π^0 measurement in Au+Au collisions at RHIC-PHENIX

RHIC-PHENIX実験における、金･金衝突時の中性パイオンの測定

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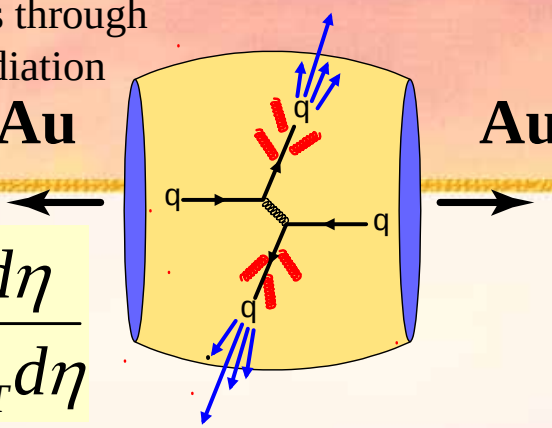
東大CNS

Contents

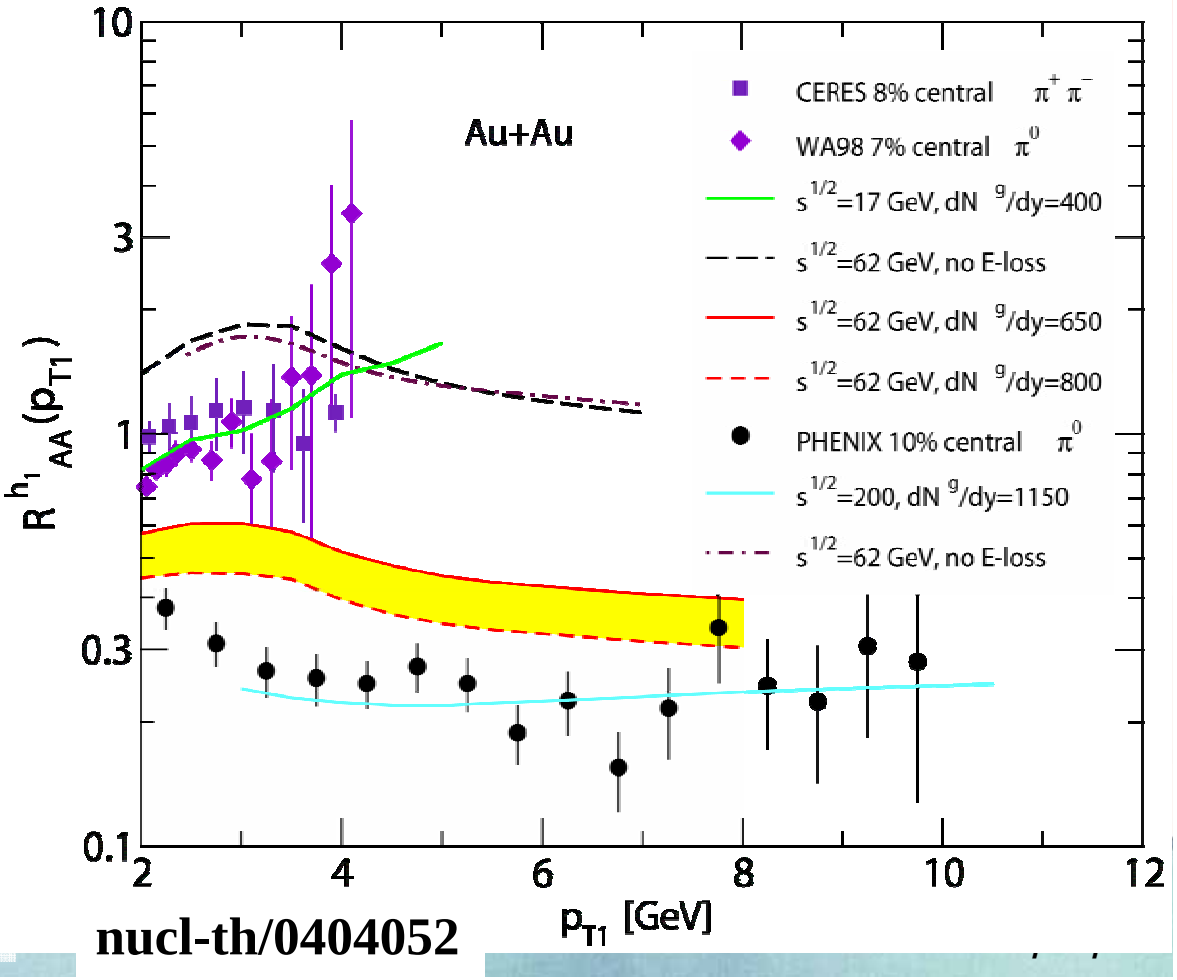
Physics motivation

- Energy loss of hard scattered partons in hot and dense matter
  - Jet quenching
- Understanding of the energy loss mechanism
- Interplay between nuclear effect and parton energy loss
  - GLV formula
  - Cronin enhancement and nuclear shadowing
- Absorption of thermally produced gluons?
- Study at intermediate energy
  - How about 62.4GeV?

Energy loss through gluon radiation



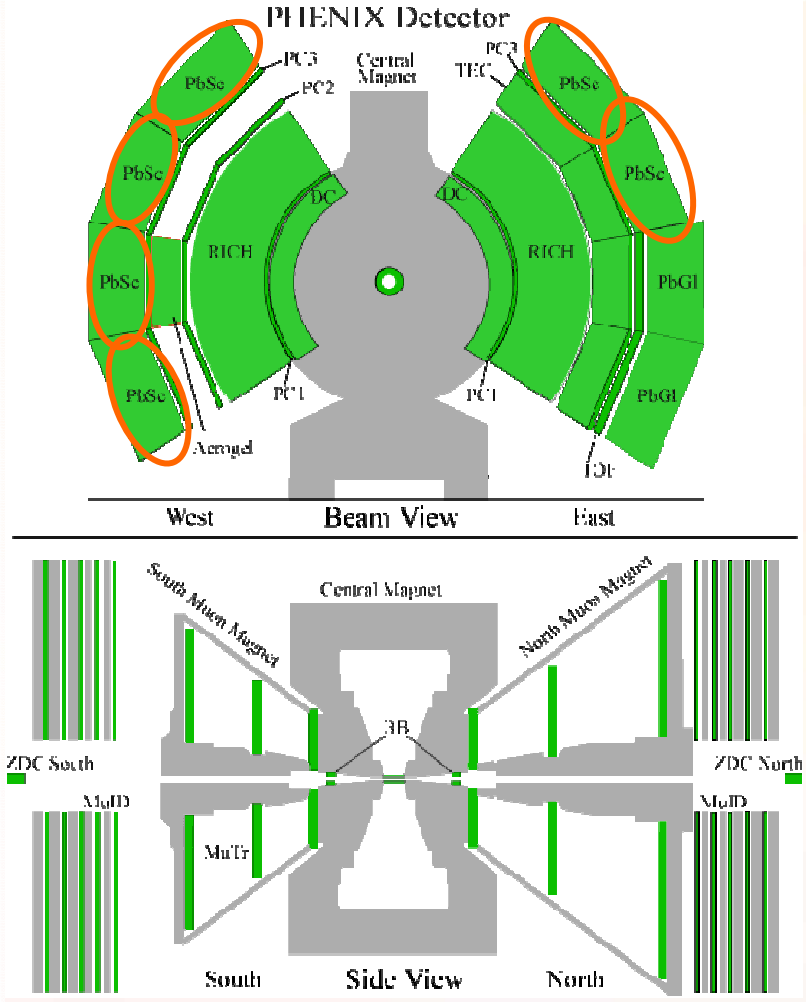
$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{NN}/dp_T d\eta}$$



nucl-th/0404052

π^0 measurement with PHENIX-EMCal

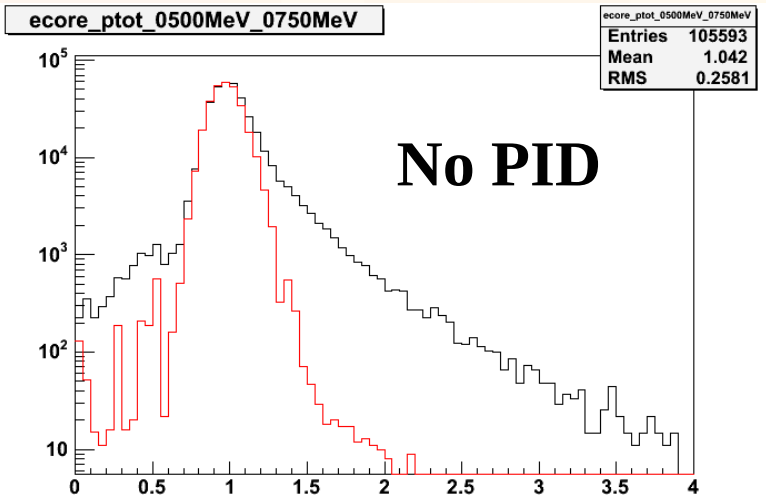
- **RHIC-PHENIX 62.4 GeV run at Year-4**
  - Au+Au collision
    - Sampled Luminosity 9.1μb-1
- **Electro Magnetic Calorimeter**
  - $\pi^0 \rightarrow 2\gamma$
  - Distance from vertex point: 5m
    - $|\eta|<0.35$ $\phi = 180°$
  - 2 arm × 4 sectors
    - Lead Scintillator Type (PbSc)
      - 6sectors (15552 channels)
      - Radiation length: $18X_0$
    - Lead Glass Type (PbGl)
      - 2 sectors (9216 channels)
      - Radiation length: $16X_0$
  - measurement of E.M. clusters using PbSc type EMCal
- **Min. Bias trigger from BBC-ZDC coincidence**



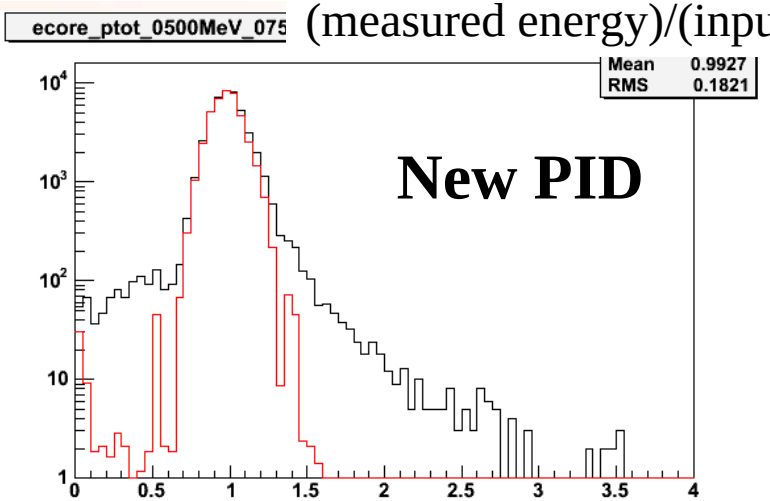
Analysis Overview(1)

Black: central
Red : peripheral

- Photon ID
  - likelihood function
    - combination of variables, shower dispersion, ratio of energy in several towers, number of tower hit…)
  - Efficient photon ID
  - Rejection of hadron contamination
- Estimation of single photon ID efficiency and smearing effect
  - From embedding study



(measured energy)/(input energy)



(measured energy)/(input energy)

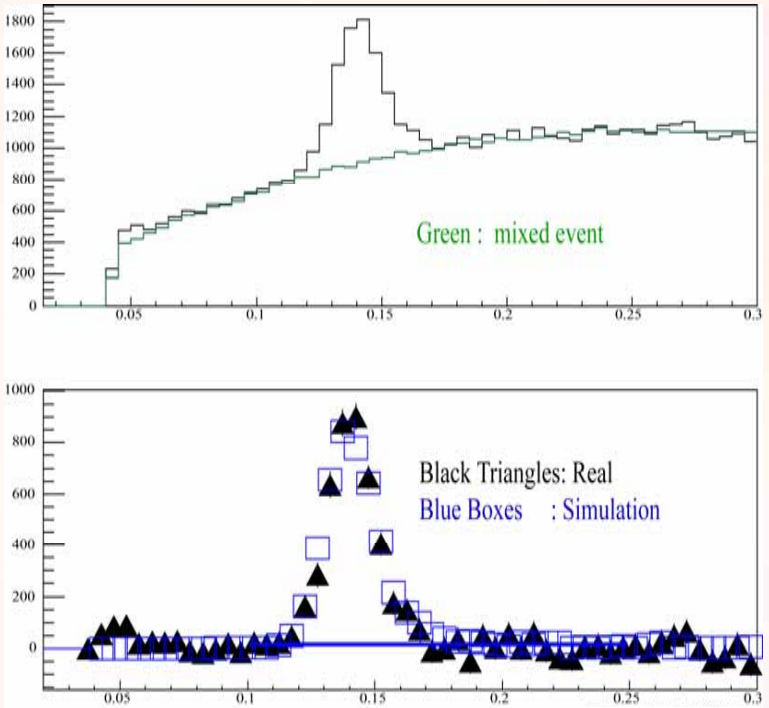
Analysis Overview(2)

- π^0 reconstruction ($\pi^0 \rightarrow 2\gamma$)
  - Energy Asymmetry cut

$$\left|\frac{E_{\gamma 1} - E_{\gamma 2}}{E_{\gamma 1} + E_{\gamma 2}}\right| < 0.8$$

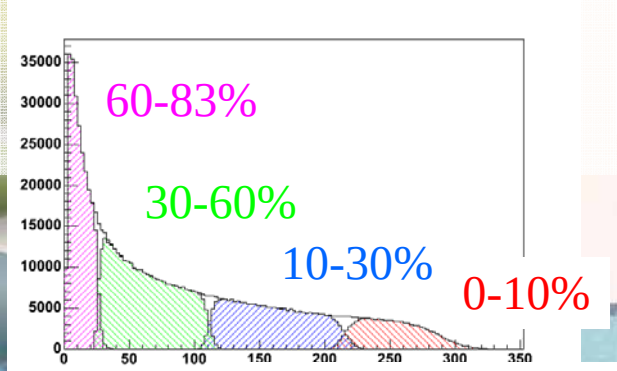
  - Reconstruction of background with "Event mixing" method.
- Calculation of π^0 reconstruction efficiency
  - Using single photon simulation result
  - with simple Monte-Carlo
- Total systematic error: 12.5-19%
  - π^0 extraction
  - Energy scale

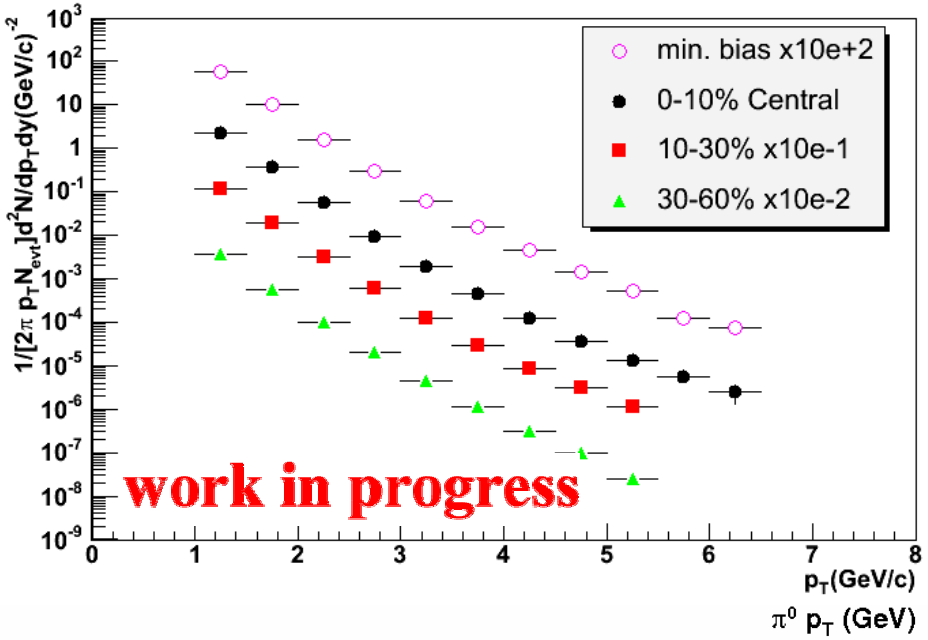
π^0 inv. mass spectra



Results(π^0 pT spectra at $\sqrt{s_{NN}}$=62.4GeV)

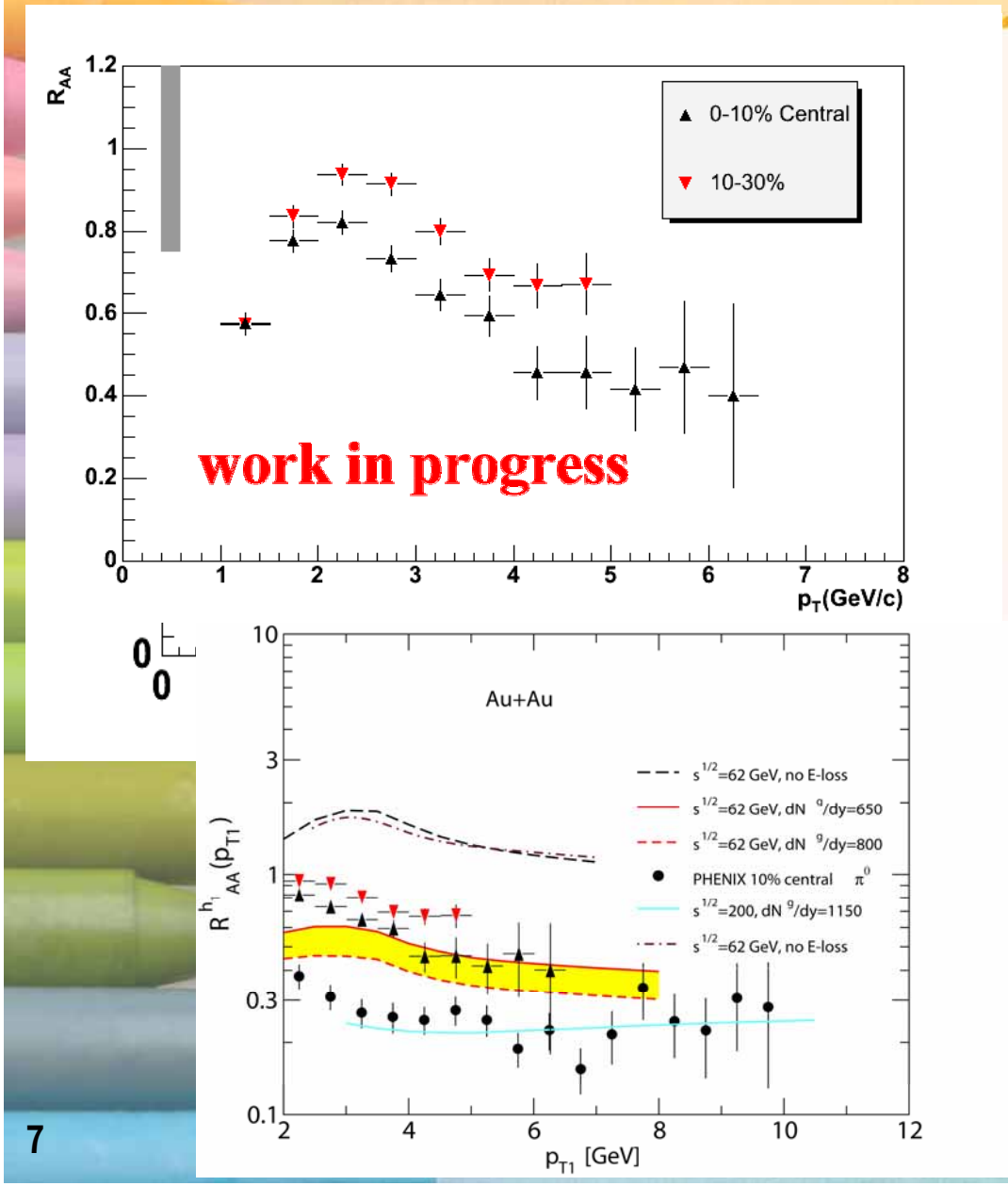
- π^0 data in Minimum Bias, 0-10%, 10-30% and 30-60% central collisions up to 6.5GeV/c
  - 60M events
- Centrality definition with BBC and PC
  - 4-centrality classes





Consistent with preliminary

Results(π^0 R_{AA} at $\sqrt{s_{NN}}$=62.4GeV)

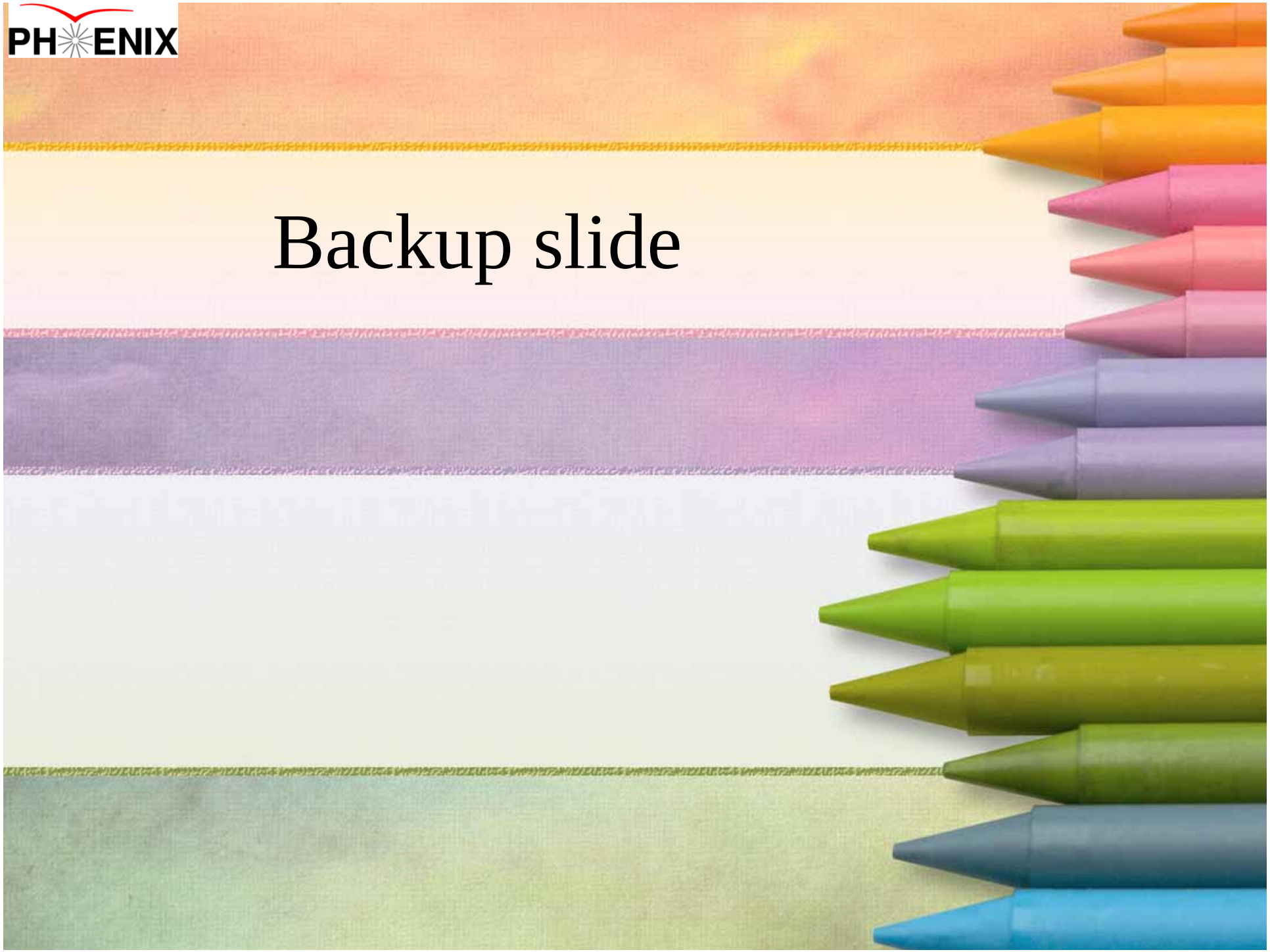


- Use CERN-ISR result as p+p reference
  - Systematic error of 25%
- R_{AA} reach close to unity at p_T~2.5GeV/c, and then decreases
  - Cronin enhancement in intermediate p_T?
  - Large suppression is seen at 6GeV/c (~0.4)

$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{NN}/dp_T d\eta}$$

Summary and Outlook

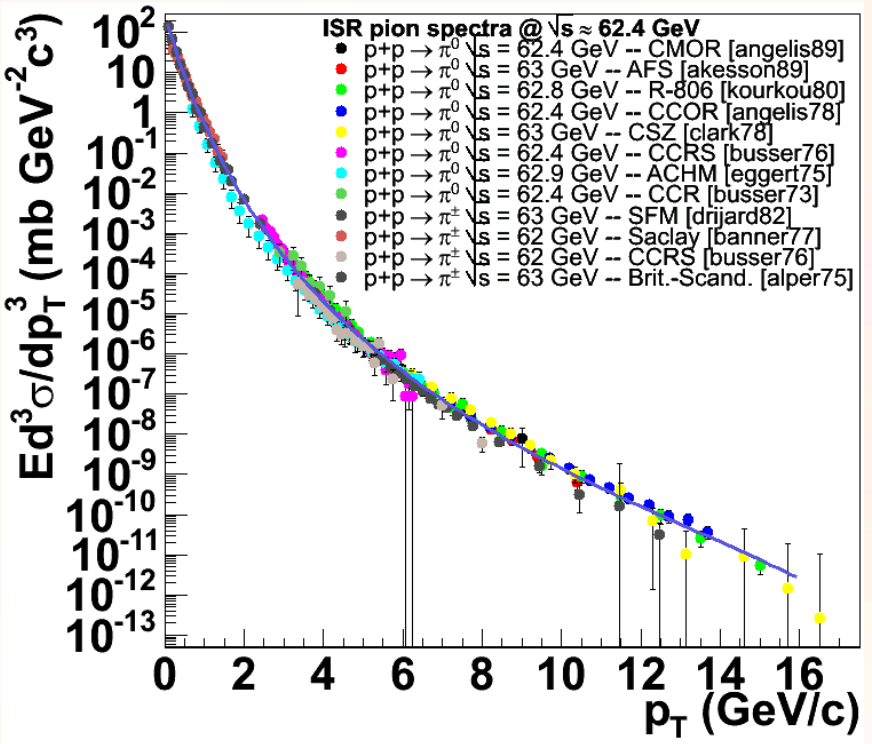
- Measurement of π^0 production in Au+Au collisions at RHIC-PHENIX
  - π^0 data at $\sqrt{s_{NN}}$=62.4GeV Au+Au collisions up to 6.5GeV/c
  - π^0 R_{AA}
    - p_T dependence is seen
    - R_{AA} for π^0 is close to unity at p_T~2.5GeV/c, and decreases to 0.4 at p_T~7GeV/c
- Huge(1.5B events) Au+Au data set at 200GeV to be analyzed.
  - p_T ~ 20GeV/c?

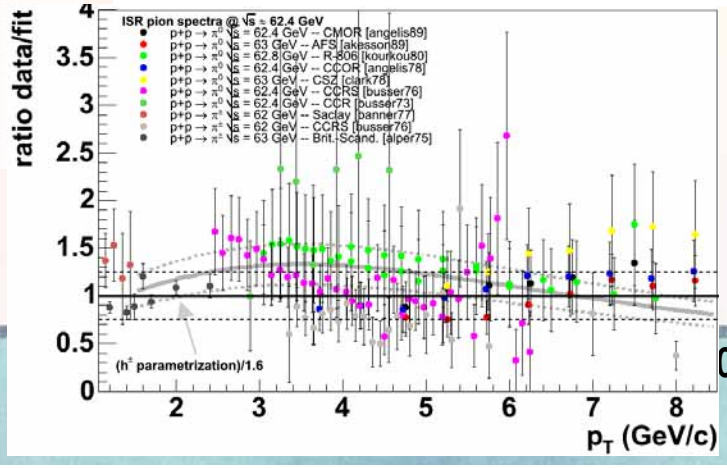

PHENIX
Backup slide

62.4GeV p+p Reference for π^0

- Compiling existing experimental pi0 and pi+/- spectra at √s=62.4GeV (12 measurements @ CERN-ISR)
- Correction for contamination from hadron and direct gamma
- Fit all the corrected data (~200points to a exponential +power-law fit)
- Compare data points and NLO calculation with data
- Assign systematic uncertainty
  - +/- 25%

$$f(p_T) = A/(e^{a\cdot x^2+b\cdot x} + x/p_0)^n$$





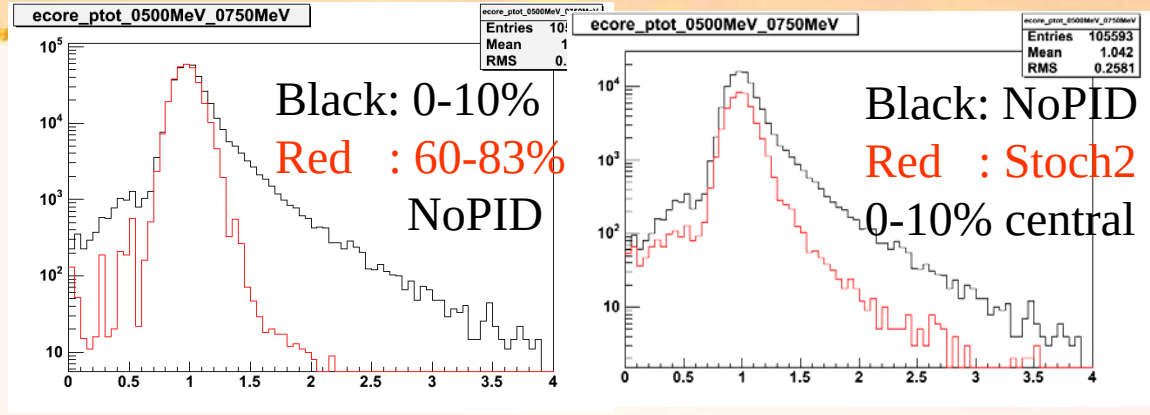
Energy loss calculation with GLV method

- Nucl. Phys. B 594 (2001) 371
- Better method for short region of interaction
  - Diameter of Au: 10fm
  - Typical mean free pass: 1fm
- LPM effect
  - Interaction effect between emitted gluons
- $$\Delta E = \frac{9\pi C_R \alpha_s^3}{4} \frac{L}{\pi R^2} \frac{dN}{dy} \ln\left(\frac{1}{x_c}\right)$$
  - Bjorken 1D simple expansion model

$$\rho(\tau) = \frac{\tau_0}{\tau}\rho(\tau_0)$$

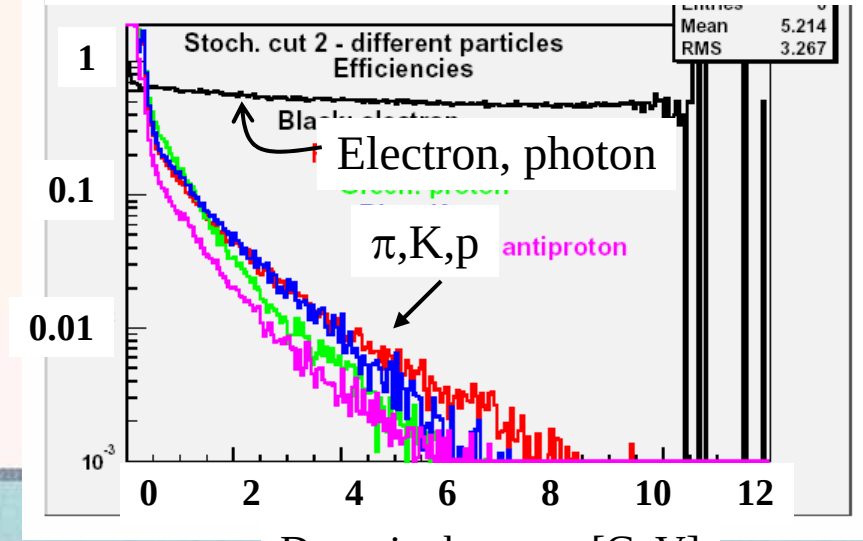
$$\rho(\tau_0) = \frac{1}{\tau_0 \pi R^2}\frac{dN}{dy}$$

- ΔE=6GeV at dN/dy=1000 for 10GeV quark



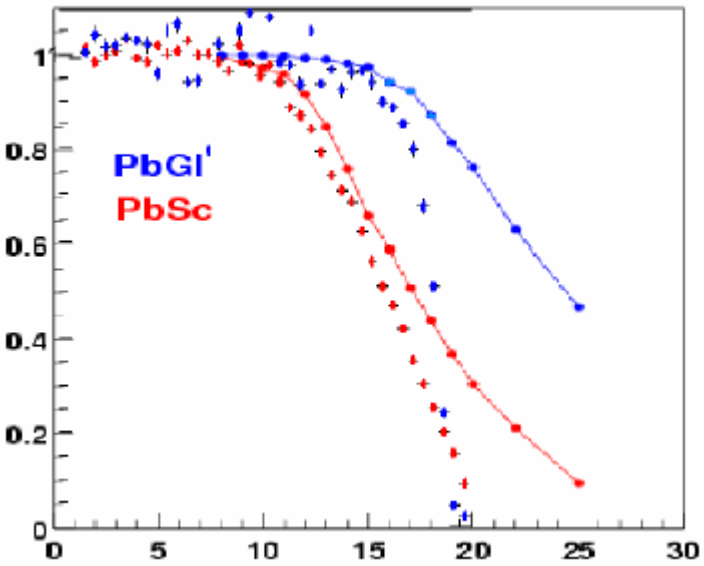
Smearing function for 500-750MeV photons
Each Centrality: left and Each pid cut: right

Contribution to cluster of various parcitles



2γ efficiency loss at high p_T

- π^0 of pT>12GeV/c is dropped off
  - 2γ from π^0 merged due to clustering algorism and tower geometry.
- PbSc: 5.5cm*5.5cm
- PbGl: 4cm*4cm



Estimation of systematic error

- Pi0 extraction (8.5%)
  - Estimated from thick conv. run
- PID efficiency (5%)
  - Ratio between each PID condition
- Energy scale (15-6%)
  - Pt correlated
  - From FastMC result
- Off vertex pi0 (5%)

Total (12.5-19%)