Neutral Pion Spectra in Au+Au Collisions at $\sqrt{s_{NN}} = 130$ GeV

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for the PHENIX Collaboration

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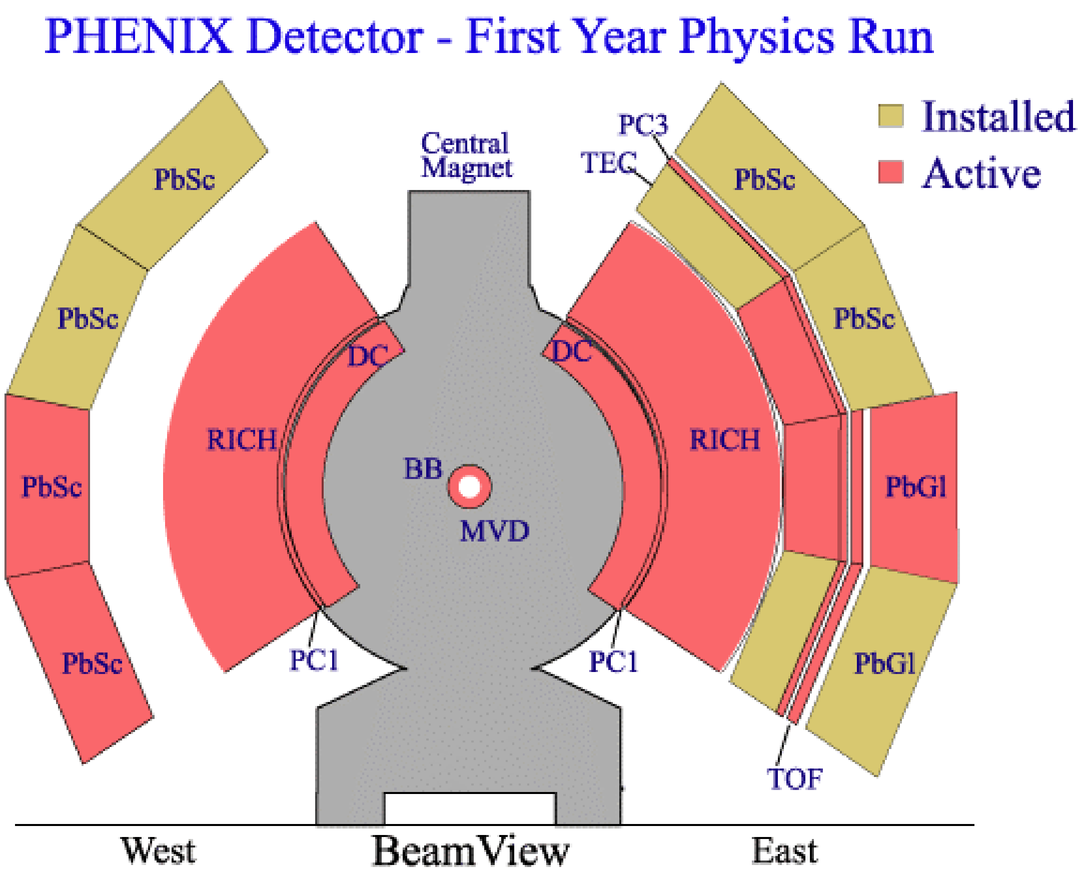
Motivation

- QGP formation expected in Au+Au collisions at $\sqrt{s_{NN}} = 130$ GeV
- In p+p: hard scattering main source of high p_T hadrons (jets)
- In A+A: hard partons experience strongly interacting medium (QGP)
- Energy loss expected (jet quenching)
- Observable consequence: suppression of high p_T hadrons (π^0)

PHENIX Year 2000 Setup



Electromagnetic calorimeter:

PbGl: lead glass

PbSc: lead scintillator

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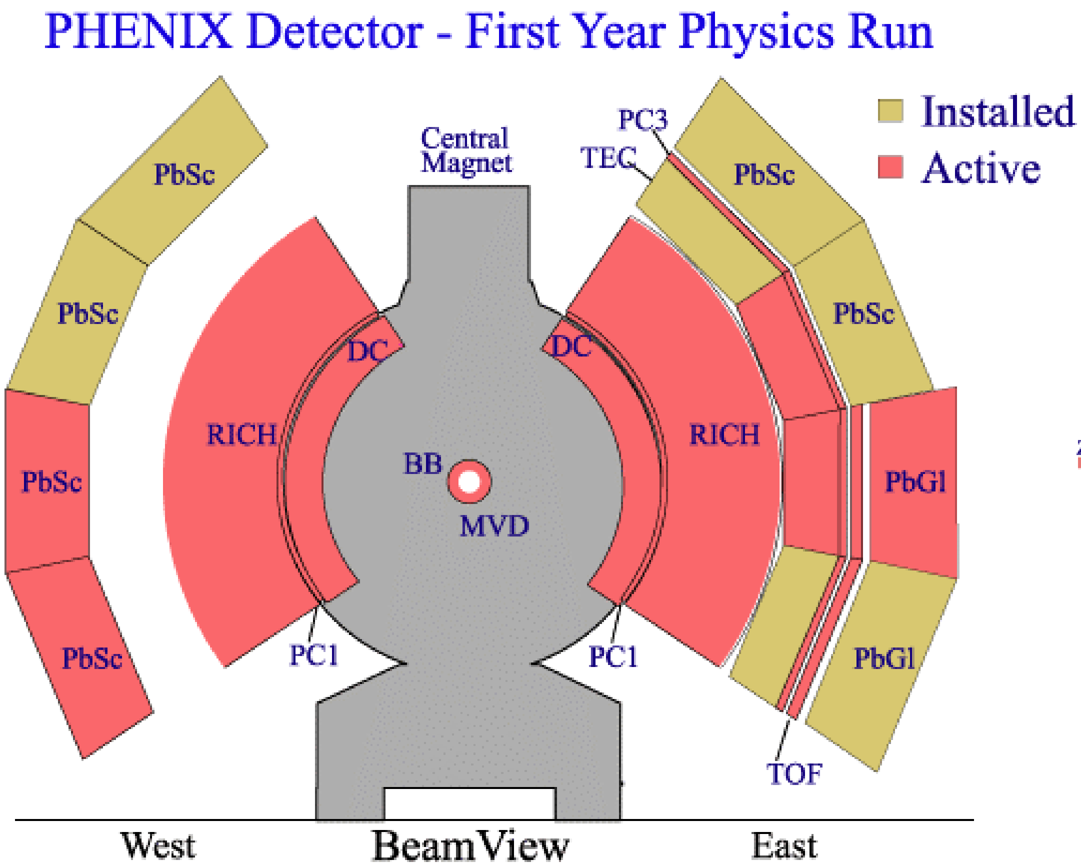
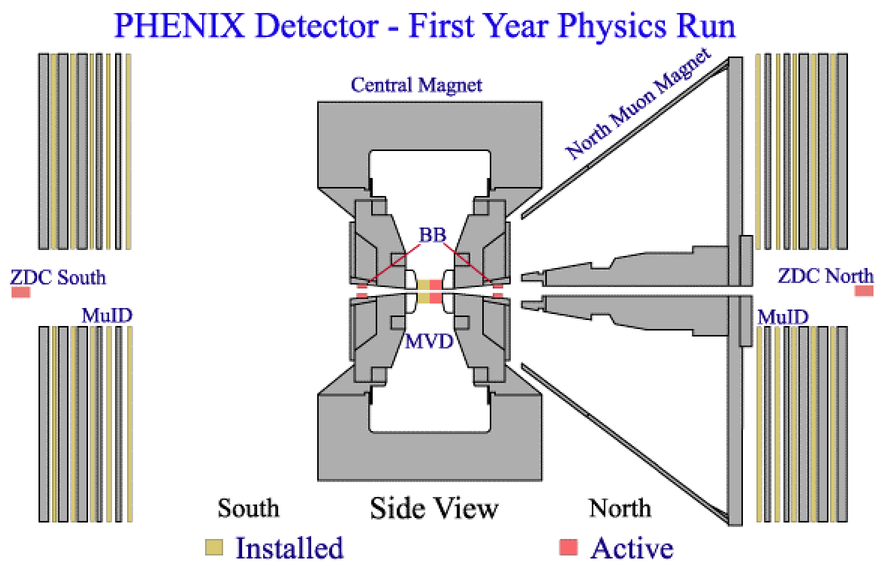




Electromagnetic calorimeter:

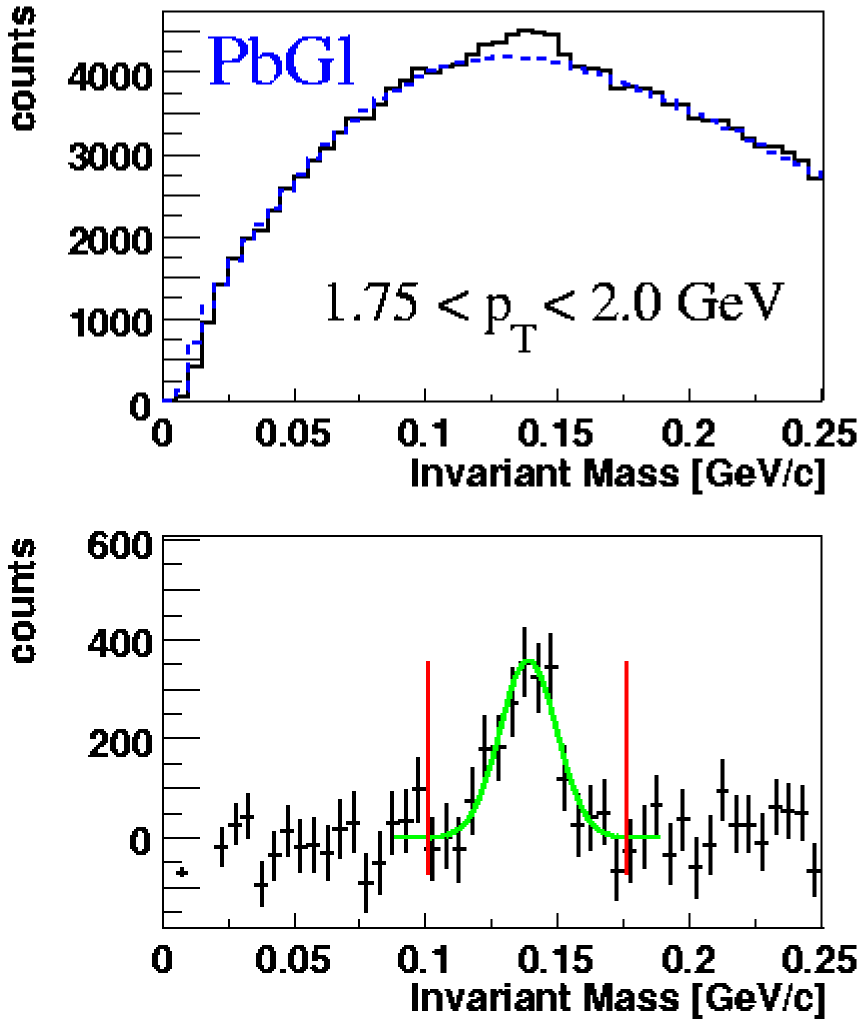
PbGl: lead glass

PbSc: lead scintillator

π^0 Reconstruction

- Measure π^0 via 2-γ-decay
- Lead glass: photon detector
- Hadrons suppressed by response
  - energy cut
  - cut on shower width
- Reconstruct π^0 via M_{inv}
  - $M_{inv} = \sqrt{2E_1E_2(1-\cos(\psi))}$
- Combinatorial background:
  - mixed events

Yield Extraction



- M_{inv} distribution for each p_T bin
- Match mixed events distribution outside peak area
- Subtract mixed events
- Integrate peak region

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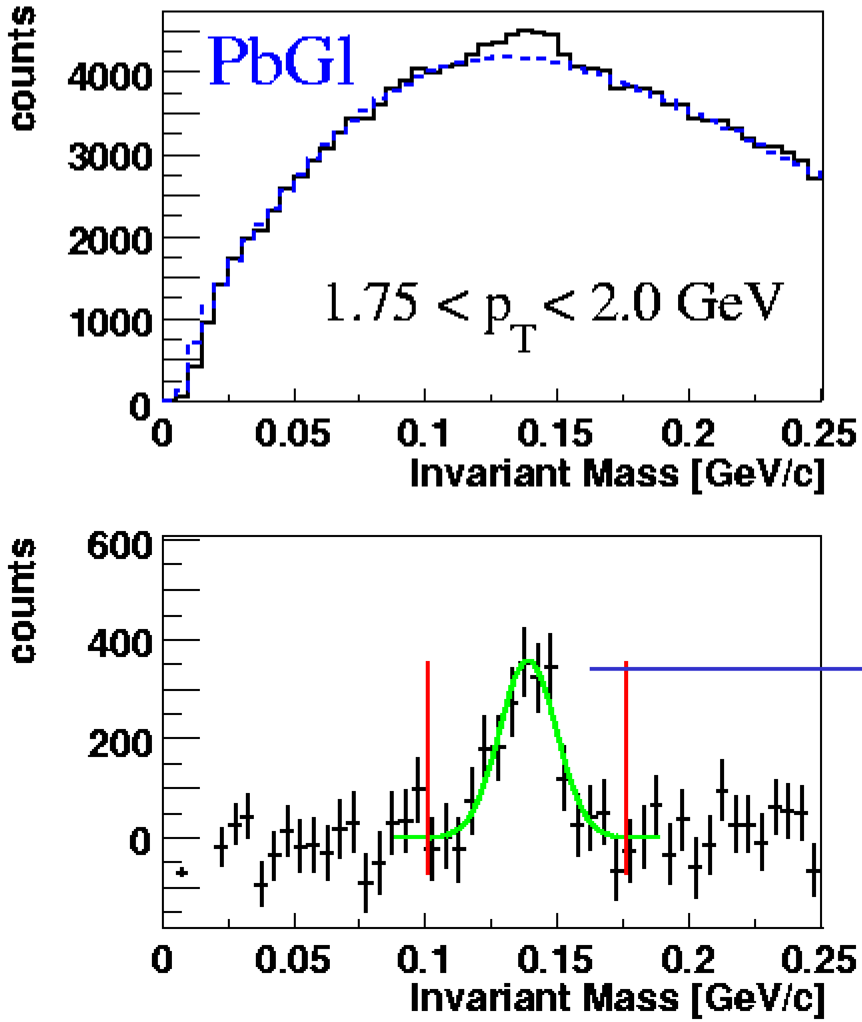
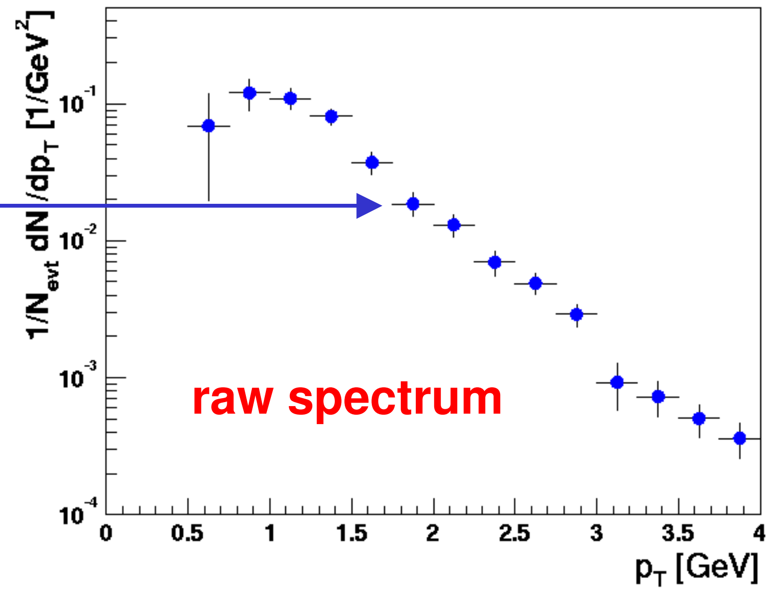
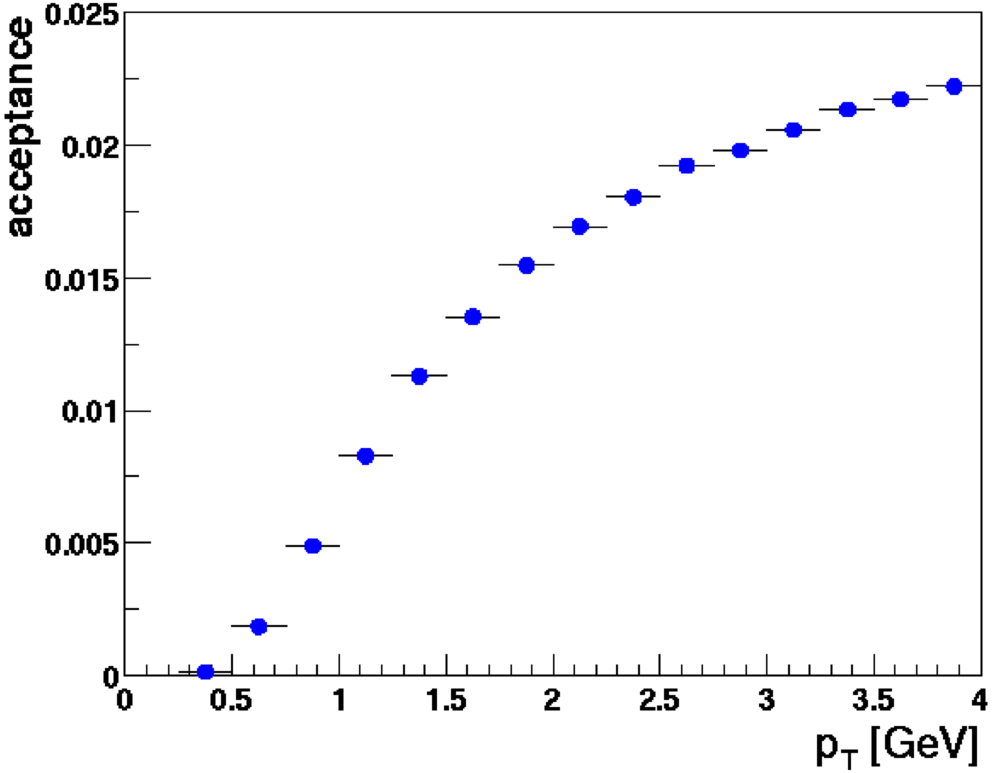




Geometrical Acceptance

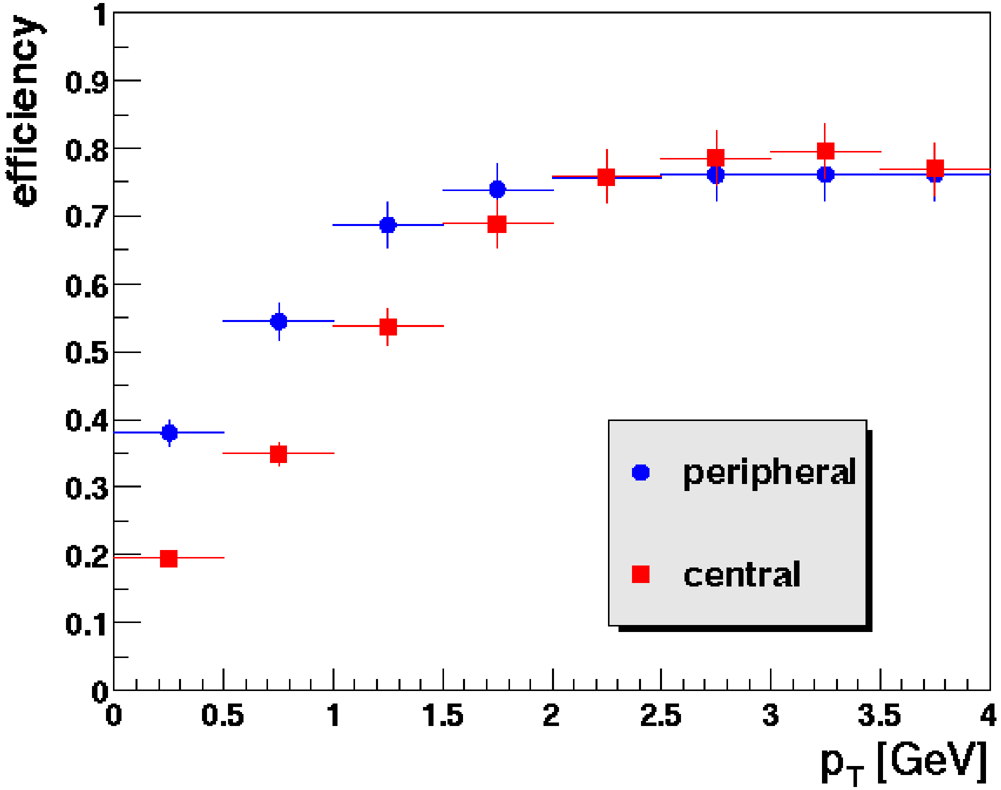


- Geometrical acceptance:
  - π^0 with both decay γ on active PbGl surface
    divided by
    all π^0 in: $- 0.45 < y < 0.45$
- Determined by Monte Carlo simulation

π^0 Efficiency

- **Efficiency definition:**

$$\varepsilon_{PbGl}(p_T) = \frac{dN_{\pi^0}/dp_T\big|_{reconstructed}}{dN_{\pi^0}/dp_T\big|_{original}}$$



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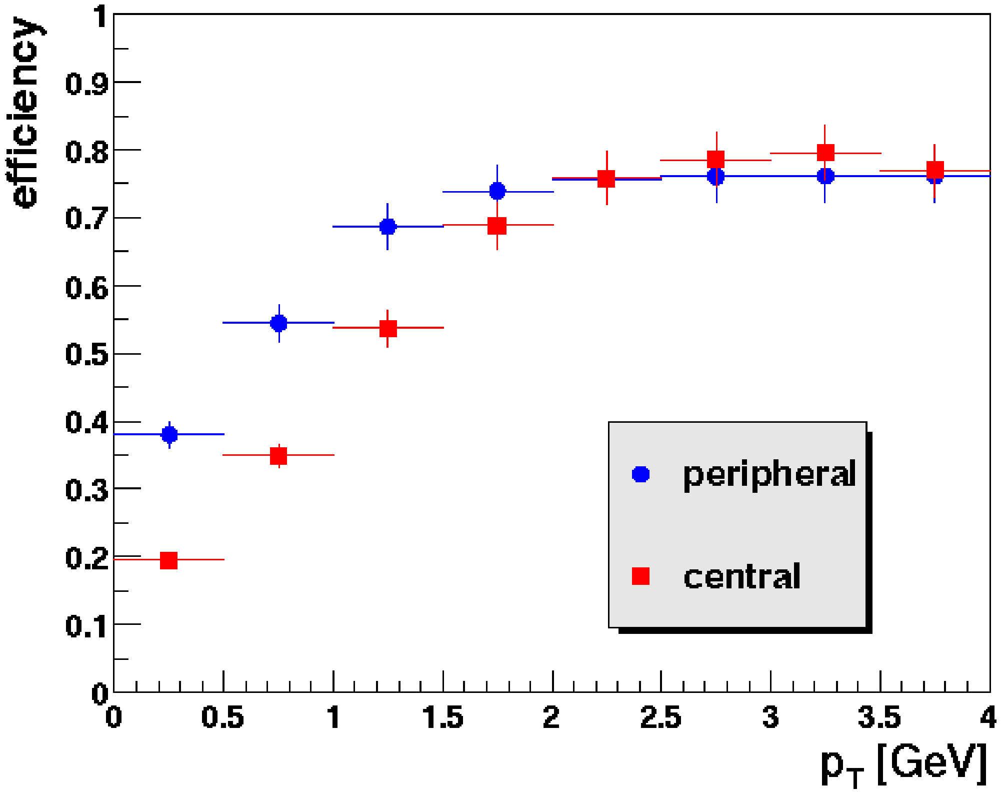
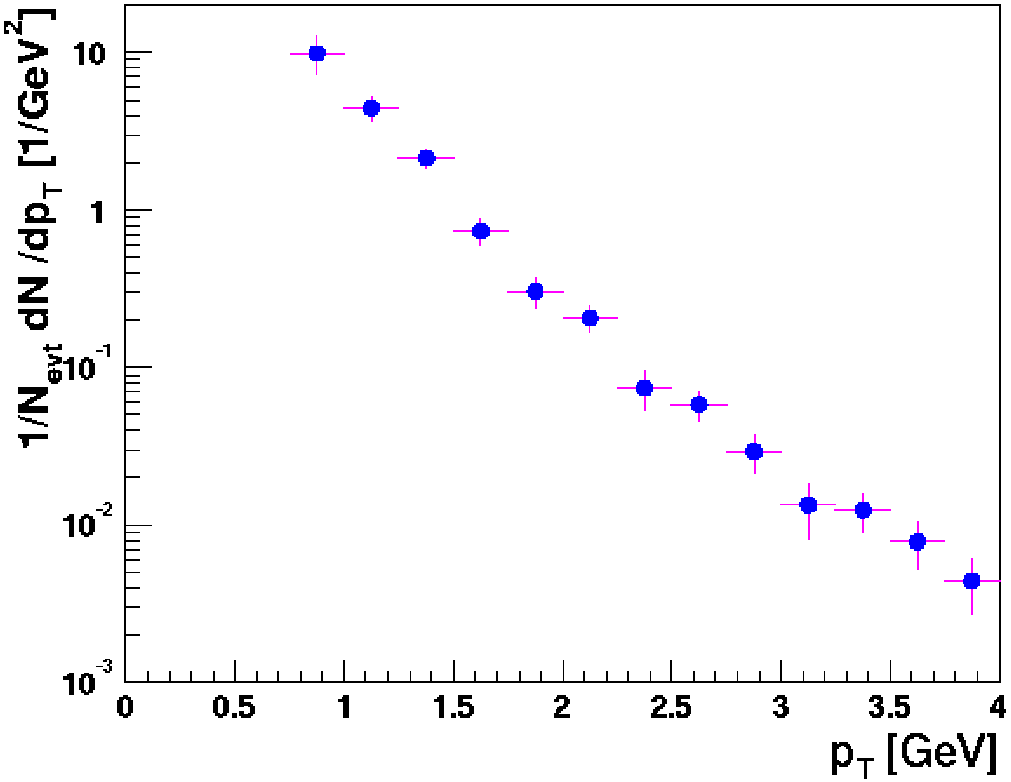


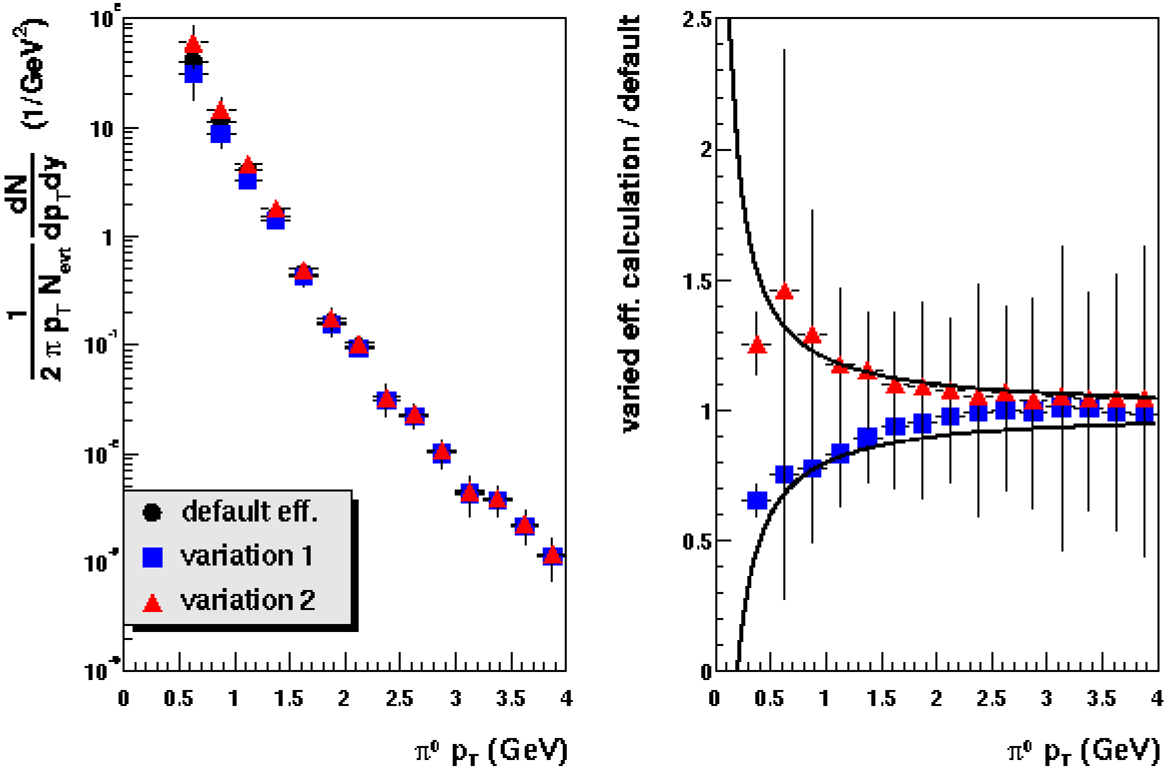
- Calculation by Monte Carlo simulation
  - intrinsic energy and position resolution
  - shower overlap
  - loss by PID cuts and integration window
- Simulation matches:
  - measured π^0 peak position and width
  - measured losses by PID cuts
- Improvement of input π^0 dN/dp_T by iteration

Corrected Spectrum



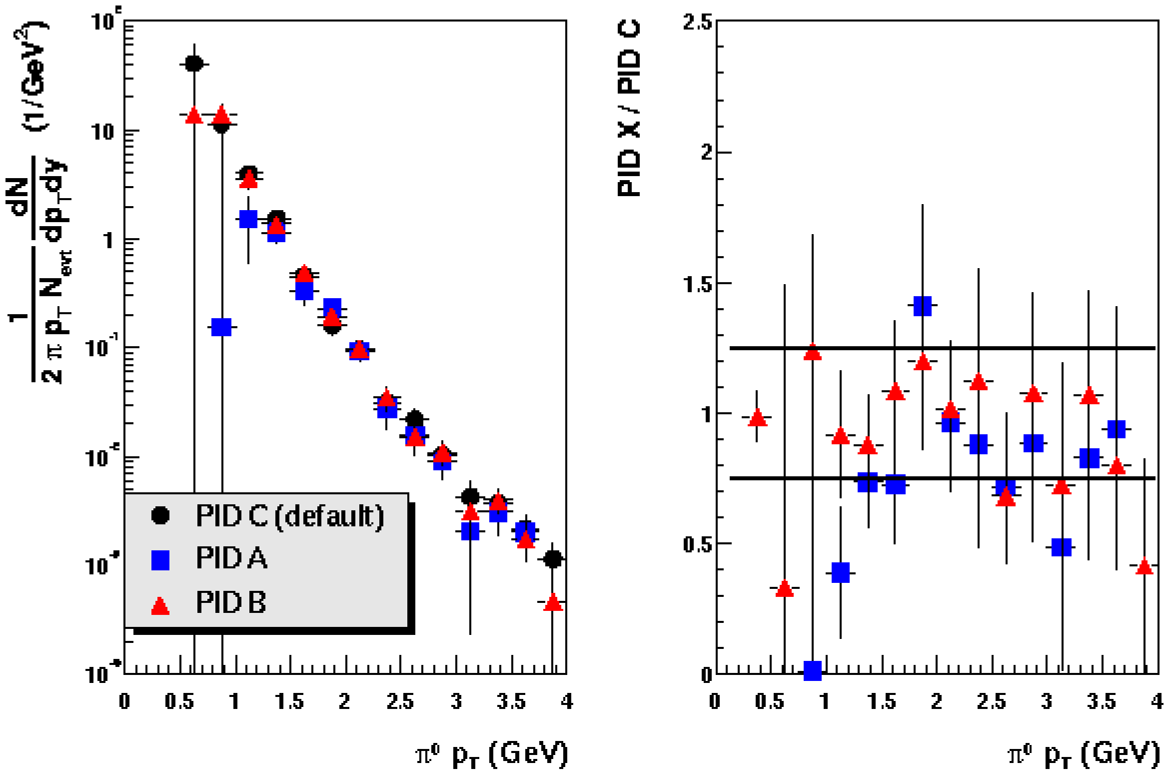
- Fully corrected spectrum
- Statistical errors only

Systematic Errors



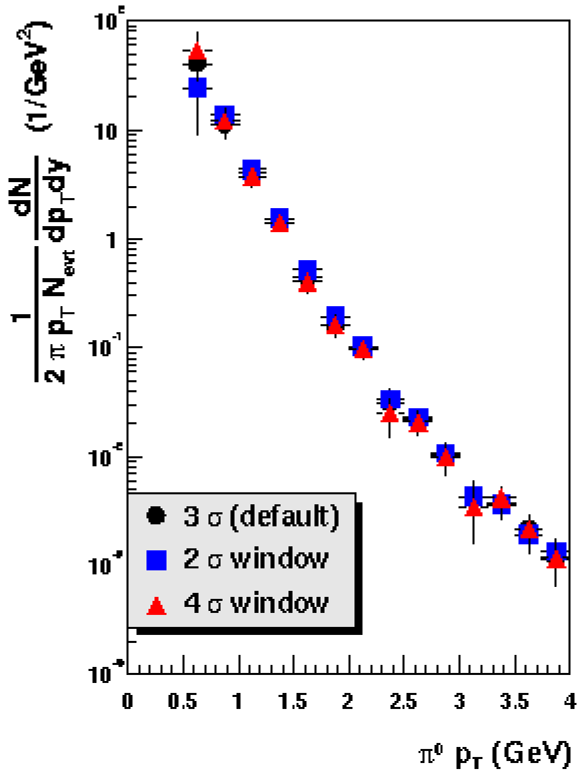
- Efficiency simulation: variation of overlap probabilities

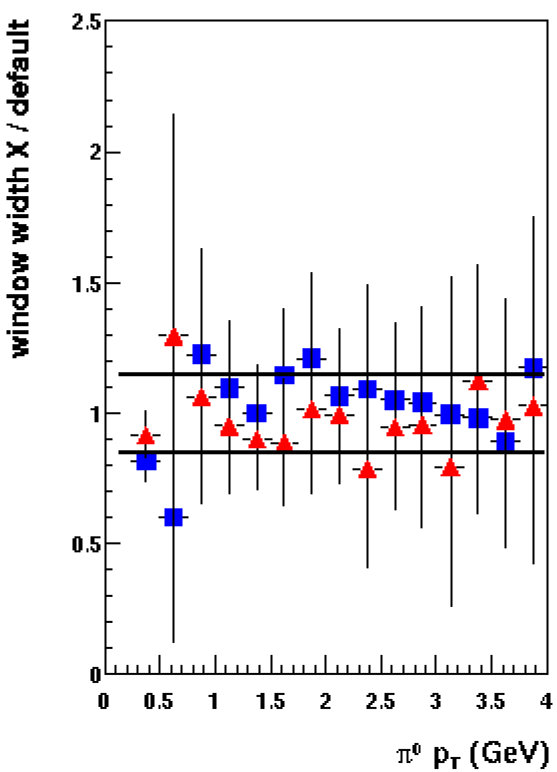
Systematic Errors



- Compare different PIDs
  - no cut (PID A)
  - energy cut (PID B)
  - energy and shower width cut (PID C)

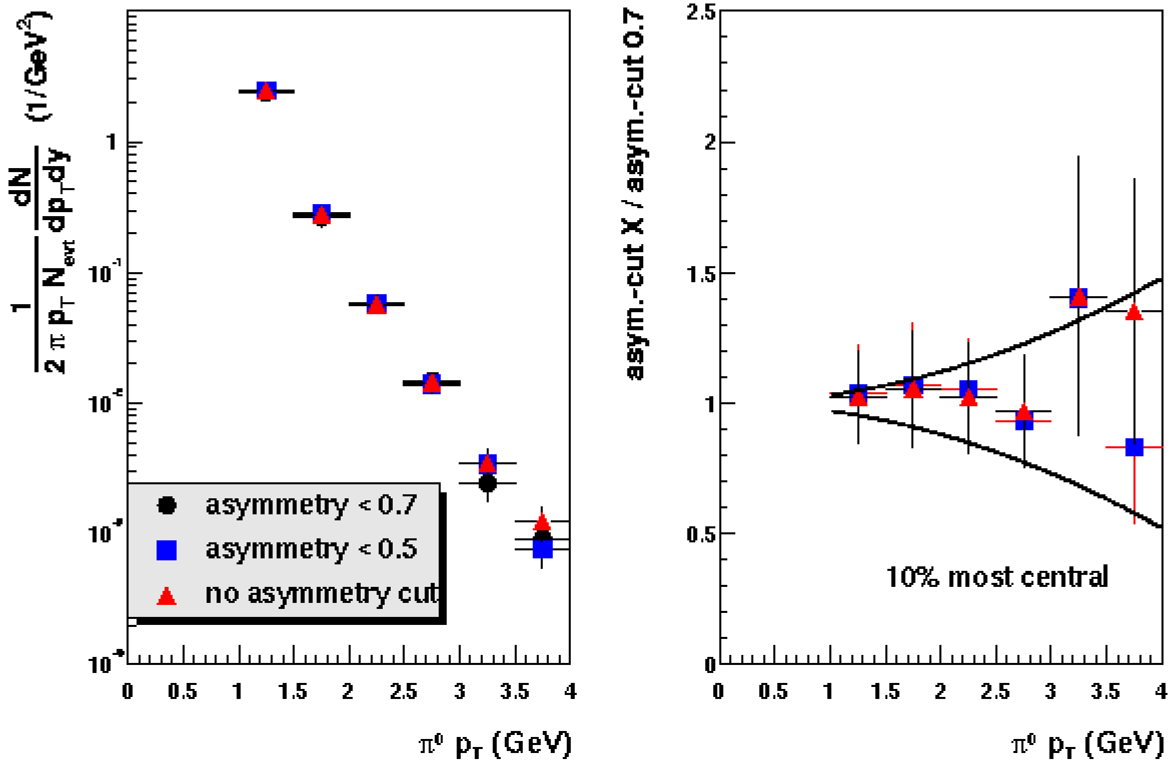
Systematic Errors





- Variation of **window size** for peak integration

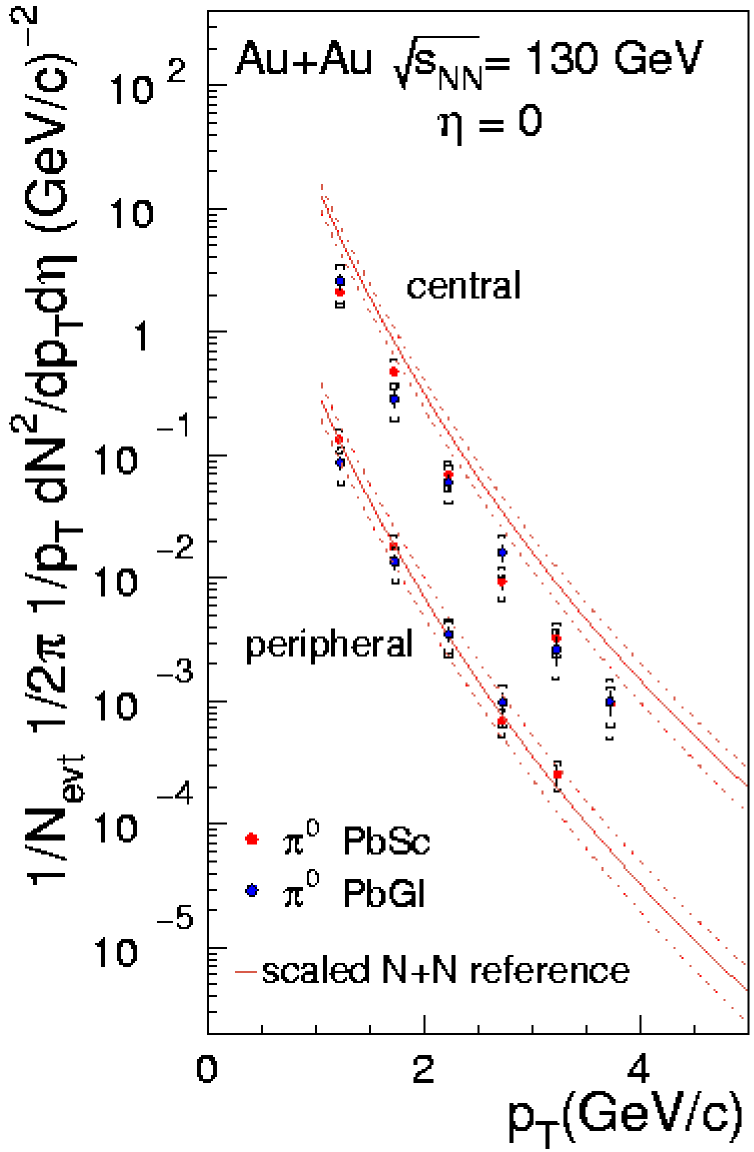
Systematic Errors



- Variation of **asymmetry cut**

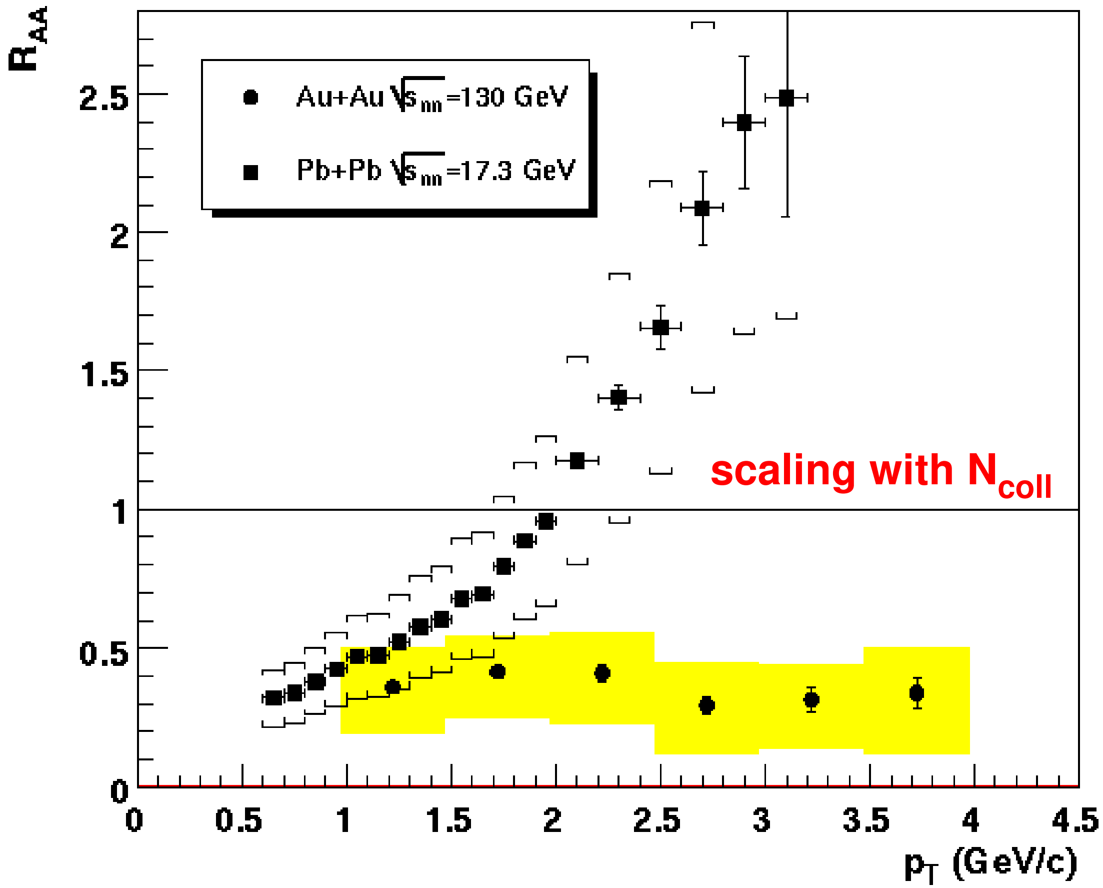
$$\alpha = \left| \frac{E_1 - E_2}{E_1 + E_2} \right|$$

Results



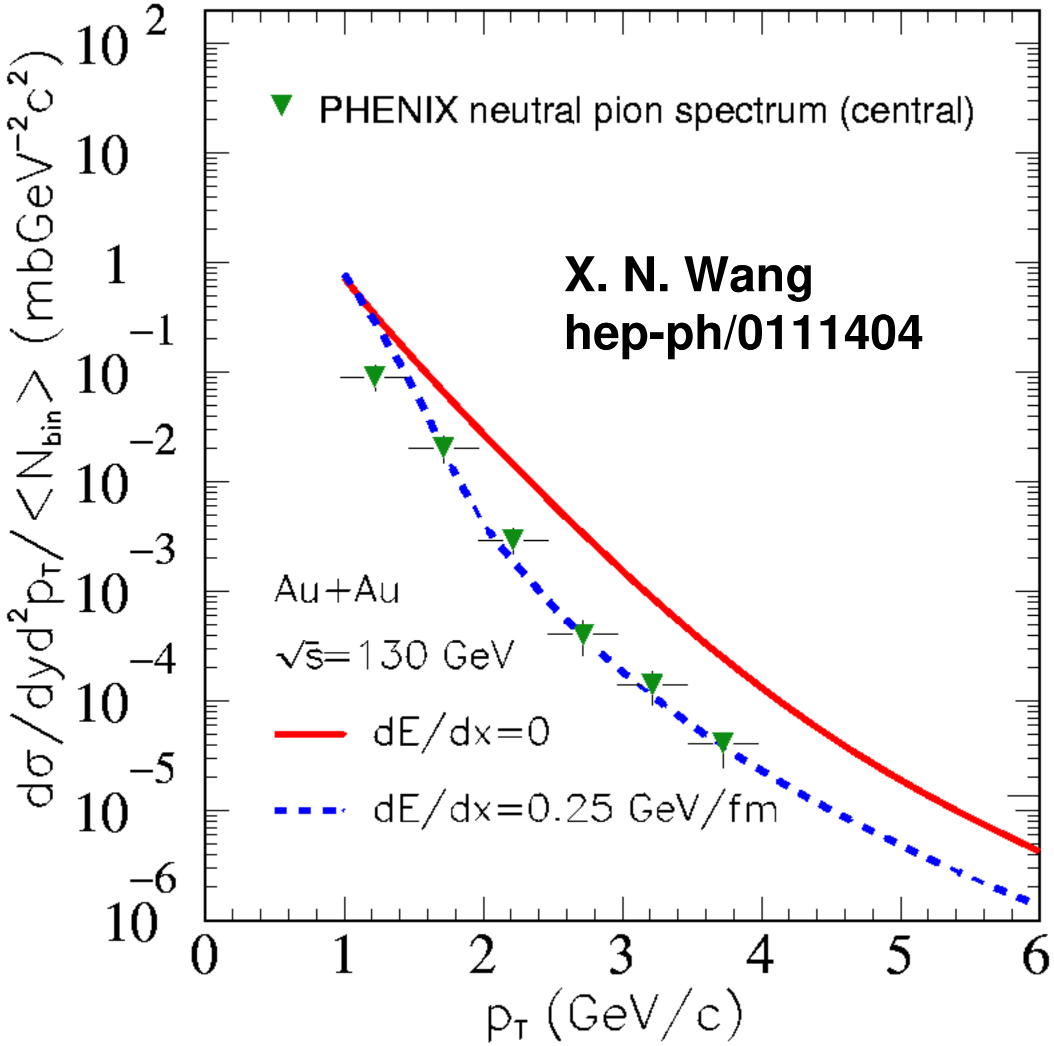
- **Final π^0 p_T spectrum**
- **Independent measurement with PbSc calorimeter:**
  - **good agreement within errors**
- **Comparison to N+N**
  - **interpolation to $\sqrt{s_{NN}}$ = 130 GeV from measured data**
  - **hard scattering: N_{coll} - scaling**
  - **peripheral: agreement**
  - **central events: below reference**

Central Au+Au to p+p



- Combined PbSc and PbGl
- $$R_{AA} = \frac{dN/dp_T(A+A)}{N_{coll} \times dN/dp_T(p+p)}$$
- Known nuclear modifications
  - Cronin effect: R_{AA}>1 at high p_T (SPS result)
  - shadowing: small
- Observed: R_{AA}<1

Comparison to pQCD Calculations

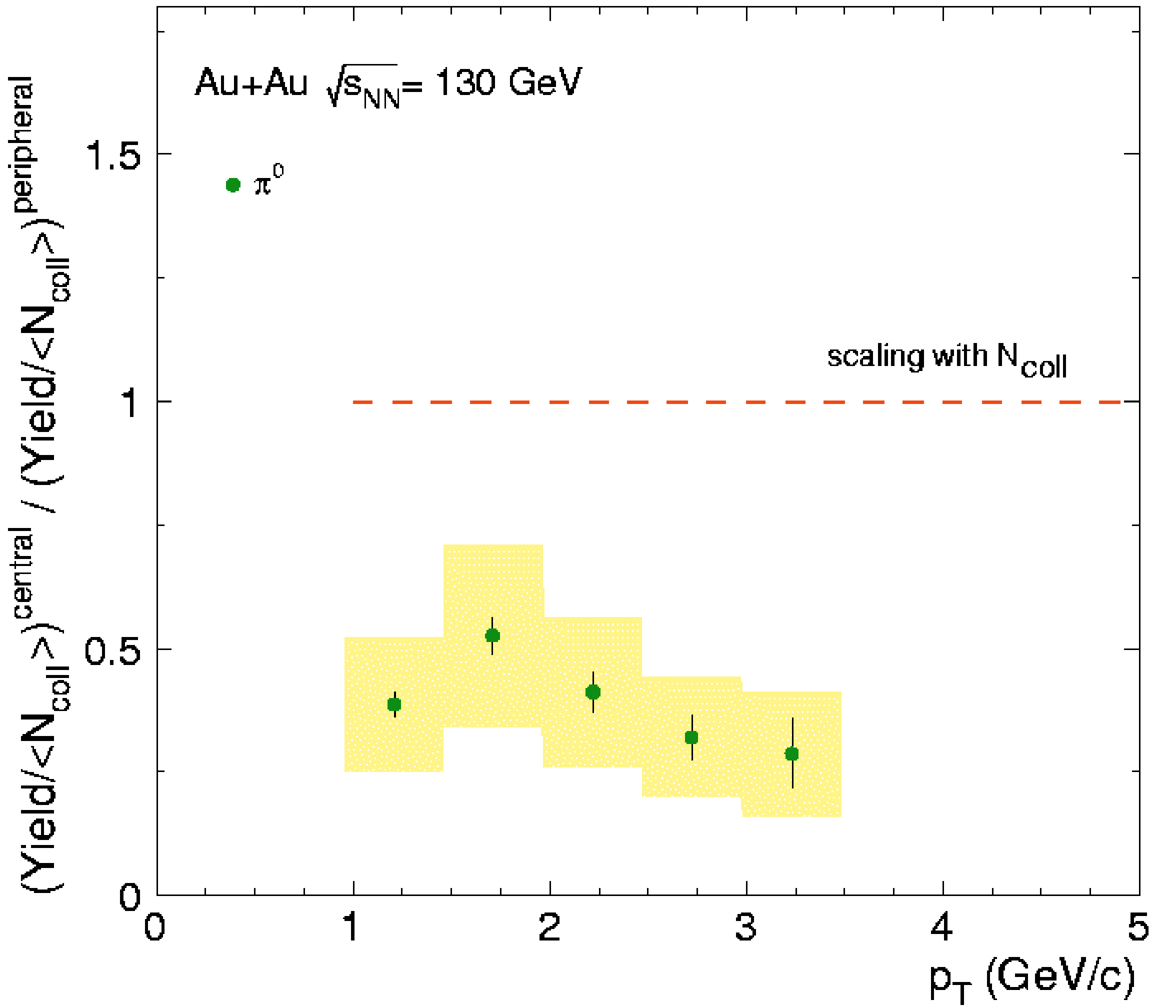


- pQCD calculation
  - dE/dx = 0.25 GeV/fm
    ≈ 7.3 GeV/fm in static system
  - Compare to
    cold nuclear matter
    dE/dx ≈ 0.5 GeV/fm (Hermes)
- Energy loss in Au+Au much higher
- Jet quenching possible explanation

Summary

- π^0 production in Au+Au at $\sqrt{s_{NN}}$ = 130 GeV
- Suppression of high p_T π^0 (central collisions) relative to N+N - reference
- Jet quenching in QGP possible explanation
- PRL 88 022301, 2002
- Looking forward to more statistics

π^0 Central/Peripheral Ratio



- Central/peripheral ratio normalized to N_{coll}:
  - many systematical errors cancel
- Scaling of π^0 yields from peripheral to central:
  - weaker than N_{coll}-scaling