Photons @ RHIC: Results from STAR

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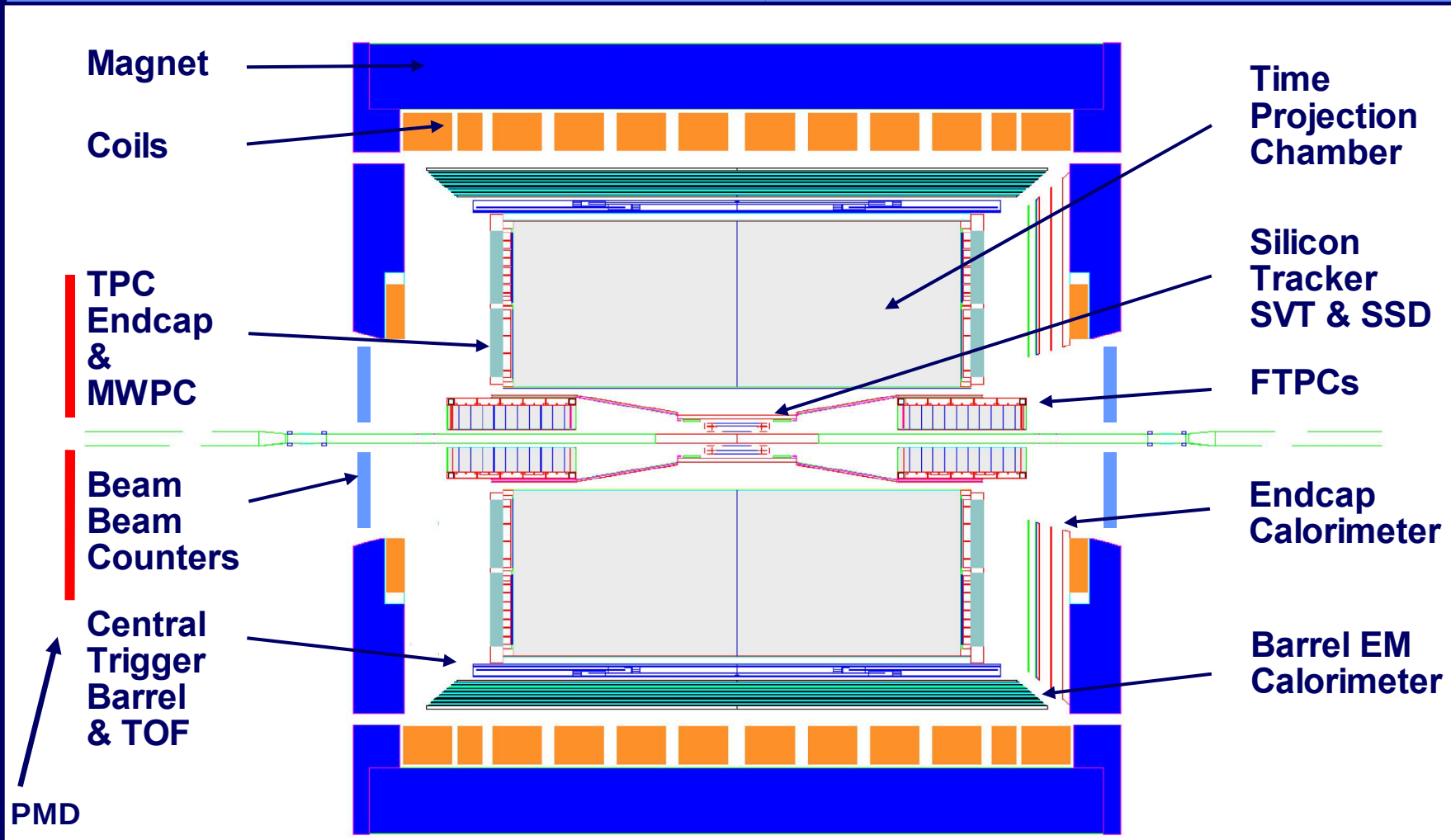
for the STAR Collaboration

STAR Experiment At RHIC



Introduction

Photons in A+A collisions

- Mainly, from π^0 , η decays
  - Important probe in many aspects
  - In STAR, allow better statistics to higher p_T than charged pions
- Direct photons
  - Main advantage – large mean free path in the created matter
  - Produced in all stages of the collision
    - thermal photons – access to temperature (initial, hadronization)
    - High p_T photons to investigate hadron supression in A+A collisions

Direct γ production

$q + \bar{q} \rightarrow g + \gamma$

$q + g \rightarrow q + \gamma$

Bremsstrahlung

Extraction of direct photon production is harder due to large hadronic decay background $\rightarrow \pi^0(\eta)$ measurements very important

Inclusive γ and π^0 from the STAR TPC

Measurement obtained from γ conversion in TPC

Material used as γ converter:

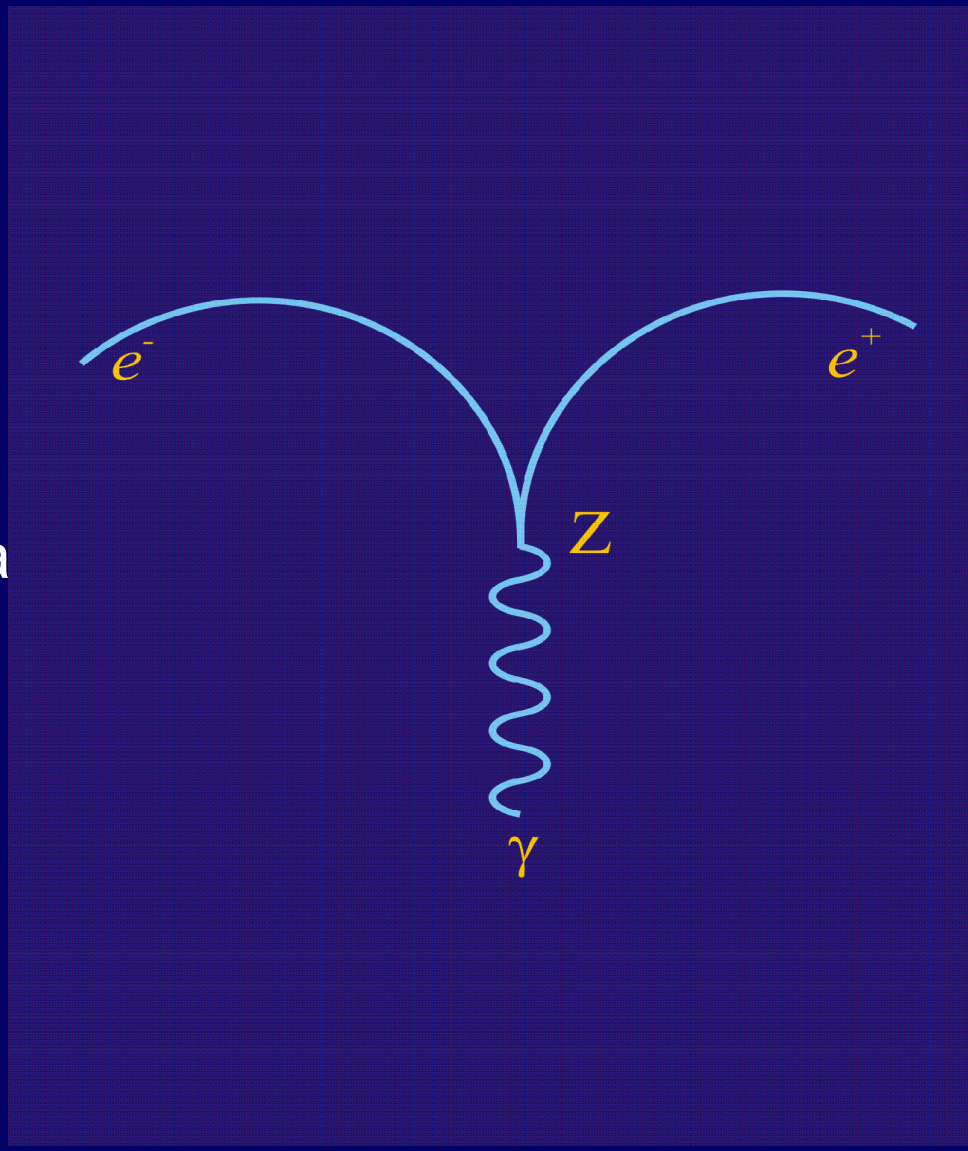
- Beampipe
- SVT
- SSD
- Inner field cage
- TPC gas

Efficiency

- $\gamma \sim 2\%$
- $\pi^0 \sim 0.04\%$

γ reconstruction

- e^+ and e^- are selected through dE/dx
  - loose cuts are applied
  - low p_T accepted only if they do not come from collision vertex
- For the pairs, it is required a small opening angle and conversion vertex different from collision vertex
- Trajectory of reconstructed γ points back to collision vertex



Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV - γ spectra

γ and π^0 – Au+Au at 130 GeV

J. Adams *et al.*, Phys. Rev. C **70** (2004) 044902

Error bars: statistical only

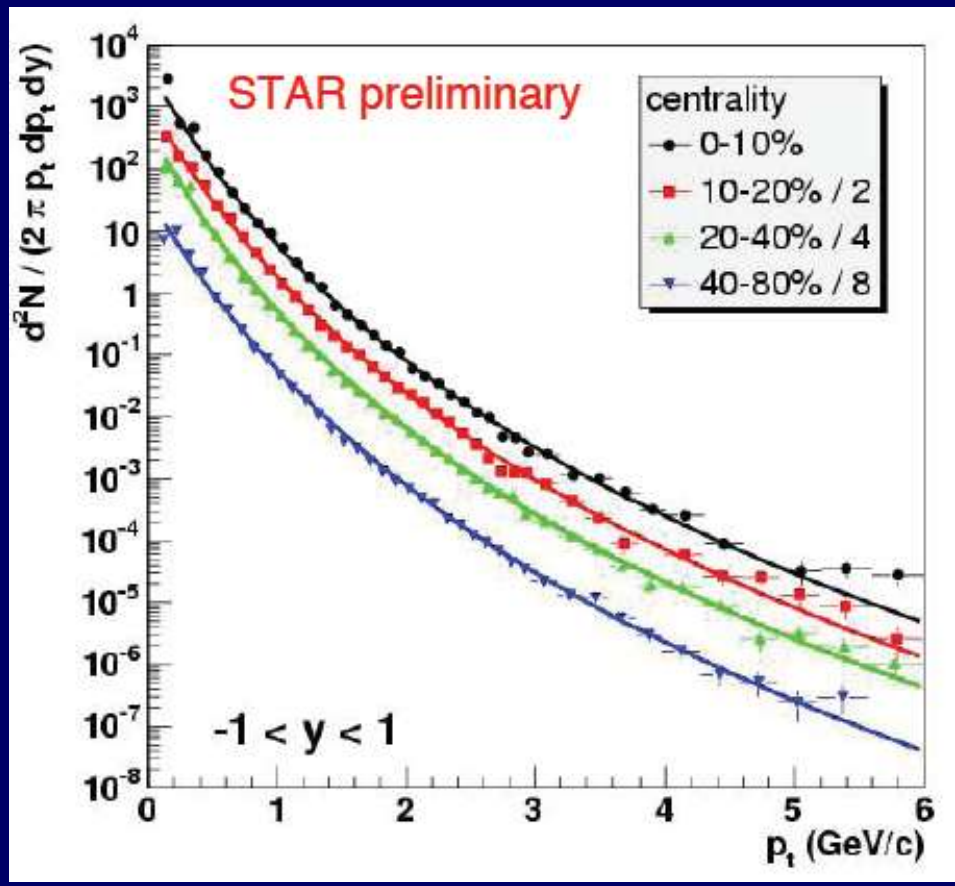
Systematic uncertainty: 20%

Combinatorial background has been subtracted

Other contributions, such as Λ decays, were verified to be negligible

Centrality dependence

Curves are power law fits



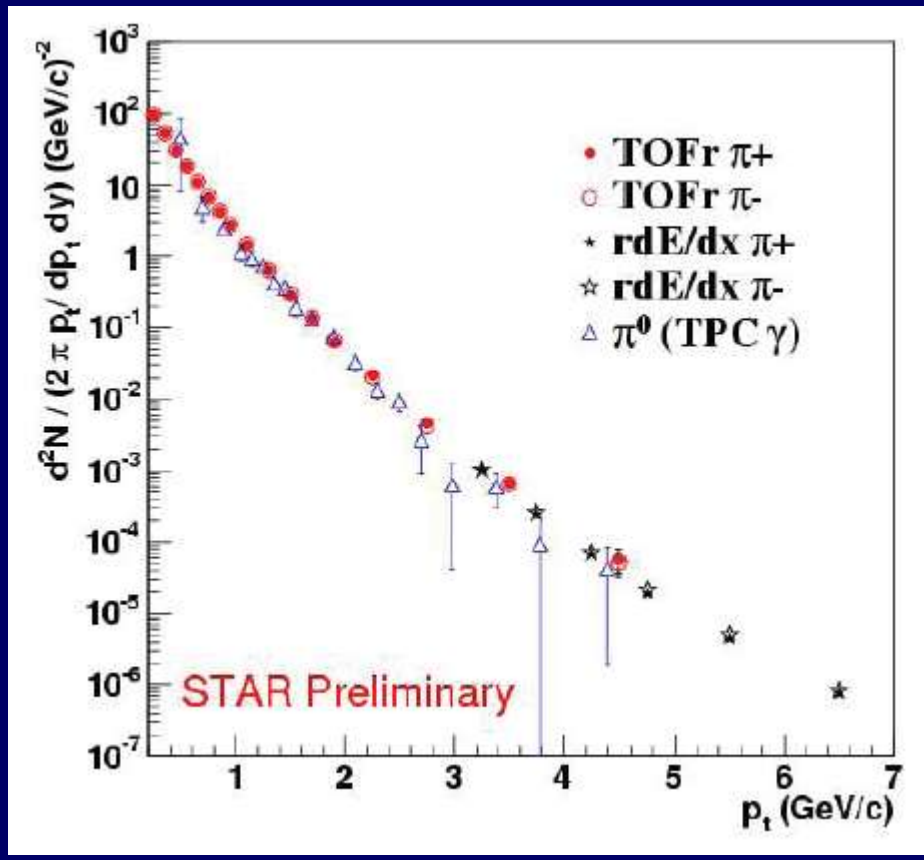
Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV - π^0 spectrum

Each point is the gaussian fit of the 2γ invariant mass distribution for a given p_T

~10 MeV width, depending on p_T

Systematic uncertainty of 30%

Comparison of π^0 to π^+ and π^- from STAR TPC dE/dx and TOFr shows good agreement.



Correlation of large E_{T} photons with charged particles

Jet studies allow further investigation of parton energy loss mechanism

2 particle correlations

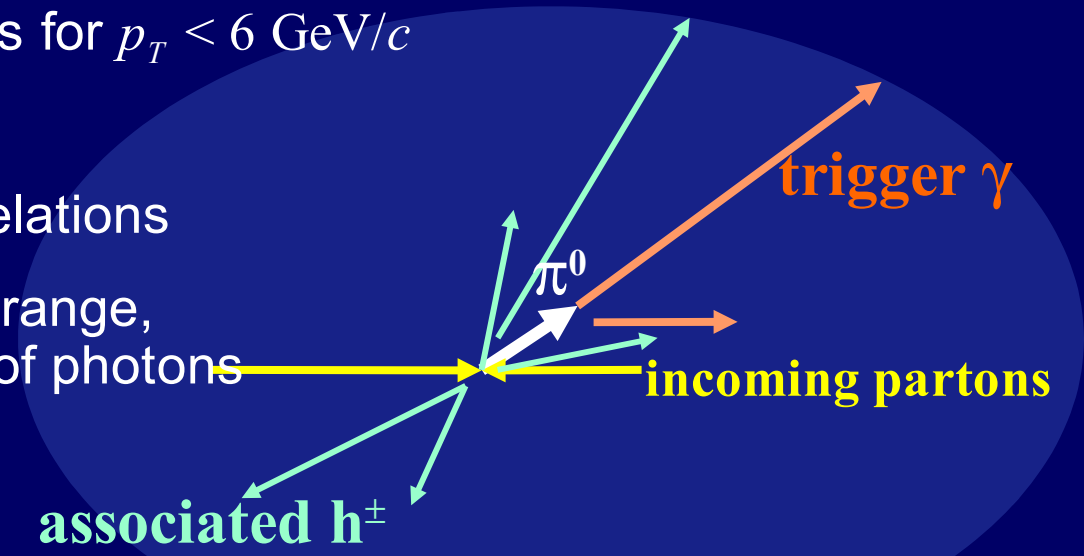
- probe of intra-jet (same side) and back-to-back jet (away side)

Previous studies

- charged particle correlations for $p_T < 6$ GeV/c

This Analysis

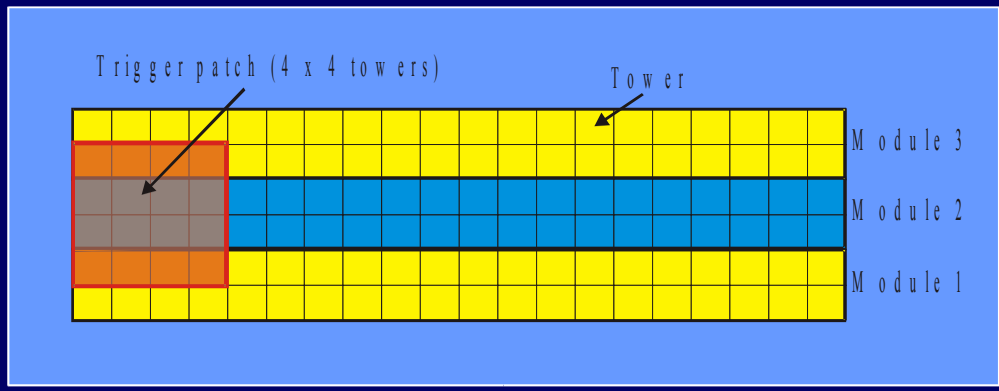
- γ (mostly from π^0) – $h^{\pm}$ correlations
- Extends correlation energy range, due to EMC measurement of photons



d+Au collisions at $\sqrt{s_{NN}}$=200 GeV

Data set

- 3.9 M High Tower triggered events
  - EMC patch - 4 x 4 towers
  - High tower trigger - tower in a patch with the highest energy above threshold

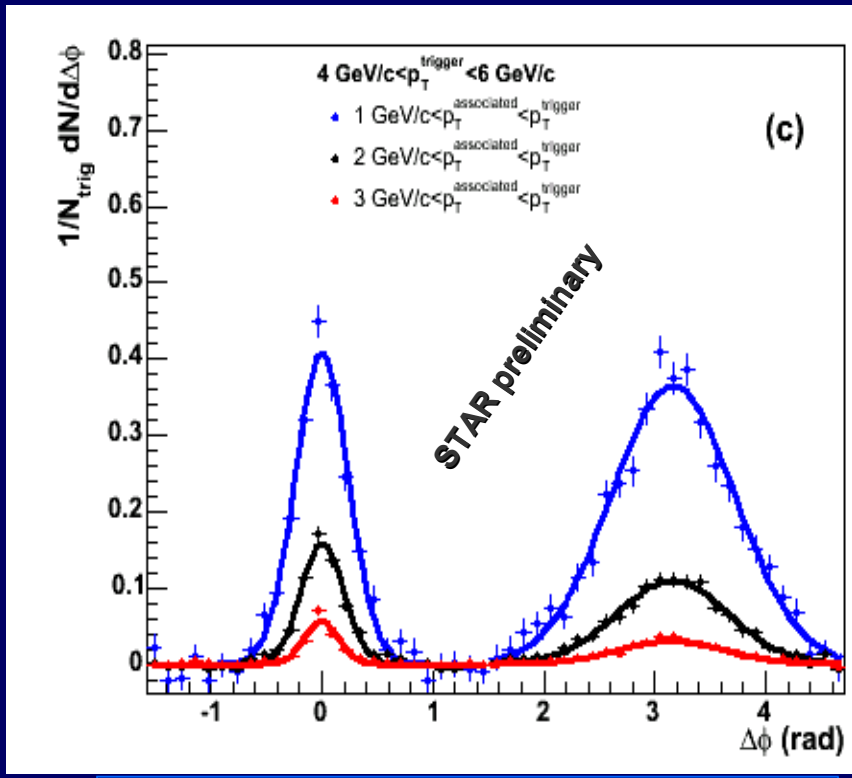


EMC Tower $\delta\eta$ x $\delta\phi$ =0.05 x 0.05

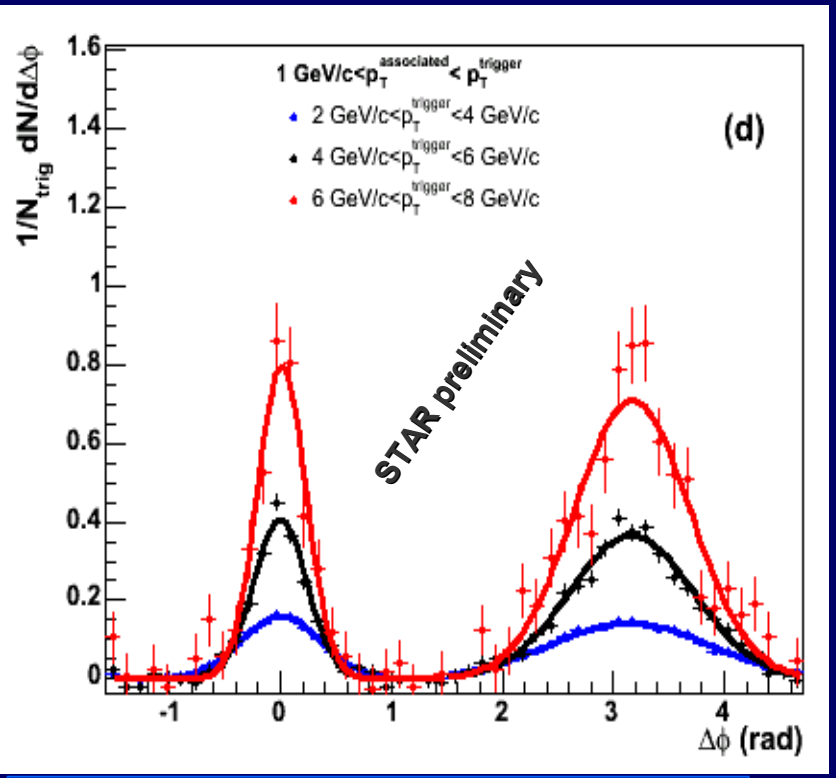
Selections and Cuts

- Highest tower energy selected
- Isolation cut
  - No track pointing in a 3 x 3 tower patch around main tower
- Associated track – basic selection criterium used in many STAR analysis

d+Au correlations



$p_T^{associated}$ dependence

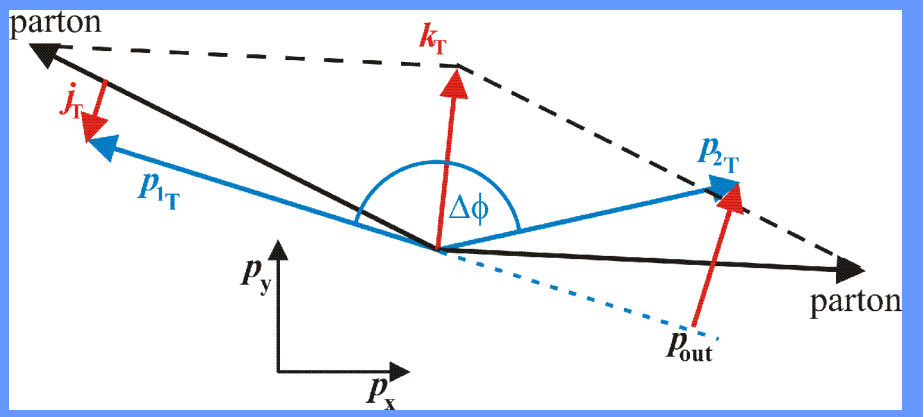


E_{trig} dependence

Jet properties – $< j_T >$ and $\sqrt{< k_T^{rms} >}$

j_T - transverse momentum component of jet from jet axis

k_T - transverse momentum component of initial parton



Correlation (Gaussian) widths

$\sigma_N \rightarrow$ near side

$\sigma_F \rightarrow$ far side

$E_T \rightarrow E_{trig}$,

$p_T \rightarrow p_T^{associated}$

$< z > \rightarrow$ fragmentation function of trigger photon (0.6~0.8)

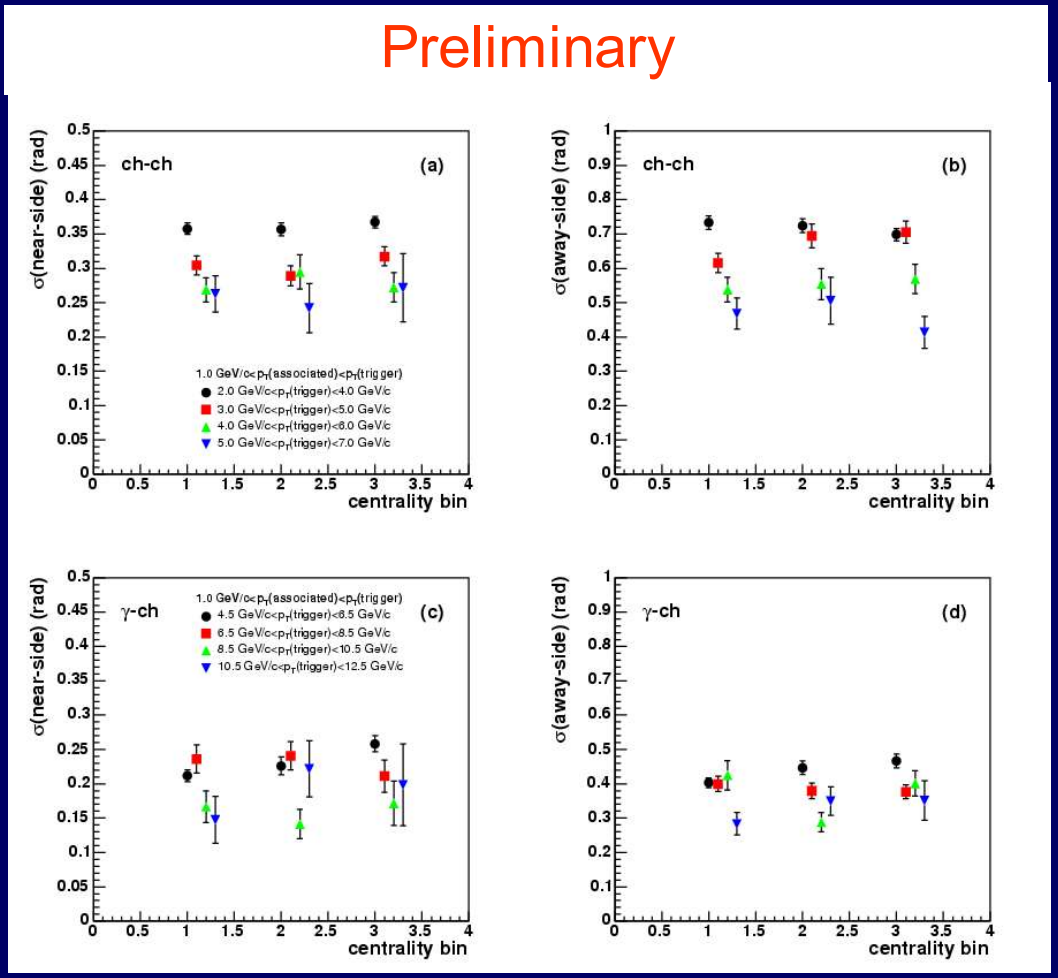
$$\sigma_N^2 \approx \frac{\langle E_T^2 \rangle + \langle p_T^2 \rangle}{2 \langle E_T^2 \rangle \langle p_T^2 \rangle} \langle j_T^2 \rangle$$

$$\langle j_T \rangle = \frac{\sqrt{\pi}}{2} \langle j_T^2 \rangle$$

$$\sqrt{\langle k_T^2 \rangle} \approx \frac{\langle E_T \rangle}{\langle z \rangle} \sqrt{\sigma_F^2 + \sigma_N^2}$$

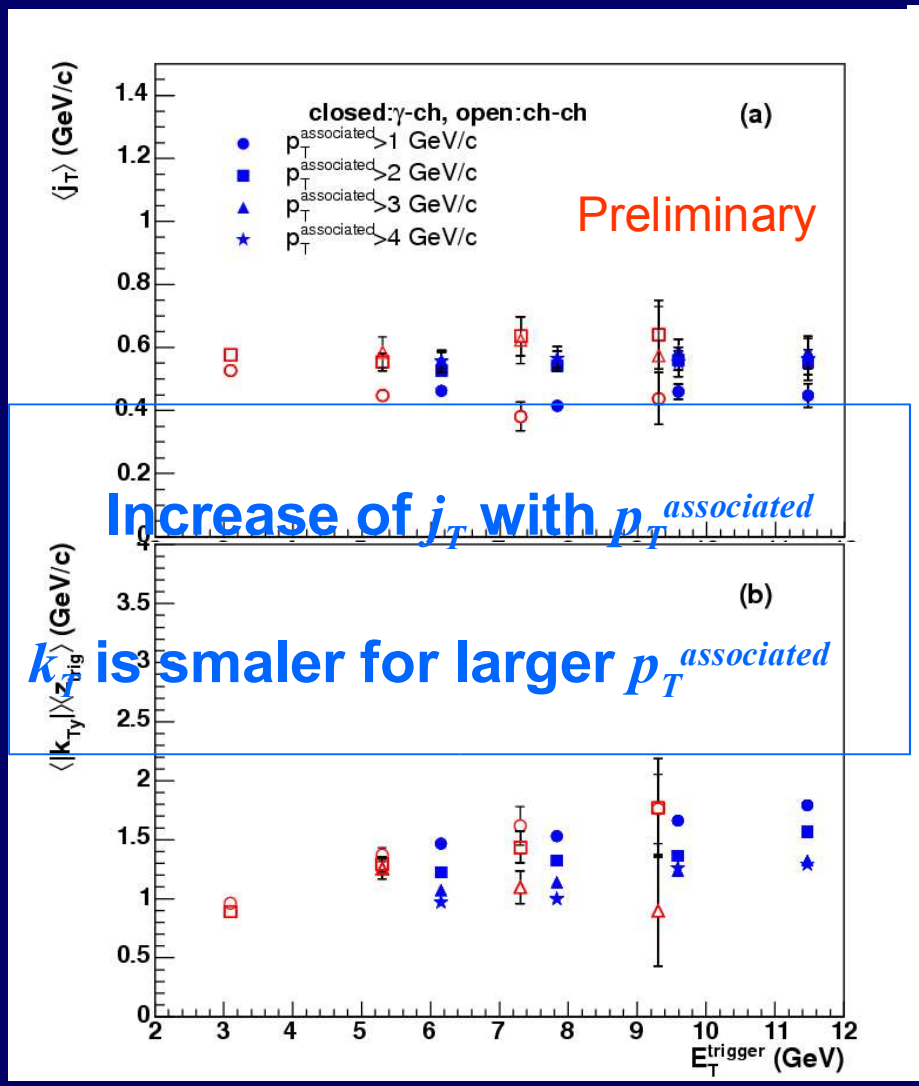
Centrality dependence of σ_N and σ_F

Preliminary



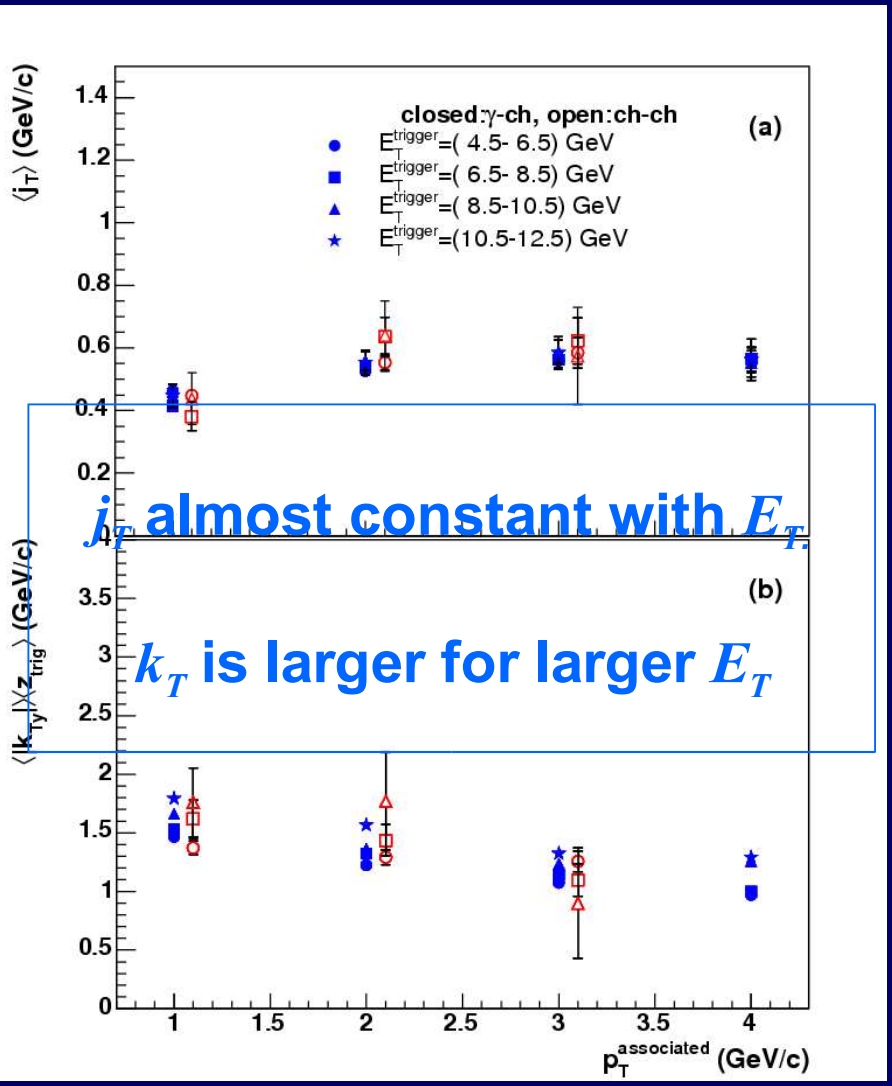
No strong centrality dependence of either near and far side widths within errors

$< j_T >$ and $\sqrt{< k_T^{rms} >}$ dependences



Increase of j_T with $p_T^{associated}$

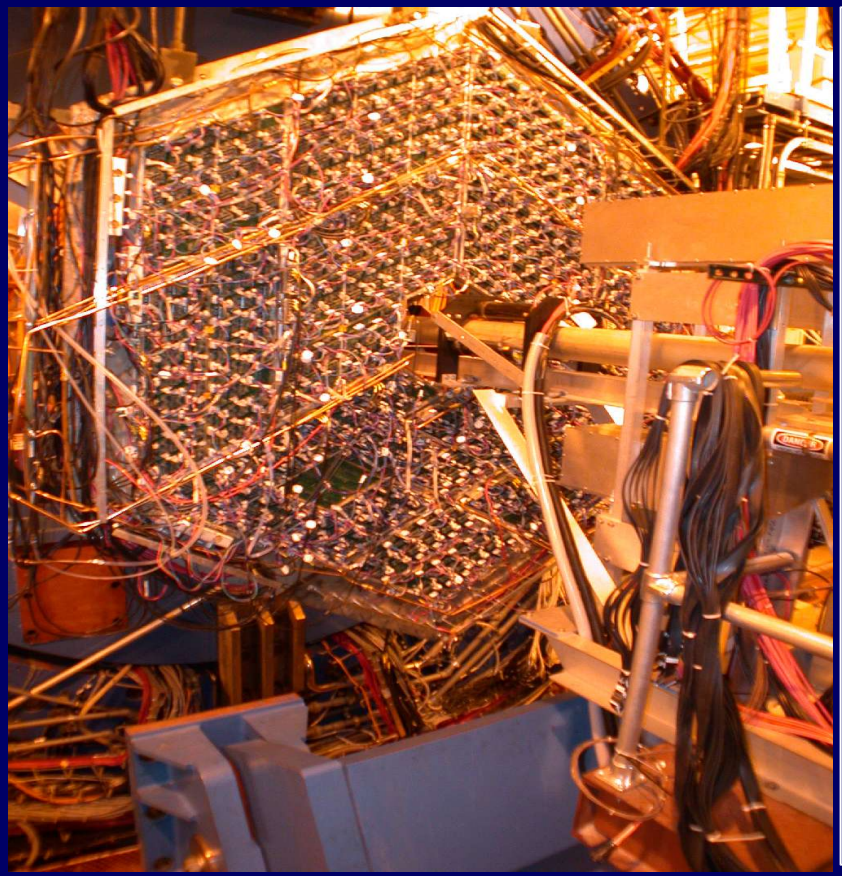
k_T is smaler for larger $p_T^{associated}$



j_T almost constant with E_T

k_T is larger for larger E_T

First Results from Photon Multiplicity Detector

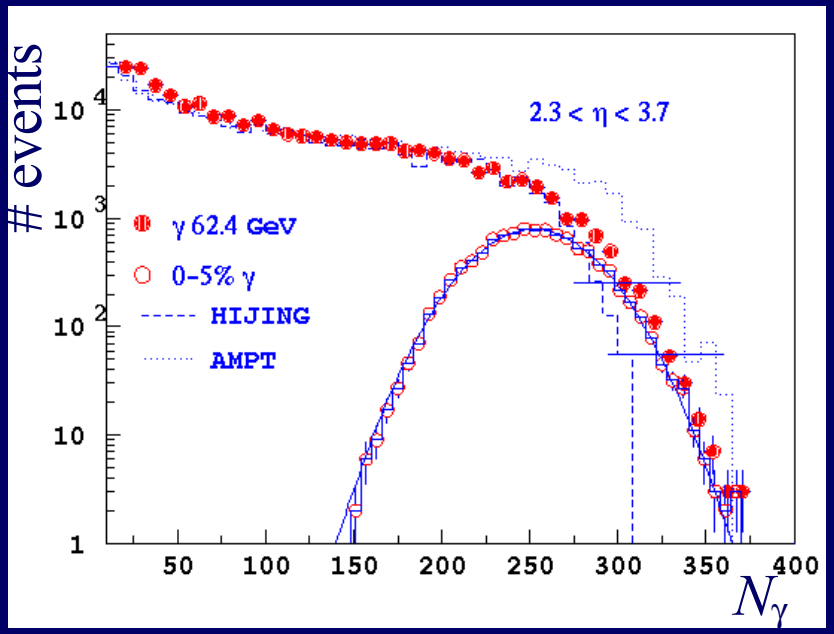


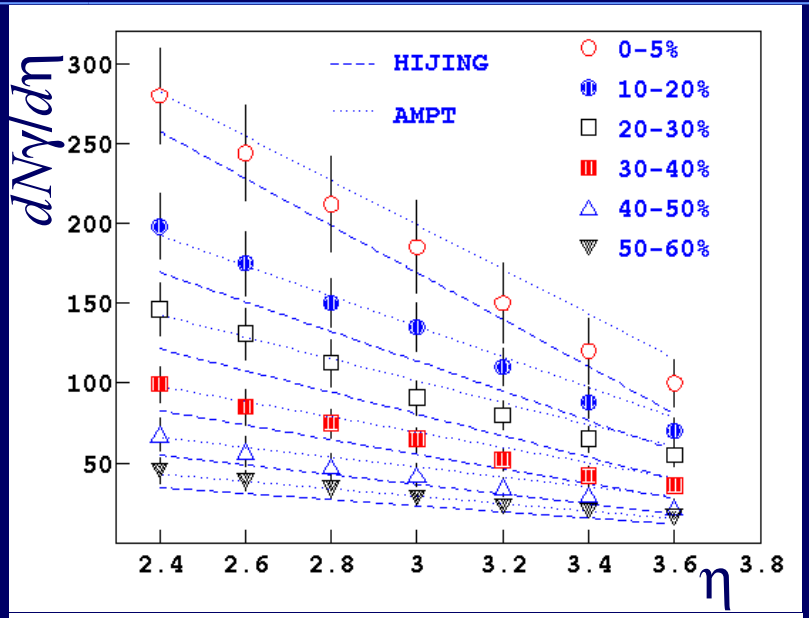
- Two planes CPV+Pre-shower
- Gas (Ar+CO_2) detector of 82944 hexagonal cells
- Detector area: 4.2 m^2
- Distance from vertex: 5.4 m
- $-3.8 < \eta < -2.3$ and full azimuthal coverage

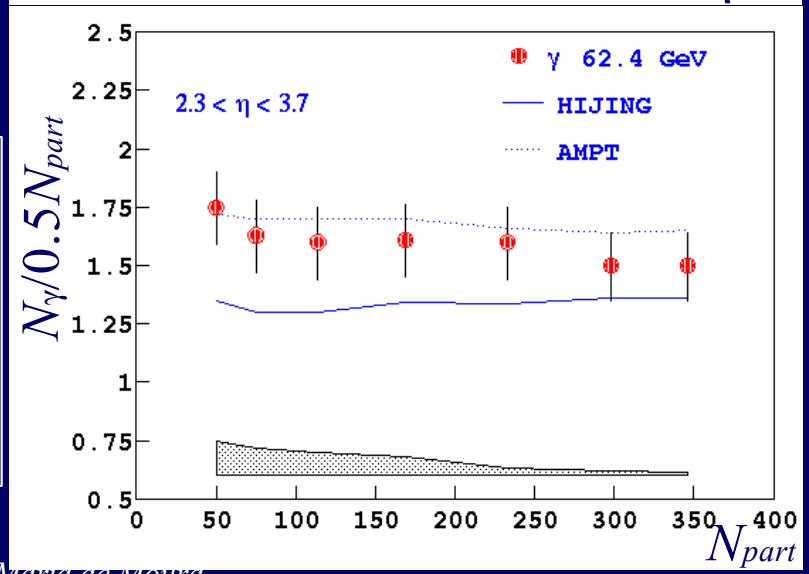
The CPV plane was not in present analysis

Photon Multiplicity Distribution

Minimum Bias Au+Au @ 62.4 GeV





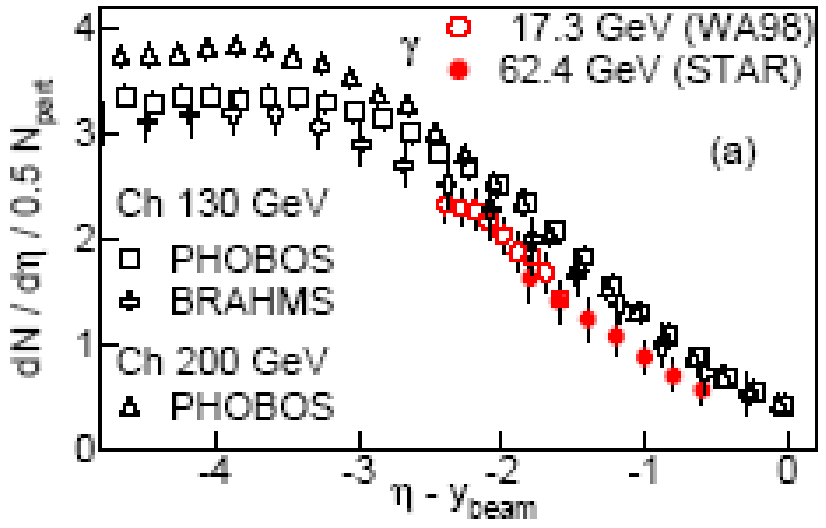


N_γ at forward rapidities scales with N_{part}

Better agreement to data of AMPT model than HIJING

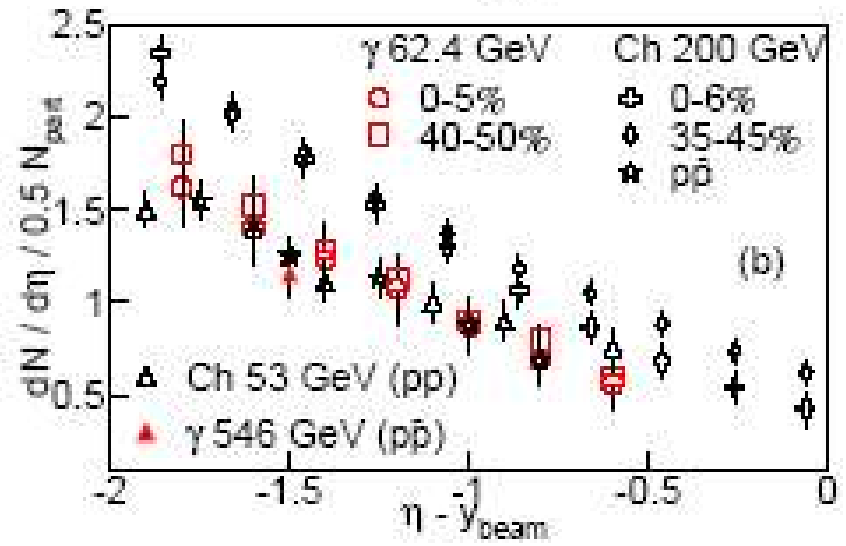
Limiting Fragmentation trend

Energy dependence



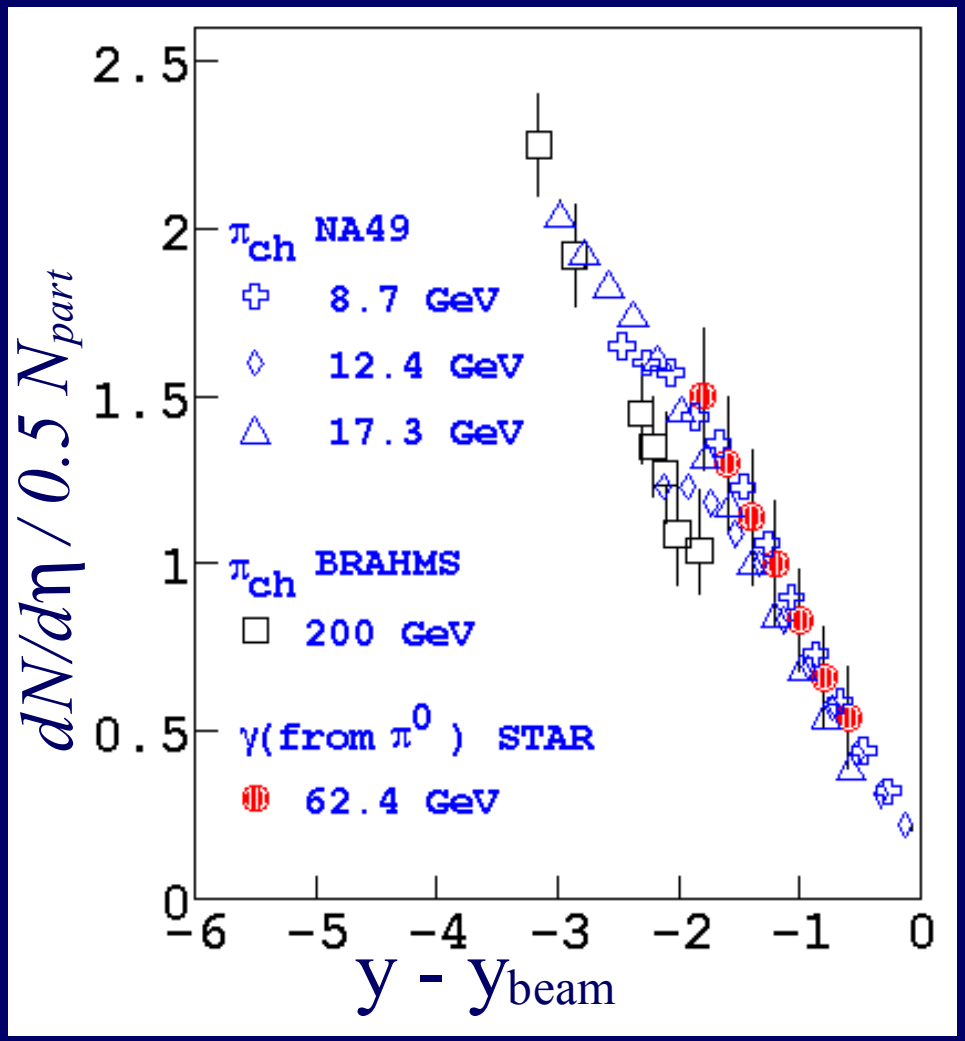
Photons undergo limiting fragmentation

Centrality dependence



No centrality dependence of limiting fragmentation for photons, unlike for charged particles

Limiting Fragmentation Scenario for π and γ



π production follows the LF scenario

Photon production is scaled down by about 7% to reflect the contribution from π^0

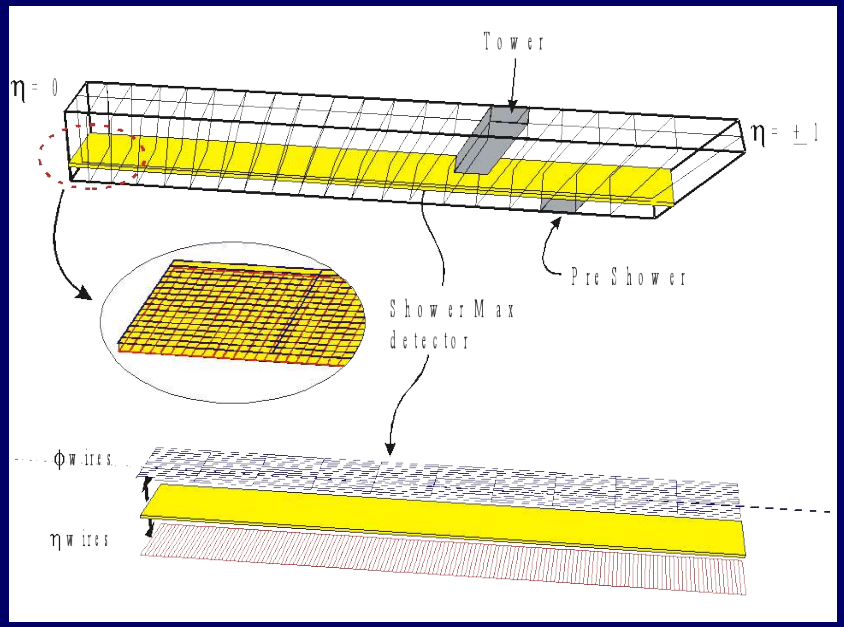
nucl-ex/0502008 - Submited to PRL

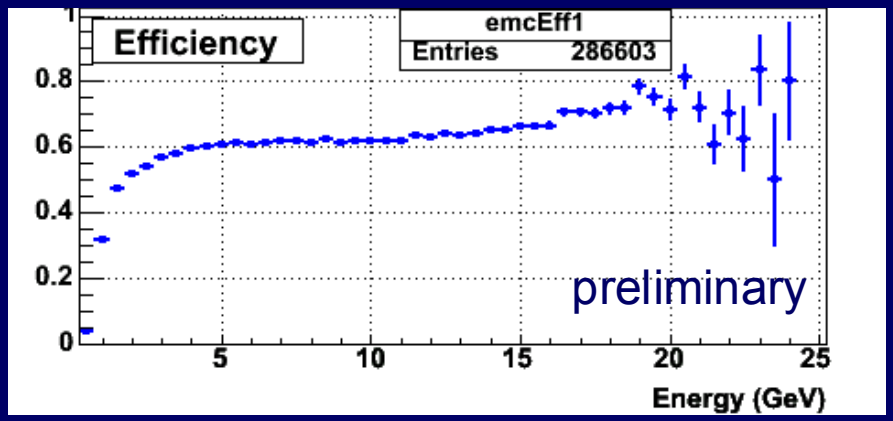
Direct Photon measurements for p+p and d+Au

- EMC measurements
  - Tower + SMD + pre-shower
- p+p and d+Au, towards Au+Au
- Direct photon spectra
  - Subtraction of background and contamination from inclusive spectra
    - π^0, η photon decays
    - other neutral contribution (n,K^0)
    - Contamination from charged hadrons
  - Acceptance/Efficiency corrections

Direct Photon Analysis Status

- Systematic studies of BEMC/BSMD
- Shower properties studies on BSMD
  - Cluster size, energy
  - Development of cluster algorhytm
- Acceptance/efficiency
  - d+Au π^0 embedded data





EMC module

Tower

$(\Delta\eta, \Delta\phi) = (0.05, 0.05)$

$\delta E/E \sim 16\%/\sqrt{E(\mathrm{GeV})}$

BMSD

$(\Delta\eta, \Delta\phi)$ strip= (0.007, 0.007)

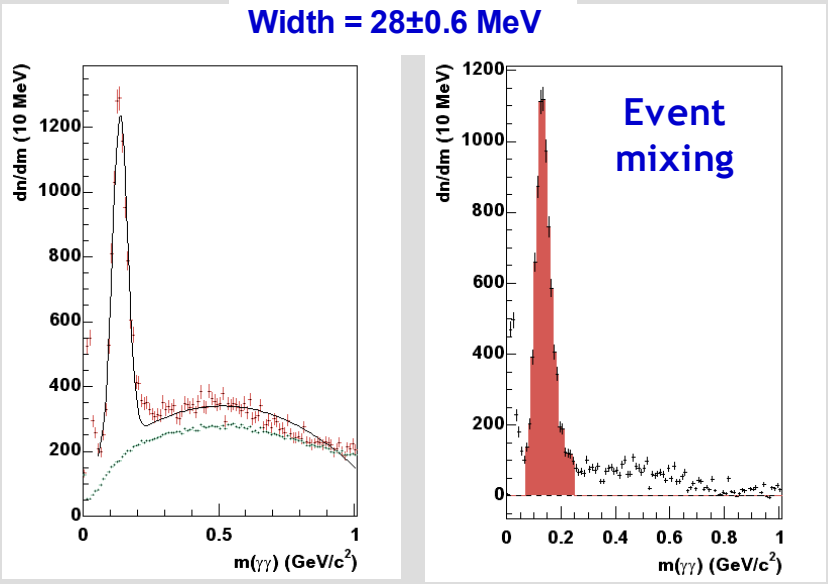
$\sigma_\eta = 2.4\ \mathrm{mm} + 5.6\ \mathrm{mm}/\sqrt{E(\mathrm{GeV})}$

$\sigma_\phi = 3.2\ \mathrm{mm} + 5.8\ \mathrm{mm}/\sqrt{E(\mathrm{GeV})}$

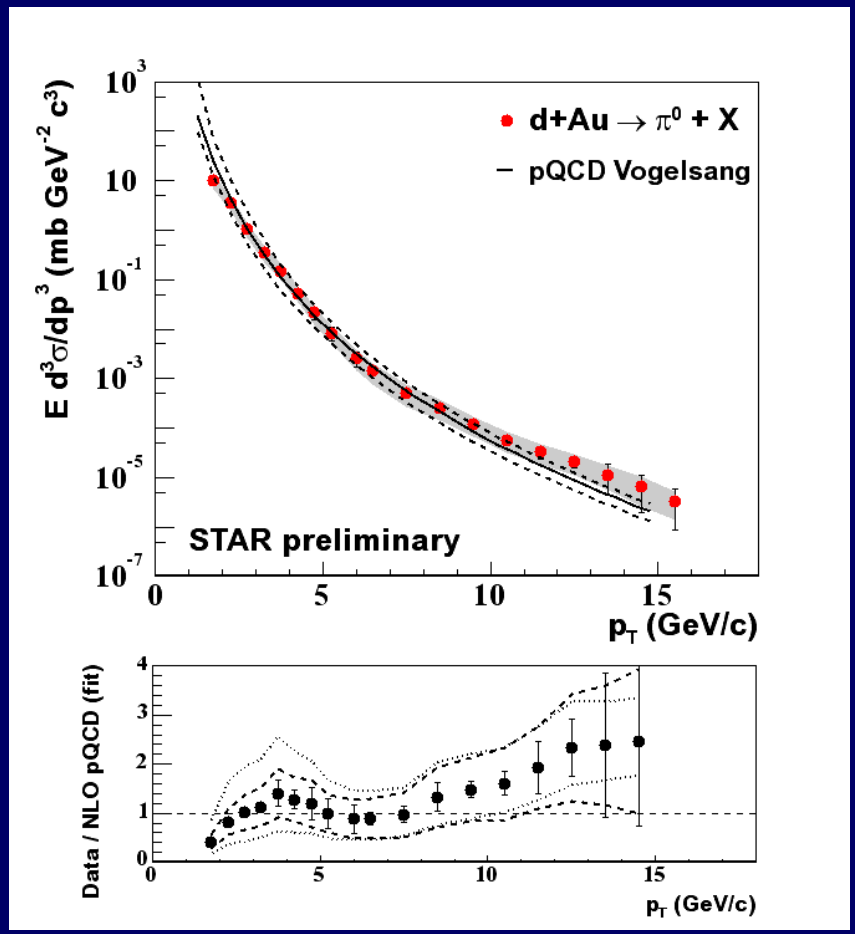
π^0 spectrum for d+Au collisions

From EMC measurements

Mass = 135±1 MeV
Width = 28±0.6 MeV



nucl-ex/0412045 – to be published in Eur. Phys. J. C.



Reasonable agreement with pQCD calculations within errors

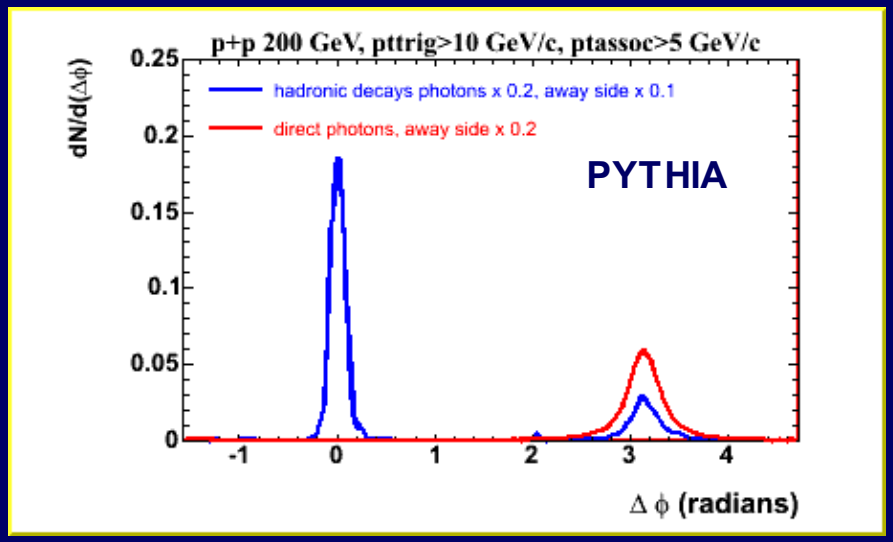
More to come...

Photon HBT (*Jack Sandweiss* talk)

Analysis of $q_{invariant}$ photon pairs distribution

HBT peak produced by direct photons

Investigation of spatial and temporal dimensions of QGP phase



γ-charged correlations in Au+Au

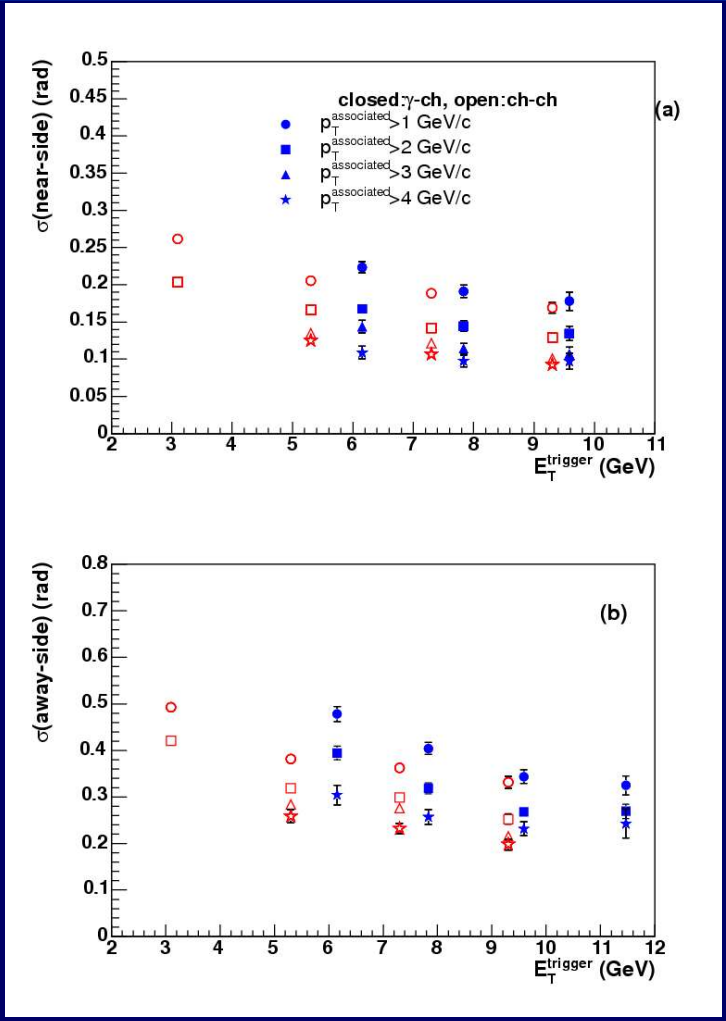
Potencial observation of away-side correlation from direct photons due to hadron (π^o) suppression

Investigation of parton energy loss

Back up slides

Near and Far side widths

Decrease with increasing E_{trig}



Decrease with increasing $p_T^{associated}$