SINAP

STAR

Non-Photonic Electron and Charged Hadron Azimuthal Correlation in 500 GeV p+p Collisions at STAR

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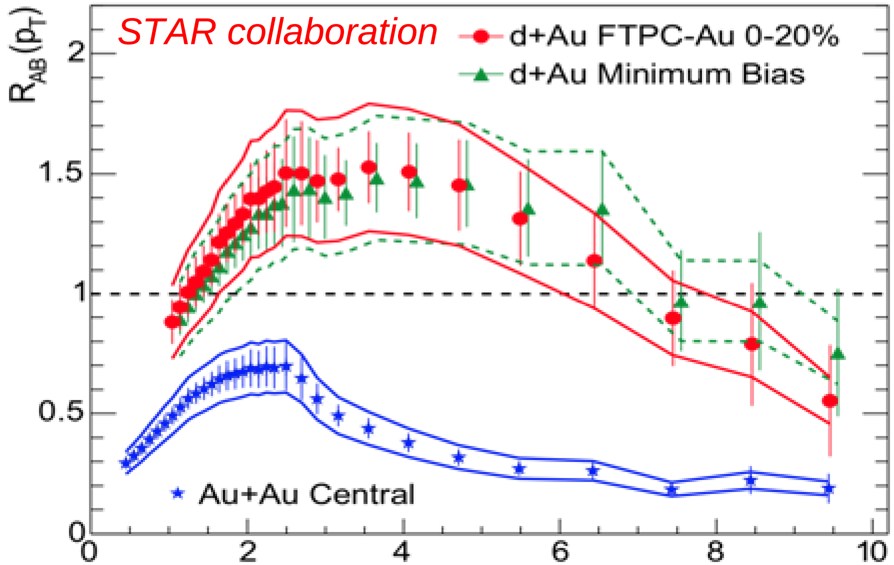
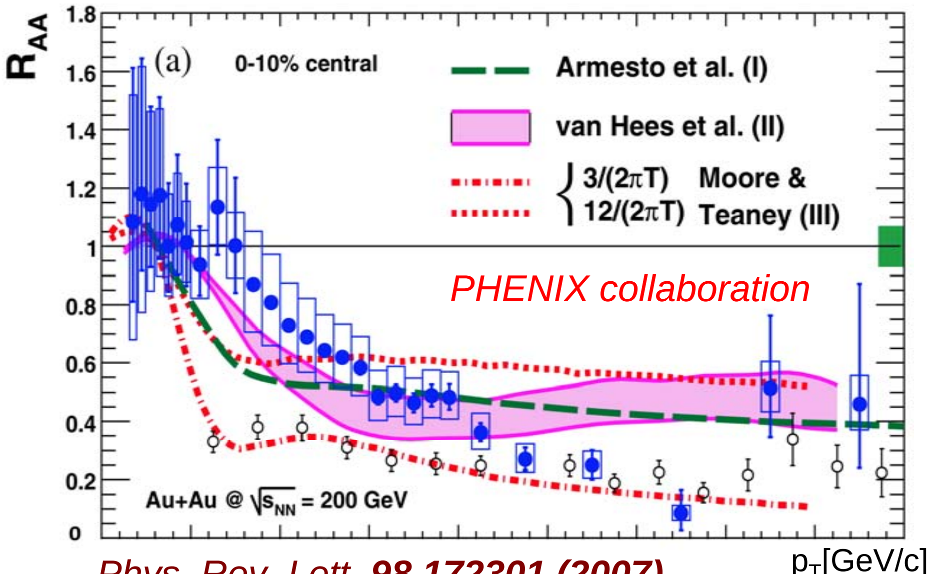
Outline

- Motivation
- NPE identification procedure
- NPE-hadron azimuthal correlation in p+p collisions at 500 GeV
- Preliminary results of $e_B/(e_B+e_D)$ ratio
- Summary

Motivation



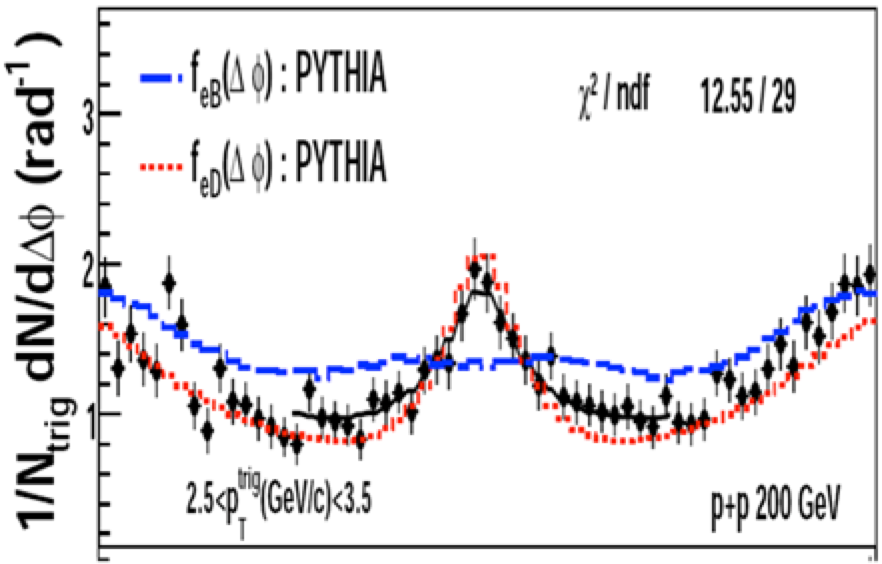
Phys. Rev. Lett. ***91 072304 (2003)***

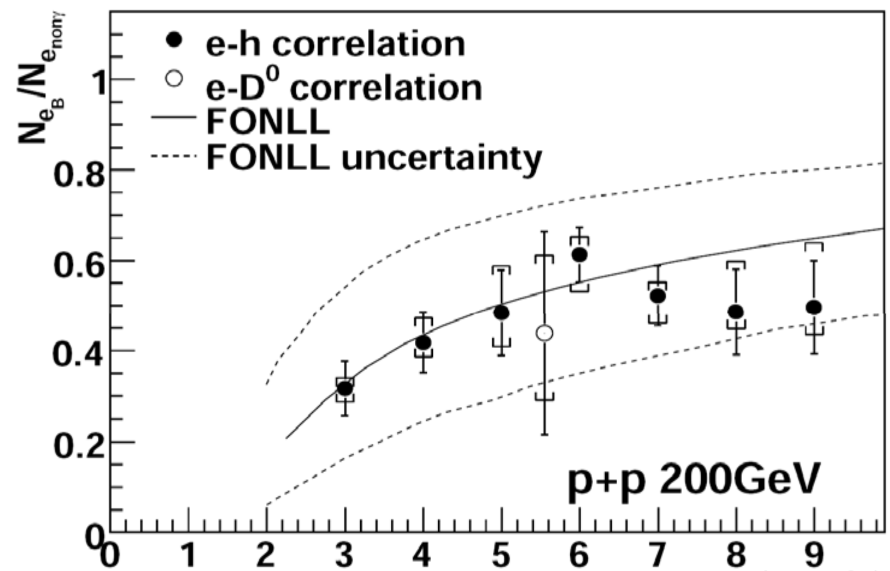


Phys. Rev. Lett. ***98 172301 (2007)***

- Charged hadron R_{AA} suppressed in central Au+Au collision which means energy loss through interaction with QGP.
- QCD predicted that heavy quark will lose less energy than light quarks due to dead cone effect.
- Heavy quarks have been studied by measuring electrons from semi-leptonic decay of heavy flavor quarks (Non-Photonic Electron)
- NPE R_{AA} suppressed at high p_T region, which implies that heavy quarks may lose a substantial amount of energy in central Au+Au collision.

Bottom quark contribution to NPE

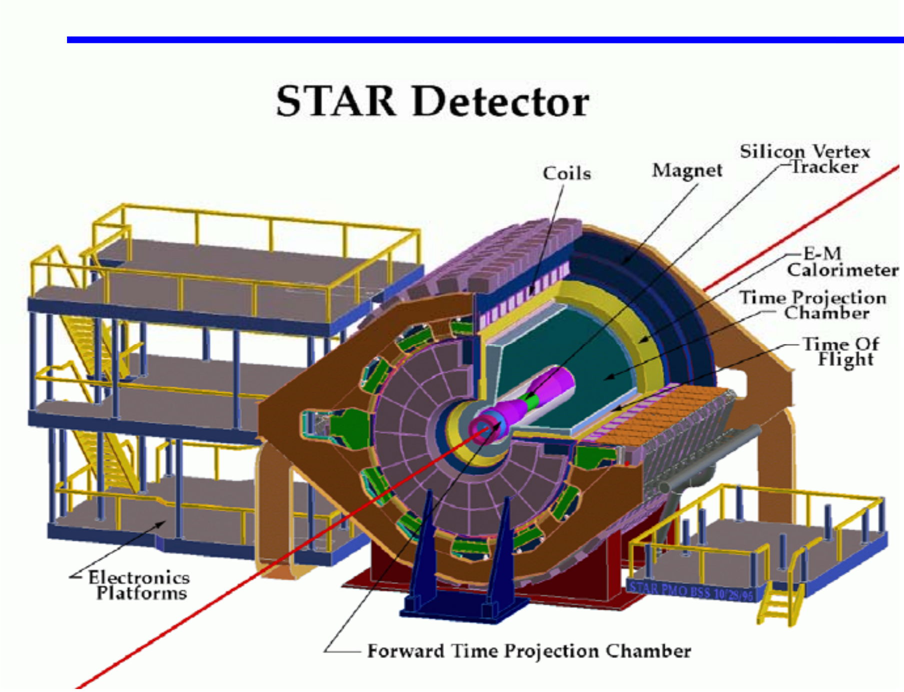


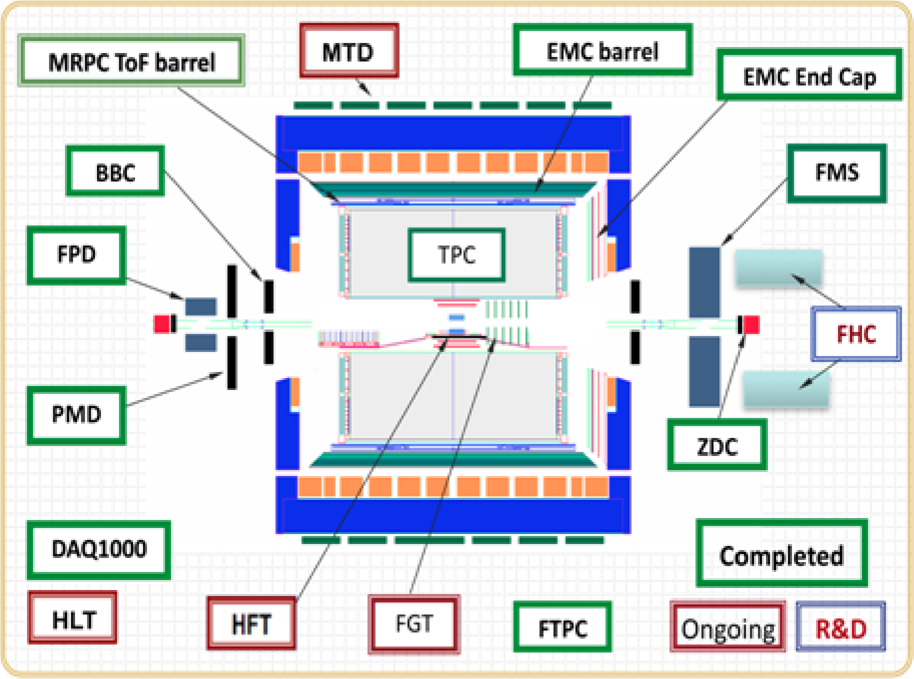


Phys. Rev. Lett. ***105 (2010) 202301***

- Separate bottom quark and charm quark contribution to non-photonic electron
  - ➡ non-photonic electron and charged hadron azimuthal correlation on near side
- B decay contribution is approximately 50% at a transverse momentum of p_T >5 GeV/c in 200 GeV p+p collisions.
- Sizable energy loss of bottom quark in medium.
- What’s bottom quark contribution to non-photonic electron in 500 GeV p+p collision ?
- Check energy dependence of bottom contribution to NPE

Electron identification





Detector used:

❖**Time Projection Chamber (TPC)**

❖**Barrel Electro-Magnetic Calorimeter (BEMC)**

❖**Barrel Shower Maximum Detector (BSMD)**

Signal:
non-photonic electron
- Charm decay
- Bottom decay
- Weak kaon decay
- Vector meson decays

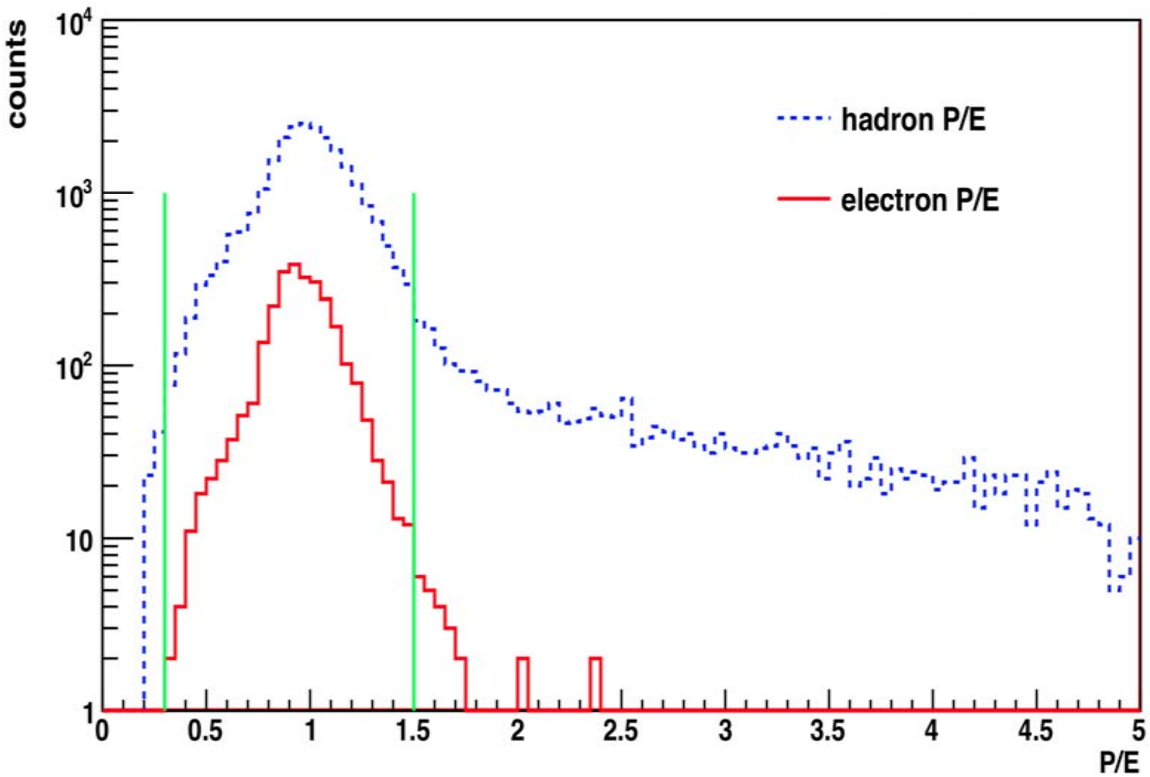
Background:
Photonic electron
- Photon conversion
- π^0 Dalitz decay
- η Dalitz decay

Data Sample:

p+p collisions at $\sqrt{s_{NN}}$ = 500 GeV in run9 (2009)

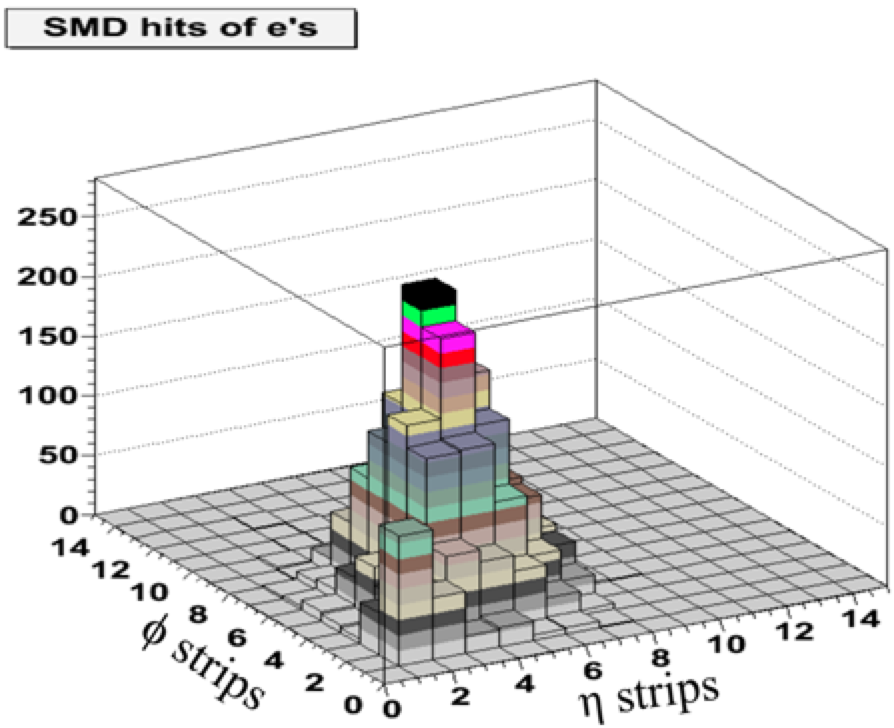
5.4 million BEMC HT3 triggered events with the E_T threshold of 7.4 GeV

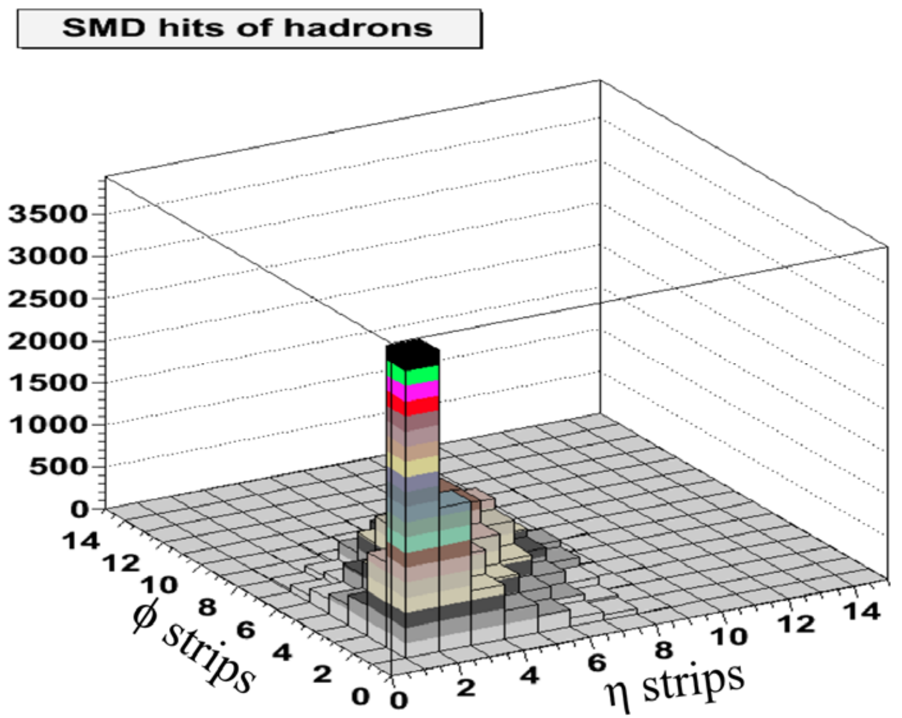
Electron Identification: P/E



- P is measured by TPC.
- E is the sum of the associated BEMC points' energy measured by BEMC.
- Electrons will deposit almost all of their energy in the BEMC towers.
- 0.3 < P/E <1.5 cuts were used to keep electrons and reject hadrons.

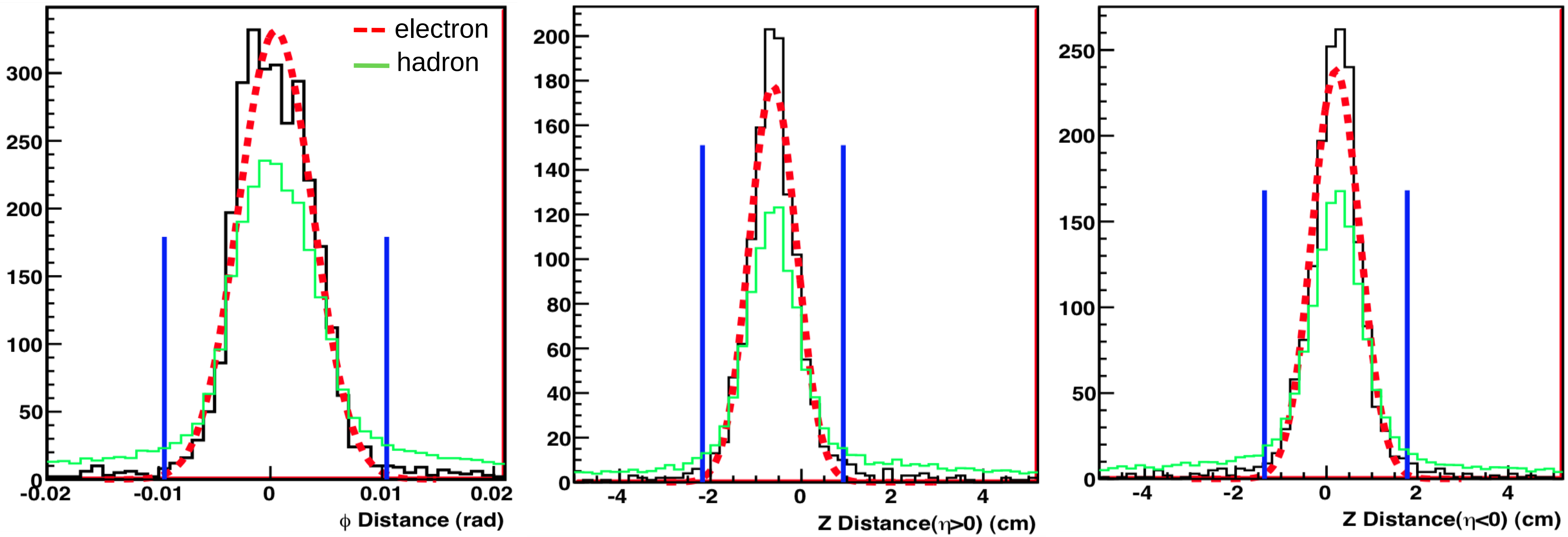
Electron Identification: Shower Size





- Number of SMD hits per shower indicates shower size.
- Hadron shower is not fully developed at SMD while electron shower is maximum at SMD.
- Electrons have larger number of BSMD hits than those for hadrons.
- We choose SMD hits larger than 2 to reject hadron contamination.

Electron Identification: Projection Distance

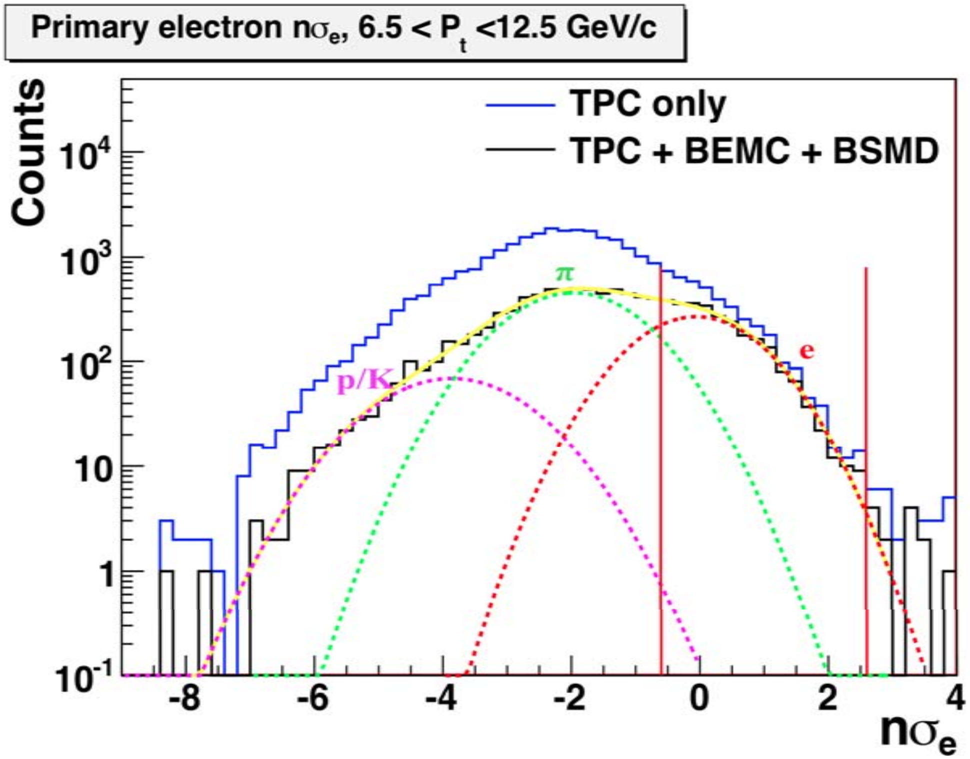


- Projection distance: distance between the TPC track projection position on BSMD η and ϕ planes and the reconstructed BEMC point position

- histograms for hadrons are scale to match the entries with that of the electrons.

- -3σ < Z Dist pos(neg) < 3σ and -3σ < Phi Dist < 3σ cuts were set to remove lots of random associations between TPC tracks and BEMC points.

Purity of Inclusive Electron



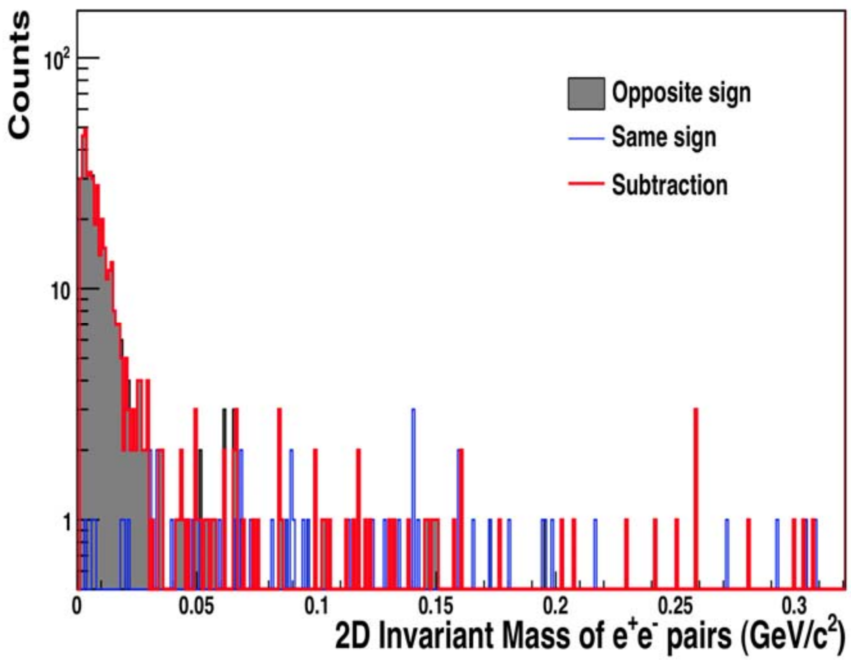
$$n\sigma_e = \frac{1}{R}\log\frac{dE/dx}{<dE/dx>_e}$$

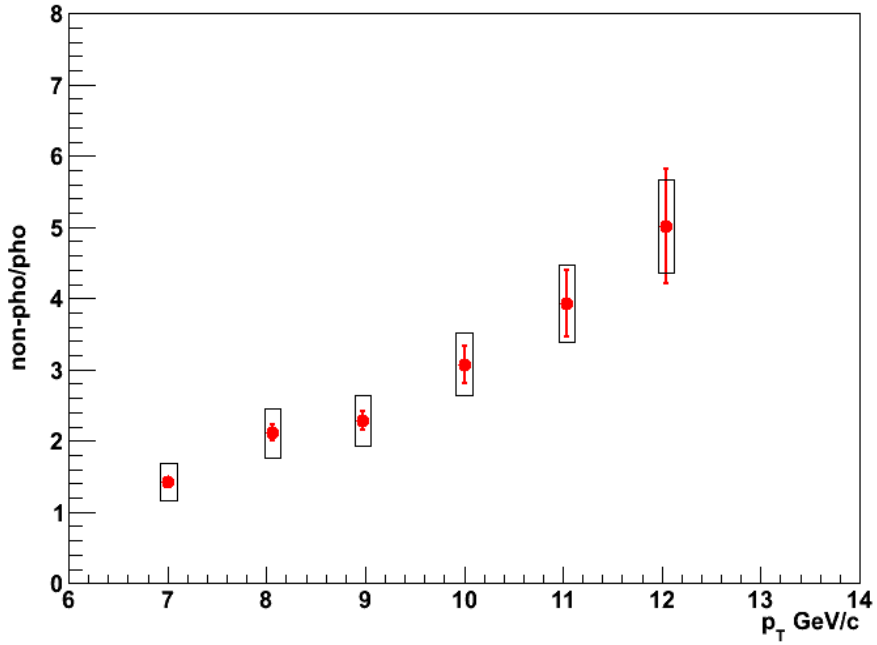
- R is the TPC resolution of energy loss
- dE/dx is the measured mean dE/dx for a track
- $<dE/dx>_e$ is the expected mean electron dE/dx from Bichsel formula with a given momentum

- $n\sigma_e$ cut: -0.6~2.6
- The purity of inclusive electron in 6.5-12.5 GeV/c p_T region is 83.5%.
- Subtract hadron contamination from signal.

Electron p_T (GeV/c)	6.5-7.5	7.5-8.5	8.5-9.5	9.5-10.5	10.5-11.5	11.5-12.5
purity	98.7%	82.6%	87.3%	86.9%	86.7%	75.1%

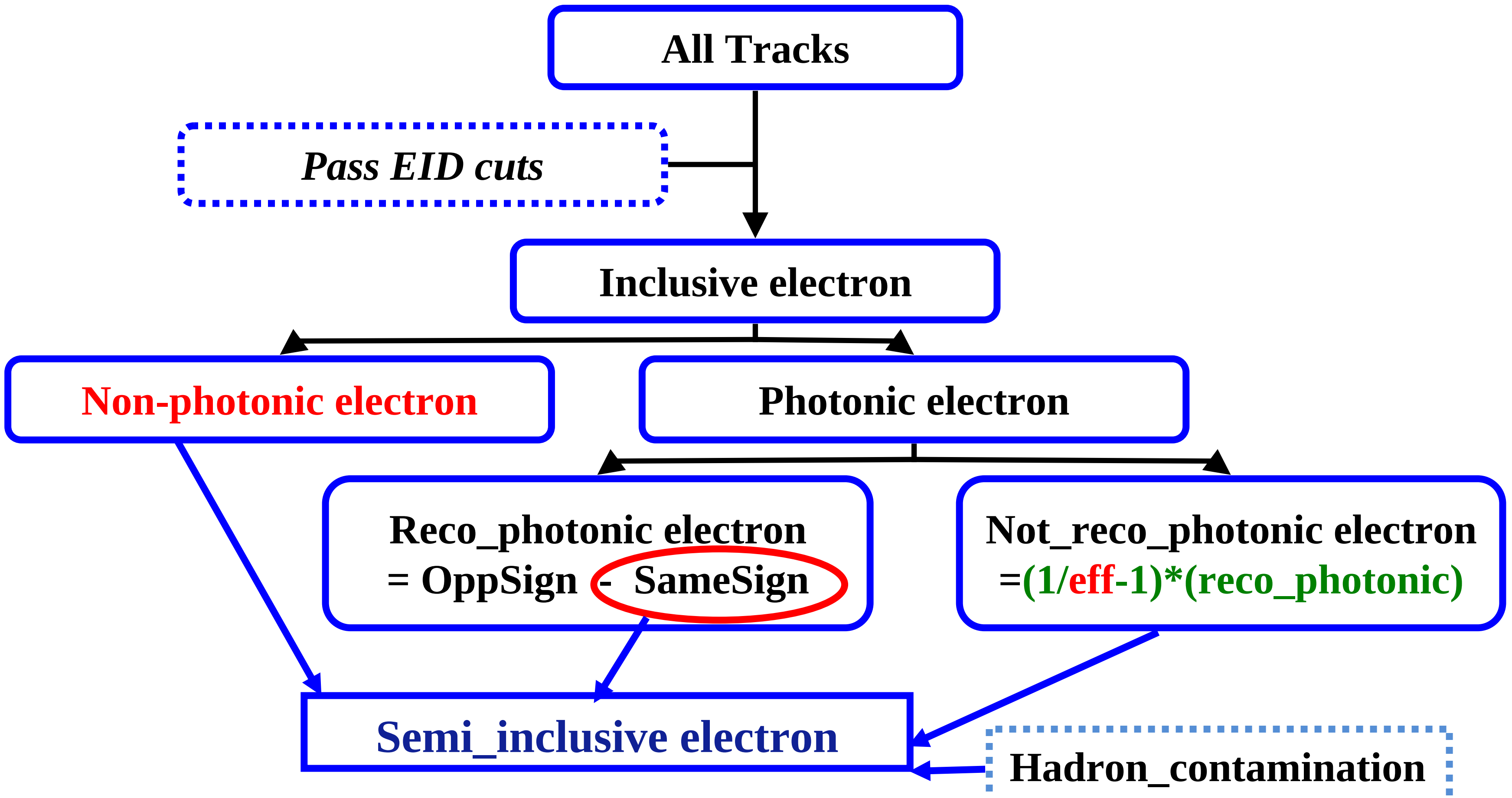
Photonic Background





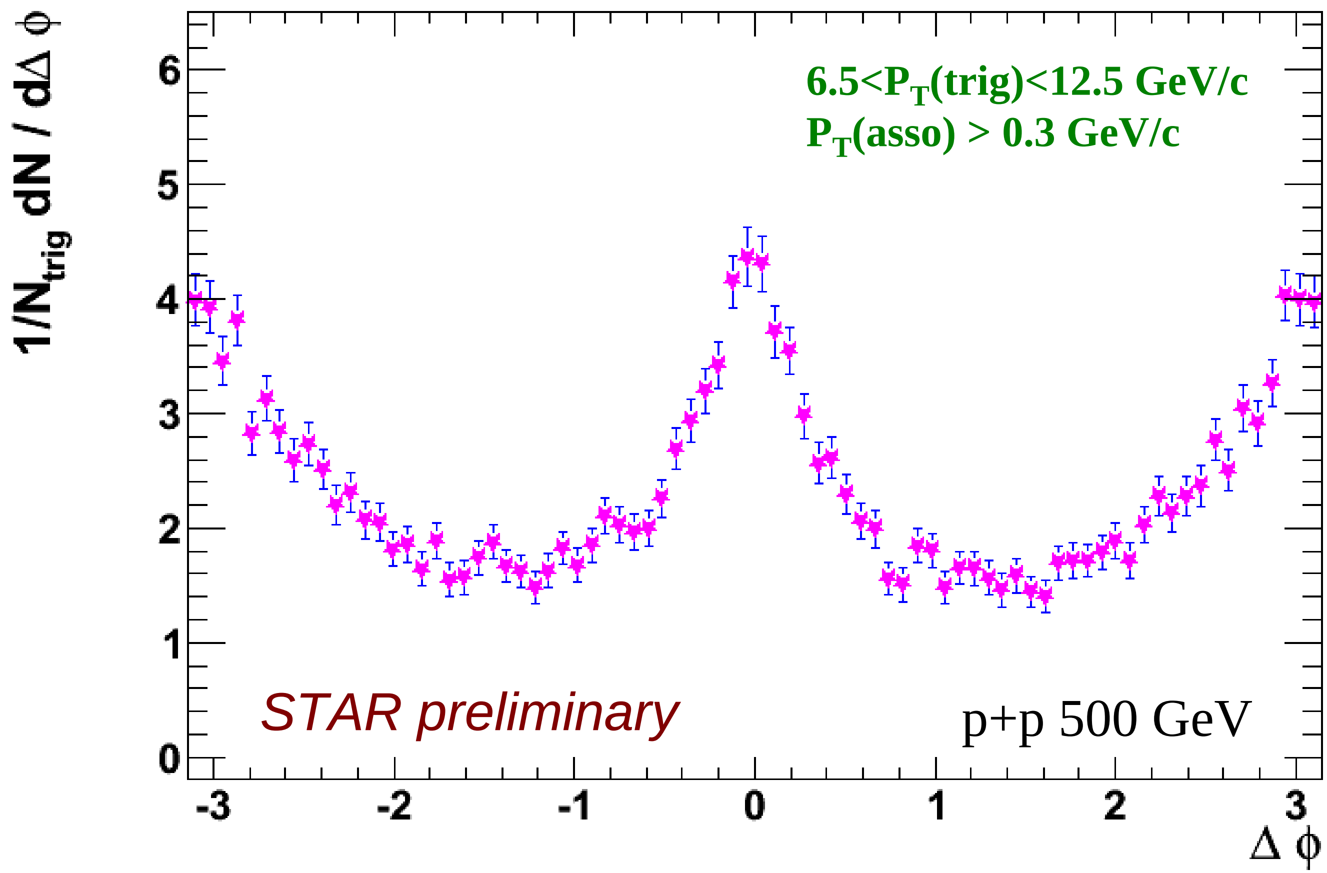
- The invariant mass for a pair of photonic electrons is small.
- Choose 2D Invariant mass < 0.1 GeV/c^2 to remove photonic background.
- Reconstructed_photonic = Opposite sign – Same sign.
- Photonic electron = Reconstructed_photonic/ ε . ε is the background reconstruction efficiency calculated from simulations.
- The photonic electron reconstruction efficiency used in this analysis is 65% ± 5%.

Method to Extract the Signal of NPE-h Correlations



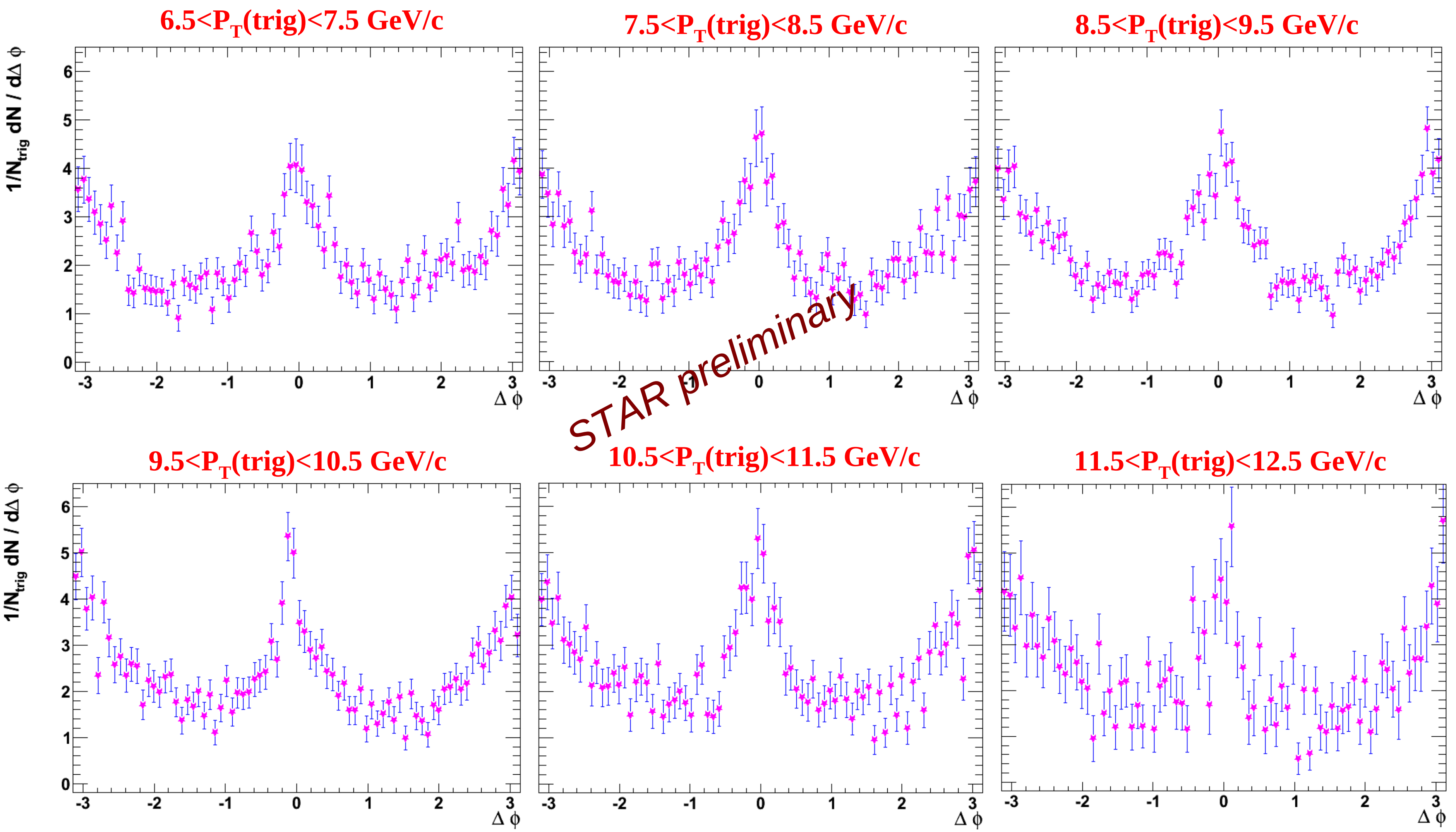
- Semi_inclusive electron = Inclusive electron － OppSign
- Signal: non-photonic = Semi_inclusive +SameSign-Not_reco_photonic -hadron_contamination
- $\Delta\phi_{Non\text{-}Pho} = \Delta\phi_{Semi\_Inc} + \Delta\phi_{SameSign} - \Delta\phi_{Not\_Reco\_Pho} - \Delta\phi_{hadron}$

Preliminary NPE-hadron Correlation Results



- Raw correlation with the photonic electron reconstruction efficiency of 65%
- Clear azimuthal correlation can be seen on near side and away side.

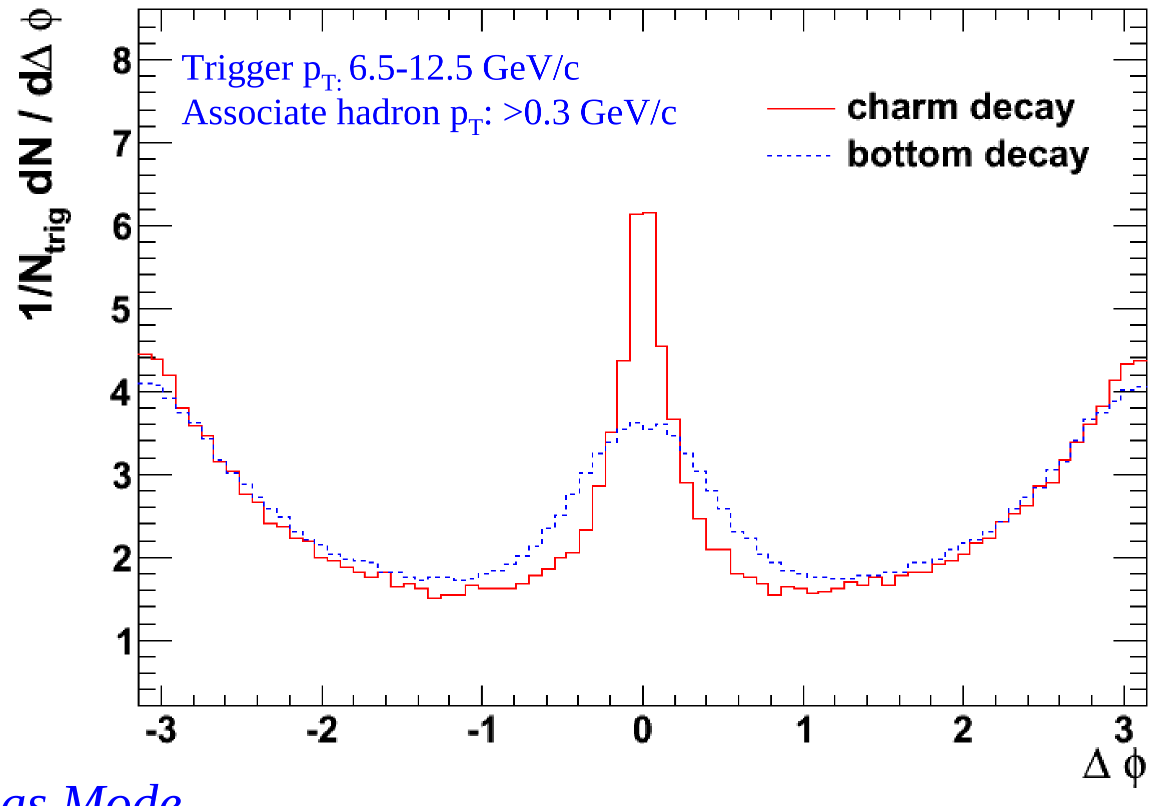
NPE-h correlation at different trigger pt region



Associated P_T > 0.3 GeV/c

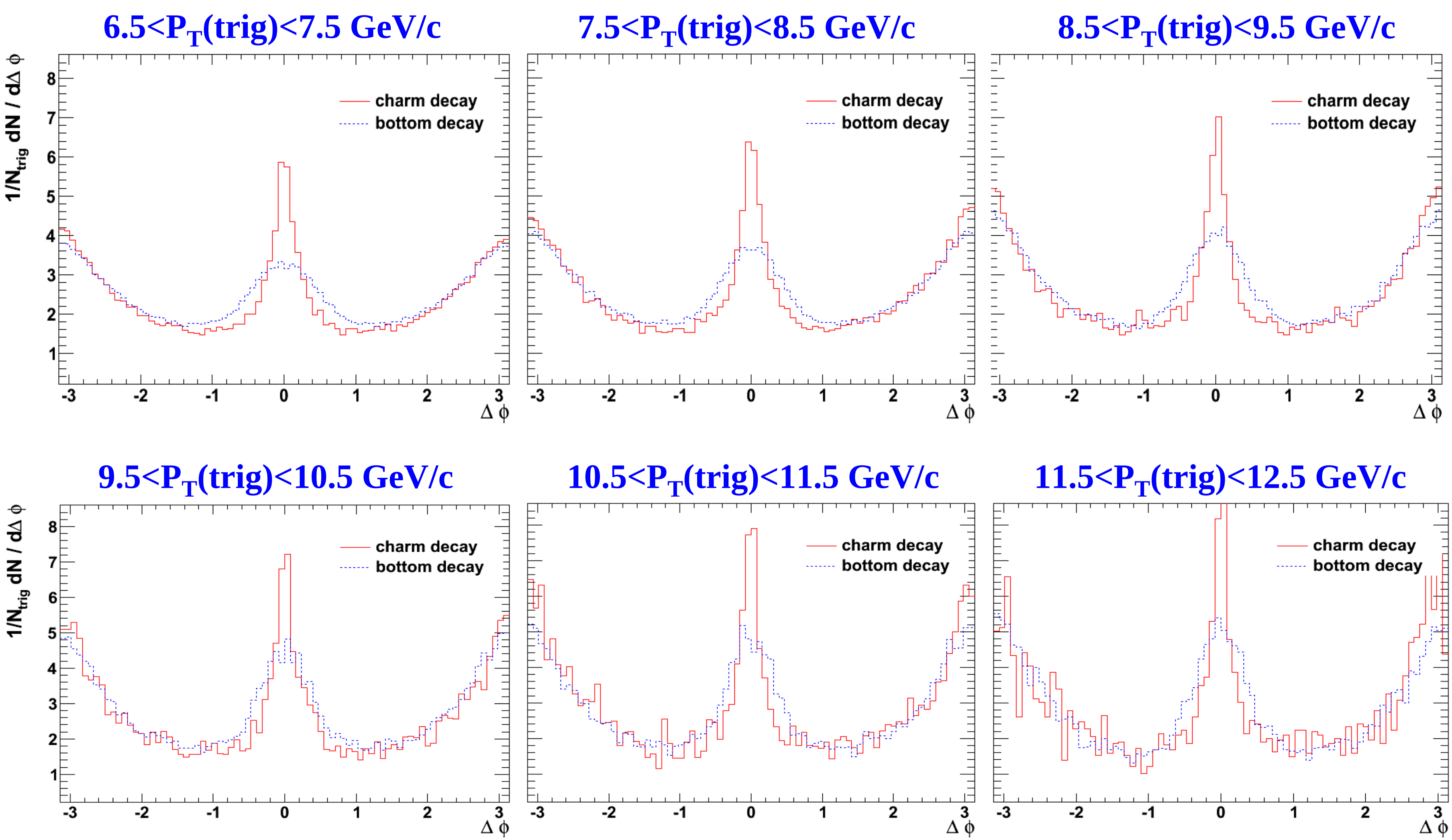
PYTHIA Simulation

We use PYTHIA 8.1 combined with STAR-HF-Tune Version 1.1 to generate e(D)-h and e(B)-h correlation in 500 GeV p+p collision



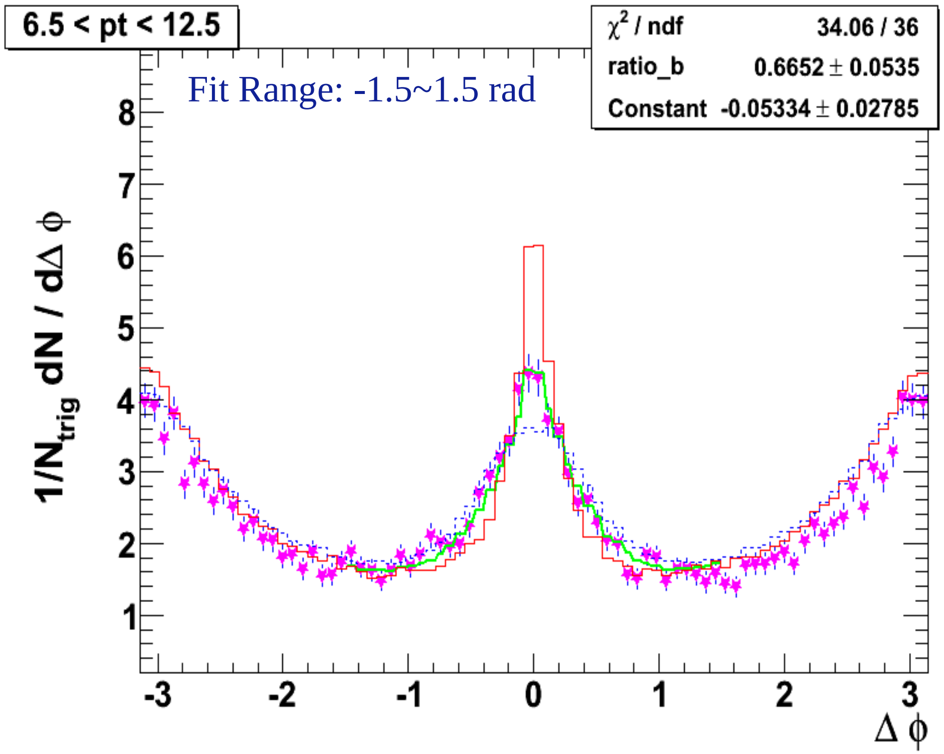
- *Mini Bias Mode*
- The statistics: Charm decayed electron: 20129
  Bottom decayed electron: 92555

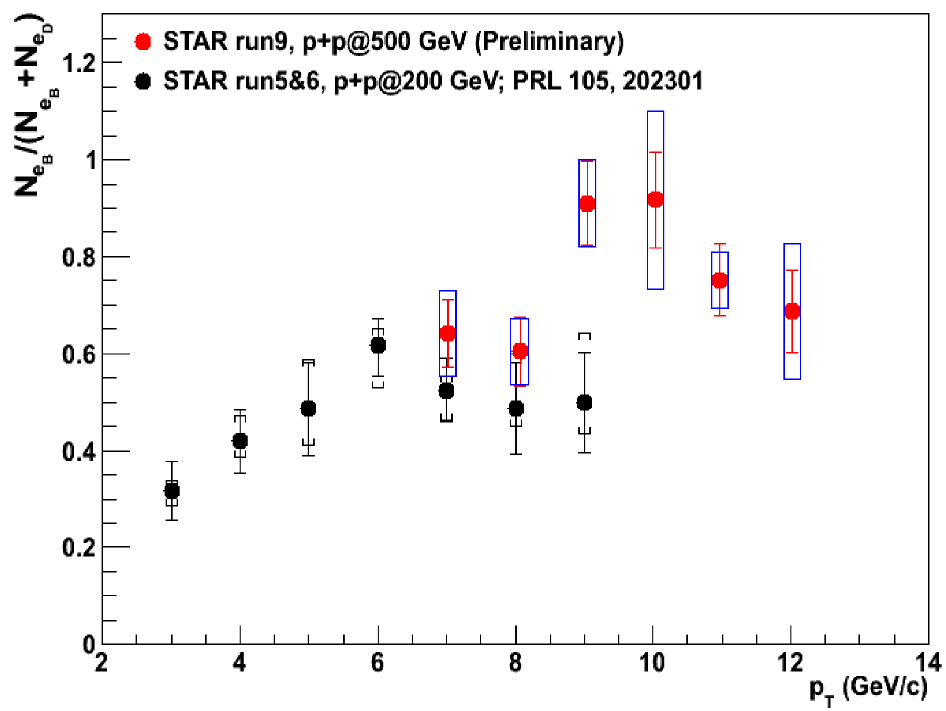
PYTHIA simulation at different p_T region



Associated hadron P_T > 0.3 GeV/c

Bottom Contribution to NPE





- Fit function: R*PYTHIA_B+(1-R)*PYTHIA_D+fitting_constant
- R is B contribution, i.e. B/(B+D), as a parameter in fit function.
- The extracted B/(B+D) ratio is above 60% with current uncertainties.
- Red bars are statistical error, blue box are systematic error introduced by different fit range, fit function and PE reco. efficiency !
- $e_B/(e_B+e_D)$ ratio is higher at 500 GeV than 200 GeV at p_T > ~7 GeV/c.

Summary

- Non-photonic electron and charged hadron azimuthal correlations have been measured in 500 GeV p+p collisions at STAR.
- PYTHIA simulation on e_D-h and e_B-h correlation have been constructed.
- PYTHIA results are compared to experimental data to extract bottom contribution.
- The extracted bottom contribution to non-photonic electron is above 60% at 6.5 $<p_T^{Trig}<$12.5 GeV/c.
- Further systematics to be studied.

Thank you !

backup

STAR-HF Tune

- The STAR-HF Tune is a set of parameters compiled in a runcard that are optimized to produce roughly what we measure at RHIC. These parameters are not cast in stone but reflect our current knowledge. Whenever someone comes up with an improvement will create a new version so we can keep track of what's going on and allow everyone to benefit from it. It also makes comparisons of data with PYTHIA results more accountable since everybody should be able to reproduce them. The name of the file is star_hf_tune_v<version number>.cmnd.
- Version 1.1 (latest) Essentially the same as 1.0 but with more process flags that make running a specific mode easier. More descriptions (how to avoid pt -> 0 divergences) and a nice way (commented for now) on how to specify which lifetimes are to be considered stable and not further decayed.
- NPE and J/ψ spectra results from PYTHIA 8.1 with STAR-HF Tune can describe STRA and PHENIX experimental data well.