The measurement of non-photonic electrons in STAR

Olga Hájková for the STAR Collaboration

Faculty of Nuclear Sciences and Physical Engineering

Czech Technical University in Prague

Hard Probes 2012

27th May – 1st June 2012, Cagliary, Italy

Outline

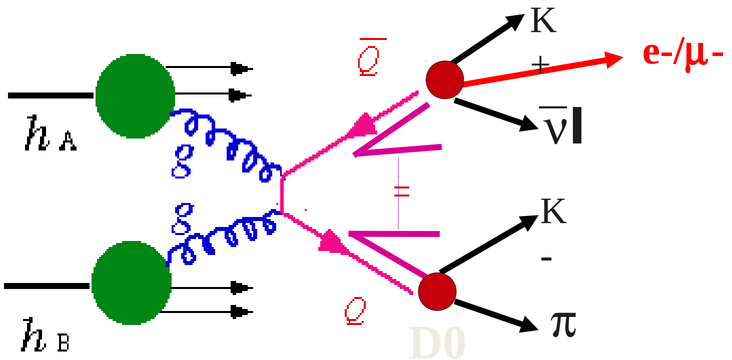
- Motivation.
- NPE analysis methods.
- NPE spectrum in p+p collisions at 200 GeV.
- NPE – hadron correlations in p+p collisions at 200GeV and 500GeV.
- NPE spectrum in Au+Au collisions.
- NPE – hadron correlation in Au+Au collisions.
- NPE elliptic flow in Au+Au collisions.
- Future – measurement with HFT and MTD.

NPE measurement as a proxy to the heavy flavor

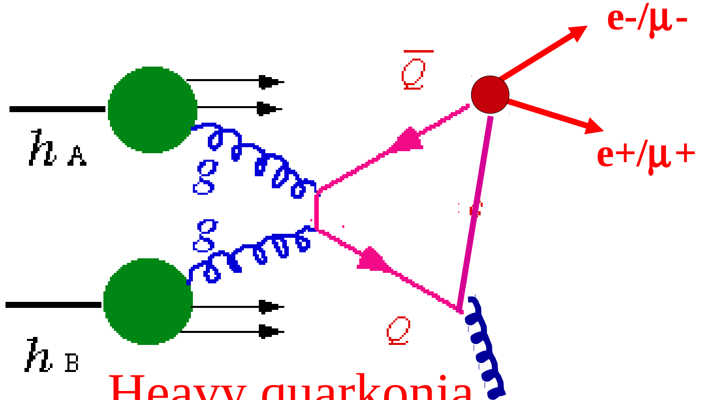
- Due to their large masses heavy quarks are produces mainly during initial parton-parton interactions at RHIC, and they are good probes to study the QCD matter.

- Study of heavy flavor production in nucleon+nucleon collisions is a test of the validity of the pQCD.

- Measurement in p+p collisions can be use as a baseline to study effect of hot and cold nuclear matter to production of heavy flavor quarks in ion-ion and ion-nucleon collisions.



Open heavy flavor



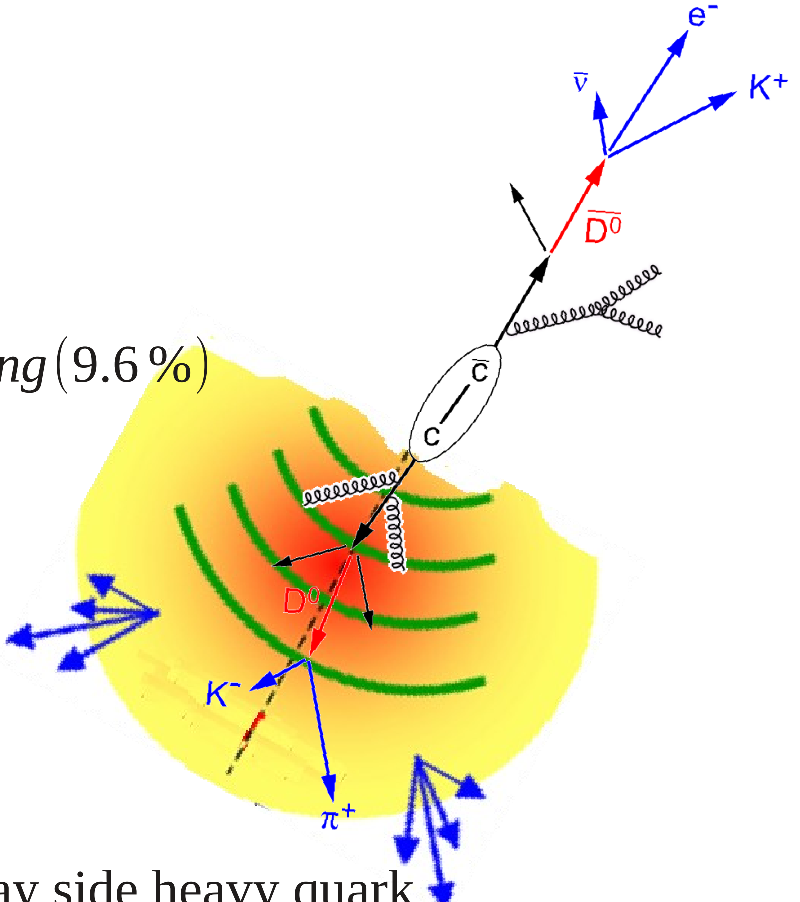
Heavy quarkonia

Today 17:30 (Room T3): Anthony KESICH - Measurements of Upsilon Production and Nuclear Modification Factor at STAR.

NPE measurement as a proxy to the heavy flavor production

- Study of non-photonic electrons is a good way to measure production of bottom and charm hadrons via semi-leptonic decays.

$b \rightarrow e^{\pm} + anything\,(10.86\,\%)$ $\quad$ $c \rightarrow e^{\pm} + anything\,(9.6\,\%)$



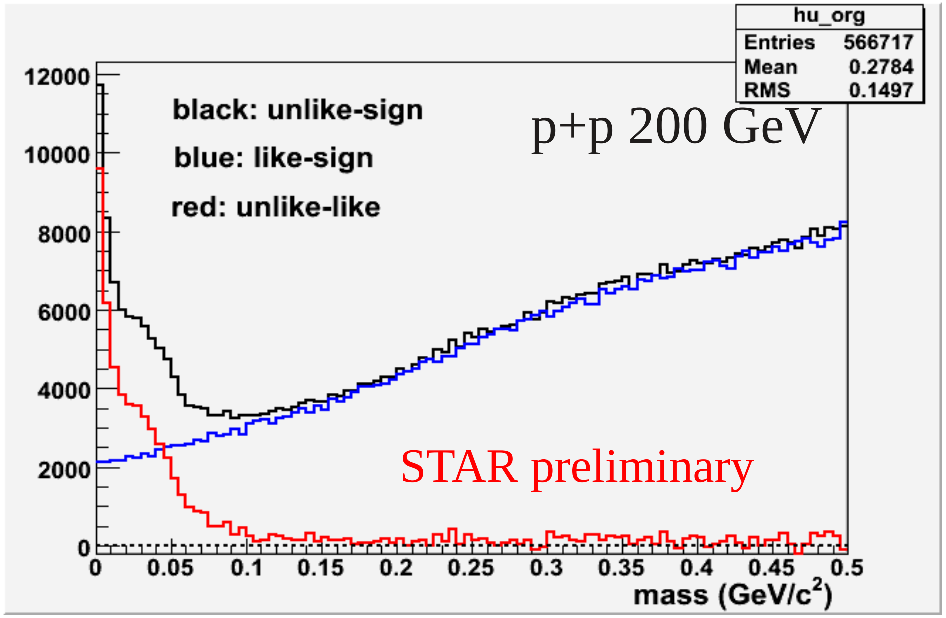
- Main background in this measurement comes from photonic electrons.
  - → Dalitz decay: $\pi^0 \rightarrow \gamma + e^+ + e^-$ (BR: ~1.2%)
  - → Gamma conversions: $\gamma \rightarrow e^+ + e^-$ (Decay prob: 7/9*Radiation Length)

Away side heavy quark medium modifications – study via correlation.

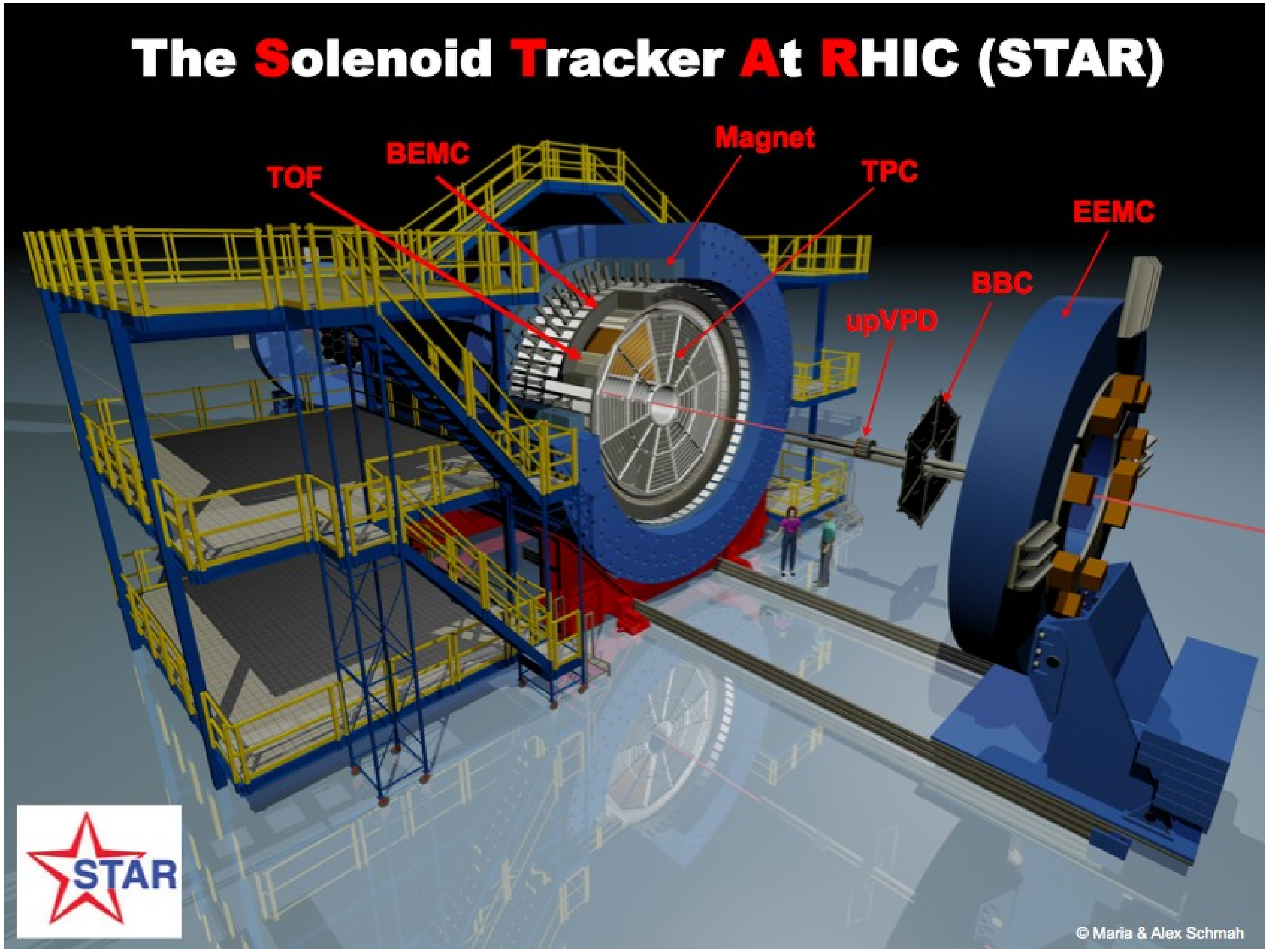
NPE analysis method

$$NPE = N_{Inclusive} * purity_{Inclusive} - \frac{N_{Photonic}}{\epsilon_{Photonic}}$$

- Inclusive electrons – pass electron identification cuts.
- Photonic electrons – identify via small invariant mass cut and spectrum is reconstructed statistically unlike-sign minus like-sign.
- Purity – from Inclusive electrons sample.
- A fraction of electrons from pairs cannot be tracked in the TPC → Photonic electron efficiency = reconstructed photonic electrons over all photonic (i.e. reconstructed and non-reconstructed).
- Same way as yield could be calculated others variables (elliptic flow).



STAR detector at RHIC



Large acceptance:
$|\eta|<1$, $0<\varphi<2\pi$

Time Projection Chamber (TPC) – tracking, particle identification, momentum

Time of Flight detector (ToF) – particle identification

BEMC – electron identification, triggering

BSMD – electron identification at high p_T

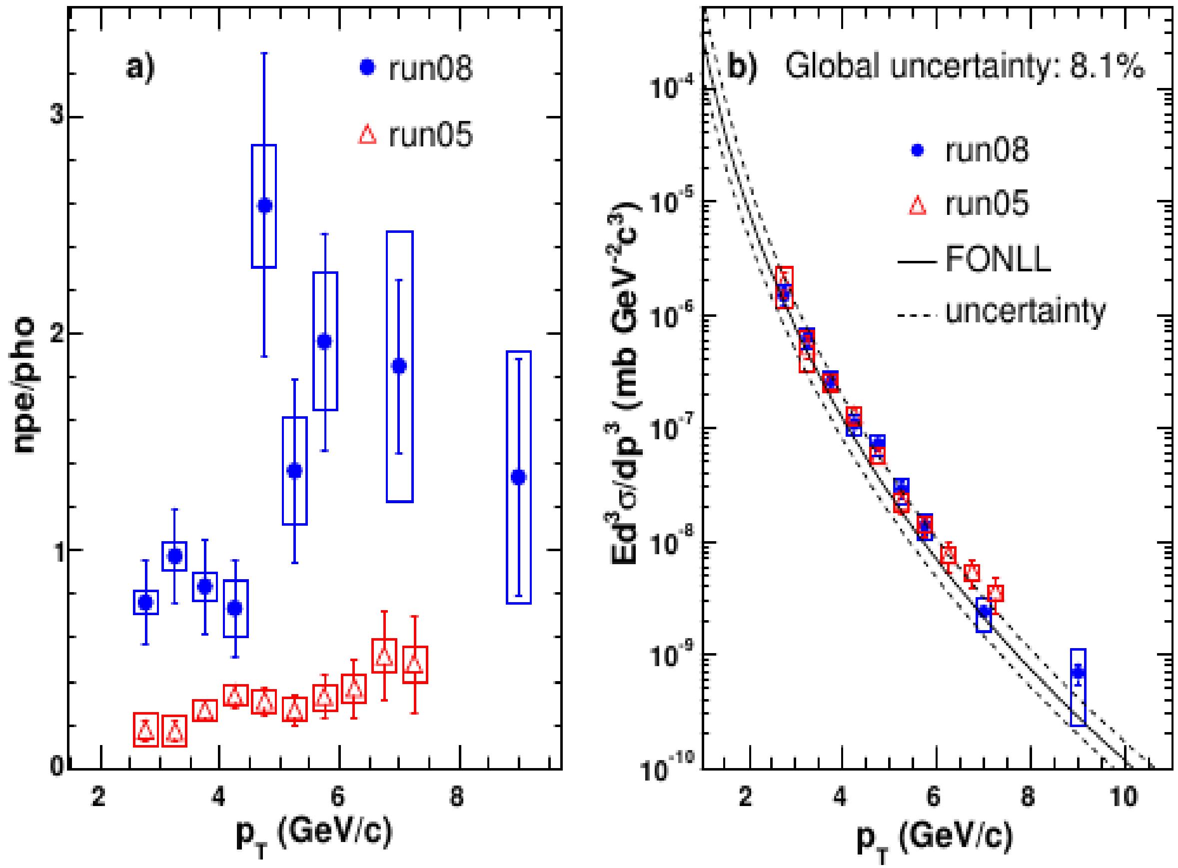
NPE spectrum in p+p collisions at √s=200GeV

- Different material thickness in years 2005 and 2008 (∼10 times more material in run05 because of silicon detectors presence).

  → much more gama conversion background in run05.

  → leads to the different NPE/PHE ratio.

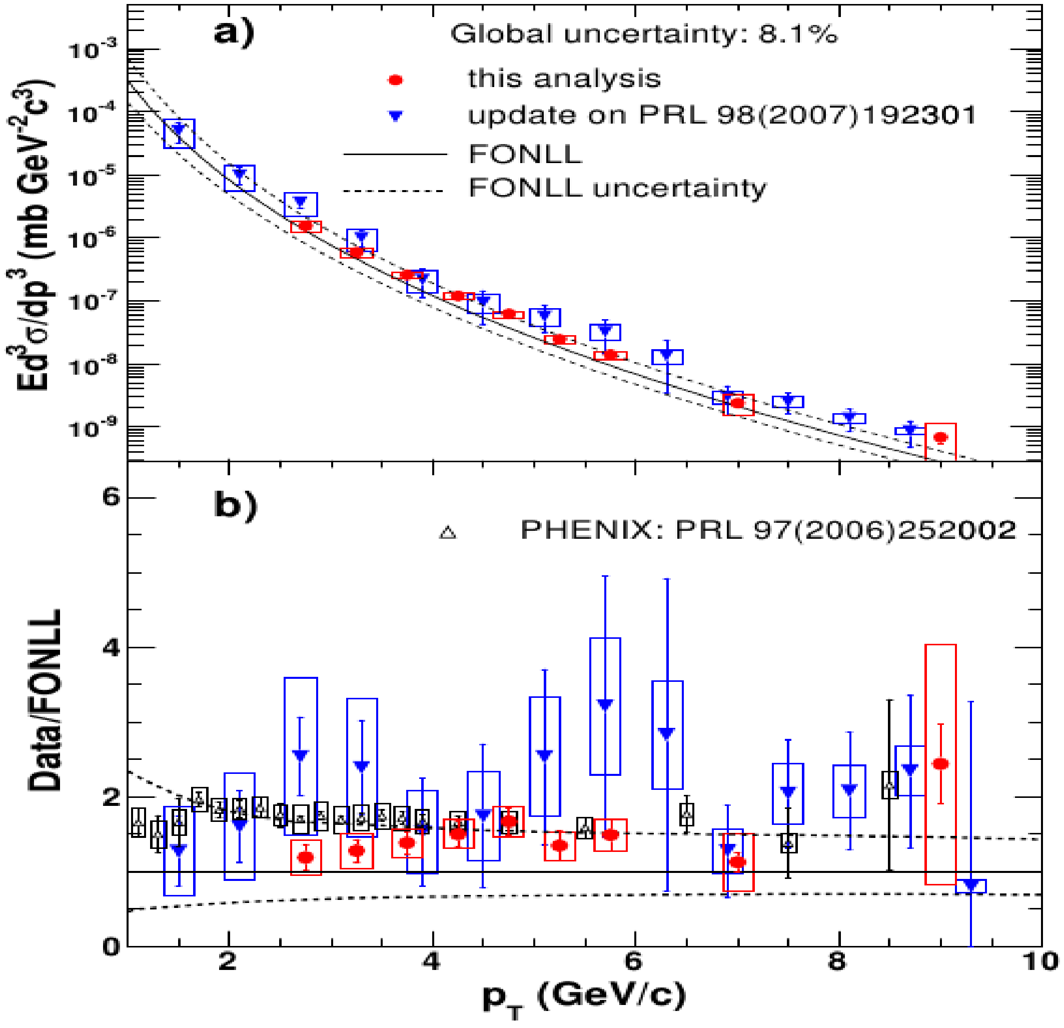
  → despite of analysis sensitivity to the amount of photonic background, results from years 2005 and 2008 agree with each other well for pT > 3 GeV.



STAR Phys. Rev. D 83 (2011) 052006

NPE spectrum in p+p collisions at √s=200GeV

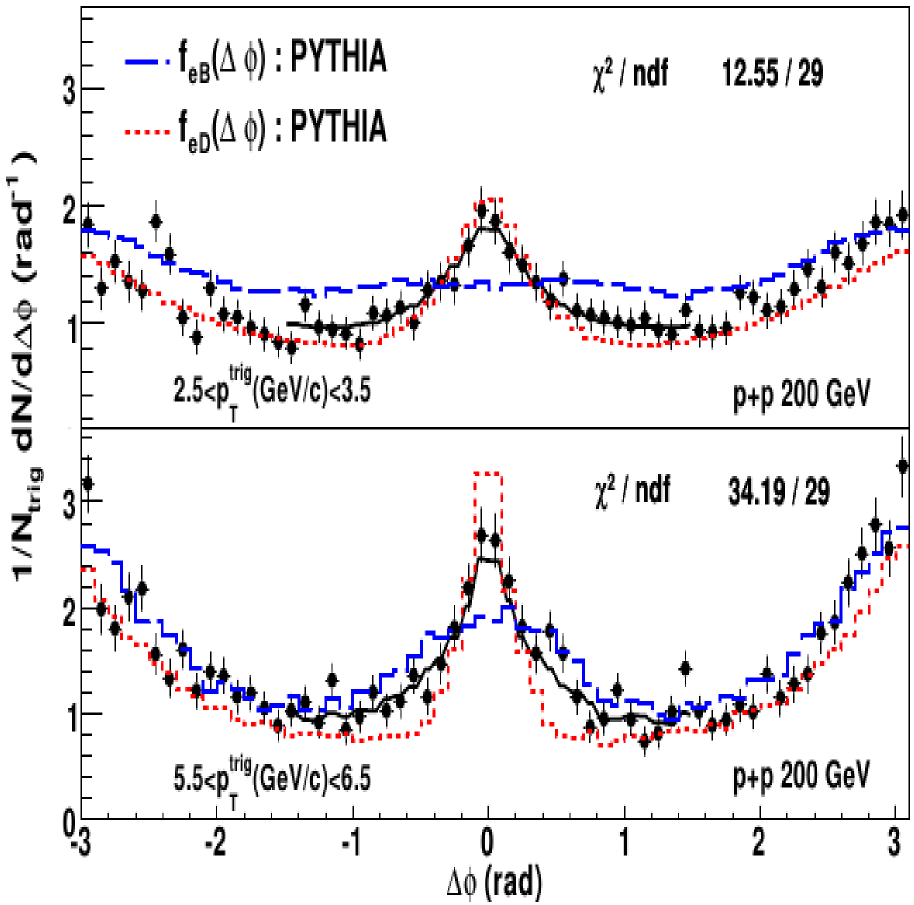
- Results from years 2005 and 2008 were combined.
- Combined results are consistent with PHENIX results, and with FONLL calculations as well.



STAR Phys. Rev. D 83 (2011) 052006

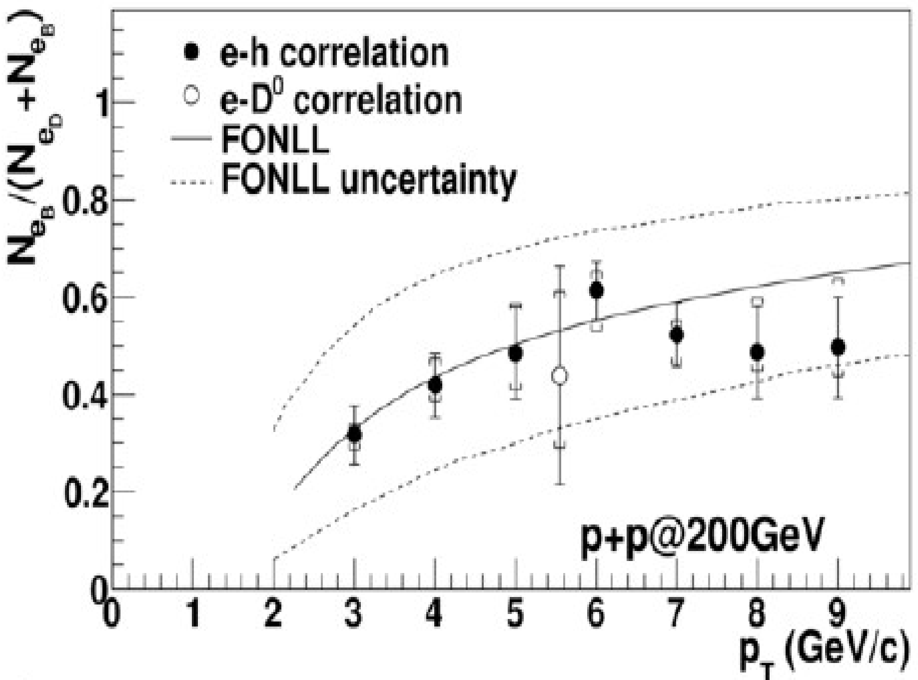
NPE – hadron azimuthal correlation

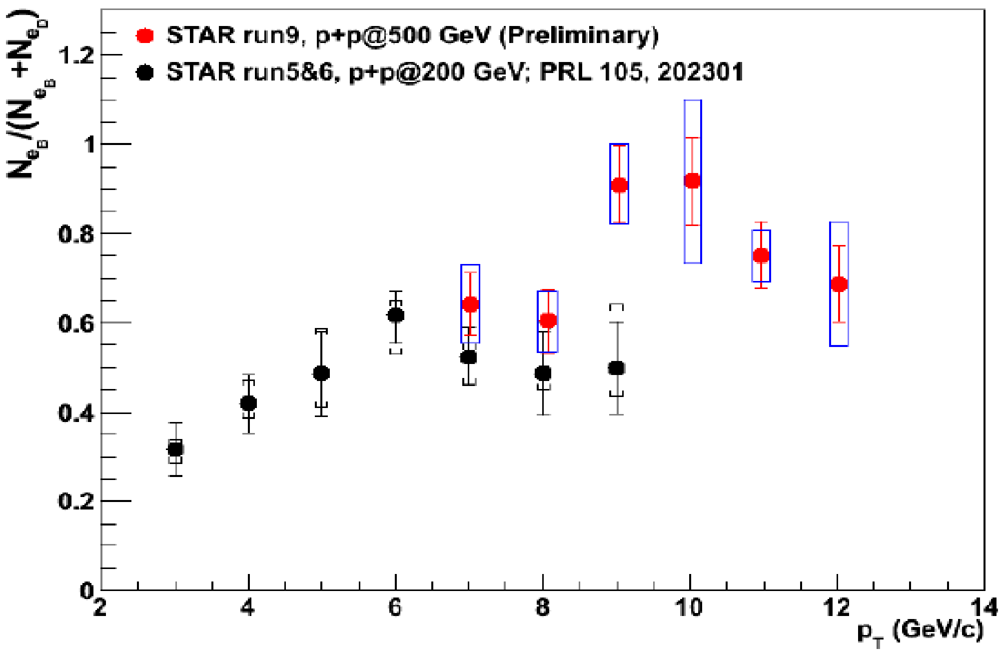
- Radiative energy loss depends on the quark matter → theoretical prediction of the non-photonic electron suppression rely on the B/D ratio.
- Study of NPE- hadron azimuthal correlations allows determine the B/D ratio of NPE.
- Bottom and charm contributions to the total NPE yields are obtained by the comparision of data with PYTHIA.



STAR: PRL 105, 202301 (2010)

Bottom contribution to the NPE in p+p at 200GeV and 500GeV





STAR: PRL 105, 202301 (2010)

- Contribution of the B mesons decay at 200GeV to the NPE spectra increase with p_T. and its comparable to the contribution from D mesons decay at pT>5GeV.
- B contribution to the NPE is about 60% for p+p collisions at 500GeV at high p_T.
- Bottom contribution to the NPE increasing with energy.

Bottom and charm contributions to the NPE at 200 GeV

- Measurement of NPE from bottom decays is consistent with the central value of FONLL, NPE from charm decays are between the central value and upper limit of the FONLL calculation.

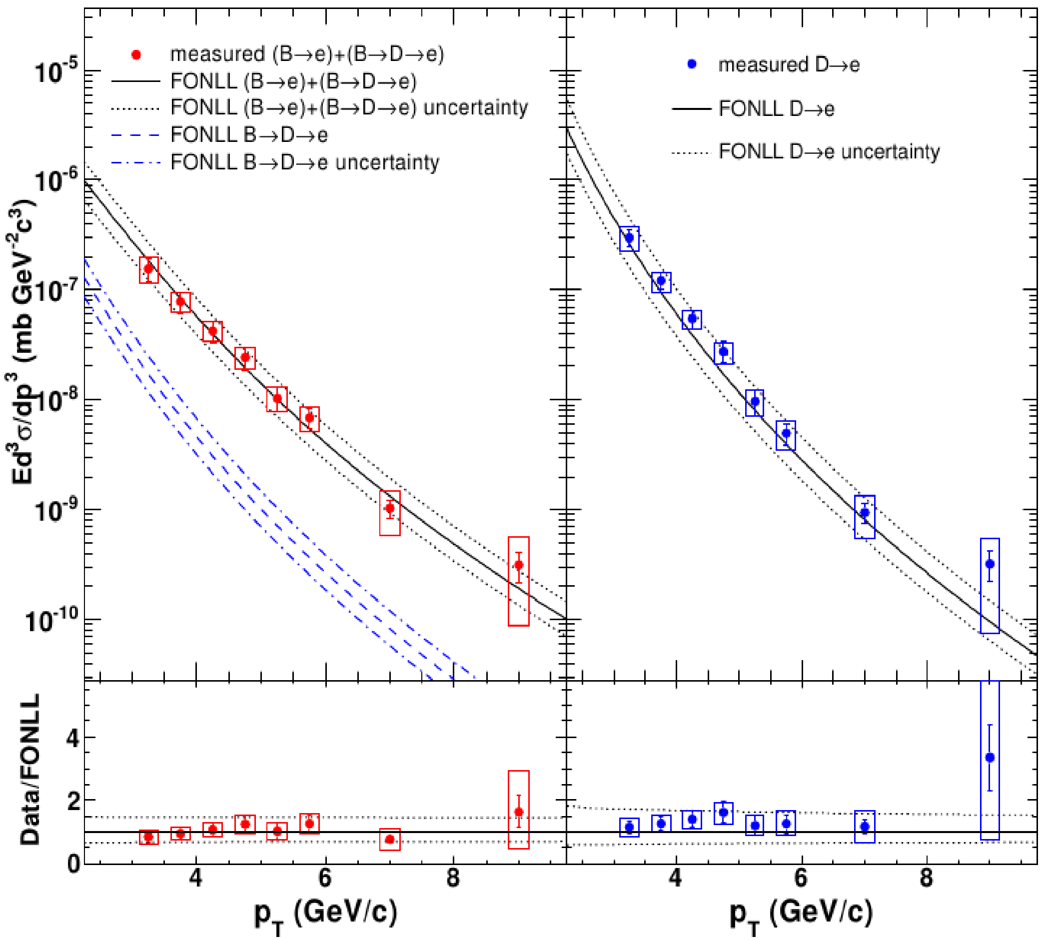
- After extrapolating the results to the full kinematics region total bottom production is:

$$\sigma_{b\bar{b}} = 1.34\,\mu b\ PYTHIA\ MinBias$$

$$\sigma_{b\bar{b}} = 1.83\,\mu b\ PYTHIA\ MSEL = 5$$

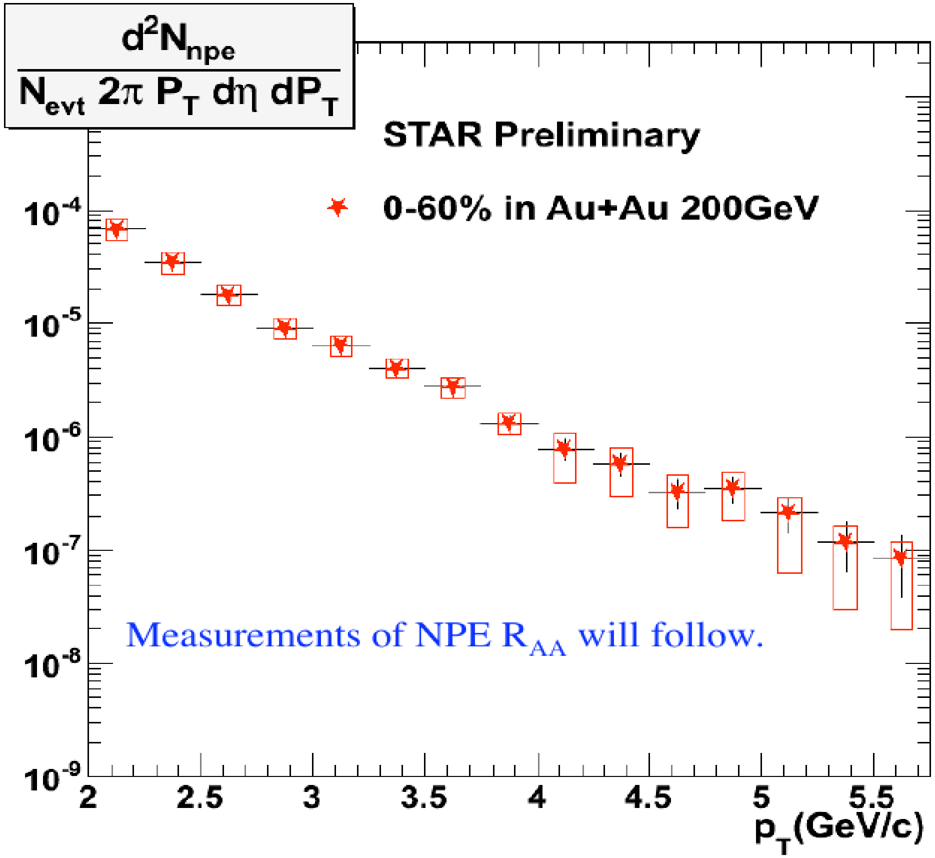
- Results uncertainties are 12.5%(stat.) and 27.5%(syst.)
- Both results are consistent with FONLL calculation.

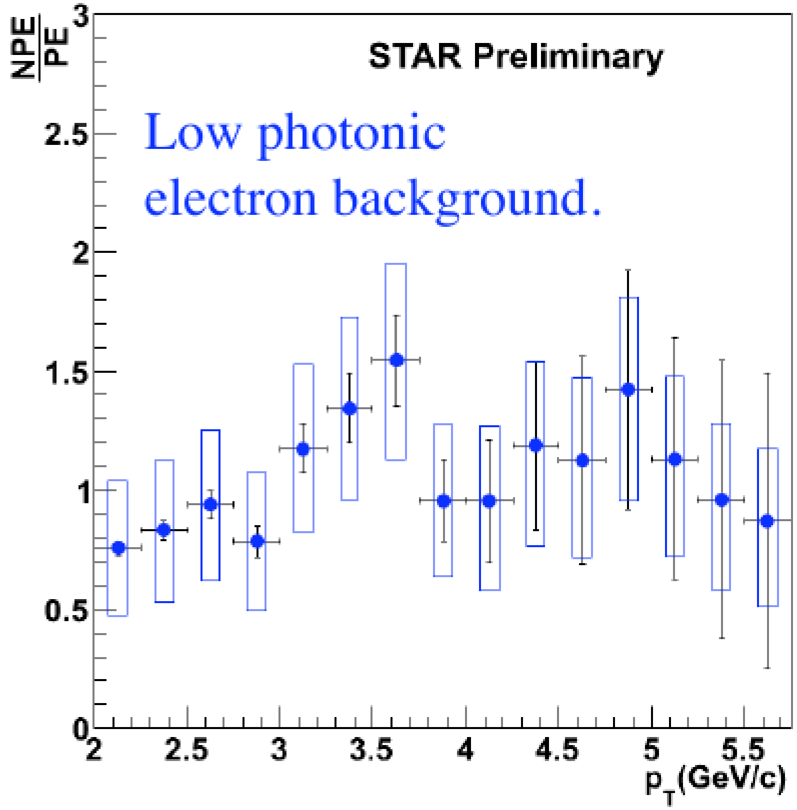
$$\sigma_{b\bar{b}} = 1.87\,\mu b\ FONLL\,calc.$$



STAR Phys. Rev. D 83 (2011) 052006

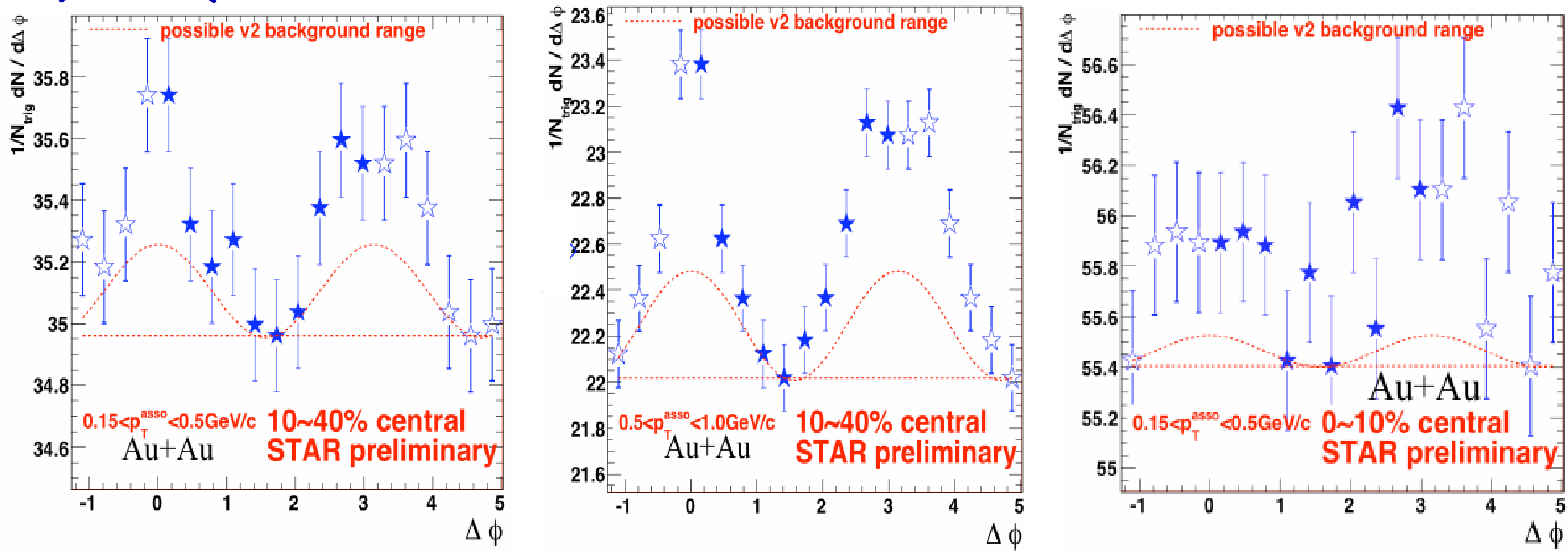
NPE in Au+Au collisions at $\sqrt{s_{NN}}$=200GeV





- NPE spectrum in central and semi-central collisions in Au+Au at 200GeV (run10) - Minimum bias events.
- Part of a data sample.

NPE-hadron correlation in Au+Au collisions at 200 GeV



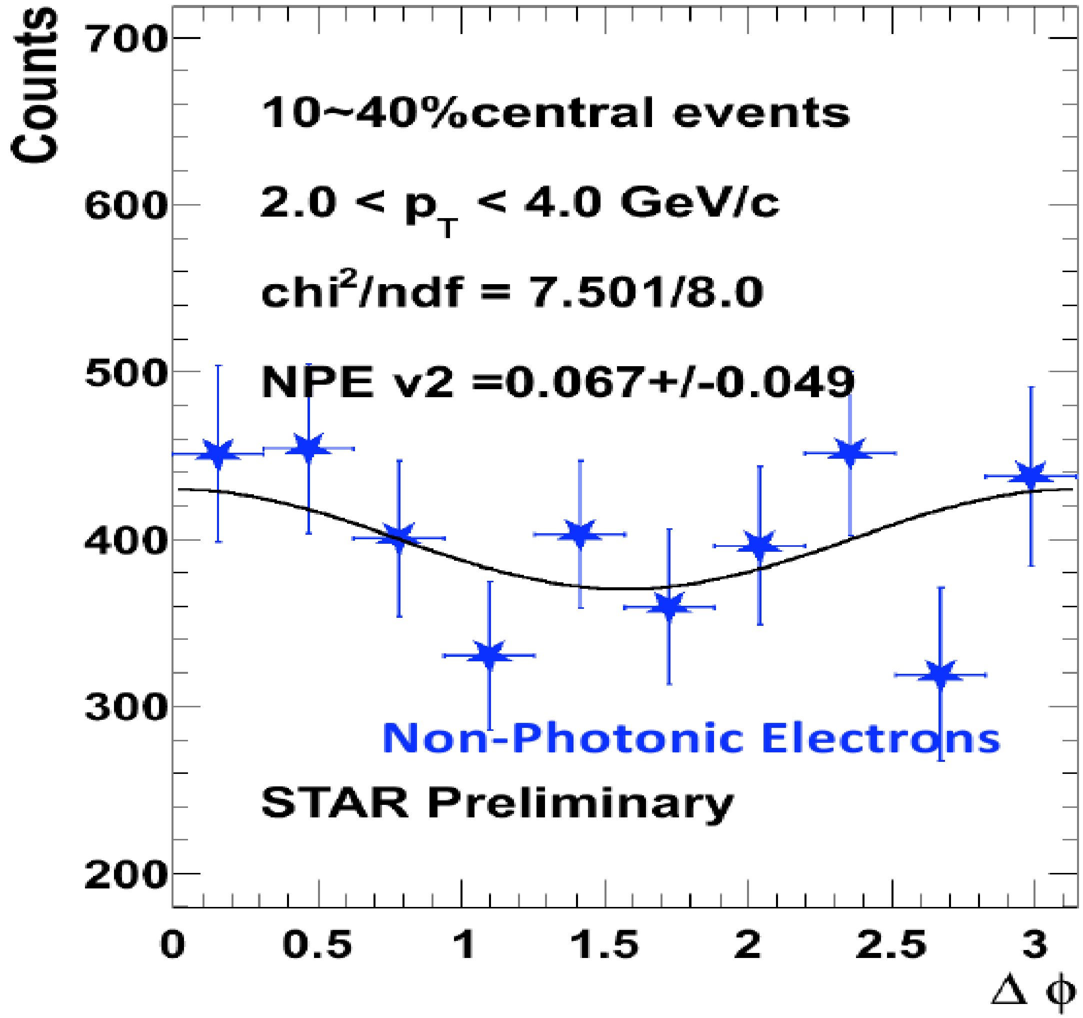
Semi-central collisions for associated track p_T 0.15-0.5GeV and 0.5-1.0GeV.

Central collisons for association track pT 0.15-0.5GeV

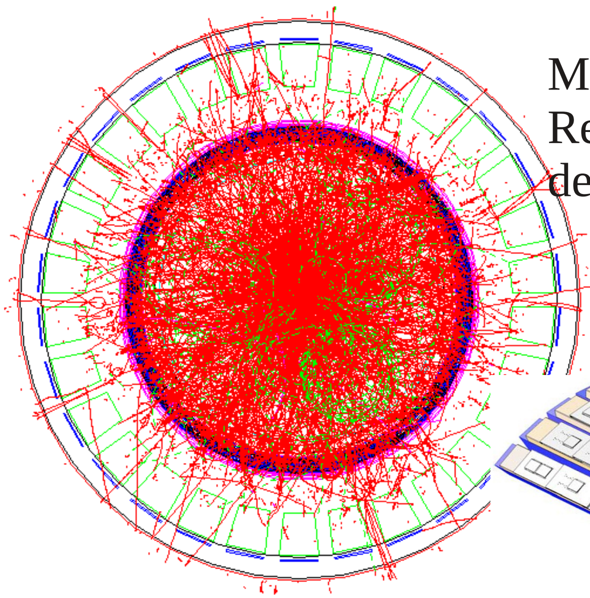
We observed both – near side and away side correlations.

NPE elliptic flow

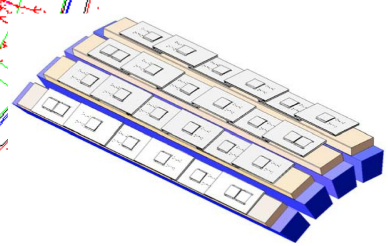
- Electron-event plane correlations → NPE elliptic flow v2.
- Finite v2 for 10-40% central events was observed.

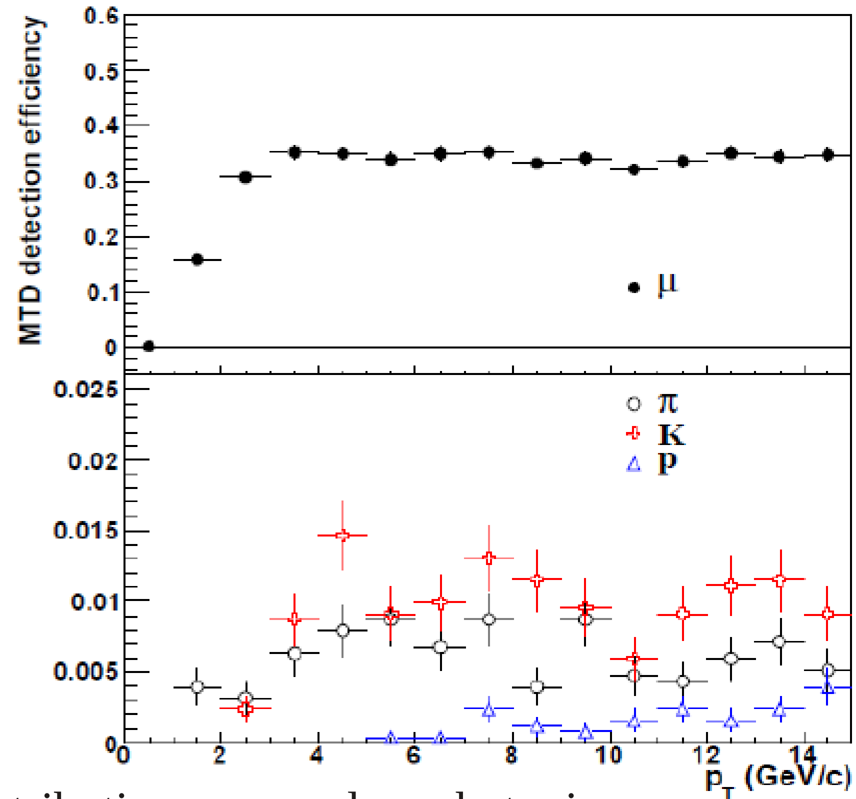


Muon Telescope Detector



MTD (MRPC): Multi-gap Resistive Plate Chamber. Gas detector.





L. Ruan et al., Journal of Physics G: Nucl. Part. Phys. 36 (2009) 095001

Advantages for open heavy flavor measurements:

→ No gamma conversion and much less Dalitz decay contribution → very low photonic background.

→ High muon efficiency.

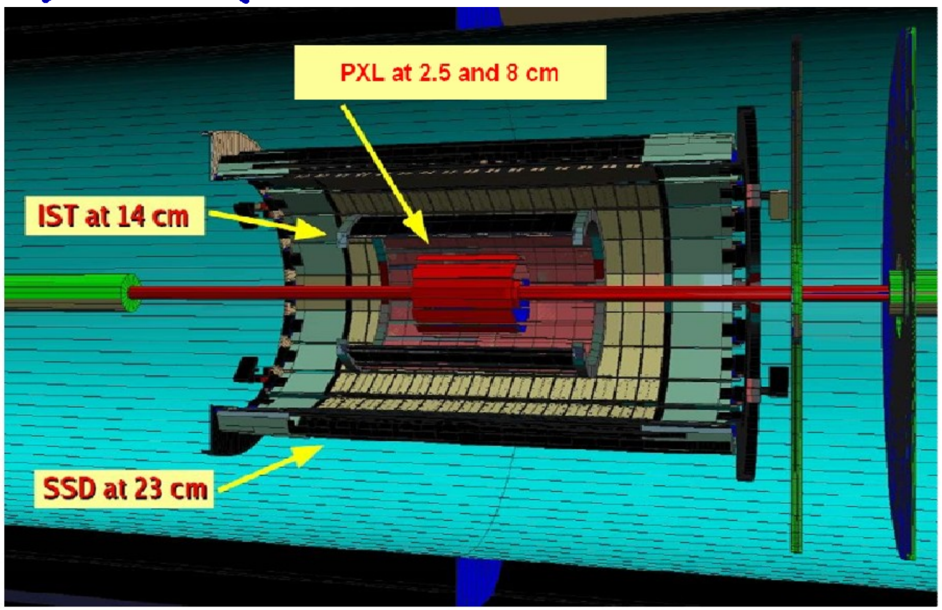
→ Muon to pion (hadron) ratio enhancement by factor ∼ 50-100 (100-1000) → less hadron contamination.

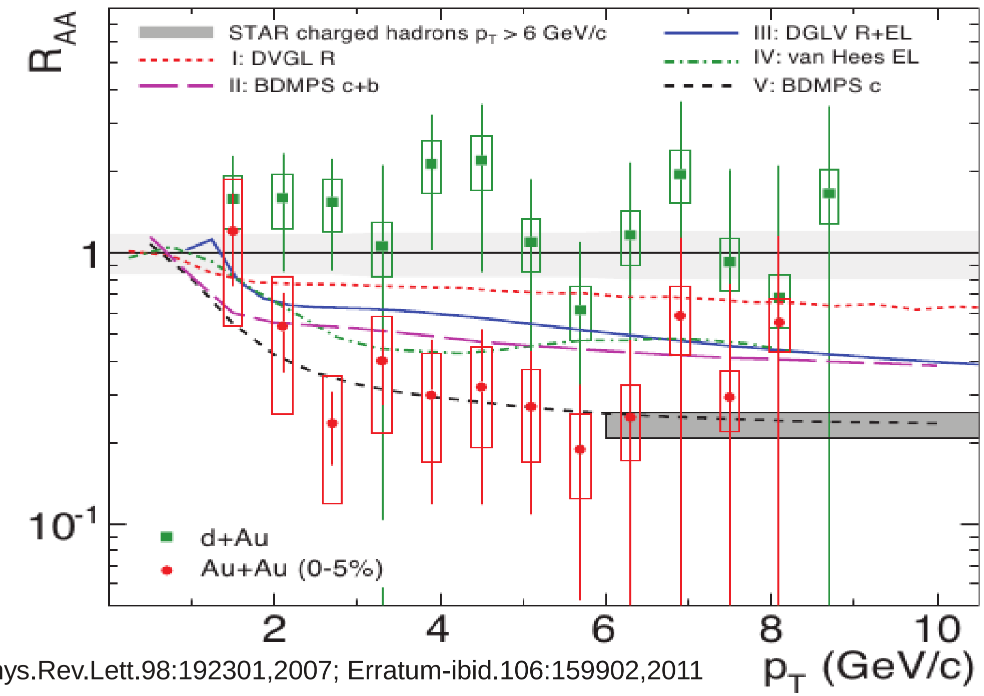
→ e-muon correlation could help distinguish heavy flavor production from initial lepton pair production.

→ no bremsstrahlung for muon-muon.

→ 43% in run 2013, and complete in run 2014.

Heavy flavor tracker (HFT)





Phys.Rev.Lett.98:192301,2007; Erratum-ibid.106:159902,2011

- Heavy Flavor Tracker (HFT) - Prototype Year 2013 and complete run in Year 2014.
- NPE R_{AA} in central Au+Au collisions shows similar suppresion as that of light spectra. Precise calculation of charm and bottom contribution to the NPE is crutial to interpret these results.
- HFT will allow measurement of B → e spectrum separately (Current method via NPE-hadron correlation has large systematics uncertainties).

Conclusions

- Non-photonic spectrum in p+p collisons at 200 GeV was presented. Results are in agreement with FONLL calculations.
- All RHIC measurements in p+p collisons at 200 GeV are consistent with each other.
- Bottom and charm contribution to the NPE in p+p collisions at 200 GeV and 500 GeV was estimated. B meson to the D meson ratio is increasing with p_T. Results are in an good agreement with FONLL calculations.
- Preliminary results in Au+Au collisions at 200 GeV was presented. Finite elliptic flow for 10-40% central events was observed.
- HFT and MTD upgrades extend the area of heavy flavor measurements.

Thank you! :-)