measurement of photons via conversion pairs with PHENIX

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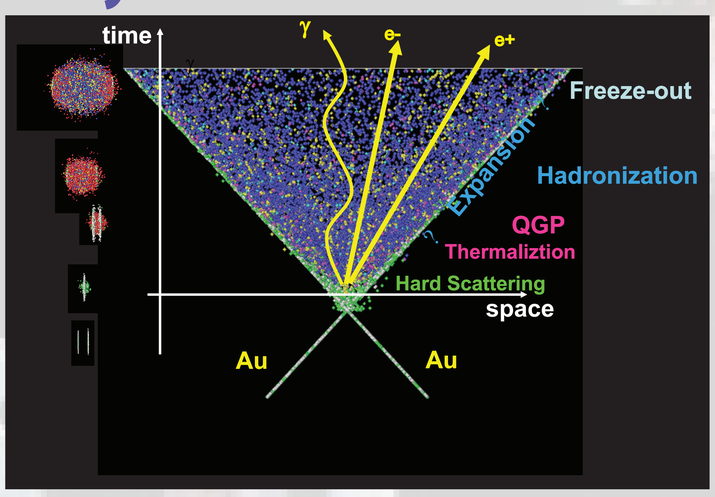
for the PHENIX Collaboration

Physics Motivations

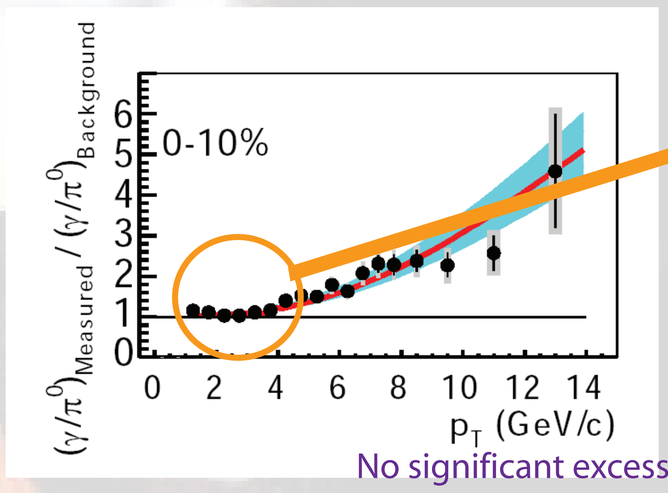


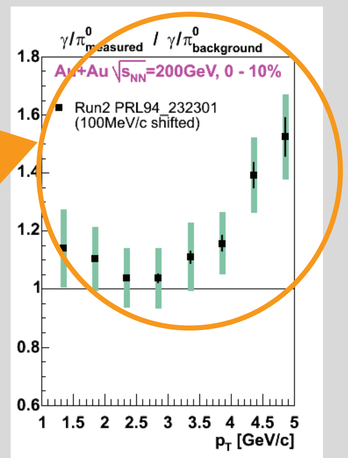
electro-magnetic radiation: γ, e^+e^-
rare, emitted "any time";
reach detector unperturbed by strong final state interaction
--> probe the full evolution of the collision

thermal γ (from QGP)
- quark-gluon Compton scattering qg->γq
- quark-antiquark annihilation q$\bar{q}$->γg
- bremsstrahlung

(initial hard scattering)

Limitations of Calorimeter Measurement





No significant excess at intermediate pT

A new method: photon conversion in the beampipe

Clean photon sample: e+e- pairs from beampipe conversion
- clear photon identification
- very good momentum resolution of charged tracks at low pT

Procedure
- identify conversion e+e- pairs in the beampipe
- combine electron pairs from conversion with photons from EmCal
- do the same in Monte Carlo

Double Ratio: efficiency and acceptance corrections cancel out

ε_{pair} = e^+e^- pair efficiency
a_{pair} = e^+e^- pair acceptance
f = conditional probability of having a photon in the acceptance, once you already have the e^+e^- pair in the acceptance

DATA

$$N_\gamma^{incl}(p_T) = \varepsilon_{pair}\, a_{pair}\, \gamma^{incl}(p_T)$$
$$N_\gamma^{\pi^0\,tag}(p_T) = \varepsilon_{pair}\, a_{pair}\, \varepsilon_\gamma\, f\, \gamma^{\pi^0}(p_T)$$

MONTE CARLO

$$N_\gamma^{hadron}(p_T) = a_{pair}\, \gamma^{hadr}(p_T)$$
$$N_\gamma^{\pi^0\,tag}(p_T) = a_{pair}\, f\, \gamma^{\pi^0}(p_T)$$

ε_γ = γ efficiency

$$\frac{\left(N_\gamma^{incl}(p_T)/N_\gamma^{\pi^0 tag}\right)_{data}}{\left(N_\gamma^{hadr}(p_T)/N_\gamma^{\pi^0 tag}\right)_{sim}} = \frac{\gamma_{incl}}{\varepsilon_\gamma \gamma_{hadr}}$$

DOUBLE RATIO

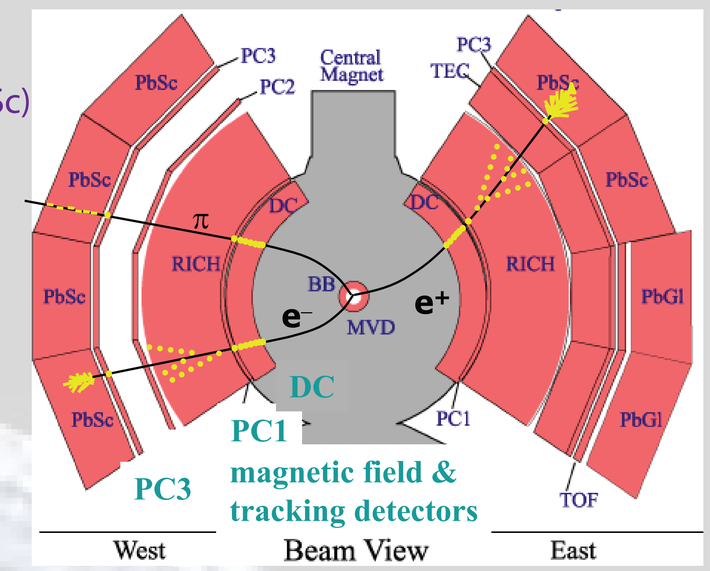
$$\Rightarrow \frac{\gamma_{incl}}{\gamma_{hadr}} = \varepsilon_\gamma \frac{\left(N_\gamma^{incl}(p_T)/N_\gamma^{\pi^0 tag}\right)_{data}}{\left(N_\gamma^{hadr}(p_T)/N_\gamma^{\pi^0 tag}\right)_{sim}}$$

everything cancels out except for ε_γ~98% → minimal systematics

Detector & Analysis

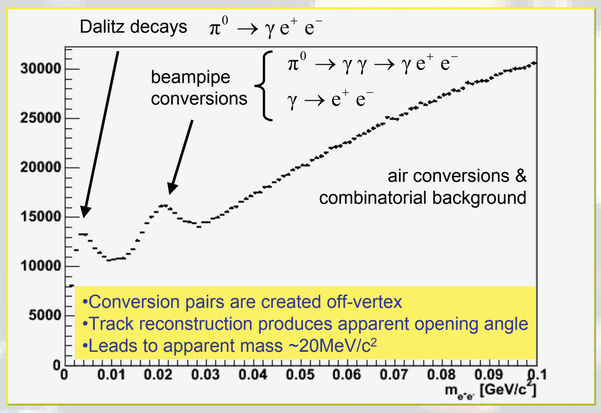
Photon ID
- EM shower EMCAL
  - Lead Scintillator Calorimeter (PbSc)
  - Lead Glass Calorimeter (PbGl)
- charged particle veto

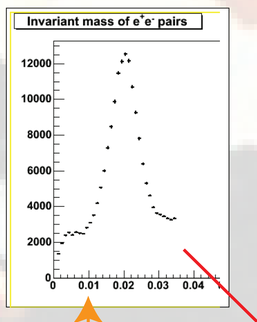
Electron ID
- Track
  - o Charged particle tracking:
  - o DC, PC1, PC2, PC3 and TEC
  - o Excellent mass resolution (1%)
- Cherenkov light RICH
- (EM shower EMCAL)



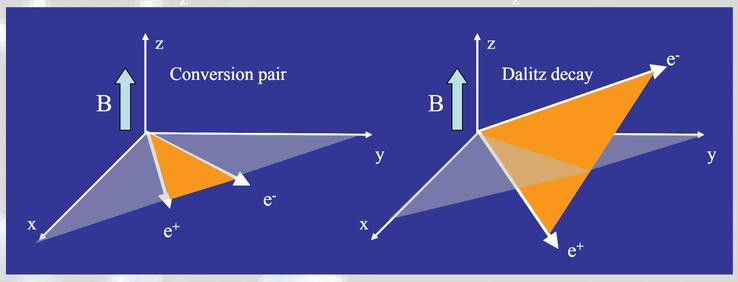
Data

Extraction of conversion photon



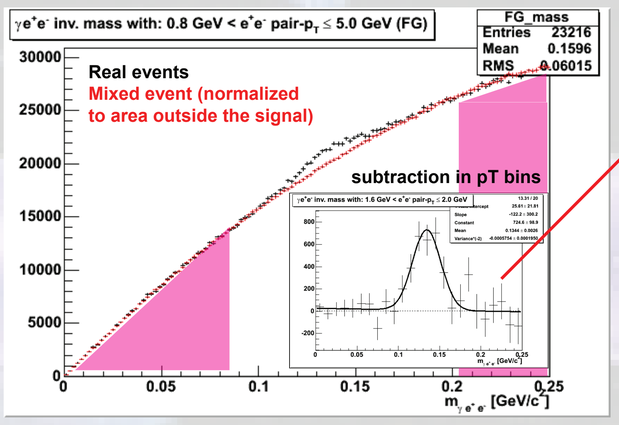


Conversion pairs have oriented opening angle in the plane perpendicular to B field



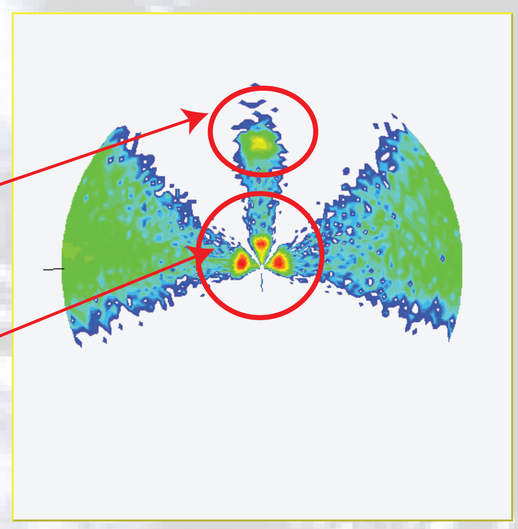
Extraction of π0 signal

All conversion pairs are combined with EmCal photons
Combinatorial Background calculated with event mixing
Normalization to area integral (pink)



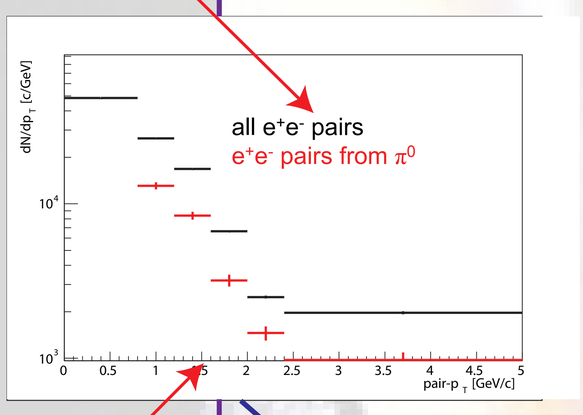
(Mis)reconstructed mass of conversion photon

Track reconstruction assumes vertex in the interaction point
-> conversion at radius r≠0 :
e+e- pair 'acquire' an opening angle
i.e. an invariant mass m = B dl ~ r > 0
(beampipe: r=4cm -> m=20MeV)

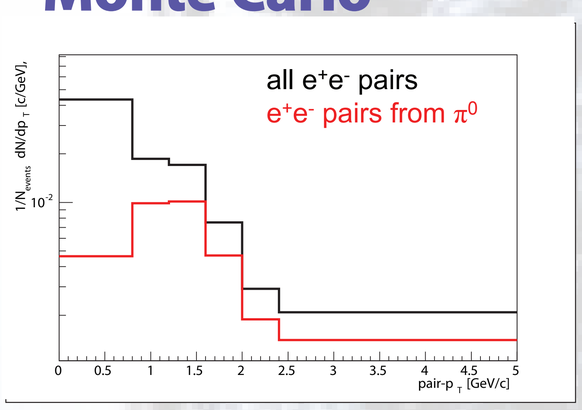


MVD support structures

beampipe

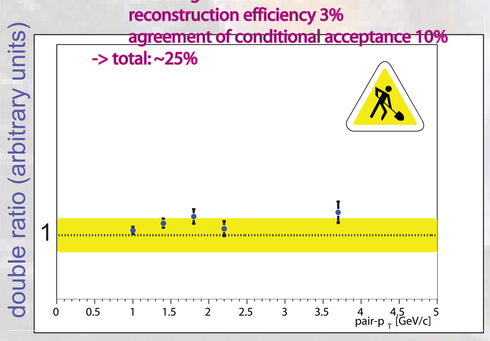


Monte Carlo



Inclusive photon spectrum
π0, η -> e+e-
- π0 parameterization from measured data
- η from mT scaling, yield normalized at high pT (0.45 from measurement)

Use Dalitz decay
(π0 -> γγ ~ π0 -> γγ* -> γe+e- for pT > 0.8 GeV/c)
All e+e- (from p0, h) in the acceptance
-> pT spectrum of e+e-
If γ from π0 is also in acceptance
-> pT spectrum of e+e- from π0

Double Ratio

Systematic uncertainties:
- conversion background 6%
- π0 background 20%
- reconstruction efficiency 3%
- agreement of conditional acceptance 10%
- -> total: ~25%