Production of non-photonic electrons in U+U collisions at 193 GeV at STAR experiment

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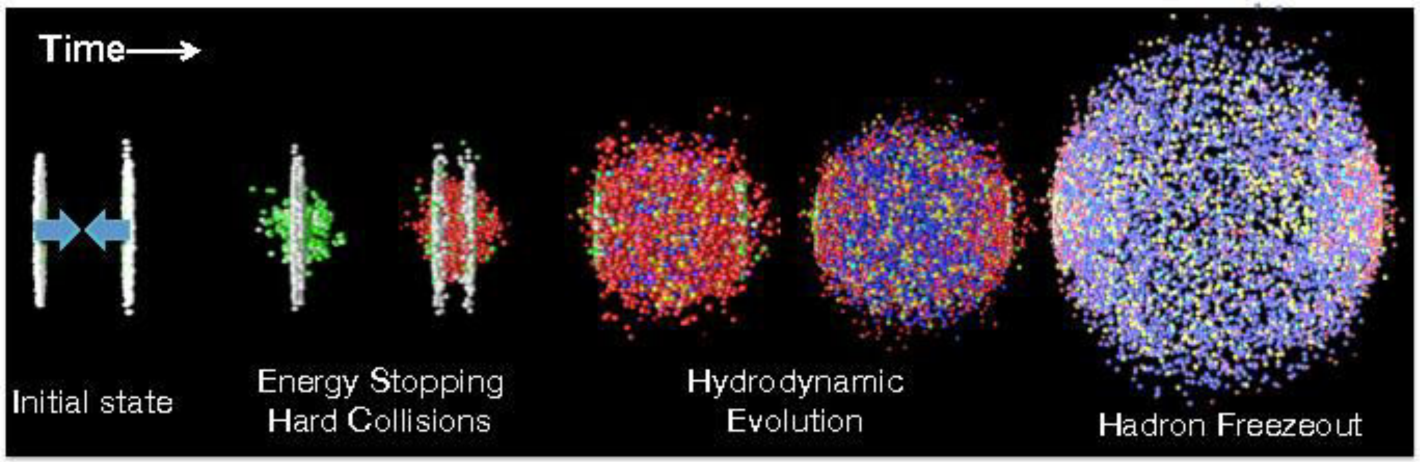
Heavy quarks – probe of QGP

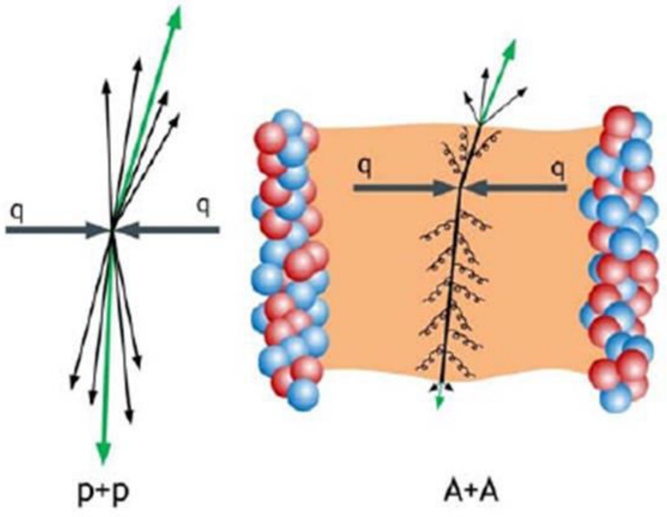


- Heavy quarks (c, b) are created during early stages of a heavy-ion collision
- Production not influenced by QGP
- Present during all stages of a heavy-ion collision

→ good probe of properties of QGP

- Try to understand energy loss mechanisms at high transverse momenta
  - Collisional energy loss - elastic scattering of heavy quarks
  - Radiative energy loss - gluon bremsstrahlung
- Energy loss studied via nuclear modification factor R_{AA}

Heavy quarks – probe of QGP



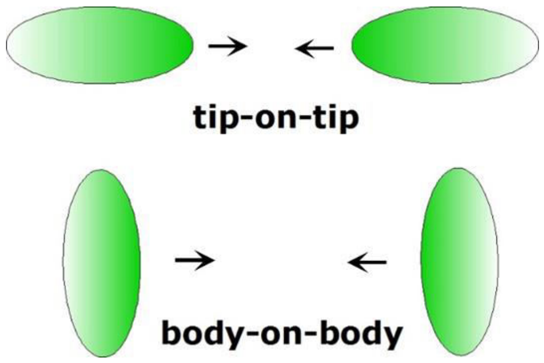
- p+p collisions: test of pQCD calculations, reference data for heavy-ion collisions
- A+A collisons: study of quark-gluon plasma
  - strongly interacting medium
  - Interactions of particles with QGP affects the final particle spectra

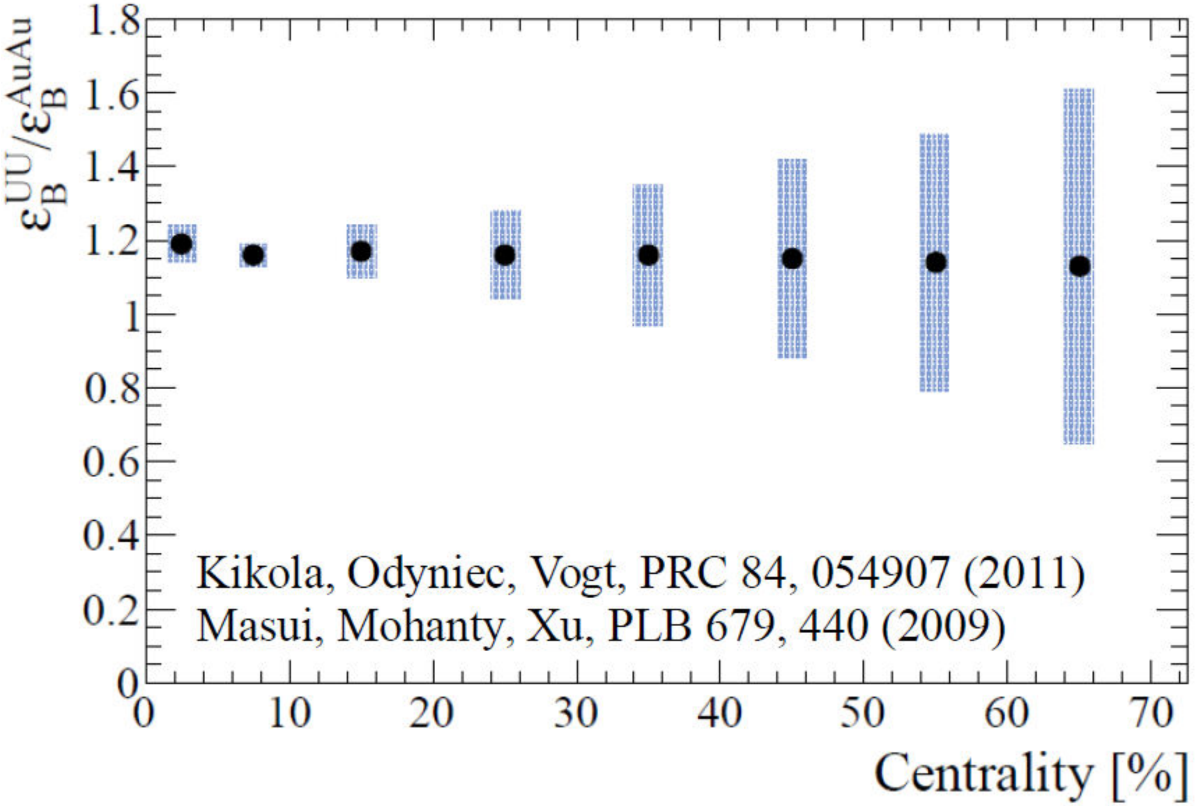
$$\boxed{R_{AA} = \frac{1}{\langle N_{bin} \rangle} \frac{d^2N_{AA}/dp_T dy}{d^2N_{pp}/dp_T dy}}$$

Nuclear modification factor:

- $R_{AA} > 1$: enhancement
- $R_{AA} = 1$: A+A collisions are superposition of p+p collisions
- $R_{AA} < 1$: suppression -> particles lose energy in hot and dense medium

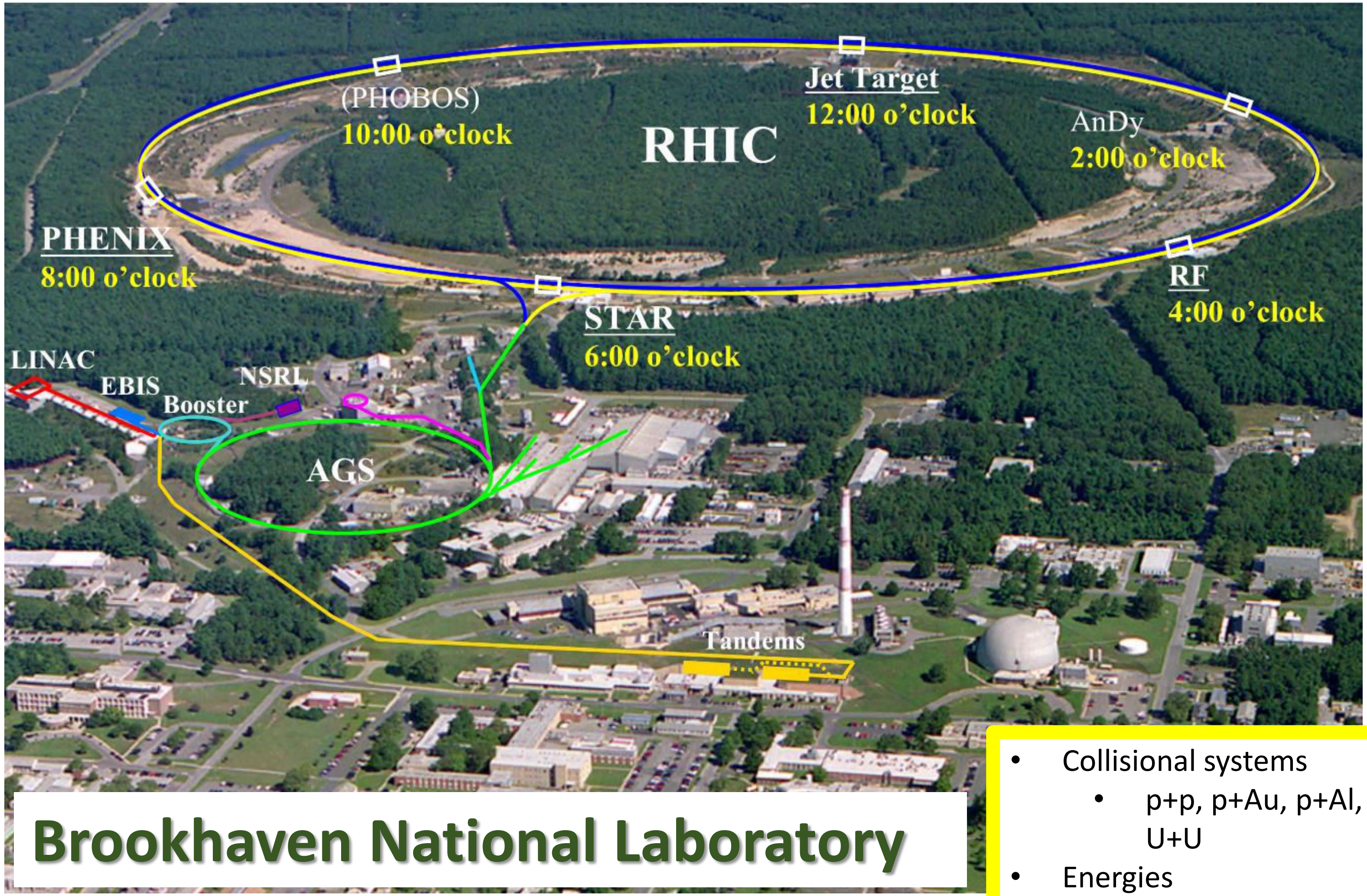
U+U collisions vs. Au+Au collisions





- Uranium nuclei have larger number of nucleons
- In U+U collisions there is 20 % more energy density than in Au+Au collisions for the same centrality class -> stronger suppression ?

Relativistic Heavy Ion Collider



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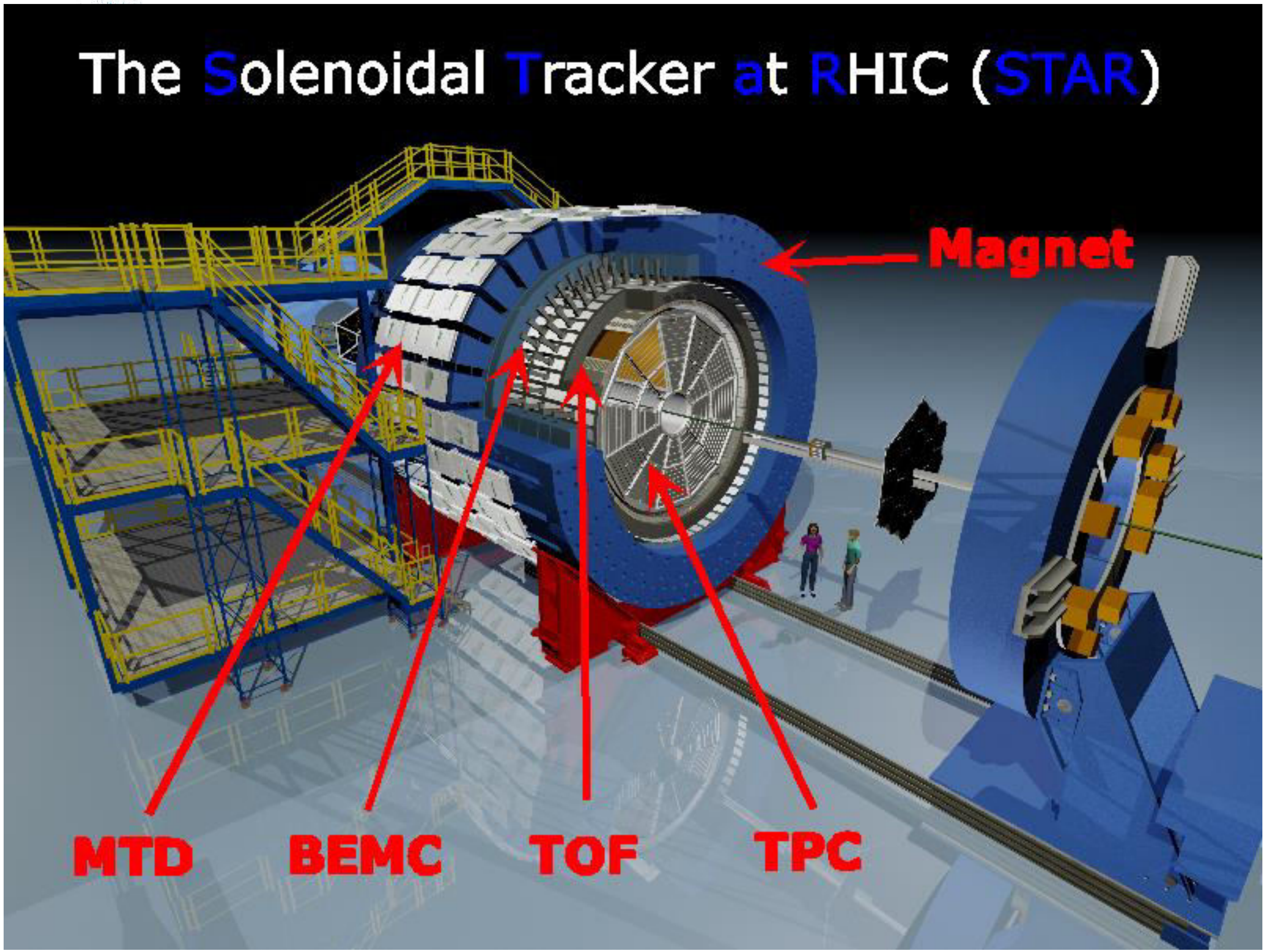
- Collisional systems
  - p+p, p+Au, p+Al, d+Au, He3+Au, Cu+Au, Cu+Cu, Au+Au, U+U
- Energies
  - 7.7, 11.5, 14.5, 19.6, 27, 39, 62.4, 193, 200, 500 GeV



- TPC (Time Projection Chamber)
  - PID via dE/dx, track reconstruction
- BEMC (Barrel Electro-Magnetic Calorimeter)
  - Energy of electrons, electron ID
- ToF (Time of Flight)
  - PID via particle velocities at low transverse momenta
  - Used for central5 trigger
- ZDC (Zero Degree Calorimeter)
  - Used for central5 trigger

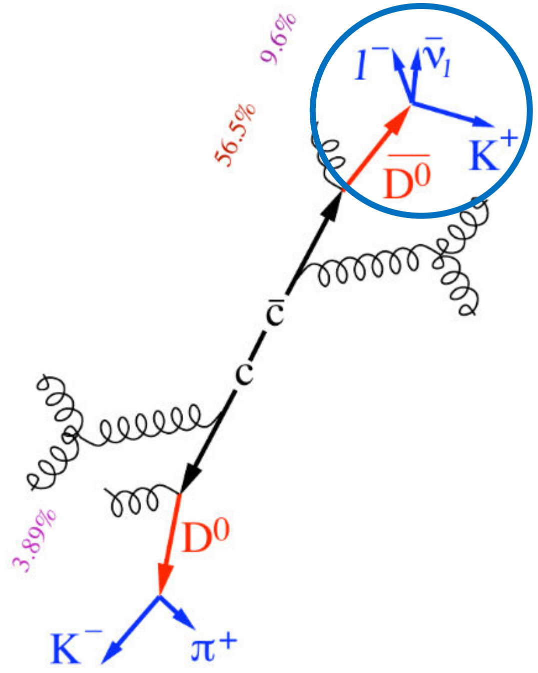
Non-photonic electrons

Open heavy flavor = D and B mesons

- Semileptonic decay channel

$$D^0 \rightarrow K^- + e^+ + \nu_e$$

  - Non-photonic electrons analysis



- Inclusive electrons N(inc) = all electrons in a collision
- Photonic electrons N(pho) = electrons produced in pairs with low invariant mass
  - Conversion $\gamma \rightarrow e^- + e^+$
  - Dalitz decay $\pi^0(\eta) \rightarrow e^+ + e^- + \gamma$
- Non-photonic electrons N(npe) = single electrons
  - Background (photonic electrons) subtracted from inclusive sample
  - Subtracted contribution of $J/\psi \rightarrow e^+ + e^-$

Data sample:

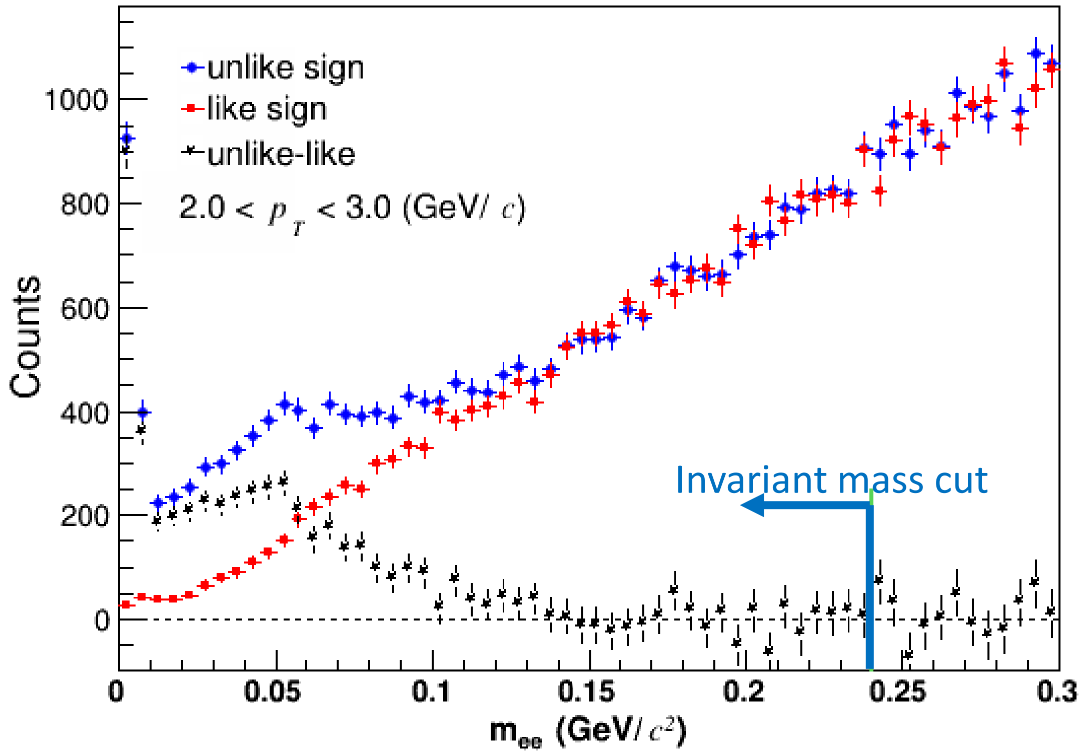
- U+U collisions, $\sqrt{s_{NN}}$ = 193 GeV, year 2012
- 0-5% central triggers based on ToF+ZDC, ~ 40M events
- Electron ID by dE/dx in TPC and BEMC

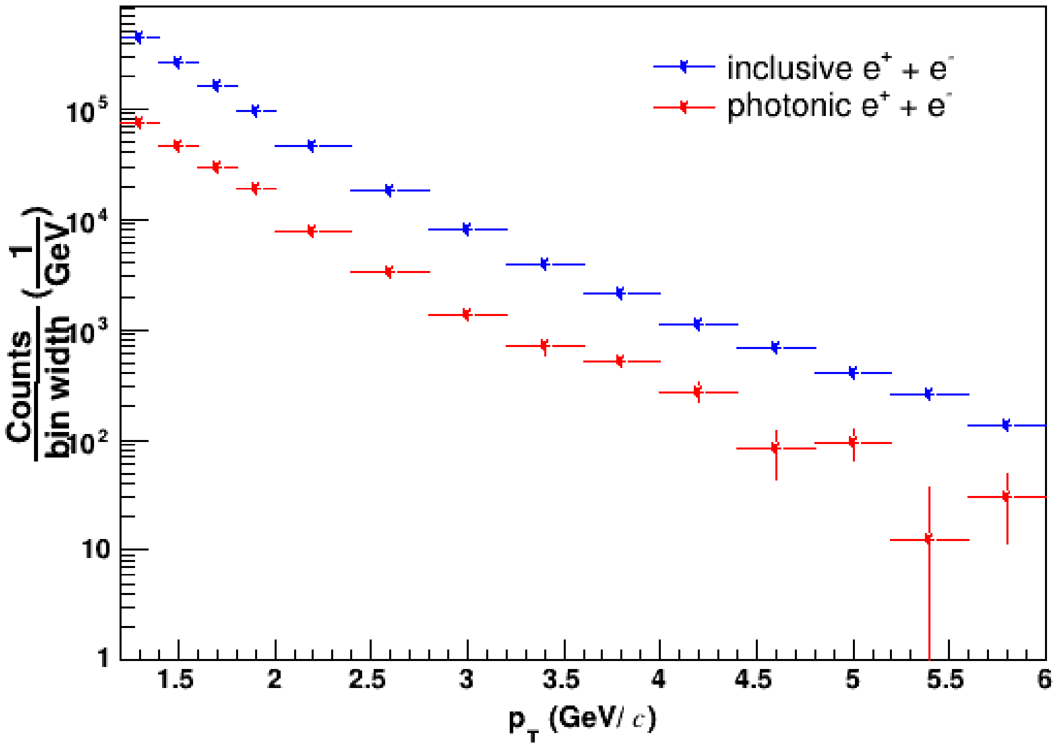
Background estimation

- For each electron track find partner electron track
- Look at their signs, invariant mass
- Like sign pairs represent combinatorial background
- N(pho) -> subtract like sign from unlike sign

$$\boxed{N(npe) = N(inc) * \epsilon_{purity} - N(pho)/\epsilon_{pho}}$$

- After background subtraction there is still contamination from e.g. vector meson decays
- Contribution is estimated and finally subtracted





Corrections of spectra

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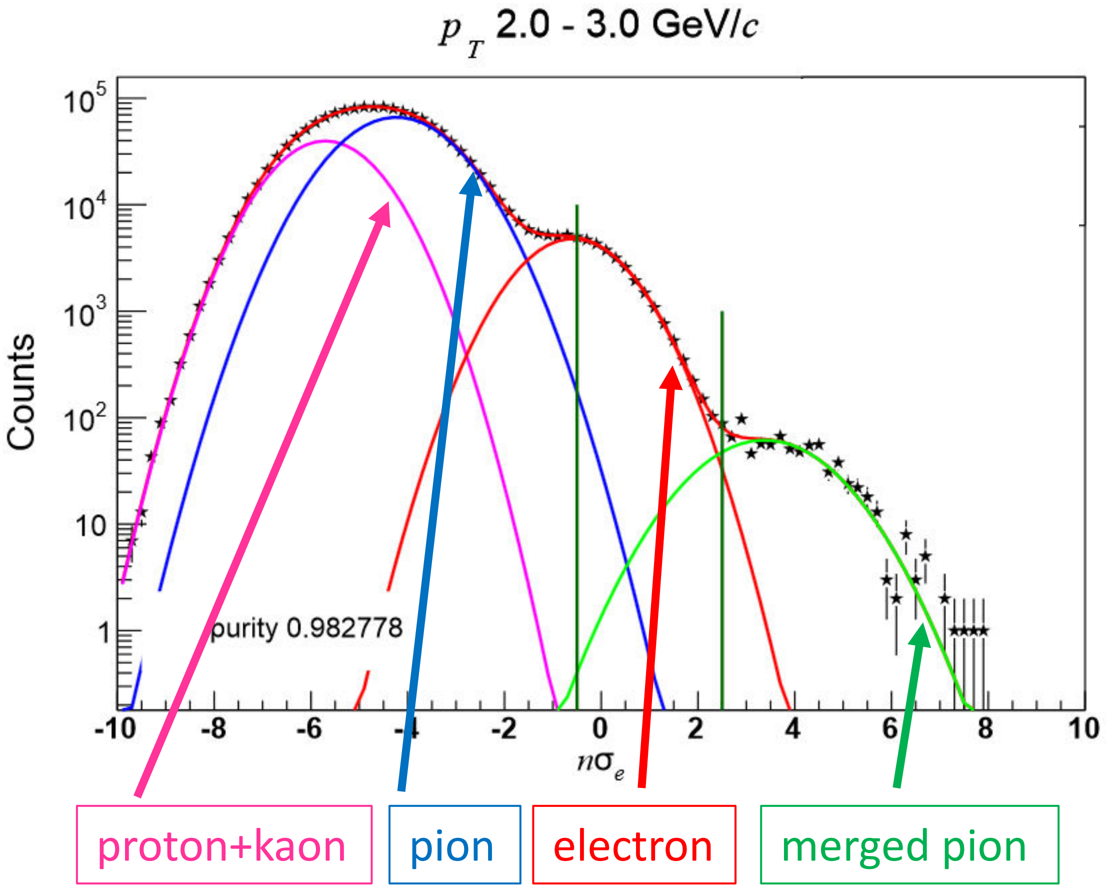
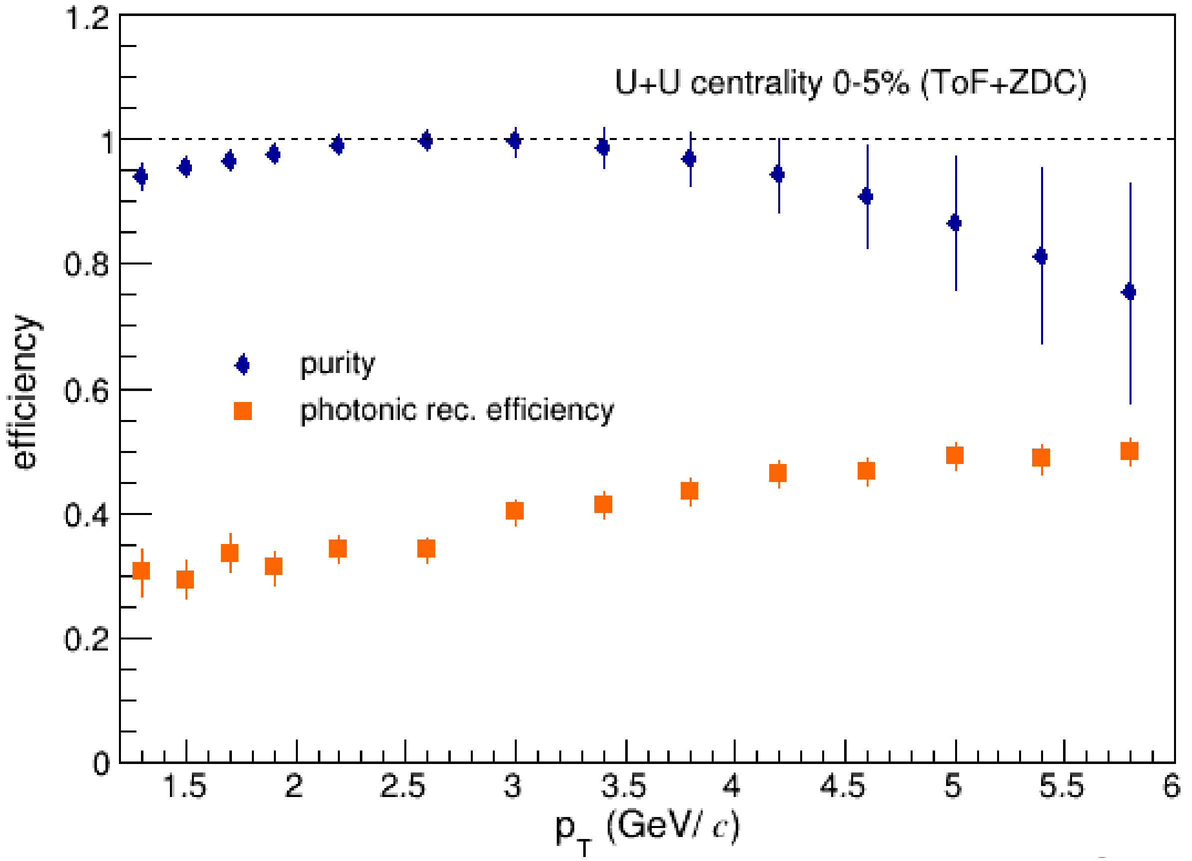
$$\boxed{N(npe) = N(inc) * \epsilon_{purity} - N(pho)/\epsilon_{pho}}$$



$$\epsilon_{purity} = \frac{\text{electron gaussian fit integral within cut}}{\text{4-gaussian fit integral within cut}}$$

- Purity calculated from energy loss distribution
- Photonic electron reconstruction efficiency calculated from U+U embedding data

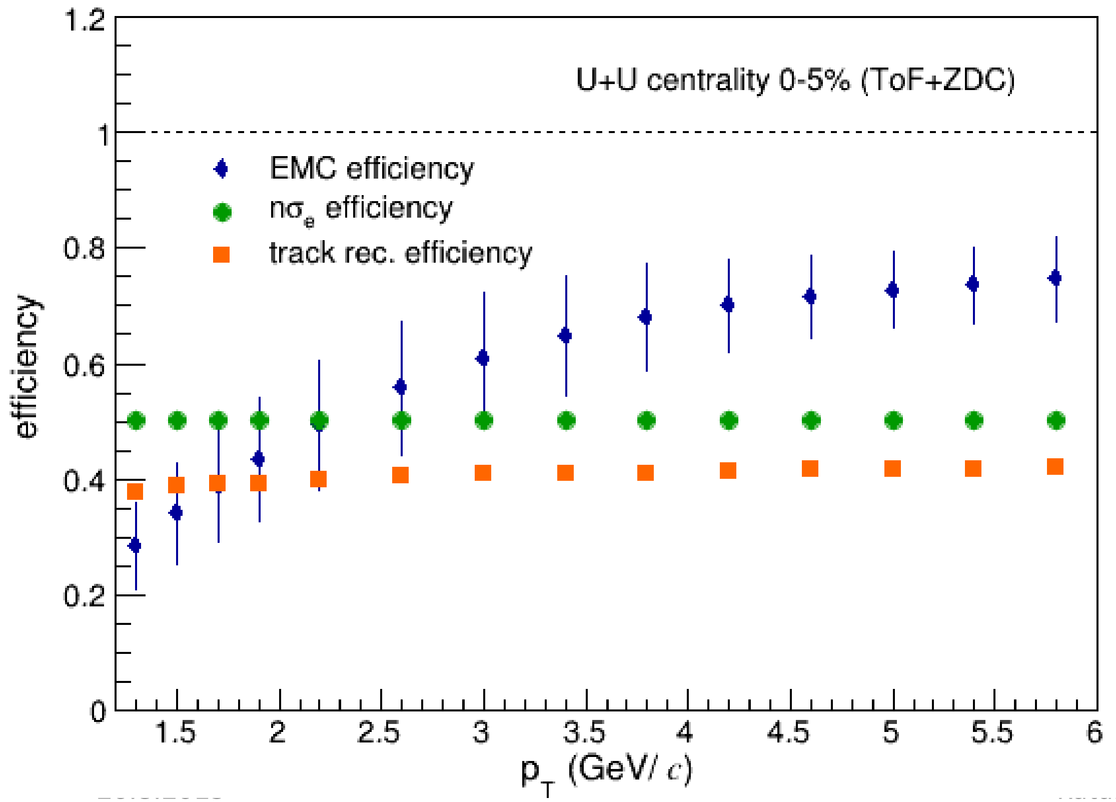


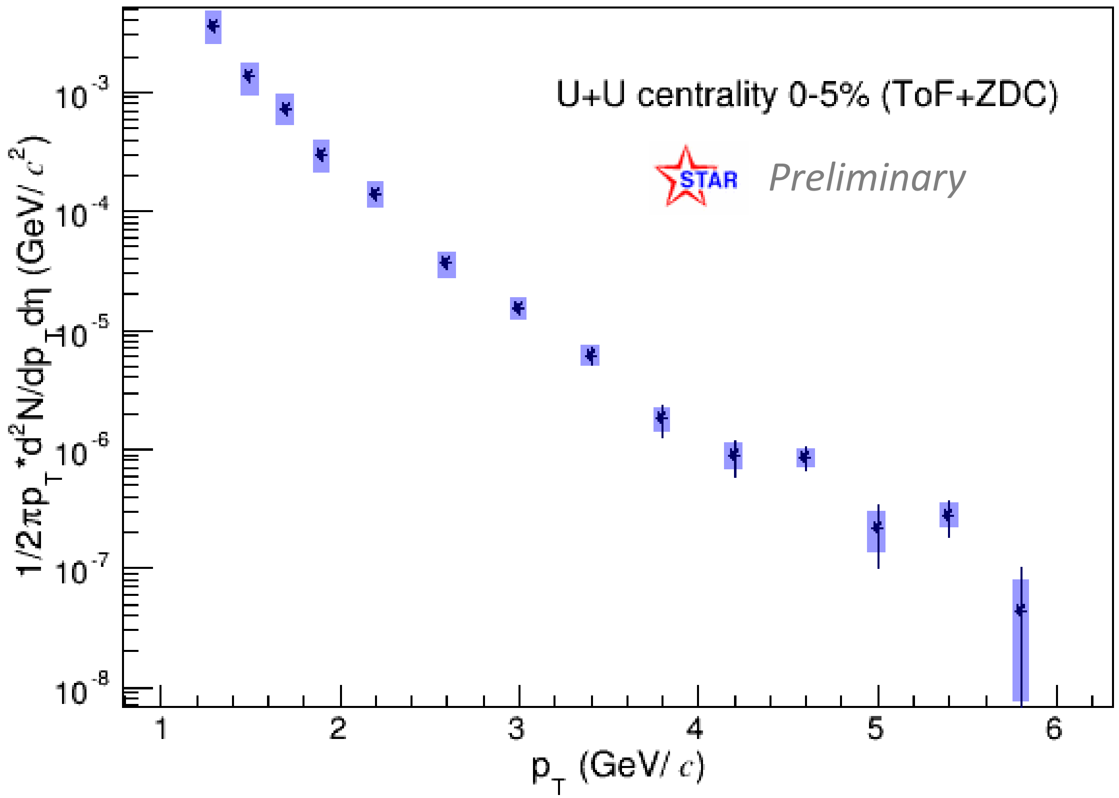
Non-photonic electron yield

$$N(npe) = N(inc) * \epsilon_{purity} - N(pho)/\epsilon_{pho}$$

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

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

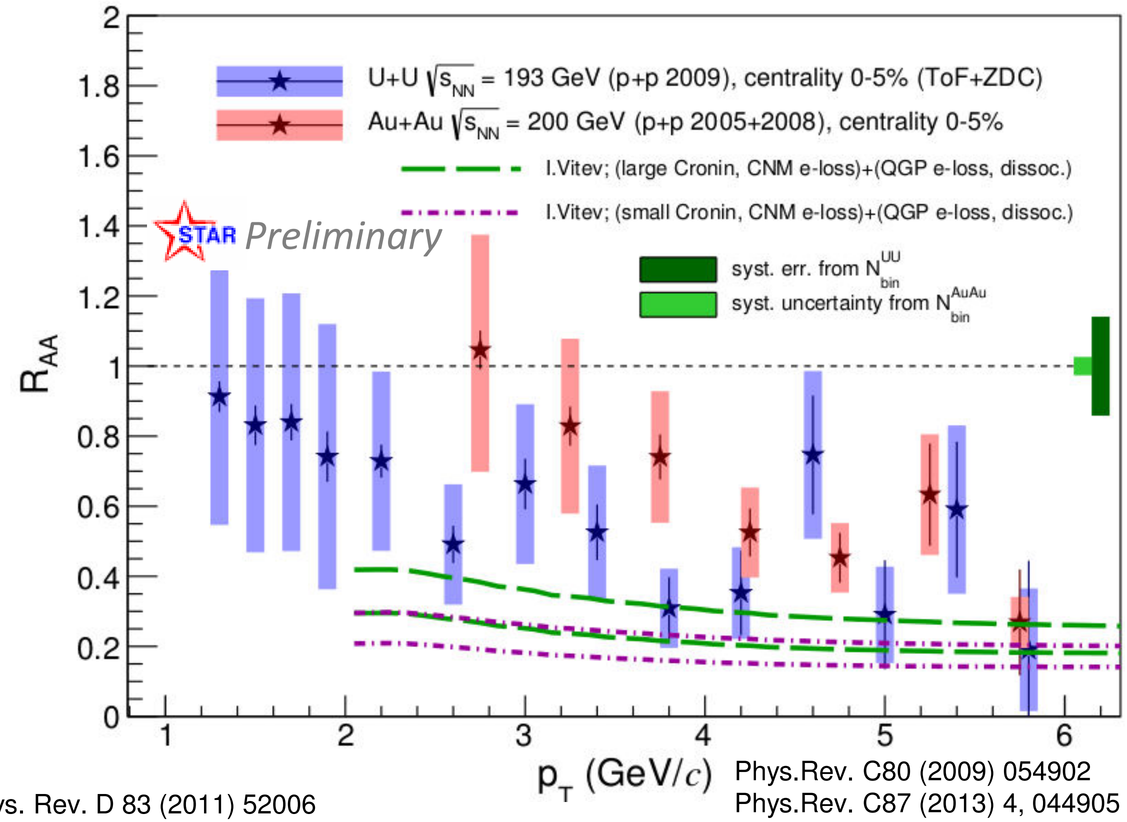


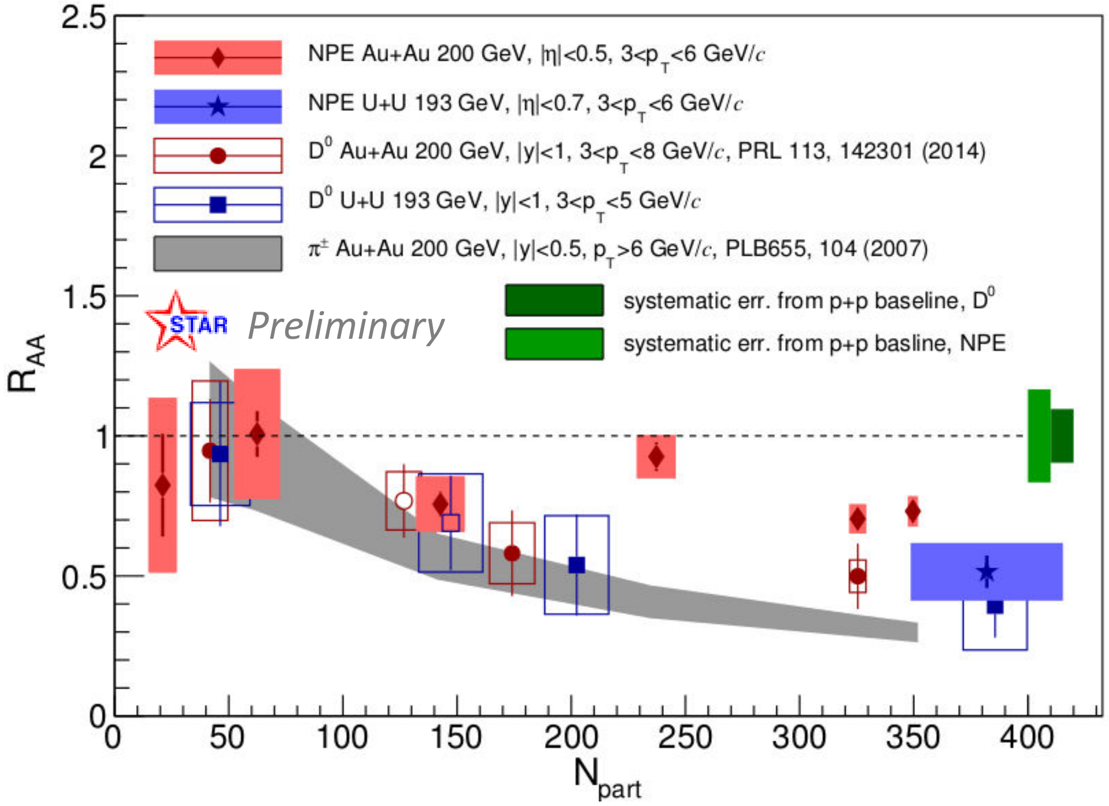


Nuclear modification factor

- Nuclear modification factor of NPE in U+U collisions is consistent within errors, but systematically lower than Au+Au collisions

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





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Conclusions

- Heavy flavor quarks are suitable probes for the study of energy loss in QGP
- Non-photonic electrons are good proxy for heavy flavor study
- In uranium collisions we can achieve higher energy density

- Analysis of non photonic electrons in 0-5% central U+U collisions was presented
- Preliminary results of invariant yield and R_{AA} obtained at $1.2 < p_T < 6.0$ GeV/*c*
  - Suppression of NPE of order ~0.5 observed at pT > 3 GeV/*c*
  - Nuclear modification factor is consistent within errors but systematically lower than those in 0-5% central Au+Au collisions at 200 GeV

Backup

Nuclear modification factor

- Two different pp baselines used to divide the U+U NPE yield