Analysis of π^0 & direct γ in the large 2014 200 GeV Au+Au/PHENIX dataset

23rd ZIMÁNYI SCHOOL
WINTER WORKSHOP ON HEAVY ION PHYSICS

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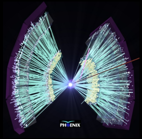
Debrecen University & PHENIX Collaboration



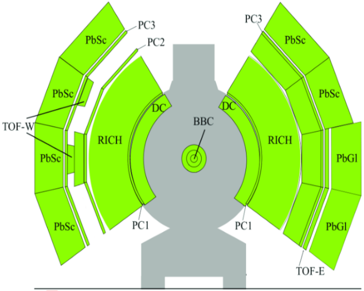
UNIVERSITY of DEBRECEN

Outline

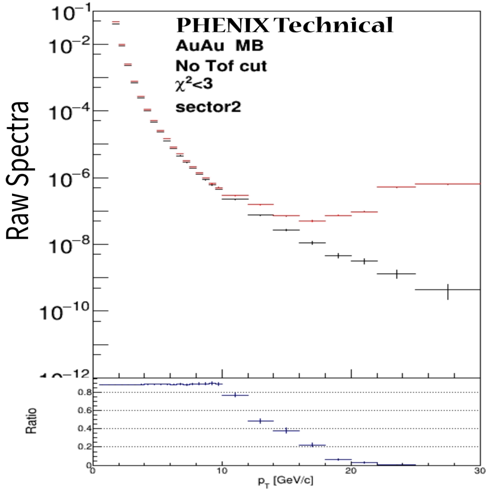
Introduction

About PHENIX Experiment

The PHENIX experiment pioneered measurements of nuclear modification factor of neutral pions and photons, providing strong evidence of the formation of Quark-Gluon Plasma (QGP) in Au+Au collisions at RHIC. In 2014 large amount of 200 GeV Au+Au data were collected, vastly exceeding the statistics of all similar data taken earlier. This makes it possible to extend the transverse momentum range of the neutral pion and photon measurements and improve the systematic uncertainties. We report on the status of this new analysis.



PHENIX Trigger Systems& Data Quality Control



PHENIX Trigger Systems:

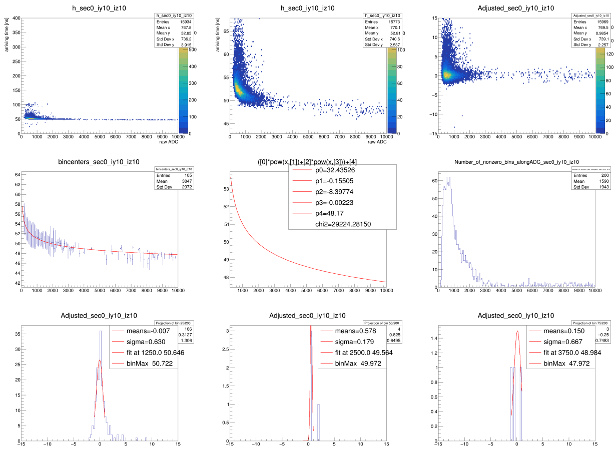
•Event Counter for minimum Bias(MB).
= 1.1222049984000000e+10
•Event Counter for EMCal/RICH(ERT).
= 1.4480652900000000e+08

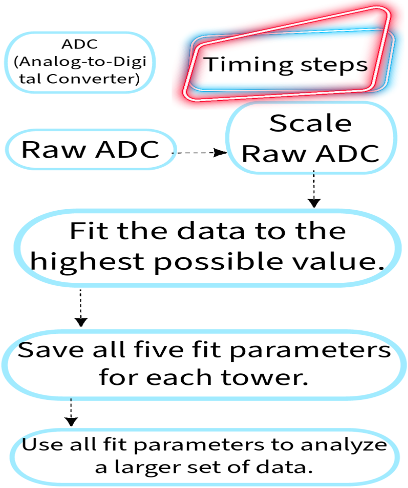
Data Quality Control:

Malfunctioning calorimeter towers are excluded by using the “Dead Hot Map”.
Red: The raw inclusive photon without “DHM”.
Black: The raw inclusive photon with “DHM”.

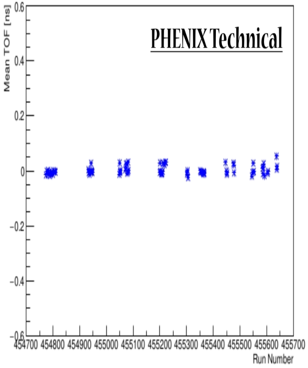
Analysis steps

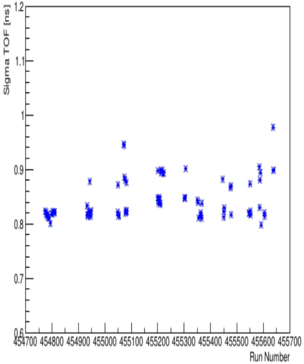
Slewing correction using photons





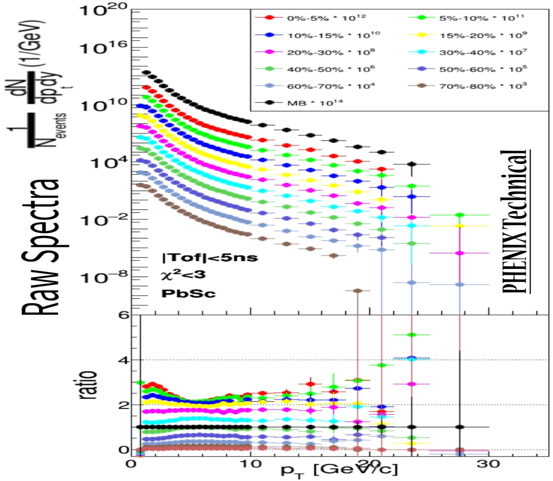
Here, we display the mean & the sigma of TOFs for each individual run:





According to PHENIX convention the TOF for photons is 0 (the collision vertex and impact-position dependent “flash time”, i.e. the expected flight time of the photon from the collision vertex to the impacted tower, is subtracted). This makes the timing cuts on photons much more simple and transparent.

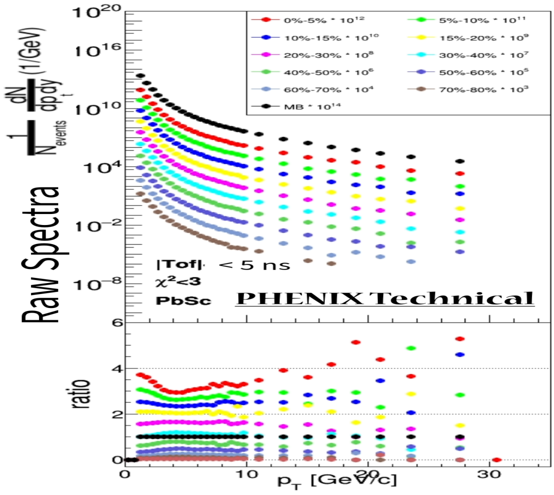
Raw π^0 Spectrum minimum Bias(MB)



Coincidence of one or more photo tubes firing in the north and south beam-beam counters (BBC) serves as the minimum bias trigger. Total charge in the BBCs is used to determine centrality.

The Fig. shows the raw yield of π^0 in centrality bins (upper panel) and the ratios of individual centrality to "MB" (lower panel).The 0-5% class means the most central collisions.

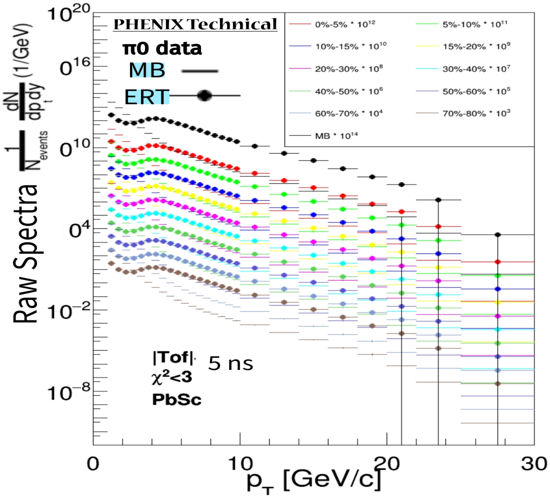
Inclusive photon spectrum minimum Bias(MB)



This spectrum includes all photons that pass the PID cuts and get reconstructed in the EMCal. It is the same method to the π^0 spectrum with regard to the of timing cuts and particle identification.

Fig: The inclusive photon spectrum in centrality bins (upper panel) and the ratios of individual centrality to MB (lower panel).The 0-5% class means the most central collisions.

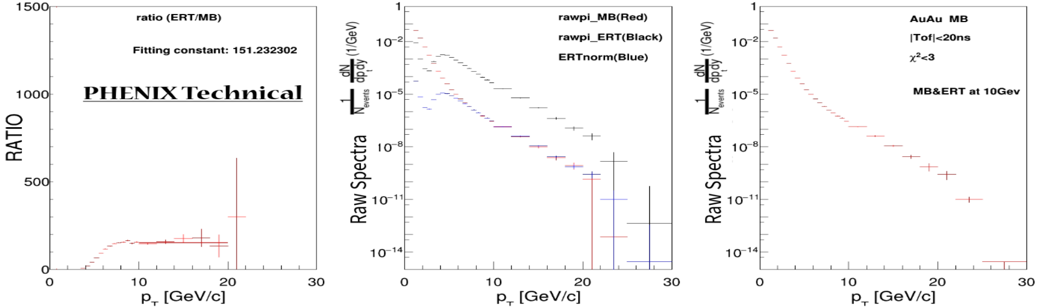
Raw π^0 Spectrum (ERT)



- PHENIX also took data with a high energy deposit trigger (ERT) to enhance rare (high p_T) events in the data sample.
- The raw yield of π^0 in centrality classes for MB & ERT trigger
- The raw π^0 spectra from the MB trigger (BBCLL1 > 0 tubes narrowvtx referred to as MB trigger) and ERT-triggered data-sets need to be merged into a single continuous spectrum.

Combining The ERT and minimum Bias(MB) Spectrum for π^0

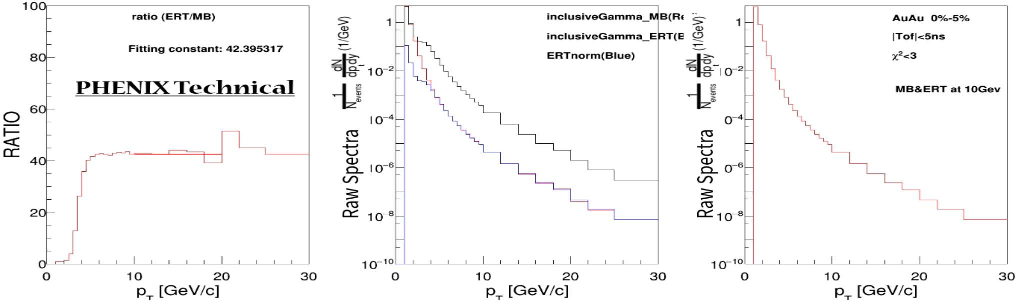
To merge into a single continuous spectrum we normalize one data-set to the other using a fit to the ratio in the overlap region(10-12 GeV).



Left: ERT/MB ratio& fitting. Middle: Normalized MB&ERT. Right: MB&ERT.

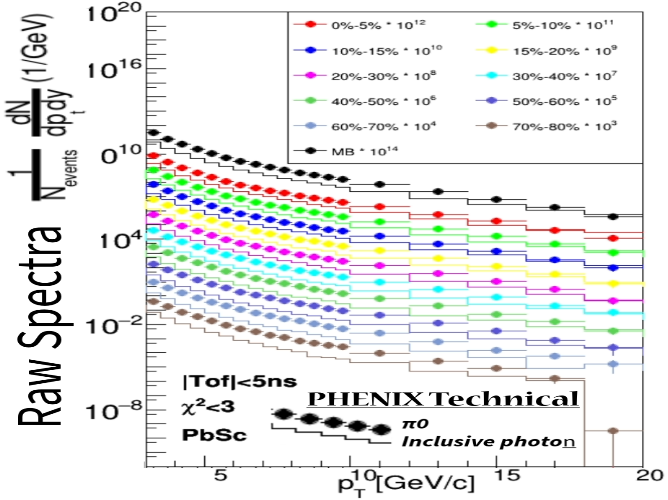
Combining The ERT and MB Spectrum for Inclusive photon

Centrality binned raw inclusive gamma spectrum from combined MB and ERT to get single continuous spectrum .



Left: ERT/MB ratio& fitting. Middle: Normalized MB&ERT. Right: ERT/MB.

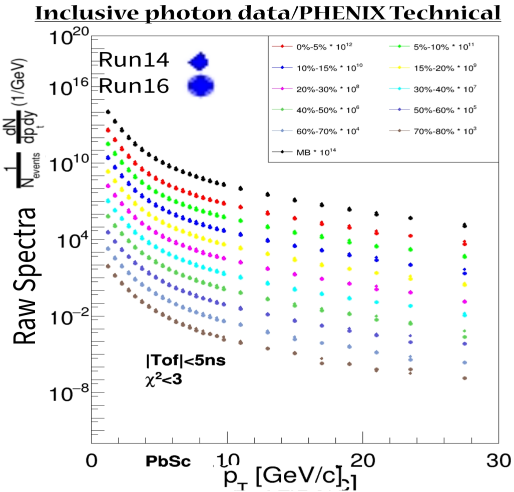
Run 14 π^0 & Inclusive Photon.

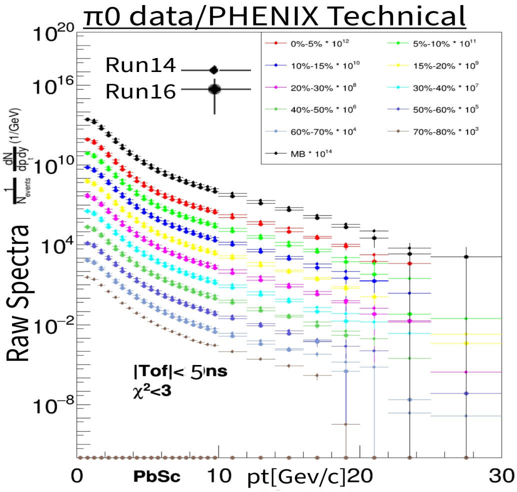


» The canvas obtained for Pt range of the measurement is extended from p_T =20 to 26 GeV/c (the highest p_T reachable at RHIC) in the 0-93% centrality bin for π^0 and the inclusive photons.

» At high p_T, we still have an insignificant statistical error.

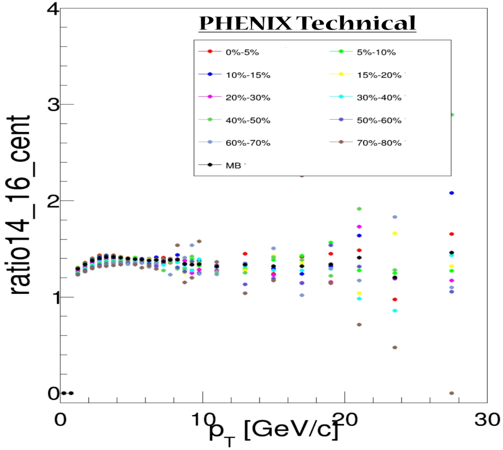
Run 14 & 16 centralities in π^0 & Inclusive photon data.



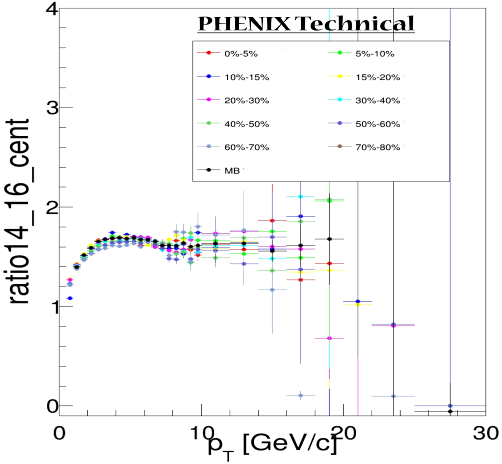


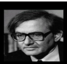
Consistency of Run 14 & 16 in π^0 & Inclusive photon data

Inclusive photon data:



π^0 data:





Simulation Techniques / I

The Simulation Purposes:

- Correct the raw π0 spectrum then use it to to calculate the raw (as measured) decay γ.

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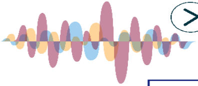
- Subtract the raw decay γ from the raw inclusive γto get the raw direct γ.



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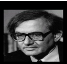
- Correct the raw direct γ with the simulated response of the detector to single photons

The Simulation Sections:

1. *PISA (PHENIX Integrated Simulation Application).*
2. *Detector geometry and response with GEANT3.*
3. *Embedding & Response 2D Matrix.*



Simulation Techniques / II

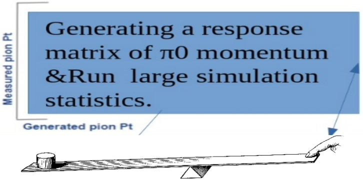
What does PISA do?

- PISA processes the single π0 events and handles the decay mechanism and its interaction with various detector subsystems.
- The energy deposited by the decay photons in the EMCal detector and their impact point is the primary information that is needed from this step.

What does the Embedding do?

- In the simulation we produced the cluster and because of the energy deposit in neighboring towers,
- Therefore, we obtain the energy distribution for each tower in the real event then we decluster the real event , add these two, and then recluster the event.
- In the process, information whether a tower has energy contributed from the simulated event, and if so, properties of the original simulated particle are preserved for evaluation purposes.

Why is Response Matrix needed?



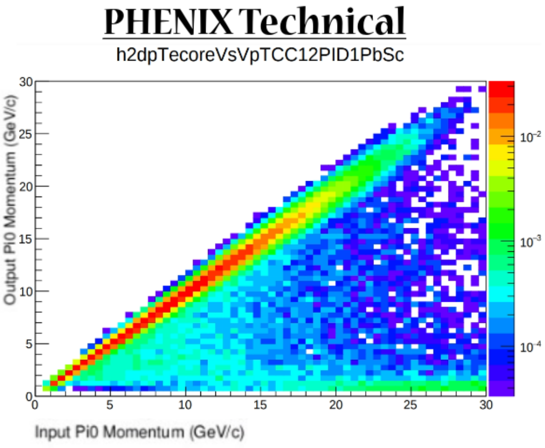
>> The response matrix describes the probability that a true value x is reconstructed at value y, where y belongs to the set of all possibilities<<

1.<u>Detector Acceptance:</u> Not all decay γs are reconstructed into π0s.
>>EMCal's limited rapidity coverage (-0.35 to +0.35) misses some π0 decay γs.
>>Only π0s with both γs in the same sector are reconstructed for improved yield accuracy.
>>Malfunctioning towers are excluded, reducing γ gamma detection.

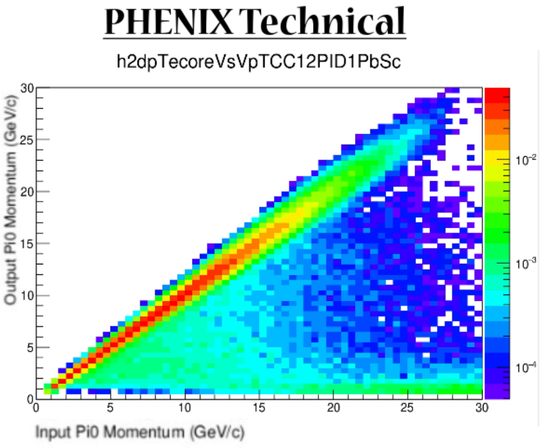
2• <u>Efficiency:</u>
>>EMCal's photon identification is imperfect due to clustering and limitations.
>>High Pt photon clusters can break up, leading to reconstruction of two separate photons.
>>High Pt decay γs may merge clusters, causing reconstruction errors.

3.<u>Smearing effects:</u>
Detector limitations can cause occasional inaccuracies in measuring photon momentum.

3. Response 2D Matrix Run 16:

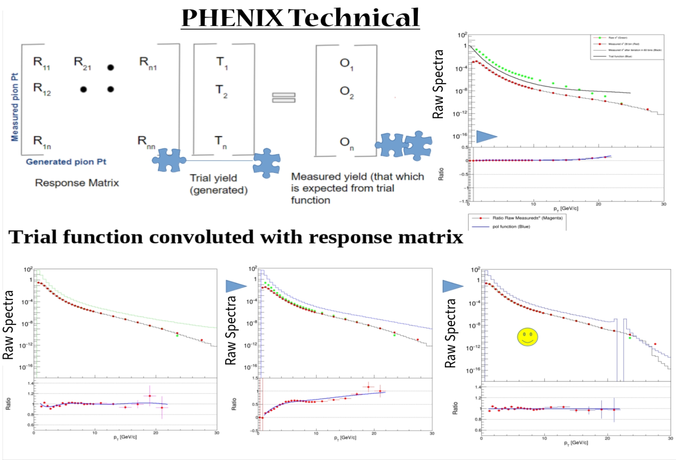


3. Response 2D Matrix Run 14:



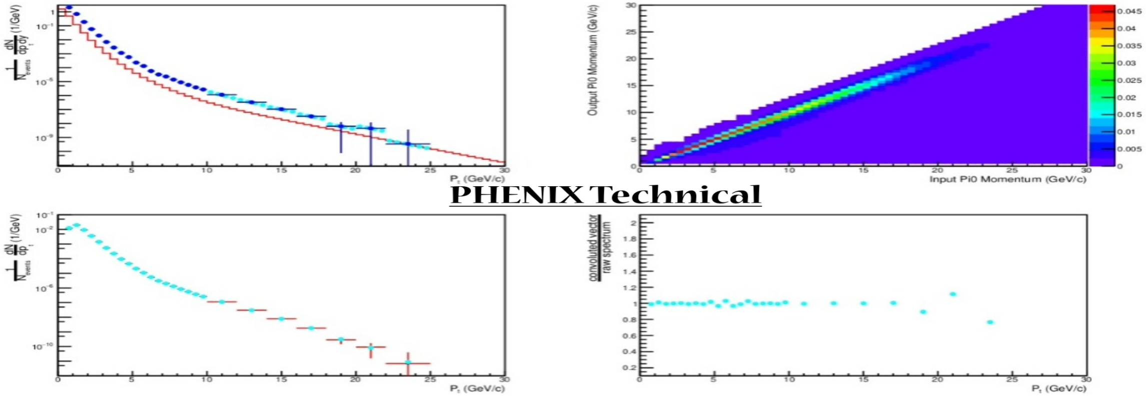
The Expected Outcome

Illustration of The Unfolding Procedure:



The process used a 2D response matrix to calculate the detector response to an initial estimation of the true spectrum. By comparing the ratio of the raw data to “measured” the initial estimation, the initial estimate is modified. This correction is repeated for 9 iterations until convergence is reached.

Illustration of the unfolding process:



A reasonable initial guess for the true spectrum is obtained(the figure is from the analysis of dAu data).

Summary

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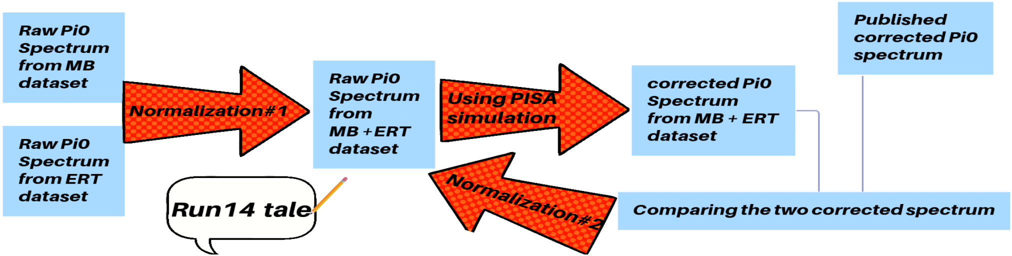

- *The range of the measurement is extended from $pt=$20 to 26 GeV/c.*
- *Deriving the important physics findings from it is the next step in this ongoing project.*
- *We have shown the importance of quality insurance, its effect on the inclusive photon spectra then comparison of the raw π^0 yields in different centrality bins indicates that the shapes at high p_T vary only slowly.*

Answering your question would be my pleasure.

Thank you!