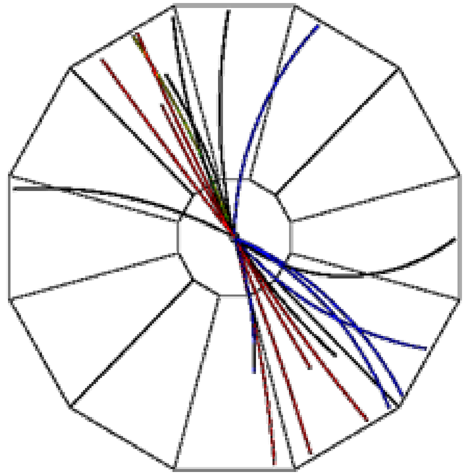


Jet Reconstruction at STAR

in p+p and d+Au collisions

Thomas Henry

Texas A&M University

for the

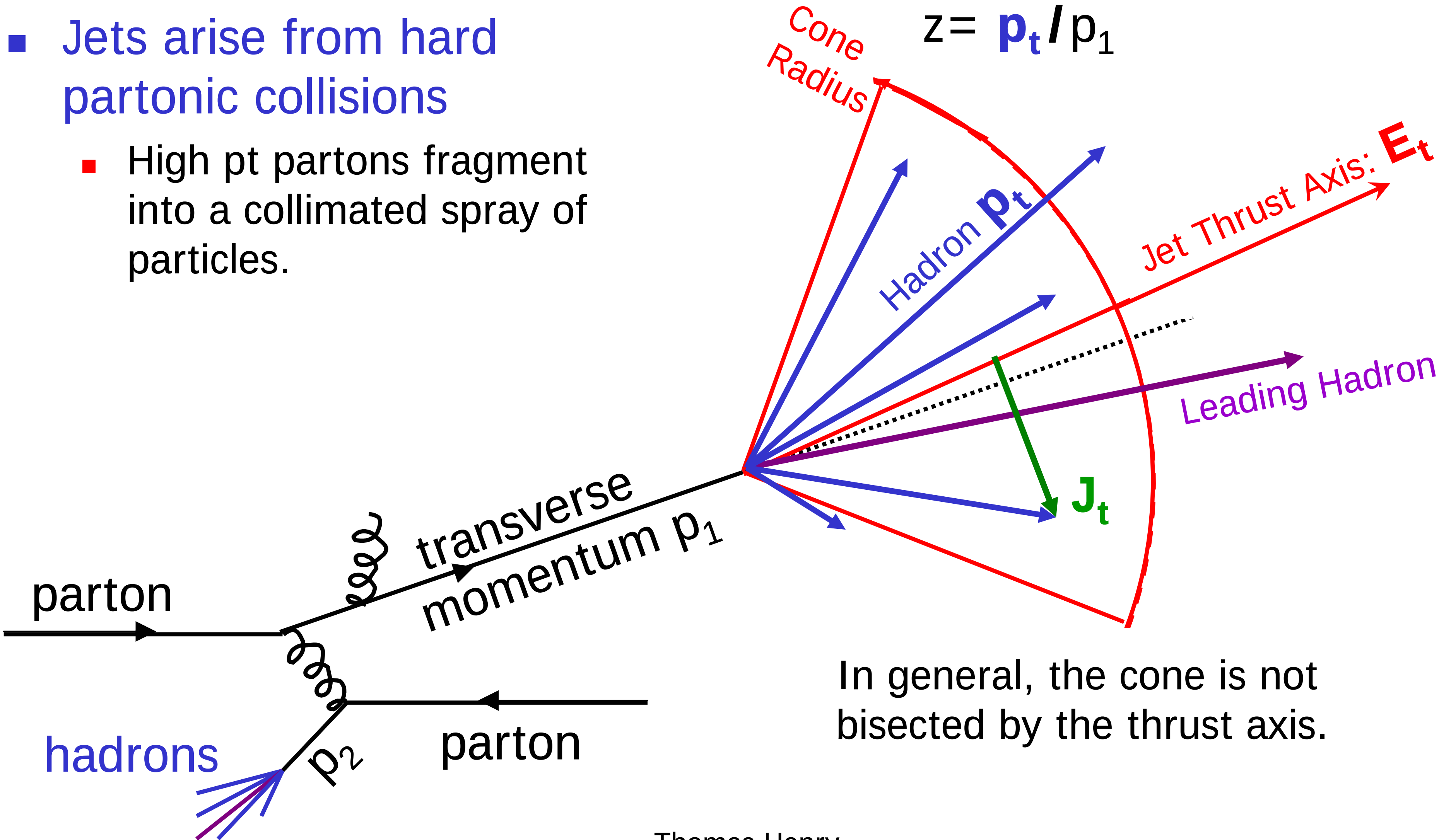
STAR Collaboration

Outline

- Introduction
- Inclusive jet studies
- Dijet studies
- Dihadron studies

What is a Jet?

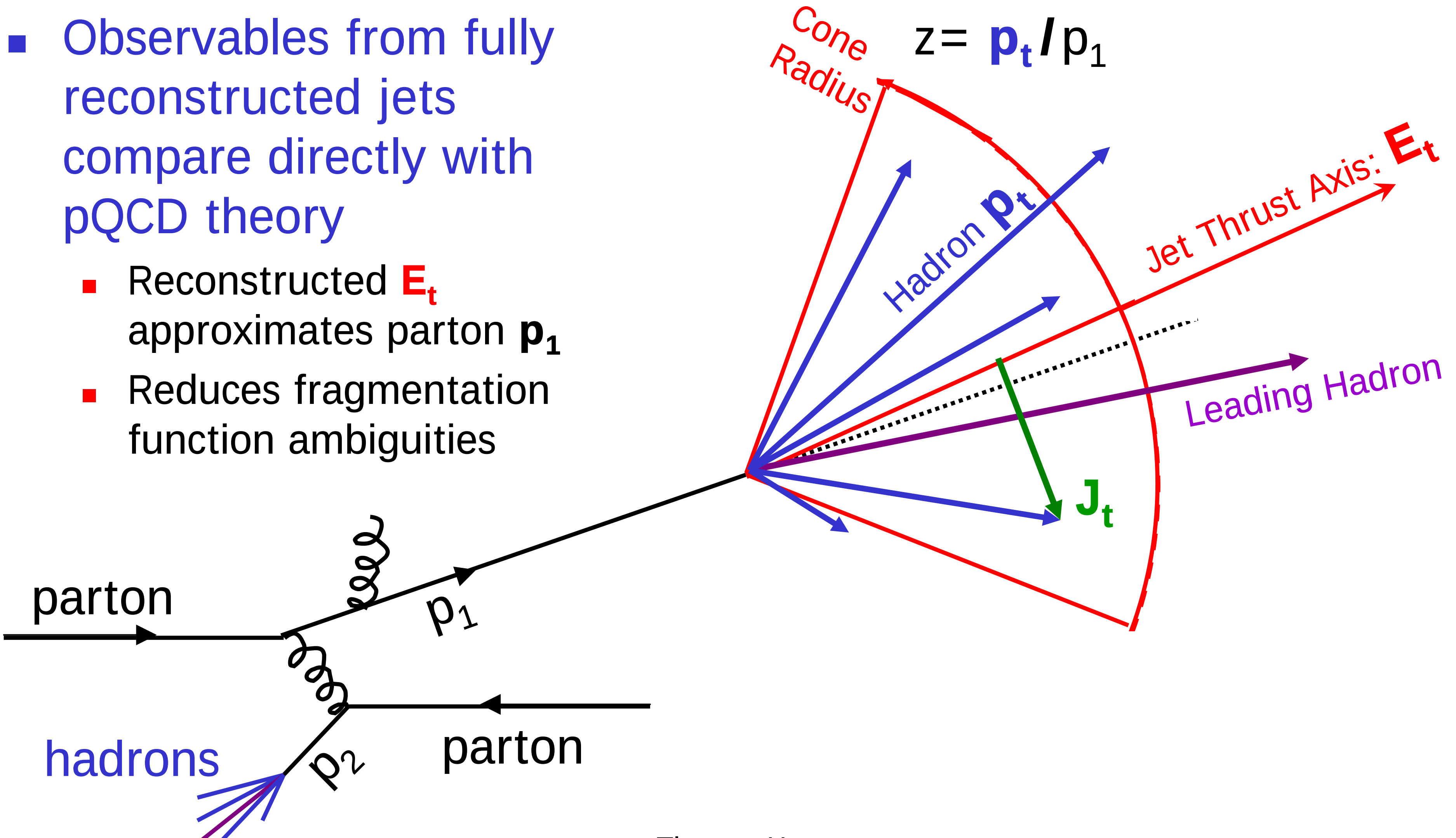
- Jets arise from hard partonic collisions
  - High pt partons fragment into a collimated spray of particles.



In general, the cone is not bisected by the thrust axis.

Why is Jet Reconstruction Important?

- Observables from fully reconstructed jets compare directly with pQCD theory
  - Reconstructed $\mathbf{E_t}$ approximates parton $\mathbf{p_1}$
  - Reduces fragmentation function ambiguities

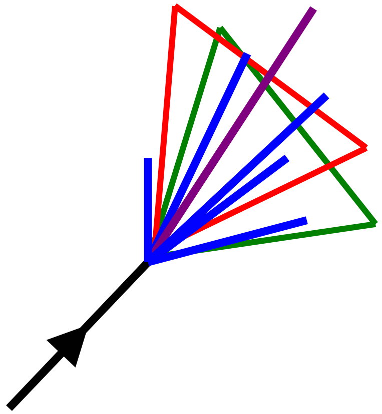


Jets in p+p, d+Au, and Au+Au

- p+p leads to J_t and intrinsic k_t
- d+Au leads to intrinsic k_t + nuclear k_t
- Au+Au jets cannot be fully reconstructed due to huge multiplicity
  - Di- (and multi-) hadron correlations necessary
  - p+p and d+Au jet reconstruction calibrates these correlations

Jet Reconstruction Algorithms

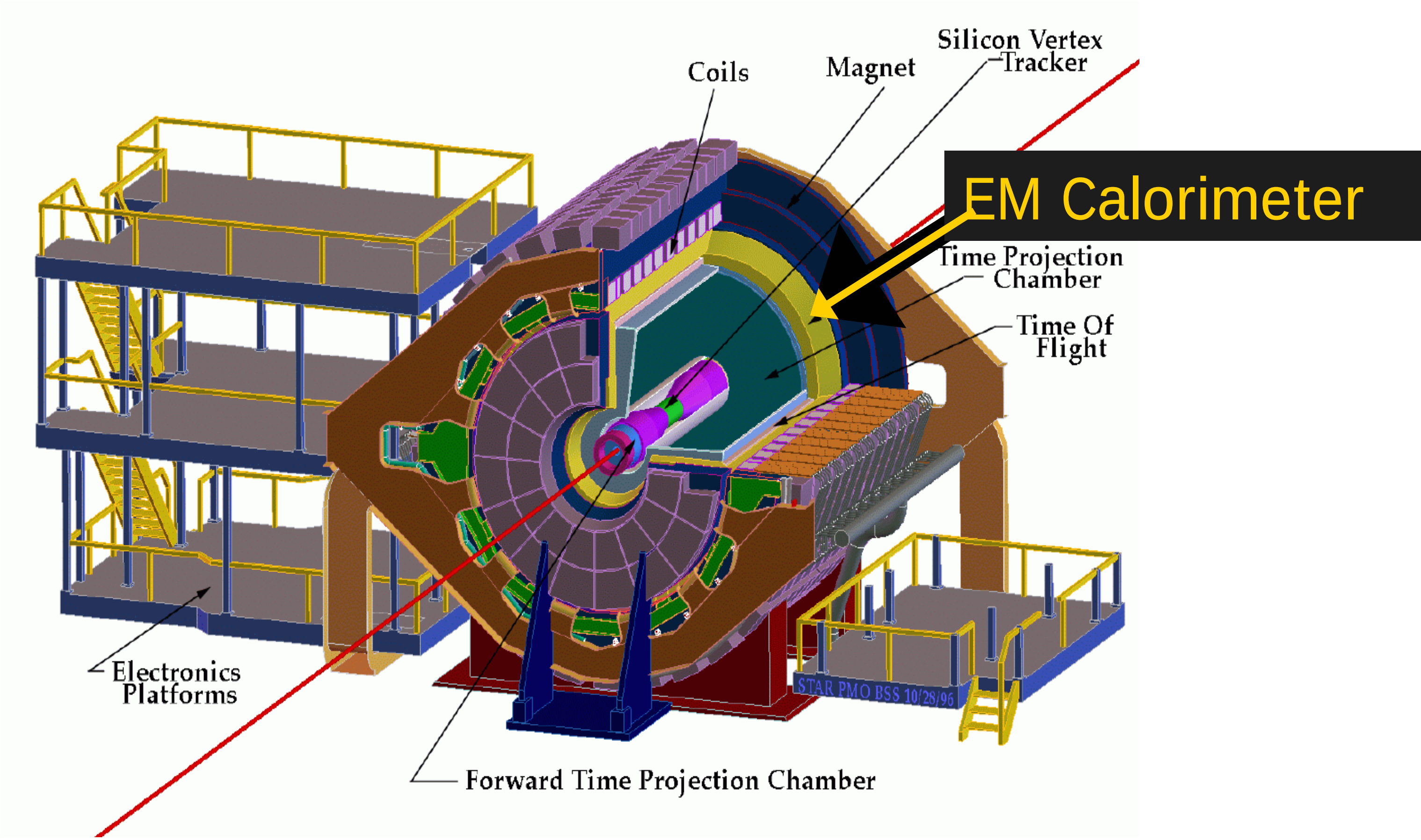
- Hard parton fragmentation products are strongly correlated in momentum
  - Jets reconstructed by exploiting hadron momenta correlations
- Cone algorithms: capture spray of particles with geometric cone. Two strategies:
  - Center the cone on the seed particle
    - More robust for high multiplicity
  - Optimize the direction of the cone
    - Cone direction optimized for maximum energy



- Kt algorithm: exploit relative p_t
  - Add hadrons with progressively larger relative momenta
  - Hadrons below p_t threshold not used

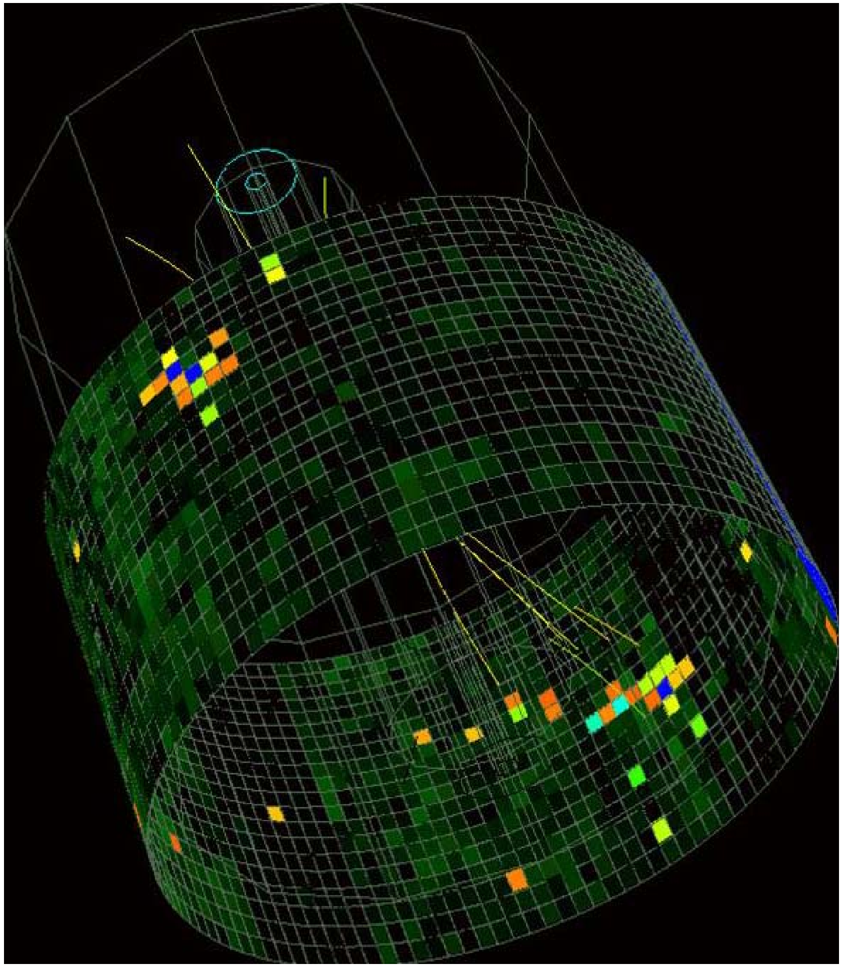
The STAR Detector

- The complete ϕ coverage and large η coverage of the TPC (with particle ID) and EMC make STAR excellent at reconstructing jets.



The STAR EMC

- Neutral energy (which includes π_0 decay photons) is measured with the STAR Electromagnetic Calorimeter
  - For 2003 RHIC run, Barrel EMC included:
    - **2π coverage in ϕ; $0 < \eta < 1$**
    - 2400 Towers ($\Delta\eta \times \Delta\phi = 0.05 \times 0.05$)
    - See posters by D. Arkhipkin, M.M. de Moura
  - Read out in Minimum Bias Events
  - Also used as trigger to select events likely to contain jets
    - **"High tower" trigger with $E_T >$ 2.5,4.5 GeV**
    - Other trigger topologies available but not used in 2003.



From Observed Energy to Jet Energy

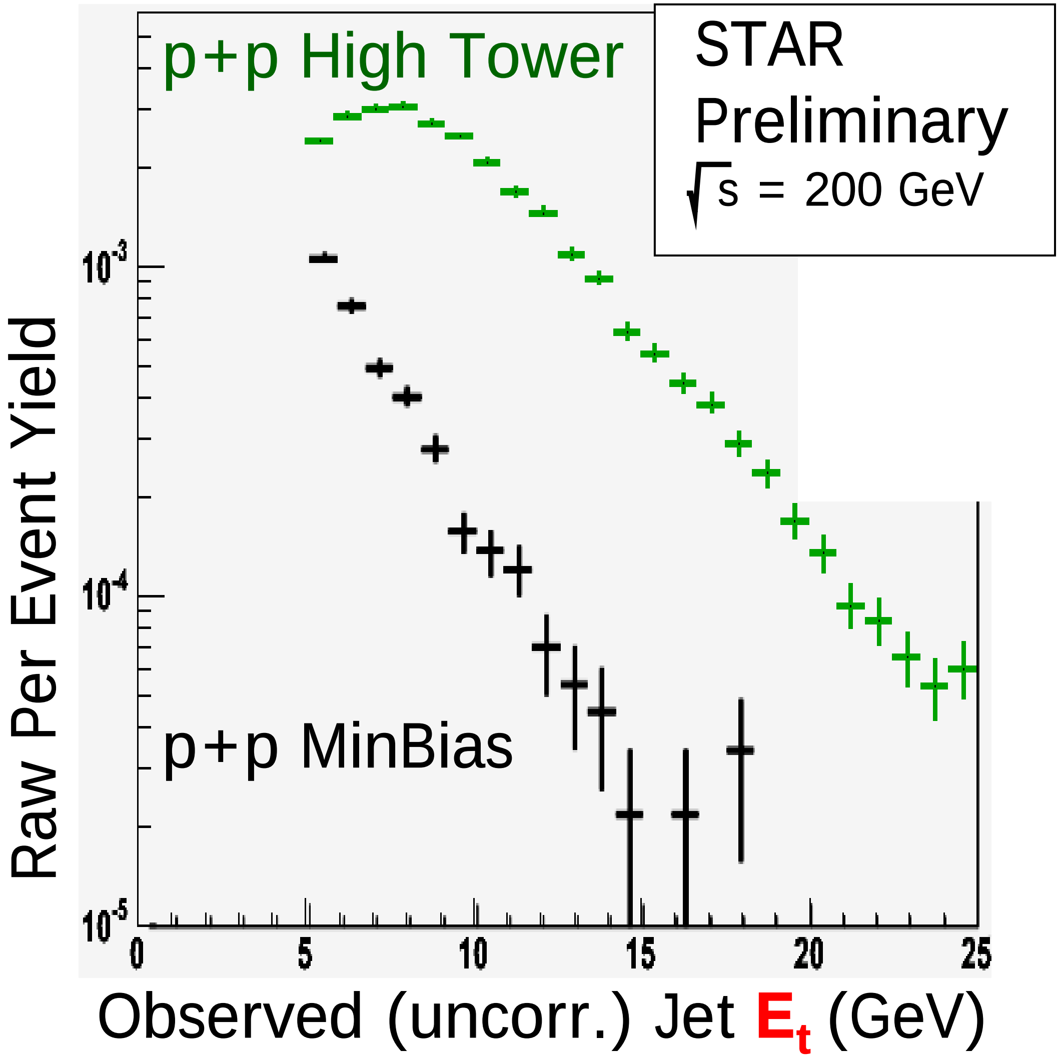
- Measure both charged tracks and neutral energy
  - Correct for double counting of charged energy
  - Charged particle tracking efficiency ~.9
  - EMC geometric acceptance ~.94
  - Long lived neutrals (n, K_L, ...) lost

- Soft particles may fall outside jet cone

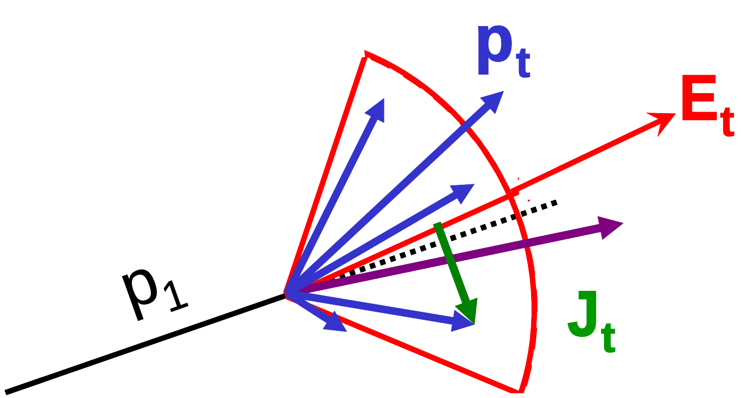
- Total correction factors from Pythia
  - 1/~0.8 for minbias
  - 1/~0.86 for high tower

  } Need verification

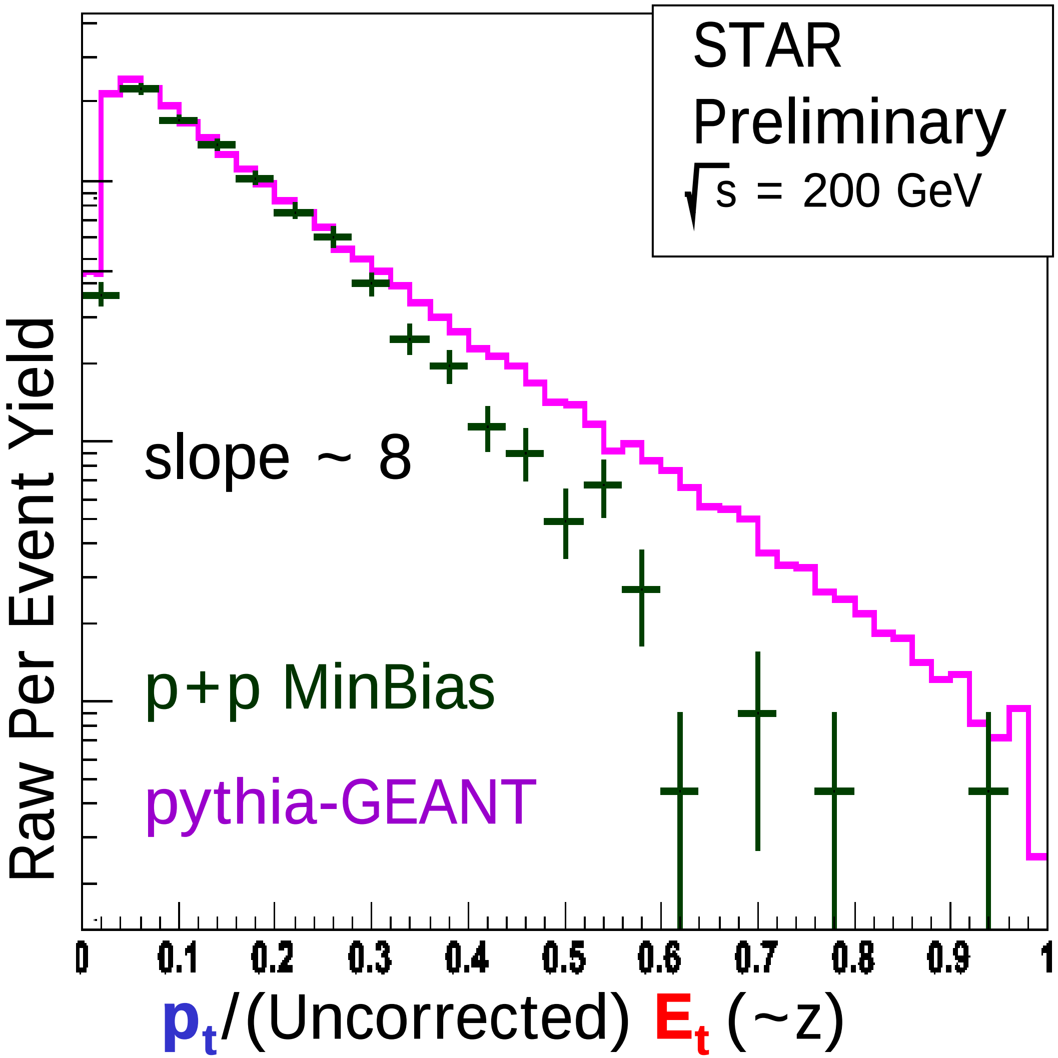
Jet E_t



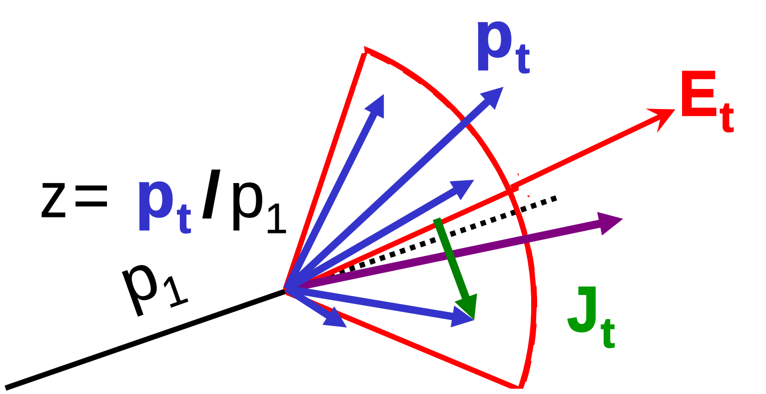
- p+p collisions; R_{cone}=.7
- MinBias
- High tower triggered
  - Corrected <E_t> = 11.3 ± 0.7_{sys} GeV



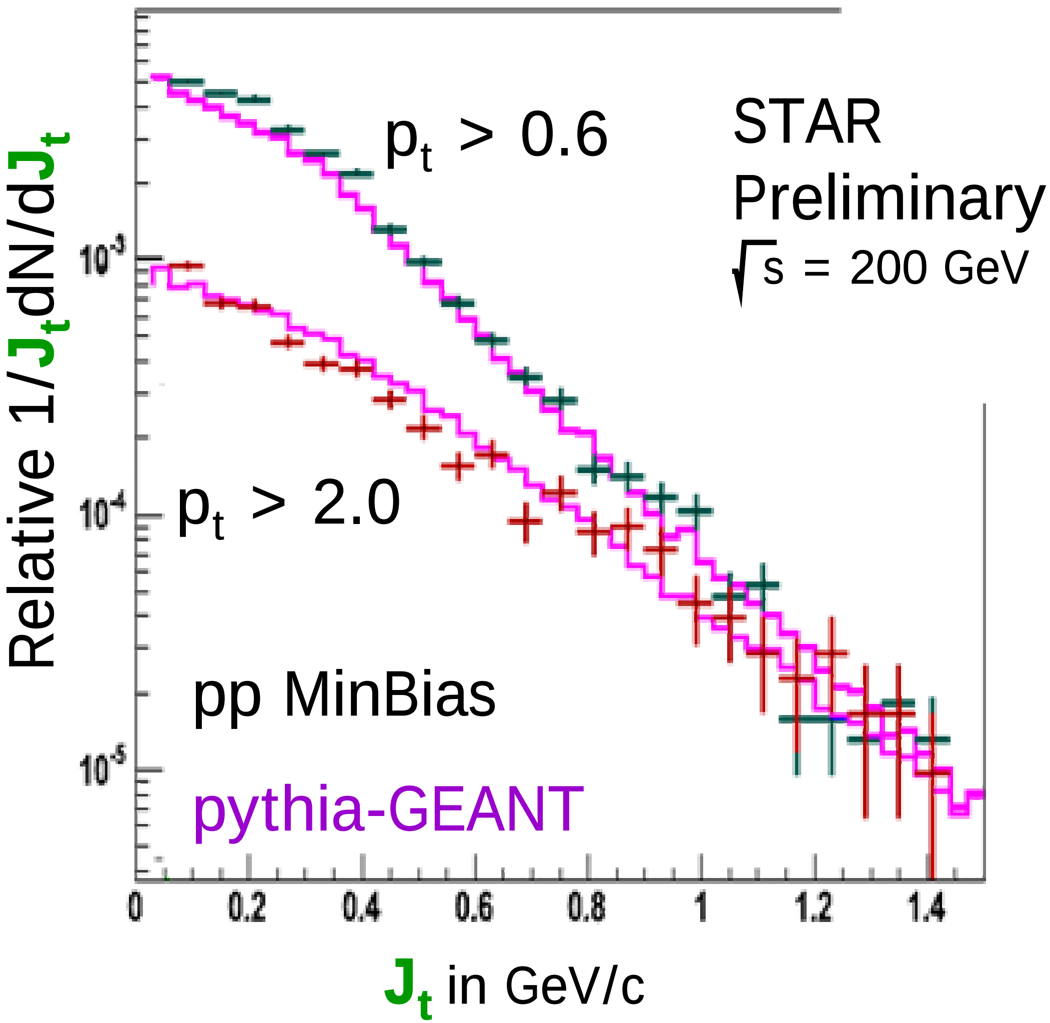
Toward a Jet Fragmentation Function



- Pythia-GEANT is pythia run through the STAR detector simulator
- Agree at low z
- High z deviations under study

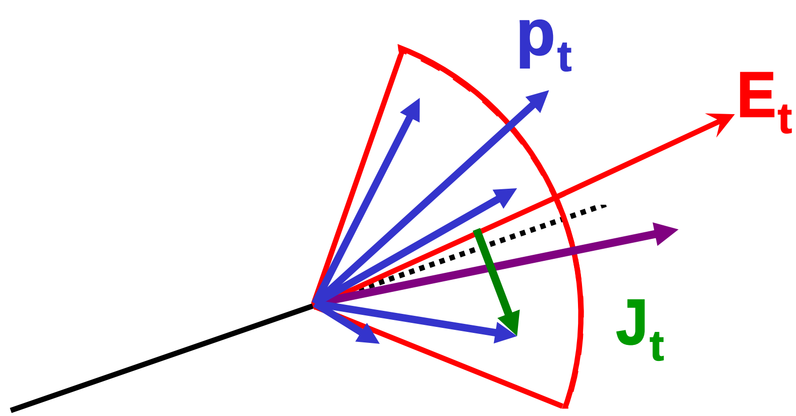


Jet J_t



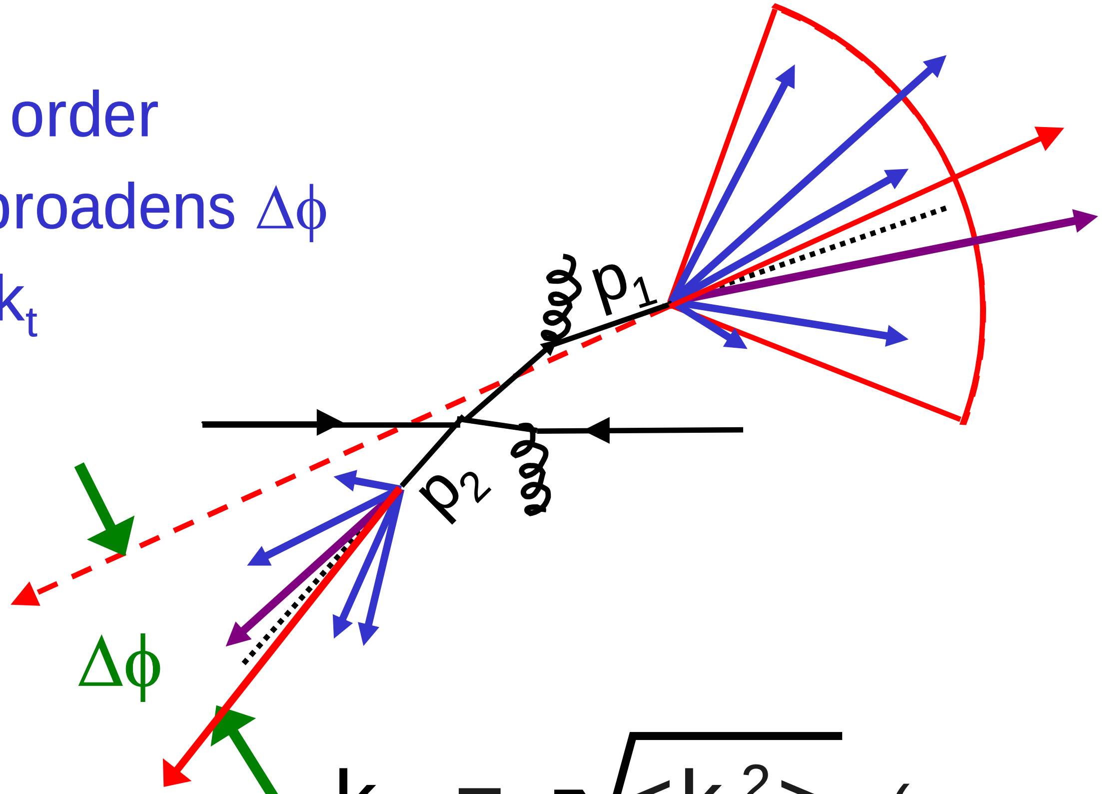
Agree within 4%

- Primarily sensitive to jet axis direction
- Low p_t kinematic limit: "Seagull Effect"
- RMS J_t
  - $490 \pm 50_{sys}$ MeV/c, p_t>0.6
  - $615 \pm 60_{sys}$ MeV/c, p_t>2.0



DiJet Δφ Distribution

- $\Delta\phi = \pi$ in leading order
- Gluon radiation broadens $\Delta\phi$
- $\Delta\phi$ is a probe of k_t

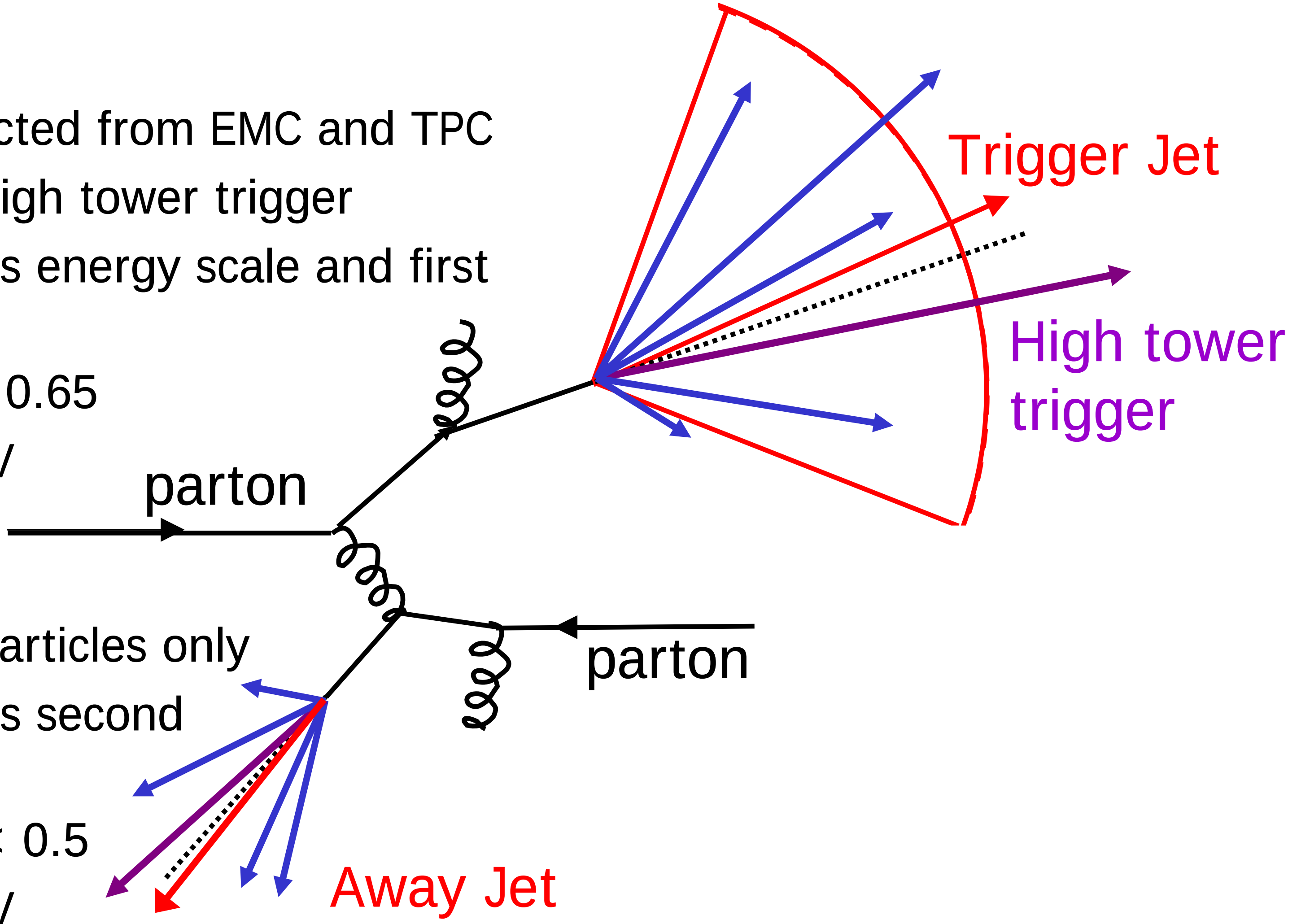


$$k_t = \sqrt{\langle k_t^2 \rangle} \quad \text{(per parton)}$$

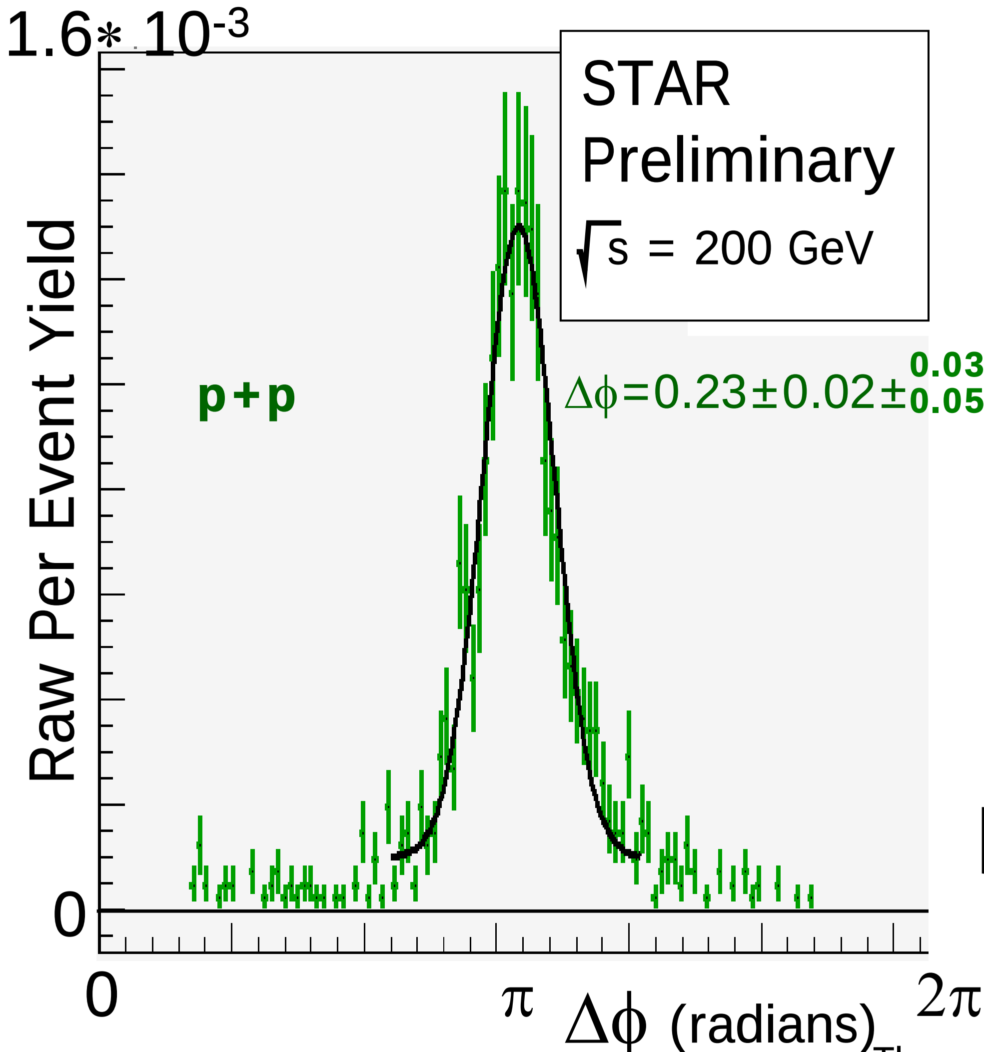
$$= \langle E_t \rangle \sin \sigma_{\Delta\phi}$$

DiJet Reconstruction

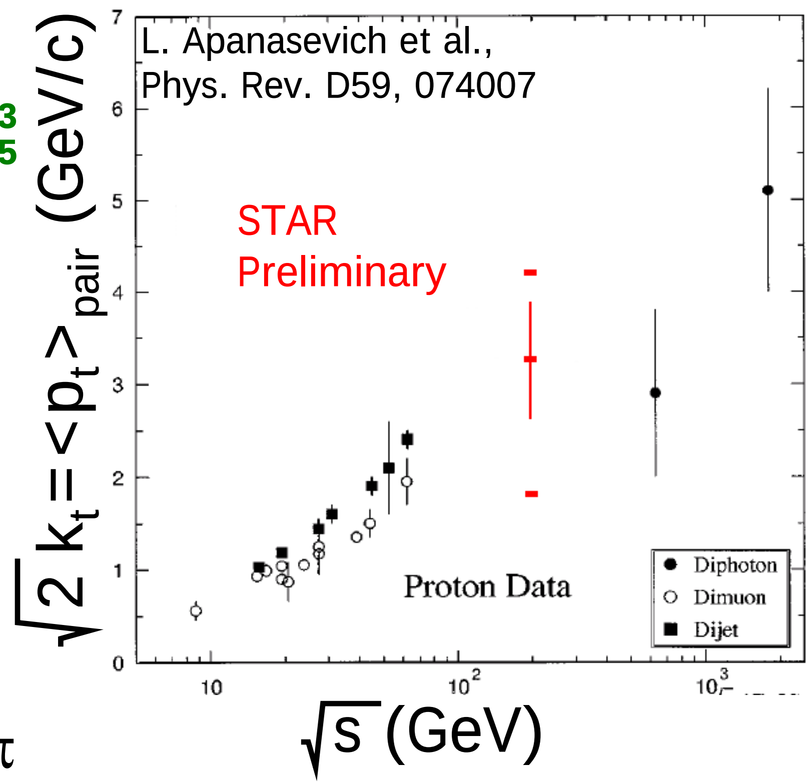
- Trigger Jet
  - Reconstructed from EMC and TPC
  - Includes high tower trigger
  - Determines energy scale and first thrust axis
  - $0.2 < \eta < 0.65$
  - $E_t > 5$ GeV
- Away Jet
  - Charged particles only
  - Determines second thrust axis
  - $-0.5 < \eta < 0.5$
  - $E_t > 4$ GeV



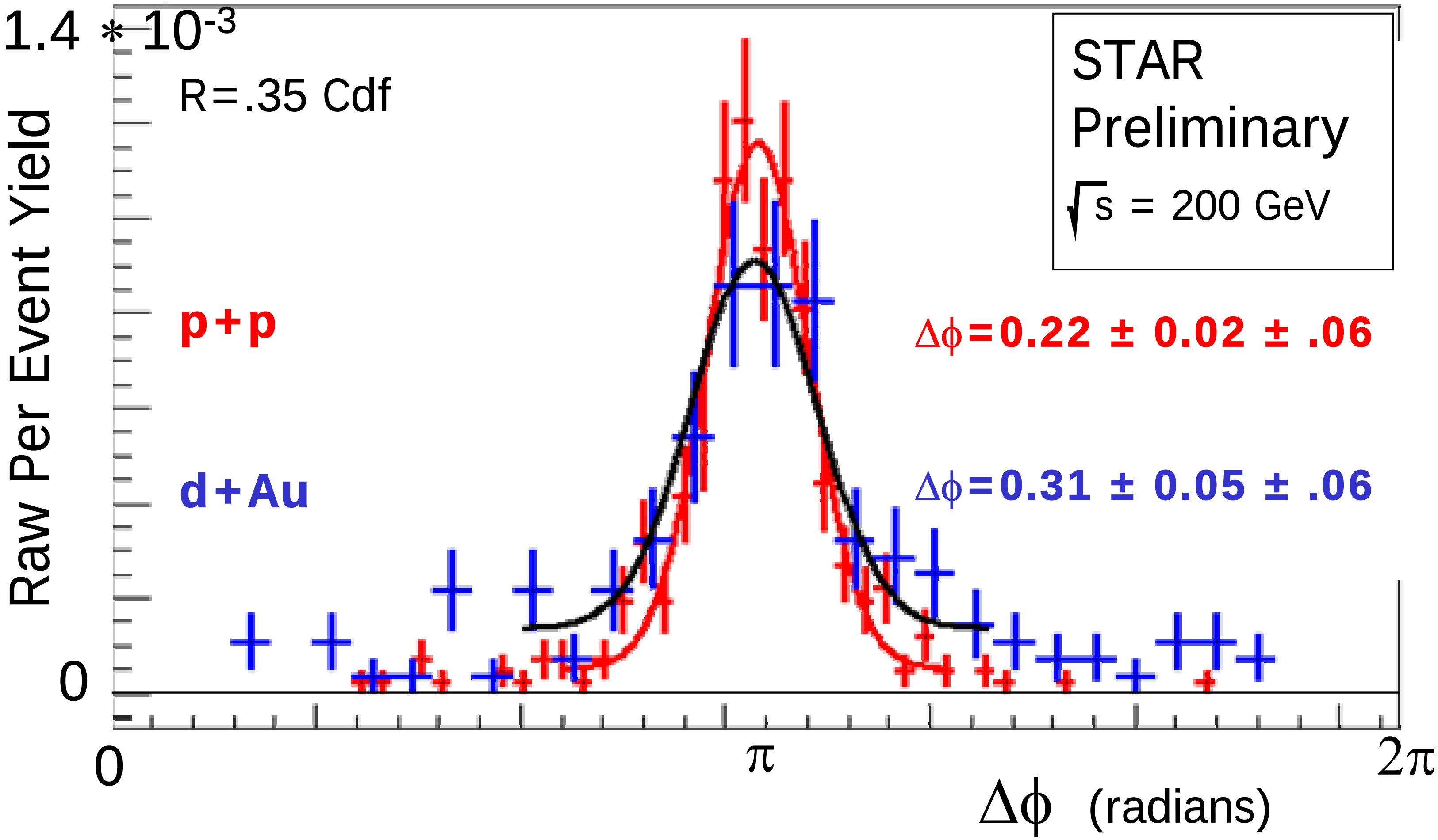
p+p DiJet Δϕ Distribution



- Dijet high tower corrected $<E_t> = 13.0 \pm 0.7_{Sys}$ GeV
- $k_t = 2.3 \pm 0.4 \pm^{0.67}_{1.11}$ GeV/c



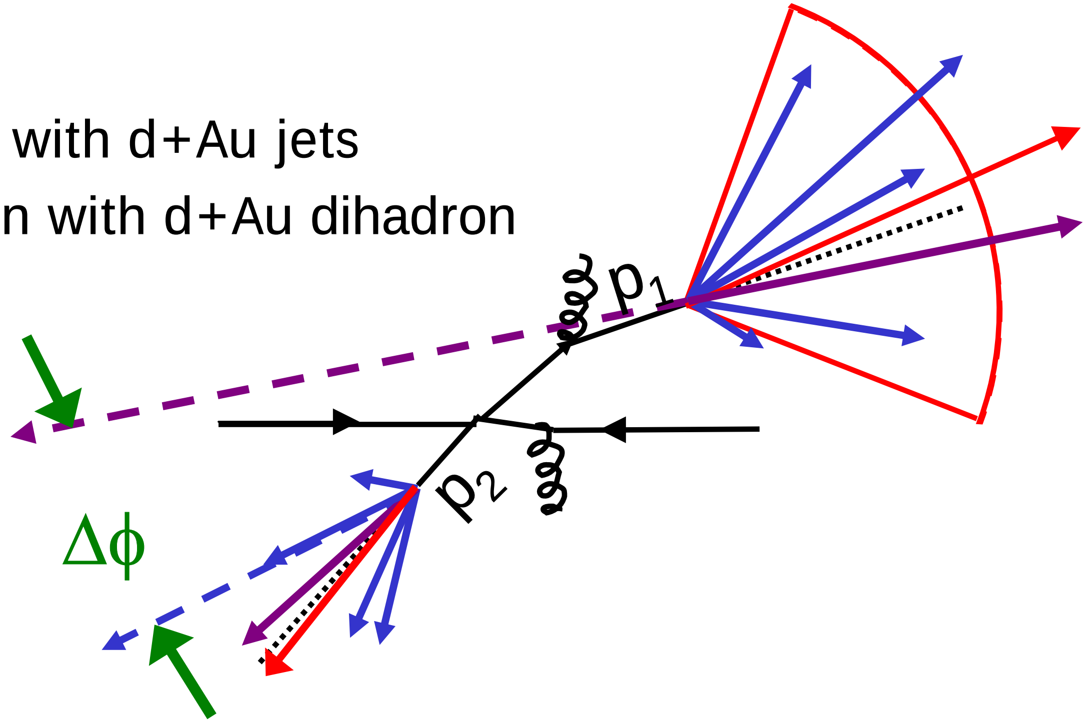
Nuclear k_t in d+Au



- $k_{t_{obs}}{}^2 = k_{t_{intrin}}{}^2 + k_{t_{nucl}}{}^2$
- d+Au vs p+p: **Nuclear k_t = 2.8±1.2±1.0 GeV/c**

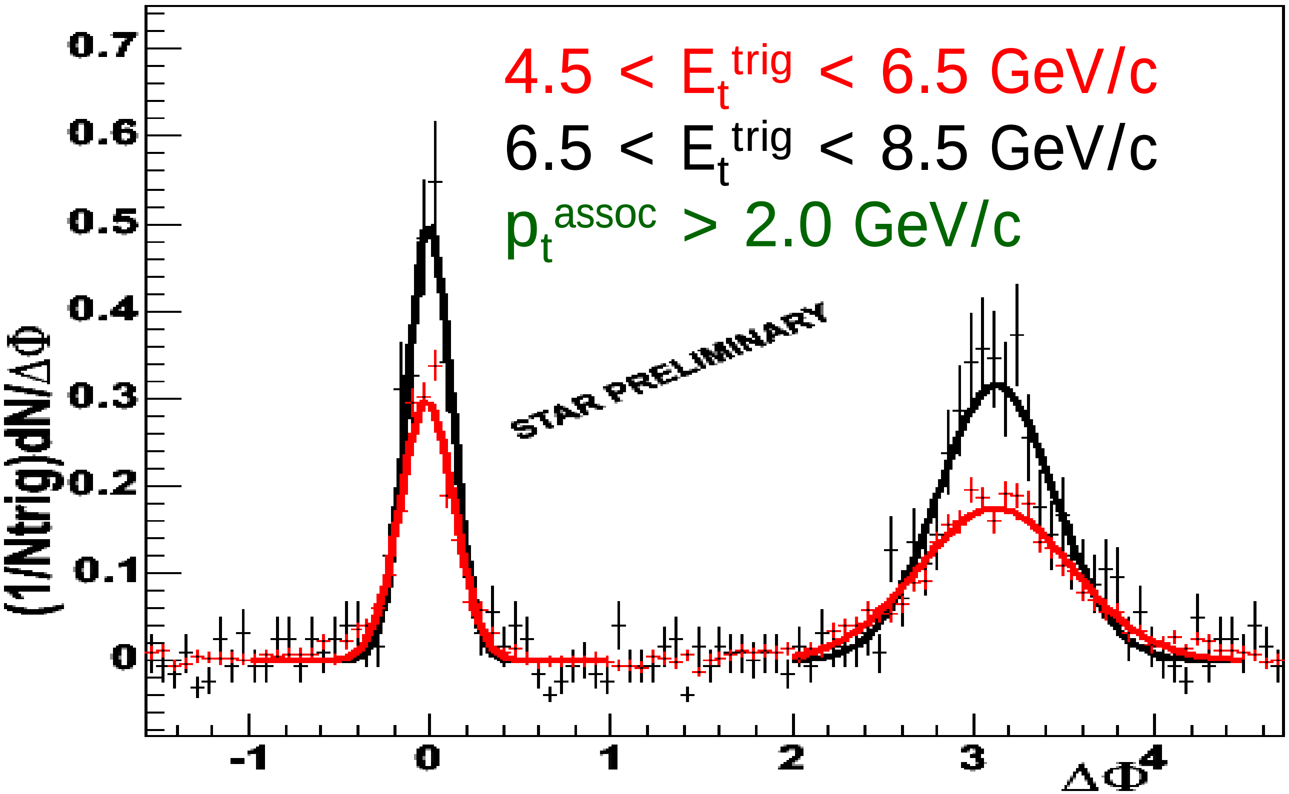
Dihadron Correlations

- Au+Au: jet reconstruction fails
- Resort to dihadron correlations:
  - extract J_t and k_t*<z>
- Strategy:
  - Calibrate d+Au dihadron with d+Au jets
  - Compare Au+Au dihadron with d+Au dihadron



High Tower – Charged Hadron Correlation Functions
(variation with trigger energy)

See poster by S. Chattopadhyay



Preliminary results:

J_t = 500 ± 40 ± 150 MeV/c

k_t= 1.9 ± 0.2 ± 0.3 GeV/c /<z>

<z> needed for trigger hadron

Will measure this to very high E_t^{trig} in Au+Au collisions during current RHIC run

DiHadrons and DiJets

- J_t
  - p+p jets: $615 \pm 60_{sys}$ MeV/c
  - d+Au dihadrons: $500 \pm 40 \pm 150$ MeV/c
  - **→ Consistent between inclusive jets and dihadrons**
- k_t
  - p+p dijets: intrinsic $k_t = 2.3 \pm 0.4^{+0.67}_{-1.11}$ GeV/c
  - d+Au dijets: nuclear $k_t = 2.8 \pm 1.2 \pm 1.0$ GeV/c
  - d+Au dihadrons: total $k_t = (1.9 \pm 0.2 \pm 0.3)/$**<z>** GeV/c
- Uncertainties are conservative

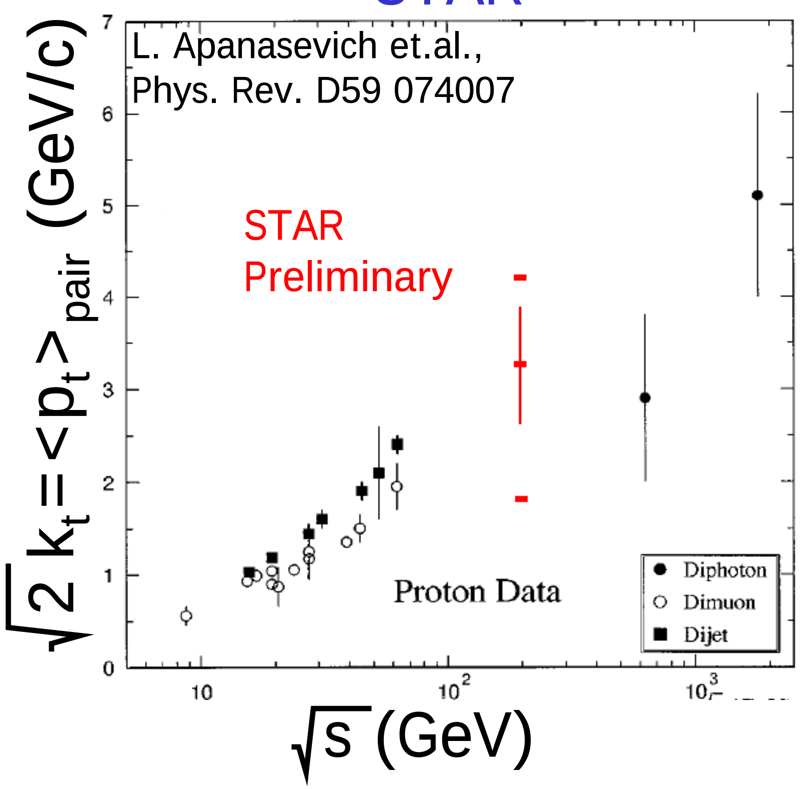
Conclusions

- Fully reconstructed jets in p+p and d+Au at RHIC
- p+p: J_t and intrinsic k_t
- d+Au: nuclear k_t
- Pythia provides a good description of J_t

- Future:
  - Jet and dijet cross sections in p+p and d+Au
  - R_{d+Au} for jets/partons

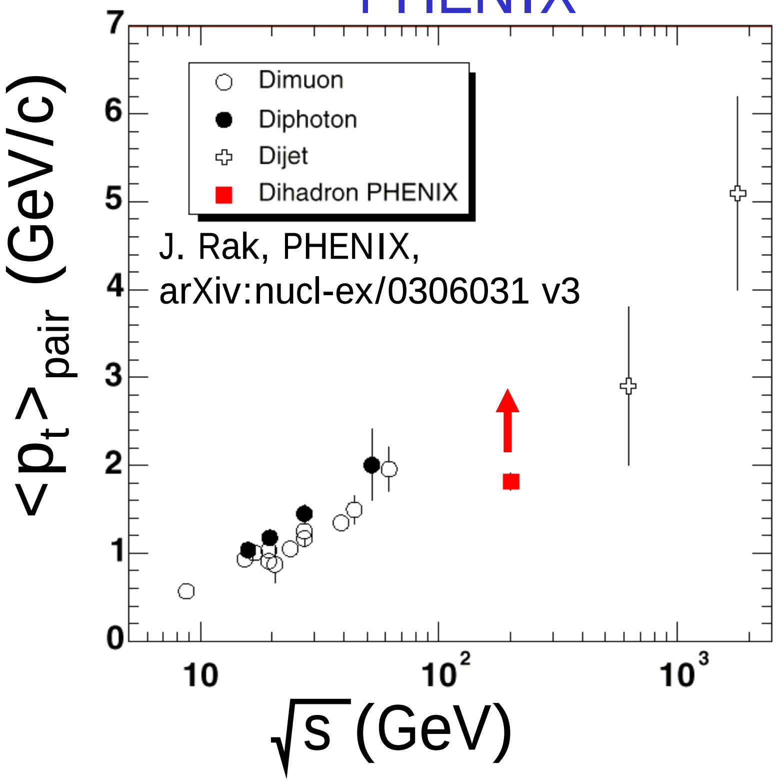
STAR-PHENIX Comparison

STAR



- $J_t = 615 \pm 60_{Sys}$ MeV/c
- $k_t = 2.3 \pm 0.4 \pm^{0.67}_{1.11}$ GeV/c

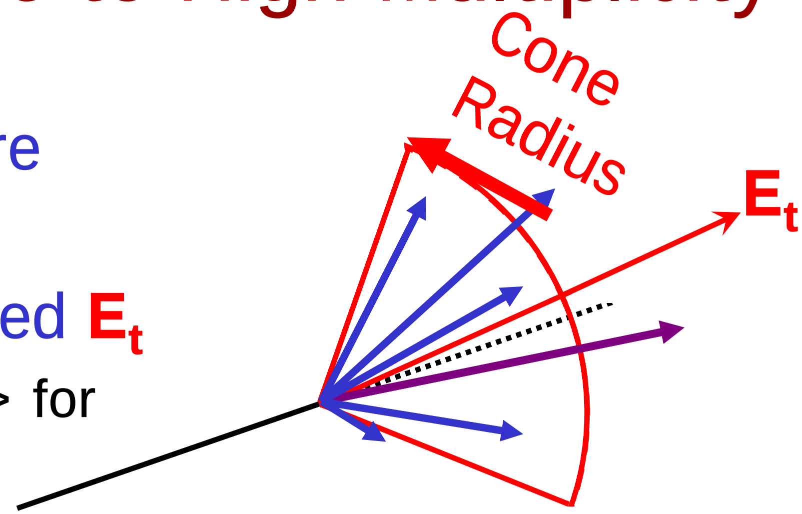
PHENIX

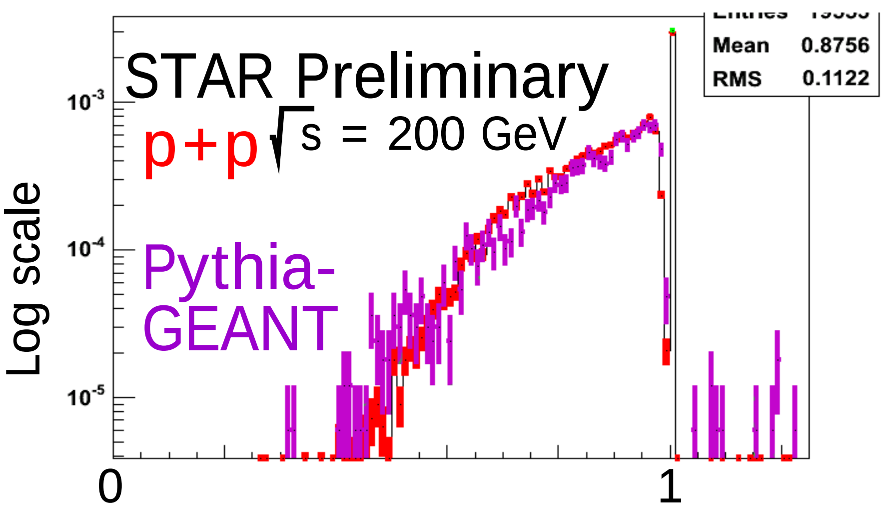


- $J_t = 661 \pm 28$ MeV/c
- $k_t = (1.3 \pm 0.06)/\langle z \rangle$ GeV/c

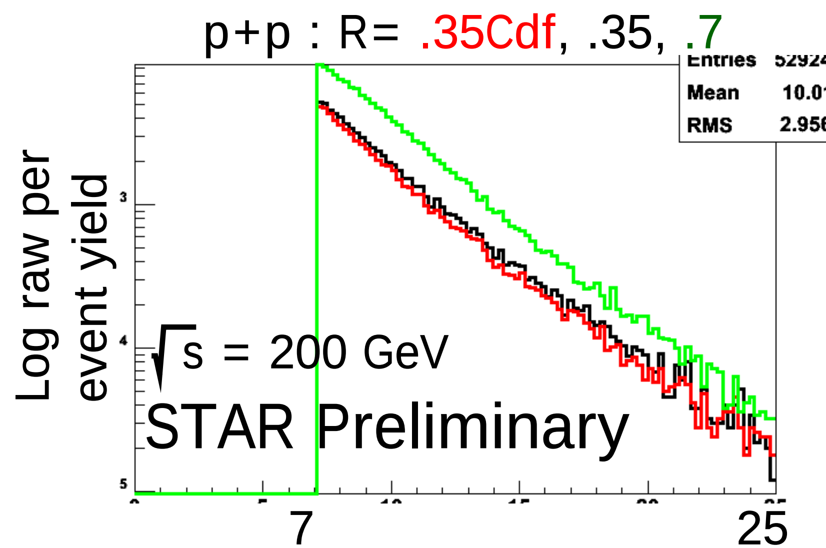
Difficulty in d+Au due to High Multiplicity

- d+Au jet signals at radius .7 are swamped by false jets
- Smaller radius reduces measured E_t
  - < E_t(R=.35)> = .88*< E_t(R=.7)> for high tower triggered events





E_t(R=.35)/ E_t(R=.7) for identical jets



E_t (Uncorrected) in GeV

Correction for Double Counting of Charged Hadron Energy

- Charged particles can leave some energy in the EMC
- Either can remove 20% of Track E or 0.3 GeV per Track from the EMC hits
  - 20% comes from Monte Carlo
  - .3 GeV = MIP
- The two approaches are consistent, and reduce the energy as expected