B Physics: QCD Monte Carlo Model Predictions

Rick Field - University of Florida
and
Keith Ellis - Fermilab

Goals:

- **Compare the LO parton level predictions of Herwig, Isajet, and Pythia with the NLO MRSR2 predictions.**
- **Compare the LO parton level predictions with the LO hadron level predictions (Herwig, Isajet, Pythia).**
- **Compare the LO hadron level predictions of Herwig, Isajet, and Pythia.**

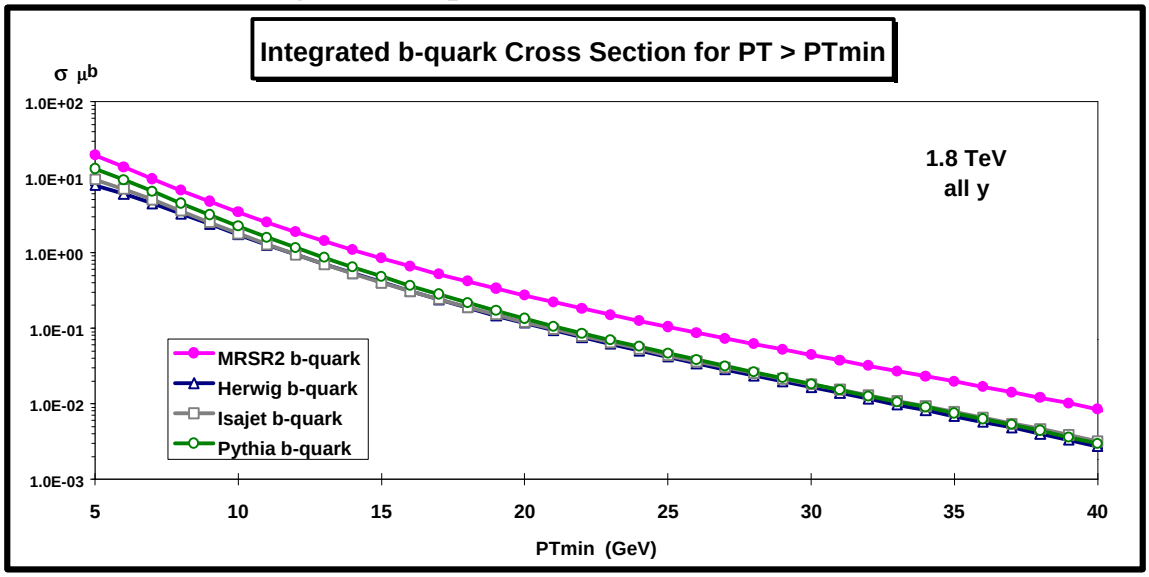
Outline:

- **Integrated Cross Sections (parton level)**
- **Transverse Momentum Distributions (parton level)**
- **Pseudo-Rapidity & Rapidity Distributions (parton level)**
- **Integrated Cross Sections (hadron level)**
- **Transverse Momentum Distributions (hadron level)**
- **PT Distributions Parton/Hadron (fragmentation)**
- **Strange Quark Production fs/(fu+fd) (fragmentation)**
- **Y and η Distributions Hadron versus Parton**
- **Azimuthal $\Delta\phi$ Correlations Hadron versus Parton**
- **PT Correlations Hadron versus Parton (PT_1-PT_2)**
- **Pseudo-Rapidity Correlations: $d\sigma/d\eta_1 d\eta_2$**
- **Normalized Correllation Functions: $R(\eta_1,\eta_2)$**

QCD Monte Carlo Models (default parameters):
Herwig 5.9 (DO1.1, Λ = 0.18 GeV)
Isajet 7.32 (CTEQ3L, Λ = 0.20 GeV)
Pythia 6.115 (GRV94LO, Λ = 0.20 GeV)

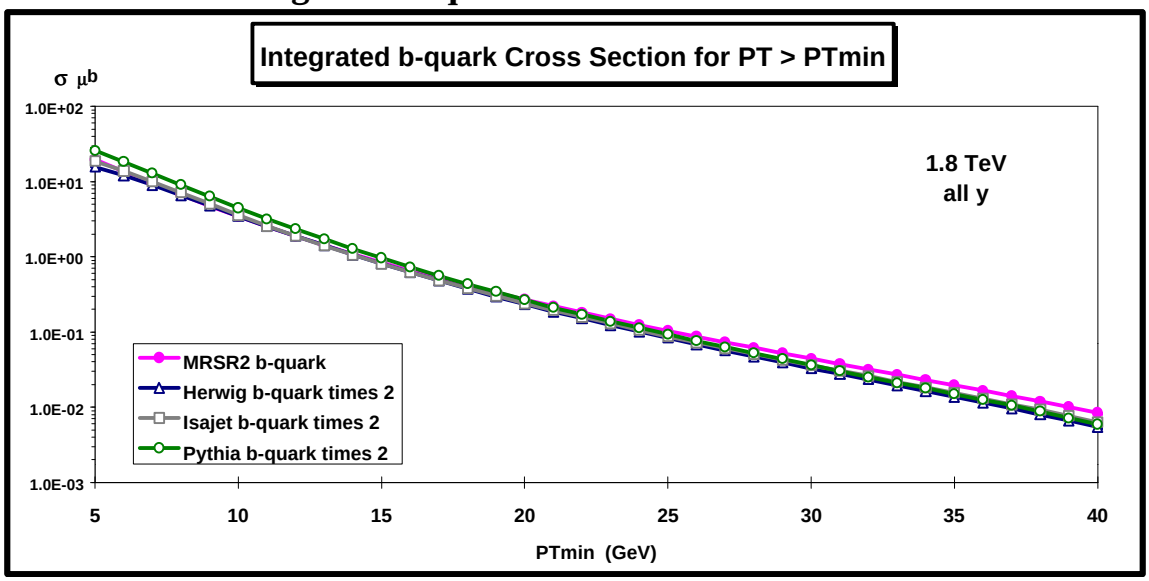
B Physics: Cross Sections

Parton Level: Integrated b-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for b-quarks at 1.8 TeV (all Y).

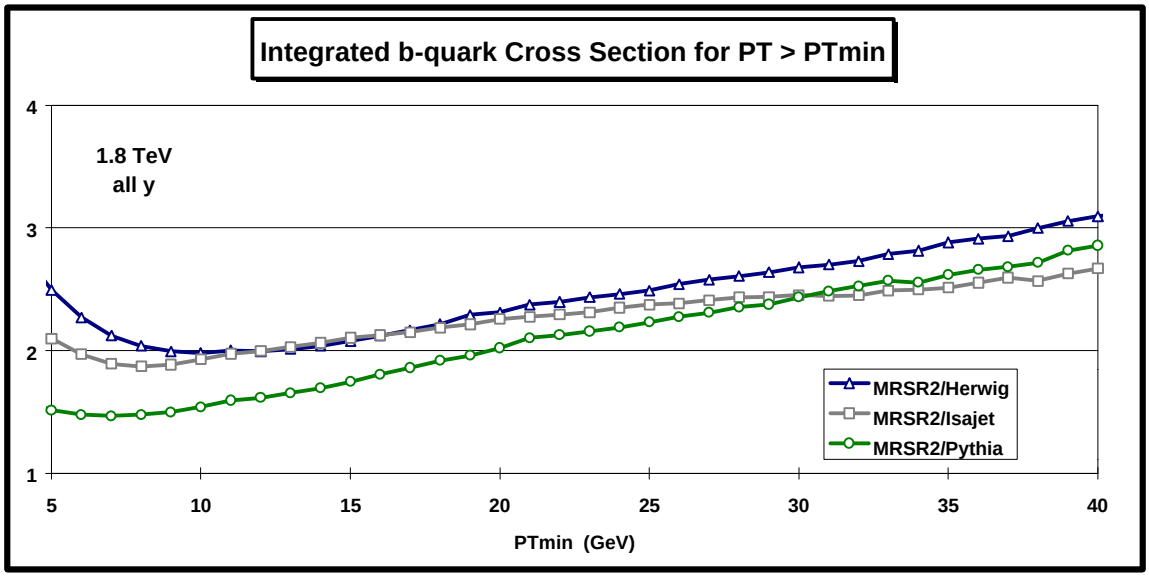
Parton Level: Integrated b-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for b-quarks at 1.8 TeV (all Y). Herwig, Isajet, and Pythia have been increased by a factor of two.

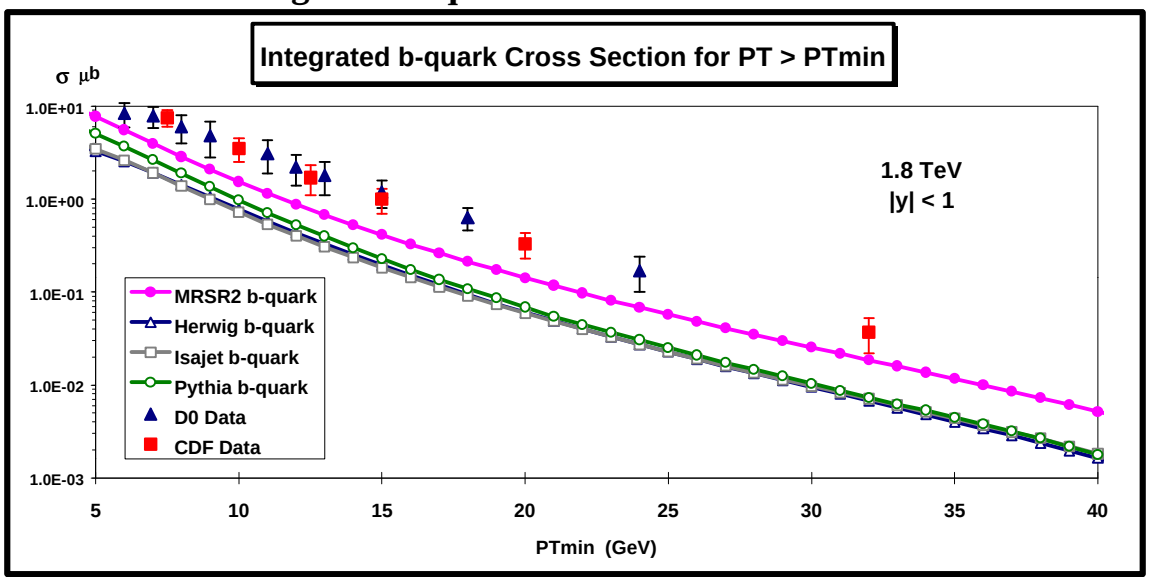
B Physics: Cross Sections

Parton Level: Ratio MRSR2/Monte-Carlos



Plot shows the ratio of σ(PT>PTmin) for b-quarks at 1.8 TeV (all Y) from MRSR2 to Herwig, Isajet, and Pythia.

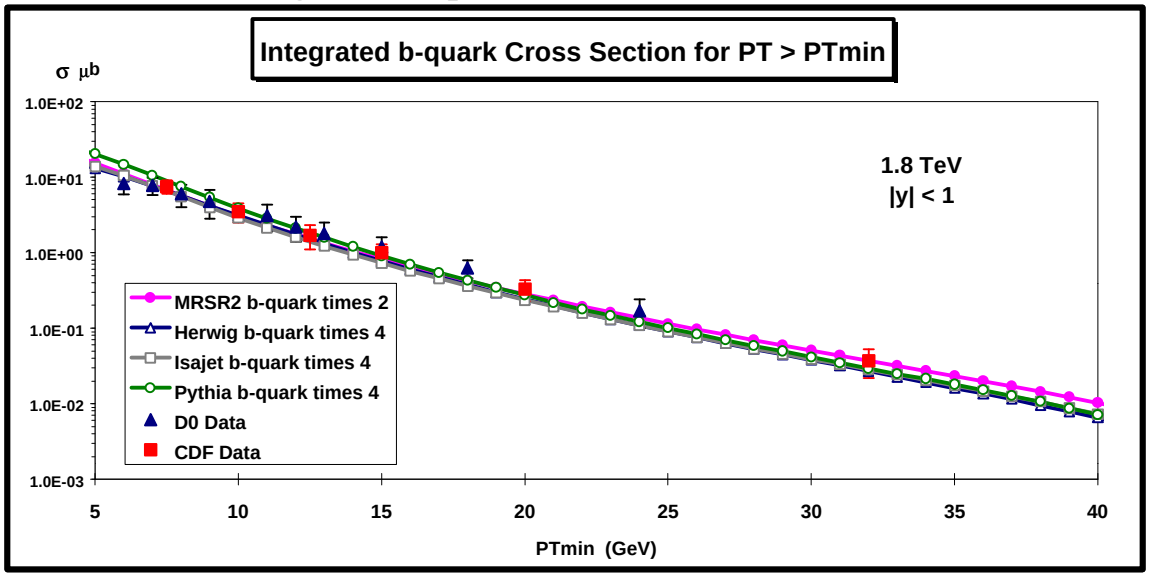
Parton Level: Integrated b-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for b-quarks at 1.8 TeV (|Y|<1).

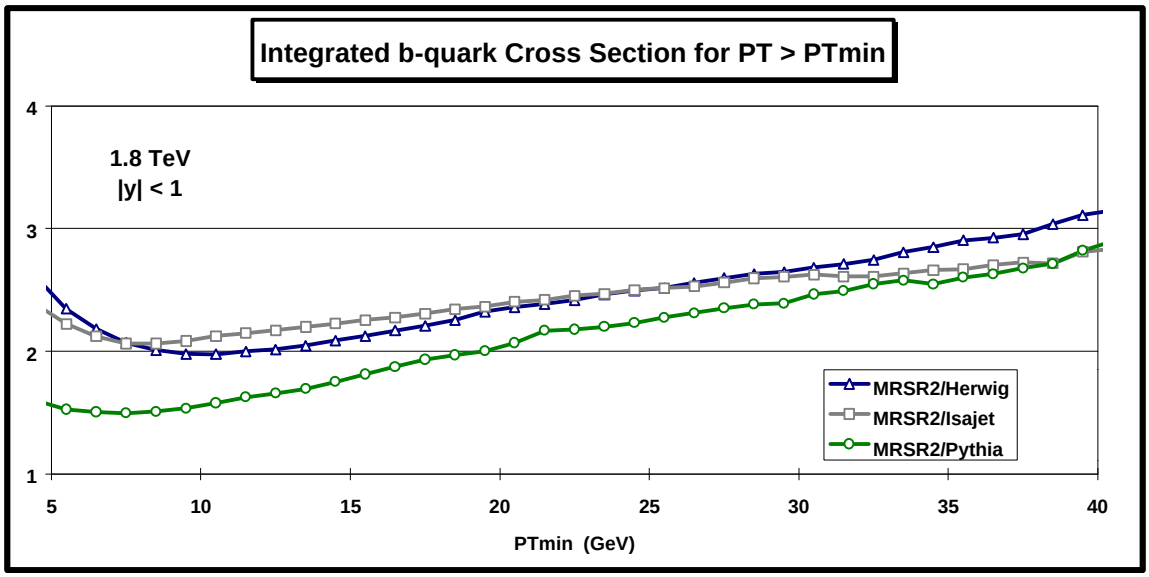
B Physics: Cross Sections

Parton Level: Integrated b-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for b-quarks at 1.8 TeV (|Y|<1). MRSR2 has been increased by a factor of two and Herwig, Isajet, and Pythia have been increased by a factor of four.

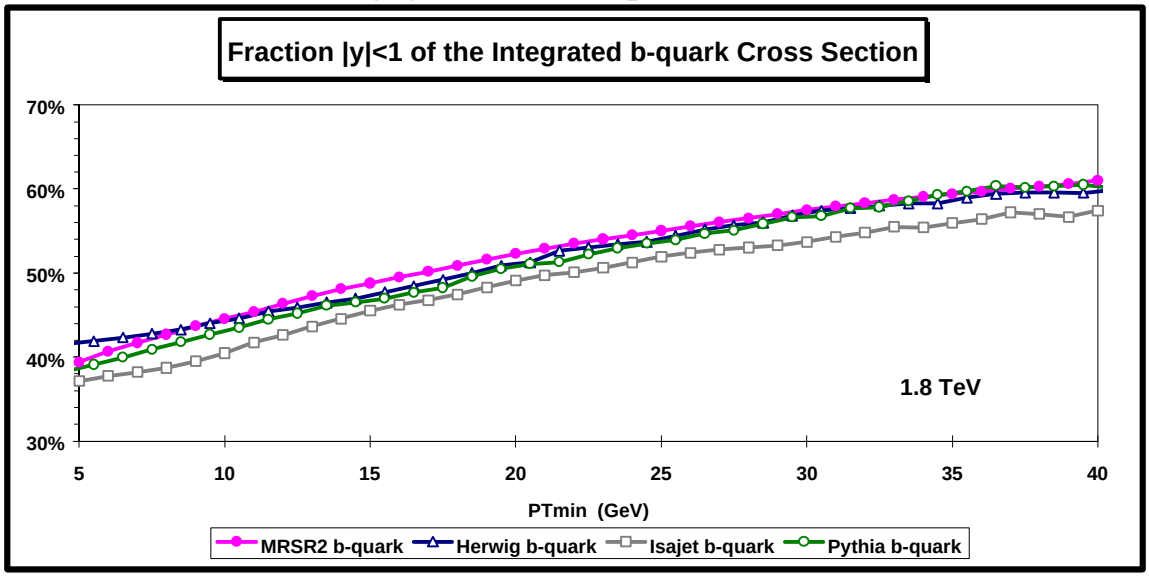
Parton Level: Ratio MRSR2/Monte-Carlos



Plot shows the ratio of σ(PT>PTmin) for b-quarks at 1.8 TeV (|Y| < 1) from MRSR2 to Herwig, Isajet, and Pythia.

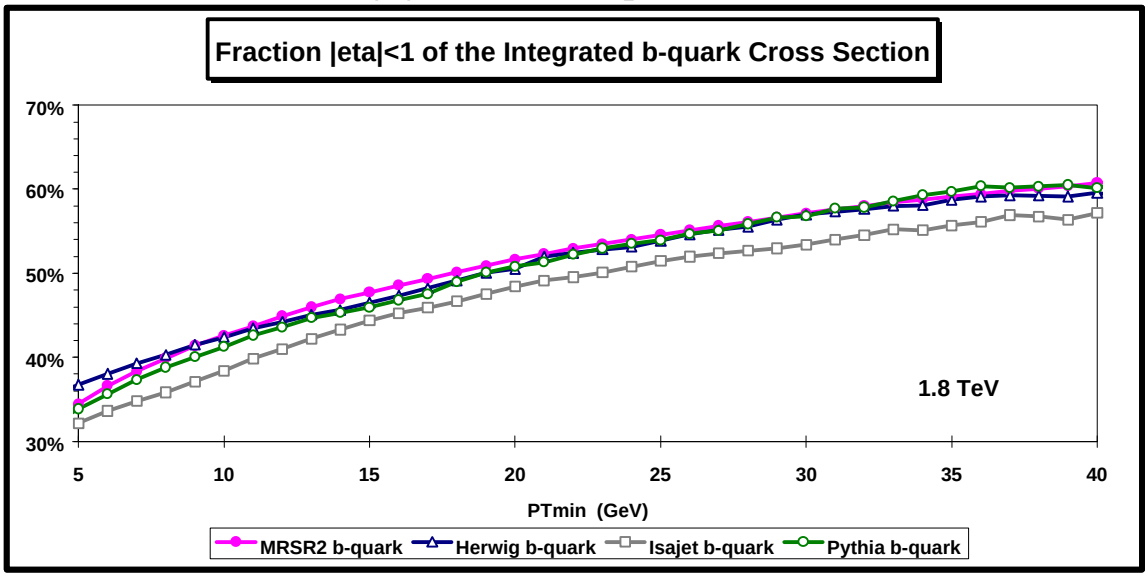
B Physics: Cross Sections

Parton Level: Fraction |Y| < 1 of the b-quark Cross Section



Plot shows the fraction |Y| < 1 of the b-quark integrated cross section (PT < PTmin).

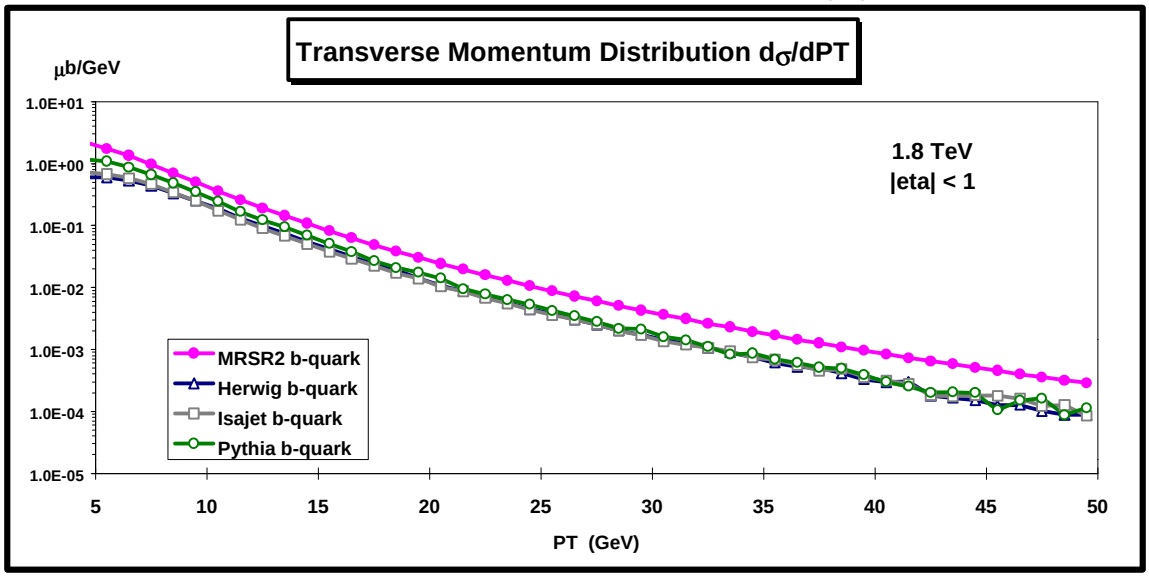
Parton Level: Fraction |η| < 1 of the b-quark Cross Section



Plot shows the fraction |η| < 1 of the b-quark integrated cross section (PT < PTmin).

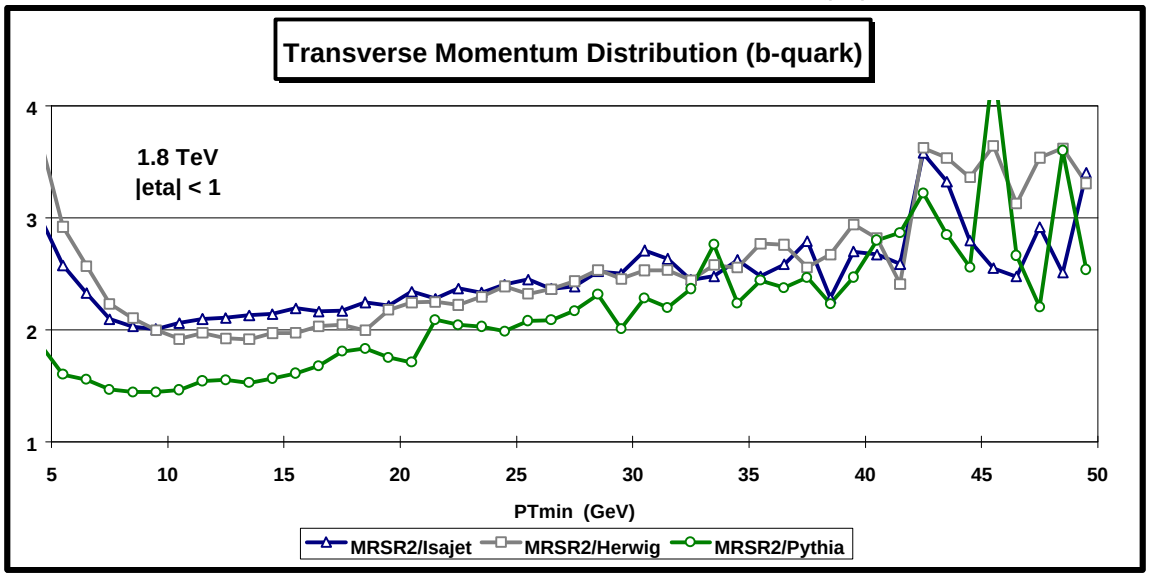
B Physics: PT Distributions

Parton Level: Transverse Momentum Distribution (|η| < 1)



Plot shows dσ/dPT (in μb/GeV) for b-quarks at 1.8 TeV (|η|<1).

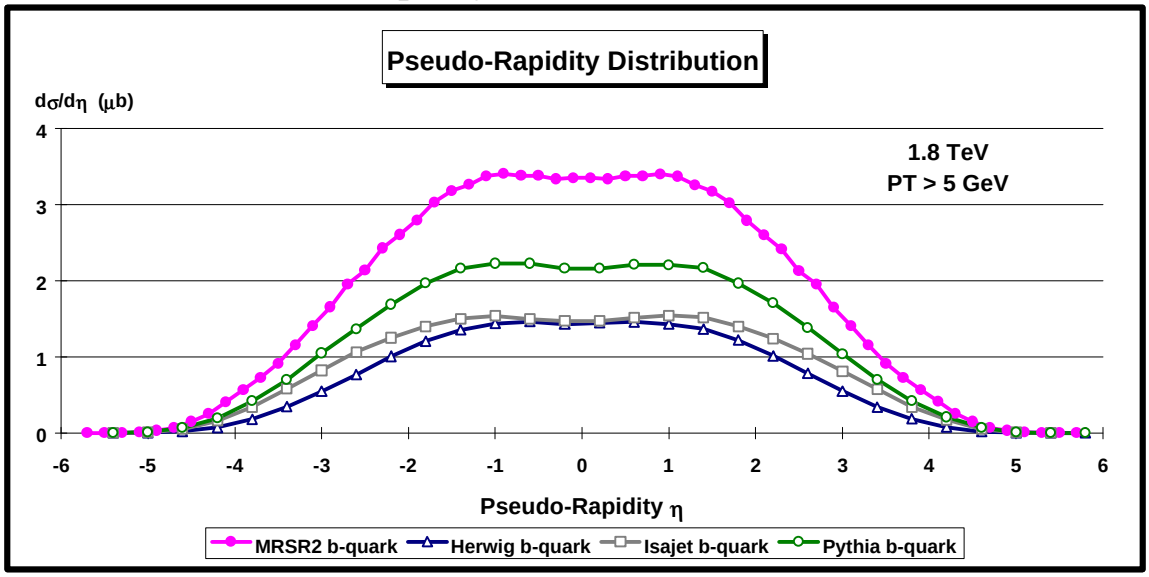
Parton Level: Transverse Momentum Distribution (|η| < 1)



Plot shows the ratio of dσ/dPT for b-quarks at 1.8 TeV (|η| < 1) from MRSR2 to Herwig, Isajet, and Pythia.

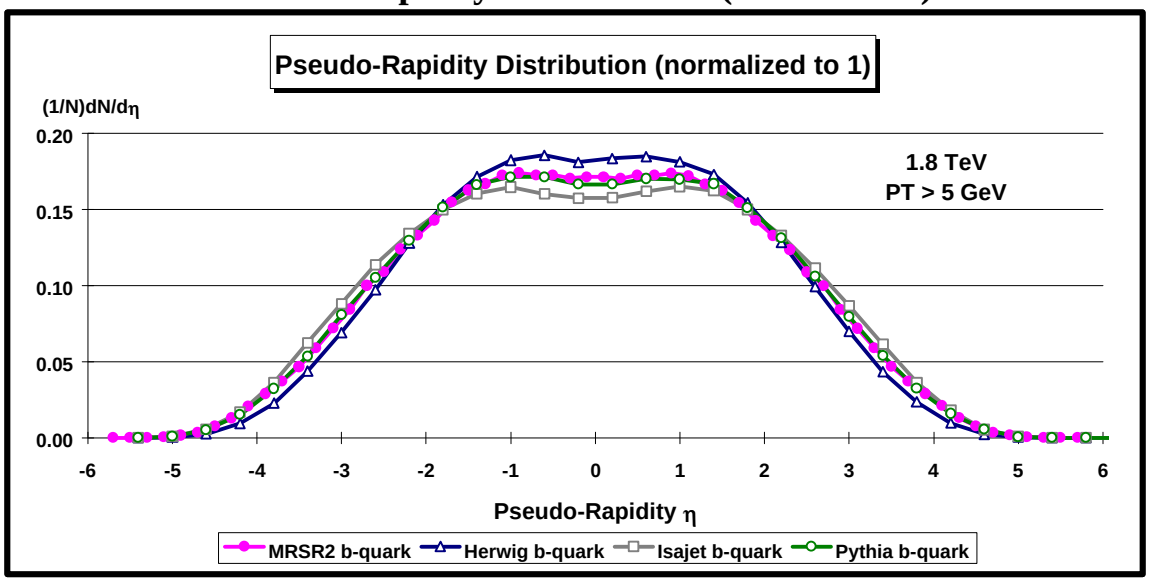
B Physics: Pseudo-Rapidity Distributions

Parton Level: Pseudo-Rapidity Distributions (PT > 5 GeV)



Plot shows dσ/dη (in μb) for b-quarks at 1.8 TeV (PT > 5 GeV).

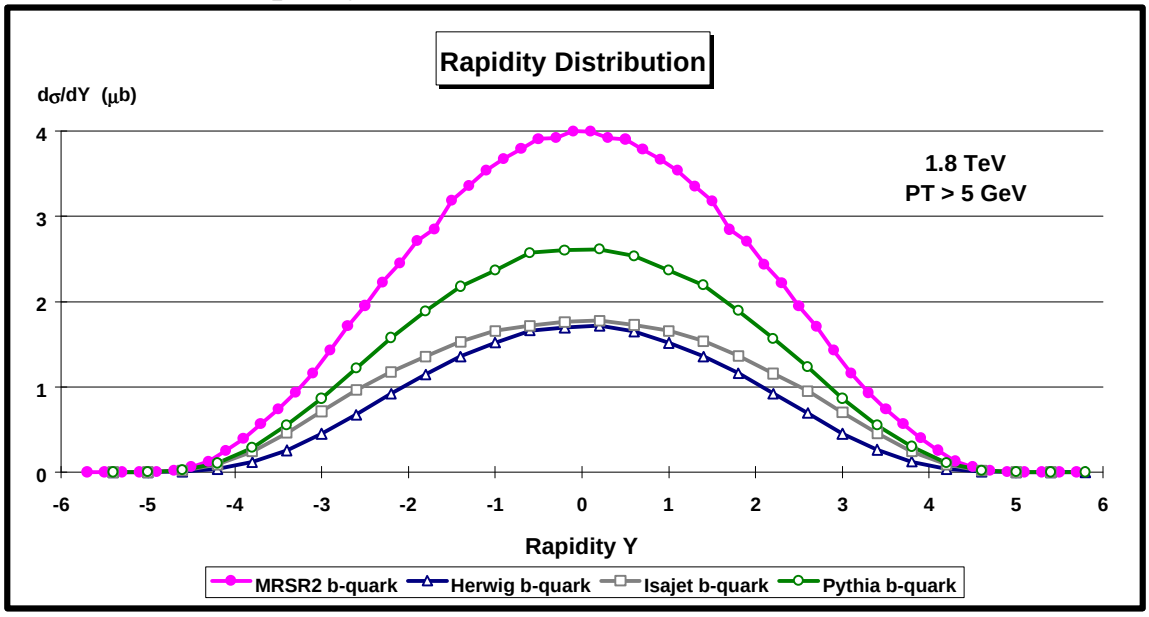
Parton Level: Pseudo-Rapidity Distributions (PT > 5 GeV)



Plot shows (1/N)dN/dη (normalized to 1) for b-quarks at 1.8 TeV (PT > 5 GeV).

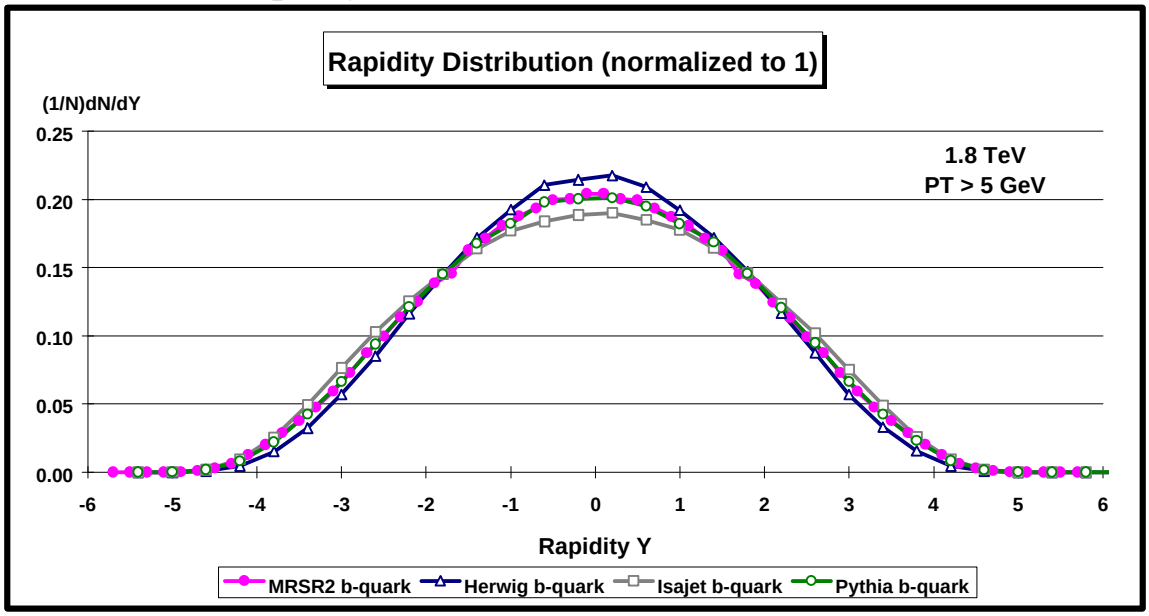
B Physics: Rapidity Distributions

Parton Level: Rapidity Distributions (PT > 5 GeV)



Plot shows dσ/dY (in μb) for b-quarks at 1.8 TeV (PT > 5 GeV).

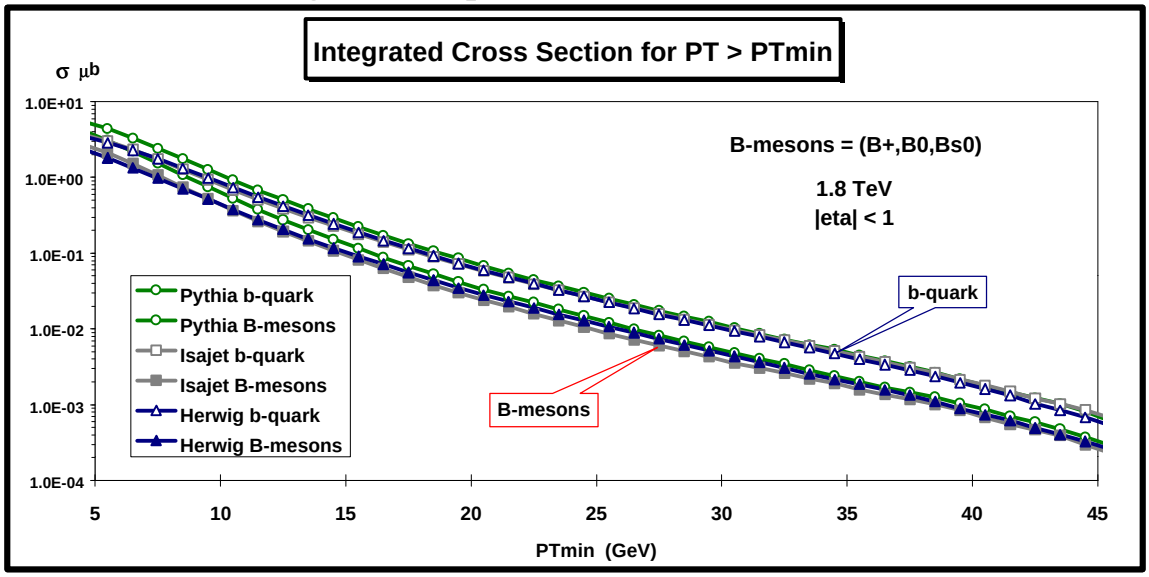
Parton Level: Rapidity Distributions (PT > 5 GeV)



Plot shows (1/N)dN/dY (normalized to 1) for b-quarks at 1.8 TeV (PT > 5 GeV).

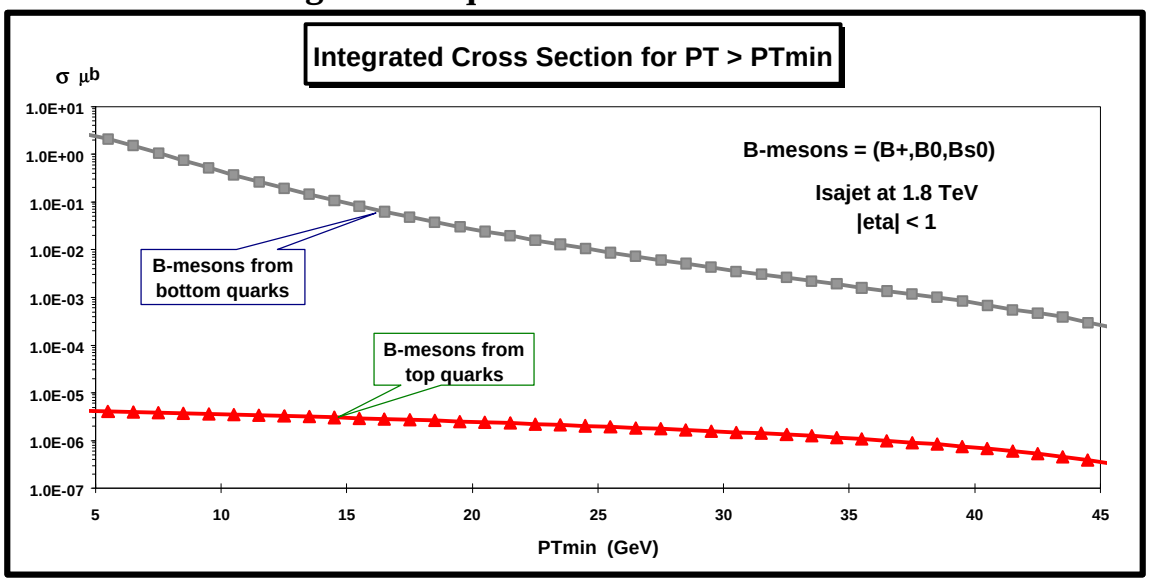
B Physics: Cross Sections

Hadron Level: Integrated B-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for B-mesons (B^+,B^0,B_s^0) and b-quarks at 1.8 TeV (|η| < 1).

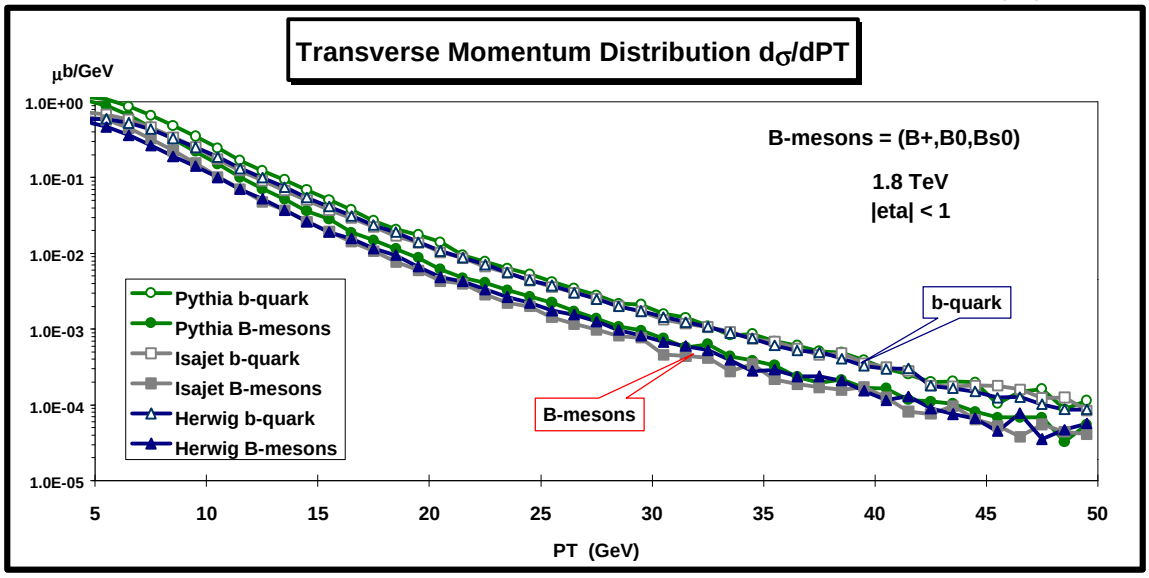
Hadron Level: Integrated B-quark Cross Section for PT > PTmin



Plot shows σ(PT>PTmin) (in μb) for B-mesons (B^+,B^0,B_s^0) from b and t-quarks 1.8 TeV (|η| < 1).

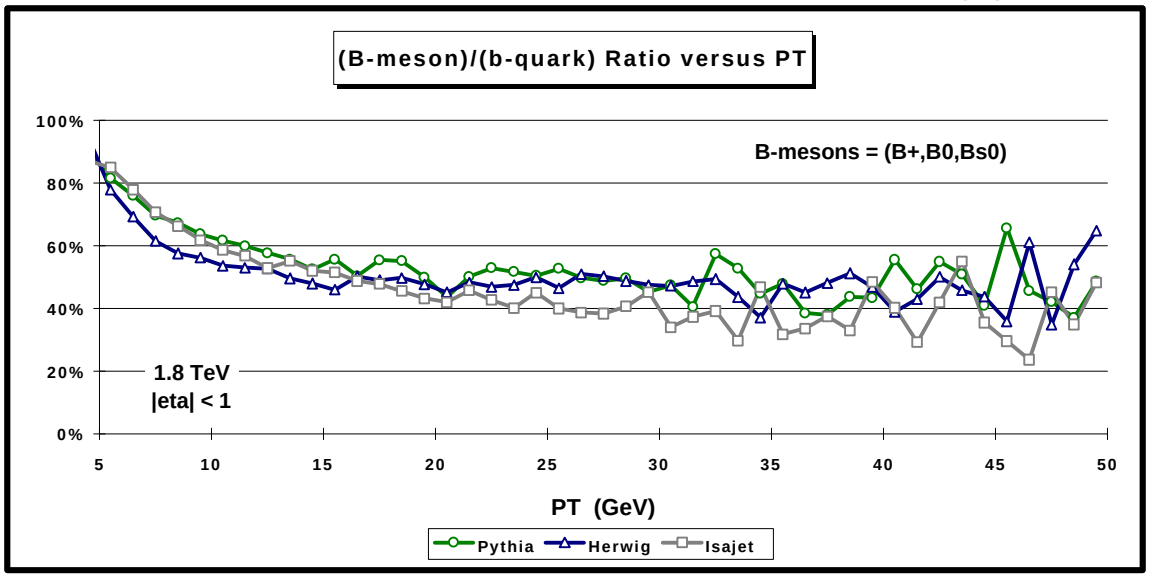
B Physics: PT Distributions

Parton & Hadron Level: Transverse Momentum Distribution (|η| < 1)



Plot shows dσ/dPT (in μb/GeV) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (|η|<1).

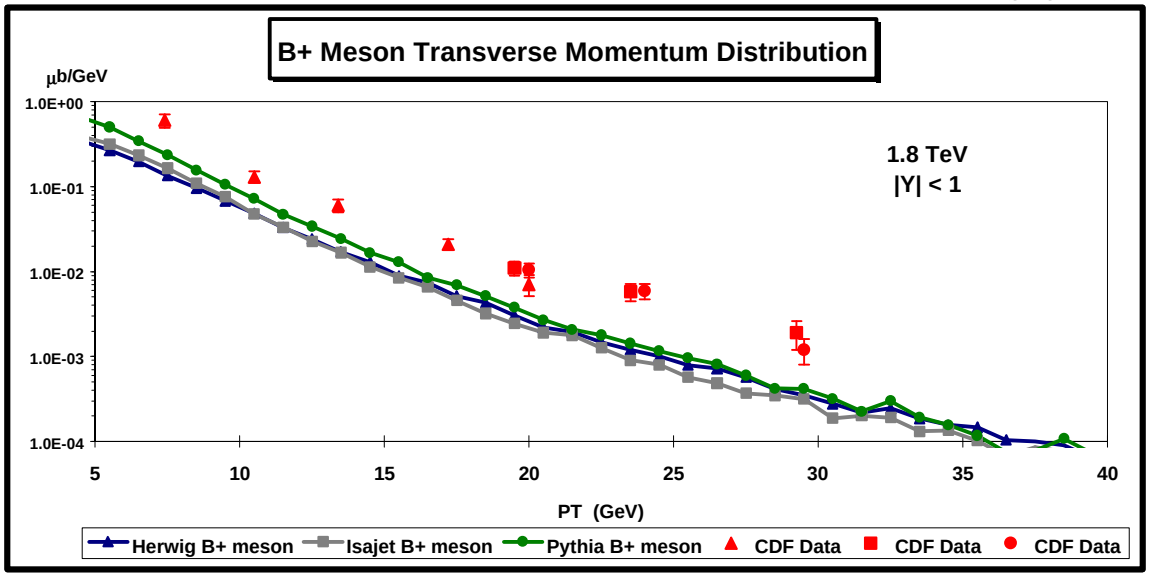
Hadron/Parton Level: Transverse Momentum Distribution (|η| < 1)



Plot shows the ratio of dσ/dPT (|η| < 1) for B-mesons (B^+,B^0,B_s^0) to b-quark at 1.8 TeV.

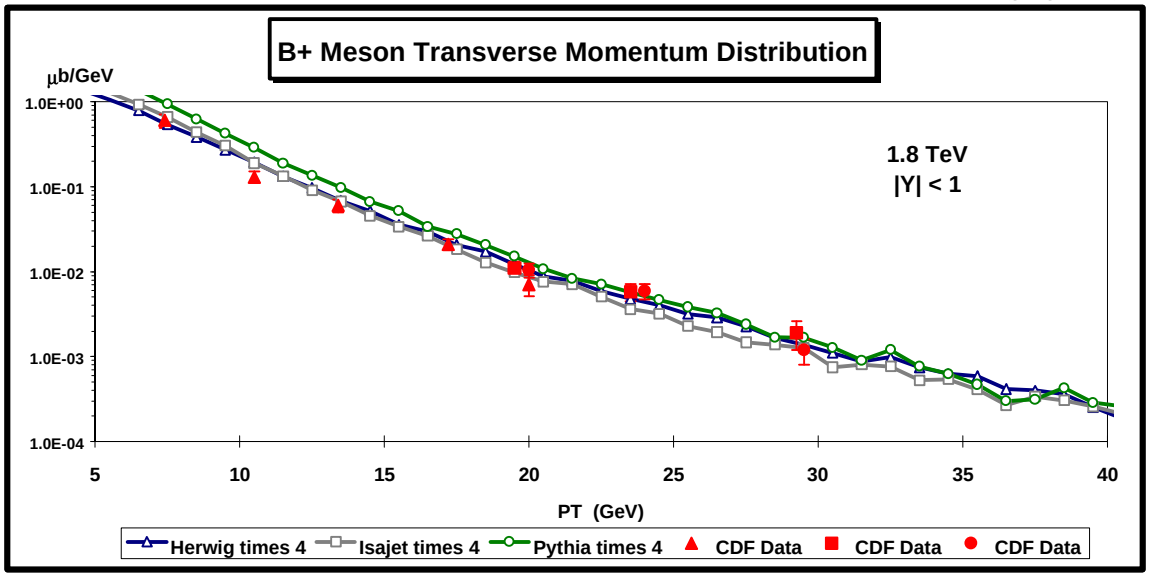
B Physics: PT Distributions

Hadron Level: B+ Meson Transverse Momentum Distribution (|Y| < 1)



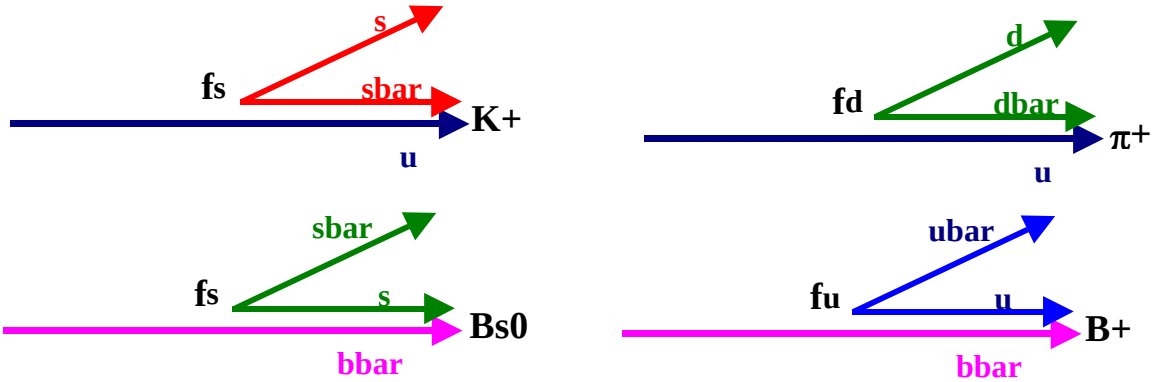
Plot shows dσ/dPT (in μb/GeV) for B^+ mesons at 1.8 TeV (|Y| < 1).

Hadron Level: B+ Meson Transverse Momentum Distribution (|Y| < 1)



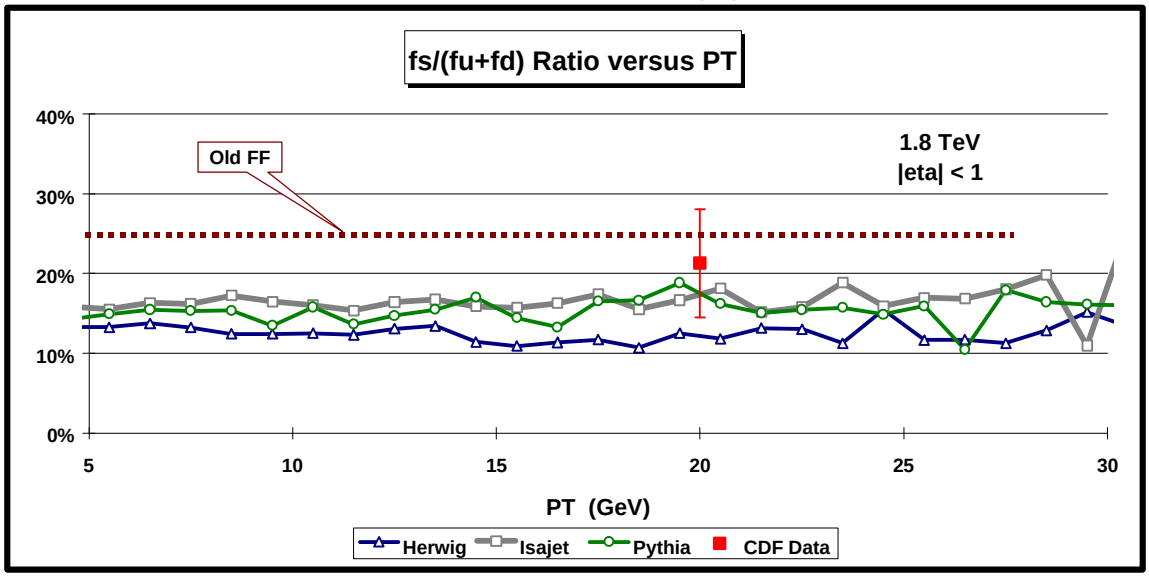
Plot shows dσ/dPT (in μb/GeV) for B^+ mesons at 1.8 TeV (|Y| < 1). The QCD Monte-Carlo predictions have been increased by a factor of four.

B Physics: Fragmentation



	CDF Run I	Old FF
fu	0.408+/-0.068	0.4
fd	0.344+/-0.039	0.4
fs	0.159+/-0.026	0.2
fbaryon	0.089+/-0.029	0.0
fs/(fu+fd)	0.213+/-0.068	0.25

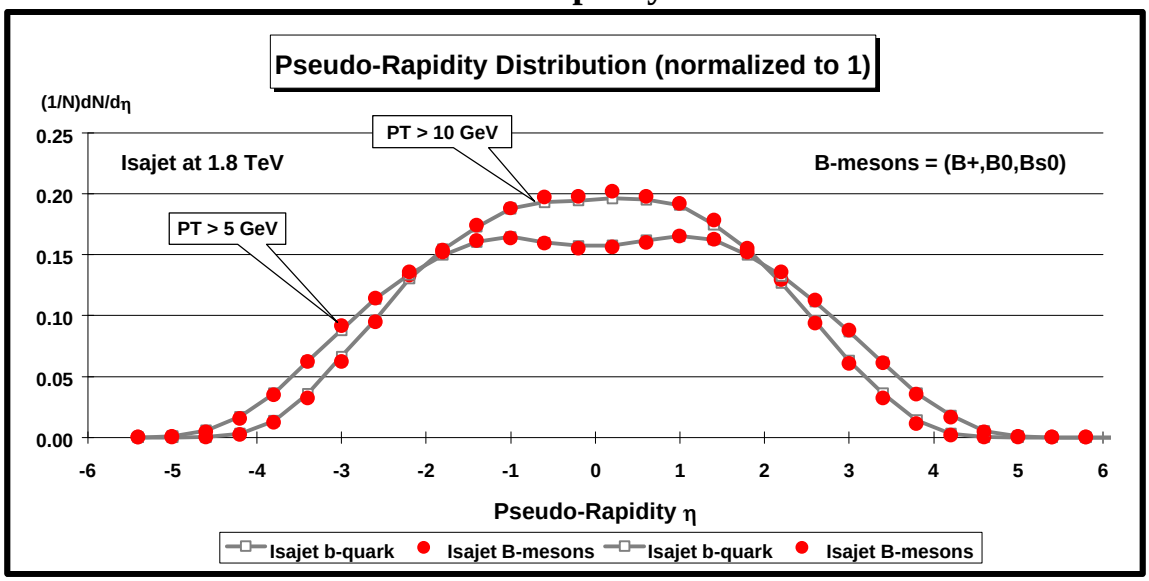
Hadron Level: fs/(fu+fd) Ration versus PT (|η| < 1)



Plot shows the ratio fs/(fu+fd) at 1.8 TeV (|η| < 1), where fs = dσ/dPT(B_s^0), fu = dσ/dPT(B^+), and fd = dσ/dPT(B^0).

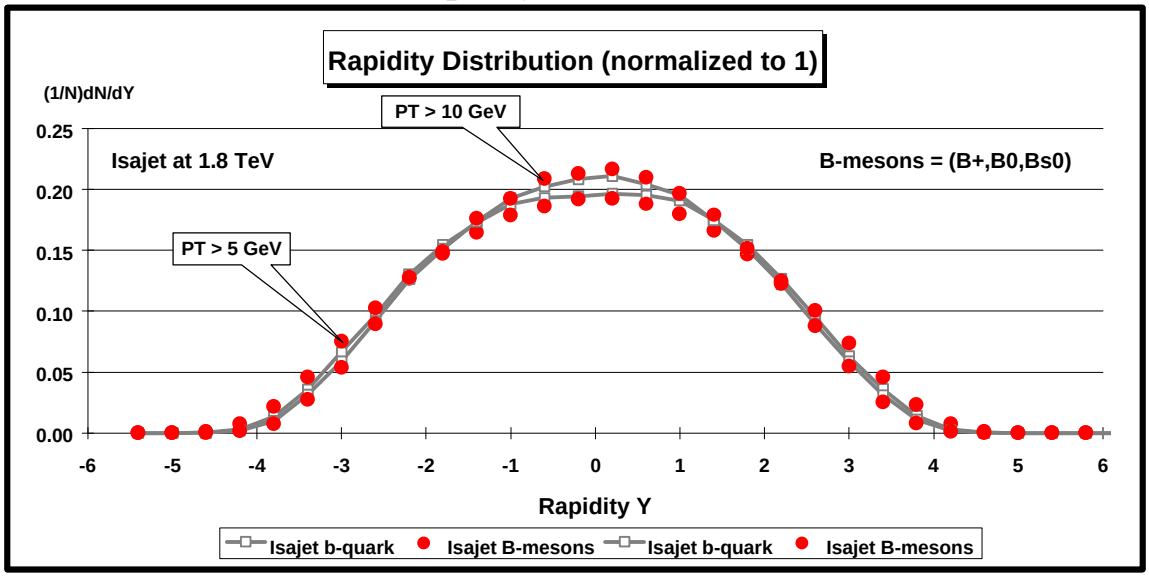
B Physics: Y and η Distributions

Parton & Hadron Level: Pseudo-Rapidity Distribution



Plot shows (1/N)dN/dη (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

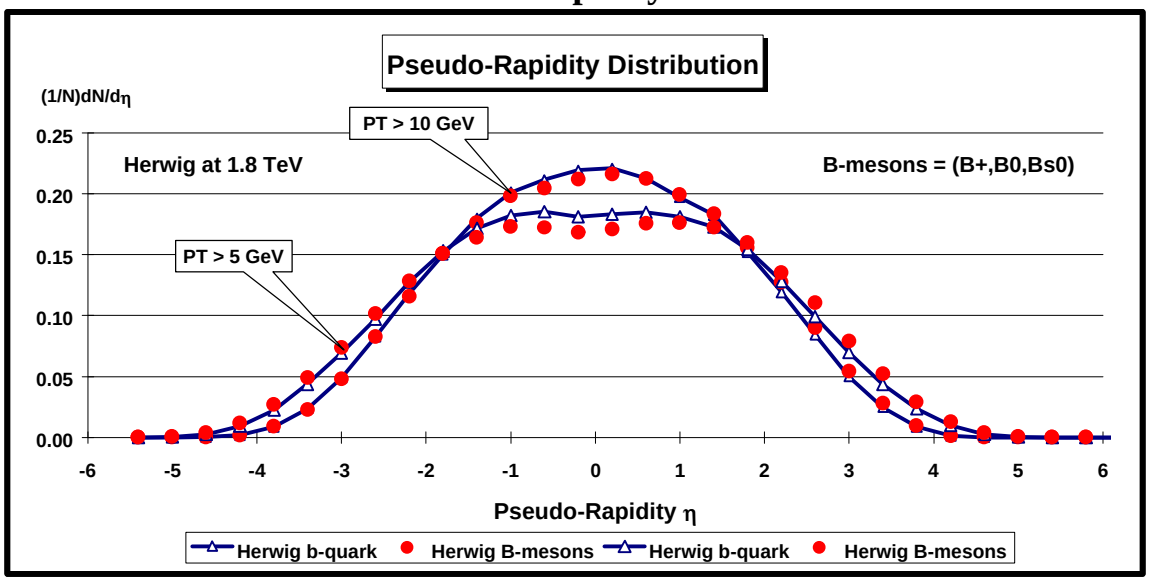
Parton & Hadron Level: Rapidity Distribution



Plot shows (1/N)dN/dY (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

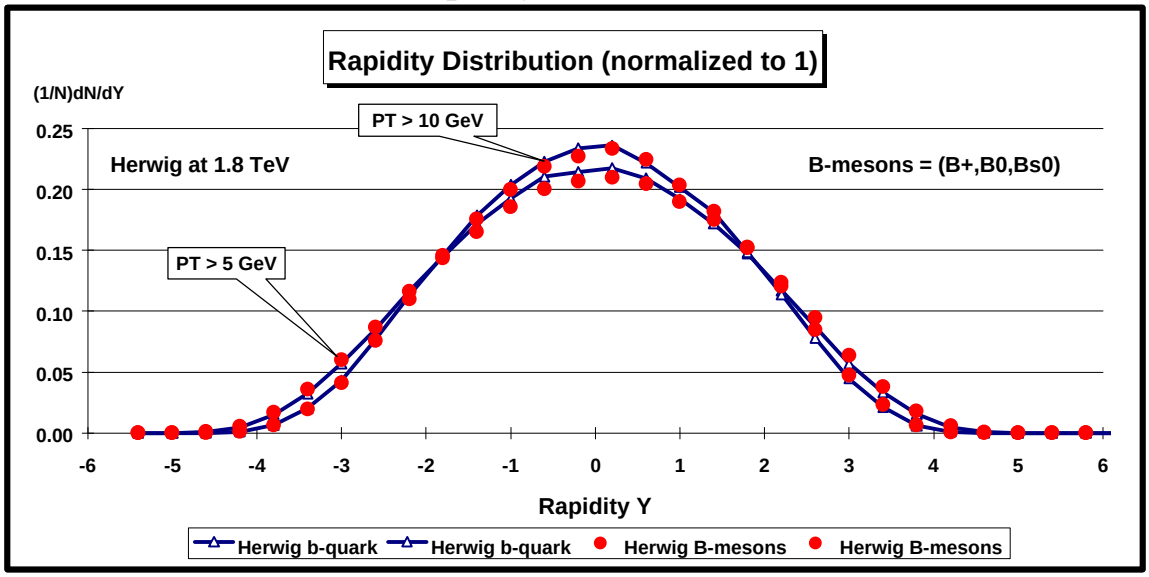
B Physics: Y and η Distributions

Parton & Hadron Level: Pseudo-Rapidity Distribution



Plot shows (1/N)dN/dη (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

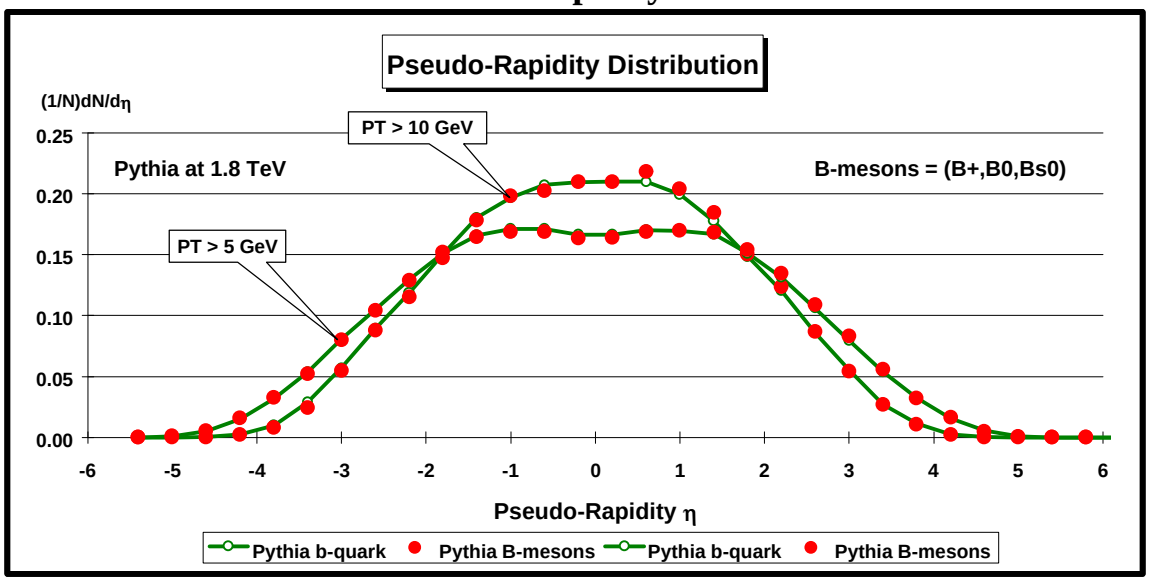
Parton & Hadron Level: Rapidity Distribution



Plot shows (1/N)dN/dY (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

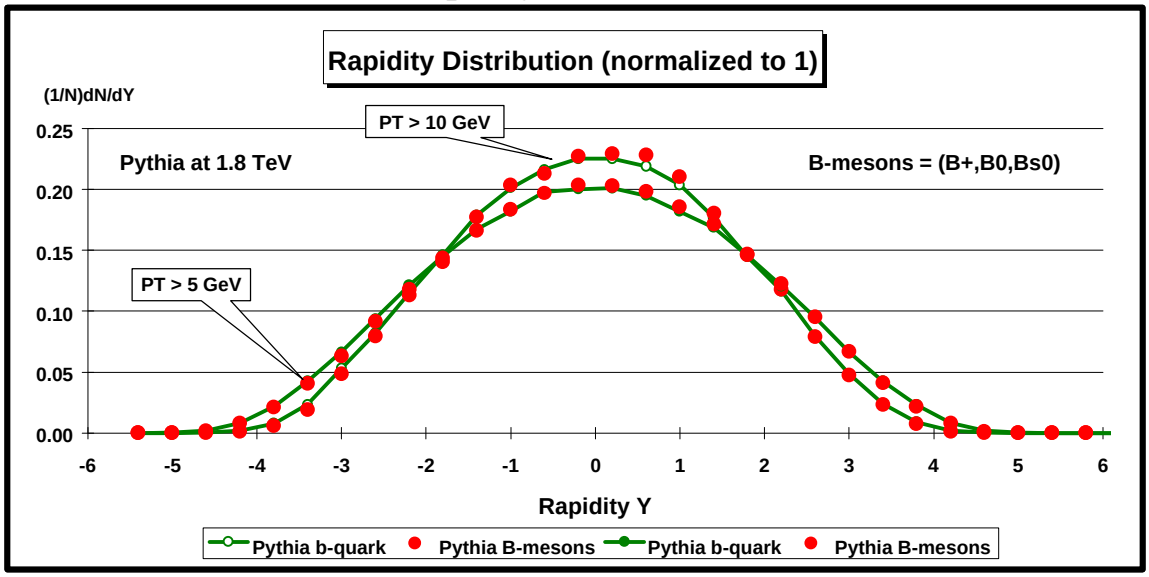
B Physics: Y and η Distributions

Parton & Hadron Level: Pseudo-Rapidity Distribution



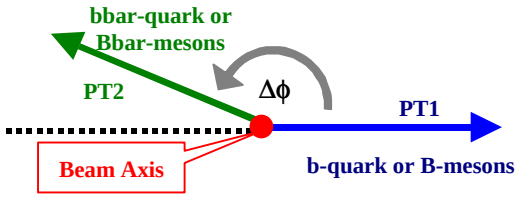
Plot shows (1/N)dN/dη (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

Parton & Hadron Level: Rapidity Distribution

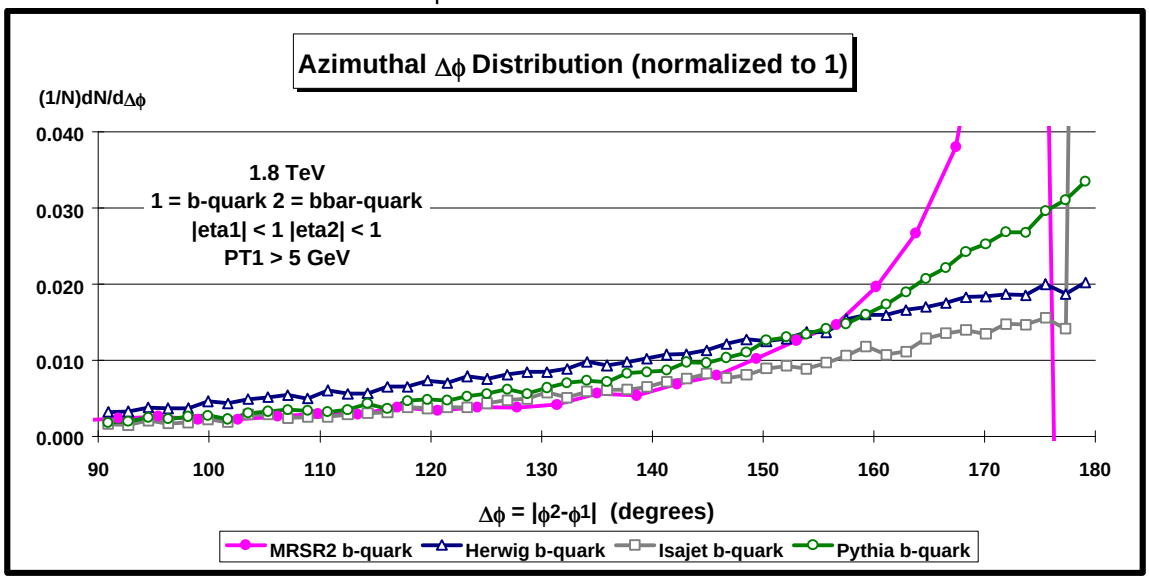


Plot shows (1/N)dN/dY (normalized to 1) for B-mesons (B^+,B^0,B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

B Physics: Azimuthal Correlations



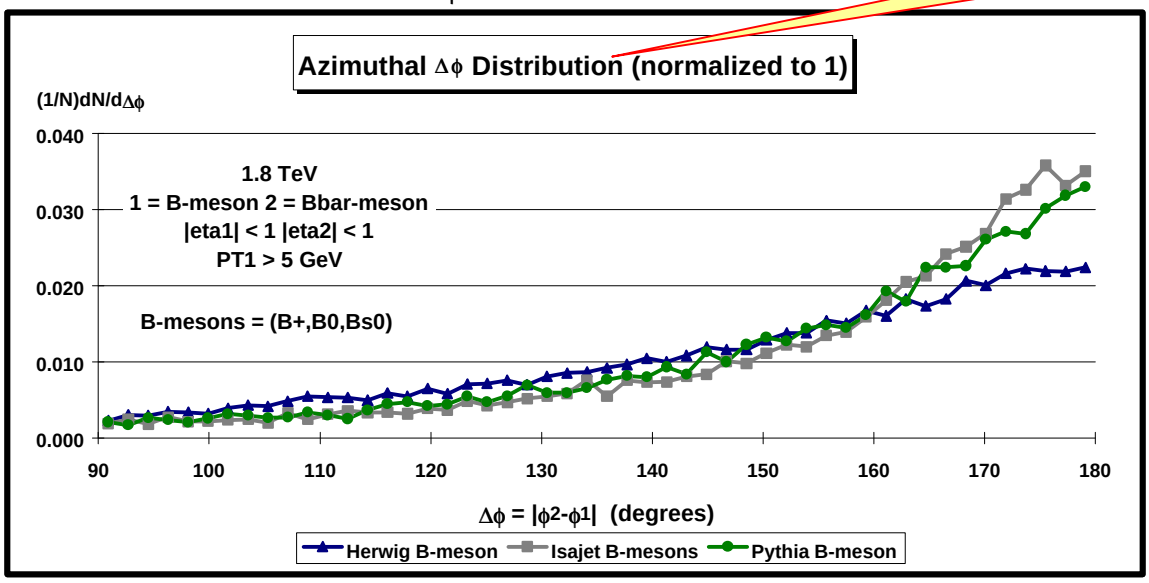
Parton Level: Azimuthal Δϕ Distribution



Plot shows (1/N)dN/dΔϕ (normalized to 1), where $\Delta\phi = |\phi_2-\phi_1|$ for 1 = b-quark and 2 = bbar-quark at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

Measures intrensic PT, gluon radiation, fragmentation.

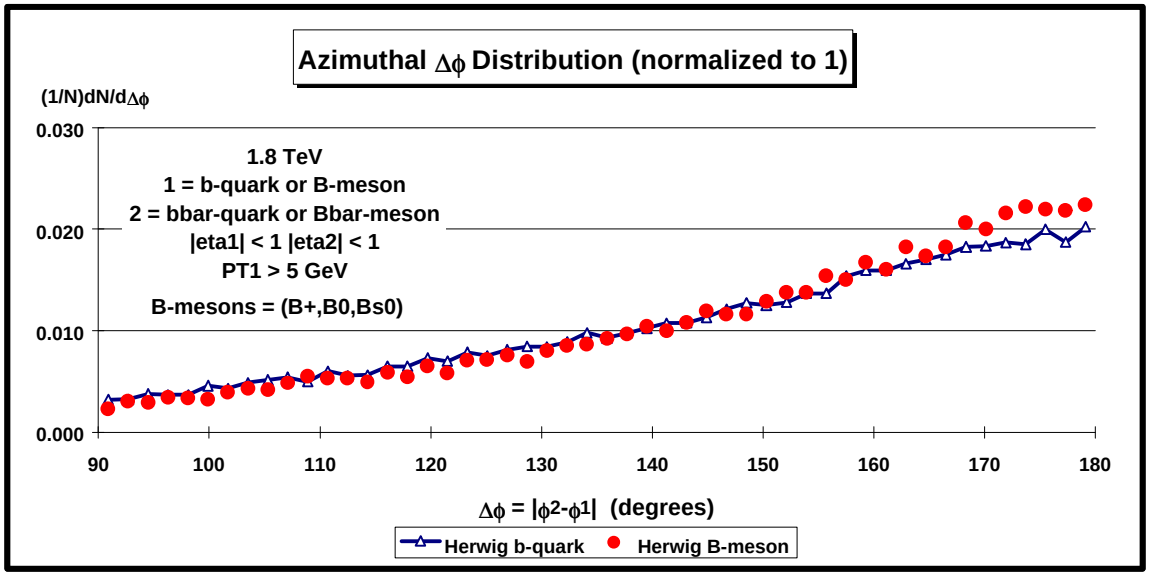
Hadron Level: Azimuthal Δϕ Distribution



Plot shows (1/N)dN/dΔϕ (normalized to 1), where $\Delta\phi = |\phi_2-\phi_1|$ for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

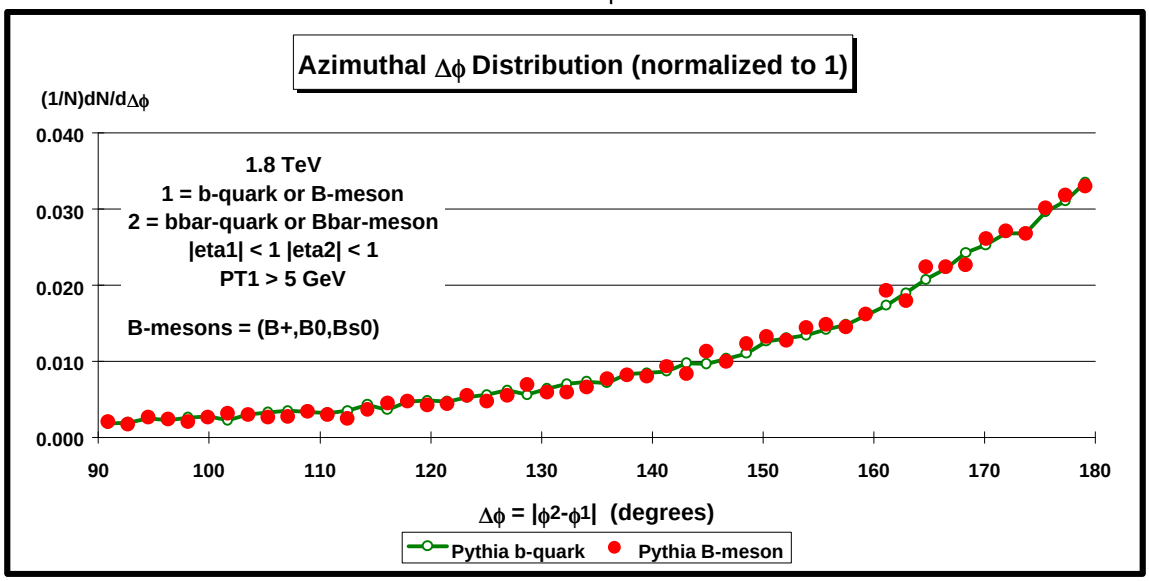
B Physics: Azimuthal Correlations

Parton & Hadron Level: Azimuthal $\Delta\phi$ Distribution



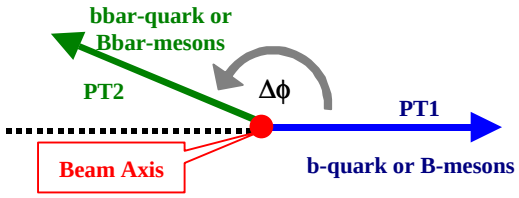
Plot shows (1/N)dN/d$\Delta\phi$ (normalized to 1), where $\Delta\phi = |\phi_2-\phi_1|$ for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

Parton & Hadron Level: Azimuthal $\Delta\phi$ Distribution

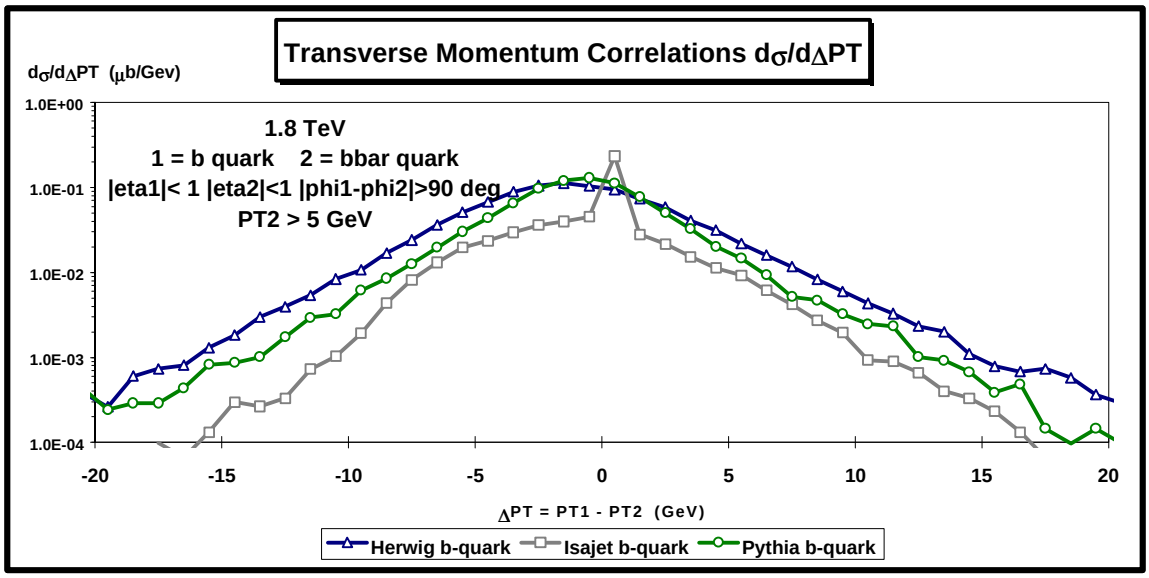


Plot shows (1/N)dN/d$\Delta\phi$ (normalized to 1), where $\Delta\phi = |\phi_2-\phi_1|$ for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

B Physics: PT Correlations

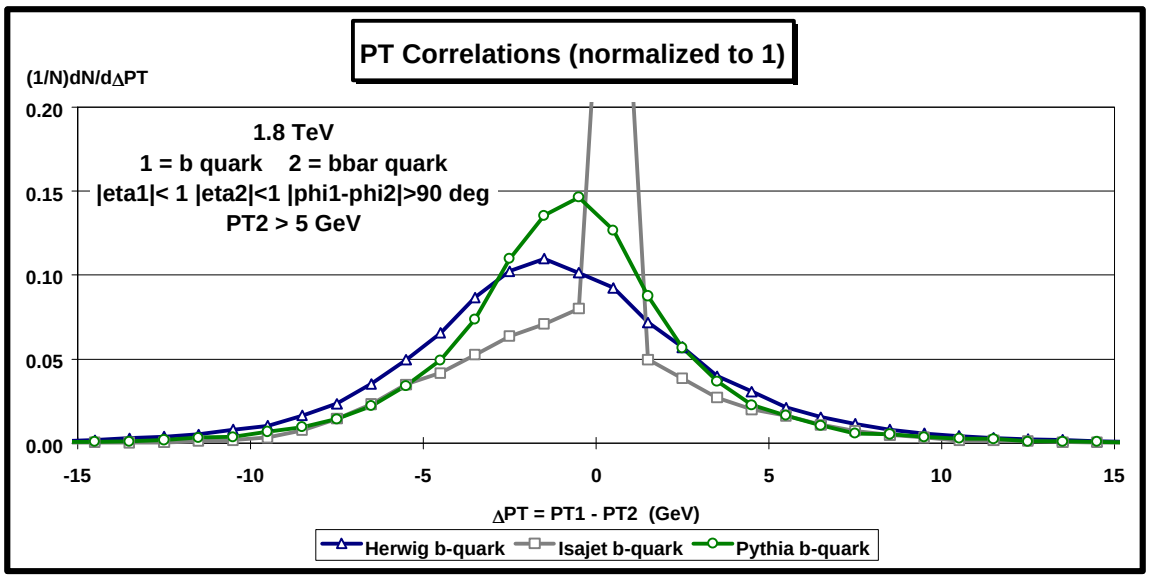


Parton Level: Transverse Momentum Correlations



Plot shows dσ/dΔPT (μb/GeV), where $\Delta PT = PT_1 - PT_2$ for 1 = b-quark and 2 = bbar-quark at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^o$, and $PT_2 > 5$ GeV.

Parton Level: Transverse Momentum Correlations

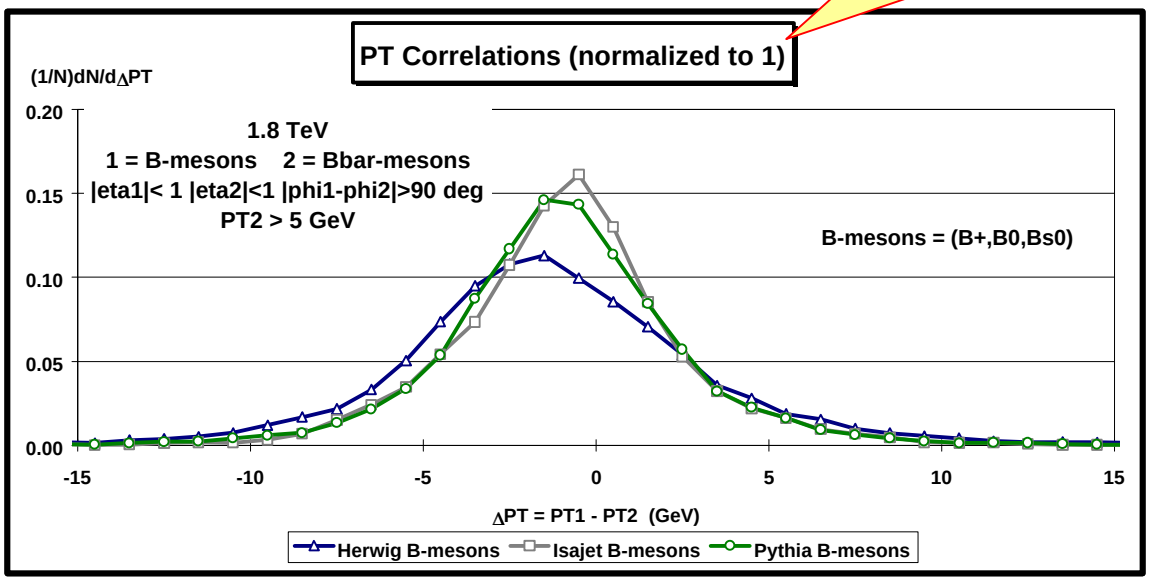


Plot shows dσ/dΔPT (μb/GeV), where $\Delta PT = PT_1 - PT_2$ for 1 = b-quark and 2 = bbar-quark at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^o$, and $PT_2 > 5$ GeV.

B Physics: PT Correlations

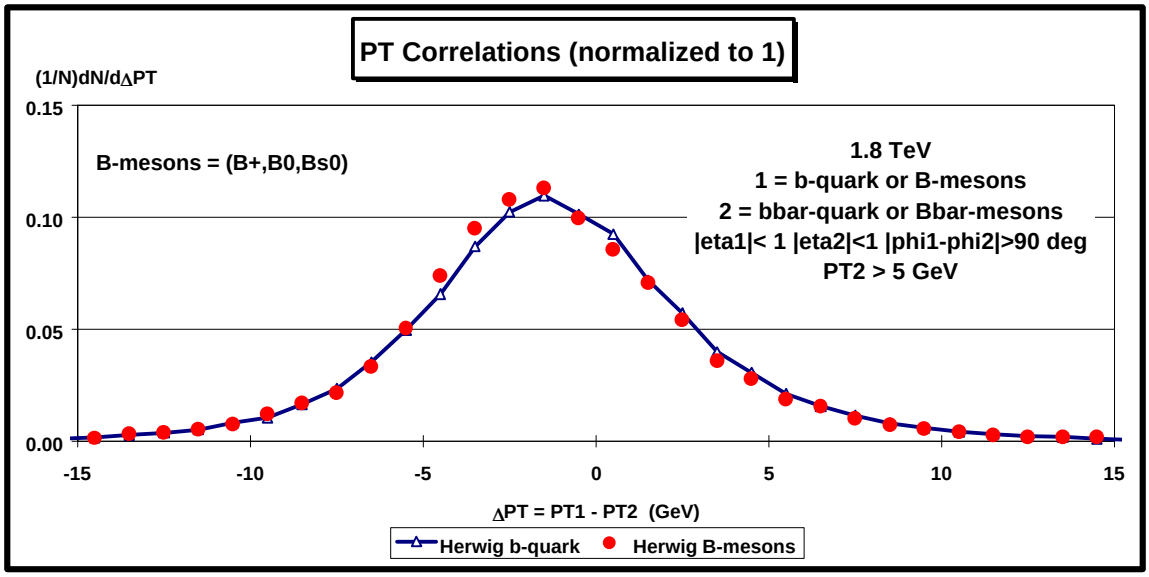
Measures intrensic PT, gluon radiation, and fragmentation.

Hadron Level: Transverse Momentum Correlations



Plot shows $d\sigma/d\Delta PT$ (μb/GeV), where $\Delta PT = PT_1 - PT_2$ for 1 = B-mesons (B^+, B^0, B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^o$, and $PT_2 > 5$ GeV.

Parton & Hadron Level: Transverse Momentum Correlations



Plot shows $d\sigma/d\Delta PT$ (μb/GeV), where $\Delta PT = PT_1 - PT_2$ for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+, B^0, B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^o$, and $PT_2 > 5$ GeV.

B Physics: Pseudo-Rapidity Correlations

Correlation Functions:

Double-Differential Cross Section

$$C(h_1,h_2)=\frac{1}{s}\frac{ds}{dh_1dh_2}-\frac{1}{s^2}\frac{ds}{dh_1}\frac{ds}{dh_2}$$

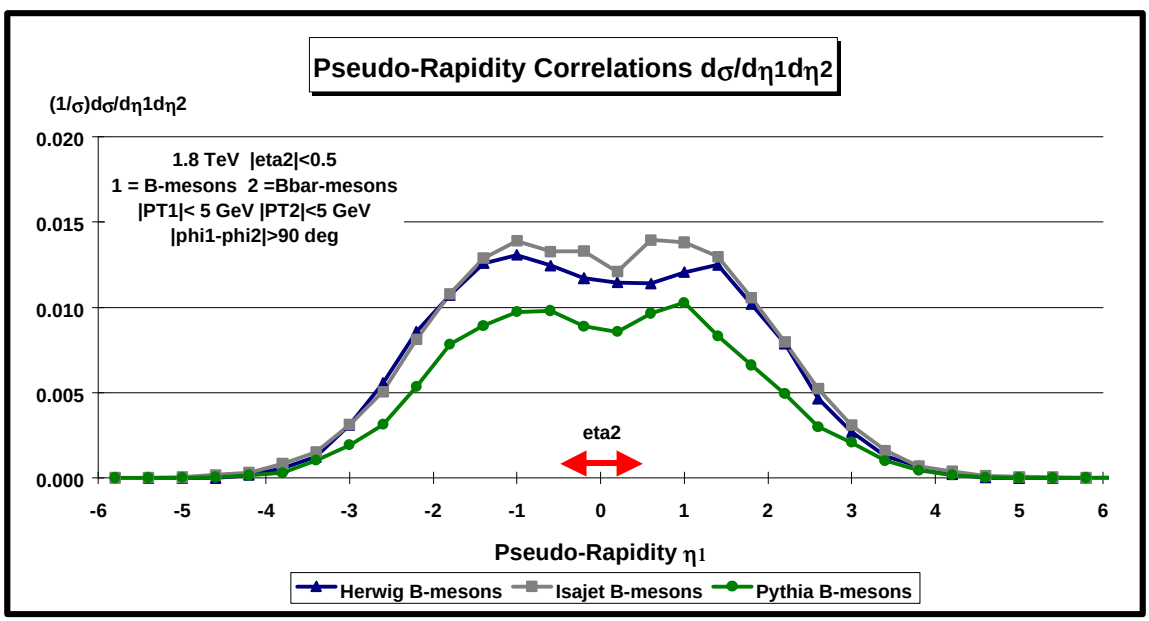
"Normalized" Correlation Functions:

$$R(h_1,h_2)=\left(\frac{1}{s}\frac{ds}{dh_1dh_2}-\frac{1}{s^2}\frac{ds}{dh_1}\frac{ds}{dh_2}\right)\Bigg/\left(\frac{1}{s^2}\frac{ds}{dh_1}\frac{ds}{dh_2}\right)$$

"Integrated" ($a < \eta_2 < b$) Normalized Correlation Functions:

$$R(h_1)=\int_a^b\left(\frac{1}{s}\frac{ds}{dh_1dh_2}-\frac{1}{s^2}\frac{ds}{dh_1}\frac{ds}{dh_2}\right)dh_2\Bigg/\int_a^b\left(\frac{1}{s^2}\frac{ds}{dh_1}\frac{ds}{dh_2}\right)dh_2$$

Hadron Level: Pseudo-Rapidity Correlations ($|\eta_2| < 0.5$)

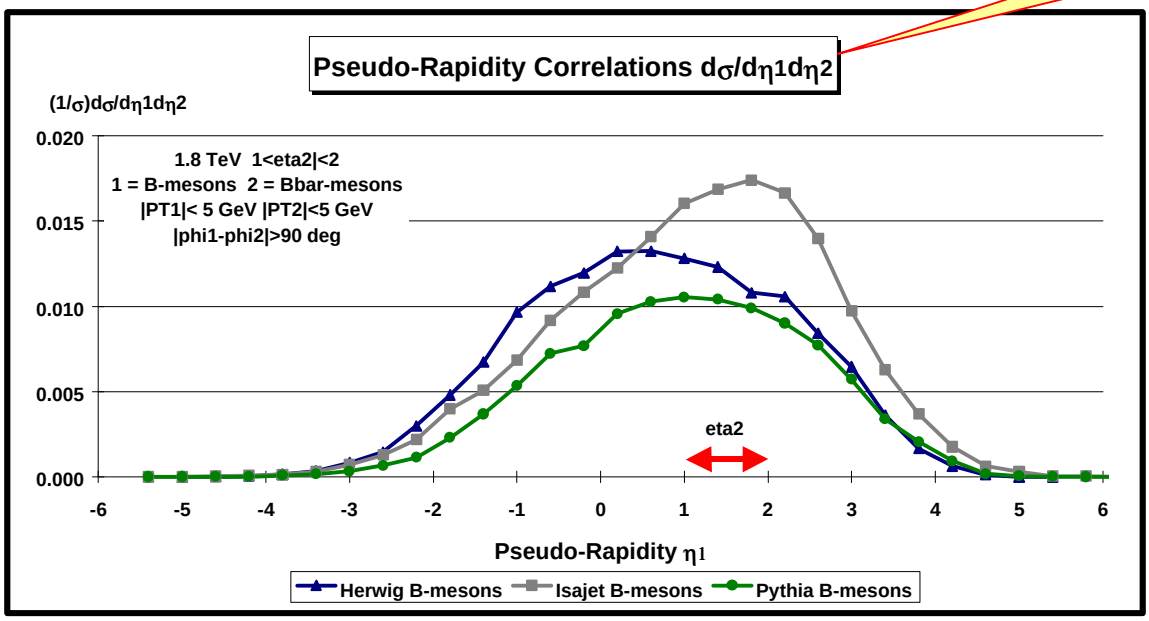


Plot shows $(1/\sigma)d\sigma/d\eta_1d\eta_2$ versus η_1, for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$, $|\phi_1-\phi_2| > 90^0$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

B Physics: Pseudo-Rapidity Correlations

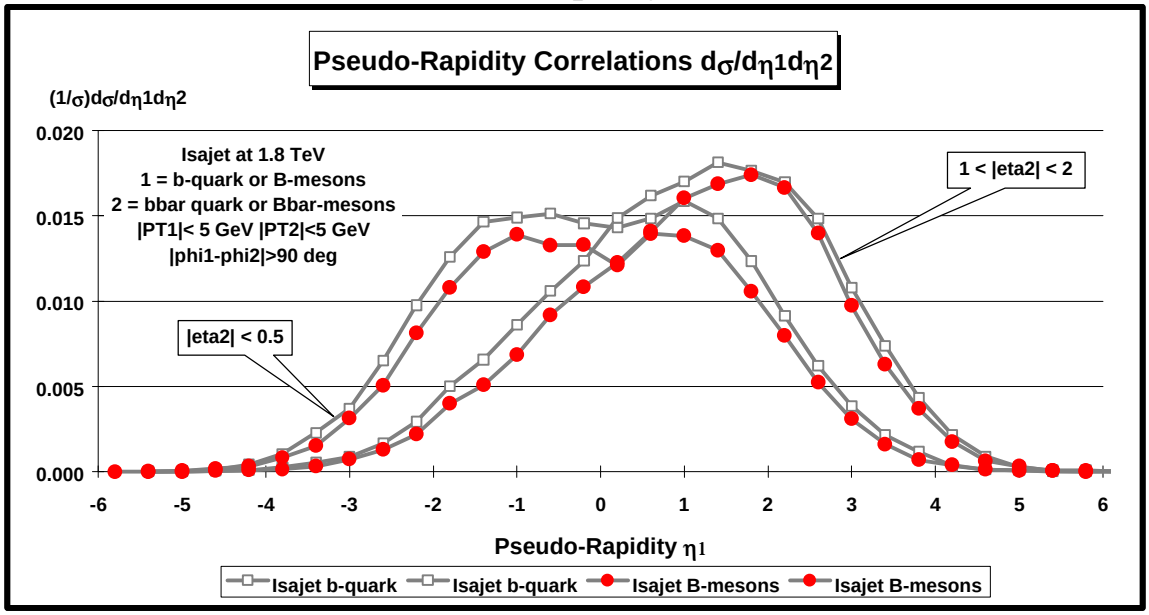
Hadron Level: Pseudo-Rapidity Correlations ($1 < |\eta_2| < 2$)

Measures PDF's, fragmentation.



Plot shows $(1/\sigma)d\sigma/d\eta_1 d\eta_2$ versus η_1, for 1 = B-mesons (B^+, B^0, B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $1 < |\eta_2| < 2$, $|\phi_1 - \phi_2| > 90^o$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

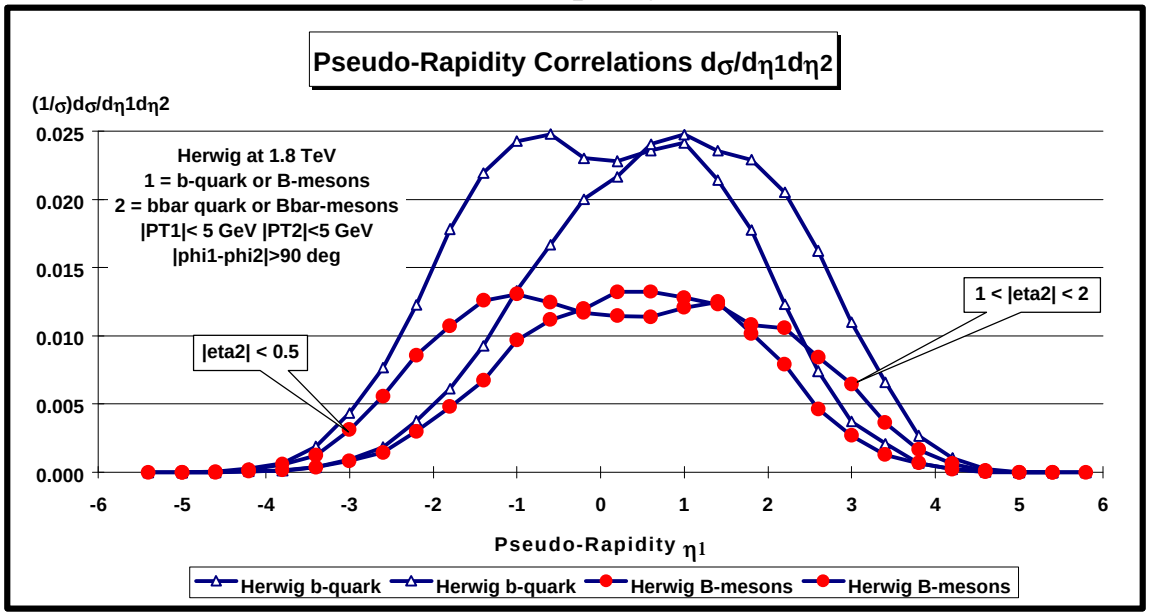
Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1 d\eta_2$ versus η_1, for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+, B^0, B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$ and with $1 < \eta_2 < 2$ and $|\phi_1 - \phi_2| > 90^o$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

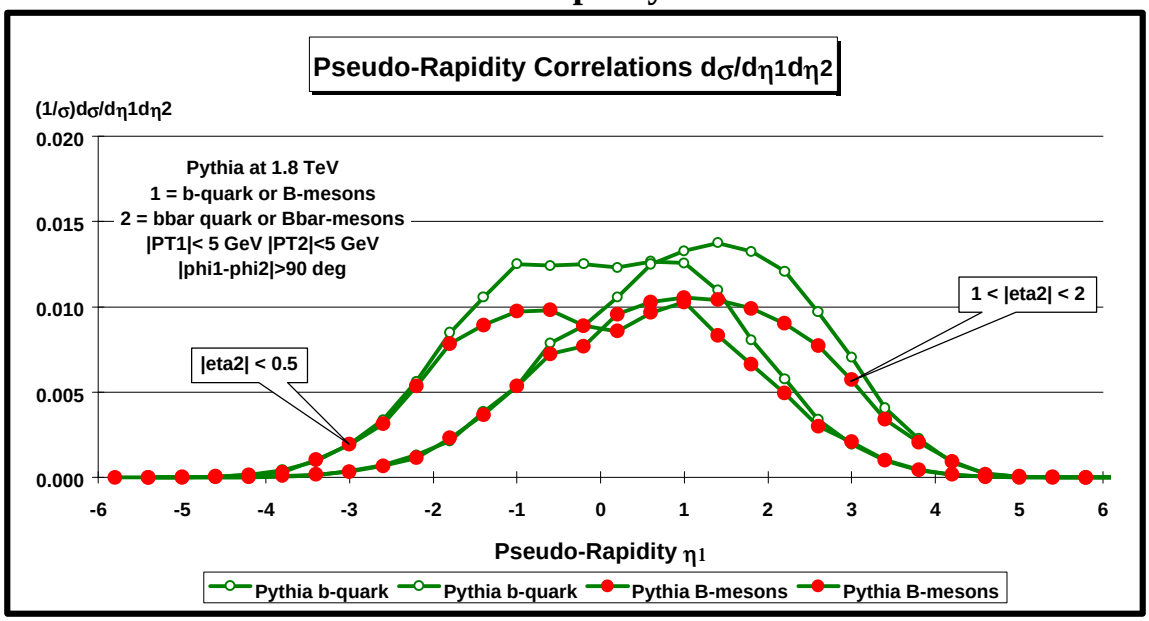
B Physics: Pseudo-Rapidity Correlations

Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1 d\eta_2$ versus η_1, for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$ and with $1 < \eta_2 < 2$ and $|\phi_1-\phi_2| > 90^o$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

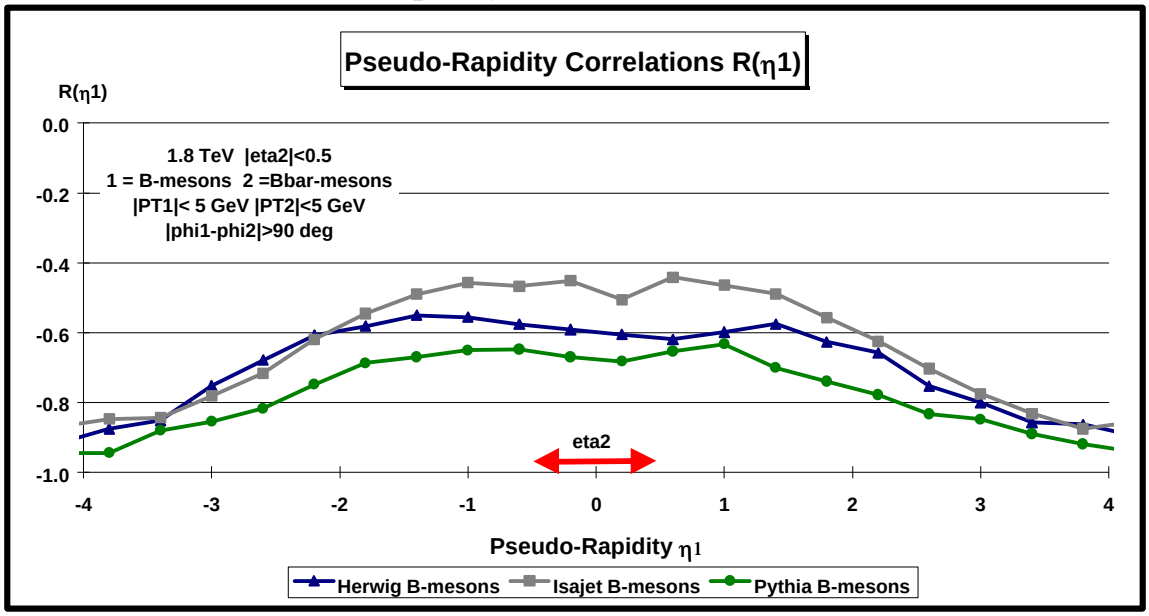
Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1 d\eta_2$ versus η_1, for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$ and with $1 < \eta_2 < 2$ and $|\phi_1-\phi_2| > 90^o$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

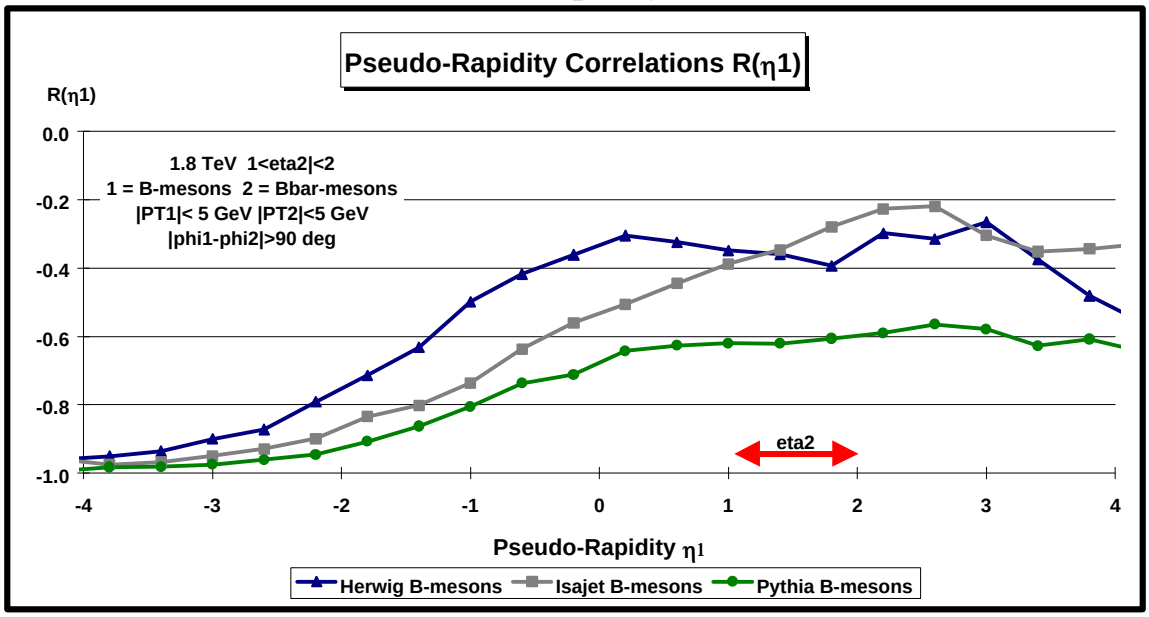
B Physics: Pseudo-Rapidity Correlations

Hadron Level: Pseudo-Rapidity Correlations



Plot shows the normalized correlation function $R(\eta_1)$ versus η_1, for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$ and $|\phi_1-\phi_2| > 90^o$, $PT_1 >$ 5 GeV, and $PT_2 >$ 5 GeV.

Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows the normalized correlation function $R(\eta_1)$ versus η_1, for 1 = B-mesons (B^+,B^0,B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $1 < \eta_2 < 2$ and $|\phi_1-\phi_2| > 90^o$, $PT_1 >$ 5 GeV, and $PT_2 >$ 5 GeV.