LPCC

LHC Physics Centre at CERN

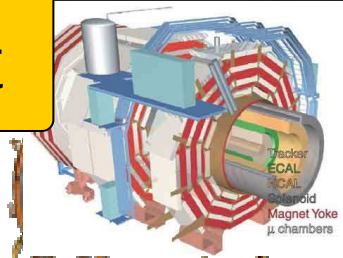
MB&UE Working Group Meeting

February 7 & 8, 2011

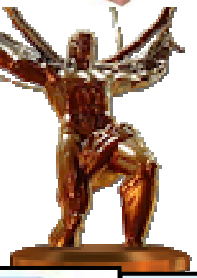
UE Lessons Learned & What's Next

Rick Field

University of Florida



CMS



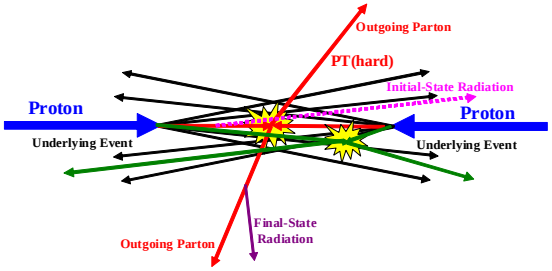
ATLAS

Outline of Talk

➡ **LHC UE Data:** **ALICE-ATLAS-CMS UE data. Comparisons with each other and with PYTHIA Tune Z1.**

➡ **LHC MB Data:** **Attempts to describe both MB and the UE with the same tune.**

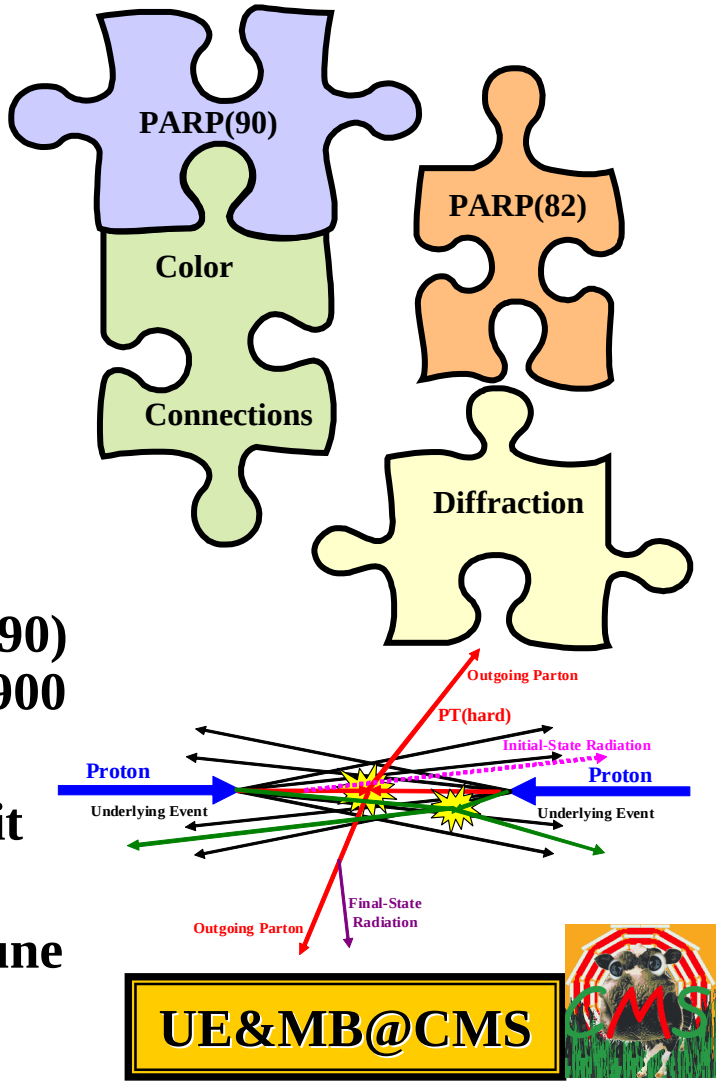
➡ **Coming Soon:** **Corrected UE from CMS!**



UE&MB@CMS

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!

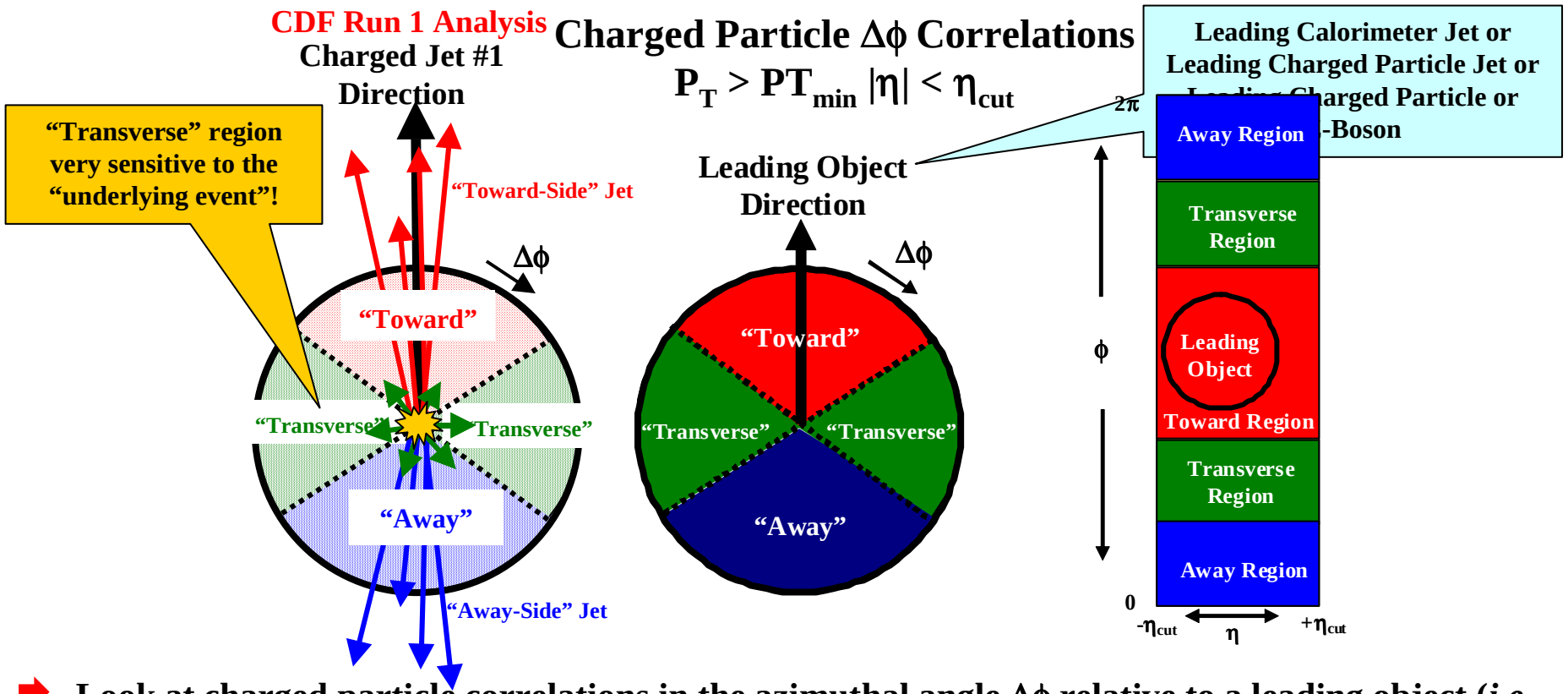


PYTHIA Tune Z1

Parameters not shown are the PYTHIA 6.4 defaults!

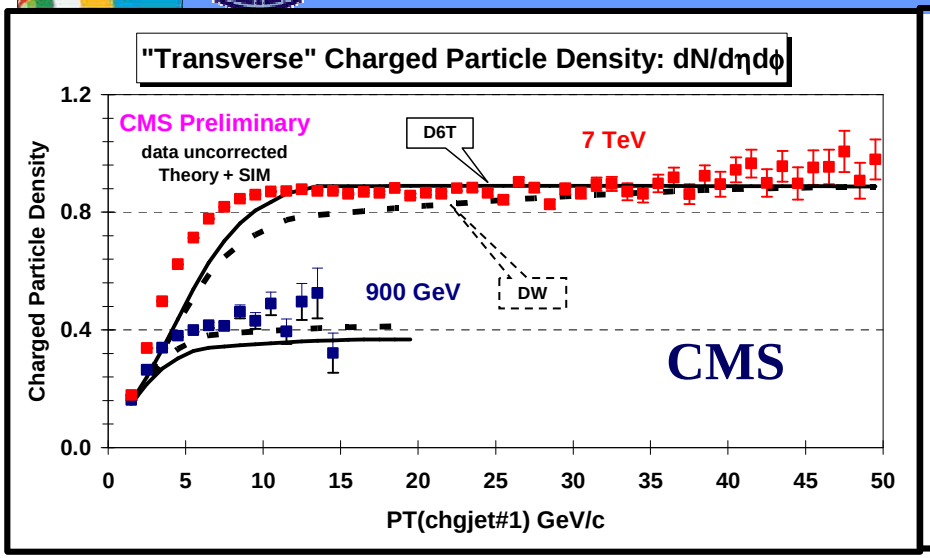
Parameter	Tune Z1 (R. Field CMS)	Tune AMBT1 (ATLAS)
Parton Distribution Function	CTEQ5L	LO*
PARP(82) – MPI Cut-off	1.932	2.292
PARP(89) – Reference energy, E0	1800.0	1800.0
PARP(90) – MPI Energy Extrapolation	0.275	0.25
PARP(77) – CR Suppression	1.016	1.016
PARP(78) – CR Strength	0.538	0.538
PARP(80) – 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

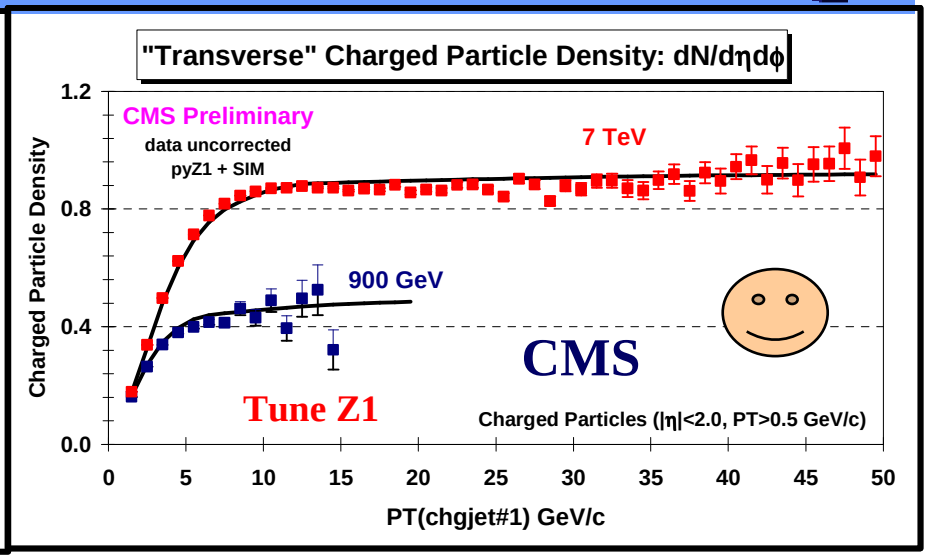
Traditional Approach



- Look at charged particle correlations in the azimuthal angle Δϕ 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, $\Delta\eta \times \Delta\phi = 2\eta_{cut} \times 120^o = 2\eta_{cut} \times 2\pi/3$. Construct densities by dividing by the area in η-ϕ space.

CMS UE Data





➡ **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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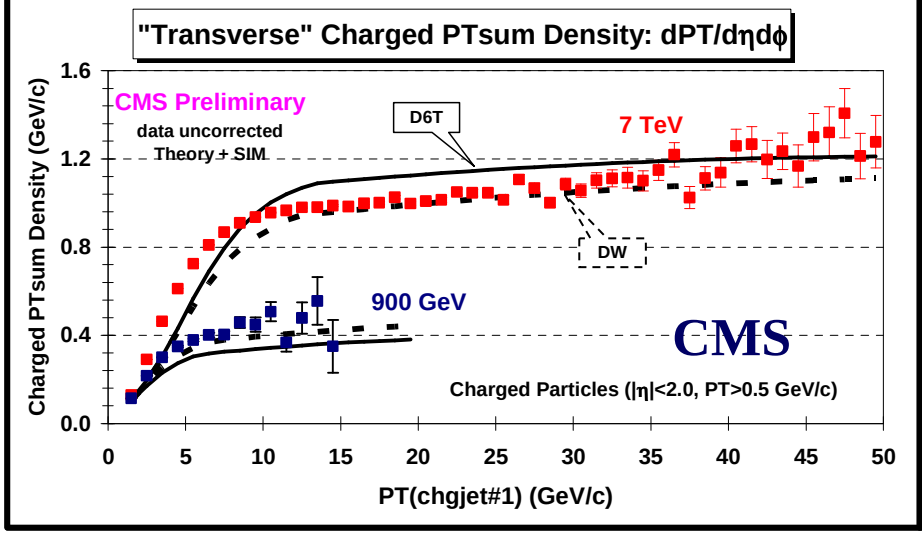
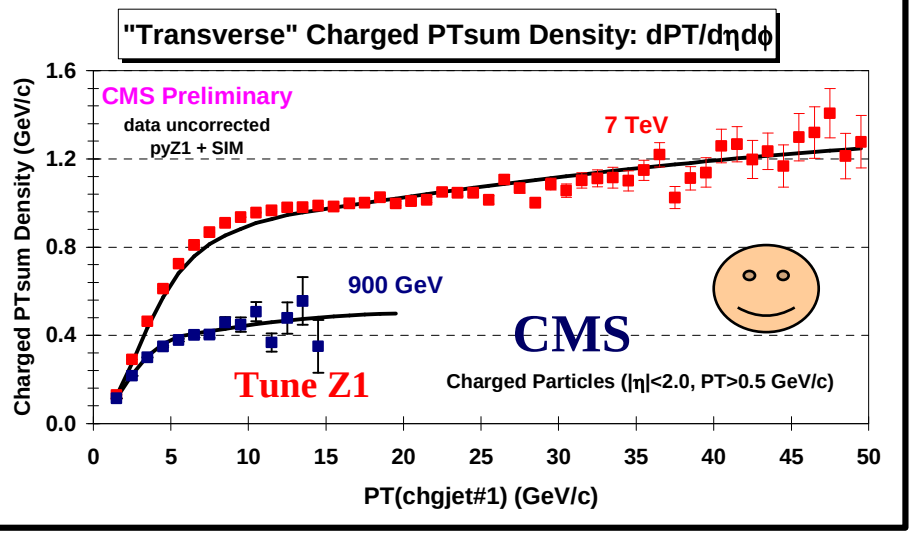
Color reconnection suppression.
Color reconnection strength.

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!

CMS UE Data





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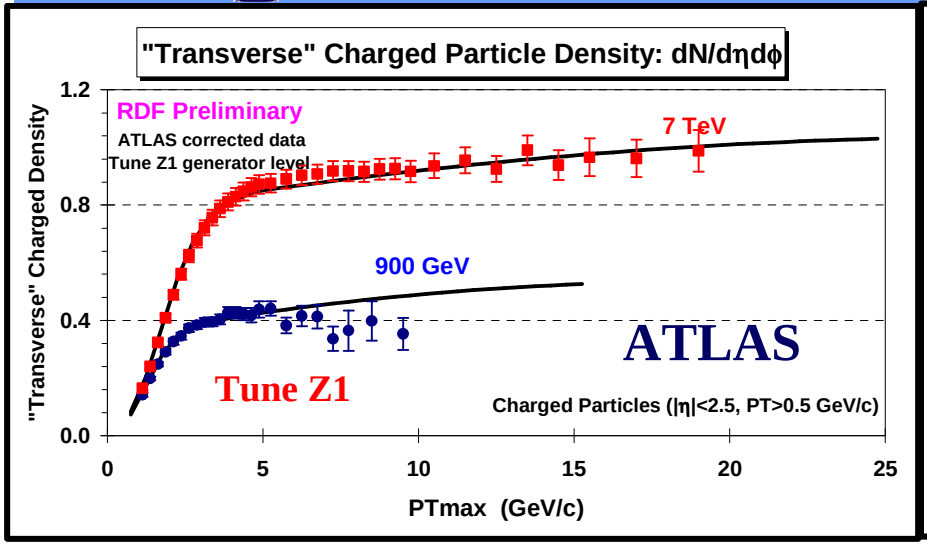
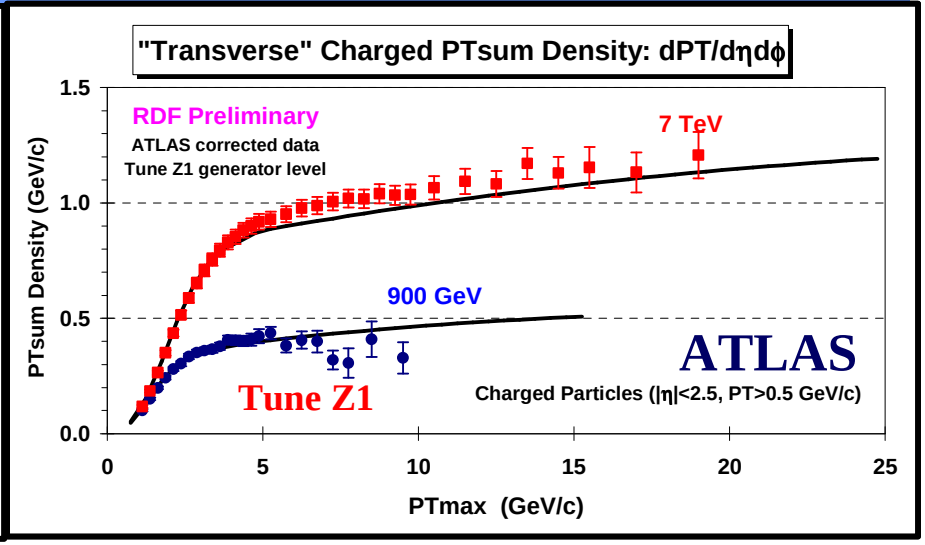
ATLAS UE Data





- **ATLAS published 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.**

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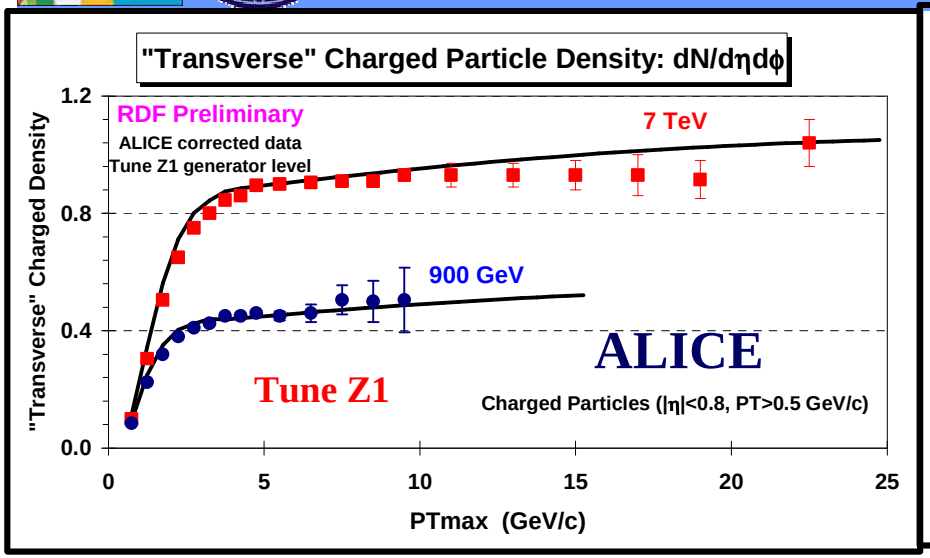
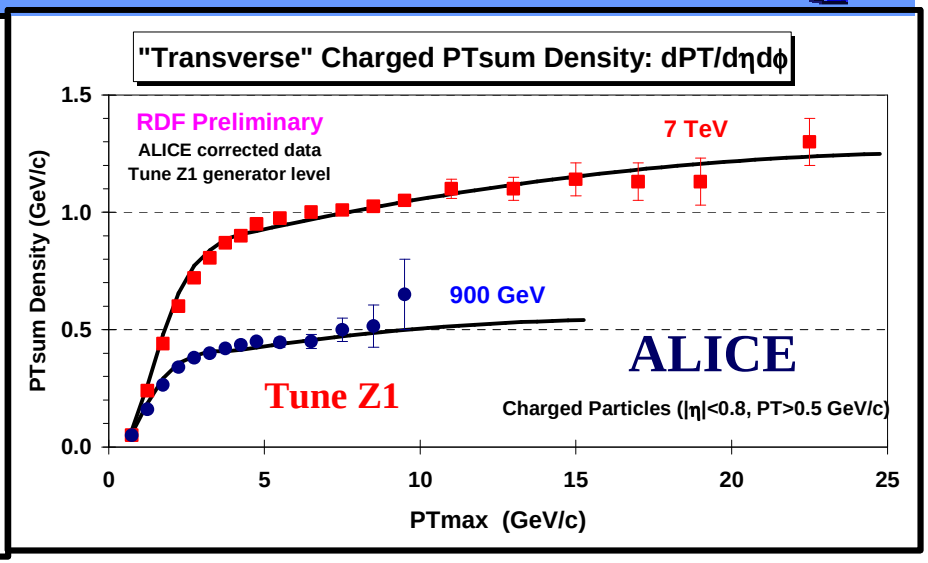
I read the points off with a ruler!

ATLAS publication – arXiv:1012.0791

December 3, 2010

ALICE UE Data





- **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 $|\eta| < 0.8$. The data are corrected and compared with PYTHIA Tune Z1 at the generator level.**

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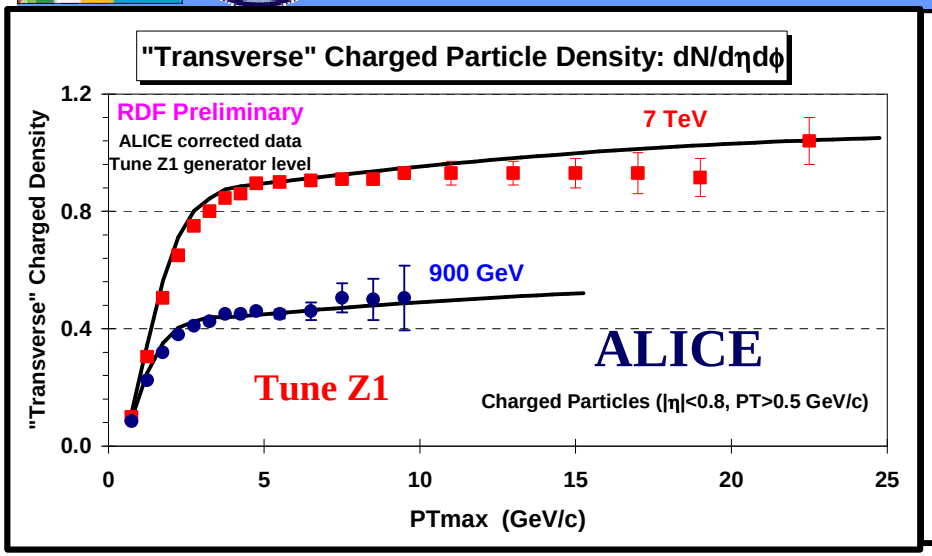
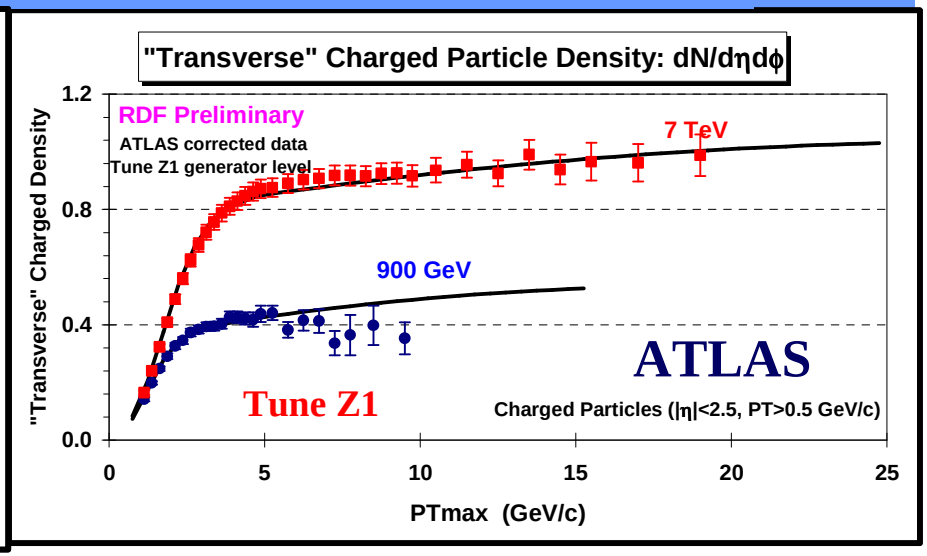
ALICE UE Data: Talk by S. Vallero
MPI@LHC 2010 Glasgow, Scotland
November 30, 2010

ALICE-ATLAS UE





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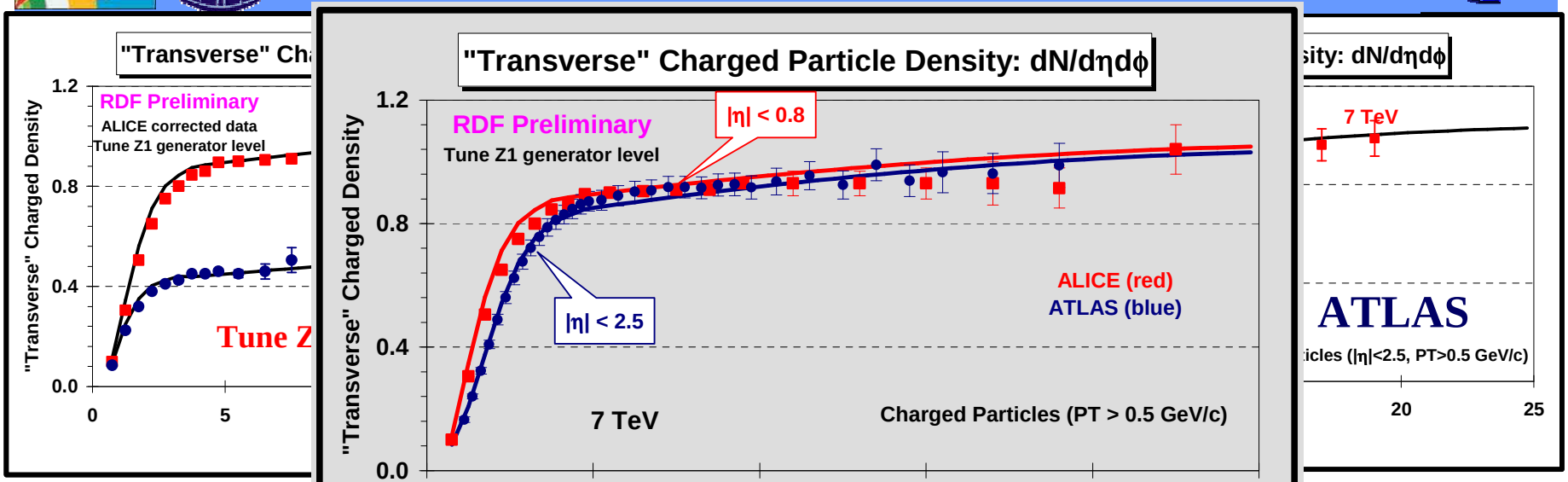
ALICE-ATLAS UE



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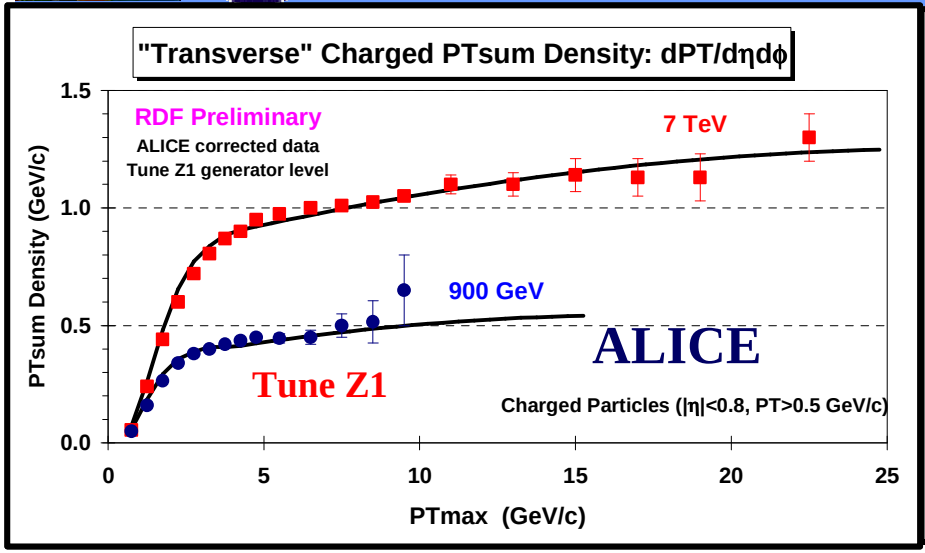

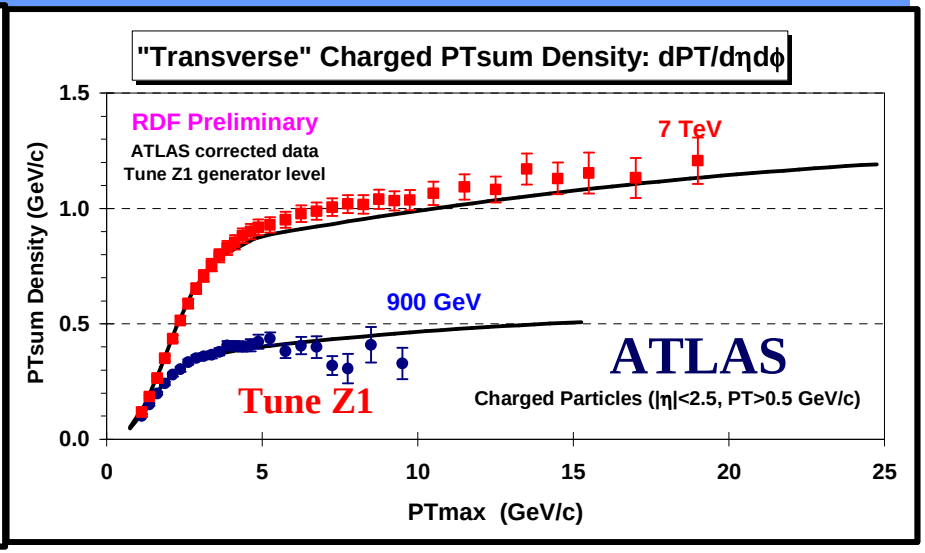

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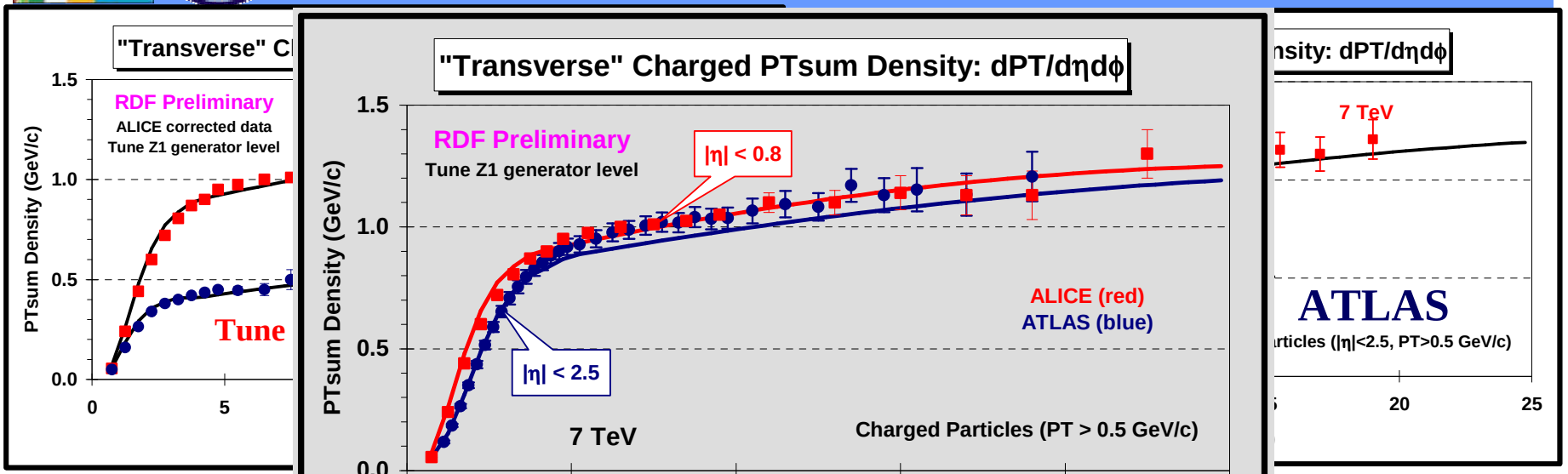

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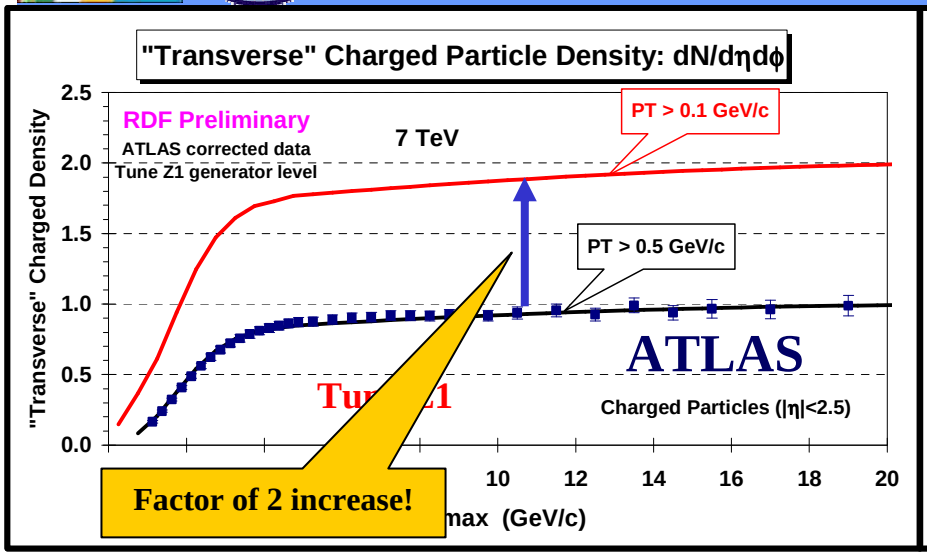
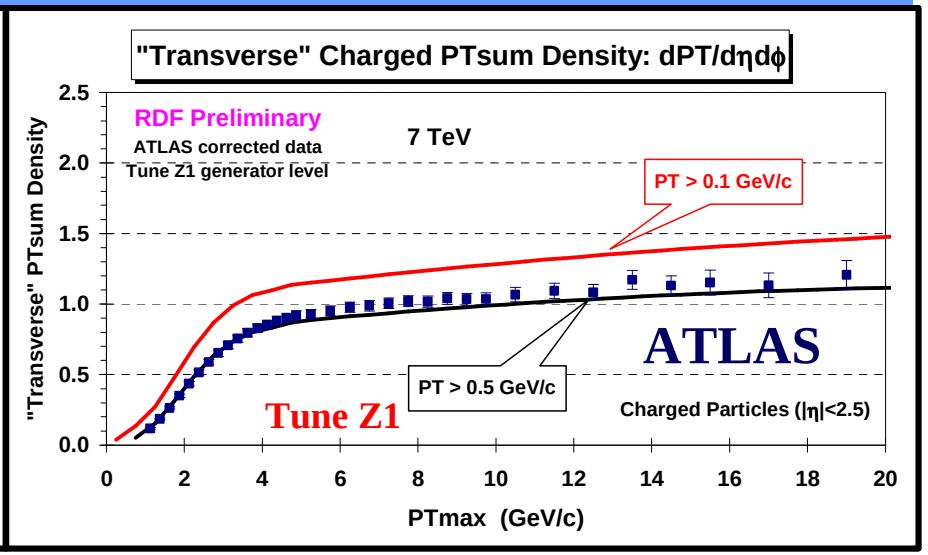
PYTHIA Tune Z1





- **ATLAS preliminary data at 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. Also shows the prediction of Tune Z1 for the "transverse" charged particle density with p_T > 0.1 GeV/c and |η| < 2.5.**

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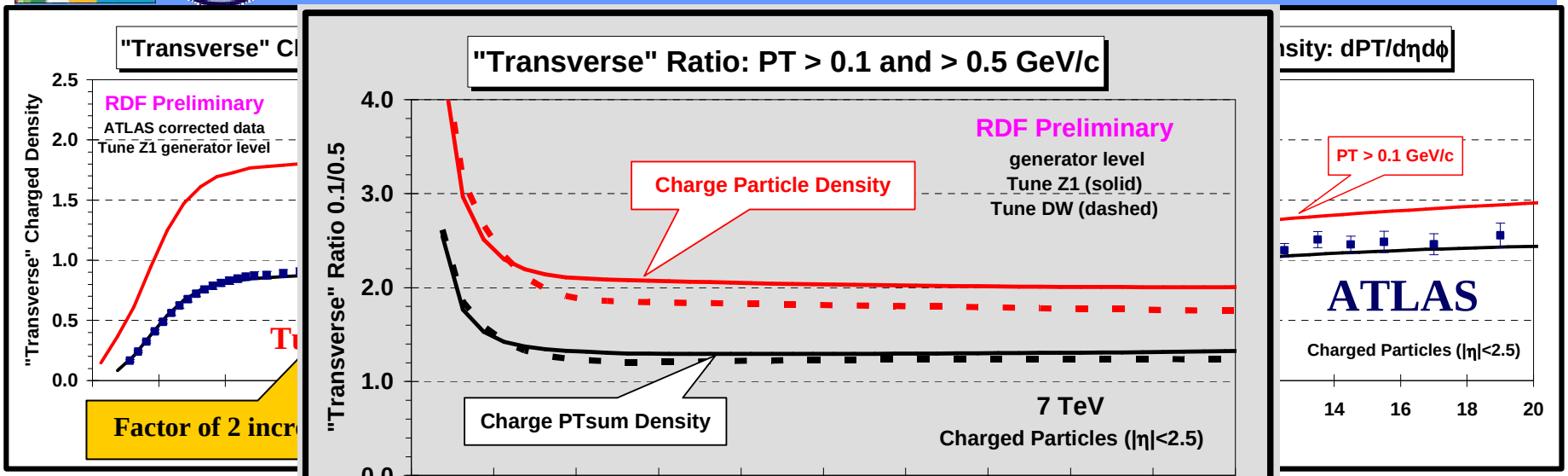

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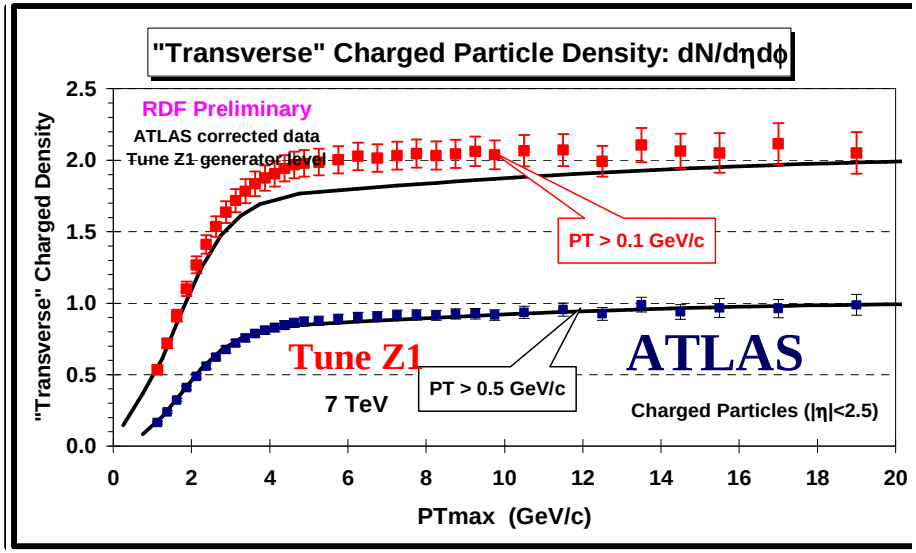
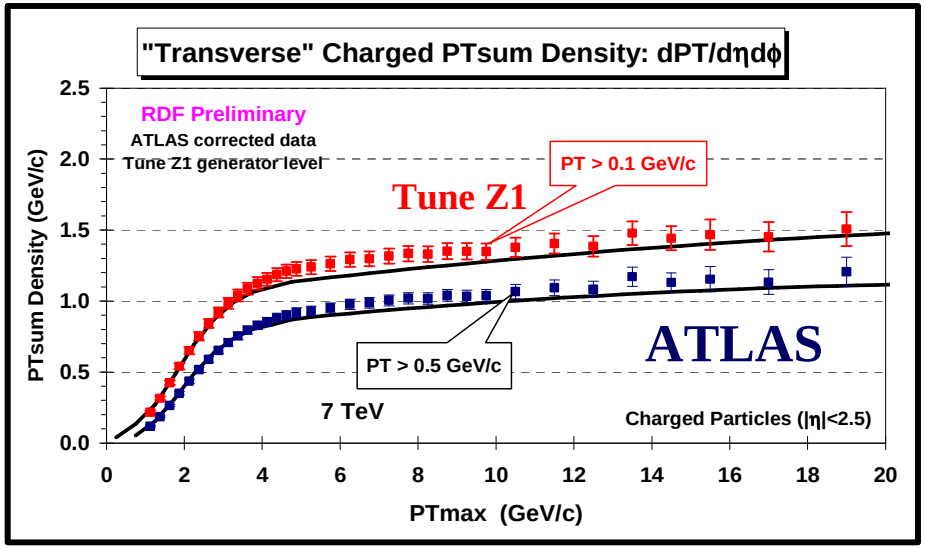
Rick Field
MPI@LHC 2010 Glasgow, Scotland
December 2, 2010

ATLAS UE Data





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I read the points off with a ruler!

ATLAS publication – arXiv:1012.0791

December 3, 2010

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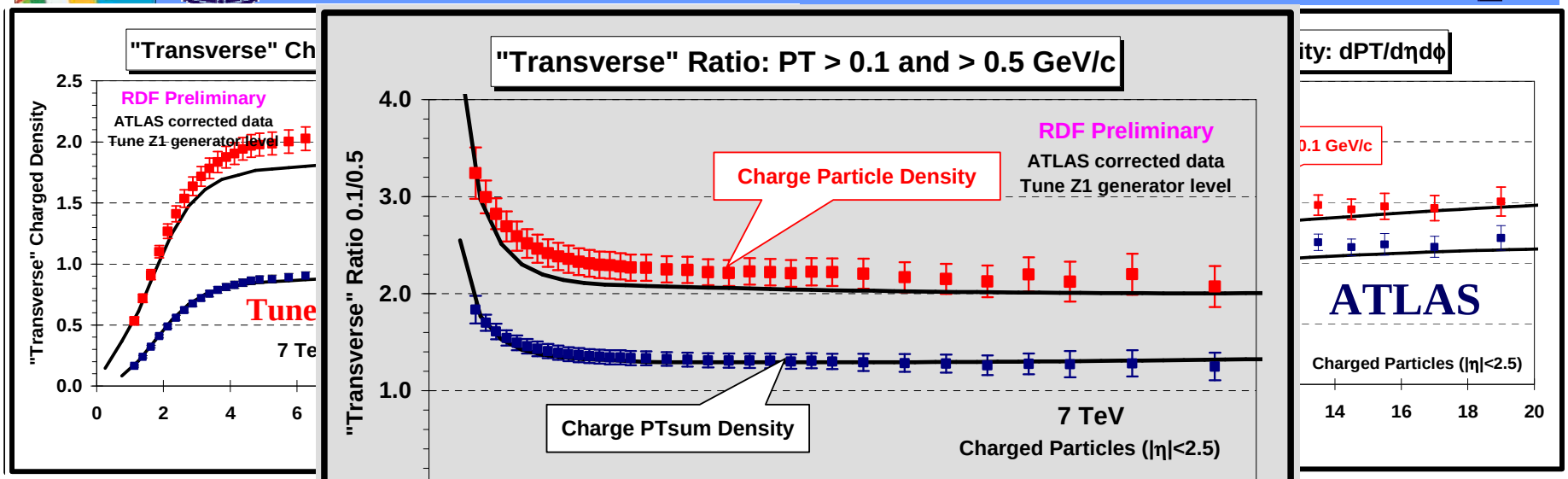

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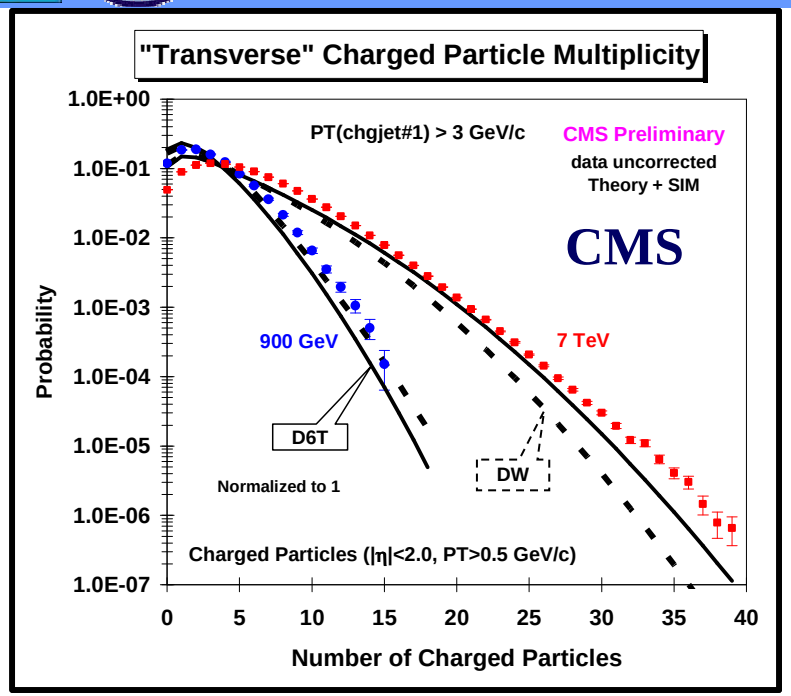
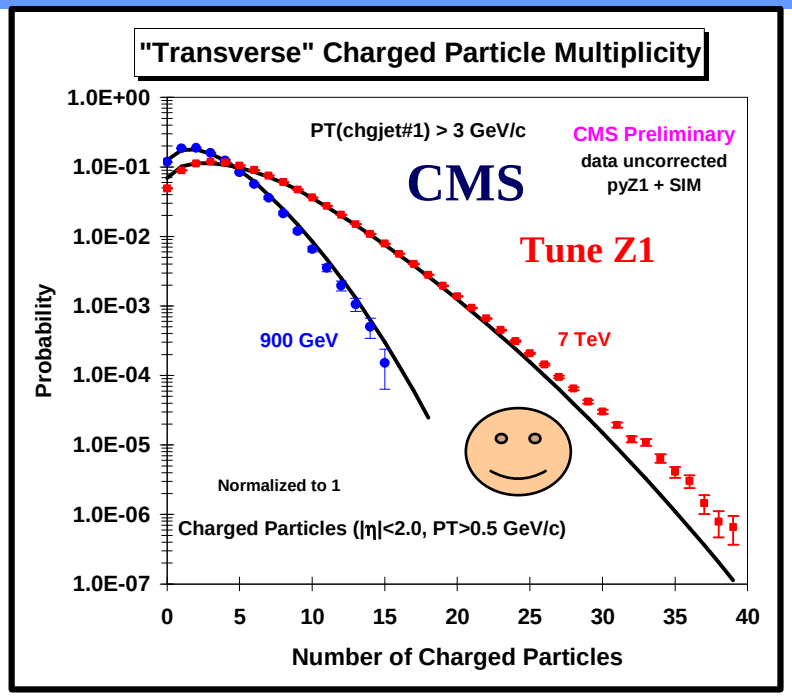
ATLAS publication – arXiv:1012.0791

December 3, 2010

"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).**

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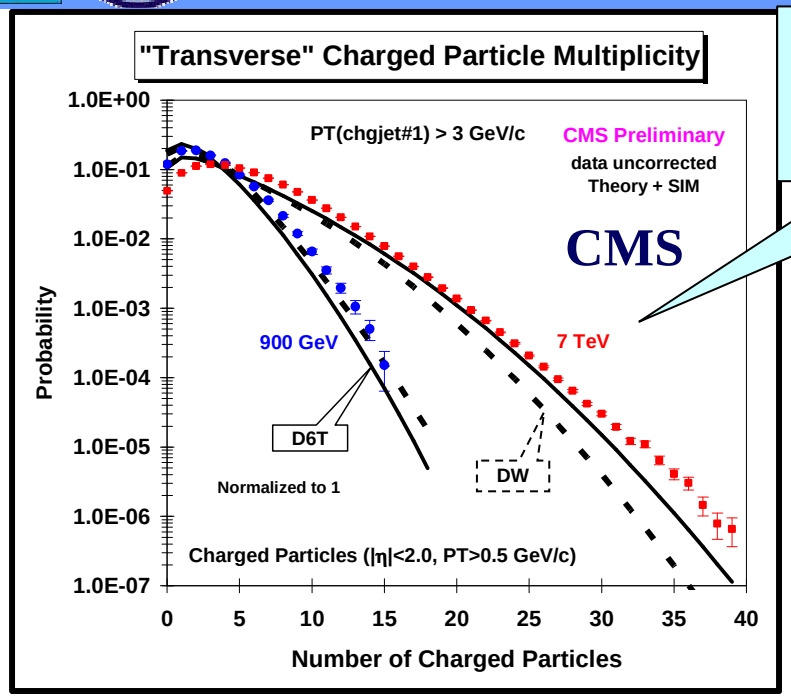
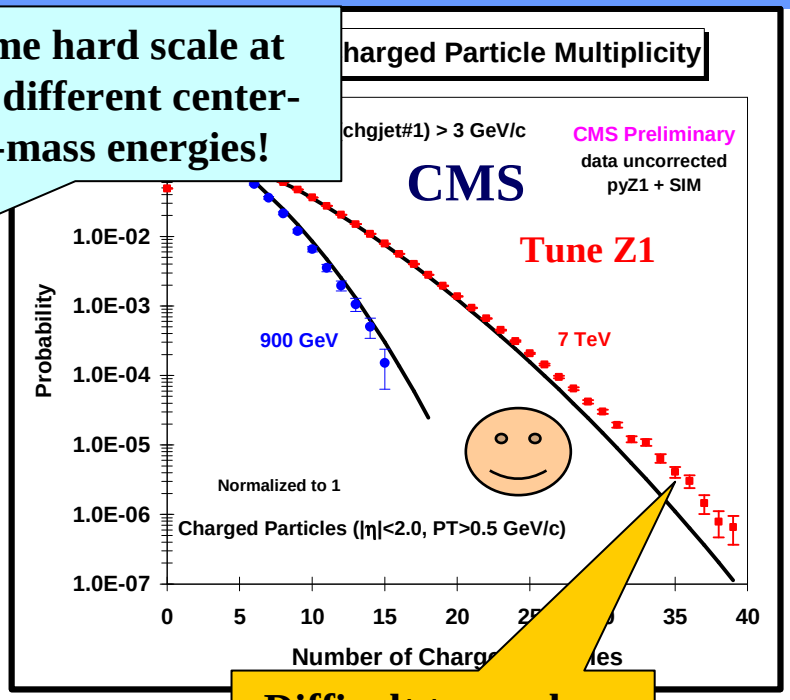
"Transverse" Multiplicity Distribution



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, |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).
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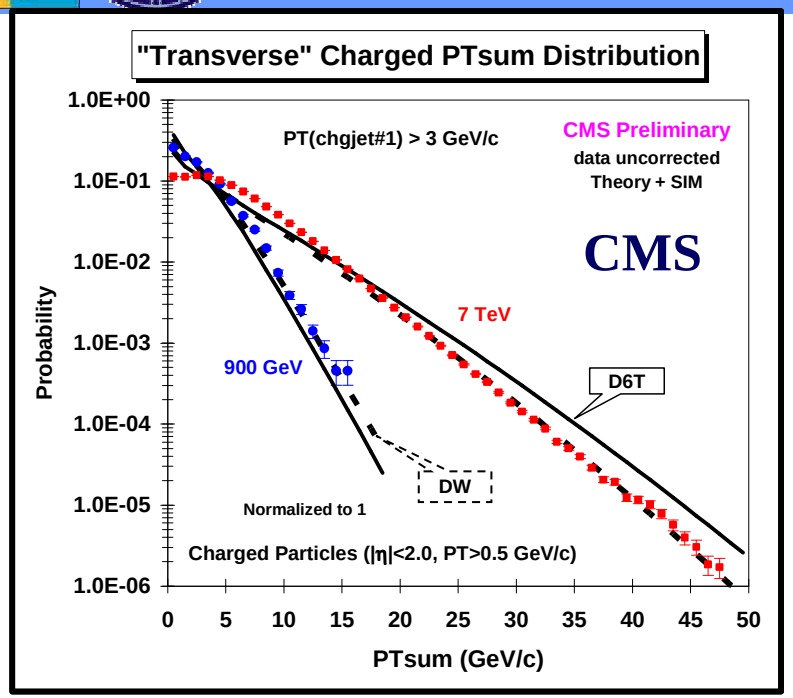
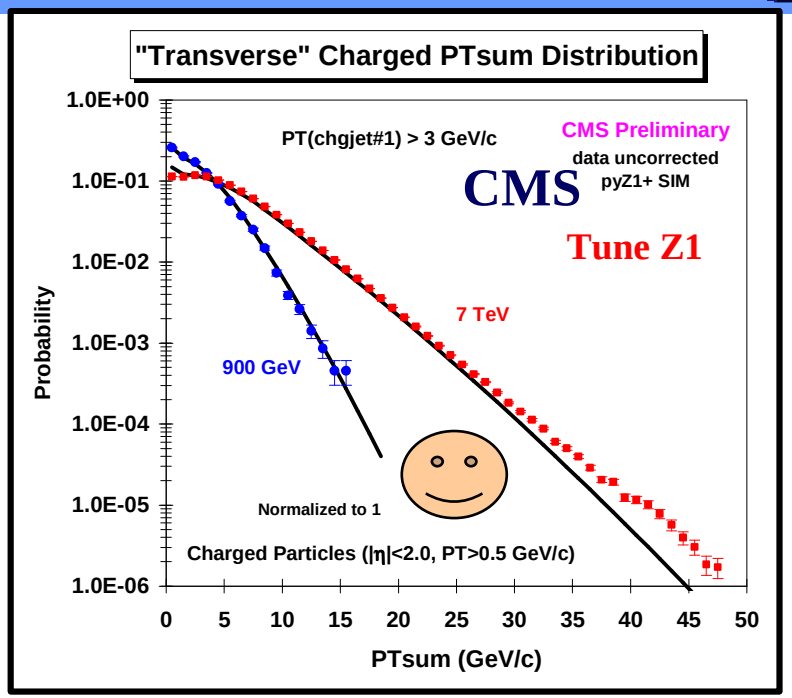
"Transverse" PTsum Distribution

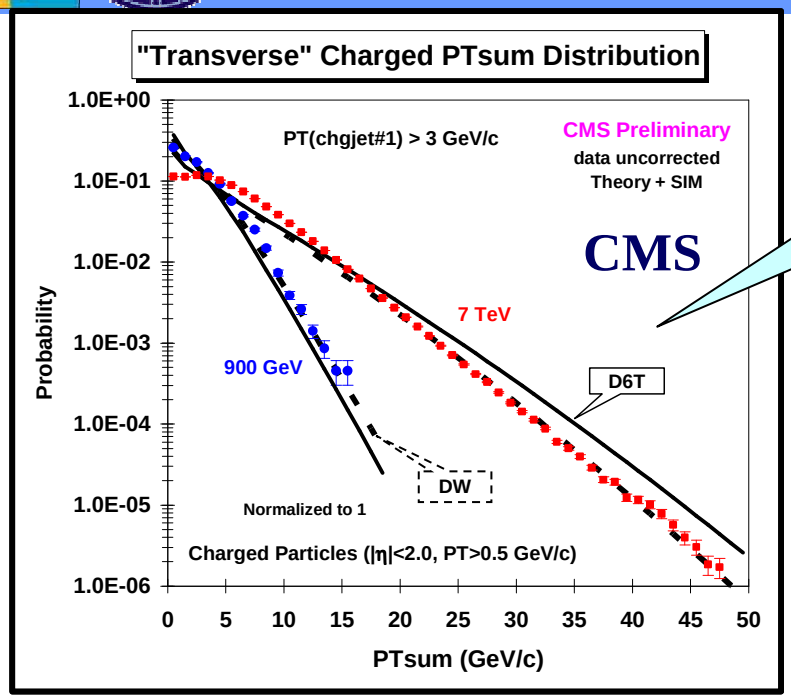




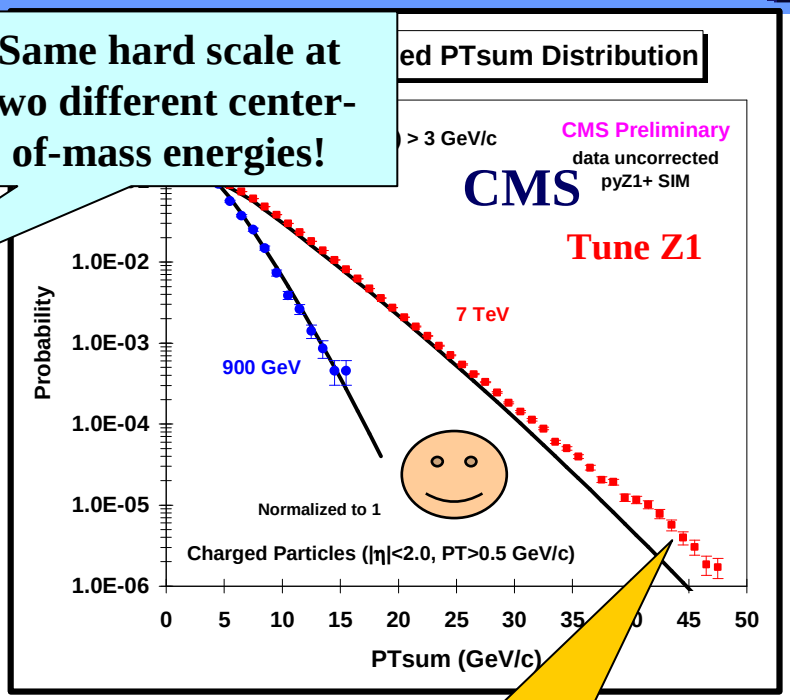
- **CMS uncorrected data at 900 GeV and 7 TeV on the charged scalar PTsum distribution in the "transverse" region for charged particles (p_T > 0.5 GeV/c, |η| < 2) as defined by the leading charged particle jet with PT(chgjet#1) > 3 GeV/c compared with PYTHIA Tune DW, and Tune D6T at the detector level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



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



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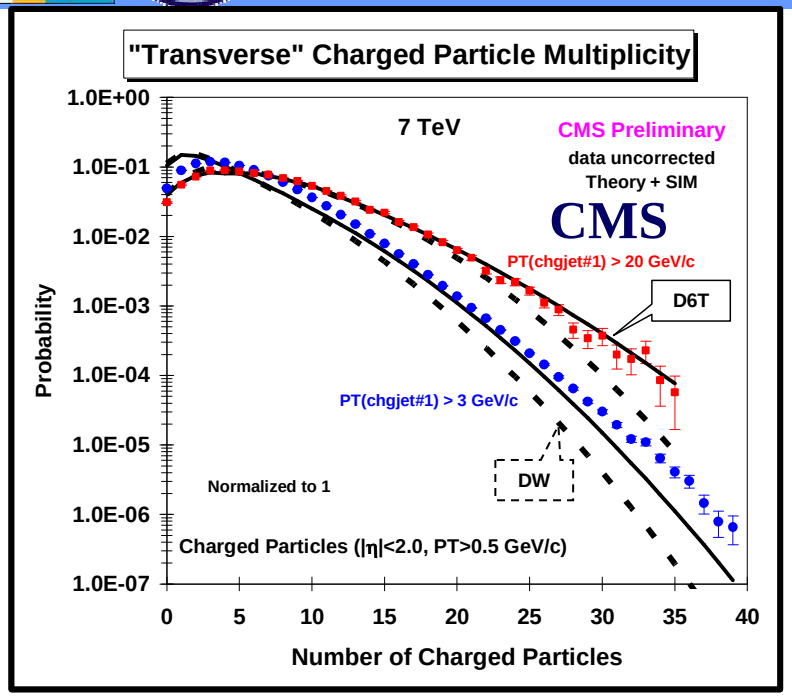

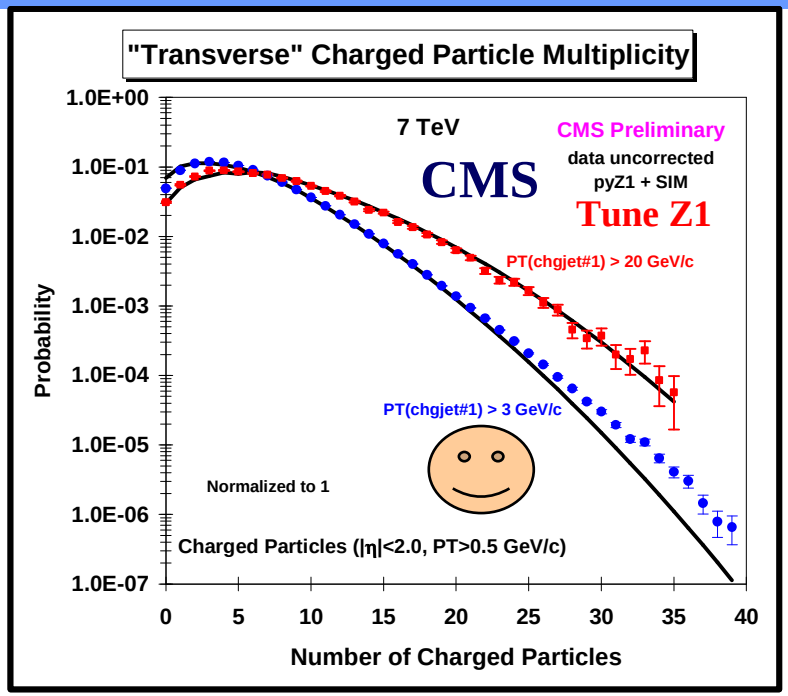

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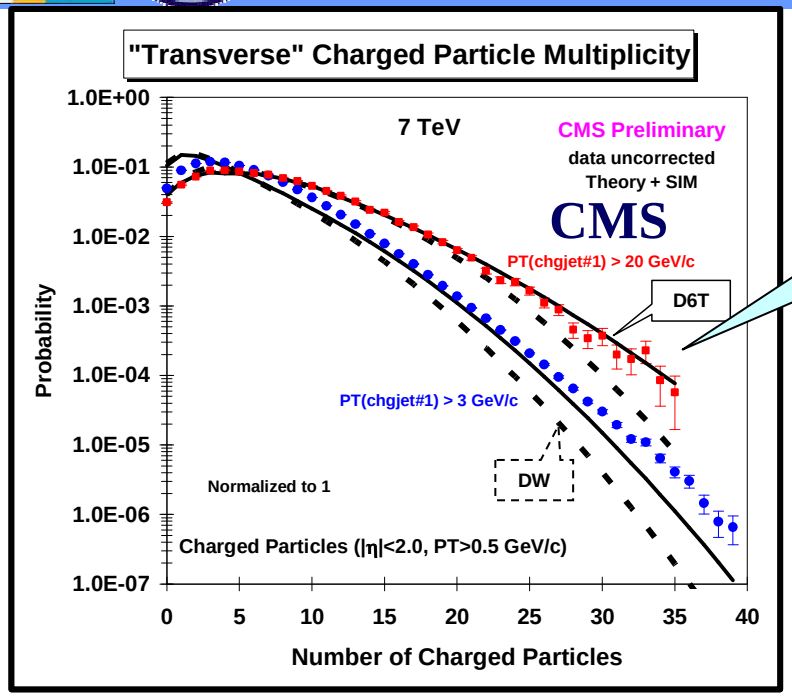

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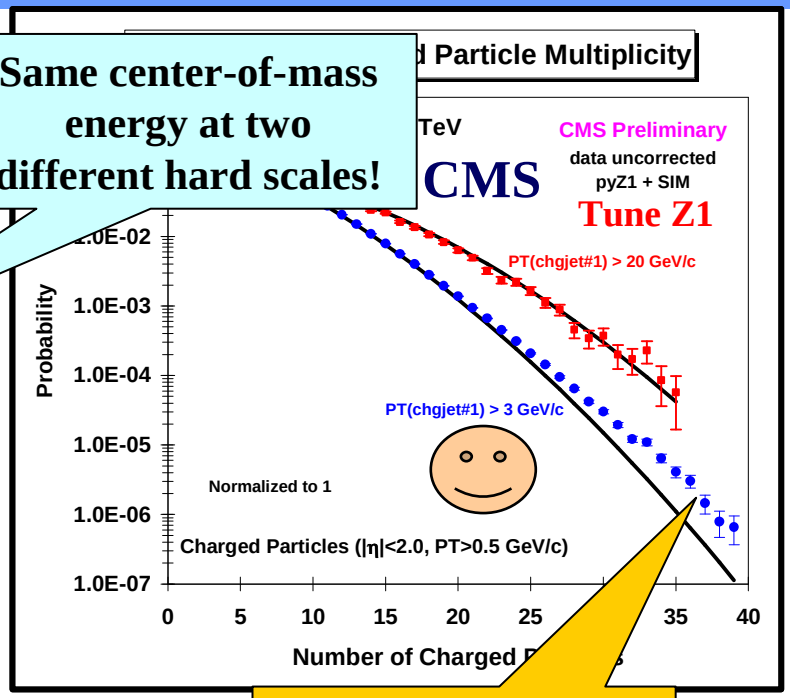

Difficult to produce enough events with large "transverse" multiplicity at low hard scale!

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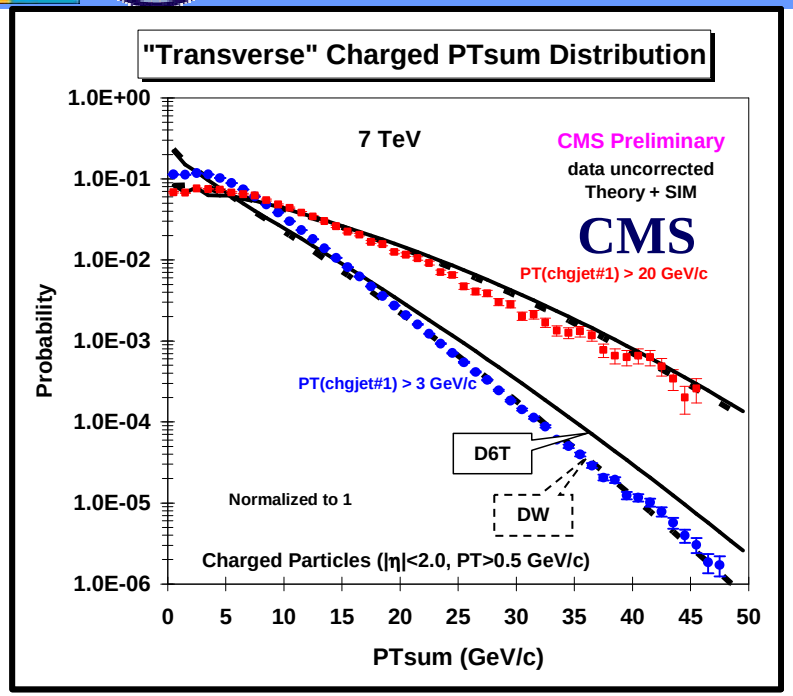

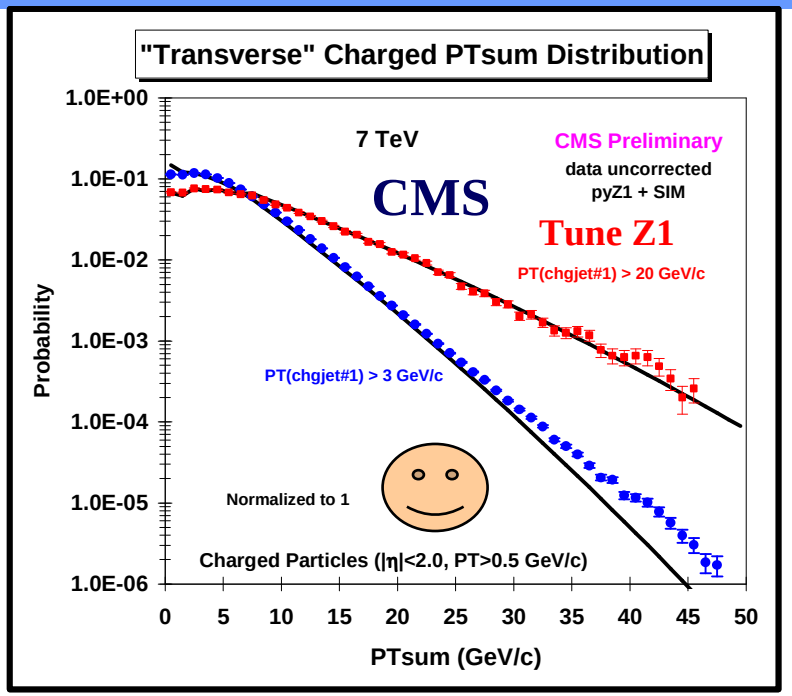

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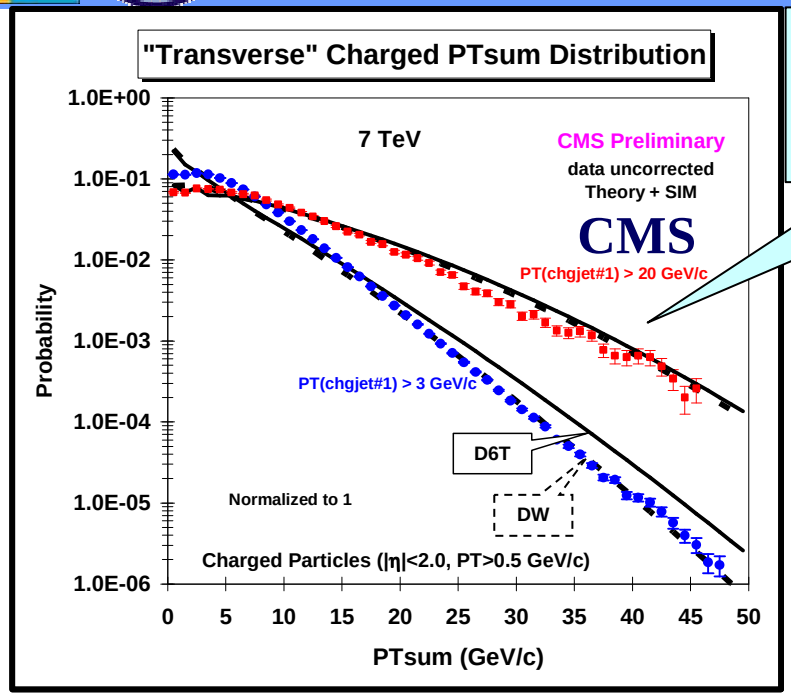

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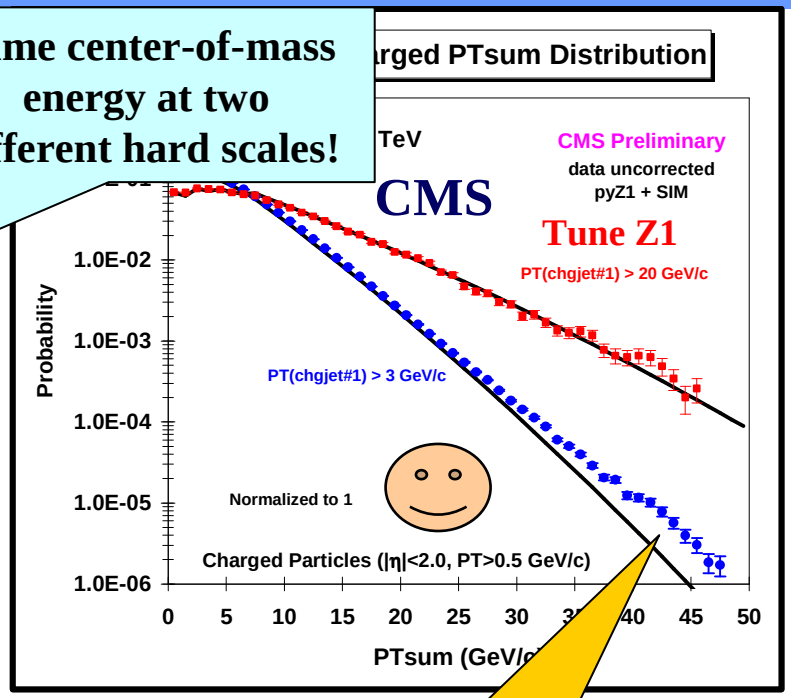

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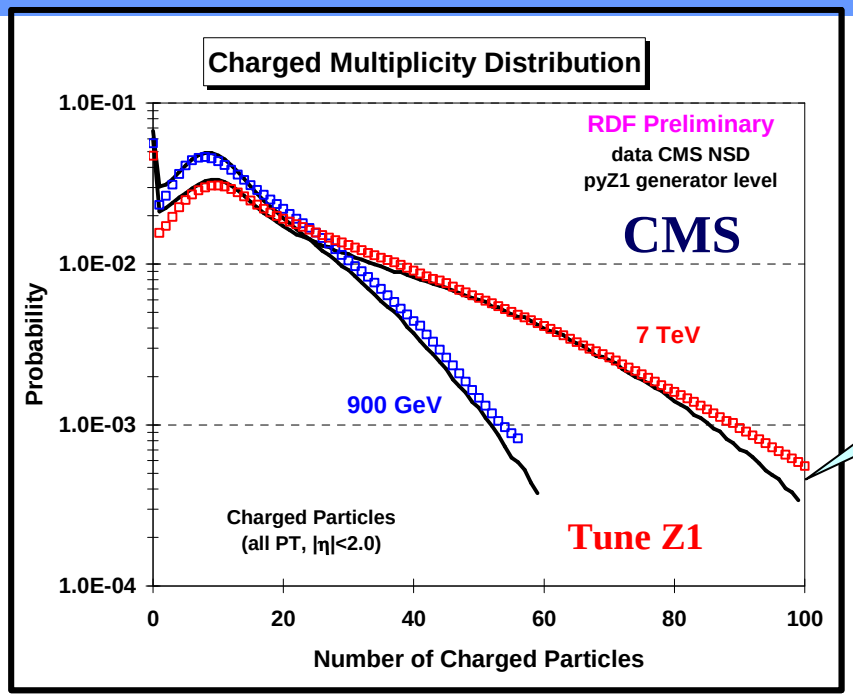
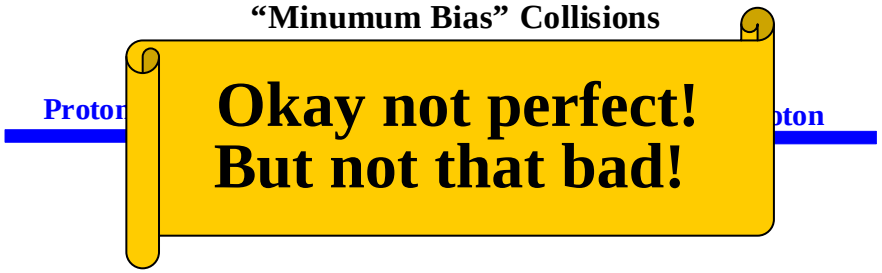
NSD Multiplicity Distribution

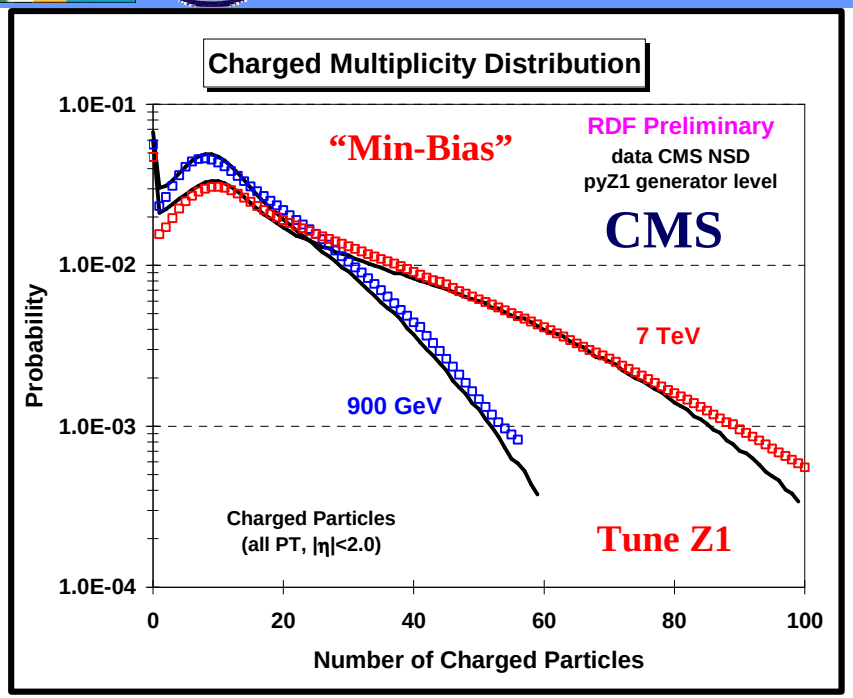


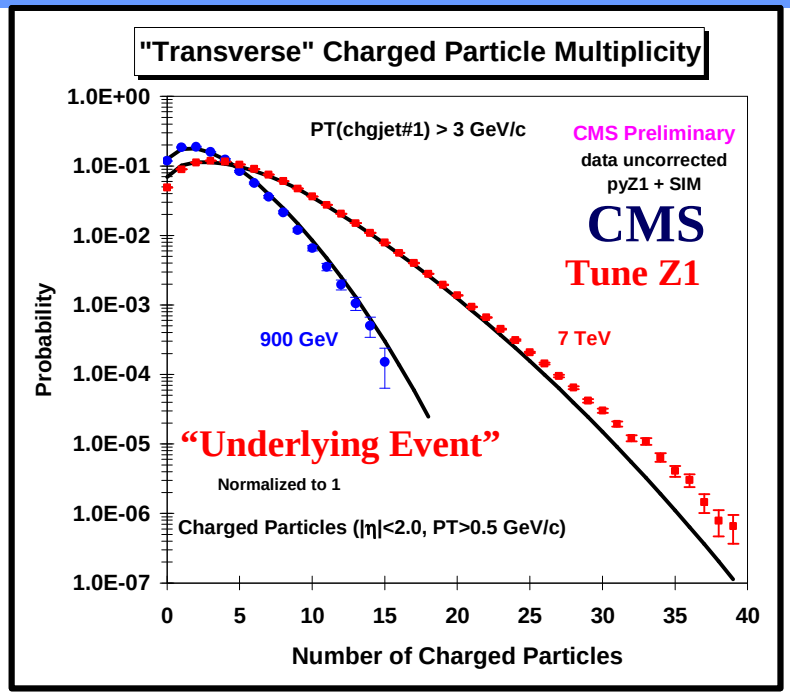
Difficult to produce enough events with large multiplicity!

- **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





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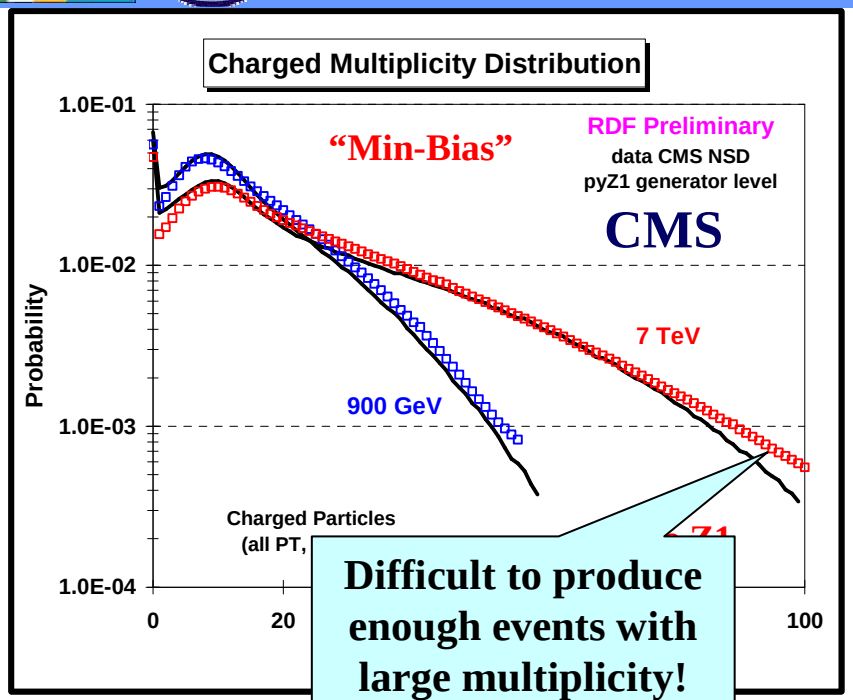

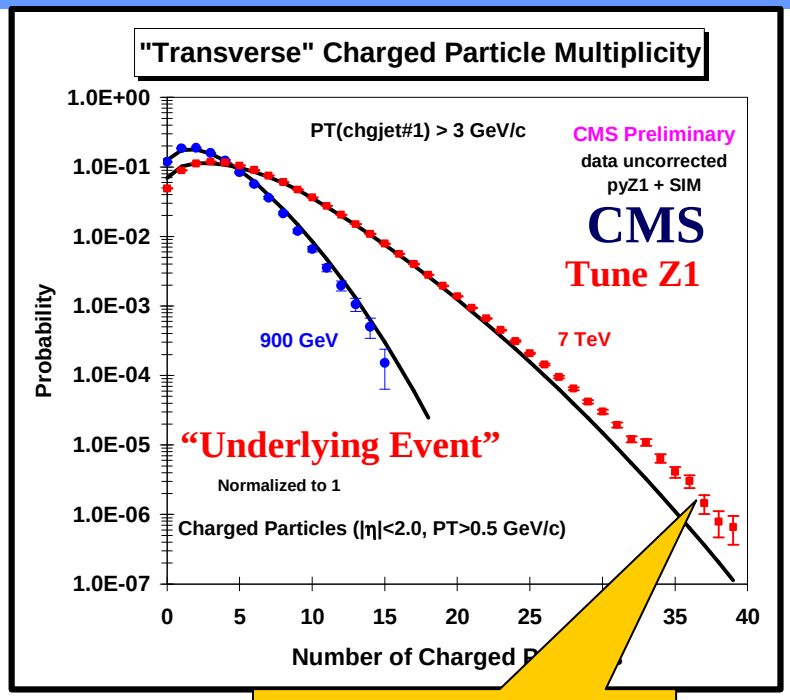

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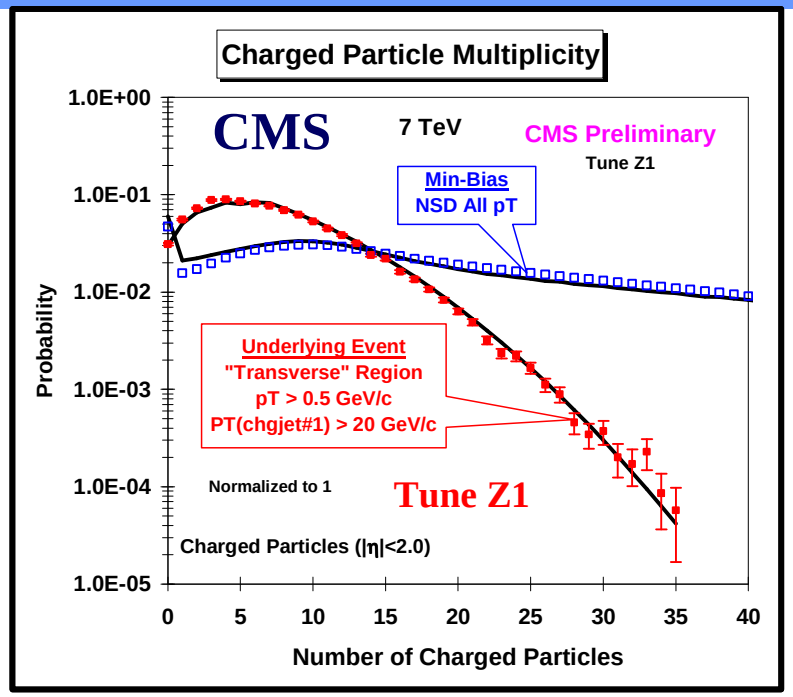

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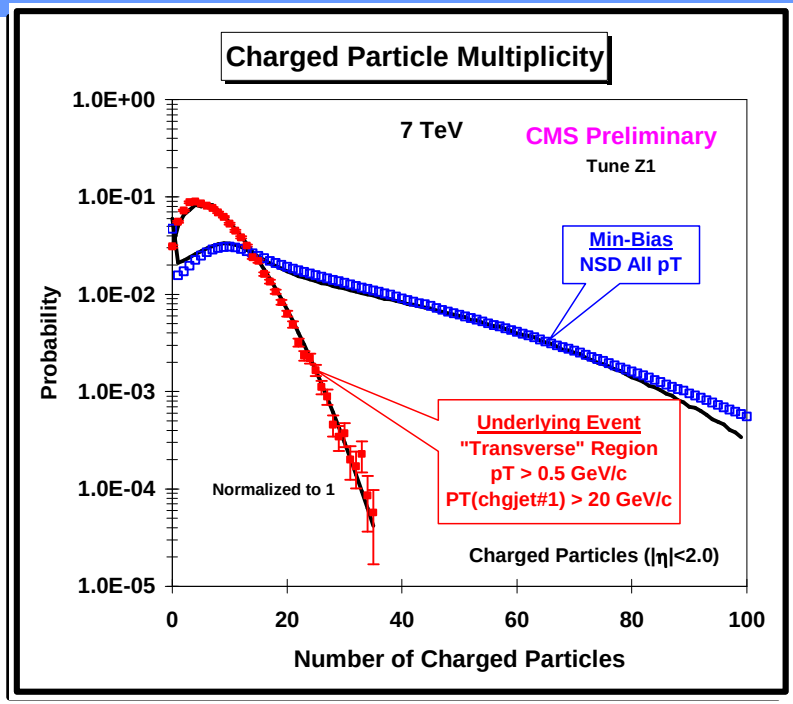
Amazing what we are asking the Monte-Carlo models to fit!

MB & UE



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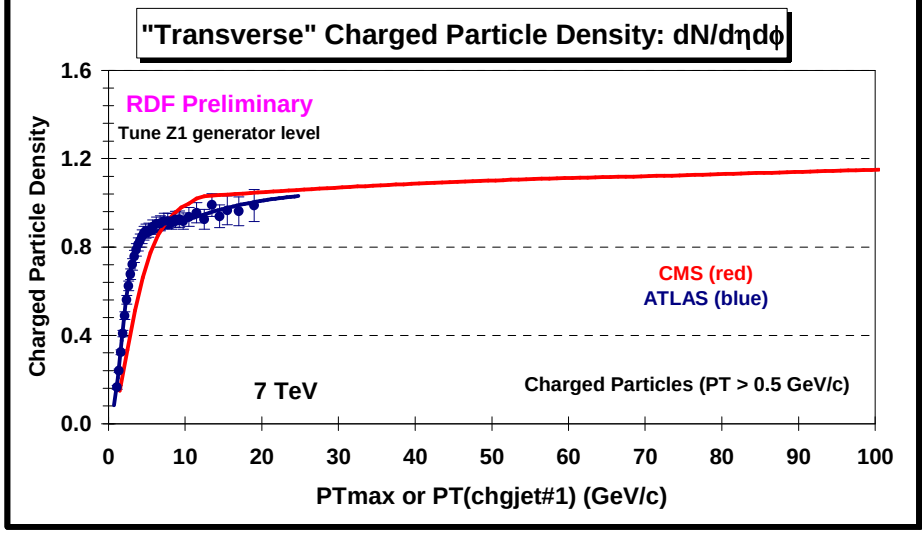

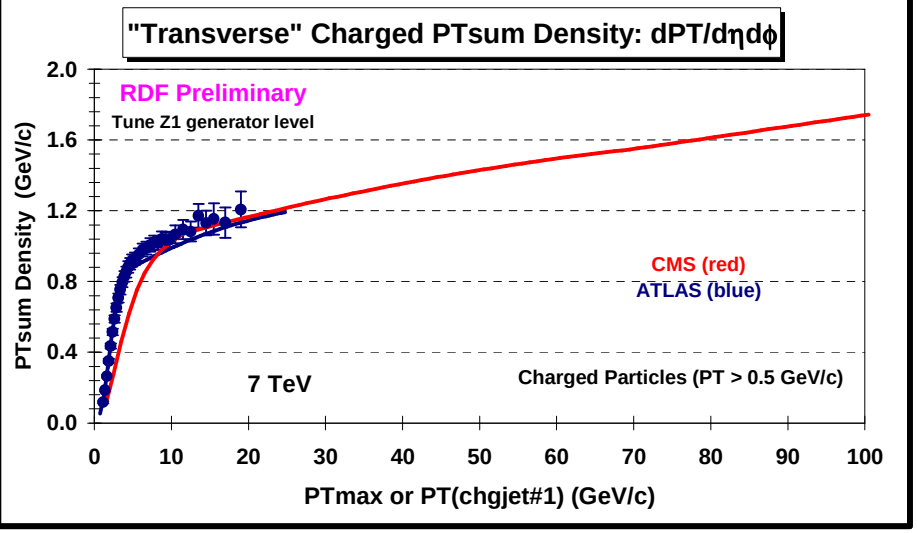

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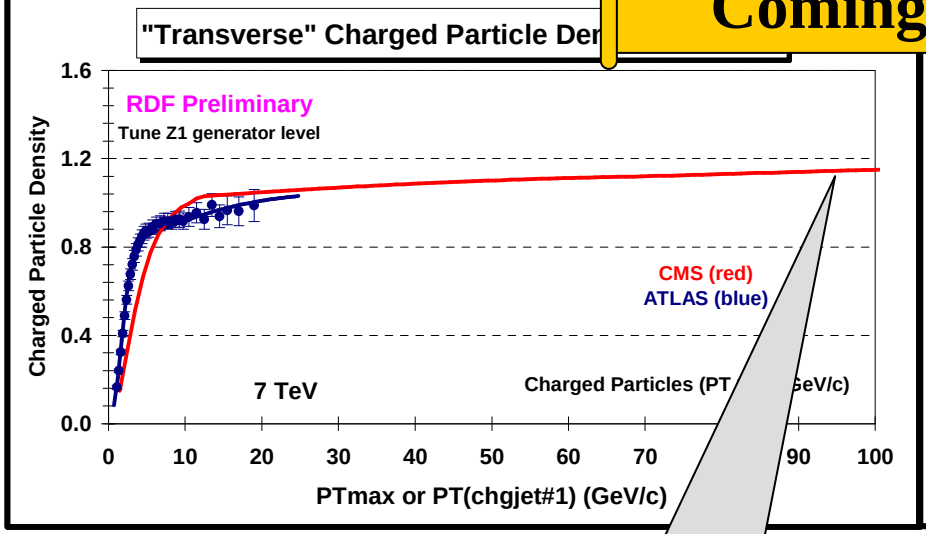
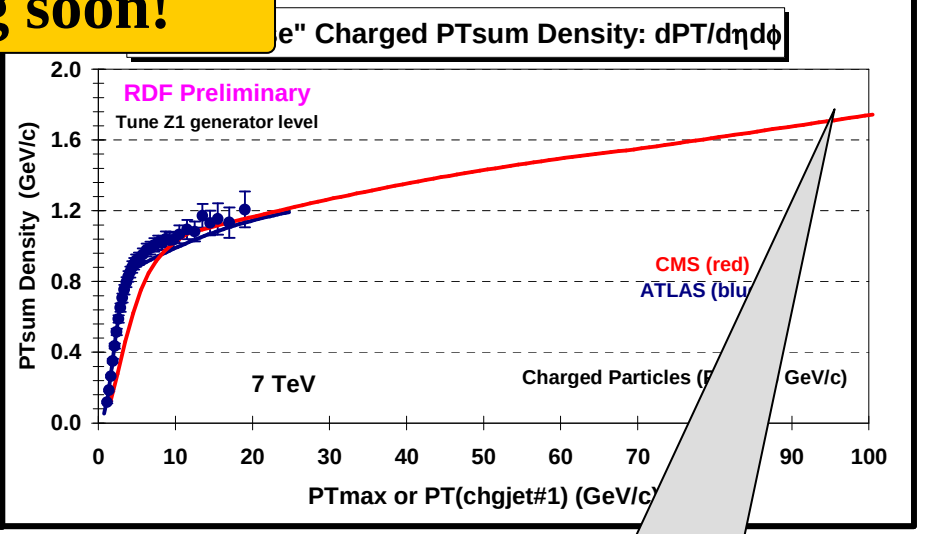
CMS Corrected Data

Coming soon!





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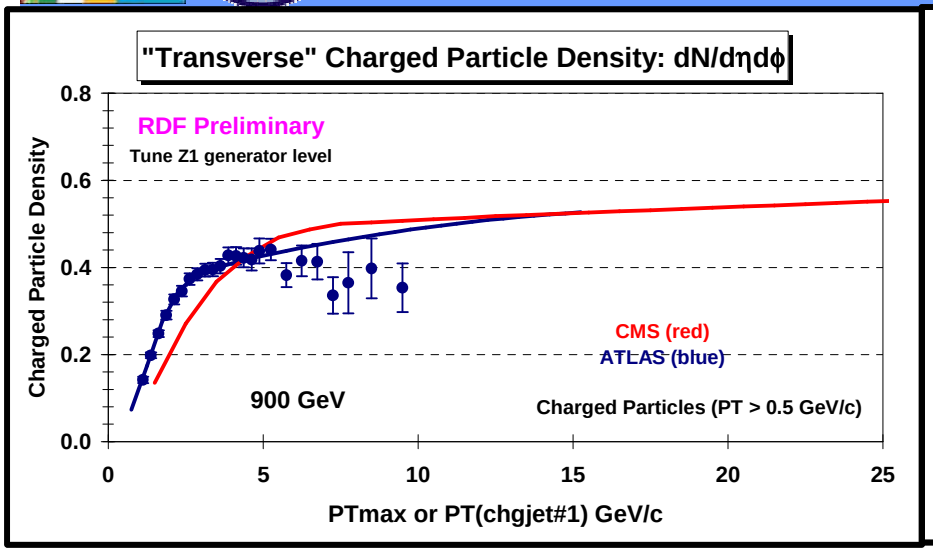

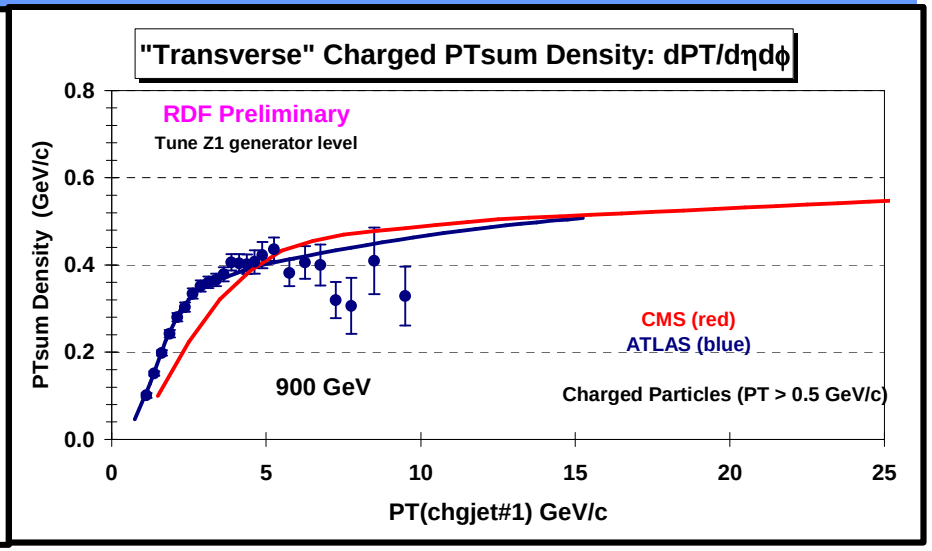

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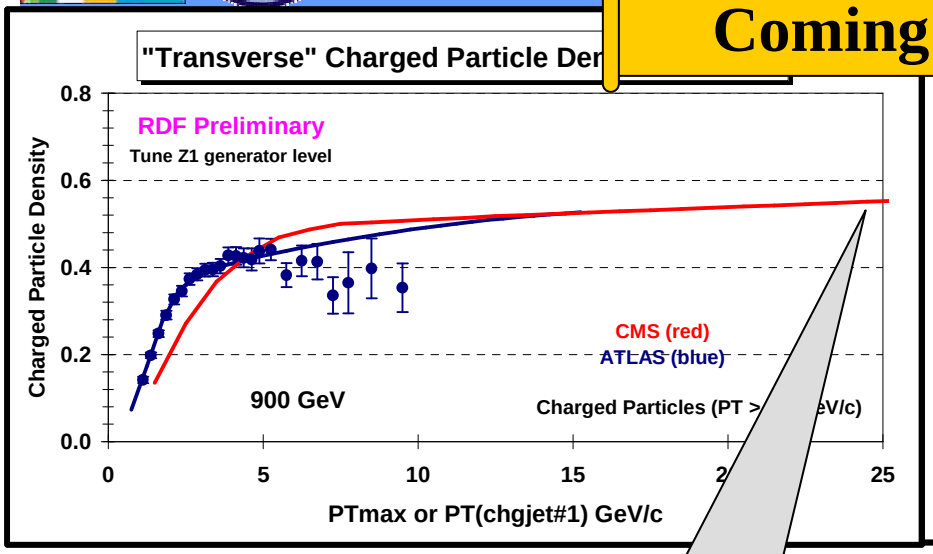

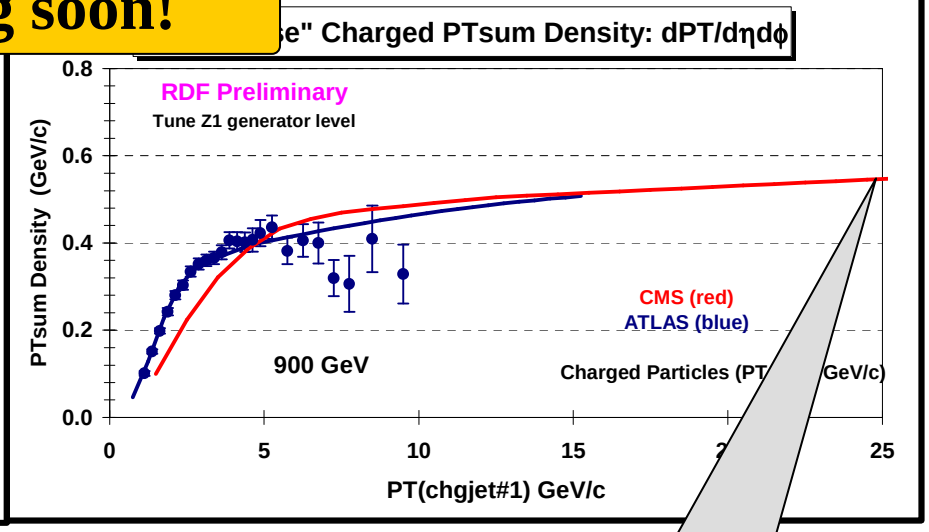

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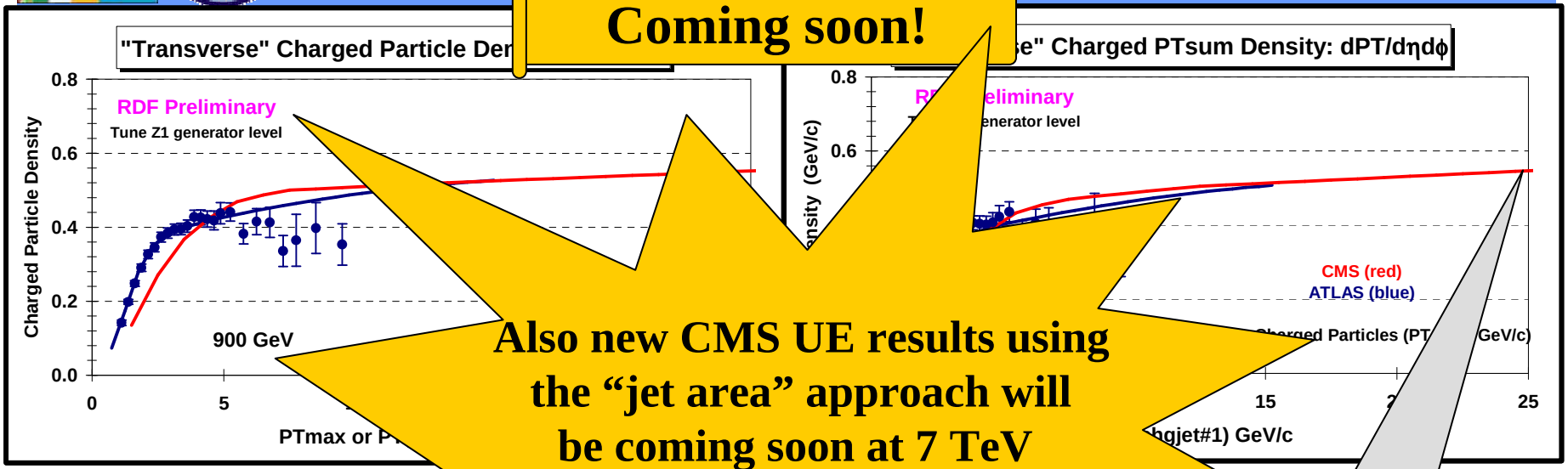

Also new CMS UE results using the "jet area" approach will be coming soon at 7 TeV with comparisons to 900 GeV!

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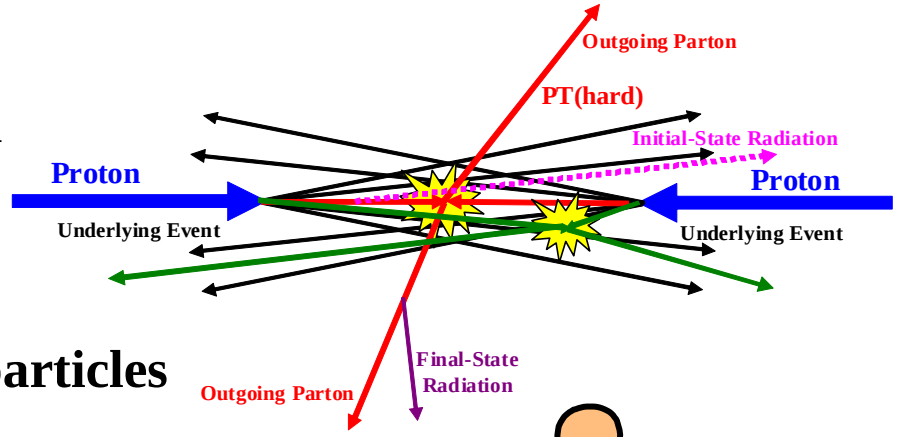
UE Summary

- The "underlying event" at 7 TeV and 900 GeV is almost what we expected! The new tunes, AMBT1, Tune Z1, and PYTHIA8 do a fairly good job of describing the LHC UE data. Need to also fit the Tevatron UE data!



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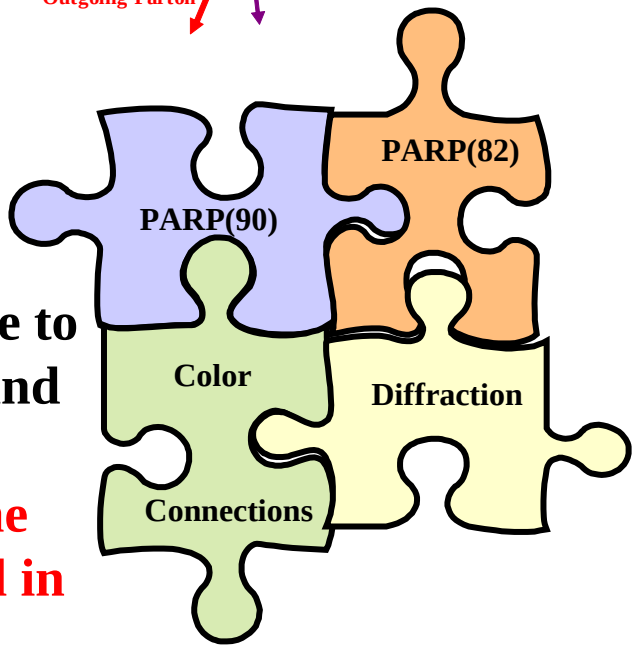

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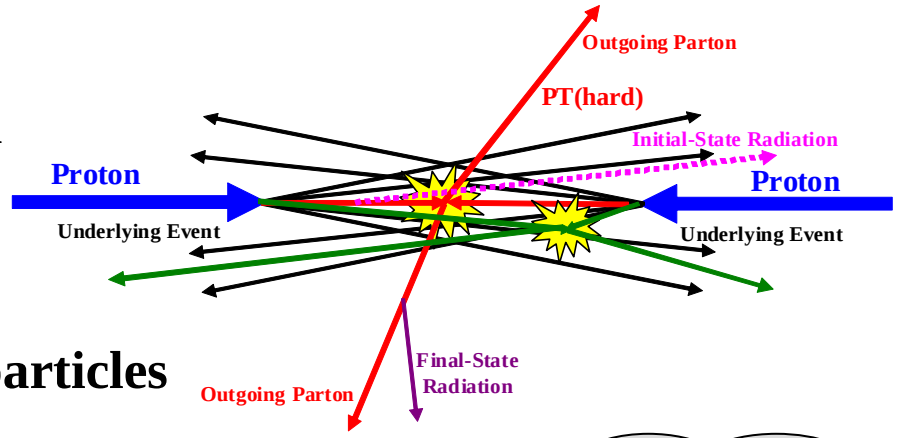

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No model describes all the features of the LHC MB data!

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