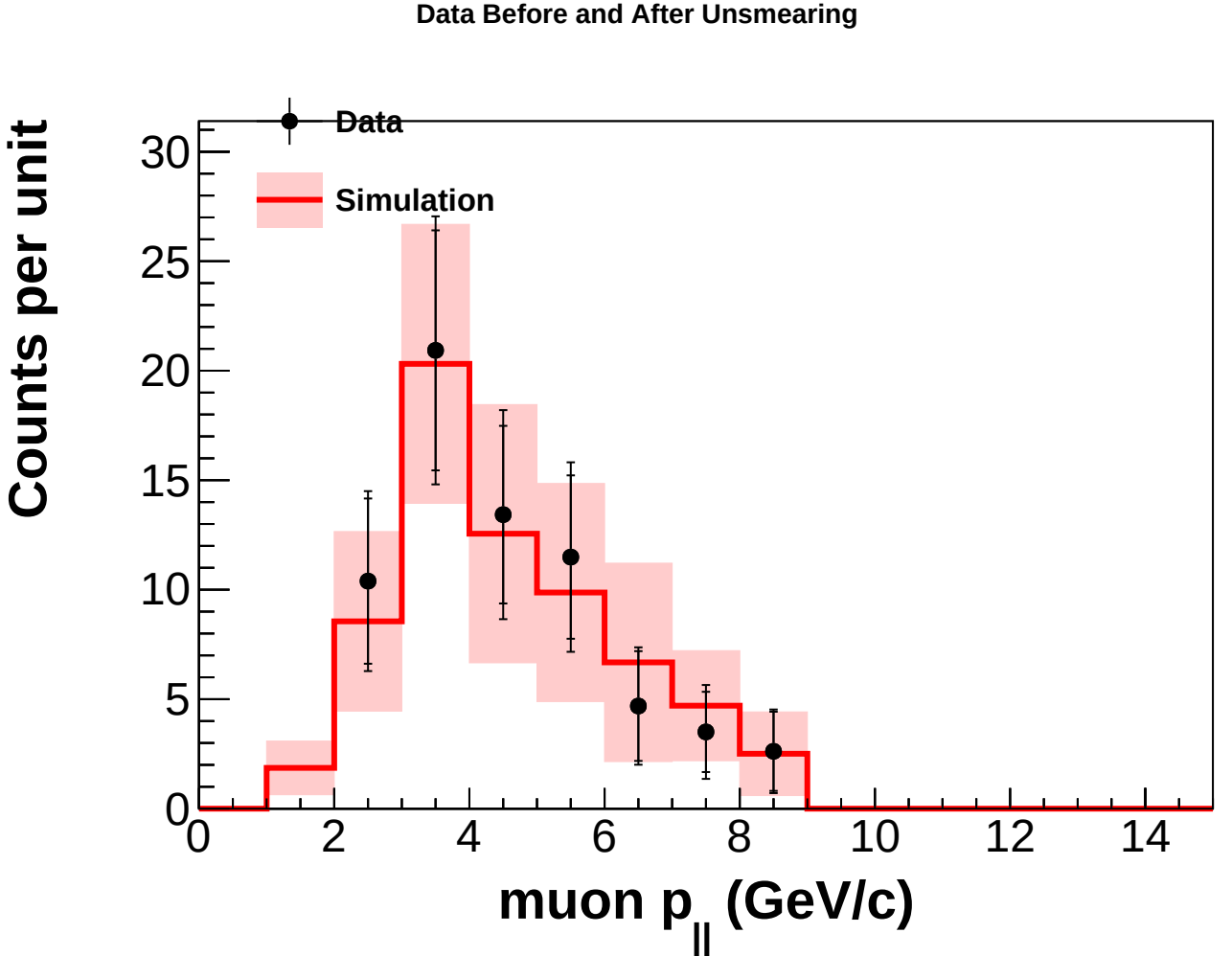

Signal Fraction
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

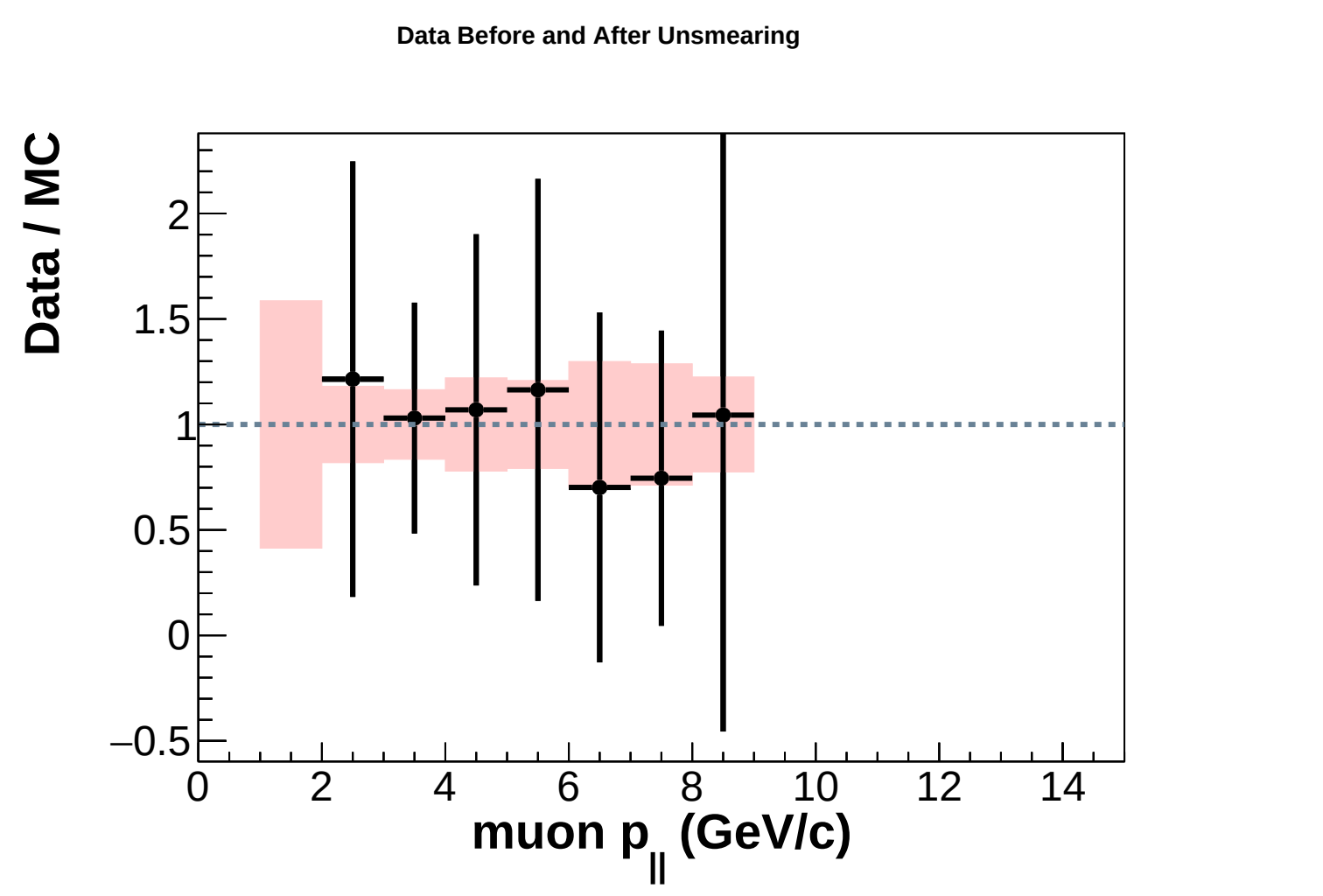

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

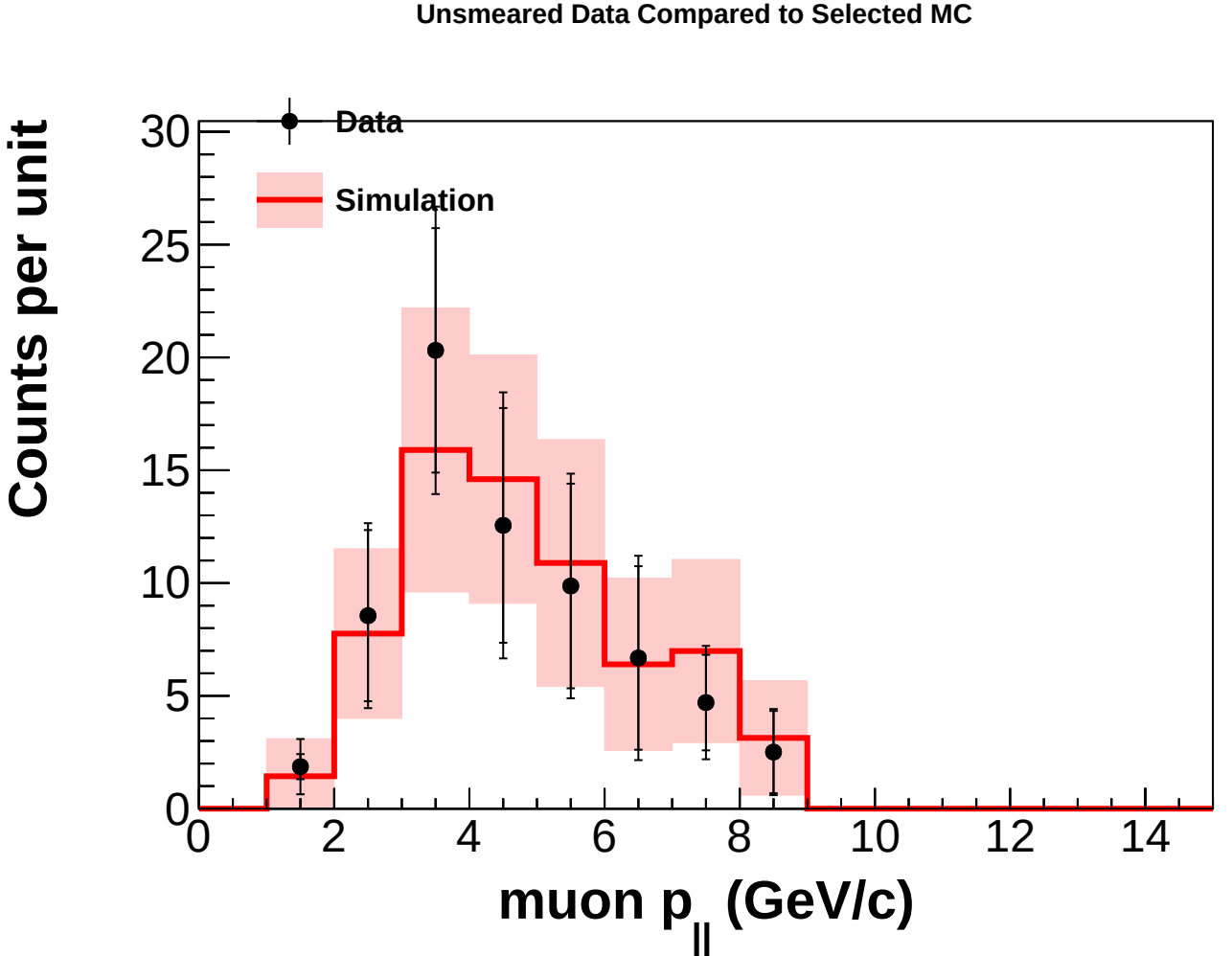

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

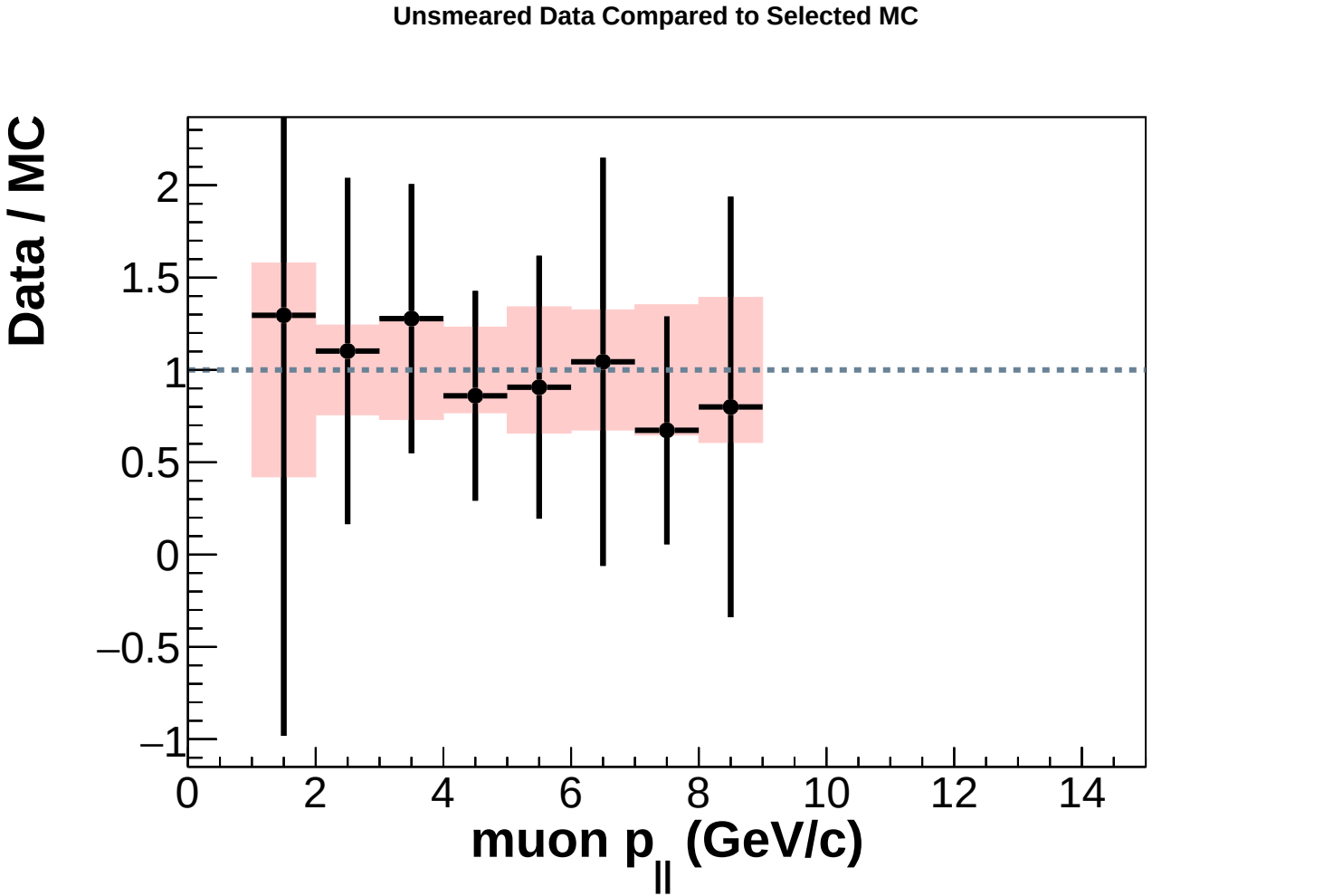

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

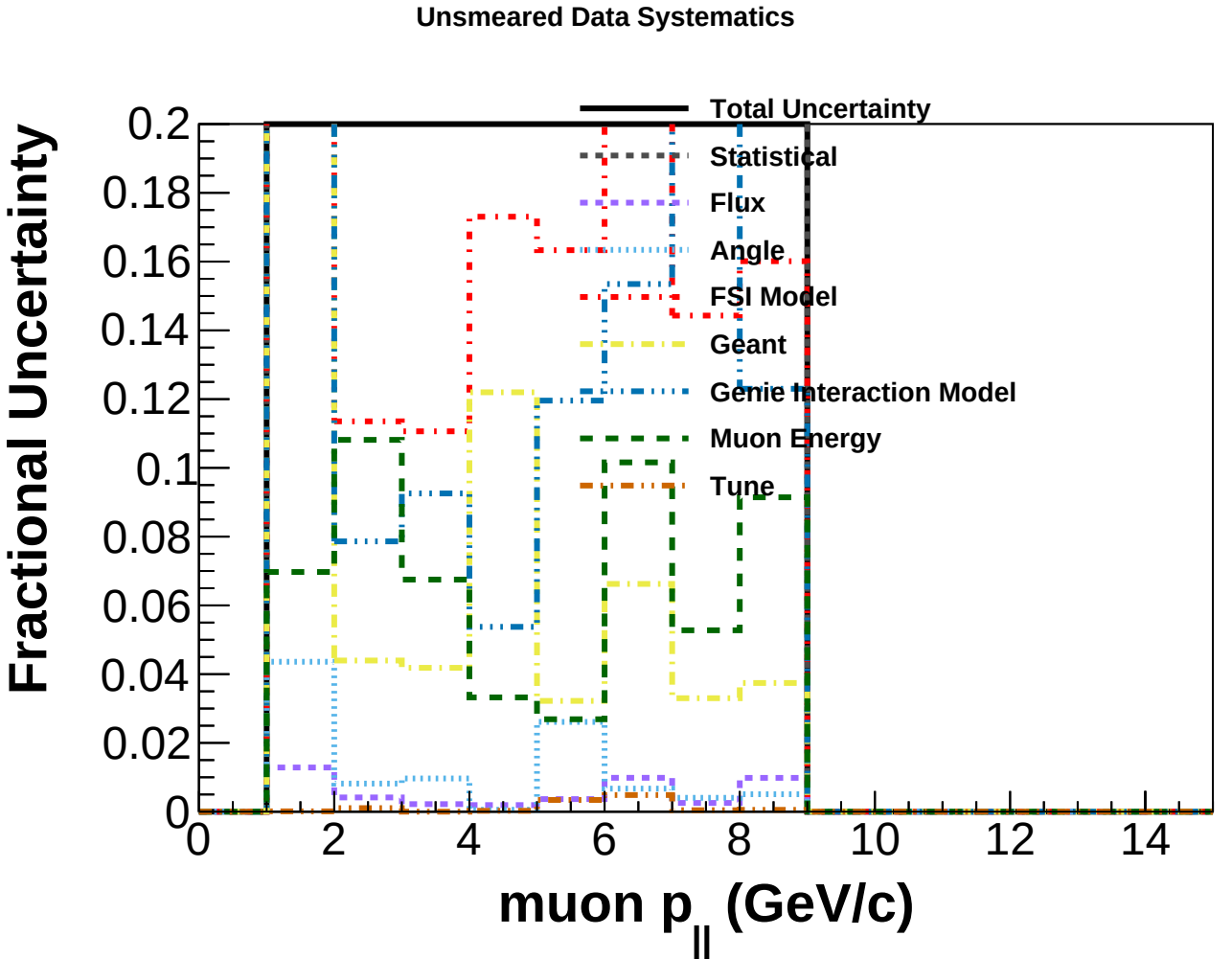

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

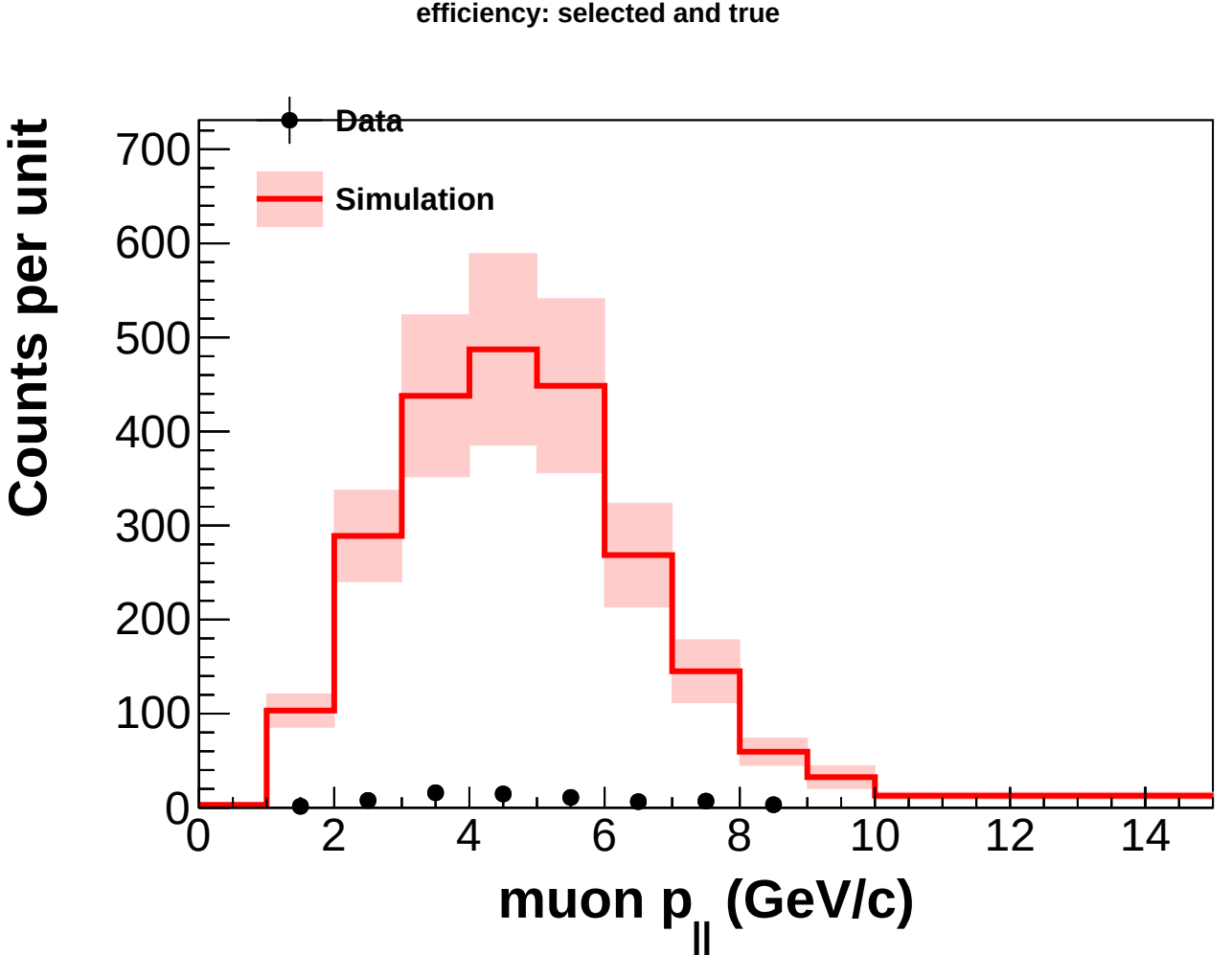

Data Before and After Unsmearing
Data
Simulation
Counts per unit
muon p_ll (GeV/c)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14

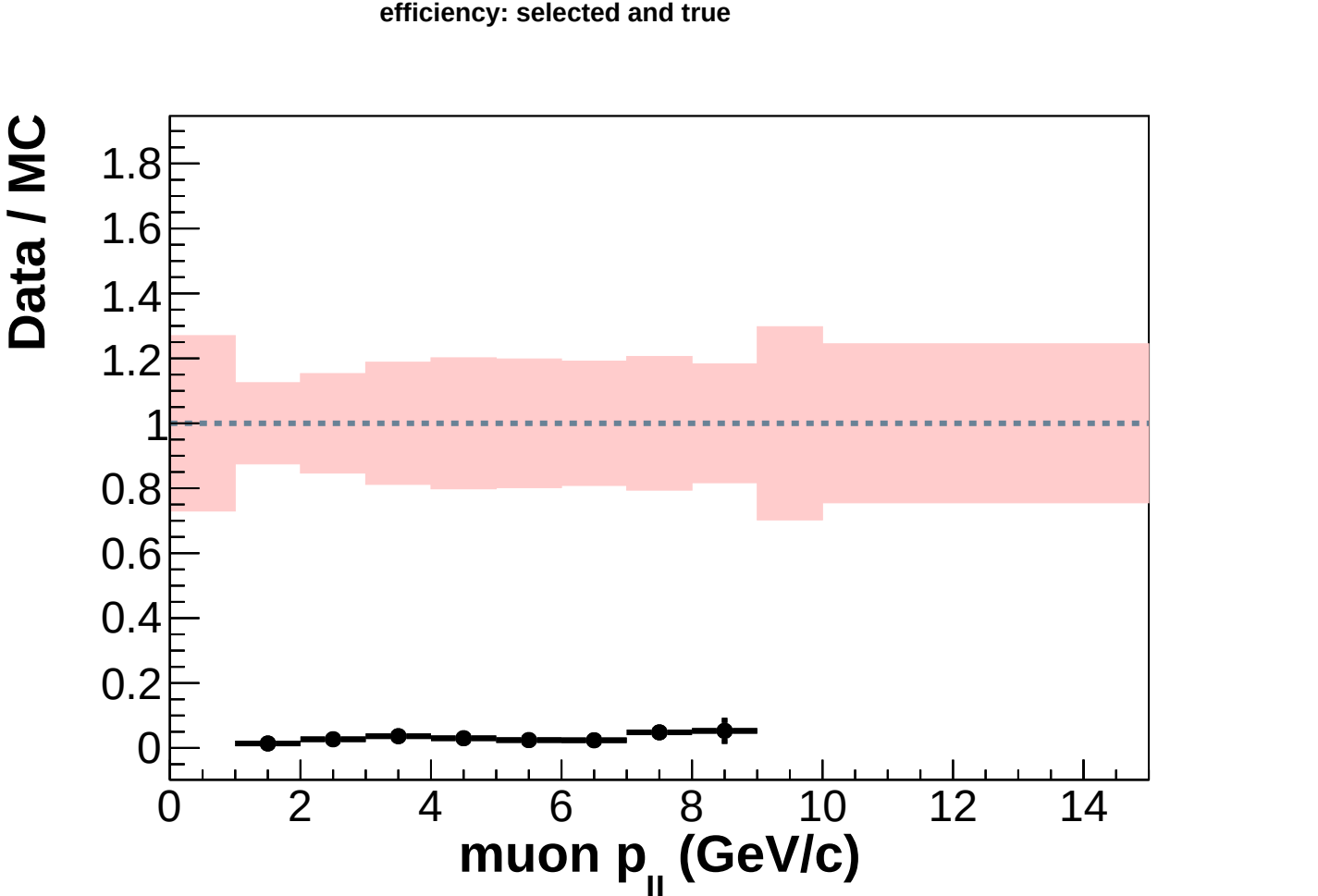

Data Before and After Unsmearing
Data / MC
2
1.5
1
0.5
0
−0.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

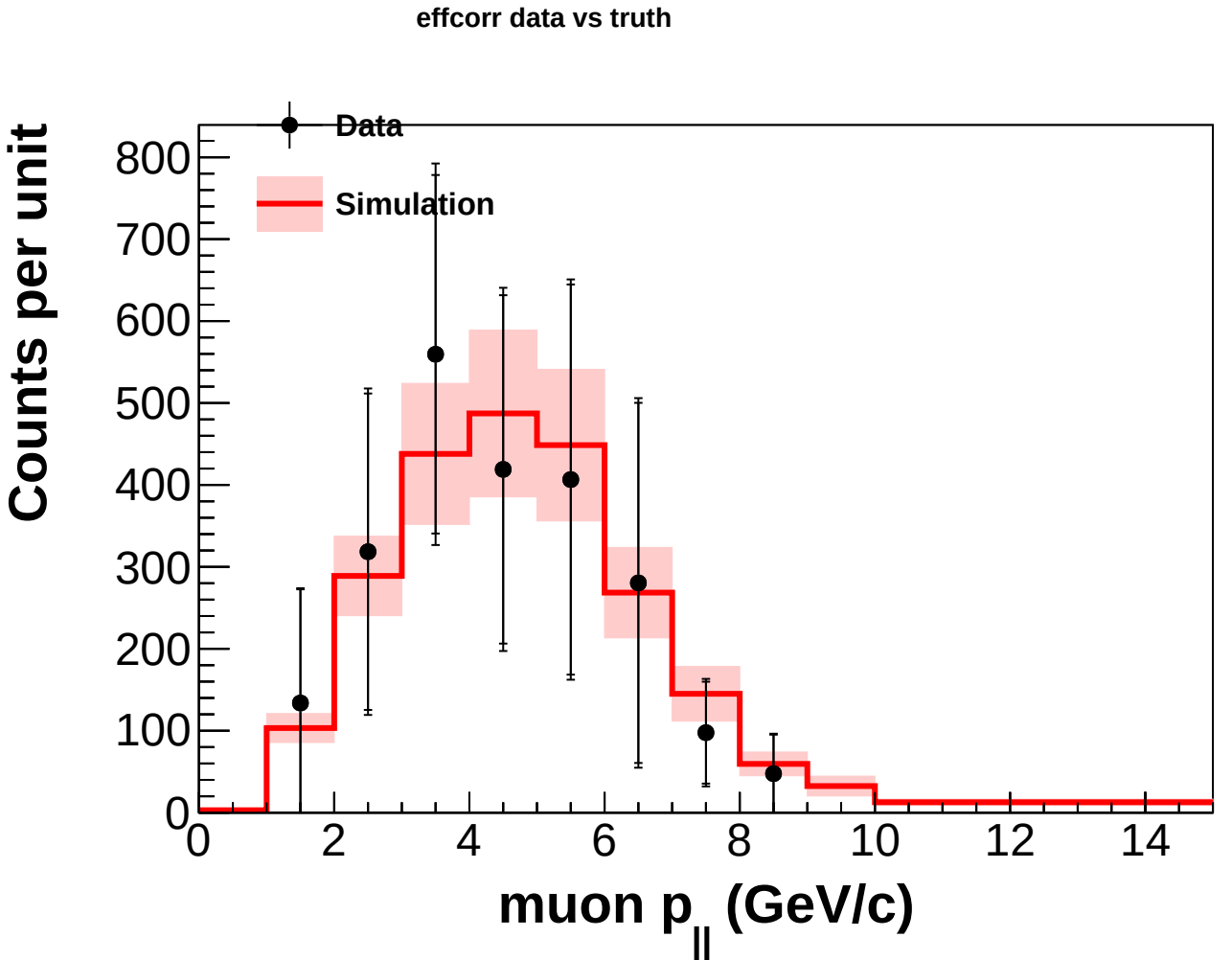

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
muon p_ll (GeV/c)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14

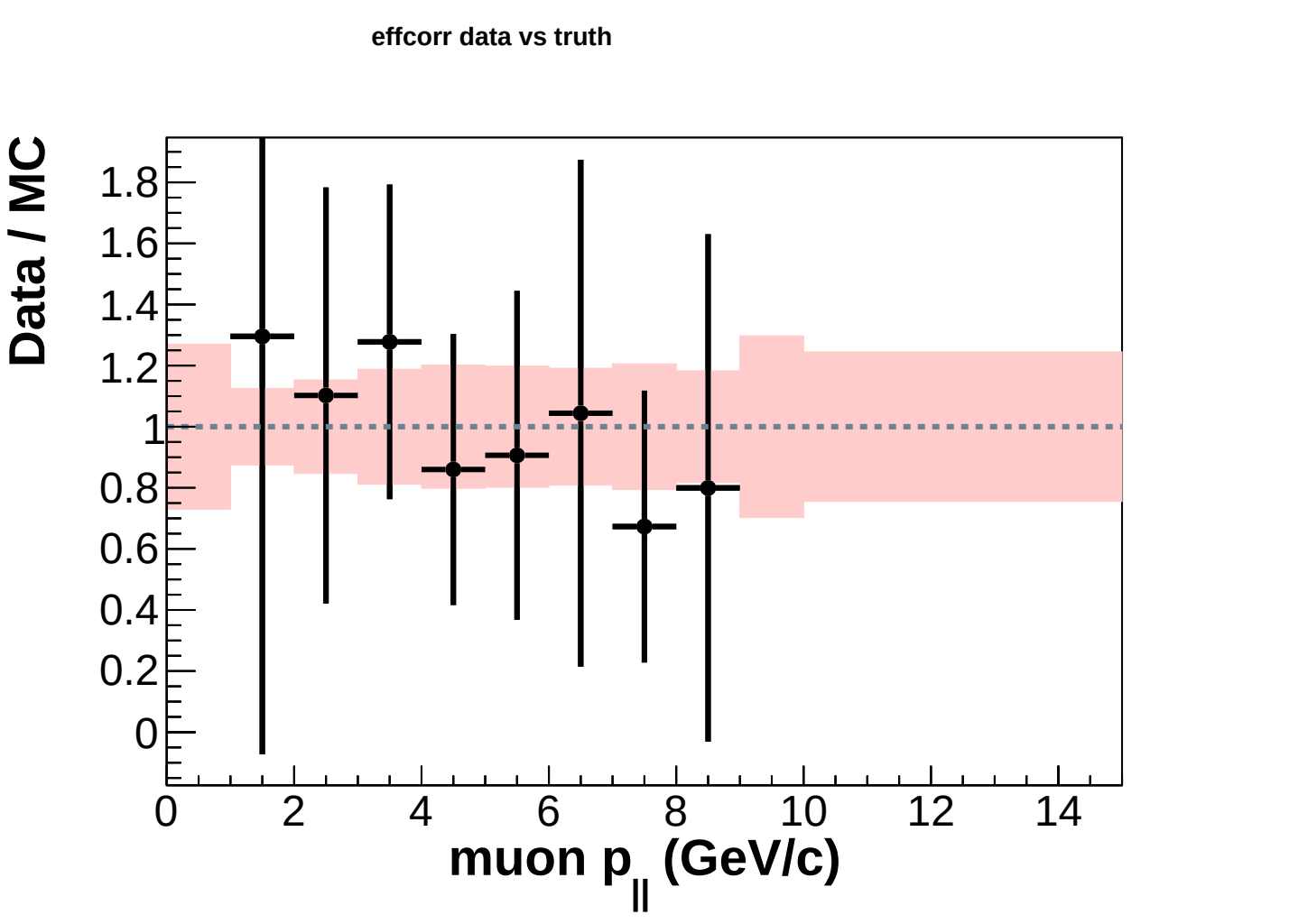

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

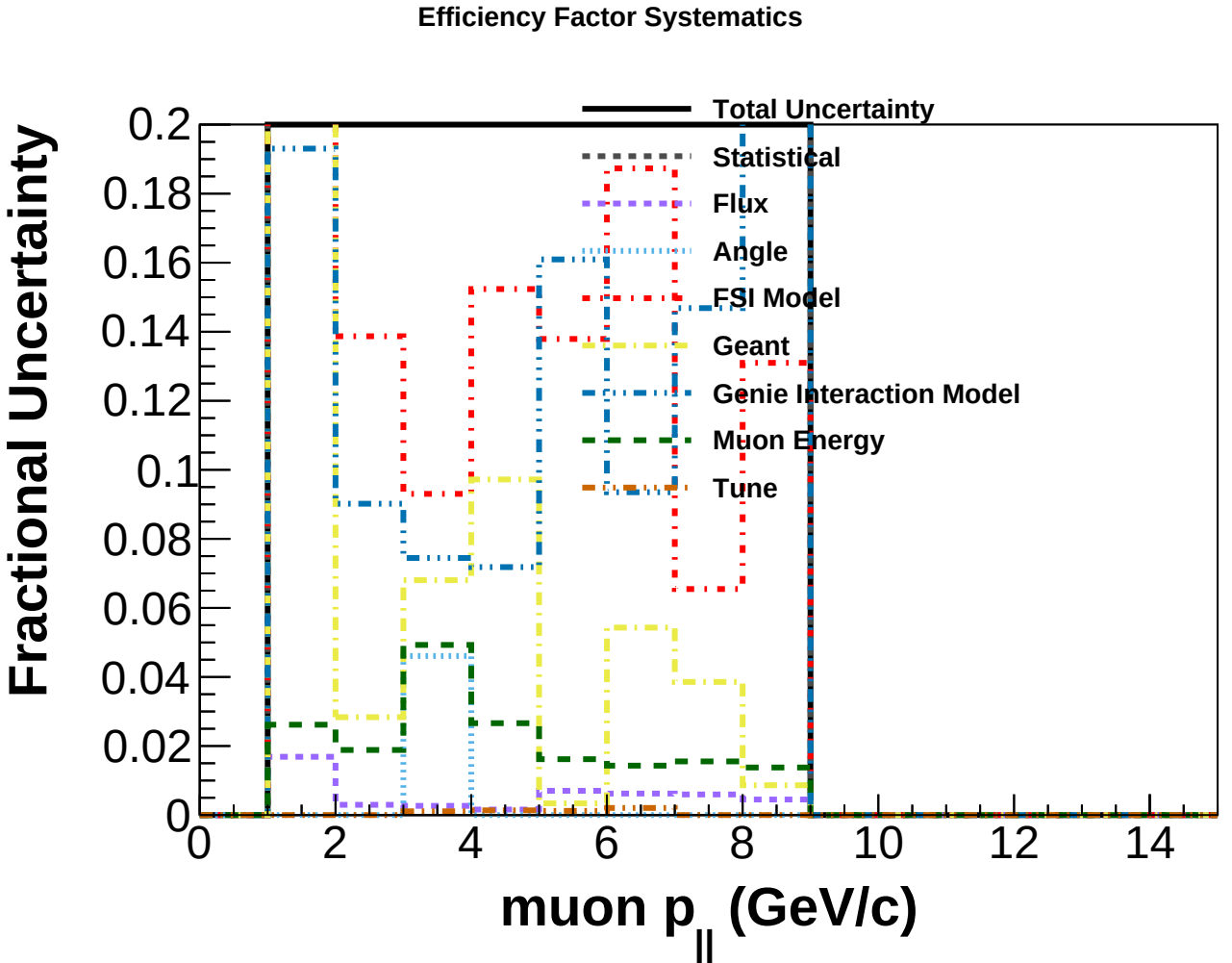

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

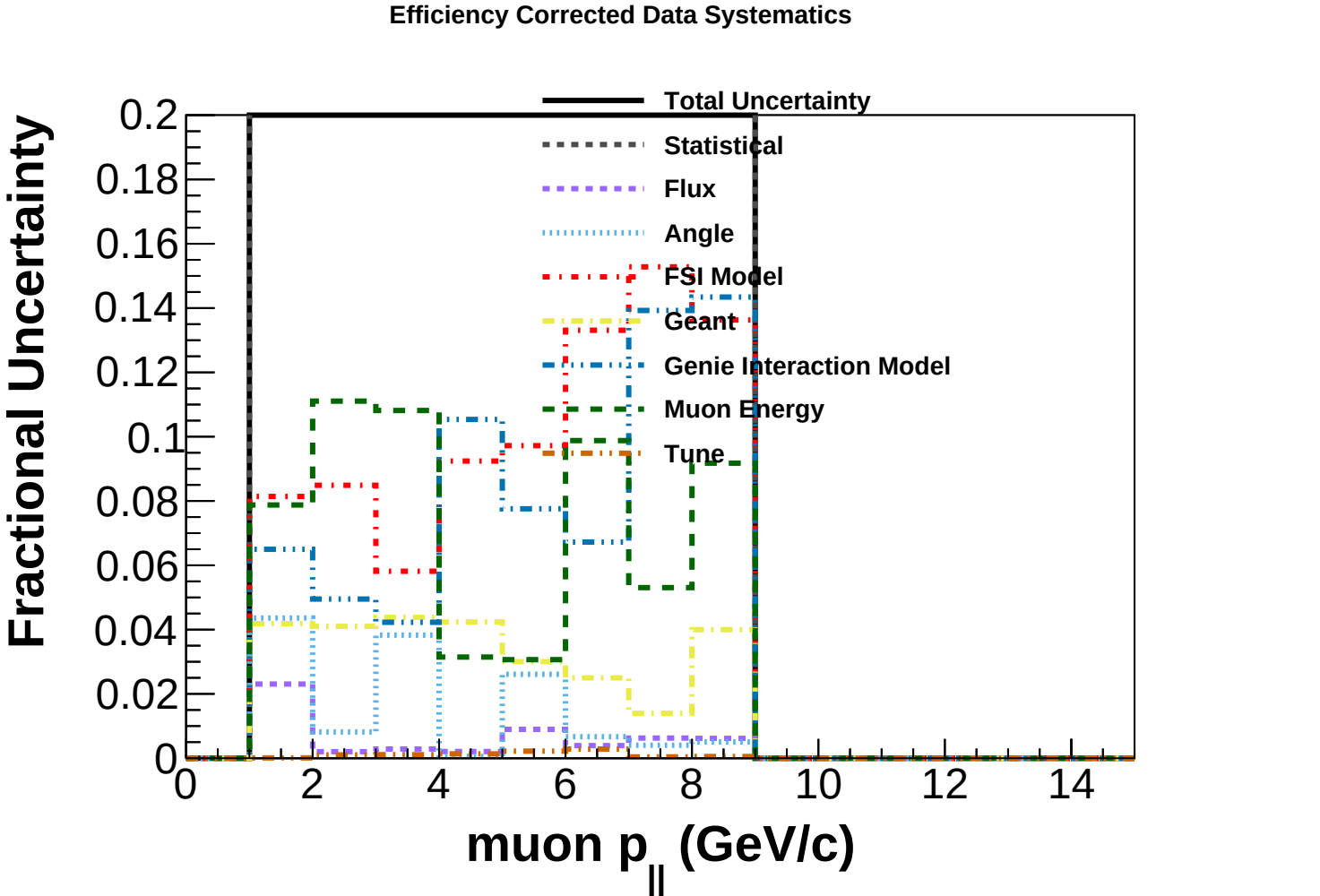

efficiency: selected and true
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

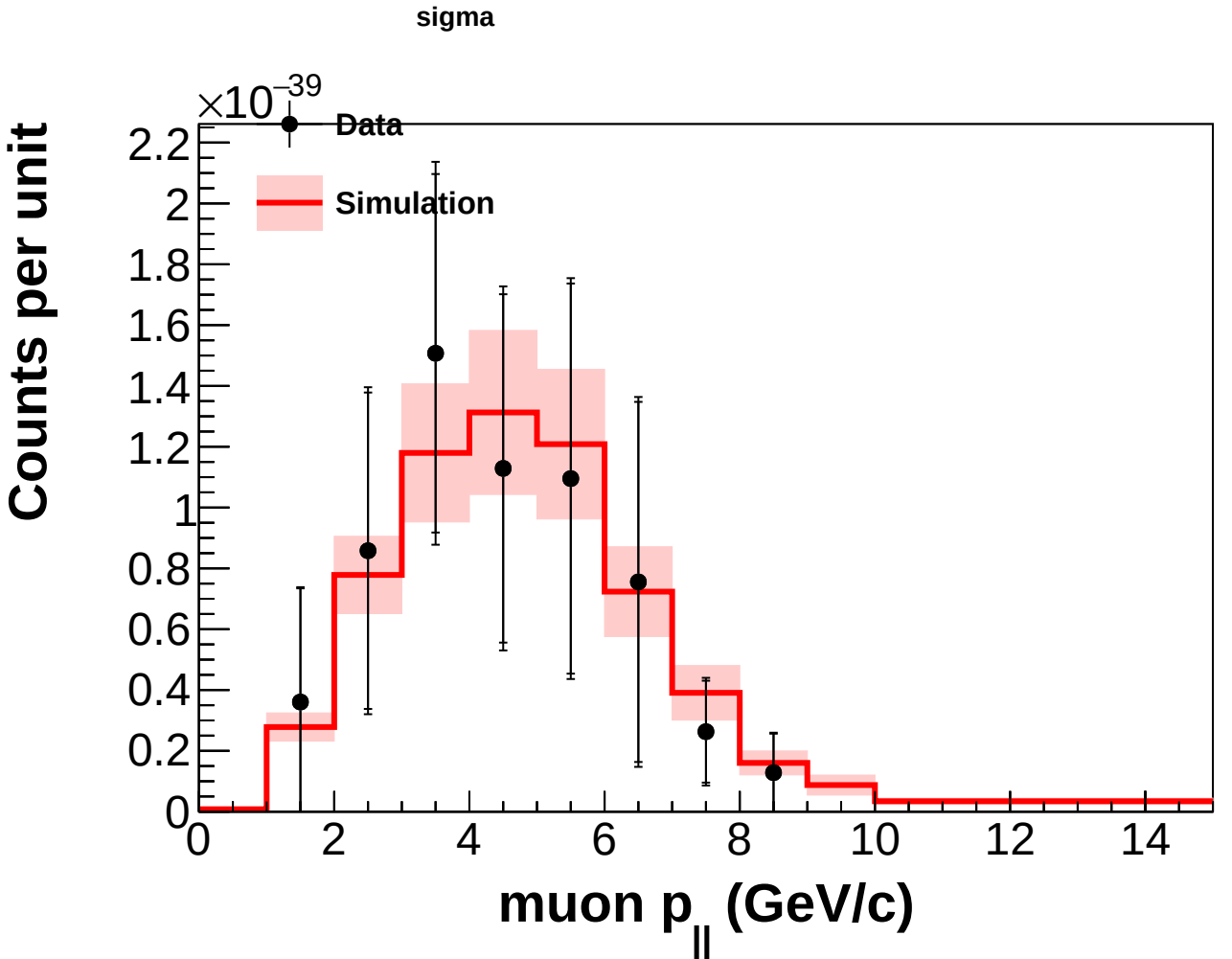

efficiency: selected and true
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

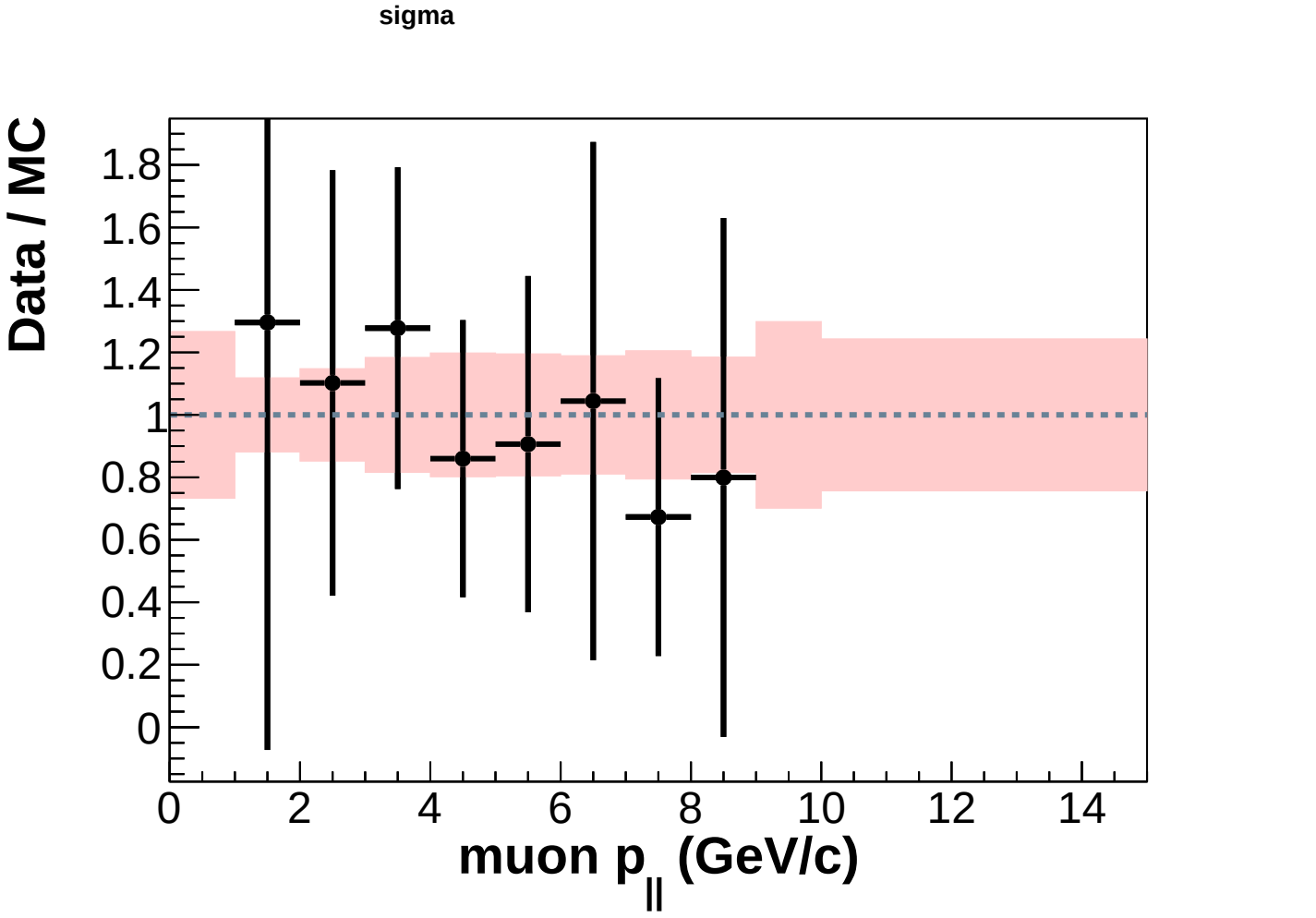

effcorr data vs truth
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
800
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

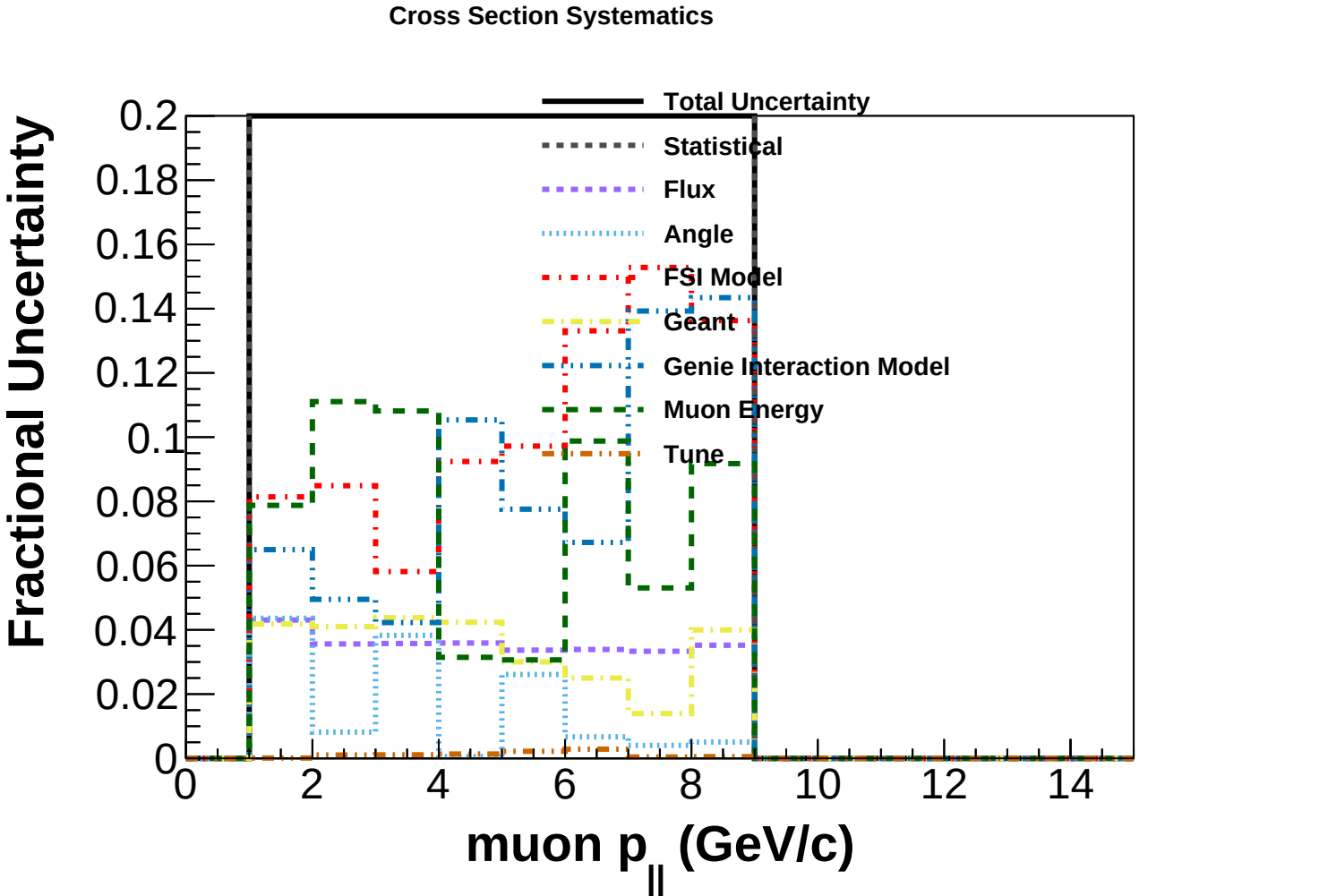

effcorr data vs truth
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

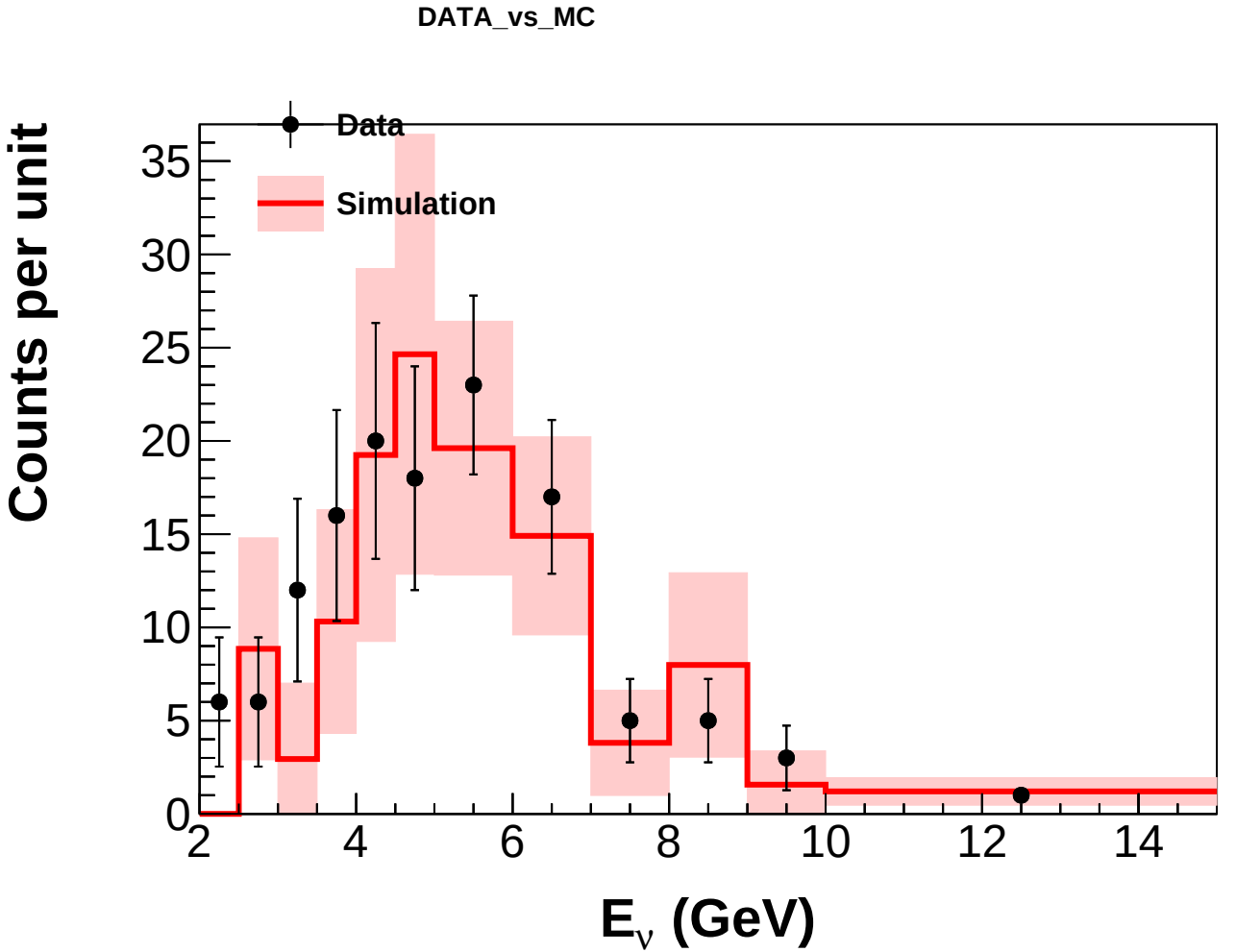

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

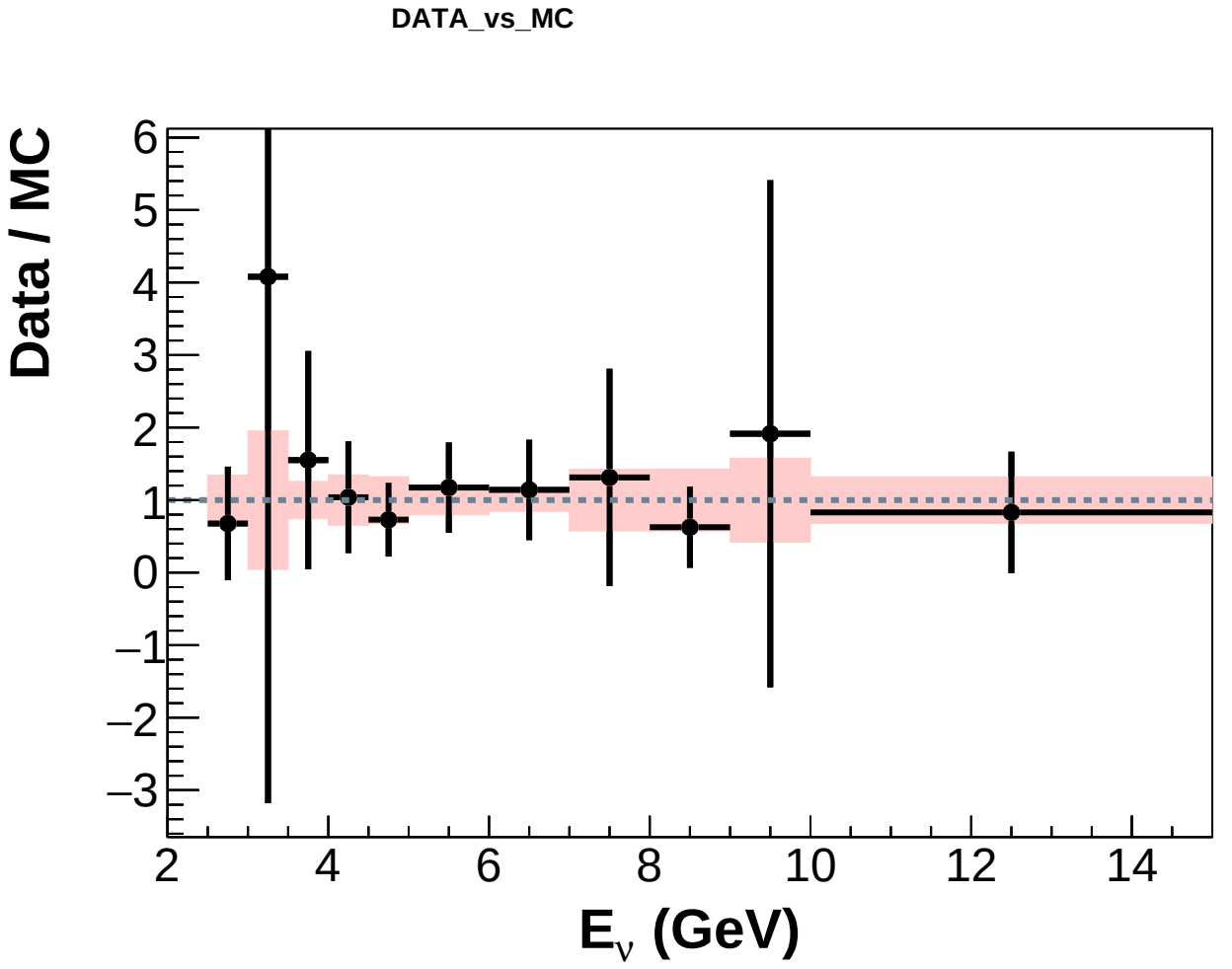

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

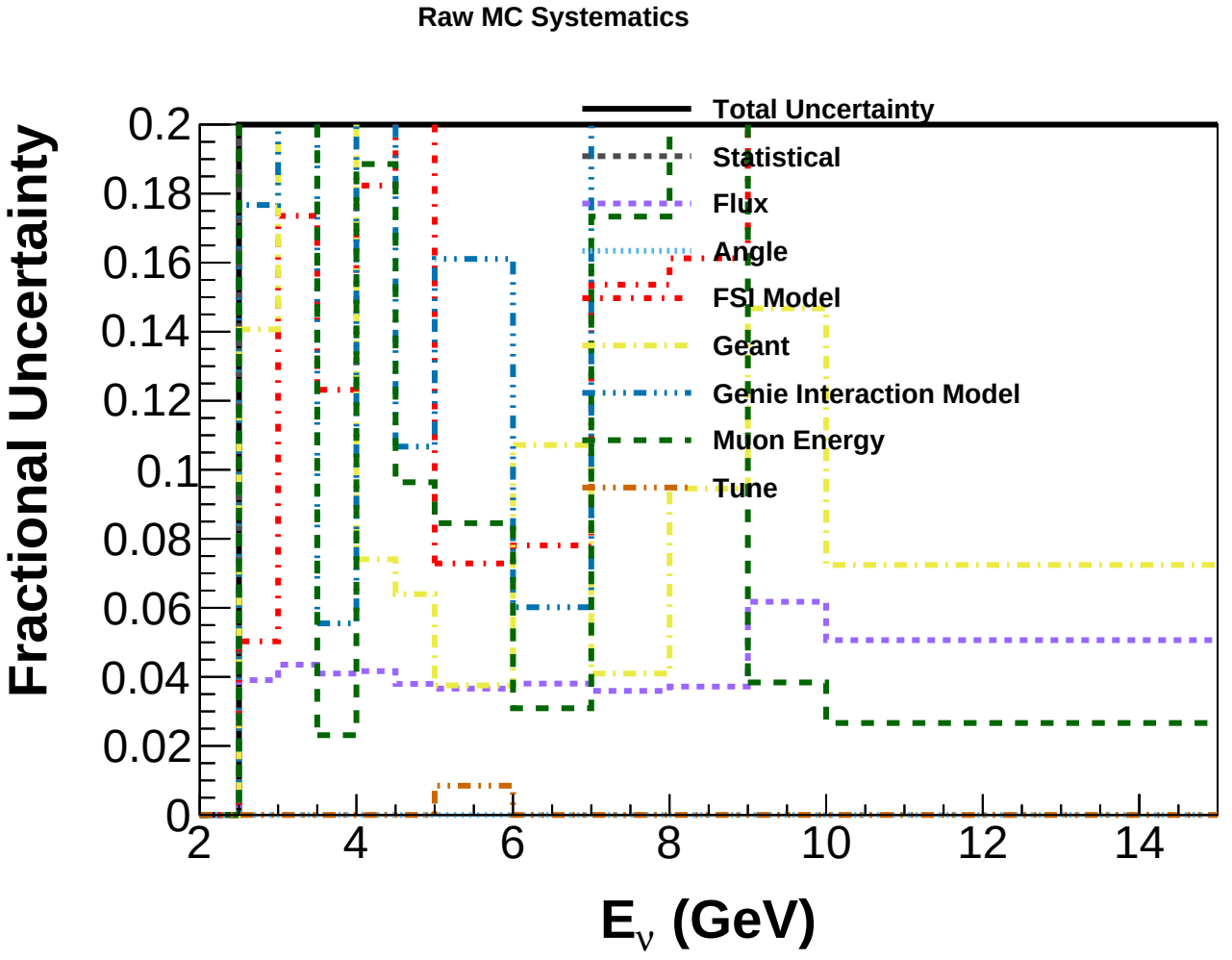

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

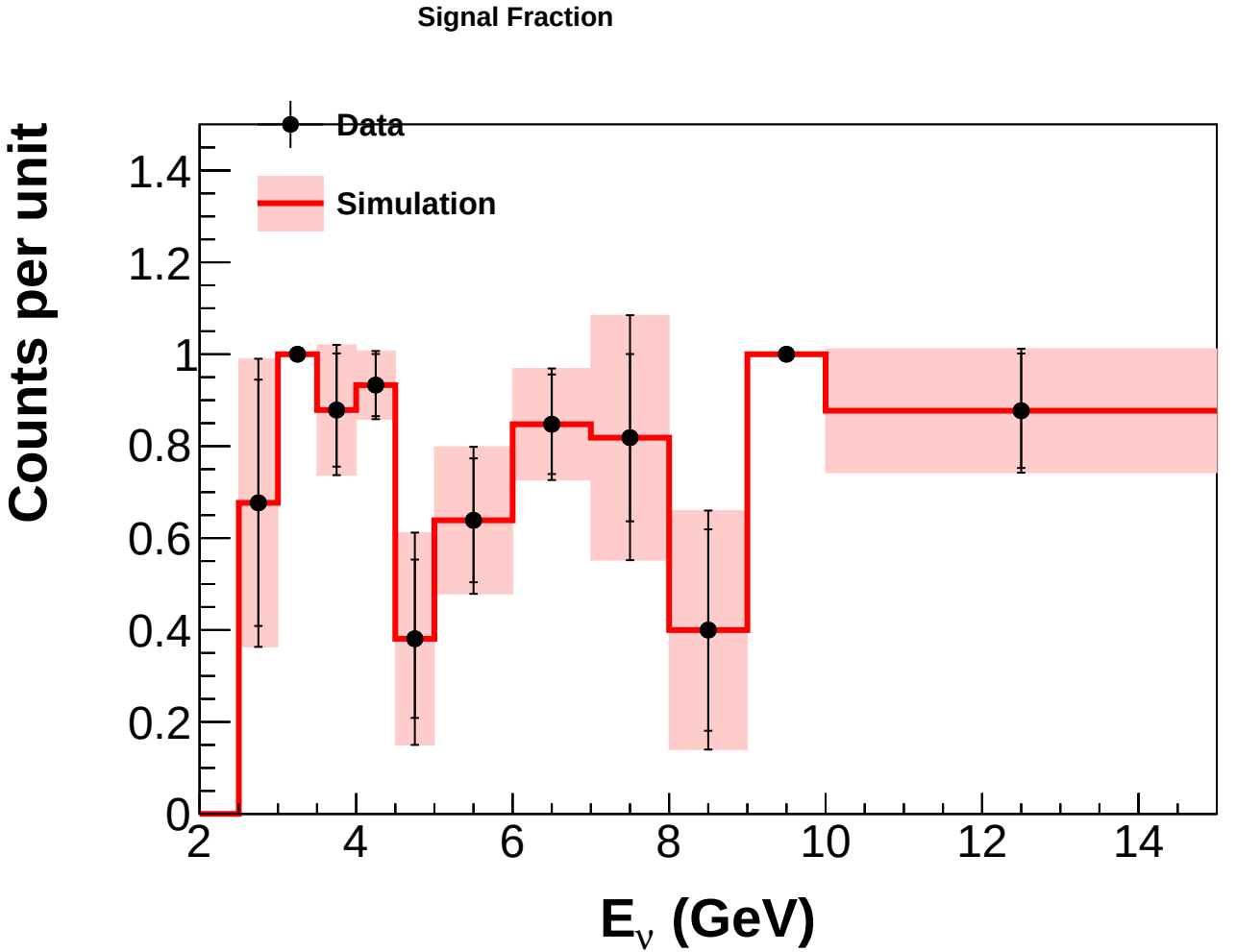

sigma
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

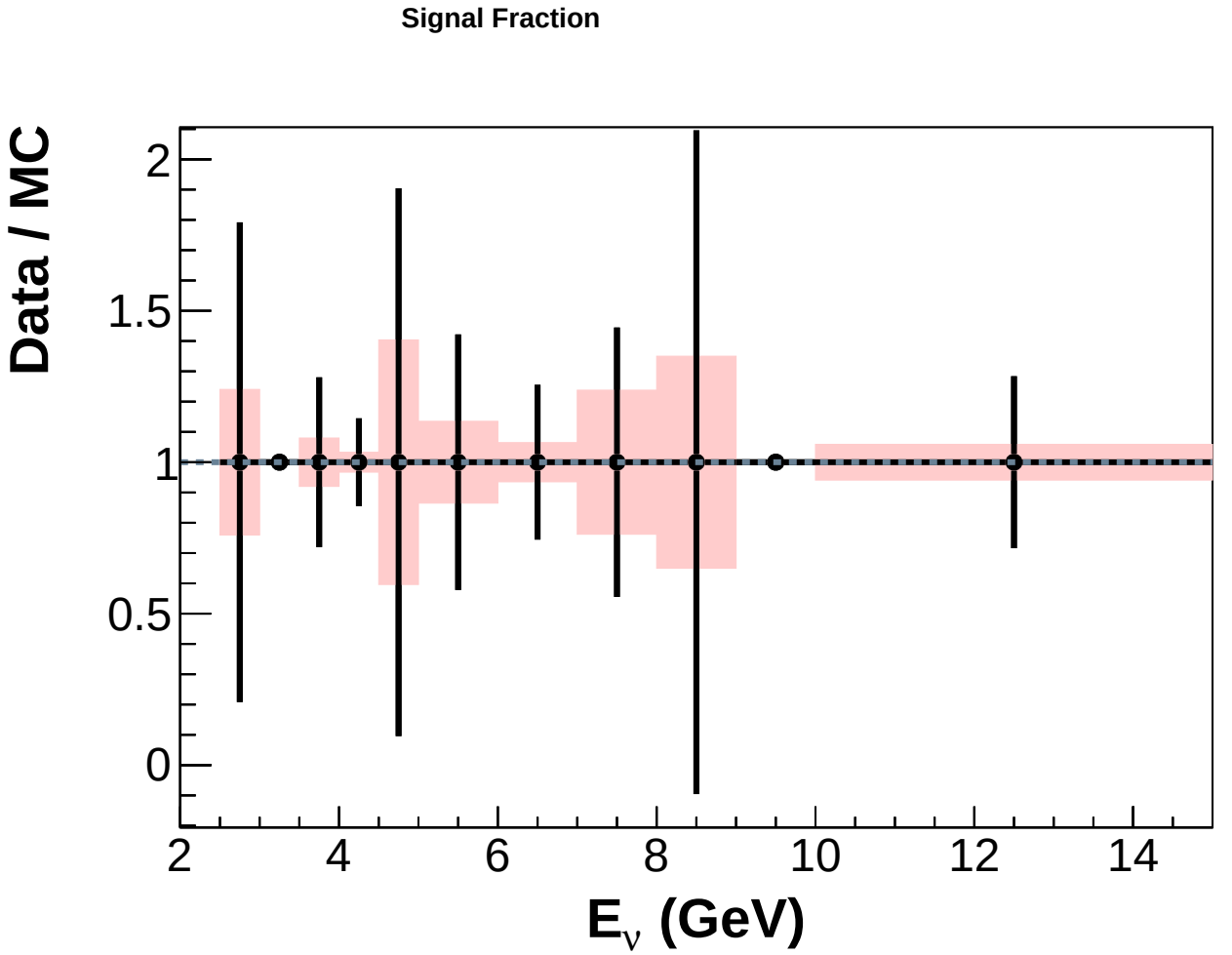

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

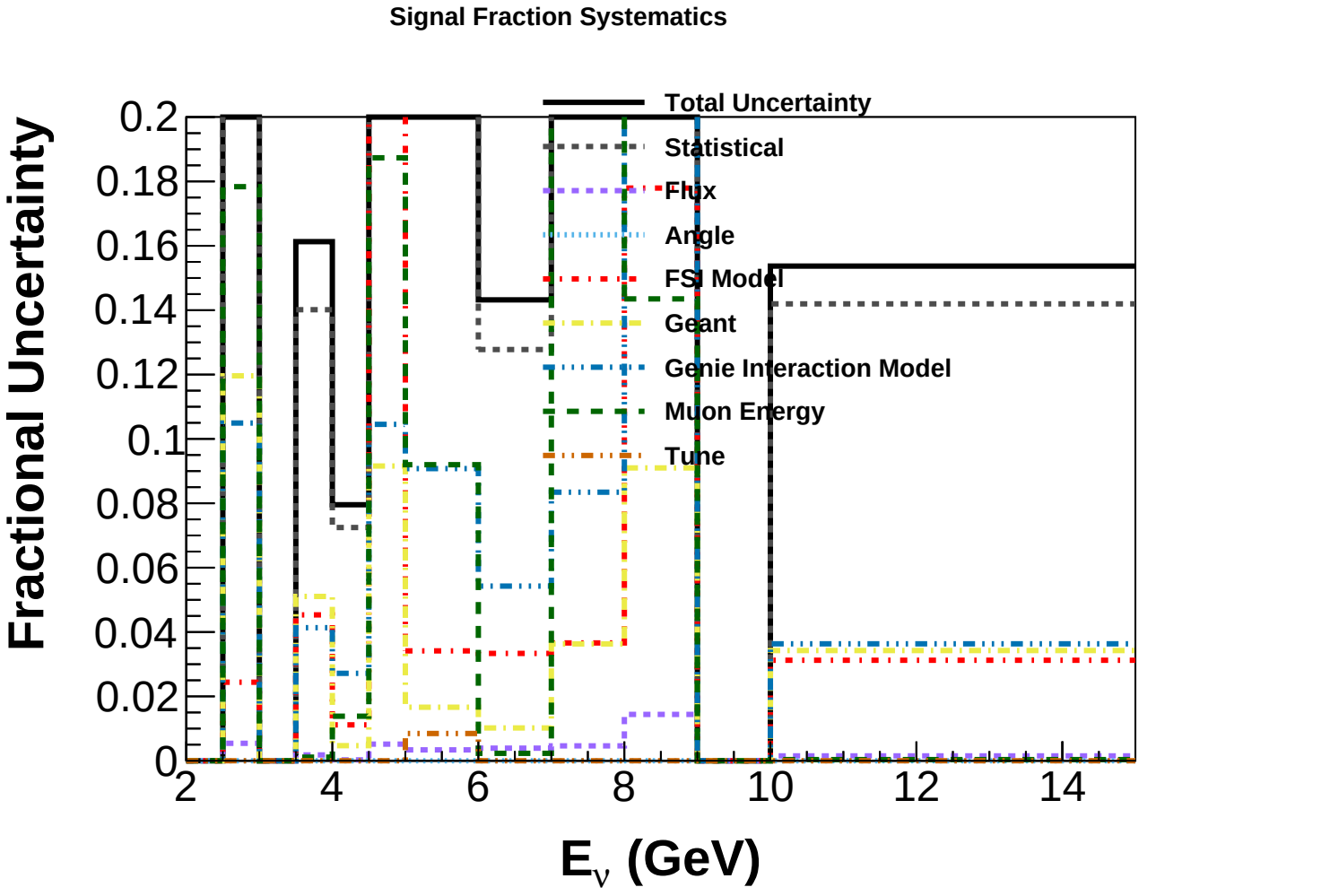

DATA_vs_MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
E_ν (GeV)

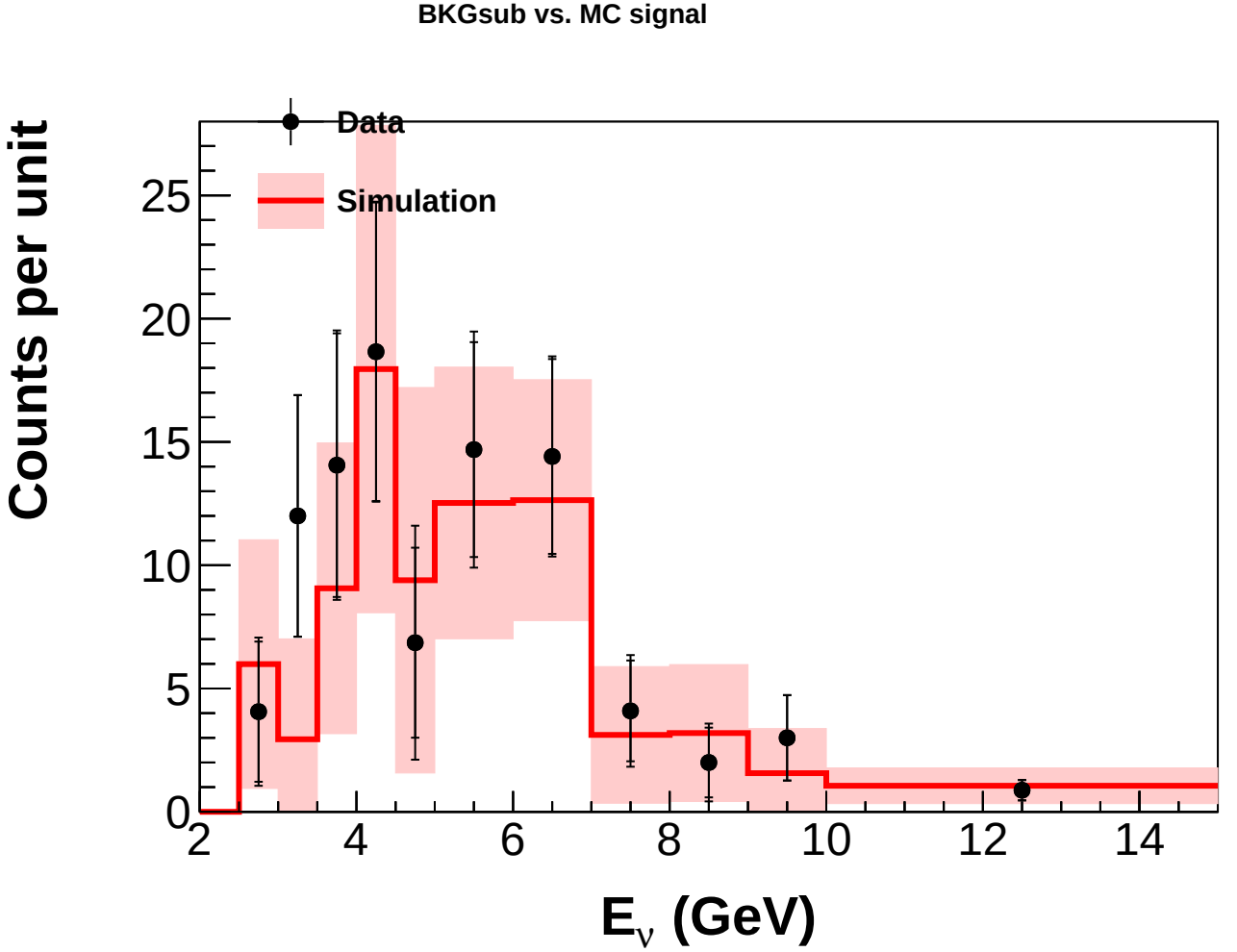

DATA_vs_MC
Data / MC
6
5
4
3
2
1
0
−1
−2
−3
2
4
6
8
10
12
14
E$_\nu$ (GeV)

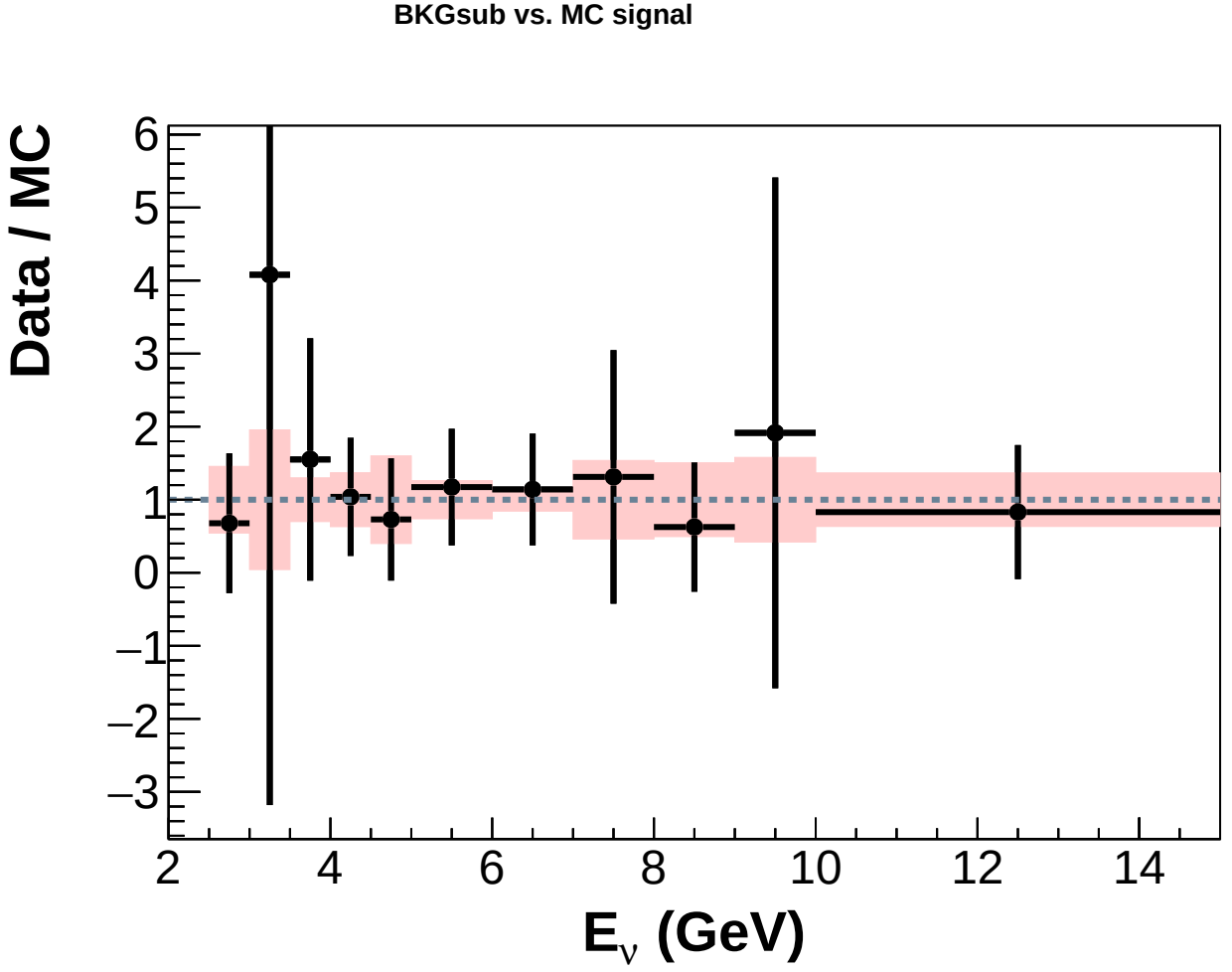

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

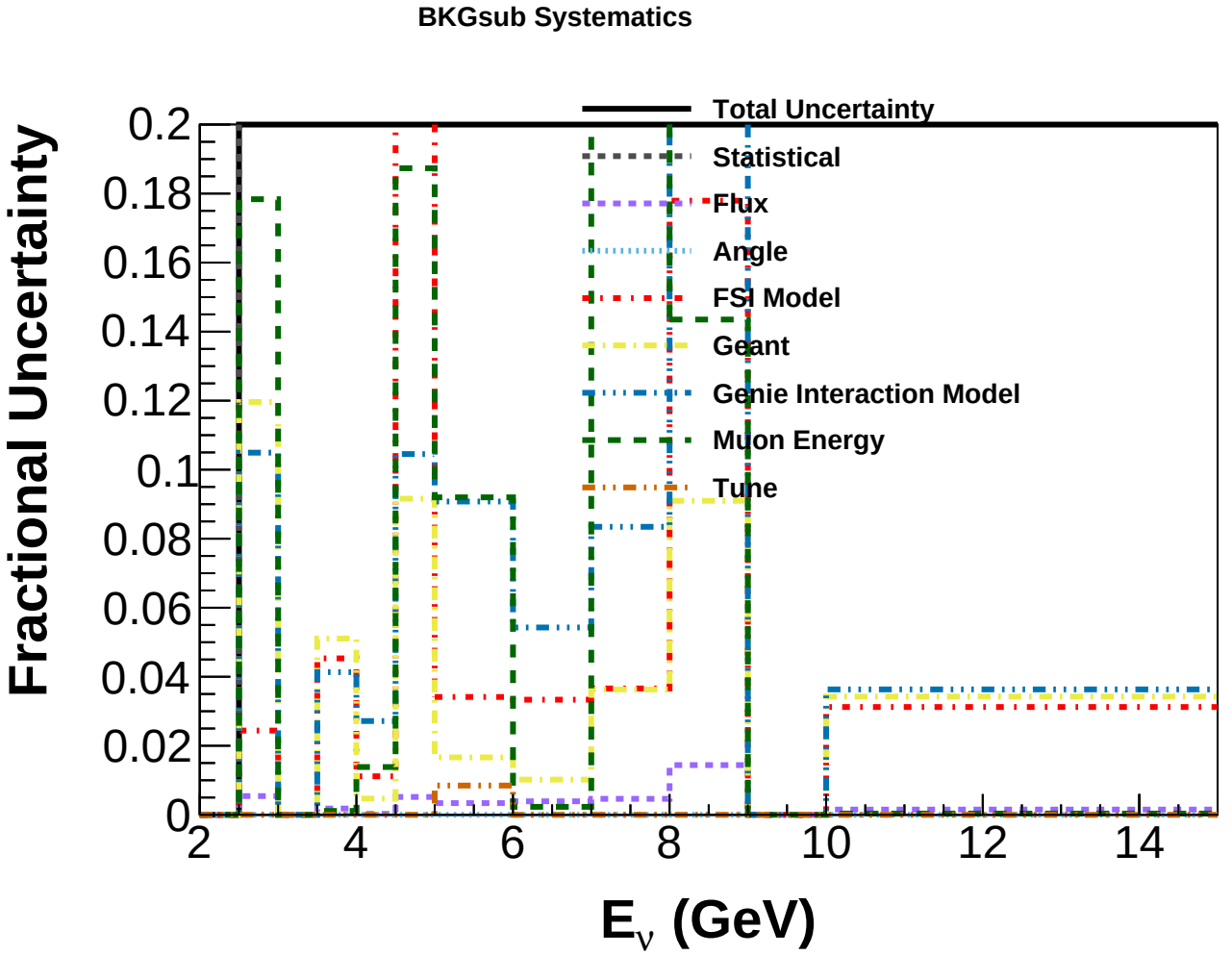

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_ν (GeV)

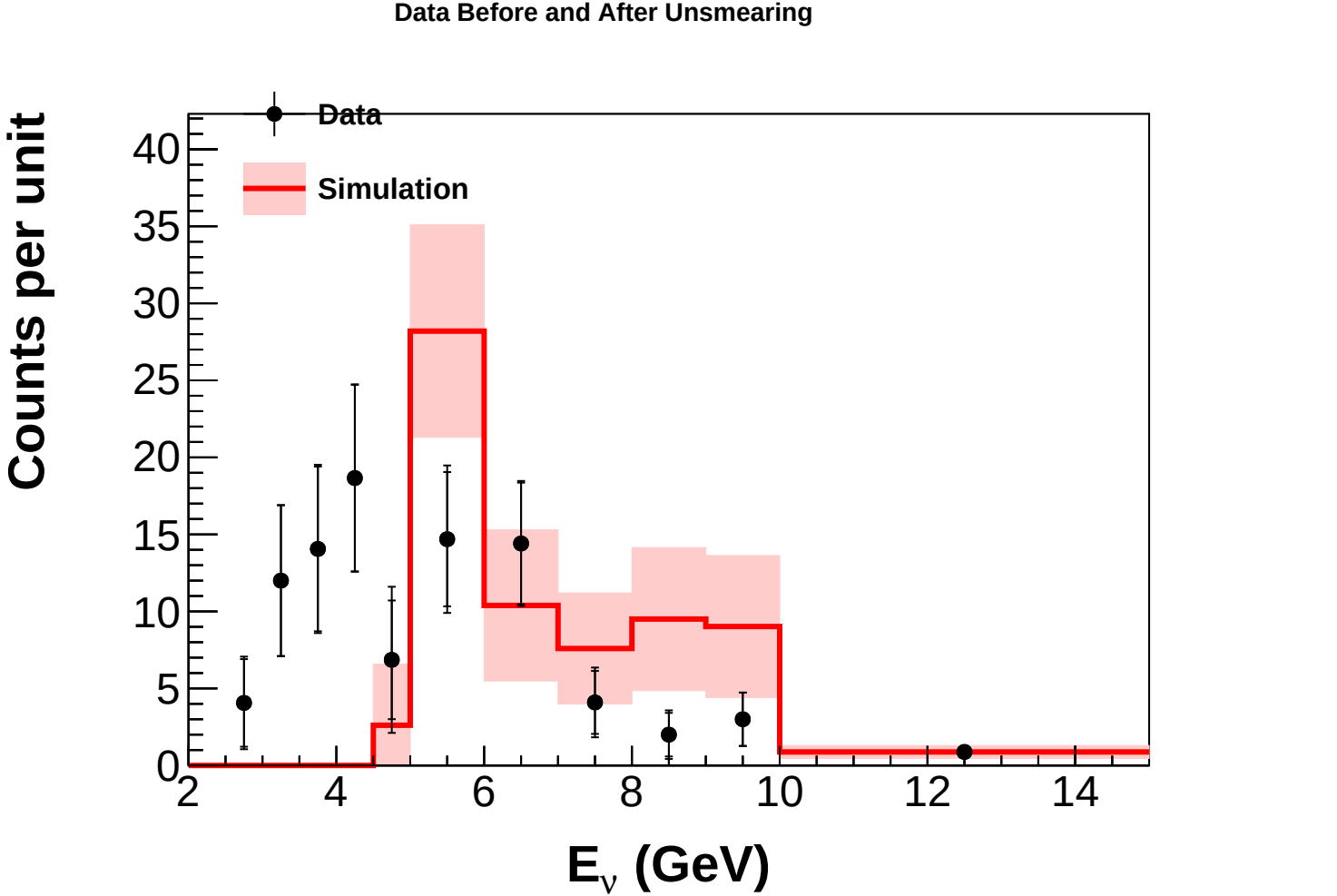

Signal Fraction
Data / MC
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

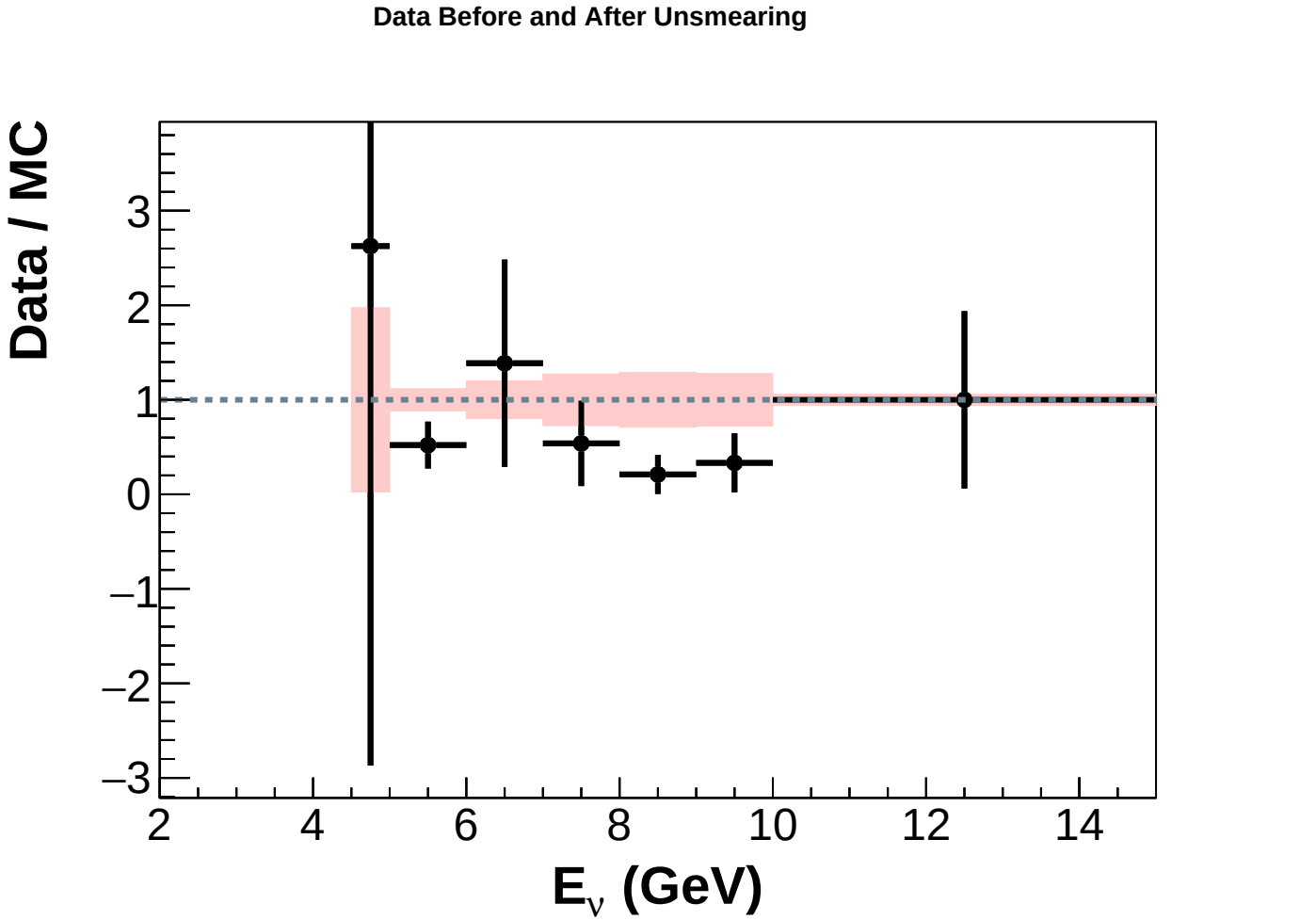

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

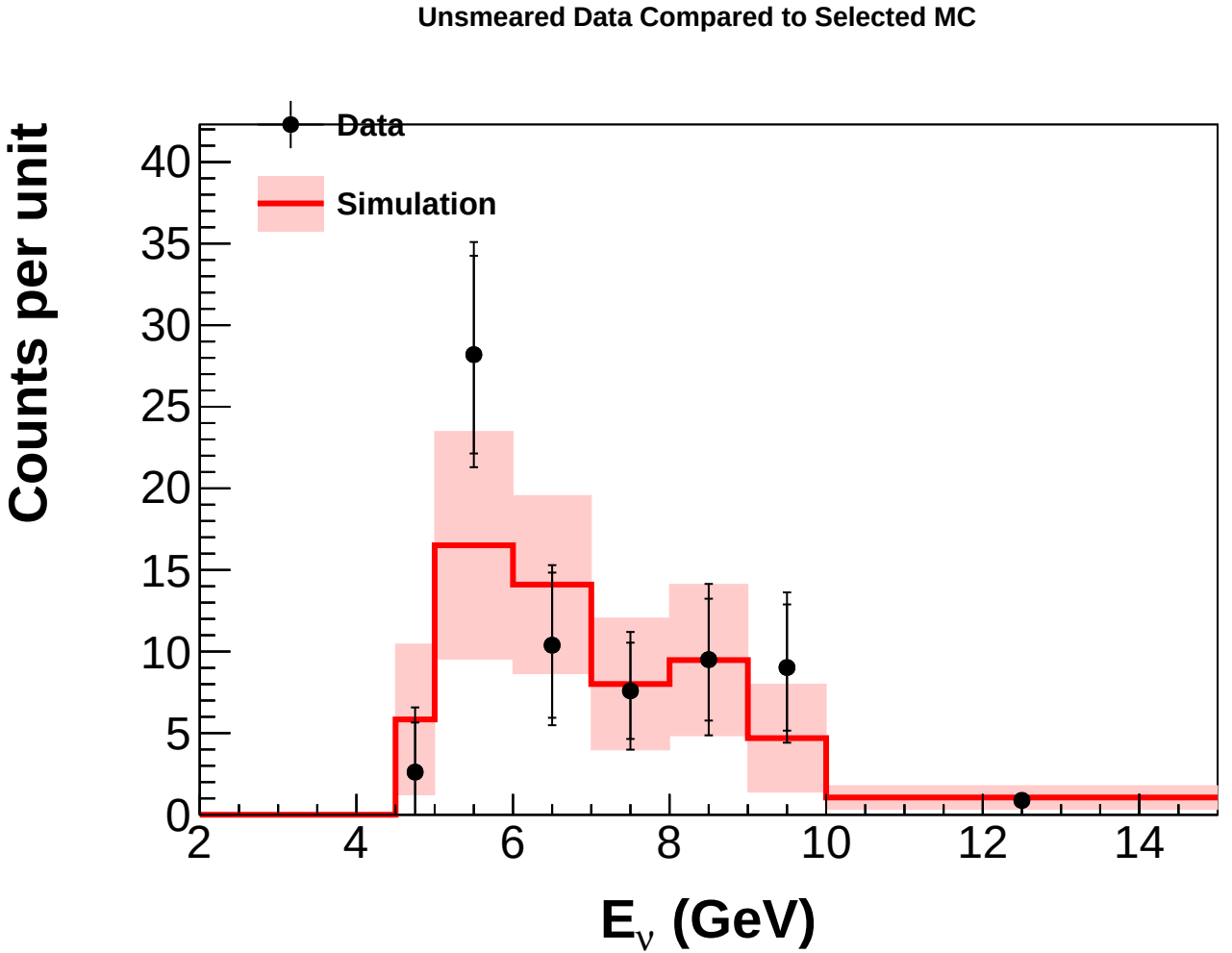

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
2
4
6
8
10
12
14
E_ν (GeV)

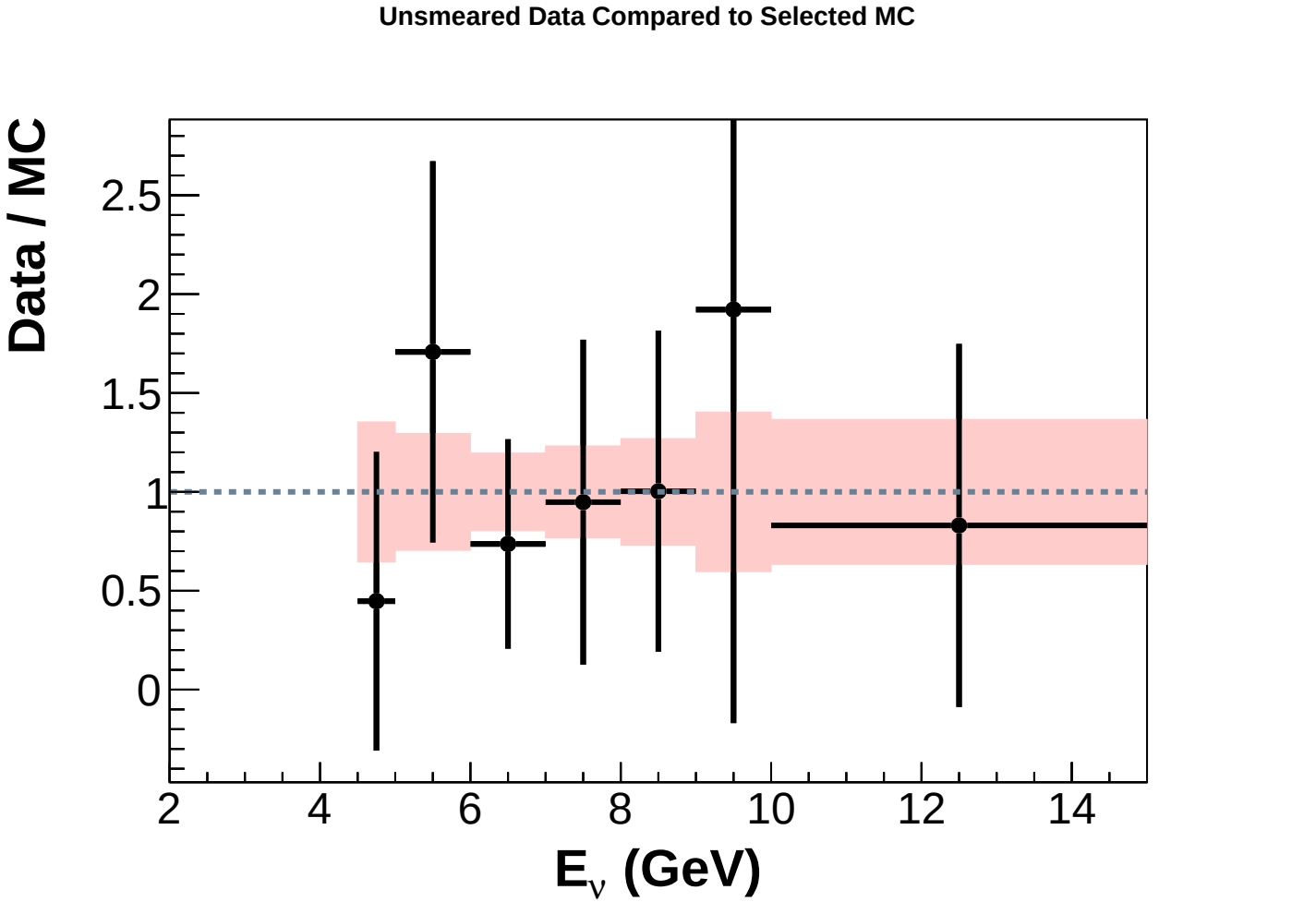

BKGsub vs. MC signal
Data / MC
6
5
4
3
2
1
0
−1
−2
−3
2
4
6
8
10
12
14
E_ν (GeV)

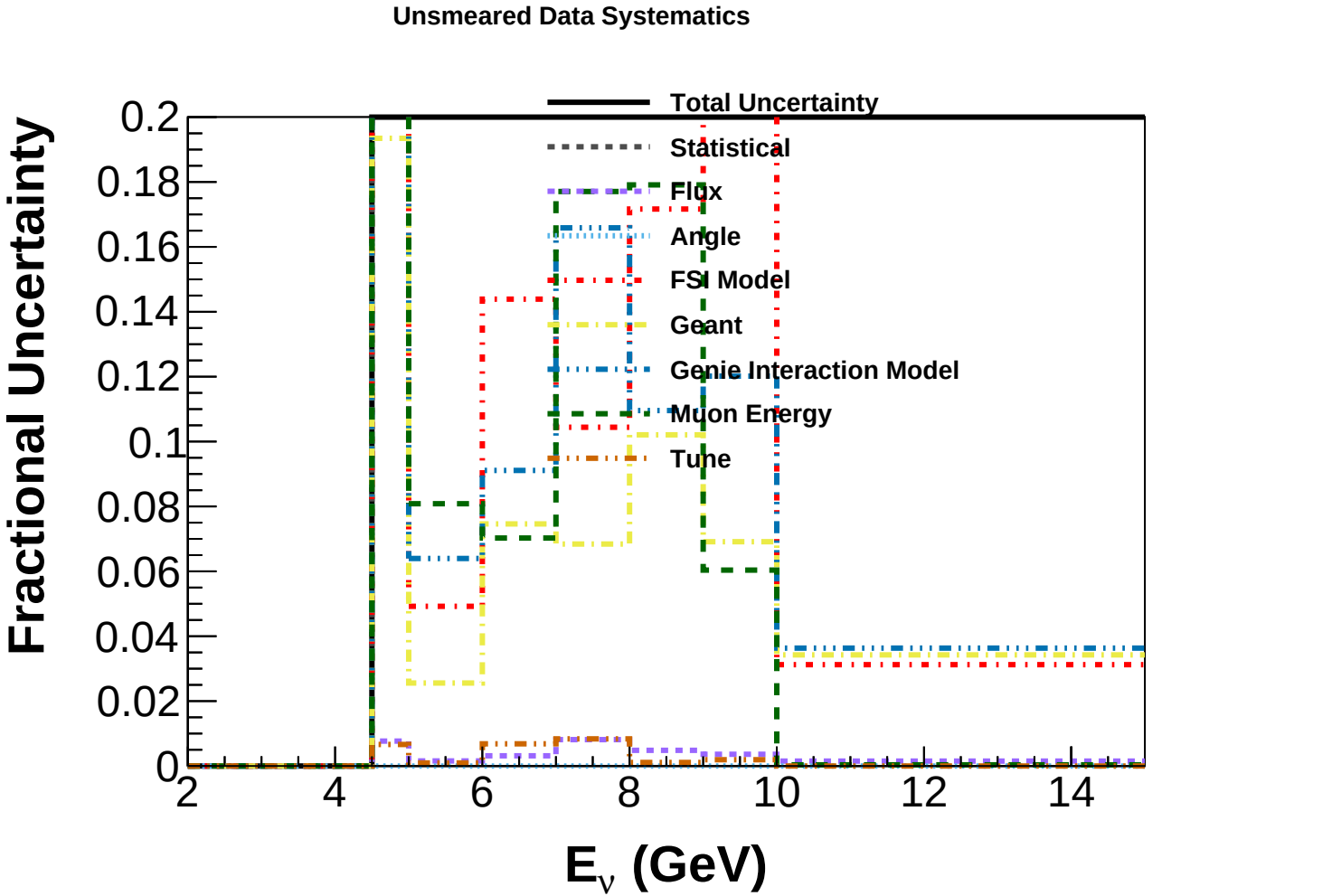

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

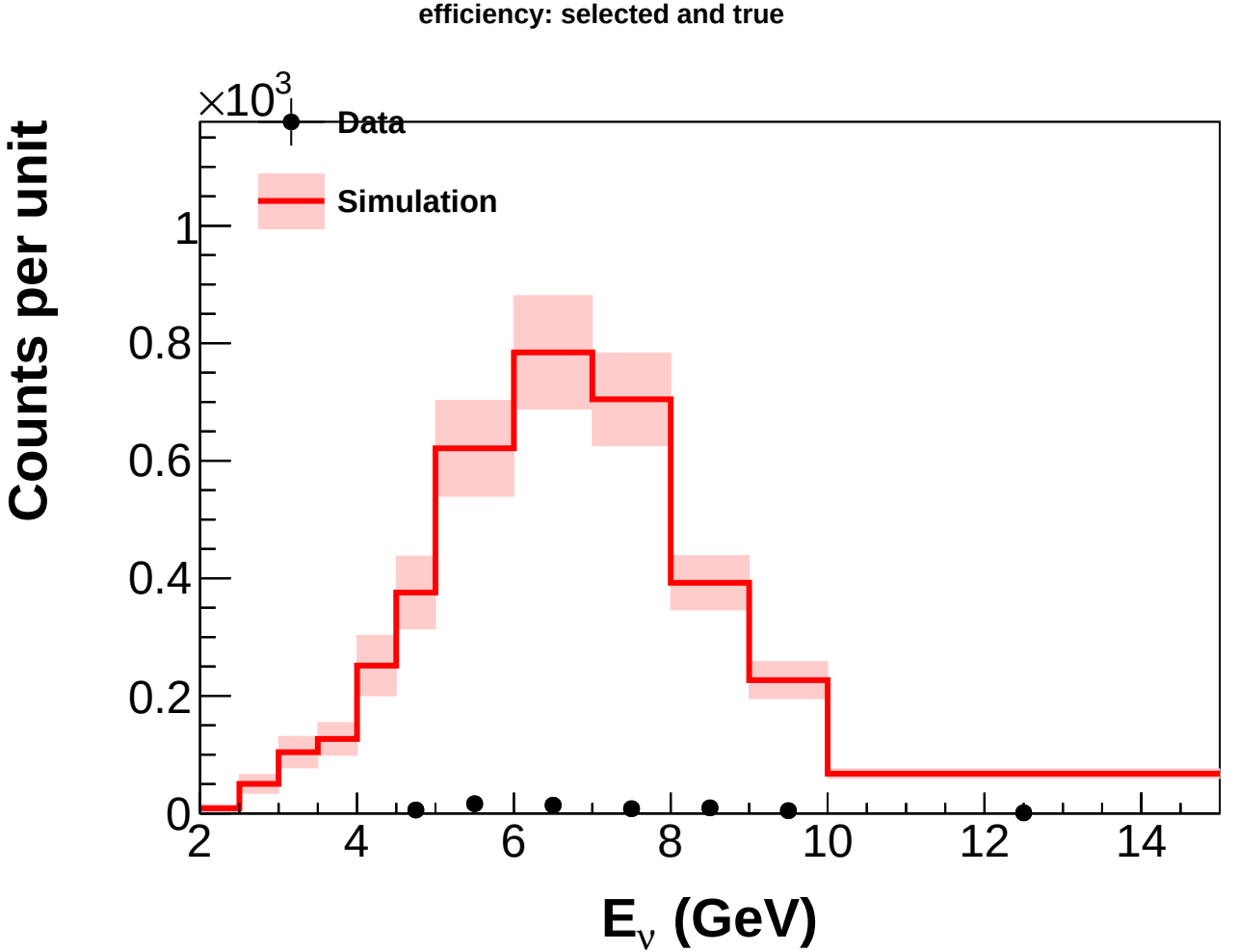

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
E_ν (GeV)

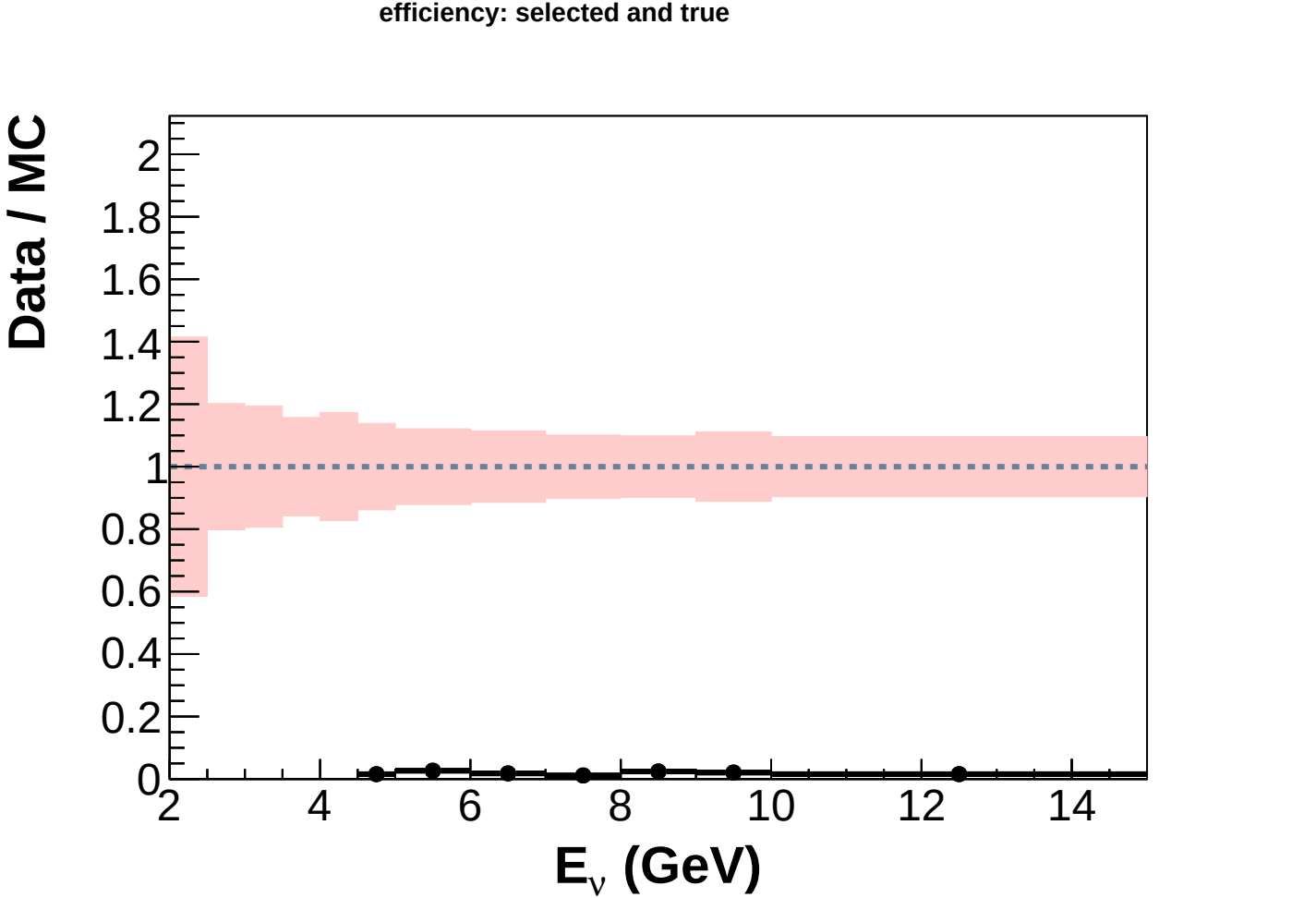

Data Before and After Unsmearing
Data / MC
3
2
1
0
−1
−2
−3
2
4
6
8
10
12
14
E_ν (GeV)

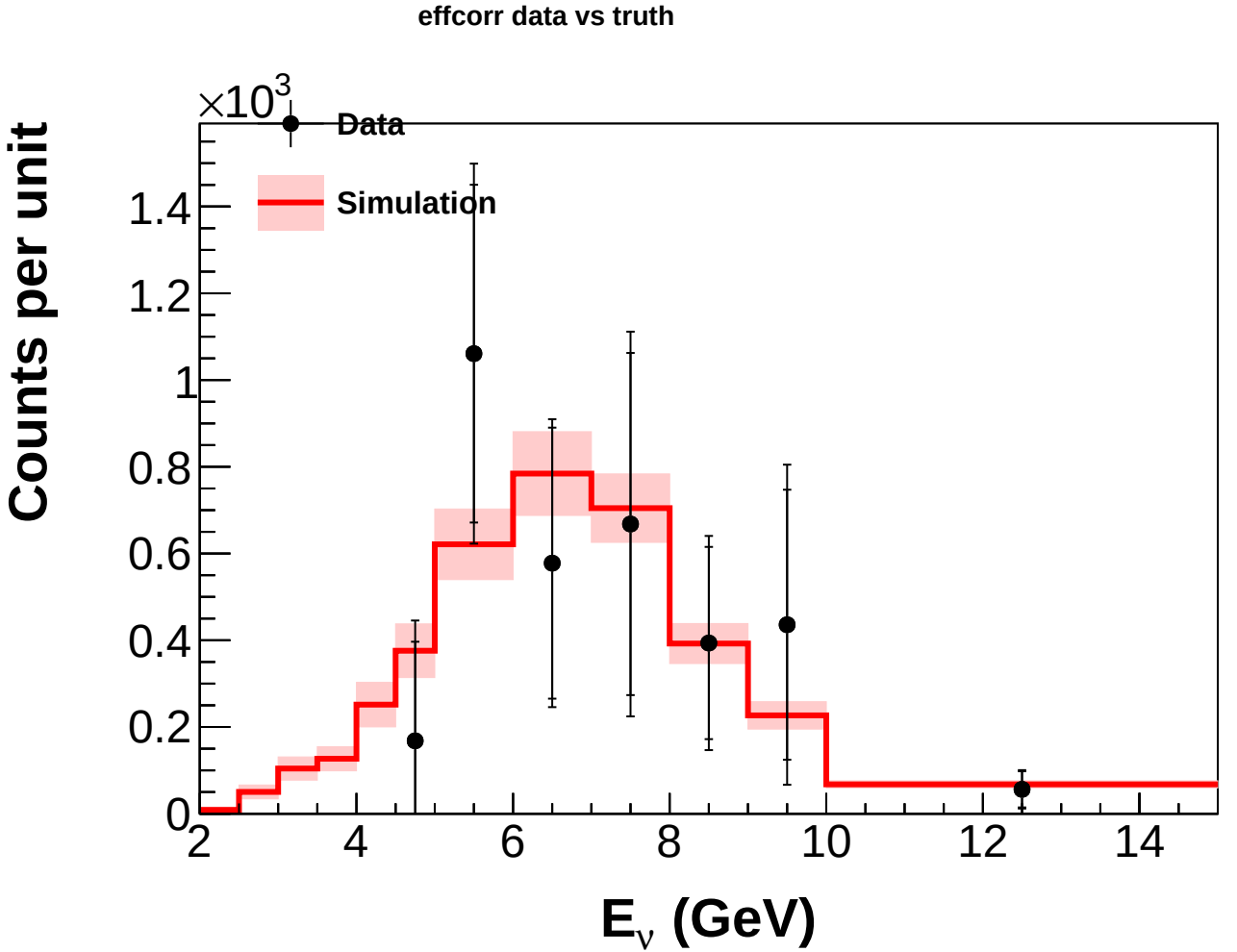

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
E_ν (GeV)

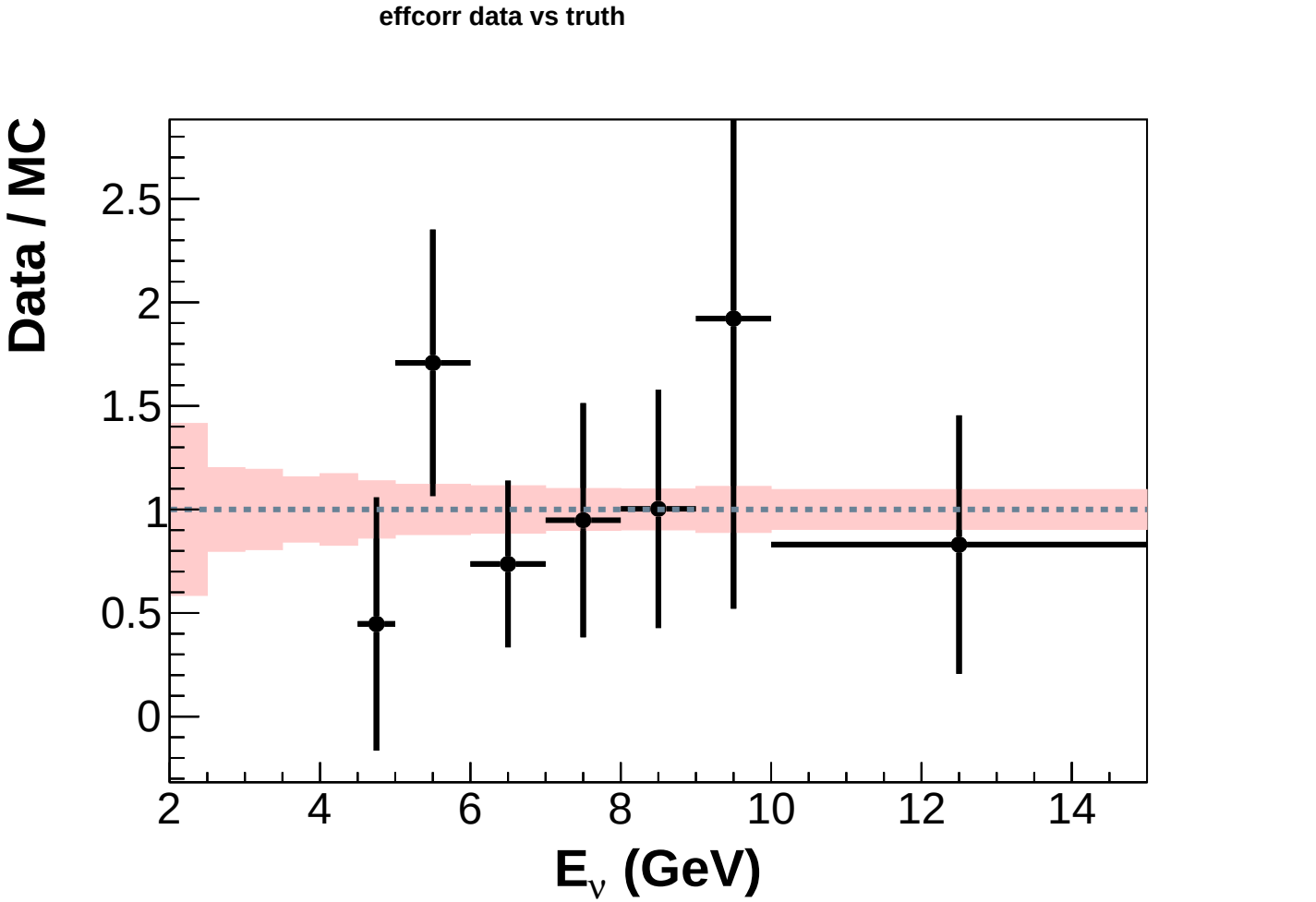

Unsmeared Data Compared to Selected MC
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

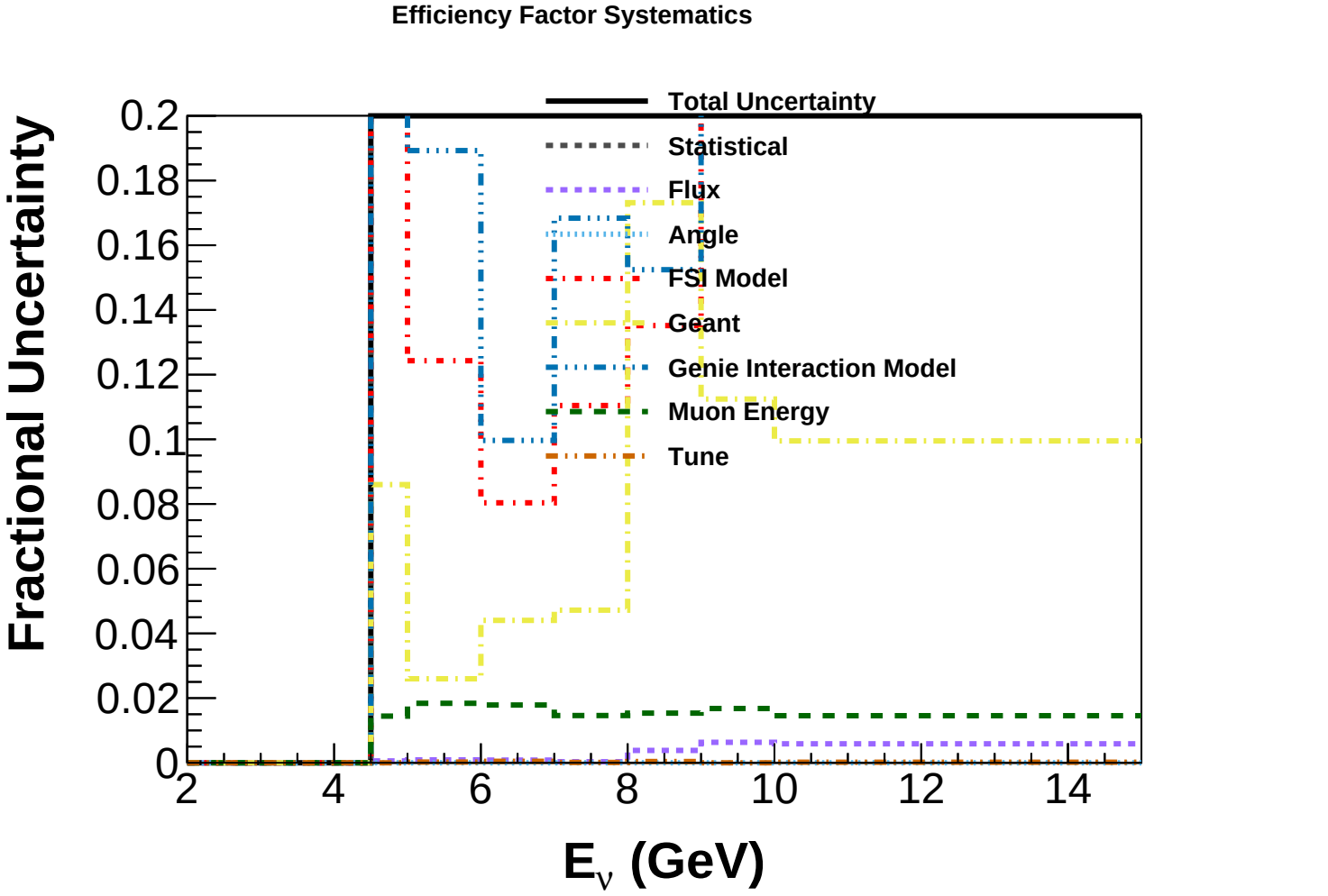

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

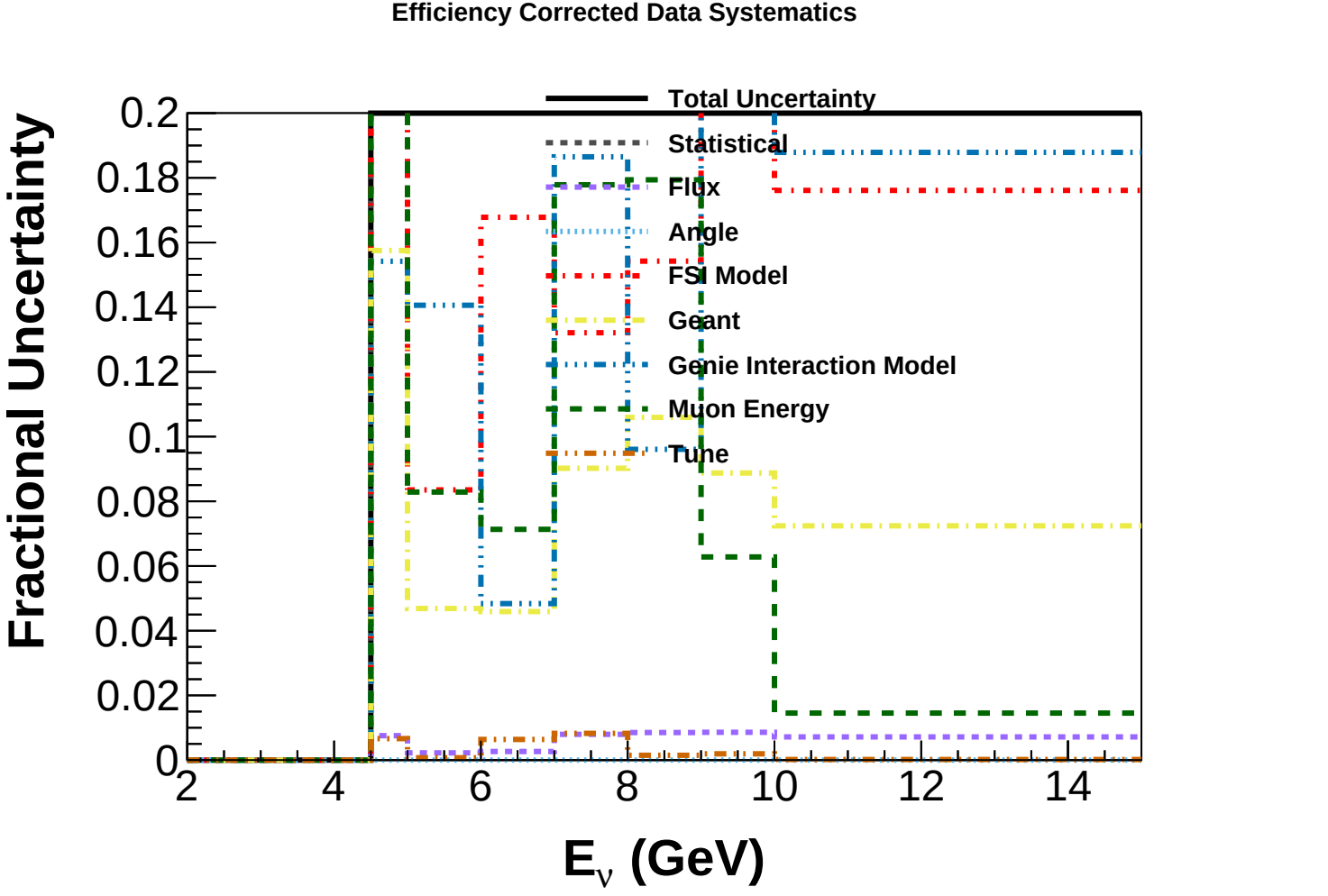

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_ν (GeV)

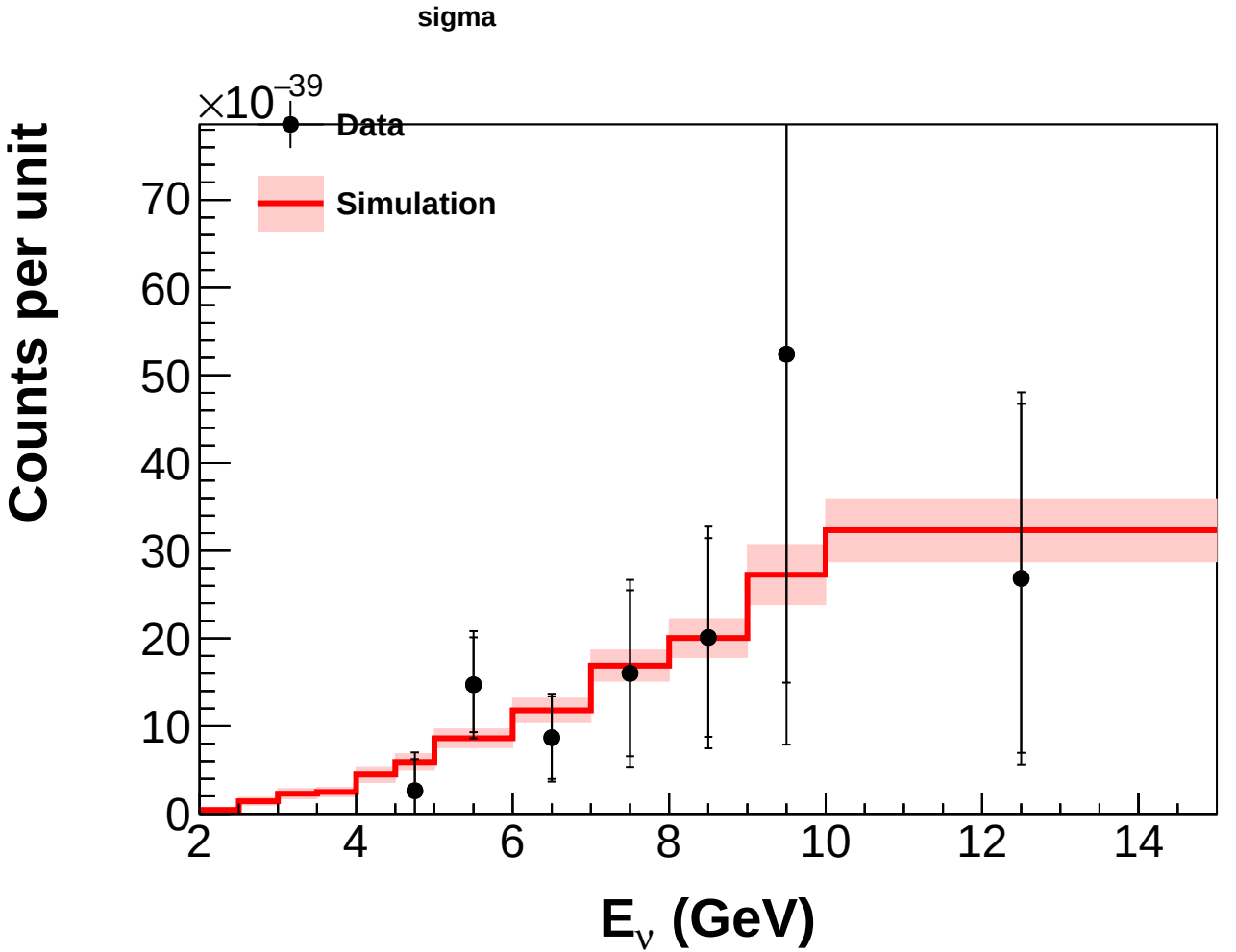

efficiency: selected and true
Data / MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

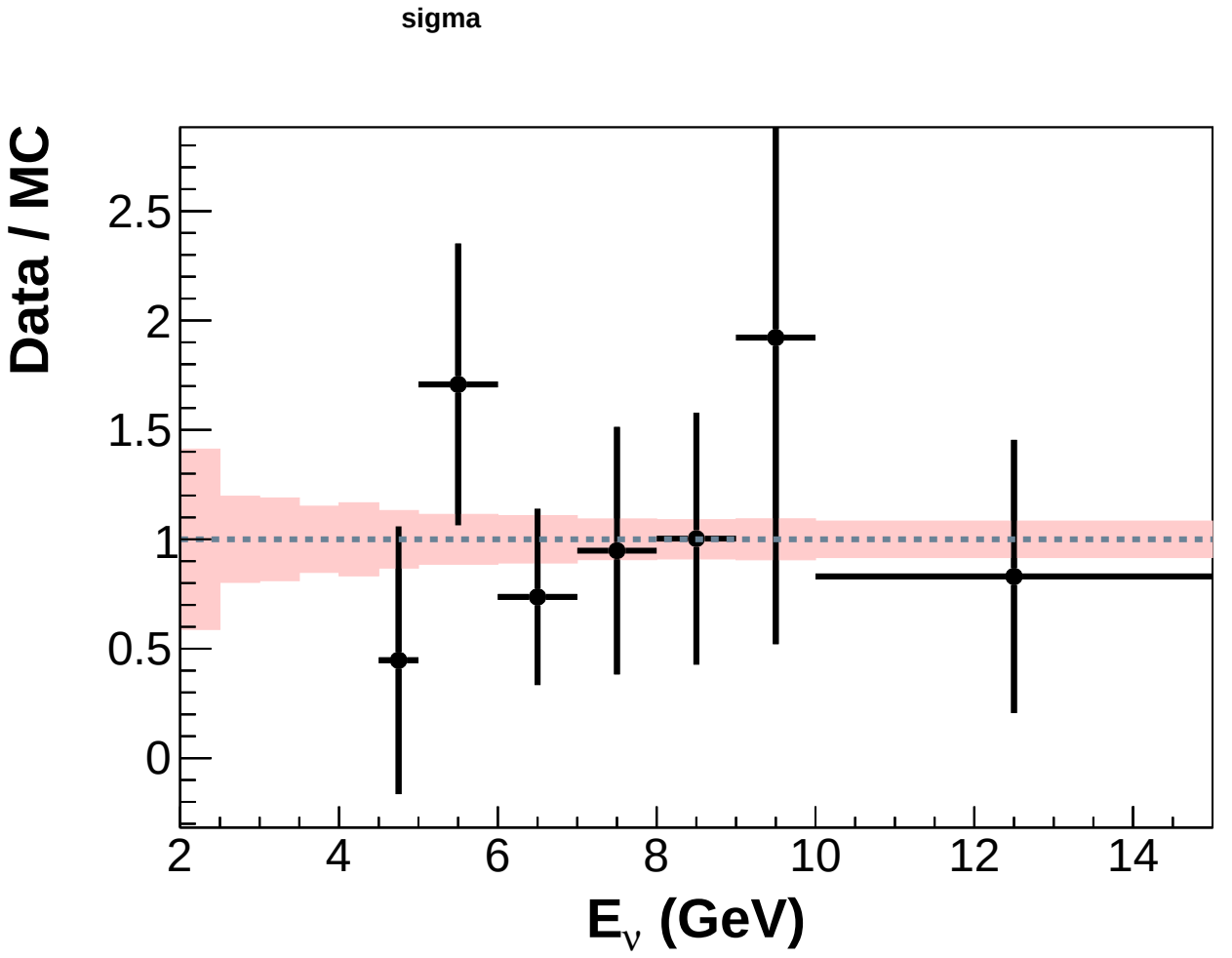

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_ν (GeV)

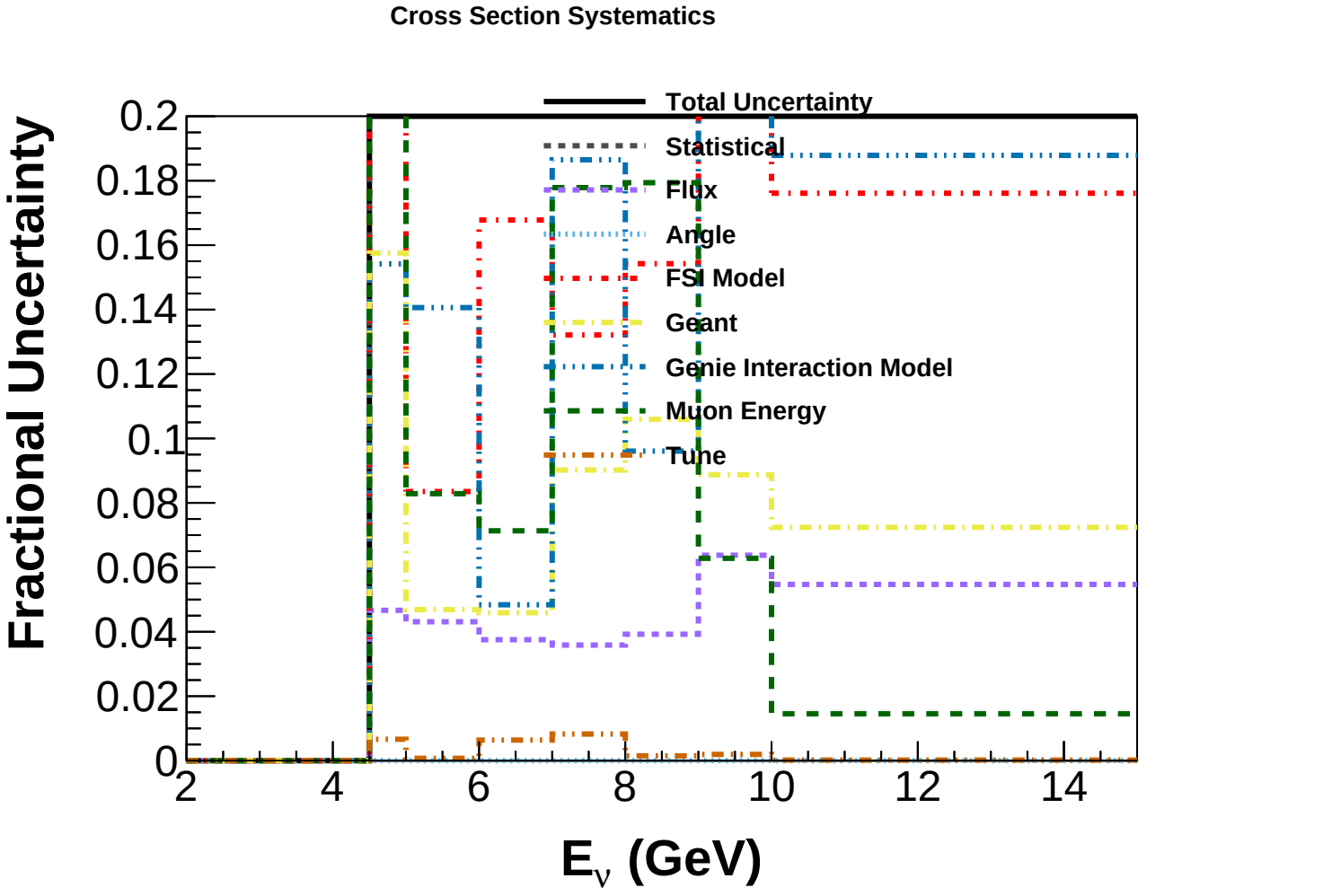

effcorr data vs truth
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

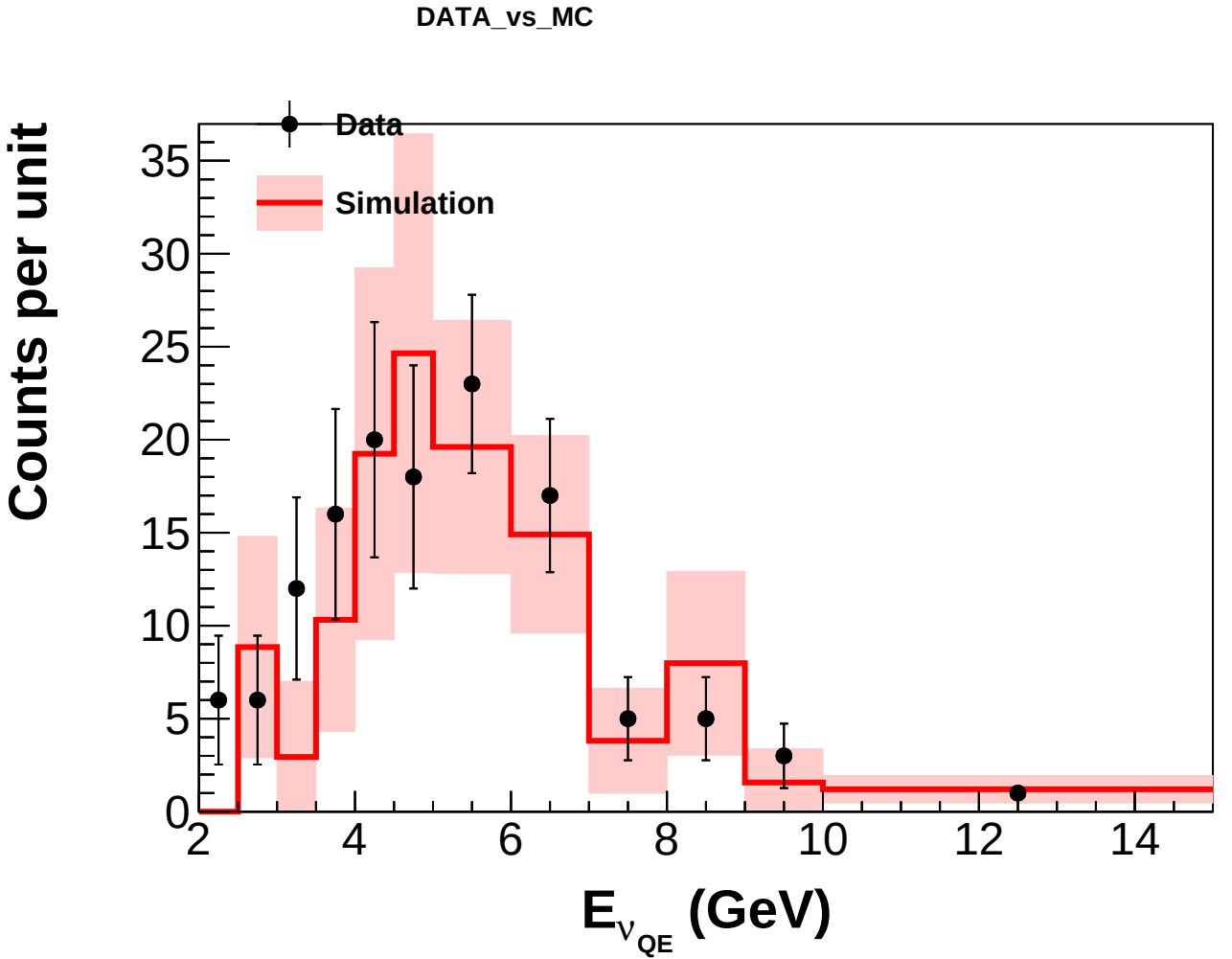

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

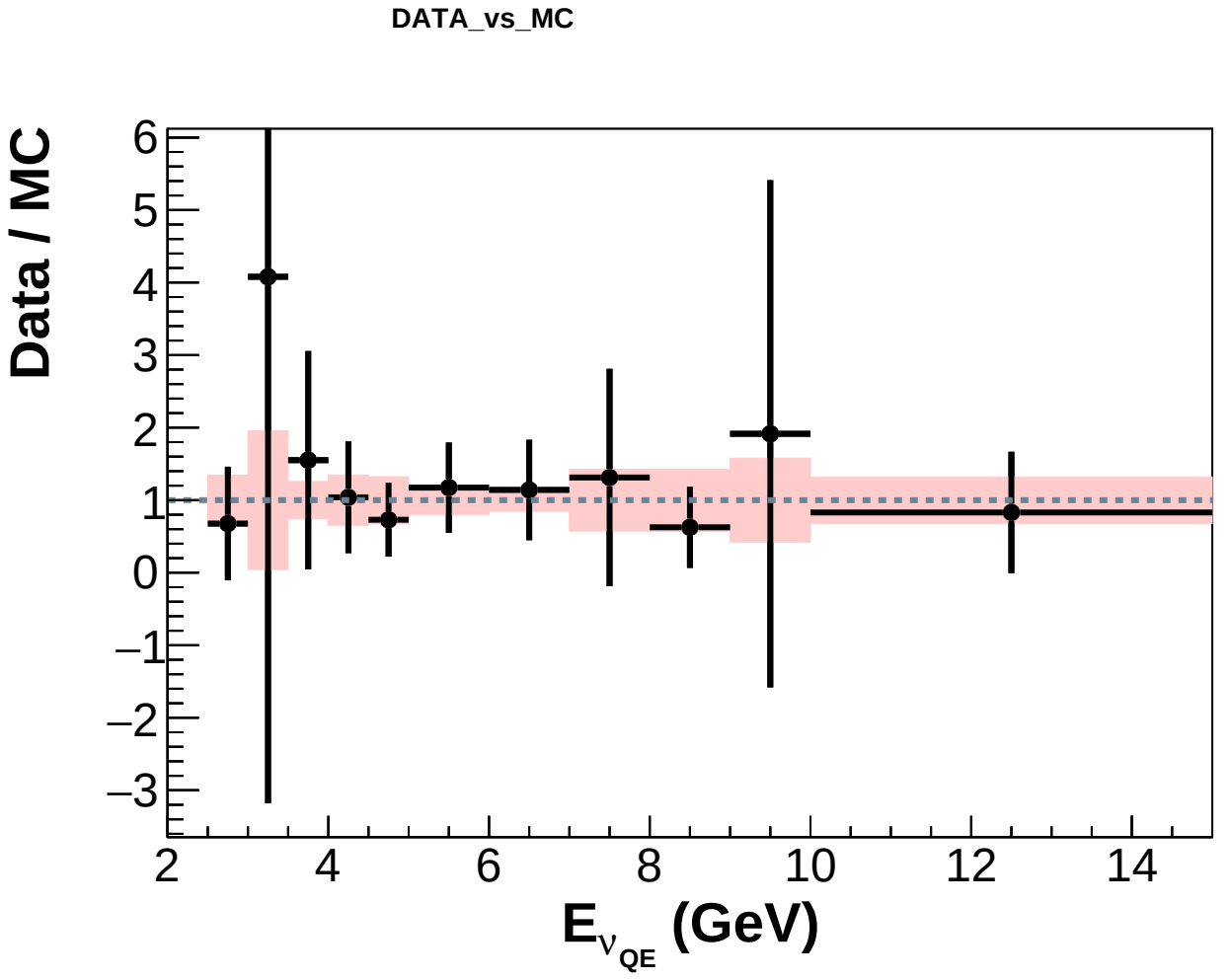

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

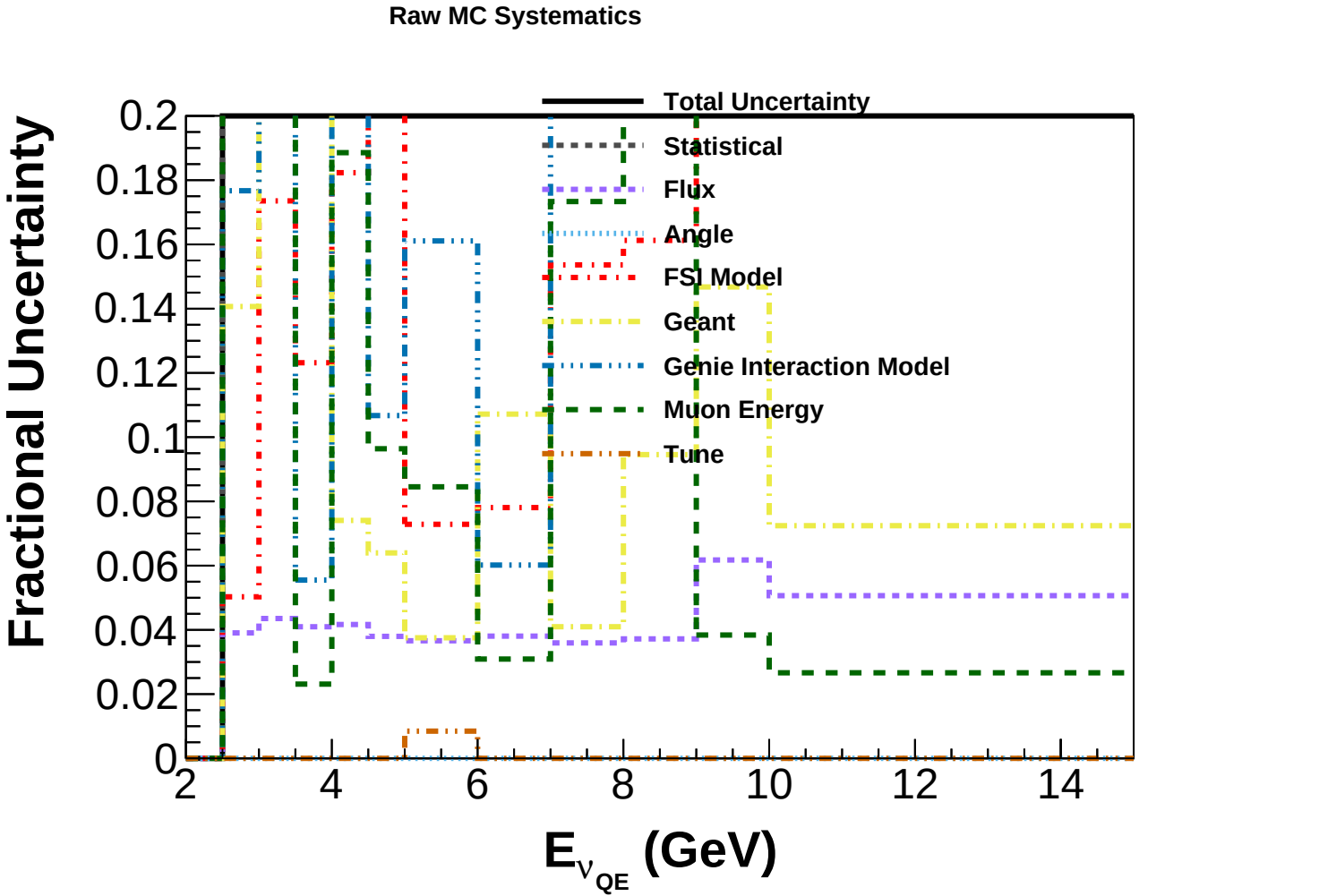

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
70
60
50
40
30
20
10
0
2
4
6
8
10
12
14
E_ν (GeV)

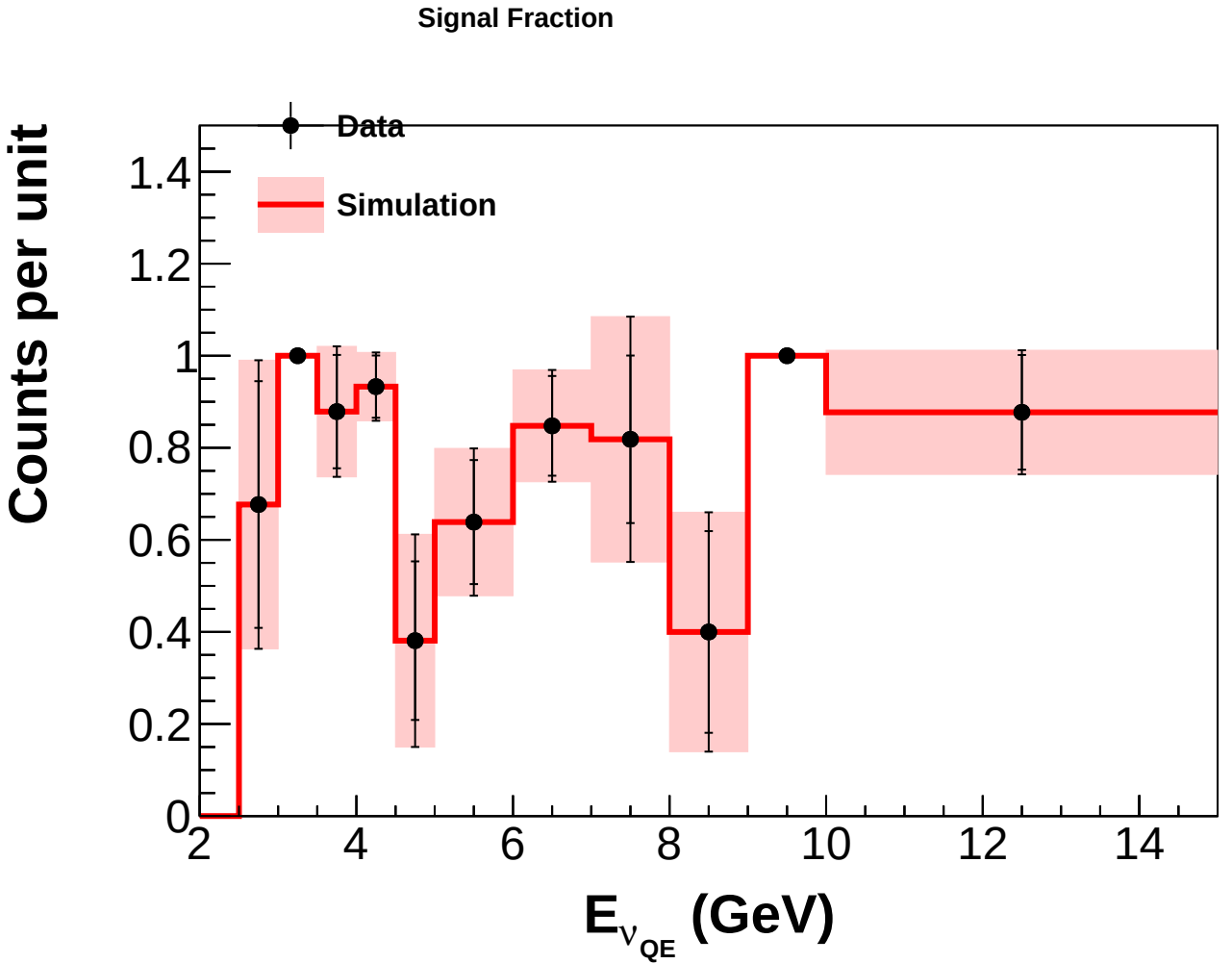

sigma
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

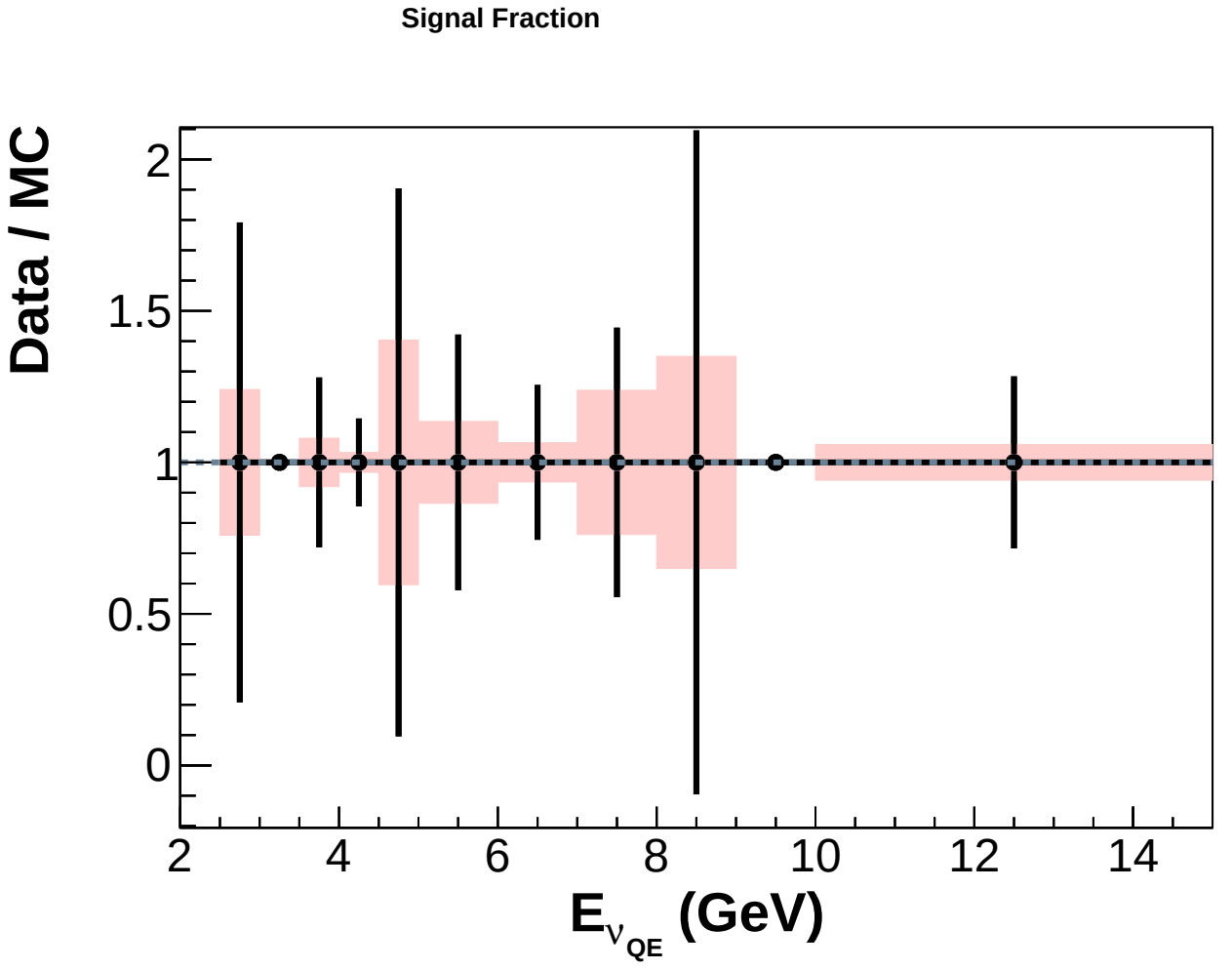

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

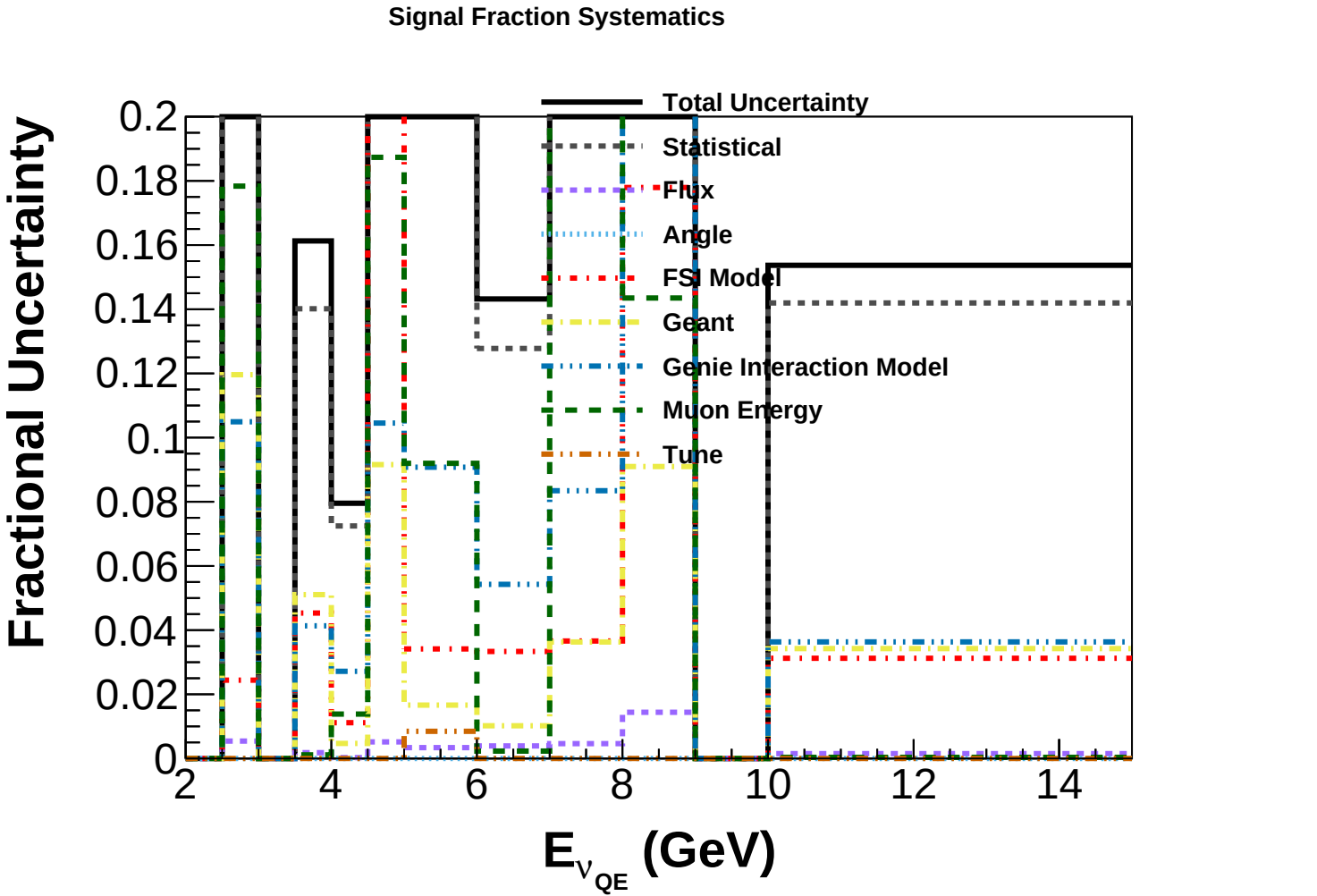

DATA_vs_MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

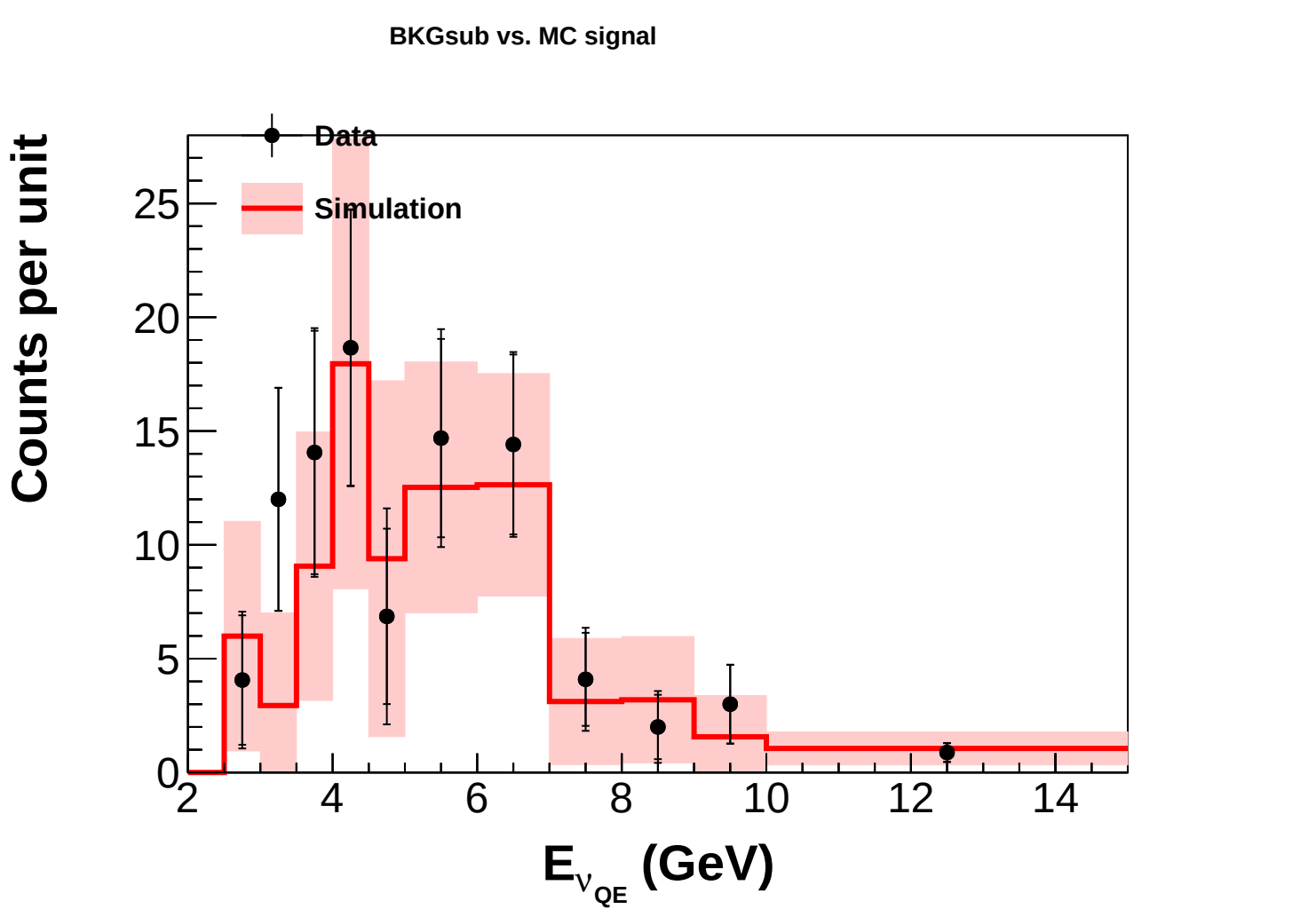

DATA_vs_MC
Data / MC
6
5
4
3
2
1
0
−1
−2
−3
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

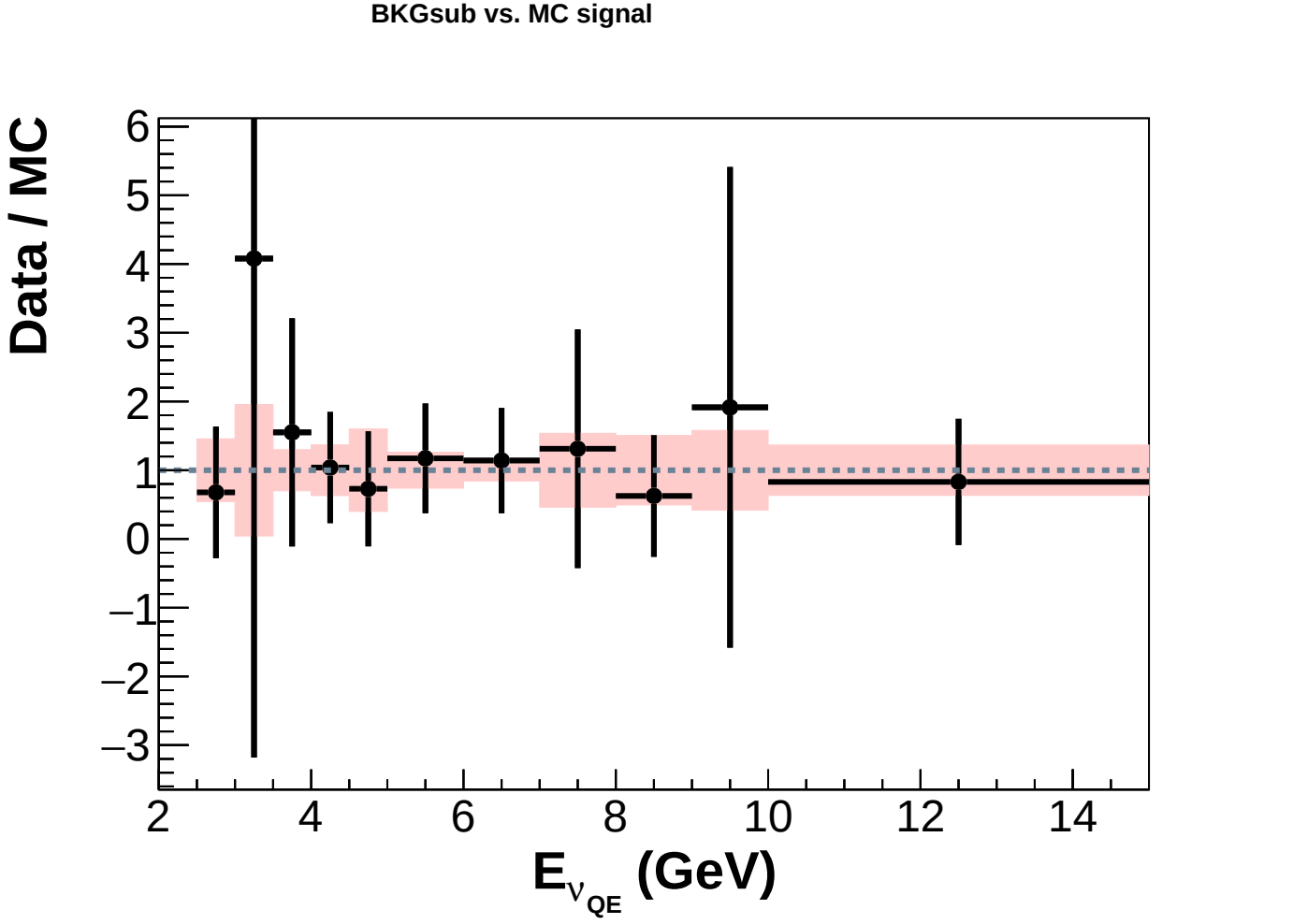

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

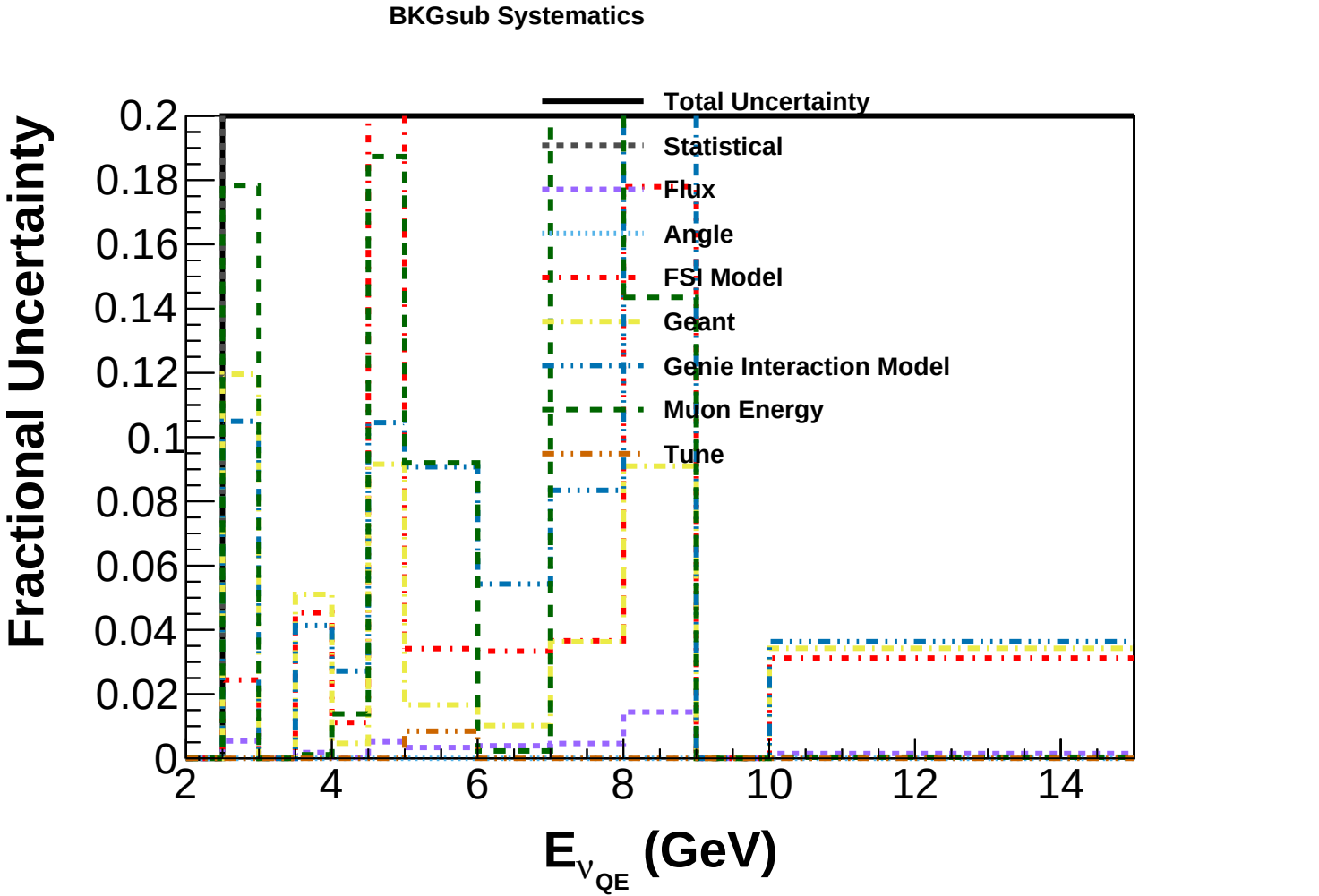

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

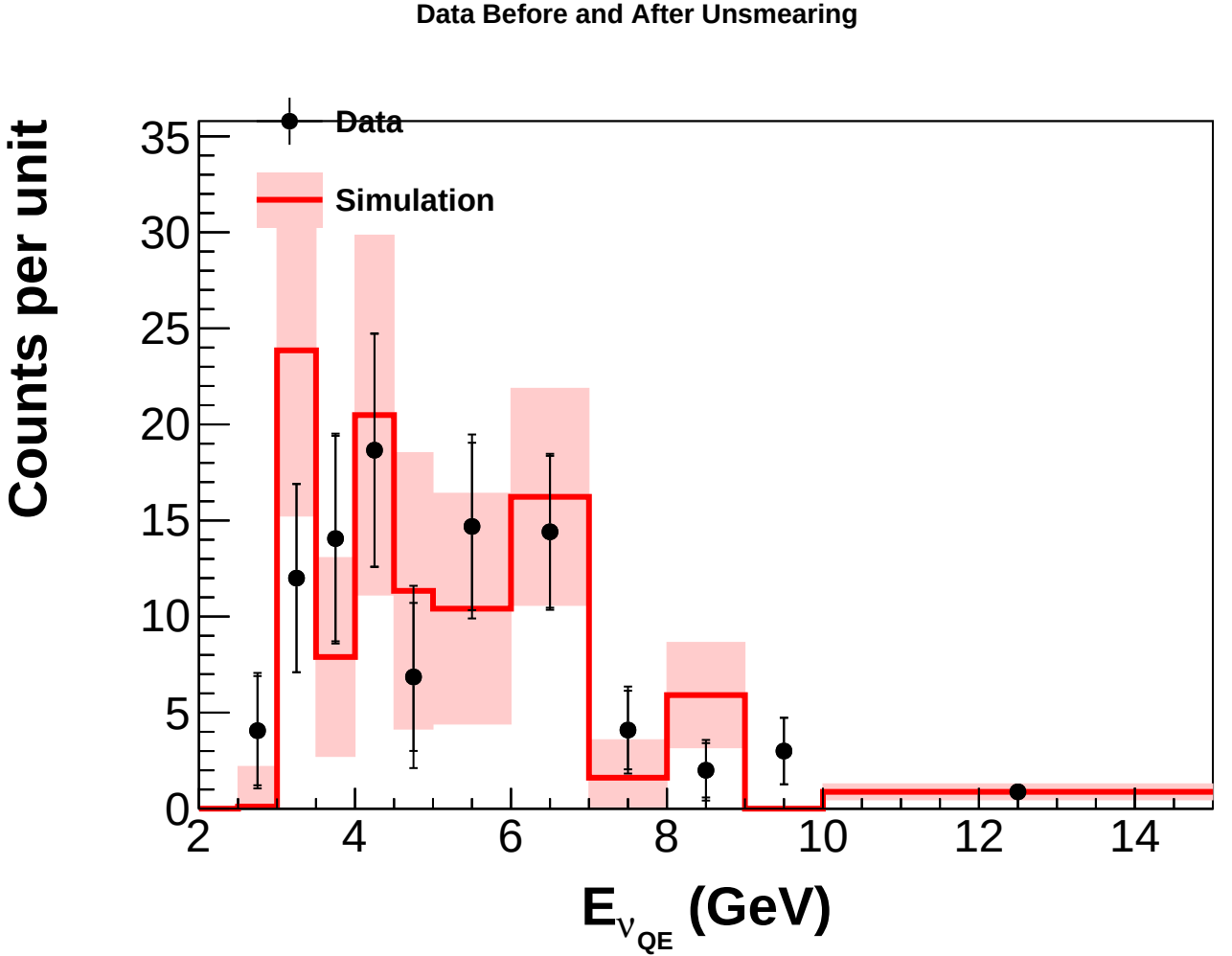

Signal Fraction
Data / MC
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

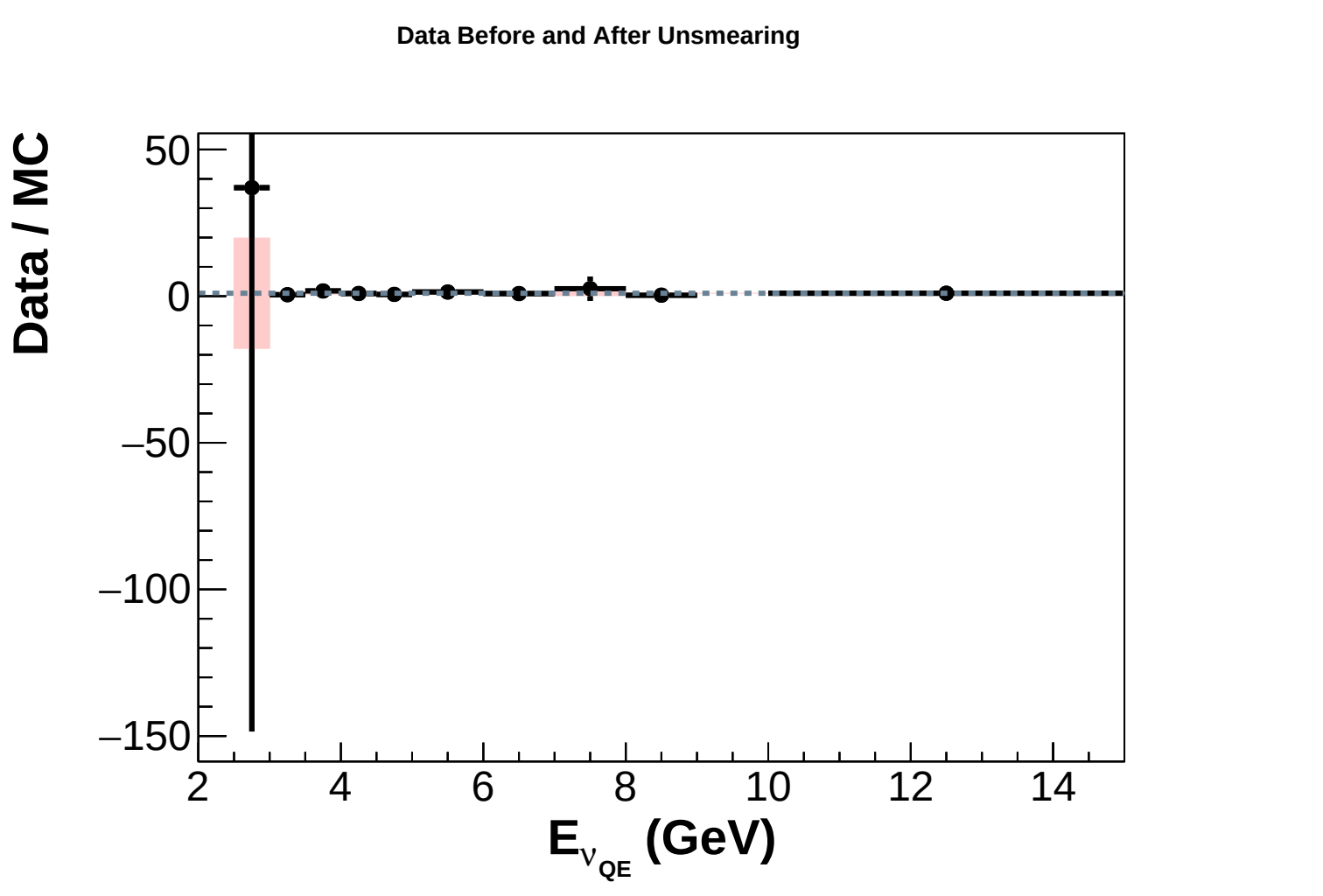

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_νQE (GeV)

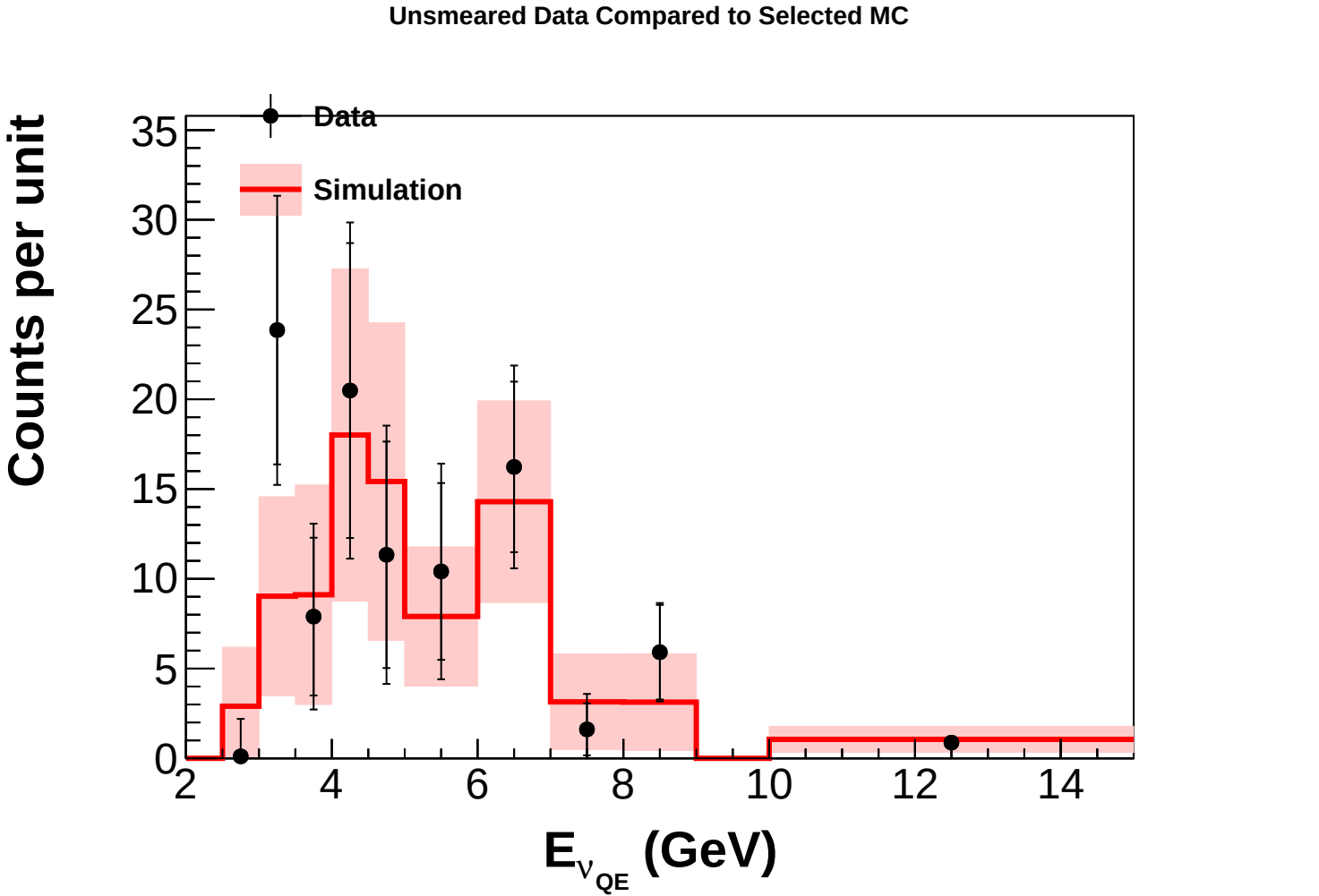

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

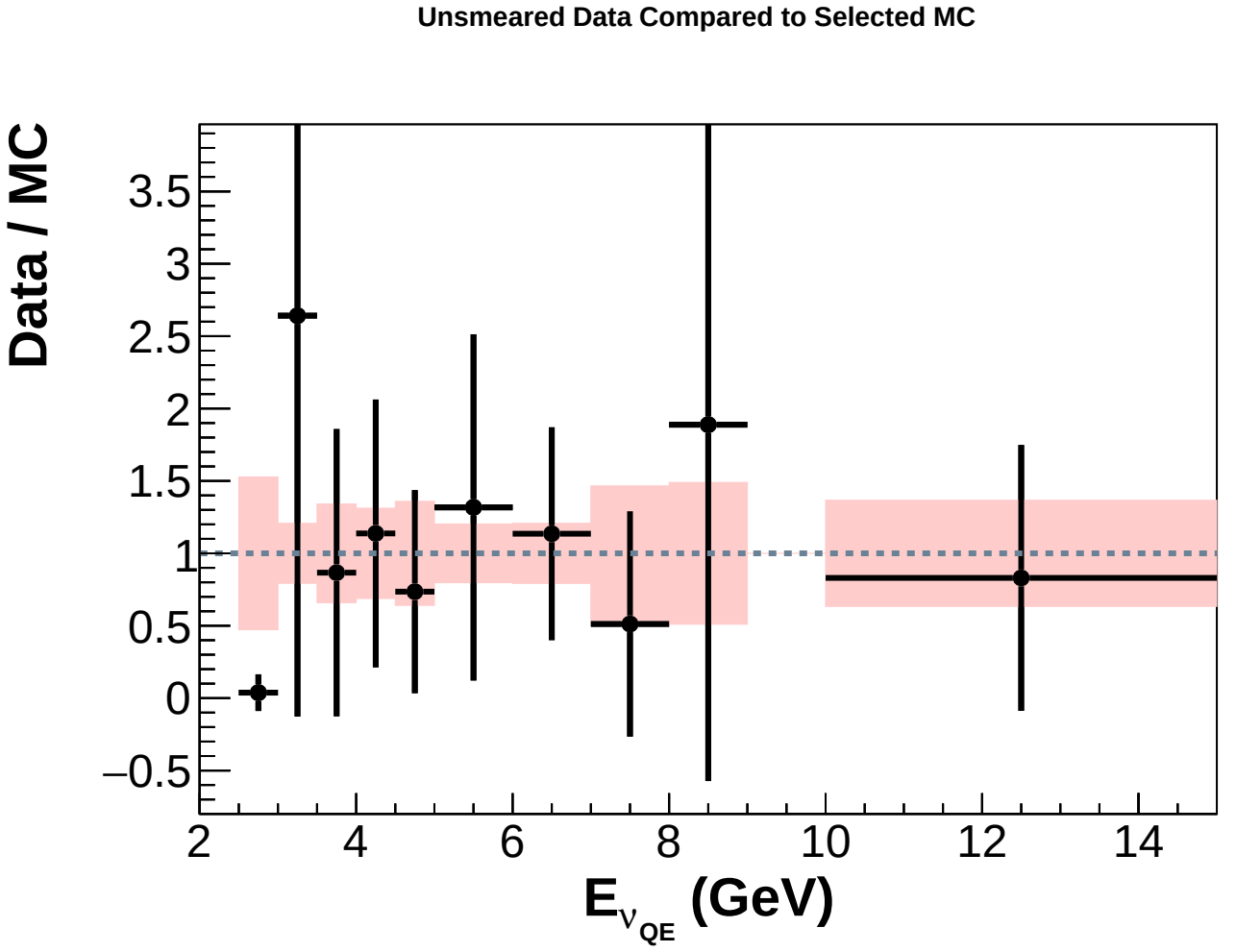

BKGsub vs. MC signal
Data / MC
6
5
4
3
2
1
0
−1
−2
−3
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

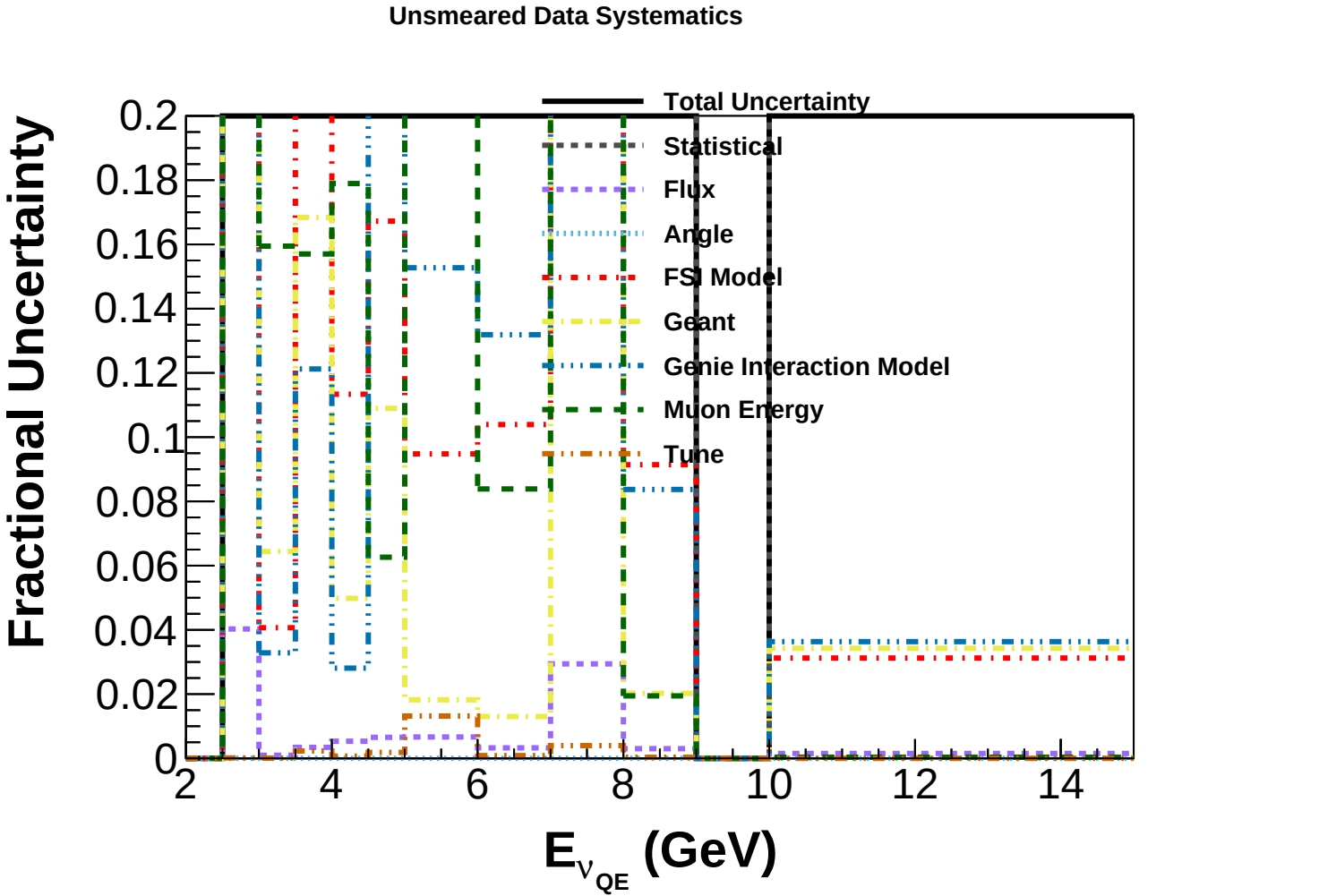

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

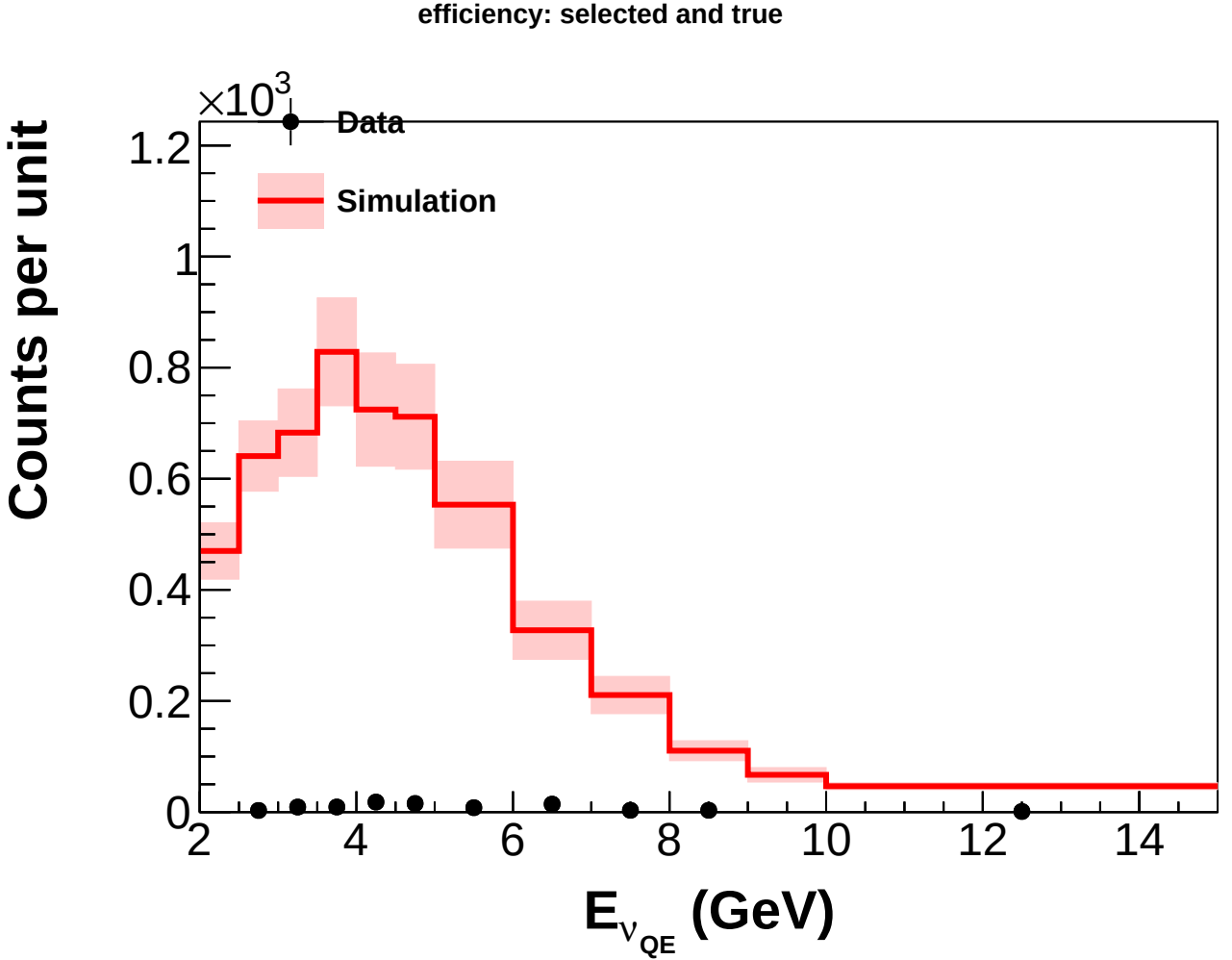

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

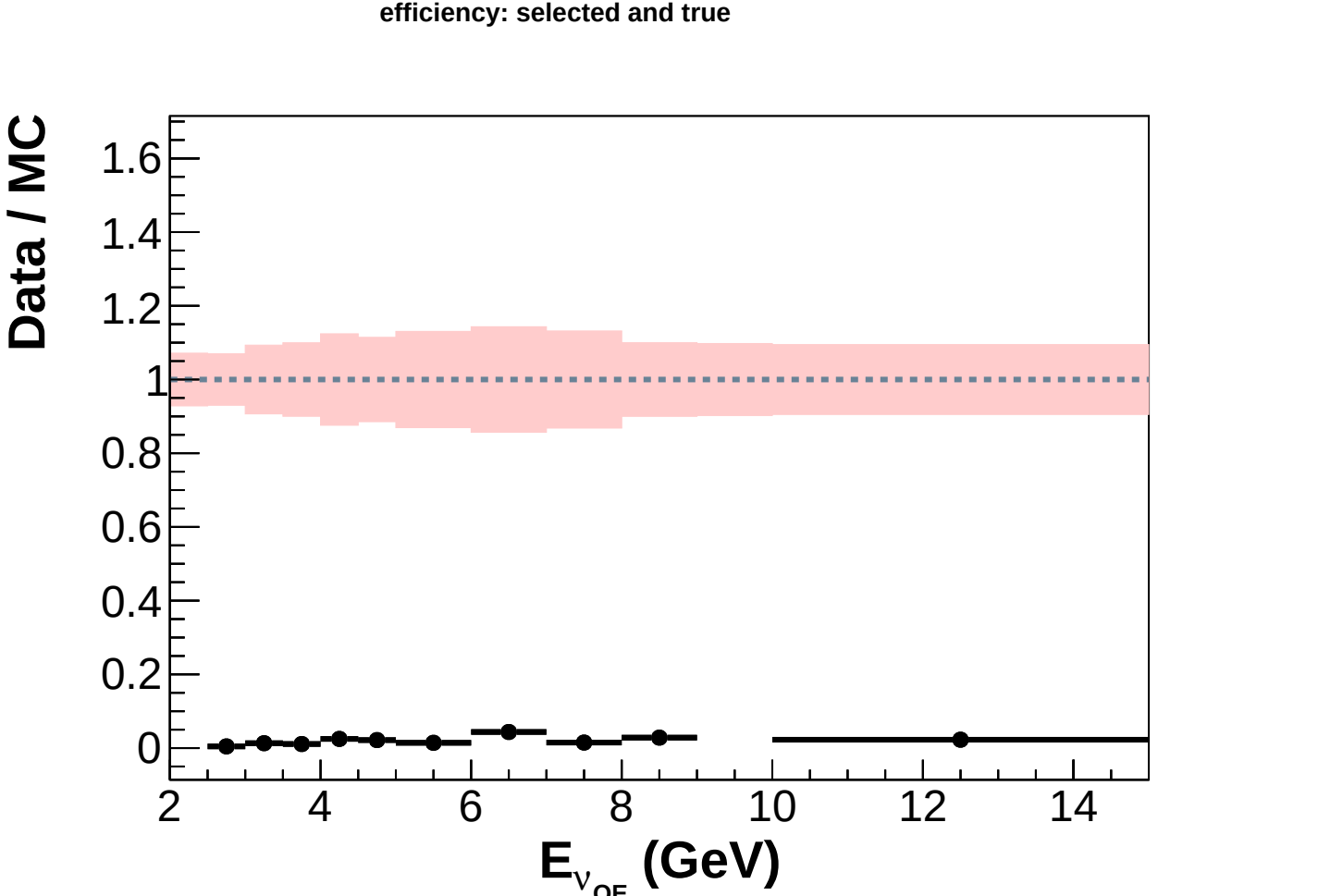

Data Before and After Unsmearing
Data / MC
50
0
−50
−100
−150
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

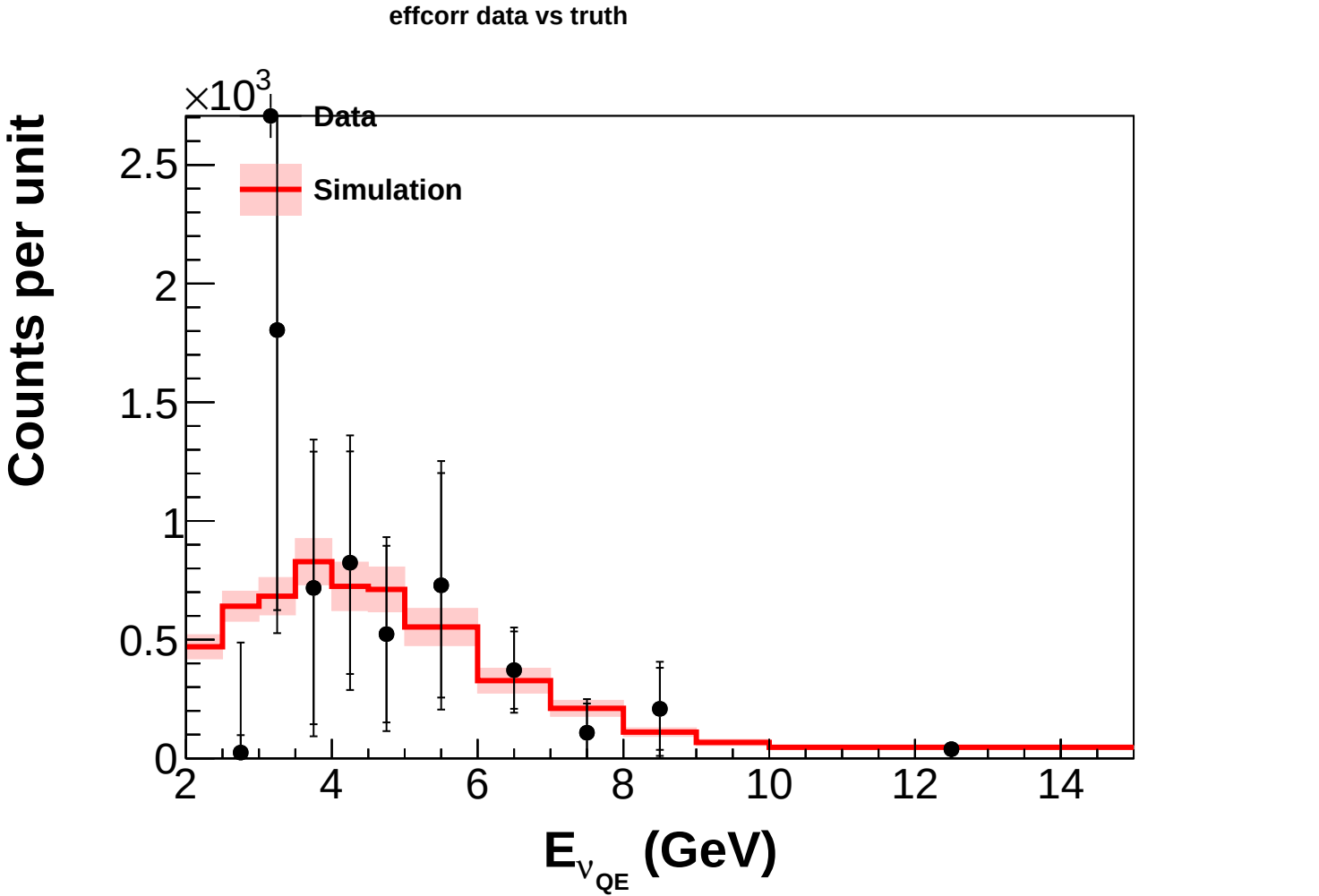

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
35
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

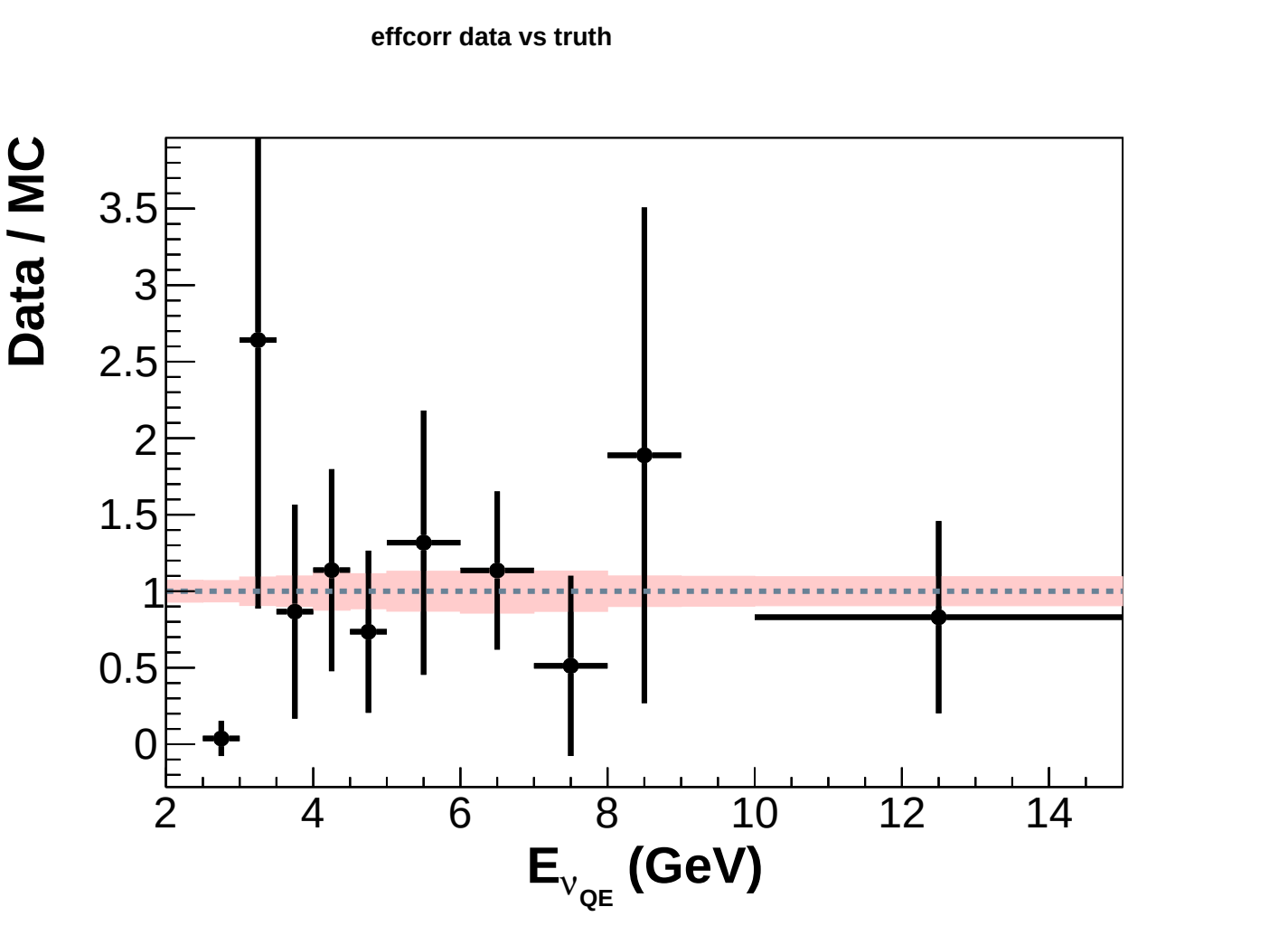

Unsmeared Data Compared to Selected MC
Data / MC
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

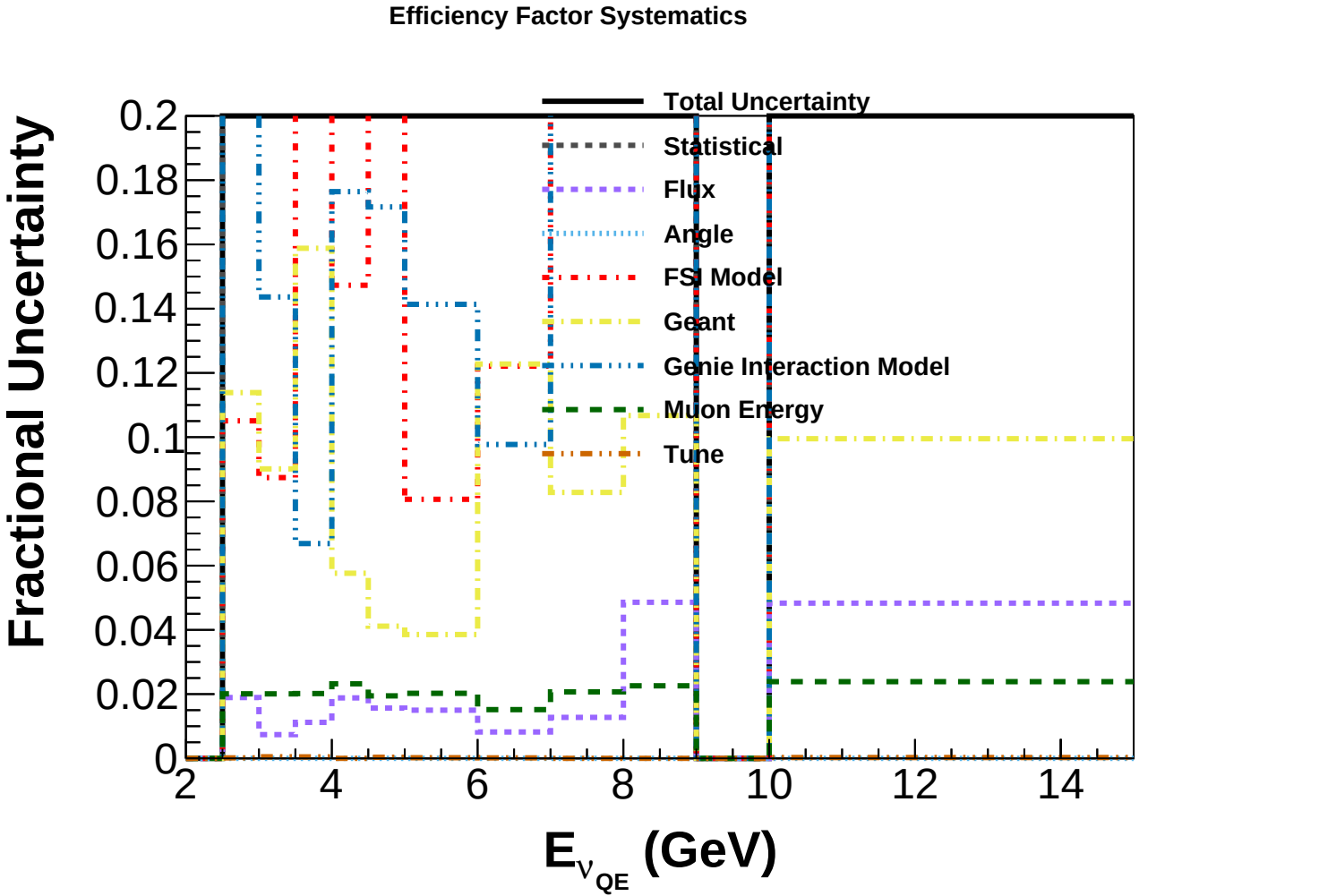

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

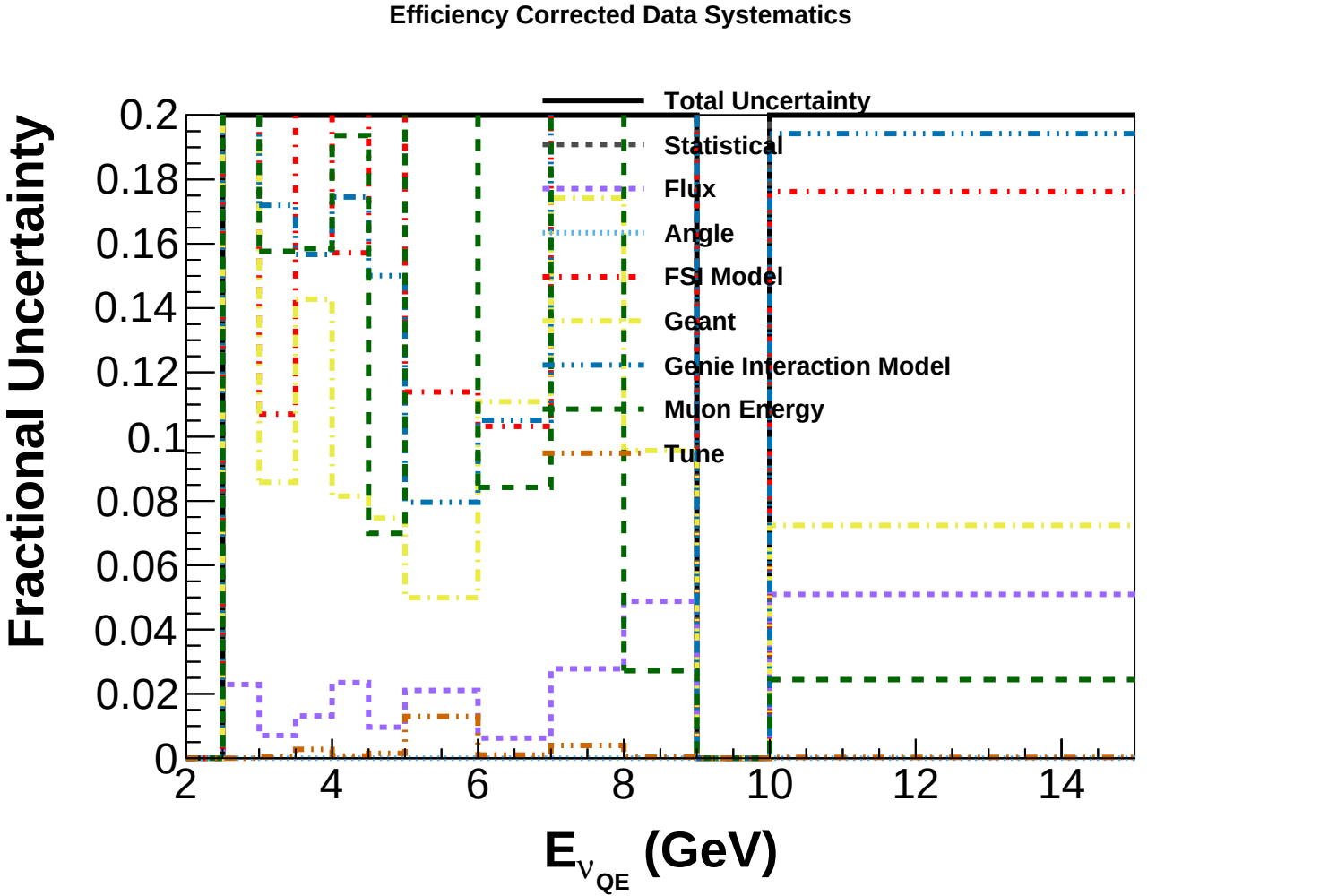

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_νQE (GeV)

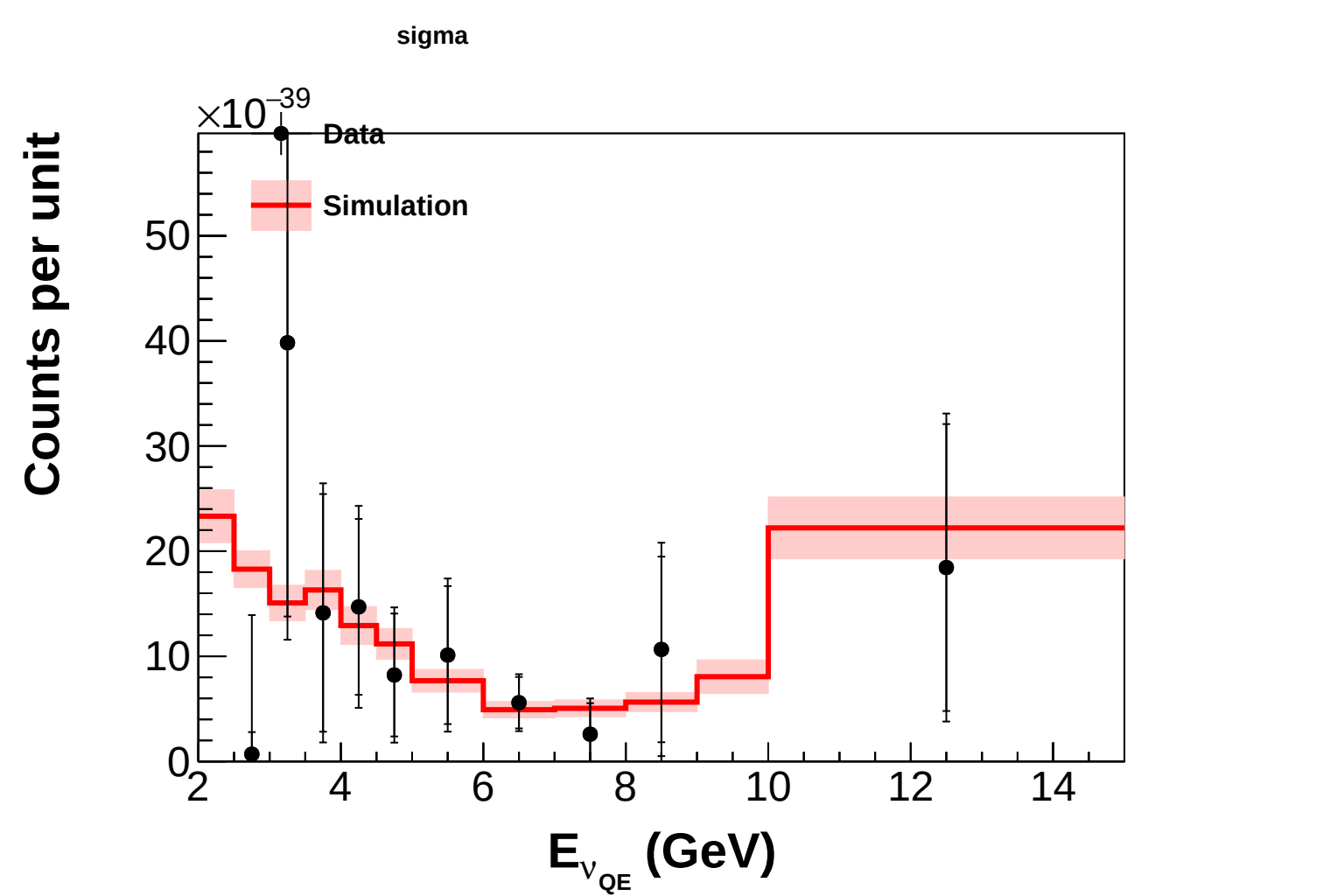

efficiency: selected and true
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

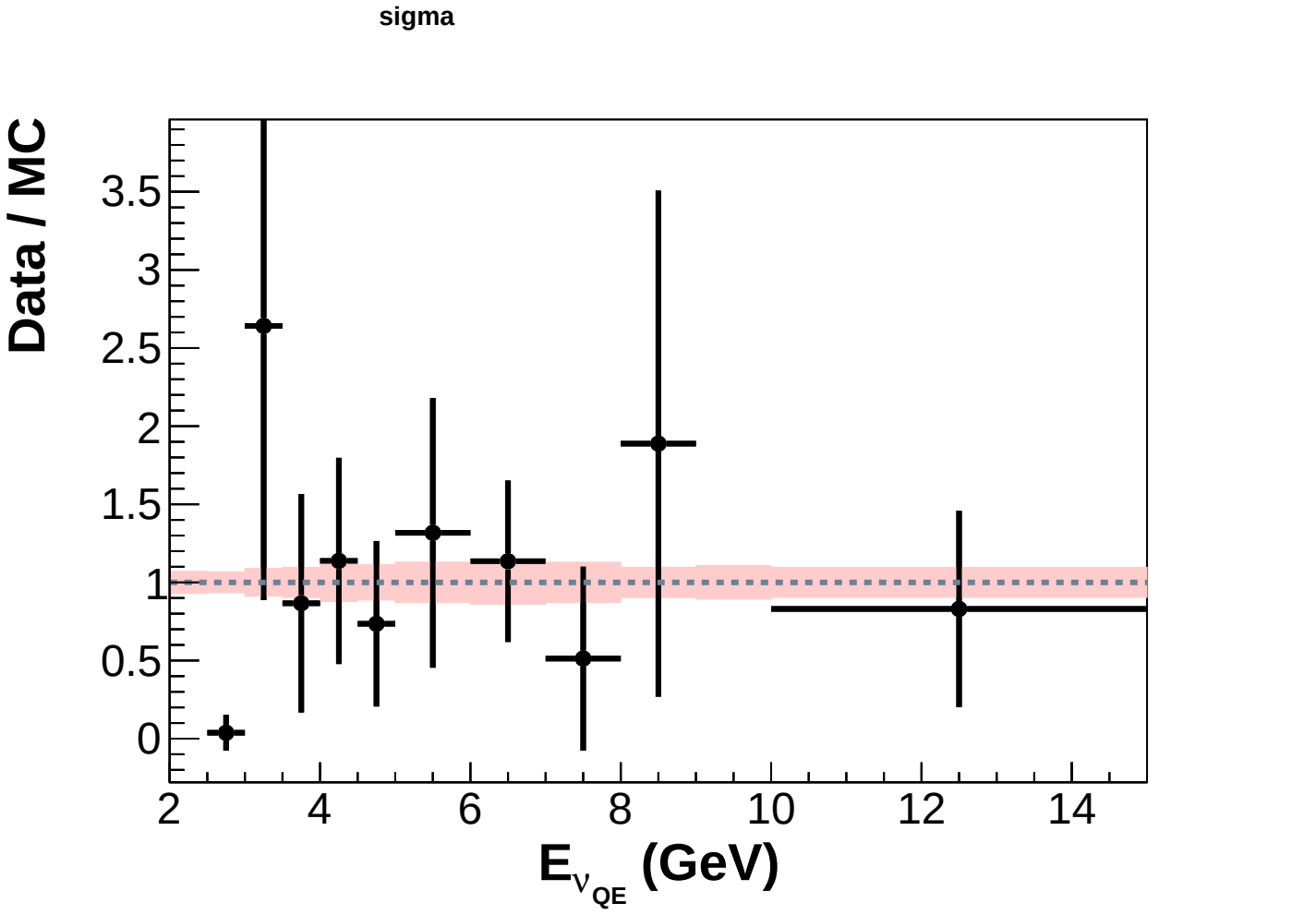

effcorr data vs truth
Counts per unit
×10^3
2.5
2
1.5
1
0.5
0
Data
Simulation
2
4
6
8
10
12
14
E_νQE (GeV)

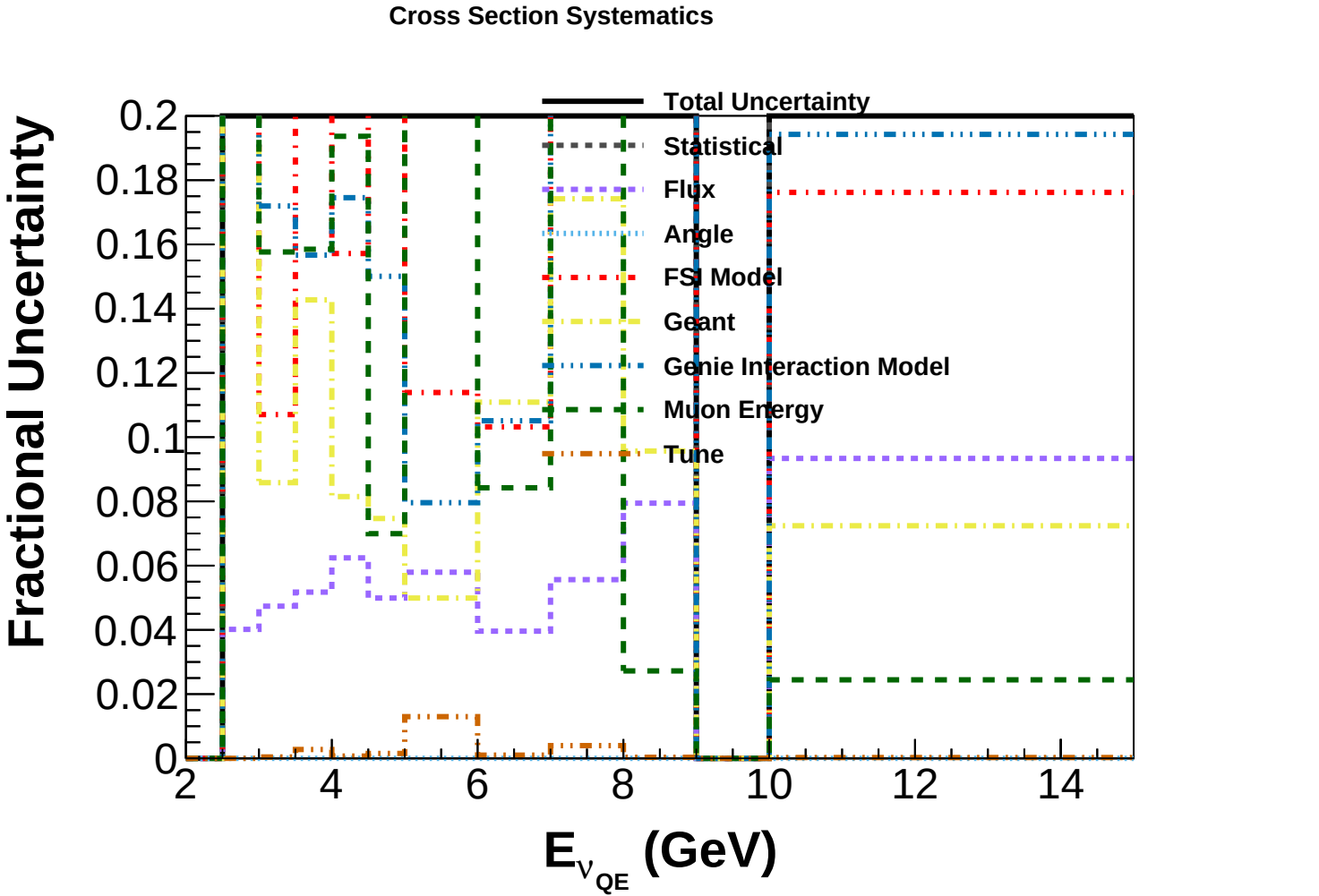

effcorr data vs truth
Data / MC
3.5
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

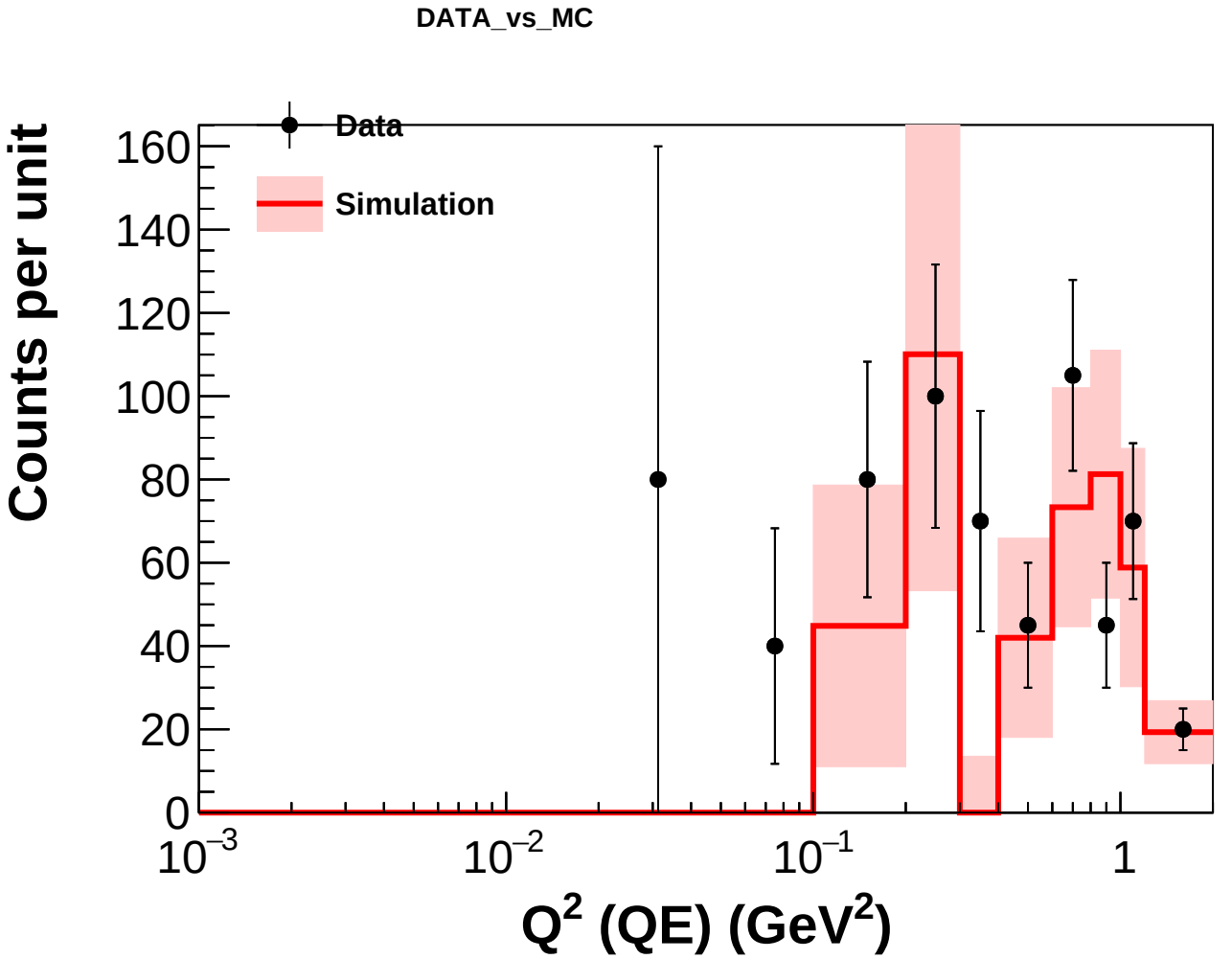

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

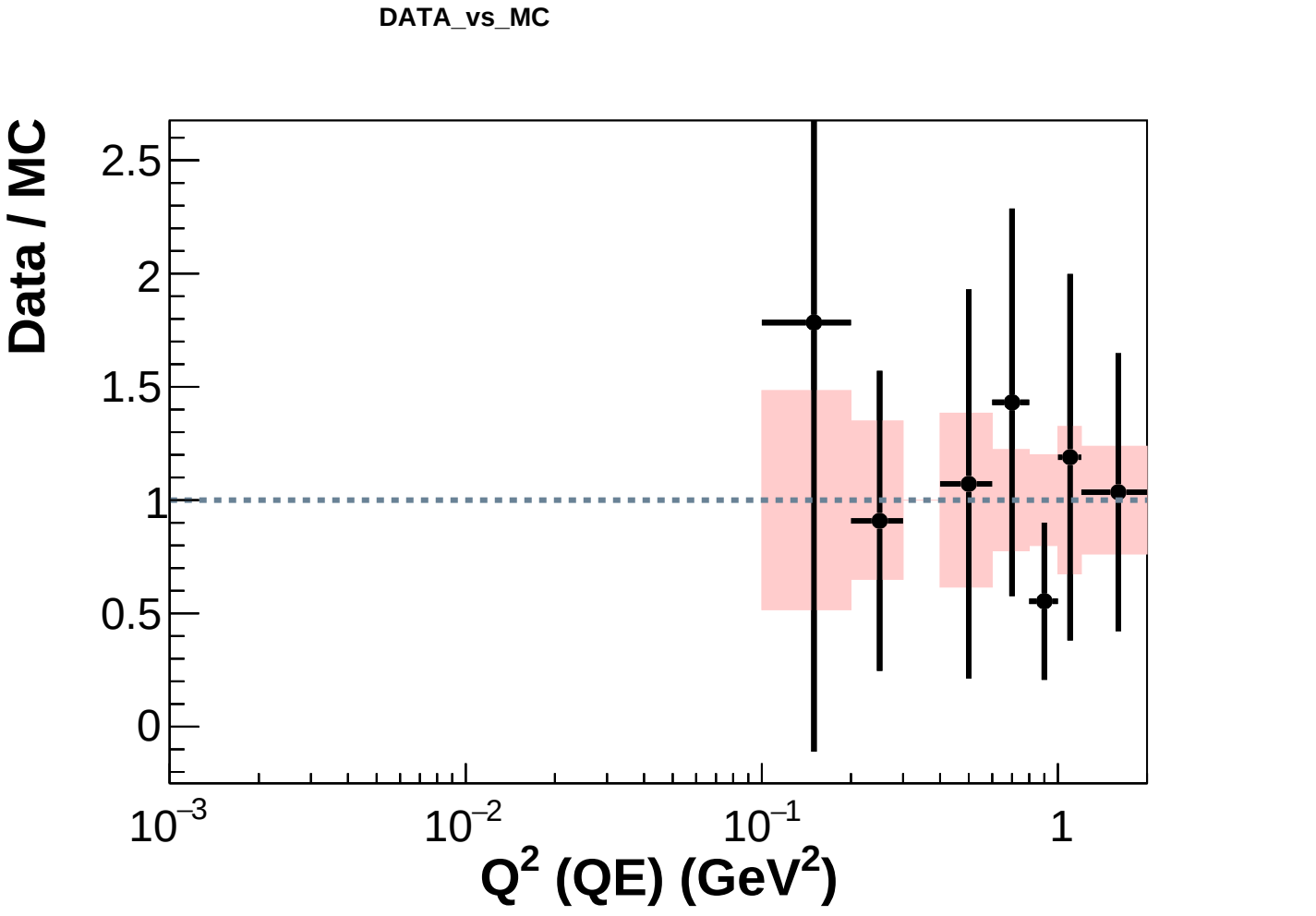

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

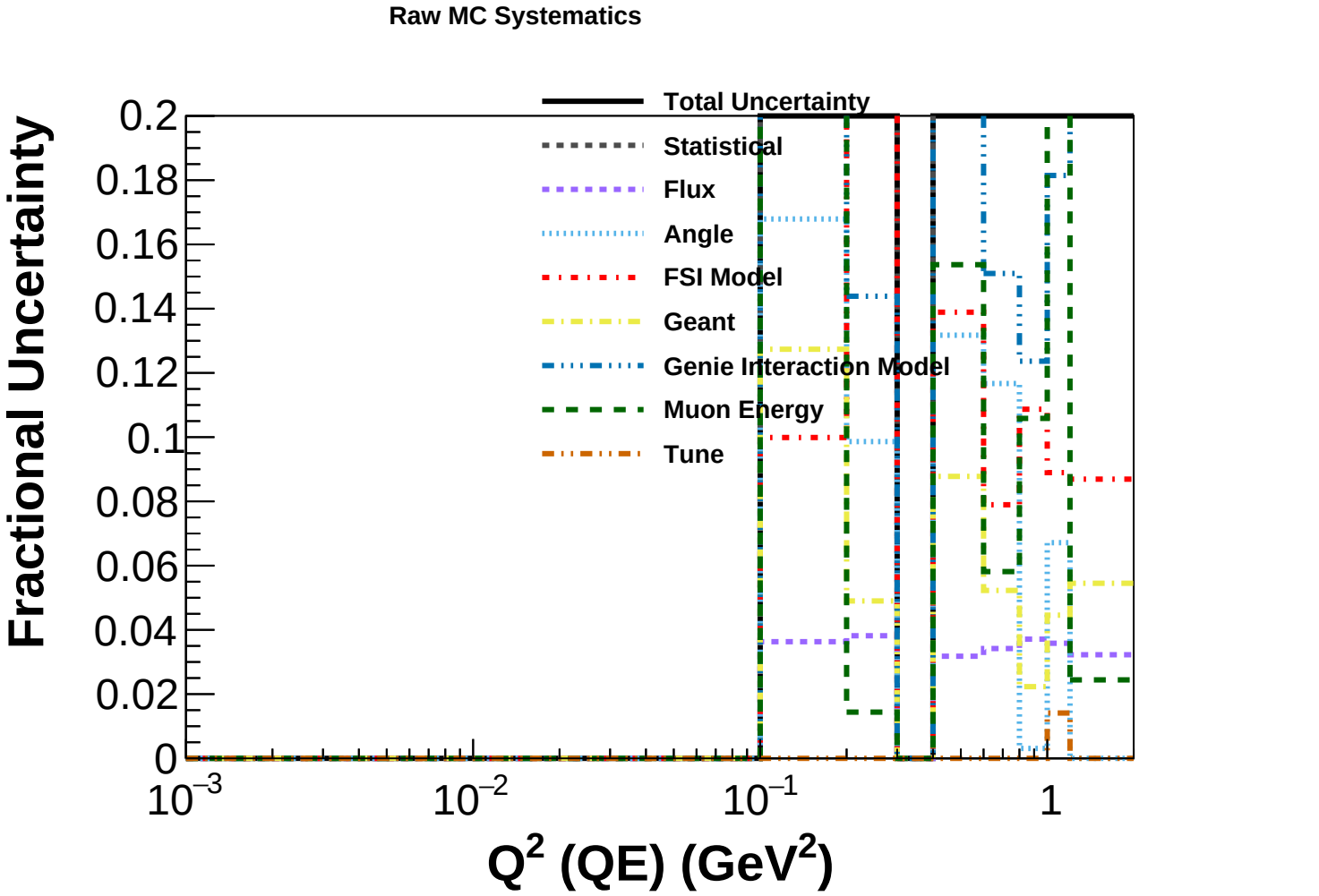

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
50
40
30
20
10
0
2
4
6
8
10
12
14
E_νQE (GeV)

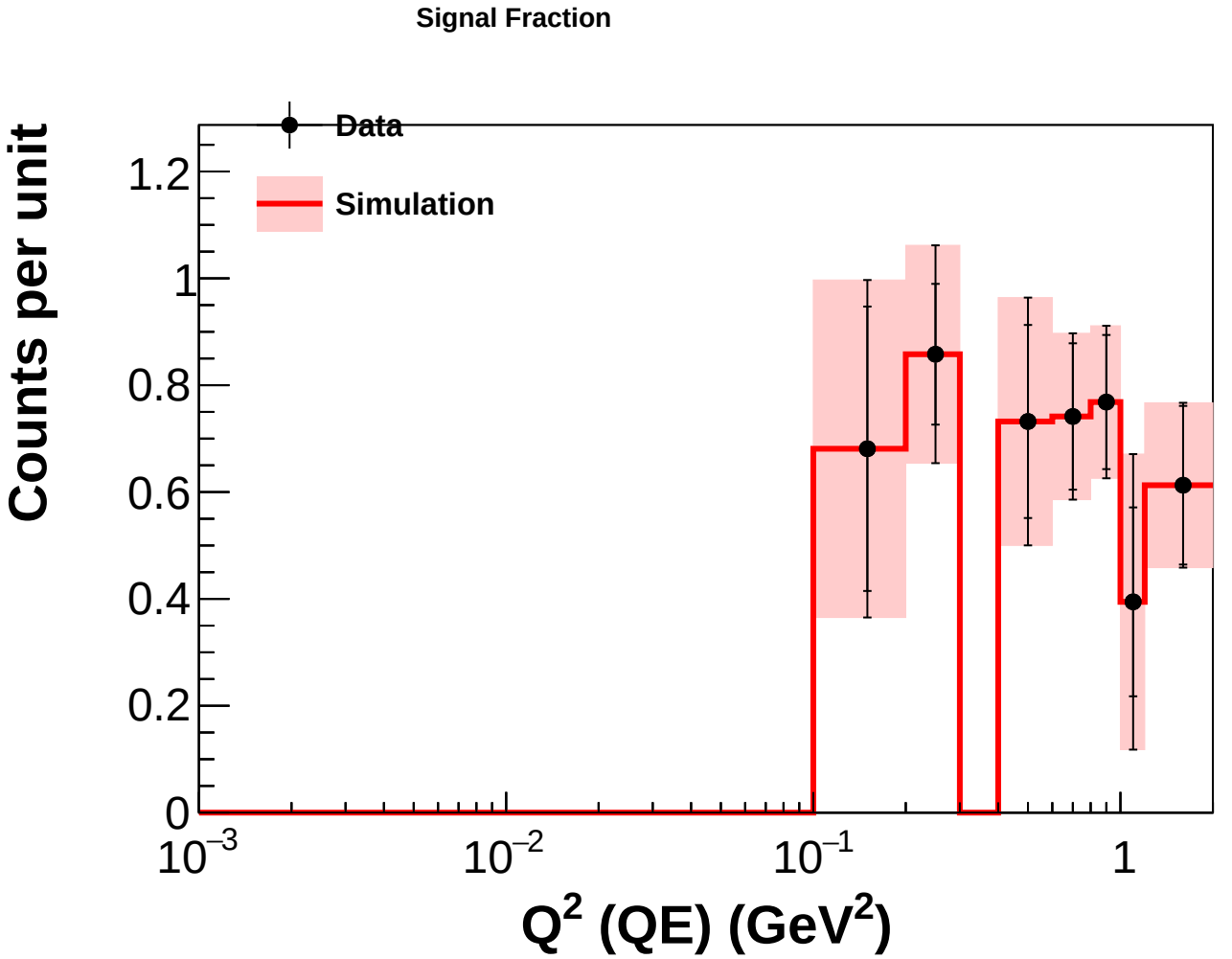

sigma
Data / MC
3.5
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

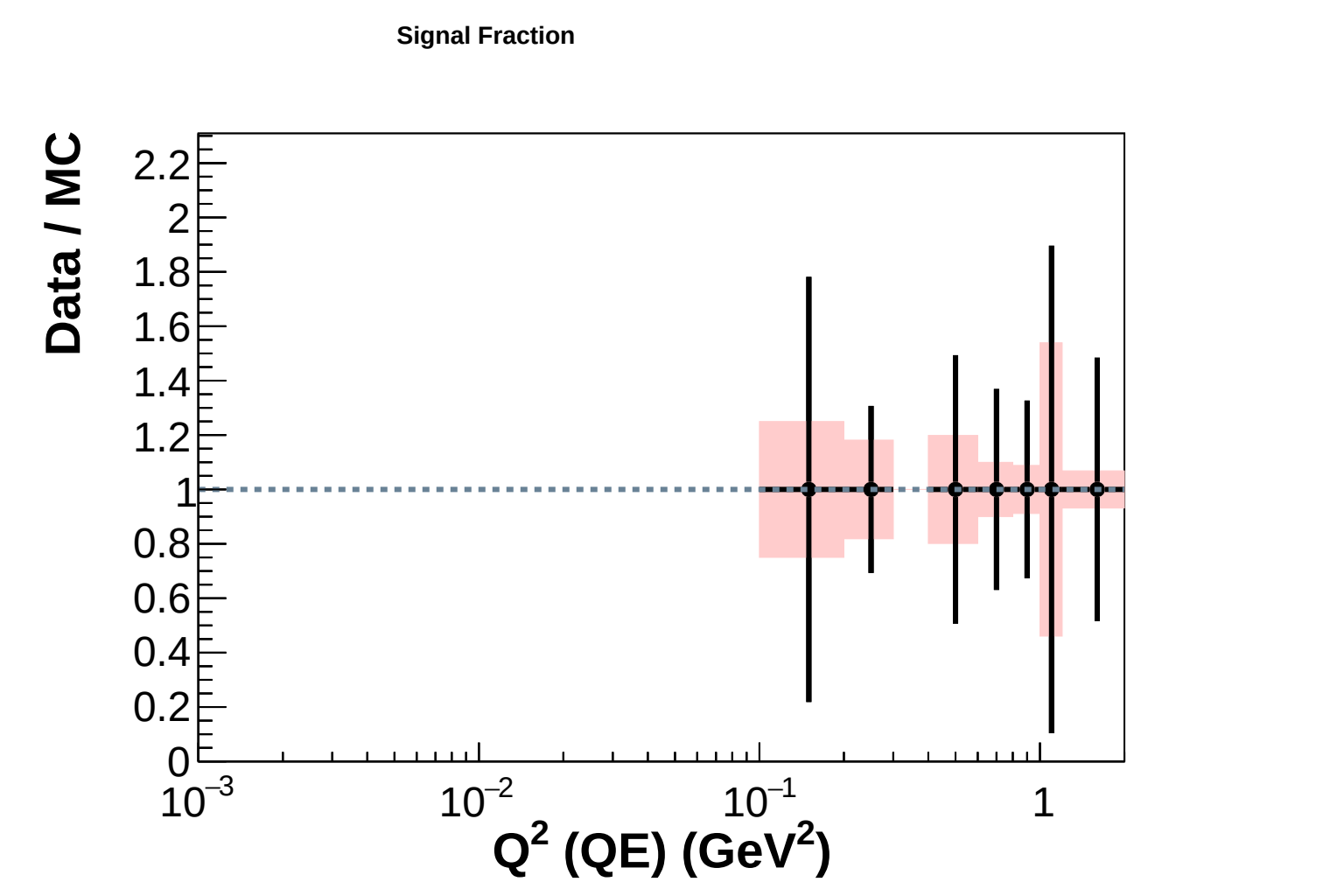

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

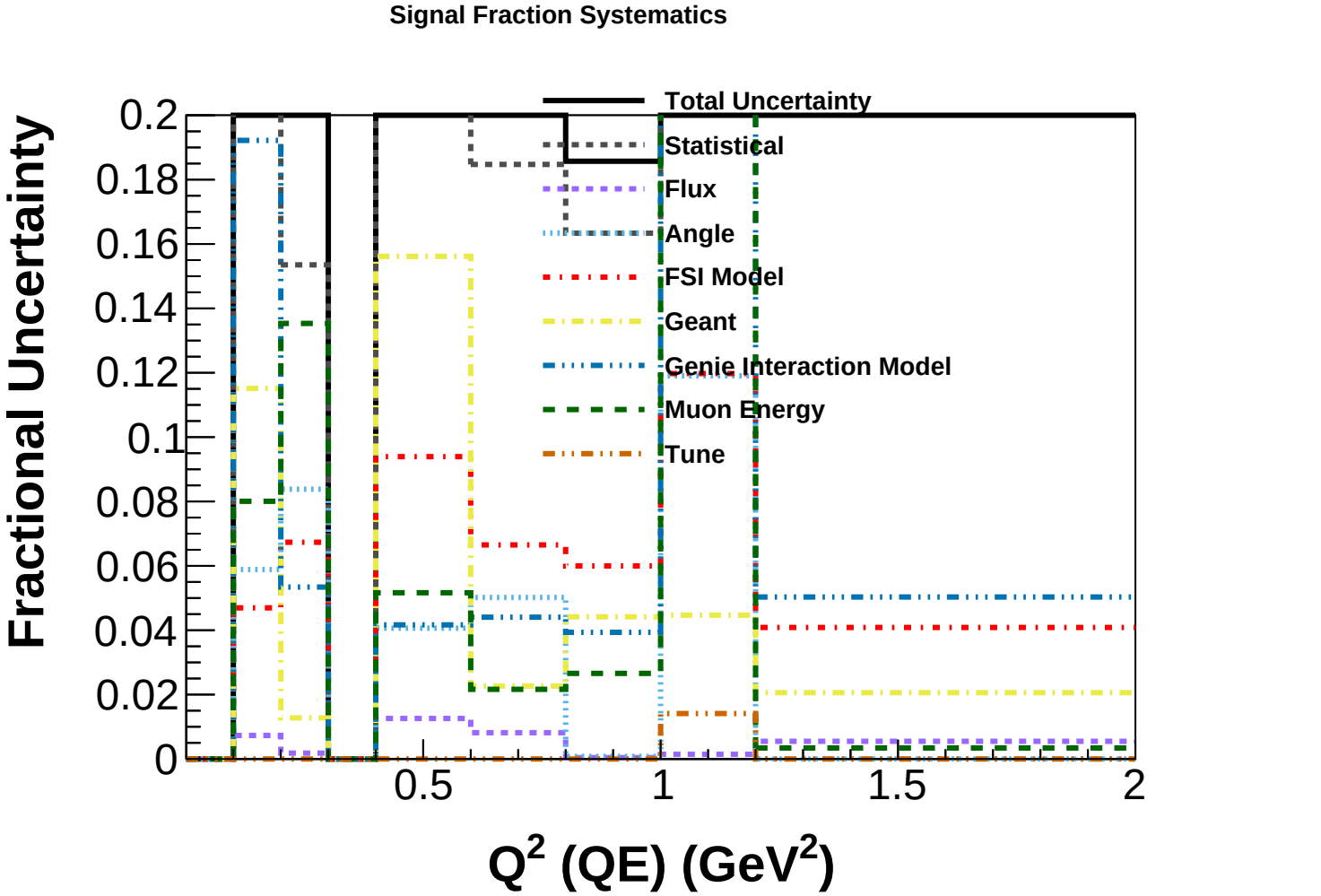

DATA_vs_MC
Data
Simulation
Counts per unit
160
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

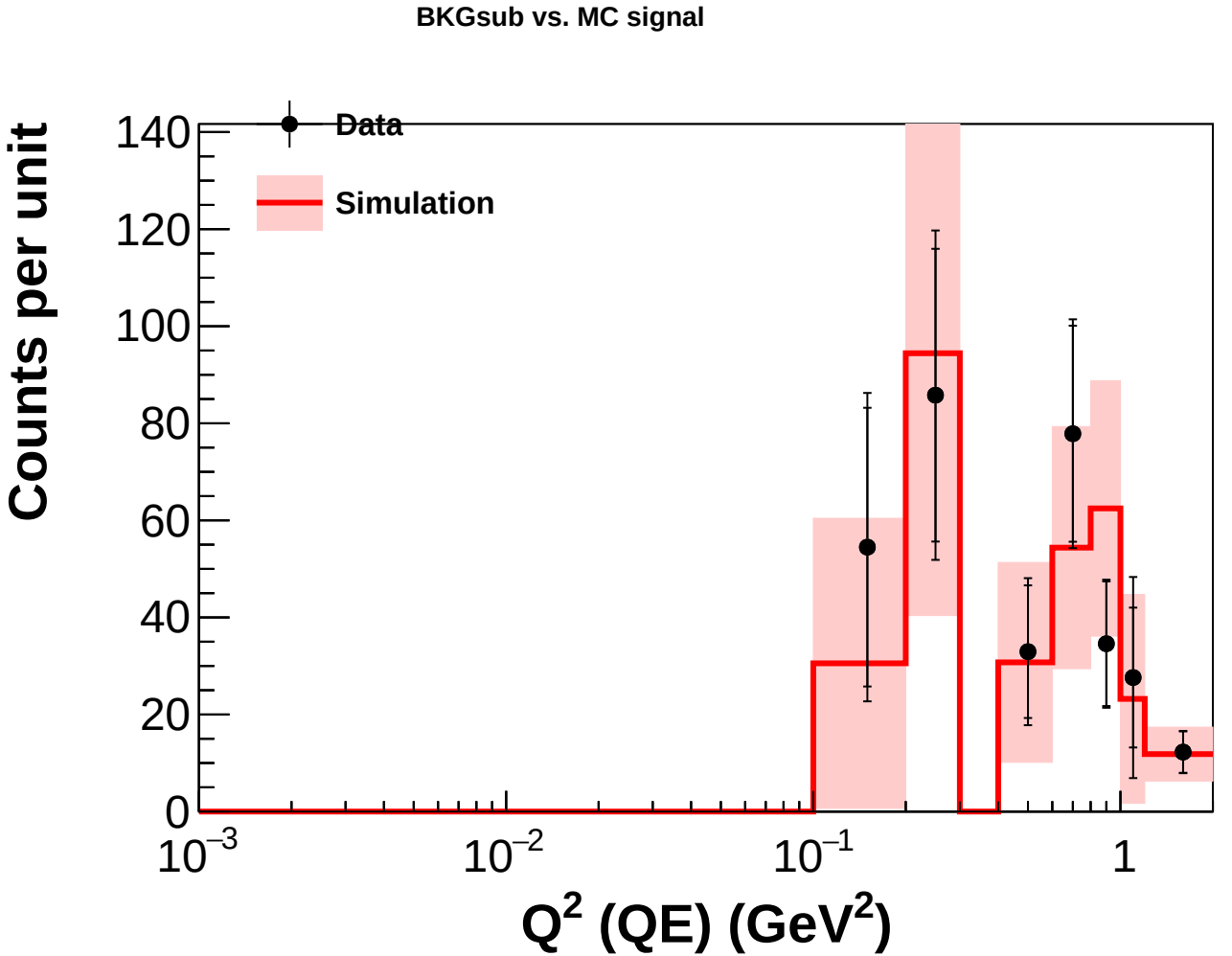

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

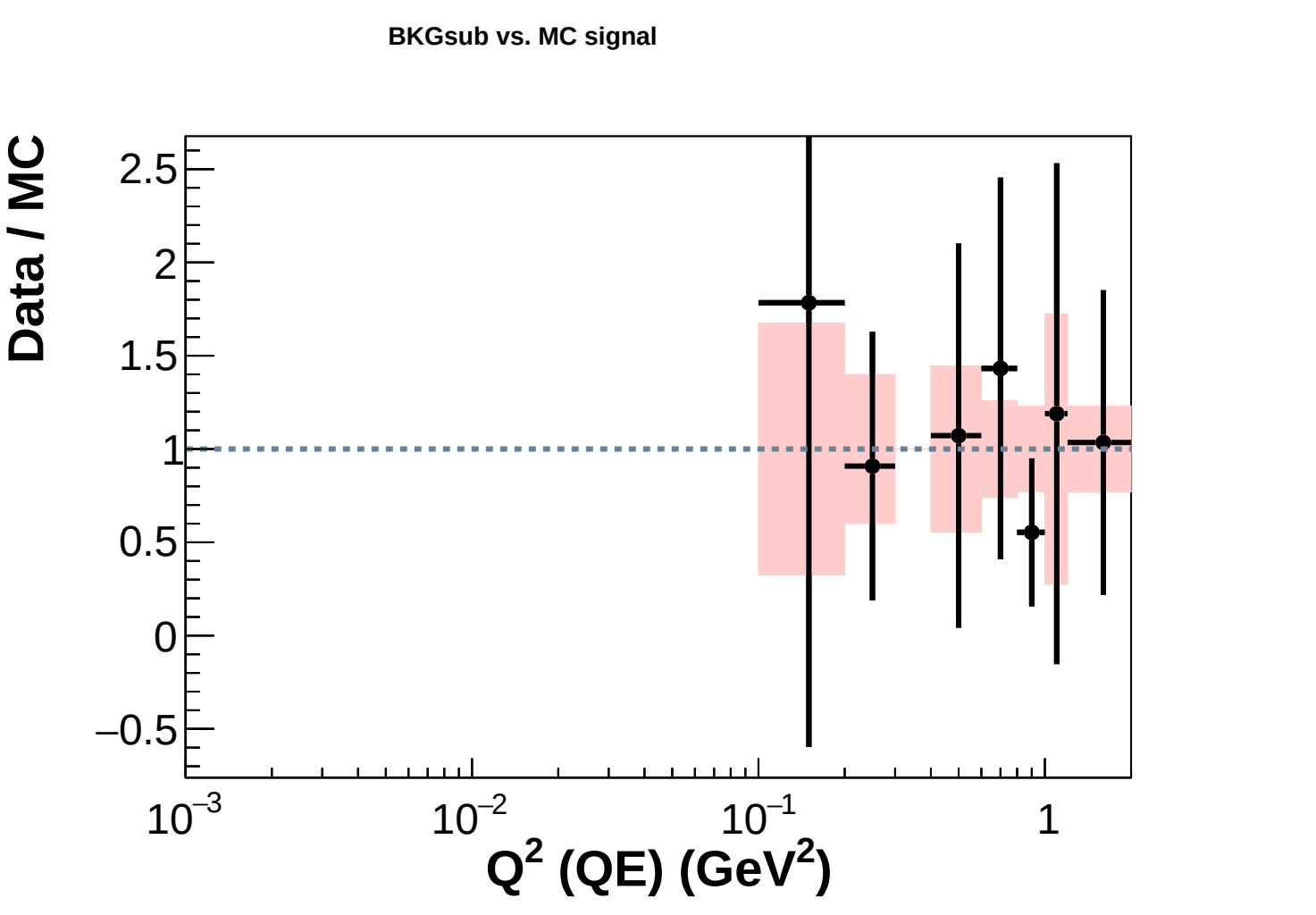

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

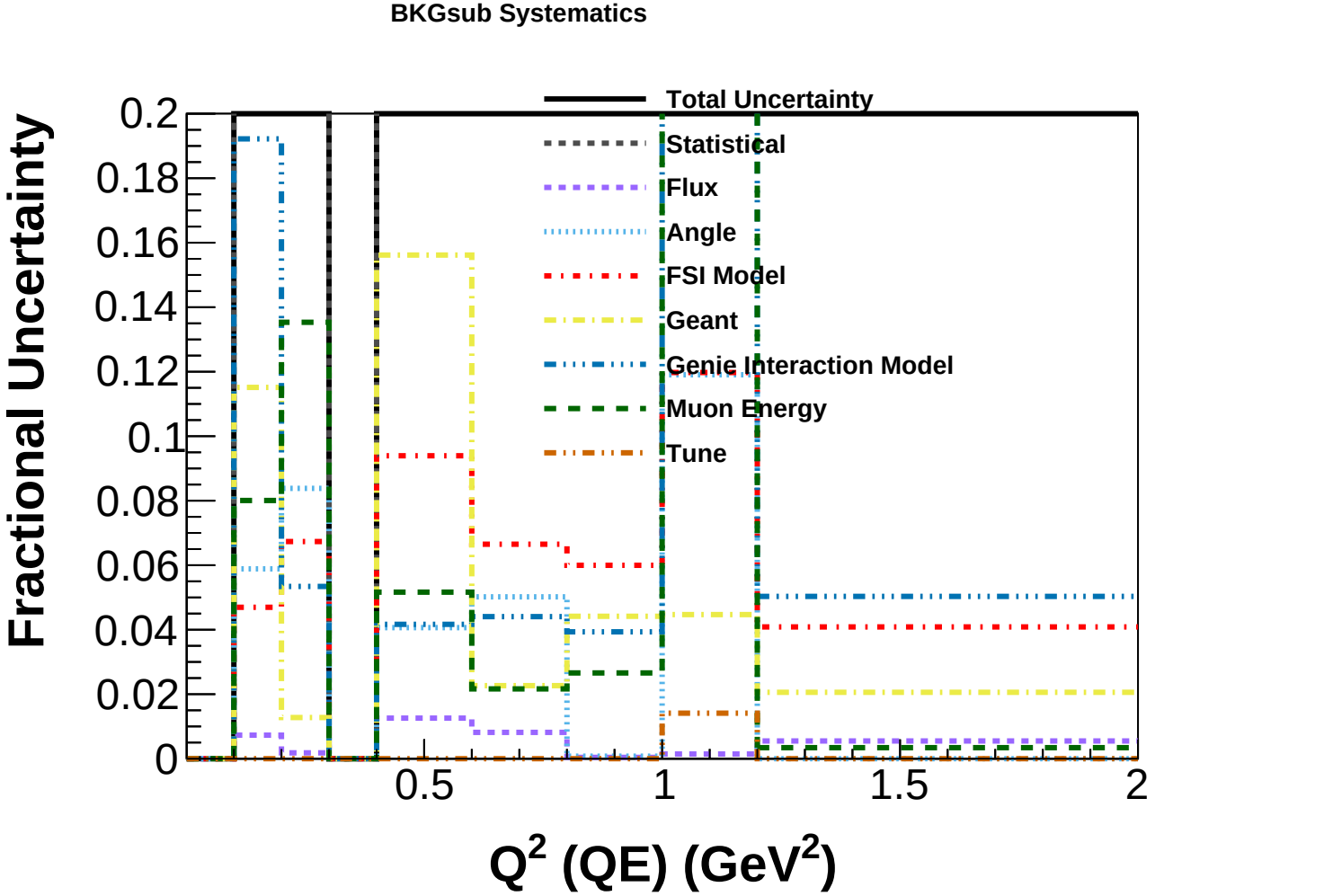

Signal Fraction
Data
Simulation
Counts per unit
1.2
1
0.8
0.6
0.4
0.2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

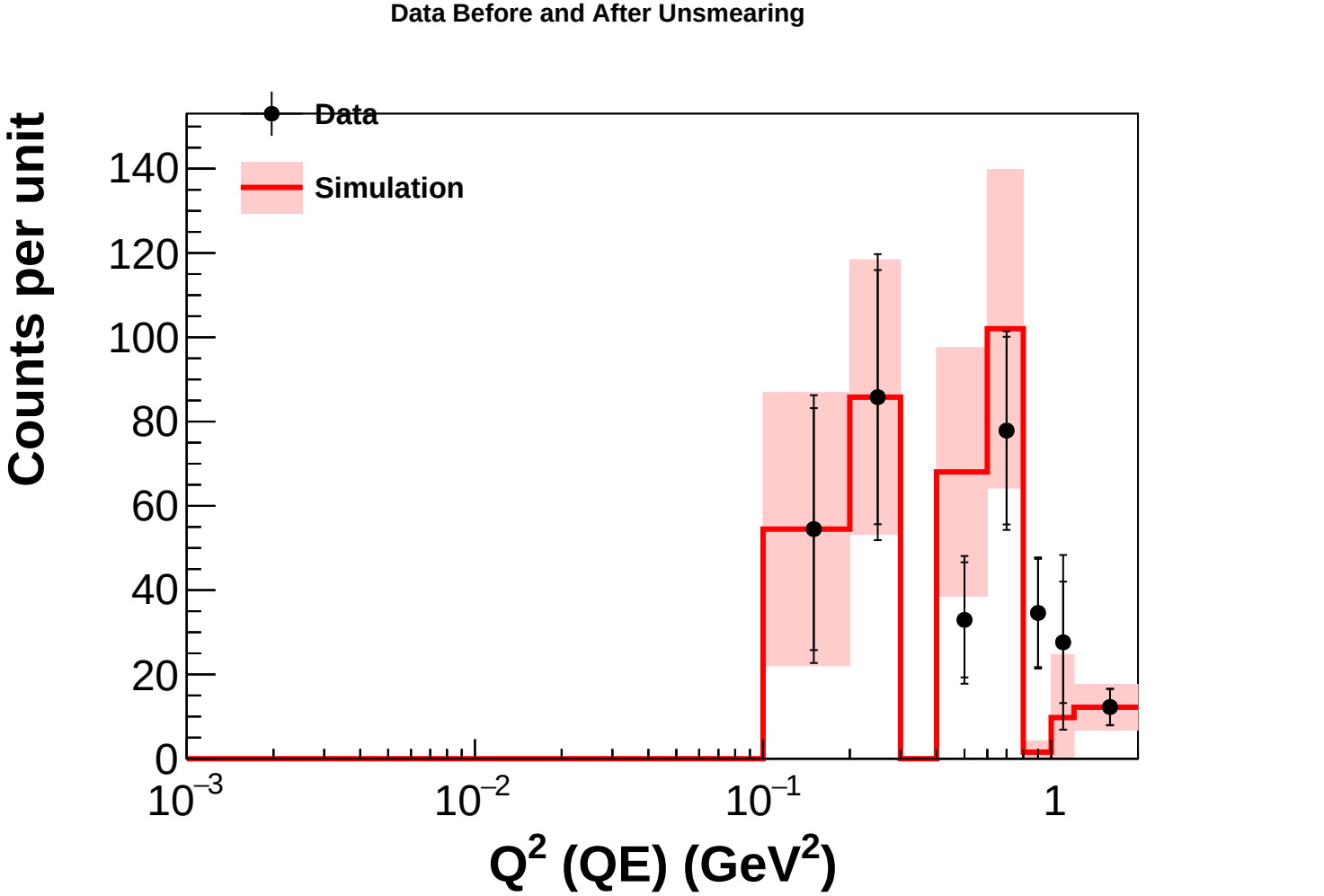

Signal Fraction
Data / MC
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

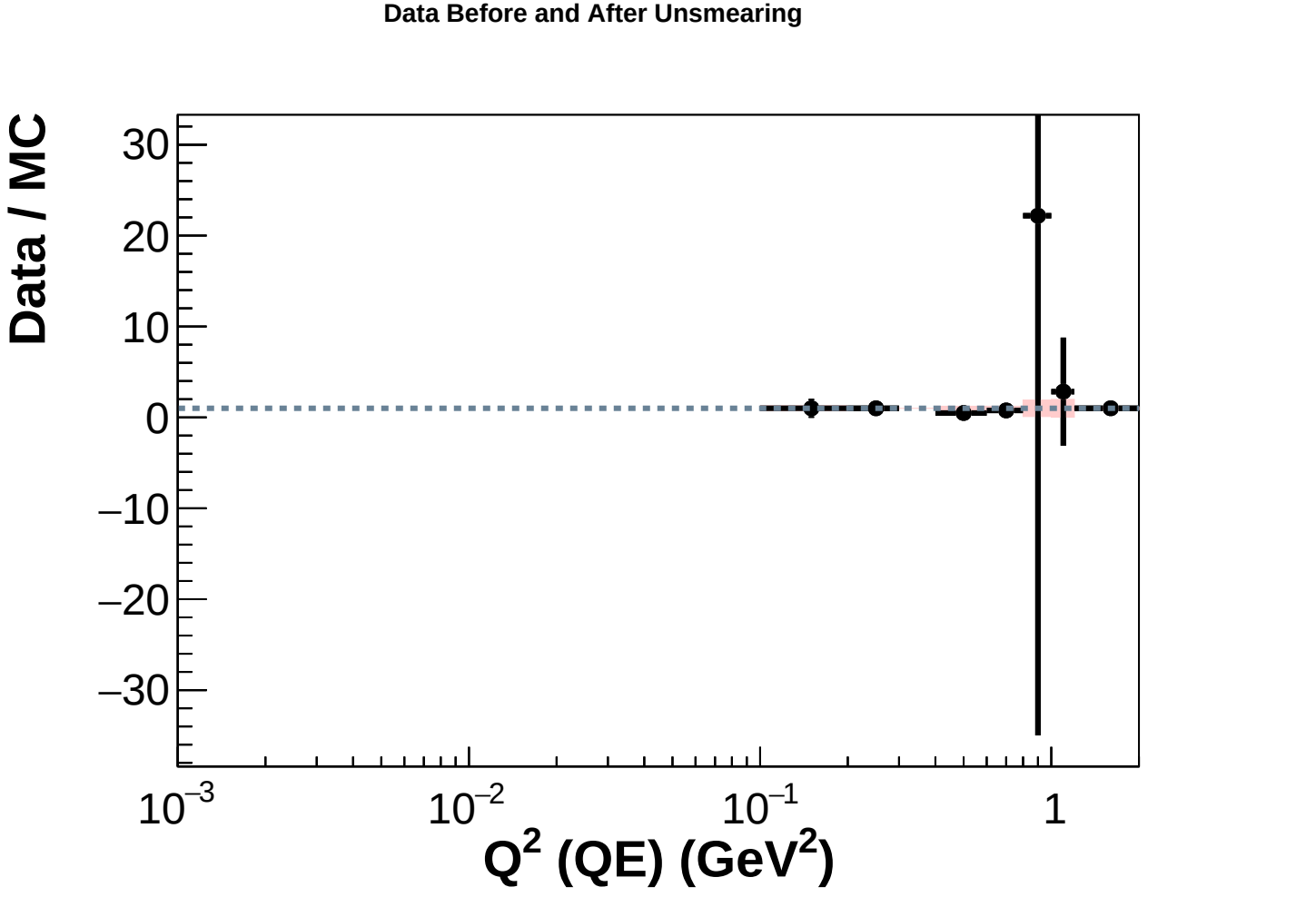

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

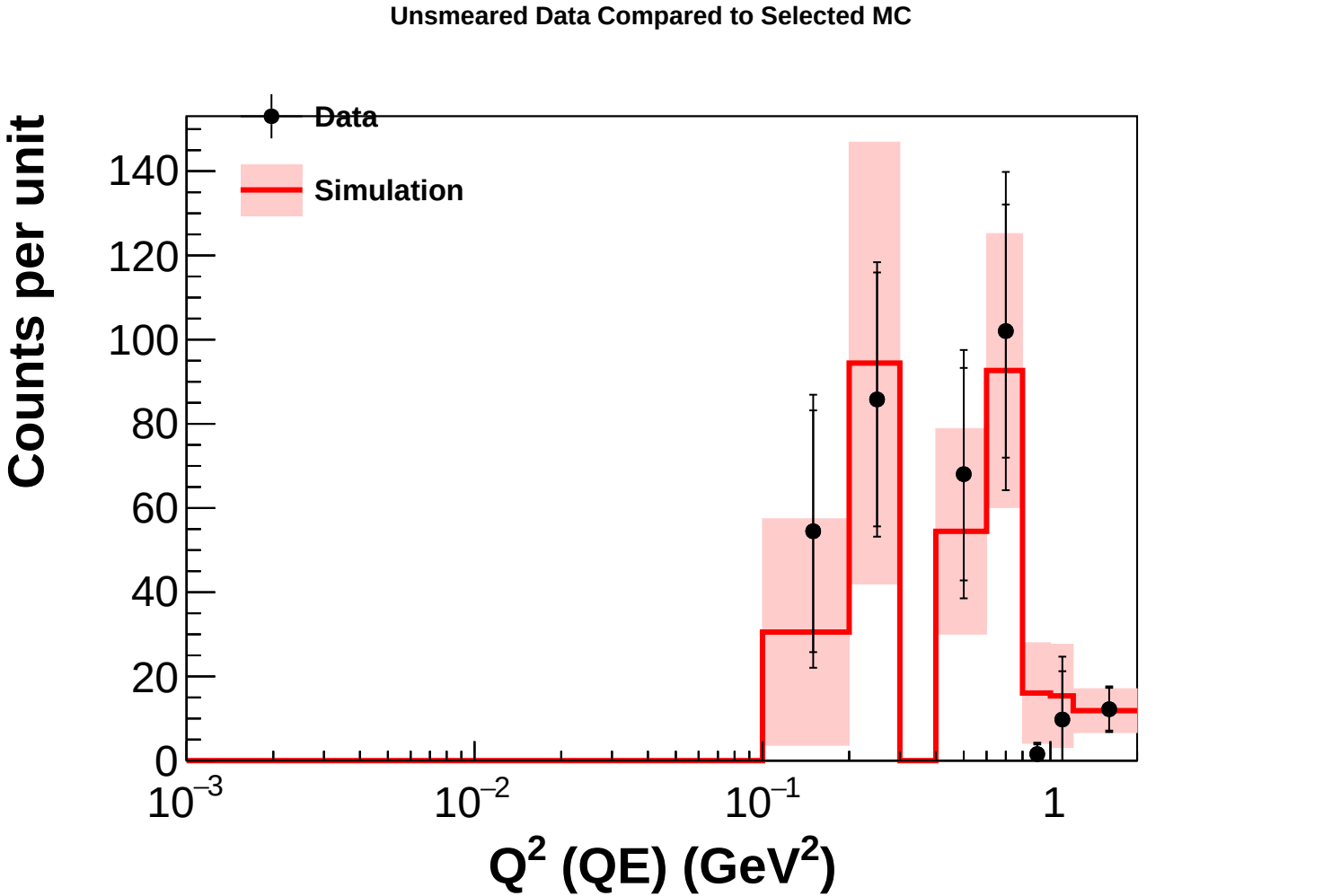

BKGsub vs. MC signal
Data
Simulation
Counts per unit
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

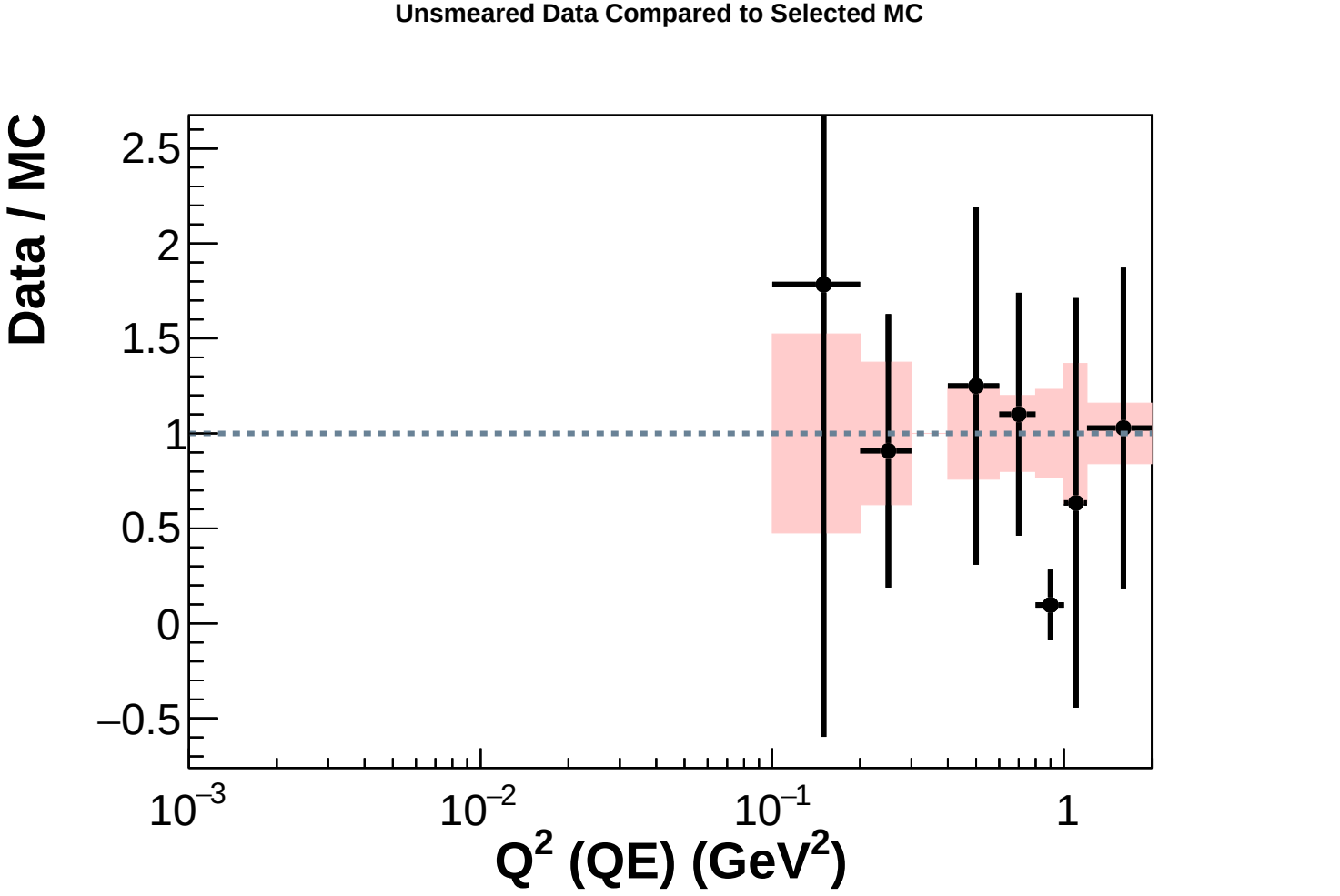

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

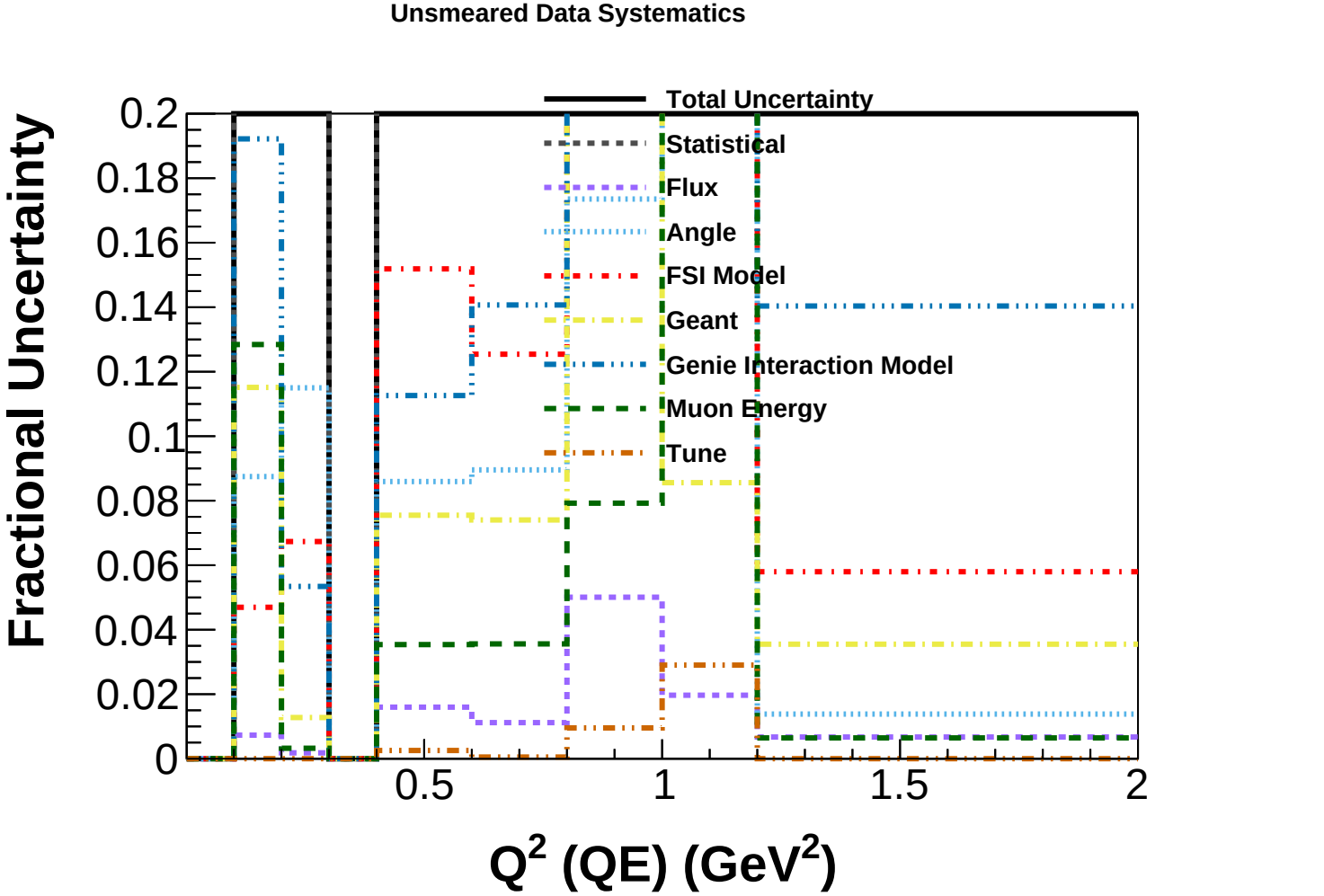

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

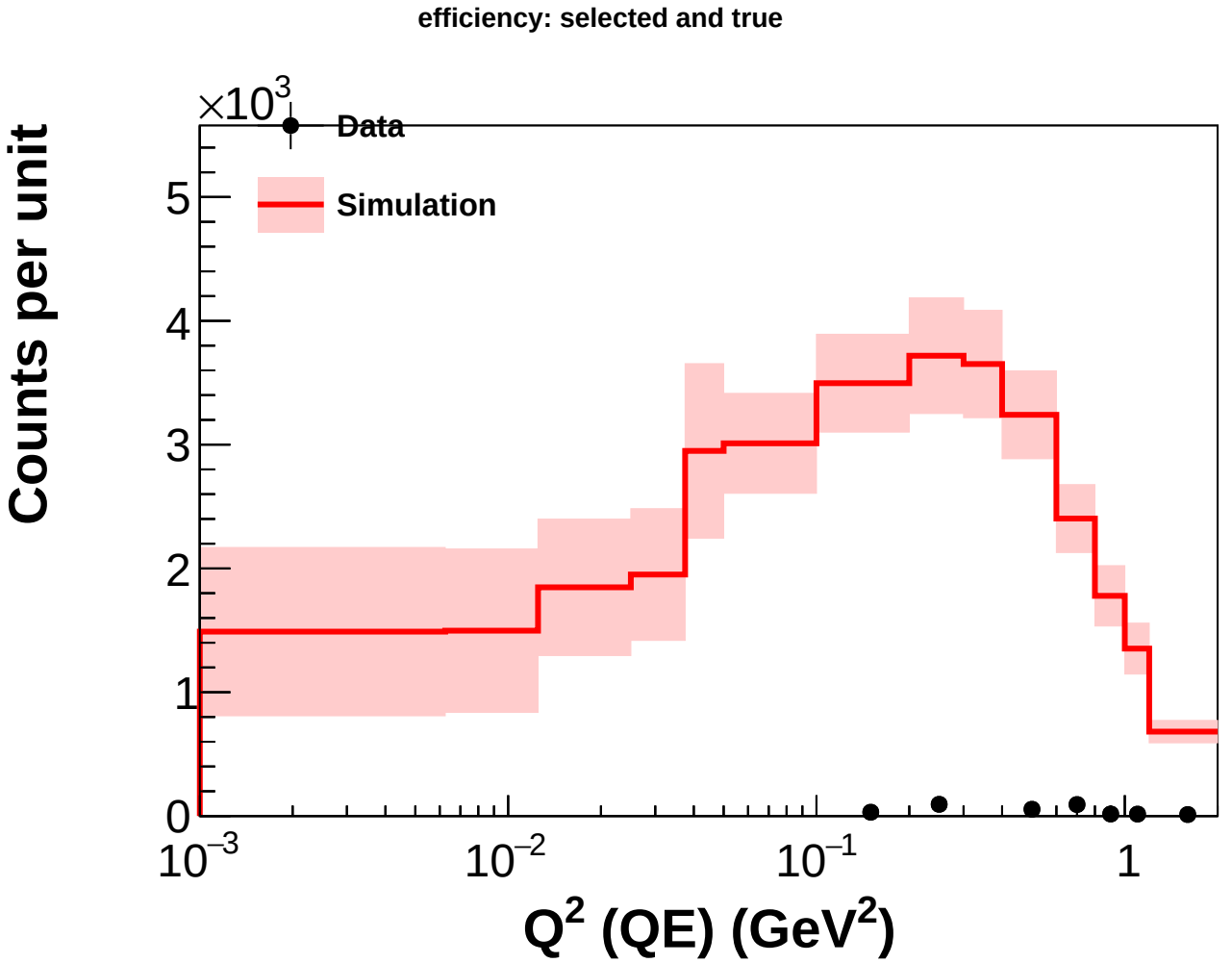

Data Before and After Unsmearing
Data
Simulation
Counts per unit
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

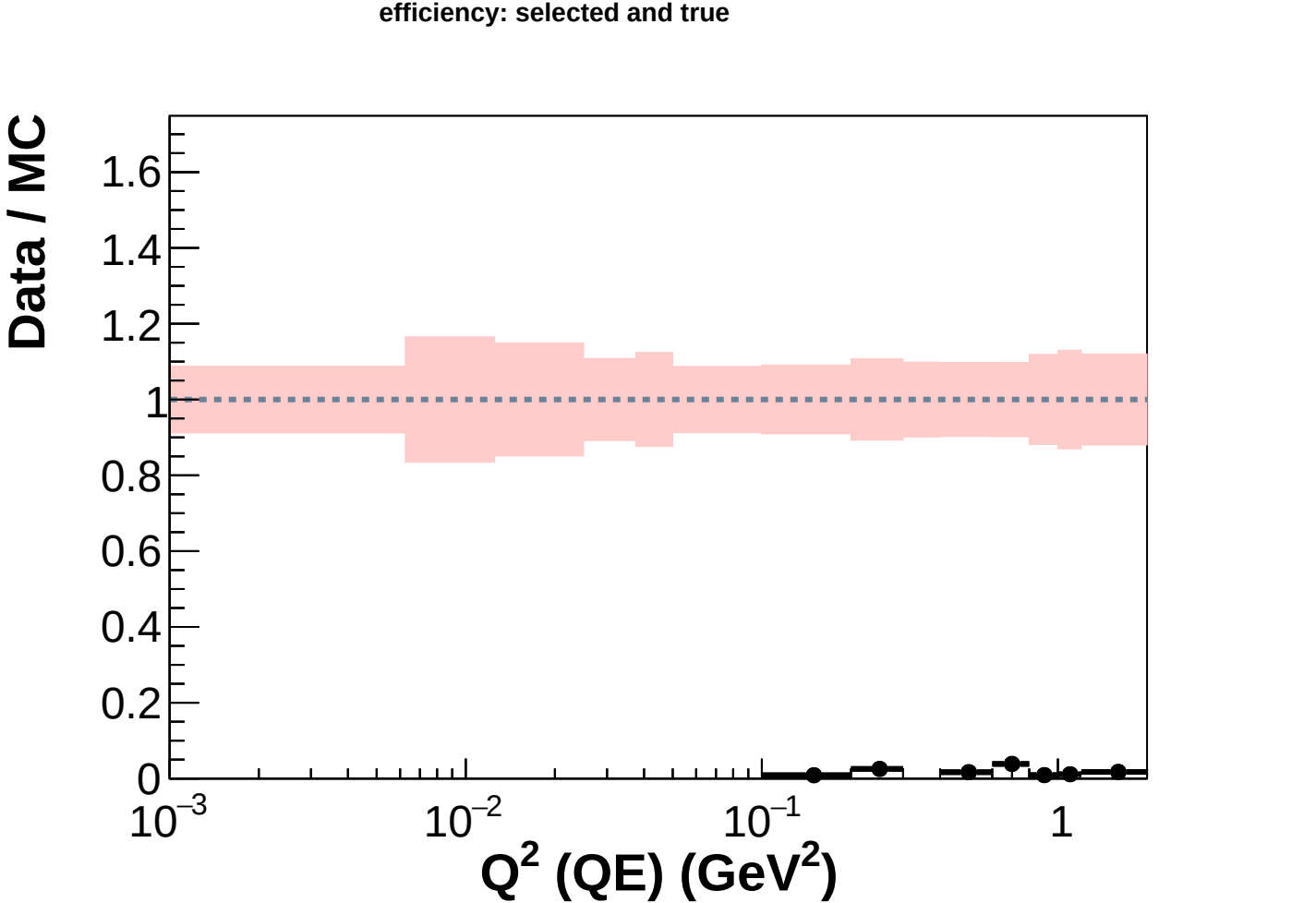

Data Before and After Unsmearing
Data / MC
30
20
10
0
−10
−20
−30
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

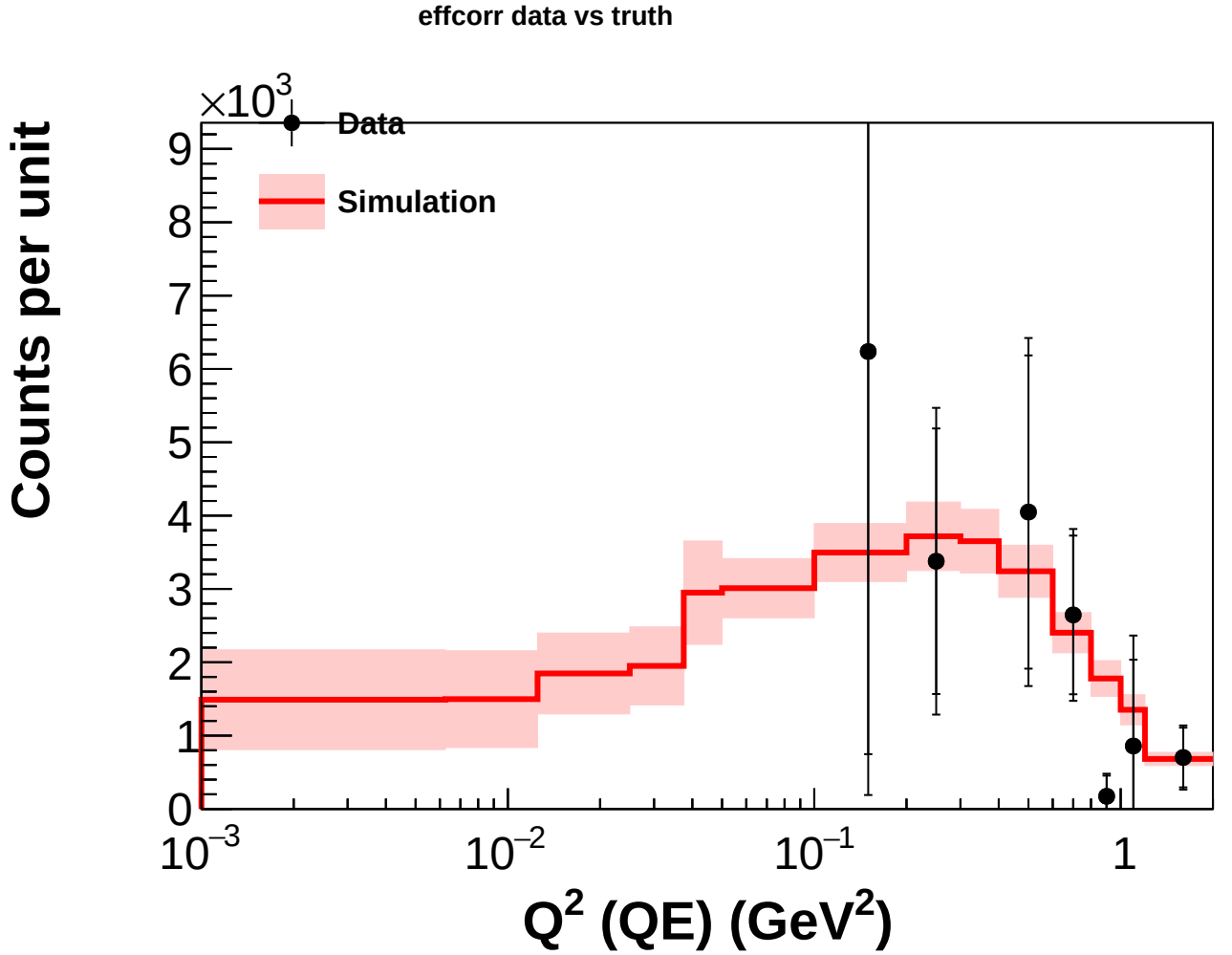

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
140
120
100
80
60
40
20
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

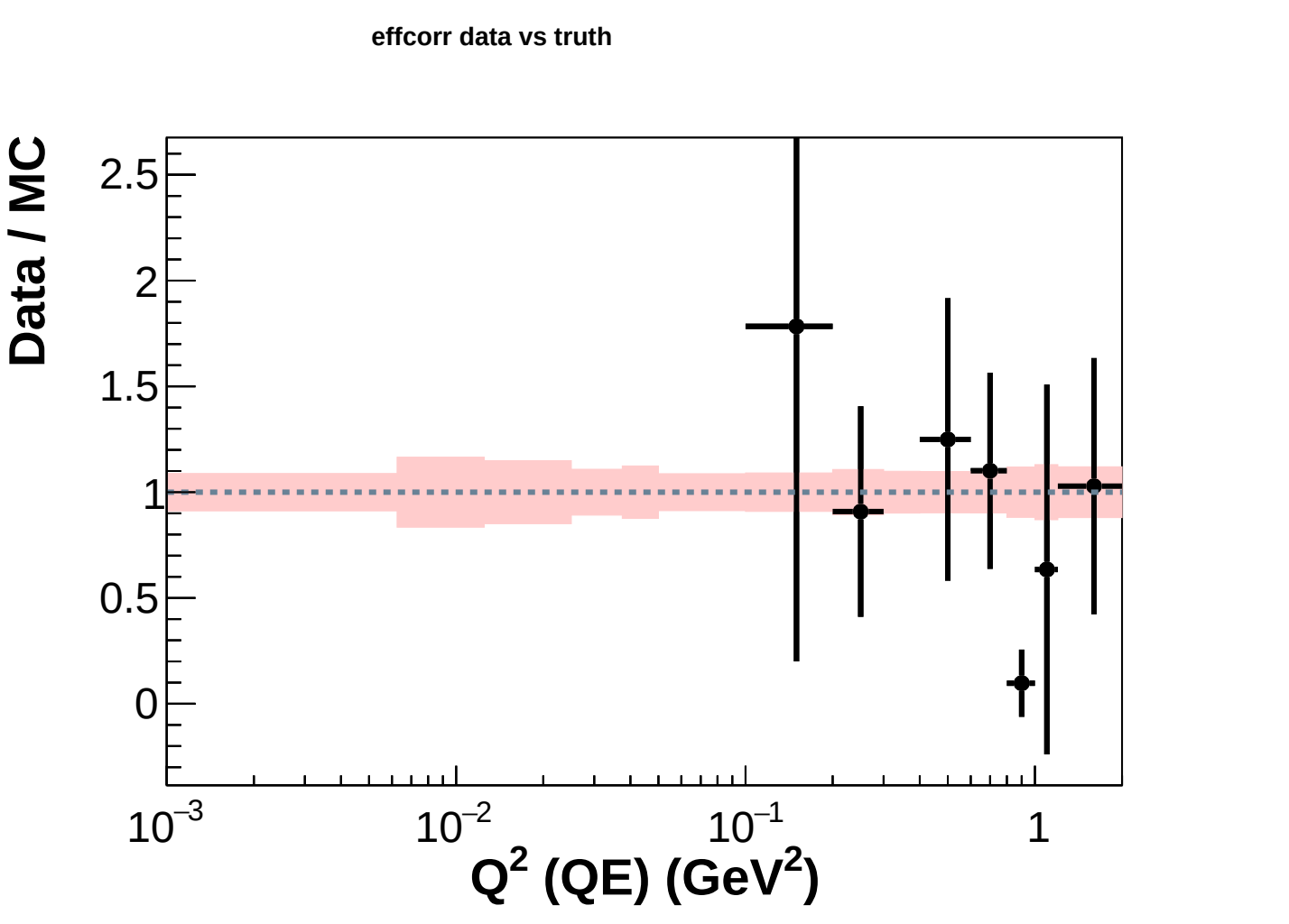

Unsmeared Data Compared to Selected MC
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

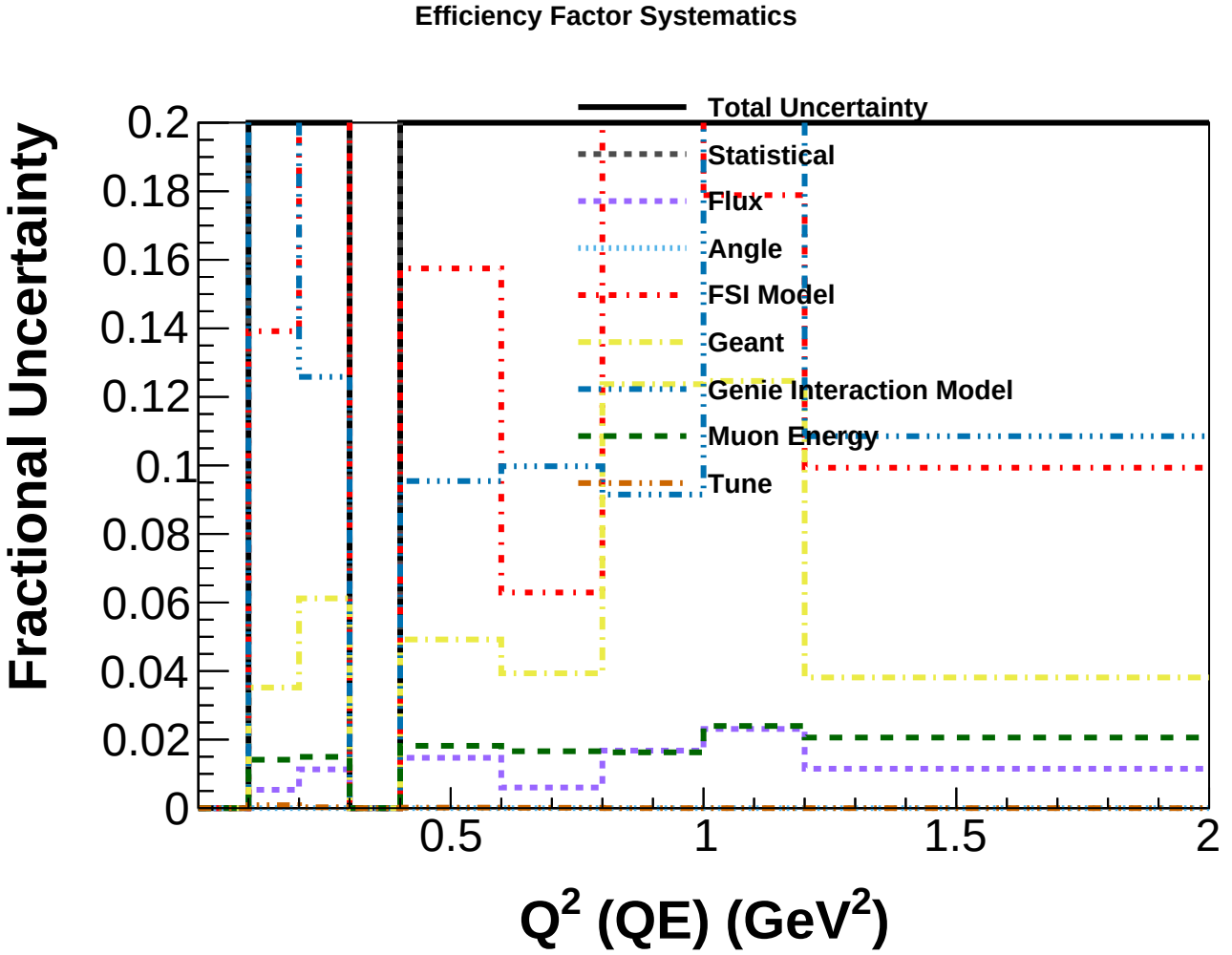

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

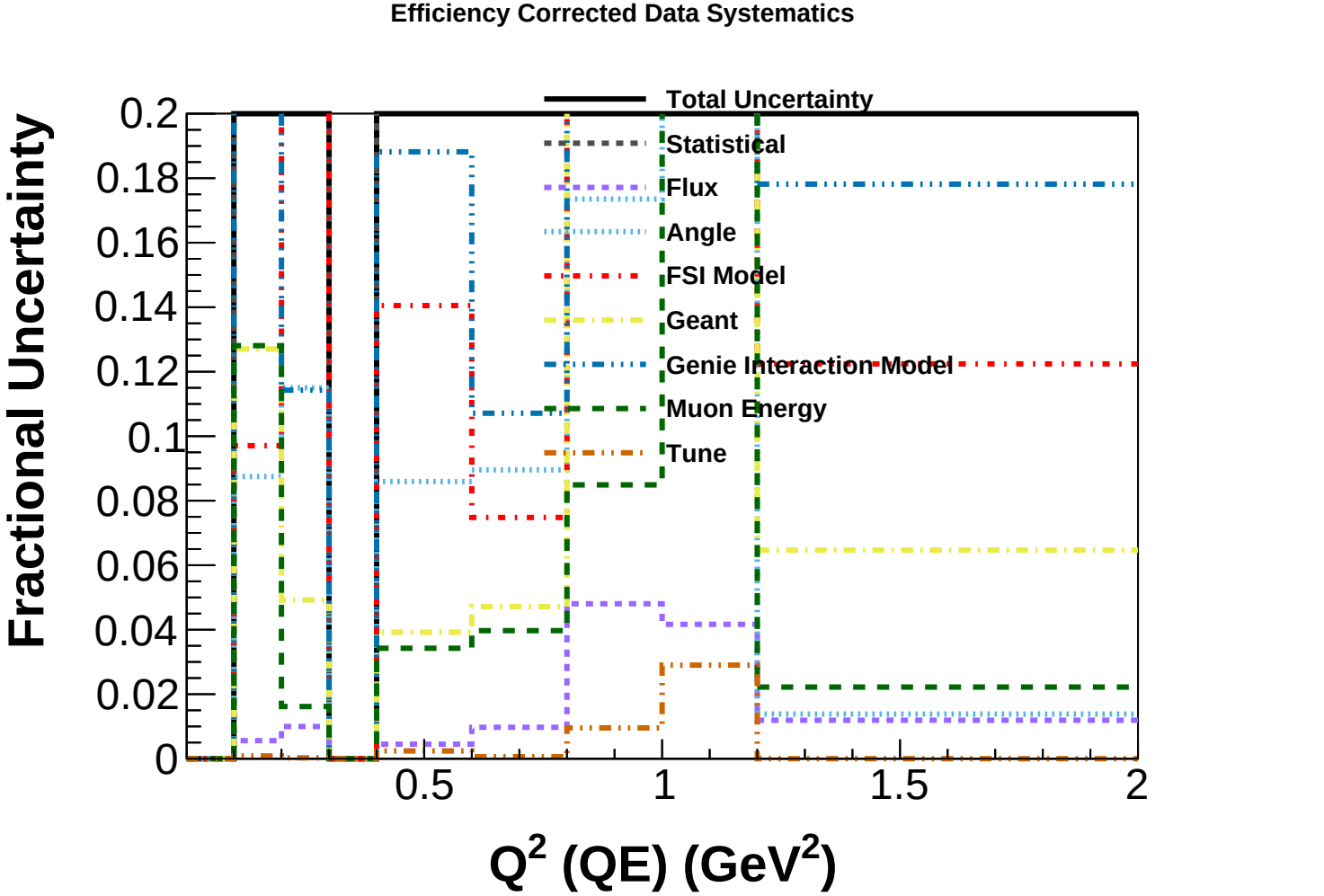

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
5
4
3
2
1
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

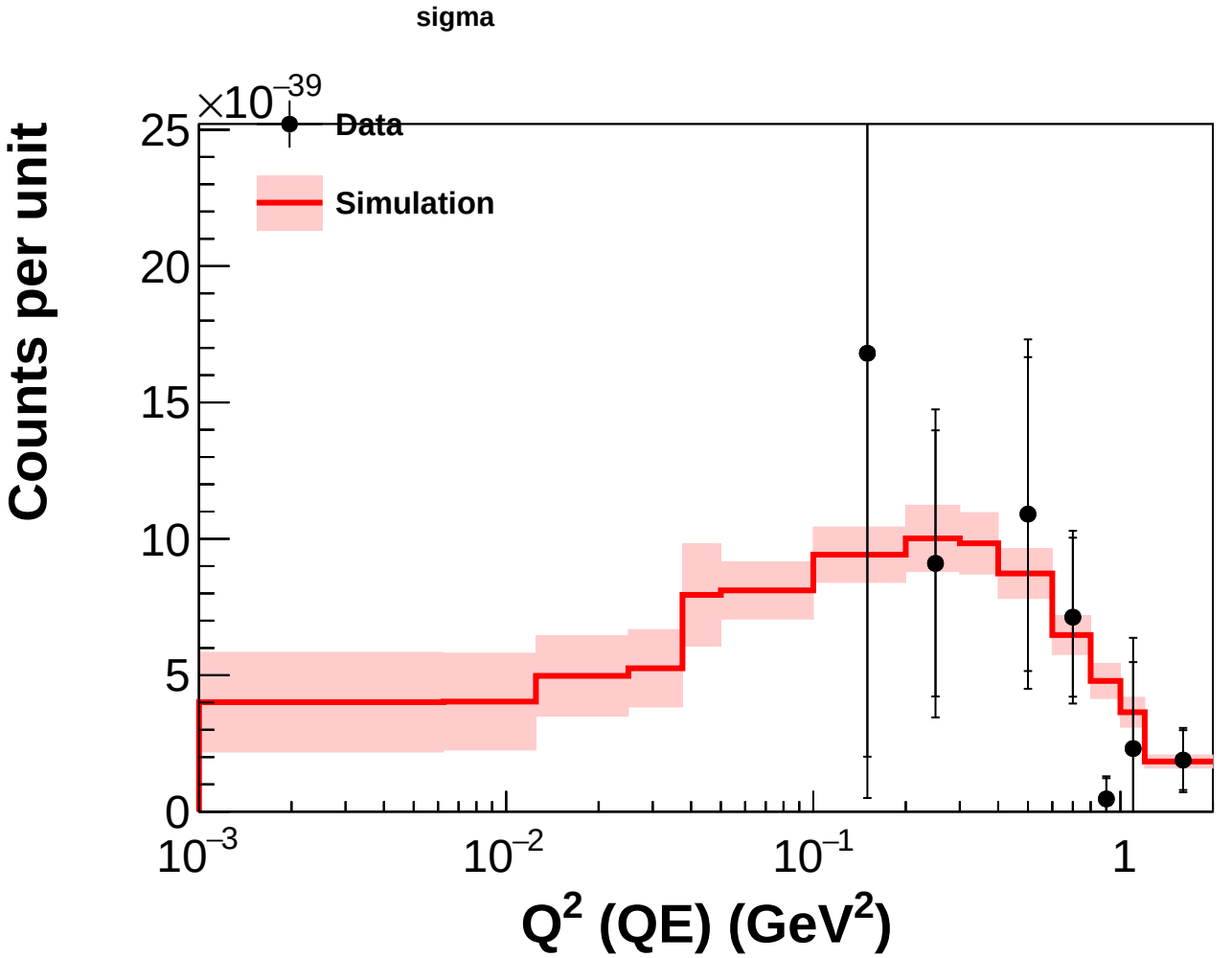

efficiency: selected and true
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

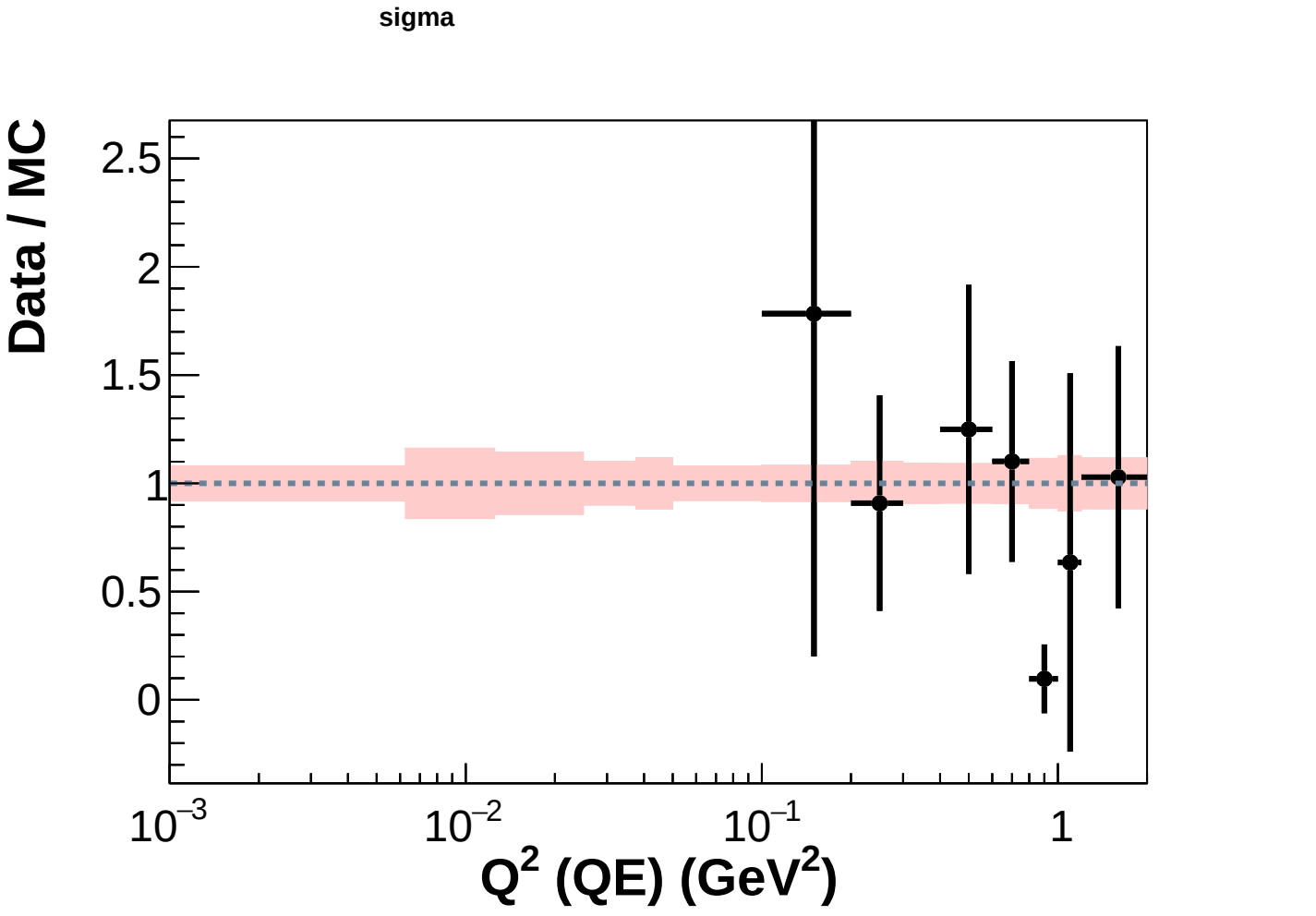

effcorr data vs truth
Counts per unit
×10^3
9
8
7
6
5
4
3
2
1
0
Data
Simulation
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

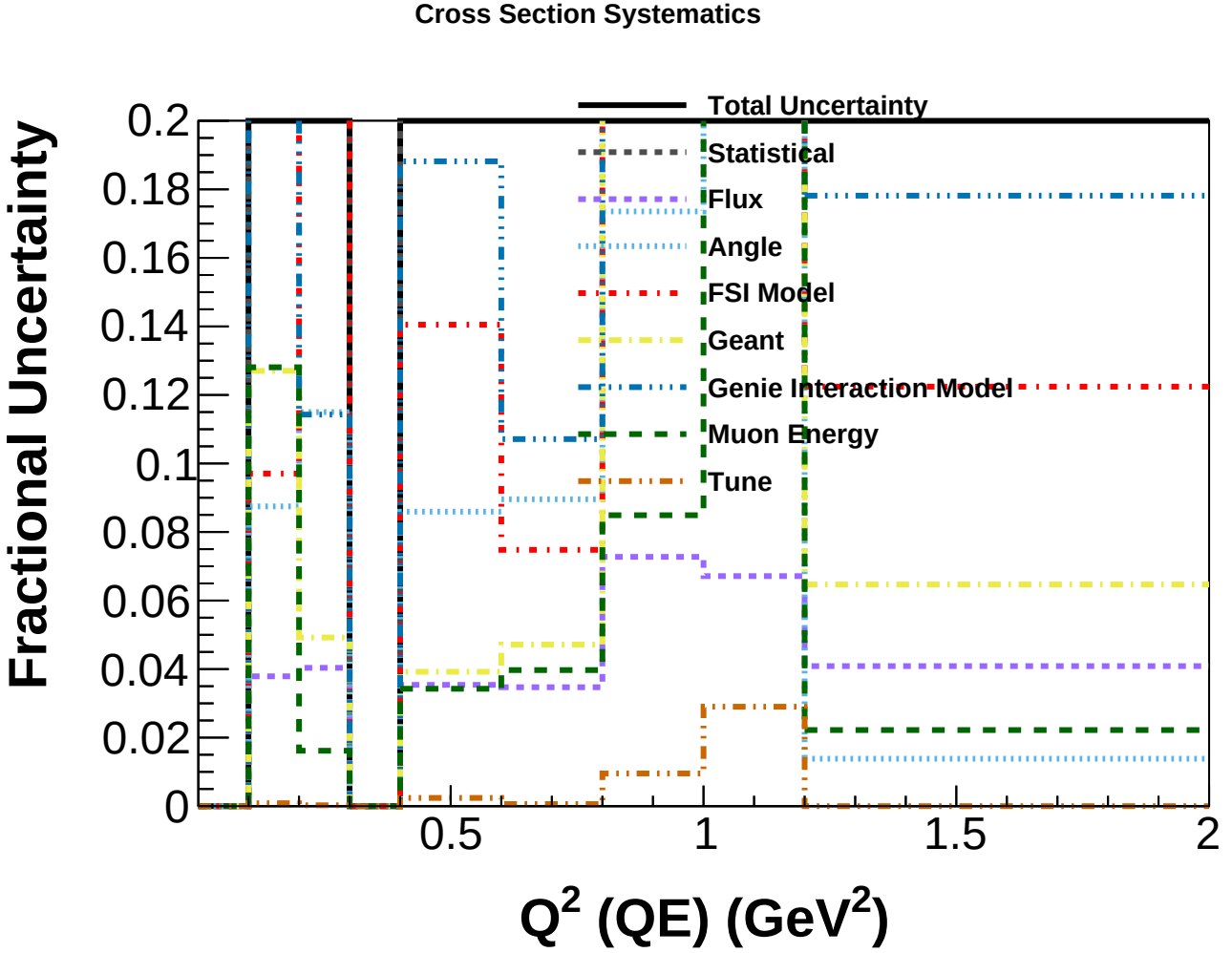

effcorr data vs truth
Data / MC
2.5
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

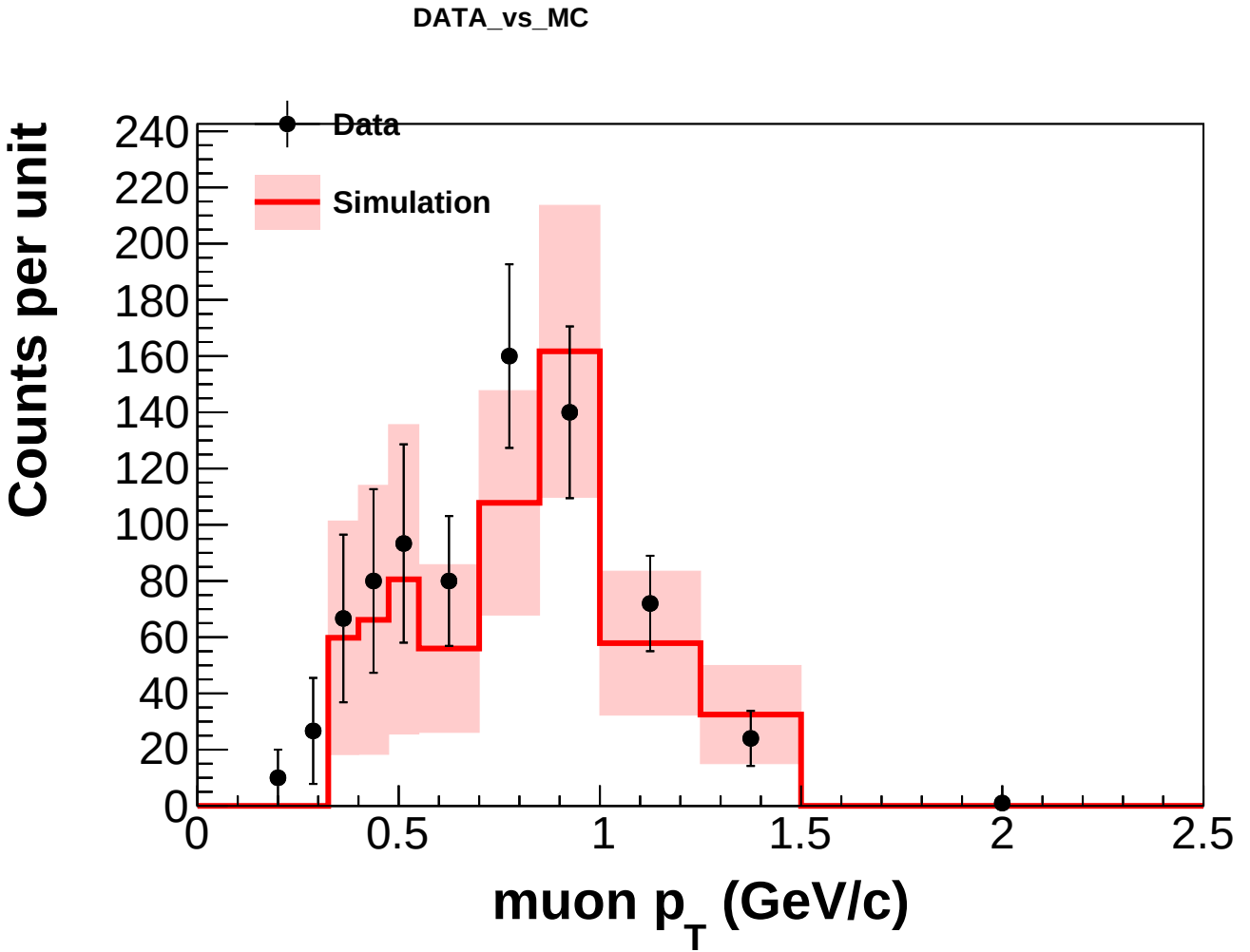

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

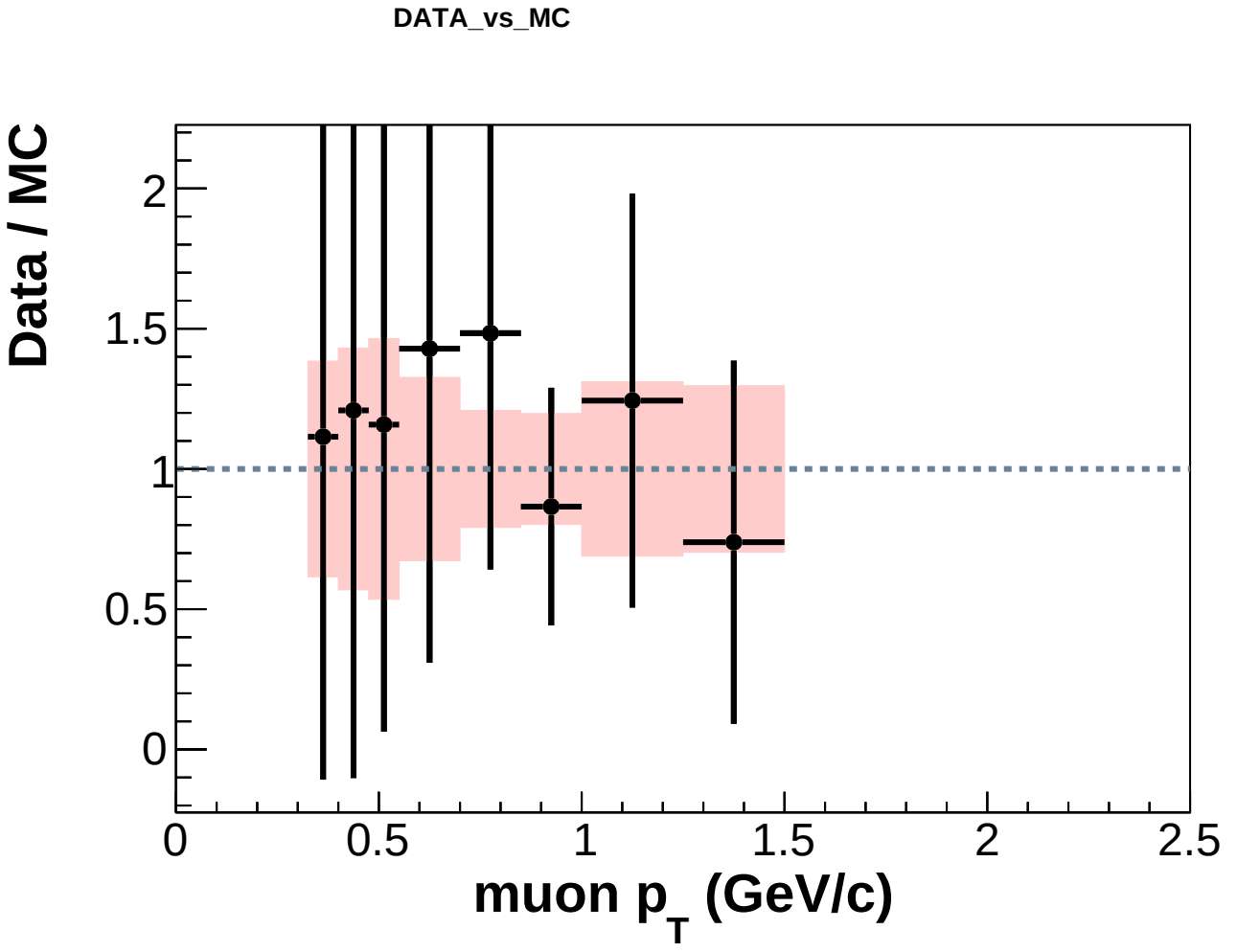

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

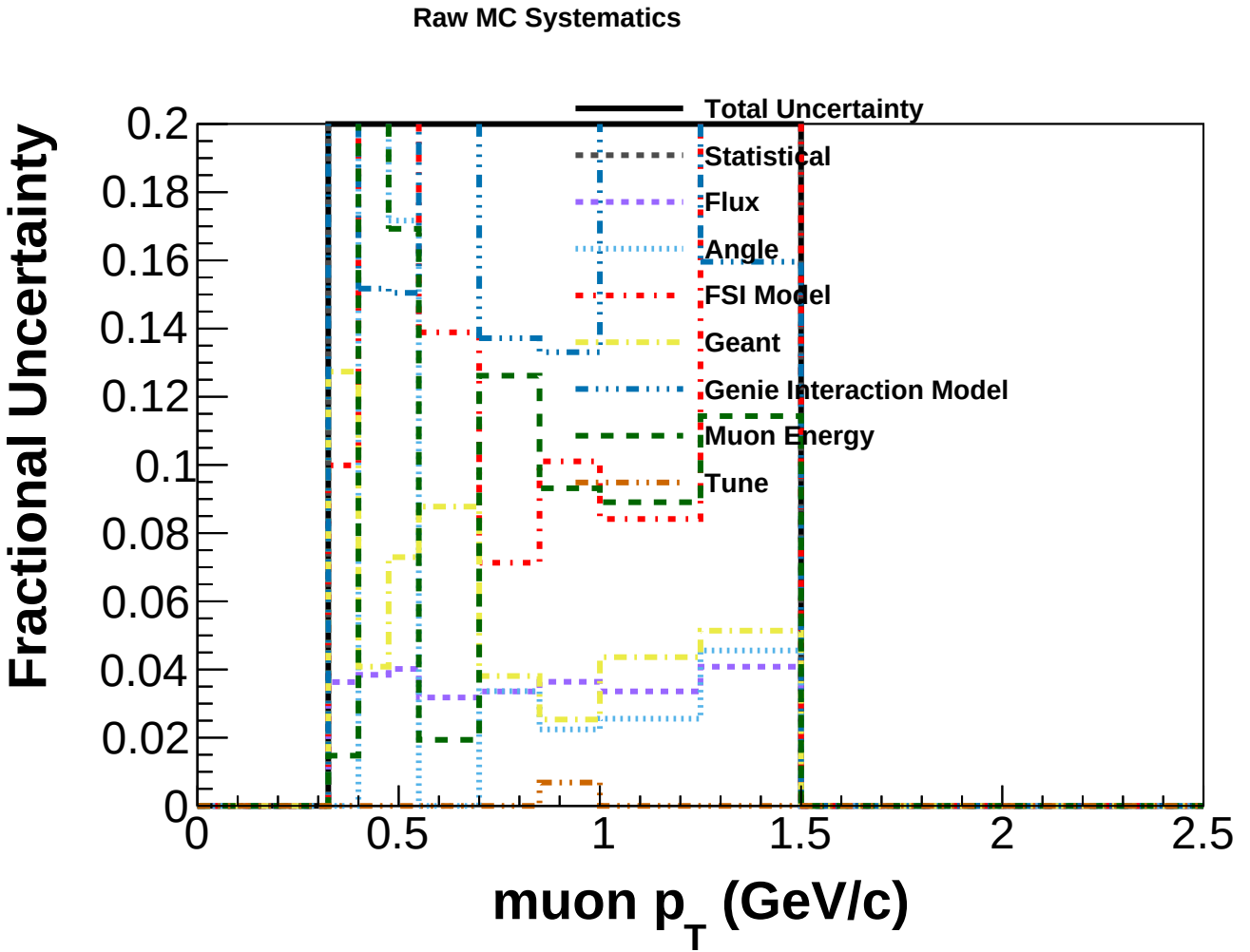

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
25
20
15
10
5
0
10⁻³
10⁻²
10⁻¹
1
Q² (QE) (GeV²)

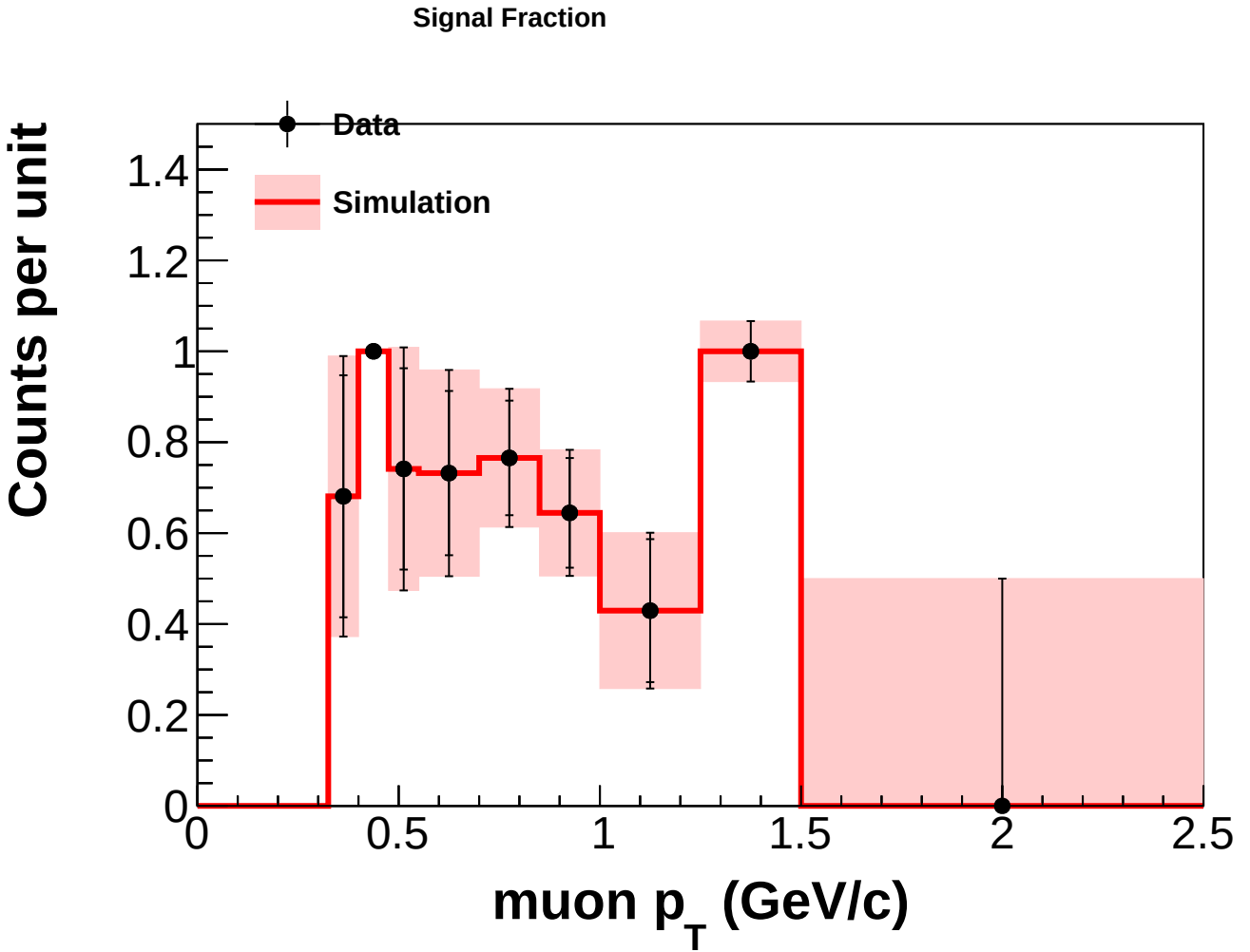

sigma
Data / MC
2.5
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

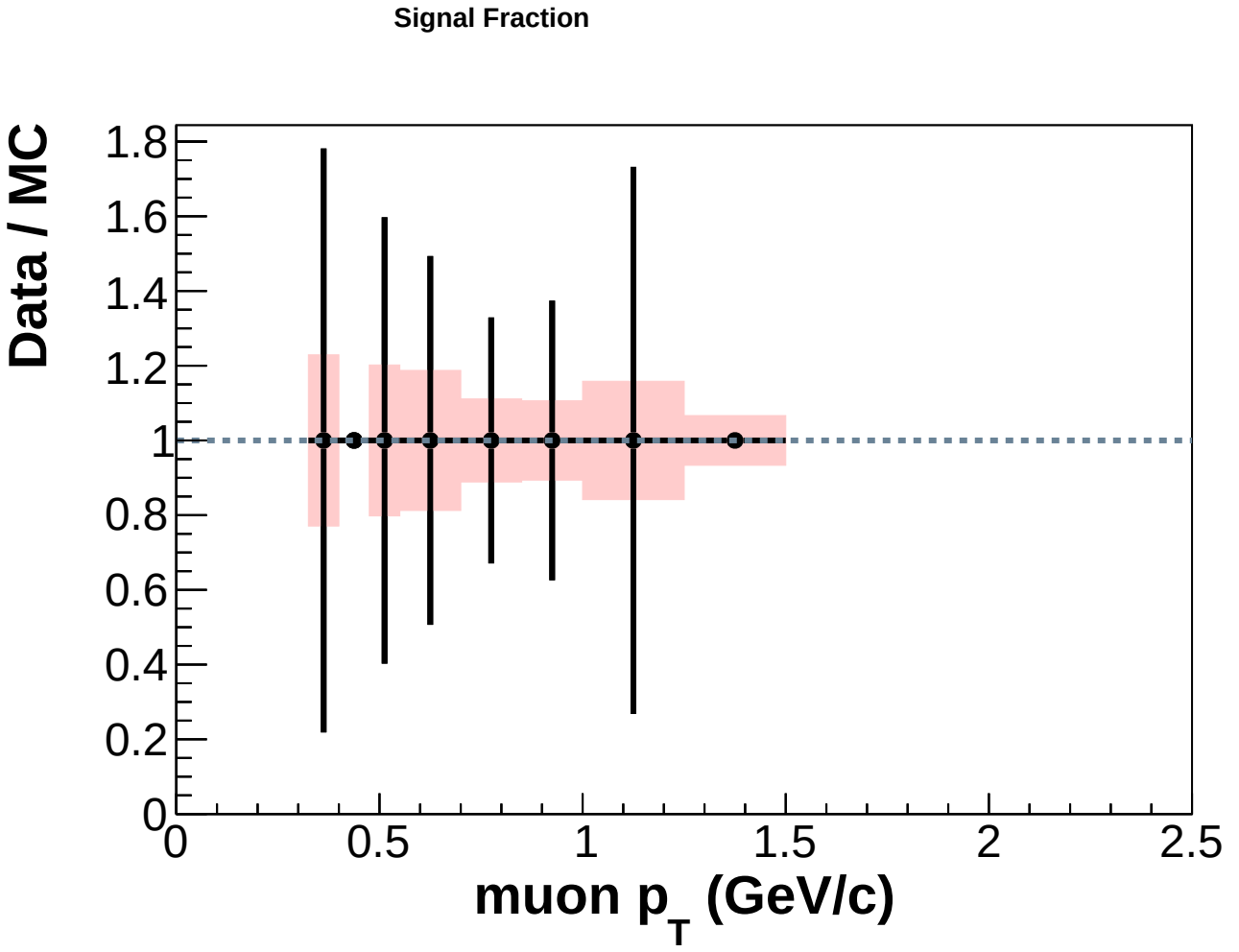

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

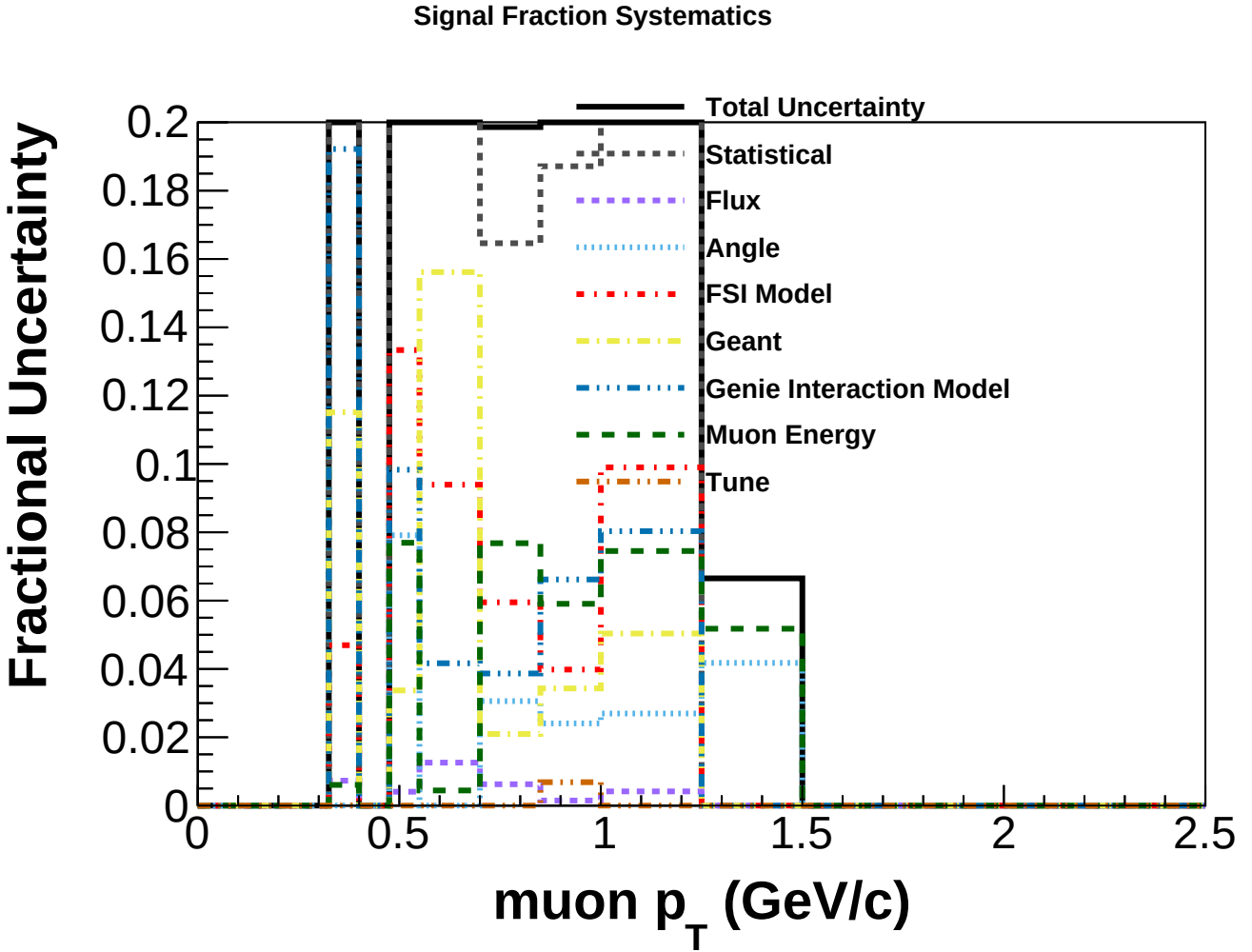

DATA_vs_MC
Data
Simulation
Counts per unit
240
220
200
180
160
140
120
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

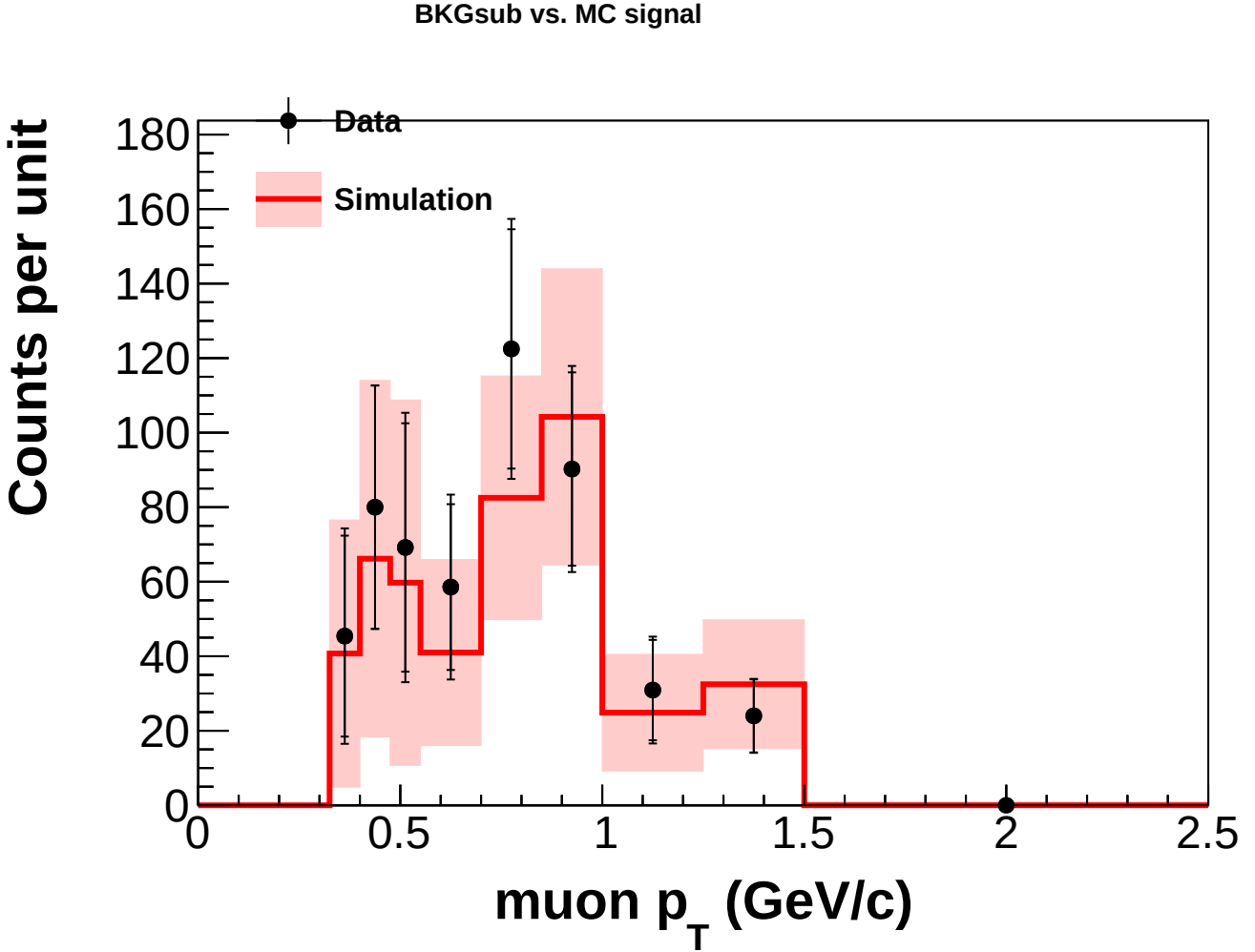

DATA_vs_MC
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

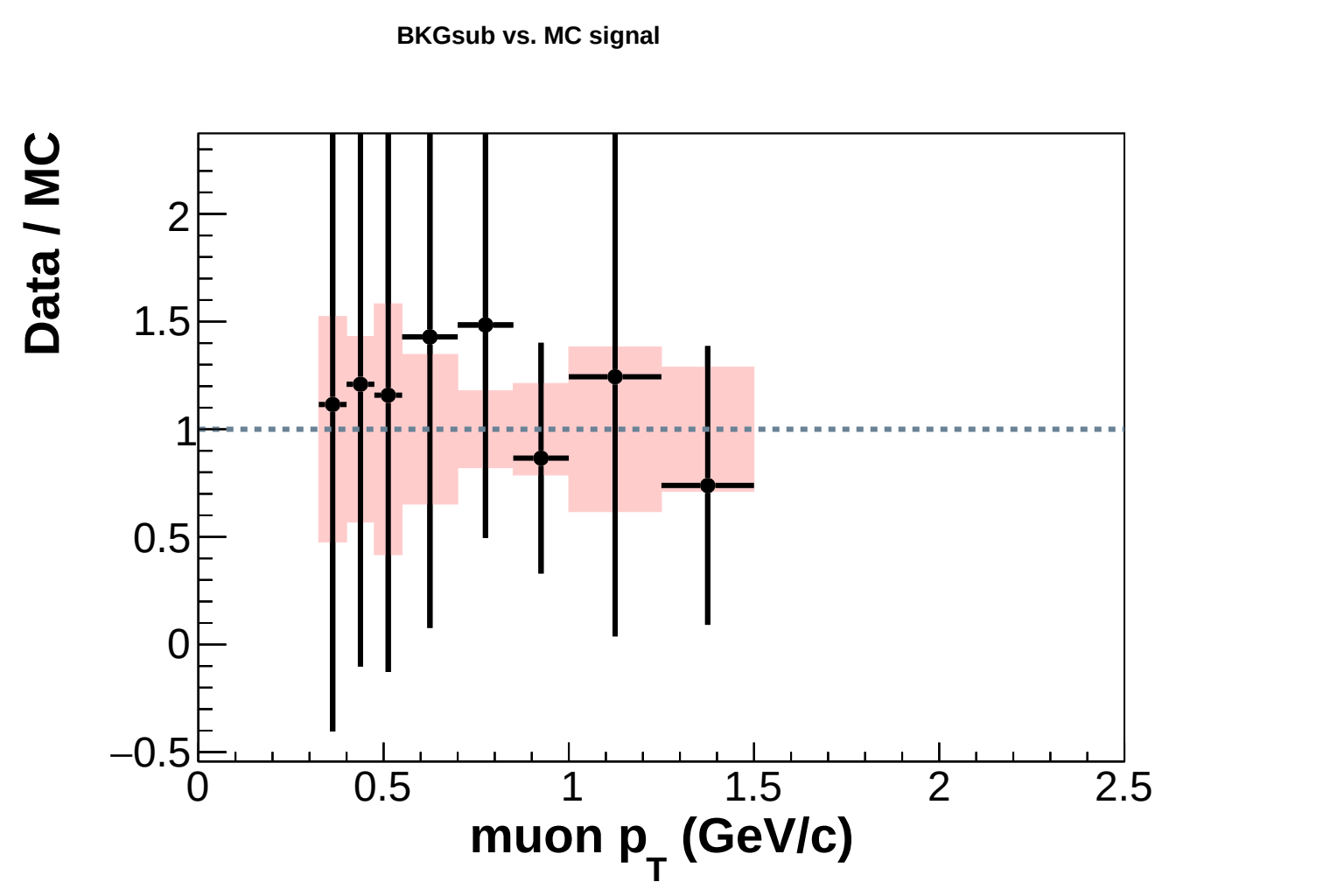

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

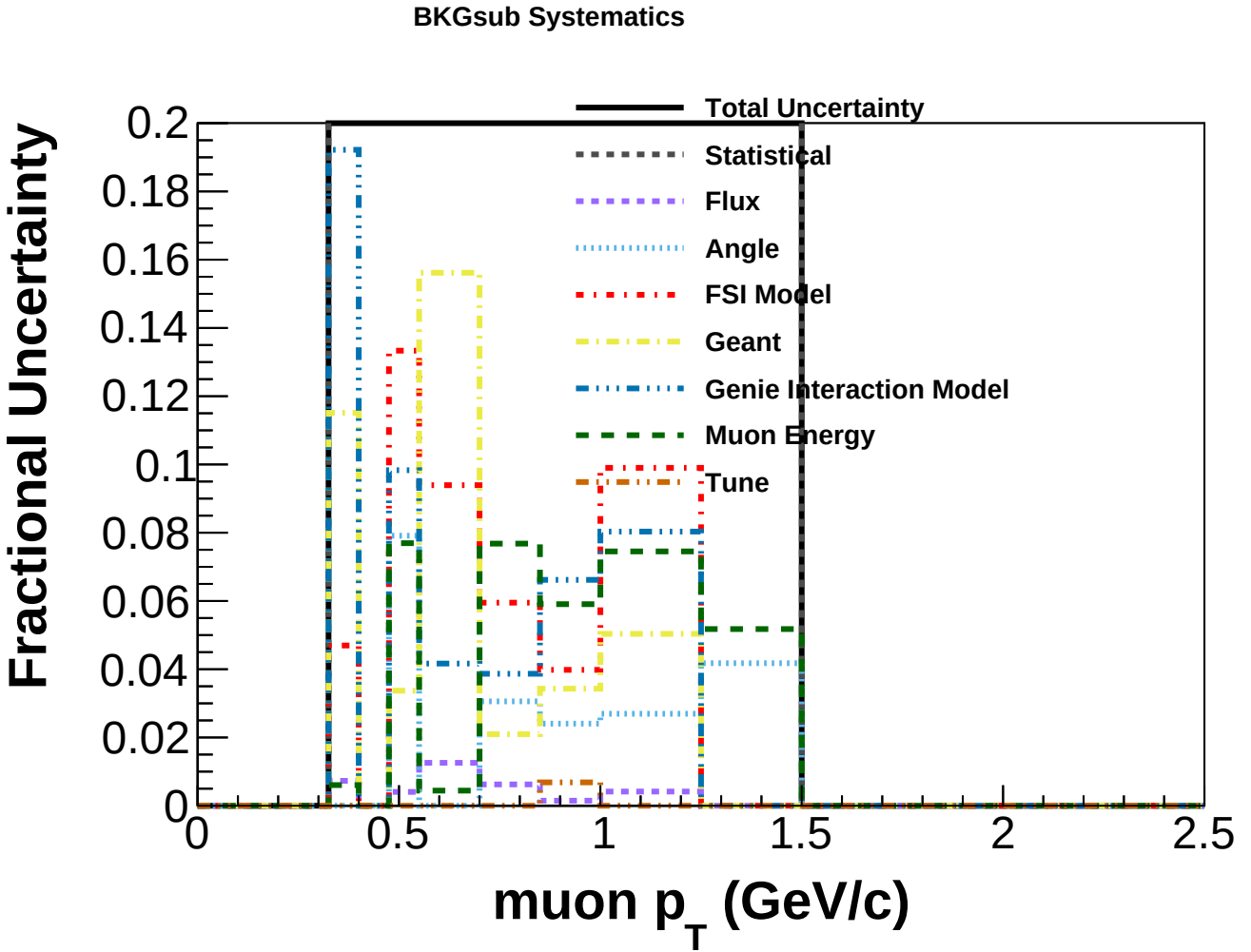

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

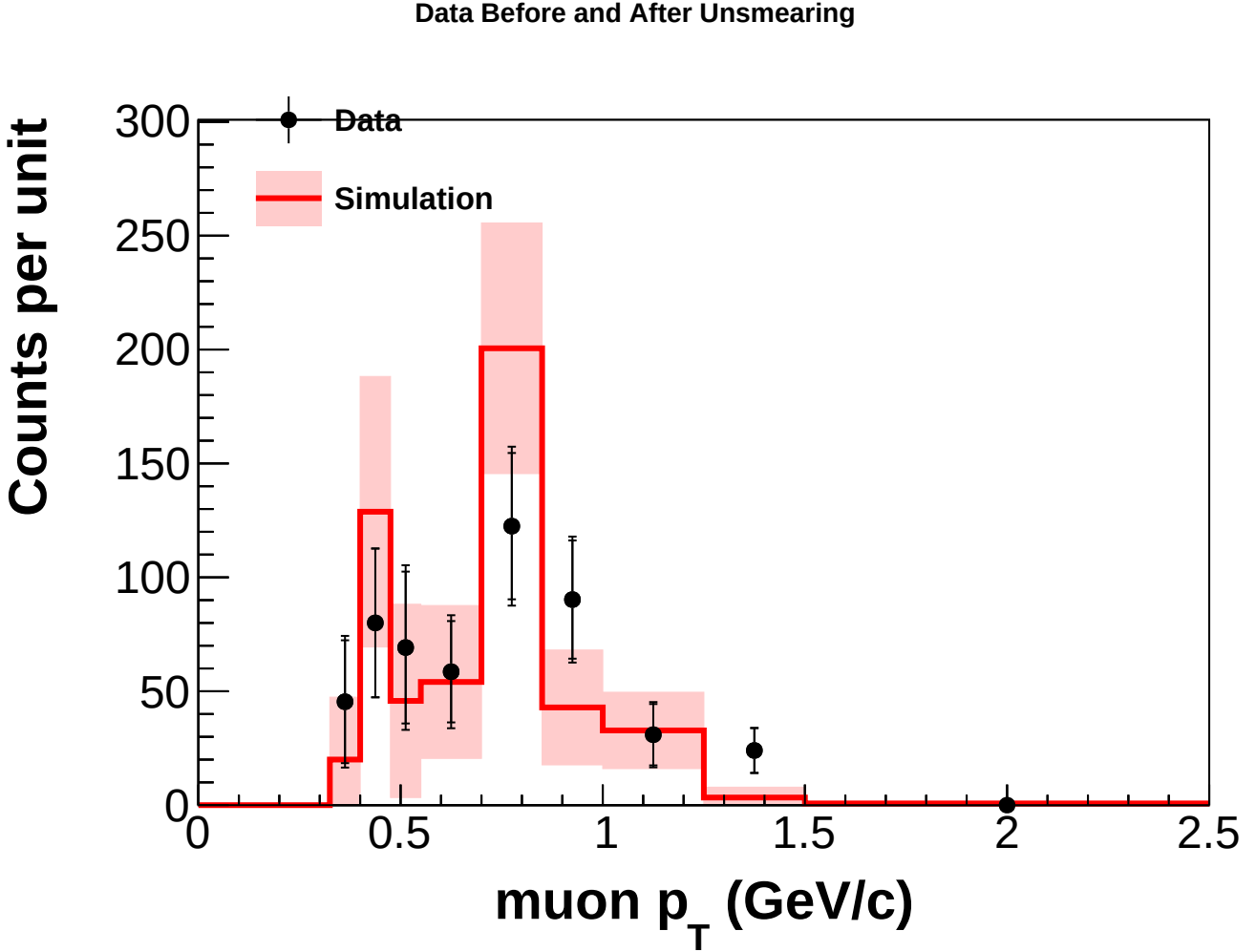

Signal Fraction
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

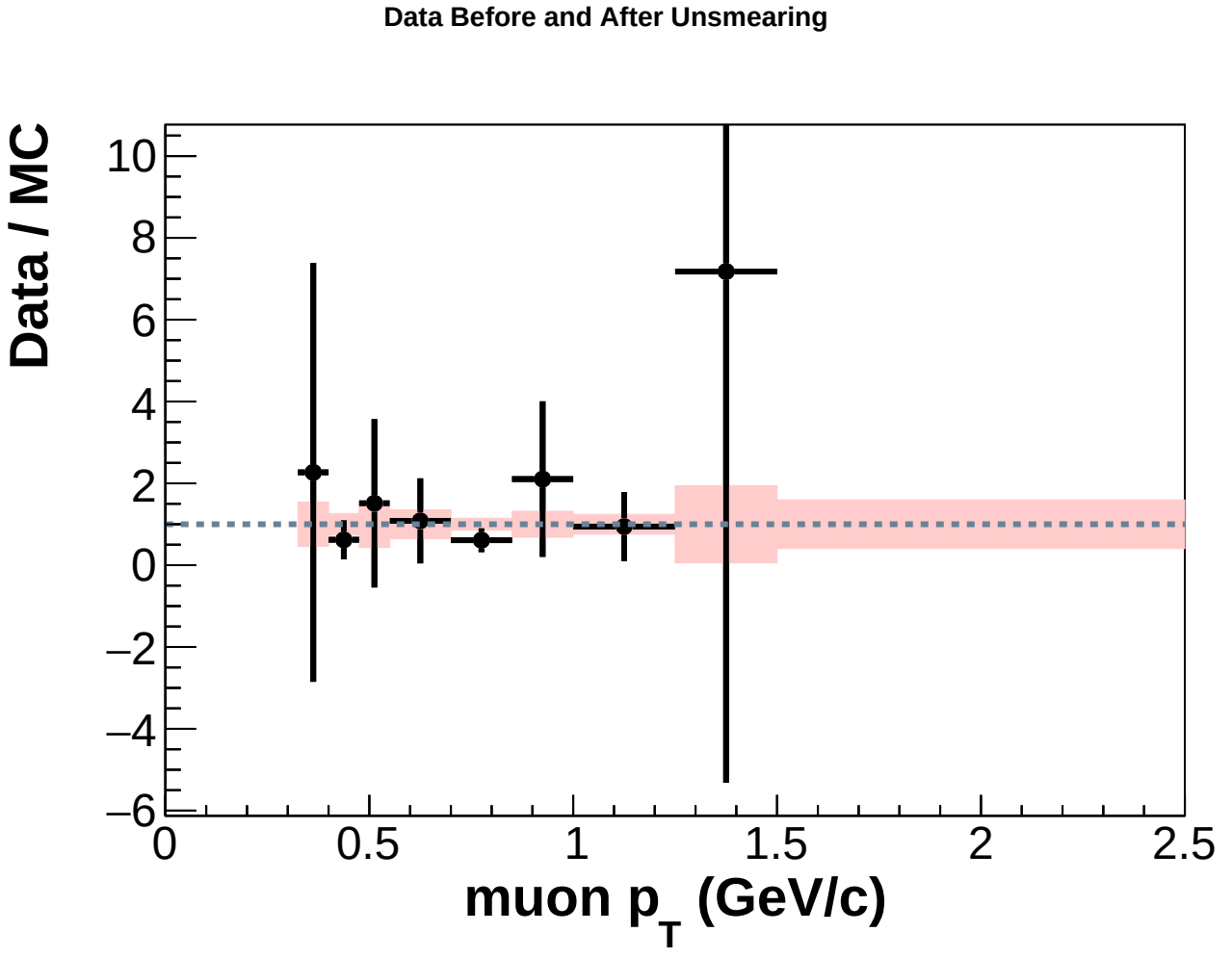

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

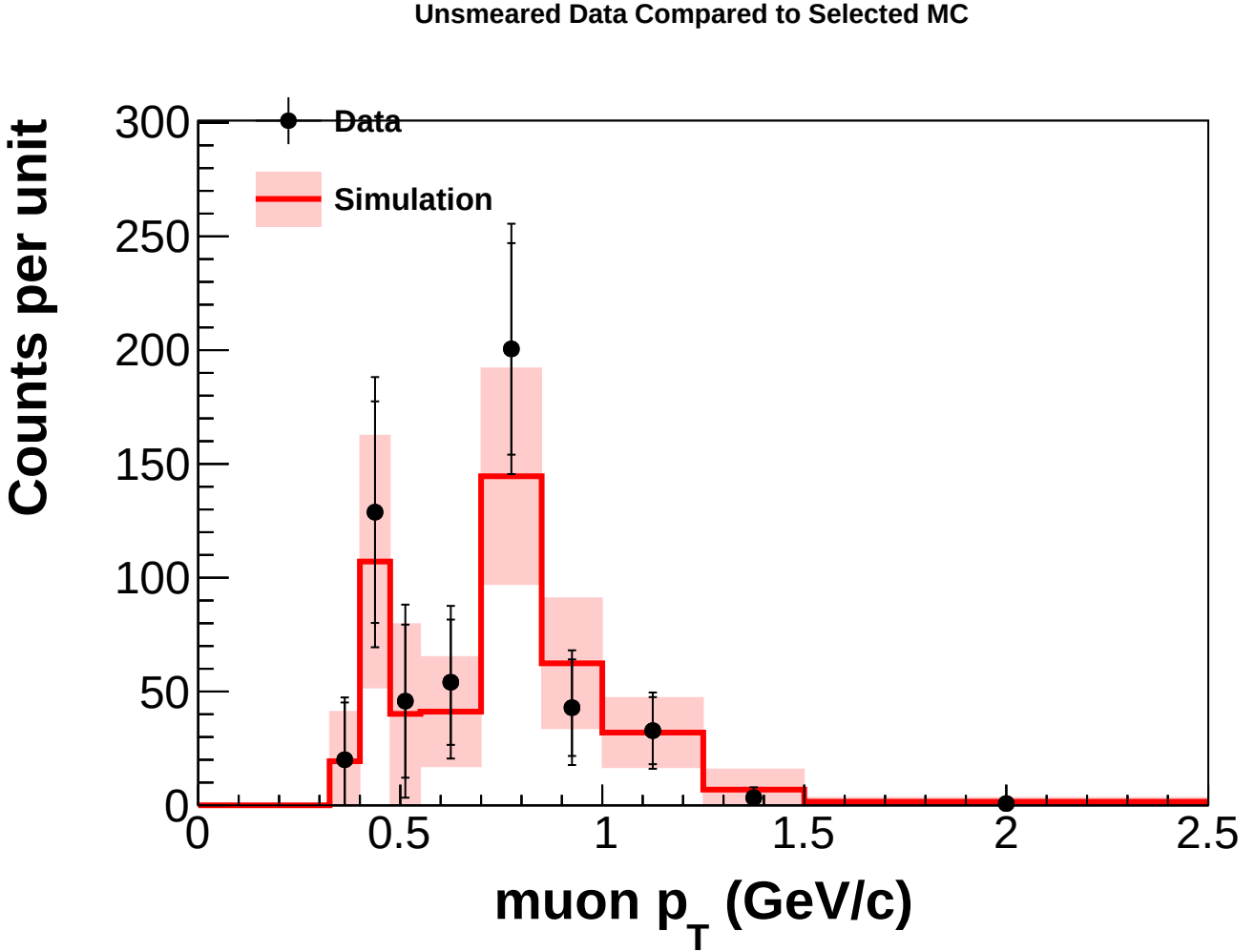

BKGsub vs. MC signal
Data
Simulation
Counts per unit
muon p_T (GeV/c)
0
20
40
60
80
100
120
140
160
180
0
0.5
1
1.5
2
2.5

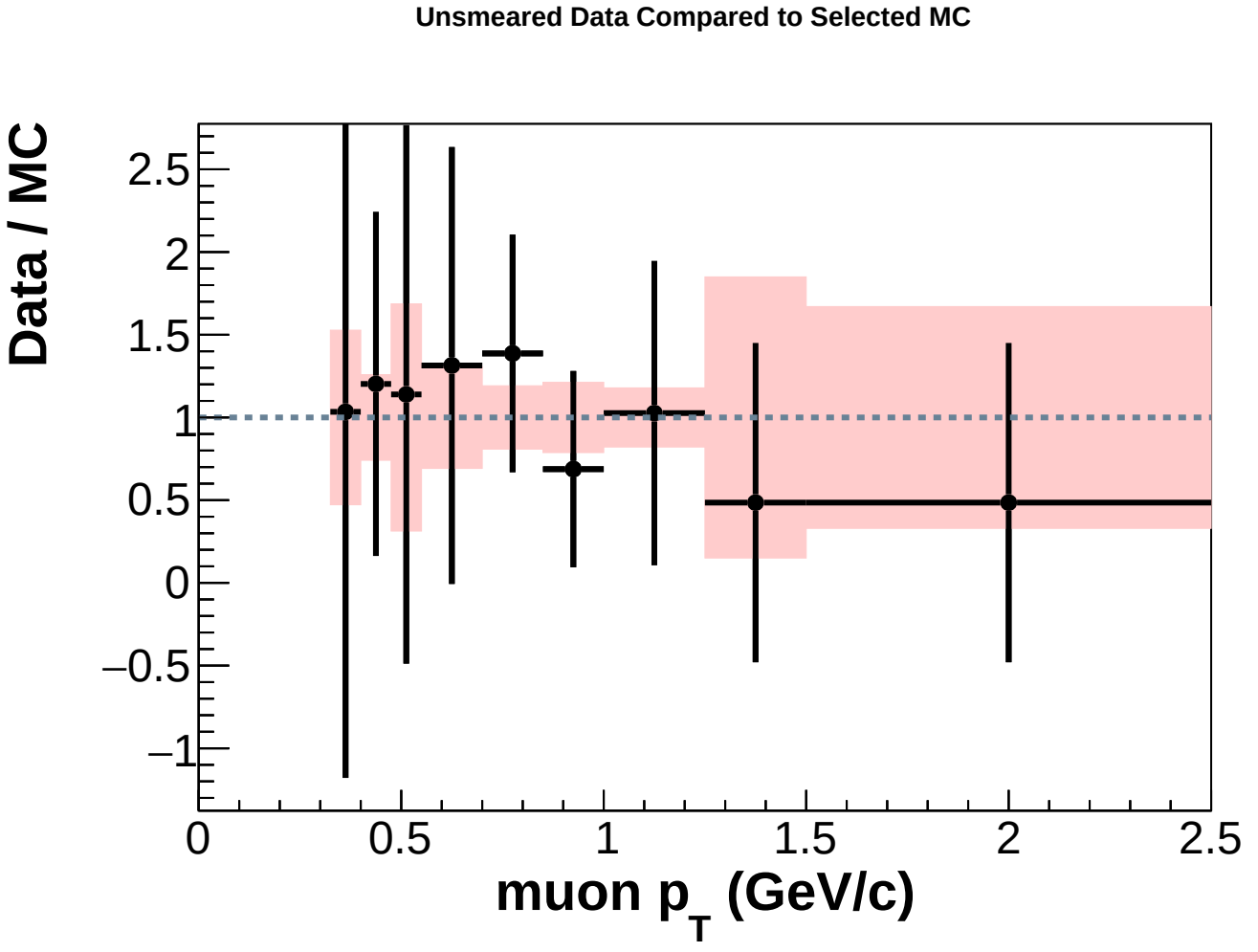

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

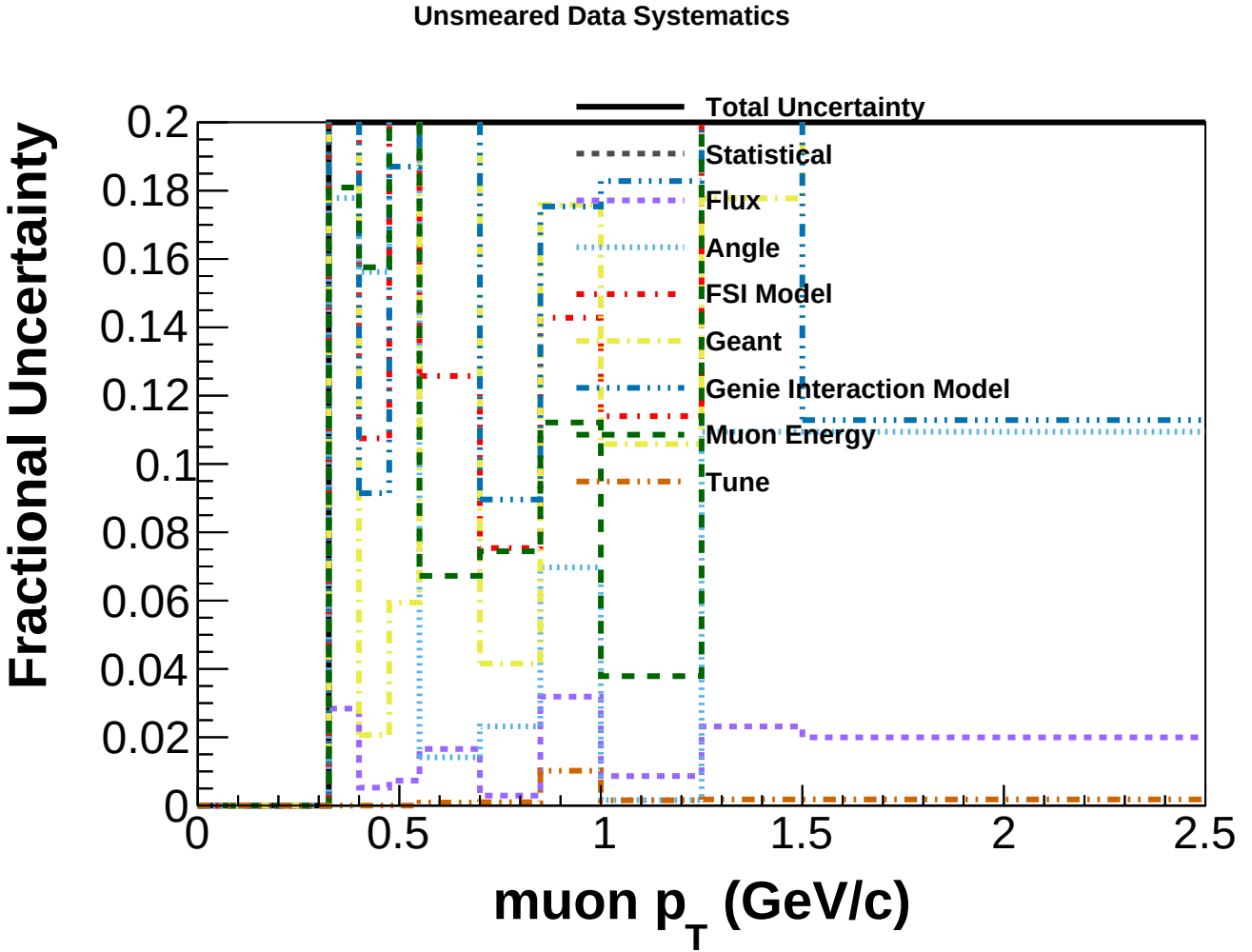

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

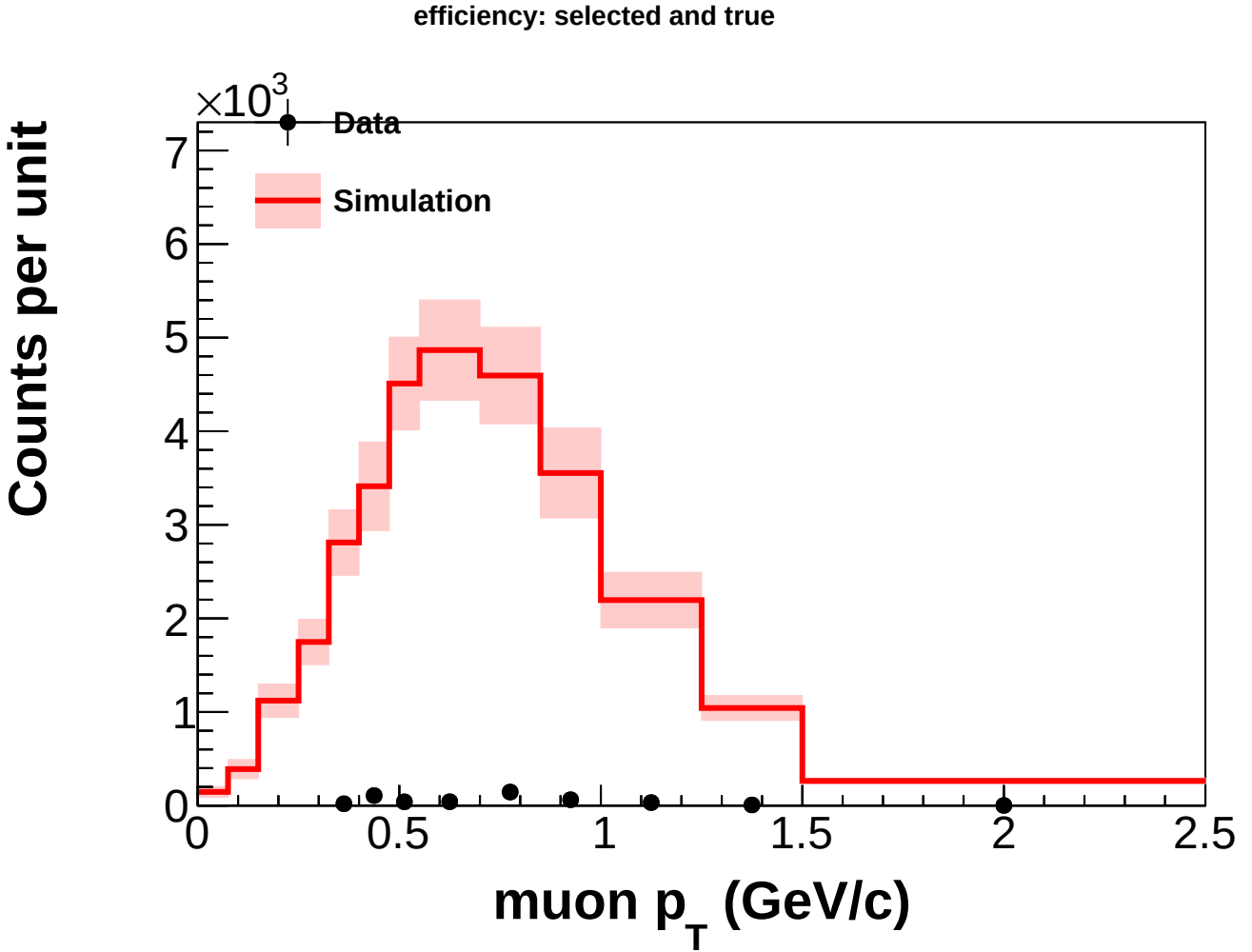

Data Before and After Unsmearing
Data
Simulation
Counts per unit
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

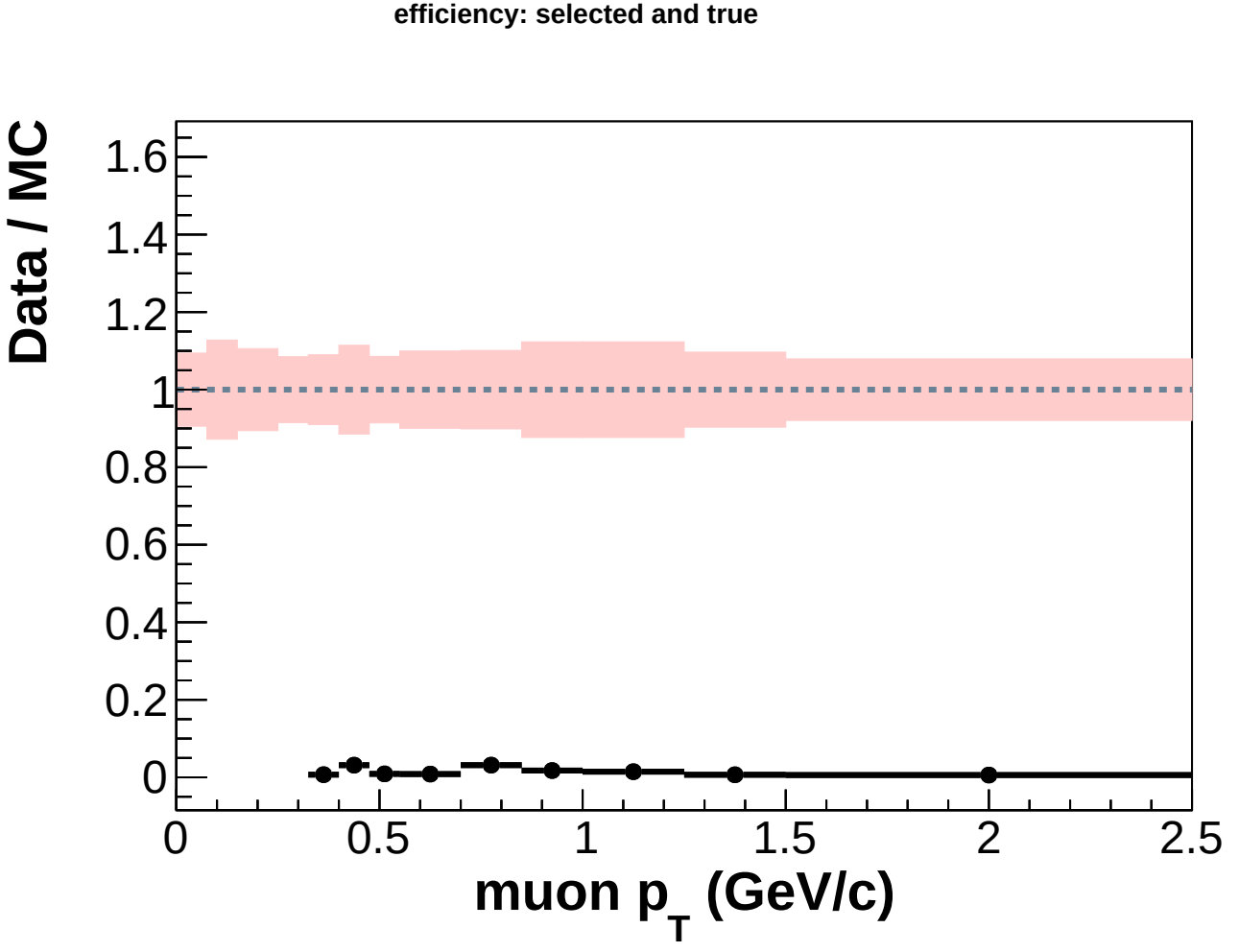

Data Before and After Unsmearing
Data / MC
10
8
6
4
2
0
−2
−4
−6
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

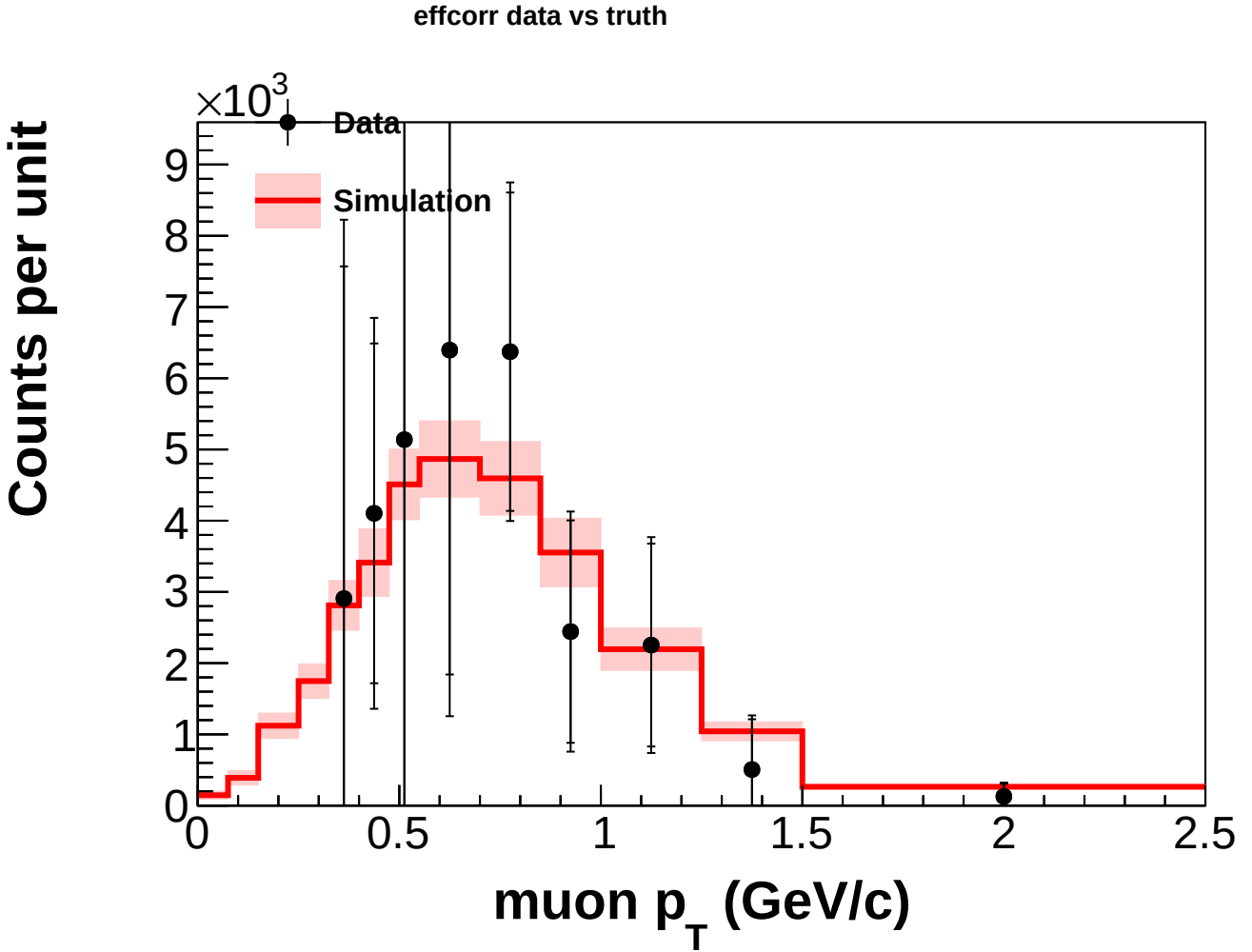

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

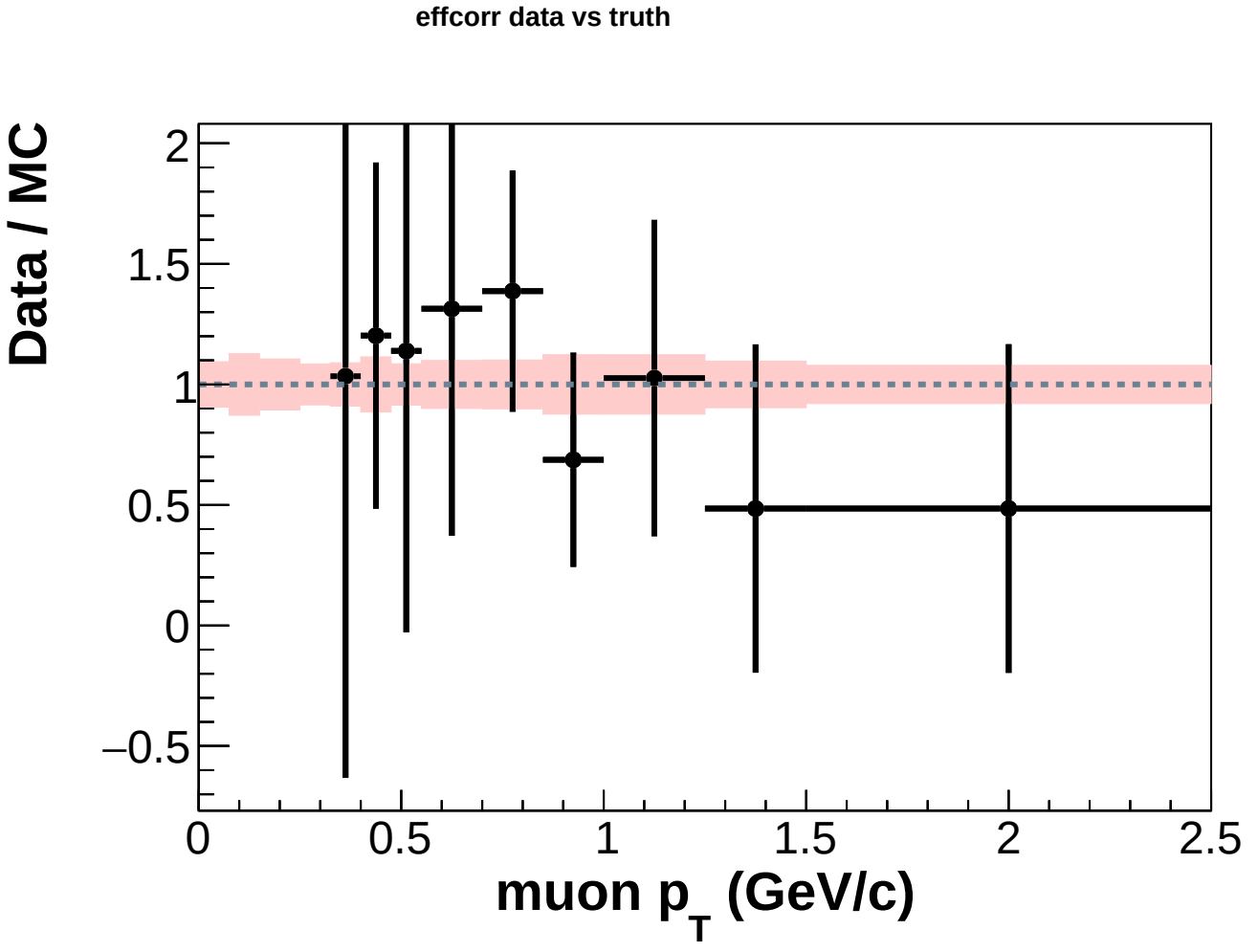

Unsmeared Data Compared to Selected MC
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

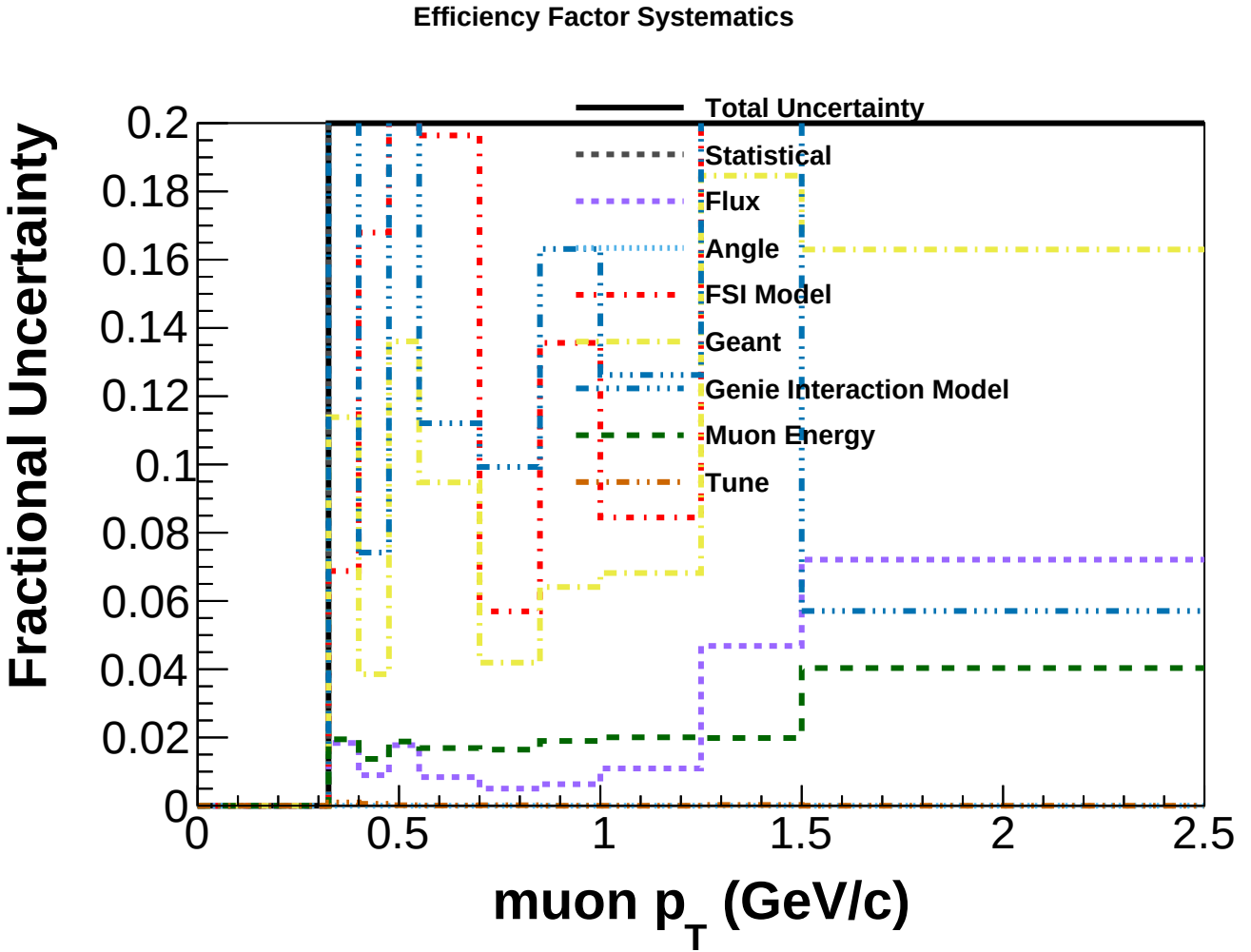

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

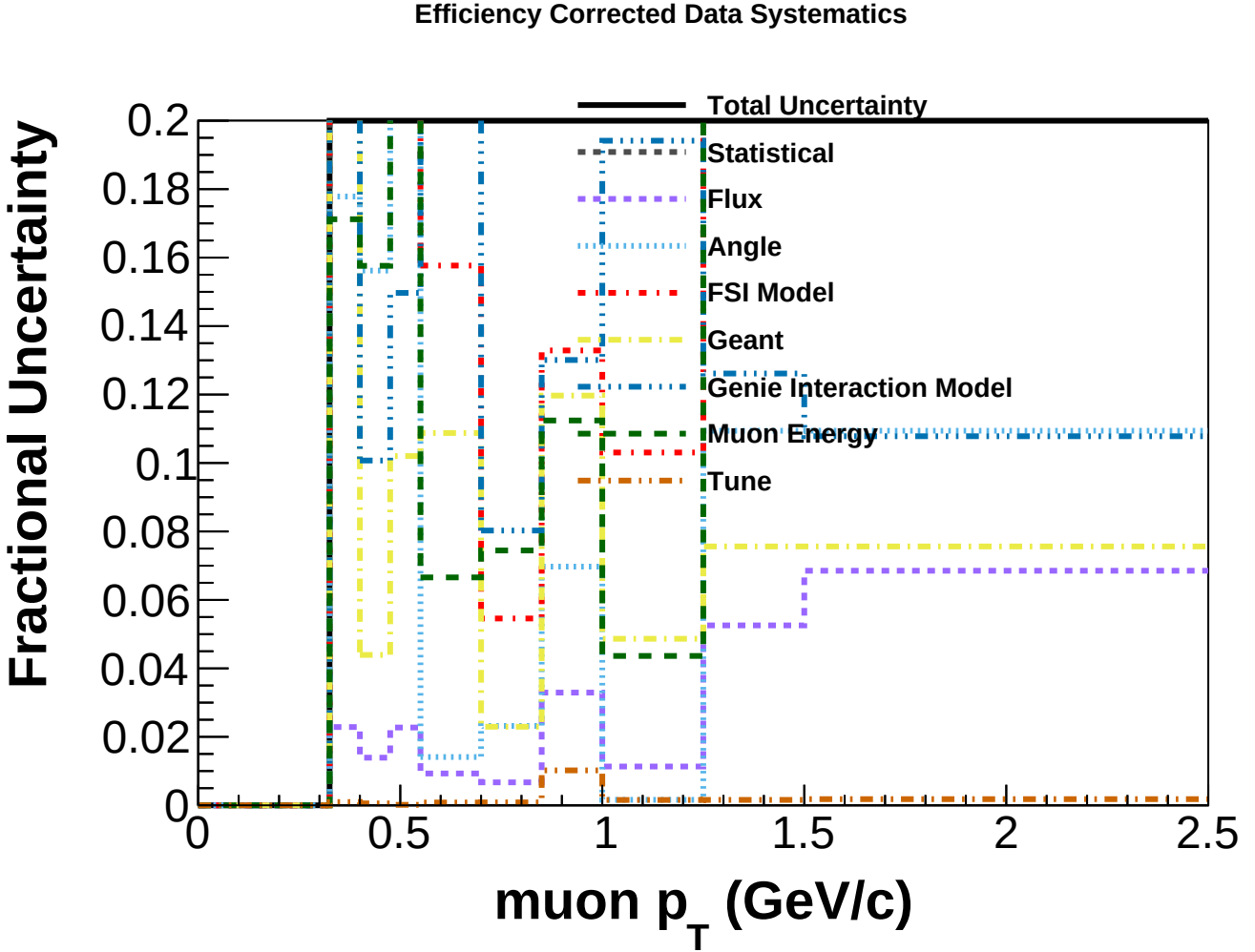

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
0
1
2
3
4
5
6
7
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

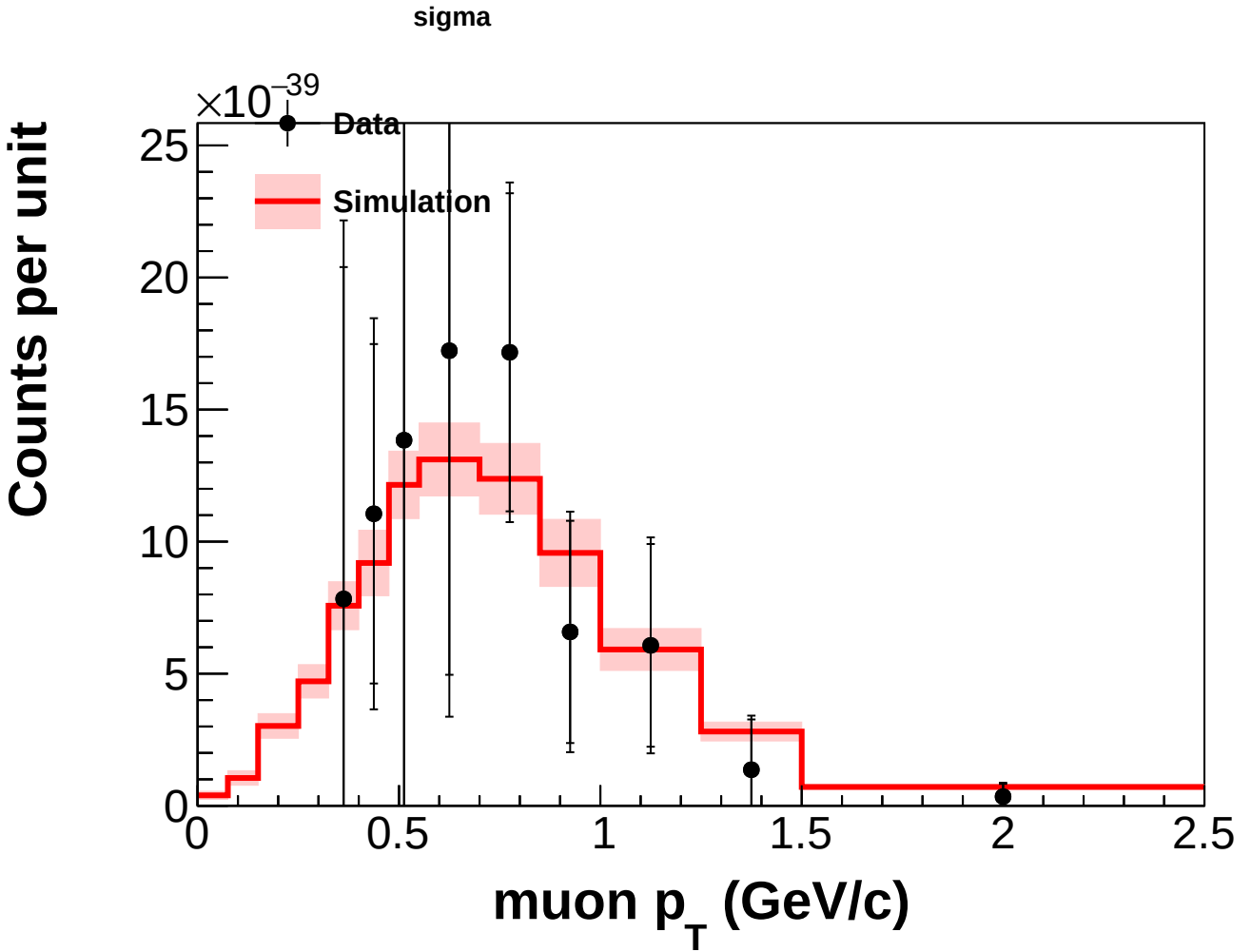

efficiency: selected and true
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

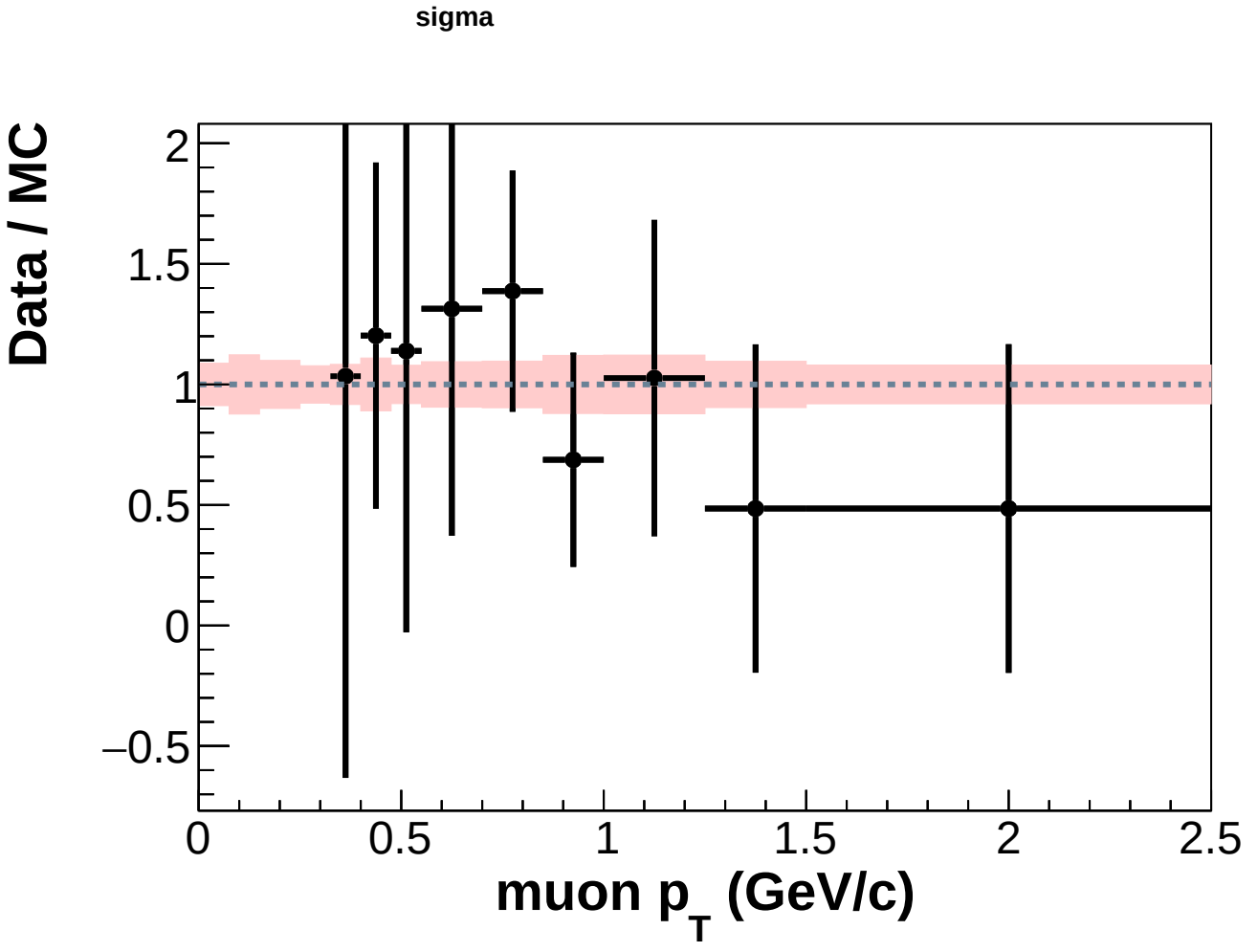

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
0
1
2
3
4
5
6
7
8
9
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

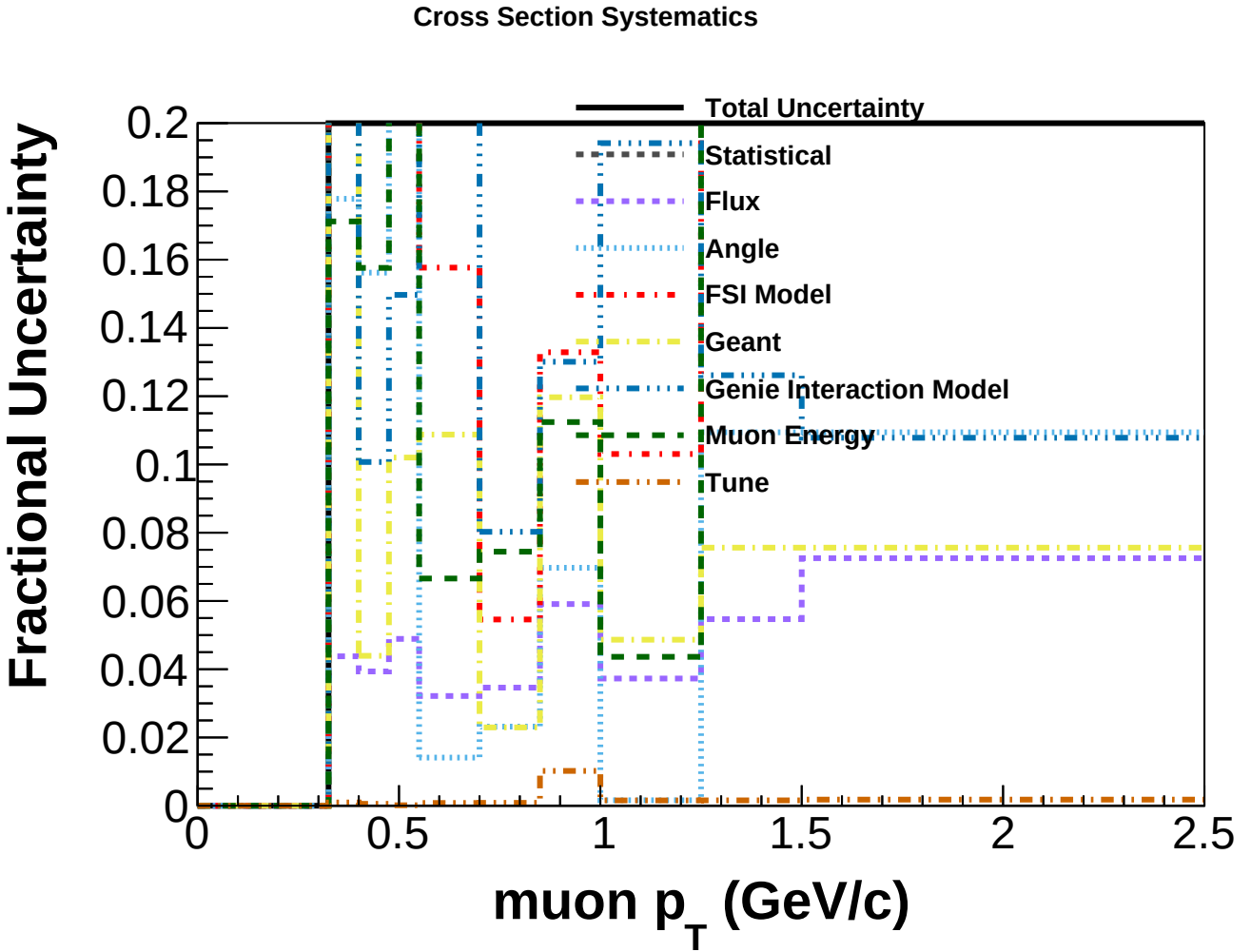

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

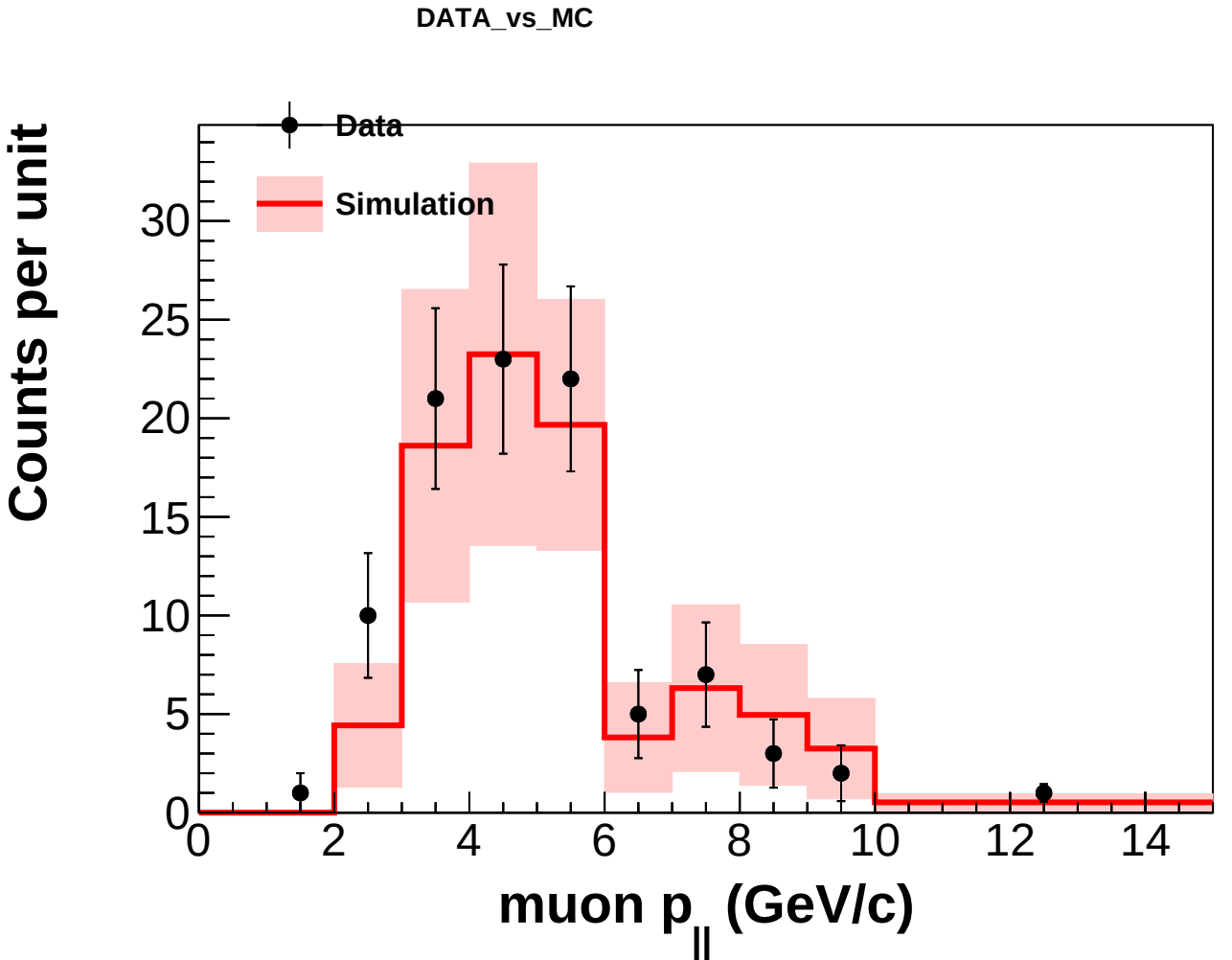

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

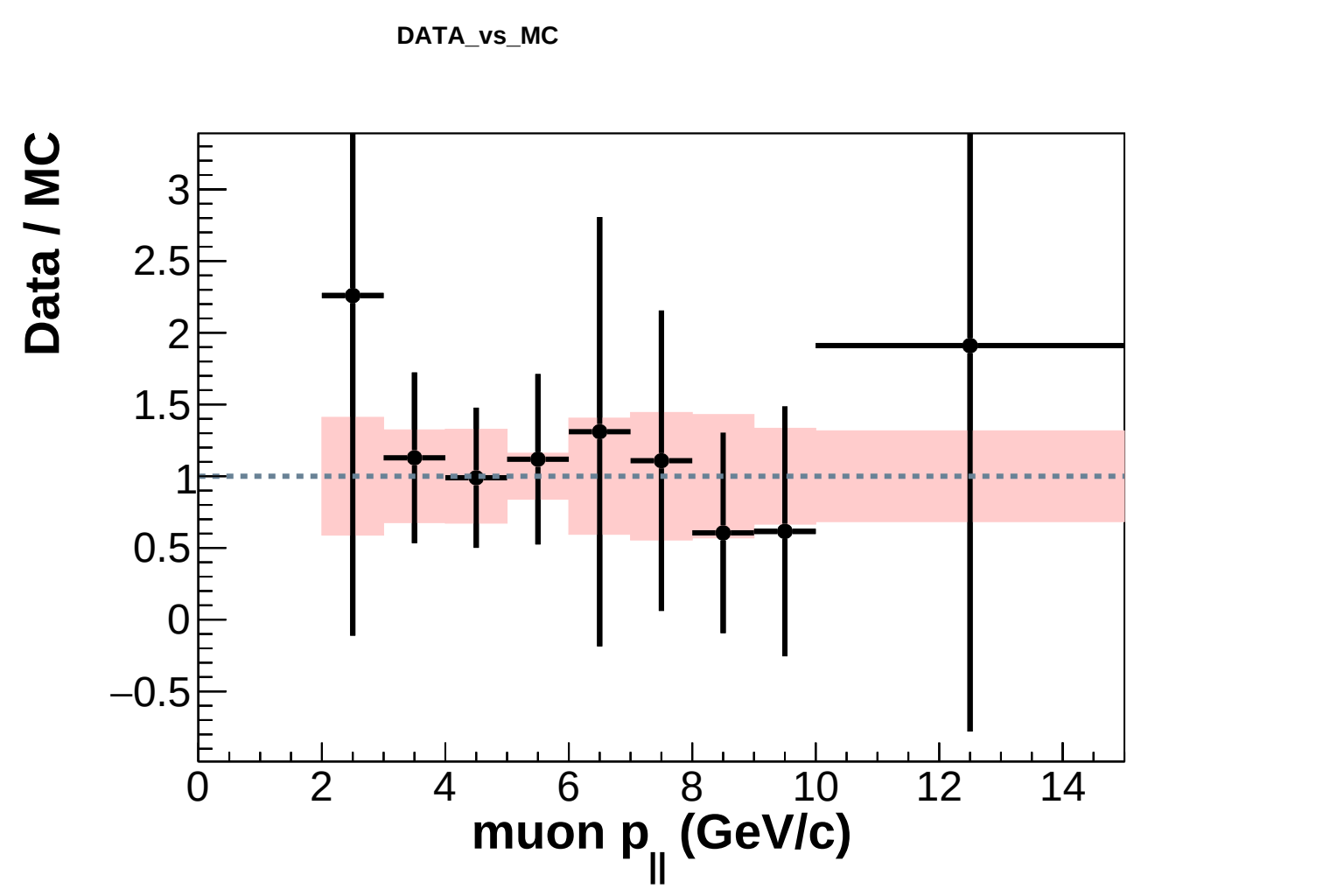

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

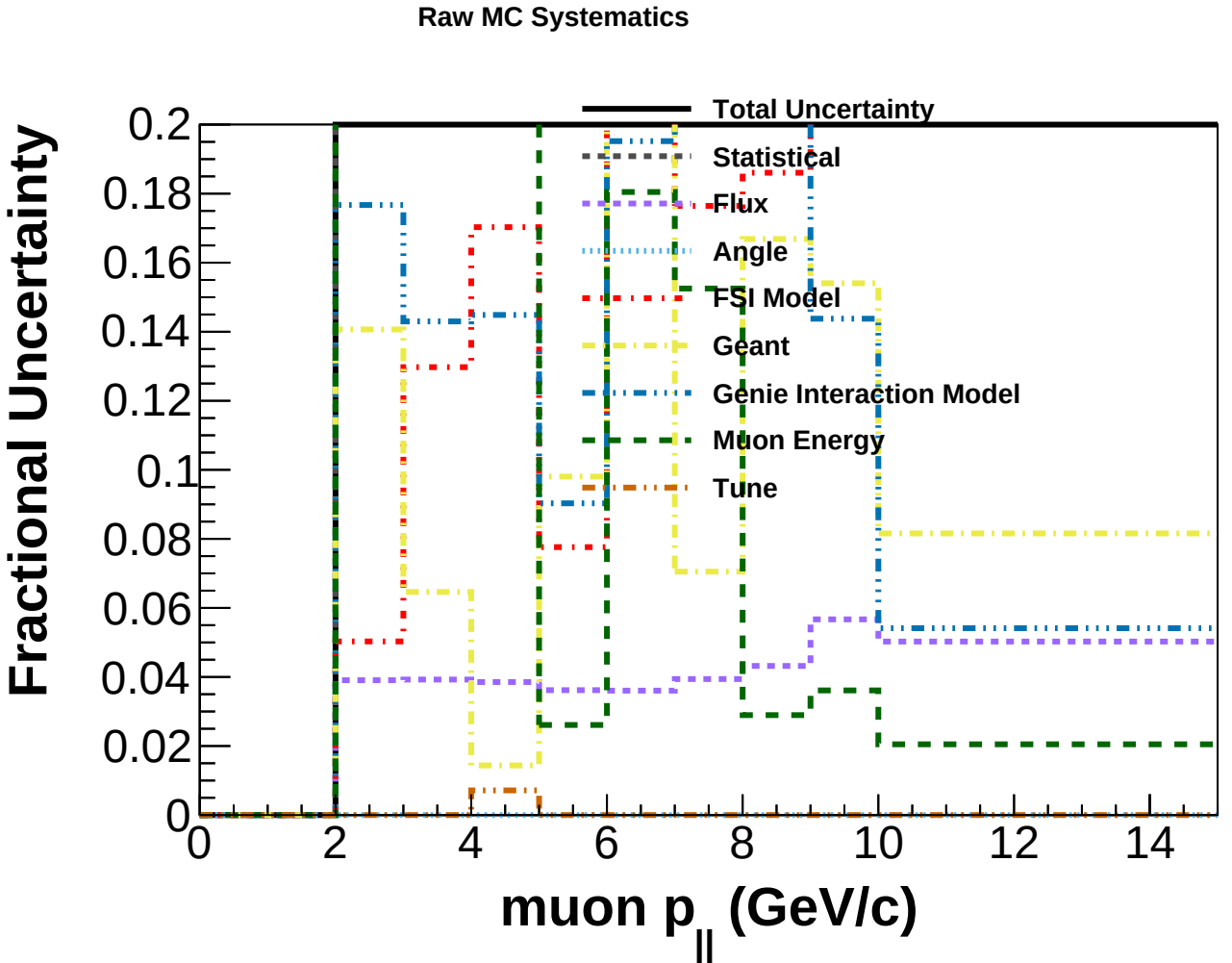

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

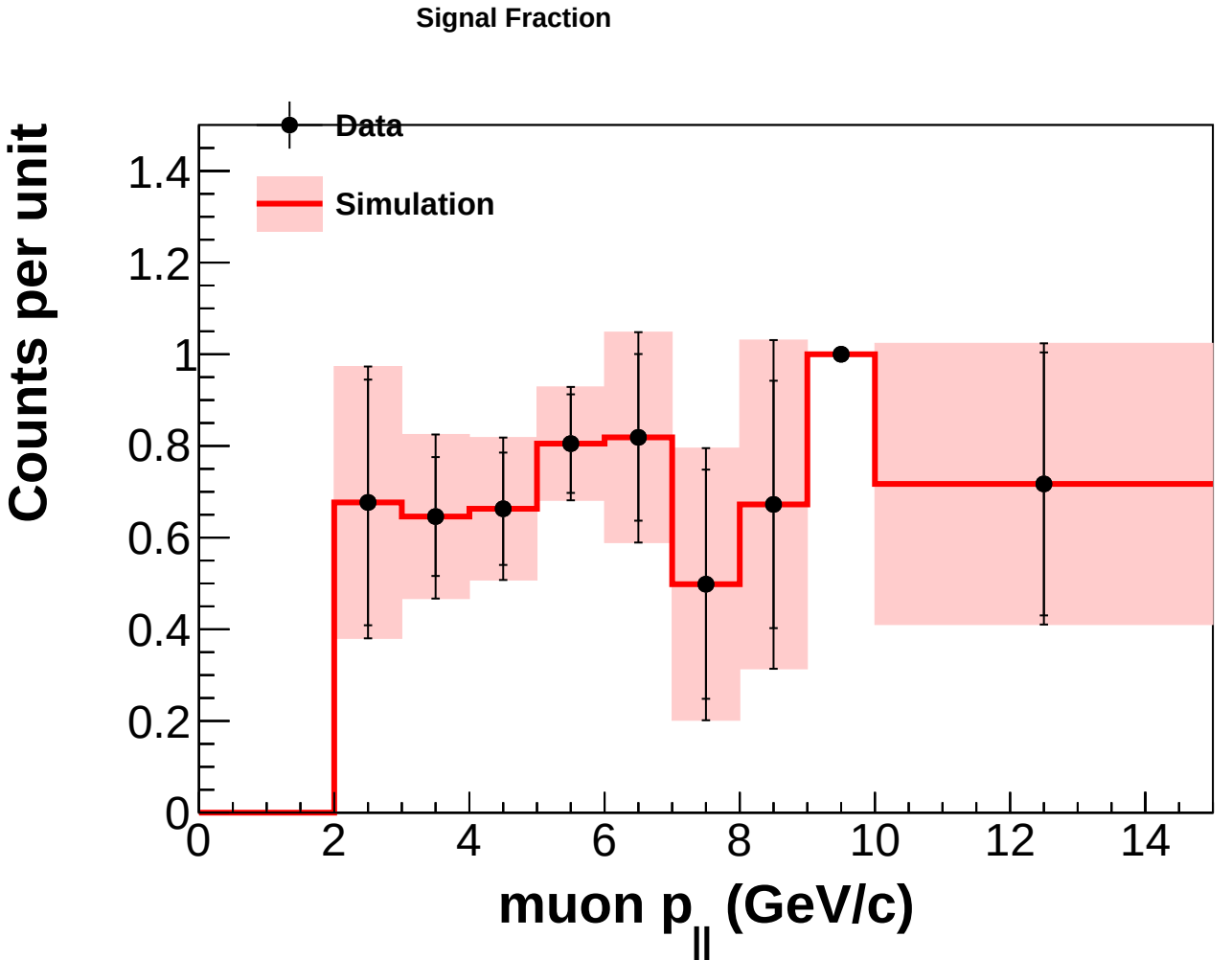

sigma
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

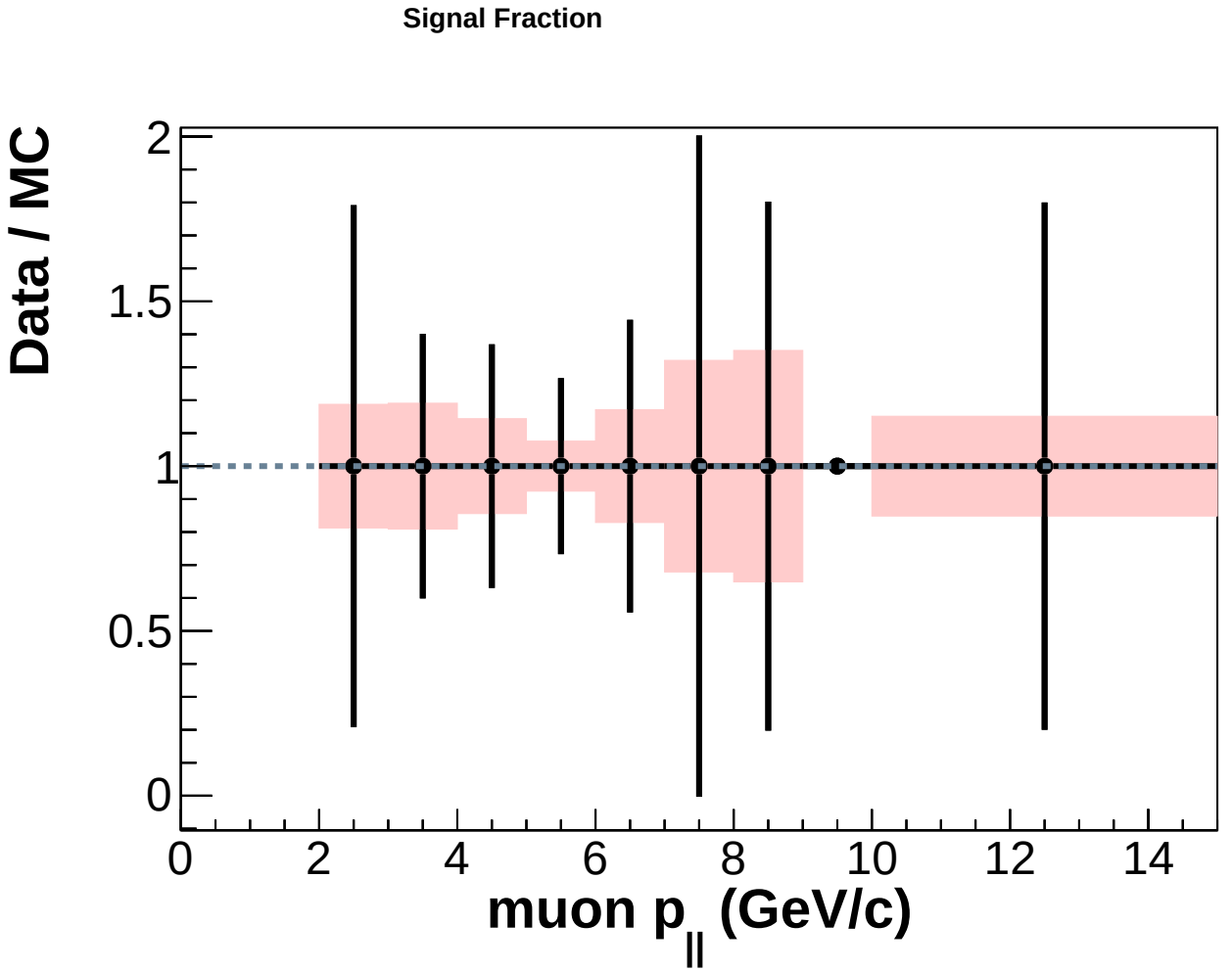

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

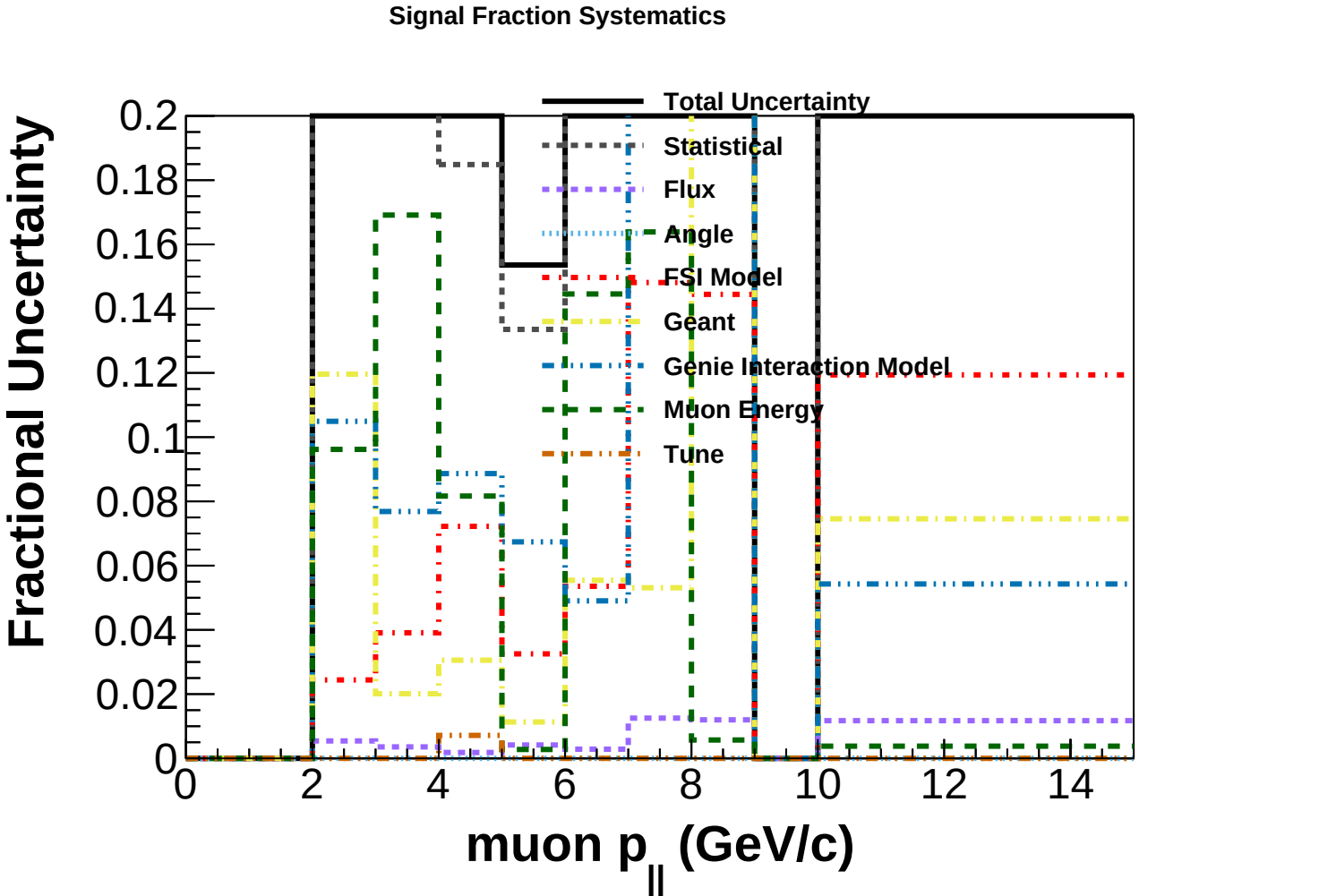

DATA_vs_MC
Data
Simulation
Counts per unit
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

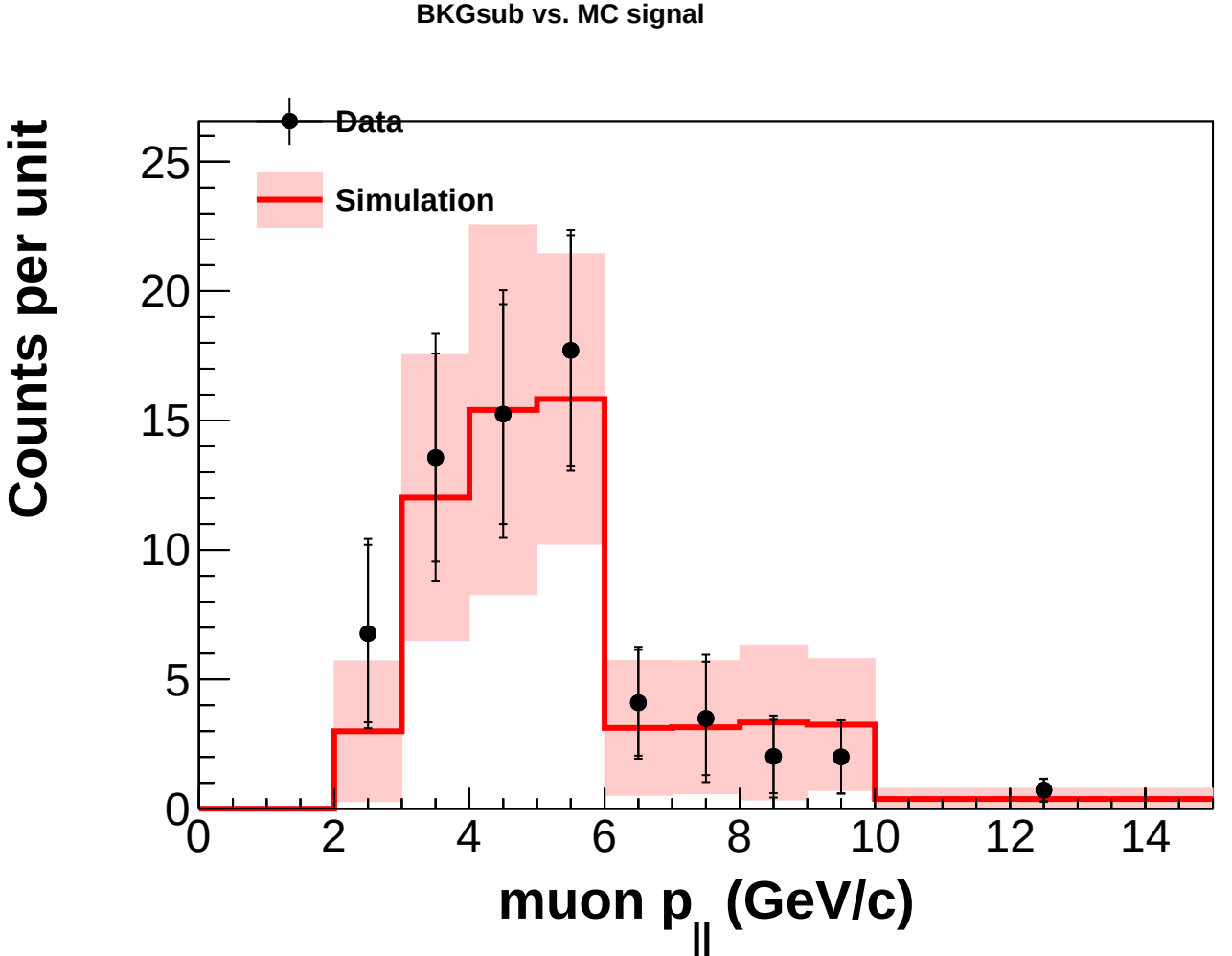

DATA_vs_MC
Data / MC
3
2.5
2
1.5
1
0.5
0
−0.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

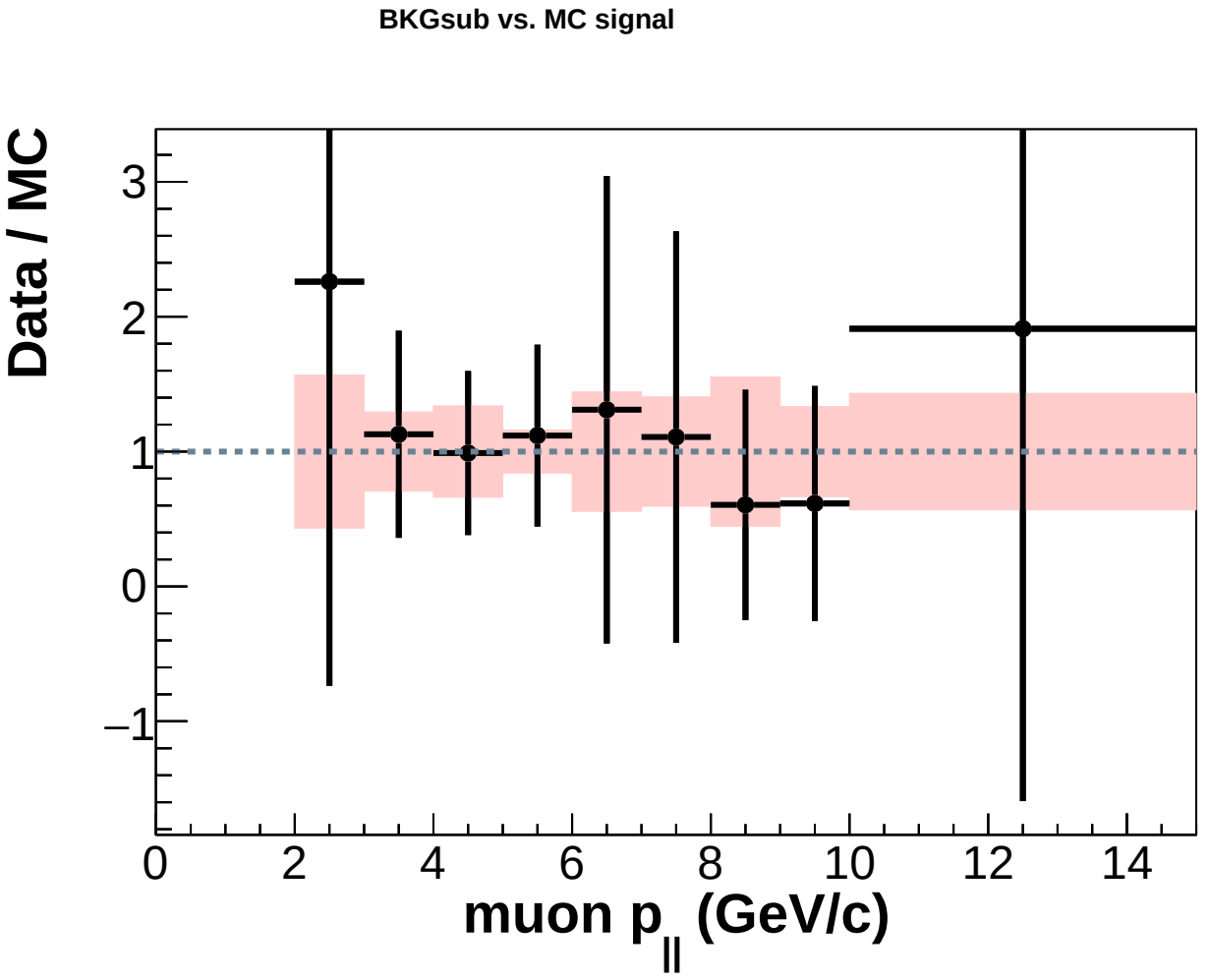

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

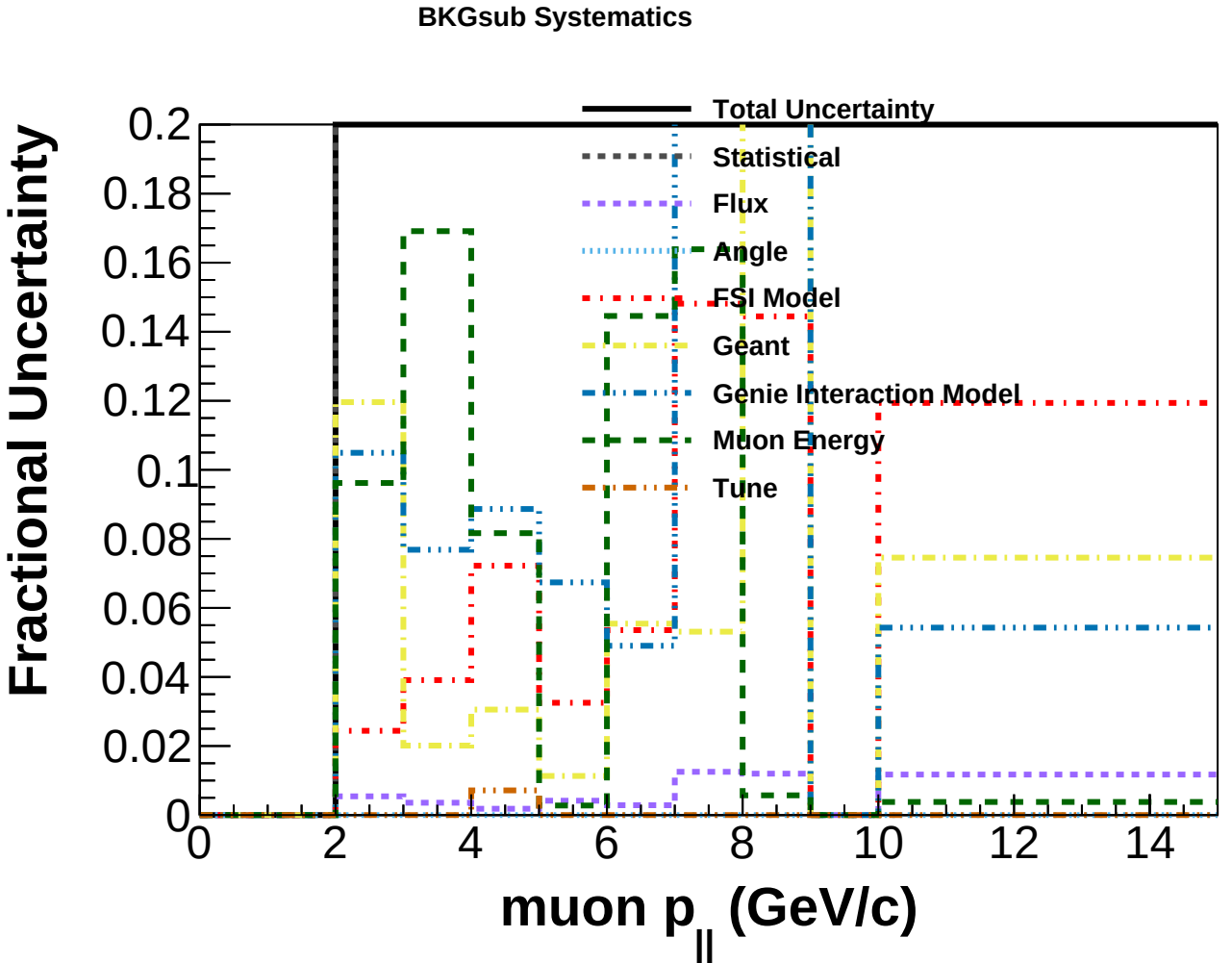

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

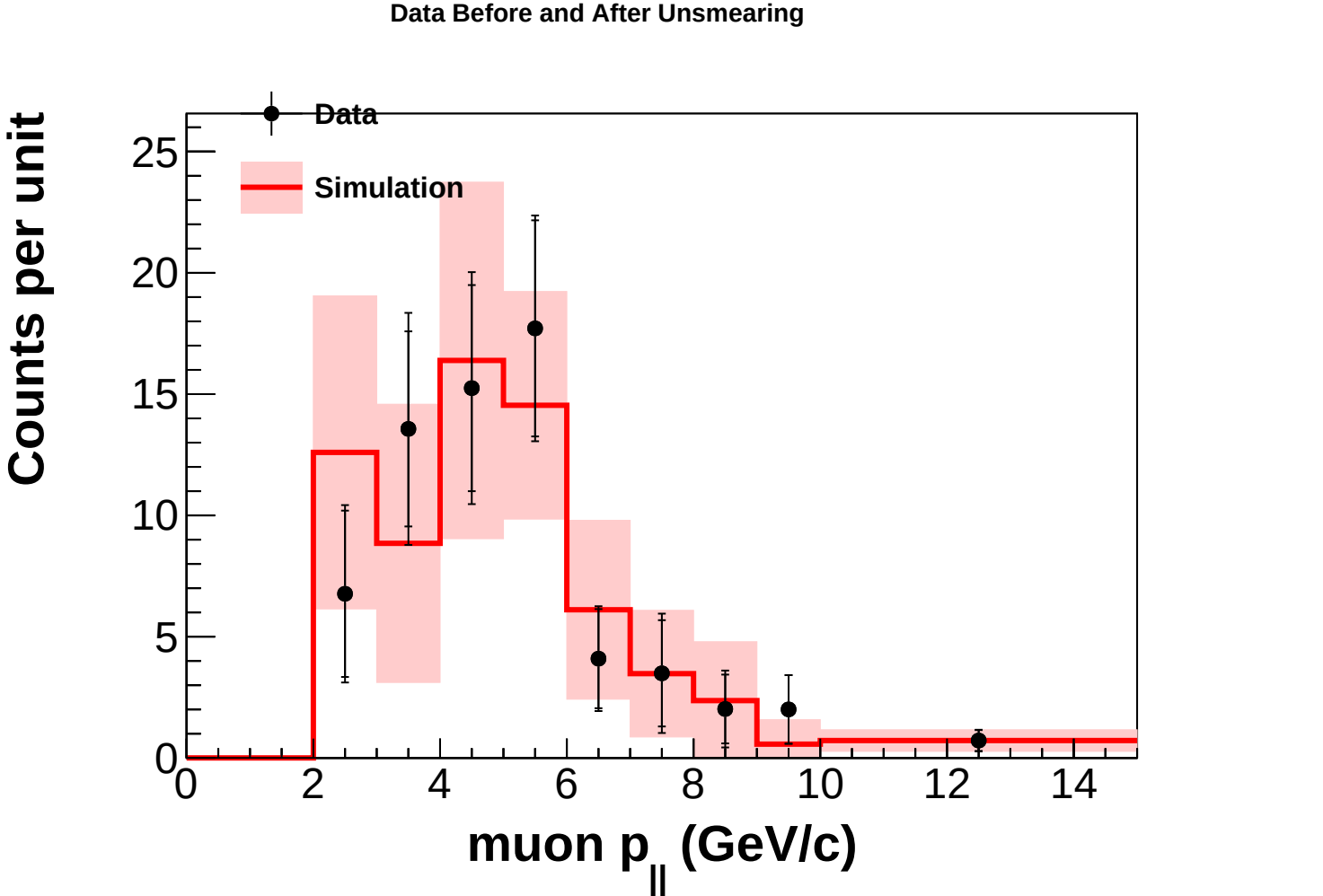

Signal Fraction
Data / MC
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

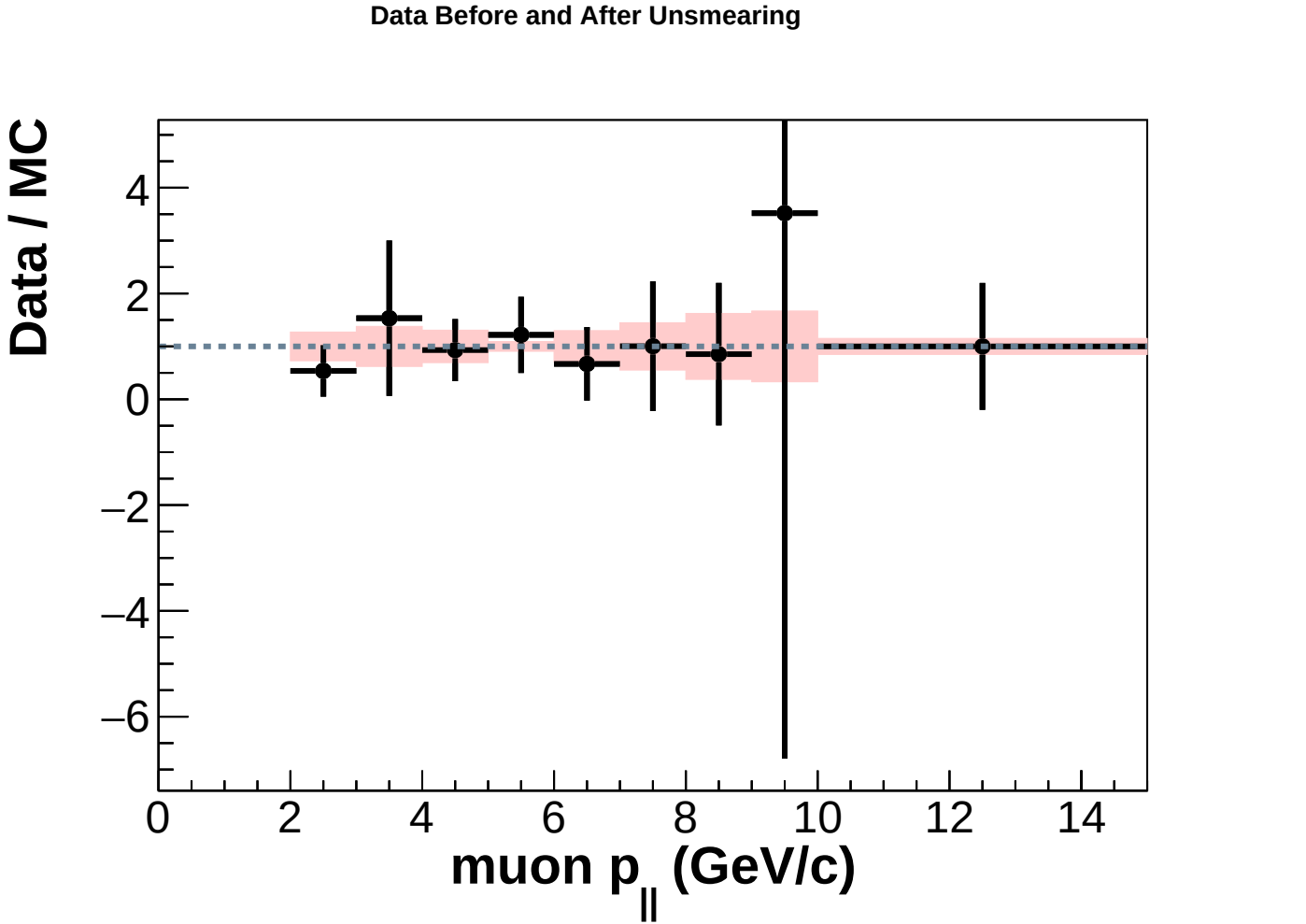

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

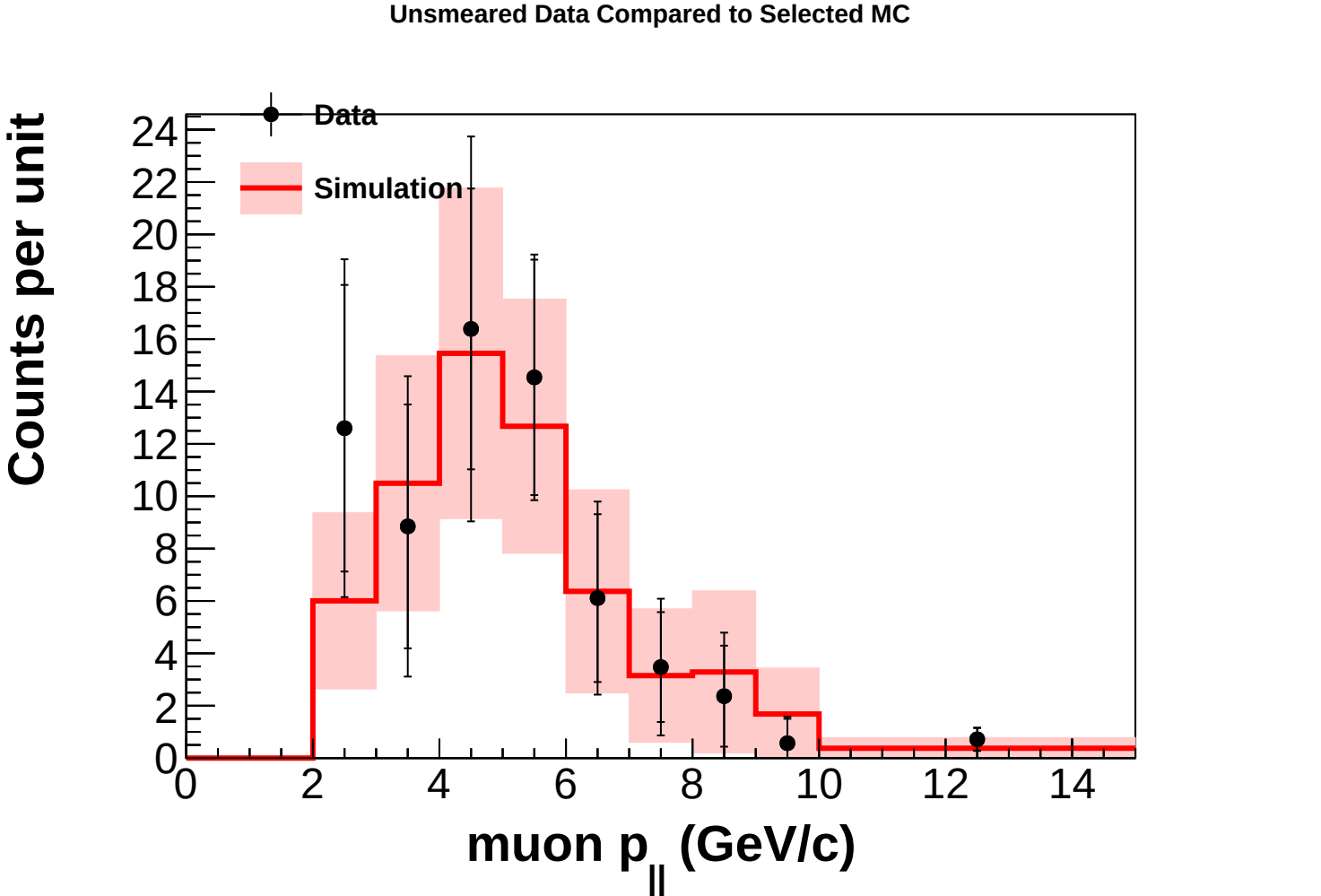

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
5
10
15
20
25
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

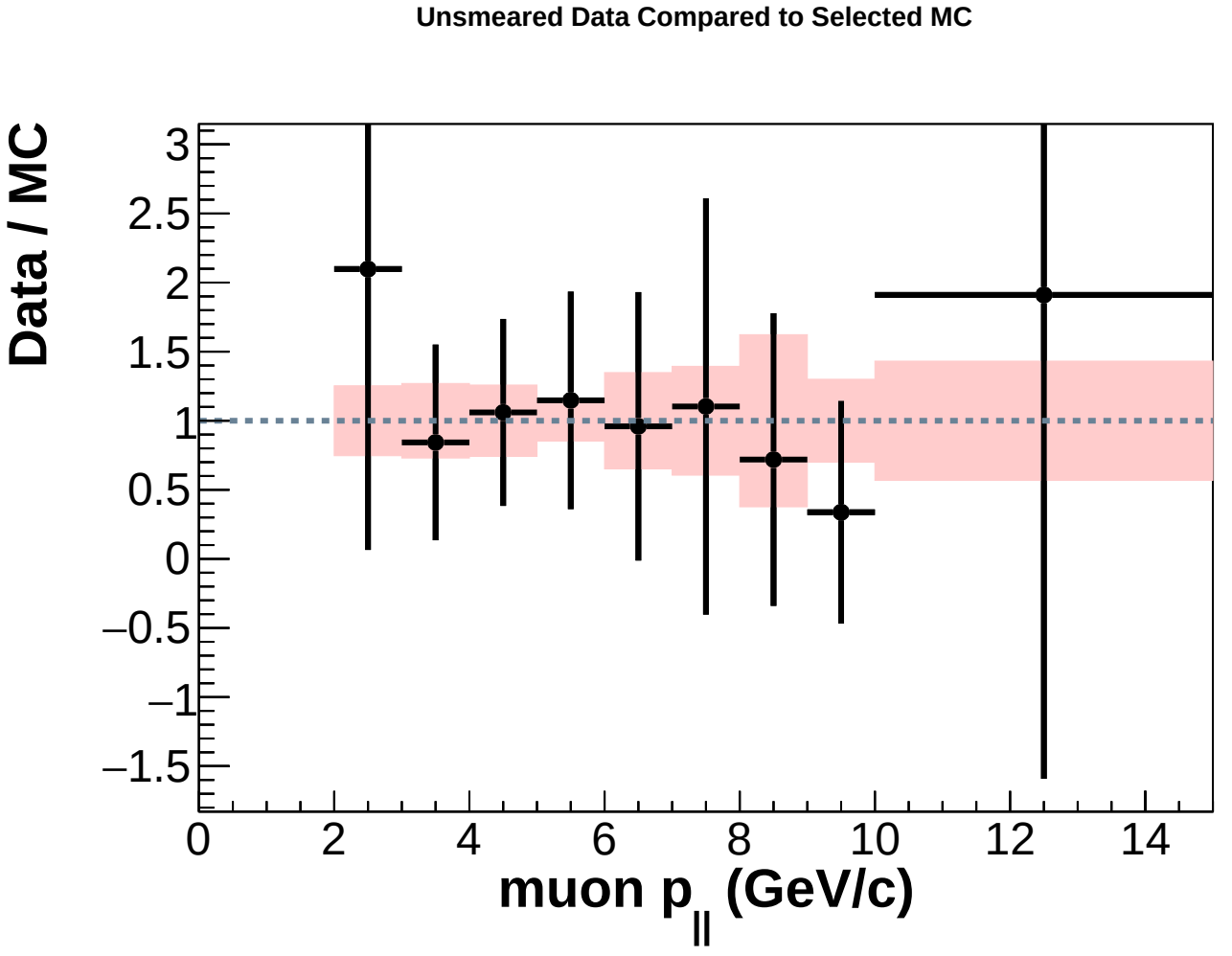

BKGsub vs. MC signal
Data / MC
3
2
1
0
−1
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

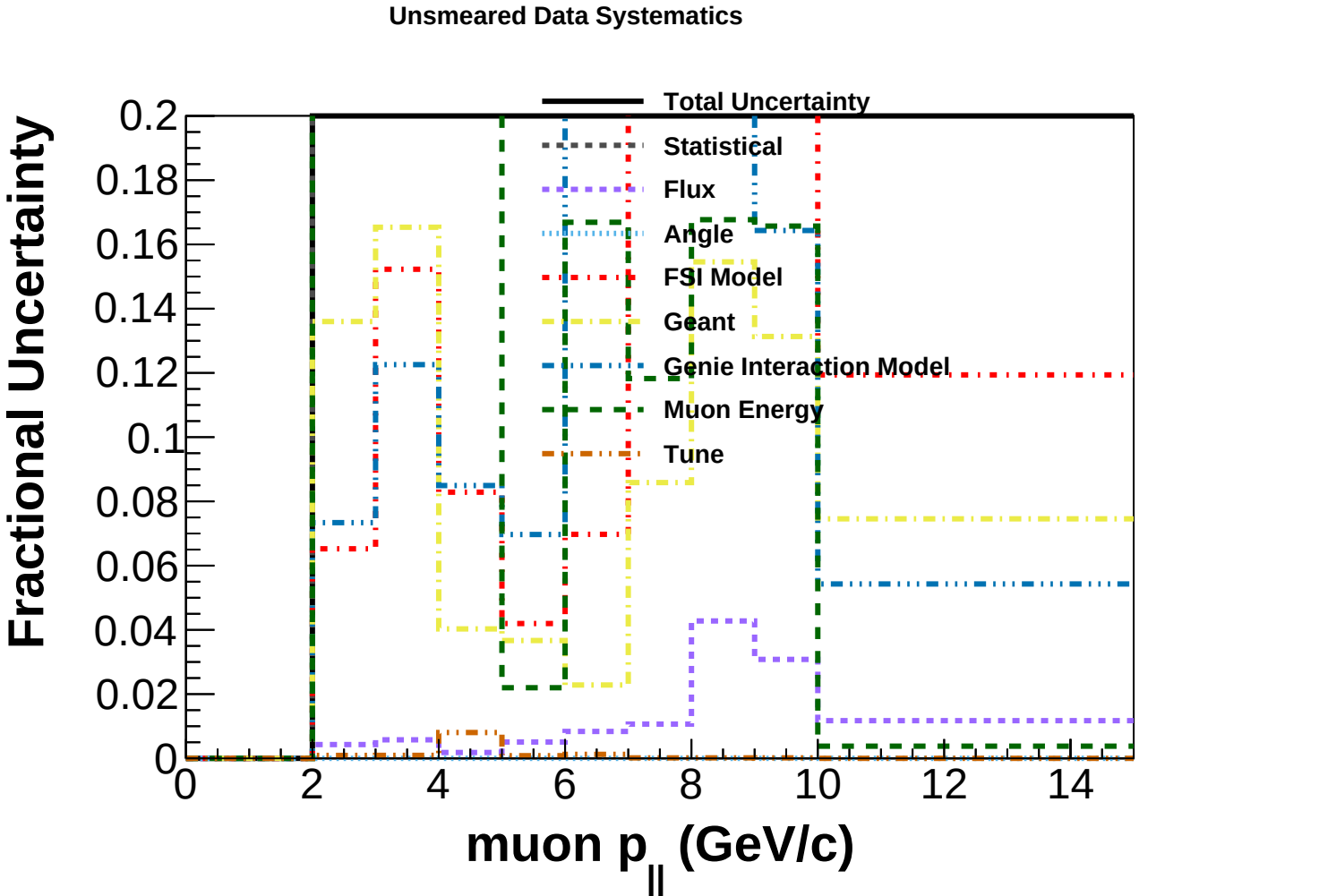

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

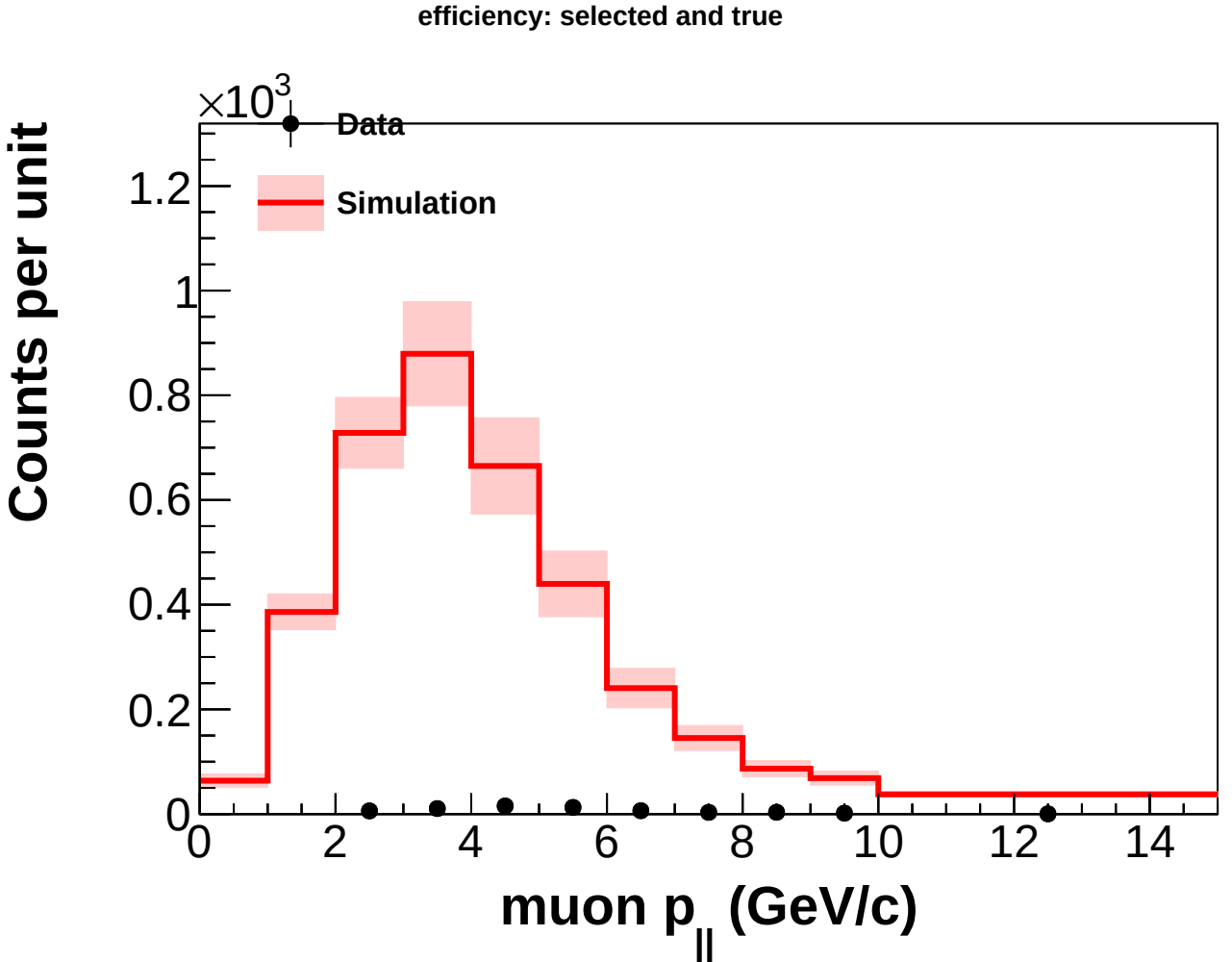

Data Before and After Unsmearing
Data
Simulation
Counts per unit
muon p_ll (GeV/c)
0
5
10
15
20
25
0
2
4
6
8
10
12
14

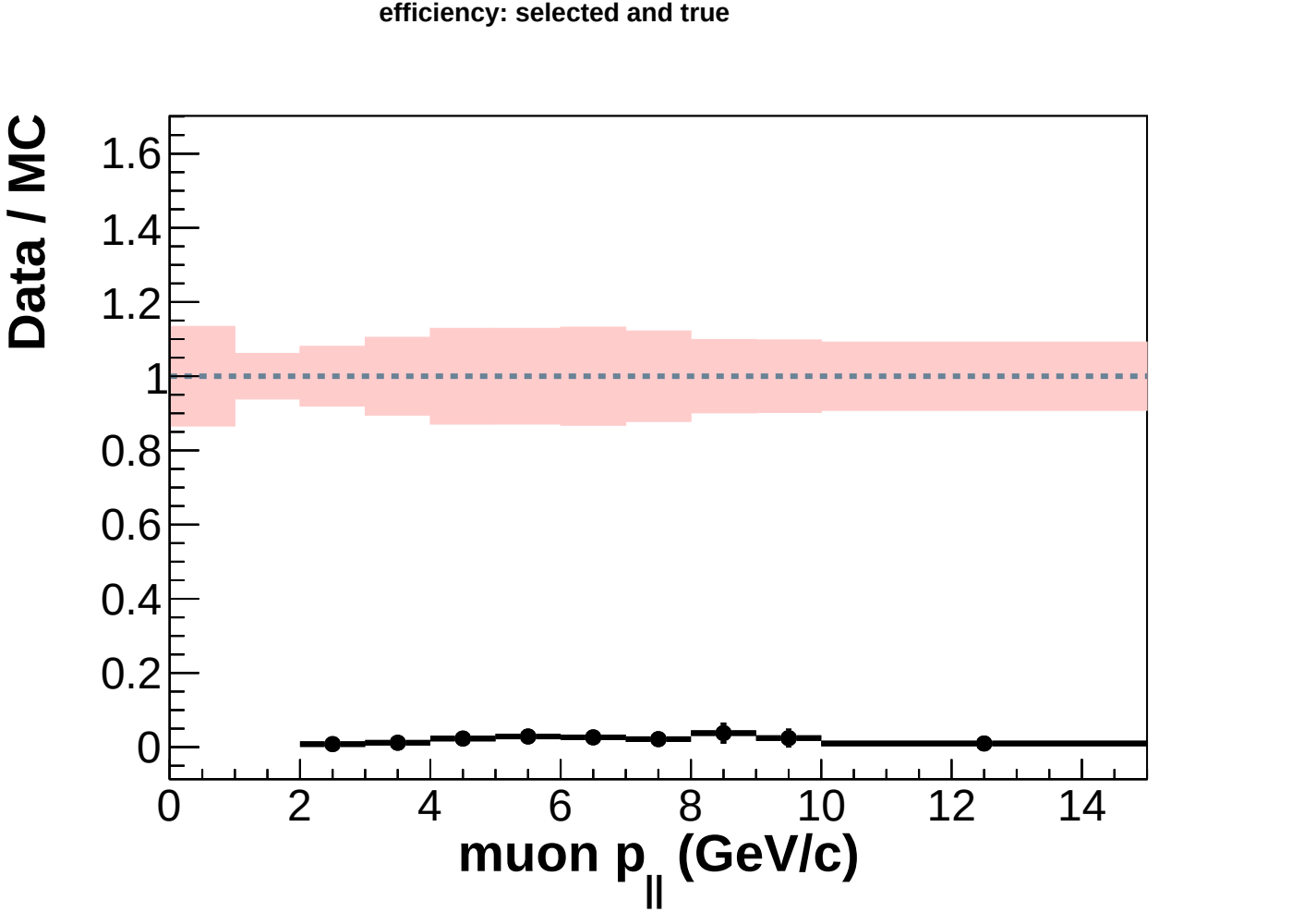

Data Before and After Unsmearing
Data / MC
4
2
0
−2
−4
−6
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

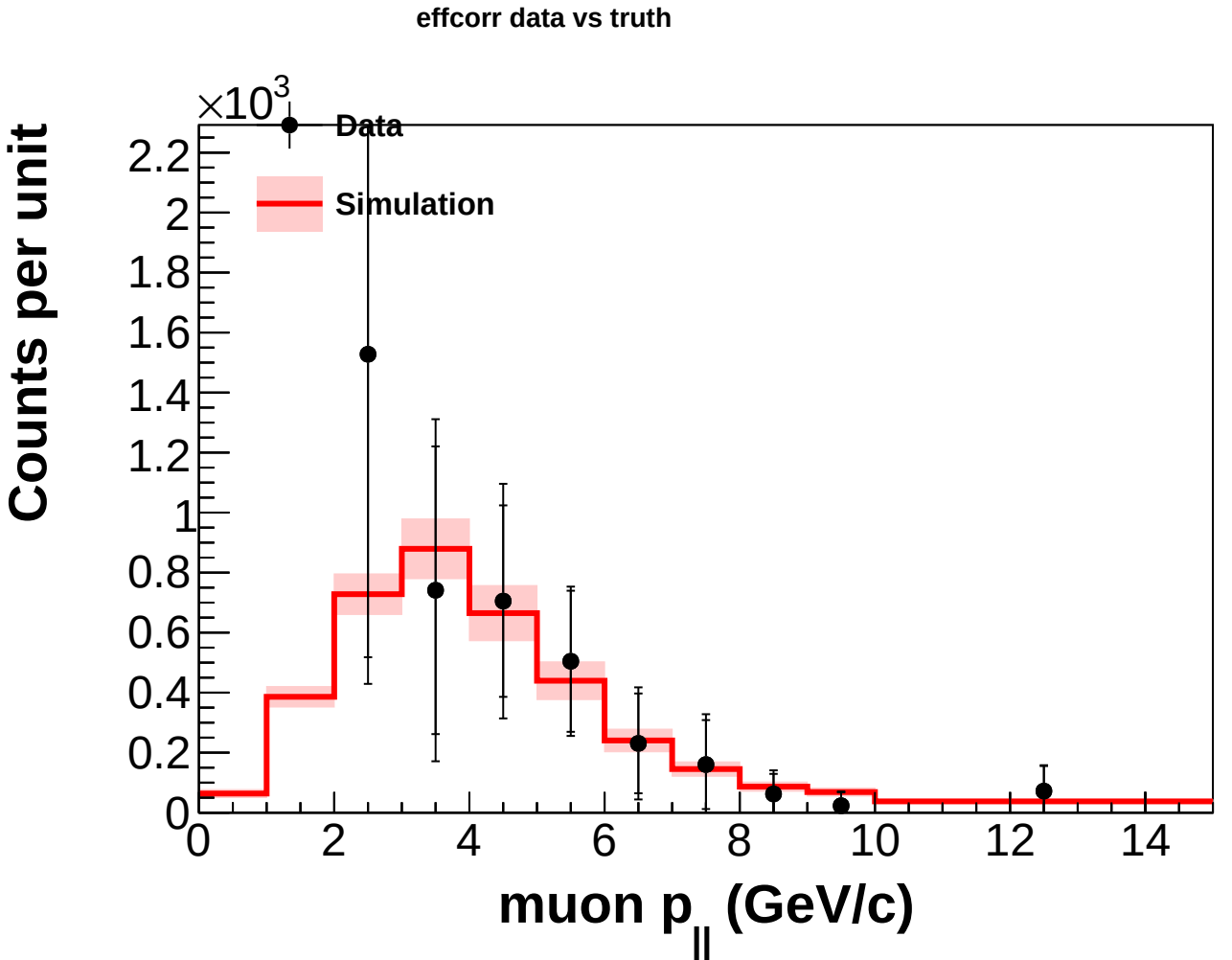

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
muon p_ll (GeV/c)
0
2
4
6
8
10
12
14
16
18
20
22
24

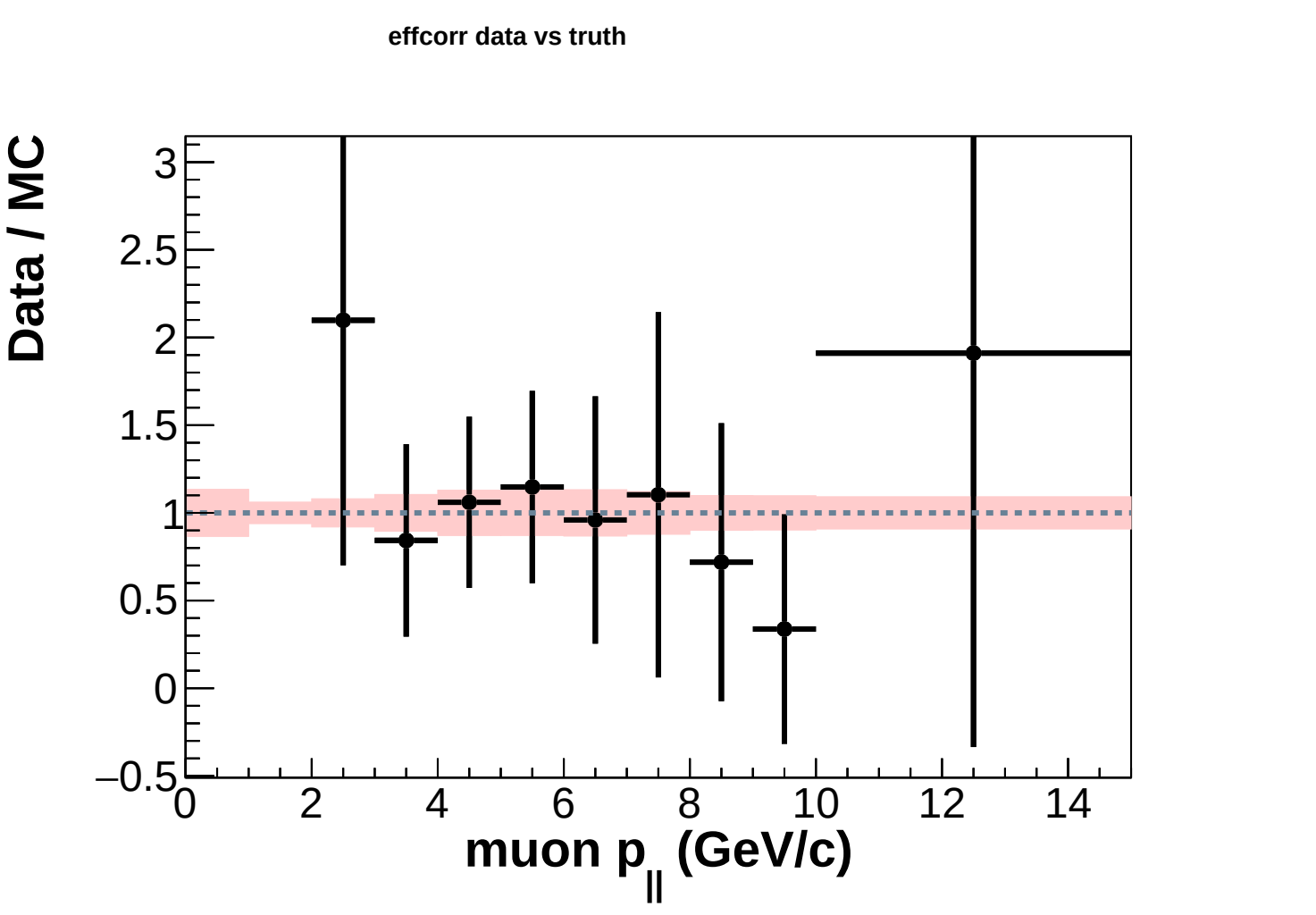

Unsmeared Data Compared to Selected MC
Data / MC
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

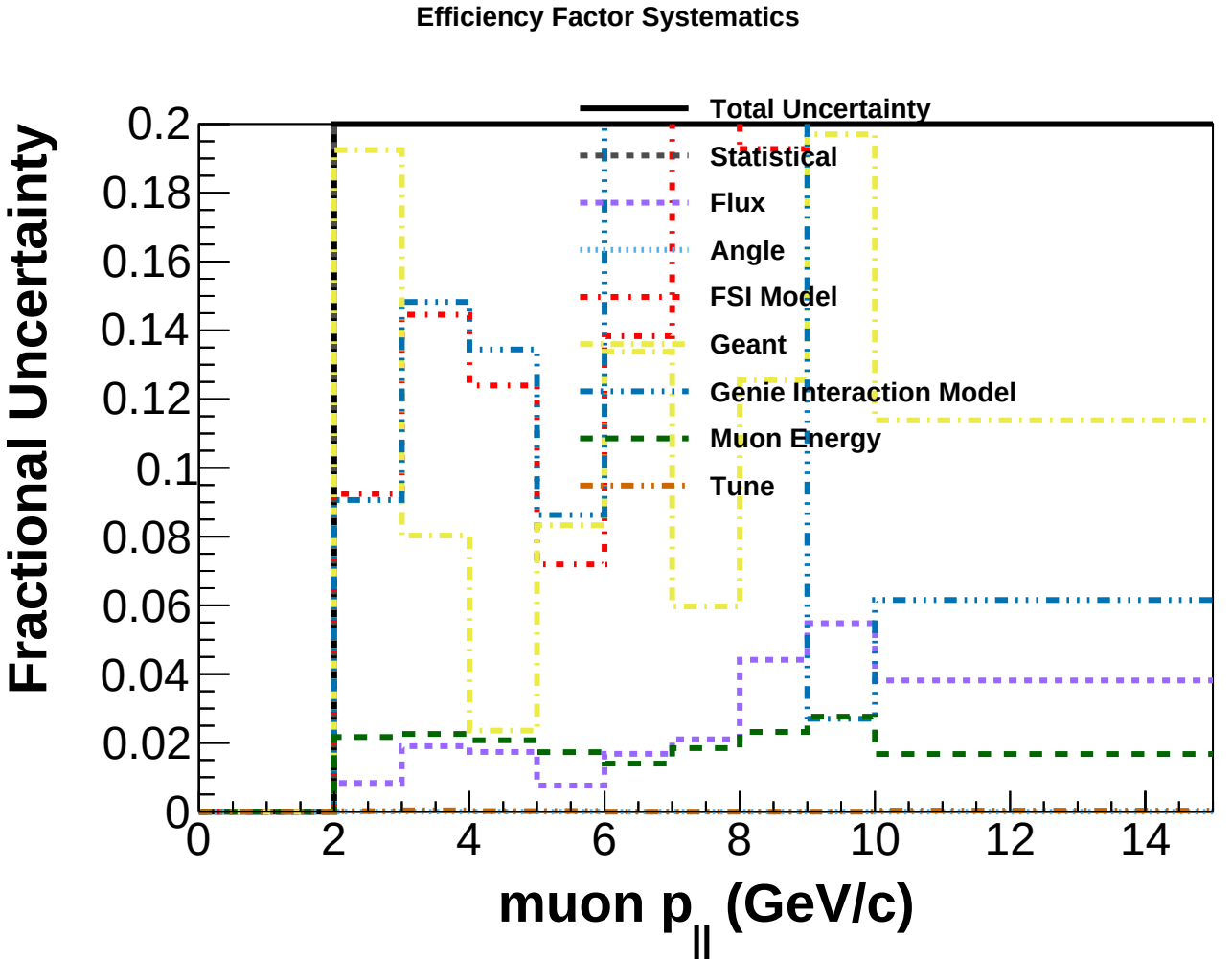

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

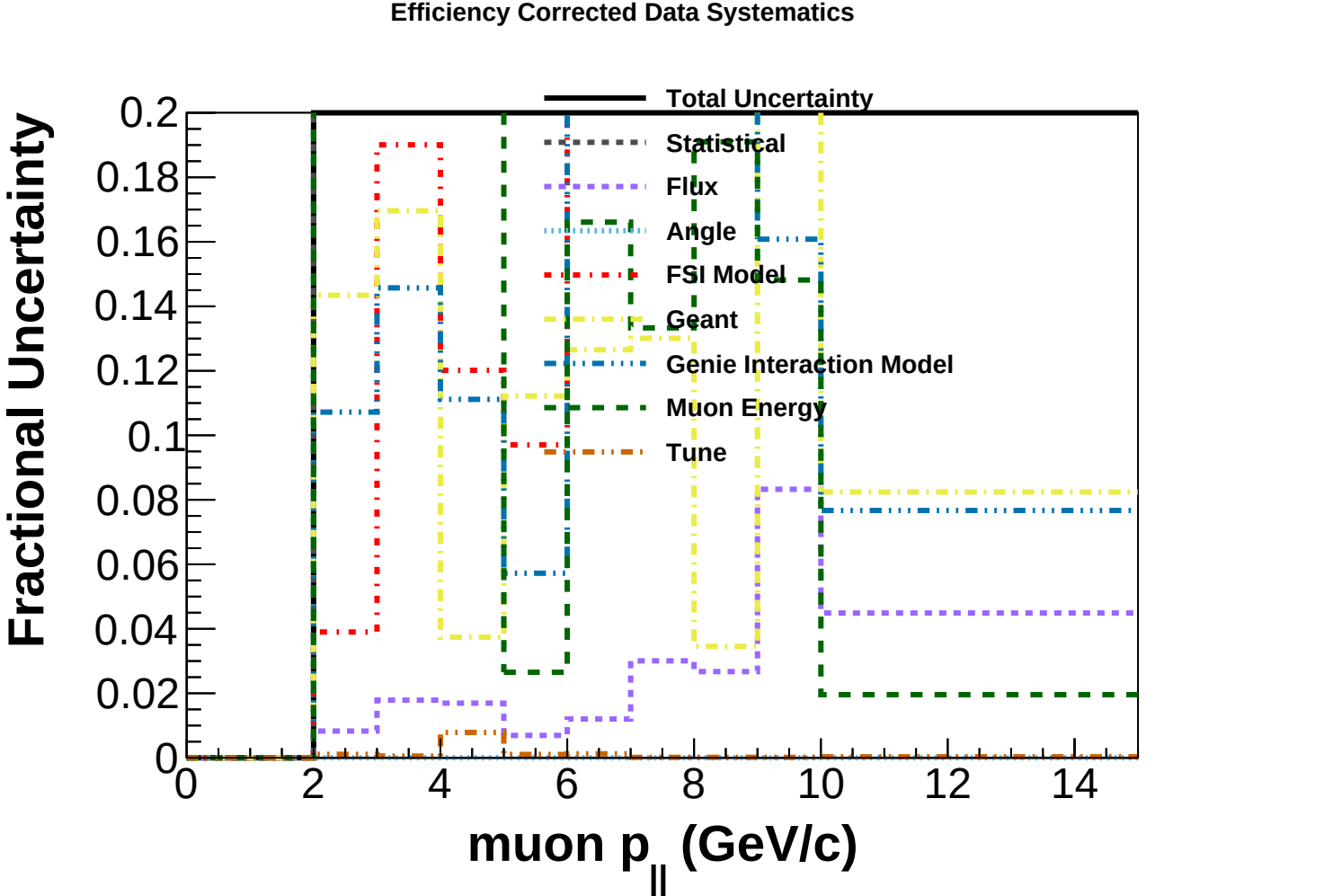

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

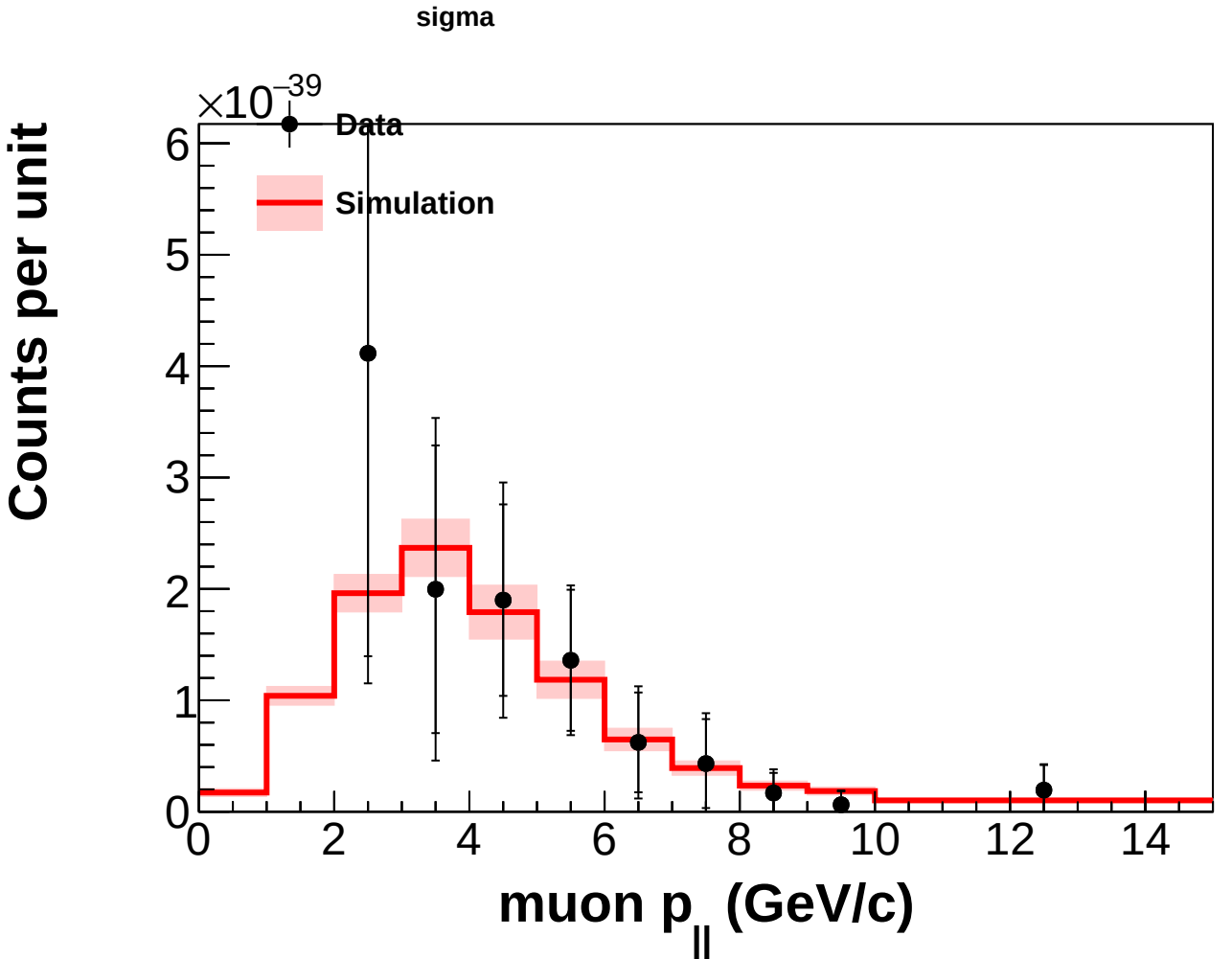

efficiency: selected and true
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


effcorr data vs truth
Counts per unit
×10^3
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Data
Simulation
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

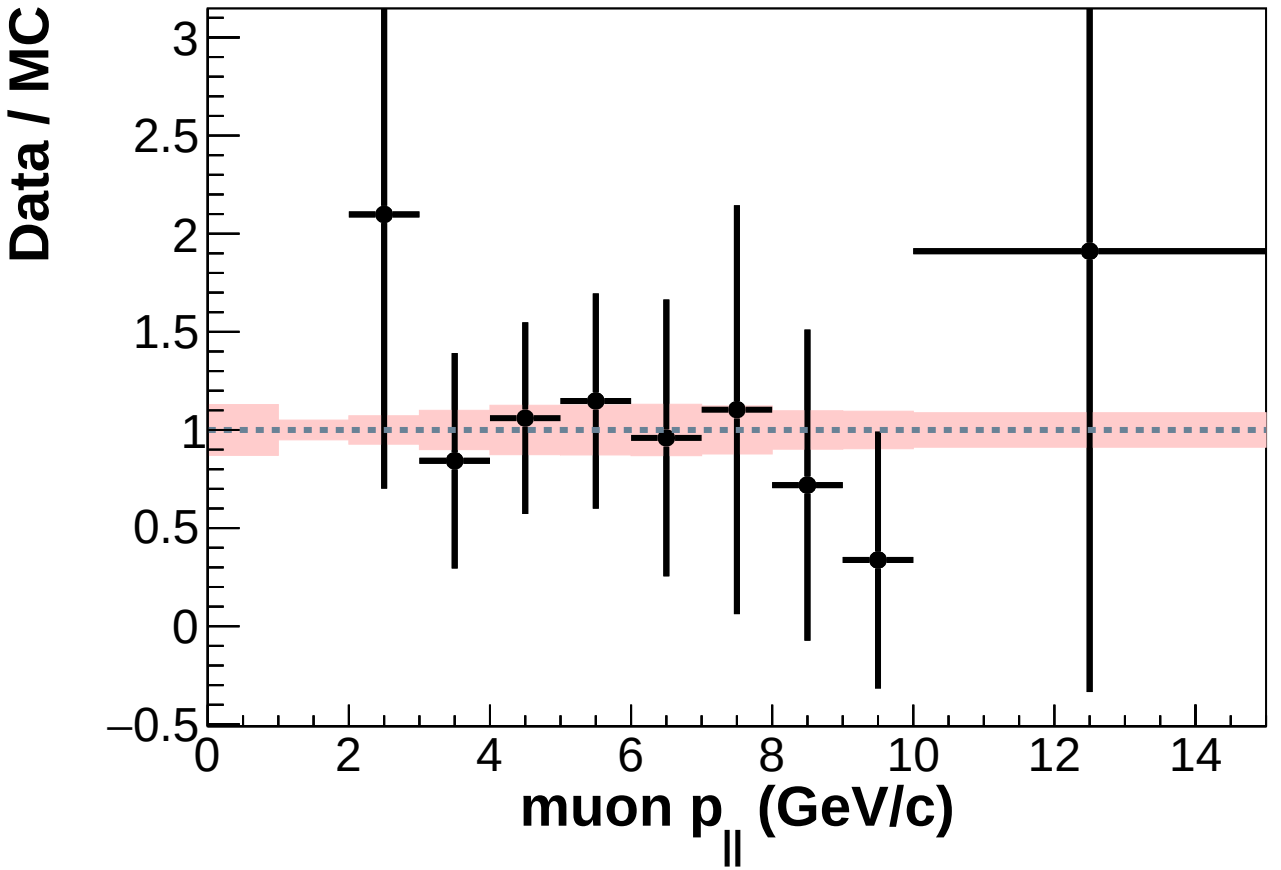

effcorr data vs truth
Data / MC
3
2.5
2
1.5
1
0.5
0
−0.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

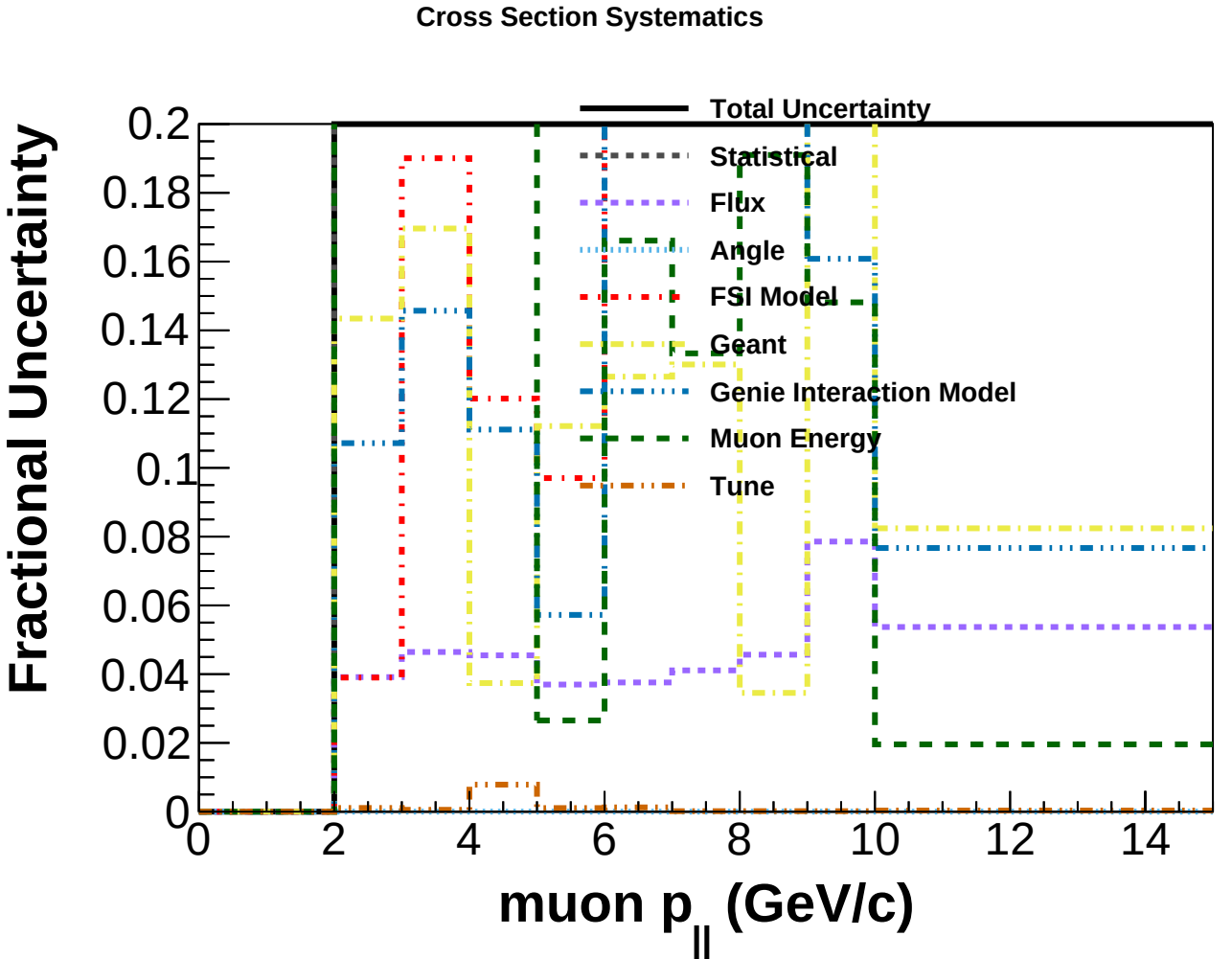

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

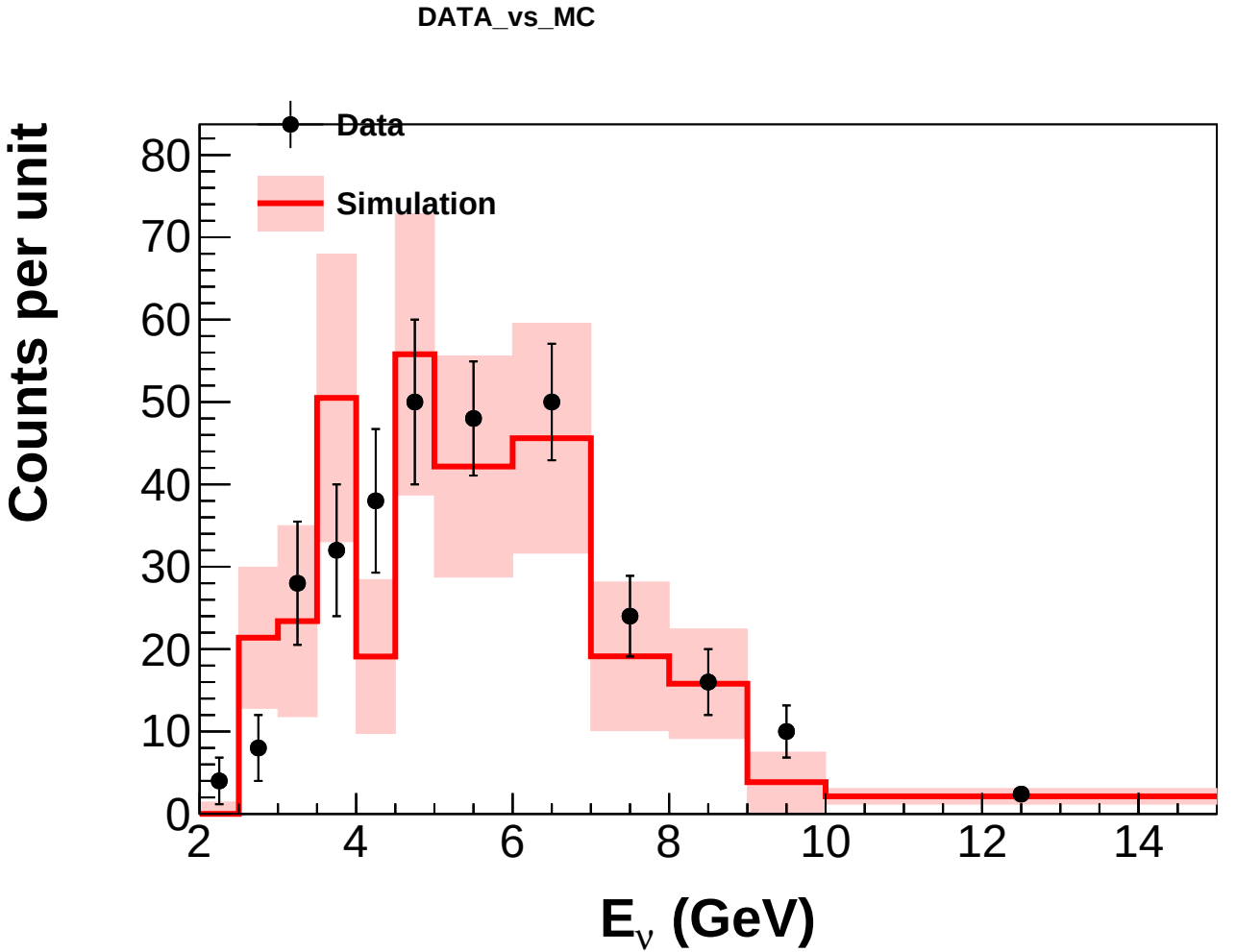

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

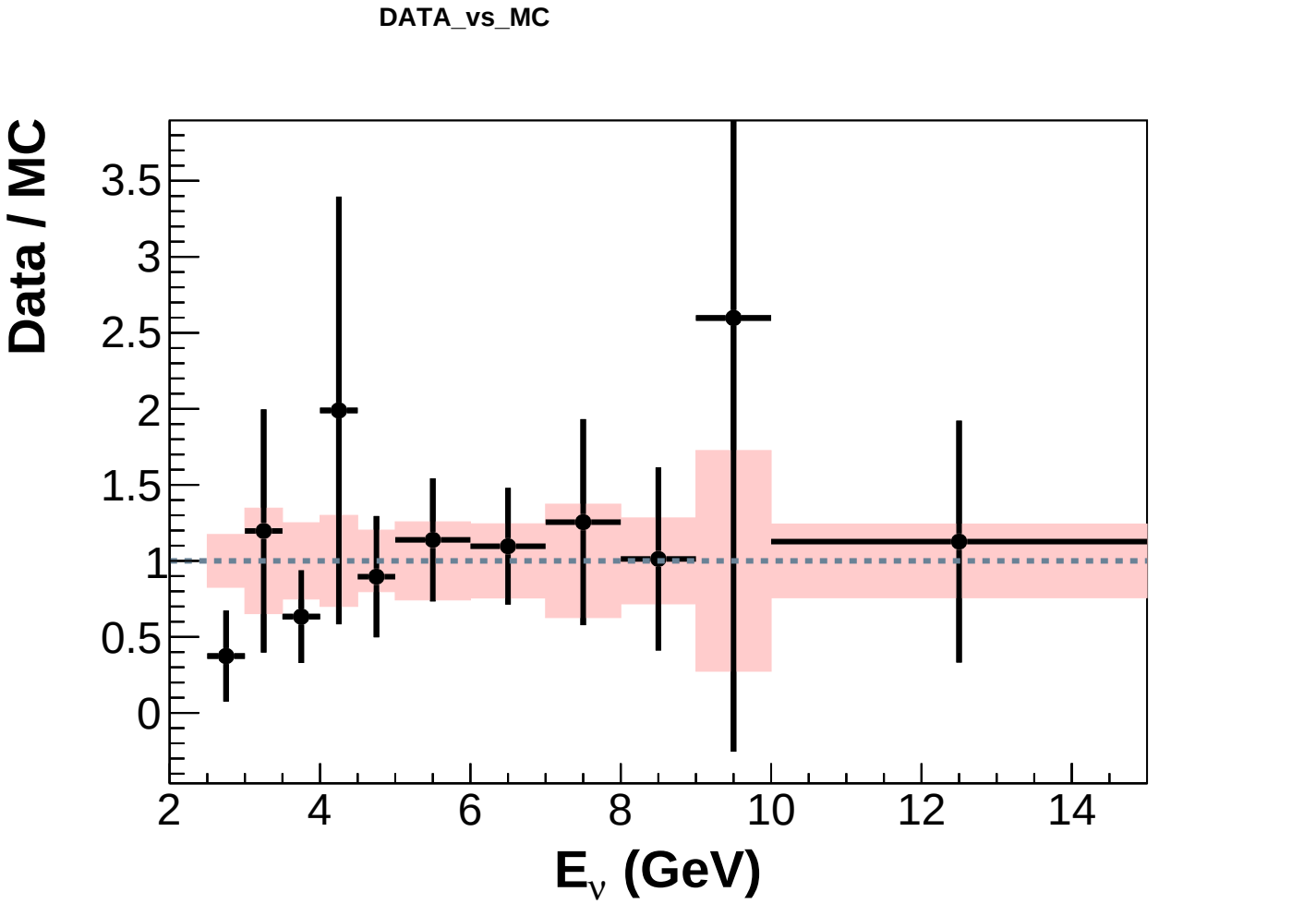

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

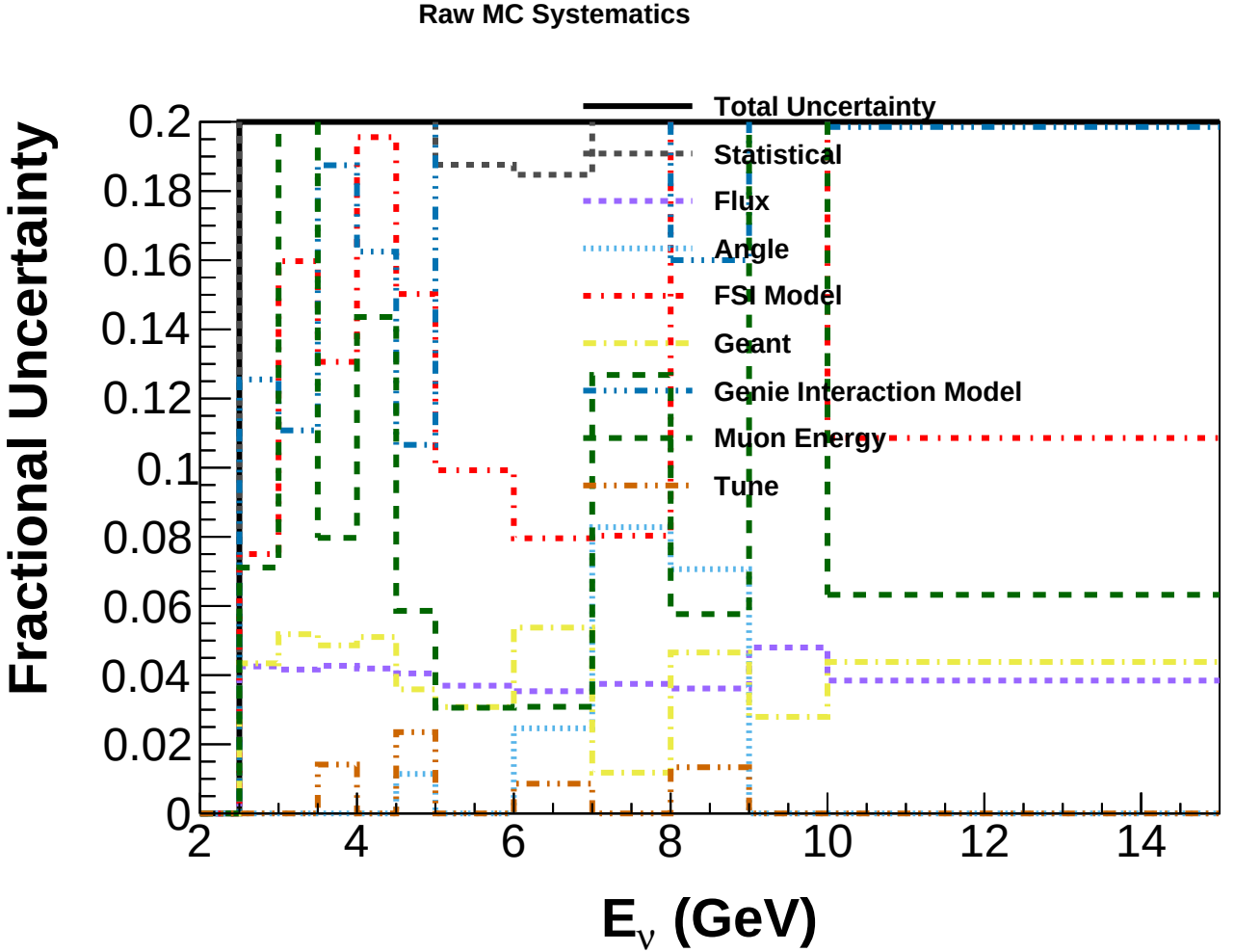
sigma

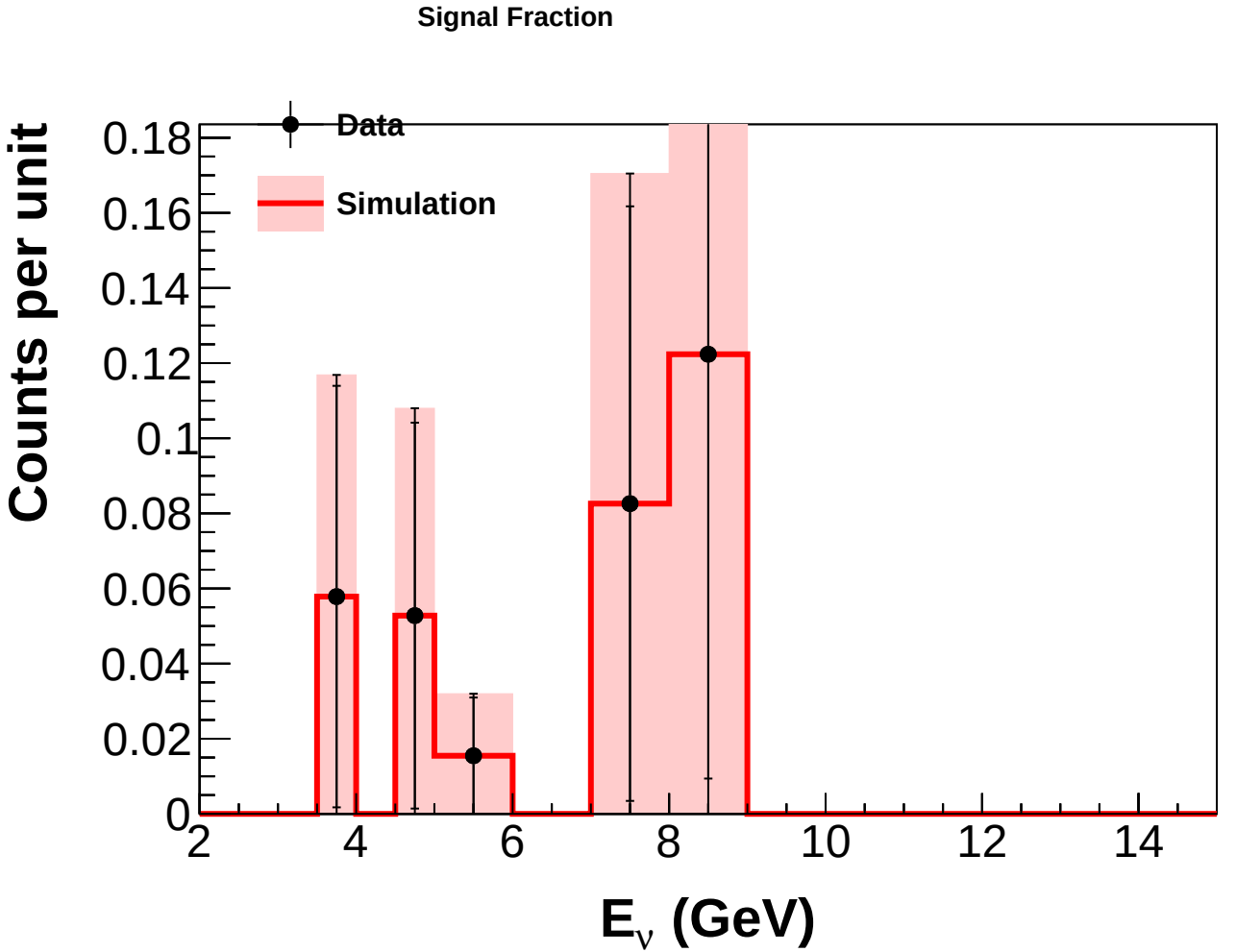


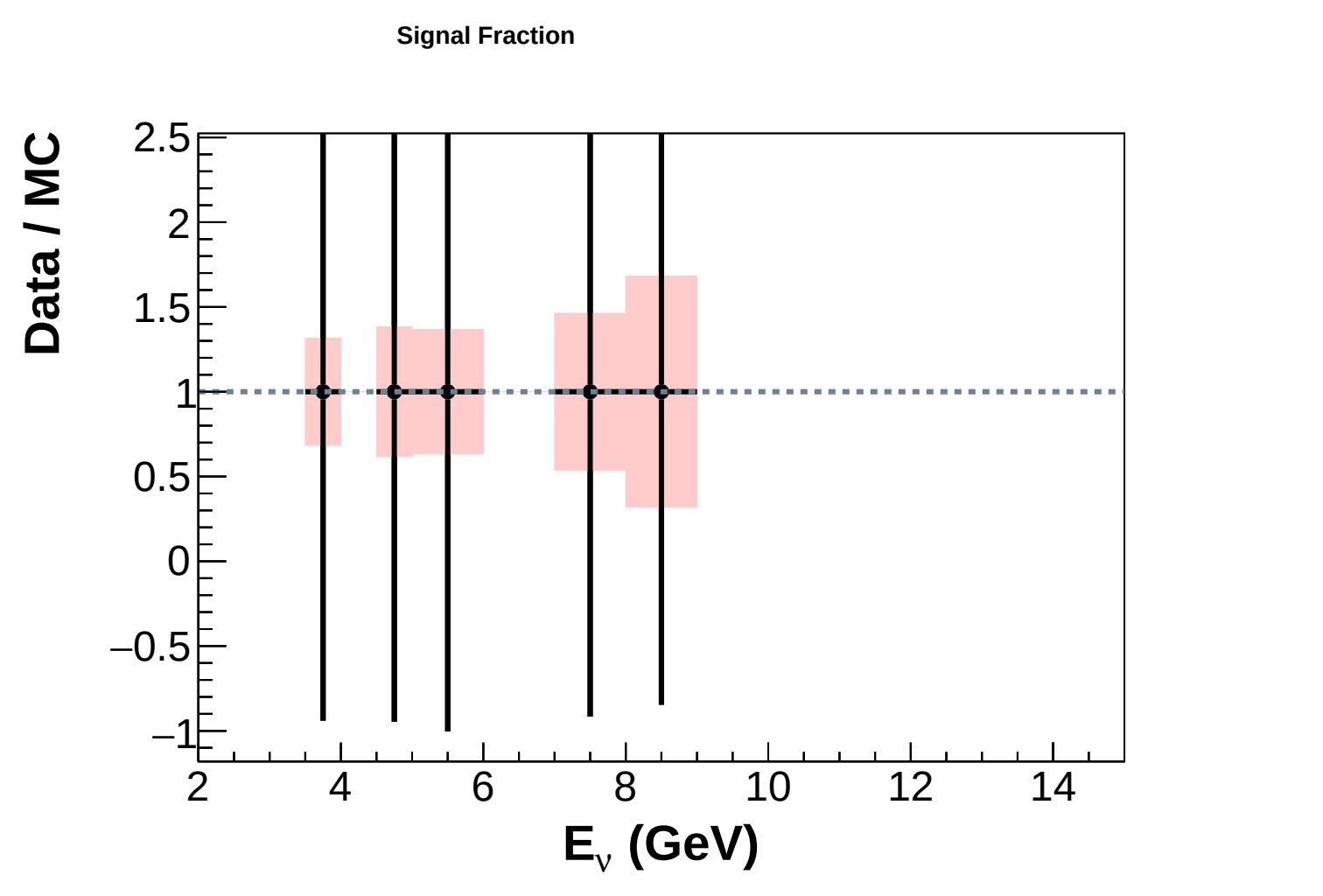

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

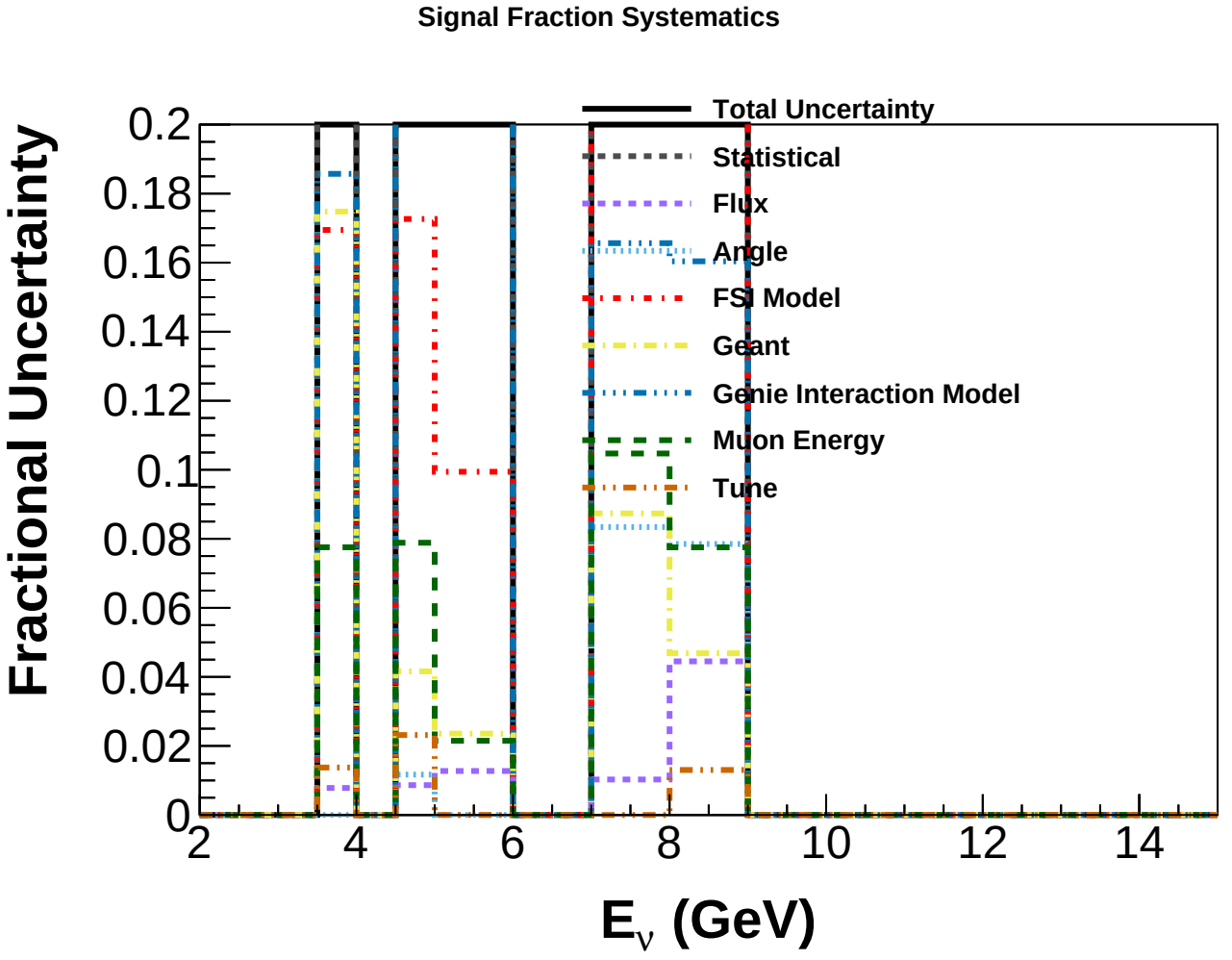

DATA_vs_MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
E_ν (GeV)

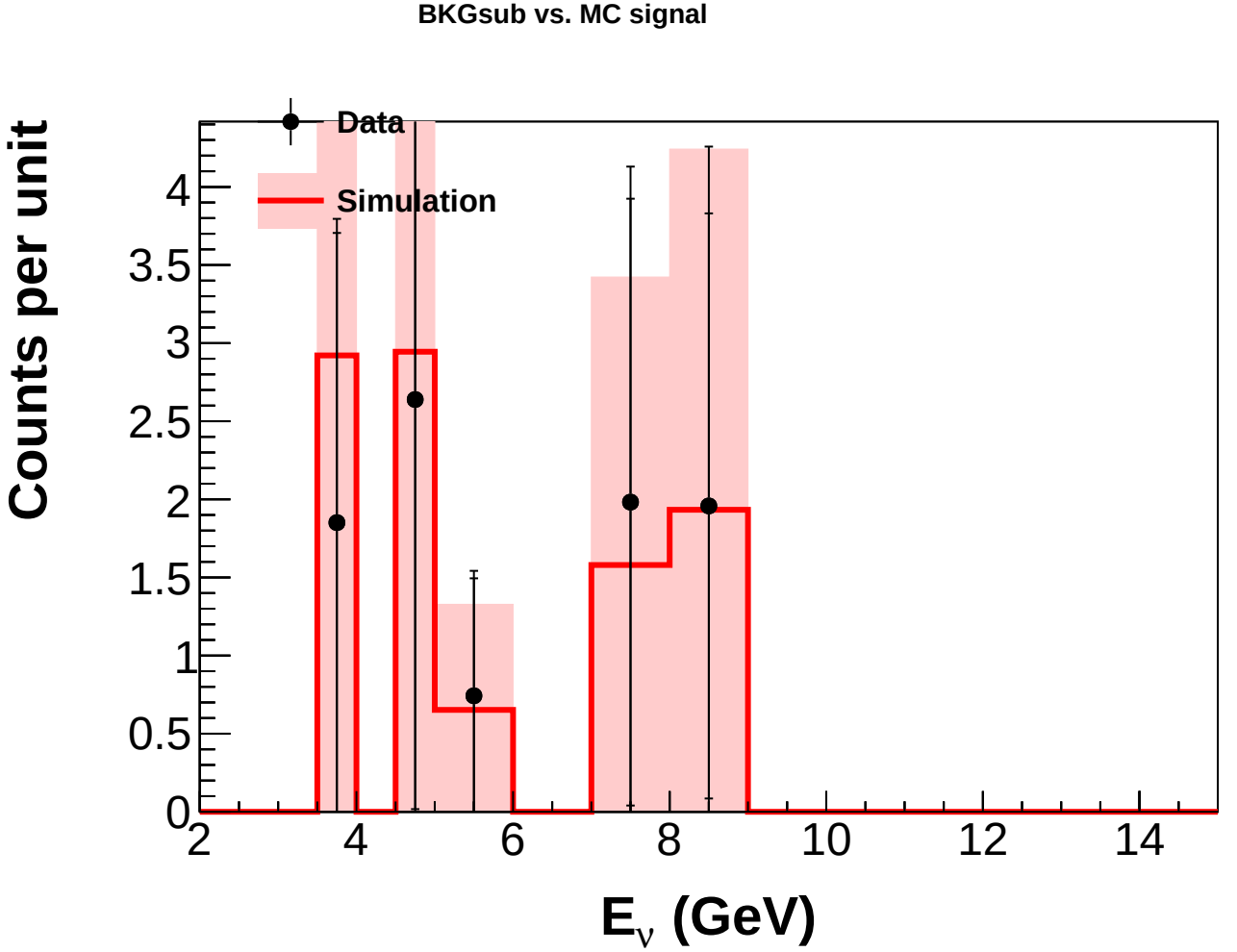

DATA_vs_MC
Data / MC
3.5
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

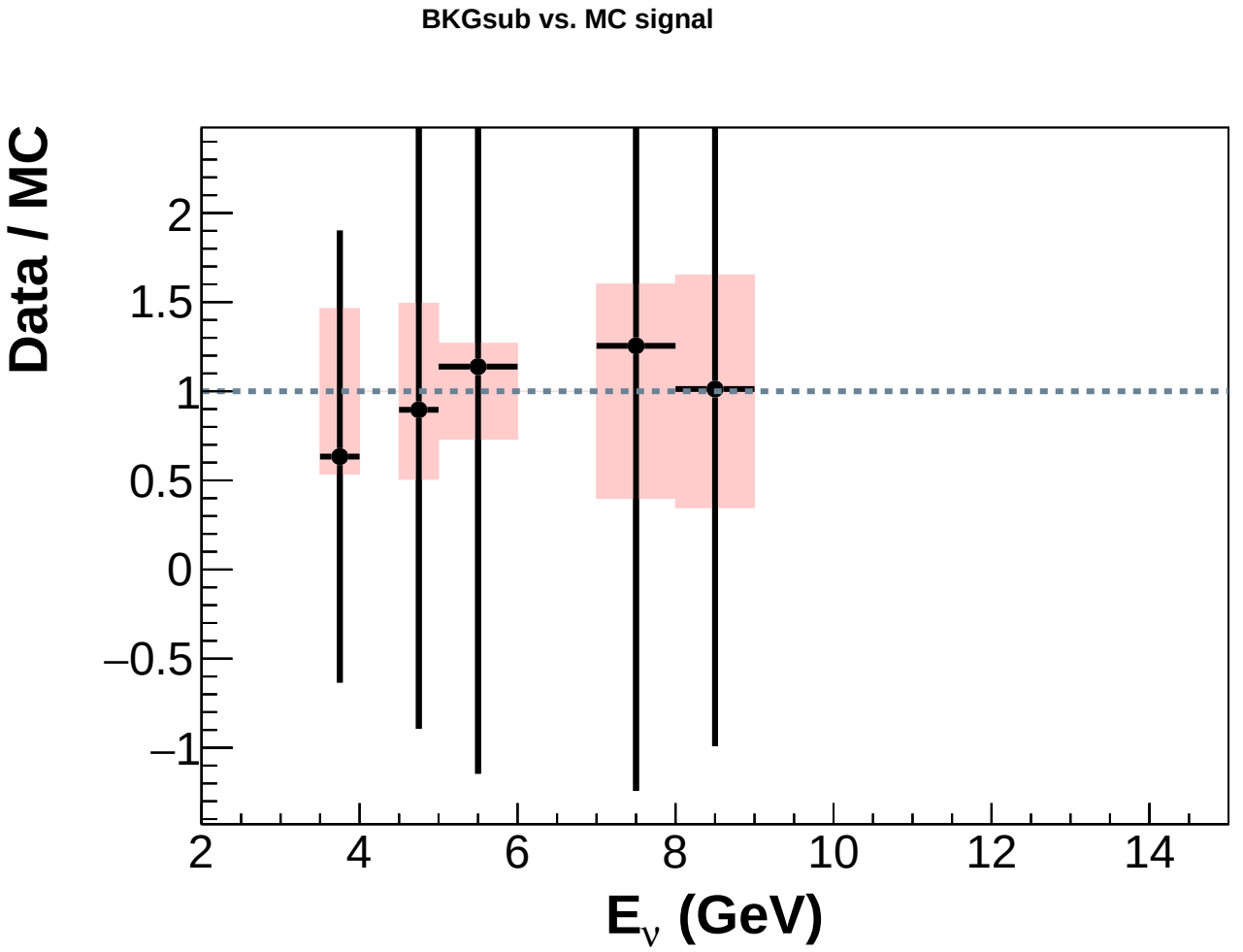

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

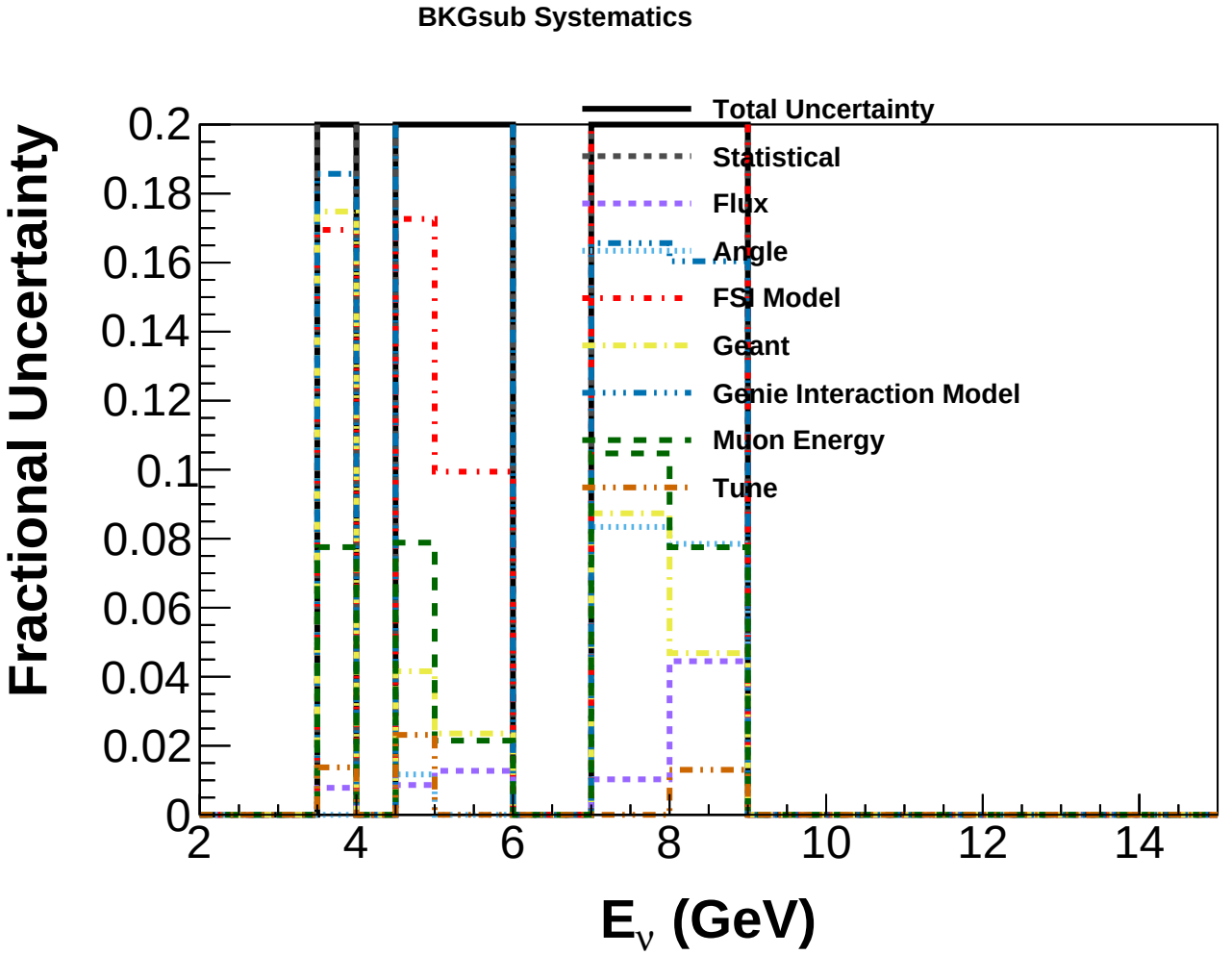

Signal Fraction
Data
Simulation
Counts per unit
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

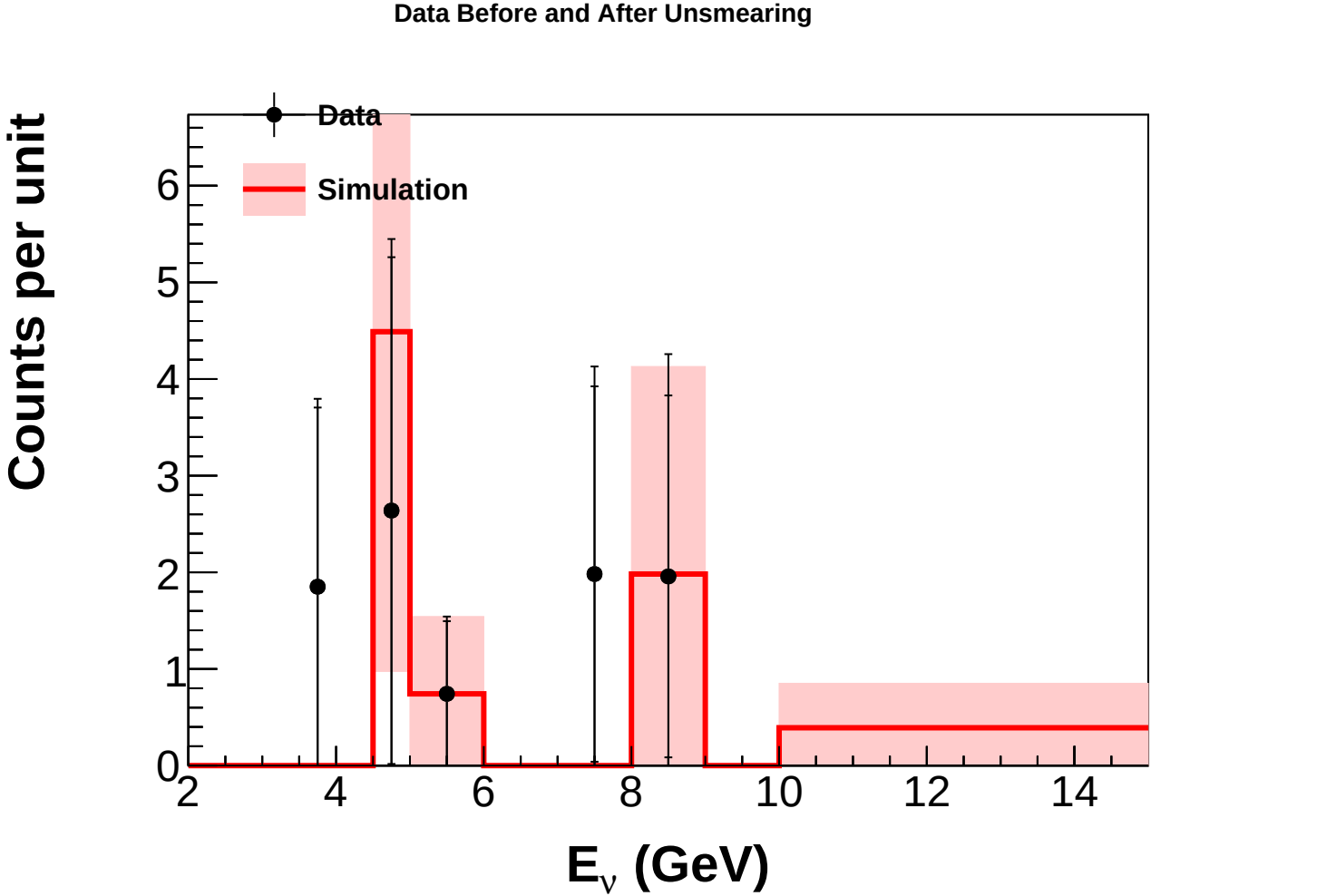

Signal Fraction
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

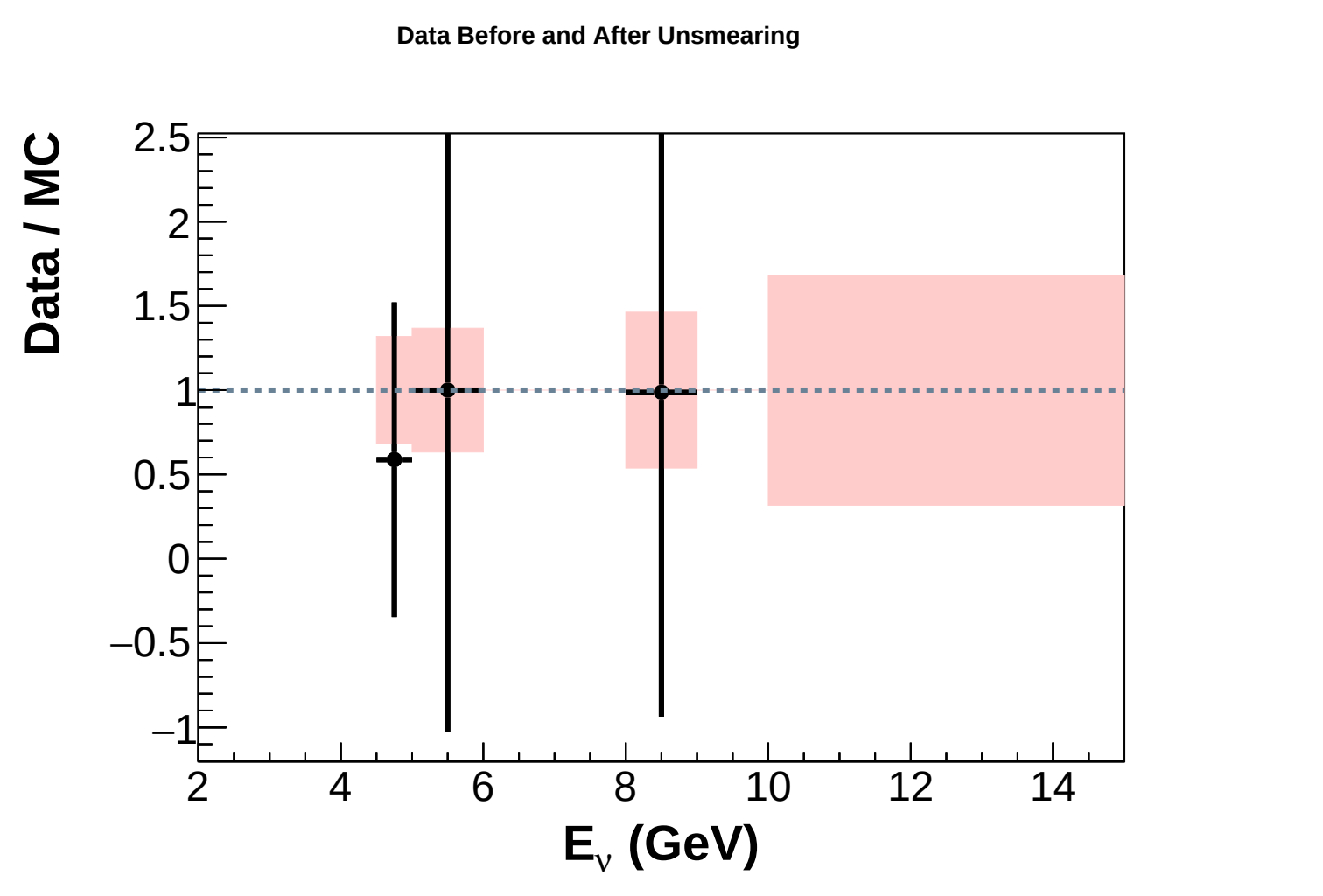

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

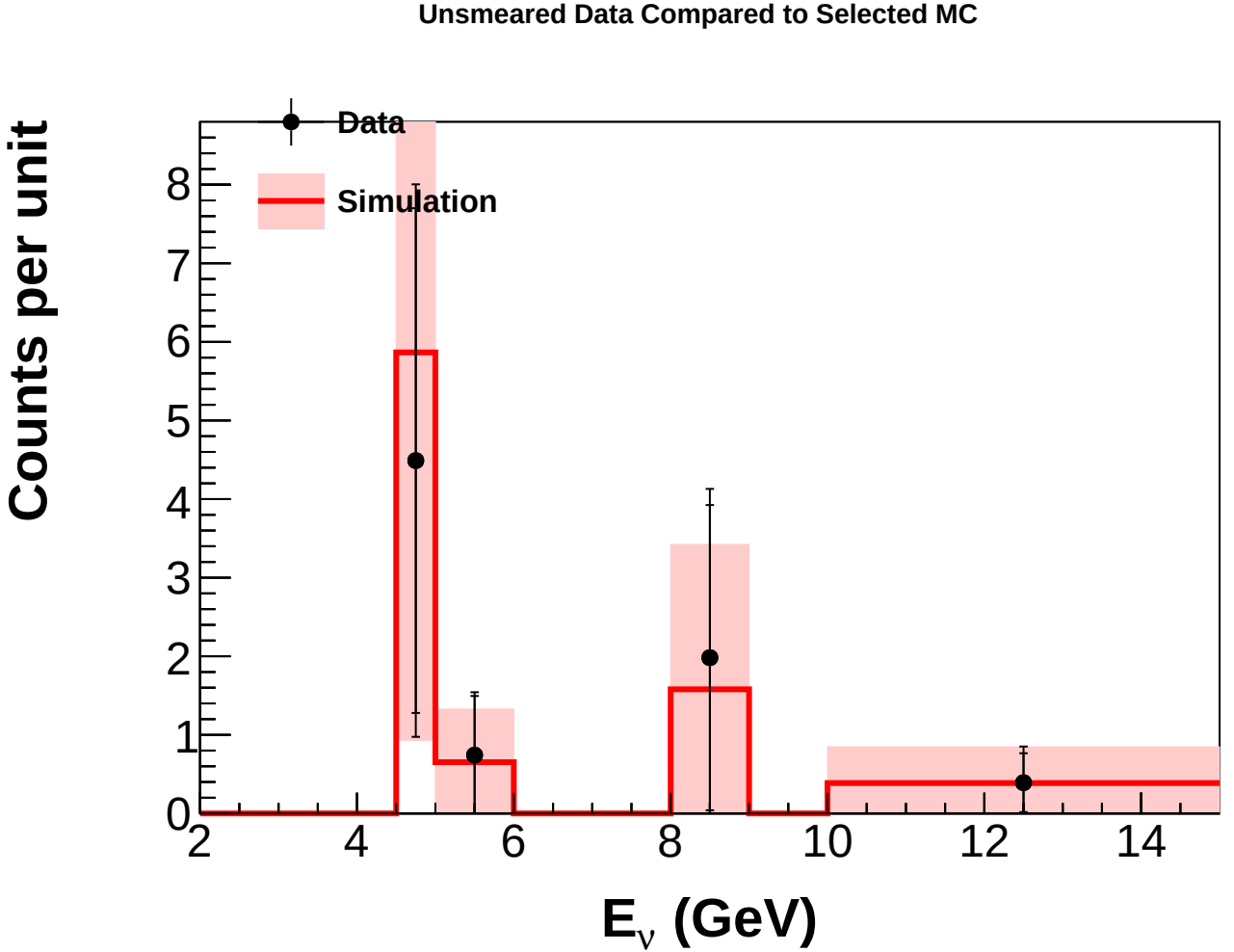

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
0.5
1
1.5
2
2.5
3
3.5
4
2
4
6
8
10
12
14
E_ν (GeV)

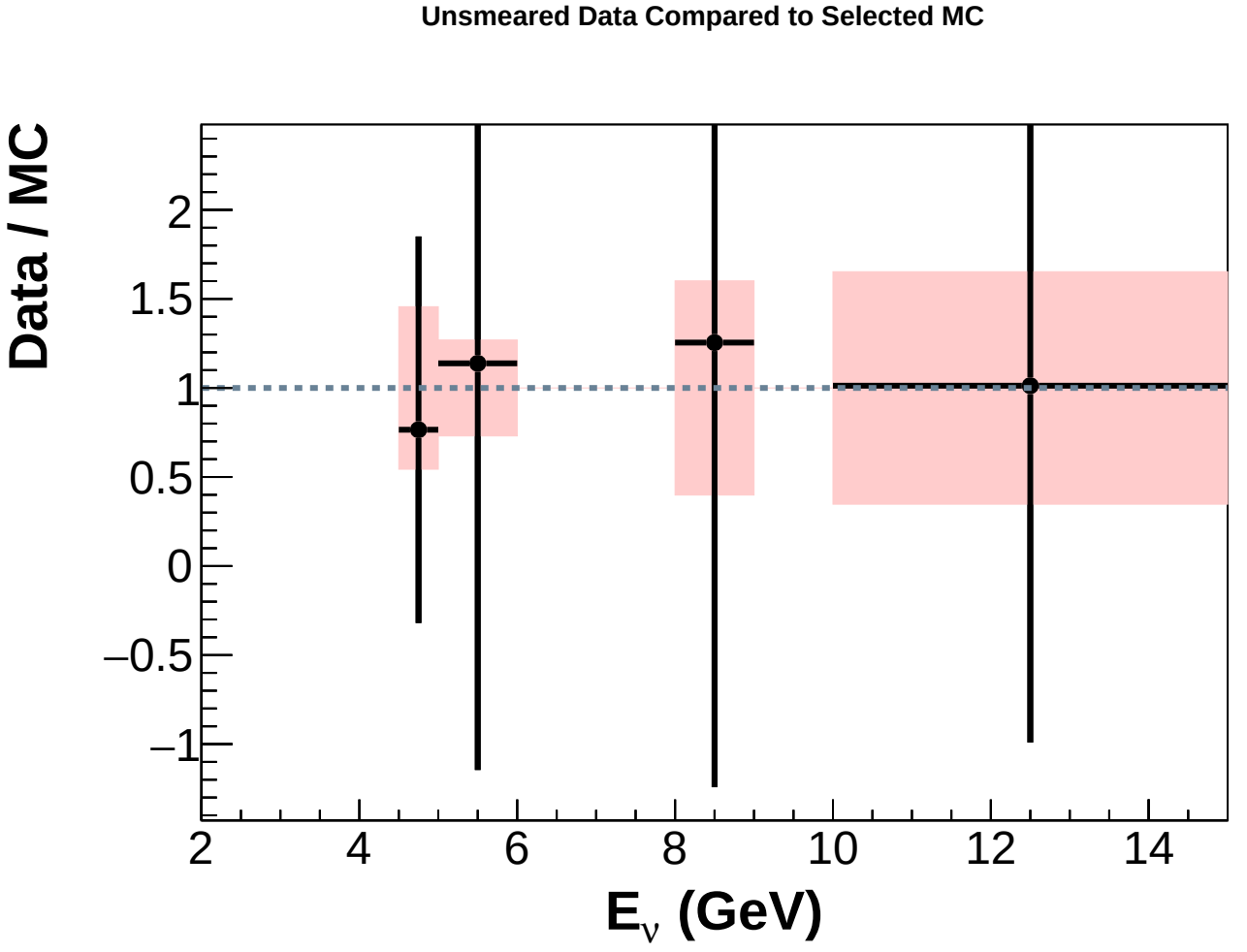

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

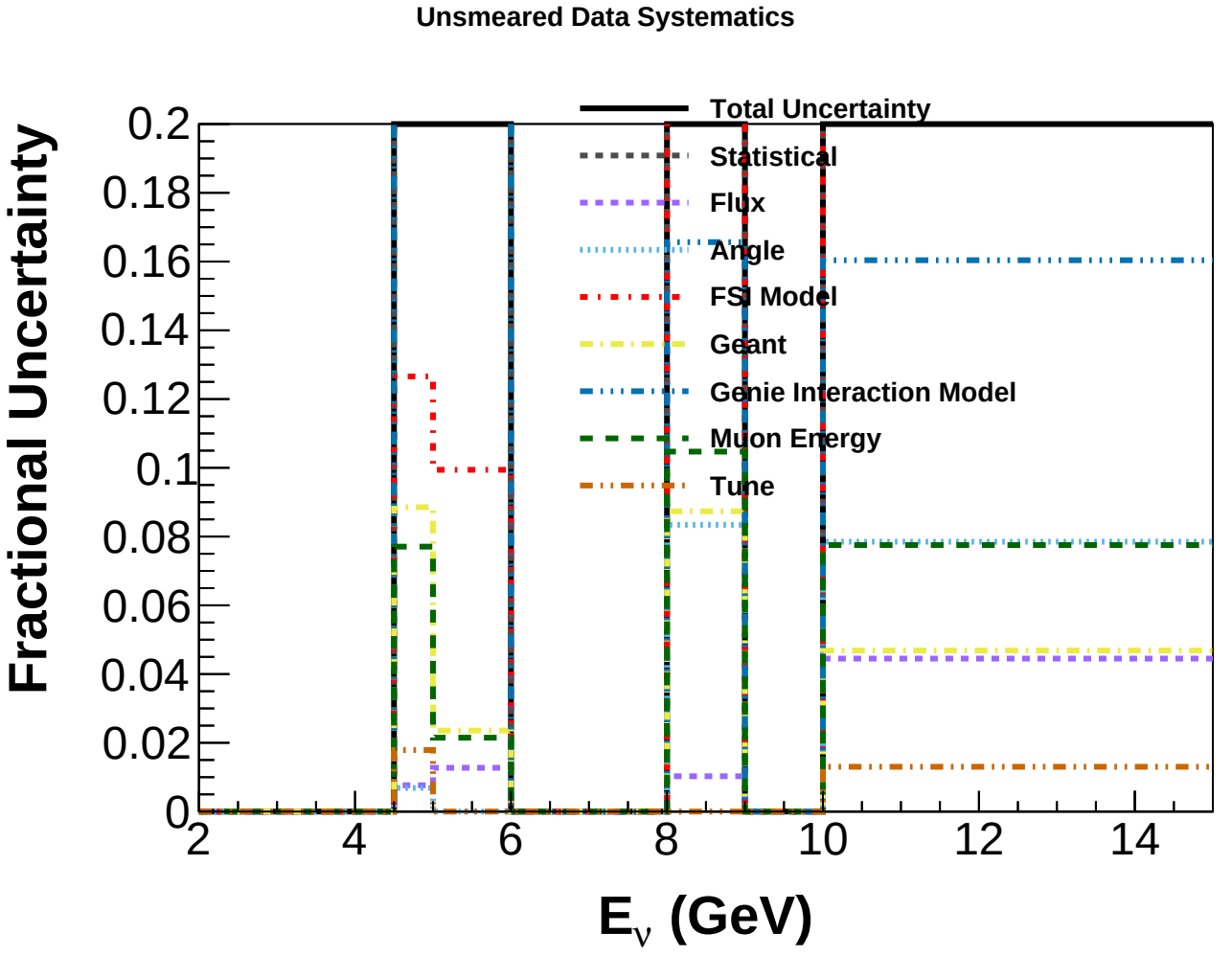

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

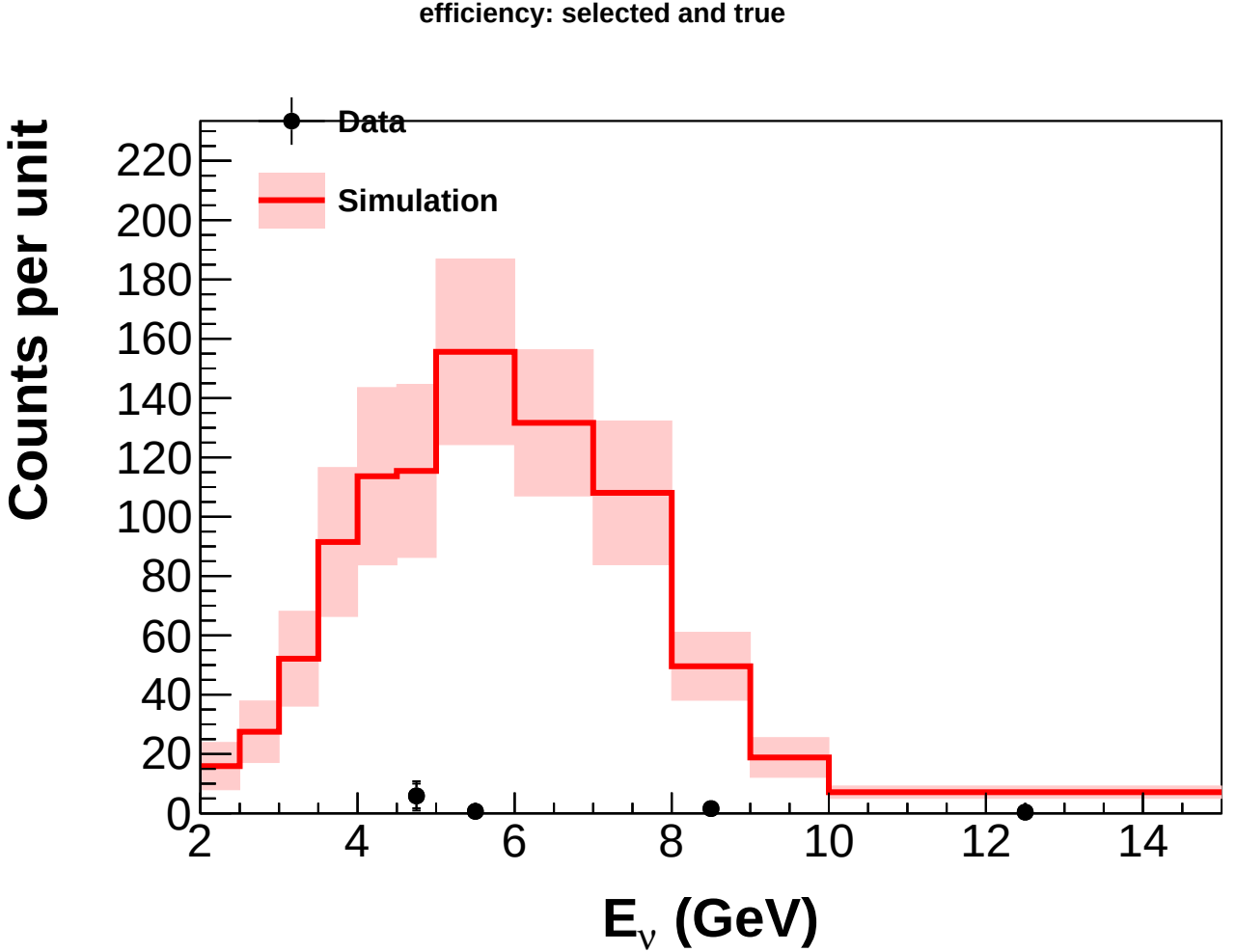

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
1
2
3
4
5
6
2
4
6
8
10
12
14
E_ν (GeV)

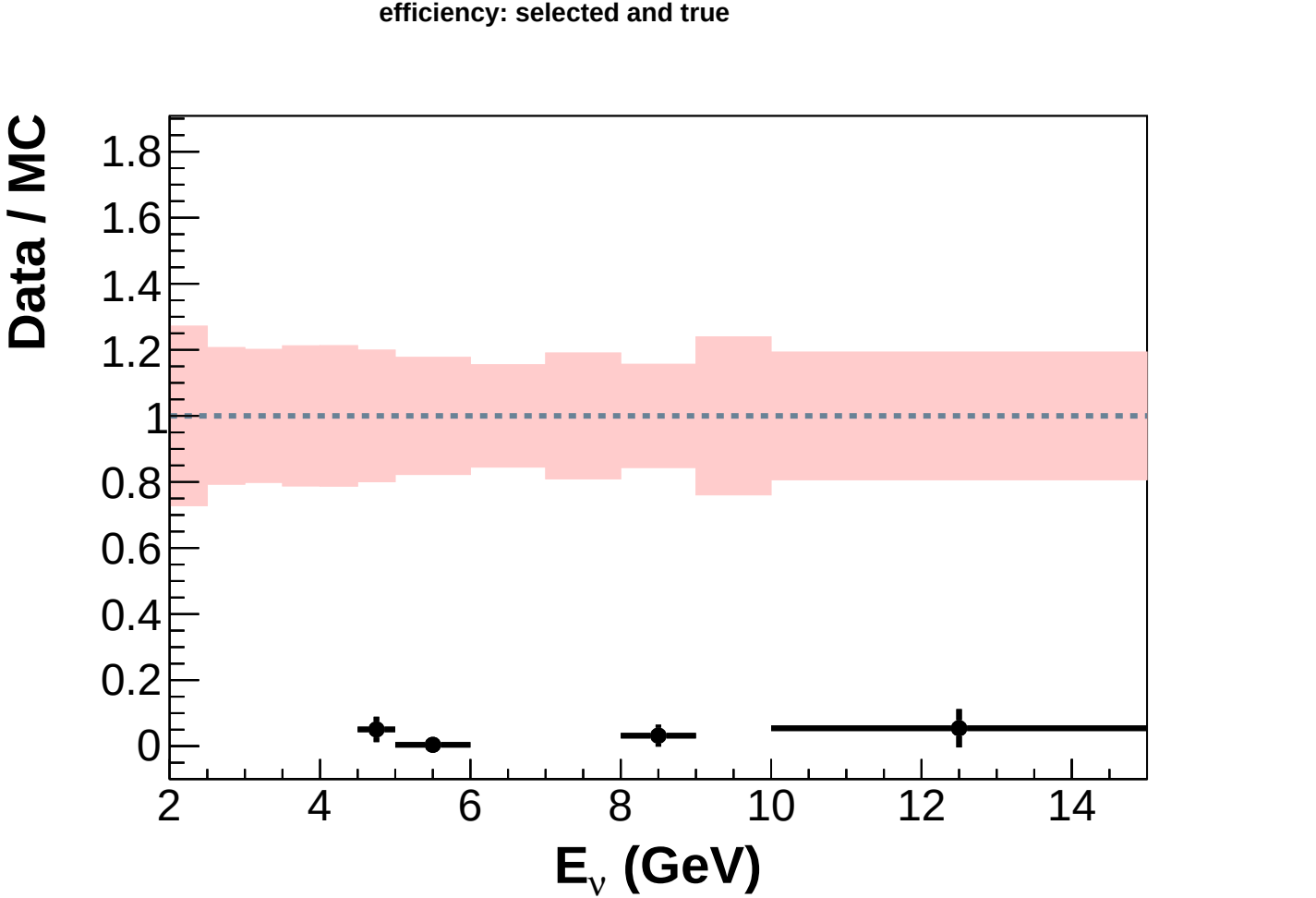

Data Before and After Unsmearing
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E$_\nu$ (GeV)

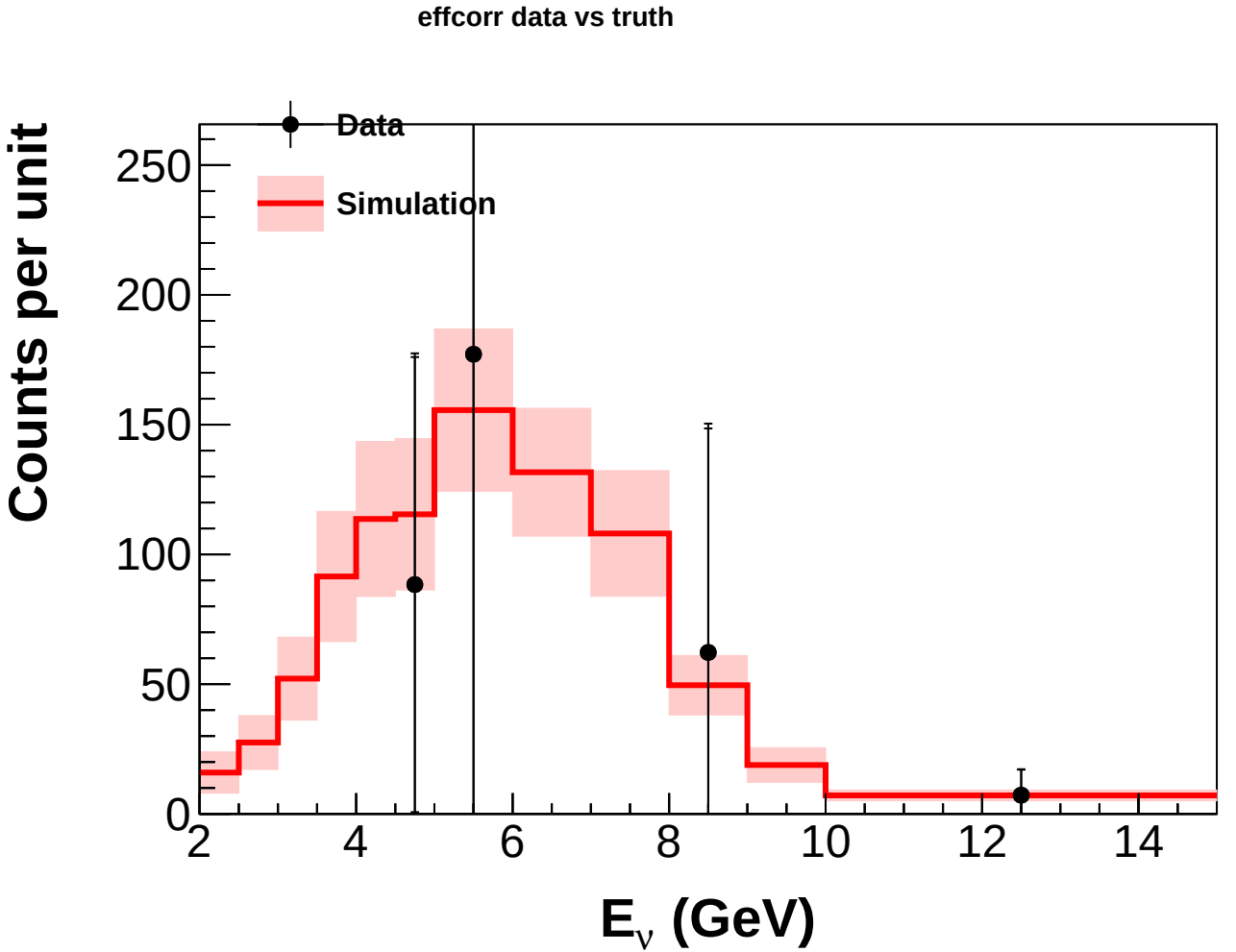

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
1
2
3
4
5
6
7
8
2
4
6
8
10
12
14
E_ν (GeV)

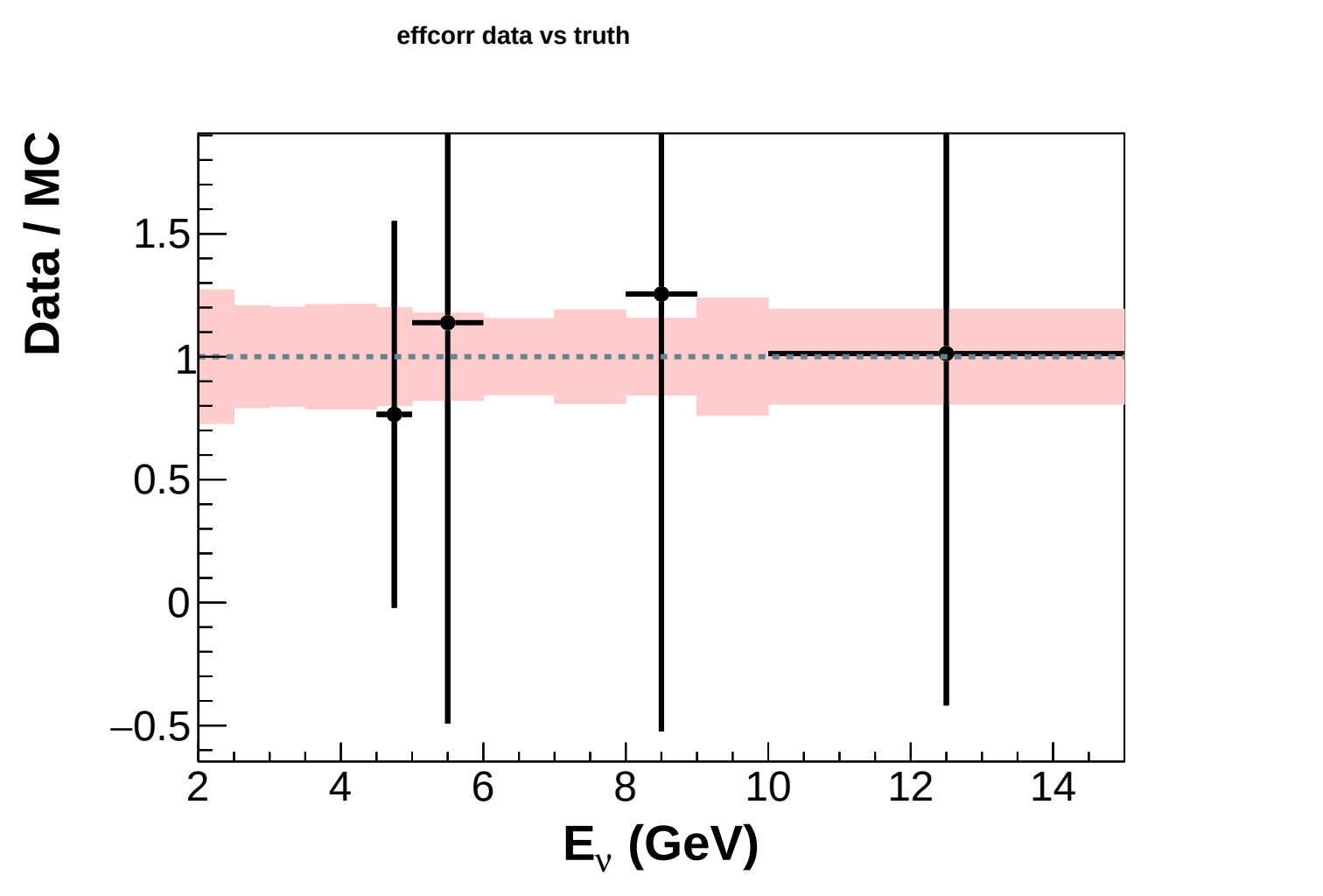

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

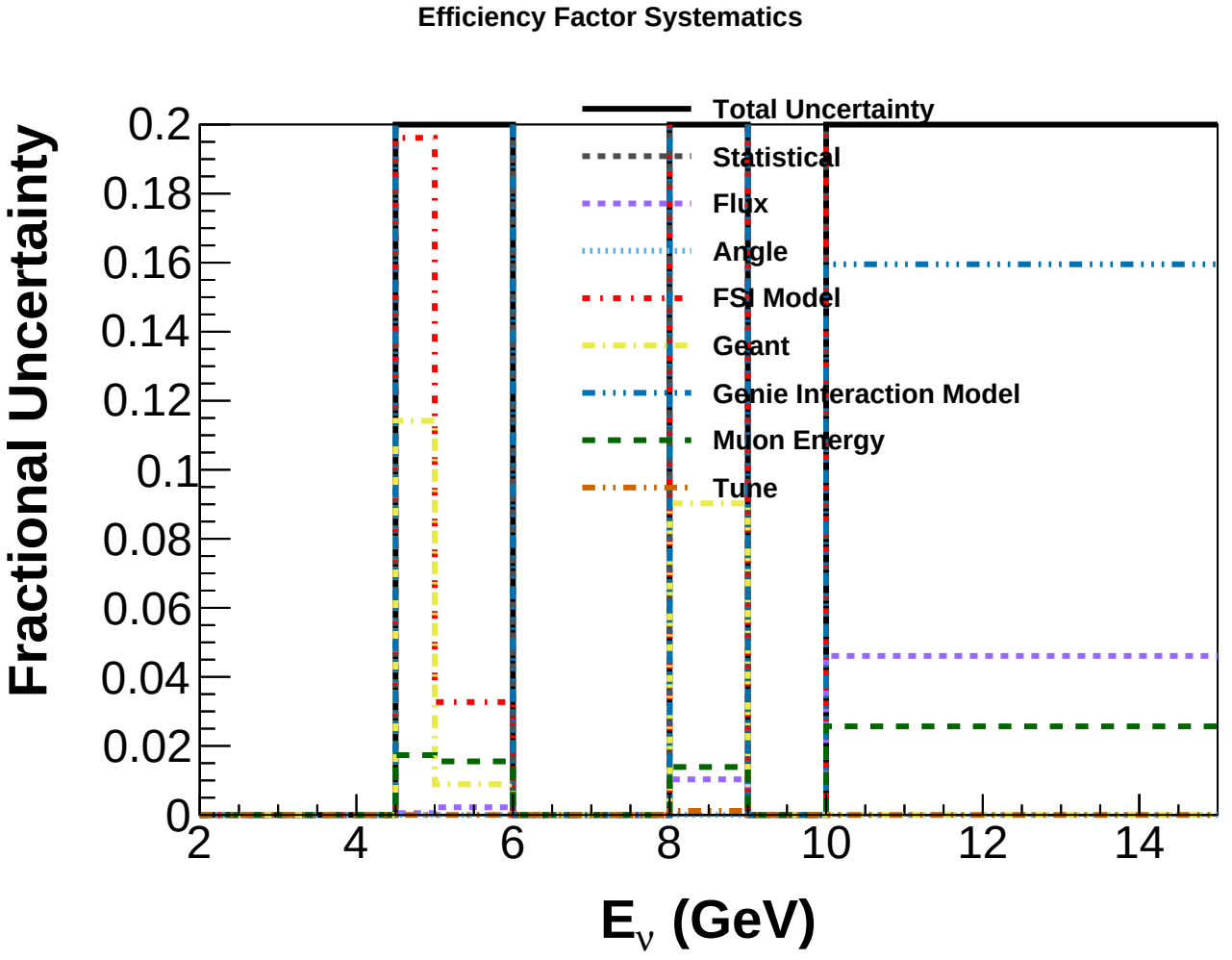

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

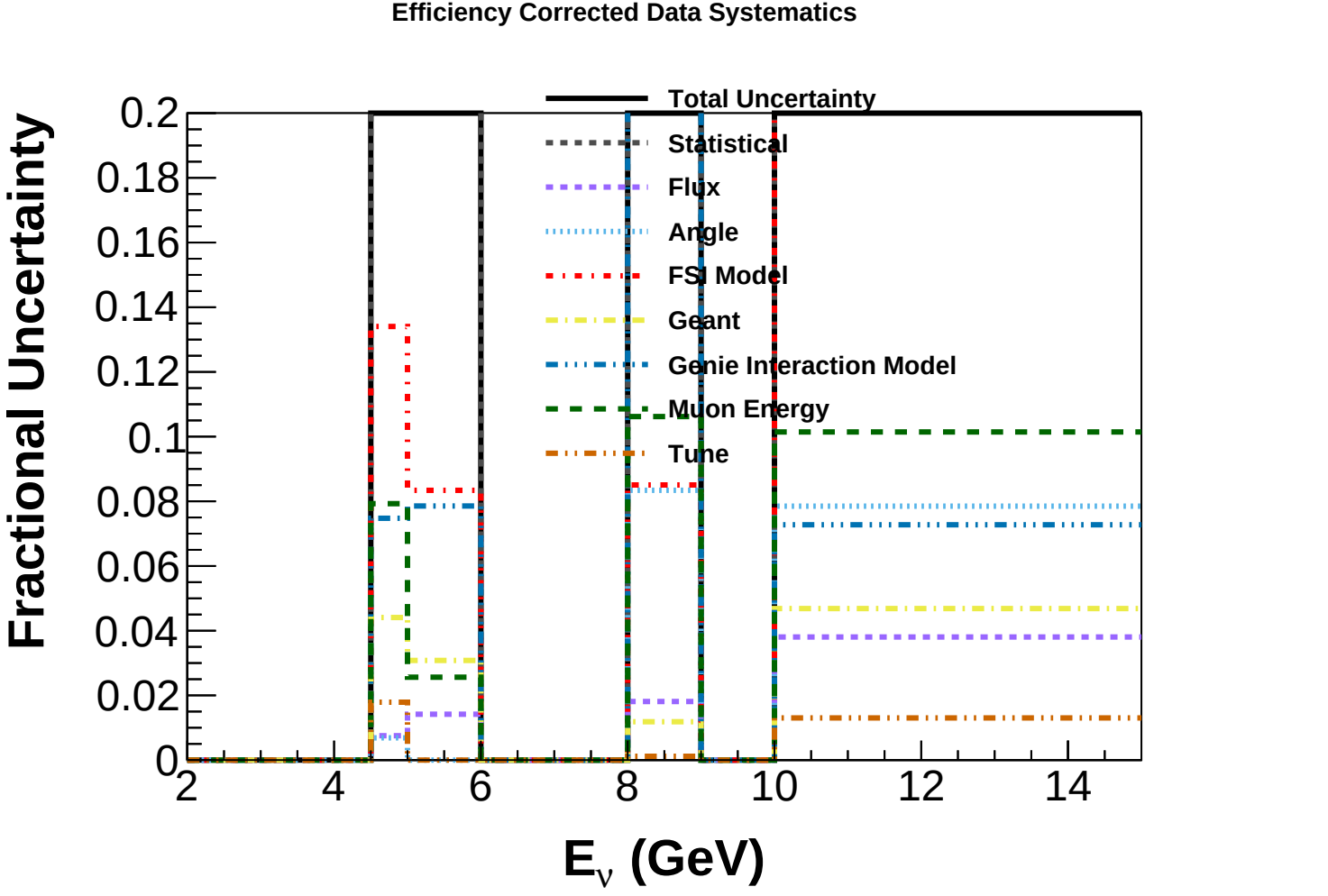

efficiency: selected and true
Data
Simulation
Counts per unit
220
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
E_ν (GeV)

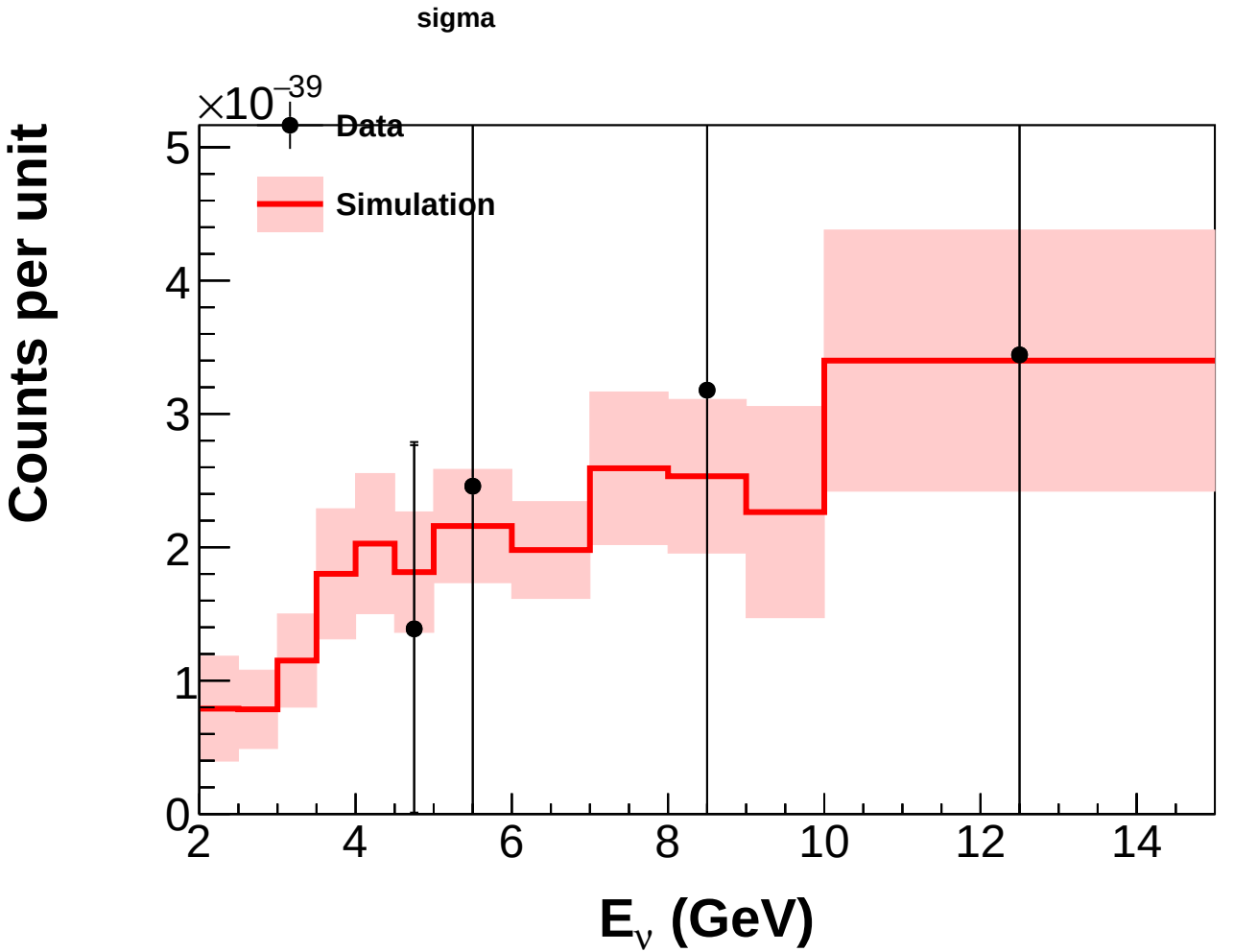

efficiency: selected and true
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_ν (GeV)

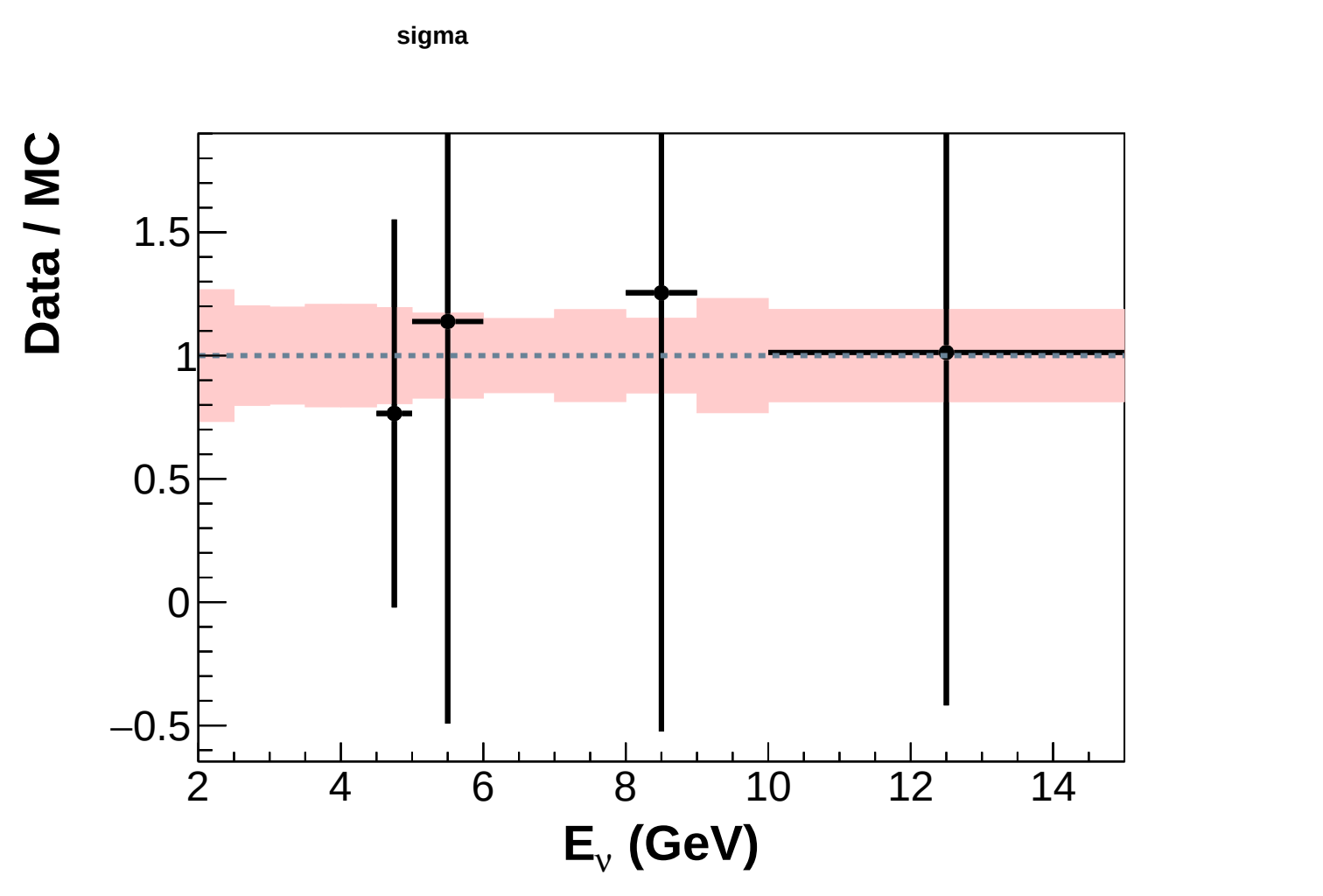

effcorr data vs truth
Data
Simulation
Counts per unit
250
200
150
100
50
0
2
4
6
8
10
12
14
E_ν (GeV)

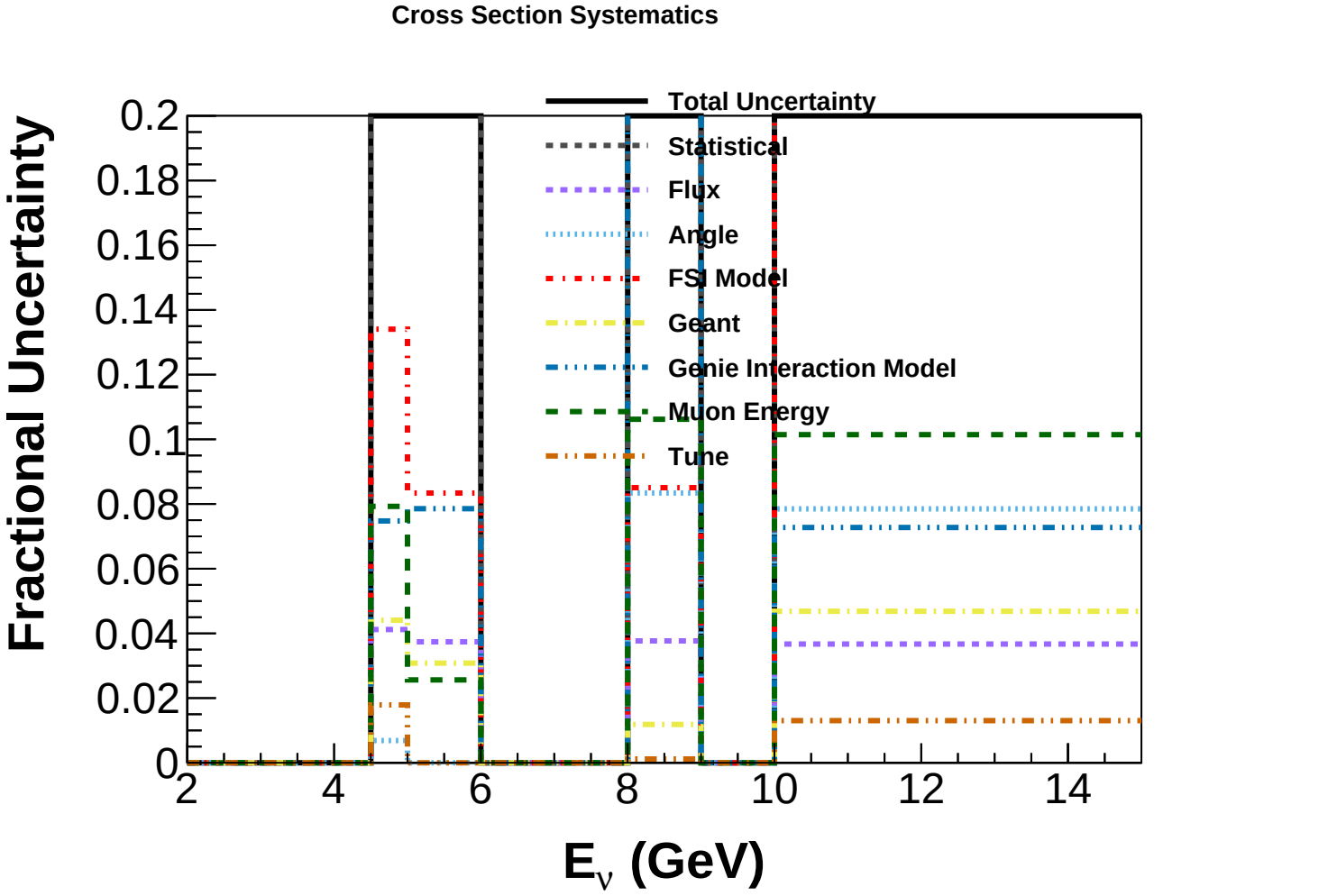

effcorr data vs truth
Data / MC
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

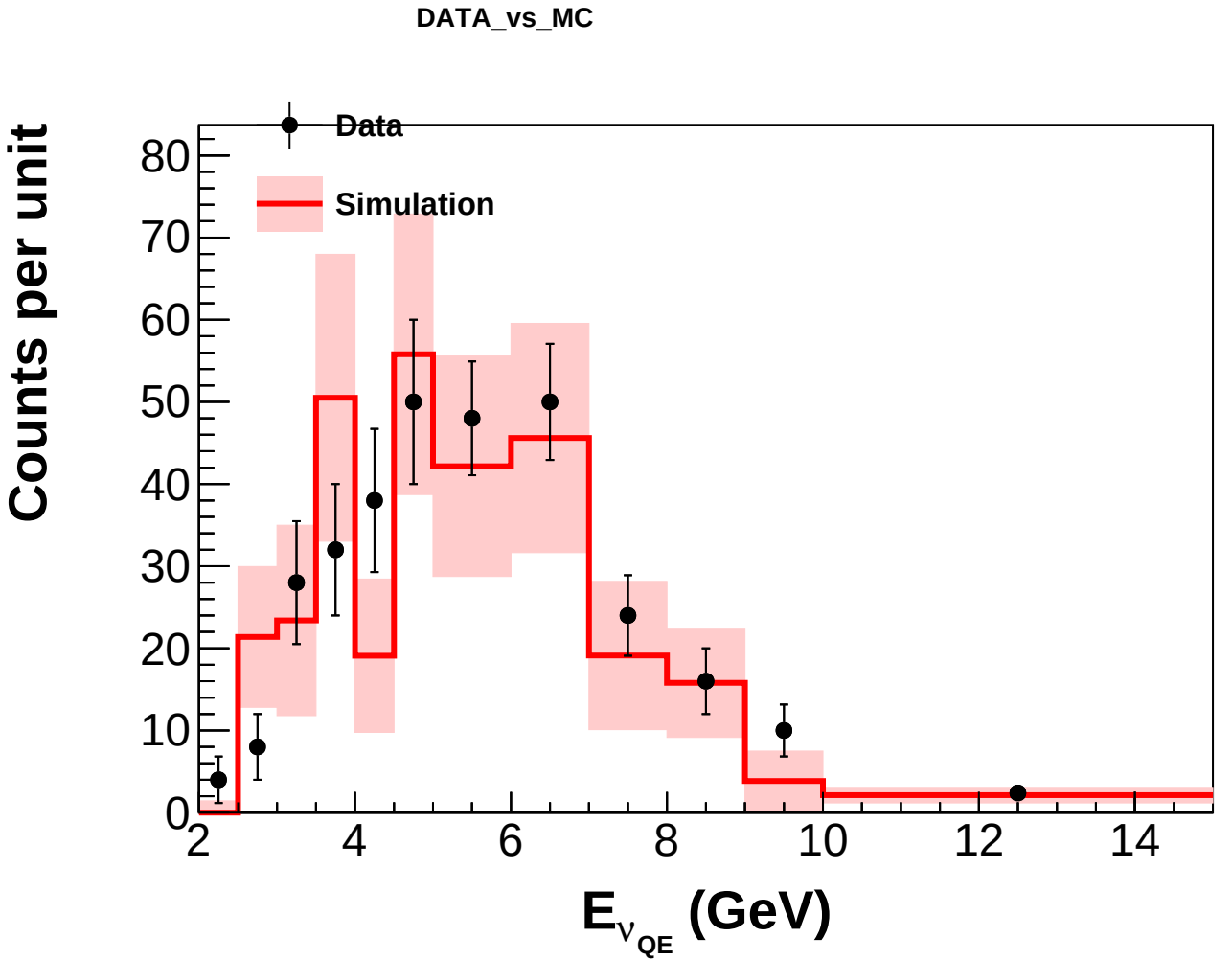

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

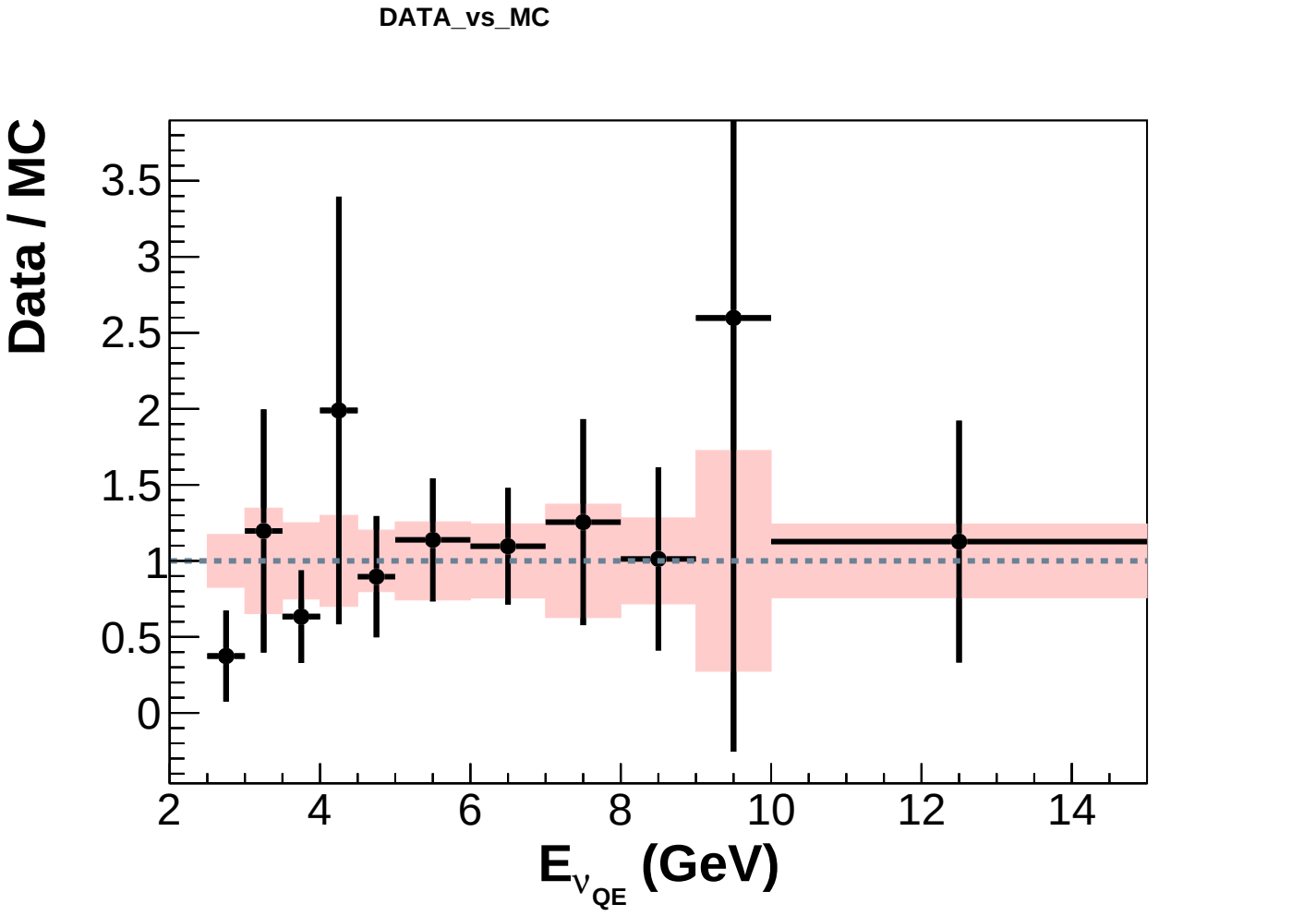

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

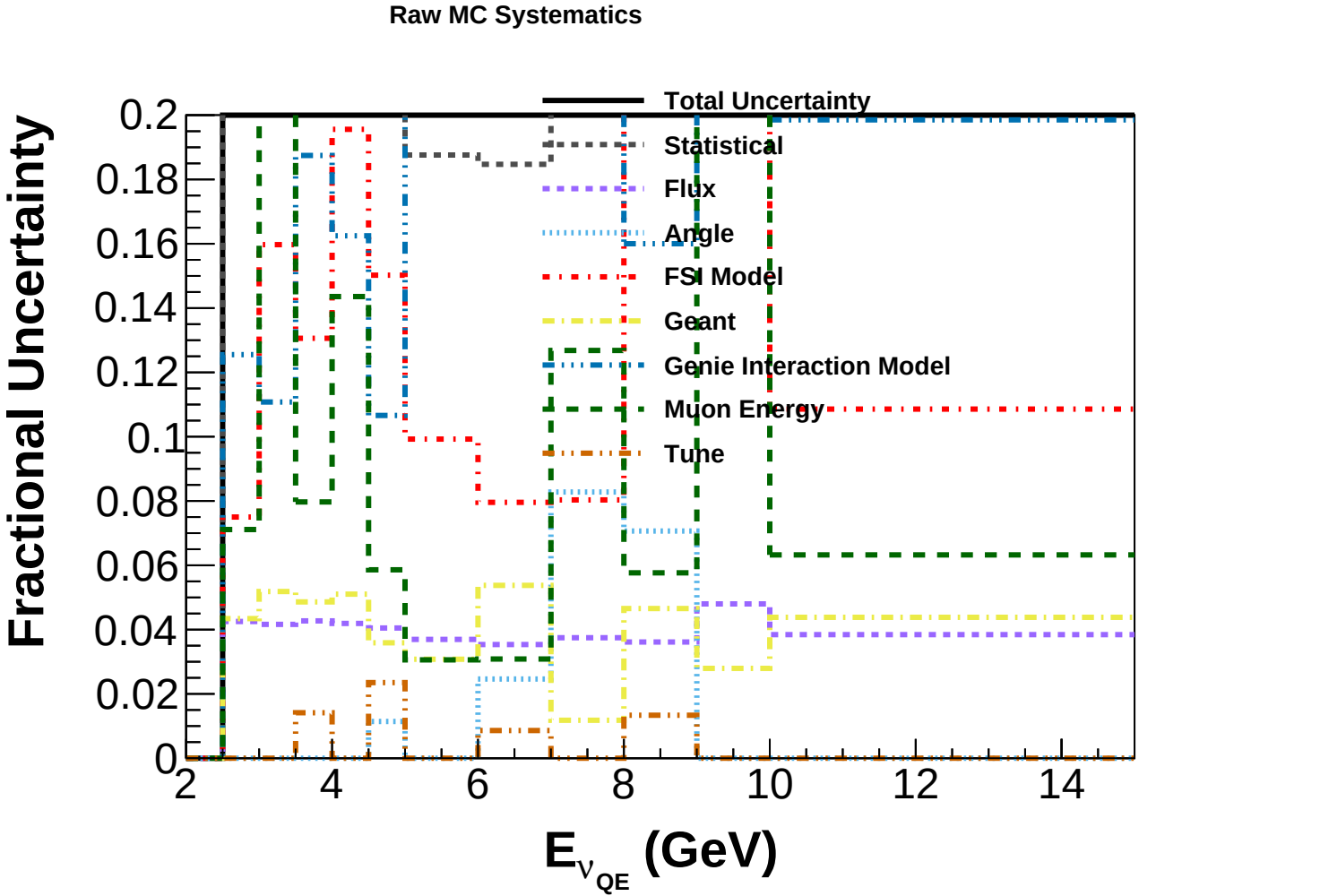

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
0
1
2
3
4
5
2
4
6
8
10
12
14
E_ν (GeV)

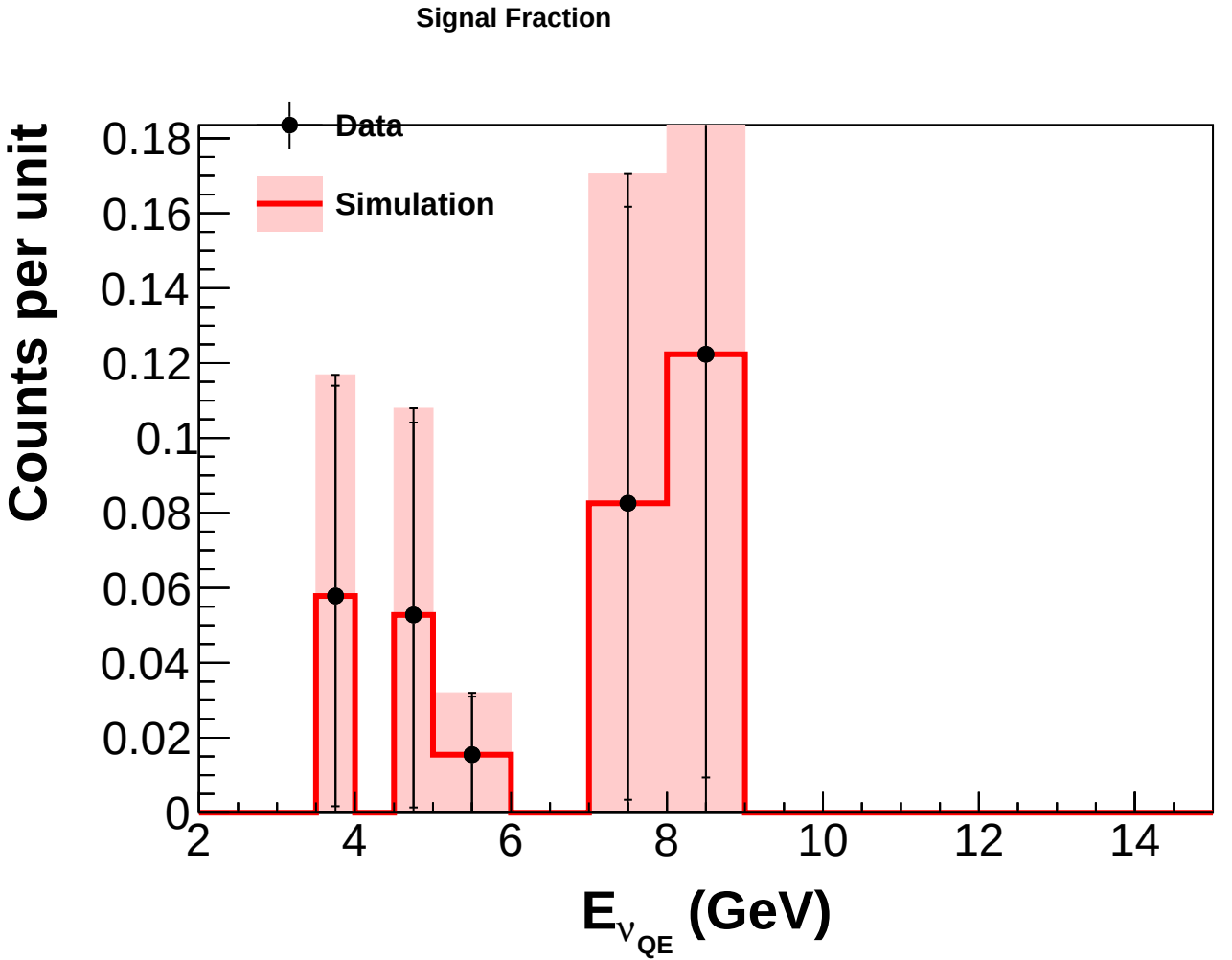

sigma
Data / MC
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

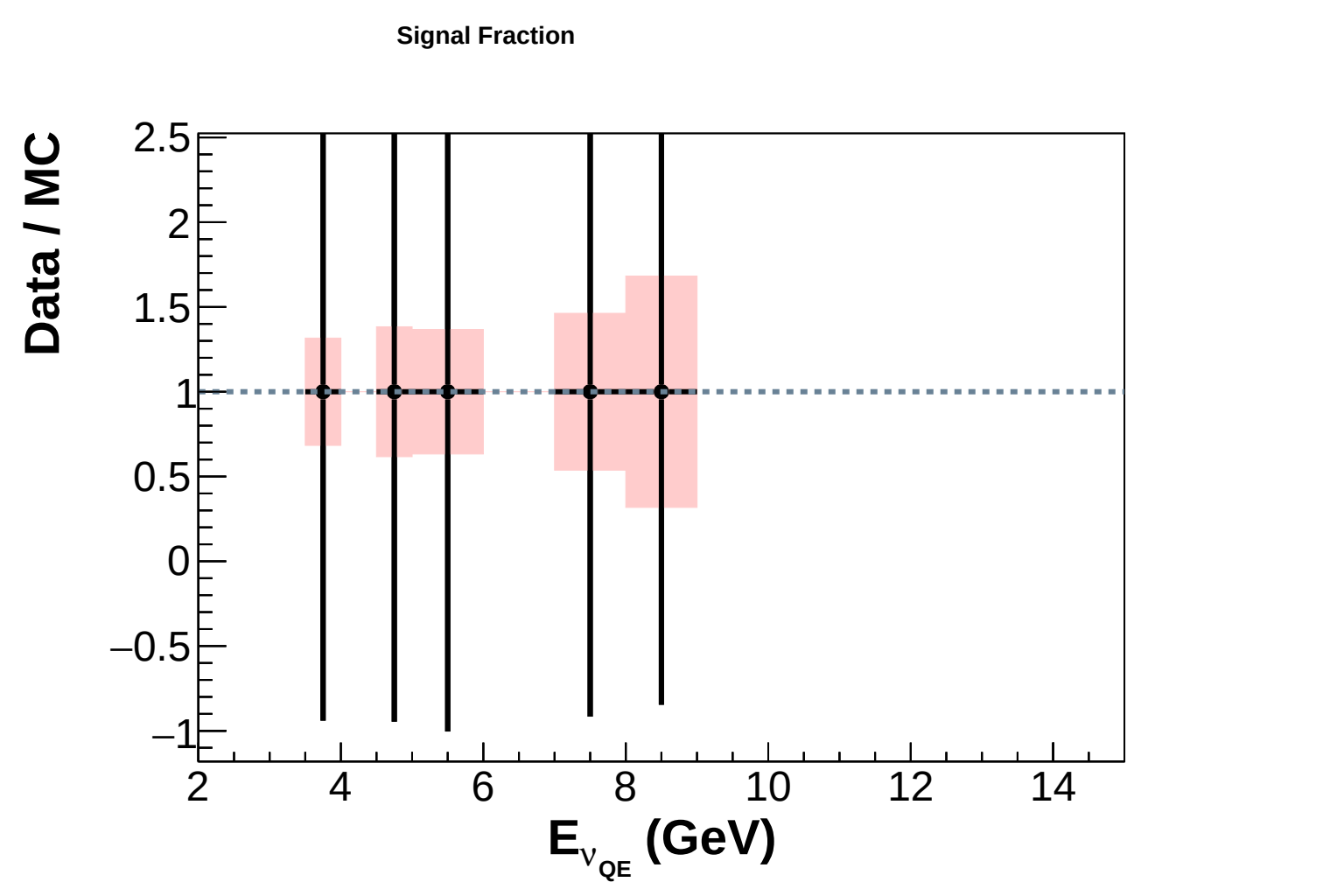

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

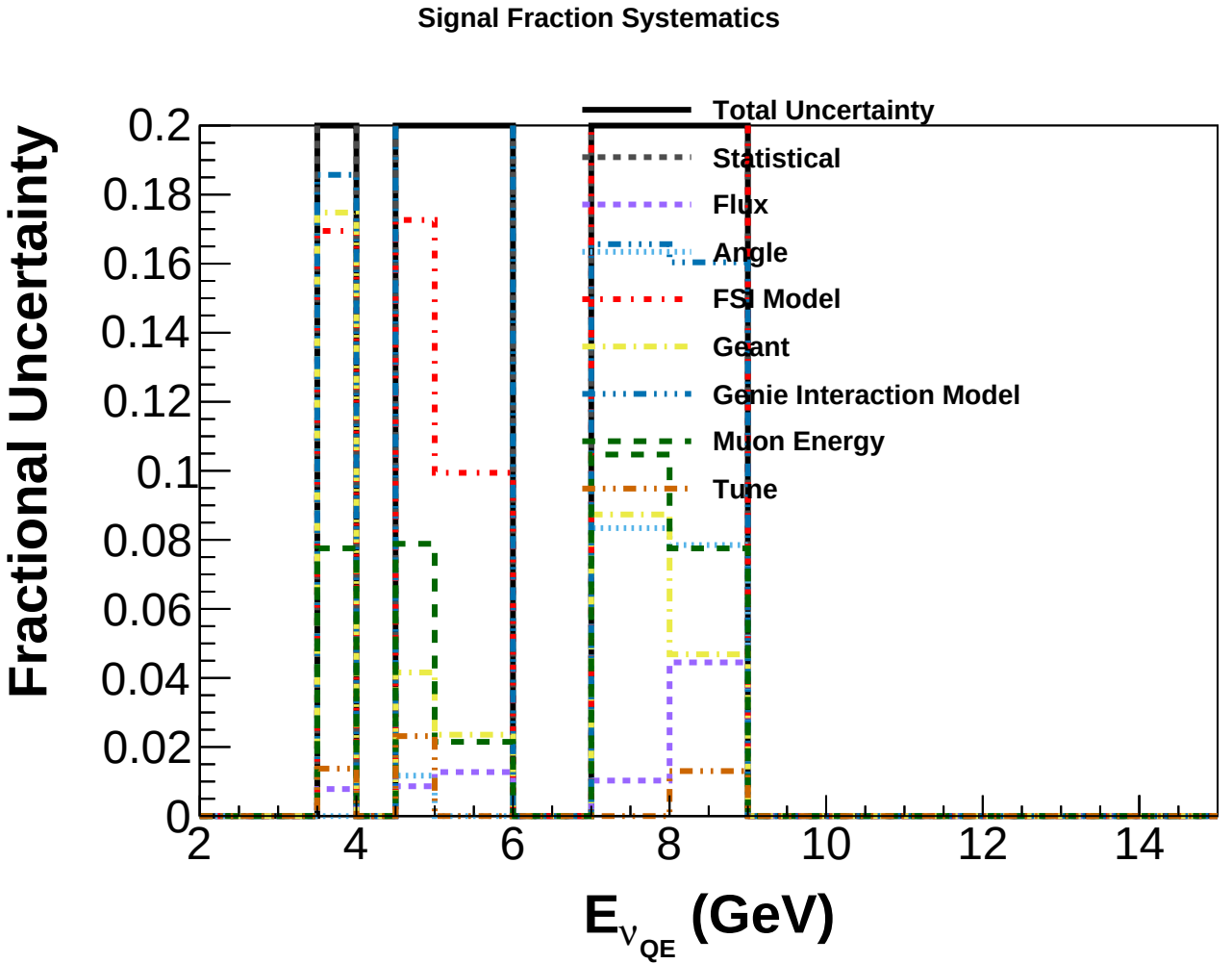

DATA_vs_MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

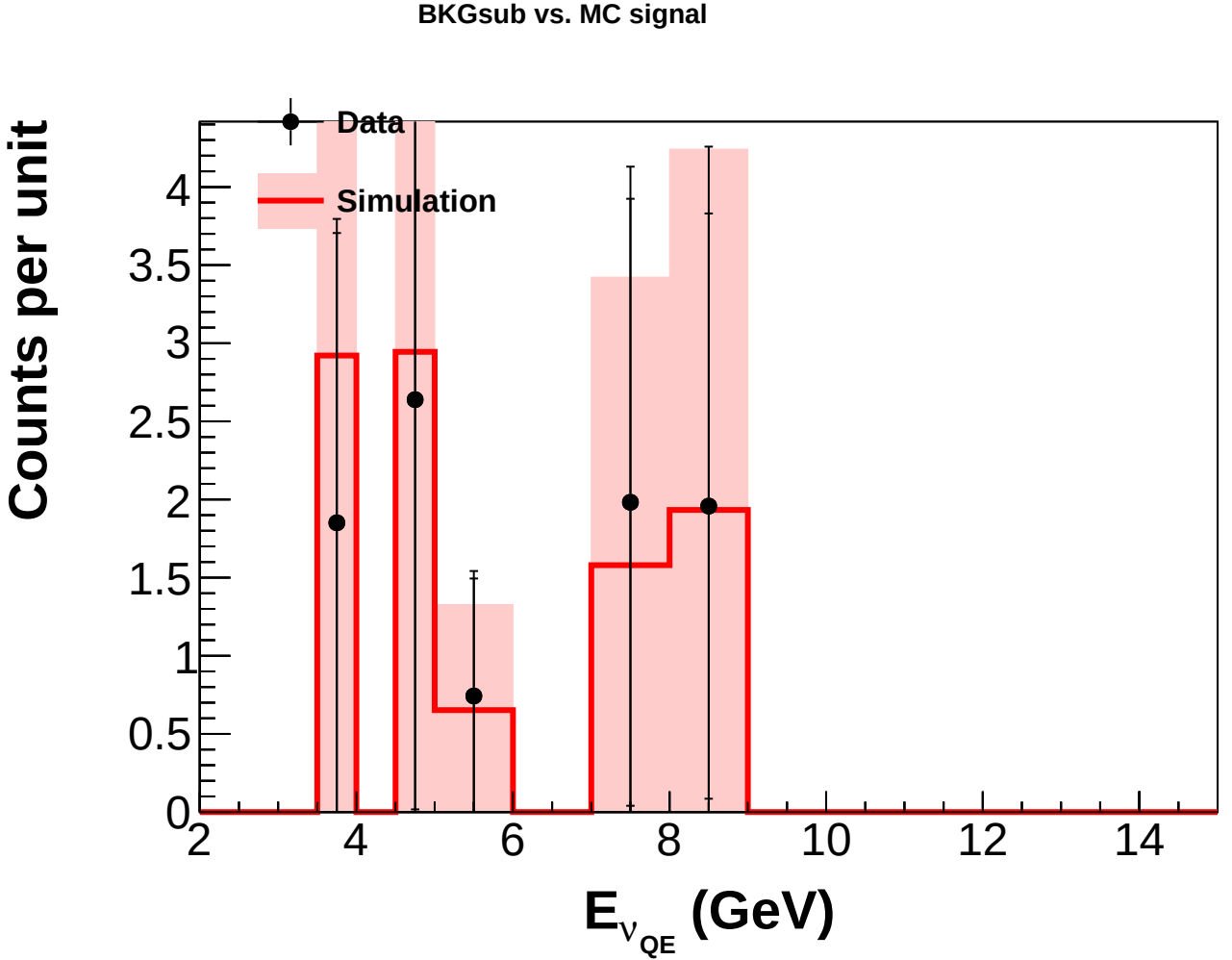

DATA_vs_MC
Data / MC
3.5
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

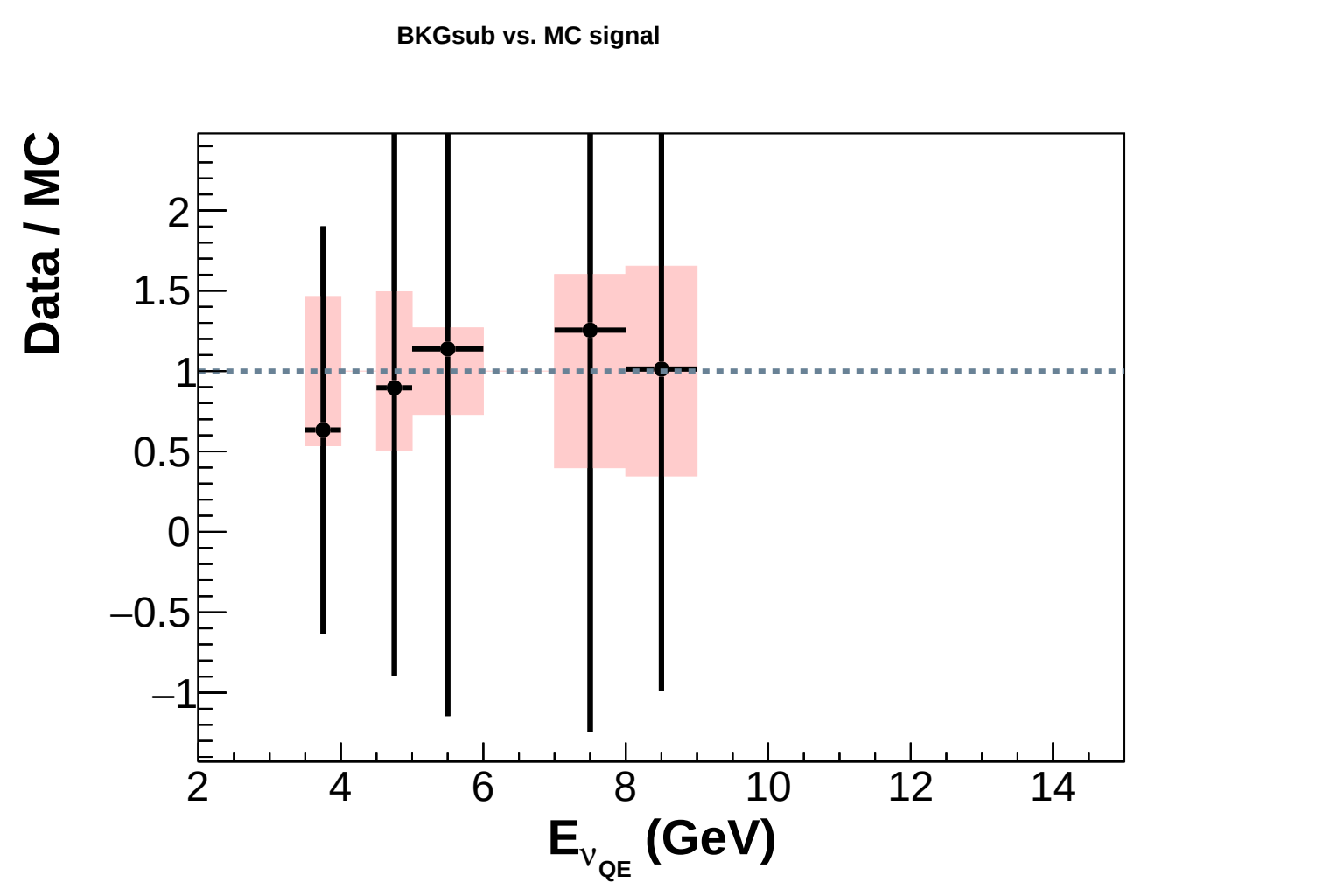

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

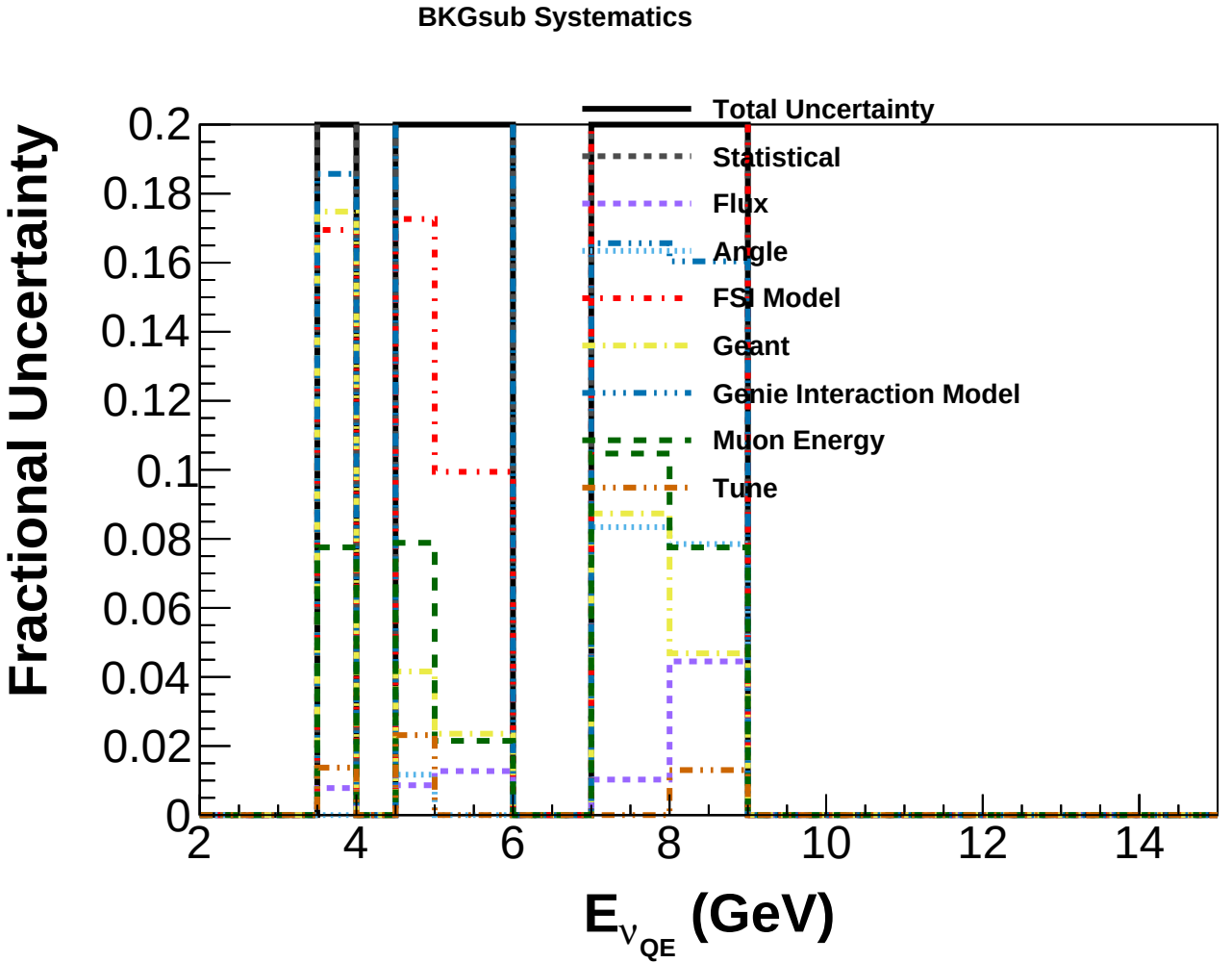

Signal Fraction
Data
Simulation
Counts per unit
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

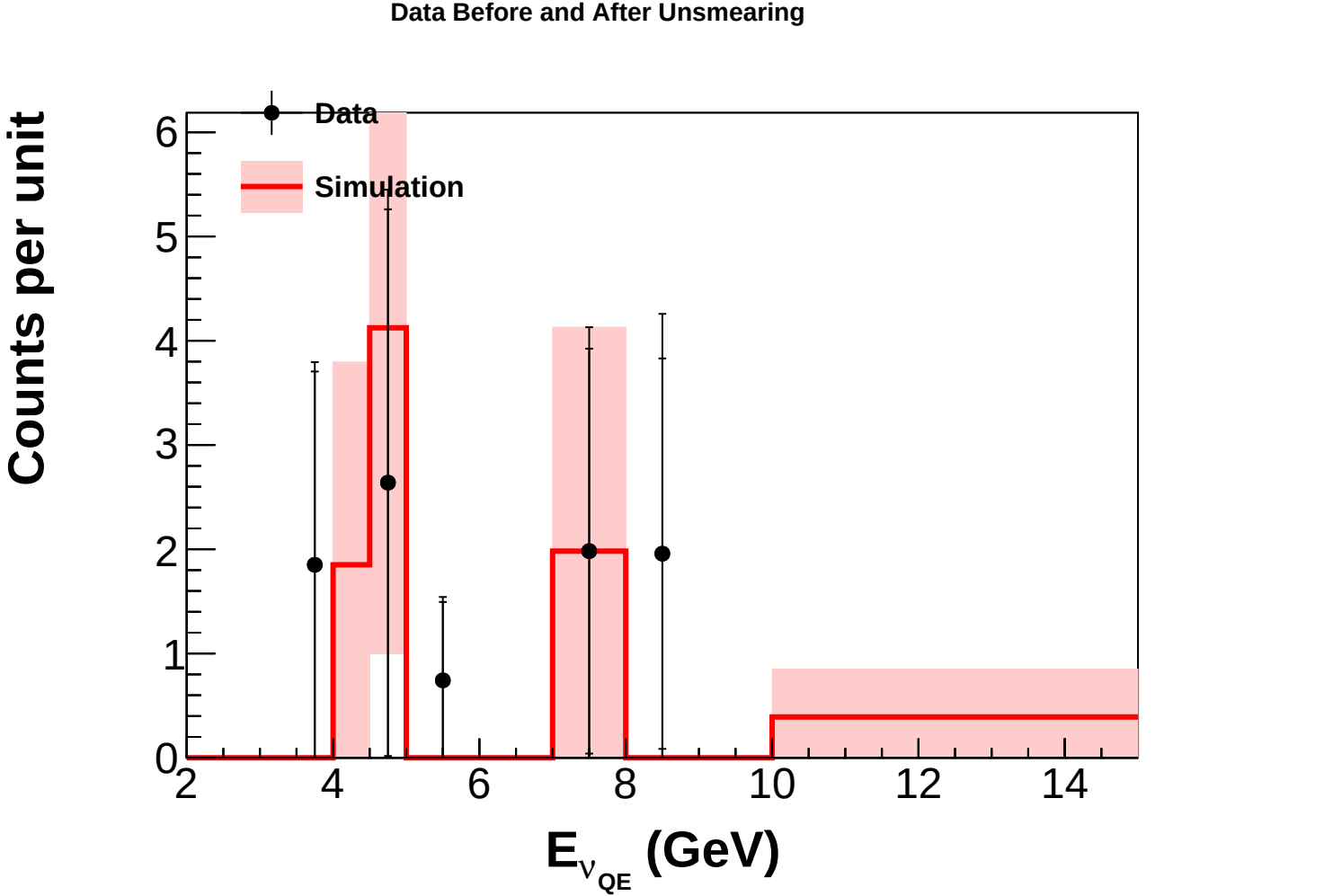

Signal Fraction
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

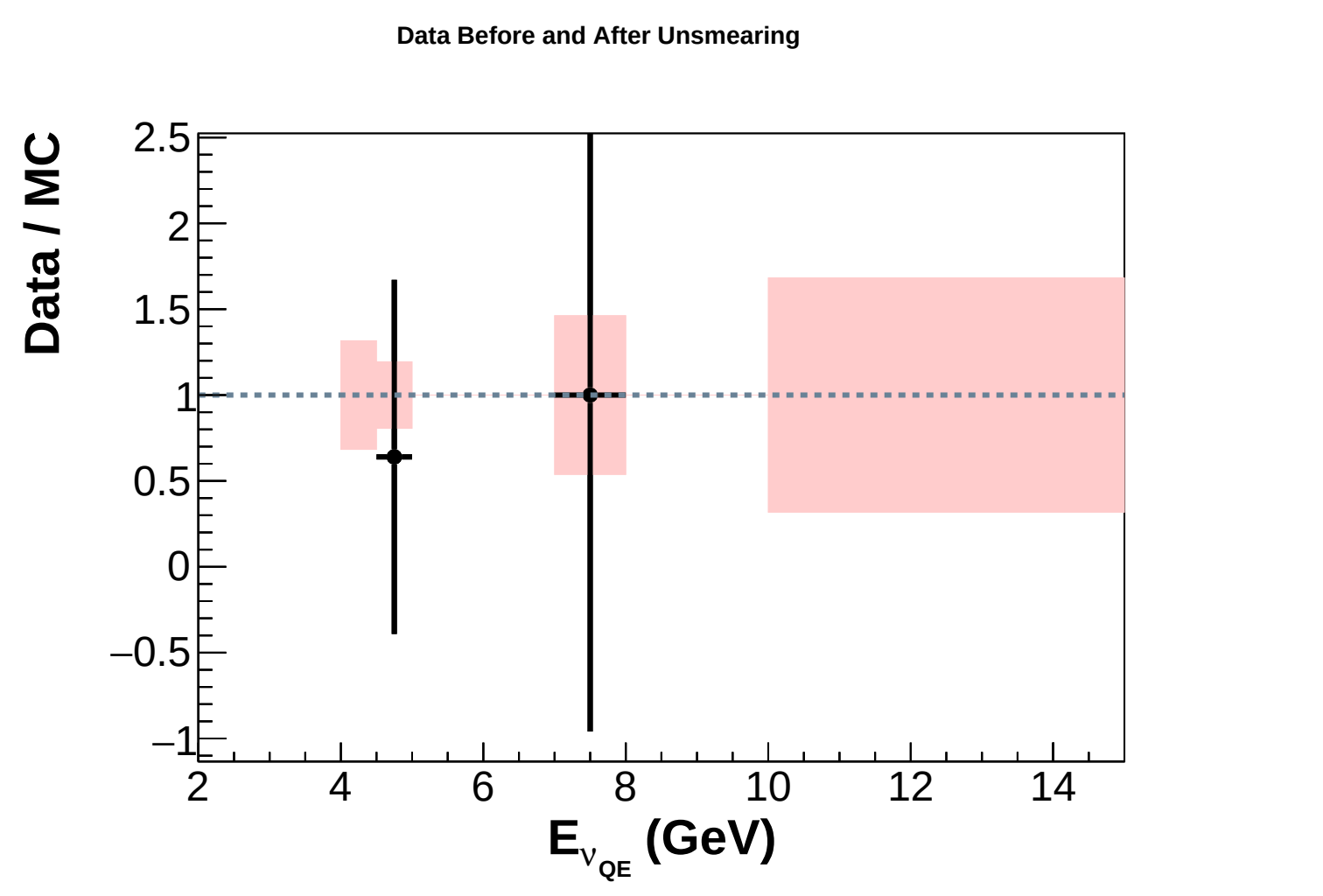

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

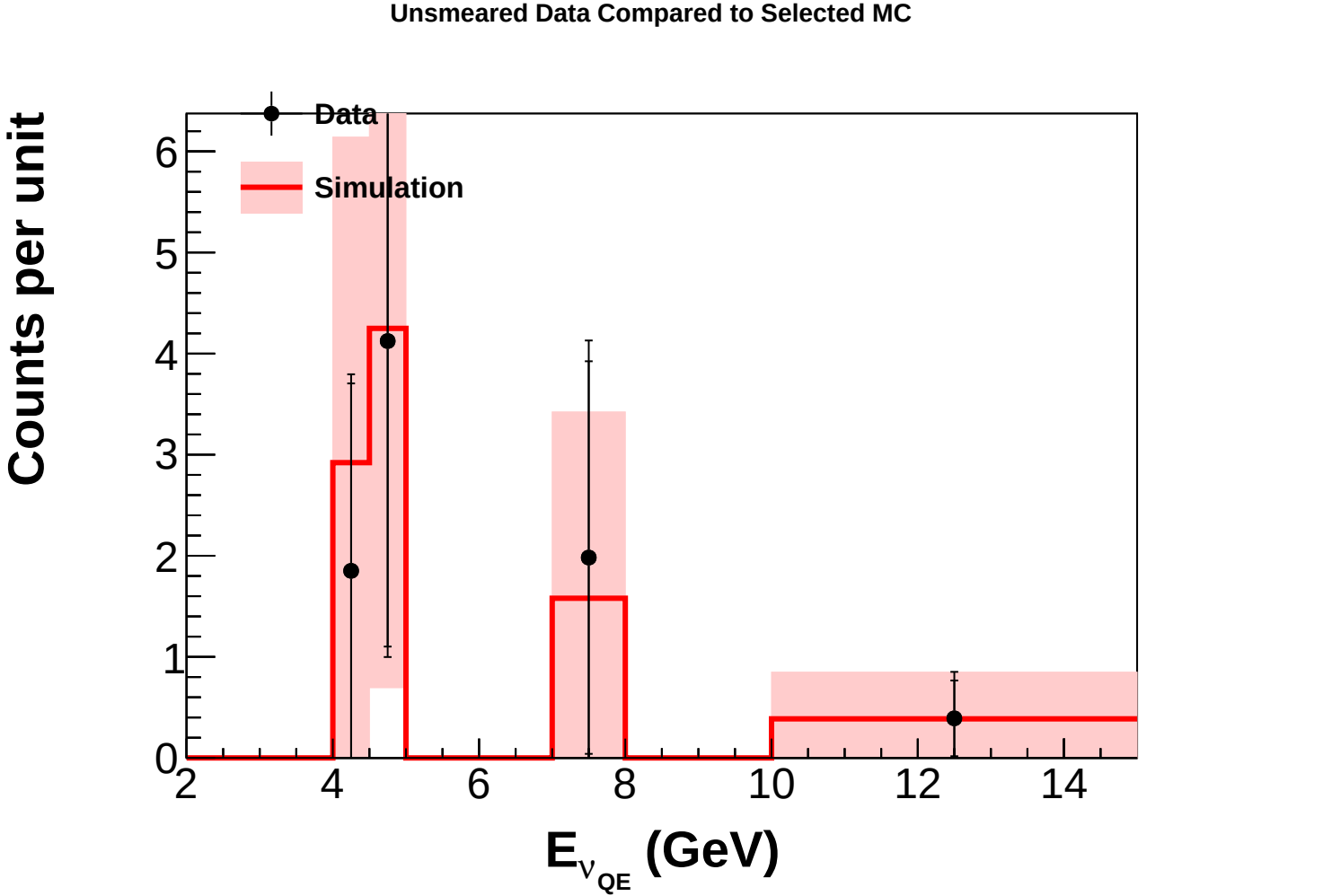

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
0.5
1
1.5
2
2.5
3
3.5
4
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

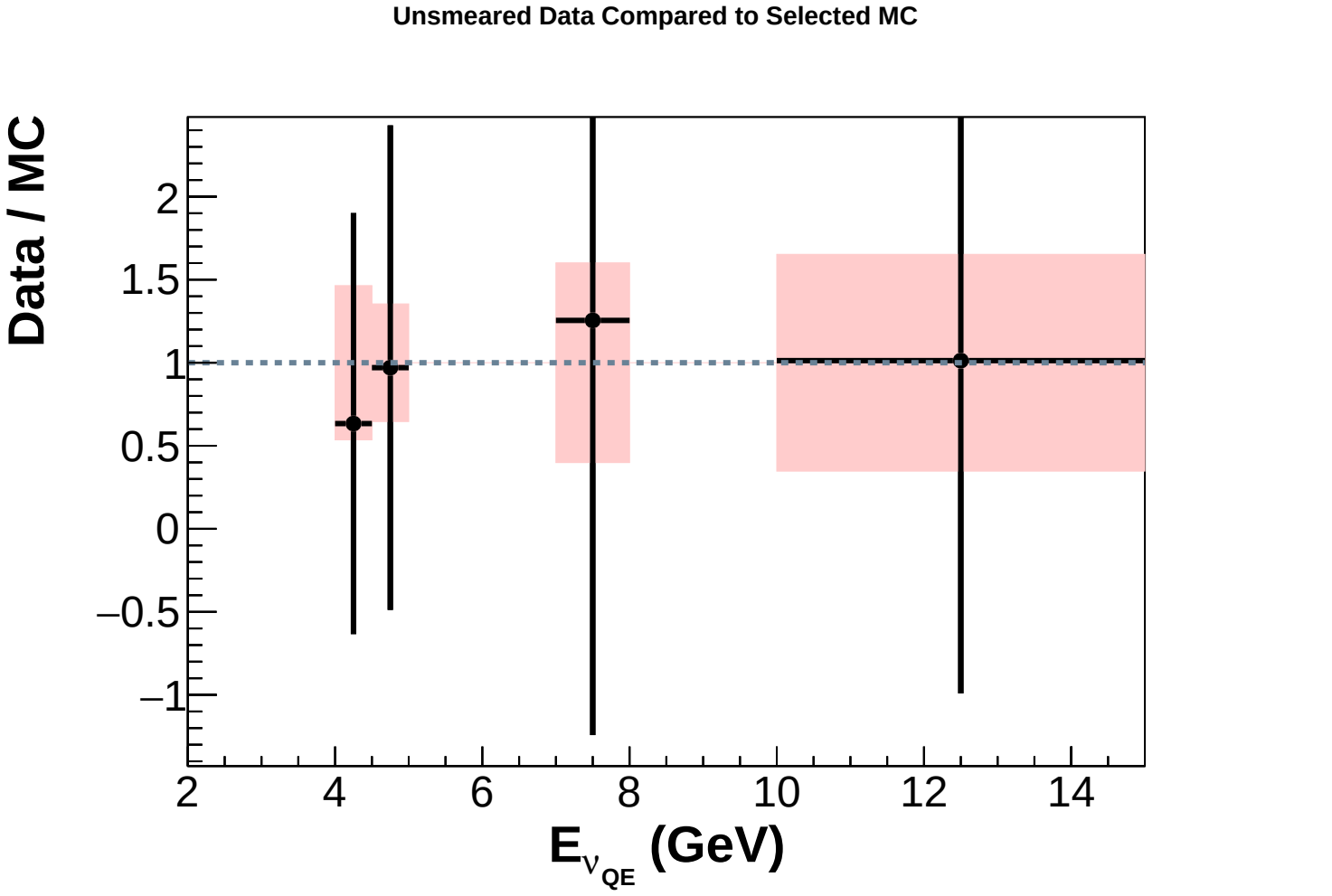

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

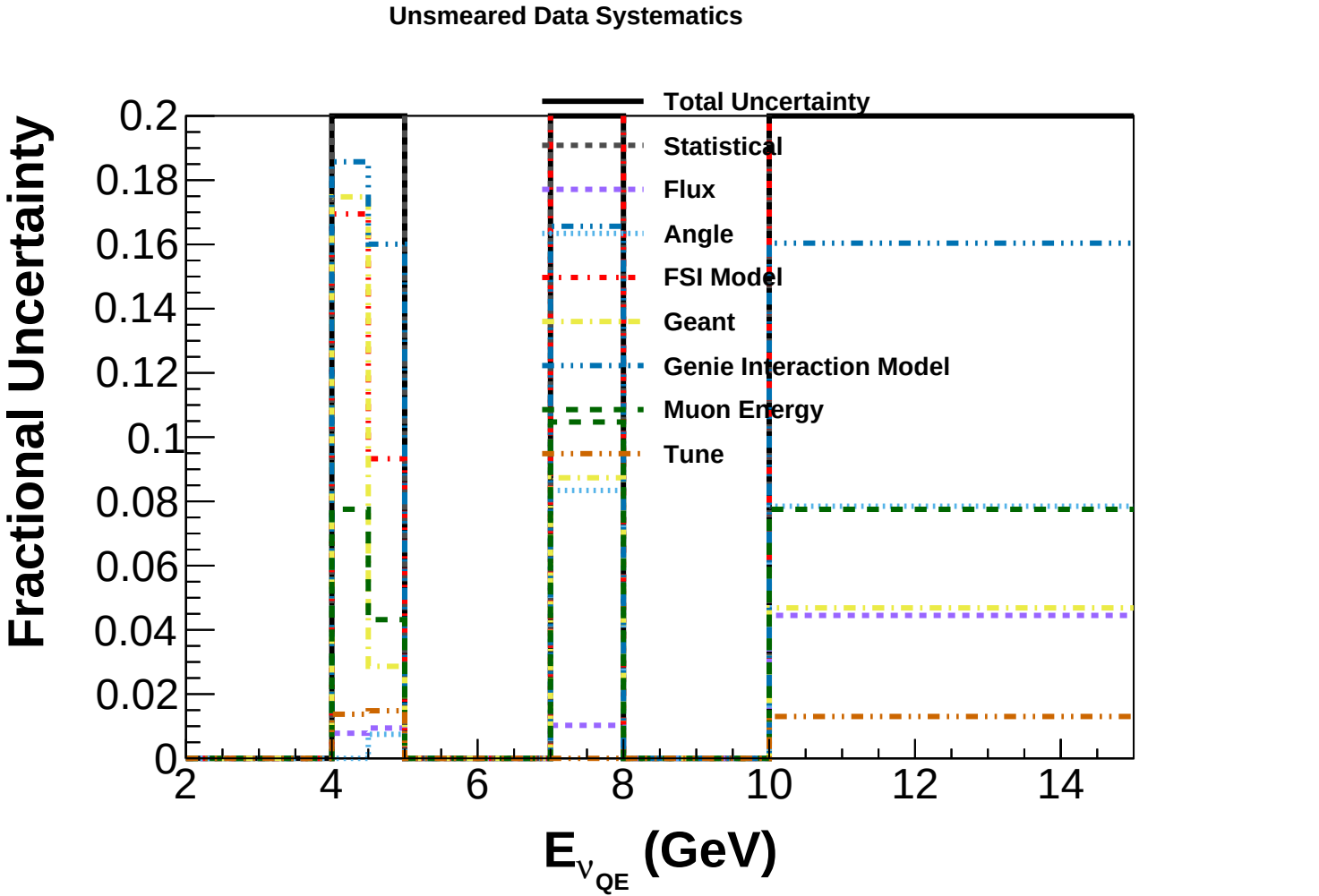

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

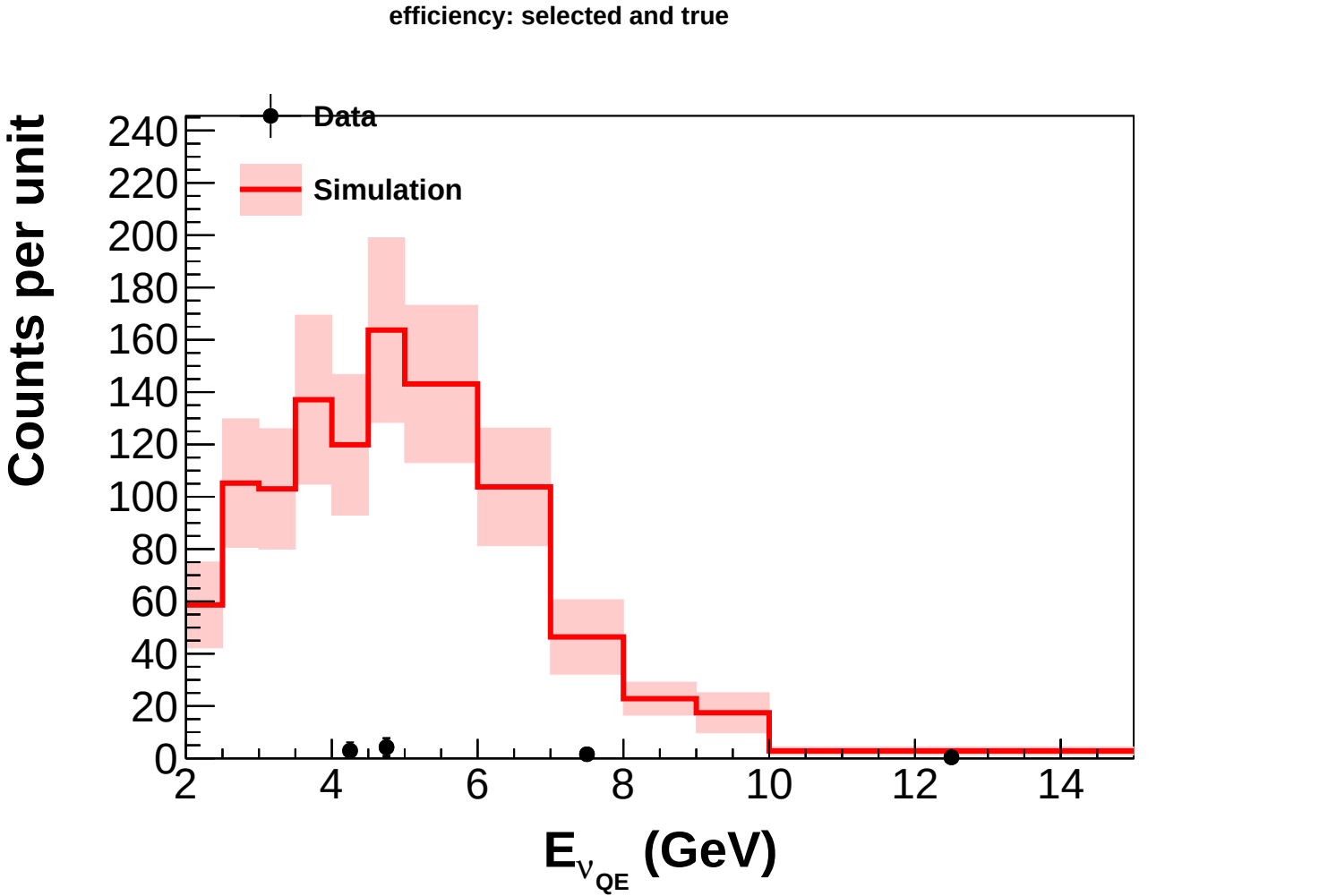

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
1
2
3
4
5
6
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

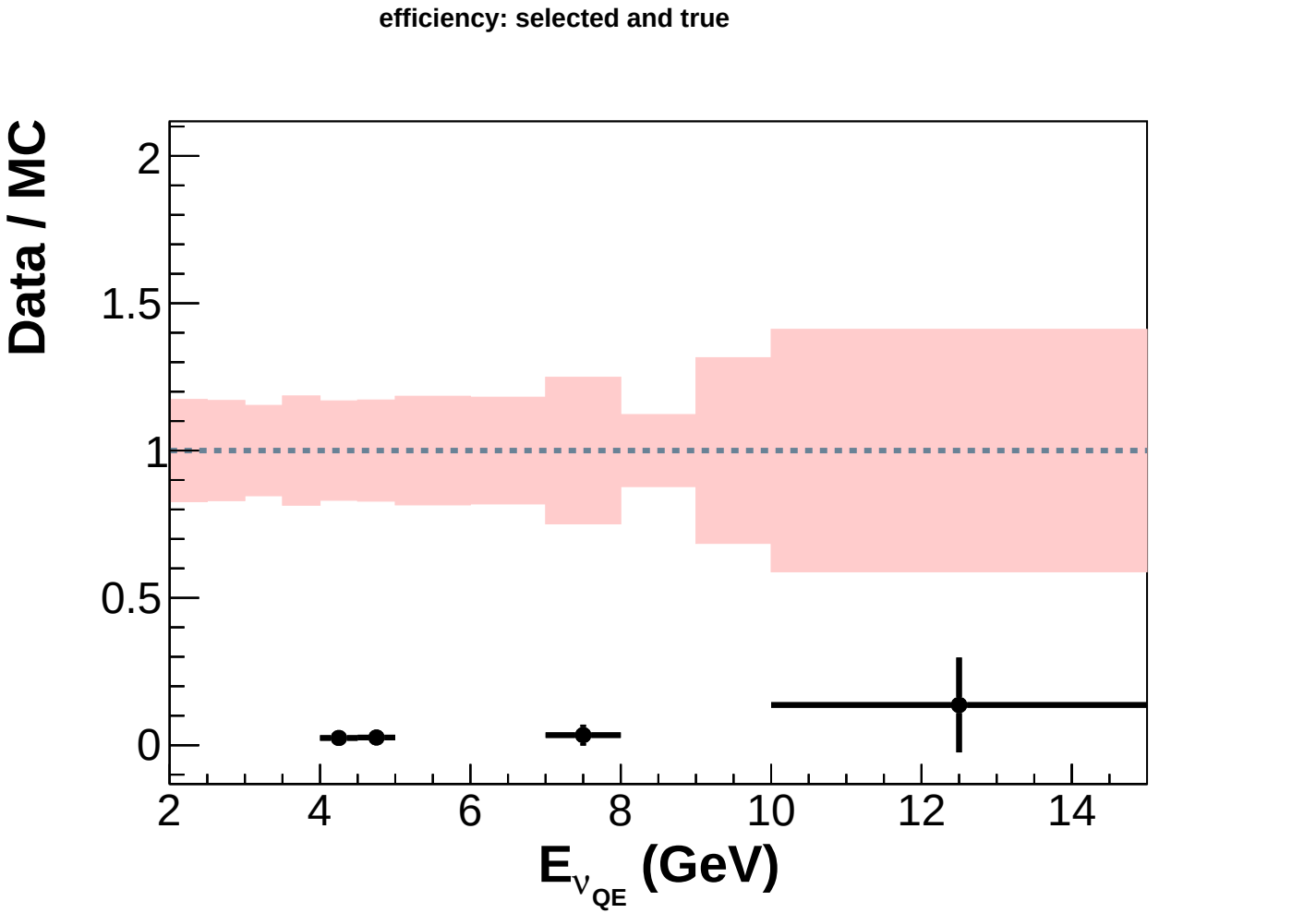

Data Before and After Unsmearing
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

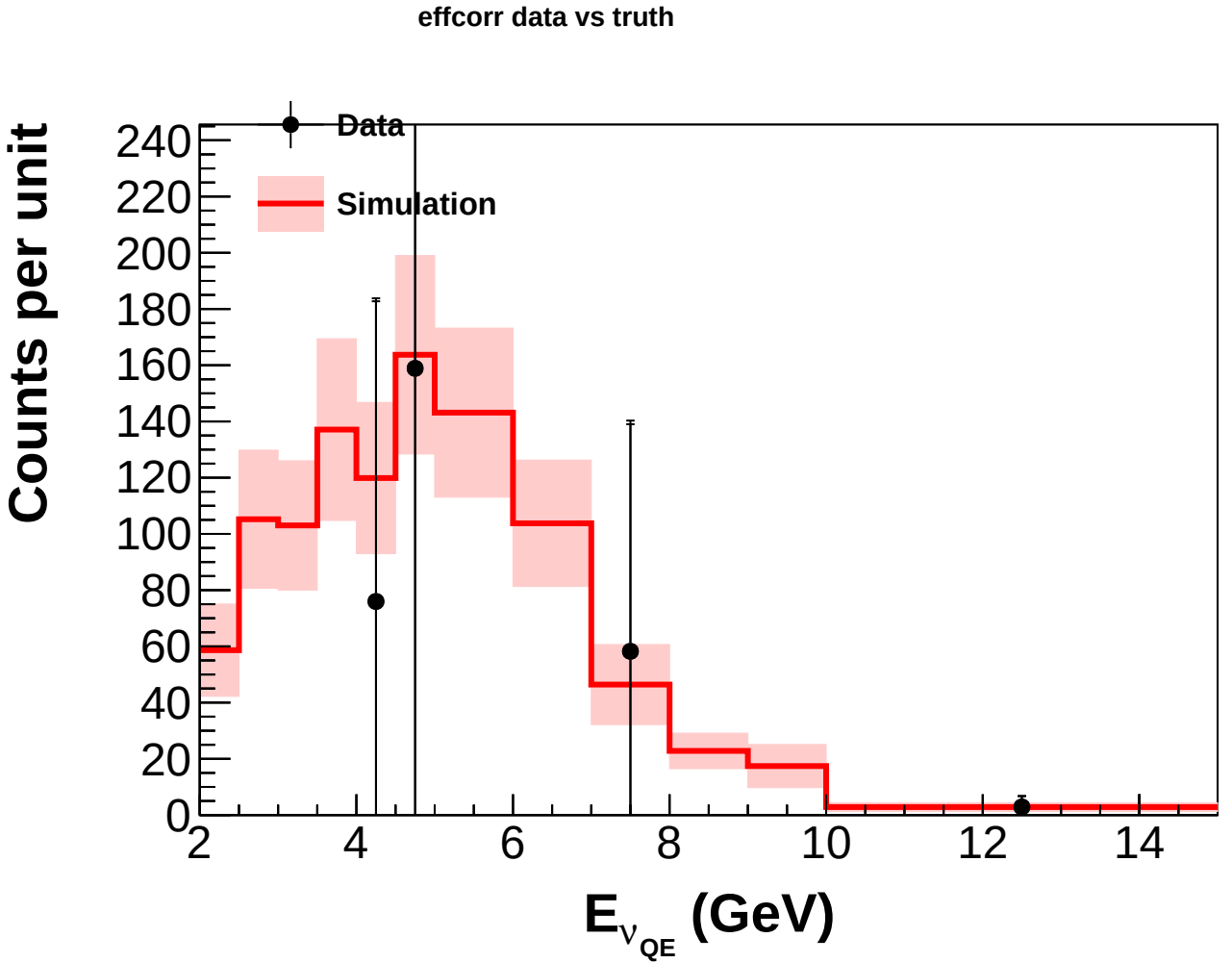

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
1
2
3
4
5
6
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

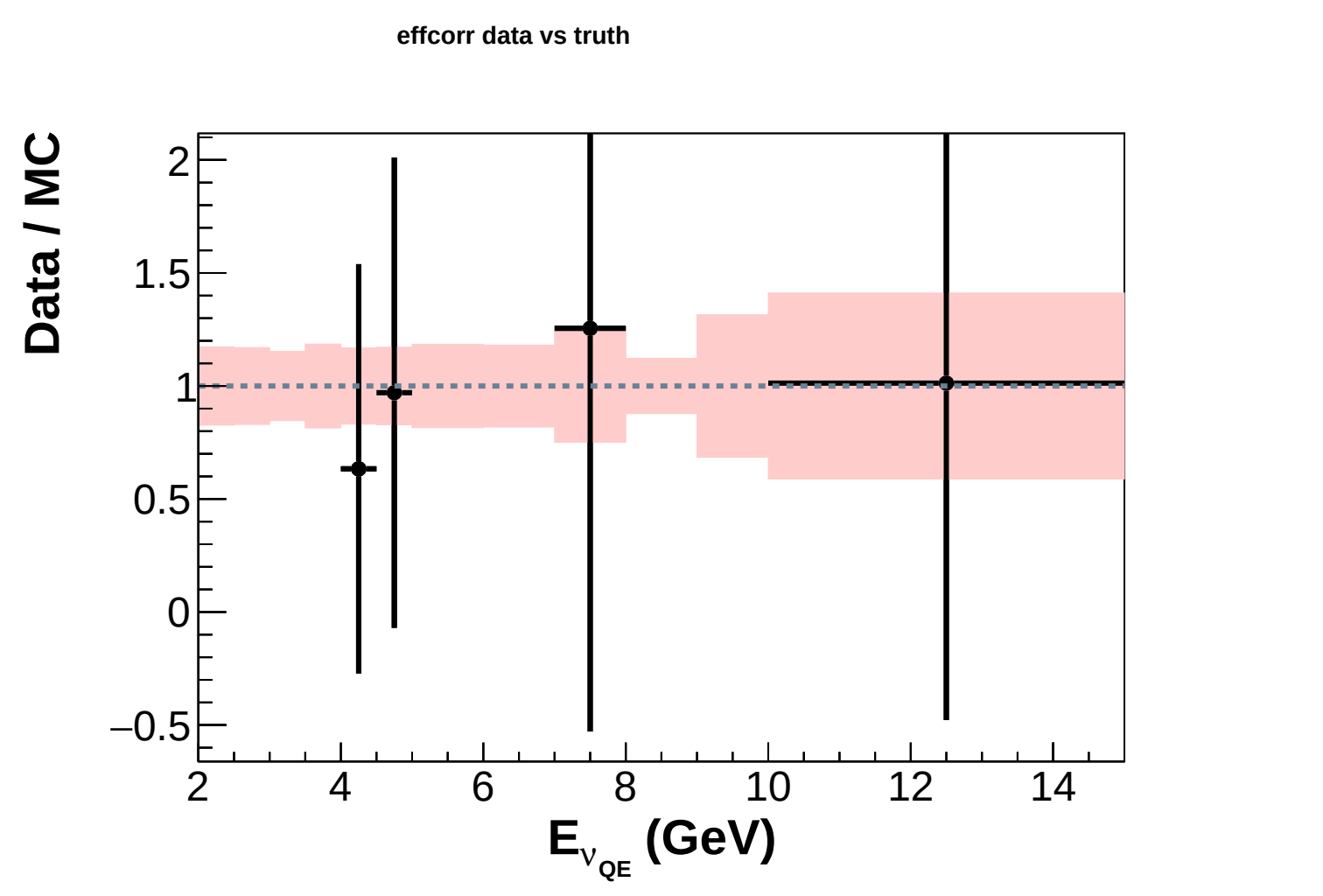

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

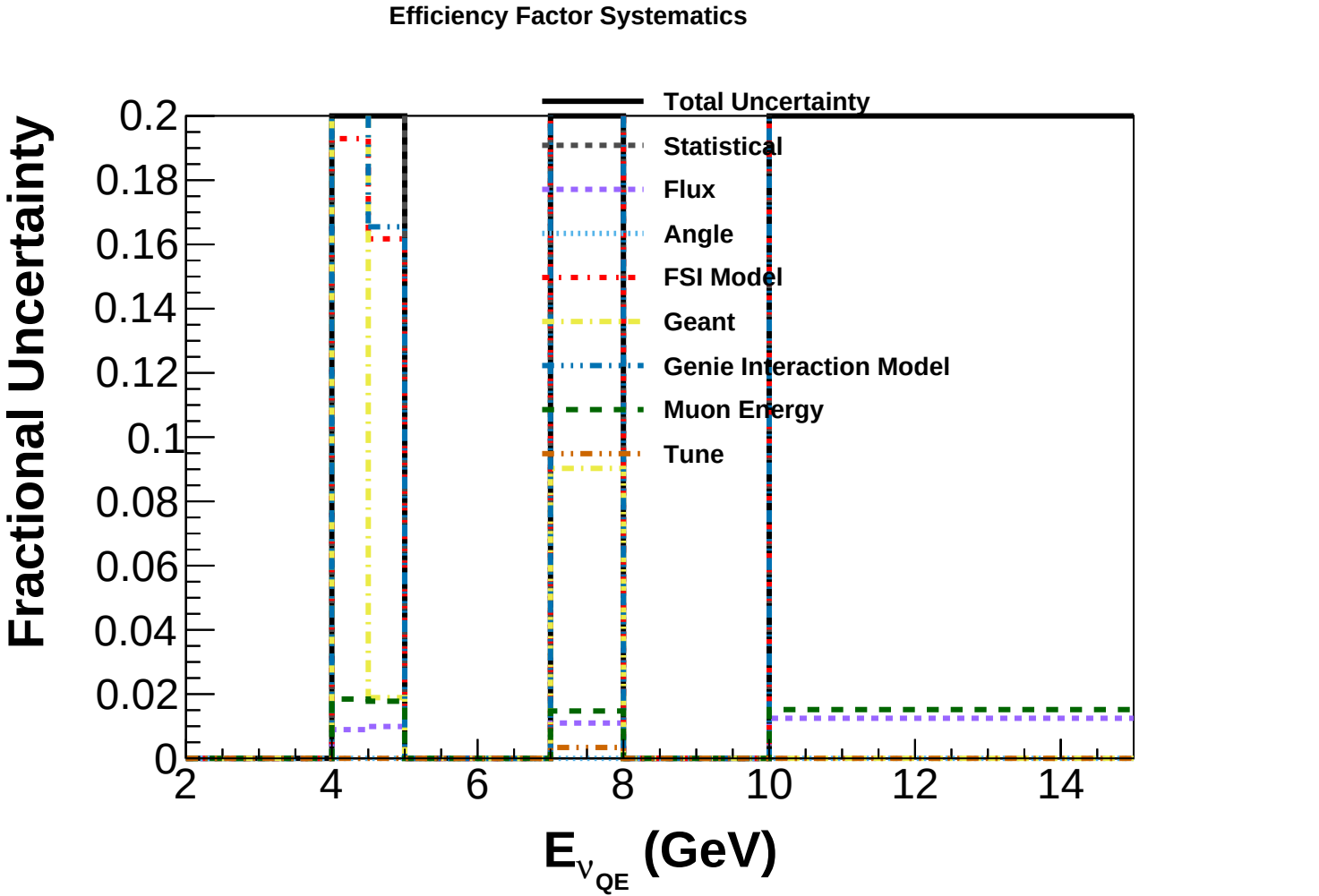

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_νQE (GeV)

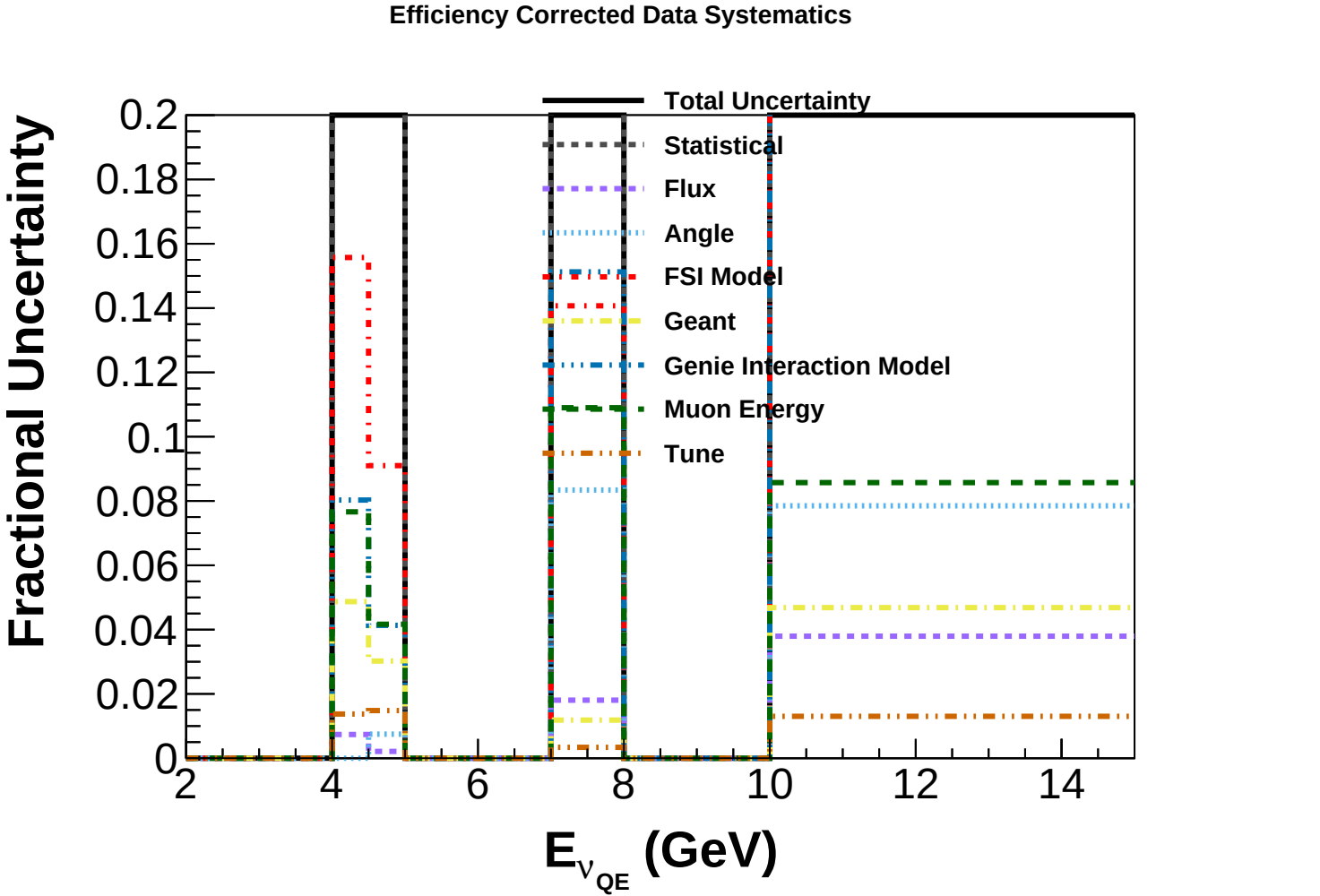

efficiency: selected and true
Data
Simulation
Counts per unit
240
220
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

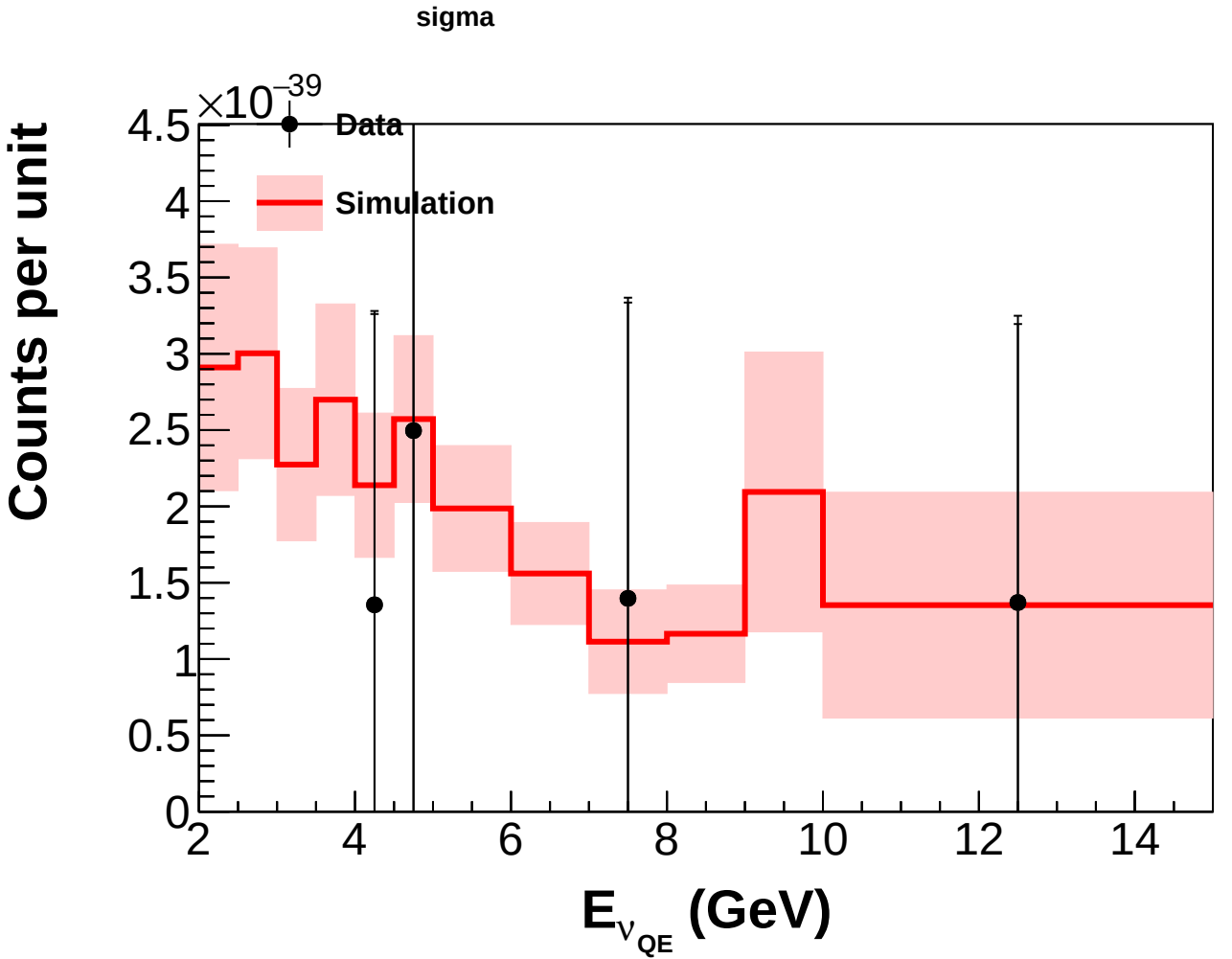

efficiency: selected and true
Data / MC
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

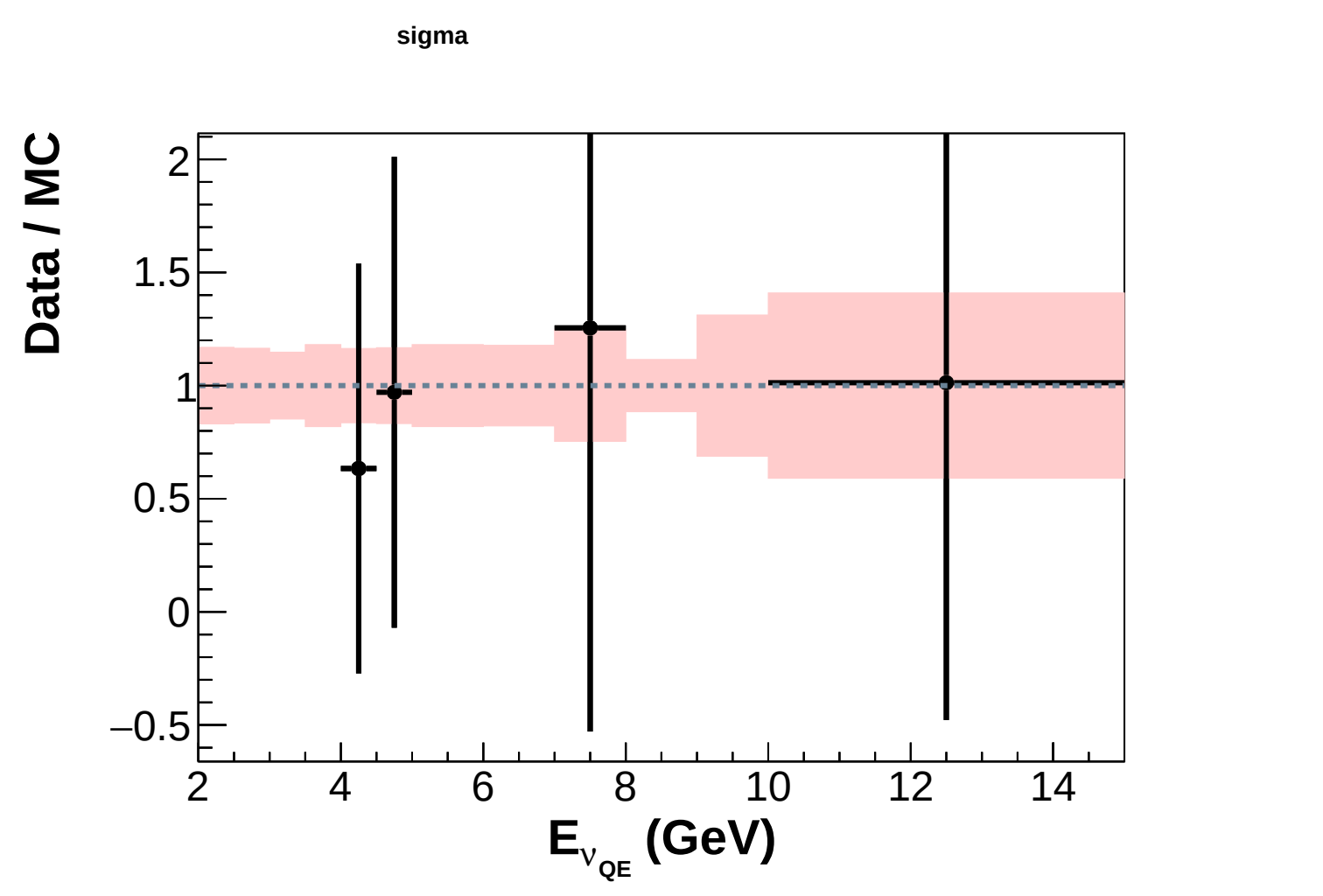

effcorr data vs truth
Data
Simulation
Counts per unit
240
220
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

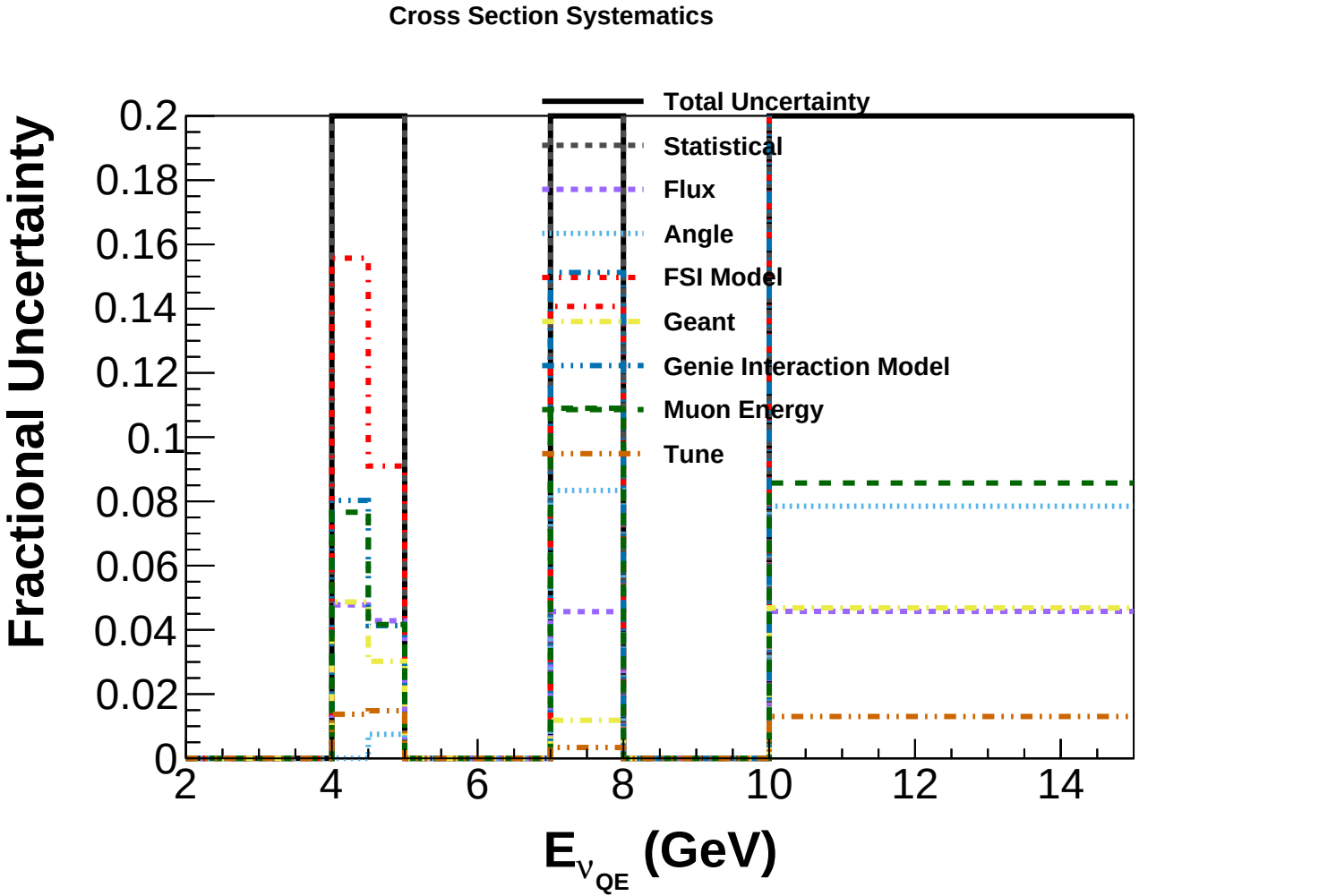

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

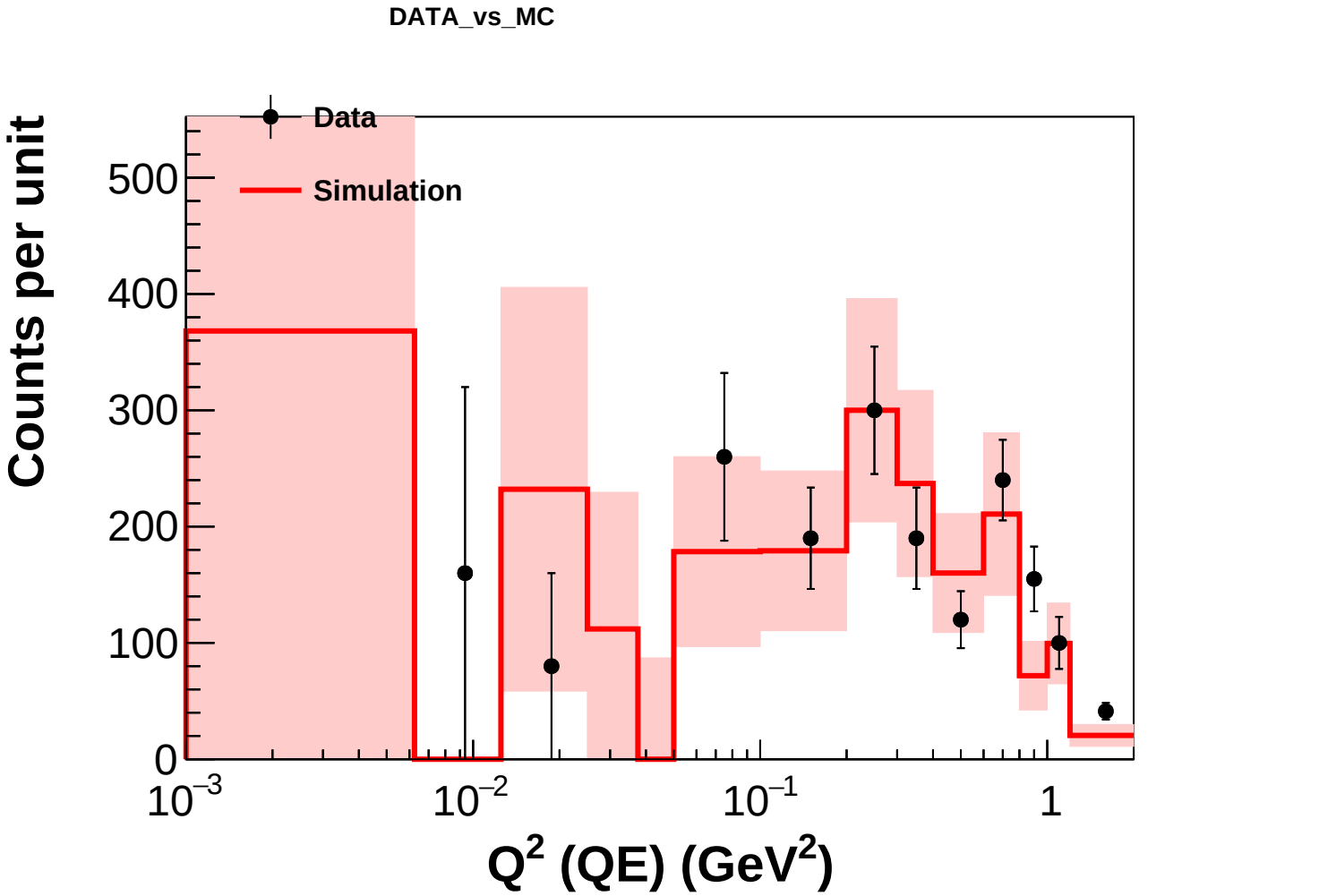

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

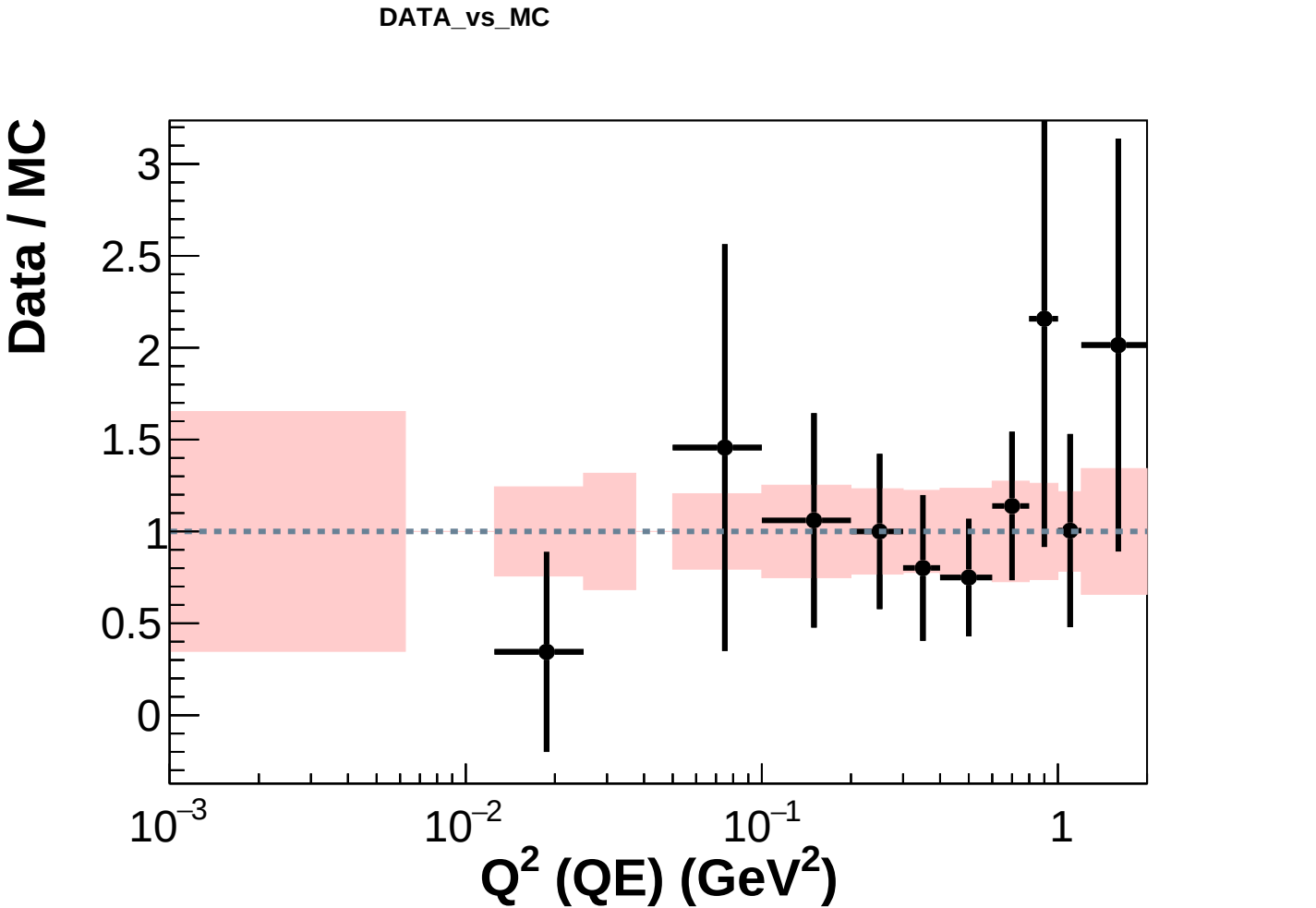

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_νQE (GeV)

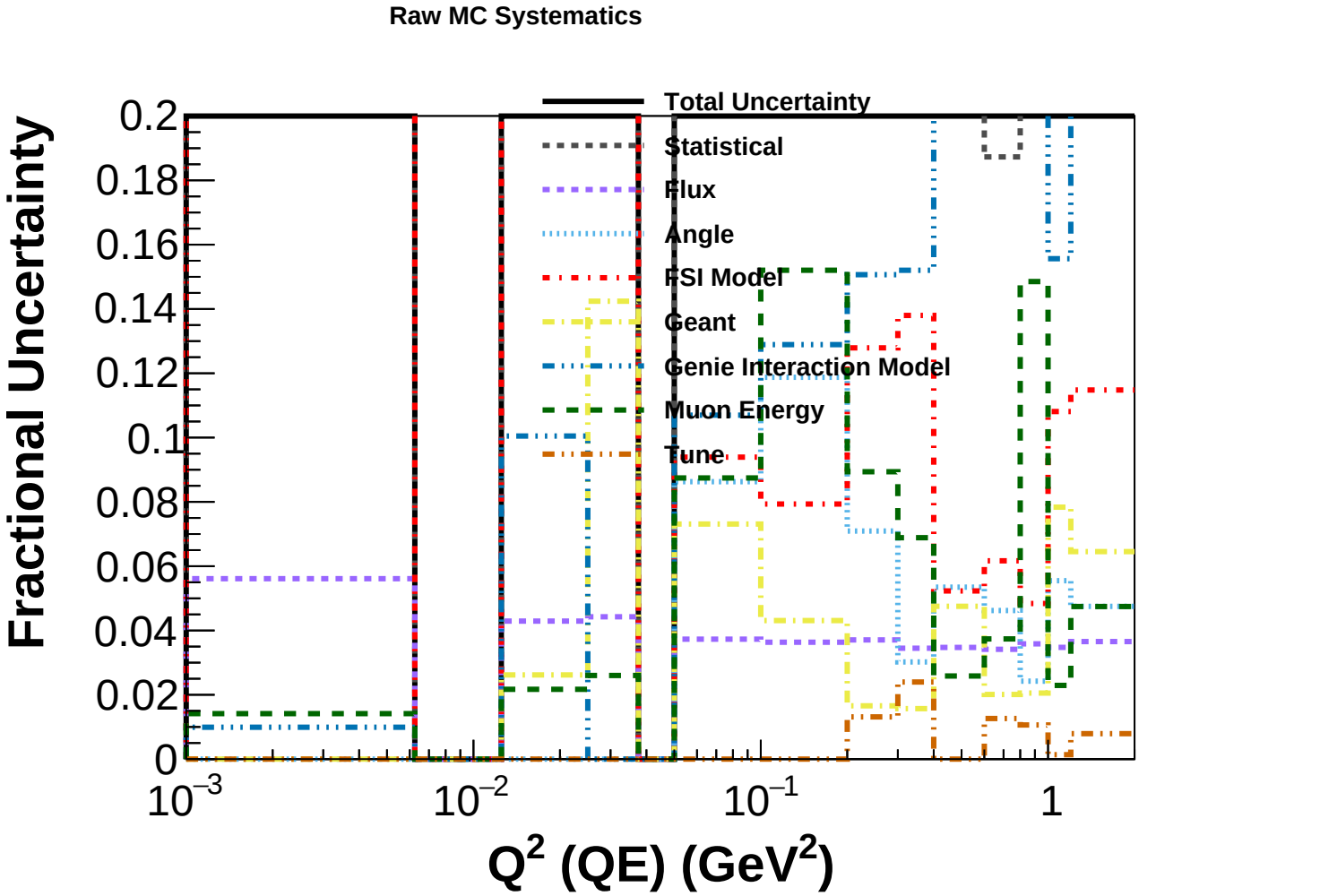

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_νQE (GeV)

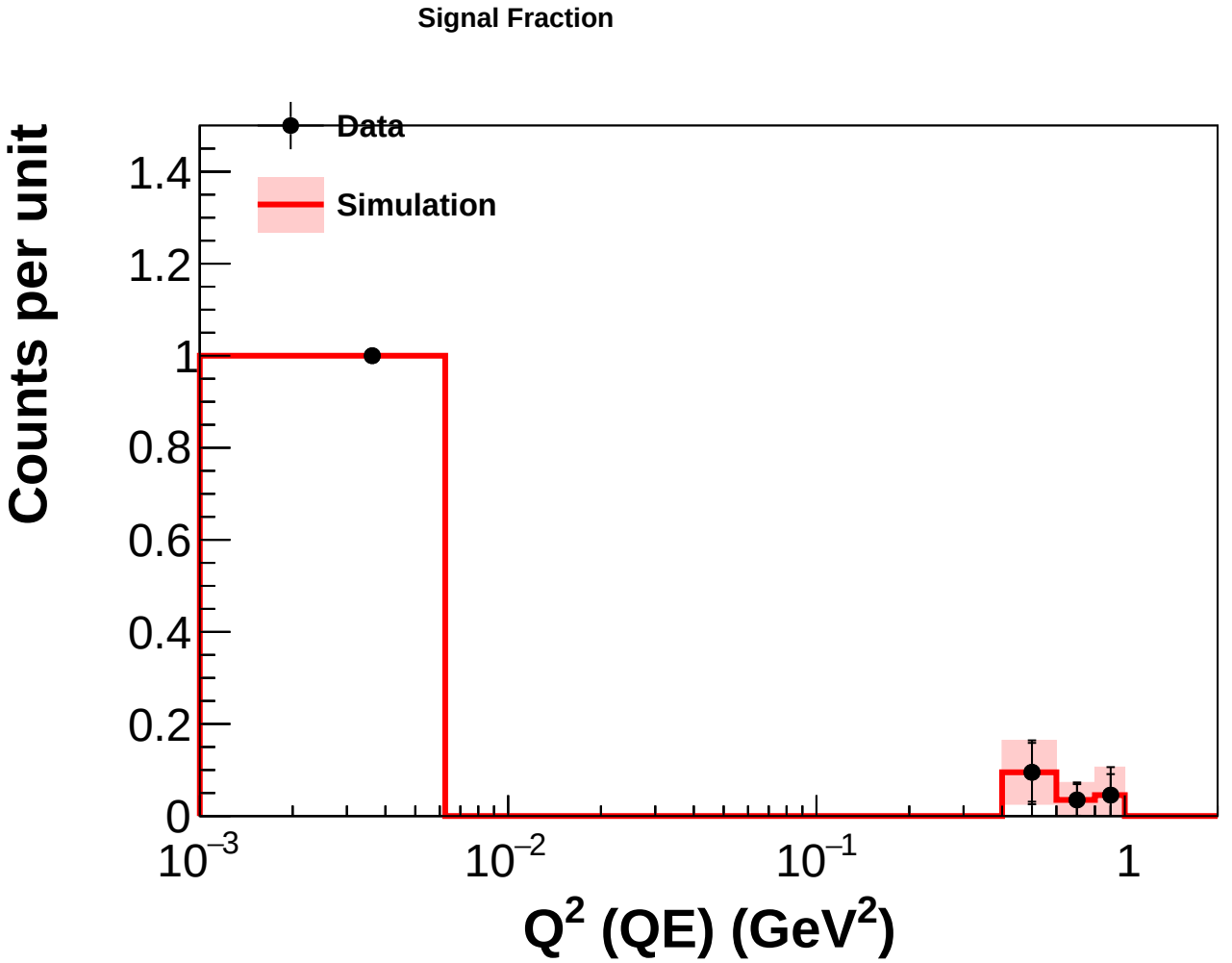

sigma
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

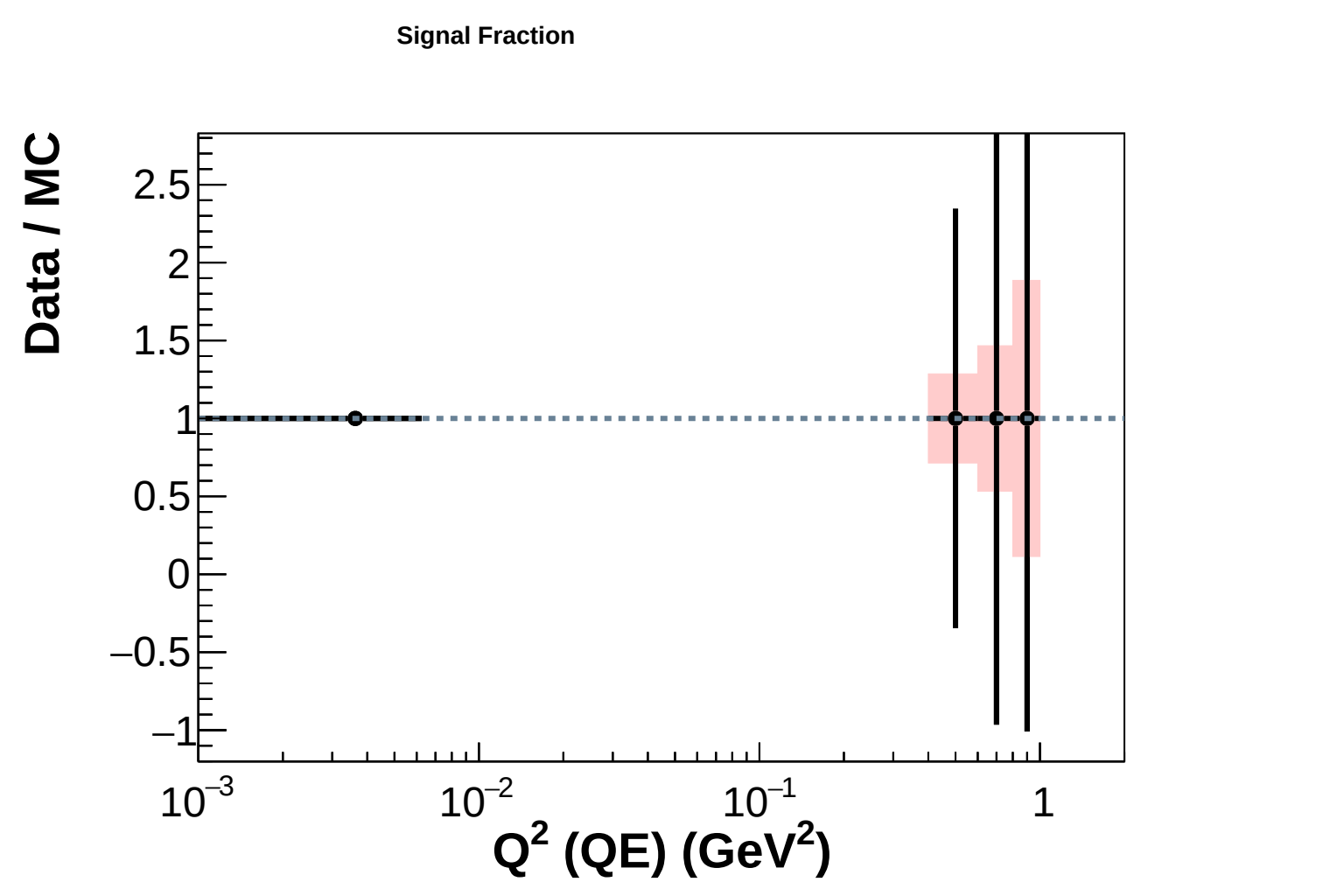

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

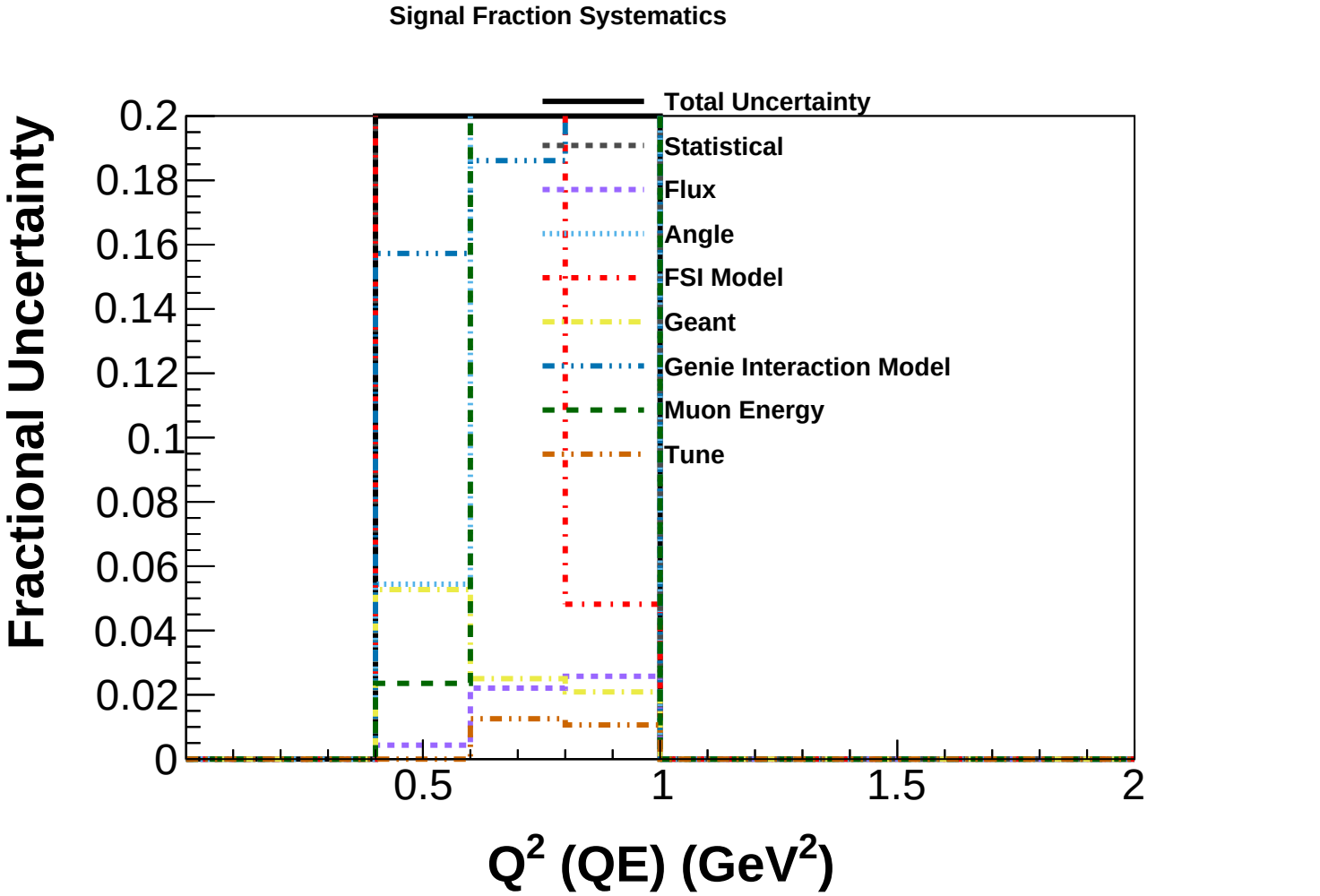

DATA_vs_MC
Data
Simulation
Counts per unit
500
400
300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

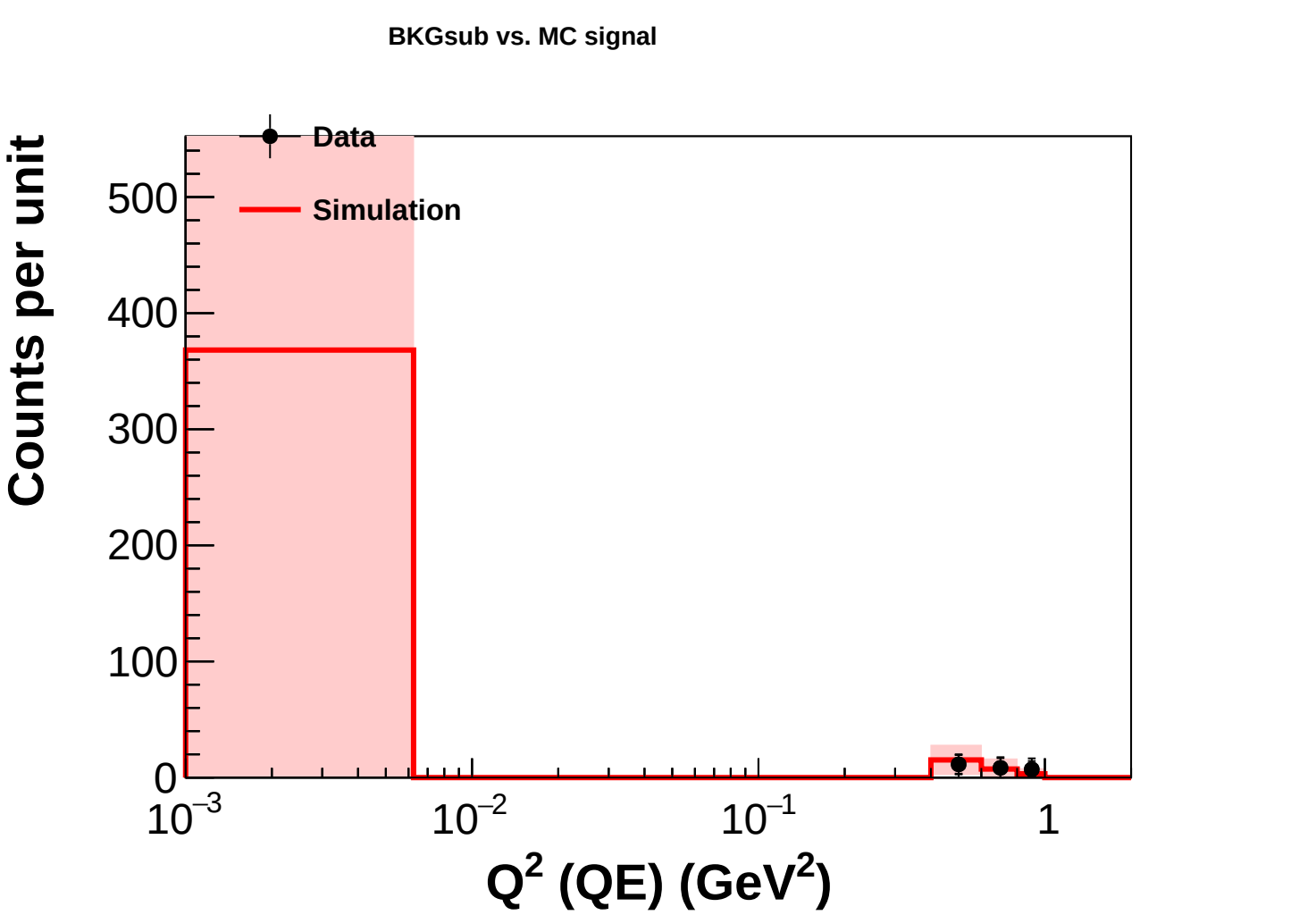

DATA_vs_MC
Data / MC
3
2.5
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

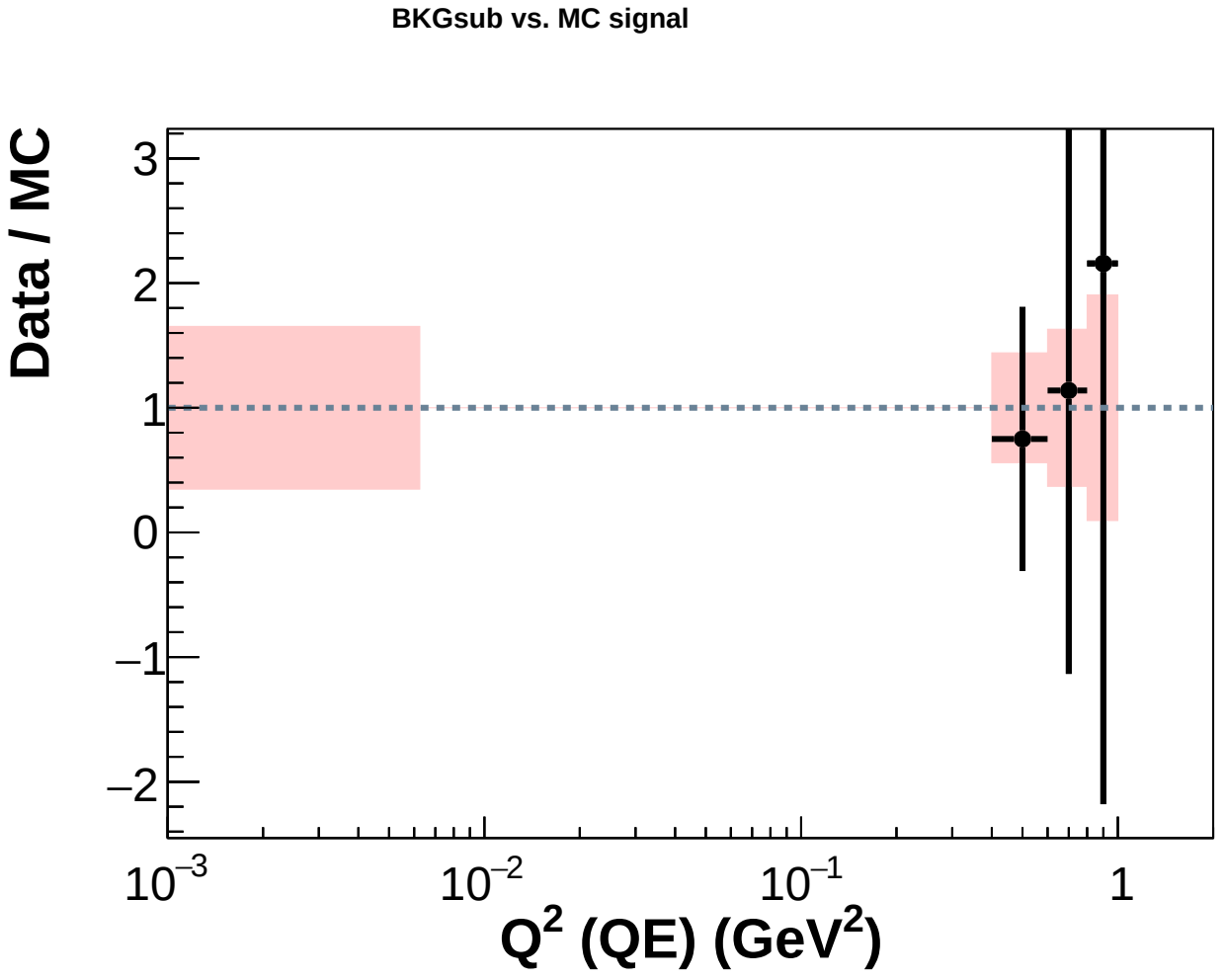

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

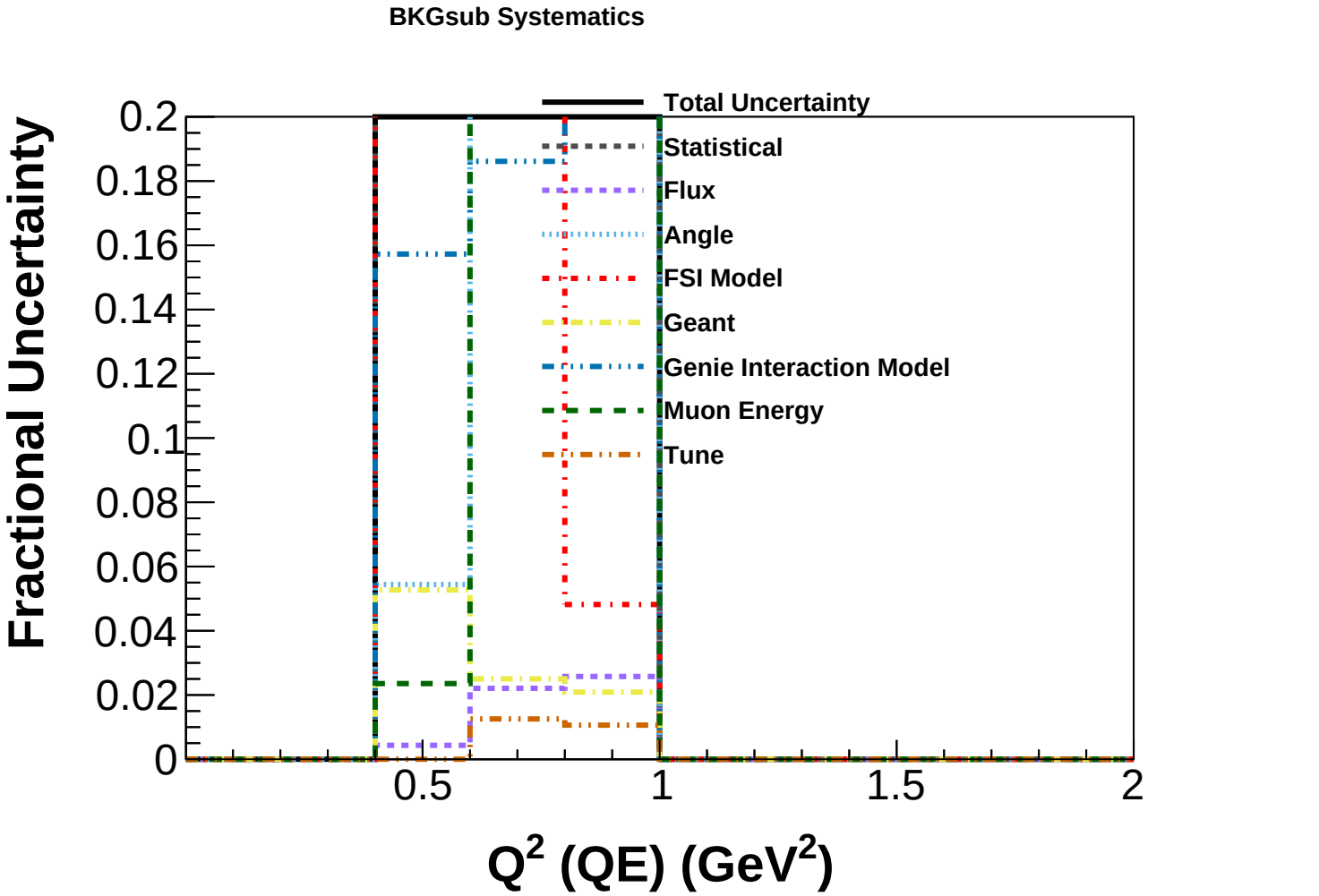

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

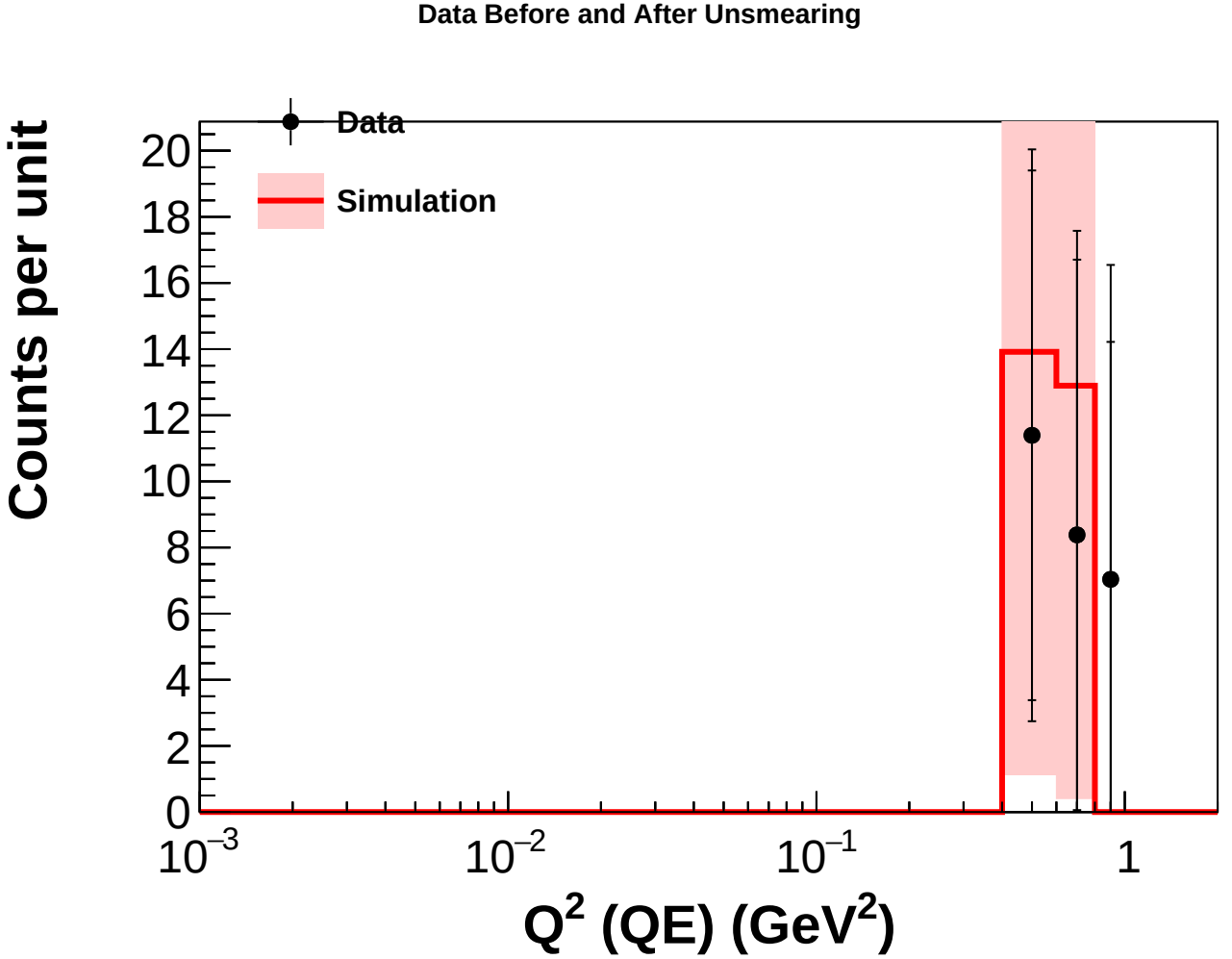

Signal Fraction
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

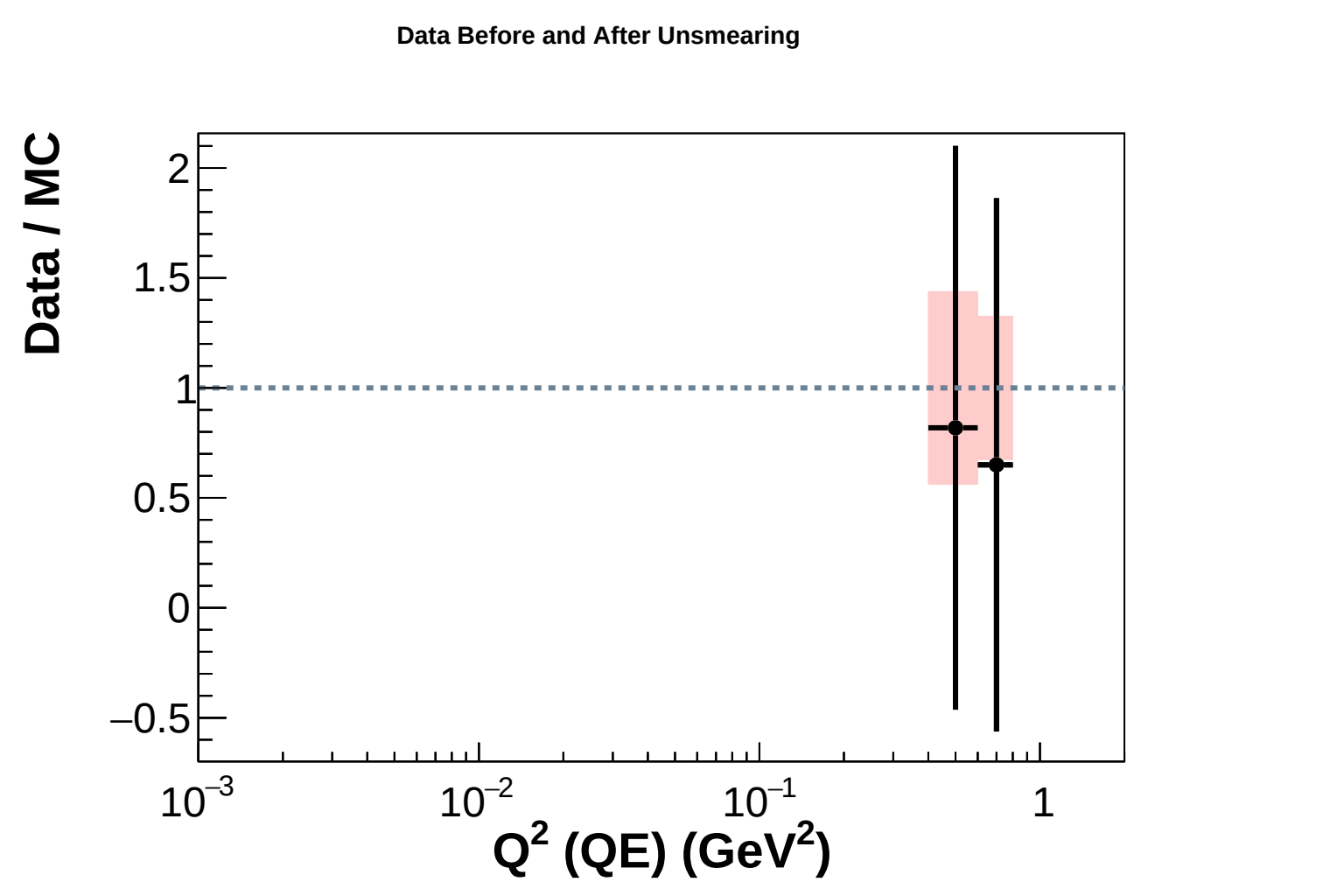

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

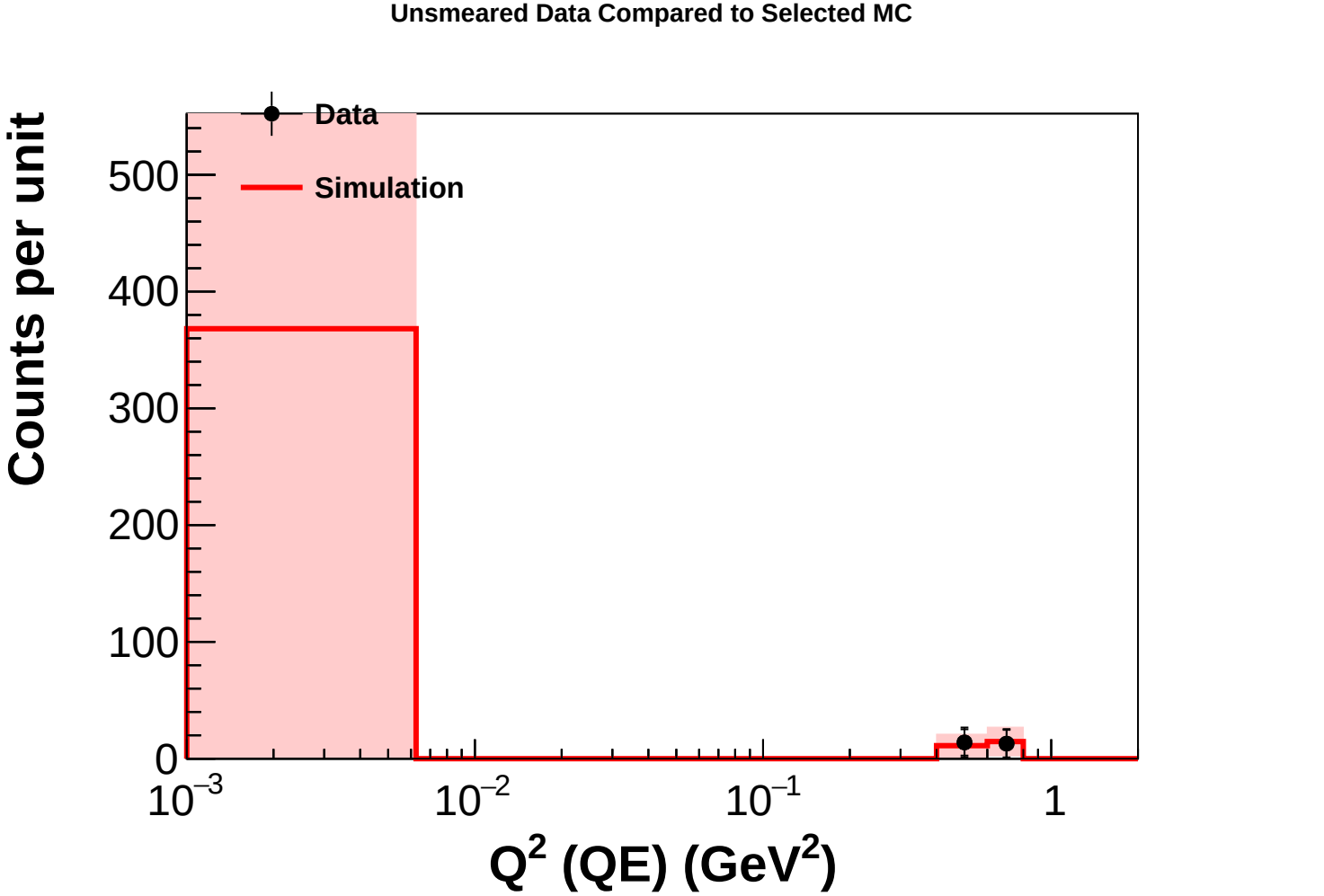

BKGsub vs. MC signal
Data
Simulation
Counts per unit
500
400
300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

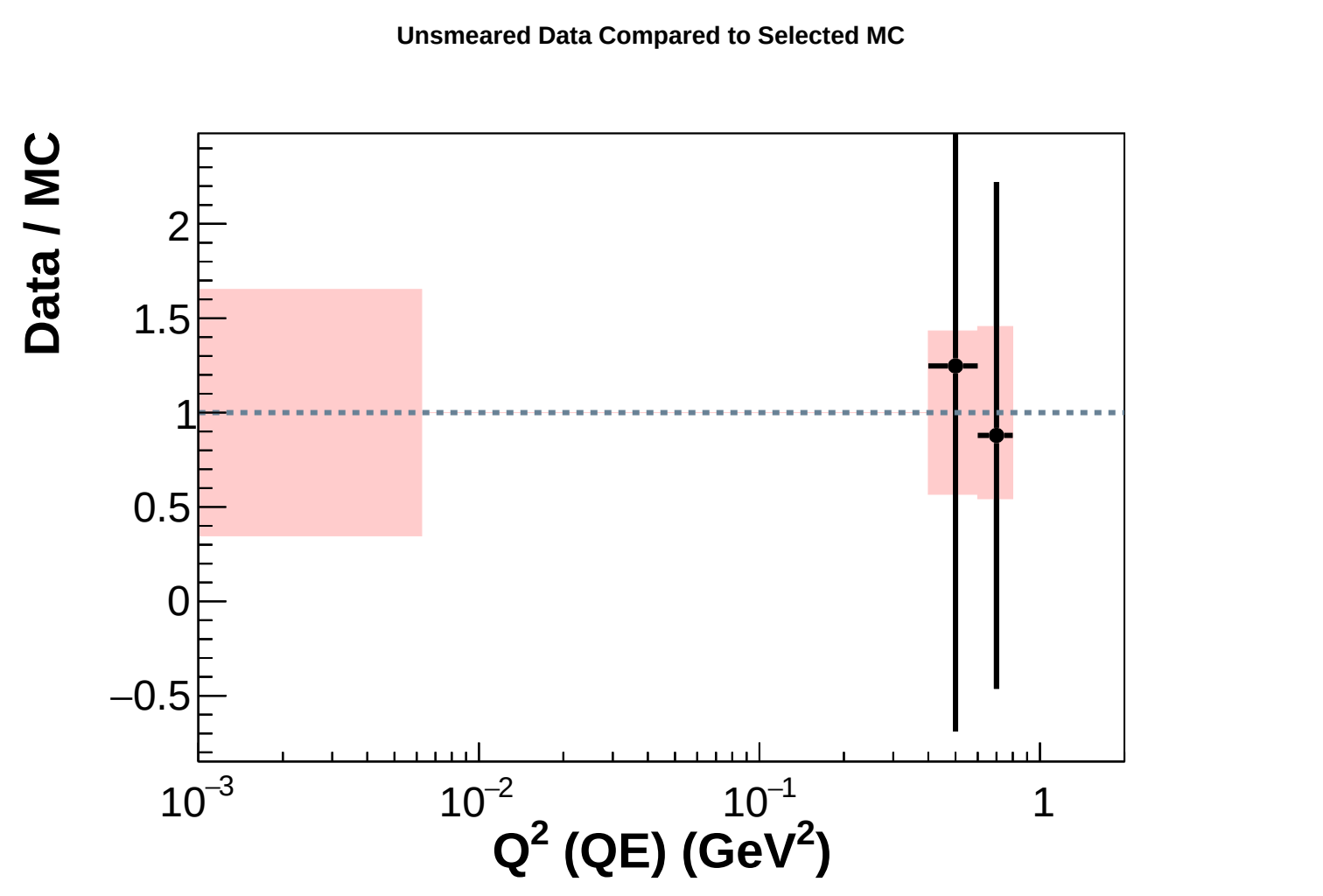

BKGsub vs. MC signal
Data / MC
3
2
1
0
−1
−2
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

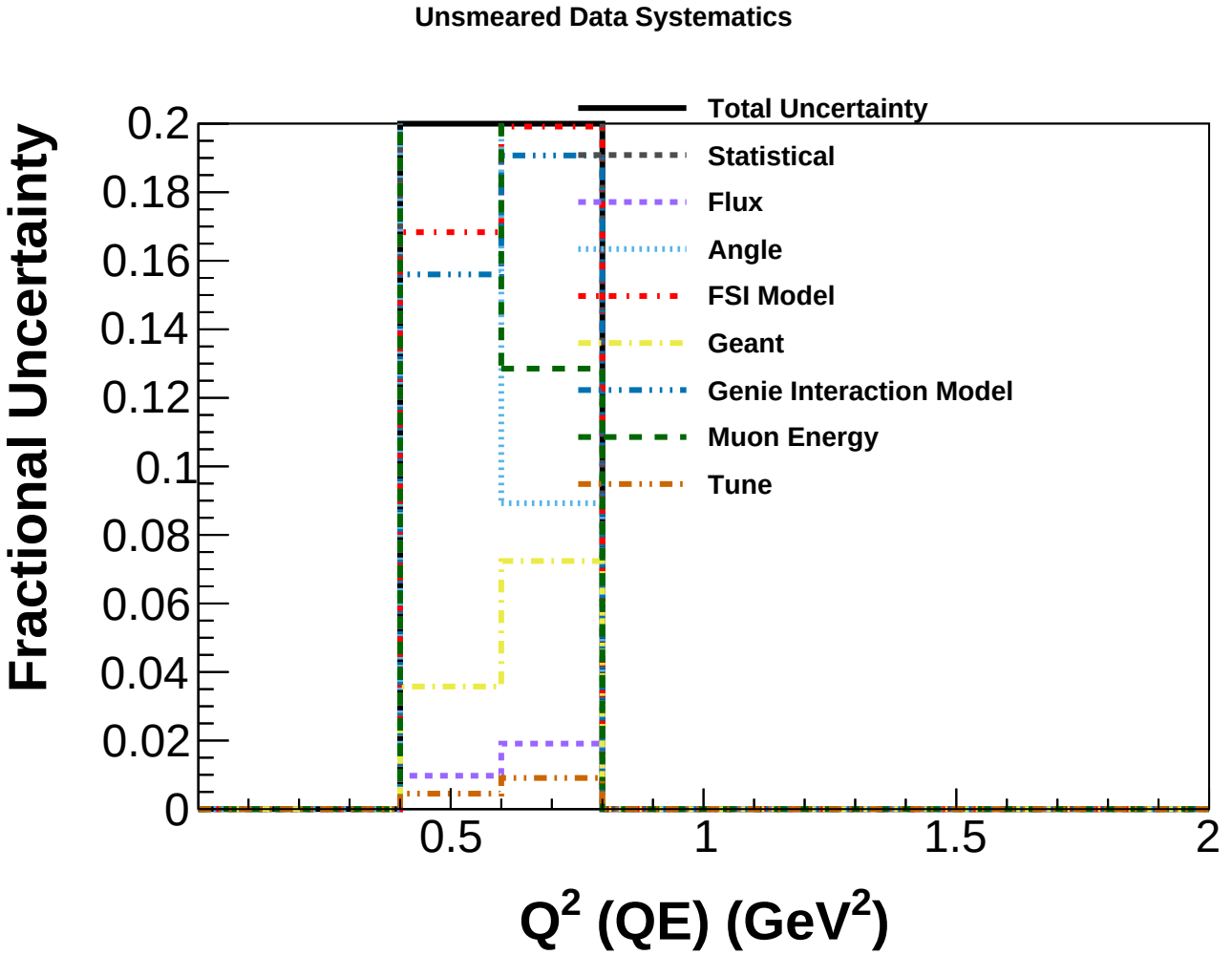

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

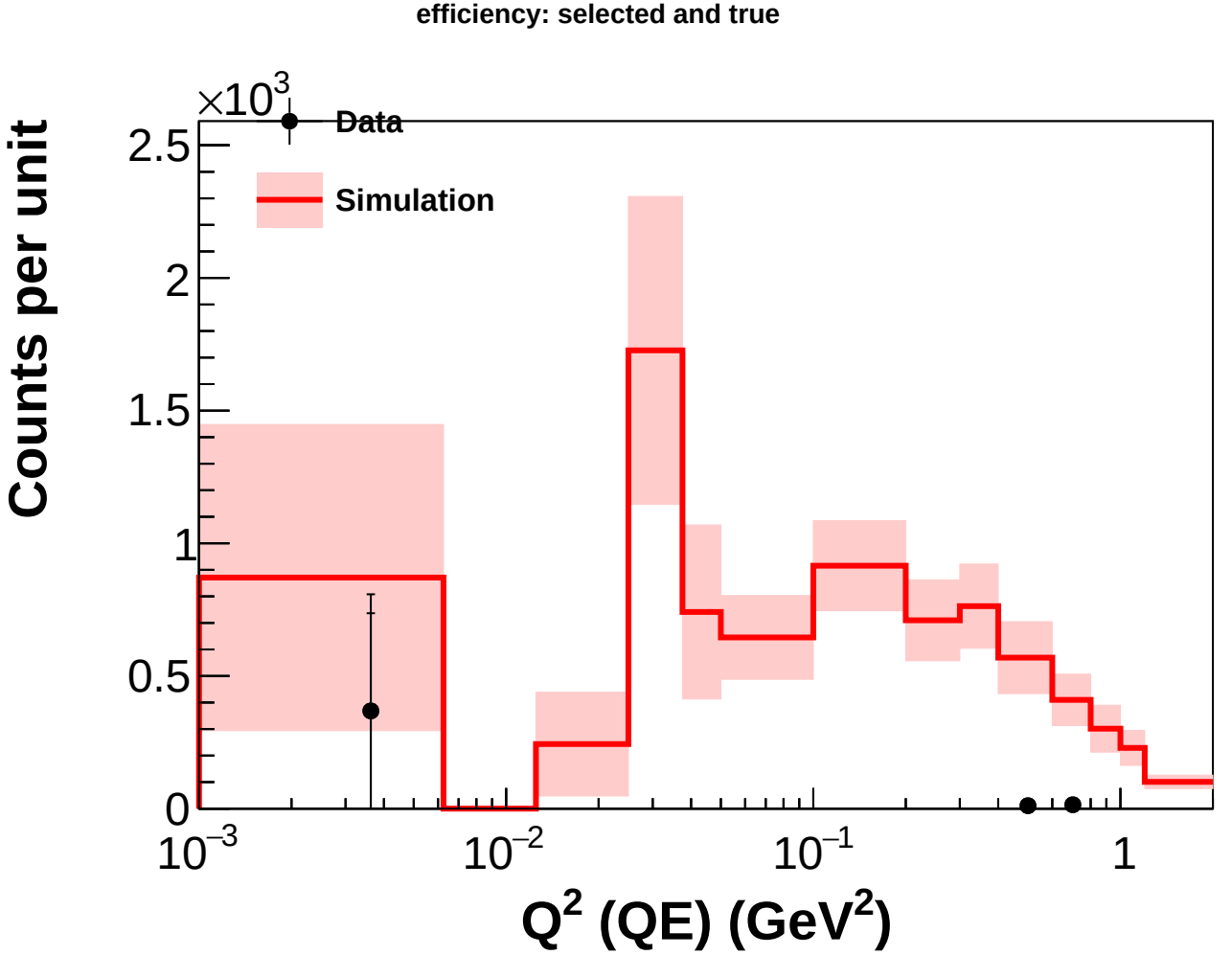

Data Before and After Unsmearing
Data
Simulation
Counts per unit
20
18
16
14
12
10
8
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

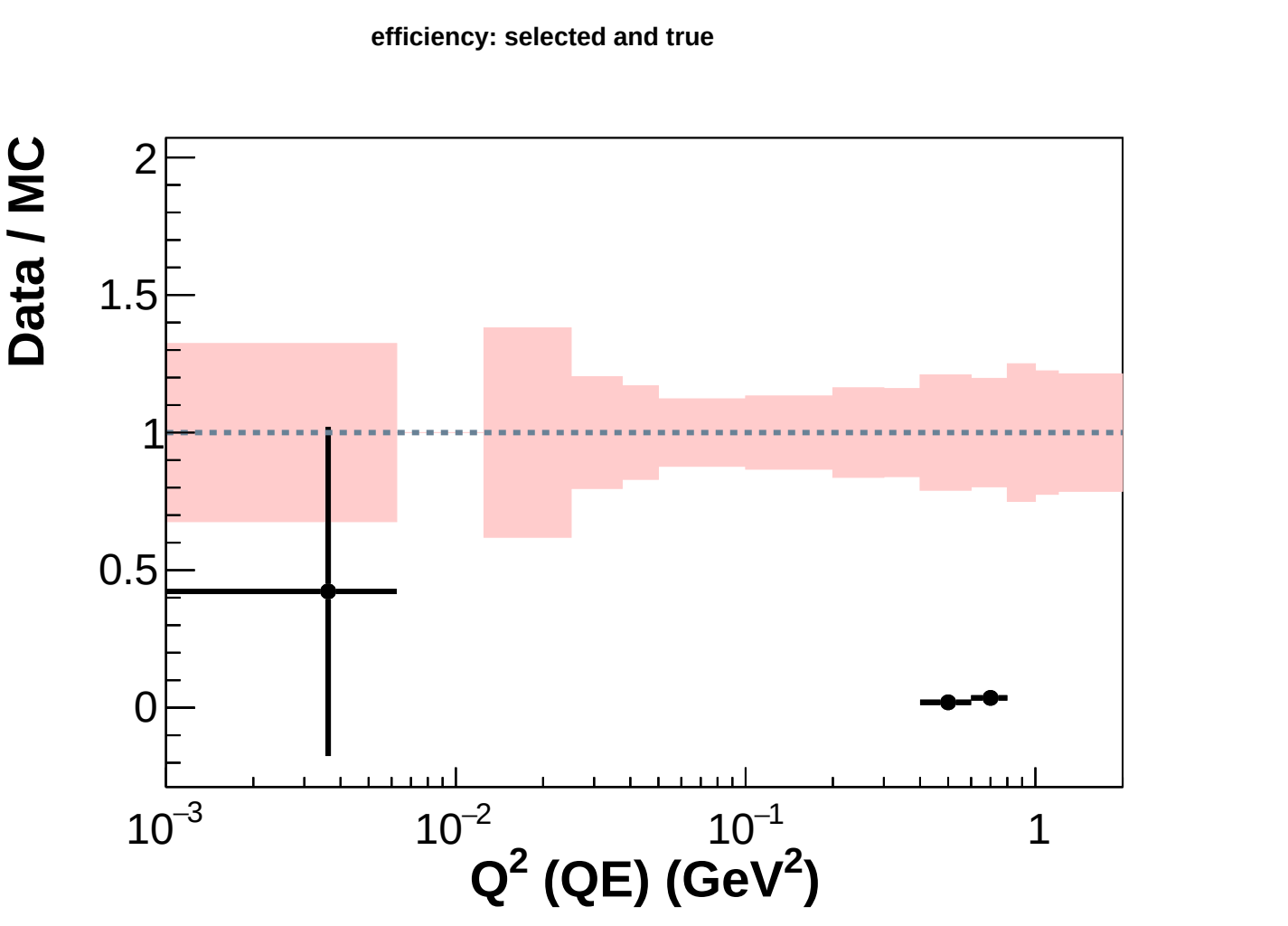

Data Before and After Unsmearing
Data / MC
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

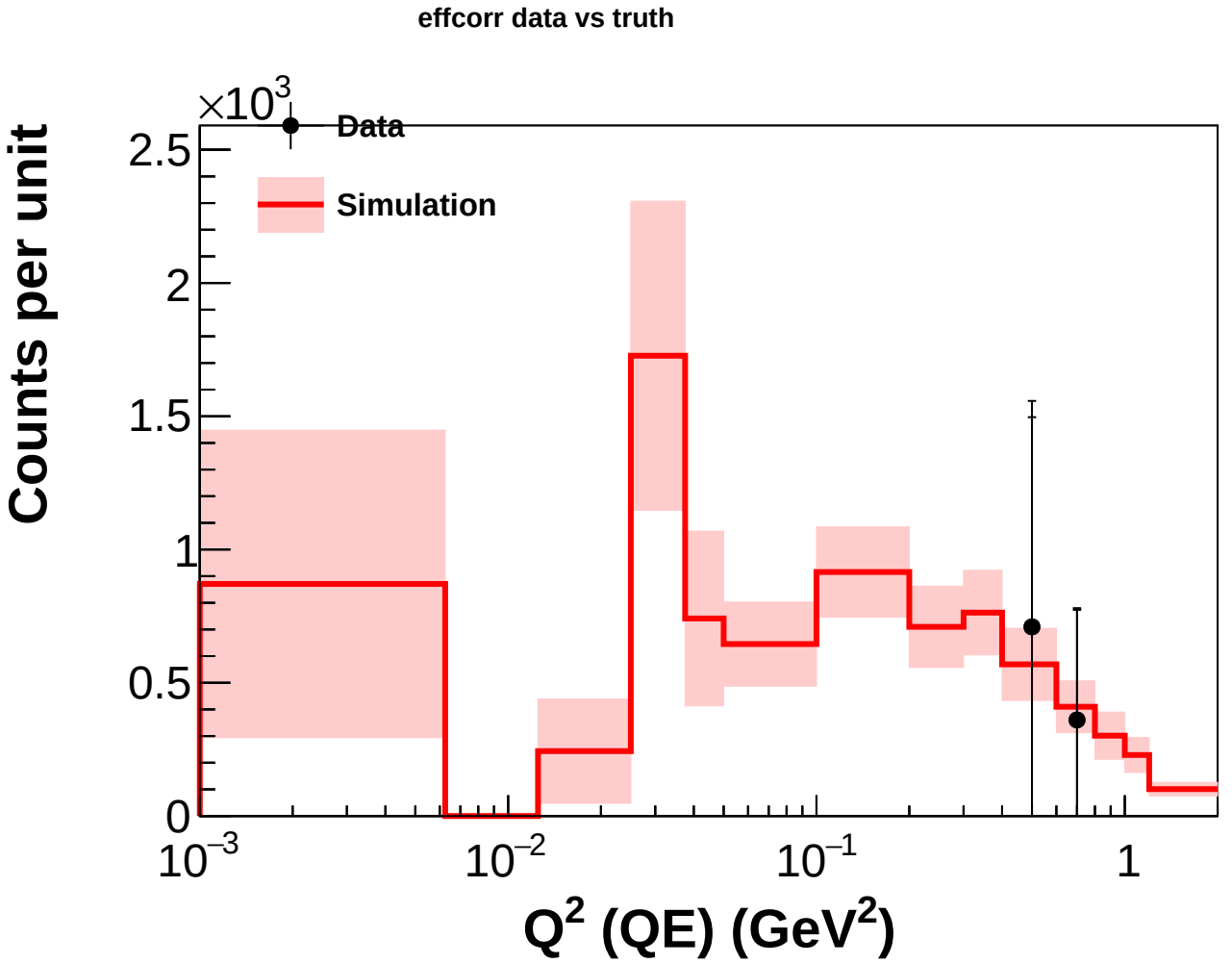

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
500
400
300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

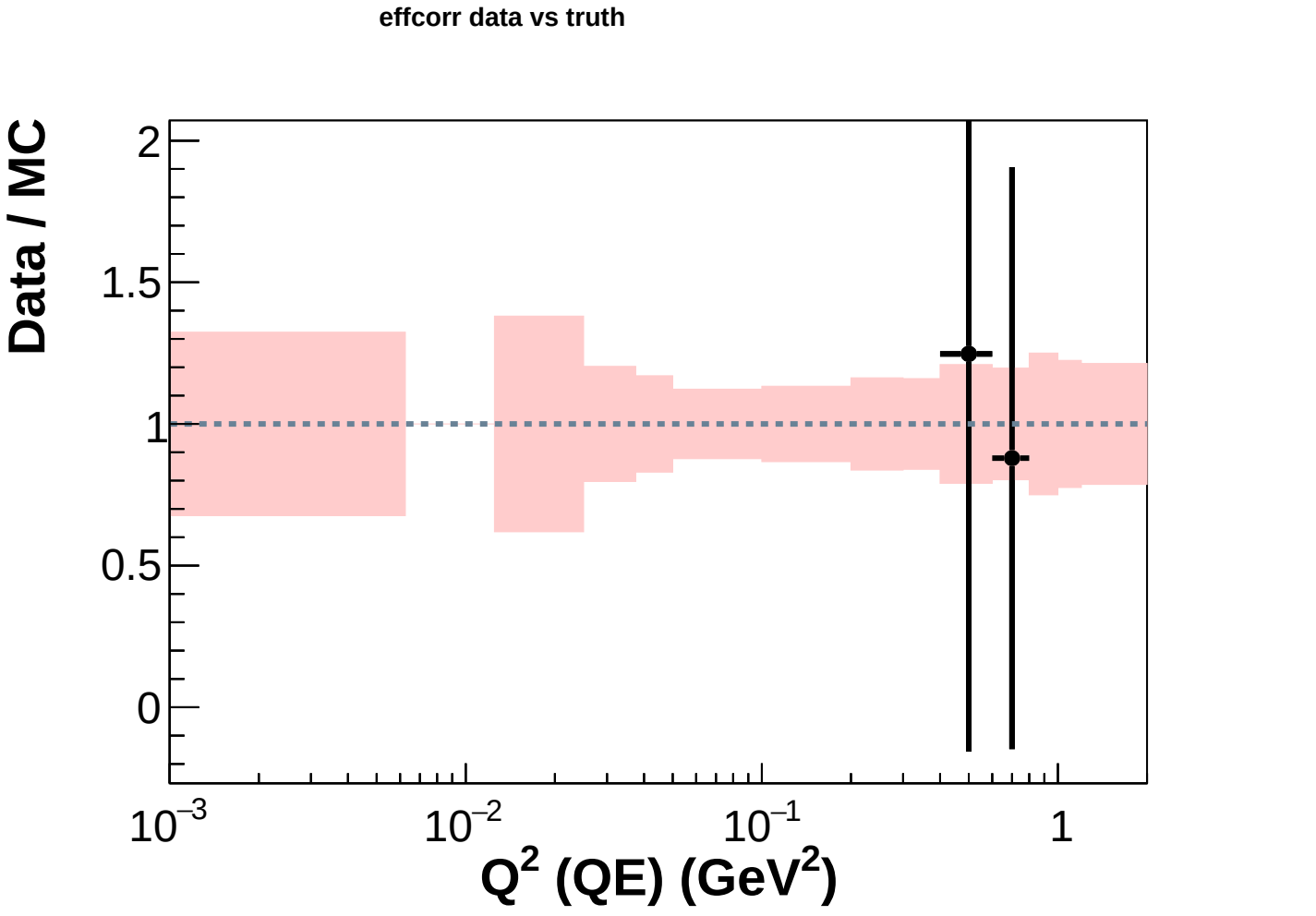

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

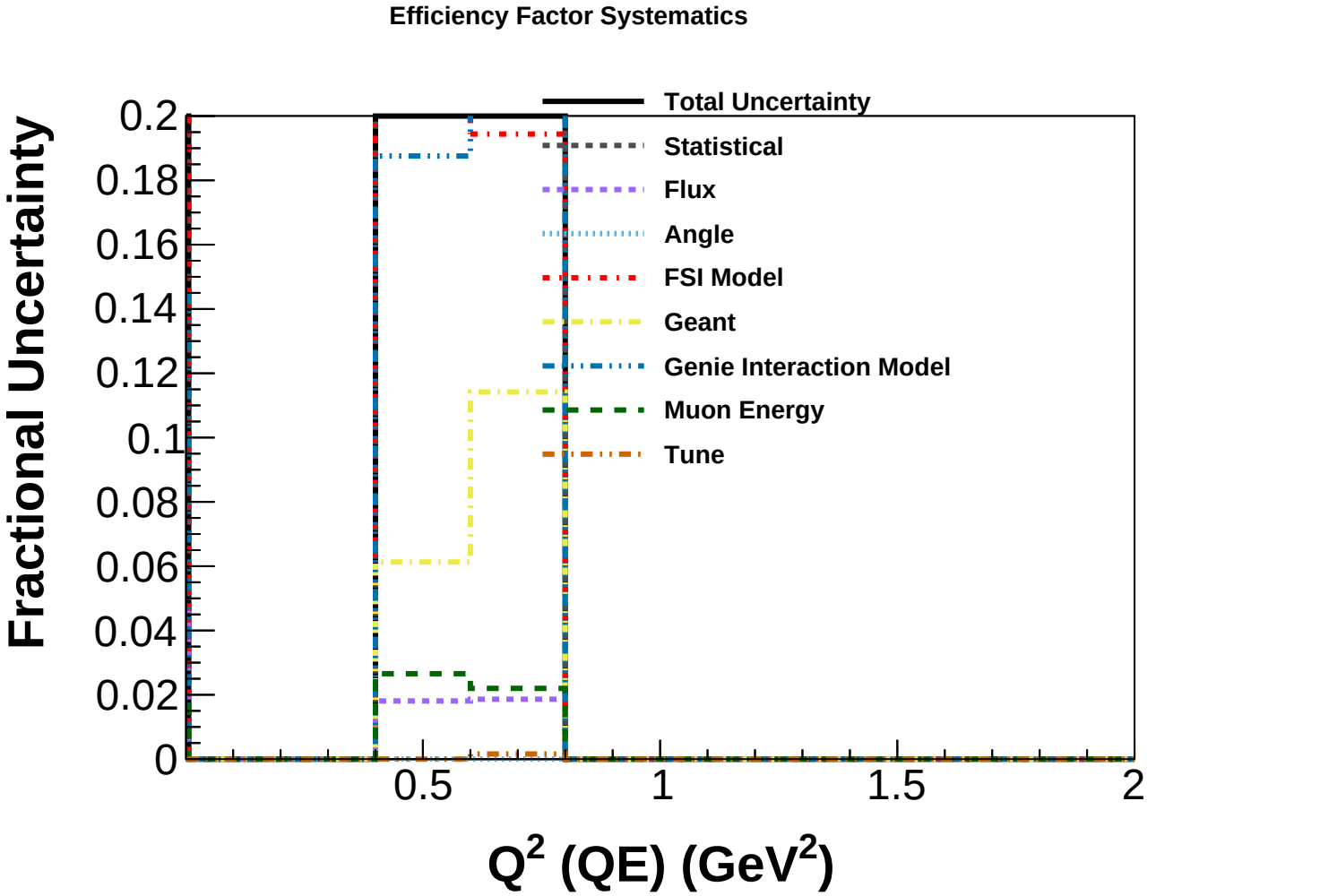

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

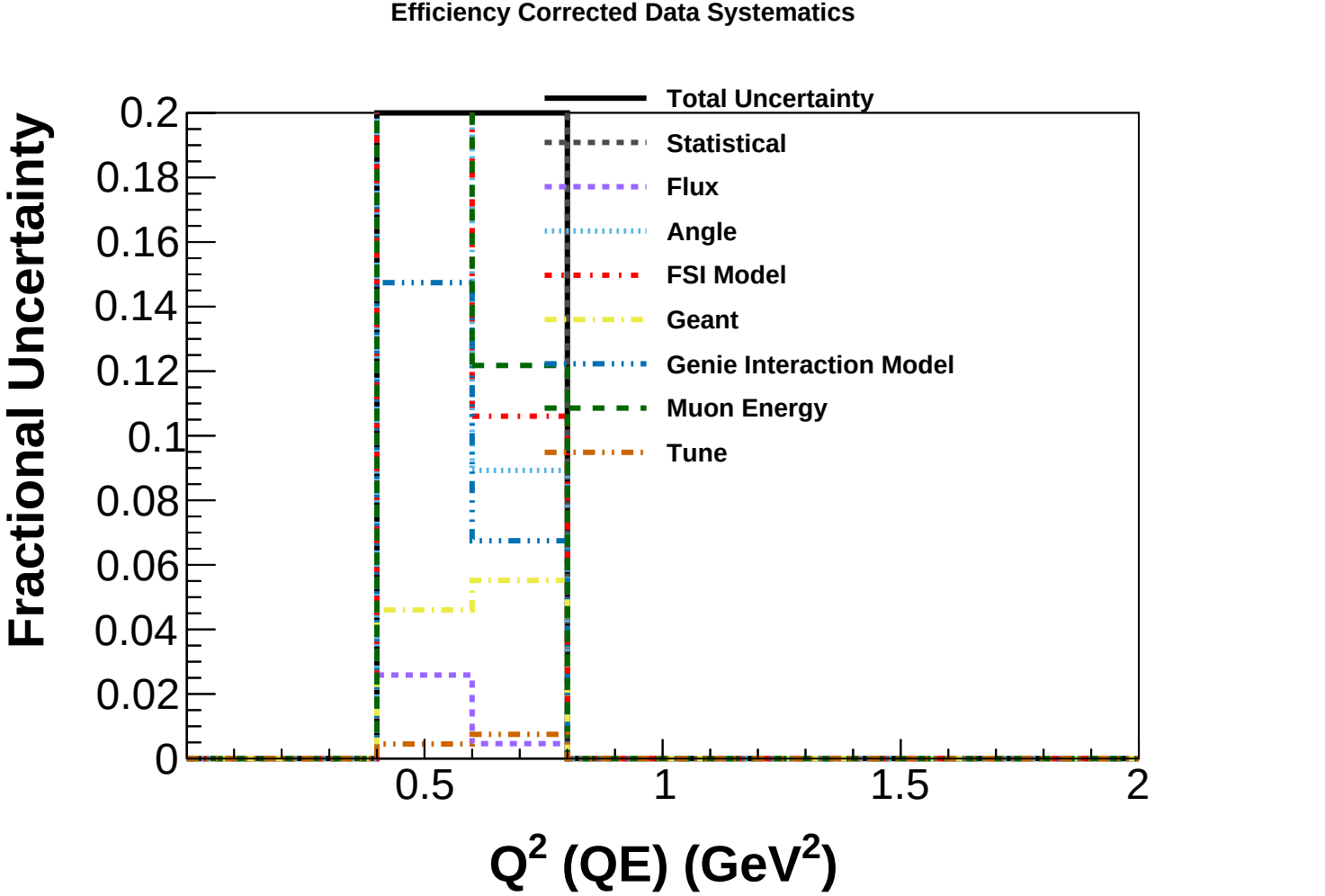

efficiency: selected and true
Counts per unit
×10^3
2.5
2
1.5
1
0.5
0
Data
Simulation
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

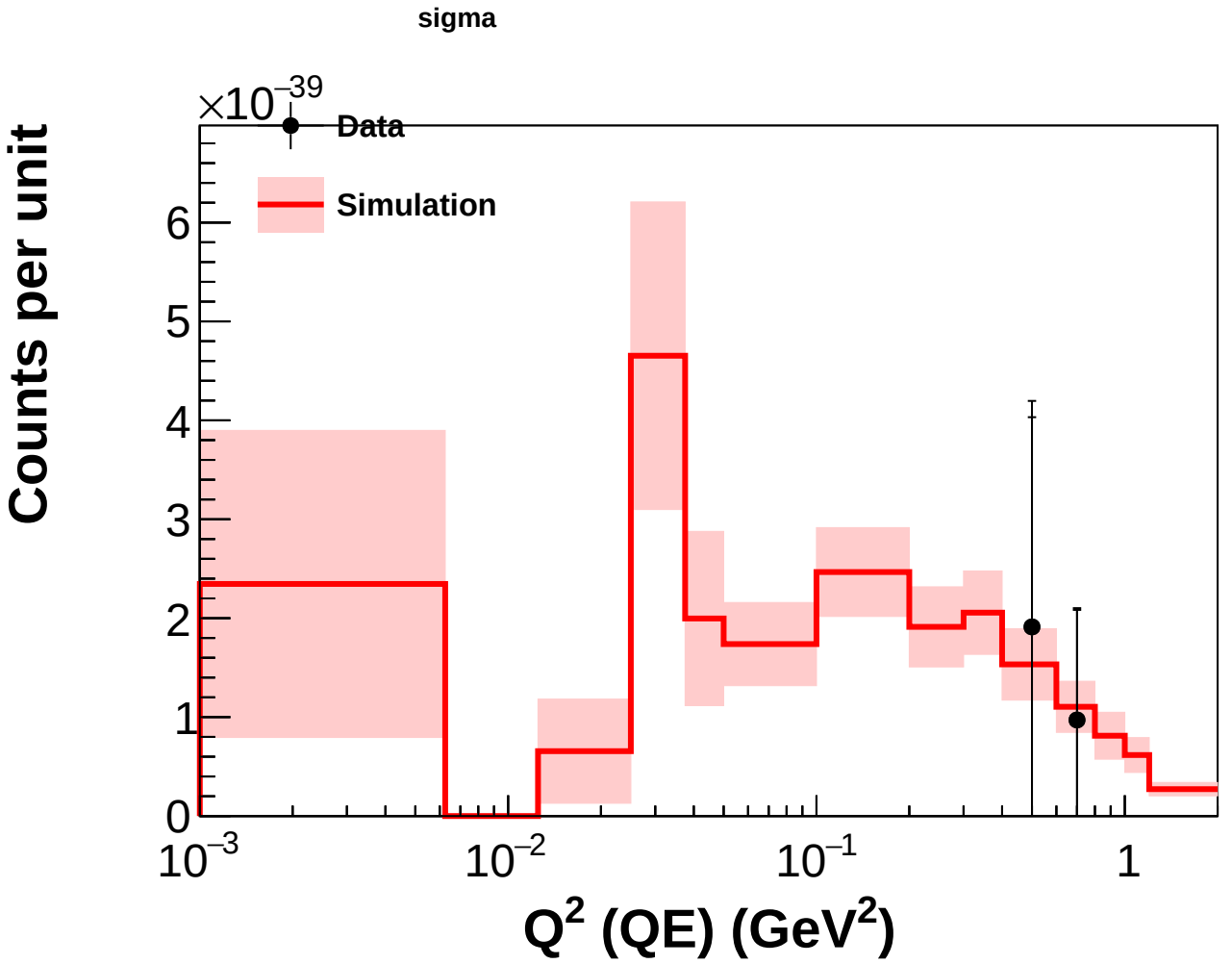

efficiency: selected and true
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

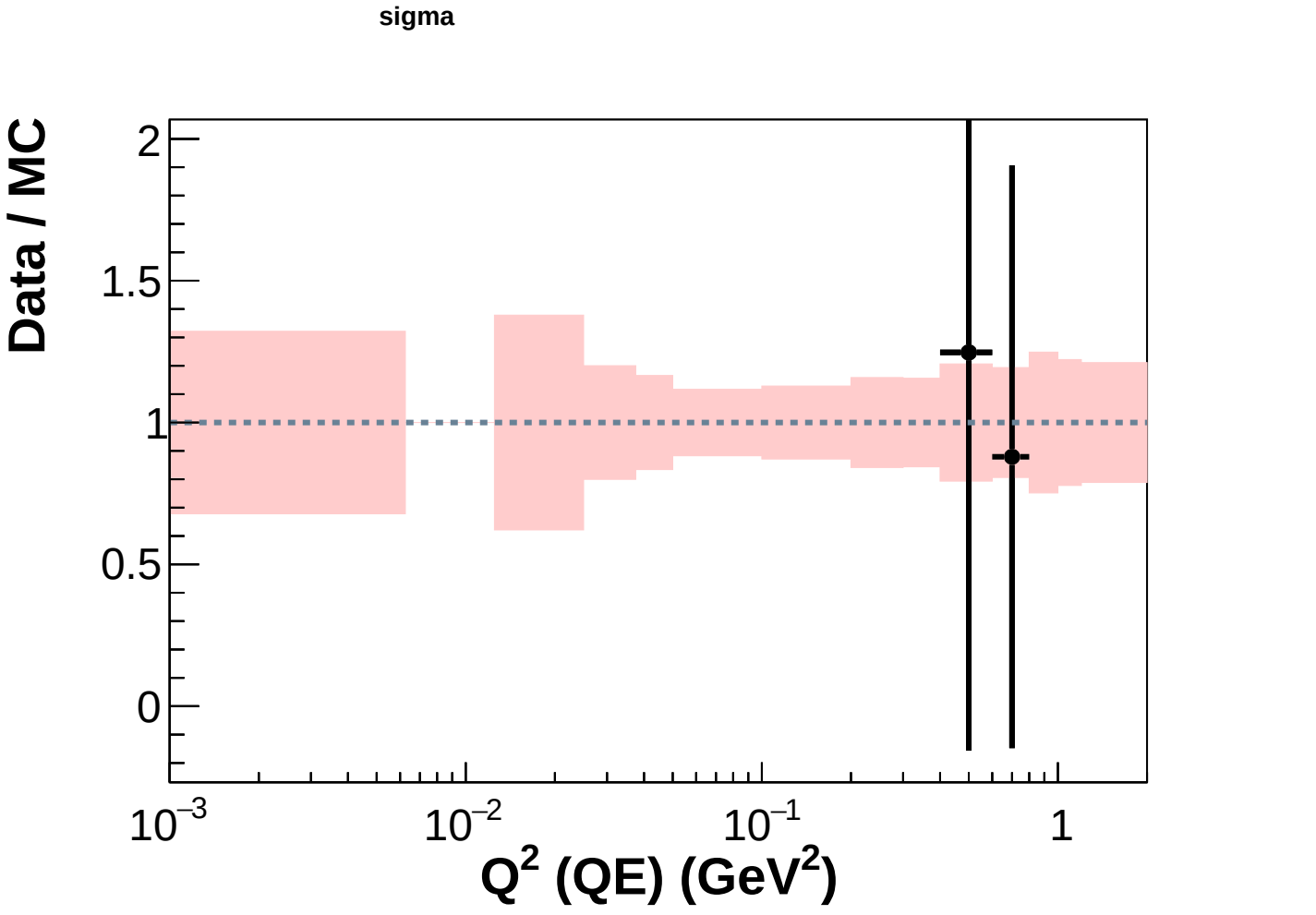

effcorr data vs truth
Counts per unit
×10^3
2.5
2
1.5
1
0.5
0
Data
Simulation
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

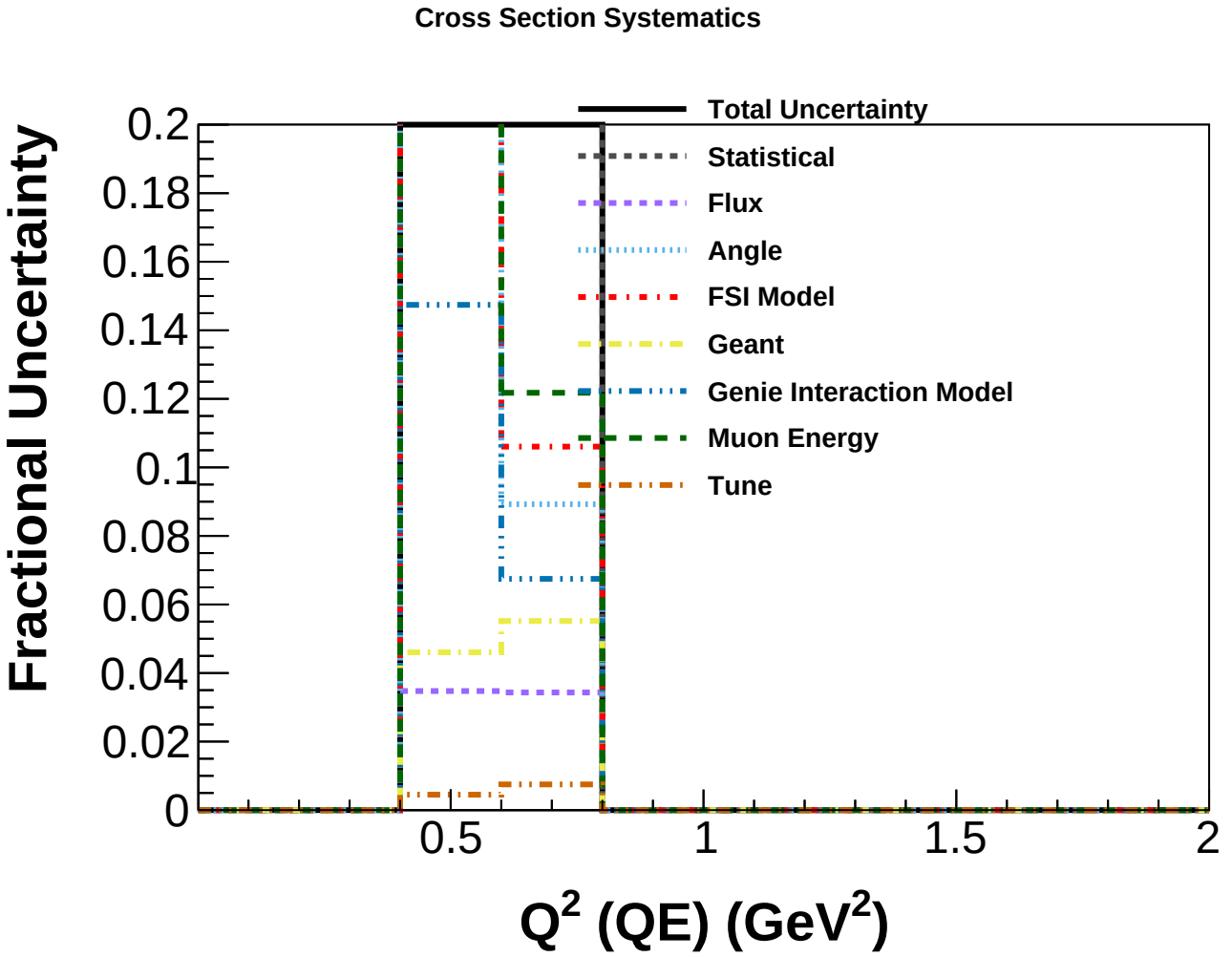

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

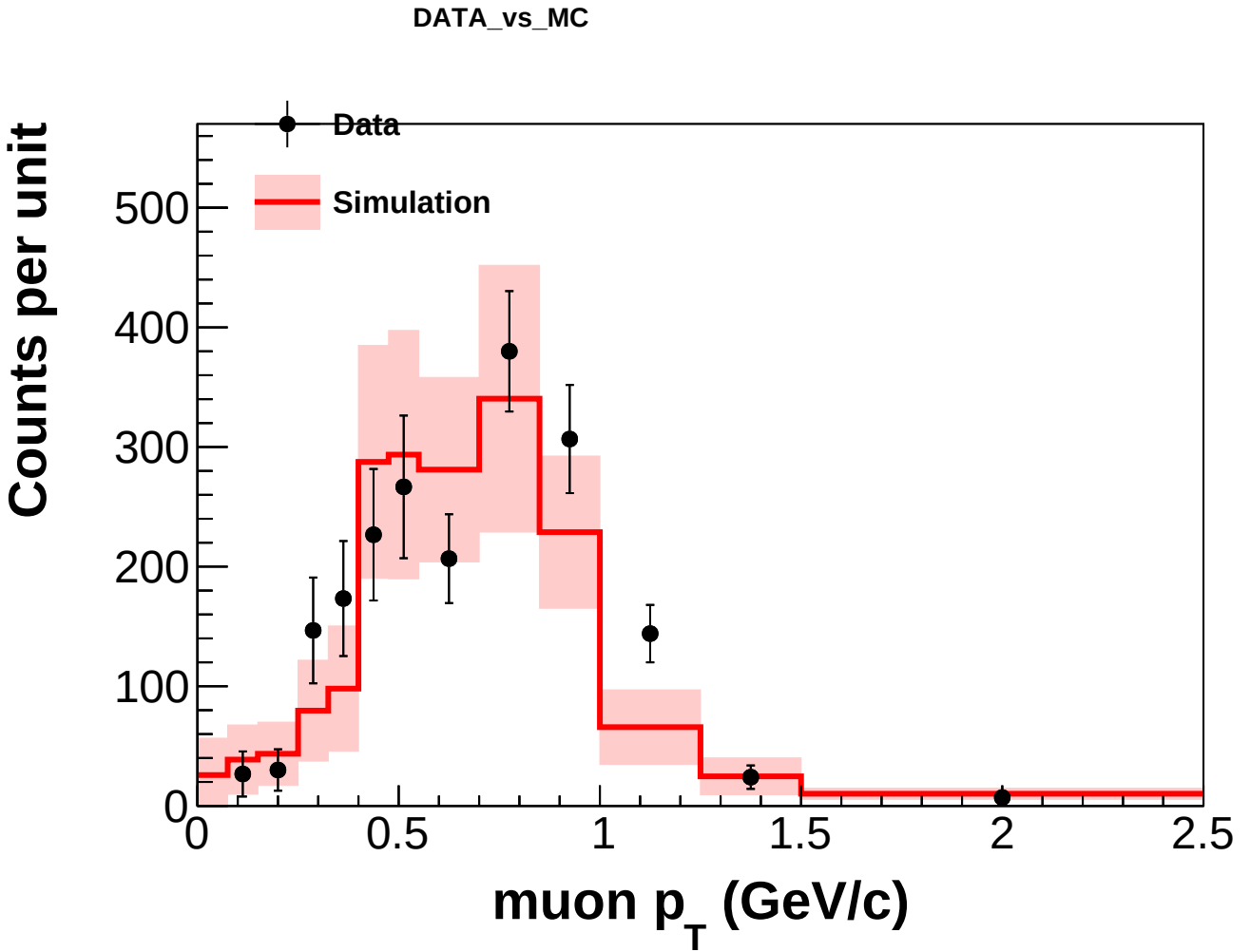

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

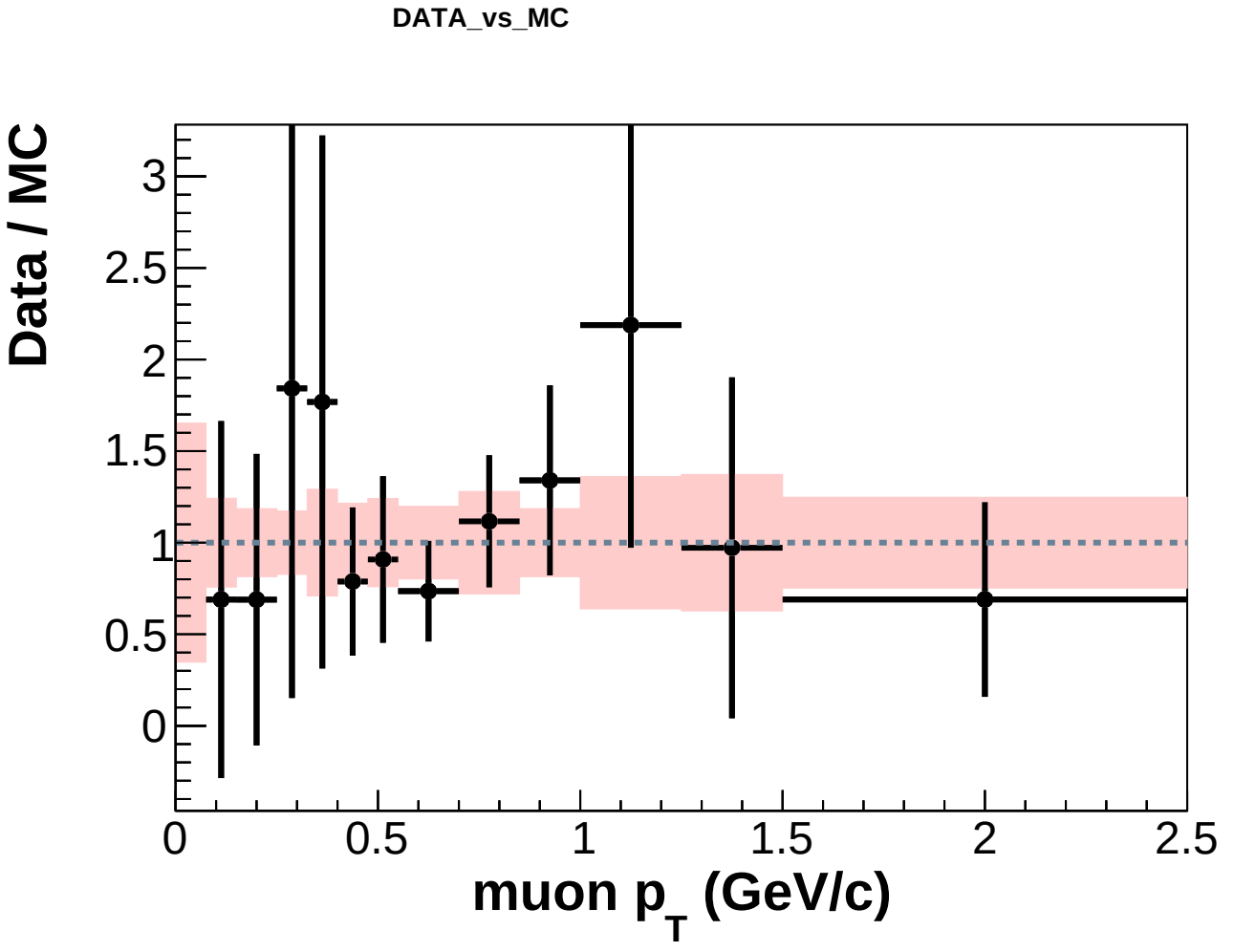

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

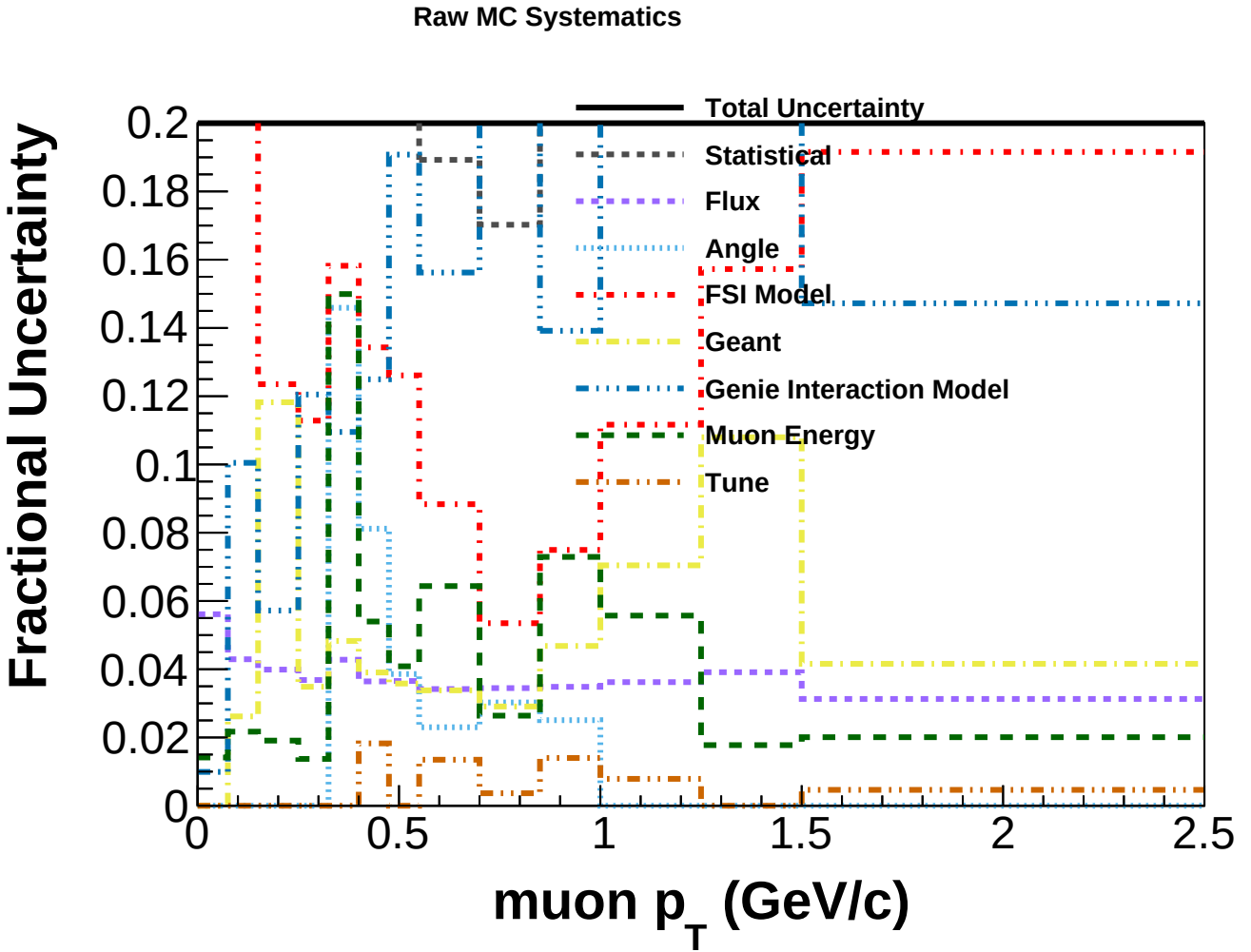

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
0
1
2
3
4
5
6
10⁻³
10⁻²
10⁻¹
1
Q² (QE) (GeV²)

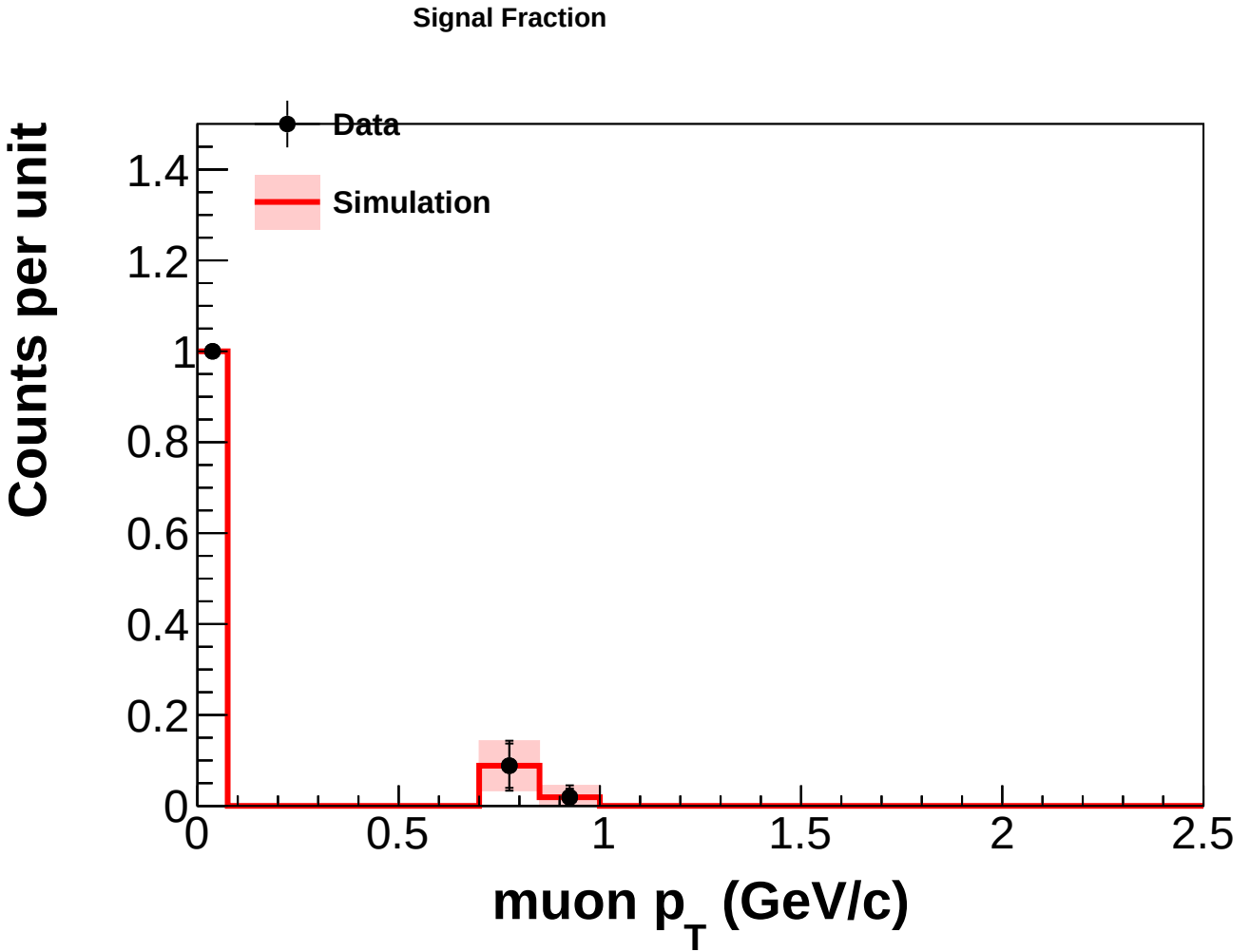

sigma
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

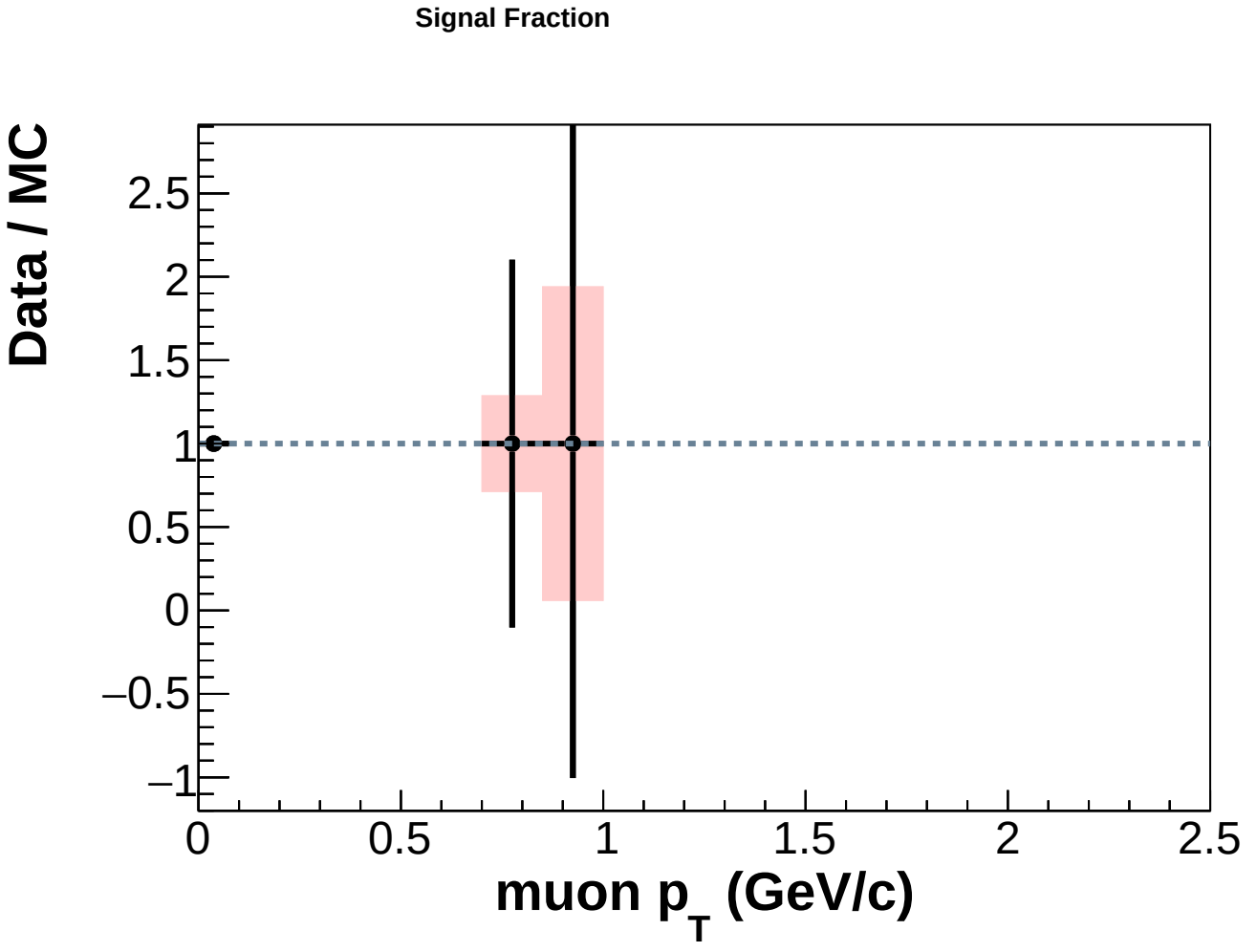

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

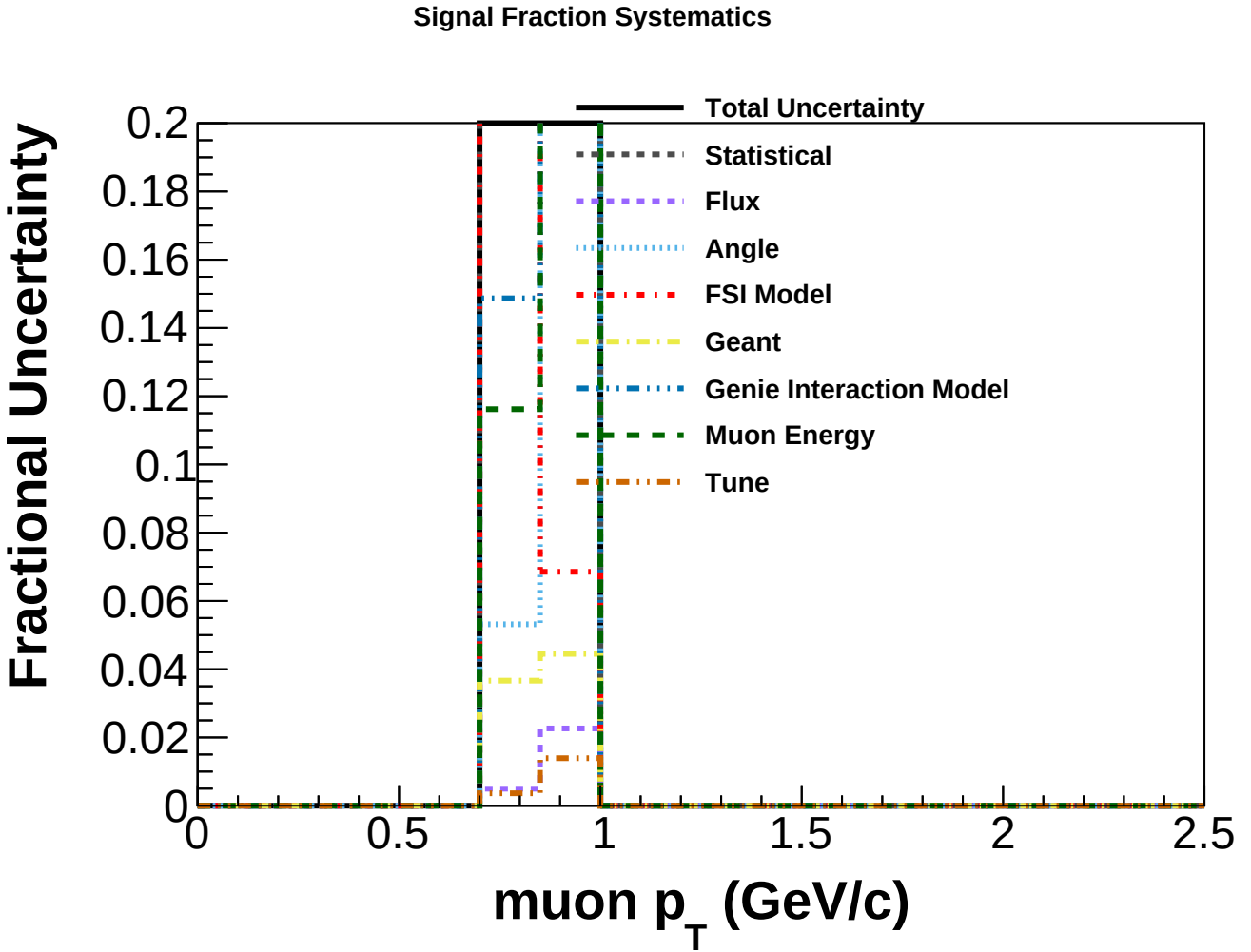

DATA_vs_MC
Data
Simulation
Counts per unit
0
100
200
300
400
500
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

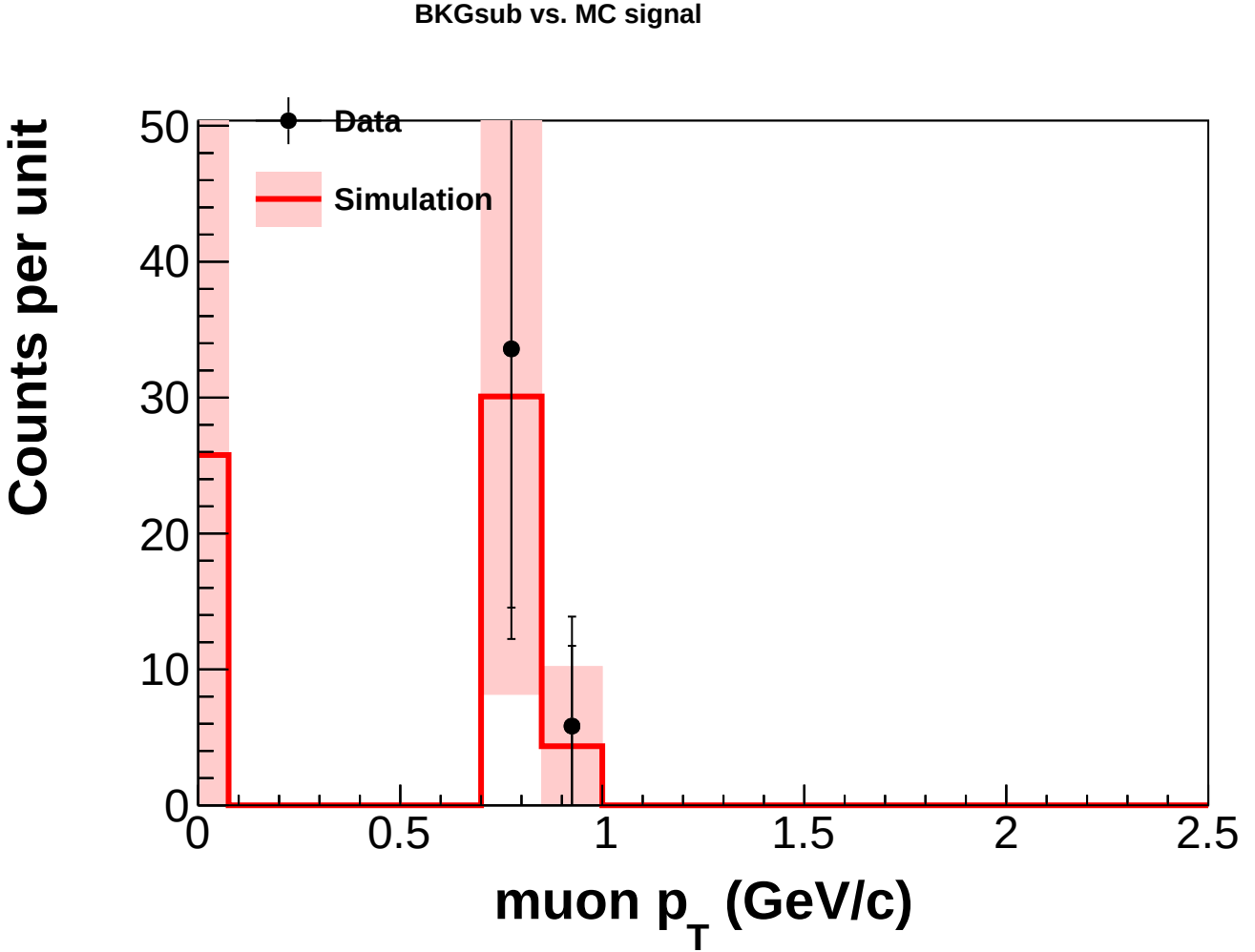

DATA_vs_MC
Data / MC
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

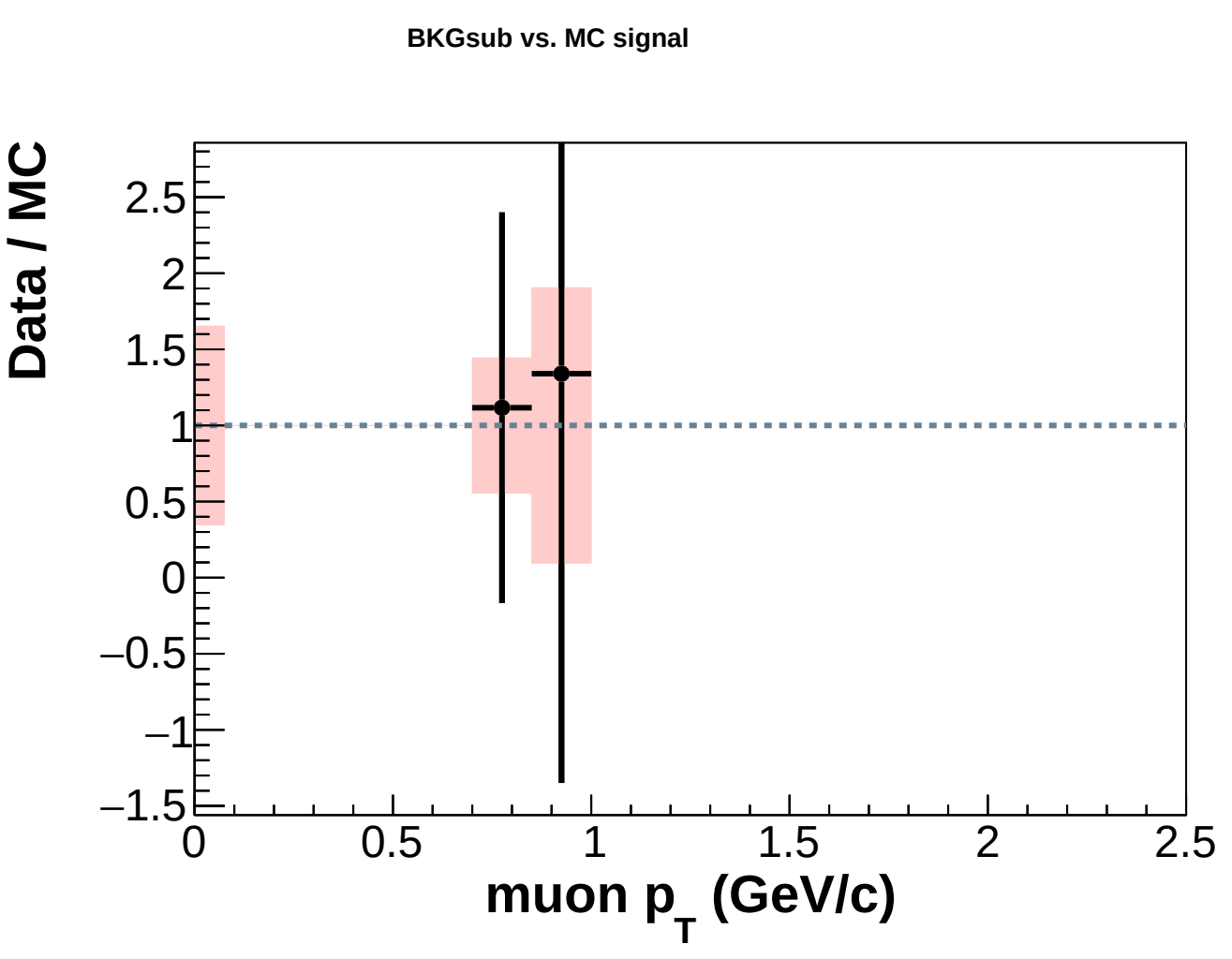

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

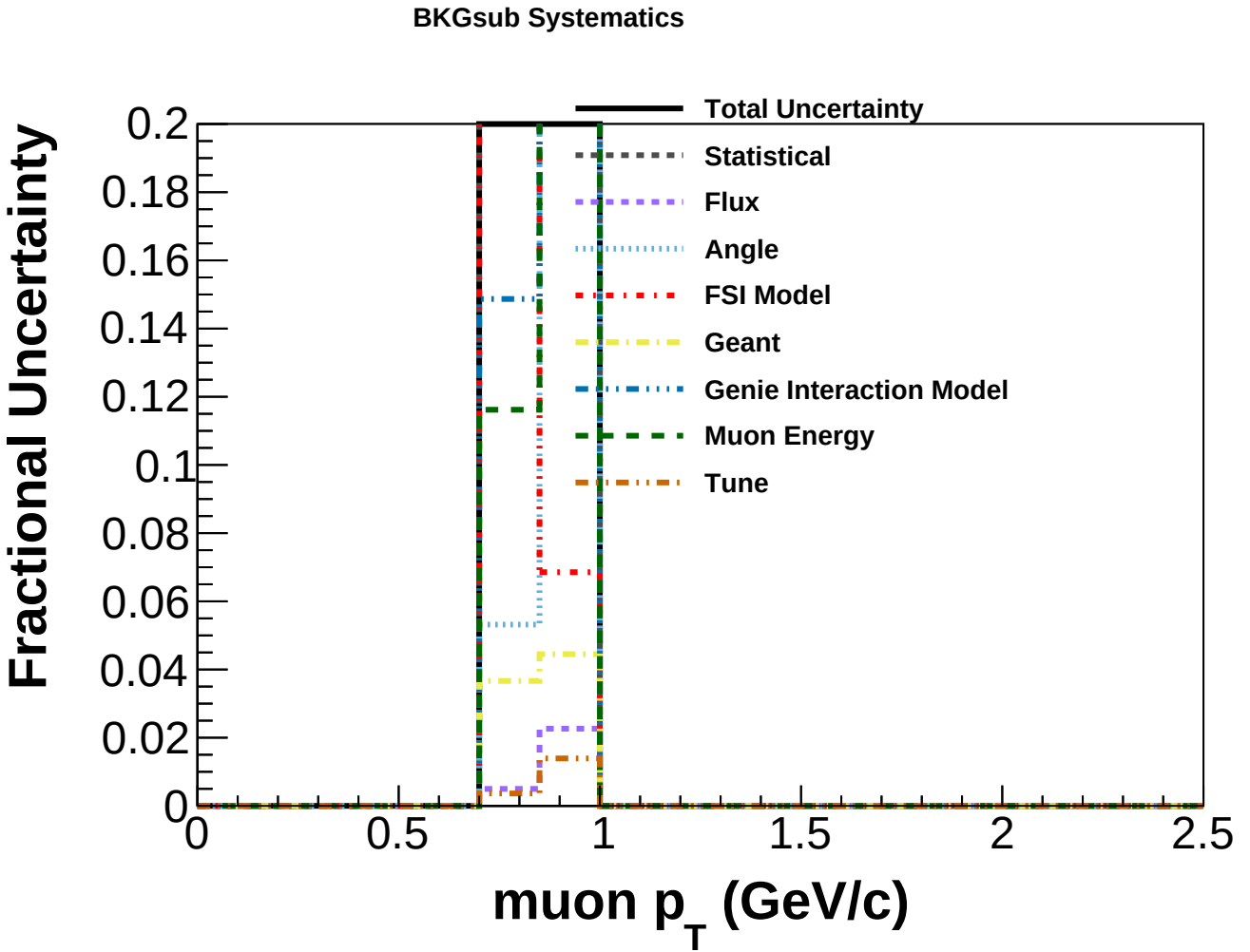

Signal Fraction
Data
Simulation
Counts per unit
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

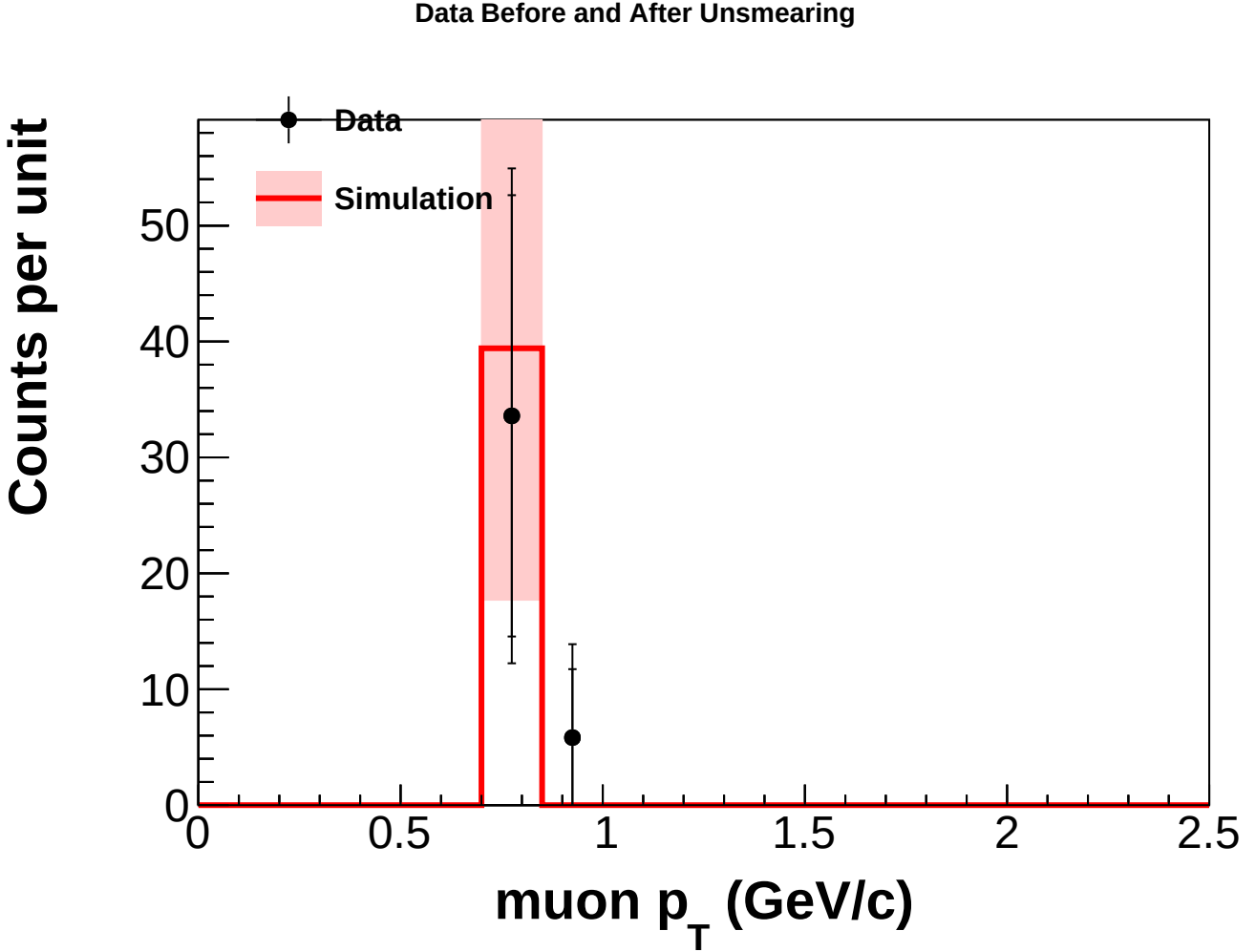

Signal Fraction
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)


Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

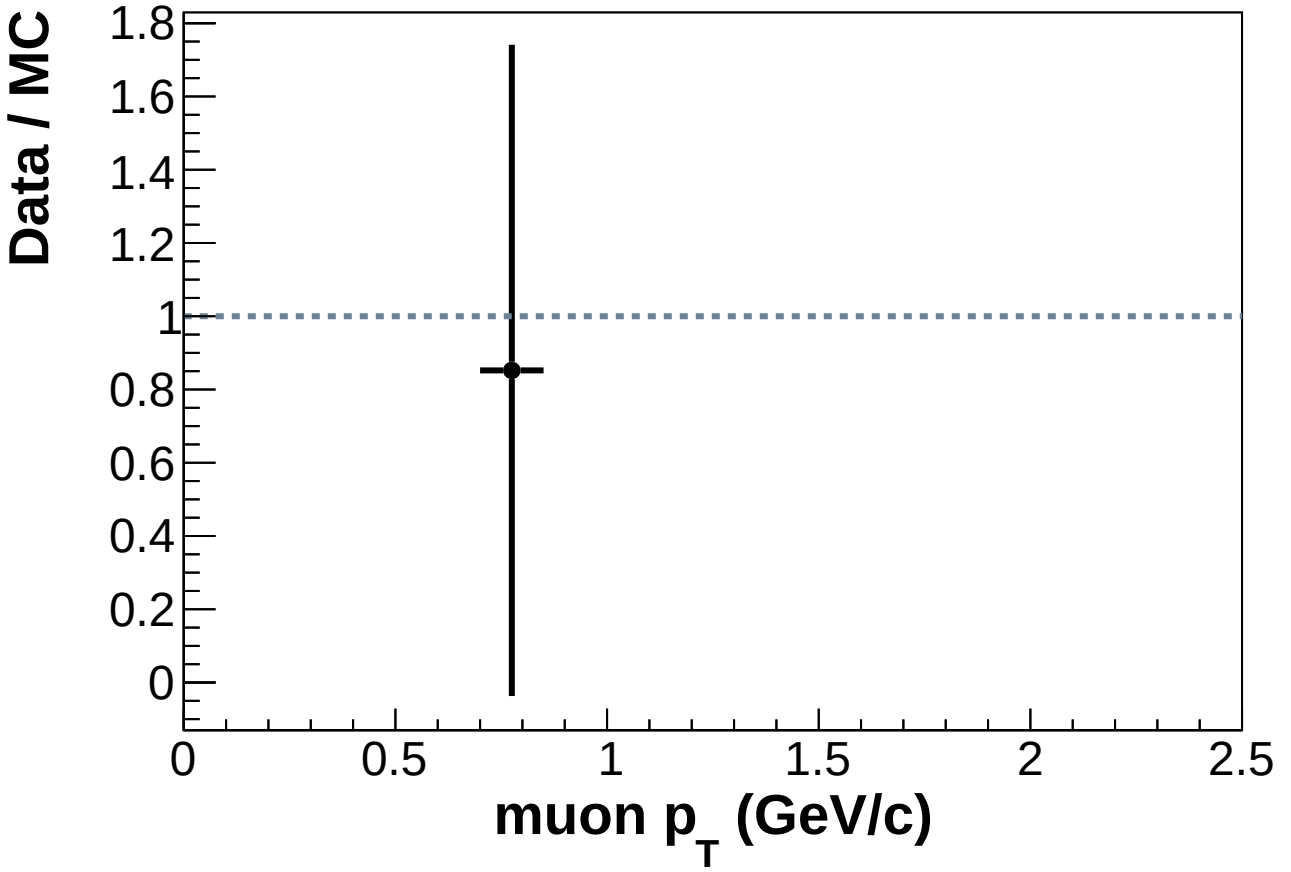

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
10
20
30
40
50
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

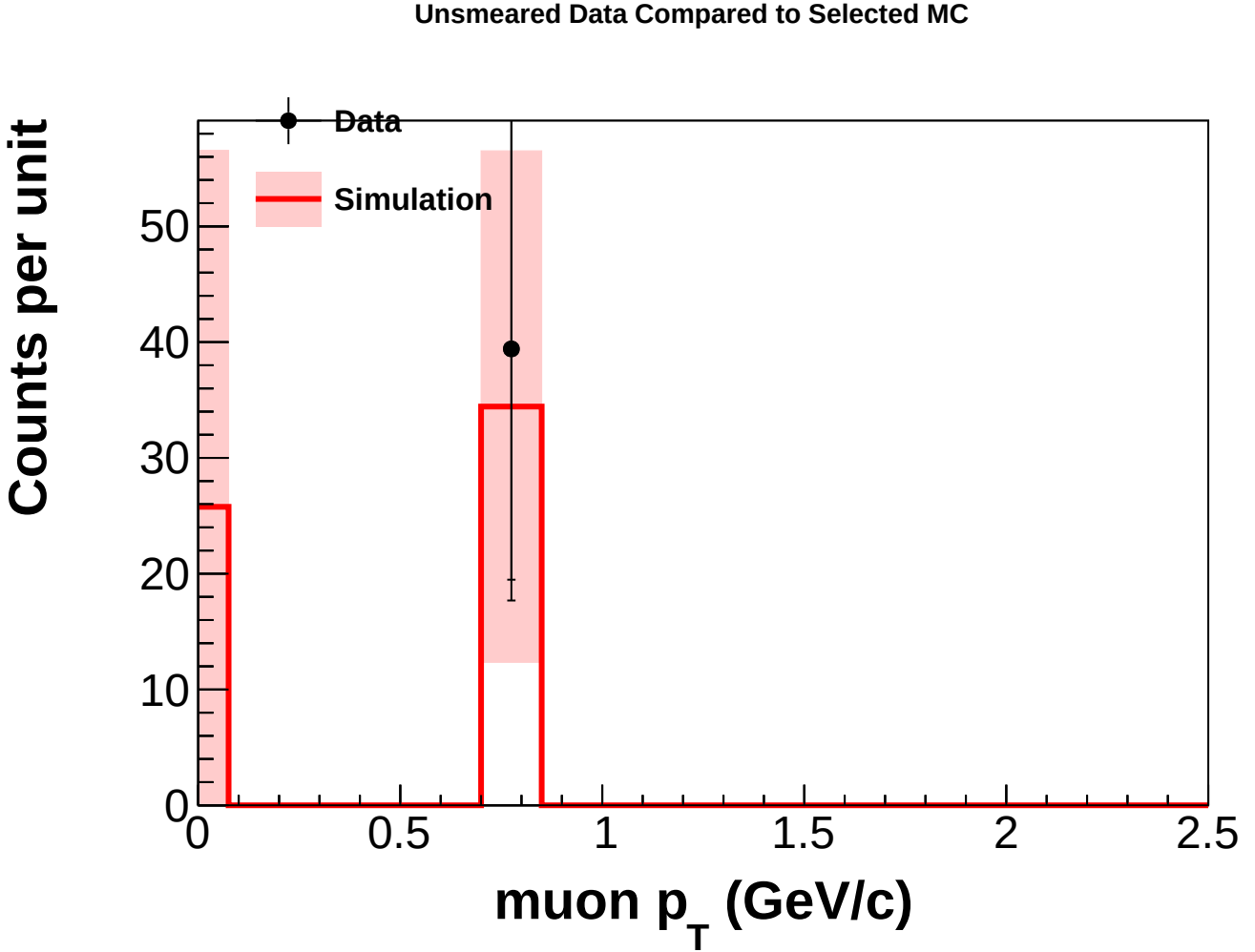

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

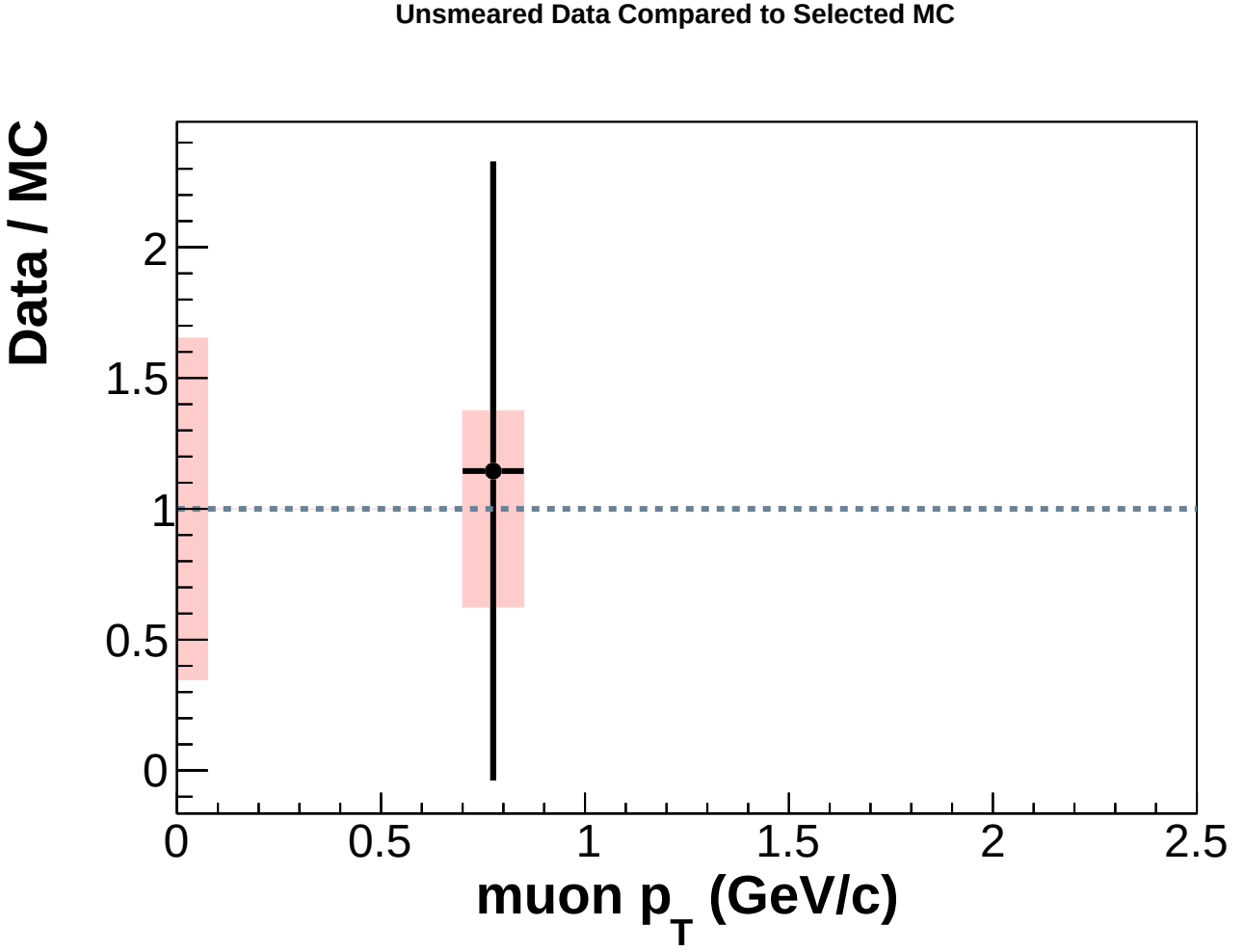

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

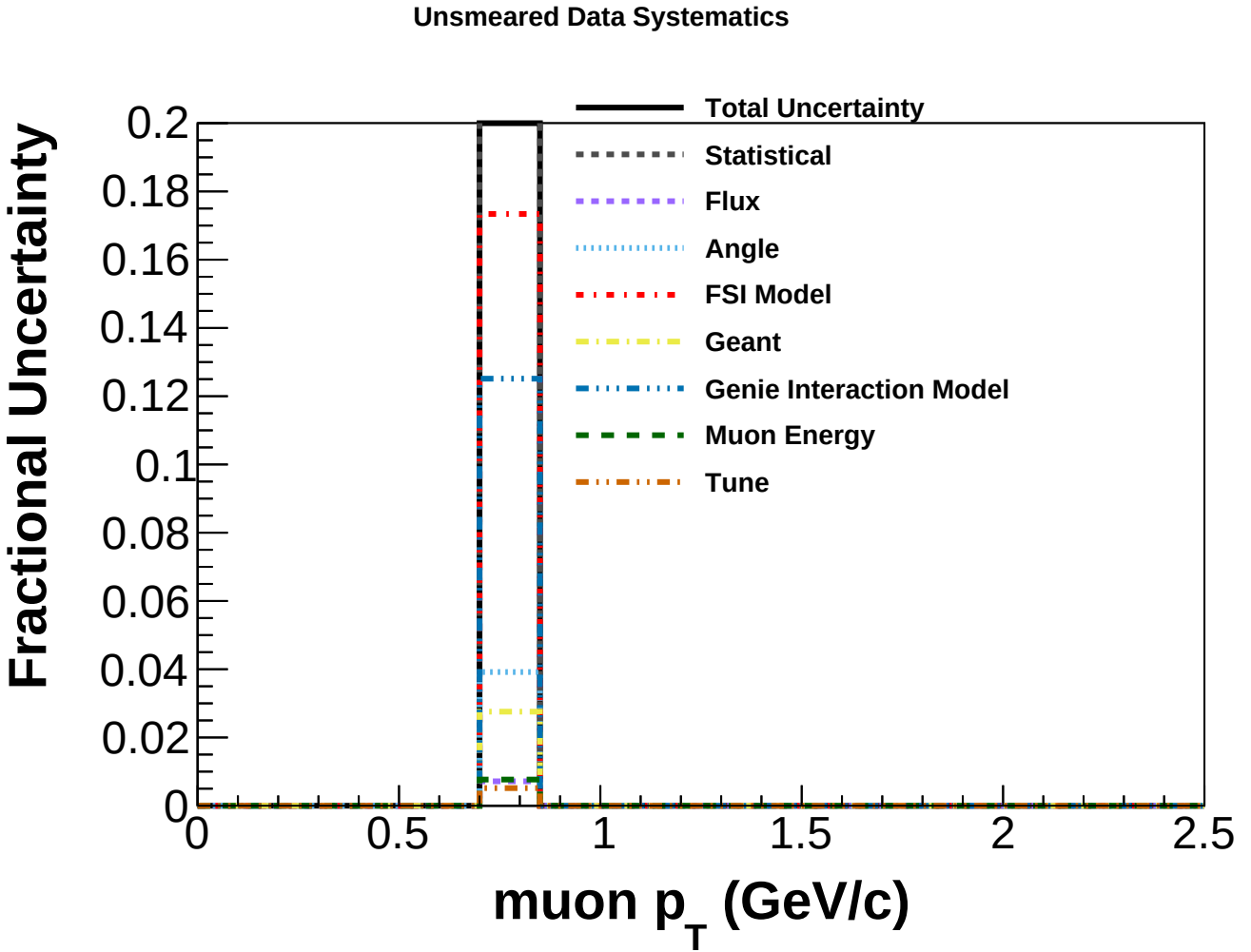

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
10
20
30
40
50
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

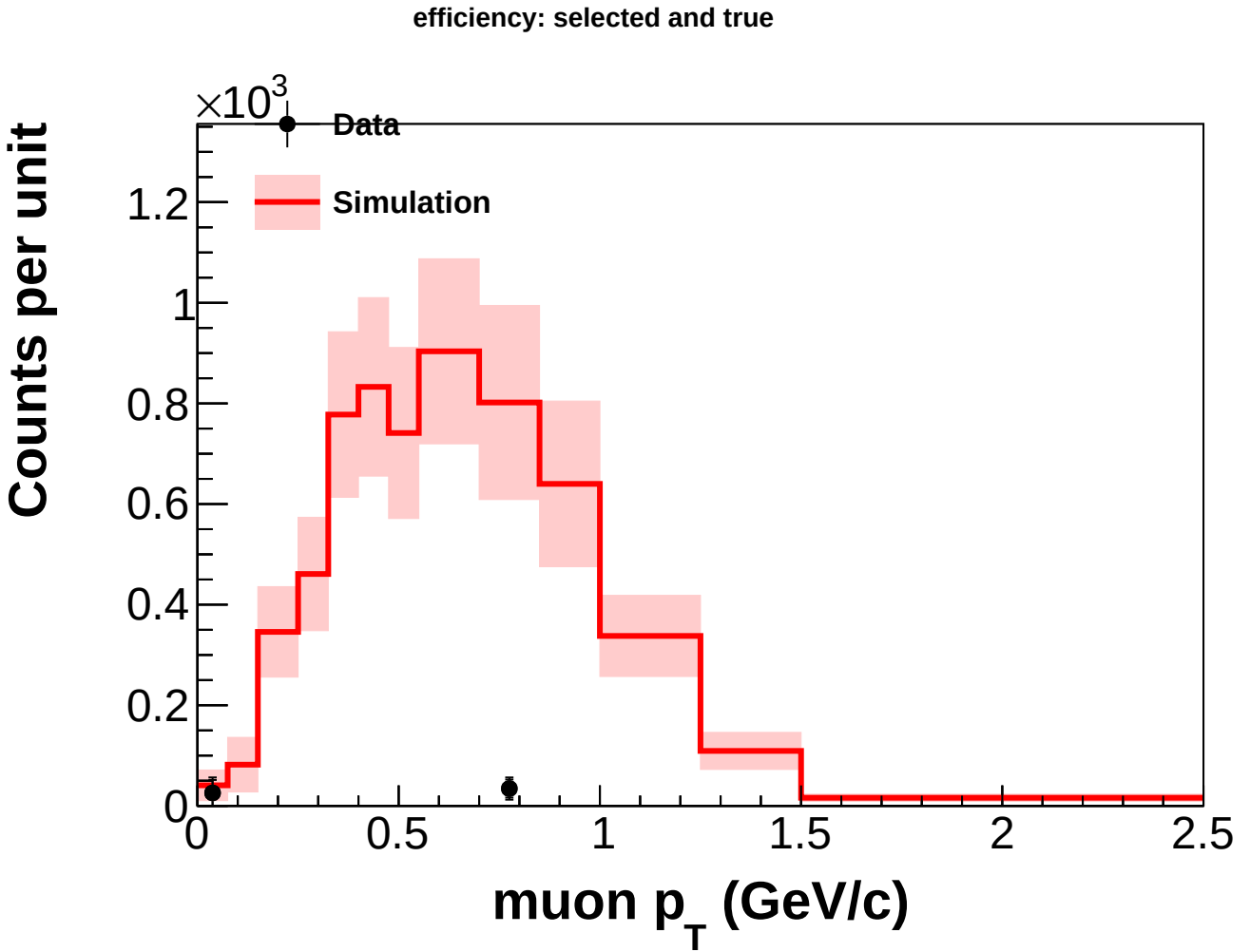
Data Before and After Unsmearing

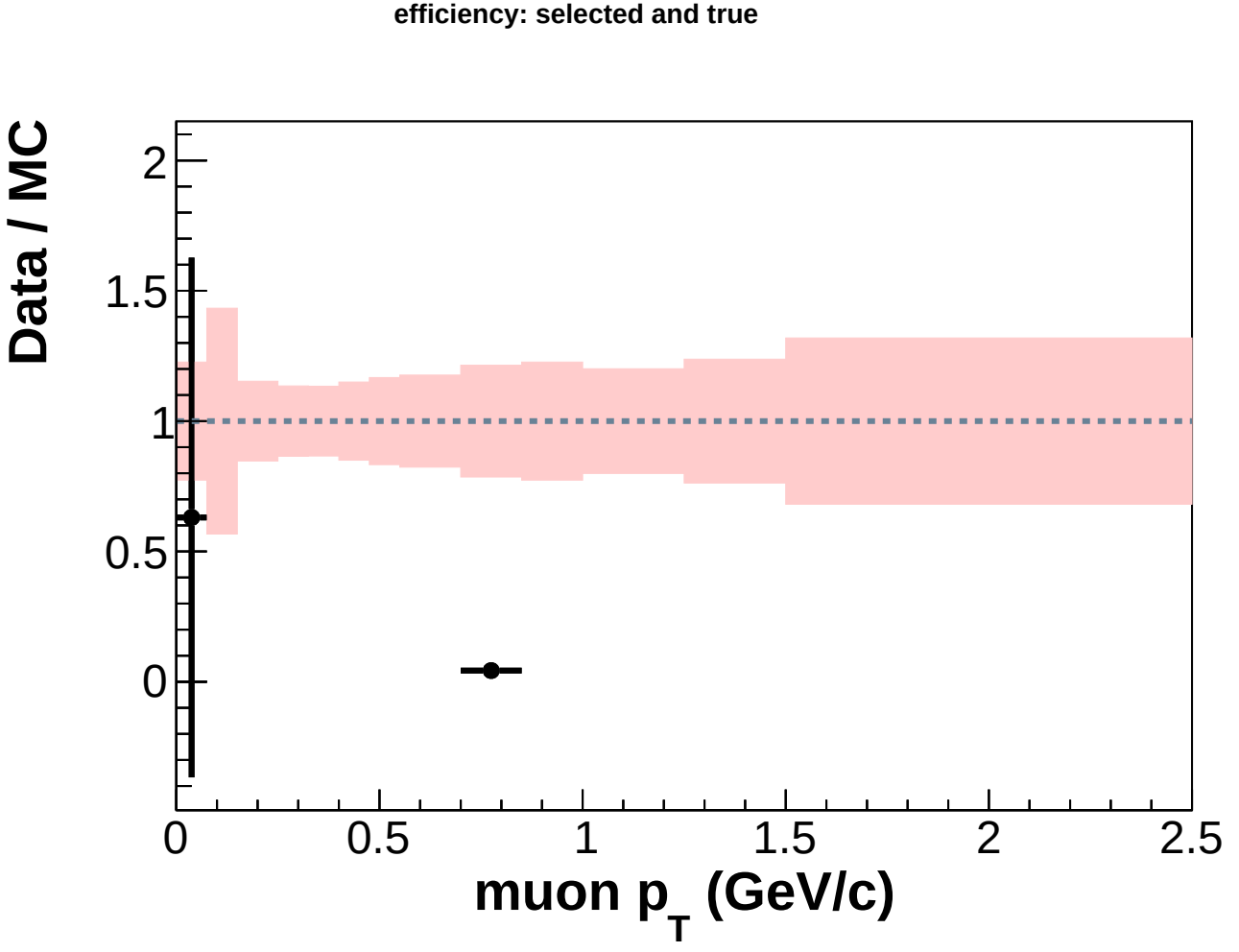


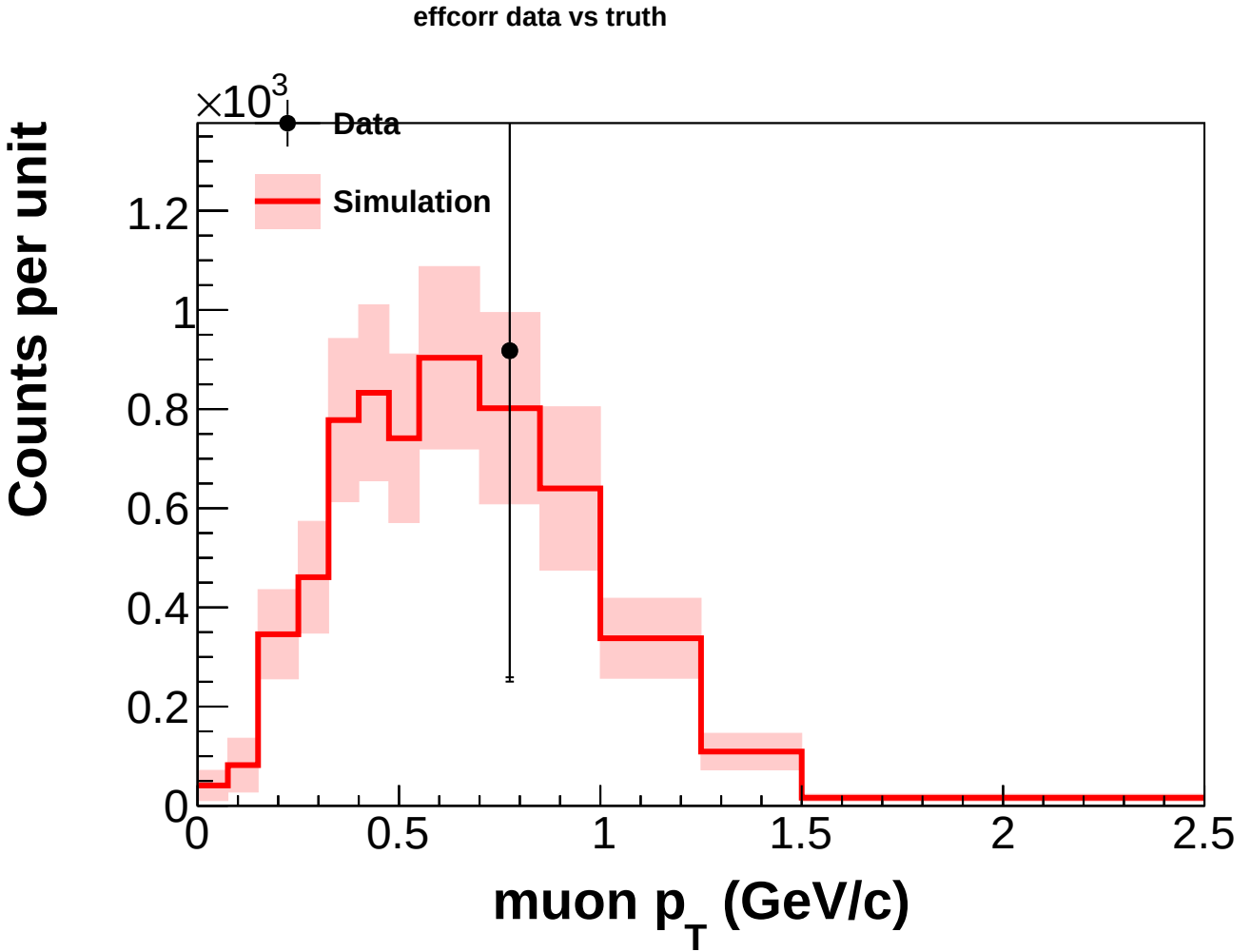

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

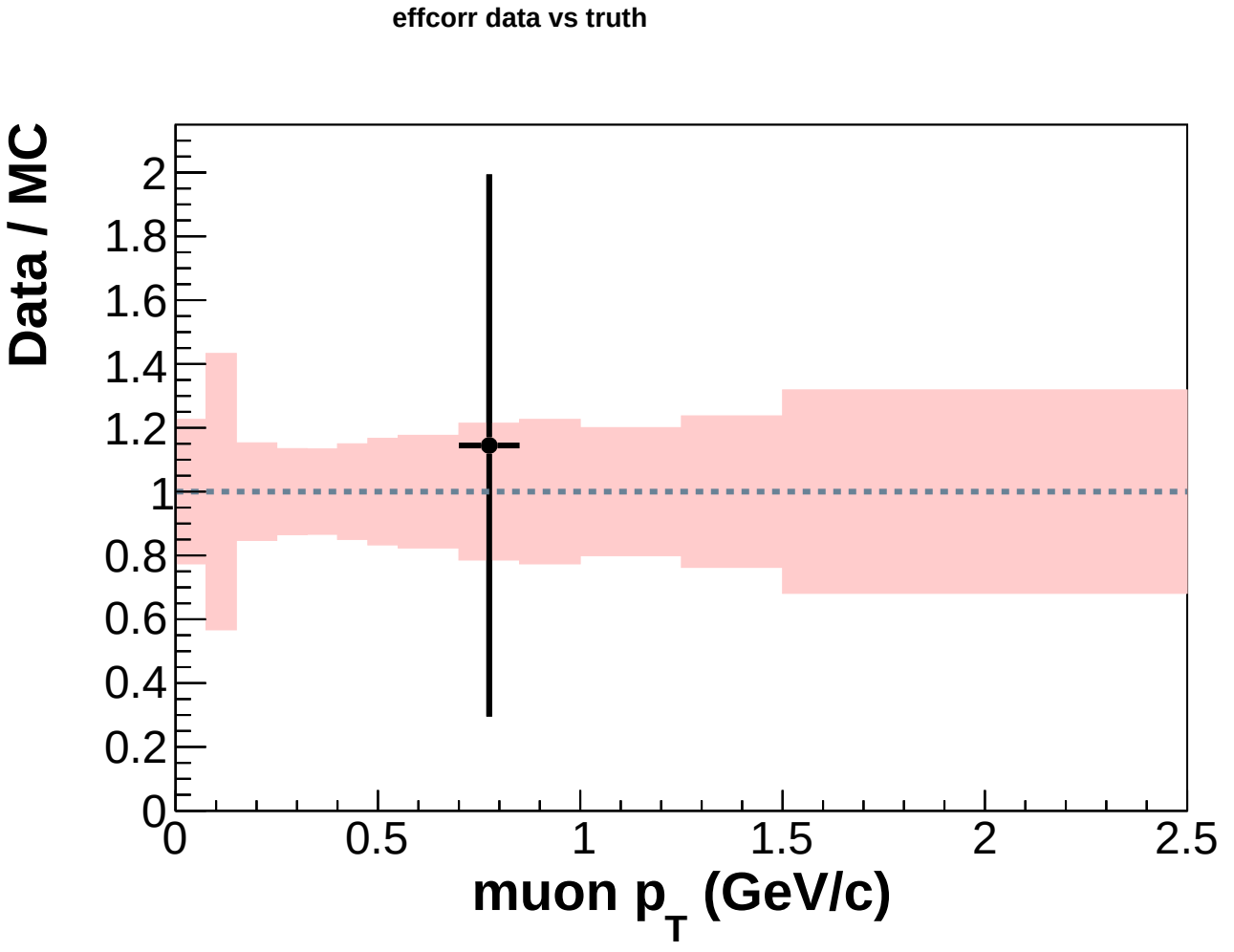

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

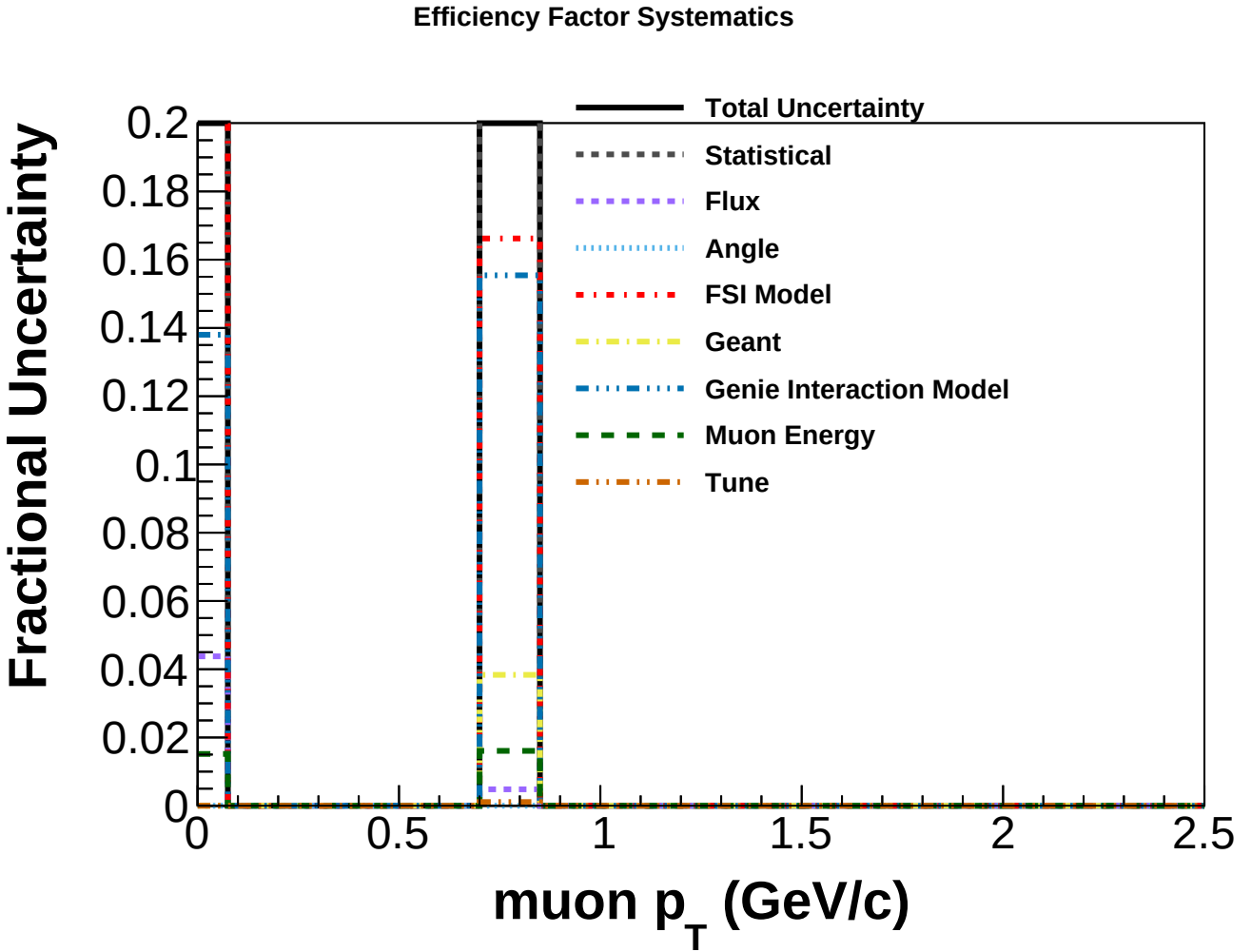

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

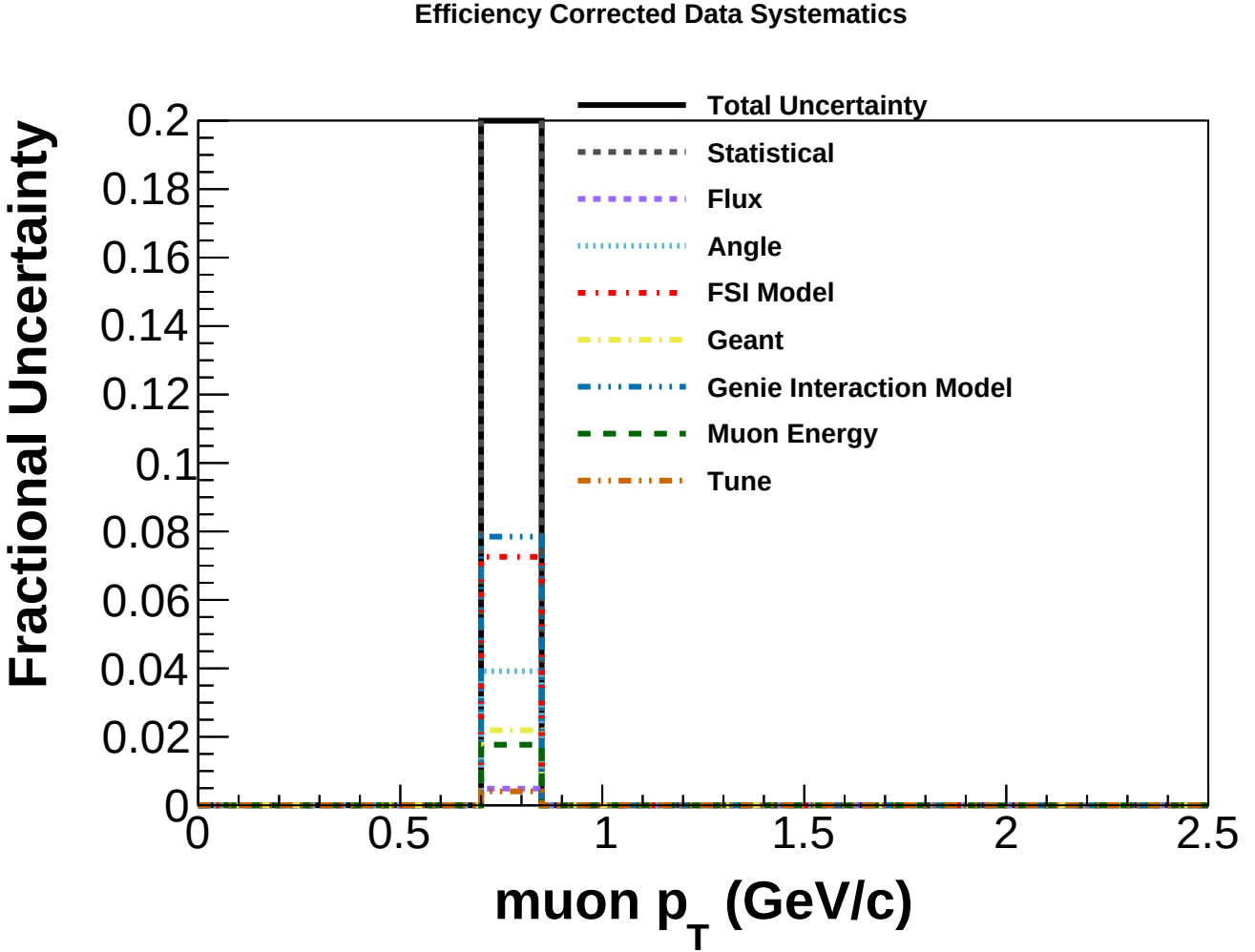

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

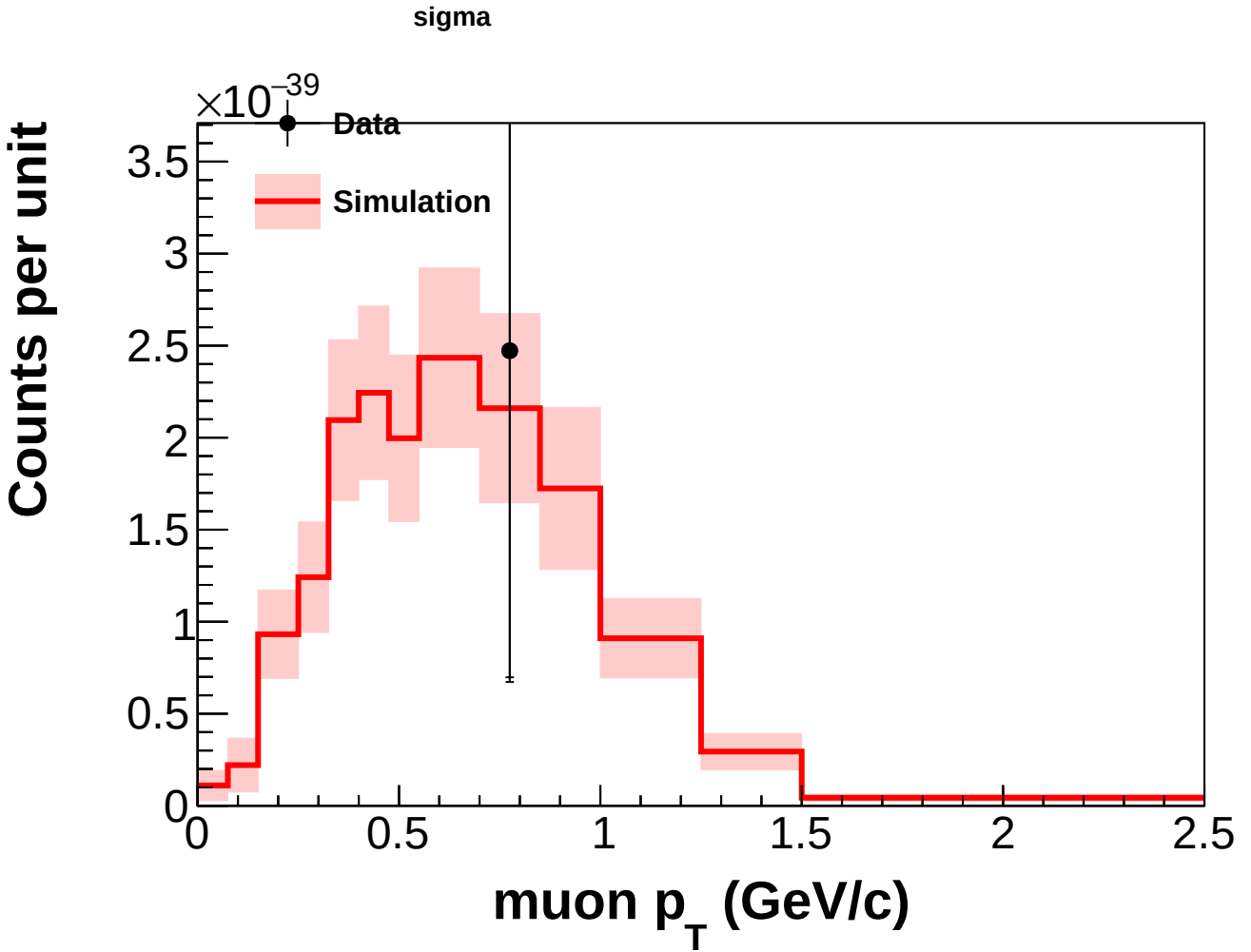

efficiency: selected and true
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

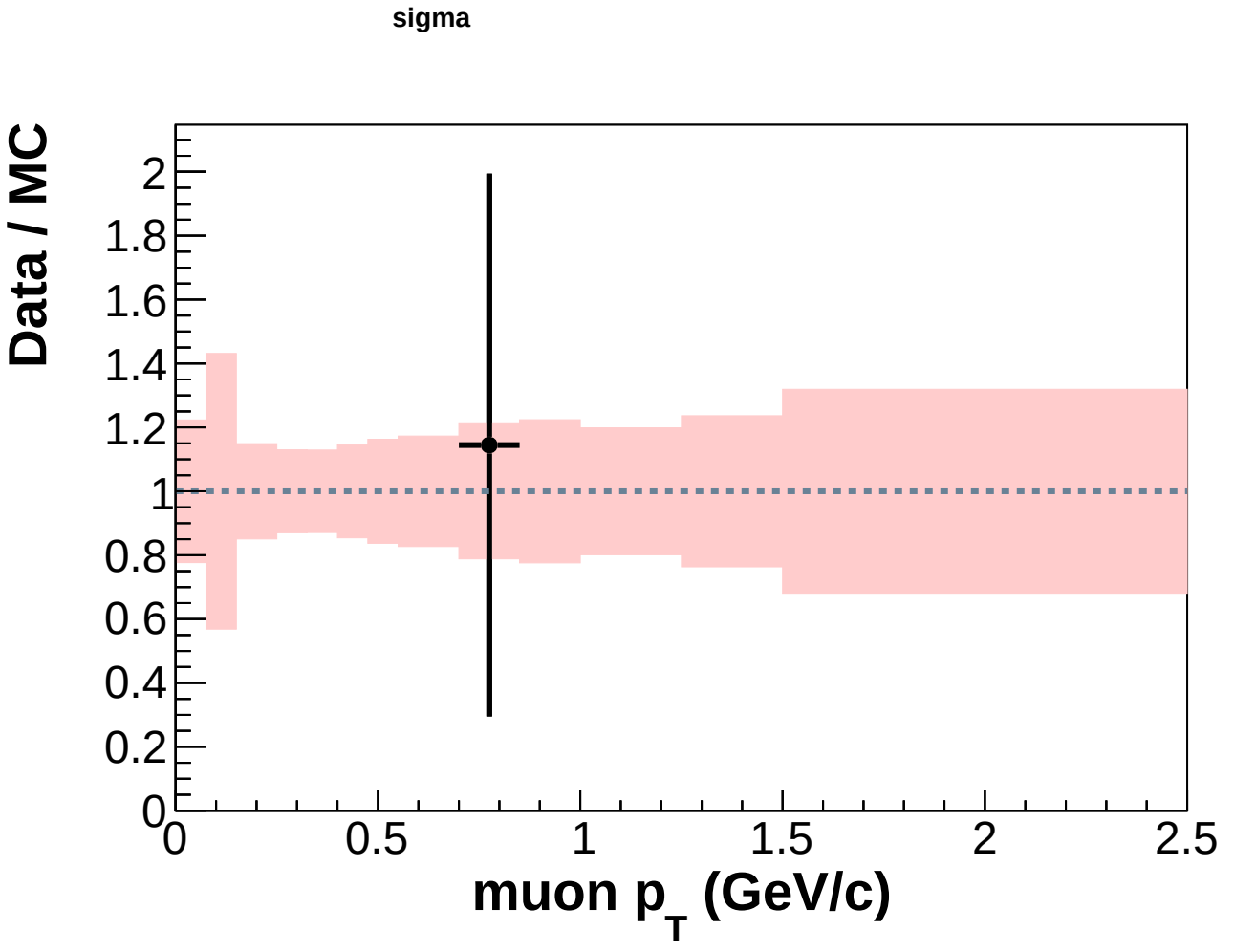

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

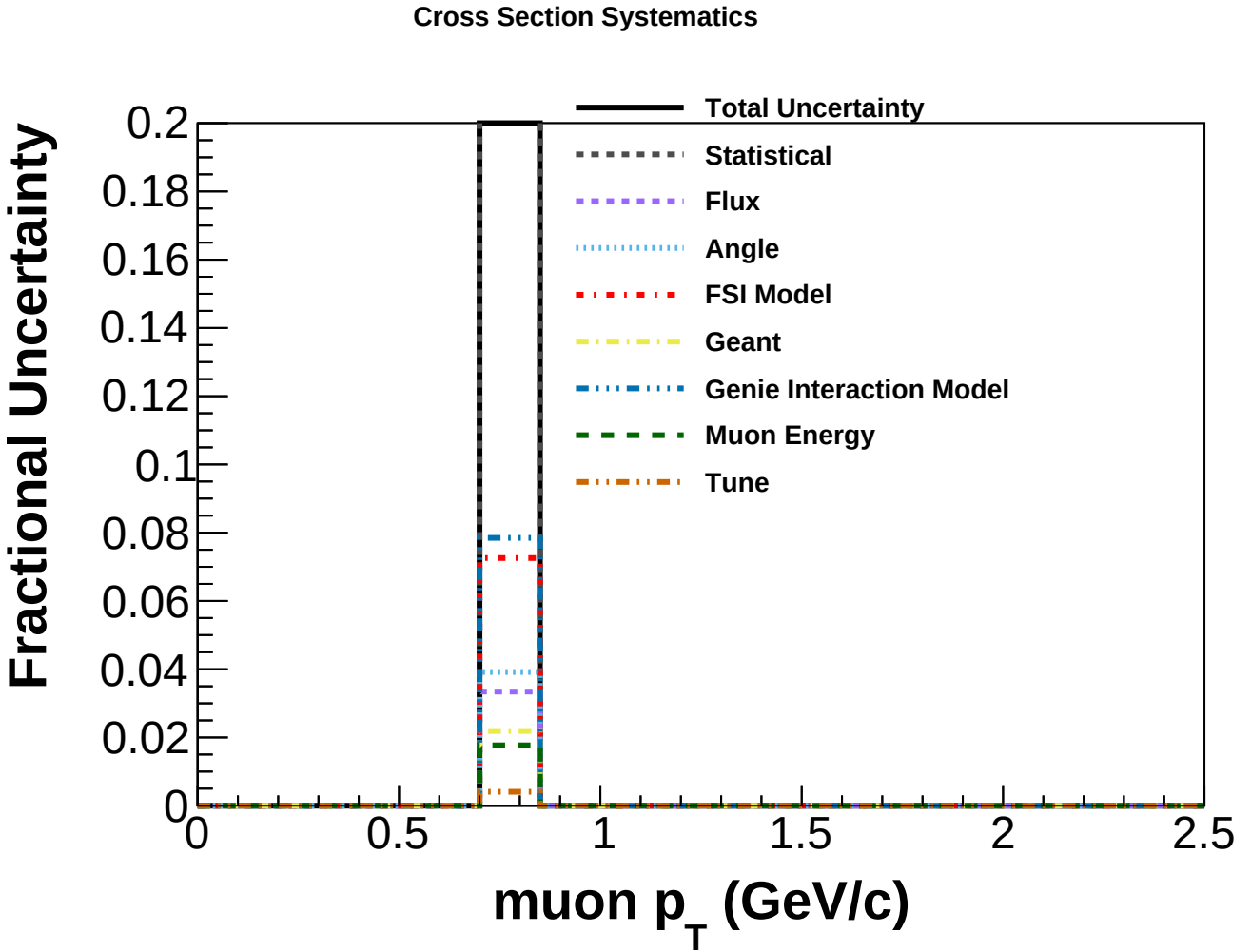

effcorr data vs truth
Data / MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

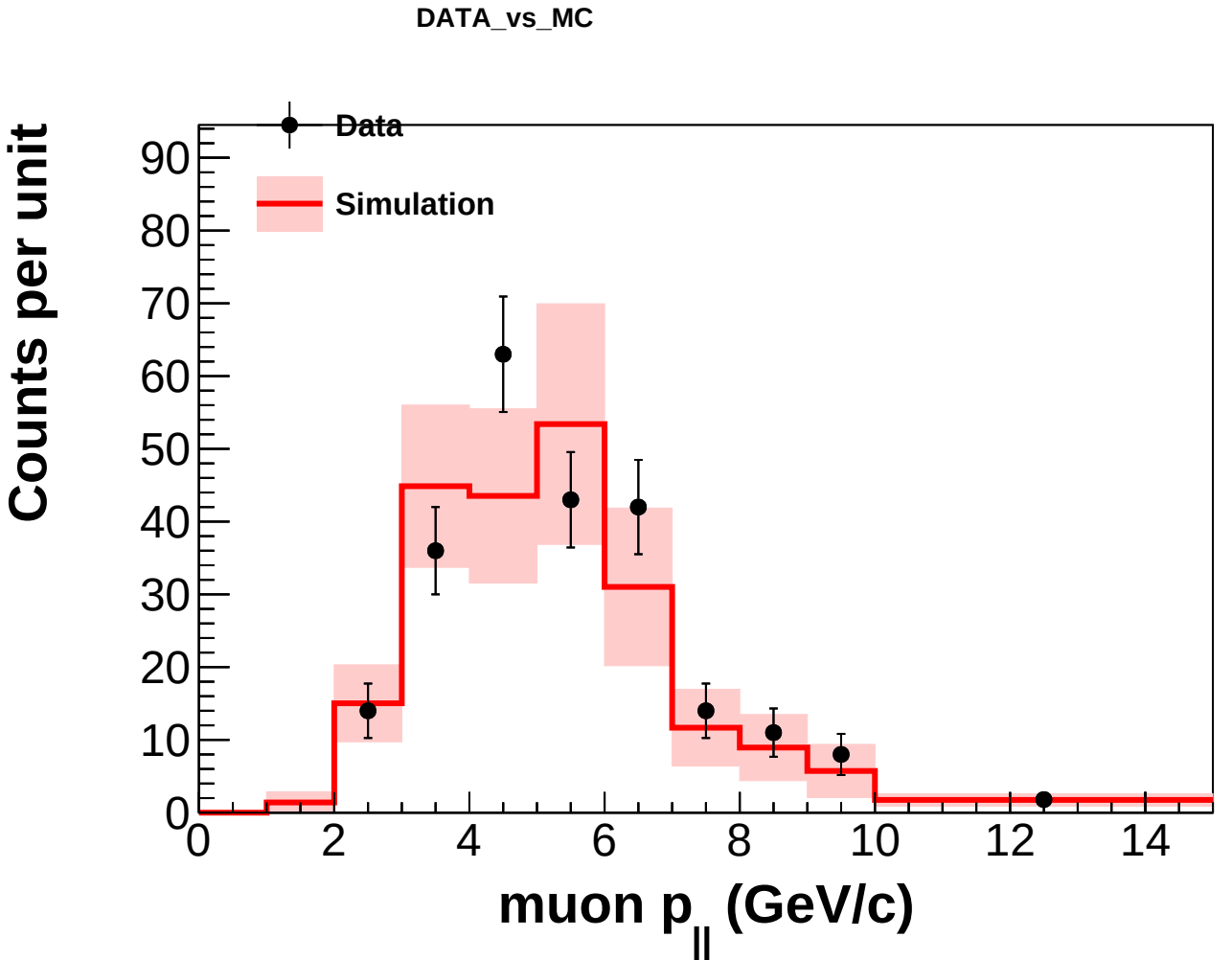

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

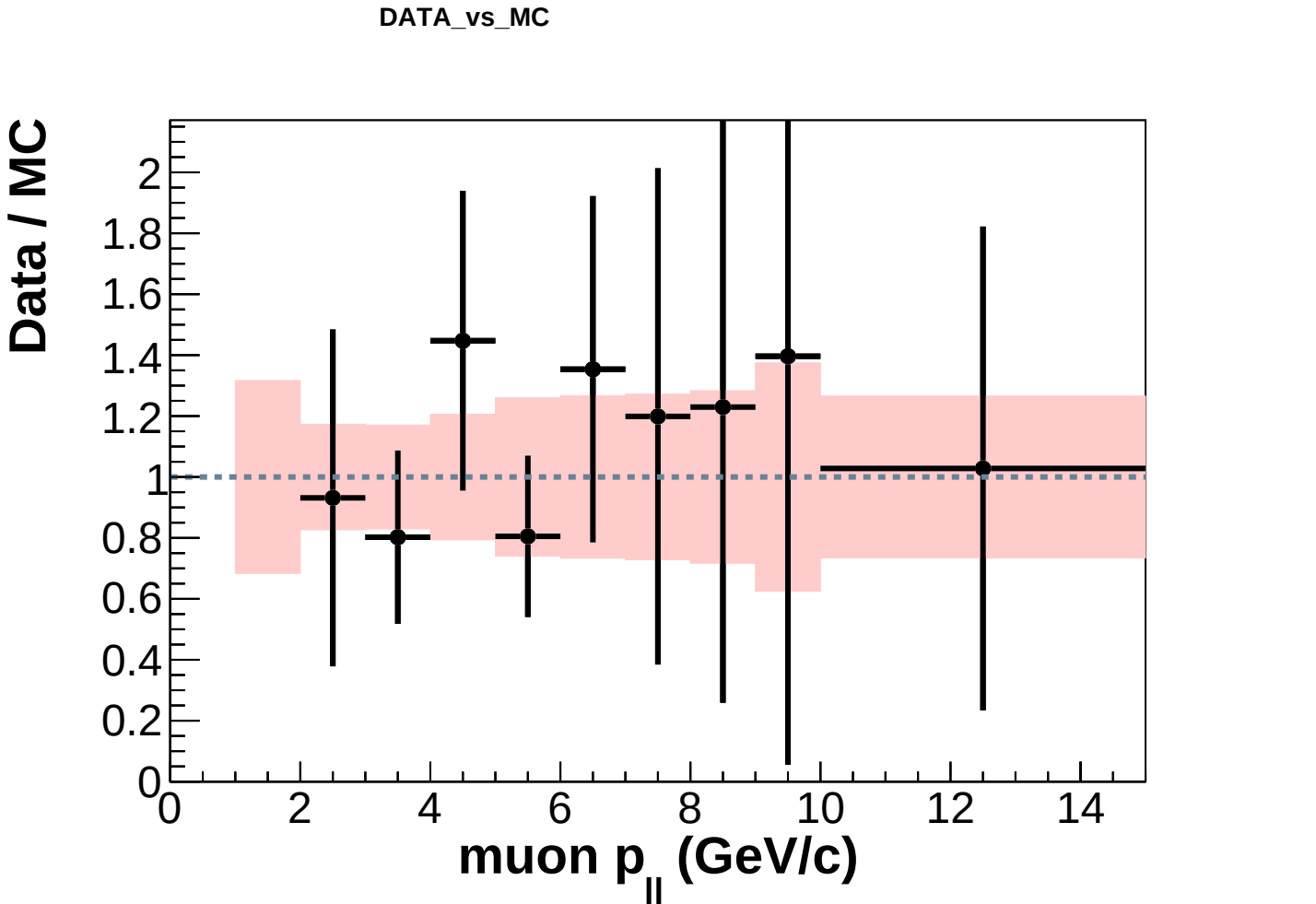

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

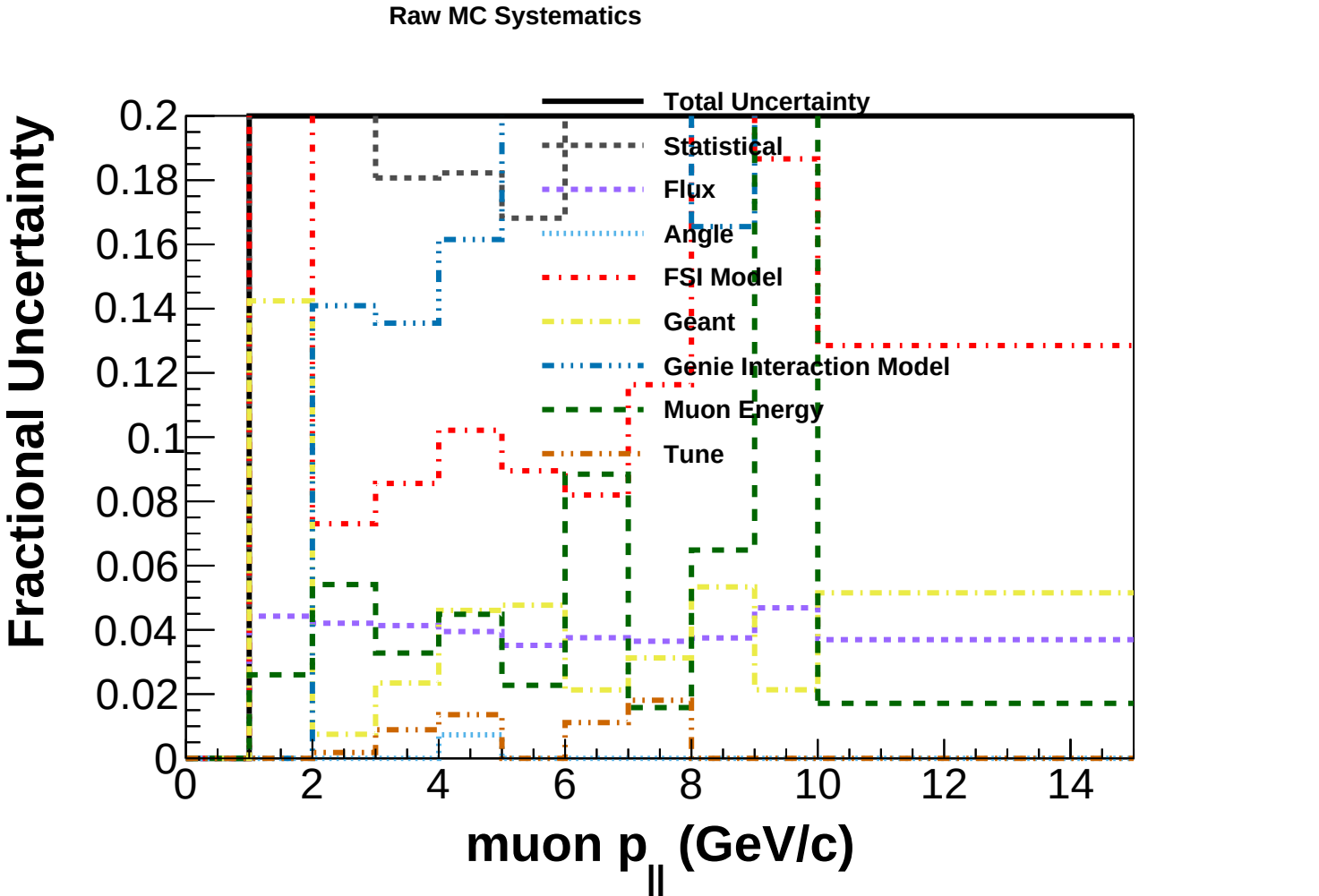

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

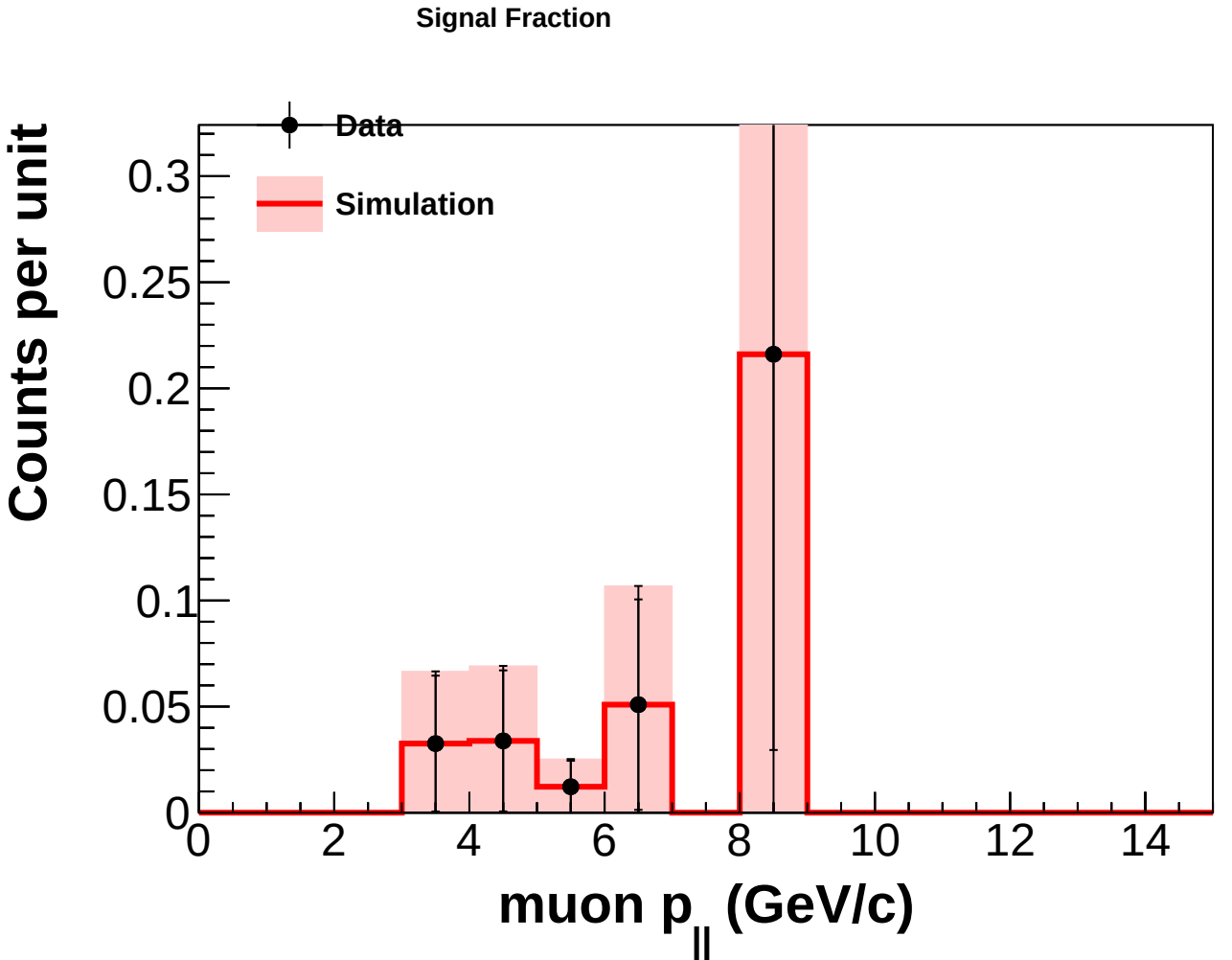

sigma
Data / MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

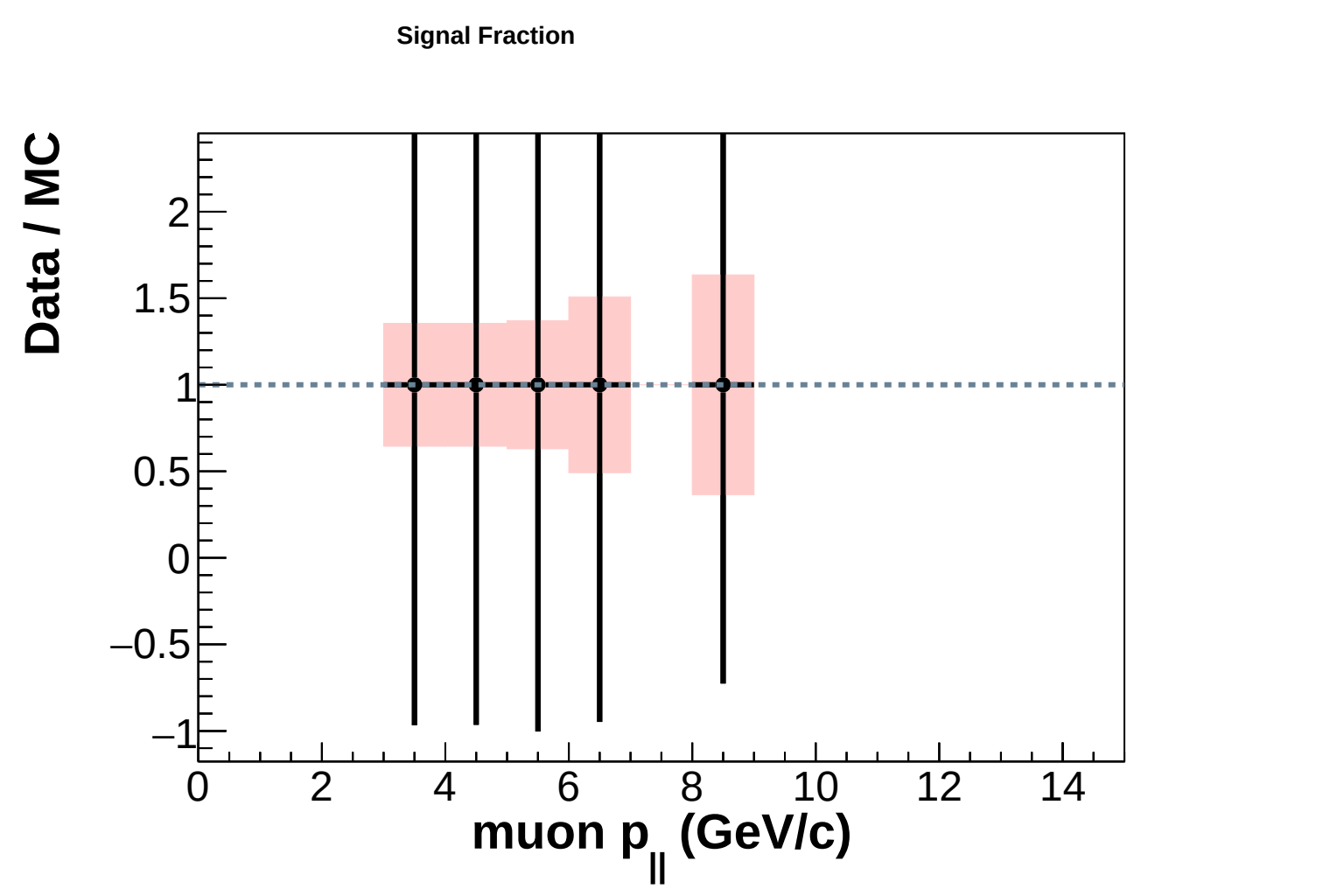

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

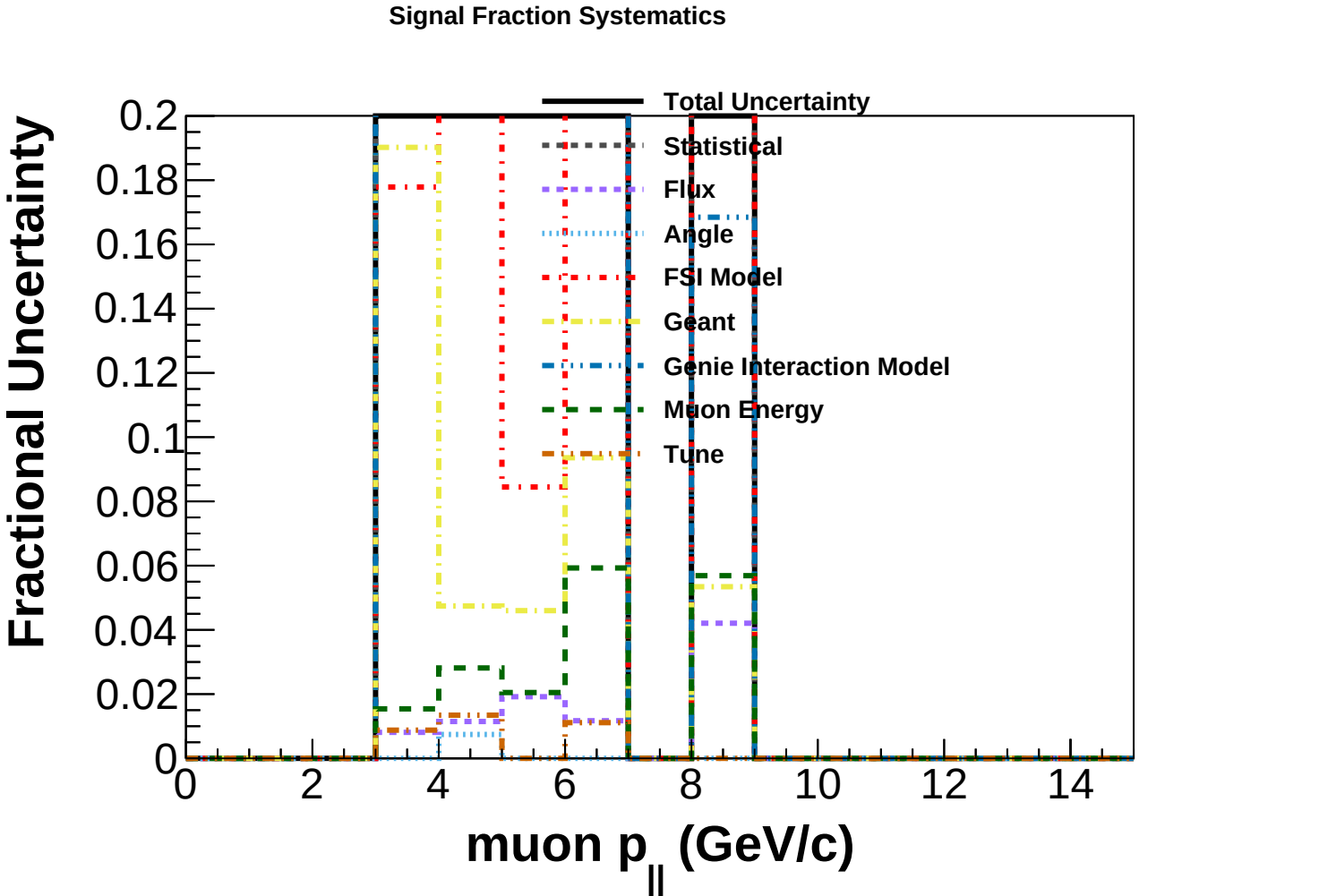

DATA_vs_MC
Data
Simulation
Counts per unit
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

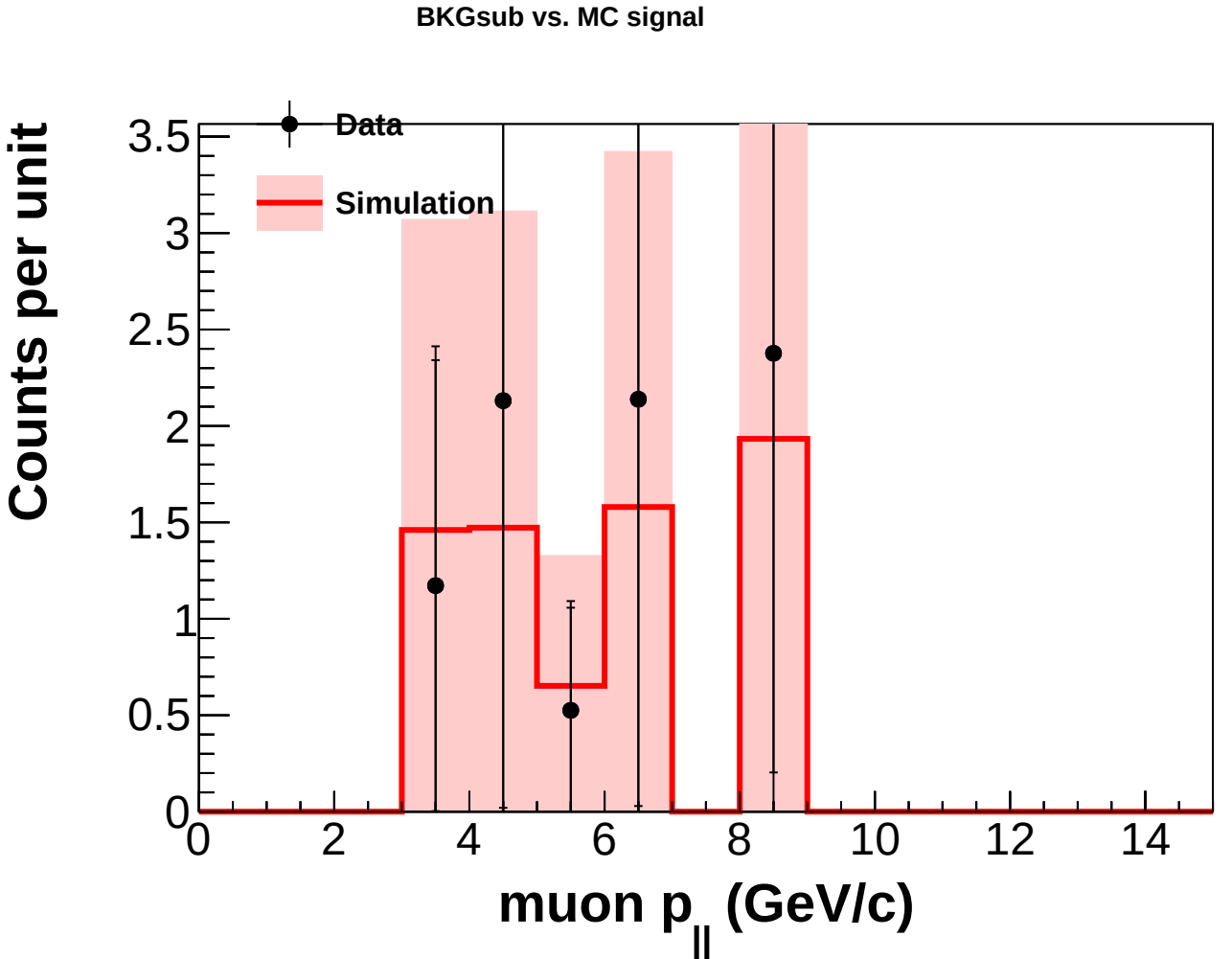

DATA_vs_MC
Data / MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

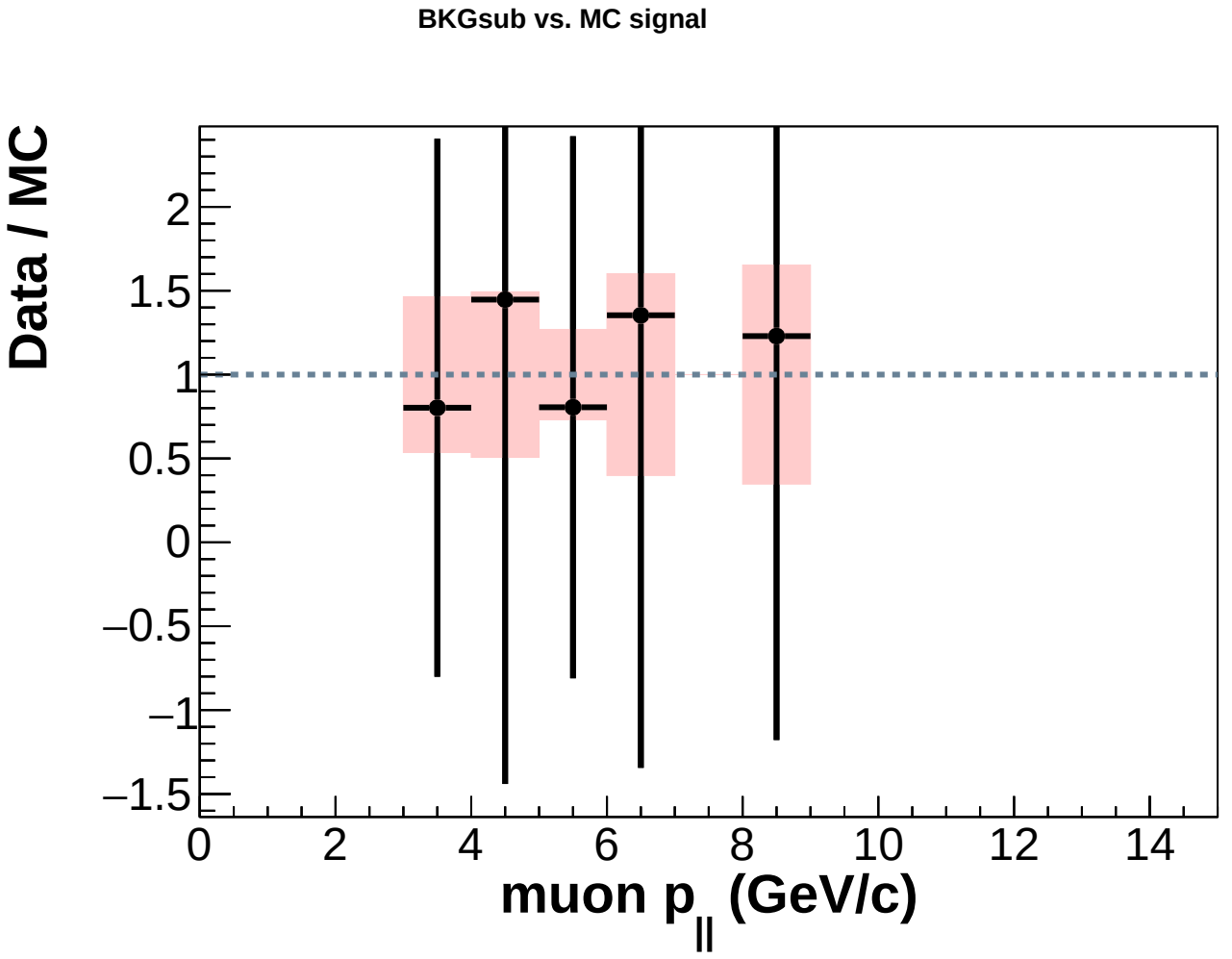

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

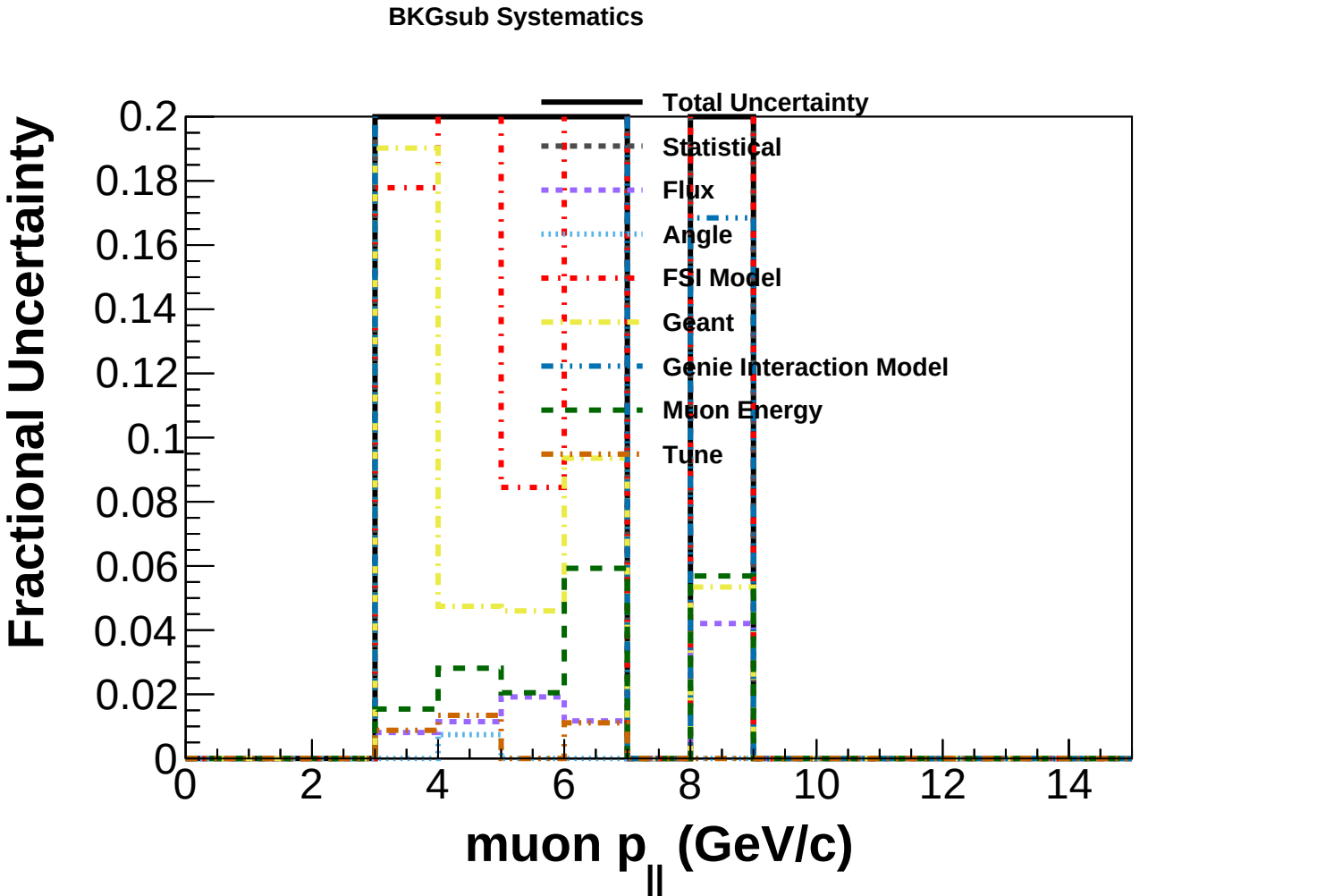

Signal Fraction
Data
Simulation
Counts per unit
0
0.05
0.1
0.15
0.2
0.25
0.3
0
2
4
6
8
10
12
14
muon p_{ll} (GeV/c)

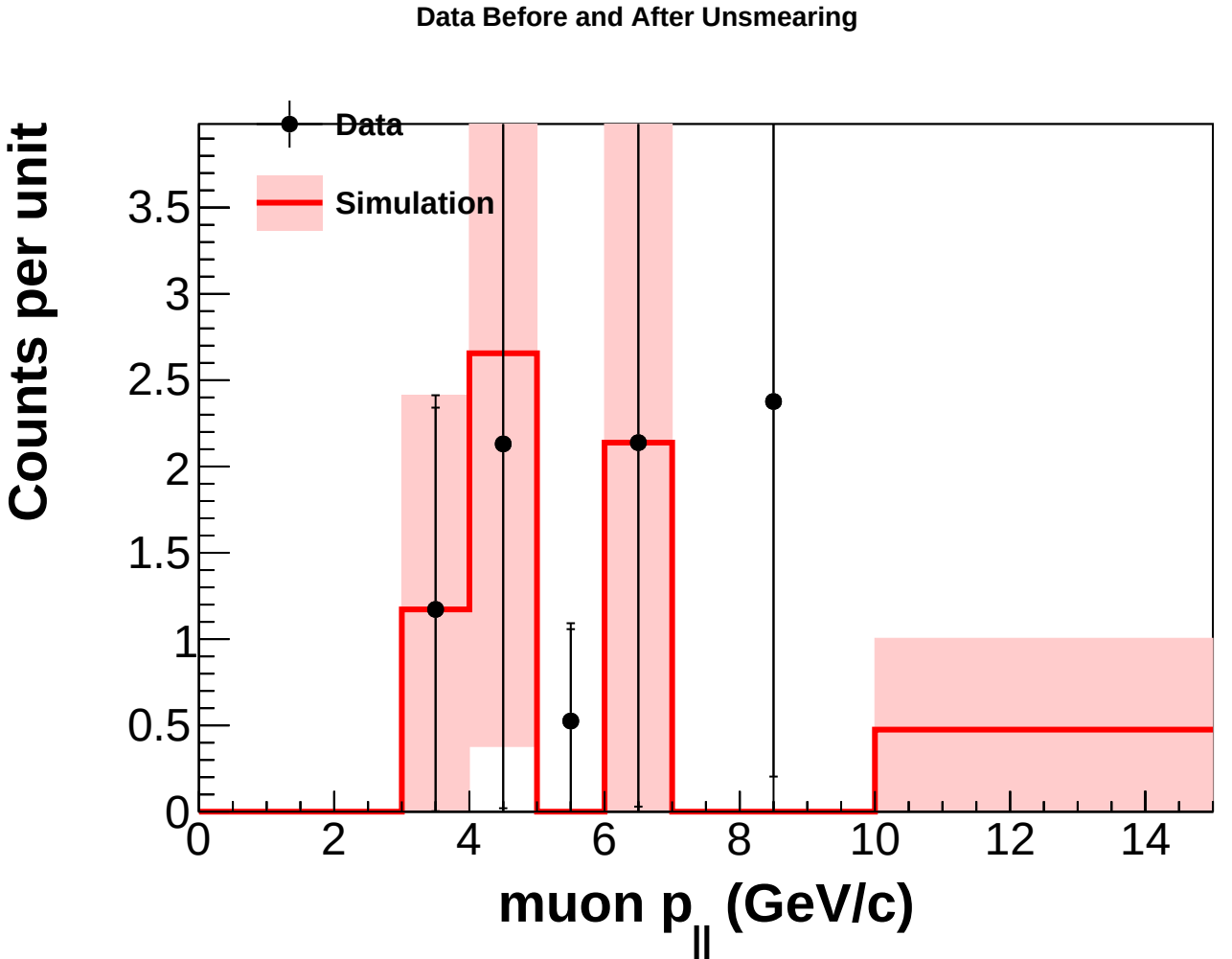

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
−1
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

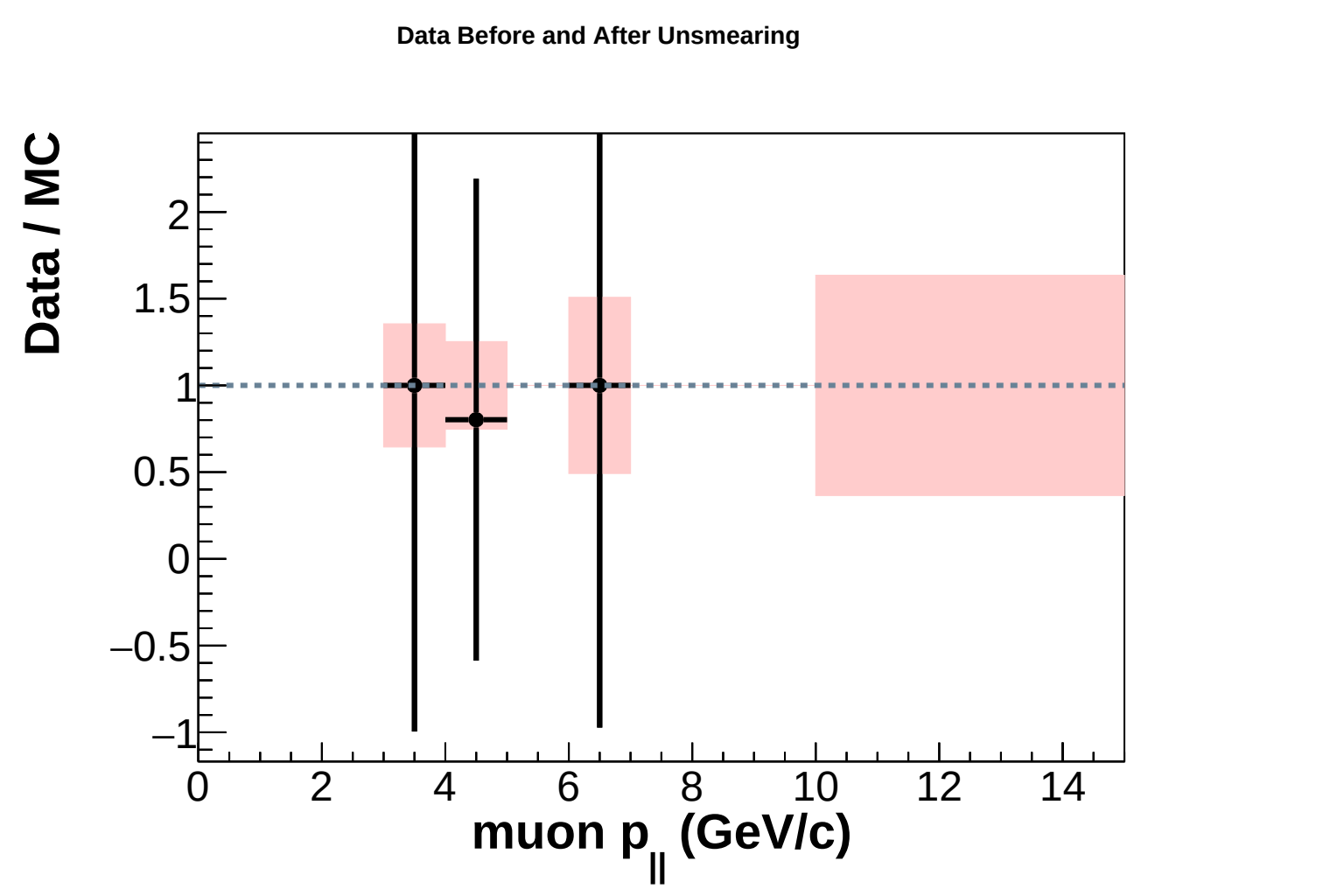

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

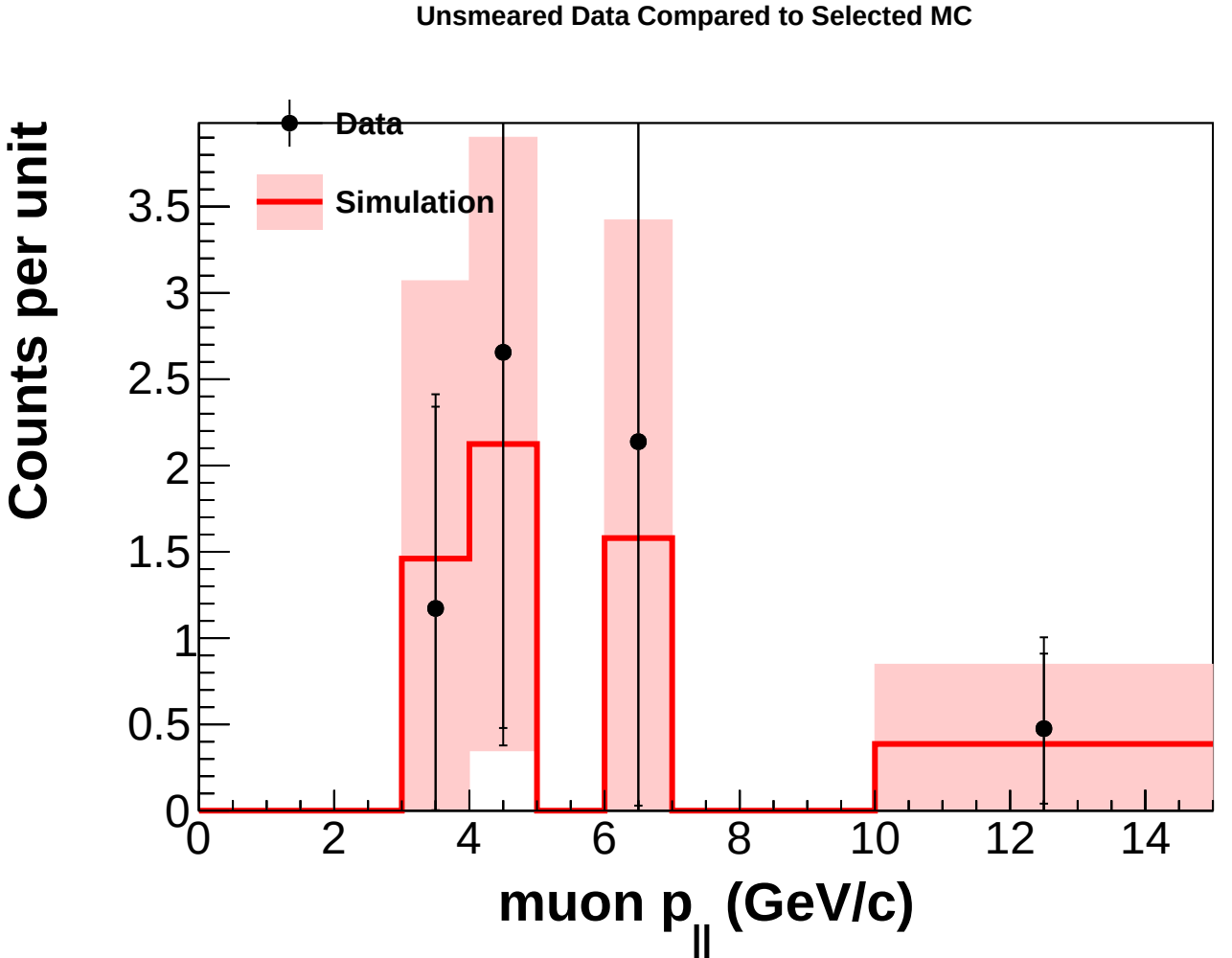

BKGsub vs. MC signal
Data
Simulation
Counts per unit
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

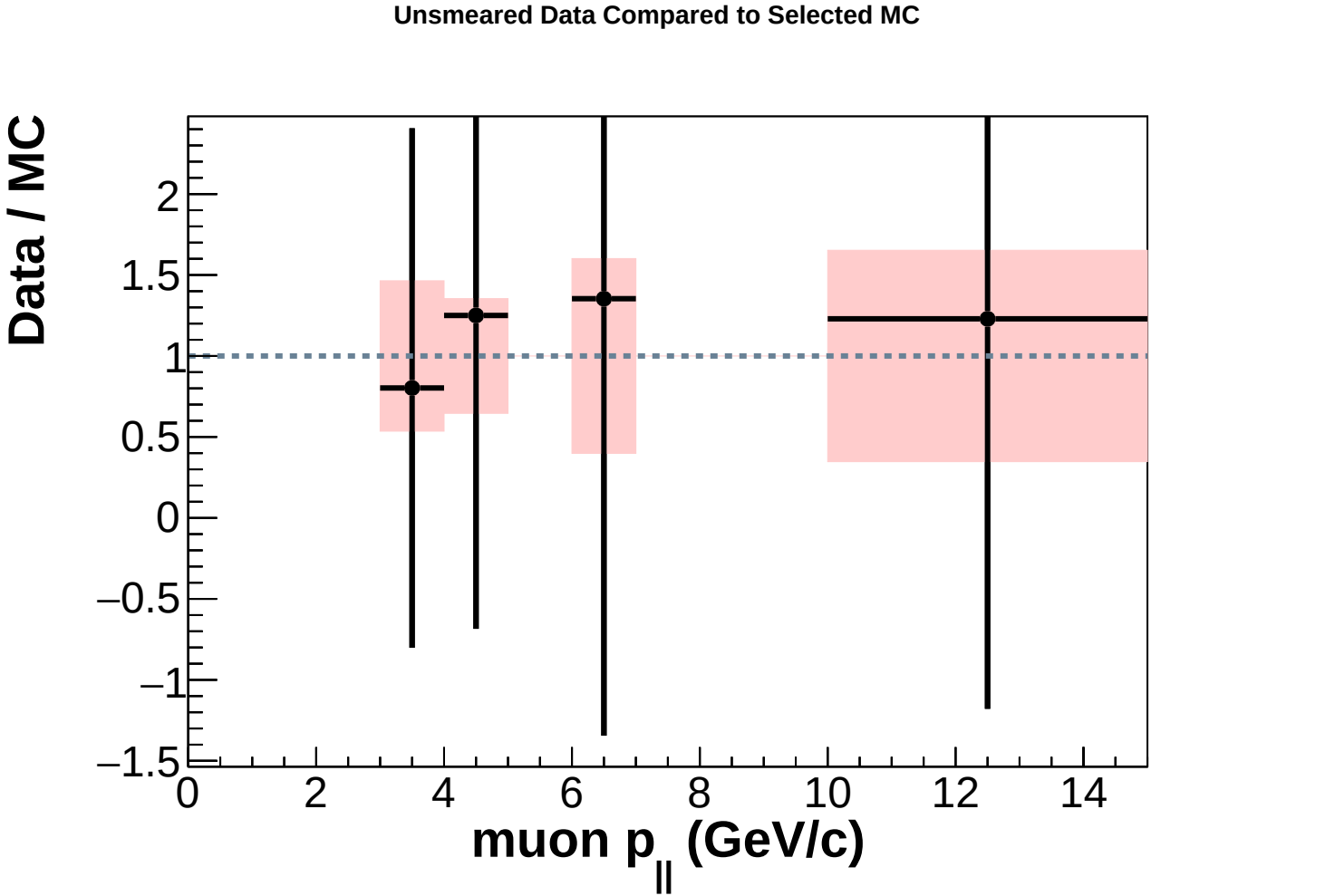

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

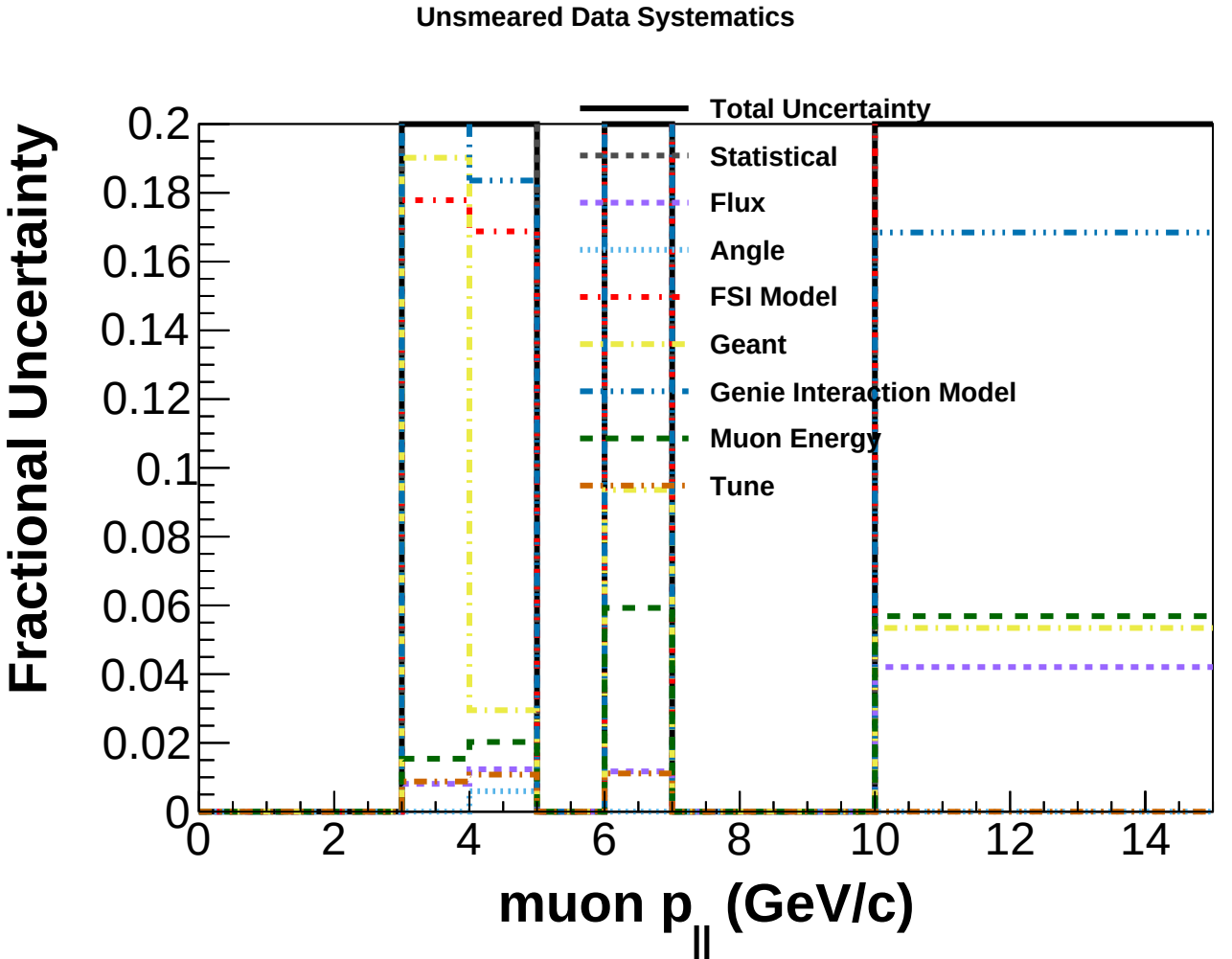

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

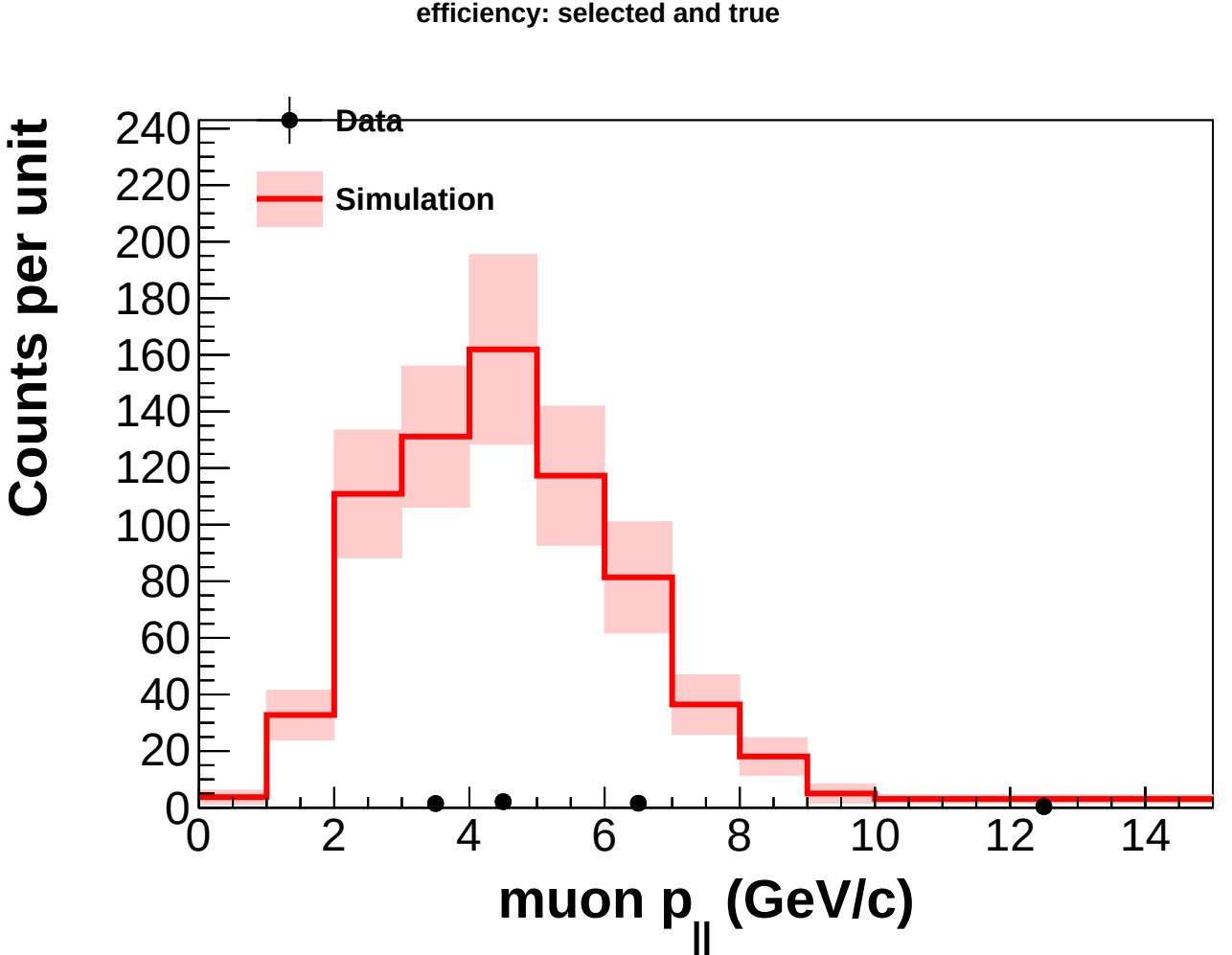

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
0.5
1
1.5
2
2.5
3
3.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


Data Before and After Unsmearing
Data / MC
2
1.5
1
0.5
0
−0.5
−1
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

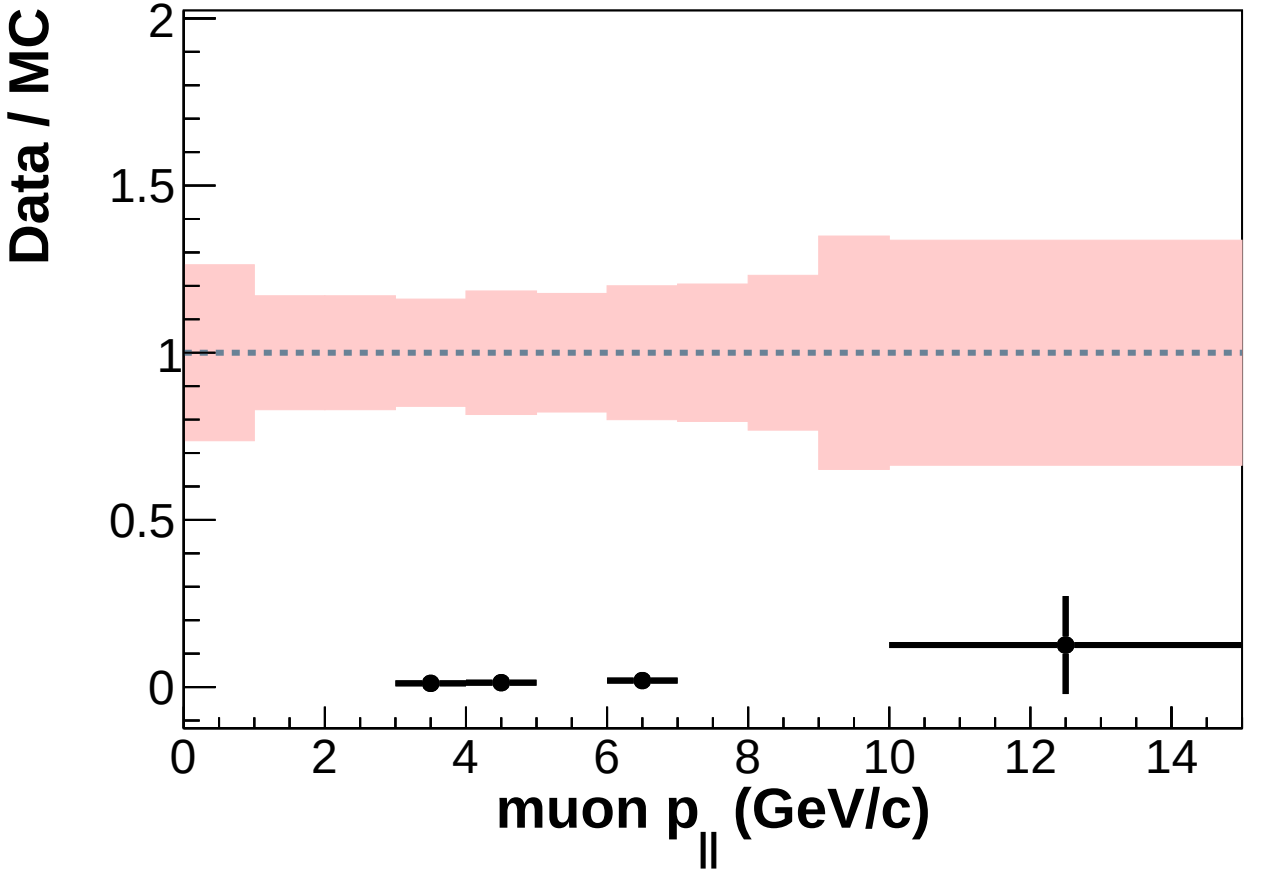

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
0.5
1
1.5
2
2.5
3
3.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

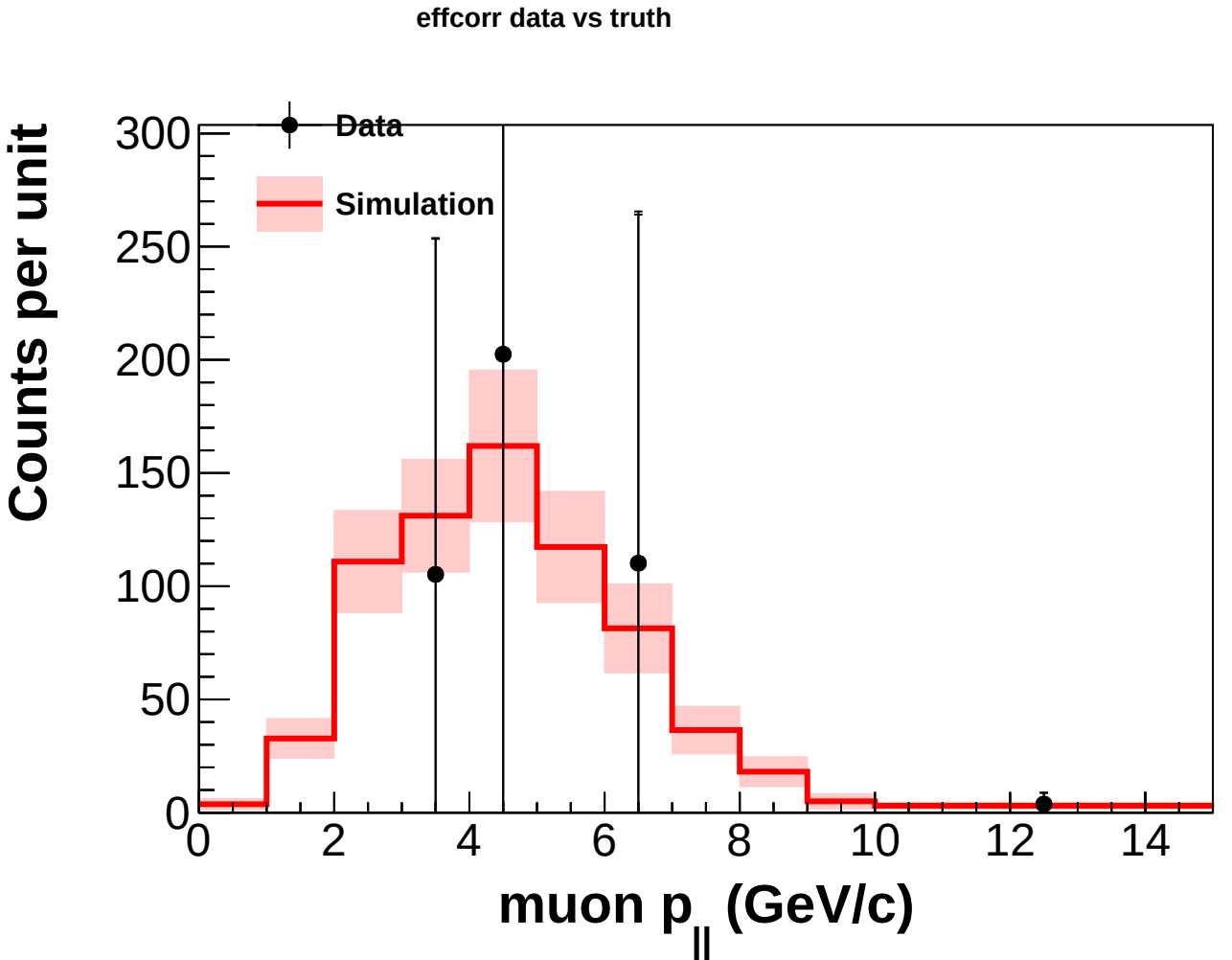

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

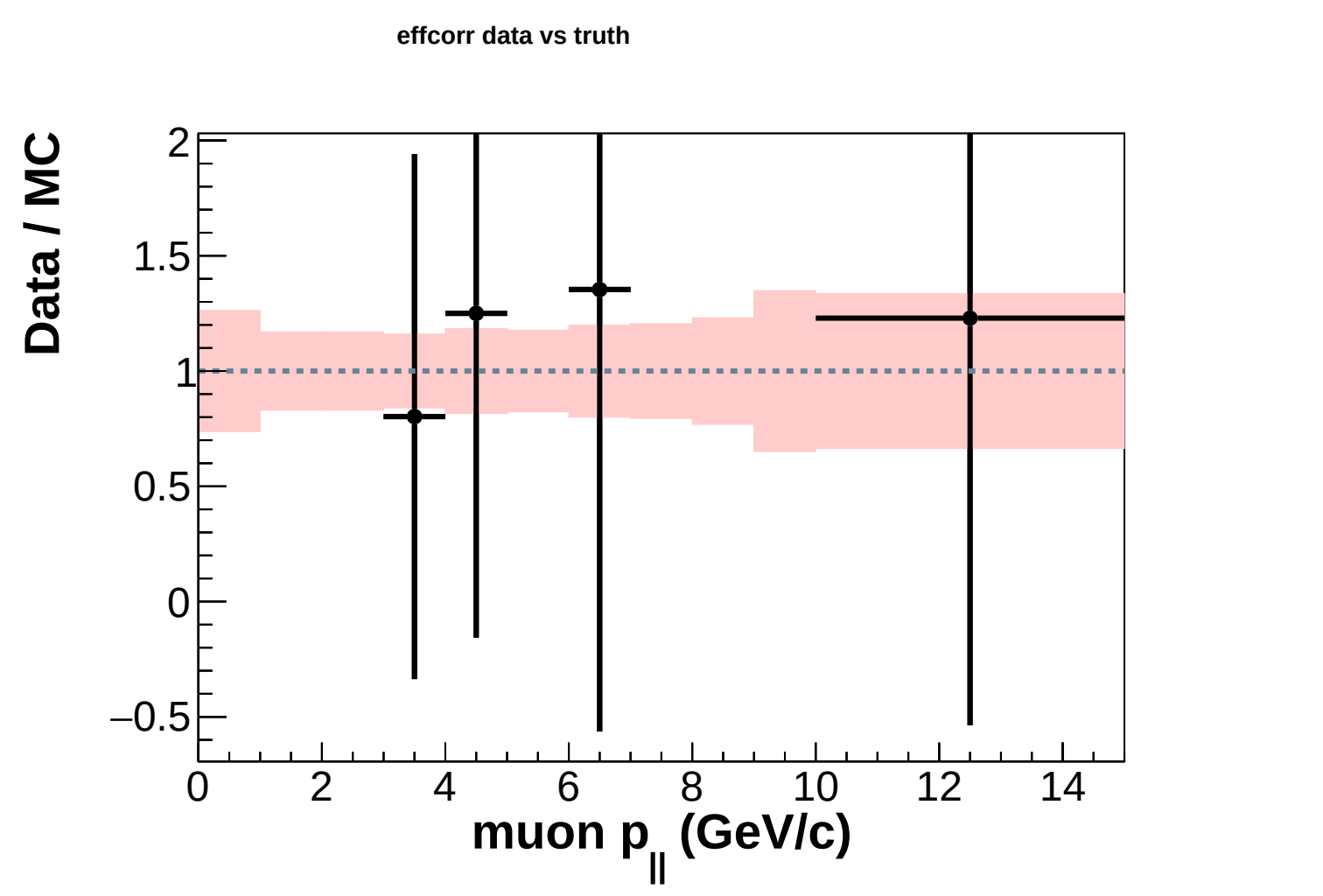

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

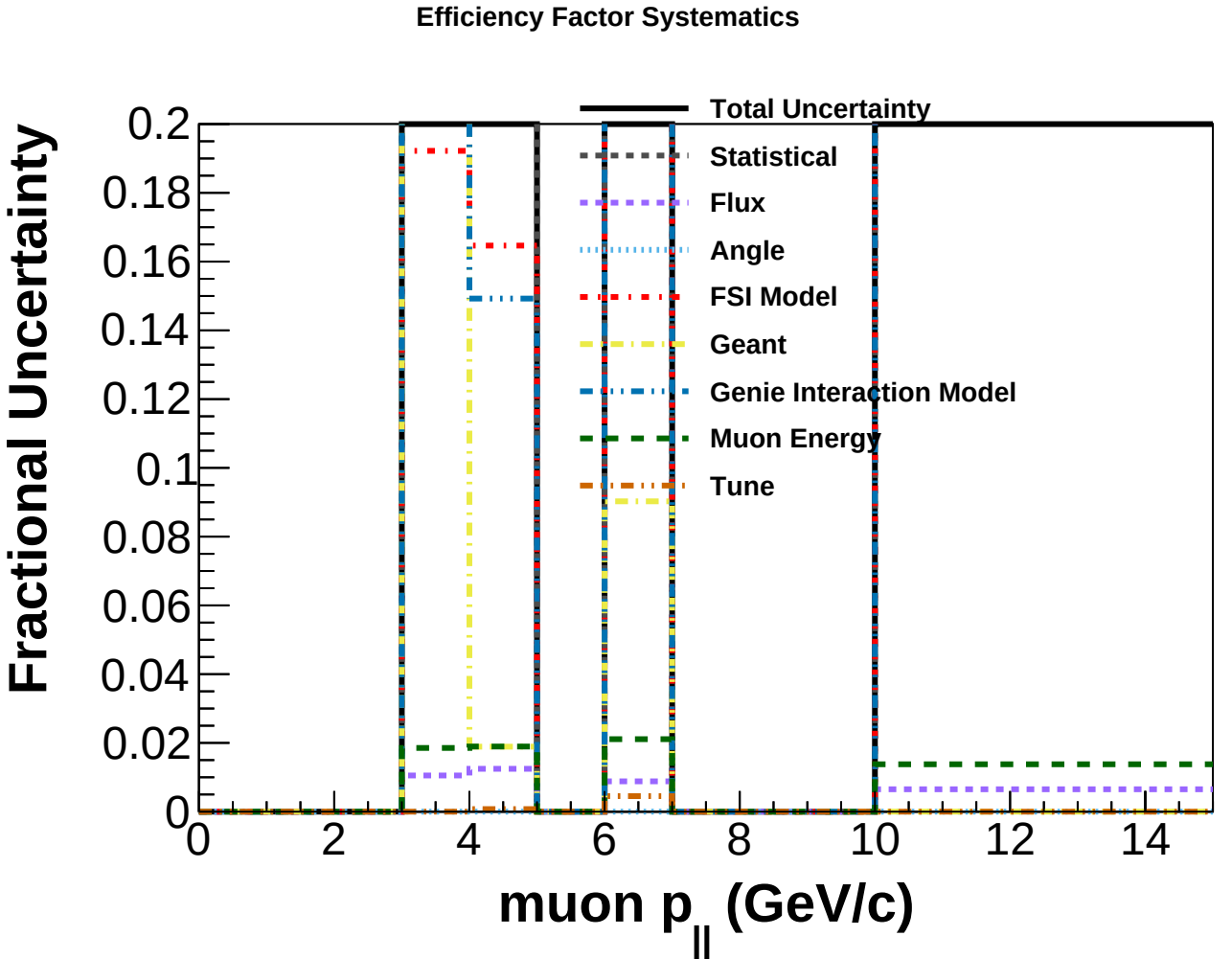

efficiency: selected and true
Data
Simulation
Counts per unit
240
220
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

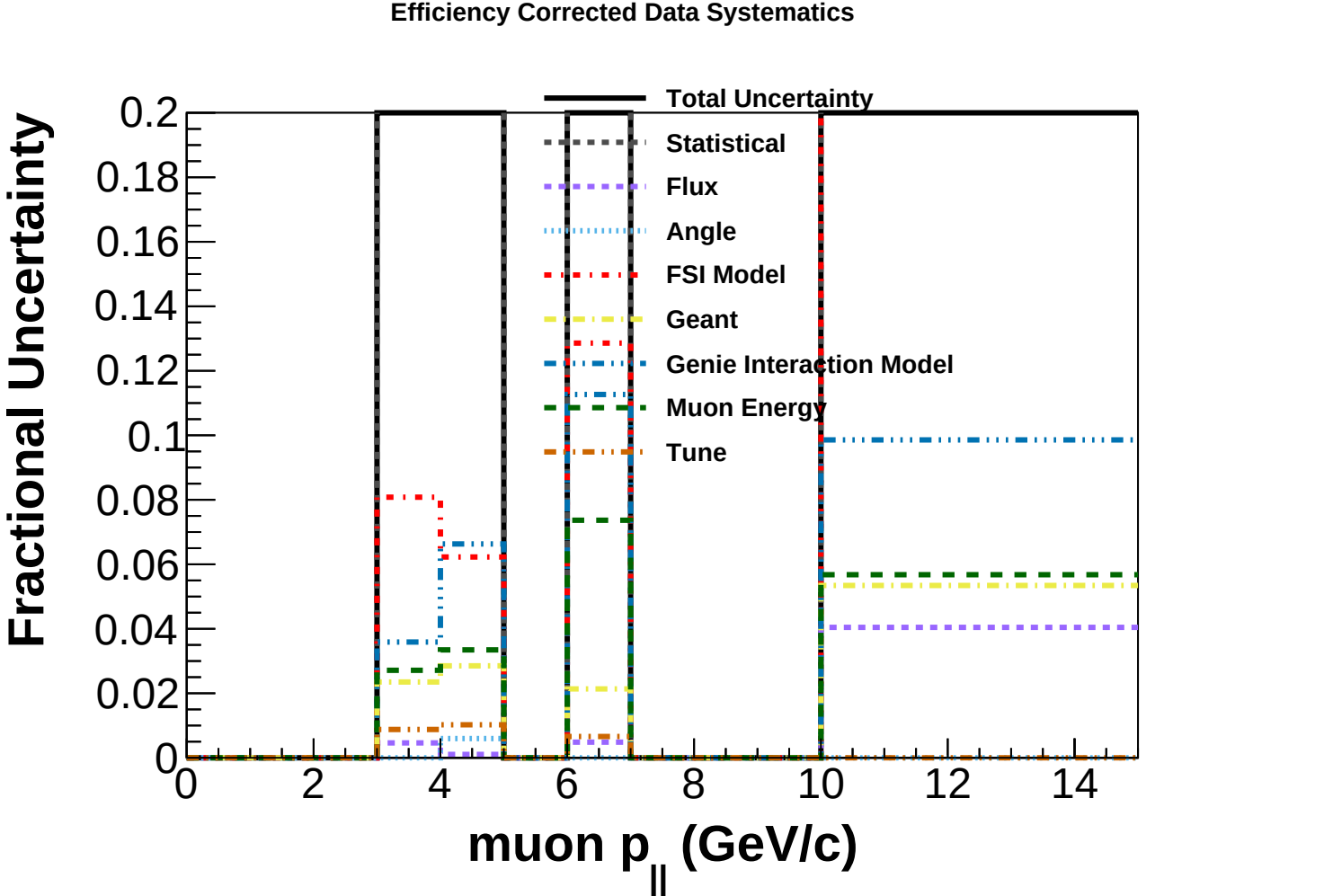
efficiency: selected and true

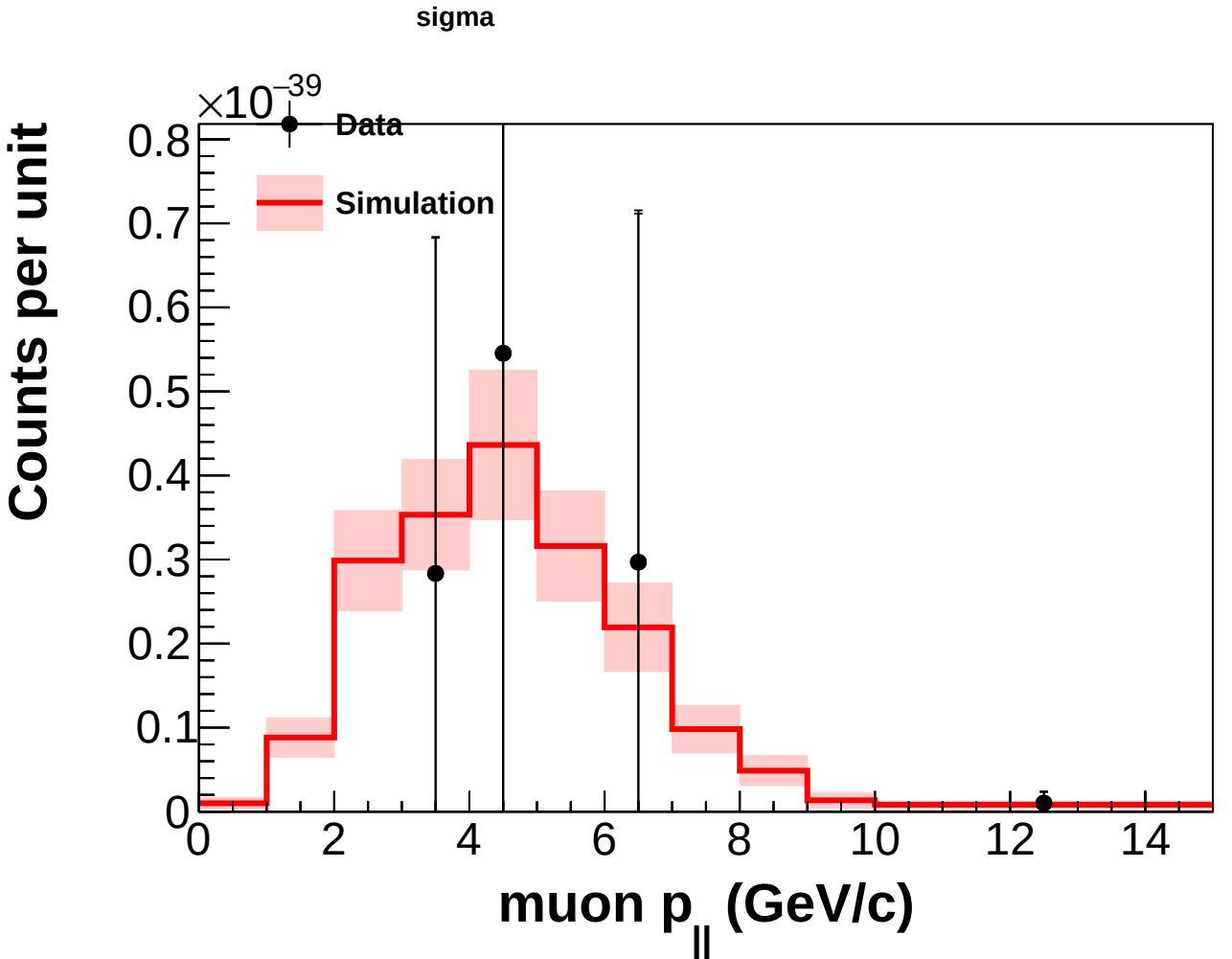


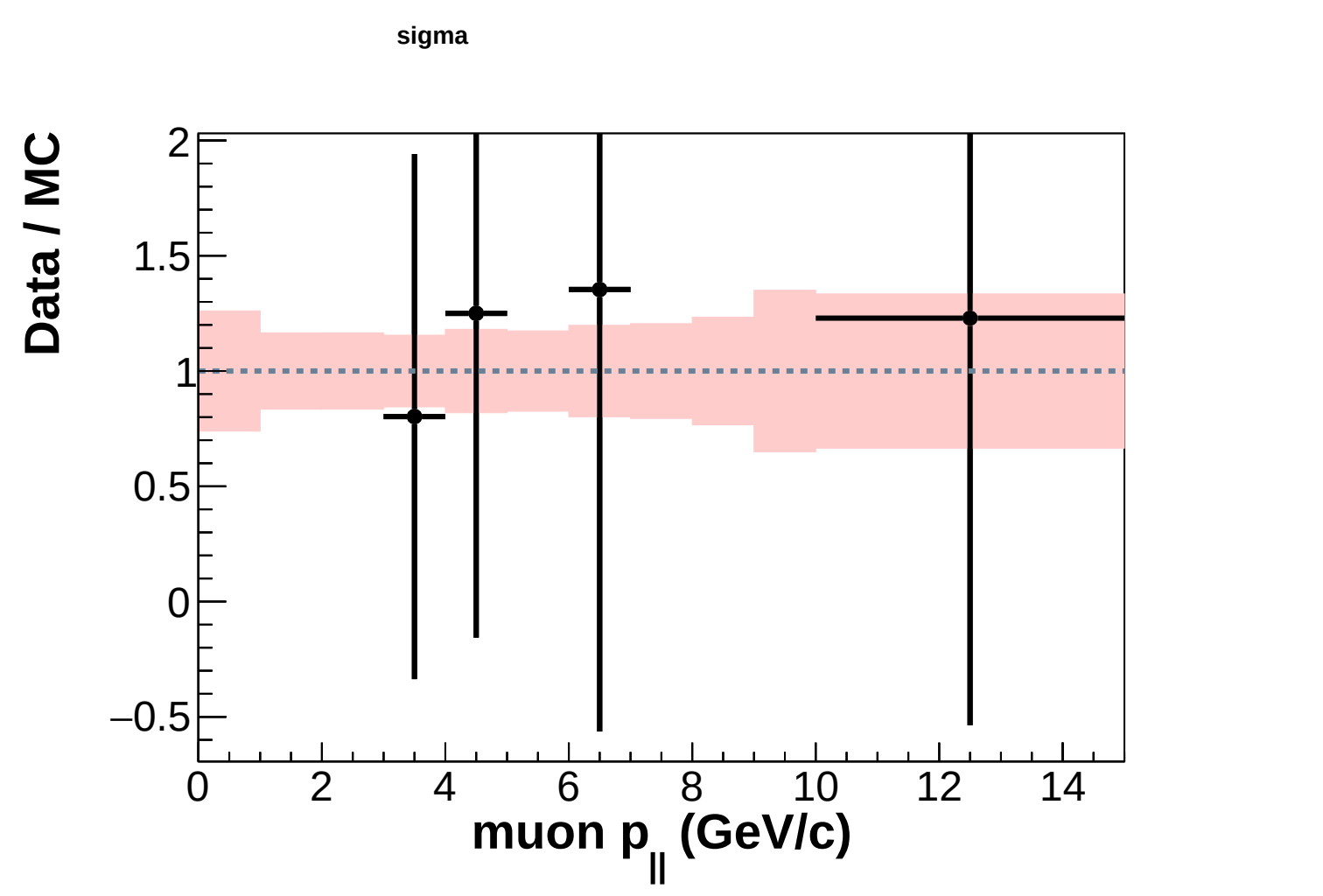

effcorr data vs truth
Data
Simulation
Counts per unit
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

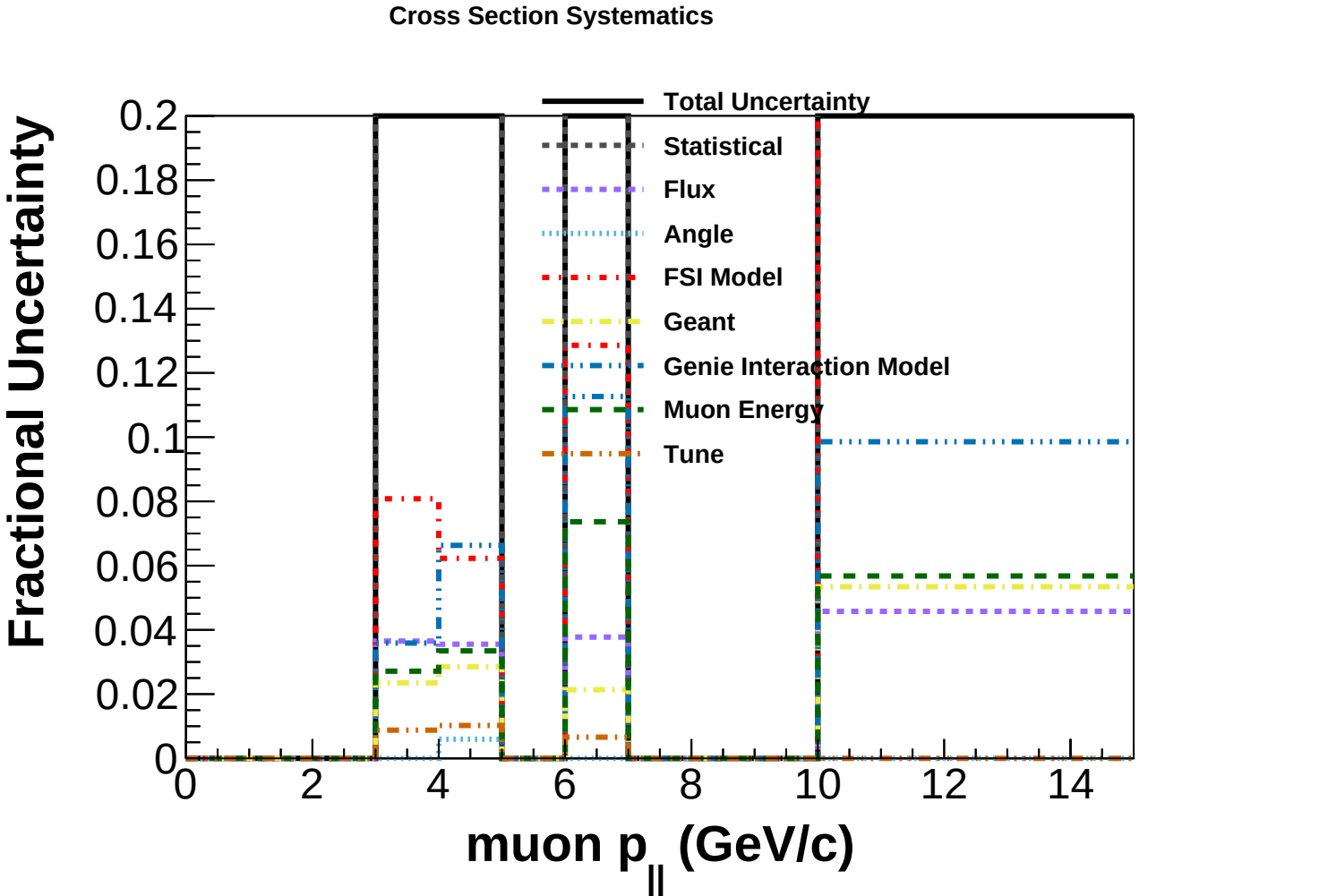

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
−0.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

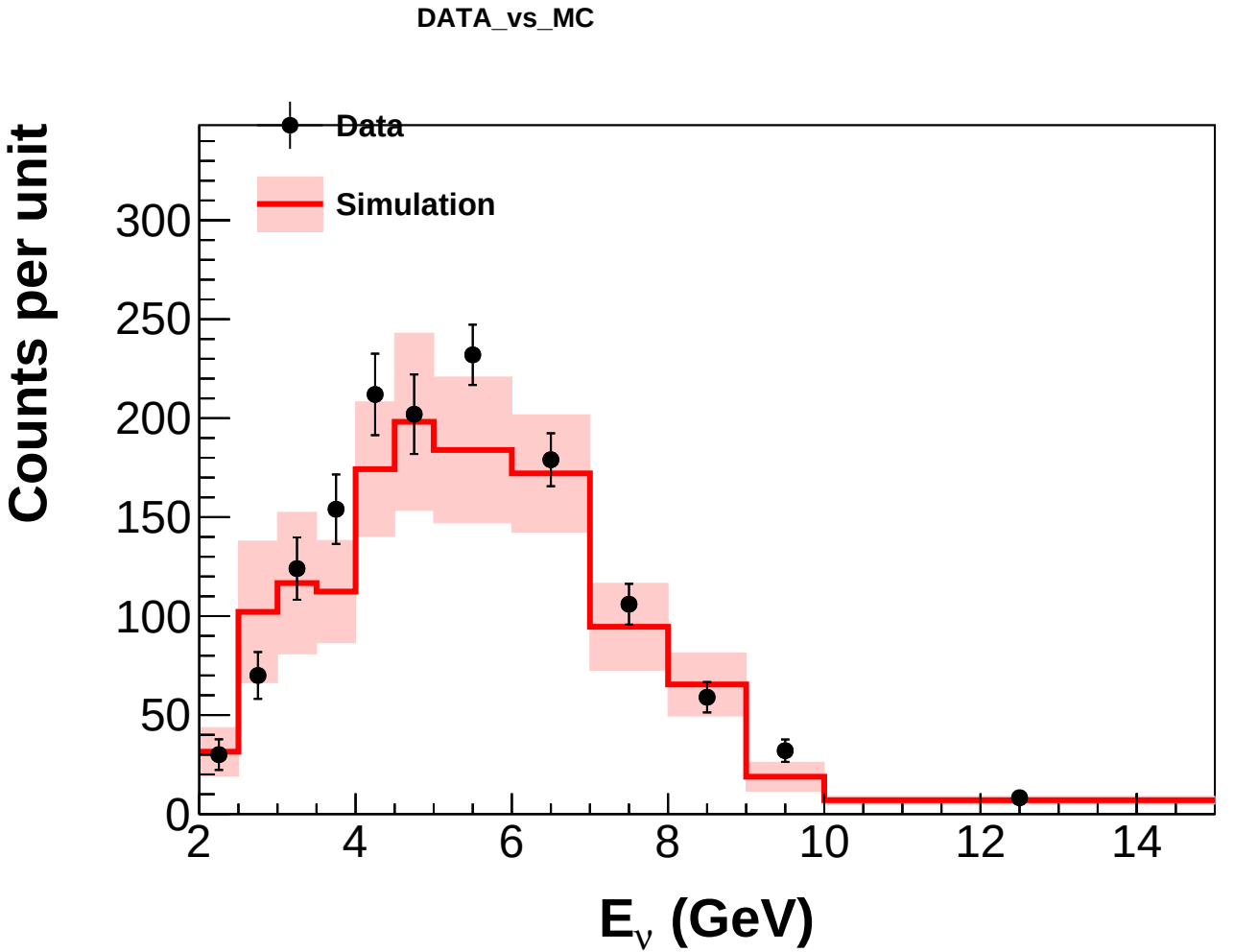

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

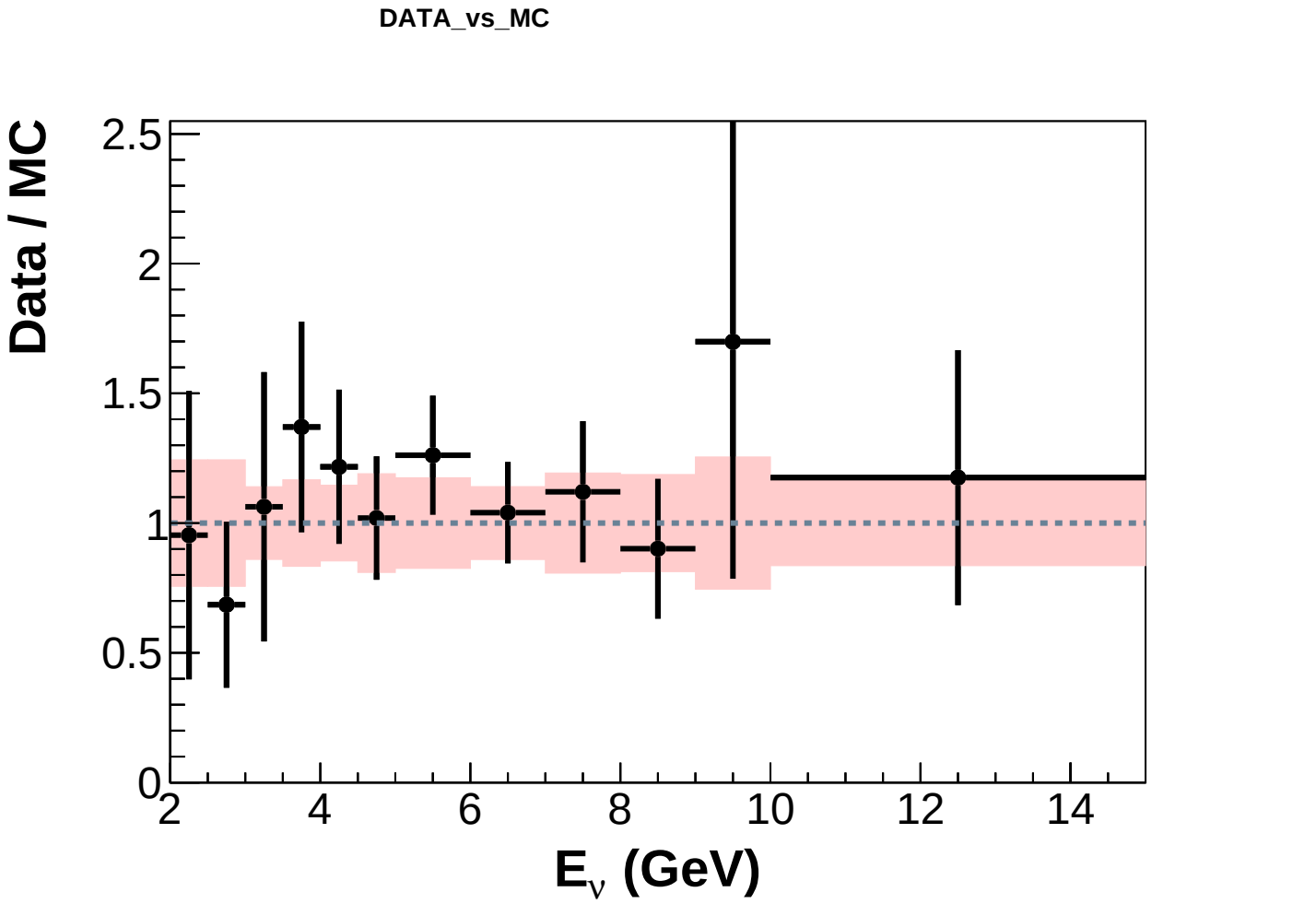

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

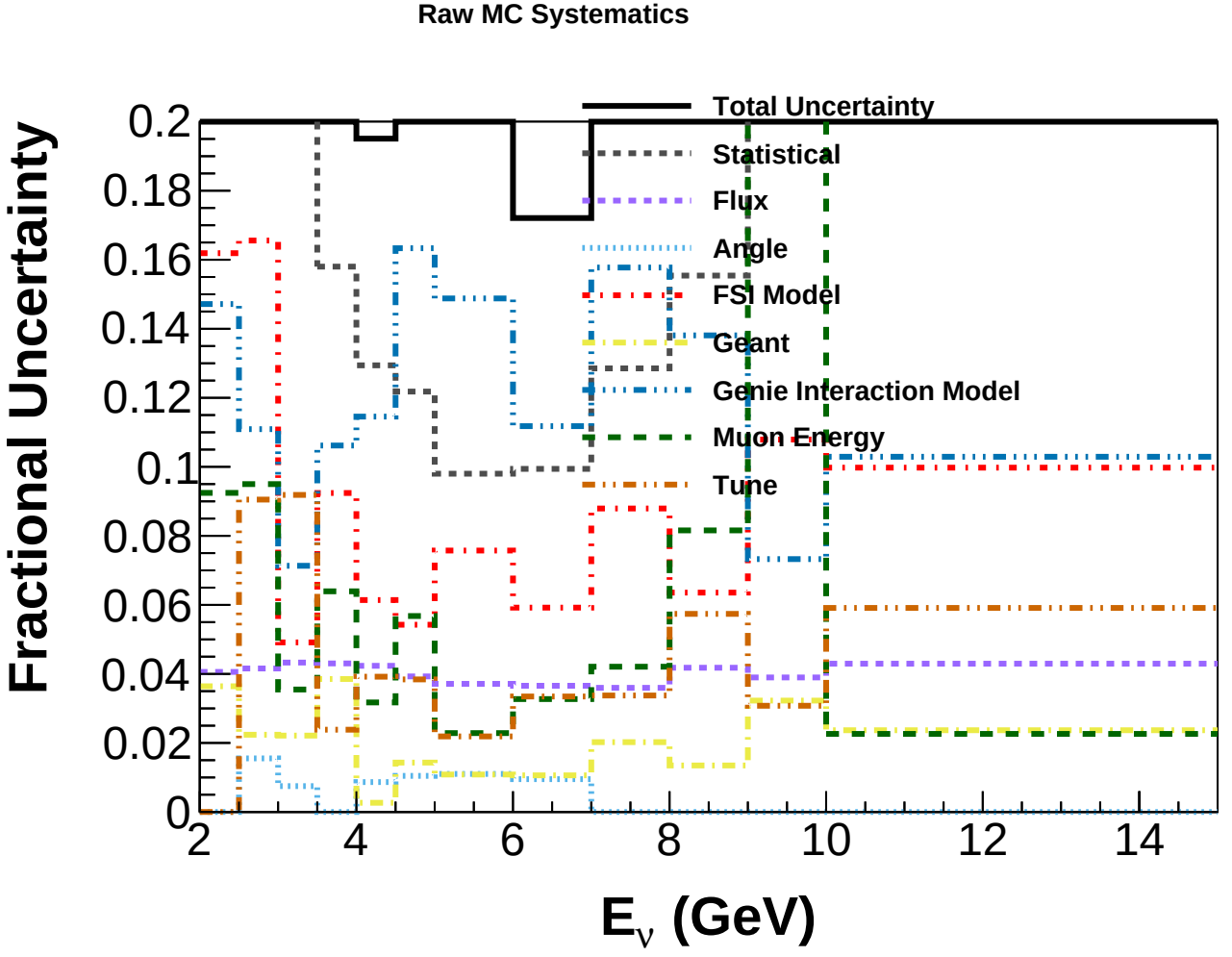

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

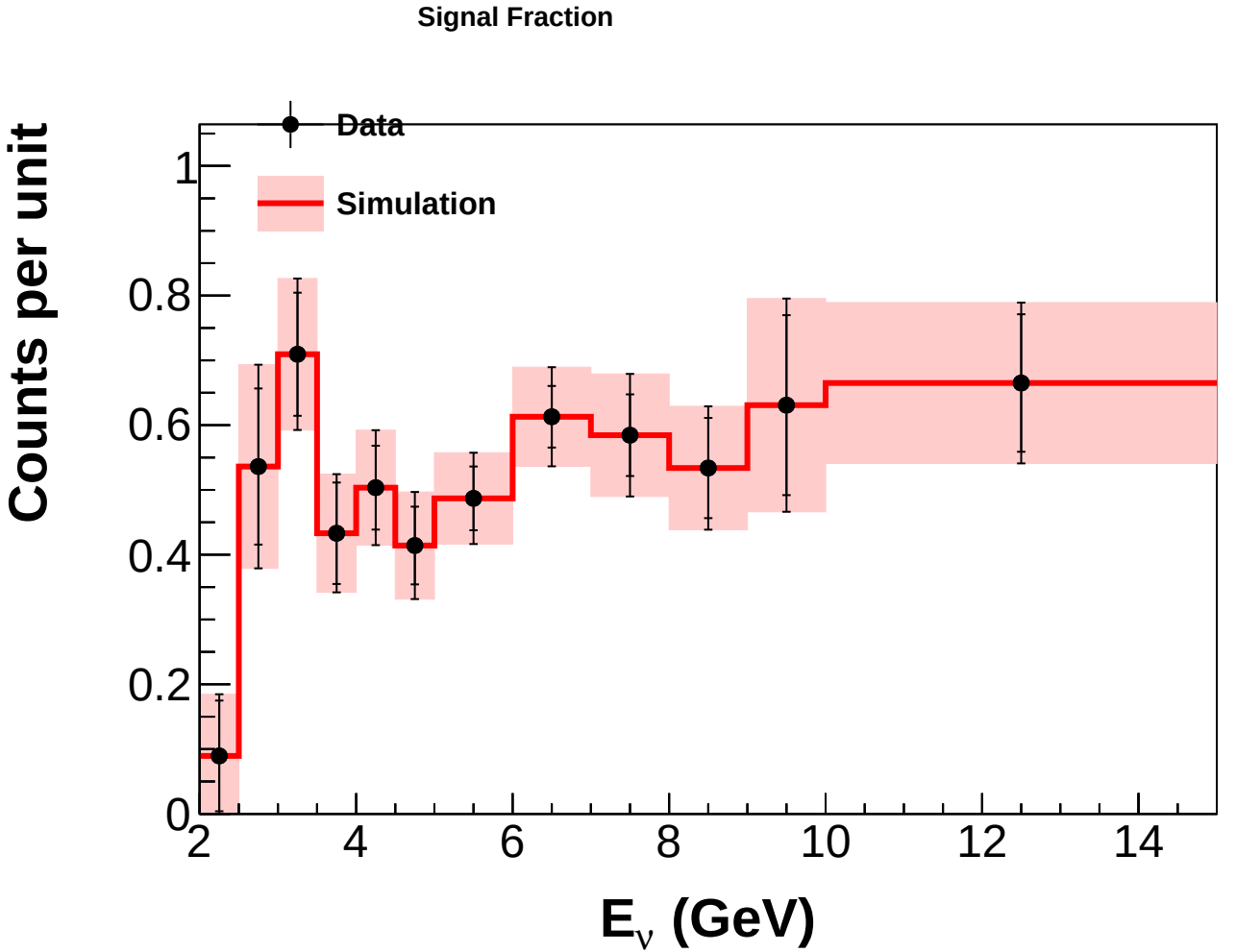

sigma
Data / MC
2
1.5
1
0.5
0
−0.5
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

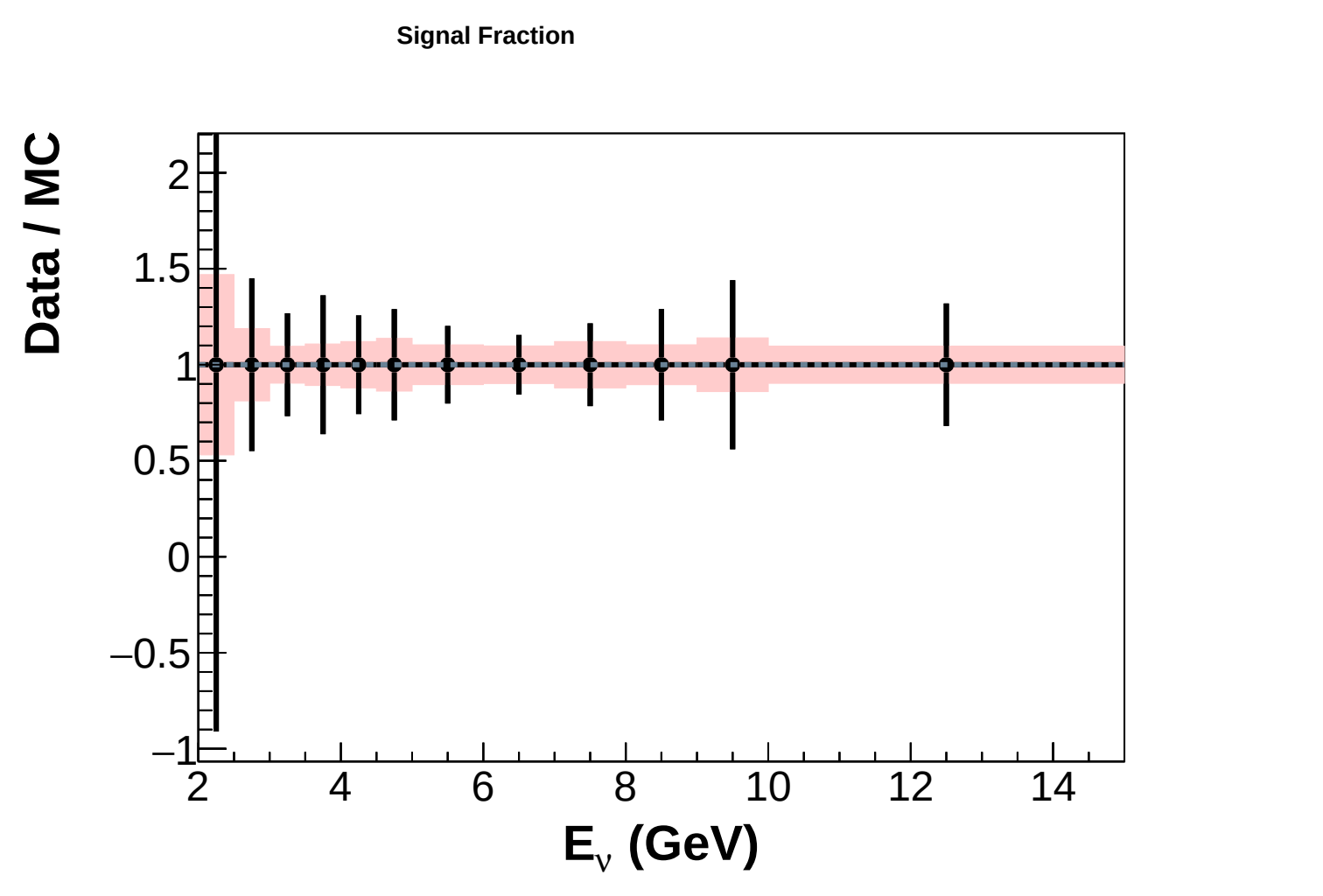

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

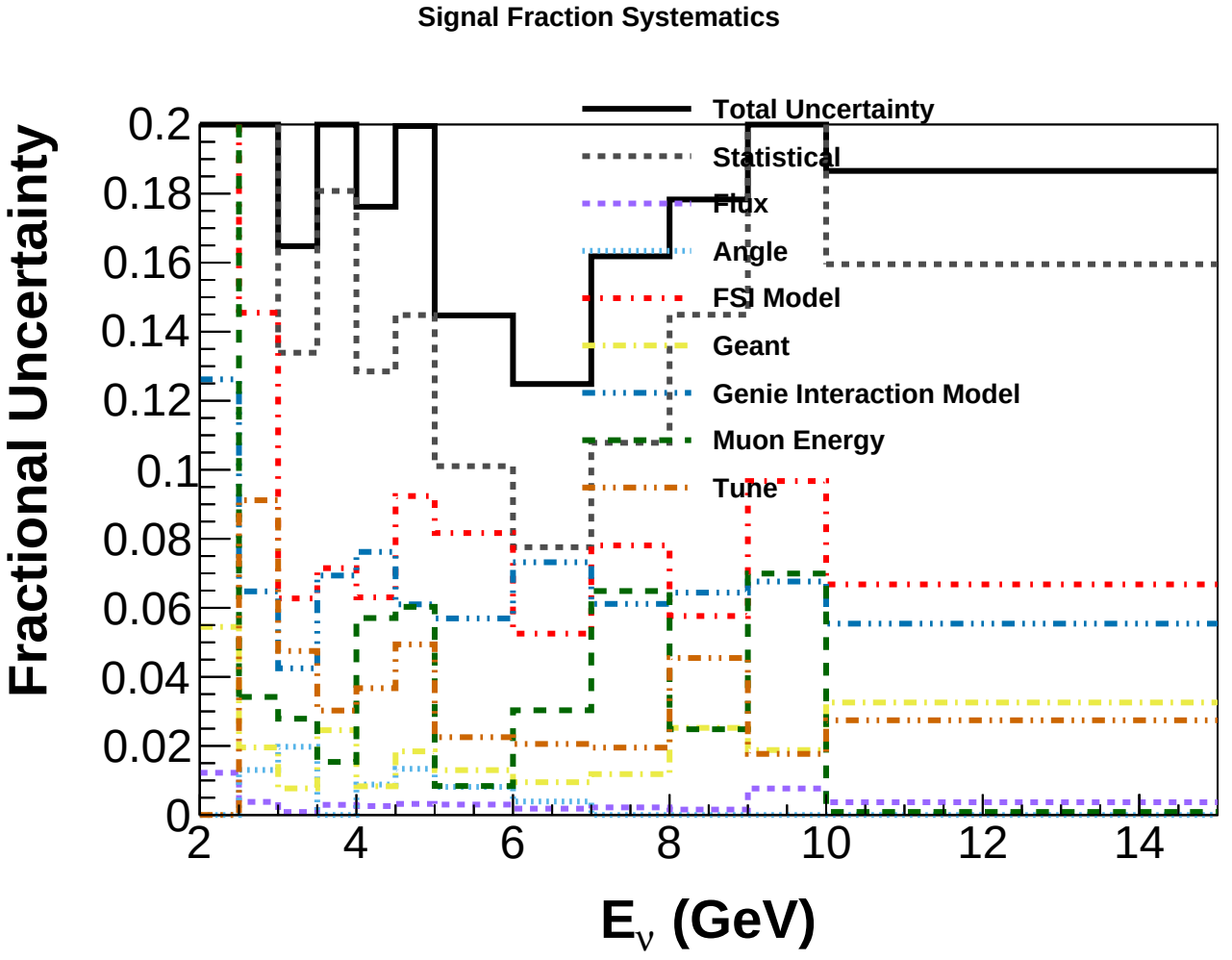

DATA_vs_MC
Data
Simulation
Counts per unit
300
250
200
150
100
50
0
2
4
6
8
10
12
14
E_ν (GeV)

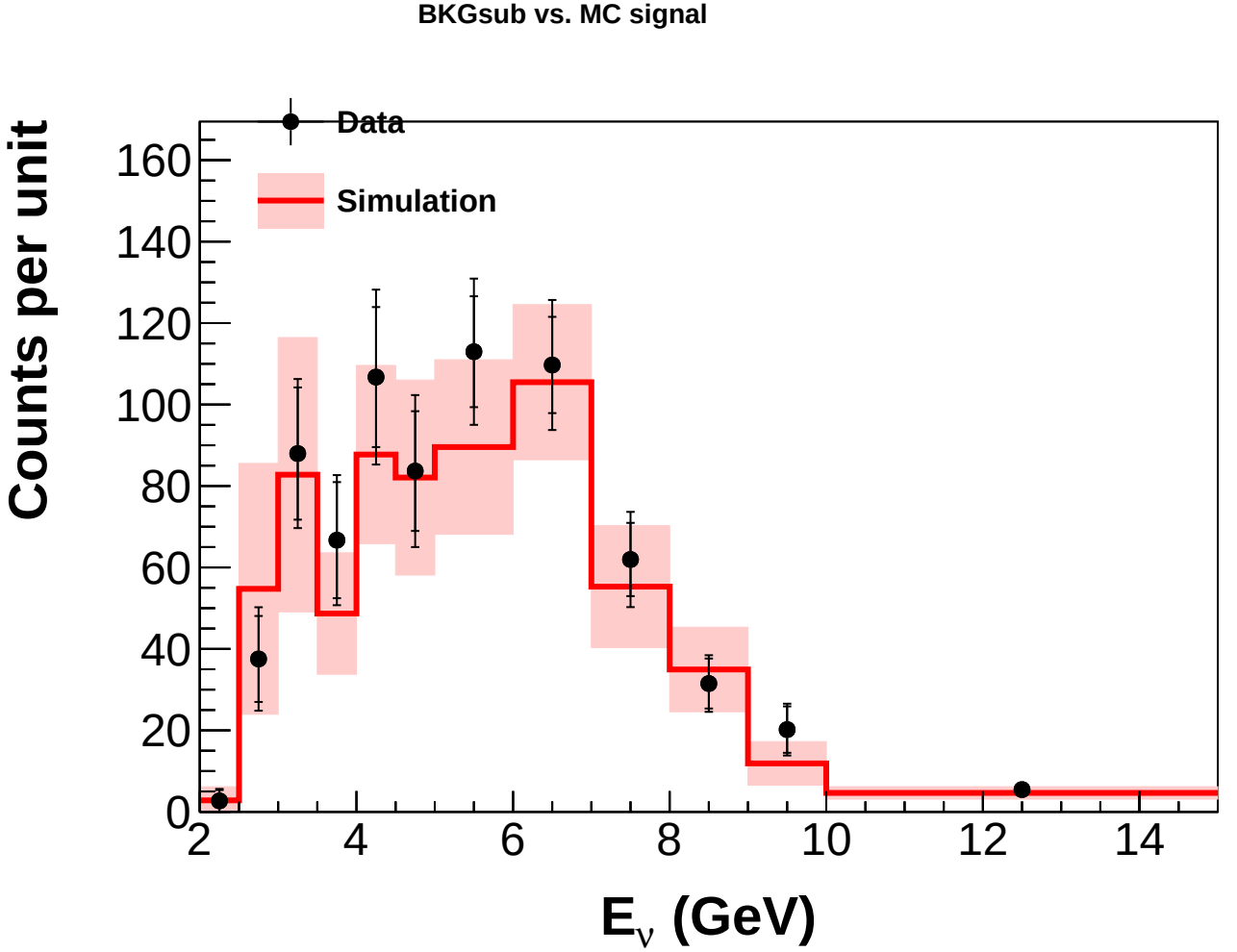

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
E_ν (GeV)

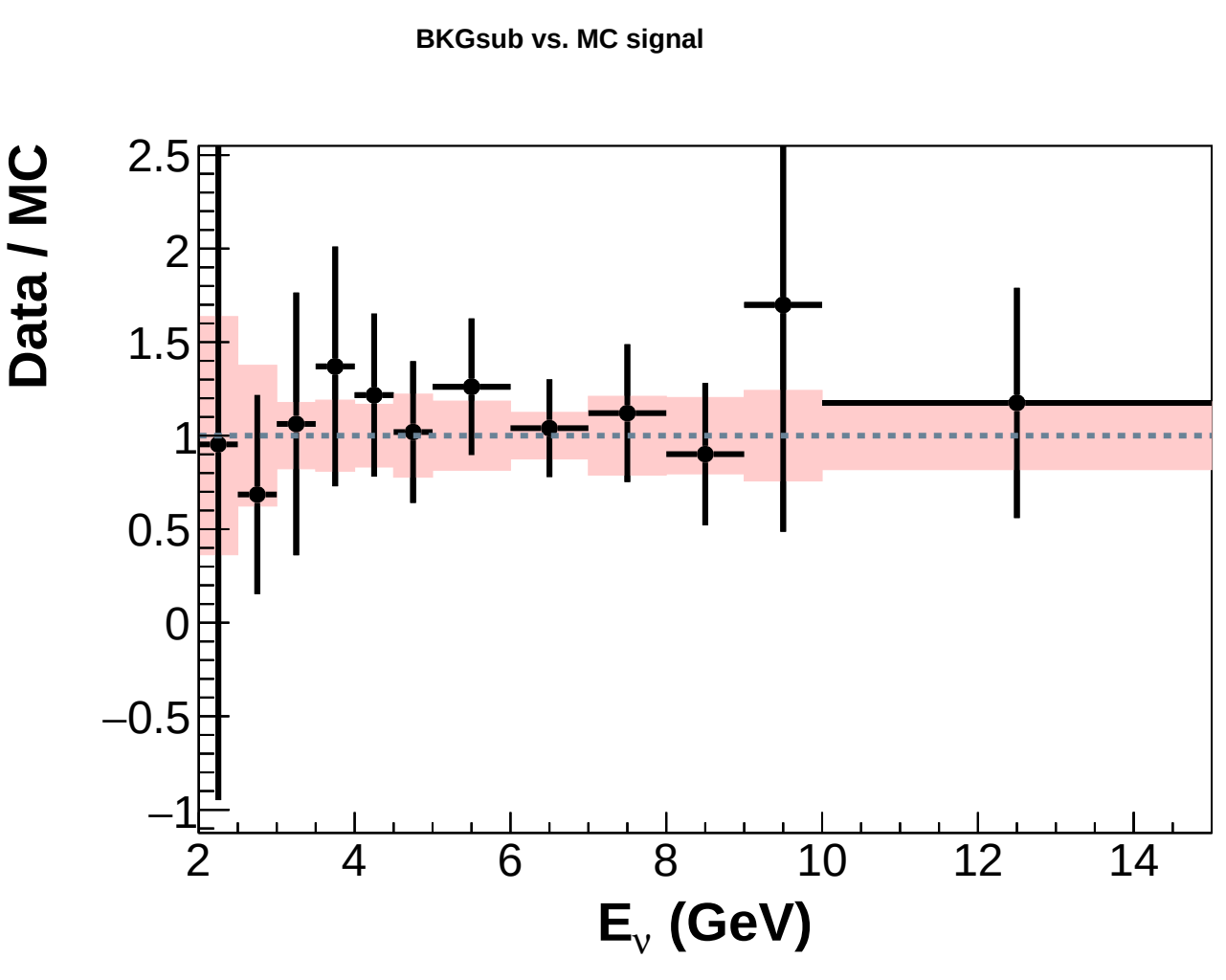

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

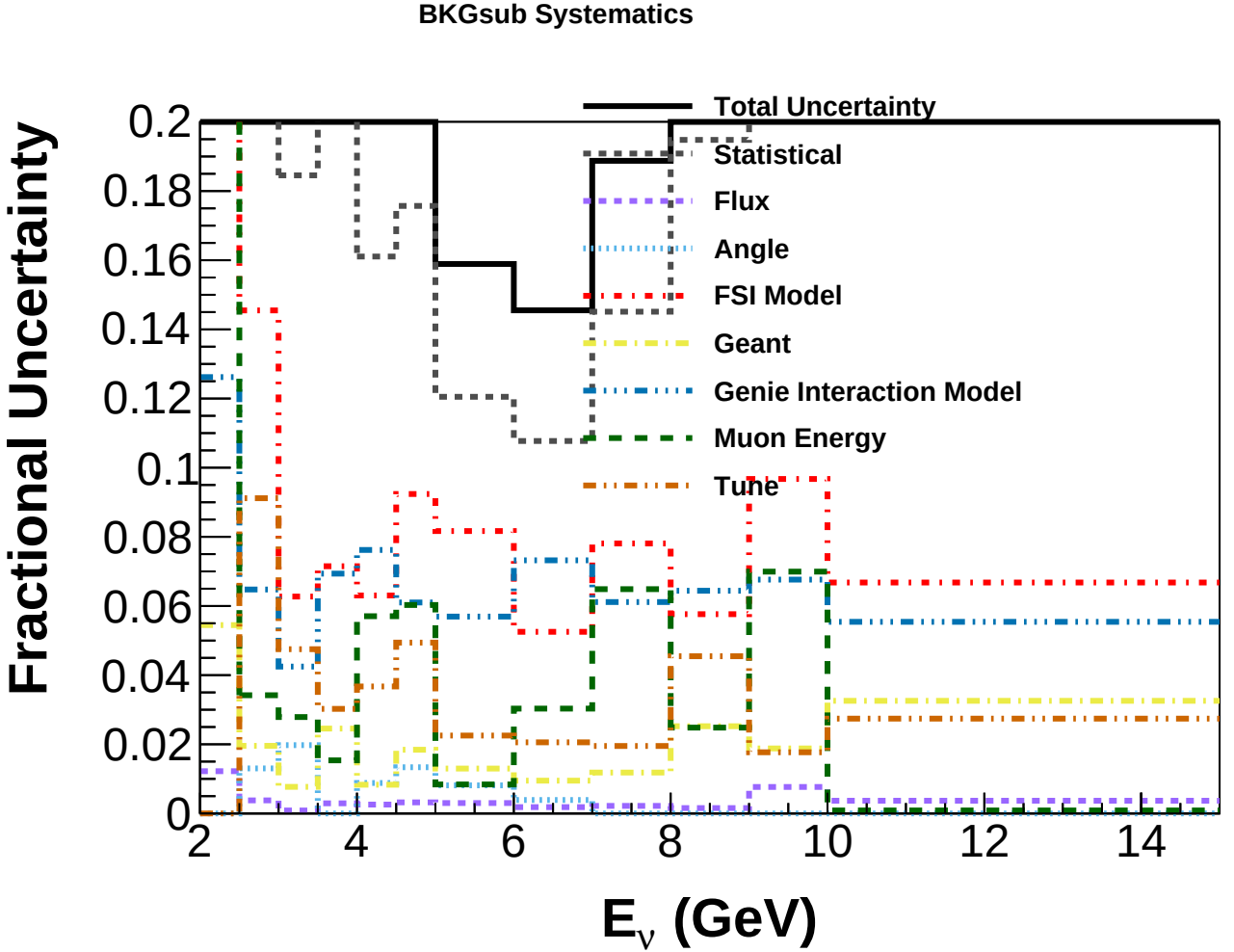

Signal Fraction
Data
Simulation
Counts per unit
0
0.2
0.4
0.6
0.8
1
2
4
6
8
10
12
14
E_ν (GeV)

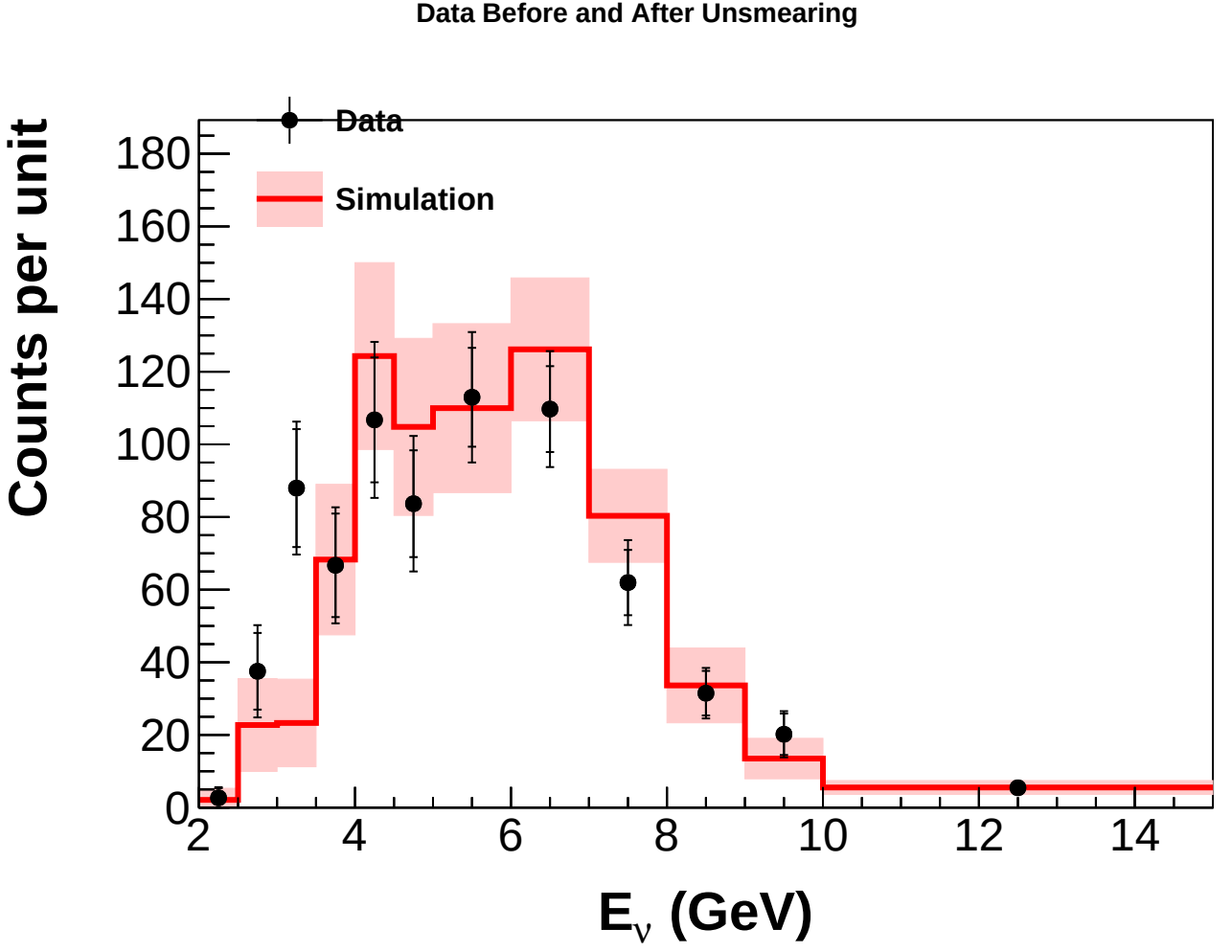

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

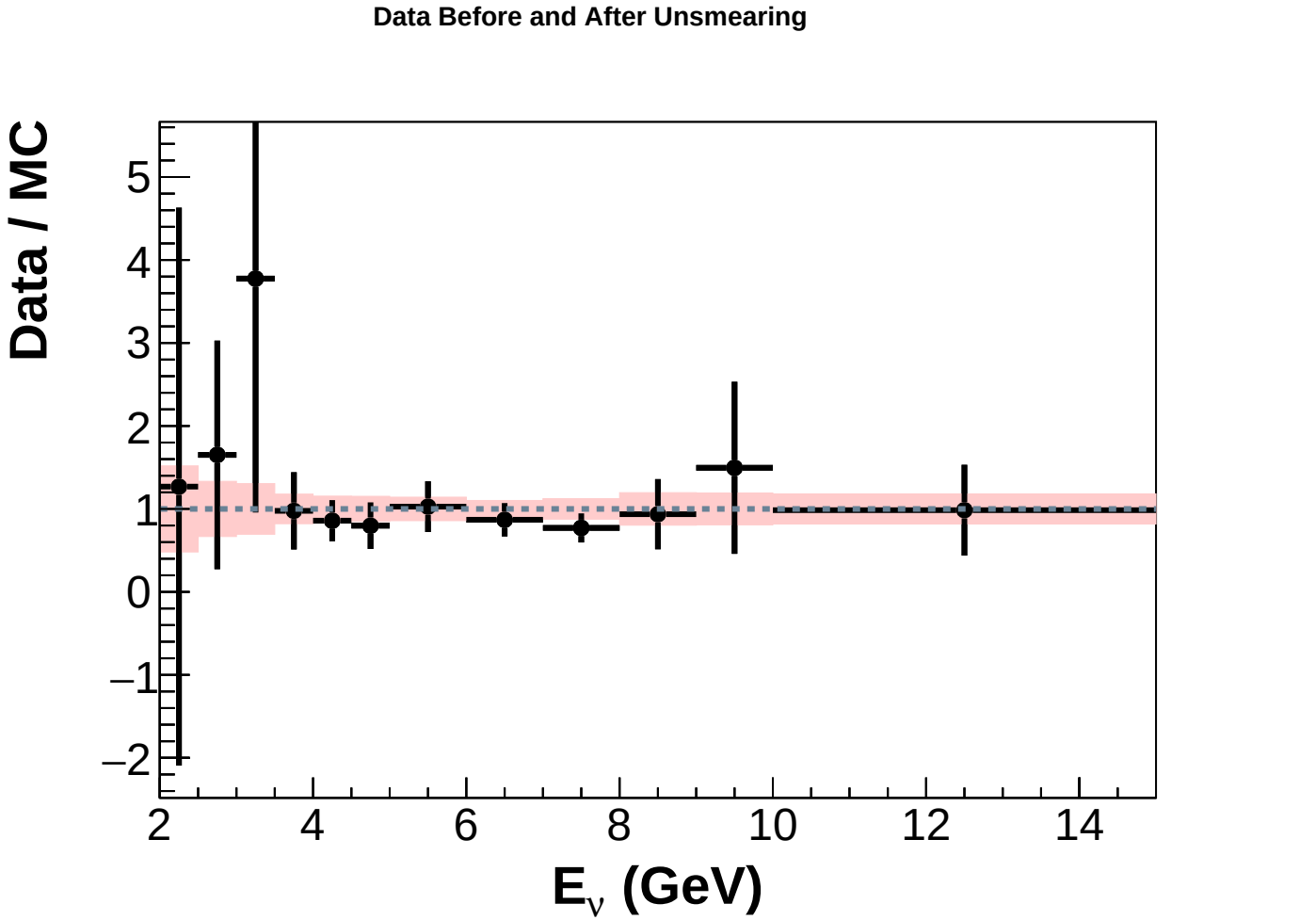

Signal Fraction Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

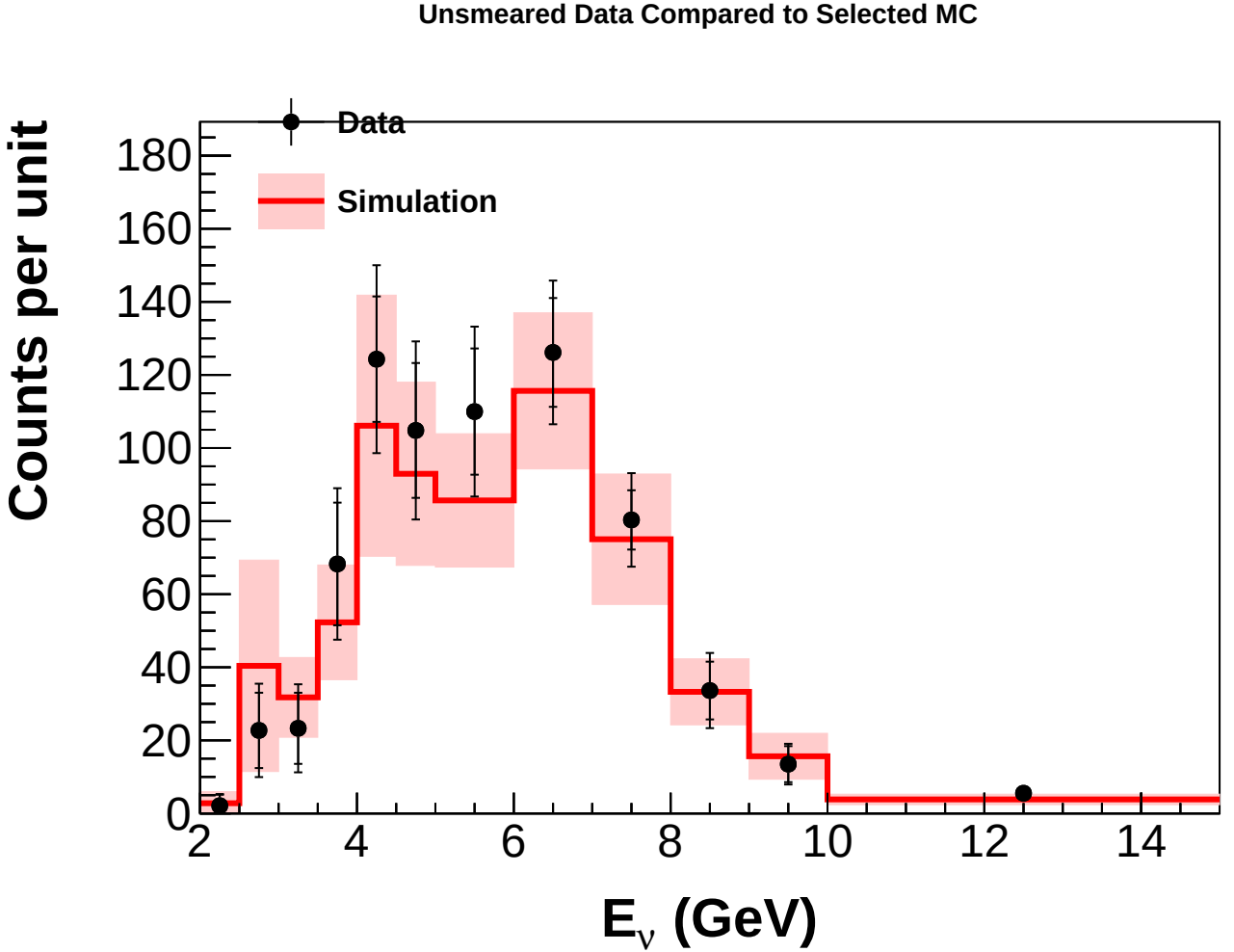

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
2
4
6
8
10
12
14
E_ν (GeV)

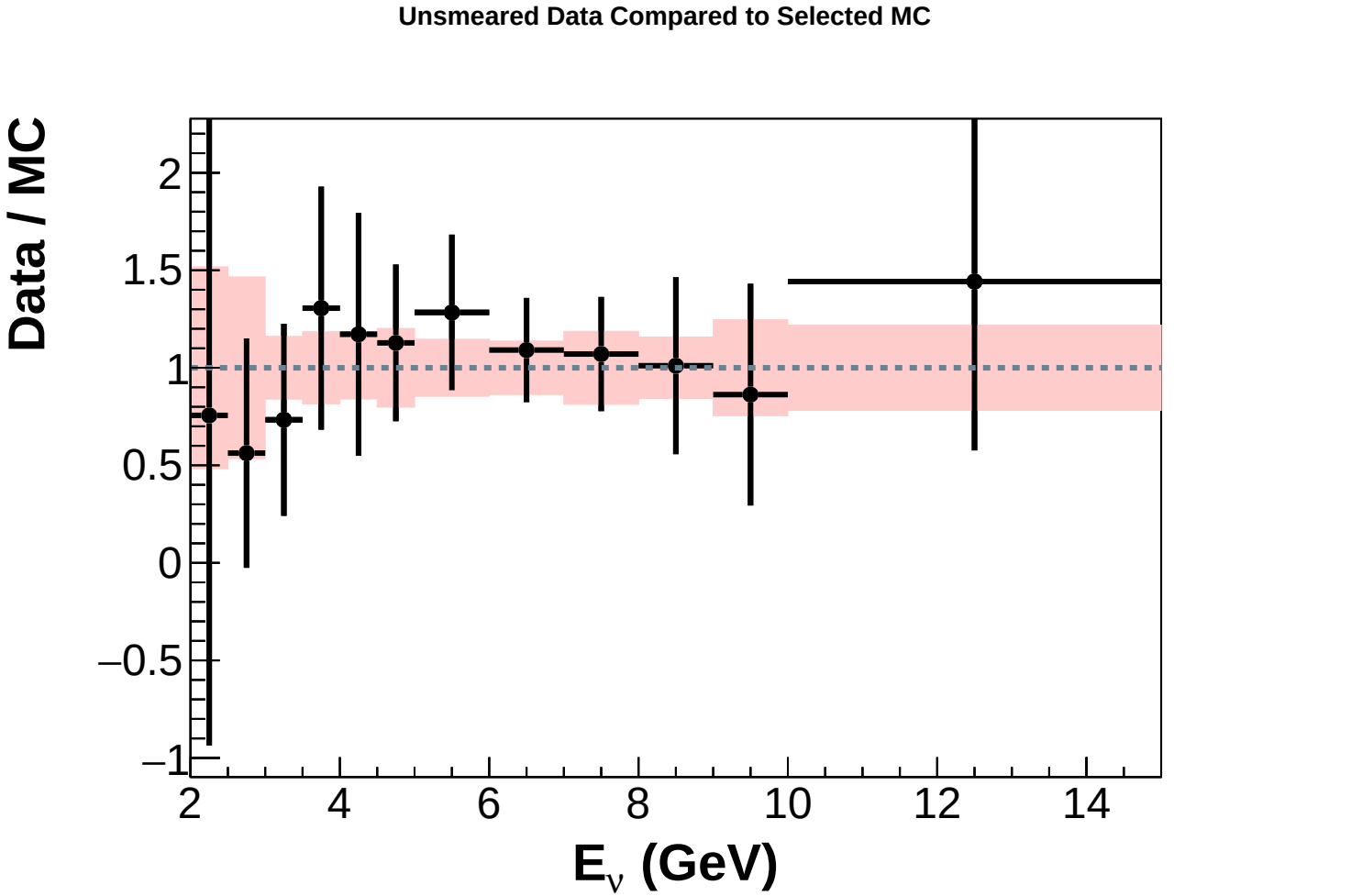

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

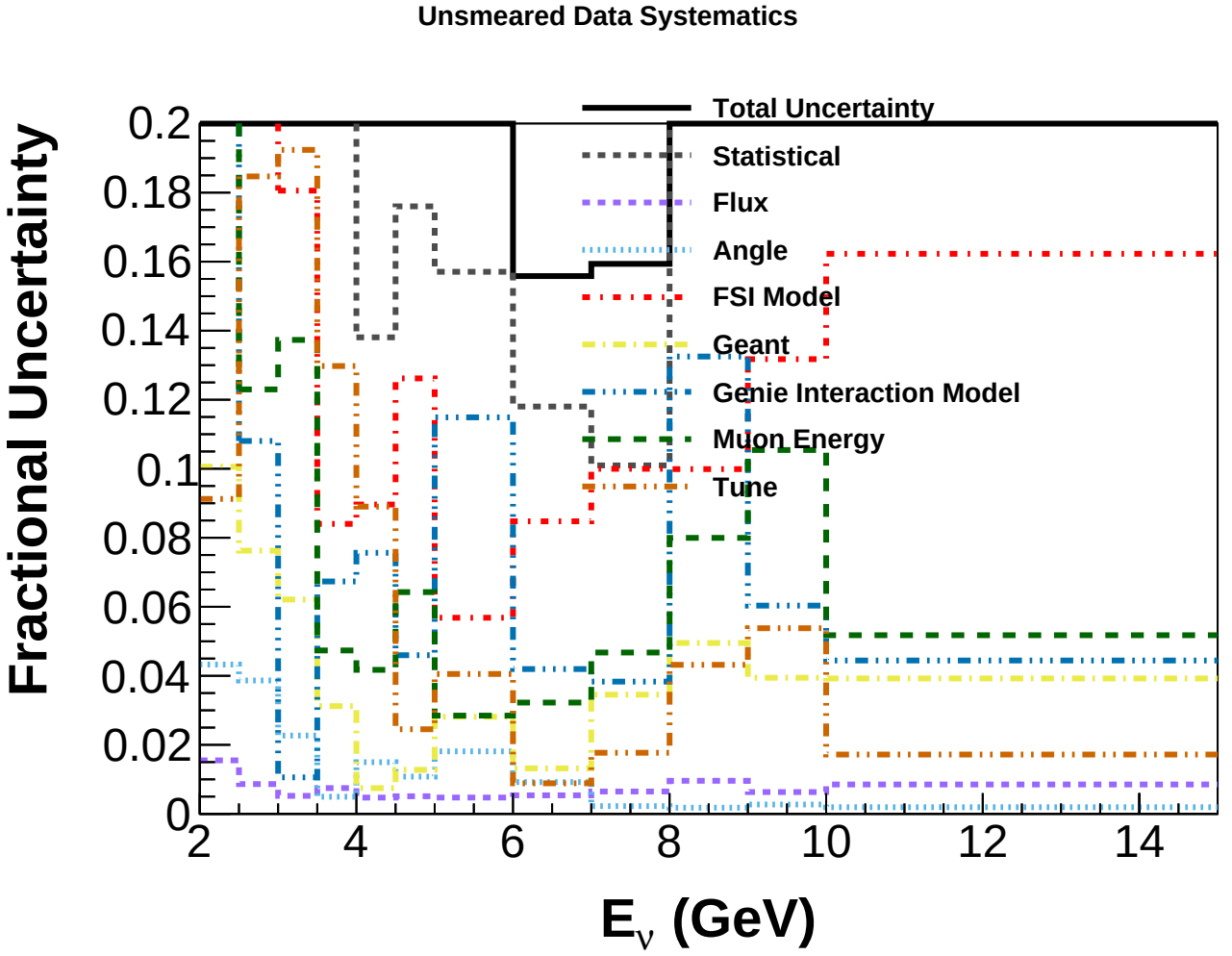

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

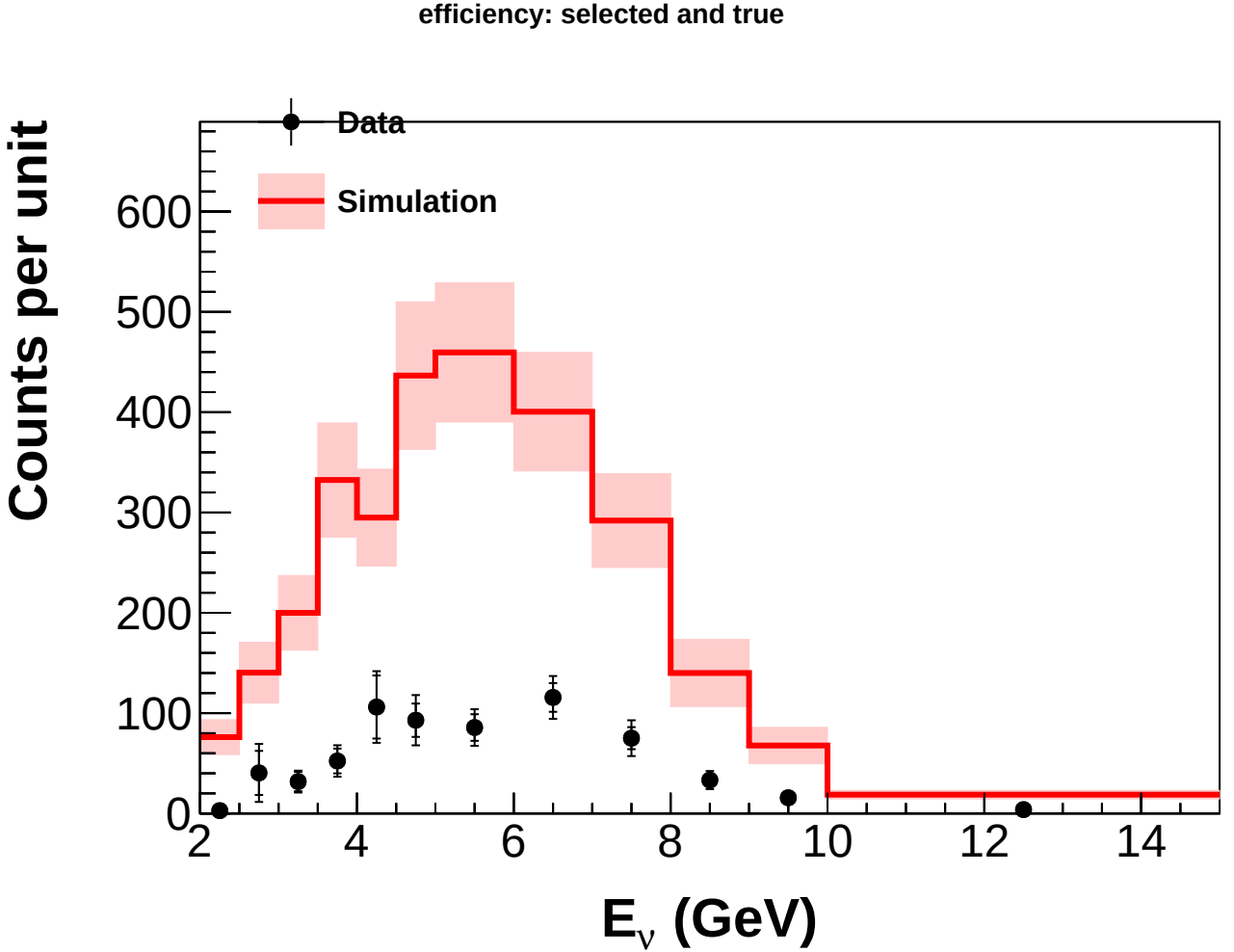

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
180
2
4
6
8
10
12
14
E_ν (GeV)

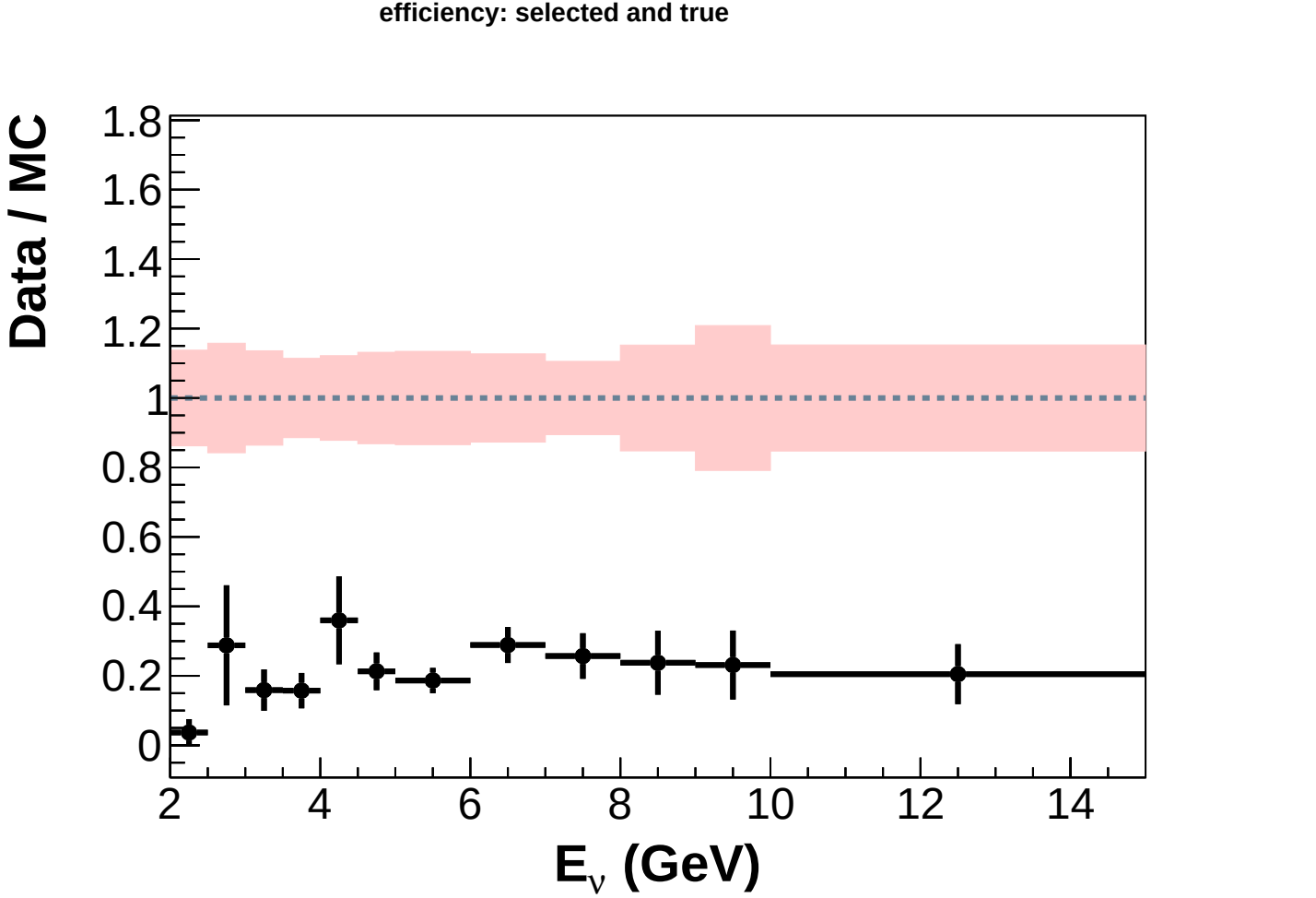

Data Before and After Unsmearing
Data / MC
5
4
3
2
1
0
−1
−2
2
4
6
8
10
12
14
E_ν (GeV)

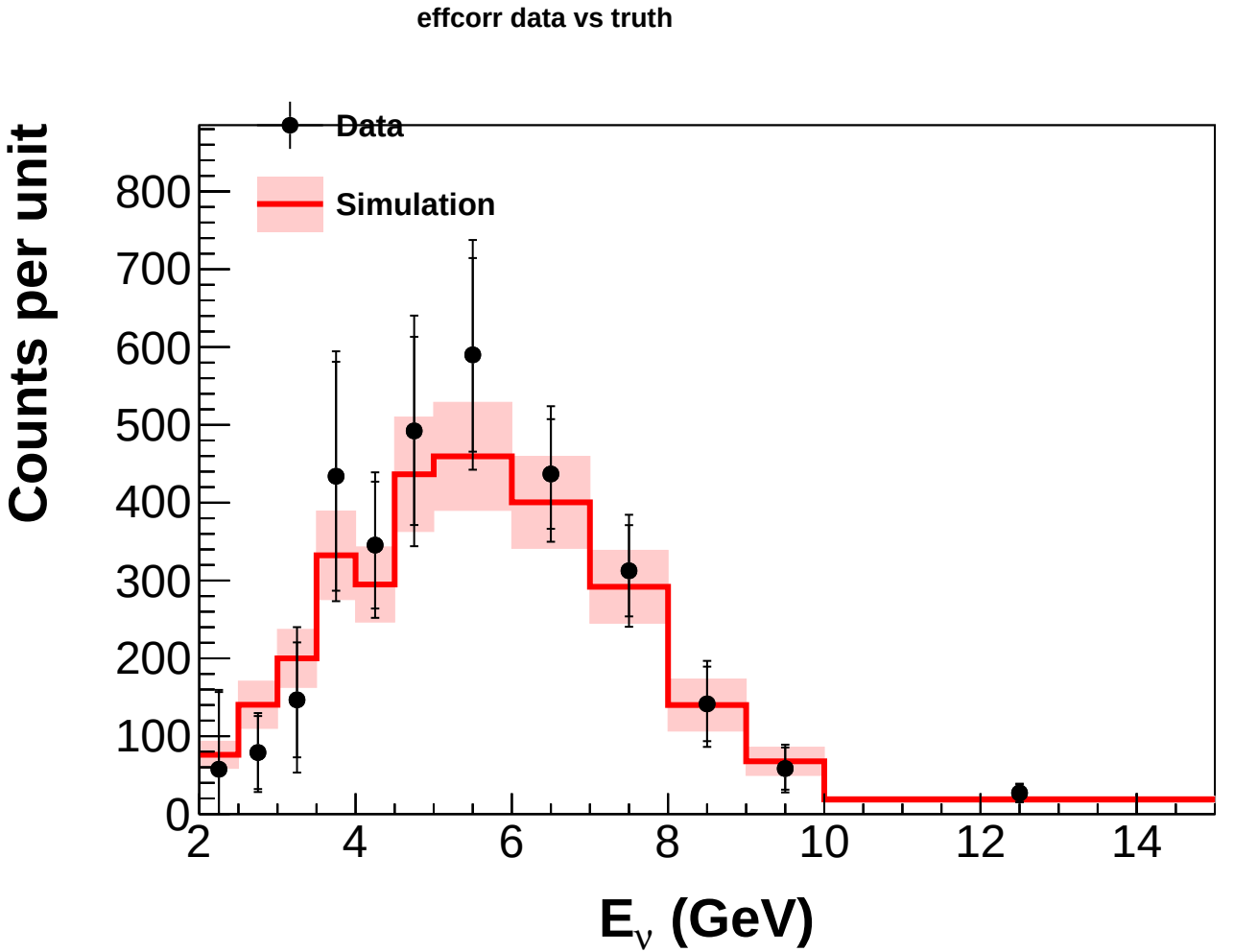

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
180
2
4
6
8
10
12
14
E_ν (GeV)

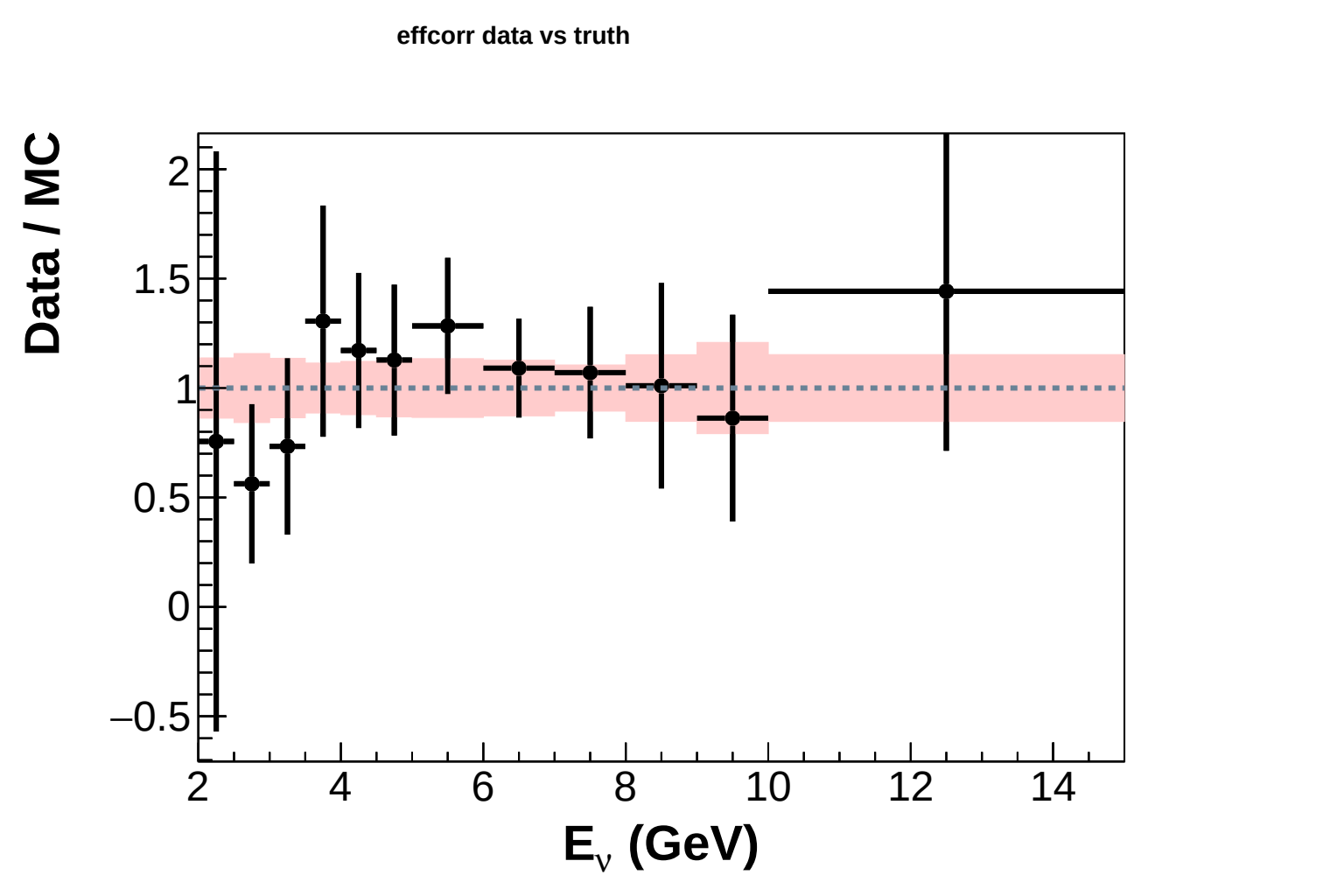

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
E_ν (GeV)

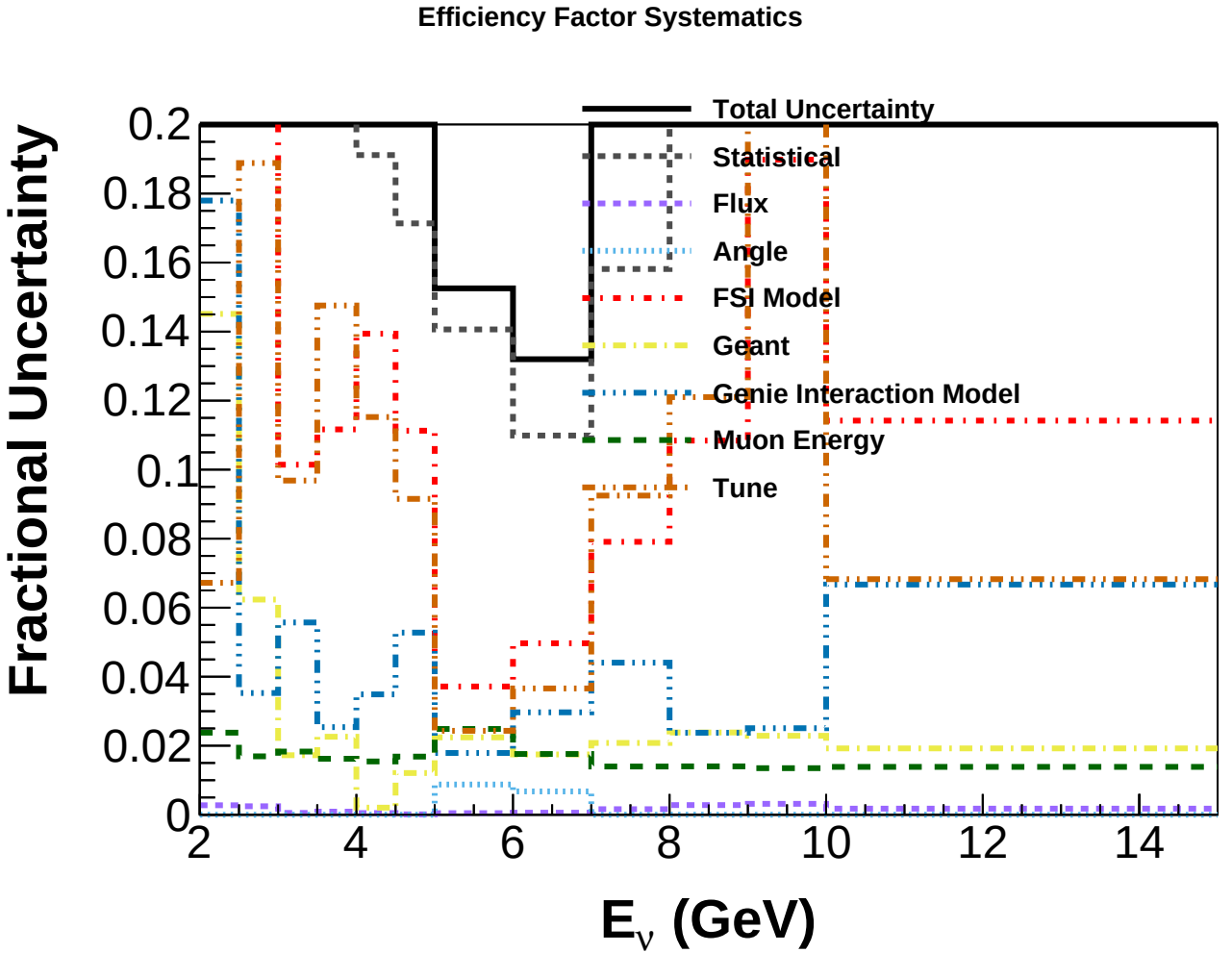

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_\nu$ (GeV)

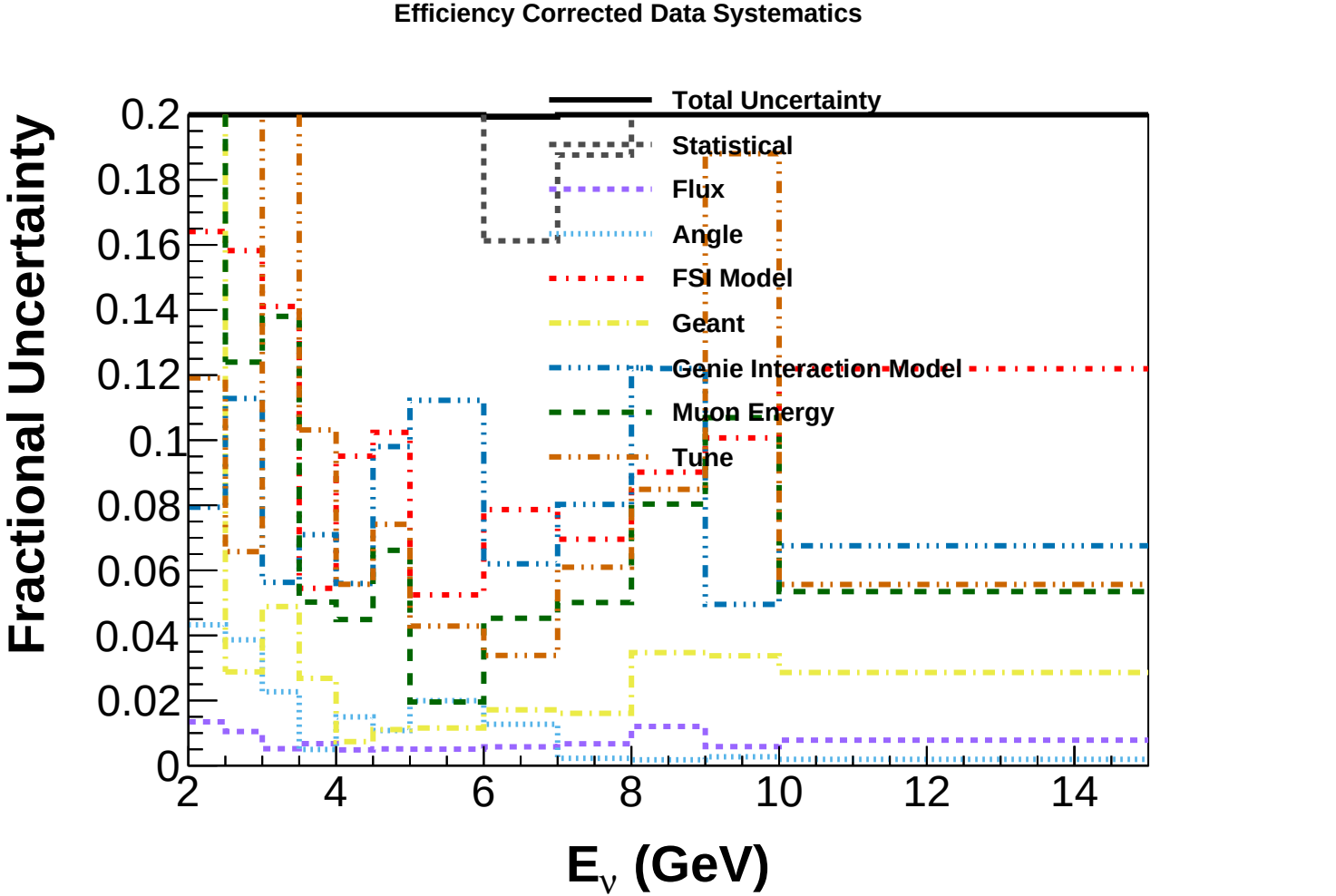

efficiency: selected and true
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
2
4
6
8
10
12
14
E_ν (GeV)

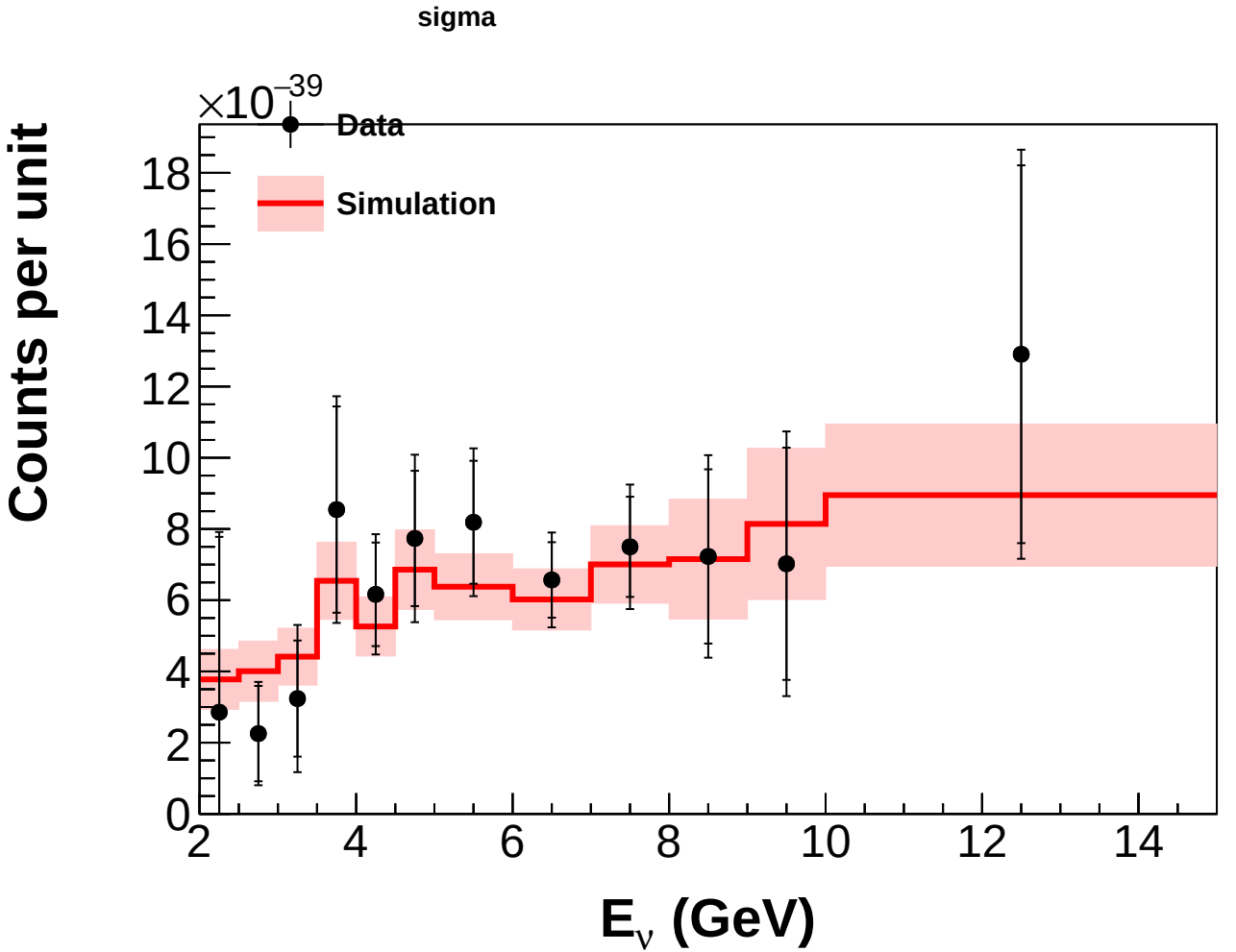

efficiency: selected and true
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
E_ν (GeV)

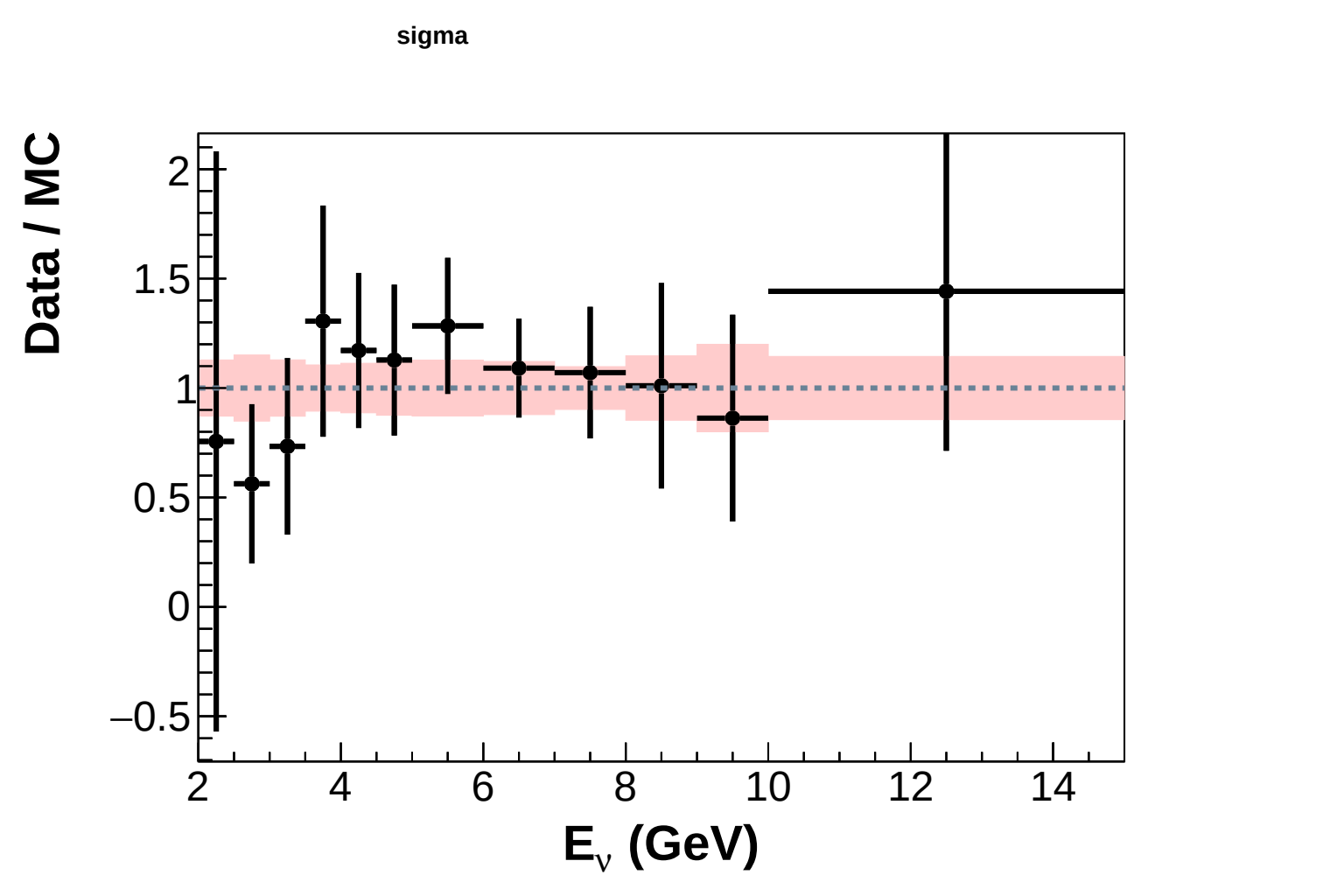

effcorr data vs truth
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
800
2
4
6
8
10
12
14
E_ν (GeV)

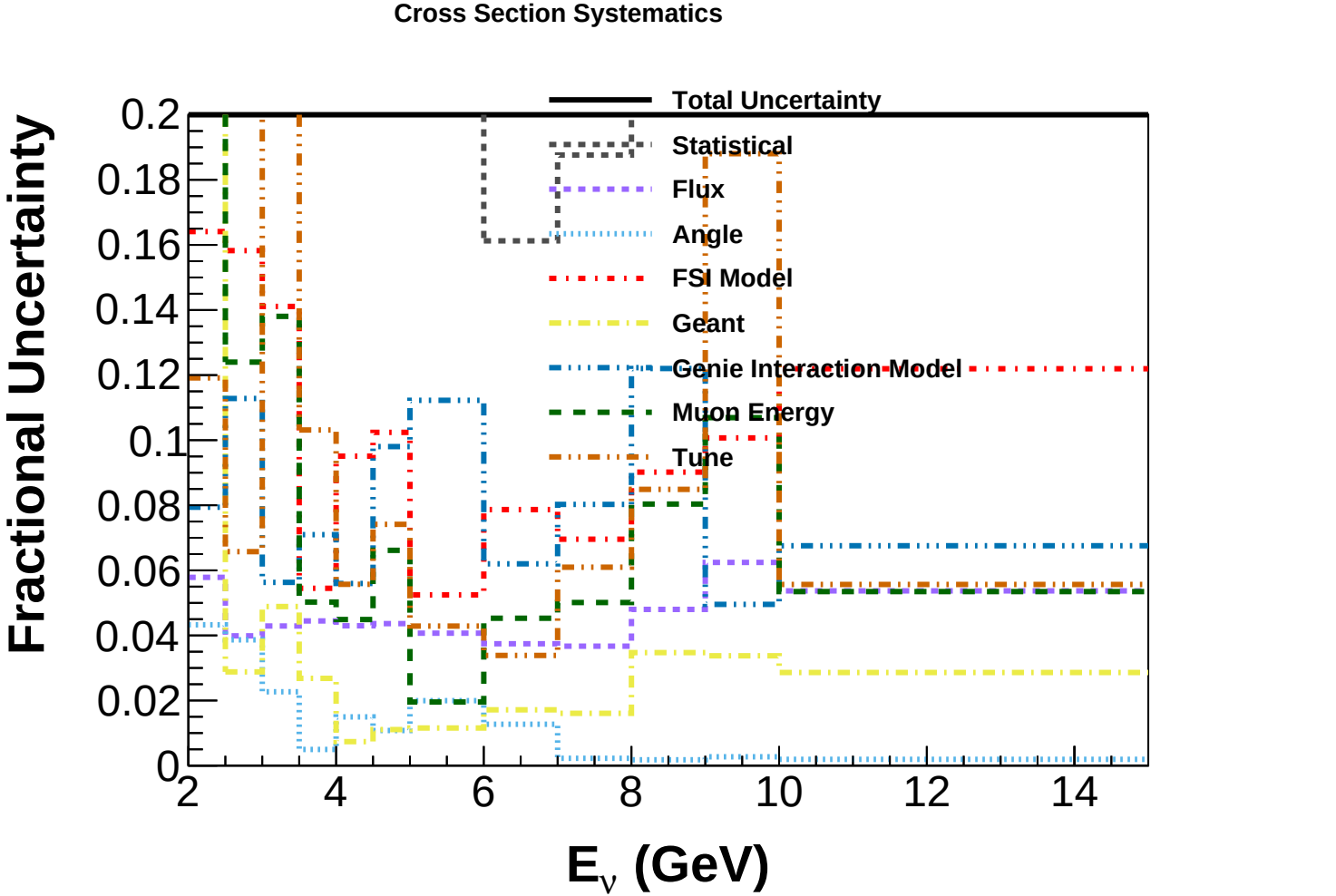

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

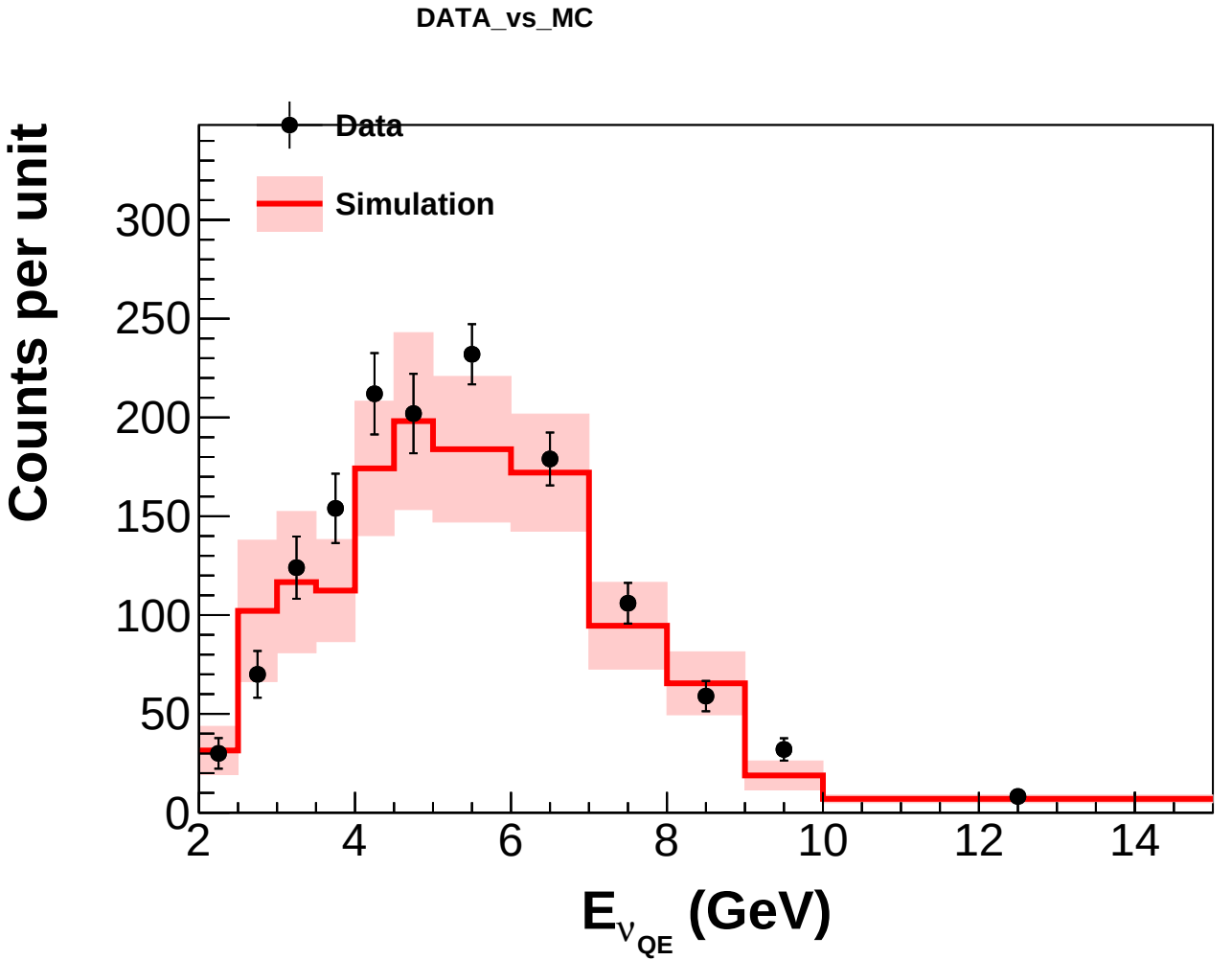

Efficiency Factor Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

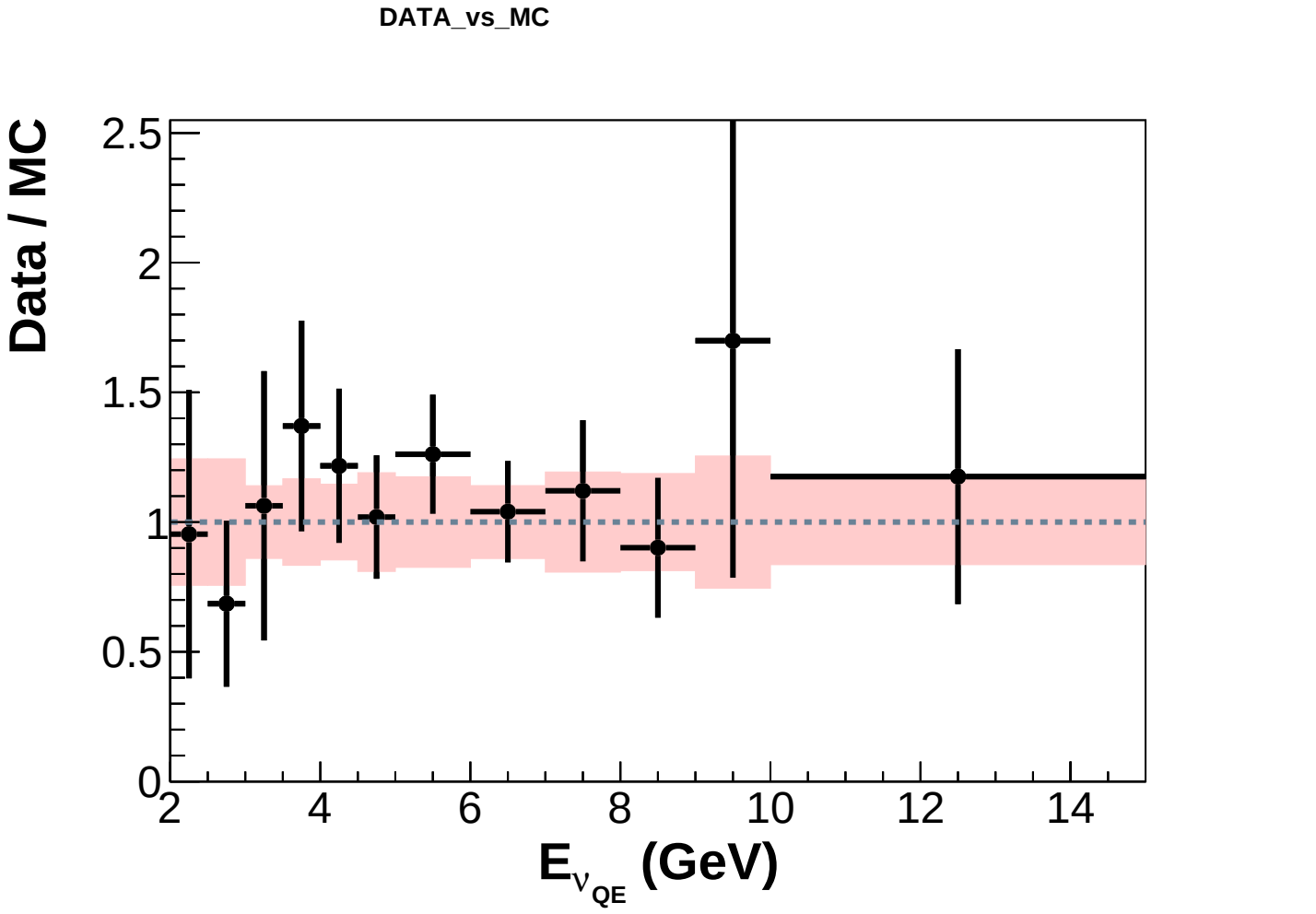

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

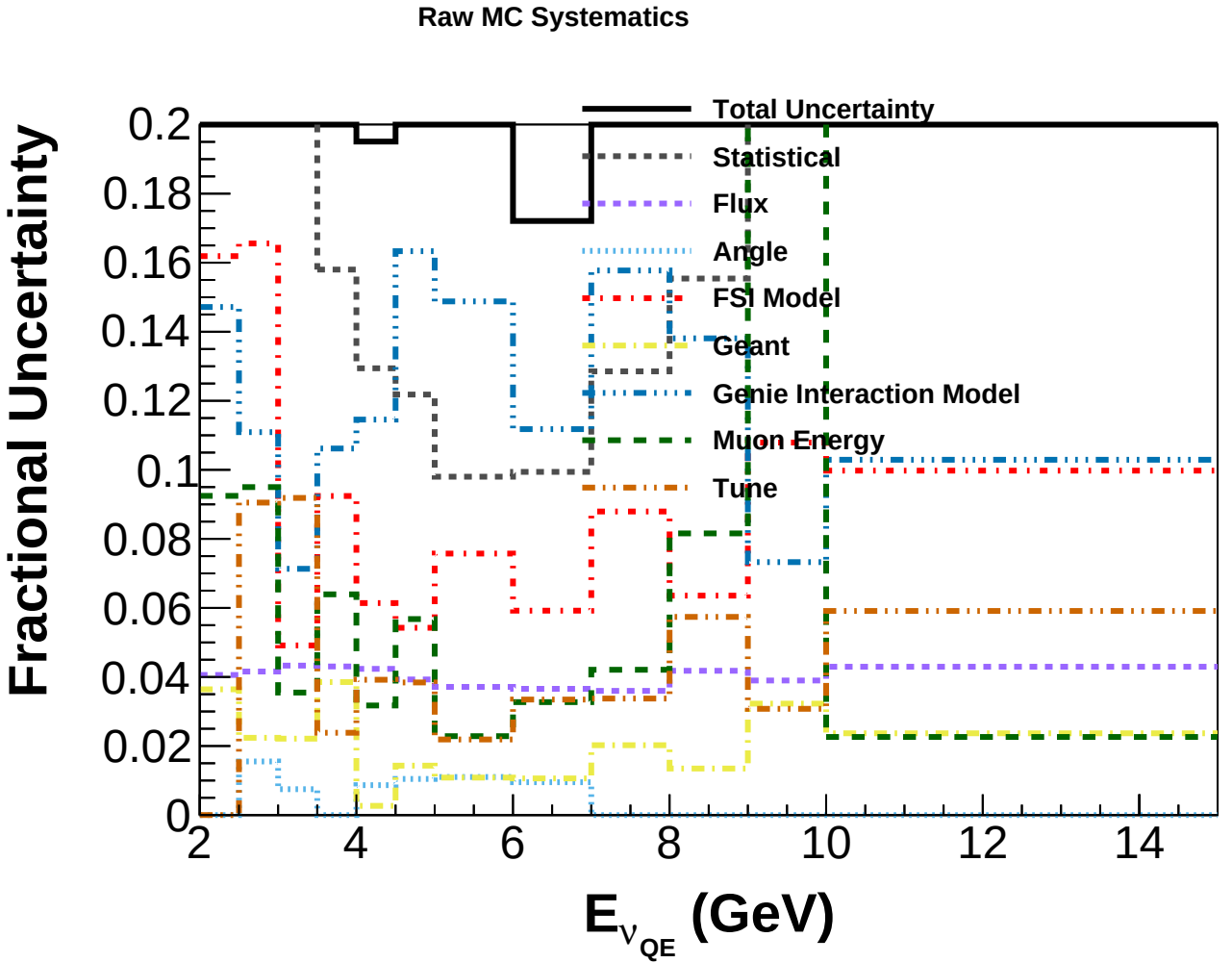

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
18
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
E_ν (GeV)

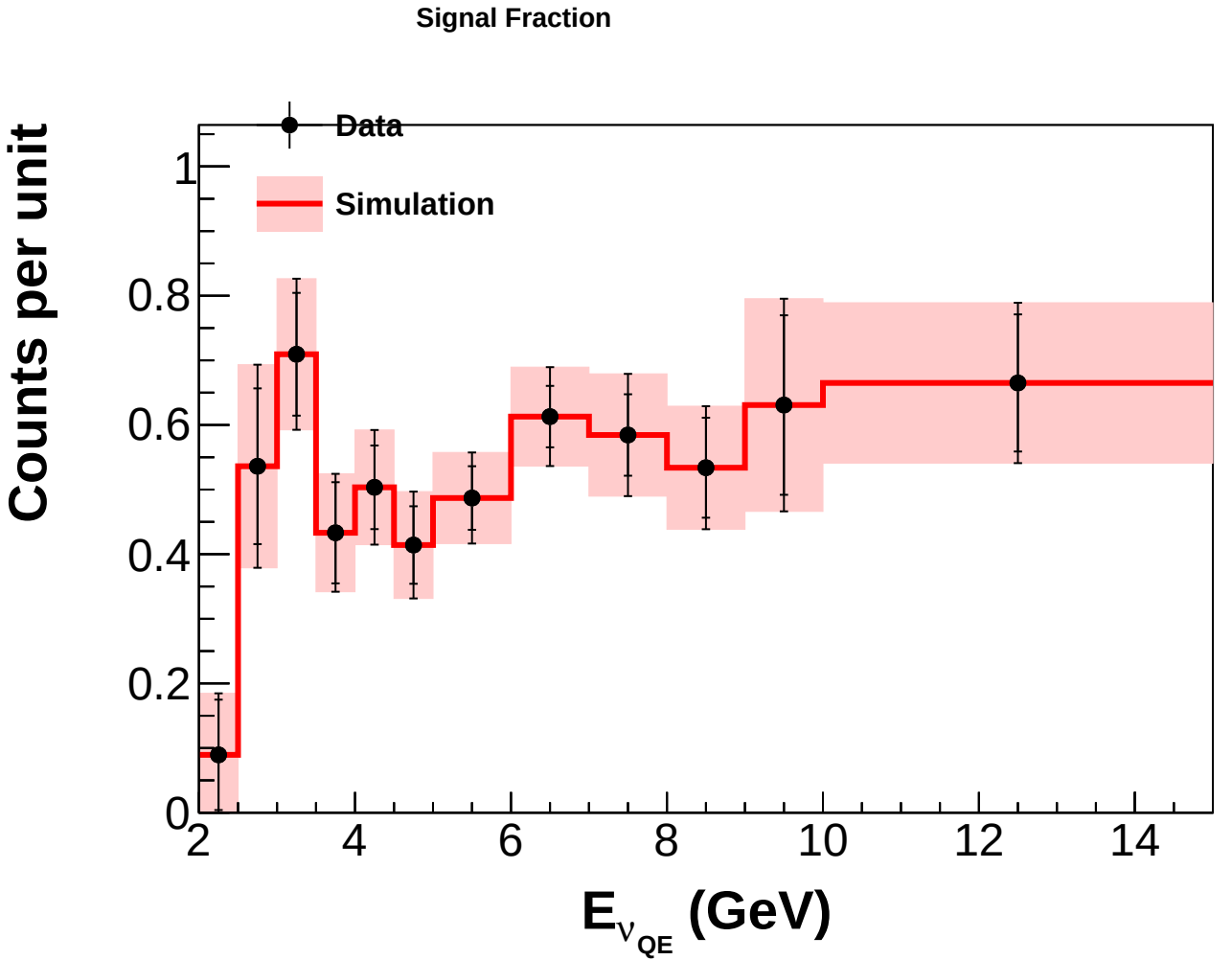

sigma
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
E$_\nu$ (GeV)

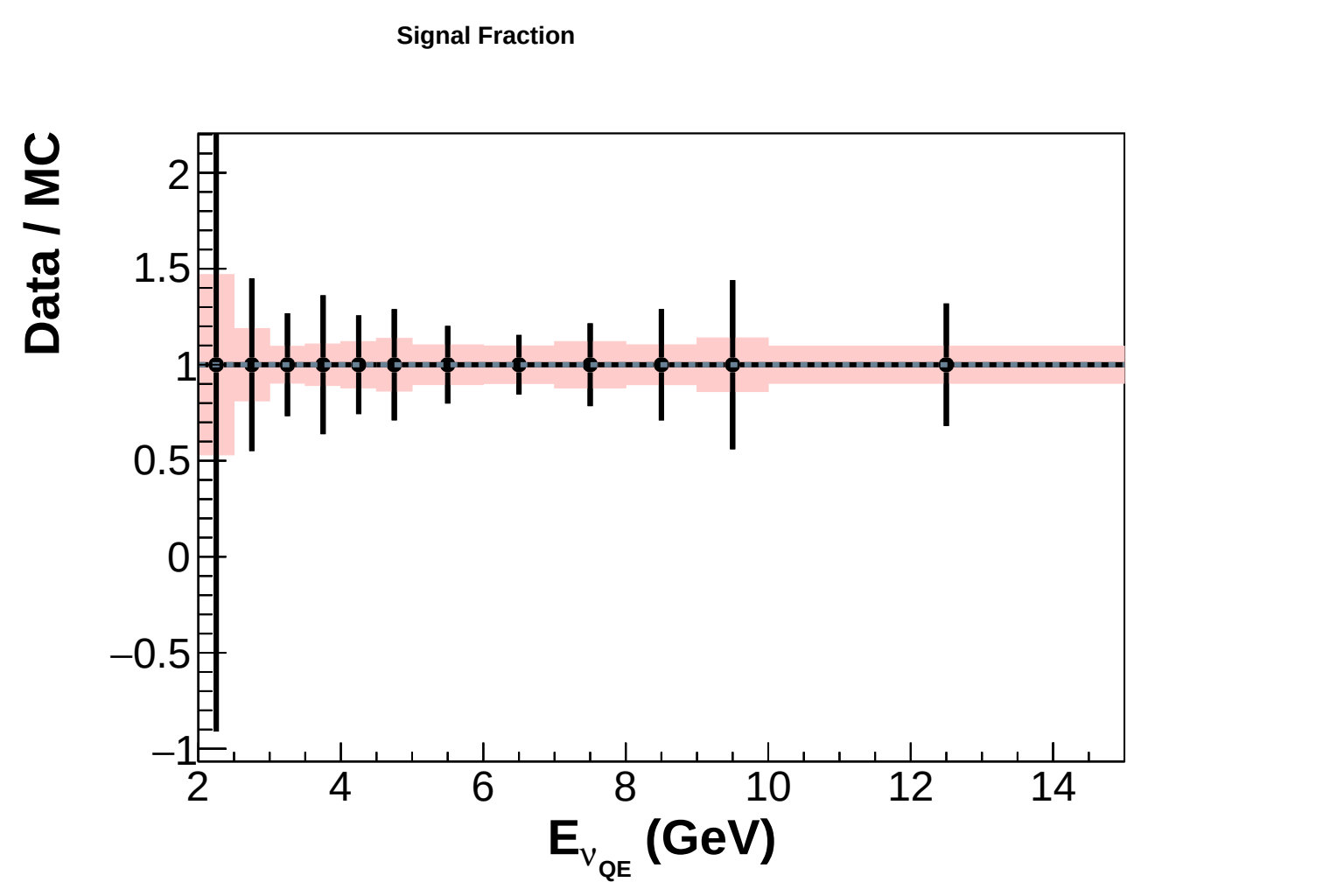

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_ν (GeV)

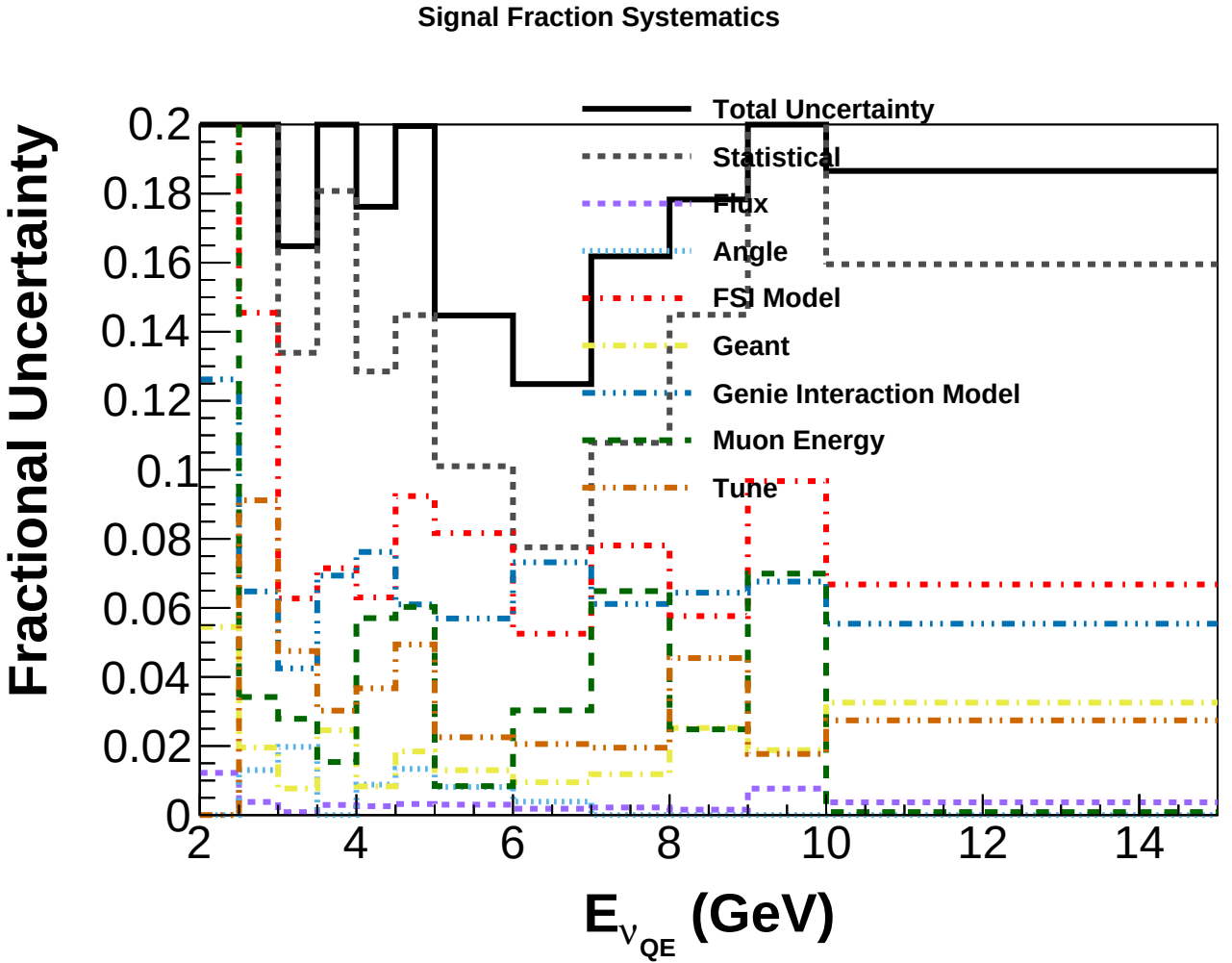

DATA_vs_MC
Data
Simulation
Counts per unit
0
50
100
150
200
250
300
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

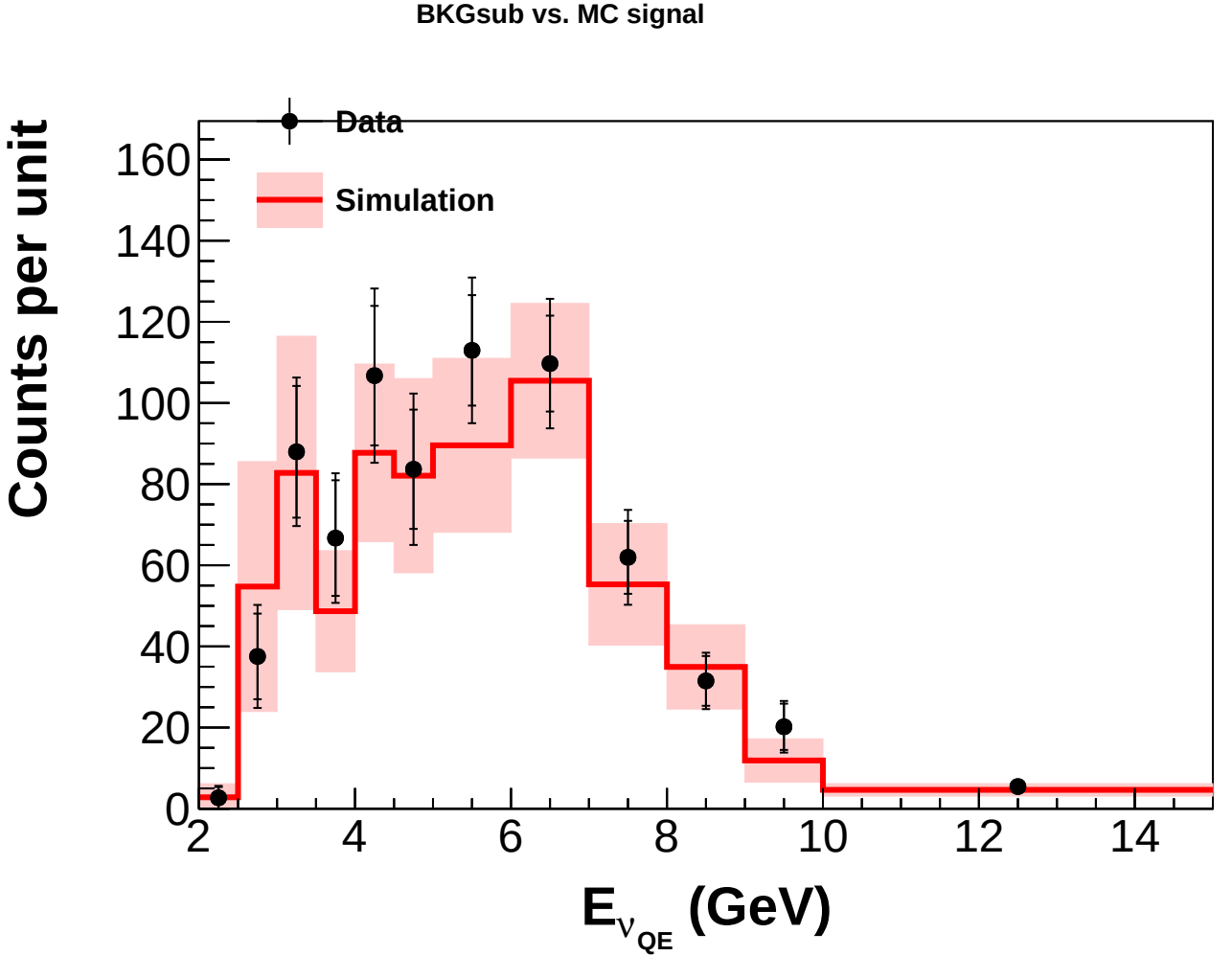

DATA_vs_MC
Data / MC
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

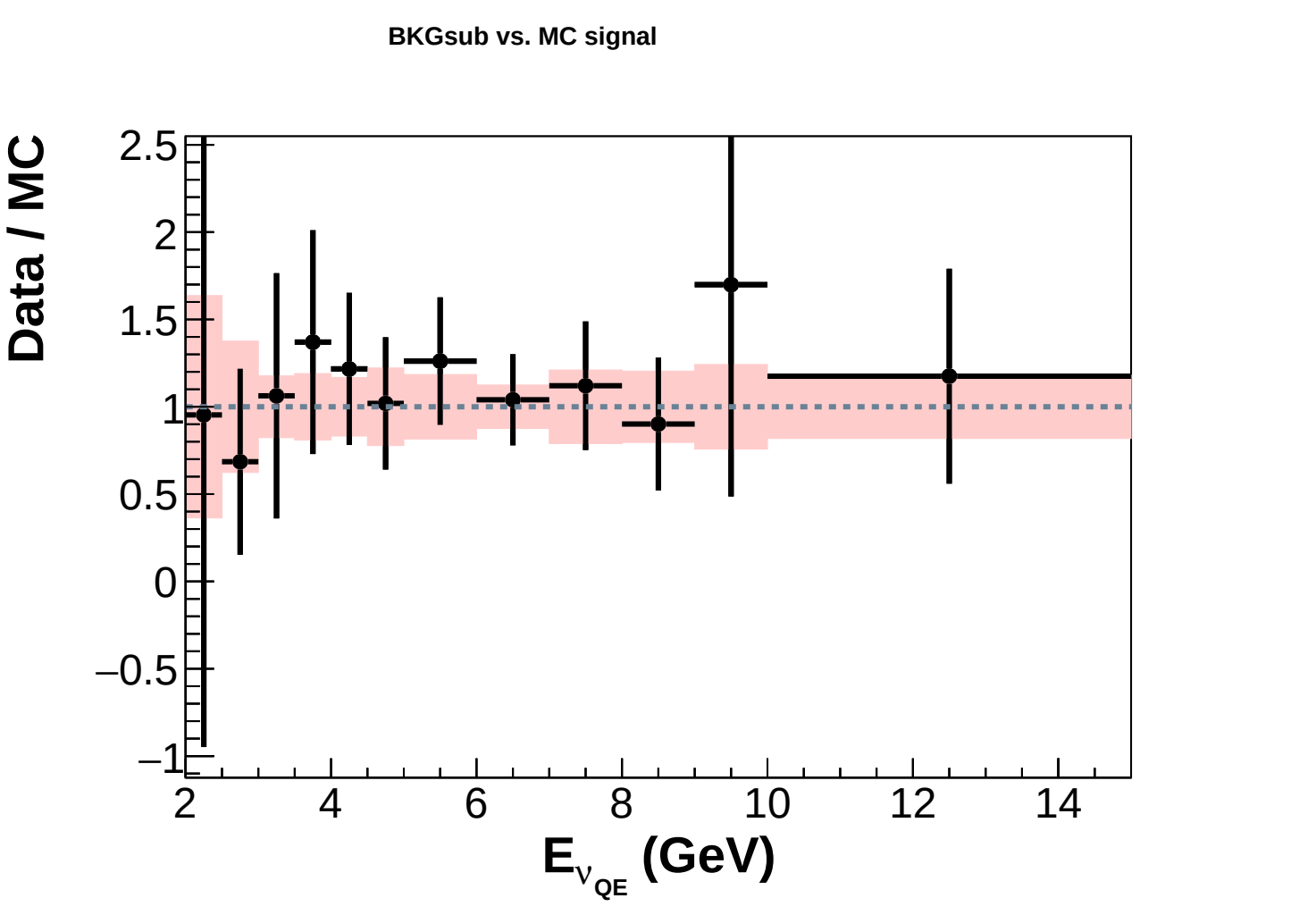

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

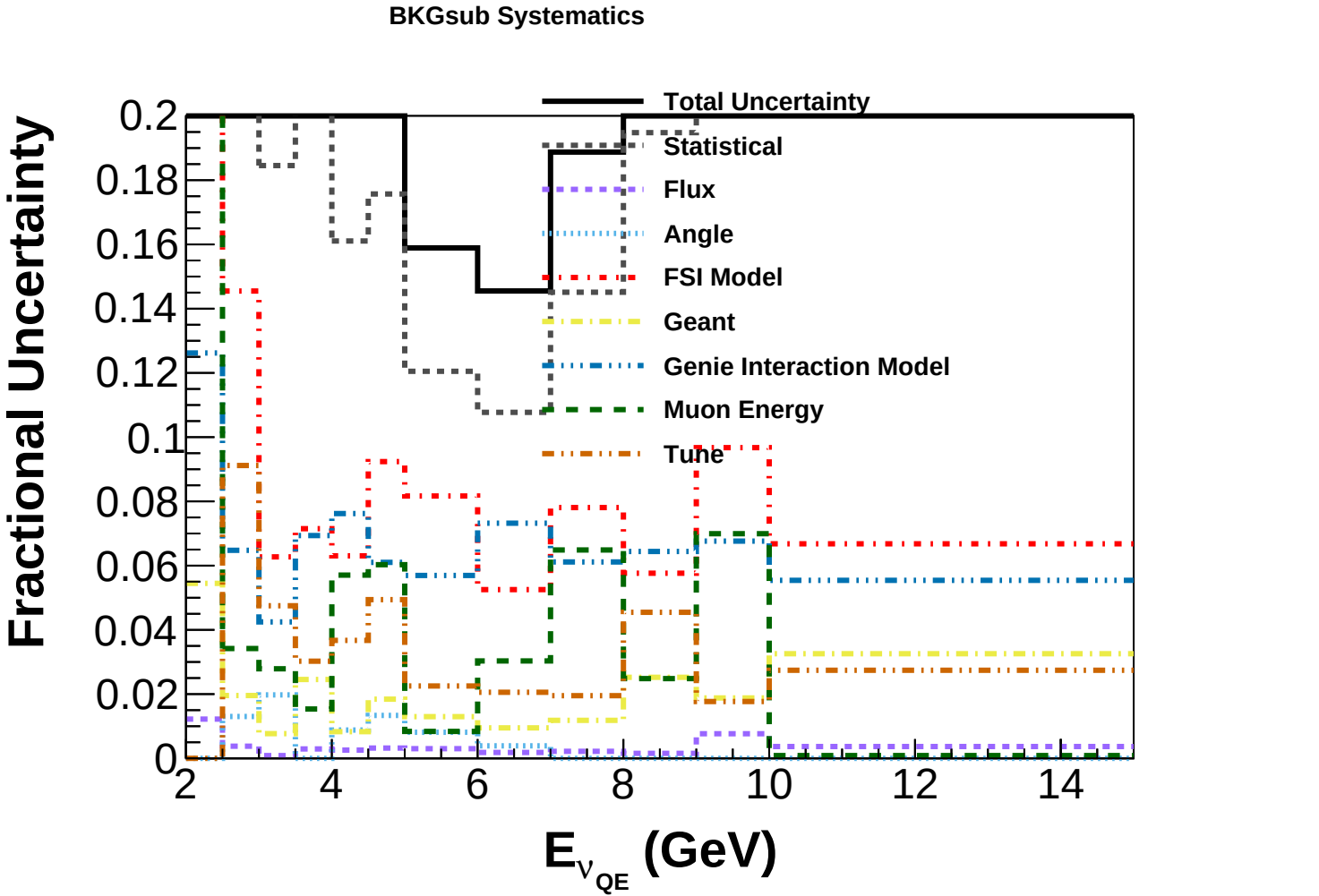

Signal Fraction
Data
Simulation
Counts per unit
0
0.2
0.4
0.6
0.8
1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

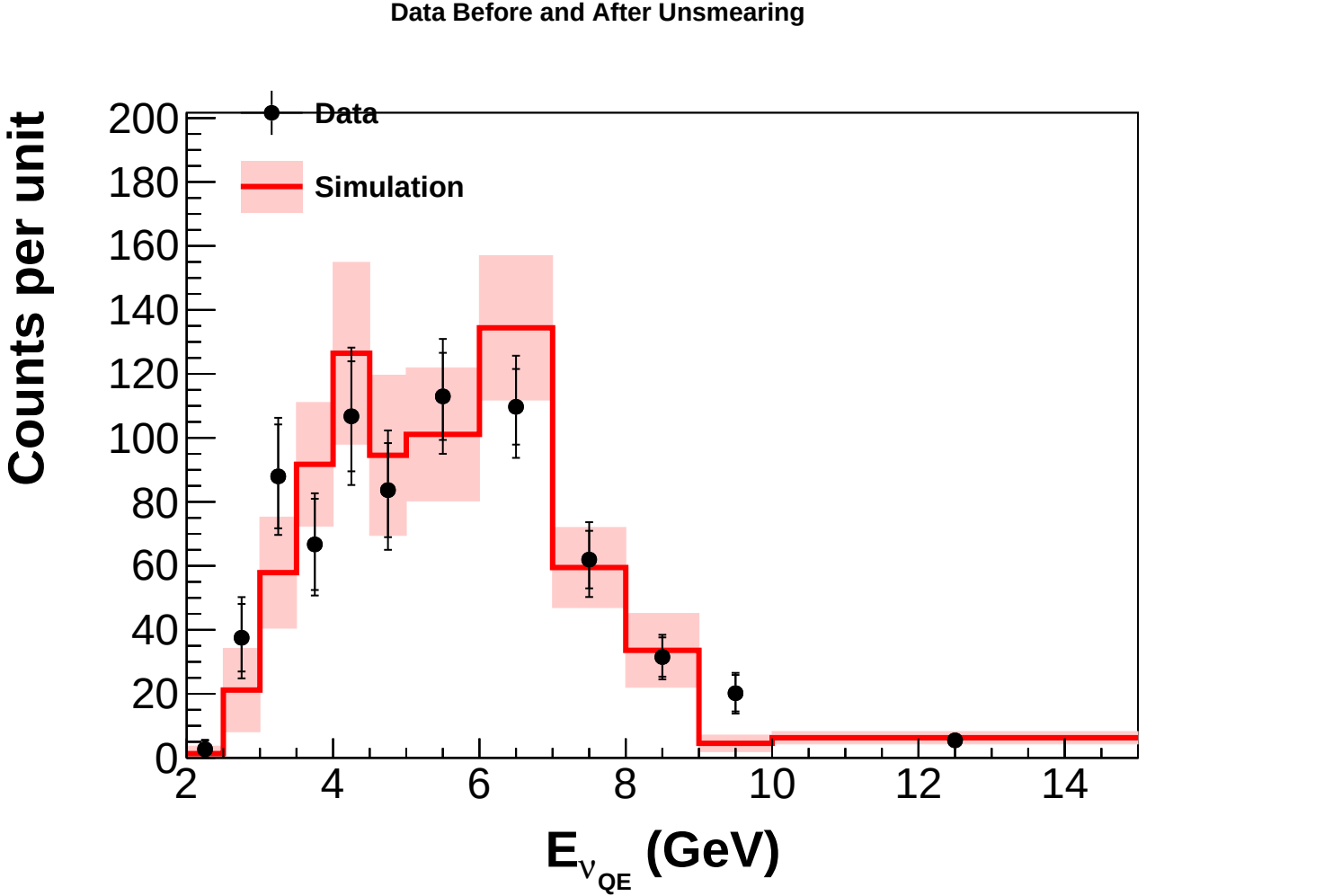

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)


Signal Fraction Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

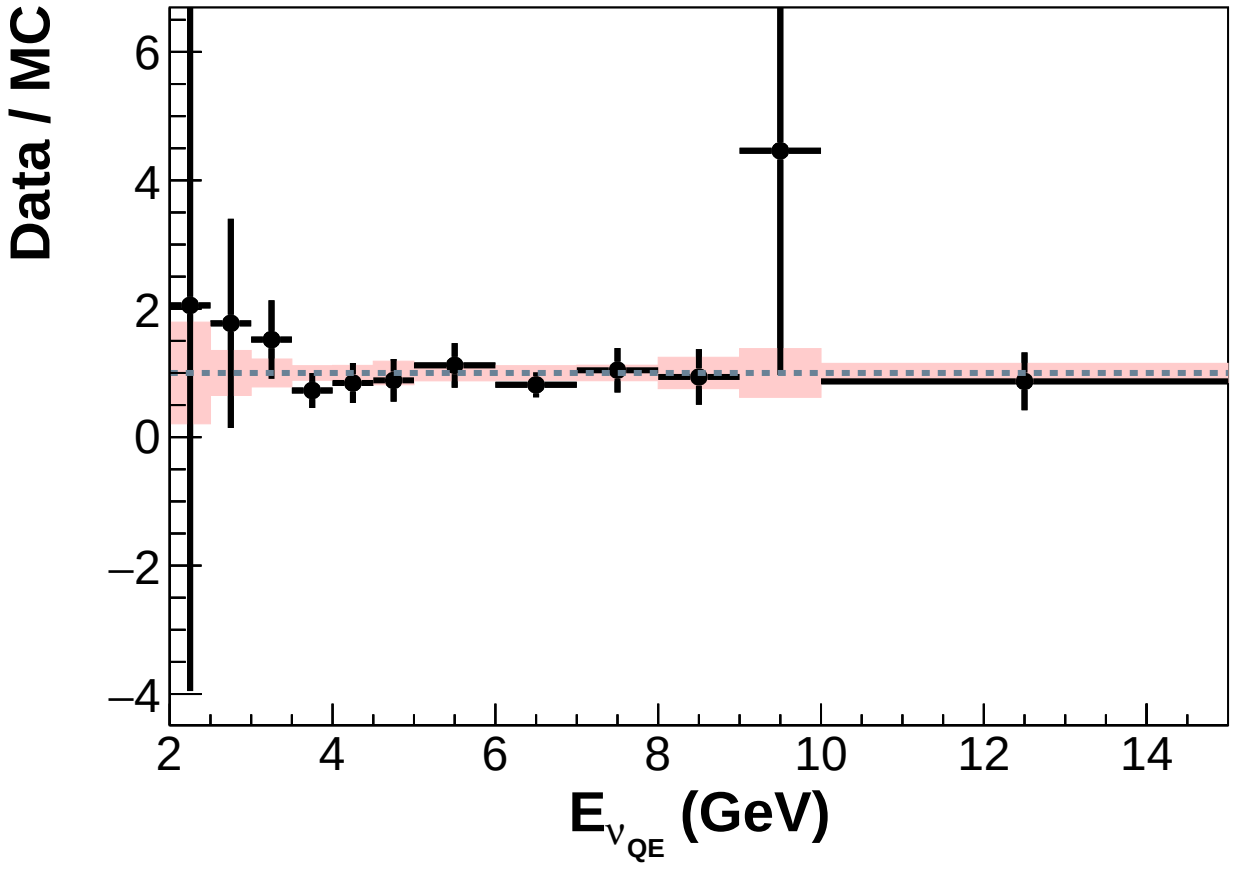

BKGsub vs. MC signal
Data
Simulation
Counts per unit
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

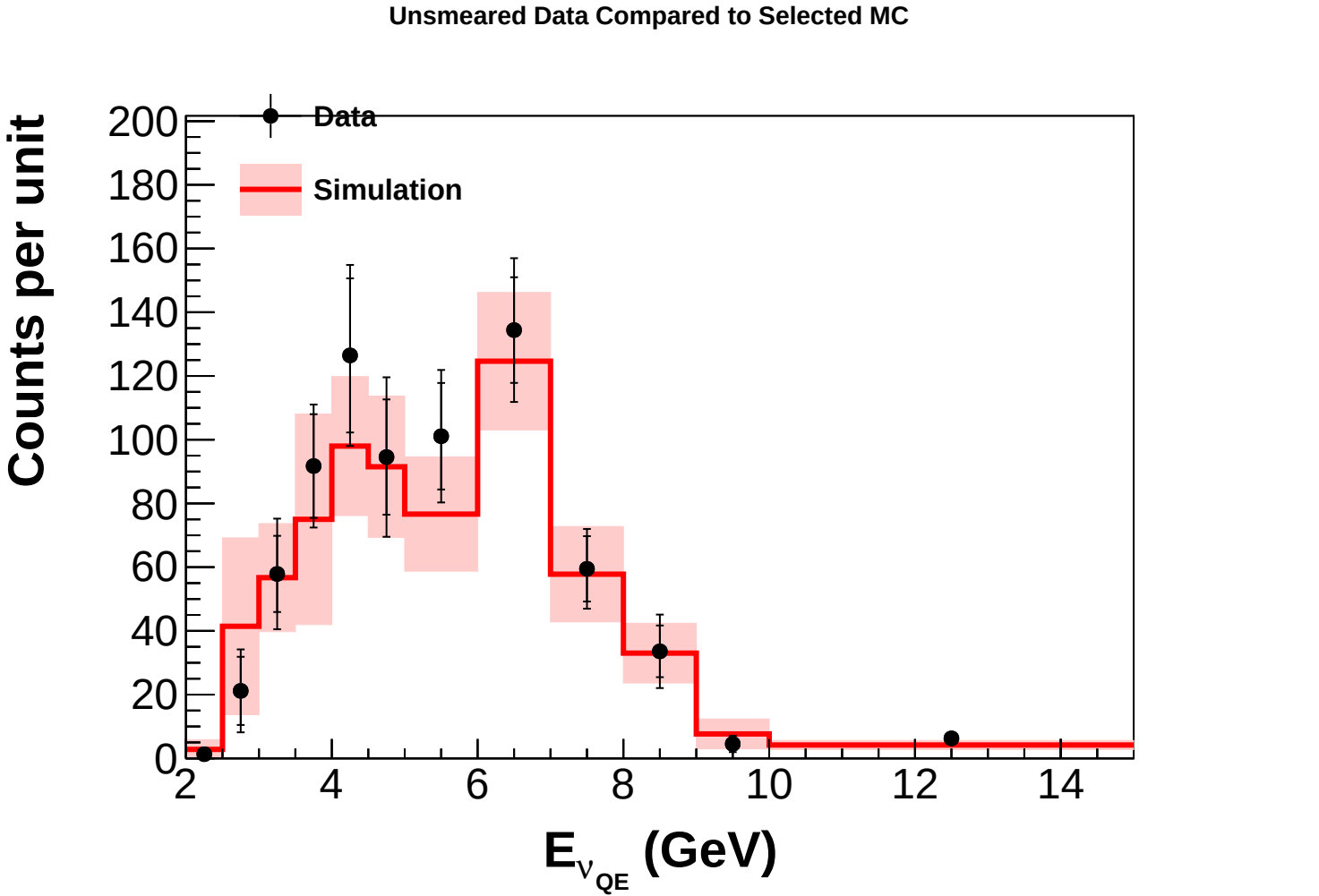

BKGsub vs. MC signal
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
−1
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

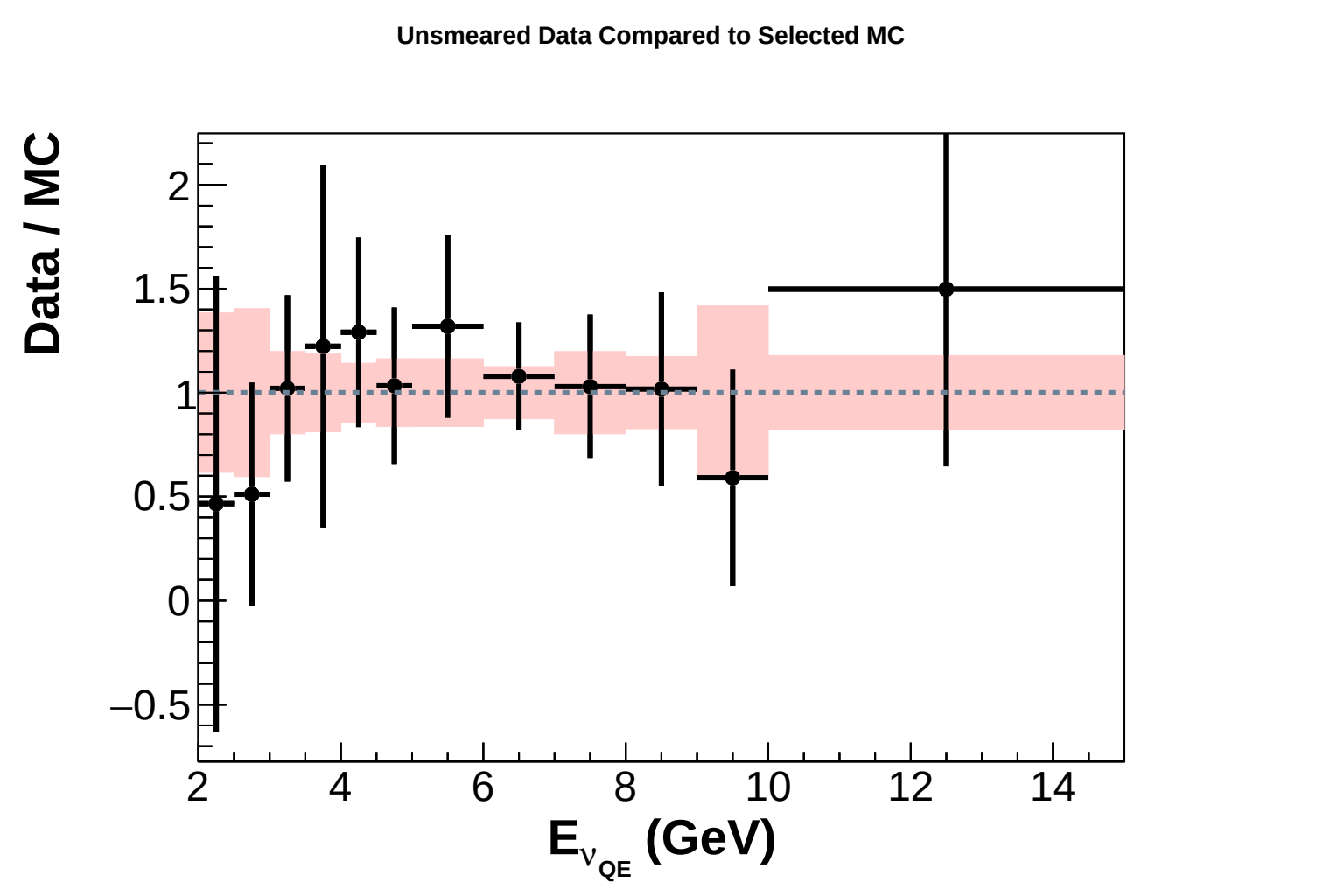

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

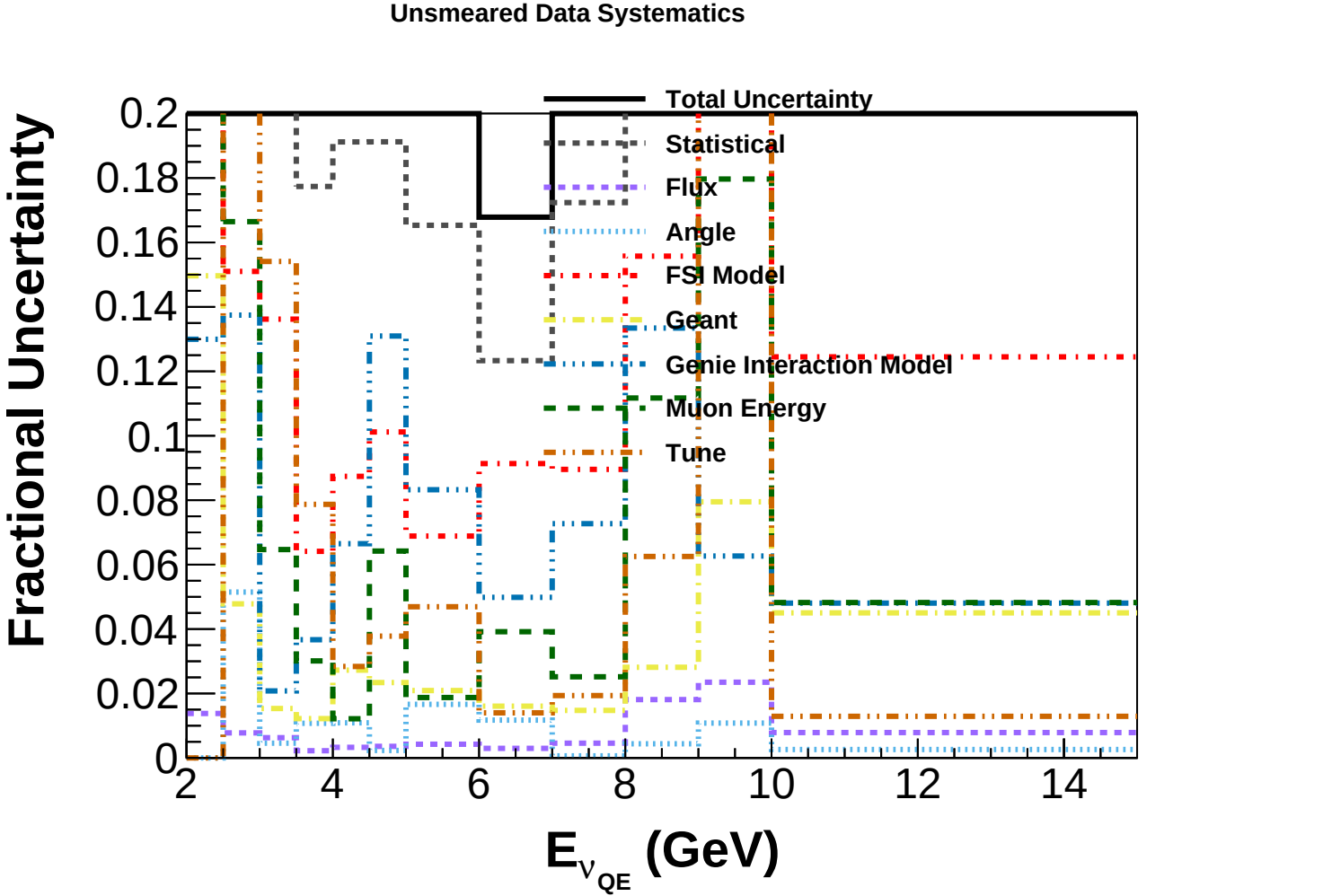

Data Before and After Unsmearing
Data
Simulation
Counts per unit
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

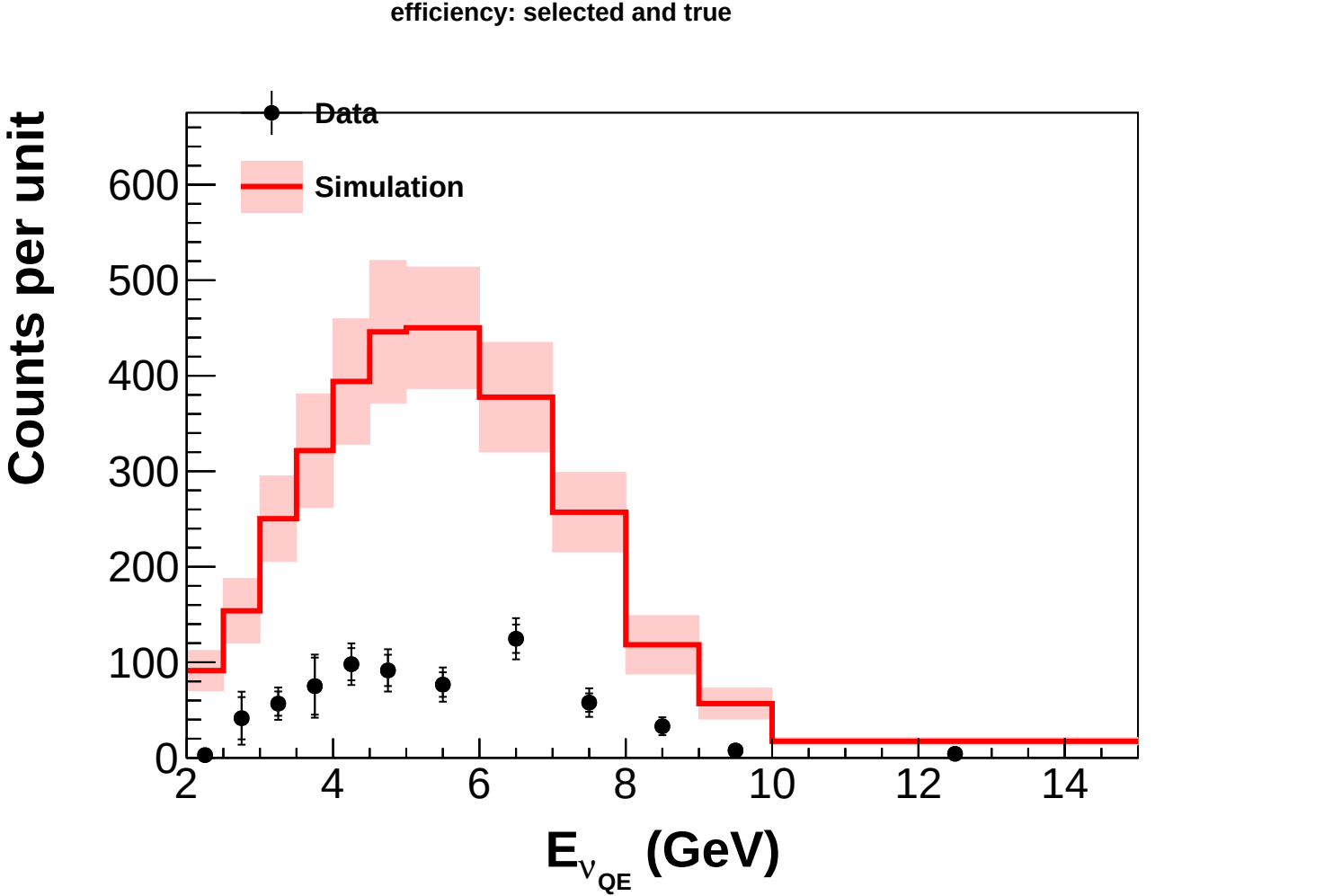
Data Before and After Unsmearing

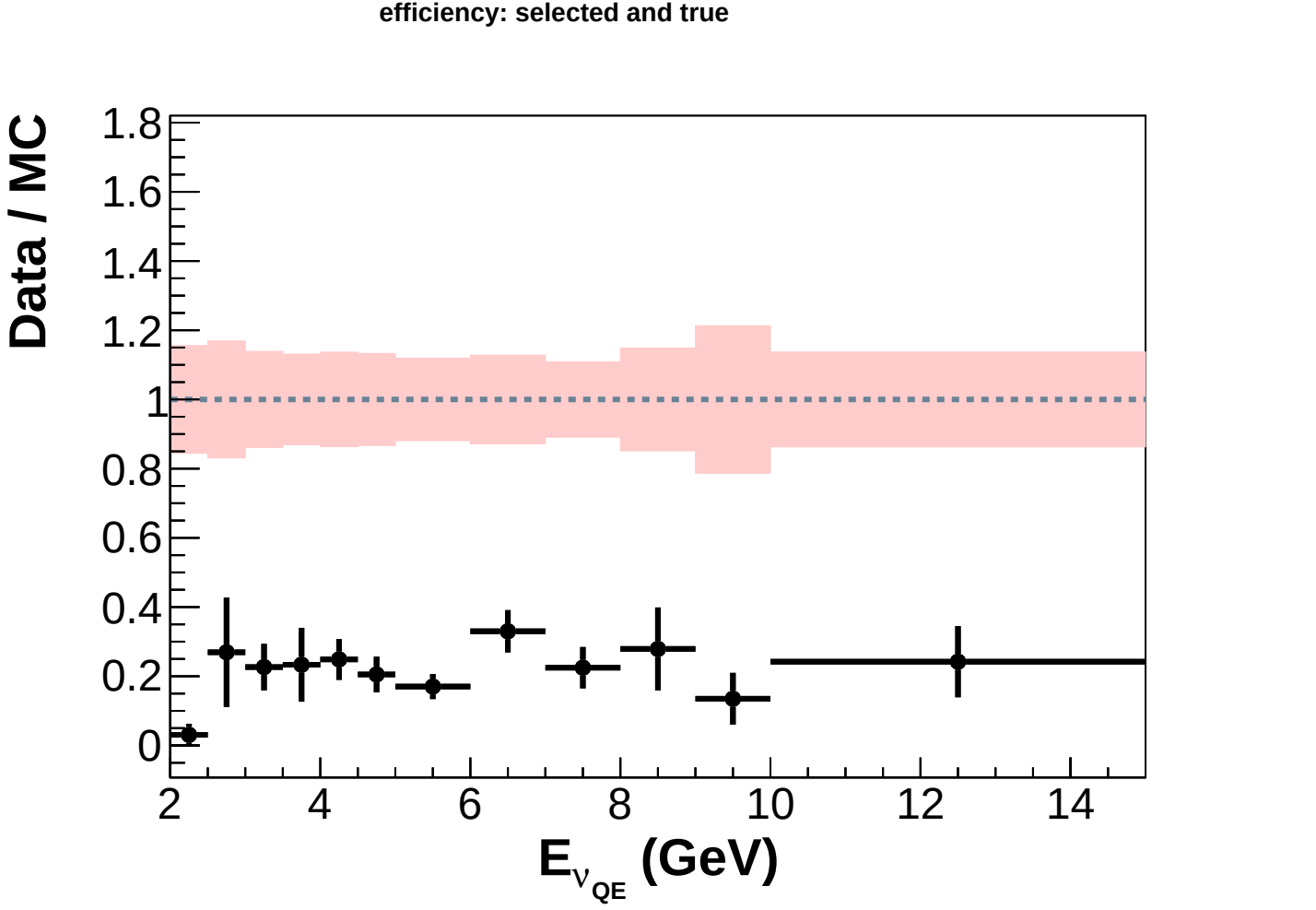


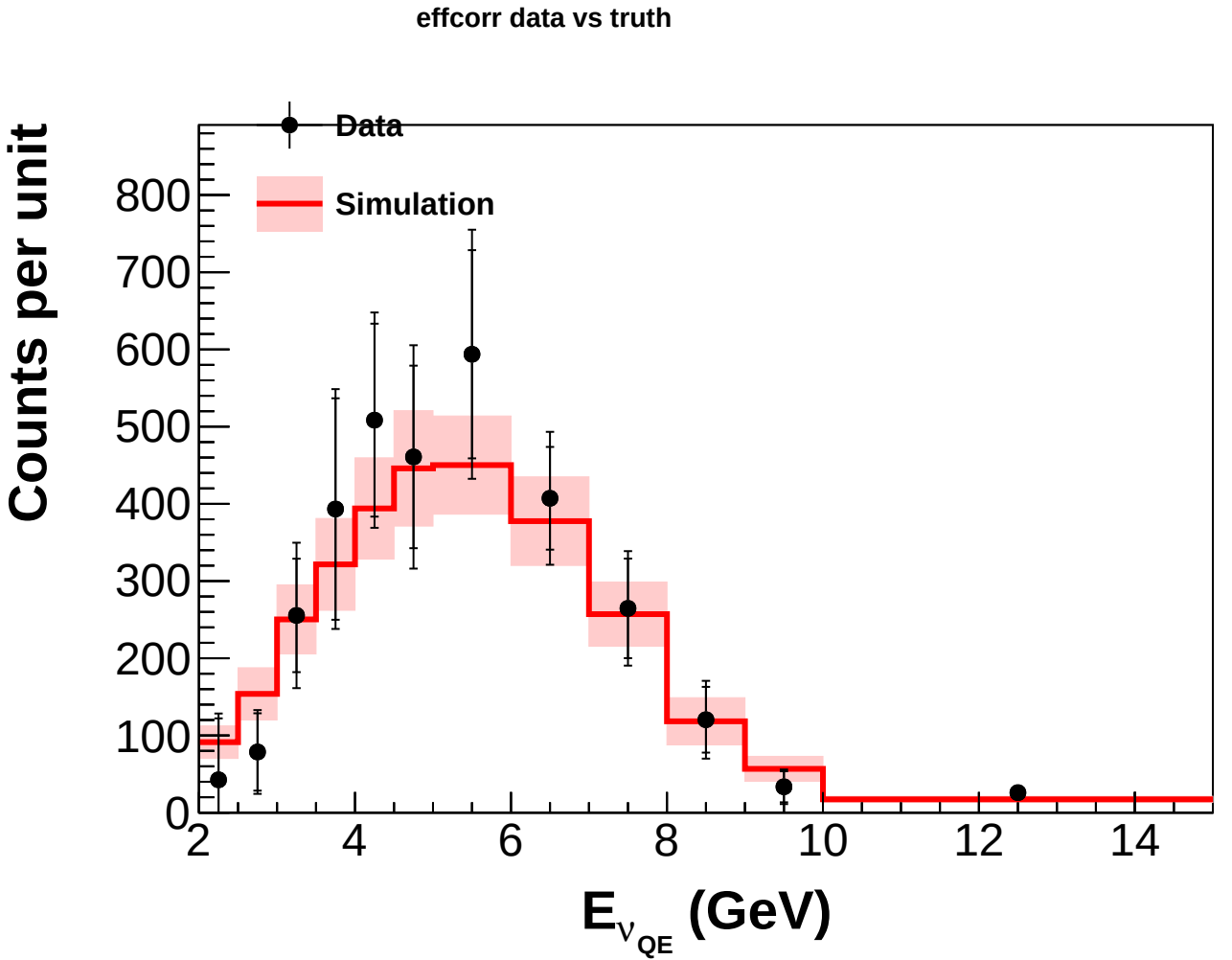

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

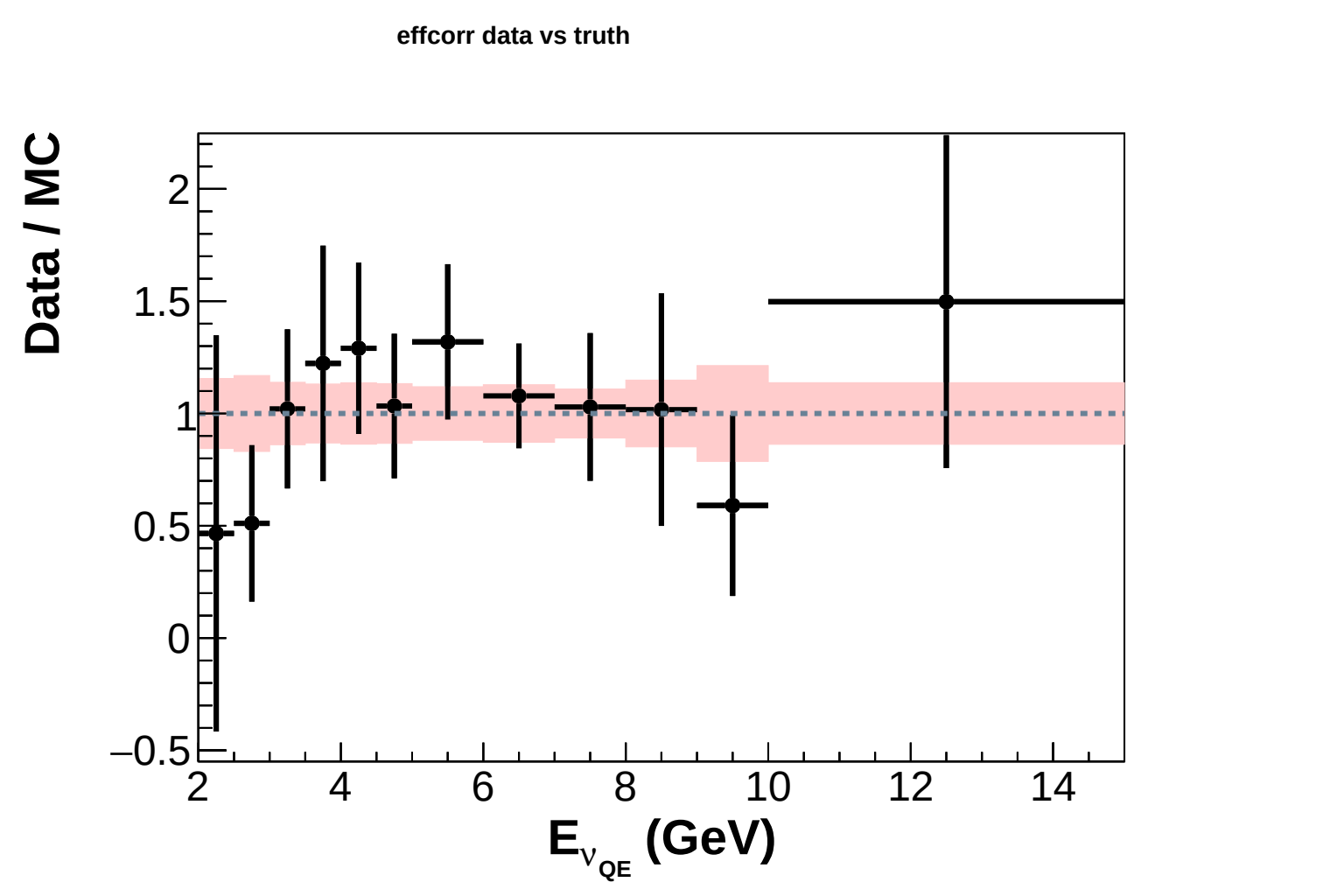

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

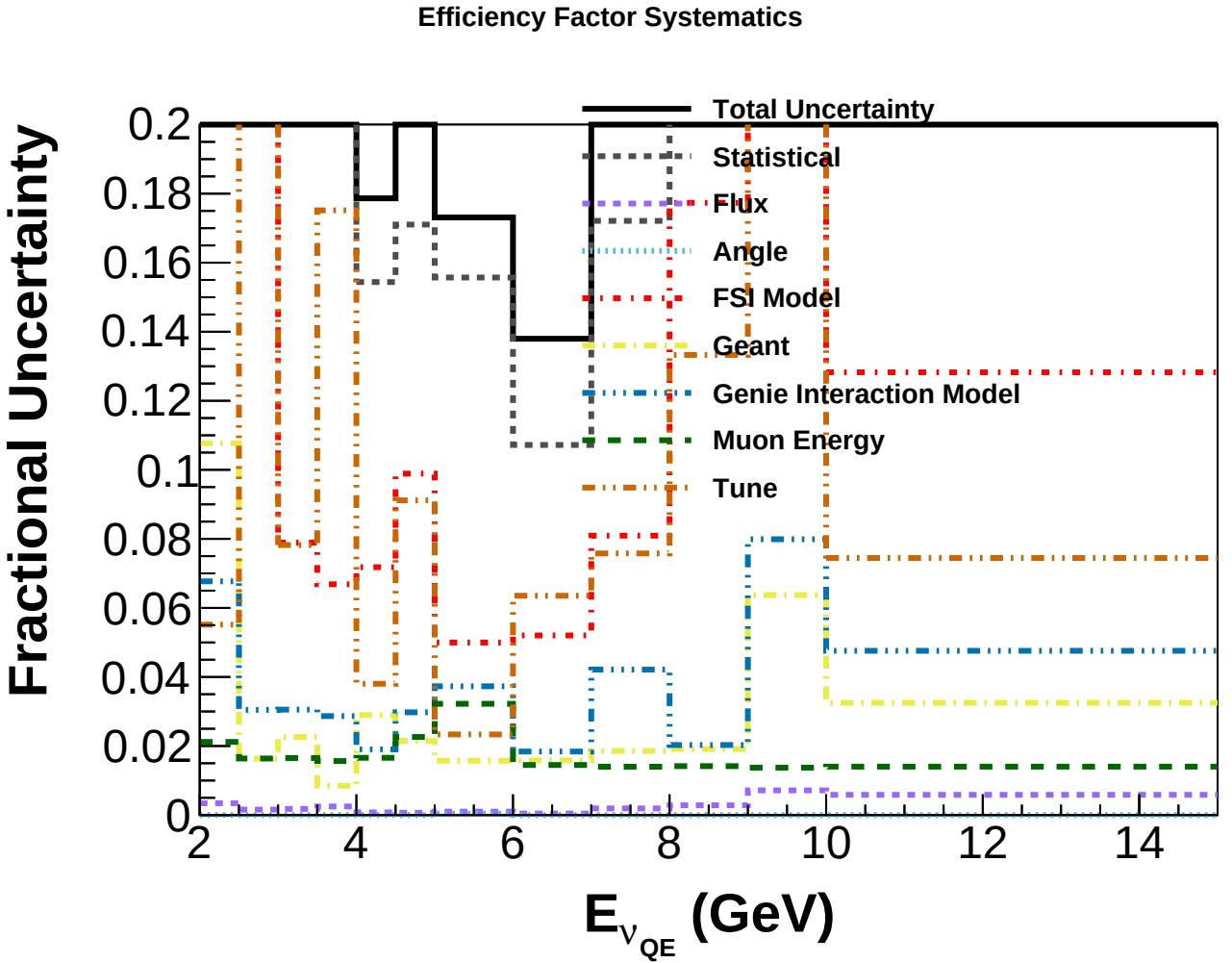

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

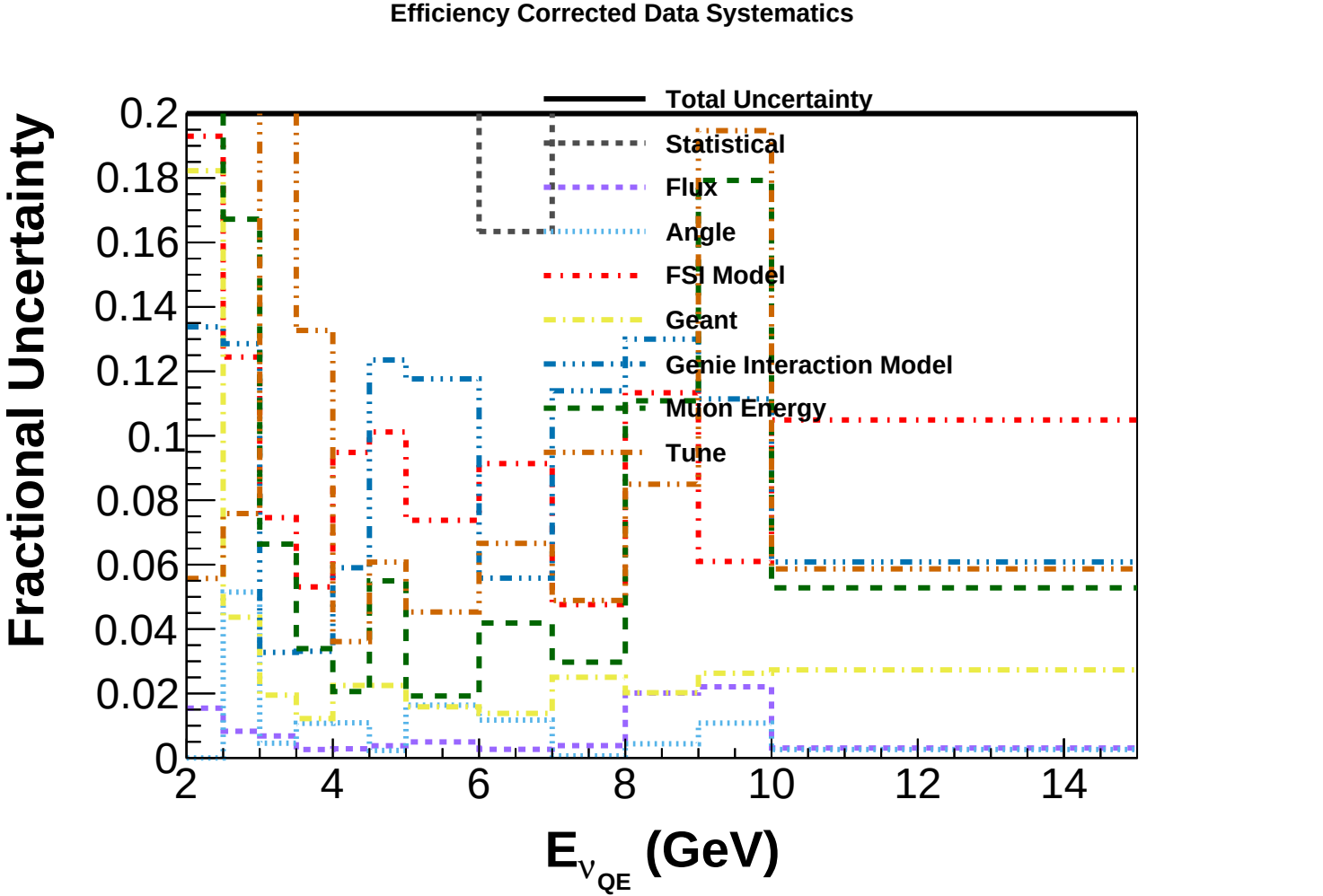

efficiency: selected and true
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

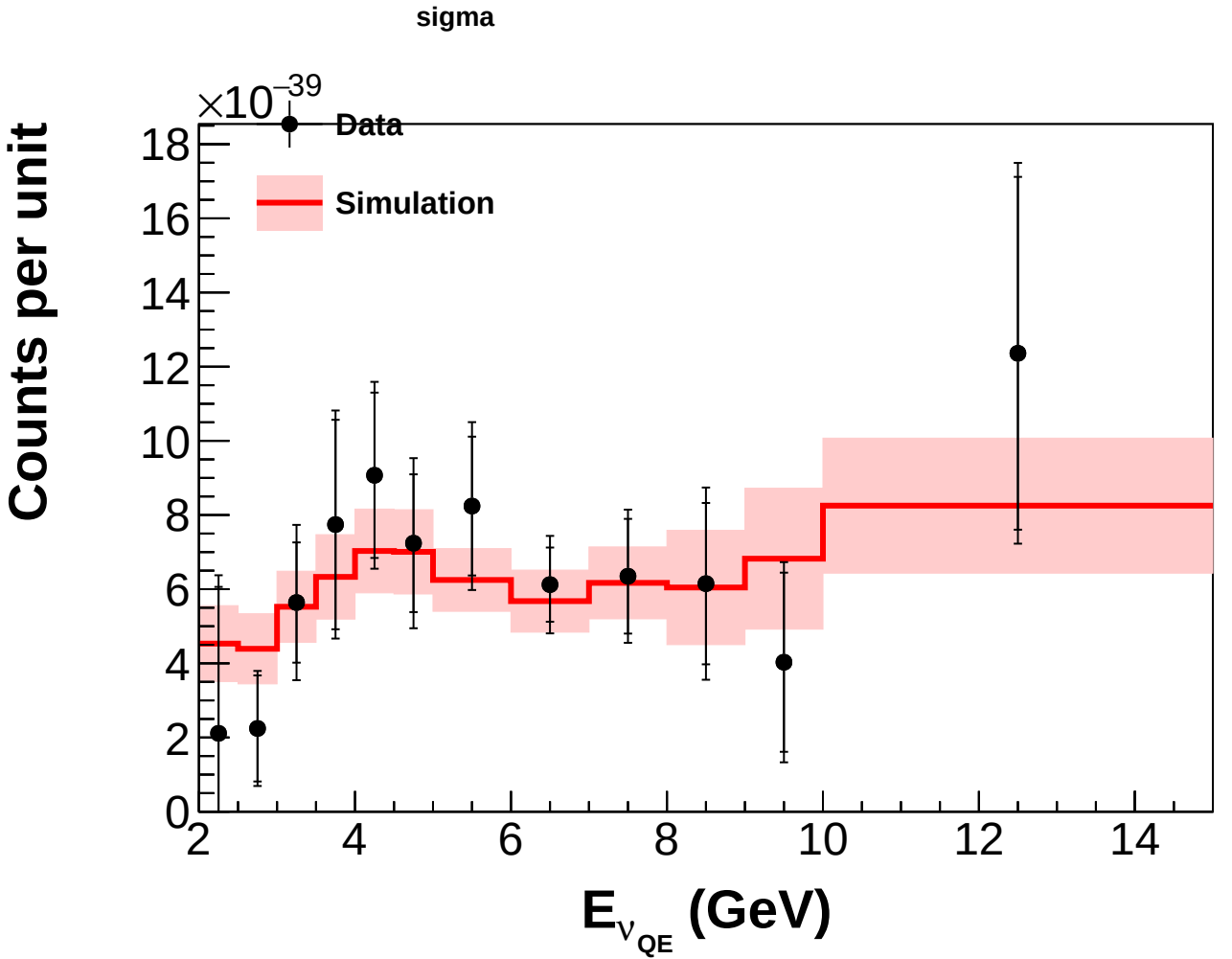

efficiency: selected and true
Data / MC
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

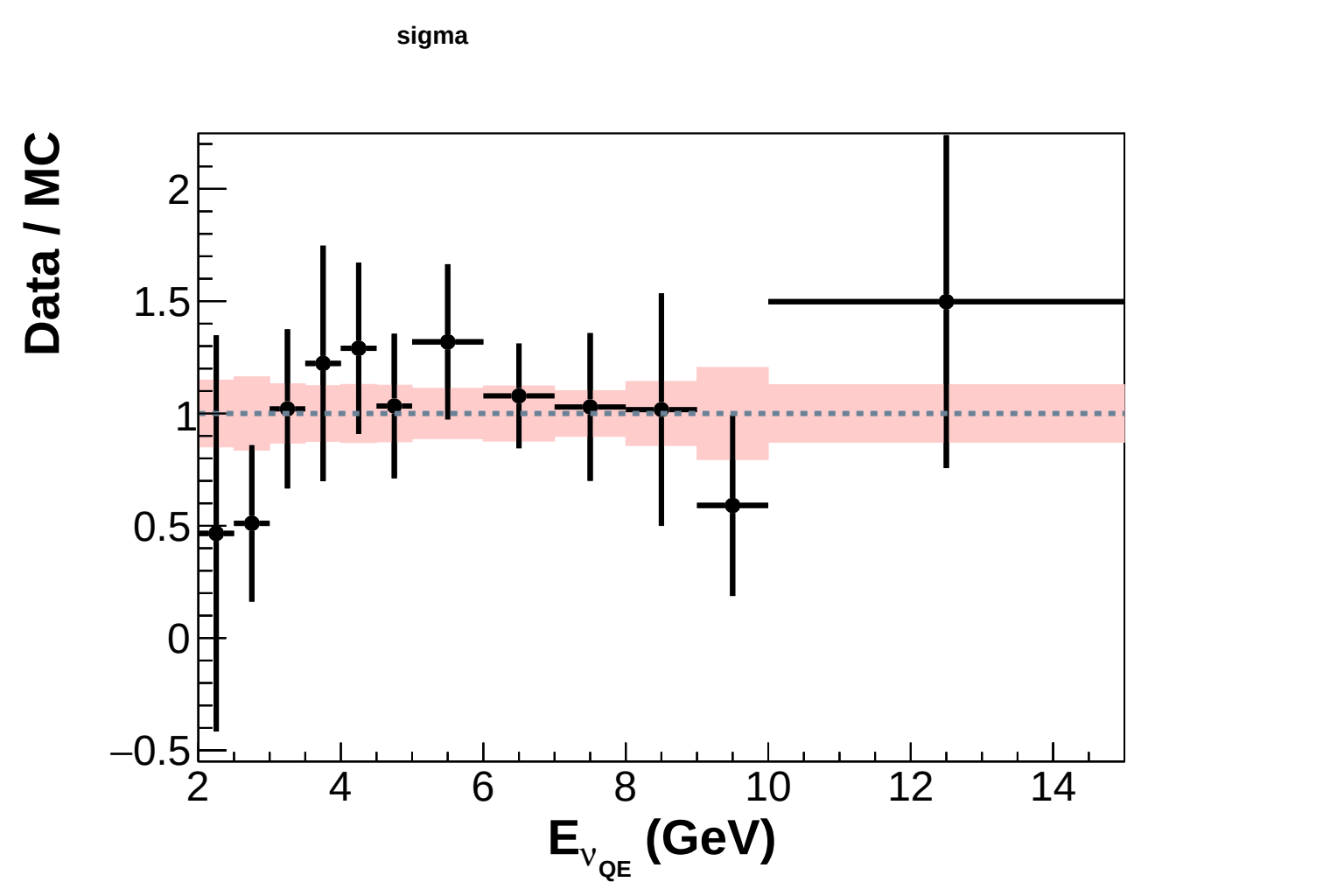

effcorr data vs truth
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
800
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

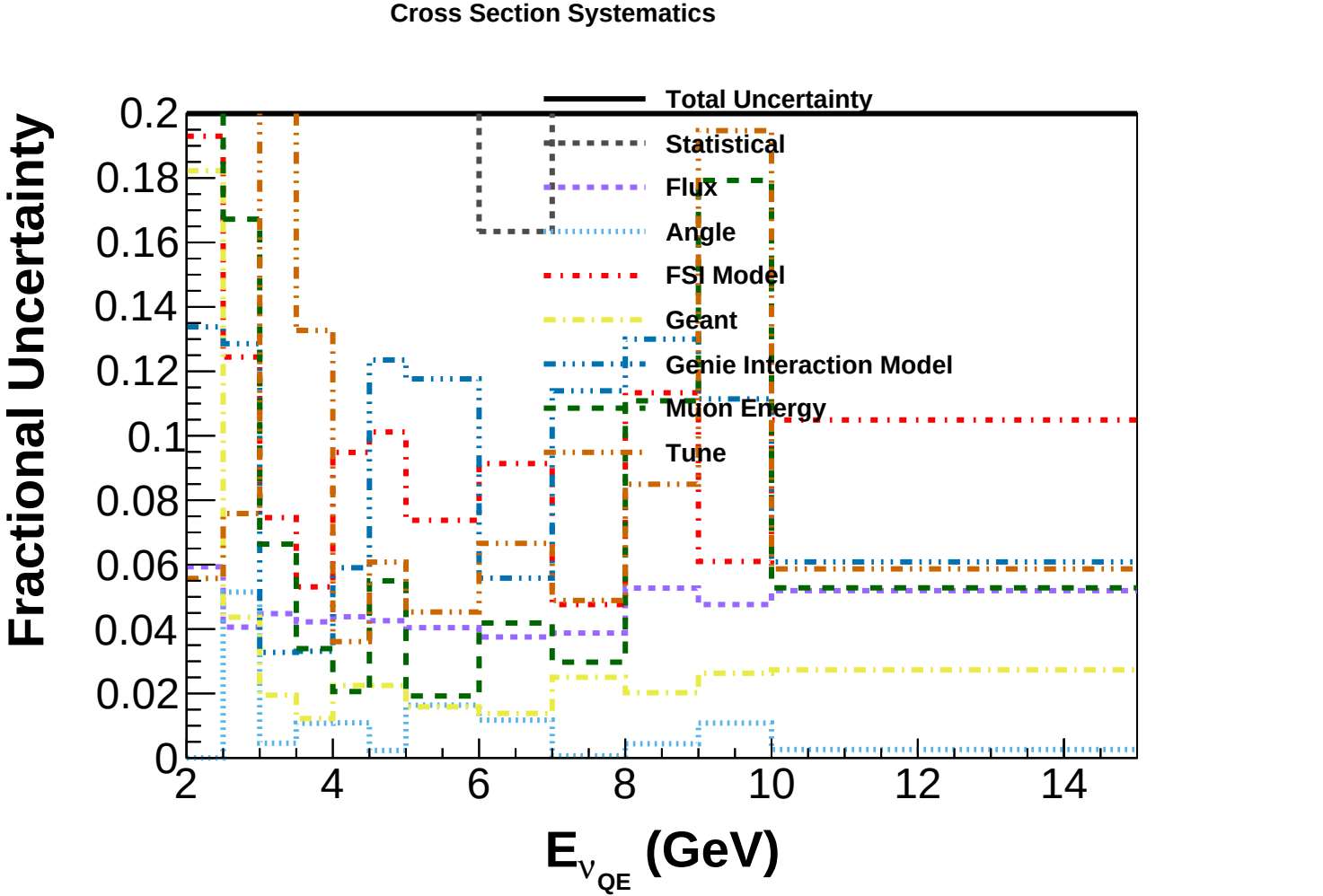

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

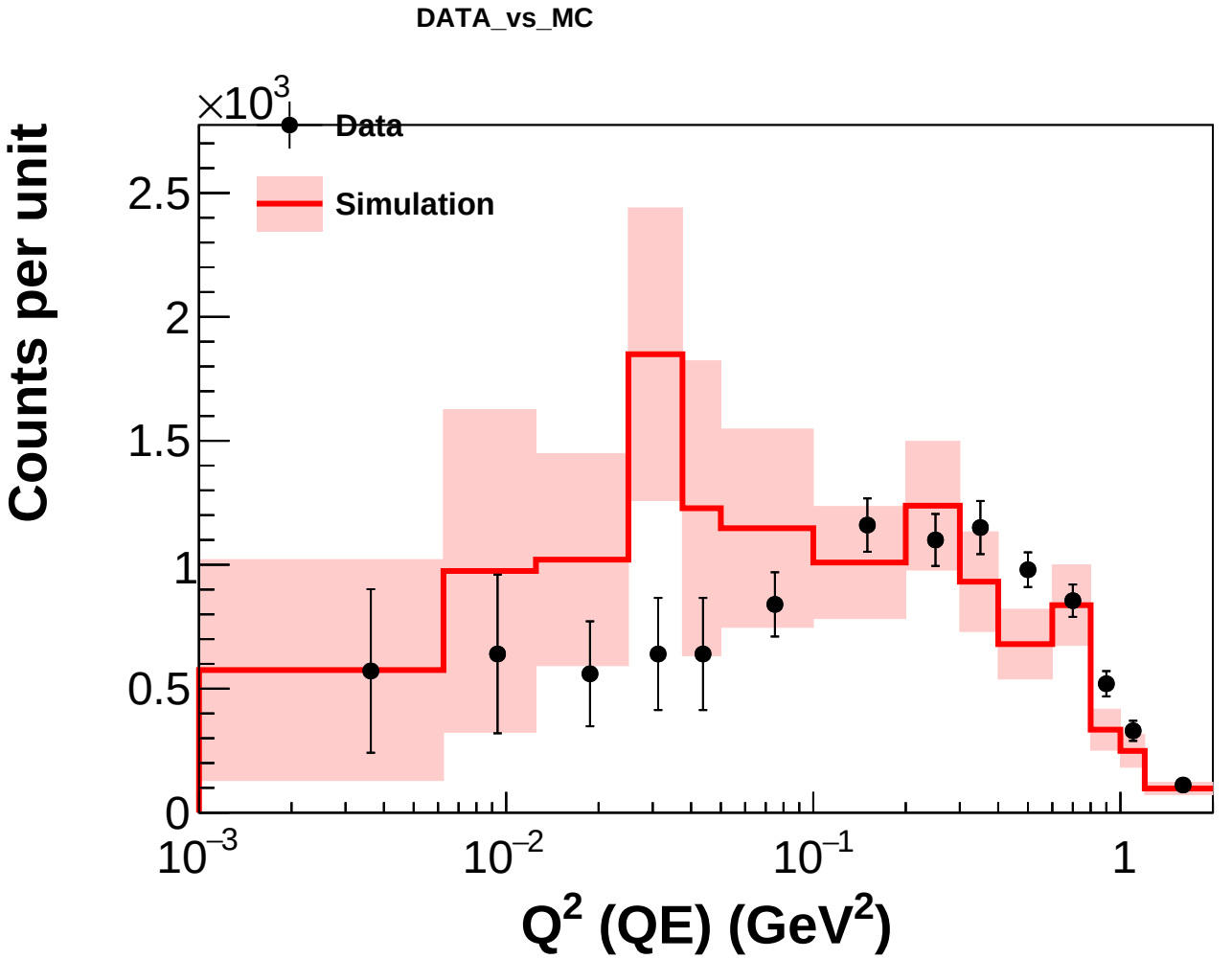

Efficiency Factor Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

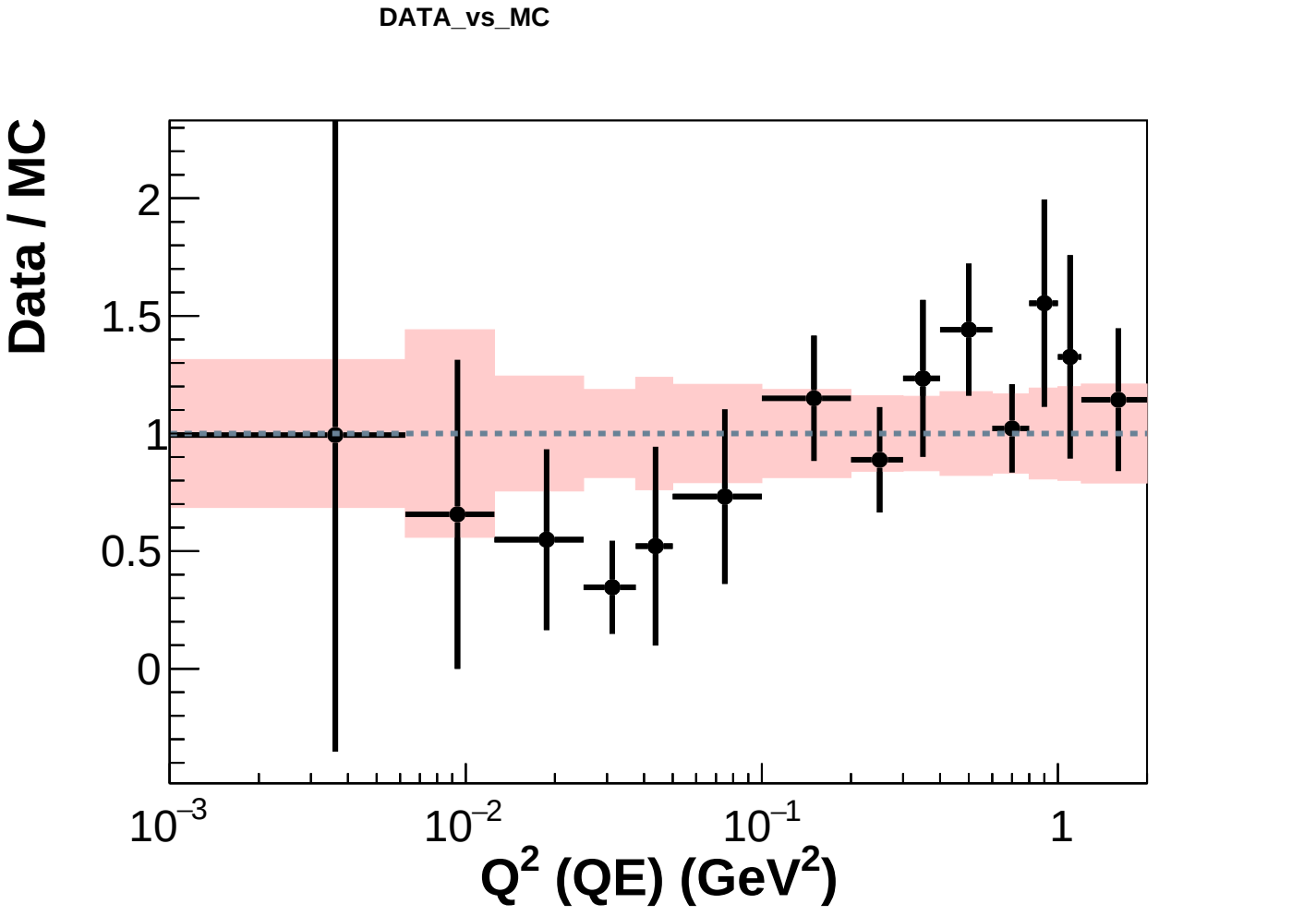

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E_νQE (GeV)

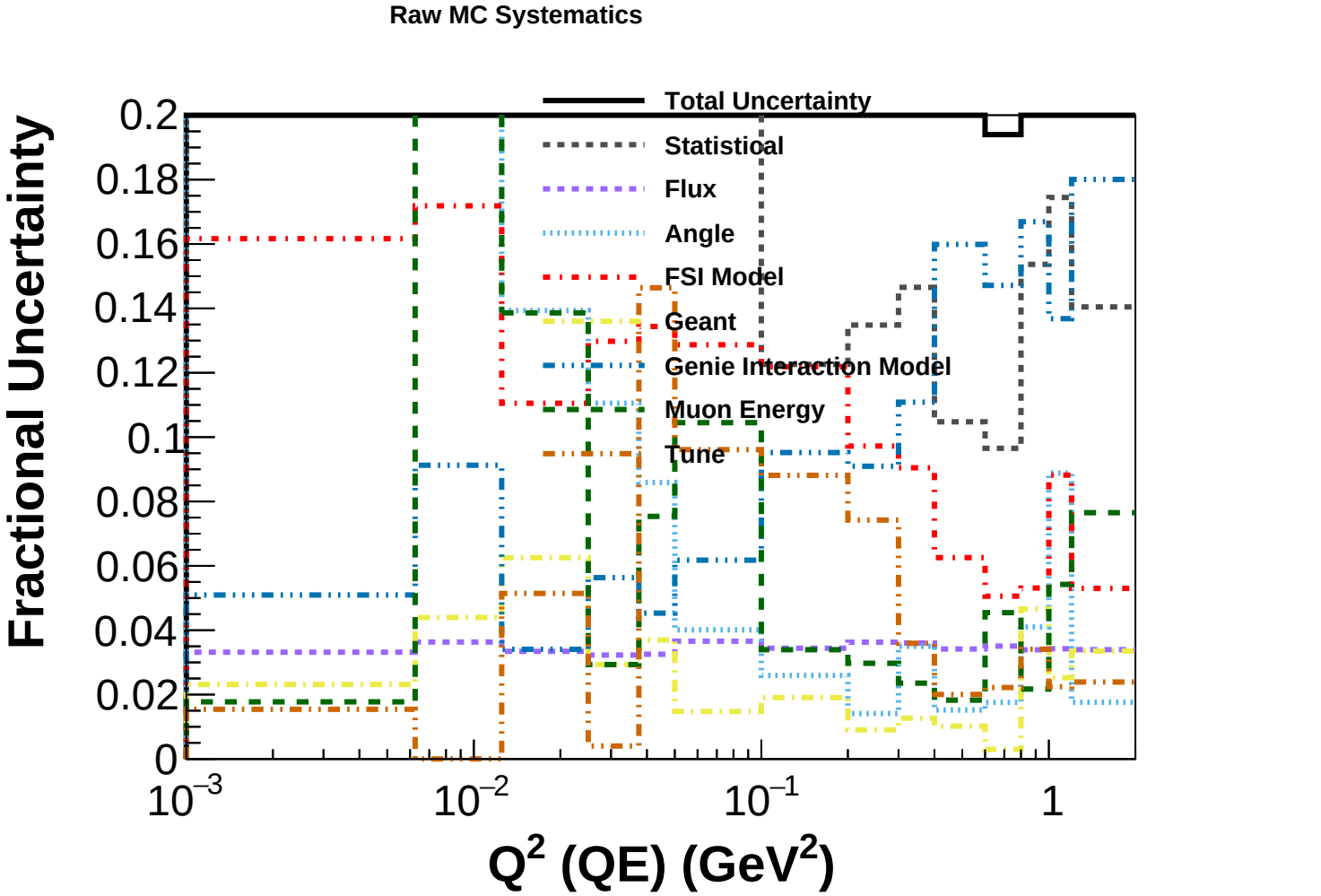

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
18
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
E_νQE (GeV)

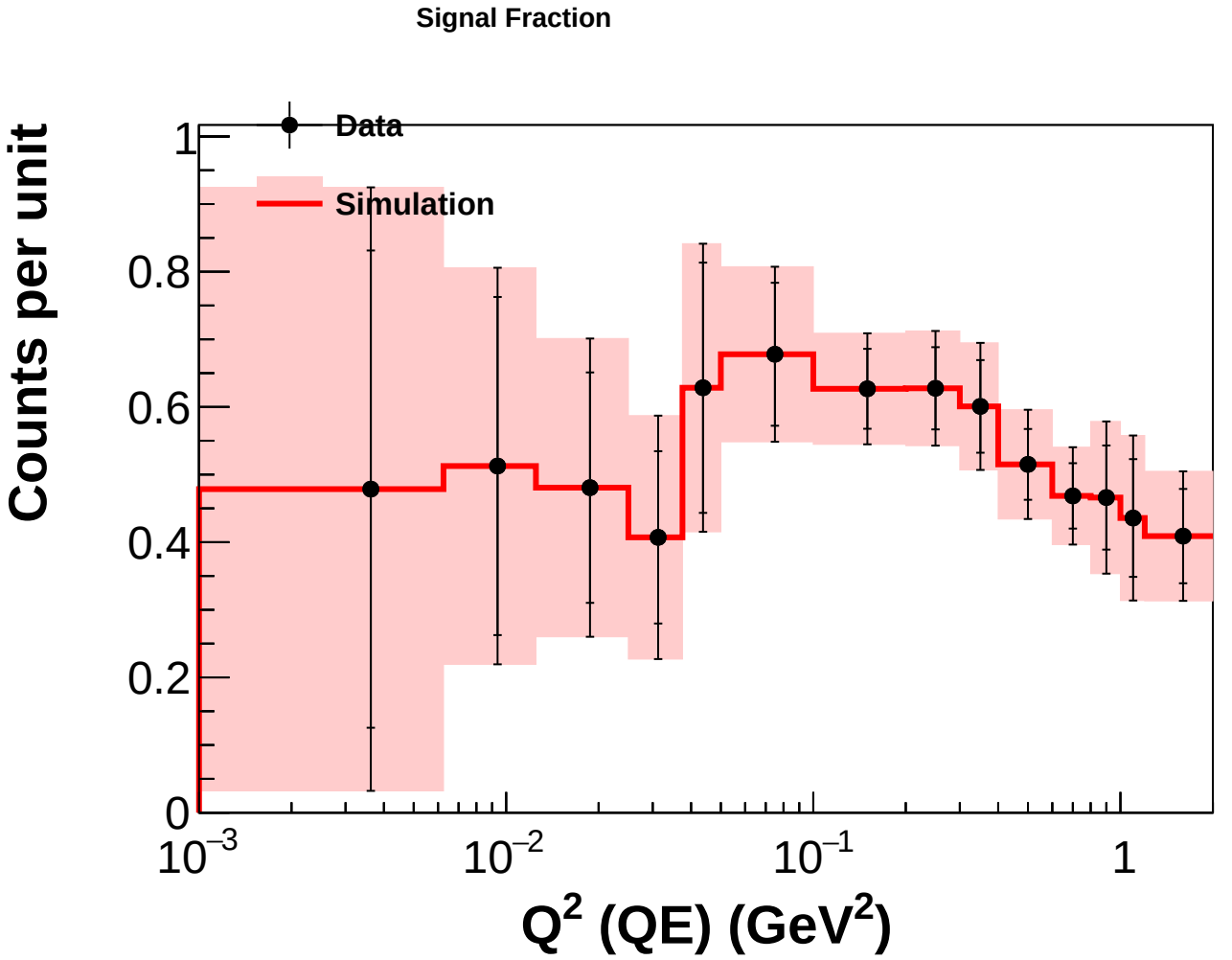

sigma
Data / MC
2
1.5
1
0.5
0
−0.5
2
4
6
8
10
12
14
$E_{\nu_{QE}}$ (GeV)

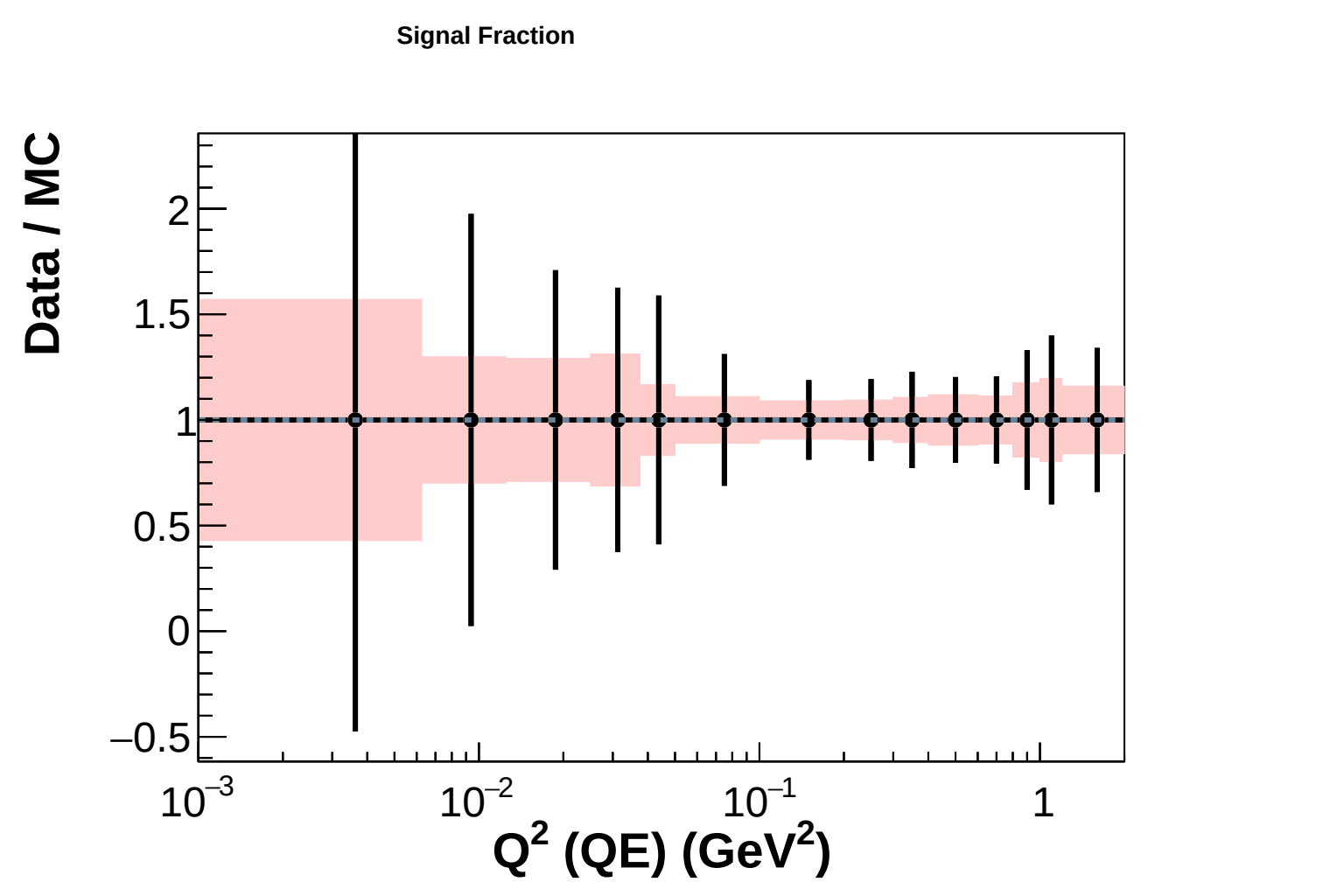

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2
4
6
8
10
12
14
E$_{\nu_{QE}}$ (GeV)

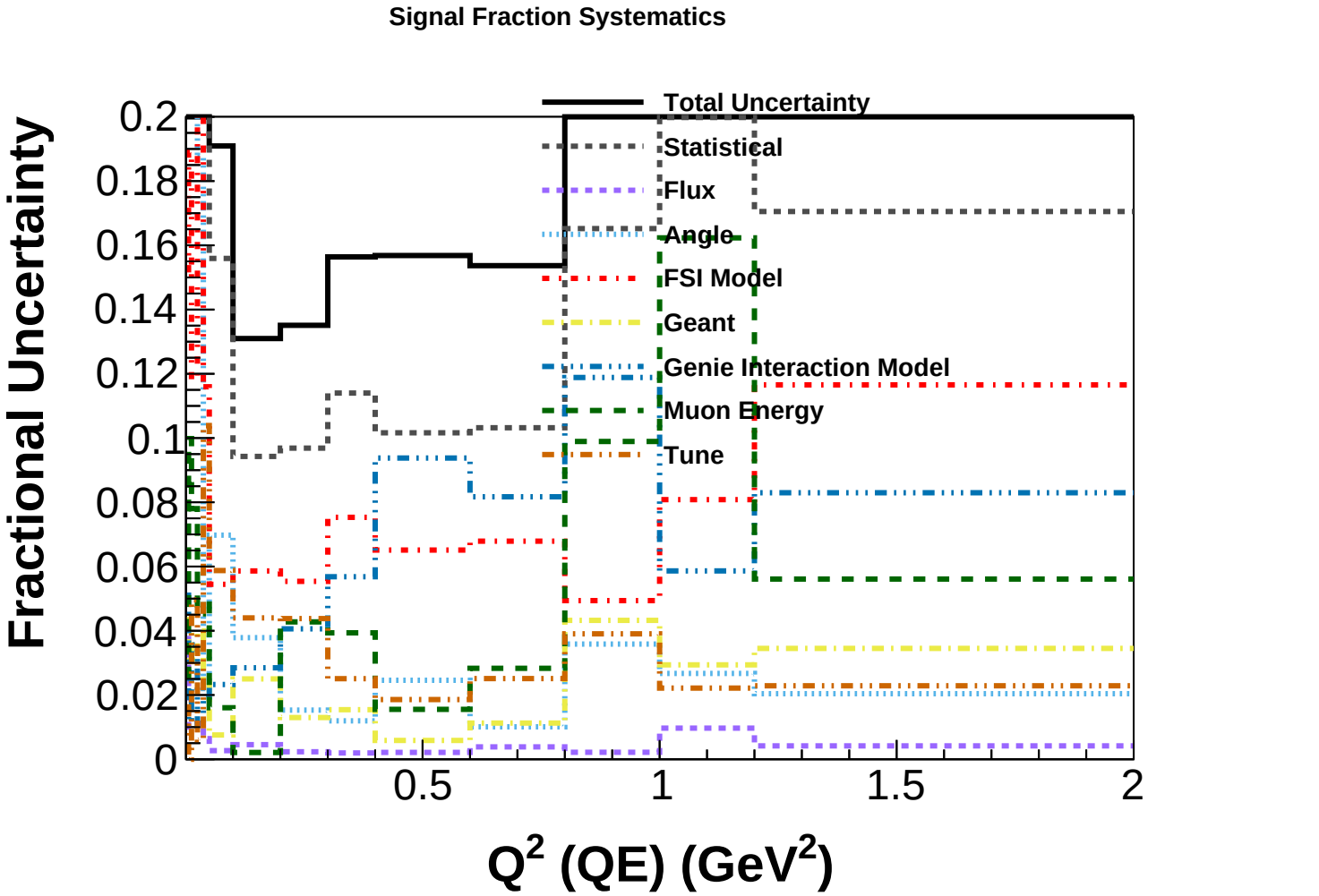

DATA_vs_MC
Counts per unit
×10^3
Data
Simulation
2.5
2
1.5
1
0.5
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

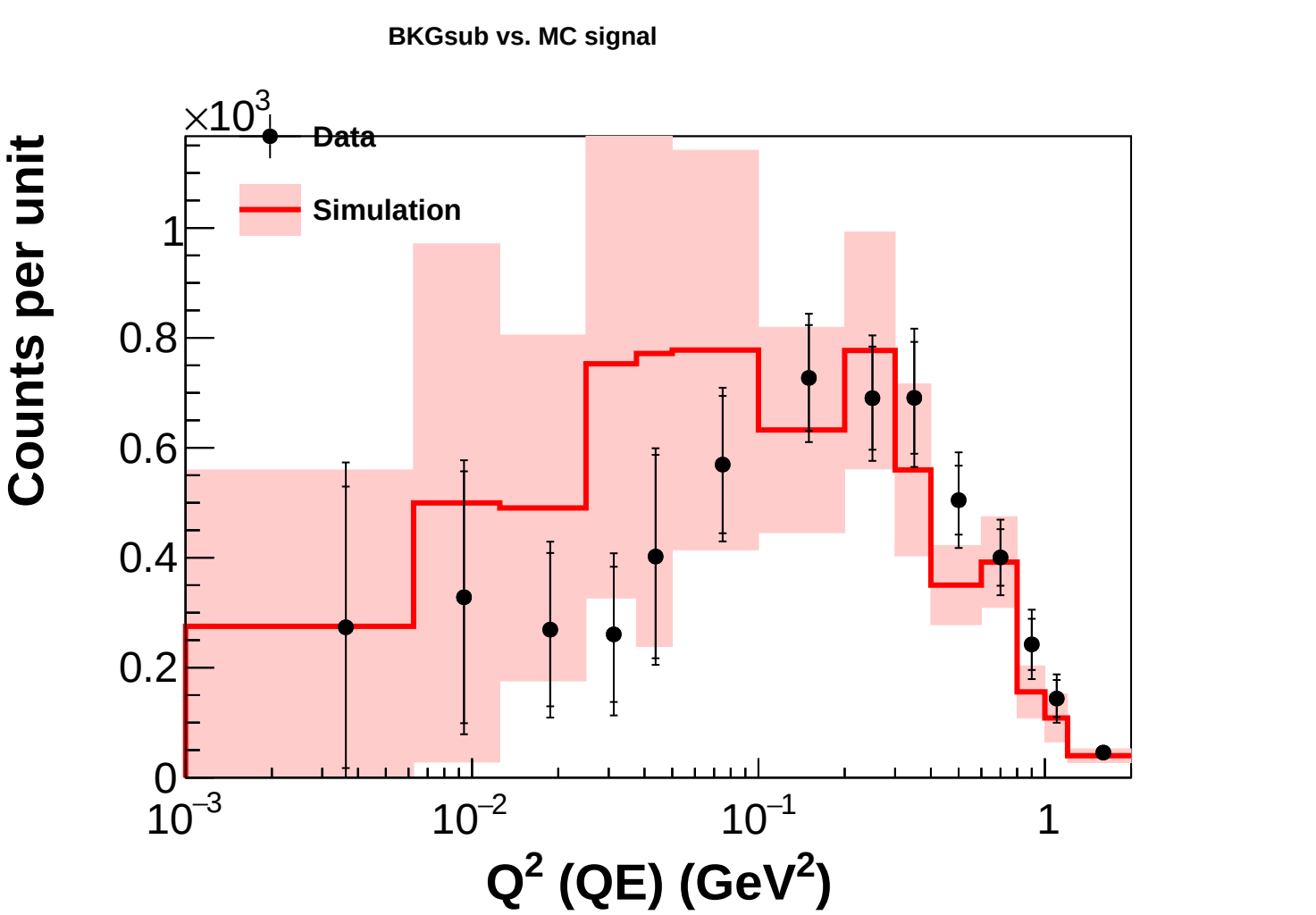

DATA_vs_MC
Data / MC
2
1.5
1
0.5
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

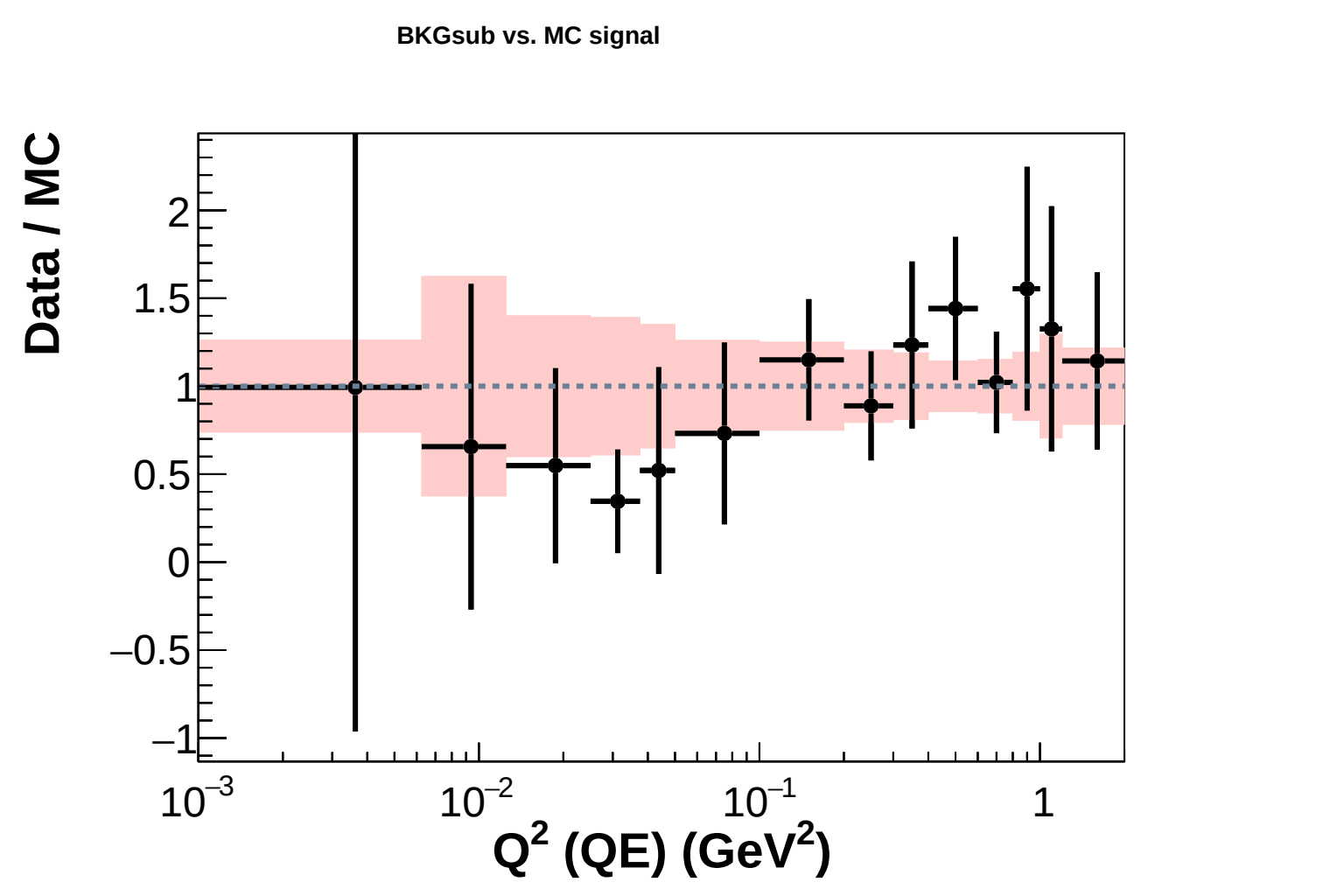

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

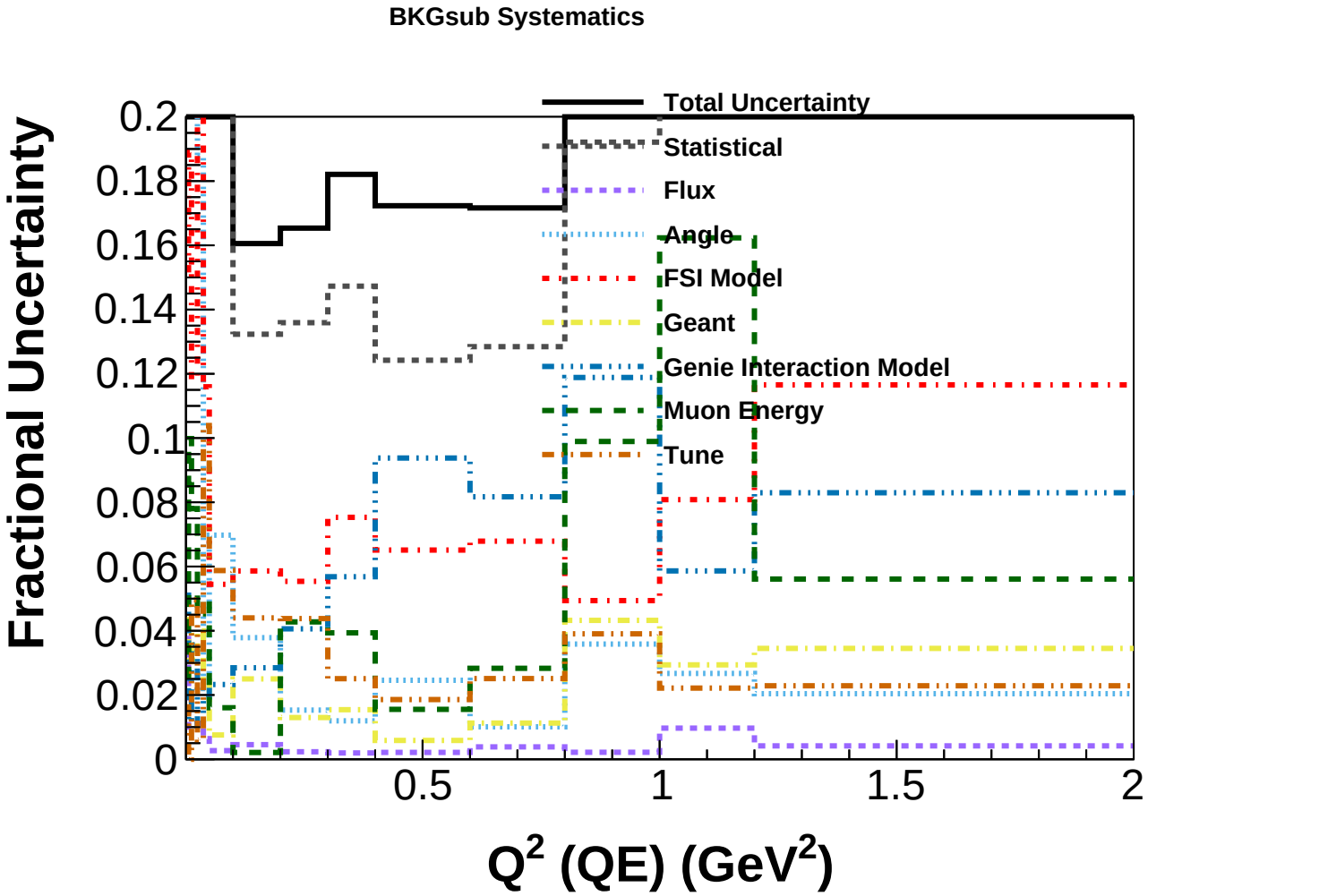

Signal Fraction
Data
Simulation
Counts per unit
1
0.8
0.6
0.4
0.2
0
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

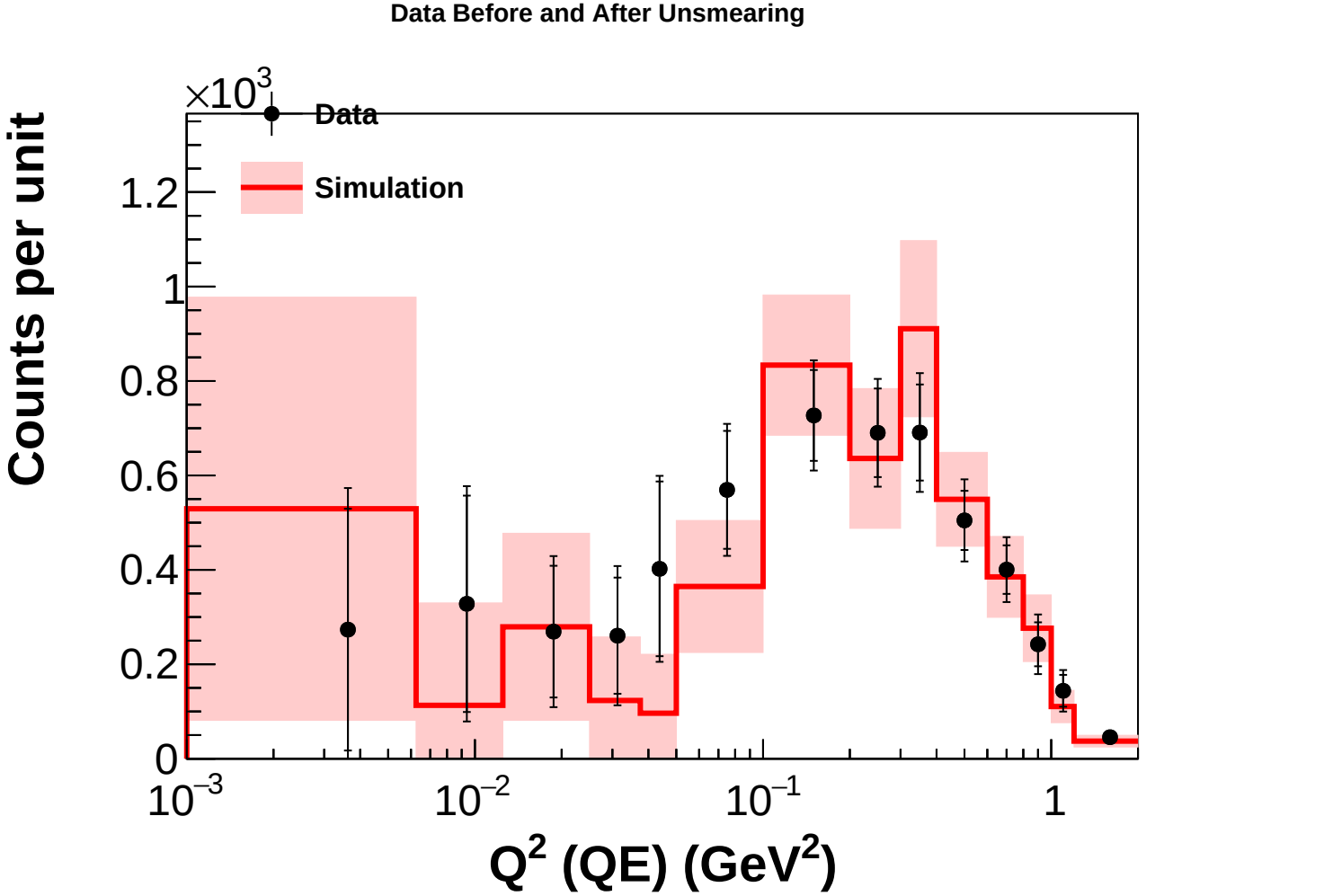

Signal Fraction
Data / MC
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

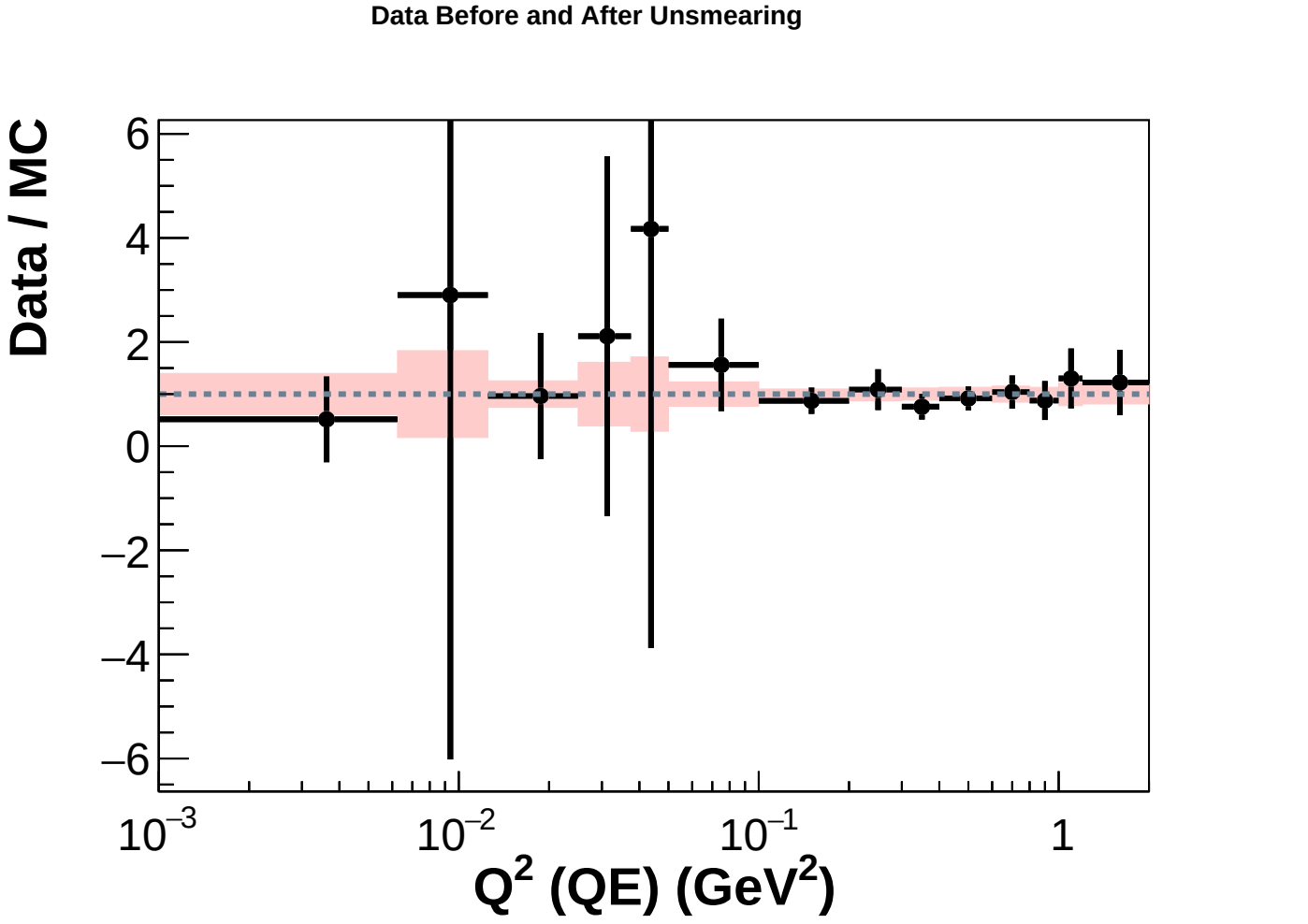

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

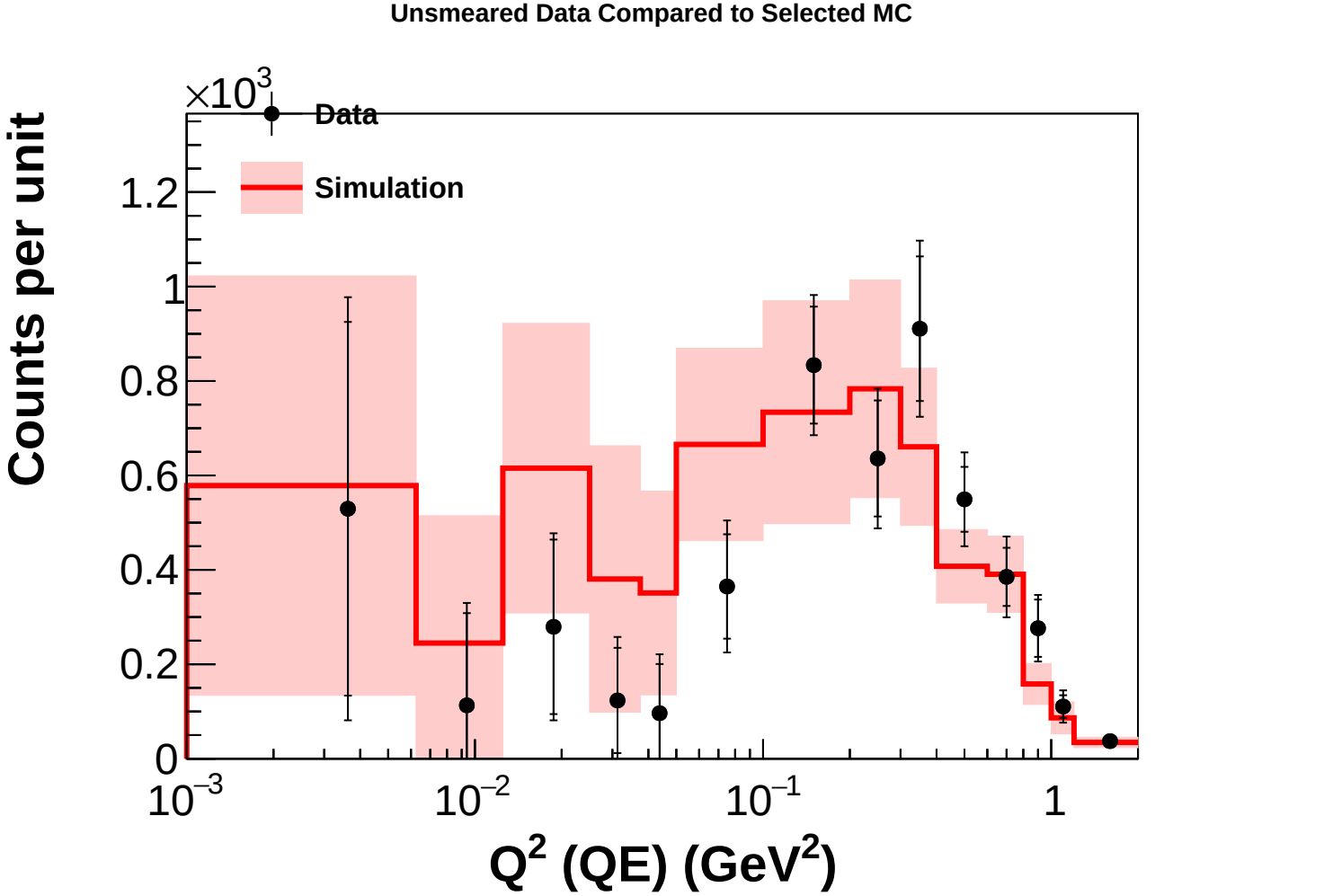

BKGsub vs. MC signal
Data
Simulation
×10^3
Counts per unit
1
0.8
0.6
0.4
0.2
0
10^−3
10^−2
10^−1
1
Q² (QE) (GeV²)

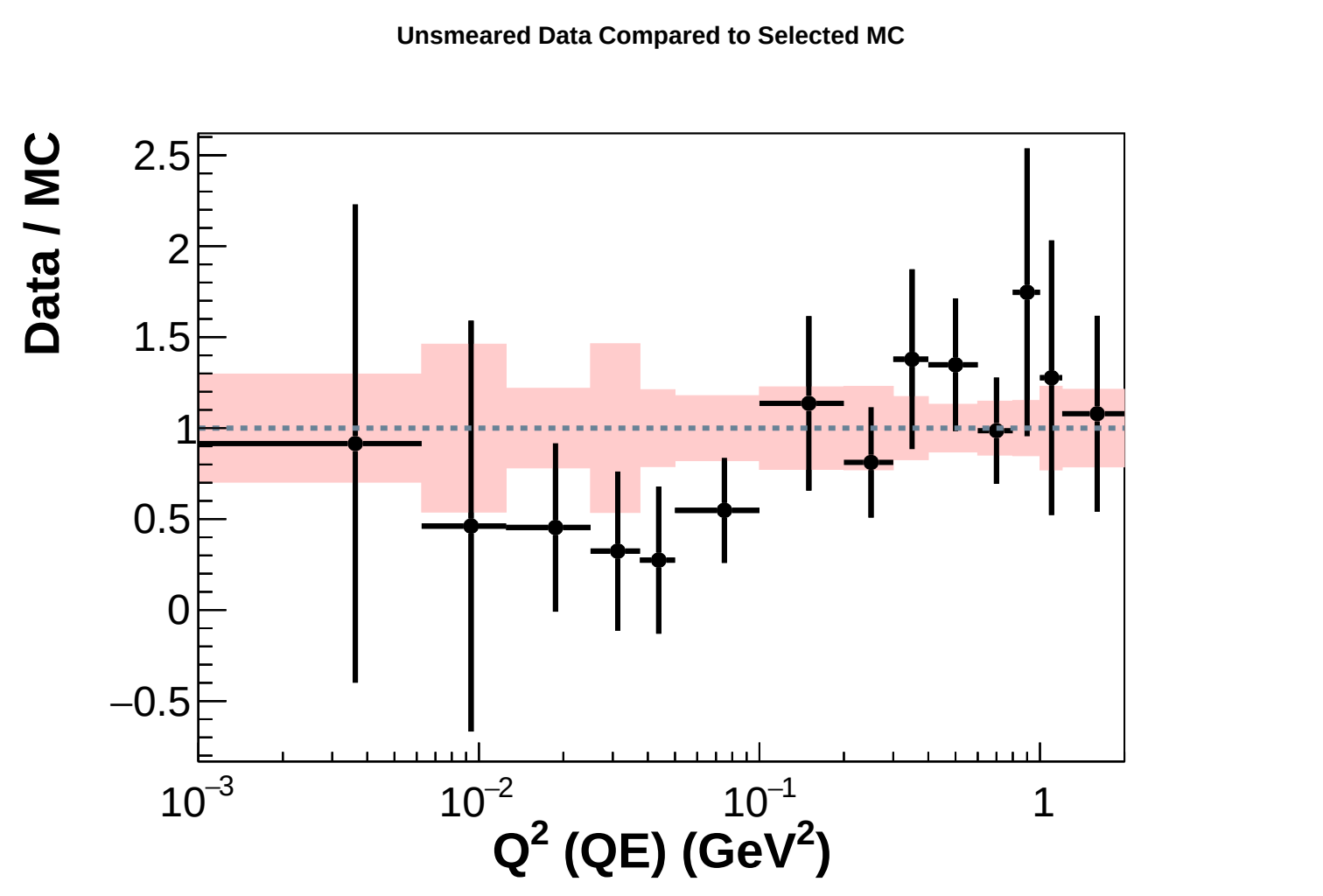

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
−1
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

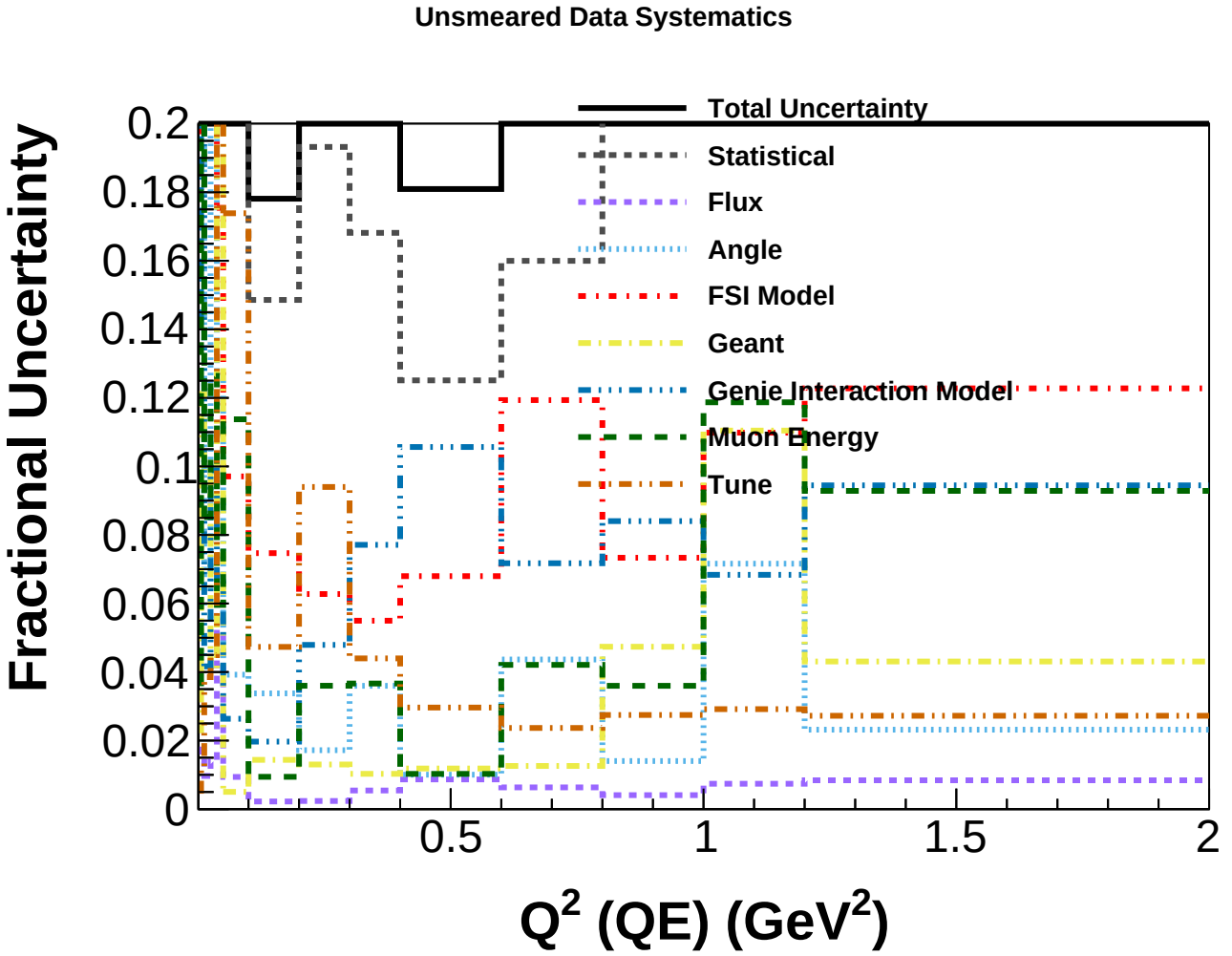

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

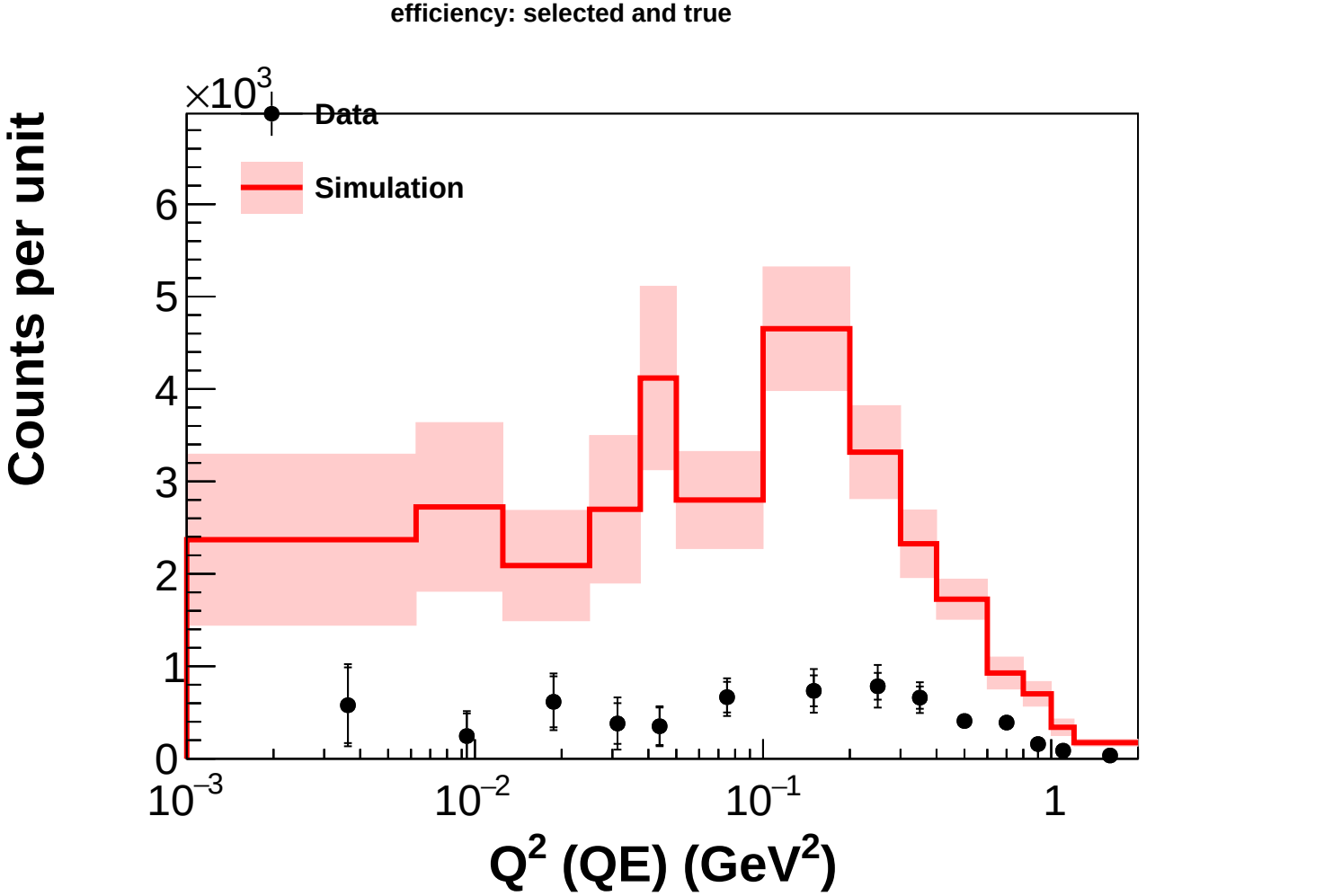

Data Before and After Unsmearing
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)


Data Before and After Unsmearing
Data / MC
6
4
2
0
−2
−4
−6
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

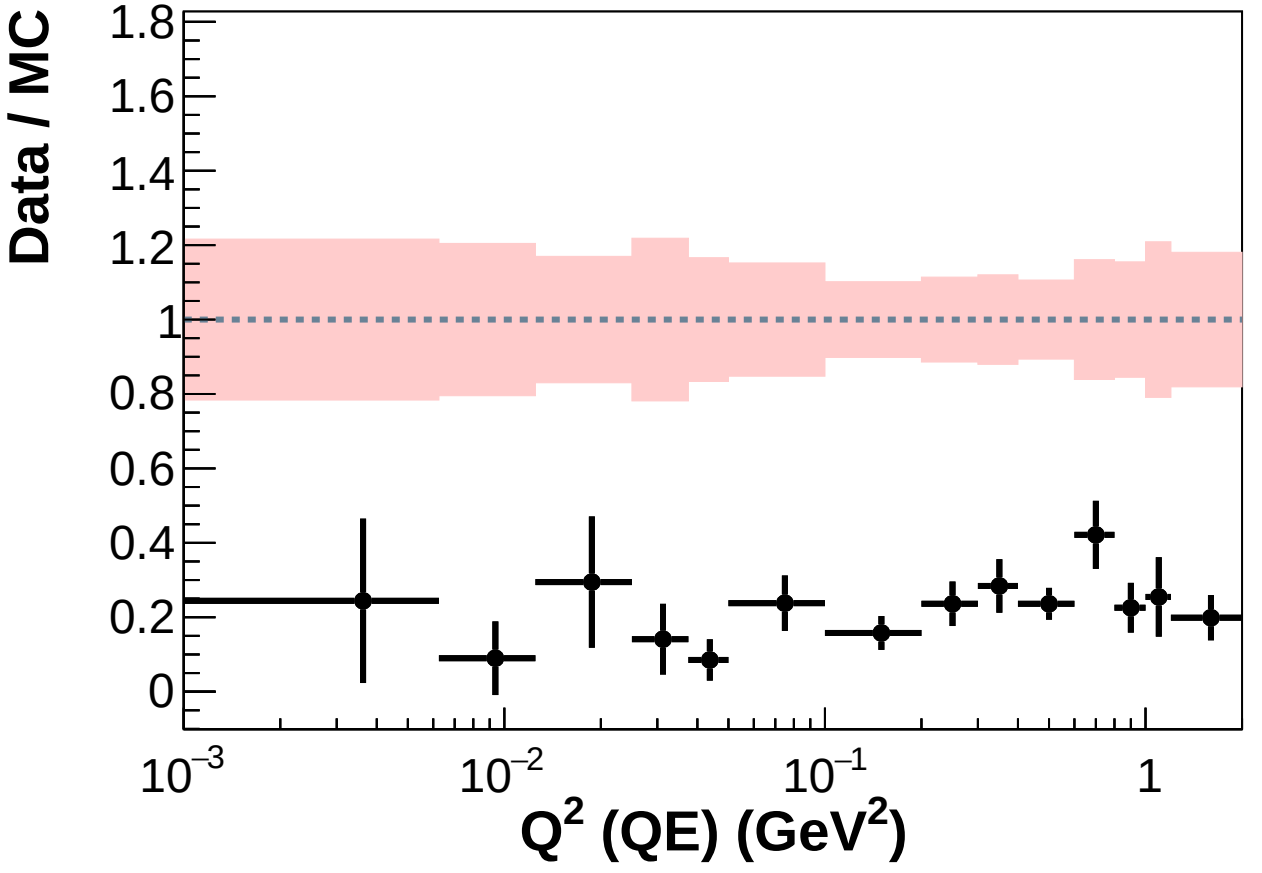

Unsmeared Data Compared to Selected MC
Counts per unit
×10^3
Data
Simulation
1.2
1
0.8
0.6
0.4
0.2
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

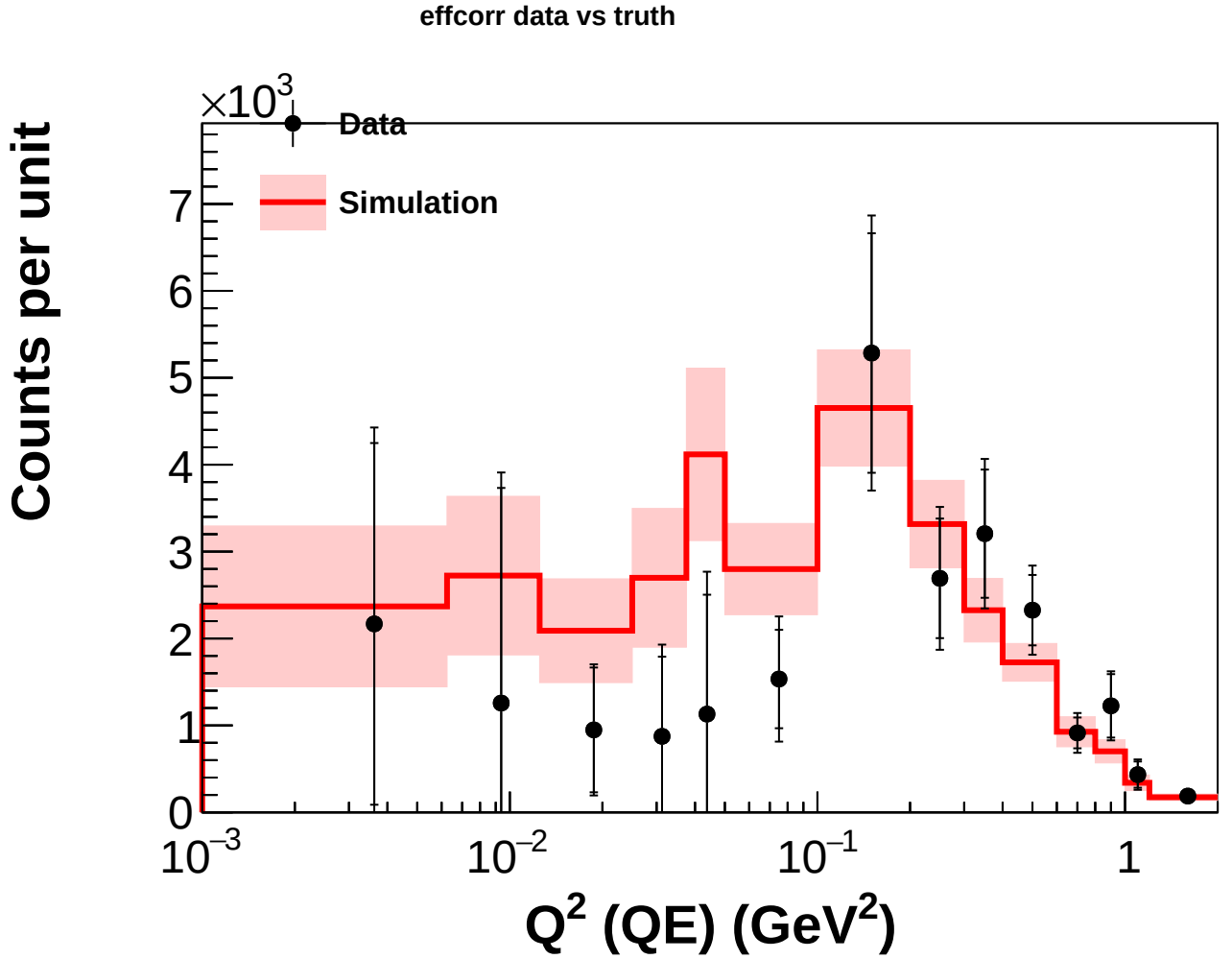

Unsmeared Data Compared to Selected MC
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

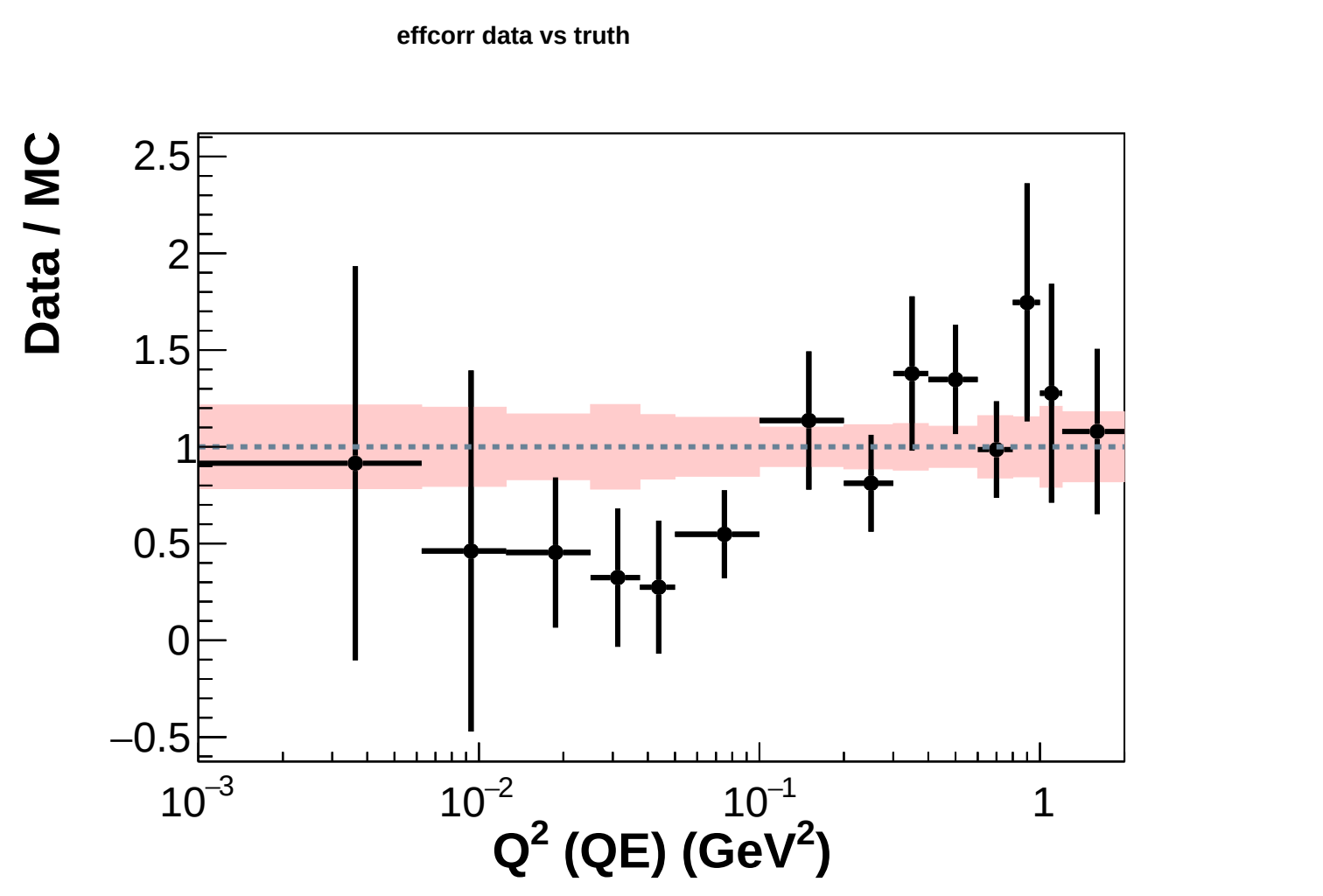

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

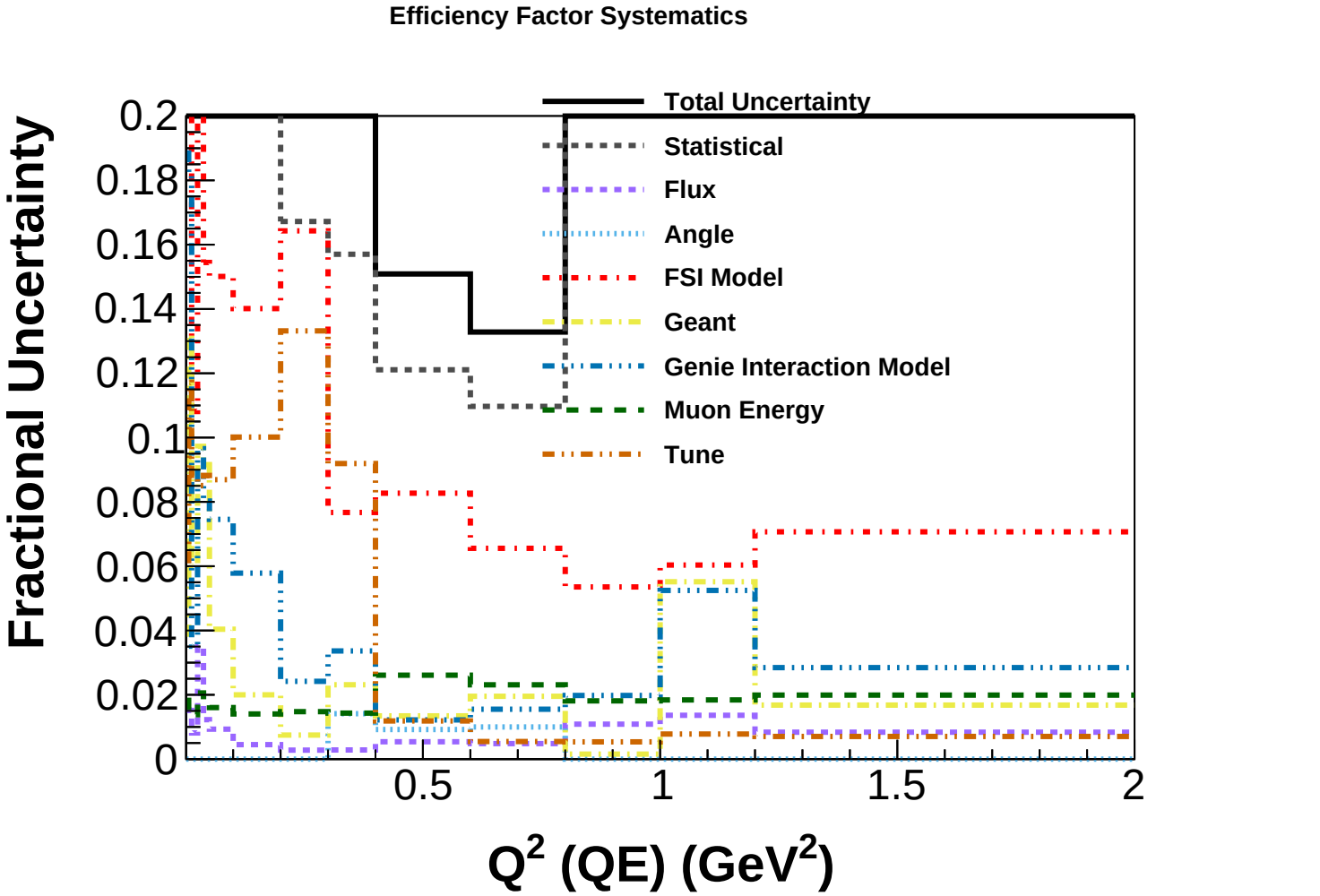

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
6
5
4
3
2
1
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

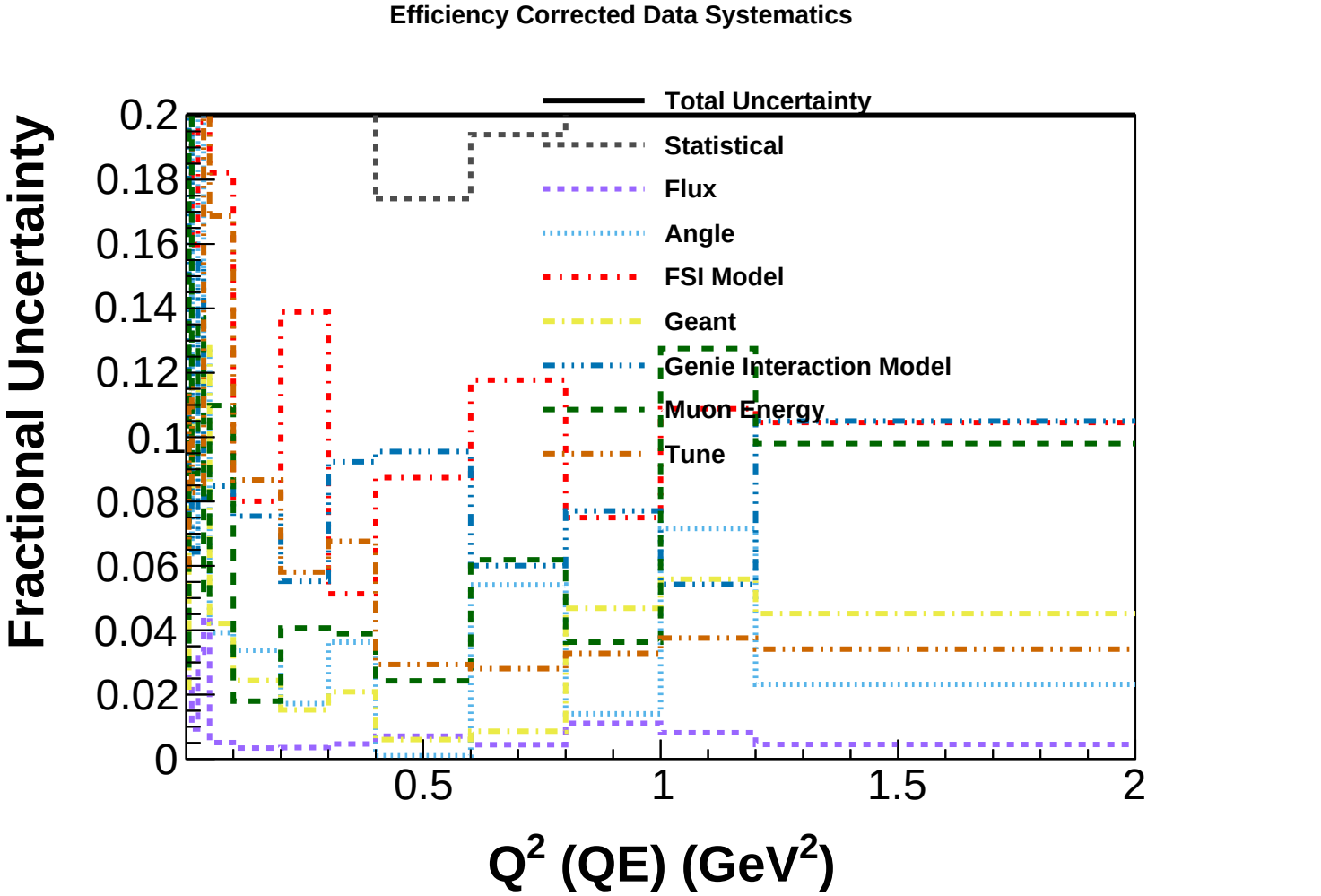
efficiency: selected and true

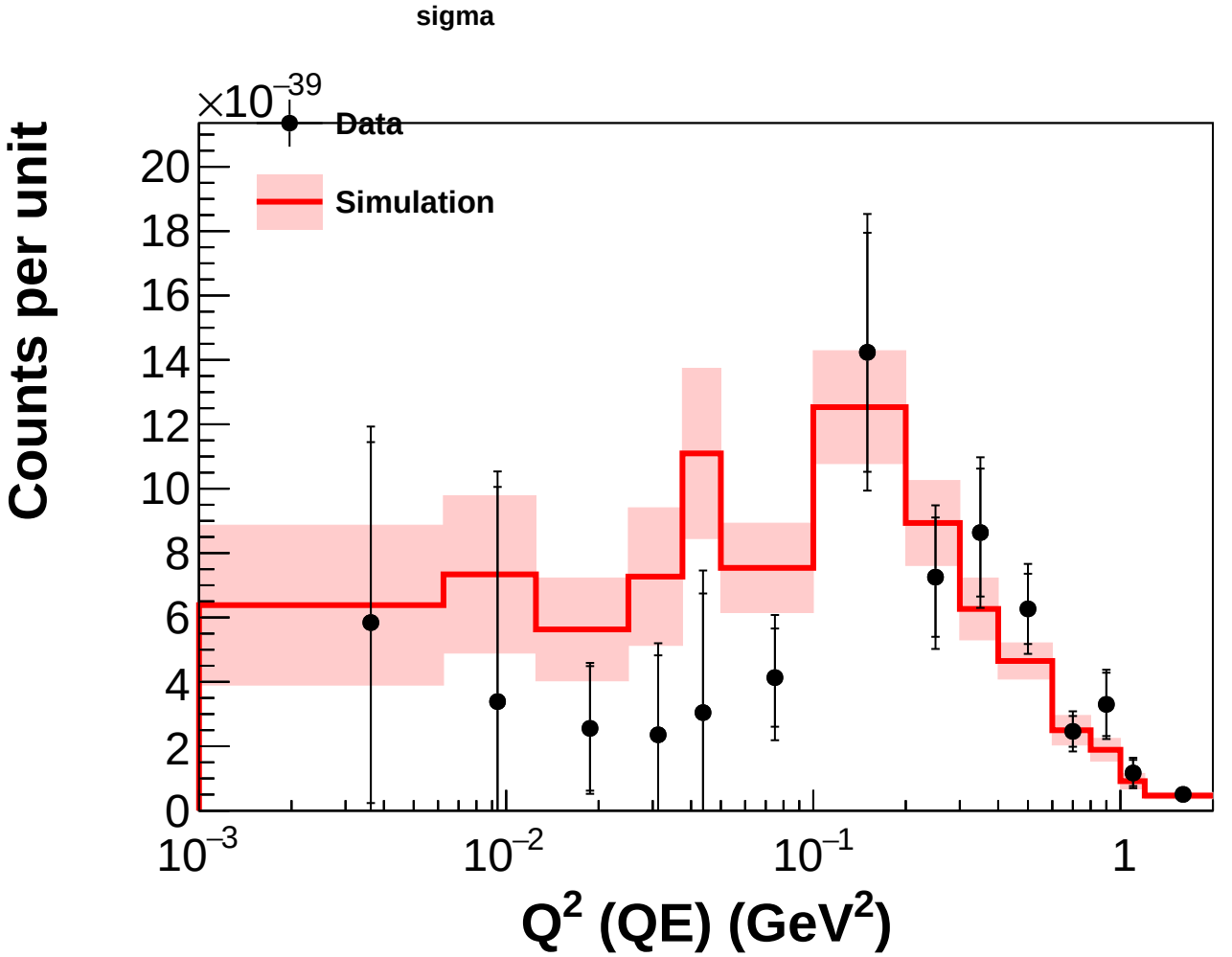


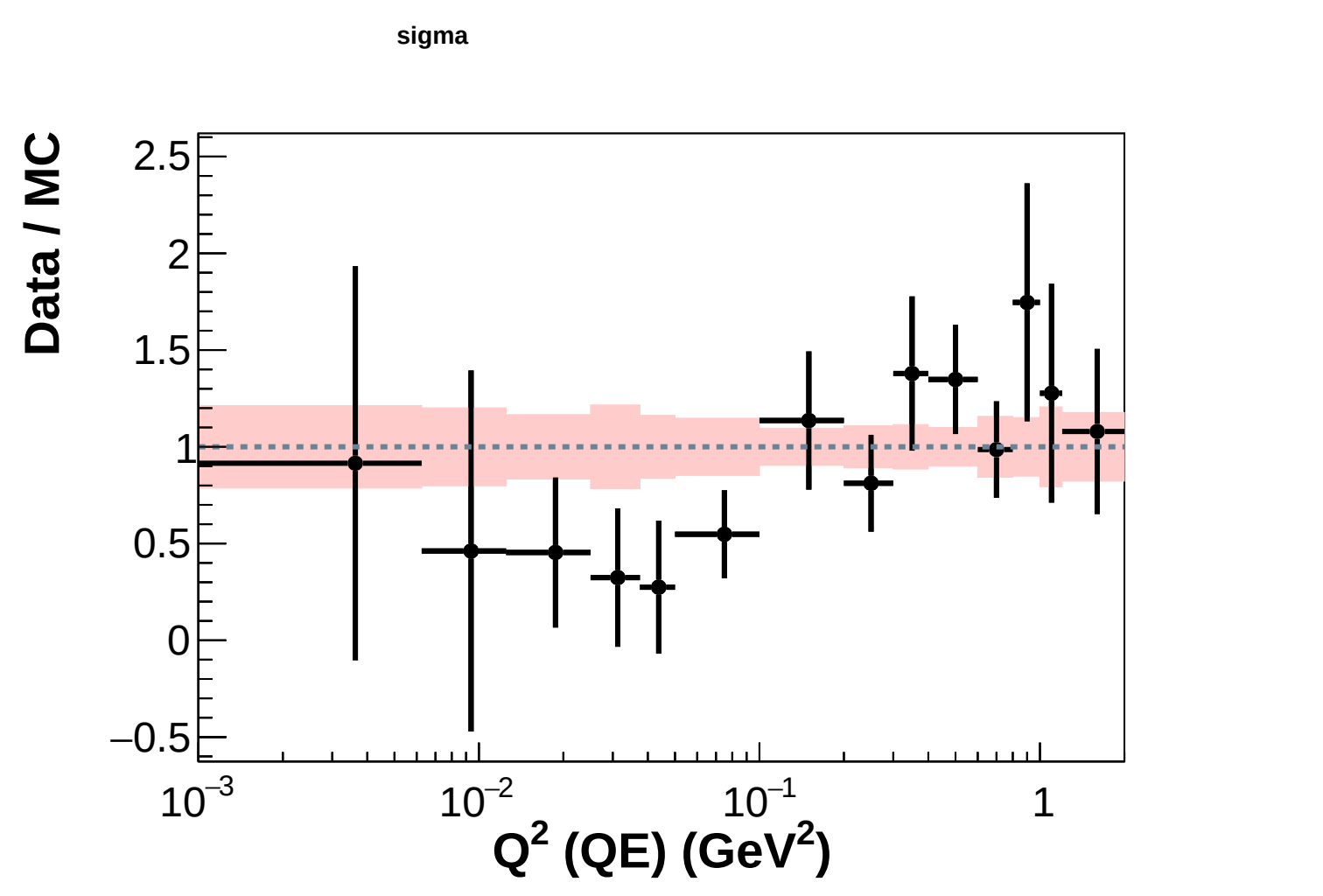

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
7
6
5
4
3
2
1
0
10^−3
10^−2
10^−1
1
Q^2 (QE) (GeV^2)

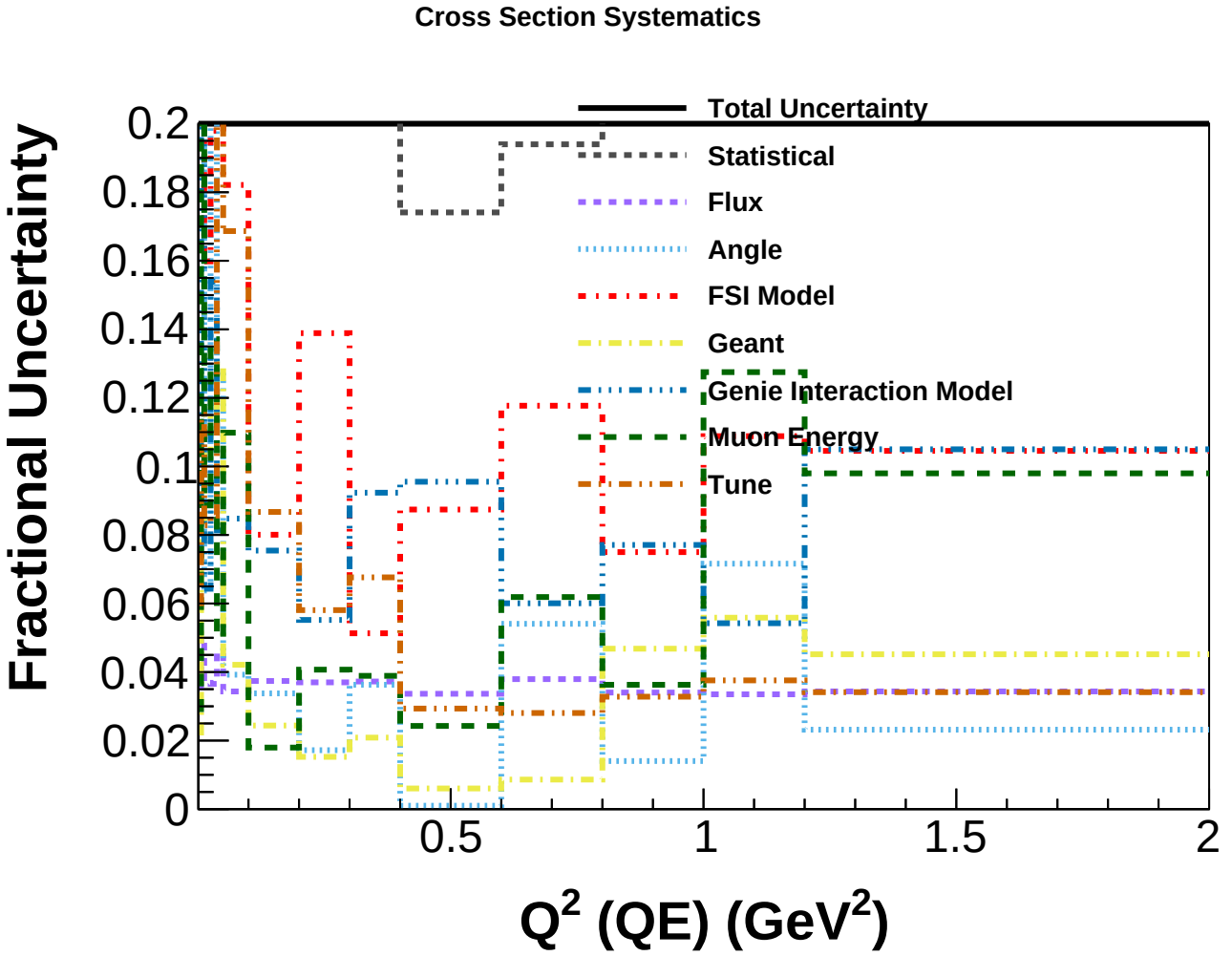

effcorr data vs truth
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

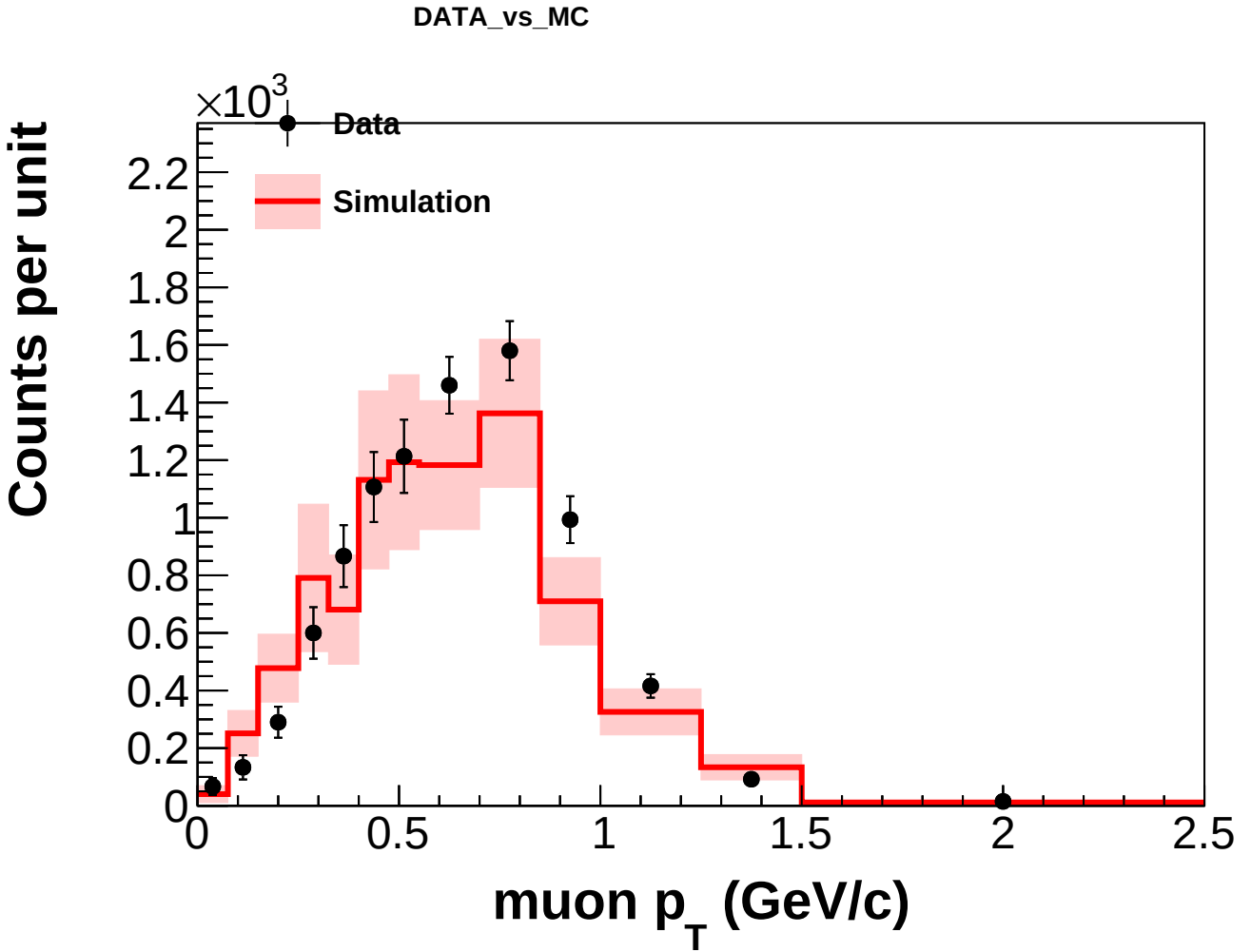

Efficiency Factor Systematics
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q^2 (QE) (GeV^2)
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune

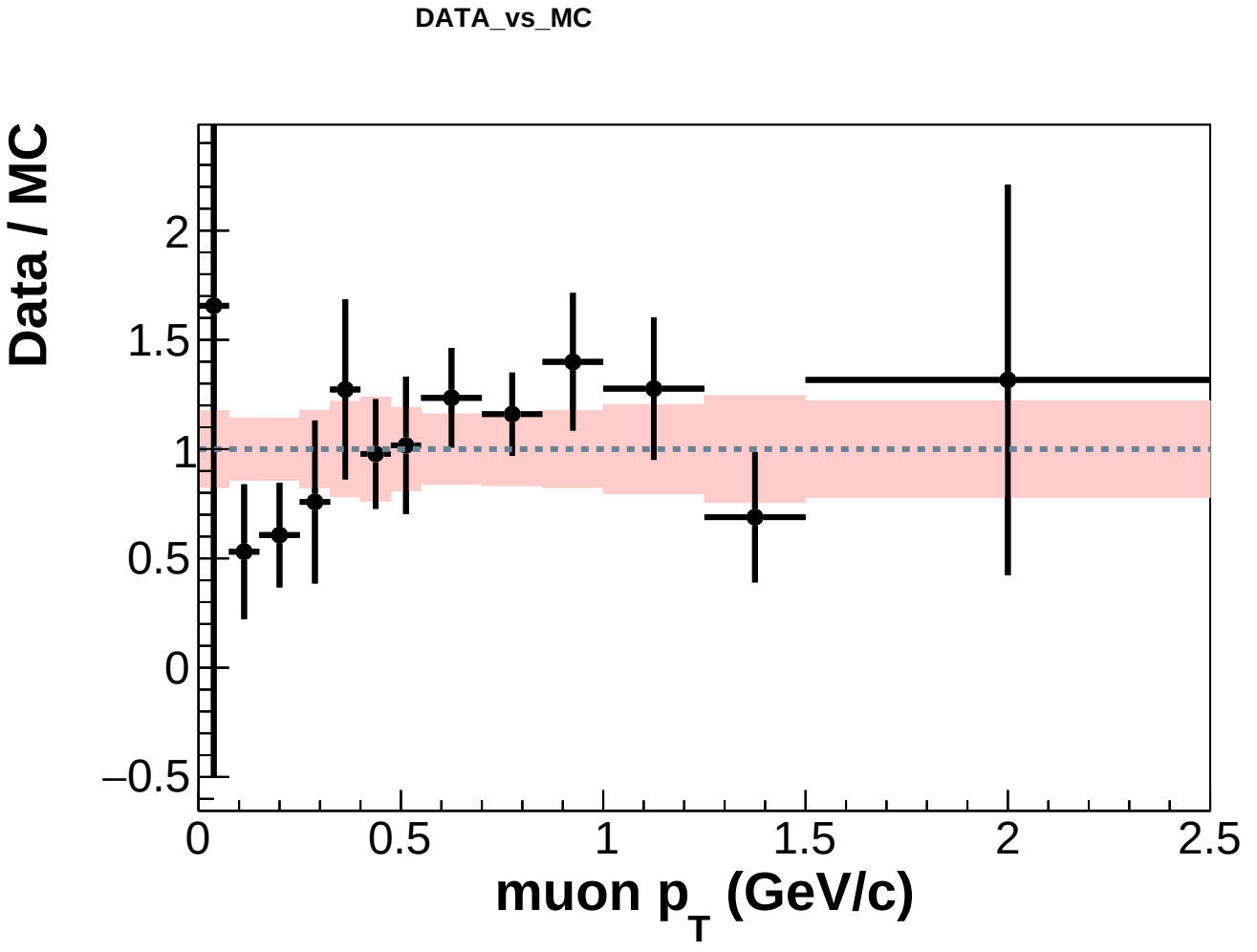

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

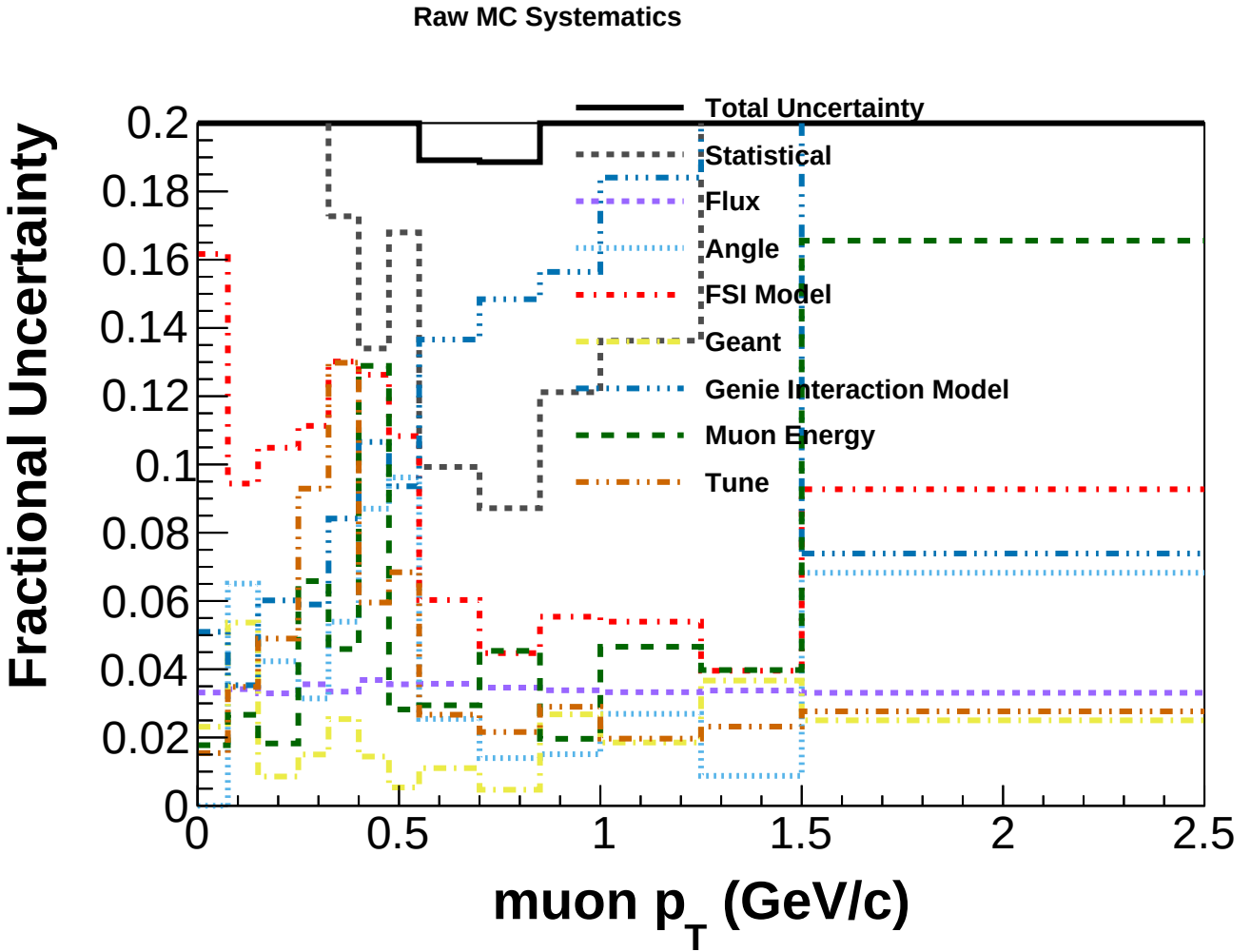

sigma
Counts per unit
×10^−39
Data
Simulation
20
18
16
14
12
10
8
6
4
2
0
10^−3
10^−2
10^−1
1
Q² (QE) (GeV²)

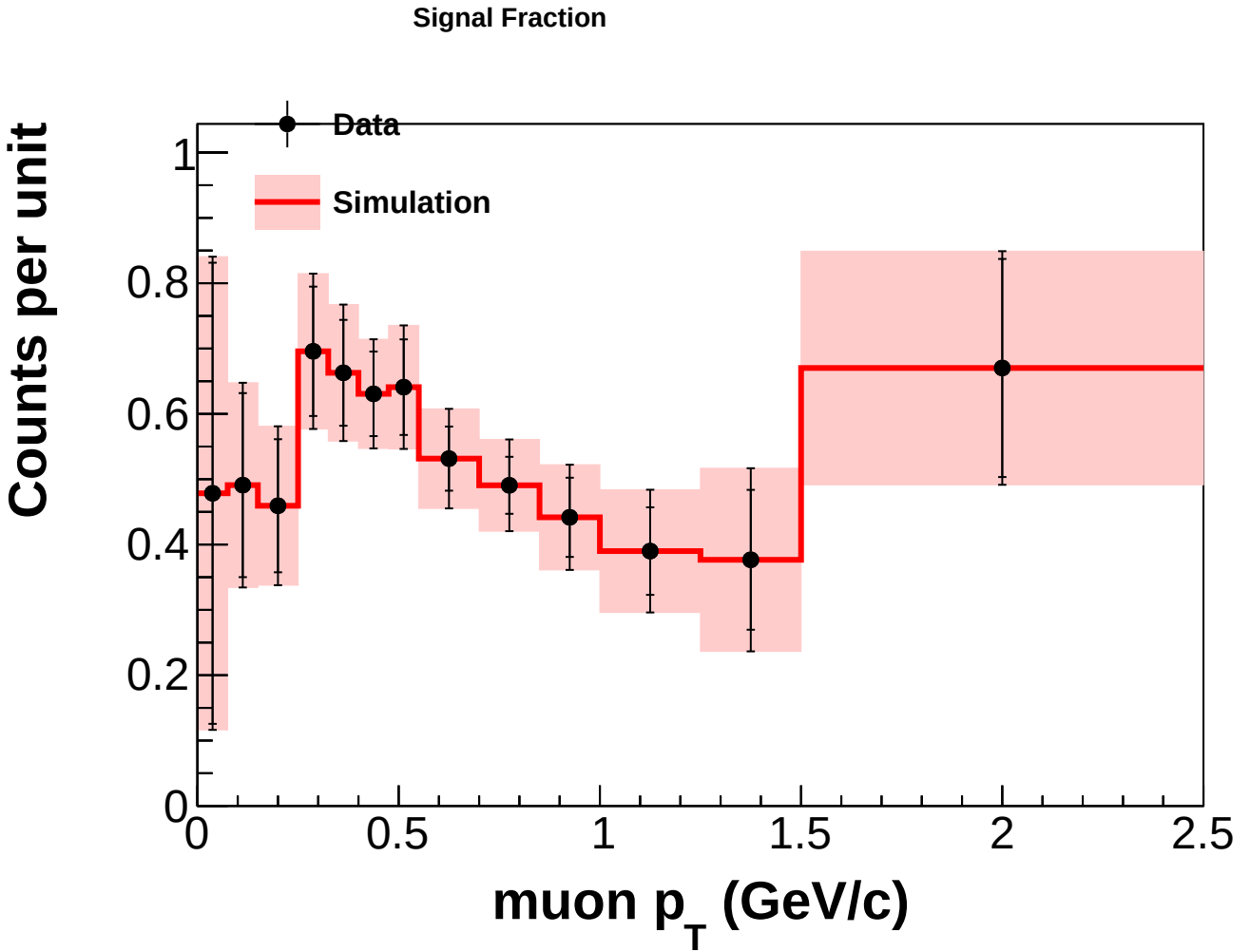

sigma
Data / MC
2.5
2
1.5
1
0.5
0
−0.5
10^{-3}
10^{-2}
10^{-1}
1
Q^2 (QE) (GeV^2)

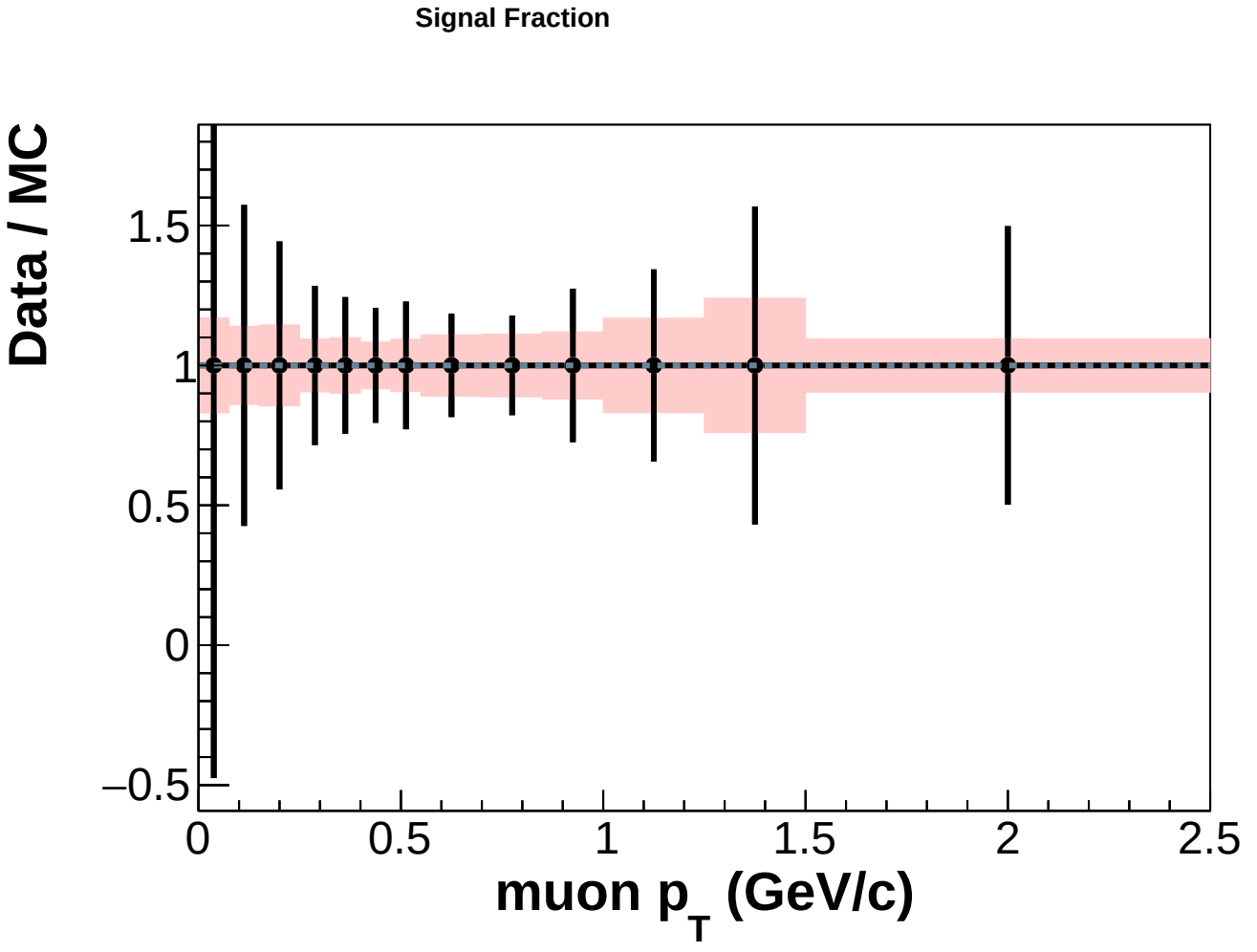

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.5
1
1.5
2
Q² (QE) (GeV²)

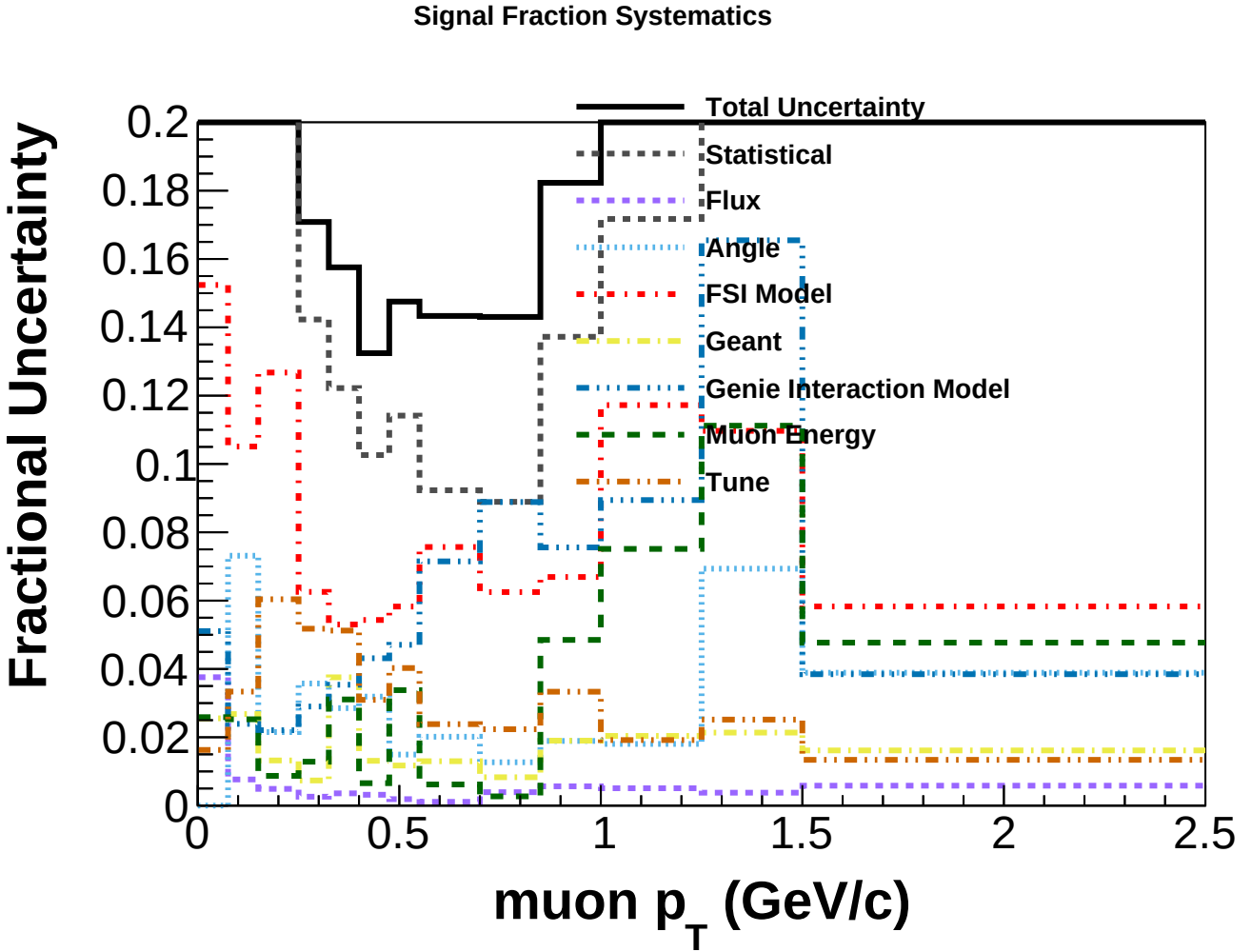

DATA_vs_MC
Counts per unit
×10^3
Data
Simulation
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

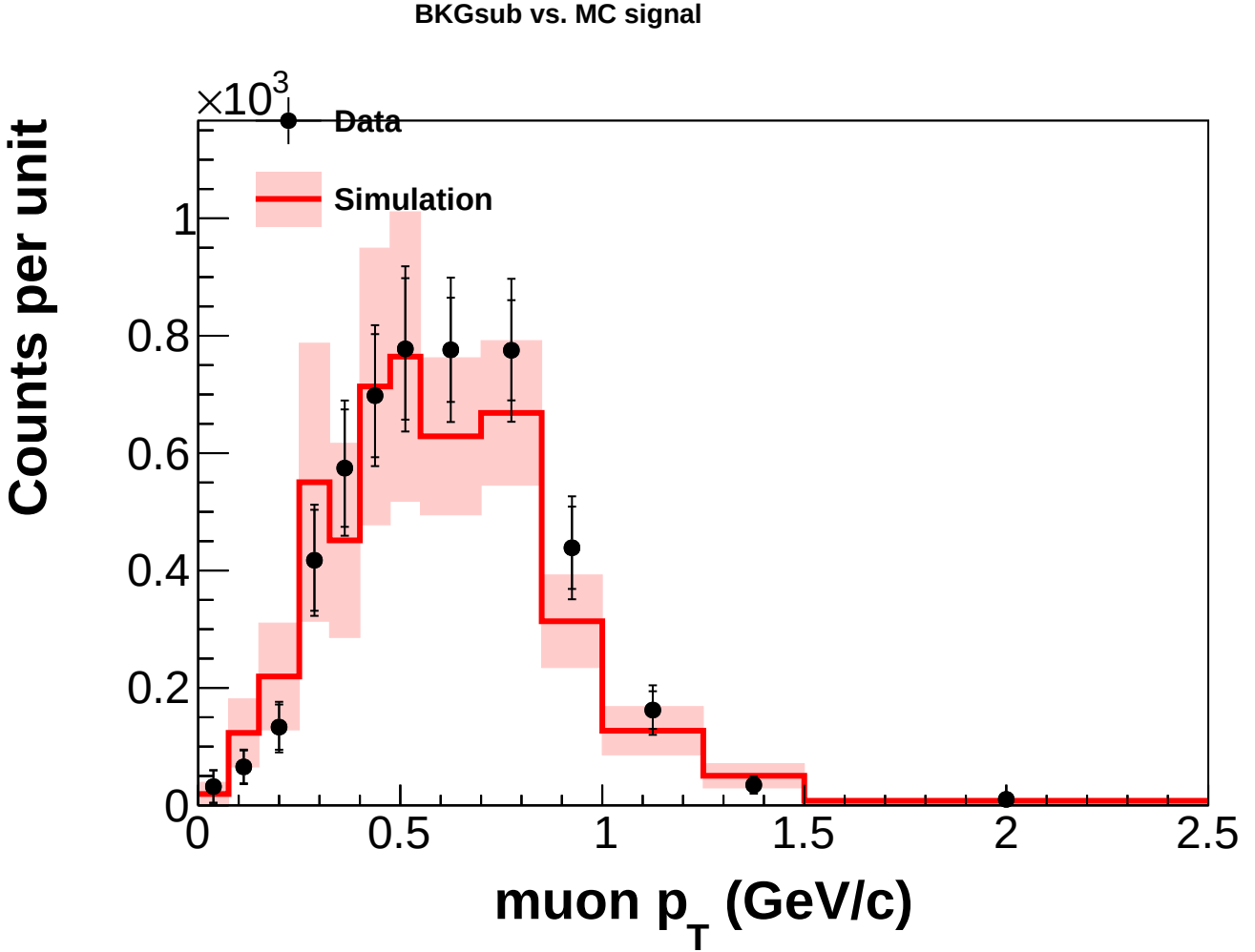

DATA_vs_MC
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

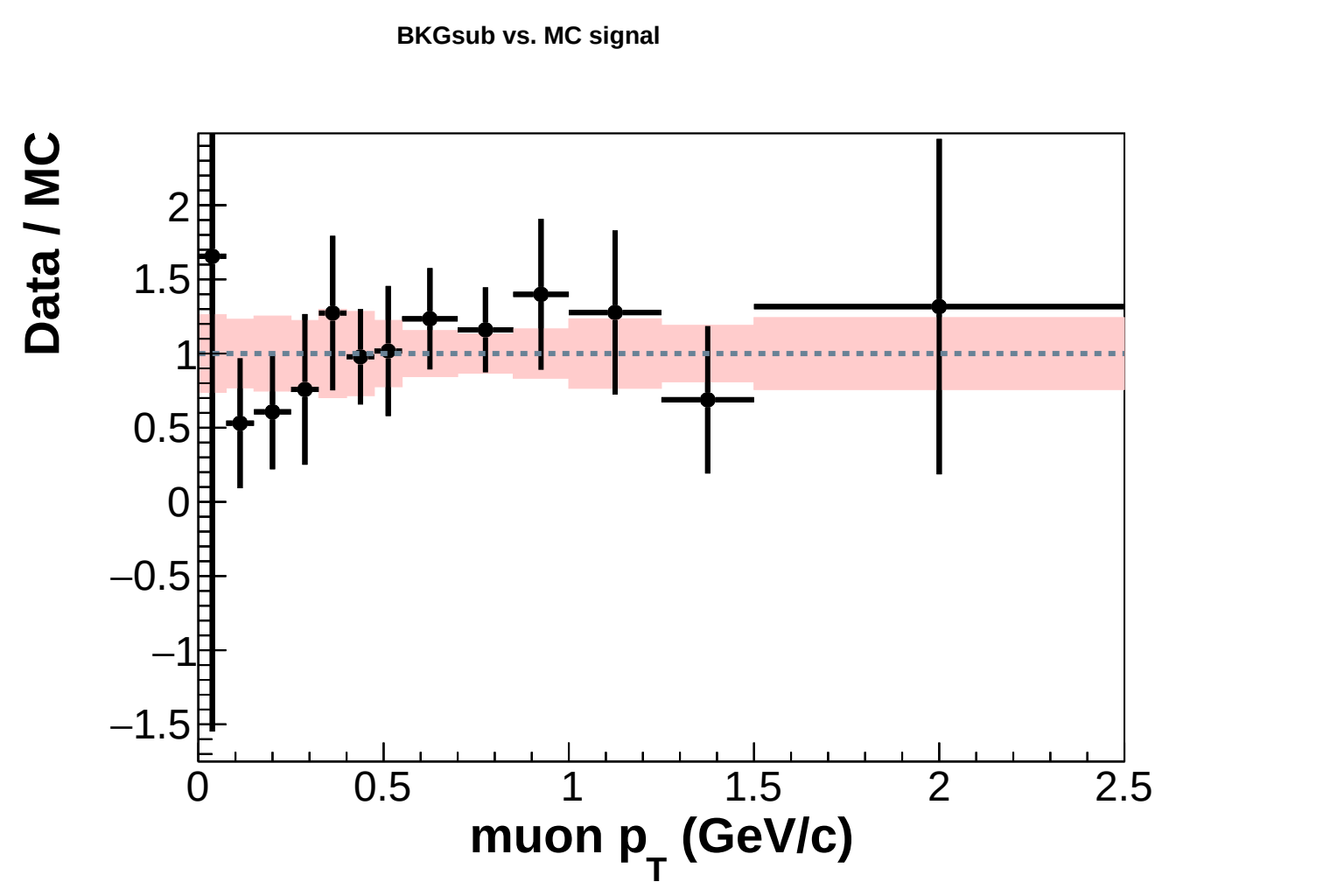

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

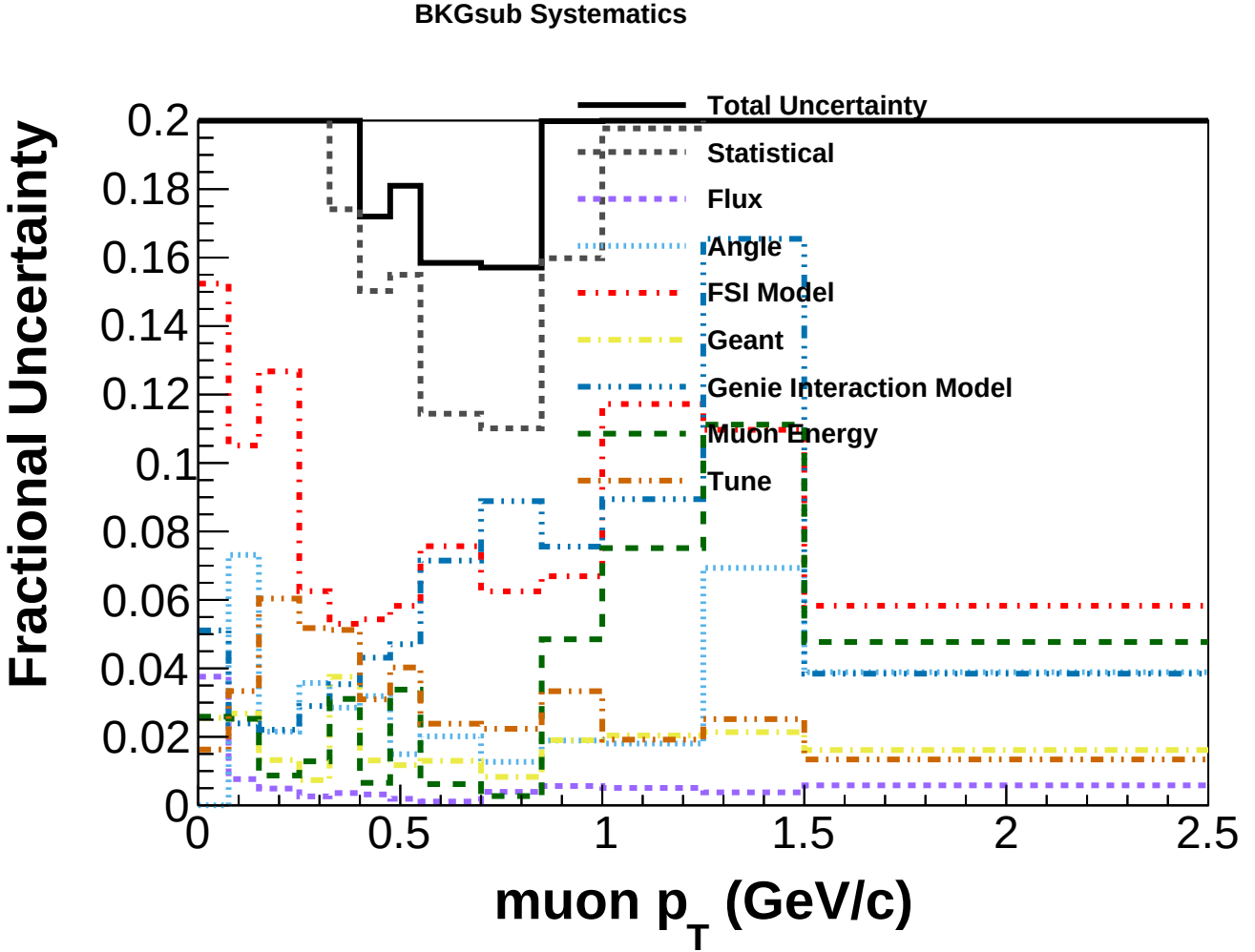

Signal Fraction
Data
Simulation
Counts per unit
0
0.2
0.4
0.6
0.8
1
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

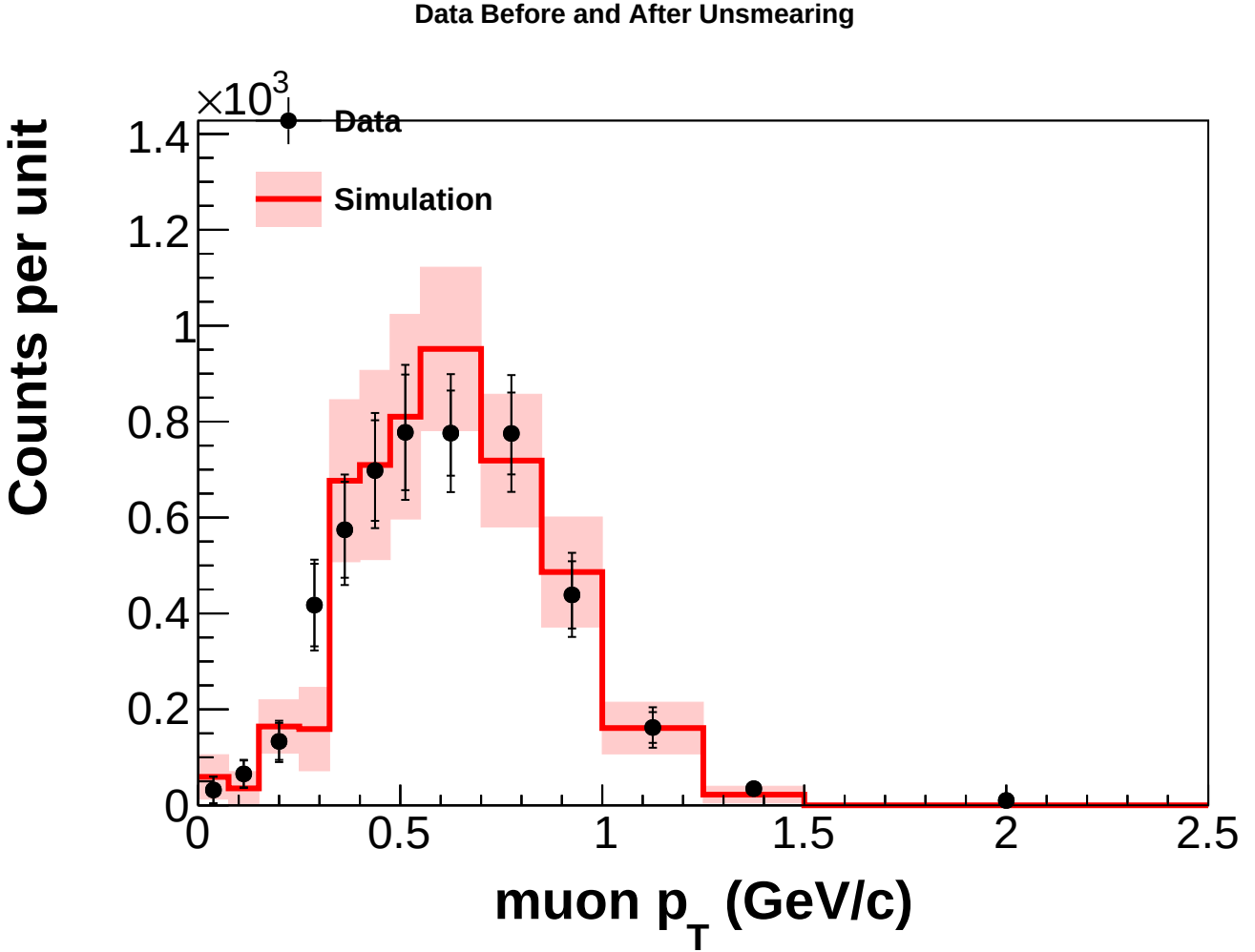

Signal Fraction
Data / MC
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

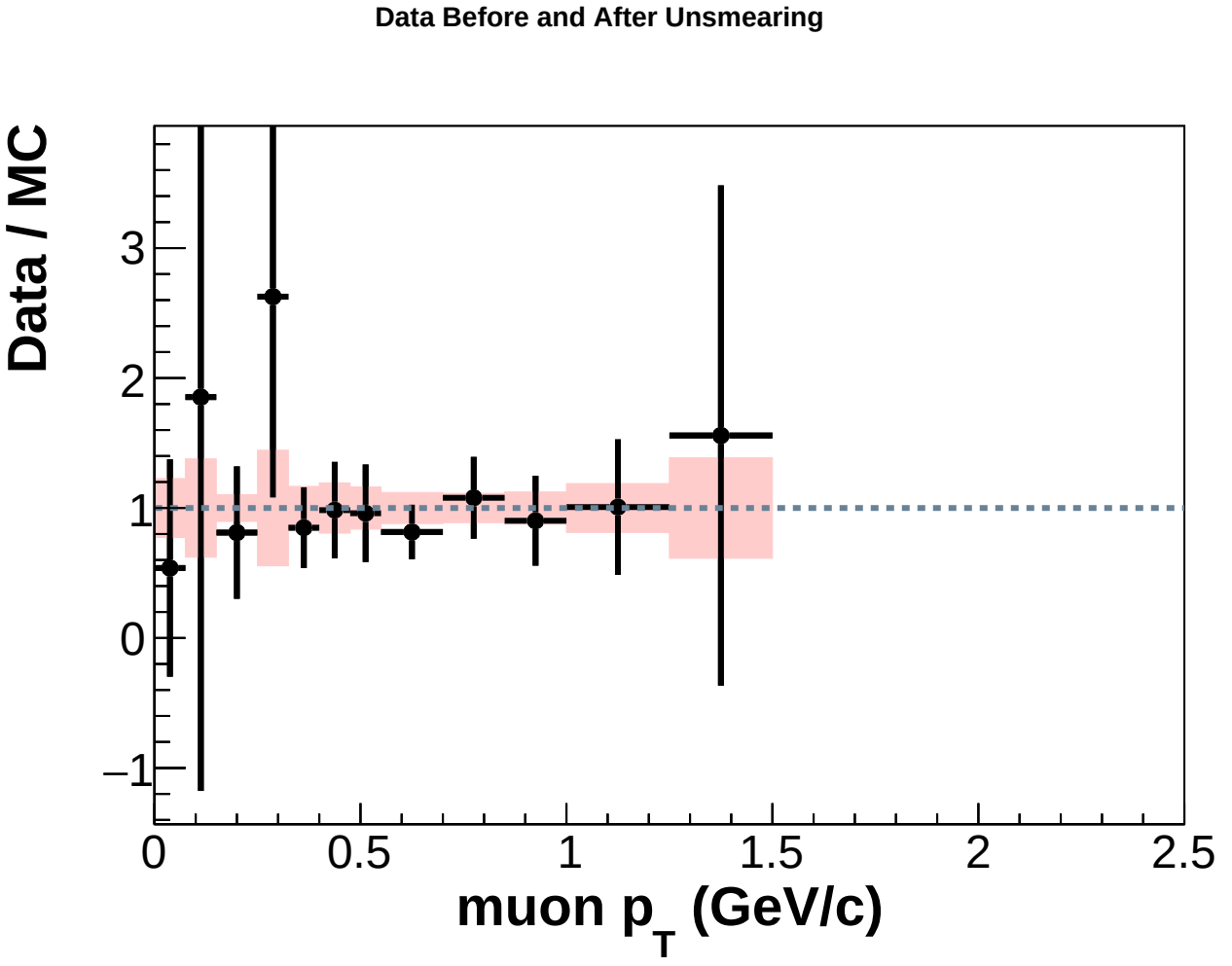

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

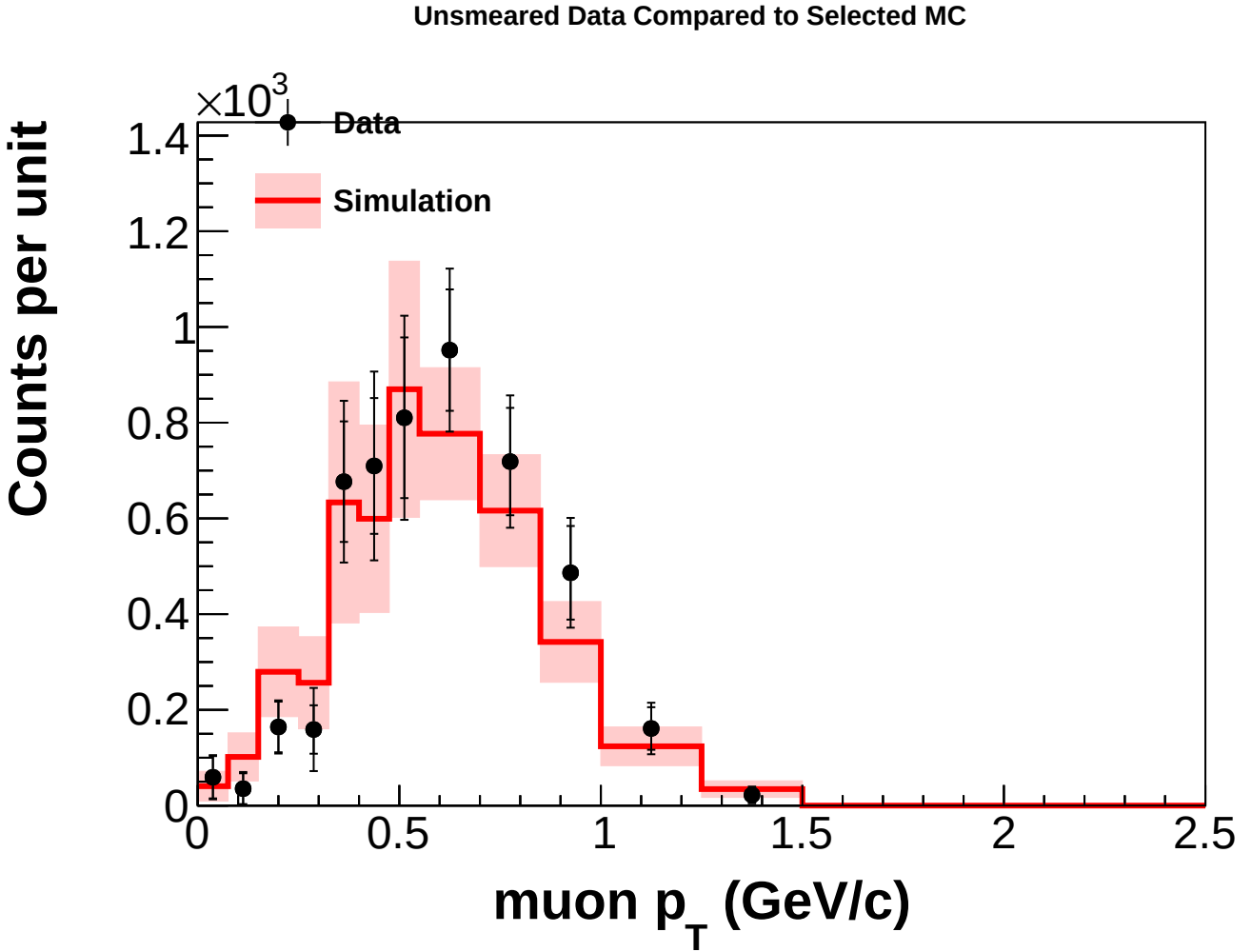

BKGsub vs. MC signal
Counts per unit
×10^3
Data
Simulation
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

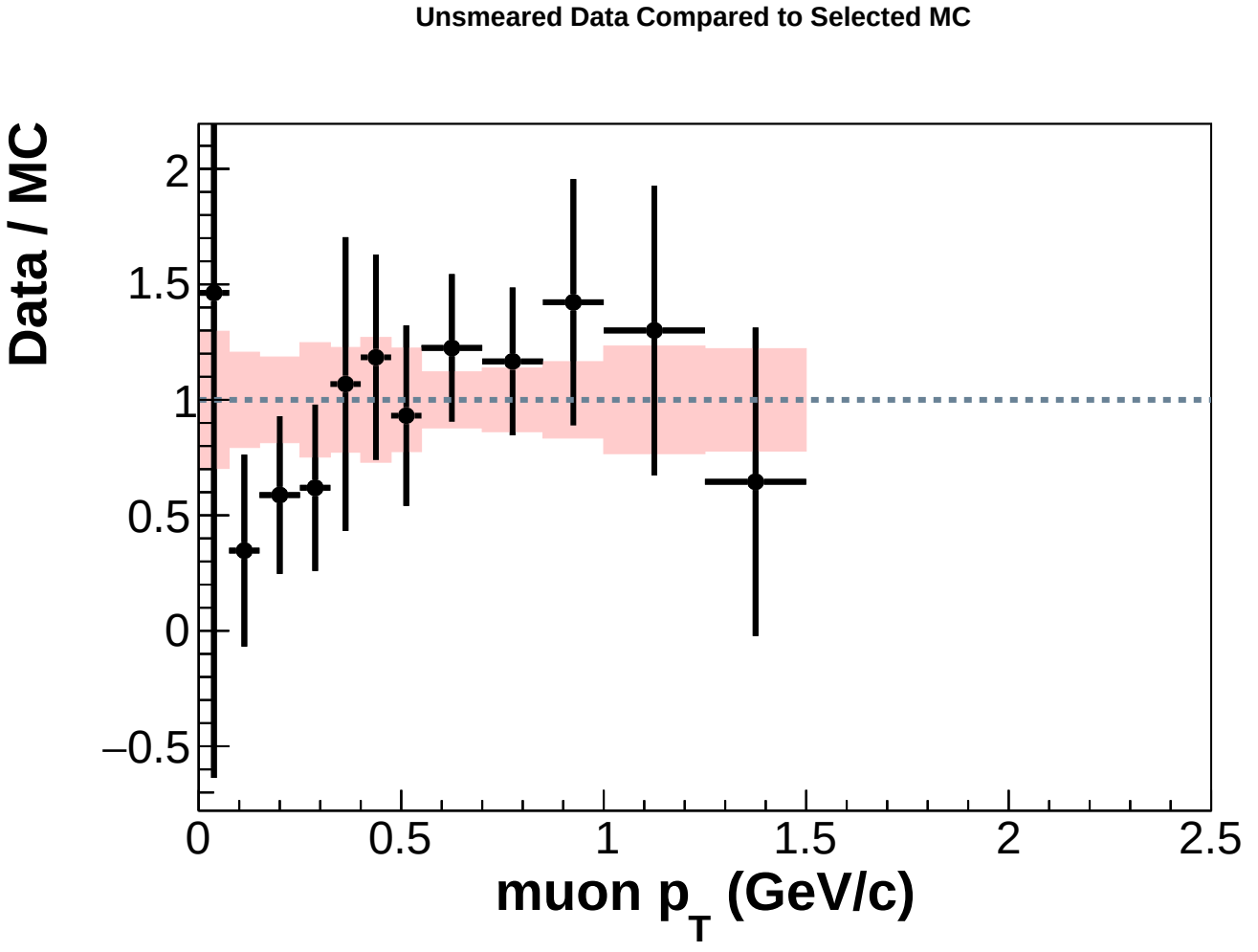

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

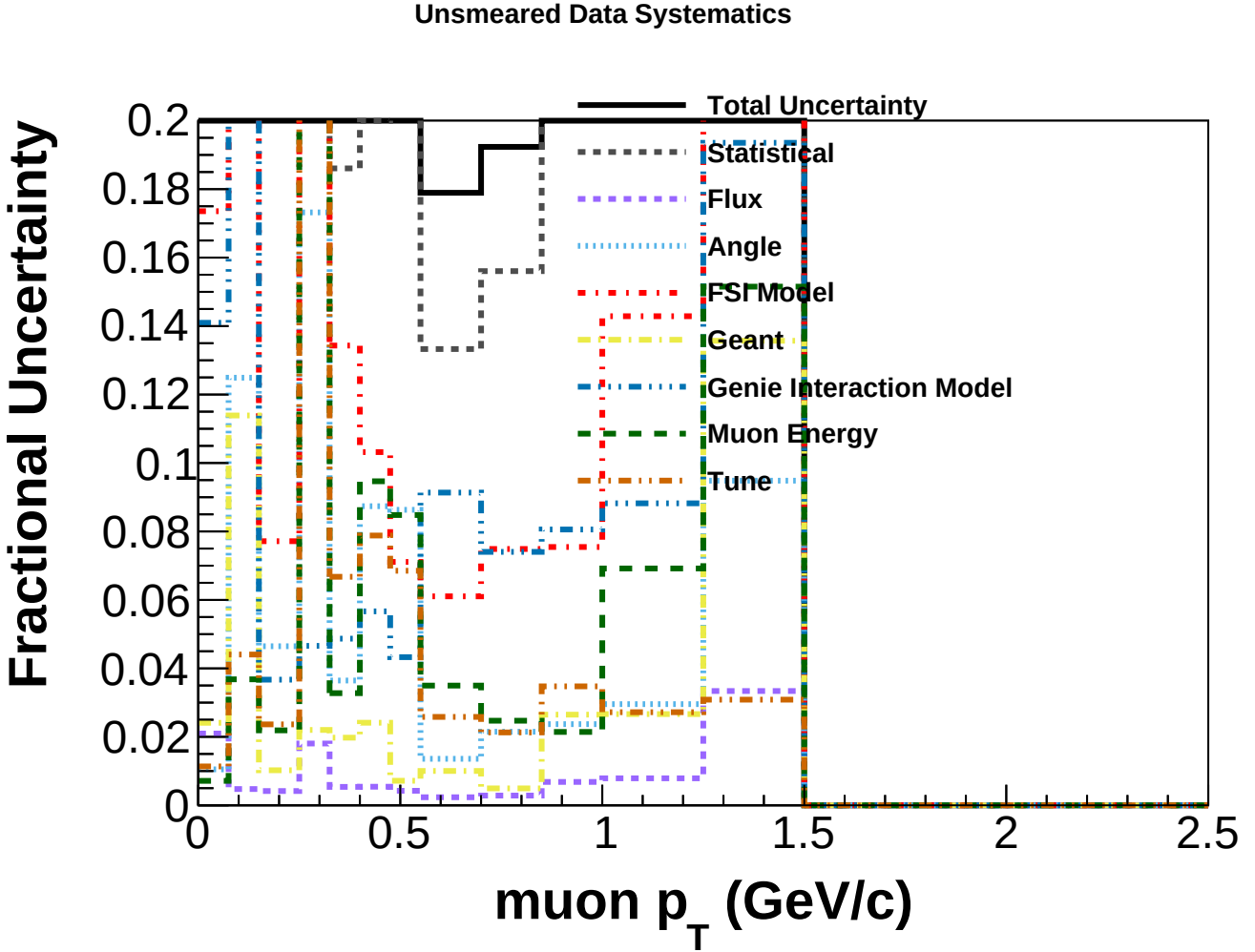

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

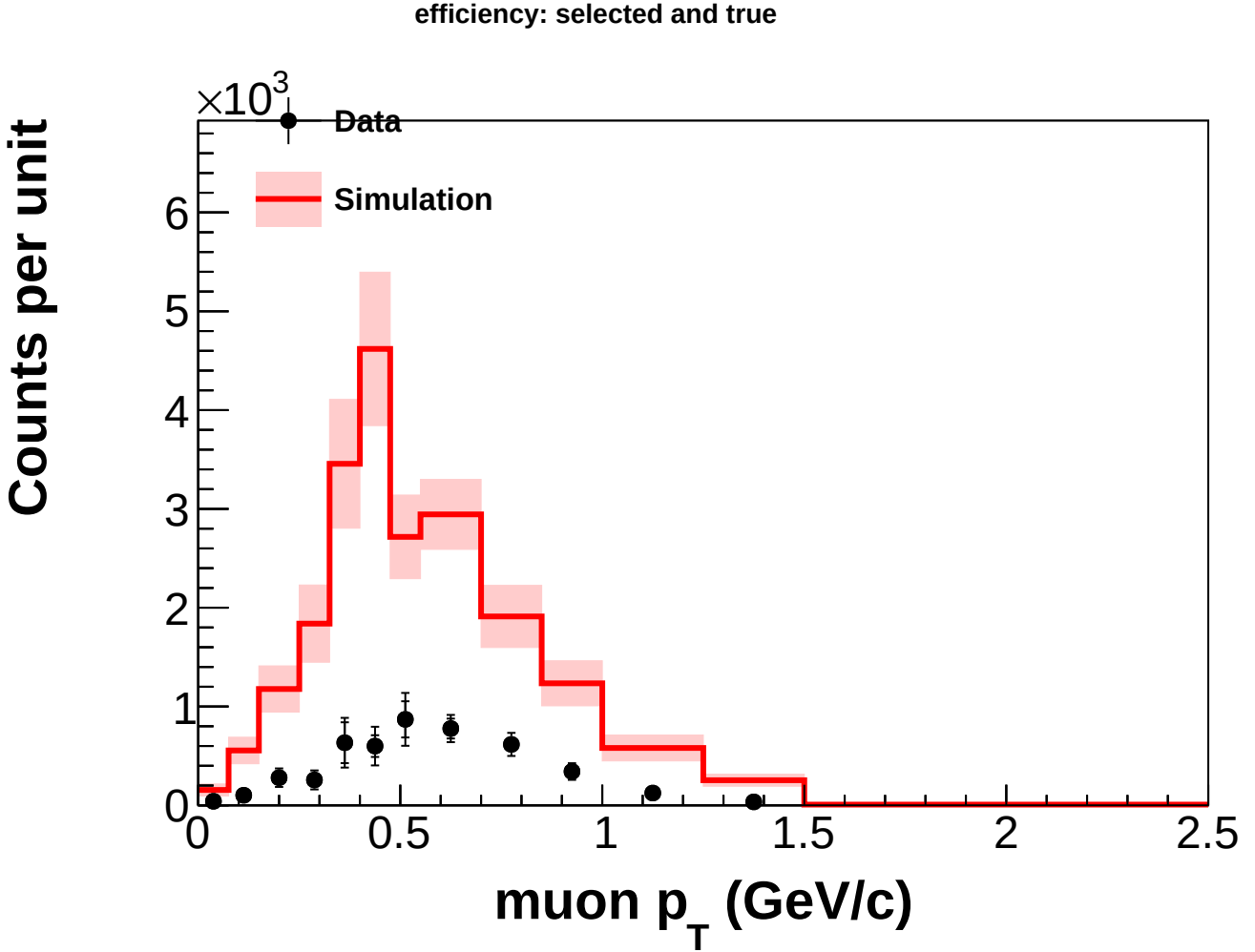

Data Before and After Unsmearing
Counts per unit
×10^3
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Data
Simulation
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

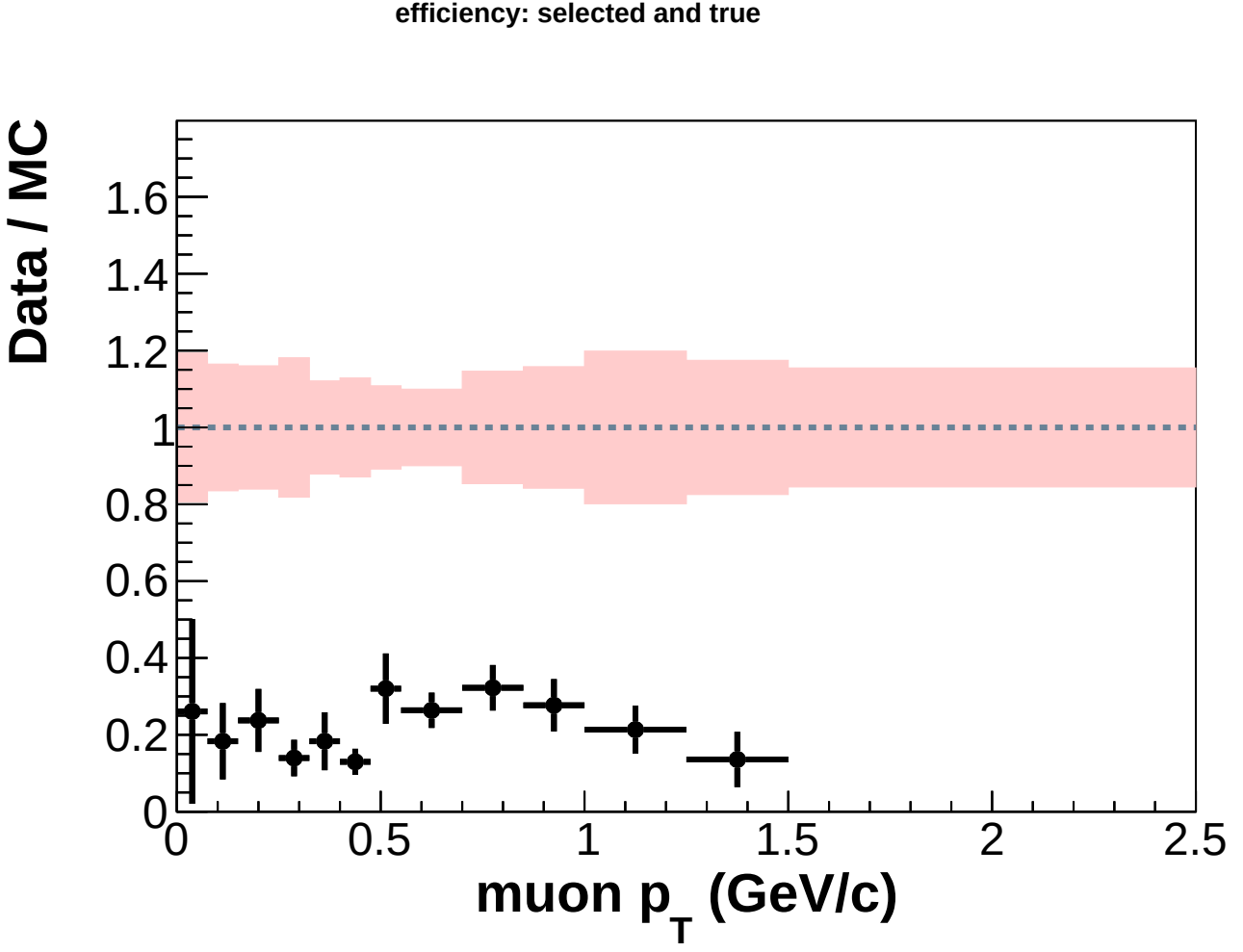

Data Before and After Unsmearing
Data / MC
3
2
1
0
−1
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

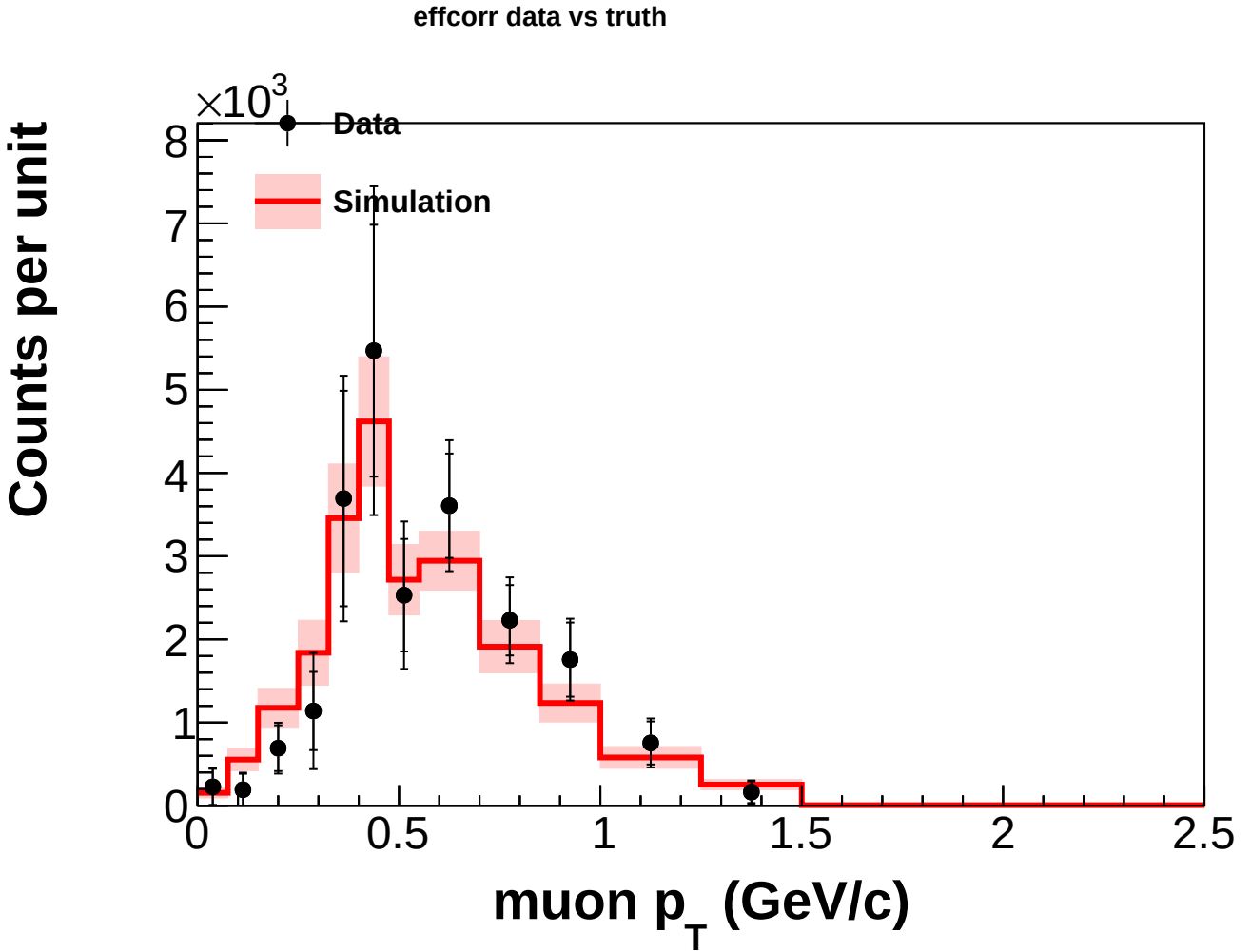

Unsmeared Data Compared to Selected MC
Counts per unit
×10^3
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Data
Simulation
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

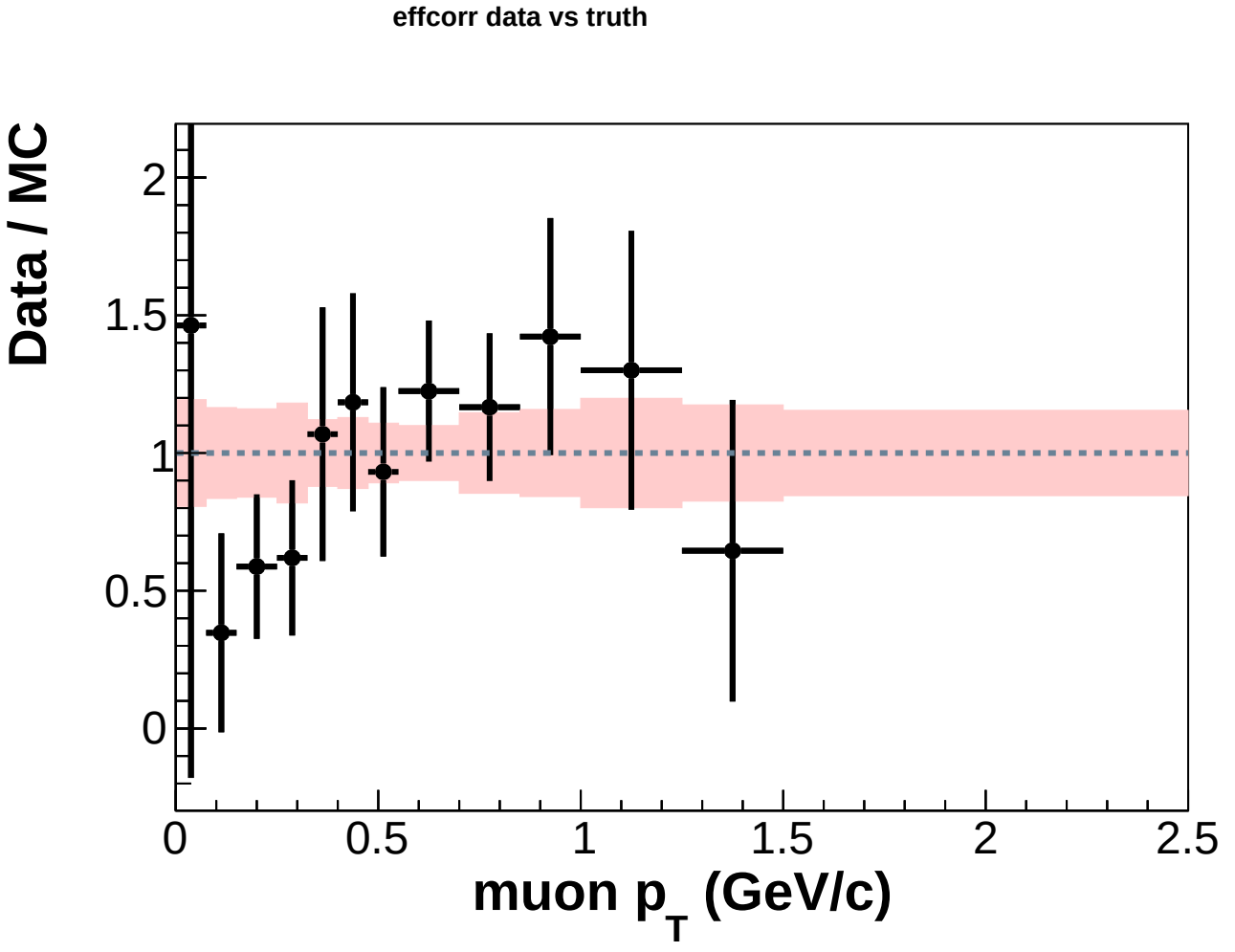

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
−0.5
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

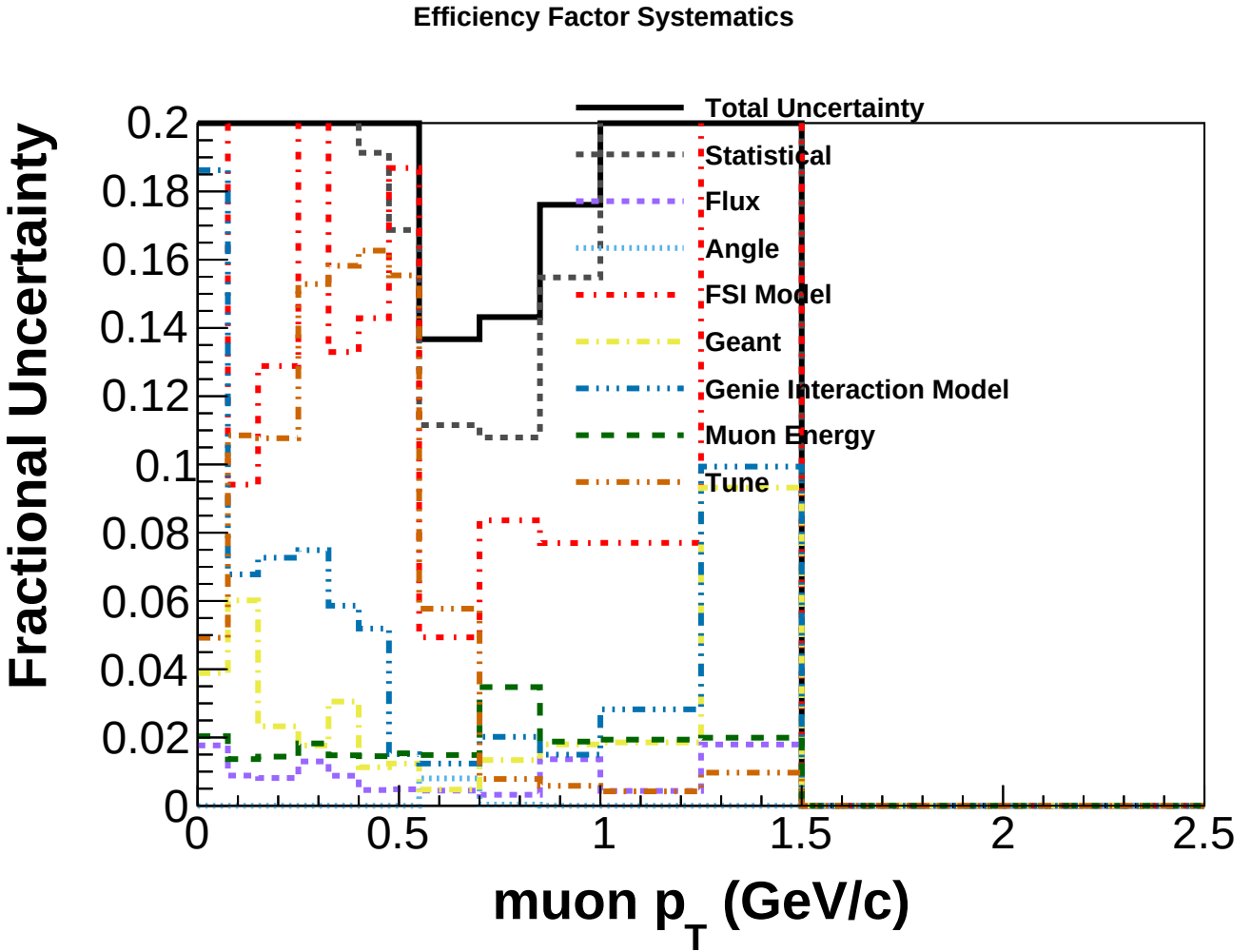

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

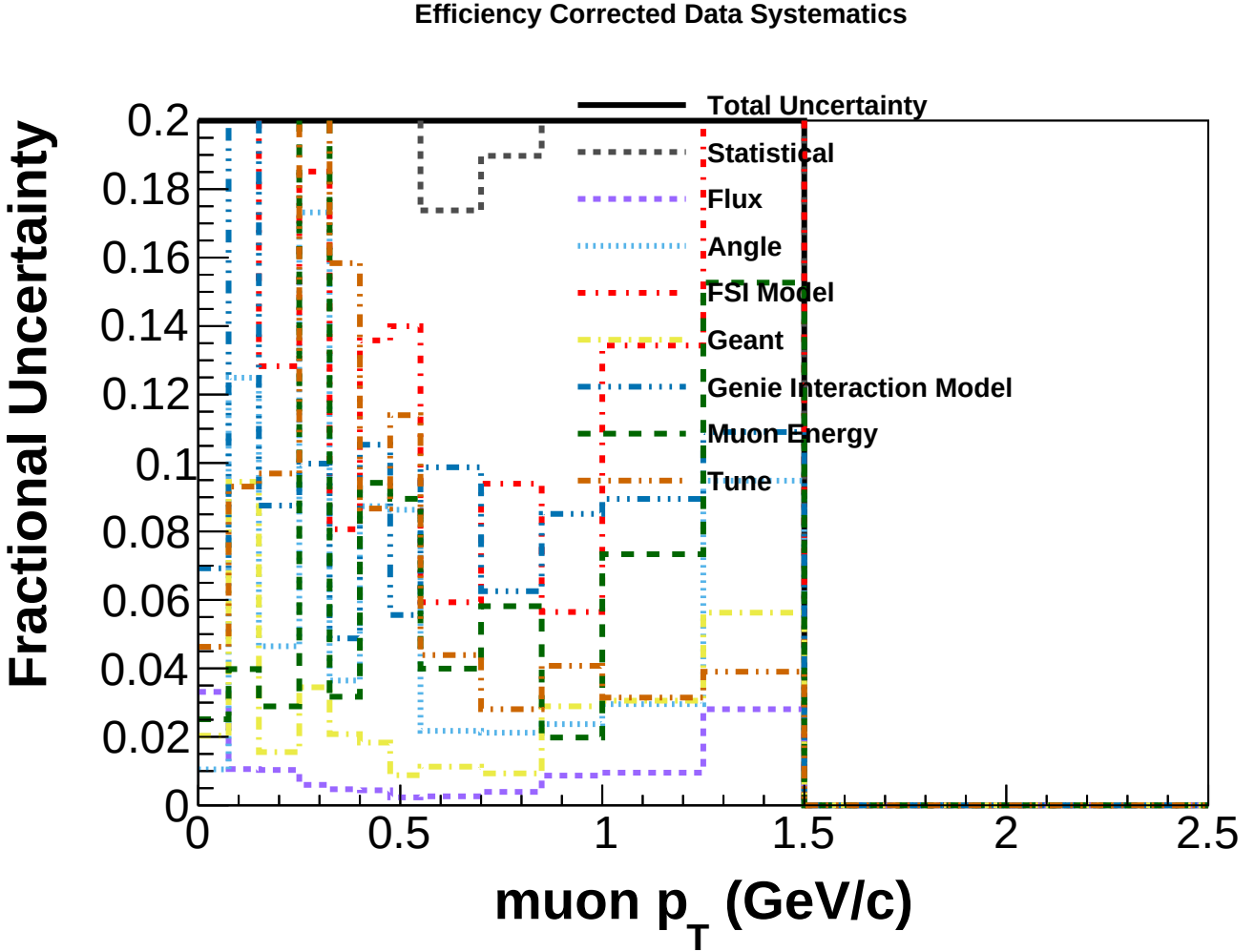

efficiency: selected and true
Counts per unit
×10^3
Data
Simulation
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

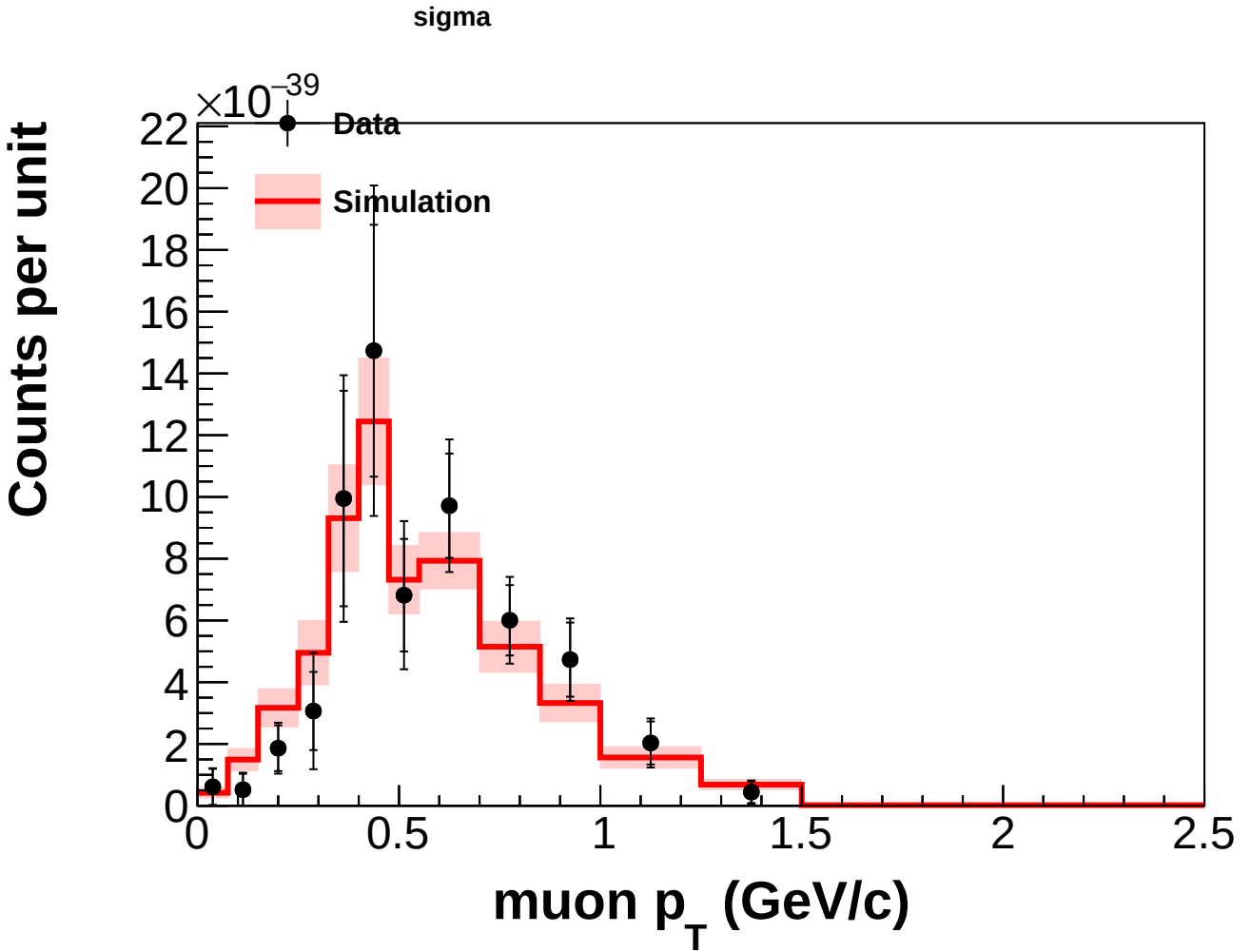

efficiency: selected and true
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

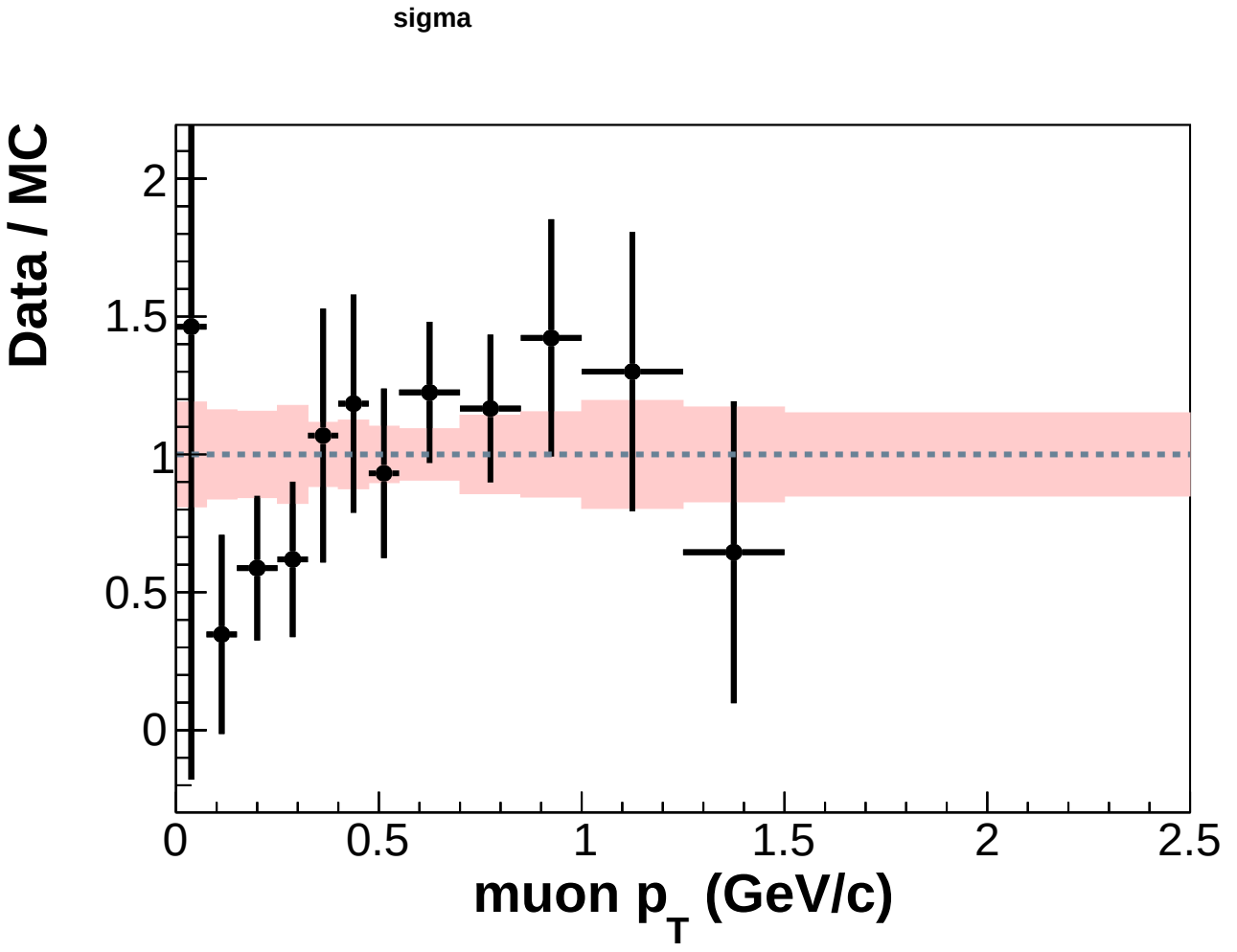

effcorr data vs truth
Counts per unit
×10^3
Data
Simulation
8
7
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

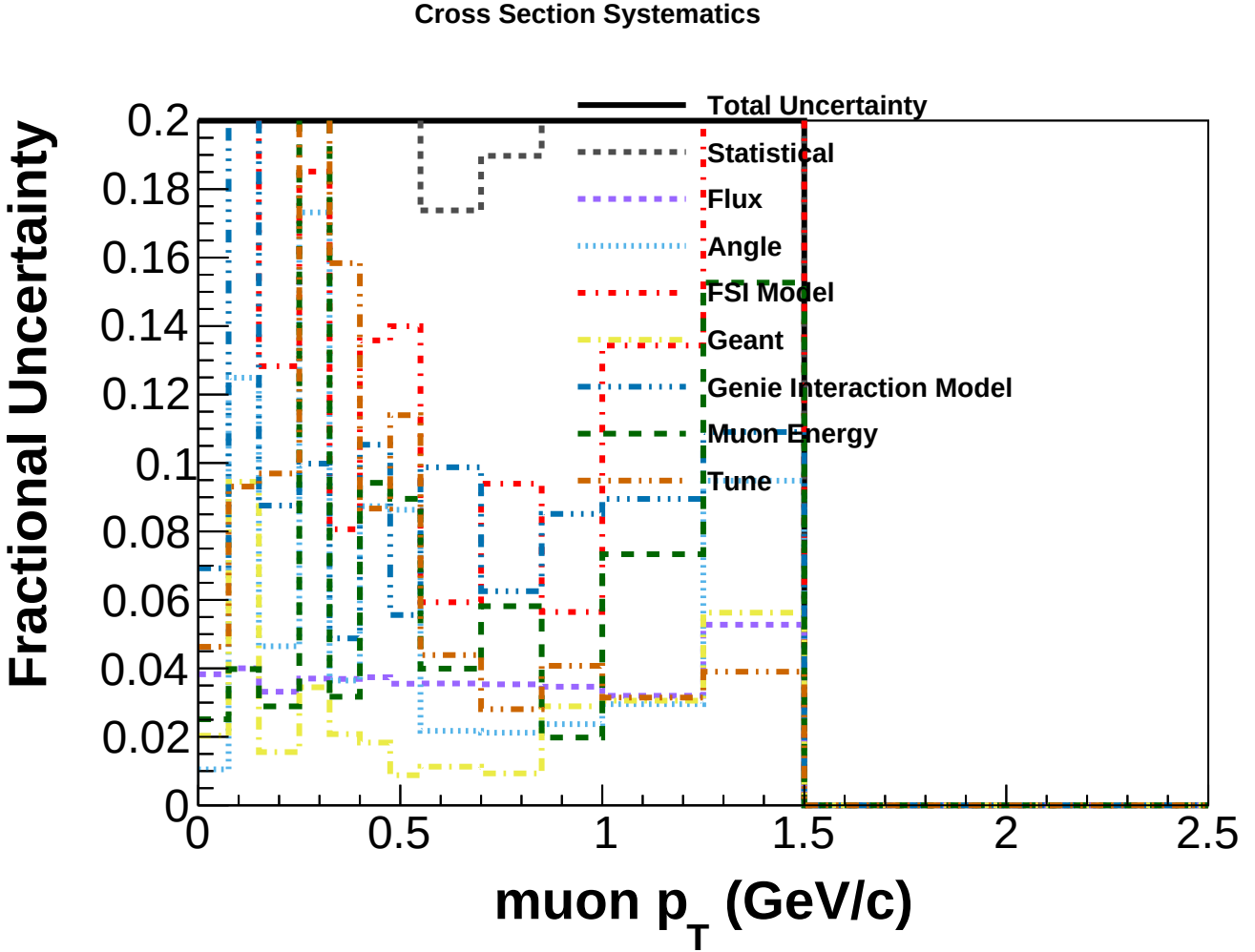

effcorr data vs truth
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

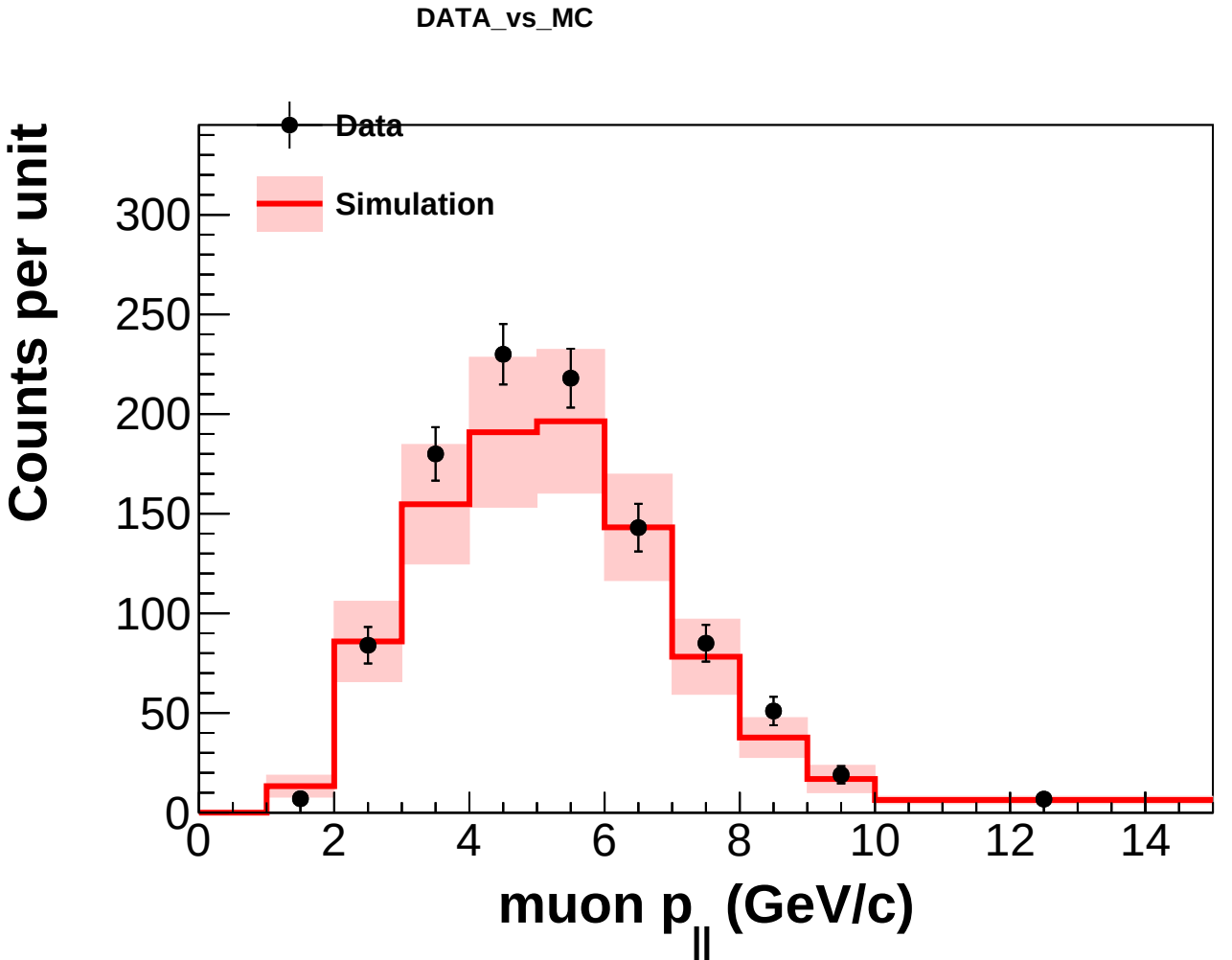

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

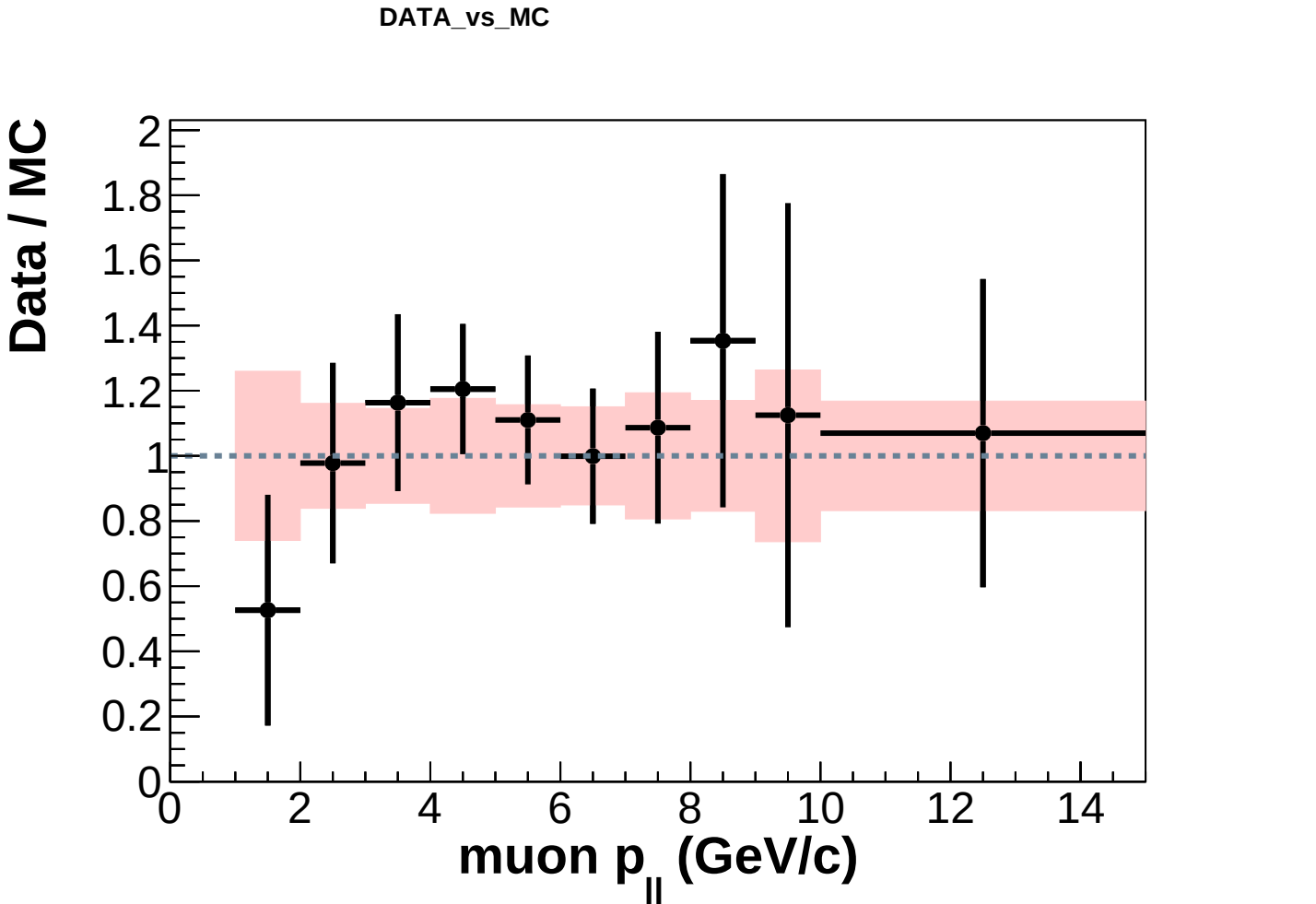

Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

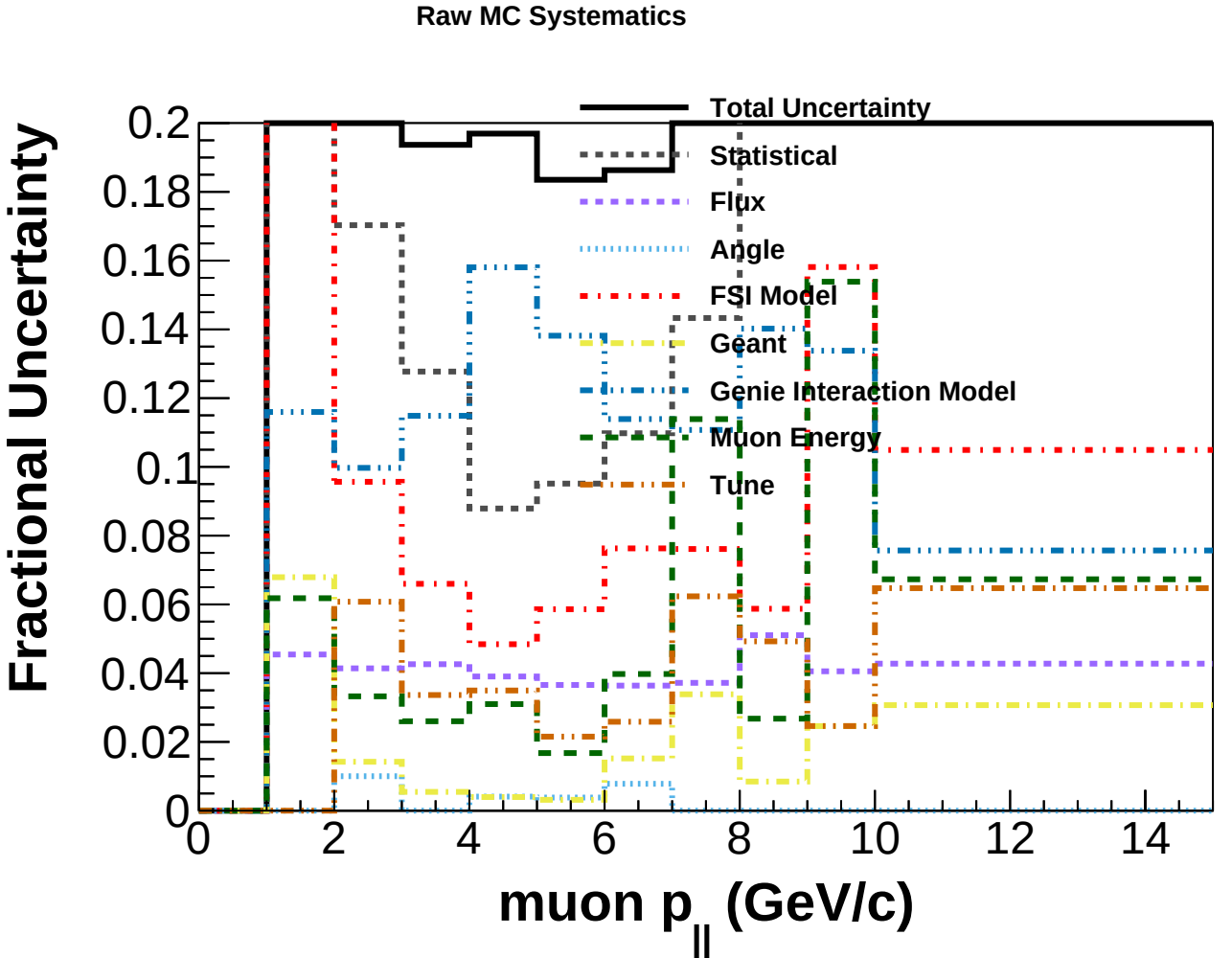

sigma
Counts per unit
×10⁻³⁹
Data
Simulation
22
20
18
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

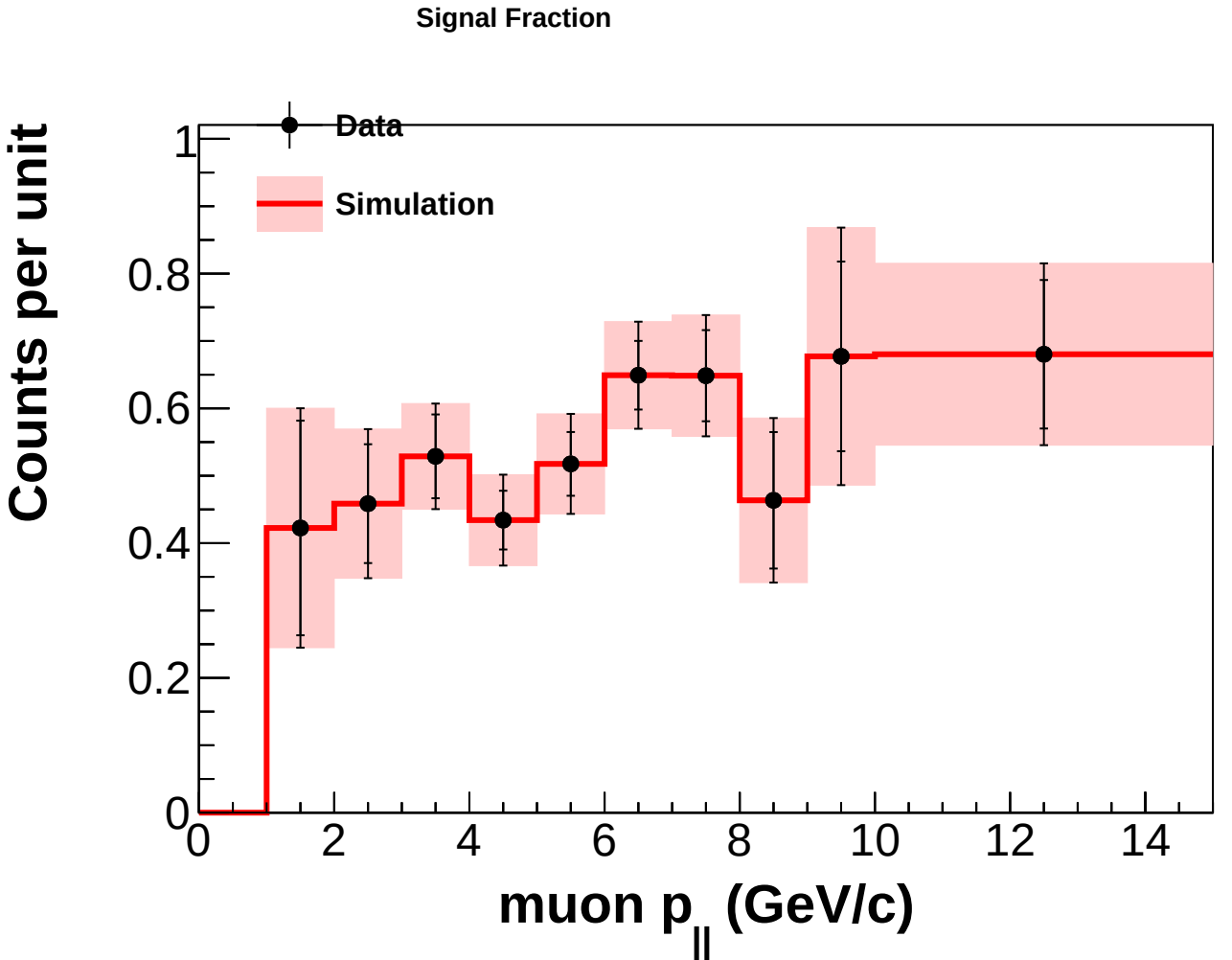

sigma
Data / MC
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

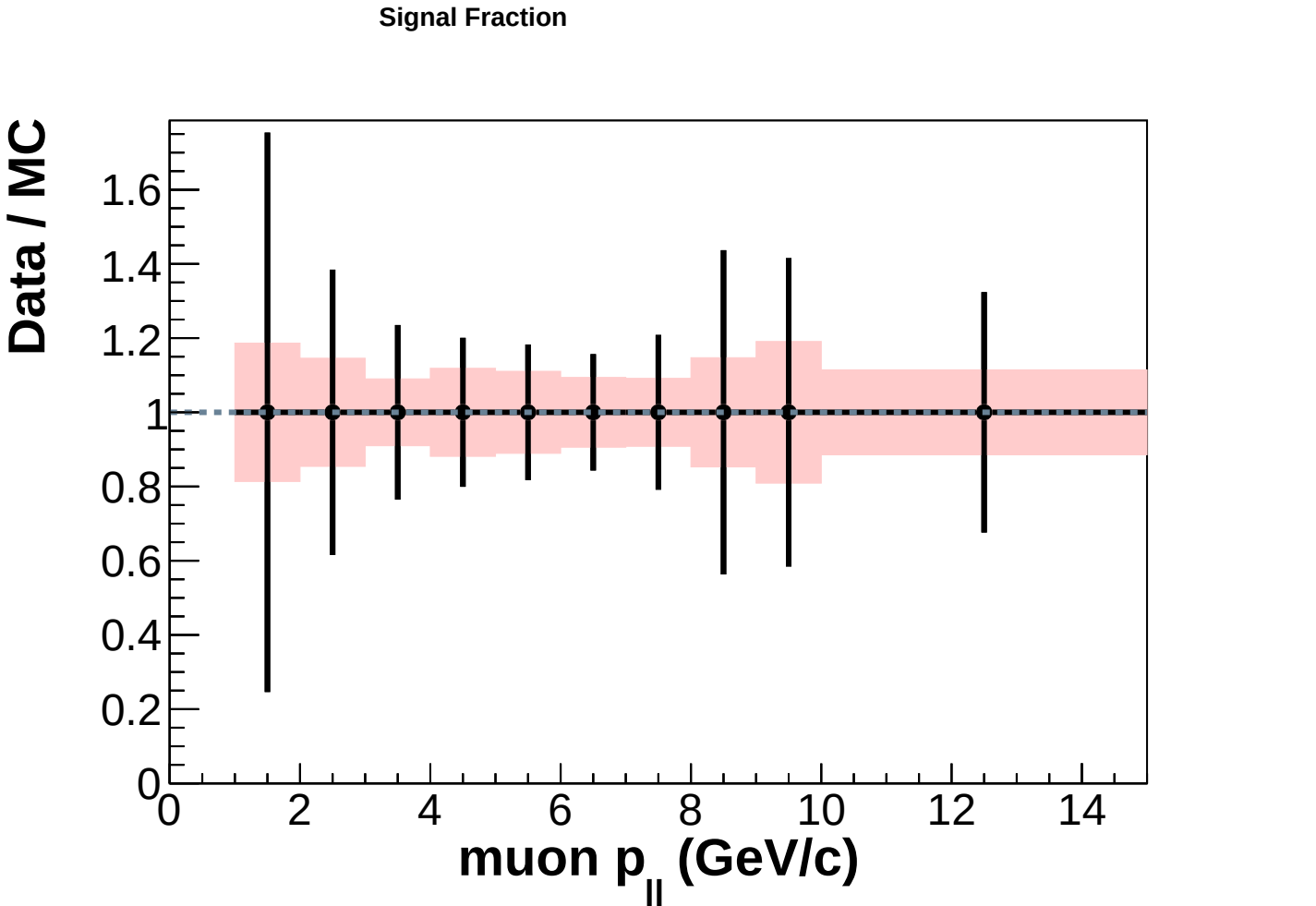

Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
muon p_T (GeV/c)

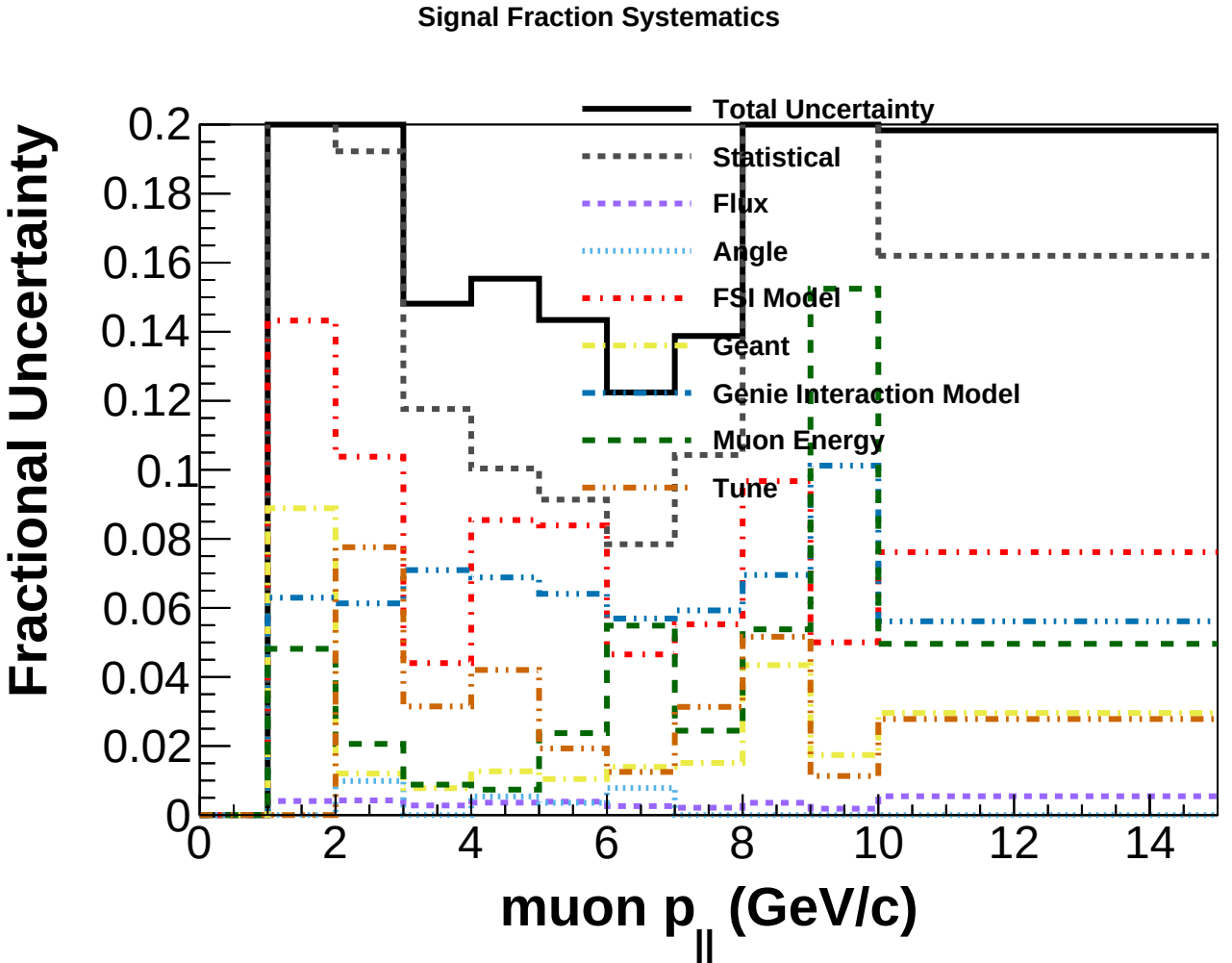

DATA_vs_MC
Data
Simulation
Counts per unit
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

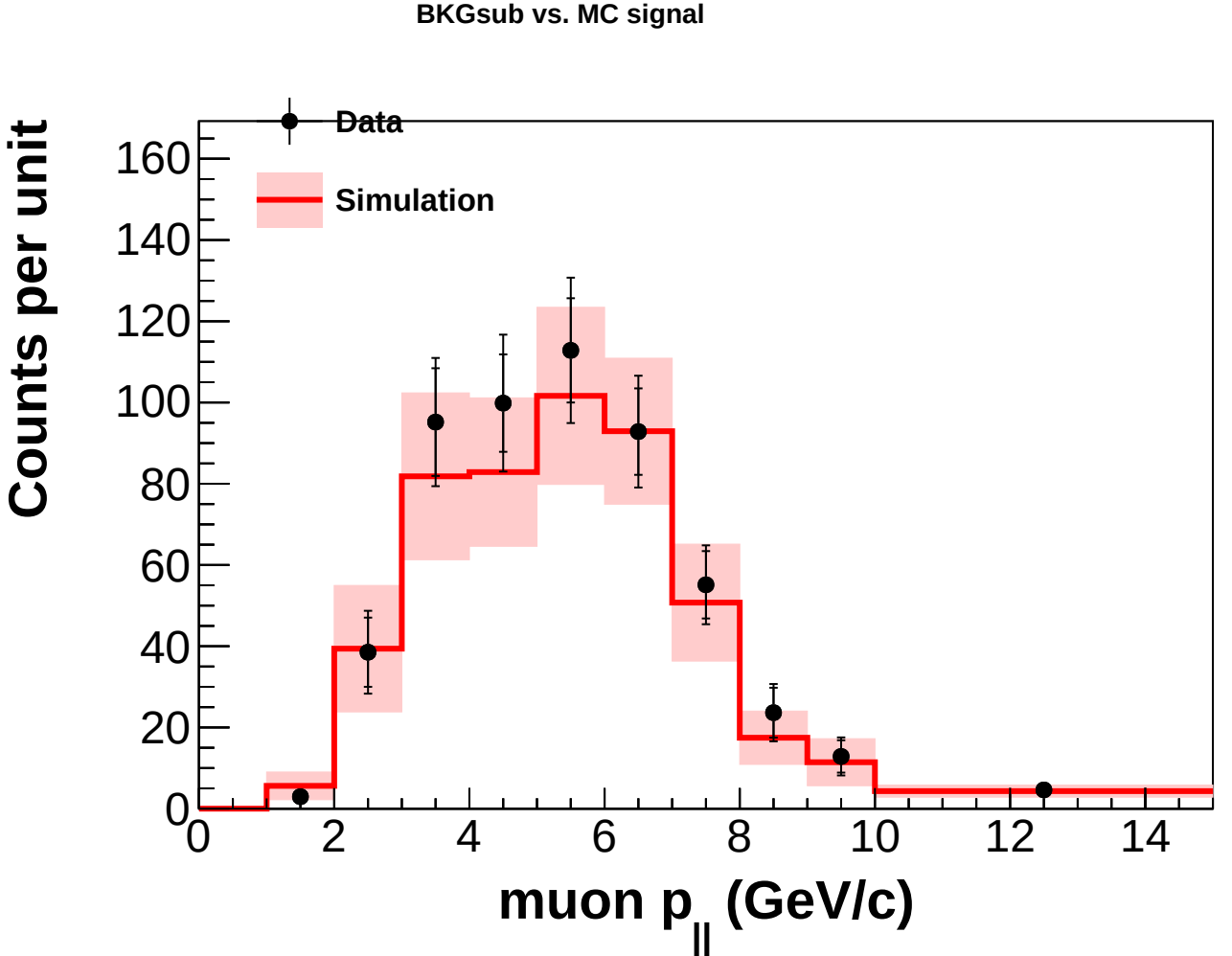

DATA_vs_MC
Data / MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

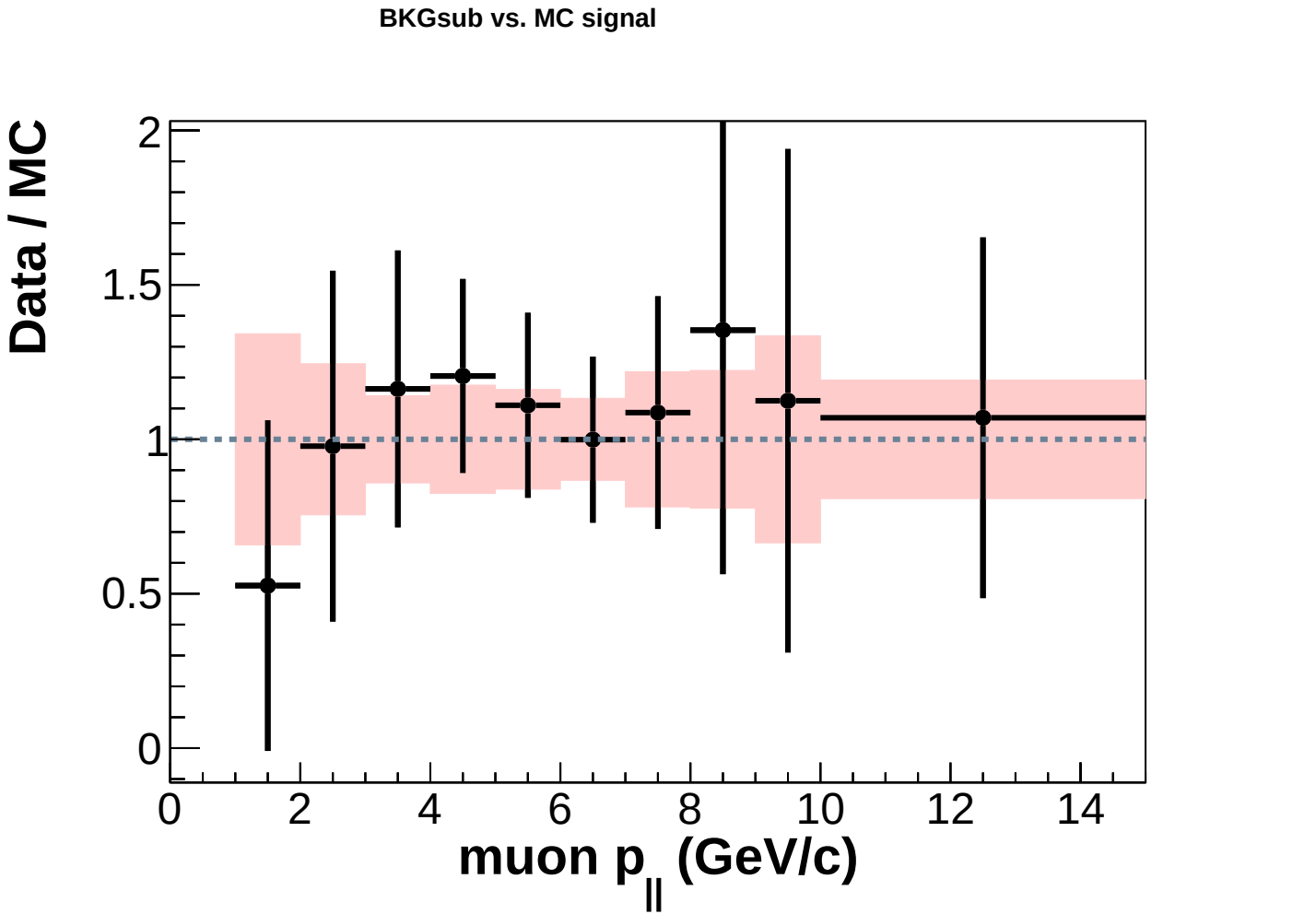

Raw MC Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

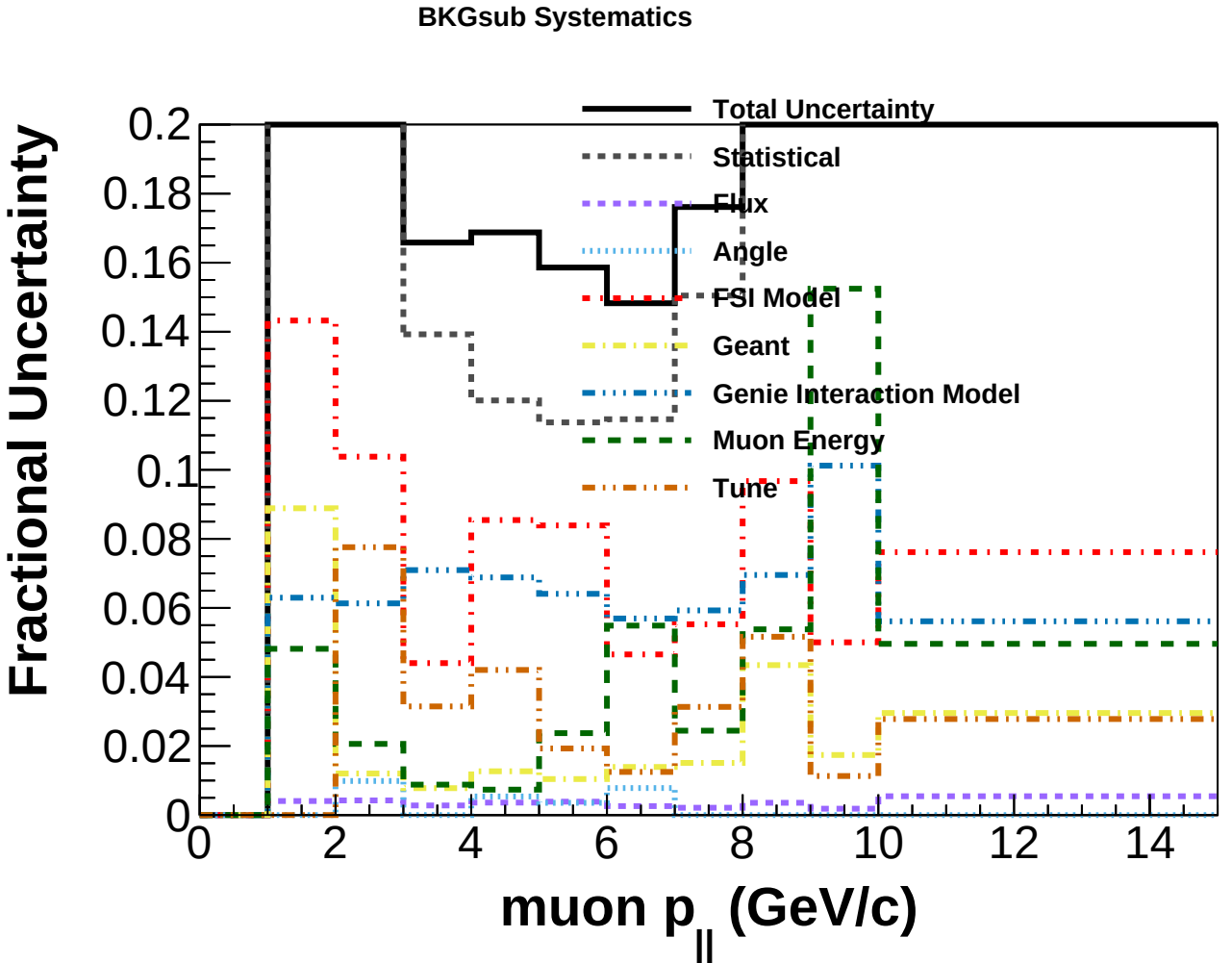

Signal Fraction
Data
Simulation
Counts per unit
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

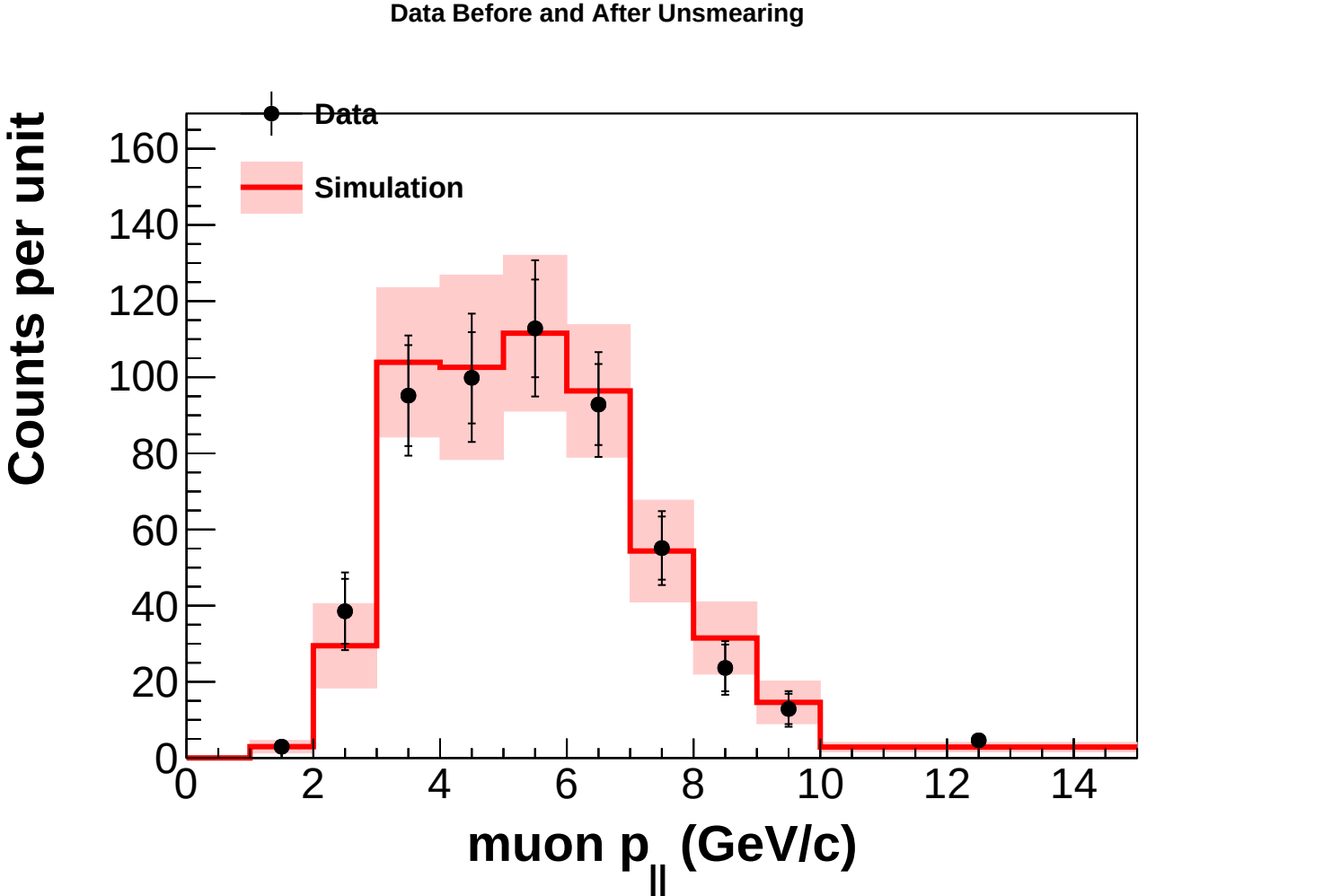

Signal Fraction
Data / MC
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

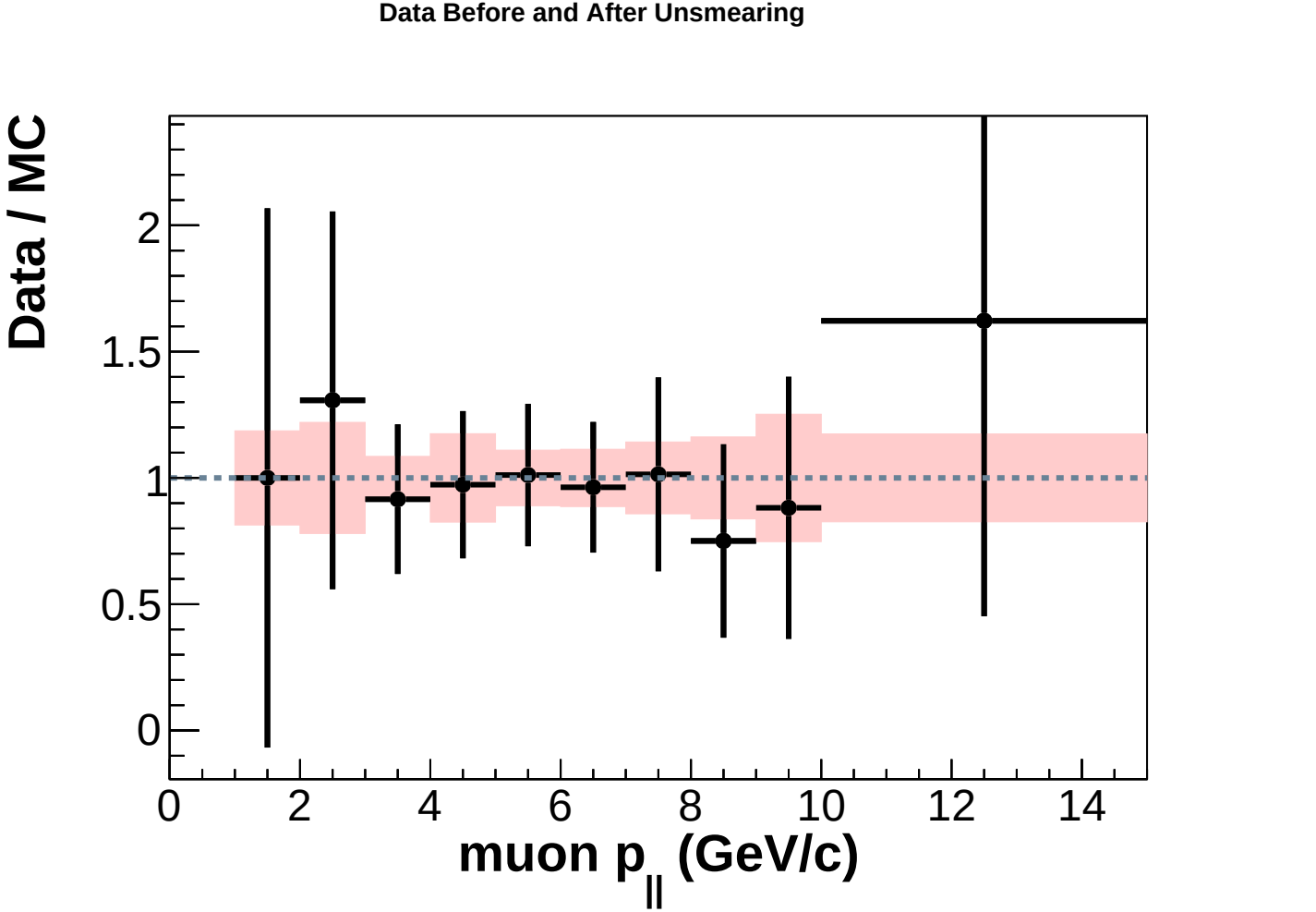

Signal Fraction Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

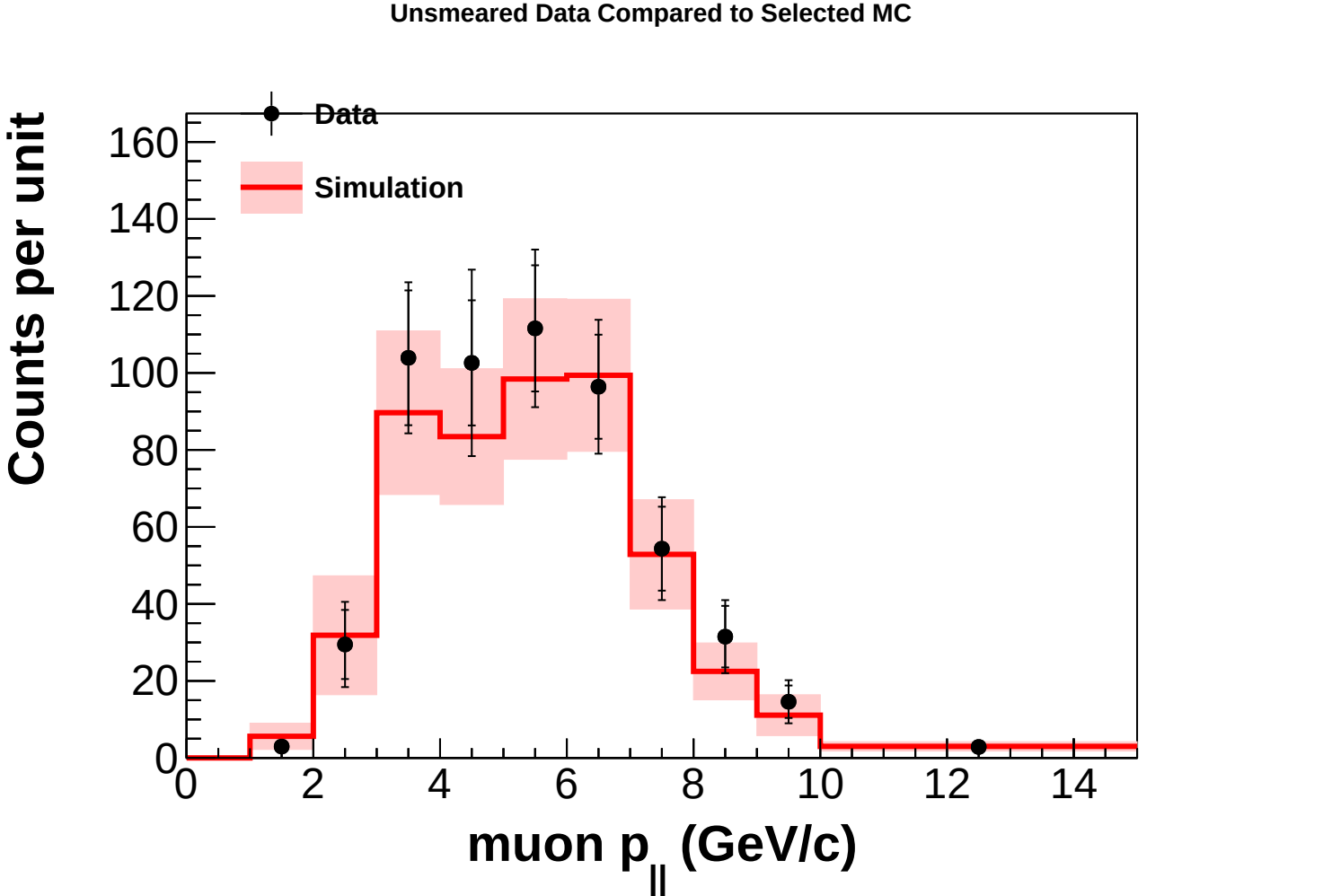

BKGsub vs. MC signal
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

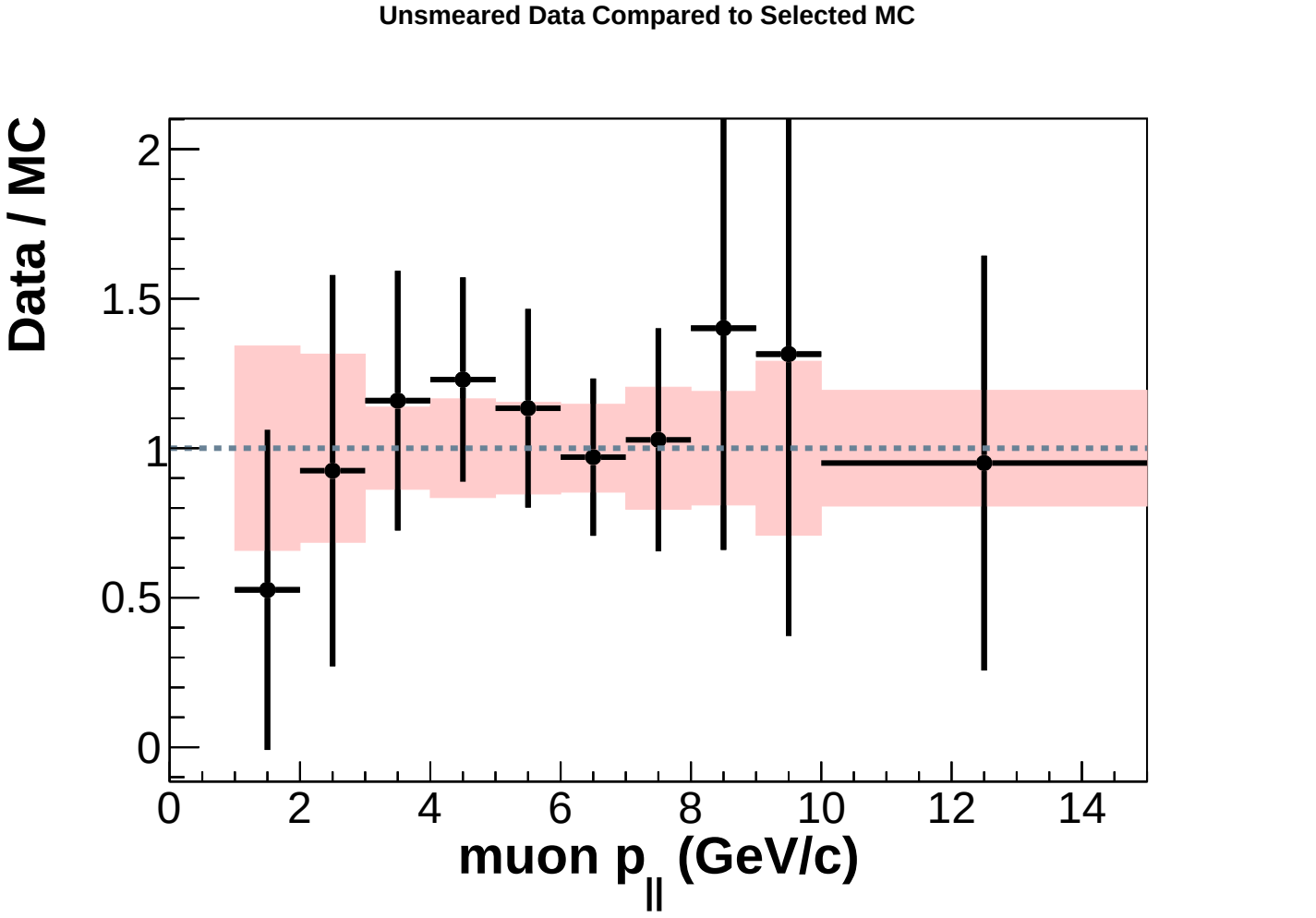

BKGsub vs. MC signal
Data / MC
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

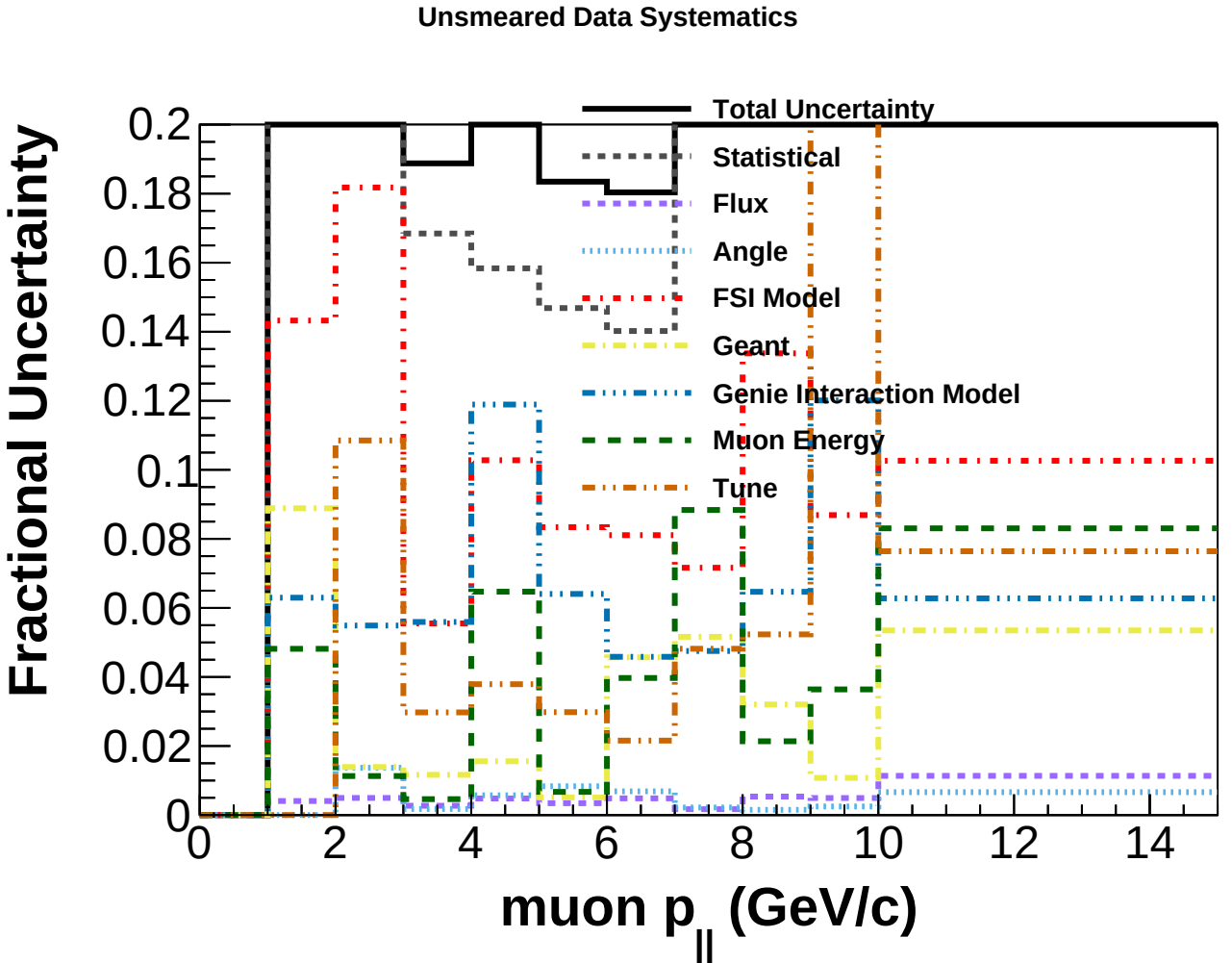

BKGsub Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

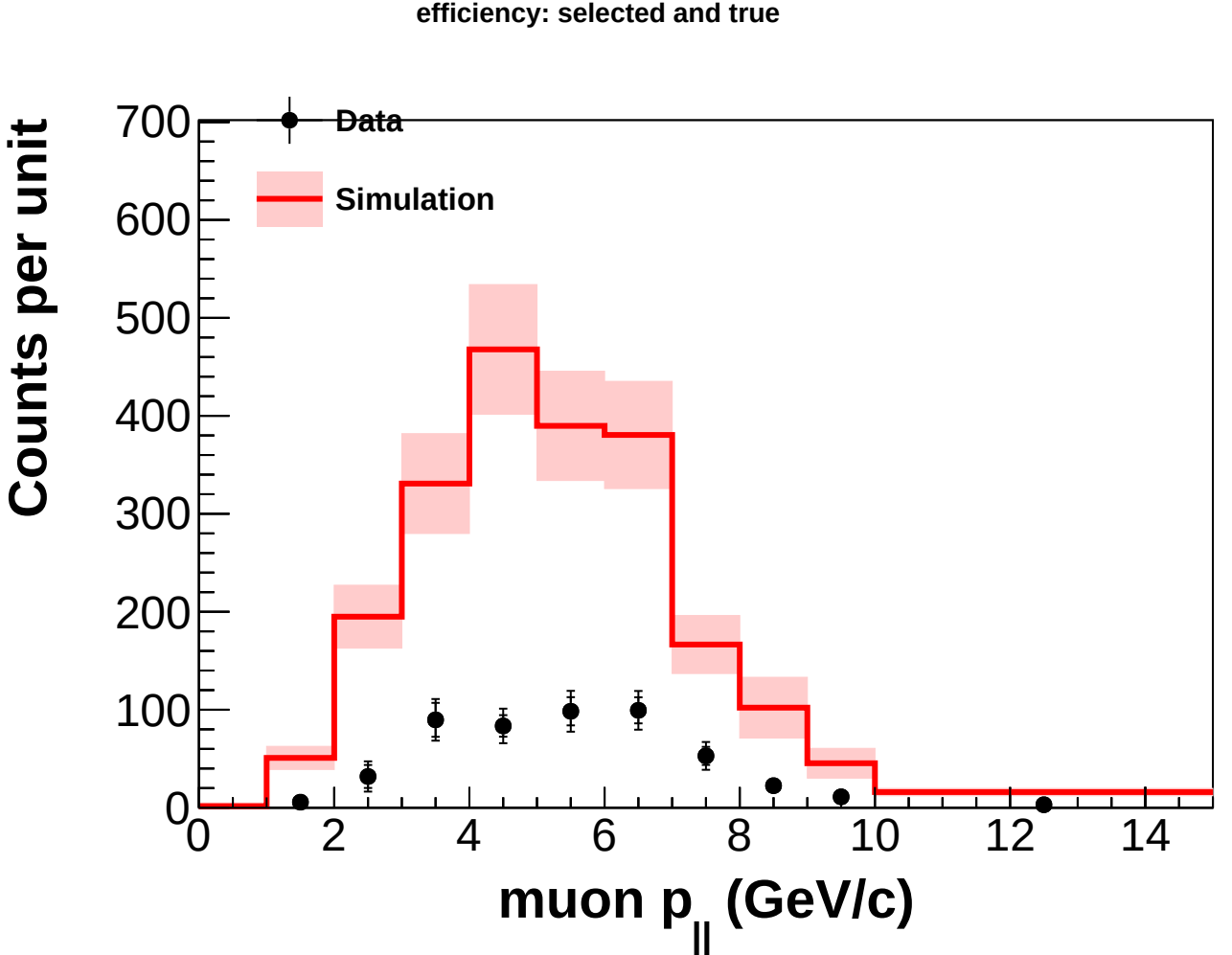

Data Before and After Unsmearing
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

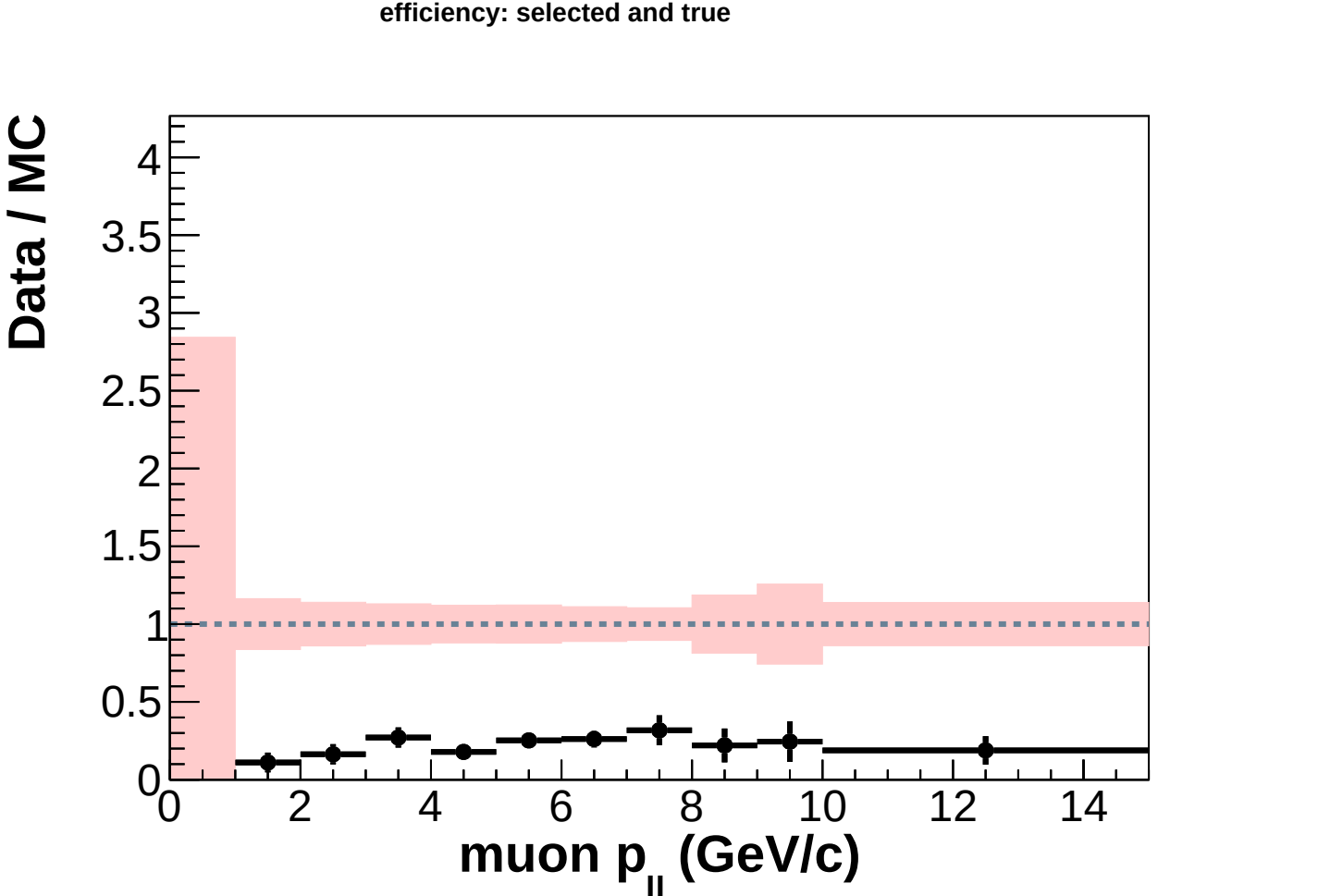

Data Before and After Unsmearing
Data / MC
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

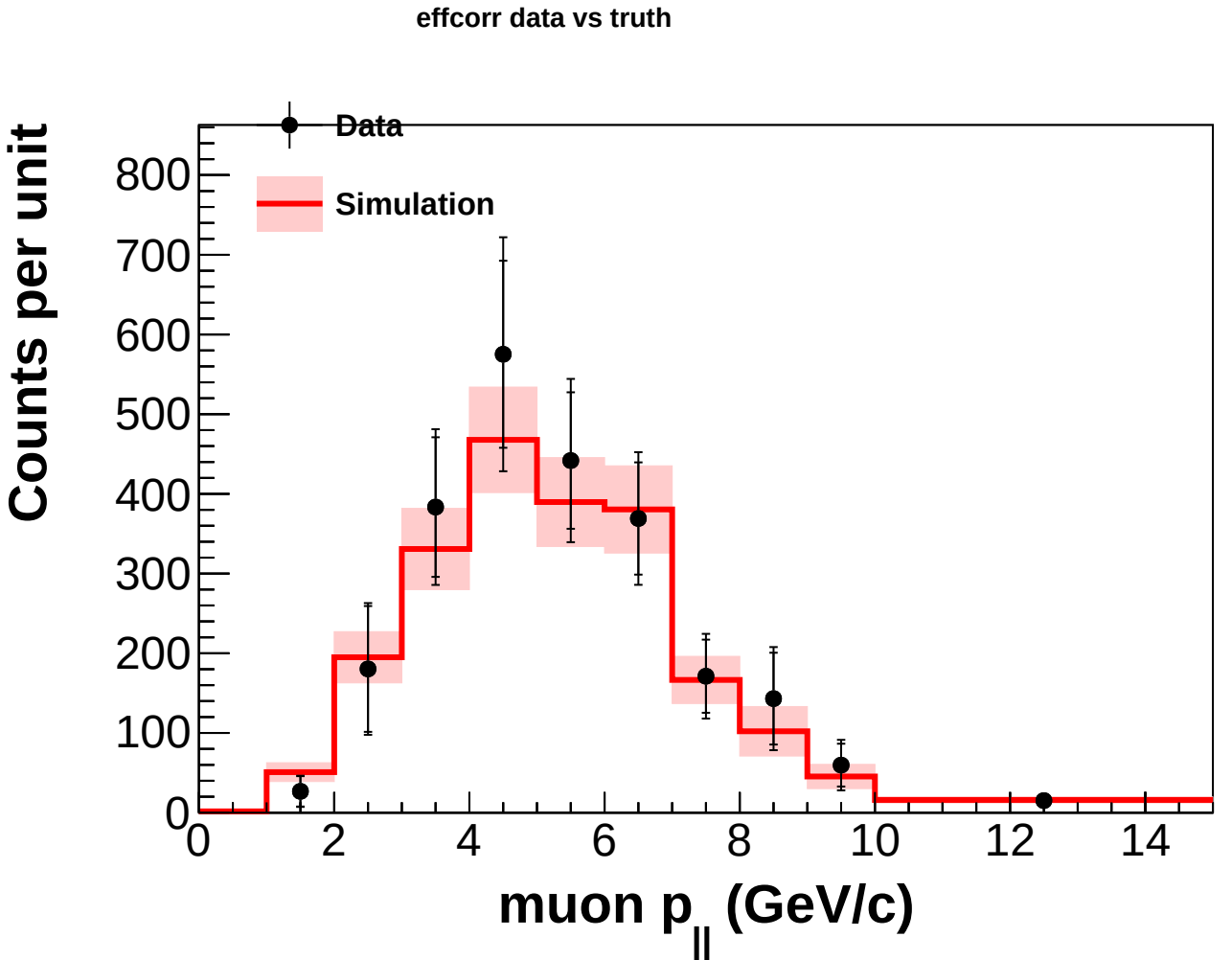

Unsmeared Data Compared to Selected MC
Data
Simulation
Counts per unit
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

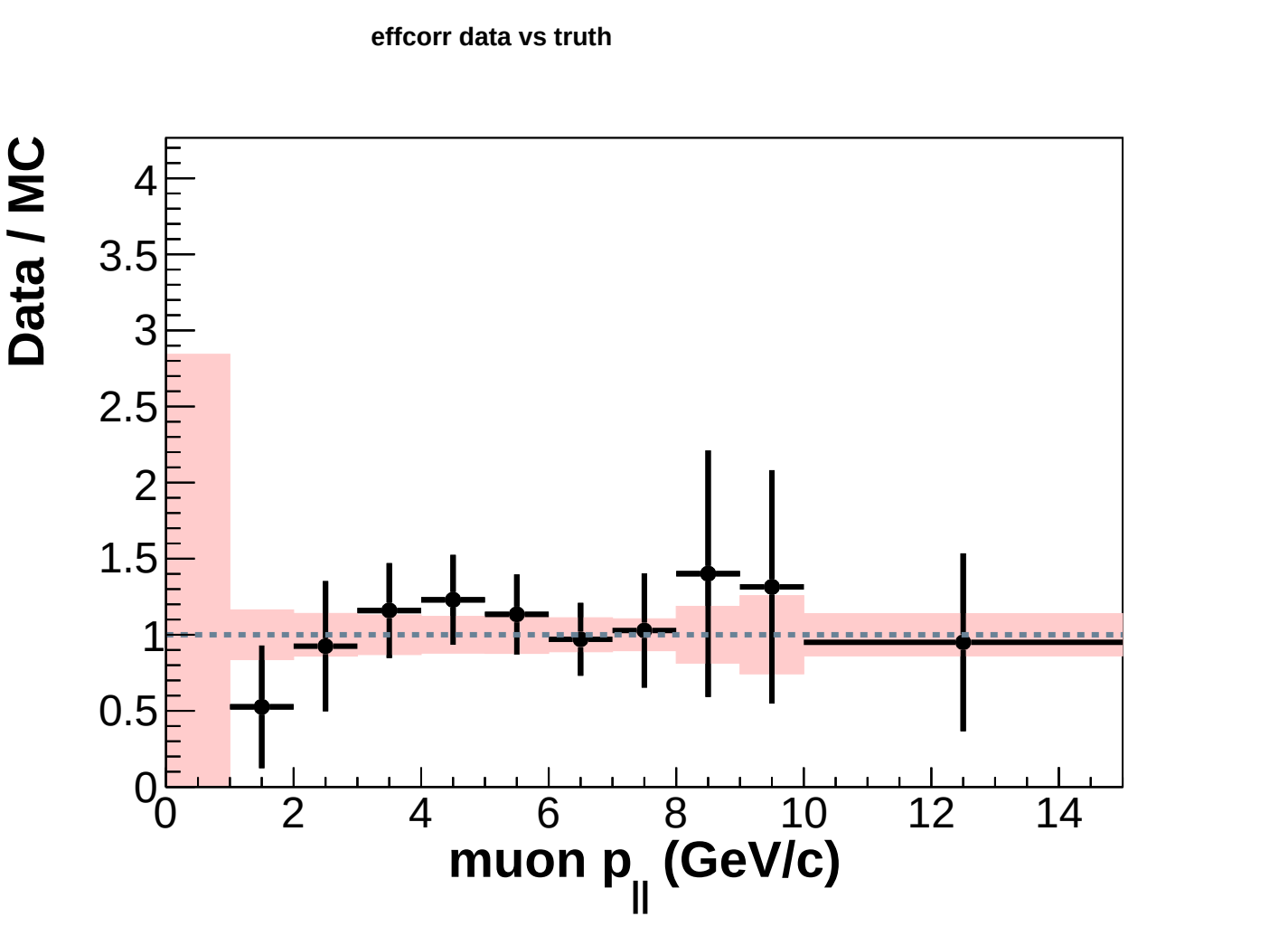

Unsmeared Data Compared to Selected MC
Data / MC
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

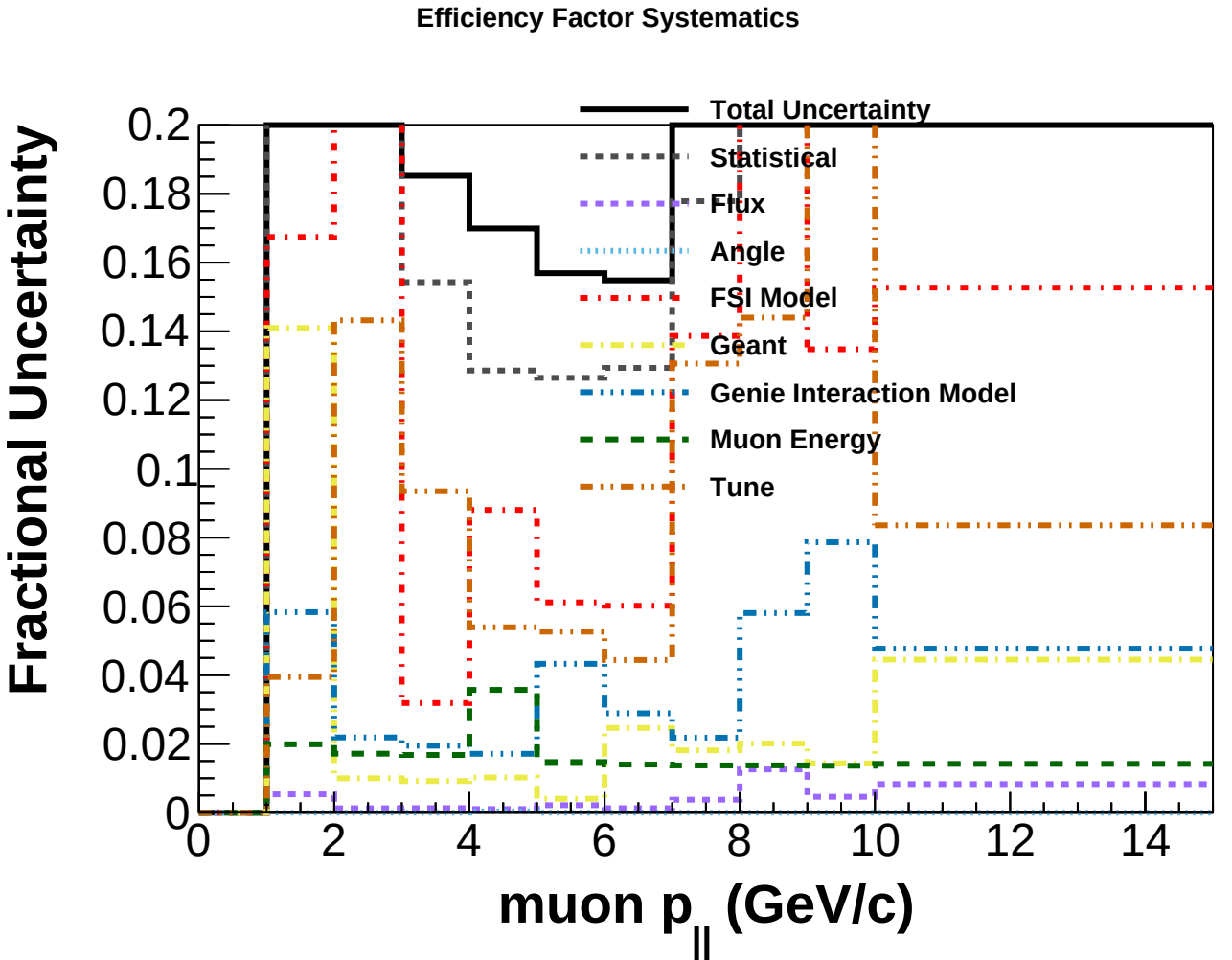

Unsmeared Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

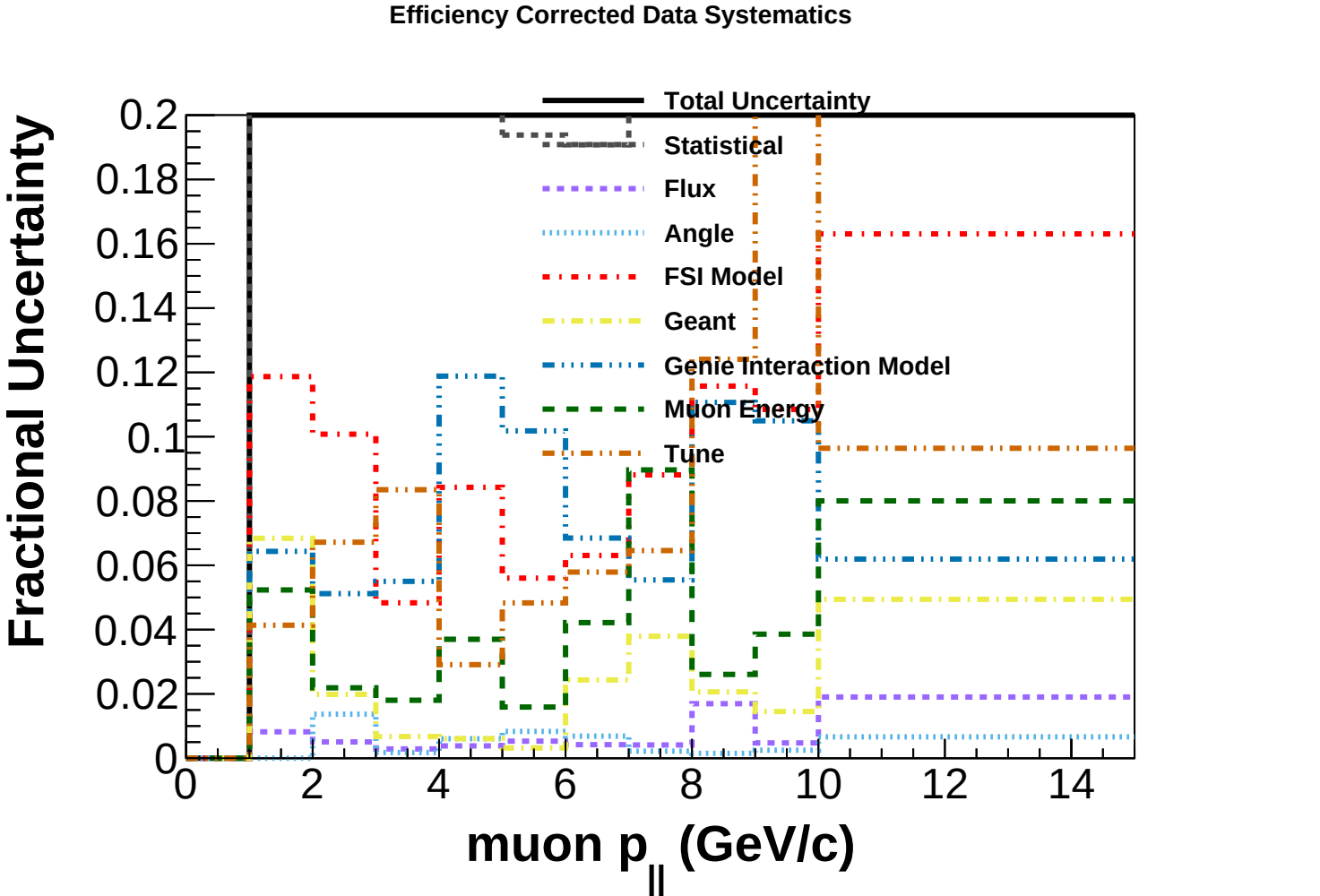

efficiency: selected and true
Data
Simulation
Counts per unit
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

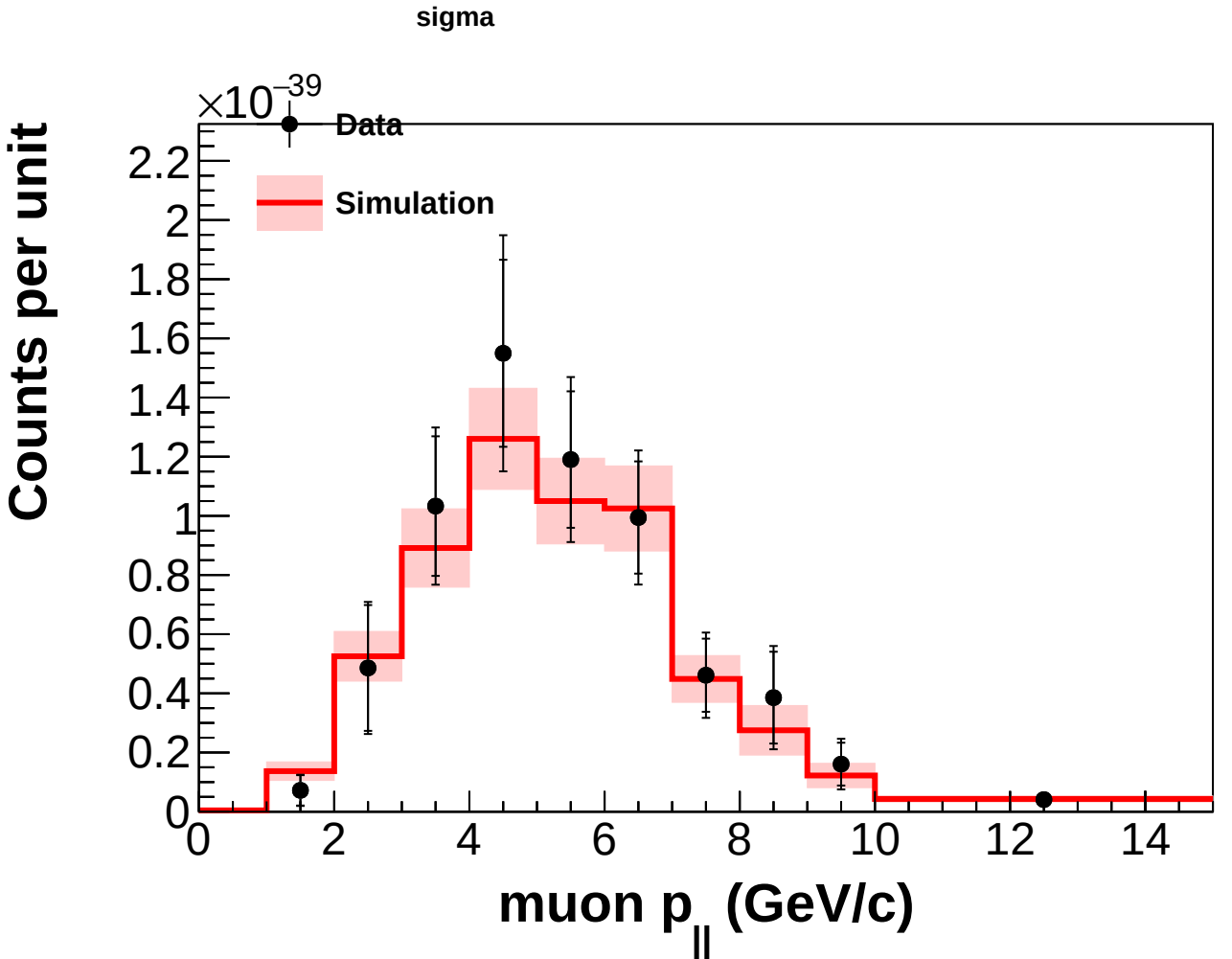

efficiency: selected and true
Data / MC
4
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


effcorr data vs truth
Data
Simulation
Counts per unit
0
100
200
300
400
500
600
700
800
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

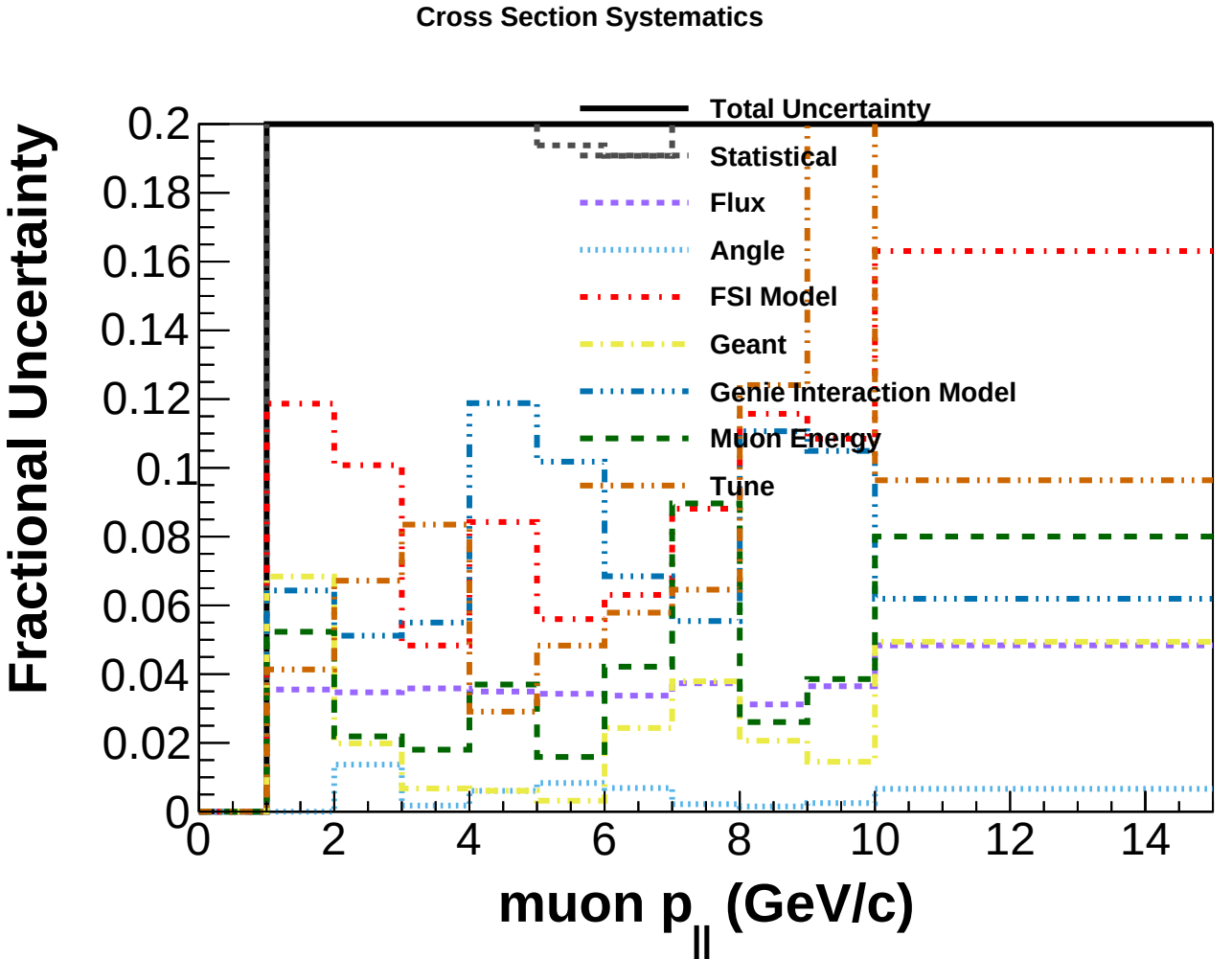

effcorr data vs truth
Data / MC
0
0.5
1
1.5
2
2.5
3
3.5
4
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

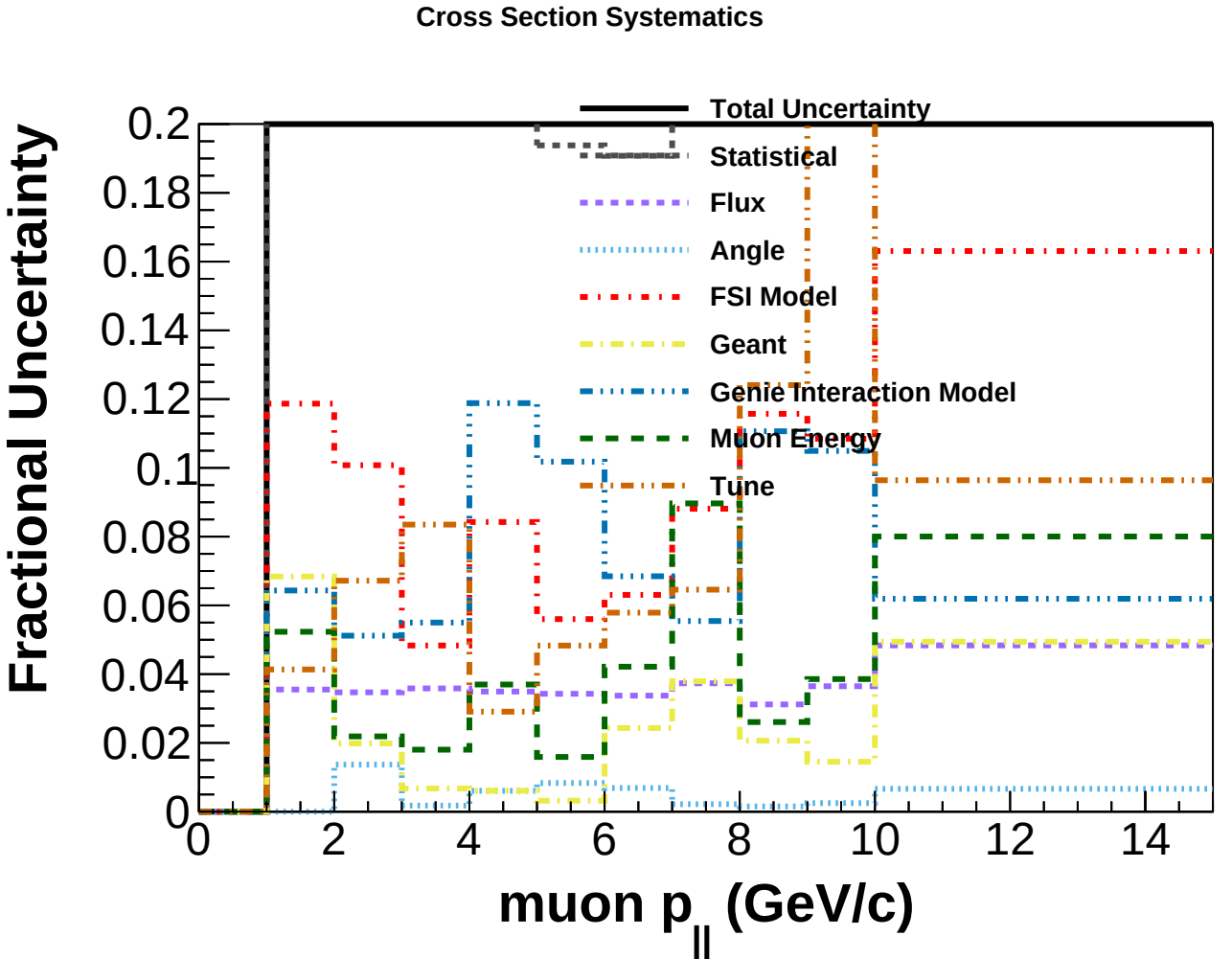

Efficiency Factor Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


Efficiency Corrected Data Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


sigma
Counts per unit
×10⁻³⁹
Data
Simulation
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)

sigma
Data / MC
muon p_ll (GeV/c)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
2
4
6
8
10
12
14


Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)


Cross Section Systematics
Total Uncertainty
Statistical
Flux
Angle
FSI Model
Geant
Genie Interaction Model
Muon Energy
Tune
Fractional Uncertainty
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
muon p_ll (GeV/c)