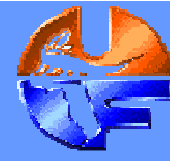




MPI@LHC 2012



New MB & UE “Common Plots”



Rick Field
University of Florida

Quantum
Chromo-
Dynamics

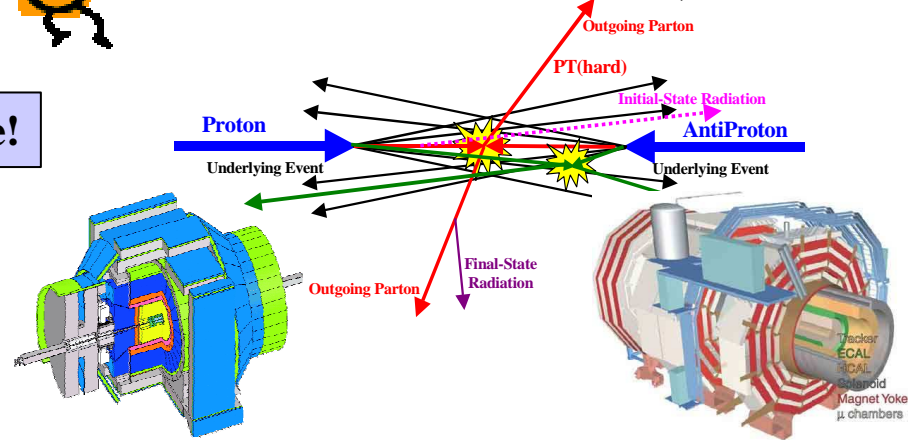
Outline of Talk

- ➔ LPCC MB&UE working group “common plots”.
- ➔ New **CMS** UE “common plots”.
- ➔ New **CDF** MB & UE “common plots” from the **Tevatron Energy Scan**.
- ➔ New **UE-MB** comparisons!
- ➔ **CDF-CMS** comparisons!
- ➔ Comparisons with **PYTHIA 6.4 Tune Z1**.
- ➔ More **data** coming!

Really nice!



CERN December 3-7, 2012



CDF Run 2

300 GeV, 900 GeV, 1.96 TeV

CMS at the LHC

900 GeV, 7 & 8 TeV

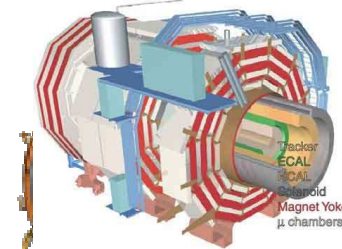
LPCC

MB&UE Working Group

LHC Physics Centre at CERN

MB & UE Common Plots

Quantum
Chromo-
Dynamics

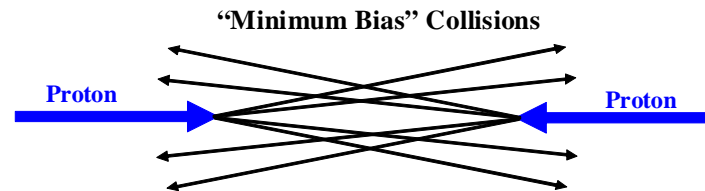
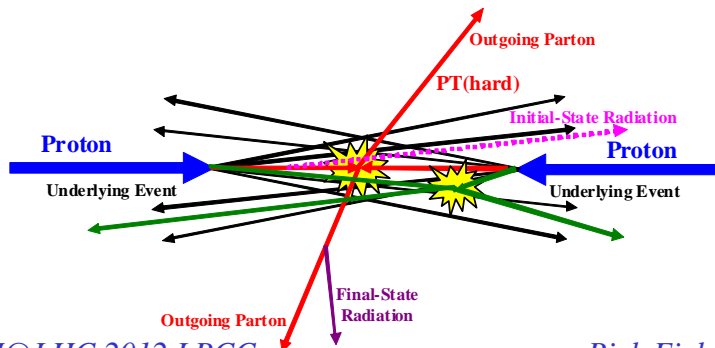


CMS



ATLAS

➔ The LPCC MB&UE Working Group has suggested several MB&UE “Common Plots” the all the LHC groups can produce and compare with each other.



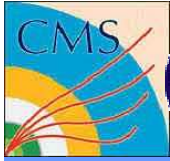


CMS Common Plots

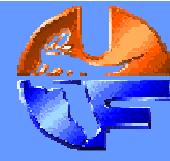


Observable	900 GeV	7 TeV
MB1: $dN_{\text{chg}}/d\eta N_{\text{chg}} \geq 1$ $\eta < 0.8 p_T > 0.5 \text{ GeV}/c \ \& \ 1.0 \text{ GeV}/c$	Done QCD-10-024	Done QCD-10-024
MB2: $dN_{\text{chg}}/dp_T N_{\text{chg}} \geq 1 \ \eta < 0.8$	Stalled	Stalled
MB3: Multiplicity Distribution $\eta < 0.8 p_T > 0.5 \text{ GeV}/c \ \& \ 1.0 \text{ GeV}/c$	Stalled	Stalled
MB4: $\langle p_T \rangle$ versus N_{chg} $\eta < 0.8 p_T > 0.5 \text{ GeV}/c \ \& \ 1.0 \text{ GeV}/c$	In progress (Antwerp)	In progress (Antwerp)
UE1: Transverse N_{chg} & PT_{sum} as defined by the leading charged particle, PT_{max} $\eta < 0.8 p_T > 0.5 \text{ GeV}/c \ \& \ 1.0 \text{ GeV}/c$	Done FSQ-12-020	Done FSQ-12-020

Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.



CMS Common Plots



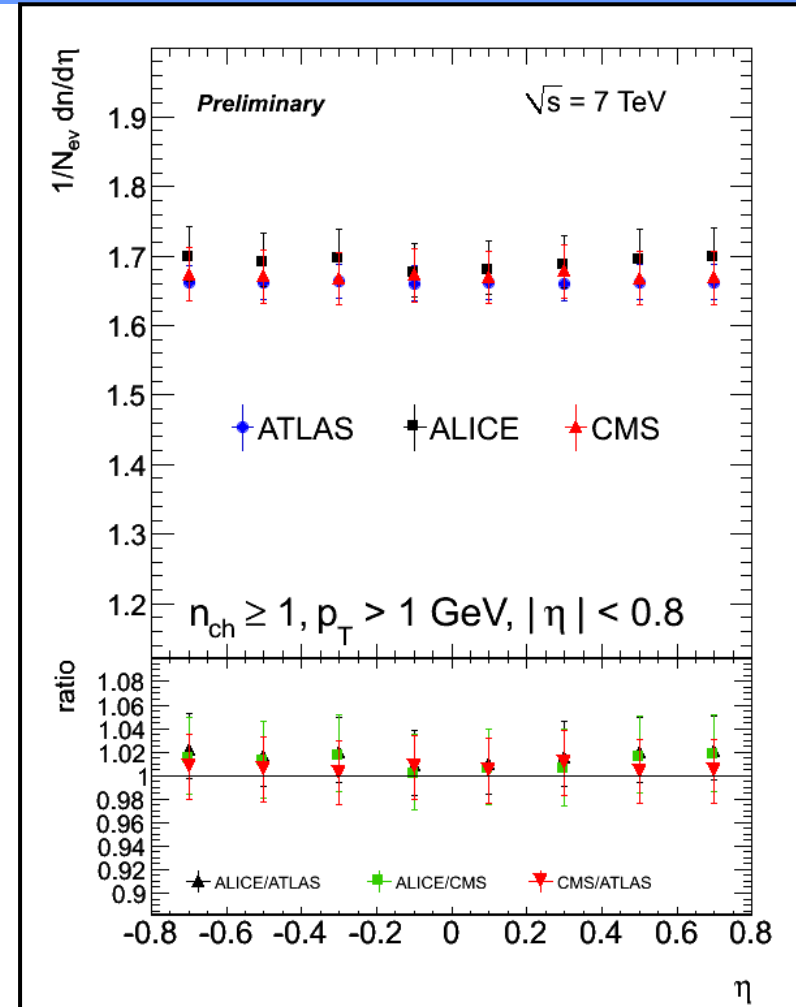
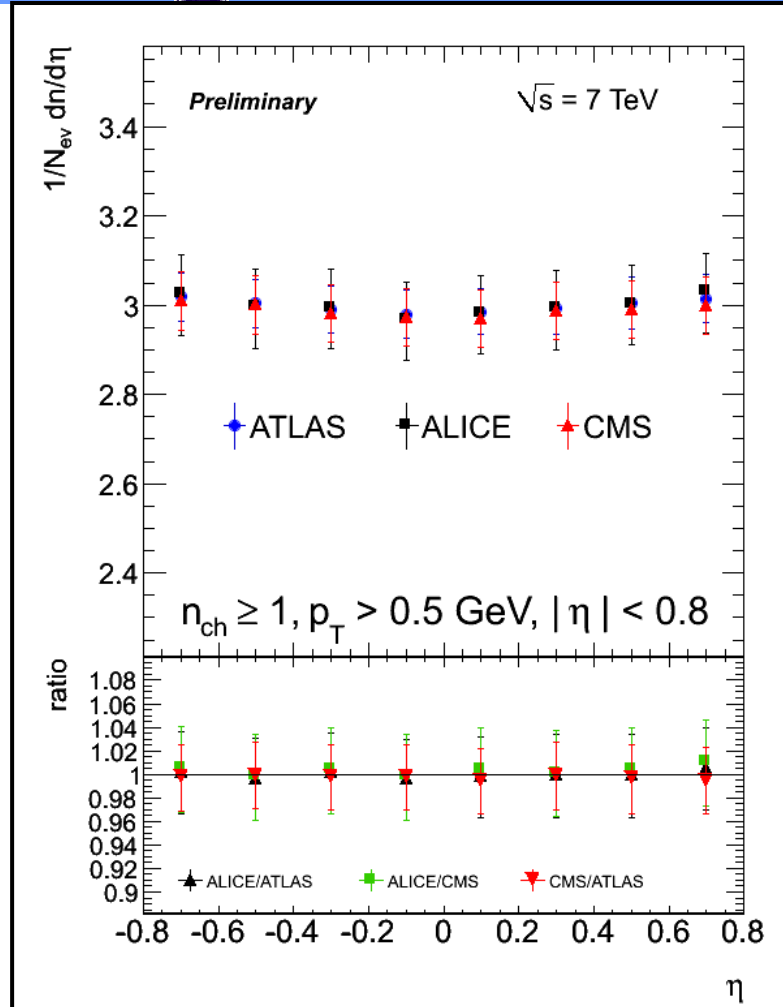
Observable	900 GeV	7 TeV
MB1: $dN_{\text{chg}}/d\ln N_{\text{chg}} \geq 1$ $ \eta < 0.8$ $p_T > 0.5 \text{ GeV/c}$ & 1.0 GeV/c	Done	Done
MB2: dN_{chg}/dp_T	QC	Stalled
MB3: $\langle p_T \rangle$ $ \eta < 0.8$ $p_T > 0.5 \text{ GeV/c}$	QC	Stalled
MB4: $\langle p_T \rangle$ vertex $ \eta < 0.8$ $p_T > 0.5 \text{ GeV/c}$	QC	Stalled
UE1: Transverse N_{chg} defined by the leading particle, PT_{max} $ \eta < 0.8$ $p_T > 0.5 \text{ GeV/c}$ & 1.0 GeV/c	Done	Done

Note that all the “common plots” require at least one charged particle with $p_T > 0.5 \text{ GeV/c}$ and $|\eta| < 0.8$! This done so that the plots are less sensitive to SD and DD.

Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.



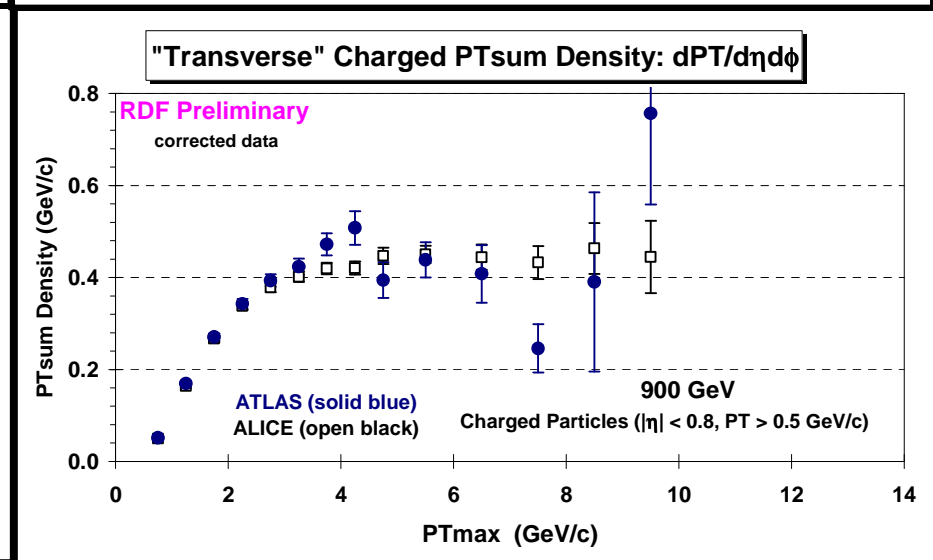
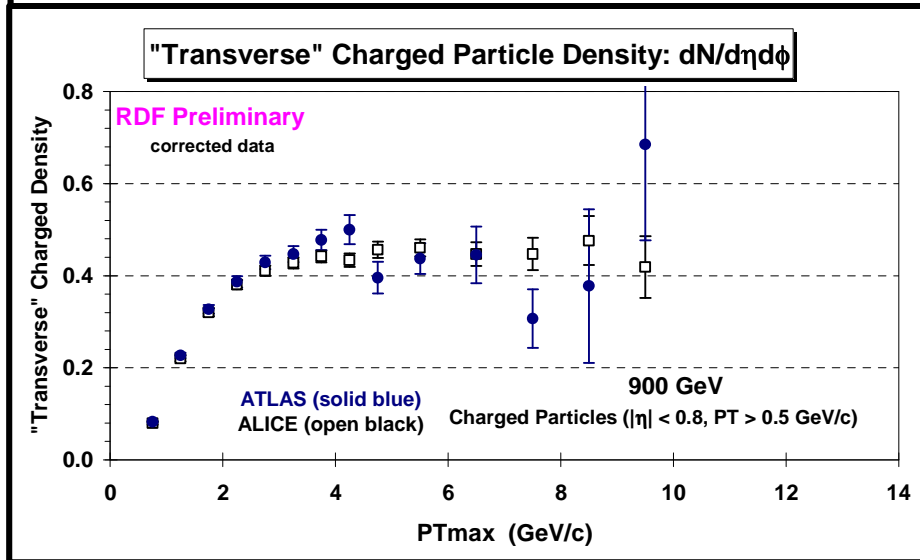
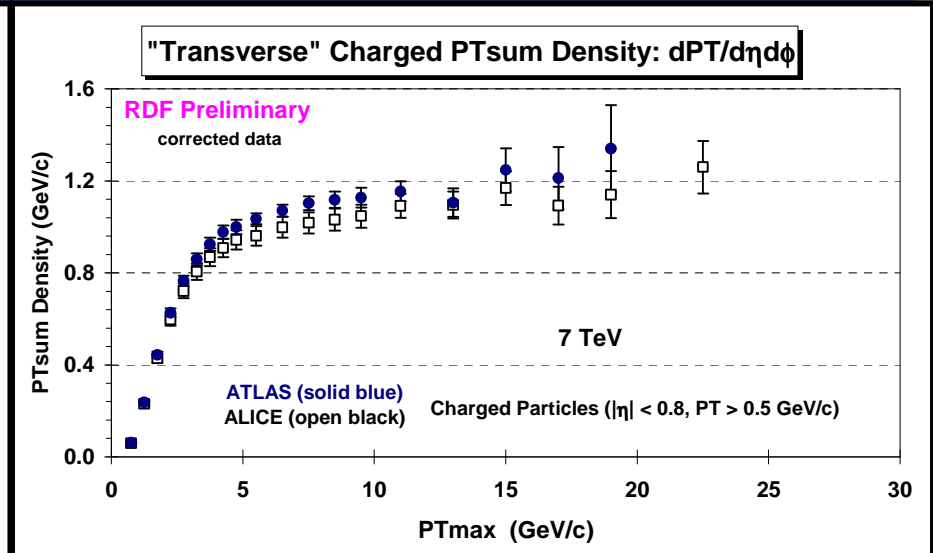
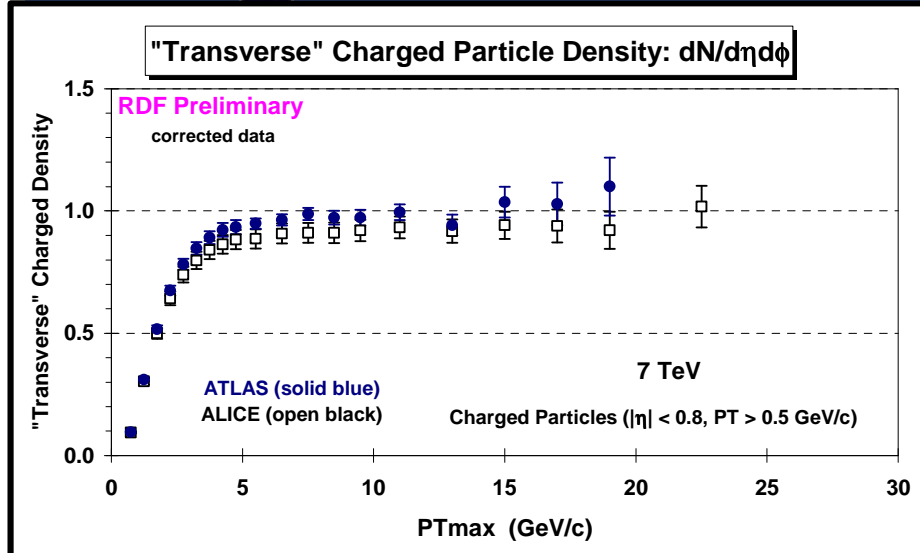
MB Common Plots 7 TeV



Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.

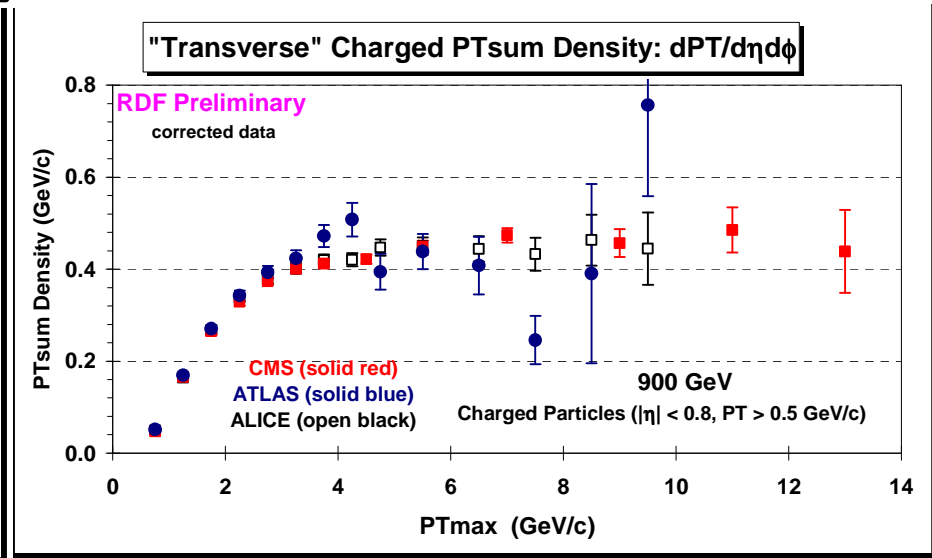
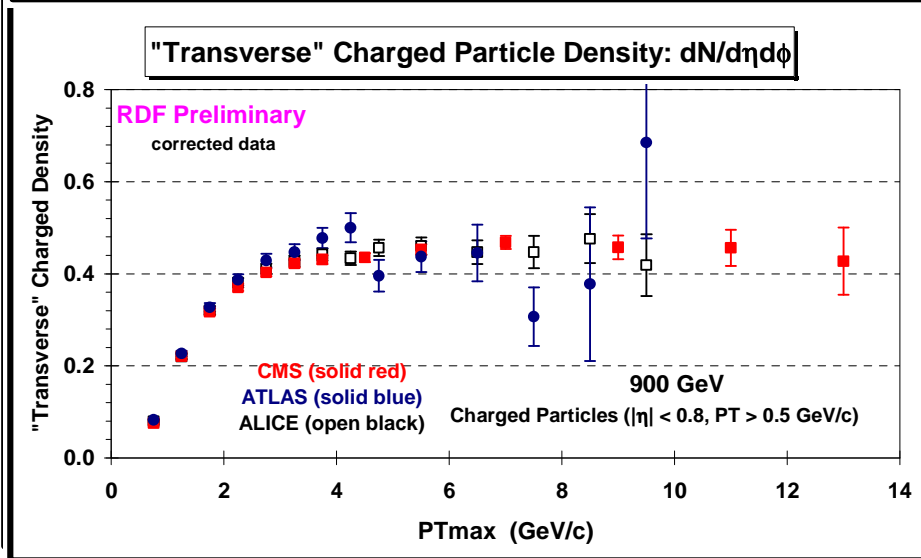
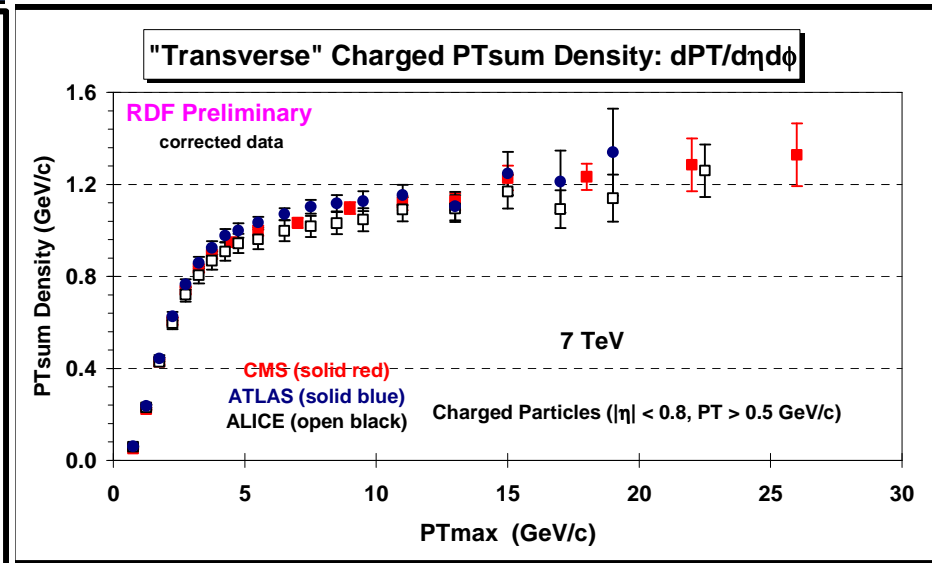
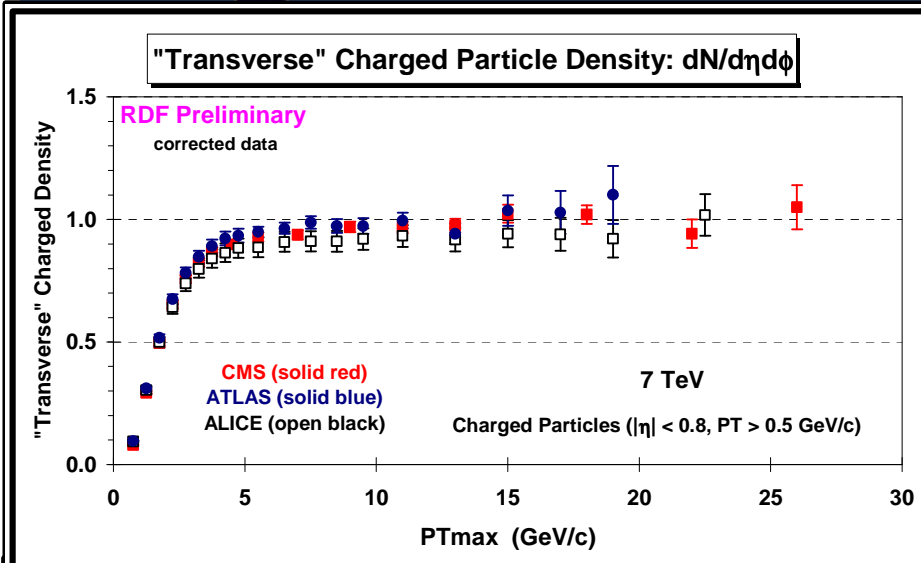
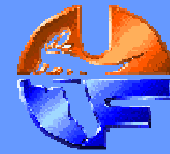


UE Common Plots



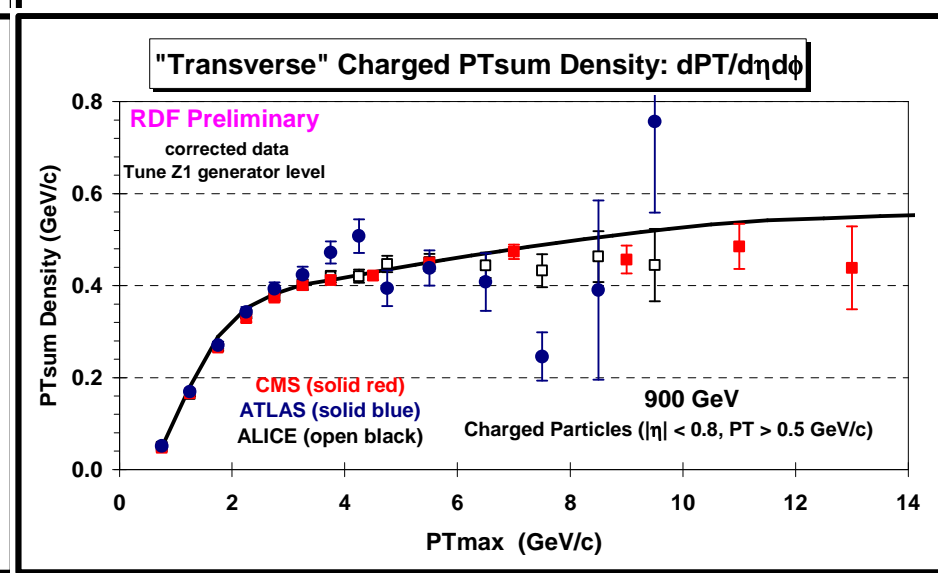
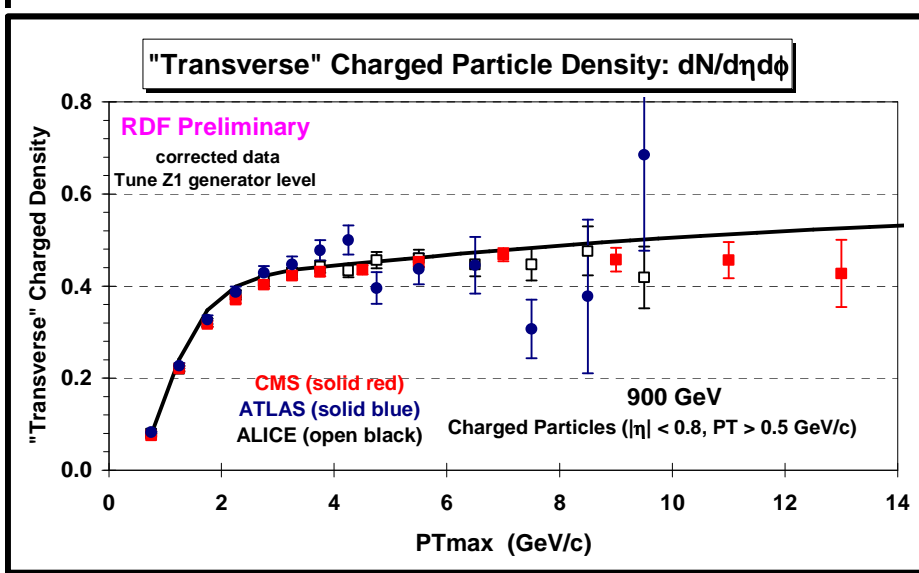
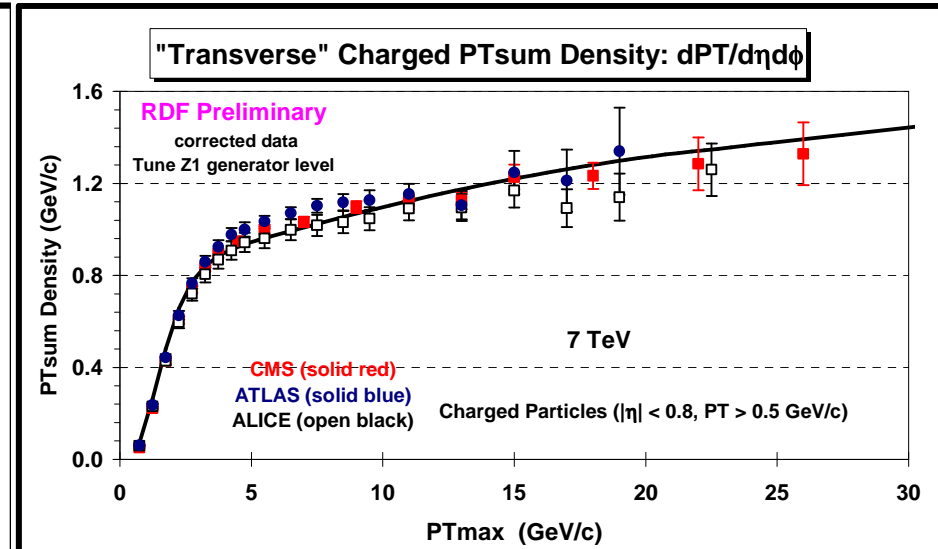
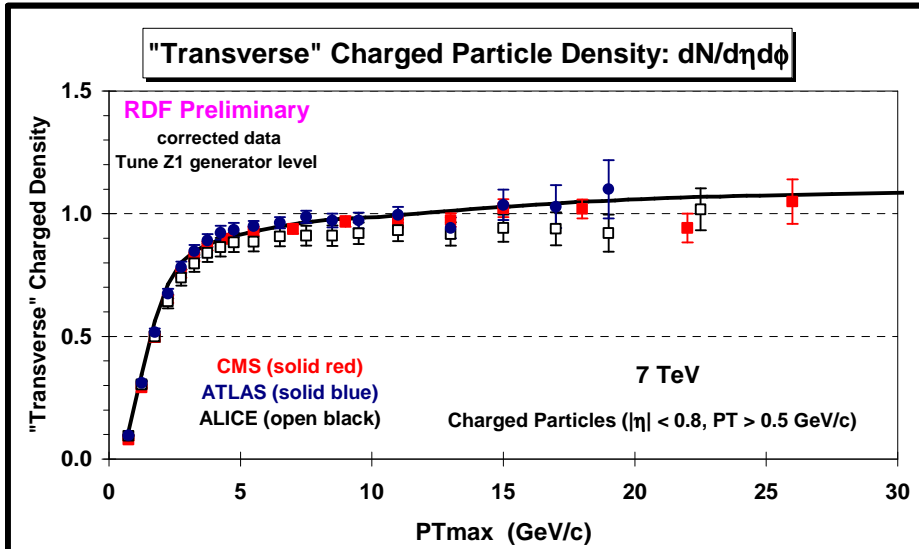
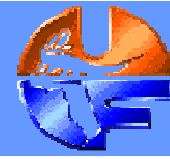


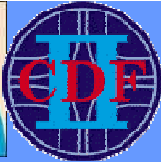
UE Common Plots



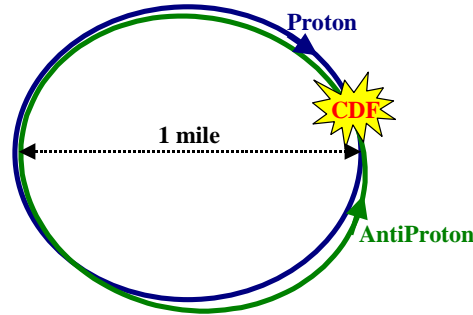
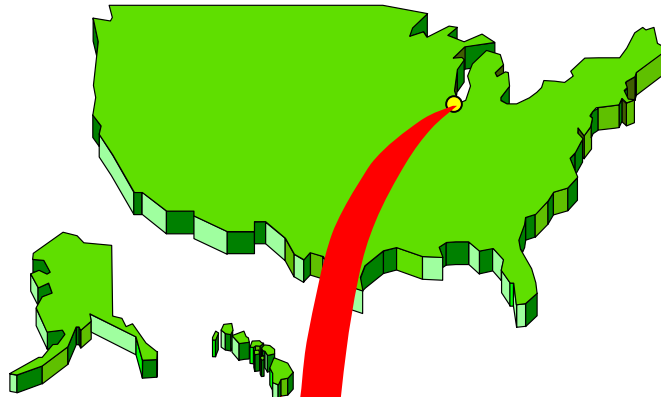
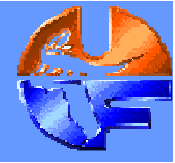


UE Common Plots





Tevatron Energy Scan



➔ Just before the shutdown of the Tevatron CDF has collected more than 10M “min-bias” events at several center-of-mass energies!

300 GeV 12.1M MB Events

900 GeV 54.3M MB Events



CDF Common Plots



Observable	300 GeV	900 GeV	1.96 TeV
MB1: $dN_{\text{chg}}/d\eta N_{\text{chg}} \geq 1$ $\eta < 0.8$ $p_T > 0.5$ GeV/c & 1.0 GeV/c	Done	Done	Done
MB2: $dN_{\text{chg}}/dp_T N_{\text{chg}} \geq 1$ $\eta < 0.8$	In progress	In progress	In progress
MB3: Multiplicity Distribution $\eta < 0.8$ $p_T > 0.5$ GeV/c & 1.0 GeV/c	In progress	In progress	In progress
MB4: $\langle p_T \rangle$ versus Nchg $\eta < 0.8$ $p_T > 0.5$ GeV/c & 1.0 GeV/c	In progress	In progress	In progress
UE1: Transverse Nchg & PTsum as defined by the leading charged particle, PTmax $\eta < 0.8$ $p_T > 0.5$ GeV/c & 1.0 GeV/c	$p_T > 0.5$ GeV/c Done	$p_T > 0.5$ GeV/c Done	$p_T > 0.5$ GeV/c Done

Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.



UE Observables

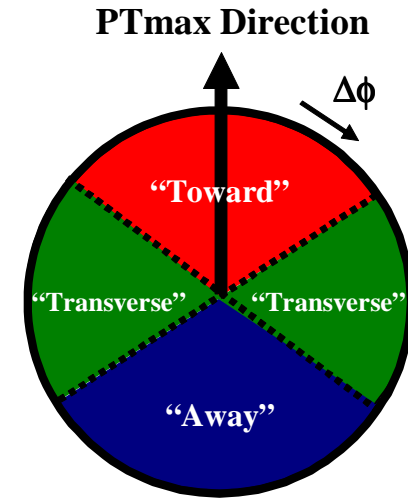


➔ **“Transverse” Charged Particle Density:** Number of charged particles ($p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$) in the “transverse” region as defined by the leading charged particle, PTmax, divided by the area in η - ϕ space, $2\eta_{\text{cut}} \times 2\pi/3$, averaged over all events with at least one particle with $p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$.

➔ **“Transverse” Charged PTsum Density:** Scalar p_T sum of the charged particles ($p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$) in the “transverse” region as defined by the leading charged particle, PTmax, divided by the area in η - ϕ space, $2\eta_{\text{cut}} \times 2\pi/3$, averaged over all events with at least one particle with $p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$.

➔ **“Transverse” Charged Particle Average p_T :** Event-by-event $\langle p_T \rangle = \text{PTsum}/\text{Nchg}$ for charged particles ($p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$) in the “transverse” region as defined by the leading charged particle, PTmax, averaged over all events with at least one particle in the “transverse” region with $p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$.

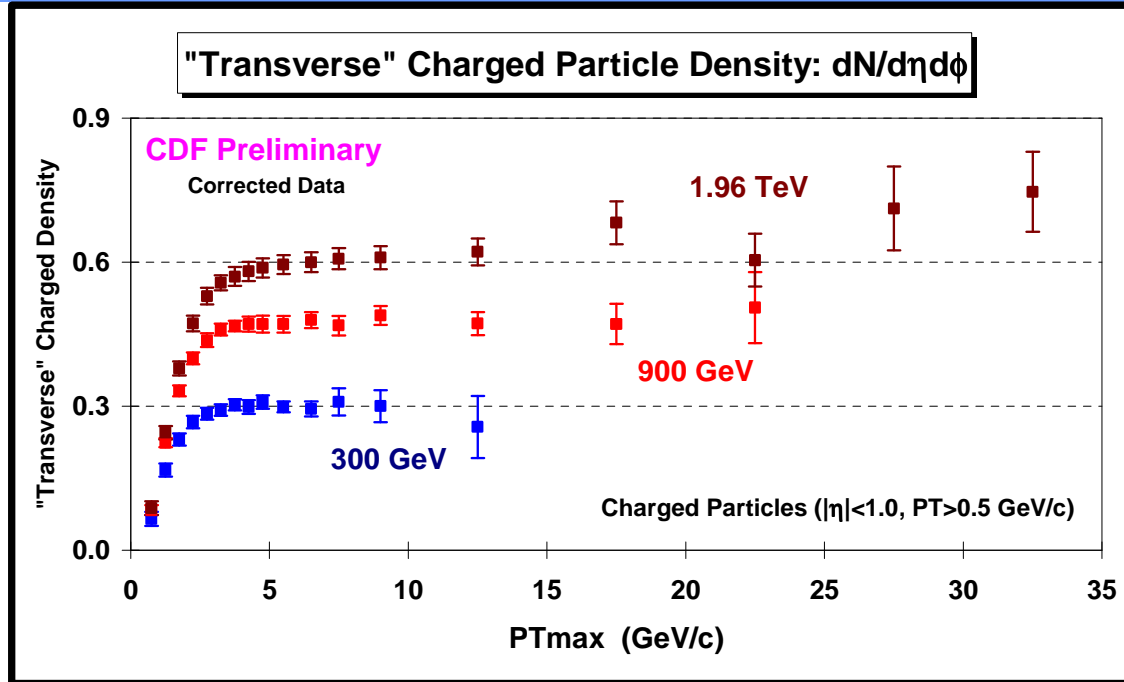
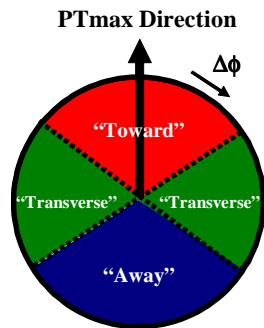
➔ **Zero “Transverse” Charged Particles:** If there are no charged particles in the “transverse” region then Nchg and PTsum are zero and one includes these zeros in the average over all events with at least one particle with $p_T > 0.5 \text{ GeV}/c$, $|\eta| < \eta_{\text{cut}}$. However, if there are no charged particles in the “transverse” region then the event is not used in constructing the “transverse” average p_T .



$$\eta_{\text{cut}} = 1.0 \text{ and } \eta_{\text{cut}} = 0.8$$



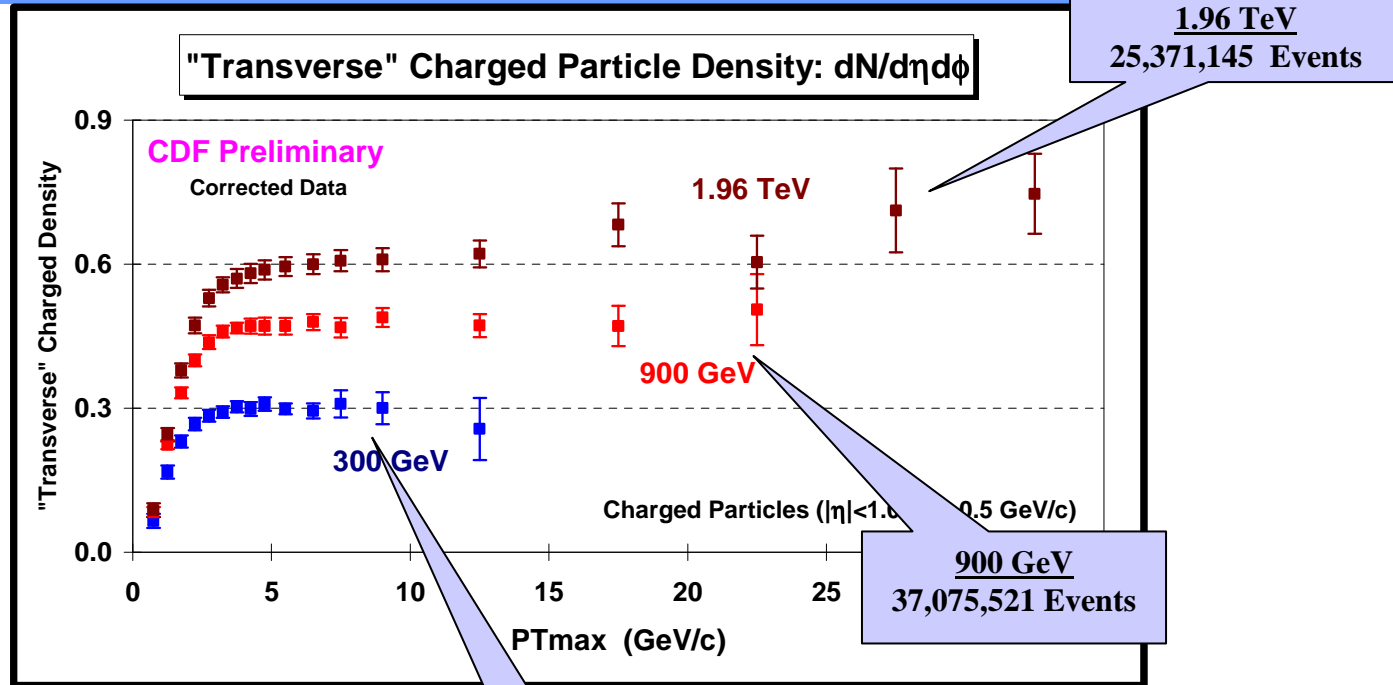
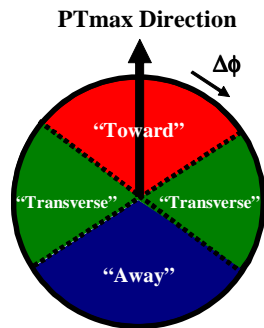
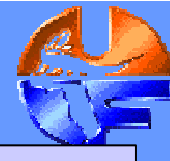
New CDF UE Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (P_{Tmax}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.



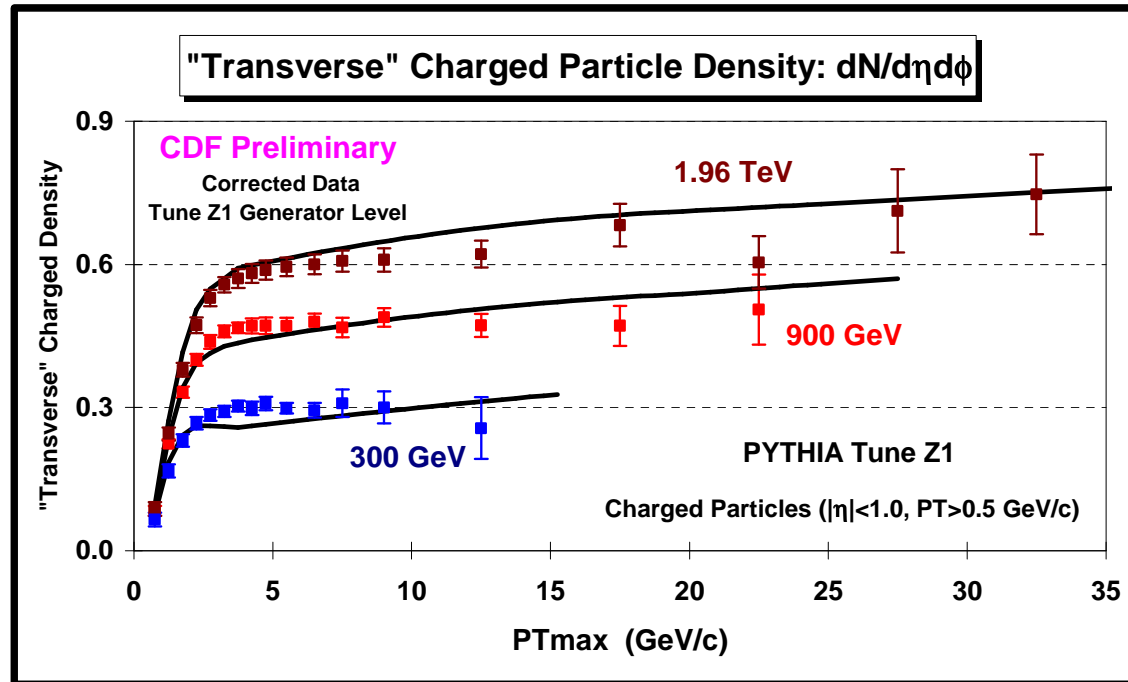
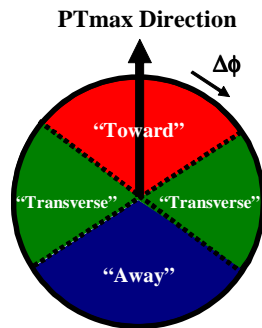
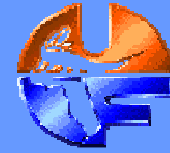
New CDF UE Data



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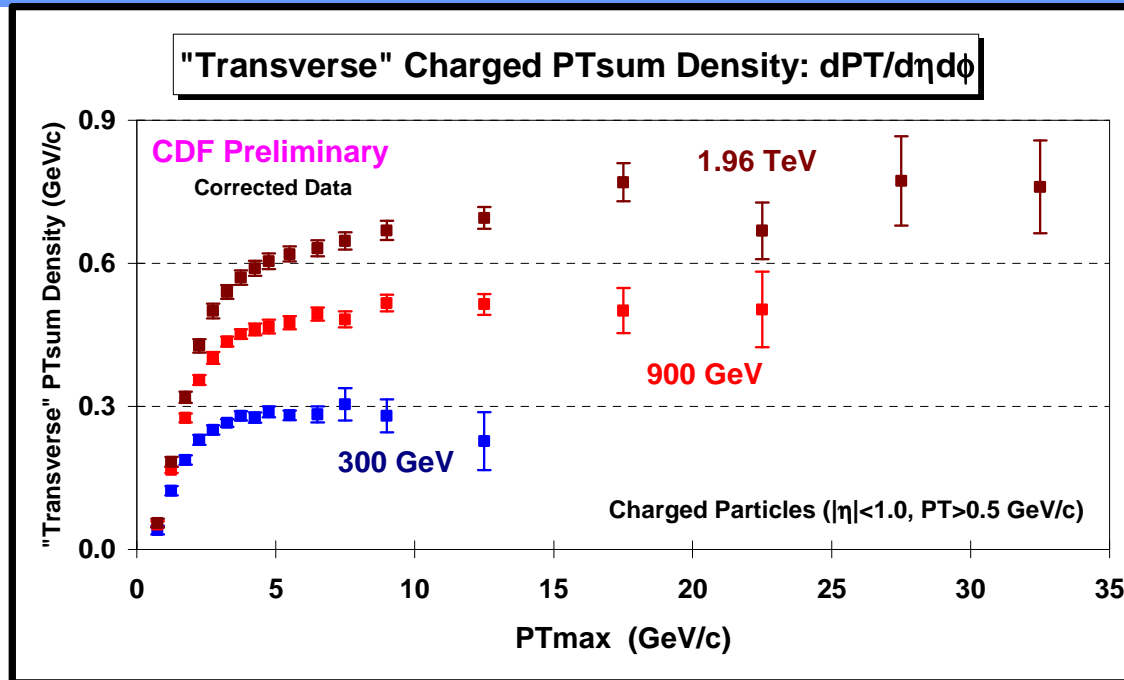
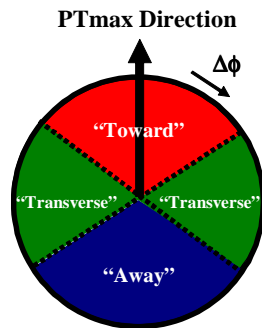
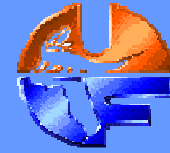
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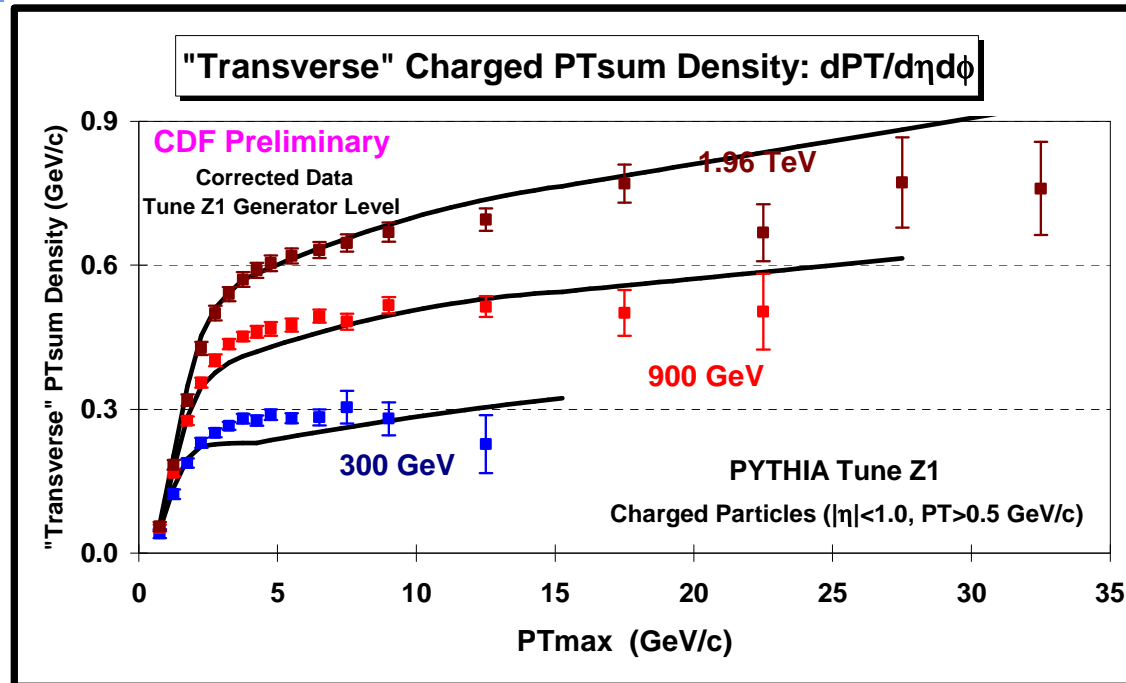
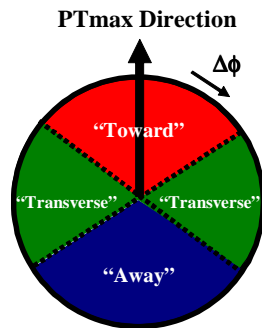
New CDF UE Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.



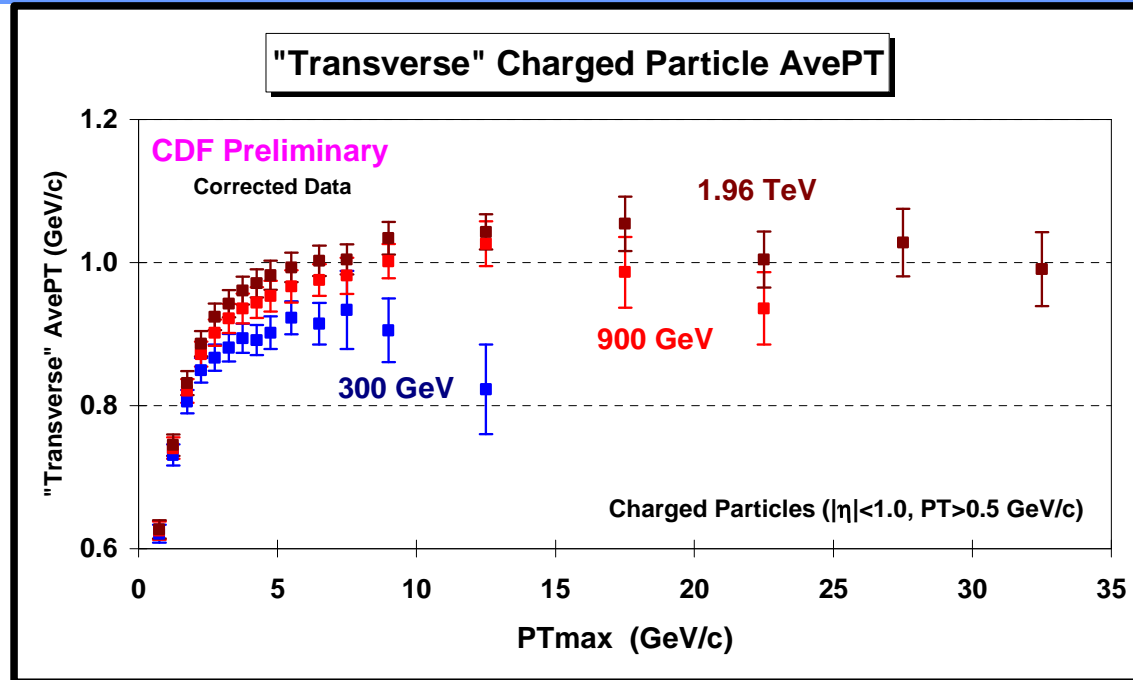
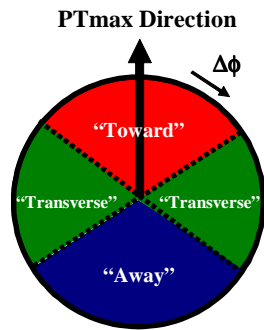
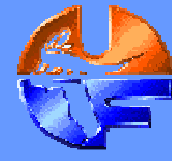
New CDF UE Data



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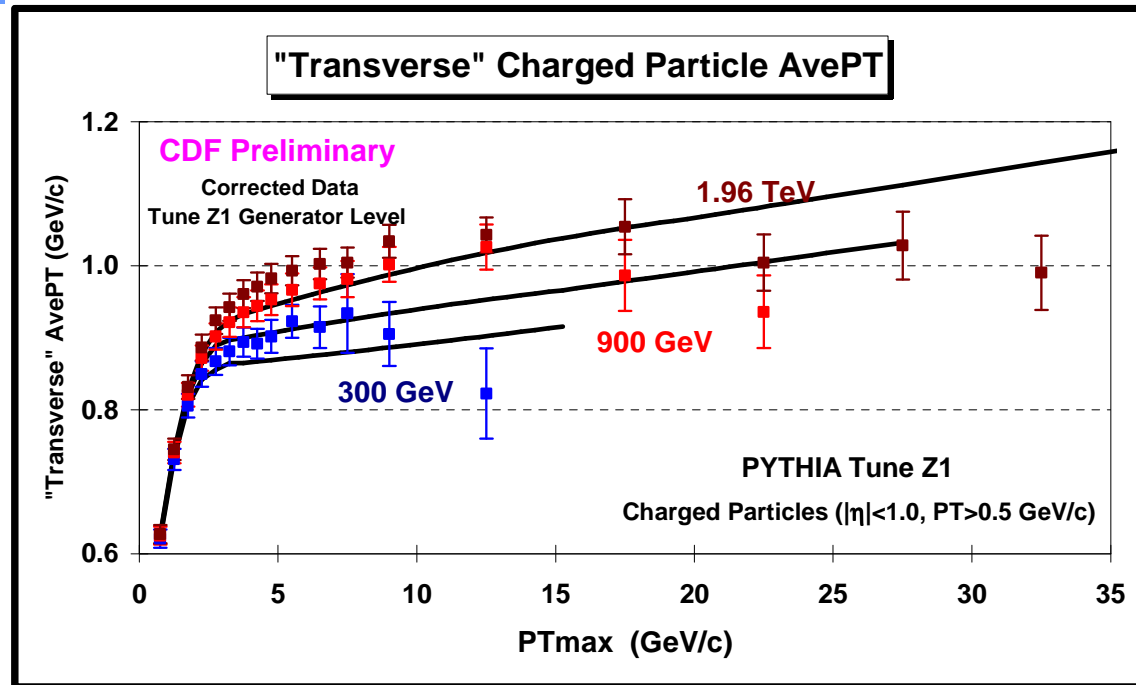
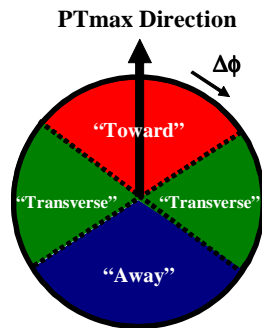
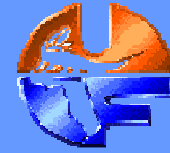
New CDF UE Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle average p_T , as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.



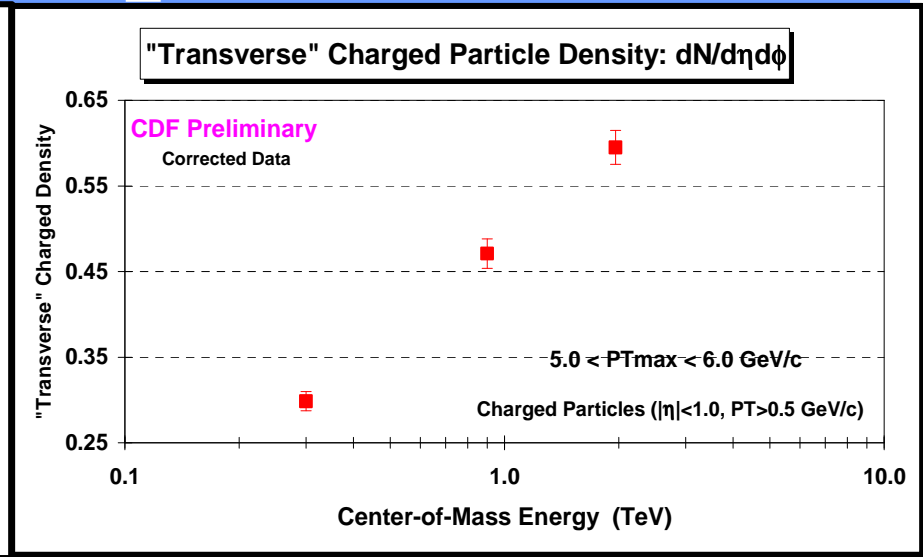
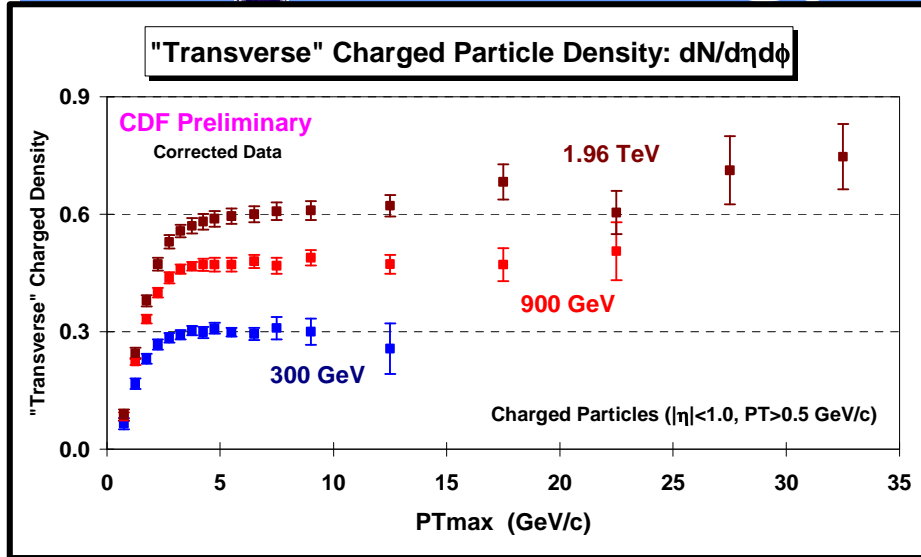
New CDF UE Data



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Energy Dependence

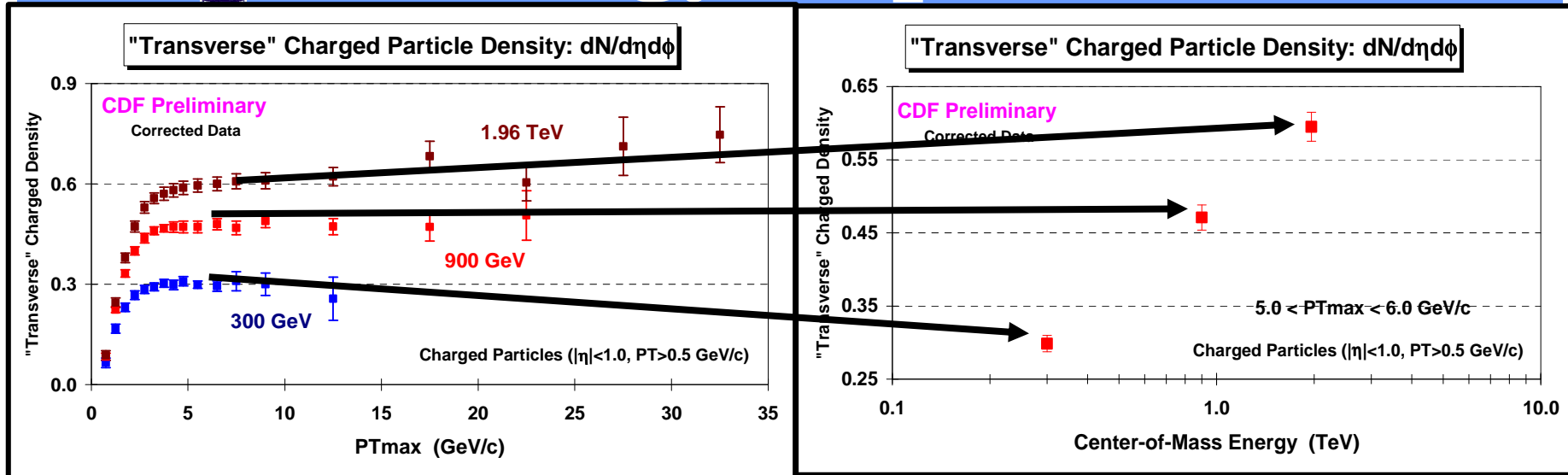
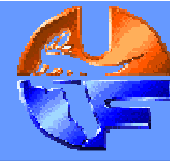


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

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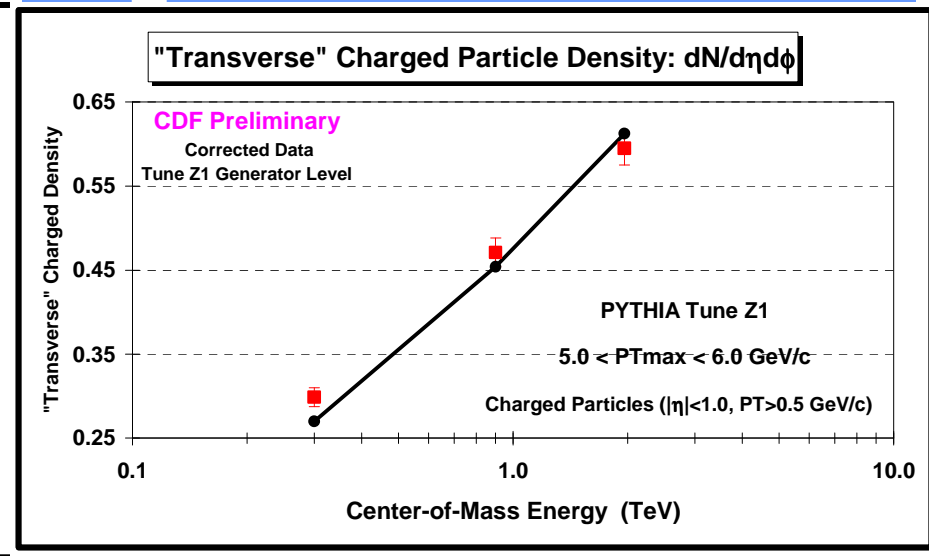
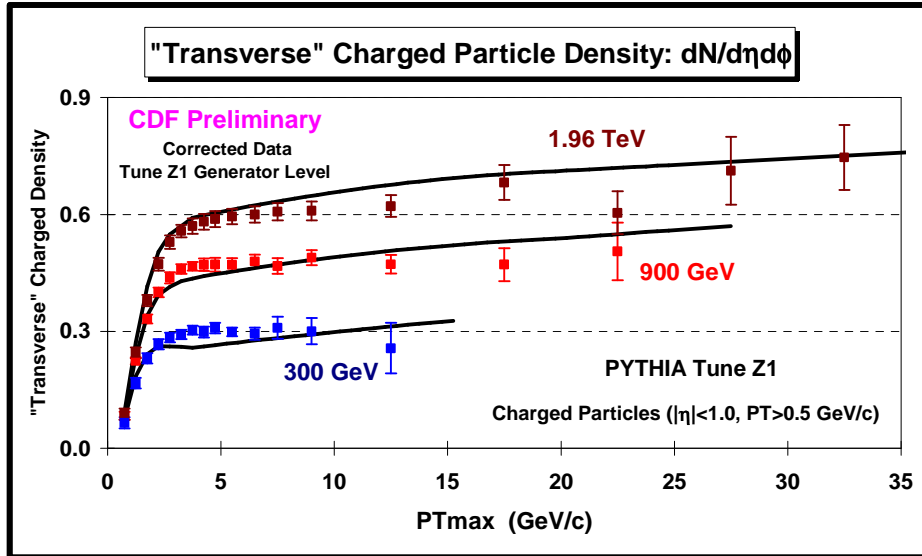


Energy Dependence



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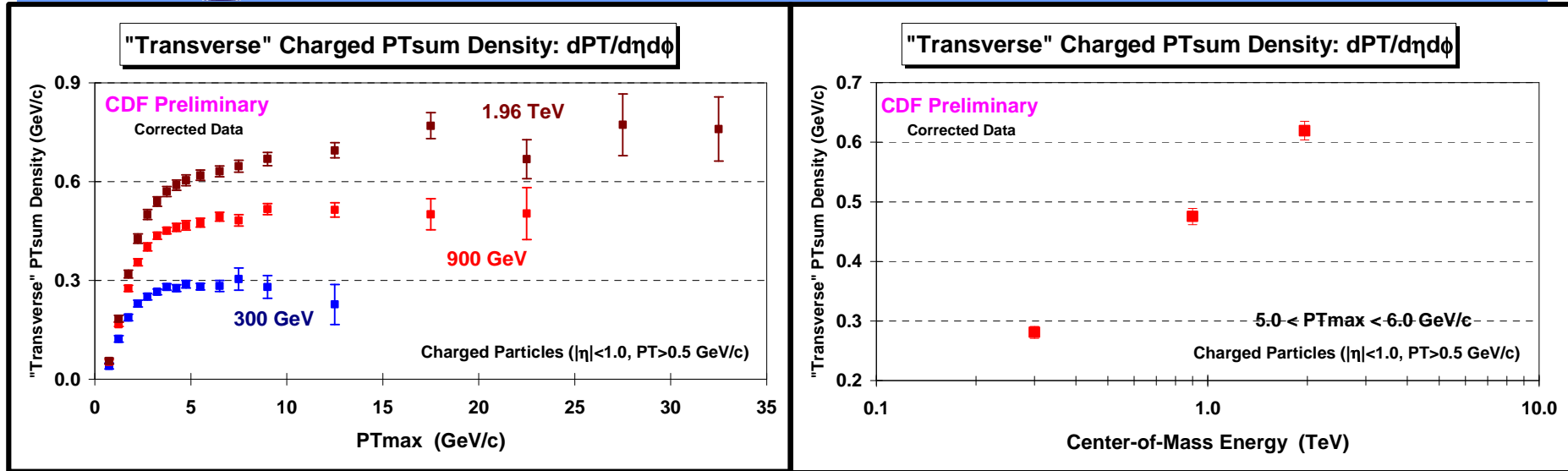


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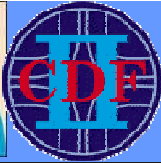


Energy Dependence

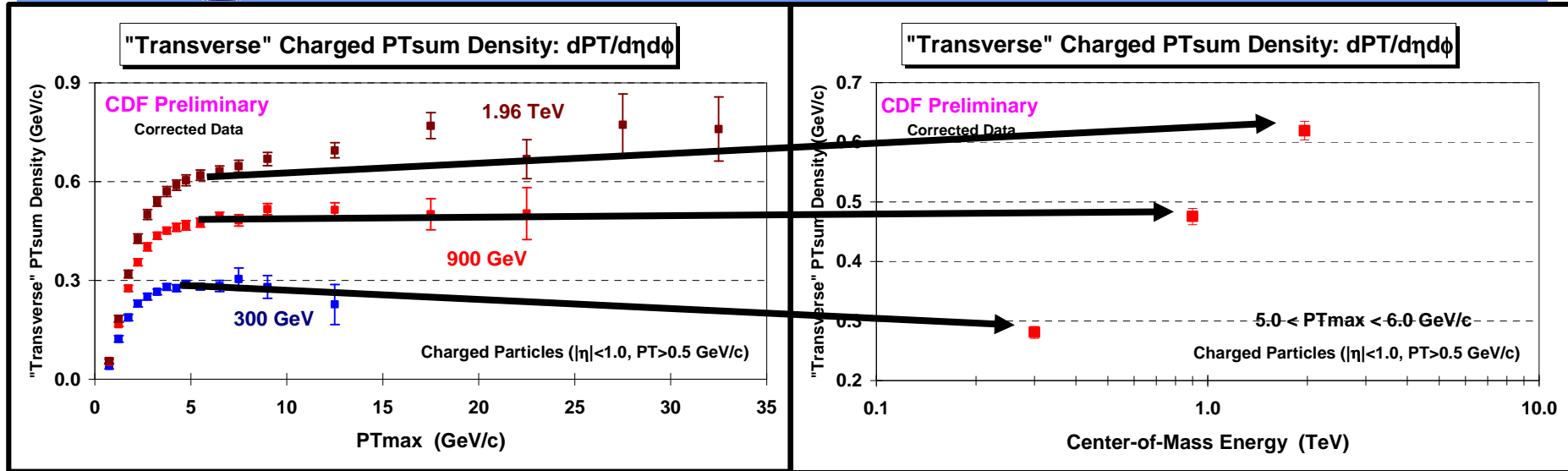


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$.**

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$ for $5.0 < PTmax < 6.0 \text{ GeV}/c$.**

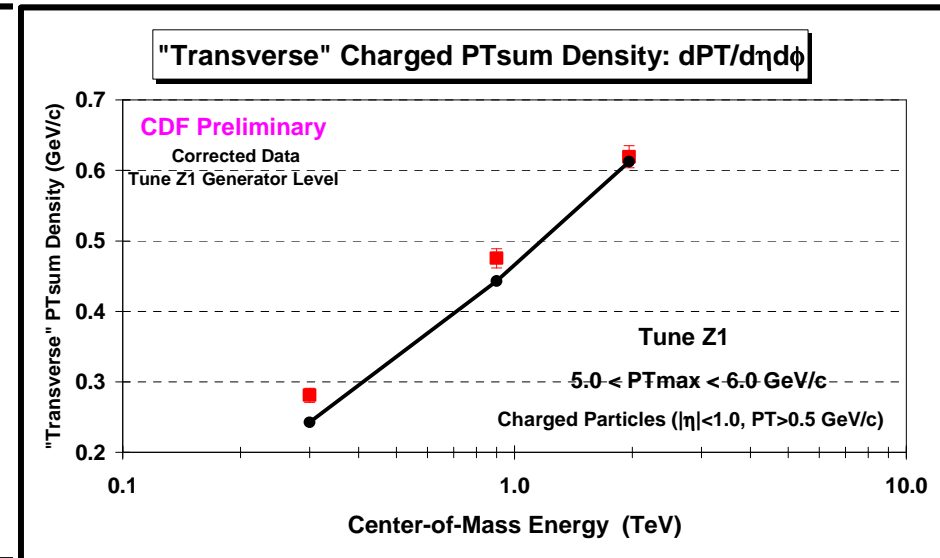
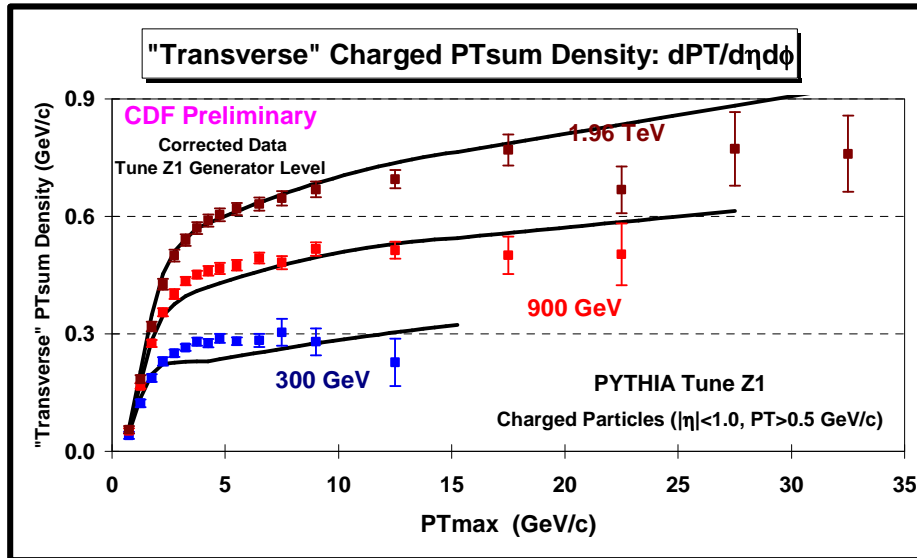


Energy Dependence



➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.**

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PT_{max} < 6.0$ GeV/c.**

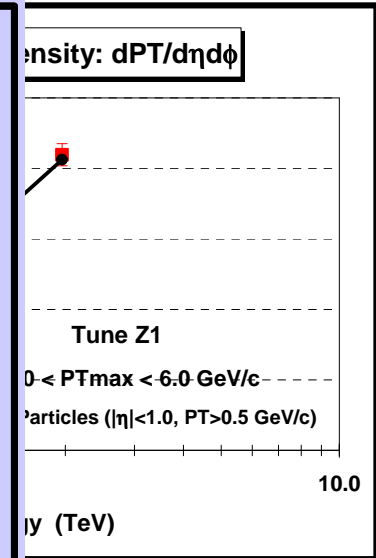
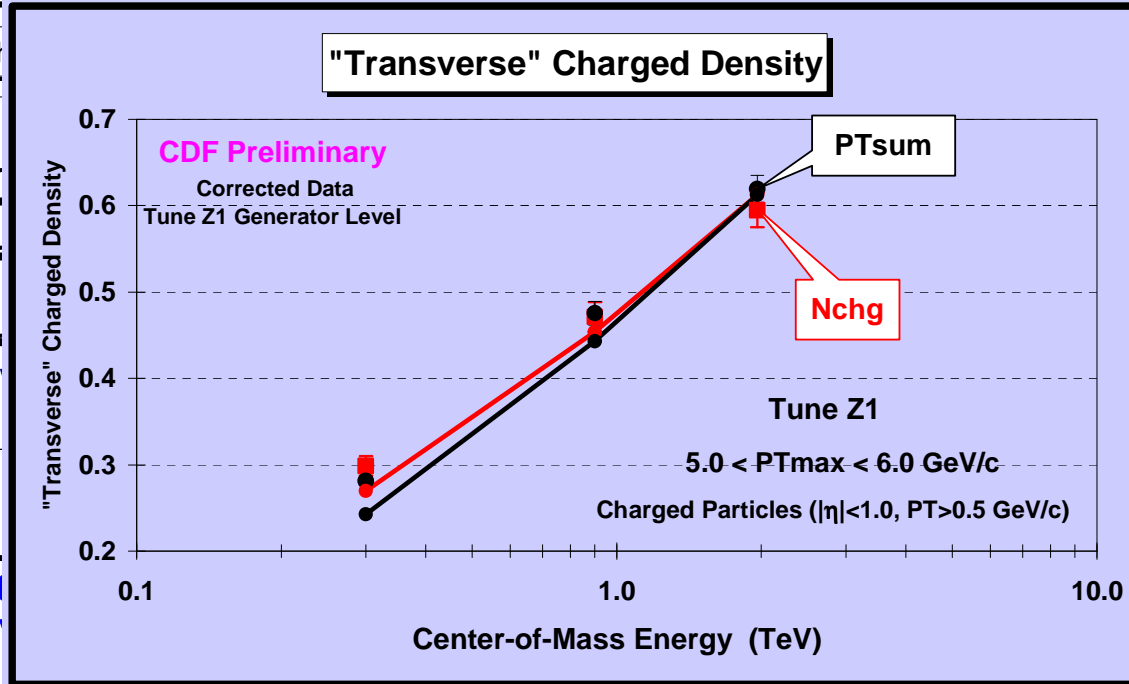
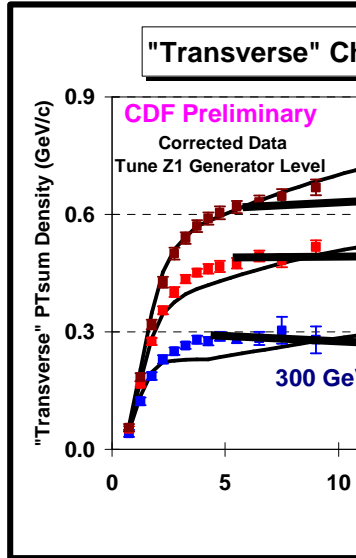
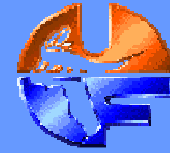


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged PTsum density, $dPT/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PTmax < 6.0$ GeV/c.



Energy Dependence

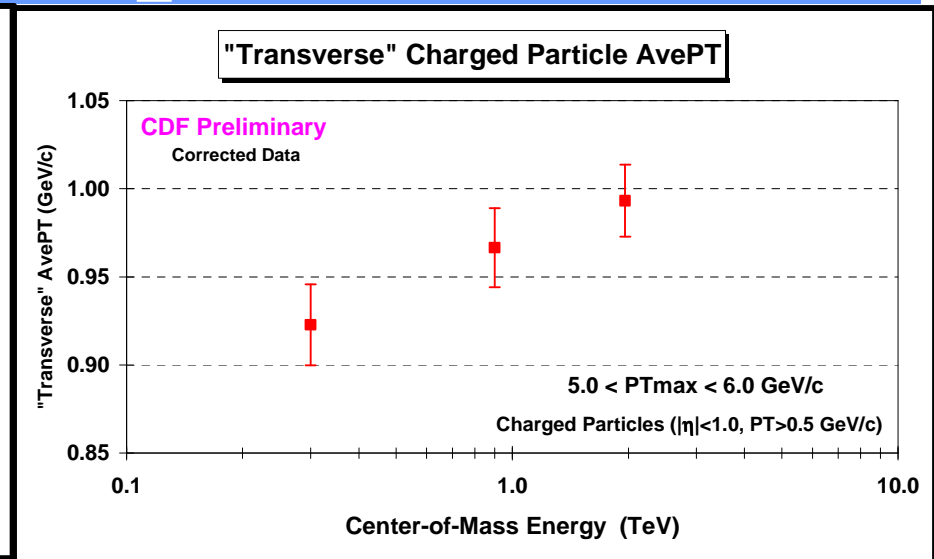
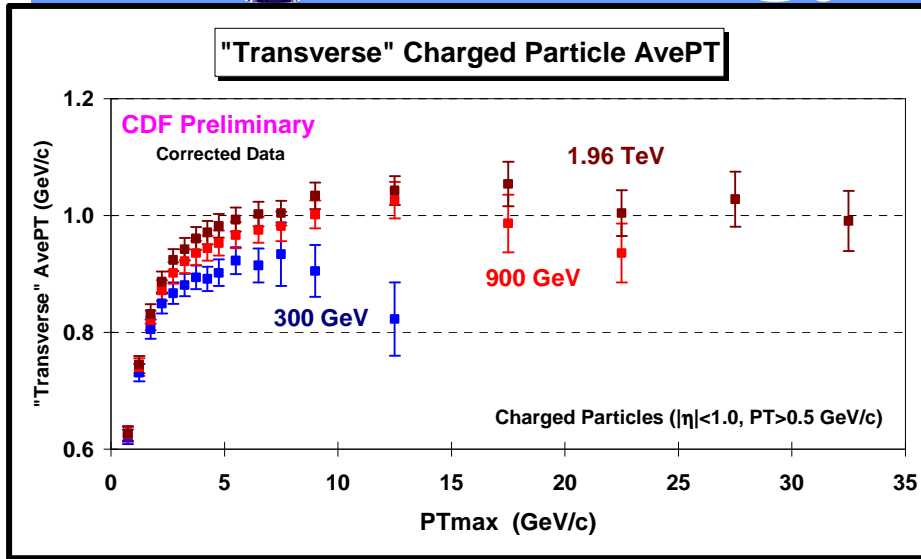


→ **New Corrected Data** at **300 GeV**, and **1.96 TeV** for **"Transverse" Charged PTsum Density** defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PT_{max} < 6.0$ GeV/c.



Energy Dependence

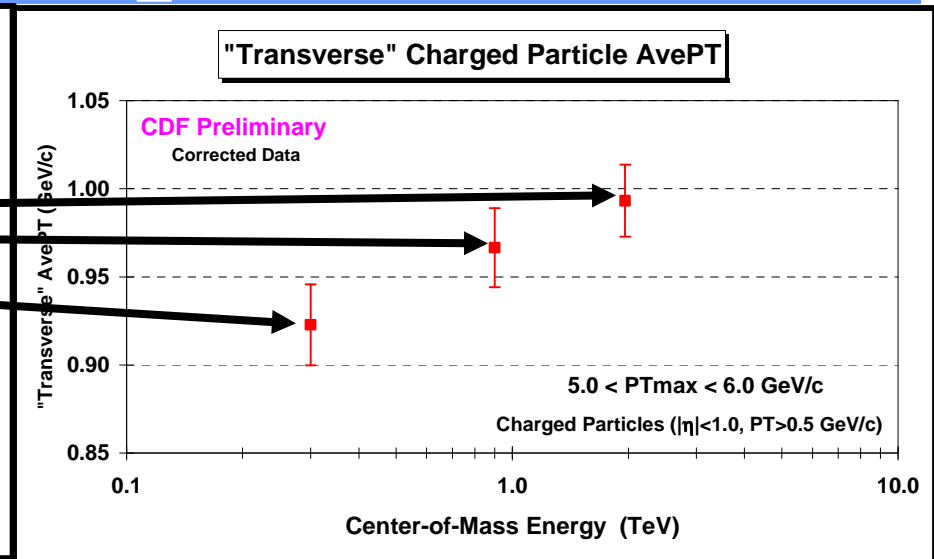
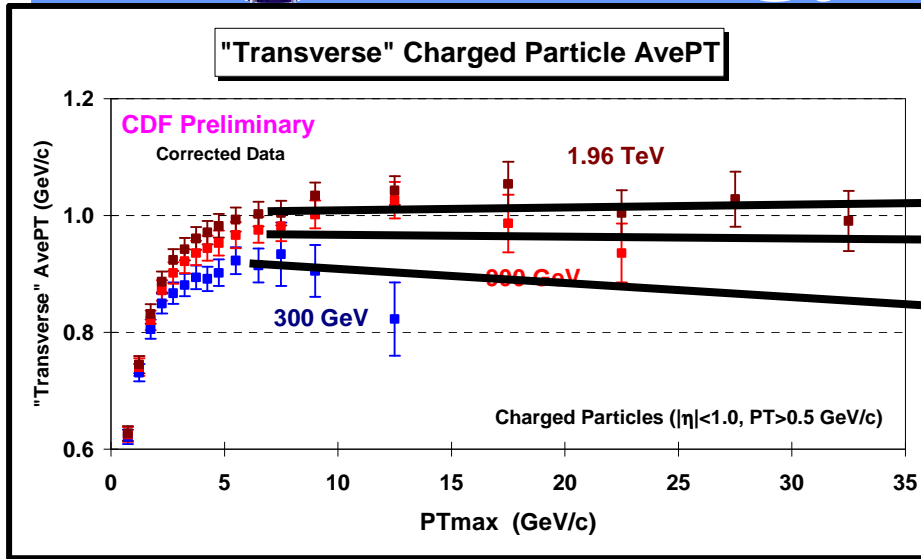
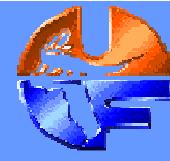


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PT_{max} < 6.0$ GeV/c.



Energy Dependence

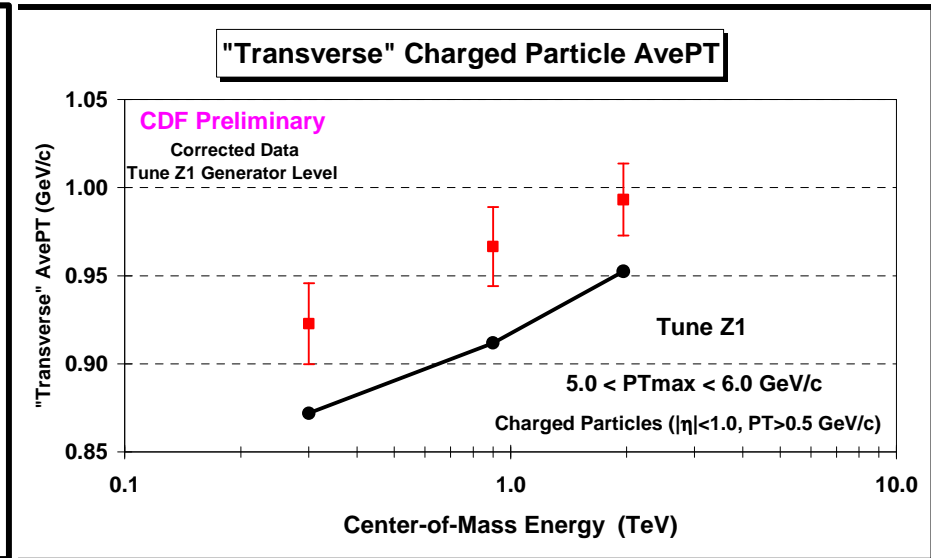
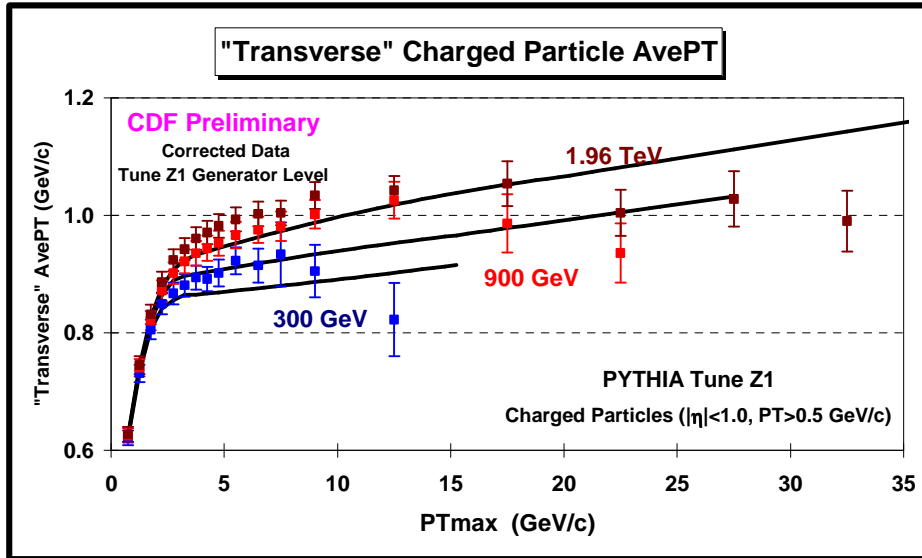


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.**

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PT_{max} < 6.0$ GeV/c.**



Energy Dependence

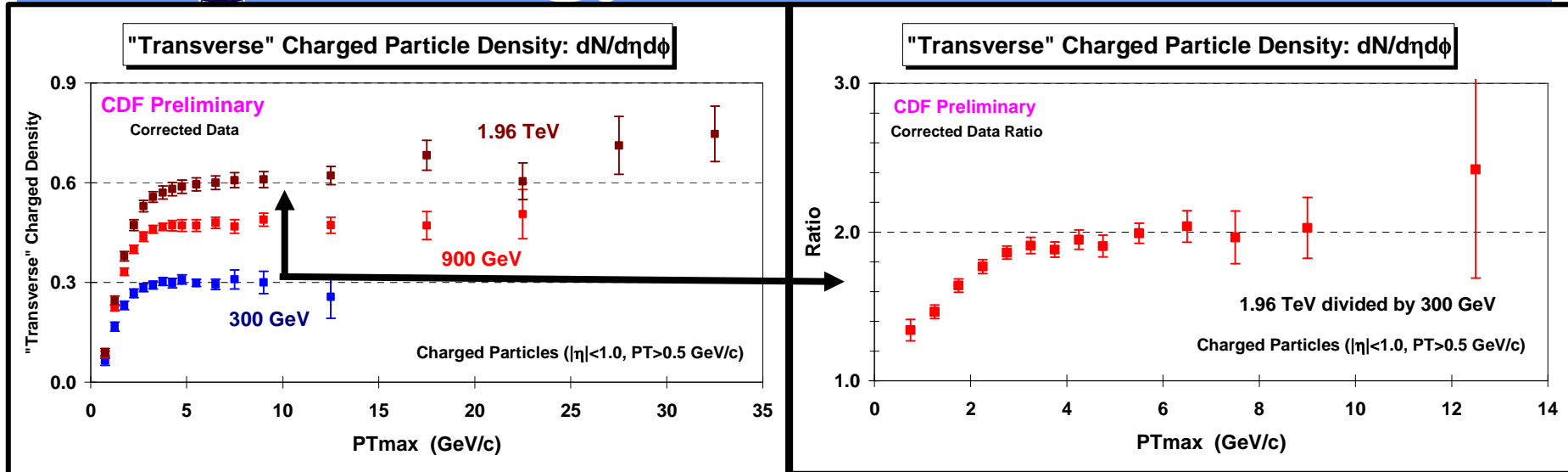
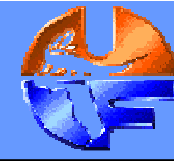


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle average p_T as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$ for $5.0 < PT_{max} < 6.0$ GeV/c.



Energy Ratio: 1960/300

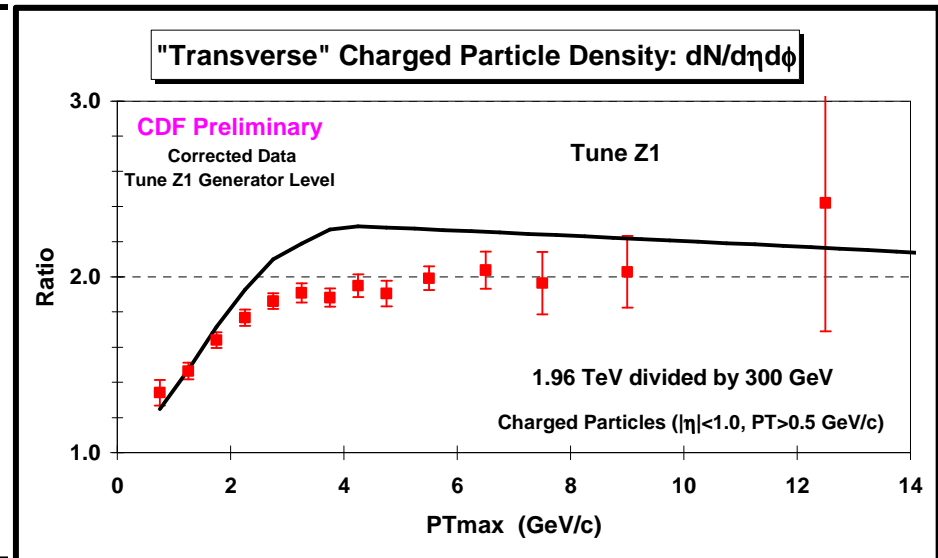
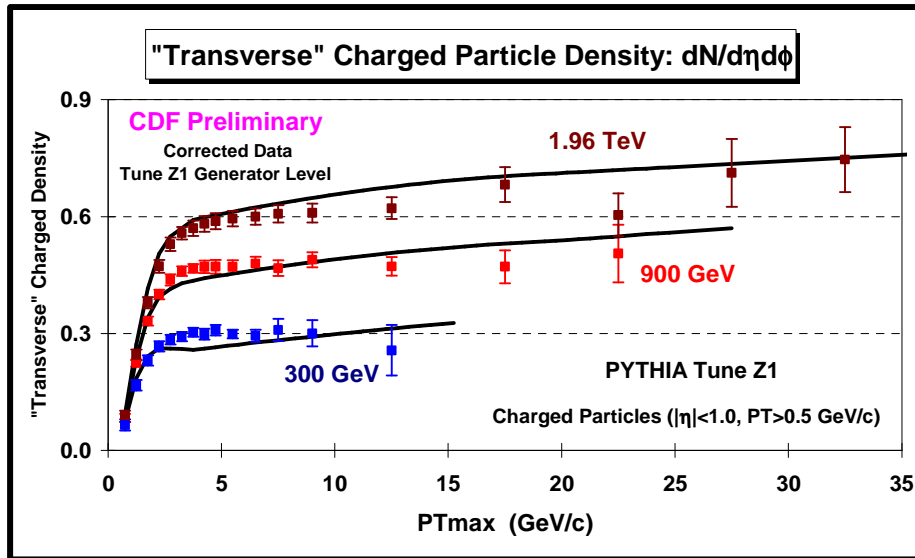
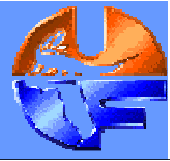


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 300 GeV and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$. Shows 1.96 TeV divided by 300 GeV.



Energy Ratio: 1960/300

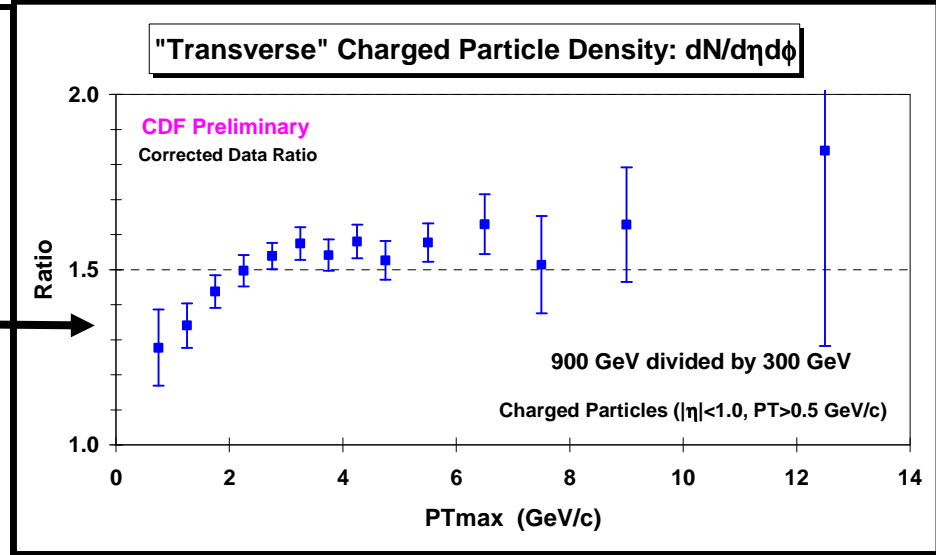
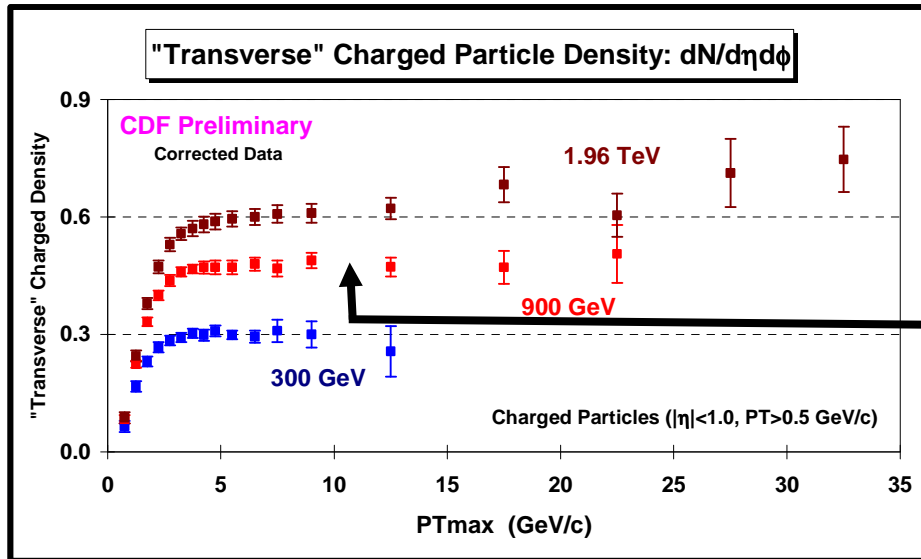


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 300 GeV and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$. Shows 1.96 TeV divided by 300 GeV.



Energy Ratio: 900/300

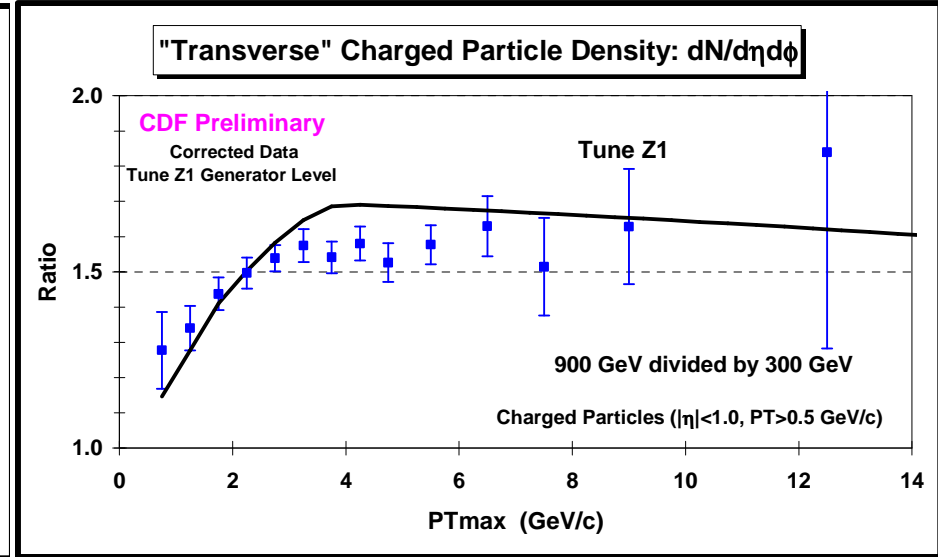
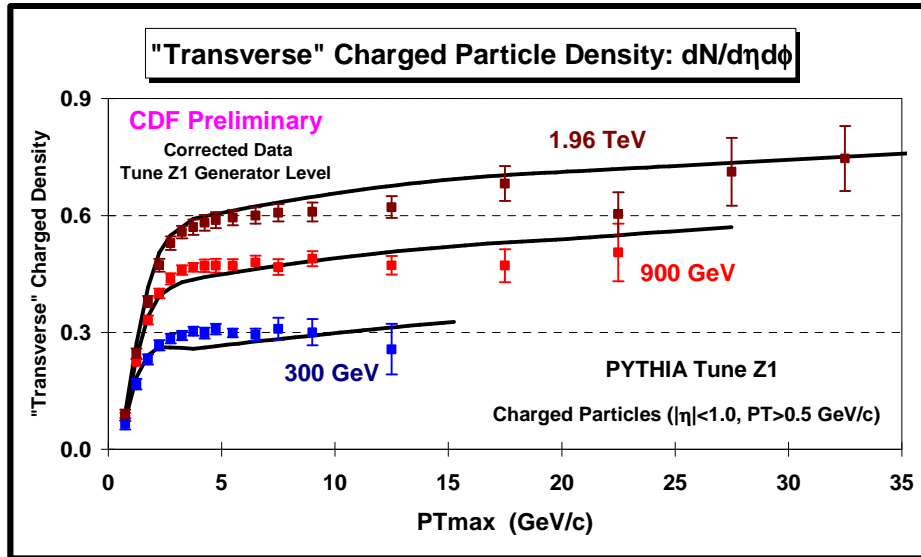


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (P_{Tmax}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 300 GeV and 900 GeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (P_{Tmax}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$. Shows 900 GeV divided by 300 GeV.



Energy Ratio: 900/300

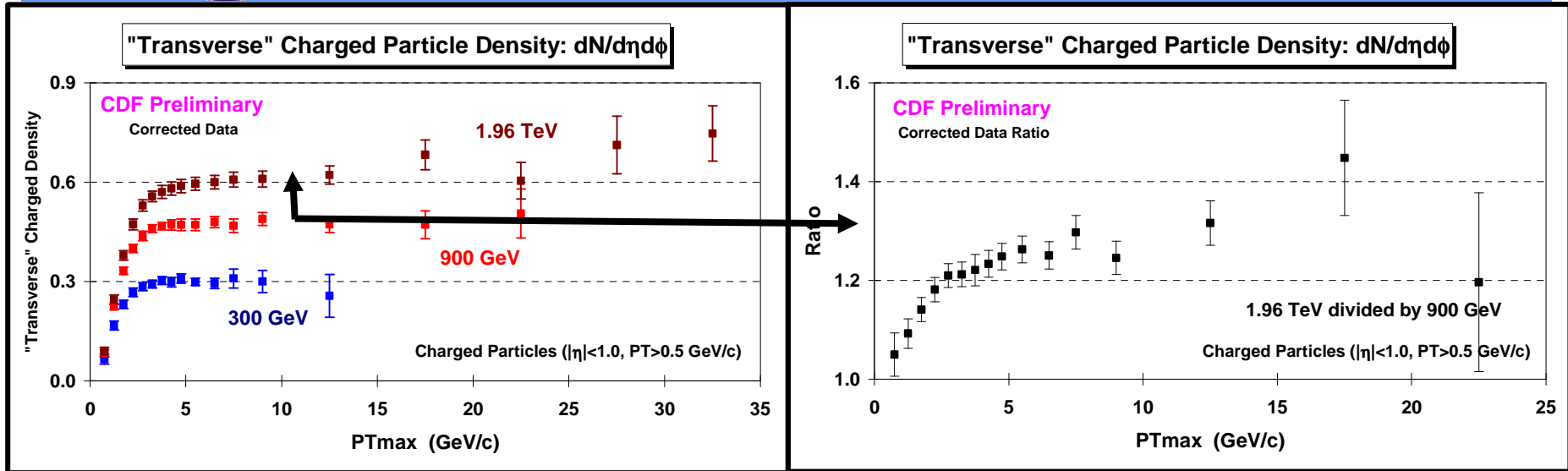


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 300 GeV and 900 GeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$. Shows 900 GeV divided by 300 GeV.



Energy Ratio: 1960/900

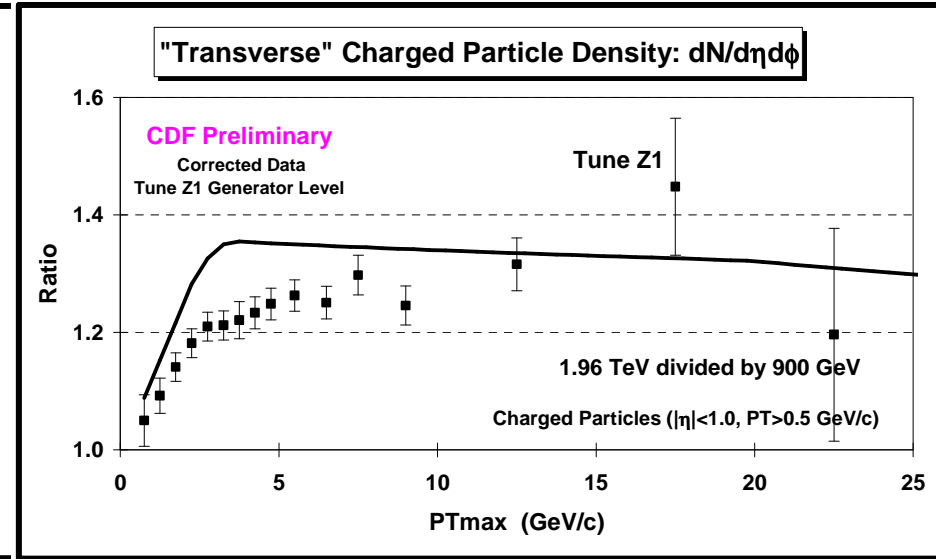
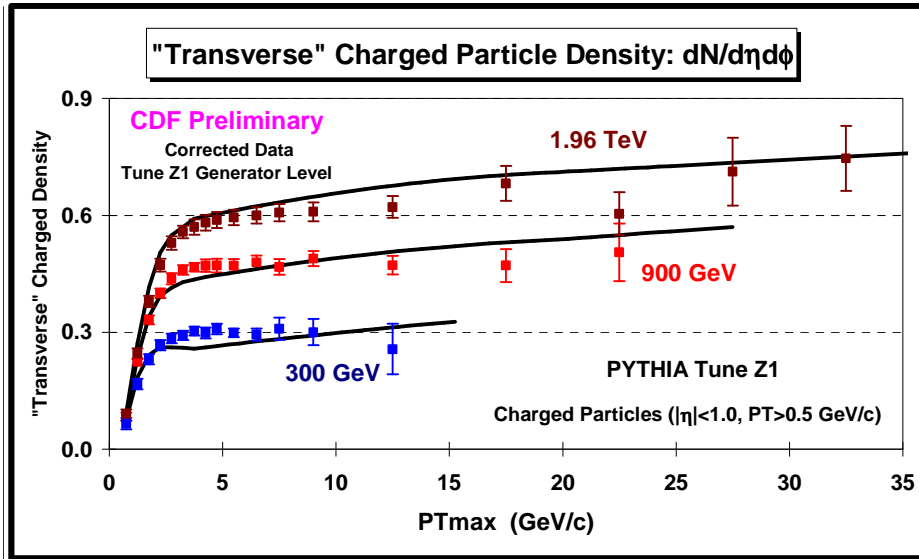
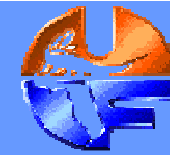


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 900 GeV and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$. Shows 1.96 TeV divided by 900 GeV.



Energy Ratio: 1960/900

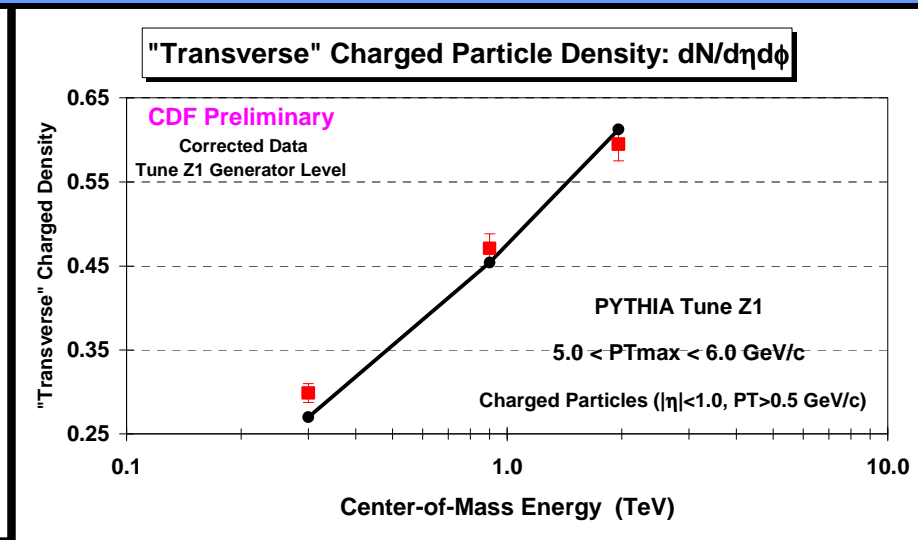
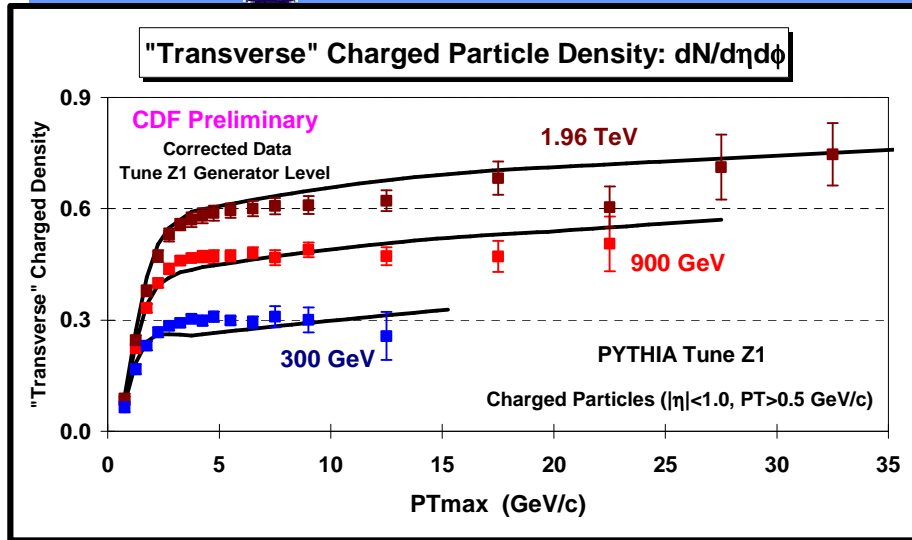
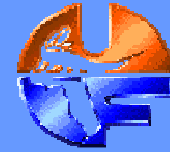


➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$.

➔ **Ratio of the CDF data at 900 GeV and 1.96 TeV** on the “transverse” charged particle density, $dN/d\eta d\phi$, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 1.0$. Shows 1.96 TeV divided by 900 GeV.

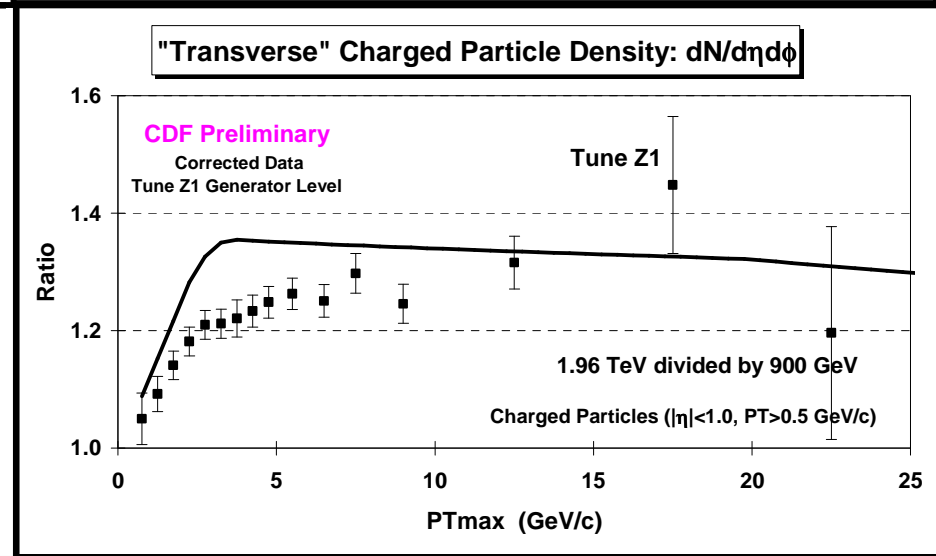
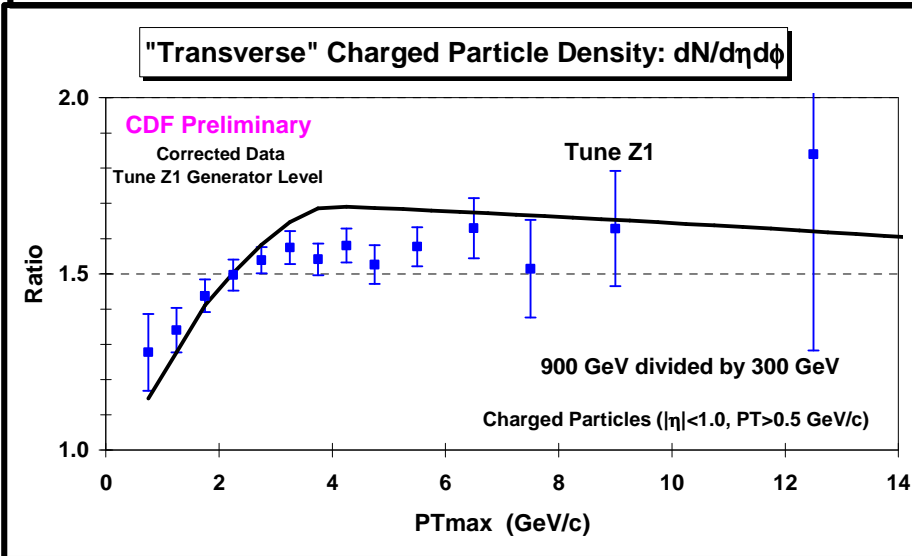
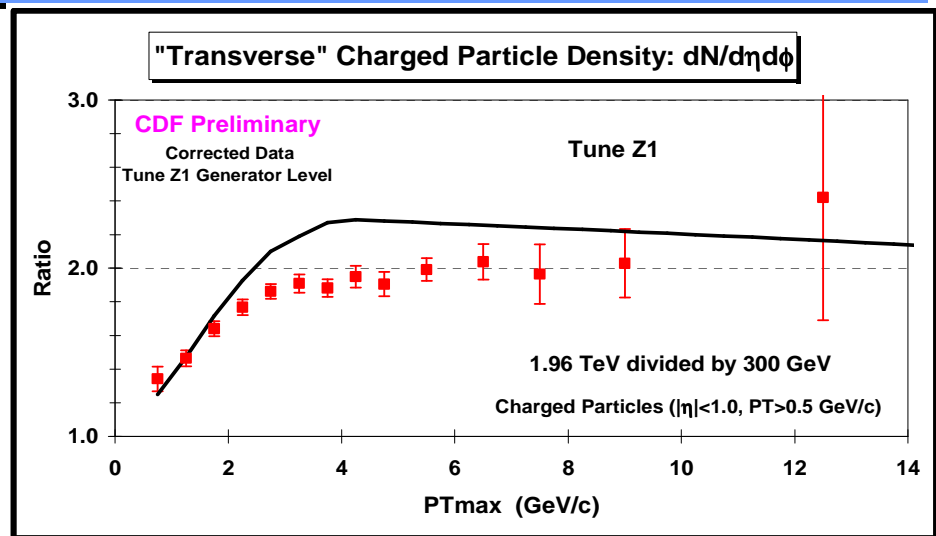
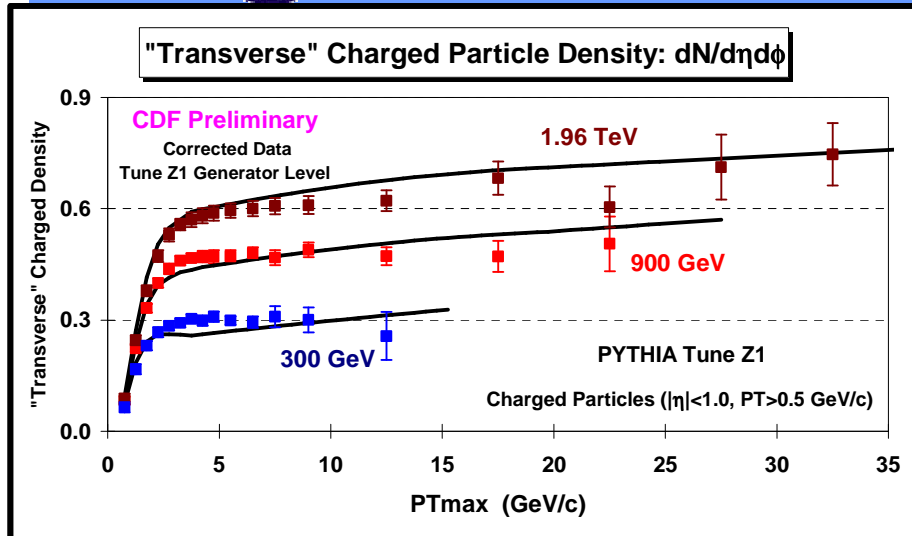


PYTHIA 6.4 Tune Z1





PYTHIA 6.4 Tune Z1





PYTHIA 6.4 Tune Z1



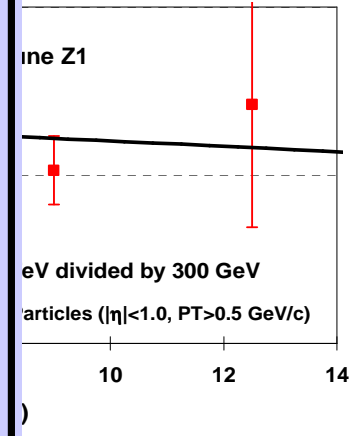
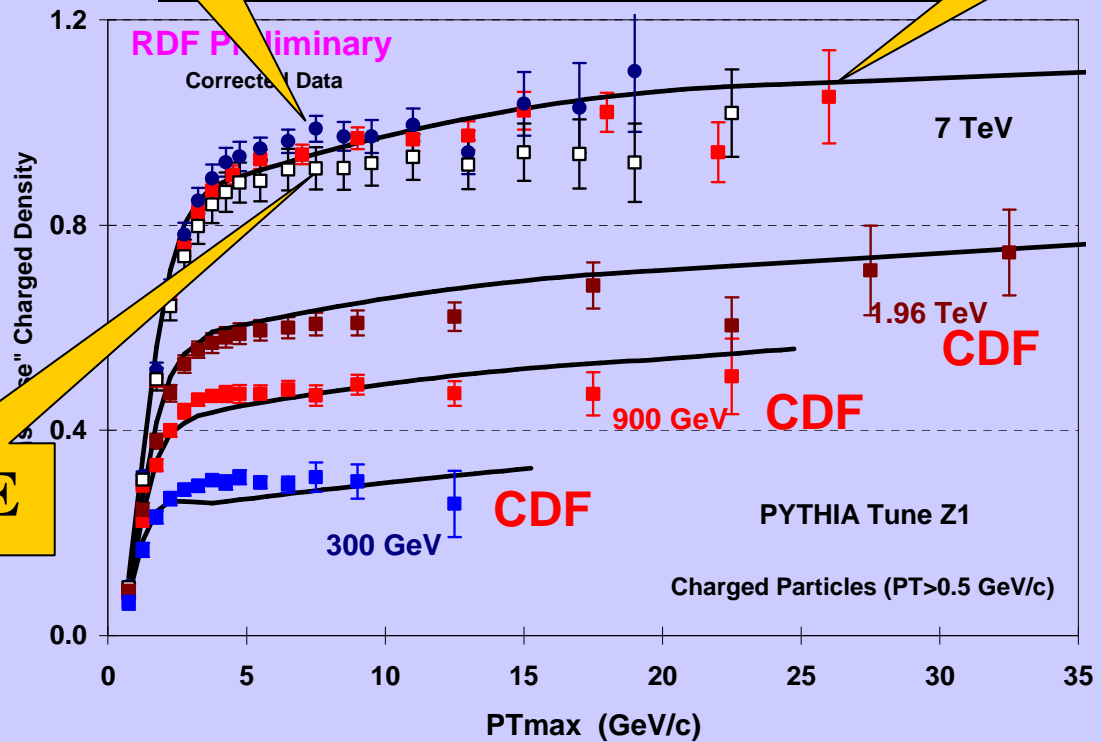
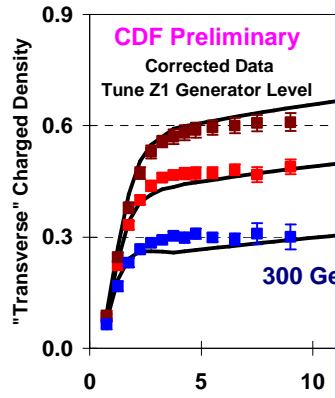
ATLAS

CMS

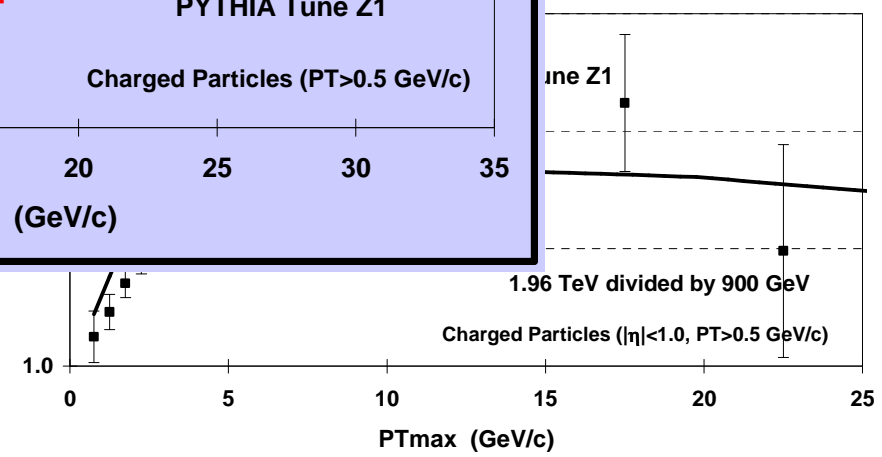
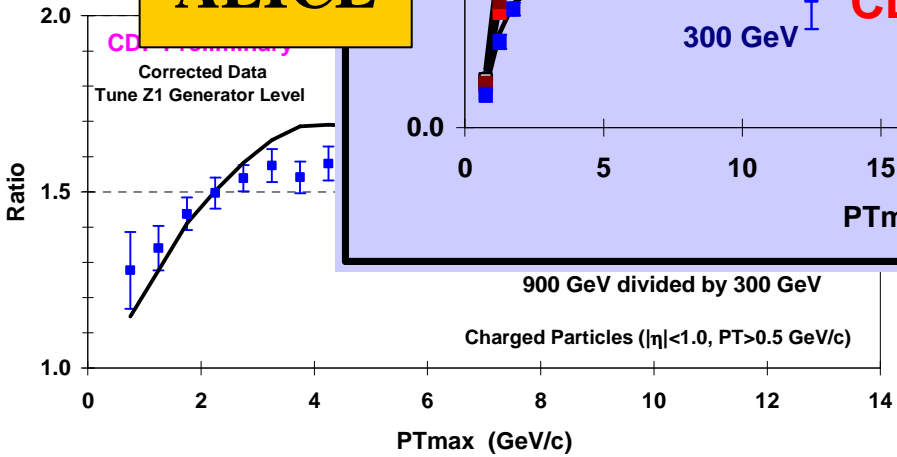
"Transverse" Charged Particle Density

"Transverse" Charged Particle Density: $dN/d\eta d\phi$

$dN/d\eta d\phi$

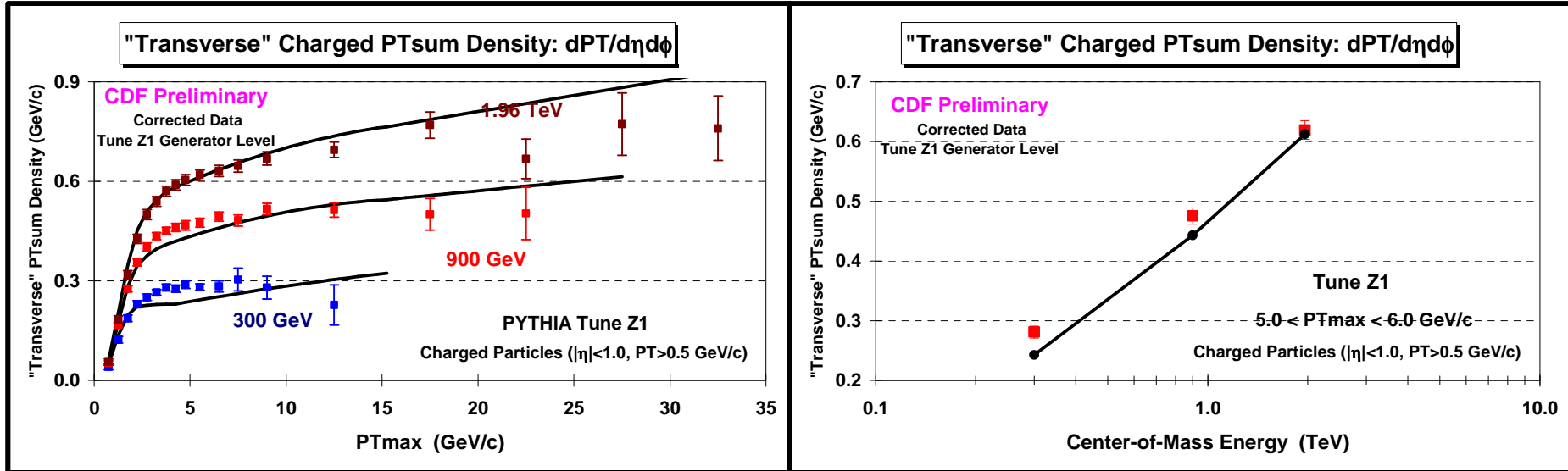


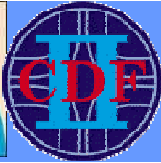
ALICE



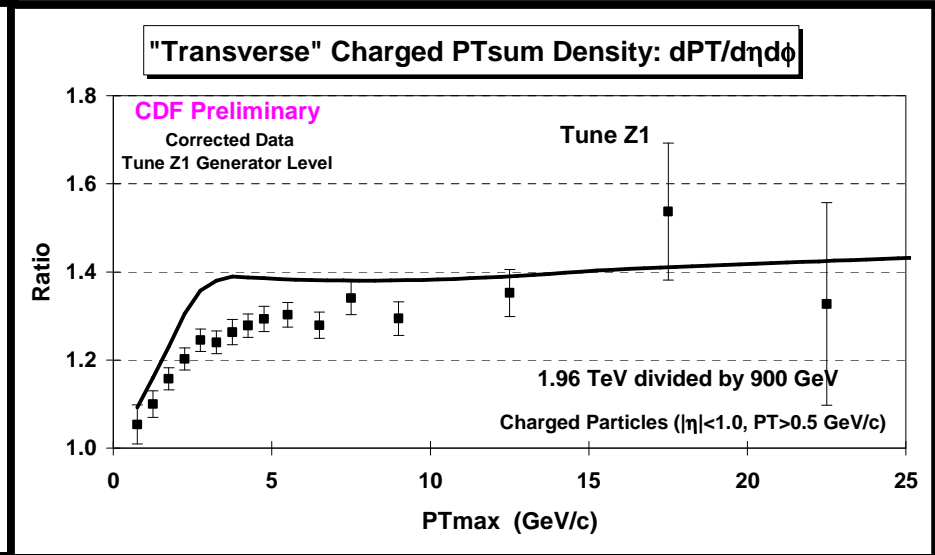
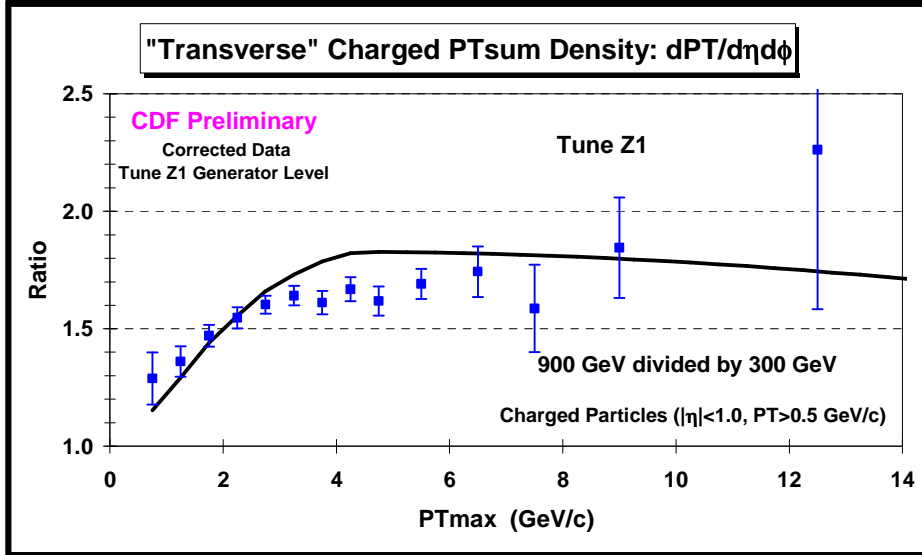
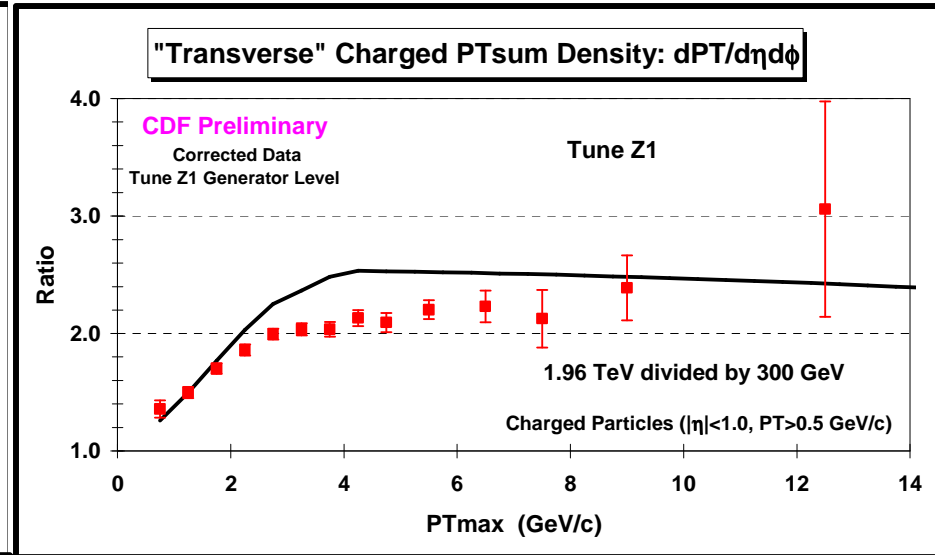
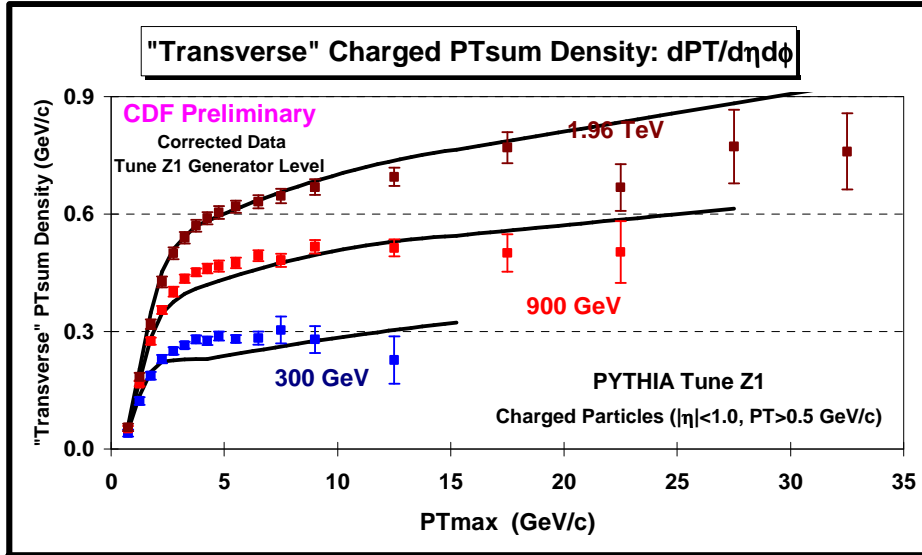
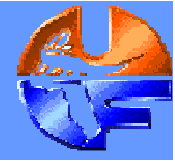


PYTHIA 6.4 Tune Z1



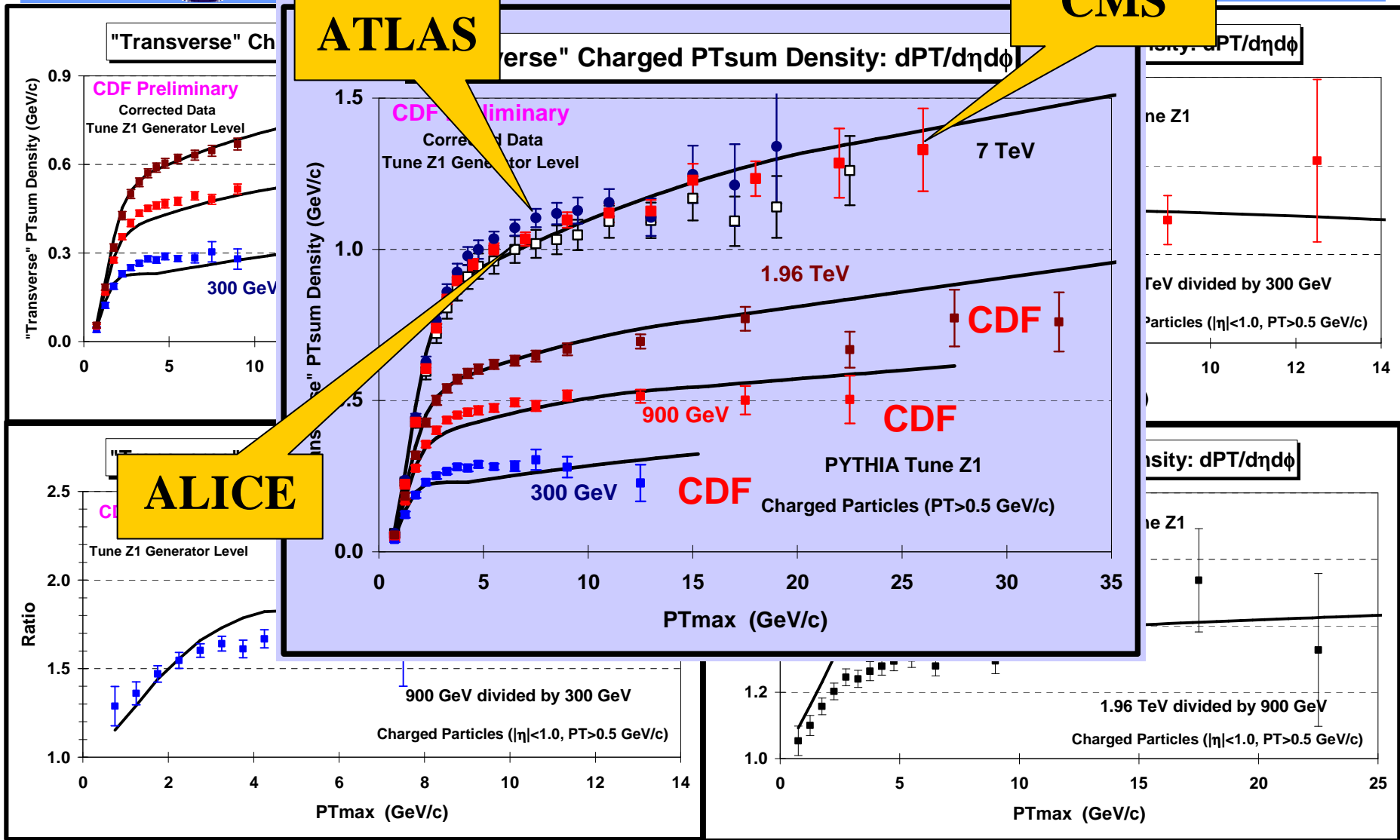
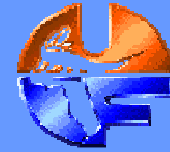


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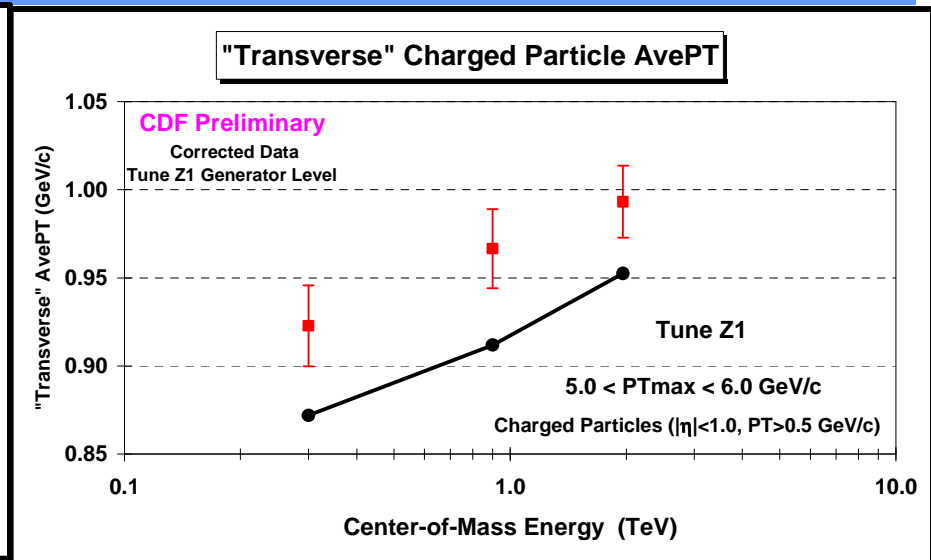
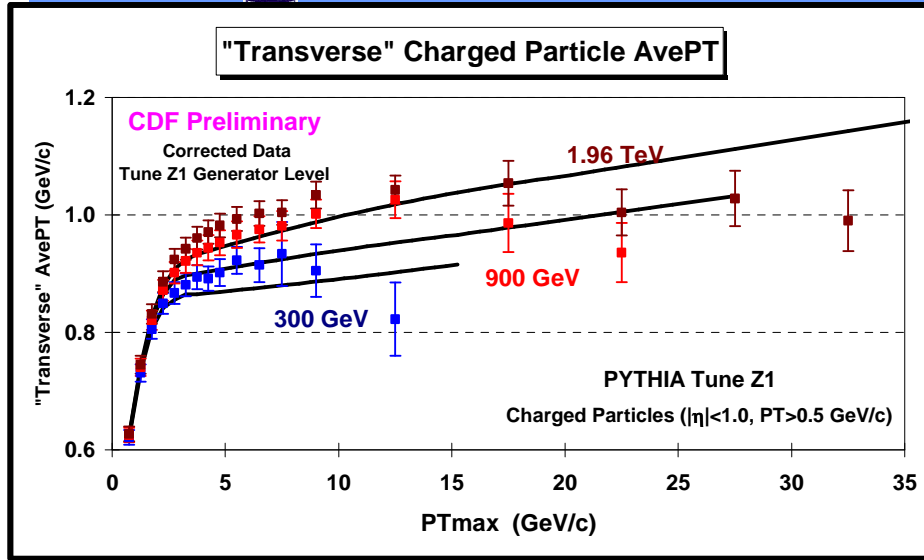
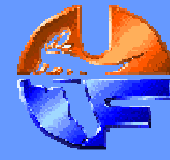


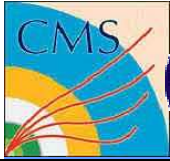
PYTHIA 6.4 Tune Z1



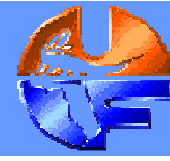


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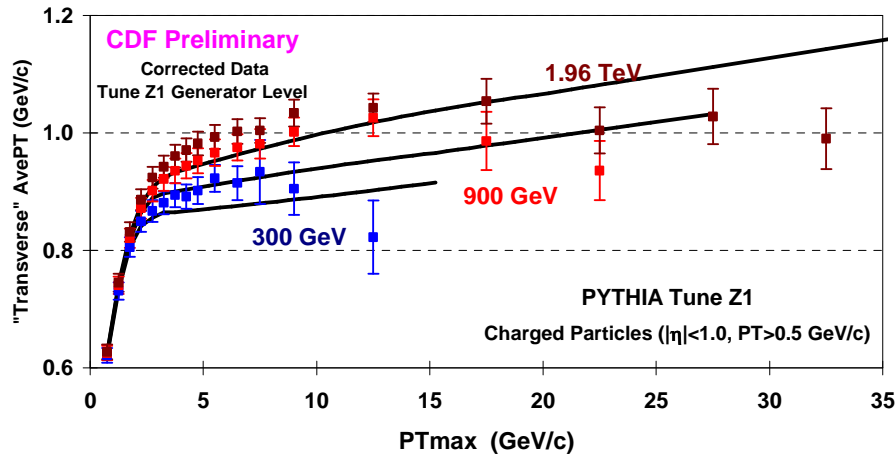




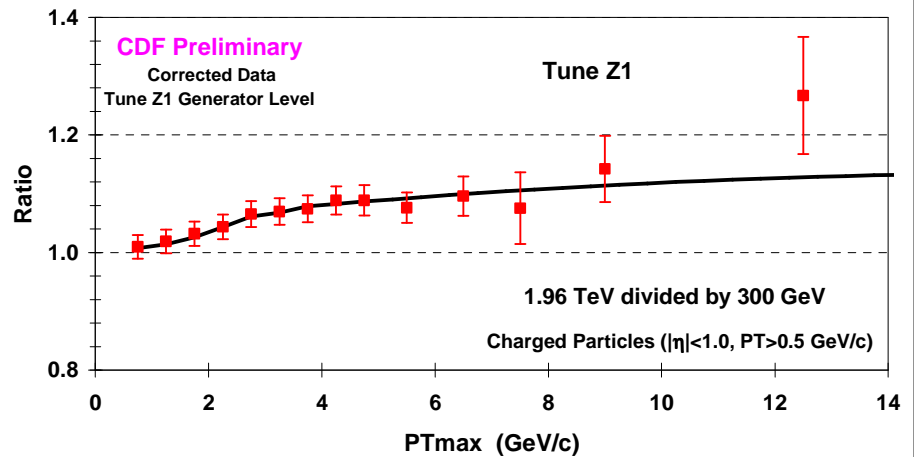
PYTHIA 6.4 Tune Z1



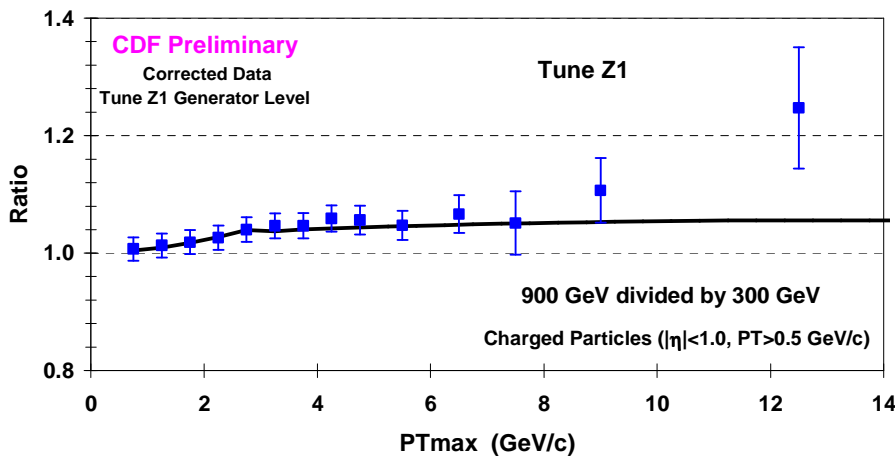
"Transverse" Charged Particle AvePT



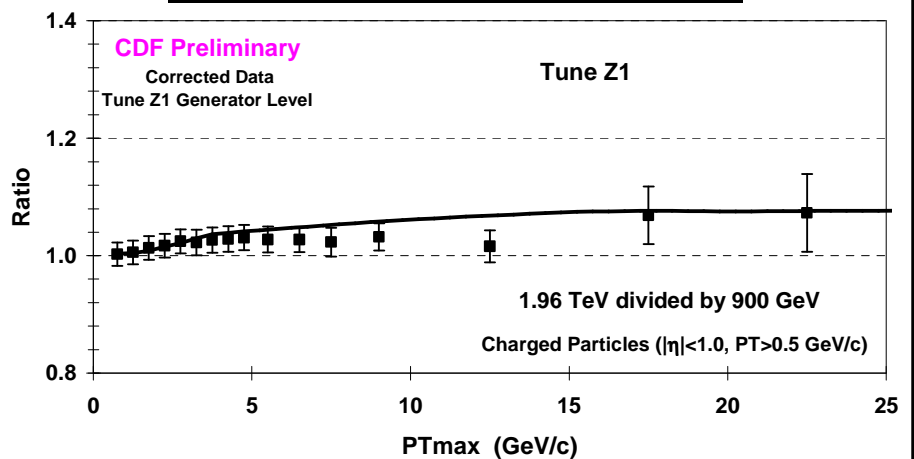
"Transverse" Charged Particle AvePT



"Transverse" Charged Particle Average PT

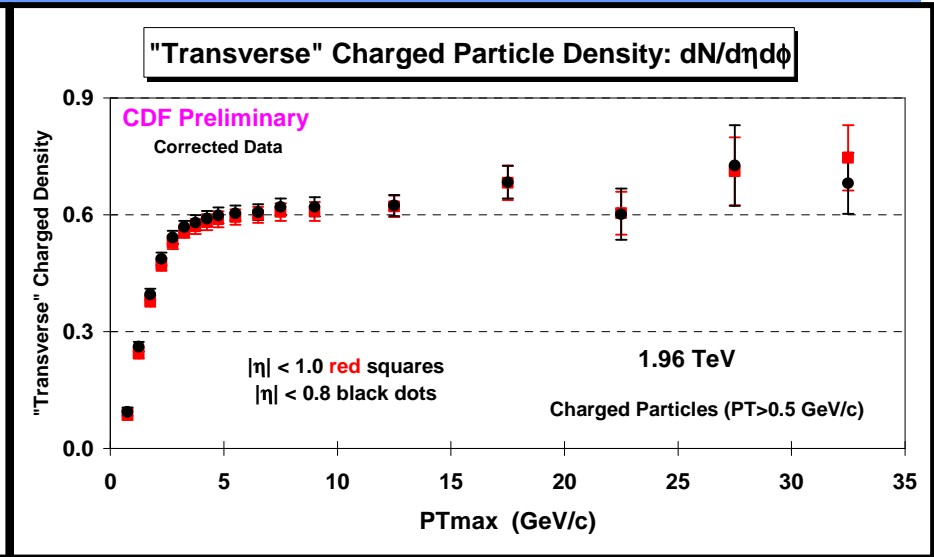
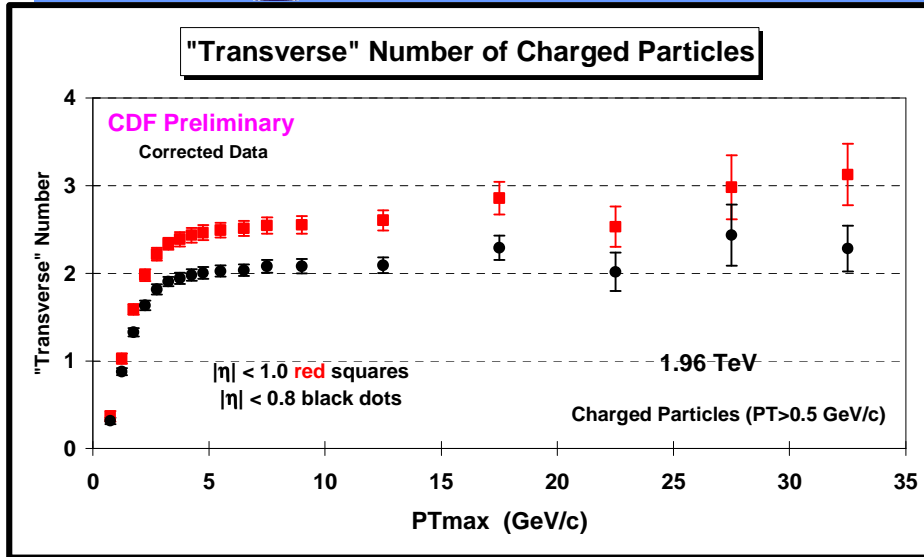


"Transverse" Charged Particle Average PT





$|\eta| < 0.8$ versus $|\eta| < 1.0$

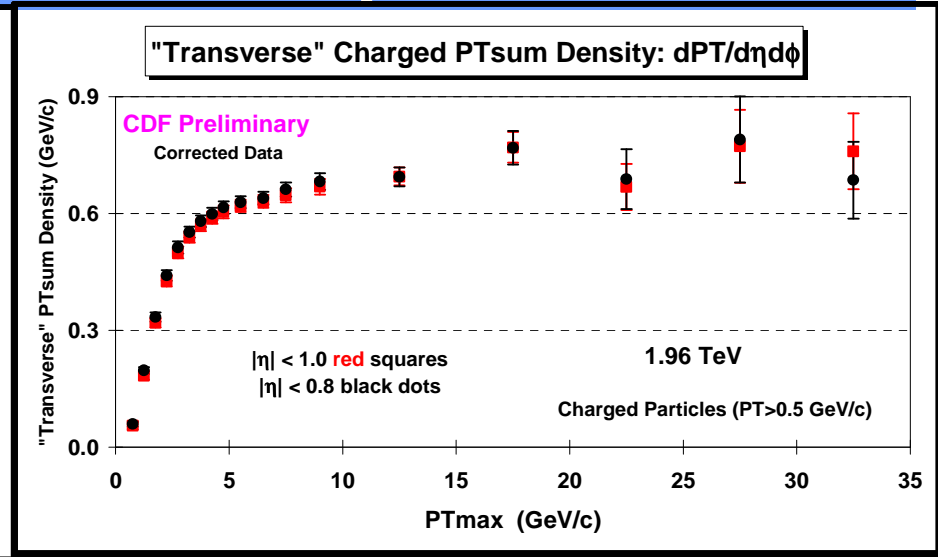
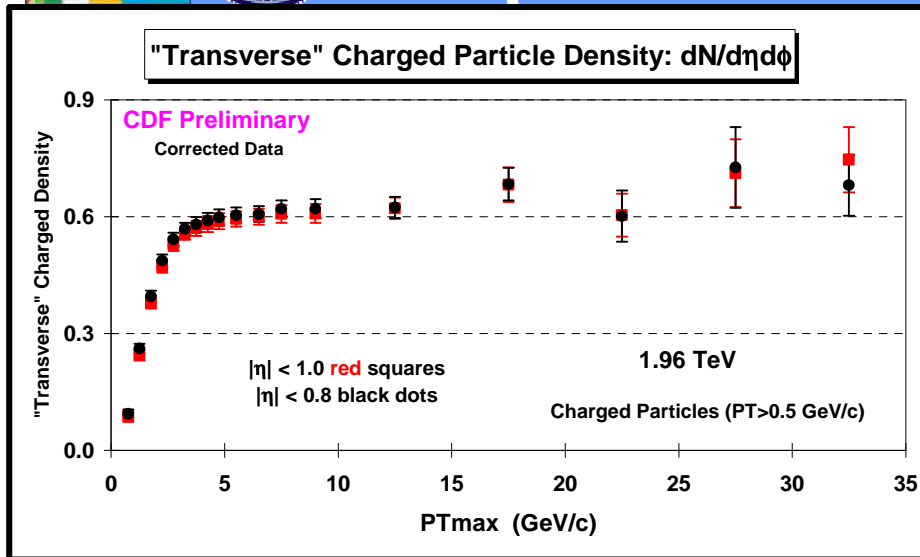
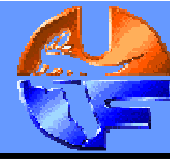


➔ **Corrected CDF data at 1.96 TeV** on the average number of charged particle in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and $|\eta| < 1.0$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

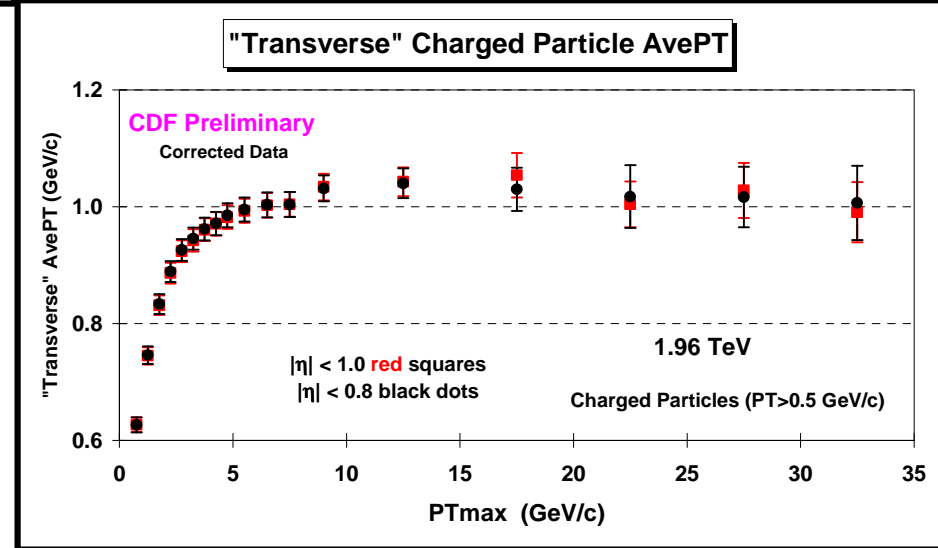
➔ **Corrected CDF data at 1.96 TeV** on the average charged particle density, $dN/d\eta d\phi$, in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and $|\eta| < 1.0$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

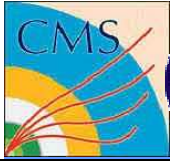


$|\eta| < 0.8$ versus $|\eta| < 1.0$

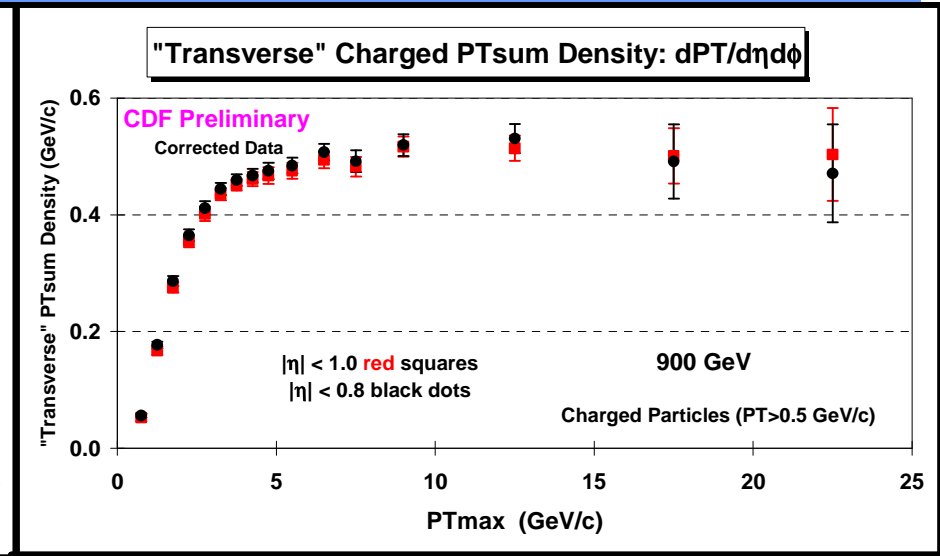
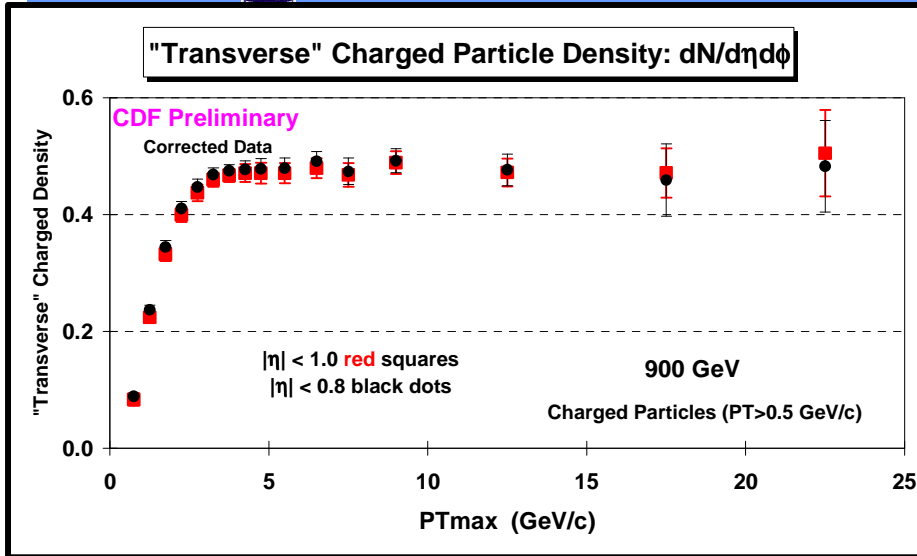
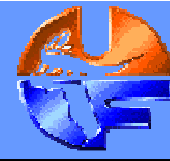


➔ **Corrected CDF data at 1.96 TeV** on the charged particle density, the charged PTsum density, and the average p_T in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and $|\eta| < 1.0$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

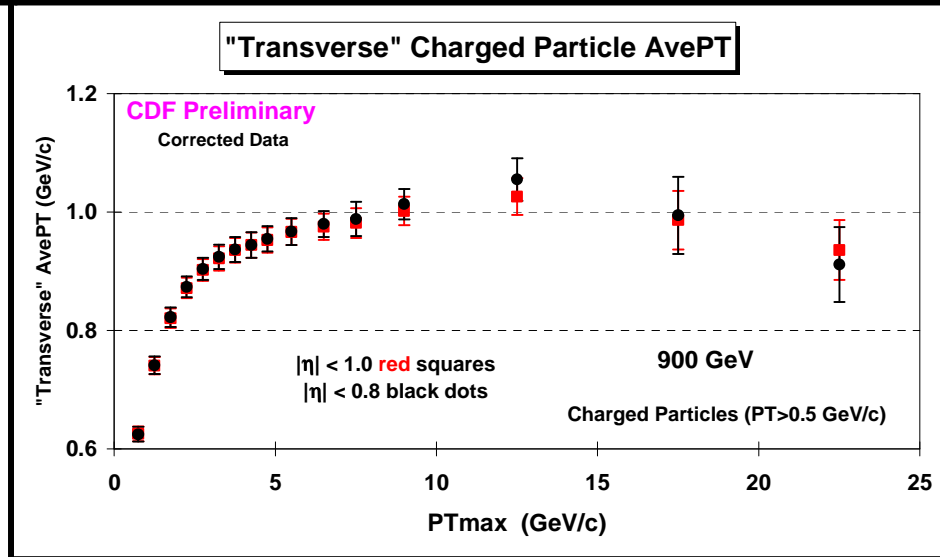




$|\eta| < 0.8$ versus $|\eta| < 1.0$

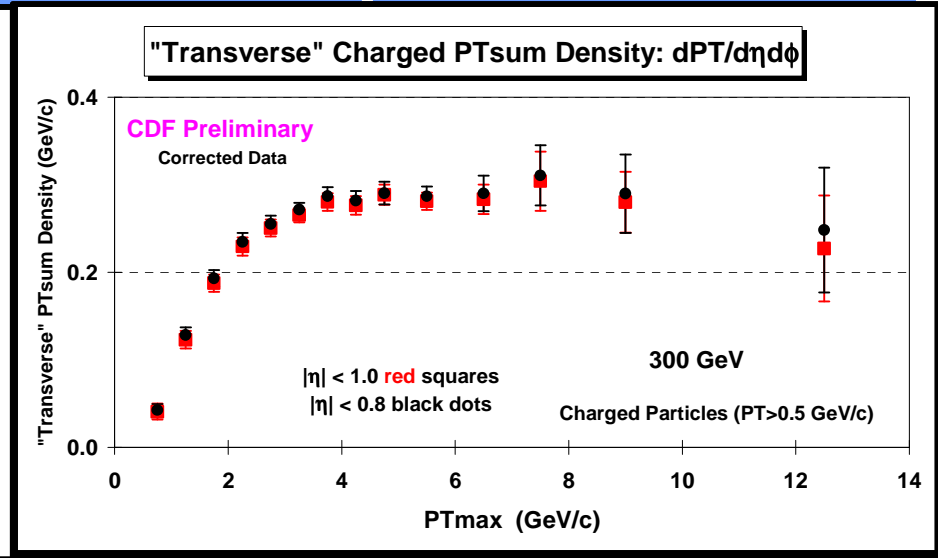
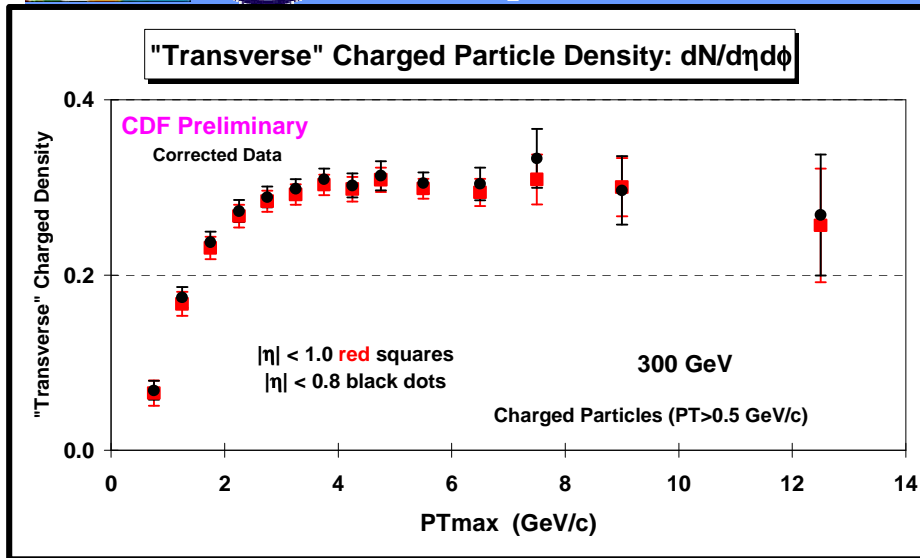


➔ **Corrected CDF data at 900 GeV** on the charged particle density, the charged PTsum density, and the average p_T in the “transverse” region as defined by the leading charged particle (PT_{max}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and $|\eta| < 1.0$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

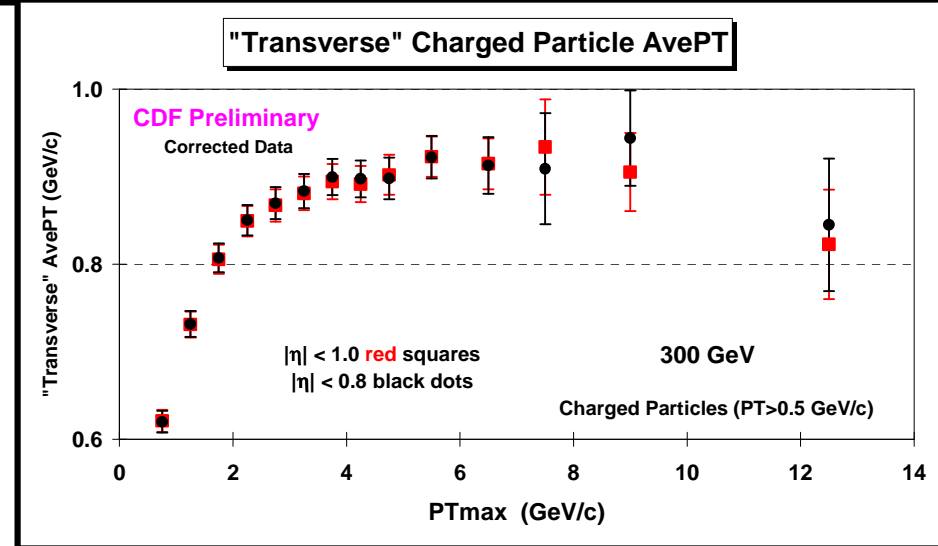




$|\eta| < 0.8$ versus $|\eta| < 1.0$

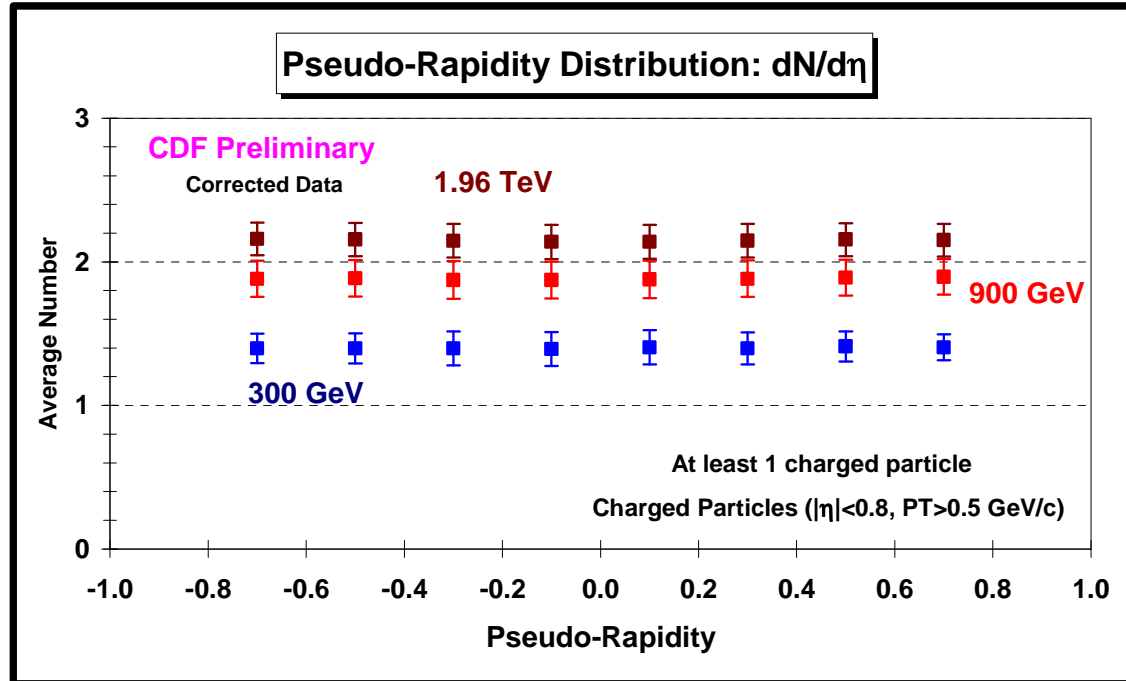


➔ **Corrected CDF data at 300 GeV** on the charged particle density, the charged PTsum density, and the average p_T in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and $|\eta| < 1.0$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.





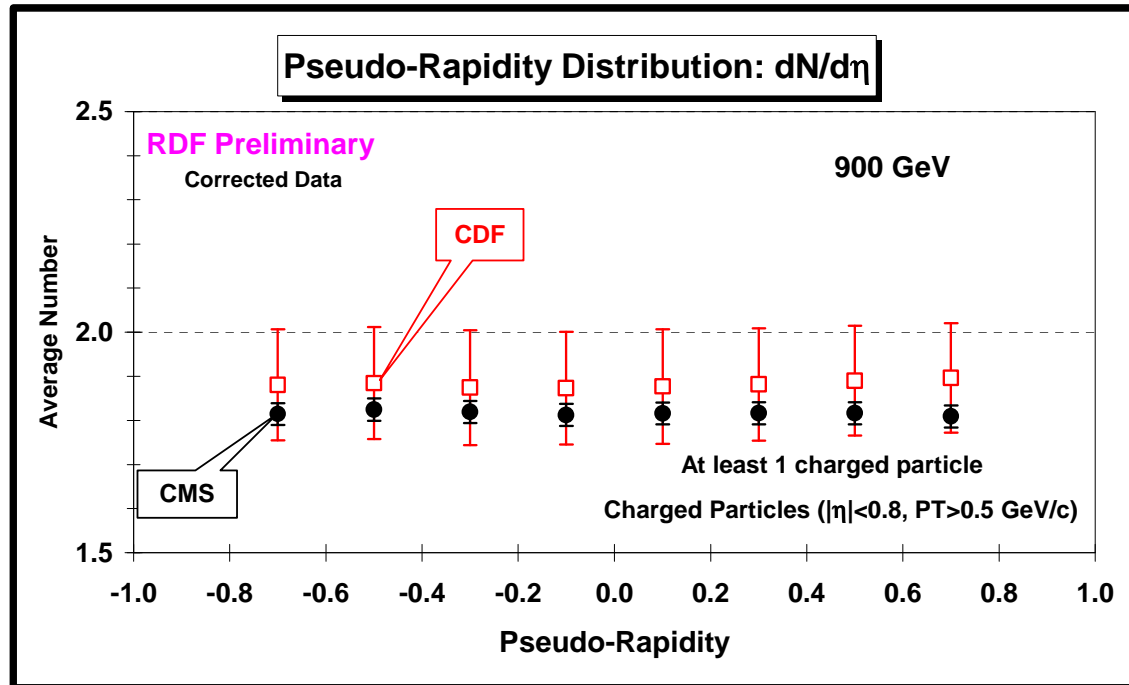
New CDF MB Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 0.5$ GeV/c. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 0.5$ GeV/c. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.**



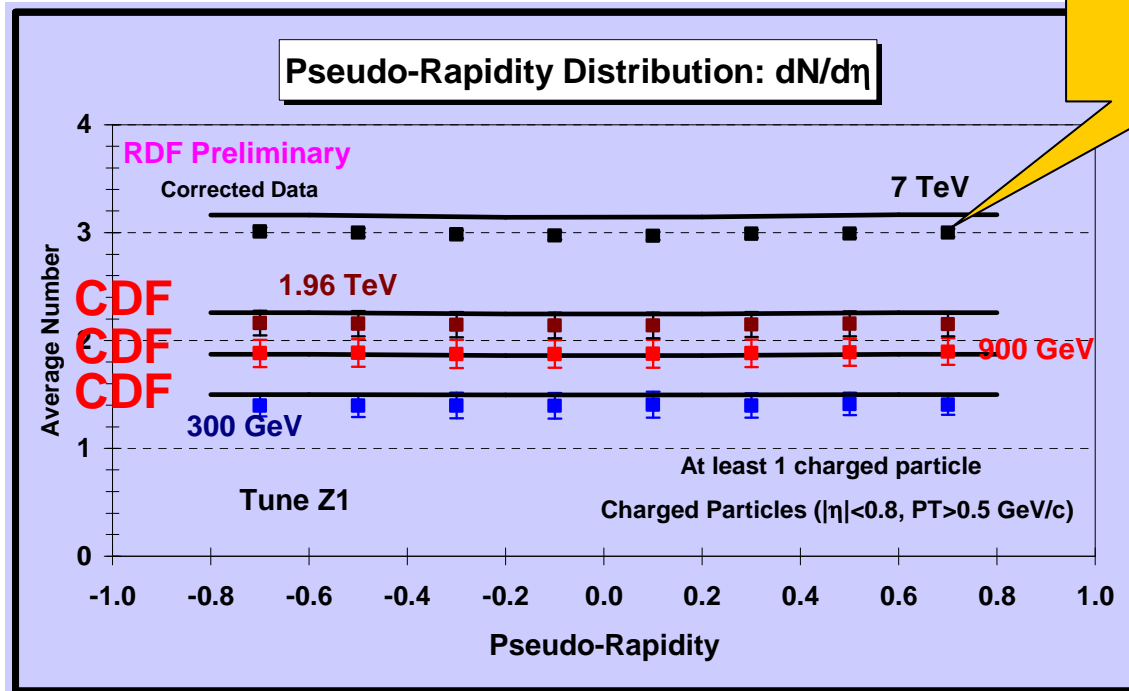
New CDF MB Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 0.5 \text{ GeV}/c$. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 0.5 \text{ GeV}/c$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.**



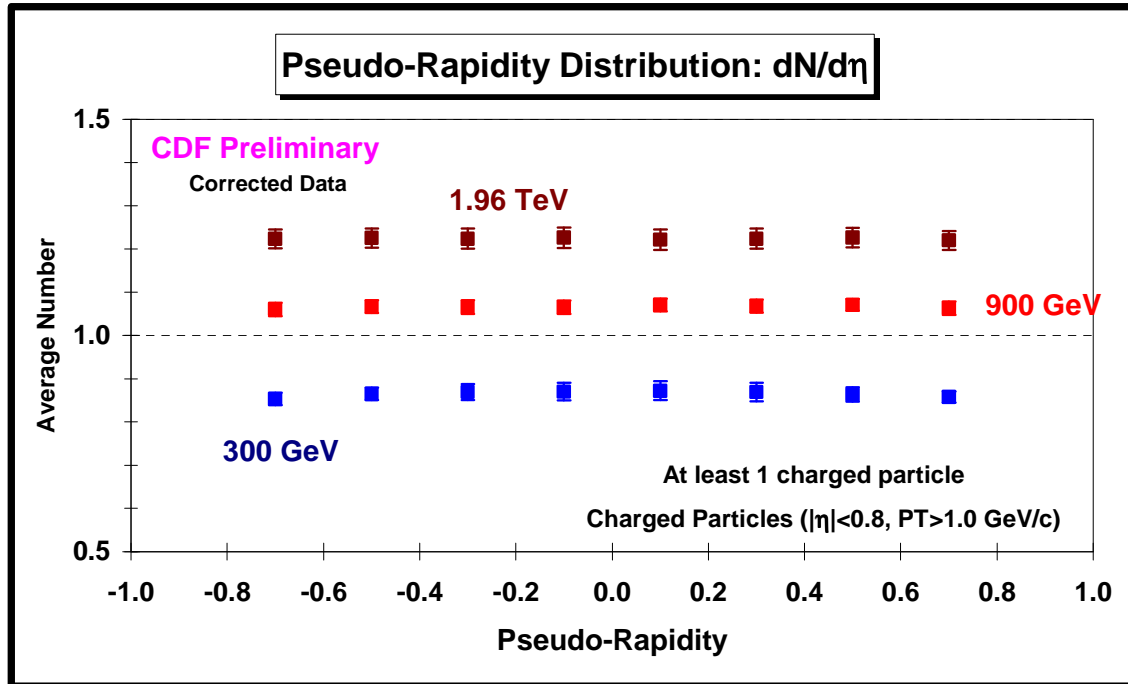
New CDF MB Data



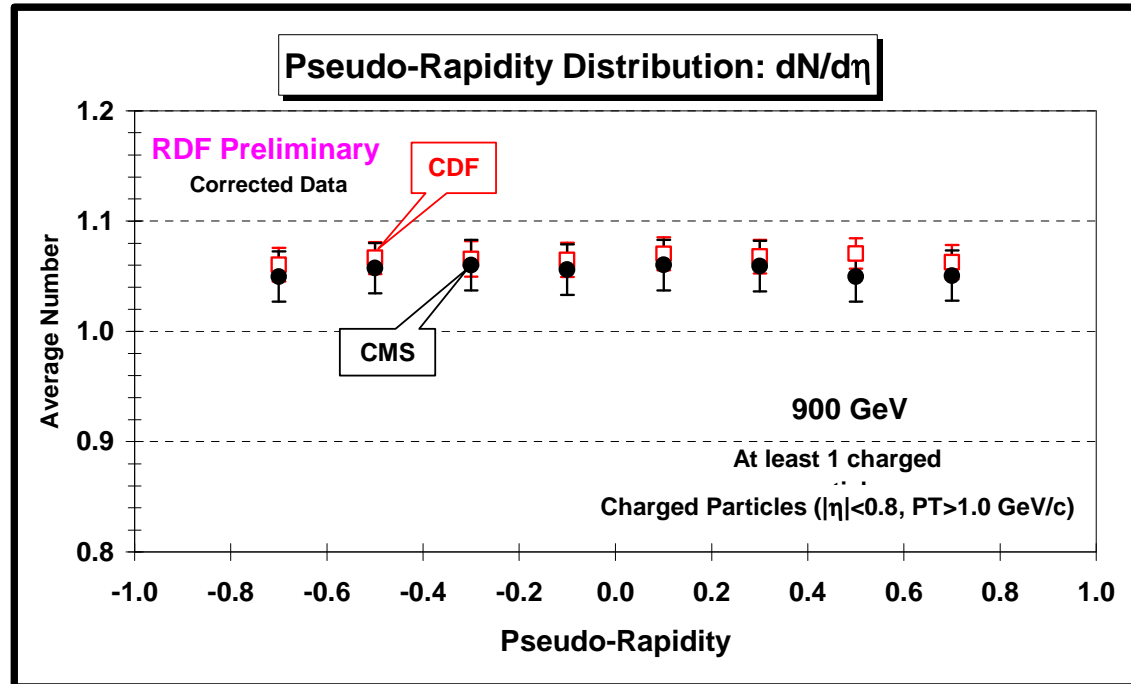
- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 0.5 \text{ GeV}/c$. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 0.5 \text{ GeV}/c$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.**



New CDF MB Data



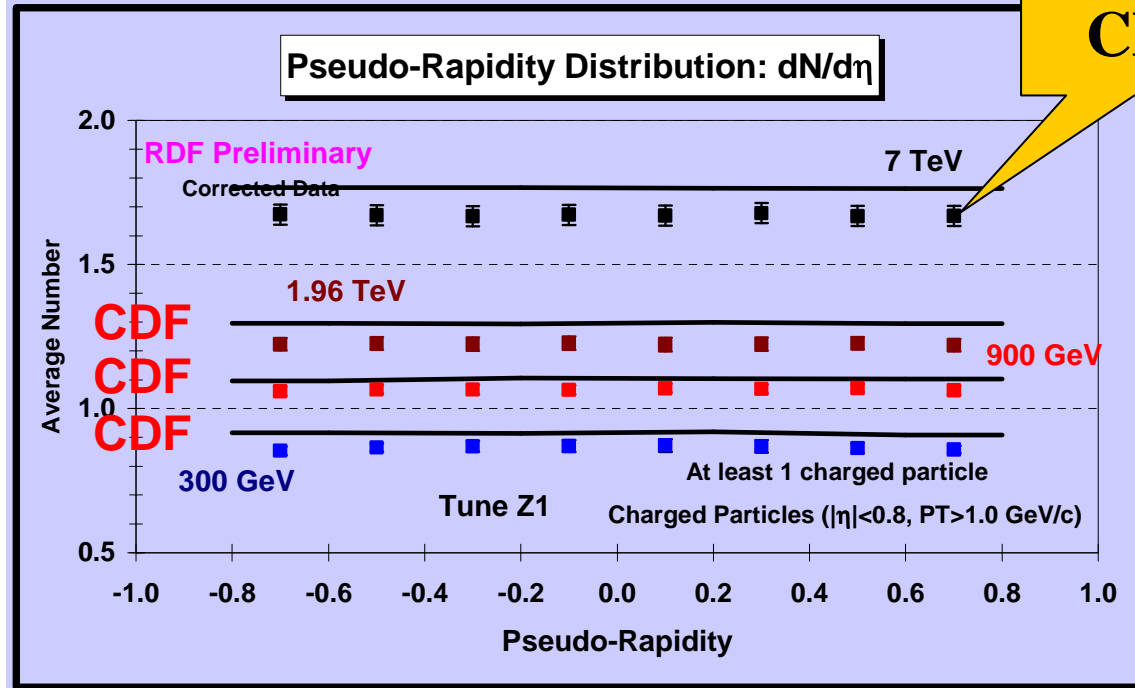
- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV on on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 1.0$ GeV/c. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 1.0$ GeV/c. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.**



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 1.0$ GeV/c. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 1.0$ GeV/c. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



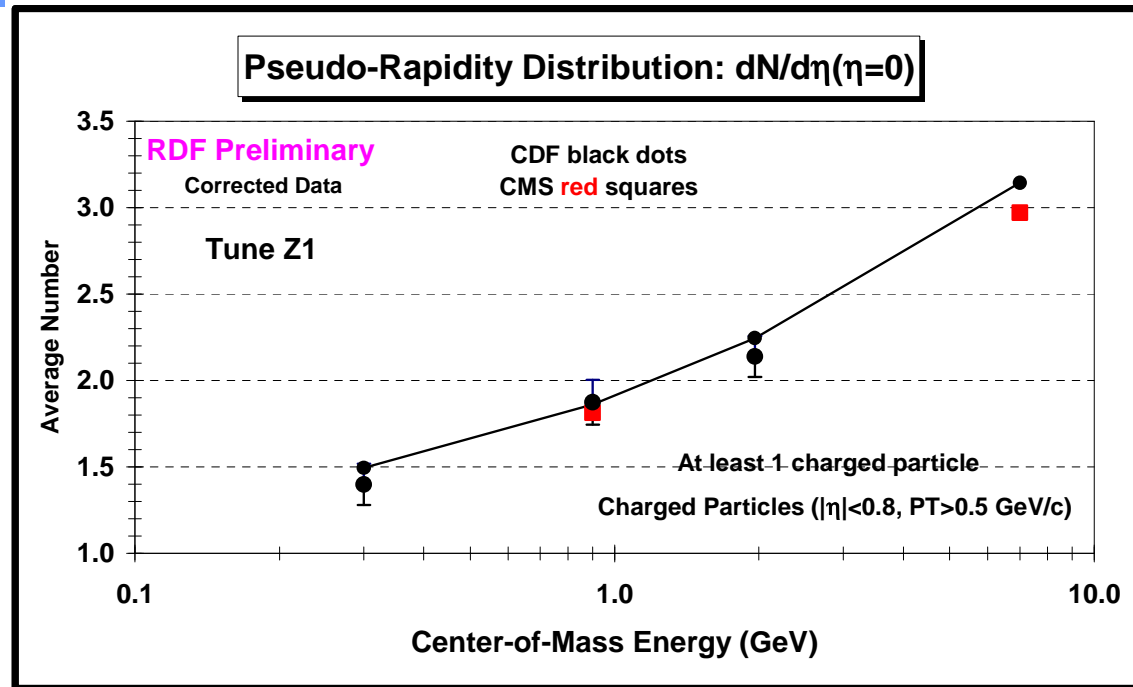
New CDF MB Data



- ➔ **New Corrected CDF data at 300 GeV, 900 GeV, and 1.96 TeV** on on pseudo-rapidity distribution of charged particles, $dN/d\eta$, with $p_T > 1.0 \text{ GeV}/c$. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 1.0 \text{ GeV}/c$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



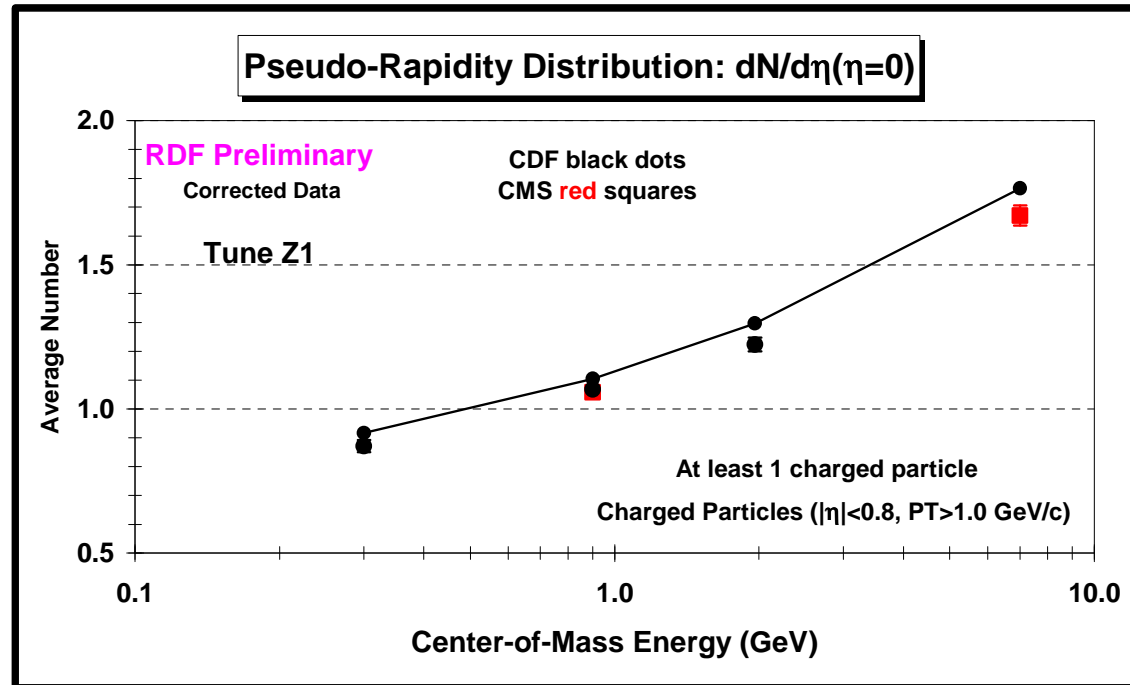
Energy Dependence $dN/d\eta$



- **CMS** data at 7 TeV and 900 GeV and **CDF** data at 1.96 TeV, 900 GeV, and 300 GeV on $dN/d\eta$ at $\eta = 0$ with $p_T > 0.5$ GeV/c as a function of the center-of-mass energy. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 0.5$ GeV/c. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



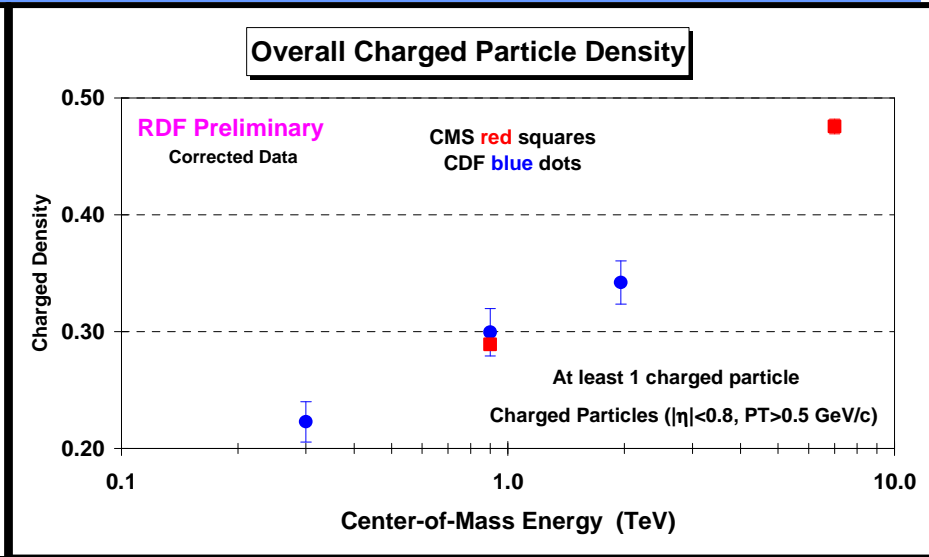
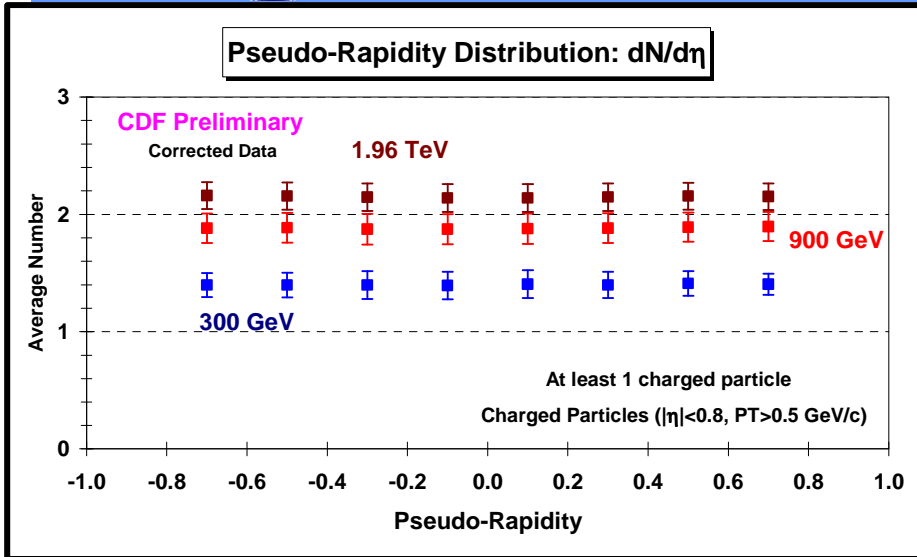
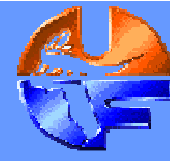
Energy Dependence $dN/d\eta$



- **CMS** data at 7 TeV and 900 GeV and **CDF** data at 1.96 TeV, 900 GeV, and 300 GeV on $dN/d\eta$ at $\eta = 0$ with $p_T > 1.0$ GeV/c as a function of the center-of-mass energy. Events are required to have at least one charged particle with $|\eta| < 0.8$ and $p_T > 1.0$ GeV/c. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



Overall Charged Particle Density



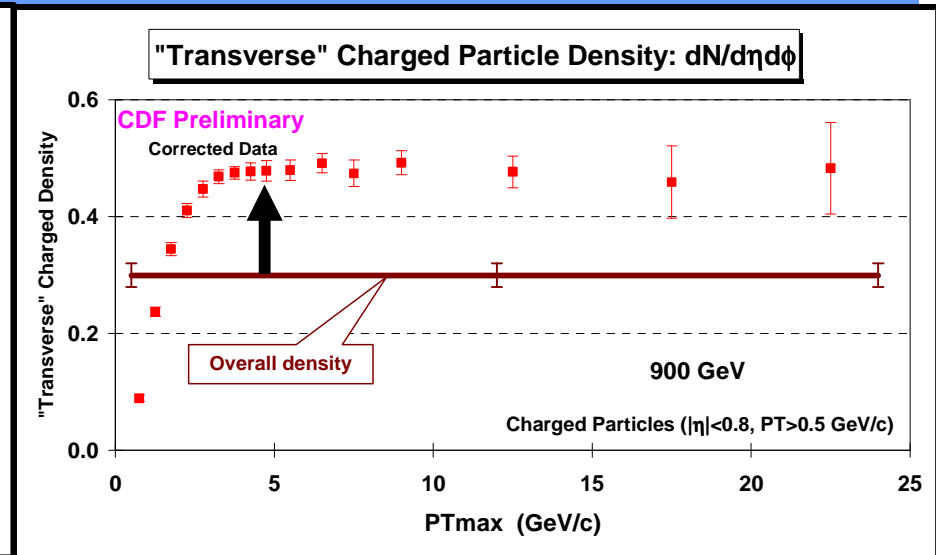
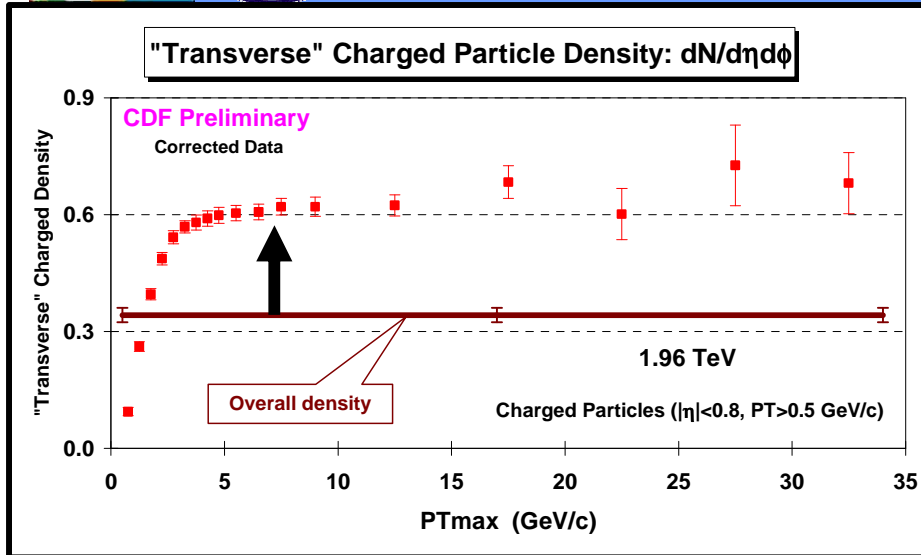
➔ **Corrected CDF data** on the pseudo-rapidity distribution, $dN/d\eta$, for charged with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$.

➔ **Corrected CDF and CMS data** overall density of charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ plotted versus the center-of-mass energy (*log scale*). The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

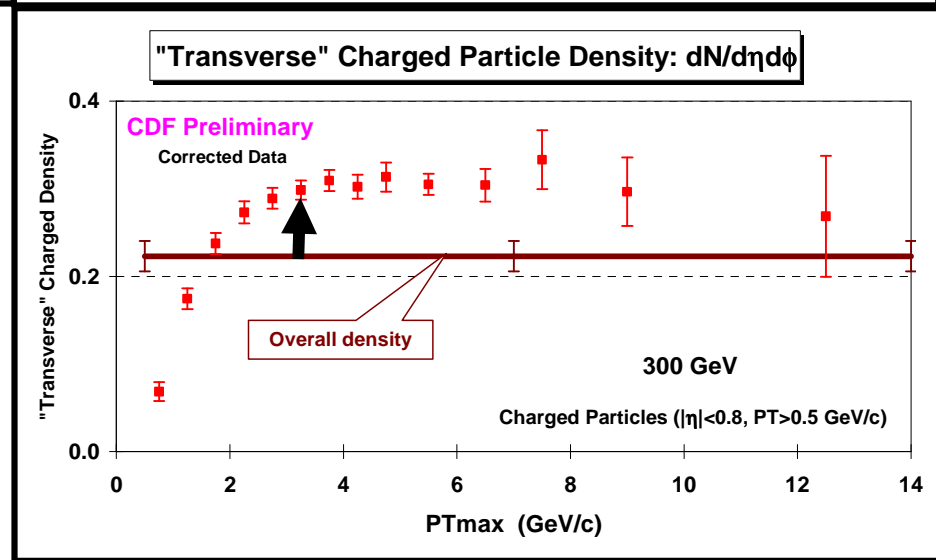
Ecm	Nchg	error	NchgDen	error
300 GeV	2.241	0.175	0.223	0.017
900 GeV	3.012	0.203	0.300	0.020
1.96 TeV	3.439	0.186	0.342	0.019

$$N_{chg} = \int_{-0.8}^{0.8} \frac{dN}{d\eta} d\eta$$

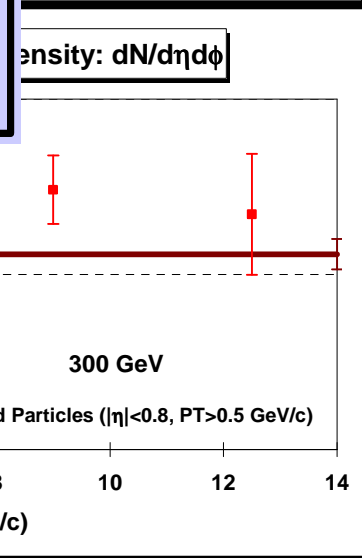
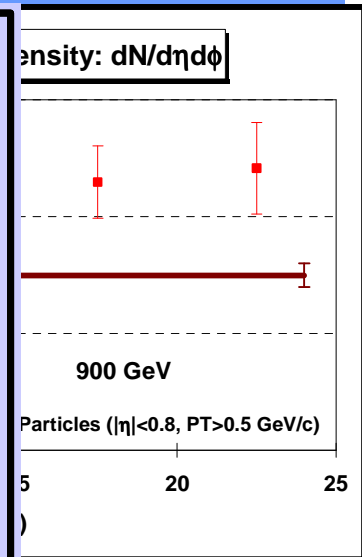
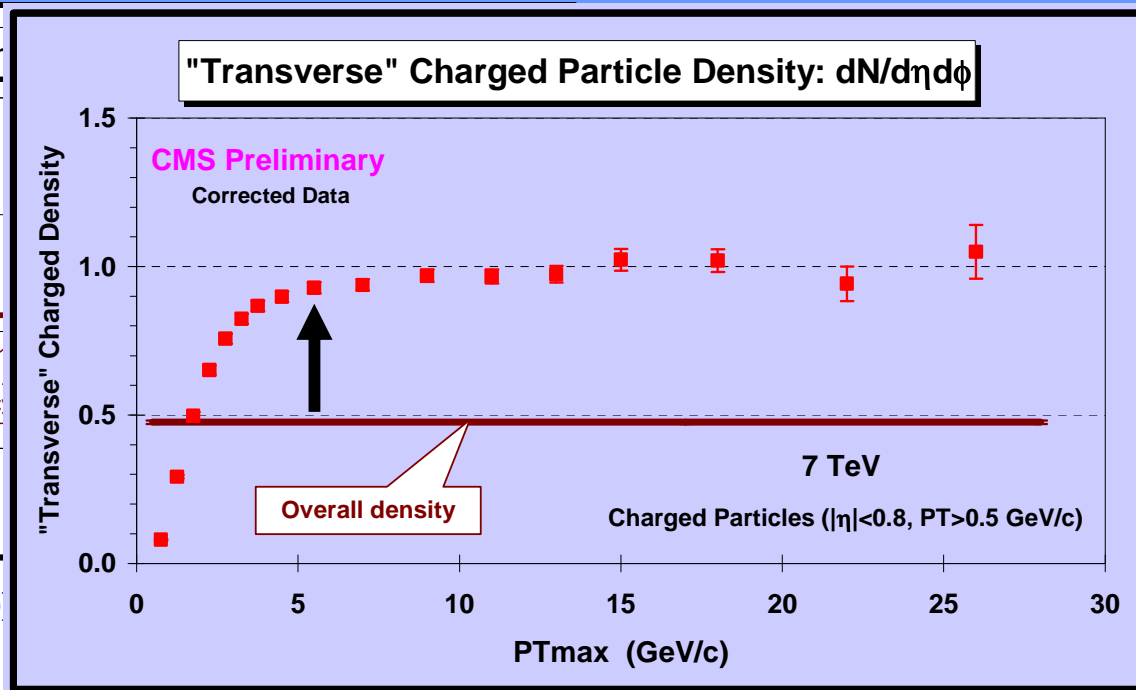
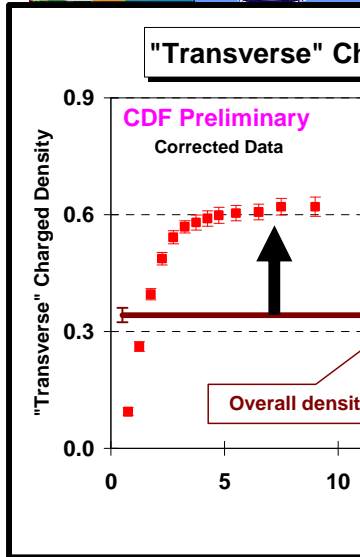
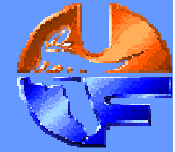
MB versus the UE



➔ **Corrected CDF data** on the charged particle density, in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty and are compared with the overall charged particle density (*straight lines*).



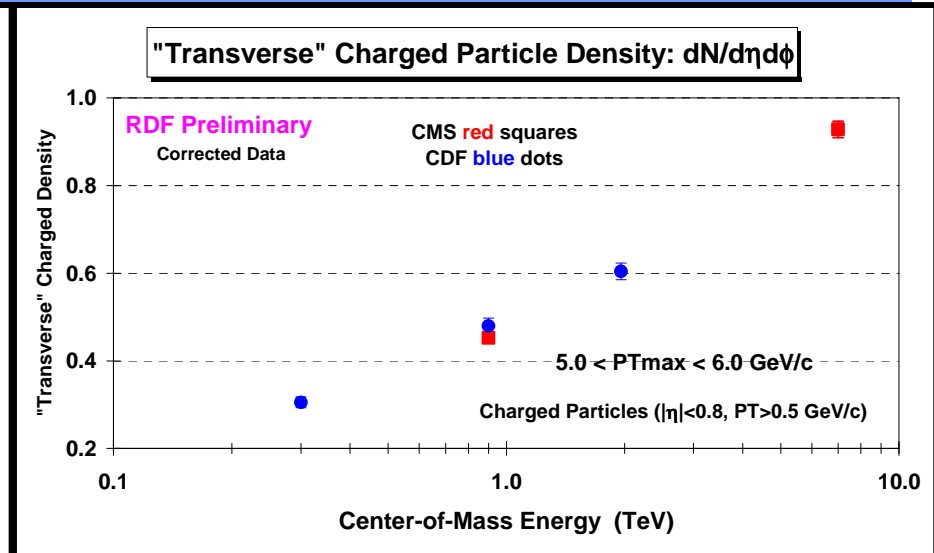
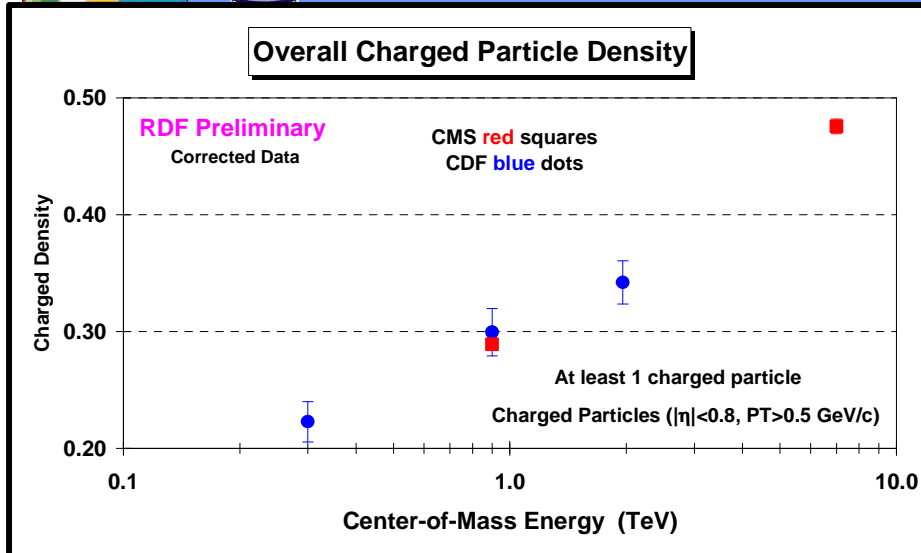
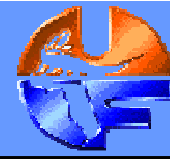
MB versus the UE



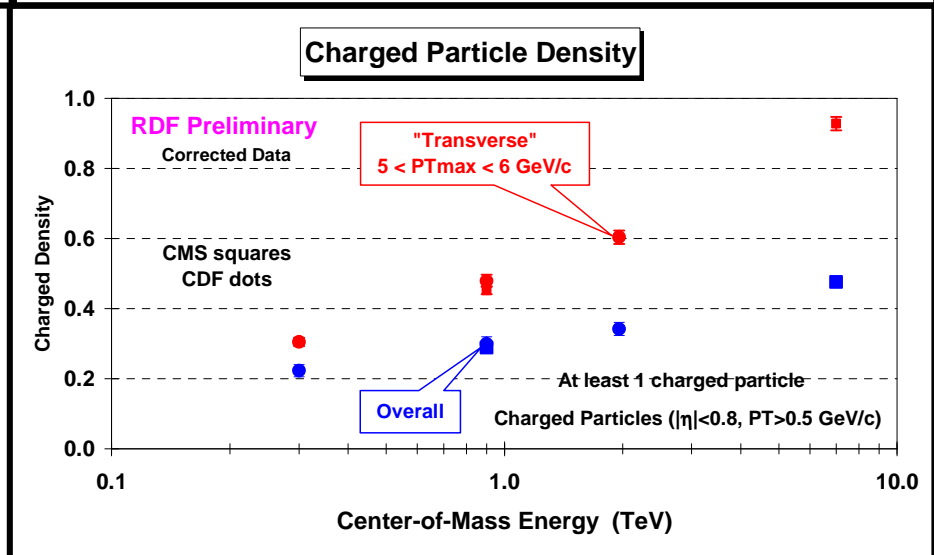
➔ **Corrected CD** density, in the defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty and are compared with the overall charged particle density (*straight lines*).



MB versus the UE

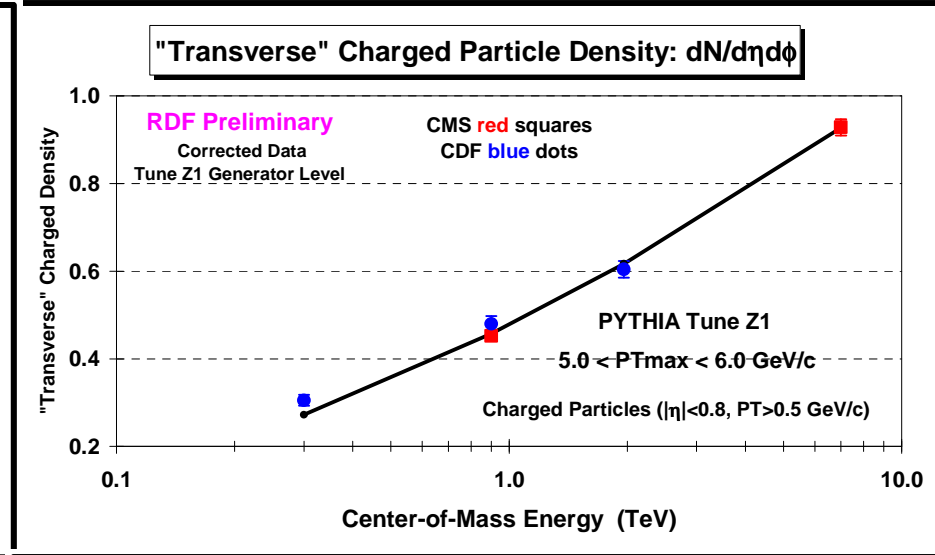
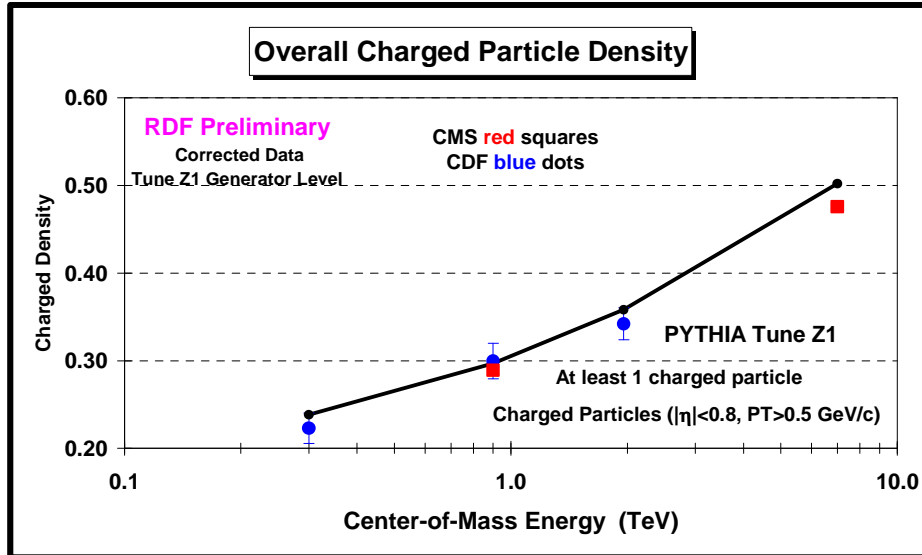
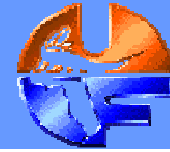


→ **Corrected CDF and CMS data on the overall density of charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ and on the charged particle density, in the "transverse" region as defined by the leading charged particle (p_{Tmax}) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ with $5 < p_{Tmax} < 6 \text{ GeV}/c$. The data are plotted versus the center-of-mass energy (*log scale*).**

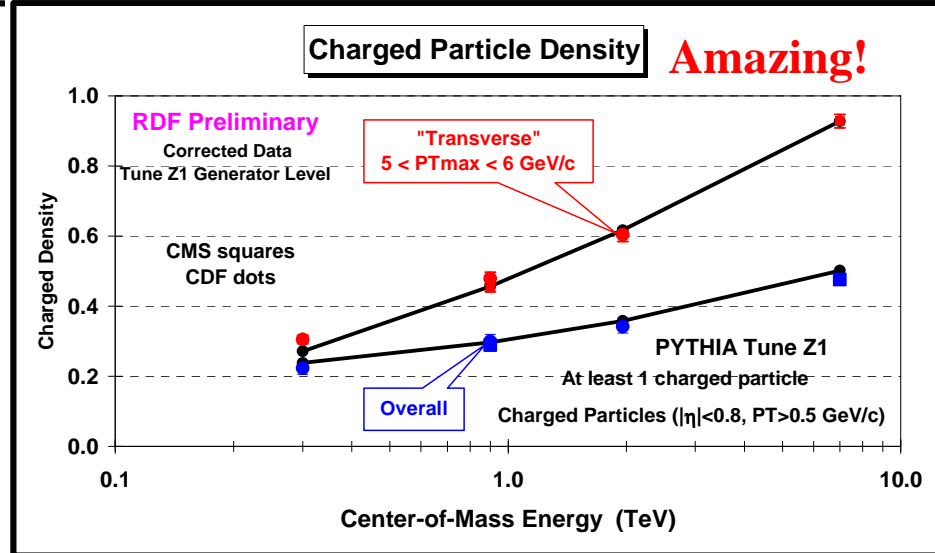


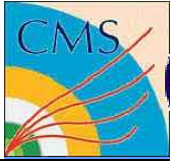


MB versus the UE

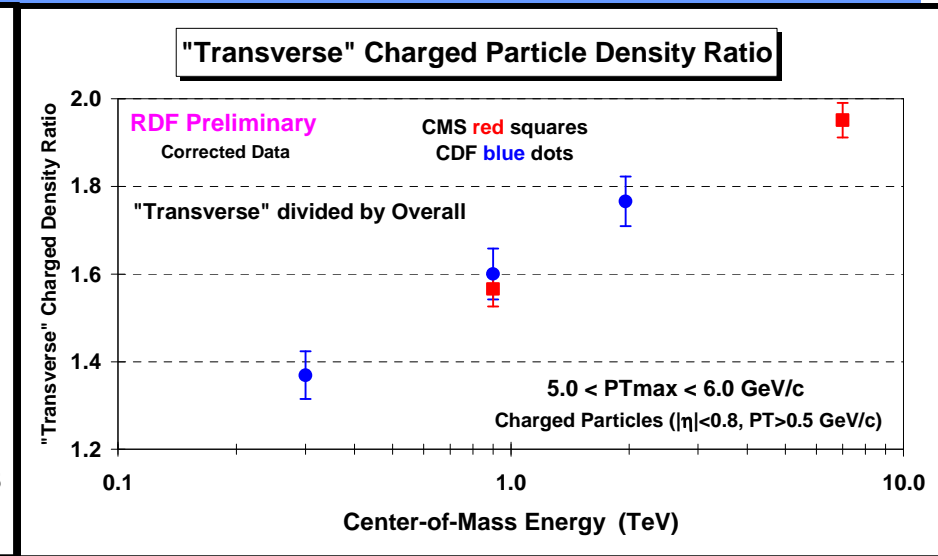
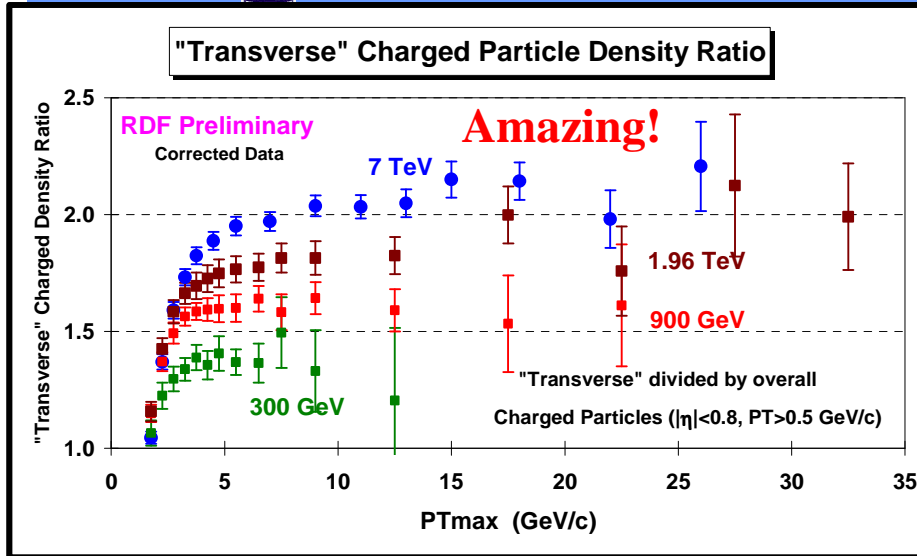
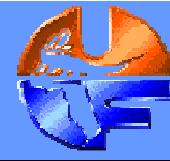


→ **Corrected CDF and CMS data** on the overall density of charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ and on the charged particle density, in the "transverse" region as defined by the leading charged particle (p_{Tmax}) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ with $5 < p_{Tmax} < 6 \text{ GeV}/c$. The data are plotted versus the center-of-mass energy (*log scale*).



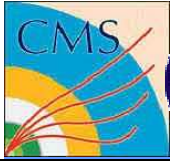


“Transverse”/Overall

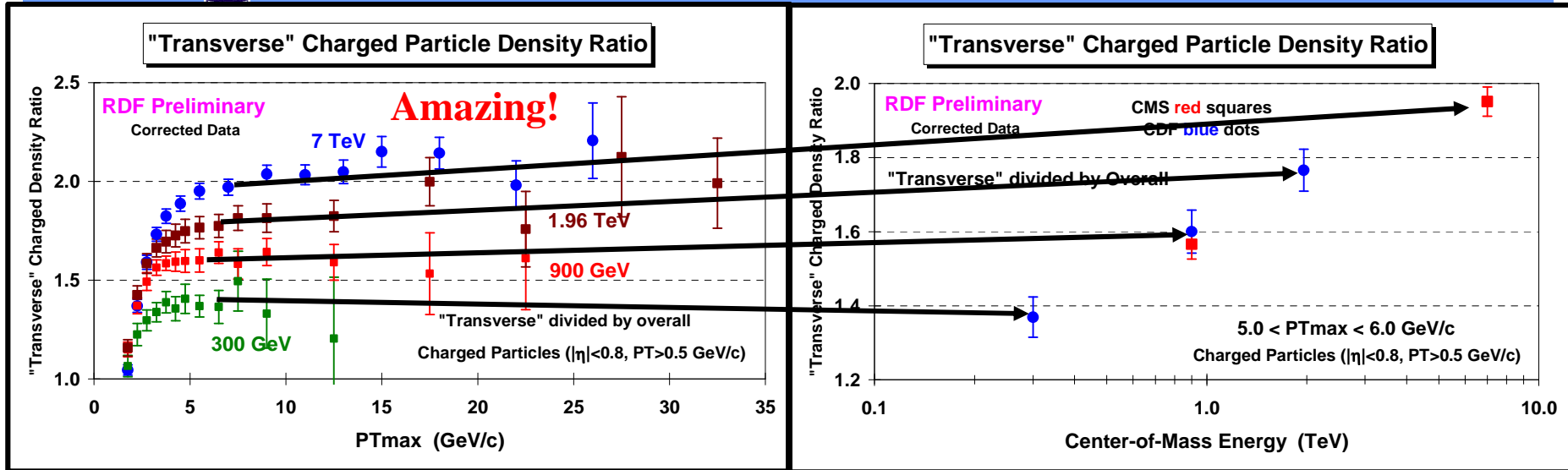
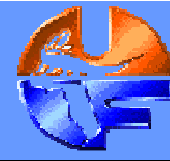


➔ **Corrected CDF and CMS data** on the charged particle density ratio, in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density.

➔ **Corrected CDF and CMS data** on the charged particle density ratio, in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for $5 < \text{PTmax} < 6 \text{ GeV}/c$. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density. The data are plotted versus the center-of-mass energy (*log scale*).



“Transverse”/Overall

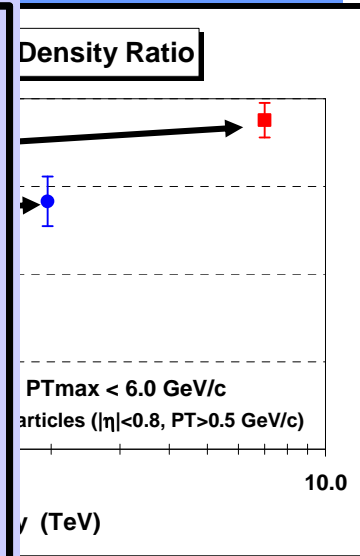
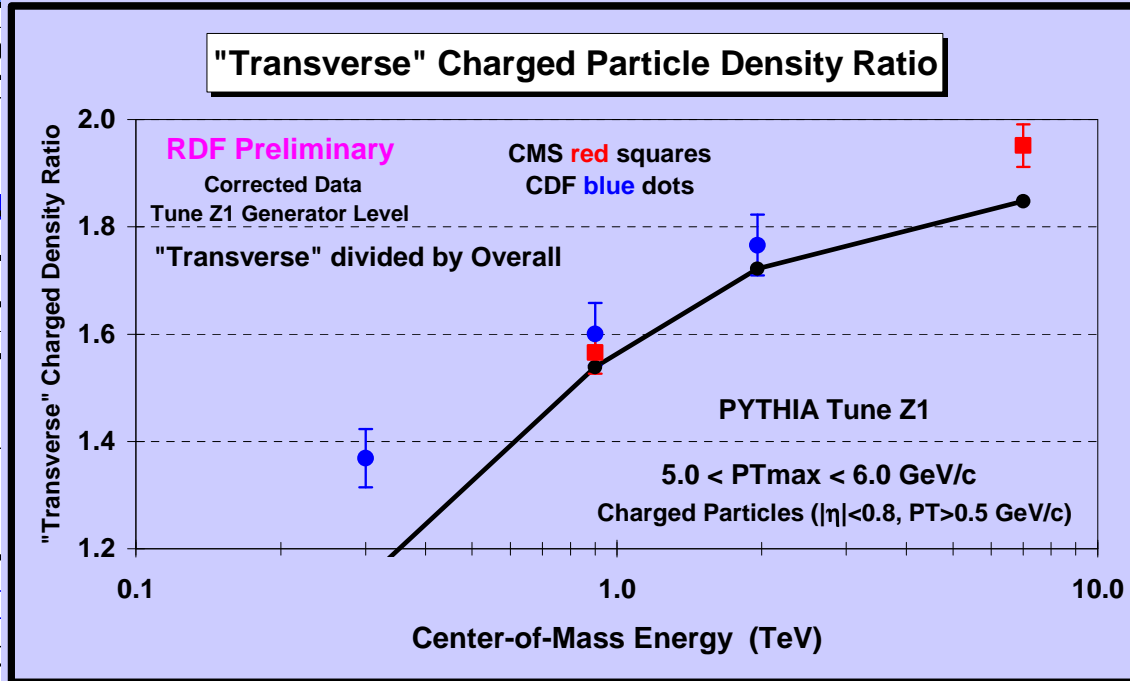
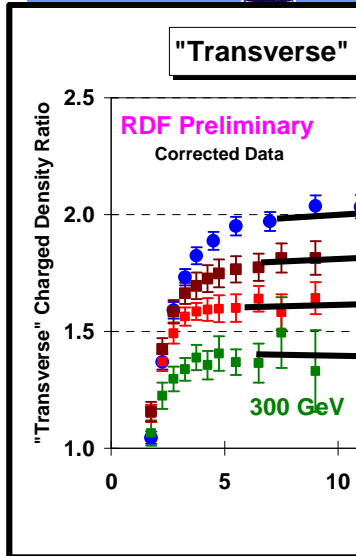
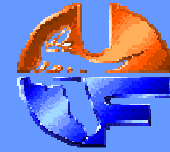


➔ **Corrected CDF and CMS data** on the charged particle density ratio, in the “transverse” region as defined by the leading charged particle (p_{Tmax}) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density.

➔ **Corrected CDF and CMS data** on the charged particle density ratio, in the “transverse” region as defined by the leading charged particle (p_{Tmax}) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for $5 < p_{Tmax} < 6 \text{ GeV}/c$. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density. The data are plotted versus the center-of-mass energy (*log scale*).

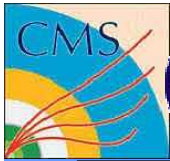


“Transverse”/Overall

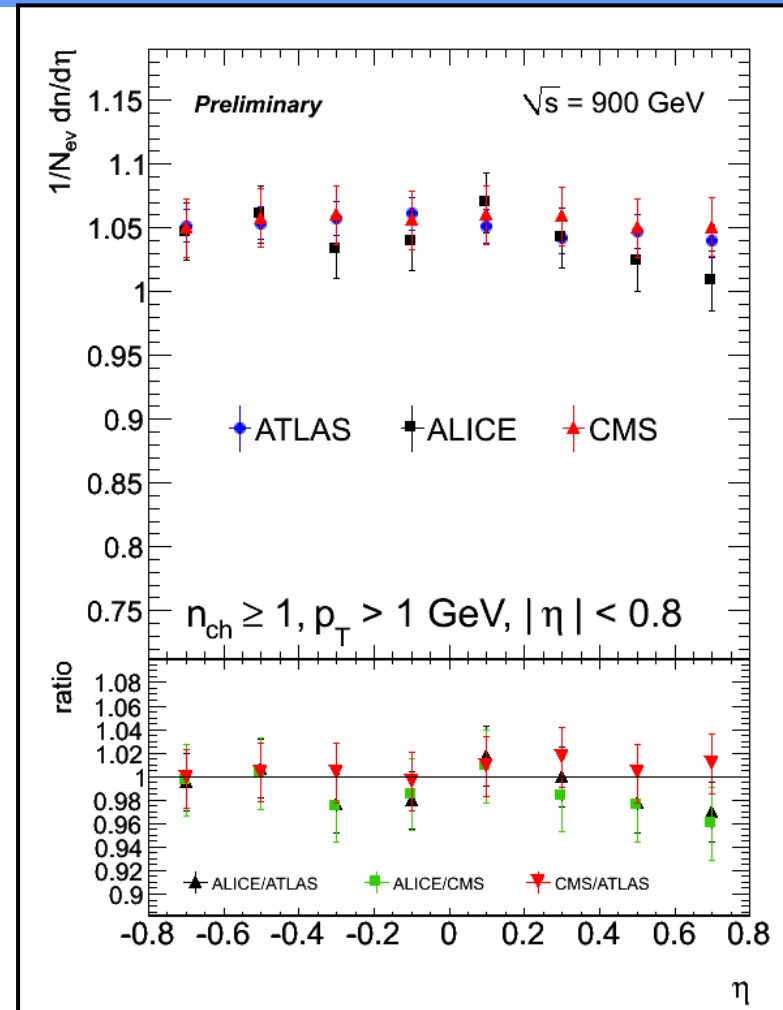
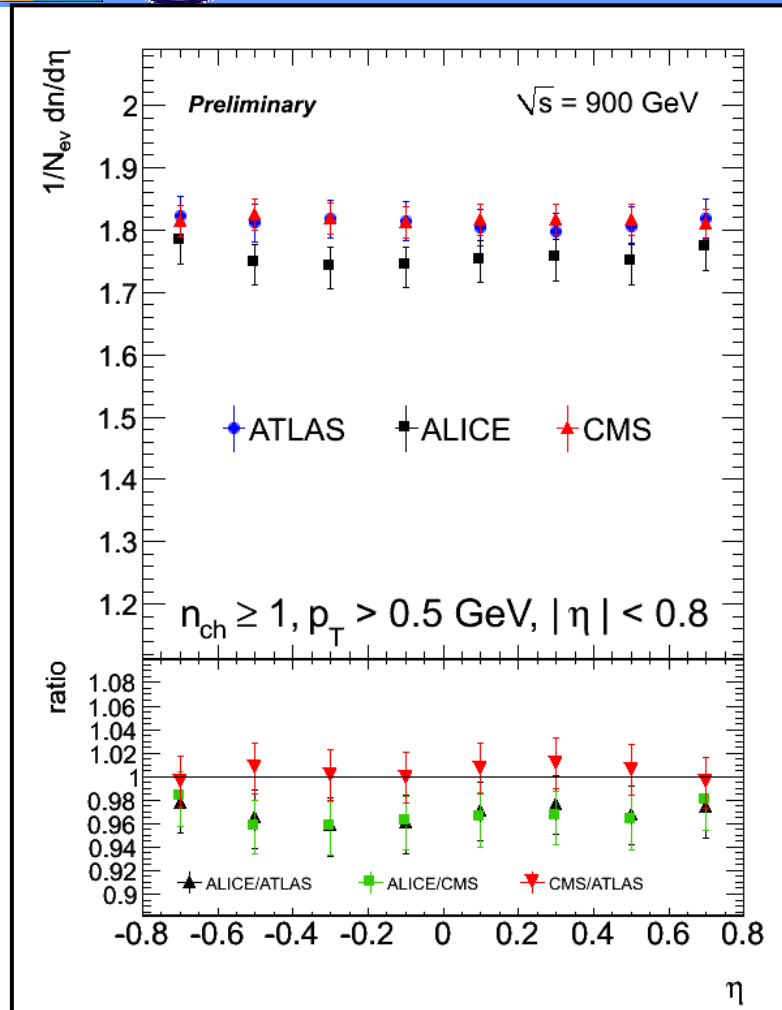
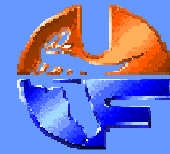


→ **Corrected CDF** data on the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density.

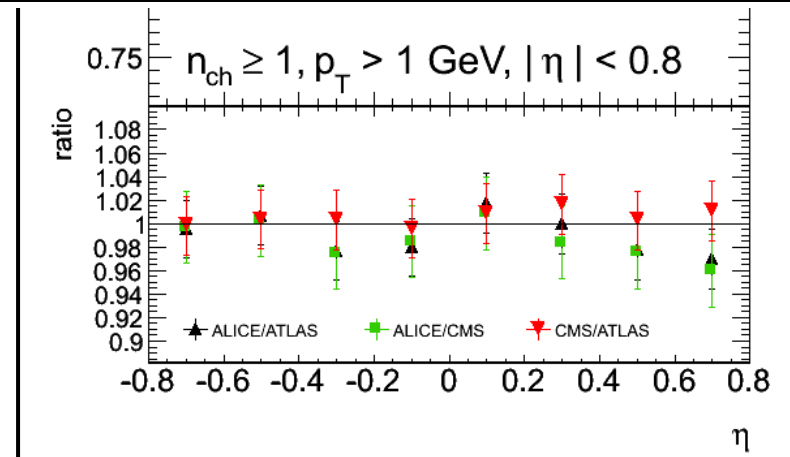
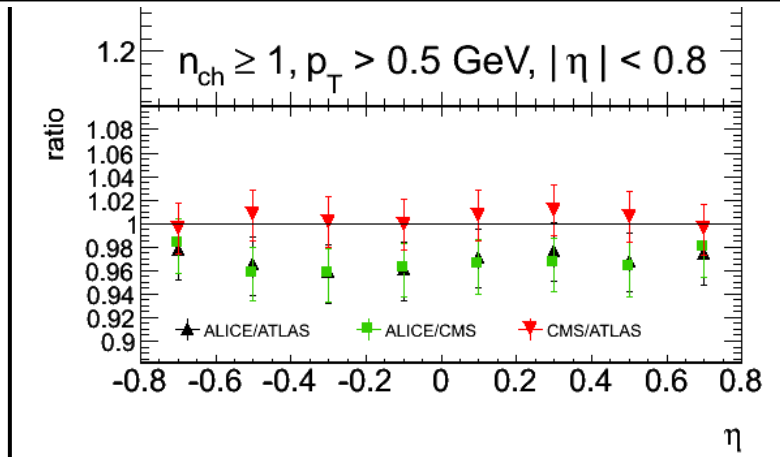
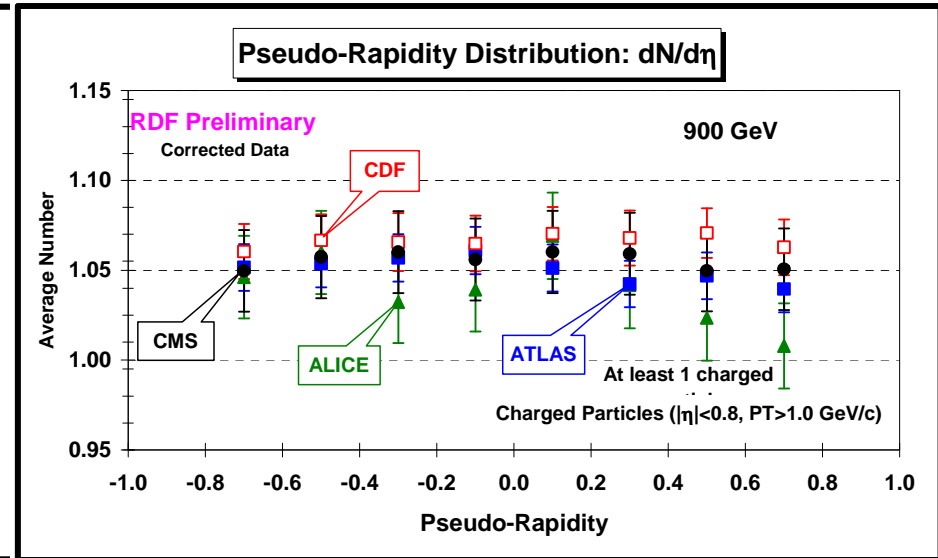
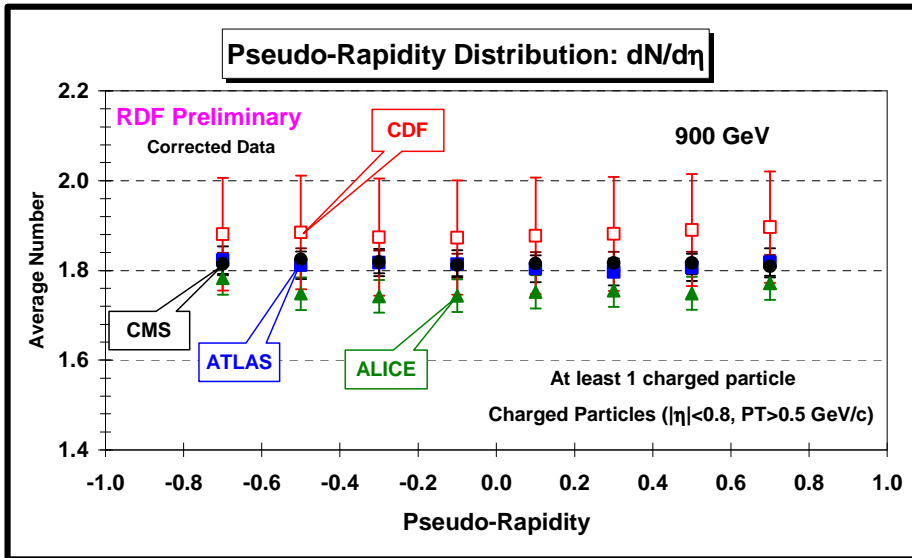
data on the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ for $5 < PTmax < 6$ GeV/c. The ratio corresponds to the “transverse” charged particle density divided by the overall charged particle density. The data are plotted versus the center-of-mass energy (*log scale*).



MB Common Plots 900 GeV



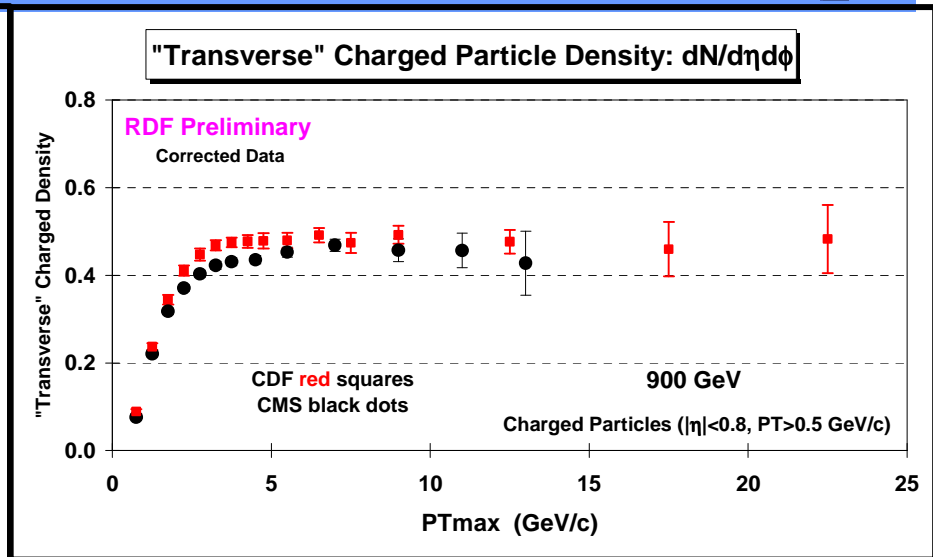
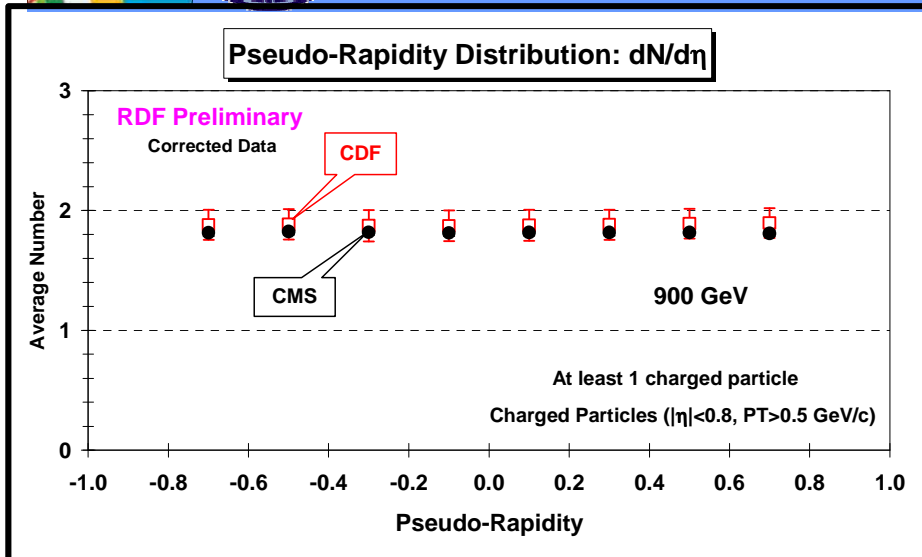
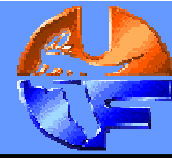
Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.



Direct charged particles (including leptons) corrected to the particle level with no corrections for SD or DD.



CDF versus CMS

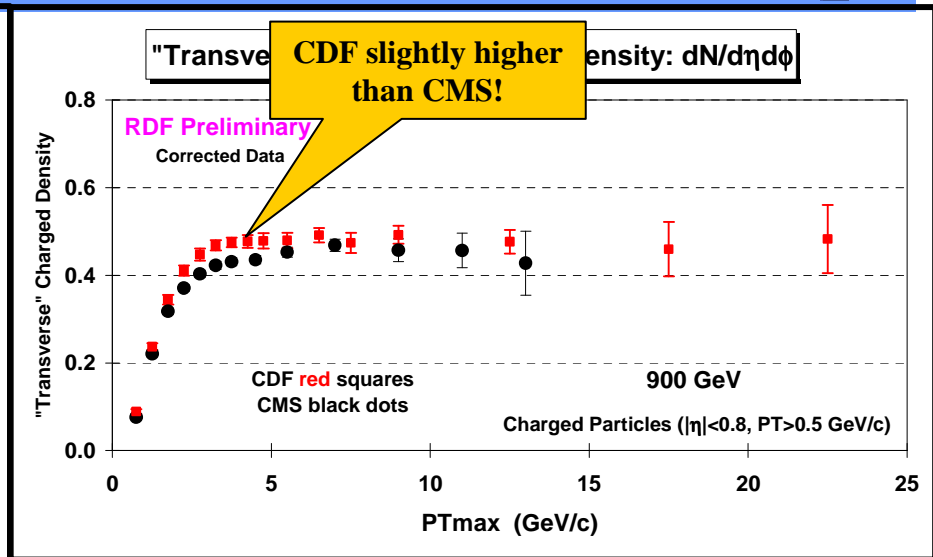
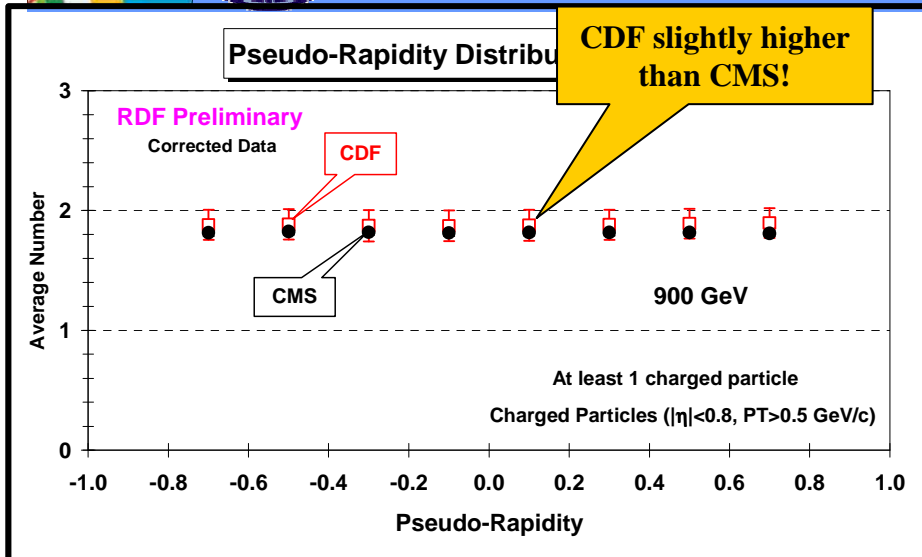
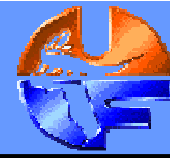


➔ **CDF and CMS data at 900 GeV** on the pseudo-rapidity distribution, $dN/d\eta$, for charged with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

➔ **CDF and CMS data at 900 GeV/c** on the charged particle density in the "transverse" region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



CDF versus CMS

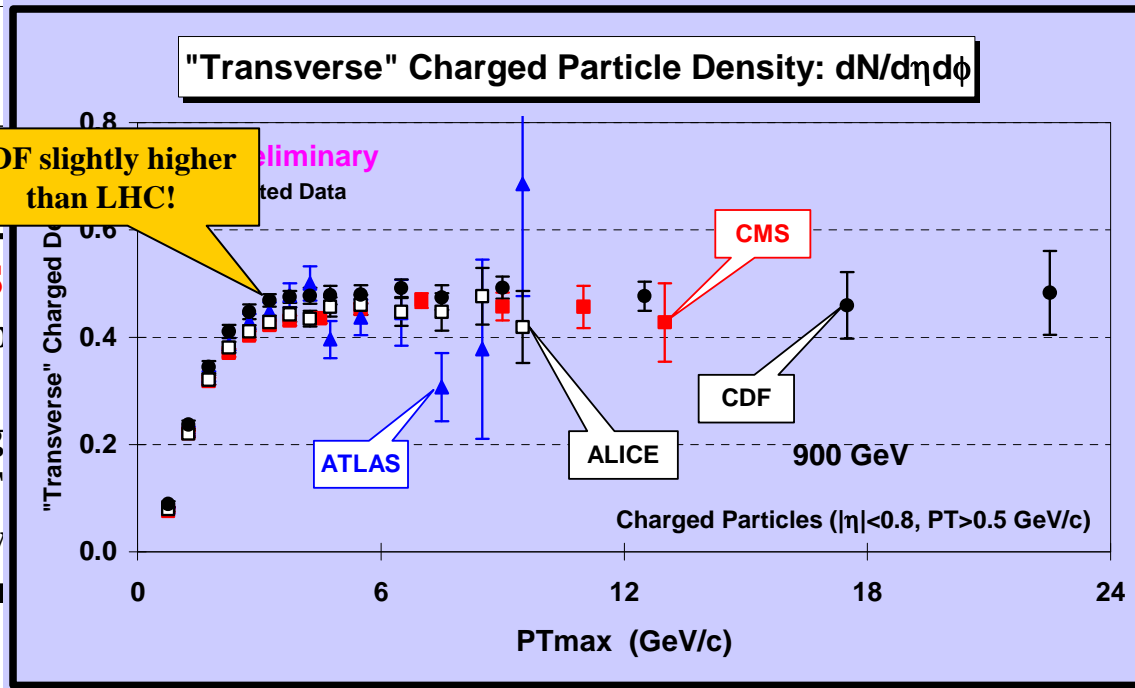
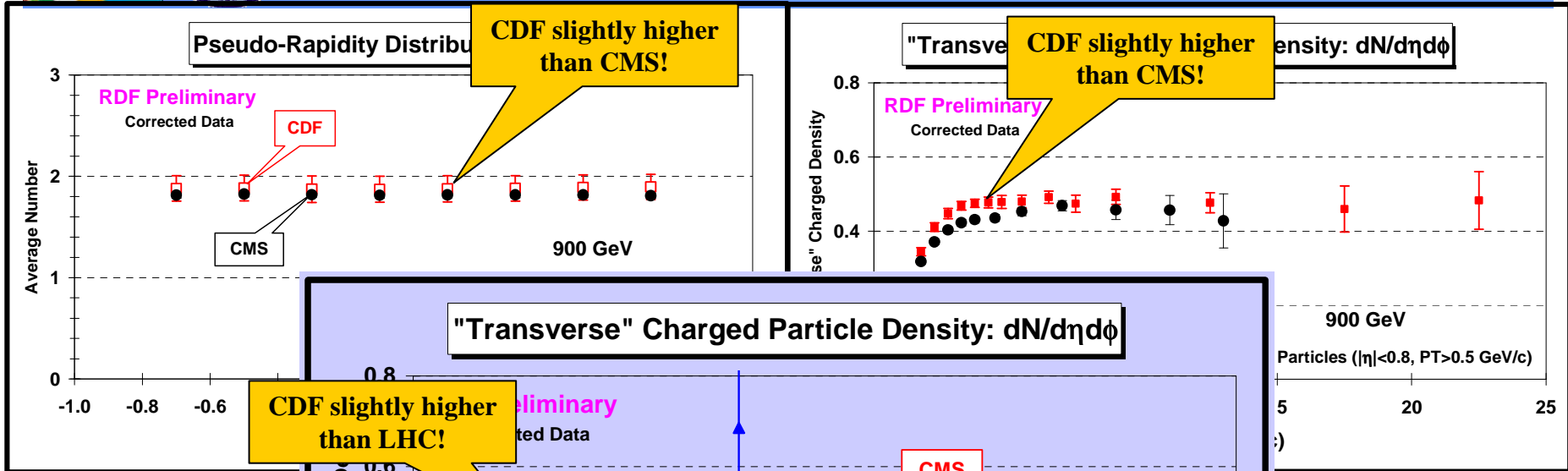
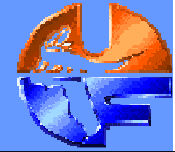


➔ **CDF and CMS data at 900 GeV** on the pseudo-rapidity distribution, $dN/d\eta$, for charged with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

➔ **CDF and CMS data at 900 GeV/c** on the charged particle density in the "transverse" region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5 \text{ GeV}/c$ and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.



CDF versus CMS

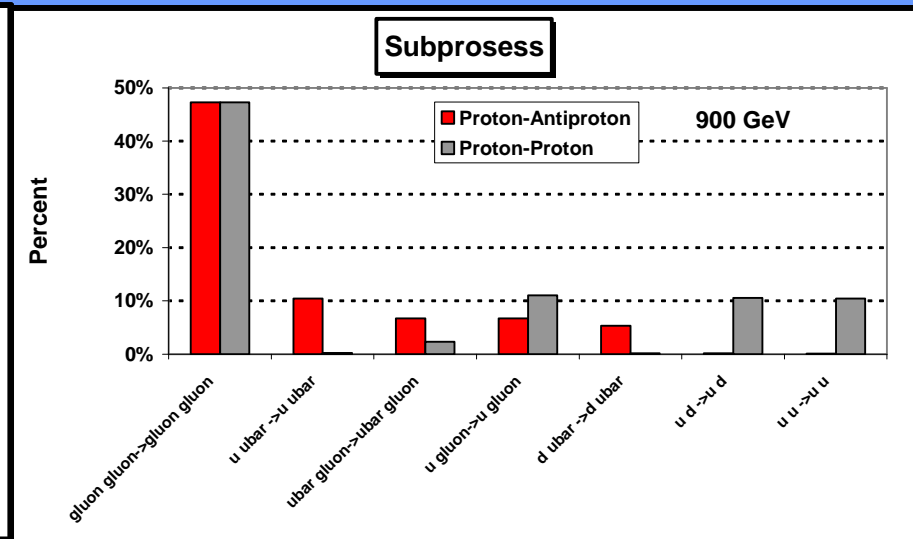
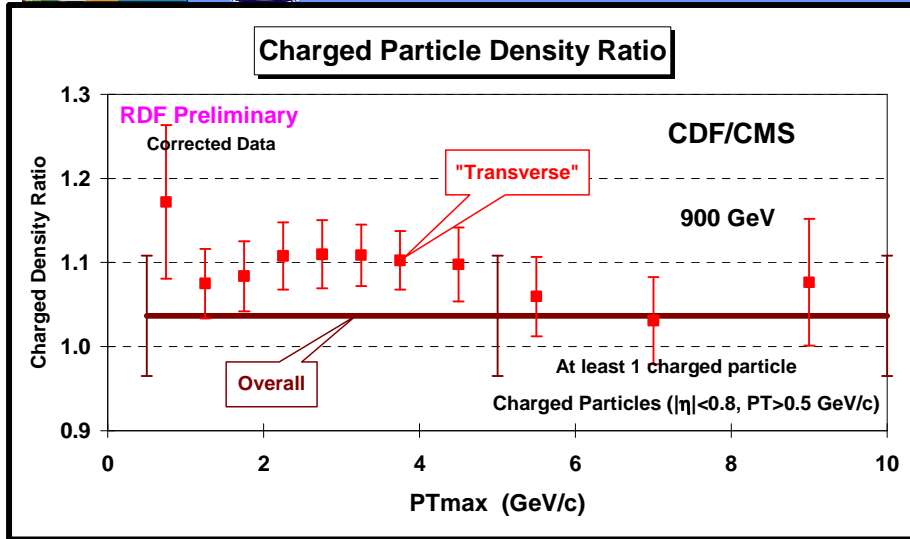
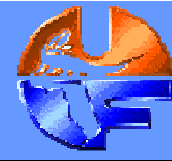


→ **CDF and CMS** pseudo-rapidity distribution for $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are at the particle level with statistical error and systematic uncertainty.

GeV/c on the the "transverse" charged particle density. The data are at the particle level with errors and systematic error and



CDF versus CMS

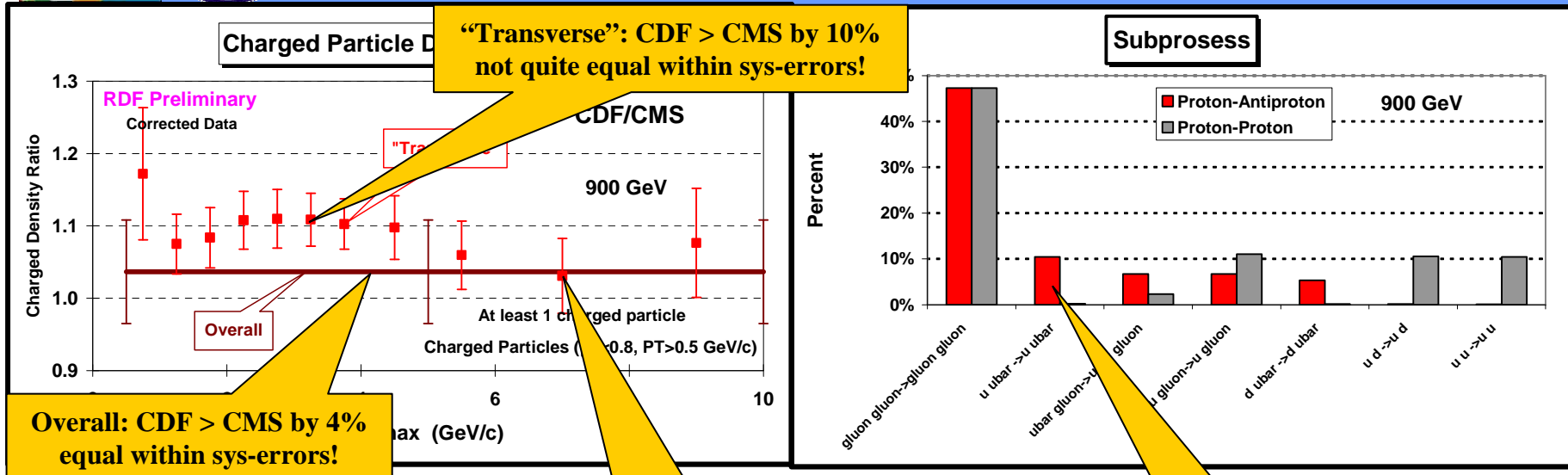
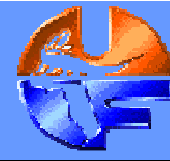


➔ **CDF data divided by the CMS data at 900 GeV** for the charged particle density in the “transverse” region as defined by the leading charged particle (p_{Tmax}) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ and for the overall density of charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ (*straight line*).

➔ **QCD 2-2 sub-processes** contributing to proton-proton and proton-antiproton collisions at 900 GeV from PYTHIA Tune Z1.



CDF versus CMS



→ CDF data divided by the CMS data at 900 GeV for the charged particle density in the “transverse” region as defined by the charged particle (p_{Tmax}) for charged particles with $p_T > 0.5$ GeV/c and for the overall density of charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ for events with at least one charged particle with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ (straight line).

→ QCD 2-2 sub-processes contributing to proton-proton and proton-antiproton collisions at 900 GeV from PYTHIA 6.4

“Transverse” Plateau: CDF > CMS by 4% equal within sys-errors!

Different sub-processes in proton-antiproton and proton-proton collisions!

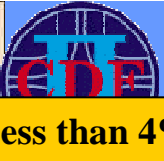


More Data Coming!

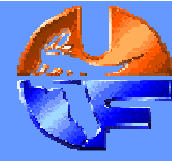


- ➔ **CDF - More UE Observables:** Nchg density, PTsum density, average p_T , “toward”, “away”, “transverse”, “transMAX”, “transMIN”, distributions, etc..
- ➔ **CDF - Two η Ranges:** Will do ($p_T > 0.5 \text{ GeV}/c$, $|\eta| < 0.8$) as well as ($p_T > 0.5 \text{ GeV}$, $|\eta| < 1$).
- ➔ **CDF - Min-Bias:** Many MB observables: Multiplicity, $dN/d\eta$, p_T distribution, $\langle p_T \rangle$ versus Nchg, etc.

Soon we will have MB & UE data at
300 GeV, 900 GeV, 1.96 TeV, 7 TeV, and 8 TeV!
We can study the energy dependence
more precisely than ever before!

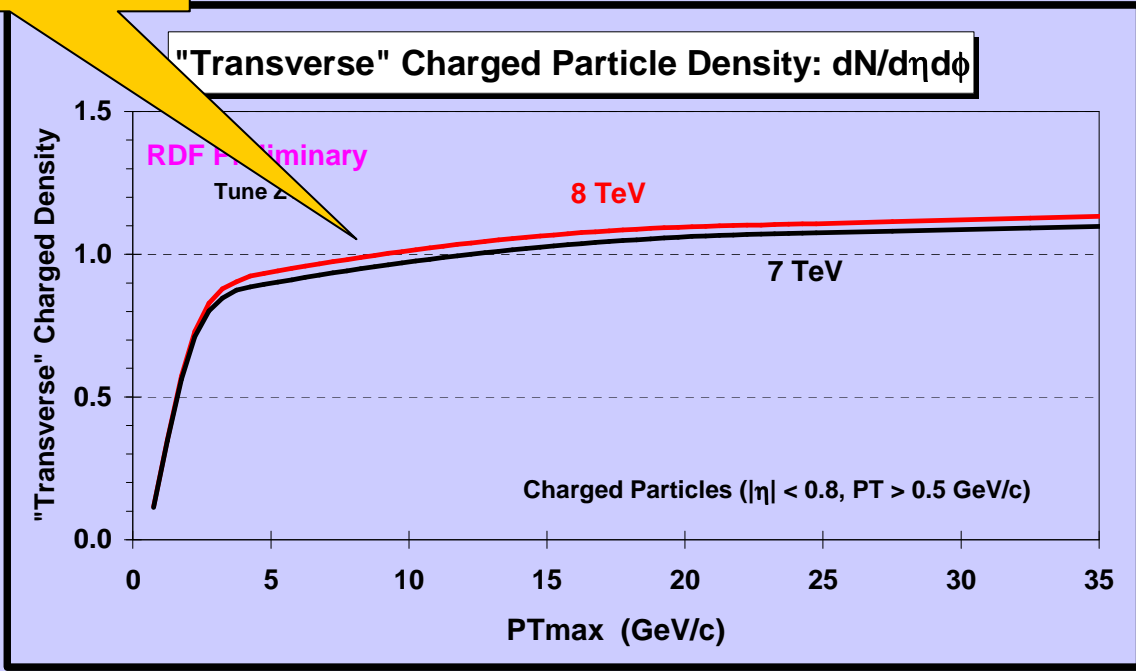


More Data Coming!



Less than 4% change!

- CDF - MB average p “transMI
- CDF - Tv well as (p
- CDF - MB dN/dη, p



n density, MAX",

(0.8) as

ity,

Soon we will have MB & UE data at 300 GeV, 900 GeV, 1.96 TeV, 7 TeV, and 8 TeV! We can study the energy dependence more precisely than ever before!

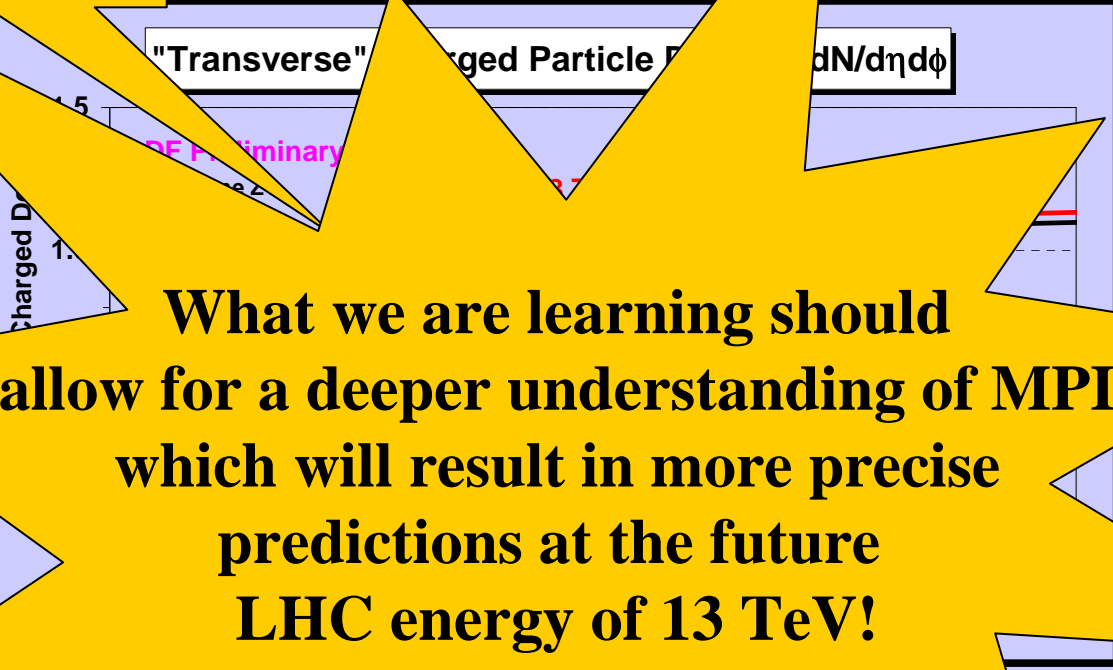


More Data Coming!



Less than 4% change!

→ CDF - $dN/d\eta$
average p
“transMI



density,
MAX”,

→ CDF - T
well as

What we are learning should allow for a deeper understanding of MPI which will result in more precise predictions at the future LHC energy of 13 TeV!

→ CDF - M
 $dN/d\eta$, p

Soon...
300 GeV, 900 GeV, 3.5 TeV, 7 TeV, and 13 TeV!
We can study energy dependence more precisely than ever before!