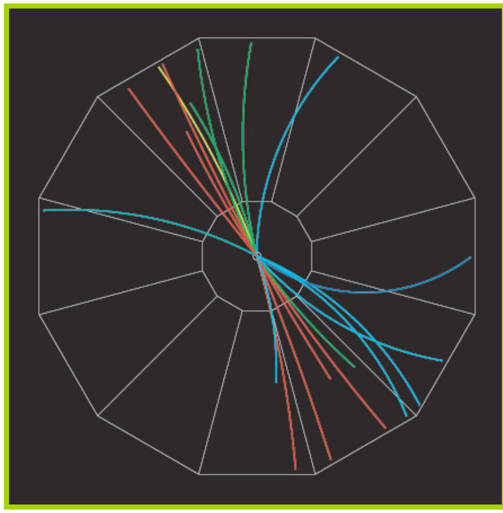
Evaluation of the Underlying Event in pp Collisions at $\sqrt{s}$=200 GeV at STAR



i. What is the Underlying Event?

ii. Techniques for measuring the UE at STAR

iii. STAR jet trigger & reconstruction

iv. STAR Underlying Event distributions

v. Comparisons with results from CDF

Grant Webb

for the STAR Collaboration

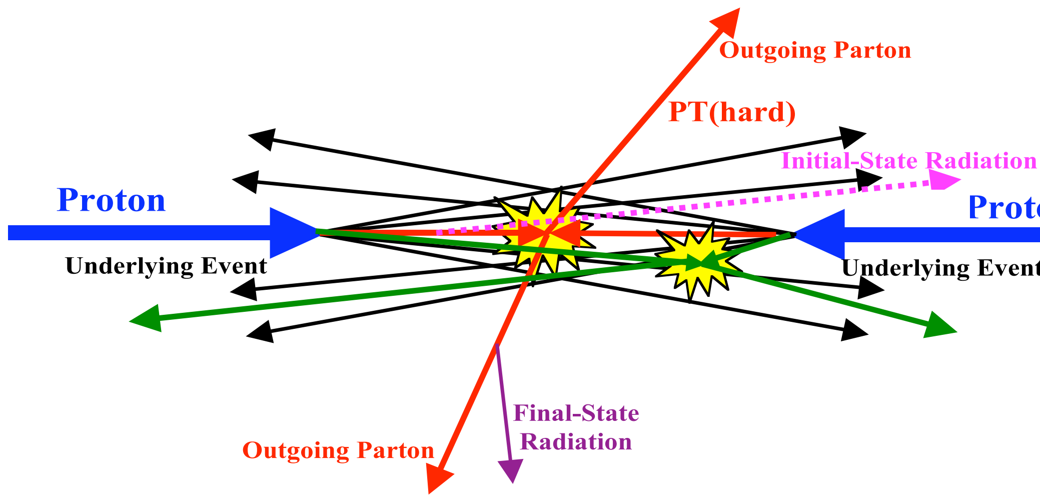
APS Meeting, Denver, Colorado, May 3, 2009

What is the Underlying Event (UE)?

Short answer: Everything except the hard partonic 2-2 scattering.

The UE includes :

- Initial and final state radiation (ISR/FSR)
- Beam remnant interactions
- Multiple Partonic Interactions (MPI)

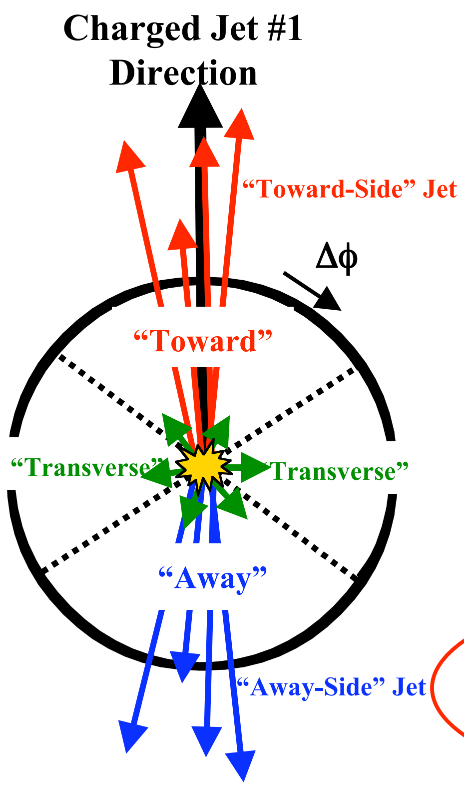


The motivation for this analysis was driven by the need to estimate from data the contribution of the UE to the reconstructed jet energy scale. Focus on isolating the beam remnant component of the UE because the NLO calculations we compare our inclusive jet measurements to include initial and final radiation.

This analysis follows closely the framework developed by Rick Field at CDF.

How can we measure the UE?

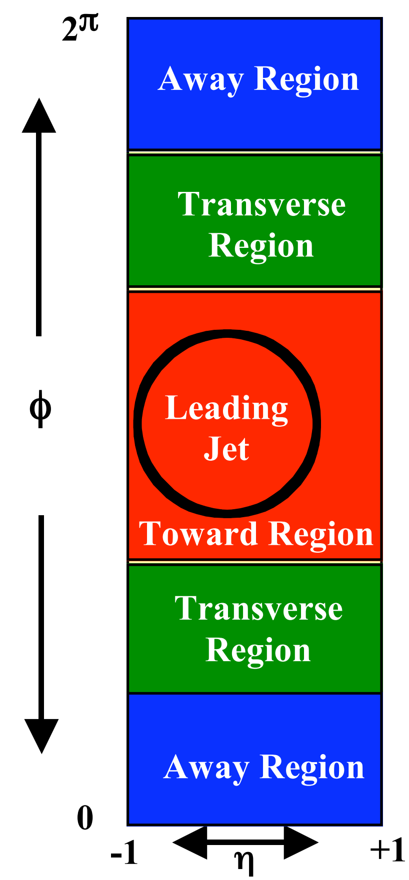
1st look at Back-to-Back Di-Jet Events in which the jet energies are relatively close so as to minimize radiation in transverse region.



Toward Region:
$|\Delta\varphi| \leq 60$, $|\eta| \leq 1$
Around highest pT jet

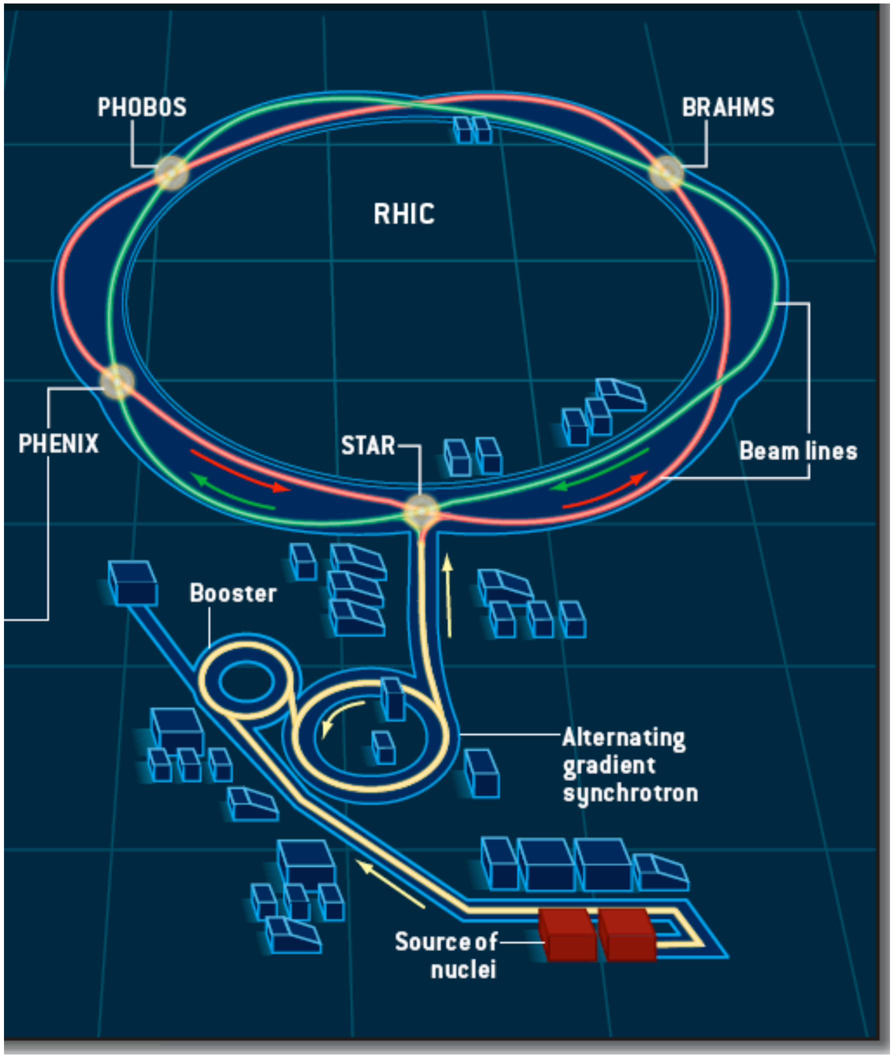
Away Region:
$|\Delta\varphi| > 120$, $|\eta| \leq 1$
From leading jet

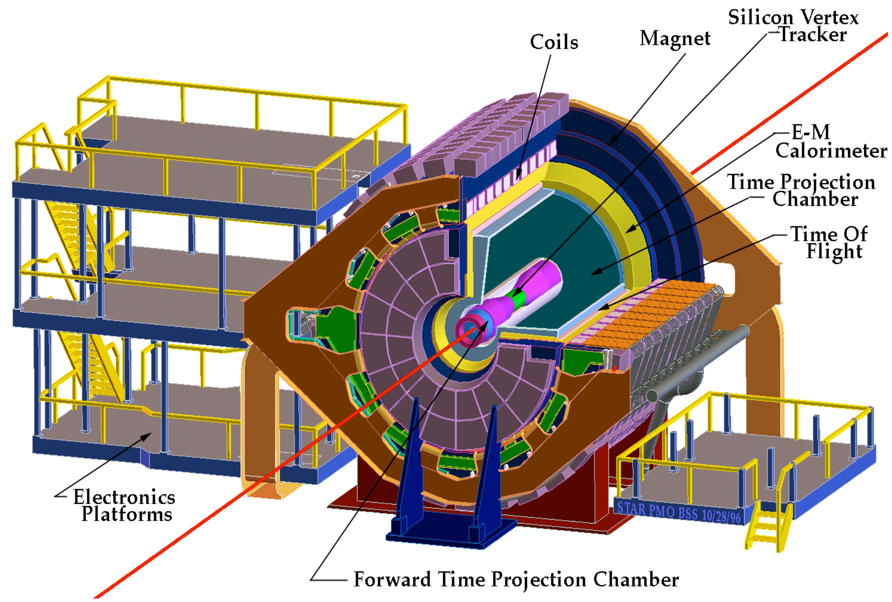
Transverse Region:
$120 > |\Delta\varphi| > 60$, $|\eta| \leq 1$



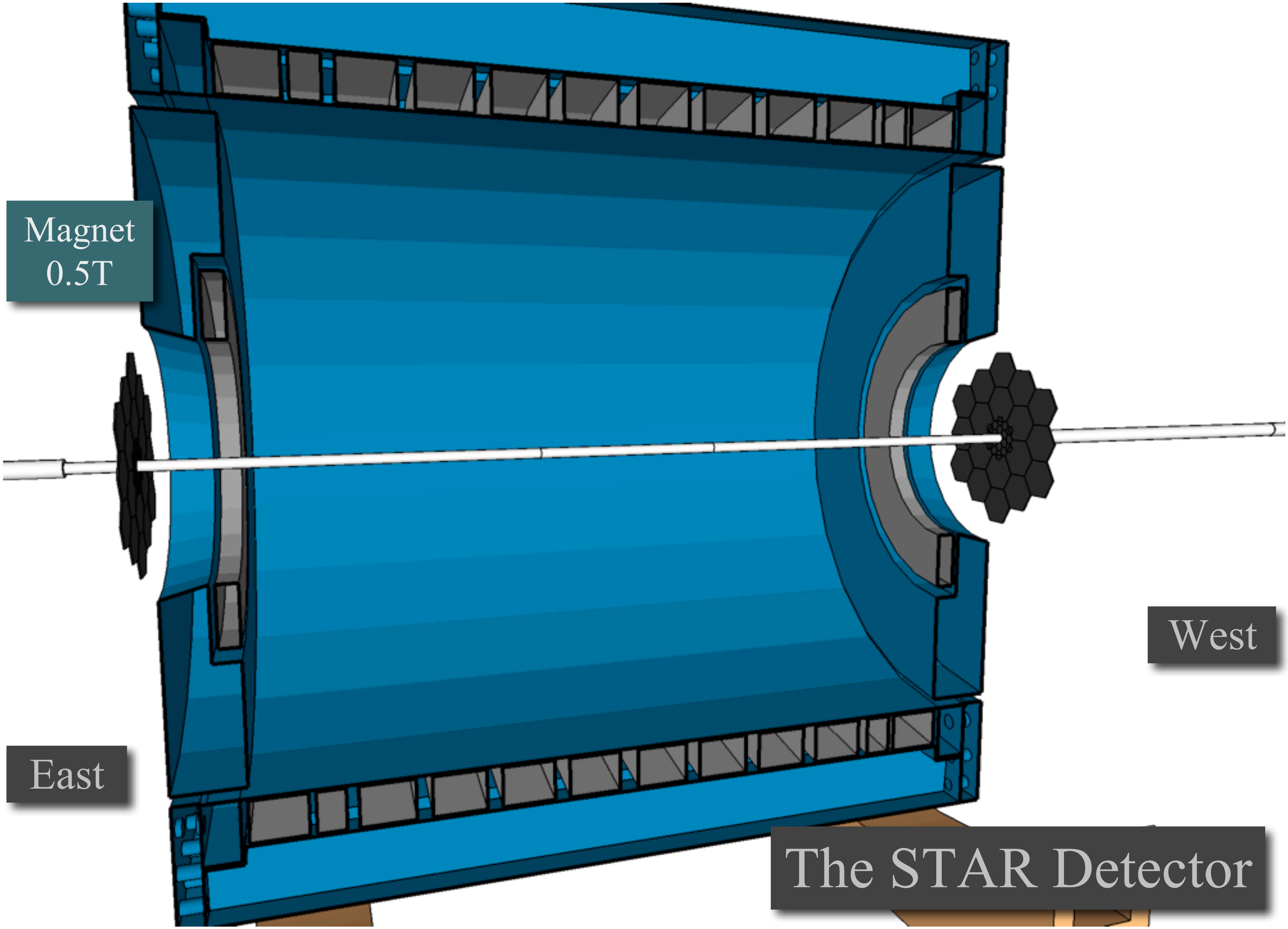
Access Underlying Event Distributions HERE!

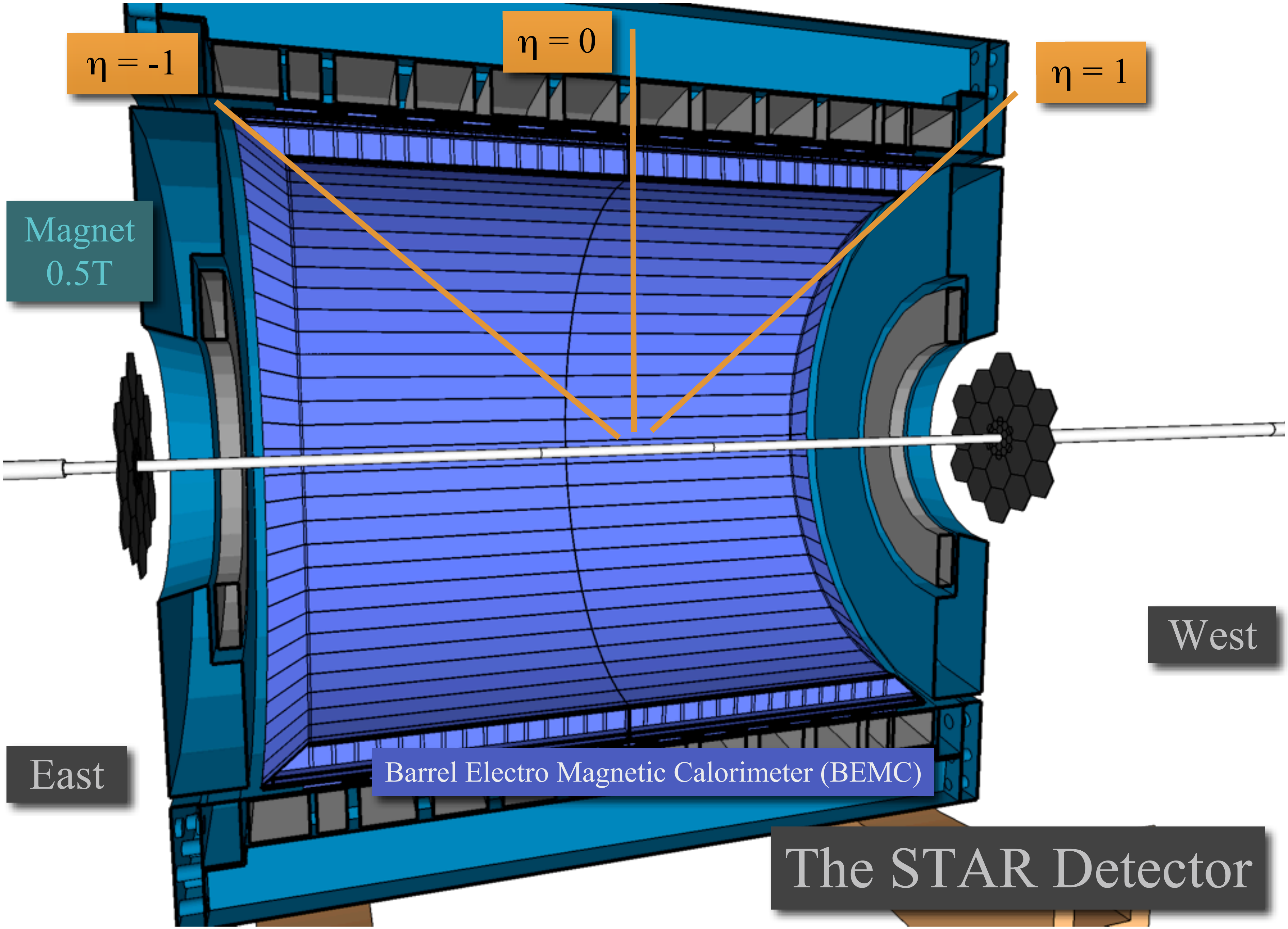
Proton-Proton Collisions at RHIC

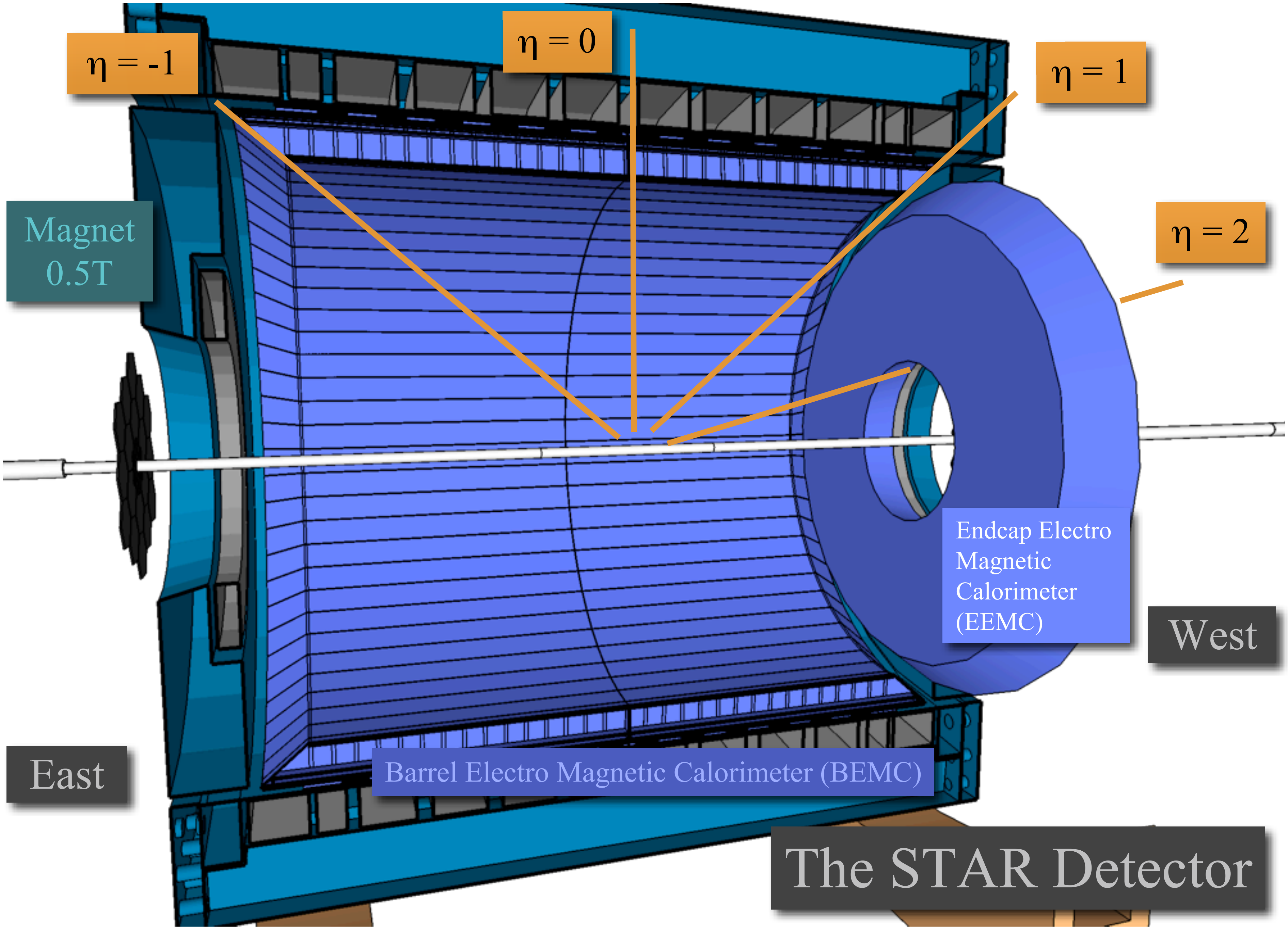




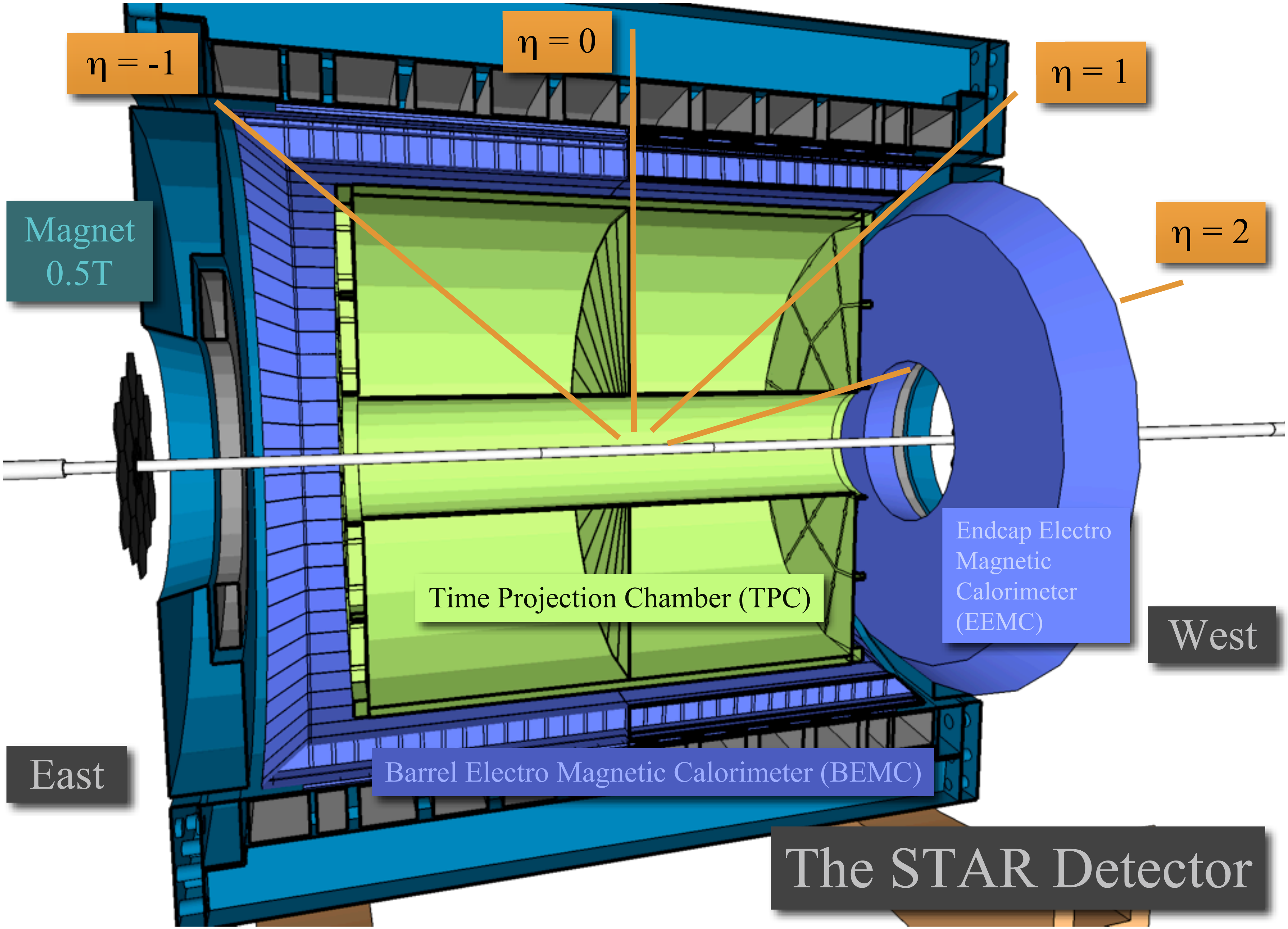
Like all most energy detectors, STAR is composed of many sub-detector systems. This talk will review only those currently used in jet triggering and reconstruction.


Magnet
0.5T
West
East
The STAR Detector

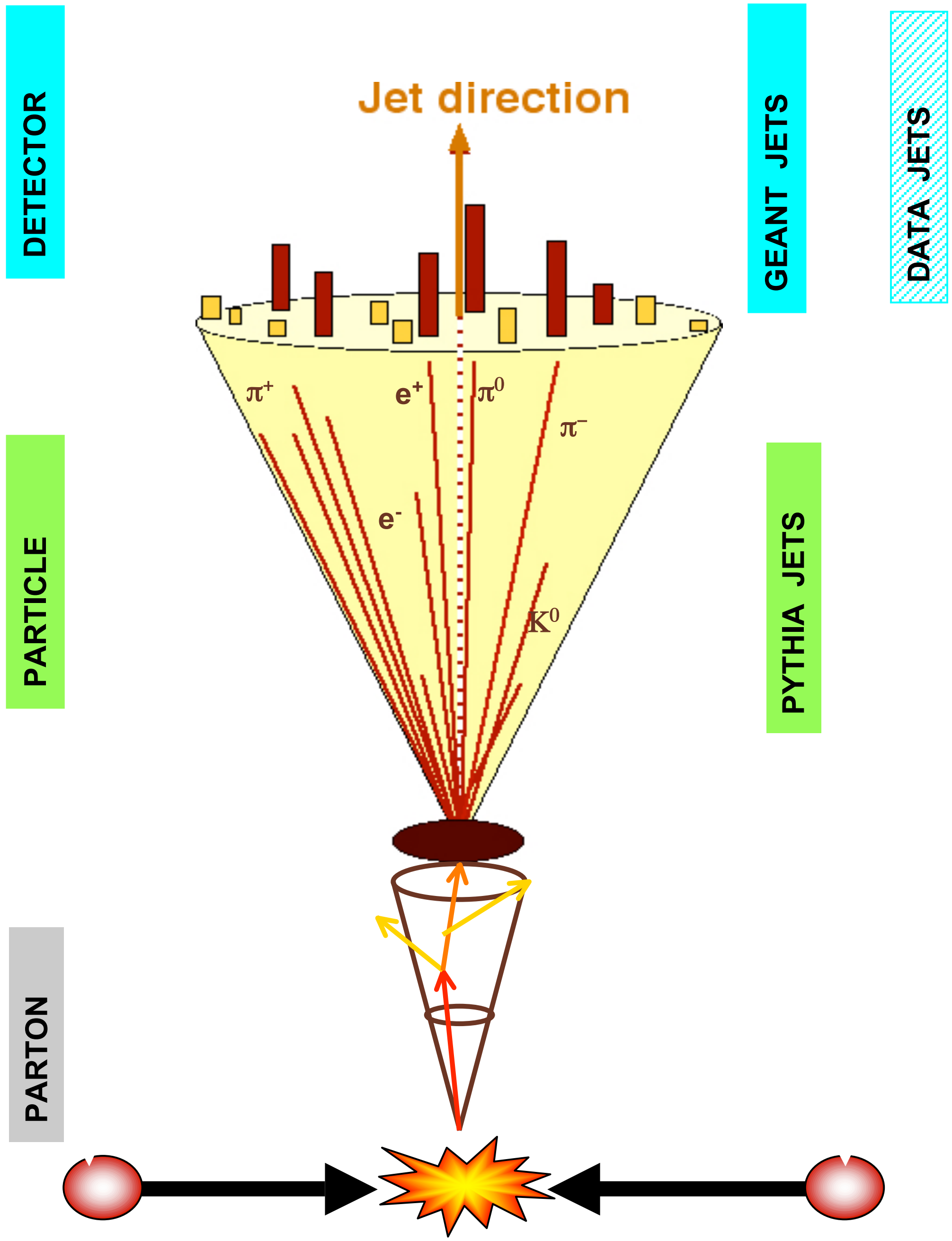

η = -1
η = 0
η = 1
Magnet
0.5T
West
East
Barrel Electro Magnetic Calorimeter (BEMC)
The STAR Detector



η = -1
η = 0
η = 1
η = 2
Magnet 0.5T
Endcap Electro Magnetic Calorimeter (EEMC)
West
East
Barrel Electro Magnetic Calorimeter (BEMC)
The STAR Detector



η = -1
η = 0
η = 1
η = 2
Magnet 0.5T
Endcap Electro Magnetic Calorimeter (EEMC)
Time Projection Chamber (TPC)
West
East
Barrel Electro Magnetic Calorimeter (BEMC)
The STAR Detector



STAR Mid-point Cone Jet Algorithm

i. P^μ of TPC track, EMC tower OR particle used as seed for cluster formation

ii. Cluster P^μ around seed inside Jet Cone Radius = 0.7

iii. Look for additional stable clusters at "midpoint" between two clusters

iv. Merge jets if Energy overlap > 50%

v. Sum of P^μ in each stable cluster forms jet

vi. Require Jet pT > 5 GeV

vii. Same algorithm used for DATA and SIMULATION

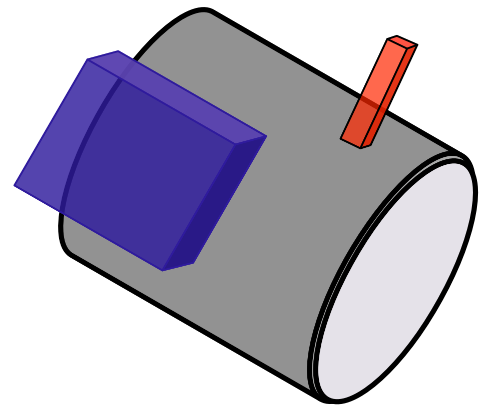
viii. Use CDF Tune for PYTHIA and GEANT for STAR Detector Simulation

Jetfinder Parameters and Data Cuts

Mid-Point Cone R=0.7
Number of jets = 2
$\lvert$Detector $\eta\rvert \leq 0.5$
Vertex Z $\leq$ 30 cm
NE ratio $\leq$ 0.85
Away Jet pT/ Toward Jet pT $\geq$ 0.7
Track pT > 0.2 GeV
Tower Et $\geq$ 0.2 GeV (MIP corrected)
Normalized to Transverse/Toward/Away $\Delta\eta\times\Delta\varphi$
Uncorrected Jet Energy Scale
2006 JP0L2 trigger JP0 thr = 5.7 + ETOT thr = 14 GeV

For CDF >0.5 GeV!

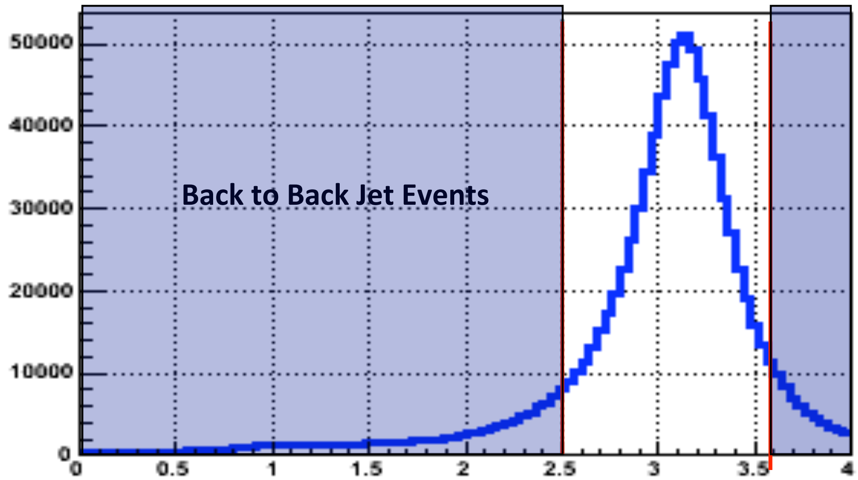
Data Sample = 2006 $\sqrt{s}$=200 GeV



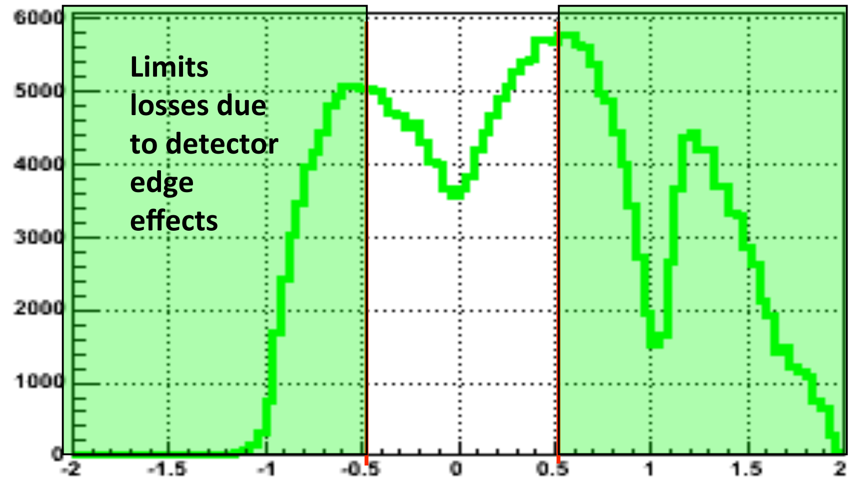
Jet Patch Trigger is defined by a minbias condition plus 400 localized towers $(\Delta\eta = \Delta\phi = 1)$ above threshold.

All Simulations are PYTHIA CDF Tune A + STAR GEANT Package

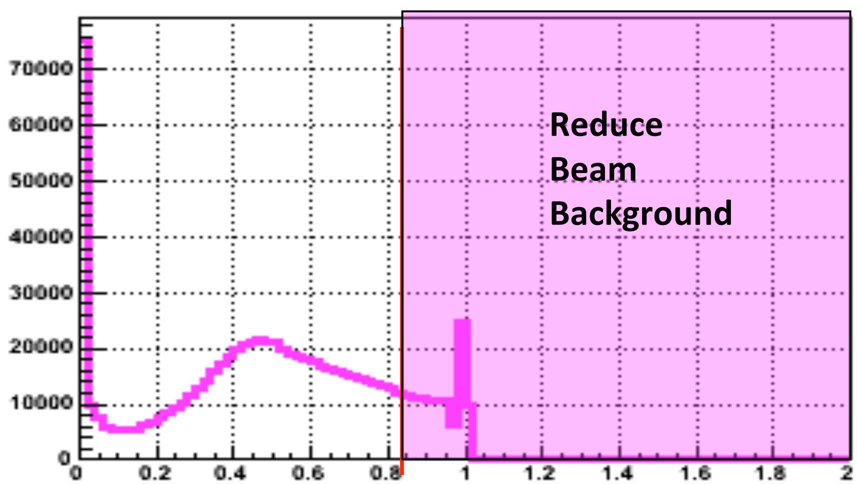
Cuts on Jet Distributions



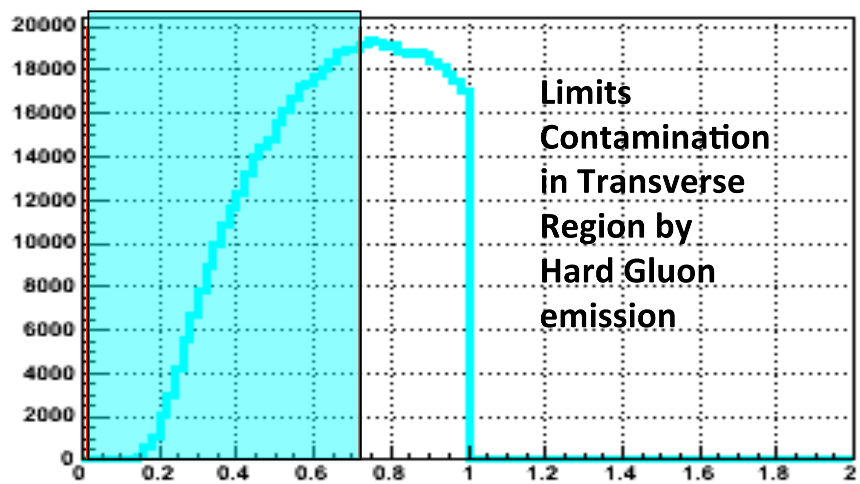
150 > Jet Δφ > 210



|Detector Eta| ≥ 0.5



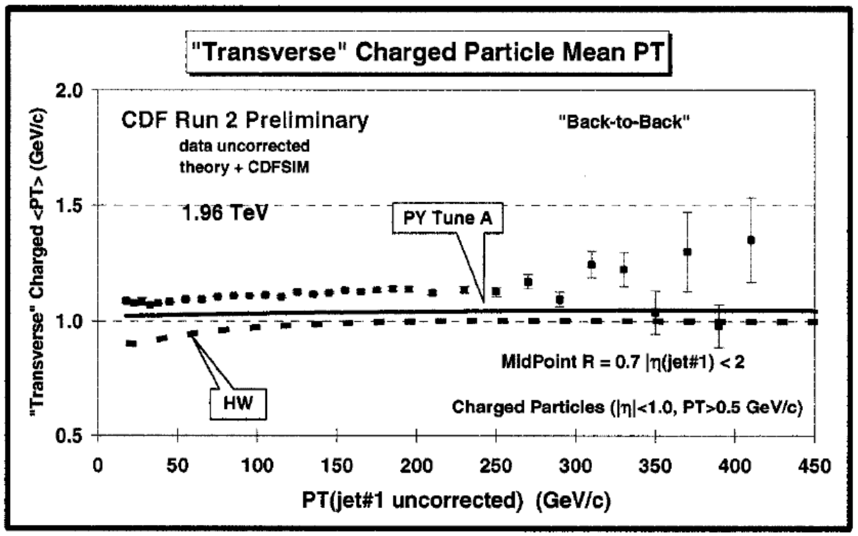
|Neutral Energy Ratio| > 0.85

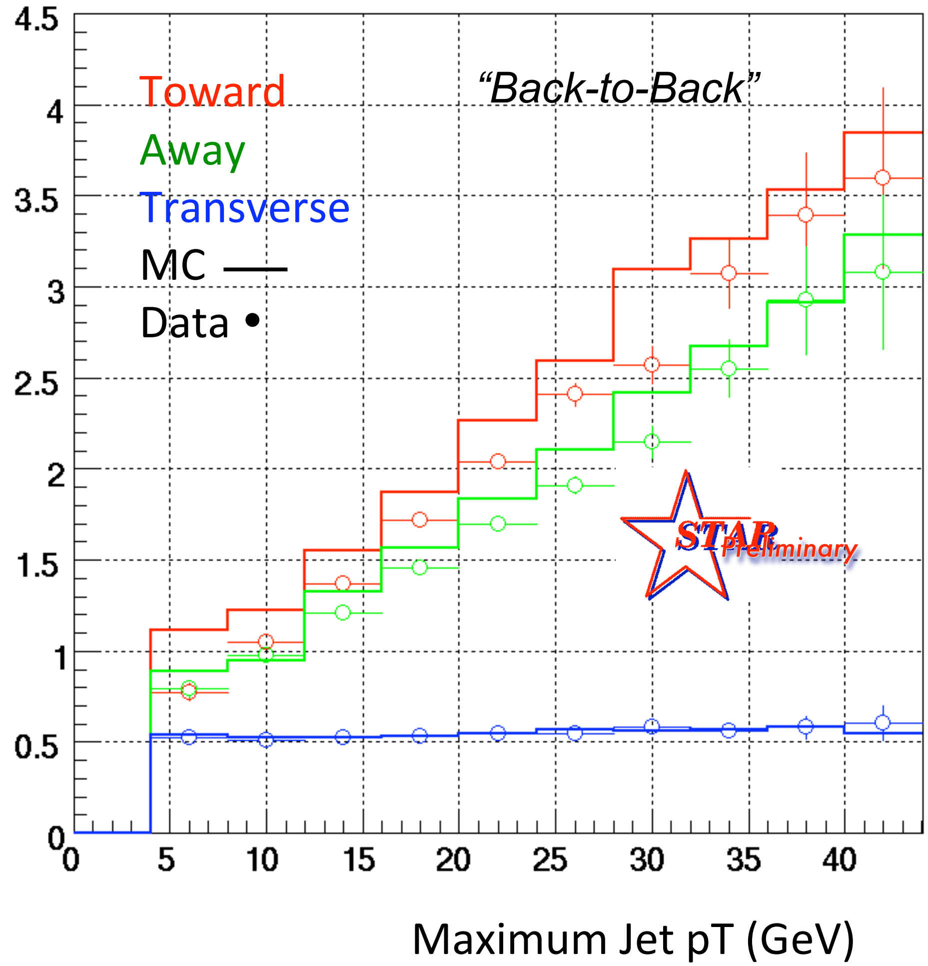


[(Jet pT Min) / (Jet pT Max)] < 0.7

Mean Charged Track p_T

UE	<Data>	<Pythia>
CDF	1.1	1.0
STAR	0.55	0.55

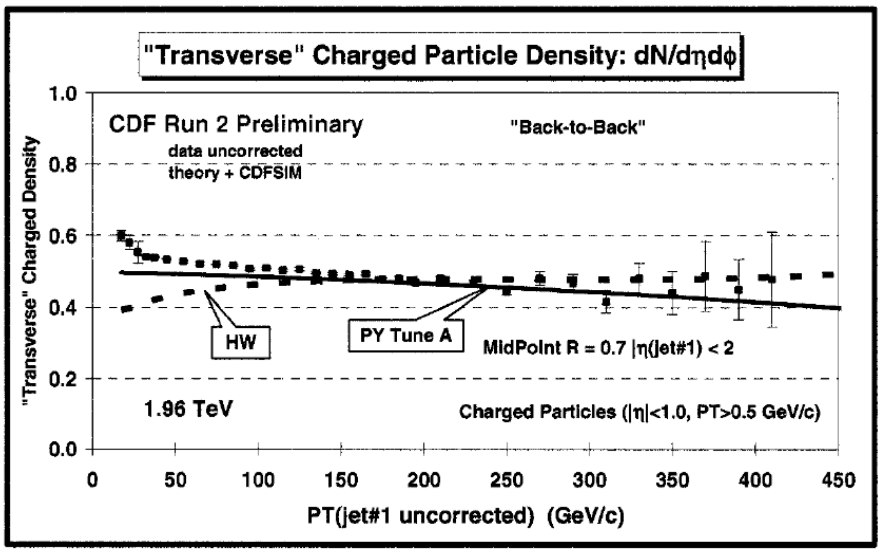




L.A. Cruz, "Using MAX/MIN transverse regions to study the underlying event in run 2at the Tevatron" UMI-31-88071, 2005.

Charged Track Multiplicity Density

	<Data>	<Pythia>
CDF	0.5	0.5
STAR	0.7	0.6



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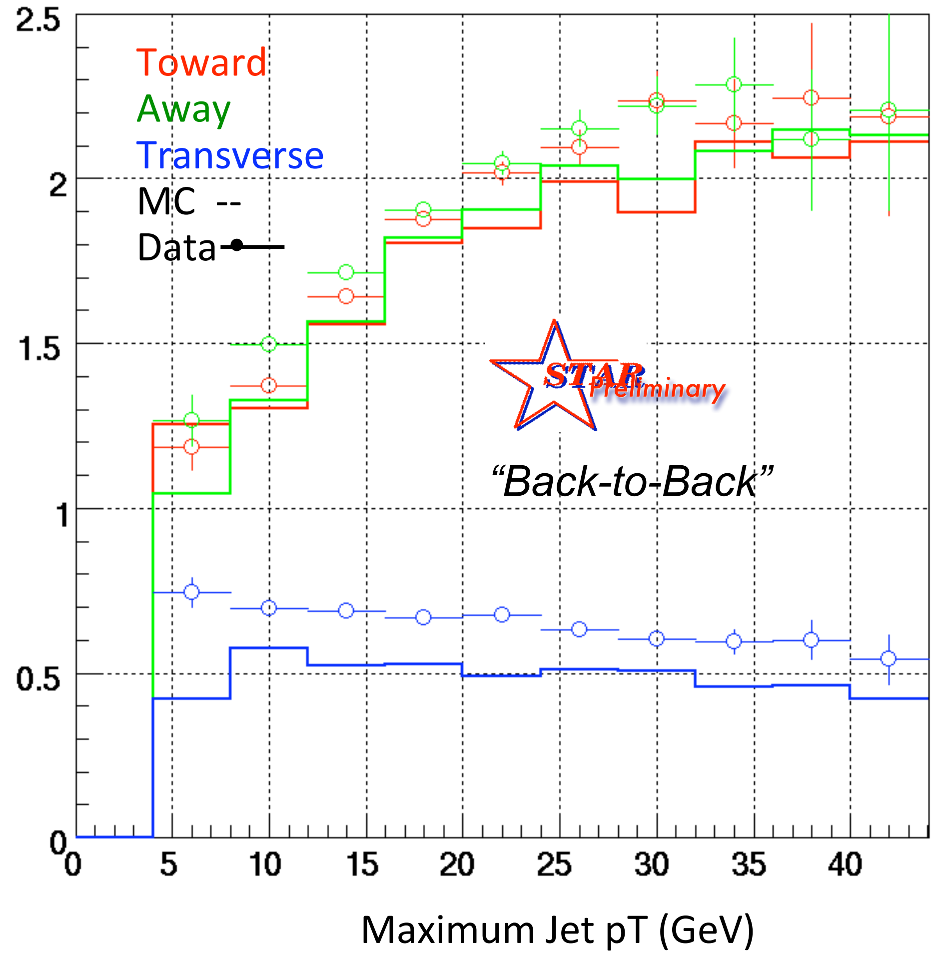
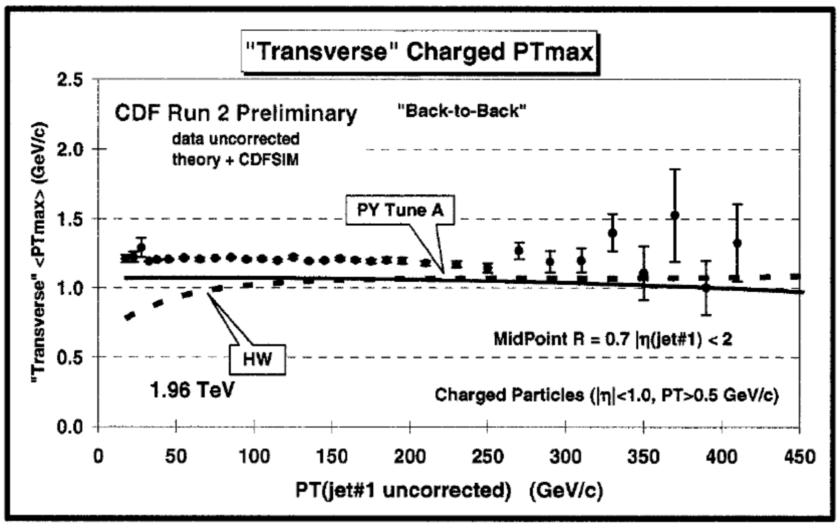
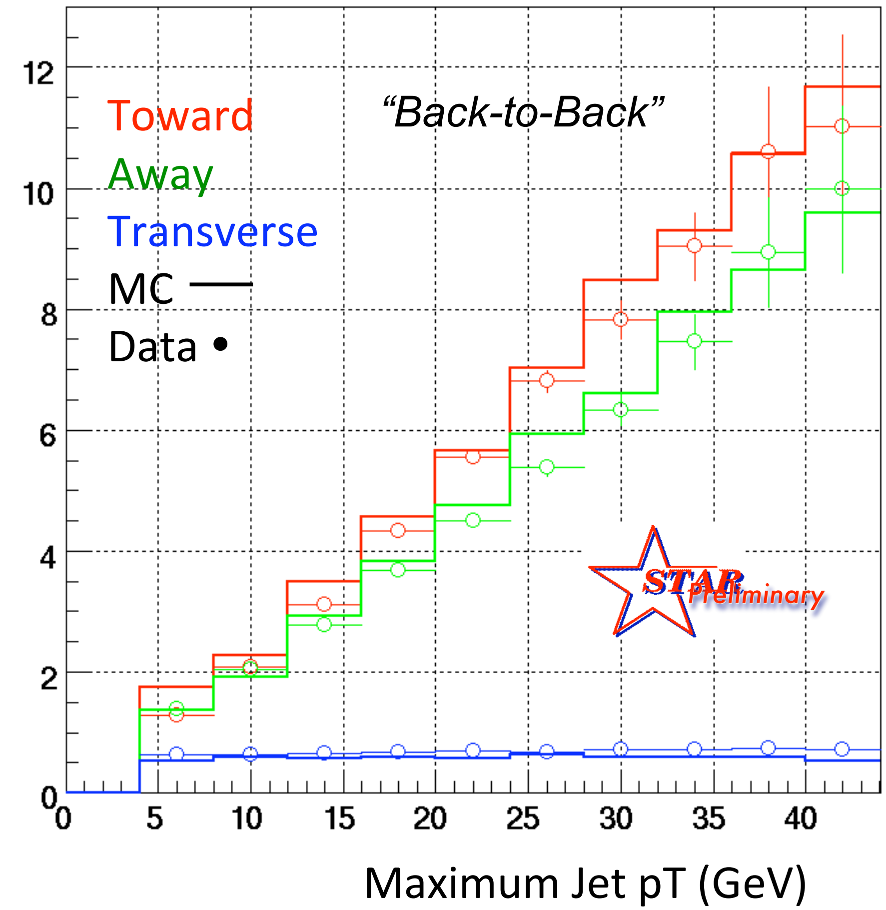


Max Charged Track p_T

UE	<Data>	<Pythia>
CDF	1.2	1.0
STAR	0.65	0.6





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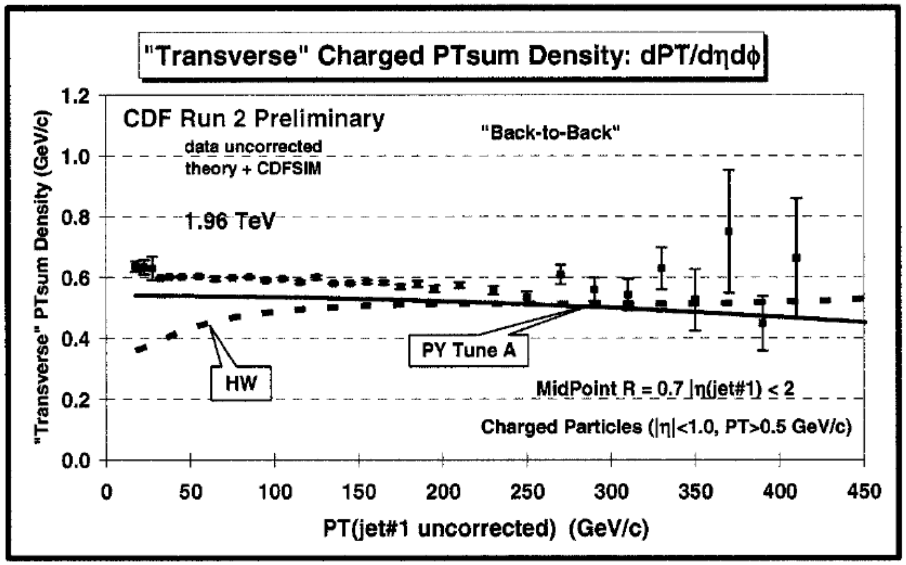
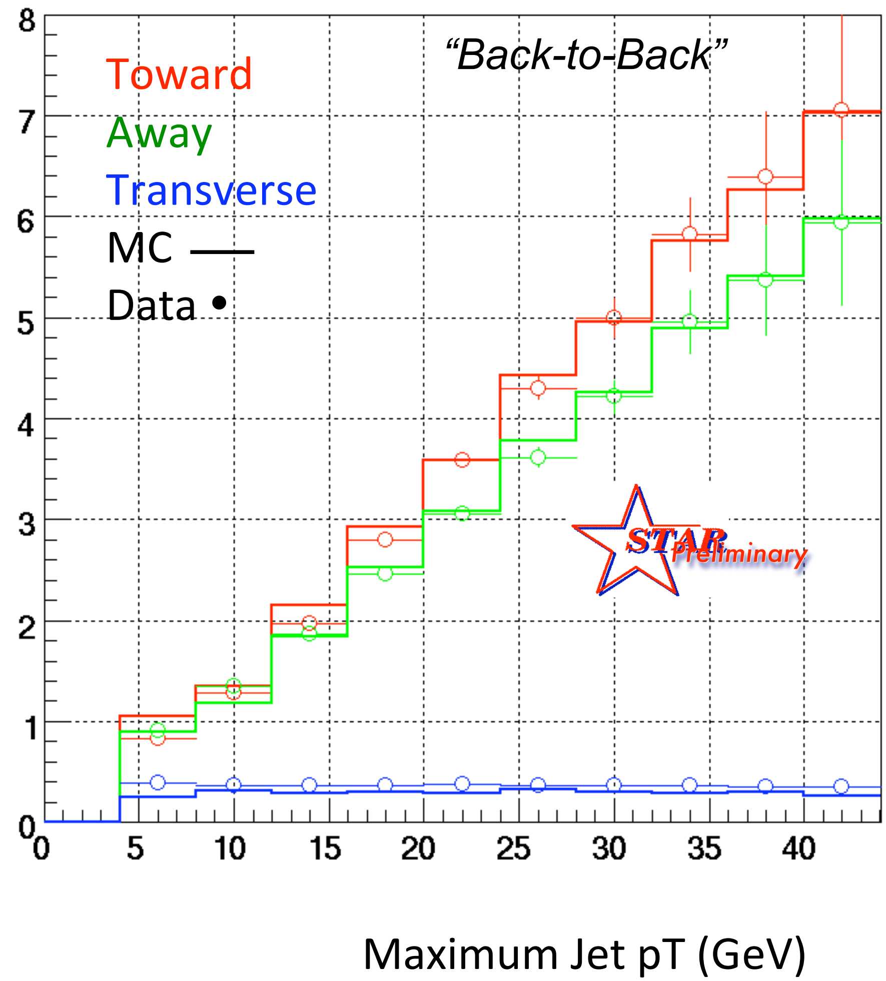
Charged Track P_TSum Density

UE	<Data>	<Pythia>
CDF	0.6	0.55
STAR	0.37	0.30

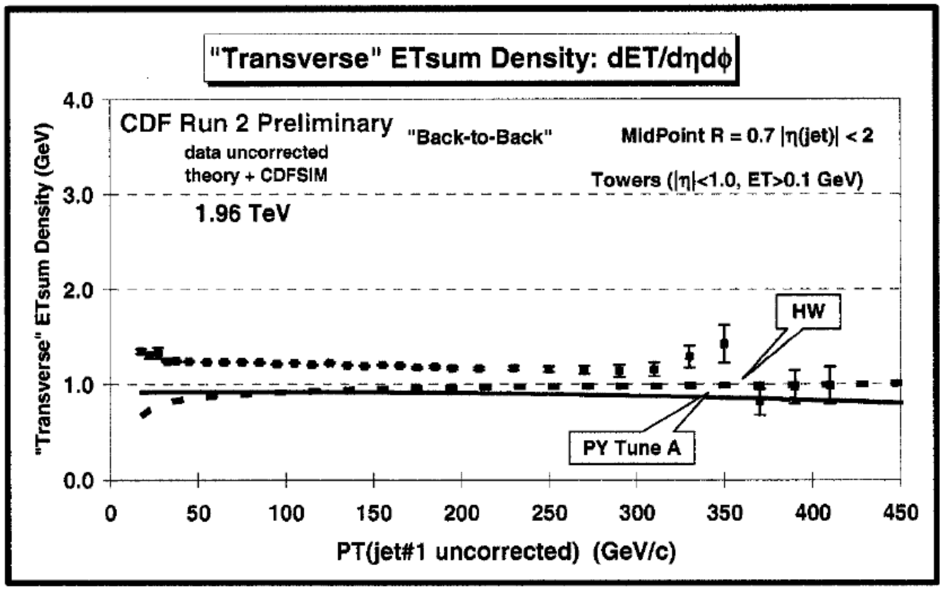




L.A. Cruz, "Using MAX/MIN transverse regions to study the underlying event in run 2at the Tevatron" UMI-31-88071, 2005.

Tower E_T Scaler Sum Density

UE	<Data >	<Pythia>
CDF	1.3	0.9
STAR	0.30	0.25



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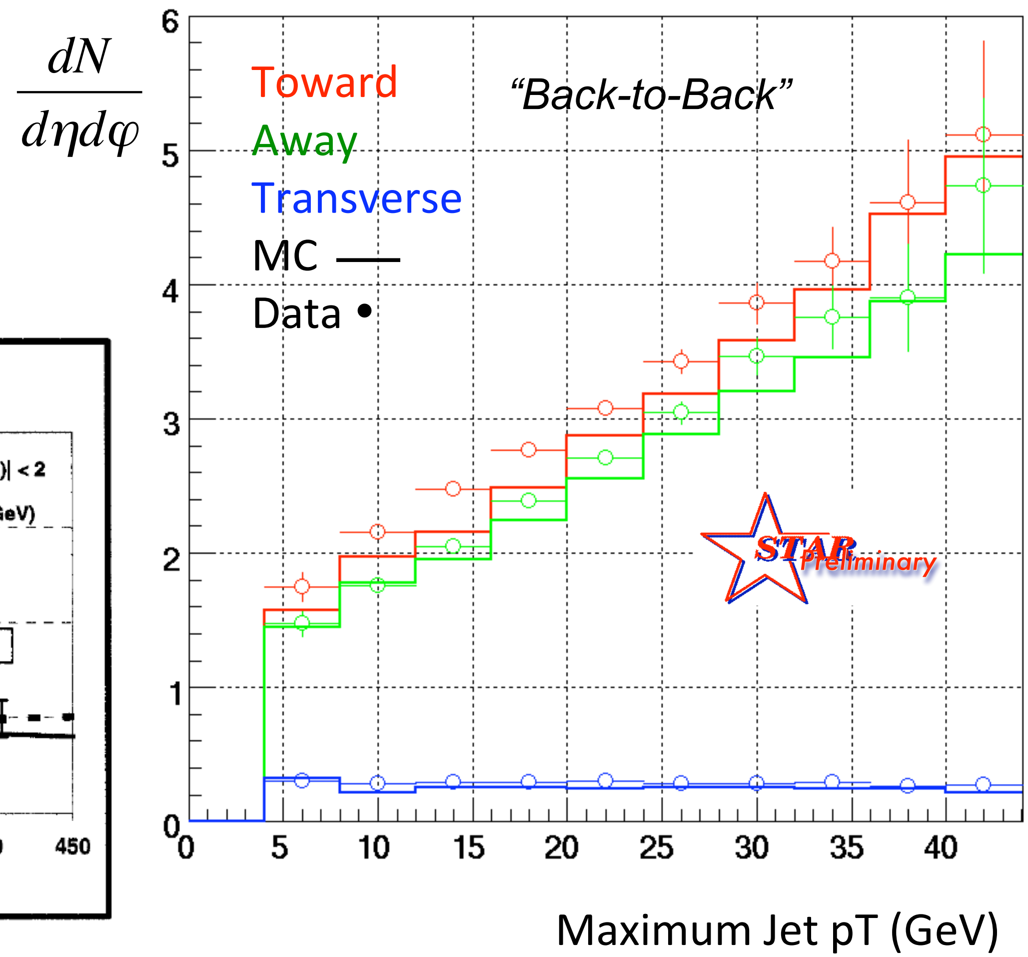

Conclusions

I. The Underlying Event at RHIC appears to be independent of jet pT and decoupled from hard interaction

II. CDF Tune A provides an excellent description of the UE for proton collisions at $\sqrt{s}$ =200 GeV

III. Agreement between data and simulation is fair in the toward in away regions. In general simulations over-predict data with the exception of multiplicity.

IV. Underlying Event distributions are generally smaller than those at CDF. Charged particle multiplicities are the exception, but this may be due to the 0.2 (STAR) versus 0.5 GeV (CDF) pT cut-off. The charged/neutral scaler pT/eT sum density is 0.37/0.3 GeV.

V. If the UE is isotropic and the jets are 50% neutral (due to triggering) for a cone jet with R=0.7 the UE contributes ~0.5 GeV.

VI. Further studies with tower and track multiplicities set at CDF values are in the works!