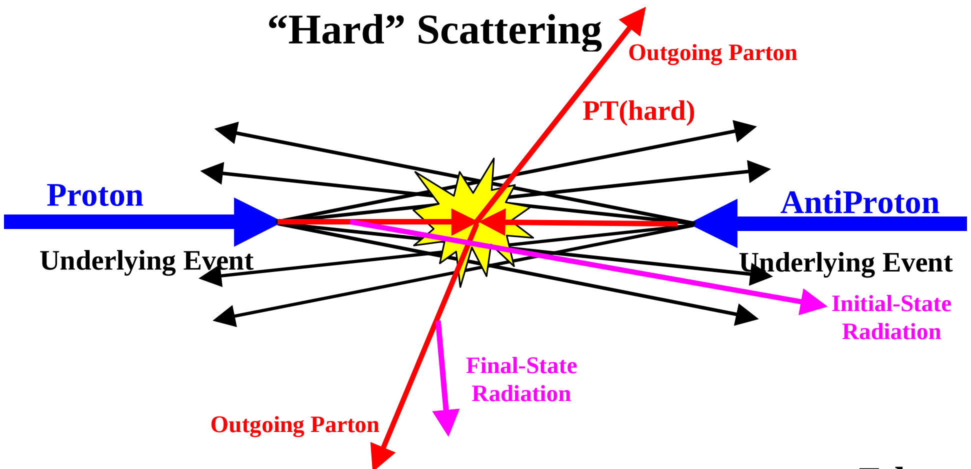
The Underlying Event:
DiJet vs Z-Jet vs B-Jet vs J/Psi

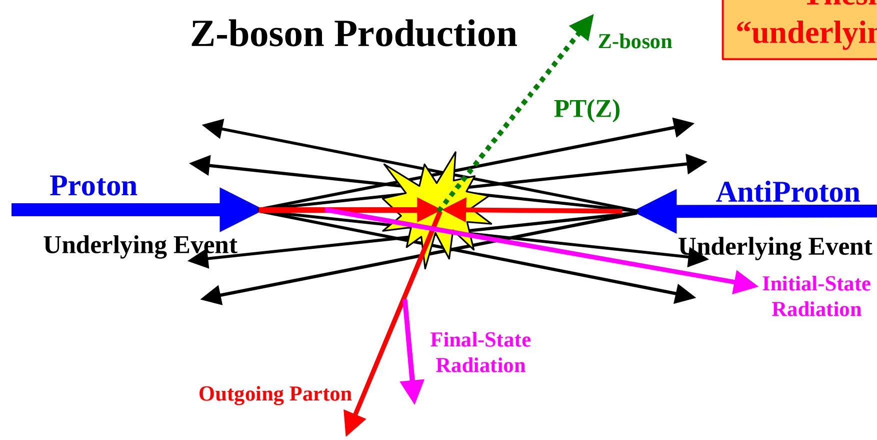
“Hard” Scattering



R. Field
H. Frisch
R. Haas
D. Stuart

Thesis on “underlying event”

Z-boson Production



The “underlying event” consists of the beam-beam remnants and initial-state radiation

Comparing Data with QCD Monte-Carlo Models

Charged Particle Data

Field-Stuart Method

QCD Monte-Carlo

Look only at the charged particles measured by the CTC

Select "clean" region

- Zero or one vertex
- $|zc-zv| < 2$ cm, $|CTC\ d0| < 1$ cm
- Require $P_T > 0.5$ GeV, $|\eta| < 1$
- Assume a uniform track finding efficiency of 92%
- Errors include both statistical and correlated systematic uncertainties

Uncorrected data

compare

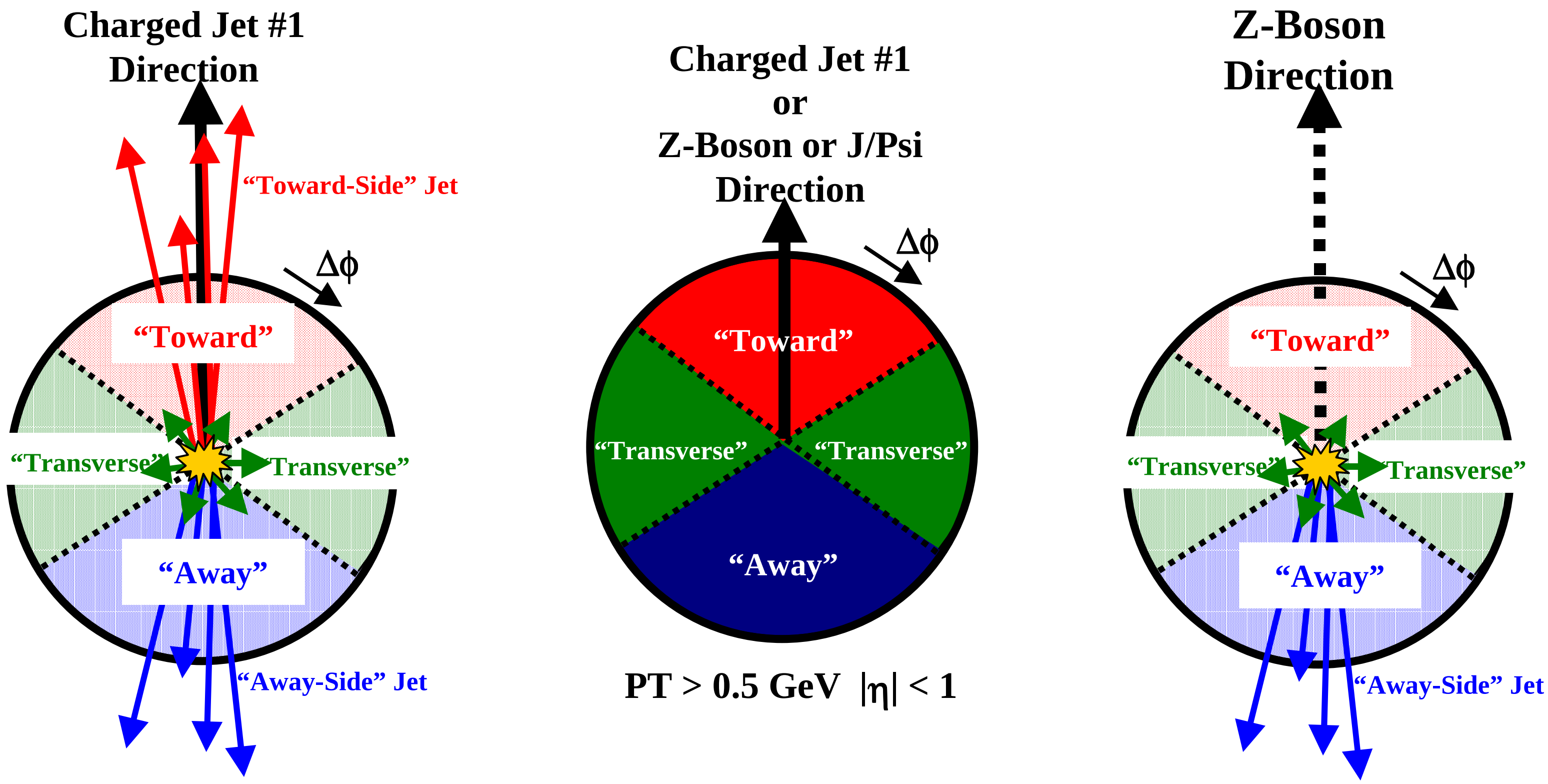
Make efficiency corrections

- Require $P_T > 0.5$ GeV, $|\eta| < 1$
- Make an 8% correction for the track finding efficiency
- Errors (statistical plus systematic) of around 5%

Corrected theory

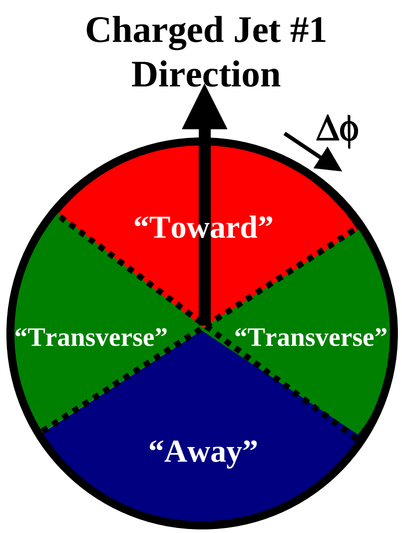
Small Corrections!

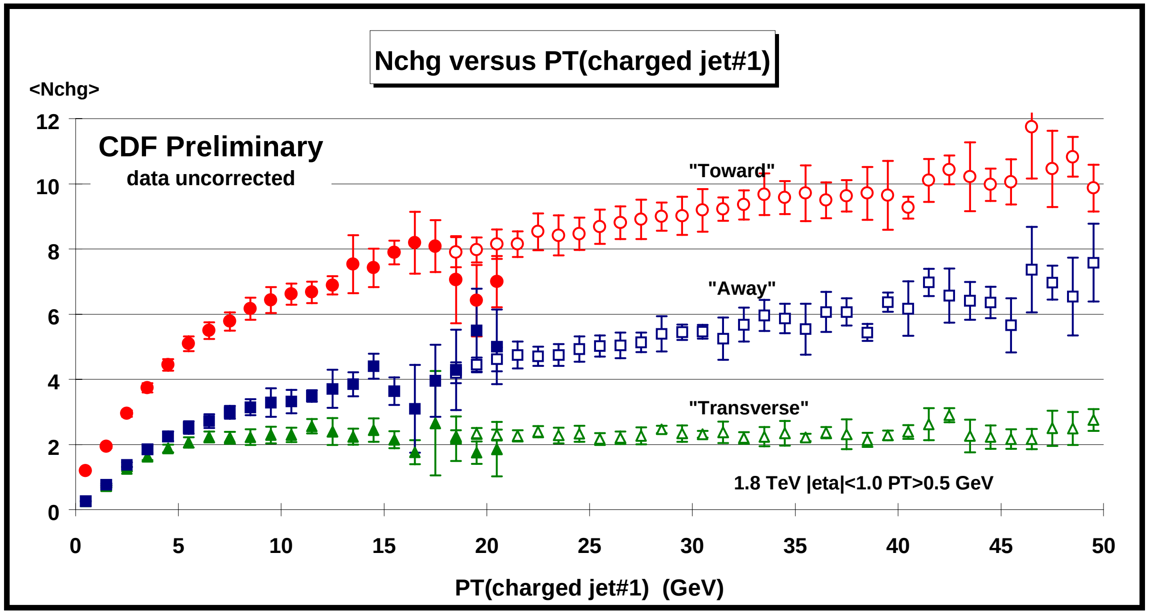
Charged Particle Δϕ Correlations



- Look at charged particle correlations in the azimuthal angle Δϕ.
- Define $|\Delta\phi| < 60^o$ as "Toward", $60^o < |\Delta\phi| < 120^o$ as "Transverse", and $|\Delta\phi| > 120^o$ as "Away".
- All three regions have the same size in η-ϕ space, $\Delta\eta x\Delta\phi = 2x120^o$.

DiJet: Charged Multiplicity versus PT(chgjet#1)

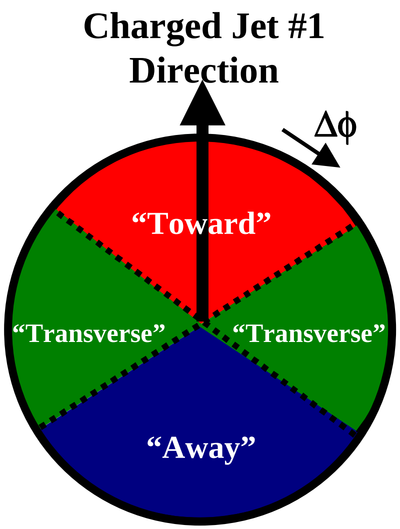


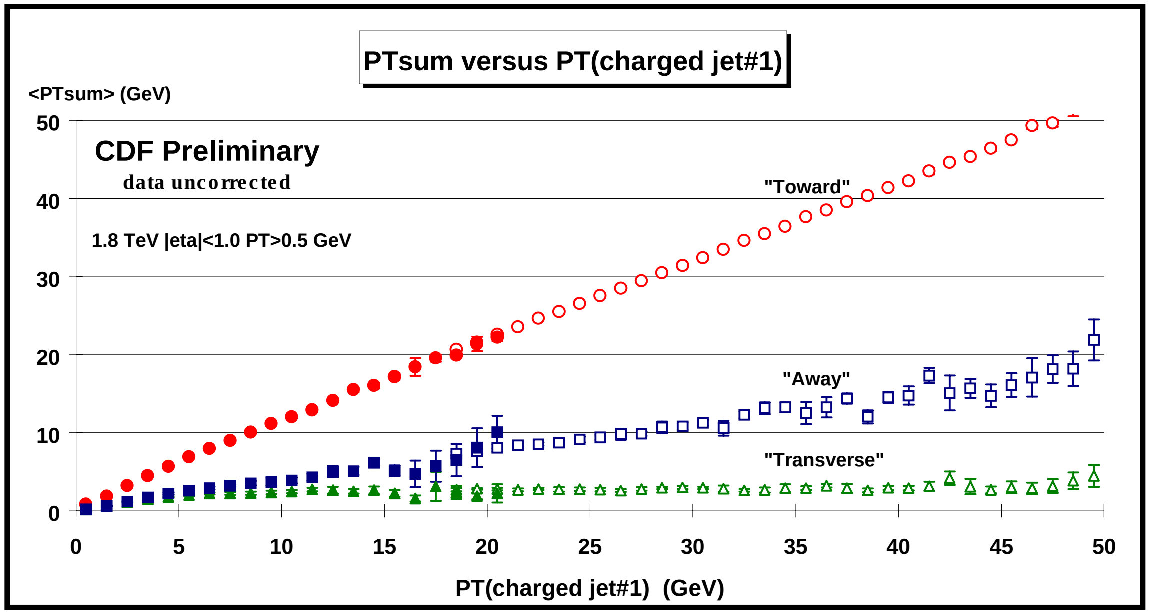


⇨ **Dijet data on the average number of "toward" ($|\Delta\phi|<60^{\circ}$), "transverse" ($60<|\Delta\phi|<120^{\circ}$), and "away" ($|\Delta\phi|>120^{\circ}$) charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$, including jet#1) as a function of the transverse momentum of the leading charged particle jet. Each point corresponds to the <Nchg> in a 1 GeV bin. The solid (open) points are the Min-Bias (JET20) data. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

Blessed on November 3, 1999

DiJet: Charged PTsum versus PT(chgjet#1)

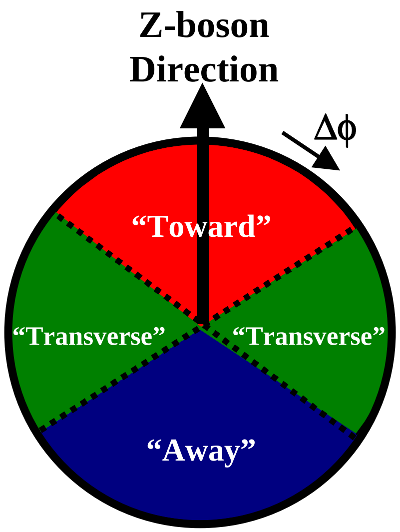


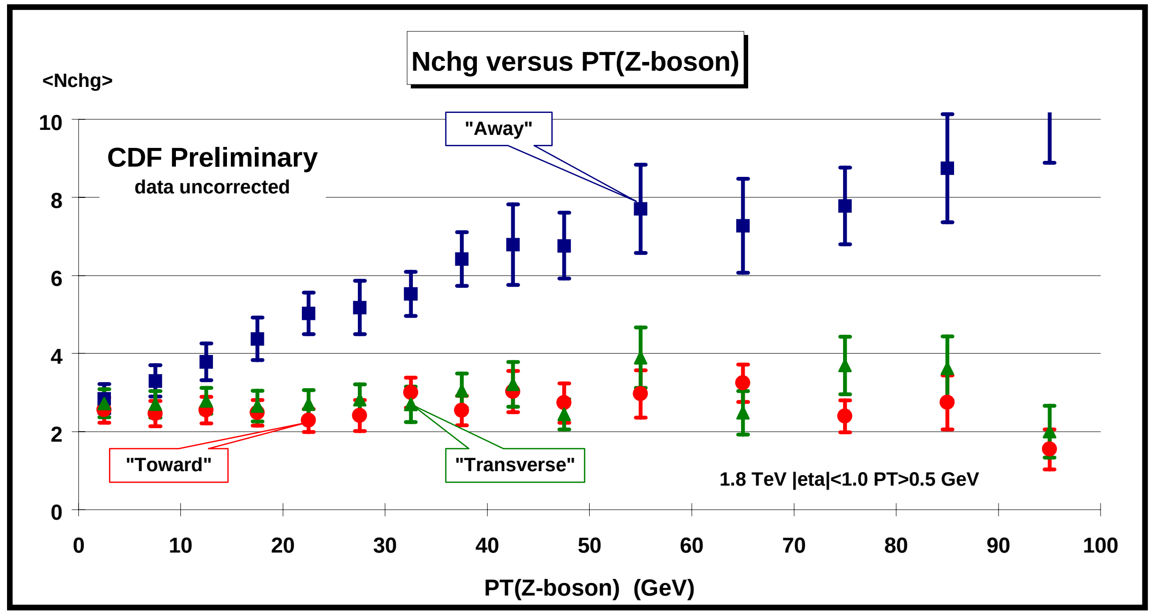


⇨ **Dijet data on the average scalar P_T sum of “toward” ($|\Delta\phi|<60^o$), “transverse” ($60<|\Delta\phi|<120^o$), and “away” ($|\Delta\phi|>120^o$) charged particles (P_T > 0.5 GeV, $|\eta|$ < 1, including jet#1) as a function of the transverse momentum of the leading charged particle jet. Each point corresponds to the <PTsum> in a 1 GeV bin. The solid (open) points are the Min-Bias (JET20) data. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

Blessed on November 3, 1999

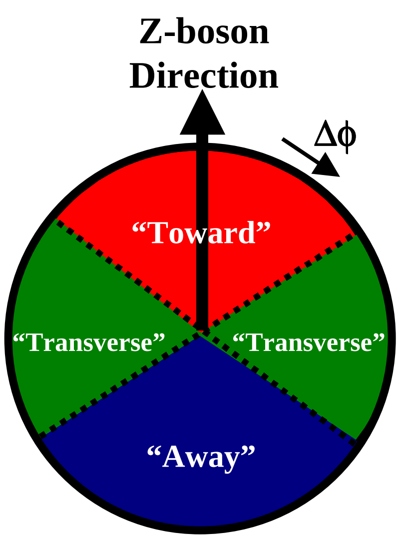
Z-boson: Charged Multiplicity versus PT(Z)

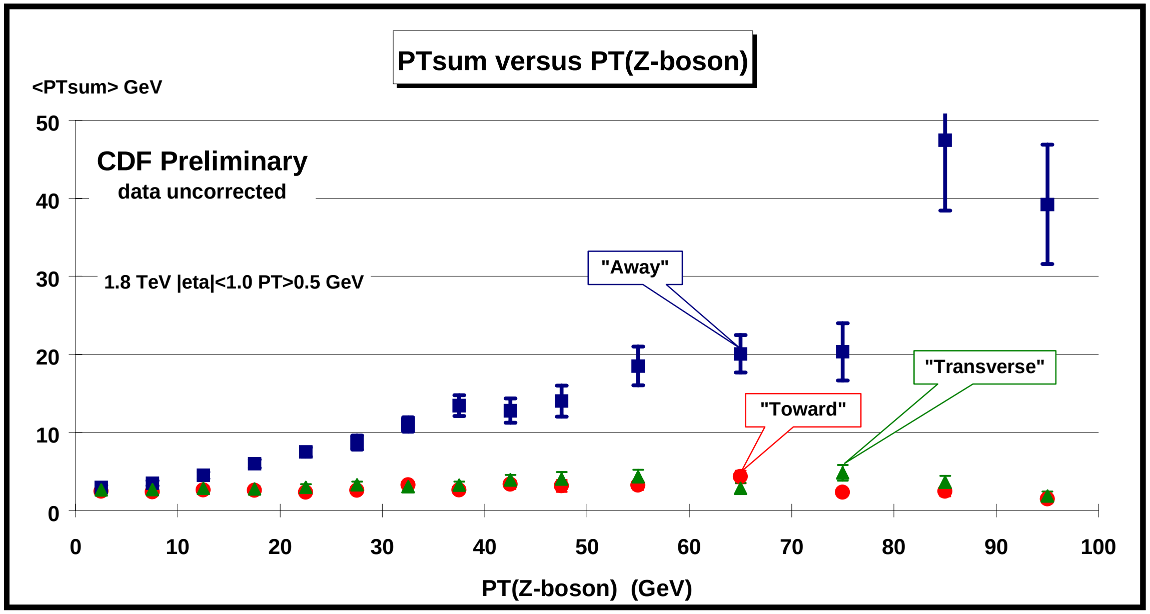




- ⇨ **Z-boson data on the average number of “toward” ($|\Delta\phi|<60^o$), “transverse” ($60<|\Delta\phi|<120^o$), and “away” ($|\Delta\phi|>120^o$) charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$, excluding decay products of the Z-boson) as a function of the transverse momentum of the Z-boson. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

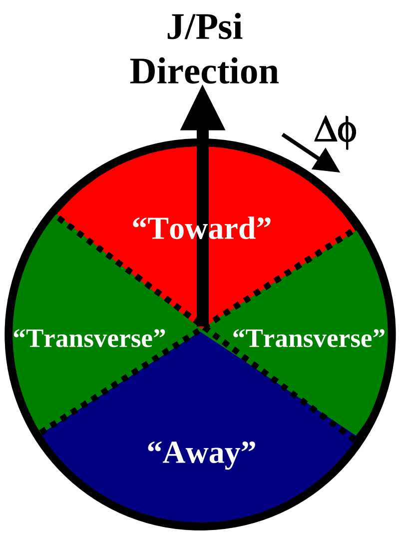
Z-boson: Charged PTsum versus PT(Z)

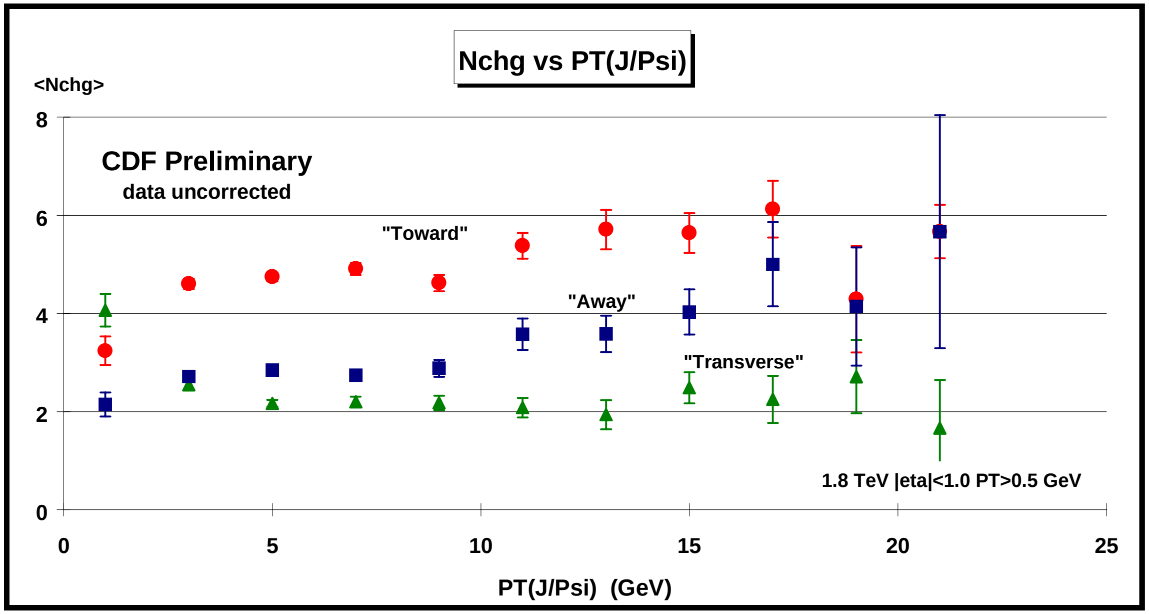




⇨ **Z-boson data on the average *scalar* P_T sum of "toward" ($|\Delta\phi|<60^o$), "transverse" ($60<|\Delta\phi|<120^o$), and "away" ($|\Delta\phi|>120^o$) charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$, excluding decay products of the Z-boson) as a function of the transverse momentum of the Z-boson. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

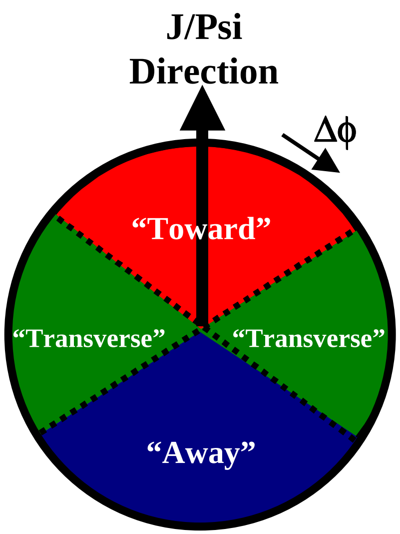
J/Psi: Charged Multiplicity versus PT(J/Psi)

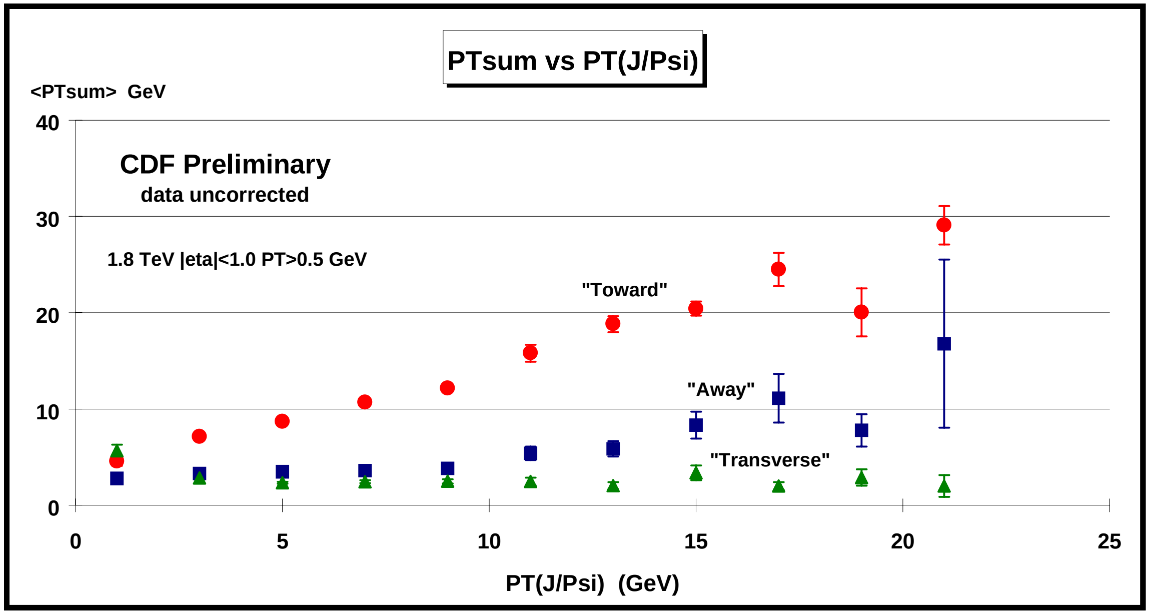




⇨ **J/Psi data on the average number of "toward" ($|\Delta\phi|<60^o$), "transverse" ($60<|\Delta\phi|<120^o$), and "away" ($|\Delta\phi|>120^o$) charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$) as a function of the transverse momentum of the J/Psi. Each point corresponds to the <Nchg> in a 1 GeV bin. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

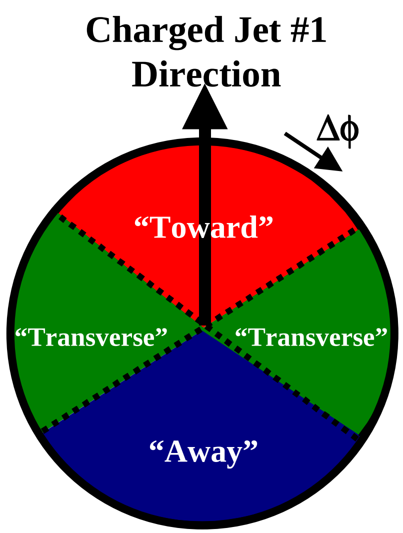
J/Psi: Charged PTsum versus PT(J/Psi)

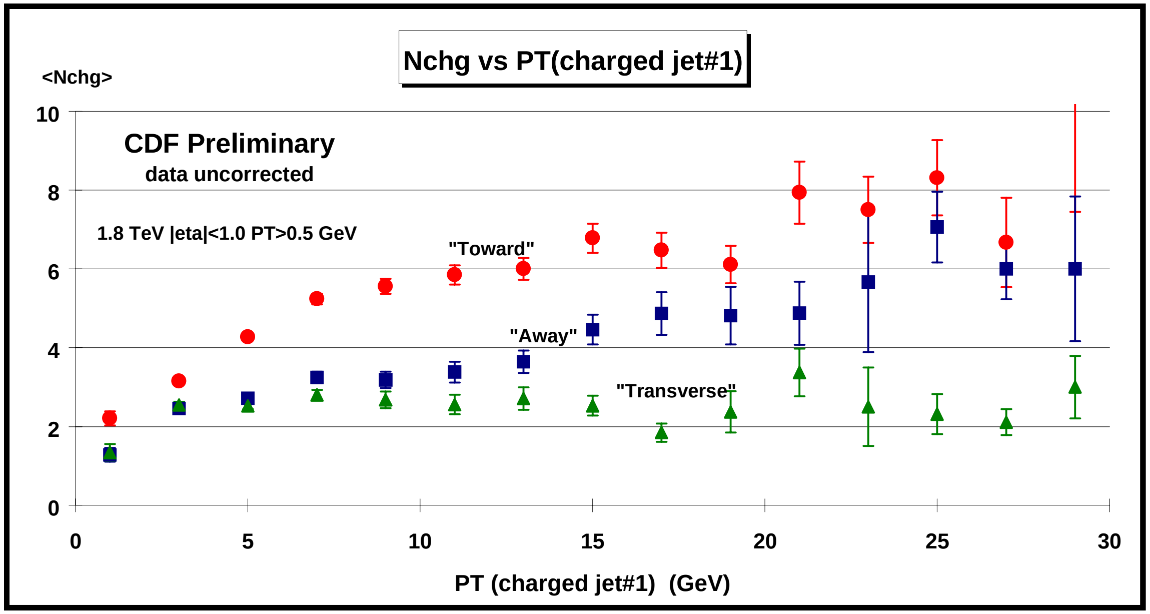




⇨ **J/Psi data on the average scalar P_T sum of "toward" ($|\Delta\phi|<60^o$), "transverse" ($60<|\Delta\phi|<120^o$), and "away" ($|\Delta\phi|>120^o$) charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$) as a function of the transverse momentum of the J/Psi. Each point corresponds to the <PTsum> in a 1 GeV bin. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.**

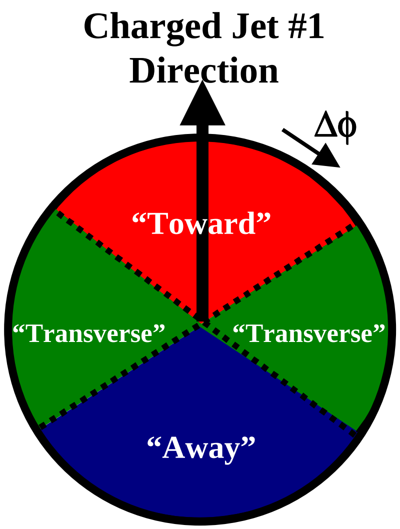
B-Jet: Charged Multiplicity versus PT(chgjet#1)

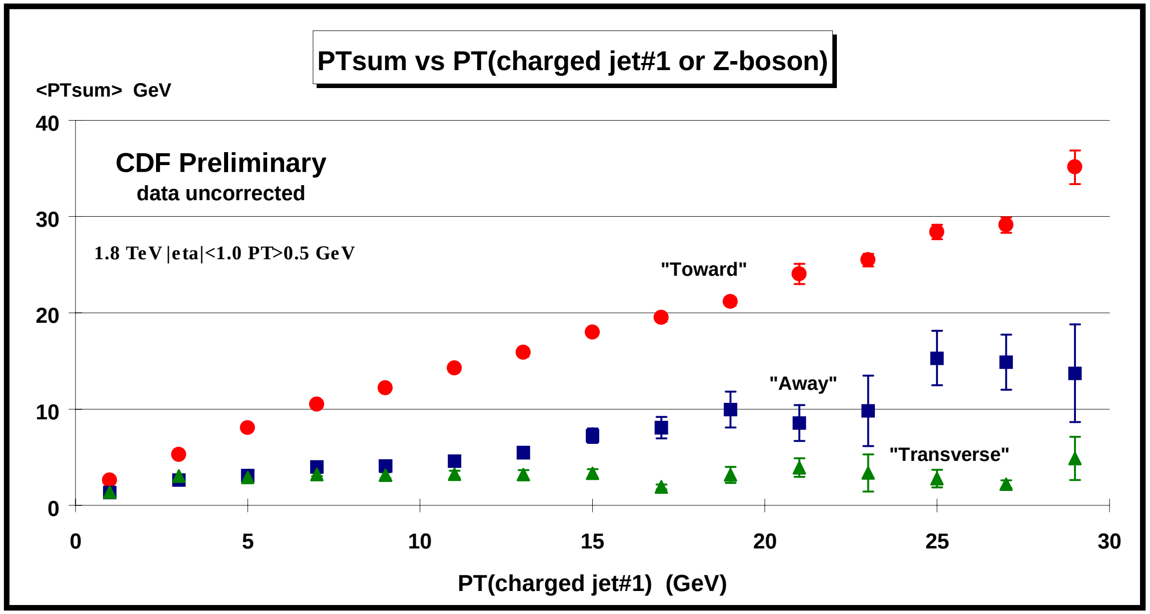




- **B-Jet data** on the average number of **"toward" ($|\Delta\phi|<60^o$)**, **"transverse" ($60<|\Delta\phi|<120^o$)**, and **"away" ($|\Delta\phi|>120^o$)** charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$, including jet#1) as a function of the transverse momentum of the leading charged particle jet. Each point corresponds to the <Nchg> in a 1 GeV bin. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.

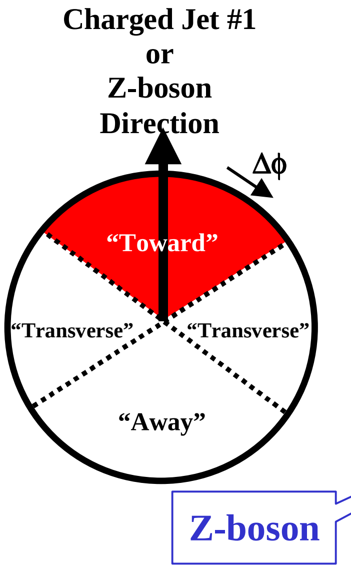
B-Jet: Charged PTsum versus PT(chgjet#1)

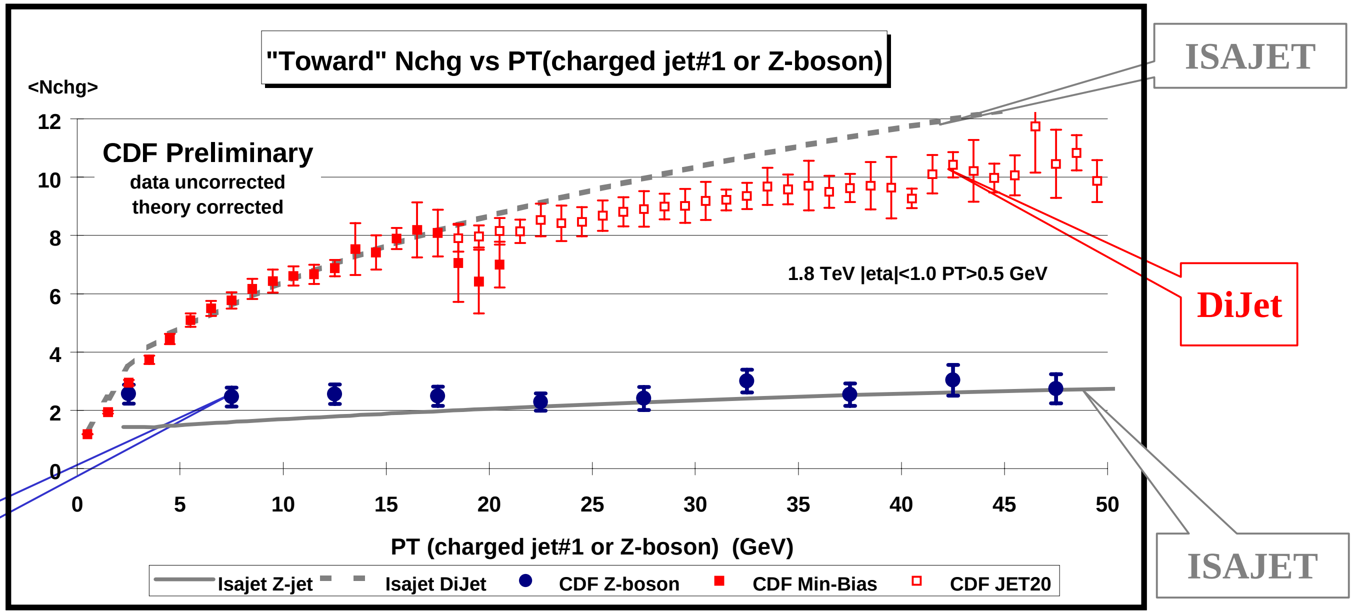




⇨ **B-Jet data** on the average scalar P_T sum of **"toward" (|Δϕ|<60°)**, **"transverse" (60<|Δϕ|<120°)**, and **"away" (|Δϕ|>120°)** charged particles (P_T > 0.5 GeV, |η| < 1, including jet#1) as a function of the transverse momentum of the leading charged particle jet. Each point corresponds to the <PTsum> in a 1 GeV bin. The errors on the (*uncorrected*) data include both statistical and correlated systematic uncertainties.

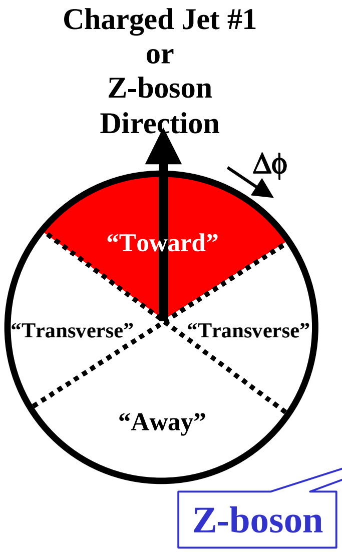
DiJet vs Z-Jet "Toward" Nchg

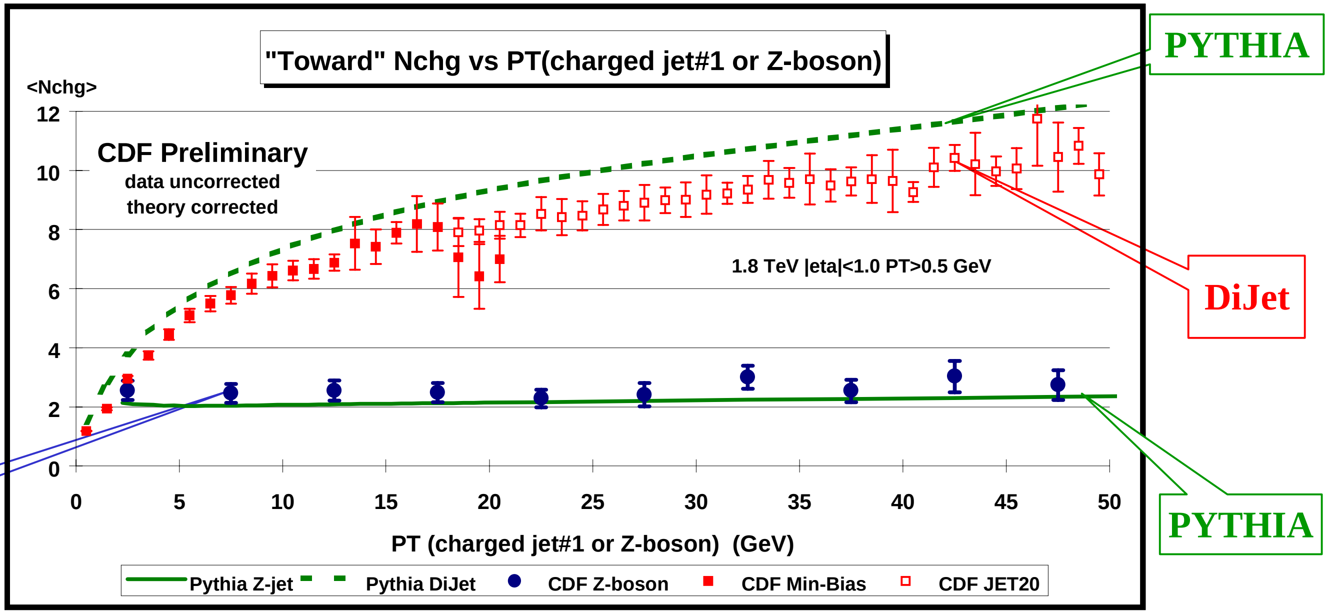




- Comparison of the dijet and the Z-boson data on the average number of charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$) for the "toward" region.
- The plot shows the QCD Monte-Carlo predictions of ISAJET 7.32 for dijet (dashed) and "Z-jet" (solid) production.

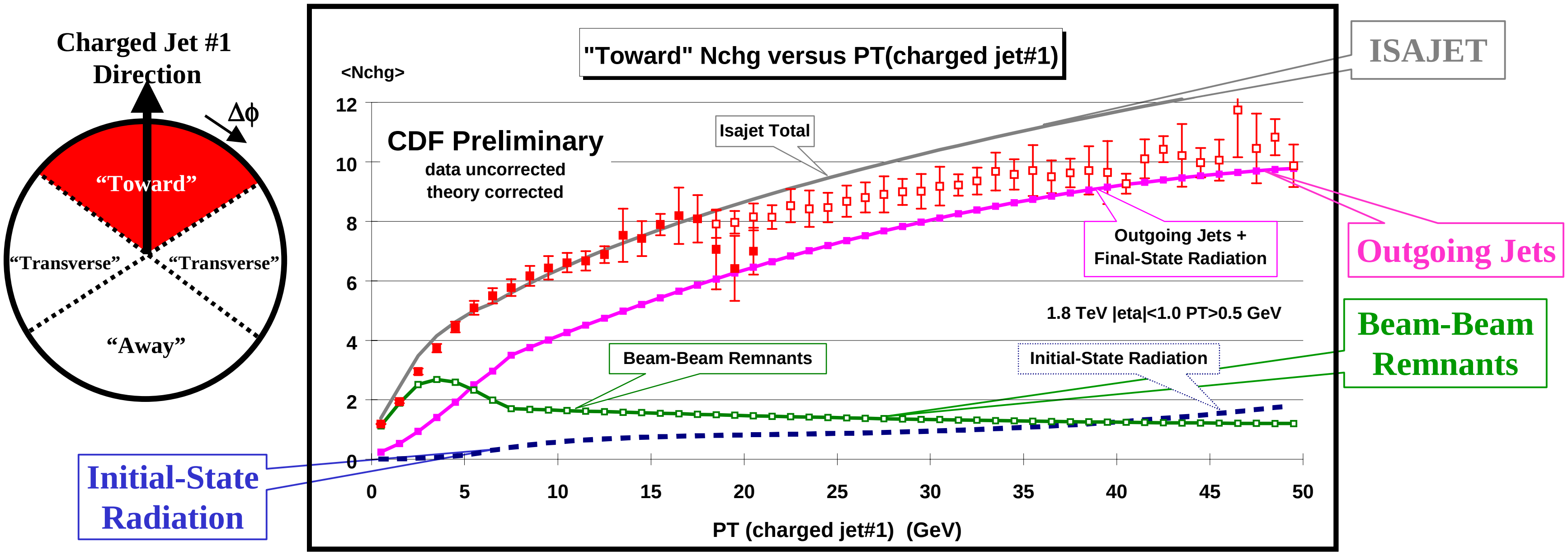
DiJet vs Z-Jet
"Toward" Nchg





- Comparison of the dijet and the Z-boson data on the average number of charged particles ($P_T > 0.5$ GeV, $|\eta| < 1$) for the "toward" region.
- The plot shows the QCD Monte-Carlo predictions of PYTHIA 6.115 for dijet (dashed) and "Z-jet" (solid) production.

DiJet: "Toward" Nchg versus PT(chgjet#1)



- Plot shows the dijet "toward" <Nchg> vs P_T(chgjet#1) compared to the QCD "hard" scattering predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jets plus final-state radiation.

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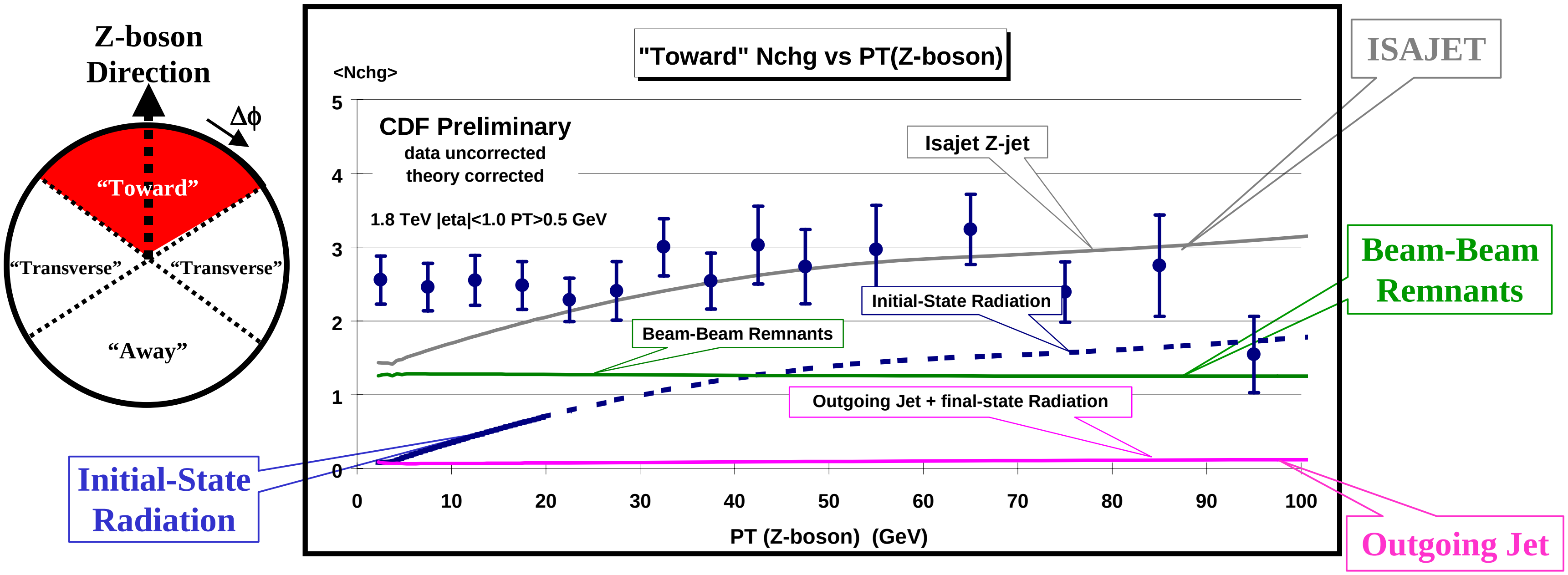
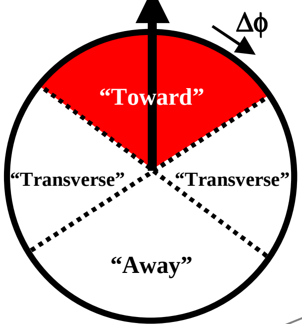
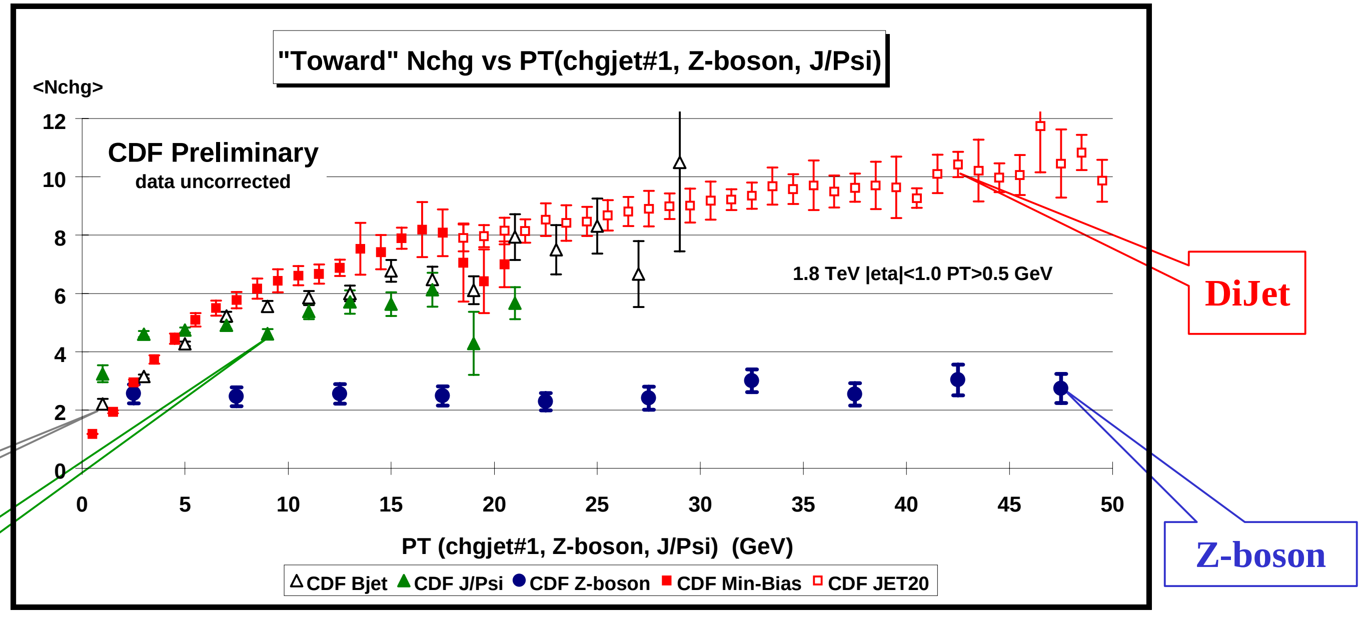
Z-boson: "Toward" Nchg versus PT(Z)



- Plot shows the Z-boson "toward" <Nchg> vs $P_T(Z)$ compared to the "Z+jet" QCD Monte-Carlo predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jet plus final-state radiation .

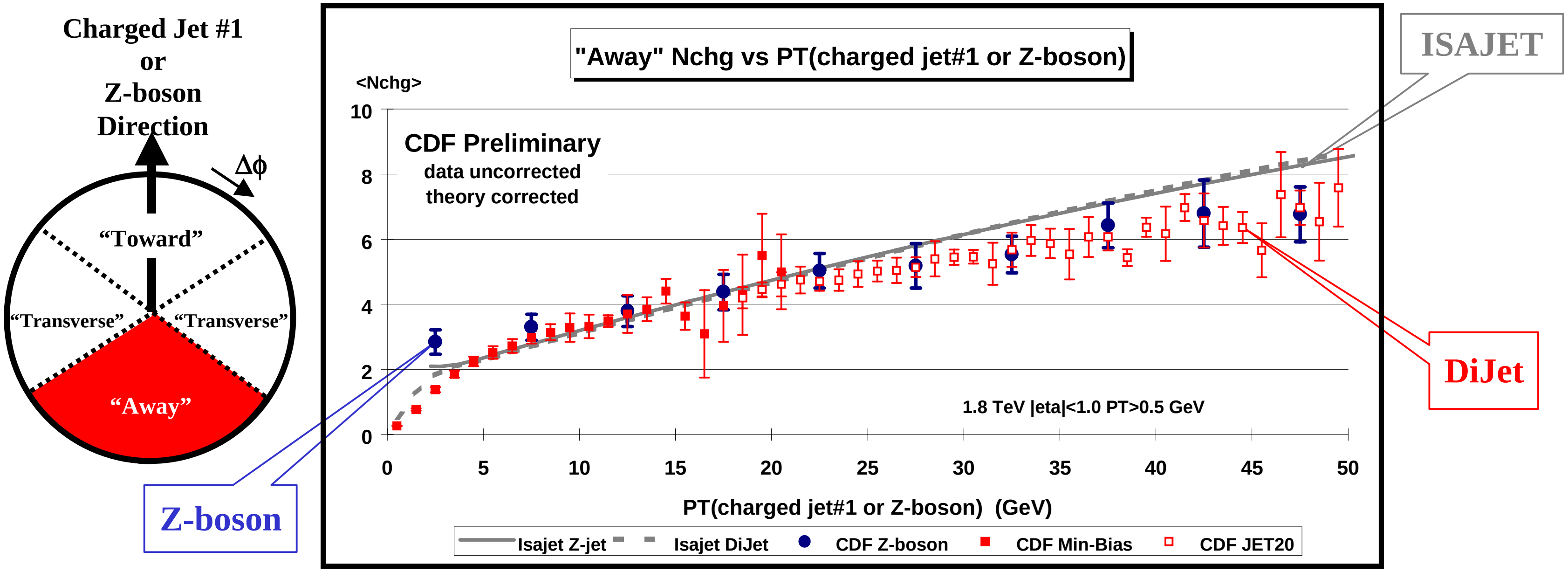
DiJet vs Z-Jet vs B-Jet vs J/Psi "Toward" Nchg





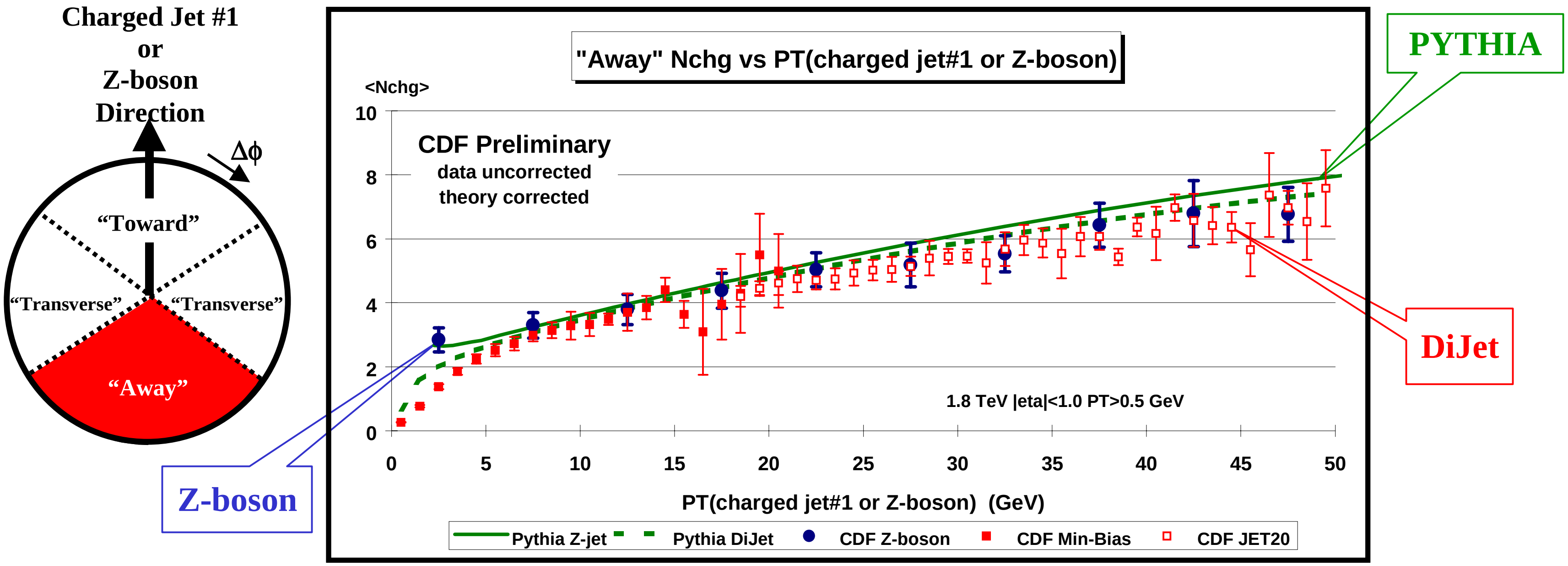
- Comparison of the **dijet**, **Z-boson**, **B-Jet**, and **J/Psi** data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the **"toward"** region.

DiJet vs Z-Jet "Away" Nchg



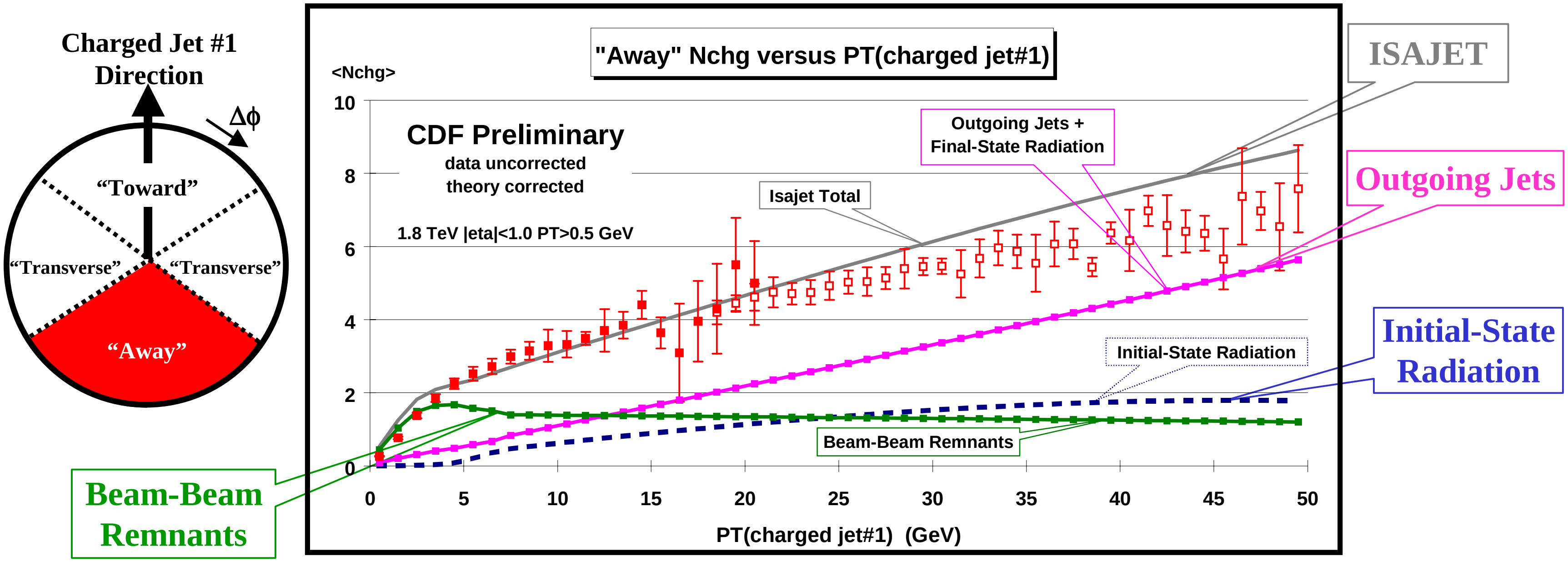
- ⇨ Comparison of the dijet and the Z-boson data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the "away" region.
- ⇨ The plot shows the QCD Monte-Carlo predictions of ISAJET 7.32 for dijet (dashed) and "Z-jet" (solid) production.

DiJet vs Z-Jet "Away" Nchg



- Comparison of the dijet and the Z-boson data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the "away" region.
- The plot shows the QCD Monte-Carlo predictions of PYTHIA 6.115 for dijet (dashed) and "Z-jet" (solid) production.

DiJet: “Away” Nchg versus PT(chgjet#1)



- Plot shows the dijet “away” <Nchg> vs P_T(chgjet#1) compared to the QCD “hard” scattering predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jets plus final-state radiation .

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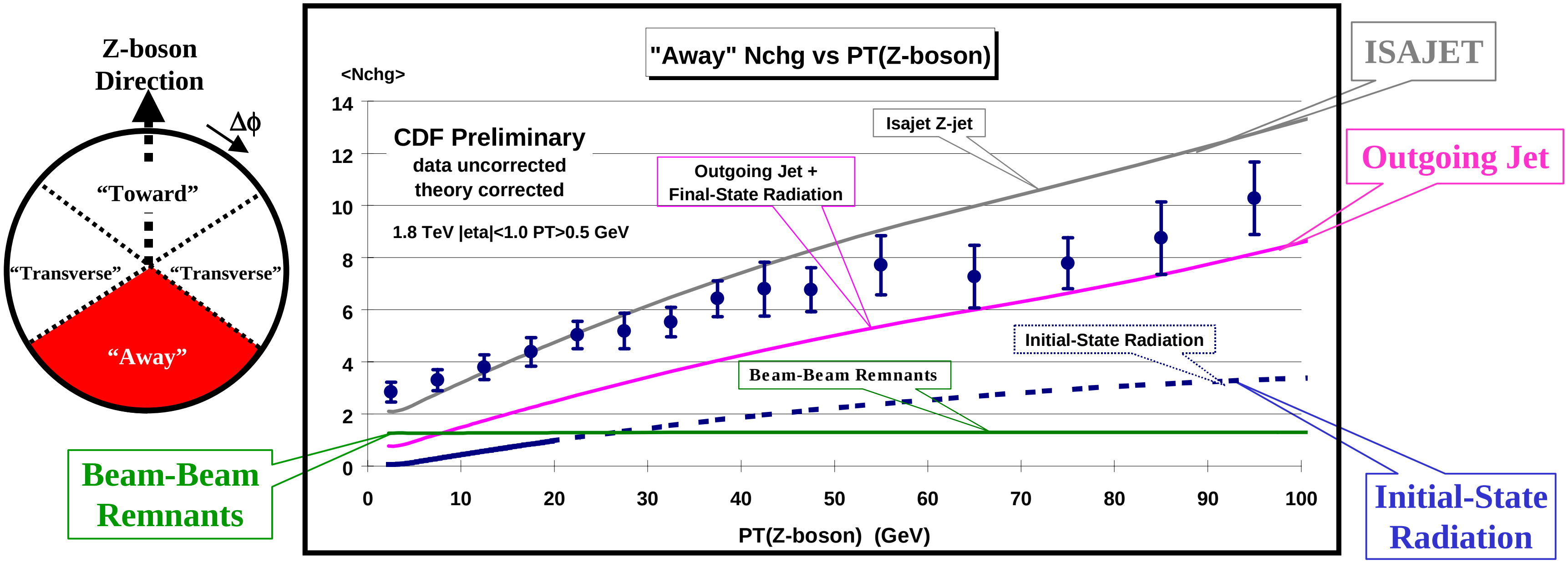
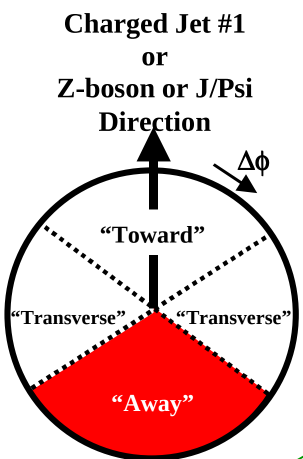
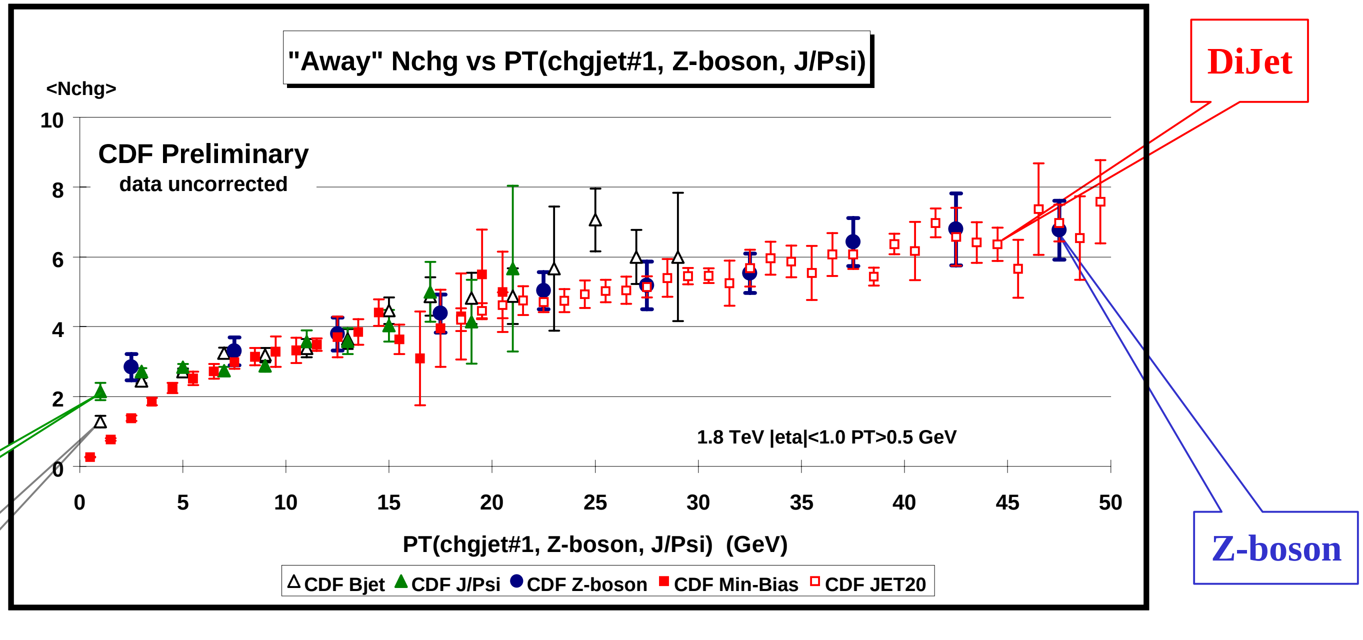
Z-boson: “Away” Nchg versus PT(Z)



- Plot shows the Z-boson “away” <Nchg> vs P_T(Z) compared to the “Z+jet” QCD Monte-Carlo predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jets plus final-state radiation.

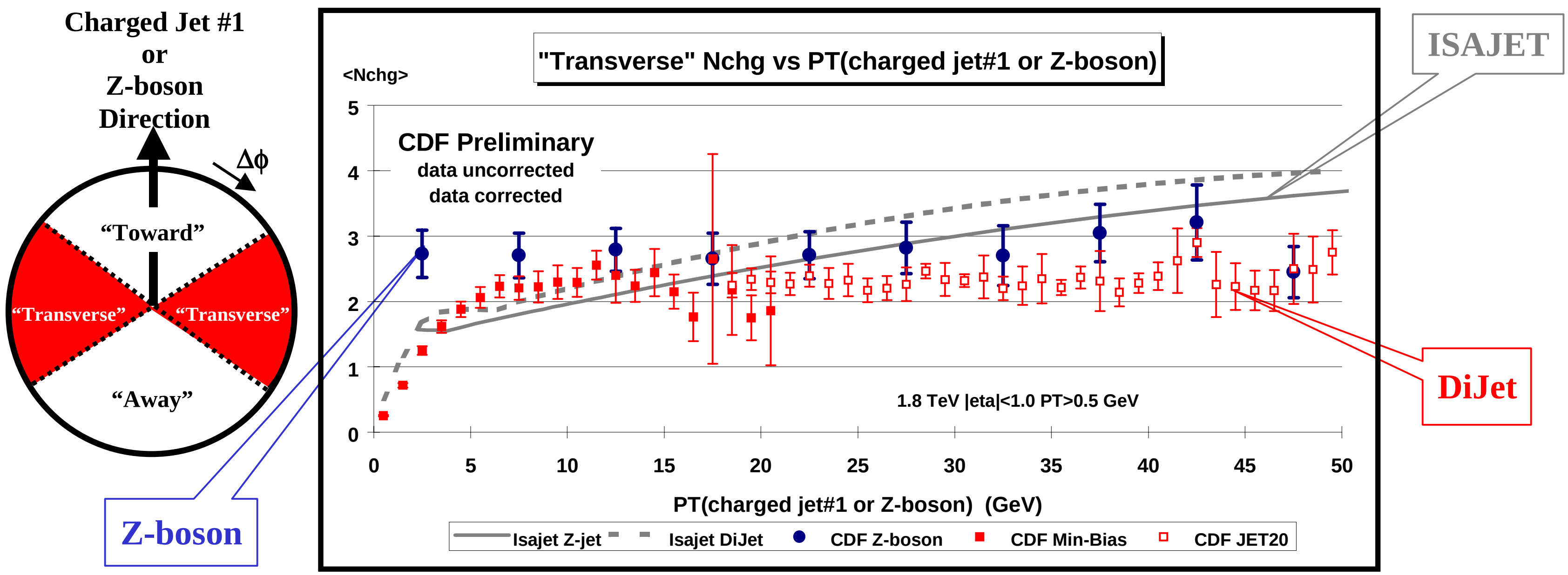
DiJet vs Z-Jet vs B-Jet vs J/Psi "Away" Nchg





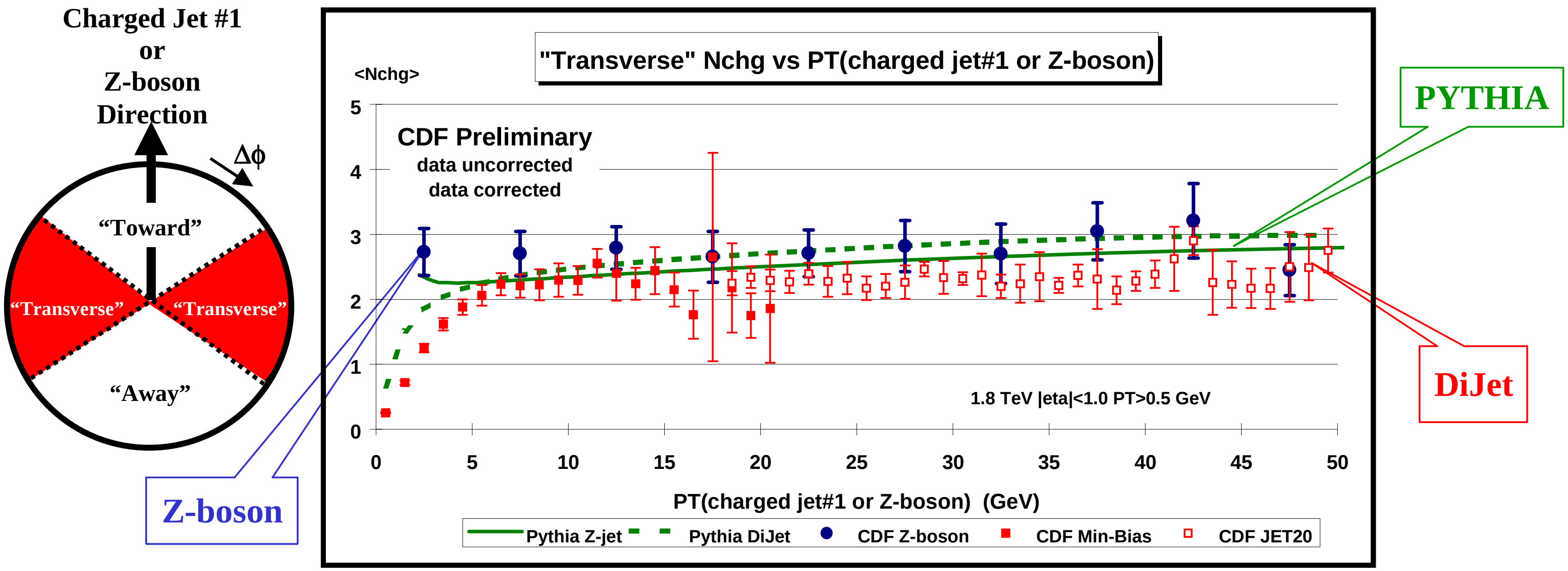
⇨ **Comparison of the dijet, Z-boson, B-Jet, and J/Psi data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the "away" region.**

DiJet vs Z-Jet
“Transverse” Nchg



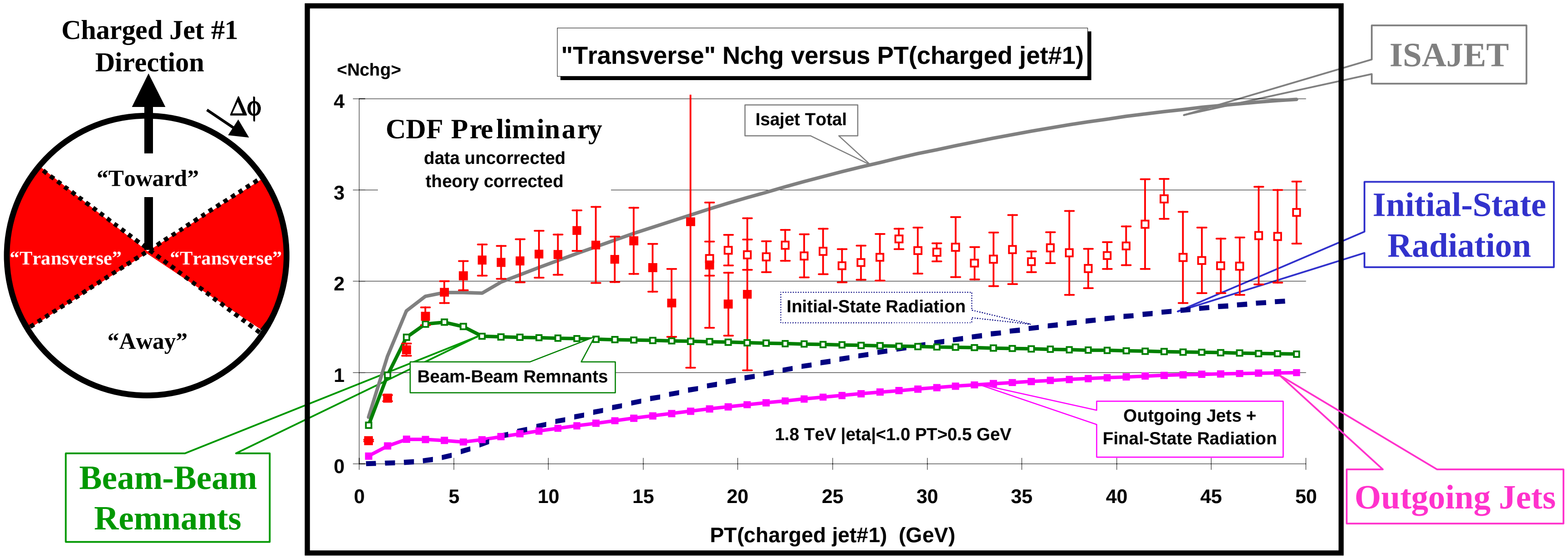
- Comparison of the dijet and the Z-boson data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the “transverse” region.
- The plot shows the QCD Monte-Carlo predictions of ISAJET 7.32 for dijet (dashed) and “Z-jet” (solid) production.

DiJet vs Z-Jet "Transverse" Nchg



- Comparison of the dijet and the Z-boson data on the average number of charged particles (P_T > 0.5 GeV, $|\eta|$ <1) for the "transverse" region.
- The plot shows the QCD Monte-Carlo predictions of PYTHIA 6.115 for dijet (dashed) and "Z-jet" (solid) production.

DiJet: "Transverse" Nchg versus PT(chgjet#1)



- Plot shows the dijet "transverse" <Nchg> vs P_T(chgjet#1) compared to the QCD "hard" scattering predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jets plus final-state radiation.

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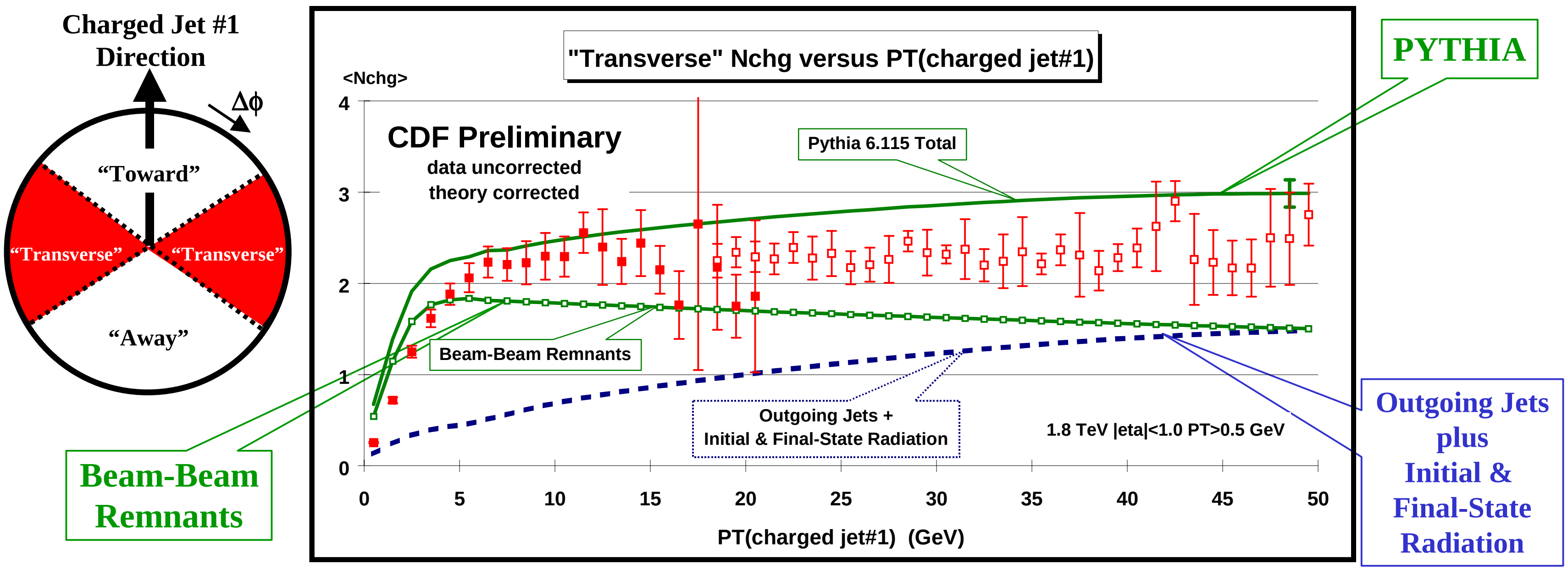
DiJet: "Transverse" Nchg versus PT(chgjet#1)



- **Plot shows the dijet "transverse" <Nchg> vs P_T(chgjet#1) compared to the QCD "hard" scattering predictions of PYTHIA 6.115.**
- **The predictions of PYTHIA are divided into two categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants); and charged particles that arise from the outgoing jet plus initial and final-state radiation (hard scattering component).**

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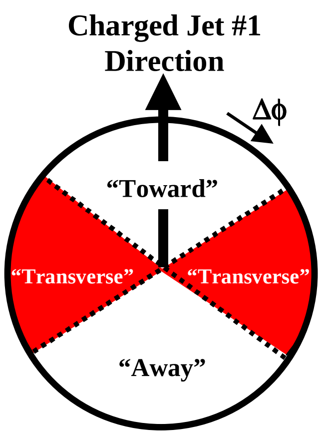
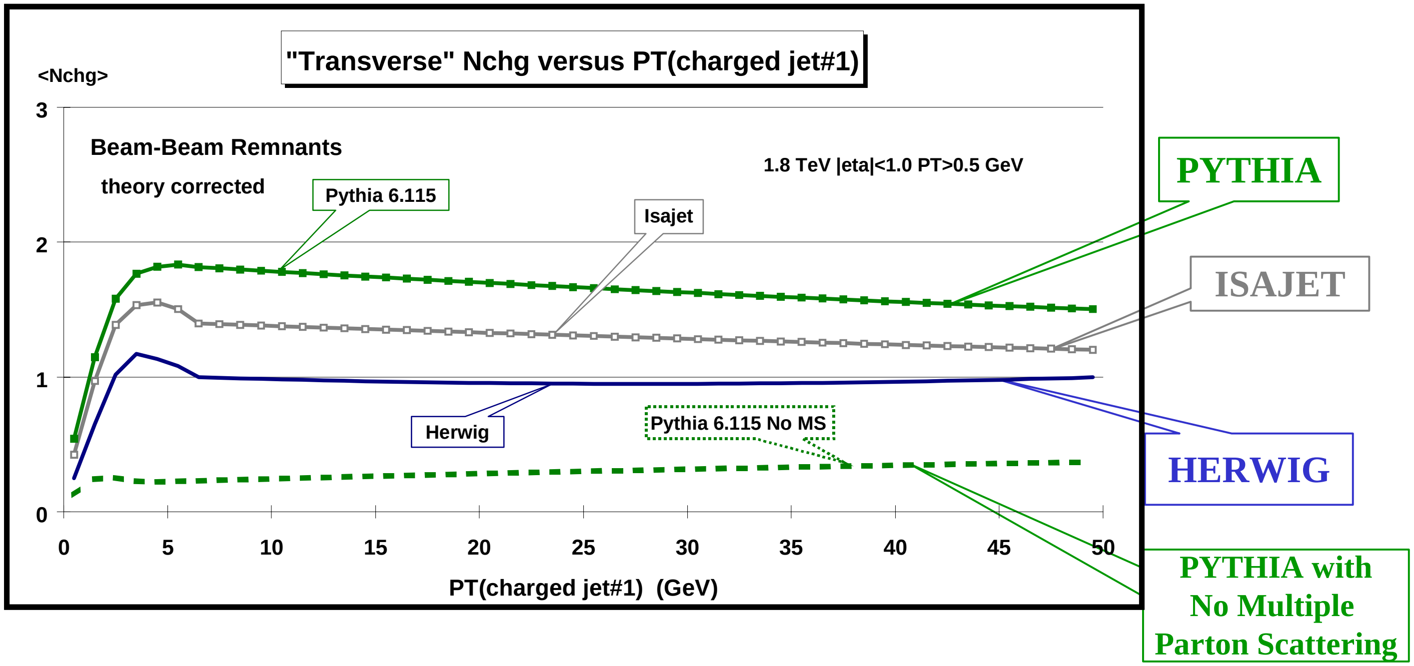
DiJet: "Transverse" Nchg versus PT(chgjet#1)





- QCD "hard" scattering predictions of **HERWIG 5.9**, **ISAJET 7.32**, and **PYTHIA 6.115**.
- Plot shows the dijet **"transverse" <Nchg> vs P_T(chgjet#1)** arising from the **beam-beam remnants**. For Pythia the beam-beam remnants include contributions from **multiple parton scattering**.

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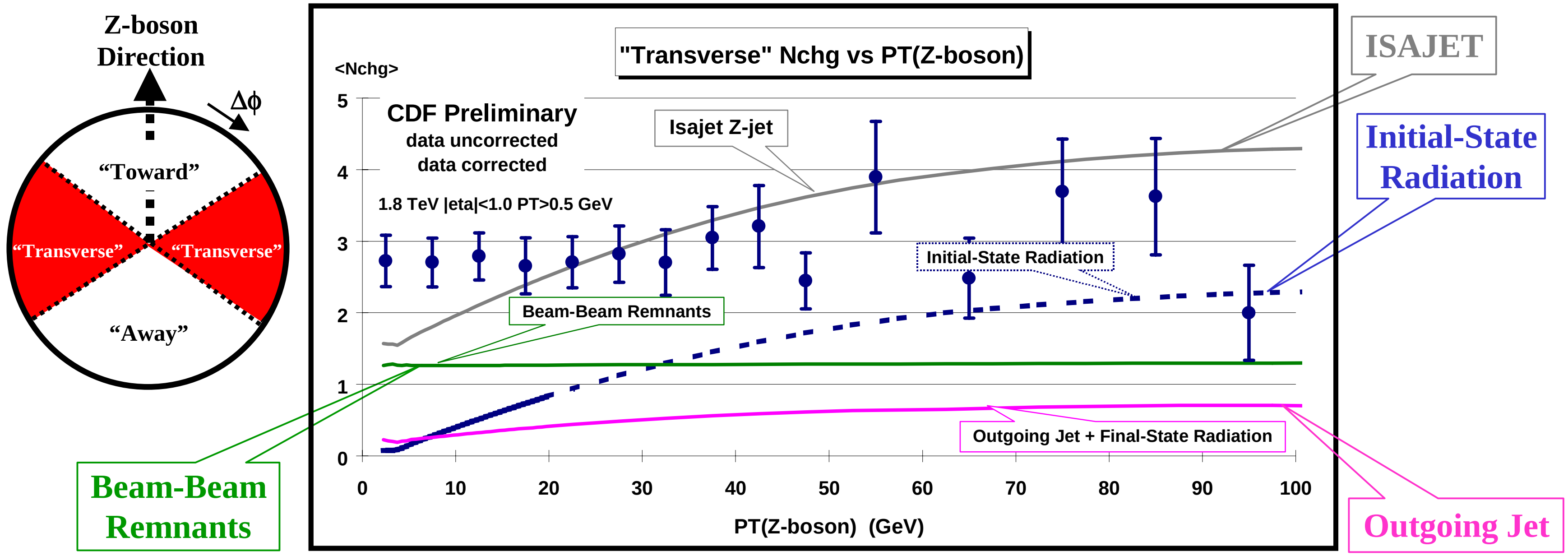
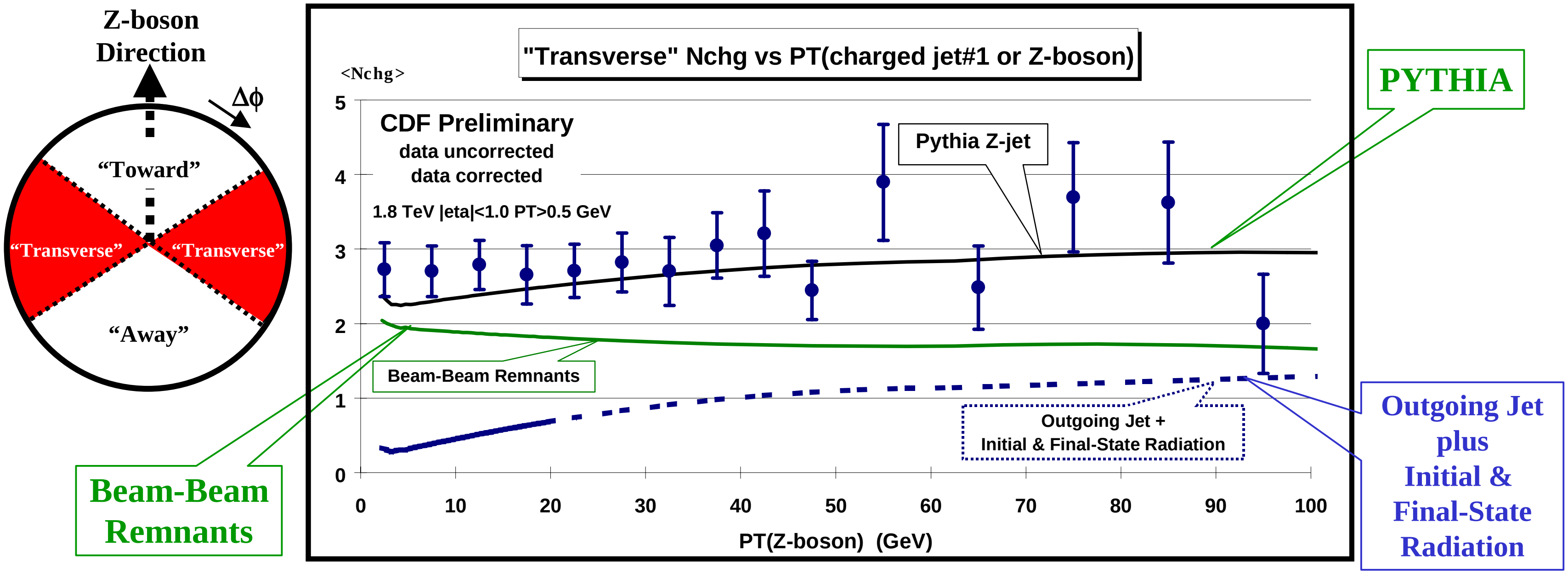
Z-boson: “Transverse” Nchg versus PT(Z)



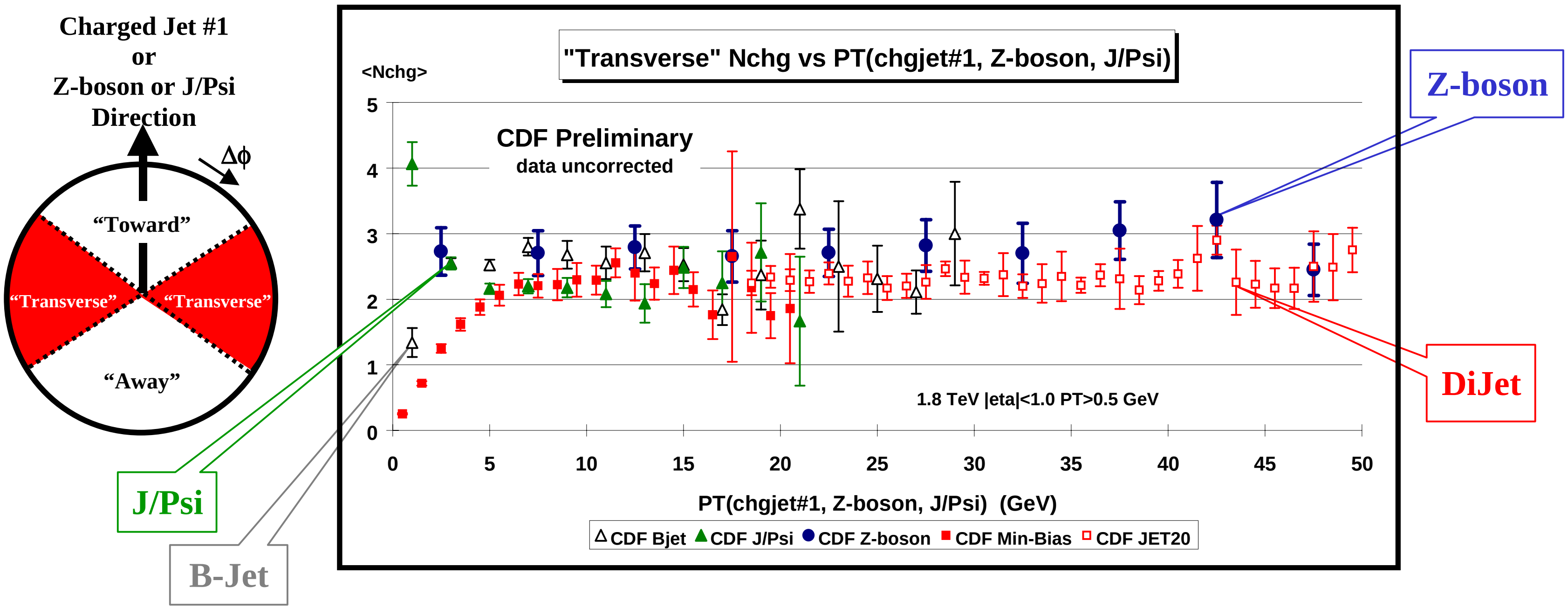
- Plot shows the Z-boson “transverse” <Nchg> vs $P_T(Z)$ compared to the “Z+jet” QCD Monte-Carlo predictions of ISAJET 7.32.
- The predictions of ISAJET are divided into three categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants), charged particles that arise from initial-state radiation, and charged particles that result from the outgoing jets plus final-state radiation.

Z-boson: “Transverse” Nchg versus PT(Z)



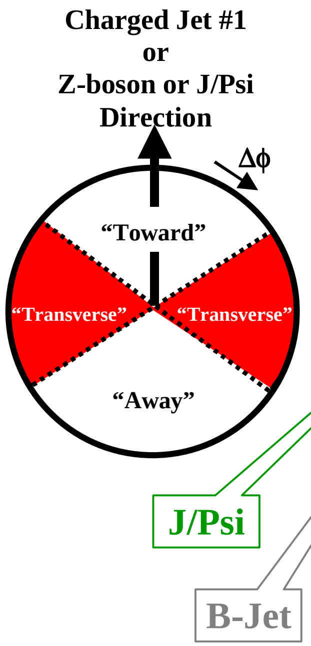
- Plot shows the Z-boson “transverse” <Nchg> vs $P_T(Z)$ compared to the “Z+jet” QCD Monte-Carlo predictions of PYTHIA 6.115.
- The predictions of PYTHIA are divided into two categories: charged particles that arise from the break-up of the beam and target (beam-beam remnants); and charged particles that arise from the outgoing jet plus initial and final-state radiation (hard scattering component).

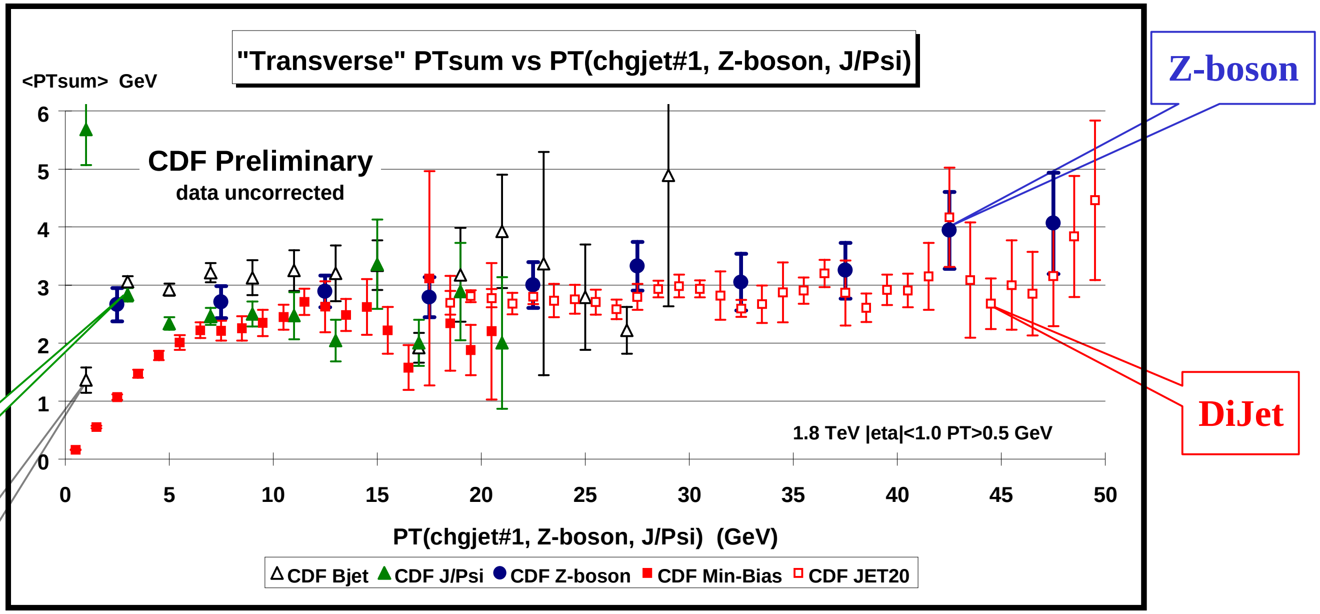
DiJet vs Z-Jet vs B-Jet vs J/Psi "Transverse" Nchg



⇨ **Comparison of the dijet, Z-boson, B-Jet, and J/Psi data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the "transverse" region.**

DiJet vs Z-Jet vs B-Jet vs J/Psi "Transverse" PTsum





⇨ **Comparison of the dijet, Z-boson, B-Jet, and J/Psi data on the average number of charged particles (P_T > 0.5 GeV, |η| <1) for the "transverse" region.**