Simulations of minimum bias and the underlying event, MC tuning and predictions for the LHC

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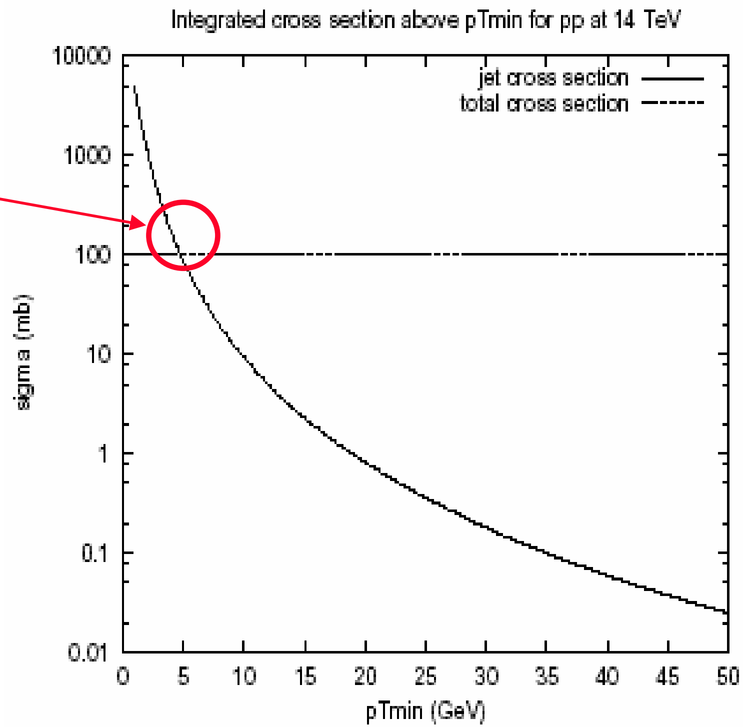
Outline

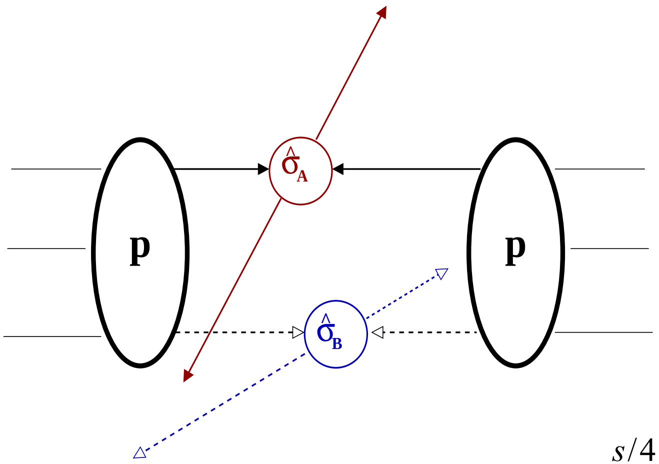
- Multi-parton scattering
- Tuning of PYTHIA
- Tuning using Jetweb
- LHC predictions
- Energy extrapolation and comparison with PHOJET
- Application to central jet veto in Higgs searches
- Summary+future work

How to describe low-pt behaviour ?

$\sigma_{2\to2} > \sigma_{pp}$ at $p_T \sim 5$GeV



Different approaches but all many to multi-parton scattering

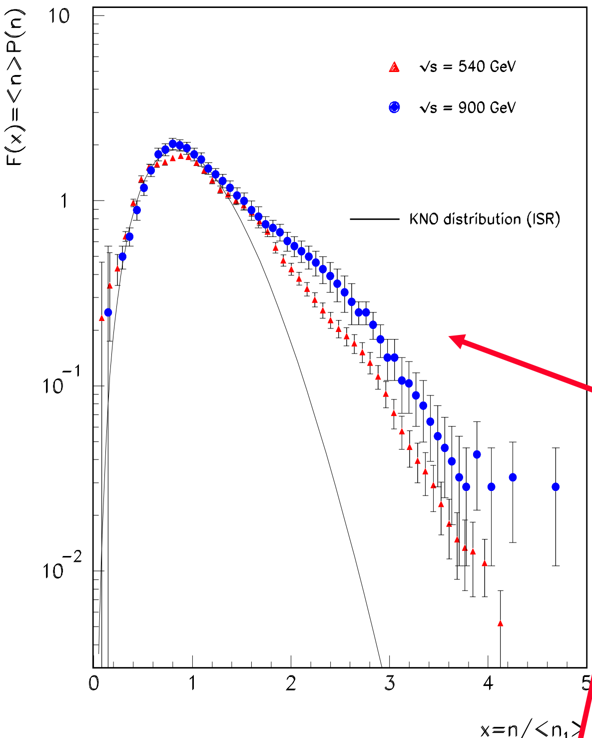


$$\bar{n} = \frac{\sigma_{hard}}{\sigma_{pp}}$$

$$\sigma_{hard} = \int_{p_T-\min}^{s/4} \frac{d\sigma}{dp_t^2} dp_t^2$$

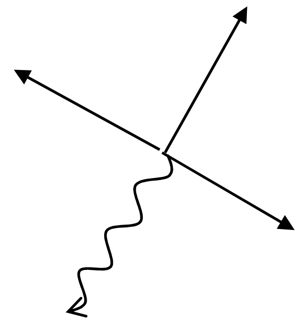
(simple scenario with sharp cut-off)

Evidence for multi-parton interactions



UA5 KNO distributions

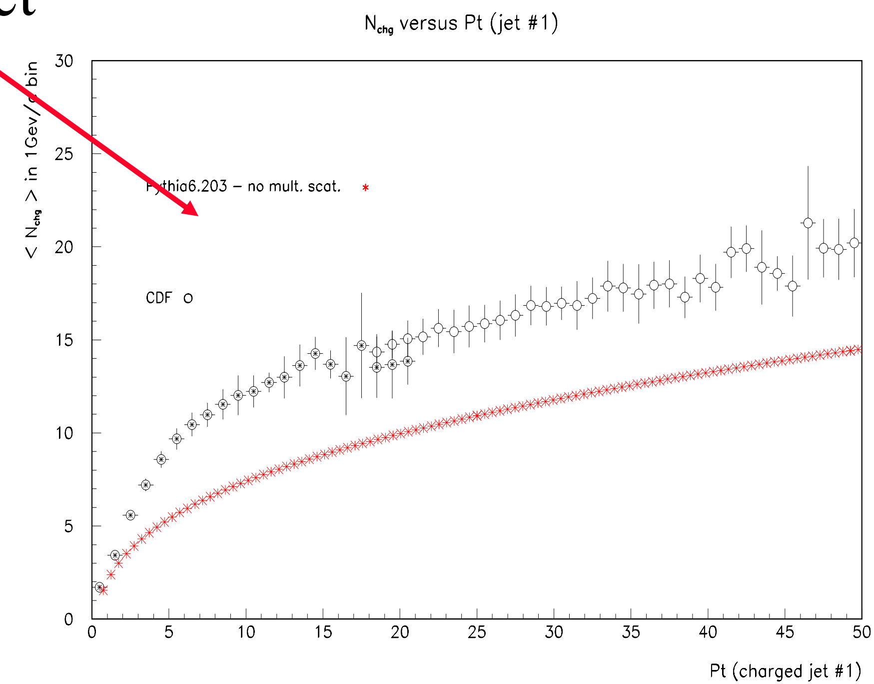
Direct



$$p\bar{p} \rightarrow \gamma / \pi^0 + 3\, jets + X$$

CDF

indirect



D0 multijet analysis

HERA photoproduction

CDF underlying event

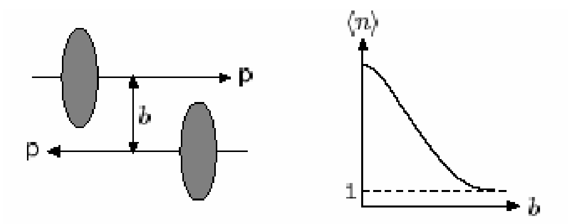
PYTHIA model

Multiple interactions solve total xsect problem
Need to tame the PT divergence over QCD cross-section
Parameters of the model:

- p_T-min ⟶ Abrupt vs smooth cut-off ⟶ Number of interactions

Impact parameter ⟶ Matter distribution ⟶ Number of interactions and fluctuations

•energy dependence ⟶ $$p_{t0} = 1.9\,\mathrm{GeV}\left(\frac{\sqrt{s}}{1\,\mathrm{TeV}}\right)^{0.16}$$



Parameters not looked at: string drawing, effect of ISR (CDF)

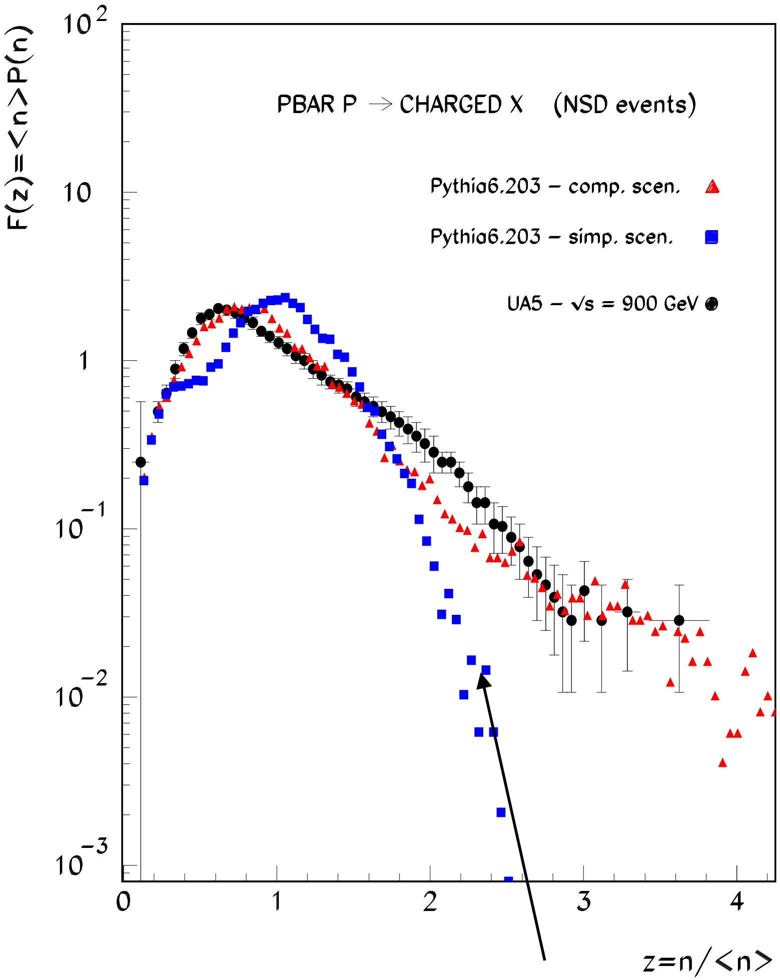
Minimum bias data:

Multiplicity information:
$\langle n_{ch} \rangle$, $dN/d\eta$, KNO, FB, etc.

Set π^0, K^0_s and Λ^0 stable

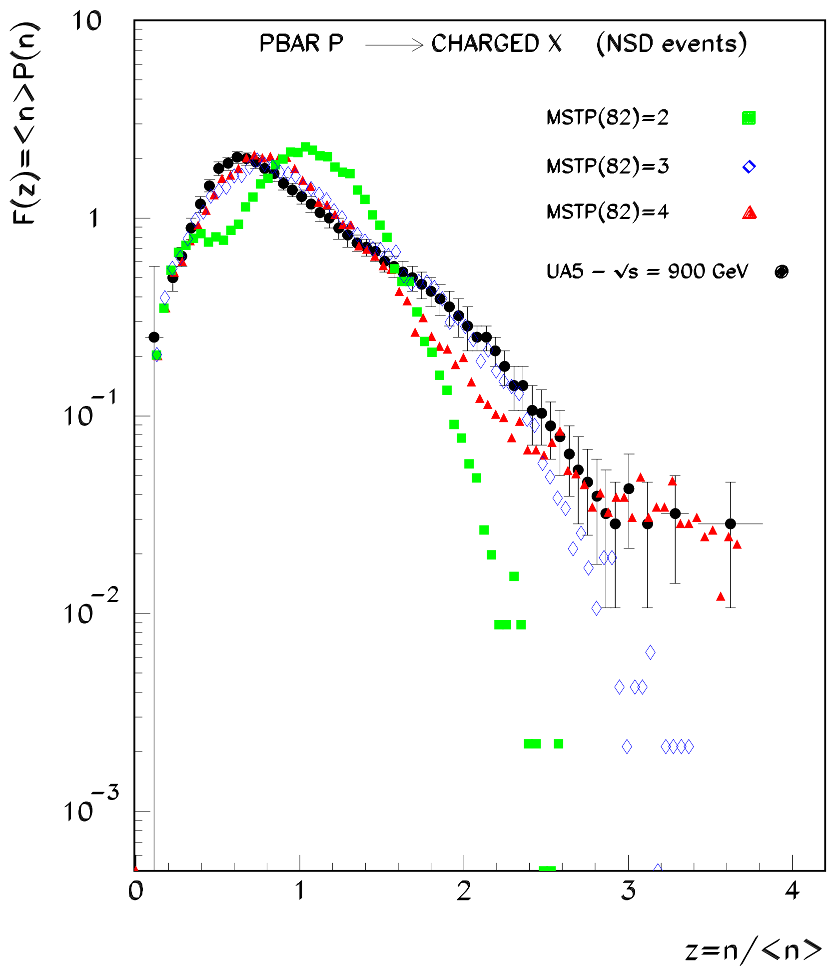
Experiment	References	Colliding beams
CERN – ISR	Phys. Rev. D 30 528 (1984)	pp at $\sqrt{s}$ = 30.4, 44.5, 52.6 and 62.2 GeV
UA5 – SPS	Phys. Rep. 154(5,6) 247 (1987) Z. Phys. C 37, 191 (1988) Z. Phys. C 43, 357 (1989)	$p\bar{p}$ at $\sqrt{s}$ = 200, 546 and 900GeV
CDF - Tevatron E735 - Tevatron	Phys. Rev. D 41 2330 (1990) Phys. Lett. B 435 453 (1998)	$p\bar{p}$ at $\sqrt{s}$ = 1.8TeV

Use ‘complex’ scenario with smooth cut-off

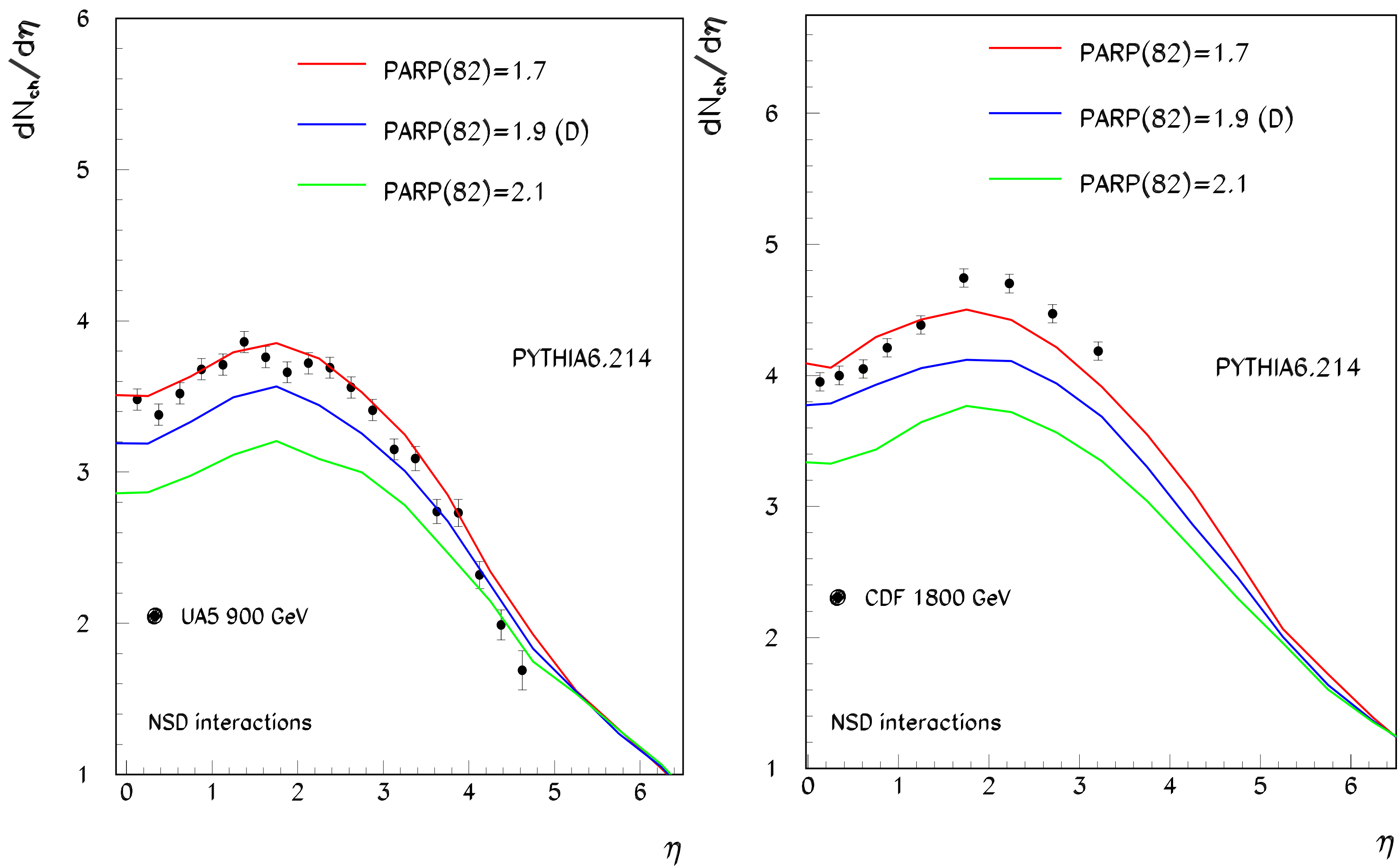


Abrupt cut-off generates too few interactions

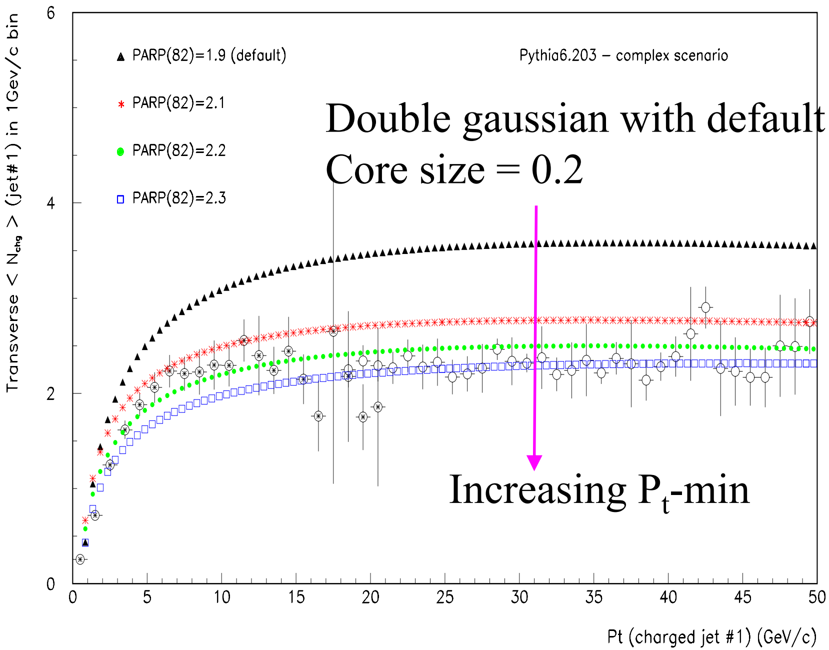
Use ‘double-gaussian’ Matter distribution

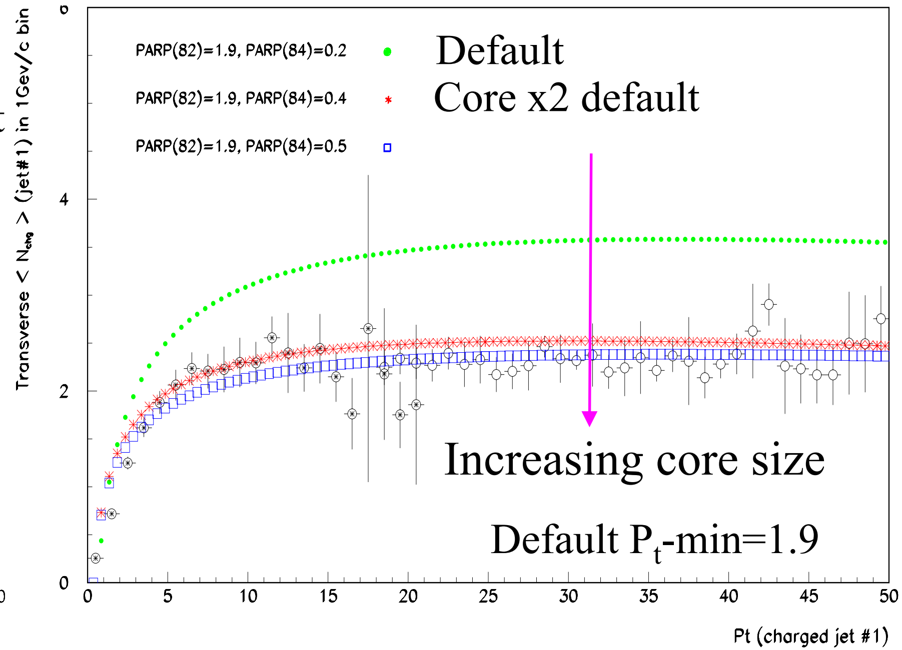


Pt-min is ~1.9GeV default value



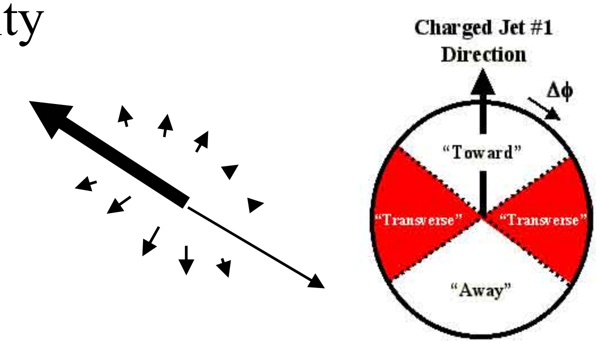
Transverse <N_{ch}> vs jet p_T





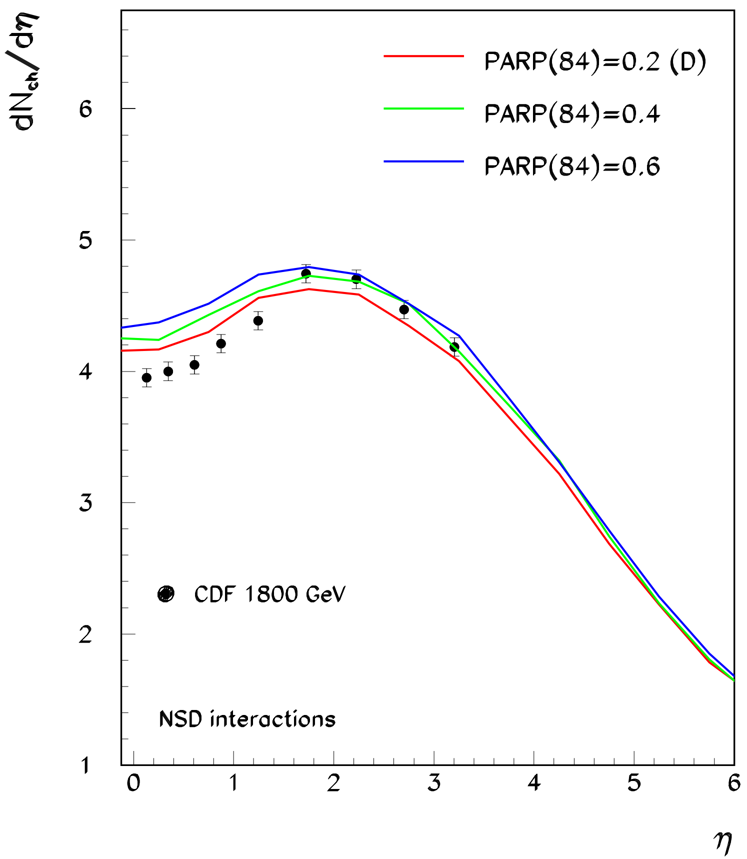
The underlying event requires less activity => higher pt
Lose 'unification' of min-bias and underlying event

Alternatively increase the core size
This reduces the core density-reducing activity

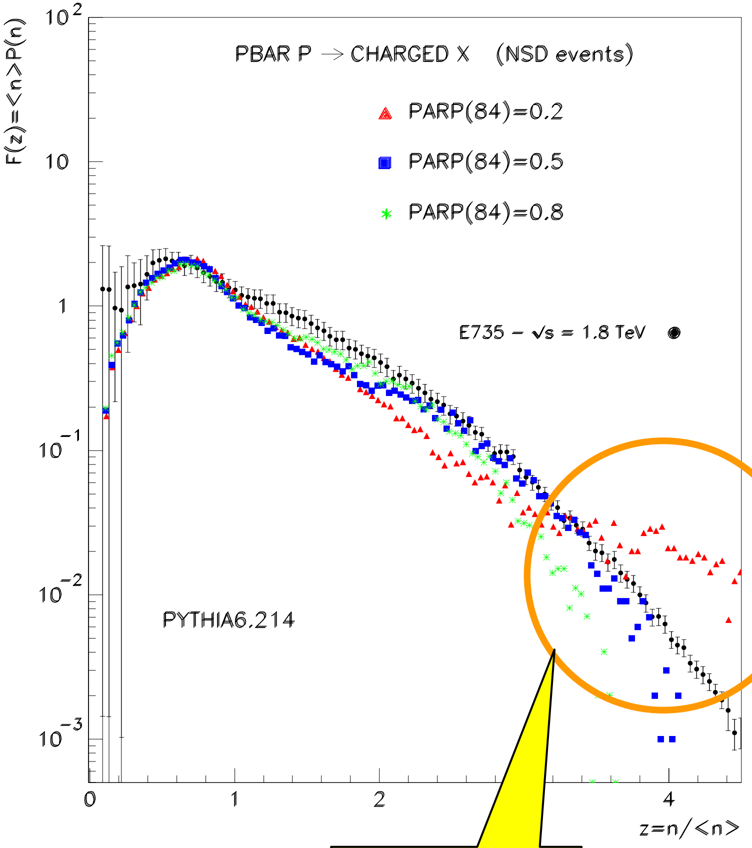


CDF Run 1 underlying event analysis
Phys. Rev. D, **65** 092002 (2002)

The rapidity distributions are insensitive to the matter distribution



Agreement with KNO improves
As it reduces the large fluctuations
in multiplicity



Effect on high multiplicity events.

PYTHIA Tuning (AM Tune)

"D" = PYTHIA's default

Minimum bias	Underlying event
MSUB(94)=1 (D=0) MSUB(95)=1 (D=1)	MSUB(95)=1 (D=1)
MSTP(51)=7 (D=7)	MSTP(51)=7 (D=7)
MSTP(81) = 1 (D=1)	MSTP(81) = 1 (D=1)
MSTP(82) = 4 (D=1)	MSTP(82) = 4 (D=1)
PARP(82) =1.8 (D=1.9)	PARP(82) =1.8 (D=1.9)
PARP(84) = 0.5 (D=0.2)	PARP(84) = 0.5 (D=0.2)
PARP(90)=0.16 (D=0.16)	PARP(90)=0.16 (D=0.16)
π^0, K^0_s and Λ^0 stable (D=decay's on!)	MC distributions corrected.

Non-diff. + d.diff.

CTEQ 5L

Multiple interactions

Double Gaussian

Required to compare to data

PT0

Core size

PT0 energy dependence

Primary vertex

Exclude 8% of chd. tracks

Jetweb

Jetweb is a database tool for tuning MCs

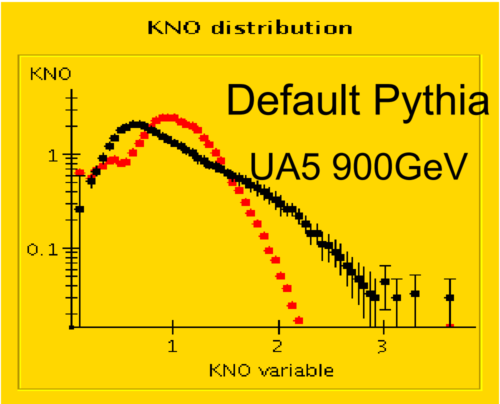
J Butterworth and S Butterworth:

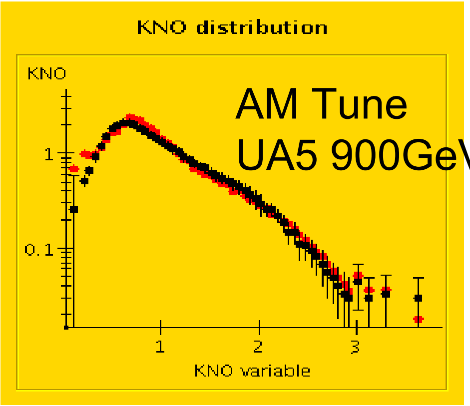
Comput. Phys. Commun. 153 (2003) 164-178

http://jetweb.hep.ucl.ac.uk

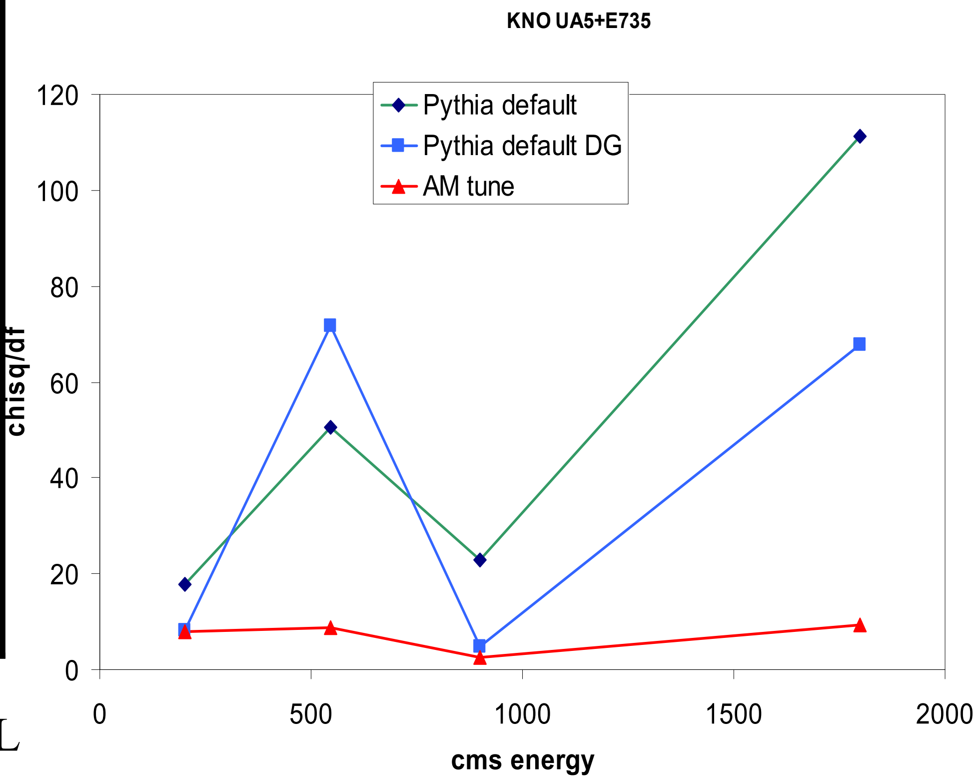
- Collection of plots from OPAL, H1, ZEUS, CDF, D0, UA5 publications, stored as distributions
- Generates events using (currently PYTHIA or HERWIG) and uses HBOOK to generate histograms to compare to data
- χ^2/**DF** calculated for distributions
- Fits are stored for future reference and comparison to different

Jetweb comparison



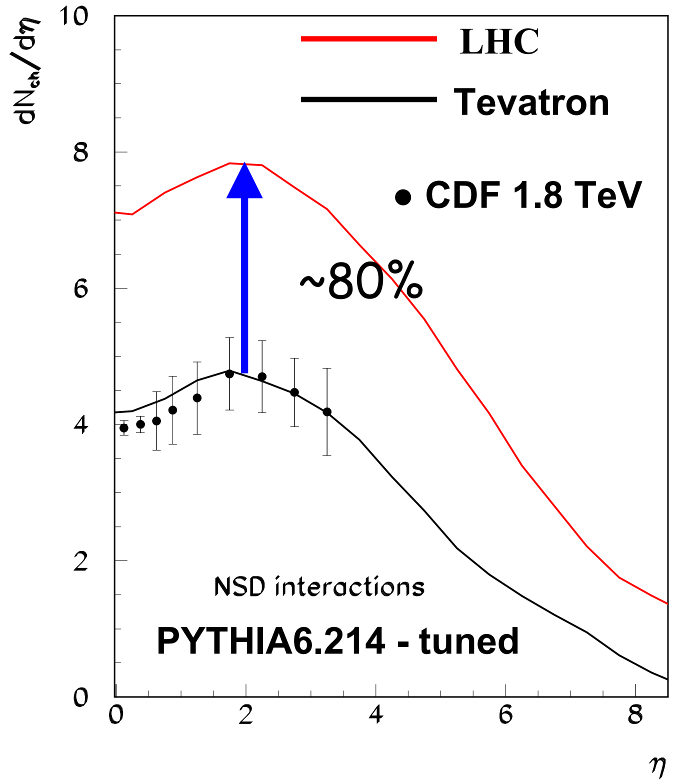


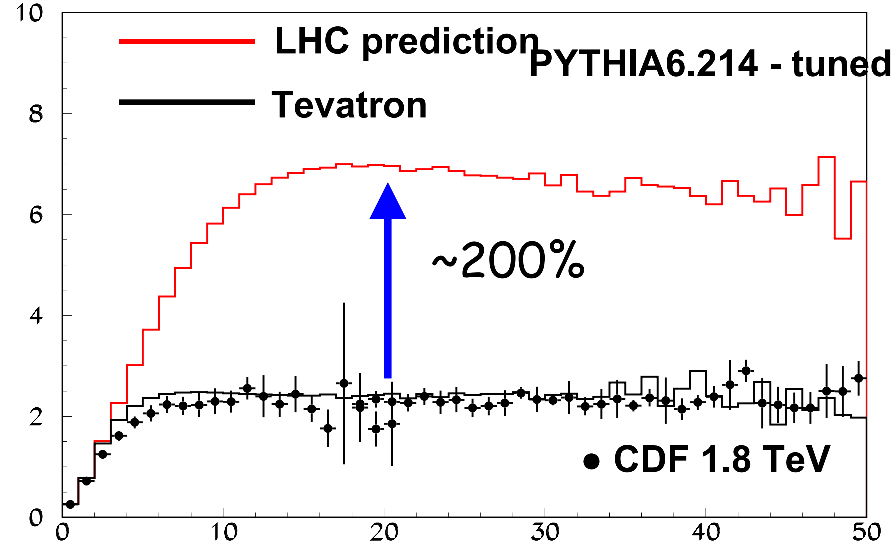
	dN/deta fit χ^2/DF		
Energy	**Default**	**Def. DG**	**AM tune**
200 (UA5)	**16.9**	**18.5**	**6.8**
900 (UA5)	**11.3**	**16.3**	**1.3**
	KNO fit χ^2/DF		
200 (UA5)	**17.7**	**8.0**	**8.0**
546 (UA5)	**50.5**	**71.6**	**8.7**
900 (UA5)	**22.9**	**7.7**	**2.5**
1800 (E735)	**27.2**	**26.2**	**6.0**



Jetweb fits generated by B. Waugh, UCL

LHC predictions

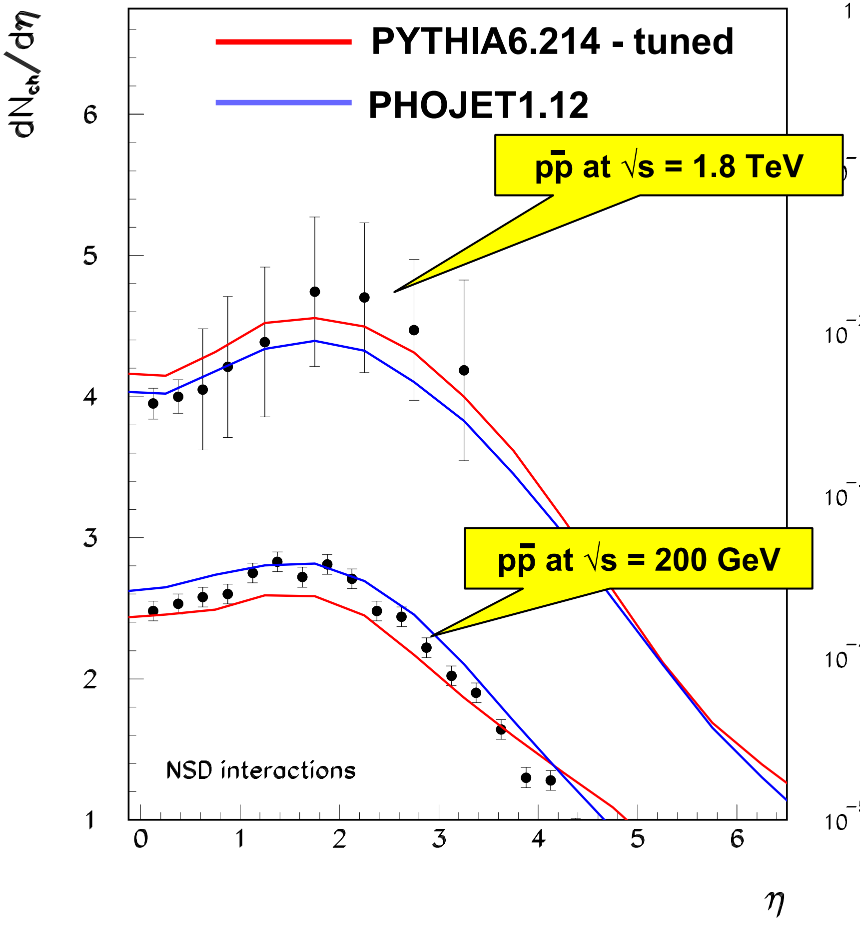


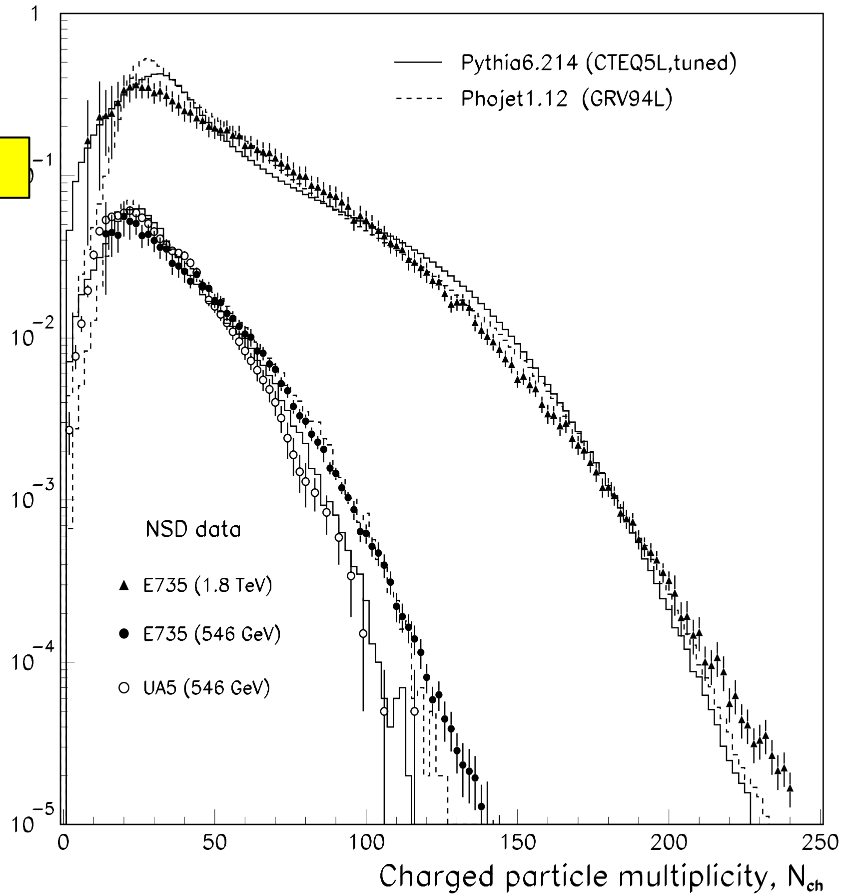


$$\frac{\left(\frac{UE(LHC)}{MB(LHC)}\right)_{\rho_{particle}}}{\left(\frac{UE(CDF)}{MB(CDF)}\right)_{\rho_{particle}}} = \frac{4.4}{2.6} = 1.7$$

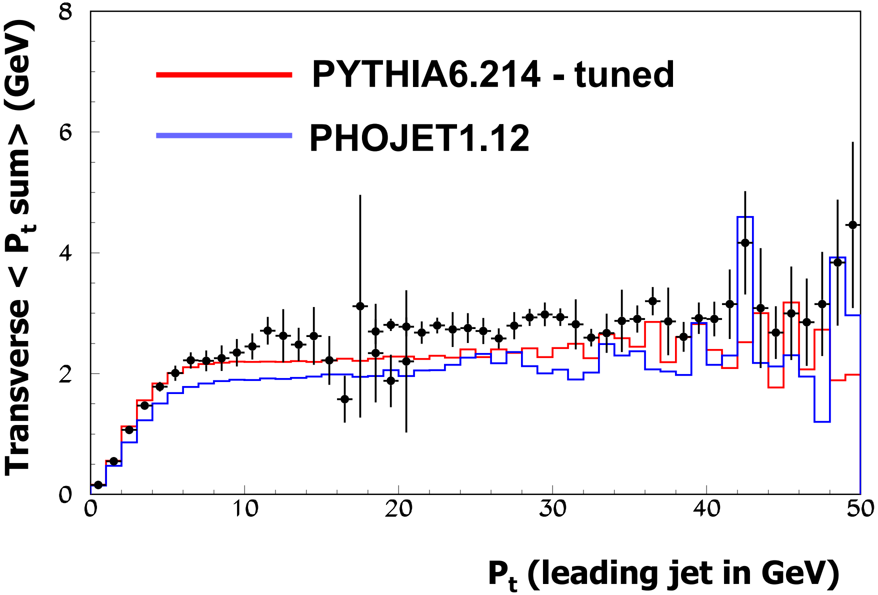
	$dN/d\eta$ ($\eta=0$)	N_{ch} jet-p_t=20GeV
1.8TeV (pp)	4.1	2.3
14TeV (pp)	7.0	7.0
increase	~x1.8	~x3

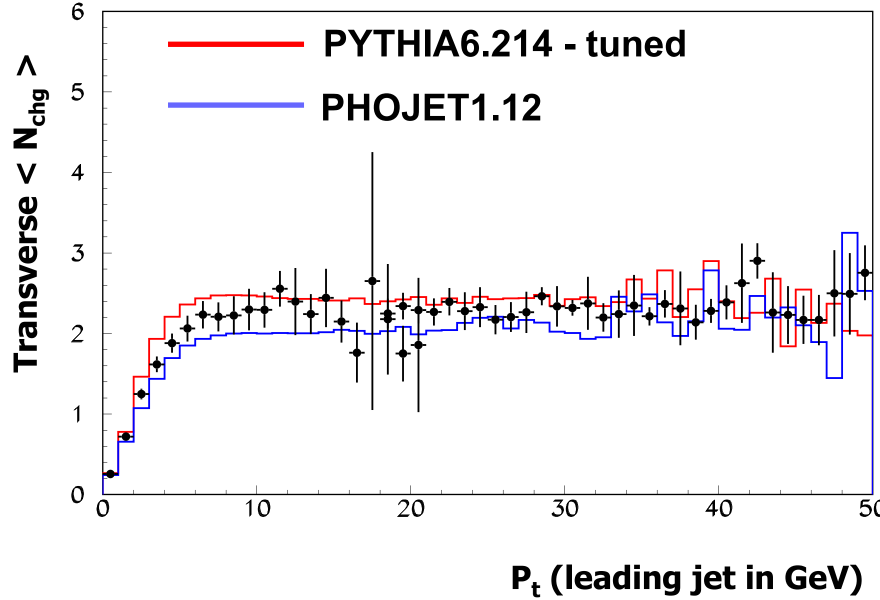
PYTHIA vs PHOJET: Minimum bias





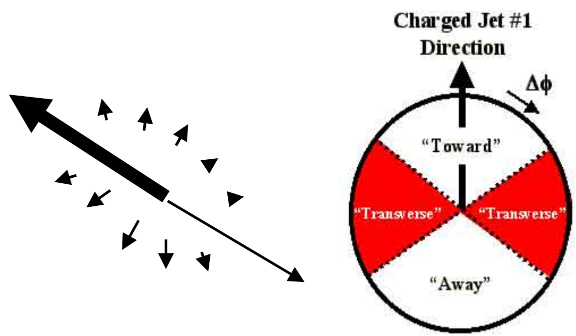
PYTHIA vs PHOJET: Underlying event



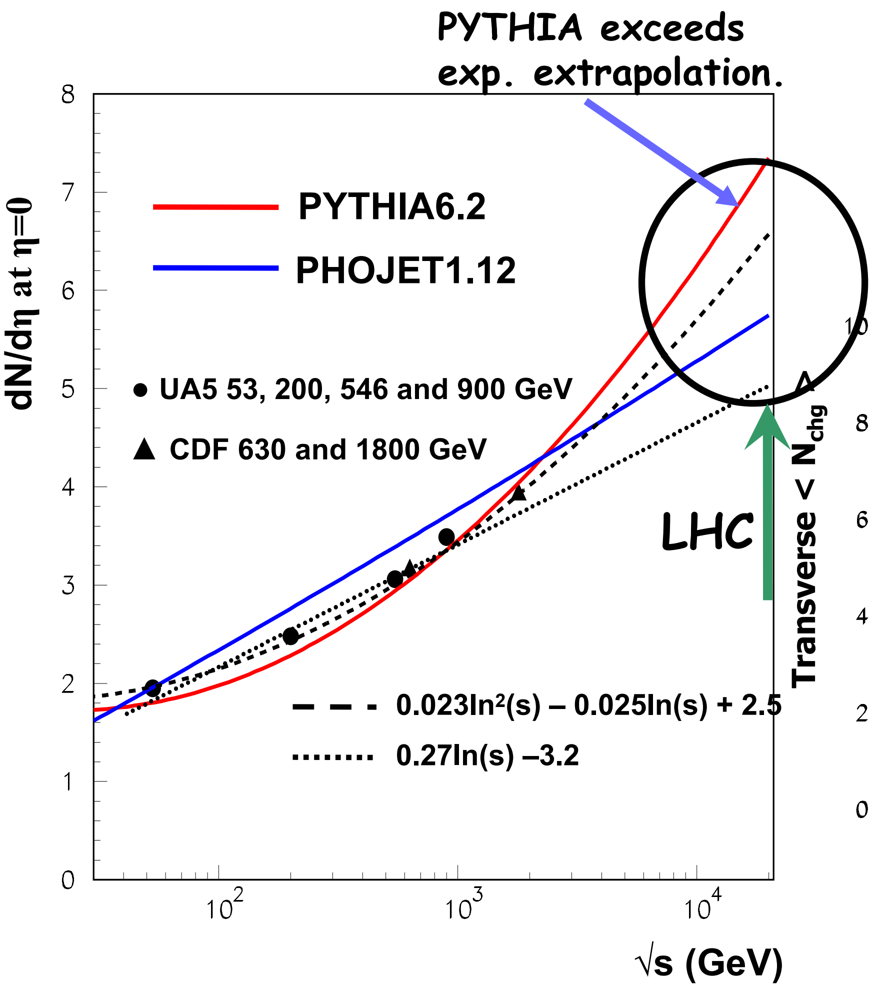


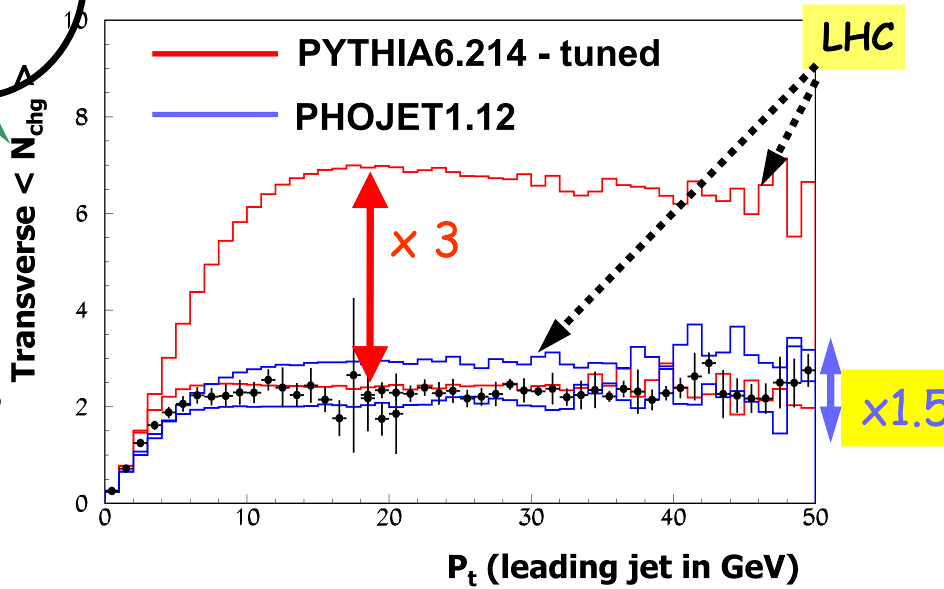
CDF Run 1 underlying event analysis

Phys. Rev. D, **65** 092002 (2002)



Extrapolation to the LHC-Comparison with PHOJET

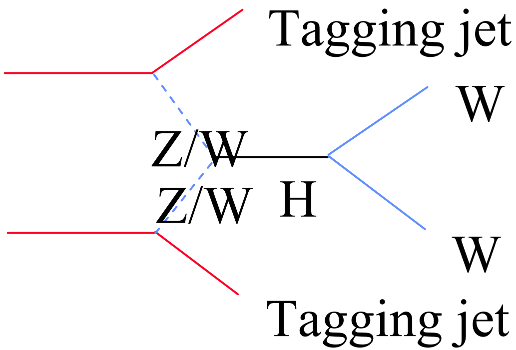


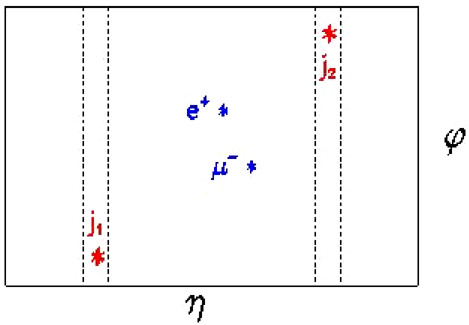


VBF Signal (H→WW→lνlν)

Prospects for the search for a standard model Higgs boson
in ATLAS using VBF, S.Asai et al, SN-ATLAS-2003-024 -> EPJ

- forward tagging jets
- correlated leptons
- **low hadronic activity in central region**
- central Higgs production





Tag jet cuts

- Candidates are two highest P_T jets in opposite hemispheres; $|\Delta\eta|>3.8$
- $P_T^1 > 40GeV$; $P_T^2>20GeV$
- Mjj>550GeV

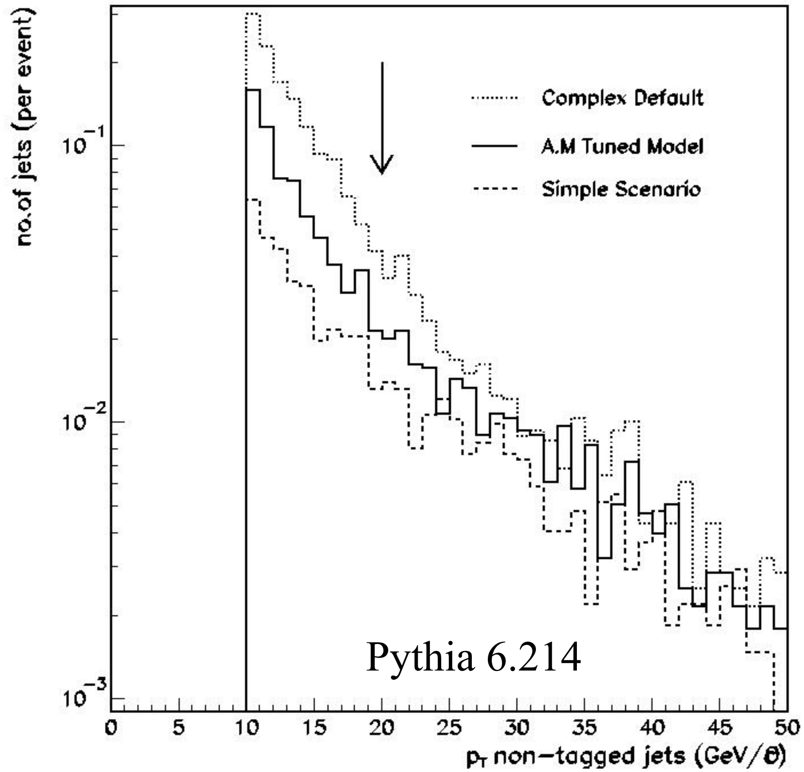
Important discovery channel
For Higgs in mass range
120-200GeV

Central-jet veto:

Cut non-tag jets in

$|\eta|<3.2$

$P_T>20GeV$



e-μ channel only
M_H=160GeV

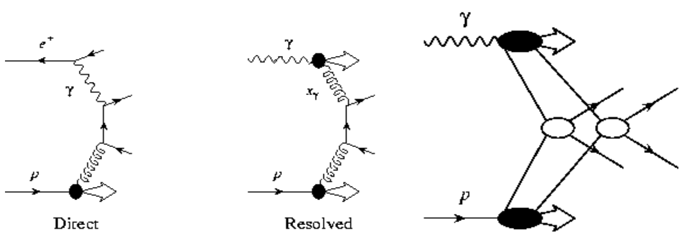
Model	CJV efficiency	Significance
Default pythia	82%	8.1
Default DG	71%	7.5
AM tuning	76%	7.6
Paper	86%	8.2

Jetweb comparison

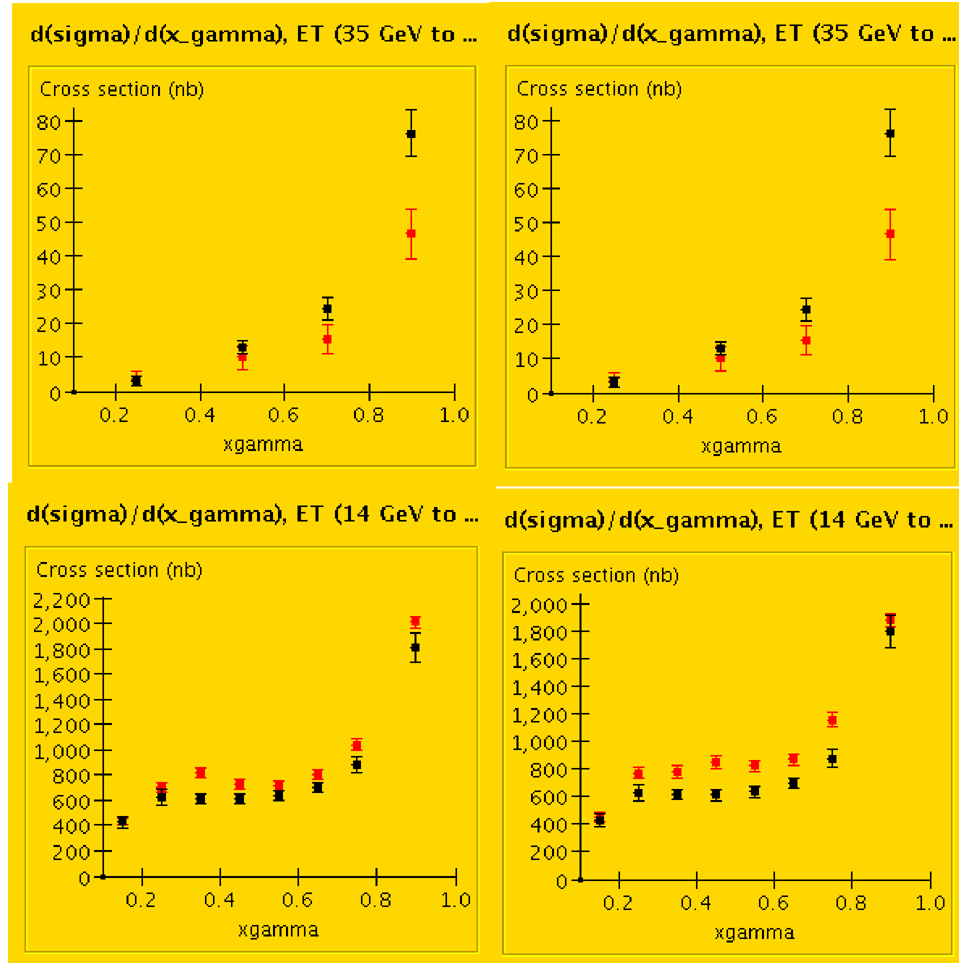
Preliminary

ZEUS precision di-jet
Photoproduction data

	$d\sigma/dx_\gamma$ χ^2/DF	
Jet ET-range	**Default**	**AM tune**
35-90	**1.4**	**3.1**
25-35	**6.8**	**2.0**
17-25	**0.9**	**1.0**
14-17	**4.0**	**7.5**



Default Pythia Tuned Pythia



Increasing sensitivity t
Underlying event

Summary and conclusions

- PYTHIA(+PHOJET) can be 'tuned' to give a good description of minimum bias and underlying event data from 200GeV-1800GeV main parameters are: p_T-min and the proton matter distribution
- PYTHIA overestimates particle multiplicities predicted by extrapolations of data, and predictions from PHOJET at LHC energies
- Underlying event activity at the LHC greater than at Tevatron by ~x3 using tuned PYTHIA
- Compare to tunings using initial state radiation (suggested by R Field (CDF))
- Use Jetweb to compare to wider range of data: HERA, other Tevatron data