ISMD 2010

Soft QCD at the LHC: Findings & Surprises

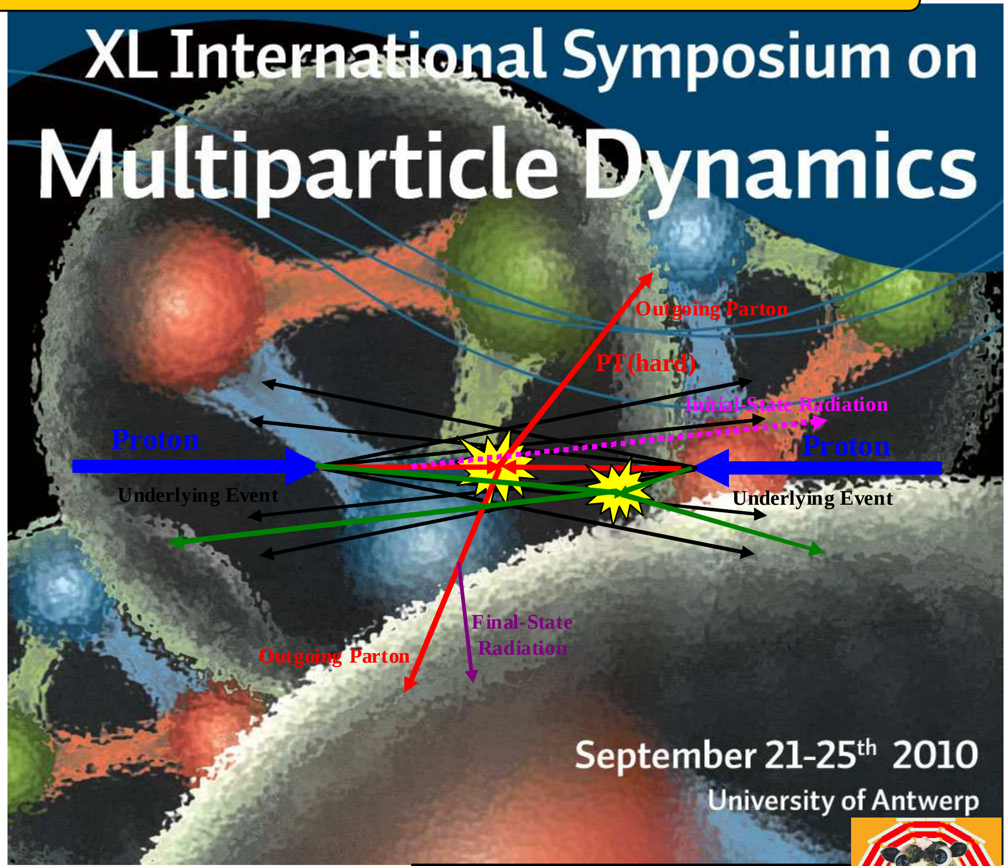
Rick Field

University of Florida

Quantum **C**hromo- **D**ynamics

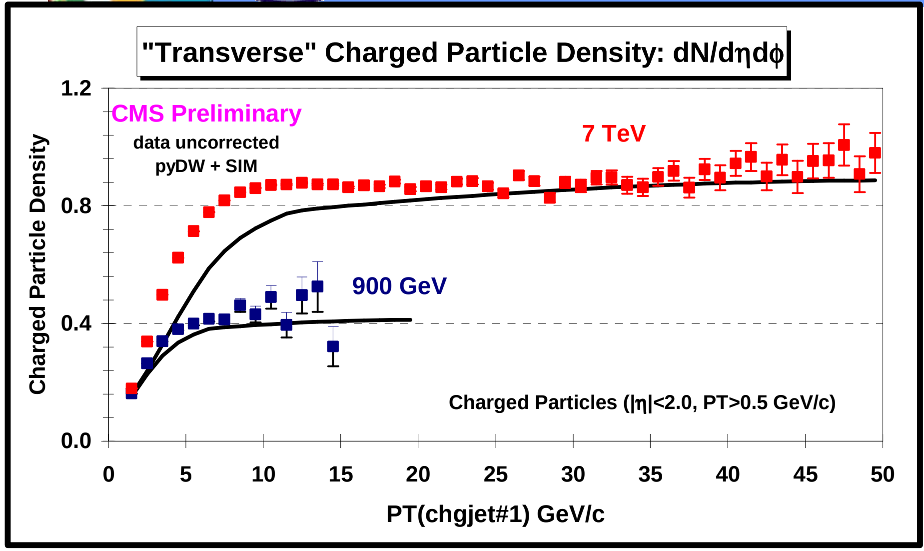
Outline of Talk

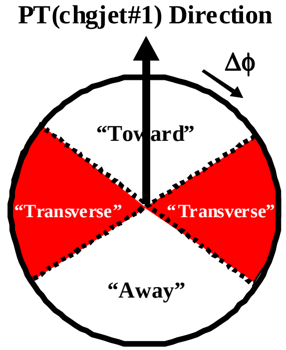
- **How well did we do at predicting the LHC UE data at 900 GeV and 7 TeV? A careful look.**
- **How well did we do at predicting the LHC MB data at 900 GeV and 7 TeV? A careful look.**
- **PYTHIA 6.4 Tune Z1: New CMS 6.4 tune (pT-ordered parton showers and new MPI) inspired by the ATLAS Tune AMBT1.**
- **Strange particle production. A problem for the models?**



UE&MB@CMS

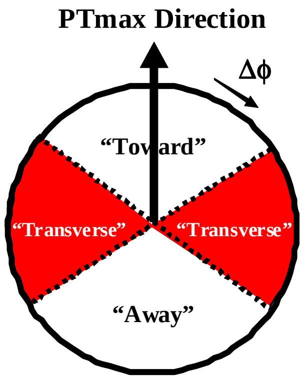
PYTHIA Tune DW

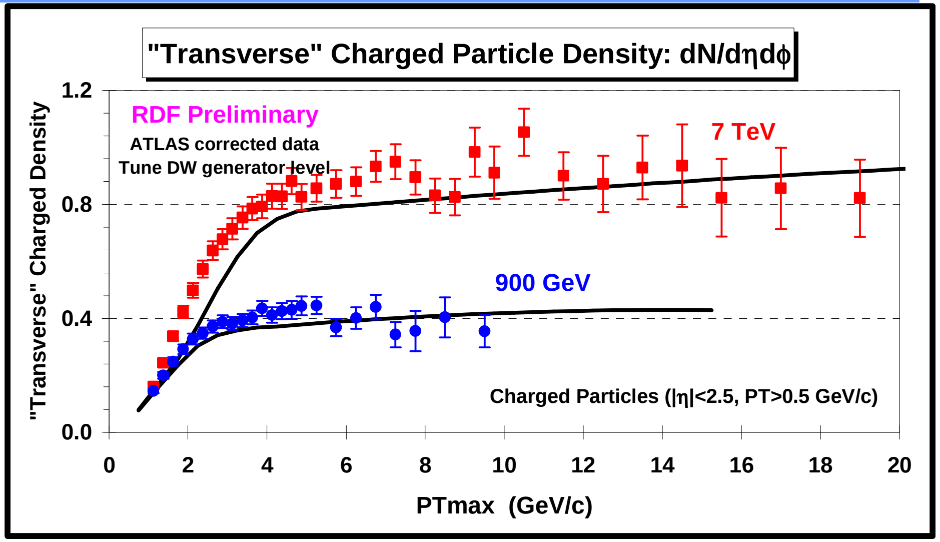




- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.**

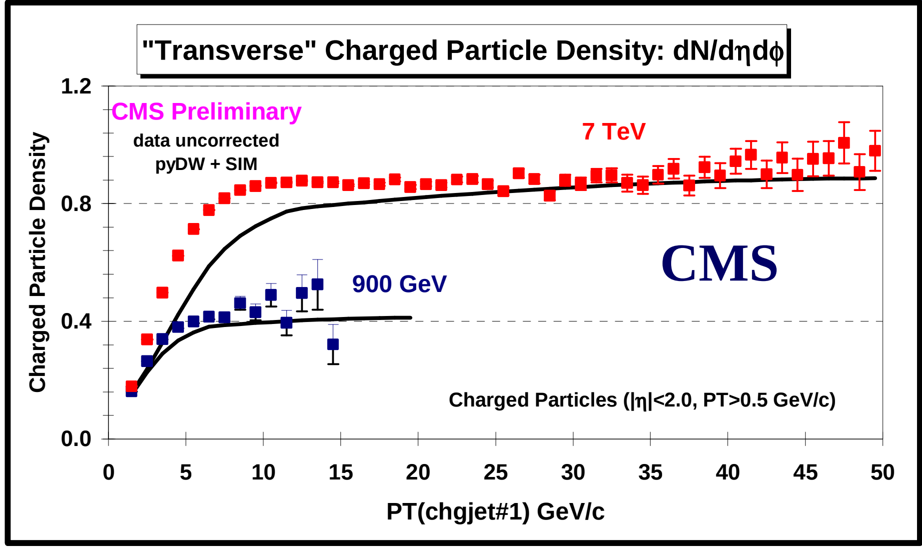
PYTHIA Tune DW

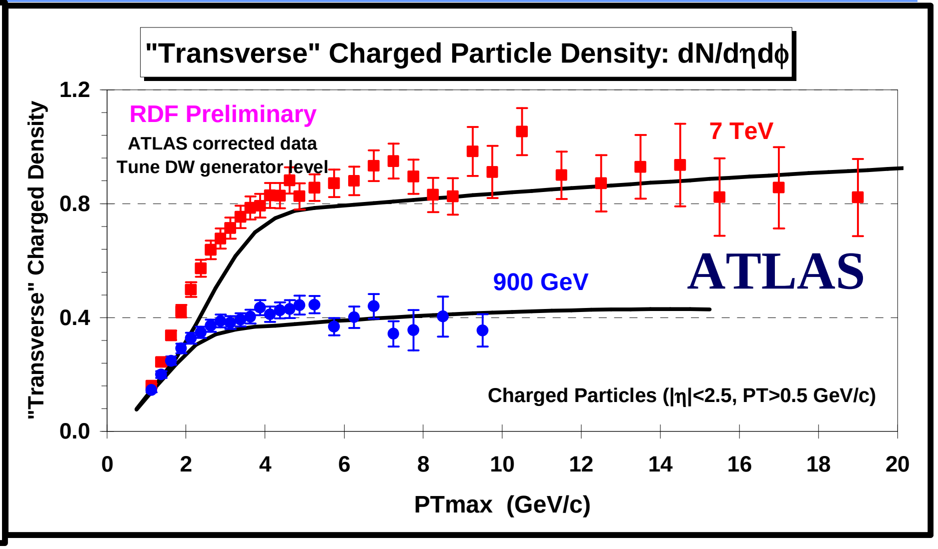




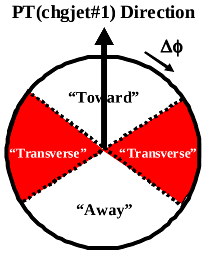
- **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

PYTHIA Tune DW

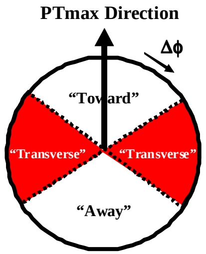




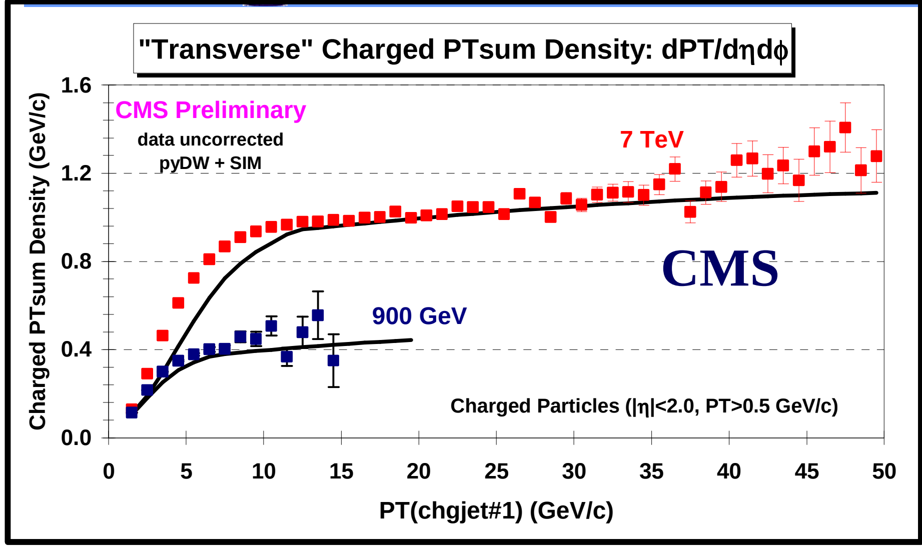
- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.**

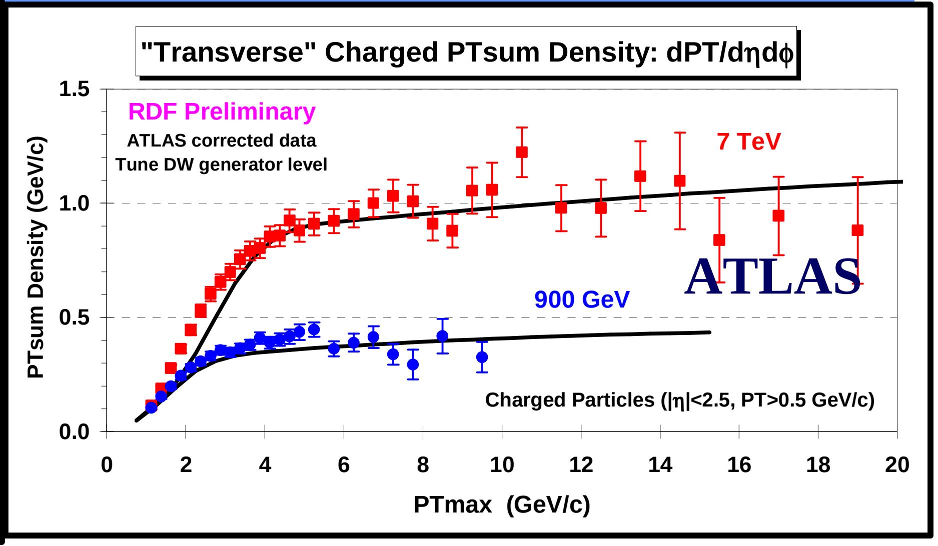


- **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

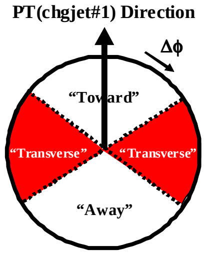


PYTHIA Tune DW

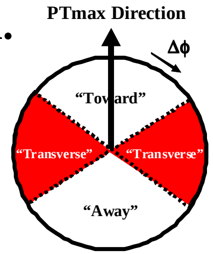




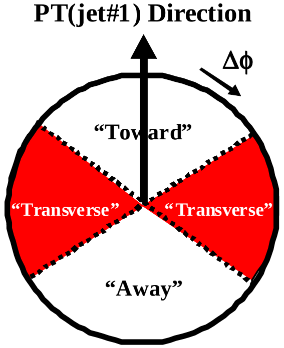
- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.**

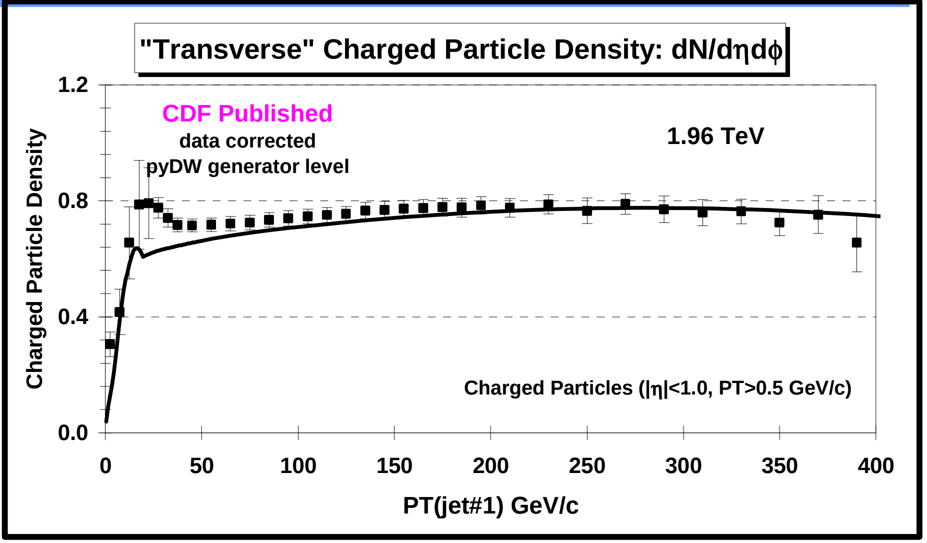


- **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune DW at the generator level.**



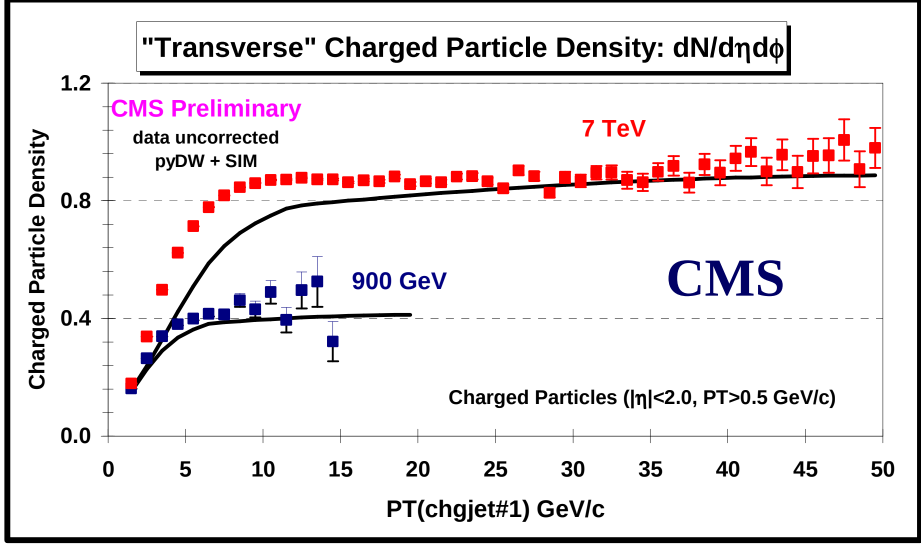
PYTHIA Tune DW

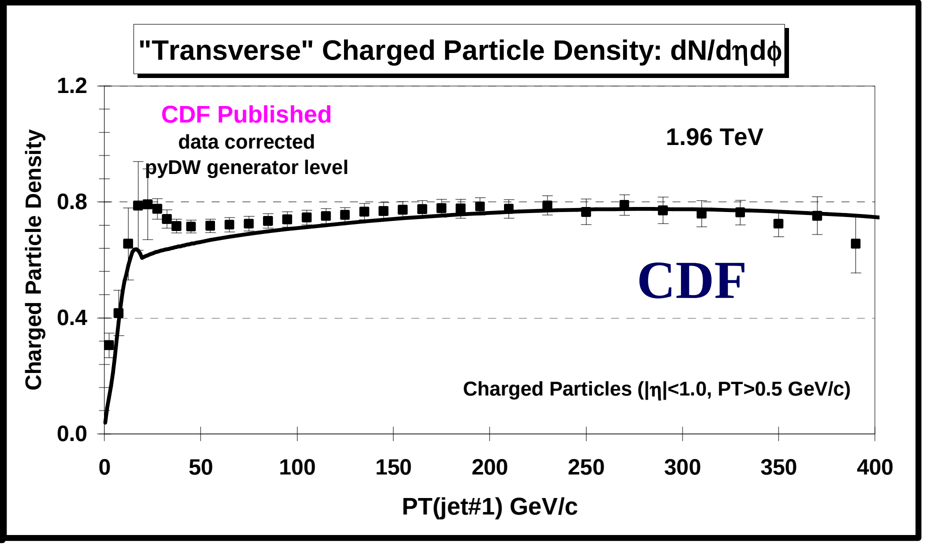




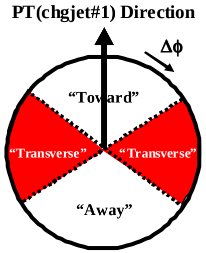
- **CDF published data at 1.96 TeV on the “transverse” charged particle density, dN/dηdϕ, as defined by the leading calorimeter jet (jet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 1.0. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

PYTHIA Tune DW

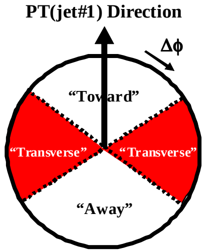




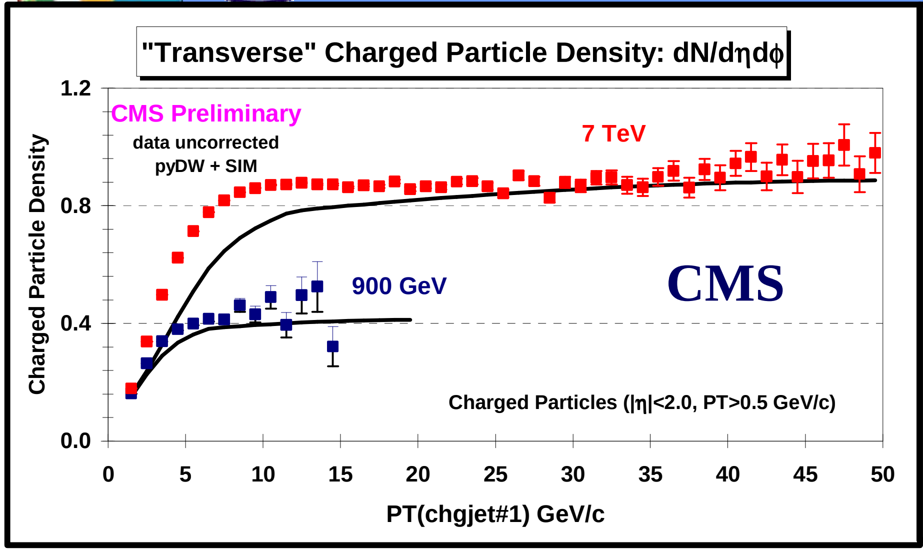
- CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.

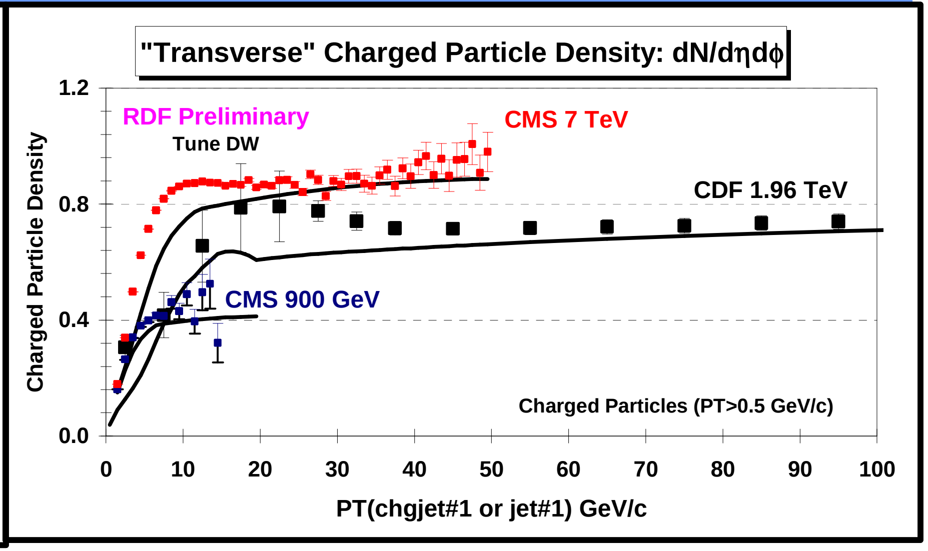


- CDF published data at 1.96 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading calorimeter jet (jet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$. The data are corrected and compared with PYTHIA Tune DW at the generator level.

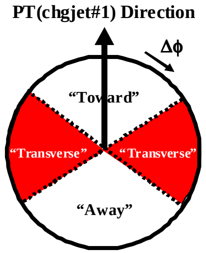


PYTHIA Tune DW

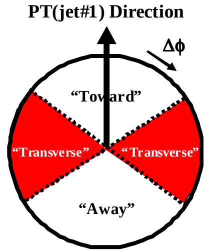




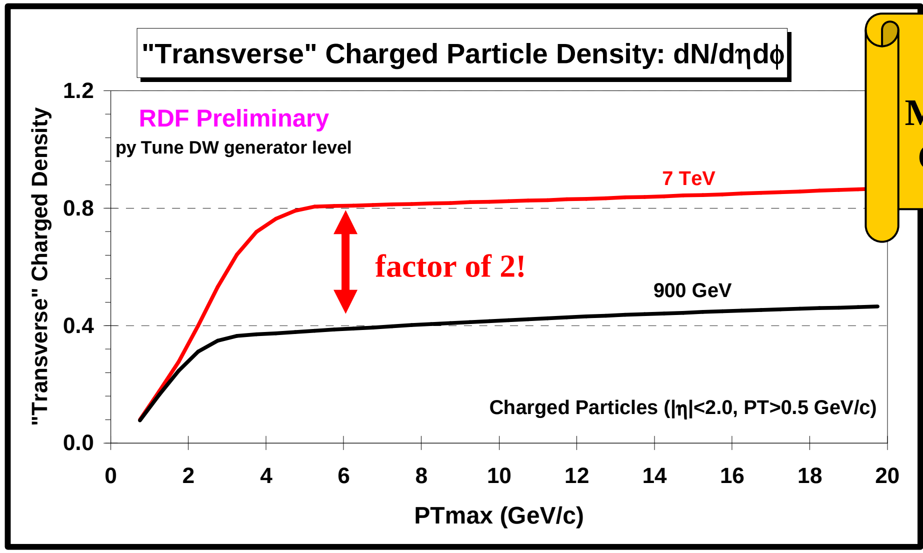
- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.**



- **CDF published data at 1.96 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading calorimeter jet (jet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 1.0. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

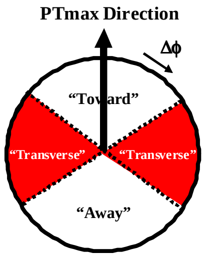


"Transverse" Charge Density



Rick Field
MB&UE@CMS Workshop
CERN, November 6, 2009

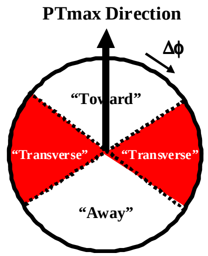
LHC
900 GeV



900 GeV → 7 TeV
(UE increase ~ factor of 2)

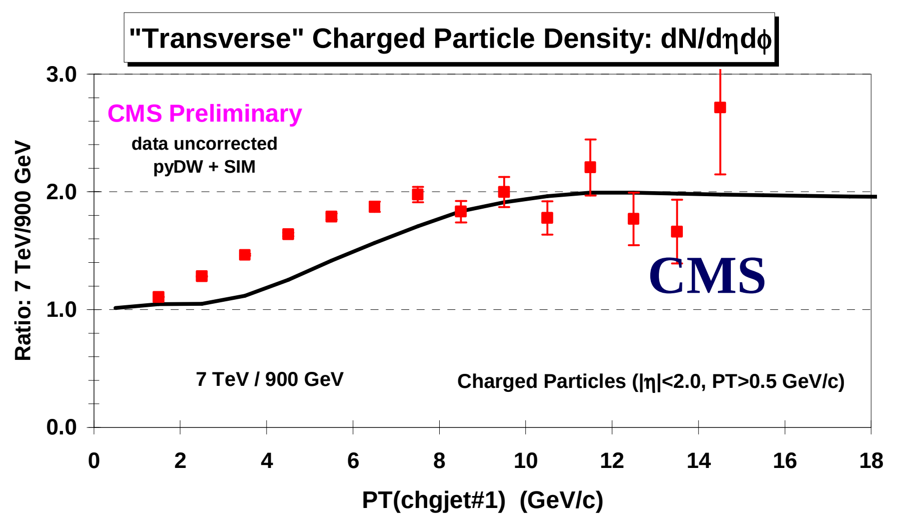
~0.4 → ~0.8

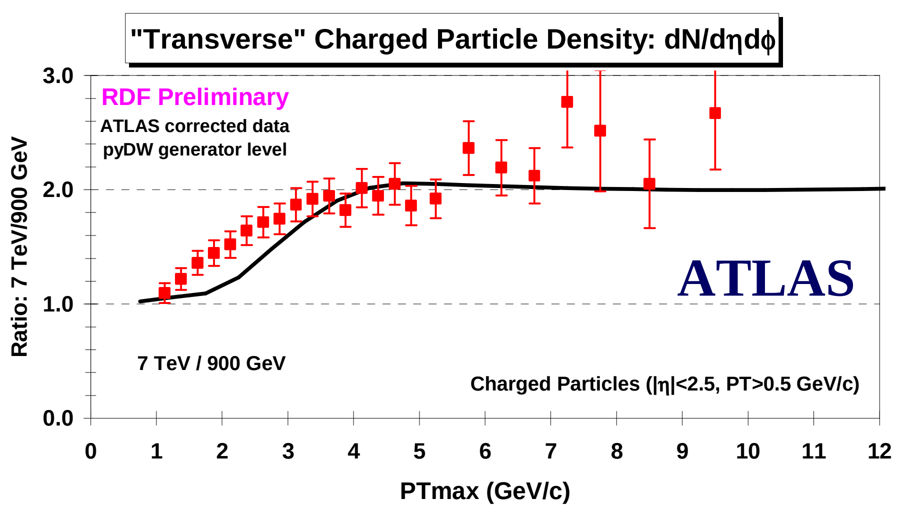
LHC
7 TeV



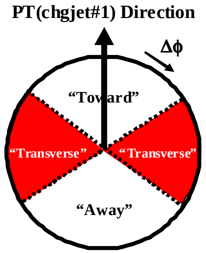
➡ **Shows the charged particle density in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) at 900 GeV and 7 TeV as defined by PTmax from PYTHIA Tune DW and at the particle level (*i.e.* generator level).**

PYTHIA Tune DW

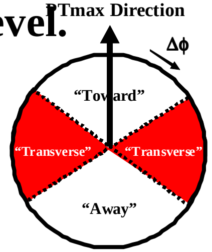




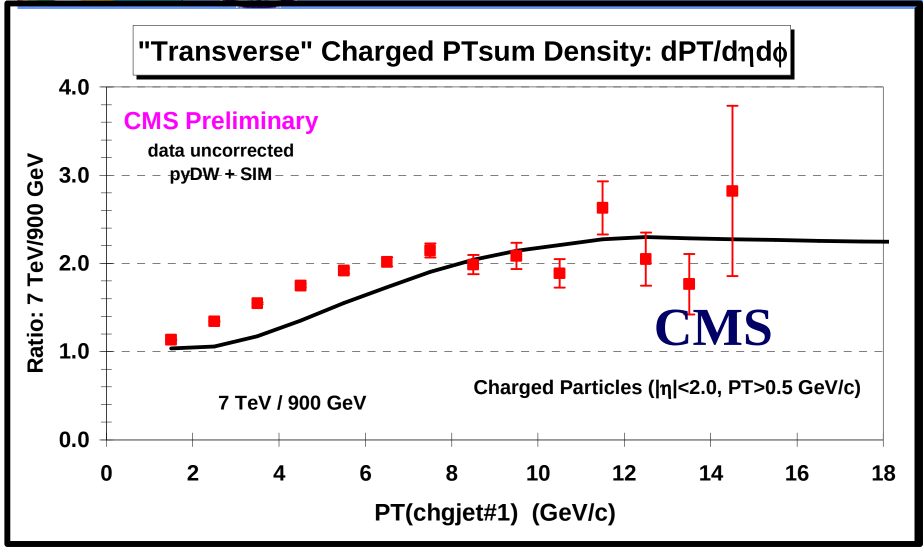
- **Ratio of CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.**

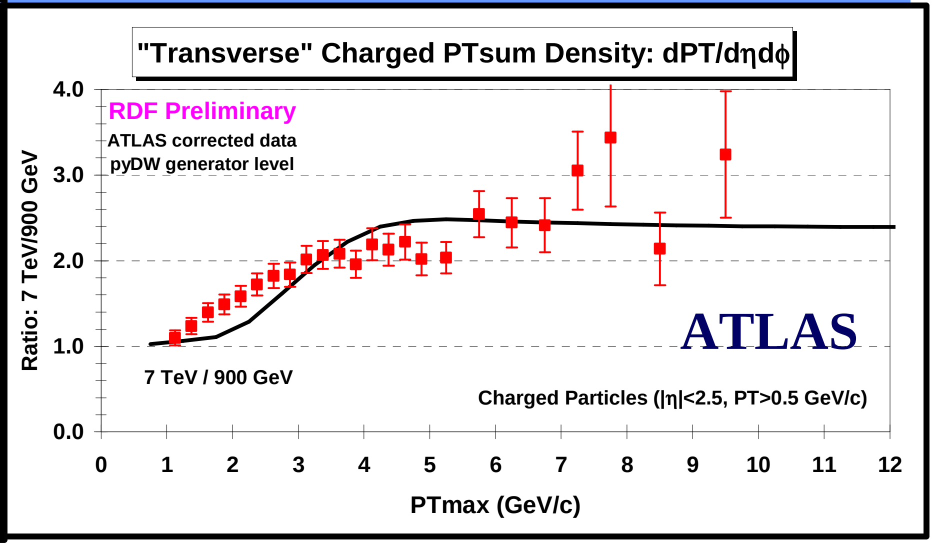


- **Ratio of the ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

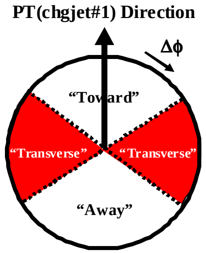


PYTHIA Tune DW

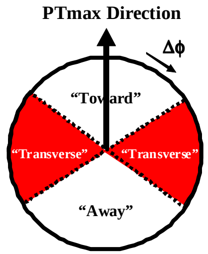




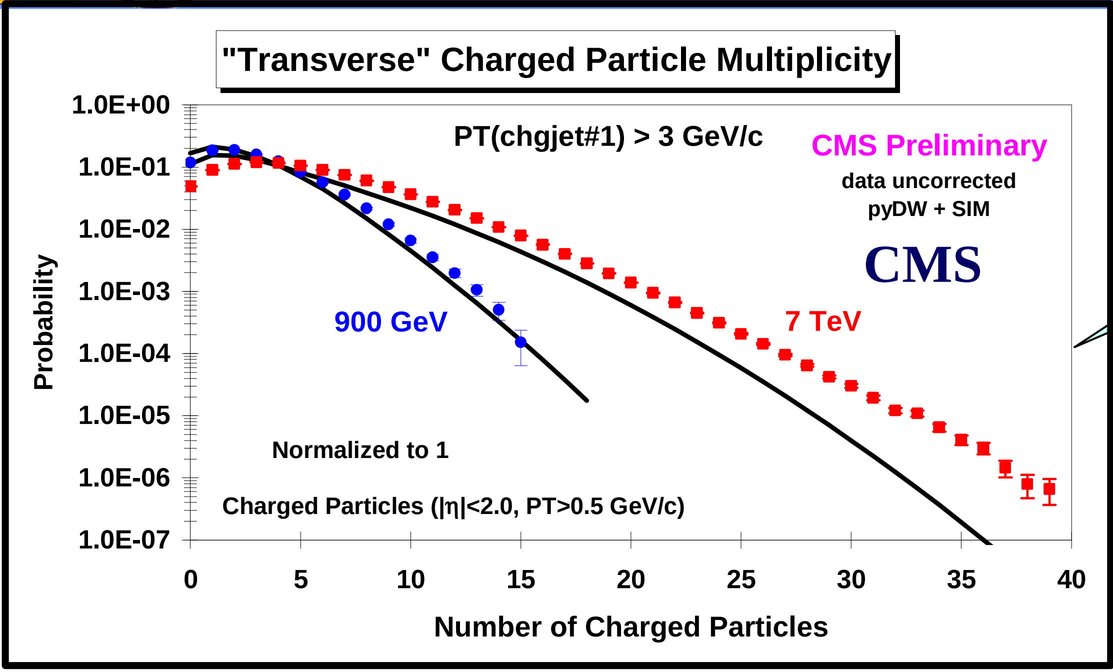
- **Ratio of the CMS preliminary data at 900 GeV and 7 TeV** on the "transverse" charged PTsum density, dPT/dηdϕ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA **Tune DW** after detector simulation.



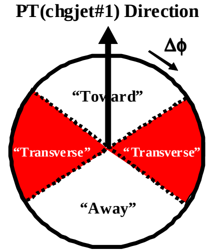
- **Ratio of the ATLAS preliminary data at 900 GeV and 7 TeV** on the "transverse" charged PTsum density, dPT/dηdϕ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA **Tune DW** at the generator level.



"Transverse" Multiplicity Distribution



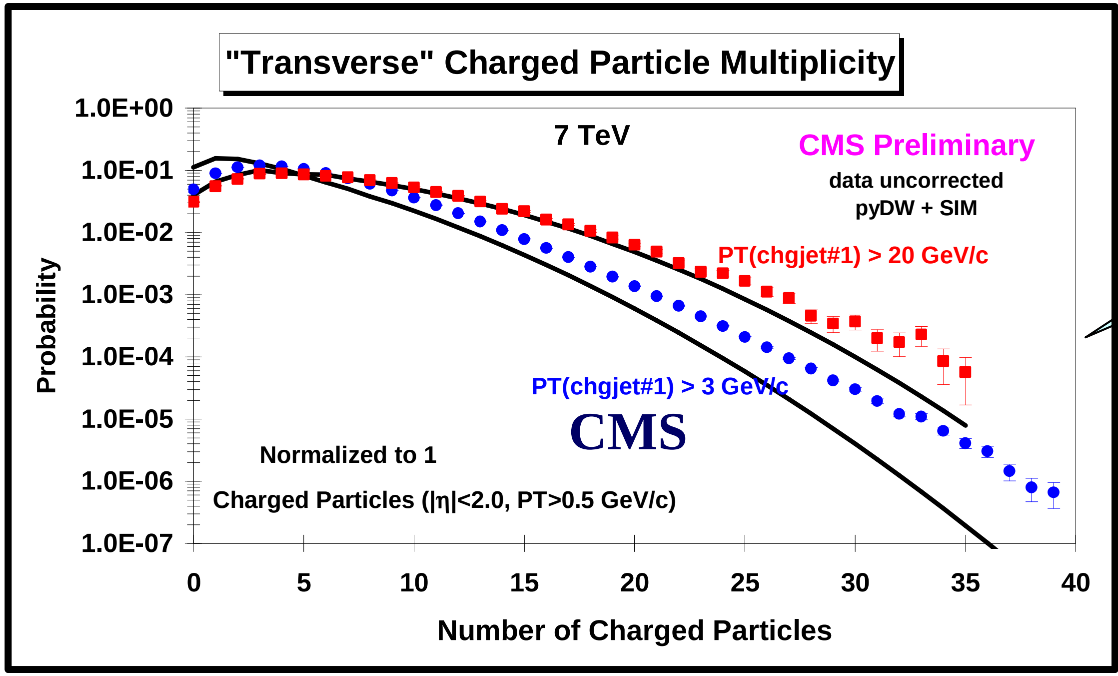
Same hard scale at two different center-of-mass energies!



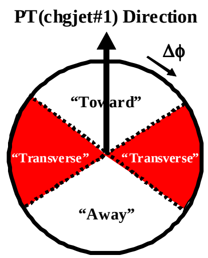
- CMS uncorrected data at 900 GeV and 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW at the detector level (*i.e.* Theory + SIM).

Shows the growth of the "underlying event" as the center-of-mass energy increases.

"Transverse" Multiplicity Distribution



Same center-of-mass energy at two different hard scales!

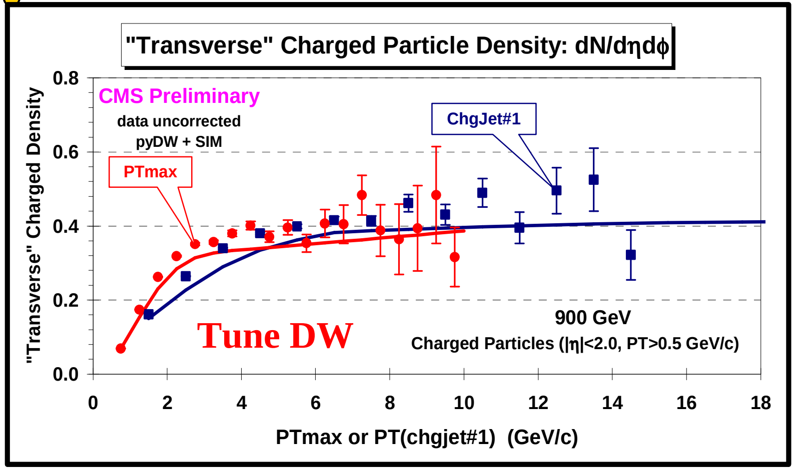


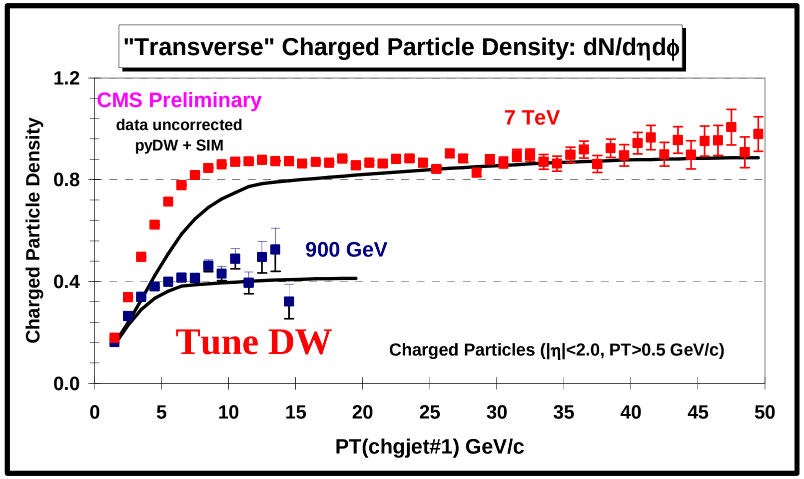
- CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune DW at the detector level (*i.e.* Theory + SIM).

Shows the growth of the "underlying event" as the hard scale increases.

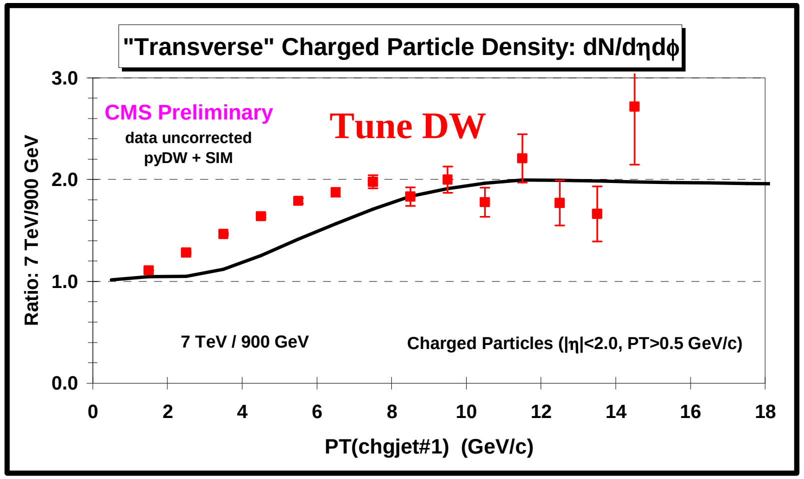
PYTHIA Tune DW

How well did we do at predicting the "underlying event" at 900 GeV and 7 TeV?



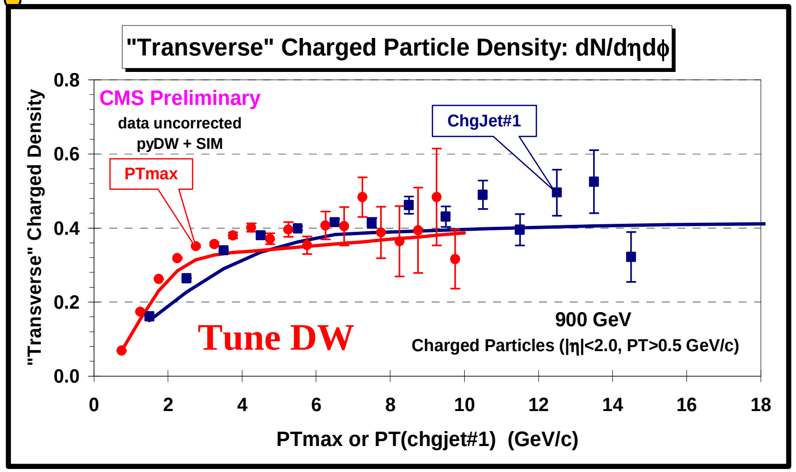


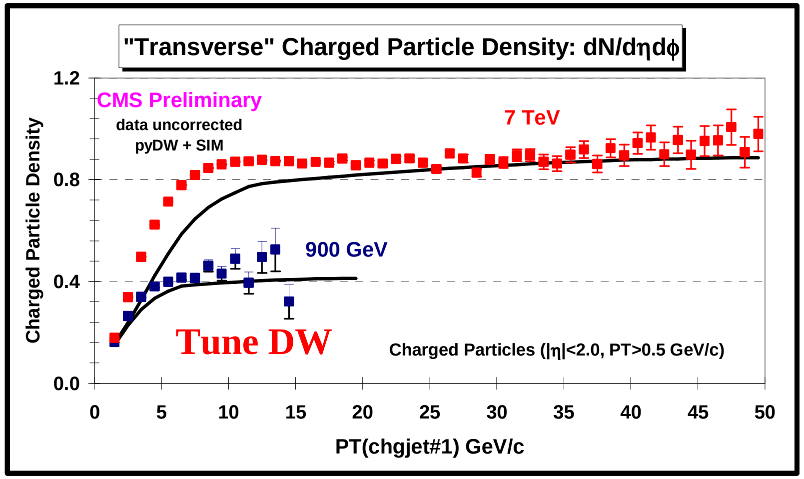
➡ **I am surprised that the Tunes did not do a better job of predicting the behavior of the "underlying event" at 900 GeV and 7 TeV!**



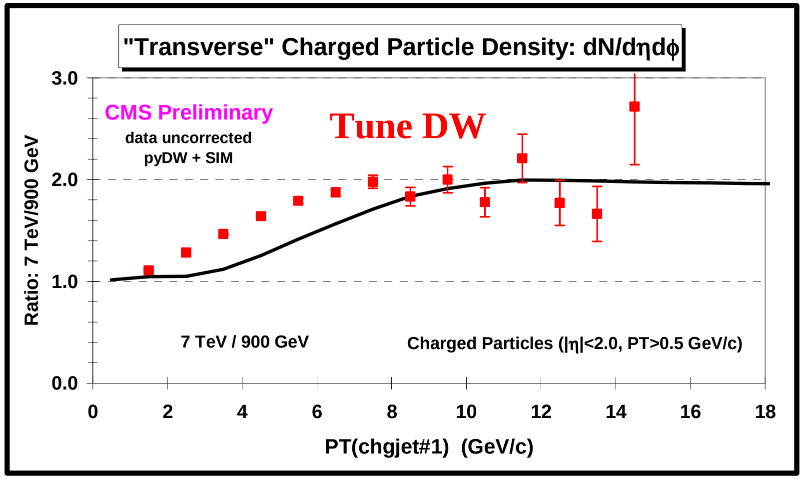
PYTHIA Tune DW

How well did we do at predicting the "underlying event" at 900 GeV and 7 TeV?



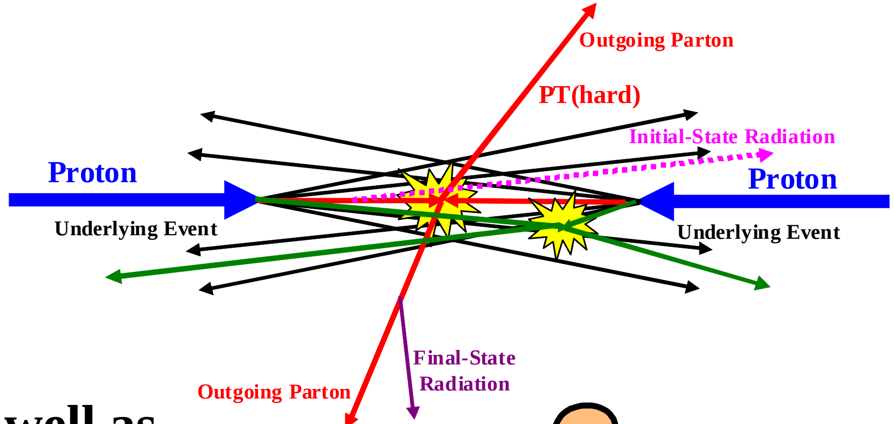


➡ **I am surprised that the Tunes did as well as they did at predicting the behavior of the "underlying event" at 900 GeV and 7 TeV!**



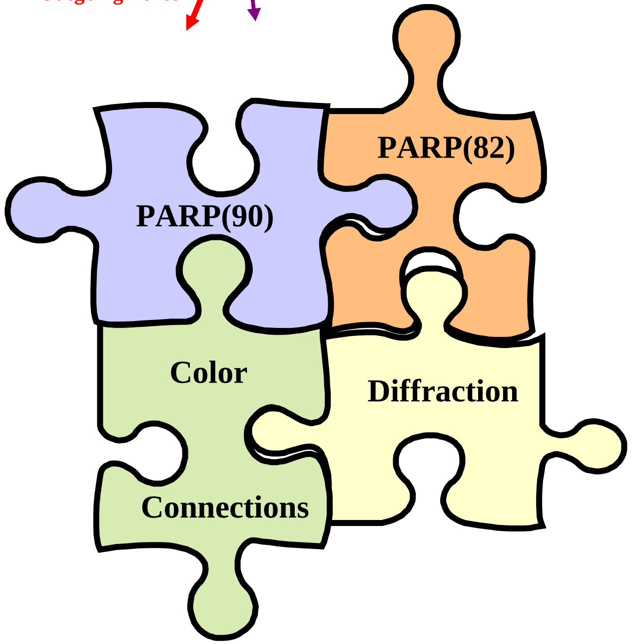
UE Summary

- The "underlying event" at 7 TeV and 900 GeV is almost what we expected! With a little tuning we should be able to describe the data very well (see Tune Z1 later in this talk).



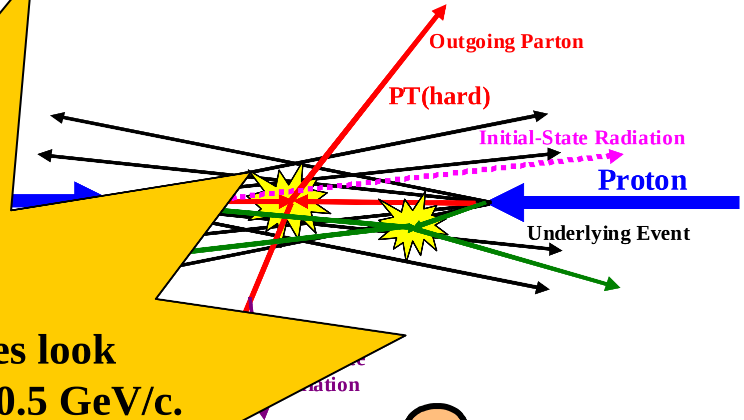
- I am surprised that the Tunes did as well as they did at predicting the behavior of the "underlying event" at 900 GeV and 7 TeV! Remember this is "soft" QCD!

- "Min-Bias" is a whole different story! Much more complicated due to diffraction!



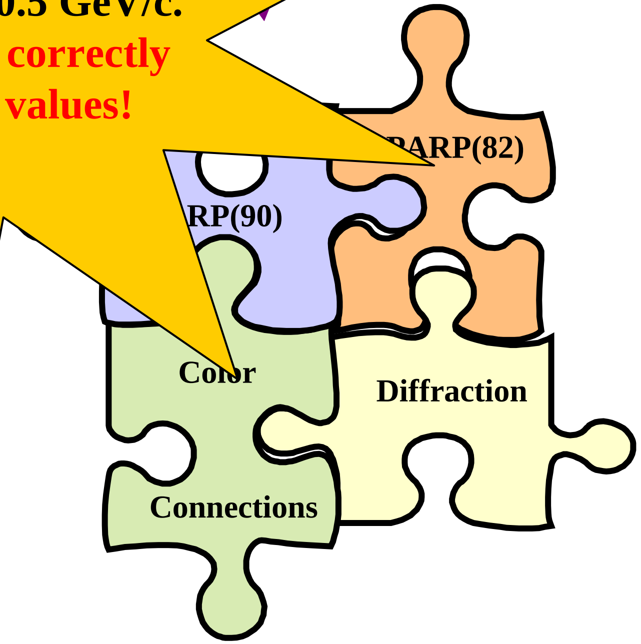
UE Summary

- The “underlying event” at 7 TeV and 900 G V is almost what e expected! W little tuni e should be able t be very well.

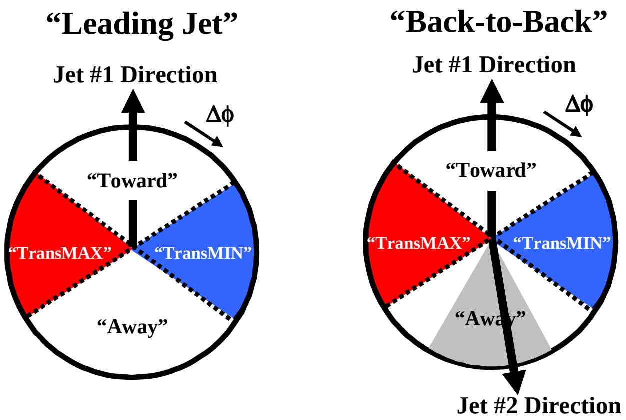


Warning! All the UE studies look at charged particles with p_T > 0.5 GeV/c.
We do not know if the models correctly describe the UE at lower p_T values!

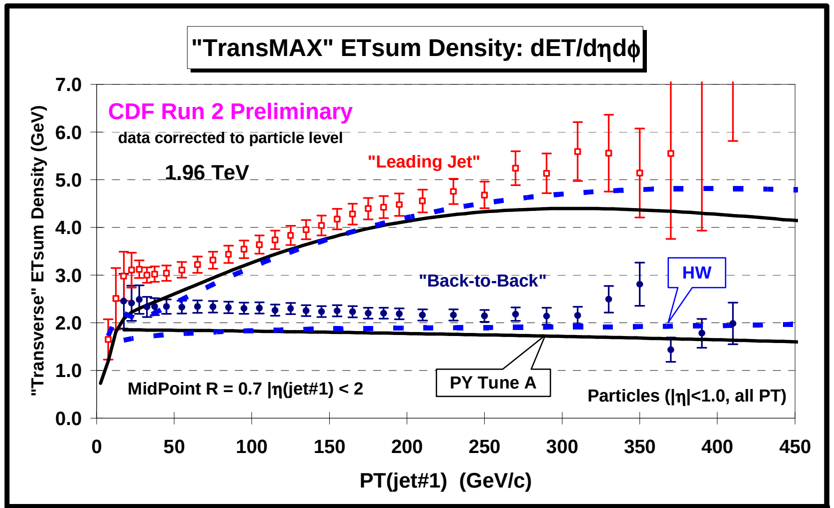
- I am surprise they did at predi “underlying e Remember this is “sof

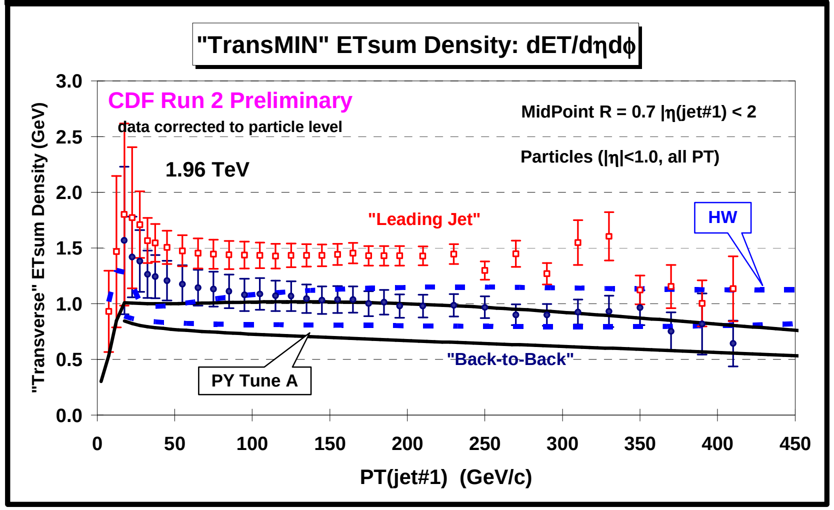


- “Min-Bias” is a whole diffe story! Much more complicated du o diffraction!

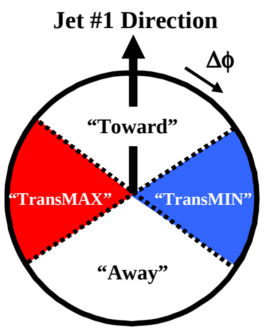


- **Shows the data on the tower ETsum density, $dET_{sum}/d\eta d\phi$, in the “transMAX” and “transMIN” region (E_T > 100 MeV, $|\eta|$ < 1) versus P_T(jet#1) for “Leading Jet” and “Back-to-Back” events.**
- **Compares the (*corrected*) data with PYTHIA Tune A (*with MPI*) and HERWIG (*without MPI*) at the particle level (all particles, $|\eta|$ < 1).**

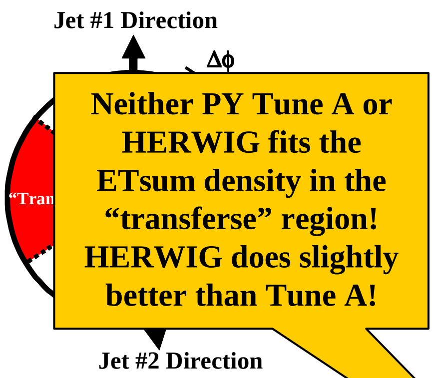




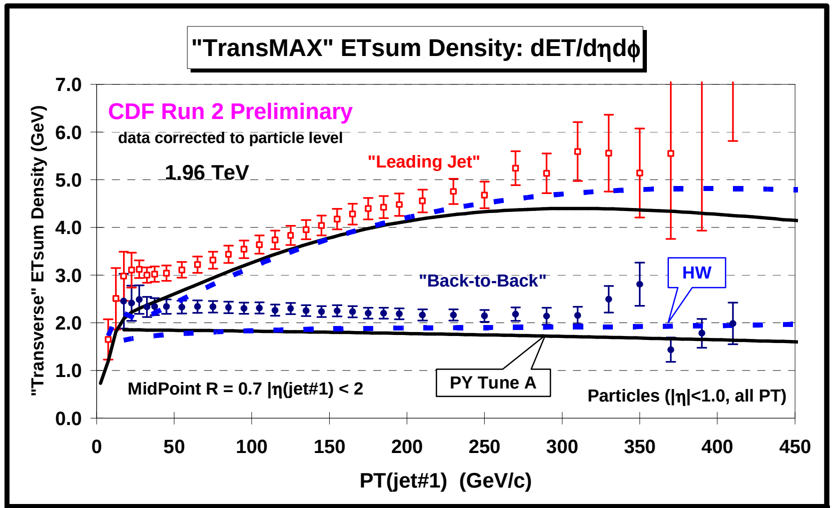
"Leading Jet"

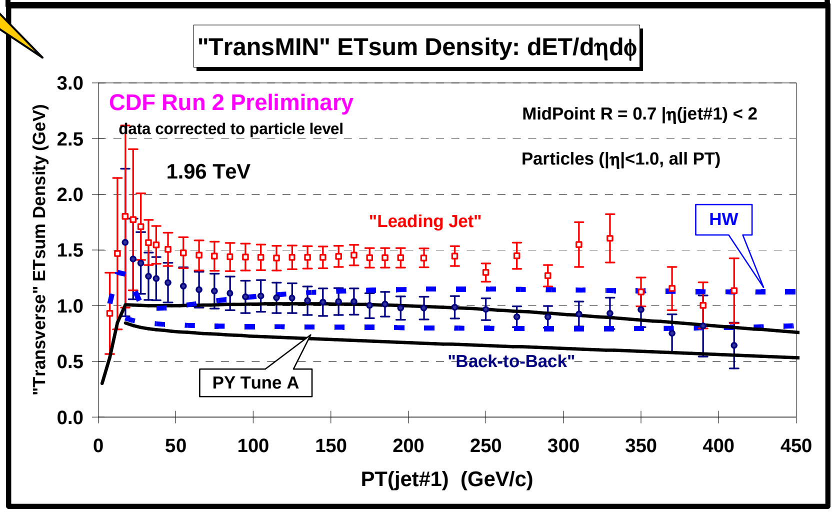


"Back-to-Back"

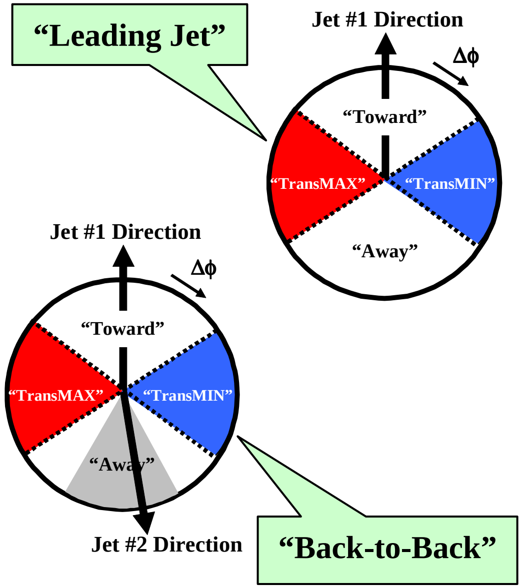


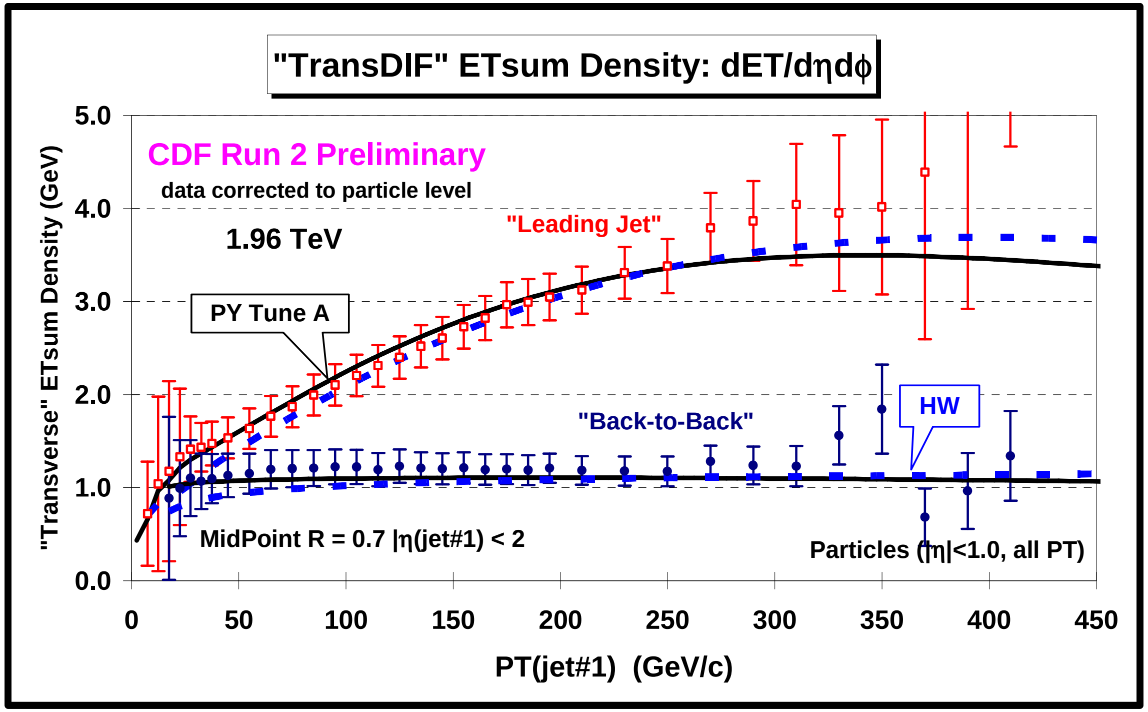
Neither PY Tune A or HERWIG fits the ETsum density in the "transferse" region! HERWIG does slightly better than Tune A!





- **Shows the data on the tower ETsum density, $dET_{sum}/d\eta d\phi$, in the "transMAX" and "transMIN" region (E_T > 100 MeV, $|\eta| < 1$) versus P_T(jet#1) for "Leading Jet" and "Back-to-Back" events.**
- **Compares the (*corrected*) data with PYTHIA Tune A (*with MPI*) and HERWIG (*without MPI*) at the particle level (all particles, $|\eta| < 1$).**

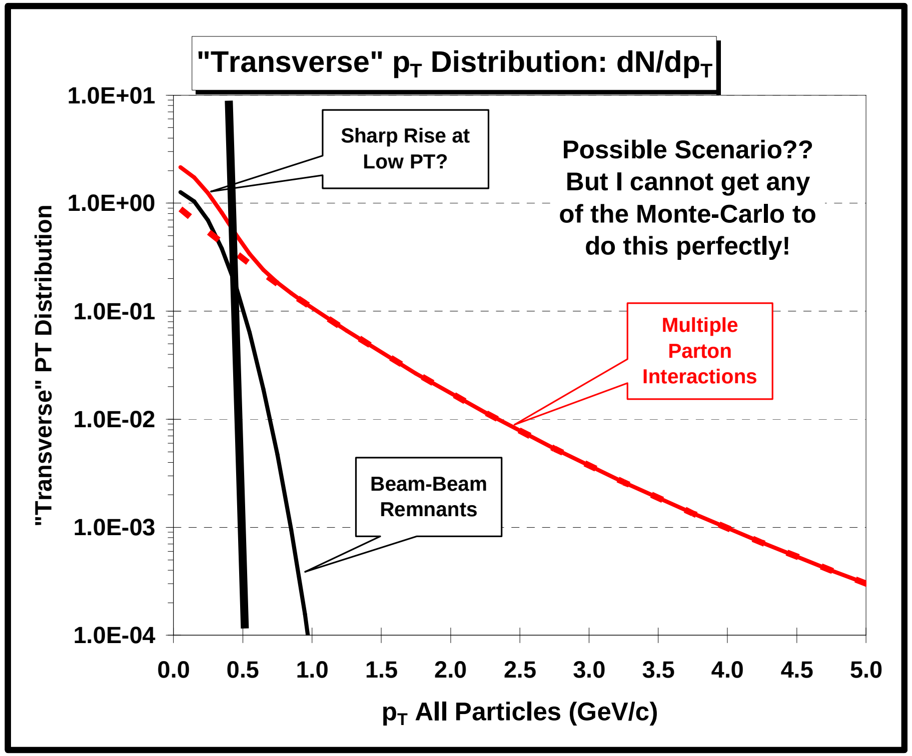




"transDIF" is more sensitive to the "hard scattering" component of the "underlying event"!

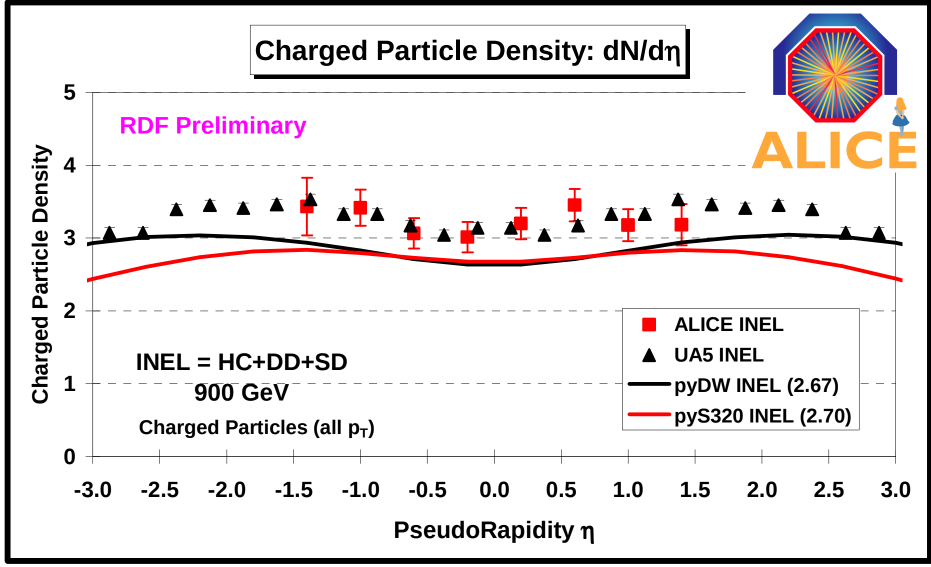
- **Use the leading jet to define the MAX and MIN "transverse" regions on an event-by-event basis with MAX (MIN) having the largest (smallest) charged PTsum density.**
- **Shows the "transDIF" = MAX-MIN ETsum density, dET$_{sum}$/dηdφ, for all particles (|η| < 1) versus P_T(jet#1) for "Leading Jet" and "Back-to-Back" events.**

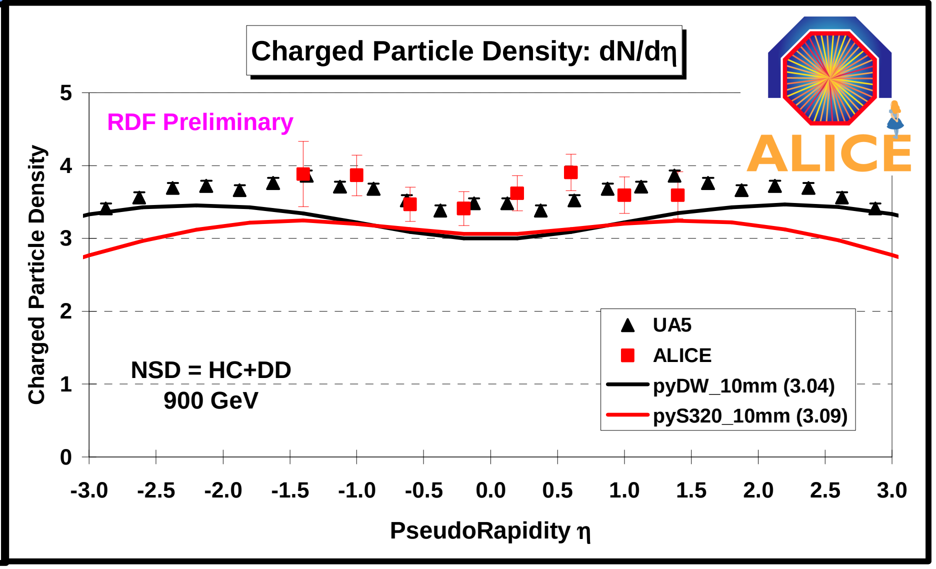
Possible Scenario??

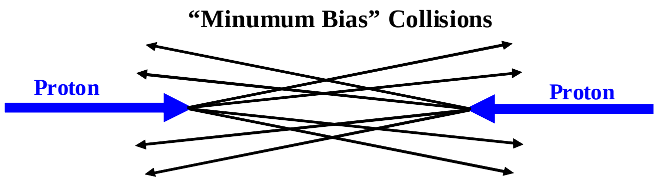


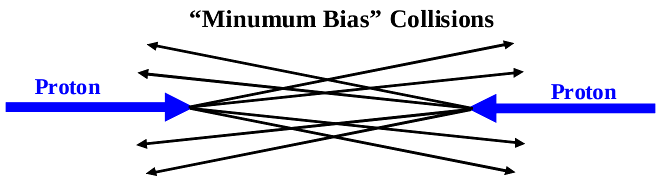
- **PYTHIA Tune A fits the charged particle PTsum density for p_T > 0.5 GeV/c, but it does not produce enough ETsum for towers with E_T > 0.1 GeV.**
- **It is possible that there is a sharp rise in the number of particles in the "underlying event" at low p_T (*i.e.* p_T < 0.5 GeV/c).**
- **Perhaps there are two components, a vary "soft" beam-beam remnant component (Gaussian or exponential) and a "hard" multiple interaction component.**

LHC MB Predictions: 900 GeV



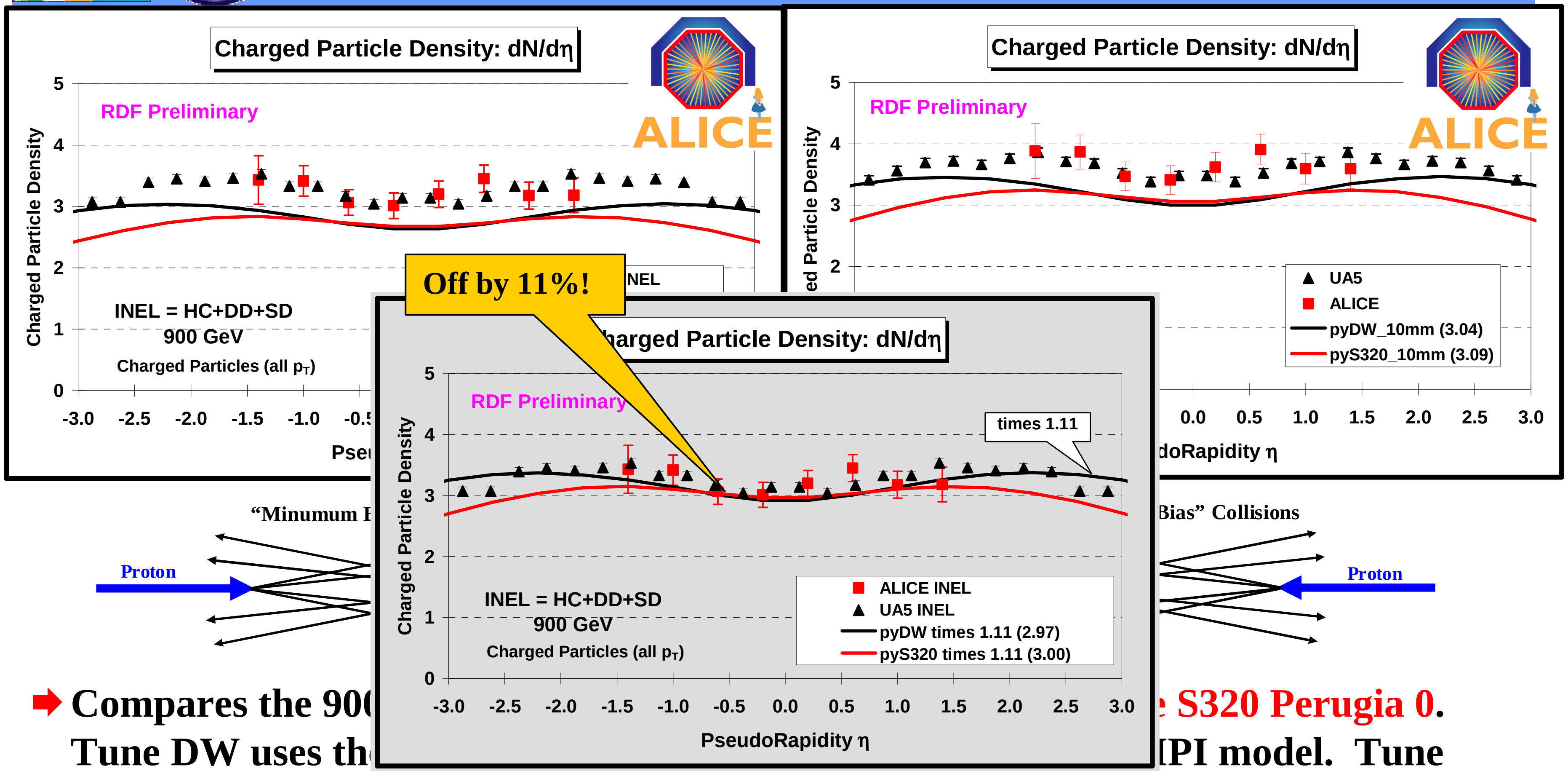






- **Compares the 900 GeV ALICE data with PYTHIA Tune DW and Tune S320 Perugia 0. Tune DW uses the old Q^2-ordered parton shower and the old MPI model. Tune S320 uses the new p_T-ordered parton shower and the new MPI model. The numbers in parentheses are the average value of dN/dη for the region $|\eta| < 0.6$.**

LHC MB Predictions: 900 GeV

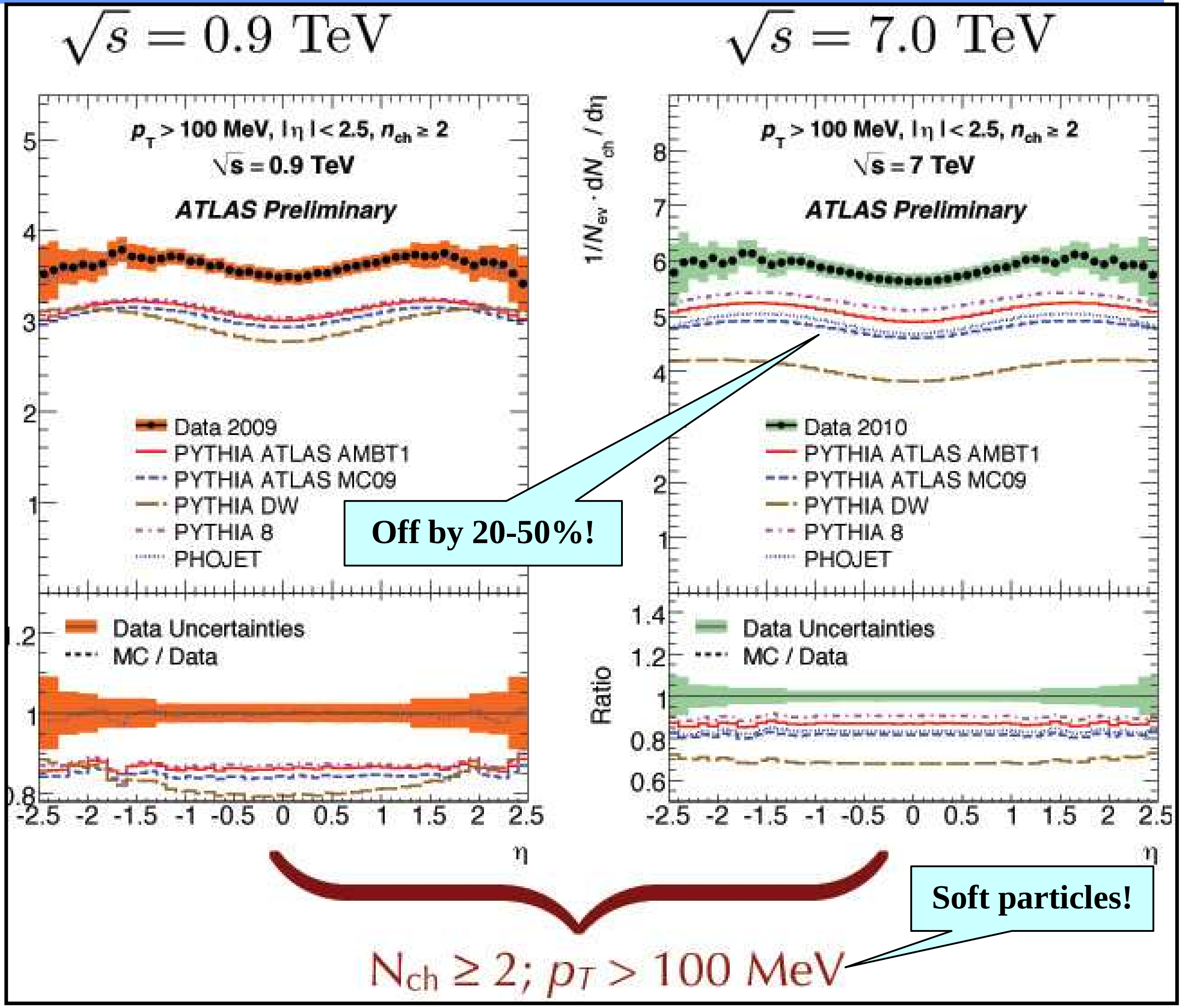


➡ Compares the 90[...] S320 Perugia 0. Tune DW uses th[...]PI model. Tune S320 uses the new p_T-ordered parton shower and the new MPI model. The numbers in parentheses are the average value of dN/dη for the region |η| < 0.6.

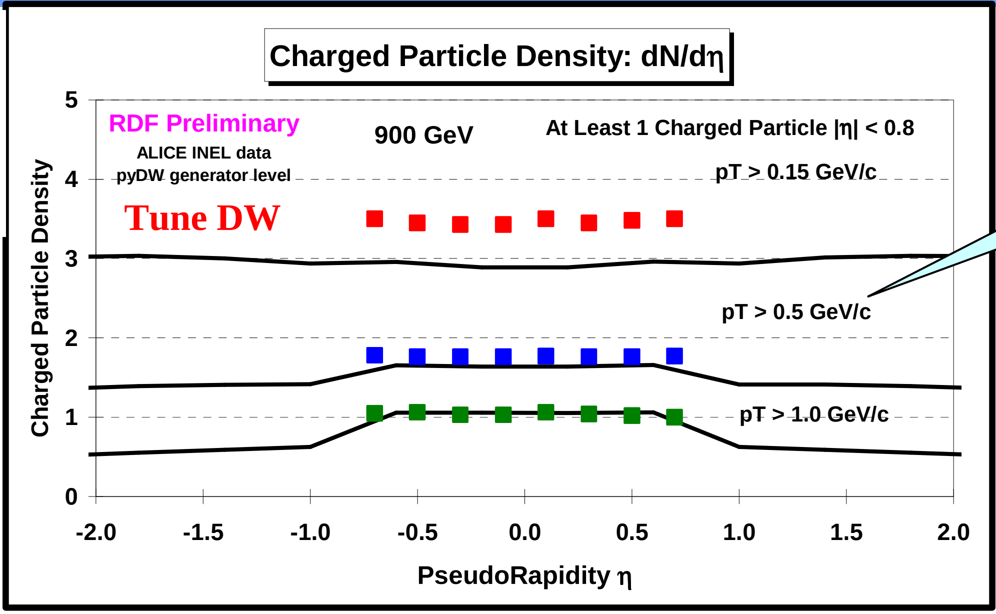
ATLAS INEL dN/dη

- None of the tunes fit the ATLAS INEL dN/dη data with PT > 100 MeV! They all predict too few particles.

- The ATLAS Tune AMBT1 was designed to fit the inelastic data for Nchg ≥ 6 with p_T > 0.5 GeV/c!



PYTHIA Tune DW

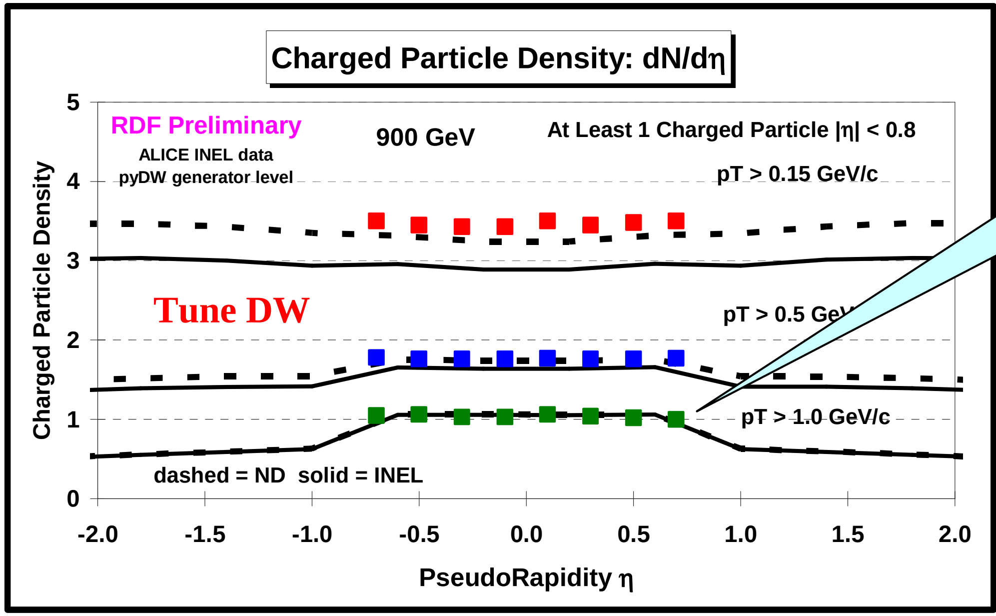


If one increases the hard scale the agreement improves!

➡ ALICE inelastic data at 900 GeV on the dN/dη distribution for charged particles (p_T > PTmin) for events with at least one charged particle with p_T > PTmin and |η| < 0.8 for PTmin = 0.15 GeV/c, 0.5 GeV/c, and 1.0 GeV/c compared with PYTHIA Tune DW at the generator level.

The same thing occurs at 7 TeV!
ALICE, ATLAS, and CMS data coming soon.

PYTHIA Tune DW

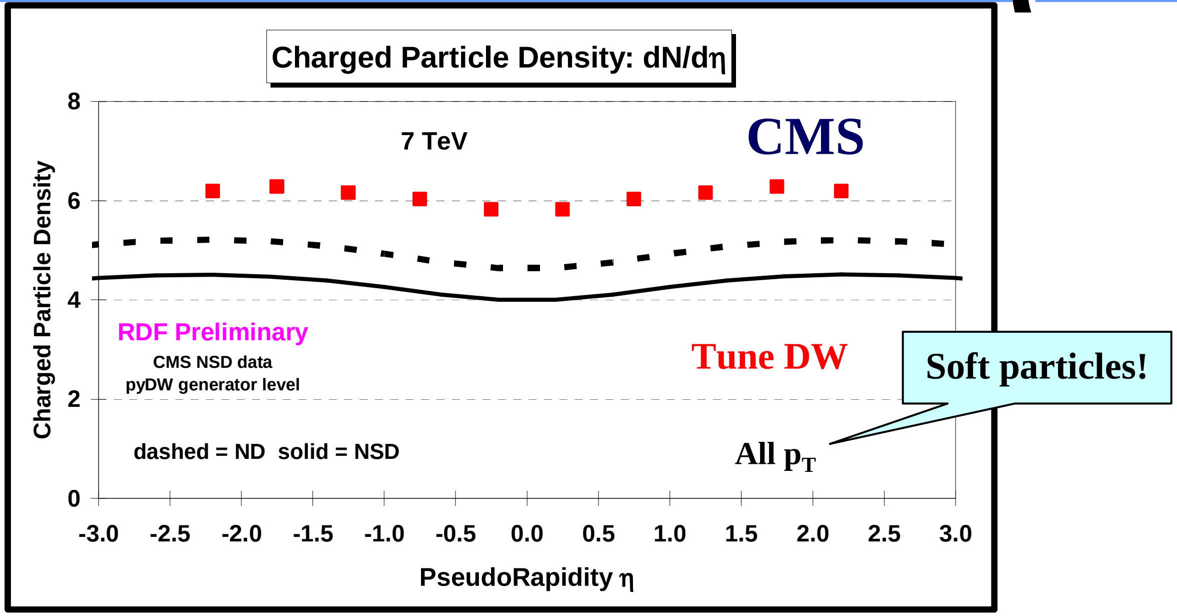


Diffraction contributes less at harder scales!

- **ALICE inelastic data at 900 GeV on the dN/dη distribution for charged particles (p_T > PTmin) for events with at least one charged particle with p_T > PTmin and |η| < 0.8 for PTmin = 0.15 GeV/c, 0.5 GeV/c, and 1.0 GeV/c compared with PYTHIA Tune Z1 at the generator level (dashed = ND, solid = INEL).**

Cannot trust PYTHIA 6.2 modeling of diffraction!

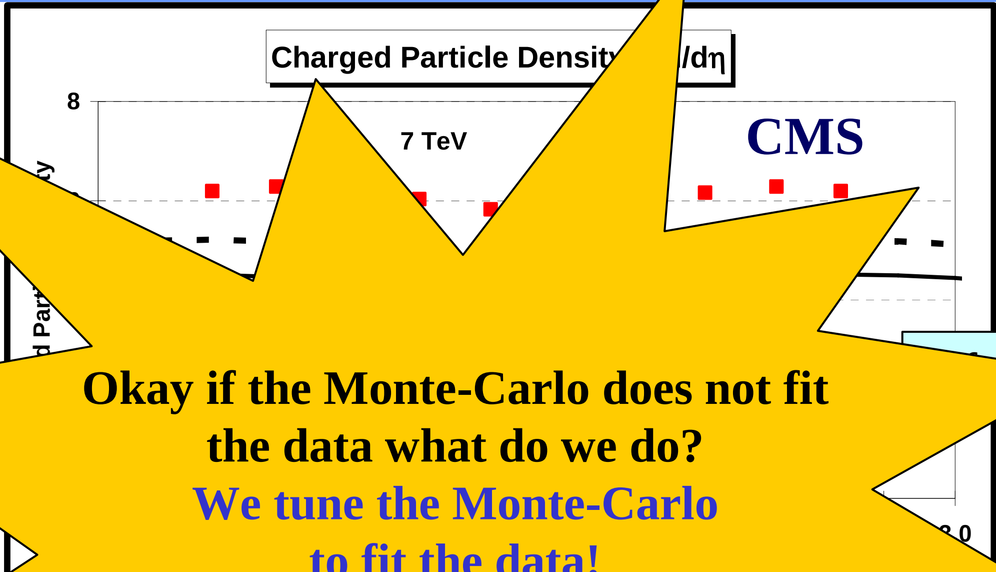
CMS dN/dη



➡ **Generator level dN/dη (all pT). Shows the NSD = HC + DD and the HC = ND contributions for Tune DW. Also shows the CMS NSD data.**

Off by 50%!

CMS dN/dη

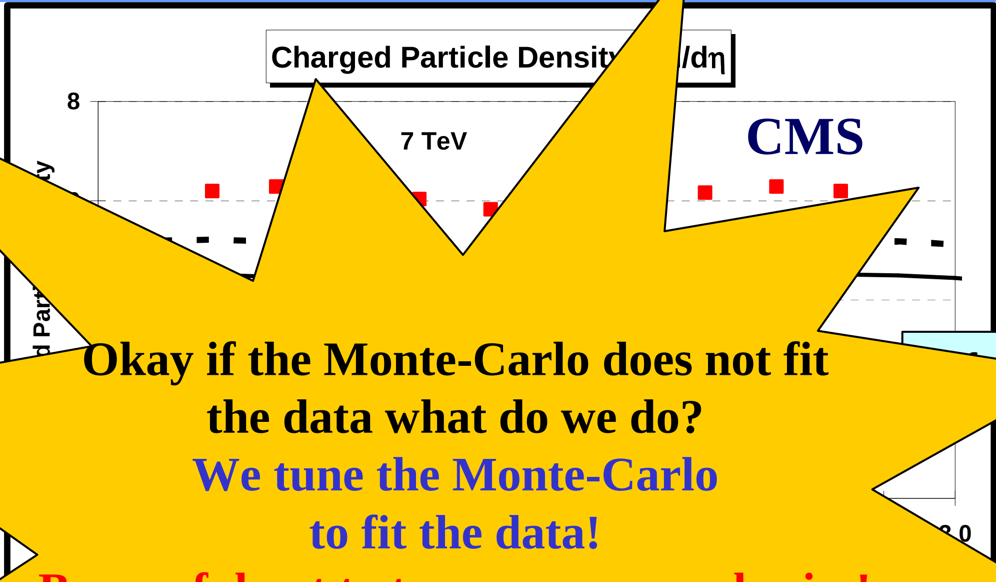


Okay if the Monte-Carlo does not fit the data what do we do?
We tune the Monte-Carlo to fit the data!

- **Generator** … **DD and the HC = ND contributions for Tune** … **S** … **ta.**

O… by 50%!

CMS dN/dη



rticles!

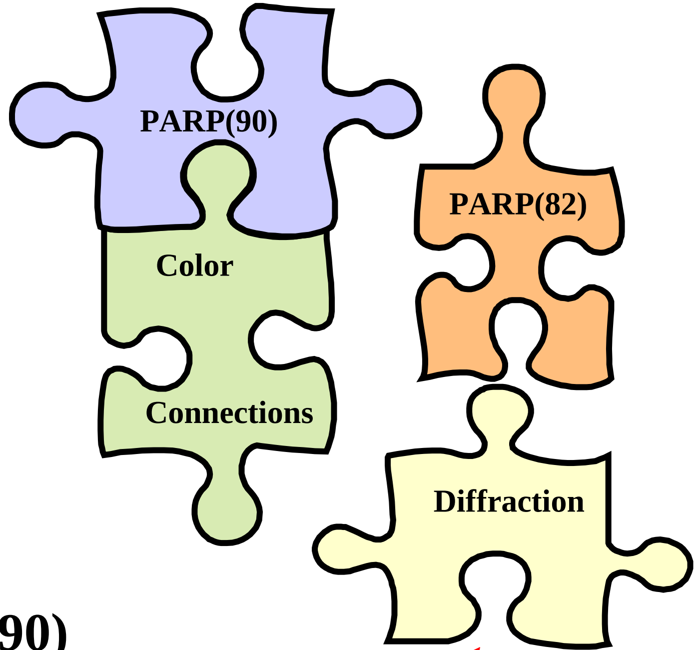
Okay if the Monte-Carlo does not fit the data what do we do?
We tune the Monte-Carlo to fit the data!
Be careful not to tune away new physics!

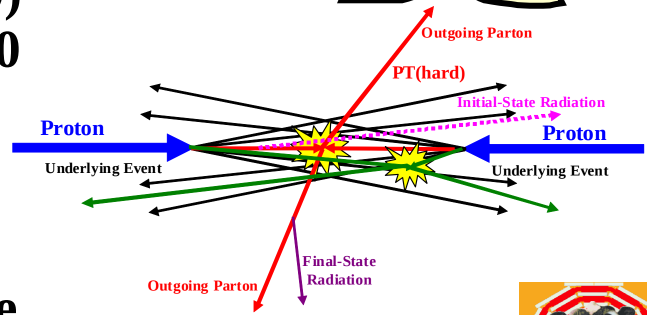
- Generator DD and the HC = ND contributions for Tune S ta.

O by 5 %!

PYTHIA Tune Z1

- **All my previous tunes (A, DW, DWT, D6, D6T, CW, X1, and X2) were PYTHIA 6.4 tunes using the old Q^2-ordered parton showers and the old MPI model (really 6.2 tunes)!**
- **I believe that it is time to move to PYTHIA 6.4 (p_T-ordered parton showers and new MPI model)!**
- **Tune Z1: I started with the parameters of ATLAS Tune AMBT1, but I changed LO* to CTEQ5L and I varied PARP(82) and PARP(90) to get a very good fit of the CMS UE data at 900 GeV and 7 TeV.**
- **The ATLAS Tune AMBT1 was designed to fit the inelastic data for Nchg ≥ 6 and to fit the PTmax UE data with PTmax > 10 GeV/c. Tune AMBT1 is primarily a min-bias tune, while Tune Z1 is a UE tune!**





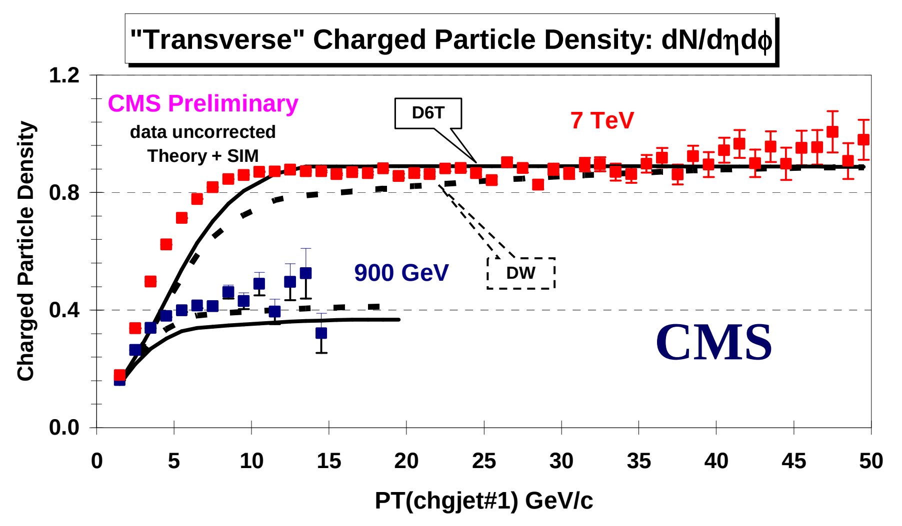
UE&MB@CMS

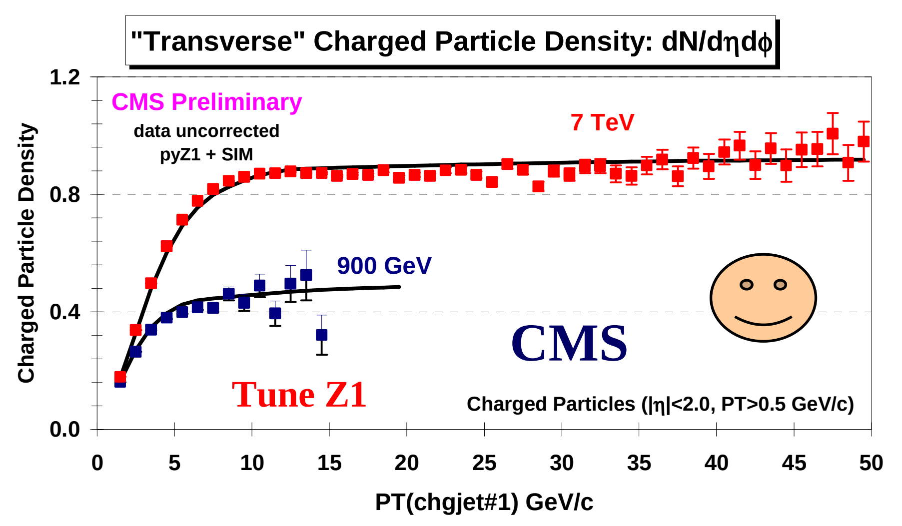
PYTHIA Tune Z1

Parameters not shown are the PYTHIA 6.4 defaults!

Parameter	Tune Z1 (R. Field CMS)	Tune AMBT1 (ATLAS)
Parton Distribution Function	CTEQ5L	LO*
PARP(82) – MPI Cut-off	1.932	2.292
PARP(89) – Reference energy, E0	1800.0	1800.0
PARP(90) – MPI Energy Extrapolation	0.275	0.25
PARP(77) – CR Suppression	1.016	1.016
PARP(78) – CR Strength	0.538	0.538
PARP(80) – Probability colored parton from BBR	0.1	0.1
PARP(83) – Matter fraction in core	0.356	0.356
PARP(84) – Core of matter overlap	0.651	0.651
PARP(62) – ISR Cut-off	1.025	1.025
PARP(93) – primordial kT-max	10.0	10.0
MSTP(81) – MPI, ISR, FSR, BBR model	21	21
MSTP(82) – Double gaussion matter distribution	4	4
MSTP(91) – Gaussian primordial kT	1	1
MSTP(95) – strategy for color reconnection	6	6

PYTHIA Tune Z1





- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2.0. The data are uncorrected and compared with PYTHIA Tune DW and D6T after detector simulation (SIM).**

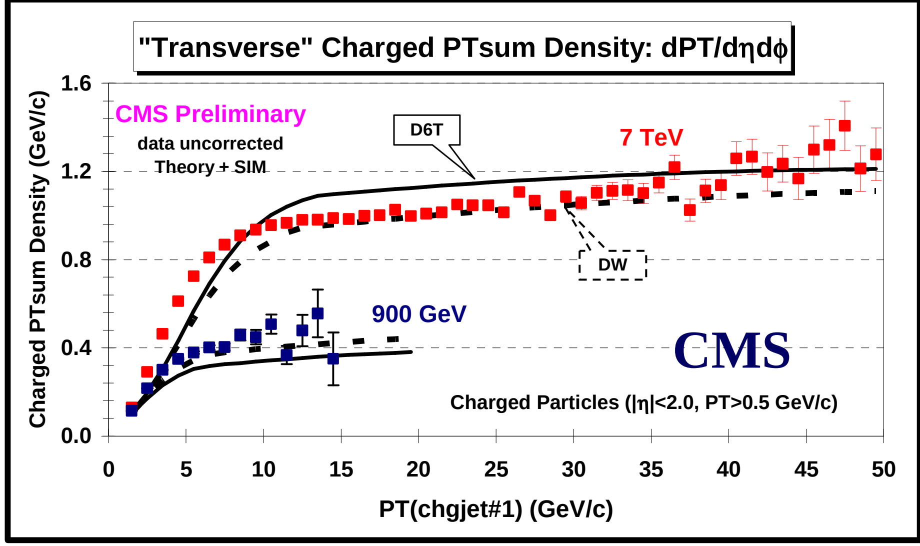
- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2.0. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation (SIM).**

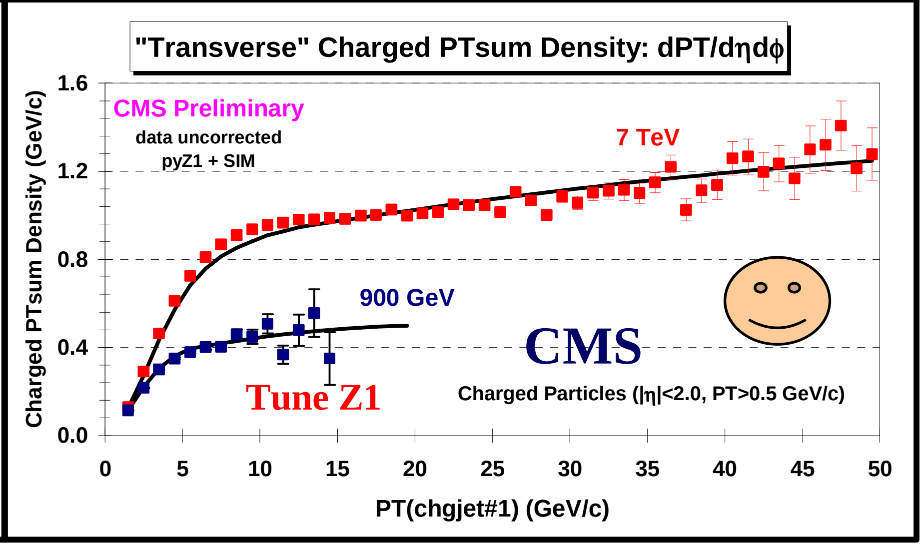
Color reconnection suppression.
Color reconnection strength.

Tune Z1 (CTEQ5L)
PARP(82) = 1.932
PARP(90) = 0.275
PARP(77) = 1.016
PARP(78) = 0.538

Tune Z1 is a PYTHIA 6.4 using p_T-ordered parton showers and the new MPI model!

PYTHIA Tune Z1





- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2.0. The data are uncorrected and compared with PYTHIA Tune DW and D6T after detector simulation (SIM).**

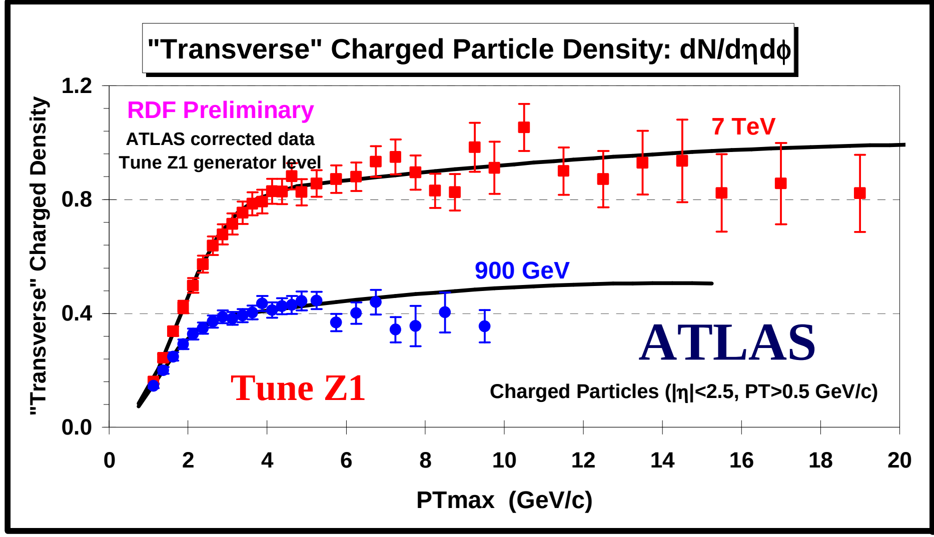
- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2.0. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation (SIM).**

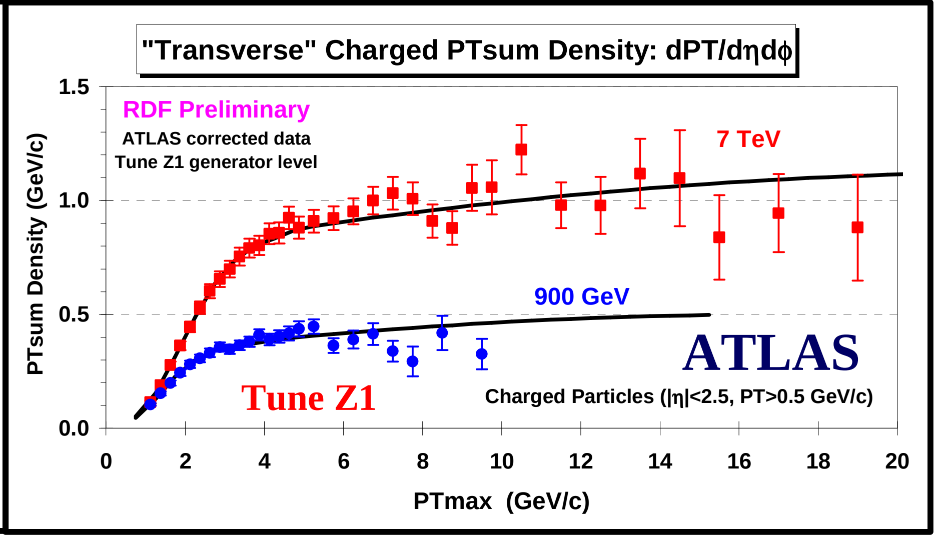
Color reconnection suppression.
Color reconnection strength.

Tune Z1 (CTEQ5L)
PARP(82) = 1.932
PARP(90) = 0.275
PARP(77) = 1.016
PARP(78) = 0.538

Tune Z1 is a PYTHIA 6.4 using p_T-ordered parton showers and the new MPI model!

PYTHIA Tune Z1





- **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.**

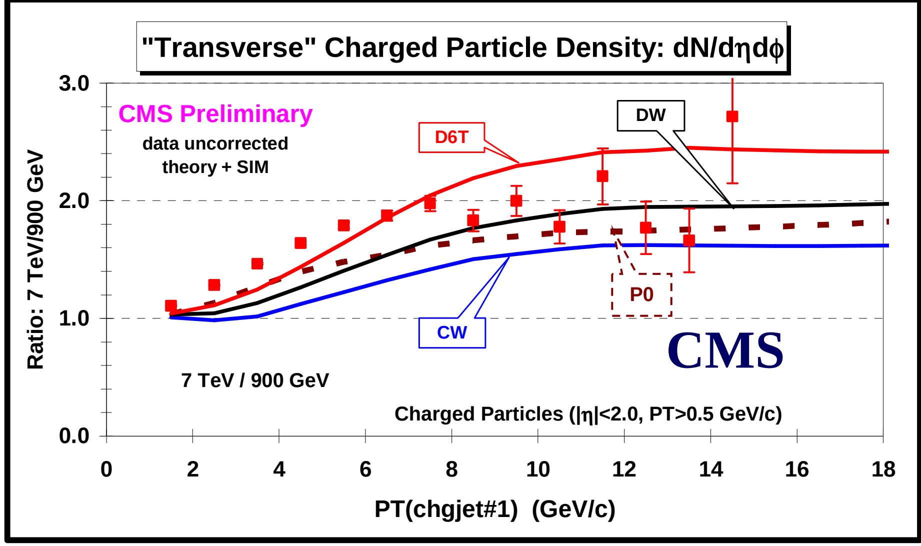
- **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune Z1 at the generrator level.**

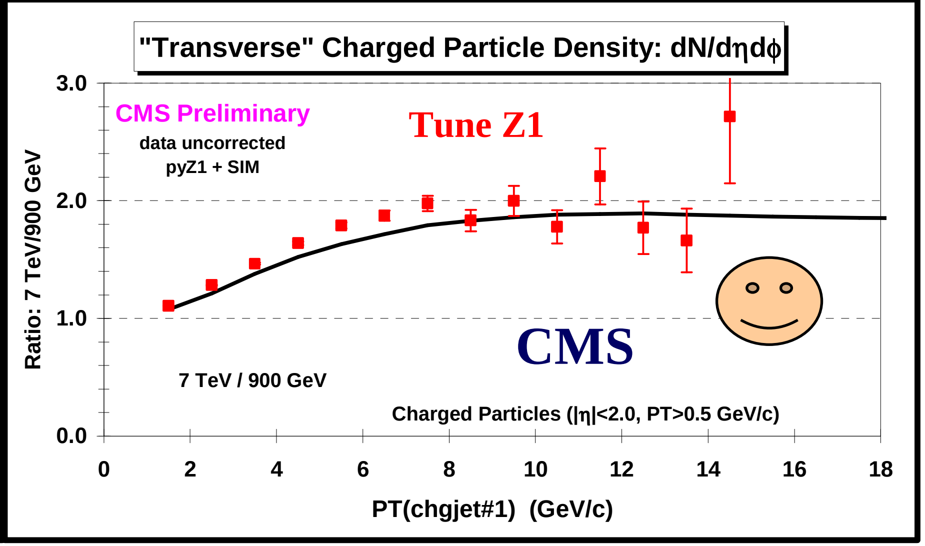
Color reconnection suppression.
Color reconnection strength.

<u>Tune Z1 (CTEQ5L)</u>
PARP(82) = 1.932
PARP(90) = 0.275
PARP(77) = 1.016
PARP(78) = 0.538

Tune Z1 is a PYTHIA 6.4 using p_T-ordered parton showers and the new MPI model!

PYTHIA Tune Z1

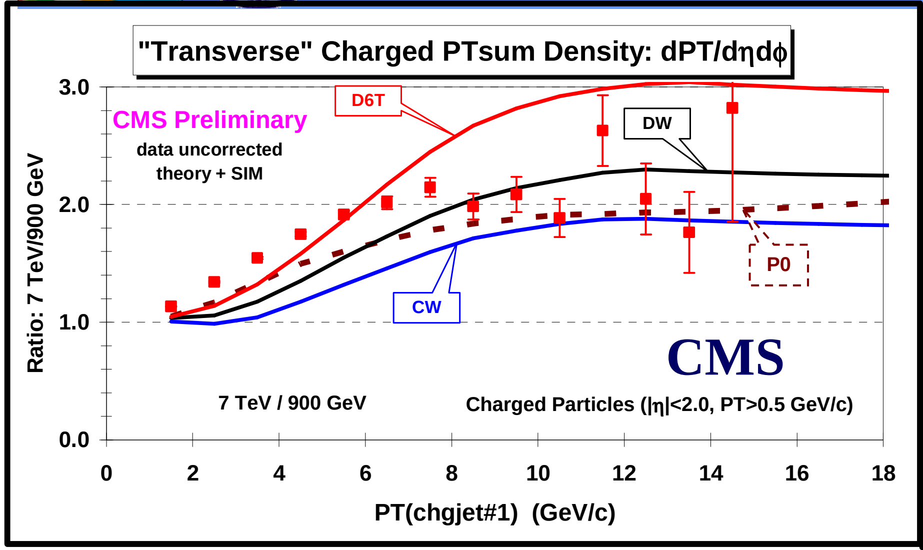


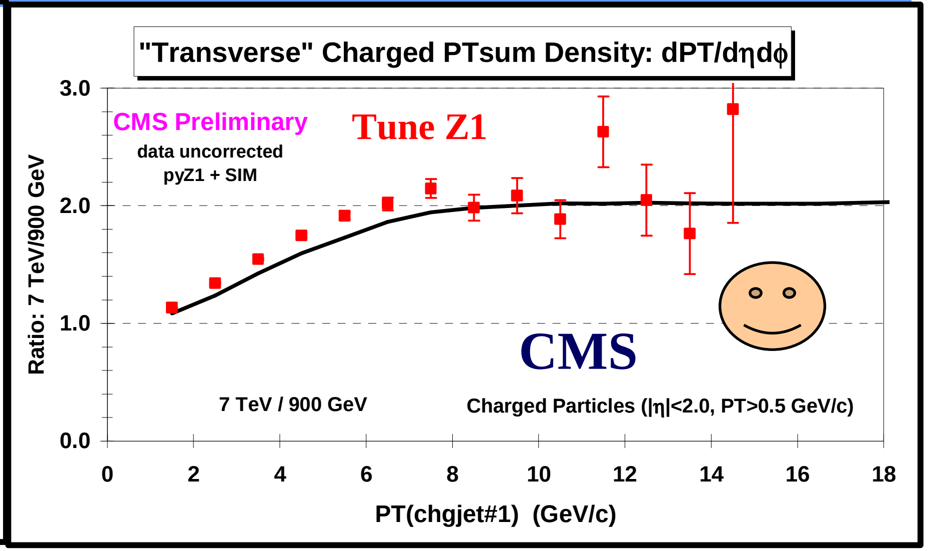


- **Ratio of CMS preliminary data at 900 GeV and 7 TeV (7 TeV divided by 900 GeV) on the "transverse" charged particle density as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.0$. The data are uncorrected and compared with PYTHIA Tune DW, D6T, CW, and P0 after detector simulation (SIM).**

- **Ratio of CMS preliminary data at 900 GeV and 7 TeV (7 TeV divided by 900 GeV) on the "transverse" charged particle density as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.0$. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation (SIM).**

PYTHIA Tune Z1

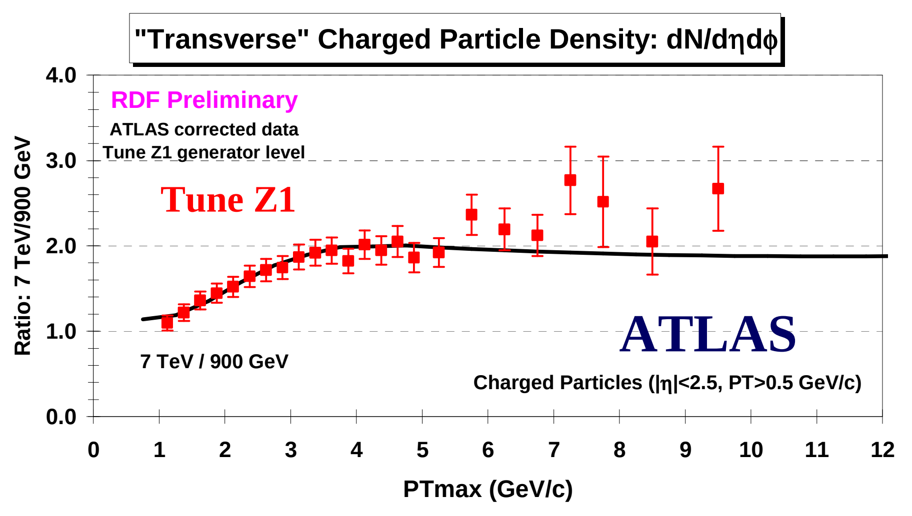


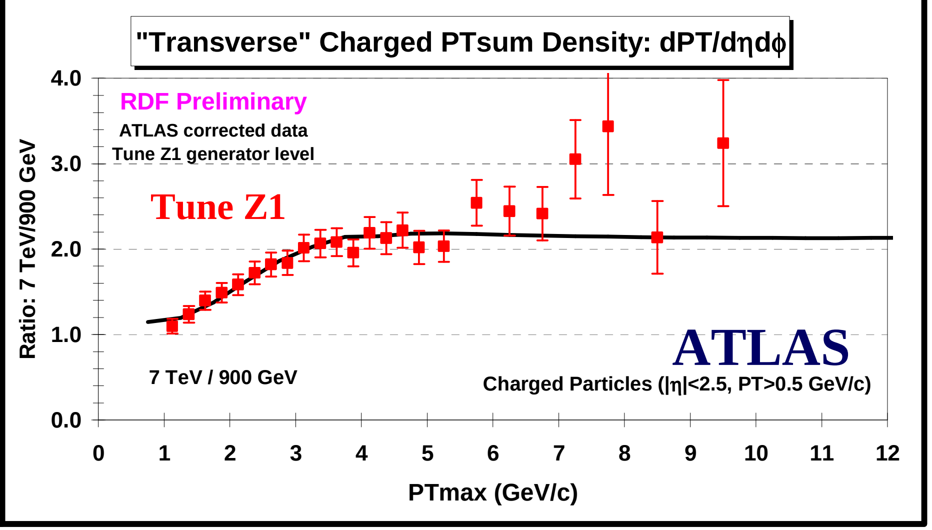


- **Ratio of CMS preliminary data at 900 GeV and 7 TeV (7 TeV divided by 900 GeV) on the "transverse" charged PTsum density as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.0$. The data are uncorrected and compared with PYTHIA Tune DW, D6T, CW, and P0 after detector simulation (SIM).**

- **Ratio of CMS preliminary data at 900 GeV and 7 TeV (7 TeV divided by 900 GeV) on the "transverse" charged PTsum density as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.0$. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation (SIM).**

PYTHIA Tune Z1

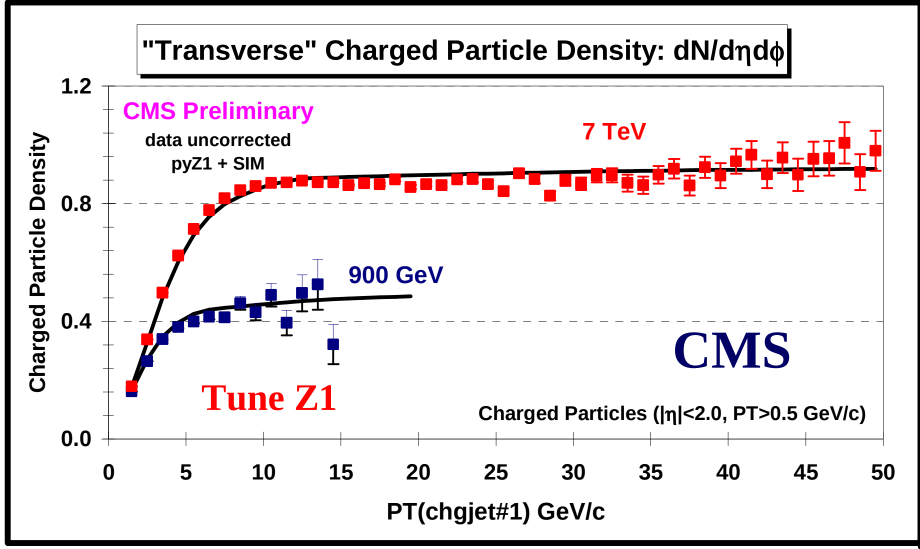


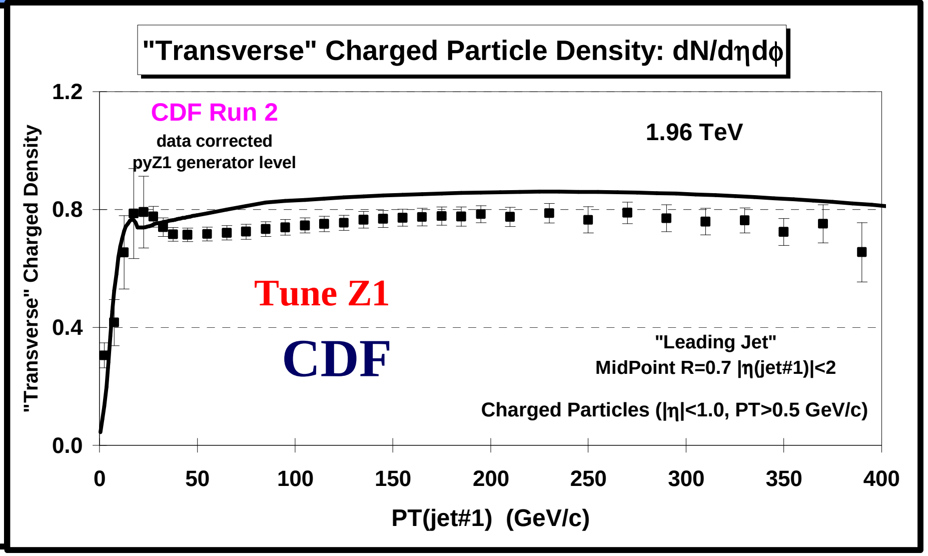


- **Ratio of the ATLAS preliminary data on the charged particle density in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2.5) at 900 GeV and 7 TeV as defined by PTmax compared with PYTHIA Tune Z1 at the generator level.**

- **Ratio of the ATLAS preliminary data on the charged PTsum density in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2.5) at 900 GeV and 7 TeV as defined by PTmax compared with PYTHIA Tune Z1 at the generator level.**

PYTHIA Tune Z1

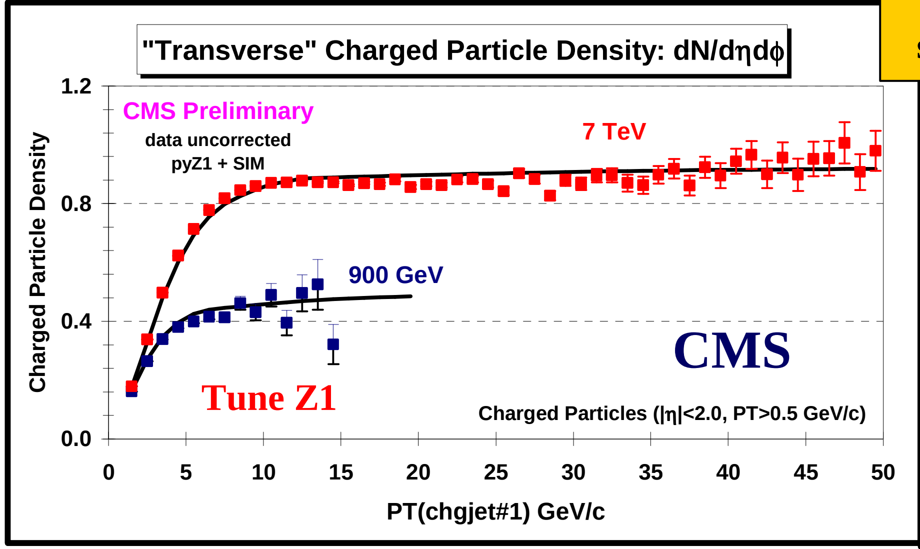


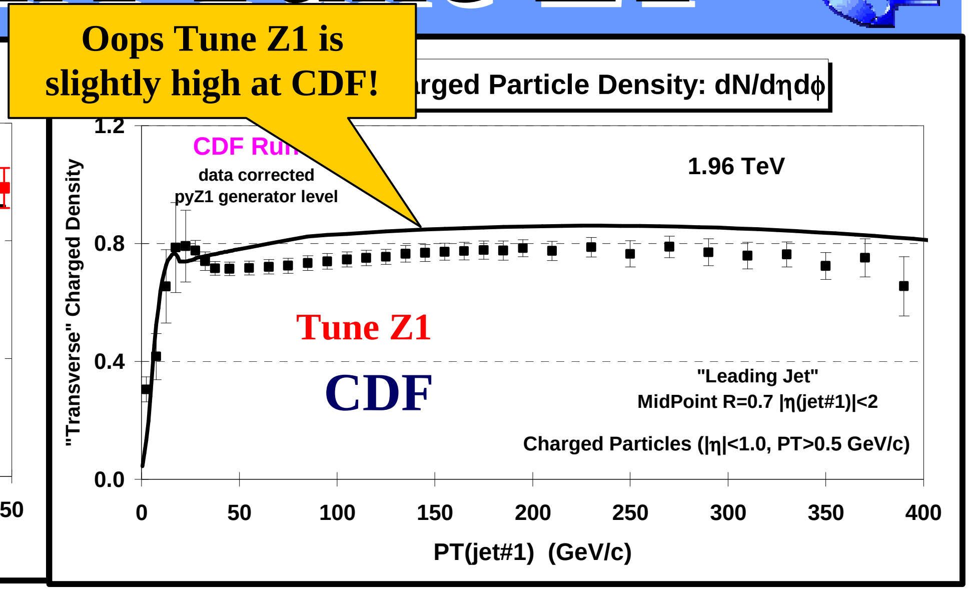


- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation.**

- **CDF published data at 1.96 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading calorimeter jet (jet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 1.0$. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.**

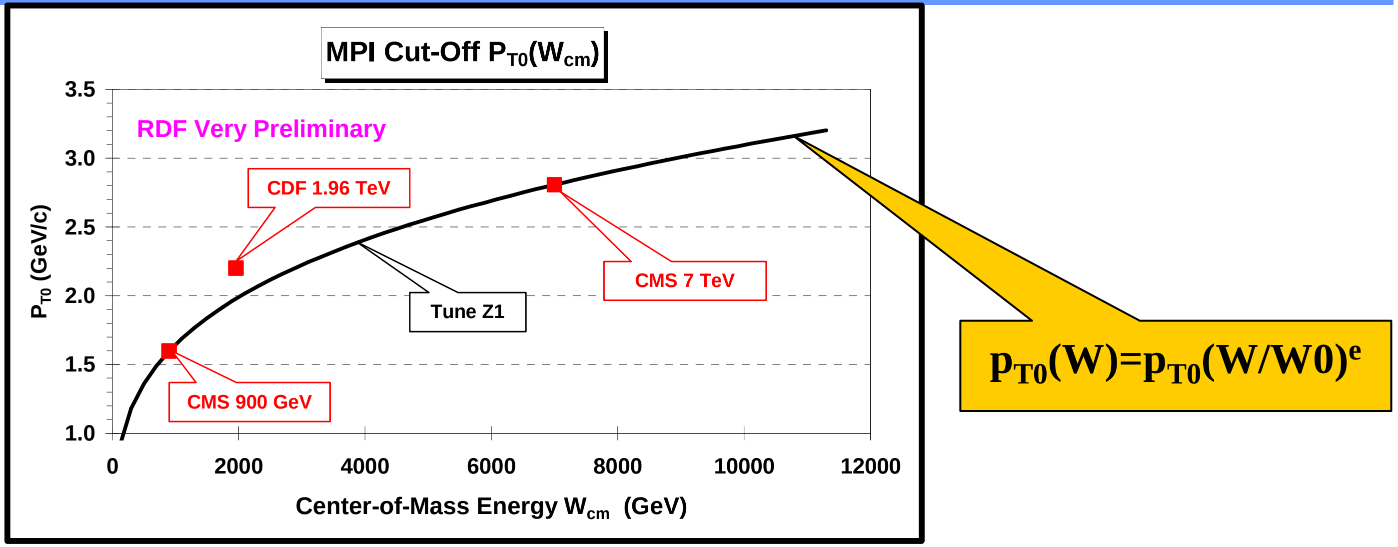
PYTHIA Tune Z1





- **CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The data are uncorrected and compared with PYTHIA Tune Z1 after detector simulation.**
- **CDF published data at 1.96 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading calorimeter jet (jet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 1.0. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.**

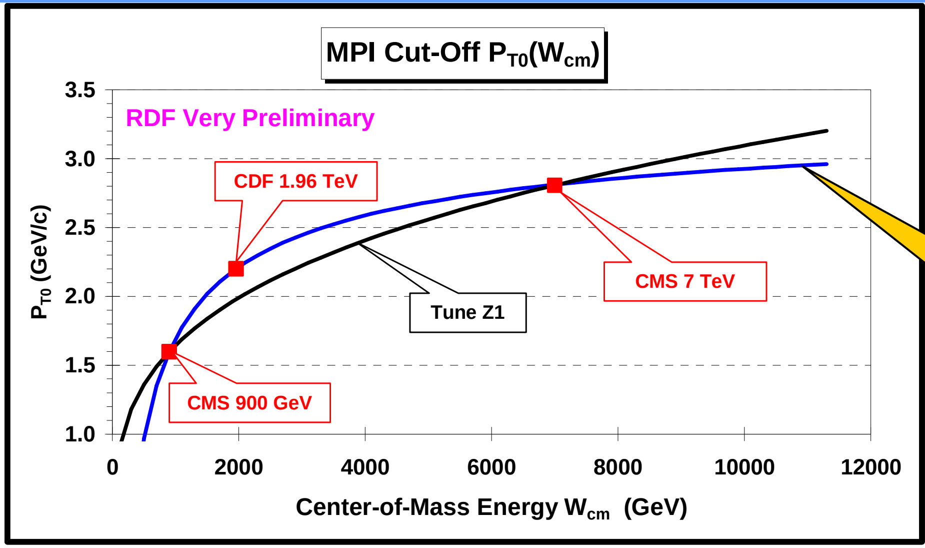
PYTHIA Tune Z1



- **MPI Cut-Off versus the Center-of Mass Energy W_{cm}: PYTHIA Tune Z1 was determined by fitting p_{T0} independently at 900 GeV and 7 TeV and calculating ε = PARP(90). The best fit to p_{T0} at CDF is slightly higher than the Tune Z1 curve. This is very preliminary! Perhaps with a global fit to all three energies (*i.e.* “Professor” tune) one can get a simultaneous fit to all three??**

$$p_{T0}(W)=p_{T0}(W/W_0)^{\varepsilon} \quad \varepsilon = \text{PARP(90)} \quad p_{T0} = \text{PARP(82)} \quad W = E_{cm}$$

PYTHIA Tune Z1



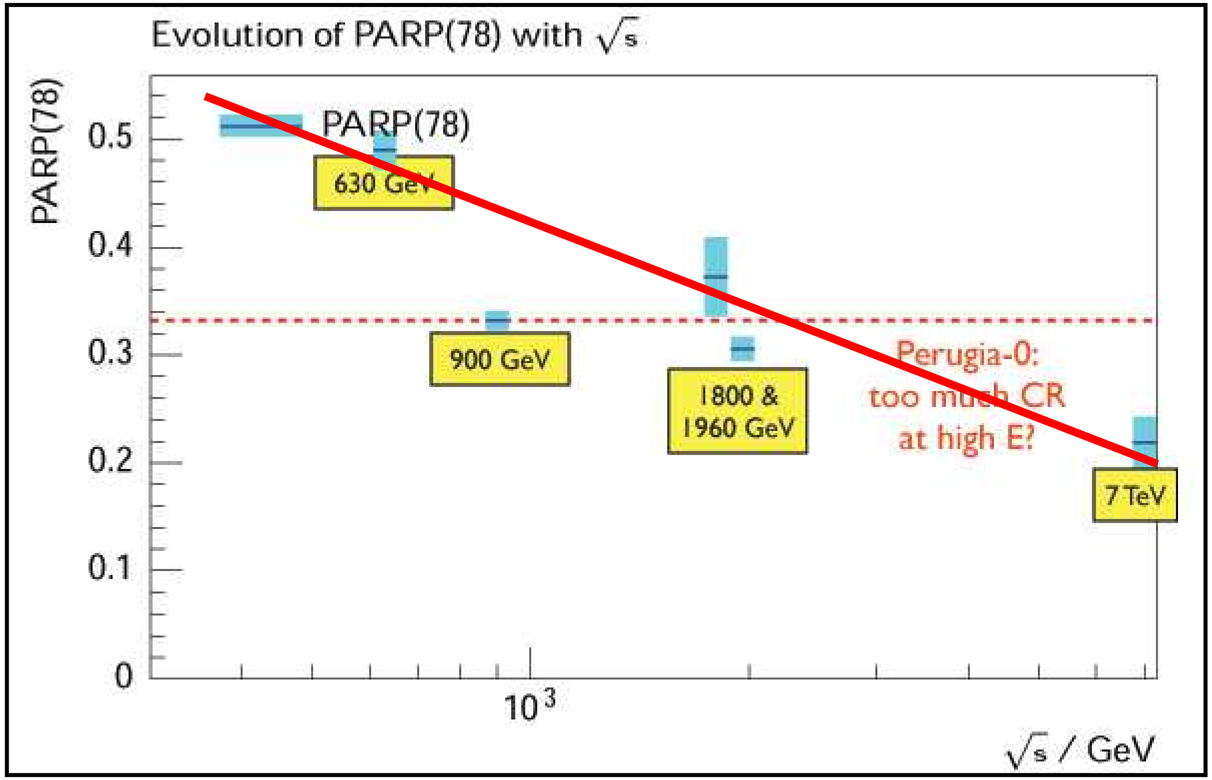
More UE activity for W > 7 TeV!??

- **MPI Cut-Off versus the Center-of Mass Energy W_{cm}: PYTHIA Tune Z1 was determined by fitting p_{T0} independently at 900 GeV and 7 TeV and calculating ε = PARP(90). The best fit to p_{T0} at CDF is slightly higher than the Tune Z1 curve. This is very preliminary! Perhaps with a global fit to all three energies (*i.e.* "Professor" tune) one can get a simultaneous fit to all three??**

$$p_{T0}(W)=p_{T0}(W/W_0)^{\varepsilon} \quad \varepsilon = \text{PARP}(90) \quad p_{T0} = \text{PARP}(82) \quad W = E_{cm}$$

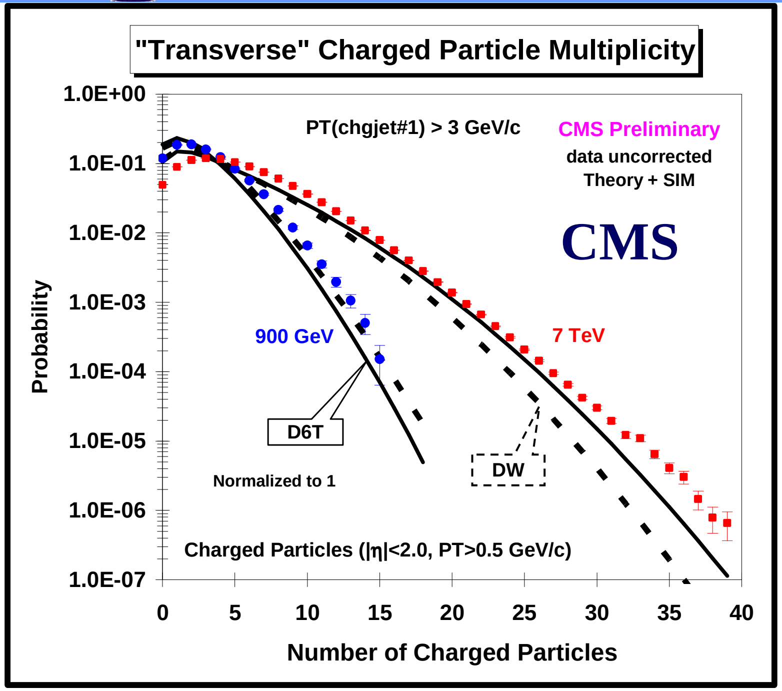
Energy Dependence of PARP(78)?

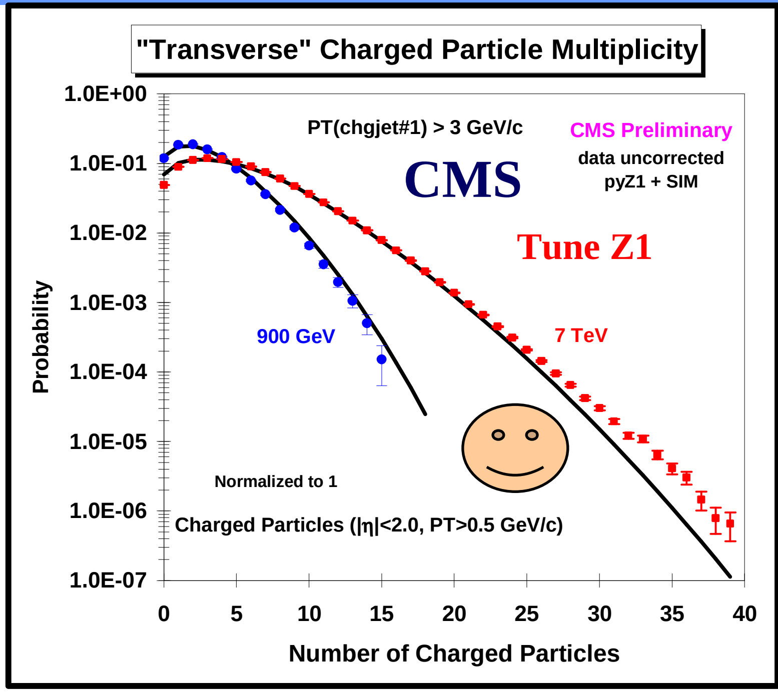
Holger Schulz & Peter Skands



➡ **In PYTHIA 6.4 the "color reconnection" strength, PARP(78), is a constant. However, if you find the best value ("min-bias" tune) at each energy independently it seems to have an energy dependence!**

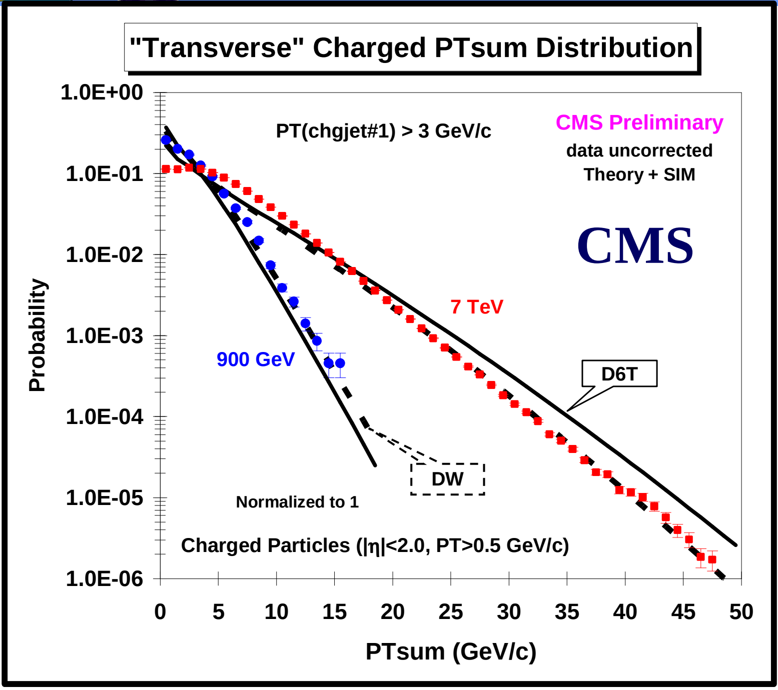
"Transverse" Multiplicity Distribution

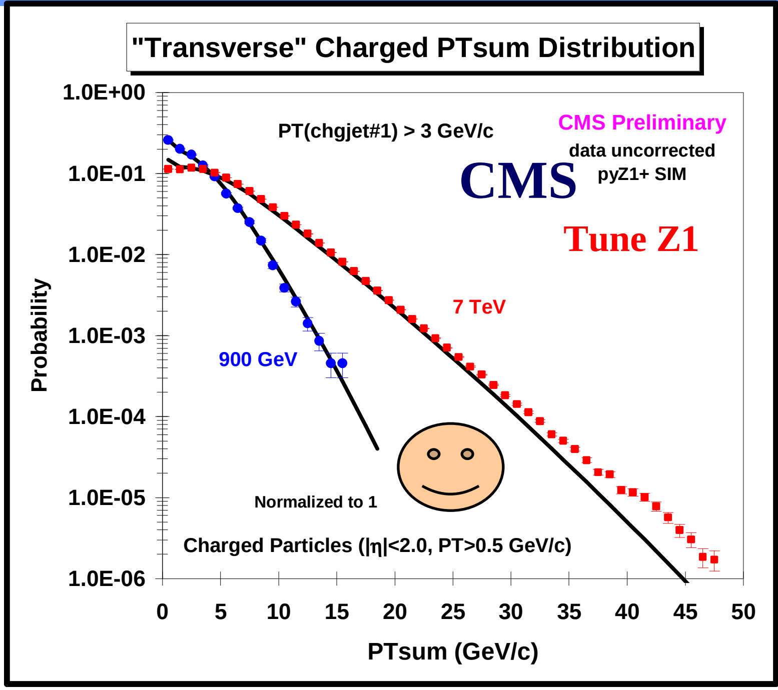




- **CMS uncorrected data at 900 GeV and 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW and Tune D6T at the detector level (*i.e.* Theory + SIM).**
- **CMS uncorrected data at 900 GeV and 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

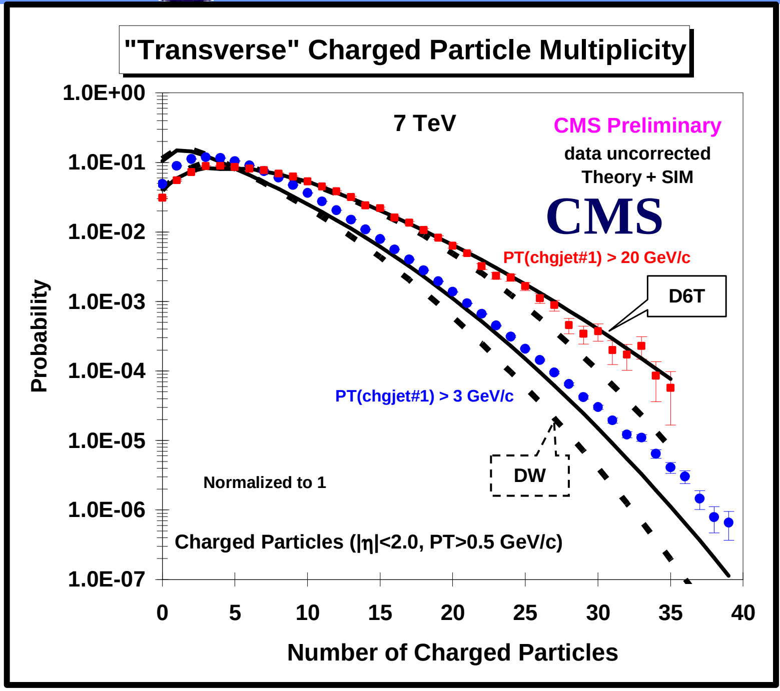
“Transverse” PTsum Distribution

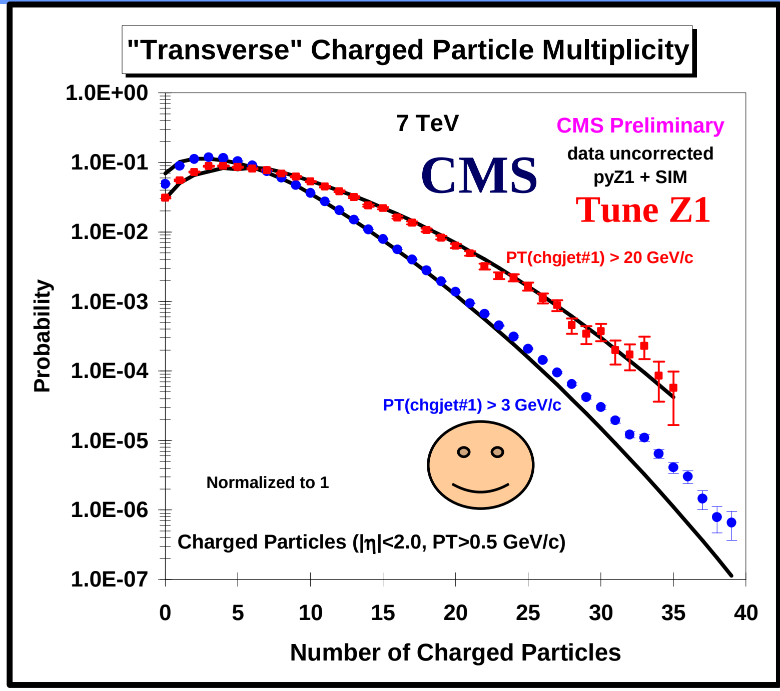




- **CMS uncorrected data at 900 GeV and 7 TeV on the charged scalar PTsum distribution in the “transverse” region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW, and Tune D6T at the detector level (*i.e.* Theory + SIM).**
- **CMS uncorrected data at 900 GeV and 7 TeV on the charged scalar PTsum distribution in the “transverse” region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune Z1, at the detector level (*i.e.* Theory + SIM).**

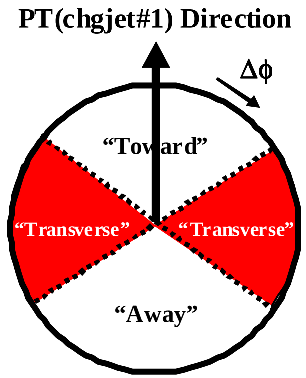
"Transverse" Multiplicity Distribution

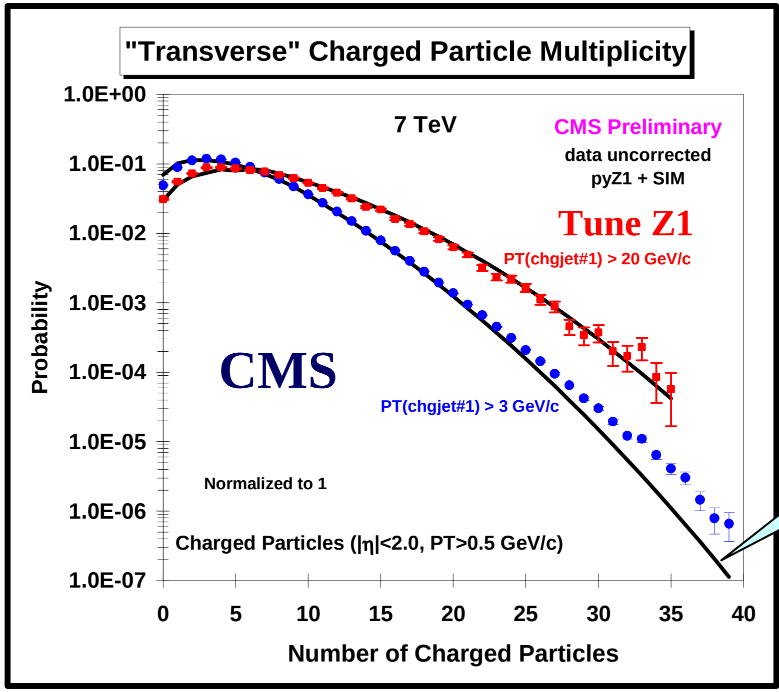




- **CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune DW and Tune D6T at the detector level (*i.e.* Theory + SIM).**
- **CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

“Transverse” Multiplicity Distribution

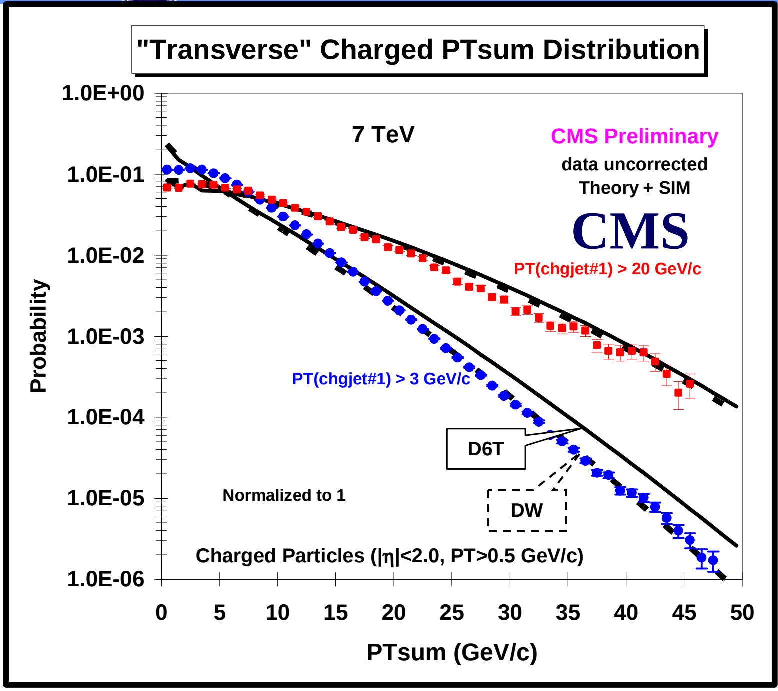


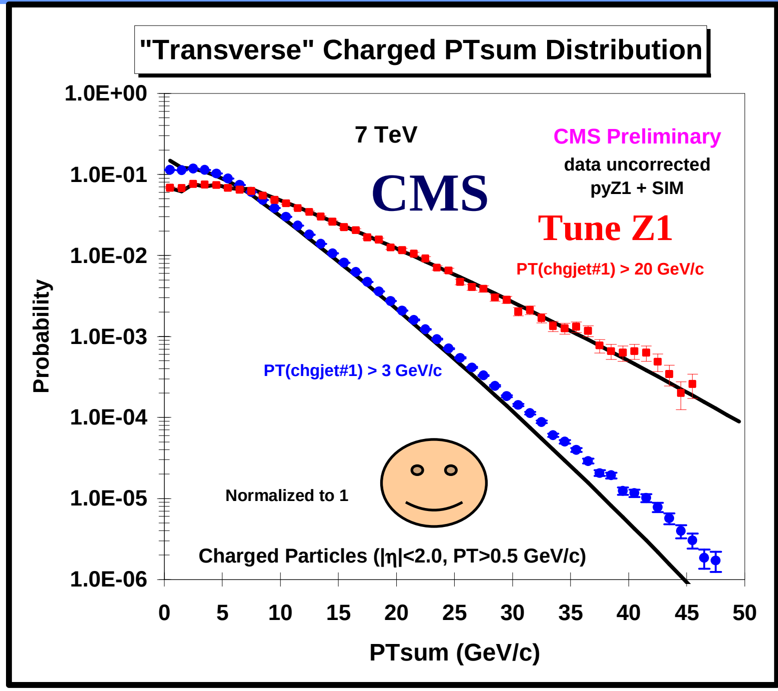


Difficult to produce enough events with large “transverse” multiplicity at low hard scale!

- **CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the “transverse” region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

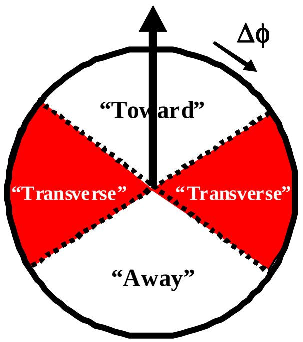
“Transverse” PTsum Distribution

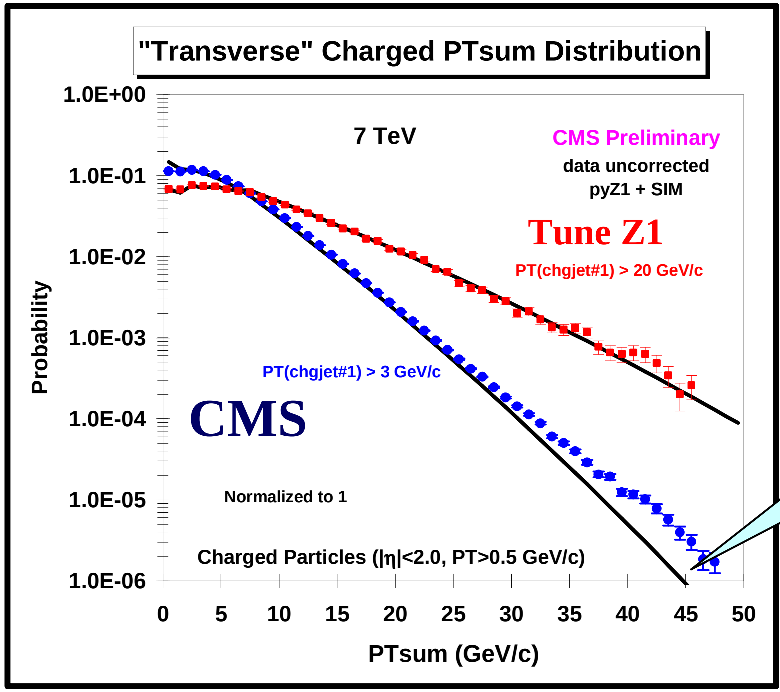




- **CMS uncorrected data at 7 TeV on the charged PTsum distribution in the “transverse” region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune DW and Tune D6T at the detector level (*i.e.* Theory + SIM).**
- **CMS uncorrected data at 7 TeV on the charged PTsum distribution in the “transverse” region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

"Transverse" PTsum Distribution

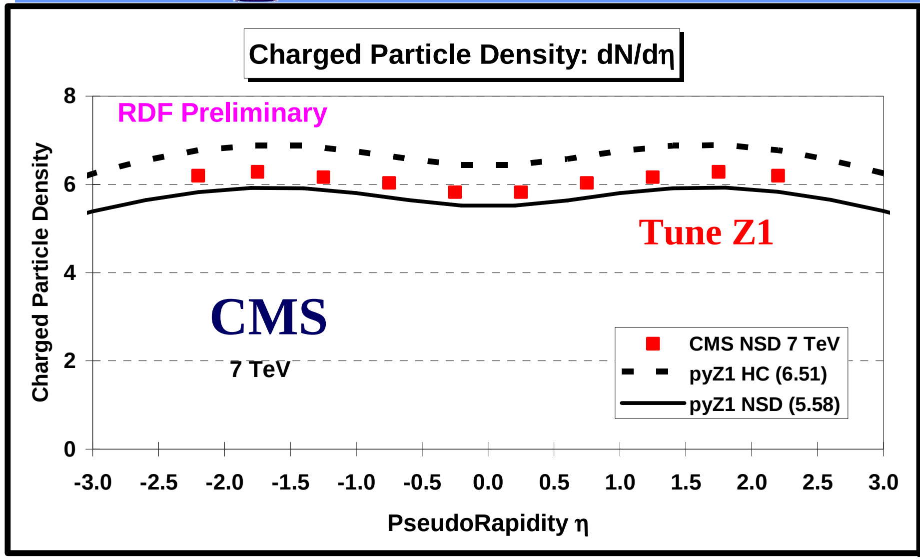


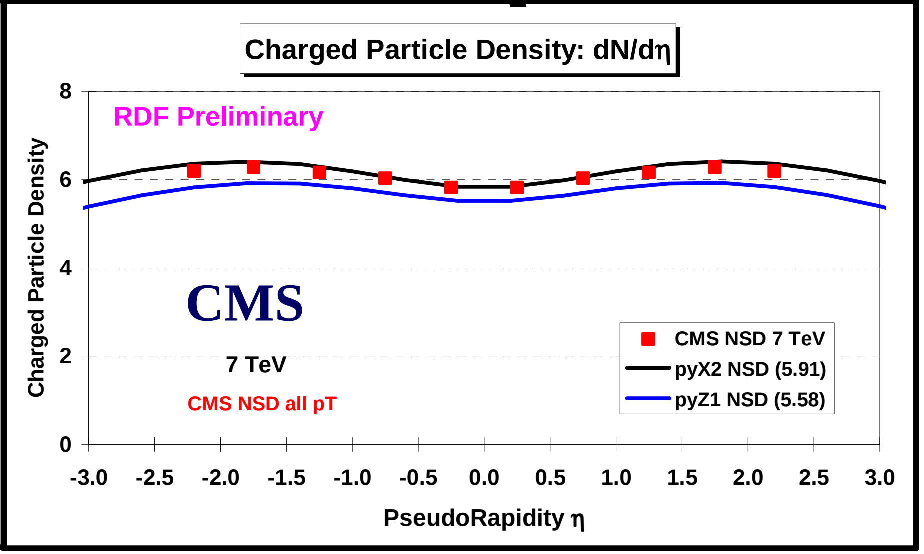


Difficult to produce enough events with large "transverse" PTsum at low hard scale!

- **CMS uncorrected data at 7 TeV on the charged PTsum distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

CMS dN/dη

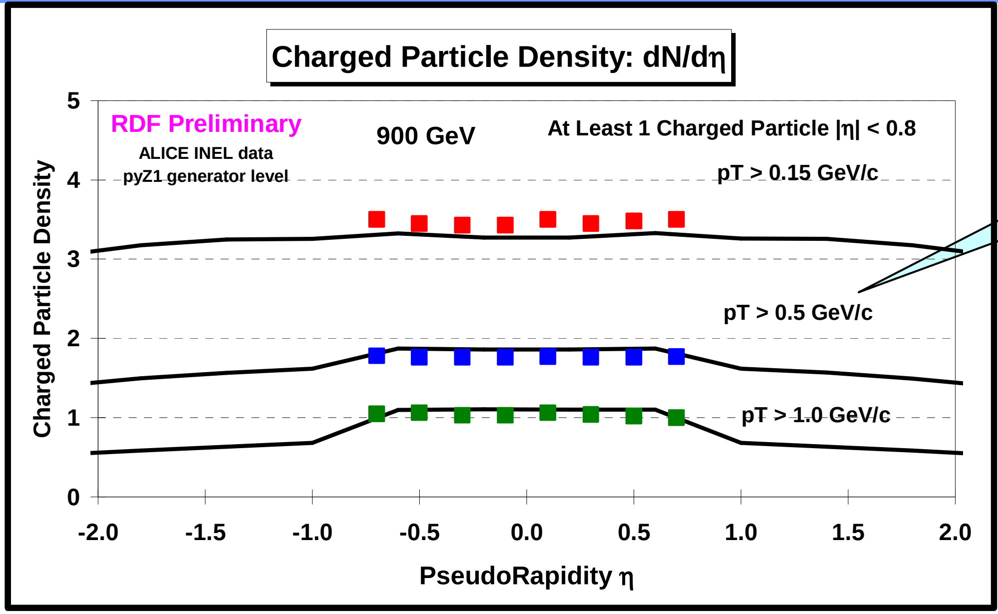




- **Generator level dN/dη (all pT). Shows the NSD = HC + DD and the HC = ND contributions for Tune Z1. Also shows the CMS NSD data.**
- **Generator level dN/dη (all pT). Shows the NSD = HC + DD prediction for Tune Z1 and Tune X2. Also shows the CMS NSD data.**

Okay not perfect, but remember we do not know if the DD is correct!

PYTHIA Tune Z1

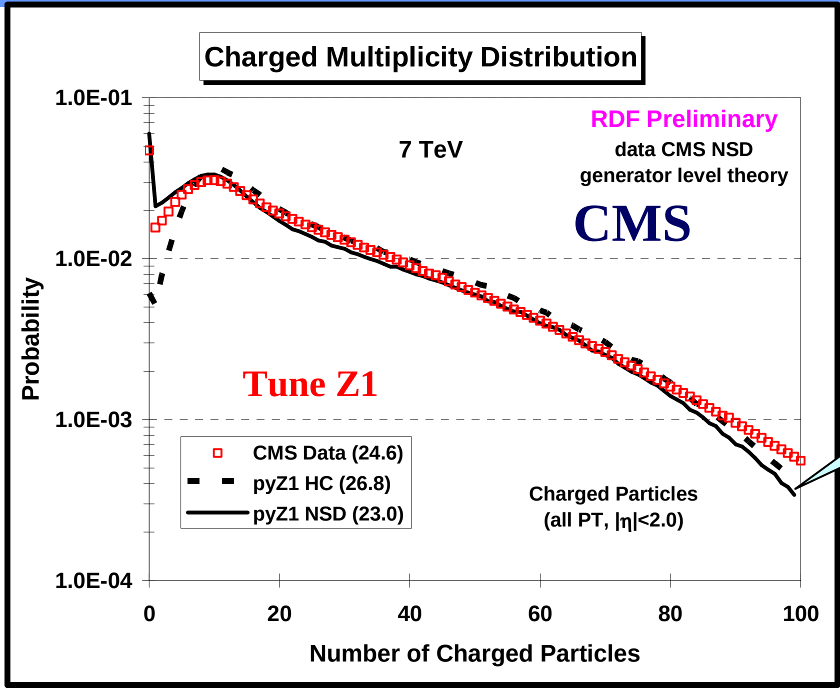


If one increases the hard scale the agreement improves!

- **ALICE inelastic data at 900 GeV on the dN/dη distribution for charged particles (p_T > PTmin) for events with at least one charged particle with p_T > PTmin and |η| < 0.8 for PTmin = 0.15 GeV/c, 0.5 GeV/c, and 1.0 GeV/c compared with PYTHIA Tune Z1 at the generator level.**

Okay not perfect, but remember we do not know if the SD & DD are correct!

NSD Multiplicity Distribution

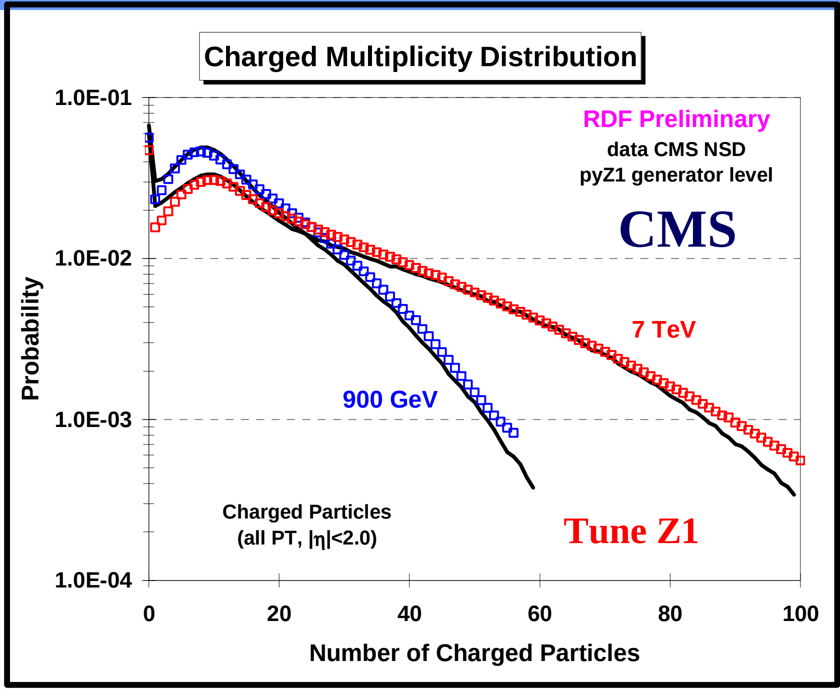


Difficult to produce enough events with large multiplicity!

➡ Generator level charged multiplicity distribution (all pT, $|\eta| < 2$) at 7 TeV. Shows the NSD = HC + DD and the HC = ND contributions for Tune Z1. Also shows the CMS NSD data.

Okay not perfect! But not that bad!

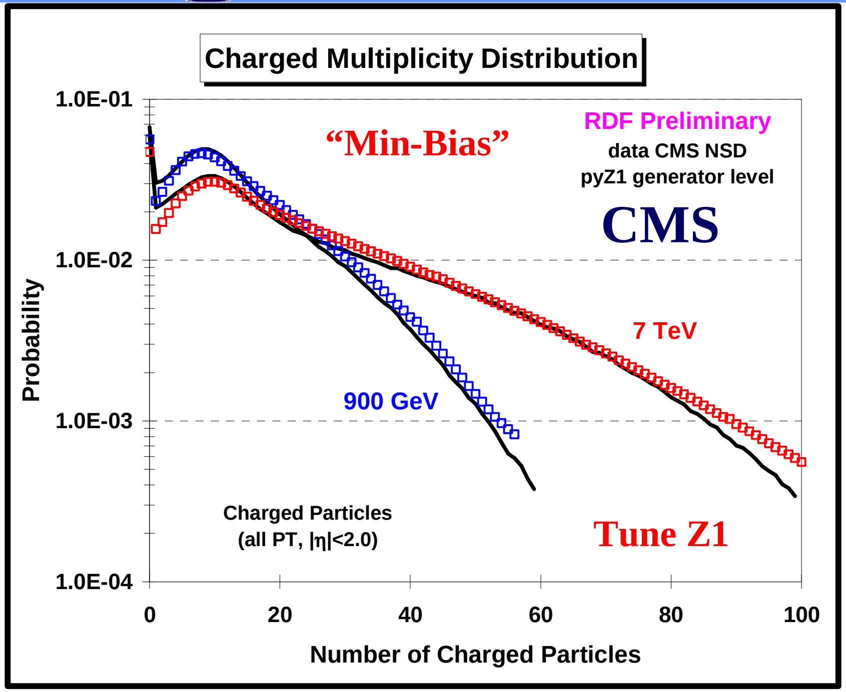
NSD Multiplicity Distribution

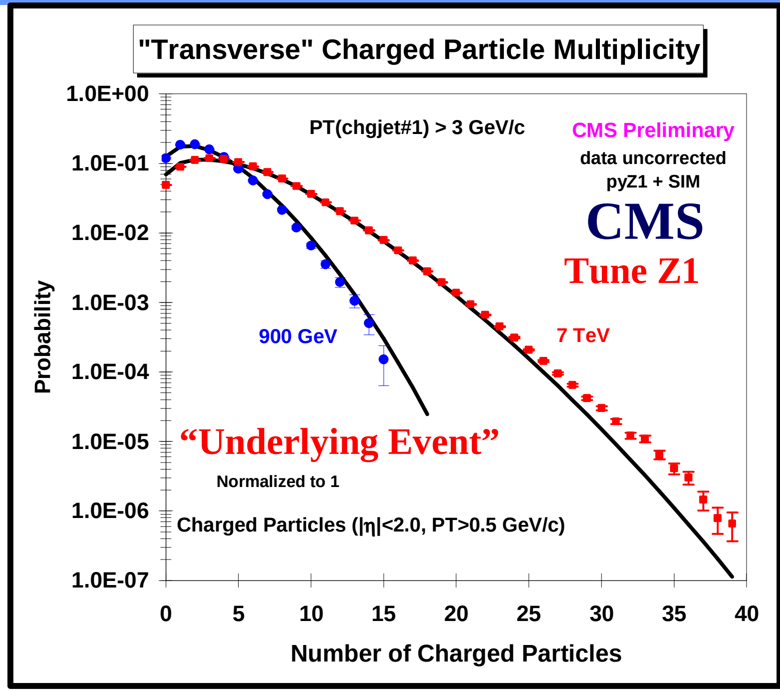


➡ **Generator level charged multiplicity distribution (all pT, |η| < 2) at 900 GeV and 7 TeV. Shows the NSD = HC + DD prediction for Tune Z1. Also shows the CMS NSD data.**

Okay not perfect!
But not that bad!

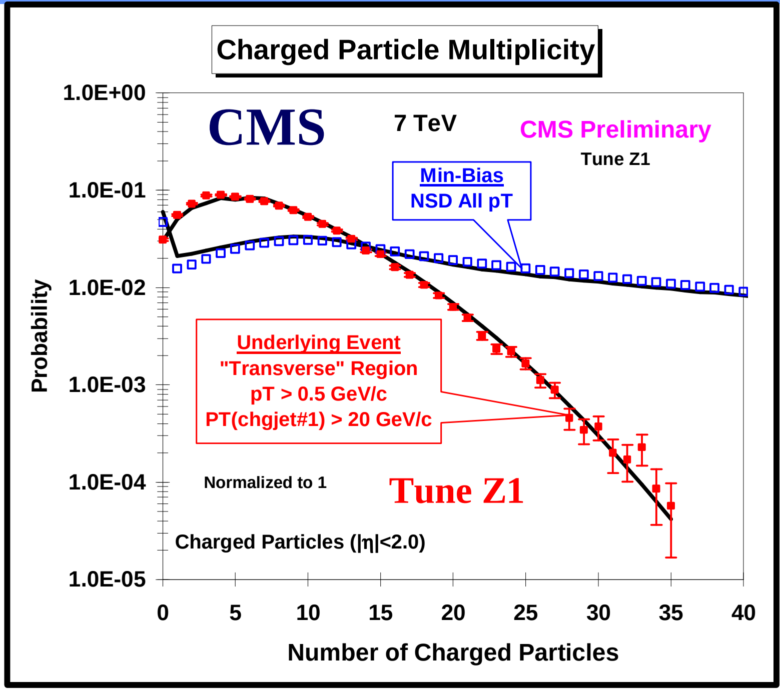
NSD Multiplicity Distribution





- **Generator level charged multiplicity distribution (all pT, |η| < 2) at 900 GeV and 7 TeV. Shows the NSD = HC + DD prediction for Tune Z1. Also shows the CMS NSD data.**
- **CMS uncorrected data at 900 GeV and 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM).**

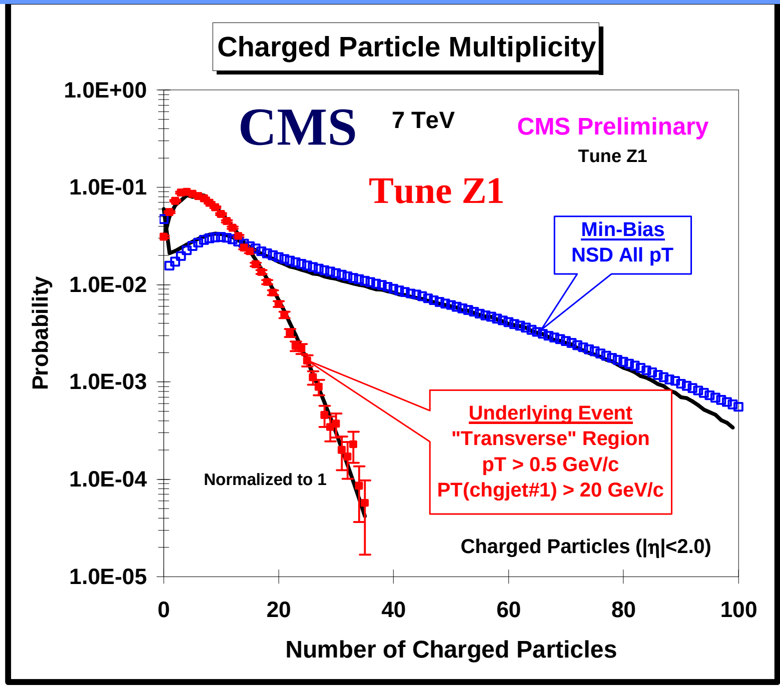
PYTHIA Tune Z1



- CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet with PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM). Also shows the CMS corrected NSD multiplicity distribution (all pT, $|\eta| < 2$) compared with Tune Z1 at the generator.

Amazing what we are asking the Monte-Carlo models to fit!

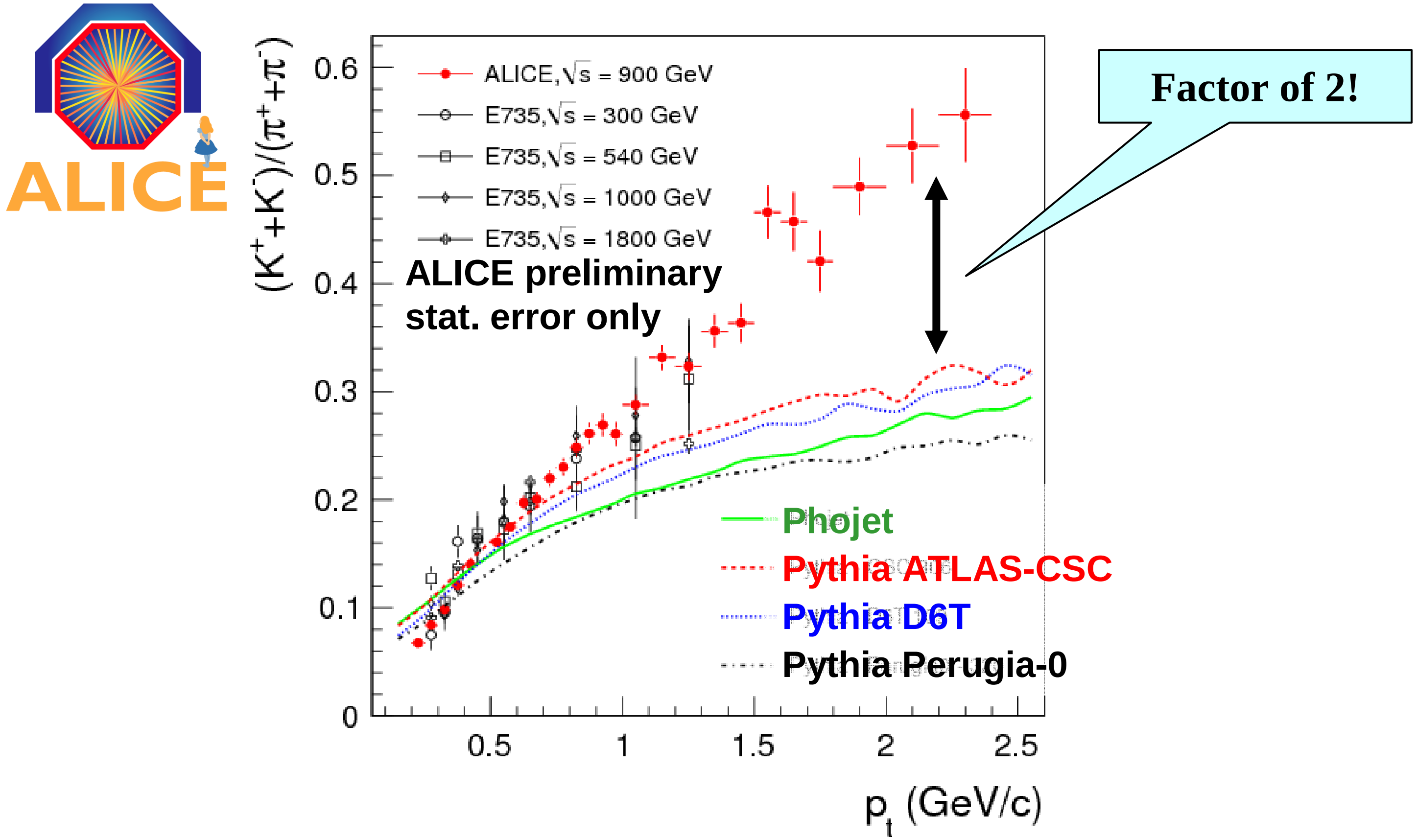
PYTHIA Tune Z1



- CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet with PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune Z1 at the detector level (*i.e.* Theory + SIM). Also shows the CMS corrected NSD multiplicity distribution (all pT, $|\eta| < 2$) compared with Tune Z1 at the generator.

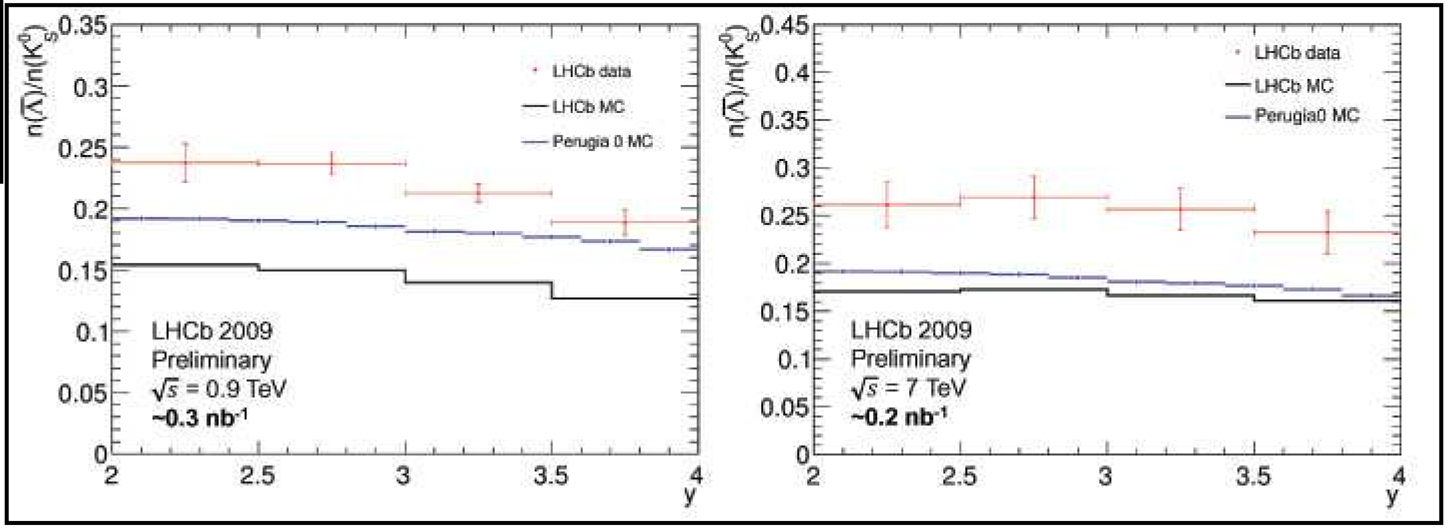
Amazing what we are asking the Monte-Carlo models to fit!

Strange Particle Production



- A lot more strange mesons at large p_T than predicted by the Monte-Carlo Models!
- K/π ratio fairly independent of the center-of-mass energy.

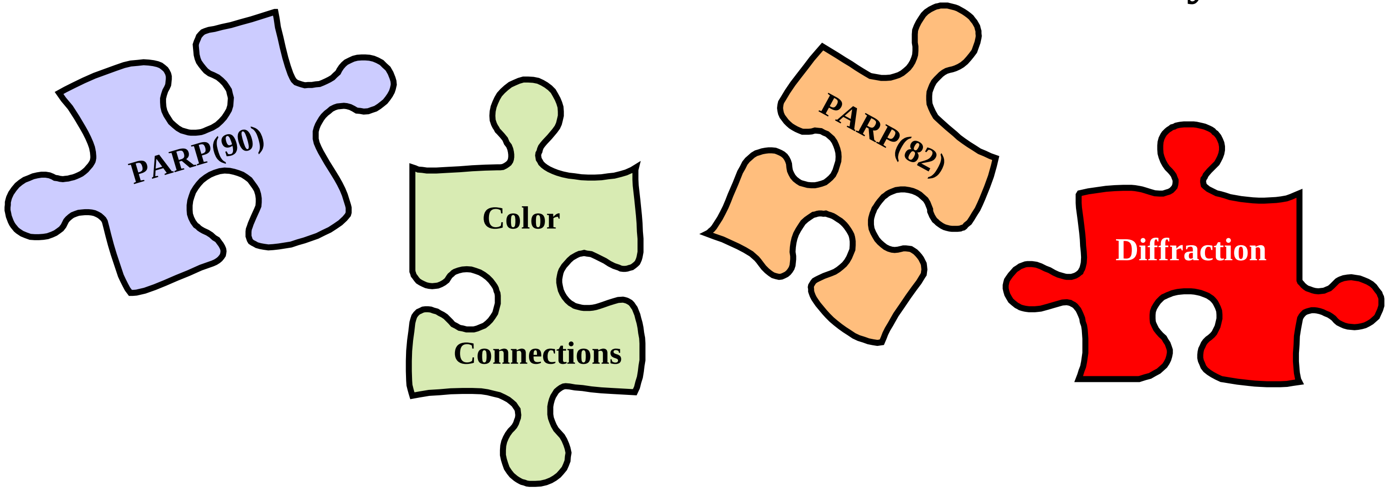
Strange Baryon Production



➡ **More strange baryons than expected!**

Min-Bias Summary

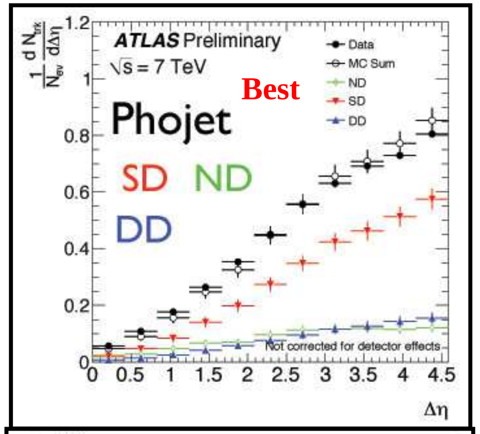
- We are a long way from having a Monte-Carlo model that will fit all the features of the LHC min-bias data! There are more soft particles that expected!
- We need a better understanding and modeling of diffraction!
- It is difficult for the Monte-Carlo models to produce a soft event (*i.e.* no large hard scale) with a large multiplicity. There seems to be more “min-bias” high multiplicity soft events at 7 TeV than predicted by the models!
- The models do not produce enough strange particles! I have no idea what is going on here! The Monte-Carlo models are constrained by LEP data.

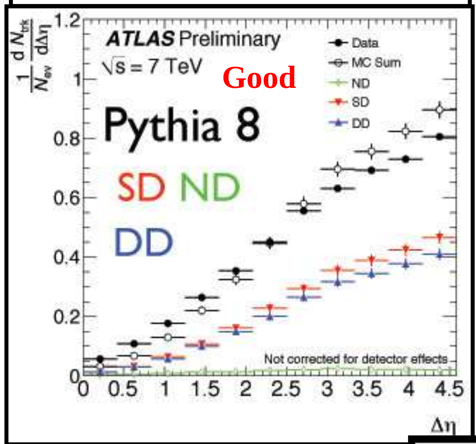


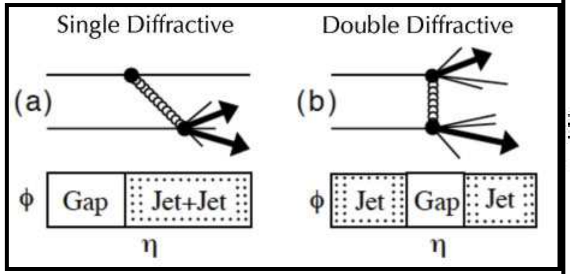
Min-Bias Summary

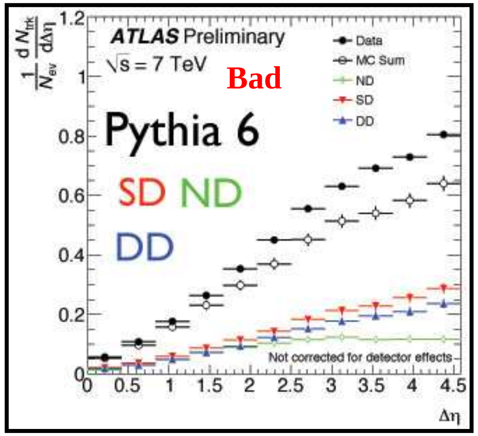
➡ **We need a better understanding and modeling of diffraction!**

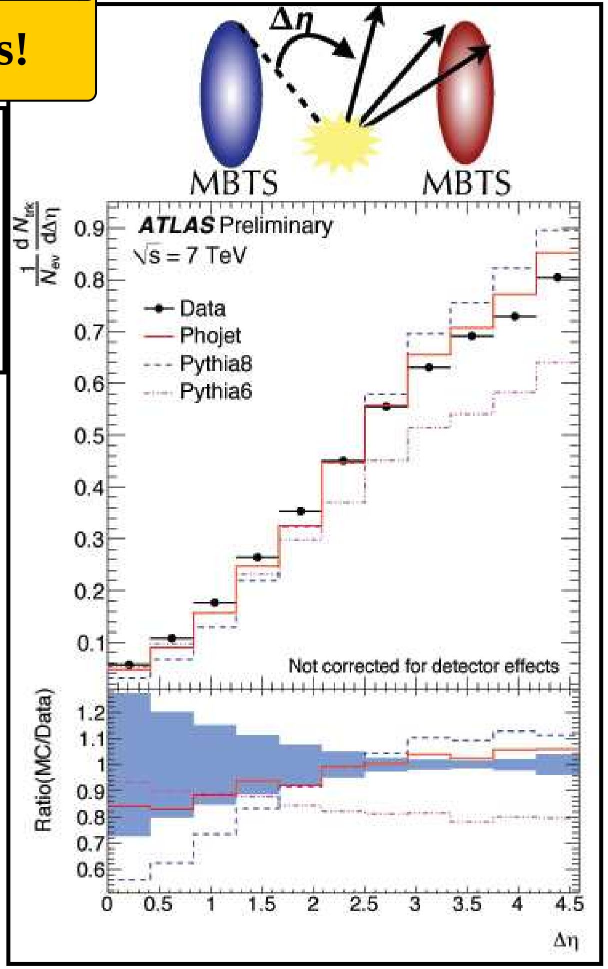
Explore by defining "diffractive enhanced" data samples!









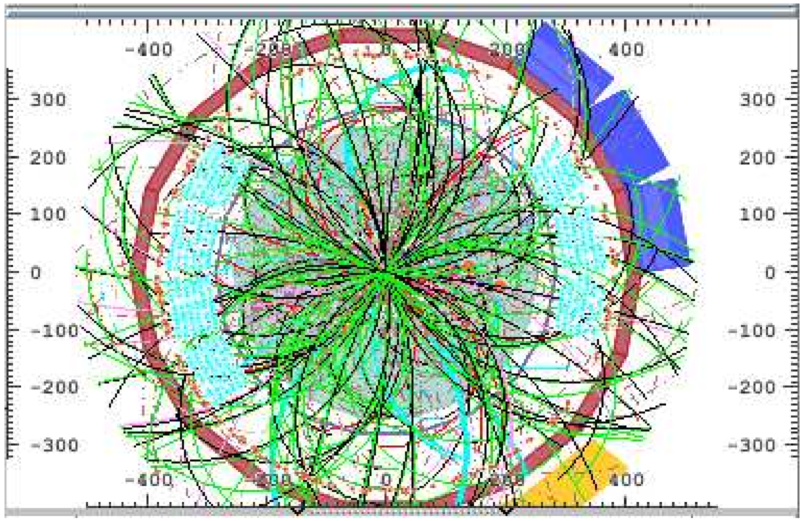


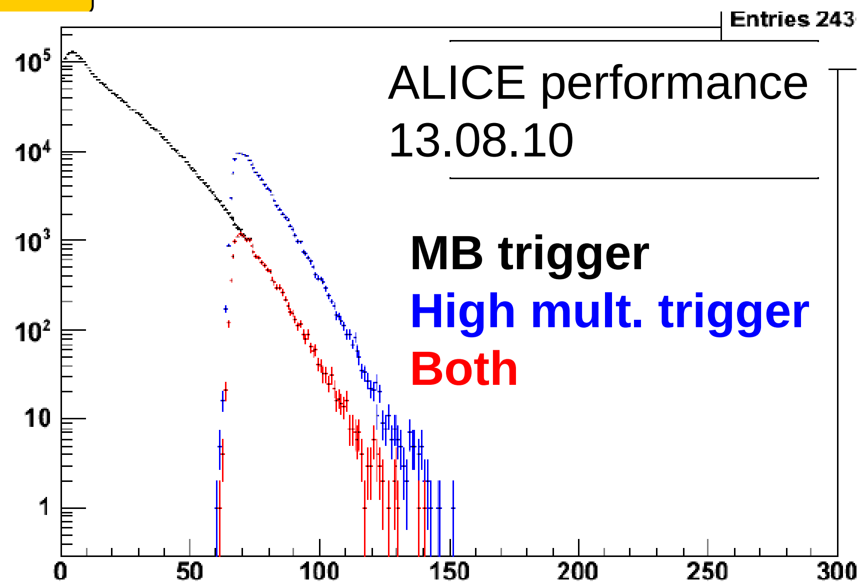
See the talk by Lauren Tompkins at the LPCC MB&UE@LHC Meeting September 6, 2010,

Min-Bias Summary

- It is difficult for the Monte-Carlo models to produce a soft event (*i.e.* no large hard scale) with a large multiplicity. **There seems to be more "min-bias" high multiplicity soft events at 7 TeV than predicted by the models!**

Explore by using a high multiplicity trigger!



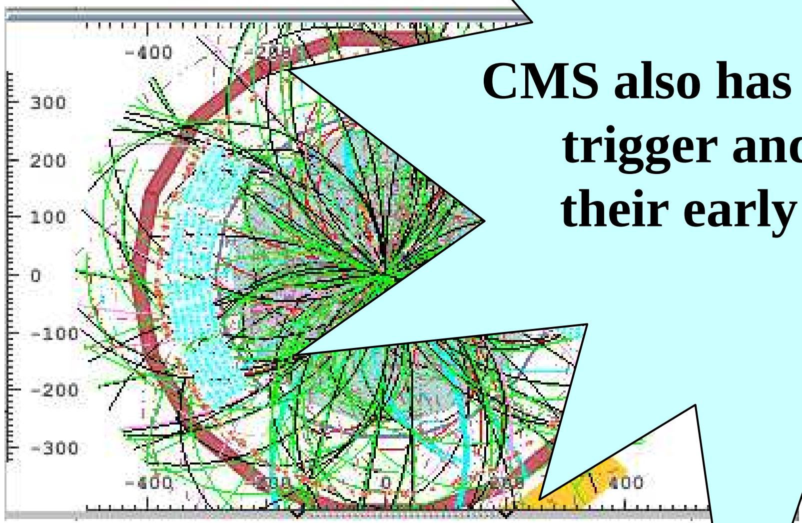


Fired chips in first pixel detector layer

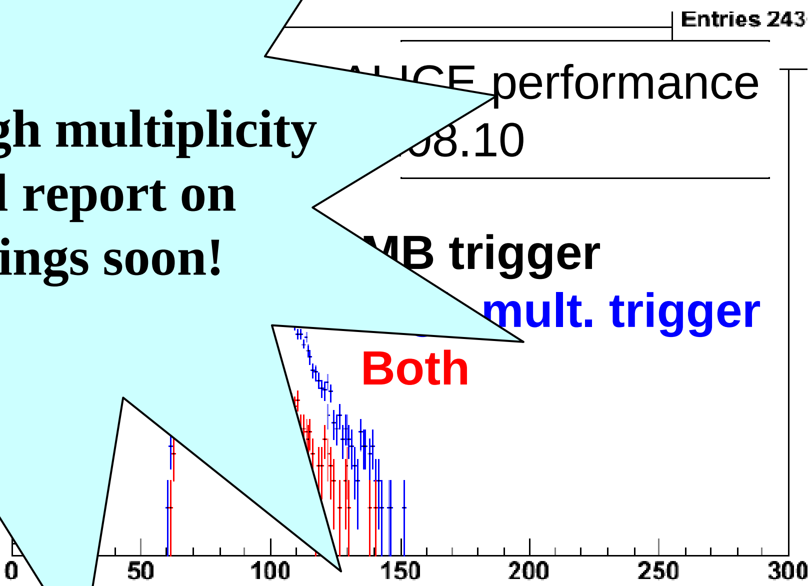
Min-Bias Summary

- It is difficult for the Monte-Carlo models to pr duce a soft event (*i.e.* no large hard scale) with a large multiplicity. **Th re seems to be more "min-bias" high multip icity soft event t 7 TeV n predicted by the models!**

Explore by using a hig tiplici er



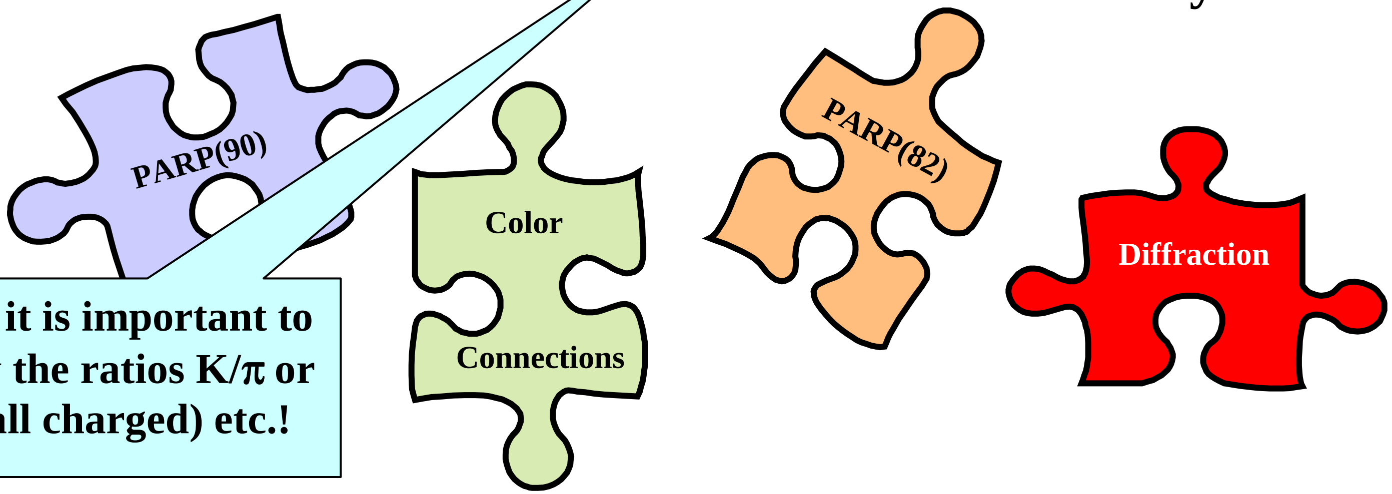
CMS also has a high multiplicity trigger and will report on their early findings soon!



Fired chips in first pixel detector layer

Min-Bias Summary

- **We are a long way from having a Monte-Carlo model that will fit all the features of the LHC min-bias data! There are more soft particles that expected!**
- **We need a better understanding and modeling of diffraction!**
- **It is difficult for the Monte-Carlo models to produce a soft event (*i.e.* no large hard scale) with a large multiplicity. There seems to be more "min-bias" high multiplicity soft events at 7 TeV than predicted by the models!**
- **The models do not produce enough strange particles! I have no idea what is going on here! The Monte-Carlo models are constrained by LEP data.**



Here it is important to study the ratios K/π or K/(all charged) etc.!