Tuning JIMMY4.31 to the Underlying Event

Arthur Moraes

University of Glasgow

ATLAS MC generator group

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Introduction:

- JIMMY simulates multiple parton interactions in hadron collisions generated by HERWIG.

  http://projects.hepforge.org/jimmy/

- JIMMY (4.31) + HERWIG (6.510) versions used are the same ones used to produce the UE tune used for MC08.
  - further discussion/reading on the previous JIMMY/CTEQ6L tune can be found in sec. 4.3 of **hep-ph/0610012** (TeV4LHC QCD group report) and in **hep-ph/0604120** (Les Houches 2005 – SM report).

- ATLAS is planning to use a new PDF set for MC09 (mLO*). New PDF sets require new tuning of the underlying event.

- Underlying event data distributions used to tune JIMMY:
  - $\langle N_{chg} \rangle$ and $\langle P_T^{sum} \rangle$ in the region transverse to the leading jet (CDF Run I data @ $\sqrt{s}$ = 1.8 TeV). **Phys. Rev. D65, 092002 (2002)**
  - dN_{chg}/dp_T spectrum of particles in the underlying event (same CDF data as above). **Phys. Rev. D65, 092002 (2002)**
  - MAX/MIN cones transverse to the leading jet (CDF Run I data @ $\sqrt{s}$ = 630 GeV and $\sqrt{s}$ = 1.8 TeV) **Phys. Rev. D70, 072002 (2004)**

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

- **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:

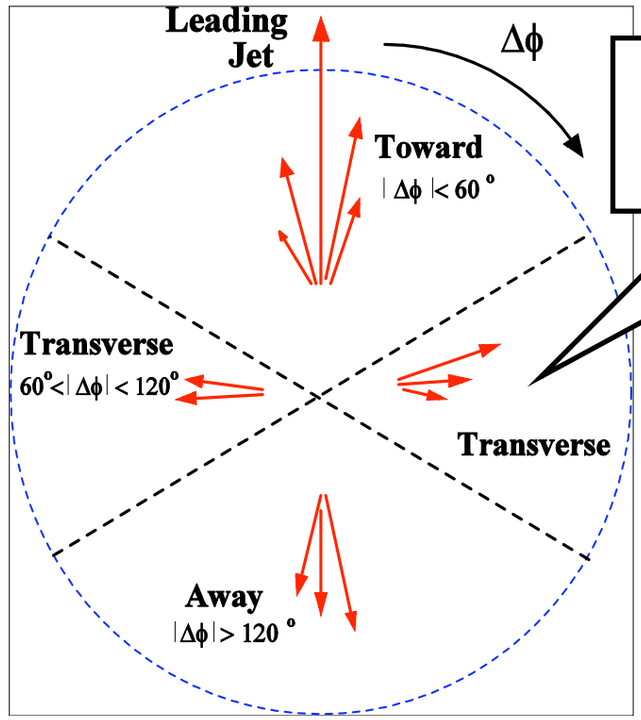
- charged particles:

p_t>0.5 GeV and $|\eta|$<1

- **cone jet finder:**

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

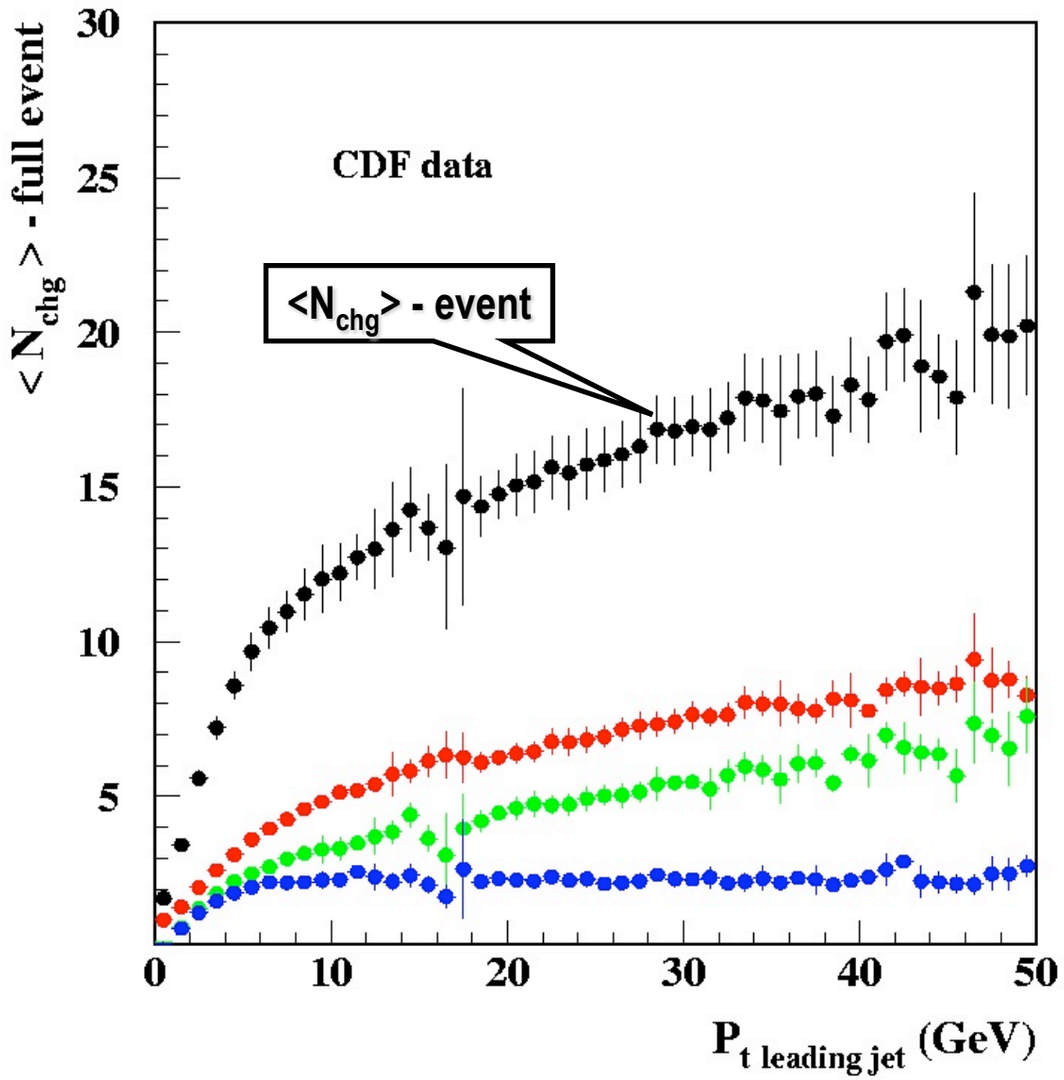
$\Delta\phi = \phi - \phi_{ljet}$

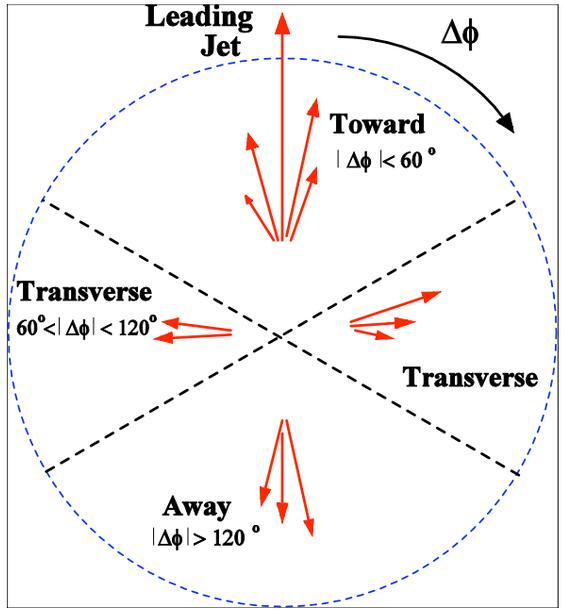


UE is defined as the Transverse Region

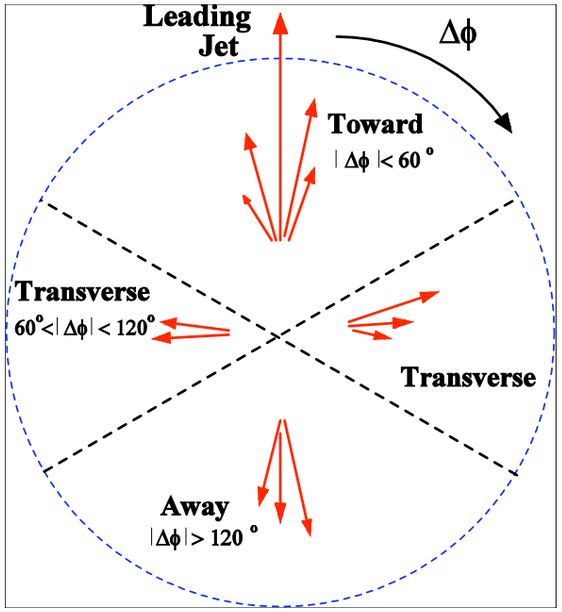
Phys. Rev. D65, 092002 (2002)

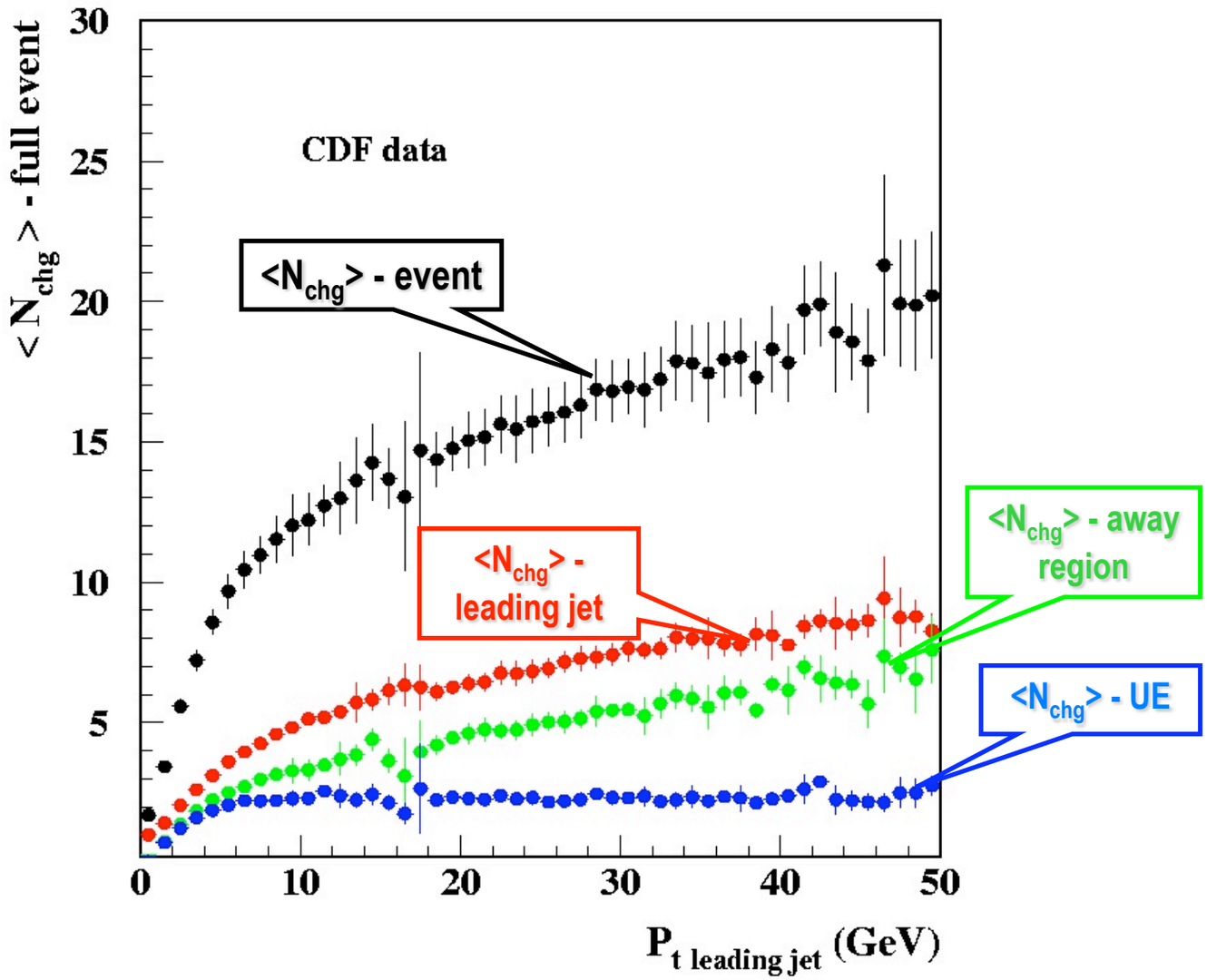
$\langle N_{chg} \rangle$ distributions (particles from different angular regions)





$\langle N_{chg} \rangle$ distributions (particles from different angular regions)



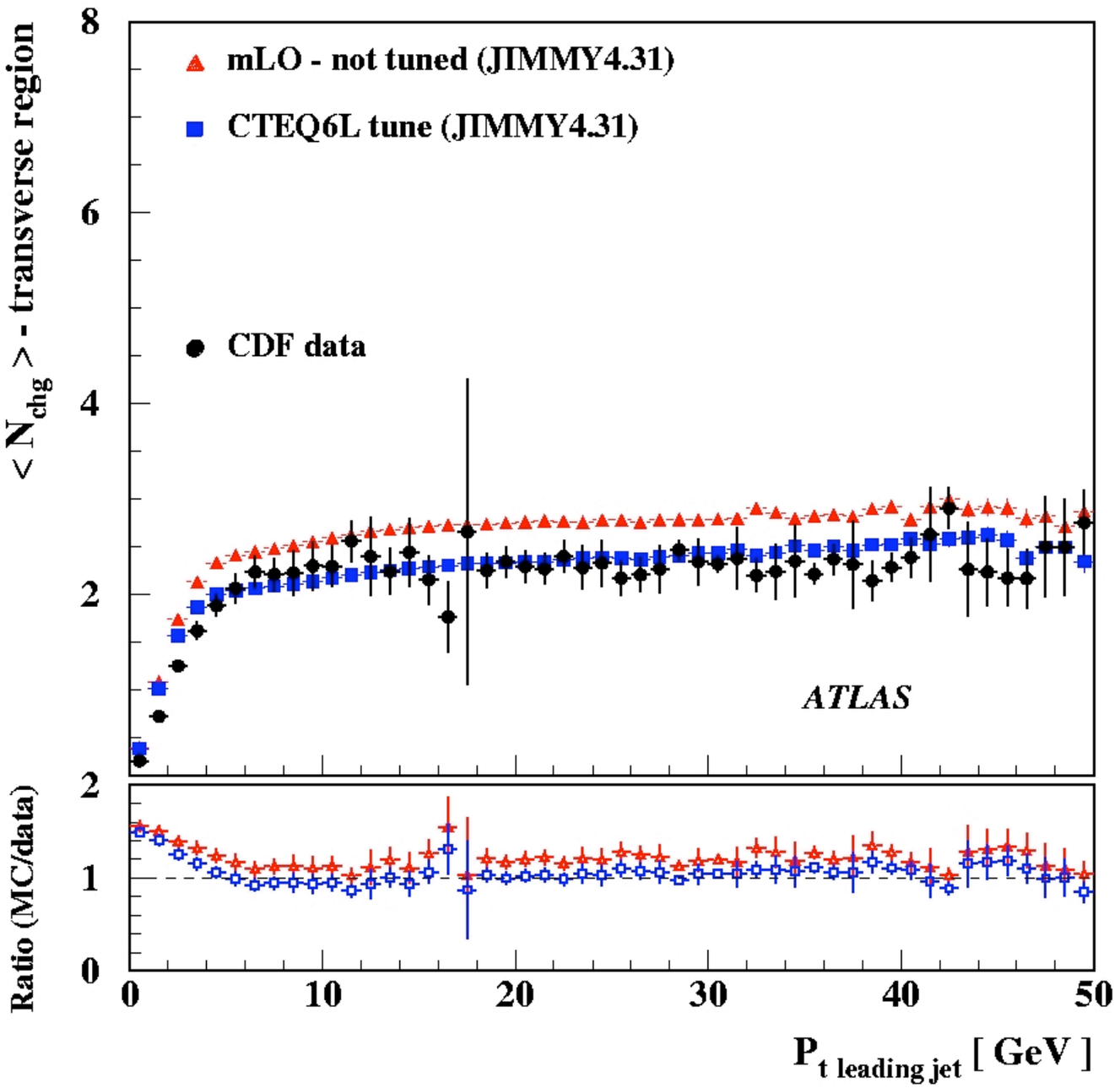


Generating events with mLO*:

- New PDF set: mLO*
(set ID: 20650 in LHAPDF)

– mLO with “old” ATLAS tune generates too many particles/ activity (similar to what is observed in PYTHIA).

– Requires new tuning to the UE data.

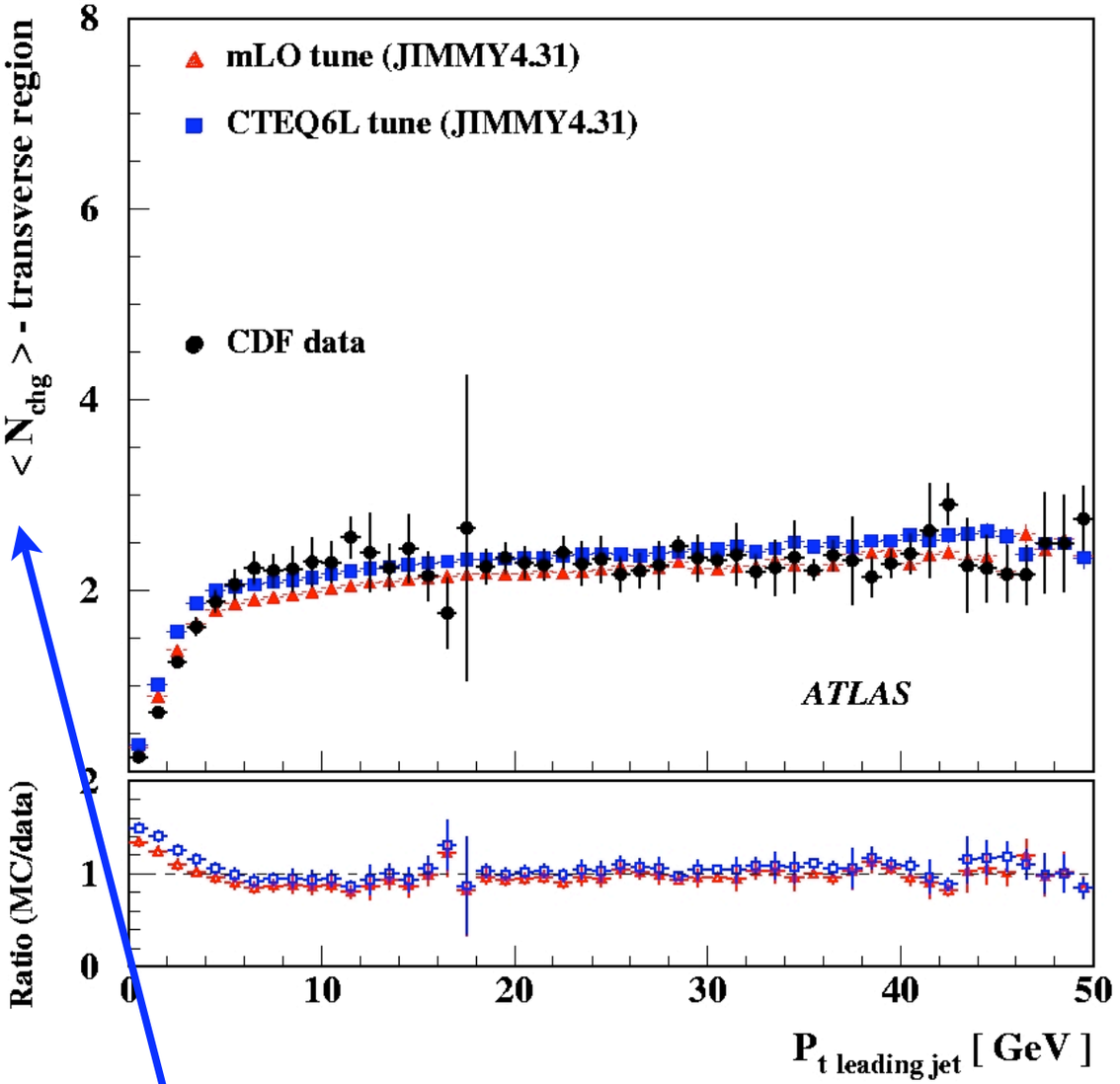


Parameters tuned:

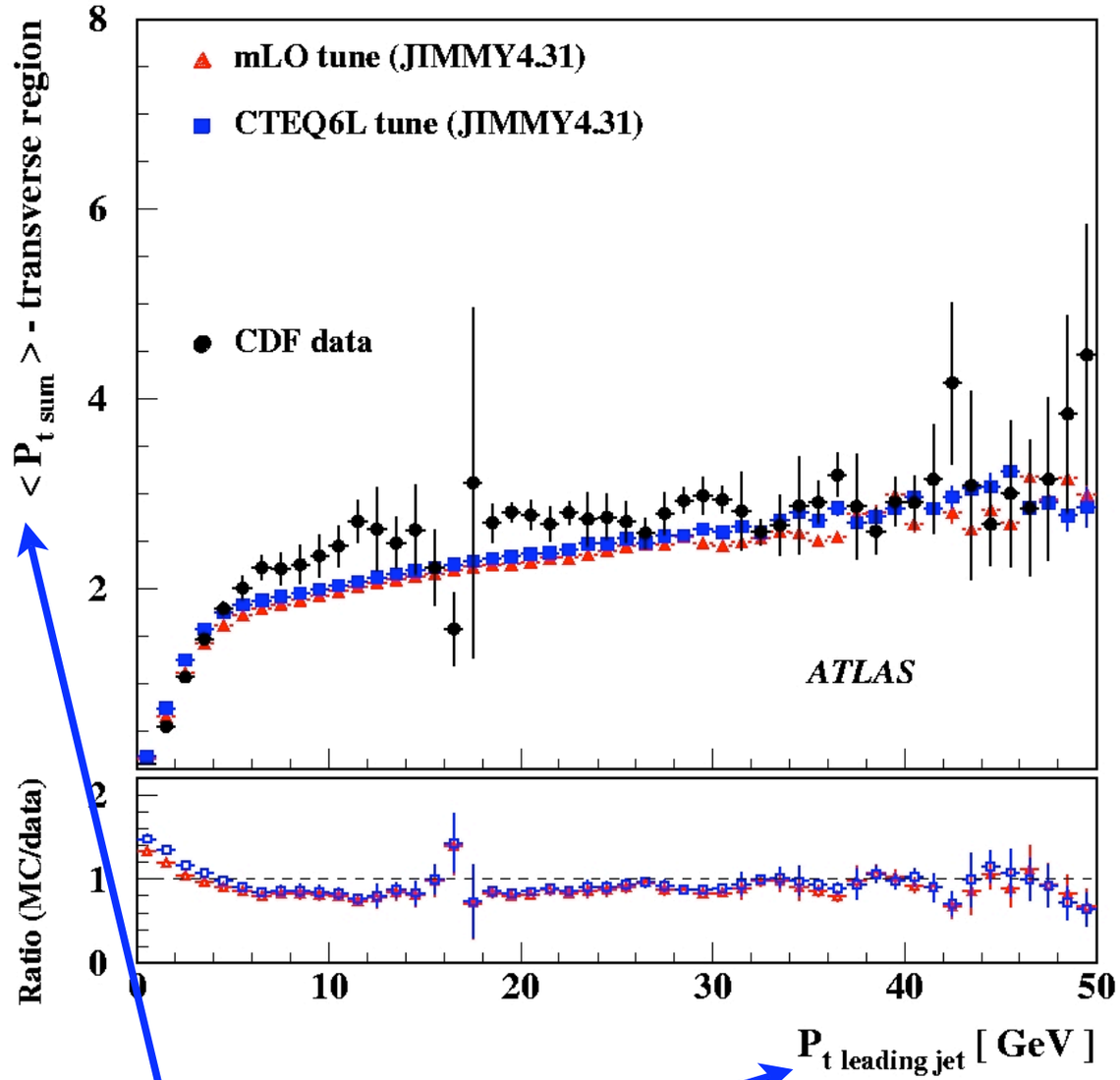
JIMMY4.31 + HERWIG6.510

Previous ATLAS tune:	*New* proposed tune:	
CTEQ6L (set ID: 10042)	mLO (set ID: 20650)	→ LHAPDF
PTMIN = 10	PTMIN = 10	
PTJIM = 2.8 x $(\sqrt{s}/1.8\text{TeV})^{0.274}$	PTJIM = 3.6 x $(\sqrt{s}/1.8\text{TeV})^{0.274}$	
JMRAD(73) = 1.8	JMRAD(73) = 2.2	
JMRAD(91) = 1.8	JMRAD(91) = 2.2	→ Note: option only used for anti-protons (not needed for LHC simulation!)

Describing the region transverse to the leading jet

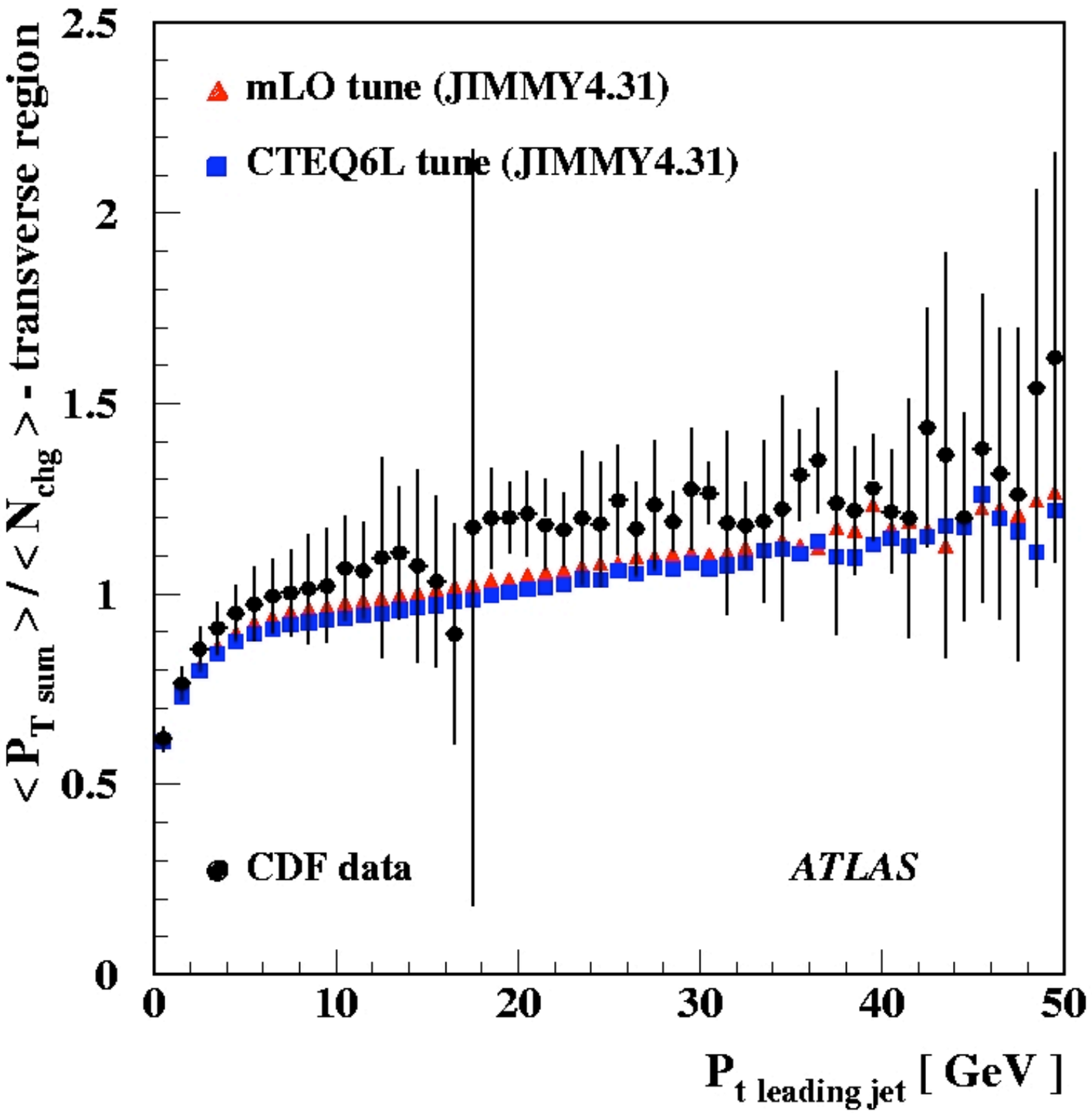


Average multiplicity of charged particles in the underlying event associated to a leading jet with P_t^{ljet} (GeV).



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

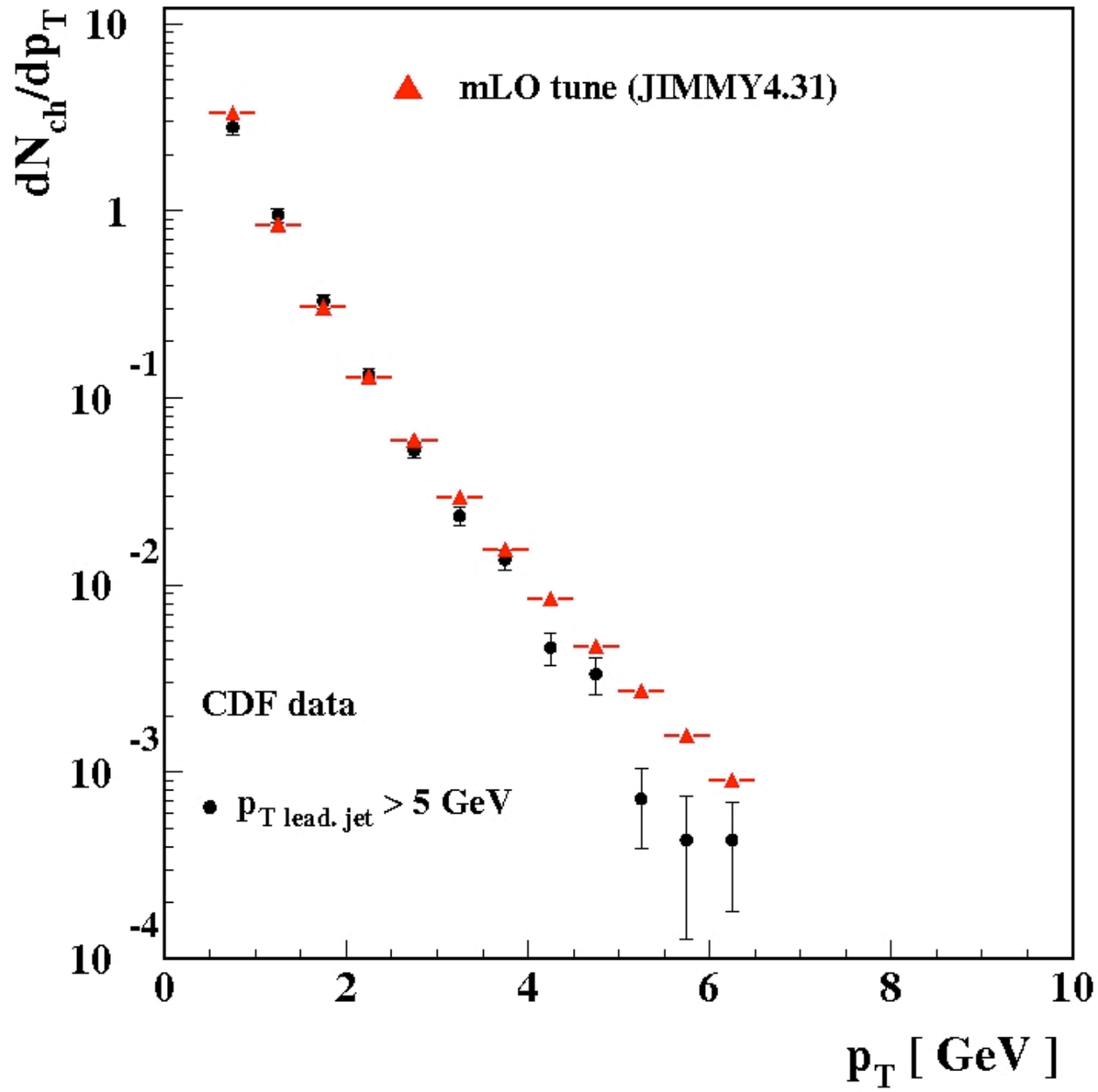
Describing the region transverse to the leading jet



Requires a "mechanism" similar to the color reconnection model implemented by PYTHIA to improve on this distribution!

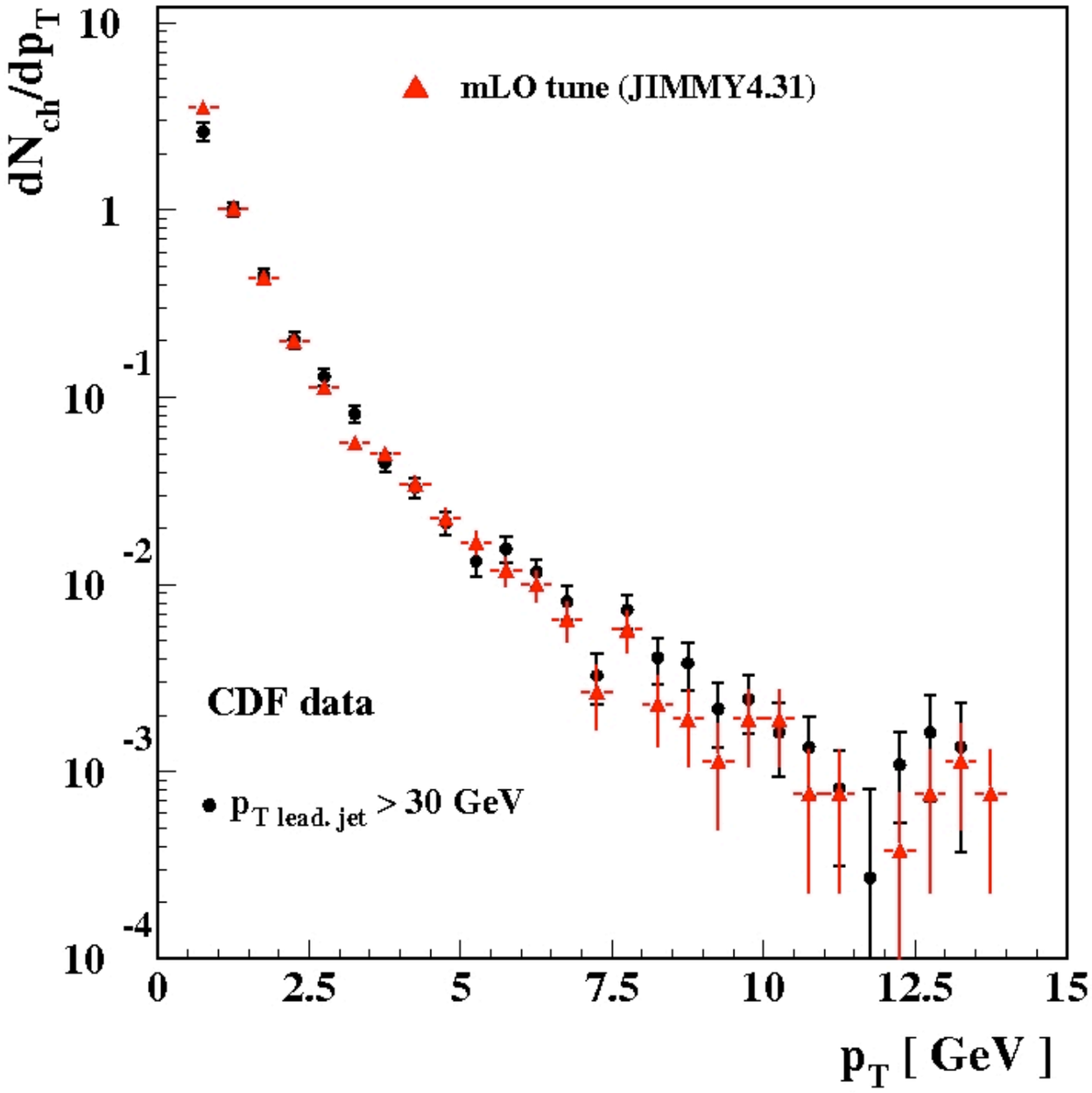
Describing the region transverse to the leading jet

dN_{chg}/dp_T spectrum:
charged particles in the underlying event for p_T leading jet > 5 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.

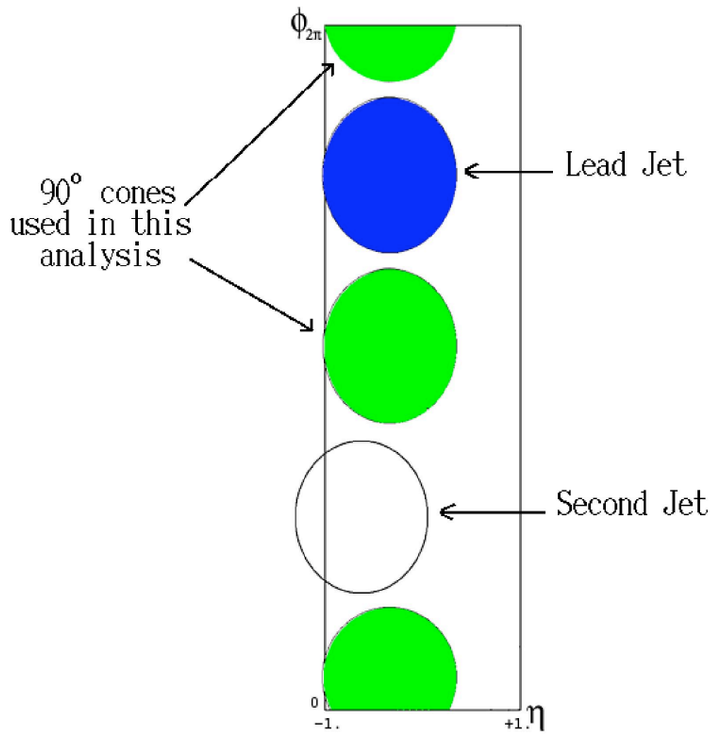
- Two cones in $\eta-\phi$ space are defined:

$\eta=\eta_{ljet}$ (same as the leading jet)

$\phi=\phi_{ljet} \pm 90°$

$R=0.7$

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

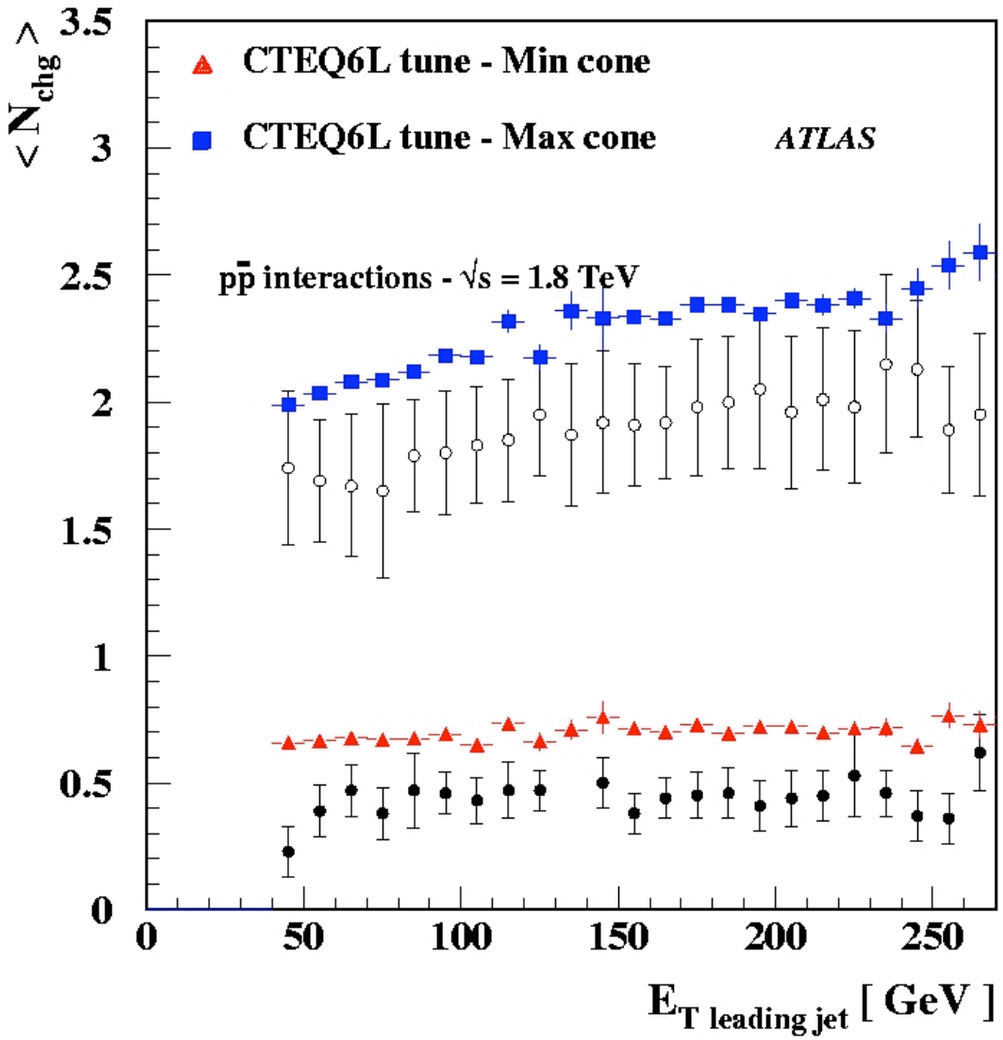


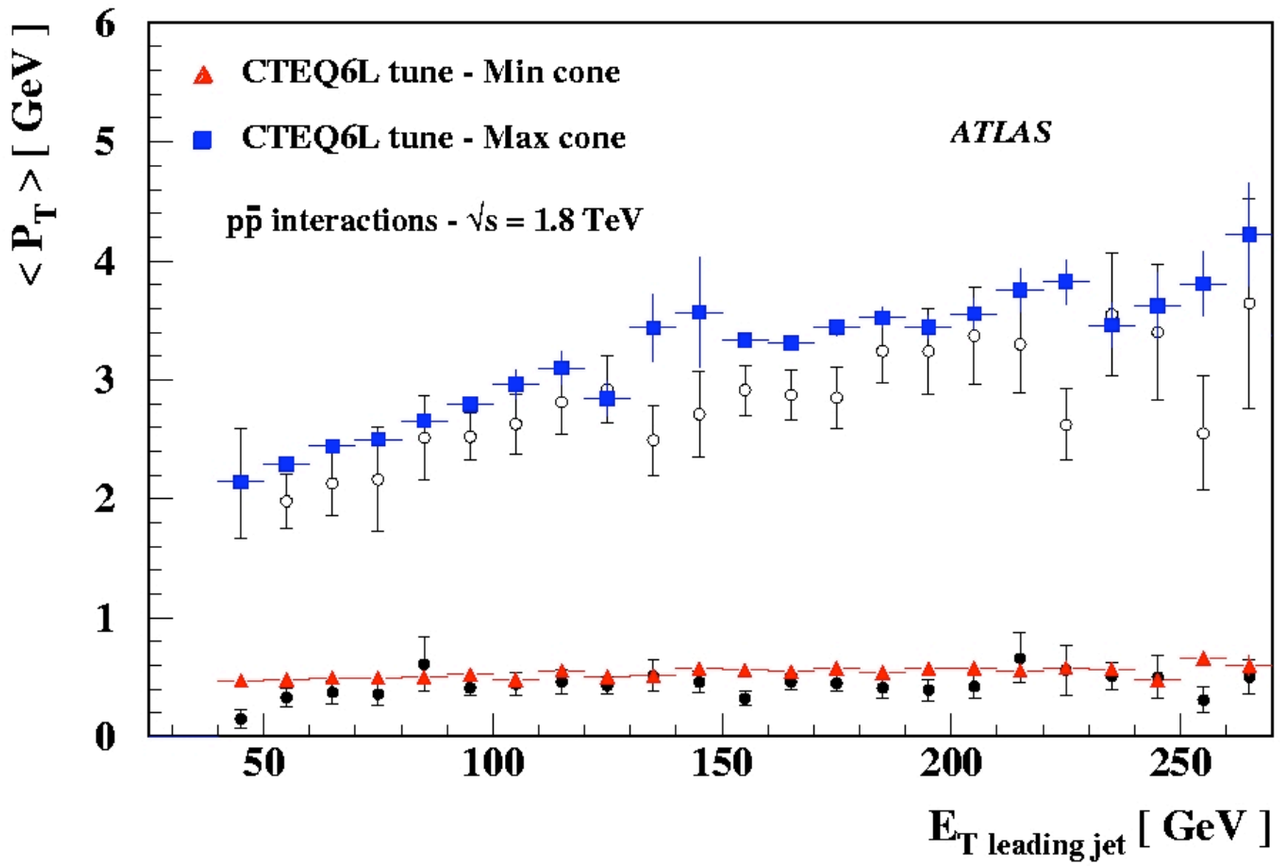
- This provides important information on how to model the energy extrapolation in UE models.

- Distributions at different energies used to tune energy dependence in PTJIM.

"MAX / MIN analysis"

$p\bar{p}$ collisions at $\sqrt{s}$=1.8TeV

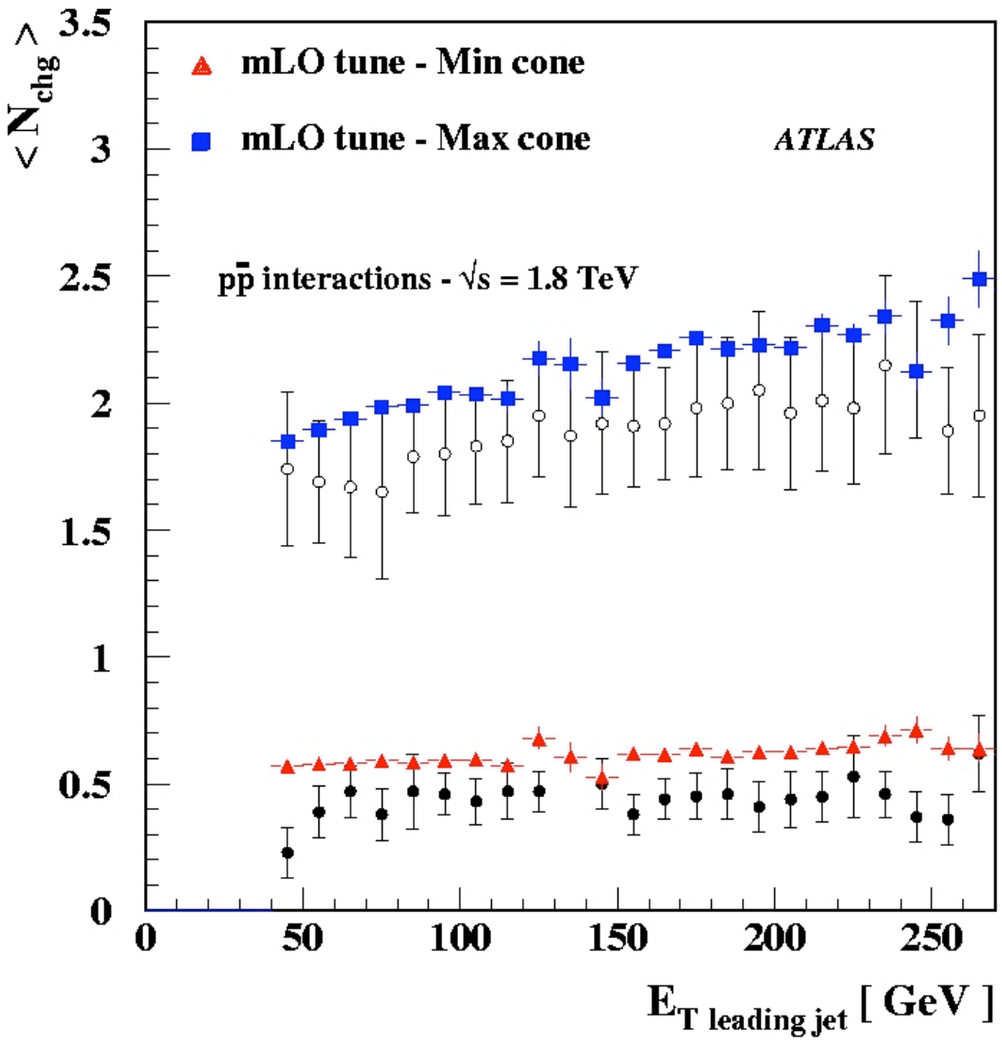


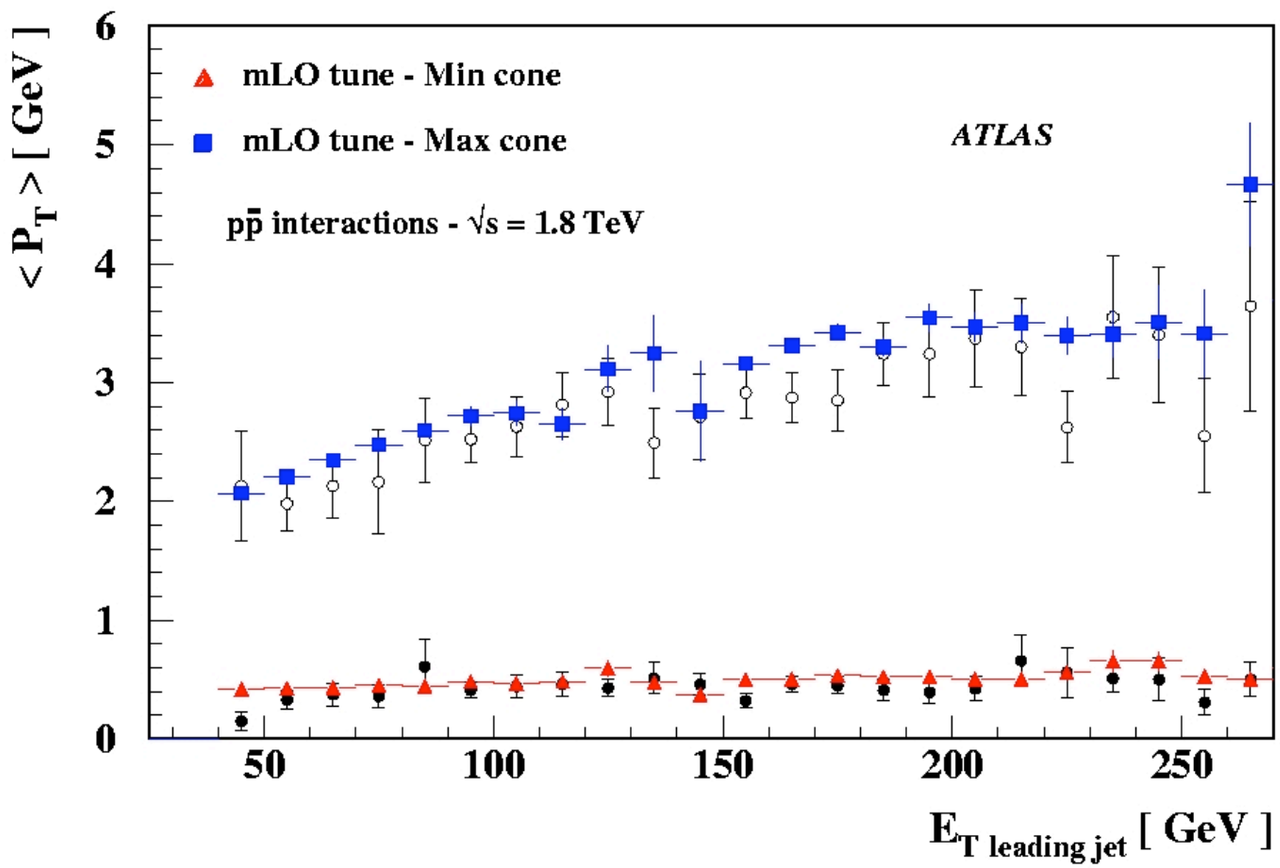


CTEQ6L tune (MC08): reasonable description for $<P_T>$ but not for <Nchg>

“MAX / MIN analysis”

$p\bar{p}$ collisions at $\sqrt{s}$=1.8TeV

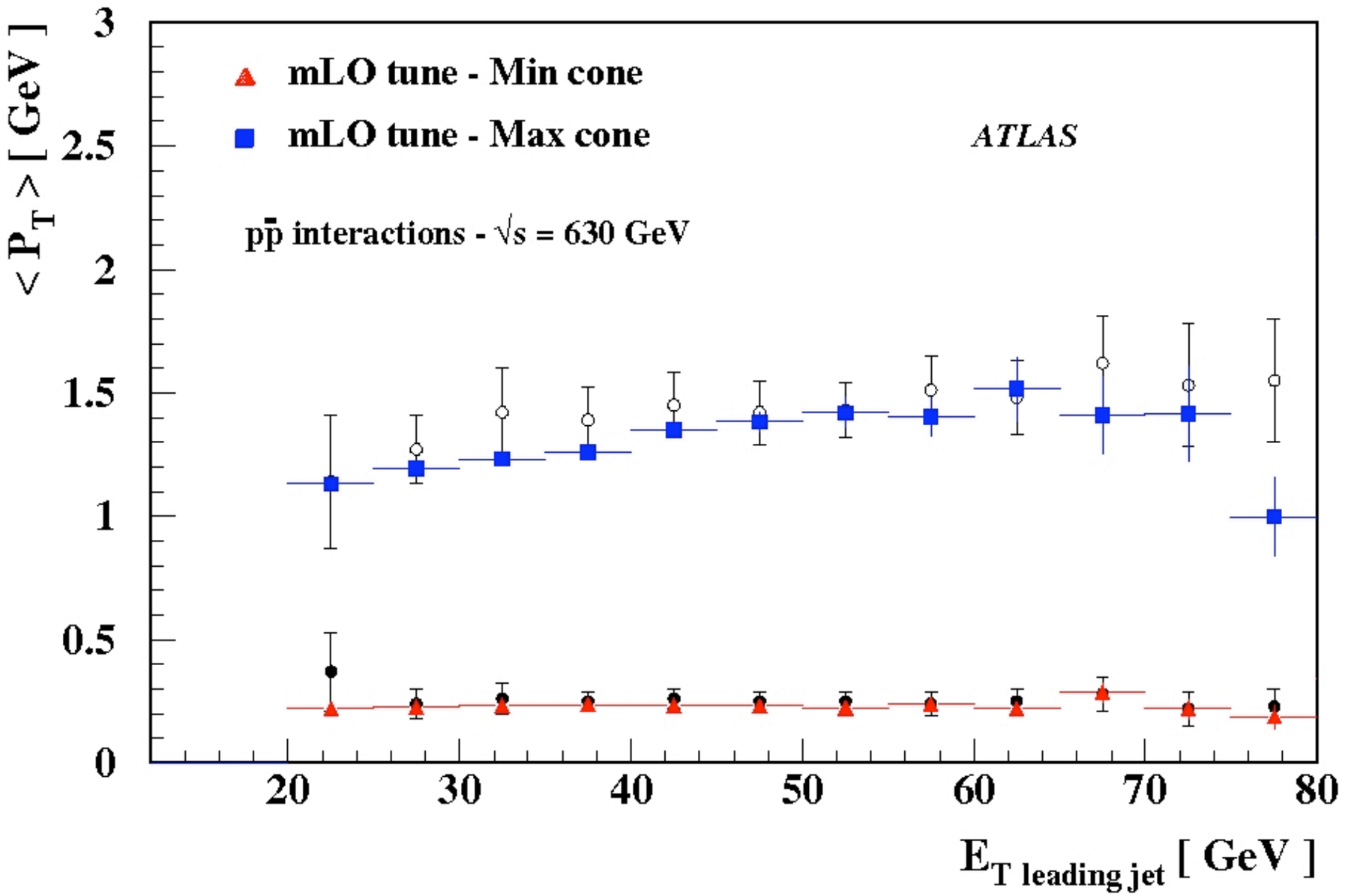




mLO* tune: improved <Nchg> description.

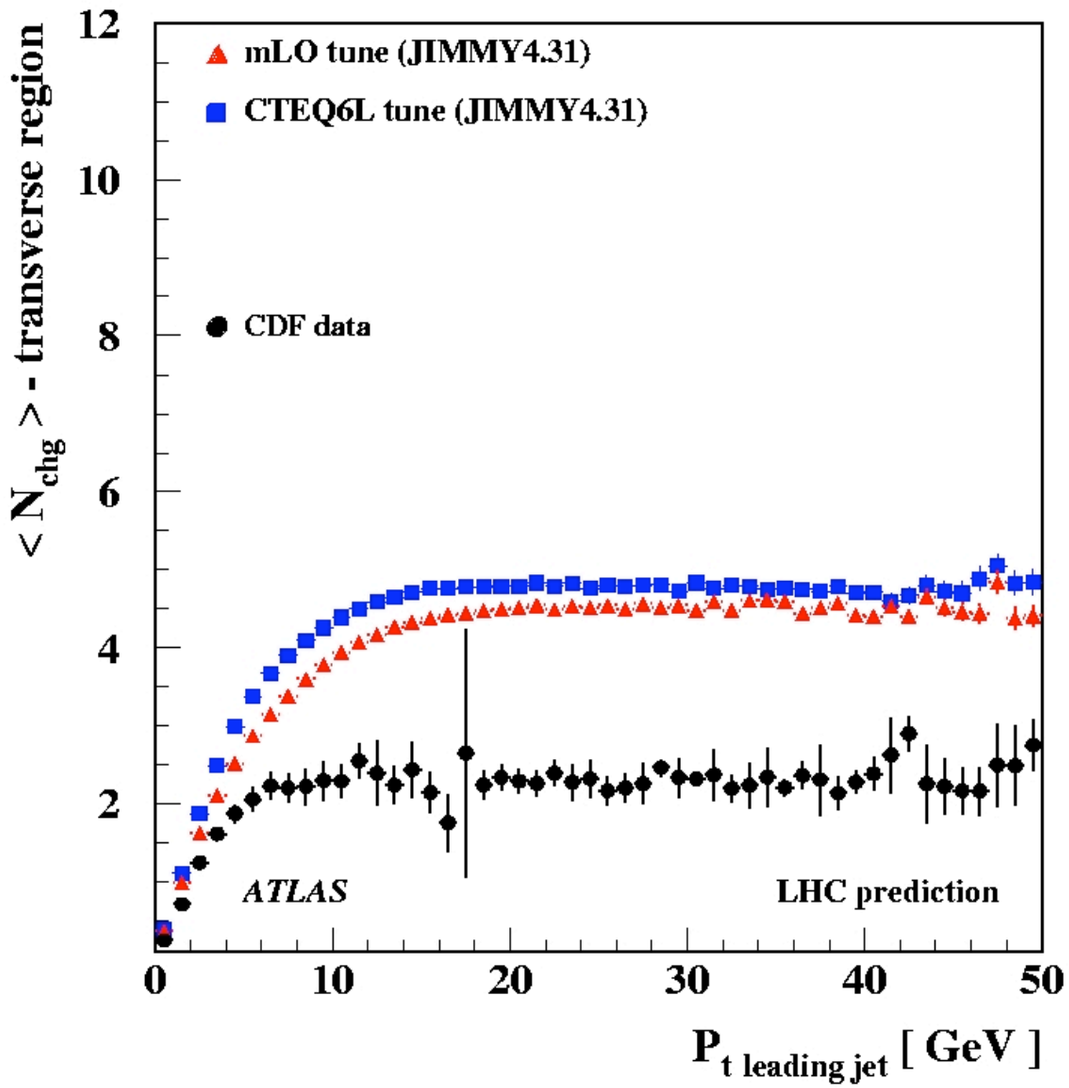
“MAX / MIN analysis”

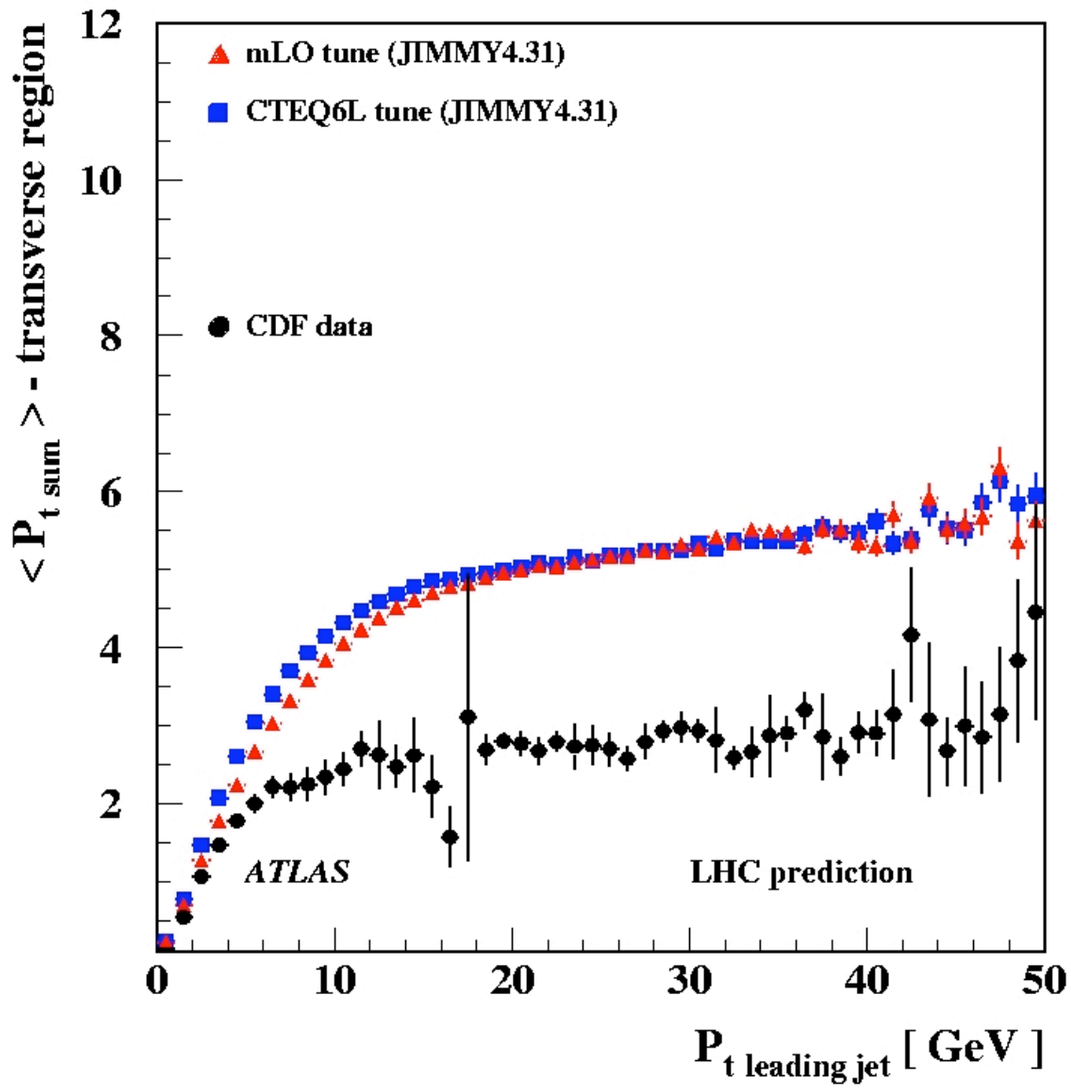
$p\bar{p}$ collisions at $\sqrt{s}$=630 GeV



LHC Predictions: describing the region transverse to the leading jet

pp collisions @ √s=10 TeV





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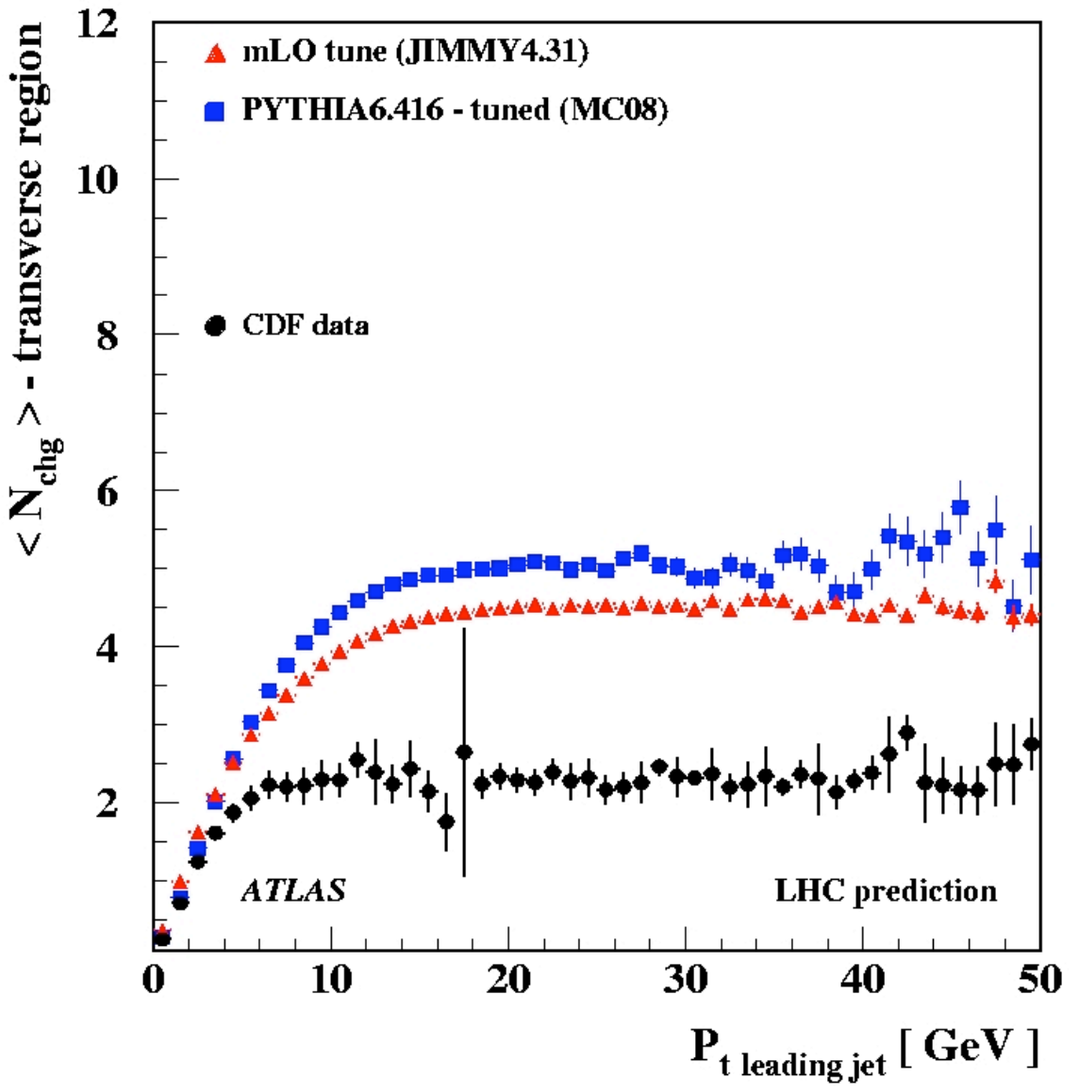

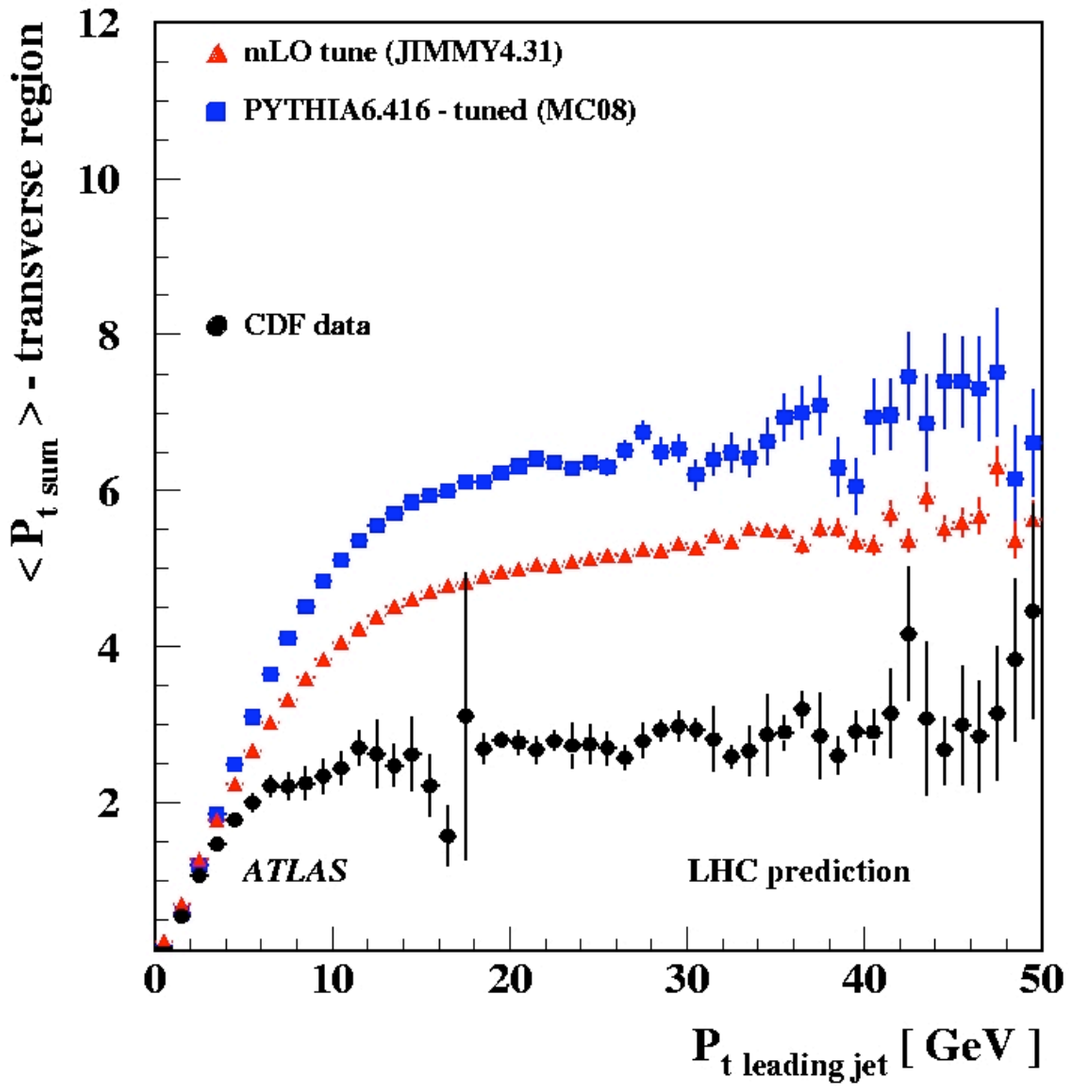

Summary:

- JIMMY4.31/HERWIG6.510 (mLO) parameters tuned to the UE:

mLO pdf
(set ID: 20650)

PTMIN = 10

PTJIM = 3.6 x $(\sqrt{s}/1.8\text{TeV})^{0.274}$ → $\sqrt{s}$=10 TeV **PTJIM = 5.8** → $\sqrt{s}$=14 TeV **PTJIM = 6.3**

JMRAD(73) = 2.2

- Results are comparable to those obtained with previous tunings.
- $\langle p_T \rangle / N_{chg}$ hasn't improved (requires a mechanism similar to the generator of shorter strings and more connections to the hard scatter system used by PYTHIA6.4).
- JIMMY is not supposed to be used for minimum bias distributions (see JIMMY manual).