The Underlying Event in Hard Interactions at the Tevatron pbar-p Collider

Paper seminar Feb. 26,2004

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for

Valeria Tano, Anwar Bhatti, Eve Kovacs

Godparents: Rick Field, Franco Rimondi, Rick Tesarek

visitor at MSU
this is her thesis
need to add her
name to paper

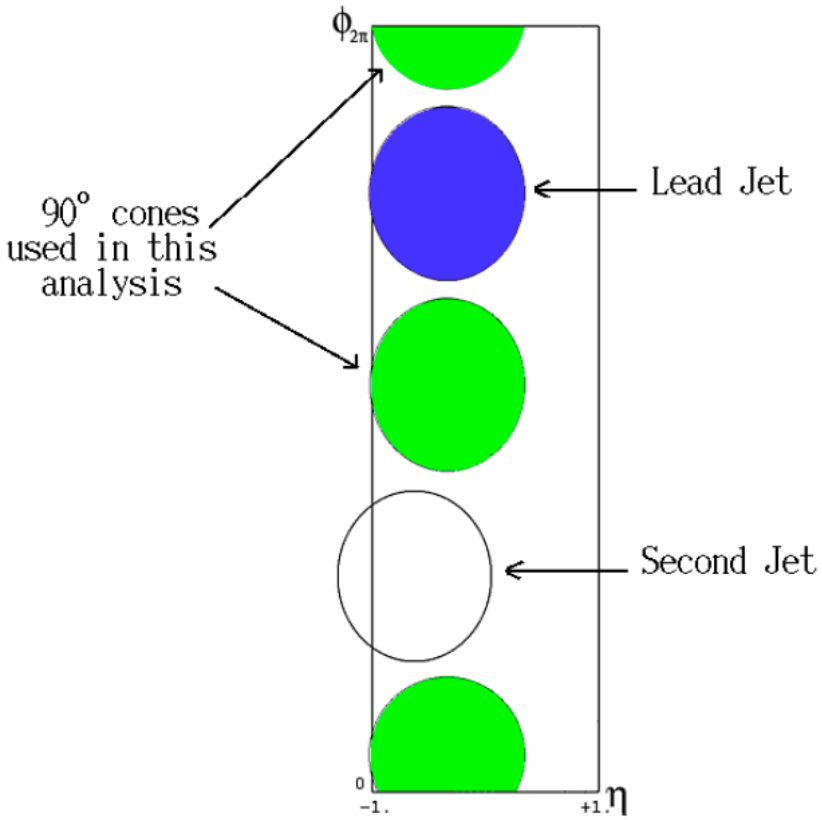
chief godparent, but I have to provide
the refreshments

Study

- This is a study performed by Valeria Tano on Run 1 data
- Long-blessed and presented at many conferences/workshops
- Valeria has left the field and we're trying to get this publication out to formally document the study
  - and to be able to use it in databases such as JetWeb
  - of interest for LHC tunes, for example
- Orthogonal and complementary to Run 1 studies that Rick Field did
  - sets the stage for Rick's Run 2 work
- Two drafts have been generated (CDF6768) and questions of godparents and interested CDF collaborators (i.e. Torontonians) have been answered
  - webpage is
    http://www.pa.msu.edu/~huston/ue_paper/ue_paper.htm

Motivation

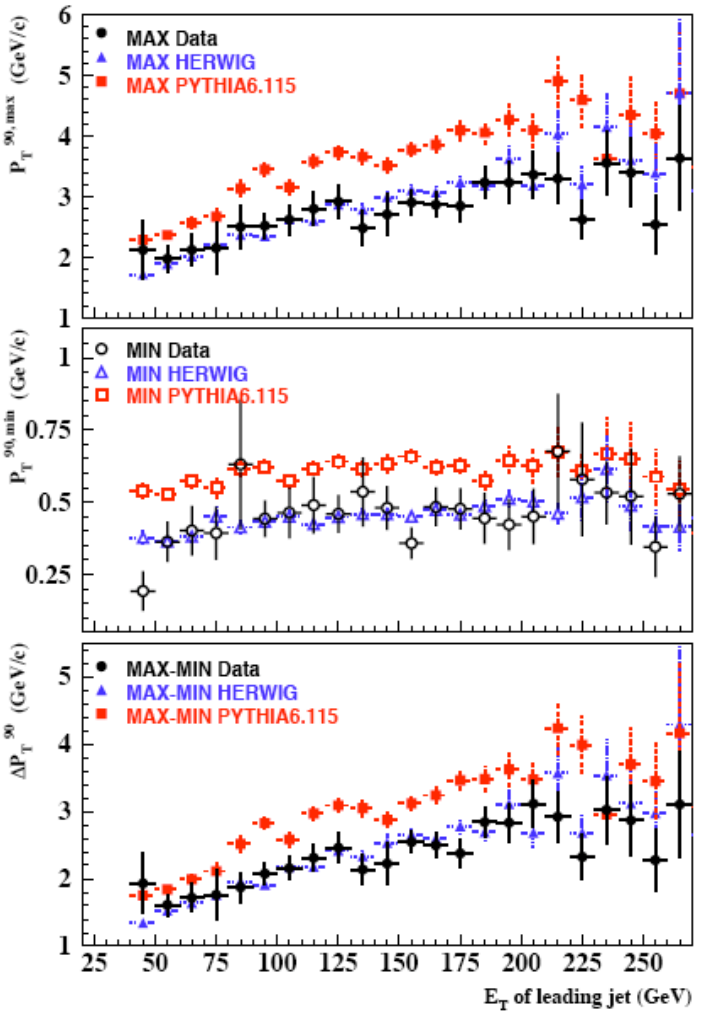
- Inclusive jet cross sections at CDF are compared to NLO QCD calculations at the parton level
- The (mostly) non-perturbative underlying event has to be subtracted in order for the comparison to be made
- The assumption made by CDF is that the underlying event measured in an *active* (class 12 vertex) should be subtracted
- This analysis sought to check this assumption and to understand how well Monte Carlo programs predicted the event structure
- In this analysis, we used the Run I inclusive cross section data but restricted there to be only 1 vertex of class 10,11 or 12 in the event



By definition there is at least one jet in the central rapidity region; we construct 2 cones (R=0.7) at the same rapidity as the lead jet and 90 degrees away in phi. One of these cones has more energy (max cone) and one has less (min cone)

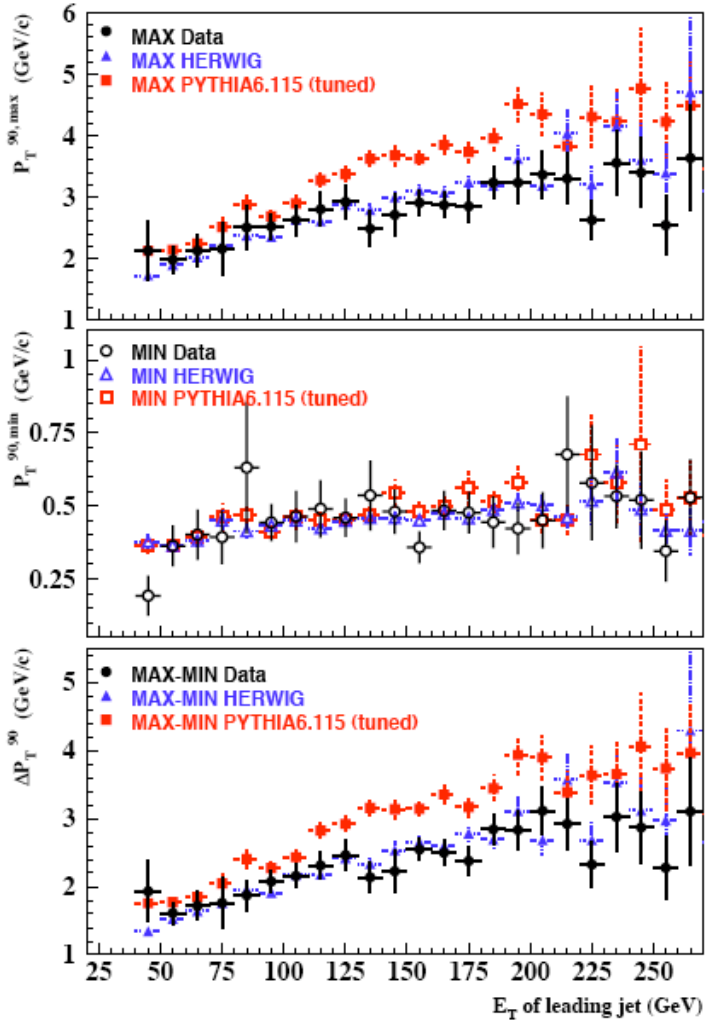
Comparisons

- We choose to work with charge track momenta rather than calorimeter energies due to the uncertainties in the CDF low energy calorimeter response
- We use charged tracks with p_T>0.4 GeV/c in the central rapidity region, correcting for track reconstruction efficiency
- The lead jet used in this analysis has to be within $|\eta|$<0.5; thus the centroid of the min/max cones are also within that range
- On the right is shown the momentum contained in the max, min and max-min cones compared to Herwig and Pythia



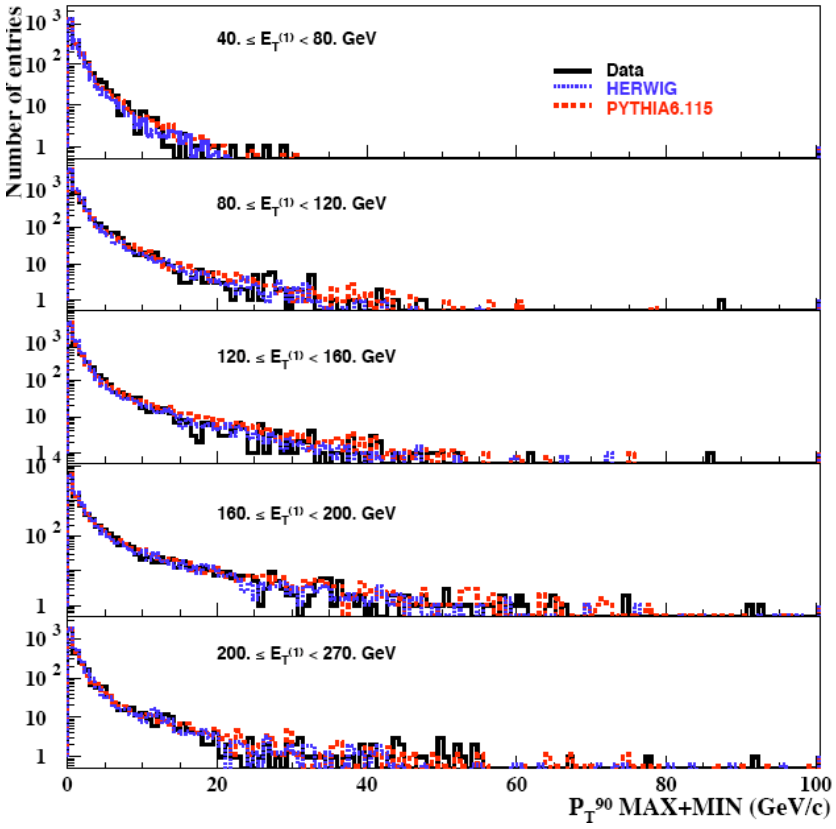
Tuning

- Working with Rick Field, we tried using one of his Pythia tunes, which resulted in better agreement
- Common features:
  - min cone is flat over range of inclusive jet data
  - max cone rises
  - both in reasonable agreement with MC predictions



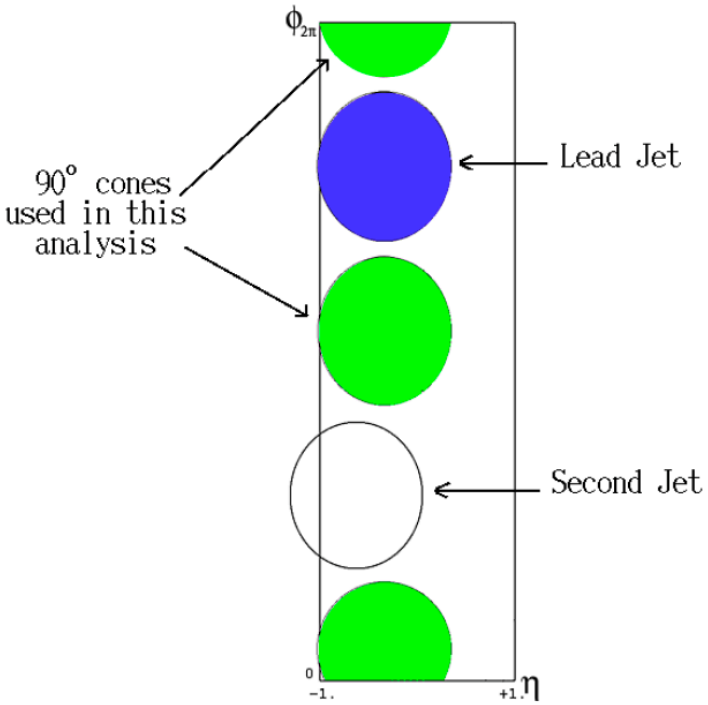
Look at distributions

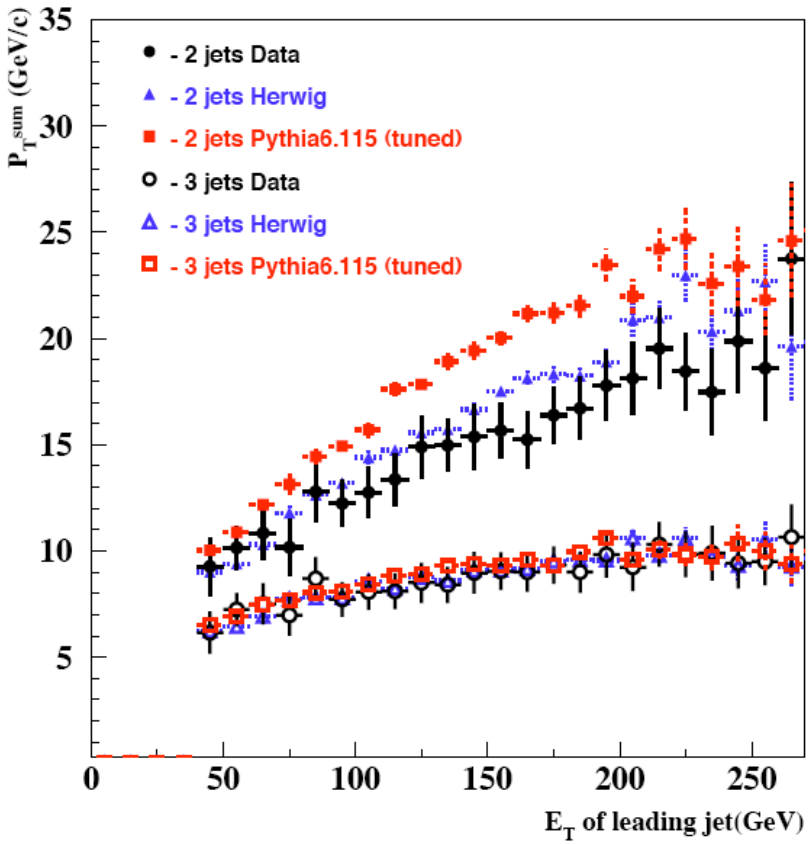
- Look at distributions of momentum in max+min cones for different lead jet bins
- Contains contributions from underlying event plus gluon radiation
  - double-log enhanced
    - basis of parton shower Monte Carlos
  - single-log enhanced
    - partially in MC's; new area of much theoretical effort
    - expect major contribution when log (E_T^{jet}/E_T^{cones}) is large
- Conclusion
  - Pythia and Herwig ain't so bad



Another observable: Swiss cheese

- Subtract energy in 2 (3) leading jets in central region and compare to MC



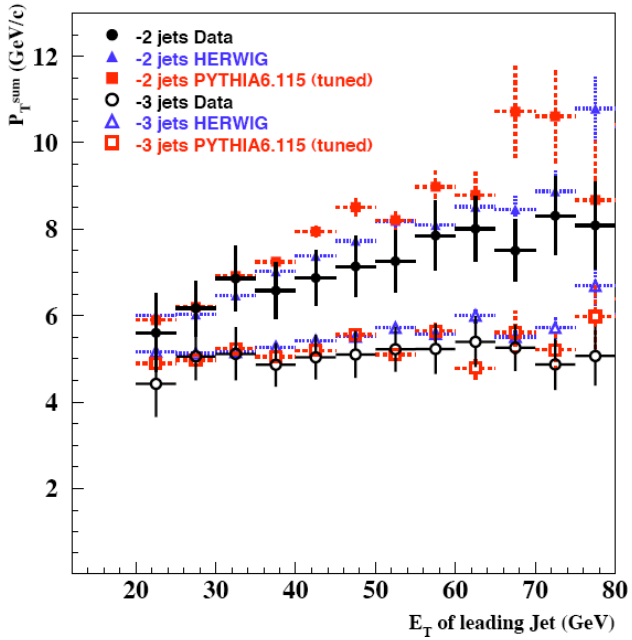


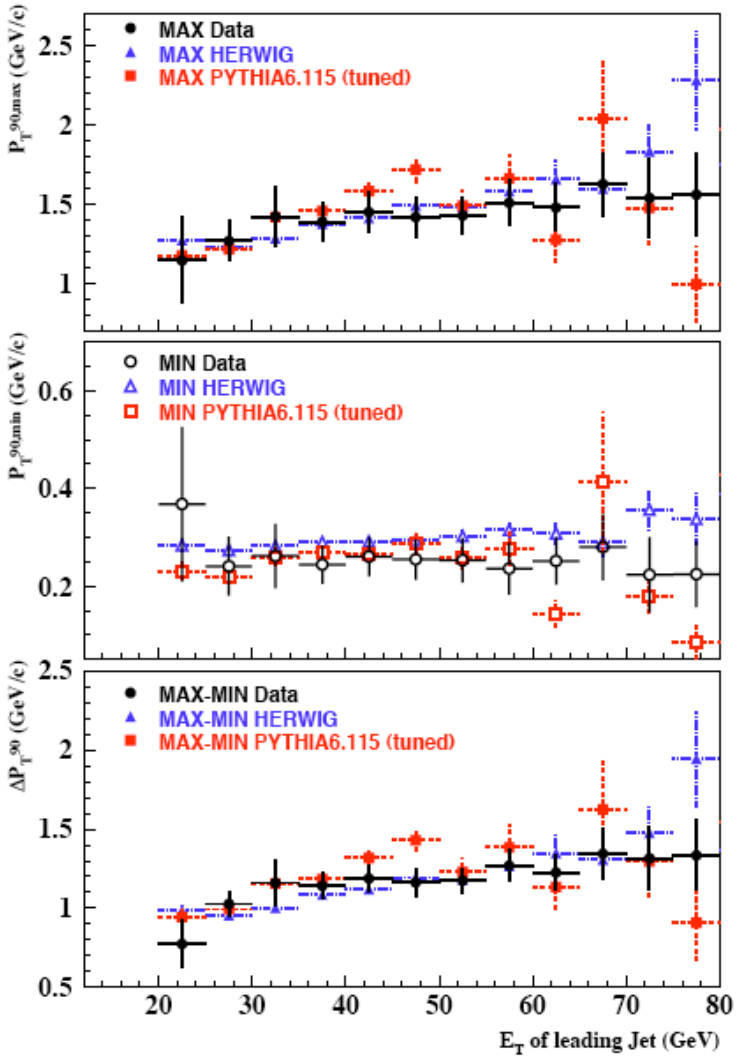
almost perfect agreement for 3-jets subtracted; no contribution from *NLO final state* for this configuration

630 GeV

- Study was repeated at 630 GeV, where qualitatively similar behavior is found (but tune works better for Pythia)
- Energy extrapolation from 1800 GeV to 630 GeV useful; probably last time anyone looks at 630 GeV data

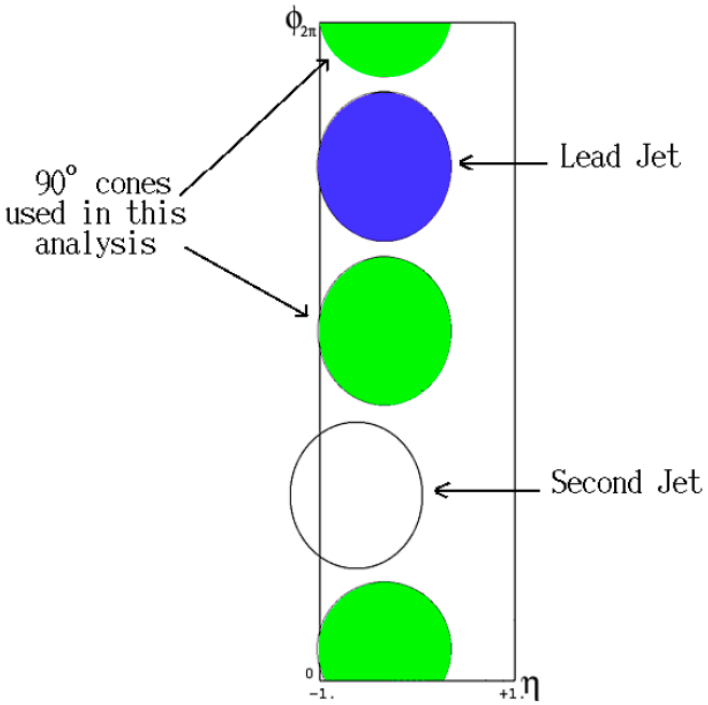
Swiss cheese

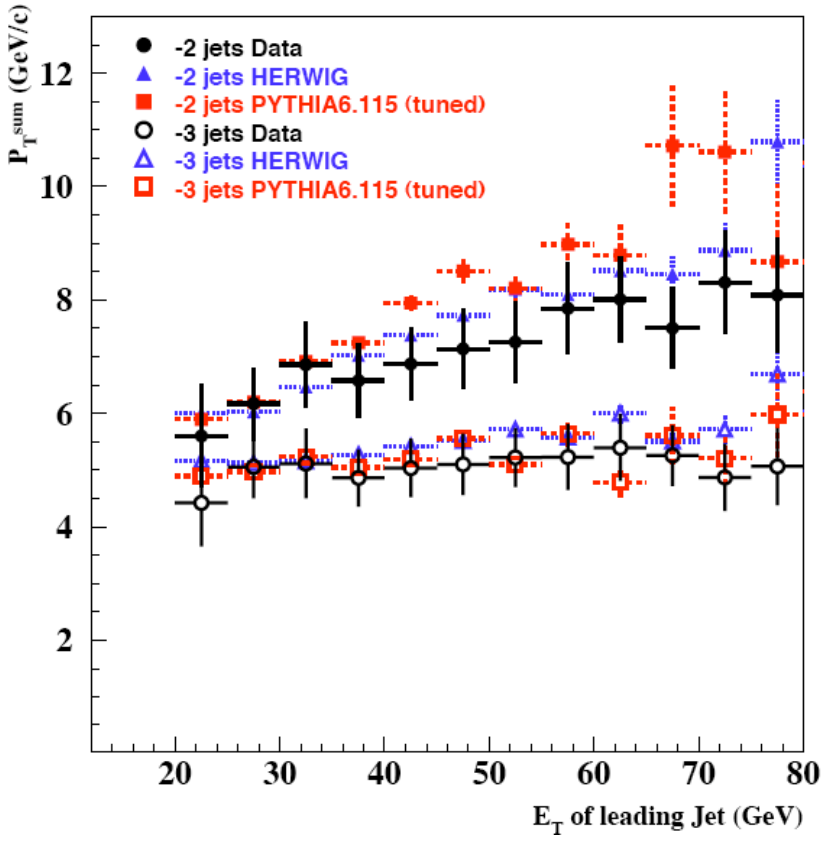




Swiss cheese at 630 GeV

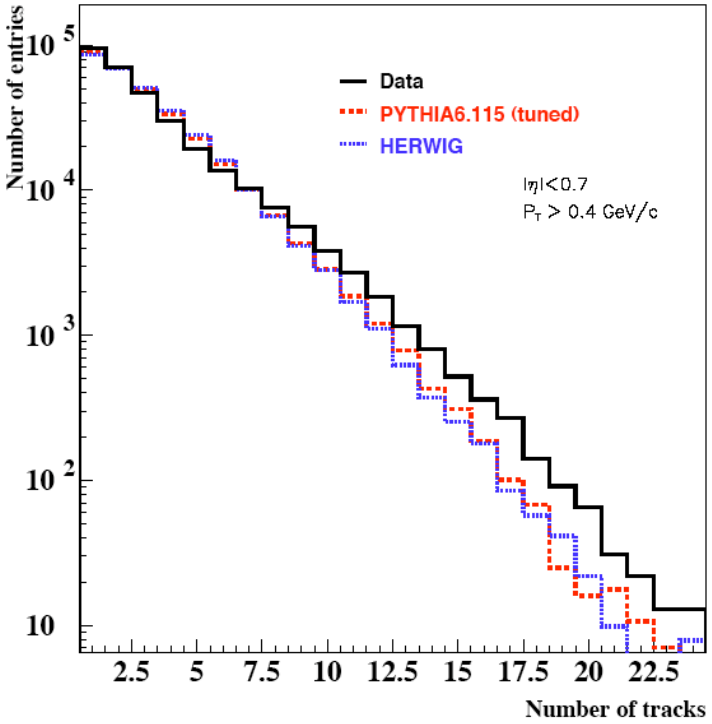
- Agreement is reasonably good for both Monte Carlos

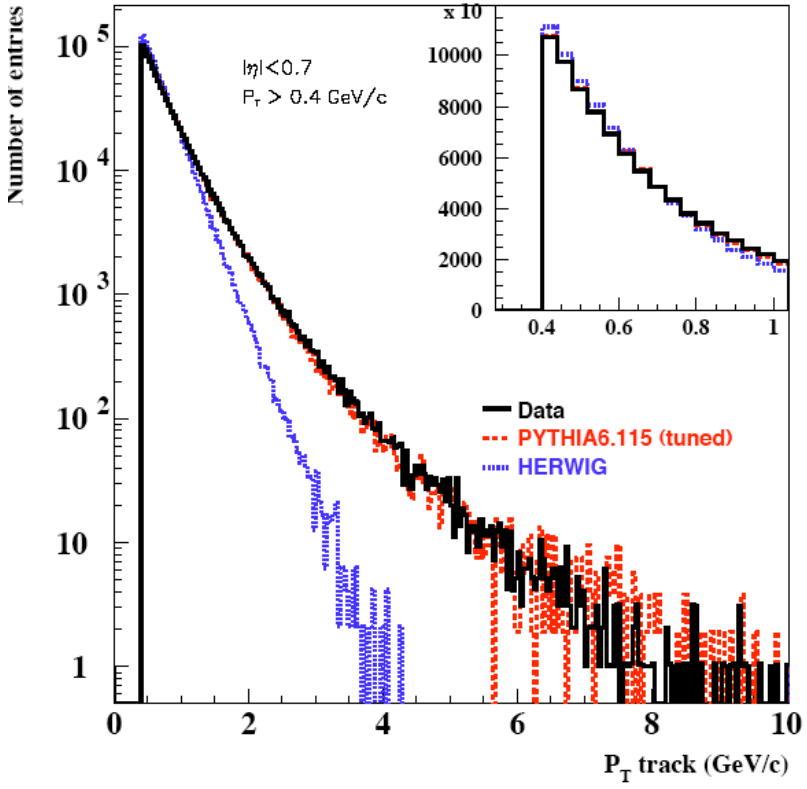




Minimum bias events

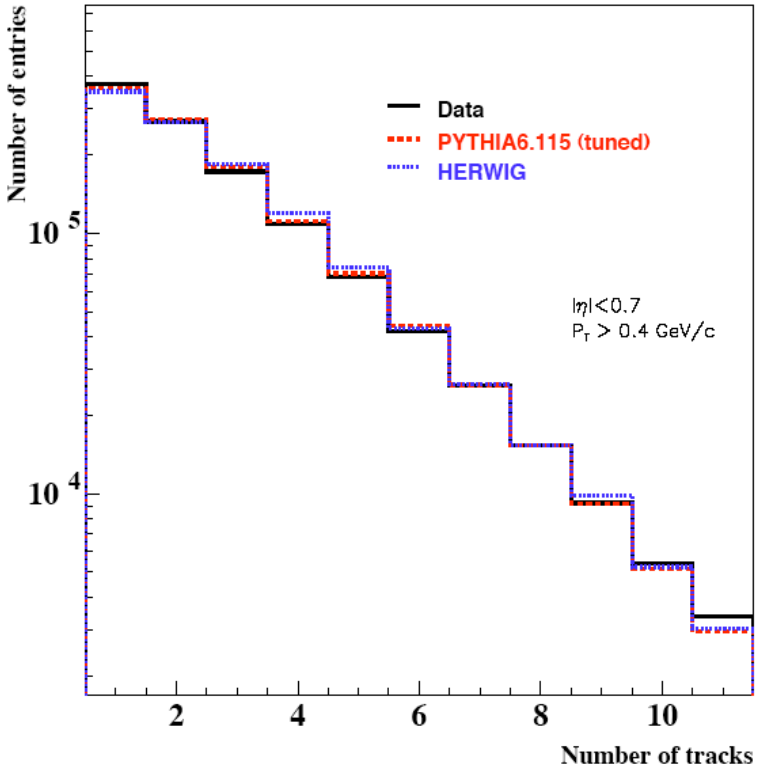
- Look at charged track multiplicity, p_T distribution
- Pythia's model of DPS does much better than Herwig at describing the high p_T end

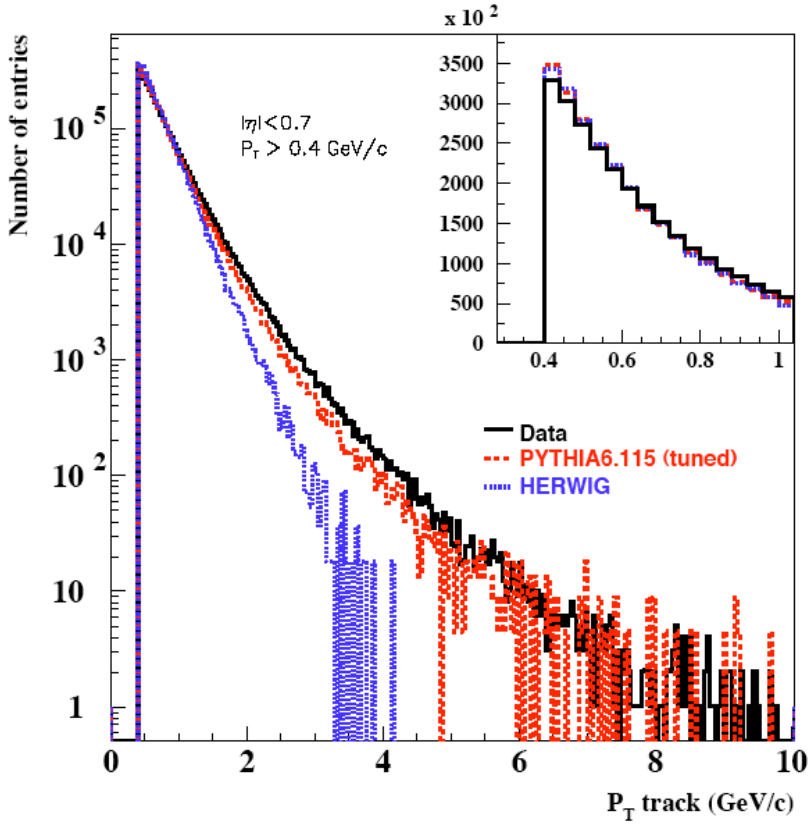




Ditto at 630 GeV

- Track multiplicity well-defined
- Could describe high p_T tail better



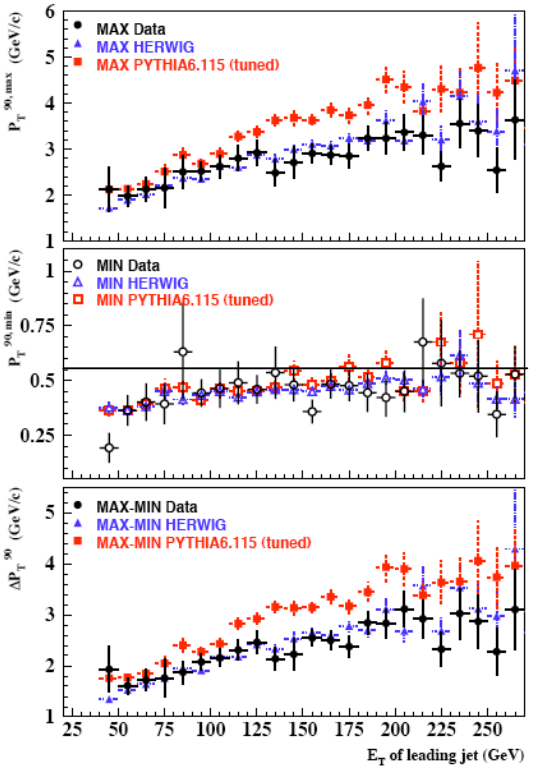


Underlying event subtraction at 1800 GeV

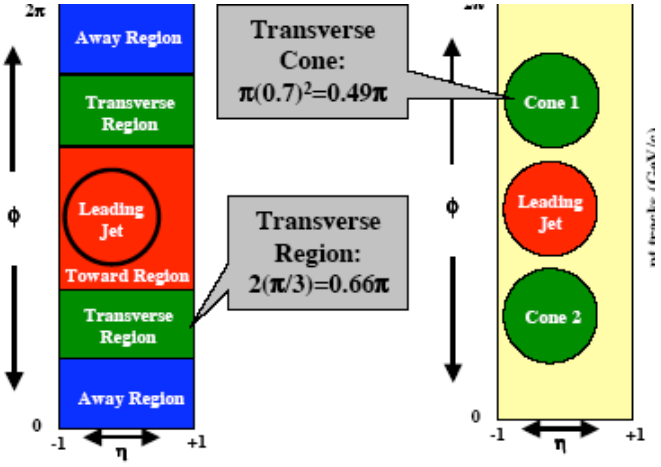
- Sum of momentum inside a random cone of radius 0.7 in high quality (class 12) vertex min bias events is a reasonable approximation for the momentum in the min cone in jet events

TABLE III: Mean $P_T^{MB,cone}$ and the mean number of tracks in a random cone of radius 0.7 in $\sqrt{s} = 1800$ GeV minimum bias data. Only systematic errors are shown. Statistical errors are less than 0.5%.

		$P_T^{MB,cone}$ (GeV/c)	Track Multiplicity
DATA	all vertices	0.36 ± 0.04	0.45 ± 0.06
	high quality vertex	0.57 ± 0.06	0.69 ± 0.09
HERWIG		0.31	0.44
PYTHIA (tuned)		0.35	0.44

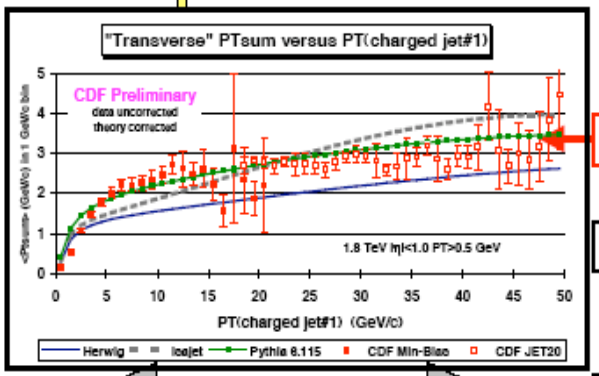


Compare to Rick's Run I analysis



Transverse Region vs Transverse Cones

Field-Stuart-Haas



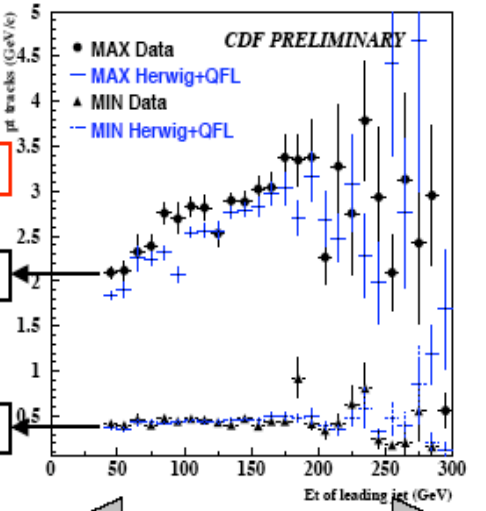
3.4 GeV/c

2.1 GeV/c

0.4 GeV/c

$0 < P_T(\text{chgjet\#1}) < 50$ GeV/c

Pt track in max and min cone



$0 < E_T(\text{jet\#1}) < 50$ GeV/c

- Add max and min cone: 2.1 GeV/c + 0.4 GeV/c = 2.5 GeV/c.
- Multiply by ratio of the areas: (2.5 GeV/c)(1.36) = 3.4 GeV/c.
- The two analyses are consistent!

Tano-Kovacs-Huston-Bhatti

Plans

- Submit to Los Alamos and then to PRD
- Go back to Santa Barbara and work on my tan
- …and while I'm talking, let me give website for Santa Barbara workshop where I've been keeping track of developments
  - http://www.pa.msu.edu/~huston/santa_barbara/collider04.html
- Developing/improving tools for use in Run II as well as answering *Big Questions*
  - for example, now both Herwig and Pythia authors are working on understanding photon+jet balancing differences
  - last week, Rick was visiting and very useful discussions of the type of physics in this paper
    - his sister was off in Mexico with Jane Fonda but he still refused my request to have a party at her house
  - all talks are stored in pdf format as well as in streaming video