

Studies of Underlying-Event Activity in Proton+Proton Collisions by STAR

Li Yi

Yale University

On behalf of the STAR Collaboration

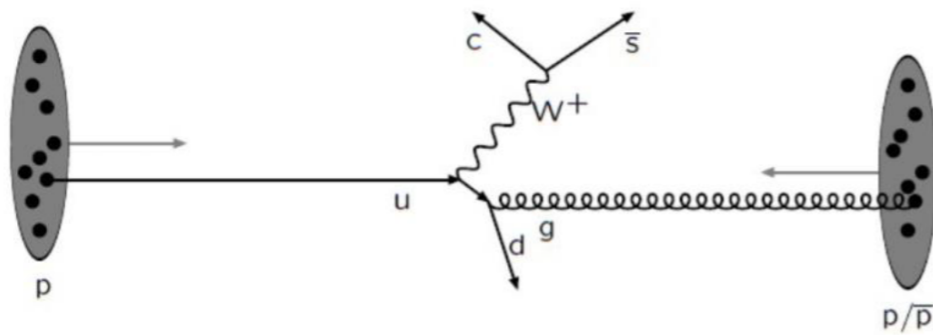
DNP 2016

2016.10.15

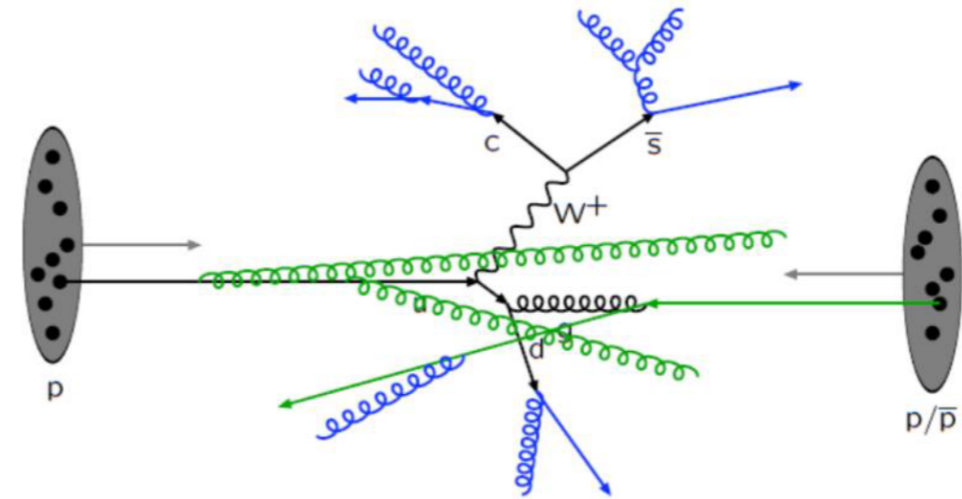


Motivation

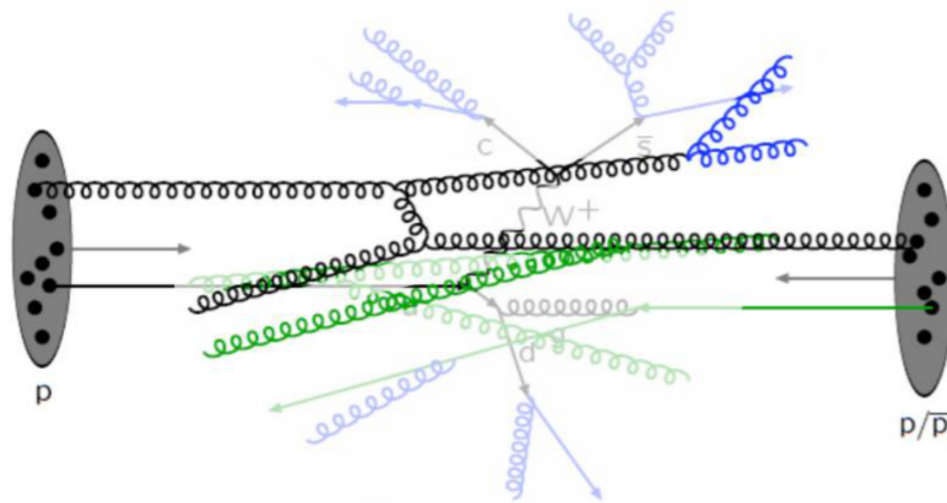
Hard Scattering



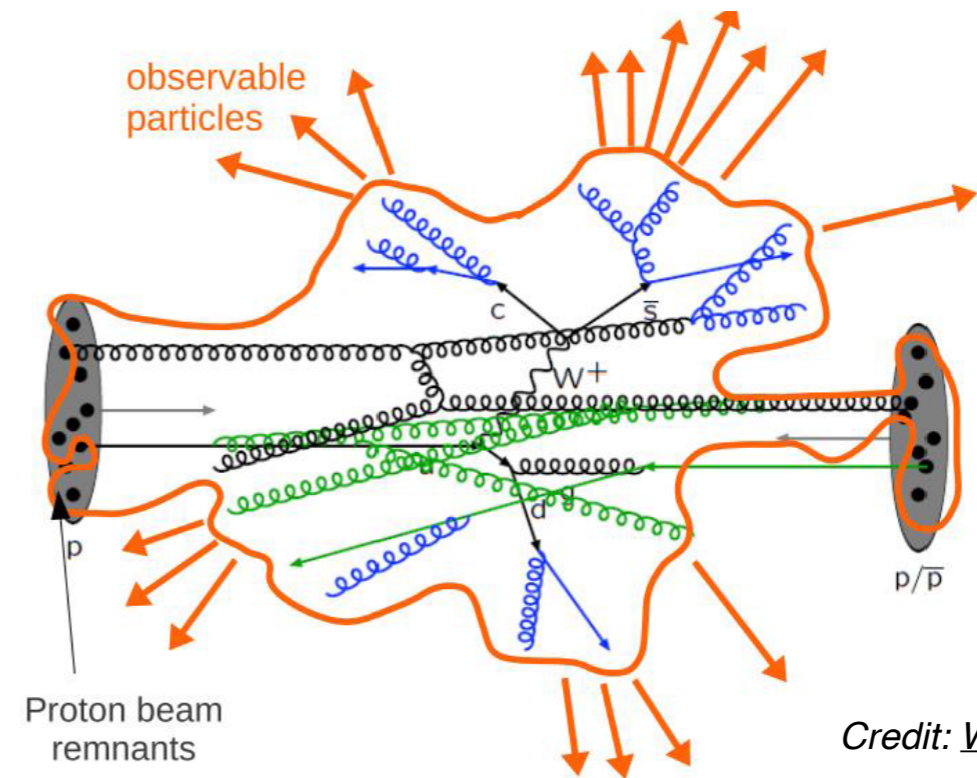
Initial / Final State Radiation (ISR/FSR)



Multiple Parton Interaction (MPI)



Color reconnection with beam remnants

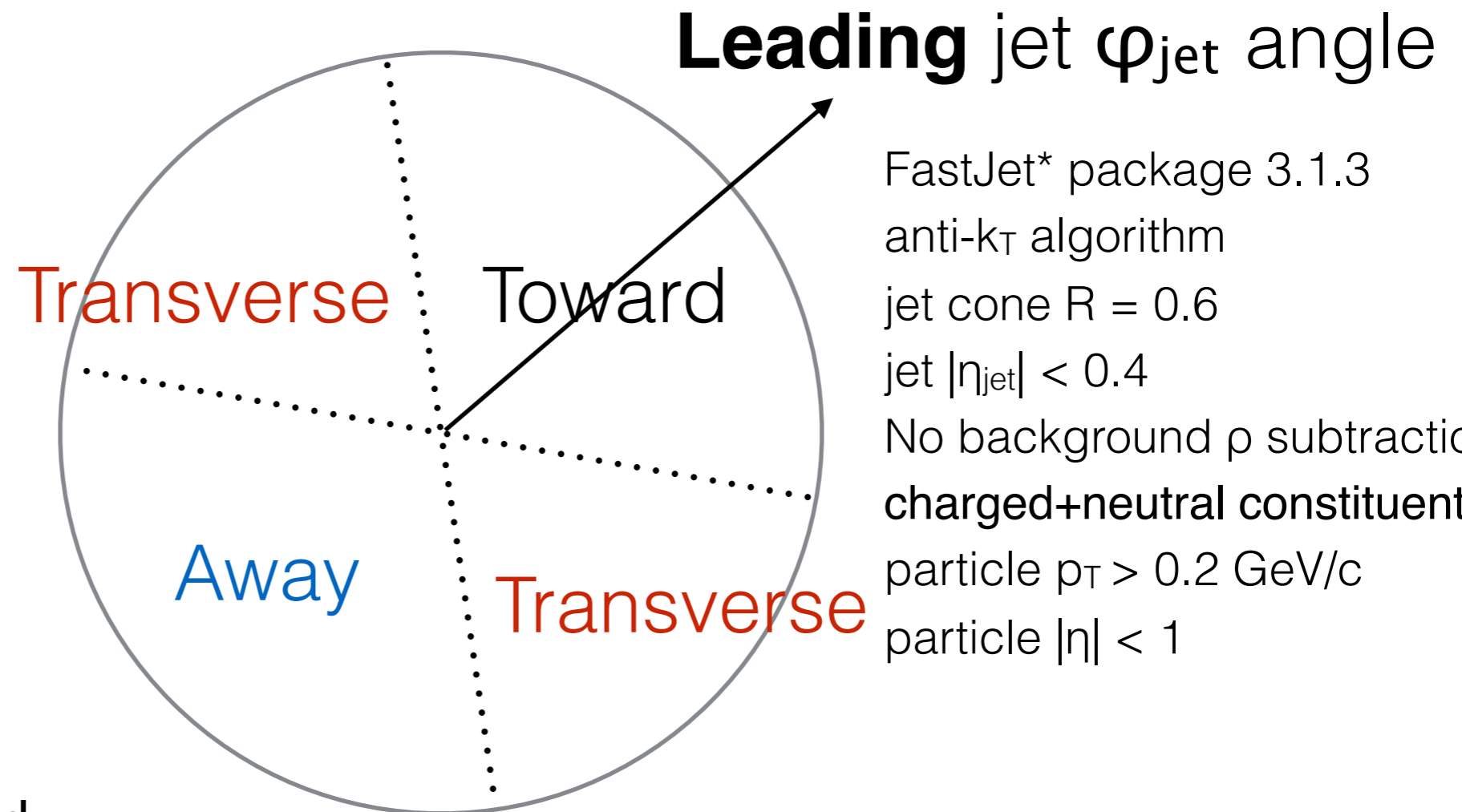


Credit: Wei Yang Wang

Underlying-event activity:

- particle productions not directly from the final fragmentation of hard-scattered partons (gluons/quarks): ISR/FSR, MPI, Color reconnection with beam remnants...
- Tool to study non-factorizable and non-perturbative phenomena

Underlying-event Observables



$|\varphi - \varphi_{\text{jet}}| < 60^\circ \text{ --> Toward}$

$|\varphi - \varphi_{\text{jet}}| > 120^\circ \text{ --> Away}$

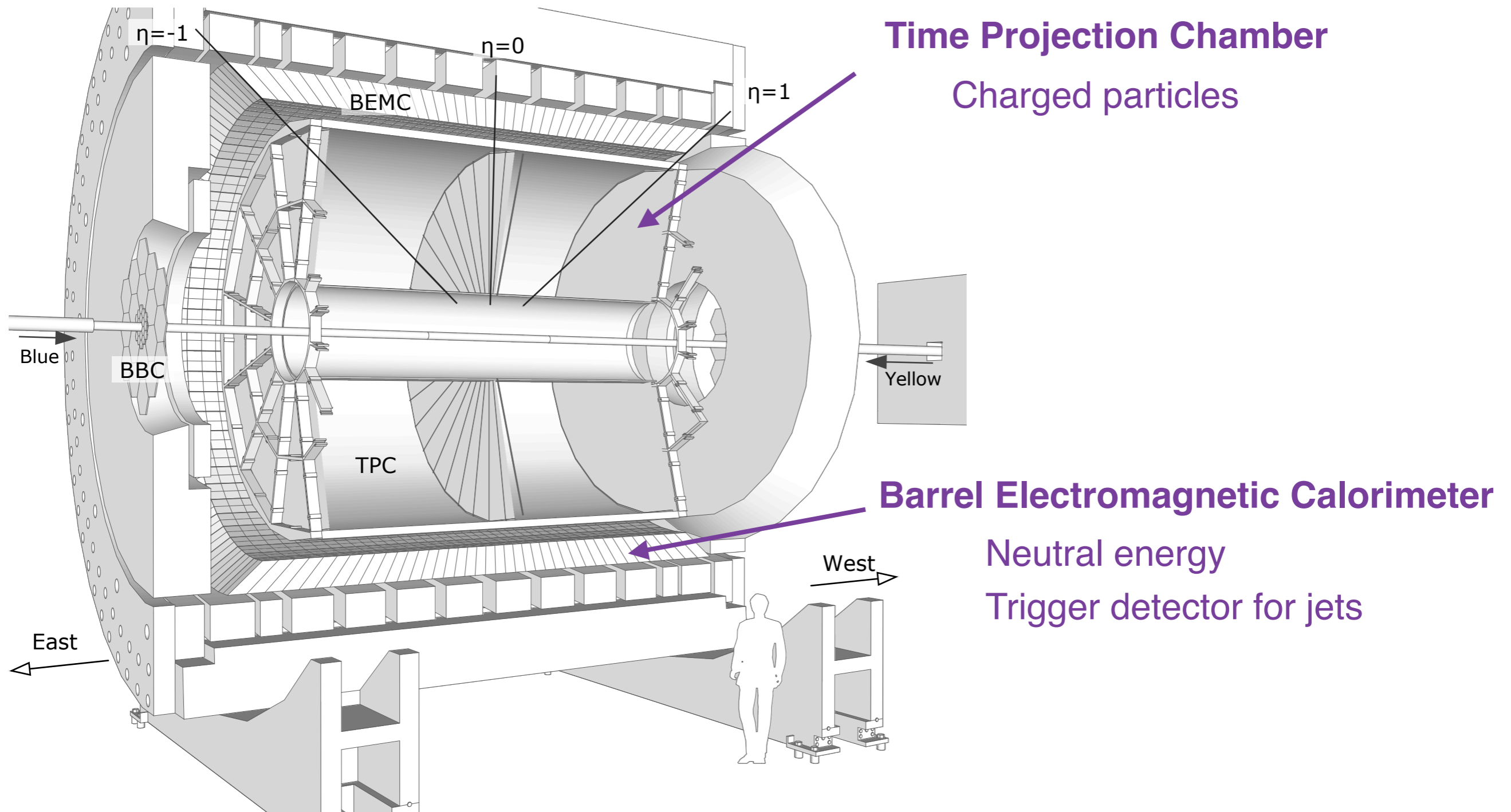
$60 \text{ degree} < |\varphi - \varphi_{\text{jet}}| < 120^\circ \text{ --> Transverse}$

Underlying event is accessed through the **Transverse** region

* FastJet package: Cacciari, Salam and Soyez, [arXiv:1111.6097](https://arxiv.org/abs/1111.6097)

STAR Detector

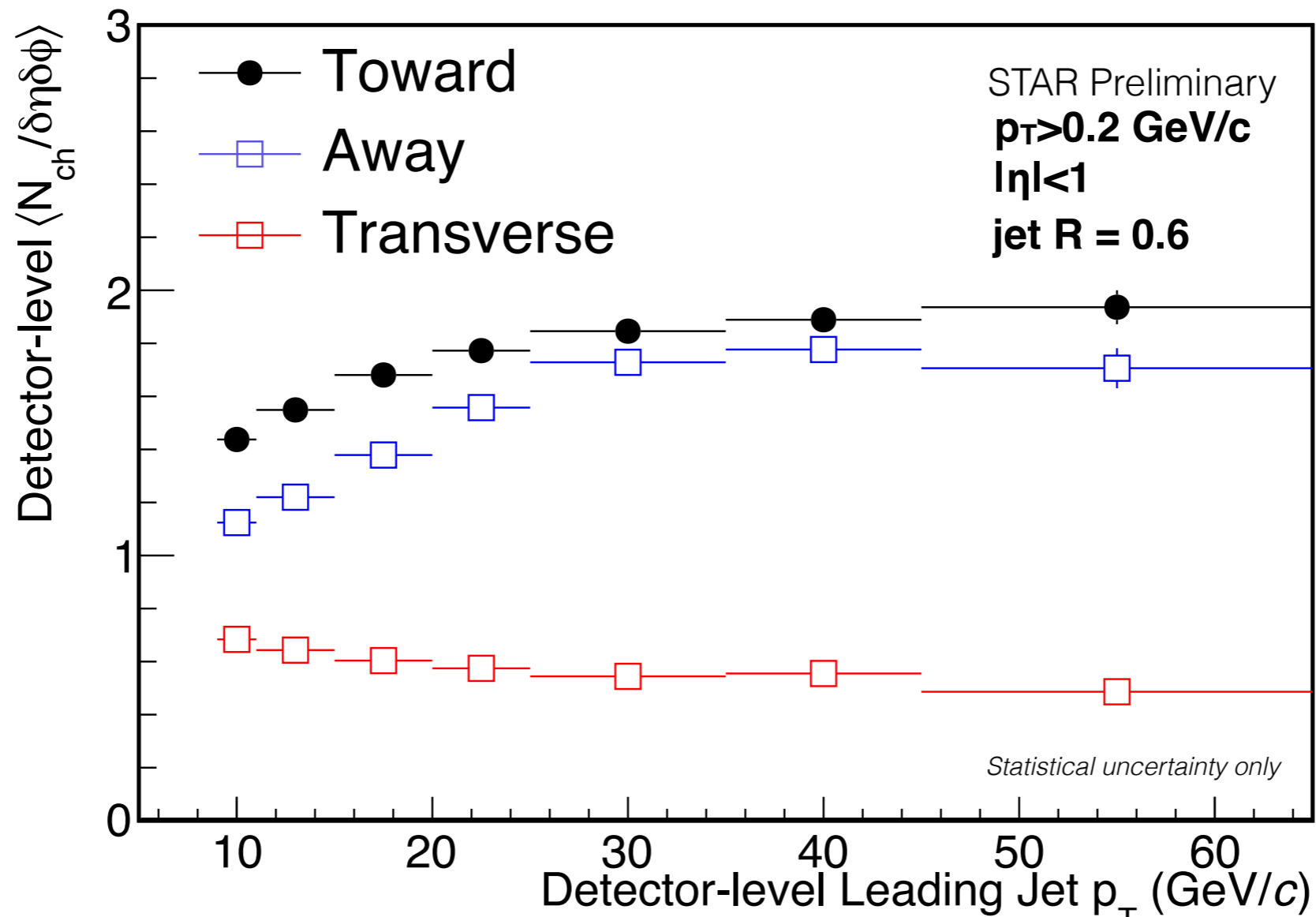
Proton+Proton collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$ and 500 GeV



Charged Particle Density

jet triggered events

p+p@200GeV Year 2012

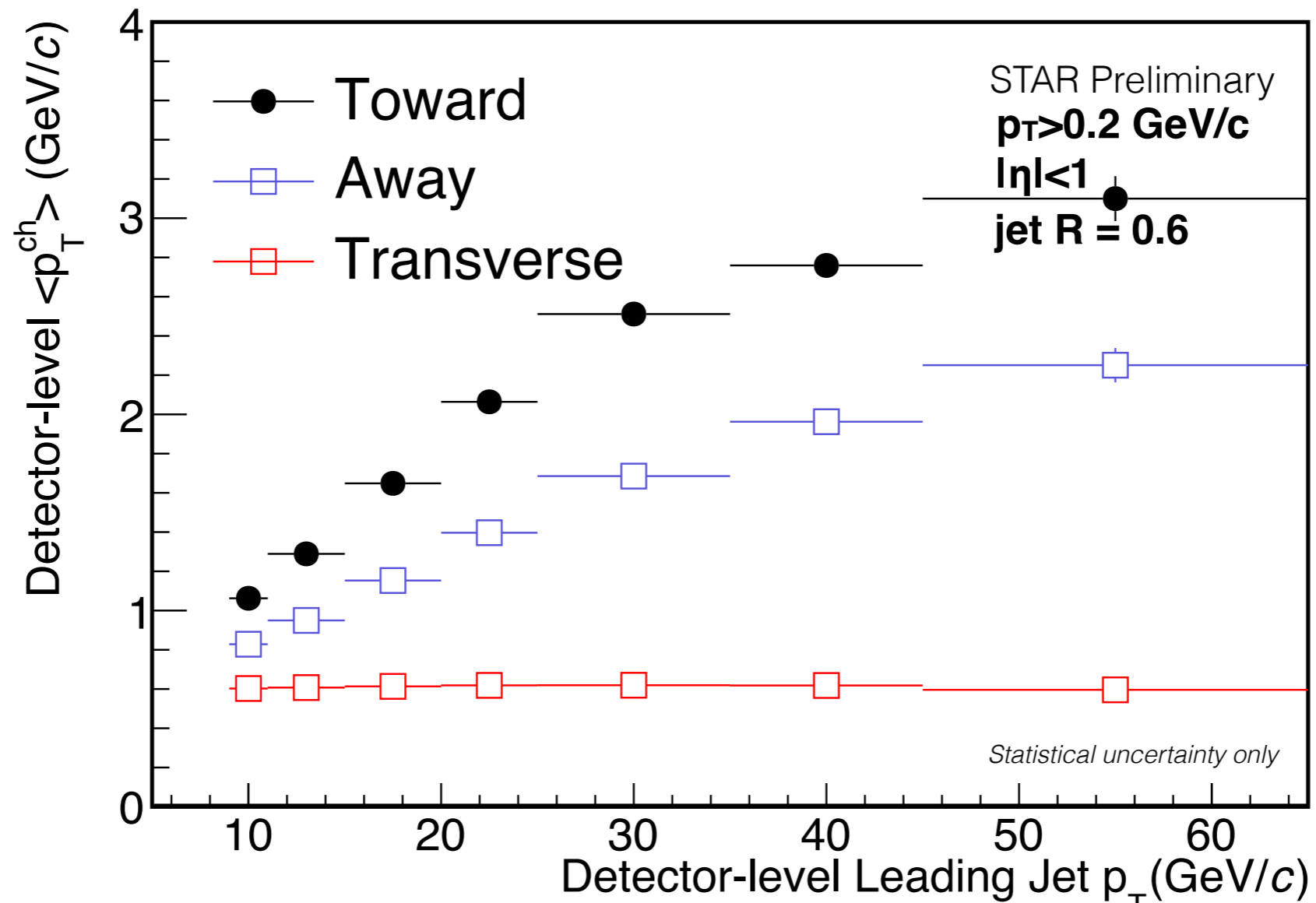


Transverse charged particle density slightly decreases with leading jet p_T for jet $p_T > 10$ GeV/c

Charged Particle Average p_T

jet triggered events

p+p@200GeV

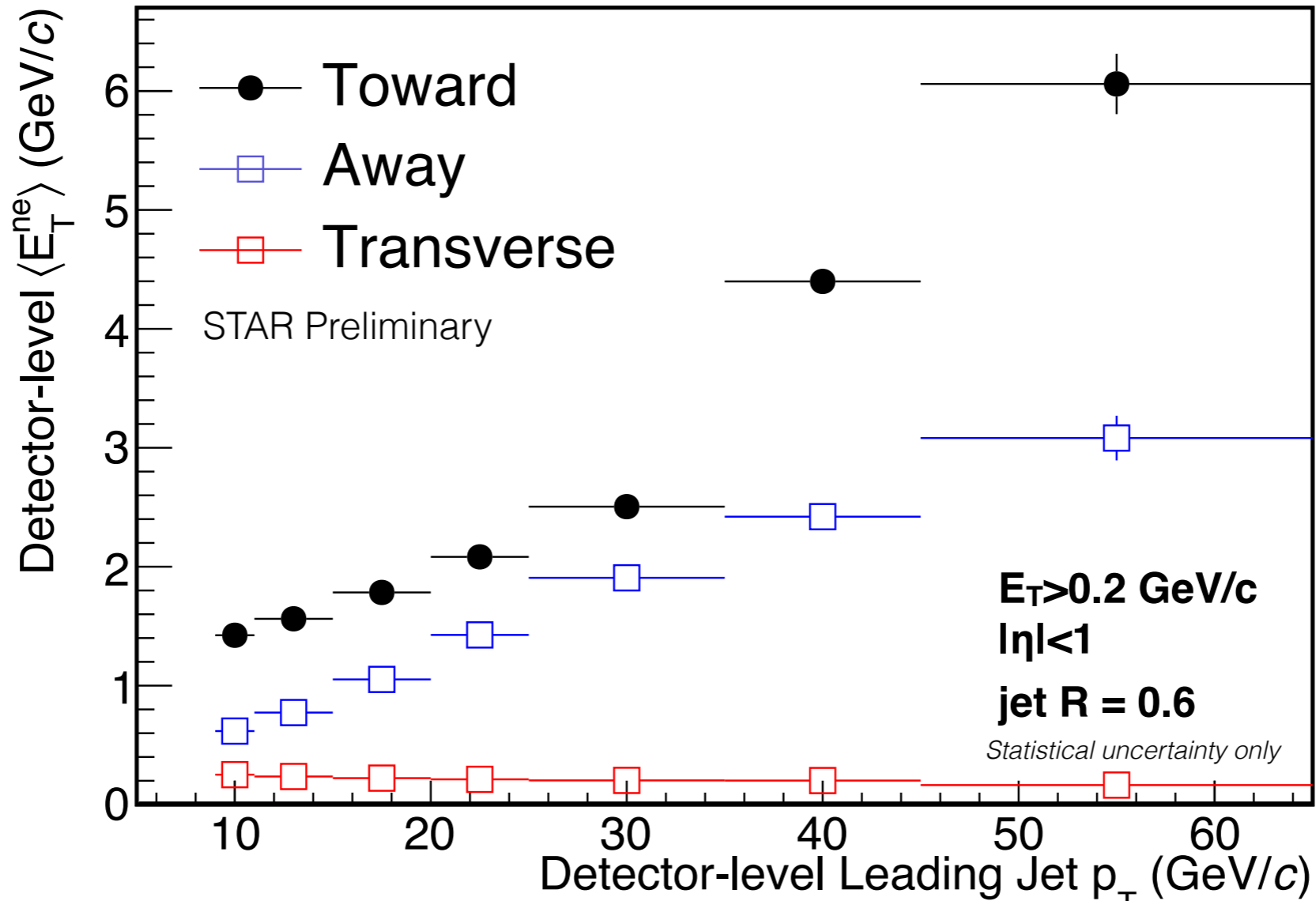


Transverse charged $\langle p_T \rangle$ weakly depends on leading jet p_T for $p_T > 10$ GeV/c

Neutral Energy Density

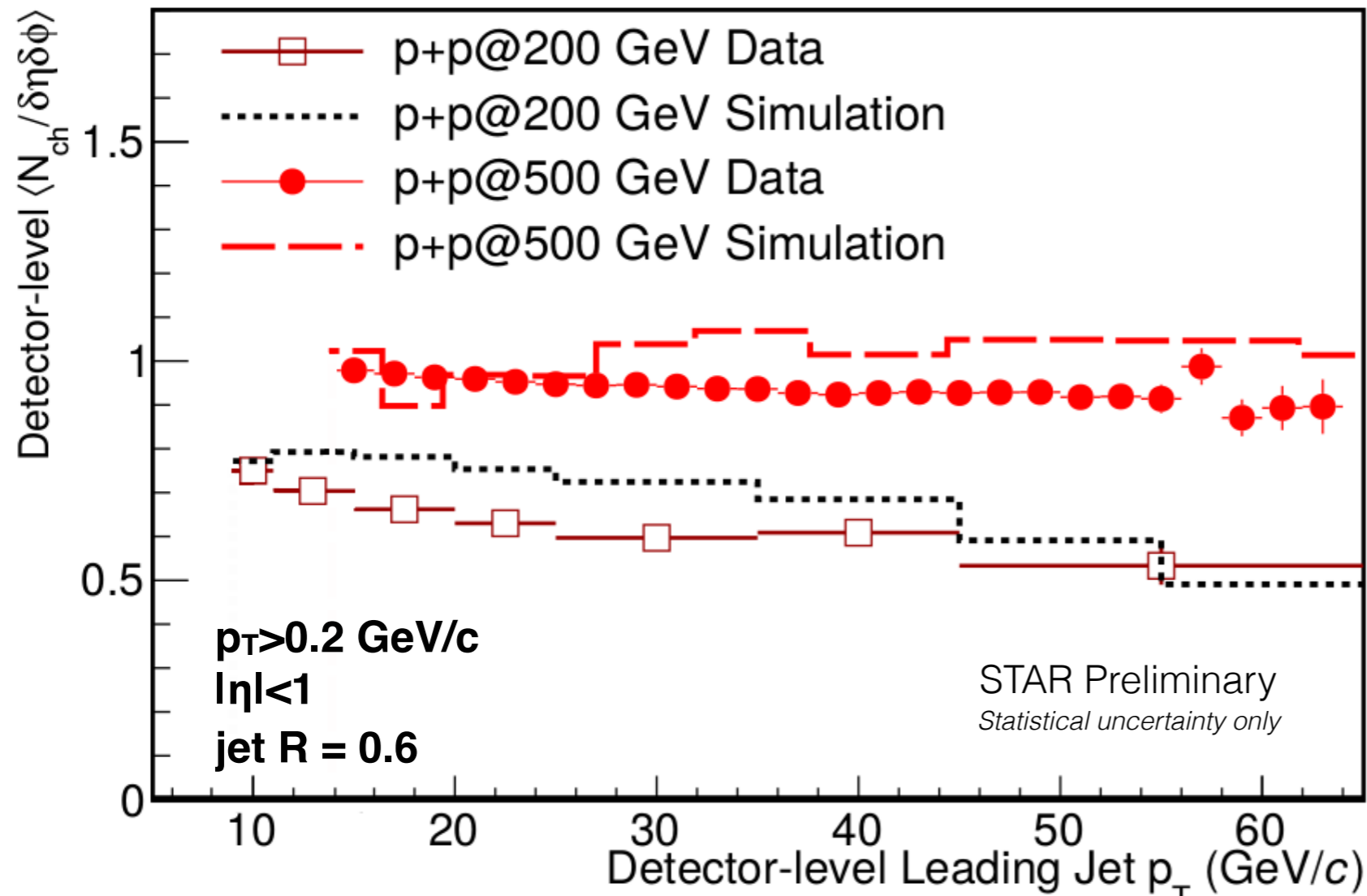
jet triggered events

p+p@200GeV



Transverse neutral energy density slightly decreases with leading jet p_T for jet $p_T > 10 \text{ GeV/c}$

Transverse Charged Particle Density Collision Energy Dependence



PYTHIA tunes into GEANT:

200GeV	perugia 2012 CTEQ6L1 PDF PARP(90)=0.213
500GeV	perugia 0

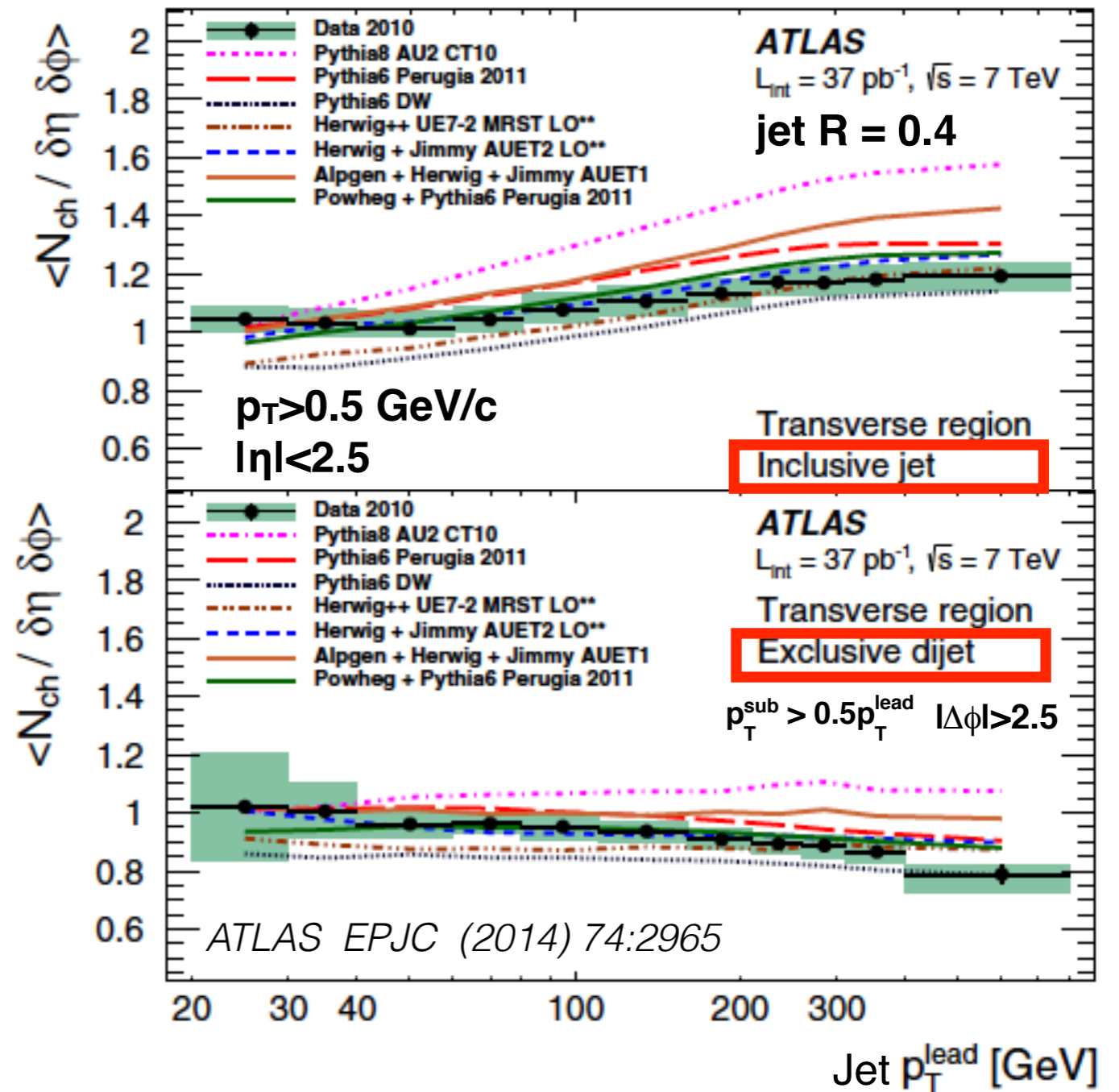
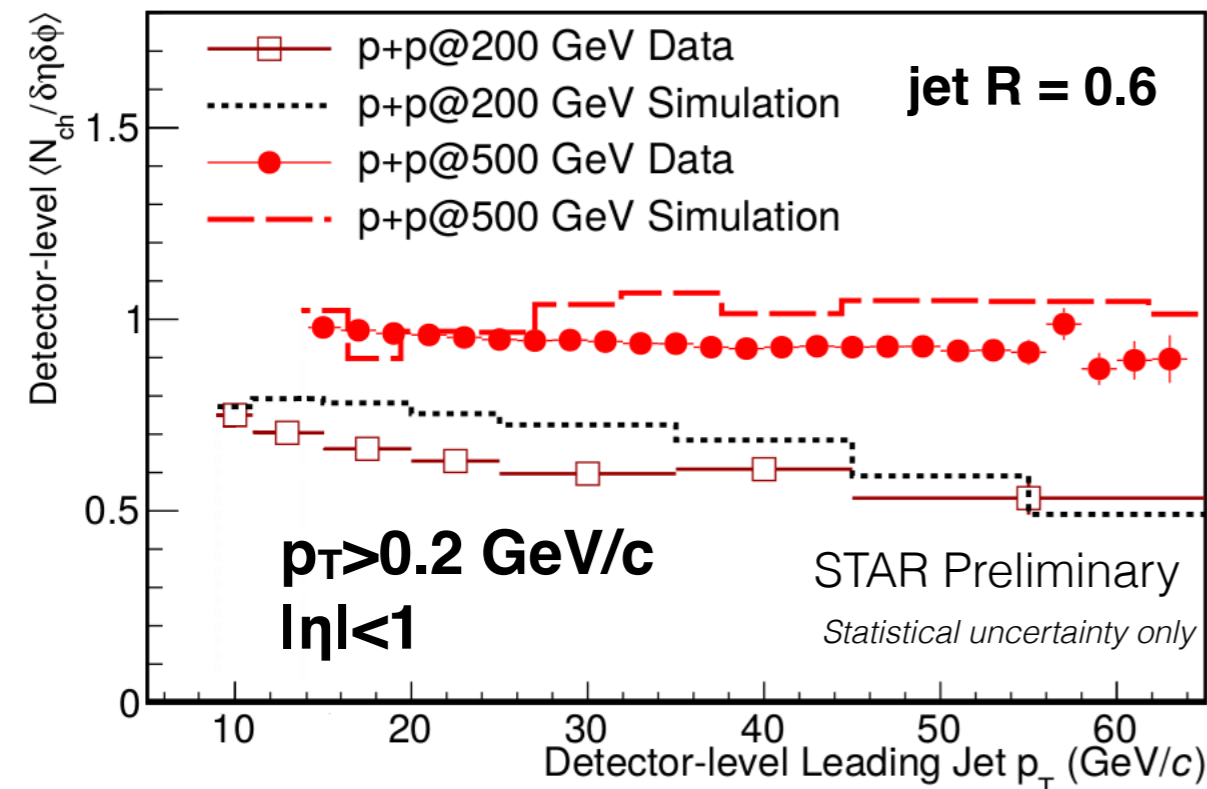
p+p@500GeV: Year 2009 data

- Transverse charged particle density slightly decreases with leading jet p_T for jet $p_T > 10$ GeV/c in both 200 and 500GeV collisions
- PYTHIA tunes over-predict data

Collision Energy Dependence

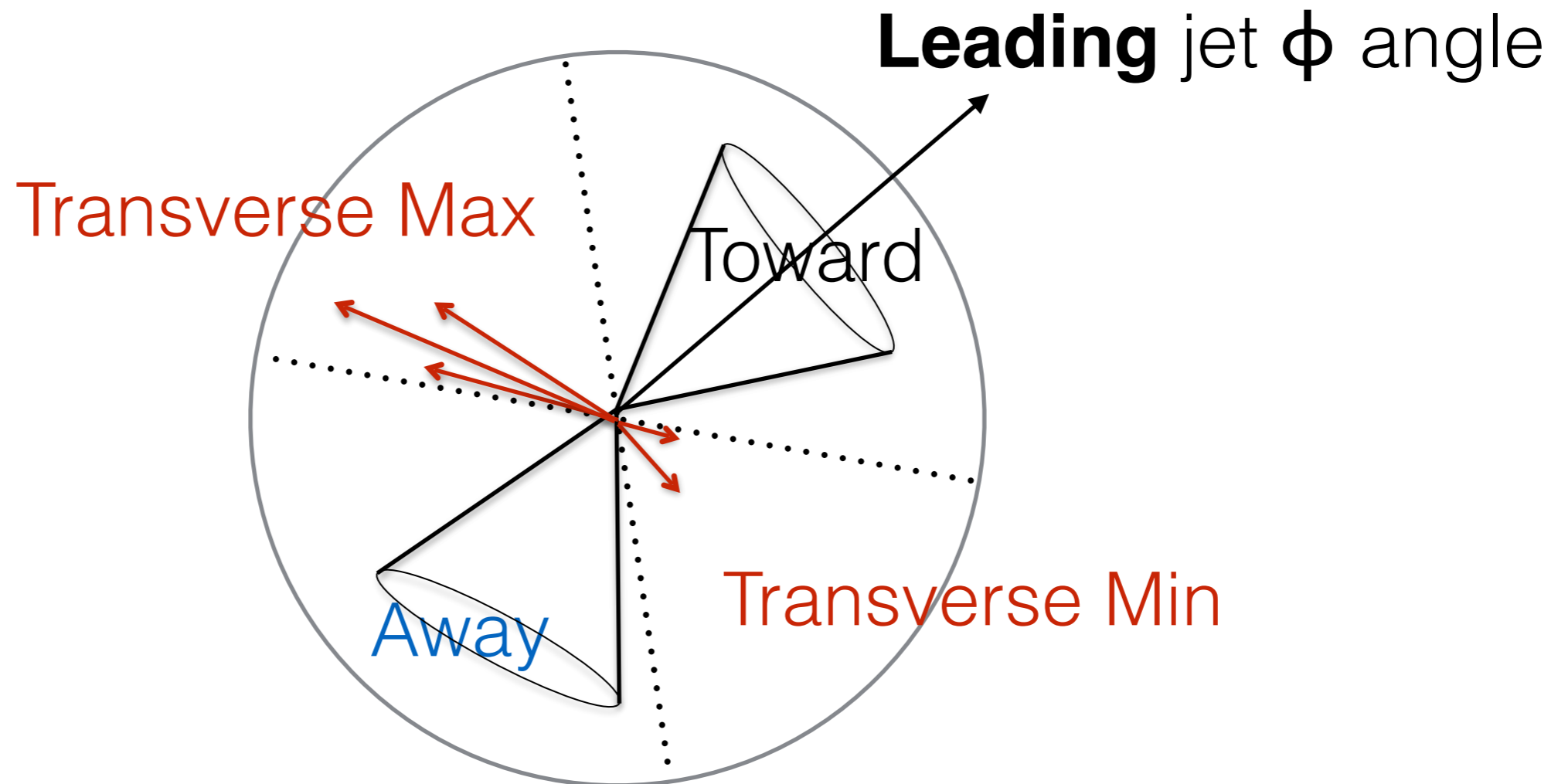
p+p@7TeV

p+p@200GeV, 500GeV



Increase at higher LHC energy could be due to 3-jet and/or MPI process

Transverse Max & Transverse Min



Smaller Multiplicity/Sum of energy --> Transverse Min

Larger Multiplicity/Sum of energy --> Transverse Max

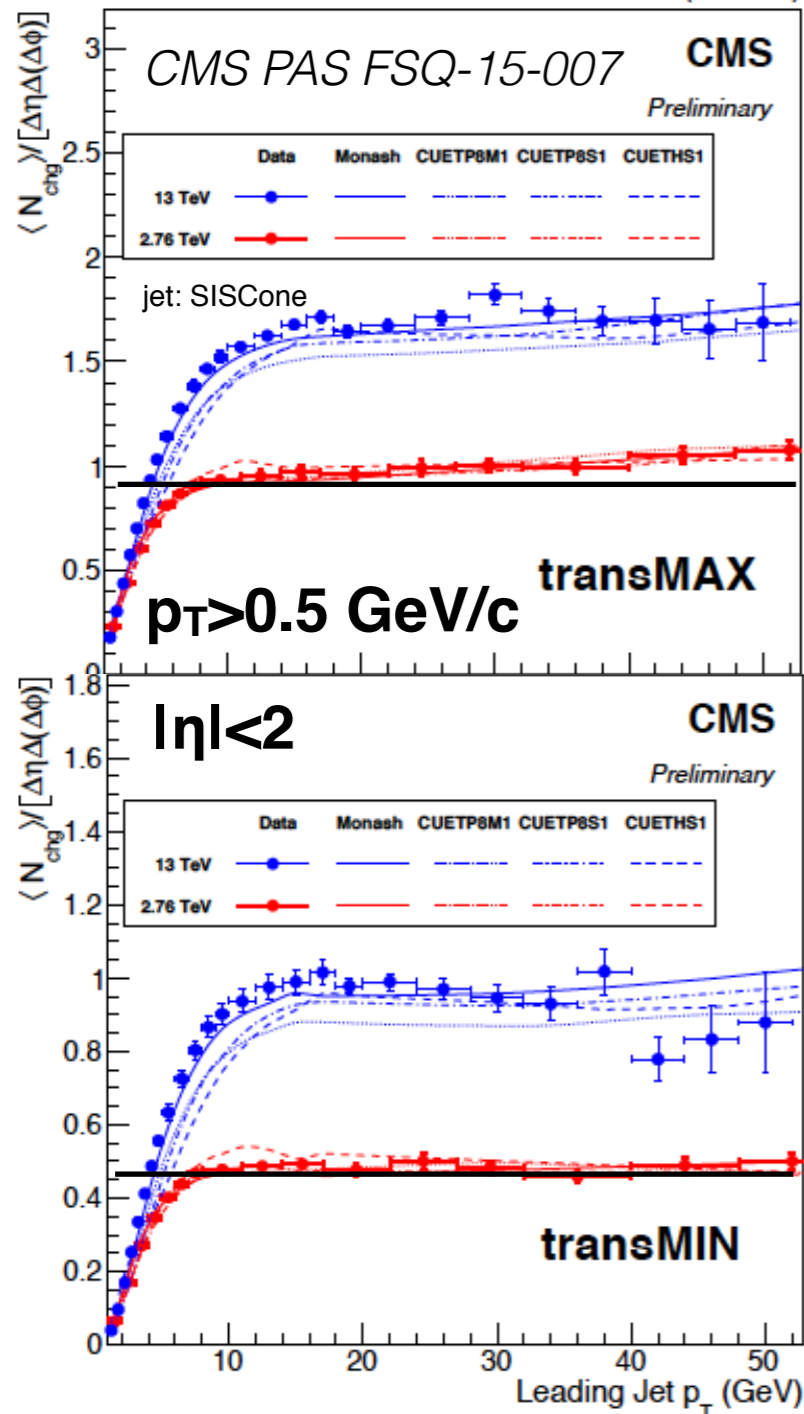
Transverse Min: more sensitive to MPI, Beam-Beam remnant

Transverse Max: more ISR/FSR contribution

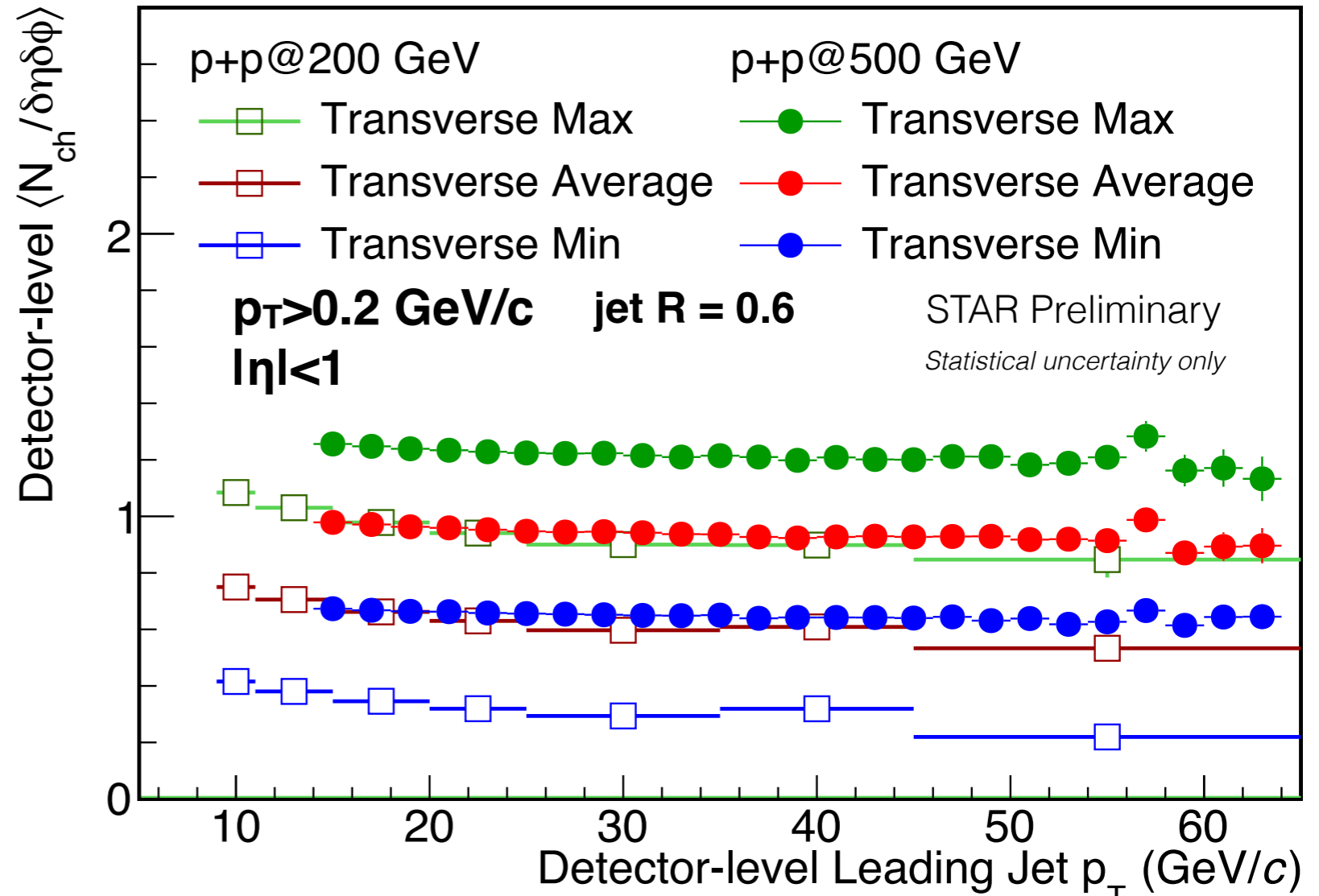
Transverse Max Vs. Transverse Min

p+p@2.76TeV, 13TeV

281 nb⁻¹ (13 TeV)



p+p@200GeV, 500GeV

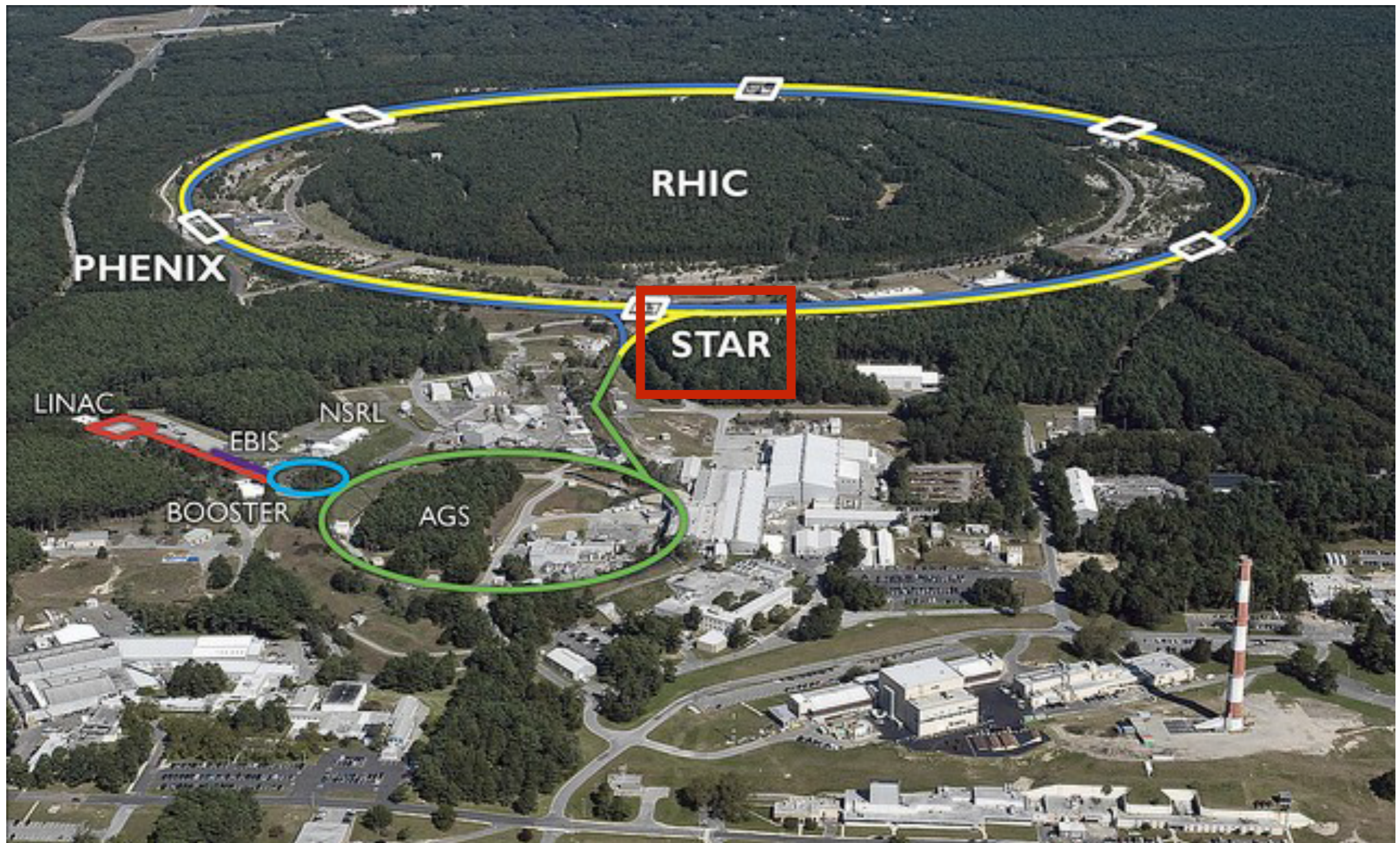


Hints of less Initial/Final State Radiation at RHIC energies

Summary

- Underlying-event activity is measured by particle production in transverse region with respect to leading jet angle at p+p@200GeV by STAR
- Transverse charged particle multiplicity and total neutral energy slightly decreases as higher leading jet p_T
- PYTHIA Perugia 2012 over-predicts transverse charged multiplicity
- Indication of less initial and final state radiation at RHIC energies than LHC energies

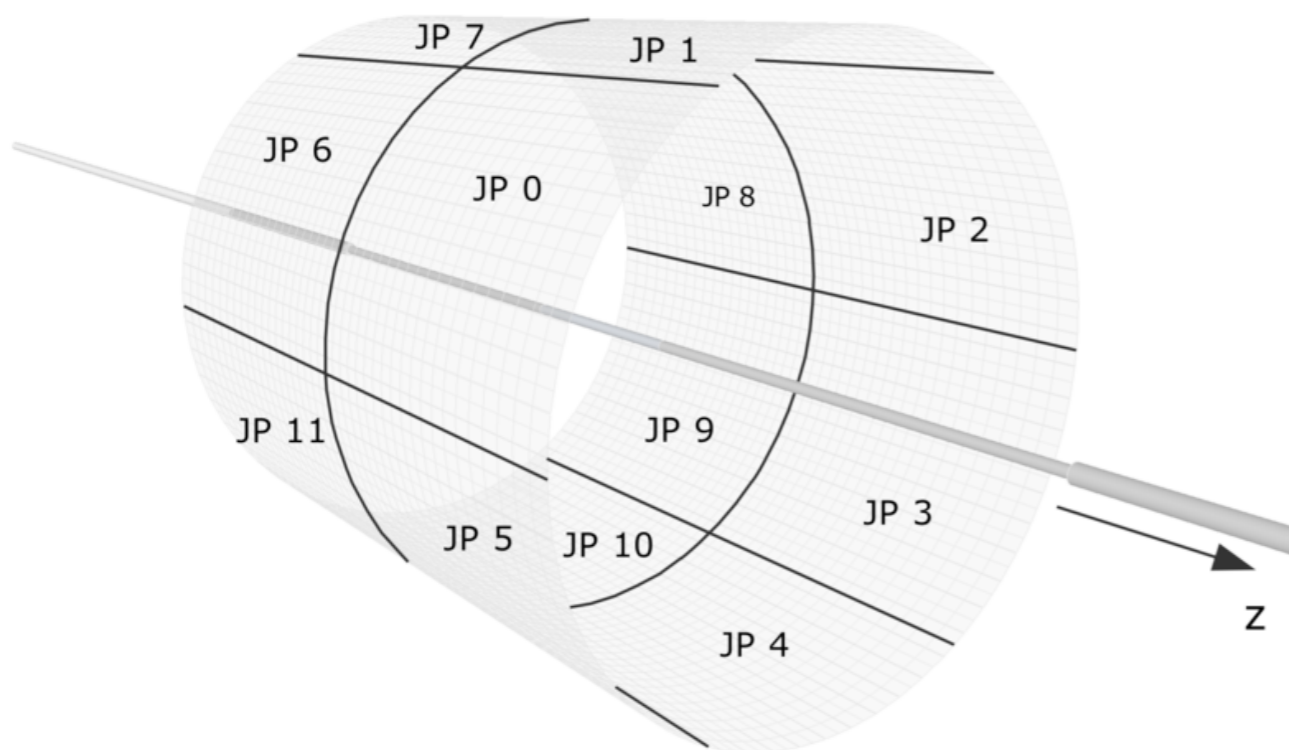
The Relativistic Heavy Ion Collider



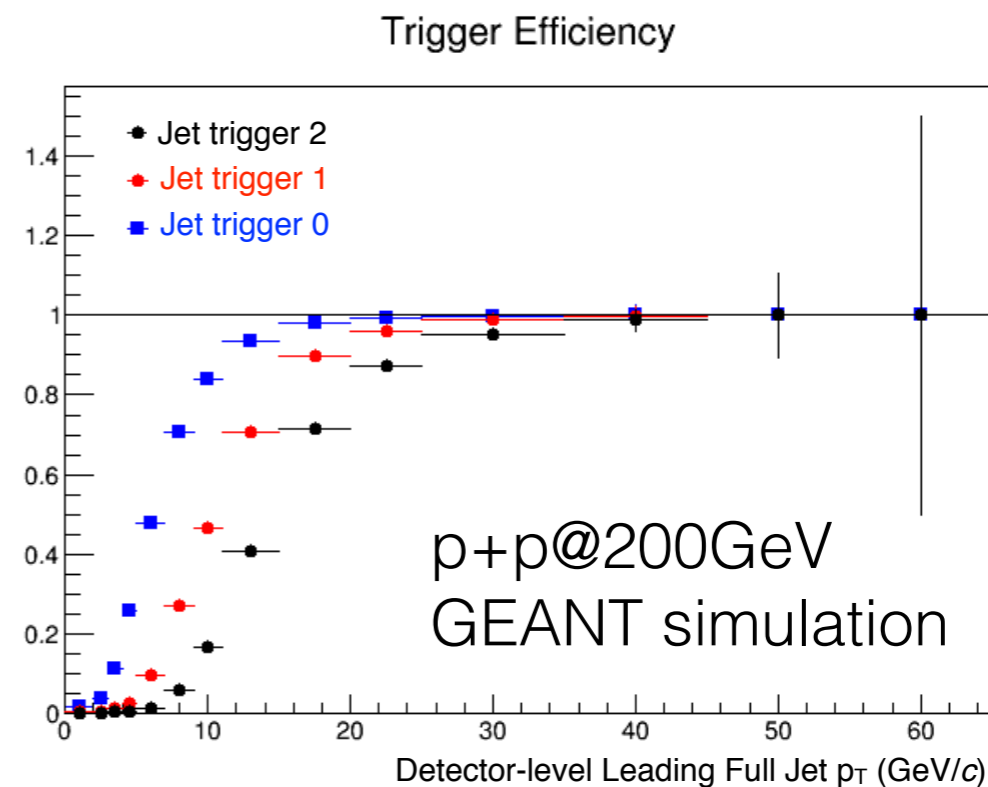
Proton+Proton collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$ and 500 GeV

Jet Triggers Setup

Barrel Electromagnetic Calorimeter as trigger detector



Jet Patch size 1x1 in $\eta \times \varphi$



Trigger Thresholds (neutral energy):

Jet trigger 0	3.5 GeV
Jet trigger 1	5.4 GeV
Jet trigger 2	7.3 GeV

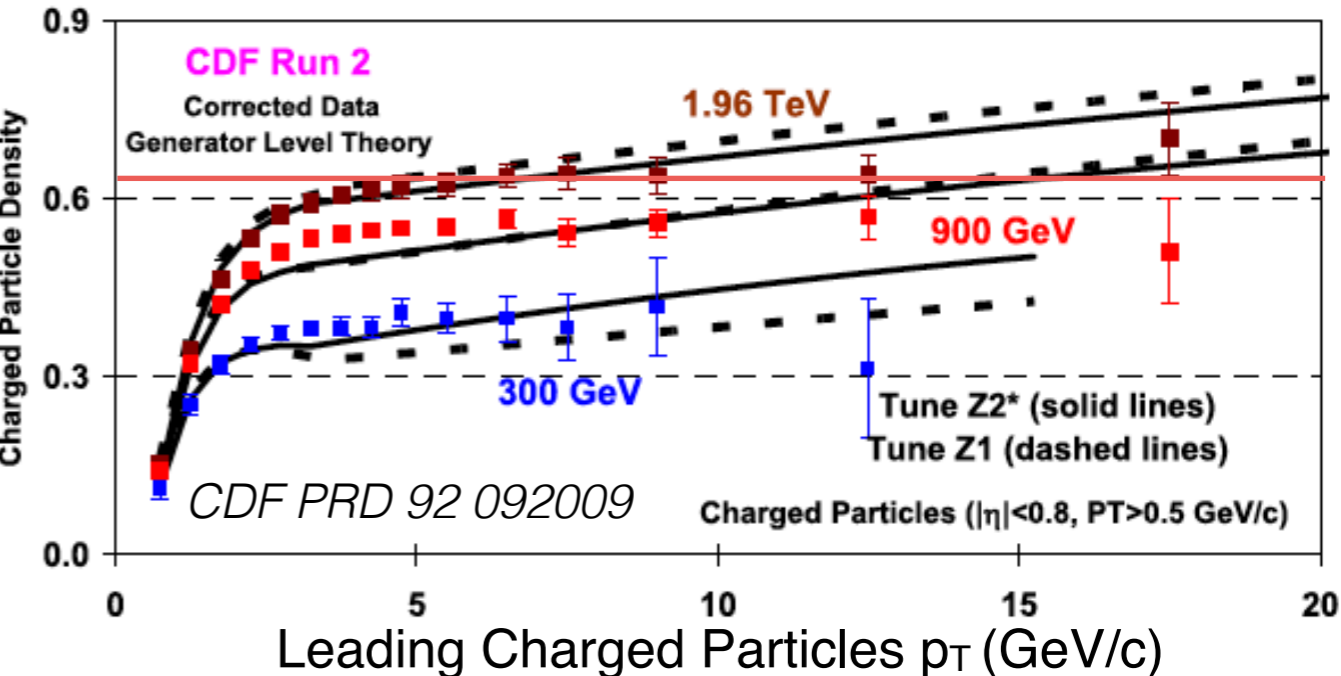
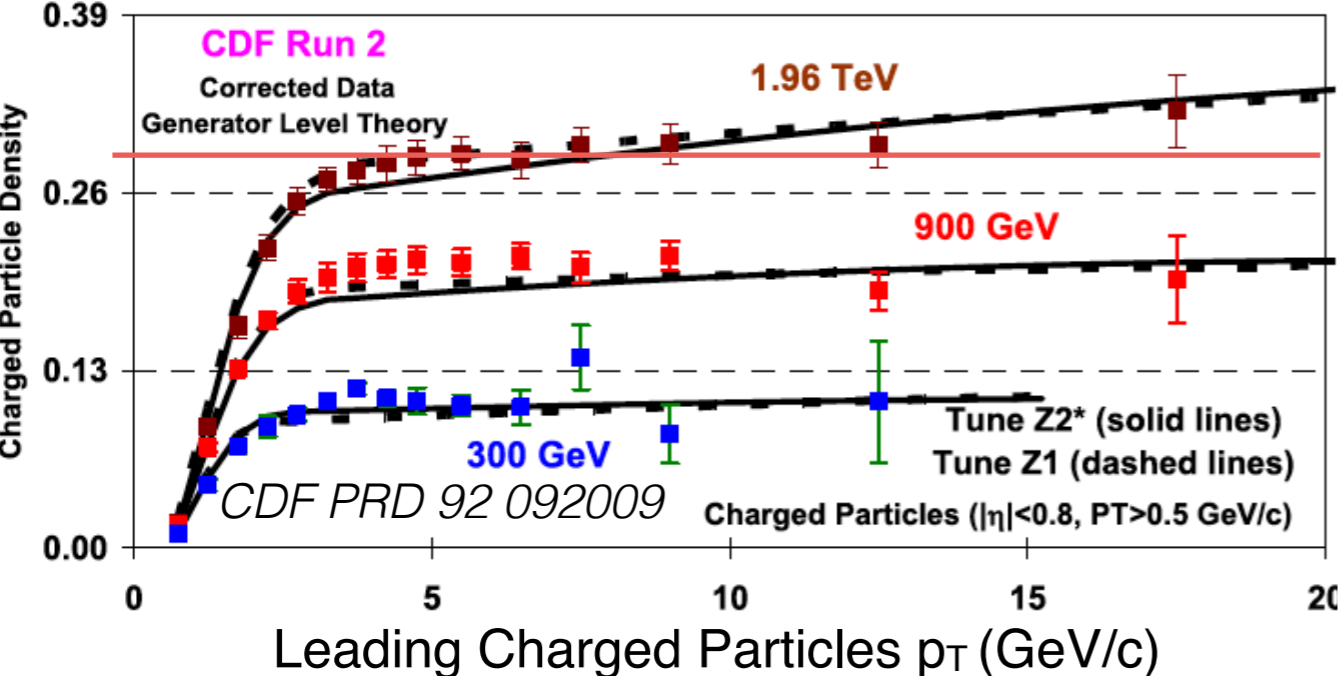
Transverse Charged Particle Density

$p+\bar{p}@300\text{GeV}, 900\text{GeV}, 1.96\text{TeV}$

$p_T > 0.5 \text{ GeV}/c$
 $|\eta| < 0.8$

Transverse Min

Transverse Max-Min



Sensitive to MPI and BBR

Sensitive to ISR/FSR

MPI increases like a power of the center-of-mass energy,
 ISR and FSR increase logarithmically