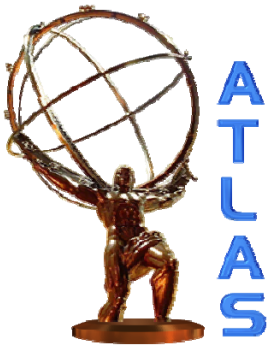


Underlying event tunings: preparing for the first LHC measurements.

Arthur M. Moraes

TRIUMF

Outline:

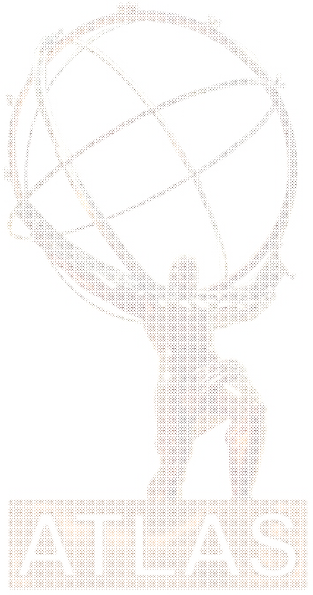
I. Introduction;

II. Transverse region distributions;

III. Describing MAX/MIN p_T distributions;

IV. Preparing for first measurements at ATLAS;

V. Summary.



MC tunings ("some…") for the underlying event

2005

1st HERA – LHC Workshop ***(Proceedings)***

- **JIMMY4.1**
- **PHOJET1.12**
- **PYTHIA6.2 : ATLAS tuning**

CDF tune A

Largely based on CDF data for the region transverse to the leading jet.

CTEQ5L

2006

Les Houches 2005: Physics at TeV Colliders ***(QCD, EW & Higgs WG report)***

- **JIMMY4.1**
- **PYTHIA6.3**

Based on CDF data for the region transverse to the leading jet & CDF data for MAX/MIN cones transverse to the highest E_T jet.

CTEQ6L

More recent UE tunings for PYTHIA used by ATLAS

- **PYTHIA has two options for underlying event models: "NEW" (PYEVNW – from version 6.3xx and newer) and "OLD" (PYEVNT) scenarios.**

- **Important bug fixes were introduced in Pythia6.403 (and newer…) which required a new tuning.**

"OLD" vs. "NEW"

p_T cut-off,
matter distribution,
energy dependence.

Approx. number of parameters tuned: ~5 (ATLAS – DC2 & Rome) or ~8 (CDF)

p_T cut-off,
matter distribution,
energy dependence,
ISR,
FSR,
colour reconnection.

Approx. number of parameters tuned: ~11 (ATLAS – CSC)

UE tuning for PYTHIA6.403 (October 2006)

PYTHIA6.403 - PYEVNW CTEQ6LO (LO fit with LO α_s) → LHAPDF

	Default:		Tuned:	
ISR	MSTP(70)=1	→	MSTP(70)=2	smooth turn-off as $p_T \rightarrow 0$
FSR	MSTP(72)=1	→	MSTP(72)=0	reduced FSR scale
	MSTP(81)=1	→		PYEVNW: new multiple interaction model & new parton shower selected!
MPI	MSTP(82)=4			
ISR	MSTP(84)=1			
FSR	MSTP(85)=1			
MPI	MSTP(86)=2			
	MSTP(87)=4			
colour reconnection	MSTP(88)=1	→	MSTP(88)=0	regulates sequence of chain formation and baryon production
	MSTP(89)=1			
	MSTP(90)=0	→	MSTP(90)=1	k_T compensation spread out across colour chain.
	MSTP(95)=1			

UE tuning for PYTHIA6.403 (October 2006)

	Default:		Tuned:	
	PARP(78)=0.025	→	PARP(78)=0.2	regulates number of attempted colour reconnections (choose shorter strings)
	PARP(80)=0.1	→	PARP(80)=0.01	
p_{T0} scale	PARP(82)=2.0	→	PARP(82)=1.9	
matter distribution	PARP(83)=0.5	→	PARP(83)=0.3	
matter distribution	PARP(84)=0.4	→	PARP(84)=0.5	
p_{T0} scale	PARP(89)=1800			
p_{T0} scale	PARP(90)=0.24	→	PARP(90)=0.22	
	PARJ(81)=0.29	→	PARJ(81)=0.14	

Underlying event in charged jet evolution (CDF analysis – Run I data)

Phys. Rev. D, 65 092002 (2002)

- **All particles from a single particle collision except the process of interest.**

- Sometimes, the underlying event can also be defined as everything in the collision except the hard process.

- **It is not only minimum bias event!**

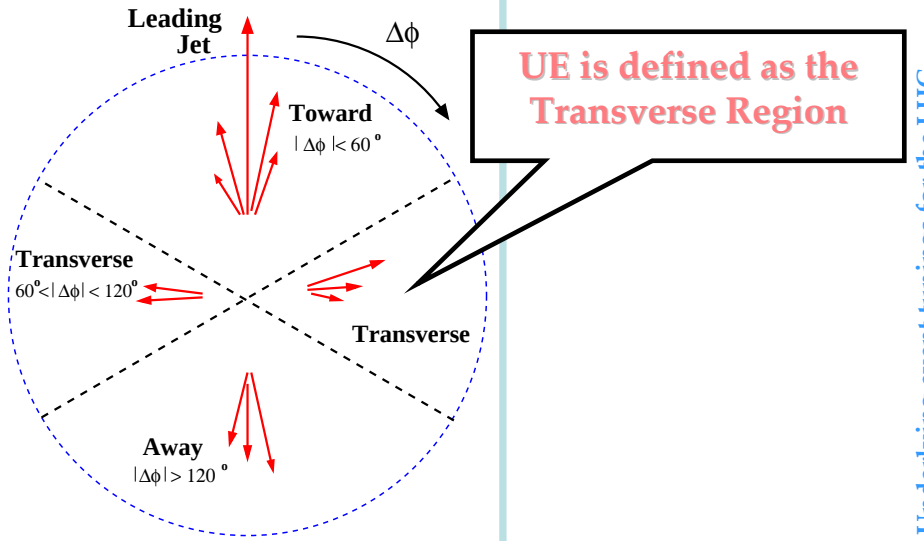
CDF analysis:

- charged particles:
  p_t>0.5 GeV and $|\eta|$<1

- **cone jet finder:**

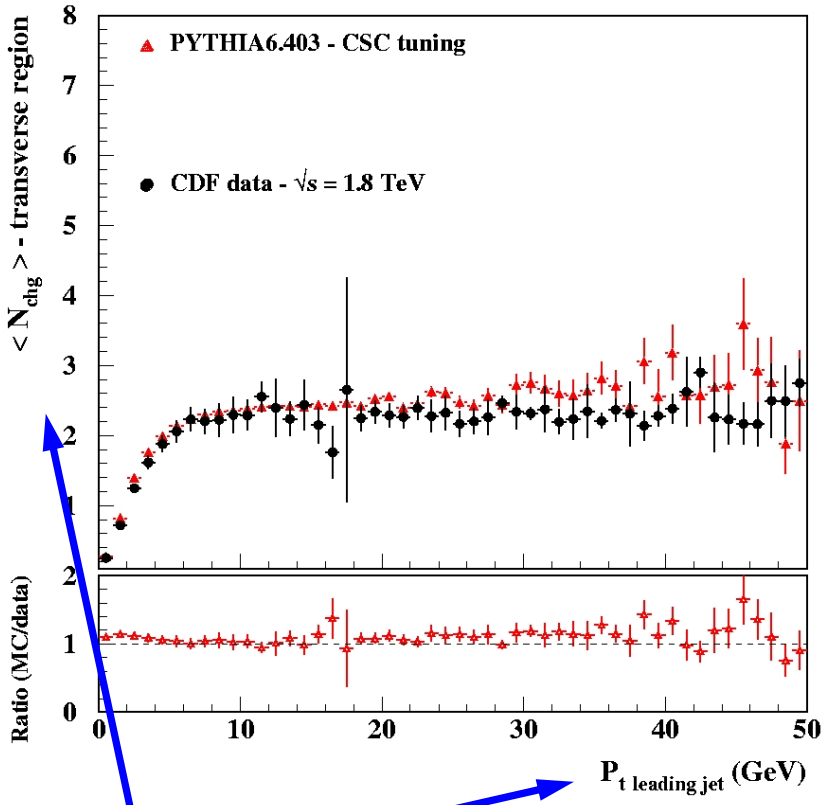
$$R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.7$$

$$\Delta\phi = \phi - \phi_{ljet}$$

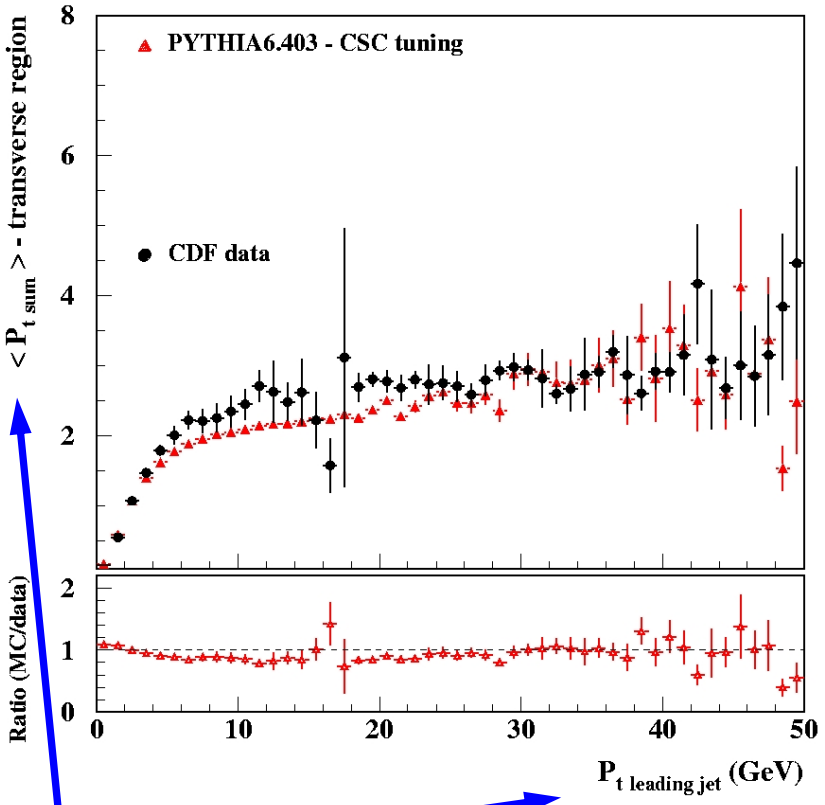


Underlying event tunings for the LHC

Describing the region transverse to the leading jet



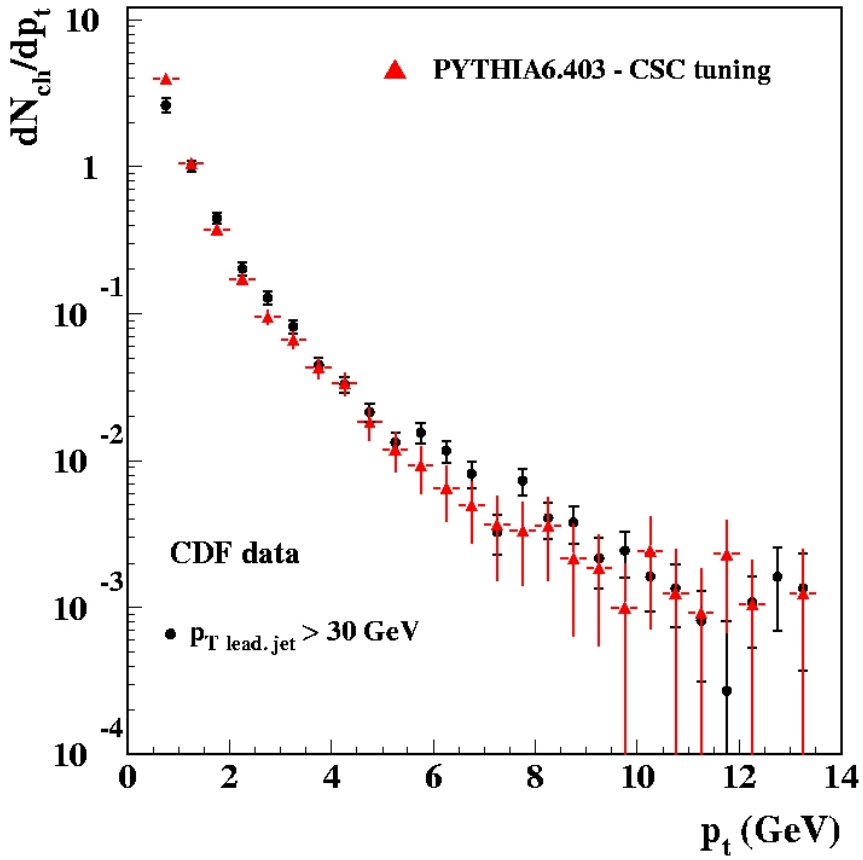
Average multiplicity of charged particles in the underlying event associated to a leading jet with $\mathbf{P_t^{ljet}}$ (GeV).



Average $\mathbf{p_T^{sum}}$ (GeV) of charged particles in the underlying event associated to a leading jet with $\mathbf{P_t^{ljet}}$ (GeV).

Describing the region transverse to the leading jet

dN_{chg}/dp_T spectrum:
charged particles in the underlying event for p_T leading jet > 30 GeV.

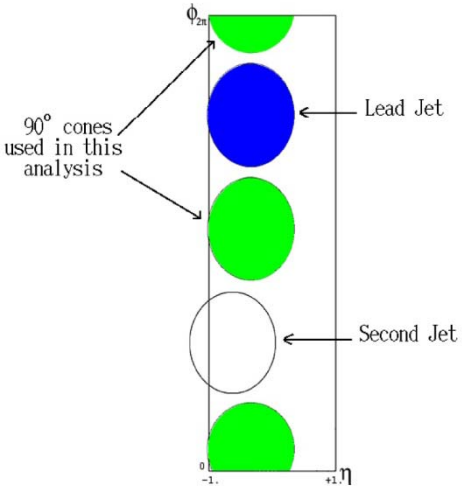


"MAX/MIN analysis"

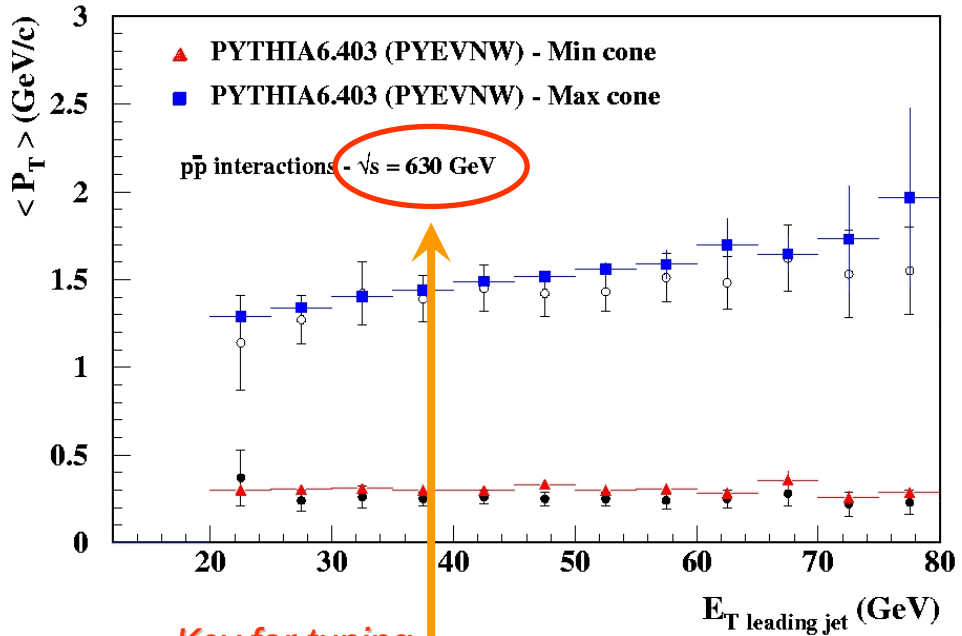
- The underlying event is measured for jet events at two different colliding energies: 630 GeV and 1800 GeV.

- Two cones in η–ϕ space are defined:
  $\eta=\eta_{ljet}$ *(same as the leading jet)*
  $\phi=\phi_{ljet} \pm 90°$
  R=0.7

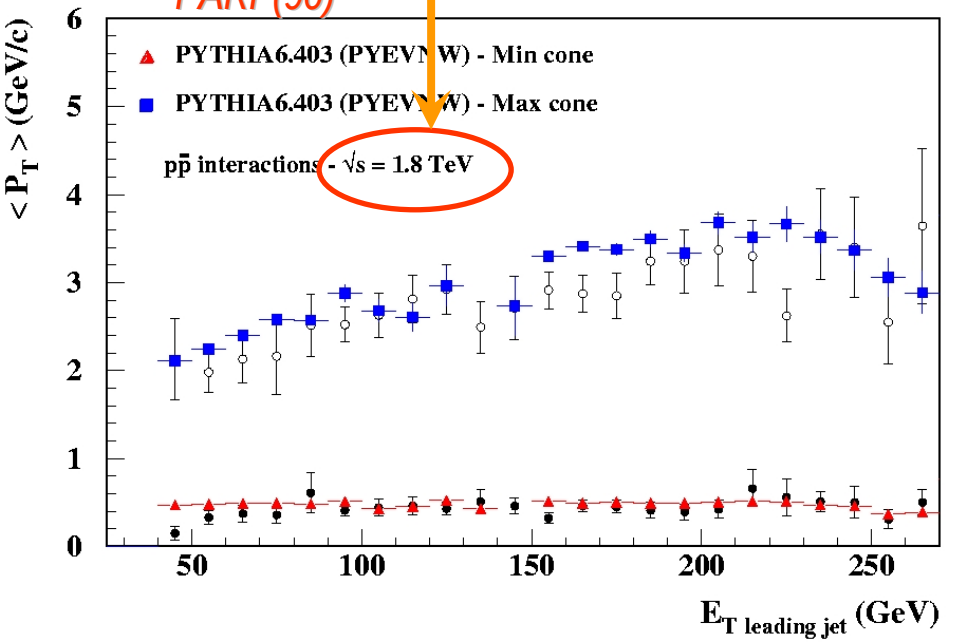
  P_T^{90max} and P_T^{90min}



- This provides important information on how to model the energy extrapolation in UE models.

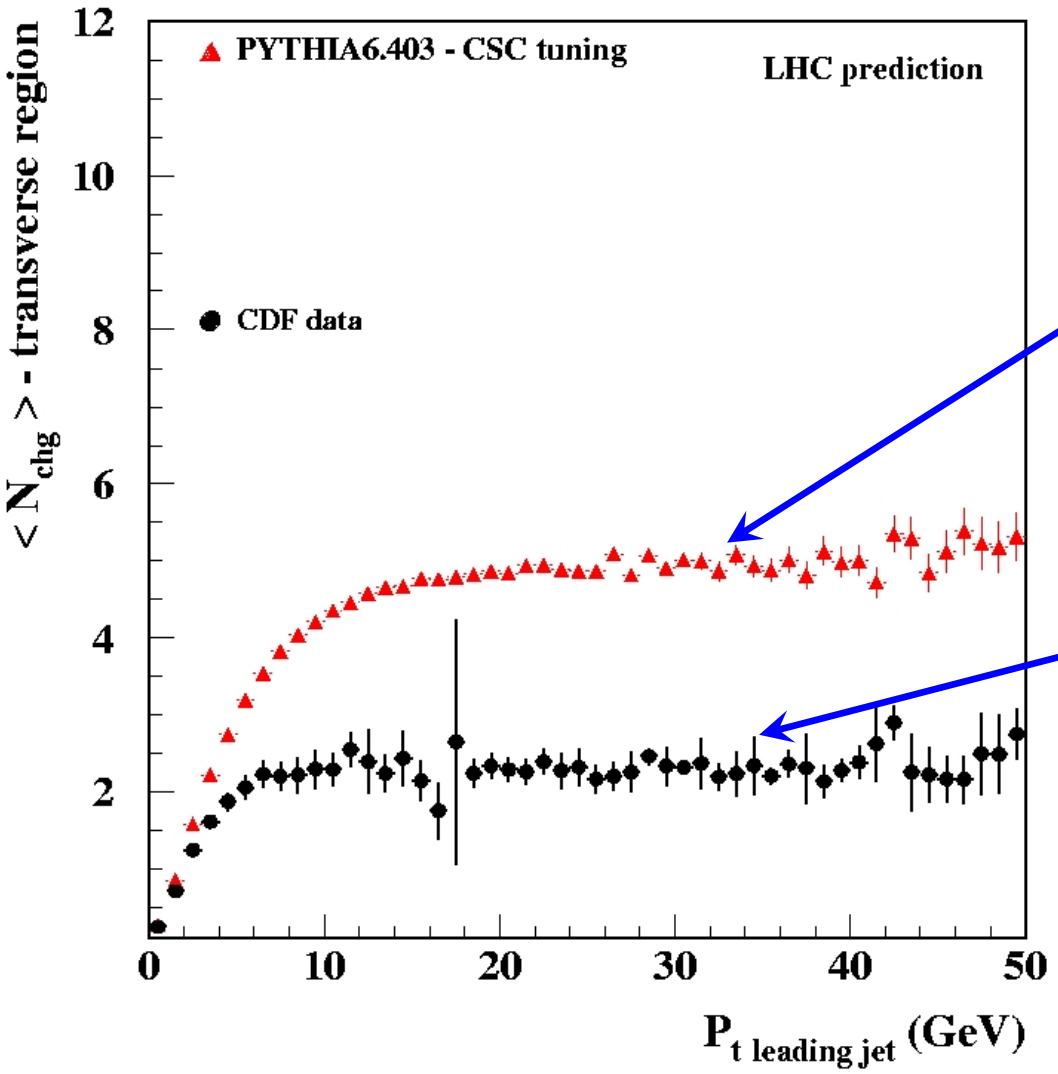


Key for tuning PARP(90)



Underlying event tunings for the LHC

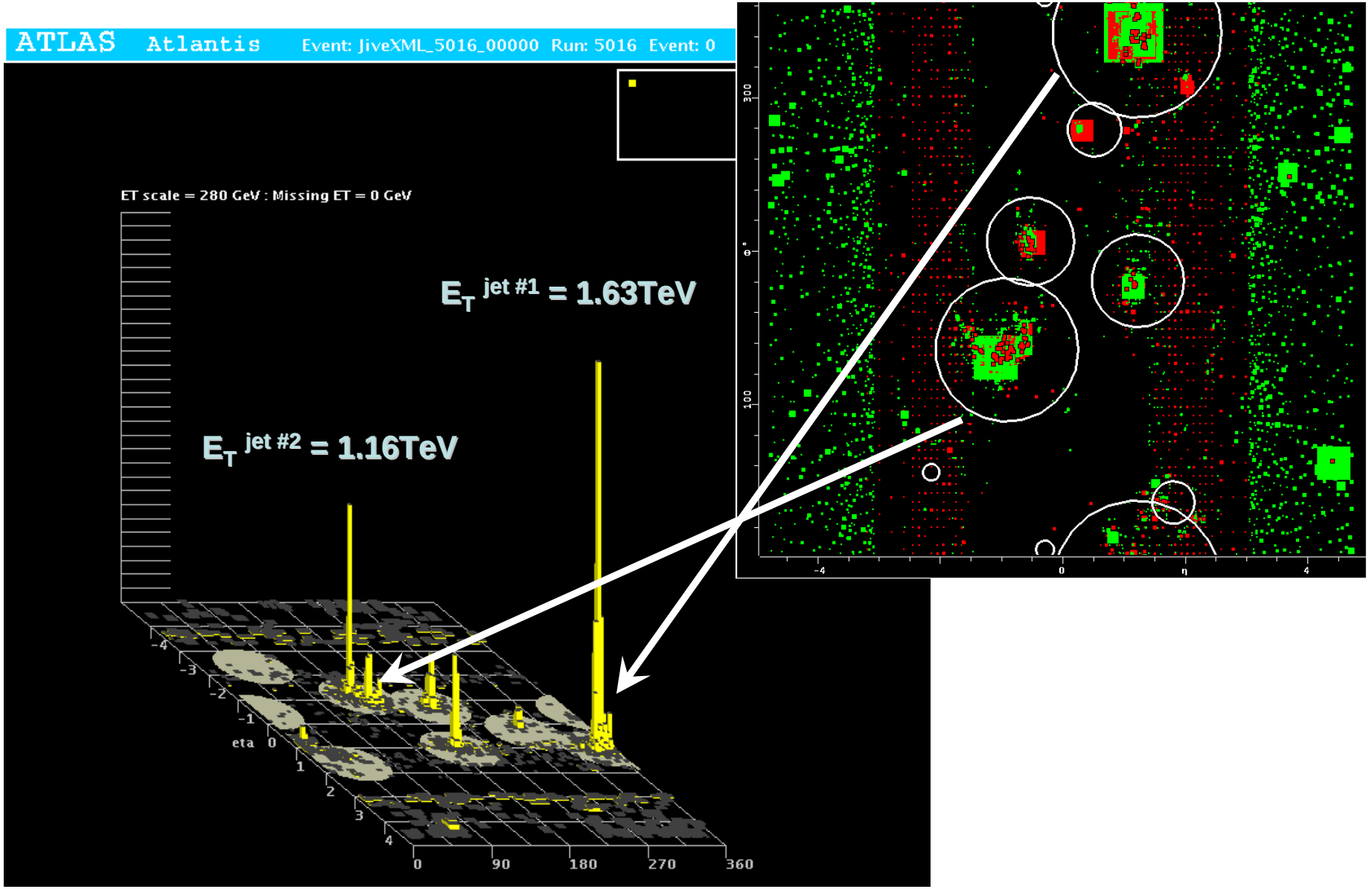
LHC prediction for the region transverse to the leading jet



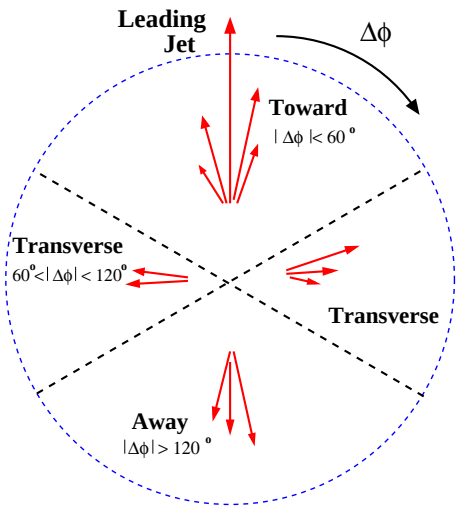
LHC prediction:
x 2.5 the activity
measured at Tevatron!

CDF measurement
(√s=1.8 TeV)

Measuring the underlying event at ATLAS



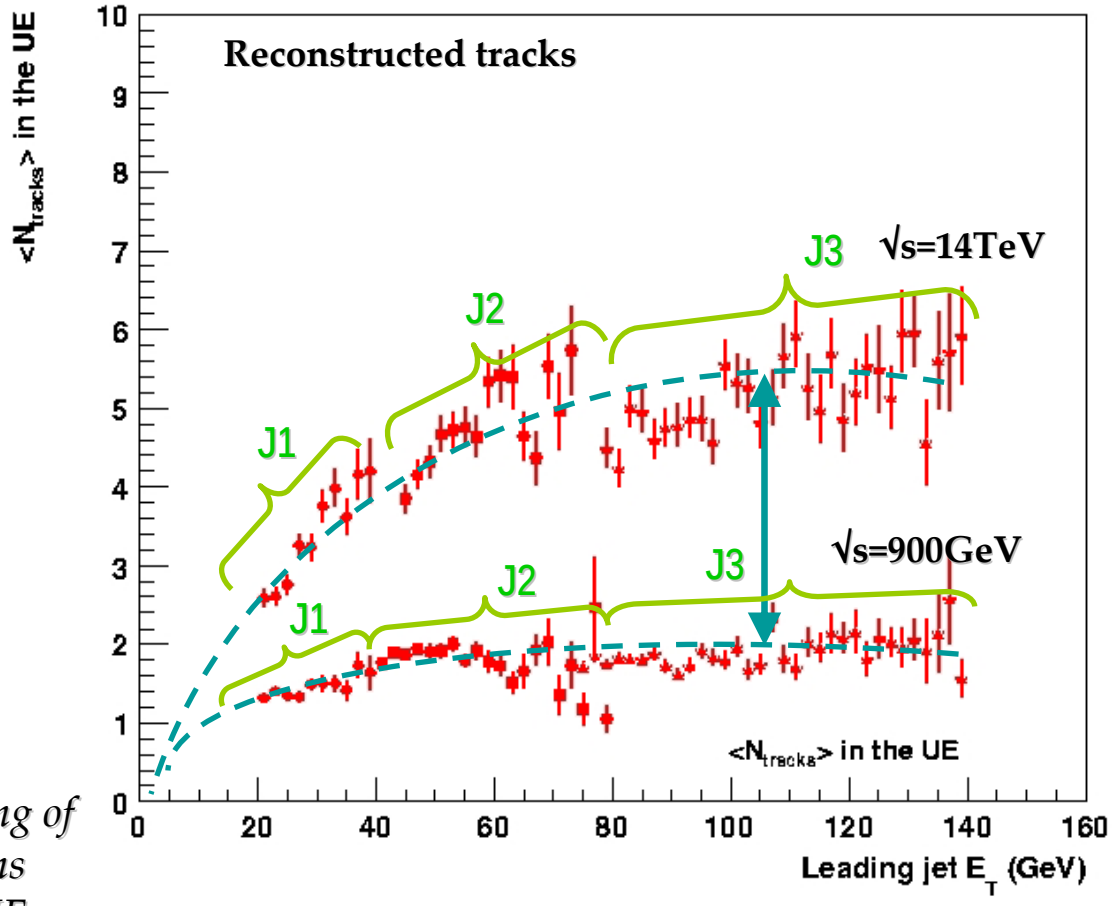
First physics studies with the underlying event



Multiplicity of charged particles with $p_T > 0.5$ GeV and $|\eta| < 1$ in region transverse to leading jet

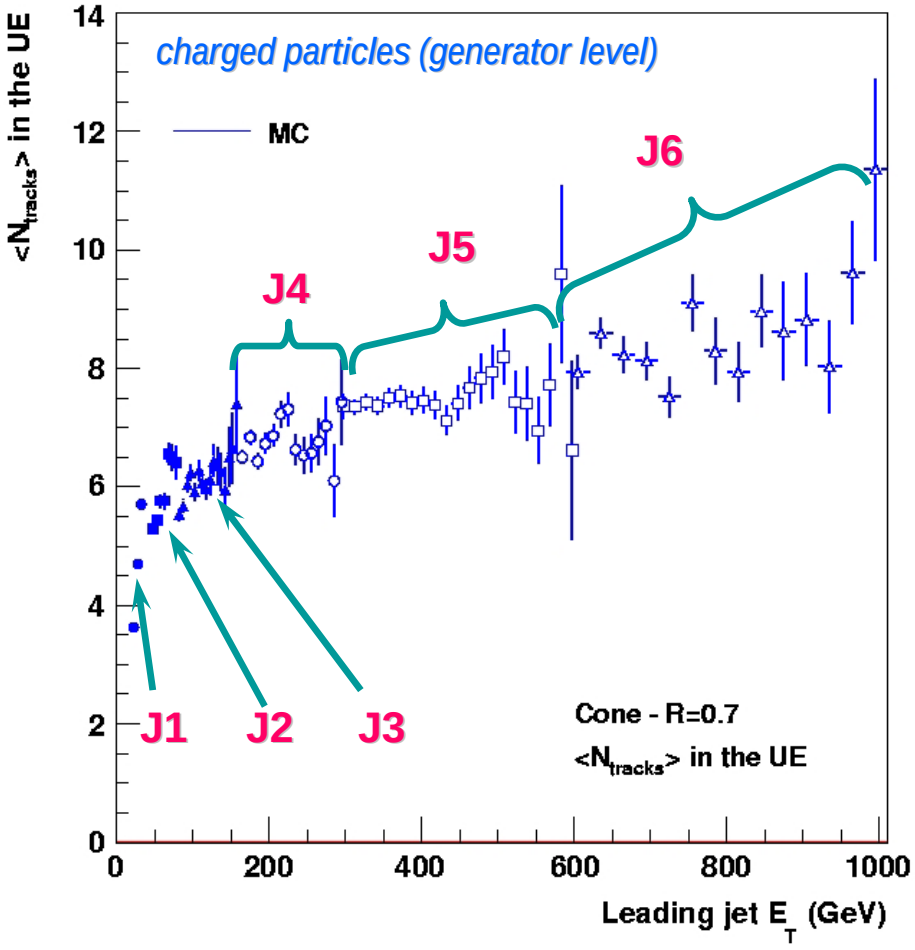
Measurements at different colliding energies will improve our understanding of multiple (semi-hard) parton interactions and will allow better modeling of the UE.

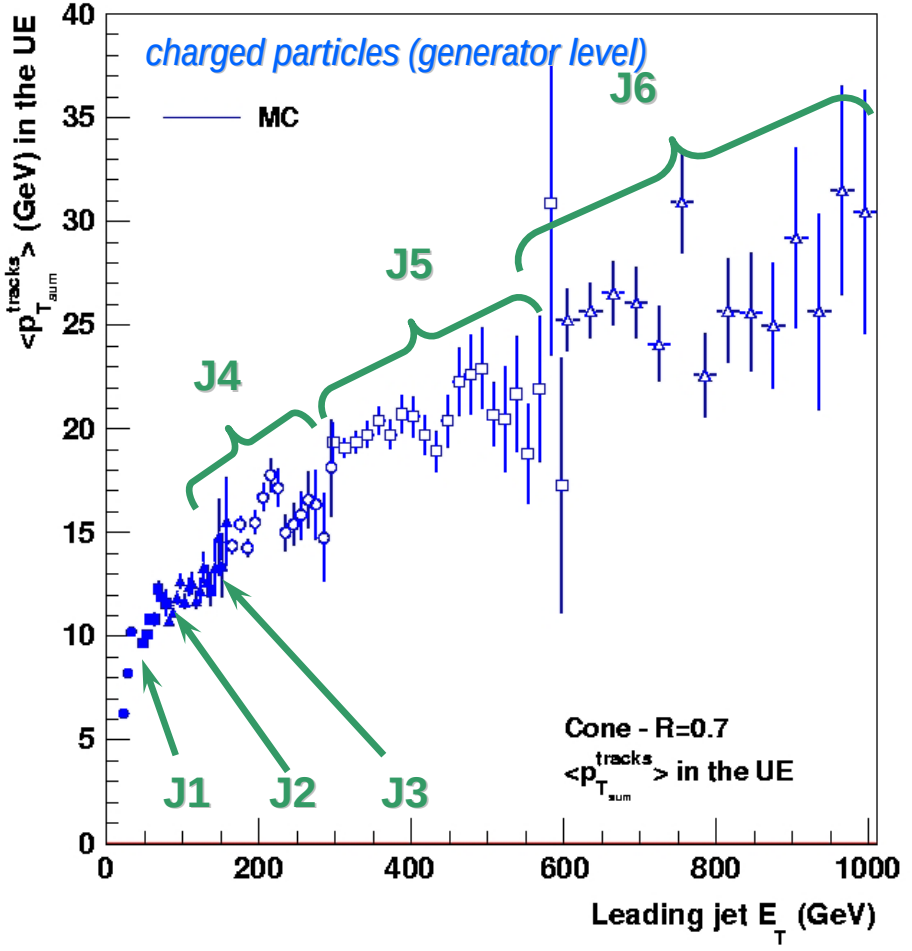
ATLAS - √s=900 GeV
ATLAS - √s=14 TeV



Measuring the underlying event in TeV jets

Selecting the underlying event: $N_{jets} > 1$, $|\eta_{jet}| < 2.5$, $E_T^{jet} > 10$ GeV, $|\eta_{track}| < 2.5$, $p_T^{track} > 1.0$ GeV/c



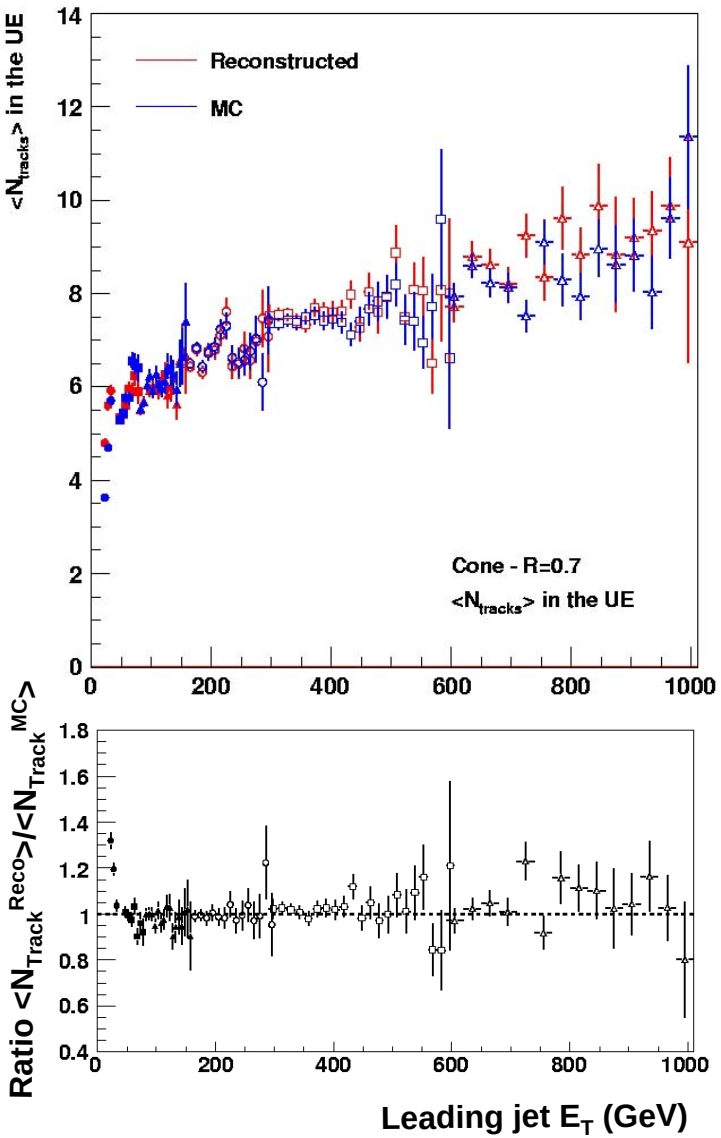


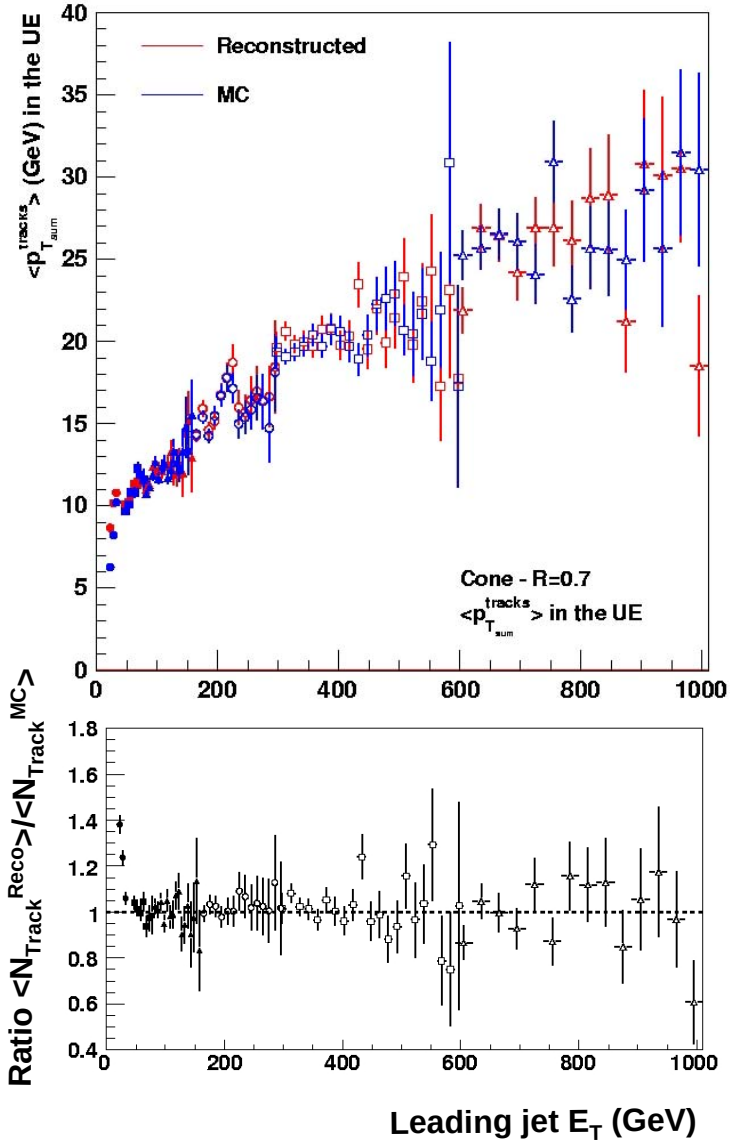
Underlying event tunings for the LHC

Selecting the underlying event:

$N_{jets} > 1$,
$|\eta_{jet}| < 2.5$,
$E_T^{jet} > 10$ GeV,

$|\eta_{track}| < 2.5$,
$p_T^{track} > 1.0$ GeV/c





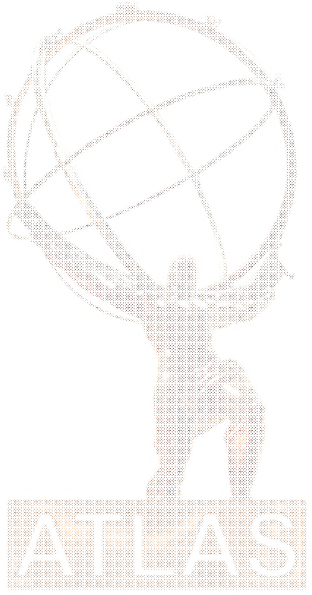
Summary:

1) PYTHIA6.403 (CTEQ6L + PYEVNW) parameters tuned to the UE:

mstp(70)=2
mstp(72)=0
mstp(81)=1
mstp(82)=4
mstp(84)=1
mstp(85)=1
mstp(86)=2
mstp(87)=4
mstp(88)=0
mstp(89)=1
mstp(90)=1
mstp(95)=1

PARP(78)=0.2
PARP(80)=0.01
PARP(82)=1.9
PARP(83)=0.3
PARP(84)=0.5
PARP(89)=1800
PARP(90)=0.22

PARJ(81)=0.14



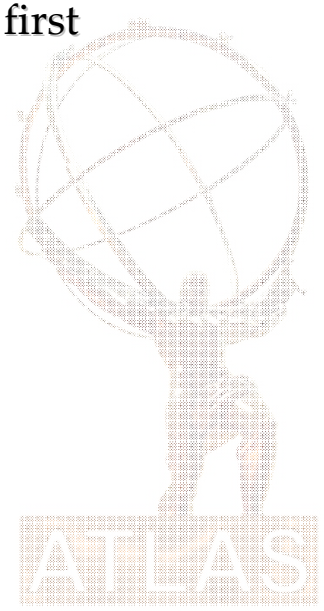
2) Generated distributions are similar (slightly better for p_T distributions!) to the tuning we had with the old model (PYTHIA6.2 + CTEQ5L)

3) Ratio <pT>/Nchg in the underlying event still needs improvement! But this is common to all the generators and models I have come across so far.

4) LHC prediction is in the same range (plateau 2-3 times higher than the Tevatron measurement) as most predictions.

5) Greater effort now is being dedicated to preparations to analyze first underlying event measurements at ATLAS.

6) Also beginning to study the underlying event associated to other channels (EW sector for example) .



Backup

Phys. Rev. D, 65 092002 (2002)

<N_{chg}> distributions (particles from different angular regions)