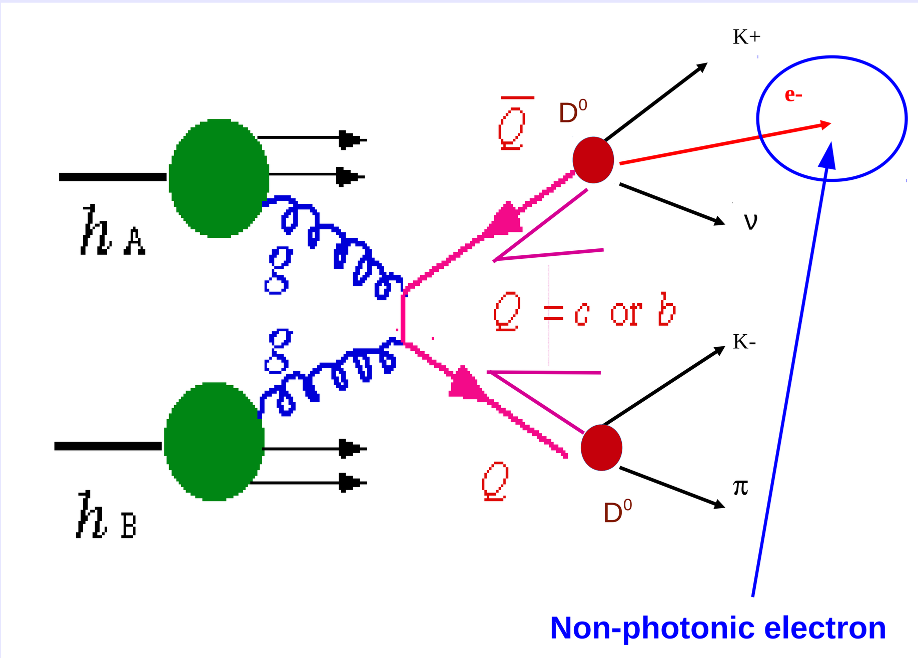
Measurements Of Non-Photonic Electron Production With STAR Experiment

Olga Rusňáková* (for the STAR Collaboration)
Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague, Czech Republic

Heavy quarks, primarily produced in initial hard scattering processes at the Relativistic Heavy Ion Collider (RHIC), are important tools for understanding the properties of the Quark-Gluon Plasma (QGP). The heavy quark interaction with the QGP can be studied through non-photonic electrons (NPE), which are produced from semi-leptonic decays of open heavy flavor hadrons. In p+p collisions measurements of heavy flavor production serve as a test of the pQCD framework and are used as a baseline for comparison to measurements from heavy ion collisions. In Au+Au collisions the medium effects can be quantified through the nuclear modification factors (R_{AA}). Models with different assumptions describe relatively well either R_{AA} or elliptic flow v_2, but not simultaneously, of NPE at the top RHIC energy. New observables are required to discriminate between models. An energy dependence of R_{AA} and v_2 and correlations of NPE to hadrons can be used to further probe the interaction of heavy quarks with the medium.
We present a new measurement of NPE production in p+p collisions at √s=200 GeV. We discuss the energy dependence of NPE production and azimuthal anisotropy measurements in Au+Au collisions at $\sqrt{s_{NN}}$ =39, 62.4 and 200 GeV.

Heavy quarks

- Due to their large masses, heavy quarks are produced mainly during initial parton-parton interaction at RHIC, before the QGP phase.
- Study of heavy flavor production in nucleon+nucleon collisions is a test of the validity of the pQCD.
- Heavy flavor production can be used to study properties of hot and dense matter (energy loss, thermalization) produced in heavy ion collisions.



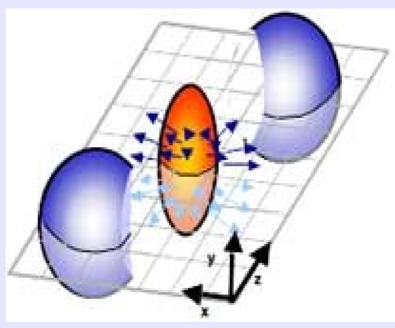
$$c \to e^{\pm} + anything\,(9.6\%)$$
$$b \to e^{\pm} + anything\,(10.86\%)$$

Nuclear modification factor

$$R_{AA} = \frac{1}{<N_{coll}>} * \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$

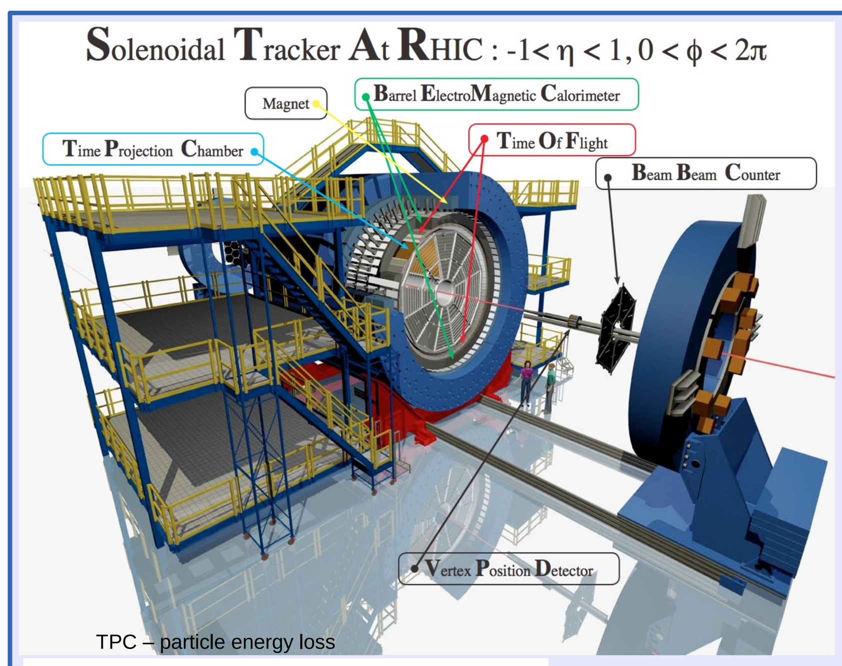
Ncoll – number of binary collisions

- Elliptic flow v_2 describes the collective evolution of system. Initial spatial anisotropy induces final momentum anisotropy.

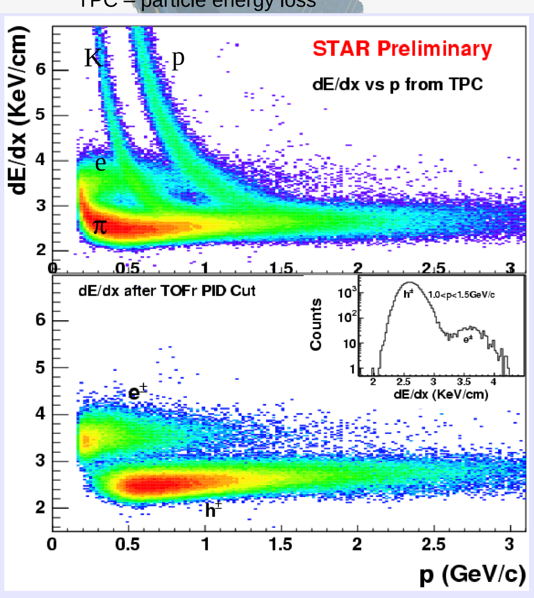


$$\frac{dN}{d\varphi} \propto \left(1+2\sum v_n \cos[n(\varphi-\psi_n)]\right)$$
$$v_n = \langle \cos n(\varphi-\psi_n)\rangle$$

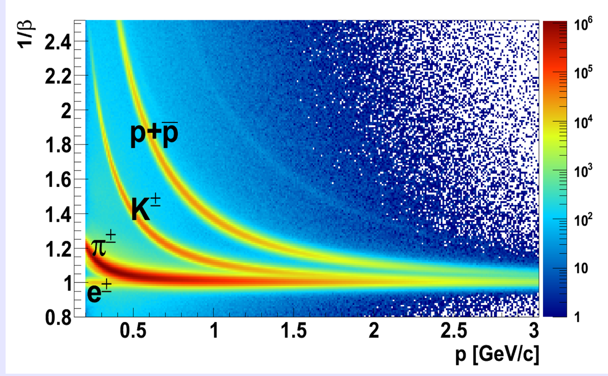
STAR detector and particle identification



- Time Projection Chamber (TPC) – tracking, particle identification, momentum
- Time-of-Flight detector – particle identification (Year 2009: 72% of full TOF, 2010: 100% of full TOF)
- BEMC – electron identification at high p_T, triggering (High-Tower triggers)
- BSMD – electron identification at high p_T



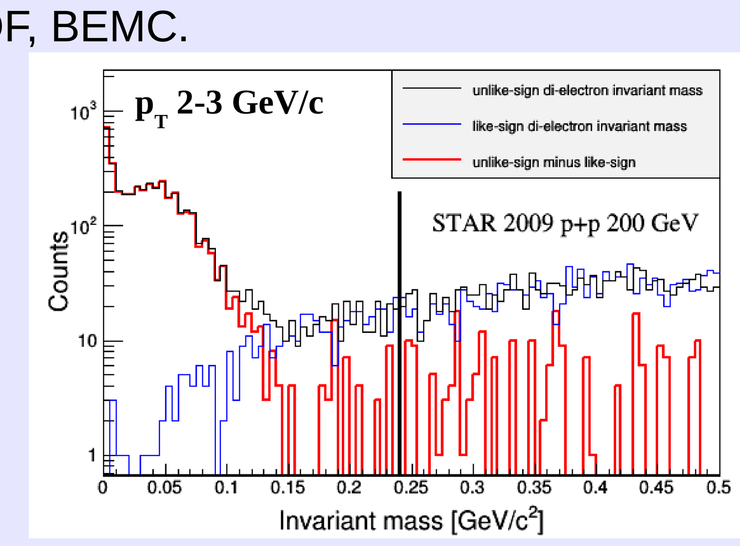
TPC and TOF together are a great tool for distinguishing electrons and hadrons in low p region.



Non-photonic electron analysis method

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

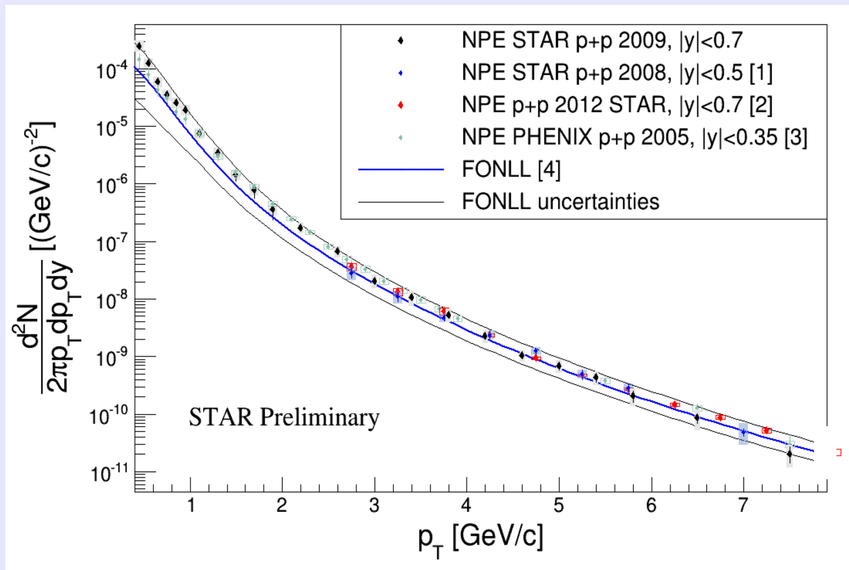
- Inclusive electrons – identification with TPC, TOF, BEMC.
- Photonic electrons – background
  → identified via small e^+e^- invariant mass
  → statistically reconstructed
  → main background comes from:
  Dalitz decay: $\pi^0 \to \gamma + e^+ + e^-$ (BR: ~1.2%)
  Gamma conversions: $\gamma \to e^+ + e^-$

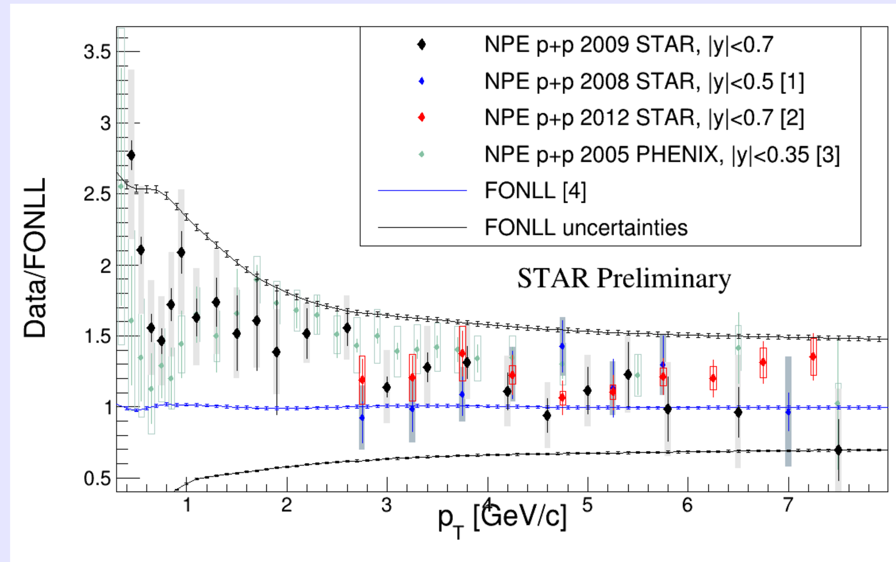


→ corrected for pair reconstruction efficiency using simulation.

Non-photonic electron spectrum in p+p collisions at √s=200 GeV

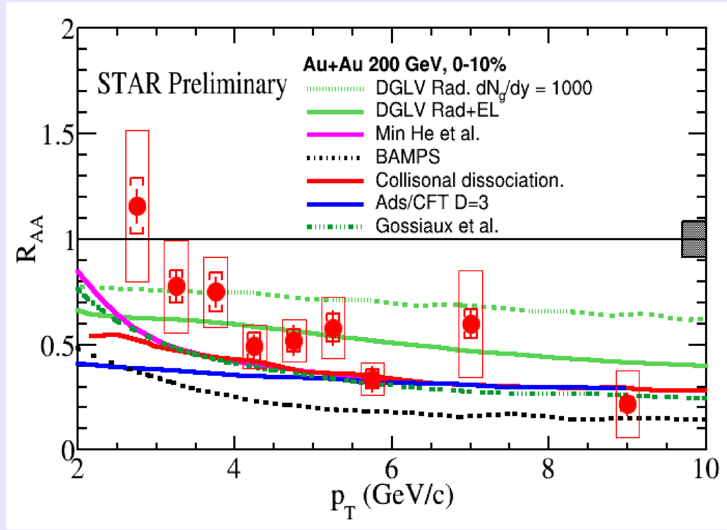
- Data are from RHIC Run 2009 √s=200 GeV: $0<p_T<2$ GeV/c minimum bias sample, $2<p_T<8$ GeV/c high-tower triggered sample.
- New STAR measurement is consistent with previous high-p_T data [1][3].
- Results are consistent with Fixed Order plus Next-to-Leading Logarithms (FONLL) pQCD calculations [4].





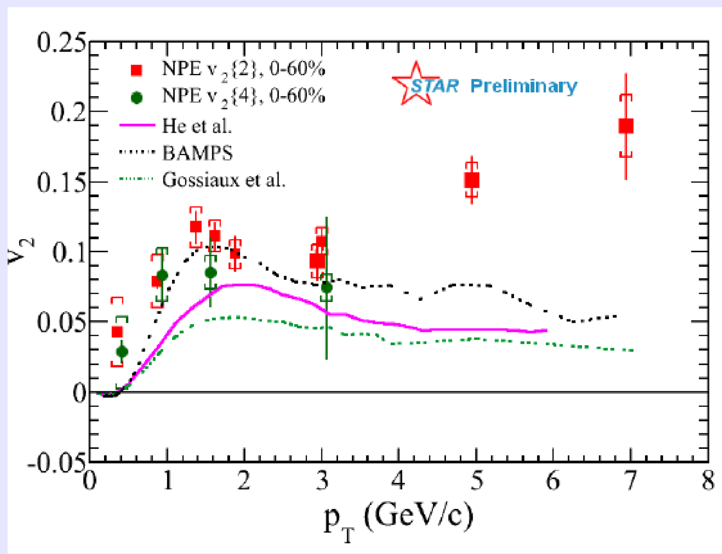
Non-photonic electron spectrum and flow in Au+Au collisions

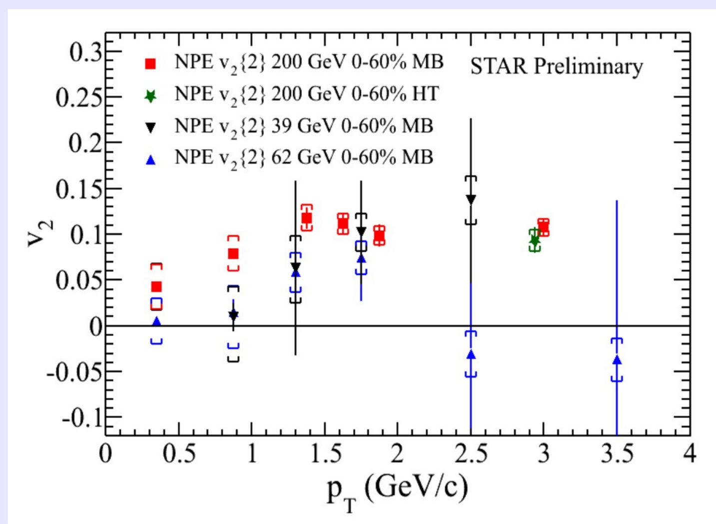
- Strong suppresion, similar as for D^0 mesons and light hadrons, is observed at high p_T at $\sqrt{s_{NN}}$ = 200 GeV (Data are from RHIC Run 2010).
- Gluon radiation scenario alone fails to explain large NPE suppression at high p_T.



Elliptic flow:

- Initial geometry asymmetry → final momentum anisotropy.
- Finite v_2 at low p_T indicates strong charm-medium interaction.
- v_2 at 39 and 62.4 GeV consistent with zero at low p_T → a hint that heavy quarks less influenced by the medium than at 200 GeV?
- None of the models describes both the R_{AA} and v_2 at the same time.





Conclusions

- We extend the measured NPE spectrum in p+p collisions at √s=200 GeV down to p_T~0.5 GeV. Our results are consistent with FONLL calculations [4].
- Finite elliptic flow at low p_T and a large suppression at high p_T in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV indicate that heavy quarks interact strongly with the QGP medium.
- It's challenging for the model calculations to describe the suppression and v_2 simultaneously.

References:
[1] H. Agakishiev et al. [STAR Collaboration], Phys. Rev. D83, 052006 (2011).
[2] X.Bai et al. for the [STAR Collaboration], poster contribution to Quark Matter 2014.
[3] A.Adare et al. [PHENIX Collaboration], , Phys. Rev. C84, 044905 (2011).
[4] A. D. Frawley, T. Ullrich, and R. Vogt, Phys. Rept. 462, 125 (2008).
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*olga.hajkova@fjfi.cvut.cz

The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations