

Inclusive p^0 spectra at high pT in d-Au collisions at RHIC

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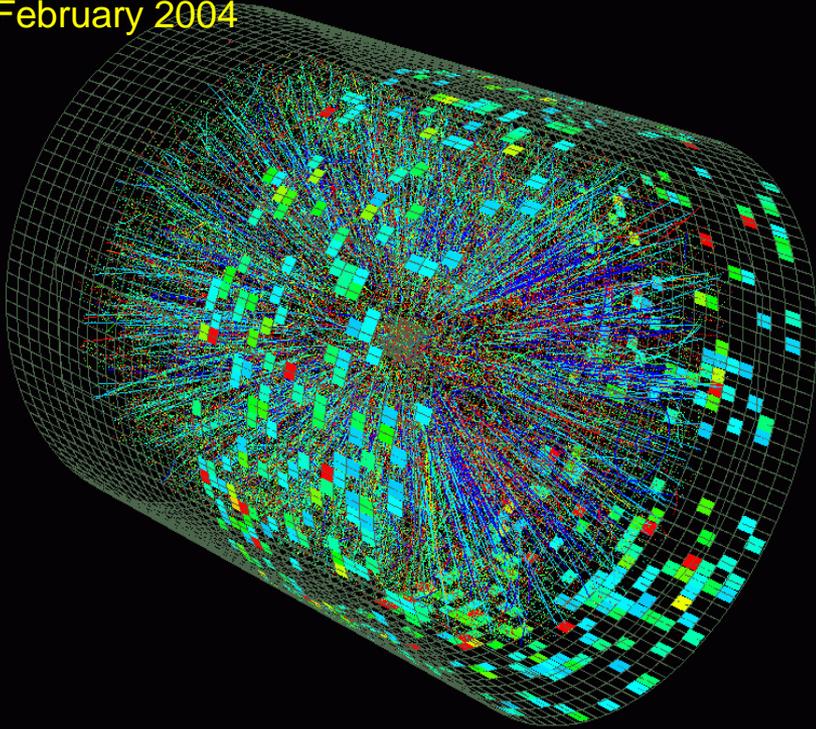
for the STAR Collaboration



Europhysics Conference, NPDC18
Prague, August 23-29, 2004

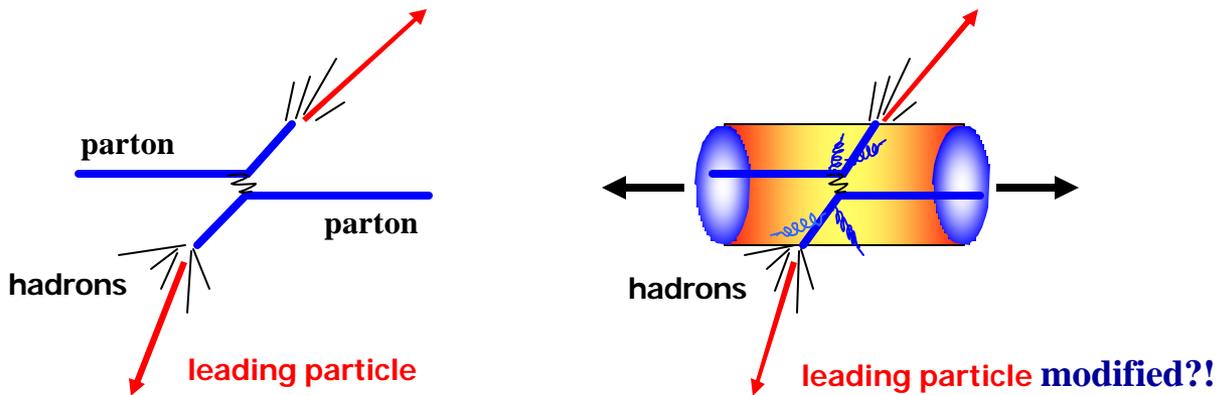
Outline

central Au-Au event at $\sqrt{s}=200$ GeV
February 2004



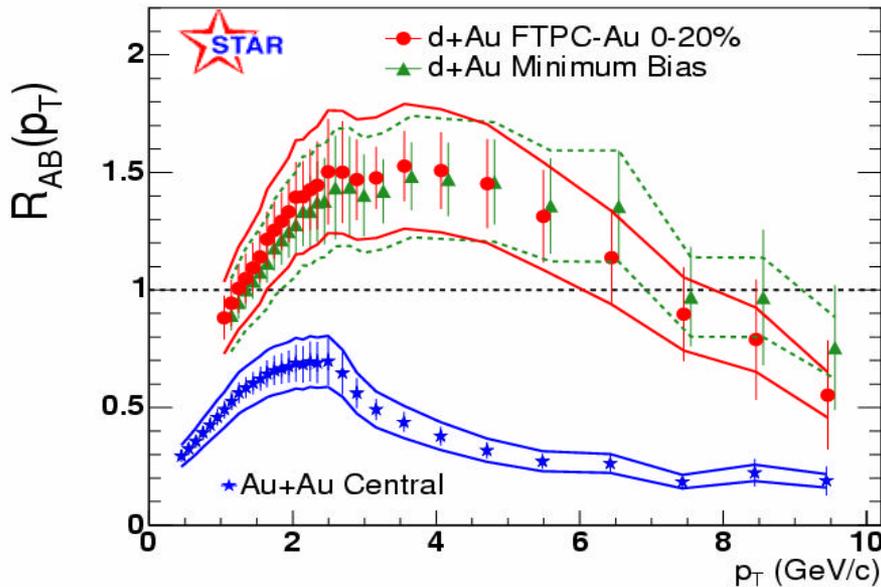
- High- p_T measurements in STAR
- The STAR experiment
- Neutral pion analysis
- Results
- Summary and outlook

Hard Processes in Heavy Ion Collisions at RHIC



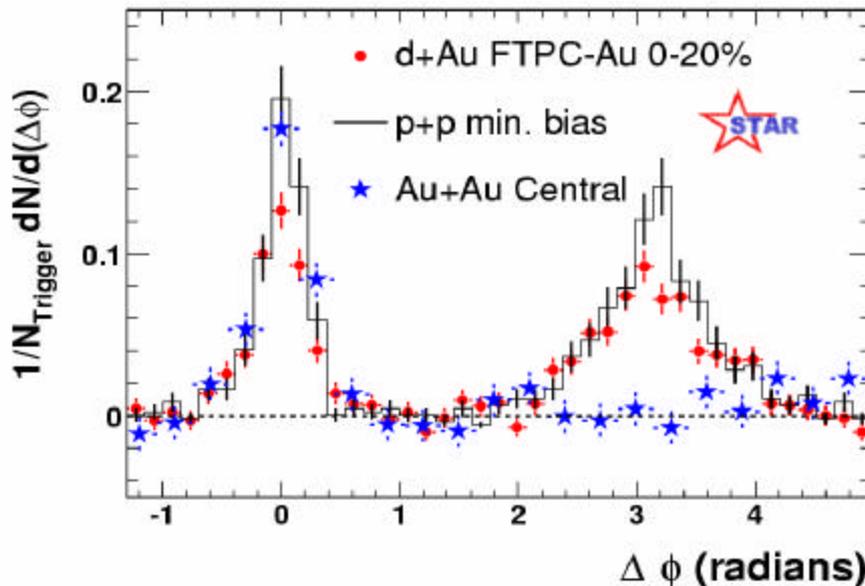
- Hard processes occur in the **early stage of the collision**
 - High momentum transfer \rightarrow perturbative QCD
 - Hard scattered partons traverse through the medium and **interact strongly**
 - Energy loss via medium induced gluon radiation
 - Jet broadening due to parton rescattering
- \rightarrow **Suppression of high p_T hadron production**

High- p_T Hadron Suppression



- Central Au-Au collisions
 - Strong high- p_T particle suppression
 - Large and saturated elliptic flow for $p_T > 2\text{GeV}/c$
 - Disappearance of the away-side jet (path length dependence)

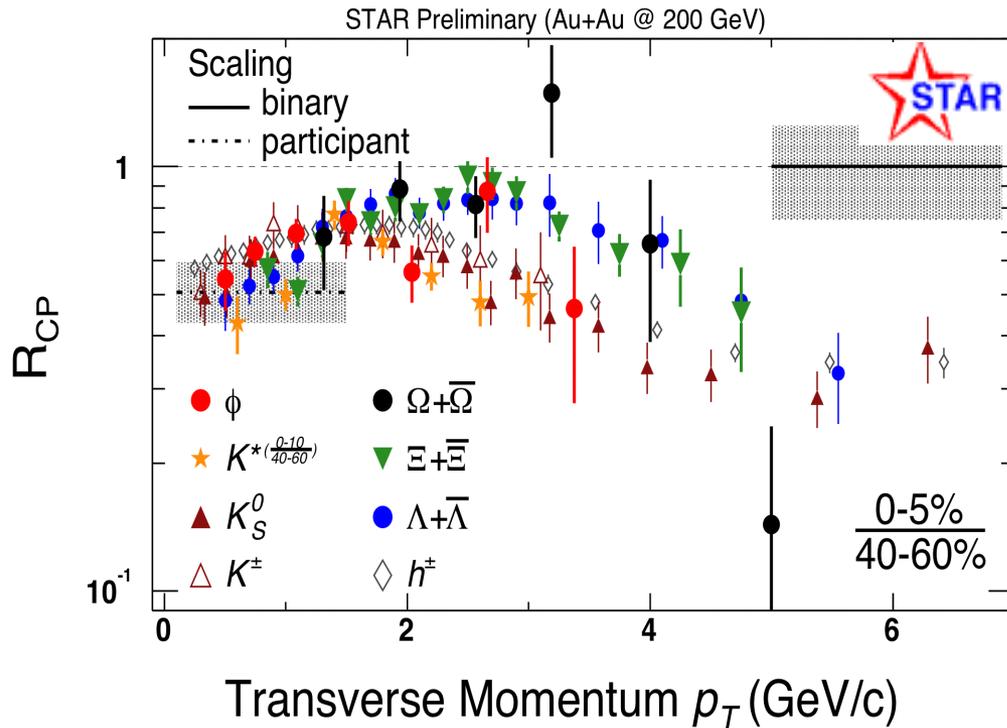
→ Medium induced energy loss



- d-Au collisions
 - Particle production in cold matter environment
 - No high- p_T particle suppression → Cronin effect instead
 - Back-to-back peak not suppressed

→ Suppression is caused by final state interactions with the dense medium

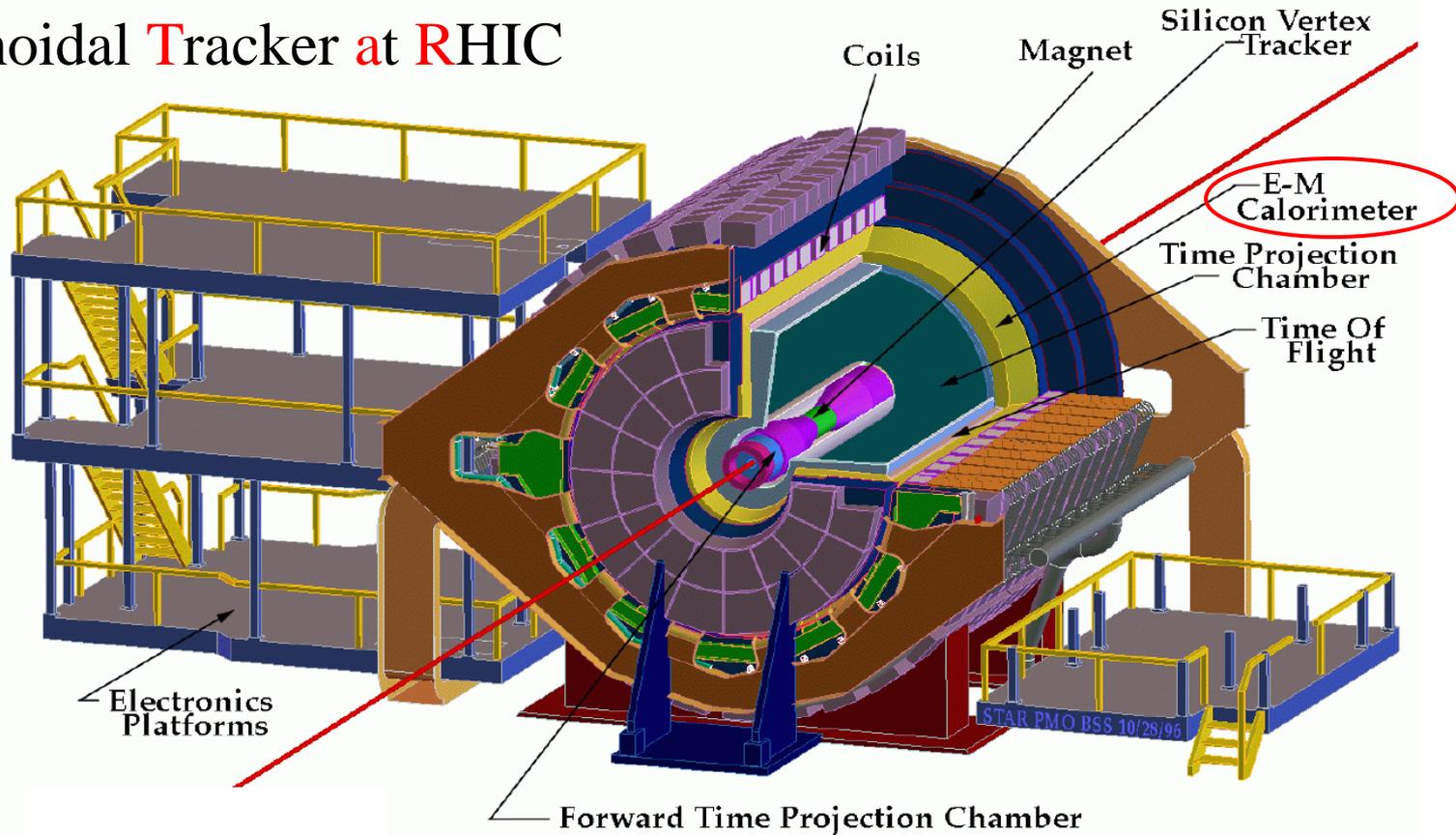
Particle Species Dependence



- Different behavior for mesons and baryons
- Dependence on number of valence quark
- Hadron production from quark coalescence ?

The STAR Detector

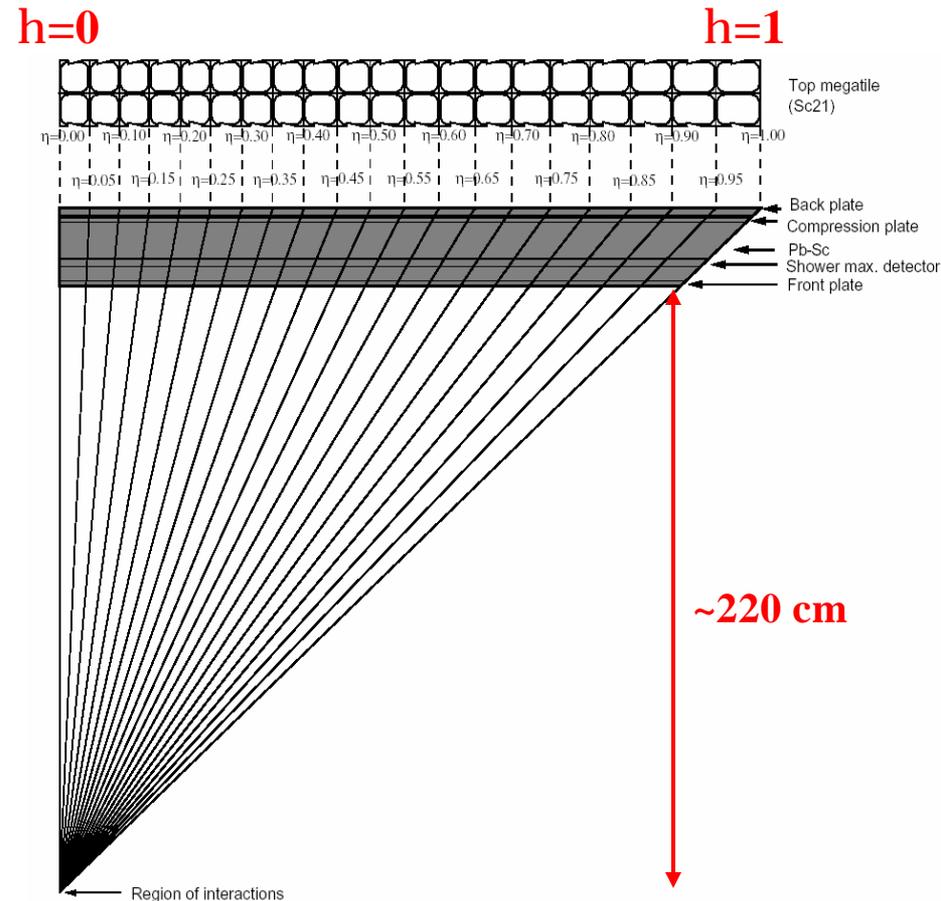
Solenoidal Tracker at RHIC



- Solenoidal field
- TPC's, ToF, SVT, PMD, EMC's
- Measurements of hadronic observables using a large acceptance
- Event-by-event analyses of hadrons
- Jets

Barrel Electro-magnetic Calorimeter

- PbSc sampling calorimeter
- 120 modules with 4800 towers
- 50% installed and operational
- $0 \leq \eta \leq 1$ and full azimuthal coverage
- Tower
 - 21 radiation length (X_0)
 - $(\Delta\eta, \Delta\phi)_{\text{tower}} \sim (0.05, 0.05)$
 - $dE/E \sim 16\%/\sqrt{E}$



BEMC (cont'd)

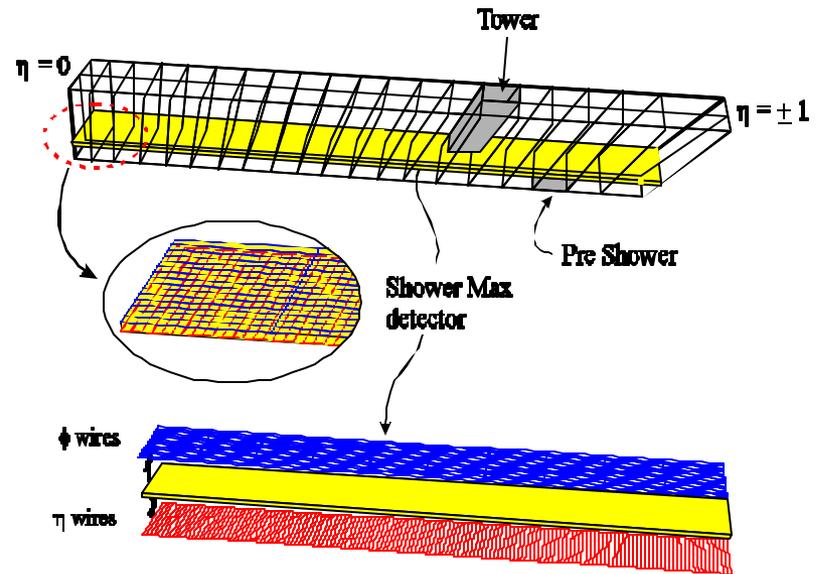
- Shower maximum detector (SMD)

- located after $5 X_0$
- wire proportional counter with strip read-out
- 150x150 strips per module
- large spatial resolution
- $(\Delta\eta, \Delta\phi)_{\text{SMD}} \sim (0.007, 0.007)$

- Pre-shower detector (PSD)

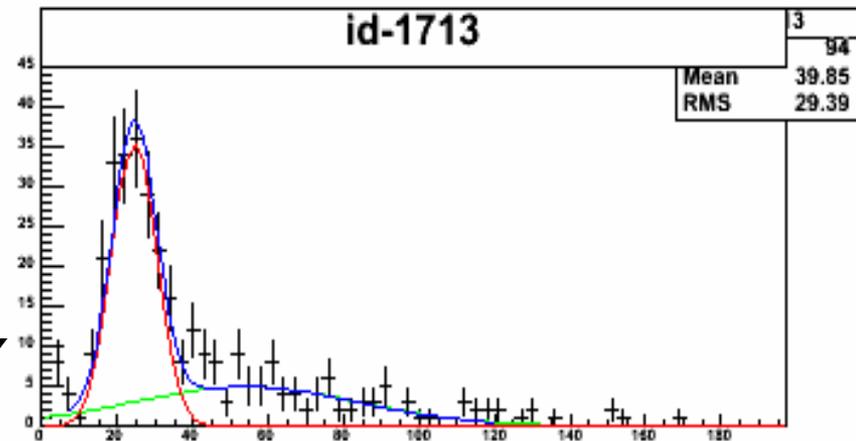
- $2 X_0$

- 45,600 channels in total

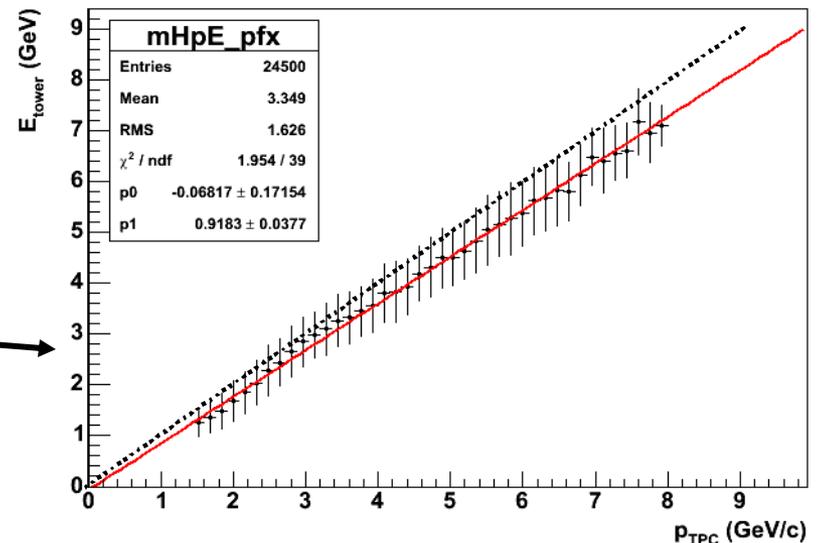


EMC Calibration

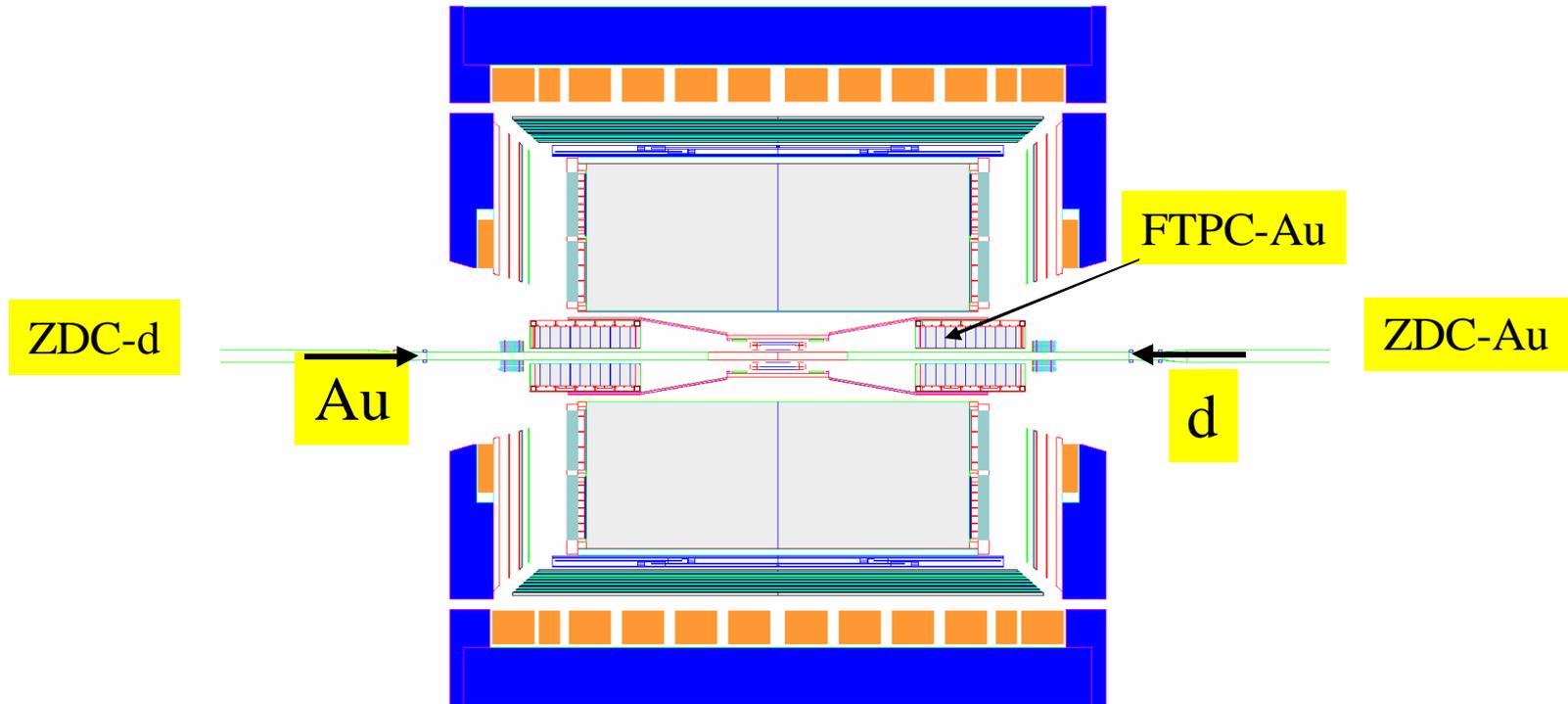
- Absolute energy calibration
 - π^- beam with 0.3-8 GeV/c
 - Average tower gain
~16 MeV/ADC counts
- Relative gain
 - Single tower MIP calibration
 - ◆ Project high-p tracks into EMC
 - ◆ $p > 1.2$ GeV/c
 - ◆ 3x3 towers isolation
 - Electron calibration
 - π^0 peak position
 - ADC slopes



p x E distribution



d-Au Event Selection



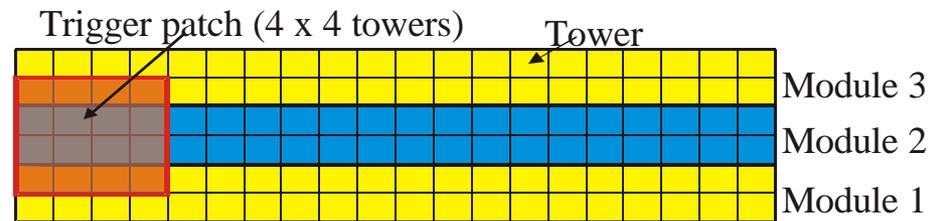
Minimum bias trigger: ZDC-Au ($95 \pm 3\%$ of σ_{hadronic})

Centrality tags:

1. FTPC-Au: charged particle multiplicity in $-3.8 < \eta < -2.8$
2. ZDC-d: neutron spectator from deuteron

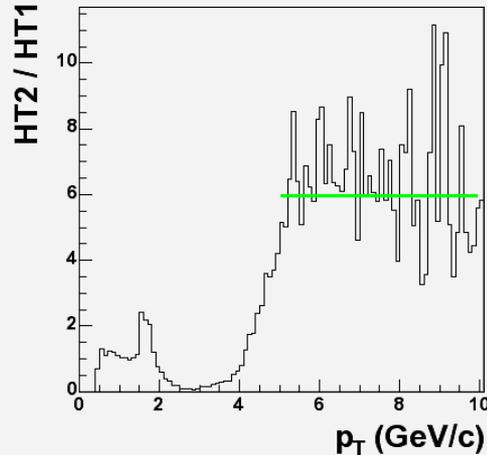
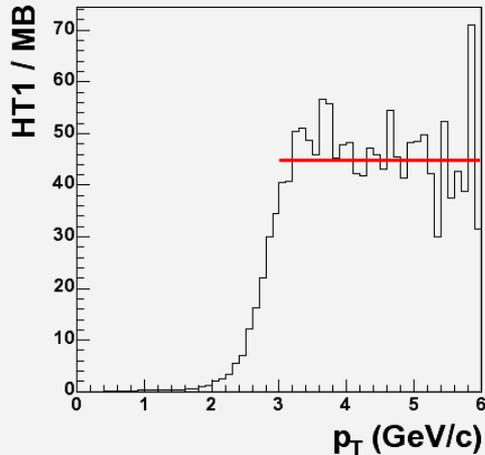
High- p_T Trigger

- Photons, electrons and π^0
- Trigger patches
 - 4 x 4 towers
 - $(\Delta\eta, \Delta\phi) \sim (0.2, 0.2)$
 - Highest tower in patch (HT)
 - ◆ 0.5 GeV energy resolution

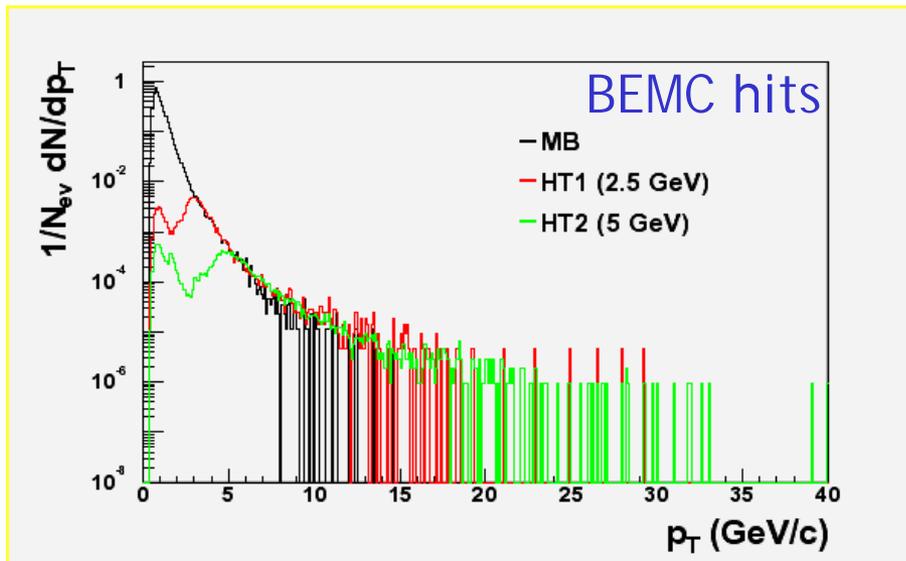


- Trigger classes
 - Minimum bias
 - High tower 1 (threshold > 2.5 GeV)
 - High tower 2 (threshold > 5.0 GeV)

Pre-scale Factors



- BEMC hits with the highest e_T
- Enhancement of about 50 at 4 GeV (HT1/MB) and 6 at 6 GeV (HT2/HT1)
- Pre-scale factors agree with the ones from the DB



π^0 Analysis

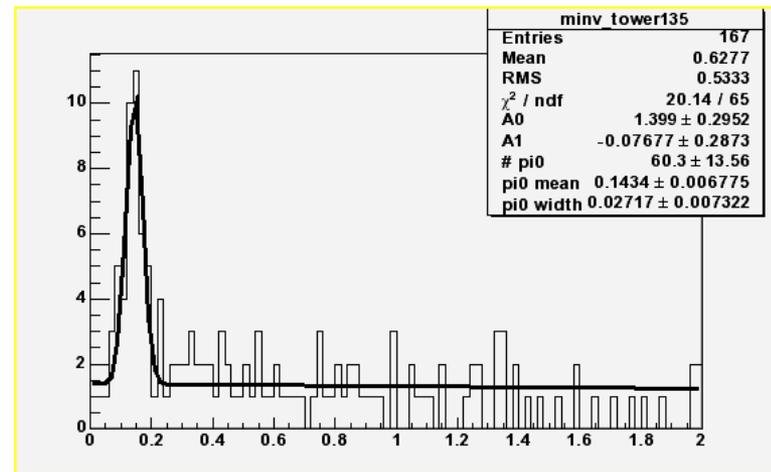
- Event statistic: 17.4 M events
- Event cuts
 - Number of Bemc hits
 - Main z-vertex
- Photon and π^0 cuts
 - Charged particle veto
 - Asymmetry of photon pairs: $a = \left| \frac{E1-E2}{E1+E2} \right| < 0.5$

π^0 Reconstruction

- π^0 reconstruction
 - $\pi^0 \rightarrow \gamma\gamma$ (branching ratio: 98.8%)
 - $m_{\text{inv}} = \sqrt{2E_1E_2(1-\cos\theta)}$
- Combinatorial background described by
 - Event-mixing method
 - with 10 events from the “pool”
 - using event classes (vertex, BEMC hits and trigger)
 - normalization region: 1-2GeV/c²
 - Polynomial fit (2nd order) to the background

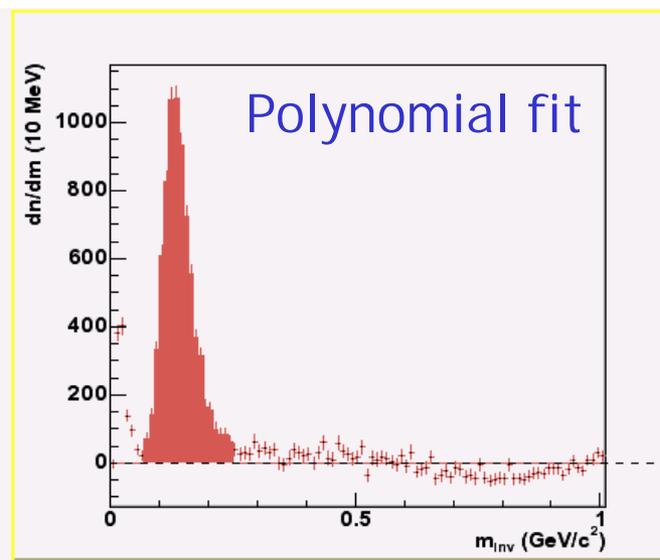
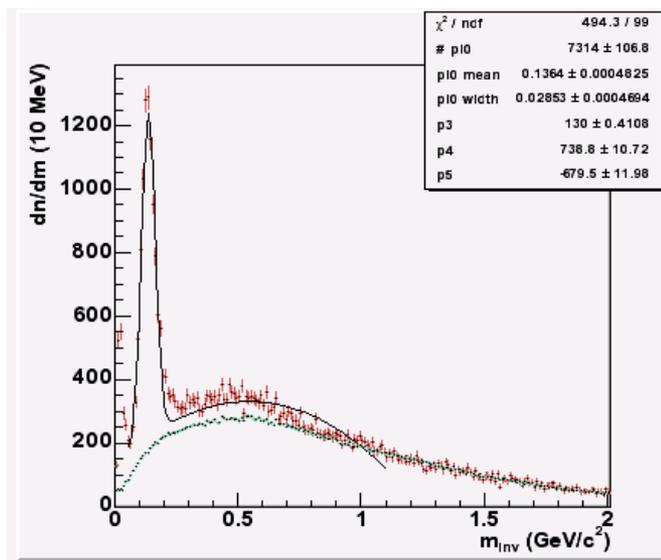
π^0 Analysis: Tower Sub-sample

- Bad towers/SMD's were not labeled up to now (status tables); work in progress
- QA: Single tower invariant mass spectra

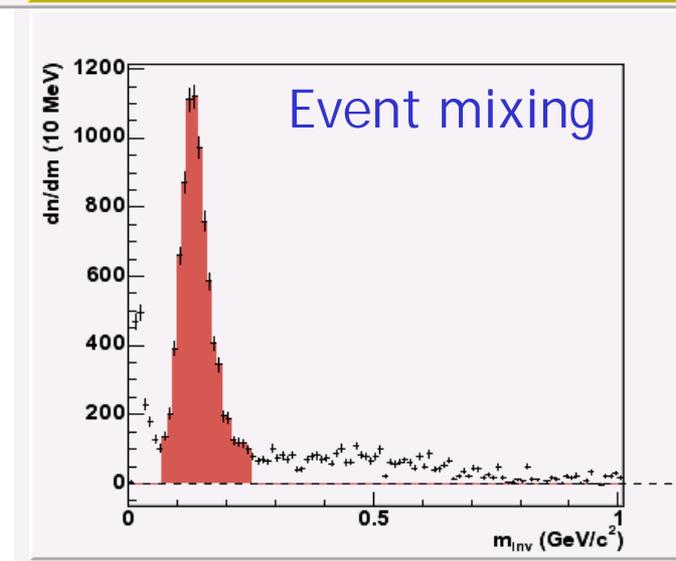


- Use π^0 peak position for additional tower gain correction (mean correction 7%)
- Sub-sample of good towers
- pi0 analysis

π^0 Invariant Mass Distribution

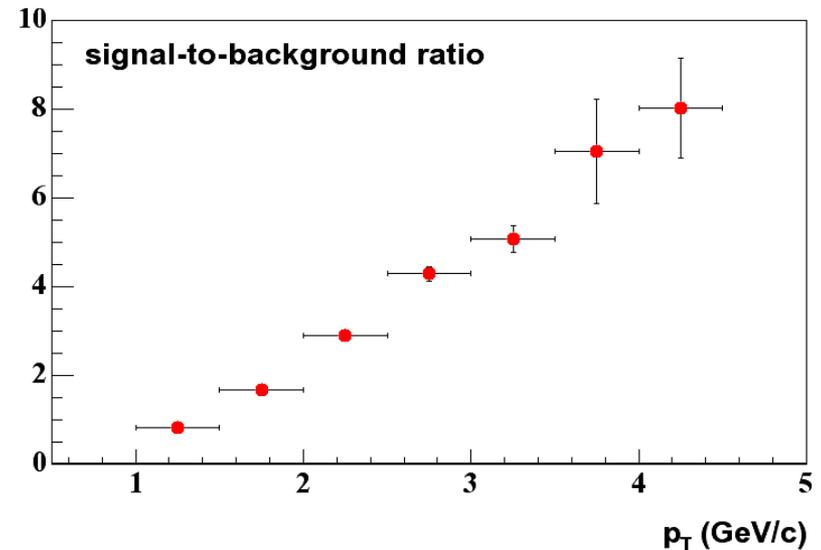
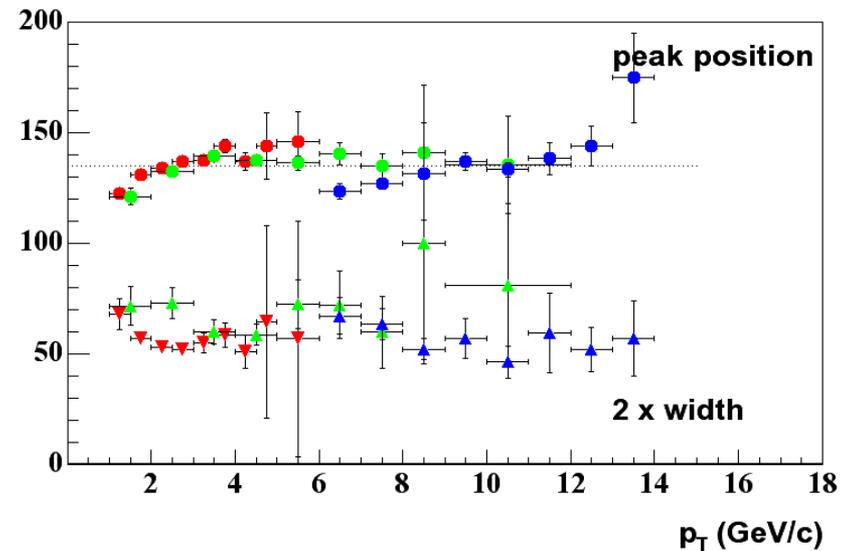


- MinBias, p_T integrated
- Mass = 135 ± 1 MeV
- Width = 28 ± 0.6 MeV
- S/B ratio ~ 2.5
- 9k raw π^0

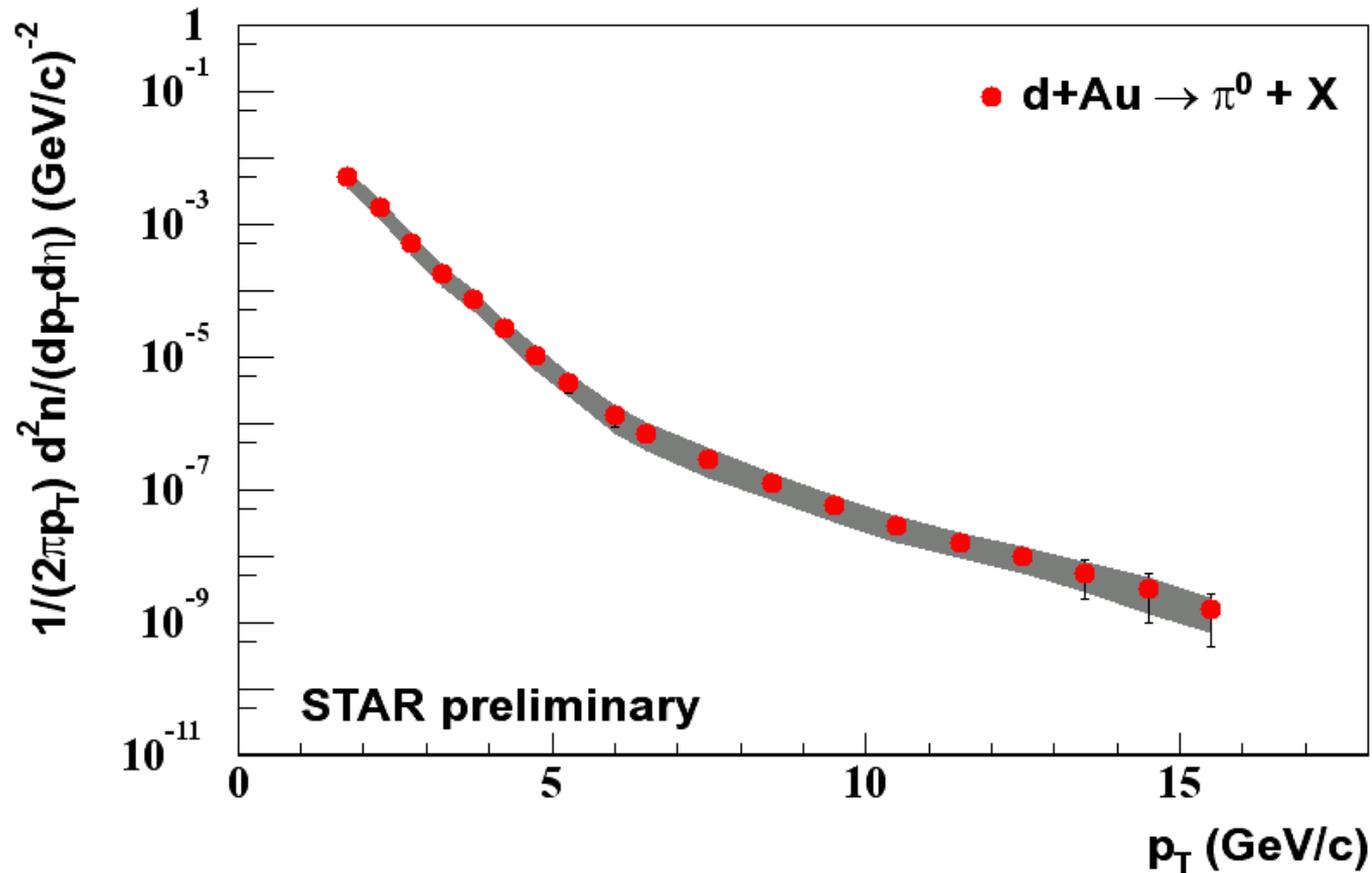


Signal Extraction and Corrections

- 0.5(1) GeV bins for MB(HT1,2)
- Signal extracted by integration of the background subtracted distribution in [0.06-0.25 GeV]
- Corrections
 - Detector efficiency
 - Acceptance
 - MC simulation
 - Particle density effects not yet included
 - Losses due to decays (K_s^0 , η) not yet included



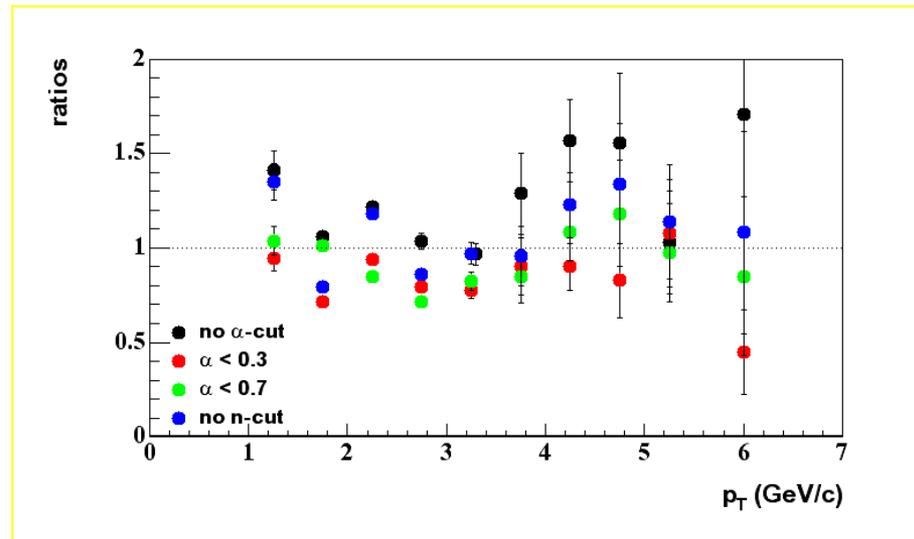
Neutral Pion p_T -Spectra



π^0 p_T measurement up to 13-16 GeV/c

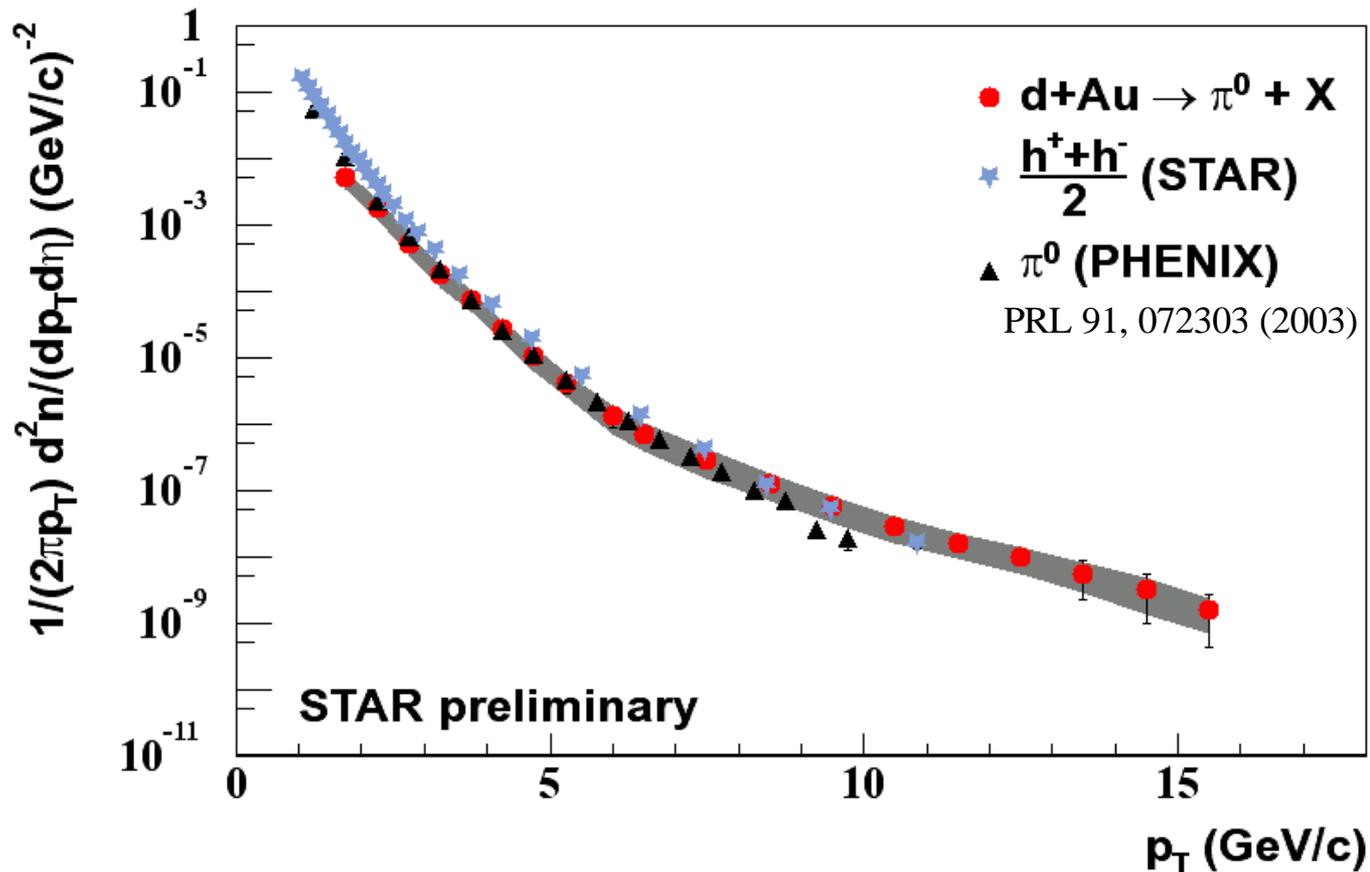
Systematic Errors

- Yield extraction: 20-30%
- Pre-scale factor: 6% (HT1), 10% (HT2)
- Quality cuts (acceptance+efficiency included): 20-30%



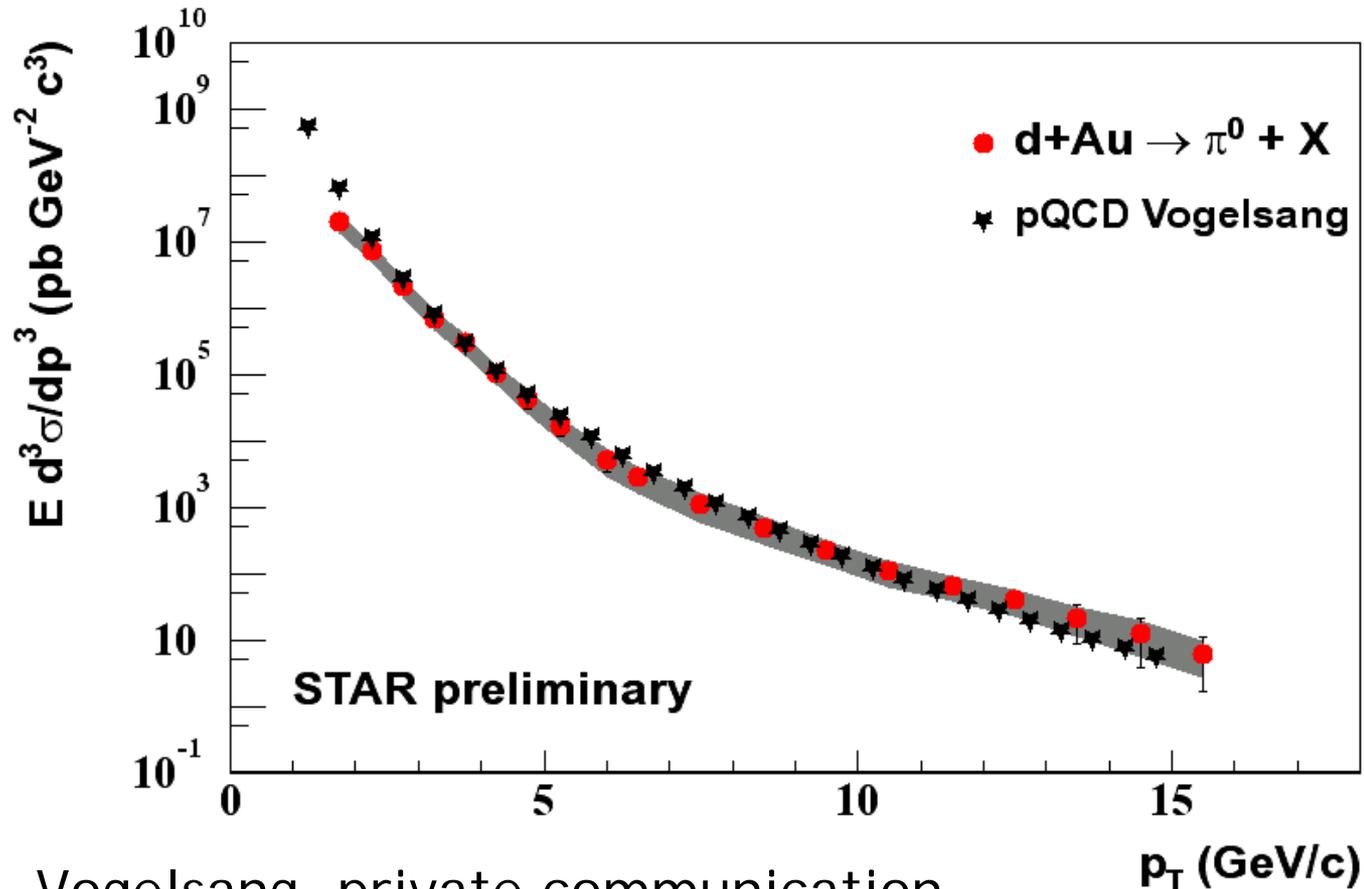
- Energy calibration uncertainty: low- p_T : 5-10%
high- p_T : 30%

Comparison with former Measurements



Agreement with PHENIX within 10%

Comparison with pQCD Calculations



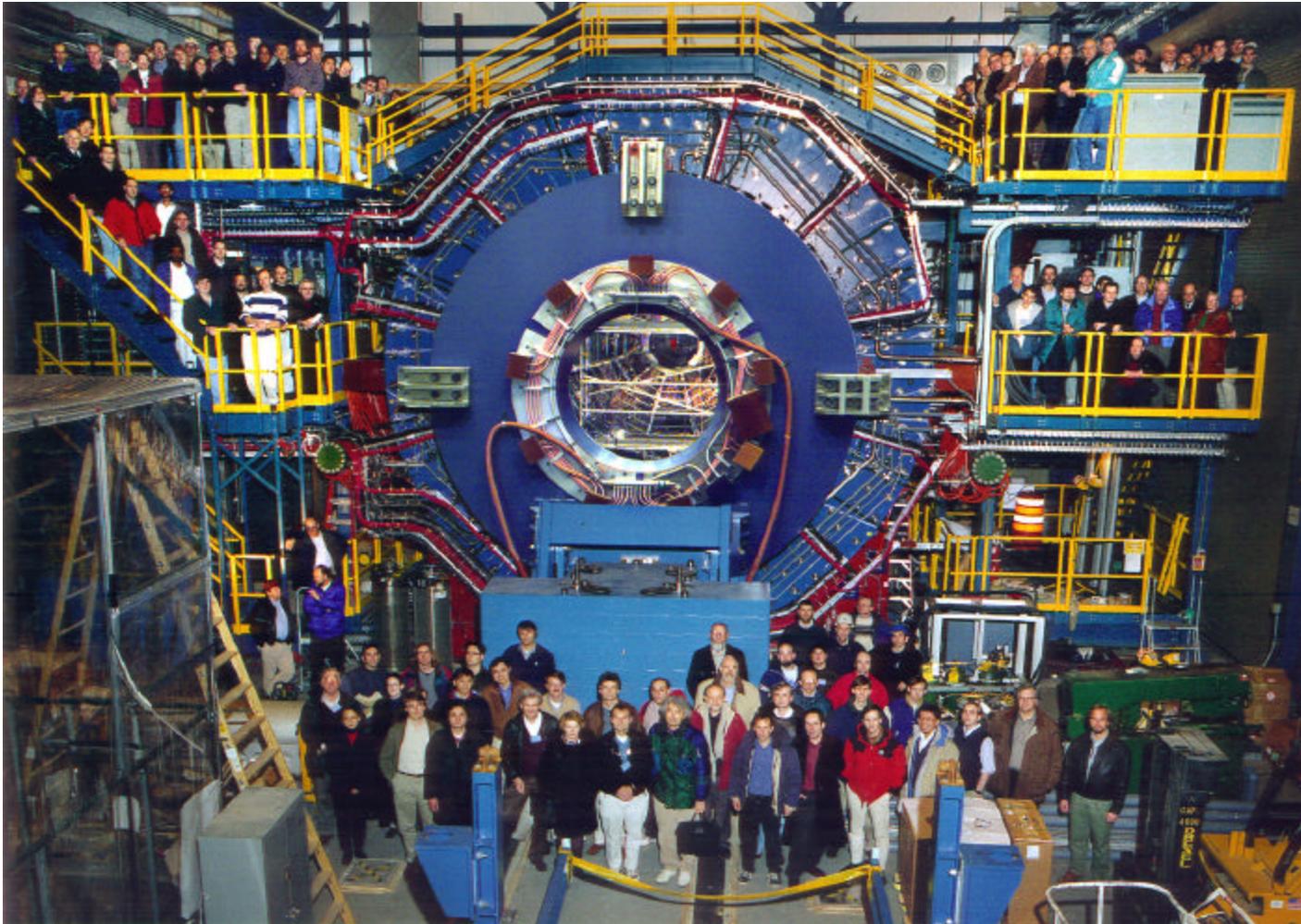
W. Vogelsang, private communication
Nuclear effects included, PDFs from Frankfurt et al.
(CTEQ6M), fragmentation function from Kniehl et al.

Summary and Outlook

- Preliminary neutral pion p_T -spectra from d-Au collisions at $\sqrt{s}=200$ GeV
- Good agreement with former PHENIX π^0 and STAR charged hadron measurement
- Reasonable agreement with pQCD calculations
- Coming soon
 - π^0 spectra in Au-Au
 - Heavy mesons: $\rho^\pm(770)$ and $\omega(782)$
 - Direct photons

The STAR collaboration

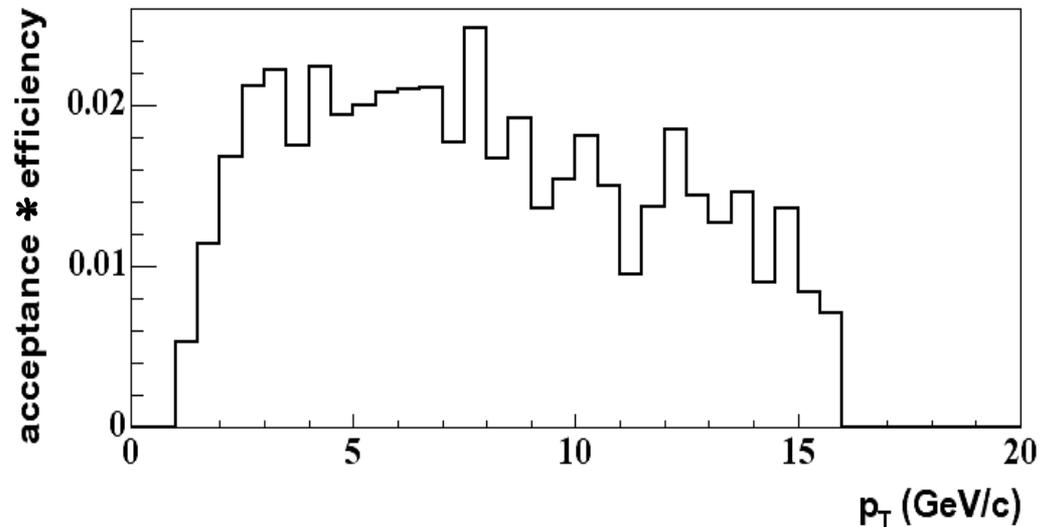
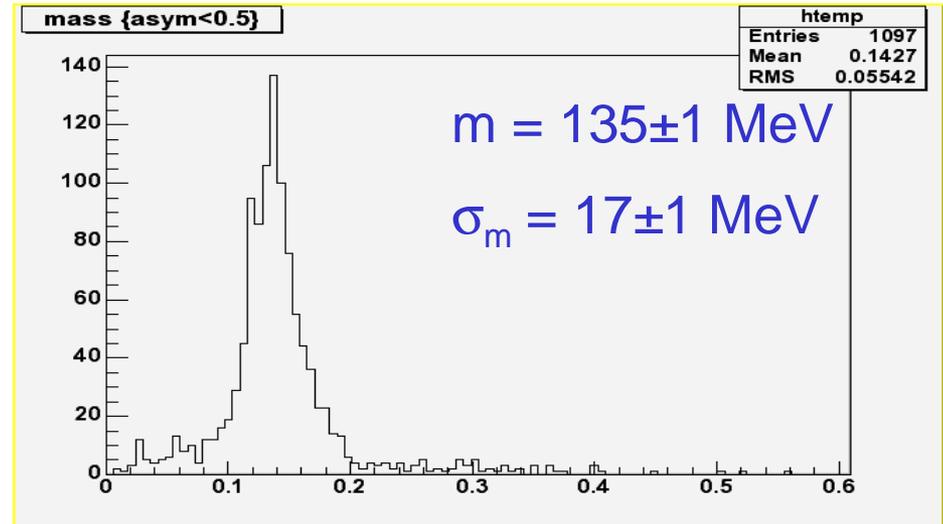
49 institutes from 12 nations
~ 500 participants



The end

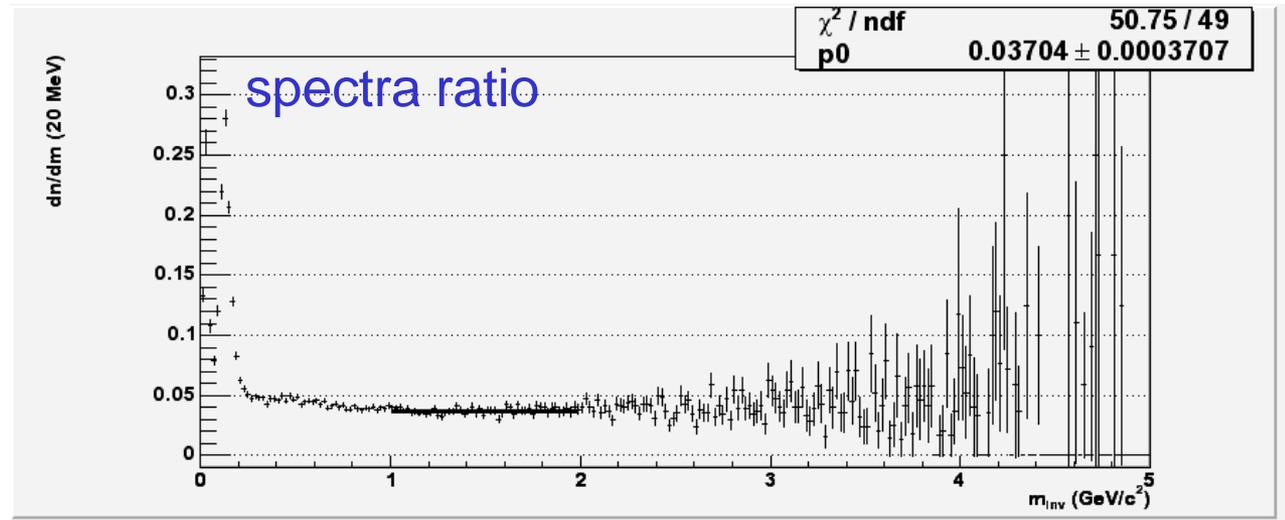
Acceptance + EMC efficiency

- 60k events
- Kinematics
 - $1 \pi^0$ per event
 - $0 \leq p_T \leq 15 \text{ GeV}/c$
 - $-0.3 < \eta < 1.3$
 - $|\phi| \leq \pi$
- Keys
 - Y2003a geometry
 - All GEANT physics on
 - Field on
- Quality cuts included



Normalization of the Combinatorial Background

- Checked with integral normalization



- Well described up to 5 GeV/c

