Dielectron Analysis for Run 10 Au+Au 200 GeV data using HBD

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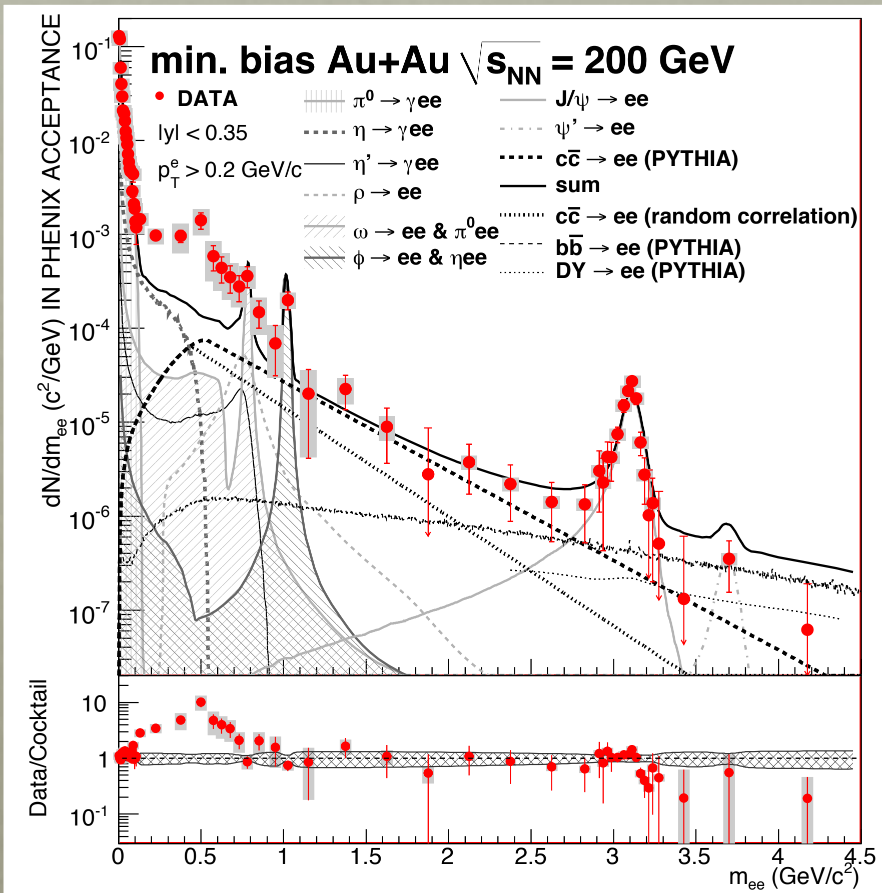
Outline

- Physics Motivation
- HBD Detector
- p+p Result
- Au+Au Result
- Summary

Dileptons in PHENIX: Au+Au Collisions



PRC 81, 034911 (2010)

Dileptons are interesting probes for studying many puzzles in Heavy Ion Physics.

Produced during all stages of collision and do not interact strongly with the medium.

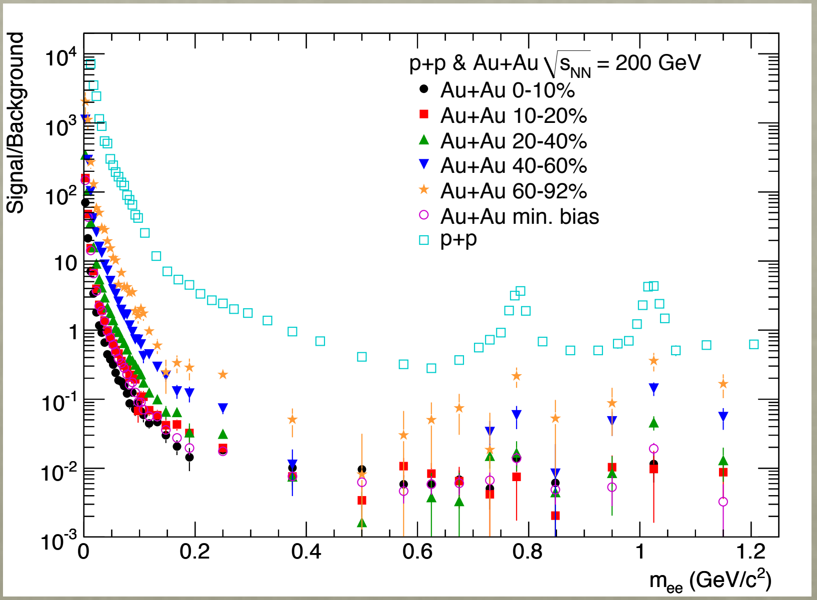
Provides access to thermal radiation, chiral symmetry restoration, medium modification of vector mesons, and uncorrelated charm/ bottom.

Strong enhancement of e^+e^- pairs at low masses. (m=0.2-0.7 GeV/c^2).

Currently no theory successfully explains this excess.

Signal/Background

- Signal to background in PHENIX published measurement ~1/200 in most interesting low mass region.
- Backgrounds dominated by uncorrelated pairs from partially reconstructed π^0 Dalitz decays and γ -conversions.
- Only way to identify such pairs is to tag them before they get separated by the magnetic field.
- The HBD was designed to help reduce these systematic errors.



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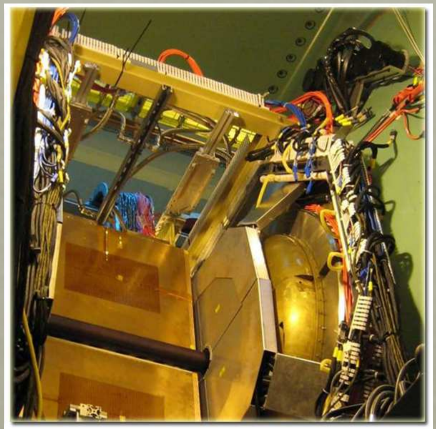
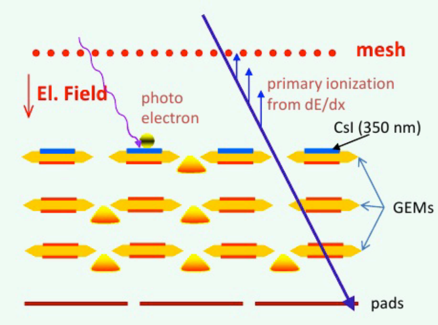
Hadron Blind Detector

HBD Detector Concept

NIM A646, 35 (2011)



Successfully operated:
- 2009 p+p data
- 2010 Au+Au data

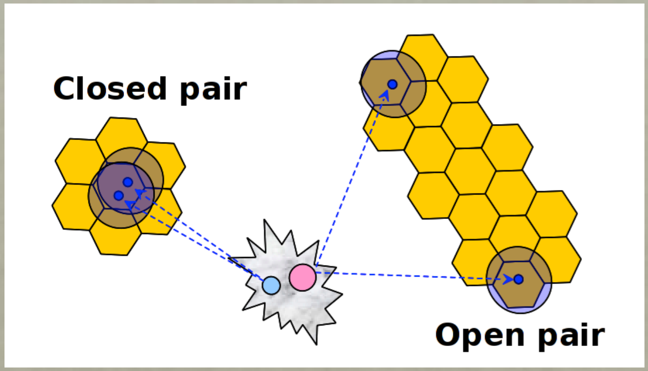


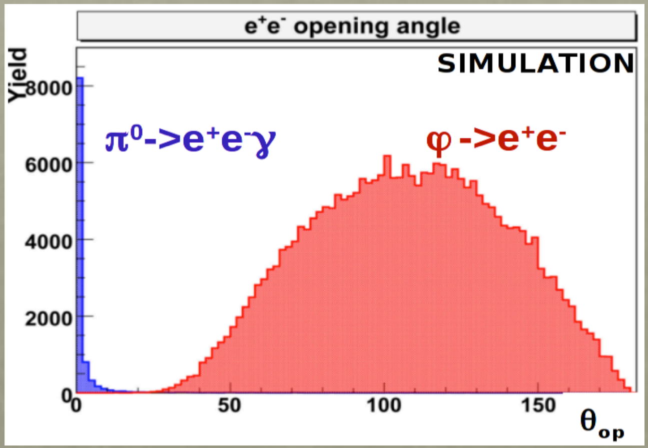
Windowless Cherenkov detector
GEM, CSI photo-cathode readout
Pure CF4: $N_0 = 322\ cm^{-1}$
2.4% total radiation length.

Opening angle preserved by creating magnetic field free region.

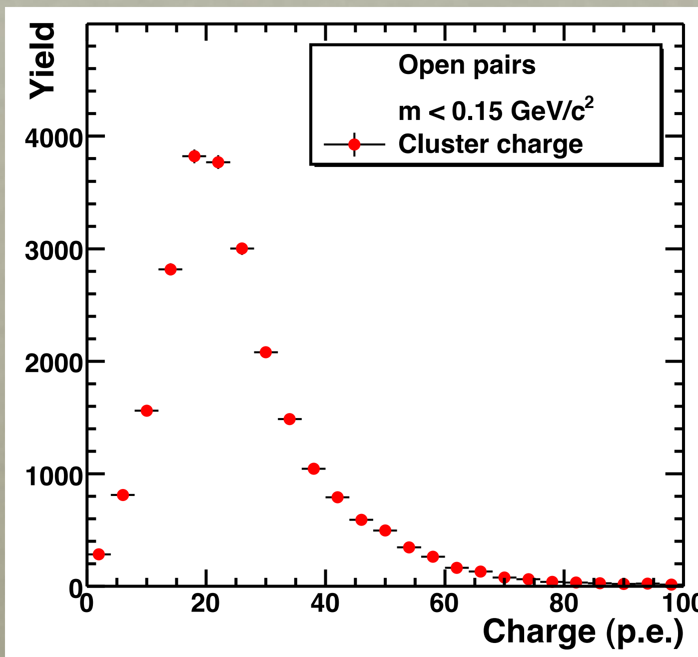
Heavier meson decays have large opening angles. Dalitz decays and conversions tightly peaked around $2m_e$.

Possible to identify e+e- from π^0 Dalitz decays and conversions by the opening angle.

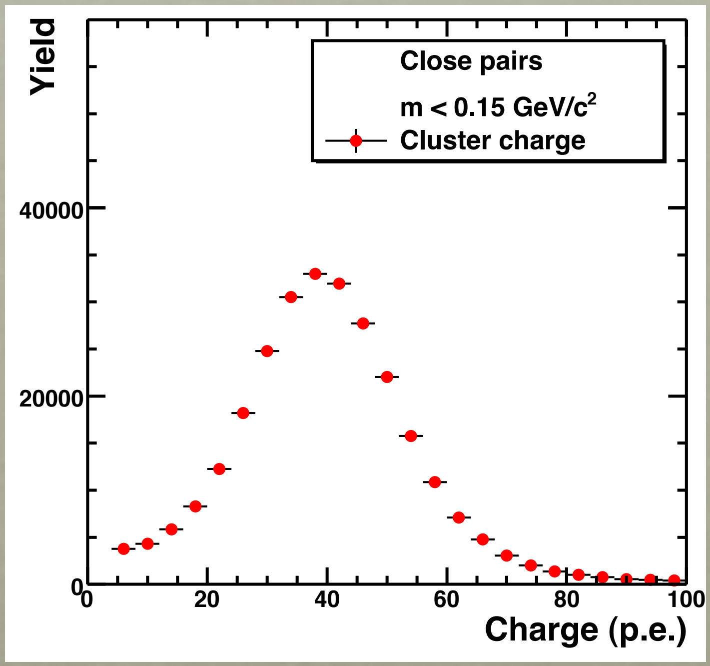




HBD Performance



Single electron charge peaks at 20 pe
e+e- large opening angle (>100 mrad)
→ Vector mesons or other signal



Double electron charge peaks at ~40 pe
e+e- small opening angle (<30 mrad)
→ Dalitz or conversion candidate

Good single to double separation

Dielectron Results in p+p 200 GeV

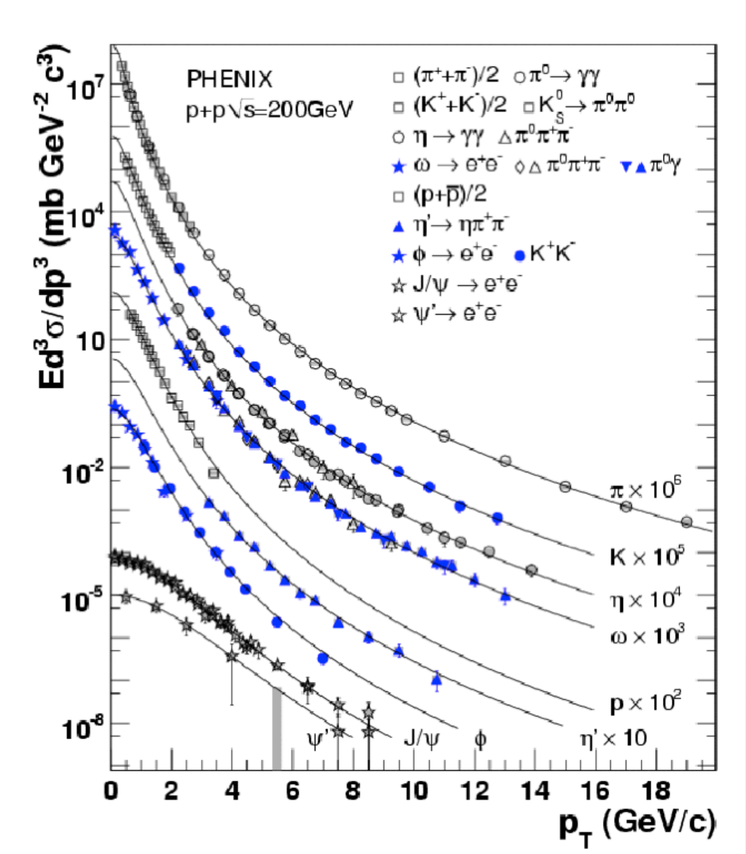
Cocktail

Hadronic cocktail is estimated using measured data from π^0 and charged pions fit to a modified Hagedorn function. m_T scaling is used for shape of other hadrons.

$$E\frac{d^3\sigma}{dp^3} = A\left(\mathrm{e}^{-\left(ap_T+bp_T^2\right)} + p_T/p_0\right)^{-n}$$

$$p_T \to \sqrt{p_T^2 - m_{\pi^0}^2 + m_h^2}$$

Open heavy flavor (c,b) contributions determined using MC@NLO



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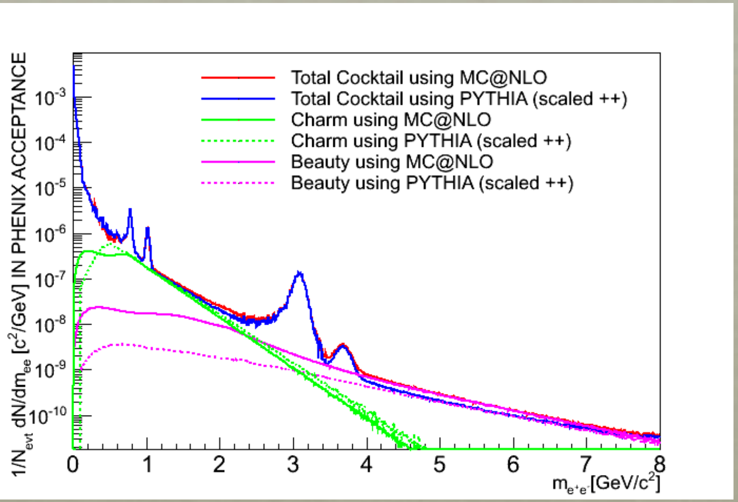
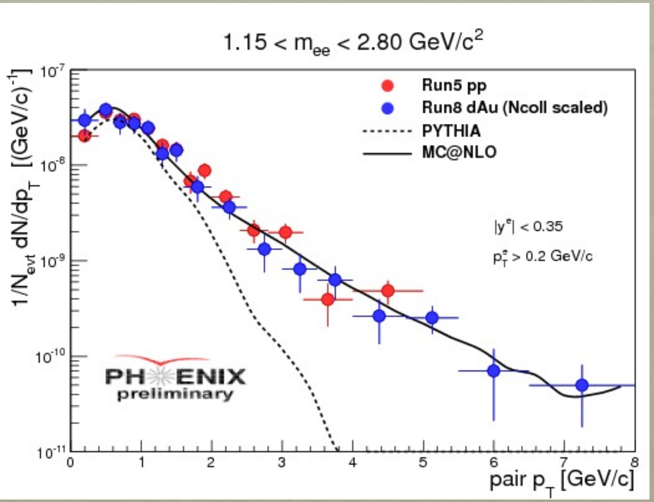
MC@NLO

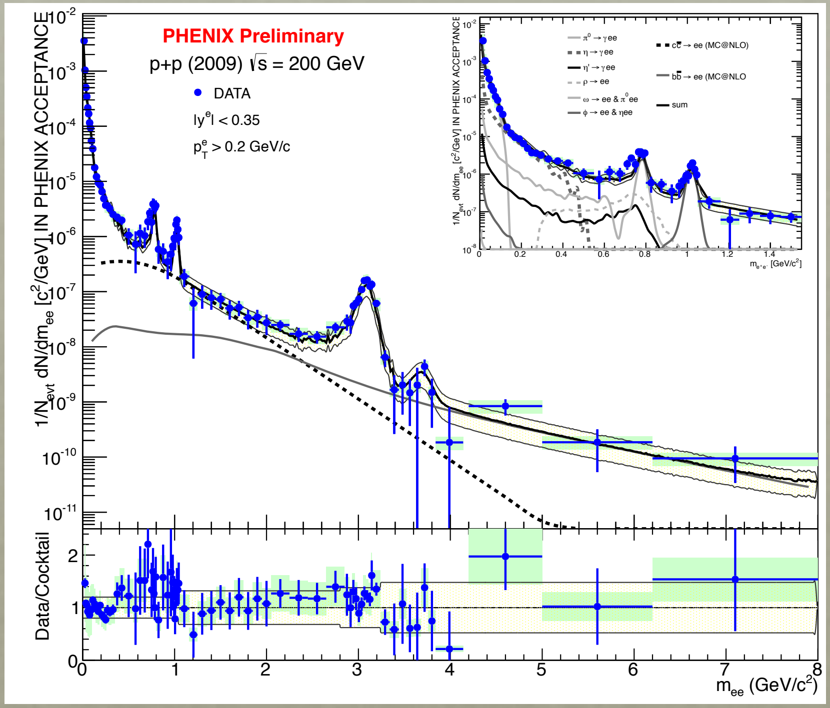


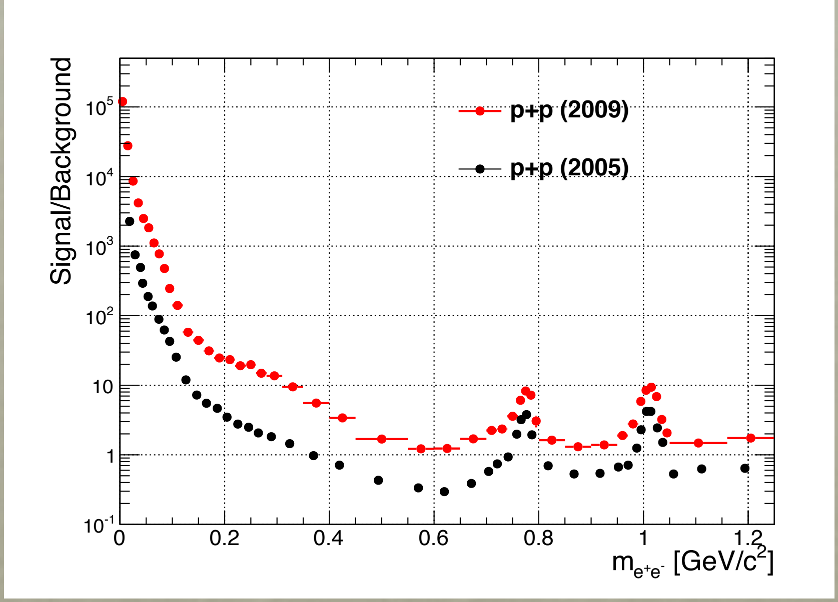


Negligible difference in total cocktail when using PYTHIA vs MC@NLO for open heavy flavor.

MC@NLO reproduces the measured pT distributions of e+e- pairs as opposed to PYTHIA.

Run 9 p+p Results





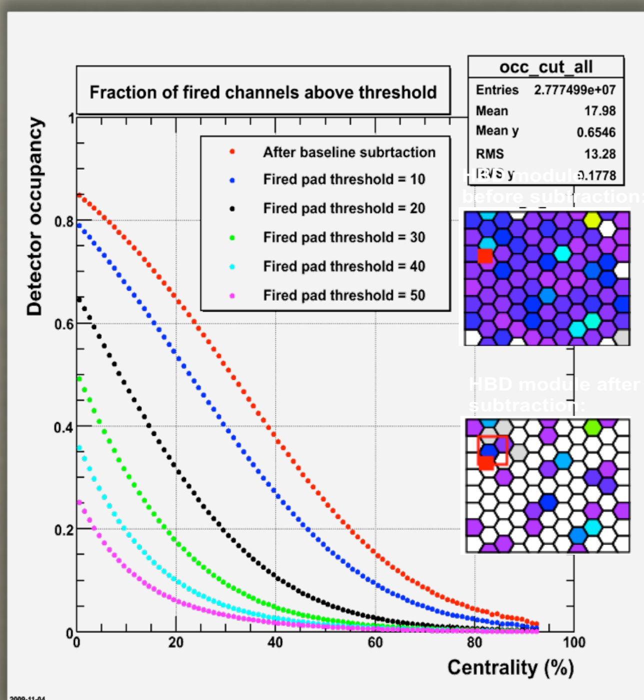
Improves S/B by factor of 5.

Excellent agreement between data and cocktail.
Fully consistent with published result PR C81, 034911 (2010)
Baseline for Au+Au analysis, provides testing ground for understanding the HBD.

Results in Au+Au

HBD in Au+Au collisions

- High Occupancy ~100% in central events mostly due to scintillation in CF_4.



- Average charge per pad is subtracted on event-by-event basis for each module.
- After subtracting the underlying event occupancy reduced to ~15% in MinBias
- The remaining fluctuations can still mimic electron signals (fake electrons)

Mean single signal ~ 20pe over 3 pads

Mean background ~ 10pe per pad

=> Very high fake id rate

Au+Au analysis Details

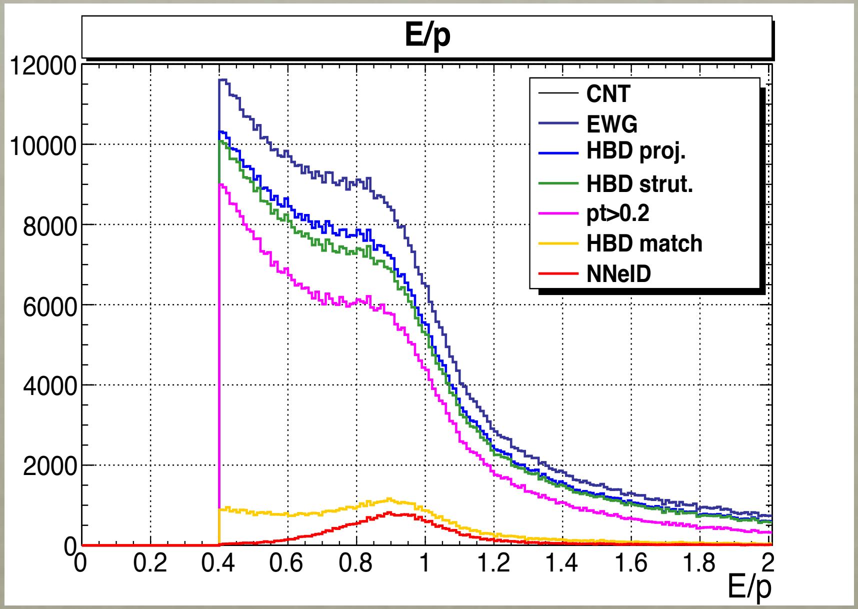
Two independent analysis streams: provide crucial consistency check
In both analyses, the combinatorial background is subtracted using mixed events.

Stream A
HBD: underlying event subtraction using average charge per pad
Neural network for eid and for single/double electron separation
Correlated background (cross pairs and jets) subtracted using acceptance corrected like-sign spectra

Stream B
HBD: underlying event subtraction using average charge in track projection neighborhood
Standard 1D eid cuts and single/double electron separation
Correlated background subtracted using MC for the cross pairs and jet pairs.

Results for stream A will be compared to cocktail: 60-92%, 40-60%, 20-40%
Results for stream B are used as a cross check.
Strong run QA and strong fiducial cuts in both analysis streams

Steps in Analysis

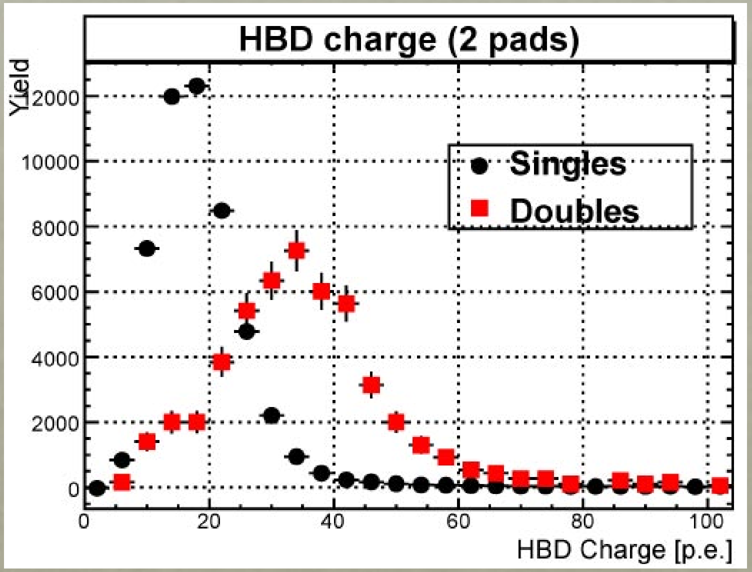


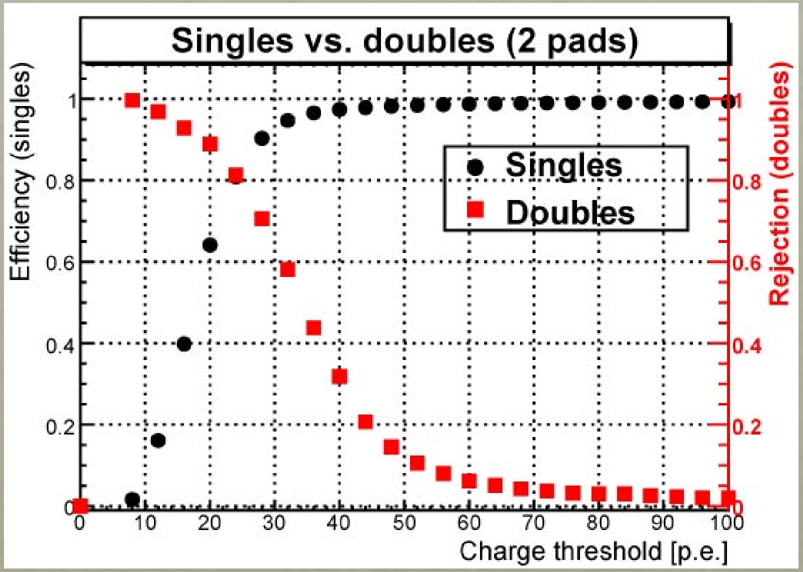
The E/p distribution for each step of the analysis.

Step in eID
Track reconstruction
Electron selection cut
HBD projection cut
HBD strut cut
pT > 0.2 GeV/c
HBD matching
Neural network eID

NN input variables: E/p, prob, n0, chi2/npe0, disp, hbdid, hbdsize

HBD double Hit Rejection

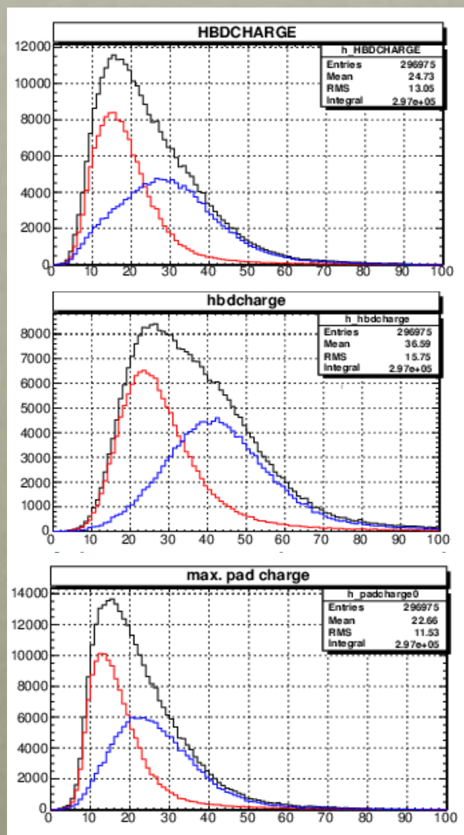


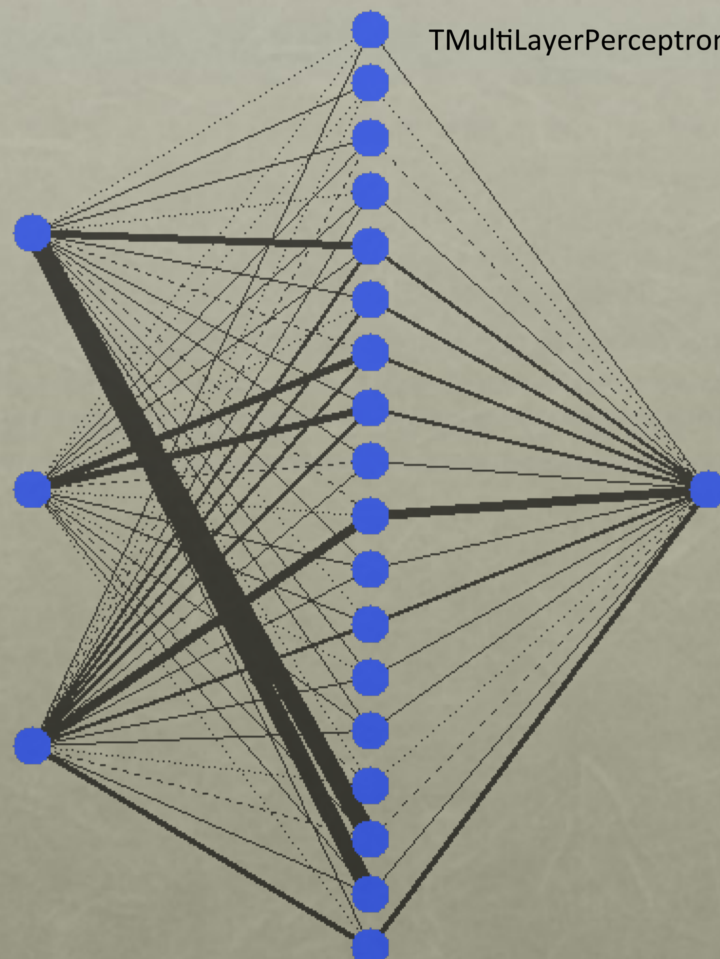


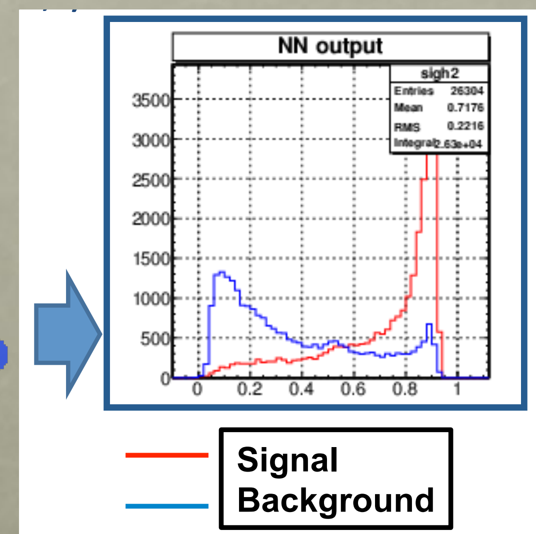
Simulated single and double charge response for clusters containing 2 pads.

Efficiency and rejection for centrality 70-80%.

Neural Network Details

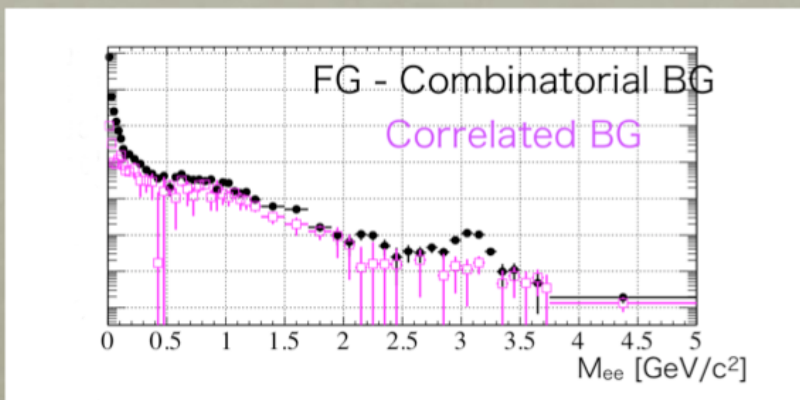


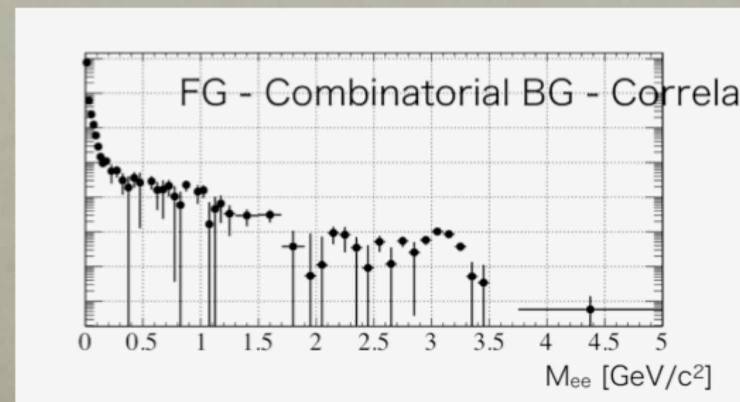




Neural Net output for signal (red) and background (blue) for the givien input variables for centrality 30-40% and HBDSIZE=2.

Background Subtraction

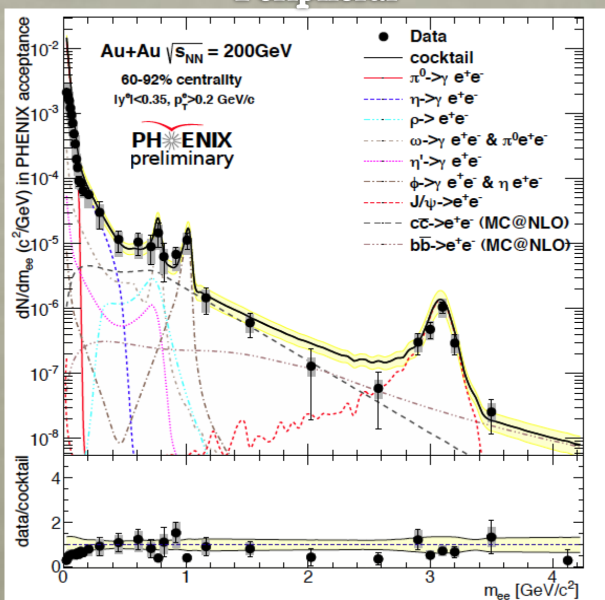




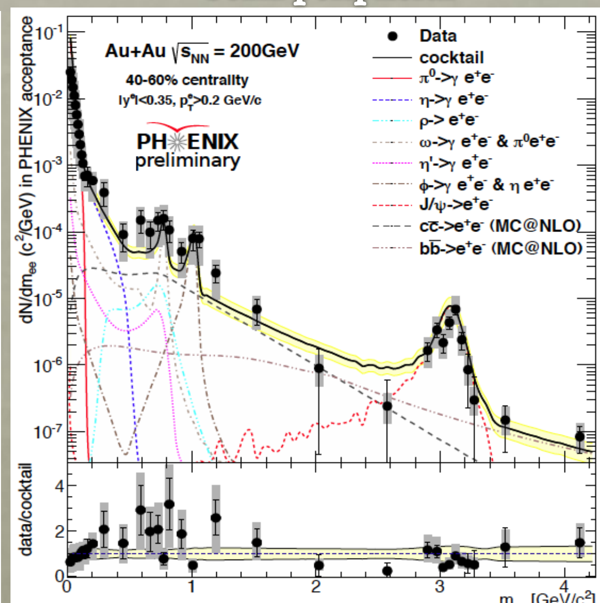
- Two types of background pairs.
  1. Combinatorial background pairs. (mixed event)
  2. Correlated background pair i.e. $\pi0 \rightarrow e^+e^- \gamma \rightarrow e^+e^-e^+e^-$ or $\pi \rightarrow \gamma\ \gamma \rightarrow e^+e^-e^+e^-$, also cross pairs and jet pairs. (acceptance corrected like-sign subtraction)

Au+Au Results

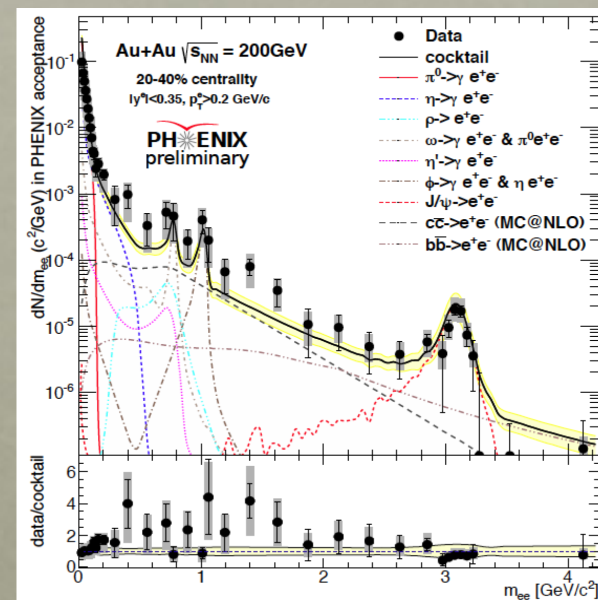
Peripheral



Semi-peripheral

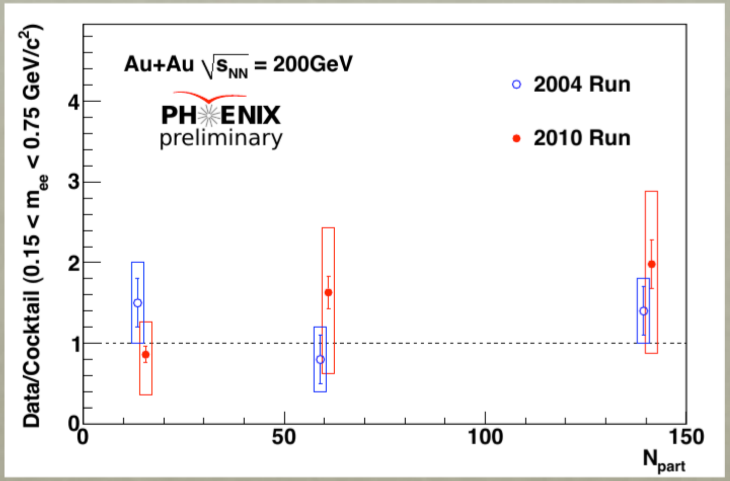


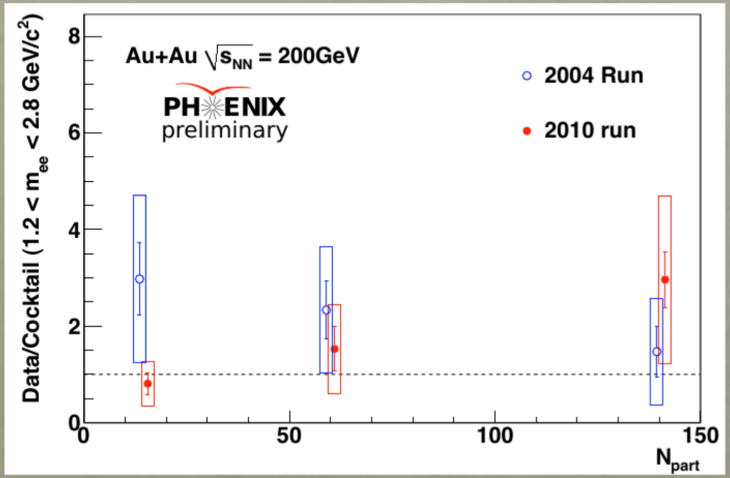
Semi-central



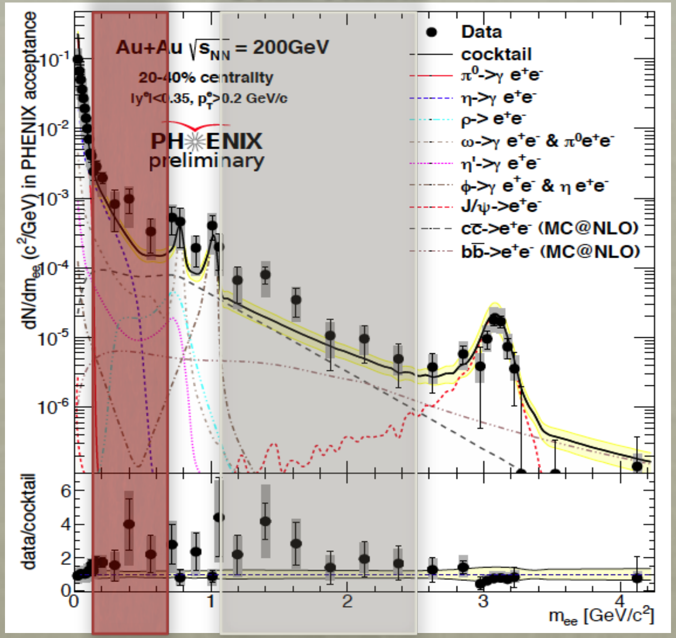
Dielectron Spectrum for 3 centrality classes: 60-92%, 40-60%, 20-40%

Au+Au Comparison



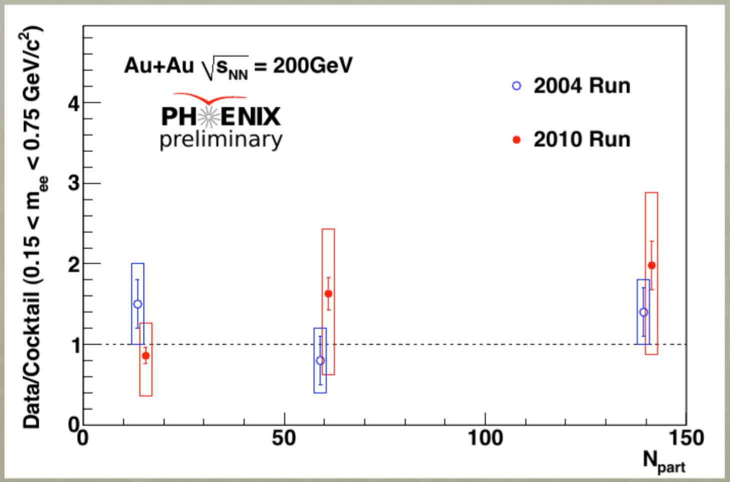


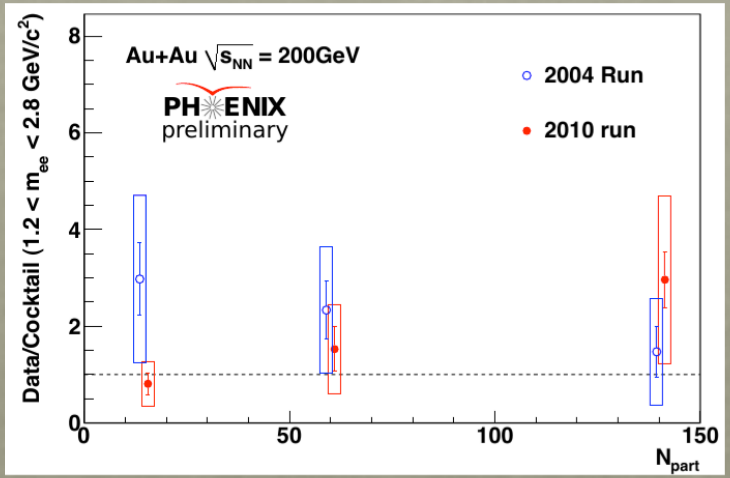
Semi-central



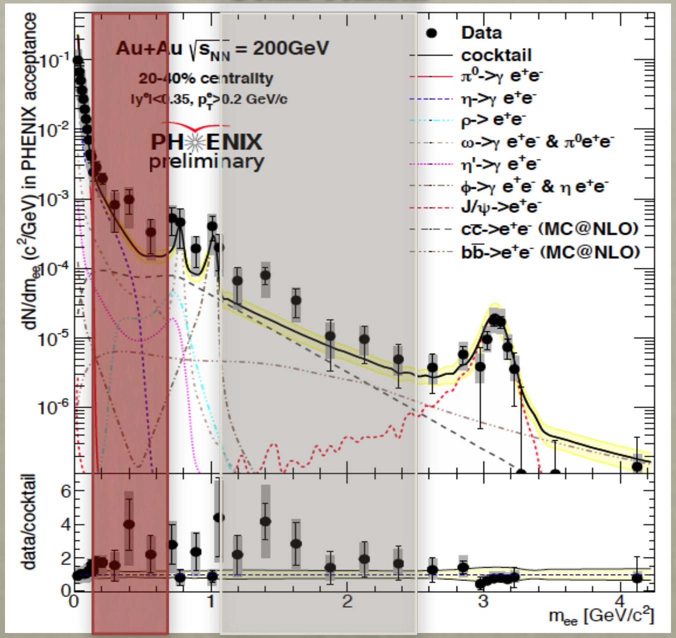
Data/Cocktail LMR (m=0.15-0.75 GeV/c^2)	(value ± stat ± sys)
PHENIX Run 4 (20-40%)	1.4 ± 0.3 ± 0.4
PHENIX Run 10 (20-40%) (preliminary)	1.98 ± 0.3 ± 0.9

Au+Au Comparison





Semi-central



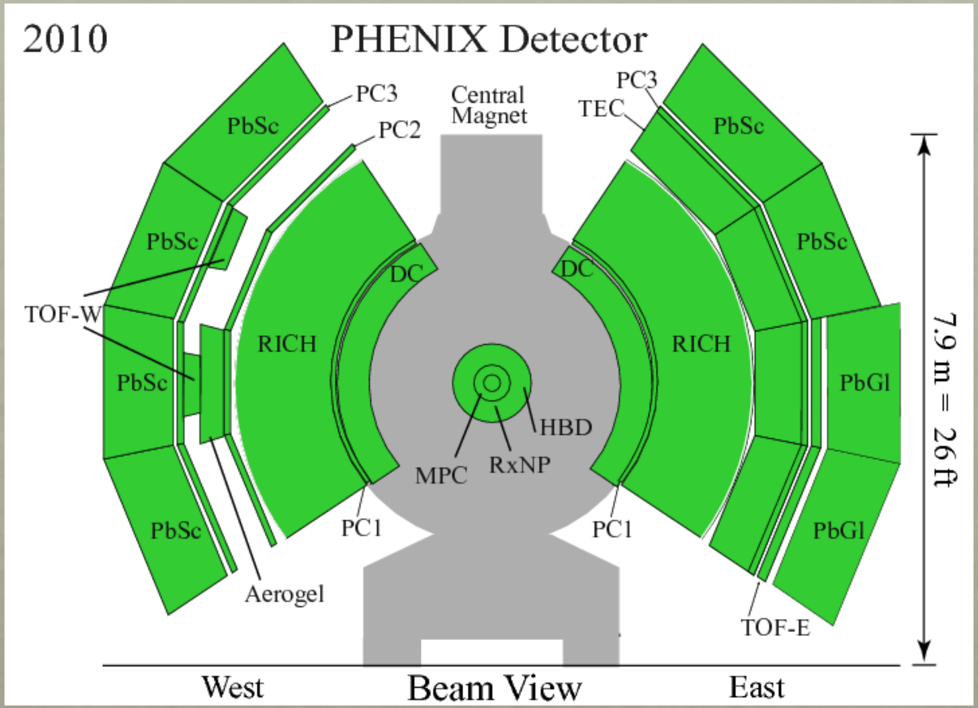
Data/Cocktail IMR (m=1.2-2.8 GeV/c²)	(value ± stat ± sys)
PHENIX Run 4 (20-40%)	1.3 ± 0.5 ± 1.0
PHENIX Run 10 (20-40%) (preliminary)	2.56 ± 0.5 ± 1.5

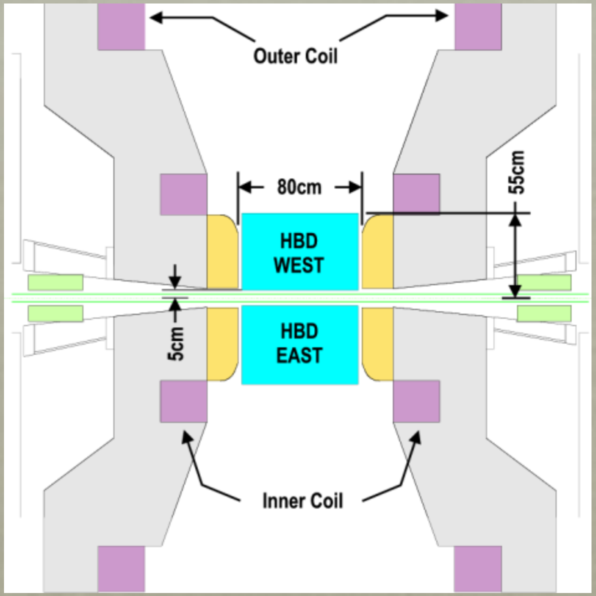
Summary

- The HBD was successfully operated in the PHENIX set-up in Run-9 (p+p) and Run-10 (Au+Au)
- Preliminary results consistent with previously published results.
- Very strong QA cuts and conservative error estimates.
- Next: relax QA and fiducial cuts, better assessment of systematics and complete analysis

Backup Slides

PHENIX detector



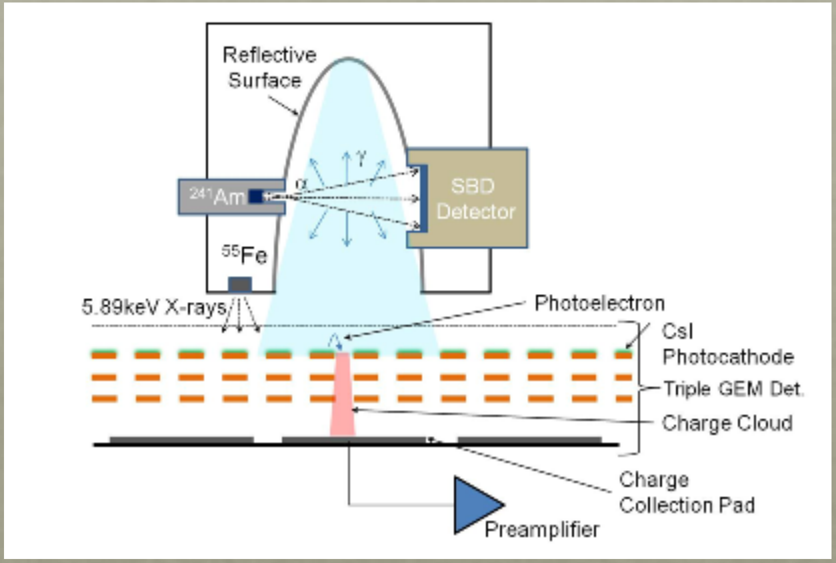


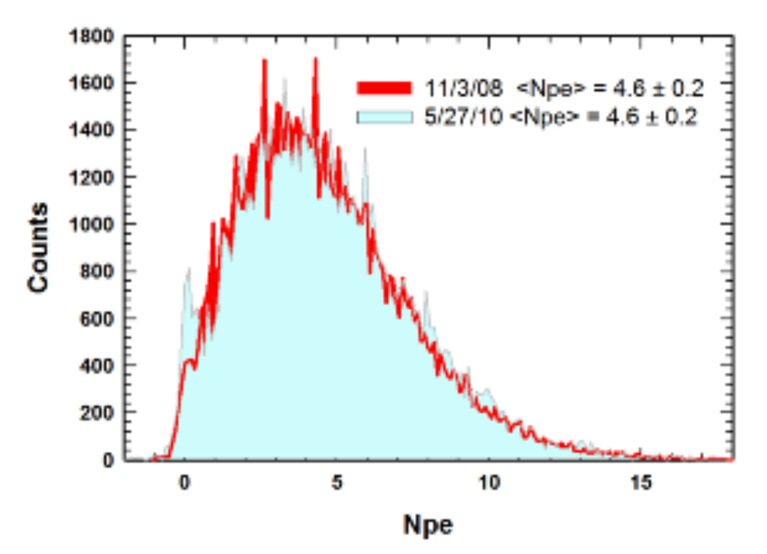
Inner and outer magnet coils producing field-free region for r < 55 cm

Detector	Δη	Δϕ	Field
PH Central Arms	+/- 0.35	180°	up to 1.15 Tm

Quantum efficiency

Quantum efficiency of the photocathode was monitored with the "Scintillation Cube"



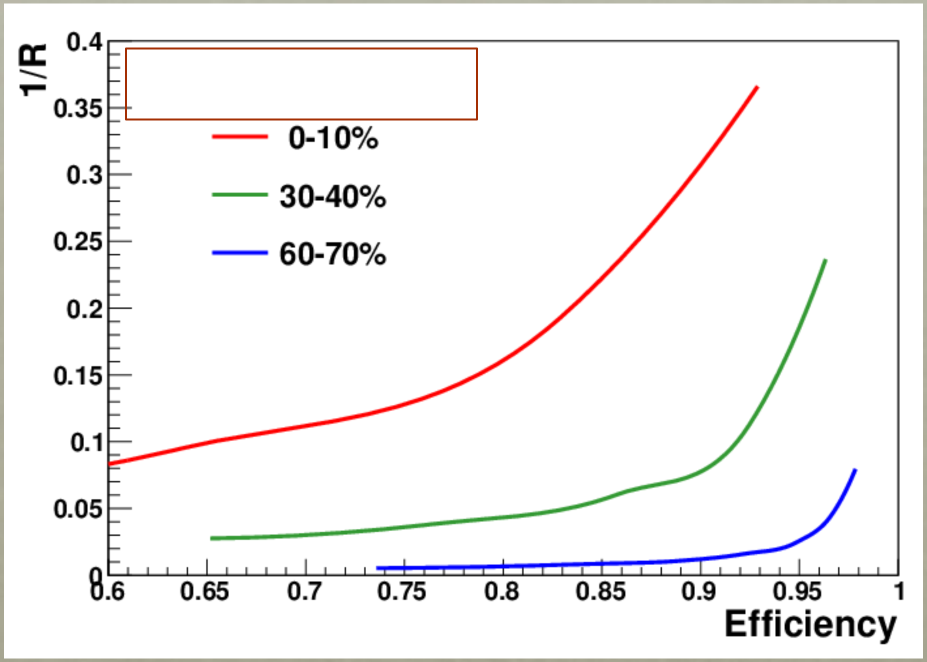


Quantum efficiency kept constant during the two years of operation!

The HBD analysis in Au+Au: matching of tracks to the HBD

Monitoring the efficiency and the rejection:

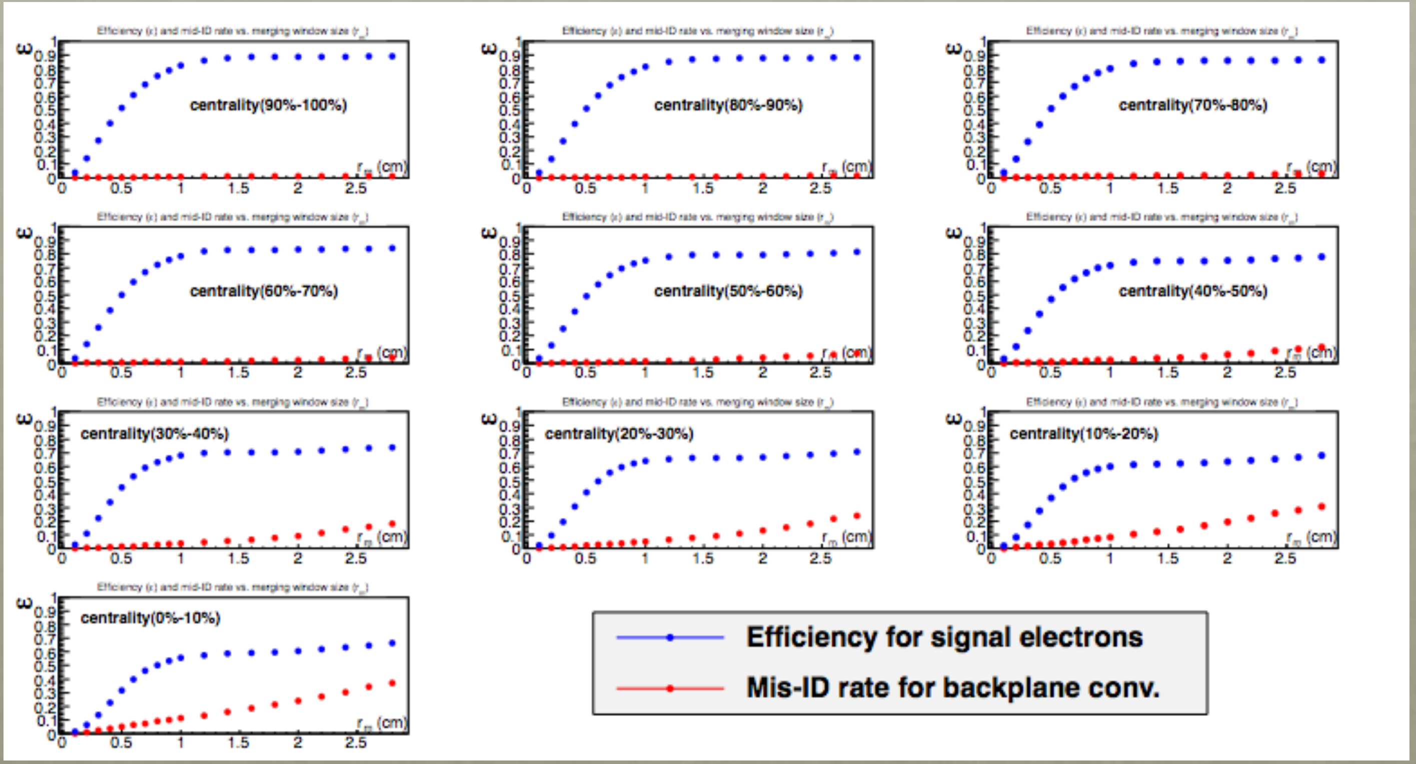
- Efficiency studied using MC electrons from $\phi \to e^+e^-$ embedded in Au+Au data
- Rejection of mis-identified hadrons and random matching determined from the data



- **Very high rejection achieved while keeping a high efficiency even in the most central events**

Performance in Au+Au collisions

- The SB reconstruction subtracts local background based on triplets around track projections.



Consistency between streams A and B