

TeV4LHC Workshop



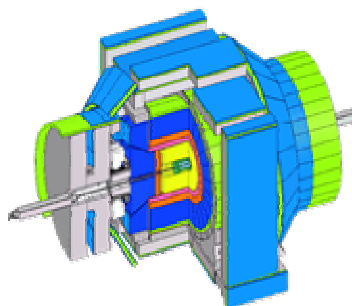
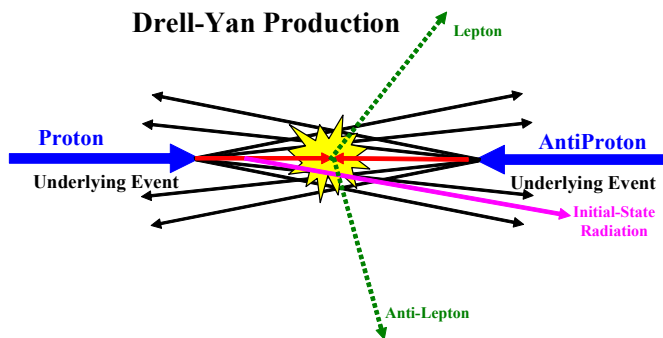
Talk #1

Quantum
Chromo-
Dynamics

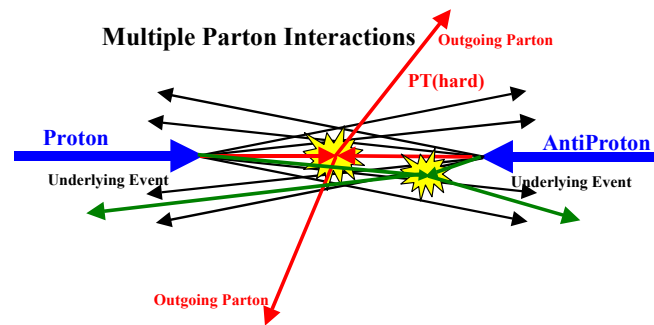


Rick Field
University of Florida

TeV4LHC

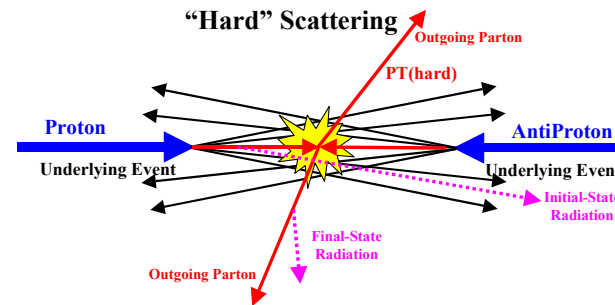
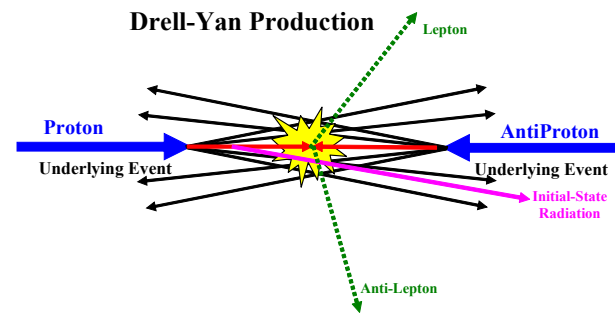
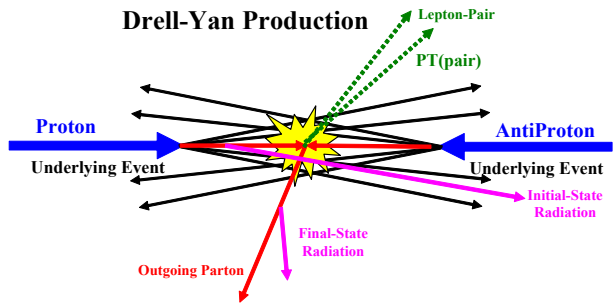


CDF Run 2





CDF Run 2 Monte Carlo Tunes



Outline of Talk

- ➔ **$P_T(\text{Z-boson})$: Tuning to fit the $P_T(\text{Z})$ distribution.**
- ➔ **Drell-Yan: Tuning to fit the “underlying event” in Drell-Yan production.**
- ➔ **Jet Production: Tuning to fit the “underlying event” is high P_T jet production.**
- ➔ **Energy: Tuning to fit the energy in the “underlying event”.**

CDF Run 2 Tunes

PYTHIA Tune A
 PYTHIA Tune A25
 PYTHIA Tune A50
 PYTHIA Tune AW
 PYTHIA Tune Q
 PYTHIA Tune QW
 JIMMY Default
 JIMMY 325



CDF Run 1 $P_T(Z)$



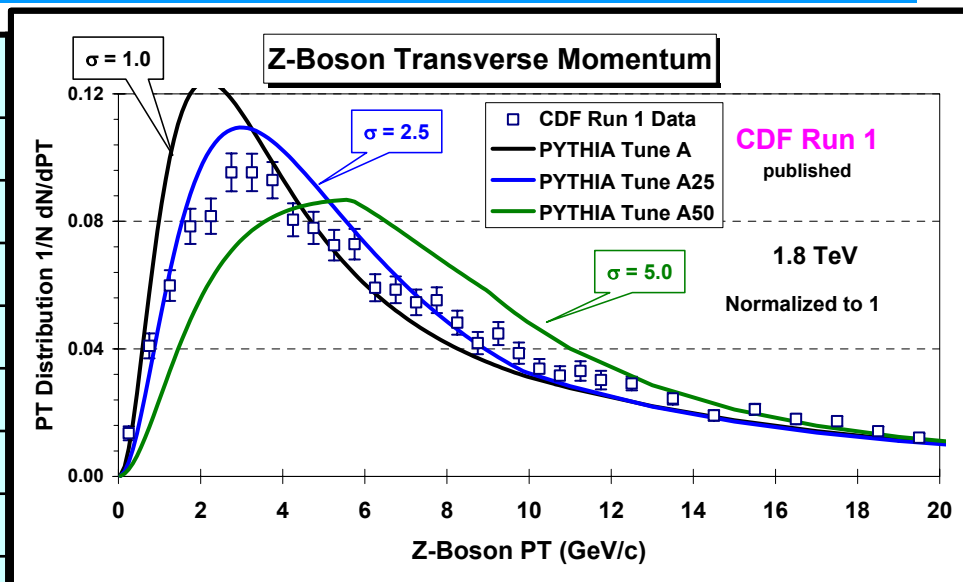
PYTHIA 6.2 CTEQ5L

UE Parameters

Parameter	Tune A	Tune A25	Tune A50
MSTP(81)	1	1	1
MSTP(82)	4	4	4
PARP(82)	2.0 GeV	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5	0.5
PARP(84)	0.4	0.4	0.4
PARP(85)	0.9	0.9	0.9
PARP(86)	0.95	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25	0.25
PARP(67)	4.0	4.0	4.0
MSTP(91)	1	1	1
PARP(91)	1.0	2.5	5.0
PARP(93)	5.0	15.0	25.0

ISR Parameter

Intrinsic KT



➔ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z) \rangle \approx 11.5$ GeV/c) compared with **PYTHIA Tune A** ($\langle p_T(Z) \rangle = 9.7$ GeV/c), **Tune A25** ($\langle p_T(Z) \rangle = 10.1$ GeV/c), and **Tune A50** ($\langle p_T(Z) \rangle = 11.2$ GeV/c).



CDF Run 1 $P_T(Z)$



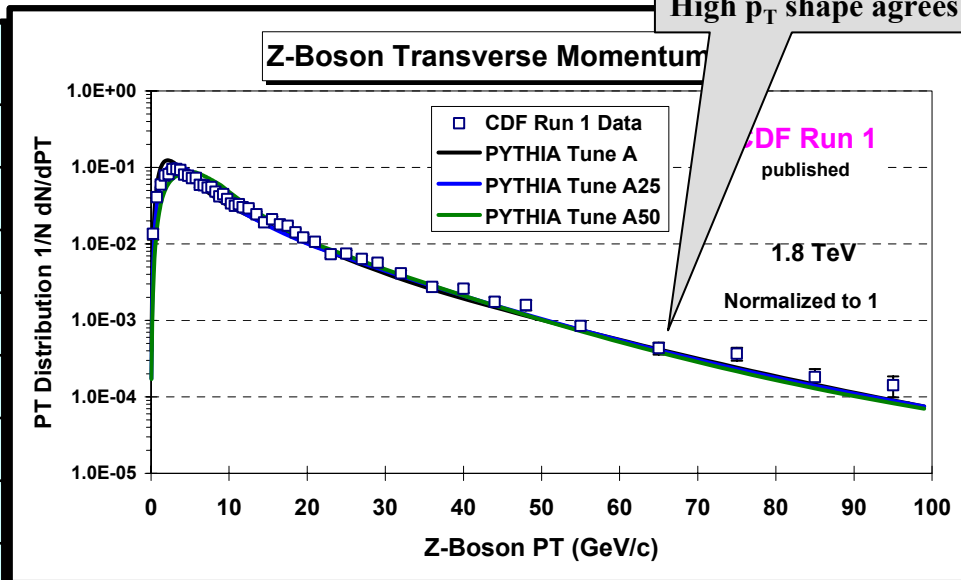
PYTHIA 6.2 CTEQ5L

UE Parameters

Parameter	Tune A	Tune A25	Tune A50
MSTP(81)	1	1	1
MSTP(82)	4	4	4
PARP(82)	2.0 GeV	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5	0.5
PARP(84)	0.4	0.4	0.4
PARP(85)	0.9	0.9	0.9
PARP(86)	0.95	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25	0.25
PARP(67)	4.0	4.0	4.0
MSTP(91)	1	1	1
PARP(91)	1.0	2.5	5.0
PARP(93)	5.0	15.0	25.0

ISR Parameter

Intrinsic KT



➔ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z) \rangle \approx 11.5$ GeV/c) compared with **PYTHIA Tune A** ($\langle p_T(Z) \rangle = 9.7$ GeV/c), **Tune A25** ($\langle p_T(Z) \rangle = 10.1$ GeV/c), and **Tune A50** ($\langle p_T(Z) \rangle = 11.2$ GeV/c).



CDF Run 1 $P_T(Z)$



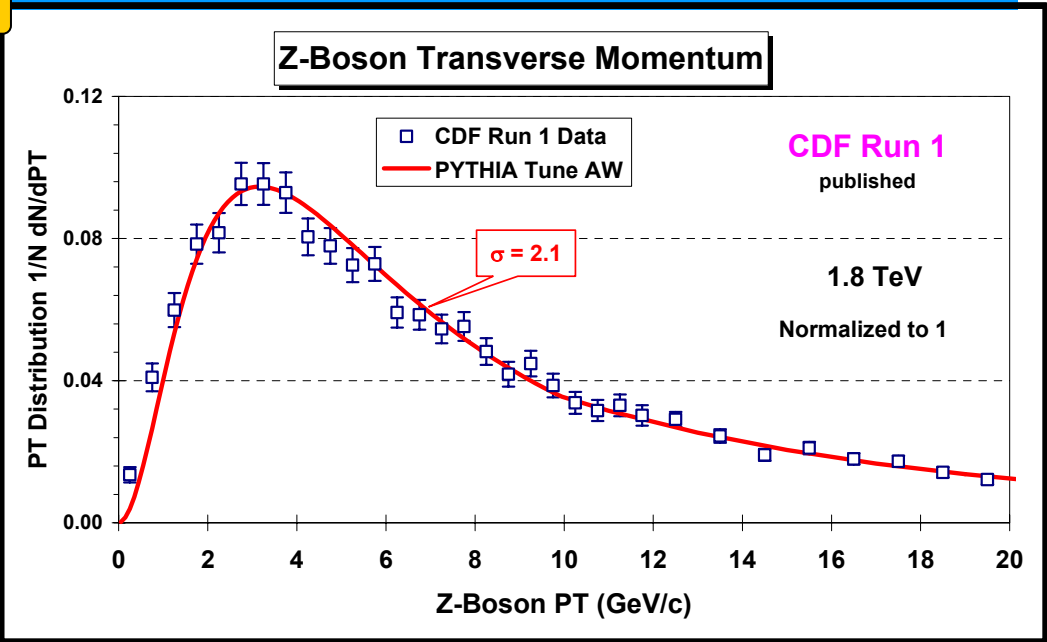
PYTHIA 6.2 CTEQ5L

UE Parameters

Parameter	Tune A	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	1.0	2.1
PARP(93)	5.0	15.0

ISR Parameters

Intrinsic k_T



➔ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z) \rangle \approx 11.5$ GeV/c) compared with **PYTHIA Tune AW** ($\langle p_T(Z) \rangle = 11.7$ GeV/c).

Effective Q cut-off, below which space-like showers are not evolved.

The $Q^2 = k_T^2$ in α_s for space-like showers is scaled by PARP(64)!



CDF Run 1 $P_T(Z)$



PYTHIA 6.2 CTEQ5L

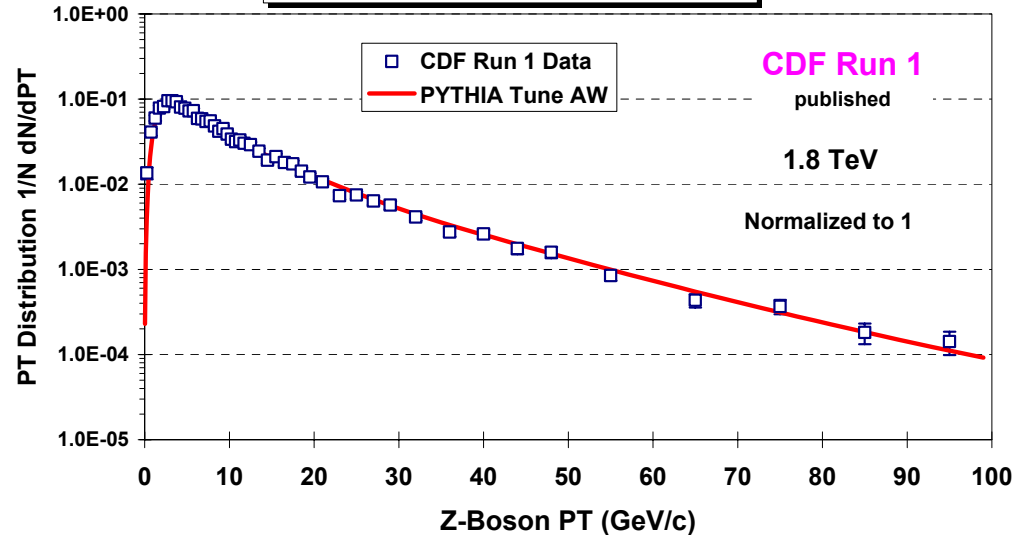
UE Parameters

ISR Parameters

Intrinsic KT

Parameter	Tune A	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	1.0	2.1
PARP(93)	5.0	15.0

Z-Boson Transverse Momentum



➔ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z) \rangle \approx 11.5$ GeV/c) compared with **PYTHIA Tune AW** ($\langle p_T(Z) \rangle = 11.7$ GeV/c).



CDF Run 1 $P_T(Z)$



PYTHIA 6.2 CTEQ5L

UE Parameters

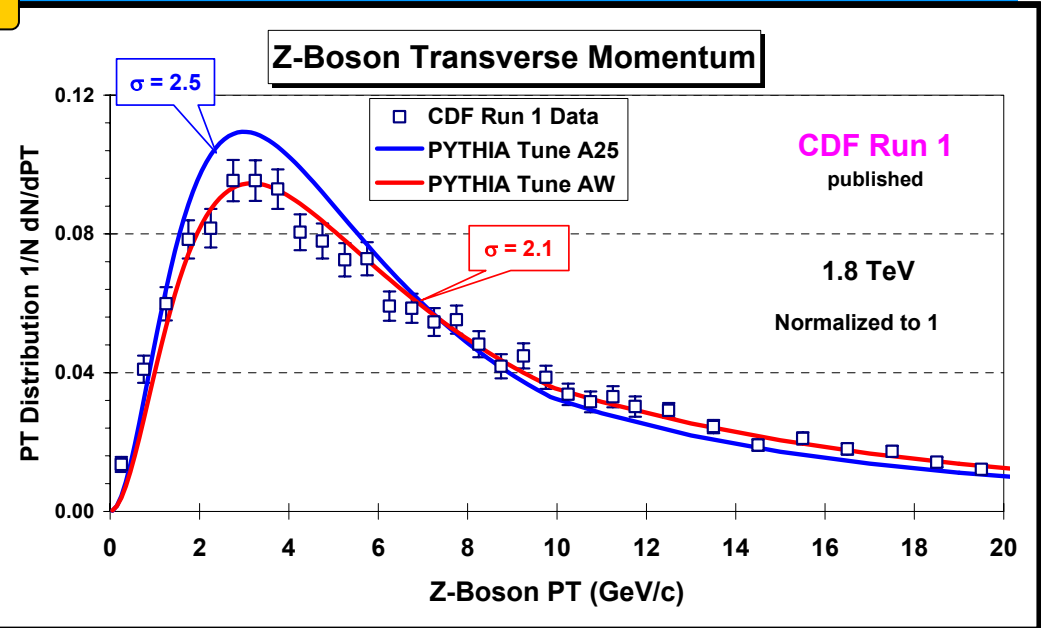
Parameter	Tune A25	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95

ISR Parameters

PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0

Intrinsic KT

MSTP(91)	1	1
PARP(91)	2.5	2.1
PARP(93)	5.0	15.0



➔ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z) \rangle \approx 11.5$ GeV/c) compared with **PYTHIA Tune AW** ($\langle p_T(Z) \rangle = 11.7$ GeV/c) and **PYTHIA Tune A25** ($\langle p_T(Z) \rangle = 10.1$ GeV/c).



CDF Run 1 $P_T(Z)$



PYTHIA 6.2 CTEQ5L

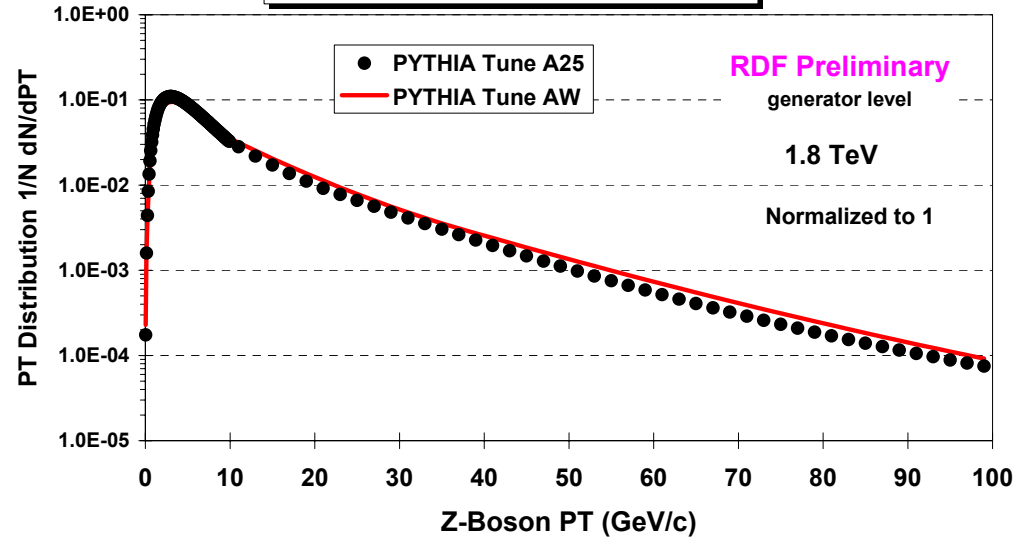
Parameter	Tune A25	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	2.5	2.1
PARP(93)	5.0	15.0

UE Parameters

ISR Parameters

Intrinsic KT

Z-Boson Transverse Momentum



➔ Compares **PYTHIA Tune AW** with **PYTHIA Tune A25** (both normalized to one).



CDF Run 1 $P_T(Z)$



PYTHIA 6.2 CTEQ5L

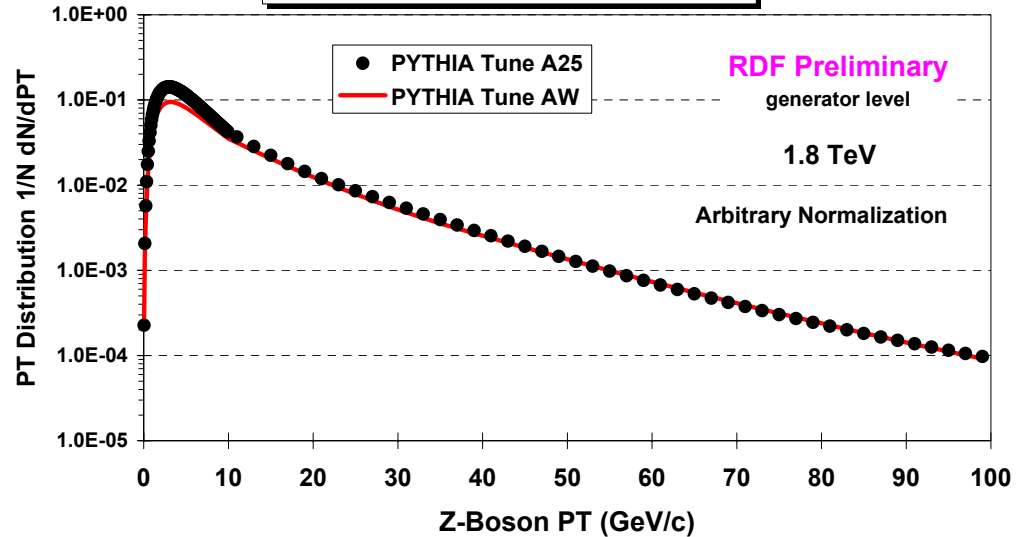
Parameter	Tune A25	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	2.5	2.1
PARP(93)	5.0	15.0

UE Parameters

ISR Parameters

Intrinsic KT

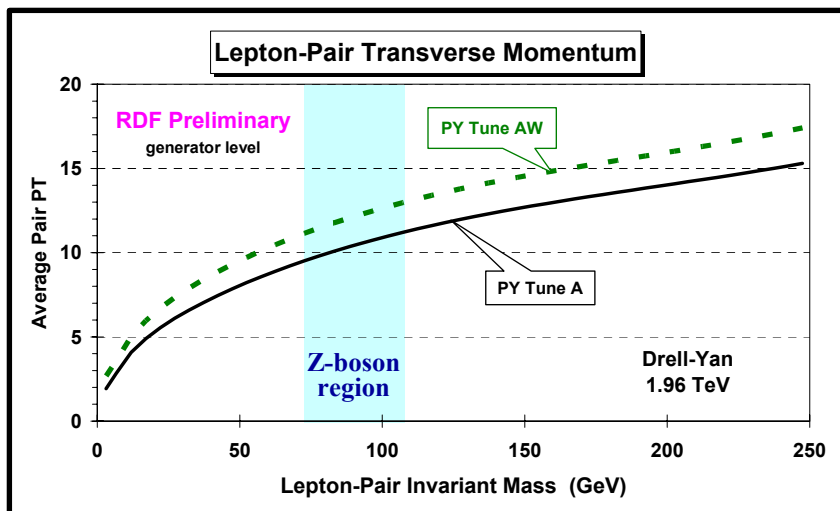
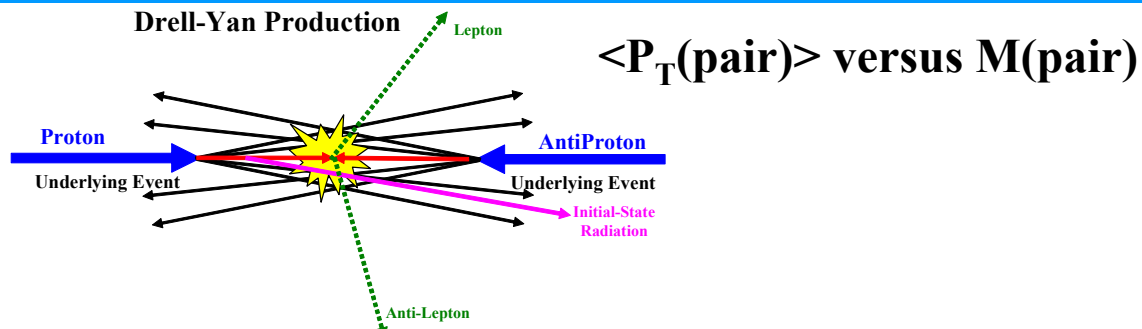
Z-Boson Transverse Momentum



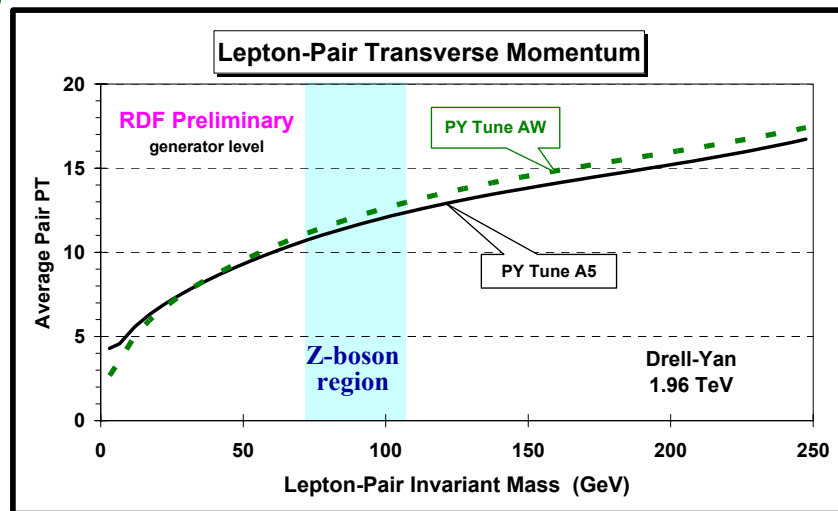
➔ Compares **PYTHIA Tune AW** with **PYTHIA Tune A25** (normalized to agree at high $P_T(Z)$).



Run 2 Drell-Yan



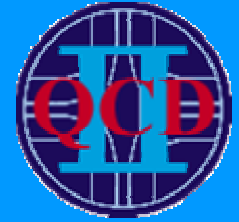
➔ Shows the lepton-pair average P_T versus the lepton-pair invariant mass at 1.96 TeV for **PYTHIA Tune AW** and **PYTHIA Tune A**.



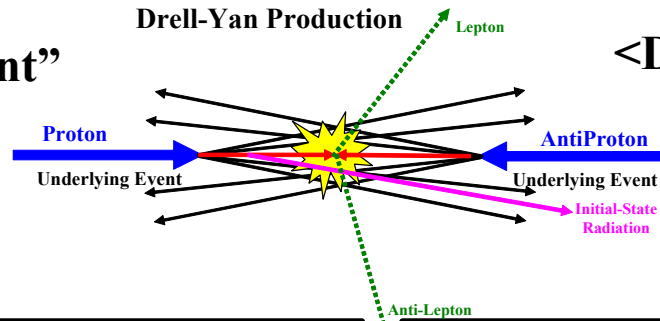
➔ Shows the lepton-pair average P_T versus the lepton-pair invariant mass at 1.96 TeV for **PYTHIA Tune AW** and **PYTHIA Tune A5**.



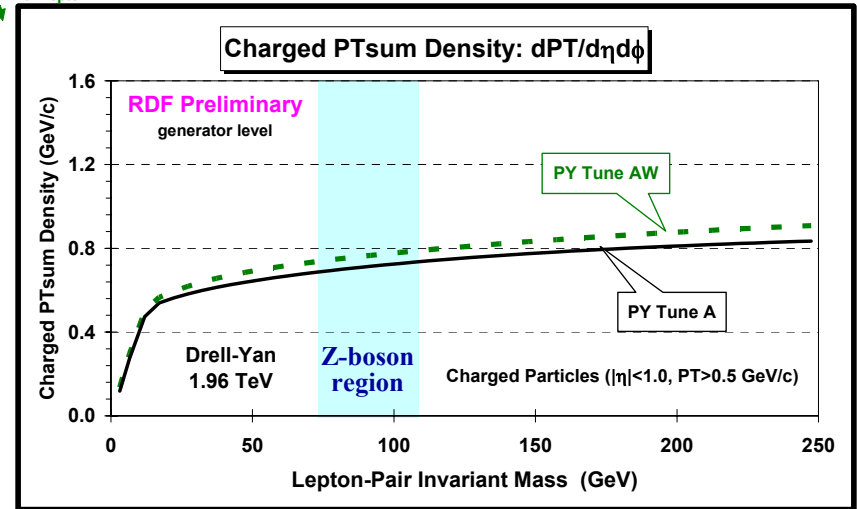
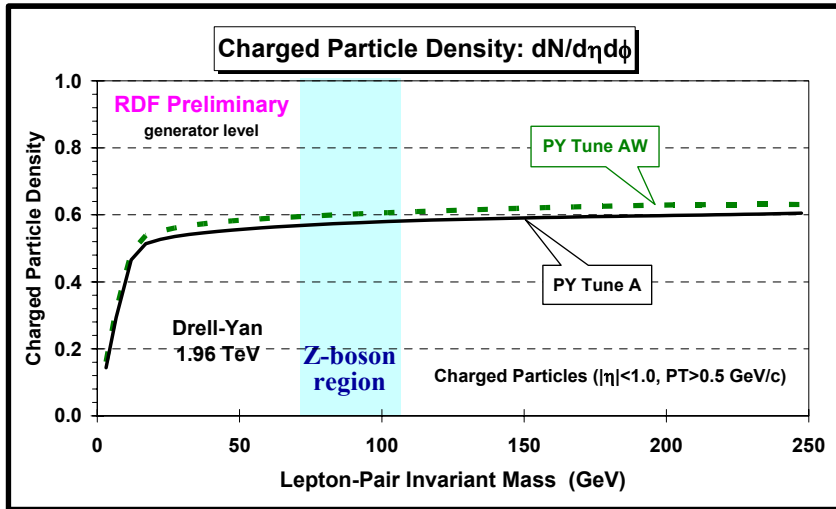
Run 2 Drell-Yan



The "Underlying Event"



<Densities> versus M(pair)



➔ Shows the charged particle density versus the lepton-pair invariant mass at 1.96 TeV for **PYTHIA Tune AW** and **PYTHIA Tune A**.

➔ Shows the charged PTsum density versus the lepton-pair invariant mass at 1.96 TeV for **PYTHIA Tune AW** and **PYTHIA Tune A**.

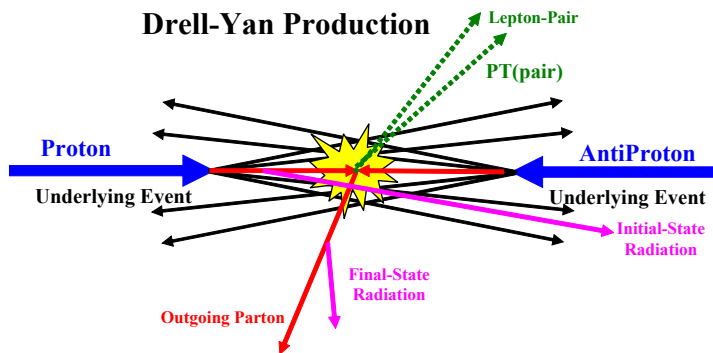
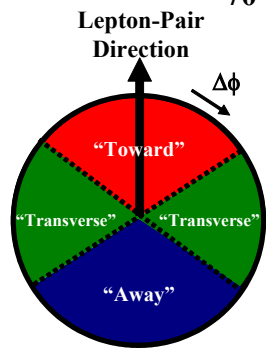


High P_T Drell-Yan

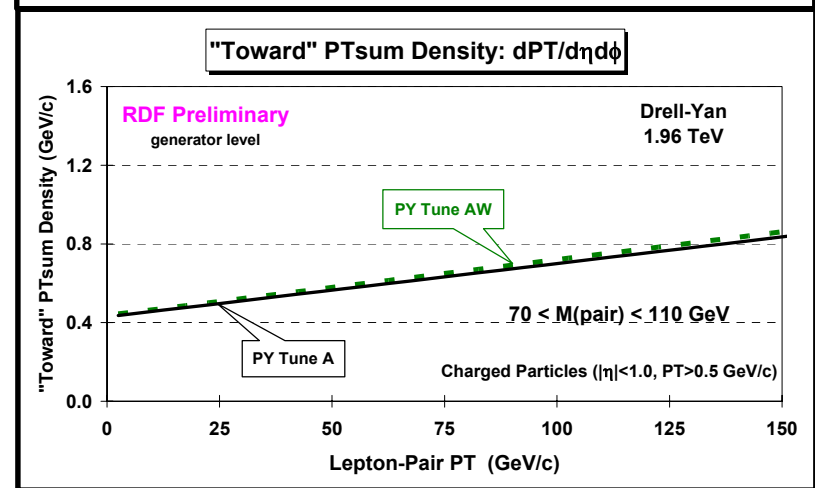
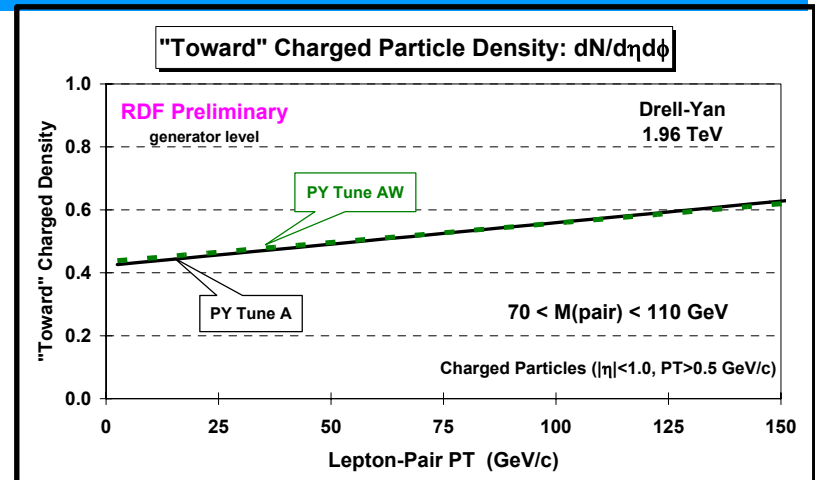


The "Underlying Event" in High P_T Lepton-Pair Production

$70 < M(\text{lepton-pair}) < 110 \text{ GeV}$



"Toward" <Densities> vs $P_T(\text{pair})$



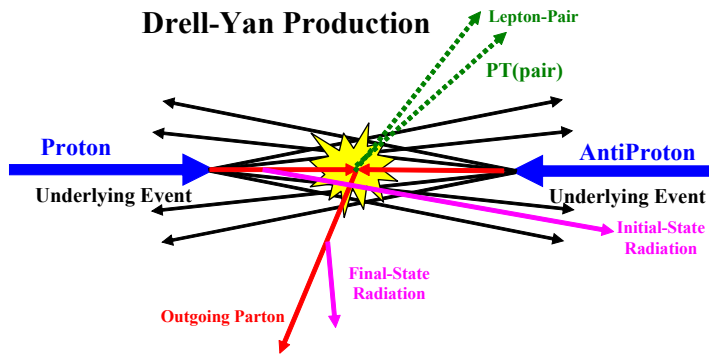
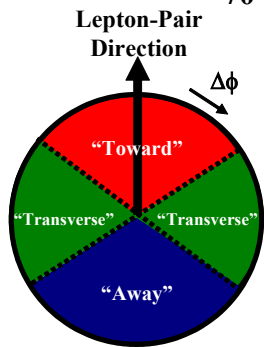


High P_T Drell-Yan

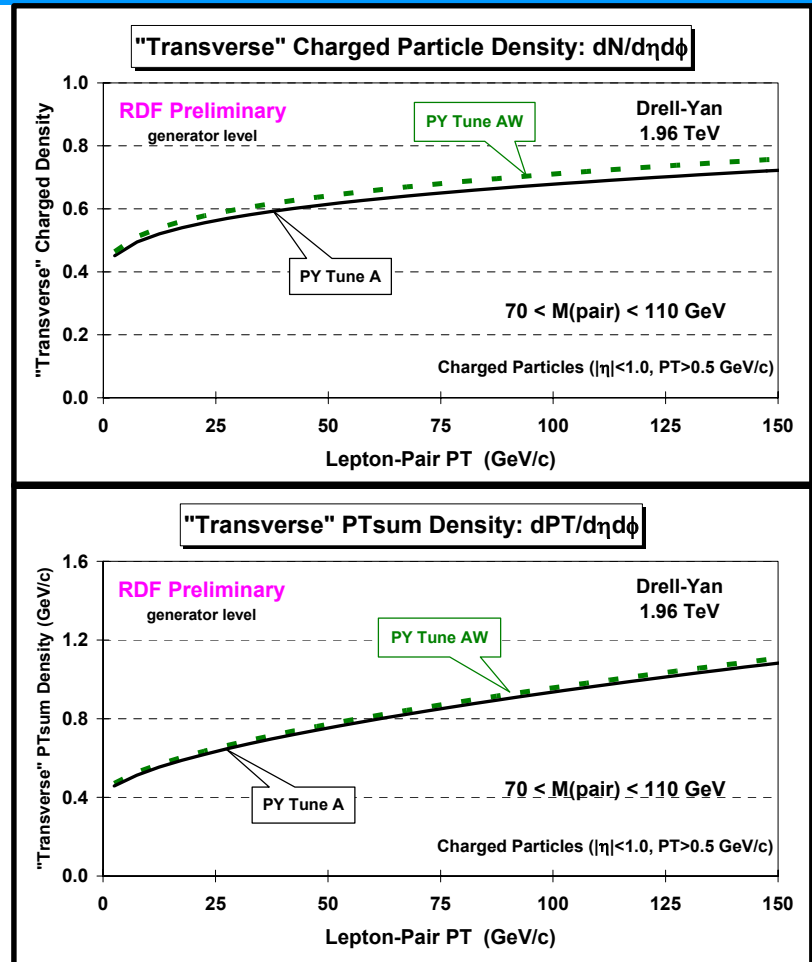


The "Underlying Event" in High P_T Lepton-Pair Production

$70 < M(\text{lepton-pair}) < 110 \text{ GeV}$

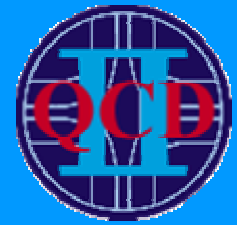


"Transverse" <Densities> vs $P_T(\text{pair})$

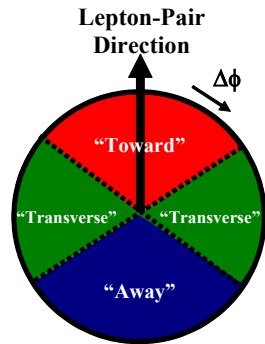
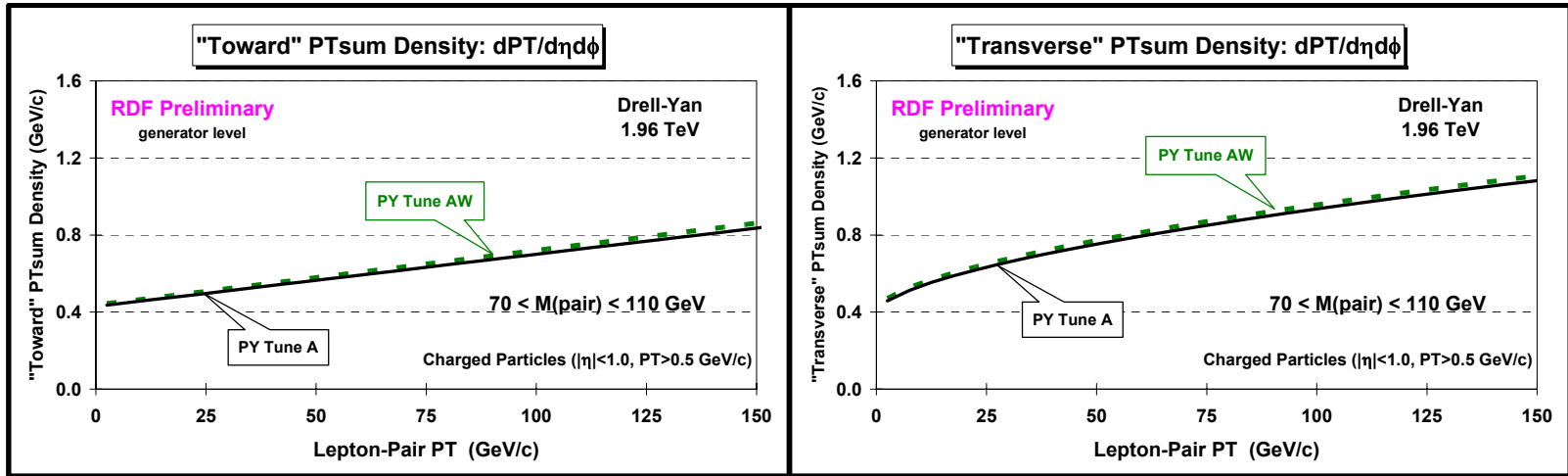




High P_T Drell-Yan

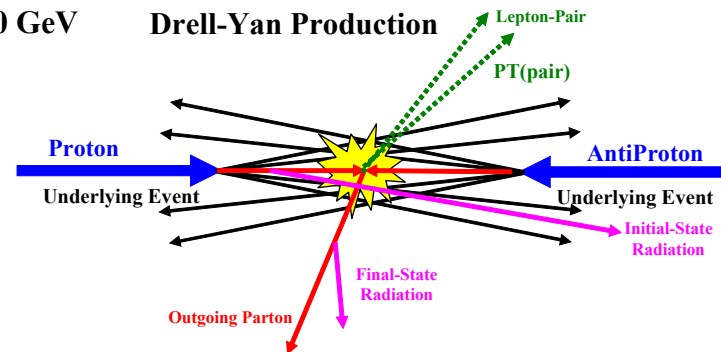


The “Underlying Event” in High P_T Lepton-Pair Production



$70 < M(\text{lepton-pair}) < 110 \text{ GeV}$

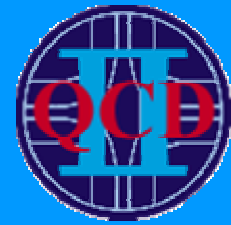
Drell-Yan Production



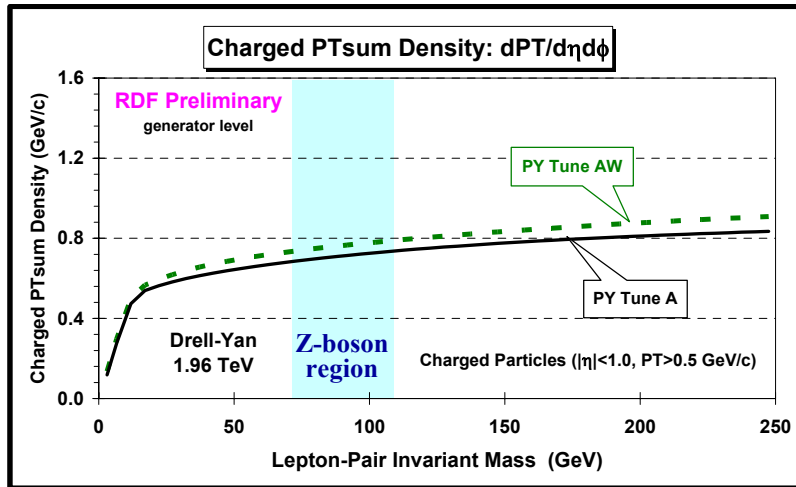
“Toward” <Densities> vs “Transverse” <Densities>



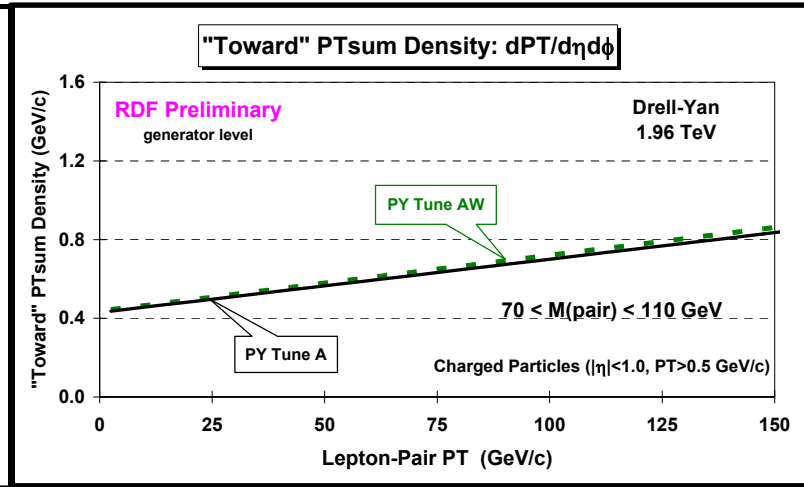
High P_T Drell-Yan



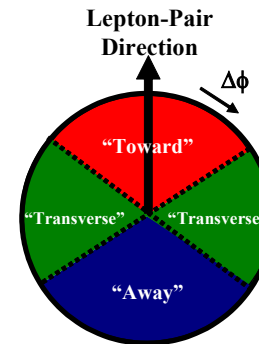
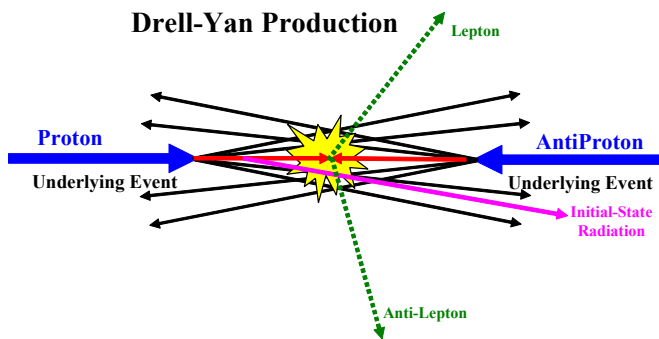
The “Underlying Event” in Lepton-Pair Production



Overall PTsum Density vs $M(\text{pair})$



“Toward” PTsum Density vs $P_T(\text{pair})$

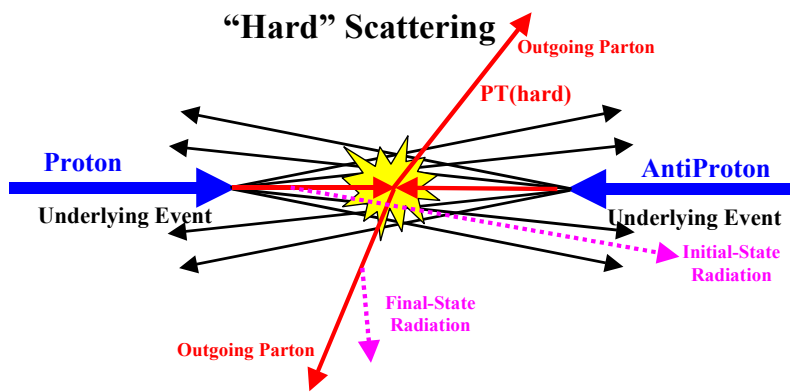
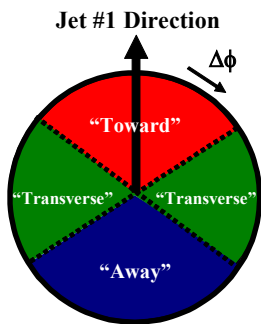




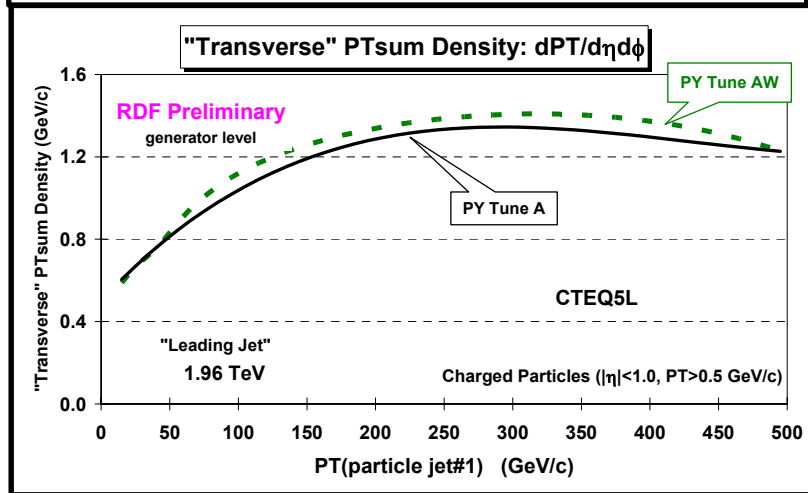
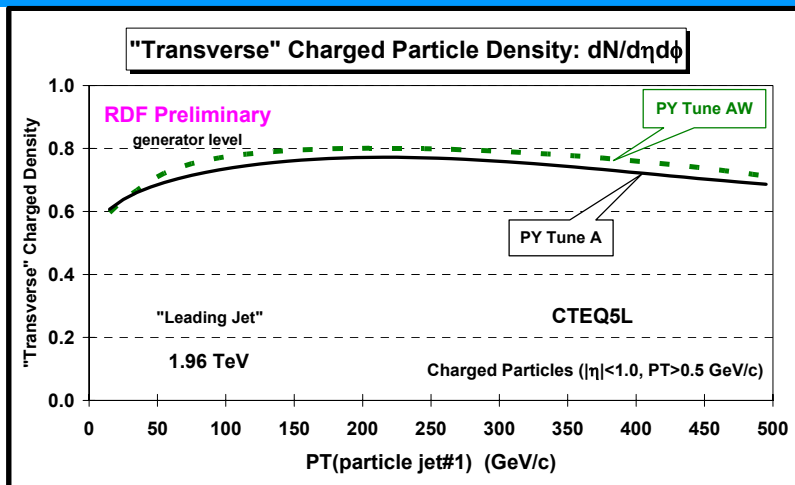
High P_T Jets



The "Underlying Event" in High P_T Jet Production



"Transverse" <Densities> vs P_T (jet#1)

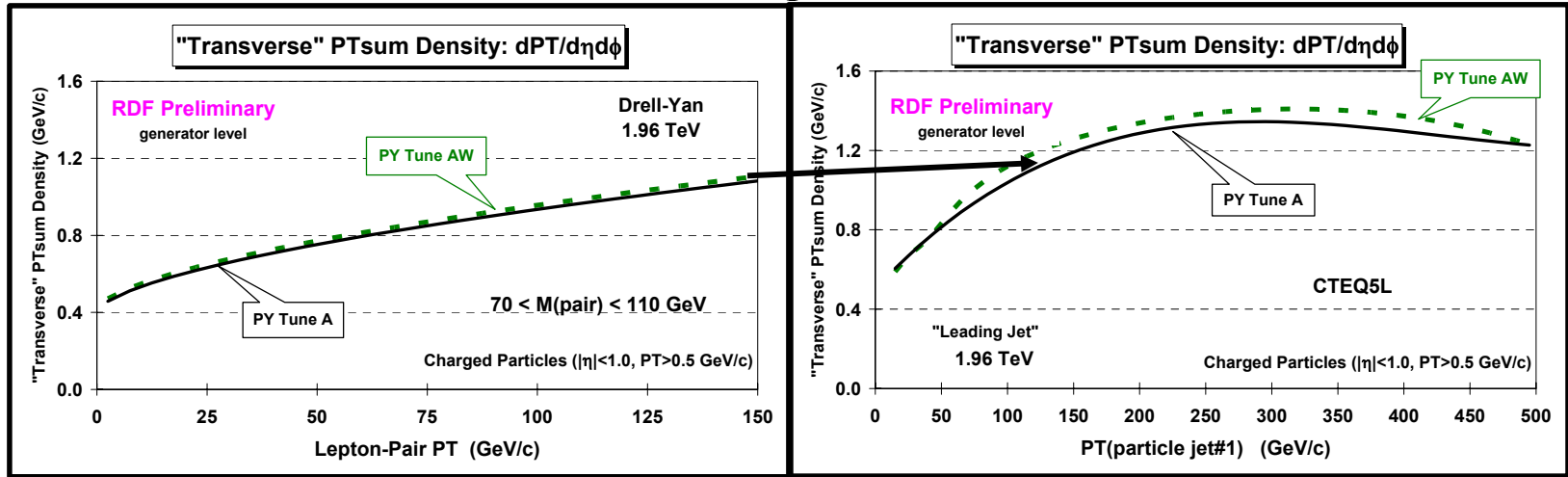




Drell-Yan vs Jets

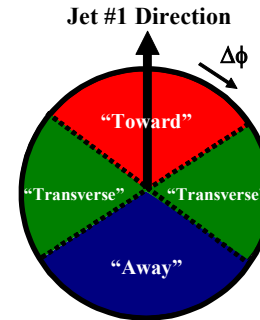
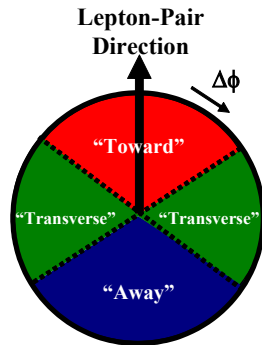


The “Underlying Event” in High P_T Lepton-Pair and Jet Production



“Transverse” <Densities> vs $P_T(\text{pair})$

“Transverse” <Densities> vs $P_T(\text{jet\#1})$





CTEQ6.1 Tune



I used **LHAPDF**! See the next talk by Craig Group!

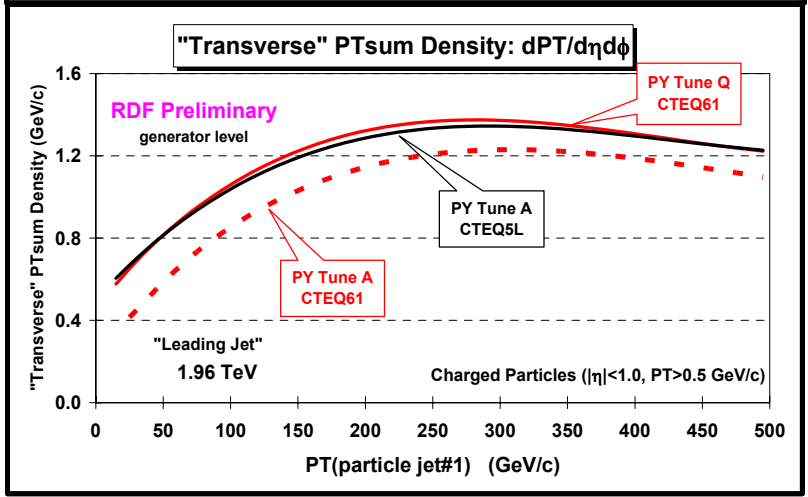
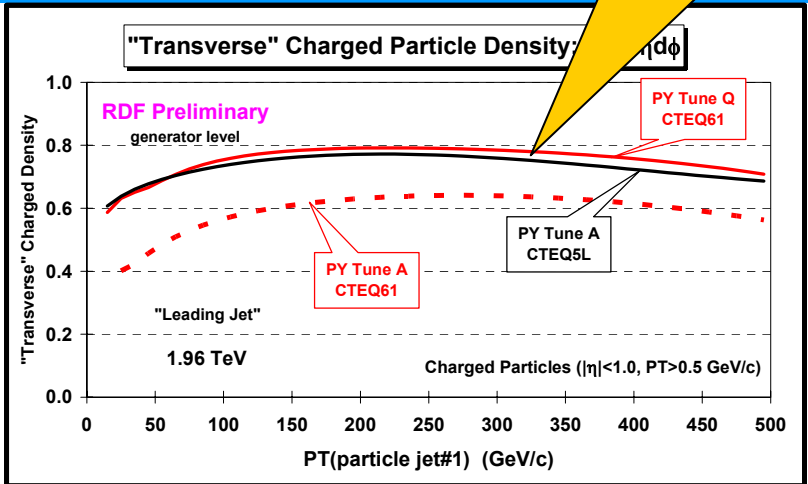
PYTHIA 6.2 CTEQ6.1

UE Parameters

ISR Parameters

Intrinsic KT

Parameter	Tune Q	Tune QW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	1.2 GeV	1.2 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	1.0	2.1
PARP(93)	5.0	15.0



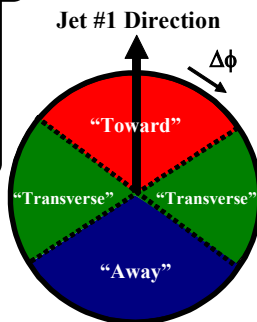
JIMMY
Runs with HERWIG and adds
multiple parton interactions!

JIMMY at CDF

JIMMY was tuned to fit
the energy density in the
“transverse” region for
“leading jet” events!

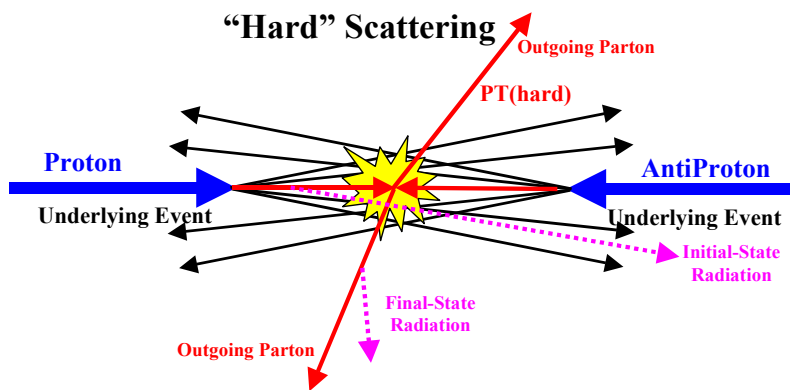
The Energy in the “Underlying Event” in High P_T Jet Production

JIMMY: MPI
J. M. Butterworth
J. R. Forshaw
M. H. Seymour

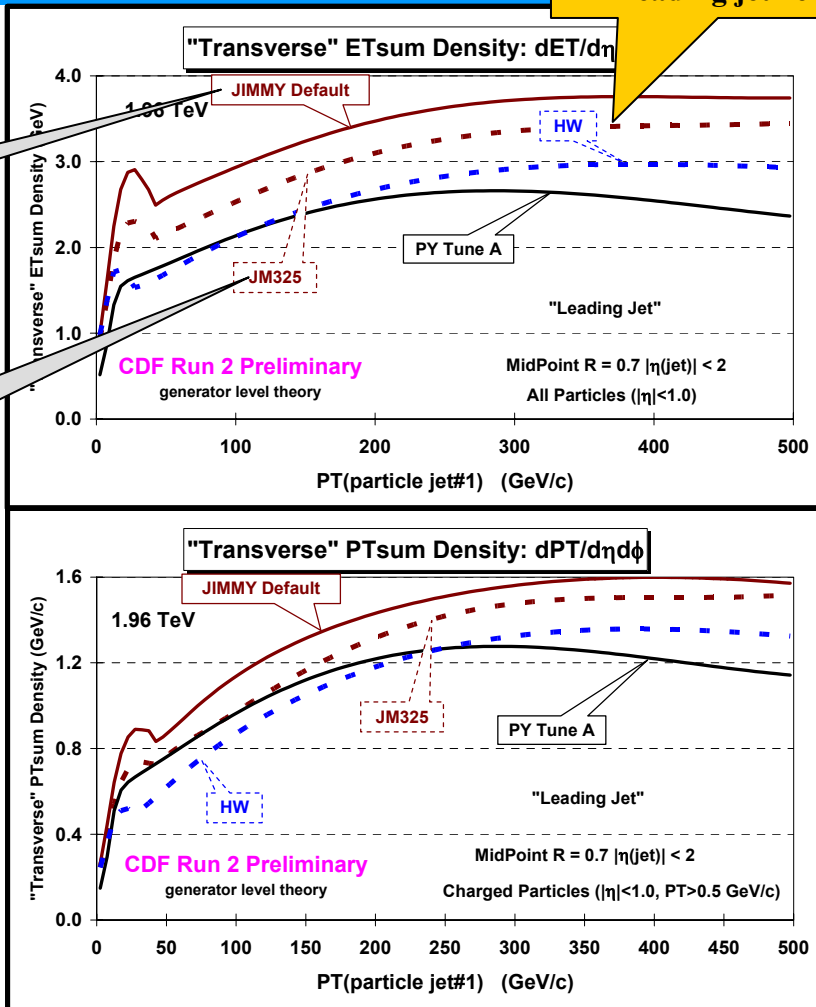


PT(JIM)= 2.5 GeV/c.

PT(JIM)= 3.25 GeV/c.



“Transverse” <Densities> vs P_T (jet#1)

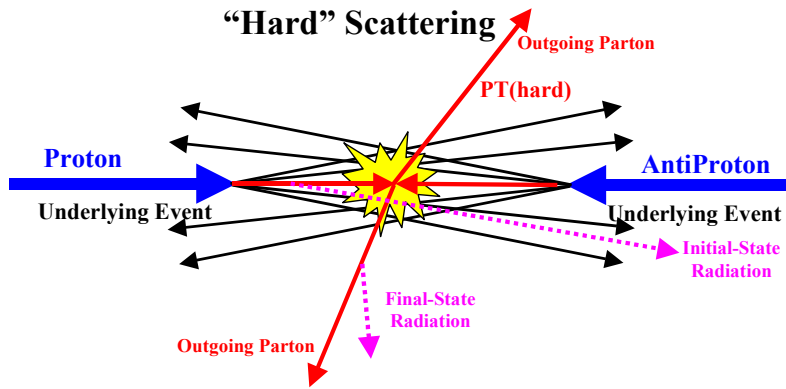
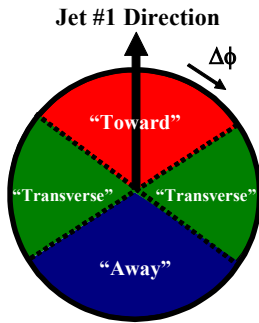




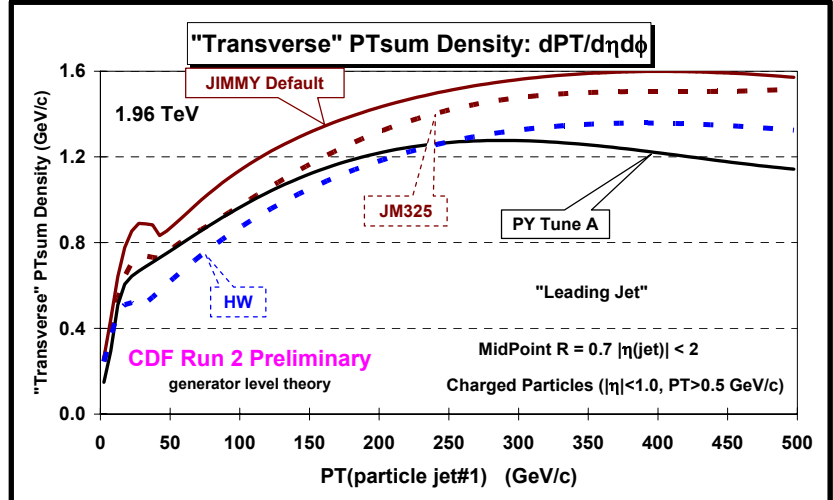
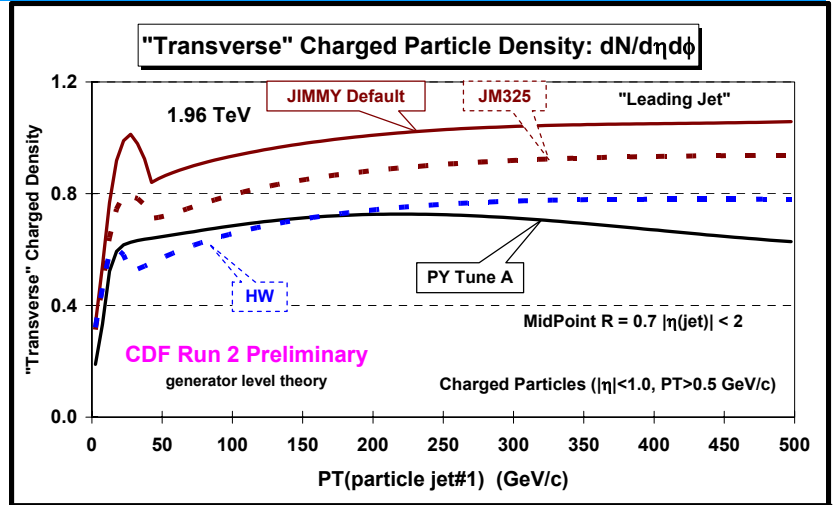
JIMMY at CDF



The "Underlying Event" in High P_T Jet Production



"Transverse" <Densities> vs P_T (jet#1)





Summary

Good way to study the “underlying event”!

- ➔ **PYTHIA Tune AW** correctly describes the Z-boson P_T distribution and also fits the “underlying event” as well as Tune A does! I do not see anything wrong with it, except that it may only work at the Tevatron. You can not trust the energy dependence!
- ➔ **PYTHIA Tune Q** works as well as Tune A but uses CTEQ6.1! At the Tevatron use Tune QW!
- ➔ **Default JIMMY (PTJIM = 2.5 GeV/c)** does not fit the CDF “underlying event” data! Default JIMMY’s “underlying event” is much too active!
- ➔ **JIMMY 325 (PTJIM = 3.25 GeV/c)** fits the energy in the “underlying event” but does so by producing too many particles (*i.e.* it is too soft). **See my talk tomorrow!**
- ➔ We are making good progress in understanding and modeling the “underlying event”. However, we do not yet have a perfect fit to all the features of the “underlying event”. **PYTHIA Tune A does not produce enough energy in the “underlying event”!** **See my talk tomorrow!**

