Describing the underlying event at the LHC with JIMMY4.1

Arthur M. Moraes

University of Glasgow

PPE - ATLAS

HERA – LHC Workshop

CERN, 11th – 13th October 2004

Outline:

- Underlying event in jet analysis.
- JIMMY4.1 tunings for the underlying event.
- PYTHIA6.214 vs. JIMMY4.1
- PHOJET1.12 vs. JIMMY4.1
- LHC predictions.
- Energy dependence: how does the event activity rise?
- Comments and conclusions.

Underlying event in charged jet evolution (CDF style analysis)

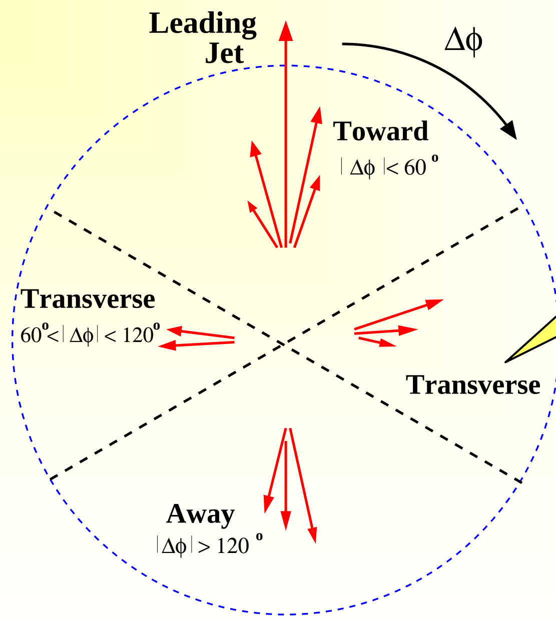
- **It is not** only minimum bias event!
- The underlying event is everything **except** the two outgoing hard scattered jets.
- In a hard scattering process, the underlying event has a **hard** component (initial + final-state radiation and particles from the outgoing hard scattered partons) and a **soft** component (beam-beam remnants).

CDF analysis:

- charged particles: **$p_t > 0.5$ GeV and $|\eta| < 1$**
- **cone jet finder:**

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

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



UE is defined as the Transverse Region

JIMMY model for the UE

(http://jetweb.hep.ucl.ac.uk/JIMMY/index.html)

- **Physics model: Eikonal hard scattering model** (see Jon Butterworth's talk on the 22nd June 2004 – "ATLAS Tutorial on MC Event Generators")**;**

- **Parton scatterings are correlated via "b" dependence of matter overlap;**

- **JIMMY underlying event options:**
  - **JMUEO=0** (QCD 2$\rightarrow$2 with pT>PTMIN);
  - **JUMEO=1, 2** ("small" cross-section scattering - pT>PTMIN - secondary scatterings with pT>PTJIM);

- **JMRAD(73) – parameter associated to the proton radius** (derived from EM form factor)**.**

- **HERWIG's old SUE model** (based on UA5 parameterization) **will not be used!**

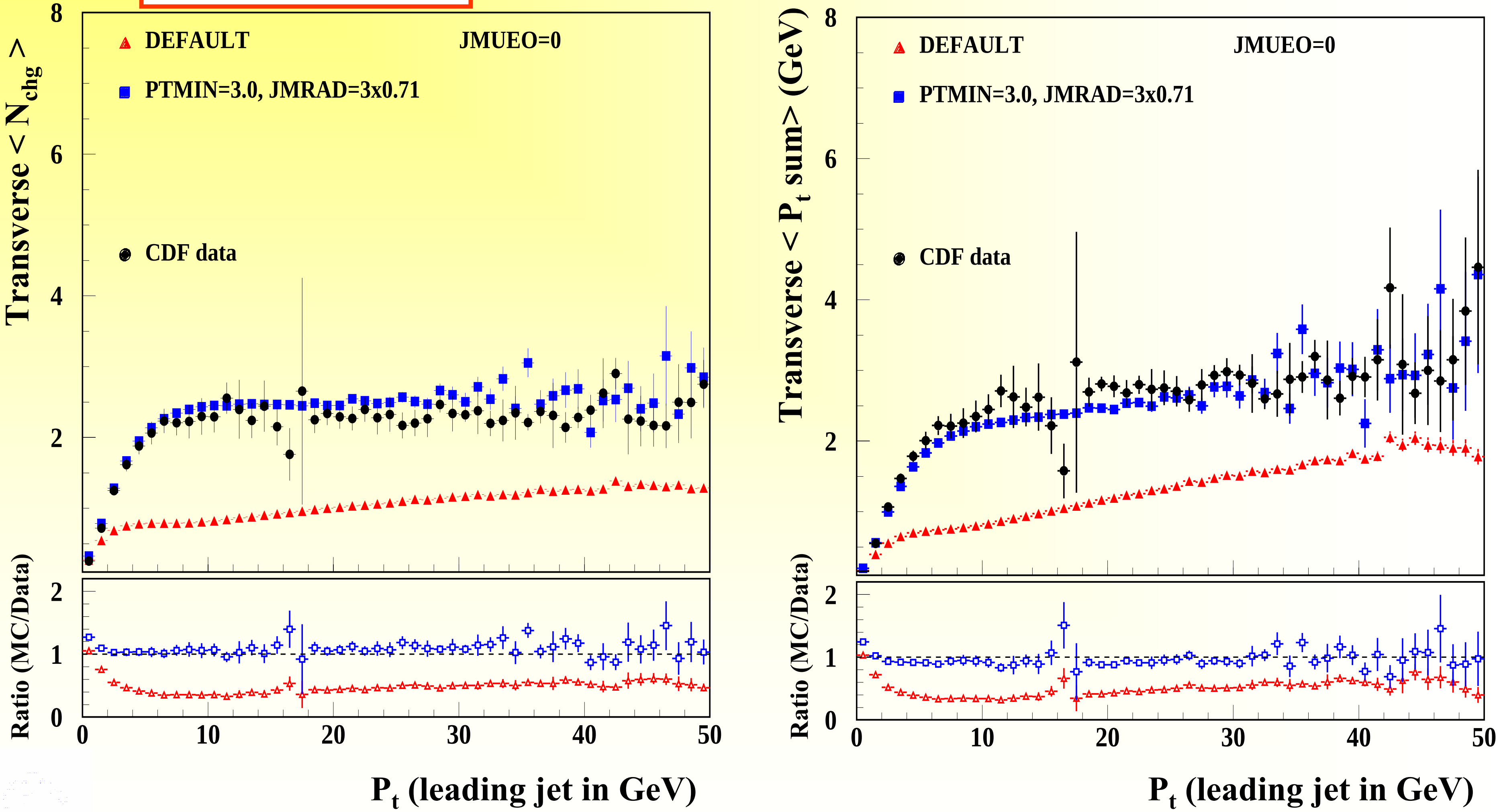
IPROC=10000+chosen process

JIMMY4.1 – Tuning A

JIMMY – Tuning A
JMUEO=0
PTMIN=3.0
JMRAD(73)=3x0.71

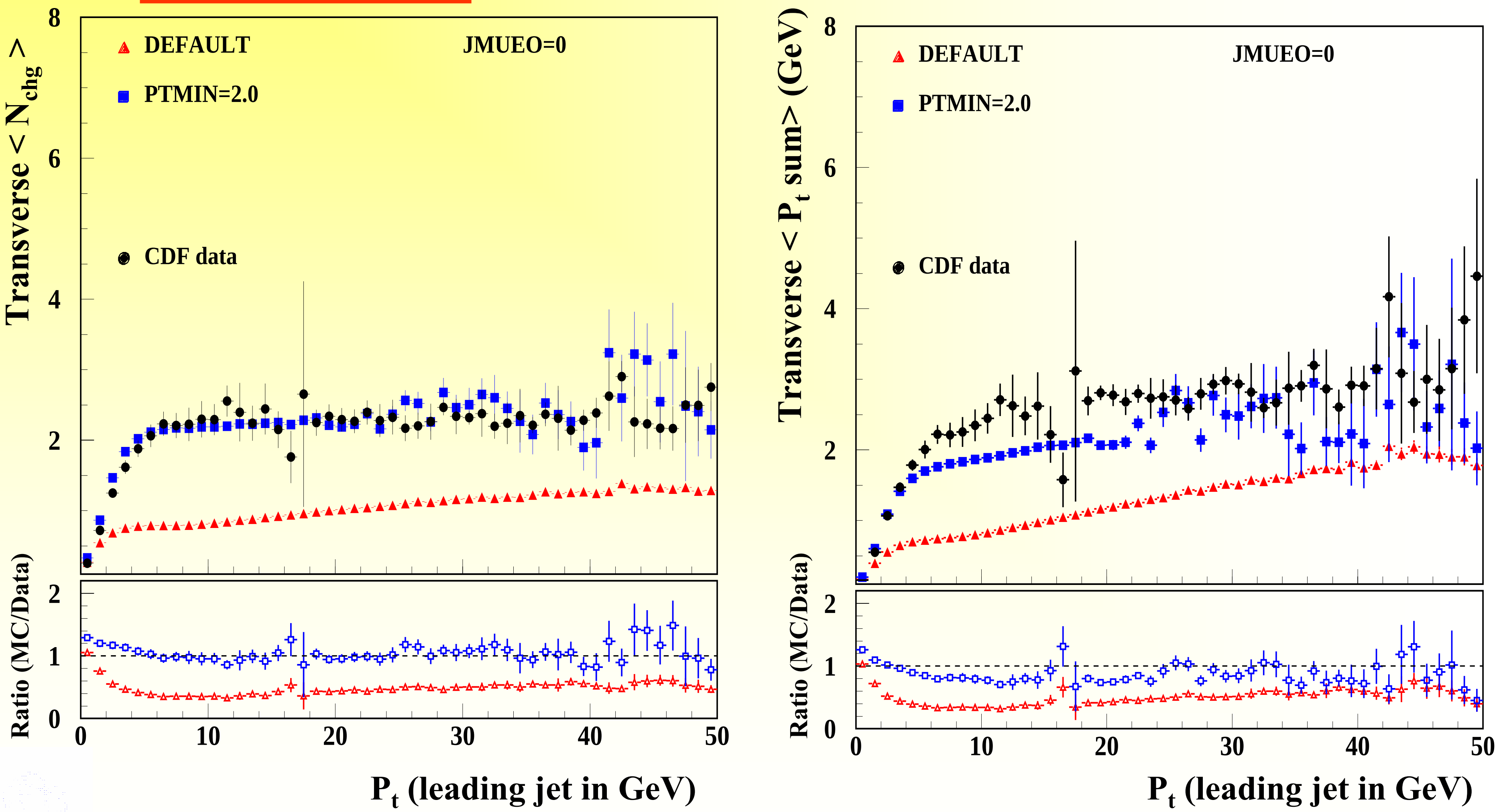
Proton radius shrunk by 1.73

Motivated by I. Borozan's work (CDF Data!). See JetWeb Fit 493



JIMMY4.1 – Tuning B

JIMMY – Tuning B
JMUEO=0
PTMIN=2.0
JMRAD(73)=0.71 (D)



Comments	PYTHIA6.2 - Default	ATLAS – TDR (PYTHIA5.7)	CDF – Tune A (PYTHIA6.206)	**PYTHIA6.214 - Tuned**
Generated processes (QCD + low-pT)	Non-diffractive inelastic (MSEL=1)	Non-diffractive inelastic (MSEL=1)	Non-diffractive inelastic + double diffraction (MSEL=0, ISUB 94 and 95)	**Non-diffractive + double diffraction (MSEL=0, ISUB 94 and 95)**
p.d.f.	CTEQ 5L (MSTP(51)=7)	CTEQ 2L (MSTP(51)=9)	CTEQ 5L (MSTP(51)=7)	**CTEQ 5L (MSTP(51)=7)**
Multiple interactions mode[illegible]	MSTP(81) = 1 MSTP(82) = 1	MSTP(81) = [illegible] MSTP[illegible]	MSTP(81) = 1 MSTP(82) = 4	**MSTP(81) = 1 MSTP(82) = 4**
pT min	[illegible]	[illegible]	[illegible]ARP(82) = 2.0 [illegible]V [illegible]P(90) = 0.25	**PARP(82) = 1.8 PARP(89) = 1 TeV PARP(90) = 0.16**
Core [illegible]	20% o[illegible] ([illegible]) = 0[illegible]	[illegible] ([illegible].2)	[illegible] of the hadron radius [illegible]RP(84) = 0.4)	**50% of the hadron radius (PARP(84) = 0.5)**
Gluon production mechanism	PARP(85) = 0.33 PARP(86) = 0.66	PARP(85) = 0.33 PARP(86) = 0.66	PARP(85) = 0.9 PARP(86) = 0.95	**PARP(85) = 0.33 PARP(86) = 0.66**
α_s and K-factors	MSTP(2) = 1 MSTP(33) = 0	MSTP(2) = 2 MSTP(33) = 3	MSTP(2) = 1 MSTP(33) = 0	**MSTP(2) = 1 MSTP(33) = 0**
Regulating initial state radiation	PARP(67) = 1	PARP(67) = 4	PARP(67) = 4	**PARP(67) = 1**

PYTHIA Tunings.

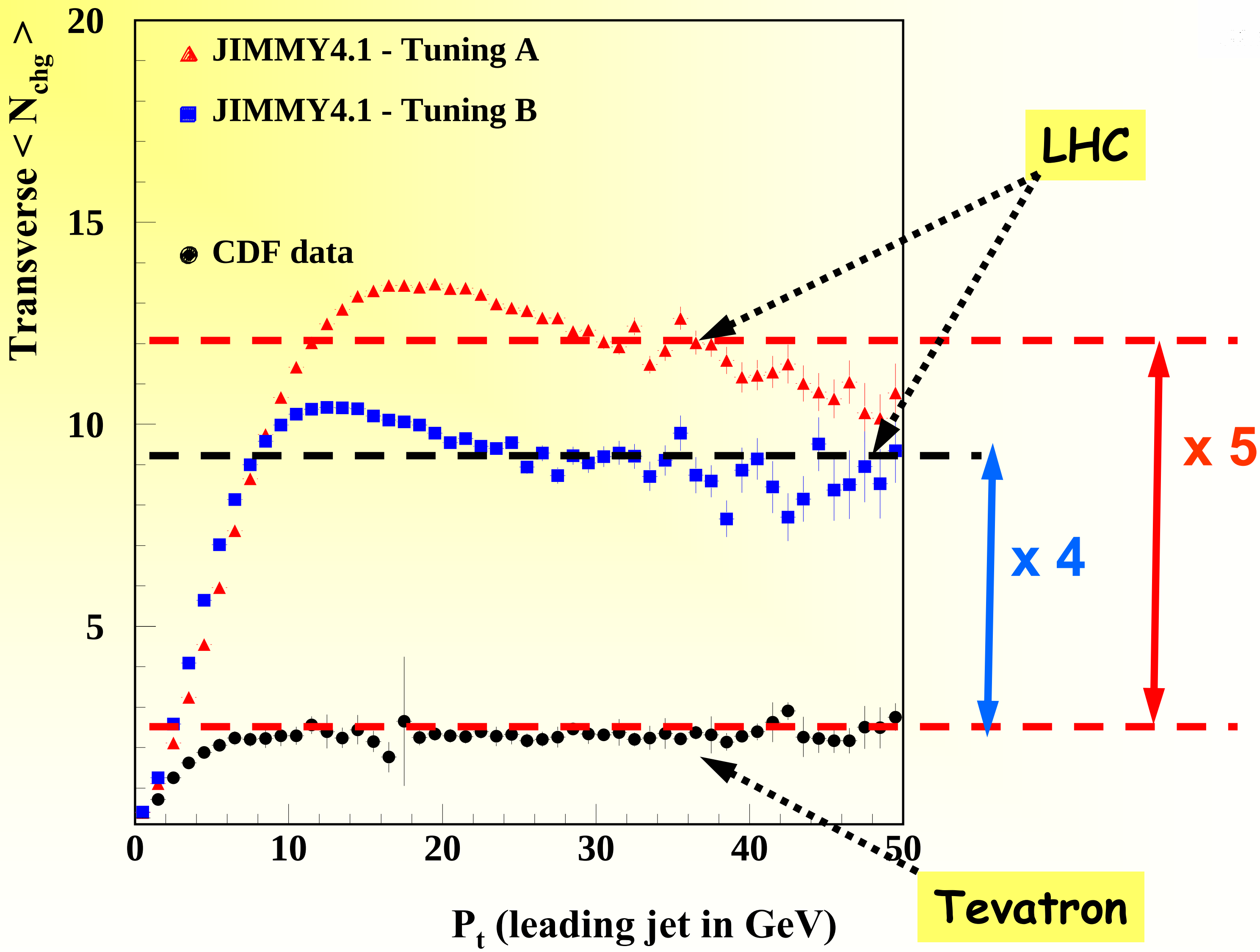
See last March's talk on Models for Min-bias and the UE!

χ^2 comparison (not the minimum χ^2 !):

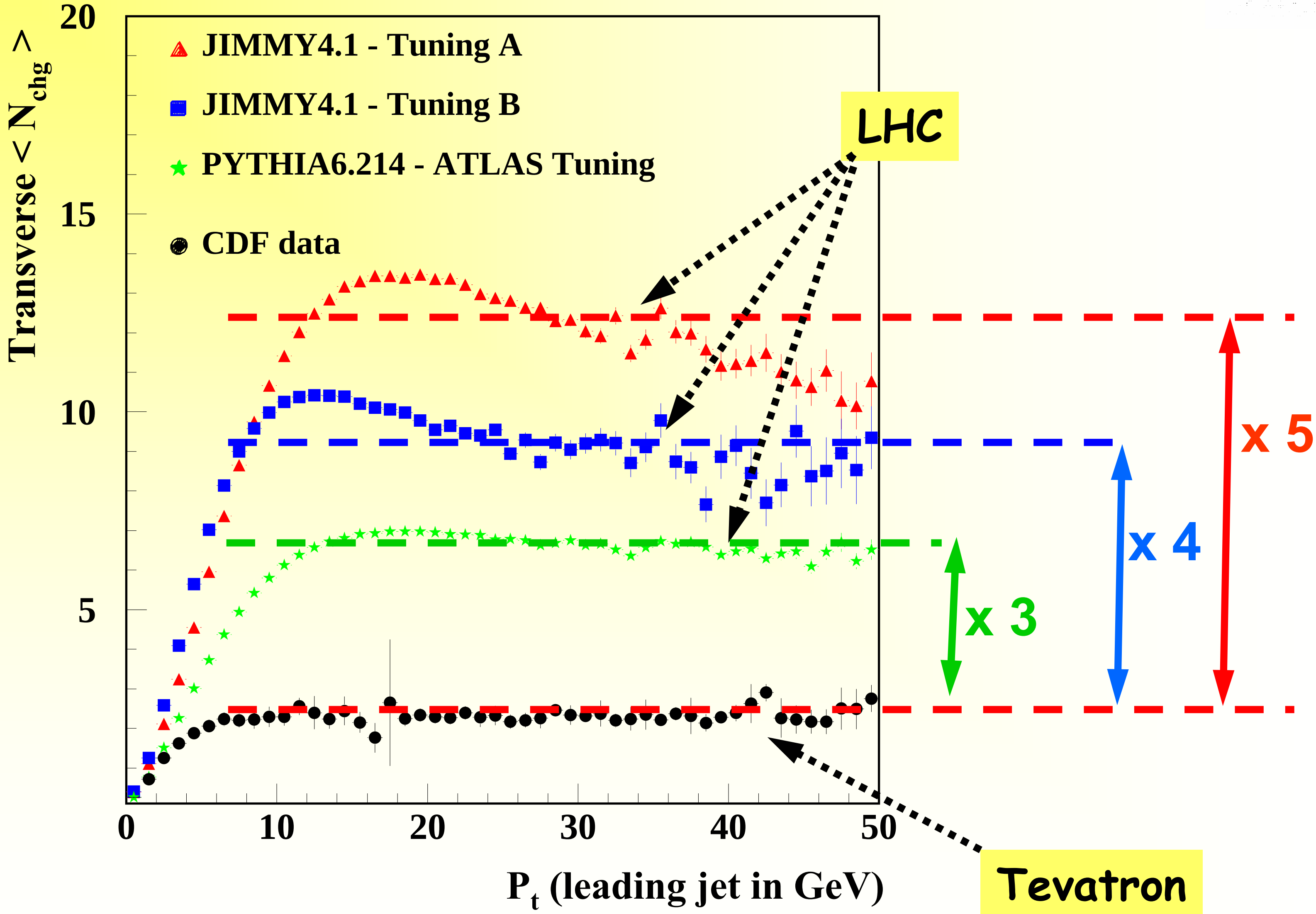
		$\chi 2_{<Nchg>}$ / 50 d.o.f	$\chi 2_{<Pt\ sum>}$ / 50 d.o.f	$\chi 2_{UE}$ / 100 d.o.f
PYTHIA 6.214	ATLAS Tuning	1.29	2.84	2.07
	CDF Tuning	1.04	1.57	1.31
	ATLAS – TDR	20.56	9.49	15.03
	PYTHIA6.214 – Default	15.68	29.68	22.68
	PHOJET1.12	5.27	9.41	7.35
JIMMY 4.1	Tuning A	2.15	2.07	2.11
	Tuning B	2.33	4.51	3.42
	JIMMY4.1 - Default	36.61	47.36	41.99

• JIMMY4.1 tunings (both A and B) describe well the UE data!

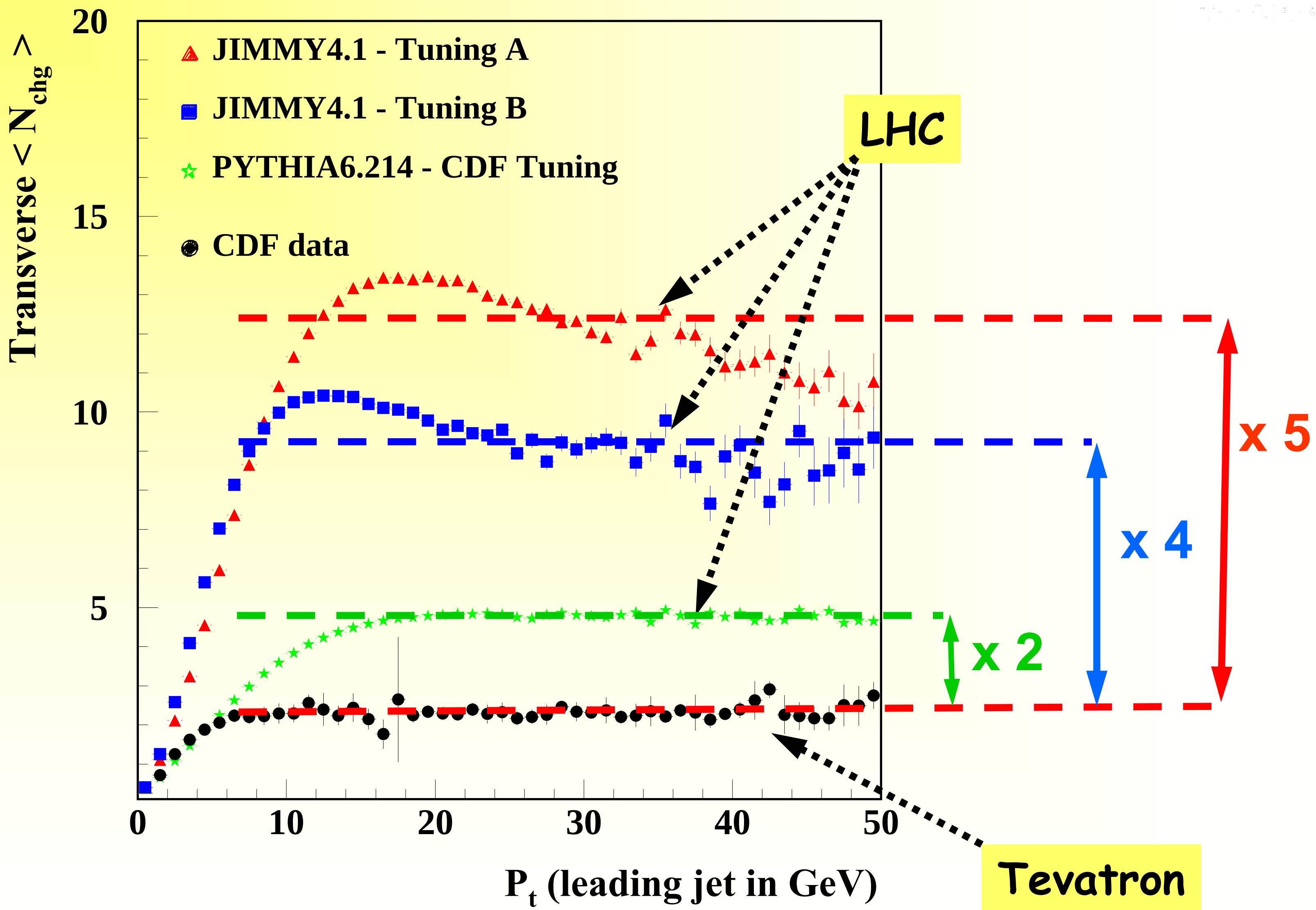
LHC predictions: JIMMY4.1 Tuning A vs. Tuning B



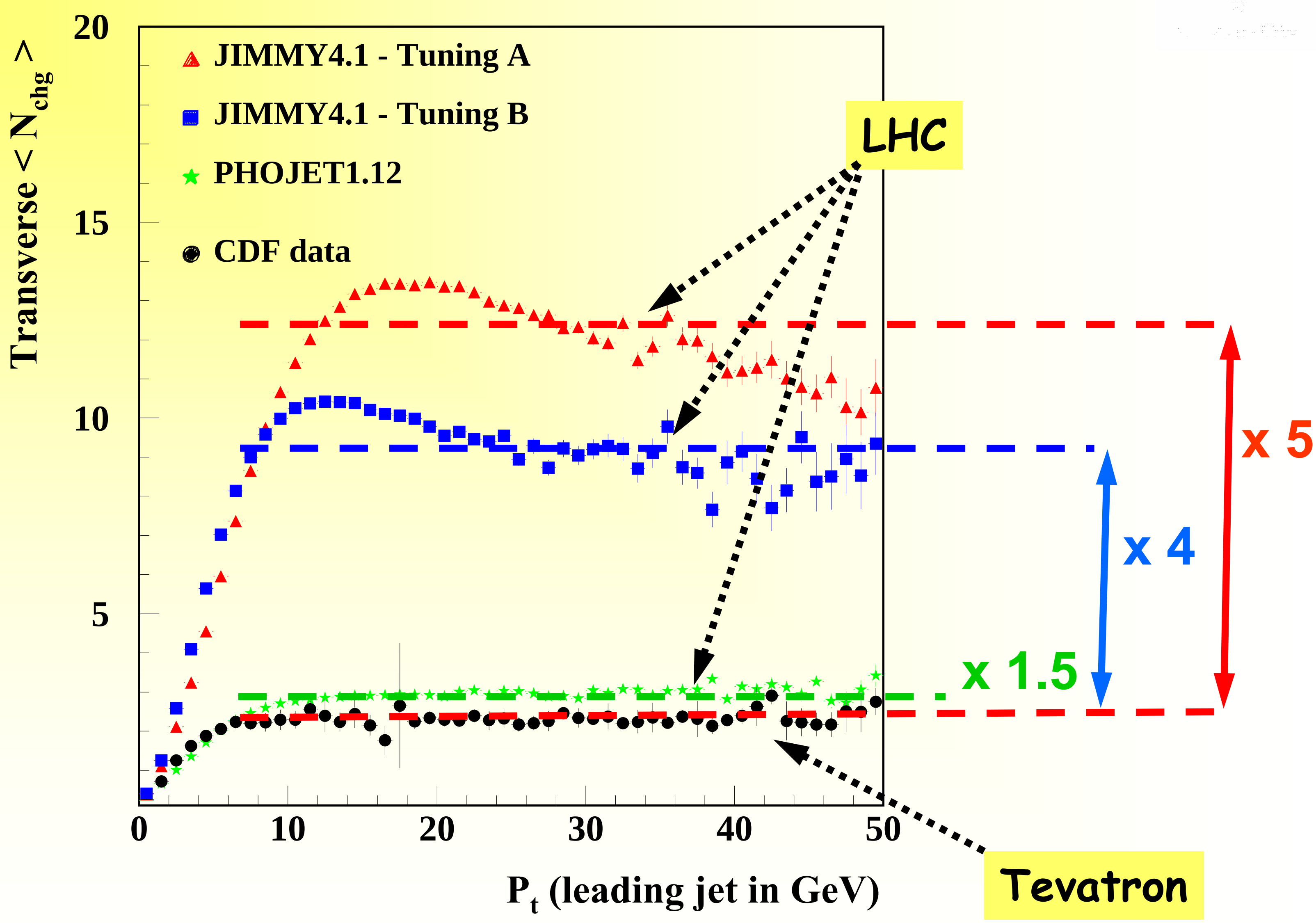
LHC predictions: JIMMY4.1 Tunings A and B vs. PYTHIA6.214 – ATLAS Tuning



LHC predictions: JIMMY4.1 Tunings A and B vs. PYTHIA6.214 – CDF Tuning



LHC predictions: JIMMY4.1 Tunings A and B vs. PHOJET1.12



Predictions for the UE: from Tevatron to LHC energies

	Measurement	JIMMY4.1		PYTHIA6.214		PHOJET1.12	Data
		Tuning A	Tuning B	ATLAS Tuning	CDF Tuning		
Tevatron	$<N_{chg}>$ $pT_{ljet} > 10$ GeV	2.4	2.3	2.4	2.3	2.1	**2.3**
Tevatron	$<pT_{sum}>$ $pT_{ljet} > 10$ GeV	2.5	2.1	2.3	2.6	2.0	**2.6**
LHC	$<N_{chg}>$ $pT_{ljet} > 10$ GeV	**12.2**	**9.2**	**6.6**	**4.7**	**3.0**	**"?"**
LHC	$<pT_{sum}>$ $pT_{ljet} > 10$ GeV	**11.5**	**8.5**	**7.5**	**6.5**	**3.5**	**"?"**

x 5 x 4

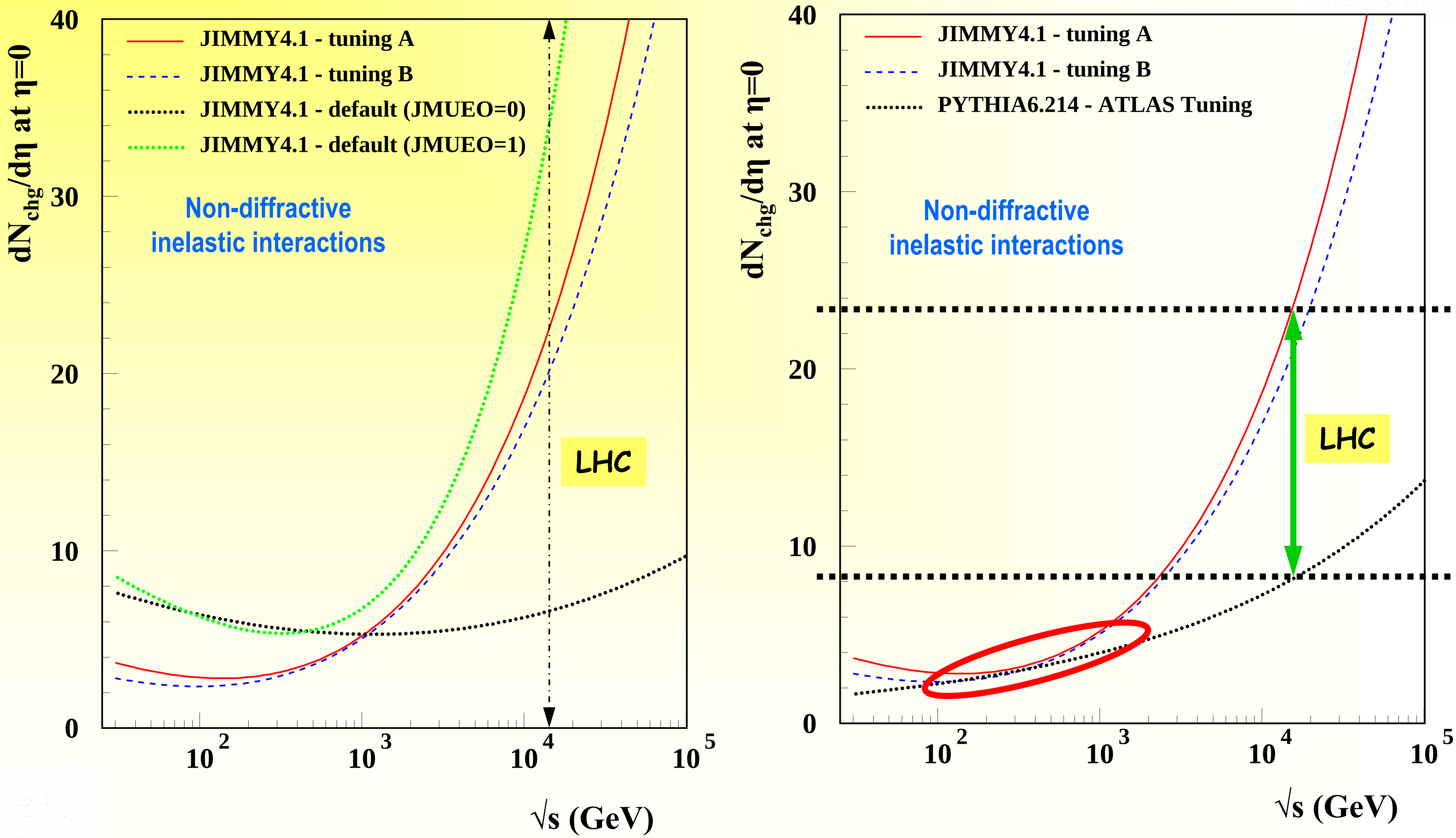
x 3 x 2

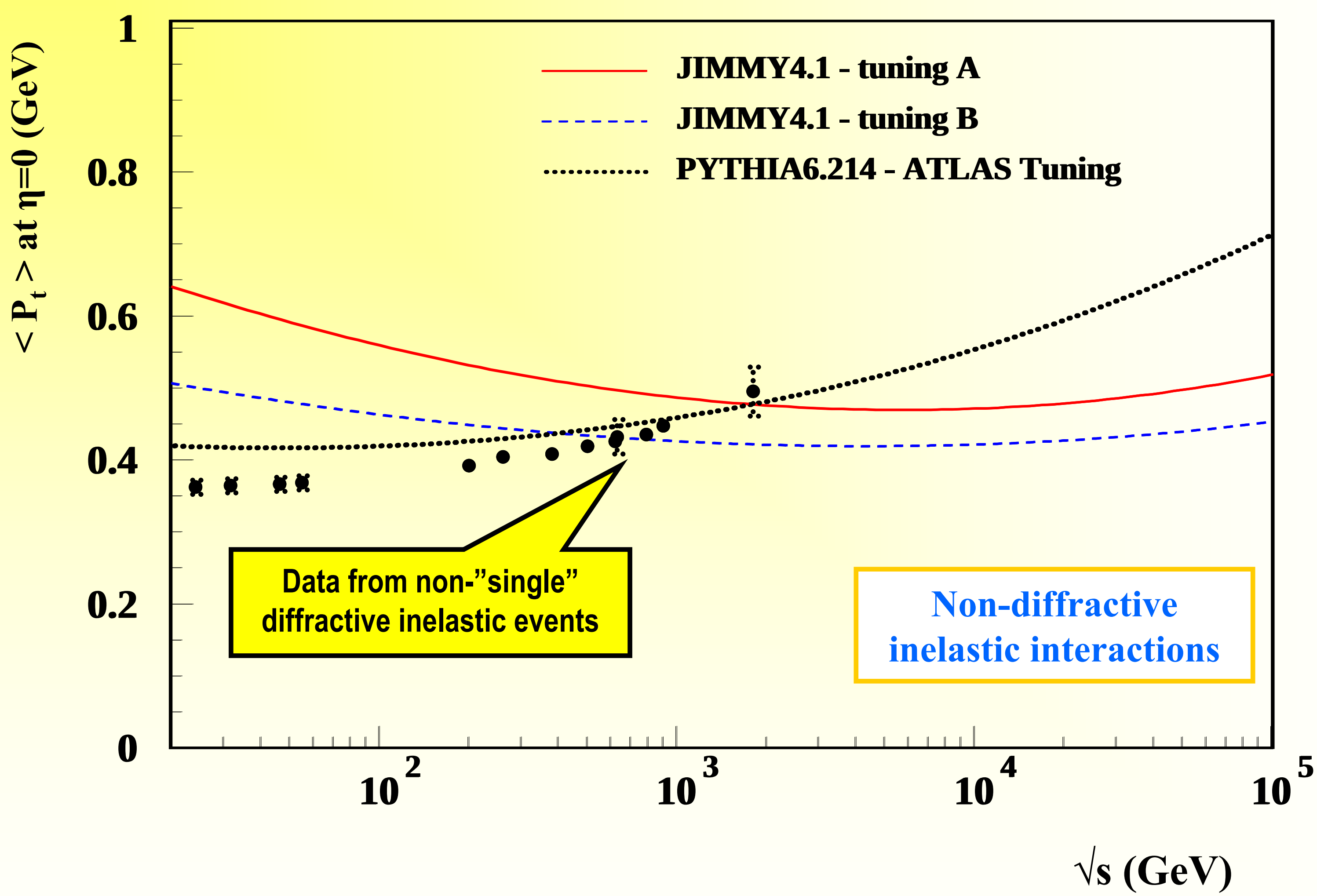
x 1.5

x "?"

LHC

Event Activity Energy Dependence: what does JIMMY4.1 predict?




1
0.8
0.6
0.4
0.2
0
< P_t > at η=0 (GeV)
JIMMY4.1 - tuning A
JIMMY4.1 - tuning B
PYTHIA6.214 - ATLAS Tuning
Data from non-"single" diffractive inelastic events
Non-diffractive inelastic interactions
10^2
10^3
10^4
10^5
√s (GeV)

Conclusions:

• The underlying event data for $p\bar{p}$ collisions at $\sqrt{s}$=1.8 TeV can be described by JIMMY4.1 with appropriate tunings. (χ^2 comparisons result in similar values obtained by the best tunings!)

• There are sizeable uncertainties in LHC/UE predictions generated by different models.

• Charged particle density (central) in non-diffractive inelastic events shows good agreement between JIMMY4.1 (Tunings A and B) and PYTHIA – ATLAS for 100 GeV < $\sqrt{s}$ < 2 TeV. However, as $\sqrt{s}$ increases, JIMMY distributions rise very steeply!

• We need to understand better how to tune the energy dependence of the event activity: multiple parton scattering rate? Any ideas on how we can make good use of HERA data?

• Updated results: *www.cern.ch/amoraes*