Production of non-photonic electrons in central U+U collisions

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Abstract

Since year 2000 the properties of Quark-Gluon Plasma (QGP) are being studied in ultrarelativistic heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC). Heavy quarks are created during early stages of a heavy-ion collision in hard processes before the system reaches thermal equilibrium and the QGP is formed. Their production is not affected by the QGP phase, which makes them a good probe for the study of the properties of hot and dense strongly interacting medium. Non-Photonic Electrons (NPE) that originate dominantly from semileptonic decays of D and B mesons can serve as a good proxy for heavy flavor quarks. In this poster the preliminary measurement of NPE in 0-5% most central U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV is presented for the transverse momentum range of 1.2 < p_T < 6.0 GeV/*c*. The nuclear modification factor shows a strong suppression for p_T > 3 GeV/*c*, similar to results in central Au+Au collisions.

1. Detector layout

The Solenoidal Tracker at RHIC (STAR) covers 2π in azimuth and two units of pseudorapidity around mid-rapidity. It is enclosed inside a solenoidal magnet, which has a field strength of 0.5 T.

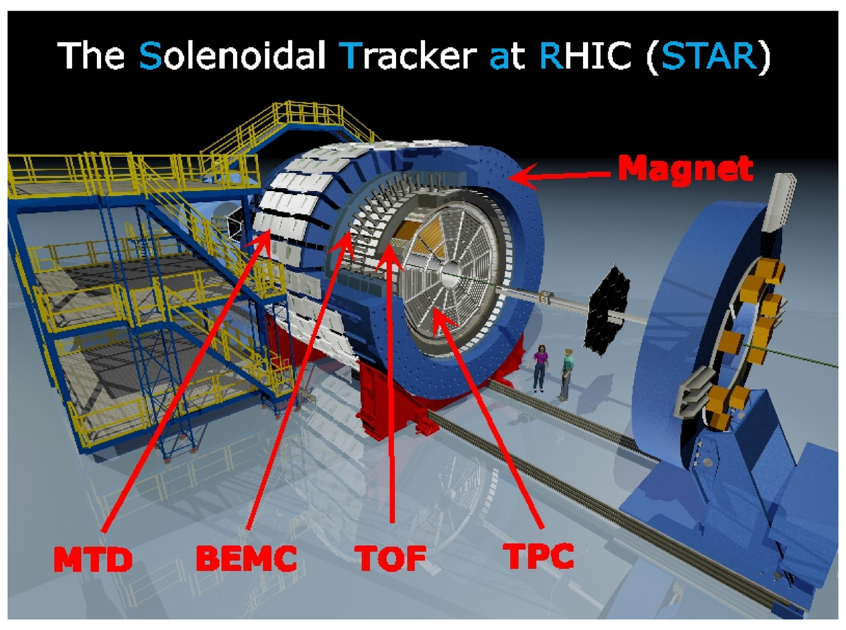

Fig. 1: Picture of the STAR detector.

- **Time Projection Chamber (TPC)** – particle identification via dE/dx, tracking
- **Barrel Electromagnetic Calorimeter (BEMC)** – energy of electrons, electron identification
- **Time of Flight (ToF)** – particle identification via velocity, triggering
- **Zero Degree Calorimeter (ZDC)** – triggering

2. Motivation

- Uranium nuclei have higher number of nucleons compared to gold nuclei
- By colliding uranium nuclei it is possible to achieve up to **20% larger energy** density than Au+Au collisions [1]
- **Larger suppression** of non-photonic electrons in uranium collisions is expected in comparison to gold nuclei at the same centrality class

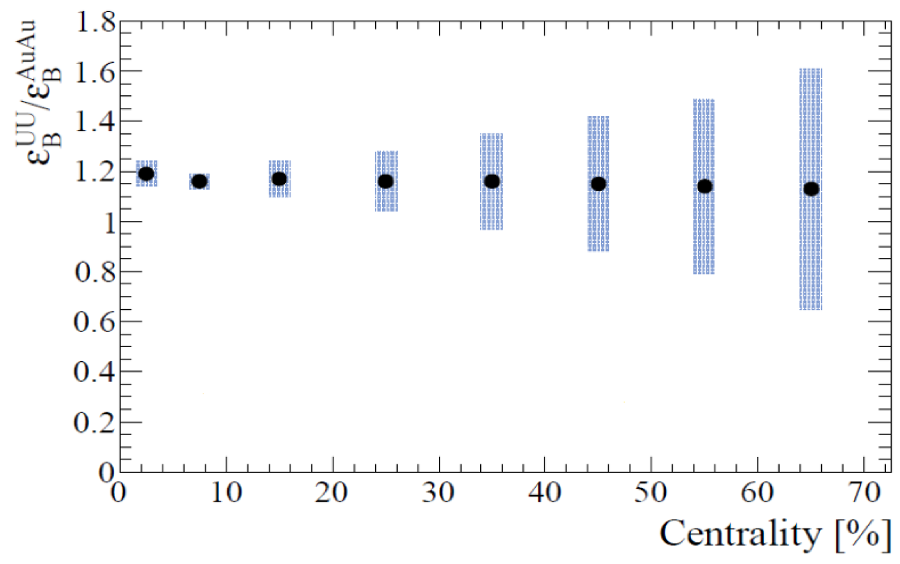

Fig. 2: Ratio of energy densities in U+U to Au+Au collisions as computed in Ref. [1].

3. Methods

- Non-photonic electrons originate from semileptonic decays of open heavy flavor hadrons: D (B) → X + e$^\pm$, Λ_C → X + e$^\pm$, etc.
- Photonic background mainly from γ conversion and π^0, η Dalitz decays has to be subtracted

$$N_{npe} = N_{inclusive} * \epsilon_{purity} - N_{photonic}/\epsilon_{photonic}$$

$N_{inclusive}$ = all identified electron candidates
ϵ_{purity} = purity of inclusive electron sample
$N_{photonic}$ = identified photonic e$^\pm$ (created in pairs)
$\epsilon_{photonic}$ = photonic e reconstruction efficiency

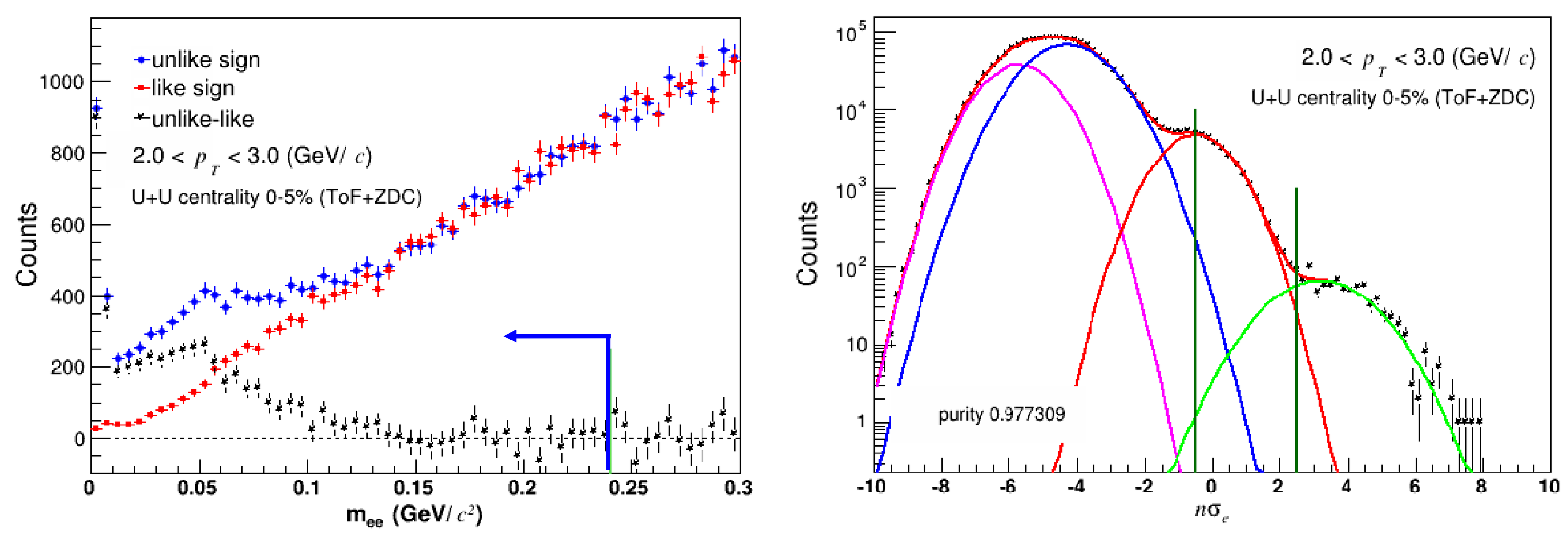

Fig. 3: Invariant mass of electron pairs (left); TPC specific energy loss of inclusive electrons before electron energy loss cuts indicated by the two vertical lines (right).

- **Invariant yield** of non-photonic electrons

$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T d\eta} = \frac{1}{2}\frac{1}{2\pi p_T}\frac{1}{\Delta p_T}\frac{1}{\Delta\eta}\frac{N_{npe}}{N_{events}}\frac{1}{\epsilon_{emc}\epsilon_{n\sigma_e}\epsilon_{trk}}$$

N_{events} = number of events
ϵ_{emc} = BEMC electron ID efficiency
$\epsilon_{n\sigma e}$ = TPC *dE/dx* electron ID efficiency
ϵ_{trk} = single track reconstruction efficiency

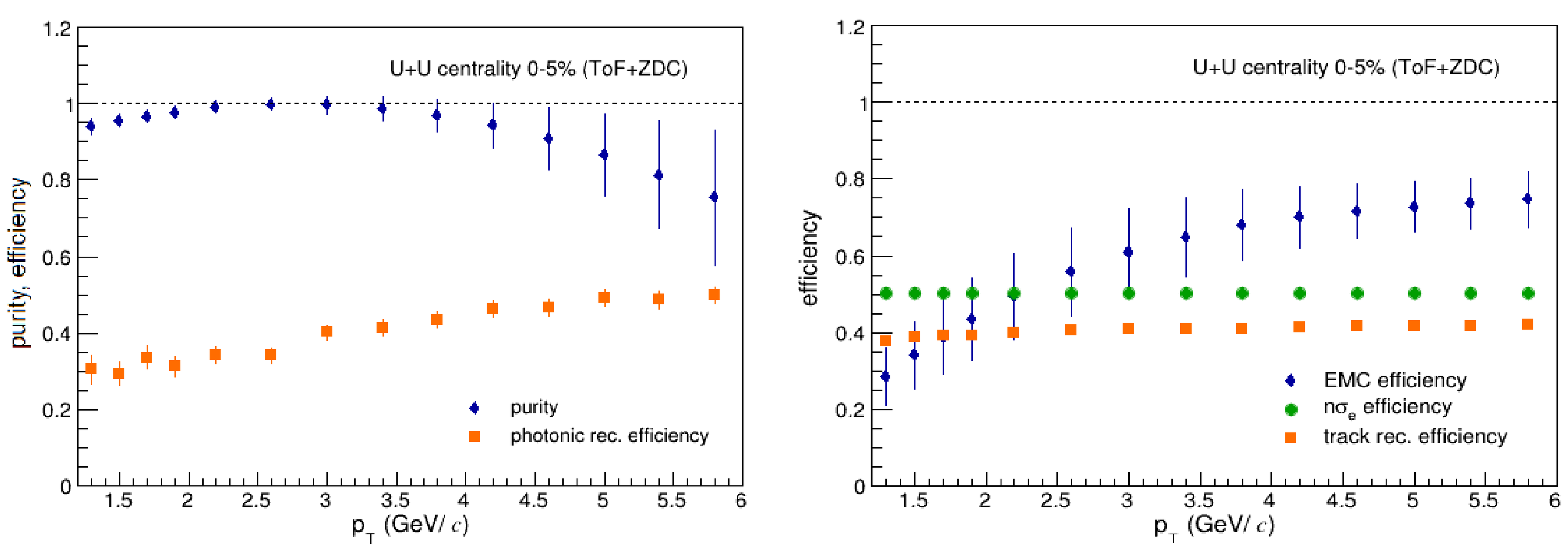

Fig. 4: Corrections for non-photonic electron invariant yield: ϵ_{purity}, $\epsilon_{photonic}$ (left); ϵ_{emc}, $\epsilon_{n\sigma e}$, ϵ_{trk} (right).

Nuclear modification factor R_{AA} is defined as the ratio of particle invariant yield in heavy-ion collisions to that in p+p collisions scaled by mean number of binary collisions

$$R_{AA} = \frac{1}{\langle N_{bin}\rangle}\frac{d^2N_{AA}/dydp_T}{d^2N_{pp}/dydp_T}$$

- p+p reference is from 200 GeV, scaled to 193 GeV using FONLL calculations [2]

4. Results

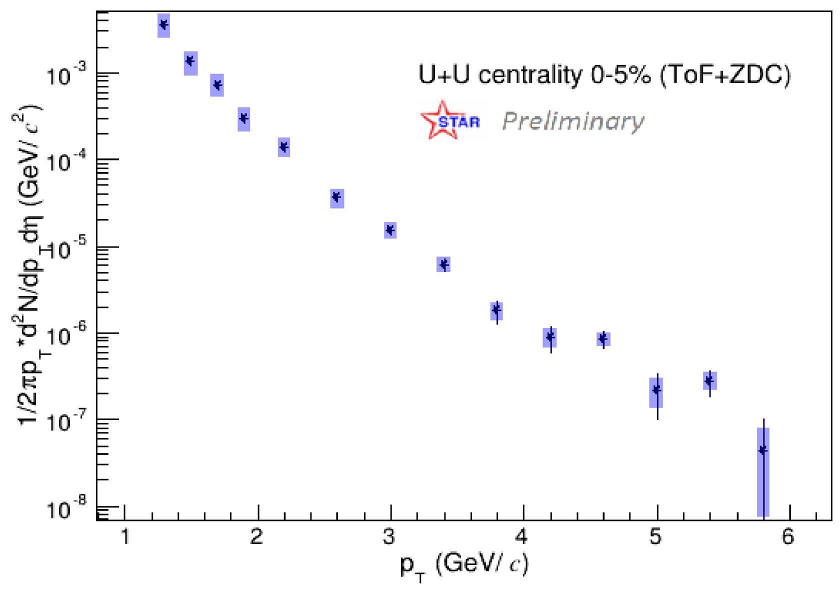

Fig. 5: Invariant yield of NPE in central U+U collisions.

- Data: year 2012, ~40M 0-5% most central events, central trigger (ToF+ZDC), p_T range: 1.2 < p_T < 6.0 GeV/*c*
- Centrality selected based on ToF and ZDC detectors
- Contribution from J/ψ → e$^+$ + e$^-$ subtracted

- First result on R_{AA} of non-photonic electrons in 0-5% most central U+U collisions obtained at 1.2 < p_T < 6.0 GeV/*c* (Fig. 6)
- R_{AA} consistent with no suppression for p_T < 2 GeV/*c*
- Large suppression is observed at high transverse momenta, for p_T > 3 GeV/*c*
- R_{AA} of NPE in U+U collisions is systematically lower than R_{AA} in Au+Au collisions but consistent within uncertainties

- Comparison with models including cold nuclear matter effects (Cronin effect and initial state energy loss), QGP effects and collisional dissociation [3]

- Nuclear modification factor of non-photonic electrons in Au+Au collisions extended to higher values of number of participants using result from 0-5% most central U+U collisions (Fig. 7)

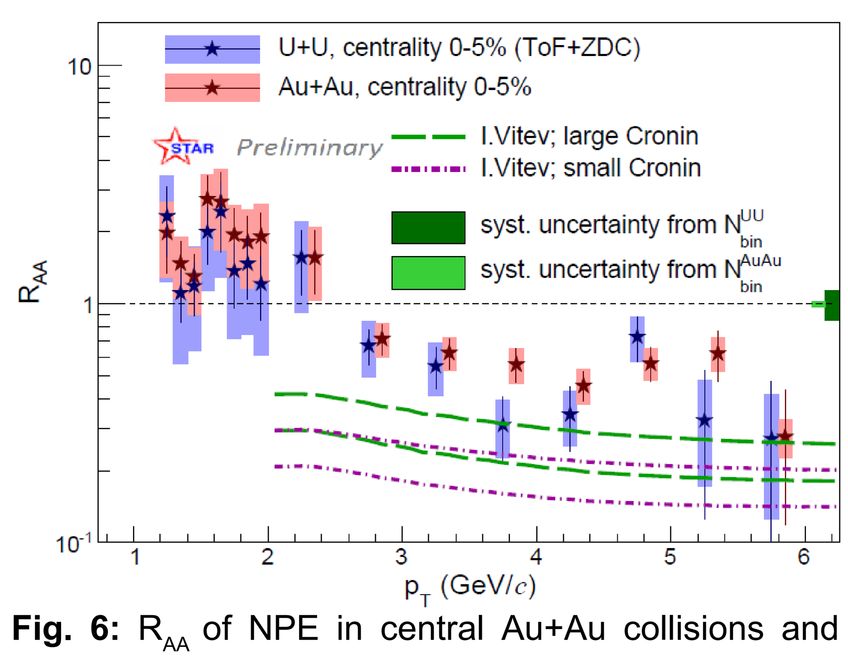

Fig. 6: R_{AA} of NPE in central Au+Au collisions and U+U collisions compared to model [3].

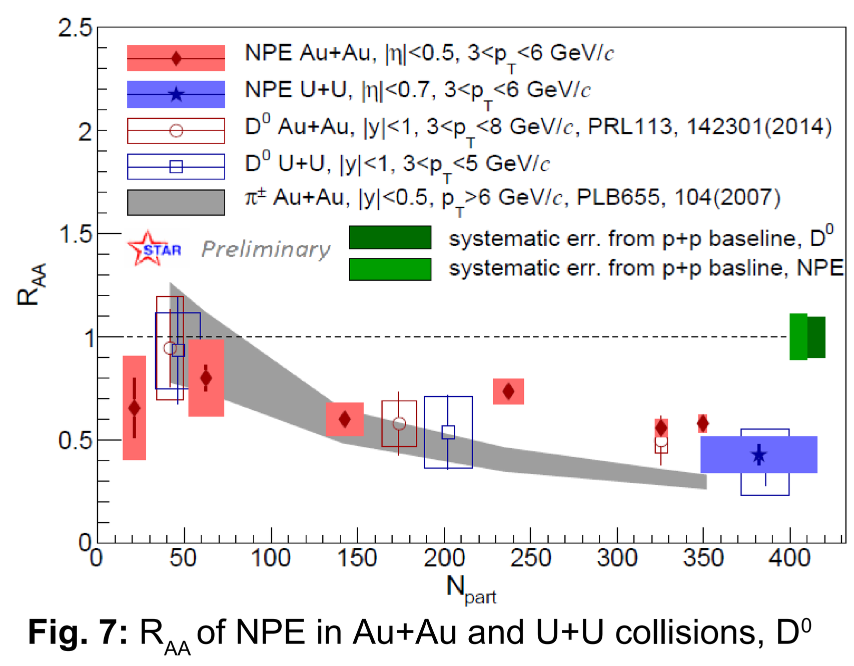

Fig. 7: R_{AA} of NPE in Au+Au and U+U collisions, D^0 mesons in Au+Au and U+U collisions and $\pi^\pm$.

5. Conclusions

A strong suppression of non-photonic electrons is observed in 0-5% most central U+U collisions at high transverse momenta p_T > 3 GeV/*c*. The nuclear modification factor in U+U collisions is consistent within errors but systematically lower than suppression of NPE in Au+Au collisions at similar centrality. R_{AA} of U+U collisions extends the trend of R_{AA} vs. number of participants in Au+Au collisions.

6. References and acknowledgements

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[3] R. Sharma, I. Vitev, B.-W. Zhang, Phys.Rev. C **80**, 054902 (2009)

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

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