Measurement of Bottom contribution to the non-photonic electron production in p+p collisions at STAR

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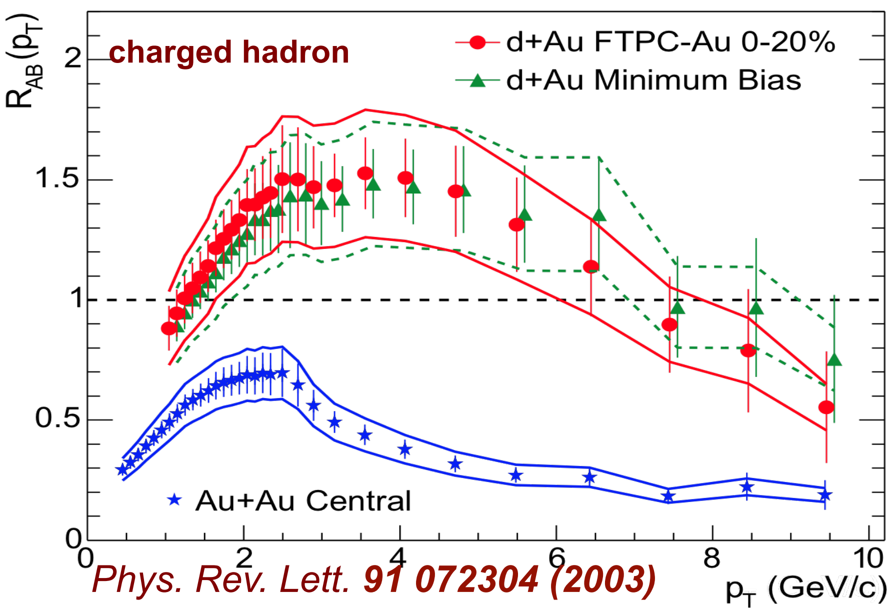
Outline

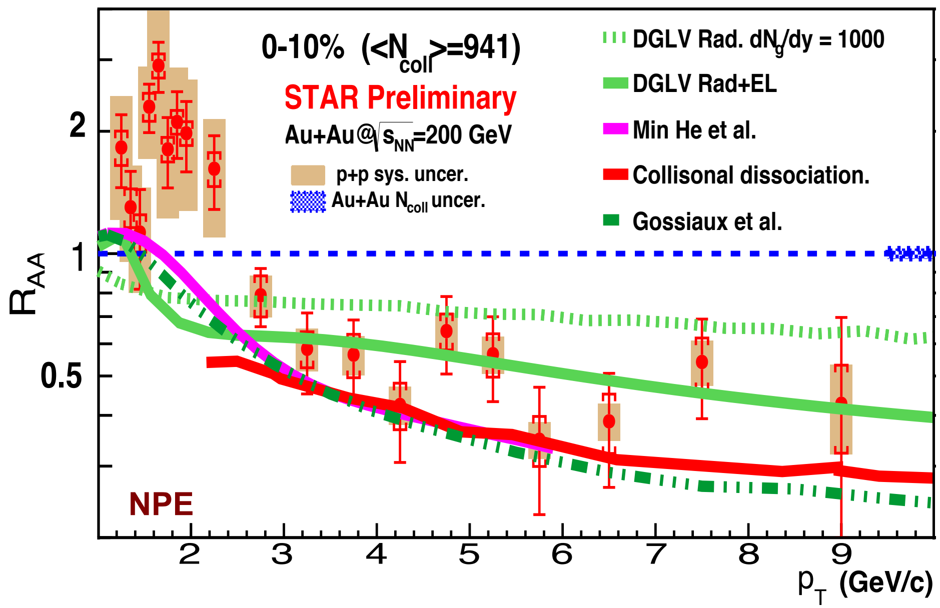
- Motivation
- Analysis method for extracting Non-Photonic Electron(NPE)
- NPE-hadron azimuthal correlation in p+p collisions at $\sqrt{s}$ = 200 GeV and 500 GeV
- Summary

Motivation

- ➢Heavy quarks are mainly produced in the INITIAL hard partonic interactions - calculable in pQCD
- ➢QCD predicts that heavy quarks lose less energy than light quarks via gluon radiation
- ➢NPE: semi-leptonic decays of open heavy flavor hadrons

  Branching ratio: $c \rightarrow e + anything$ (9.6%) $b \rightarrow e + anything$ (11%)
- ➢NPE is good proxy of heavy flavor quarks





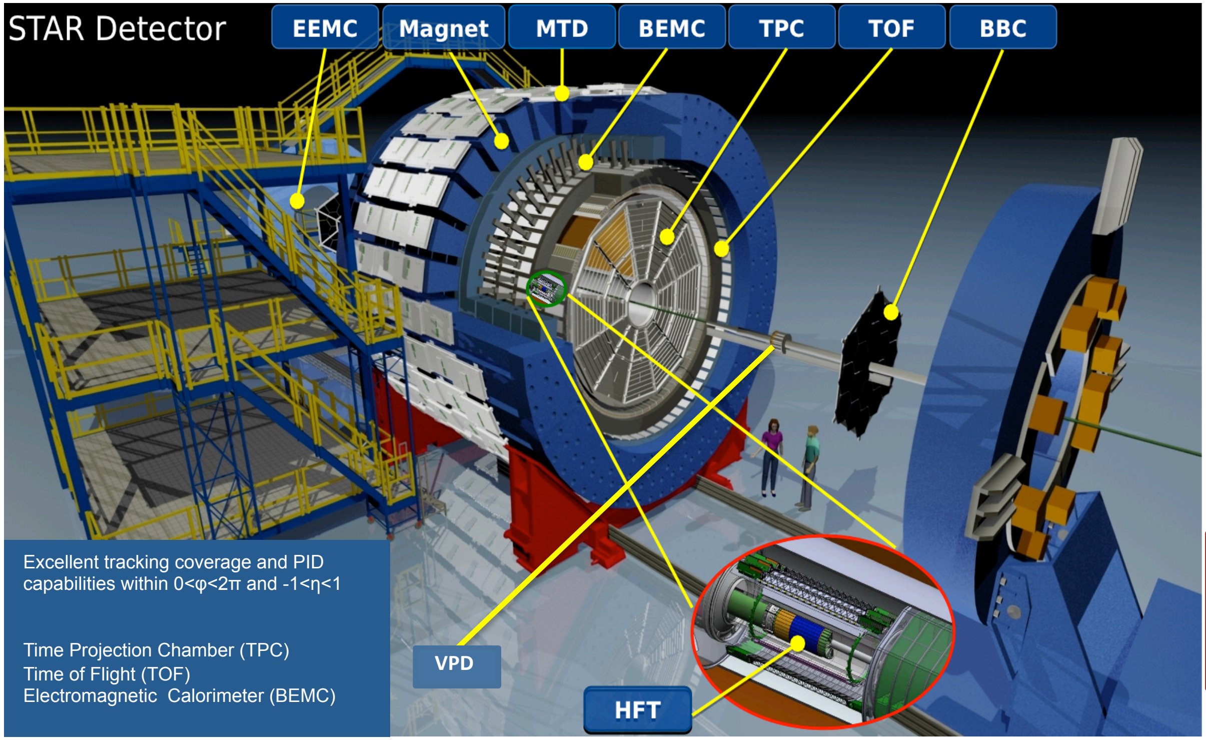
- ➢NPE is suppressed at high p_T in central Au+Au collisions, which implies substantial energy loss of heavy quarks.

Separate bottom contribution to NPE

- ➢ Theoretical calculation predicts less radiative energy loss for bottom quarks compared to charm quarks, which can be studied through suppression of D- and B-decayed NPE separately in Au+Au w.r.t p+p collisions

- ➢ Contributions of D- and B-decayed NPE in p+p collisions can be determined through studying NPE-hadron azimuthal correlation: different charm and bottom decay kinematics
  - ✓ Extracting D- and B-decayed NPE contributions in p+p collisions at 200 GeV as a reference for studies in Au+Au collisions at 200 GeV
  - ✓ Extracting D- and B-decayed NPE contributions in p+p collisions at 500 GeV to examine the collision energy dependence and compare with pQCD predictions

STAR Detector



Detector used:

- Time Projection Chamber (TPC)
- Barrel Electro-Magnetic Calorimeter (BEMC)
- Barrel Shower Maximum Detector (BSMD)
- Time Of Flight
- Vertex Position Detector

Data Sample:
Run11 p+p collisions at $\sqrt{s}$ = 500 GeV
Run12 p+p collisions at $\sqrt{s}$ = 200 GeV

Signal:
non-photonic electron
- Charm decay
- Bottom decay

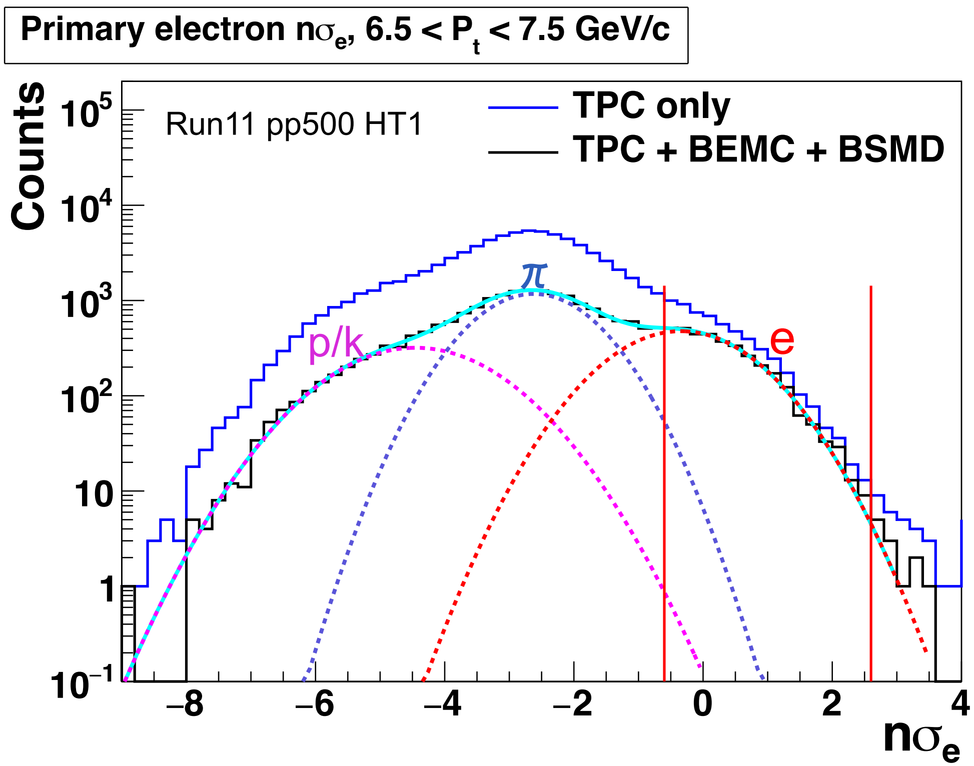
Background:
photonic electron
- Photon conversion
- π^0 Dalitz decay
- η Dalitz decay

Hadron contamination

Electron trigger threshold (electron E_T):
run11 500GeV: HT0~2.6 GeV, HT1~4.3 GeV, HT2~6.0 GeV

run12 200GeV: HT0~2.6 GeV, HT2~4.3 GeV

Purity of Inclusive Electron



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

- R is the resolution of energy loss measurement by TPC
- dE/dx is the measured energy loss for a track
- $\langle dE/dx \rangle_e$ is the expected energy loss for electrons from Bichsel formula at a given momentum

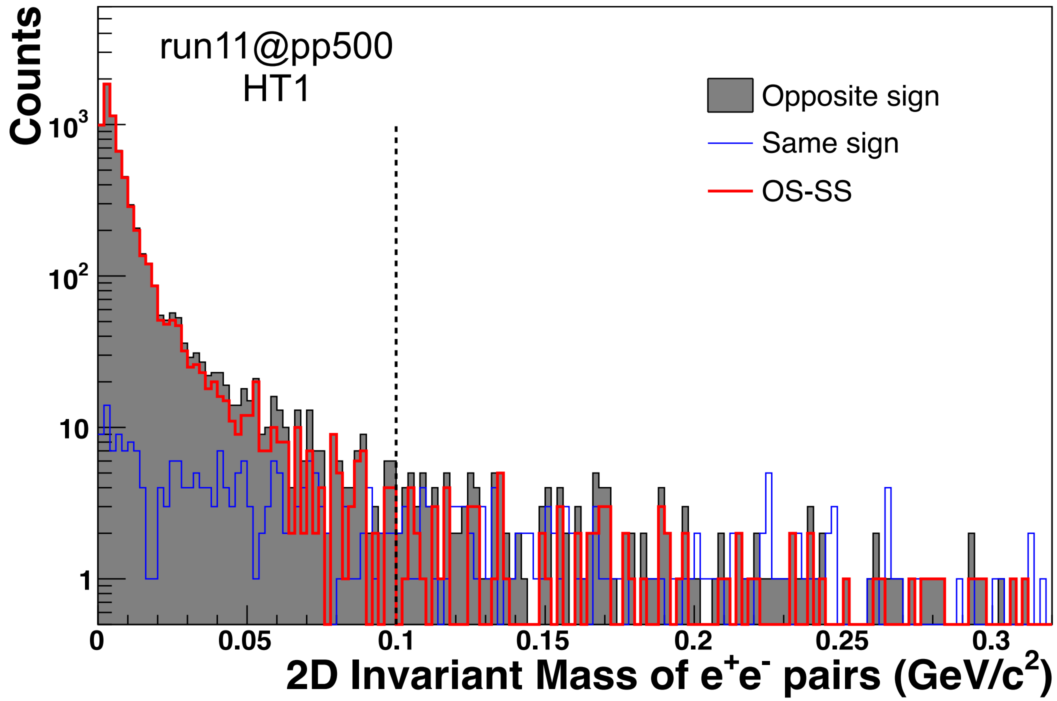
Purity

Run11: above 99% for 2.5< p_T< 4.5 GeV/c

above 96% for 4.5< p_T< 8.5 GeV/c ; above 86% for 8.5< p_T< 10.5 GeV/c

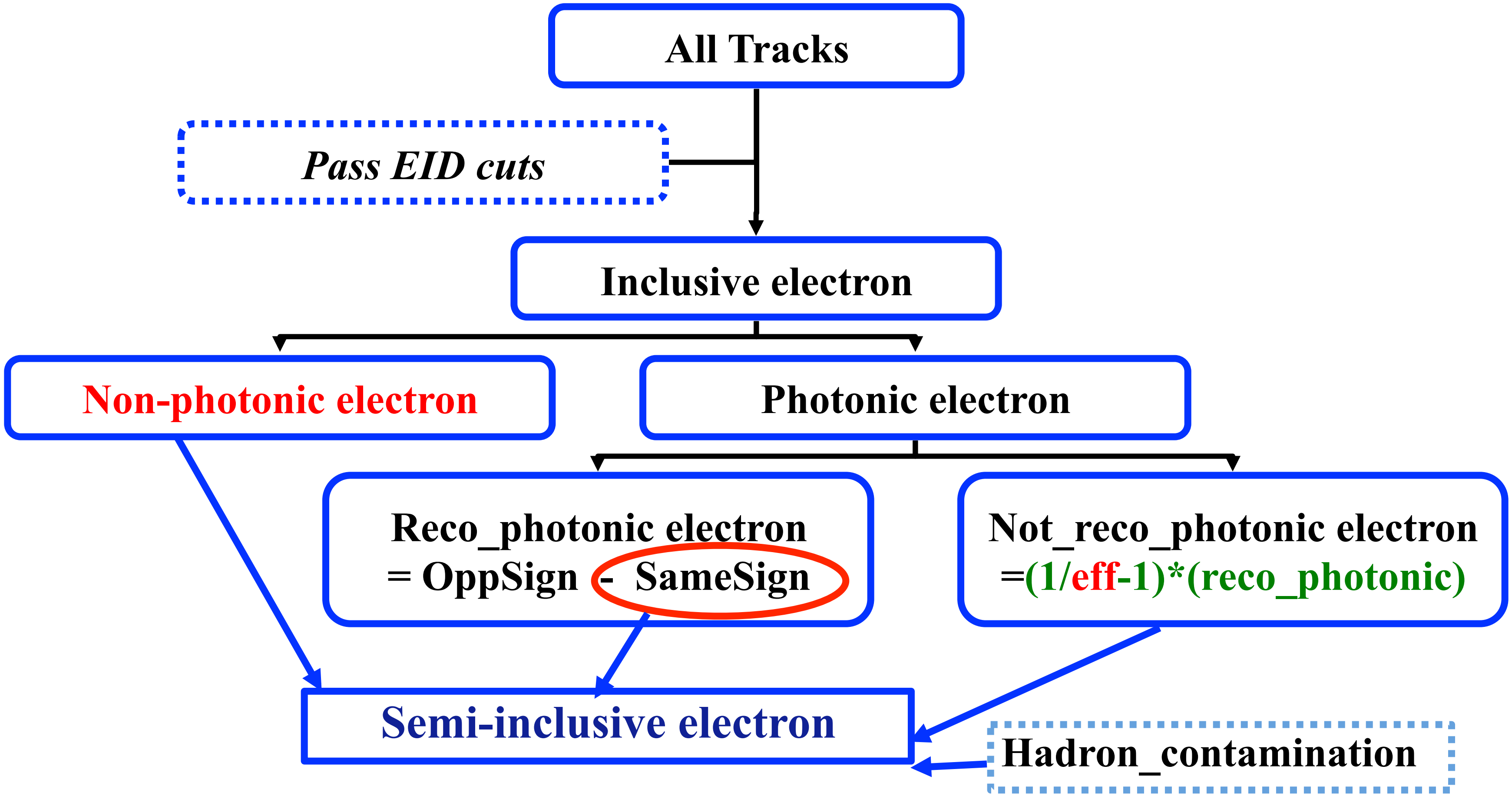
Run12: above 90% for p_T< 7 GeV/c ; above 80% for p_T< 10 GeV/c

Photonic Background



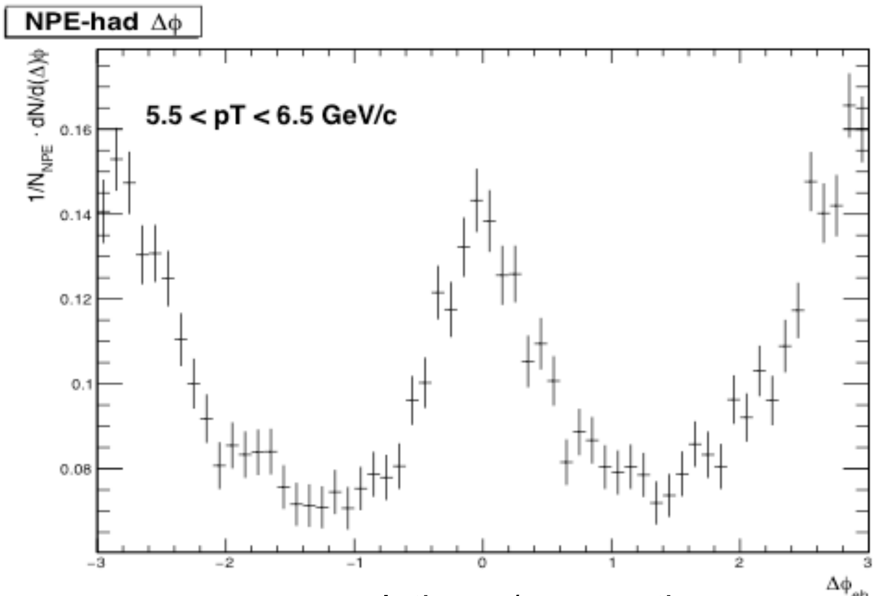
- The invariant mass for a pair of photonic electrons is small.
- Choose invariant mass < 0.1 GeV/c^2 to remove photonic background.
- Reconstructed photonic electron= Opposite sign – Same sign.
- Photonic electron = Reconstructed photonic electron/ε. ε is the reconstruction efficiency for photonic electrons calculated using simulations.

Method to Extract NPE-h Correlations

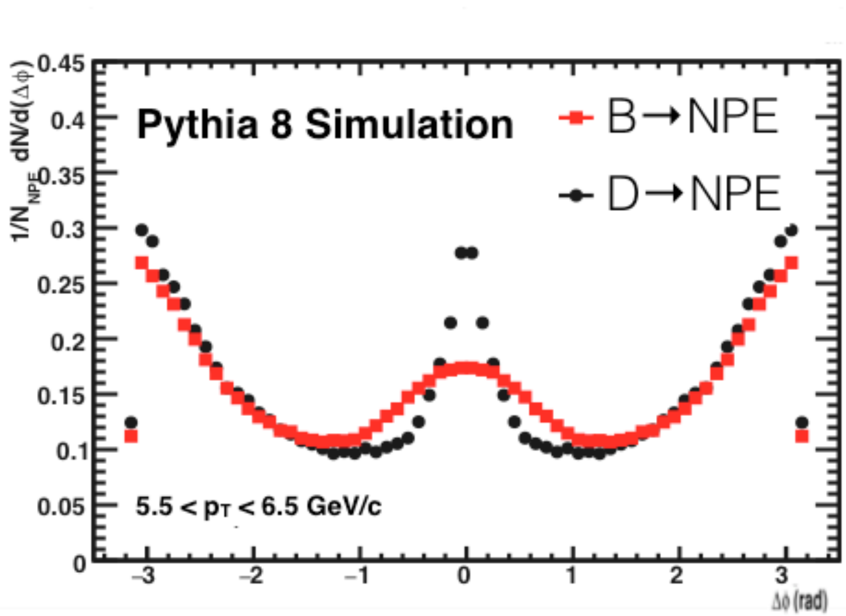


- Semi-inclusive electron = Inclusive electron − OppSign
- Signal: NPE= Semi-inclusive +SameSign-(1/eff-1)*reco-photonic-Hadron_contamination
- $\Delta\varphi_{Non\text{-}Pho} = \Delta\varphi_{Semi\_Inc} + \Delta\varphi_{SameSign} - \Delta\varphi_{Not\_Reco\_Pho} - \Delta\varphi_{hadron}$

NPE-h correlation in 200 GeV p+p Collisions



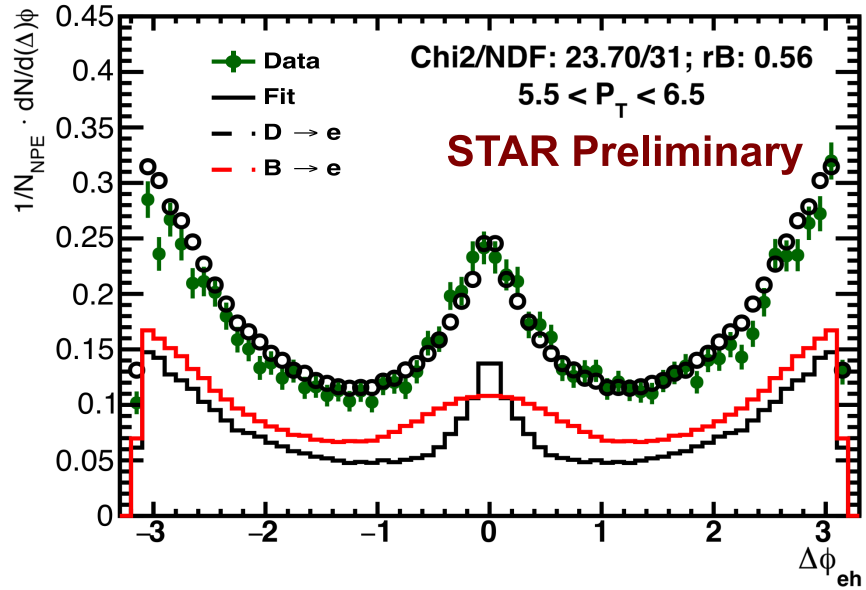
raw correlation w/o correction



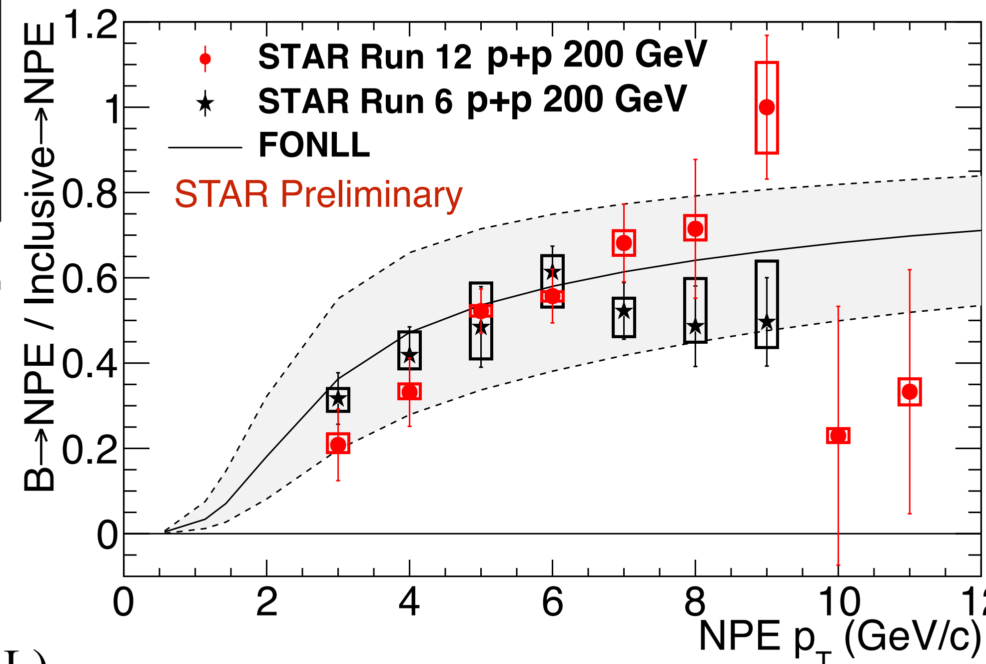
- Prominent correlation signals on both near-side and away-side
- PYTHIA 8.1 combined with STAR-HF-Tune Version 1.1 to generate e(D)-h and e(B)-h correlation in 200 GeV p+p collisions
- Significant difference on the near-side of correlation distributions between D and B decays due to different decay kinematics

B->NPE Contribution in 200 GeV p+p Collisions

Fit function: (R*PYTHIA_B+(1-R)*PYTHIA_D)*Norm



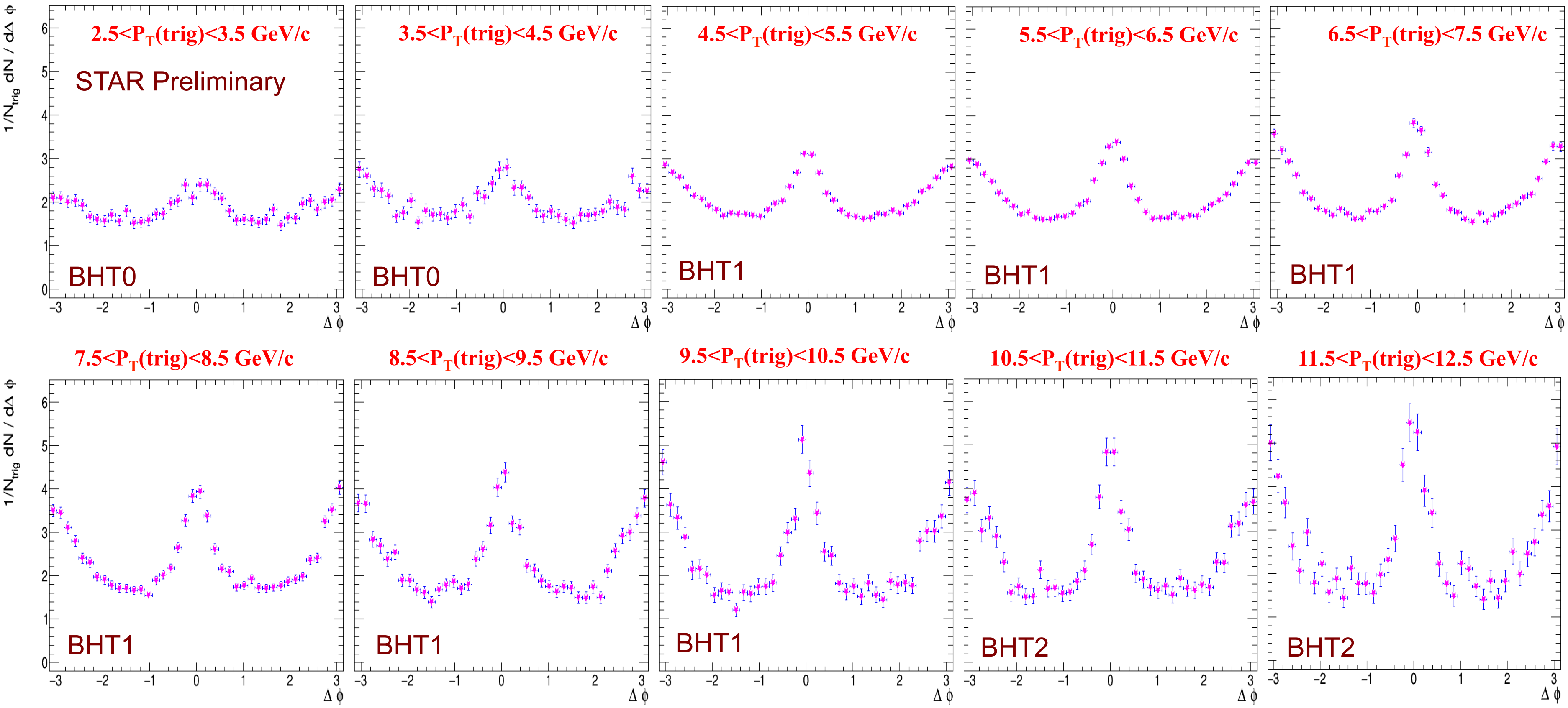
- R is B contribution, i.e. B/(B+D), as a parameter in fit function
- Norm acts as an overall normalization



STAR Run 6: Phys.Rev.Lett. 105, 202301 (2010)
FONLL: Phys.Rev.Lett. 95 122001 (Preprint hep-ph/0502203)

- Preliminary result agrees with previous STAR analysis for p_T <8.5 GeV/c
  - -Systematic uncertainties are significantly reduced
- STAR results are consistent with Fixed Order Next to Leading Logarithm (FONLL) calculation within uncertainties

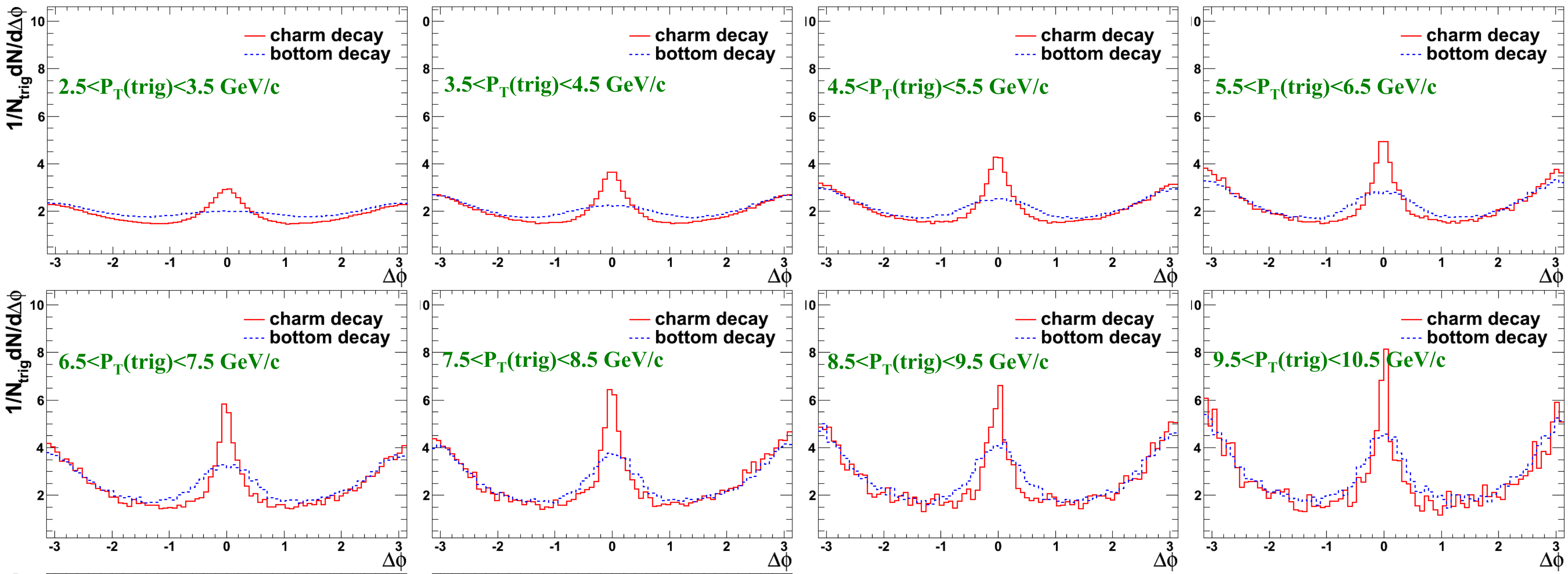
NPE-h correlation in 500 GeV p+p Collisions

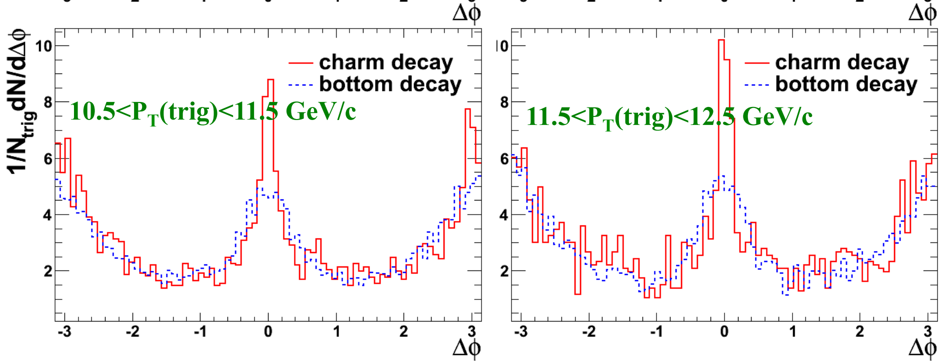


- Raw correlation w/o efficiency correction
- Associated hadron with $p_T > 0.3$ GeV/c
- Clear azimuthal correlation on the near-side, and the correlation signal increases as NPE p_T increases.

PYTHIA Simulation for 500 GeV p+p Collisions

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





- Significant difference between D and B decays on the near-side at low p_T
- Correlation signal increases as trigger p_T increases
- Difference between e(D)-h and e(B)-h correlation decreases as trigger p_T increases

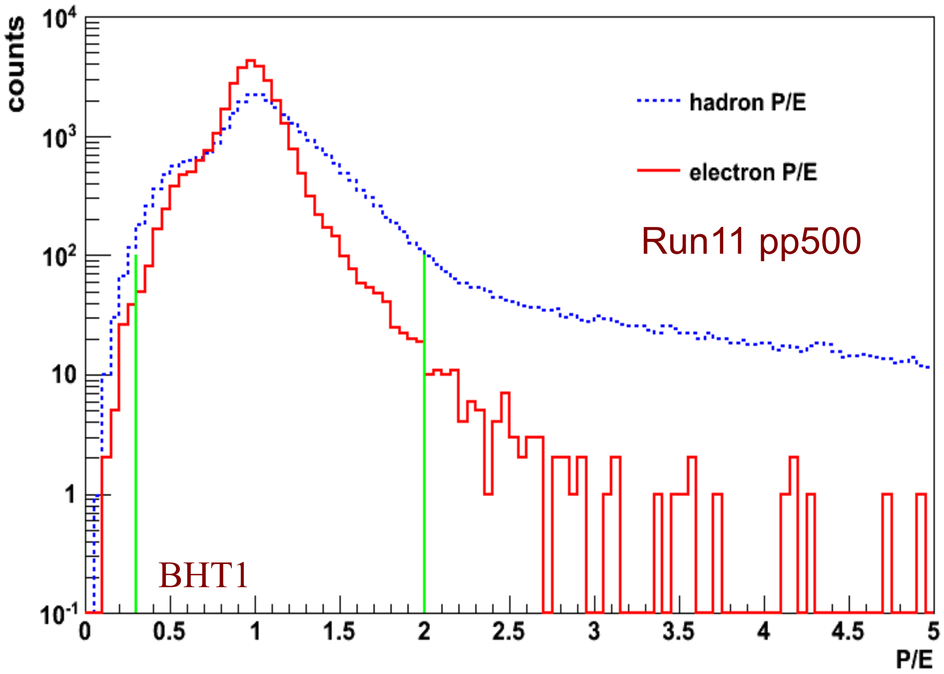
Summary

- Bottom contribution to NPE is extracted using NPE-h correlations in p+p collisions at $\sqrt{s}$ = 200 GeV.
- The 200 GeV p+p results have an extented p_T range and reduced systematic uncertainties than previous measurements. They also confirm theory calculations.
- Clear NPE-h correlation on near side can be seen in 500 GeV p+p collisions, and the correlation signal increases as trigger p_T increases. Efficiency corrections and systematics under the way.
- The HFT allows direct access to B contributions to NPE in Au+Au collisions via topological reconstruction of decay vertex.

Thank you for your attention!

BACKUP

Electron Identification: P/E



➢ P is the momentum measured by TPC, E is the sum of the associated BEMC points' energy measured by BEMC.

➢ Electrons will deposit almost all of their energies in the BEMC towers.

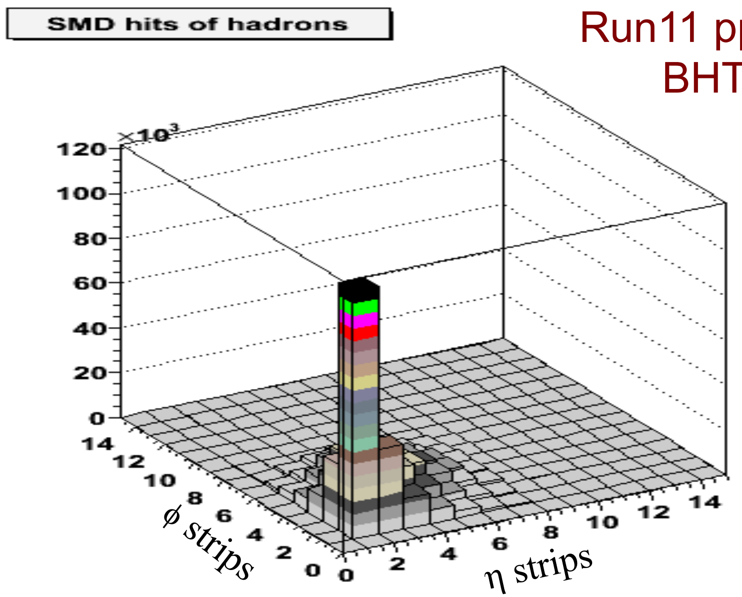
➢ 0.3 < P/E <2.0 cuts were used to keep electrons and reject hadrons.

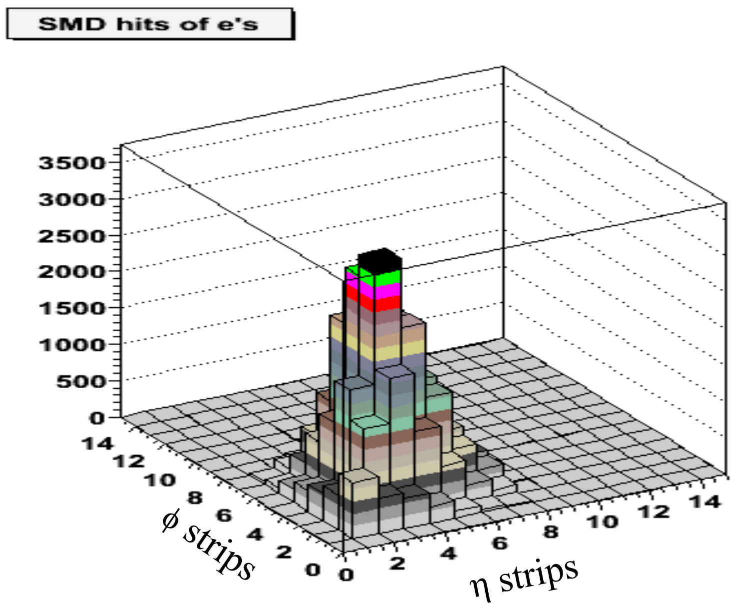
Electron Identification: Shower Size

SMD hits of hadrons

SMD hits of electrons

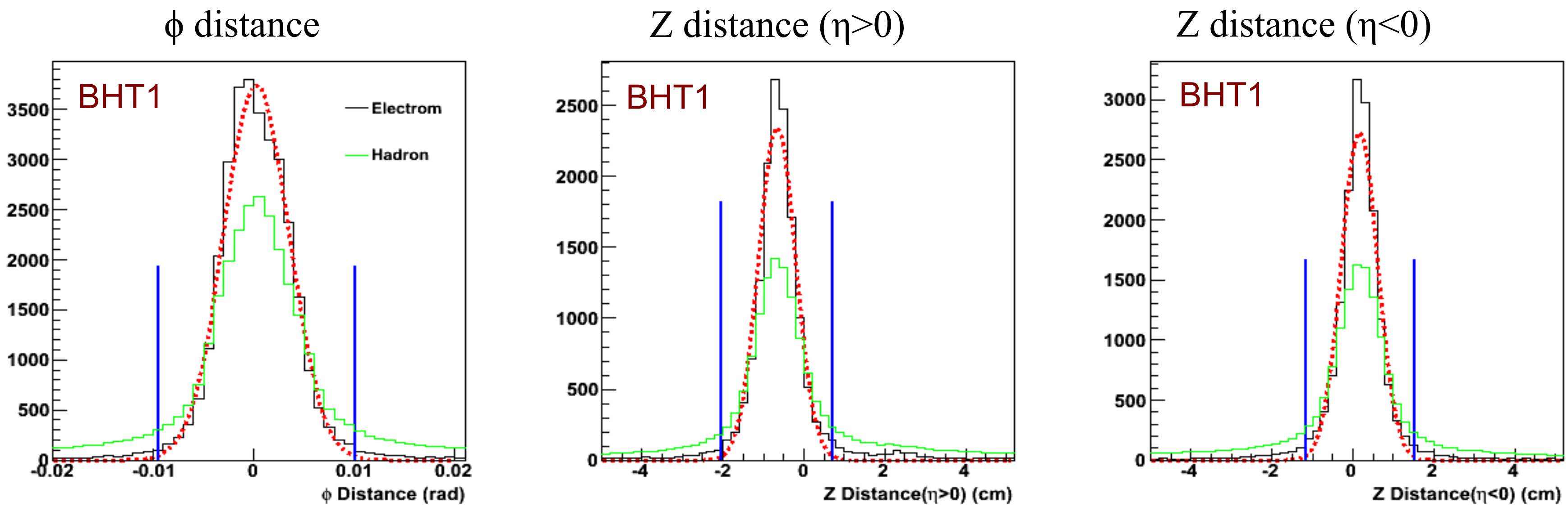
Run11 pp500
BHT1





- Number of SMD hits per shower indicates shower size.
- Electrons have larger number of BSMD hits than hadrons.
- We choose SMD hits larger than 2 to reject hadron contamination

Electron Identification: Projection Distance



Run11 pp500 $2.5<p_T<10.5$ *GeV/c*

➢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 scaled to match the entries of electrons

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