

B Physics: QCD Monte Carlo Model Predictions

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QCD Run II Workshop

<http://www.phys.ufl.edu/~rfield/cdf/>

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 $f_s/(f_u+f_d)$ (**fragmentation**)
- Y and η Distributions Hadron versus Parton
- Azimuthal $\Delta\phi$ Correlations Hadron versus Parton
- PT Correlations Hadron versus Parton (**PT₁-PT₂**)
- Pseudo-Rapidity Correlations: **$d\sigma/d\eta_1d\eta_2$ & $R(\eta_1,\eta_2)$**
- Comparisons between 1.8 TeV and 2.0 TeV

New

QCD Monte Carlo Models (default parameters):

Herwig 5.9 (DO1.1, $\Lambda = 0.18$ GeV)

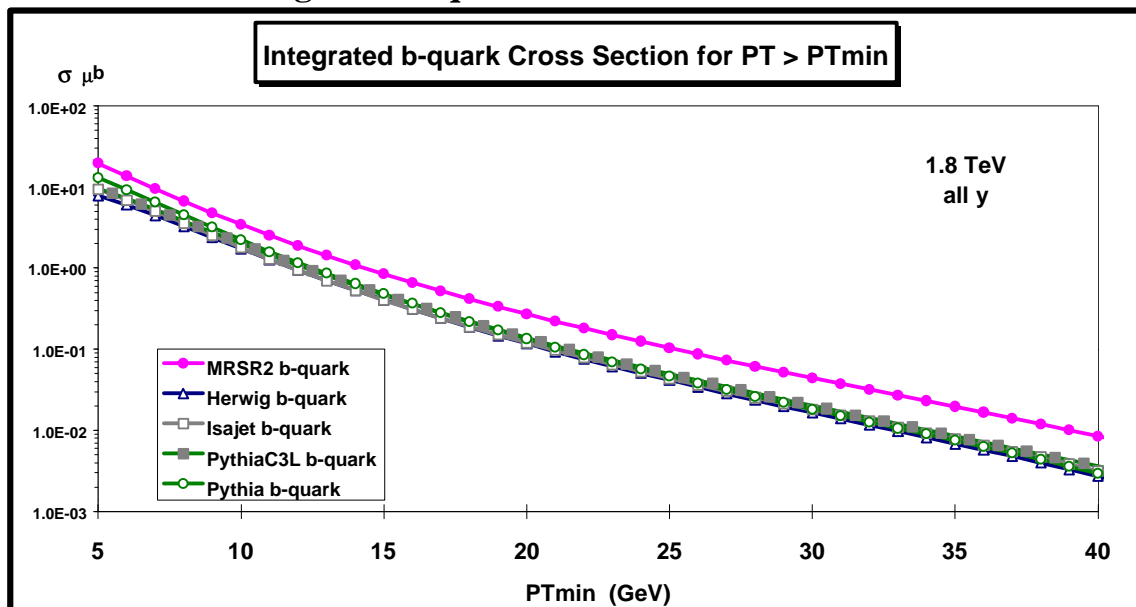
Isajet 7.32 (CTEQ3L, $\Lambda = 0.20$ GeV)

Pythia 6.115 (GRV94LO, $\Lambda = 0.23$ GeV)

Pythia 6.115 (CTEQ3L, $\Lambda = 0.18$ GeV)

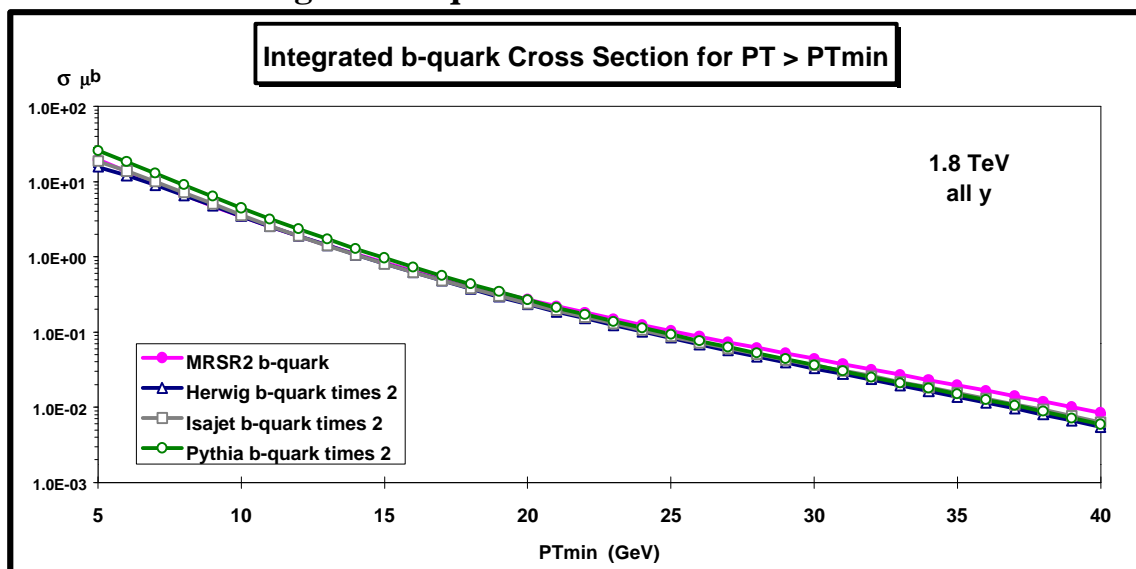
B Physics: Cross Sections

Parton Level: Integrated b-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (in μb) for b-quarks at 1.8 TeV (all Y).

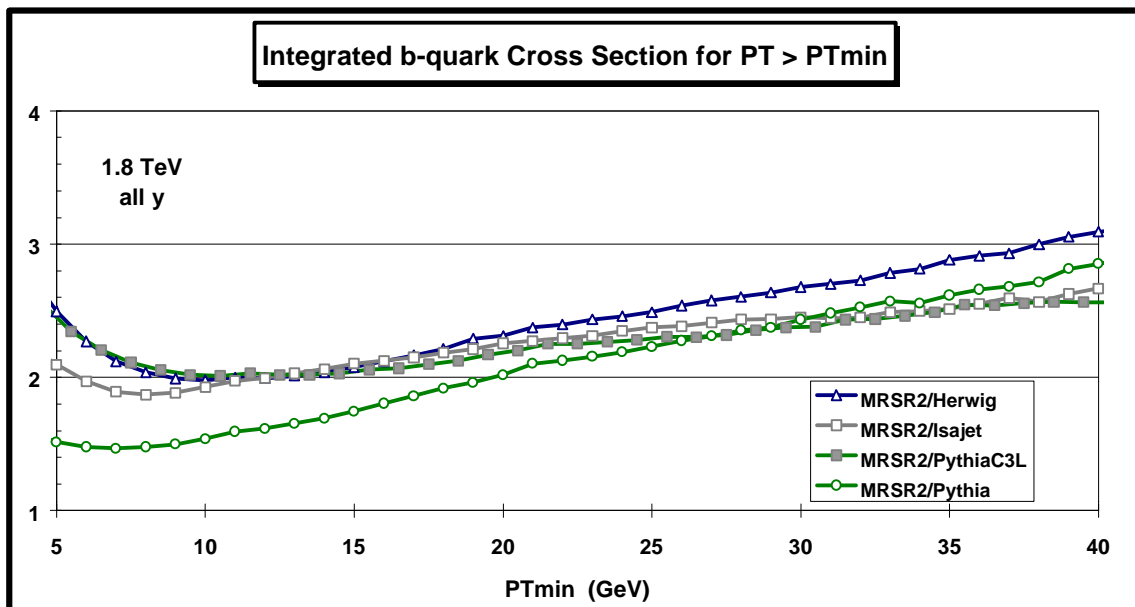
Parton Level: Integrated b-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (in μb) for b-quarks at 1.8 TeV (all Y). Herwig, Isajet, and Pythia have been increased by a factor of **two**.

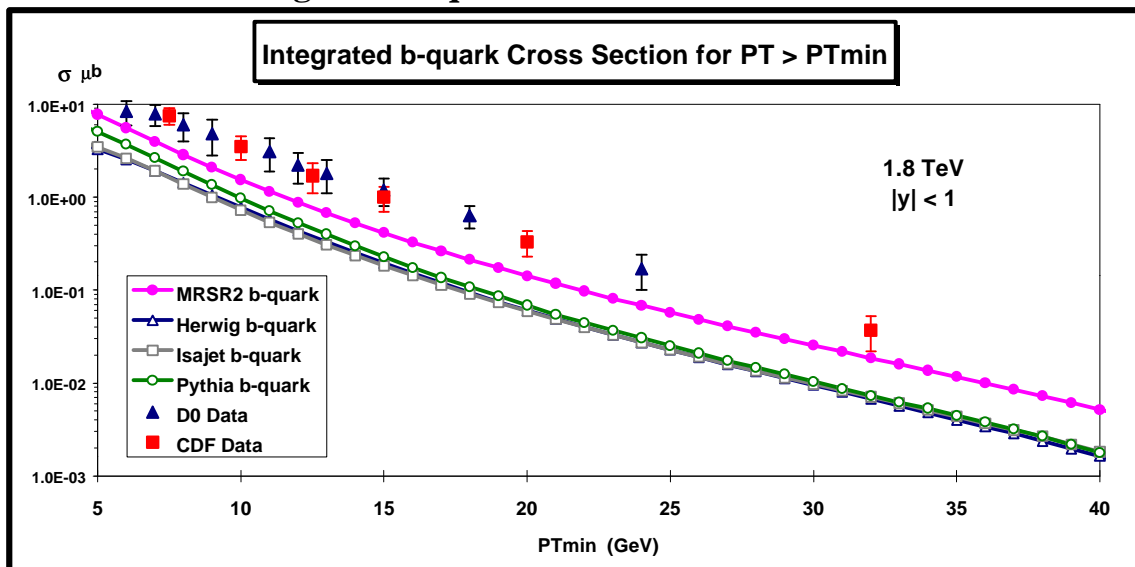
B Physics: Cross Sections

Parton Level: Ratio MRSR2/Monte-Carlos



Plot shows the ratio of $\sigma(PT > PT_{min})$ for b-quarks at 1.8 TeV (all Y) from MRSR2 to Herwig, Isajet, Pythia, and PythiaC3L.

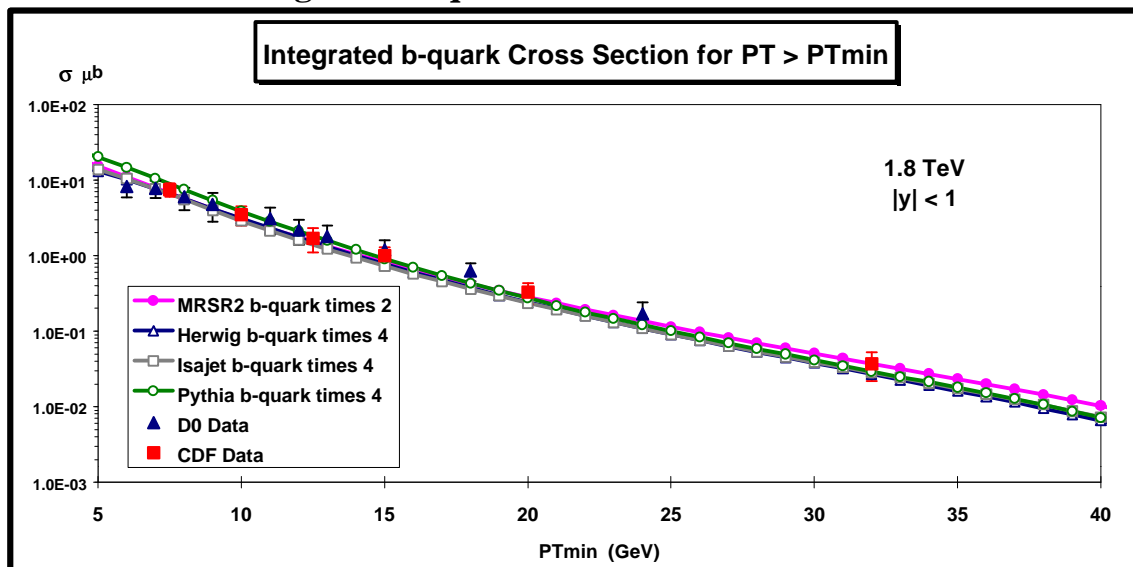
Parton Level: Integrated b-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (in μb) for b-quarks at 1.8 TeV ($|Y| < 1$).

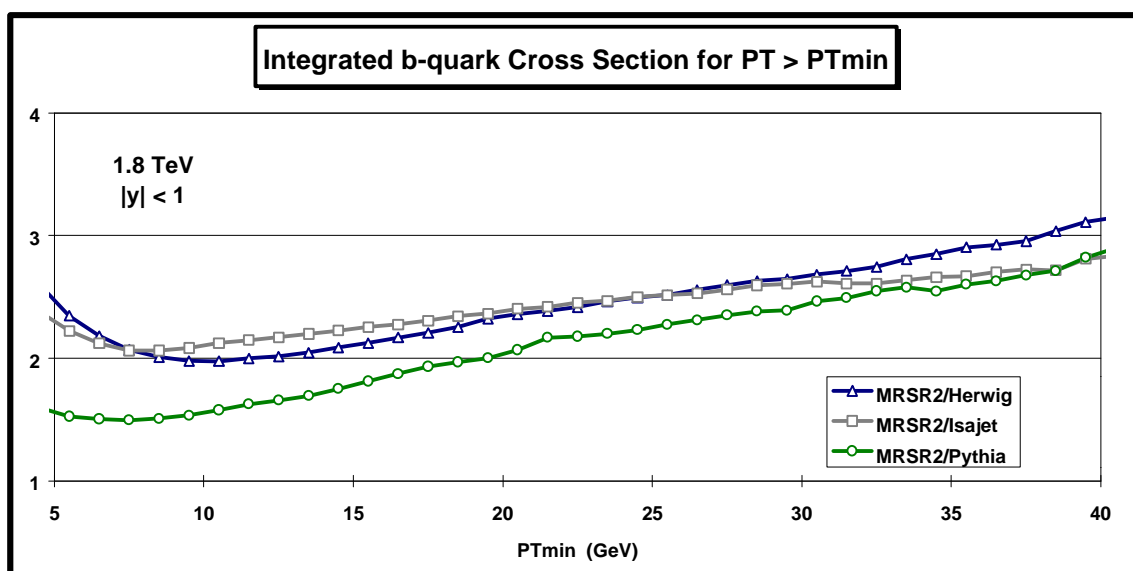
B Physics: Cross Sections

Parton Level: Integrated b-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (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**.

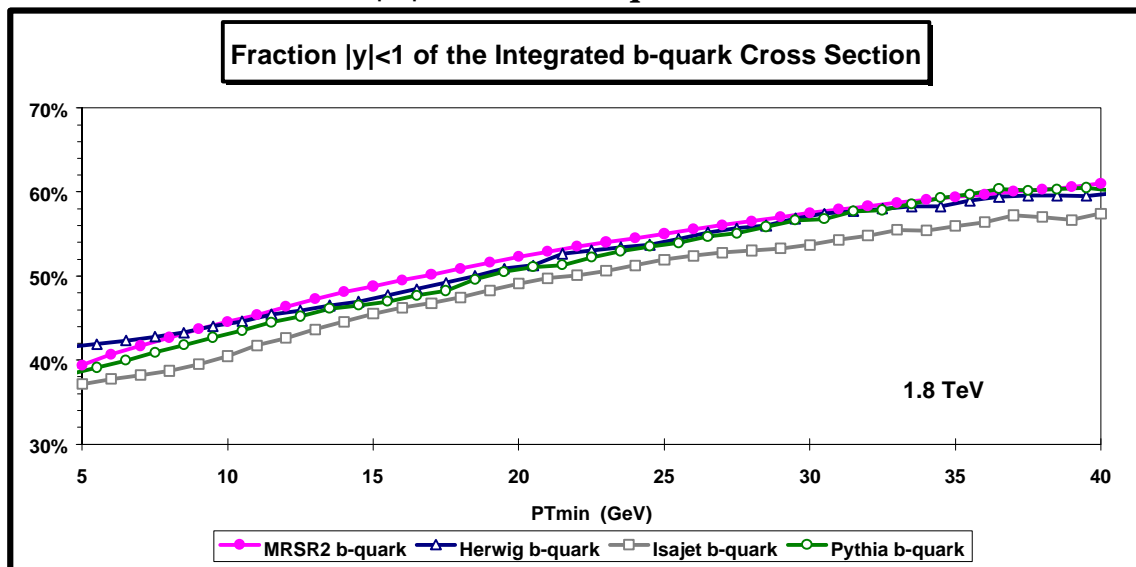
Parton Level: Ratio MRSR2/Monte-Carlos



Plot shows the ratio of $\sigma(PT > PT_{min})$ for b-quarks at 1.8 TeV ($|Y| < 1$) from MRSR2 to Herwig, Isajet, and Pythia.

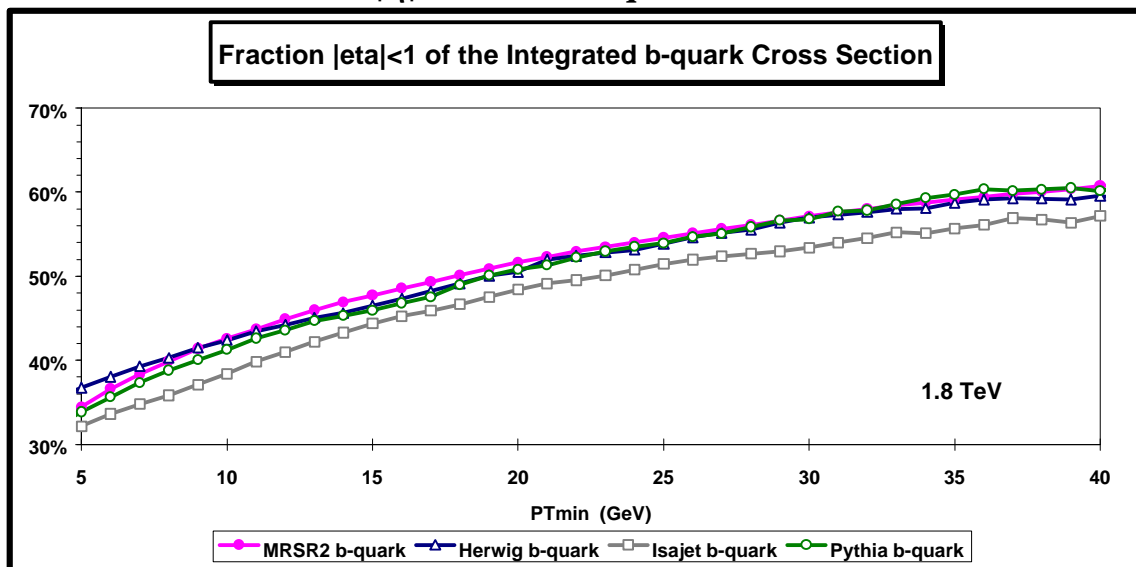
B Physics: Cross Sections

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



Plot shows the fraction $|Y| < 1$ of the b-quark integrated cross section ($PT < PT_{min}$).

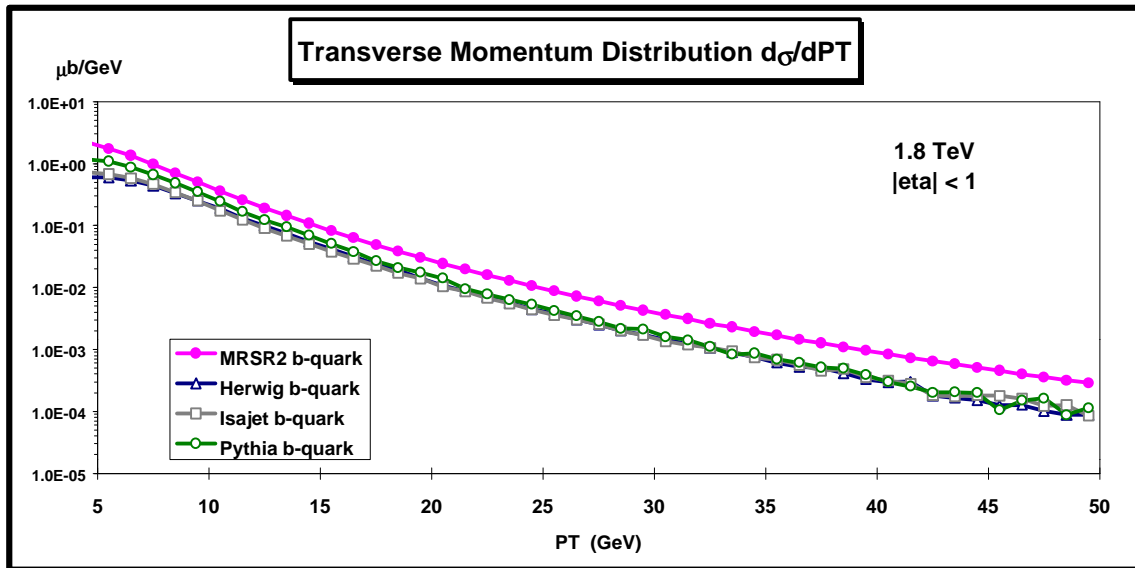
Parton Level: Fraction $|\eta| < 1$ of the b-quark Cross Section



Plot shows the fraction $|\eta| < 1$ of the b-quark integrated cross section ($PT < PT_{min}$).

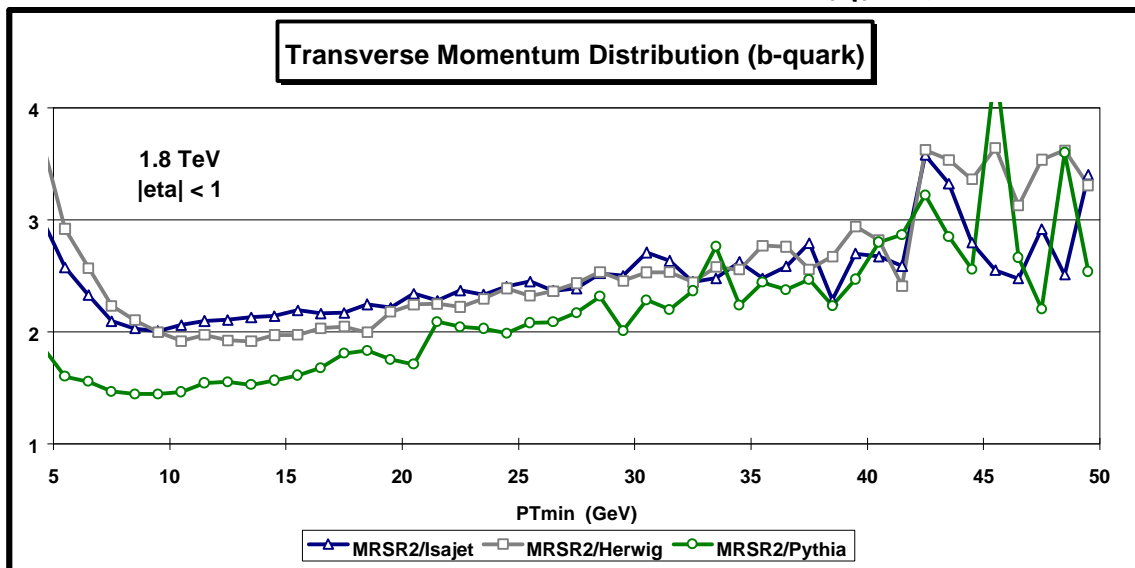
B Physics: PT Distributions

Parton Level: Transverse Momentum Distribution ($|\eta| < 1$)



Plot shows $d\sigma/dPT$ (in $\mu\text{b}/\text{GeV}$) for b-quarks at 1.8 TeV ($|\eta| < 1$).

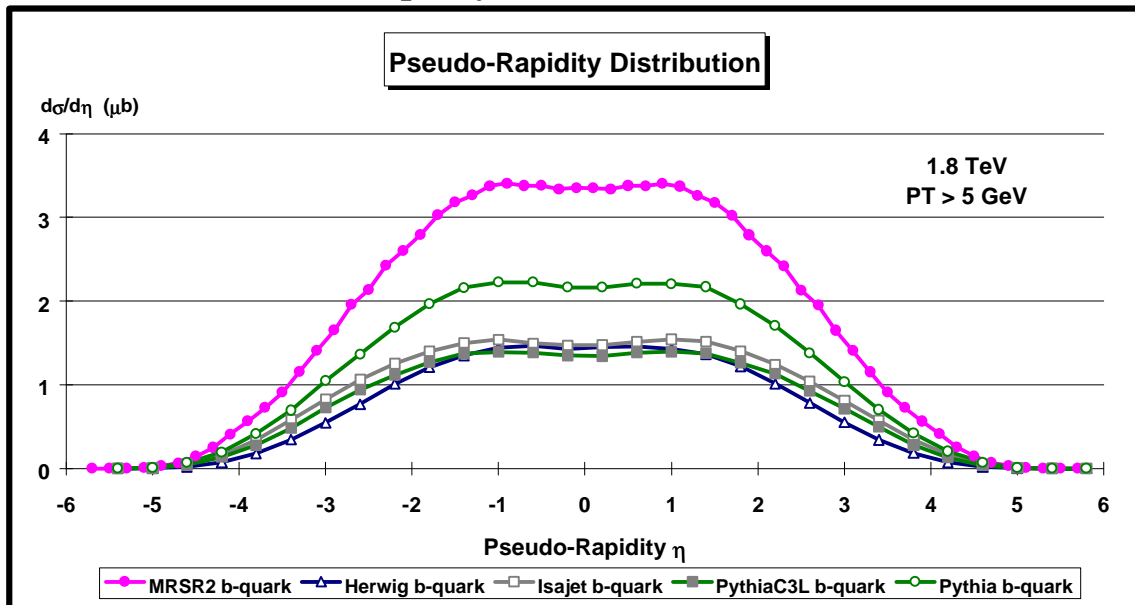
Parton Level: Transverse Momentum Distribution ($|\eta| < 1$)



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

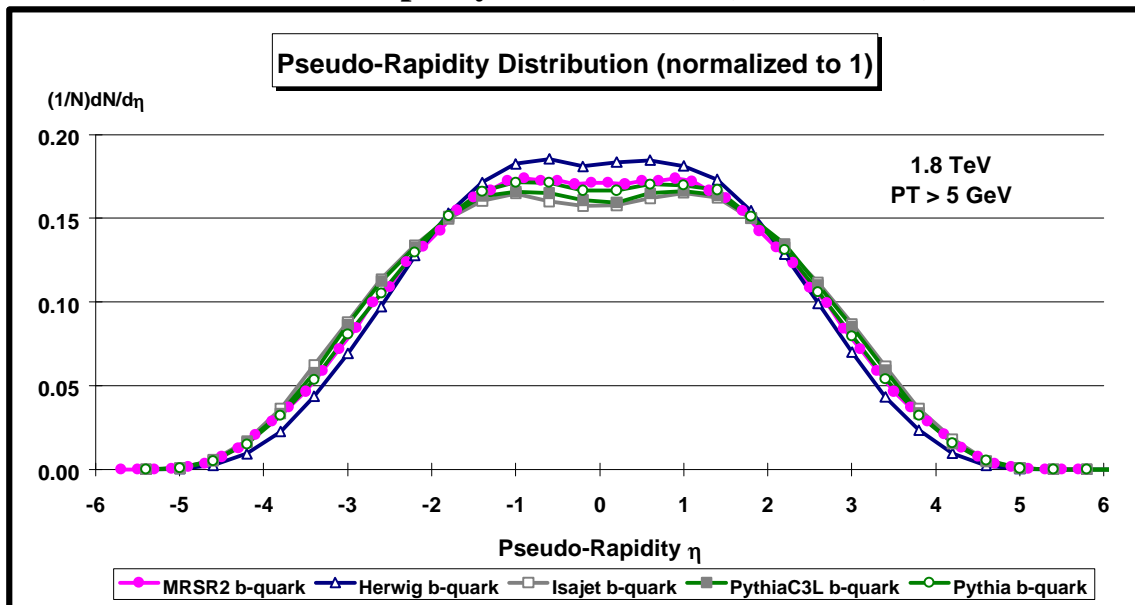
B Physics: Pseudo-Rapidity Distributions

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



Plot shows $d\sigma/d\eta$ (in μb) for b-quarks at 1.8 TeV (PT > 5 GeV).

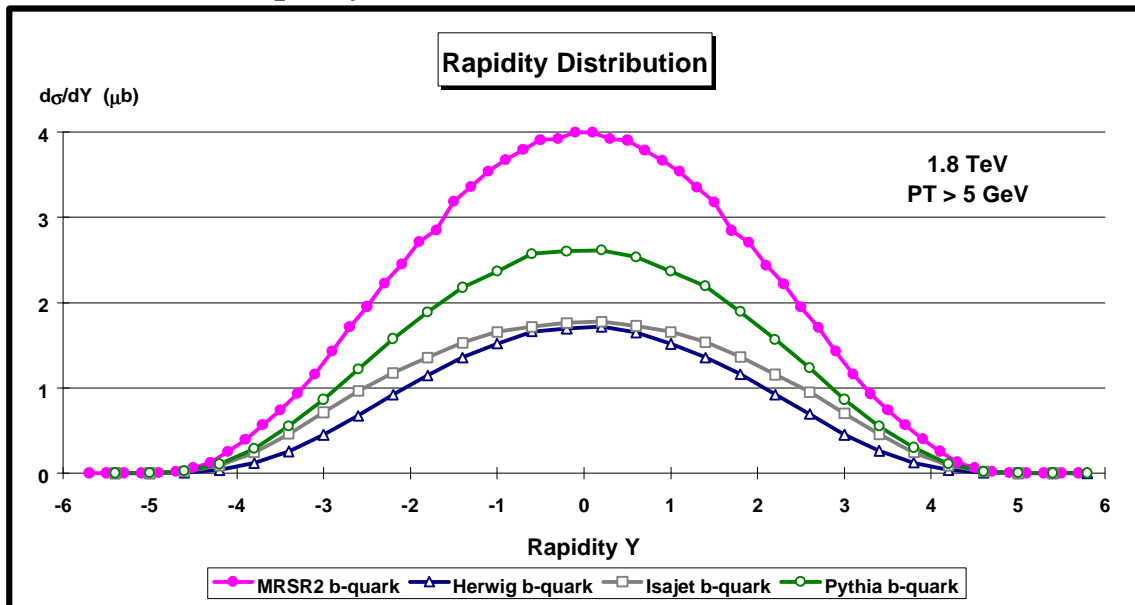
Parton Level: Pseudo-Rapidity Distributions (PT > 5 GeV)



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

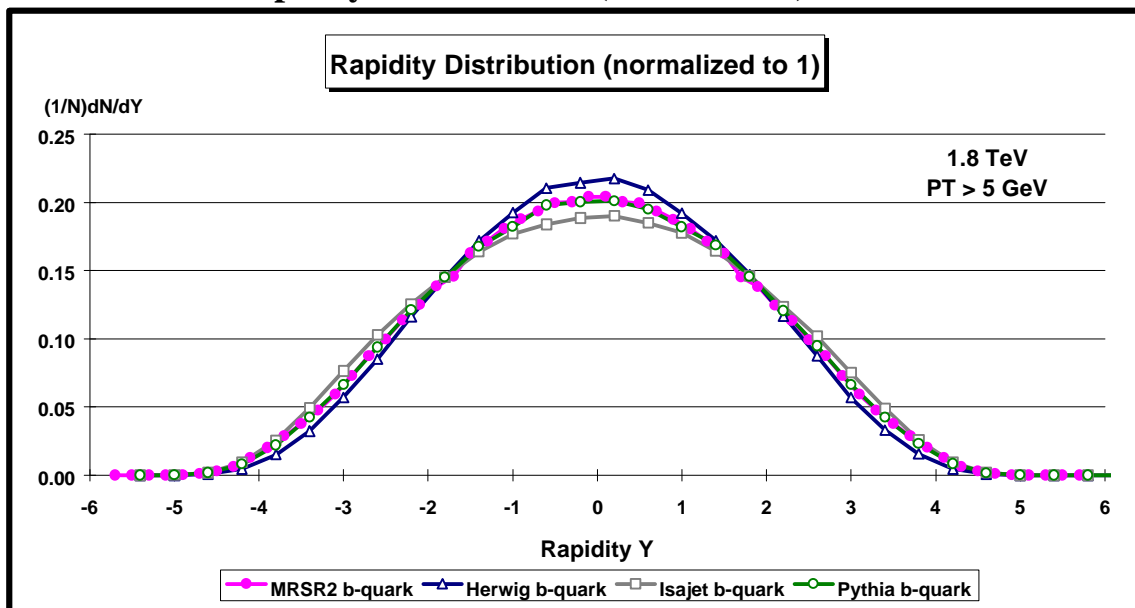
B Physics: Rapidity Distributions

Parton Level: Rapidity Distributions (PT > 5 GeV)



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

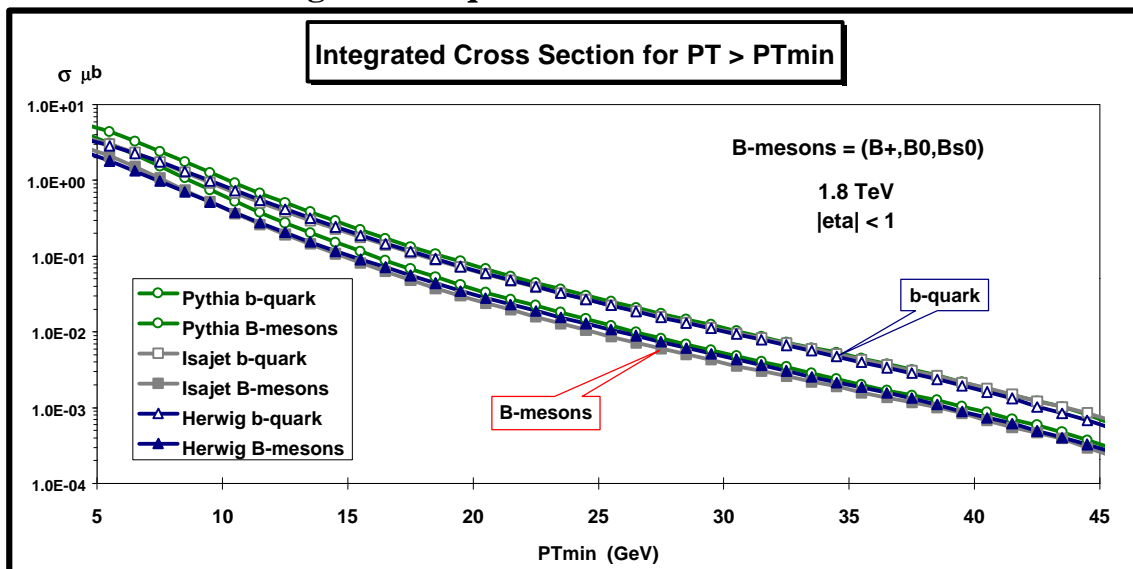
Parton Level: Rapidity Distributions (PT > 5 GeV)



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

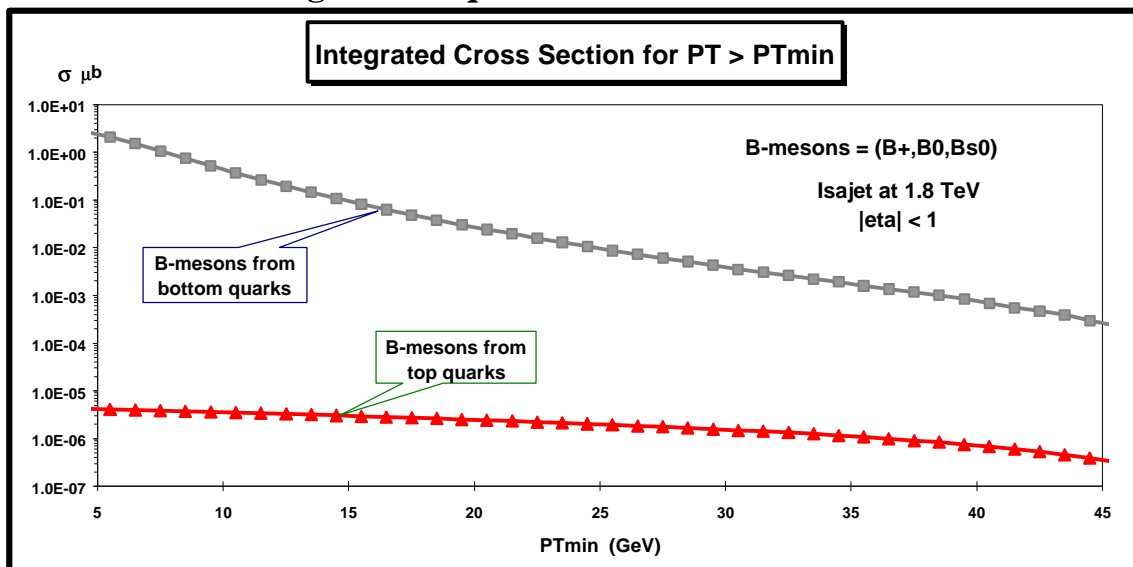
B Physics: Cross Sections

Hadron Level: Integrated B-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (in μb) for B-mesons (B^+ , B^0 , B_s^0) and b-quarks at 1.8 TeV ($|\eta| < 1$).

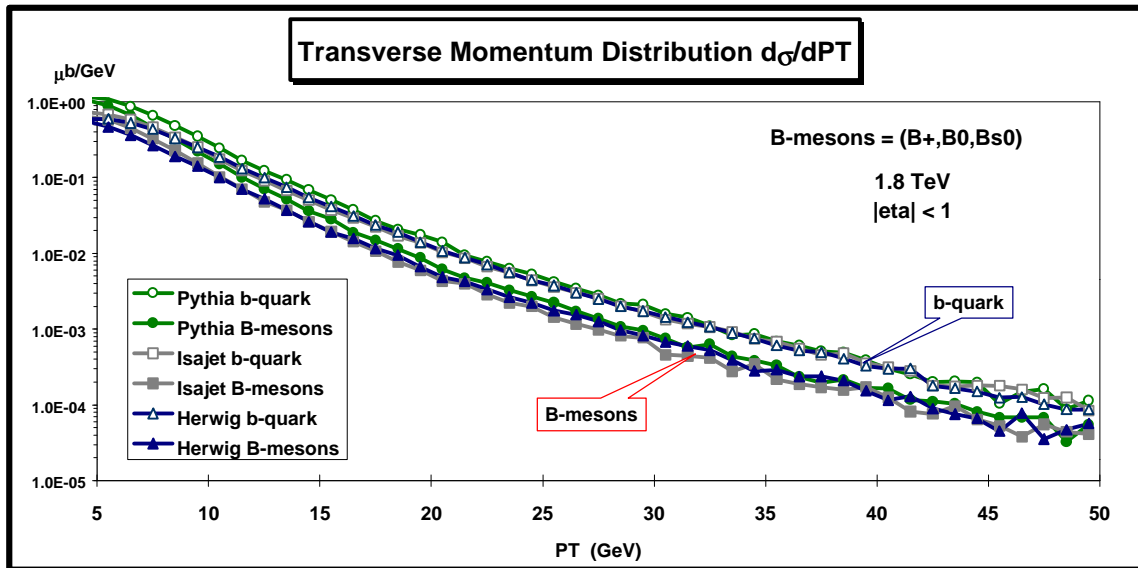
Hadron Level: Integrated B-quark Cross Section for $PT > PT_{min}$



Plot shows $\sigma(PT > PT_{min})$ (in μb) for B-mesons (B^+ , B^0 , B_s^0) from b and t-quarks 1.8 TeV ($|\eta| < 1$).

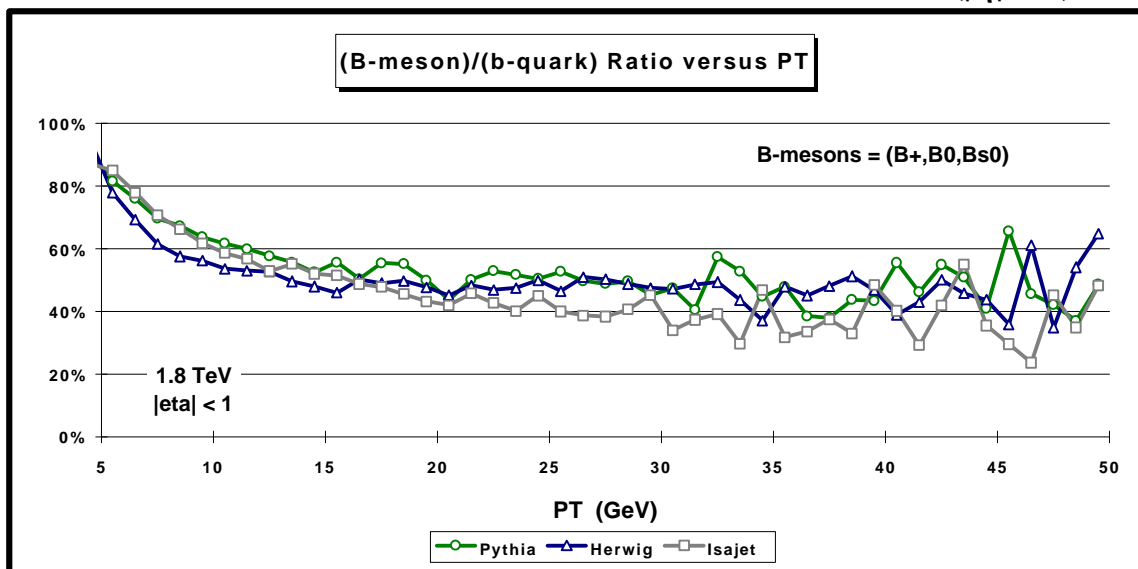
B Physics: PT Distributions

Parton & Hadron Level: Transverse Momentum Distribution ($|\eta| < 1$)



Plot shows $d\sigma/dPT$ (in $\mu\text{b}/\text{GeV}$) for B-mesons (B^+ , B^0 , B_s^0) and for the b-quark at 1.8 TeV ($|\eta| < 1$).

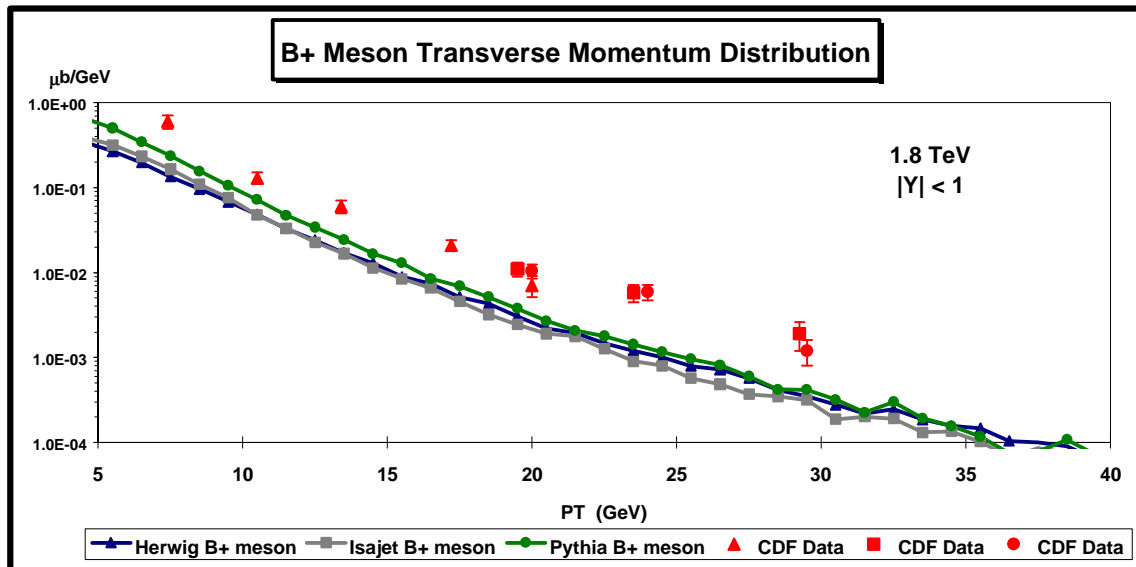
Hadron/Parton Level: Transverse Momentum Distribution ($|\eta| < 1$)



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

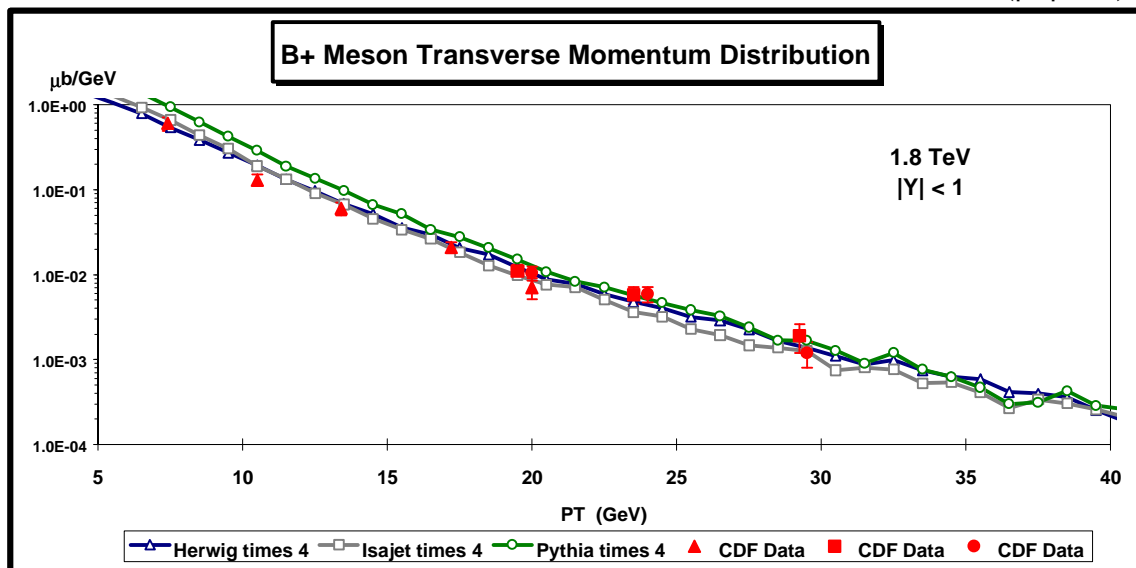
B Physics: PT Distributions

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



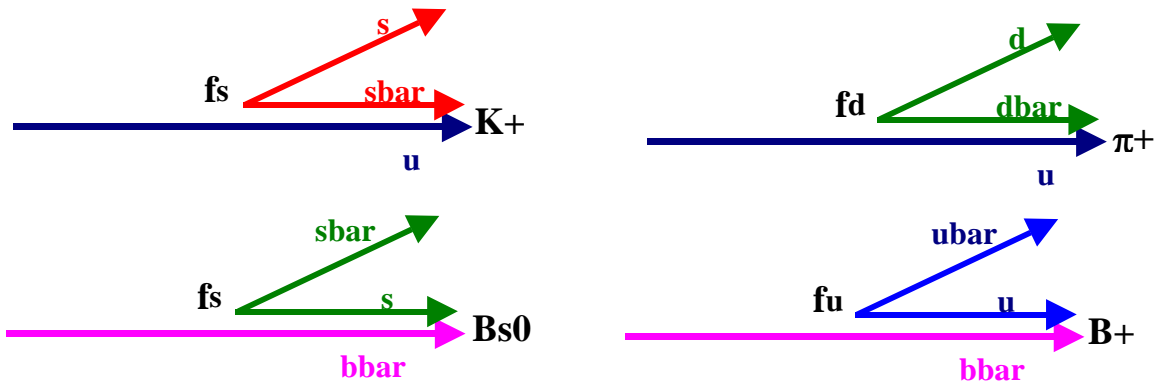
Plot shows $d\sigma/dPT$ (in $\mu\text{b}/\text{GeV}$) for B⁺ mesons at 1.8 TeV ($|Y| < 1$).

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



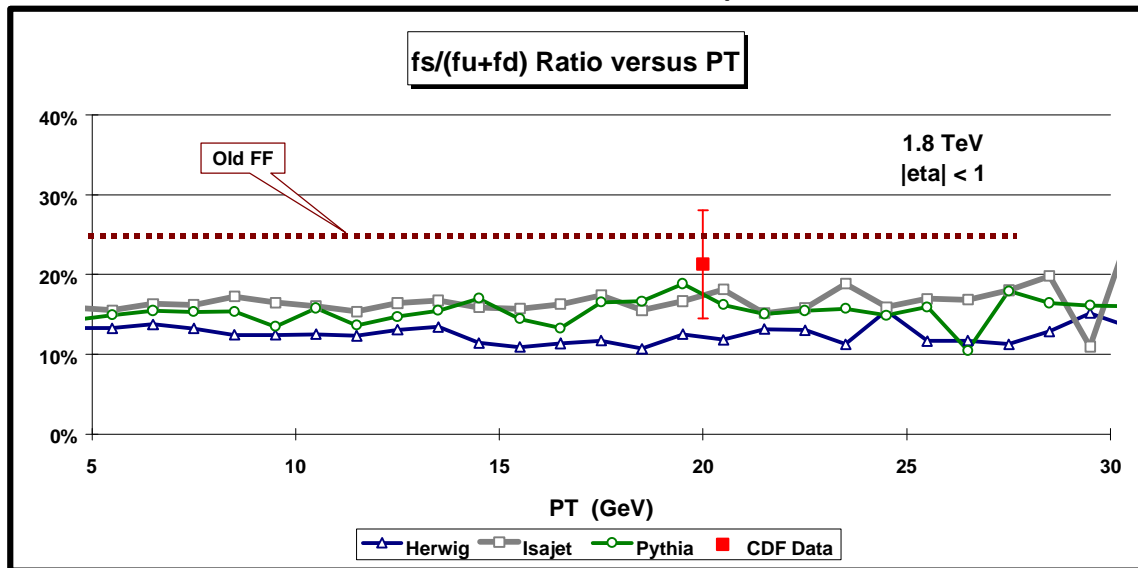
Plot shows $d\sigma/dPT$ (in $\mu\text{b}/\text{GeV}$) for B⁺ mesons at 1.8 TeV ($|Y| < 1$). The QCD Monte-Carlo predictions have been increased by a factor of **four**.

B Physics: Fragmentation



	CDF Run I	Old FF
fu	0.408\pm0.068	0.4
fd	0.344\pm0.039	0.4
fs	0.159\pm0.026	0.2
fbaryon	0.089\pm0.029	0.0
fs/(fu+fd)	0.213\pm0.068	0.25

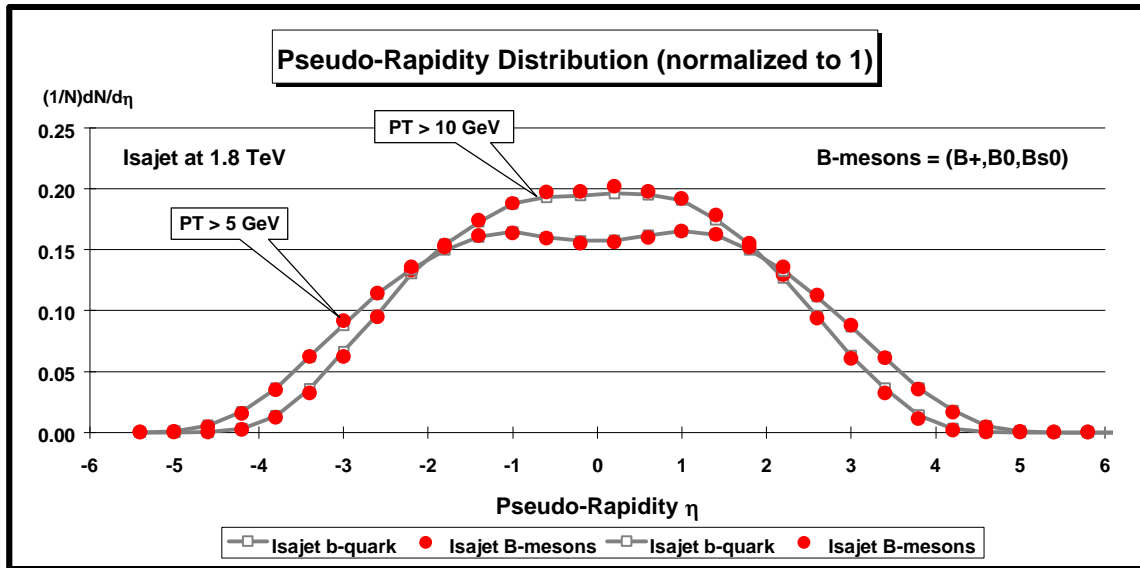
Hadron Level: $fs/(fu+fd)$ Ratio versus PT ($|\eta| < 1$)



Plot shows the ratio $fs/(fu+fd)$ at 1.8 TeV ($|\eta| < 1$), where $fs = d\sigma/dPT(B_s^0)$, $fu = d\sigma/dPT(B^+)$, and $fd = d\sigma/dPT(B^0)$.

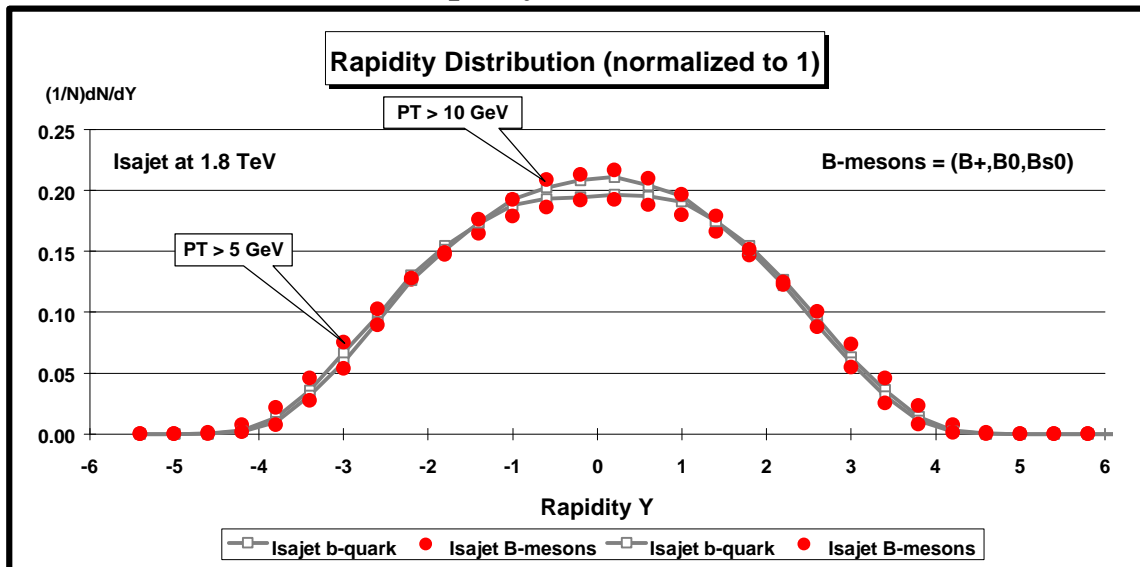
B Physics: Y and η Distributions

Parton & Hadron Level: Pseudo-Rapidity Distribution



Plot shows $(1/N)dN/d\eta$ (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).

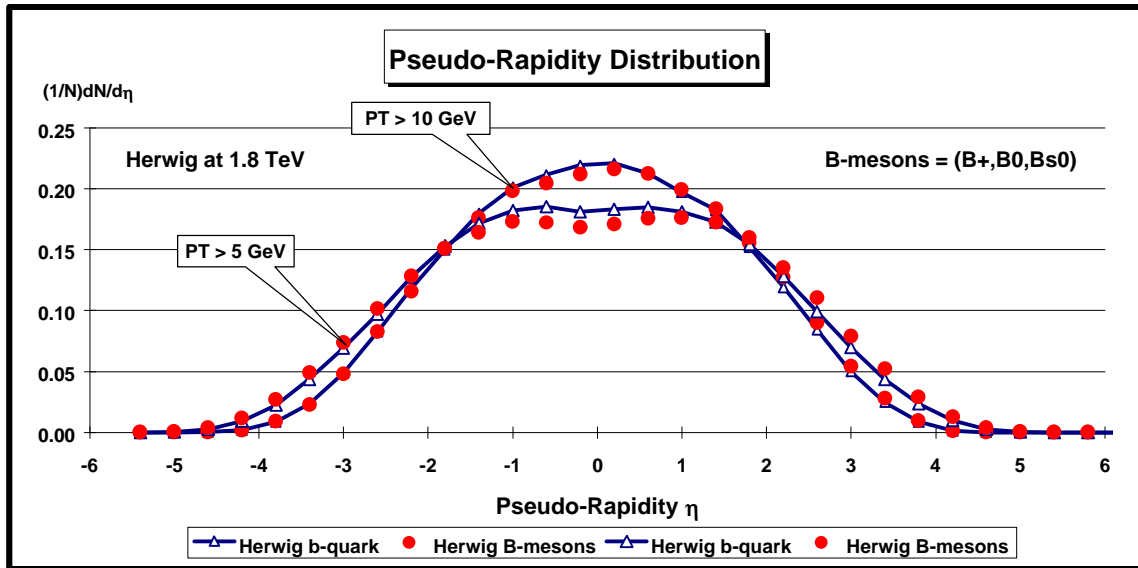
Parton & Hadron Level: Rapidity Distribution



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).

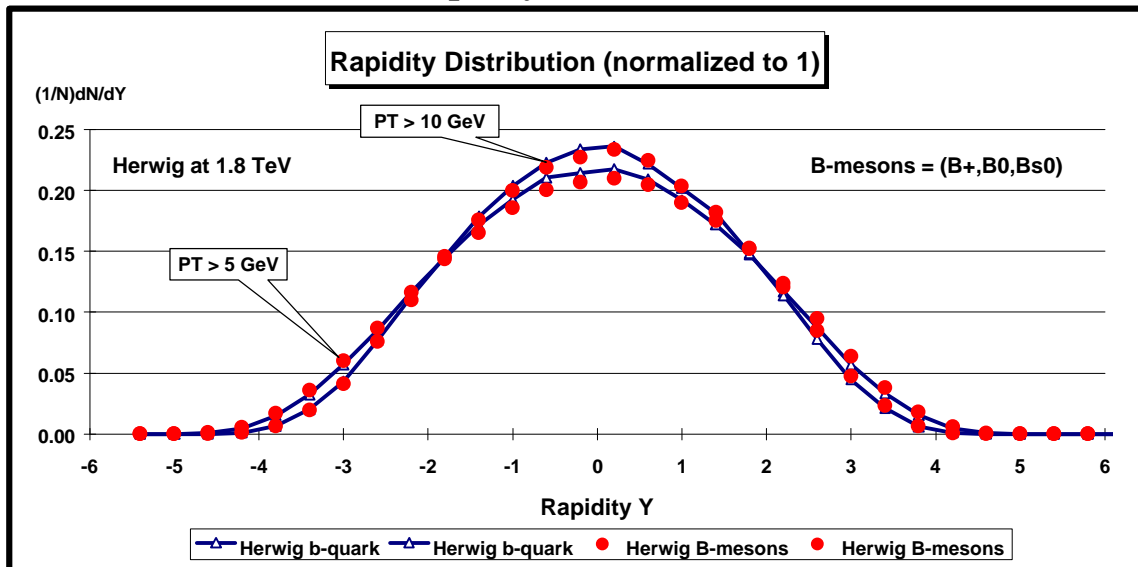
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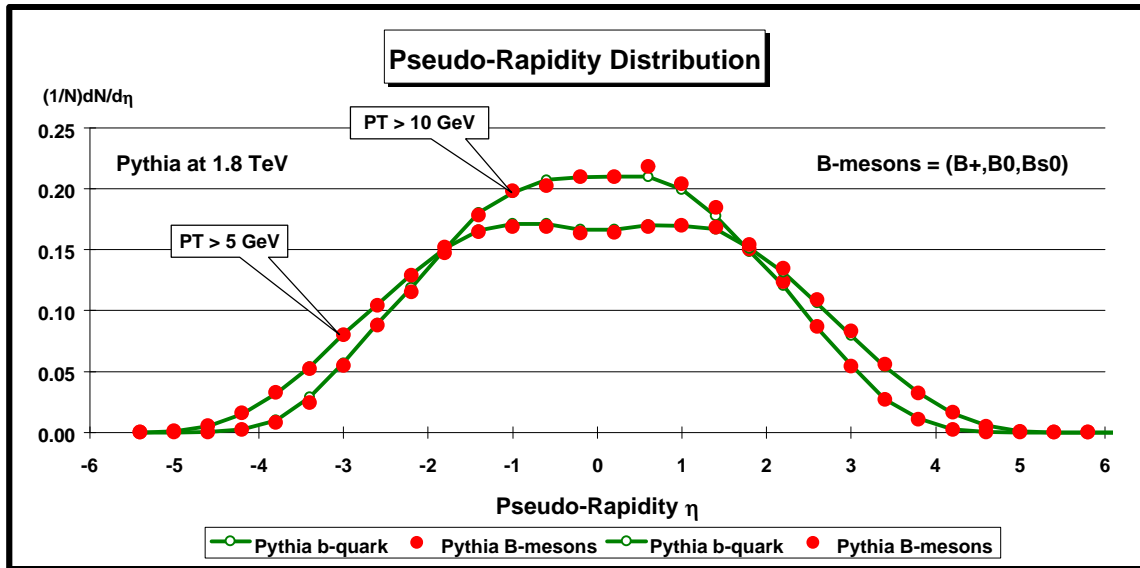
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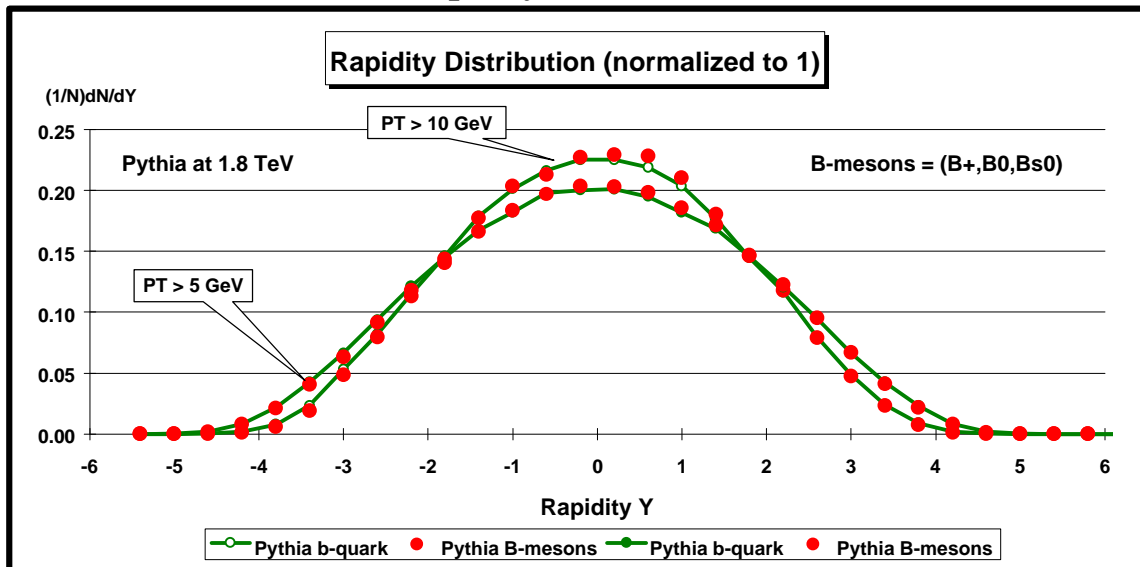
B Physics: Y and η Distributions

Parton & Hadron Level: Pseudo-Rapidity Distribution



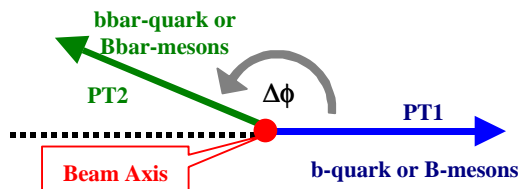
Plot shows $(1/N)dN/d\eta$ (normalized to 1) for B-mesons (B^+ , B^0 , B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

Parton & Hadron Level: Rapidity Distribution

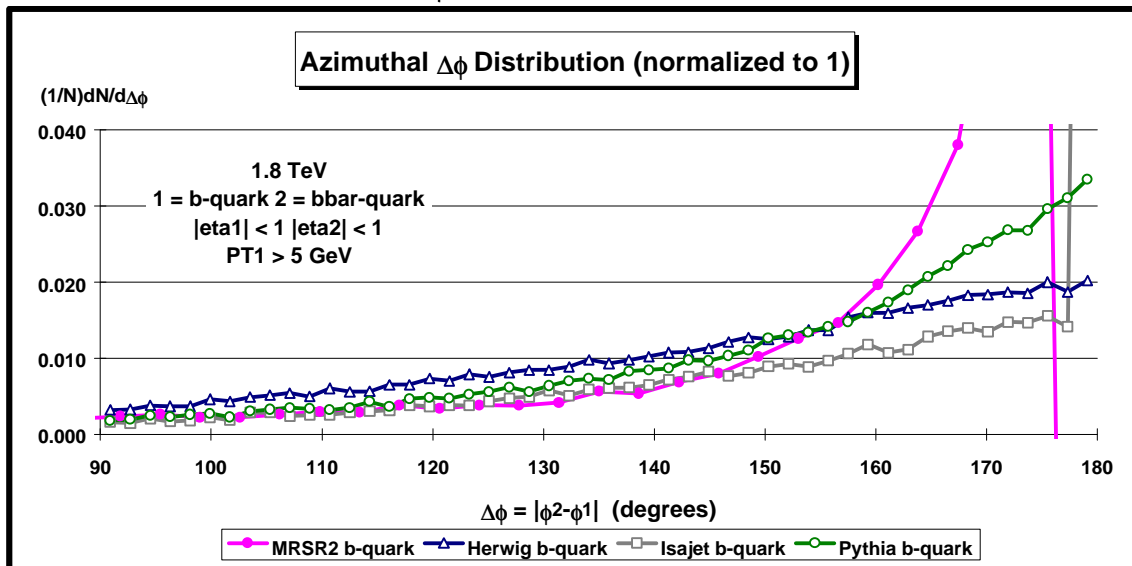


Plot shows $(1/N)dN/dY$ (normalized to 1) for B-mesons (B^+ , B^0 , B_s^0) and for the b-quark at 1.8 TeV (PT > 5 GeV and PT > 10 GeV).

B Physics: Azimuthal Correlations



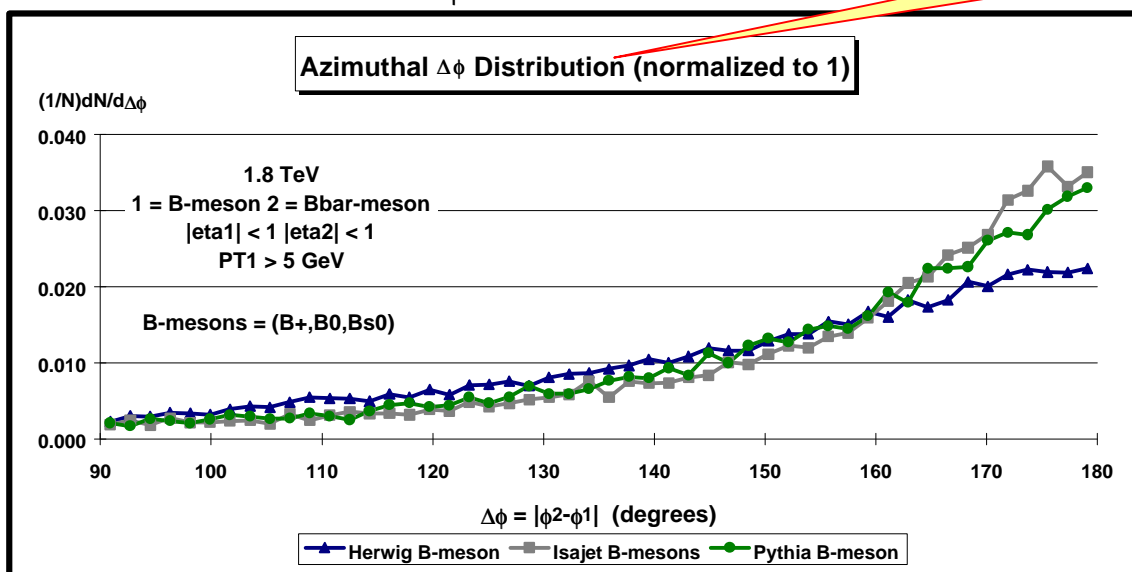
Parton Level: Azimuthal $\Delta\phi$ Distribution



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 at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

Measures intrinsic PT, gluon radiation, fragmentation.

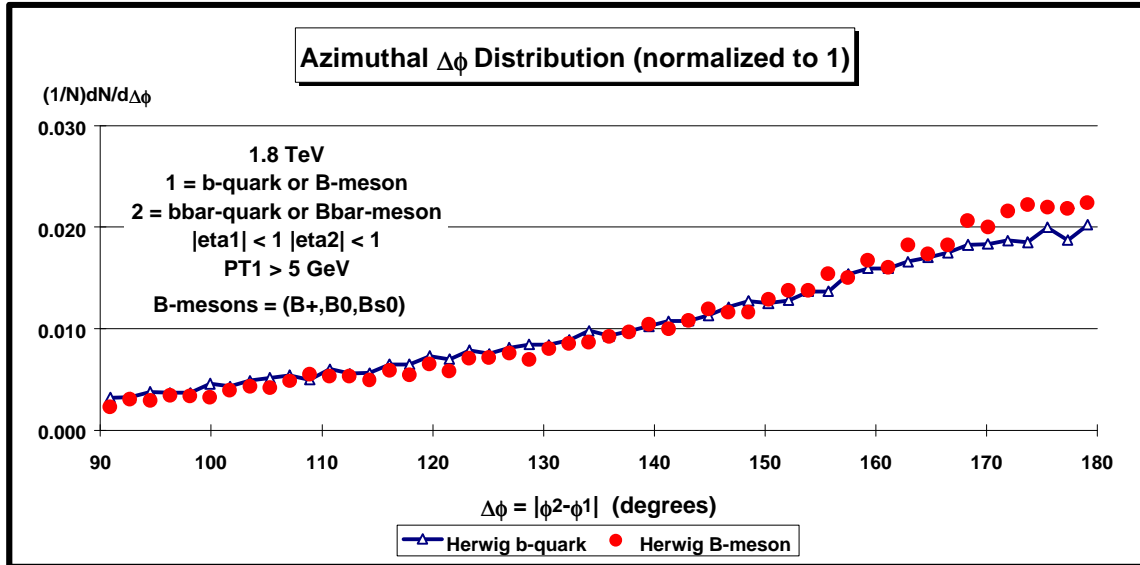
Hadron Level: Azimuthal $\Delta\phi$ Distribution



Plot shows $(1/N)dN/d\Delta\phi$ (normalized to 1), where $\Delta\phi = |\phi_2 - \phi_1|$ for 1 = B-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.

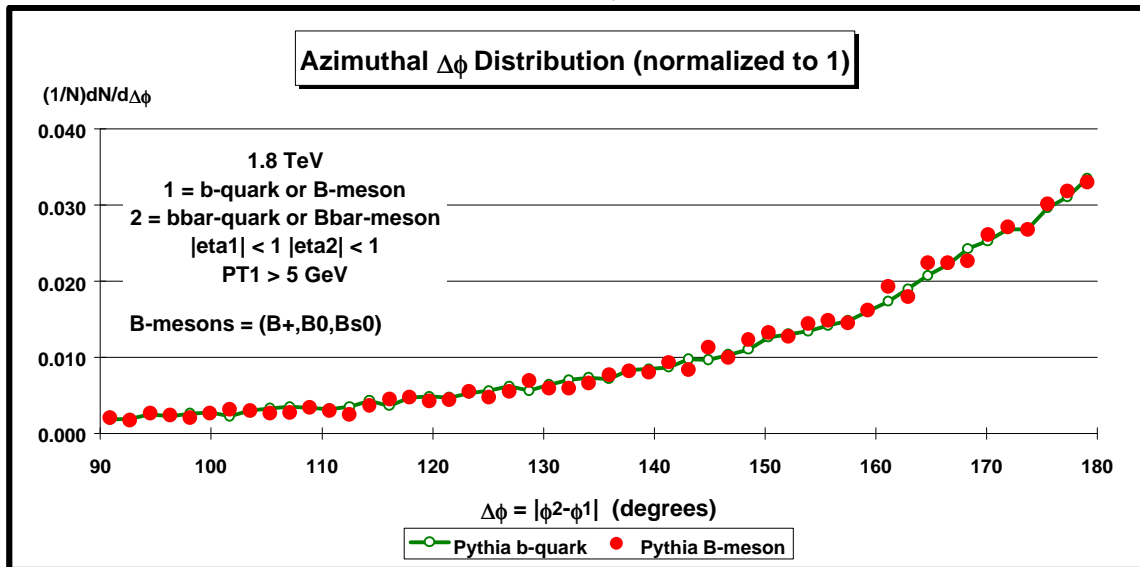
B Physics: Azimuthal Correlations

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



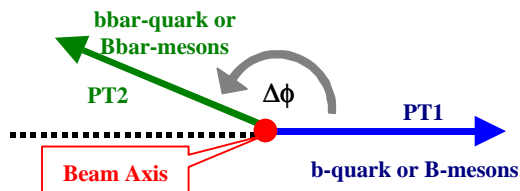
Plot shows $(1/N)dN/d\Delta\phi$ (normalized to 1), where $\Delta\phi = |\phi_2 - \phi_1|$ for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B⁺, B⁰, B_s⁰) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

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

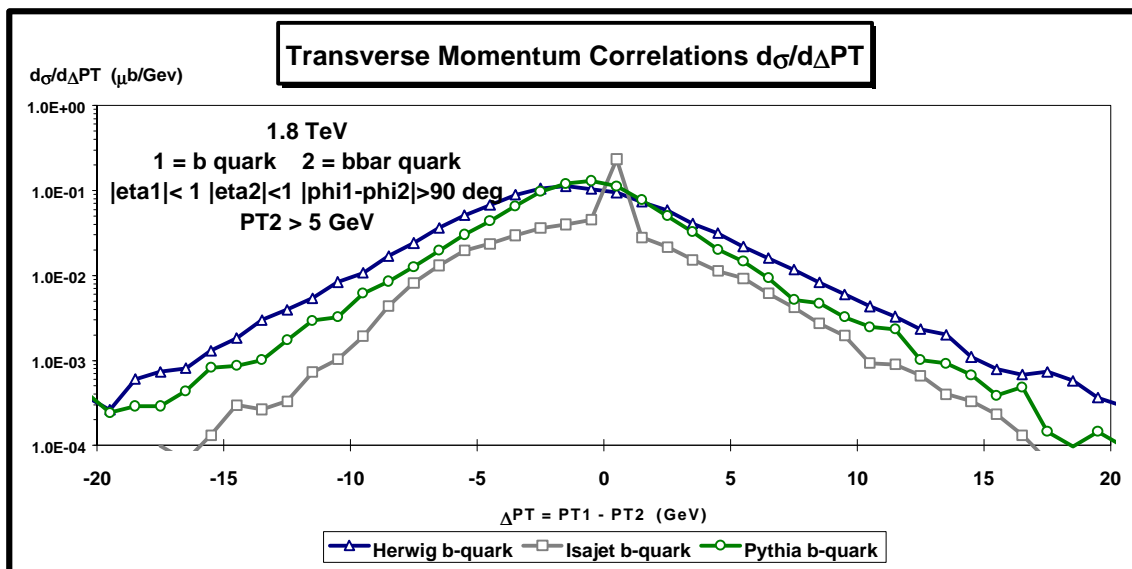


Plot shows $(1/N)dN/d\Delta\phi$ (normalized to 1), where $\Delta\phi = |\phi_2 - \phi_1|$ for 1 = b-quark and 2 = bbar-quark and for 1 = B-mesons (B⁺, B⁰, B_s⁰) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, and $PT_1 > 5$ GeV.

B Physics: PT Correlations

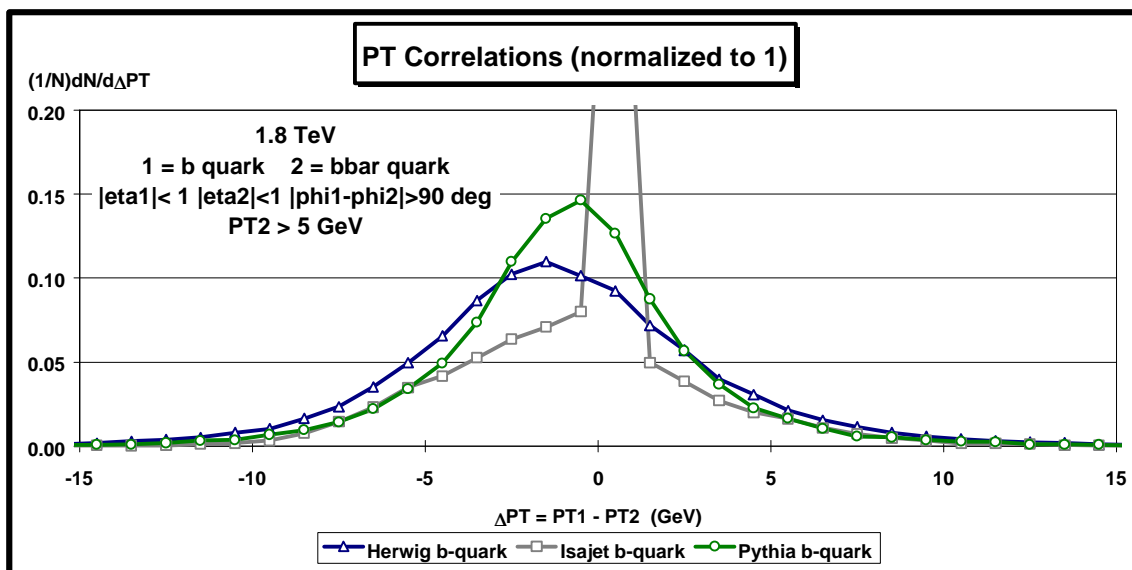


Parton Level: Transverse Momentum Correlations



Plot shows $d\sigma/d\Delta PT$ ($\mu\text{b}/\text{GeV}$), where $\Delta PT = PT_1 - PT_2$ for 1 = b-quark and 2 = bbar-quark at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^\circ$, and $PT_2 > 5$ GeV.

Parton Level: Transverse Momentum Correlations

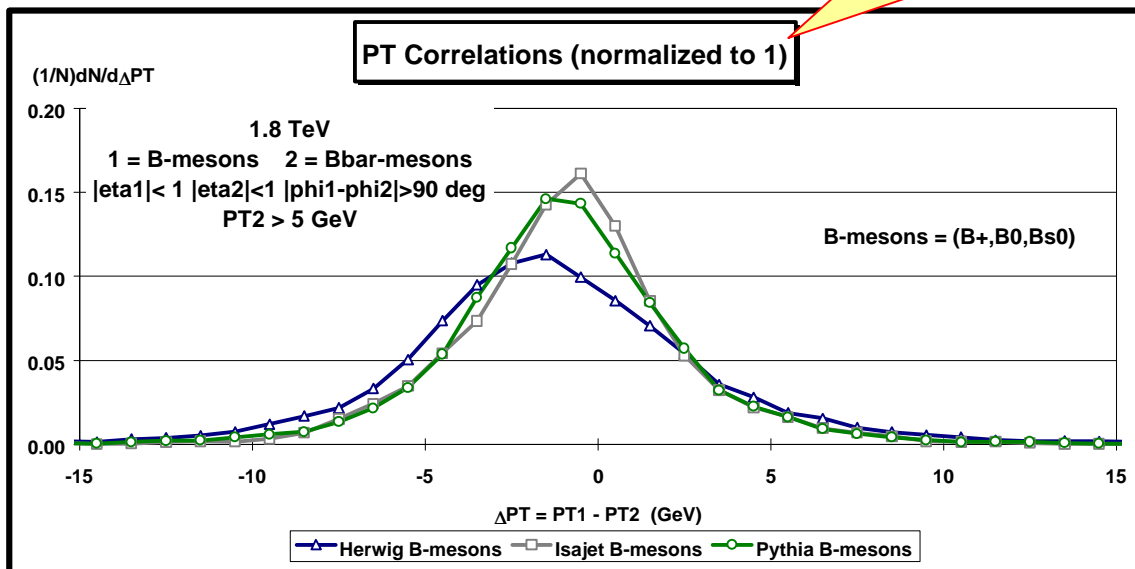


Plot shows $d\sigma/d\Delta PT$ ($\mu\text{b}/\text{GeV}$), where $\Delta PT = PT_1 - PT_2$ for 1 = b-quark and 2 = bbar-quark at 1.8 TeV with $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^\circ$, and $PT_2 > 5$ GeV.

B Physics: PT Correlations

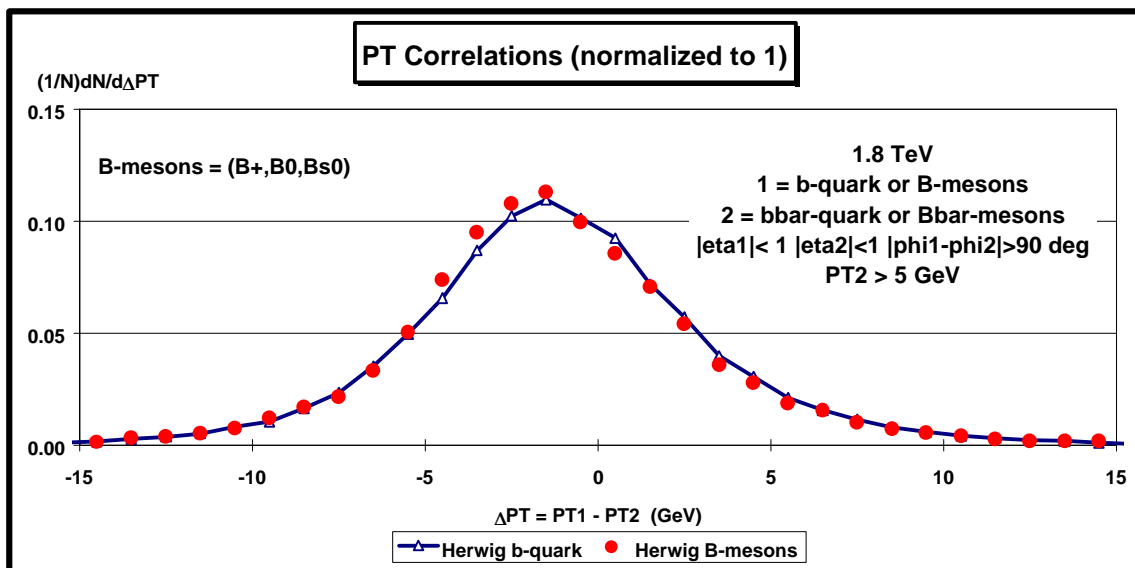
Measures intrinsic PT, gluon radiation, and fragmentation.

Hadron Level: Transverse Momentum Correlations



Plot shows $d\sigma/d\Delta PT$ ($\mu\text{b}/\text{GeV}$), 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 $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^\circ$, and $PT_2 > 5$ GeV.

Parton & Hadron Level: Transverse Momentum Correlations



Plot shows $d\sigma/d\Delta PT$ ($\mu\text{b}/\text{GeV}$), 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 $|\eta_1| < 1$, $|\eta_2| < 1$, $|\phi_1 - \phi_2| > 90^\circ$, and $PT_2 > 5$ GeV.

B Physics: Pseudo-Rapidity Correlations

Double-Differential Cross Section

Correlation Functions:

$$C(\mathbf{h}_1, \mathbf{h}_2) = \frac{1}{s} \frac{d\mathbf{s}}{d\mathbf{h}_1 d\mathbf{h}_2} - \frac{1}{s^2} \frac{d\mathbf{s}}{d\mathbf{h}_1} \frac{d\mathbf{s}}{d\mathbf{h}_2}$$

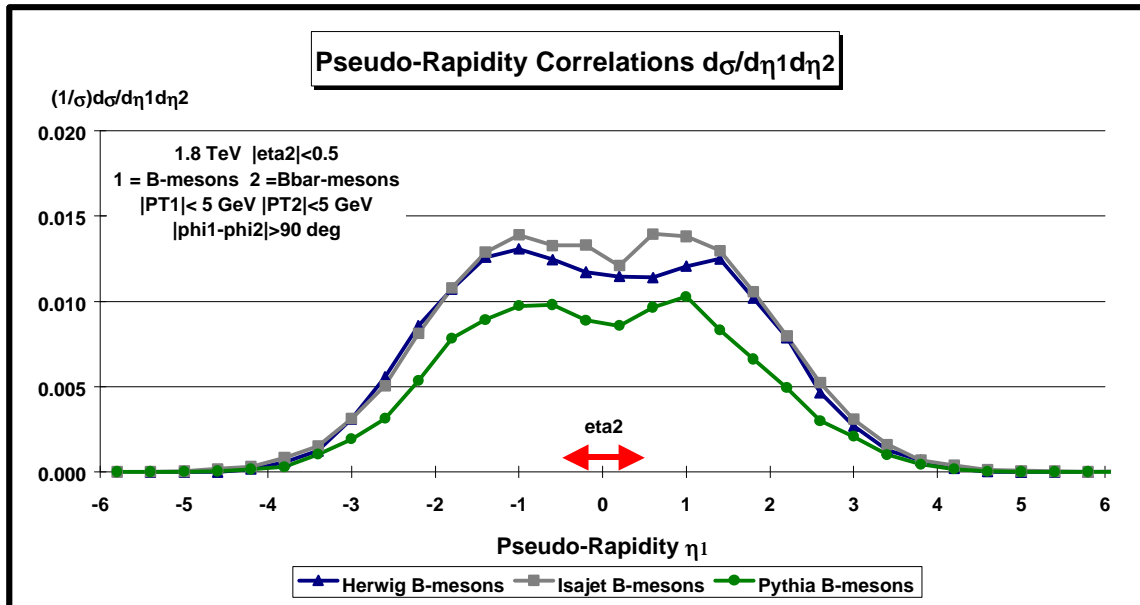
“Normalized” Correlation Functions:

$$R(\mathbf{h}_1, \mathbf{h}_2) = \left(\frac{1}{s} \frac{d\mathbf{s}}{d\mathbf{h}_1 d\mathbf{h}_2} - \frac{1}{s^2} \frac{d\mathbf{s}}{d\mathbf{h}_1} \frac{d\mathbf{s}}{d\mathbf{h}_2} \right) / \left(\frac{1}{s^2} \frac{d\mathbf{s}}{d\mathbf{h}_1} \frac{d\mathbf{s}}{d\mathbf{h}_2} \right)$$

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

$$R(\mathbf{h}_1) = \int_a^b \left(\frac{1}{s} \frac{d\mathbf{s}}{d\mathbf{h}_1 d\mathbf{h}_2} - \frac{1}{s^2} \frac{d\mathbf{s}}{d\mathbf{h}_1} \frac{d\mathbf{s}}{d\mathbf{h}_2} \right) d\mathbf{h}_2 / \int_a^b \left(\frac{1}{s^2} \frac{d\mathbf{s}}{d\mathbf{h}_1} \frac{d\mathbf{s}}{d\mathbf{h}_2} \right) d\mathbf{h}_2$$

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

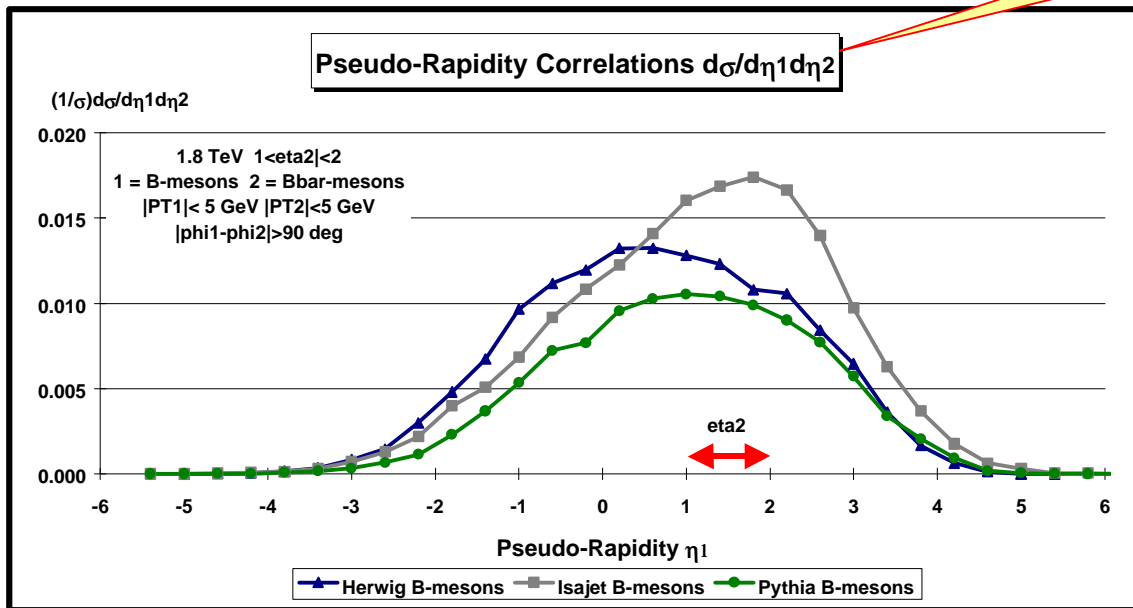


Plot shows $(1/\sigma)d\sigma/d\eta_1 d\eta_2$ versus η_1 , for 1 = B-mesons (B^+, B^0, B_s^0) and 2 = Bbar-mesons at 1.8 TeV with $|\eta_2| < 0.5$, $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

B Physics: Pseudo-Rapidity Correlations

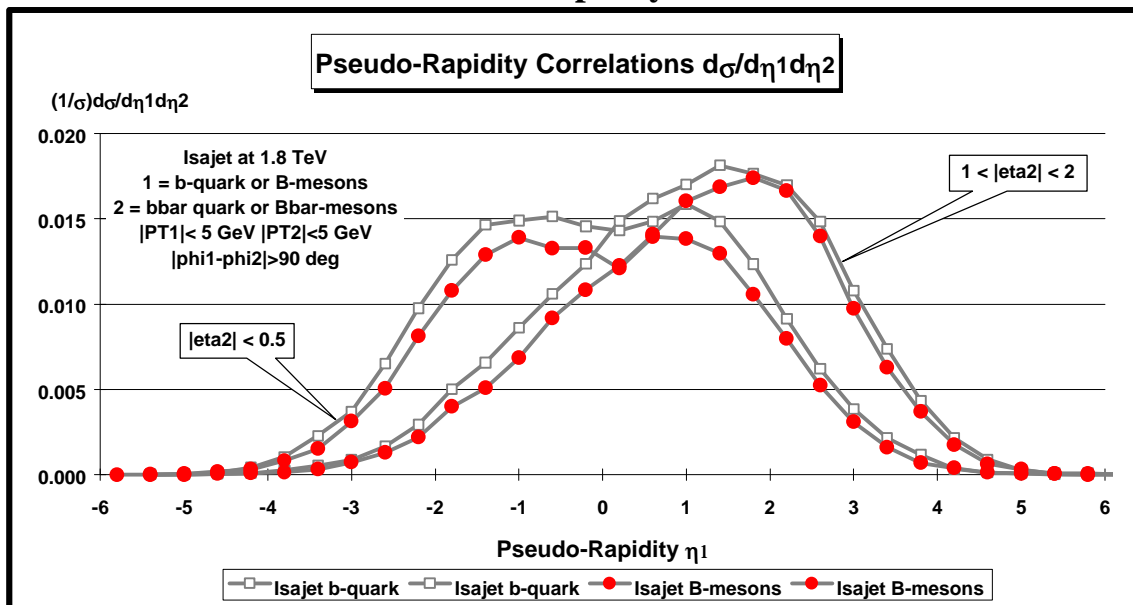
Hadron Level: Pseudo-Rapidity Correlations ($1 < |\eta_2| < 2$)

Measures PDF's, fragmentation.



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

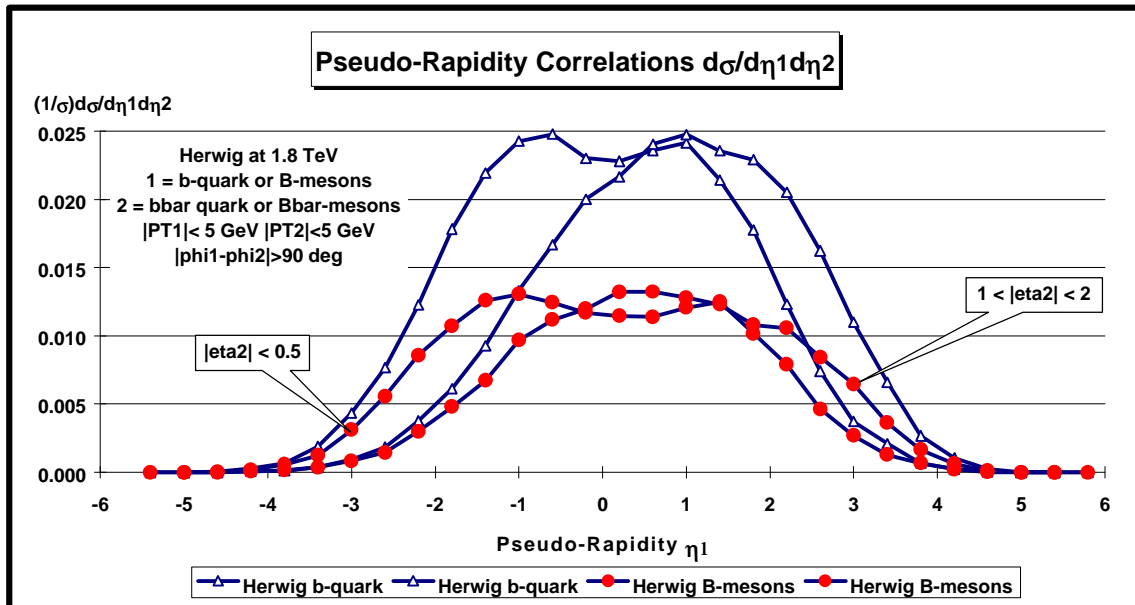
Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1d\eta_2$ 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 $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5$ GeV, and $PT_2 > 5$ GeV.

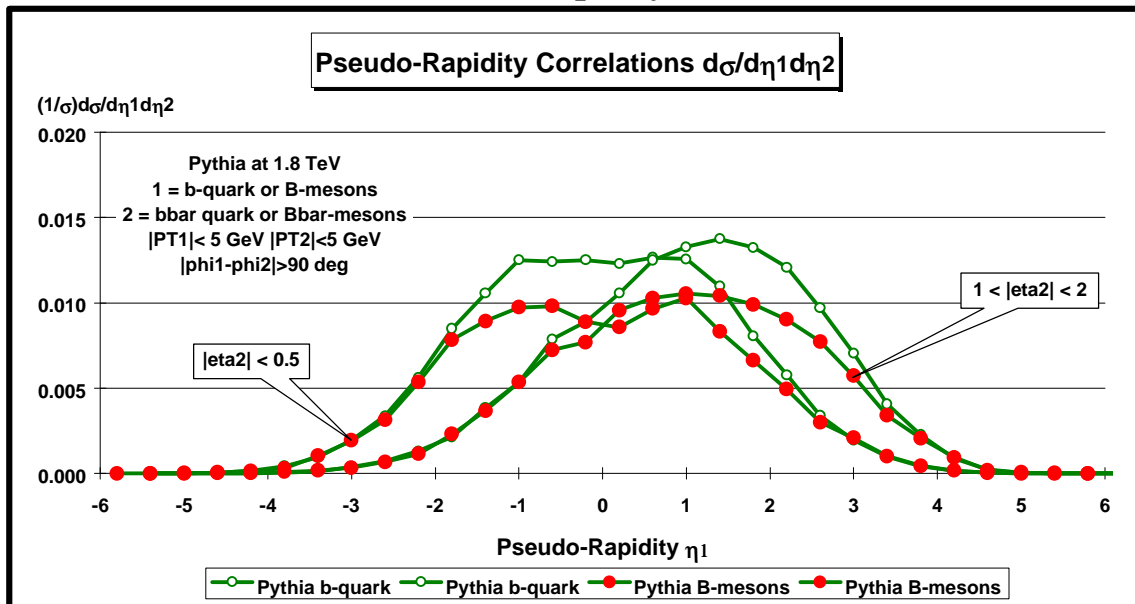
B Physics: Pseudo-Rapidity Correlations

Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1d\eta_2$ 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 $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5 \text{ GeV}$, and $PT_2 > 5 \text{ GeV}$.

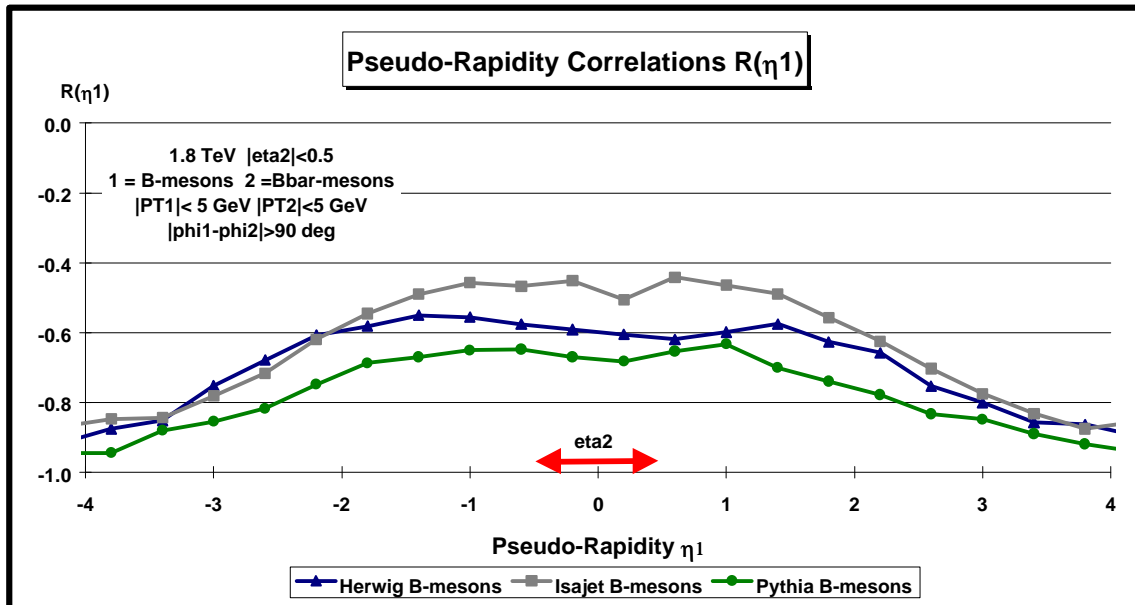
Parton & Hadron Level: Pseudo-Rapidity Correlations



Plot shows $(1/\sigma)d\sigma/d\eta_1d\eta_2$ 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 $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5 \text{ GeV}$, and $PT_2 > 5 \text{ GeV}$.

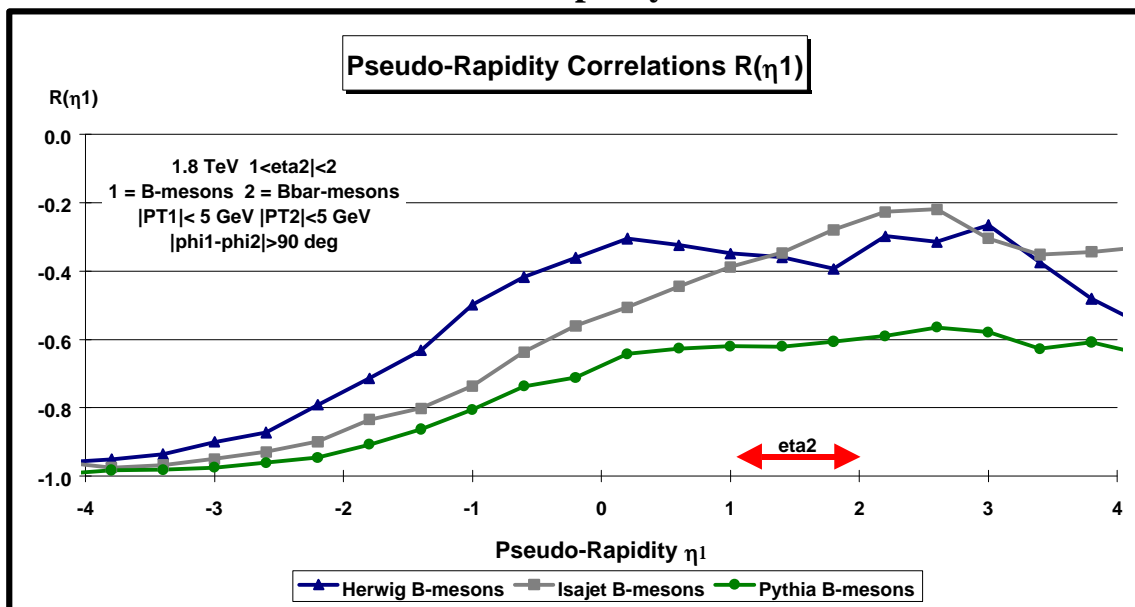
B Physics: Pseudo-Rapidity Correlations

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 $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5 \text{ GeV}$, and $PT_2 > 5 \text{ GeV}$.

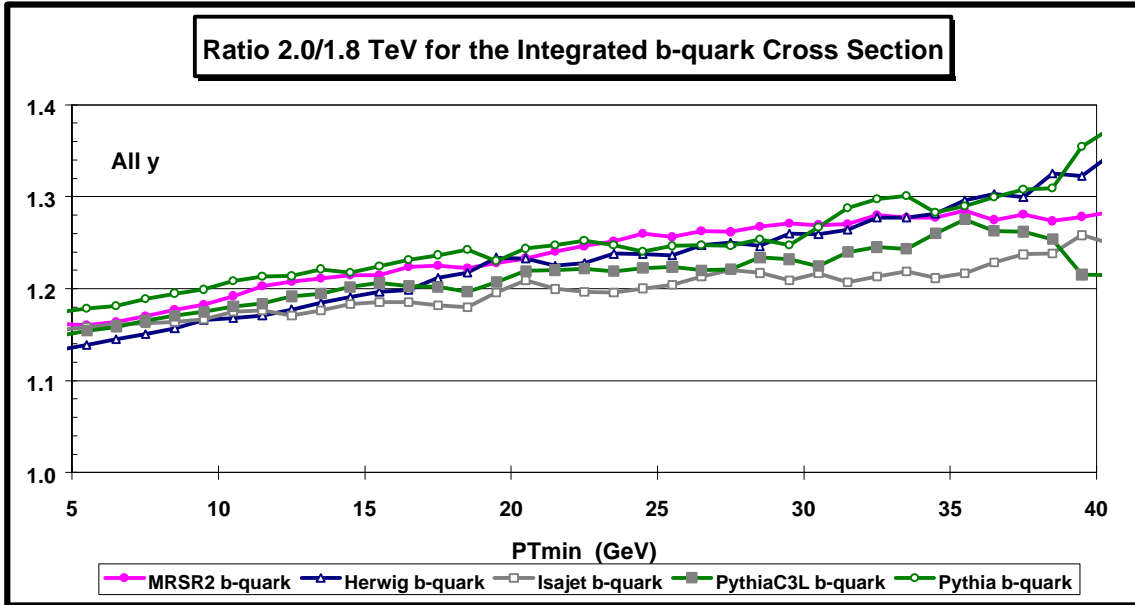
Parton & Hadron Level: Pseudo-Rapidity Correlations



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 $|\phi_1 - \phi_2| > 90^\circ$, $PT_1 > 5 \text{ GeV}$, and $PT_2 > 5 \text{ GeV}$.

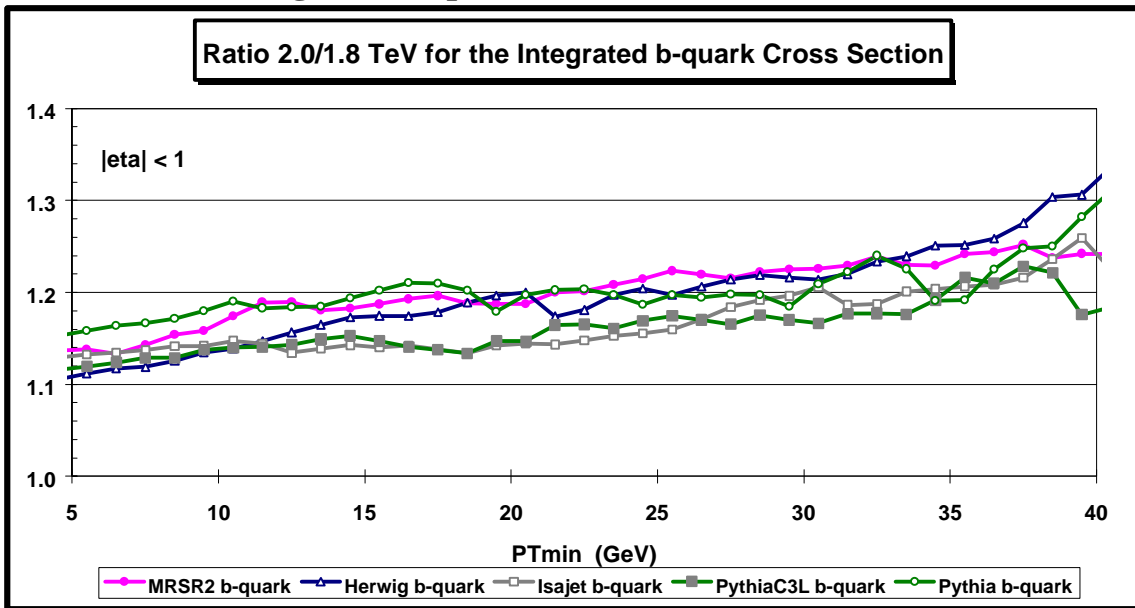
B Physics: 2.0/1.8 TeV Cross Section Ratio

Parton Level: Integrated b-quark Cross Section Ratio for $PT > PT_{min}$



Plot shows the 2.0/1.9 TeV ratio of $\sigma(PT > PT_{min})$ for b-quarks (all Y).

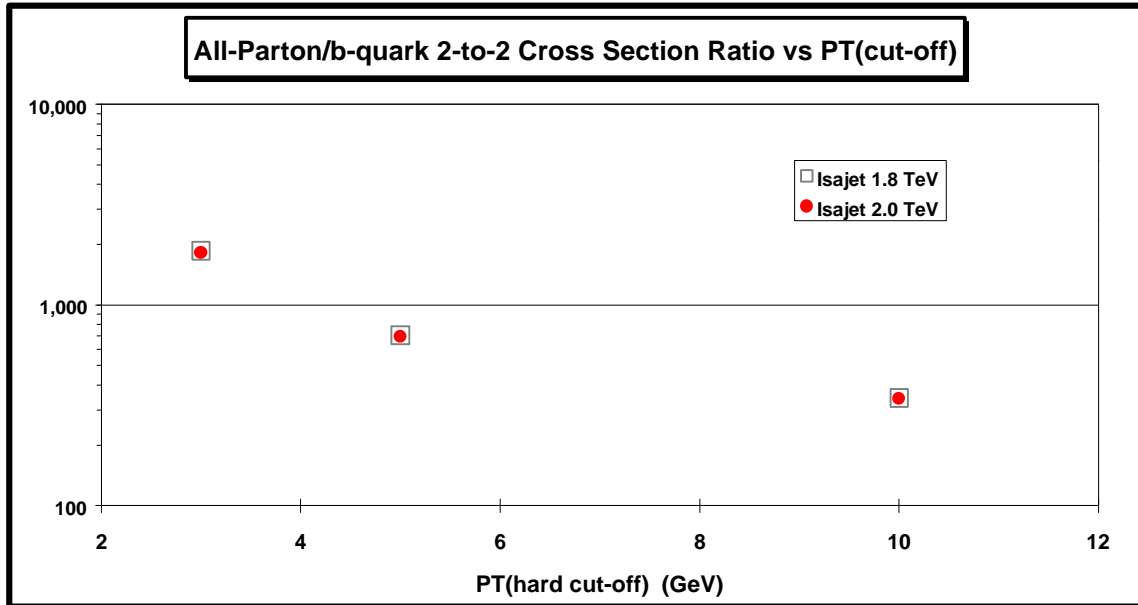
Parton Level: Integrated b-quark Cross Section Ratio for $PT > PT_{min}$



Plot shows the 2.0/1.9 TeV ratio of $\sigma(PT > PT_{min})$ for b-quarks ($|\eta| < 1$).

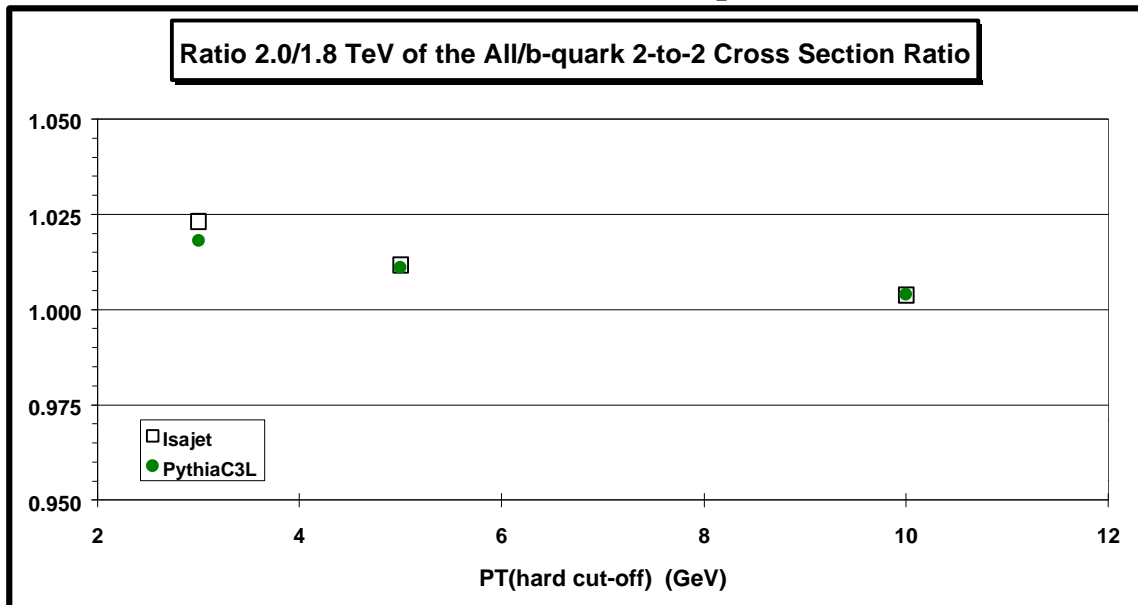
B Physics: Parton 2-to-2 Cross Section Ratio

Parton Level: All-Parton/b-quark 2-to-2 Cross Section Ratio



Plot shows the ratio of the cross sections of all QCD parton 2-to-2 subprocesses to the 2-to-2 b-quark production subprocesses at 1.8 and 2.0 TeV versus the hard-scattering transverse momentum cut-off.

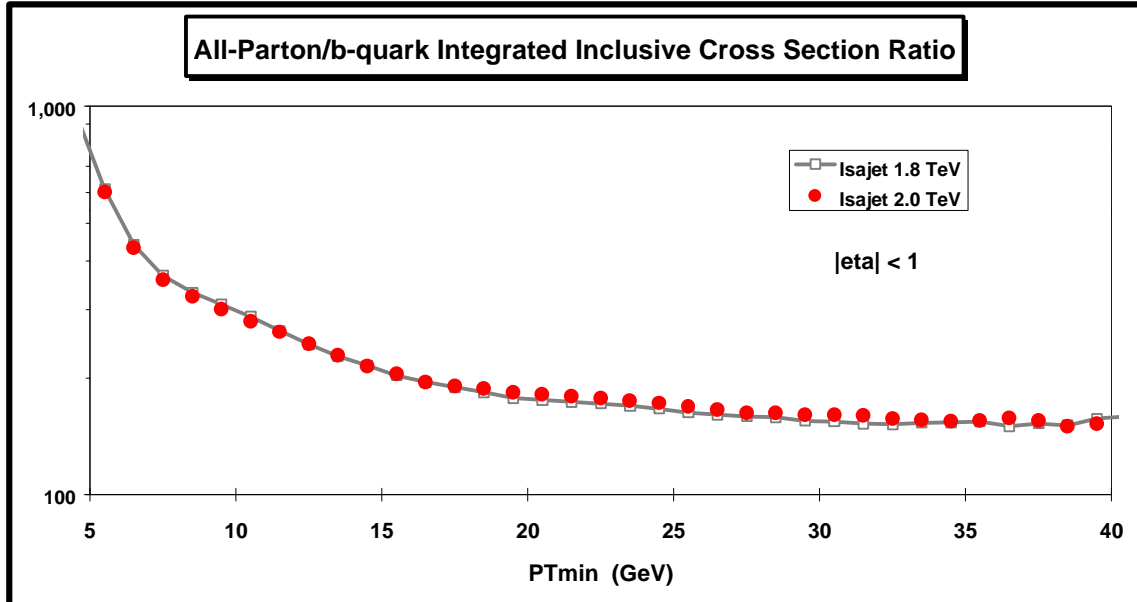
Parton Level: Ratio 2.0/1.8 TeV of the All/b-quark Cross Section Ratio



Plot shows the All/b-quark 2-to-2 subprocess cross section ratio at 2.0 TeV divided by All/b-quark 2-to-2 subprocess cross section ratio at 1.8 TeV versus the hard-scattering transverse momentum cut-off (i.e. background/signal at 2.0 TeV divided by background/signal at 1.8 TeV).

B Physics: Parton Invariant Cross Section Ratio

Parton Level: Integrated Inclusive All/b-quark Cross Section Ratio



Plot shows the inclusive cross section $\sigma(\text{PT} > \text{PT}_{\text{min}}, |\eta| < 1)$ for all partons (divided by 2) divided by $\sigma(\text{PT} > \text{PT}_{\text{min}}, |\eta| < 1)$ for b-quarks at 1.8 TeV and 2.0 TeV.