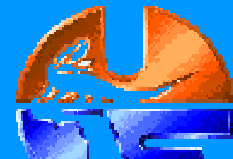




The “Underlying” Event in Run II ChgJets versus JetClu Jets



Outline of Talk

➔ The evolution of “**charged particle jets**” and the “underlying event”. Study the event topology relative to the leading “chgjet” and compare with Run I.

➔ The evolution of “**calorimeter jets**” and the “underlying event”. Study the event topology relative to the leading “JetClu” jet.

➔ “**Charged particle jets**” versus “**calorimeter jets**”. Study the relationship between “chgjets” and “JetClu” jets.

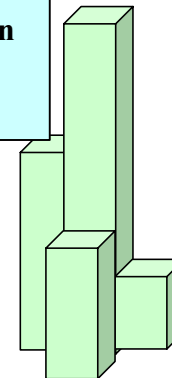
Look at the charged particle correlation relative to the leading chgjet.

Charged Particle Jet

Look at the charged particle correlation relative to the leading calorimeter jet.

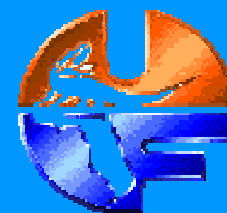
Calorimeter Jet

Look correlation between the leading chgjet and calorimeter jets.





Data Selection



Event Selection

Good Runs
Bad Stntuples Removed
 $\text{MetSig} < 5$ $\text{sumET} < 2 \text{ TeV}$
One and only one Z-vertex
 $|z_0| < 60 \text{ cm}$

Same as our
Run 1
analysis!

Track Selection

COT measured tracks
 $|z-z_0| < 2 \text{ cm}$
 $|d_0| < 1 \text{ cm}$
 $P_T > 0.5 \text{ GeV}/c$ $|\eta| < 1$

Form charged particle
jets ($R = 0.7$) as we did
our Run 1 analysis

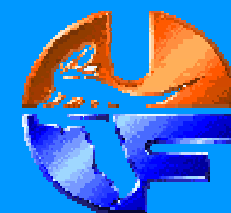
Calorimeter Jet Selection

JetClu ($R = 0.7$)
 $|\eta(\text{jet})| < 2$ or $|\eta(\text{jet})| < 0.7$

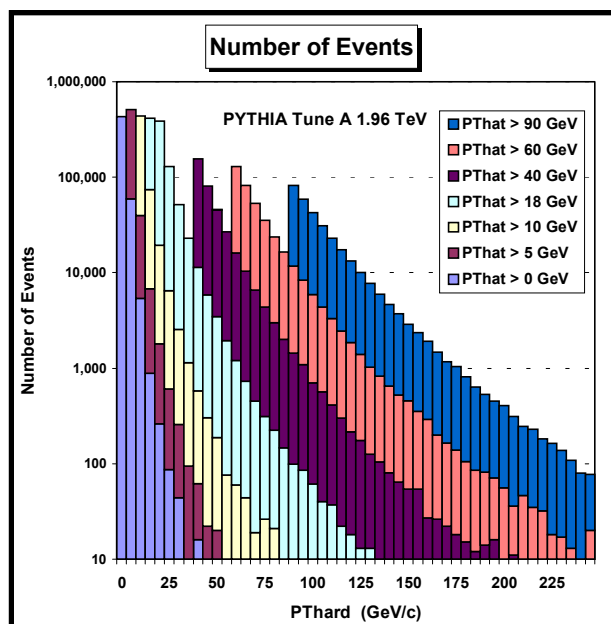
Anwar's New Stntuples	JET20	JET50	JET70	JET100
Total Events	7,388,639	1,844,407	826,597	1,052,530
Good Events (Rob's WEB)	5,185,515	1,397,771	642,289	822,466
Met Cut ($\text{MetSig} < 5$, $\text{sumET} < 2 \text{ TeV}$)	5,177,984	1,370,267	607,794	690,242
1 ZVTX $ z < 60 \text{ cm}$	3,038,879	793,145	350,146	391,034
JetClu ($ \eta(\text{jet}) < 2$, $R = 0.7$)	2,422,404	728,816	336,238	386,991
JetClu ($ \eta(\text{jet}) < 0.7$, $R = 0.7$)	1,118,787	379,443	188,441	240,296
ChgJet ($P_T > 0.5 \text{ GeV}$, $ \eta < 2$, $R = 0.7$)	3,018,847	790,136	349,135	390,276



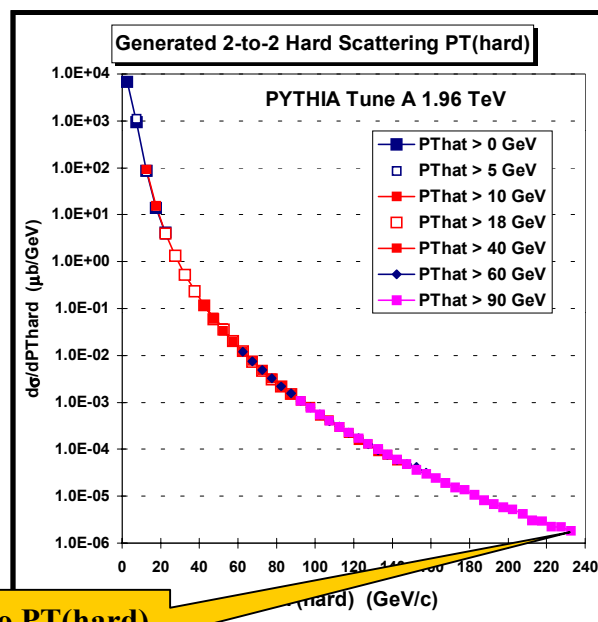
PYTHIA Tune A



Charles Currat's Stntuples
(PYTHIA Tune A at 1.96 TeV)



PT(min)	N(events)
0	500,000
5	497,500
10	497,500
18	927,000
40	331,500
60	338,000
90	271,900
Total	3,363,400

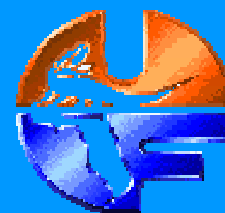


Can only go out to PT(hard)
of about 250 GeV/c.

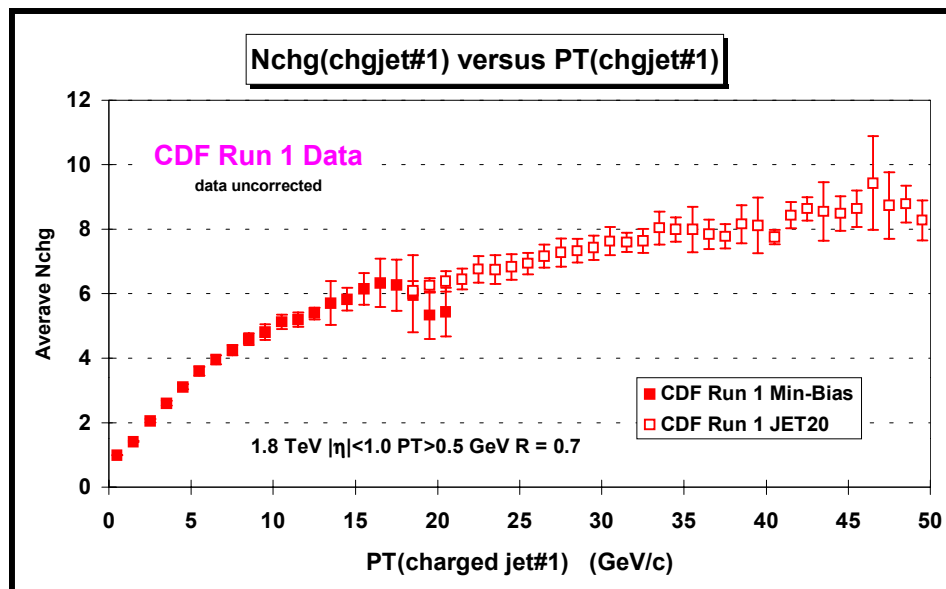
➔ Form “weighted” histograms using $P_T(\text{hard})$ so that I can use all **3,363,400** generated events! **Need another run with $PT(\text{min}) = 125 \text{ GeV/c}$!**



Evolution of Charged Jets

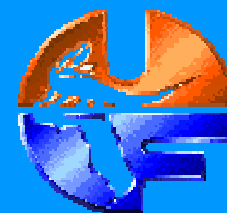


- ➔ Shows the data on the average number of charged particles within the leading charged particle jet ($|\eta| < 1$, $P_T > 0.5$ GeV, $R = 0.7$) as a function of the transverse momentum of the leading charged particle jet from Run 1.

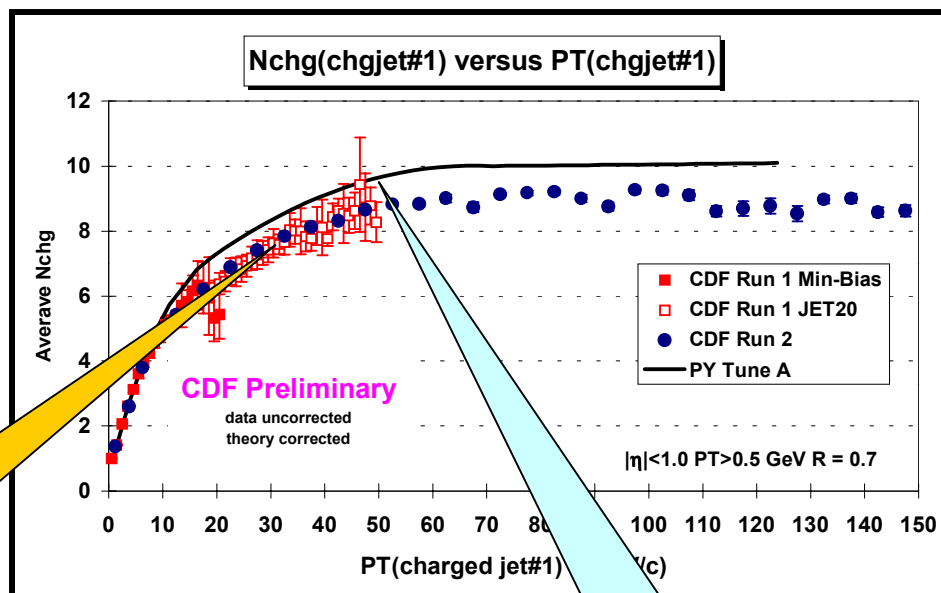




Evolution of Charged Jets



- ➔ Shows the data on the average number of charged particles within the leading charged particle jet ($|\eta| < 1$, $P_T > 0.5$ GeV, $R = 0.7$) as a function of the transverse momentum of the leading charged particle jet from Run 1.



Excellent agreement
between Run 1 and 2!

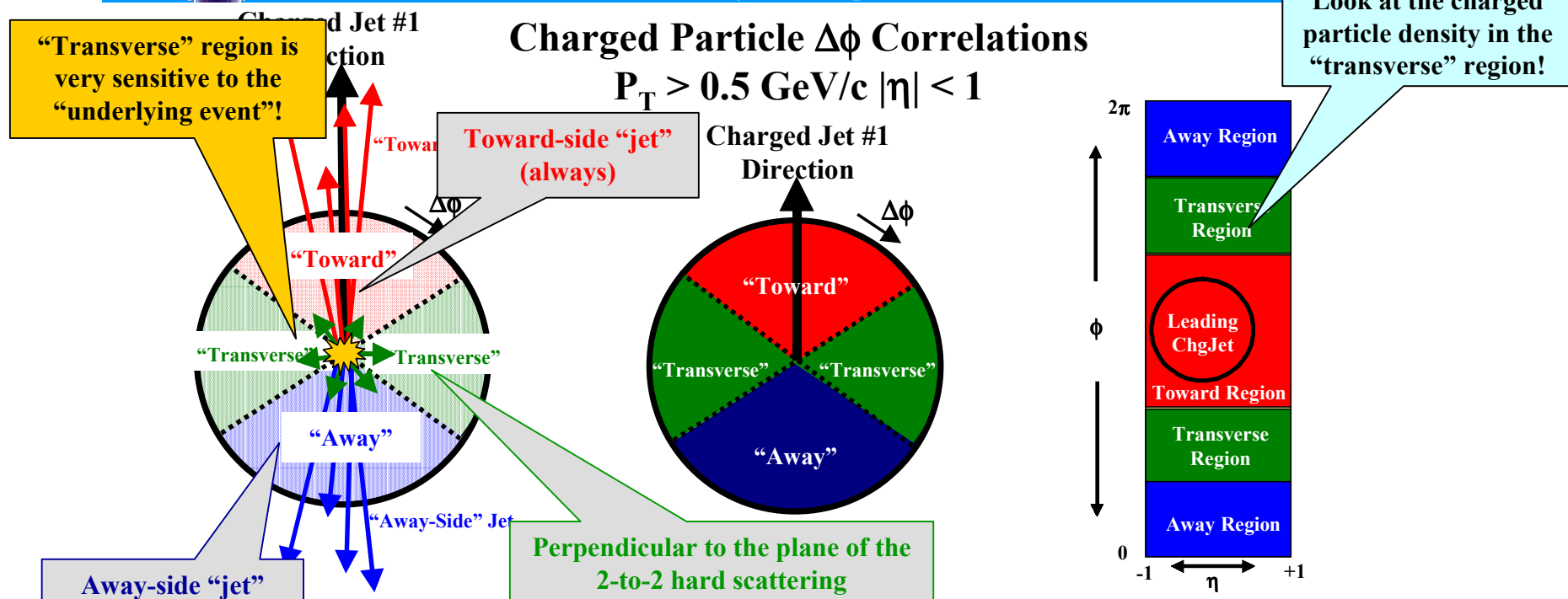
To Be Blessed

- ➔ Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) with Run 1.

PYTHIA produces too many charged particles in the leading chgjet!



Evolution of Charged Jets “Underlying Event”

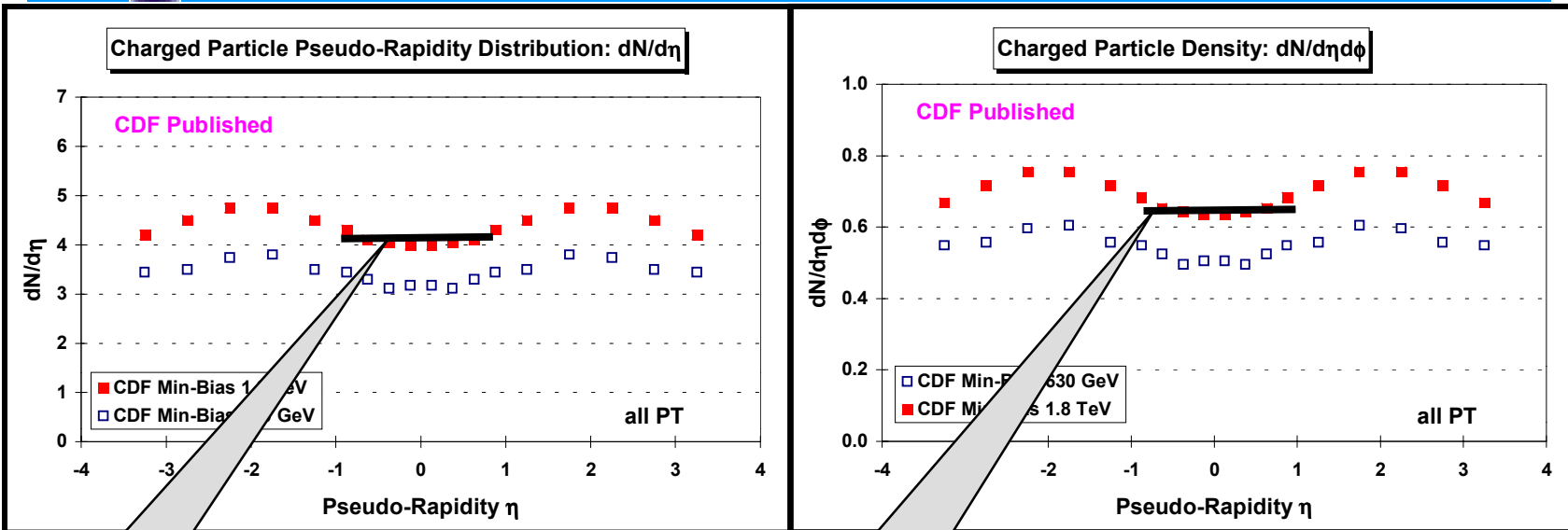


Look at charged particle correlations in the azimuthal angle $\Delta\phi$ relative to the leading charged particle jet.

- ➔ Define $|\Delta\phi| < 60^\circ$ as “Toward”, $60^\circ < |\Delta\phi| < 120^\circ$ as “Transverse”, and $|\Delta\phi| > 120^\circ$ as “Away”.
- ➔ All three regions have the same size in η - ϕ space, $\Delta\eta \times \Delta\phi = 2 \times 120^\circ = 4\pi/3$.



CDF “Min-Bias” Data Charged Particle Density



$\langle dN_{\text{chg}}/d\eta \rangle = 4.2$

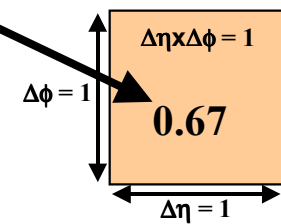
CDF “Min-Bias” data on the

$\langle dN_{\text{chg}}/d\eta d\phi \rangle = 0.67$

particles per unit pseudo-rapidity

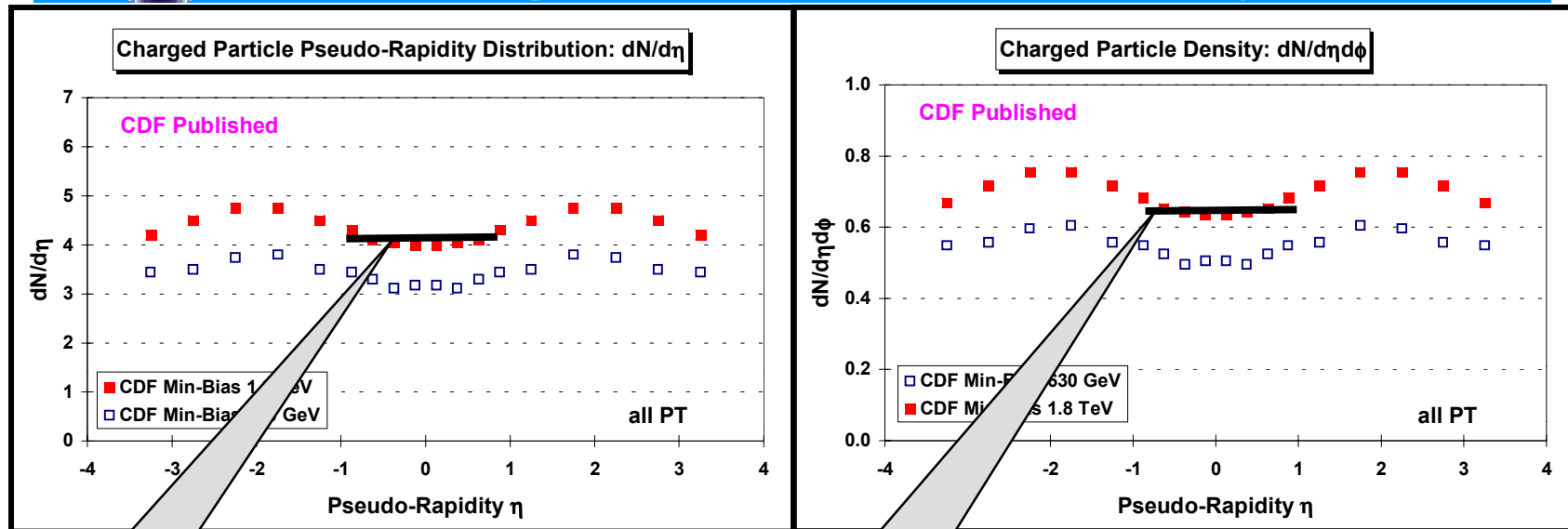
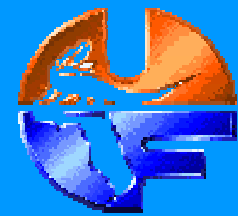
at 630 and 1,800 GeV. There are about **4.2 charged particles per unit η in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all P_T).**

- ➔ Convert to charged particle density, $dN_{\text{chg}}/d\eta d\phi$, by dividing by 2π . There are about **0.67 charged particles per unit η - ϕ in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all P_T).**





CDF “Min-Bias” Data Charged Particle Density



$$\langle dN_{\text{chg}}/d\eta \rangle = 4.2$$

“Min-Bias” data on the

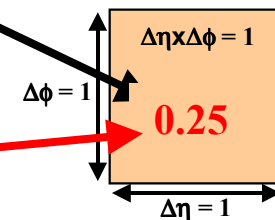
$$\langle dN_{\text{chg}}/d\eta d\phi \rangle = 0.67$$

particles per unit pseudo-rapidity

at 630 and 1,800 GeV. There are about **4.2 charged particles per unit η in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all P_T).**

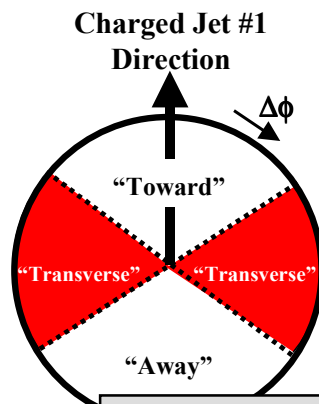
- ➔ Convert to charged particle density, $dN_{\text{chg}}/d\eta d\phi$, by dividing by 2π . There are about **0.67 charged particles per unit η - ϕ in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all P_T).**

- ➔ There are about **0.25 charged particles per unit η - ϕ in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, $P_T > 0.5$ GeV/c).**

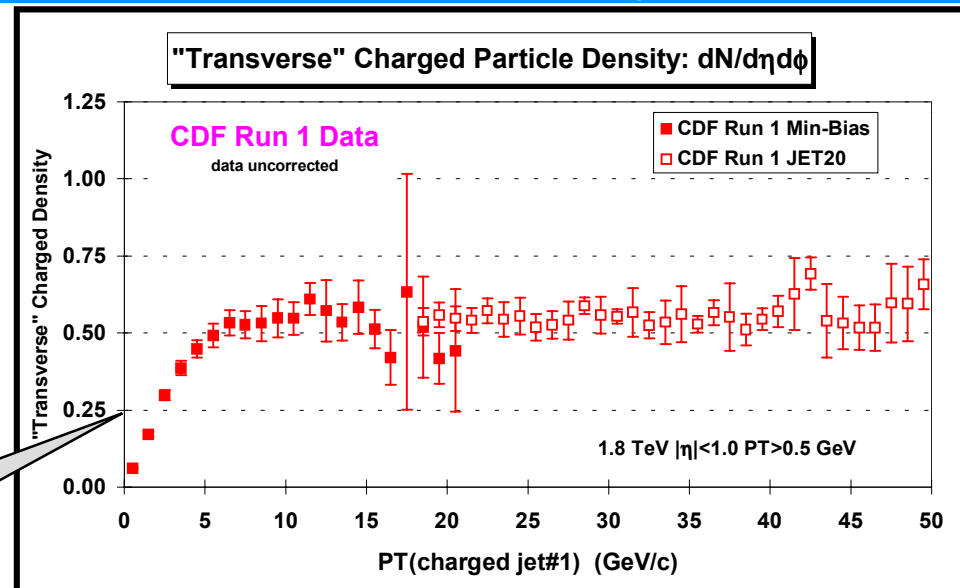




“Transverse” Charged Particle Density



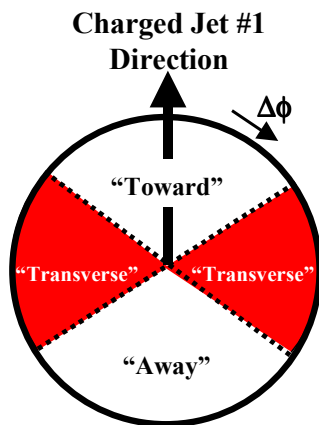
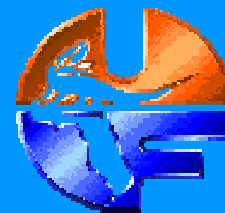
CDF “Min-Bias” data
($|\eta| < 1$, $P_T > 0.5$ GeV)
 $\langle dN_{\text{chg}}/d\eta d\phi \rangle = 0.25$



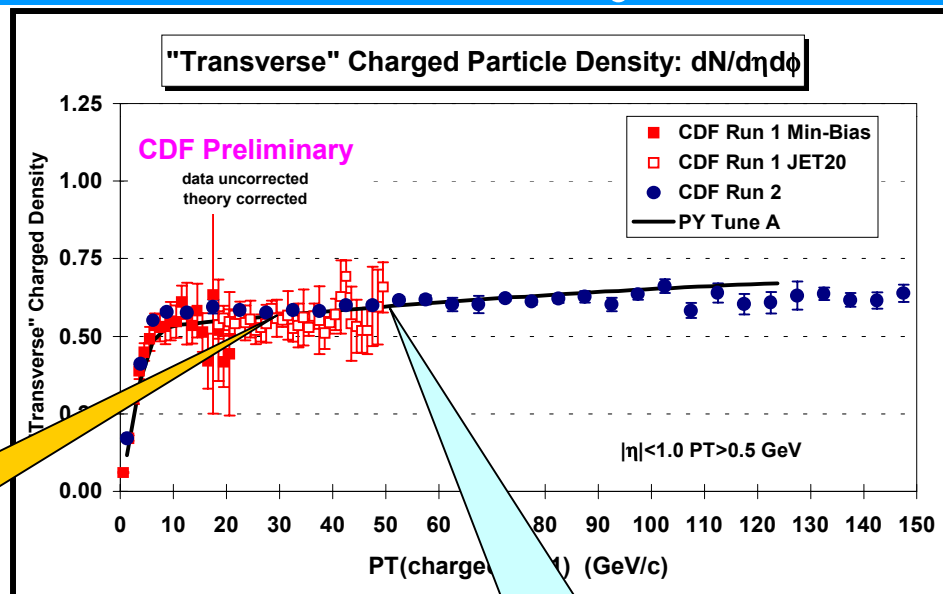
- ➔ Shows the data on the average “transverse” charge particle density ($|\eta| < 1$, $P_T > 0.5$ GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.



“Transverse” Charged Particle Density



Excellent agreement
between Run 1 and 2!



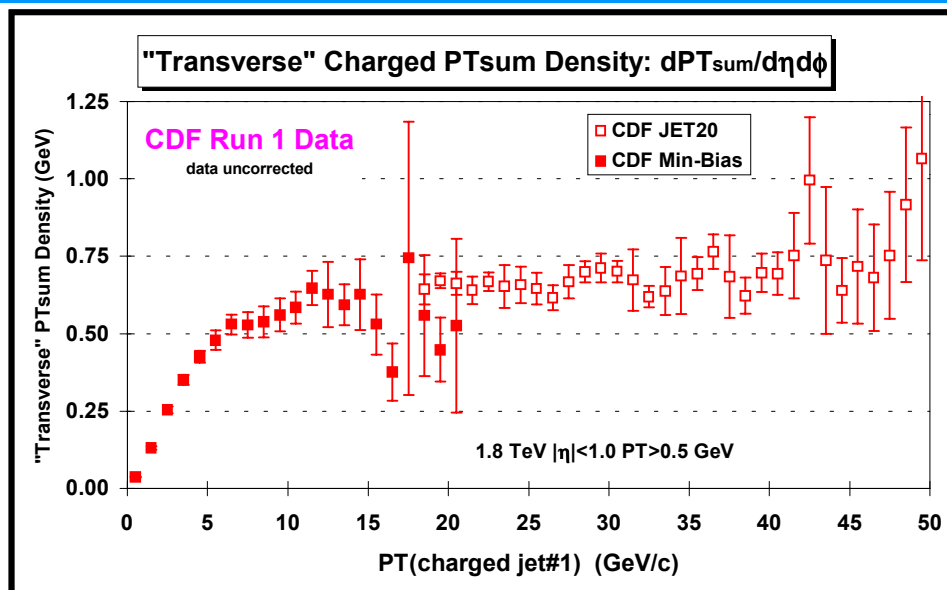
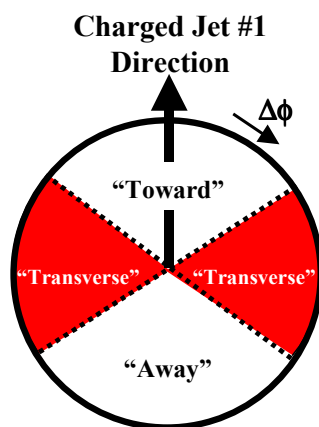
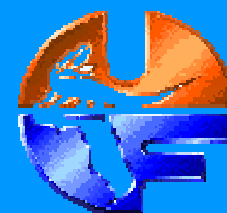
To Be Blessed

- ➔ Shows the data on the average “transverse” charge particle density ($|\eta| < 1, P_T > 0.5$ GeV) as a function of the transverse momentum of the leading charged particle from Run 1.
- ➔ Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) to the Run 1 data.

PYTHIA Tune A was tuned to fit the “underlying event” in Run I!



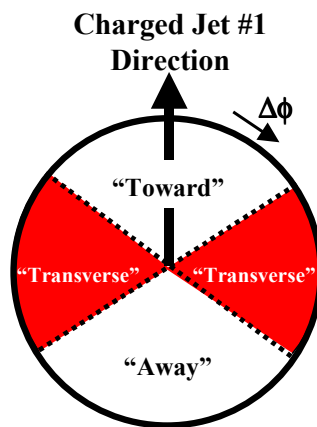
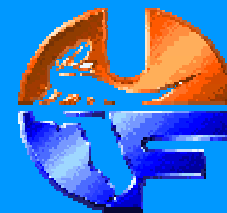
“Transverse” Charged PTsum Density



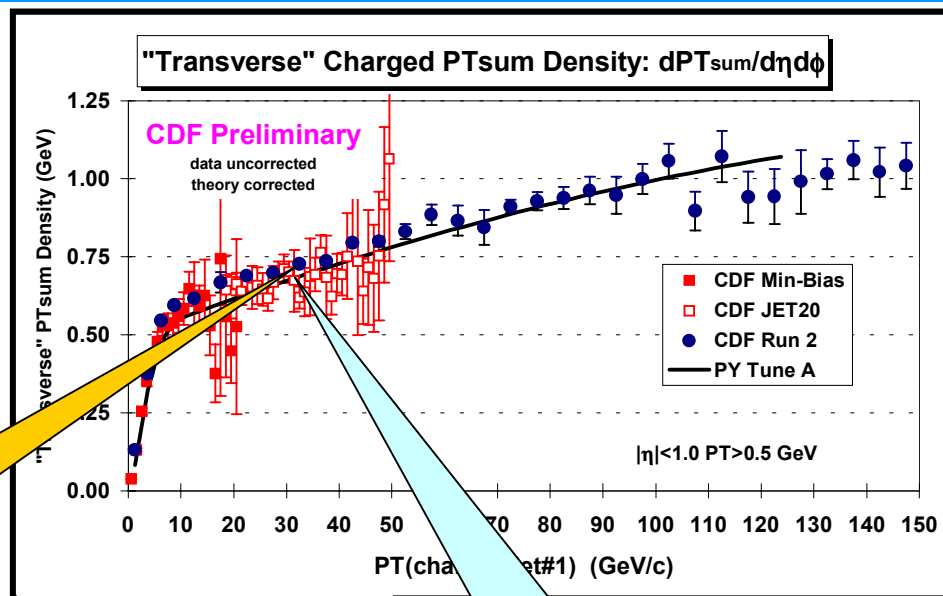
- ➔ Shows the data on the average “transverse” charged PTsum density ($|\eta| < 1$, $P_T > 0.5$ GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.



“Transverse” Charged PTsum Density



Excellent agreement
between Run 1 and 2!



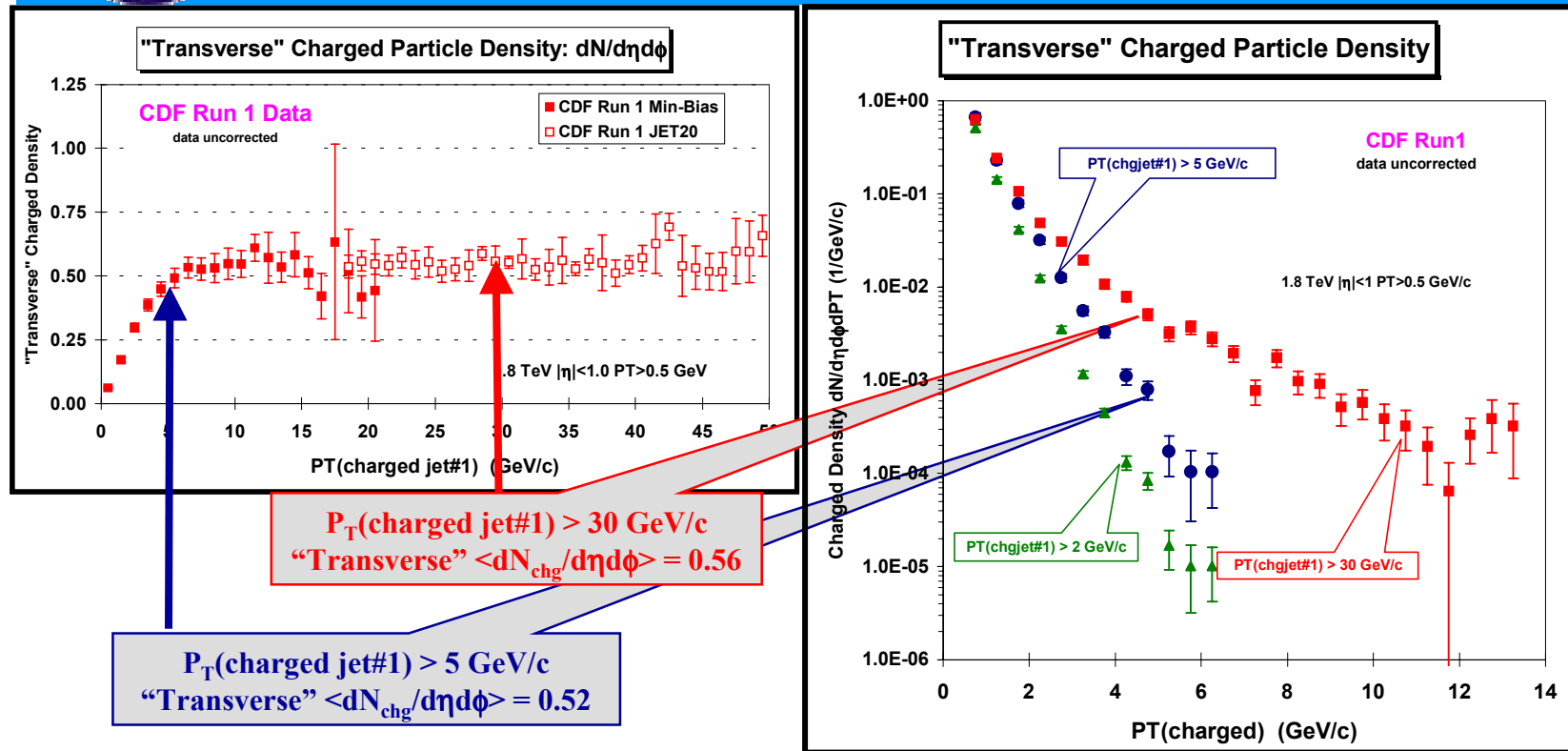
To Be Blessed

- ➔ Shows the data on the average “transverse” charged PTsum density ($|\eta| < 1, P_T > 0.5 \text{ GeV}$) as a function of the transverse momentum of the leading charged single jet from Run 1.
- ➔ Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) to the Run 1.

PYTHIA Tune A was tuned to fit the “underlying event” in Run I!



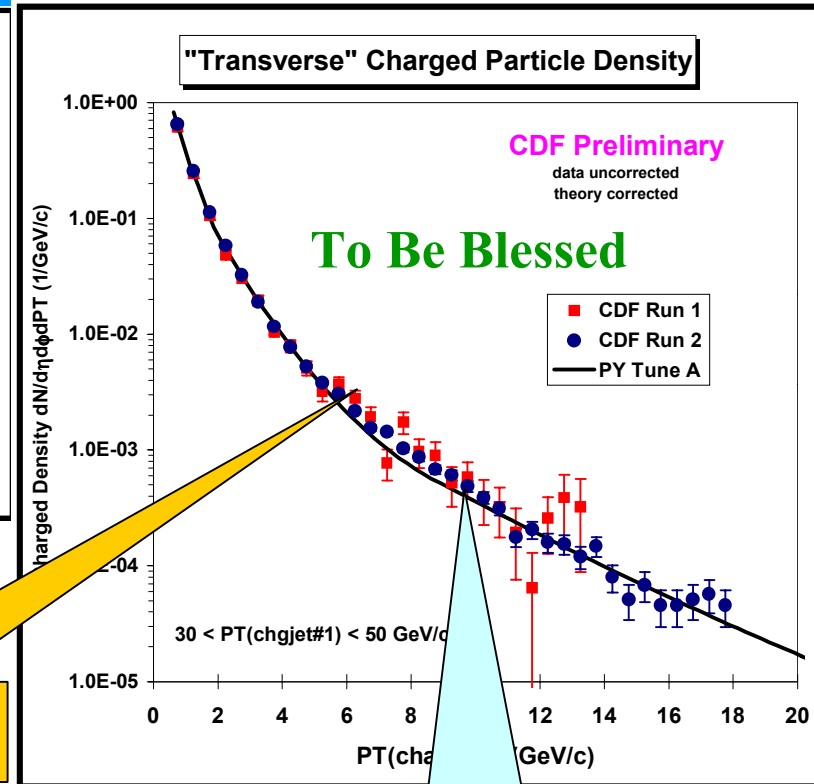
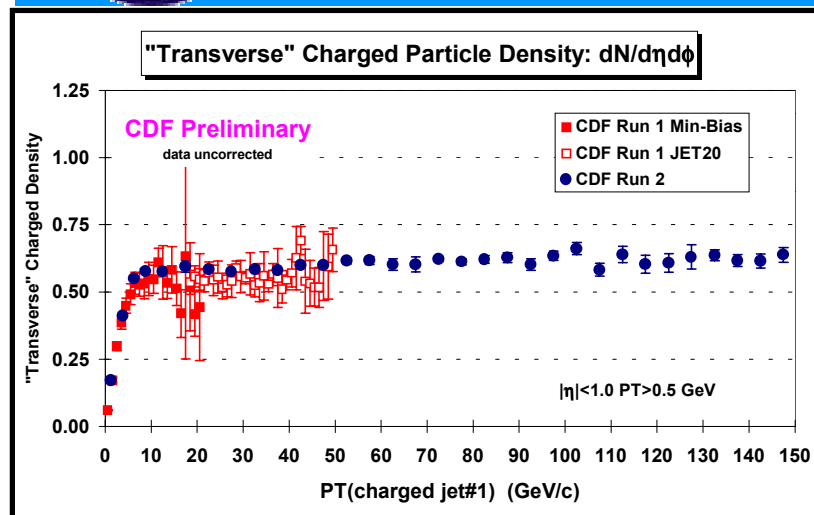
Charged Particle Density “Transverse” P_T Distribution



- ➔ Compares the average “transverse” charge particle density ($|\eta| < 1$, $P_T > 0.5$ GeV) versus $P_T(\text{charged jet\#1})$ with the P_T distribution of the “transverse” density, $dN_{\text{chg}}/d\eta d\phi dP_T$. Shows how the “transverse” charge particle density is distributed in P_T .



Charged Particle Density “Transverse” P_T Distribution



- ➔ Compares the average “transverse” charge particle density ($|\eta| < 1$, $P_T > 0.5$ GeV) versus P_T (charged jet#1) for Run 1 and Run 2. Shows how the “transverse” charge particle density is distributed in P_T .

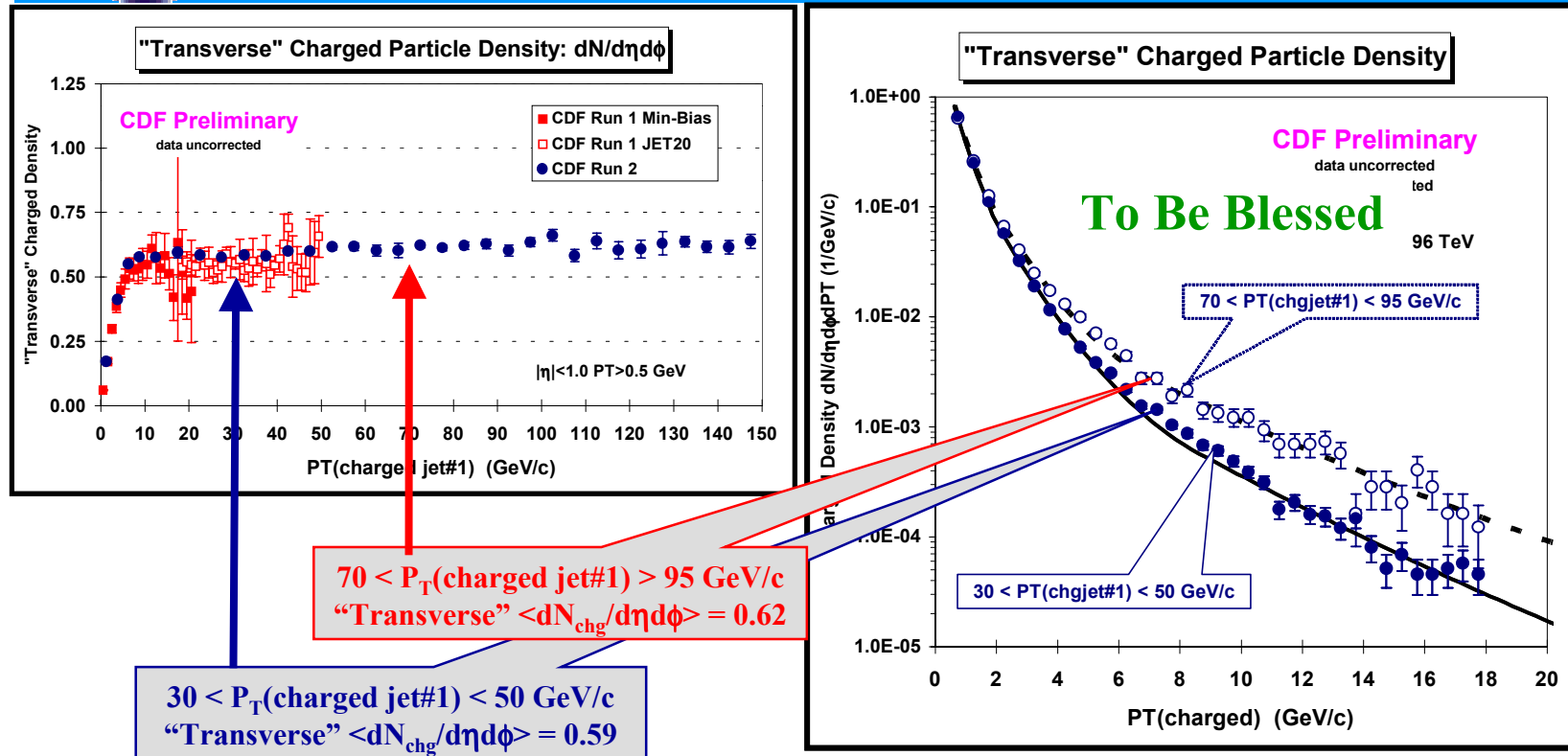
Excellent agreement
between Run 1 and 2!

- ➔ Compares the Run 2 data (JET20) with Run 1.

PYTHIA Tune A was tuned to fit the “underlying event” in Run I!



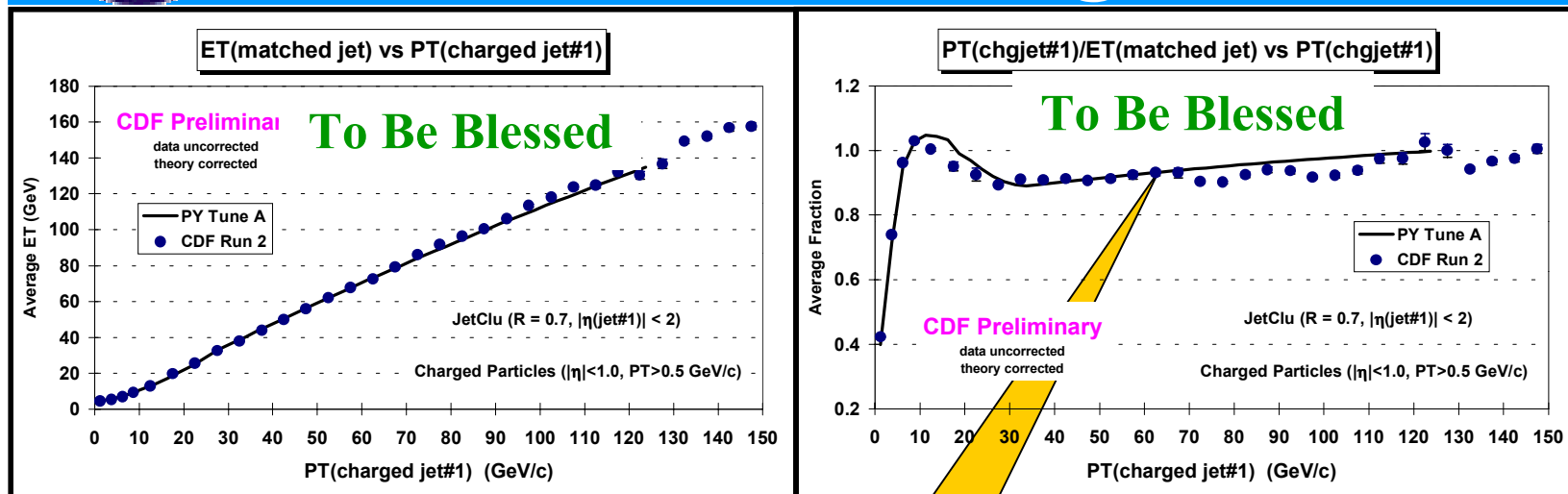
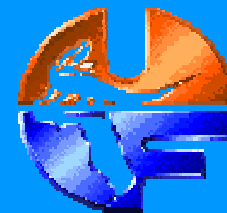
Charged Particle Density “Transverse” P_T Distribution



- ➔ Compares the average “transverse” charge particle density ($|\eta| < 1$, $P_T > 0.5$ GeV) versus $P_T(\text{charged jet\#1})$ with the P_T distribution of the “transverse” density, $dN_{\text{chg}}/d\eta d\phi dP_T$. Shows how the “transverse” charge particle density is distributed in P_T .



Relationship Between JetClu Jets and ChgJets



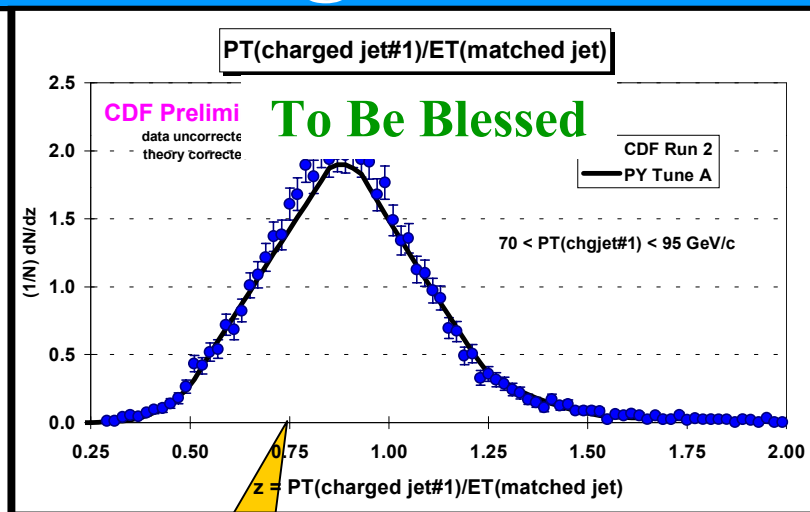
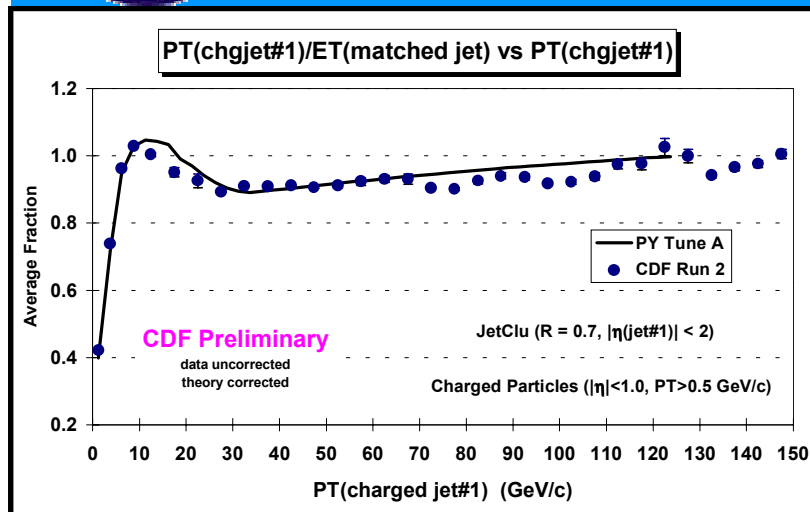
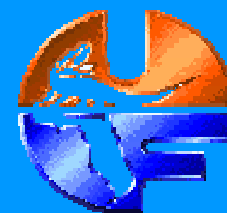
➔ Shows the matched JetClu jet ET versus the transverse momentum of the leading charged particle jet (**matched means closest jet within $R = 0.7$ of the leading chgjet**).

➔ Shows the ratio of $P_T(\text{chgjet\#1})$ to the matched JetClu jet ET versus $P_T(\text{chgjet\#1})$.

The leading chgjet comes from a JetClu jet that is, on the average, about 90% charged!



Relationship Between JetClu Jets and ChgJets



➔ Shows the ratio of $P_T(\text{chgjet\#1})$ to the matched JetClu jet ET versus $P_T(\text{chgjet\#1})$ (**matched means closest jet within $R = 0.7$ of the leading chgjet**).

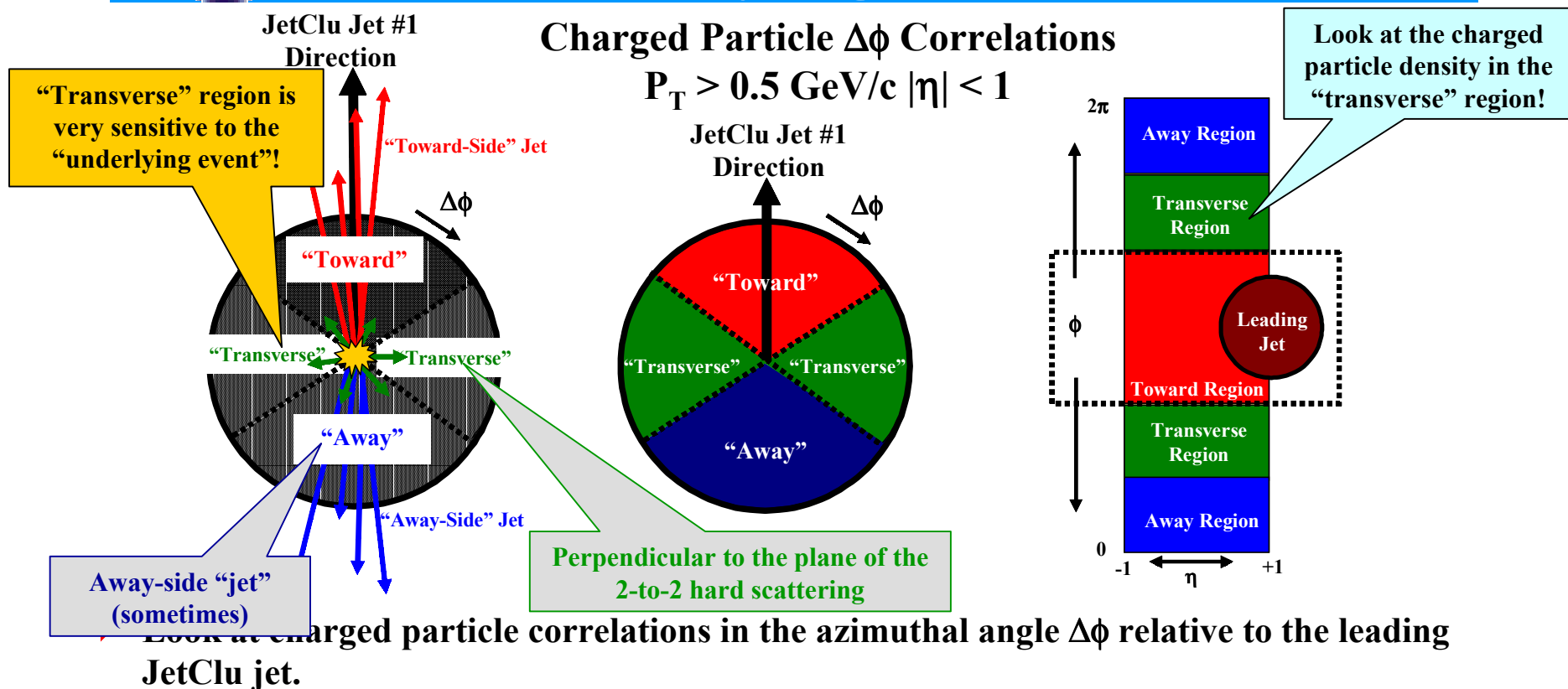
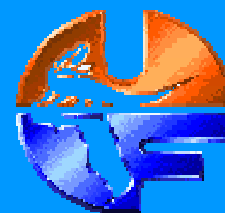
➔ Shows the distribution of $z = P_T(\text{chgjet\#1})/ET(\text{matched jet})$ for $70 < P_T(\text{chgjet\#1}) < 95 \text{ GeV/c}$.

About 77% of charged jets ($70 < P_T(\text{chgjet}) < 95 \text{ GeV/c}$) come from jets in which they carry greater than 75 % of the overall jet energy!



Evolution of JetClu Jets

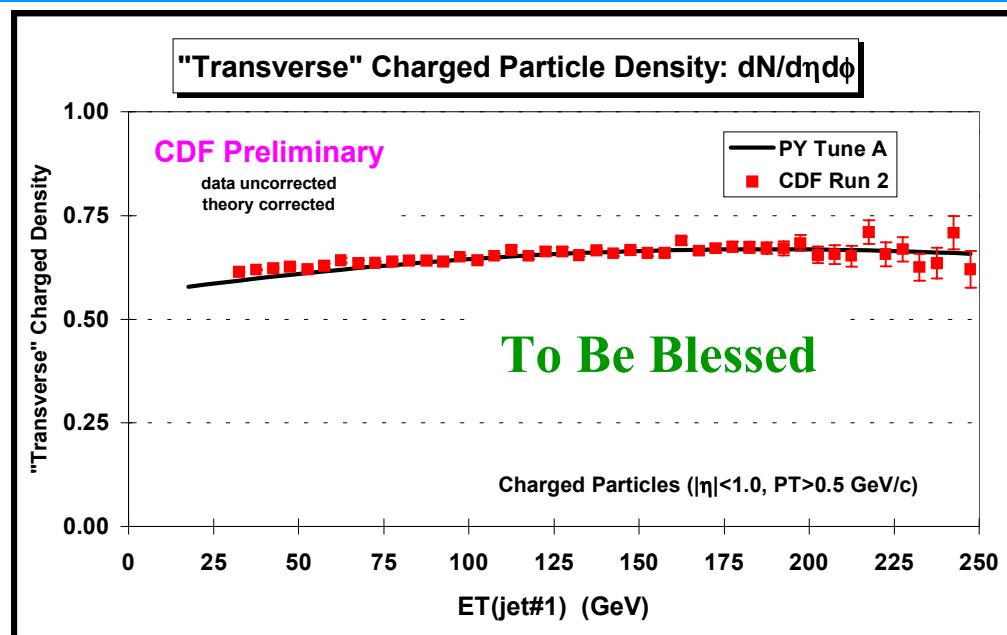
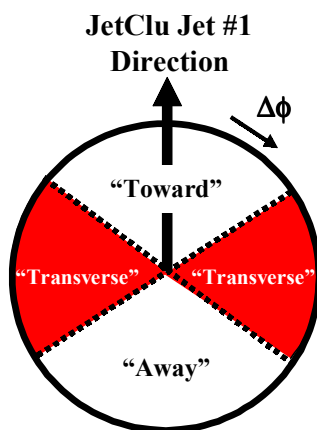
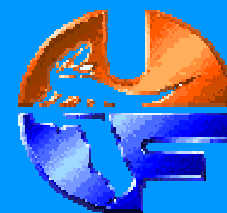
“Underlying Event”



- ➡ Define $|\Delta\phi| < 60^\circ$ as “Toward”, $60^\circ < |\Delta\phi| < 120^\circ$ as “Transverse”, and $|\Delta\phi| > 120^\circ$ as “Away”.
- ➡ All three regions have the same size in η - ϕ space, $\Delta\eta \times \Delta\phi = 2 \times 120^\circ = 4\pi/3$.



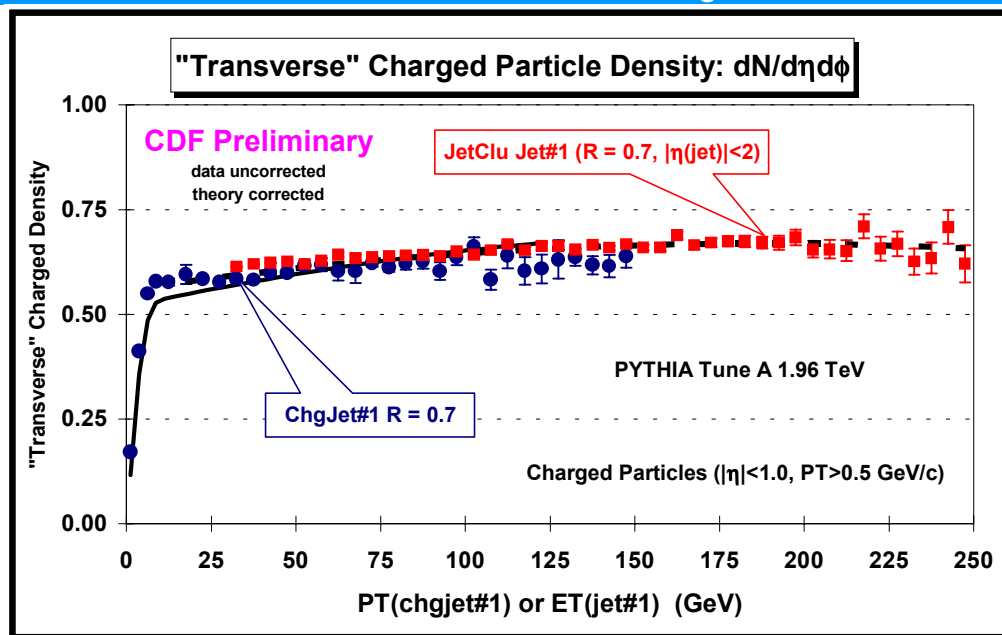
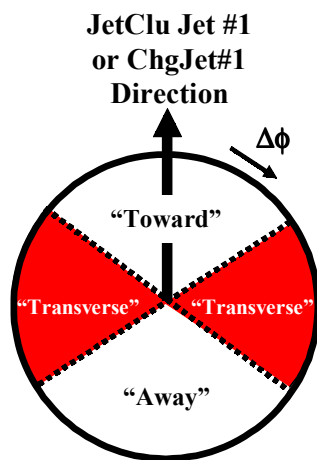
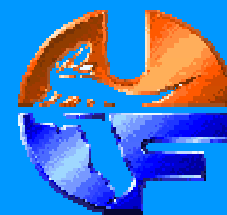
JetClu “Transverse” Charged Particle Density



- ➡ Shows the data on the average “transverse” charge particle density ($|\eta| < 1$, $PT > 0.5$ GeV) as a function of the transverse energy of the leading JetClu jet ($R = 0.7$, $|\eta(\text{jet})| < 2$) from Run 2 compared with the predictions of PYTHIA Tune A.



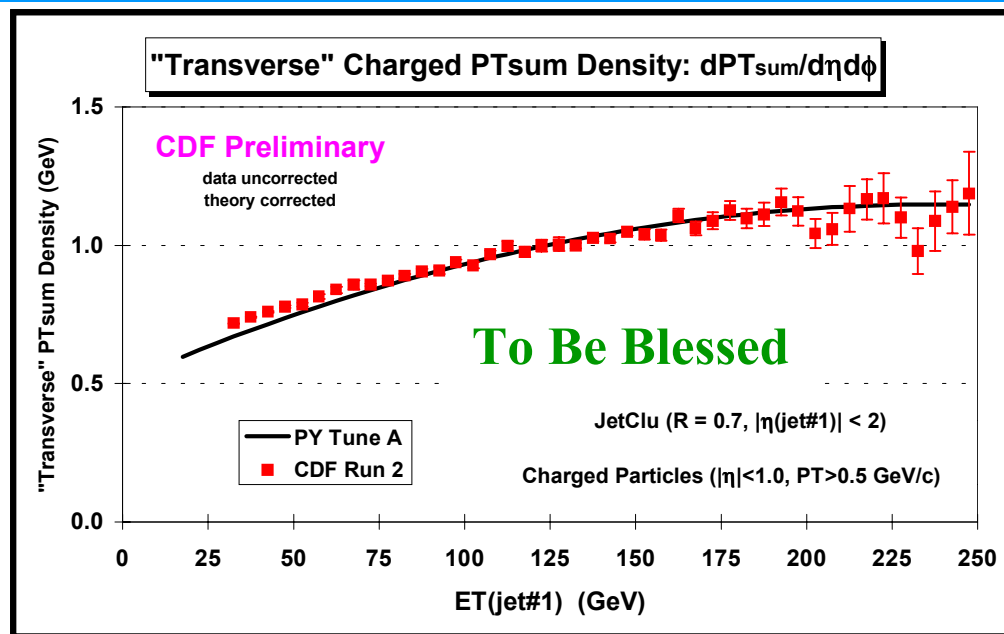
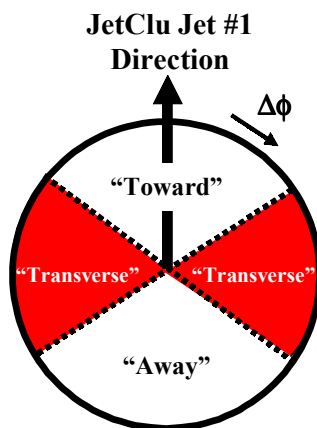
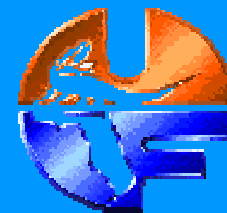
JetClu “Transverse” Charged Particle Density



- ➡ Shows the data on the average “transverse” charge particle density ($|\eta| < 1, PT > 0.5 \text{ GeV}$) as a function of the transverse energy of the leading JetClu jet ($R = 0.7, |\eta(\text{jet})| < 2$) from Run 2 compared with the predictions of PYTHIA Tune A.
- ➡ Compares the “transverse” region of the leading chgjet with the “transverse” region of the leading JetClu jet.



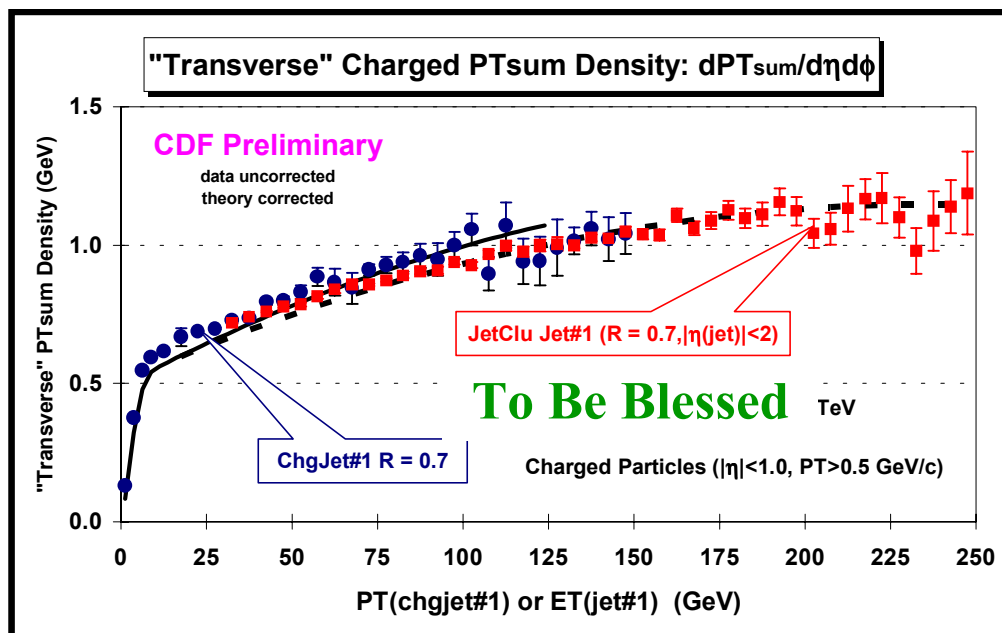
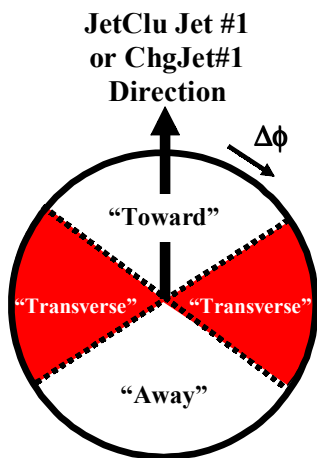
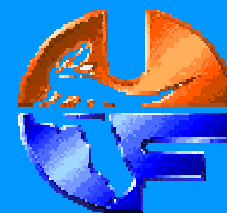
JetClu “Transverse” Charged PTsum Density



- ➡ Shows the data on the average “transverse” charged PTsum density ($|\eta| < 1, P_T > 0.5 \text{ GeV}$) as a function of the transverse energy of the leading JetClu jet ($R = 0.7, |\eta(\text{jet})| < 2$) from Run 2 compared with the predictions of PYTHIA Tune A.



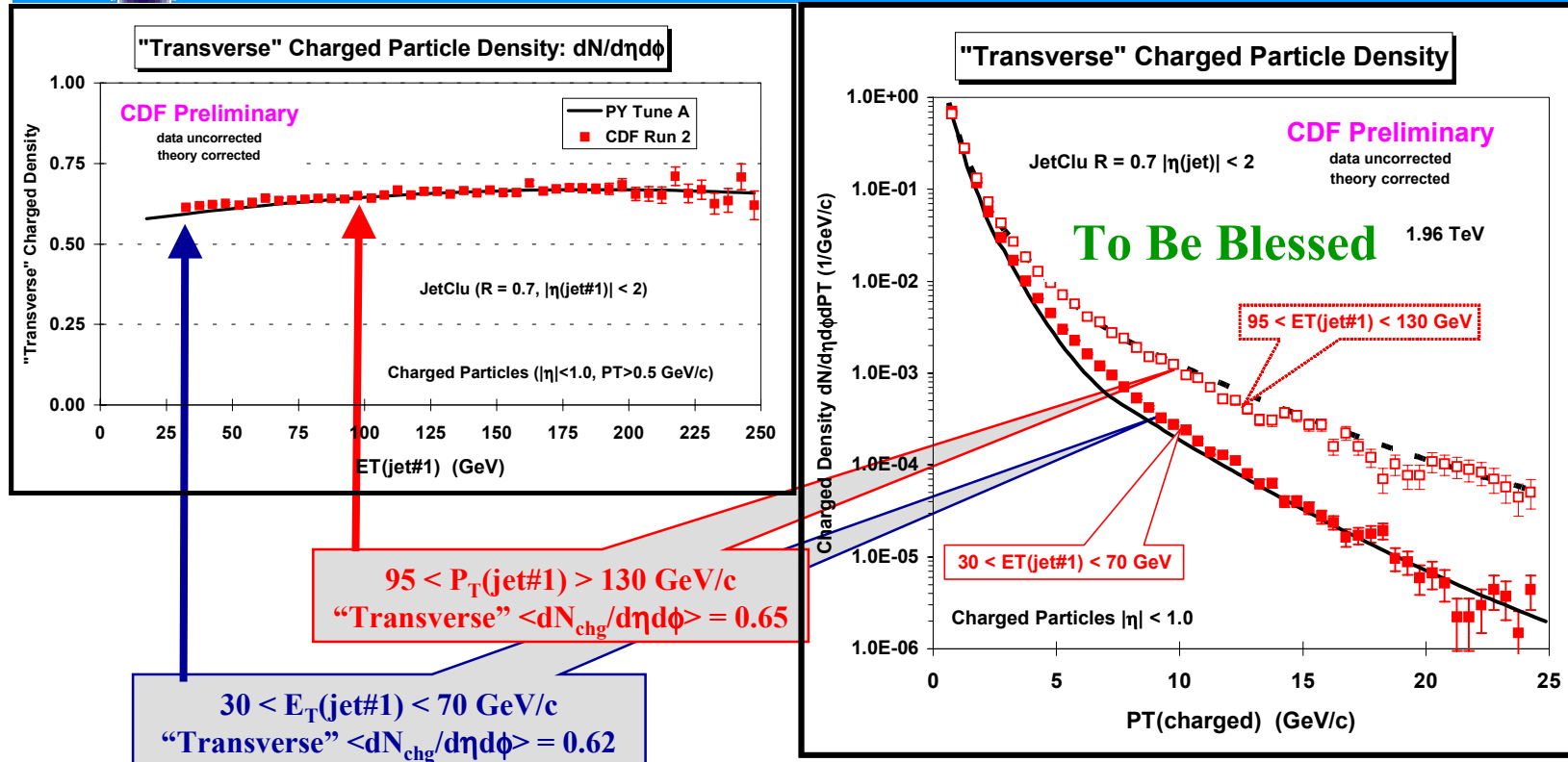
JetClu “Transverse” Charged PTsum Density



- ➡ Shows the data on the average “transverse” charged PTsum density ($|\eta| < 1$, $PT > 0.5$ GeV) as a function of the transverse energy of the leading JetClu jet ($R = 0.7$, $|\eta(jet)| < 2$) from Run 2 compared with the predictions of PYTHIA Tune A.
- ➡ Compares the “transverse” region of the leading chgjet with the “transverse” region of the leading JetClu jet.



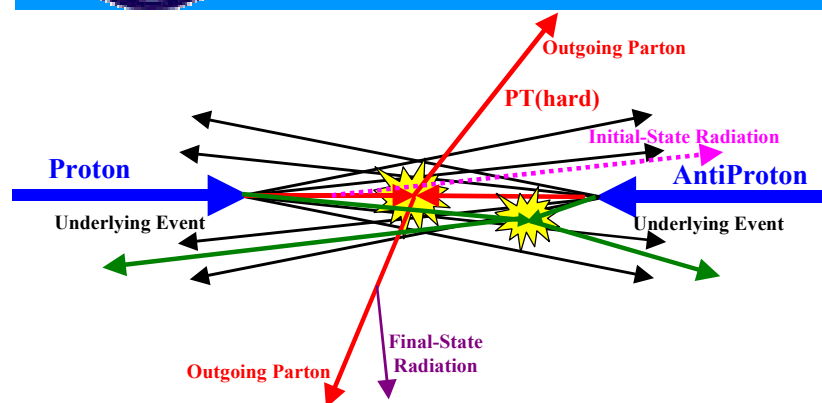
Charged Particle Density “Transverse” P_T Distribution



- ➔ Compares the average “transverse” charge particle density ($|\eta| < 1, P_T > 0.5 \text{ GeV}$) versus $E_T(jet\#1)$ with the P_T distribution of the “transverse” density, $dN_{chg}/d\eta d\phi dP_T$. Shows how the “transverse” charge particle density is distributed in P_T .



Summary



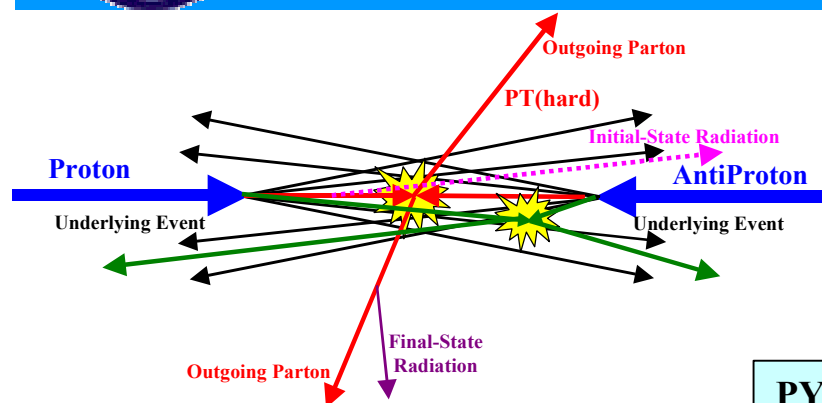
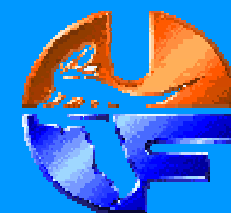
The “Underlying Event” in Run 2

Same conclusion
as Mario!

- ➔ There is excellent agreement between Run 1 and Run 2 for charged particles. The “underlying event” is the same in Run 2 as in Run 1 but now we can study the evolution out to much higher energies!
- ➔ PYTHIA Tune A does a good job of describing the “underlying event” in the Run 2 data for both charged particle jets and calorimeter jets. However, I still need to study the distributions in the “transverse” region.
- ➔ With the new Min-Bias Stntuples (**thanks Anwar!**) so I can follow the evolution of charged particle jets (and calorimeter jets) to lower energies.
- ➔ Lots more to come including MAX/MIN “transverse” and MAX/MIN “cones” and “transverse” P_T distributions.



Summary



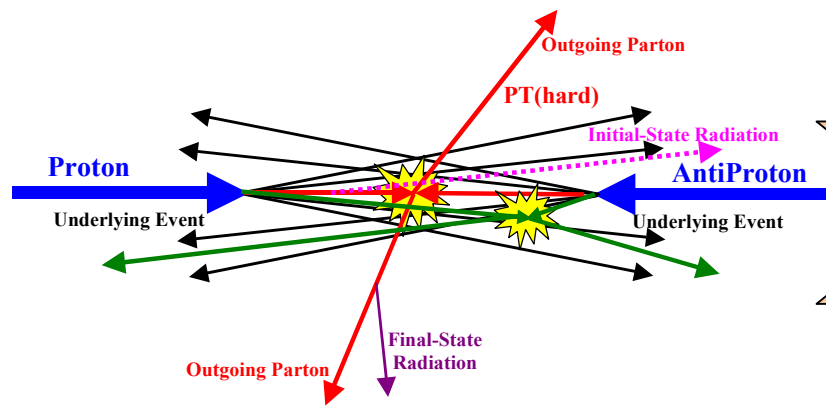
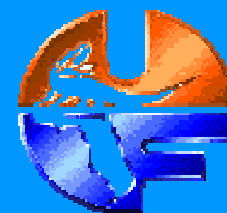
The “Overall Event”
in Run 2

PYTHIA Tune A does
not fit everything!

- ➡ PYTHIA Tune A (CTEQ5L) does not agree with the shape of the calorimeter jet cross-section and it predicts a larger charged particle fraction (*i.e.* larger charged $P_{T\text{sum}}$) within the leading calorimeter jet than in the Run 2 data. I still need to study the distributions!
- ➡ PYTHIA Tune A produces too many charged particles within the leading calorimeter jet and within the leading chgjet. (I tuned the “underlying event” not the jet fragmentation!).
- ➡ Much more to come, but we need another PYTHIA Tune A run with $P_{T(\text{min})} = 125$ GeV/c so we can compare at high ET.



Time Table for Blessing



Like to give a talk at the
MC Workshop (April 29-30)

If Joey asks me?

- ➡ Blessing in 4 weeks (QCD meeting on April 18).
- ➡ CDF Note by Monday April 1 (3 weeks before blessing).