LHC First Data

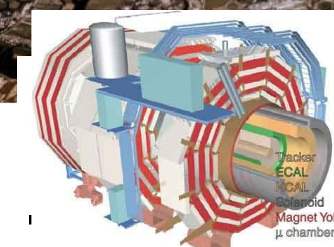
Monte-Carlo Models Facing Real Data

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

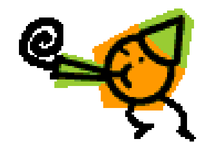
Rick Field
University of Florida

Outline of Talk

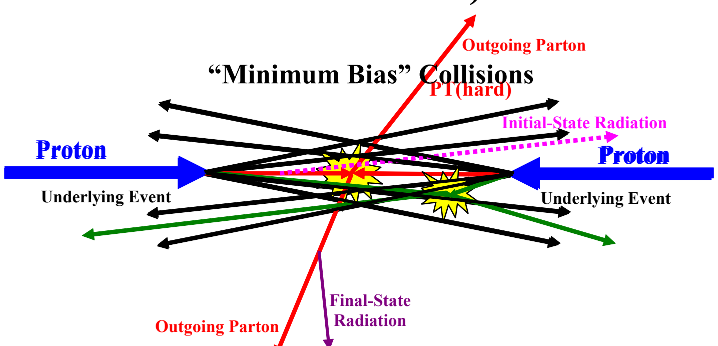
- How well did we do at predicting the behavior of the "underlying event" at 900 GeV and 7 TeV? A careful look.
- How well did we do at predicting the behavior of "min-bias" collisions at 900 GeV and 7 TeV? A careful look.
- **PYTHIA 6.4 Tune Z1:** New CMS 6.4 tune (p_T-ordered parton showers and new MPI).



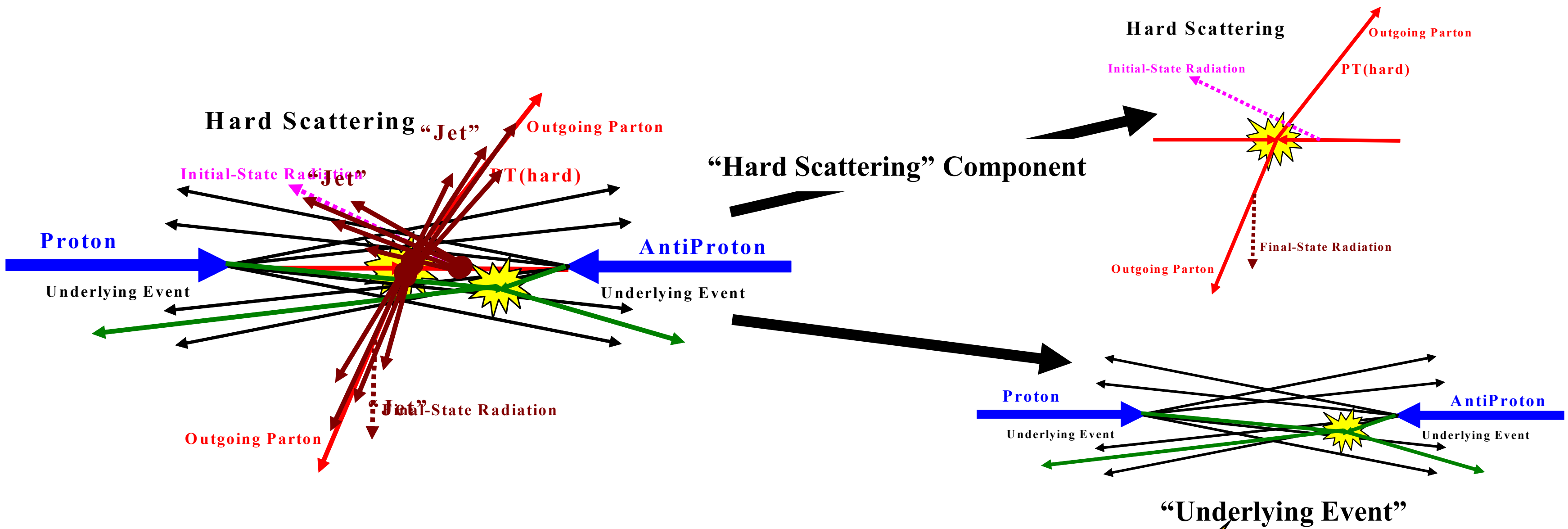
CMS



ATLAS



QCD Monte-Carlo Models: High Transverse Momentum Jets



- **Start with the perturbative 2-to-2 (or sometimes 2-to-3) parton-parton scatter[…]g and add initial and final-state gluon radiation (in the leading log approximation or modified leadin[…] approximation).**
- **The "underlying event" consists of the "beam-beam remnants" and […]articles arising from soft or semi-soft multiple parton interactions (MPI).**
- **Of course the outgoing colored parton[…]bly "underlying event" observables receive contributions fron[…]**

The "underlying event" is an unavoidable background to most collider observables and having good understand of it leads to more precise collider measurements!

Traditional Approach

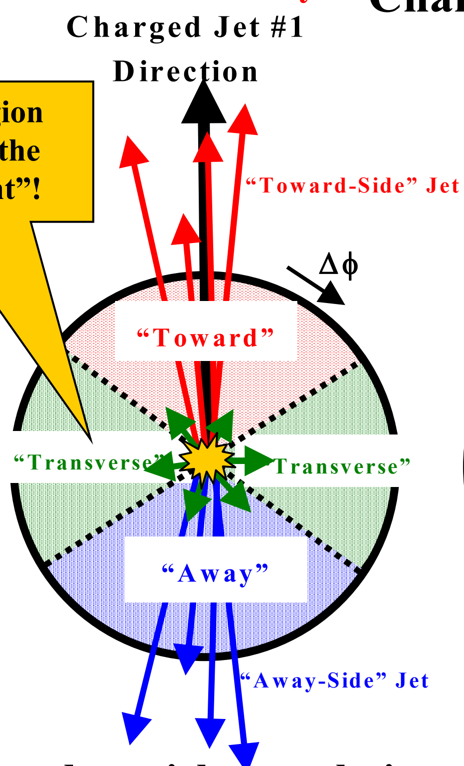
CDF Run 1 Analysis

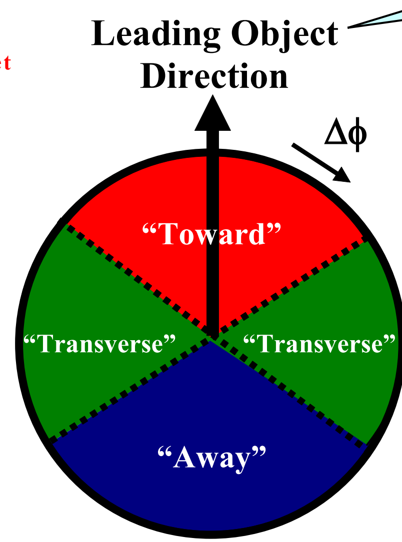
Charged Particle $\Delta\phi$ Correlations

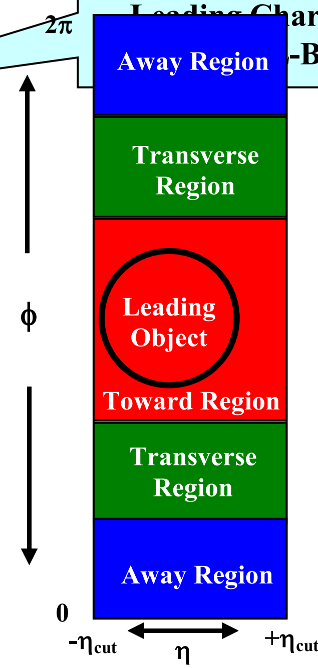
$P_T > PT_{min}$ $|\eta| < \eta_{cut}$

“Transverse” region very sensitive to the “underlying event”!

Leading Calorimeter Jet or
Leading Charged Particle Jet or
Leading Charged Particle or
-Boson

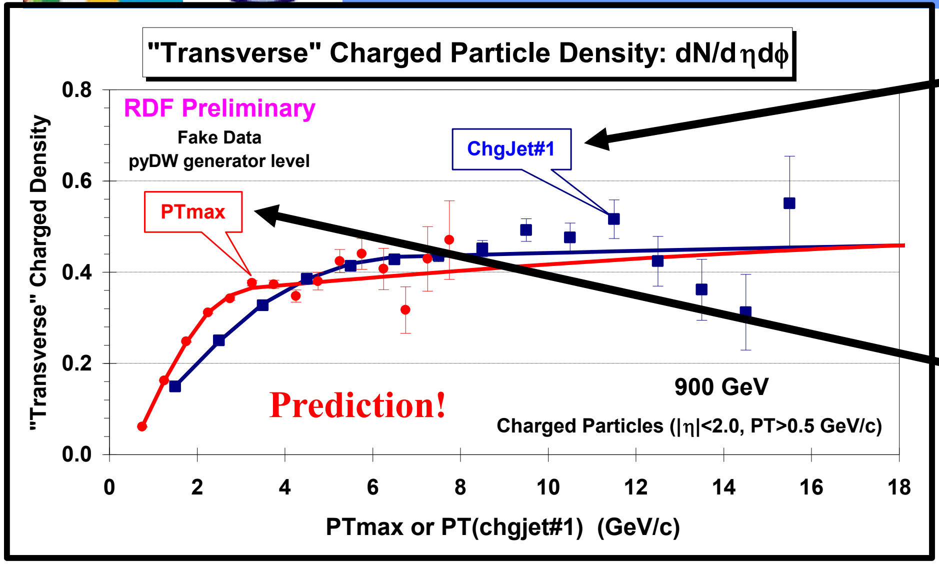


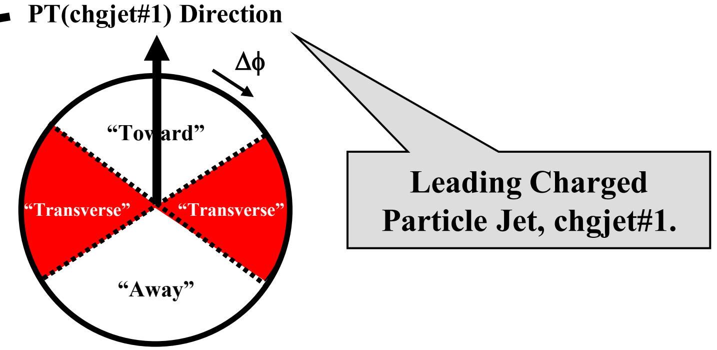


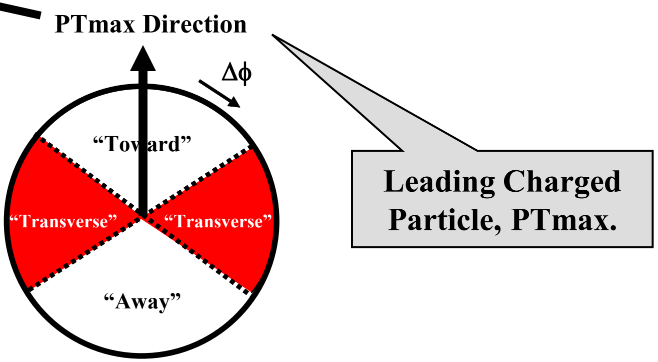


- Look at charged particle correlations in the azimuthal angle $\Delta\phi$ relative to a leading object (*i.e.* CaloJet#1, ChgJet#1, PTmax, Z-boson). For CDF PTmin = 0.5 GeV/c $\eta_{cut} = 1$.
- Define $|\Delta\phi| < 60^o$ as “Toward”, $60^o < |\Delta\phi| < 120^o$ as “Transverse”, and $|\Delta\phi| > 120^o$ as “Away”.
- All three regions have the same area in η-ϕ space, $\Delta\eta\times\Delta\phi = 2\eta_{cut}\times120^o = 2\eta_{cut}\times2\pi/3$. Construct densities by dividing by the area in η-ϕ space.

"Transverse" Charged Particle Density



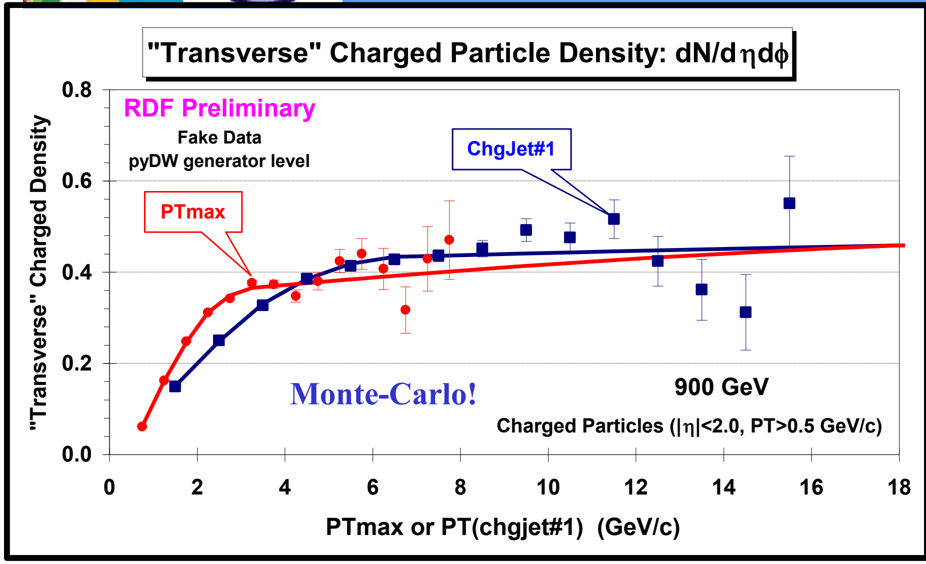


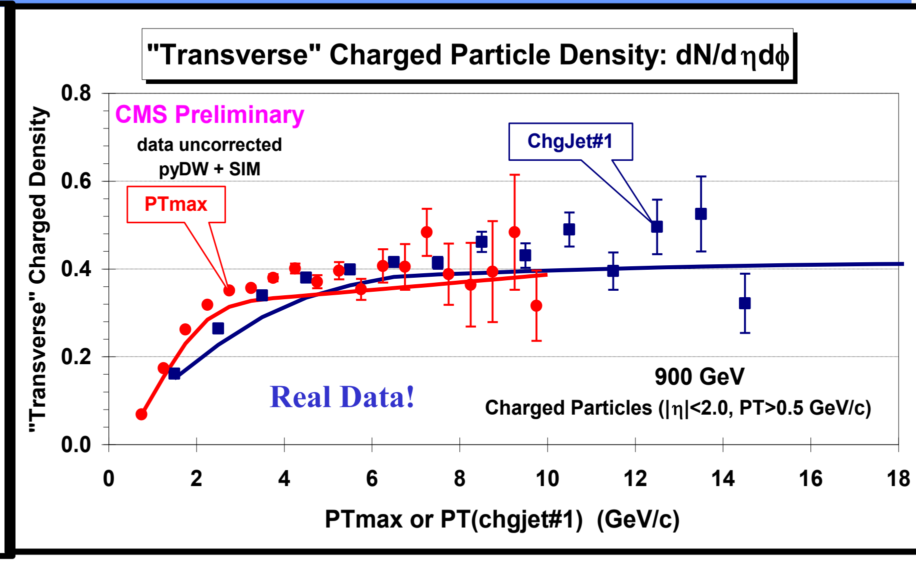


- **Fake data (from MC) at 900 GeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) and the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The fake data (from PYTHIA Tune DW) are generated at the particle level (*i.e.* generator level) assuming 0.5 M min-bias events at 900 GeV (361,595 events in the plot).**

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

“Transverse” Charged Particle Density





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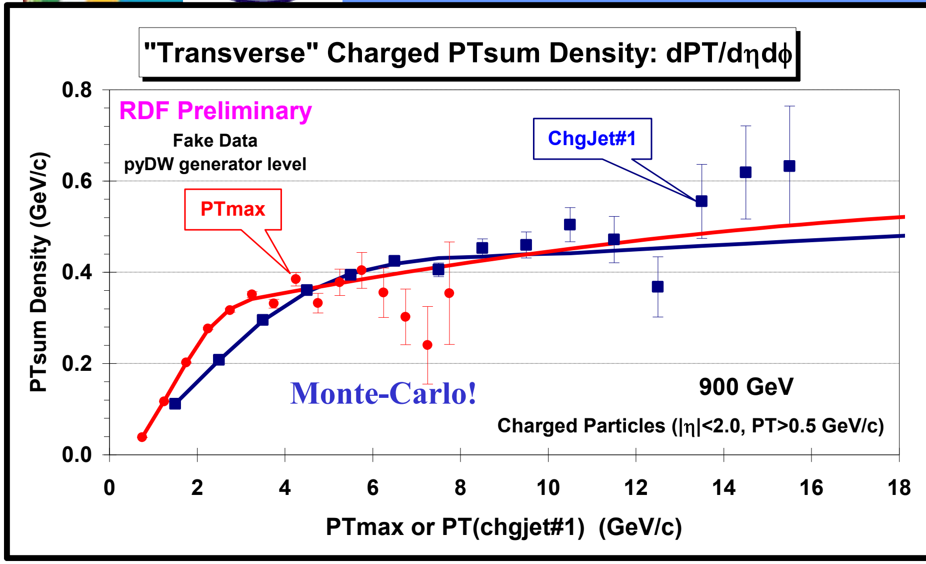
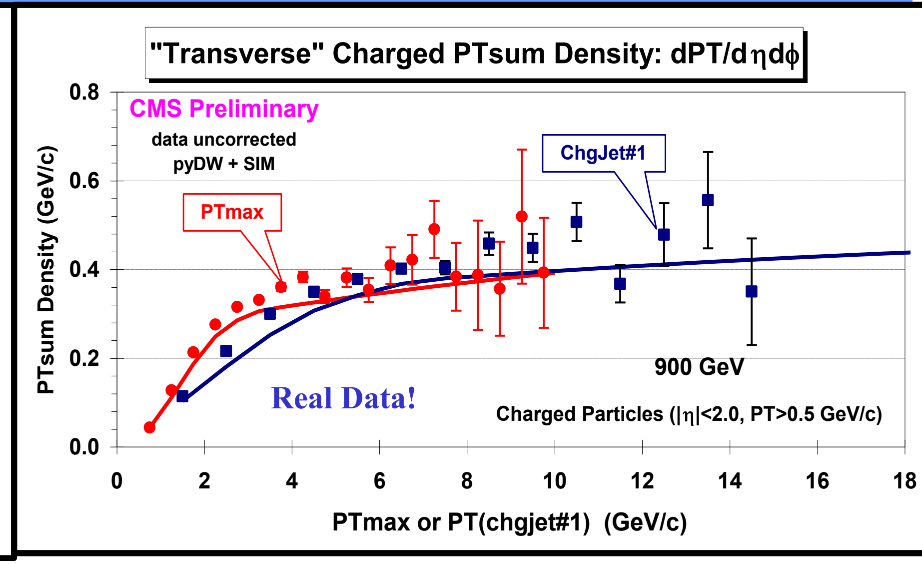
- **CMS preliminary data at 900 GeV on the “transverse” charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) and the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation (216,215 events in the plot).**

“Transverse” Charged PTsum Density





- **Fake data (from MC) at 900 GeV on the “transverse” charged PTsum density, dPT/dηdϕ, as defined by the leading charged particle (PTmax) and the leading charged particle jet (chgjet#1) for charged particles with p_T > 0.5 GeV/c and |η| < 2. The fake data (from PYTHIA Tune DW) are generated at the particle level (*i.e.* generator level) assuming 0.5 M min-bias events at 900 GeV (361,595 events in the plot).**

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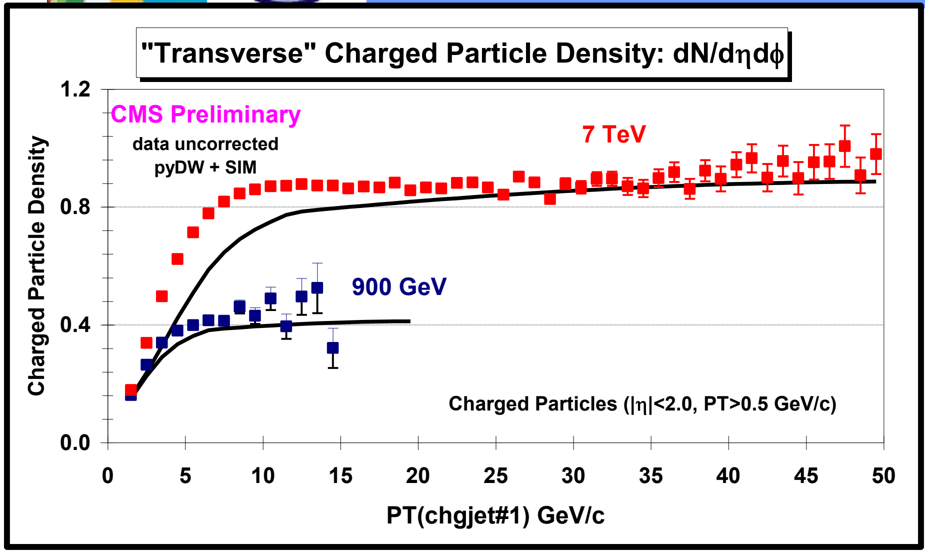
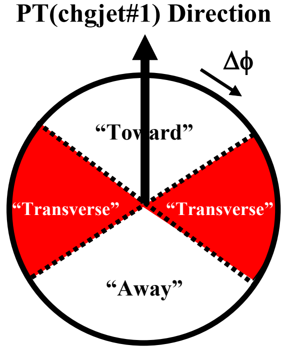
PYTHIA Tune DW





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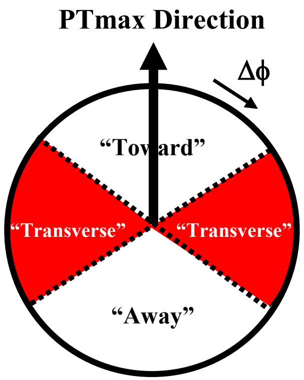
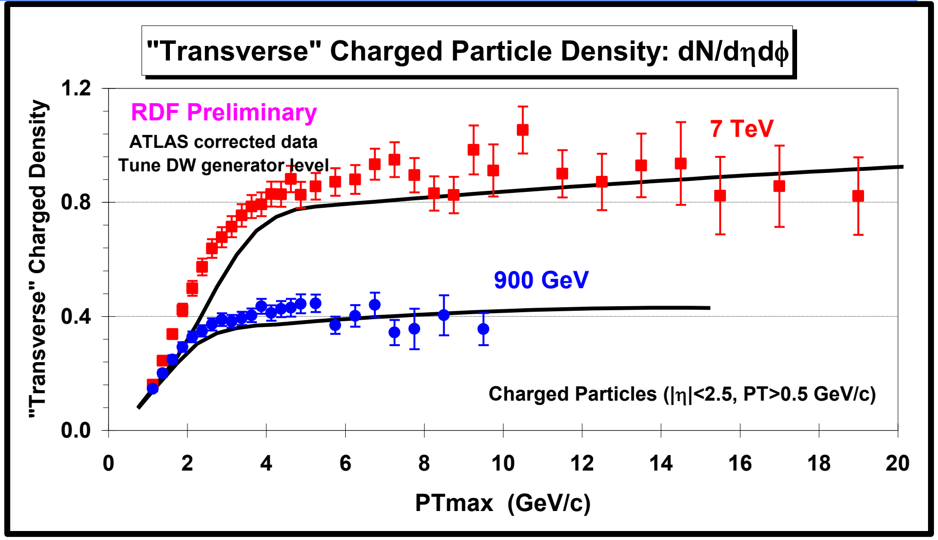


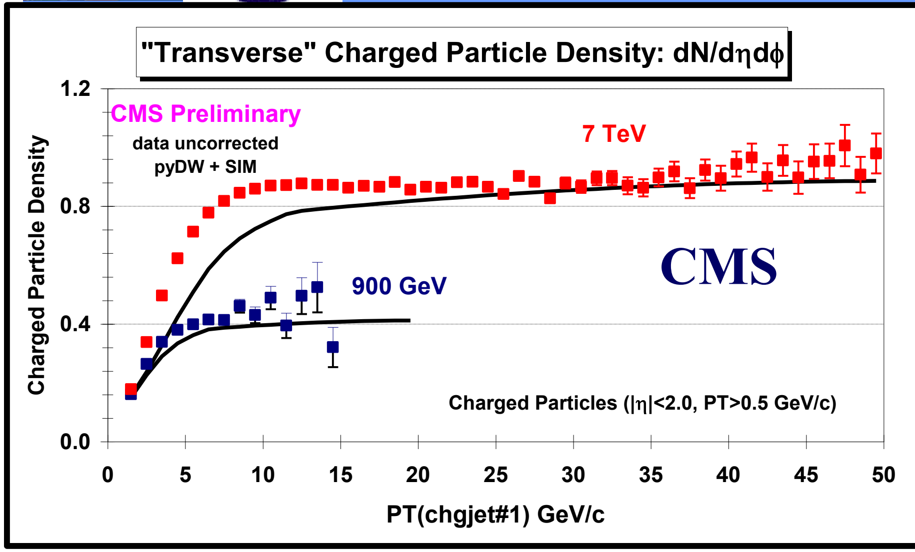


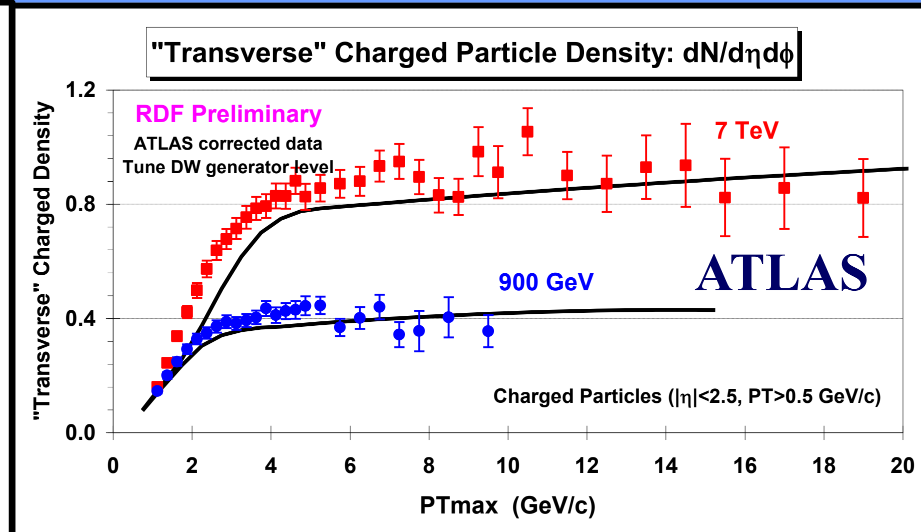
➡ **ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdϕ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 2.5. The data are corrected and compared with PYTHIA Tune DW at the generator level.**

I read the point off with a ruler!

ATLAS Note: ATLAS-CONF-2010-029
May 29, 2010

PYTHIA Tune DW





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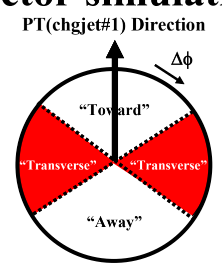
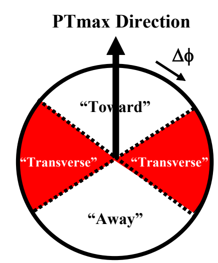
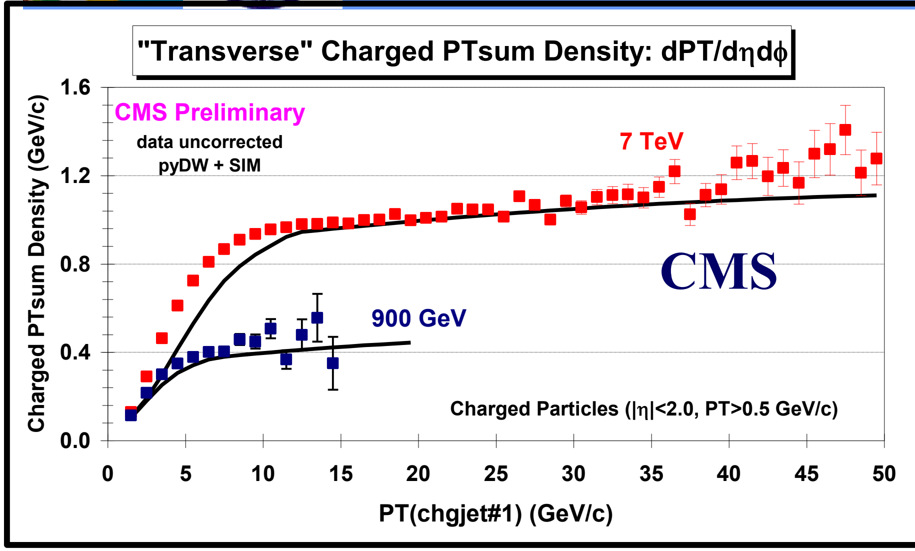
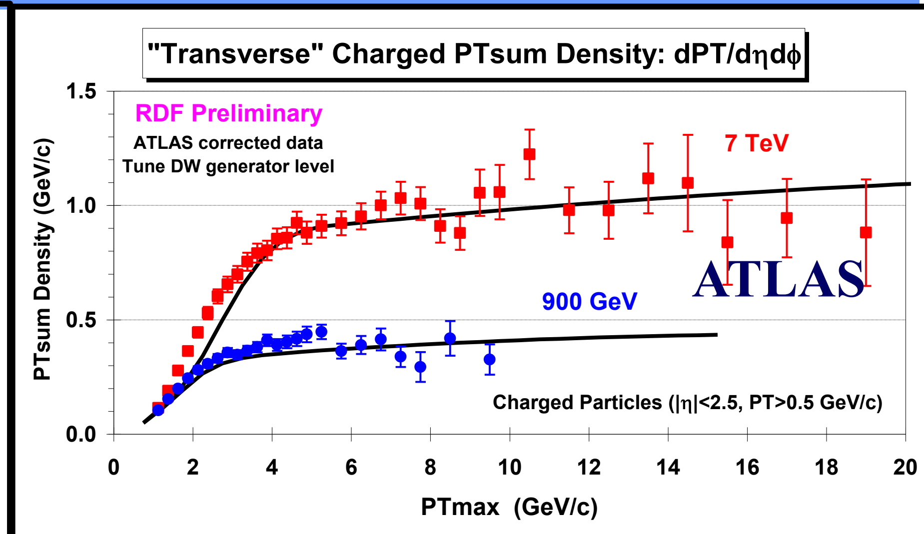




PYTHIA Tune DW





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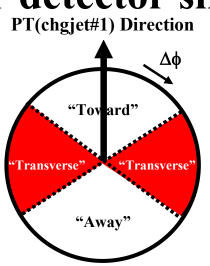

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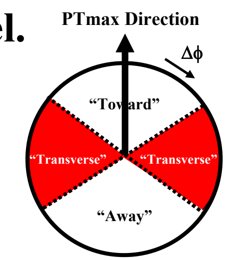

"Transverse" Charge Density

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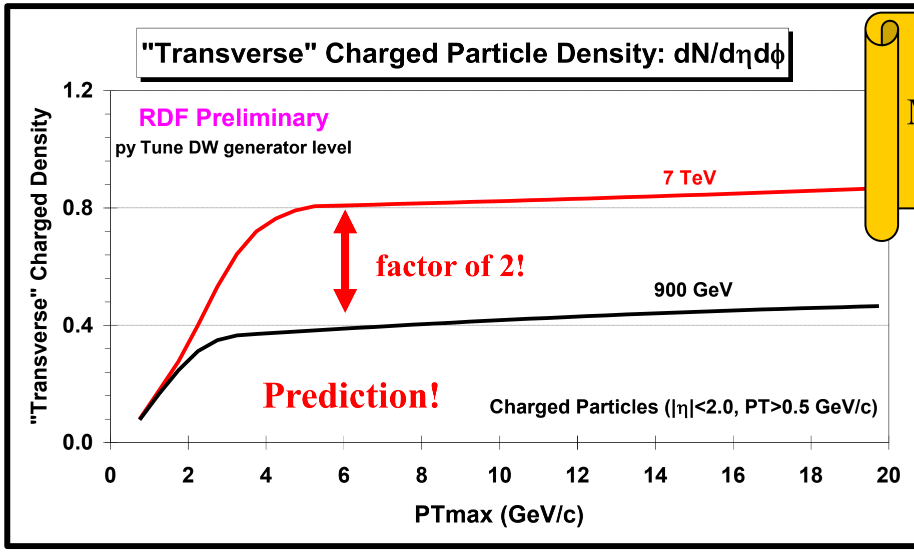
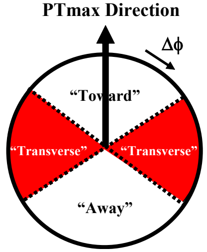


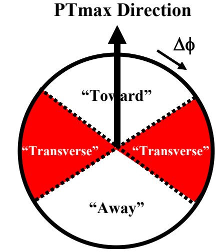
LHC
900 GeV



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

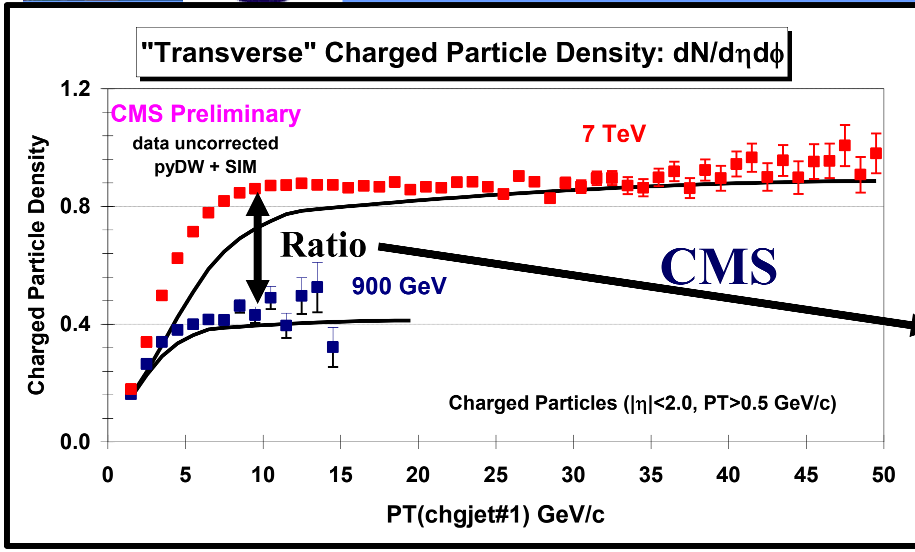
~0.4 → ~0.8

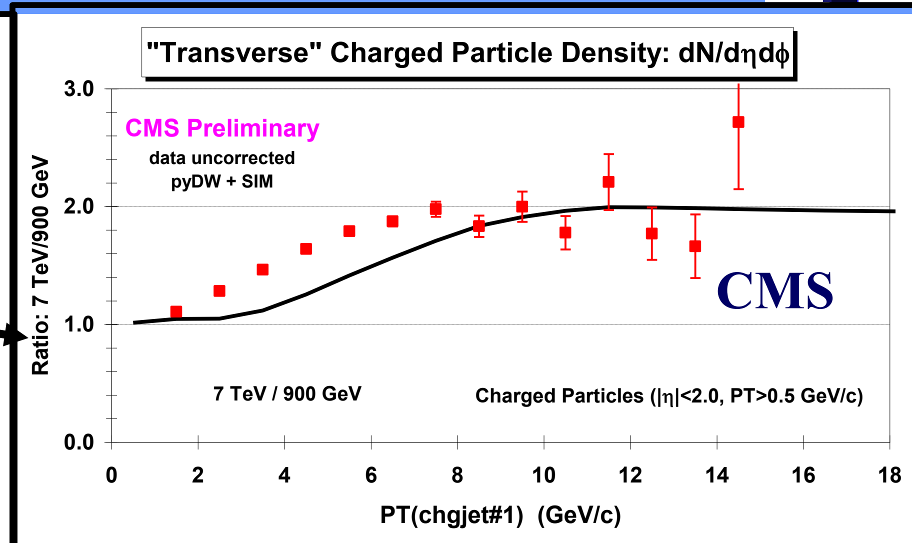
LHC
7 TeV



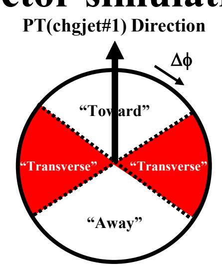
- **Shows the charged particle density in the "transverse" region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) at 900 GeV and 7 TeV as defined by PTmax from PYTHIA Tune DW and at the particle level (*i.e.* generator level).**

PYTHIA Tune DW

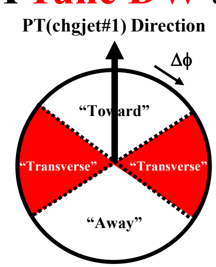




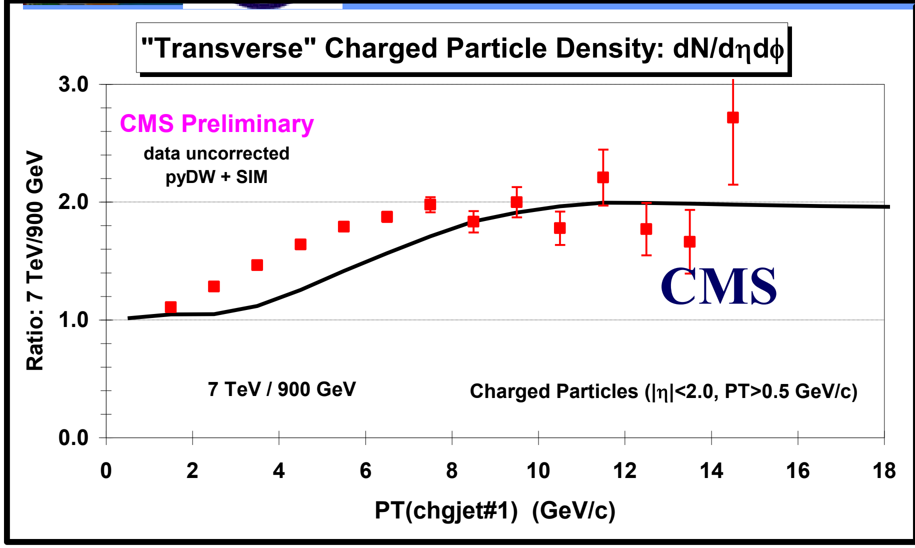
- CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune DW after detector simulation.

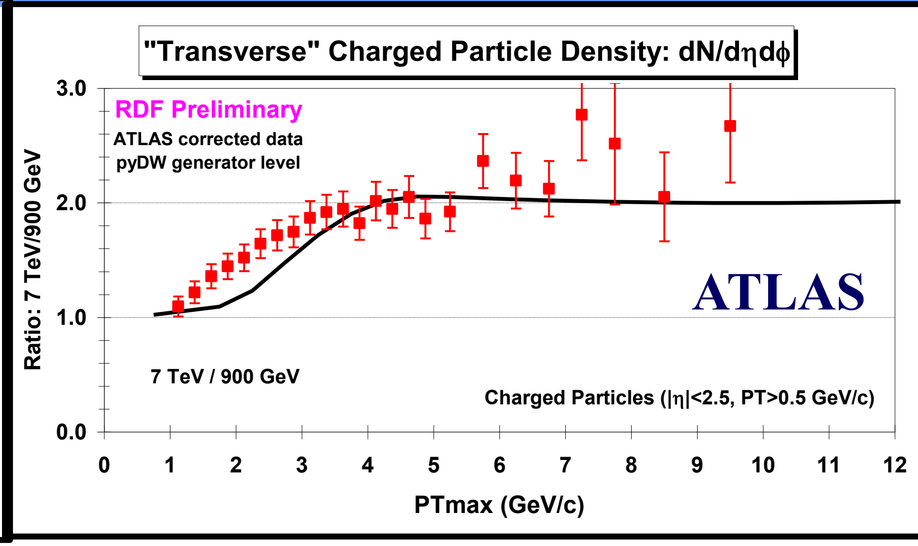


- Ratio of CMS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle jet (chgjet#1) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2$. The data are uncorrected and compared with PYTHIA Tune DW after detector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



PYTHIA Tune DW





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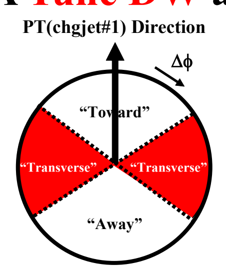

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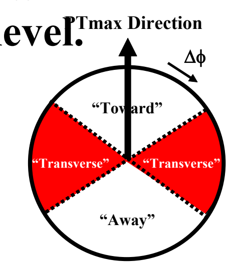

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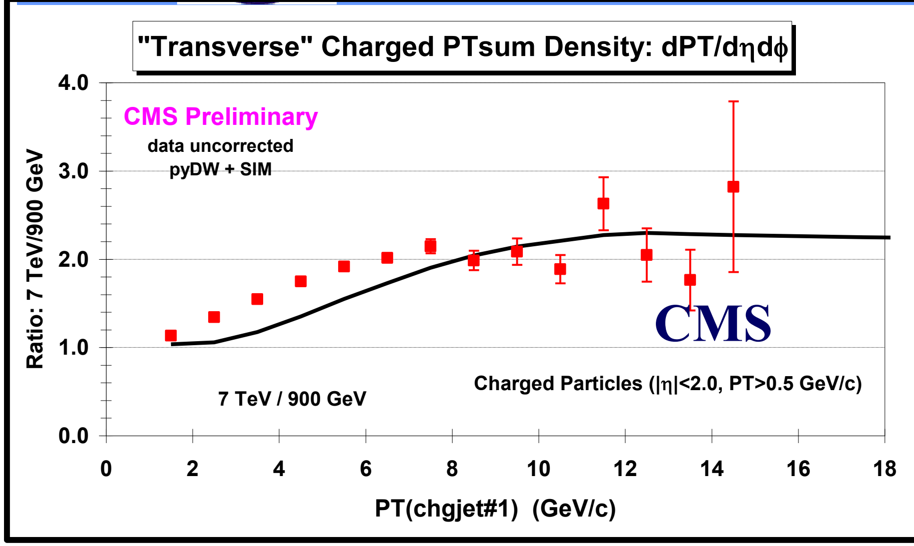

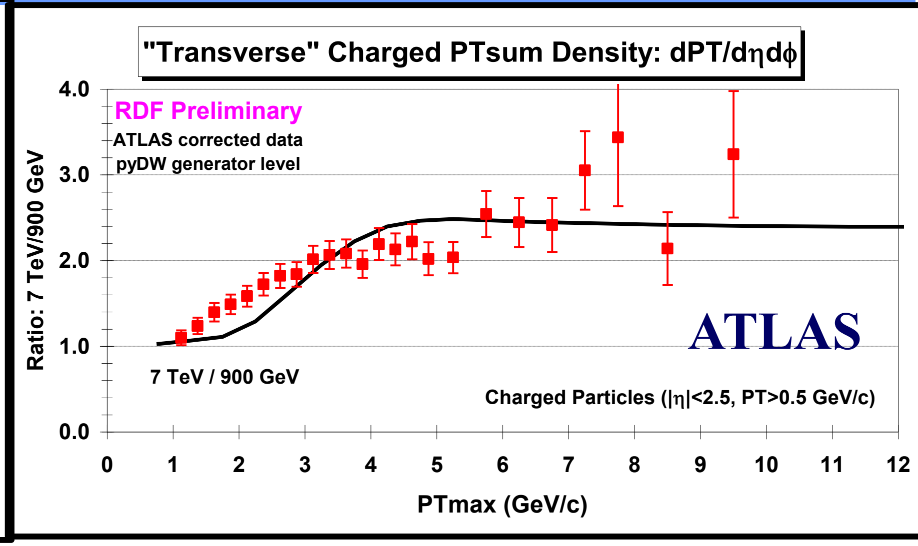

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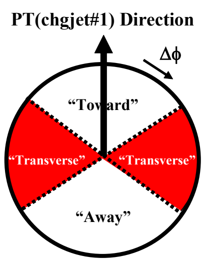

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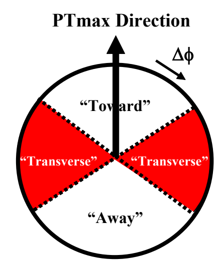
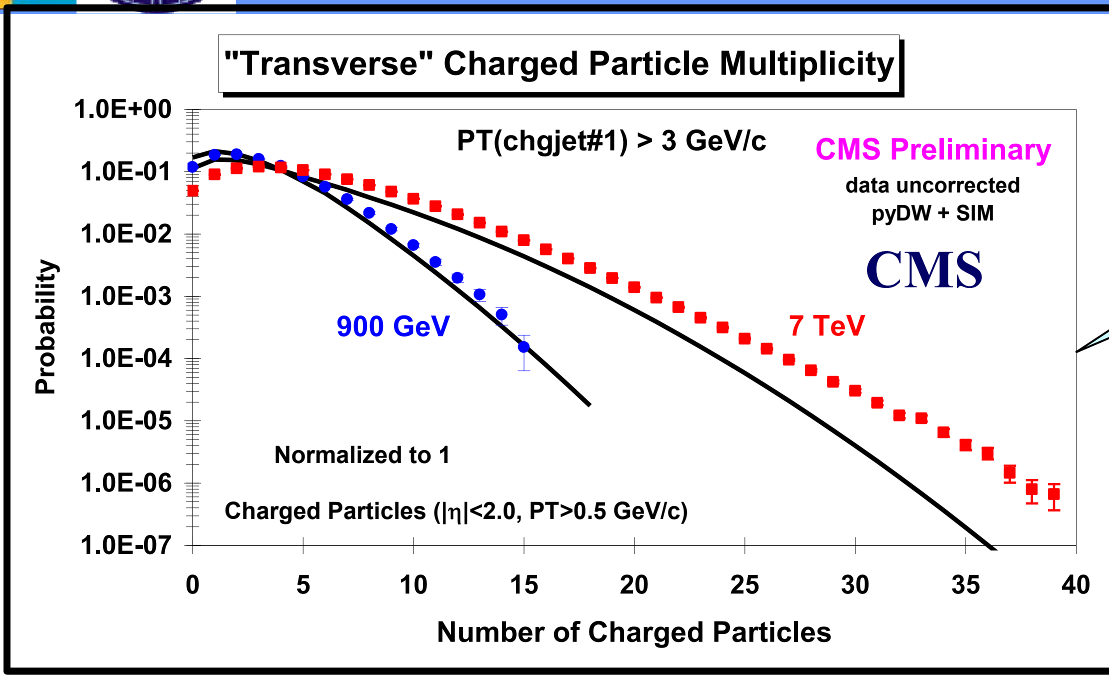
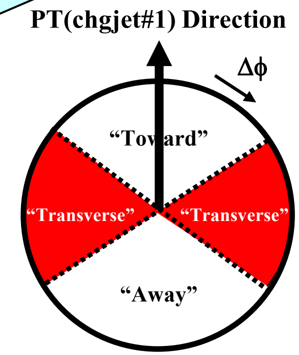


"Transverse" Multiplicity Distribution



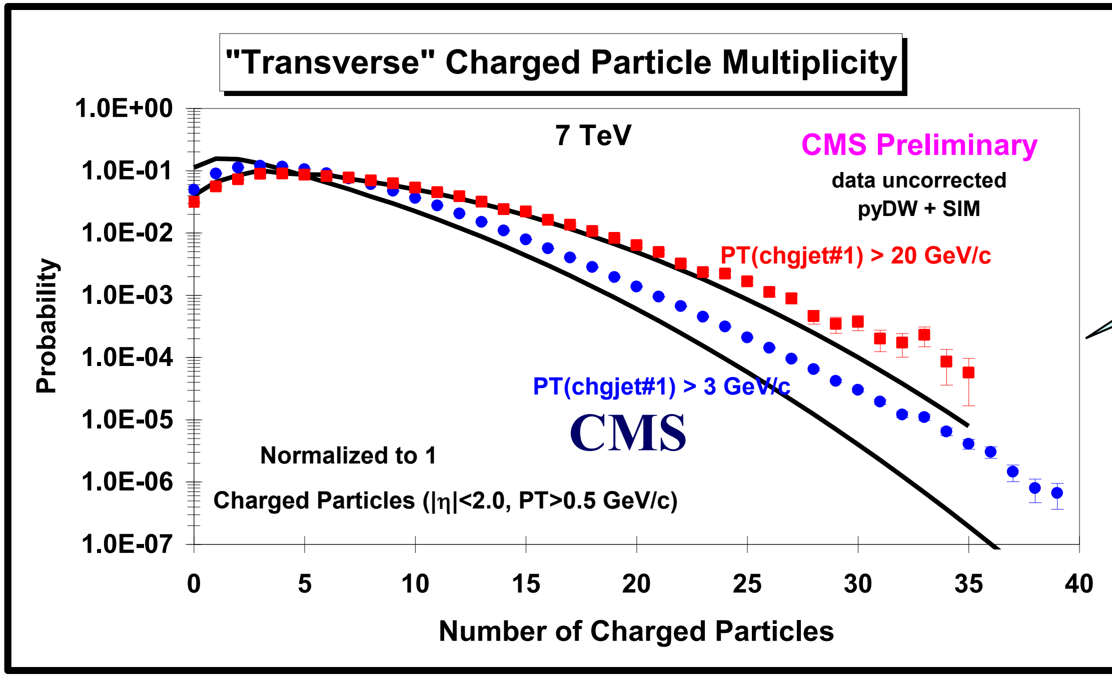
Same hard scale at two different center-of-mass energies!



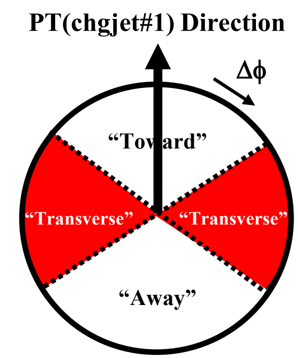
- CMS uncorrected data at 900 GeV and 7 TeV on the charged particle multiplicity distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW at the detector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

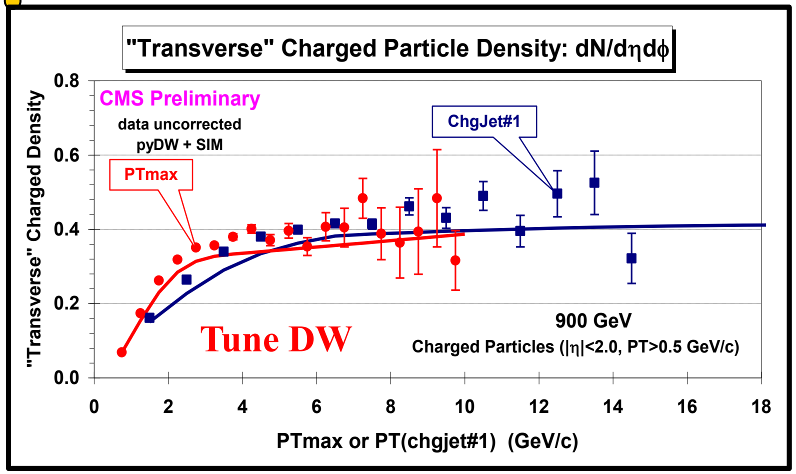


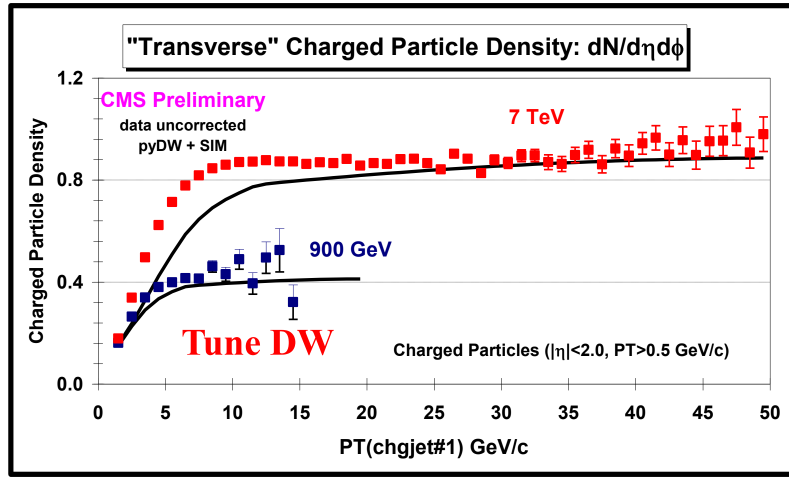
- **CMS uncorrected data at 7 TeV on the charged particle multiplicity distribution in the “transverse” region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet, chgjet#1, with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune DW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

Shows the growth of the “underlying event” as the hard scale increases.

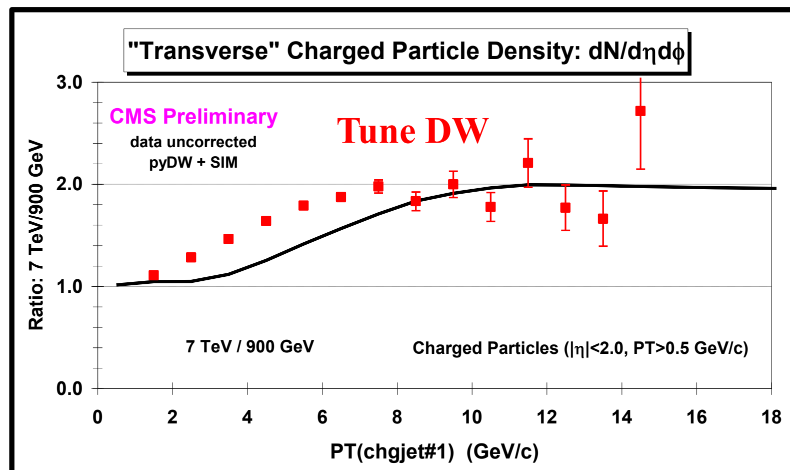
PYTHIA Tune DW

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

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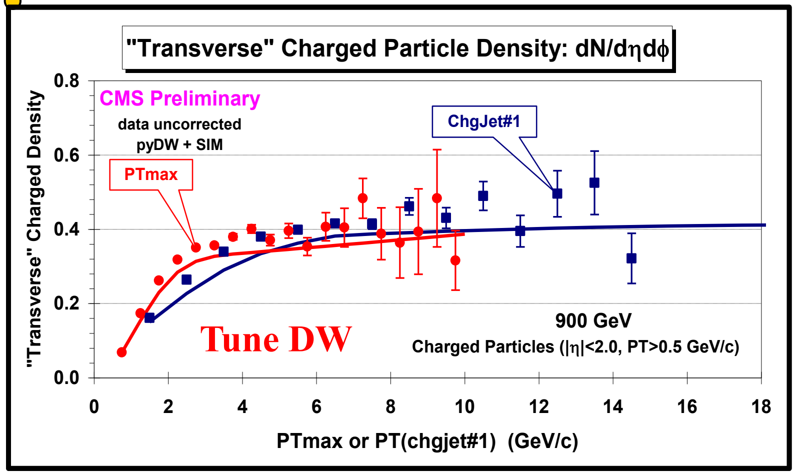
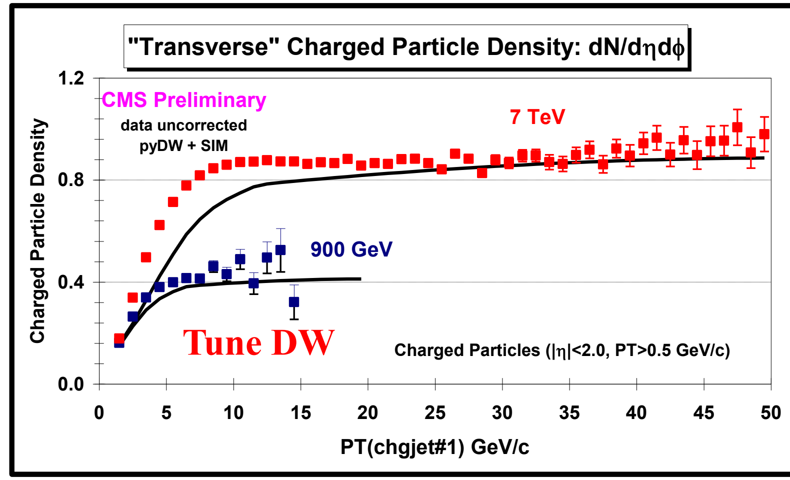
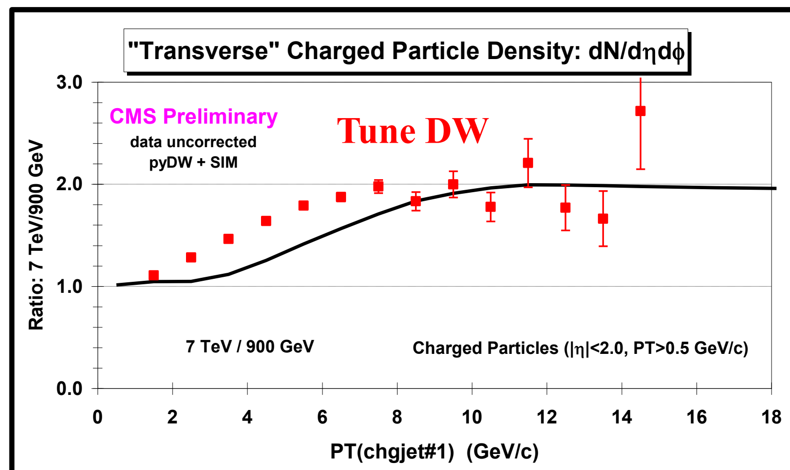


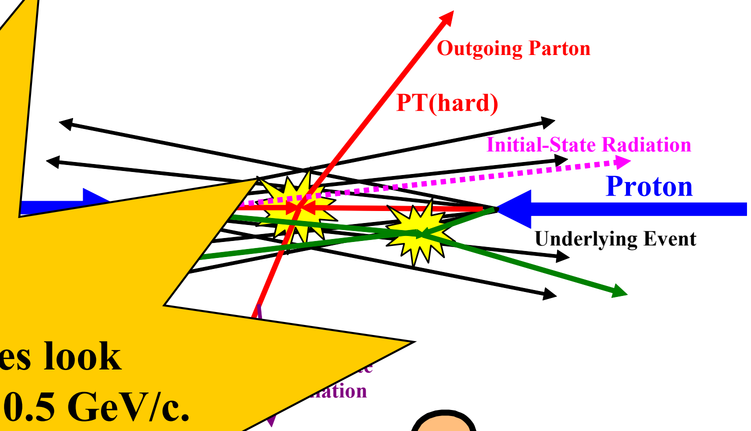


➡ **I am surprised that the Tunes did as well as they did at predicting the behavior of the "underlying event" at 900 GeV and 7 TeV!**



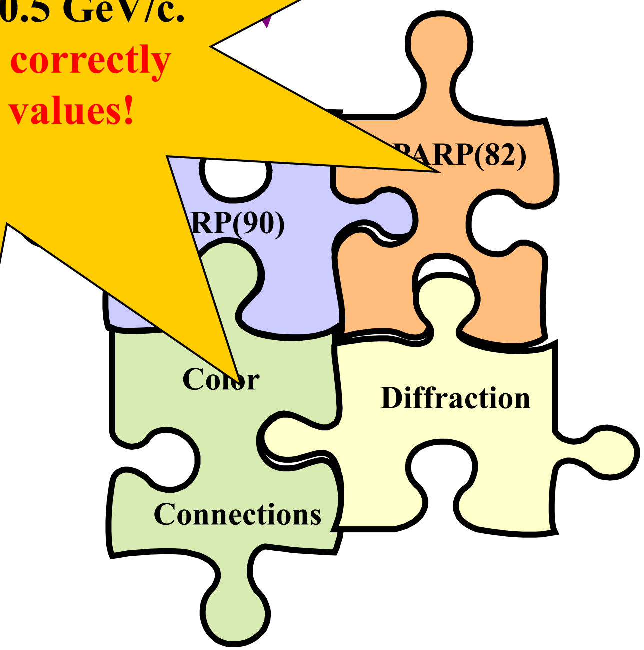
UE Summary

- The "underlying event" at 7 TeV and 900 GeV is almost what we exp cted! With a little t g we should ble to describe the d well Tune Z1 later in th



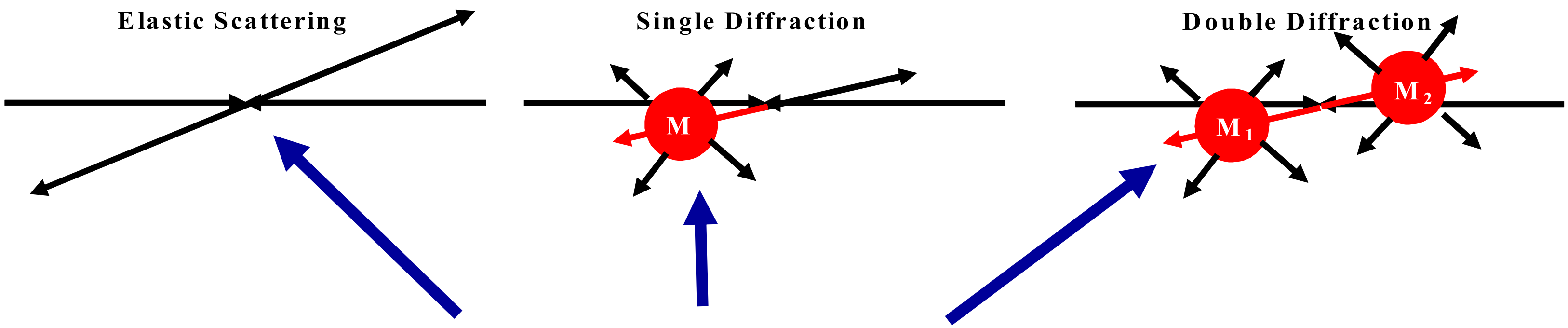
Warning! All the UE studies look at charged particles with $p_T > 0.5$ GeV/c.
We do not know if the models correctly describe the UE at lower p_T values!

- I am surprise they did at predic "underlying e Rememb "sof



- "Min-Bias" is a whole diffe t story! Much more complicated du o very soft particles and diffractio !

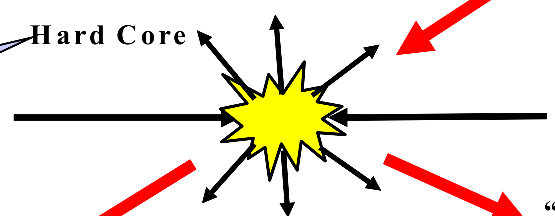
Proton-Proton Collisions

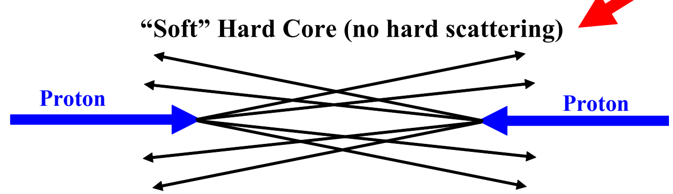


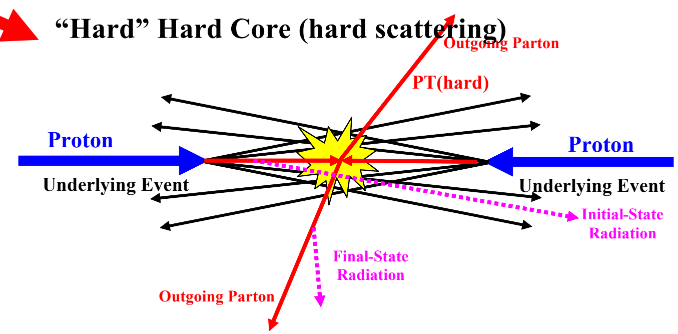
$$\sigma_{tot} = \sigma_{EL} + \sigma_{SD} + \sigma_{DD} + \sigma_{ND}$$

"Inelastic Non-Diffractive Component"

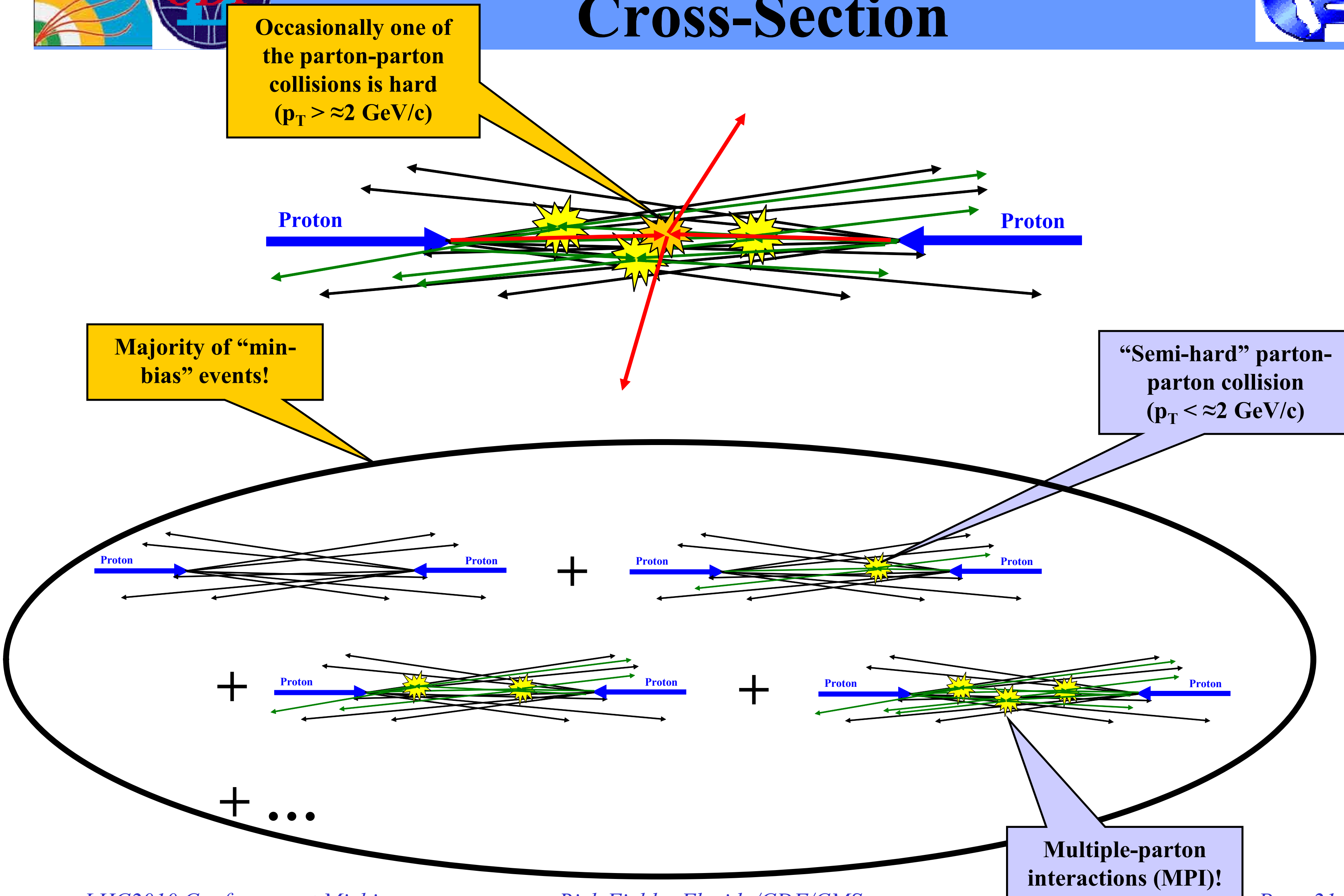
The "hard core" component contains both "hard" and "soft" collisions.





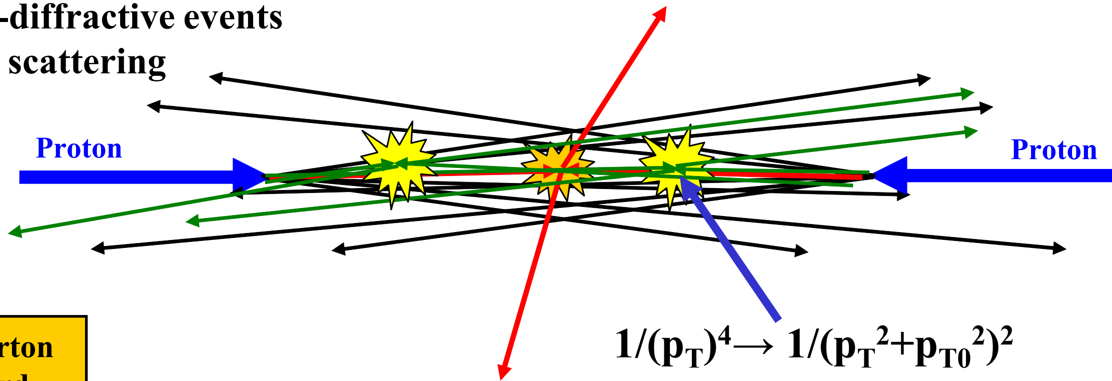


The Inelastic Non-Diffractive Cross-Section



The "Underlying Event"

Select inelastic non-diffractive events that contain a hard scattering

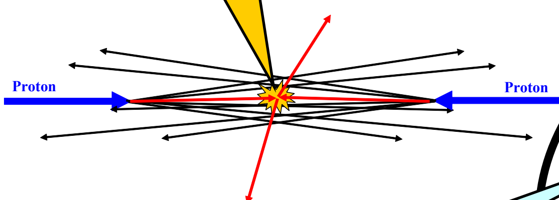


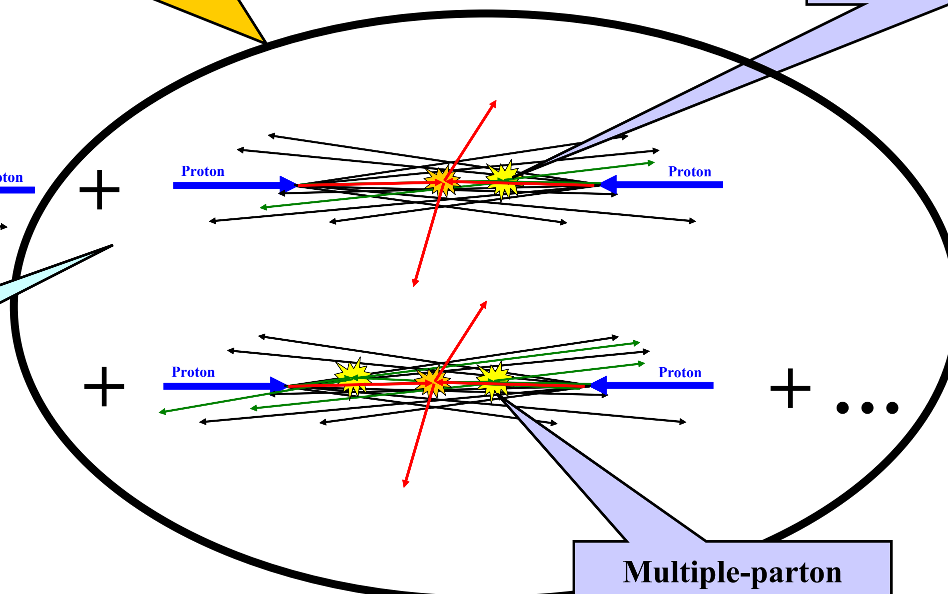
$1/(p_T)^4 \rightarrow 1/(p_T^2+p_{T0}^2)^2$

Hard parton-parton collisions is hard ($p_T > \approx 2$ GeV/c)

The "underlying-event" (UE)!

"Semi-hard" parton-parton collision ($p_T < \approx 2$ GeV/c)



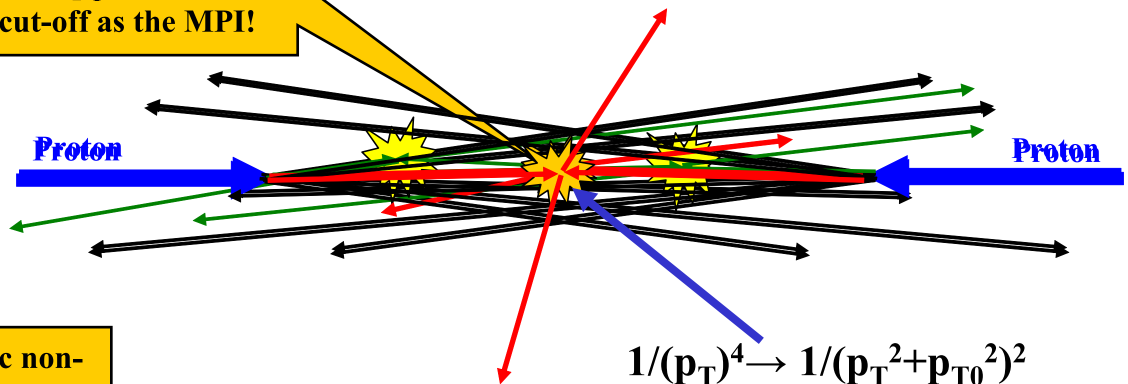


Given that you have one hard scattering it is more probable to have MPI! Hence, the UE has more activity than "min-bias".

Multiple-parton interactions (MPI)!

Model of σ_{ND}

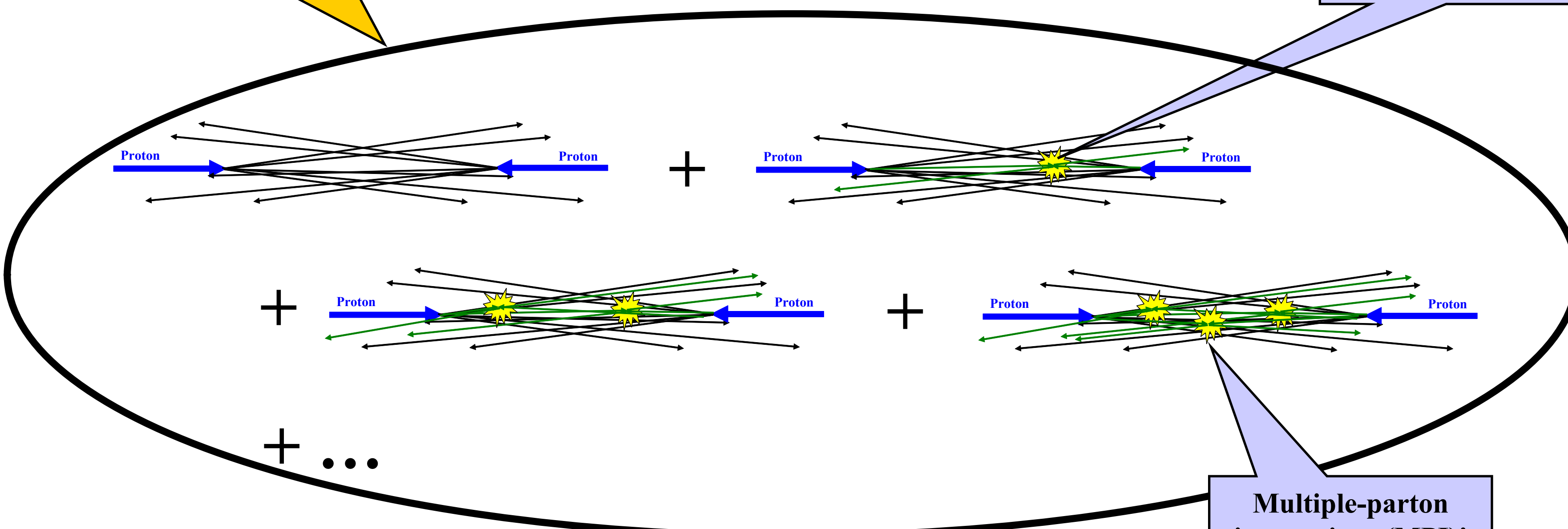
Allow leading hard scattering to go to zero p_T with same cut-off as the MPI!



$1/(p_T)^4 \rightarrow 1/(p_T^2+p_{T0}^2)^2$

Model of the inelastic non-diffractive cross section!

“Semi-hard” parton-parton collision ($p_T < \approx 2$ GeV/c)



Multiple-parton interactions (MPI)!

UE Tunes

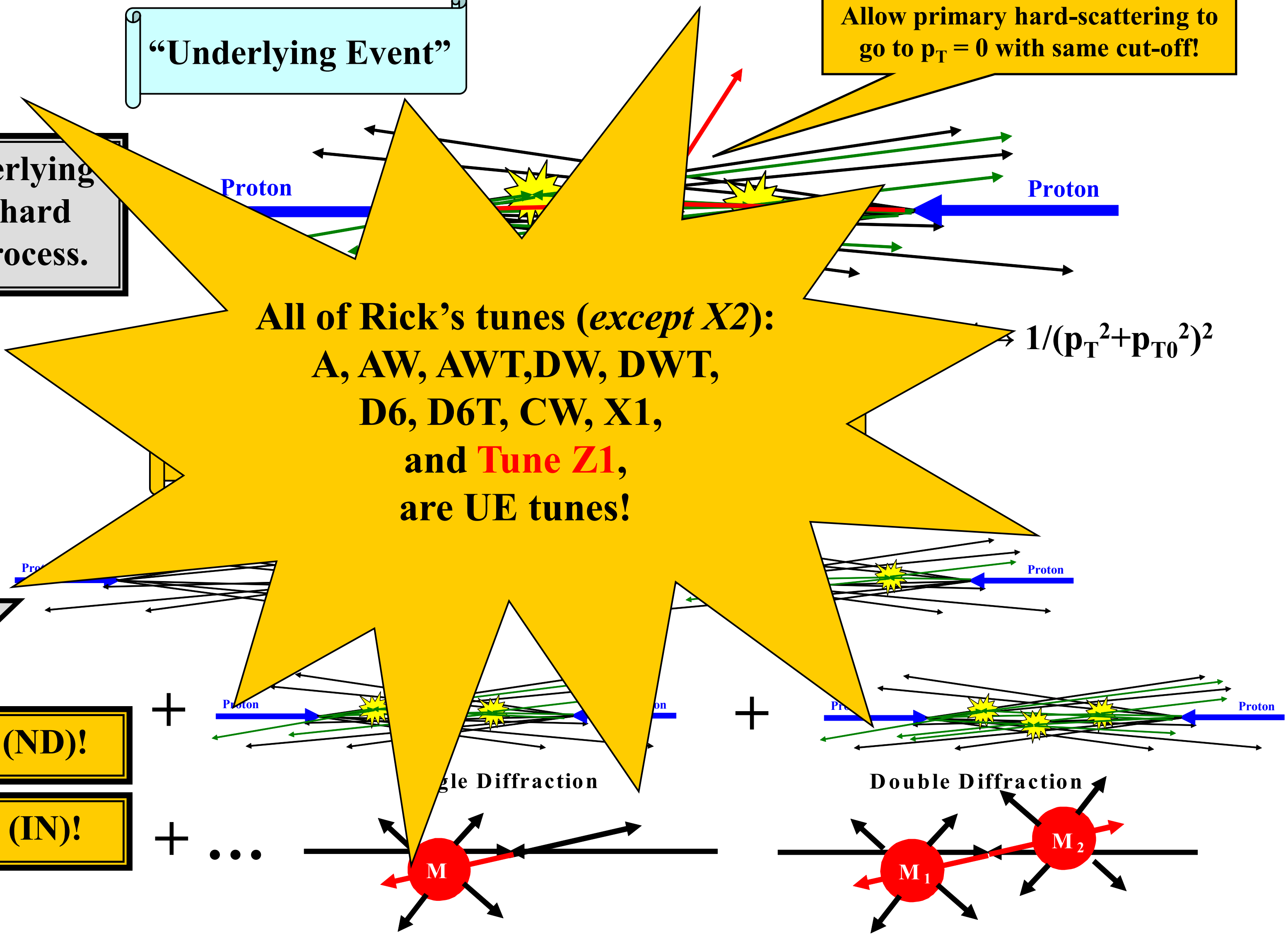
"Underlying Event"

Allow primary hard-scattering to go to $p_T = 0$ with same cut-off!

Fit the "underlying event" in a hard scattering process.

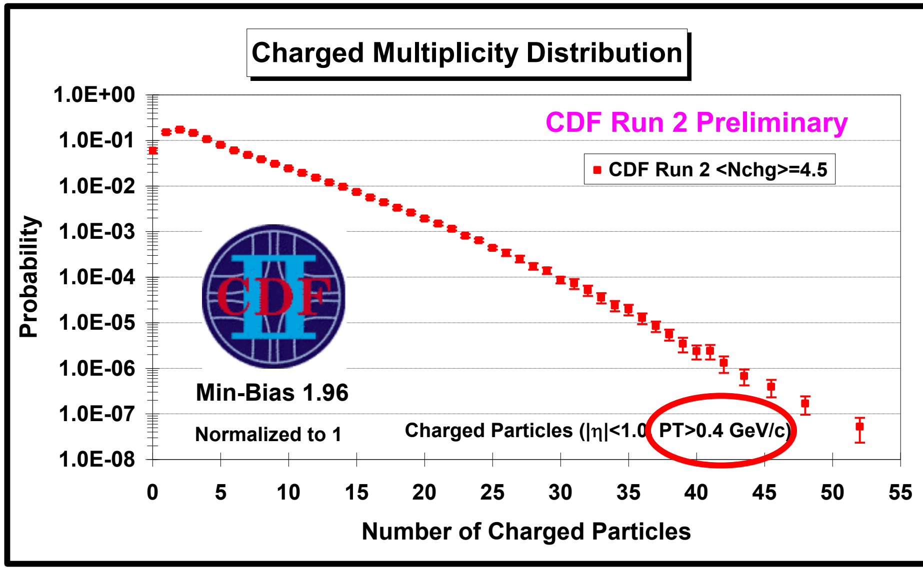
Predict MB (ND)!

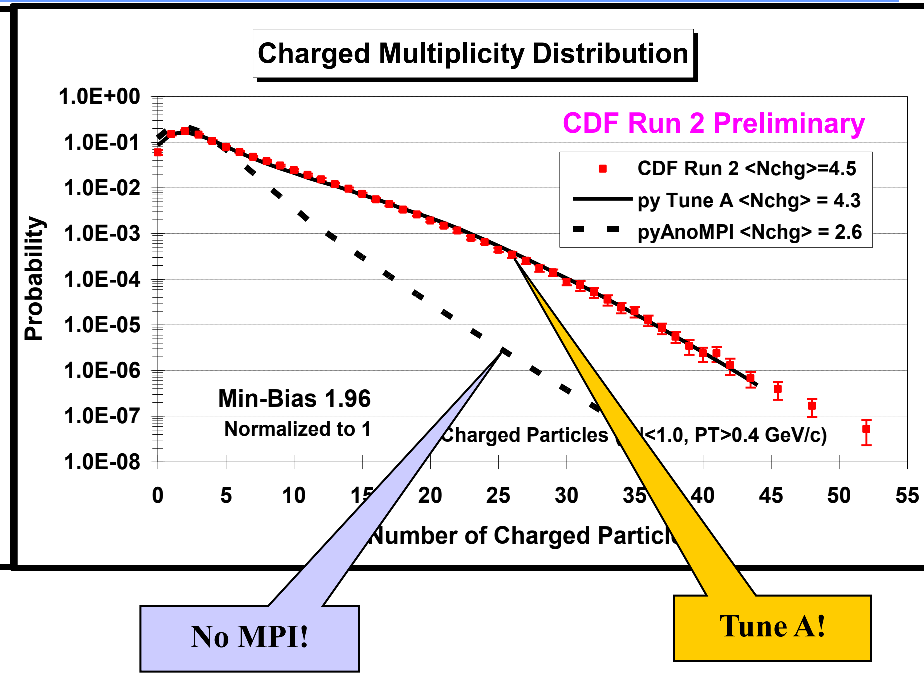
Predict MB (IN)!

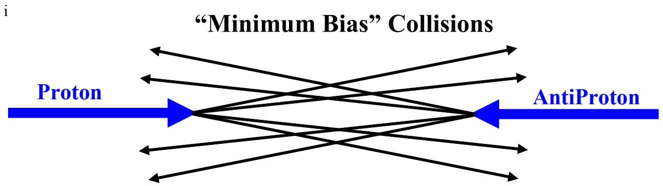


All of Rick's tunes (*except X2*):
A, AW, AWT,DW, DWT,
D6, D6T, CW, X1,
and Tune Z1,
are UE tunes!

Charged Particle Multiplicity



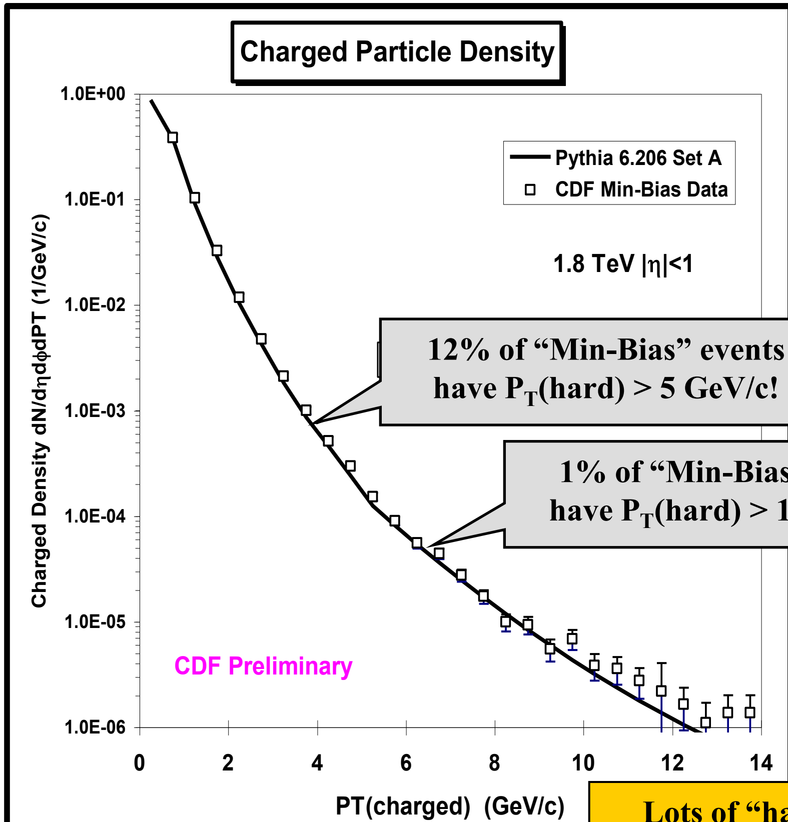




- Data at 1.96 TeV on the charged particle multiplicity (p_T > 0.4 GeV/c, |η| < 1) for "min-bias" collisions at CDF Run 2 (non-diffractive cross-section).
- The data are compared with PYTHIA Tune A and Tune A without multiple parton interactions (pyAnoMPI).

PYTHIA Tune A Min-Bias "Soft" + "Hard"

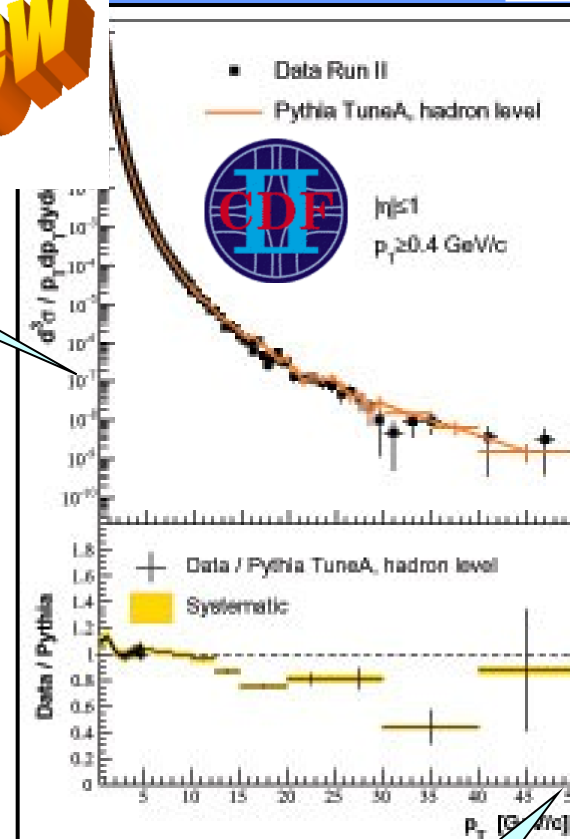
New



12% of "Min-Bias" events have P_T(hard) > 5 GeV/c!

1% of "Min-Bias" events have P_T(hard) > 10 GeV/c!

Ten decades!

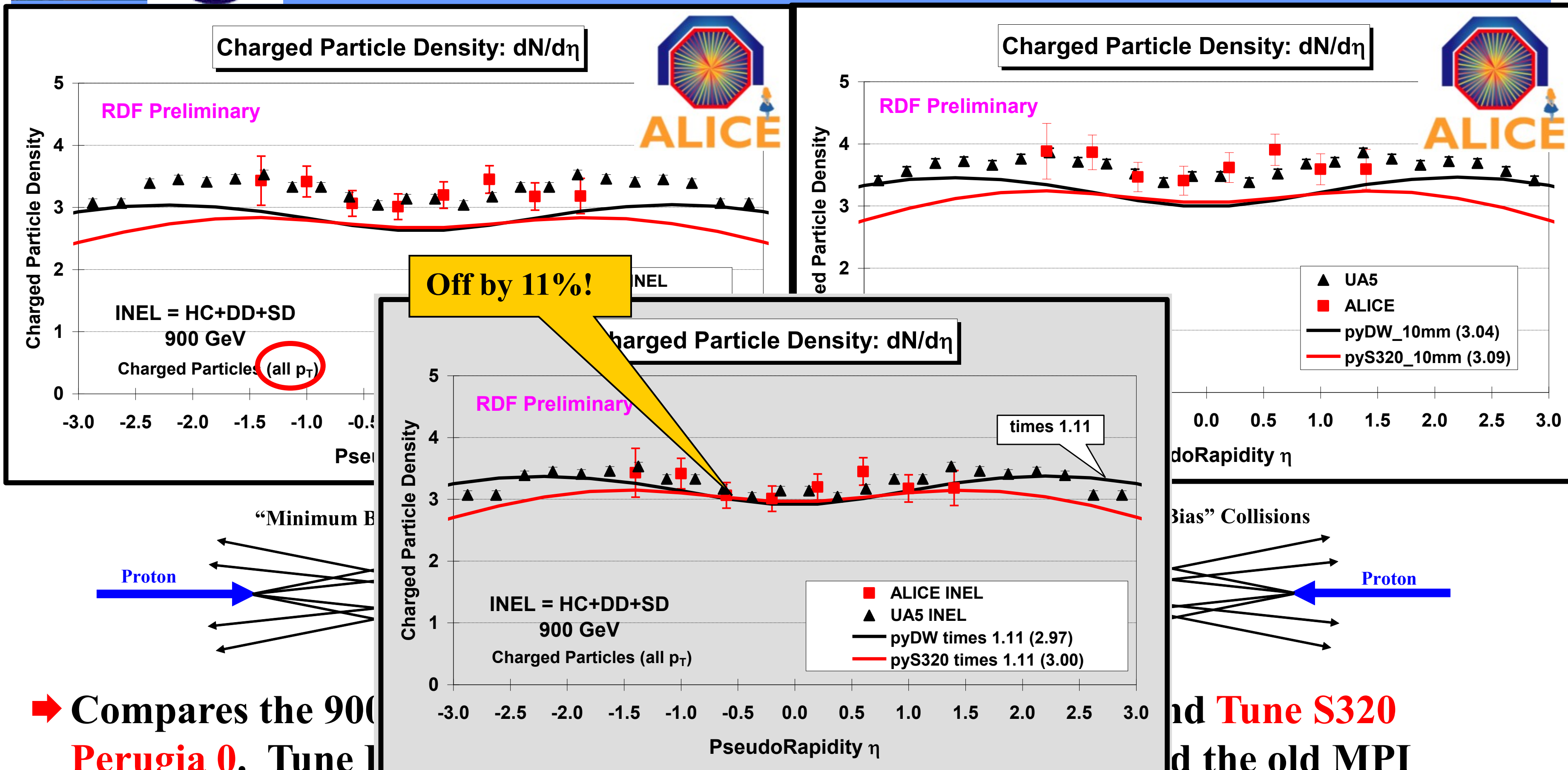


Lots of "hard" scattering in "Min-Bias" at the Tevatron!

p_T = 50 GeV/c!

- Comparison of PYTHIA Tune A with the p_T distribution of charged particles for "min-bias" collisions at CDF Run 1 (non-diffractive cross-section).
- PYTHIA Tune A predicts that 12% of all "Min-Bias" events are a result of a hard 2-to-2 parton-parton scattering with P_T(hard) > 5 GeV/c (1% with P_T(hard) > 10 GeV/c)!

LHC MB Predictions: 900 GeV

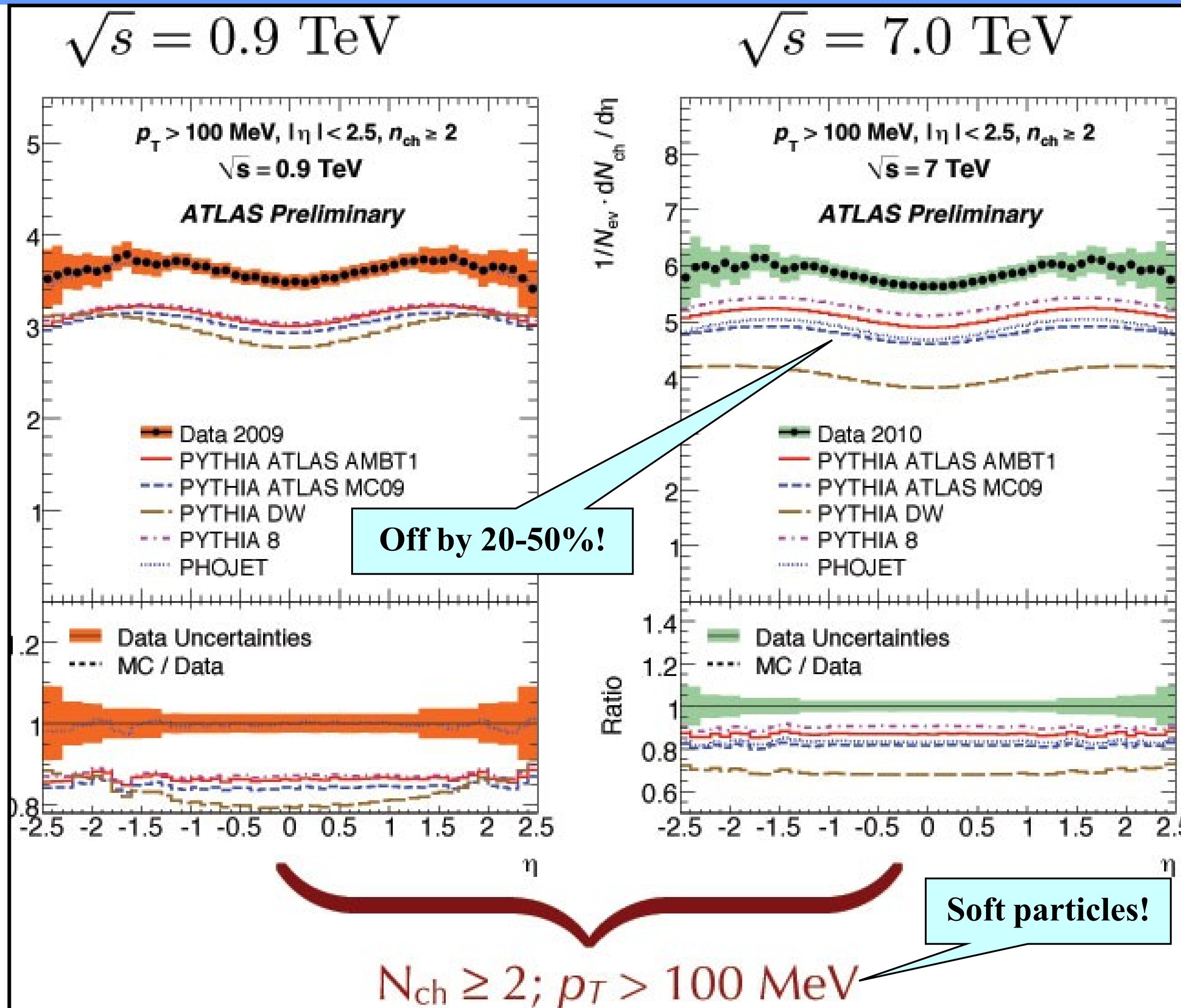


➡ Compares the 900 … nd Tune S320 Perugia 0. Tune … d the old MPI model. Tune S320 uses the new p_T-ordered parton shower and the new MPI model. The numbers in parentheses are the average value of dN/dη for the region |η| < 0.6.

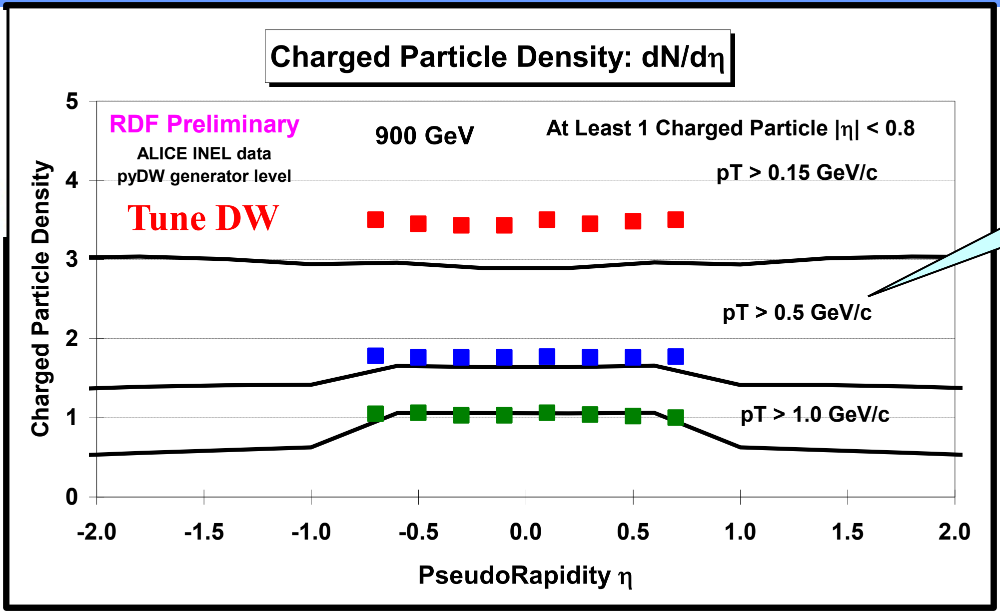
ATLAS INEL dN/dη

- 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



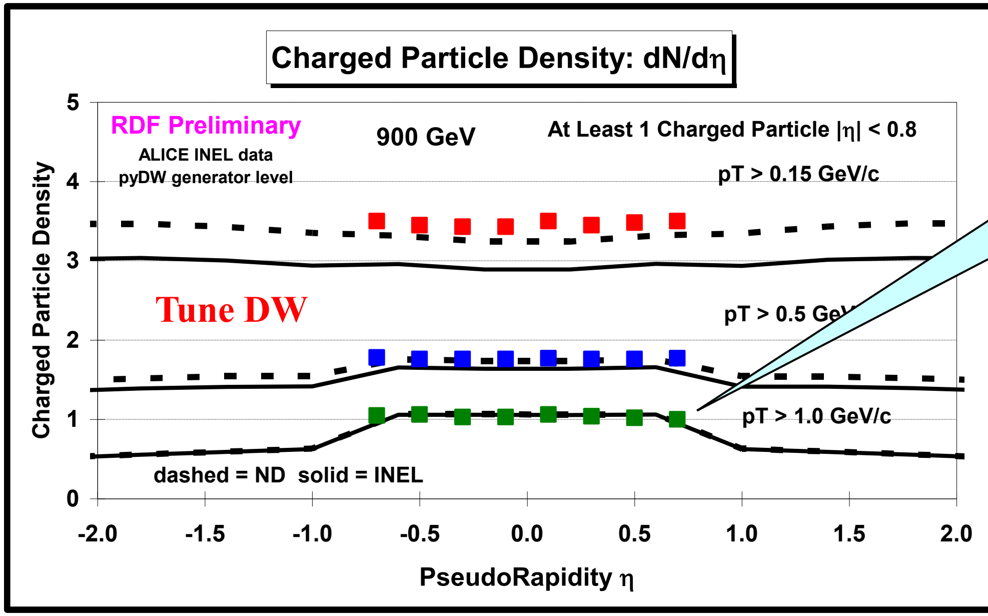
If one increases the p_T the agreement improves!

- **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.**

"Minimum Bias" Collisions

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

PYTHIA Tune DW



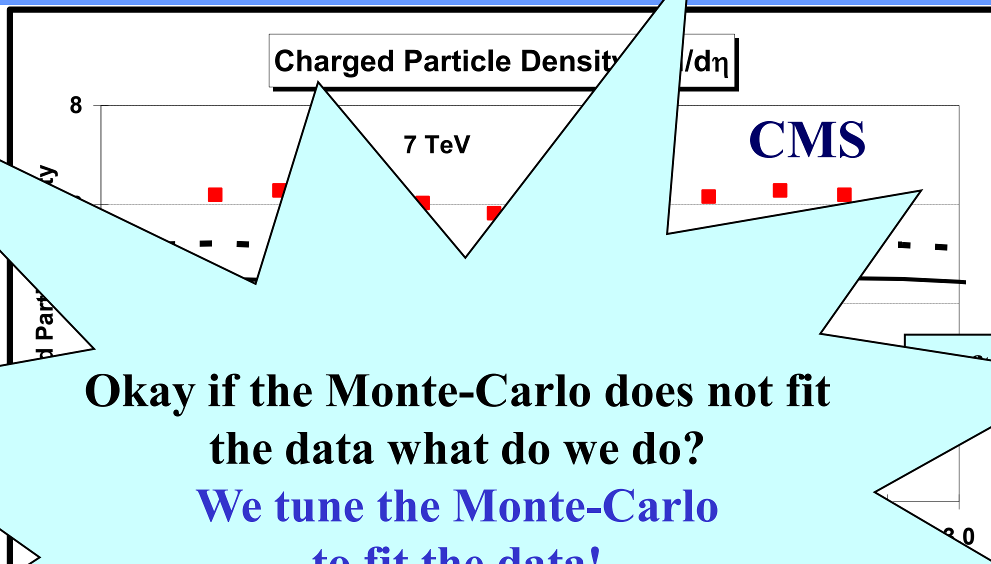
Diffraction contributes less at harder scales!

- **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).**

"Minimum Bias" Collisions

Cannot trust PYTHIA 6.2 modeling of diffraction!

CMS dN/dη

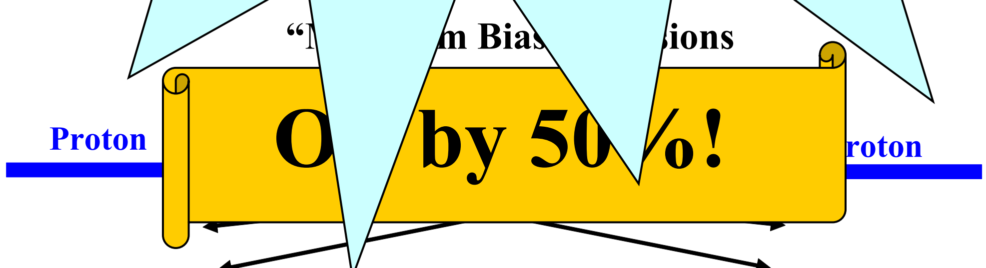


Okay if the Monte-Carlo does not fit the data what do we do?

We tune the Monte-Carlo to fit the data!

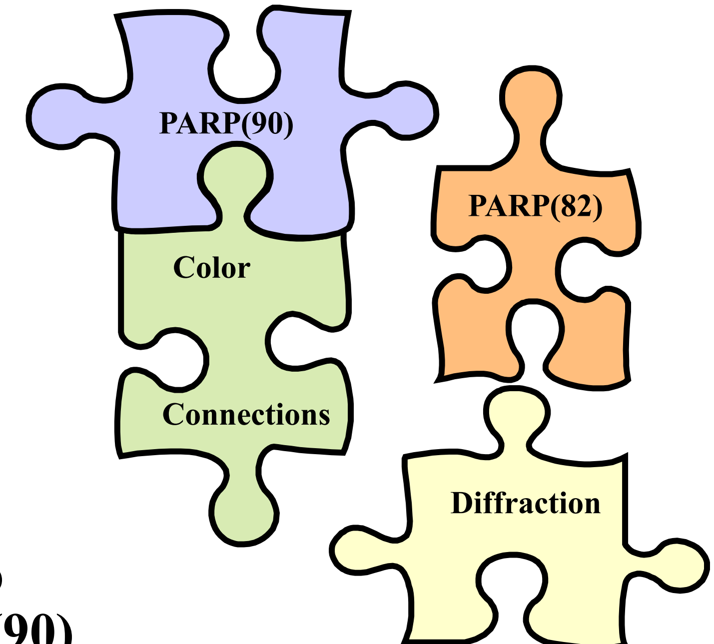
Be careful not to tune away new physics!

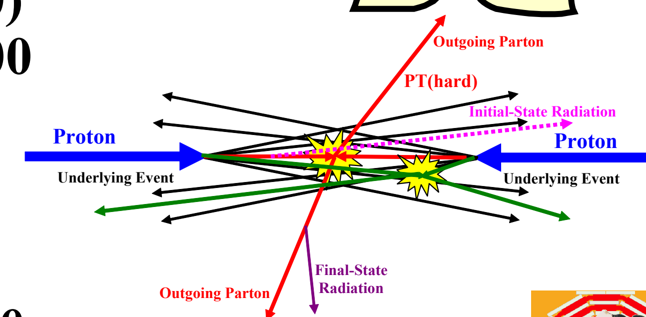
- Generator DD and the HC = ND contributions for Tune a.



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!**





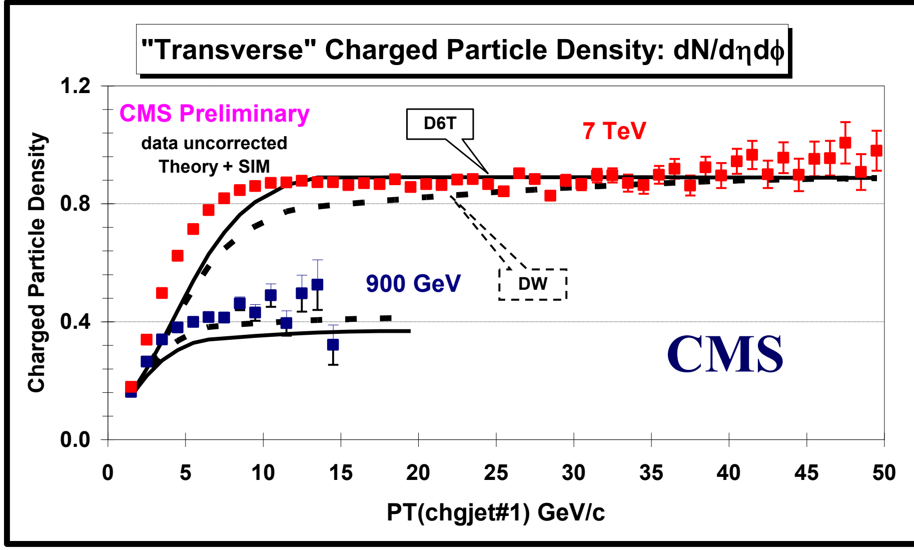
UE&MB@CMS

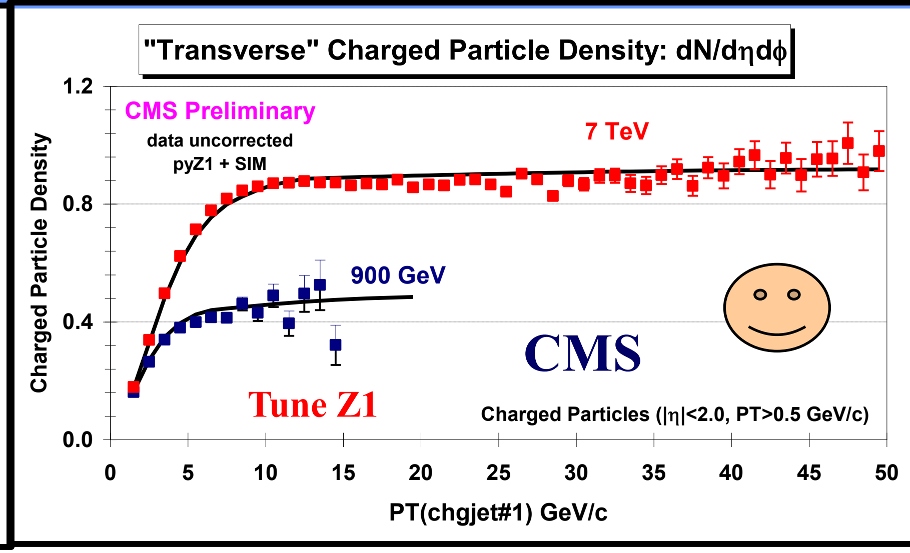
PYTHIA Tune Z1

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 $|\eta| < 2.0$. The data are uncorrected and compared with **PYTHIA Tune DW and D6T** after detector simulation (SIM).

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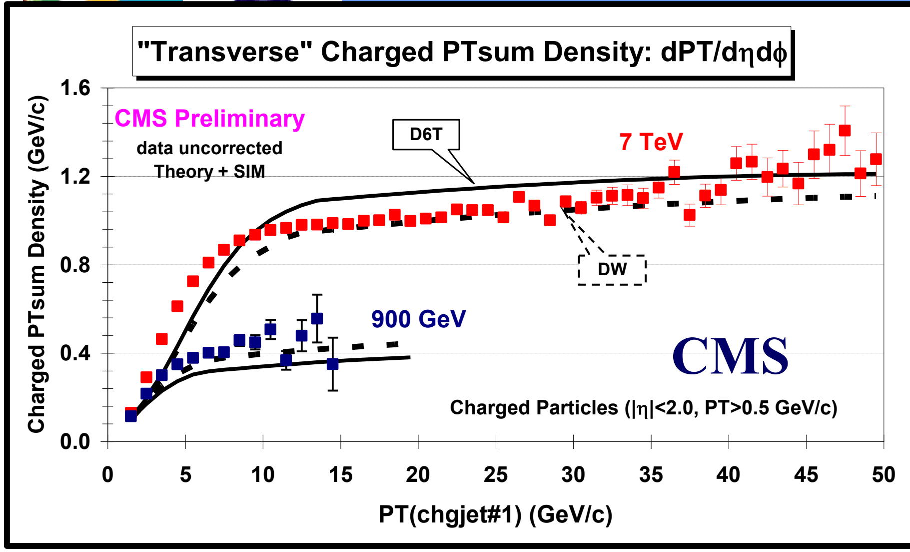
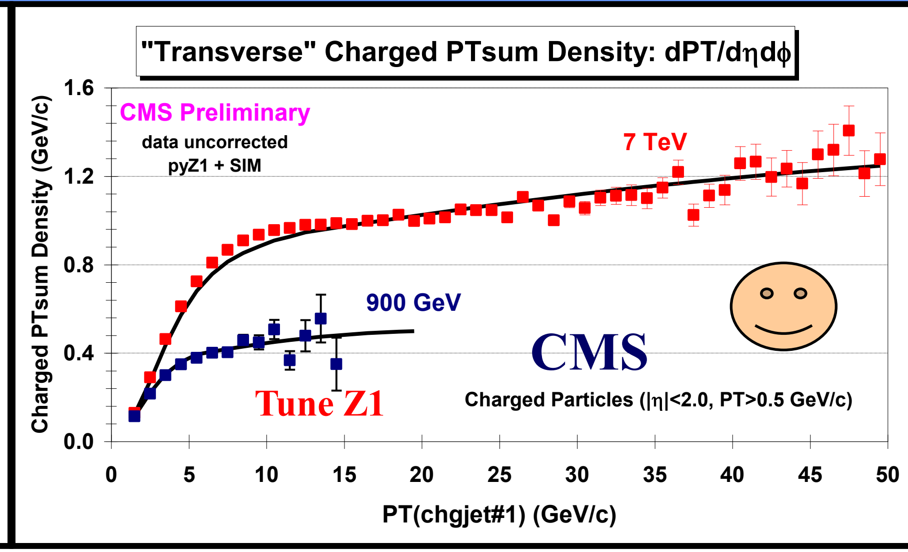
Color reconnection suppression.
Color reconnection strength.

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 $|\eta| < 2.0$. The data are uncorrected and compared with **PYTHIA Tune DW and D6T** after detector simulation (SIM).

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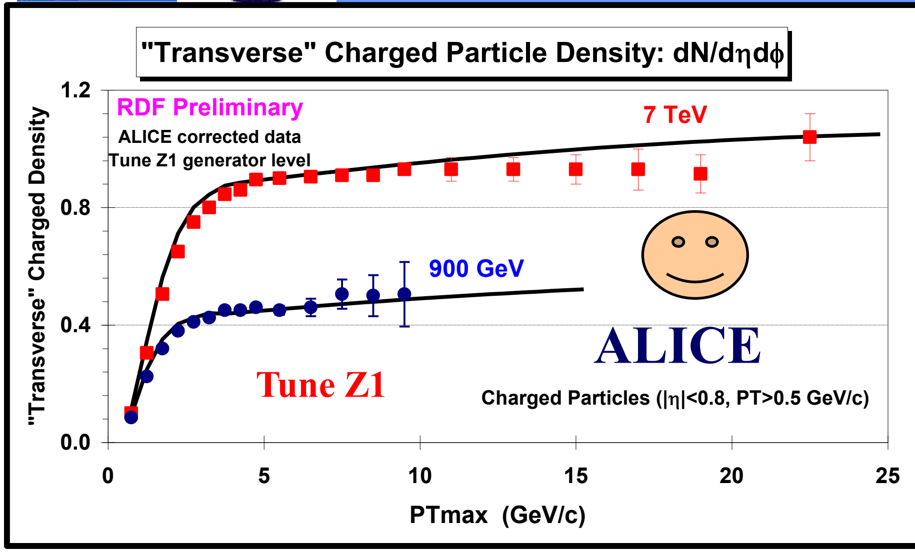
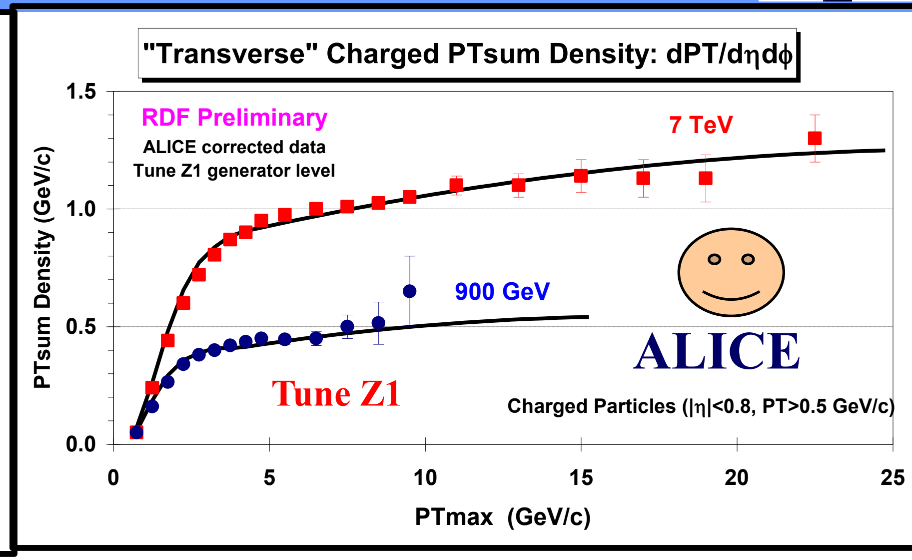




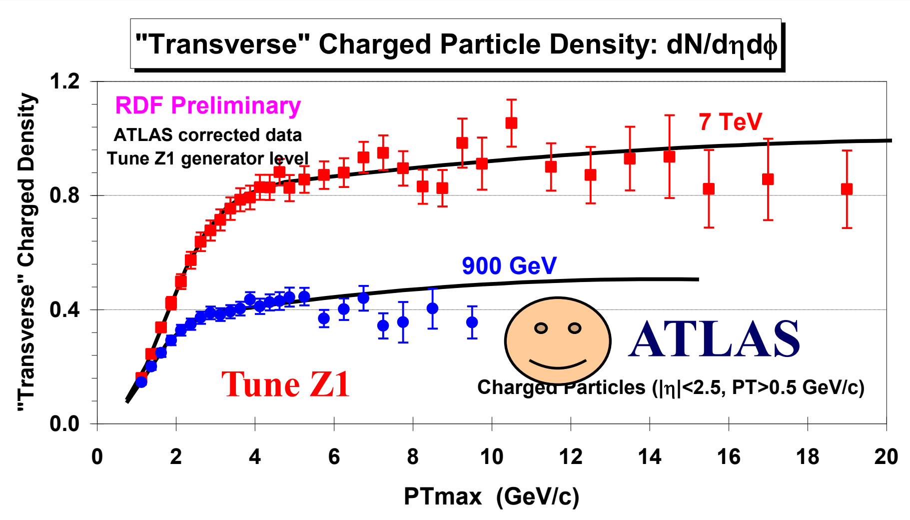
- **ALICE preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.**

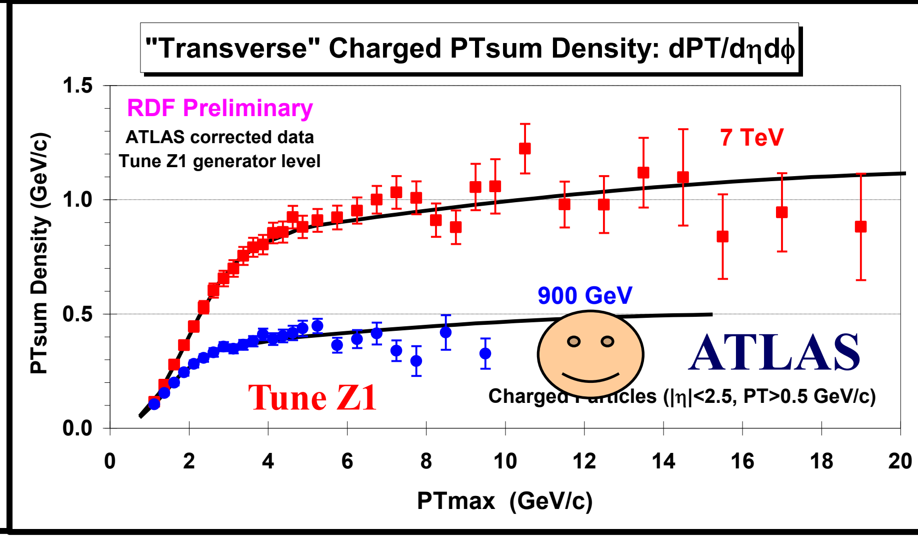
- **ALICE preliminary data at 900 GeV and 7 TeV on the "transverse" charged PTsum density, dPT/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8. The data are corrected and compared with PYTHIA Tune Z1 at the generrator level.**

I read the point off with a ruler!

ALICE UE Data: Talk by S. Vallero
MPI@LHC 2010 Glasgow, Scotland
November 30, 2010

PYTHIA Tune Z1





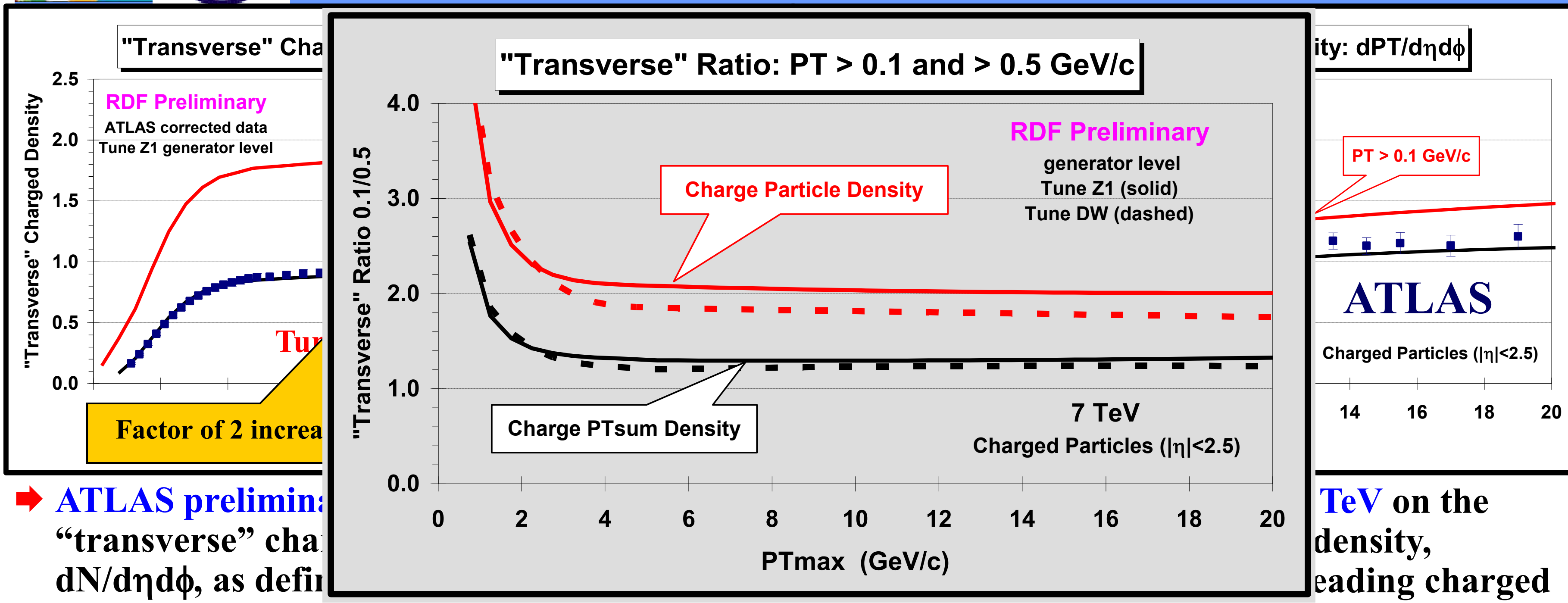
- ATLAS preliminary data at 900 GeV and 7 TeV on the "transverse" charged particle density, dN/dηdφ, as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.5$. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.

- 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 $|\eta| < 2.5$. The data are corrected and compared with PYTHIA Tune Z1 at the generrator level.

I read the point off with a ruler!

ATLAS Note: ATLAS-CONF-2010-029
May 29, 2010

PYTHIA Tune Z1

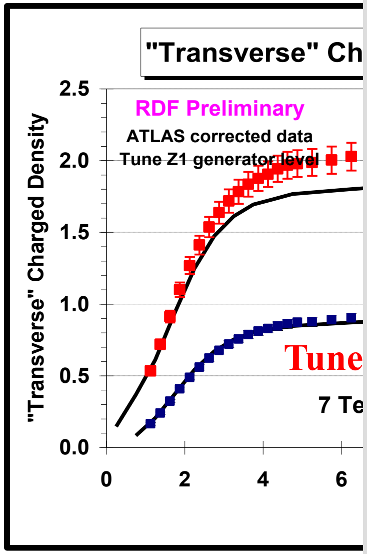


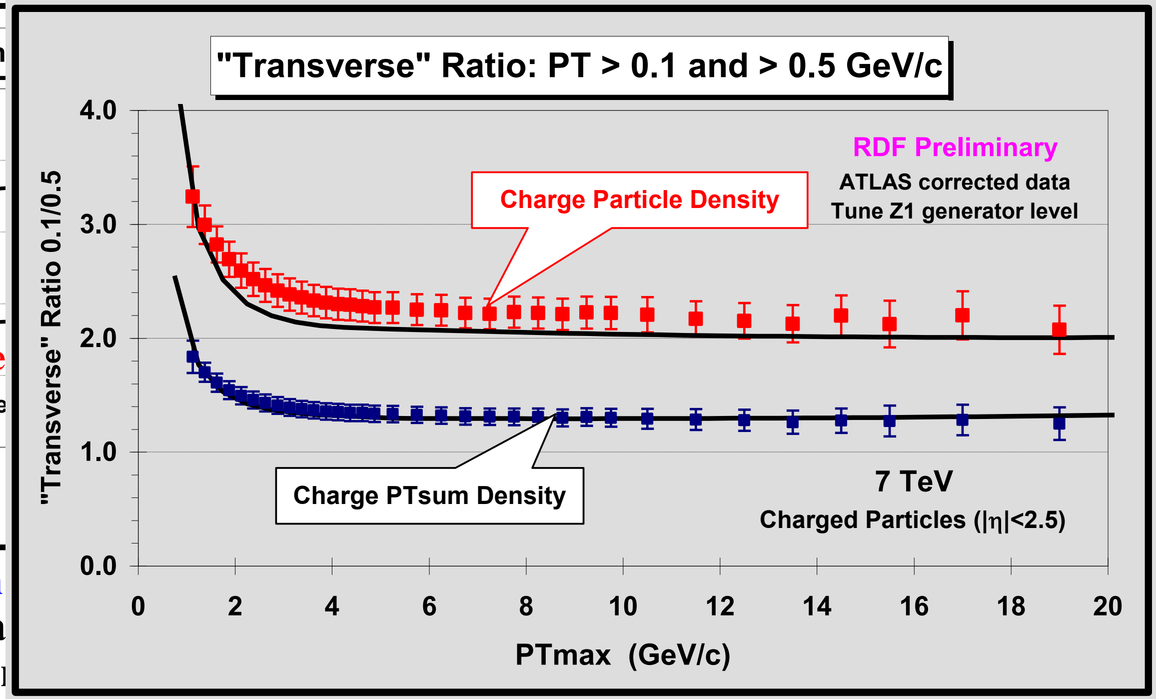
- ATLAS prelimina
"transverse" cha
dN/dηdφ, as defi
particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.5$. The data are corrected and compared with PYTHIA Tune Z1 at the generator level. Also shows the prediction of Tune Z1 for the "transverse" charged particle d
and $|\eta| < 2.5$.

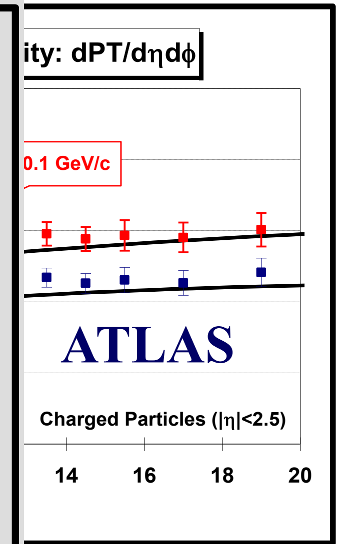
TeV on the
density,
eading charged
particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 2.5$. The data are corrected and compared with PYTHIA Tune Z1 at the generator level. Also shows the prediction of Tune Z1 for the "transverse"
y with $p_T > 0.1$ GeV/c

Rick Field
MPI@LHC 2010 Glasgow, Scotland
December 2, 2010

PYTHIA Tune Z1







- ATLAS prelimin... TeV on the "transverse" cha... density, dN/dηdϕ, as defi... eading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $p_T > 0.1$ GeV/c ($|\eta| < 2.5$). The data are corrected and compared with PYTHIA Tune Z1 at the generator level.

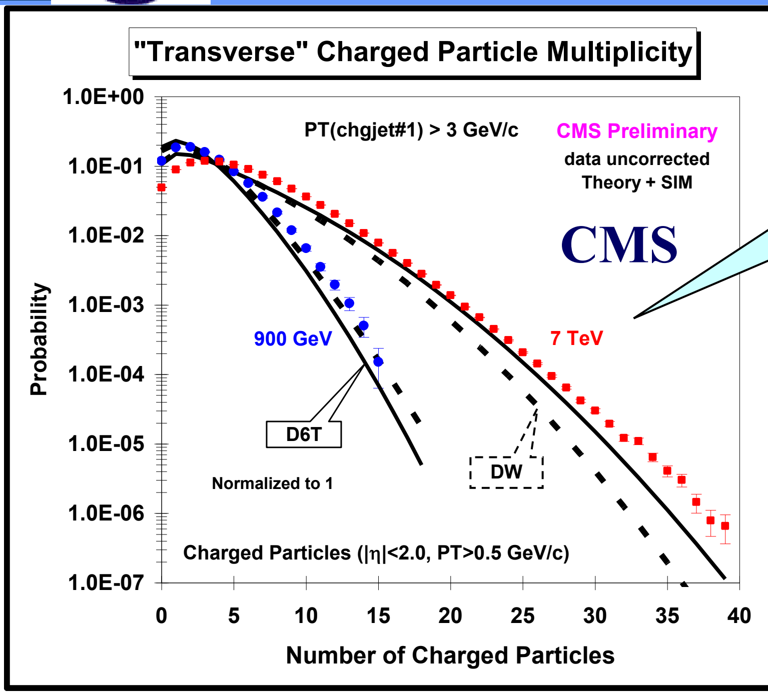
particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $p_T > 0.1$ GeV/c ($|\eta| < 2.5$). The data are corrected and compared with PYTHIA Tune Z1 at the generator level.

I read the point off with a ruler!

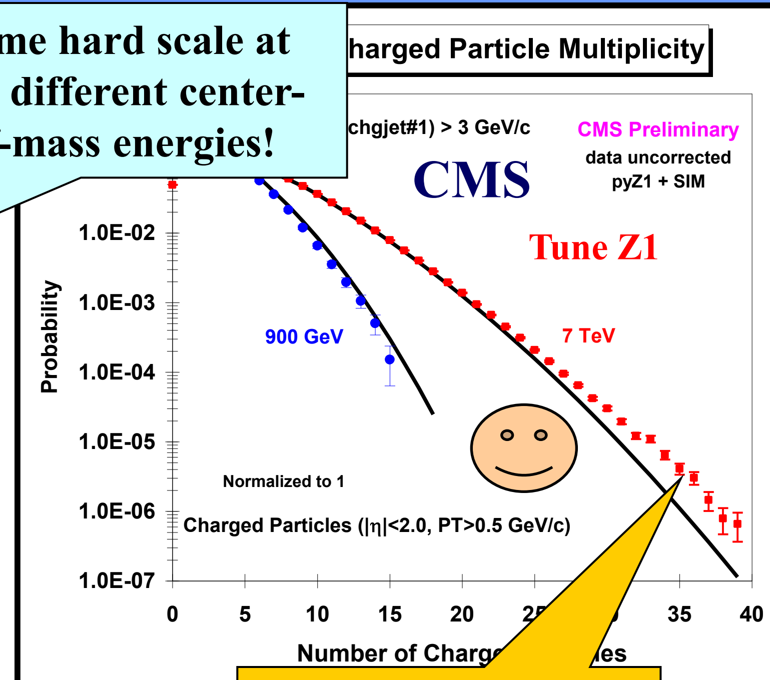
ATLAS publication – arXiv:1012.0791

December 3, 2010

"Transverse" Multiplicity Distribution



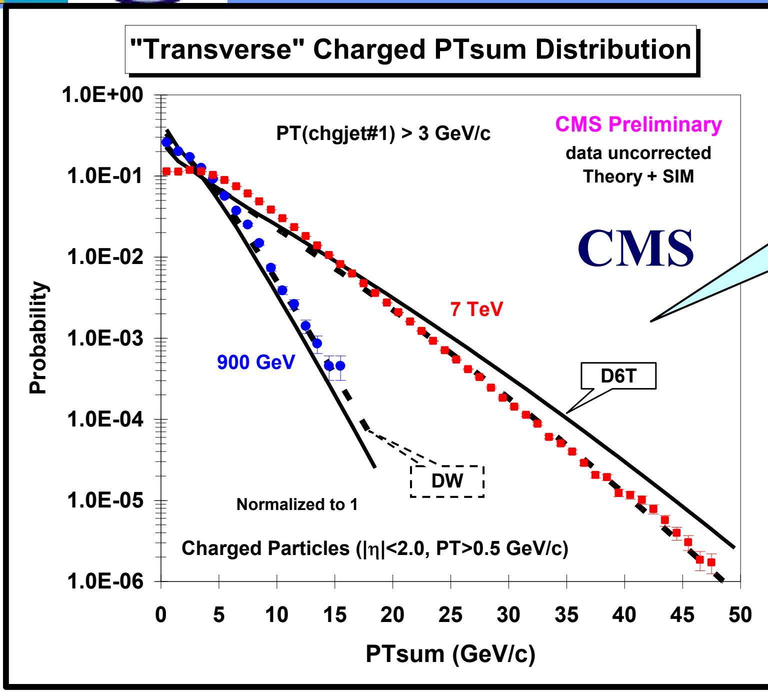
Same hard scale at two different center-of-mass energies!



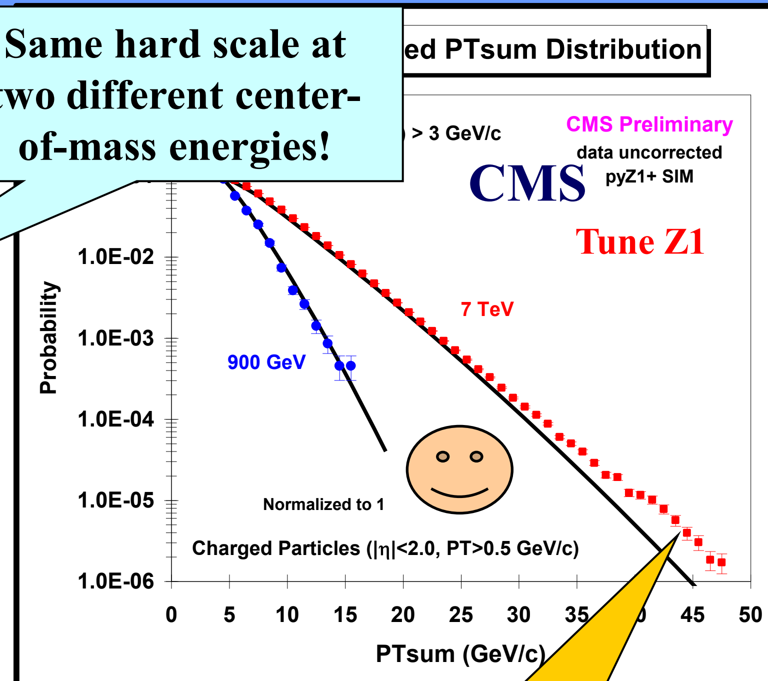
Difficult to produce enough events with large "transverse" multiplicity at low hard scale!

- 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, $|\eta| < 2$) 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 unc… V and 7 TeV on th… iplicity distributi… egion for charge… V/c, $|\eta|$ < 2) as def… rged 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



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

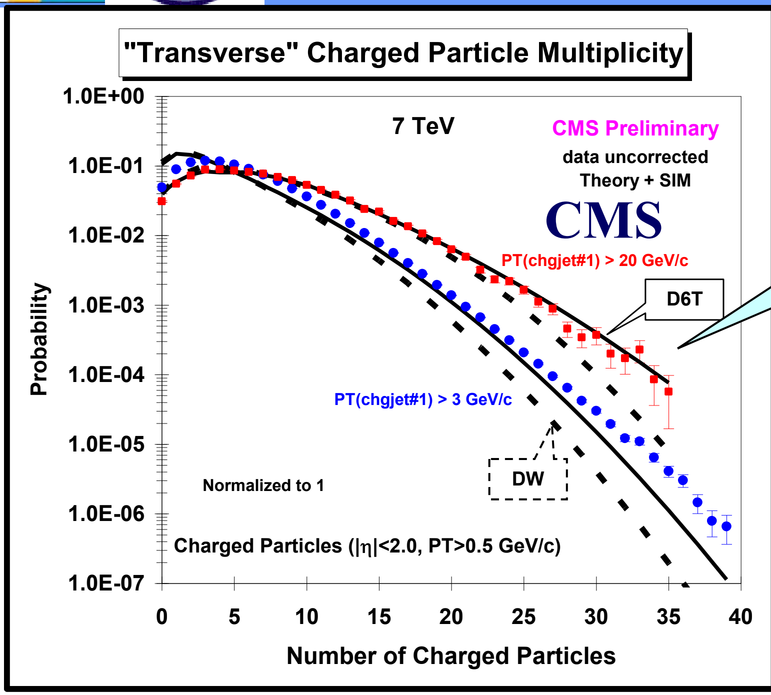


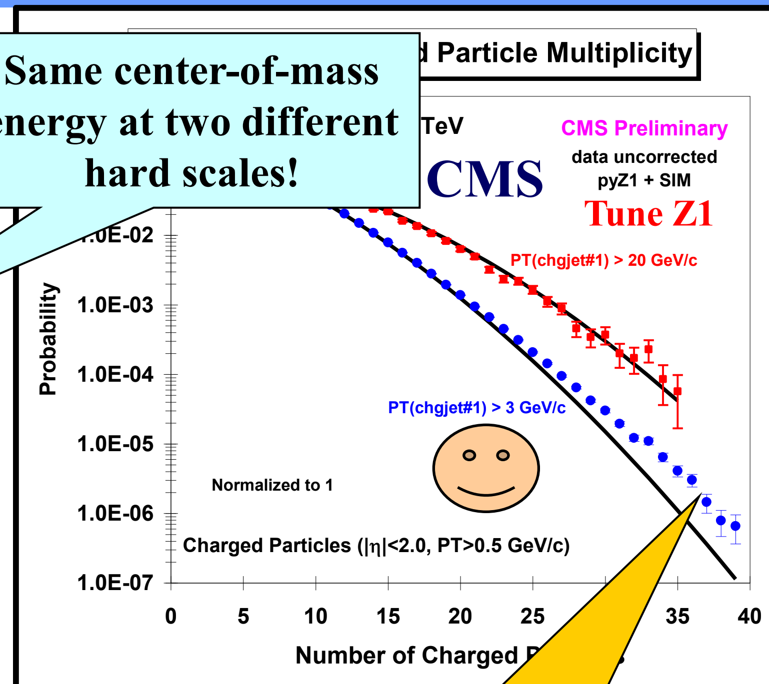
- **CMS uncorrected data at 900 GeV and 7 TeV on the charged scalar PTsum distribution in the "transverse" region for charged particles ($p_T > 0.5$ GeV/c, $|\eta| < 2$) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW, and Tune D6T at the detector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

- **CMS uncor... ...and 7 TeV on the char... ...bution in the "transv... ...d particles ($p_T > 0.5$ Ge... ...by the leading cha... PT(chgjet#1... ...with PYTHIA Tune Z1, at the detector level (*i.e.* Theory + SIM).**

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

"Transverse" Multiplicity Distribution



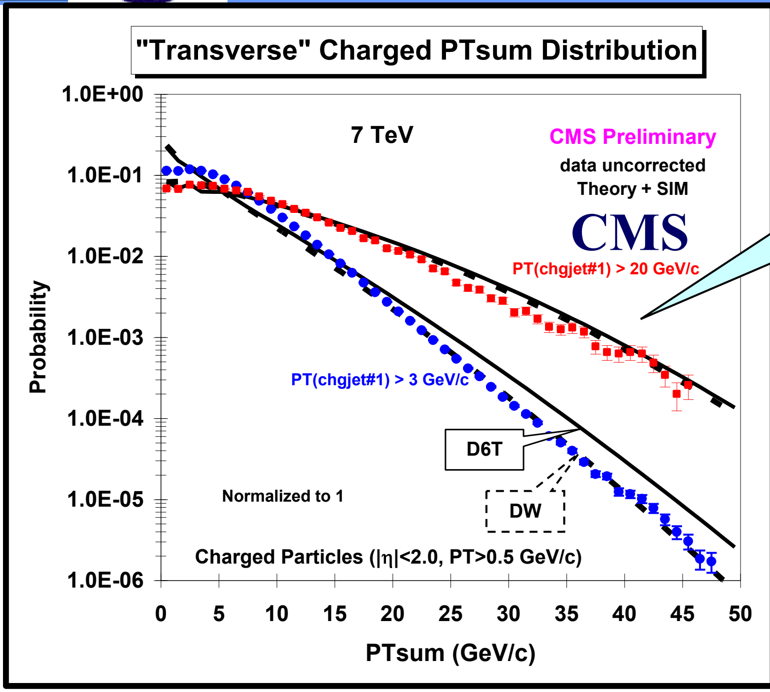


Same center-of-mass energy at two different hard scales!

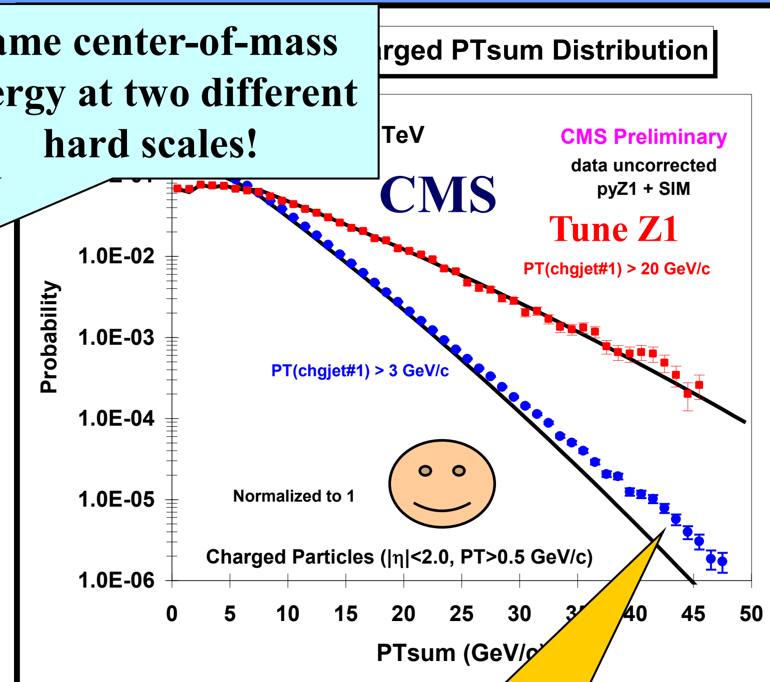
Difficult to produce enough events with large "transverse" multiplicity at low hard scale!

- 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 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 uncor[...] the charged par[...]ution in the "transve[...] particles ($p_T > 0.5$ Ge[...]by the leading char[...]T(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



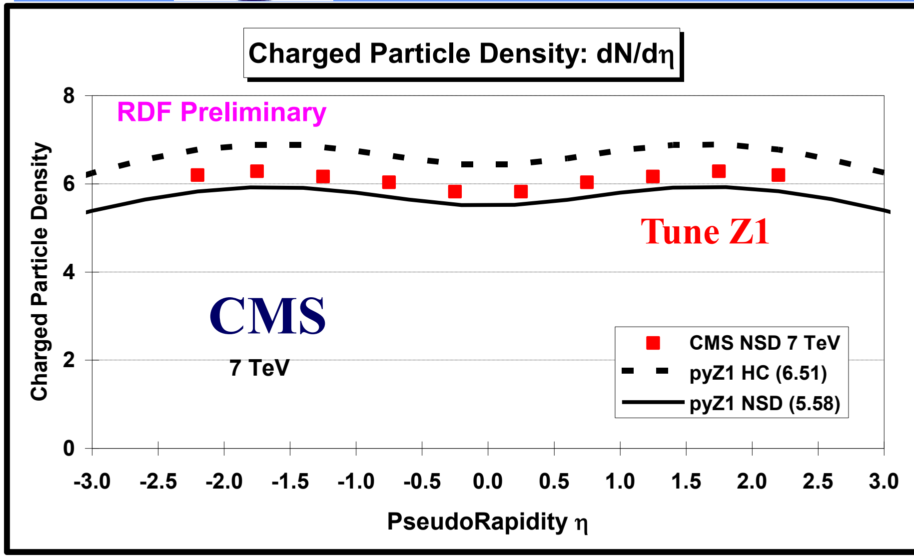
Same center-of-mass energy at two different hard scales!

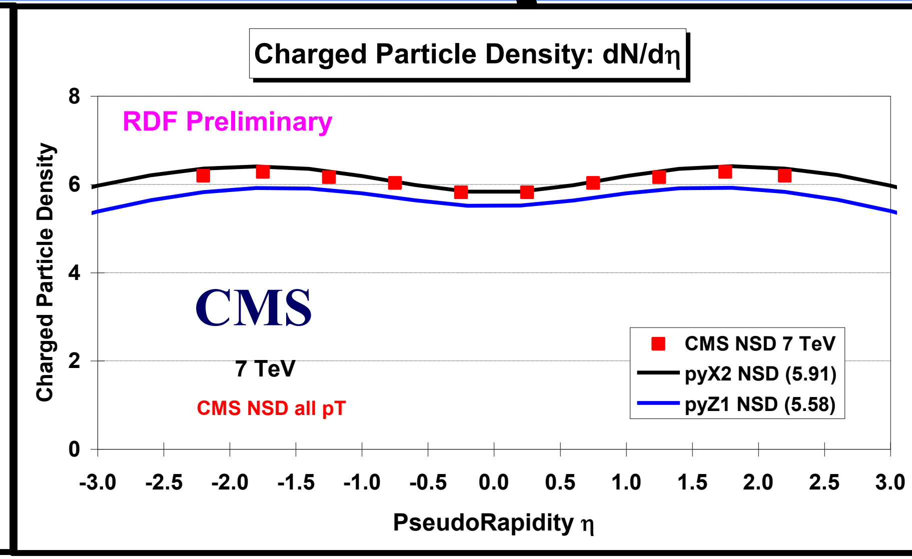


- CMS uncorrected data at 7 TeV on the charged PTsum distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c and PT(chgjet#1) > 20 GeV/c compared with PYTHIA Tune DW and Tune D6T at the detector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

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

CMS dN/dη



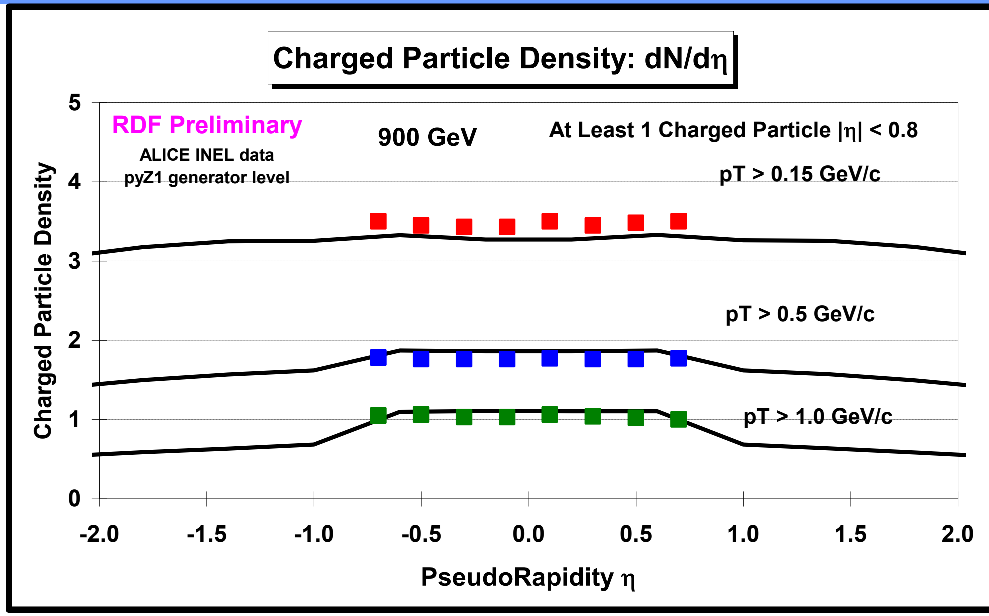


- **Generator level dN/dη (all pT). Shows the NSD = HC + DD and the HC = ND contributions for Tune Z1. Also shows the CMS NSD data.**
- **Generator level dN/dη (all pT). Shows the NSD = HC + DD prediction for Tune Z1 and Tune X2. Also shows the CMS NSD data.**

"Minimum Bias" Collisions

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

PYTHIA Tune Z1

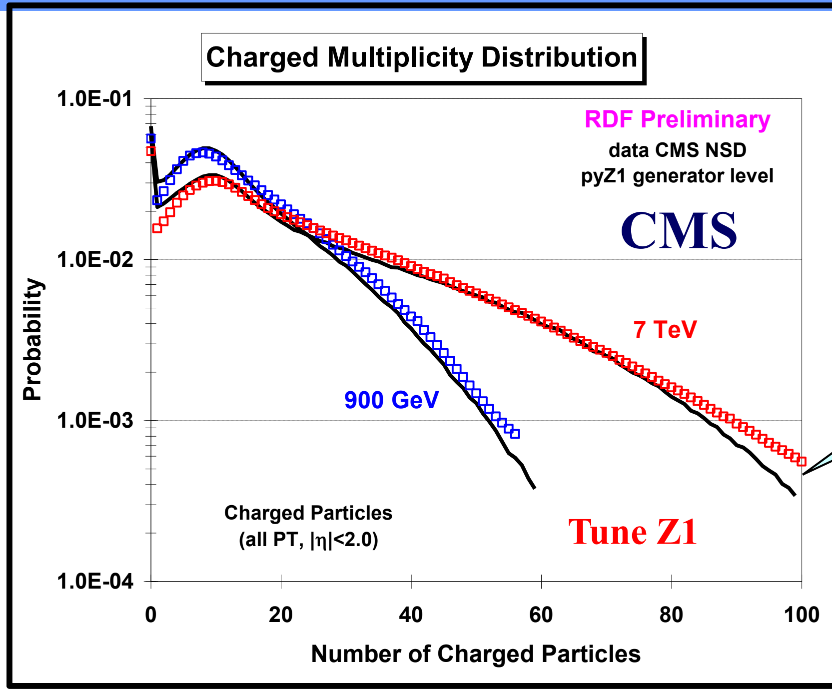


- **ALICE inelastic data at 900 GeV on the dN/dη distribution for charged particles (p_T > PTmin) for events with at least one charged particle with p_T > PTmin and |η| < 0.8 for PTmin = 0.15 GeV/c, 0.5 GeV/c, and 1.0 GeV/c compared with PYTHIA Tune Z1 at the generator level.**

"Minumum Bias" Collisions

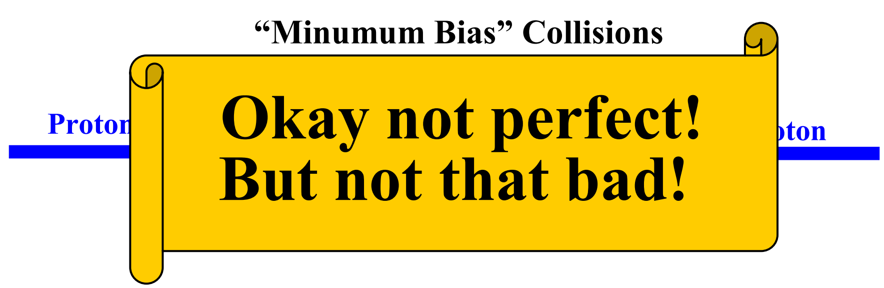
Okay not perfect, but remember
we do not know if the SD & DD are correct!

NSD Multiplicity Distribution

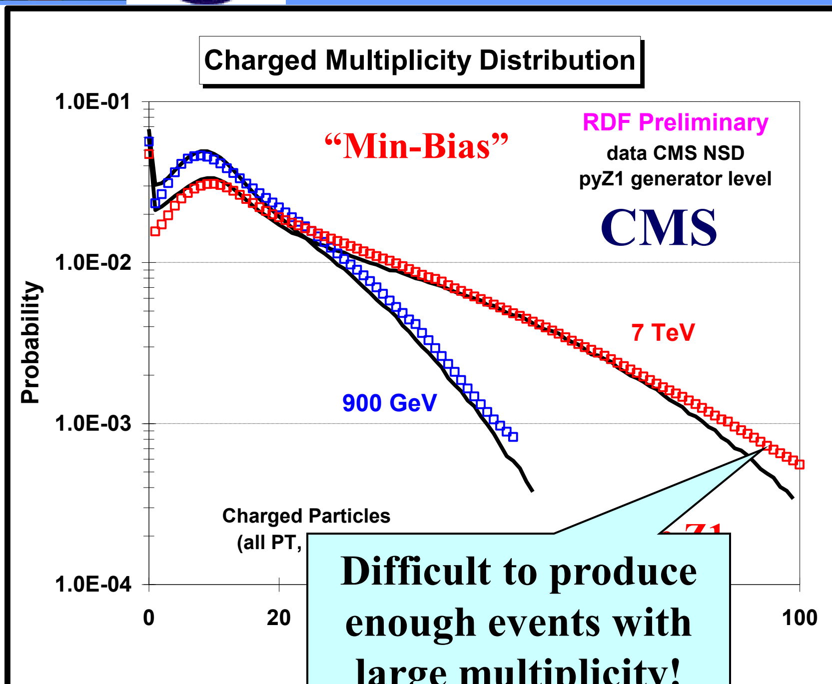


Difficult to produce enough events with large multiplicity!

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

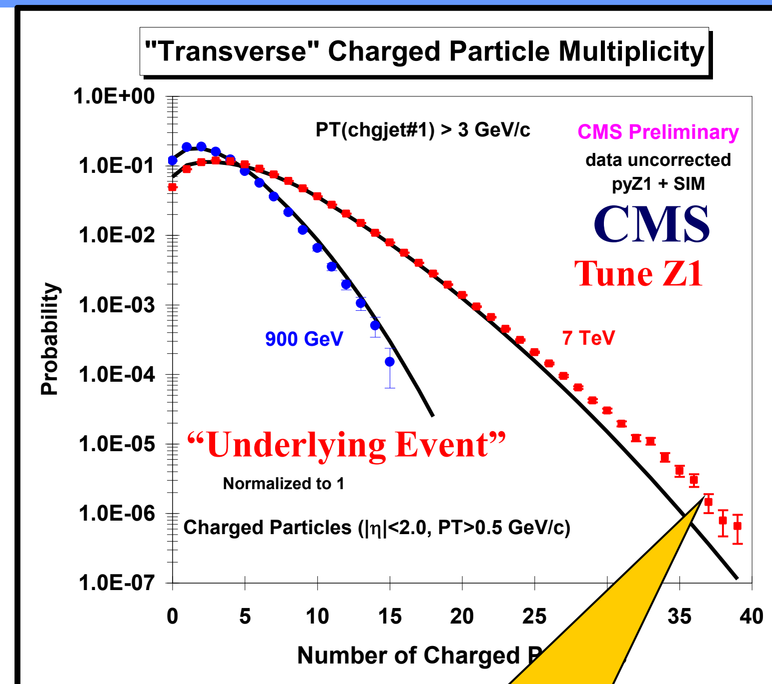


MB & UE



Difficult to produce enough events with large multiplicity!

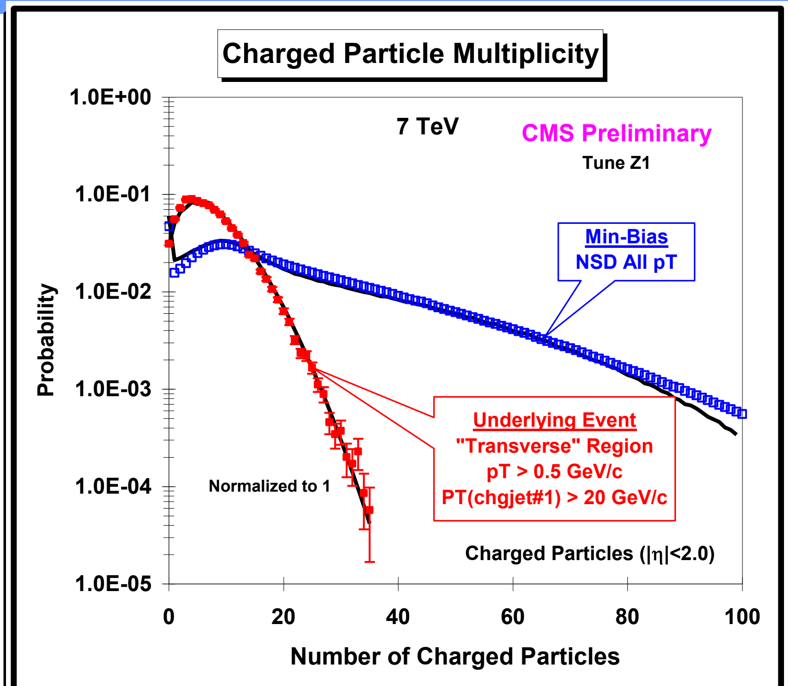
- Generator level charged multiplicity distribution (all pT, |η| < 2) at 900 GeV and 7 TeV. Shows the NSD = HC + DD prediction for **Tune Z1**. Also shows the CMS NSD data.



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

- CMS uncor... and 7 TeV on the ...licity distributio... gion for charged .../c, |η| < 2) as defi... ged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA **Tune Z1** at the detector level (*i.e.* Theory + SIM).

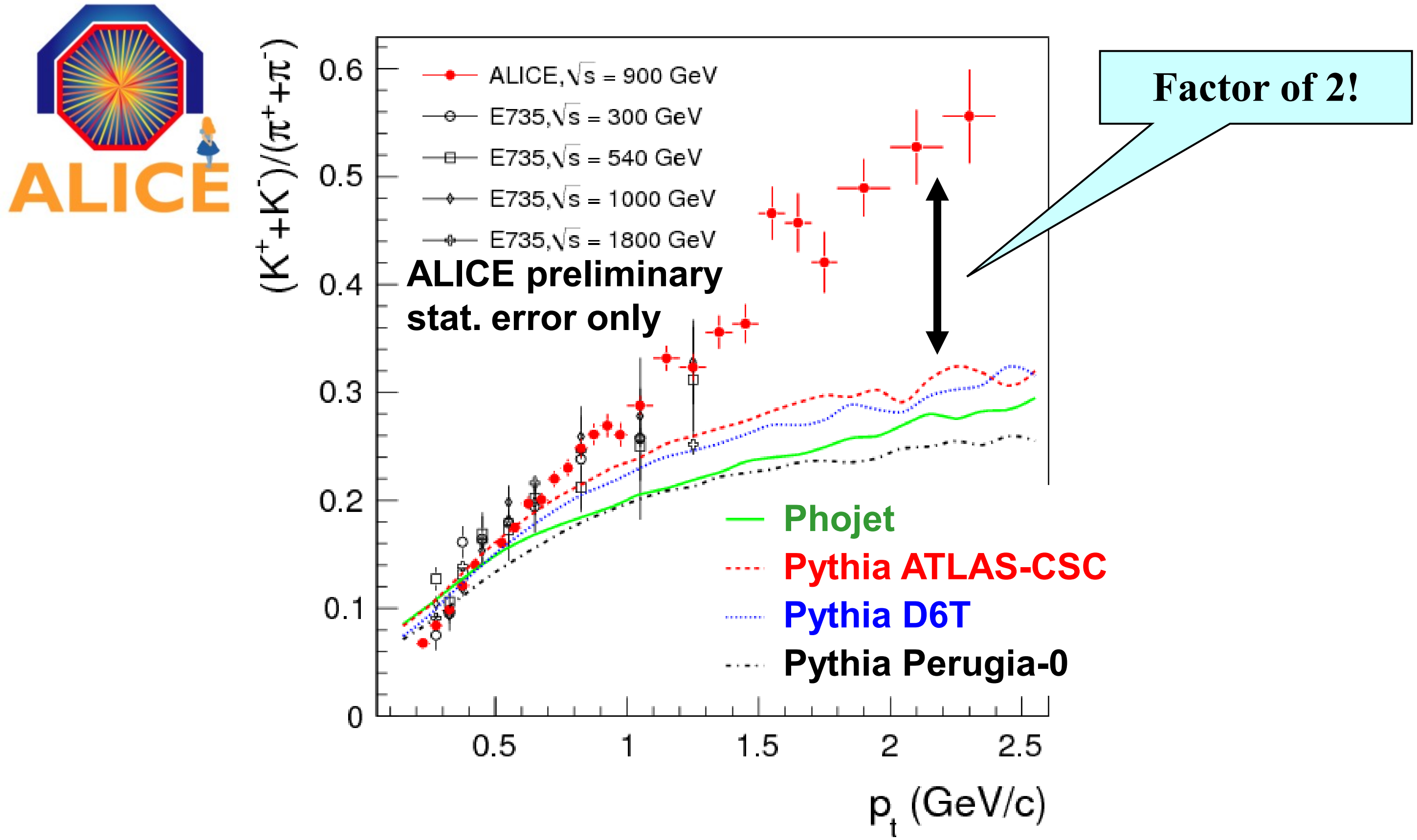
MB & UE



- 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!

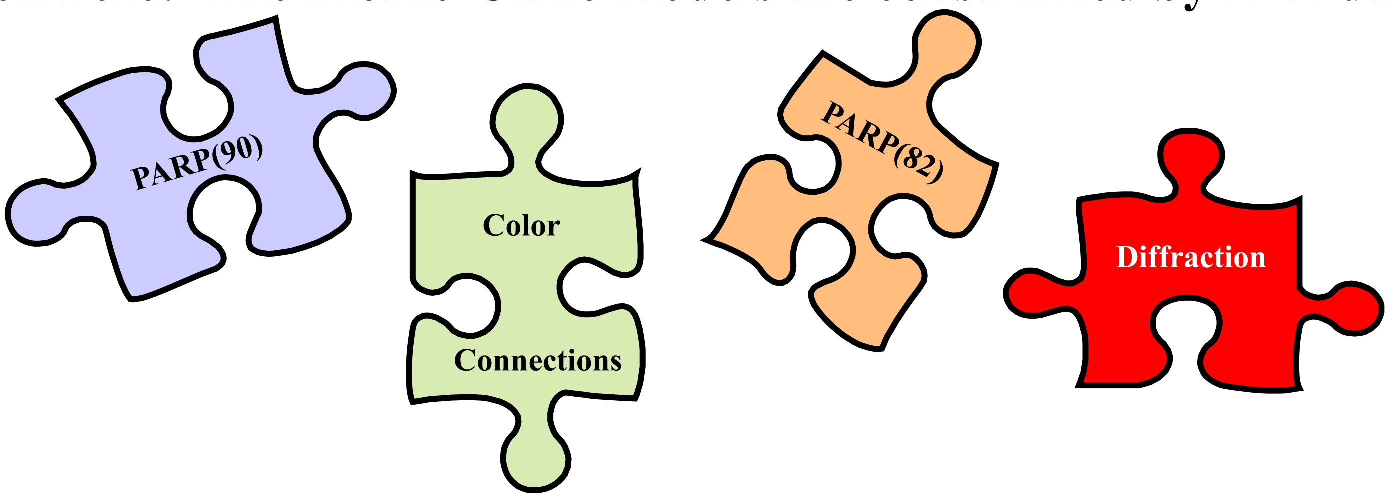
Strange Particle Production



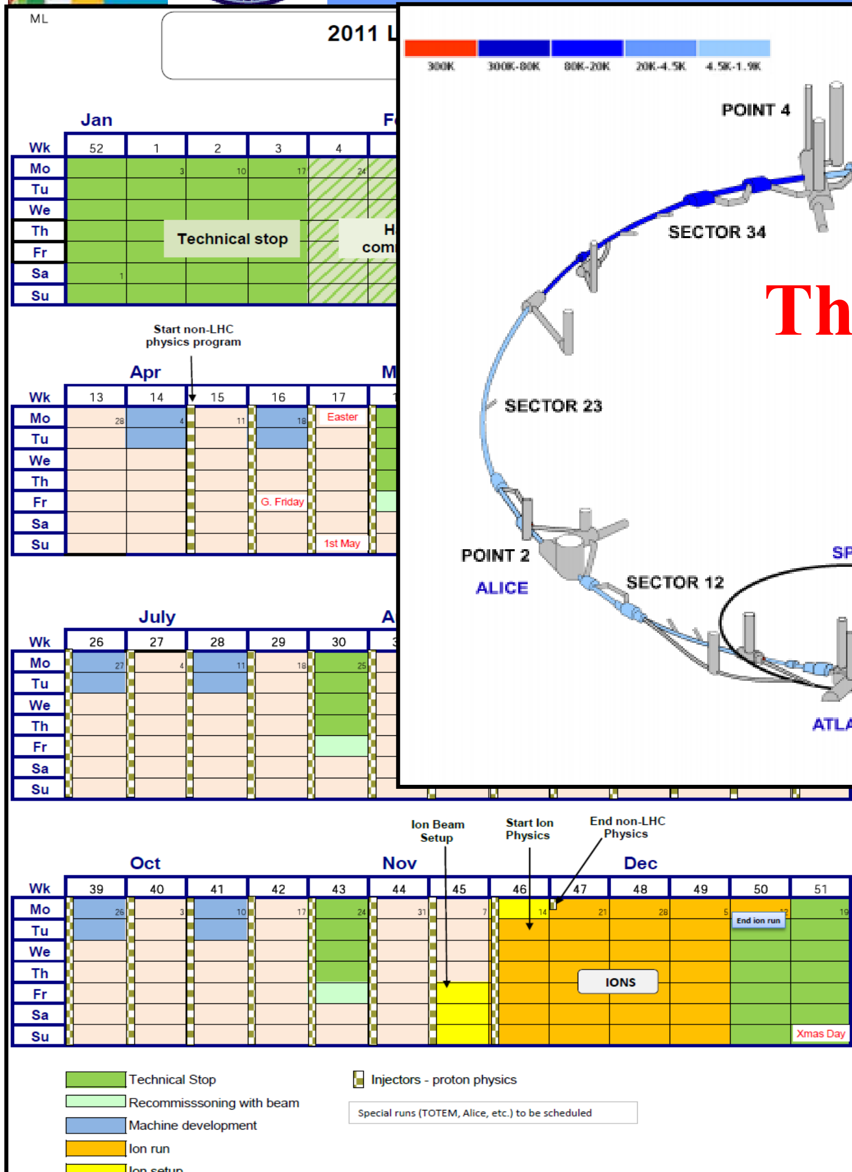
- ➡ A lot more strange mesons at large p_T than predicted by the Monte-Carlo Models!
- ➡ K/π ratio fairly independent of the center-of-mass energy.

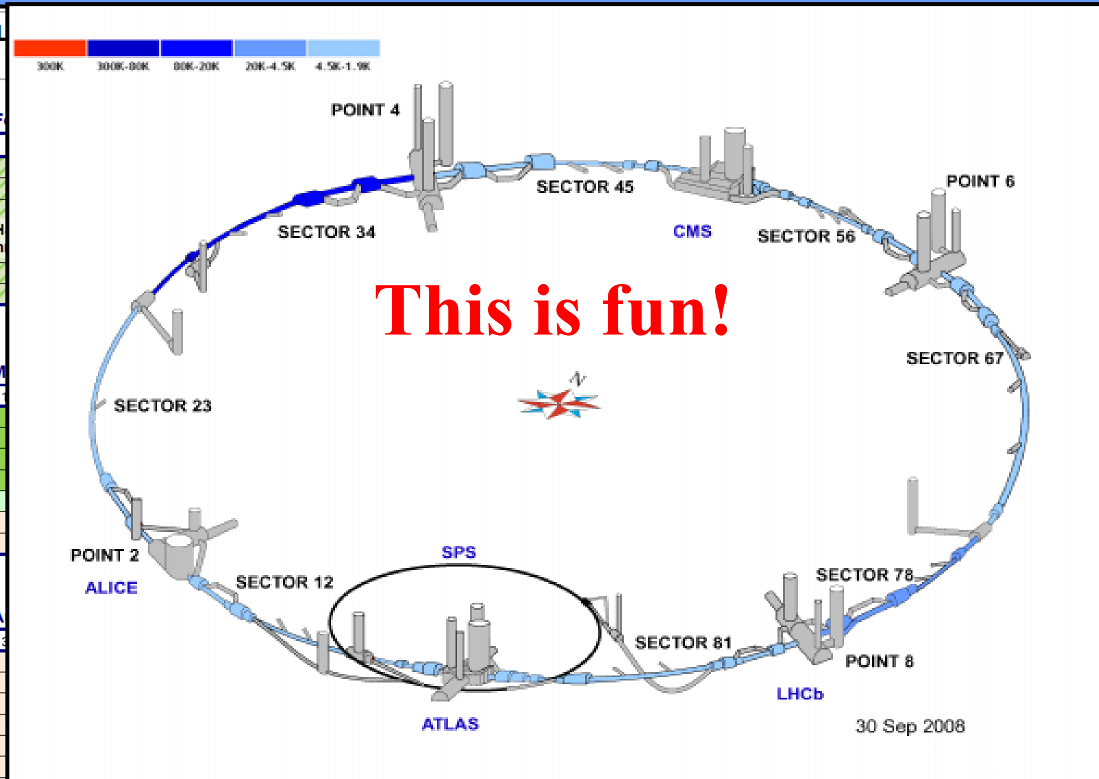
Min-Bias Summary

- 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.



The LHC in 2011





uary 21st!

with beam (at

6 weeks.

h.

roton physics!

).

Peak luminosity	6.4 x 10^{32}
Integrated per day	11 pb^{-1}
200 days	2.2 fb^{-1}
Stored energy	72 MJ