XXVIII Reunião de Trabalhos sobre Física Nuclear No Brasil

Direct Photons in Relativistic Heavy Ion Collisions

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Direct Photons

Simplest definition – photons not coming from electromagnetic decays ($e.g.$, π^0, η)

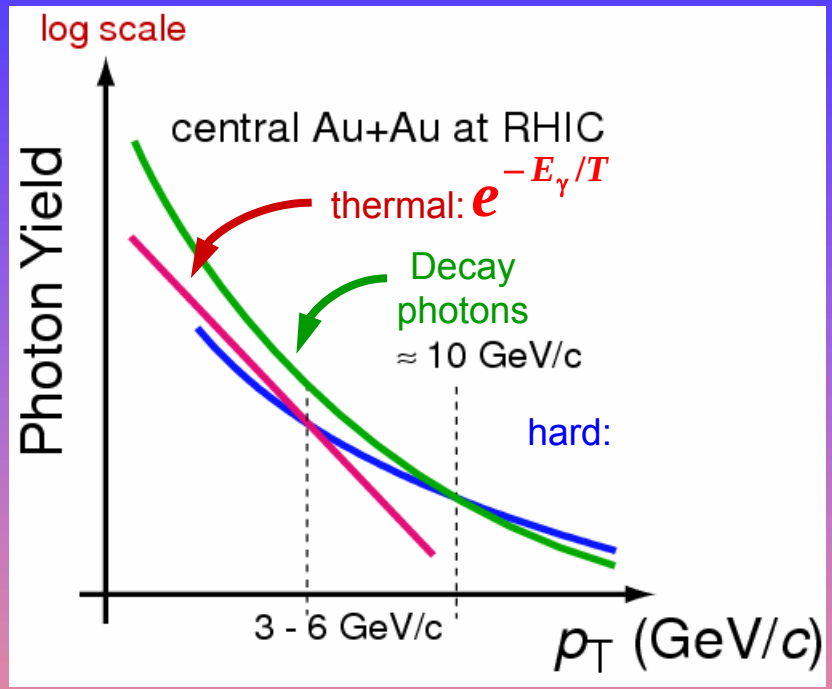
- First measurements – p+p collisions
- A+A collisions
  - emitted throughout all collision history, but mostly in early hot phase
  - negligible interaction with formed matter
  - suitable probe of initial temperature
  - high p_T photons – quantitative probe of hadron suppression (jet-quenching)

Direct Photons in A+A

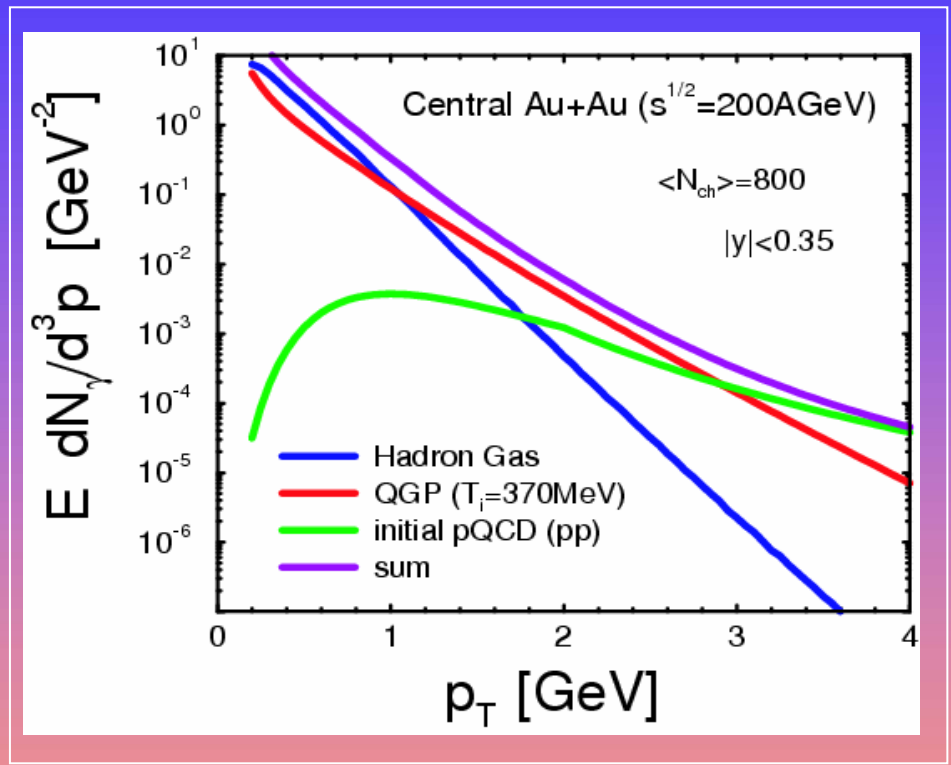
Photons in A+A	Hadronic decay			
	Direct photons	non-thermal	• initial hard scattering – prompt photons • non-equilibrium	
		thermal	QGP	• q+anti-q→γ+g and q+g→q+γ • bremsstrahlung
			Hadron Gas	• $\pi^+ + \pi \rightarrow \gamma + \rho^0$ • $\pi^\pm + \pi^0 \rightarrow \gamma + \rho^\pm$ • $\pi^\pm + \rho^0 \rightarrow \gamma + \pi^\pm$ • $\pi^+ + \rho^- \rightarrow \gamma + \pi^+$ • $\pi^0 + \rho^+ \rightarrow \gamma + \pi^+$
		thermal+hard	• q+anti-q→γ+g and q+g→q+γ • medium induced bremsstrahlung	

Photon Spectrum in A+A

Schematic



Realistic calculation



- A+A central collisions at RHIC: largely reduced decay background due to hadron suppresion

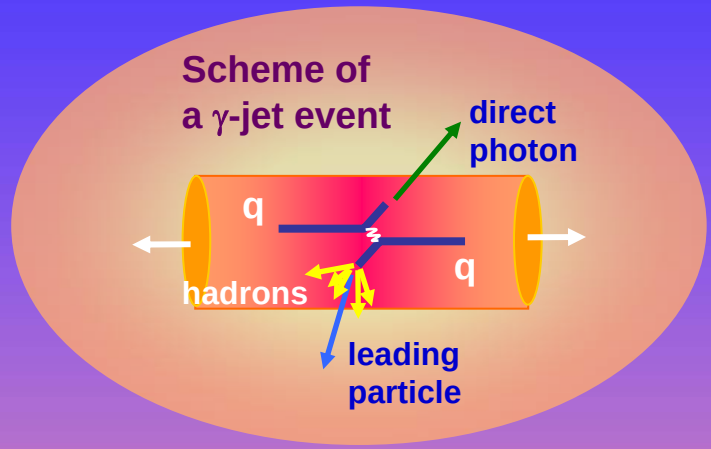
Turbide, Rapp, Gale, Phys. Rev. C 69 (014902), 2004

Thermal window for QGP : p_T 1 – 3 GeV/c

High p_T direct photons in A+A

Direct Photon spectrum - Probe for N_{coll} scaling of hard processes.

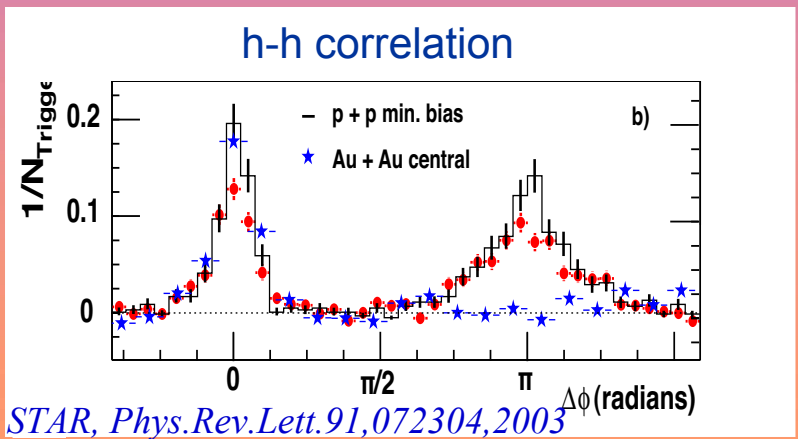
γ-jet correlations – further investigation of hadron suppression



Jets – final products of parton hard scattering

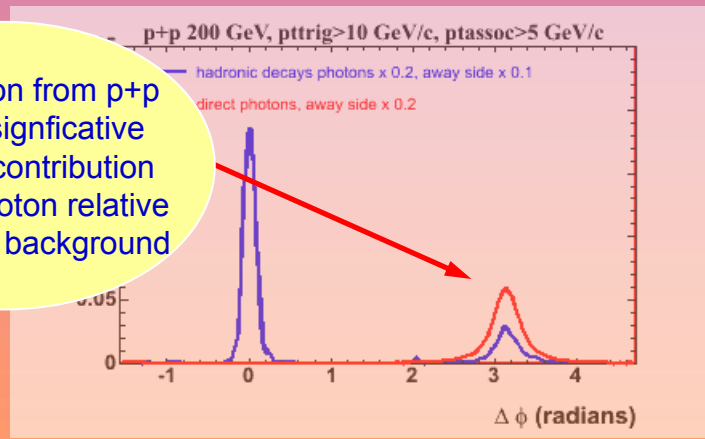
- leading particle (most of parton p_T) + low p_T particles

Energy loss - Scattered partons propagate through matter and radiates energy in the coloured medium (gluon bremsstrahlung)

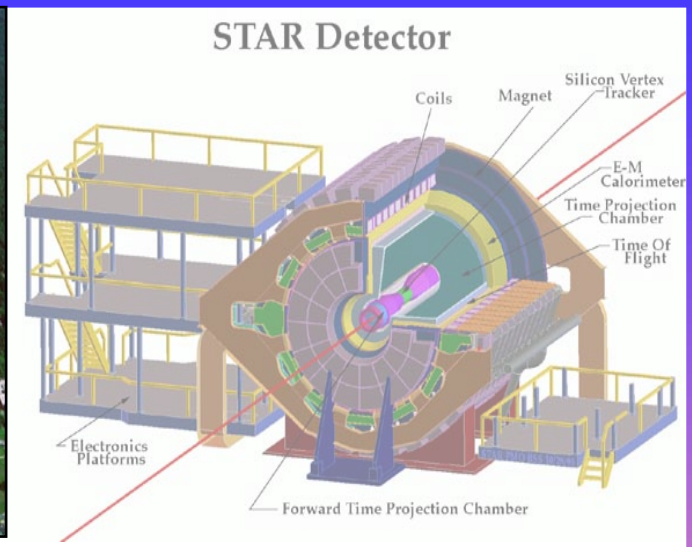


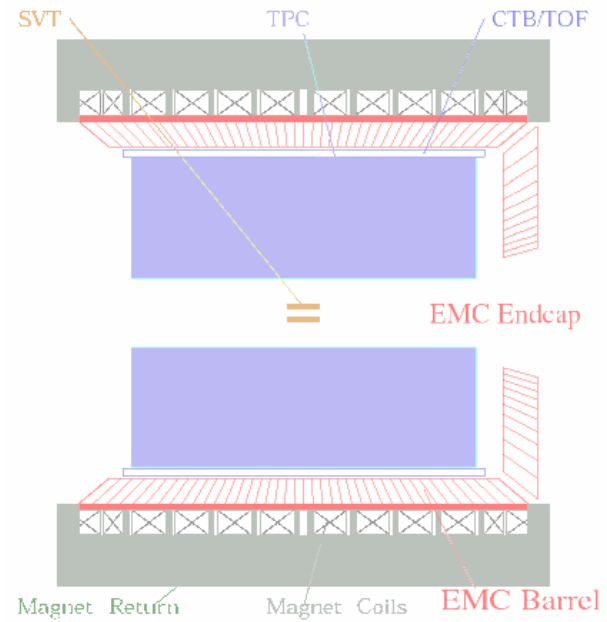
STAR, Phys.Rev.Lett.91,072304,2003

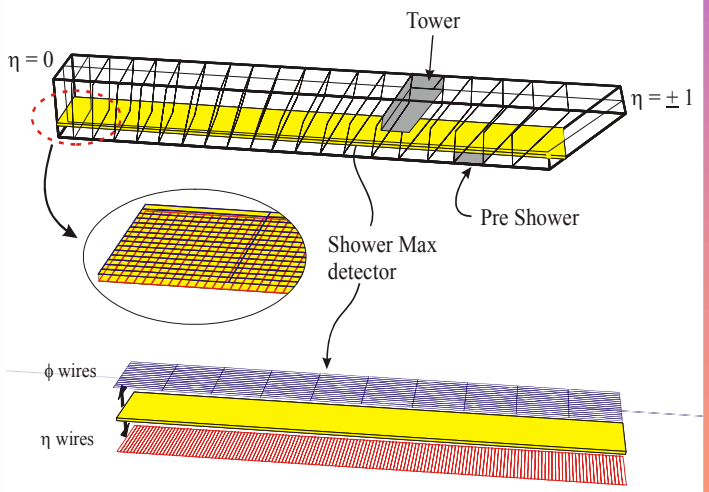
Extrapolation from p+p to AuAu – signficative away-side contribution of direct photon relative to hadronic background



STAR at RHIC







STAR Electromagnetic Calorimeter

Barrel (BEMC)

- 2,3 m radius (modular detector)
- 60 modules; 2 halves; 4800 towers
- $-1 < \eta < 1$ $\eta = -\ln\left[\tan(\theta/2)\right]$
- 2π coverage in ϕ

Shower Maximum Detector (SMD)

Pre-Shower

Analysis Strategy

Goal - Direct Photon Production

p+p,d+Au towards Au+Au

Starting Point – Inclusive Neutral Production

- EMC measurement–TPC track matching

Next Steps

- Efficiency correction
- Subtraction of n, anti-n, K^0 contamination
- Subtraction of hadronic background
  - mostly π^0 (2γ br~98,8%) and η (2γ br~38,9%) decays ; also η', ω;

$$\gamma_{direct} = \gamma_{incl} - \gamma_{bkgr}$$

Analysis Details

Efficiency correction – Embeded data

- acceptance
- occupancy
- distinguishment between one γ and two γ measurement

Background subtraction

- π^0 distribution (EMC measurement)

☐ lower limit for E_γ measurement reduces efficiency for cases with high energy assimetry of decay photons

☐ γ from high p_T $\pi^0 \rightarrow$ position resolution limit to separate the two decay photons

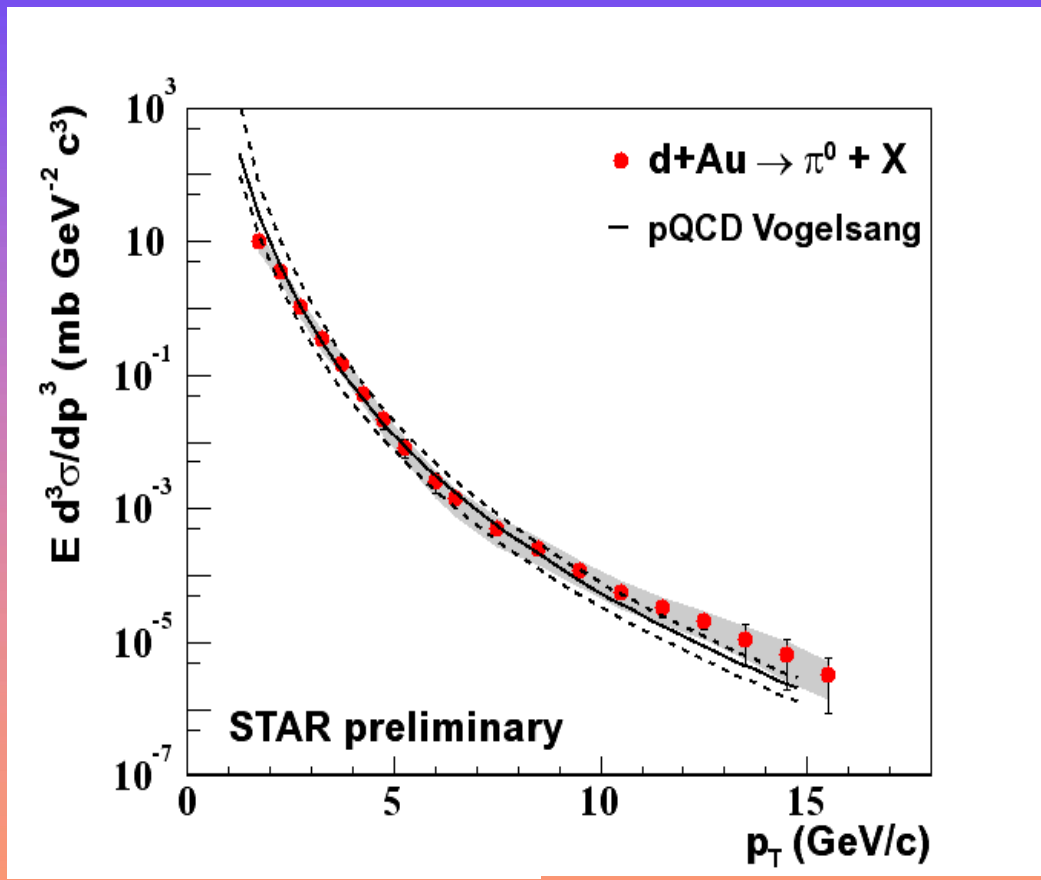
- η, η', ω distributions (m_T scaling)
- decay γ distribution – Monte Carlo over hadronic distributions

π^0 Reconstruction

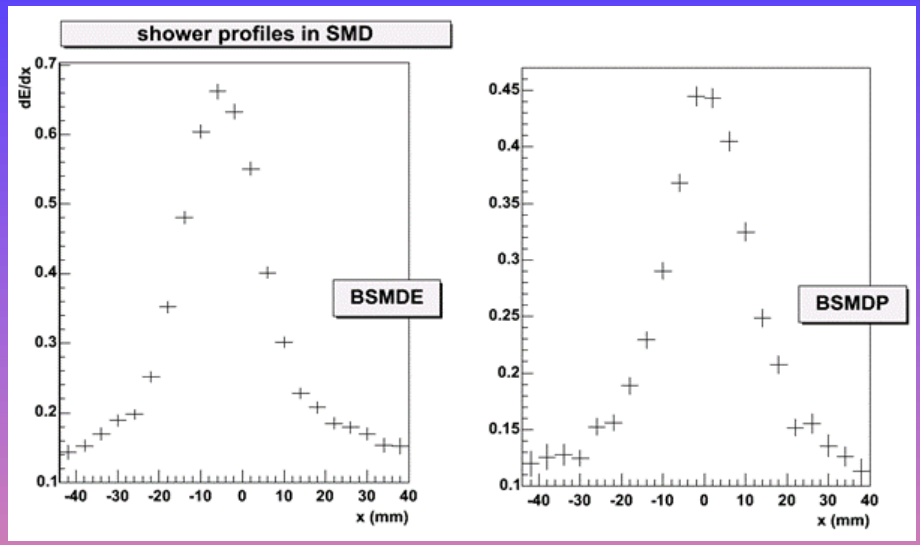
- 2γ m_{inv} spectrum

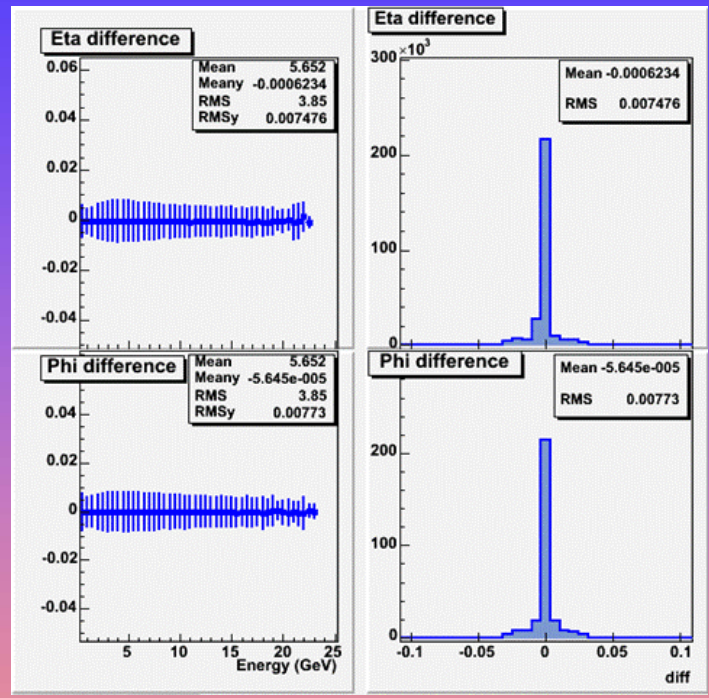
$$m_{inv} = \sqrt{2E_{\gamma 1}E_{\gamma 2}\left(1-\cos\theta_{\gamma 12}\right)}$$

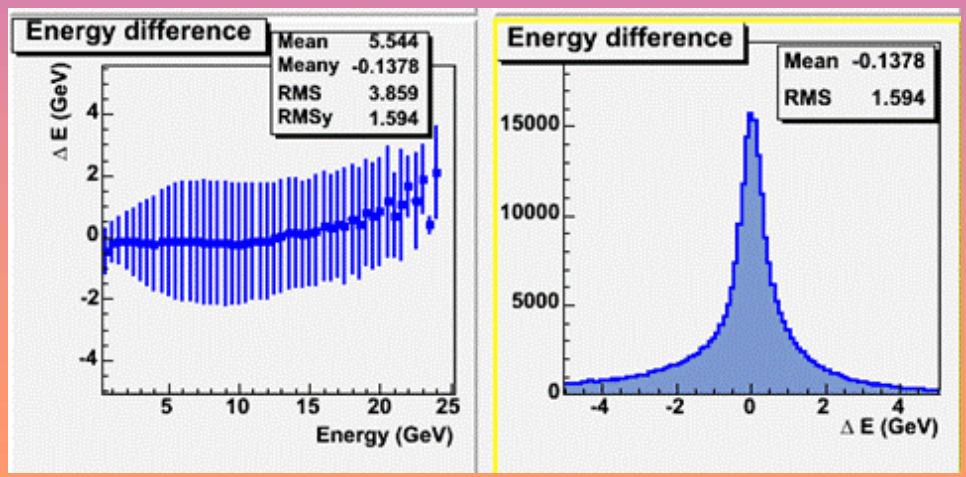
- combinatoric background to be subtracted (very significative in A+A)
  - event mixing thecnique
- π^0 production – m_{inv} spectrum integral peak after background subtraction



Point Reconstruction Evaluation

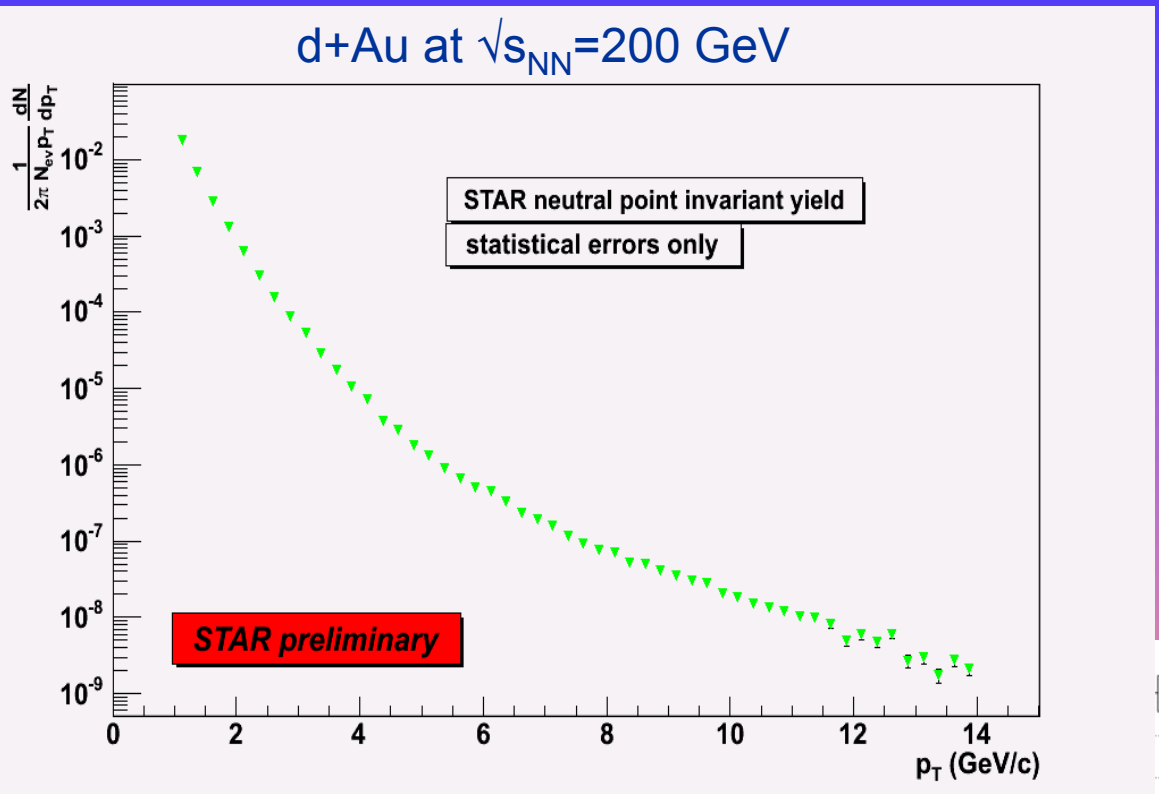


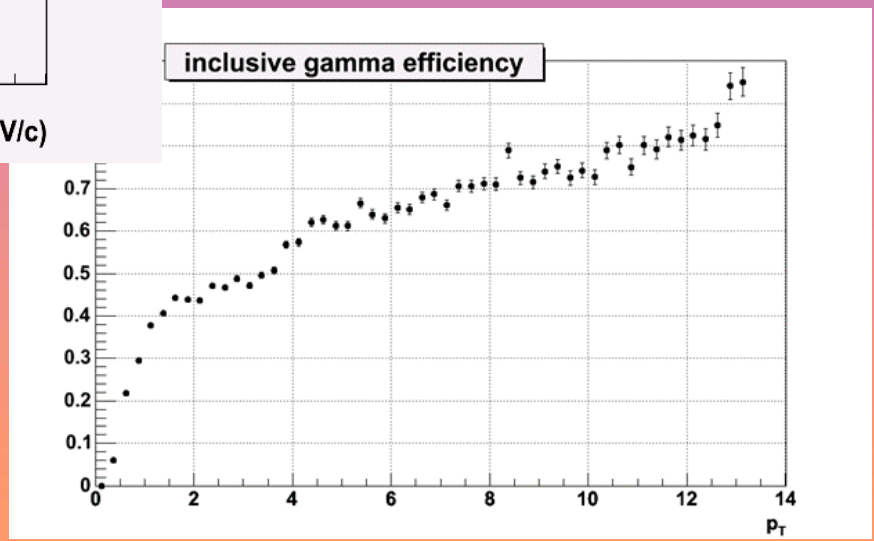




Improvement of cluster finder is needed to enhance energy reconstruction.

Inclusive Neutral Spectrum





Perspectives

- Improvement of cluster finder
- Final cross check of π^0 spectrum with the new cluster finder
- Subtraction of hadronic background from the many contributions
- Evaluation and correction for other neutral contributions