Performance of PHENIX HBD in Au + Au central collisions

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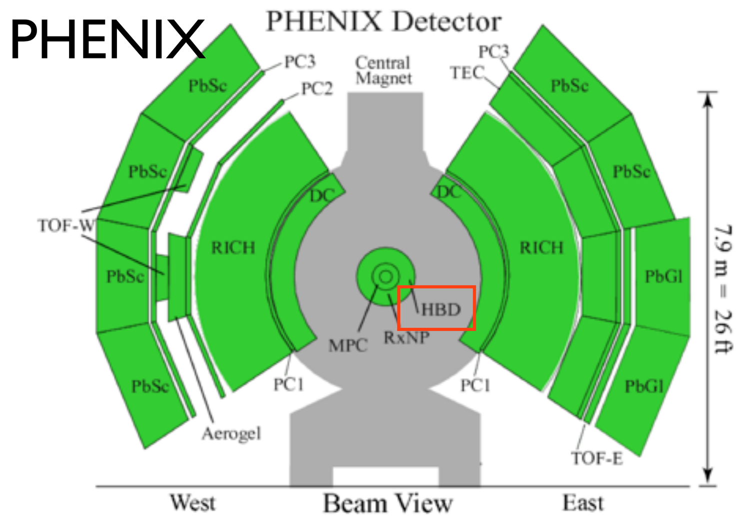
0. Introduction

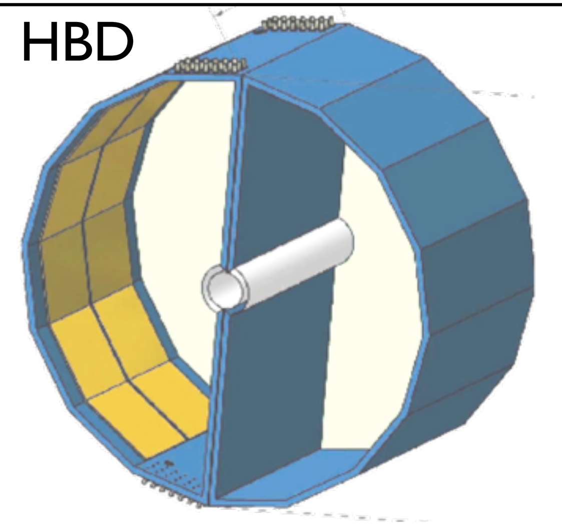
The PHENIX experiment observed a large enhancement of electron-positron pairs in the invariant mass range of 0.2 to 0.5GeV/c^2 in Au+Au collisions at $\sqrt{s_{NN}}$ = 200GeV. However, it is difficult to draw firm physics conclusions from the measurement, since the measurement still has large statistical and systematic uncertainties. The main uncertainty comes from the small signal-to-background ratio of about 1/200 in minimum bias collisions. The electron decay branching ratios of light vector mesons are very small(~10^{-4}), while there are many background electrons mainly originating from π^0 Dalitz decays and γ conversions. A Hadron Blind Detector(HBD) has been installed into PHENIX to reject such background electrons.

1. PHENIX with HBD

γ conversions and π^0 Dalitz decays can be recognized and rejected using the fact that the opening angle of electron pairs from these sources are very small compared to the light vector mesons case. A Hadron Blind Detector is placed in a field-free region, where the opening angle is preserved.

The HBD is a Cherenkov detector operated with pure CF_4 gas. It has a 50cm long radiator directly coupled to a readout element with a windowless configuration. The readout consists of a triple GEM stack, with a CsI photocathode evaporated on the top surface of the top GEM and hexagonal pad readout at the bottom of the stack.



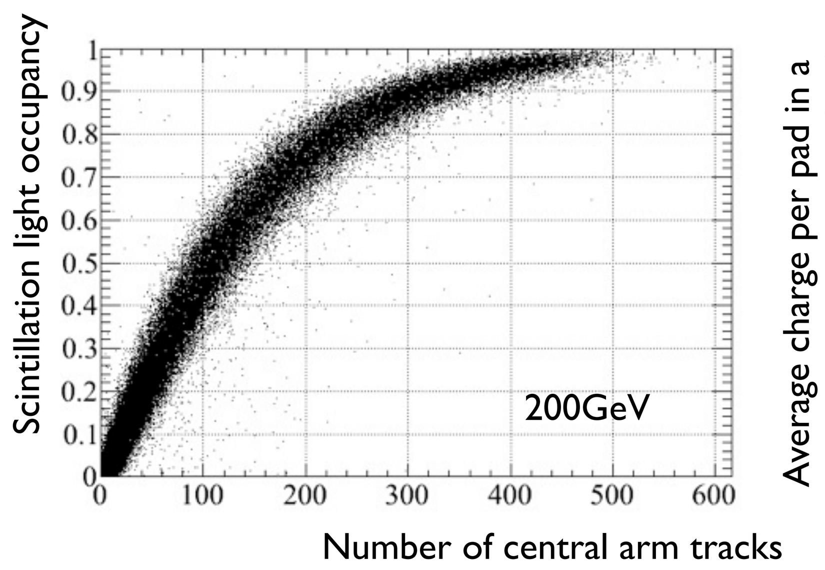


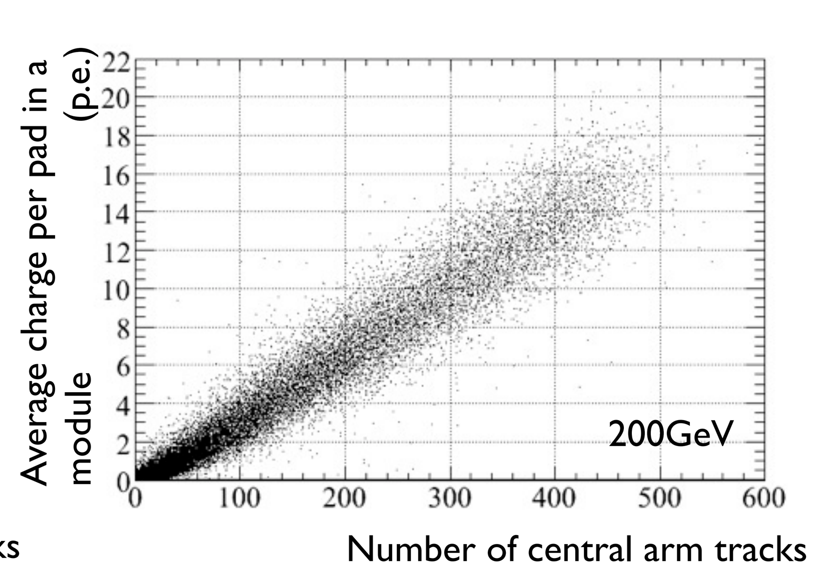
The HBD was successfully operated in the RHIC runs of 2009 and 2010 in measurements of p+p and Au+Au collisions. The detector performed to its design specifications. A detailed account of the construction, operation and performance of the HBD can be found in doi: 10.1016/j.nima.2011.04.015 .

2. HBD analysis scheme for the Au+Au central collisions

Issue: High occupancy due to scintillation light of CF_4

In central Au+Au collisions, there is a large background mainly due to the scintillation light emitted by charged hadron tracks. In Au+Au peripheral collisions or p+p collisions, the effect of scintillation light is negligible compared to the Cherenkov light by electrons. However, in central Au+Au collisions, the number of charged particles is so large that the effect of scintillation light becomes significant. Two different algorithms are developed to handle the issue. This poster describes one of them. The other algorithm is presented by E. Atomssa at board #114.



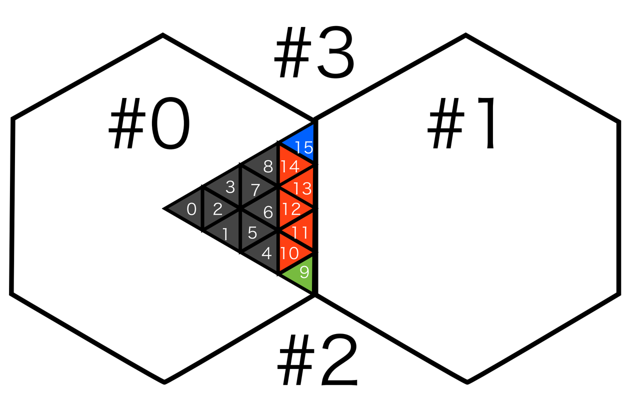


Step1: Subtraction of underlying events

Average charge per pad is subtracted on event-by-event basis for each detector module.

Step2: Clustering

Potential clusters are determined from the projection points of tracks which pass the Central Arm electron cuts. If a cluster is made only by HBD information, many fake clusters are generated. This cluster algorithm truncates the cluster charge but achieves a good rejection of fake clusters while keeping a high electron efficiency.



Potential clusters depending on projection points

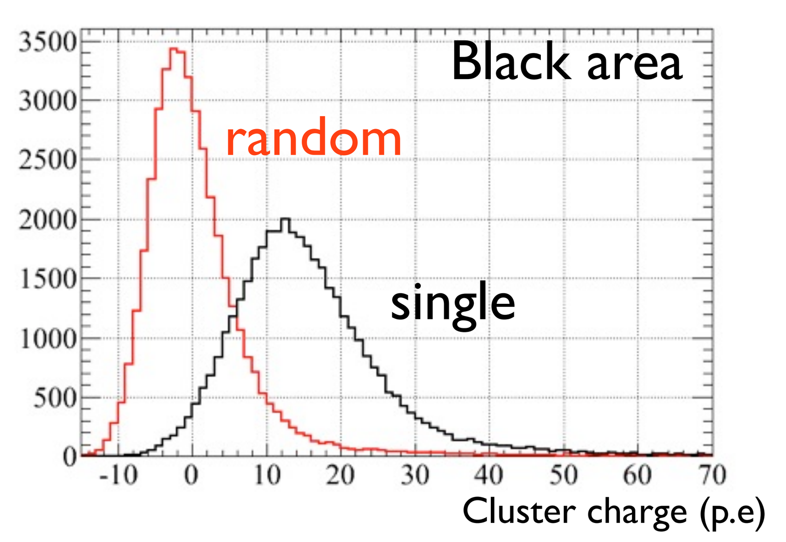
- Black: #0
- Red: #0, #1
- Blue: #0, #1, #3
- Green: #0, #1, #2

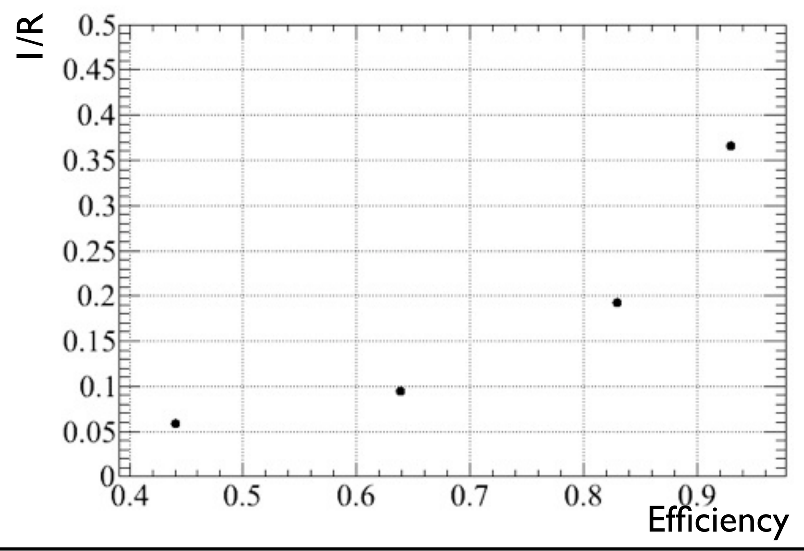
Step3: Rejection of random matching

γ conversions outside HBD are recognized as electrons in Central Arm detectors and can be assigned fake clusters at HBD. Such tracks are rejected using cluster charge information.

The left figure shows the total charge of single electron clusters and randomly matched clusters. Single electrons are generated using GEANT3-based simulation and embedded into data to have areal background. The random matching distribution is generated using data. The right figure shows the inverse of rejection as a function of efficiency.

200GeV, Centrality: 0-10%



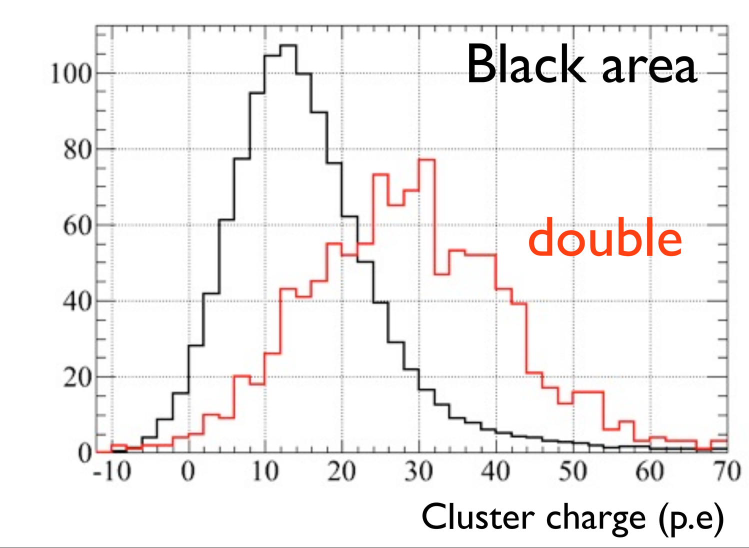


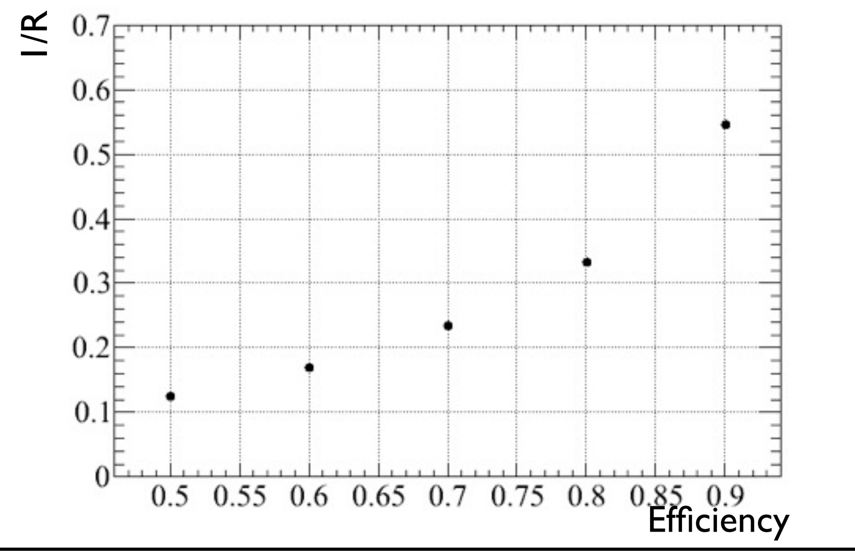
Step4: Rejection of overlapping double clusters

γ conversions in the beam pipe and π^0 Dalitz decays with small opening angle are considered here. Those tracks leave twice as much signal as that of single electron tracks.

The left figure shows the total charge of single electron clusters and "double" electron clusters. "Double" electrons are generated from γ decays in the beam pipe with GEANT3-based simulation. The right figure shows the inverse of double rejection as a function of efficiency.

200GeV, Centrality: 0-10%

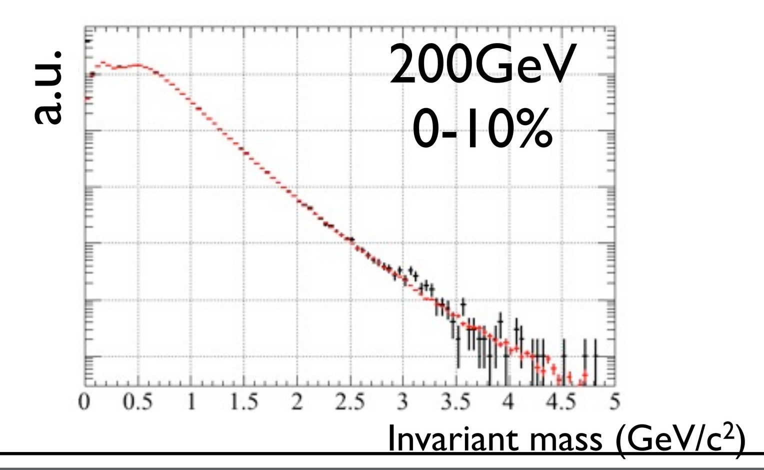


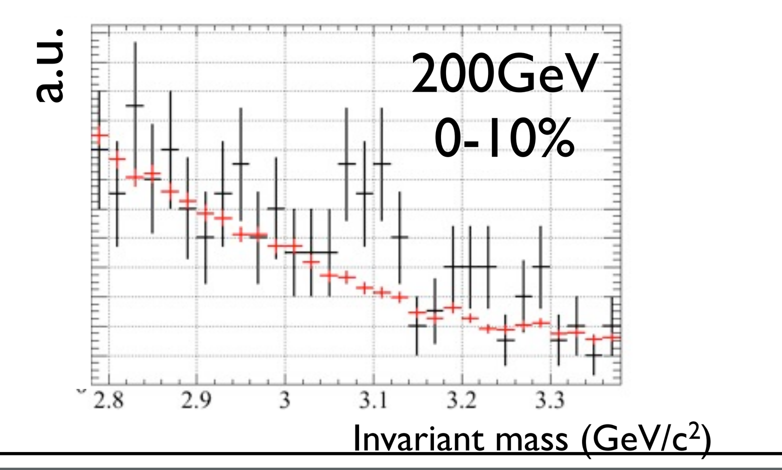


Mass spectra

Right panels show mass spectra generated with the HBD analysis scheme.

Black line: Foreground
Red line: Mixed background





3. Summary and outlook

Analysis scheme of HBD for Au+Au central collision is developed. Mass spectra using the scheme are being studied more quantitatively.

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