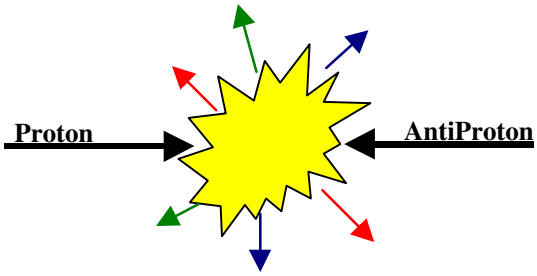
Min-Bias Data: Fitting the Event Shapes

Rick Field & Dave Stuart

Talk by Rick Field Presented at the QCD Meeting June 18, 1999



- Study the CDF "Min-Bias" Data with the goal of finding a Monte-Carlo Generator that will fit the data. Would like to describe (approximately) all the features of the entire inelastic ("hard core") cross section (low PT and high PT)!
- Look at the data (plot many observables) and compare to MBR and Herwig and Isajet and Pythia 6.115 and Pythia 6.125 and Pythia (no multiple scattering) and Pythia 4097.
- For now consider only charged particles in the region, PT > 0.5 GeV $|\eta| < 1$, where efficiency is good.
- In this talk I will concentrate on the event shape and study of how charged particles are distributed relative to the direction of the leading jet ("Jet" = circular region).
- Look at Nchg-Flow and PTsum-Flow relative to the leading jet direction.
- Look at PT(jet#1) dependence (plot averages versus PTjet#1): <"Toward" Nchg>, <"Transverse" Nchg>, <"Away" Nchg>, <"Toward" PTsum>, <"Transverse" PTsum>, <"Away" PTsum>
- Many more transparencies than I can show in this talk! All 24 transparencies are on the WEB.

http://www.phys.ufl.edu/~rfield/cdf/QCD_Talk3.html

Does not include PTmax (Nchg >=2)

MB Jets – Jet Algorithm

Examine "Circular Regions" in η-ϕ space with "distance" defined by

$$d = \sqrt{\Delta\eta^2 + \Delta\phi^2}$$

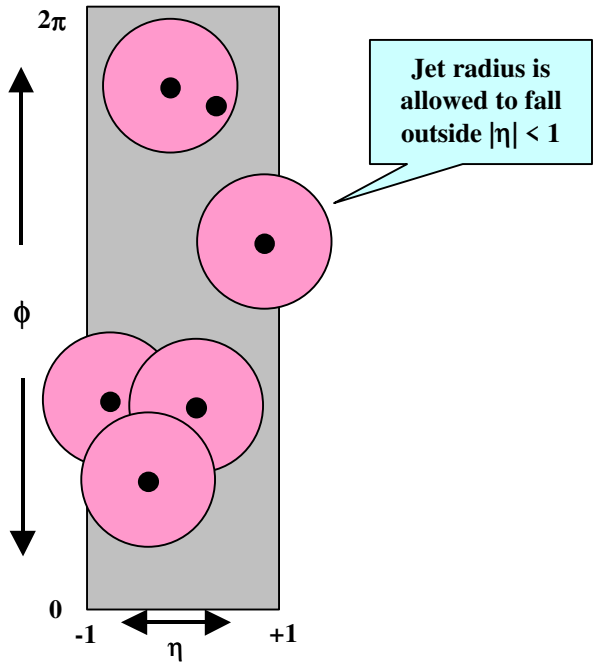
Use a Simple Jet Algorithm ("Jet" = circular region):

- **Order Charged Particles (PT > 0.5 GeV |η| < 1)**
- **Start with highest P_T particle and include in the "Jet" all particles (PT > 0.5 GeV |η| < 1) within radius R = 0.7**
- **Go to the next highest P_T particle (not already included in a previous jet) and include in the "Jet" all particles (PT > 0.5 GeV |η| < 1) within radius R = 0.7 (not already included in a previous jet)**
- **Continue until all particles are in a jet**

Example (6 particles, 5 jets):

The maximum number of jets is

~ 2(2)(2π)/(π(0.7)^2) ~ 16



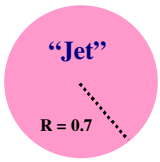
Jets have a momentum given by

$$\vec{P}_{jet} = \sum_{i=1}^{N_j} \vec{p}_i ,$$

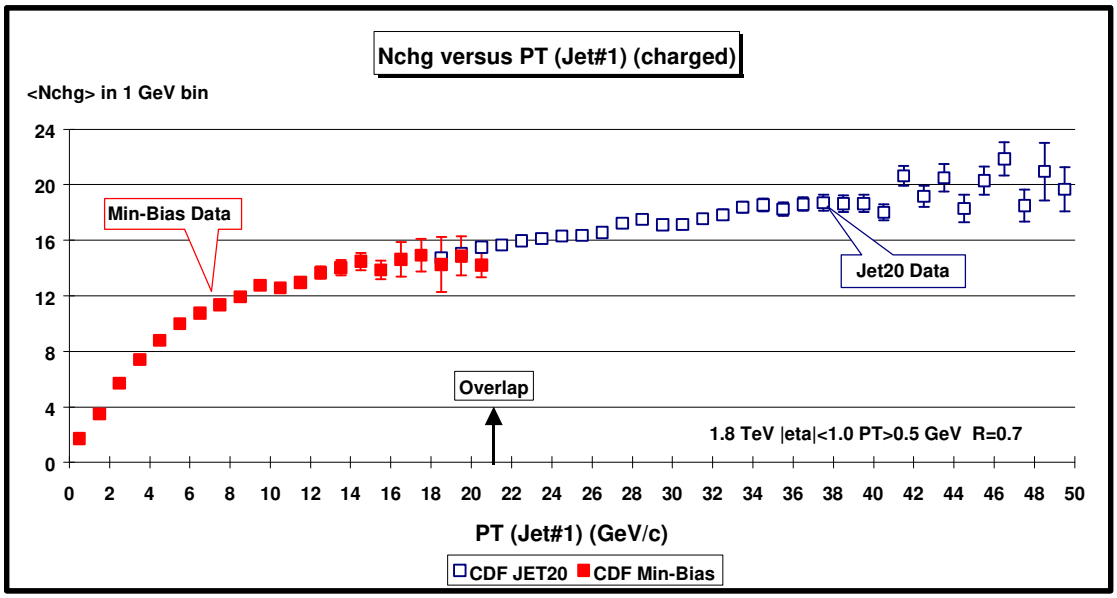
where Nj = NchgJet is the number of charged particles in the jet and

$$P_T(jet) = \sqrt{P_x(jet)^2 + P_y(jet)^2}$$

CDF MB Data – <Nchg> vs PT(jet#1)

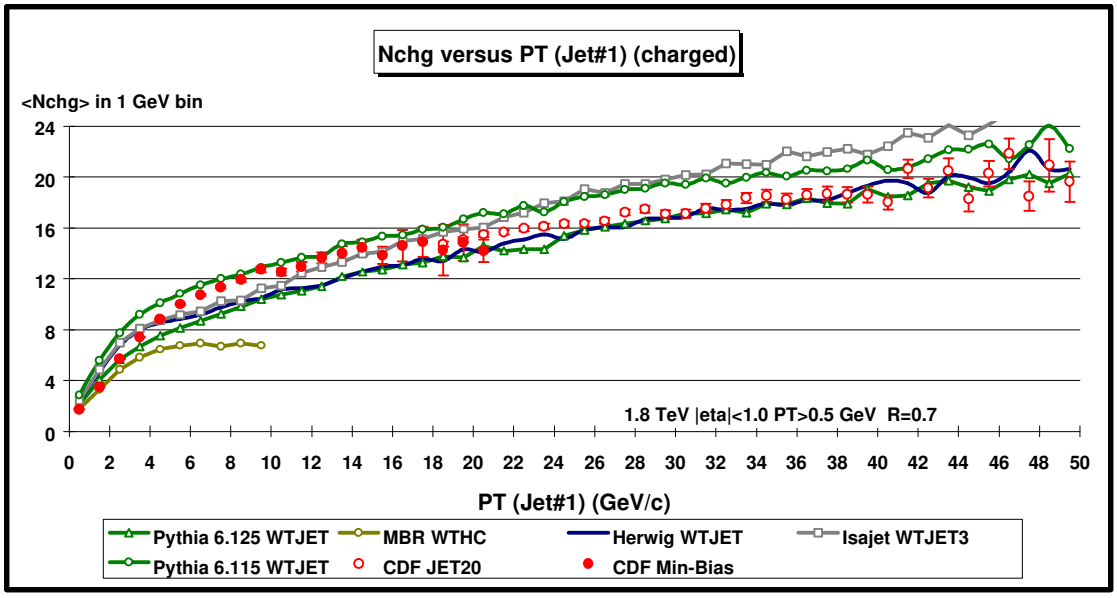
"Jet" = Circular Region → 

Average Number of Charged Particles versus PT(jet#1) (highest PT jet):



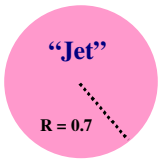
CDF data only

Average Number of Charged Particles versus PT(jet#1) (highest PT jet):

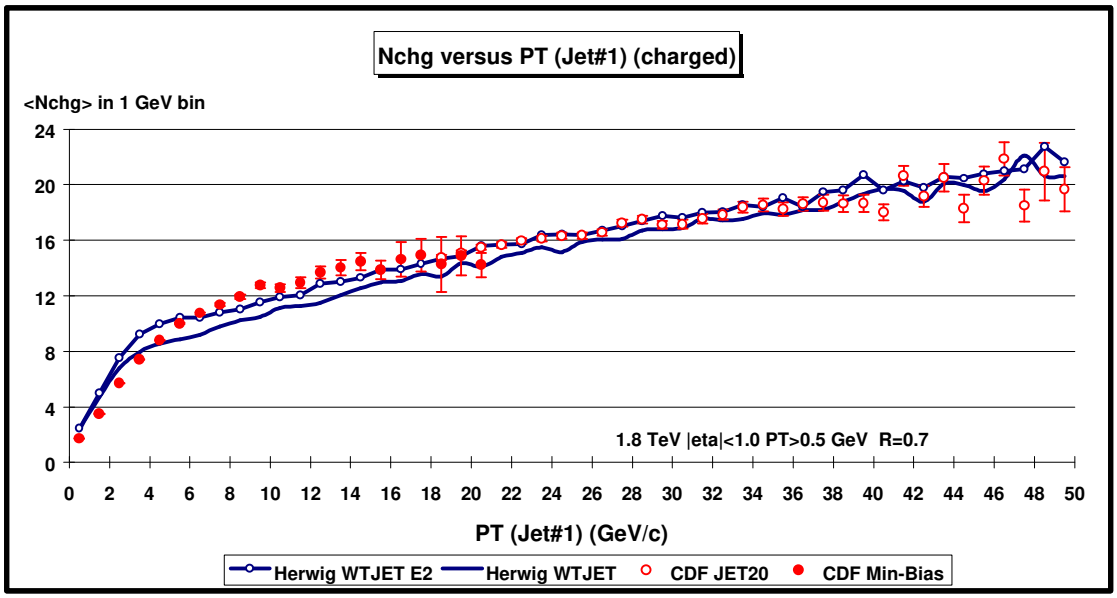


CDF data versus Herwig, Pythia, Isajet, & MBR

CDF MB Data – <Nchg> vs PT(jet#1)

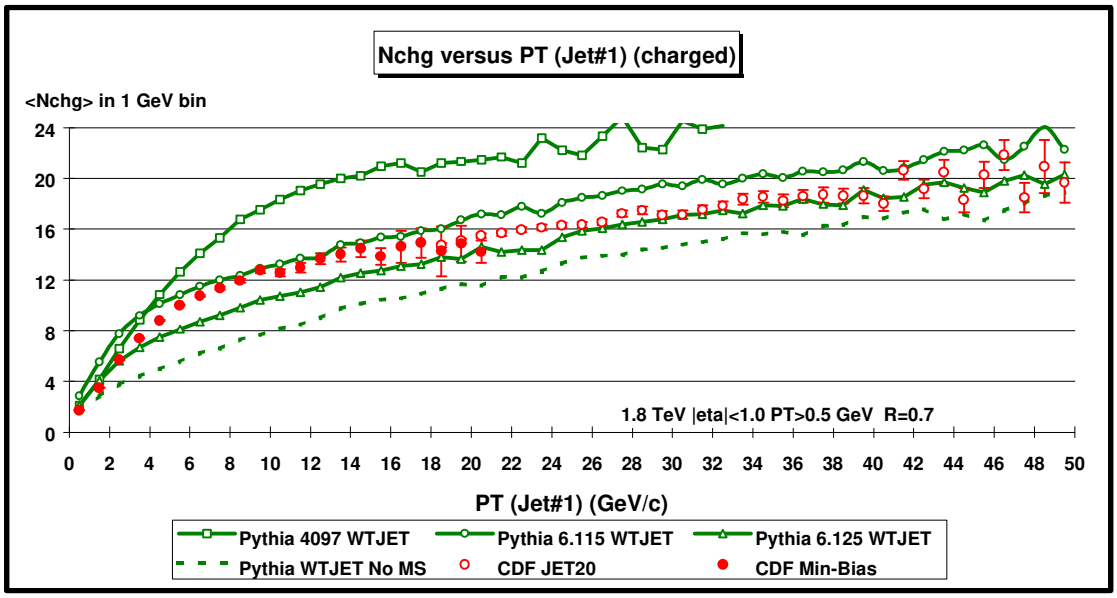
"Jet" = Circular Region 

Average Number of Charged Particles versus PT(jet#1) (highest PT jet):



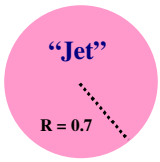
CDF data versus Herwig (default) and Herwig (ENSOF=2)

Average Number of Charged Particles versus PT(jet#1) (highest PT jet):

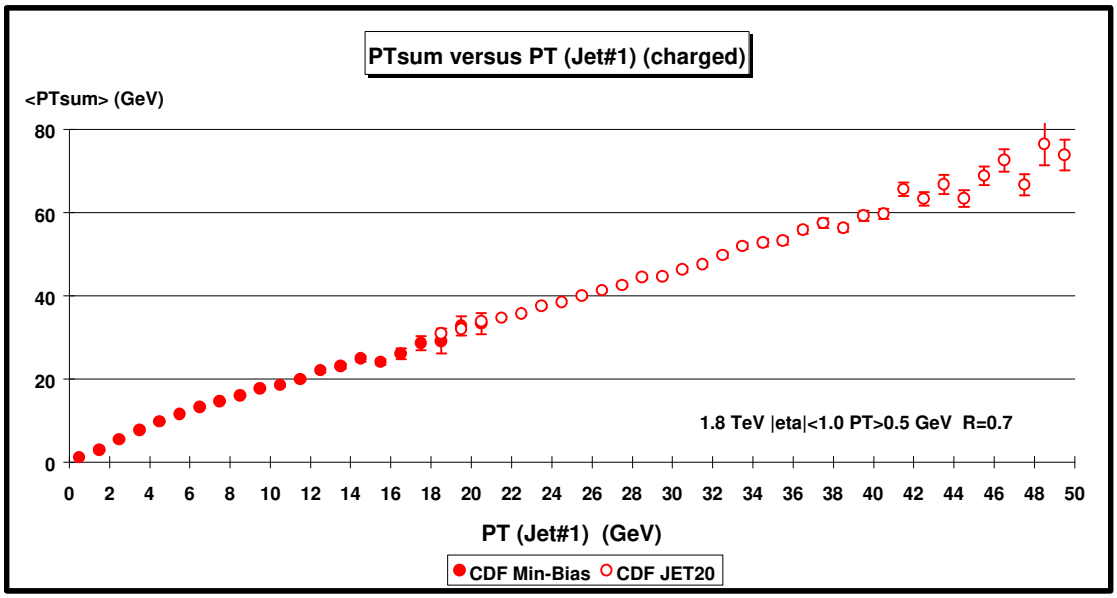


CDF data versus Pythia 6.126, 6.115, 4097, & no multiple scatering

CDF MB Data – <PTsum> vs PT(jet#1)

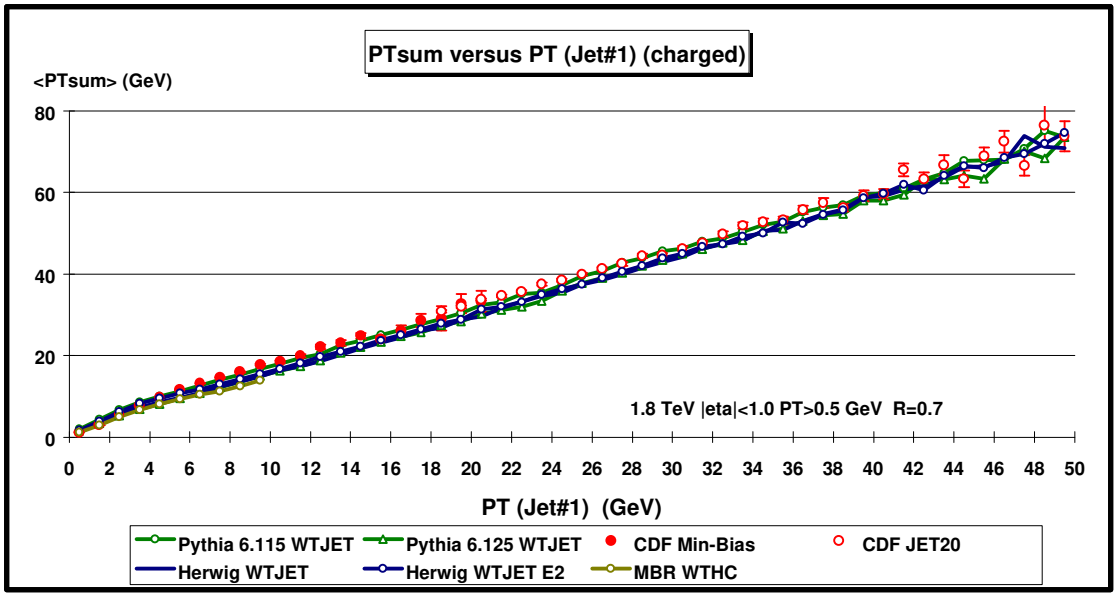
"Jet" = Circular Region → 

Average PTsum versus PT(jet#1) (highest PT jet):



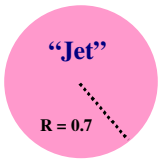
CDF data only

Average PTsum versus PT(jet#1) (highest PT jet):



CDF data versus Herwig, Pythia, & MBR

CDF MB Data – <PTsum> vs PT(jet#1)

"Jet" = Circular Region → 

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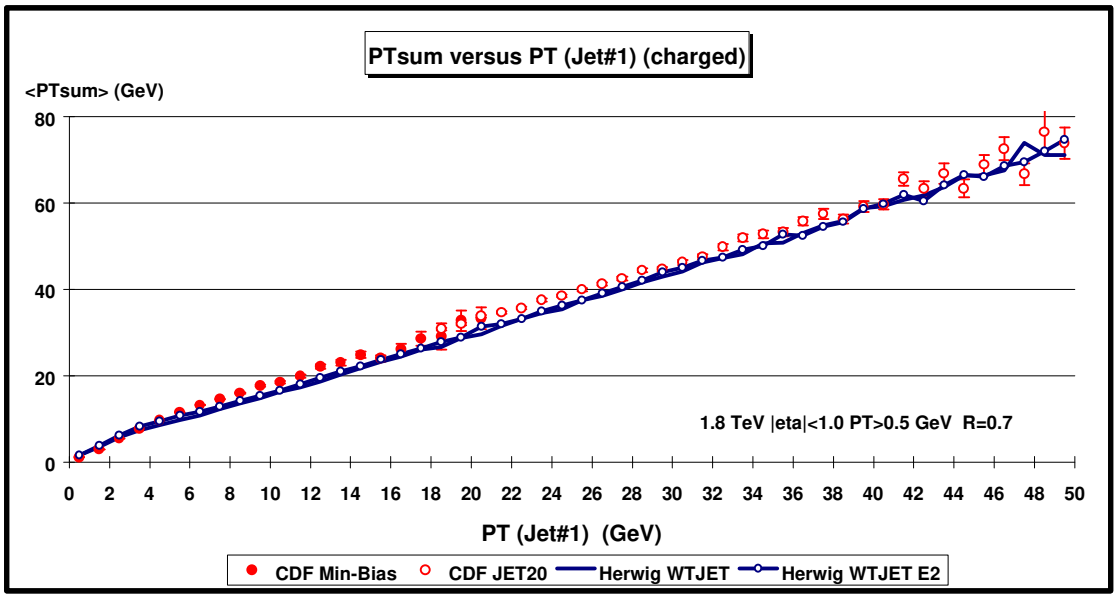
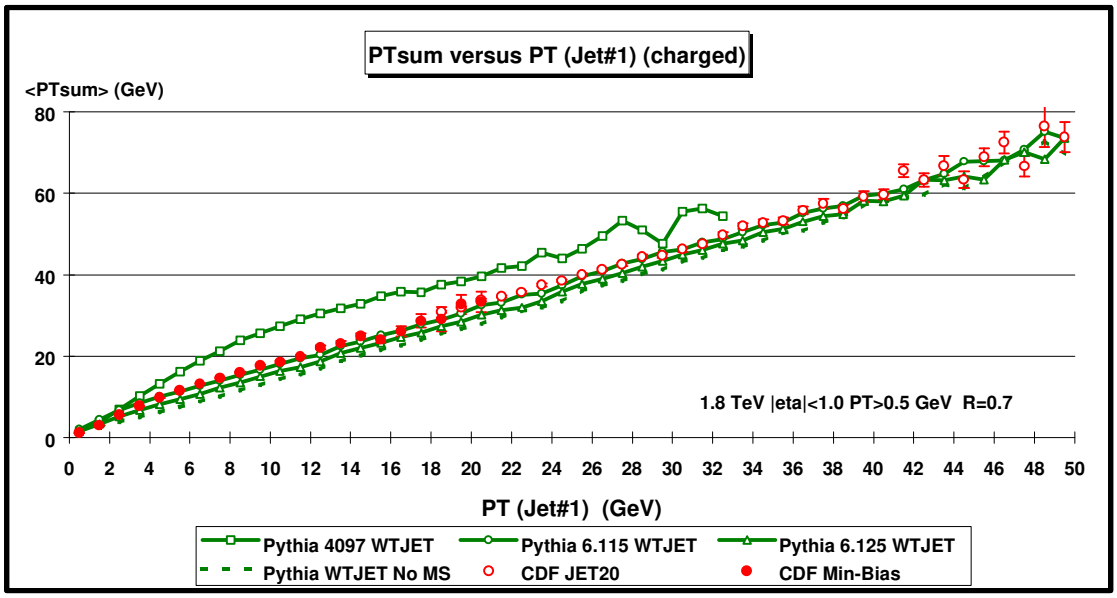


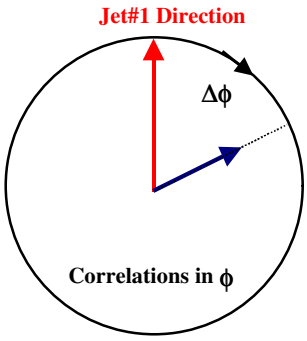
CDF data versus Herwig (default) and Herwig (ENSOF=2)

Average PTsum versus PT(jet#1) (highest PT jet):



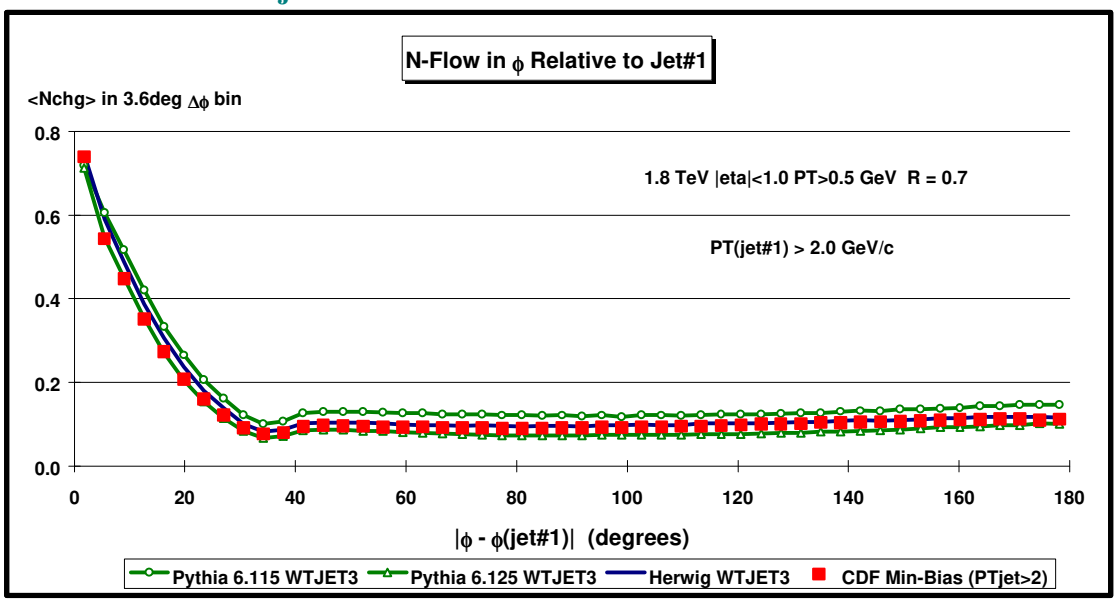
CDF data versus Pythia 6.126, 6.115, 4097, & no multiple scatering

MB Jets: Nchg-Flow Relative to Jet#1



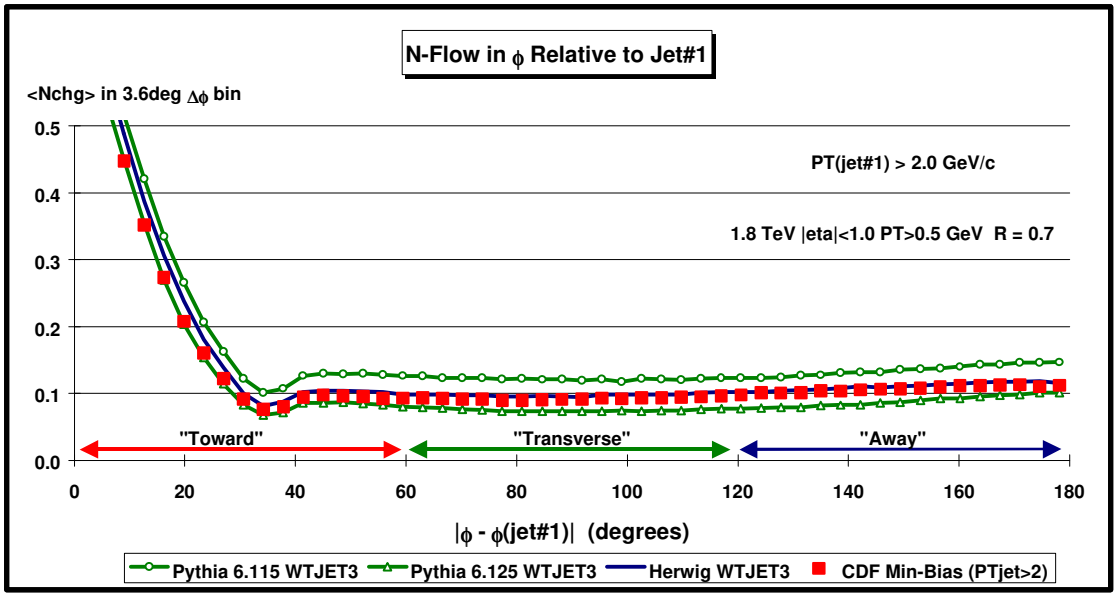
Define Jet#1 to be the highest PT jet in the event (PT > 0.5 GeV, |η| < 1) and look at correlations in azimuthal angle φ.

<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 2 GeV:

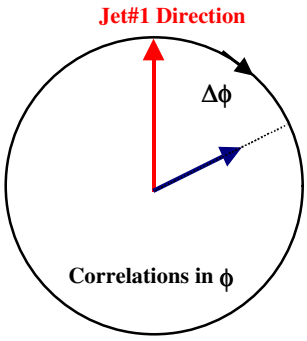


CDF data versus Herwig (default), Pythia 6.115, & Pythia 6.125

<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 2 GeV:



MB Jets: PTsum-Flow Relative to Jet#1



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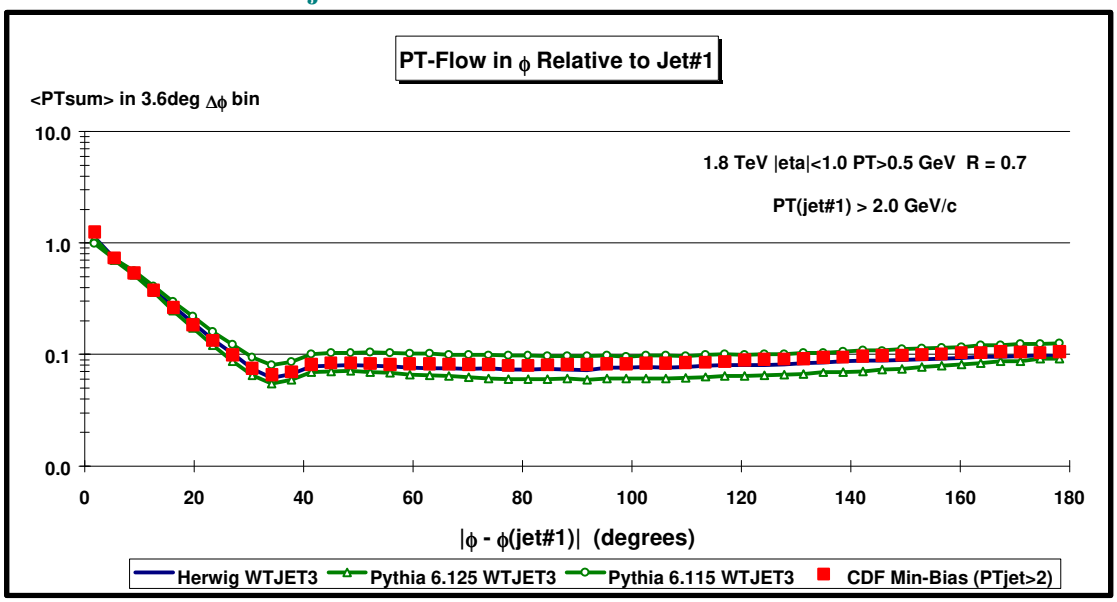

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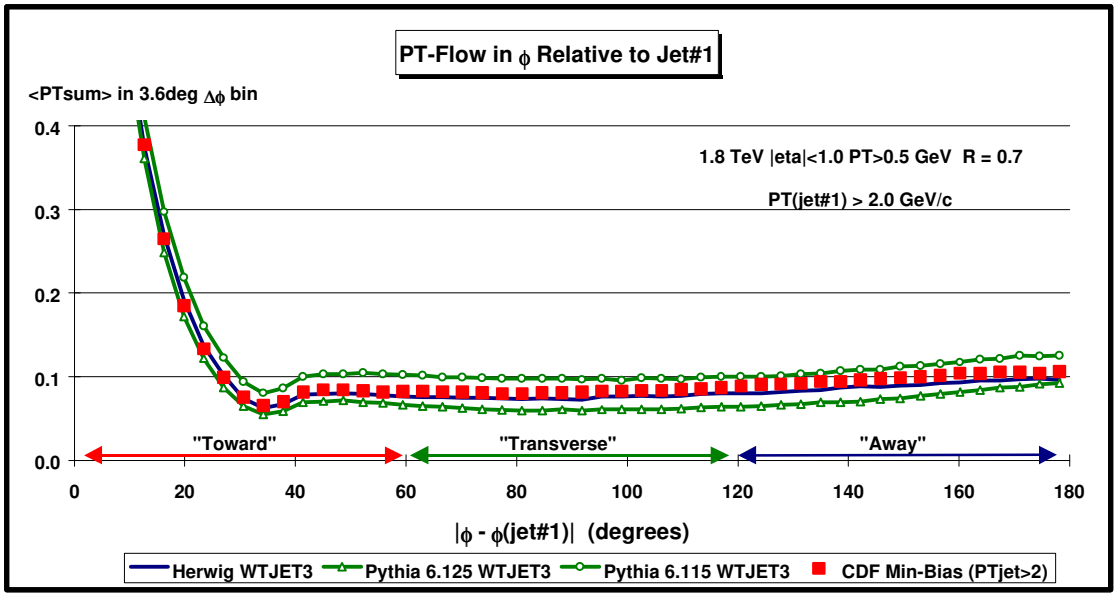
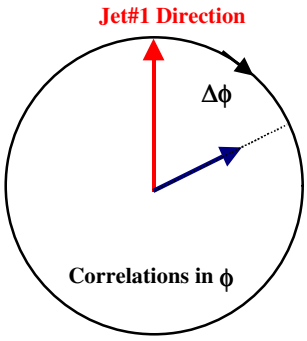
<PTsum> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 2 GeV:

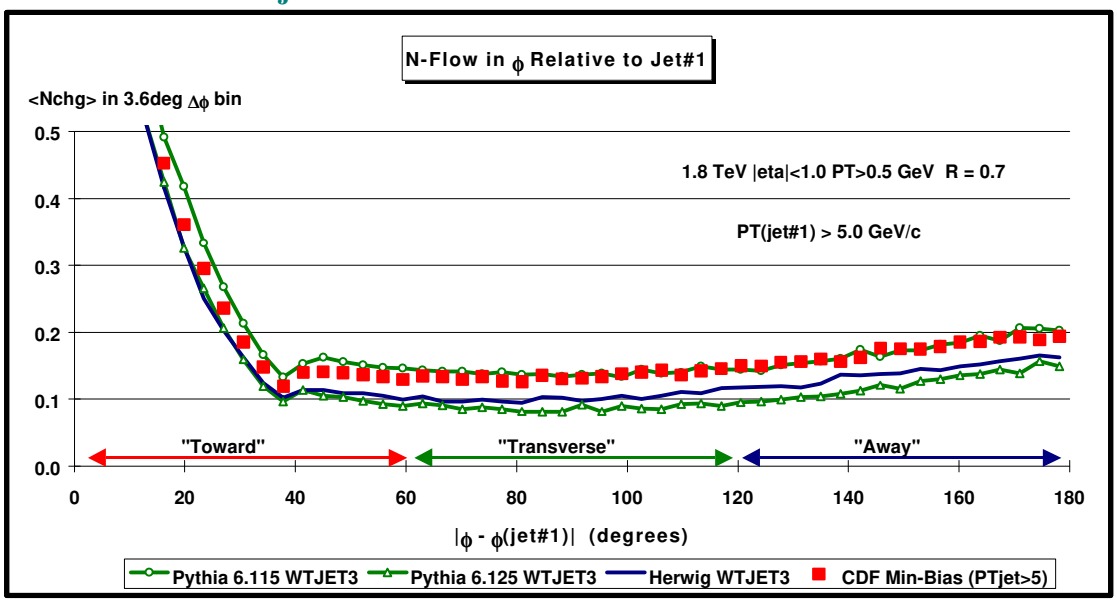


MB Jets: Nchg-Flow Relative to Jet#1



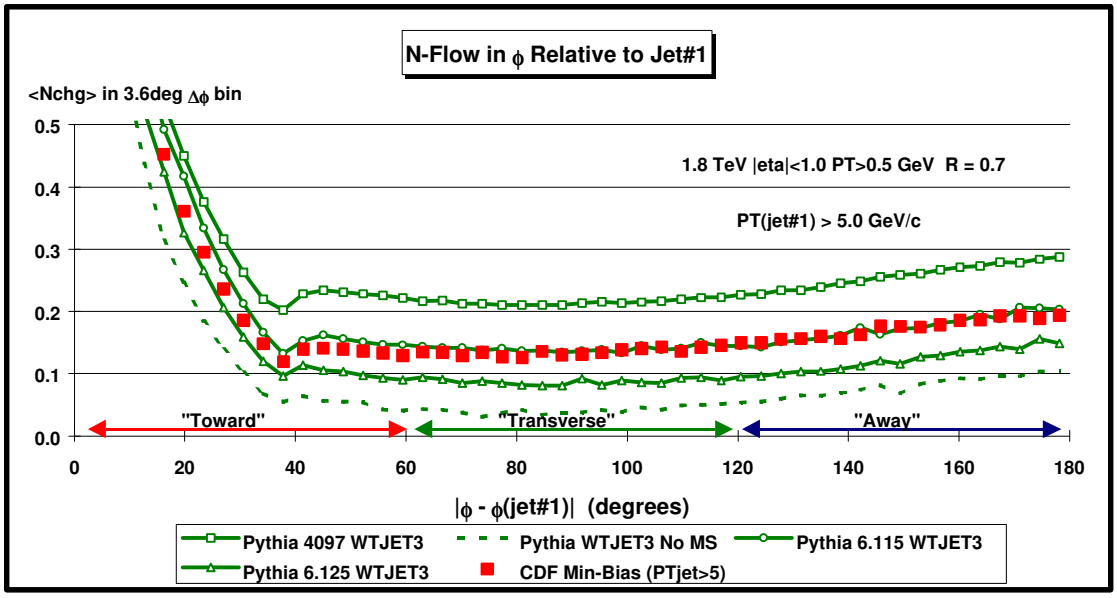
Define Jet#1 to be the highest PT jet in the event (PT > 0.5 GeV, |η| < 1) and look at correlations in azimuthal angle ϕ.

<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 5 GeV:

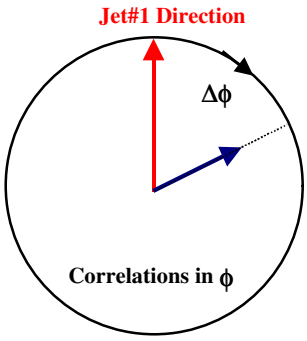


CDF data versus Herwig (default), Pythia 6.115, & Pythia 6.125

<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 5 GeV:



MB Jets: PTsum-Flow Relative to Jet#1



Define Jet#1 to be the highest PT jet in the event (PT > 0.5 GeV, |η| < 1) and look at correlations in azimuthal angle φ.

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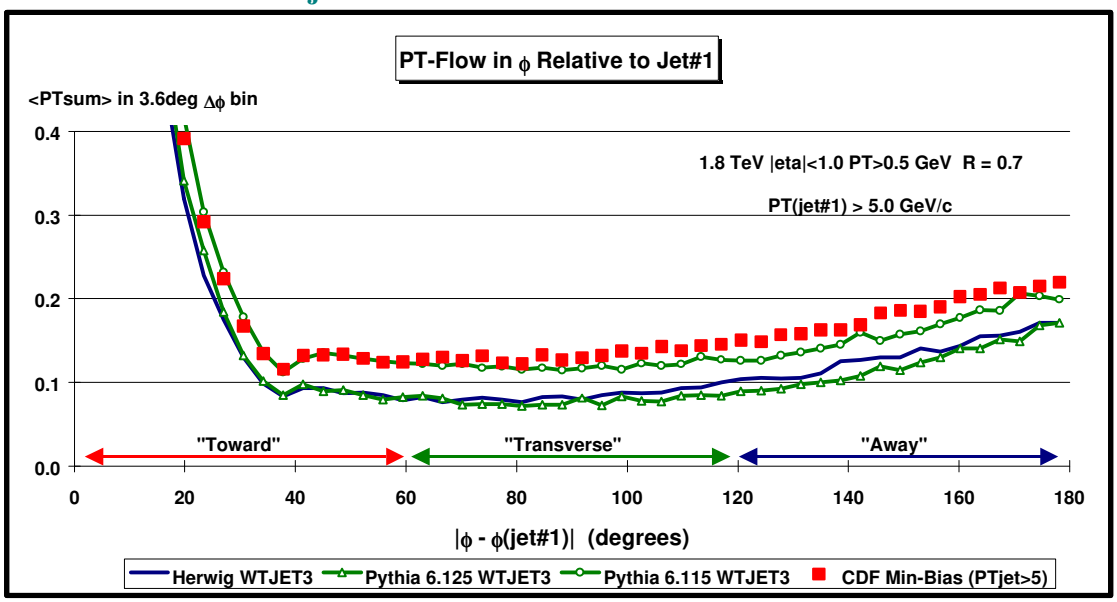
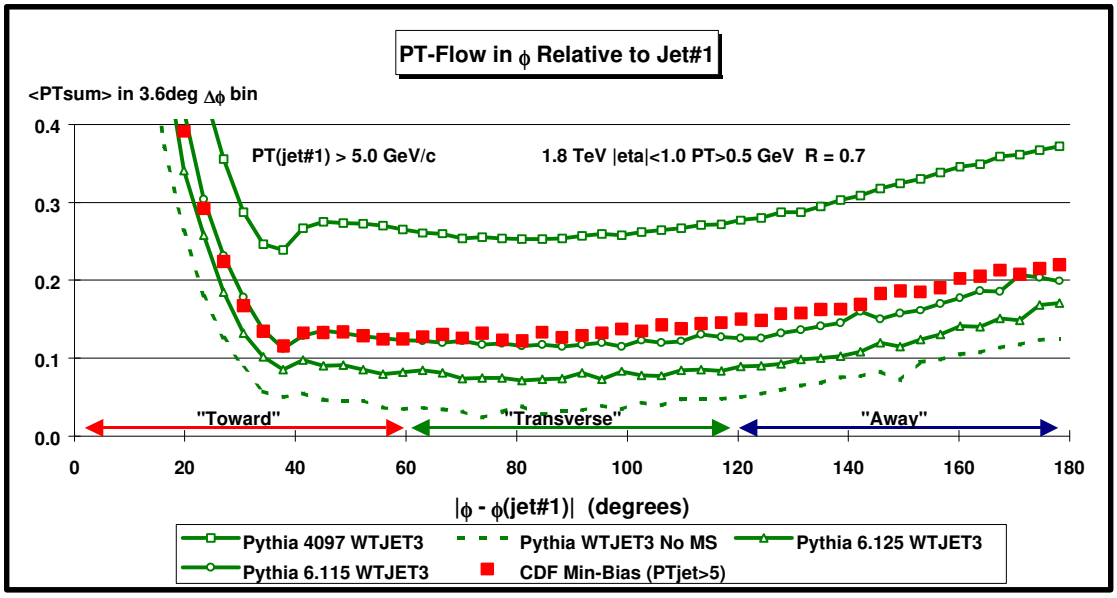
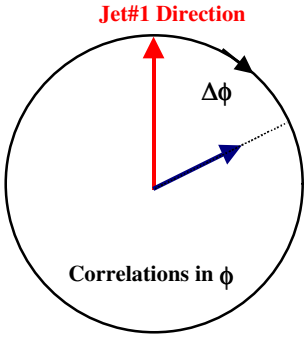


CDF data versus Herwig (default), Pythia 6.115, & Pythia 6.125

<PTsum> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 5 GeV:

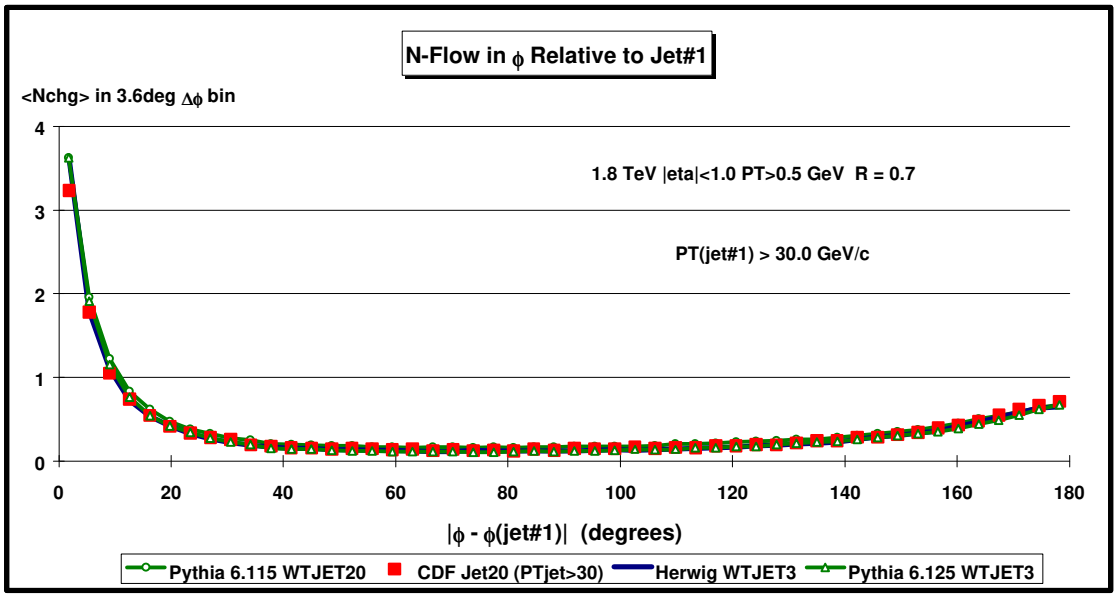


MB Jets: Nchg-Flow Relative to Jet#1



Define Jet#1 to be the highest PT jet in the event (PT > 0.5 GeV, |η| < 1) and look at correlations in azimuthal angle φ.

<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 30 GeV:



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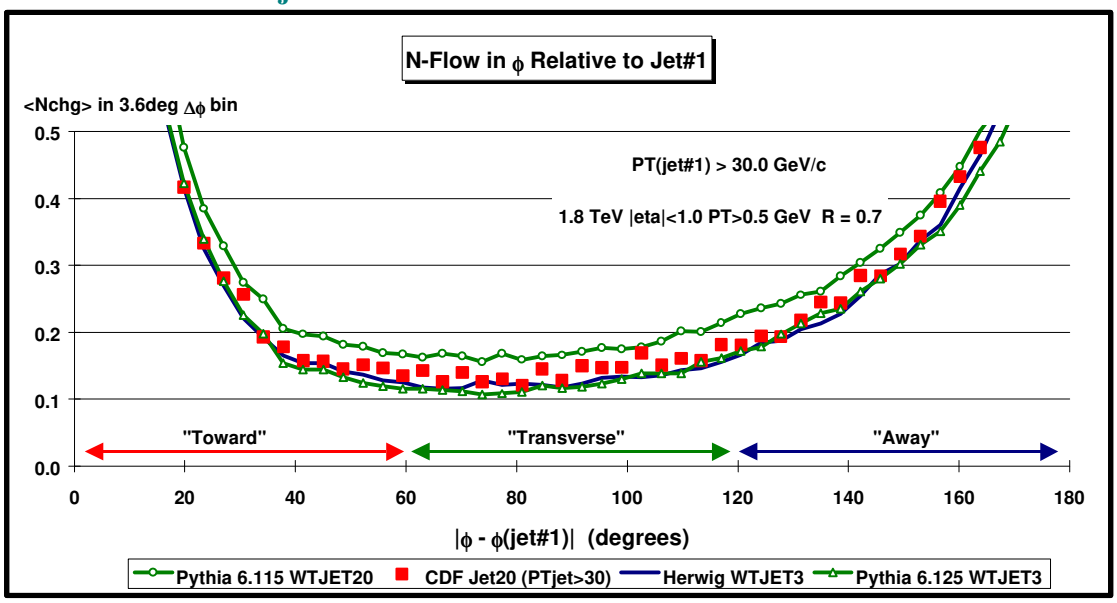
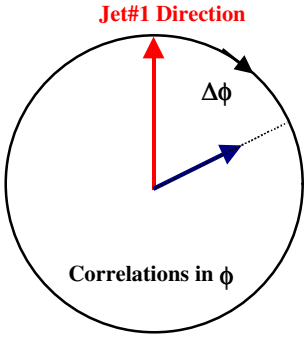
<Nchg> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 30 GeV:



MB Jets: PTsum-Flow Relative to Jet#1



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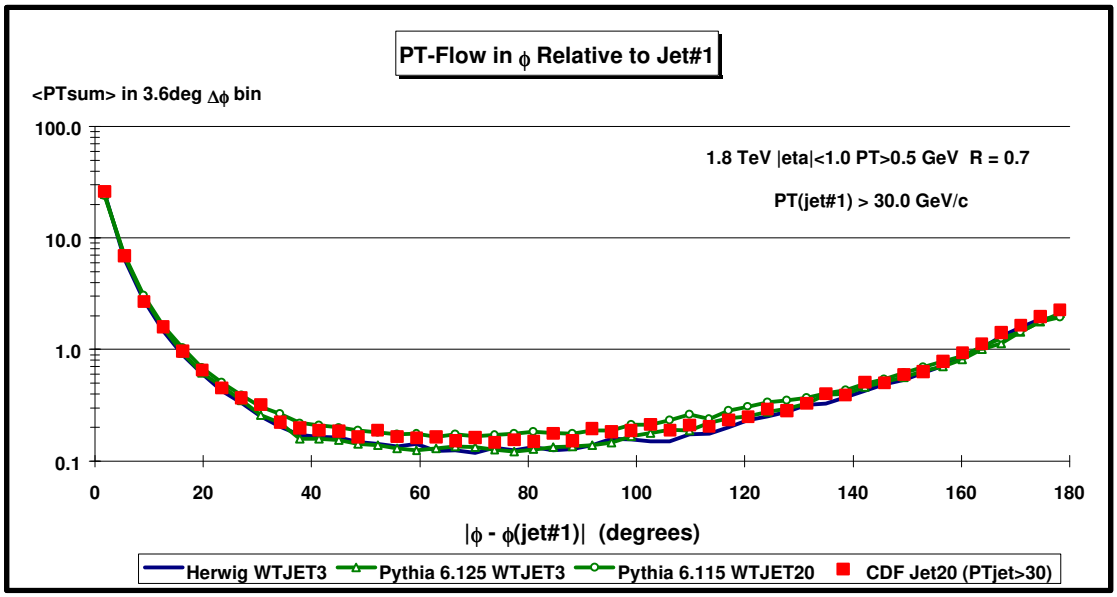
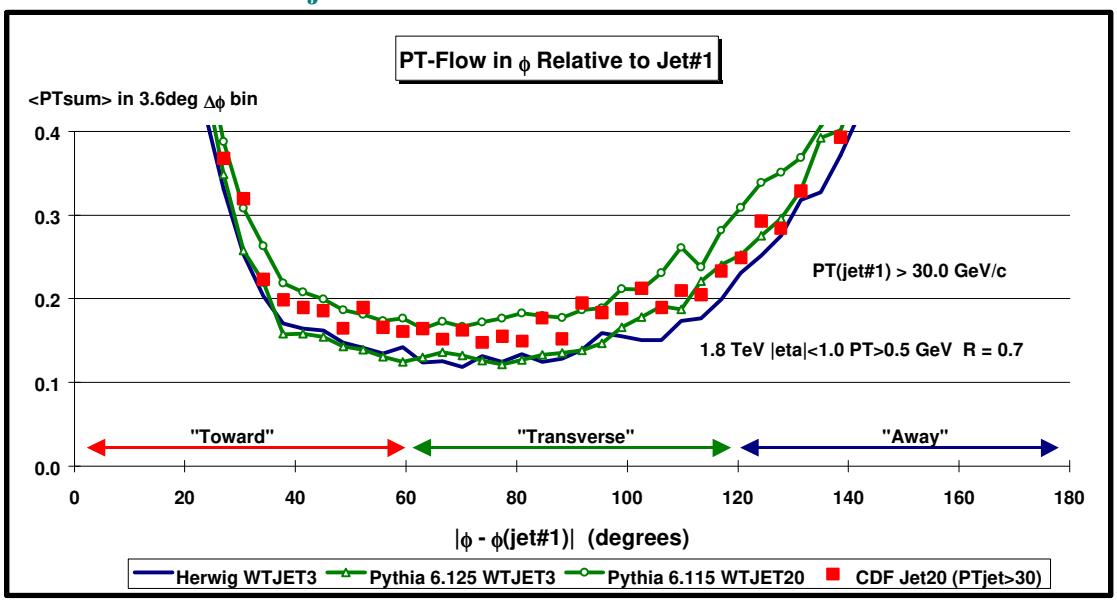
<PTsum> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 30 GeV:



CDF data versus Herwig (default), Pythia 6.115, & Pythia 6.125

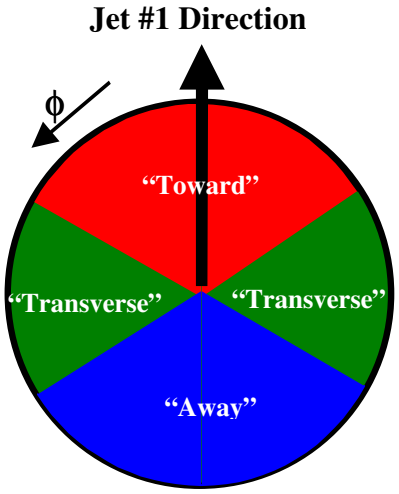
<PTsum> versus $|\phi-\phi_{jet\#1}|$ when PT(jet#1) > 30 GeV:



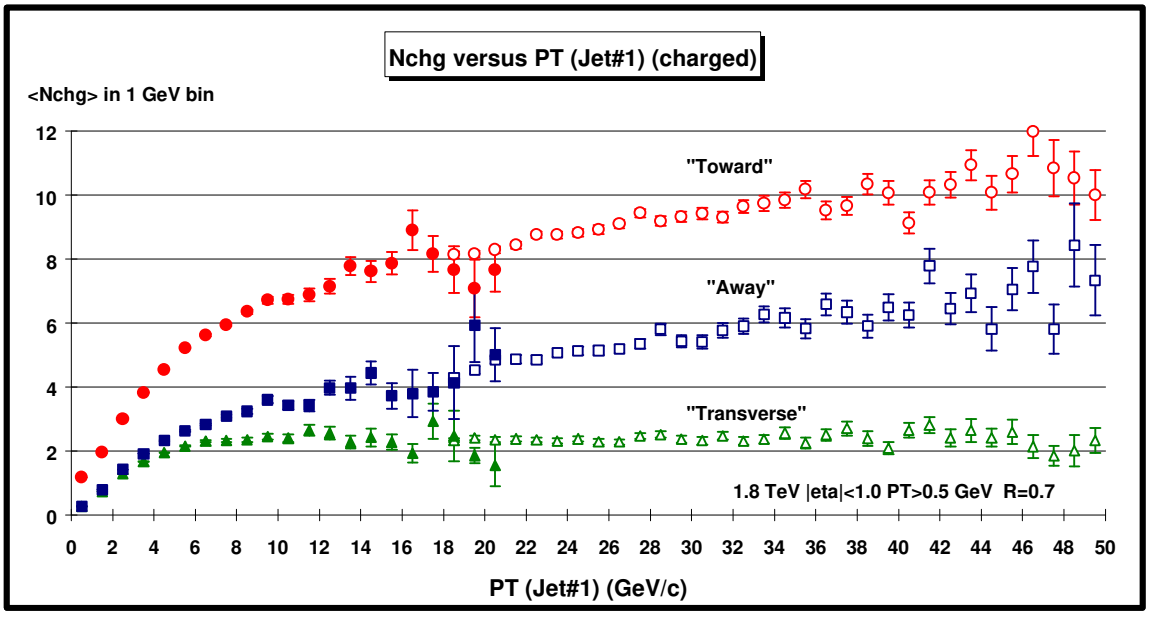
Distribution of <Nchg> Relative to Jet#1

Look at the ϕ dependence relative to Jet#1:

"Toward" $|\phi-\phi_{jet}| < 60^o$
"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$
"Away" $|\phi-\phi_{jet}| > 120^o$

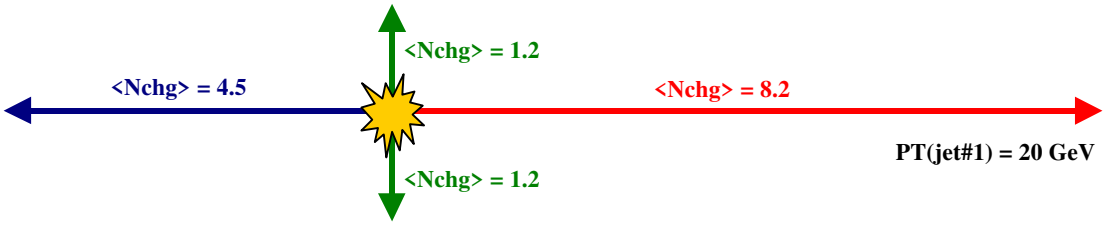


Average Charged Multiplicity versus P_T(jet#1):



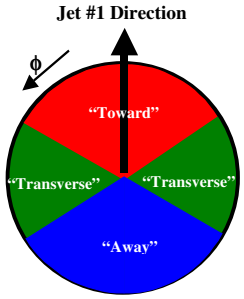
CDF data: Min Bias + Jet20

Average Event "Shape" P_T(jet#1) = 20 GeV:



$|\eta| < 1$ $P_T > 0.5$ GeV

Distribution of <Nchg> Relative to Jet#1



Look at the ϕ dependence relative to Jet#1:

"Toward" $|\phi-\phi_{jet}| < 60^o$
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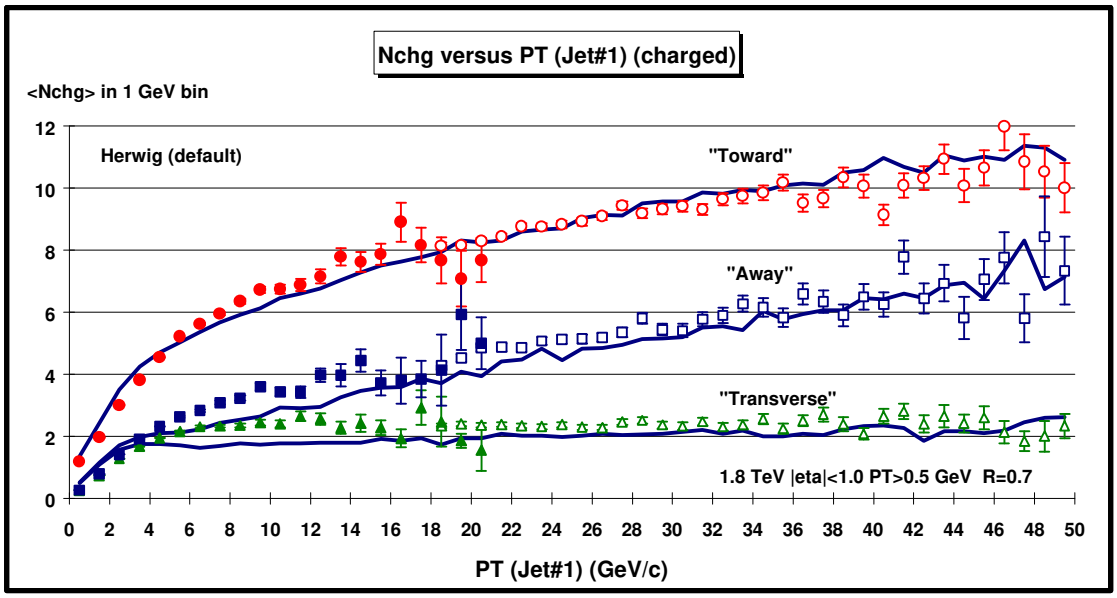
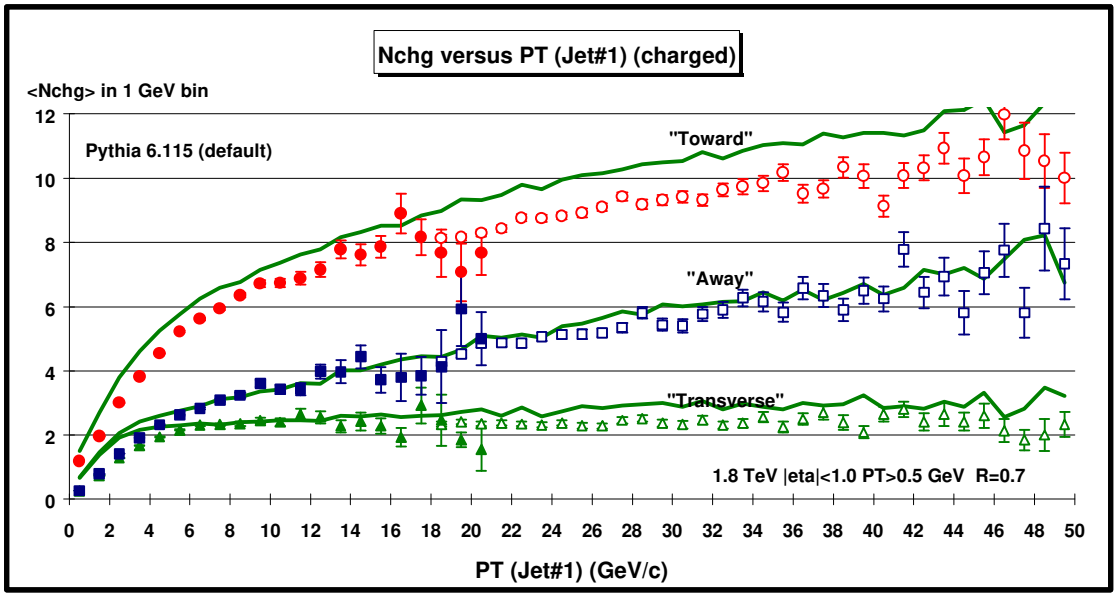
"Away" $|\phi-\phi_{jet}| > 120^o$

<Nchg> versus P_T(jet#1) (data vs Herwig default):

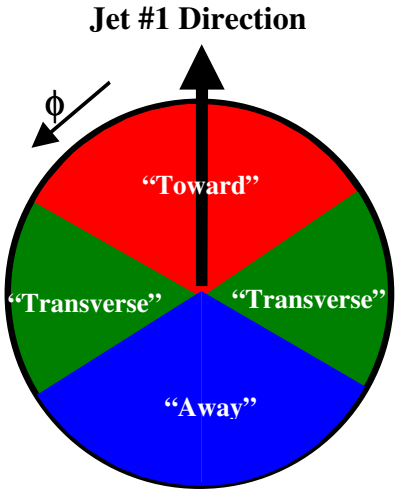


<Nchg> versus P_T(jet#1) (data vs Pythia 6.115):



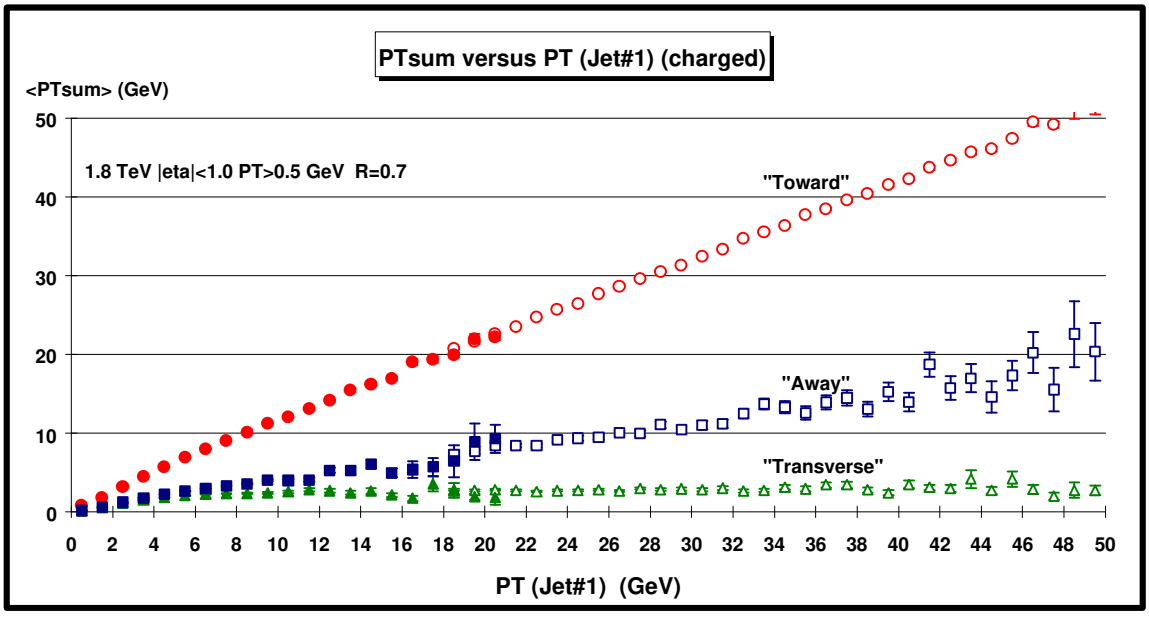
Distribution of <PTsum> Relative to Jet#1

Look at the ϕ dependence relative to Jet#1:



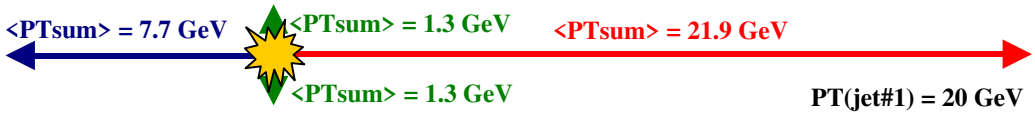
"Toward" $|\phi-\phi_{jet}| < 60^o$
"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$
"Away" $|\phi-\phi_{jet}| > 120^o$

Average PTsum (scalar PT sum) versus P_T(jet#1):



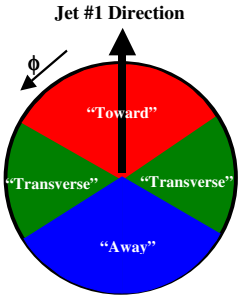
CDF data: Min Bias + Jet20

Average Event "Shape" P_T(jet#1) = 20 GeV:



$|\eta| < 1$ $P_T > 0.5$ GeV

Distribution of <PTsum> Relative to Jet#1



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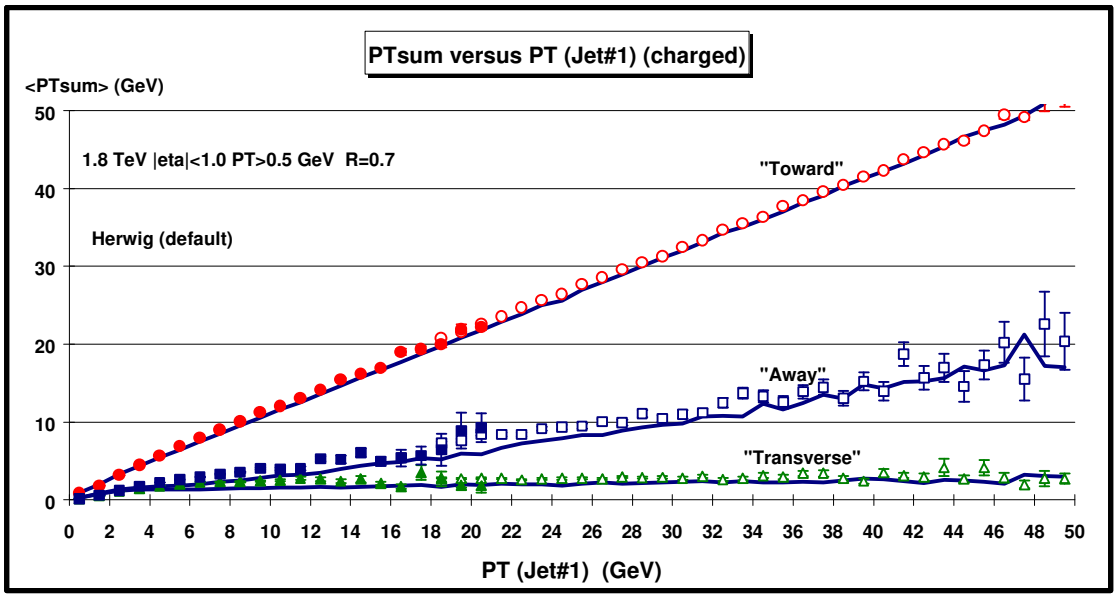
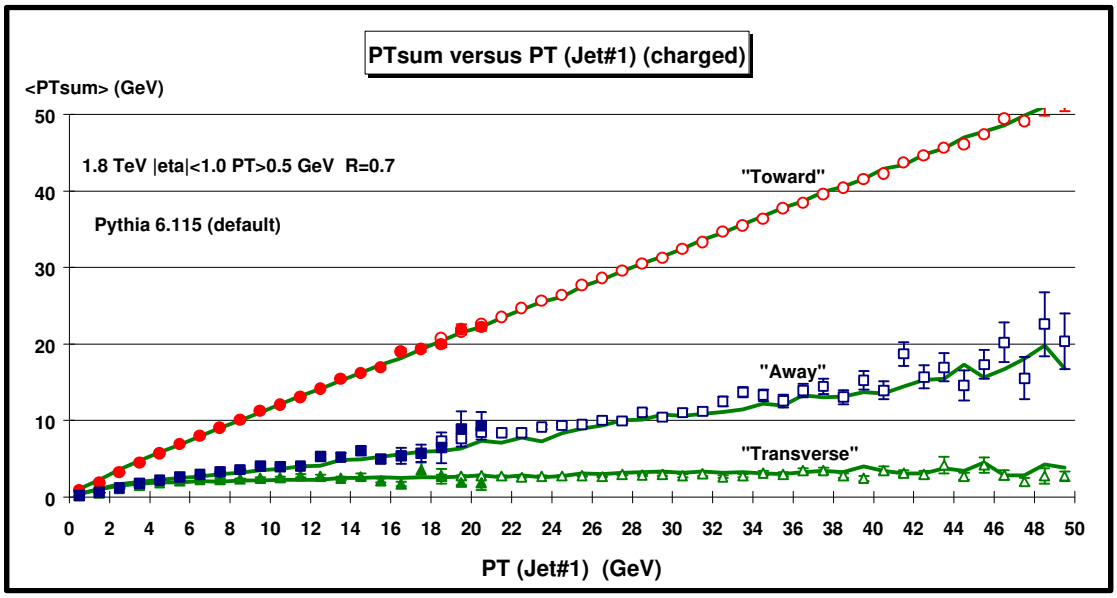
"Away" $|\phi-\phi_{jet}| > 120^o$

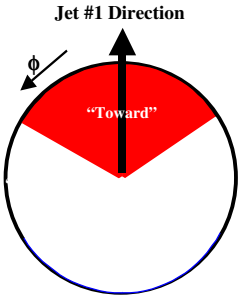
<PTsum> versus P_T(jet#1) (data vs Herwig default):



<PTsum> versus P_T(jet#1) (data vs Pythia 6.115):



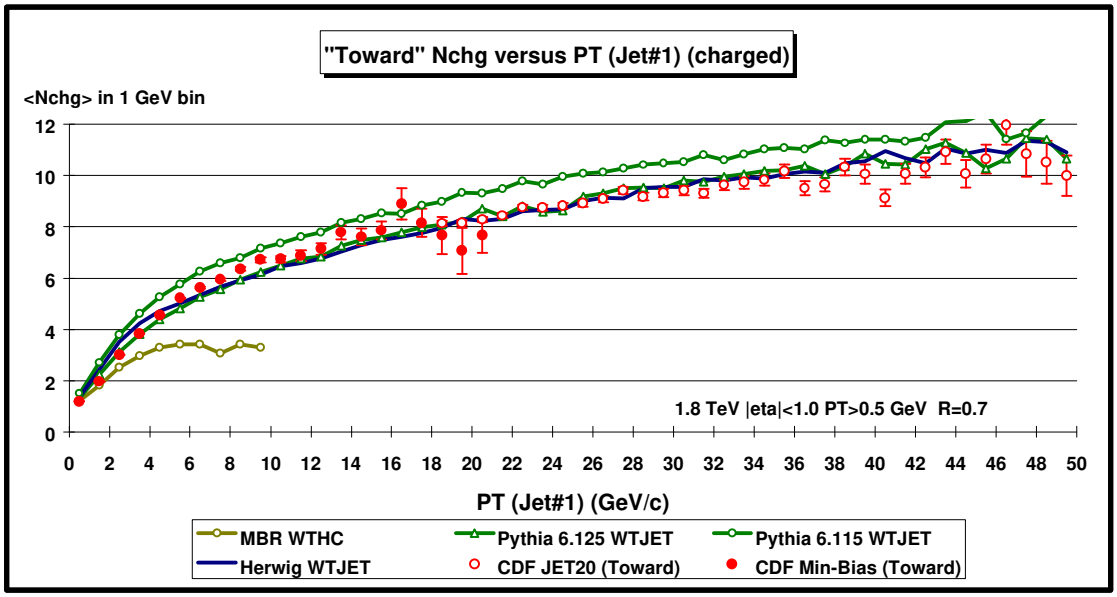
"Toward" <Nchg> versus PT(jet#1)



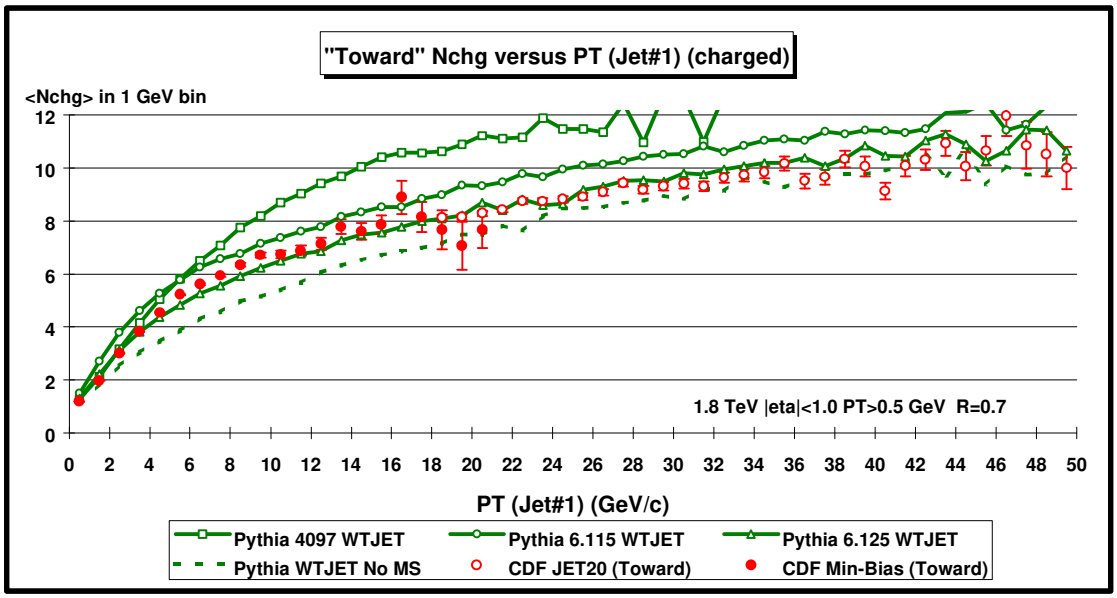
Look at the ϕ dependence relative to Jet#1:

"Toward" $|\phi-\phi_{jet}| < 60^o$

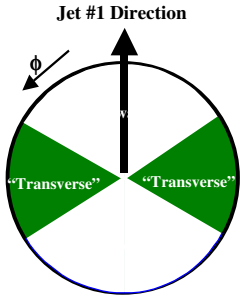
<Nchg> versus P_T(jet#1) (data vs Herwig, Pythia, & MBR):



<Nchg> versus P_T(jet#1) (data vs four versions of Pythia):



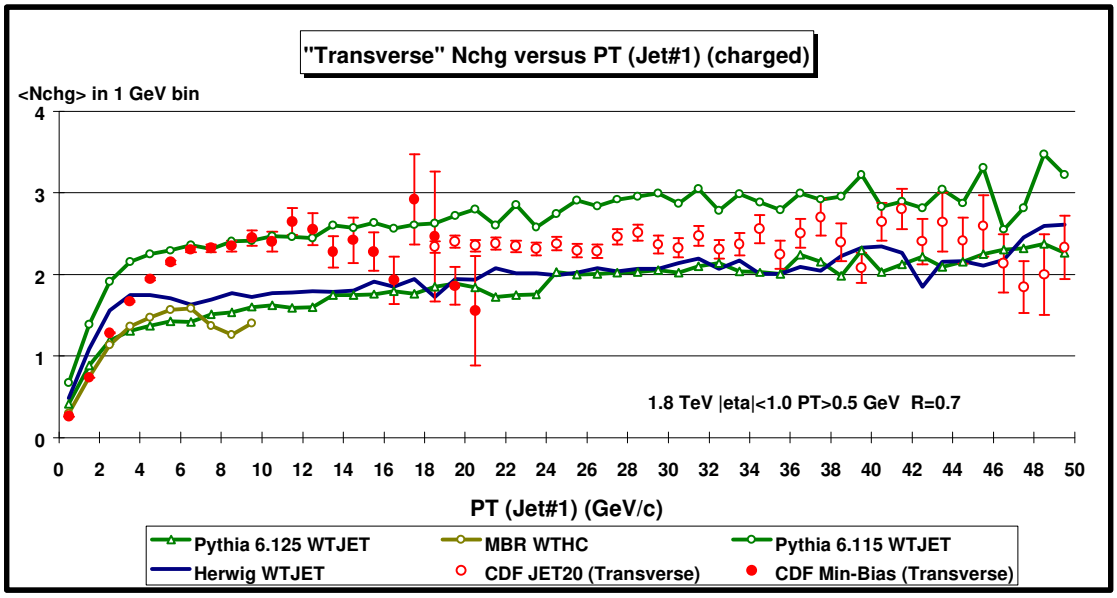
"Transverse" <Nchg> versus PT(jet#1)



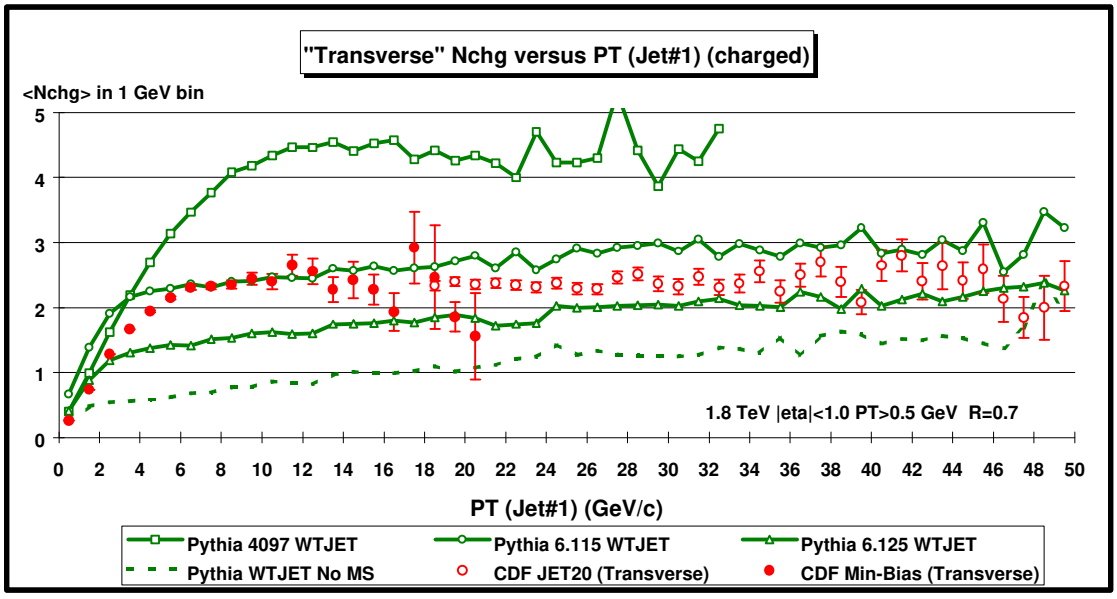
Look at the ϕ dependence relative to Jet#1:

"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$

"Transverse" <Nchg> vs P_T(jet#1) (data vs Herwig, Pythia, & MBR):

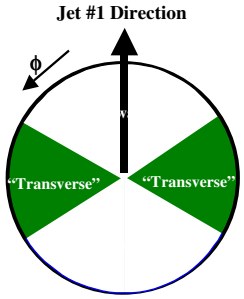


"Transverse" <Nchg> vs P_T(jet#1) (data vs four versions of Pythia):



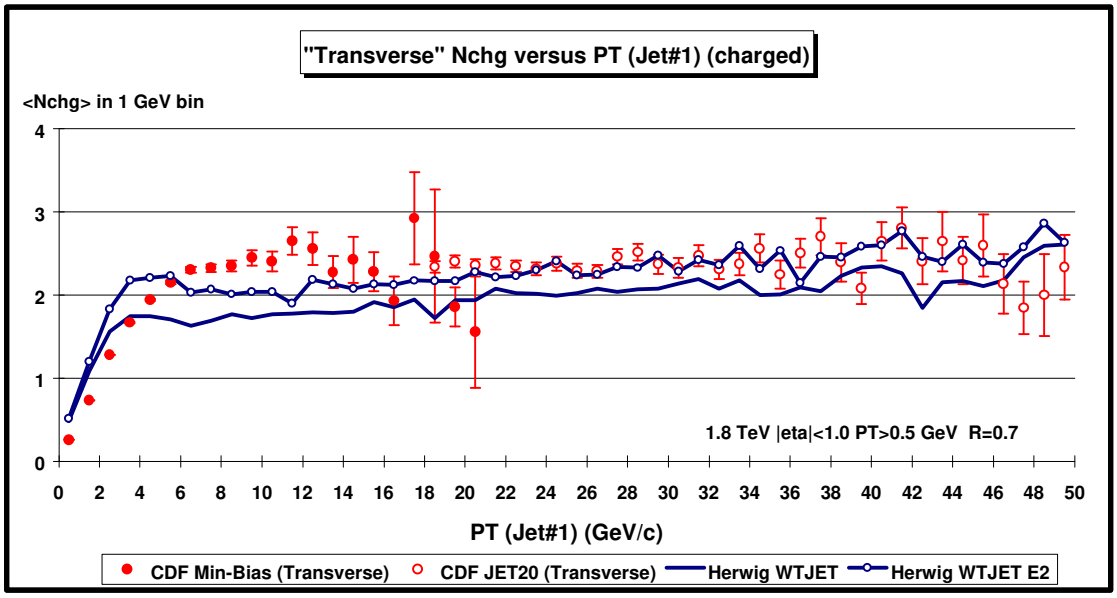
"Transverse" <Nchg> versus PT(jet#1)

Look at the ϕ dependence relative to Jet#1:

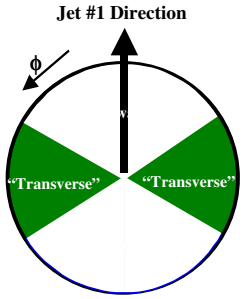


"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$

"Transverse" <Nchg> vs P_T(jet#1) (data vs two versions of Herwig):



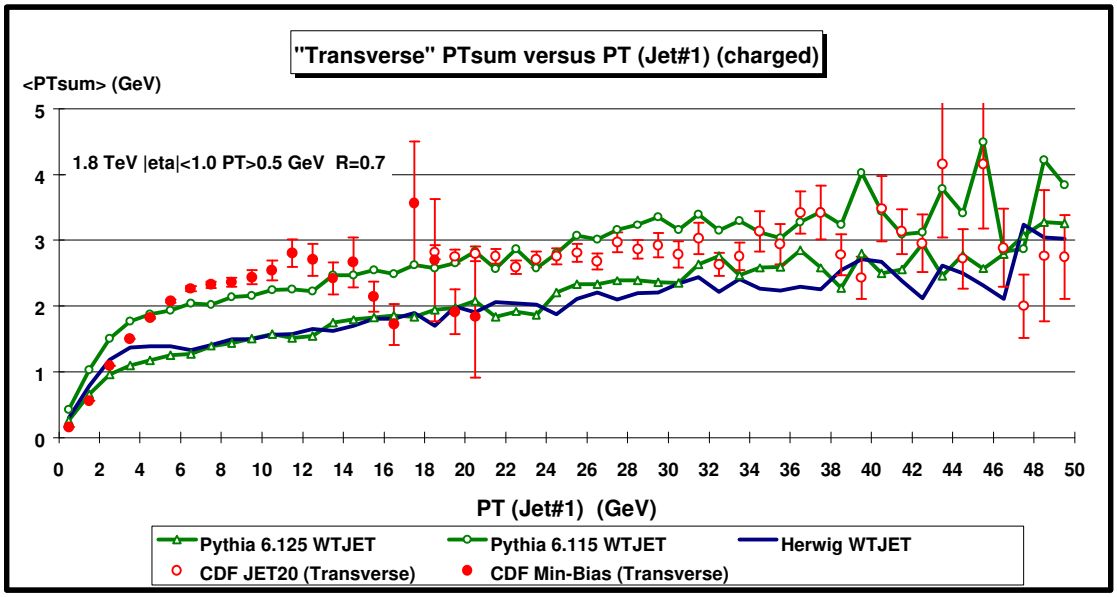
"Transverse" <PTsum> versus PT(jet#1)



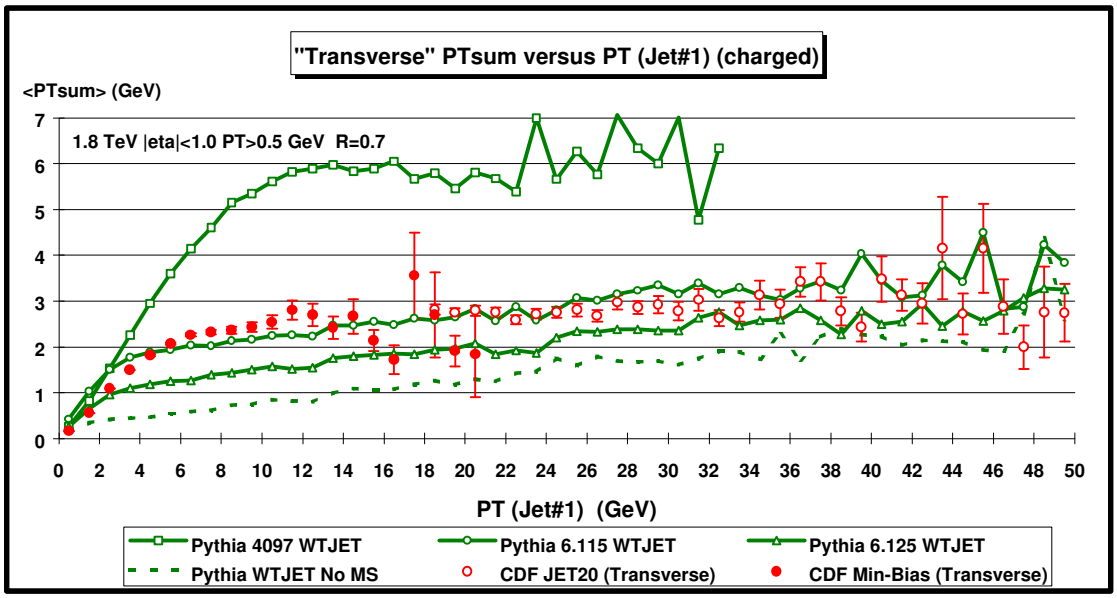
Look at the ϕ dependence relative to Jet#1:

"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$

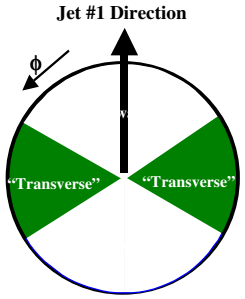
"Transverse" <PTsum> vs P_T(jet#1) (data vs Herwig and Pythia):



"Transverse" <PTsum> vs P_T(jet#1) (data vs four versions of Pythia):



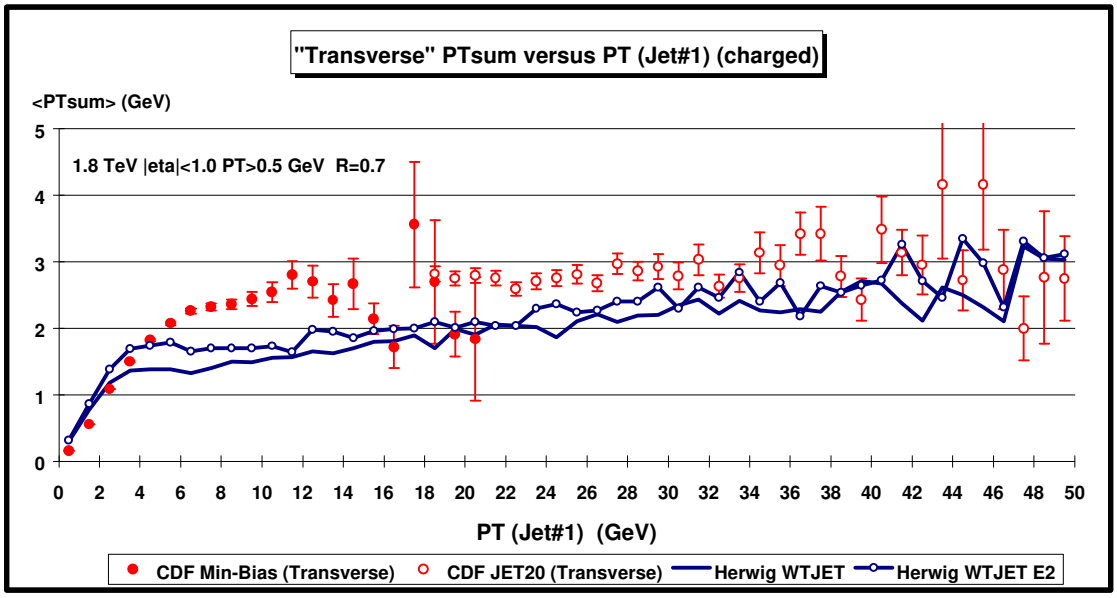
"Transverse" <PTsum> versus PT(jet#1)



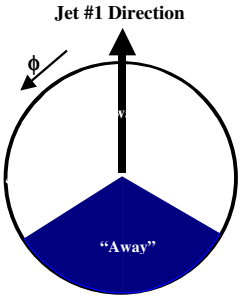
Look at the ϕ dependence relative to Jet#1:

"Transverse" $60^o < |\phi-\phi_{jet}| < 120^o$

"Transverse" <PTsum> vs P_T(jet#1) (data vs two versions of Herwig):



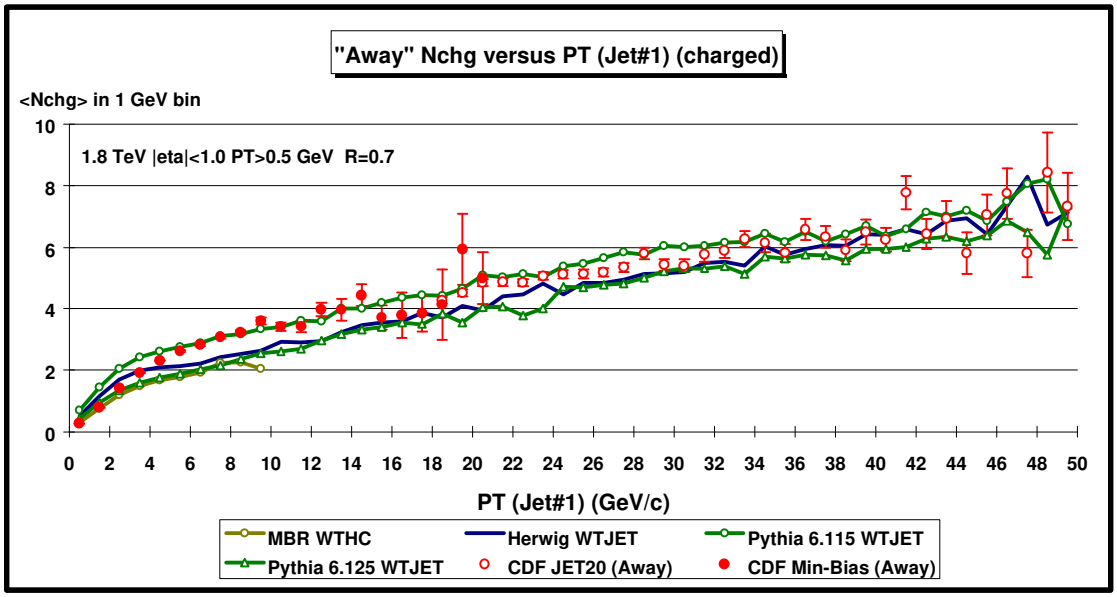
"Away" <Nchg> versus PT(jet#1)



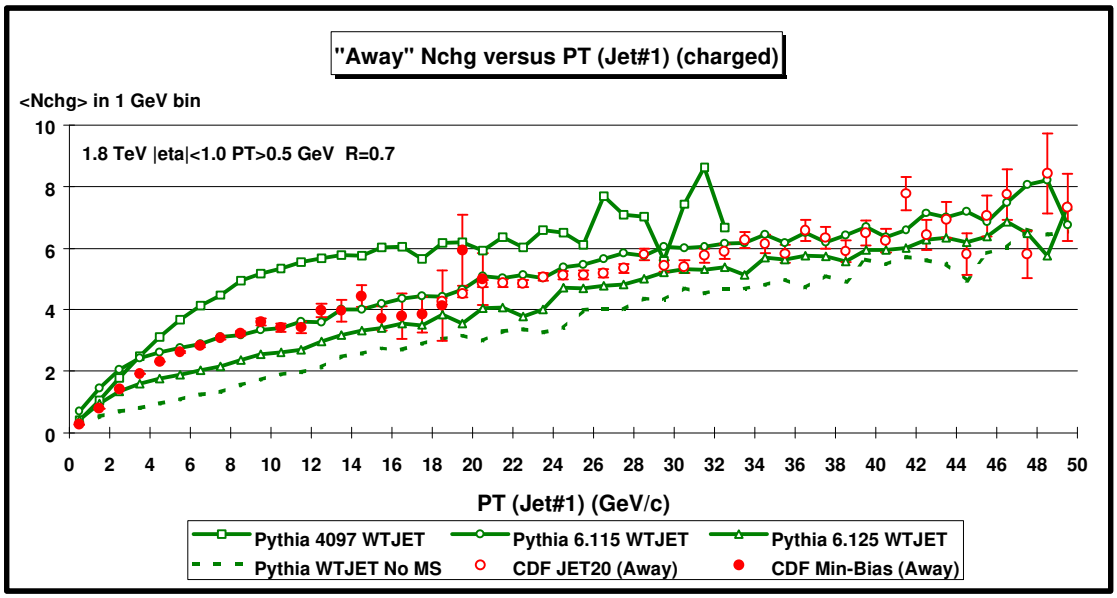
Look at the ϕ dependence relative to Jet#1:

"Away" $|\phi-\phi_{jet}| > 120^o$

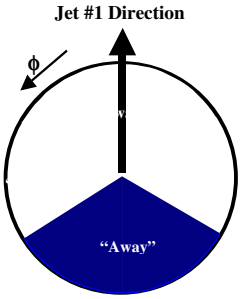
"Away" <Nchg> vs P_T(jet#1) (data vs Herwig, Pythia, & MBR):



"Away" <Nchg> vs P_T(jet#1) (data vs four versions of Pythia):



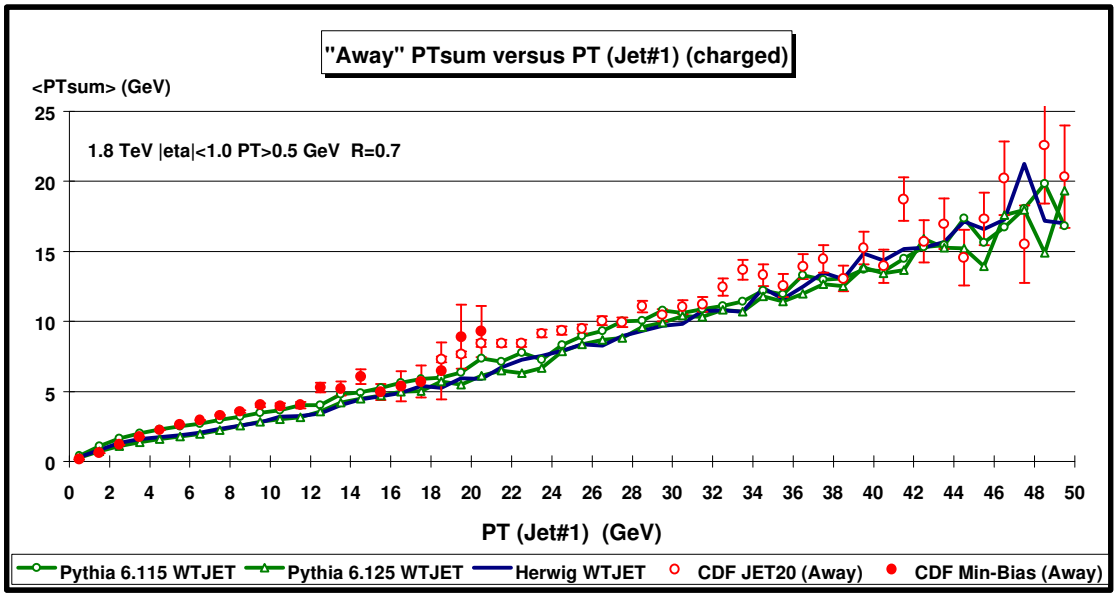
"Away" <PTsum> versus PT(jet#1)



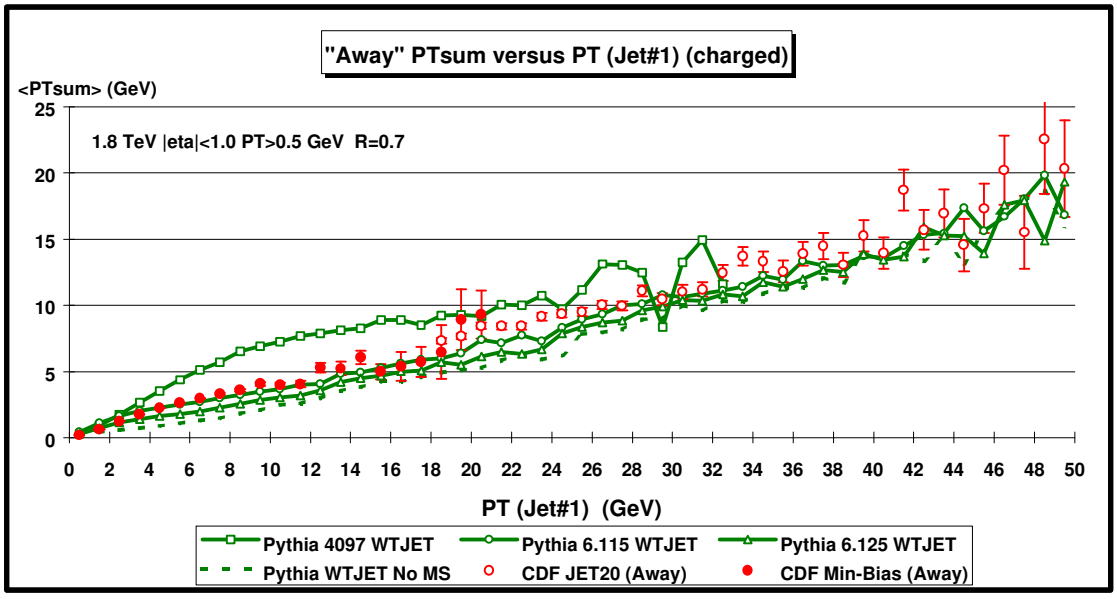
Look at the ϕ dependence relative to Jet#1:

"Away" $|\phi-\phi_{jet}| > 120^o$

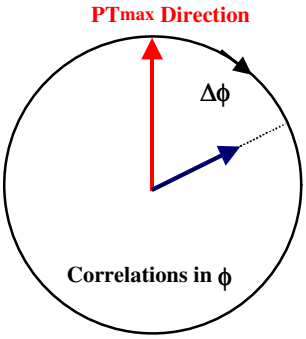
"Away" <PTsum> vs P_T(jet#1) (data vs Herwig and Pythia):



"Away" <PTsum> vs P_T(jet#1) (data vs four versions of Pythia):

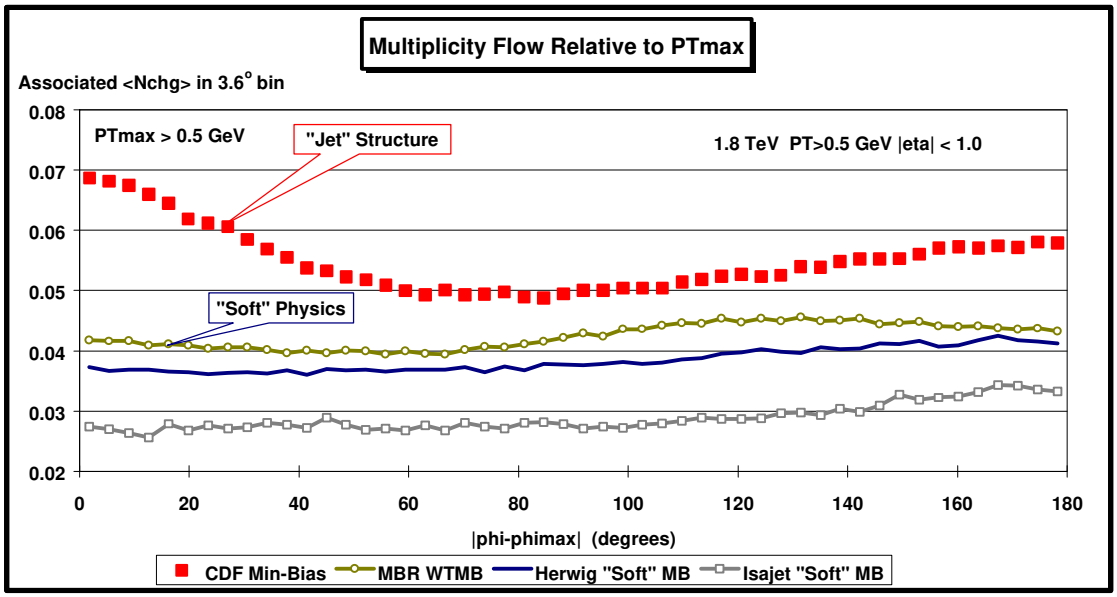


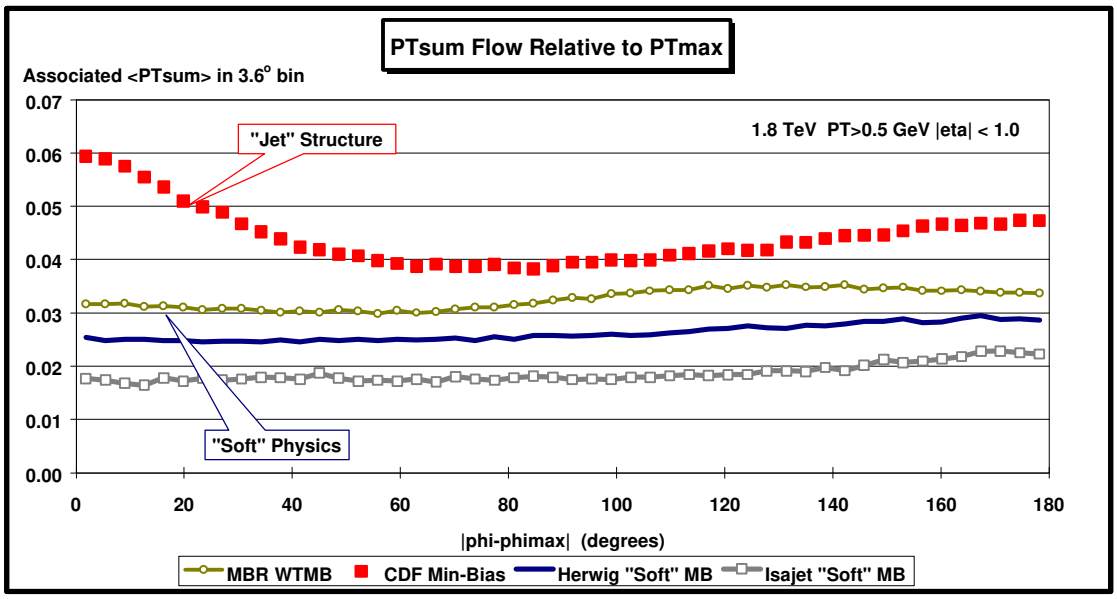
MB Jets – N-Flow & PT-Flow Relative to PTmax



Define PTmax to be the highest PT charged particle in the event (PT > 0.5 GeV, |η| < 1) and look at correlations in azimuthal angle φ.

<Nchg> Produced in Association with PTmax versus $|\phi-\phi_{max}|$:



Does not include PTmax (Nchg >=2)

<PTsum> Produced in Association with PTmax versus $|\phi-\phi_{max}|$: