Measurement of photon conversions with the PHENIX experiment at RHIC

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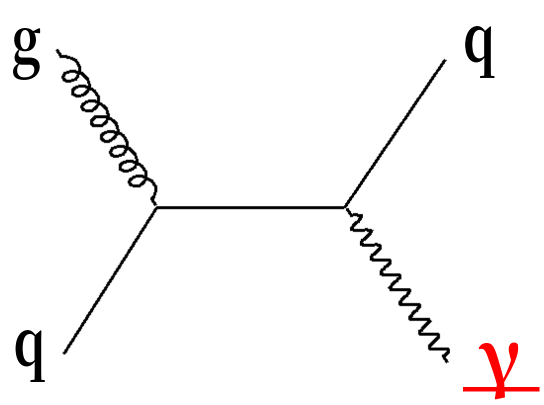
for the PHENIX collaboration

Quark Matter 2002, Nantes, France

Photon as a signal from QGP

Thermal Photon is one of important observable to probe early stage of collisions --- QGP

Thermal Photon excess will appear in less than 3GeV/c in some predictions.

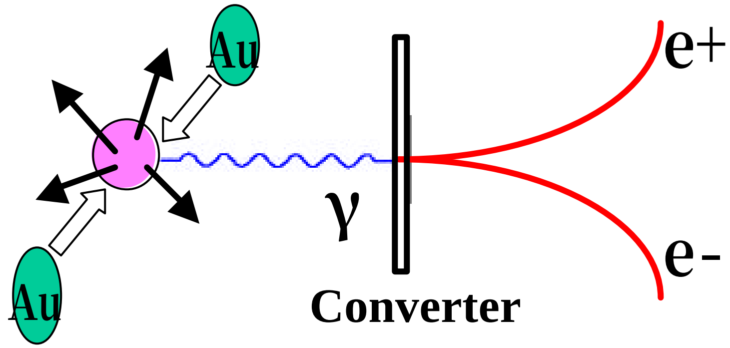


Photon is not affected by strong interaction in final stage of collisions

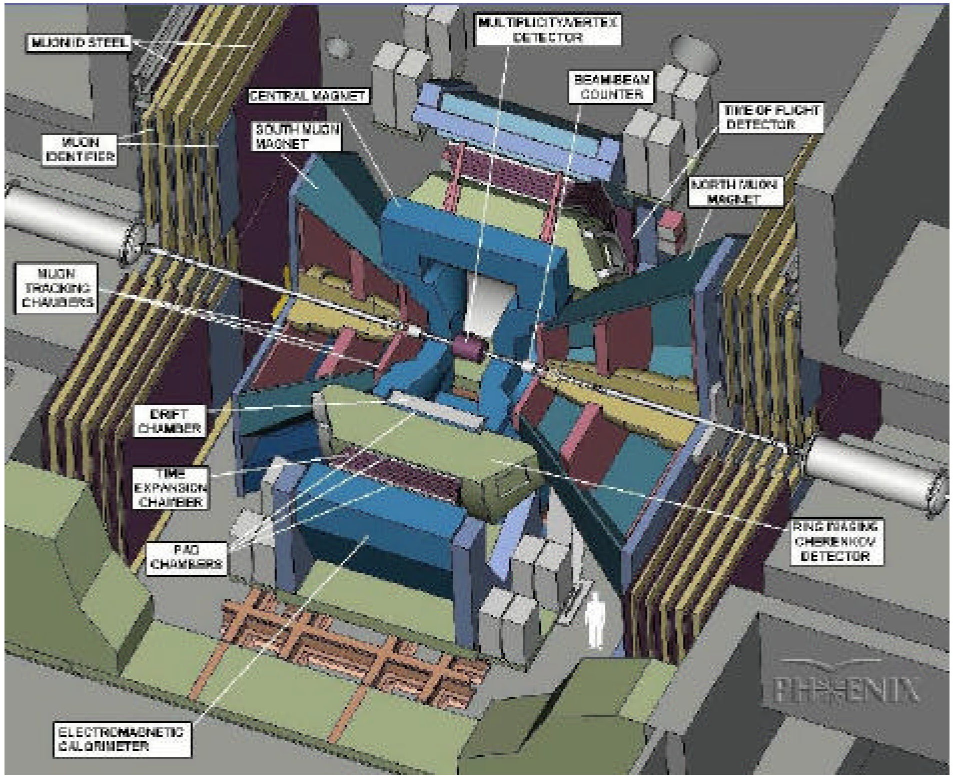
We can measure hot and dense matter directly.

The characteristics of QGP (Temperature, Energy Density) can be measured

We measure photon through their conversion into e+e- pairs



PHENIX Experiment



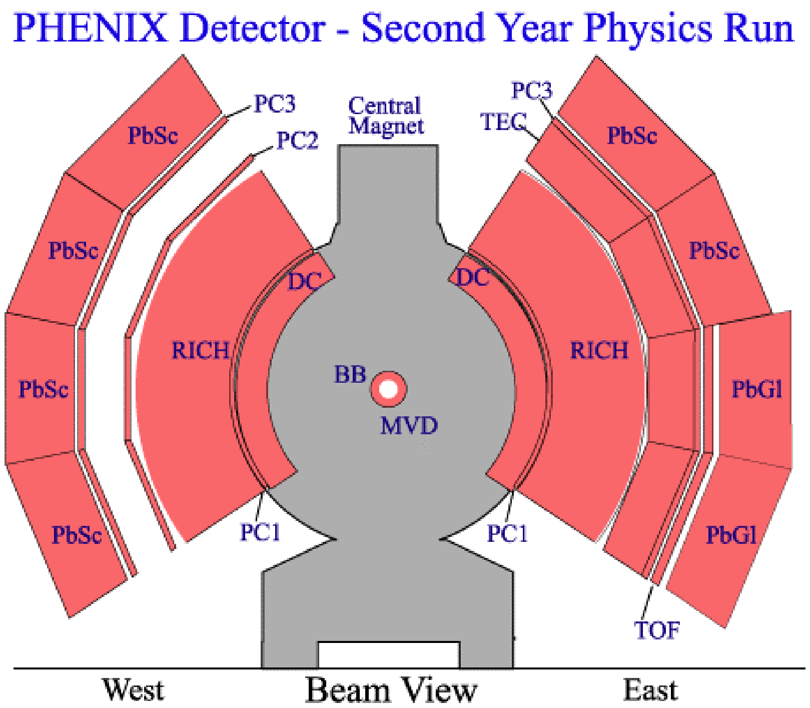
Purpose :

- Search for the signals from QGP produced $\sqrt{s_{NN}}$=200GeV, Au+Au collisions

Coverage:

Central Arm

- -0.35 < ? < 0.35
- 30? < |?| < 120?



Trigger

- Beam Beam Counters
- Zero Degree Calorimeters

Collision vertex

- Beam Beam Counters

Photon Measurement via Photon Conversion

Photons convert e+e- pairs in beam pipe and MVD outer shell

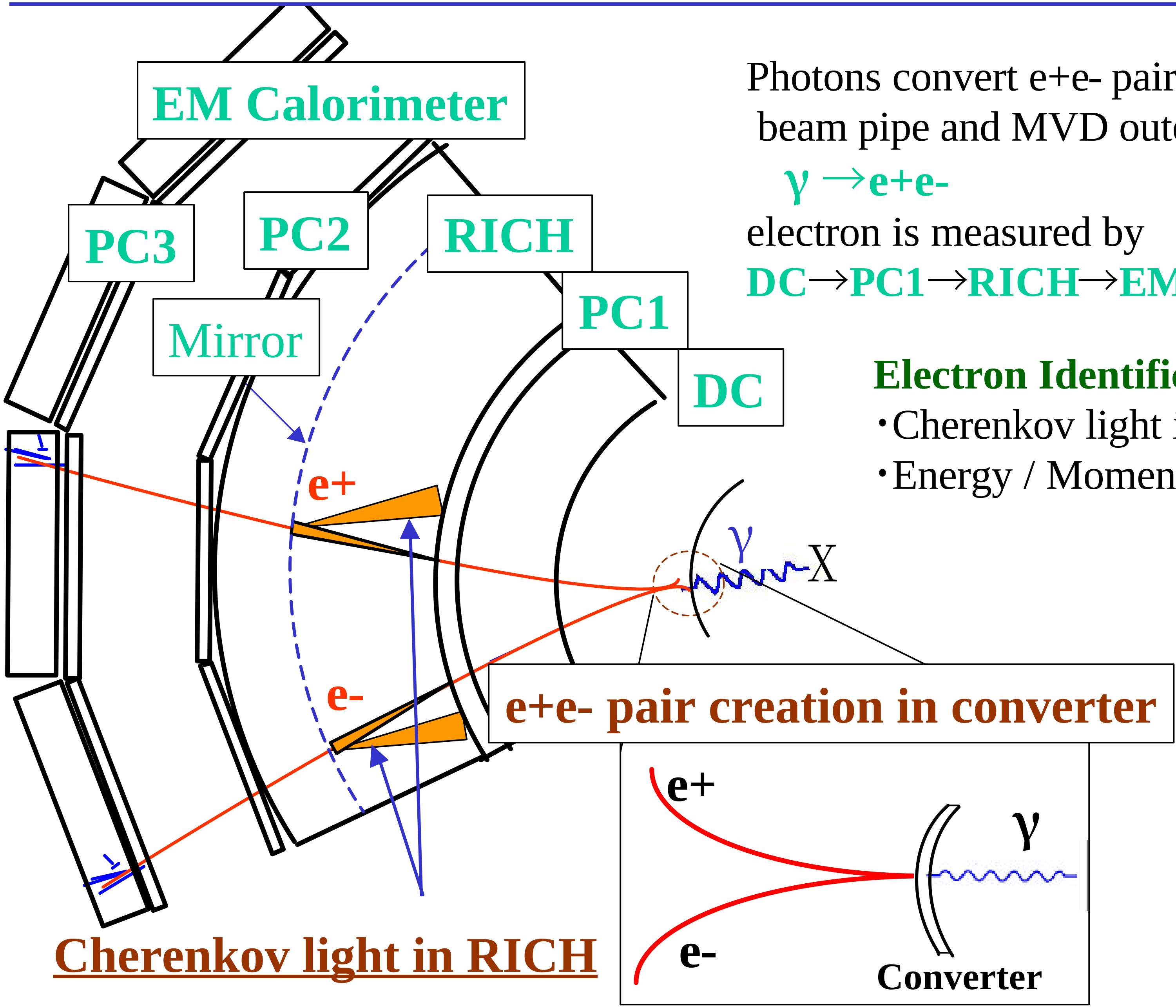
$\gamma \rightarrow e^+e^-$

electron is measured by

DC→PC1→RICH→EMCal

Electron Identification

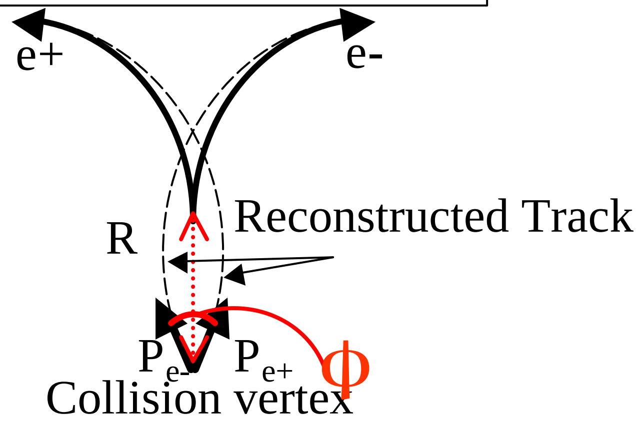
- Cherenkov light in RICH
- Energy / Momentum ratio(**E/p**)



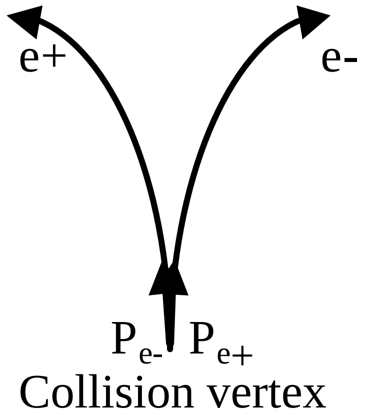
Shift of Invariant Mass

Our tracking algorithm always require position of collision vertex.
For photon conversion at R!=0, opening angle of e+e- pair is reconstructed effectively large. It is affected to Mee value.

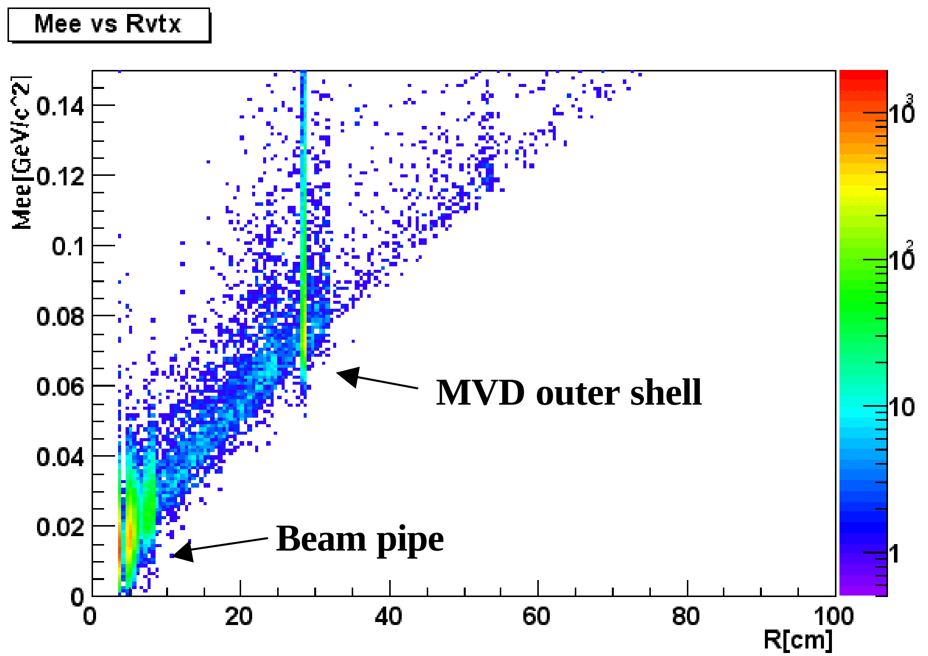
Case 1 : conversion at R!=0



Case 2: e+e- pair from collision vertex



Result from MC of photon conversion



Position of photon conversion

Invariant Mass Spectrum of e+e- pairs

Event selection:

- |Z|< 30cm
- Min. bias event sample

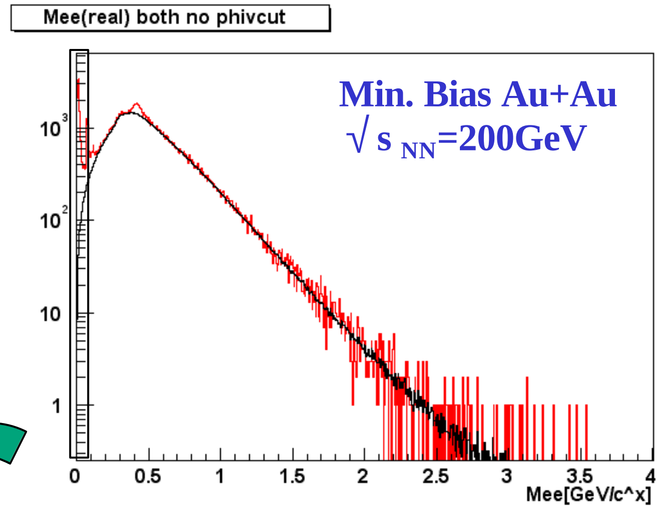
Electron ID:

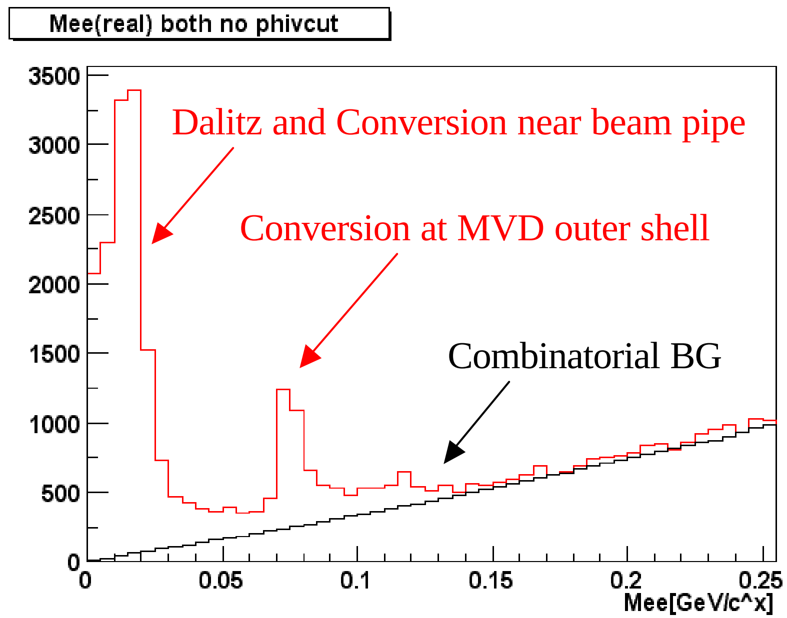
RICH variables

- N0>=3, (HitPmt)
- N3>=1,
- ?^{2}<10, (Ring shape cut)
- disp<5, (Ring/Track association)
- (E-p)/p/? >-2,
- Temc-Texp<2

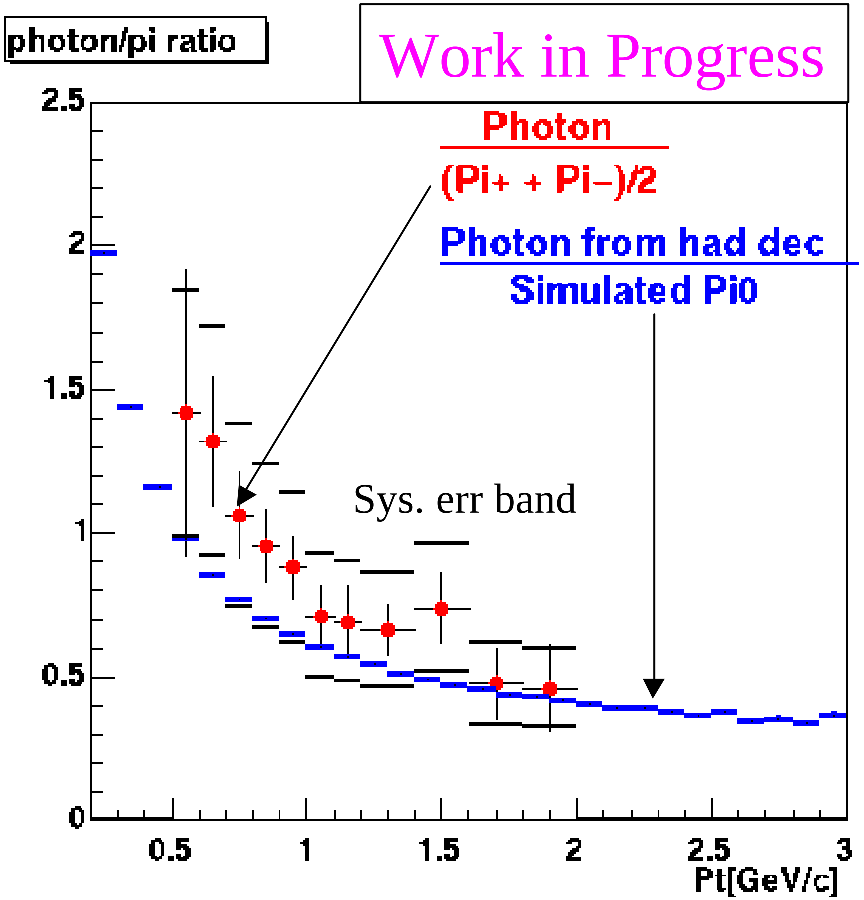
Red : Real

Black : Combinatorial BG





γ / π ratio in Data and Simulation : Run 1 Status

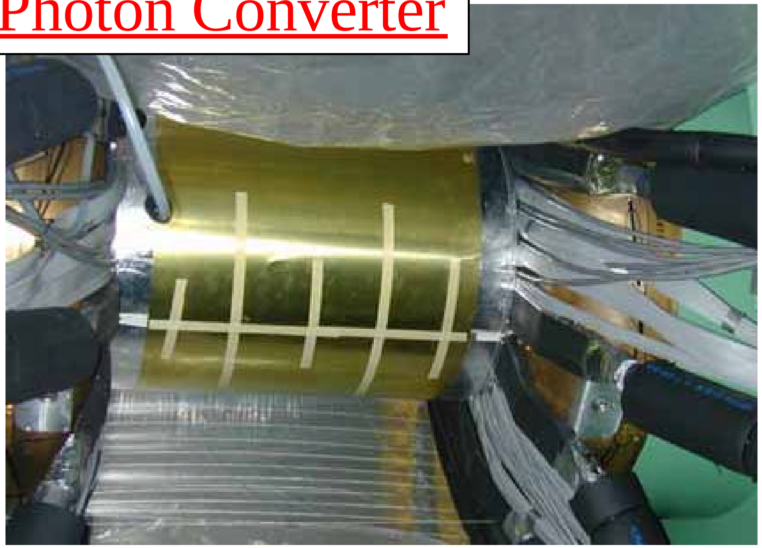


- γ / π is measured in Run 1 data.
- Systematic Error in data is roughly 30% (black band)
- γ / π from Data is not inconsistent with expected γ / π ratio within Systematic & Statistical Error.

We have much larger statistics in Run 2.

Photon Converter in Run 2

Photon Converter



Photon Converter :

- Brass shim
  (Zn:30 Cu:70%,)
- 600mm*2 π *0.254 mm
- Rad. length : 1.7 %

Special runs with a photon converter.

Benefit of the converter

- We can measure the conversion pairs from the converter.
- We can measure the single electron from the conversion
- We can know the efficiency of electron completely

By using with and without the converter

$$N^{Conv}_{ee} ? ?^{e?} ?^{e?} ? ?^{Geom}_{ee} ? ?^{Conv} ? N_{?}$$

$$N^{Conv}_{e?} ? ?^{e?} ? ?^{Geom}_{e?} ? ?^{Conv} ? N_{?}$$

$$N^{Conv}_{e?} ? ?^{e?} ? ?^{Geom}_{e?} ? ?^{Conv} ? N_{?}$$

Known value

Calculated by MC

It is a powerful tool

Statistics in Run 2

Comparison of statistics (min. bias)

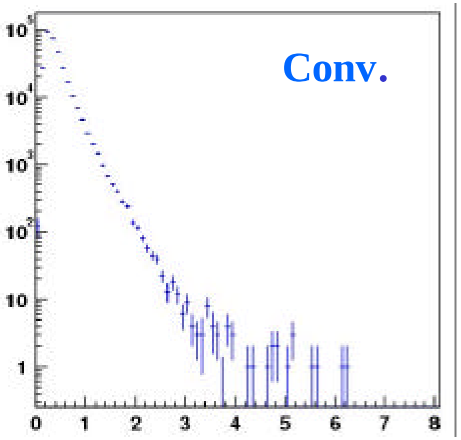
Run 1		: 1.3M
Run 2	Converter	: 5M
	W/O converter	: 30M
Total min. bias events		: 35M

Acceptance is 4 times larger than Run 1

27 x 4 times larger statistics

Method 1: Measurement of e+(e-) from the conversion

Un-corrected P_t Spectra of electron



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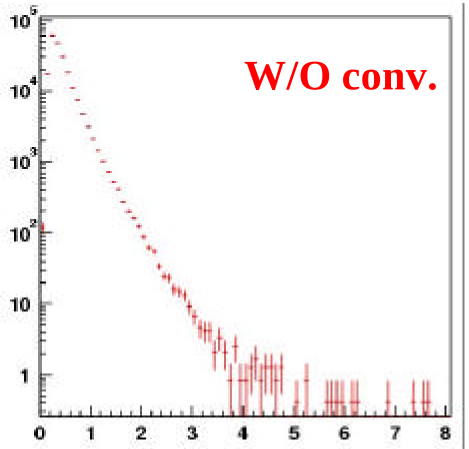

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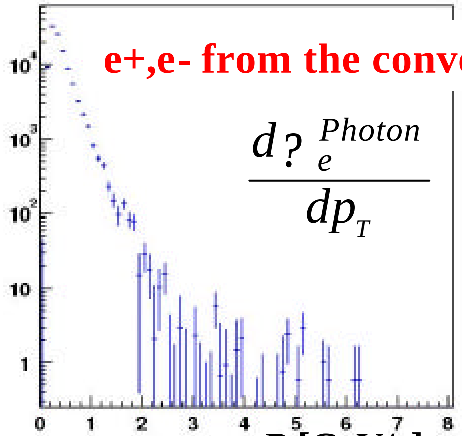


$$\frac{d?_e^{Photon}}{dp_T}$$

We can measure electrons from **purely photon conversions**.

? Photons can be measured.

$$\frac{d?_e^{Photon}}{dp_T} ? \frac{d?_?}{dp_T}$$

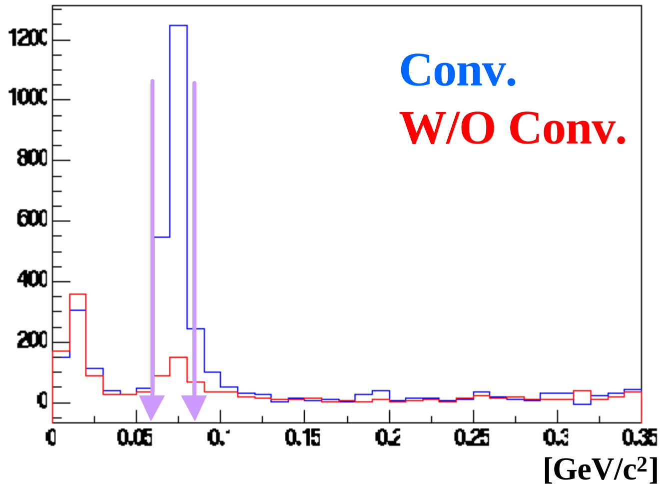
- We can also measure inclusive electrons ----- including charm decay.

$$\frac{d?_e^{Inclusive}}{dp_T} ? \frac{d?_e^{Photon}}{dp_T} ? \frac{d?_e^{prompt}}{dp_T}$$

Link : Ralf Averbeck 7/22(Mon) Leptons/Photons

Method 2: Measurement of e+ e- pairs

Invariant mass

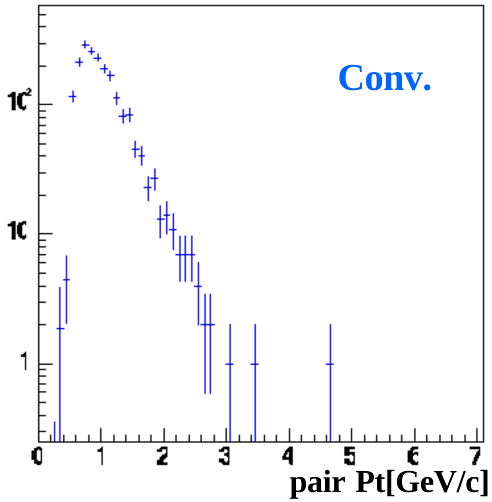


- Combinatorial BG is subtracted
- Clear peaks are shown at 75MeV

Mass region in 60MeV<Mee<85MeV is used.
--- e+e- pairs coming from the conversion

Need to correct the tracking efficiency, etc.

Un-corrected P_t spectra of e+e- pairs



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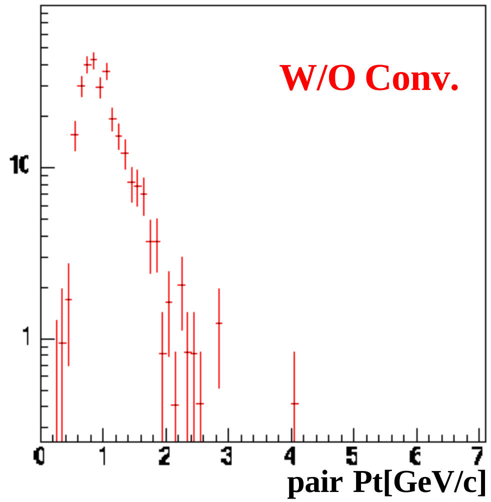

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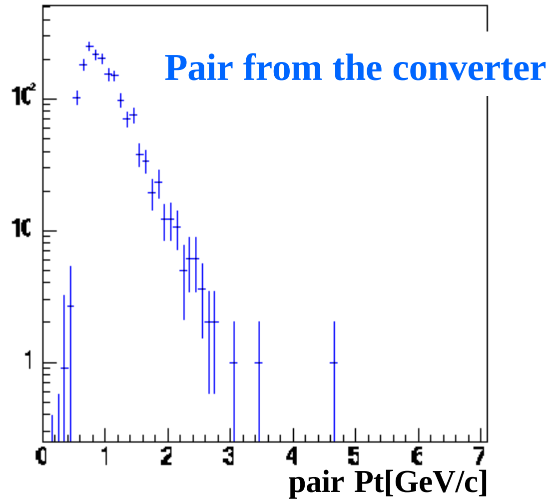
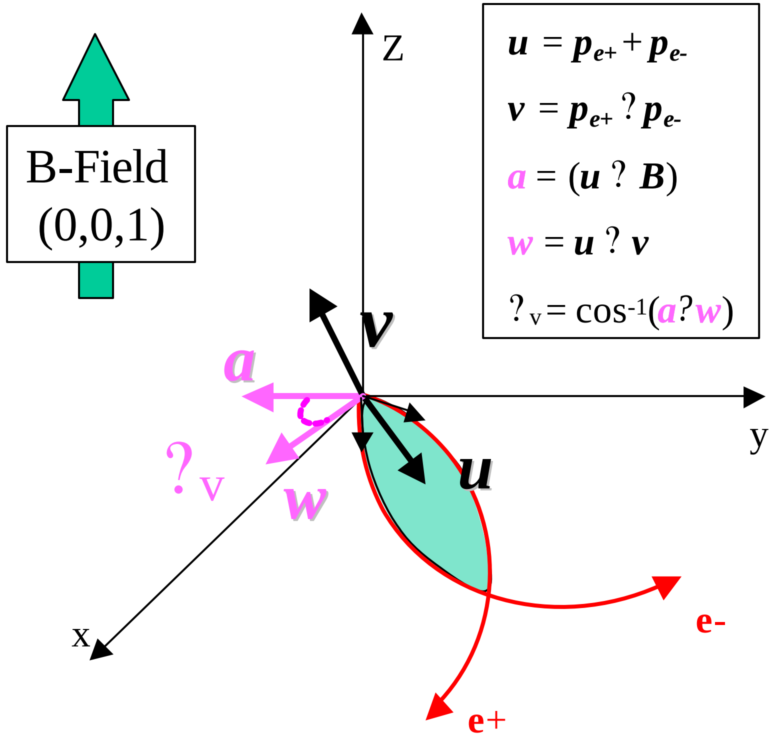
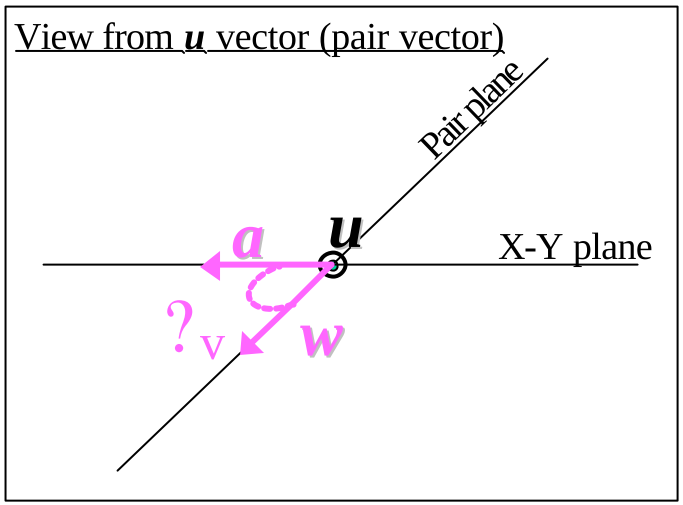


Conversions / Dalitz separation





Reconstructed momentum vectors of e+e- pair made a plane(pair plane). If e+e- pairs come from photon conversion at R!=0, the plane is apparently made by B-field. Therefore, the plane is always perpendicular to B-field.

On the other hand, If e+e- pairs come from the collision vertex, for example Dalitz decay, pair plane is not perpendicular to B-field and randomly rotated to B-field.

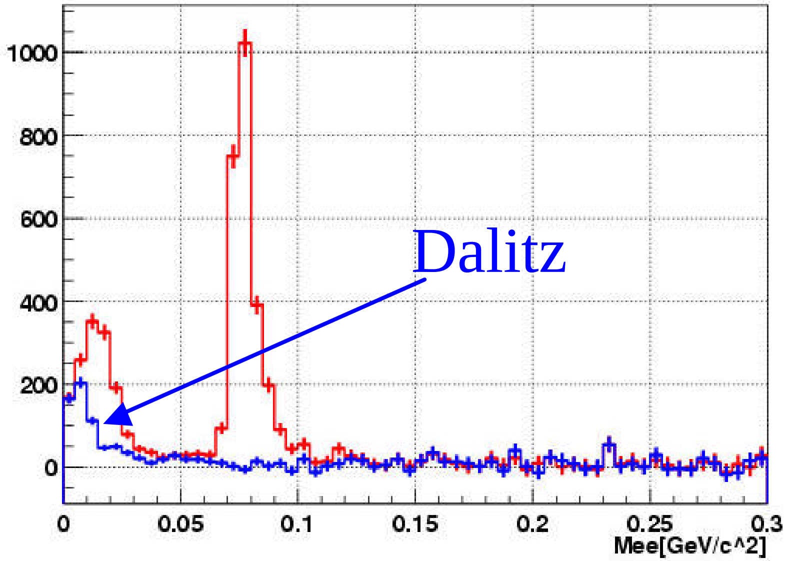
Those characteristics is quantified as the rotation angle $?_V$ between pair plane and X-Y plane on the pair vector(***u***) as a rotation axis, where X-Y plane is perpendicular to B-field. $?_V$ angle and some vectors are explained in left two figures.

Using the characteristics, we can separate whether the pair is from the conversion or not.

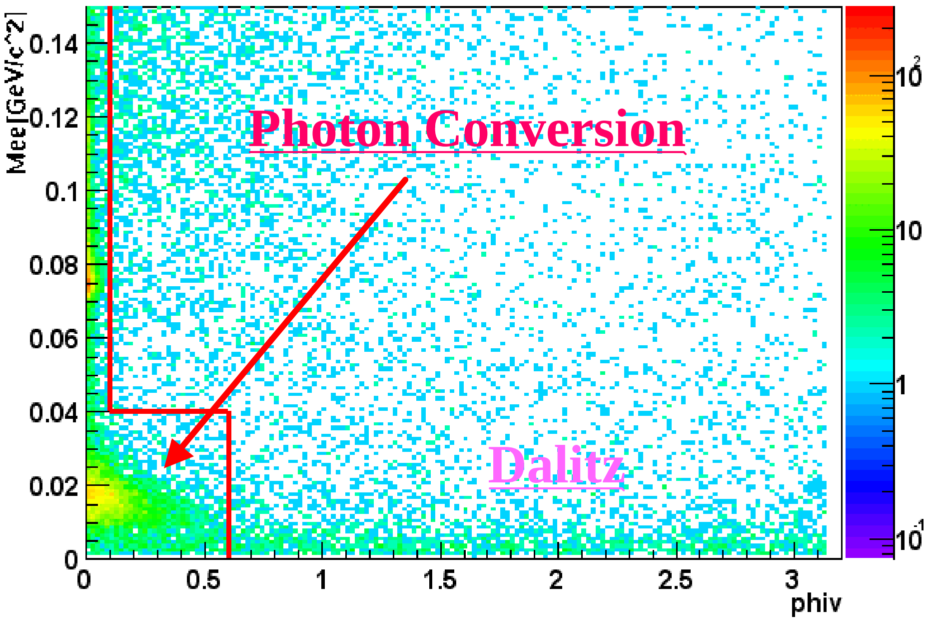
Conversions / Dalitz separation

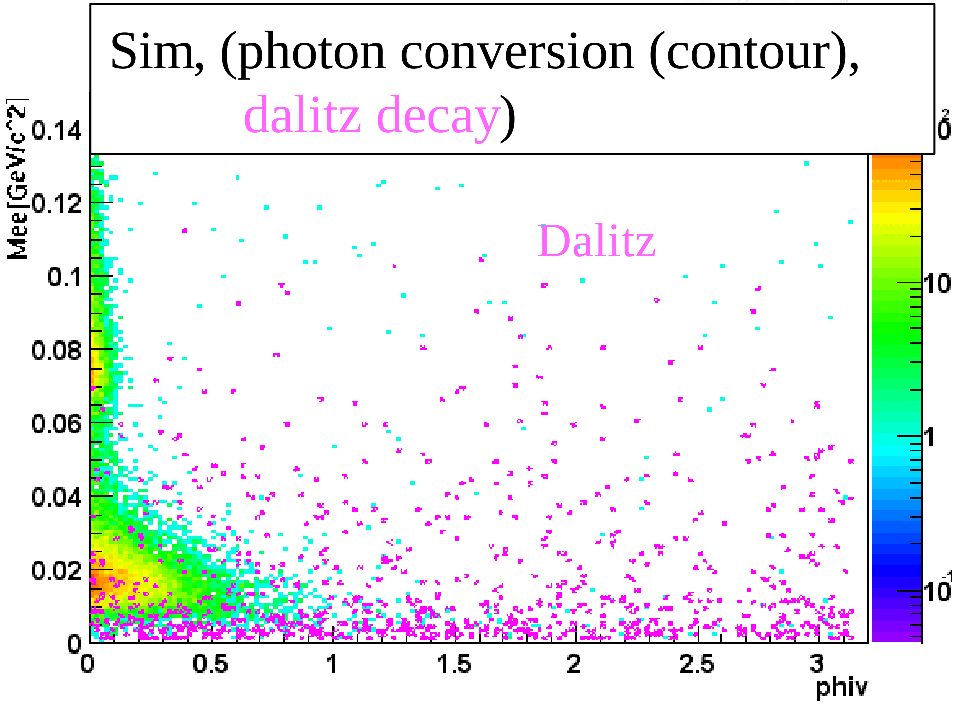
Even if we separated conversions from dalitz decays by ?$_{v}$, there are still small contributions from dalitz decay.

Those dalitz conponents in the separated conversion pairs are estimated as 32% from the simulation.

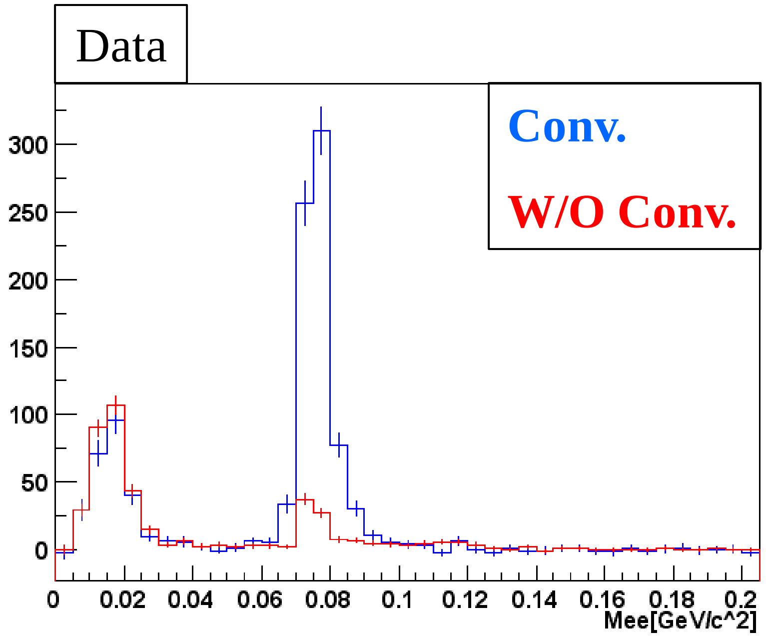


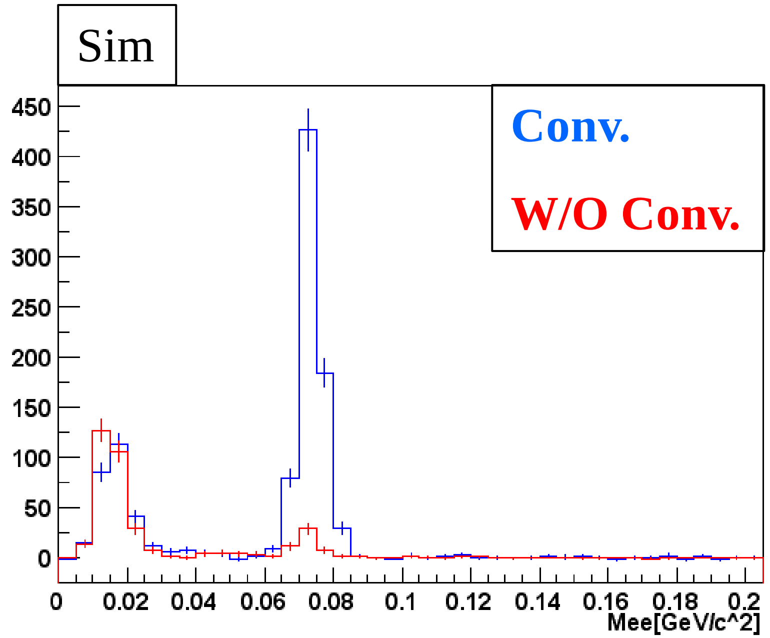
M($e^{+}e^{-}$) vs ?$_{v}$





Comparison Mee: Data/Simulation





Data : $\frac{N(w ? conv)}{N(w/o ? conv)}$? 2.67

Sim : $\frac{N(w ? conv)}{N(w/o ? conv)}$? 2.51

Amount of materials in real PHENIX and simulation are very similar.
But there is small difference around 75MeV peak (R=30cm)

Summary

- We have started the photon conversion analysis in Au+Au collisions at ?s_{NN}=200GeV.
- Large statistics (35M events) is obtained in Run 2 .
- Comparison of the data taken with and without the converter is useful for photon measurement.
- Clear conversion peak in Mee is shown.
- (Un-corrected) Pt spectra of conversion pairs and single electron from photon conversion are measured.
- Simulation work for estimating the acceptance and efficiencies is working in progress.
  - Amount of the material are similar with real PHENIX.
  - ?$_V$ method can separate the Conversions from Dalitz decays.

Backup Slide

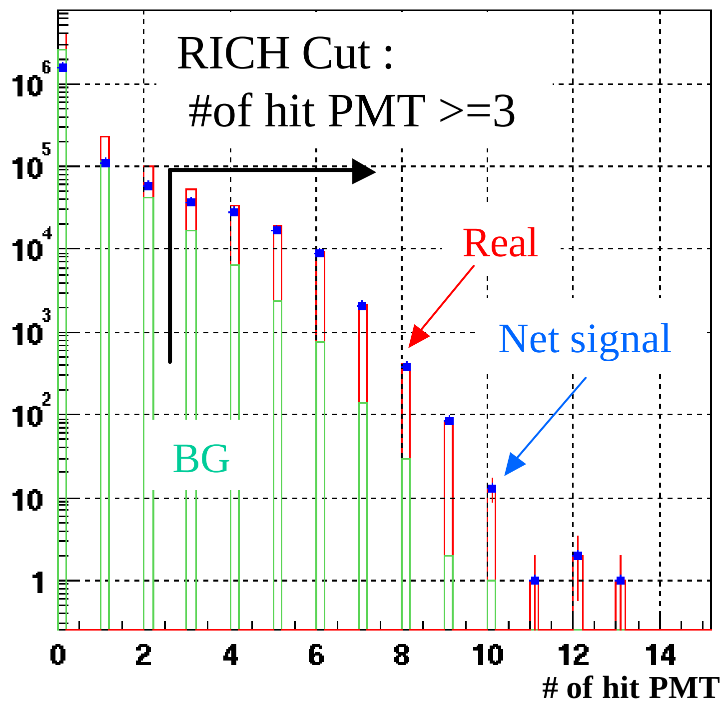
Electron Identification

RICH – our primary eID device
- Number of Hit PMT per electron track
- ?2 of Ring shape

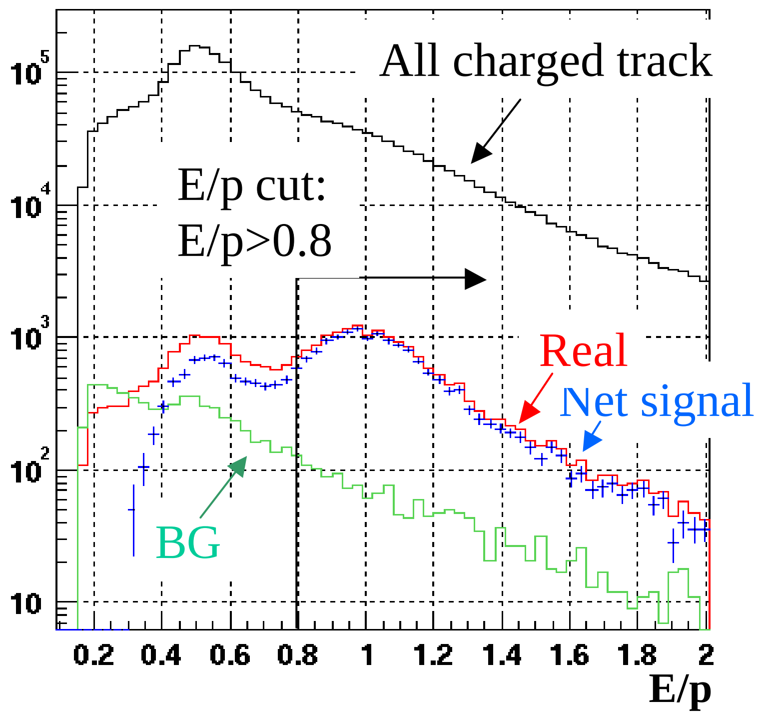
E/p matching – reject hadron Background

E : Energy measured by the EMCal
p : Momentum measured by the Dch.
The peak at E/p=1 is electron signal

# of hit PMT



E/p ratio



Electron signals are clearly measured.

Comparison Data with expected photon from hadron decay

To evaluate photon yield, Photon/Pion ratio from data is compared with expected Photon/Pion from hadron decay.

- Both of Photon and Pion yield are measured at PHENIX.

Expected photon yield from conventional photon source (neutral mesons decay)

- π^0, η, η', ω are taken into account.
- Pt slope of π^0 is obtained by fit to the average of PHENIX charged π data with power low function
- Pt slopes of other hadrons are obtained by mT scaling of π
- η/π^0=0.55, η'/π^0=0.25, ω/π^0=1.0 at High Pt from p+p data

PHENIX RICH

Our mail electron ID device

- RICH with EMCal and TEC can reject 10^{-4} hadron BG
- Placed on Central Arm Spectrometer
  - |y| < 0.35 ; df = 90 degrees x 2
- Cherenkov radiator
  - CO_2(g_{th} ~ 35)
  - eID p_t range : ~ 4.9 GeV/*c*
- Total number of PMT in RICH
  - 5,120
- Volume $40m^3$