**Outline of Talk**

- **CMS UE Tunes**: Three PYTHA 8 tunes (CTEQ6L, HERALOPDF, NNPDF2.3LO) and one PYTHIA 6 tune (CTEQ6L) from the CMS “Physics Comparisons & Generator Tunes” subgroup.
- **UE Observables**: “transMAX”, ”transMIN”, “transAVE”, “transDIF”.
- **The Energy Dependence of the UE**: Detailed look at the energy dependence of the UE and the extrapolation to 13 TeV.
- **Predictions at 13 TeV**: Compare the CMS PYTHIA 8 tunes with the Skands Monash tune and the PYTHIA 6 Tune Z2* at 13 TeV.
- **MB Studies**: Look at dN/dη and the energy flow in the forward region.
PYTHIA 6.4 Tune Z2*- CTEQ6L: Start with Tune Z2 and tune to the CMS leading charged particle jet UE data at 900 GeV and 7 TeV. Improved version of Tune Z2.

PYTHIA 6.4 Tune CUETP6S1-CTEQ6L: Start with Tune Z2*-lep and tune to the CDF PTmax “transMAX” and “transMIN” UE data at 300 GeV, 900 GeV, and 1.96 TeV and the CMS PTmax “transMAX” and “transMIN” UE data at 7 TeV. Improved version of Tune Z2*.

PYTHIA 6.4 Tune CUETP8S1-CTEQ6L: Start with Tune 4C and tune to the CDF PTmax “transMAX” and “transMIN” UE data at 900 GeV, and 1.96 TeV and the CMS PTmax “transMAX” and “transMIN” UE data at 7 TeV. Exclude 300 GeV data. Improved version of Tune 4C.

PYTHIA 8 Tune CUETP8S1-CTEQ6L: Start with Tune 4C and tune to the CDF PTmax “transMAX” and “transMIN” UE data at 900 GeV, and 1.96 TeV and the CMS PTmax “transMAX” and “transMIN” UE data at 7 TeV. Exclude 300 GeV data. Improved version of Tune 4C.

PYTHIA 8 Tune CUETP8S1-HERALOPDF: Start with Tune 4C and tune to the CDF PTmax “transMAX” and “transMIN” UE data at 900 GeV, and 1.96 TeV and the CMS PTmax “transMAX” and “transMIN” UE data at 7 TeV. Exclude 300 GeV data. Improved version of Tune 4C.

PYTHIA 8 Tune CUETP8M1-NNPDF2.3LO: Start with the Skands Monash-NNPDF2.3LO tune and tune to the CDF PTmax “transMAX” and “transMIN” UE data at 900 GeV, and 1.96 TeV and the CMS PTmax “transMAX” and “transMIN” UE data at 7 TeV. Exclude 300 GeV data.
**PYTHIA 8 Tunes:** Corke & Sjöstrand Tune 4C-CTEQ6L and CMS Tune CUETP8S1-CTEQ6L (CMS1).

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**CMS Tune CUETP8S1-CTEQ6L**
- pT0Ref = 2.1006
- ecmPow = 0.21057
- ecmRef = 1800

\[
pT0(E_{cm}) = pT0Ref \times \left( \frac{E_{cm}}{ecmRef} \right)^{ecmPow}
\]
**PYTHIA 8 Tunes:** Peter Skands Tune Monash-NNPDF2.3LO and CMS Tune CUETP8M1-NNPDF2.3LO (MonashStar).

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Start with Monash and change 3 parameters!

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

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

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

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

\[ \eta_{\text{cut}} = 0.8 \]
"transMAX" and "transMIN" Charged Particle Density: Number of charged particles \((p_T > 0.5 \text{ GeV/c}, |\eta| < 0.8)\) in the the maximum (minimum) of the two “transverse” regions as defined by the leading charged particle, \(p_{T\text{max}}\), divided by the area in \(\eta-\phi\) space, \(2\eta_{\text{cut}} \times 2\pi/6\), averaged over all events with at least one particle with \(p_T > 0.5 \text{ GeV/c}, |\eta| < \eta_{\text{cut}}\).

"transMAX" and "transMIN" Charged PTsum Density: Scalar \(p_T\) sum of charged particles \((p_T > 0.5 \text{ GeV/c}, |\eta| < 0.8)\) in the the maximum (minimum) of the two “transverse” regions as defined by the leading charged particle, \(p_{T\text{max}}\), divided by the area in \(\eta-\phi\) space, \(2\eta_{\text{cut}} \times 2\pi/6\), averaged over all events with at least one particle with \(p_T > 0.5 \text{ GeV/c}, |\eta| < \eta_{\text{cut}}\).

Note: The overall “transverse” density is equal to the average of the “transMAX” and “TransMIN” densities. The “TransDIF” Density is the “transMAX” Density minus the “transMIN” Density.

Overall “Transverse” = “transMAX” + “transMIN”

“Transverse” Density = “transAVE” Density = ("transMAX” Density + “transMIN” Density)/2

“TransDIF” Density = “transMAX” Density - “transMIN” Density
The “toward” region contains the leading “jet”, while the “away” region, on the average, contains the “away-side” “jet”. The “transverse” region is perpendicular to the plane of the hard 2-to-2 scattering and is very sensitive to the “underlying event”. For events with large initial or final-state radiation the “transMAX” region defined contains the third jet while both the “transMAX” and “transMIN” regions receive contributions from the MPI and beam-beam remnants. Thus, the “transMIN” region is very sensitive to the multiple parton interactions (MPI) and beam-beam remnants (BBR), while the “transMAX” minus the “transMIN” (i.e. “transDIF”) is very sensitive to initial-state radiation (ISR) and final-state radiation (FSR).

“TransMIN” density more sensitive to MPI & BBR.

“TransDIF” density more sensitive to ISR & FSR.

0 ≤ “TransDIF” ≤ 2×”TransAVE”

“TransDIF” = “TransAVE” if “TransMIX” = 3×”TransMIN”
The LPCC MB&UE Working Group has suggested several MB&UE “Common Plots” the all the LHC groups can produce and compare with each other.
“Transverse” Charged Particle Density: \( \frac{dN}{d\eta d\phi} \)

- **CMS (solid red)**
- **ATLAS (solid blue)**
- **ALICE (open black)**

Charged Particles (|\(\eta| < 0.8, \text{PT} > 0.5 \text{ GeV/c})

**RDF Preliminary corrected data**

**7 TeV**

**900 GeV**

**Transverse** Charged PTsum Density: \( \frac{d\text{PT}}{d\eta d\phi} \)

- **CMS (solid red)**
- **ATLAS (solid blue)**
- **ALICE (open black)**

Charged Particles (|\(\eta| < 0.8, \text{PT} > 0.5 \text{ GeV/c})

**RDF Preliminary corrected data**

**7 TeV**

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

CDF and LHC data at 900 GeV/c on the charged PTsum density in the “transverse” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.
CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 6.4 Tune Z2*.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 8 Tune CUETP8S1-CTEQ6L (excludes 300 GeV in fit).
CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 6.4 Tune Z2*.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 8 Tune CUETP8S1-CTEQ6L (excludes 300 GeV in fit).
CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “TransAVE” region 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 compared with the PYTHIA 8 Tune Monash-NNPDF2.3LO.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “TransAVE” region 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 compared with the PYTHIA 8 Tune CUETP8M1-NNPDF2.3LO (excludes 300 GeV in fit).
CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with \( p_T > 0.5 \) GeV/c and \( |\eta| < 0.8 \). The data are compared with the PYTHIA 8 Tune Monash-NNPDF2.3LO.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with \( p_T > 0.5 \) GeV/c and \( |\eta| < 0.8 \). The data are compared with the PYTHIA 8 Tune CUETP8M1-NNPDF2.3LO (excludes 300 GeV in fit).
CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8.

CMS and CDF data on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8 with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (log scale).
Energy Dependence

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

- **CMS solid dots**
- **CDF solid squares**

**Tune Z2*-CTEQ6L (solid line)**

**5.0 < PTmax < 6.0 GeV/c**

**Charged Particles ($|\eta|<0.8$, PT>0.5 GeV/c)**

**Center-of-Mass Energy (GeV)**

13 TeV
Energy Dependence

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

Charged Particle Density

Charged Particles ($|\eta|<0.8$, $p_T>0.5$ GeV/c)

5.0 < $p_T_{max}$ < 6.0 GeV/c

CMS solid dots
CDF solid squares

Tune Z2*-CTEQ6L (solid line)
CUETP8S1-CTEQ6L (solid line)
Monash-NNPDF2.3LO (solid line)
CUETP8M1-NNPDF2.3LO (solid line)

13 TeV
CMS and CDF data on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with $5 < PT_{max} < 6$ GeV/c. The data are plotted versus the center-of-mass energy (log scale). The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.

CMS and CDF data on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with $5 < PT_{max} < 6$ GeV/c. The data are plotted versus the center-of-mass energy (log scale). The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.
Predictions at 13 TeV

"TransMAX" Charged Particle Density

13 TeV

Average Density

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

Tune Z2*-CTEQ6L (green line)
CUETP8S1-CTEQ6L (black line)
Monash-NNPDF2.3LO (red line)
CUETP8M1-NNPDF2.3LO (blue line)

"TransMIN" Charged Particle Density

13 TeV

Average Density

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

Tune Z2*-CTEQ6L (green line)
CUETP8S1-CTEQ6L (black line)
Monash-NNPDF2.3LO (red line)
CUETP8M1-NNPDF2.3LO (blue line)

"TransMAX" Charged PTsum Density

13 TeV

Average Density (GeV/c)

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

Tune Z2*-CTEQ6L (green line)
CUETP8S1-CTEQ6L (black line)
Monash-NNPDF2.3LO (red line)
CUETP8M1-NNPDF2.3LO (blue line)

"TransMIN" Charged PTsum Density

13 TeV

Average Density (GeV/c)

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

Tune Z2*-CTEQ6L (green line)
CUETP8S1-CTEQ6L (black line)
Monash-NNPDF2.3LO (red line)
CUETP8M1-NNPDF2.3LO (blue line)
Predictions at 13 TeV

"TransAVE" Charged Particle Density

- **13 TeV**

  - Tune Z2*-CTEQ6L (green line)
  - CUETP8S1-CTEQ6L (black line)
  - Monash-NNPDF2.3LO (red line)
  - CUETP8M1-NNPDF2.3LO (blue line)

Average Density

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

"TransDIF" Charged Particle Density

- **13 TeV**

  - Tune Z2*-CTEQ6L (green line)
  - CUETP8S1-CTEQ6L (black line)
  - Monash-NNPDF2.3LO (red line)
  - CUETP8M1-NNPDF2.3LO (blue line)

Average Density

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

"TransAVE" Charged PTsum Density

- **13 TeV**

  - Tune Z2*-CTEQ6L (green line)
  - CUETP8S1-CTEQ6L (black line)
  - Monash-NNPDF2.3LO (red line)
  - CUETP8M1-NNPDF2.3LO (blue line)

Average Density (GeV/c)

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)

"TransDIF" Charged PTsum Density

- **13 TeV**

  - Tune Z2*-CTEQ6L (green line)
  - CUETP8S1-CTEQ6L (black line)
  - Monash-NNPDF2.3LO (red line)
  - CUETP8M1-NNPDF2.3LO (blue line)

Average Density (GeV/c)

Charged Particles (|η|<0.8, PT>0.5 GeV/c)

PTmax (GeV/c)
CMS and CDF data on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with $5 < \text{PTmax} < 6$ GeV/c. The data are plotted versus the center-of-mass energy (log scale). The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.
Predictions at 13 TeV

CMS and CDF data on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with $5 < PT_{\text{max}} < 6$ GeV/c. The data are plotted versus the center-of-mass energy (log scale). The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.

CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged PTsum density in the “transAVE” region as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$. The data are compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.
Predictions at 13 TeV

CMS and CDF data at 7 TeV and CDF data at 1.96 TeV and 300 GeV on the charged PT sum density in the "transAVE" region 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 compared with PYTHIA 6 Tune Z2* and PYTHIA 8 Tune CUETP8S1, Tune Monash, and Tune CUETP8M1.

I believe we know what the UE will look like at 13 TeV!
The charged particle density, \( dN/d\eta \), for charged particles with \( p_T > 40 \text{ MeV/c} \) at 7 TeV predicted by the Monash tune for the non-diffractive component (ND) and the inelastic component (IN = ND+SD+DD).

The ratio on the inelastic component (IN = ND+SD+DD) and the non-diffractive component (ND) for the charged particle density, \( dN/d\eta \), for charged particles with \( p_T > 40 \text{ MeV/c} \) as predicted by the Monash tune at 7 TeV.
The charged particle density, \(dN/d\eta\), for charged particles with \(p_T > 40\) MeV/c at 7 TeV predicted by the Monash tune for the non-diffractive component (ND) and the inelastic component (IN = ND+SD+DD).

The ratio on the inelastic component (IN = ND+SD+DD) and the non-diffractive component (ND) for the charged particle density, \(dN/d\eta\), for charged particles with \(p_T > 40\) MeV/c as predicted by the Monash tune at 7 TeV.

Adding SD+DD reduces the ND contribution by \(\approx 22\%\)!
The charged particle density, $dN/d\eta$, for charged particles with $p_T > 40$ MeV/c at 7 TeV predicted by the Monash tune and the CMS tune CMS tune CUETP8S1-CTEQ6L for the inelastic component ($IN = ND+SD+DD$).

The charged particle difference, $\Delta N_{chg}$, for charged particles with $p_T > 40$ MeV/c at 7 TeV between the Monash tune and the CMS tune CMS tune CUETP8S1-CTEQ6L for the inelastic component ($IN = ND+SD+DD$), where $\Delta N_{chg} = N_{chg}(Monash)-N_{chg}(CMS1)$ and corresponds to the number of charged particles in 0.5 $\eta$. 
The charged particle density, $dN/d\eta$, for charged particles with $p_T > 40$ MeV/c at 7 TeV predicted by the Monash-NNPDF2.3LO tune, the tune CUETP8S1-CTEQ6L (CMS1), and tune CUEP8M1-NNPDF2.3LO (Mstar) for the inelastic component (IN = ND+SD+DD).

Shows the charged particle difference, $\Delta N_{chg}$, for charged particles with $p_T > 40$ MeV/c at 7 TeV between the Monash-NNPDF2.3LO tune and tune CUETP8S1-CTEQ6L (CMS1), and tune CUEP8M1-NNPDF2.3LO (Mstar) for the inelastic component (IN = ND+SD+DD), where $\Delta N_{chg} = N_{chg}(\text{Monash}) - N_{chg}(\text{tune})$ and corresponds to the number of charged particles in 0.5 $\eta$. 
The energy density, $dE/d\eta$, at 7 TeV predicted by the Monash tune for the non-diffractive component (ND) and the inelastic component (IN = ND+SD+DD).

The ratio on the inelastic component (IN = ND+SD+DD) and the non-diffractive component (ND) energy density, $dE/d\eta$, predicted by the Monash tune at 7 TeV.
The energy density, \( \frac{dE}{d\eta} \), at 7 TeV predicted by the Monash tune for the non-diffractive component (ND) and the inelastic component (IN = ND+SD+DD).

The ratio on the inelastic component (IN = ND+SD+DD) and the non-diffractive component (ND) energy density, \( \frac{dE}{d\eta} \), predicted by the Monash tune at 7 TeV.

Adding SD+DD reduces the ND contribution by \( \approx 23\% \)!
The energy density, $dE/d\eta$, at 7 TeV predicted by the Monash-NNPDF2.3LO tune and the tune CUETP8S1-CTEQ6L (CMS1) for the inelastic component ($IN = ND+SD+DD$).

The energy difference, $\Delta E$, at 7 TeV between the Monash-NNPDF2.3LO and tune CUETP8S1-CTEQ6L (CMS1) for the inelastic component ($IN = ND+SD+DD$), where $\Delta E = E(Monash)-E(CMS1)$ and corresponds to the amount of energy in GeV in 0.5 $\eta$. 
Shows the energy density difference, $\Delta E$, at 7 TeV between the Monash-NNPDF2.3LO tune, and tune CUETP8S1-CTEQ6L (CMS1), and tune CUEP8M1-NNPDF2.3LO (Mstar) for the inelastic component ($IN = ND+SD+DD$), where $\Delta E = E(\text{Monash}) - E(\text{tune})$ and corresponds to the amount of energy in GeV in 0.5 $\eta$. 
Start with the HERALOPDF functions, $f(x)$. Modify the gluon distribution at small $x$ by adding a function $f_1(x,p_1,p_2)$ with 2 parameters ($p_1 = x_0$, $p_2 = \text{slope}$).

New Approach

Tune the PDF

Started with the Skands Monash-NNPDF2.3LO tune!
Use the CMS Tune CUETP8M1-HERALOPDF and vary the low x gluon distribution to try to improve the fit to the forward region (TOTEM data). Need to increase the gluon distribution at $x < \approx 10^{-5}$!
Can improve agreement with TOTEM!

MPI contributes a lot to both central and forward $dN/d\eta$!
Use the CMS Tune CUETP8M1-HERALO PDF and vary the low x gluon distribution to try to improve the fit to the forward region (TOTEM data).

Can improve agreement with TOTEM! Does not affect the central region.

However, changing the gluon distribution at low x destroys the fit to the UE data! If you change the PDF, you must change the UE tune accordingly!
Starting with the tunes that fit to the forward region (TOTEM data) re-tune the UE parameters of CMS Tune CUETP8S1-HERALOPDF to fit the UE data.

Need to start with a slightly different low x gluon distribution or do a simultaneous fit that varies both the low x gluon distribution and the UE parameters in an attempt to fit the central and forward dN/d\eta and the UE data.

Oops! Now agrees in the central region and is low in the forward region.
Starting with a different low x gluon distribution re-tune the UE parameters of CMS Tune CUETP8S1-HERALOPDF to fit the UE data.

Perhaps we should do a simultaneous fit that varies both the low x gluon distribution and the UE parameters in an attempt to fit the central and forward dN/d\eta and the UE data.
Starting with a different low x gluon distribution re-tune the UE parameters of CMS Tune CUETP8M1-HERALOPDF to fit the UE data.

Perhaps we should do a simultaneous fit that varies both the low x gluon distribution and the UE parameters in an attempt to fit the central and forward $dN/d\eta$ and the UE data.

Not bad! Now fits the forward region and the UE data. A little low in the central region.

More CMS tunes coming!