Heavy Flavor Physics in STAR

SQM 2004, Capetown - 09/17/04

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Heavy Flavor in STAR

Direct reconstruction of open charm hadrons using invariant mass technique:

$D^0 \rightarrow K\,\pi$, $D^+ \rightarrow K\,\pi\pi$, $D^{*+} \rightarrow D^0\,\pi$, $D^0 \rightarrow K\,\rho\,\pi$

Huan Huang talk this morning

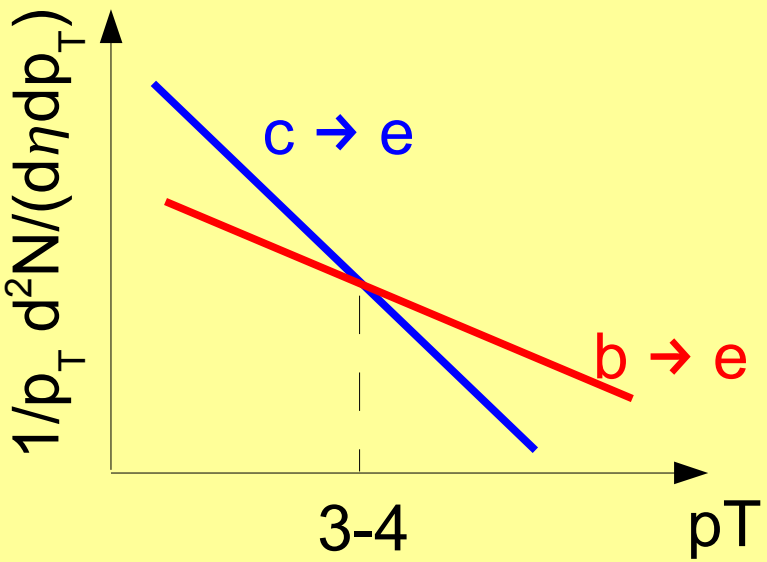
Decays into electrons:

$D^+ \rightarrow e^+$ anything (17.2%)

$D^0 \rightarrow e^+$ anything (6.87%)

$B^+ \rightarrow e^+$ anything (10.2%)

$B^0 \rightarrow e^+$ anything (10.5%)



$J/\psi \rightarrow e^+ e^-$ (5.9%)

$\Upsilon \rightarrow e^+ e^-$ (2.38%)

Charm and Bottom from Electrons

1) Measure electron p_T spectrum

inclusive electrons

But: Many other sources of electrons

- photon conversitions in the detector
- Dalitz decays
- vector meson decays
- ...

"photonic" background

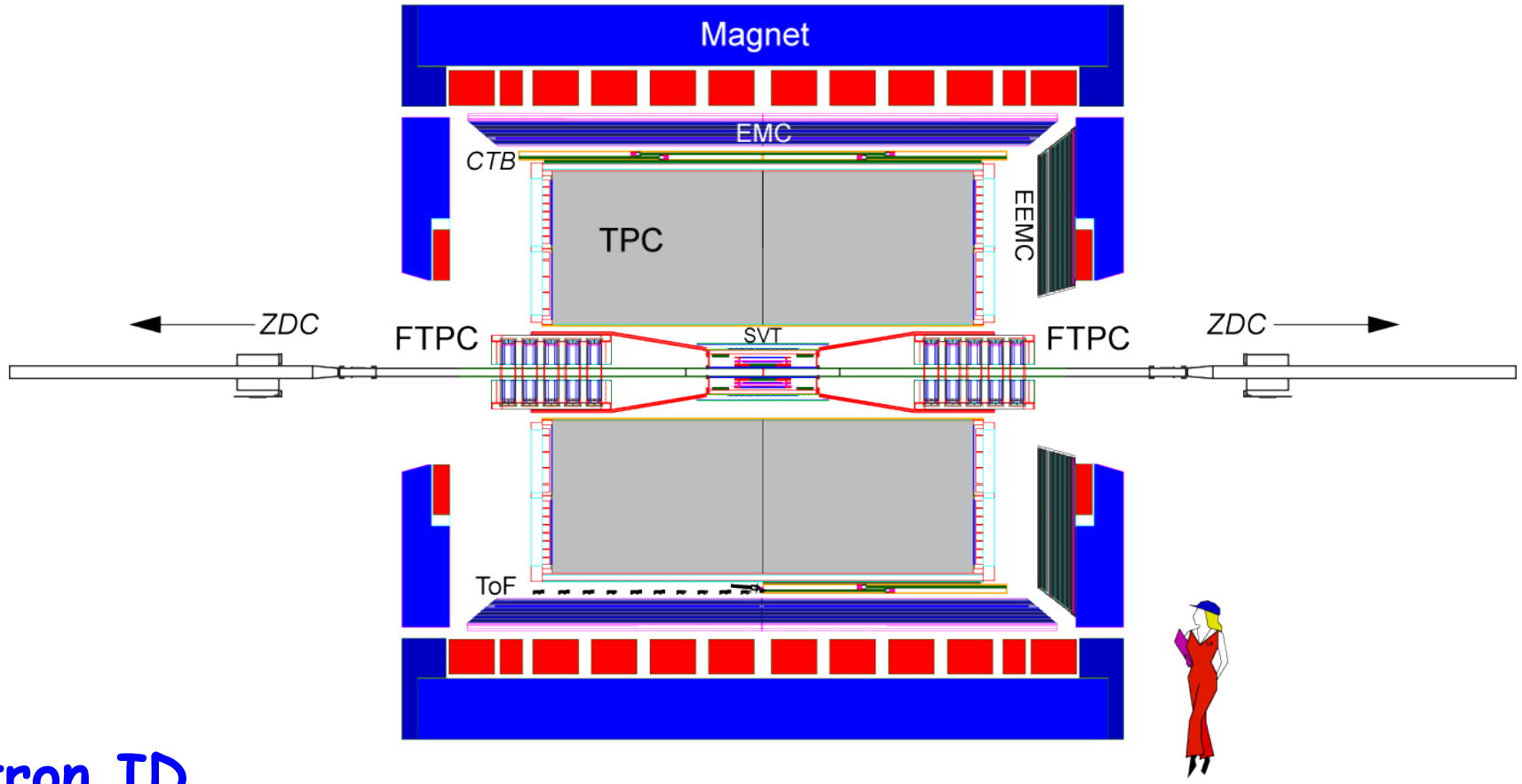
Large contributions to inclusive electrons at low p_T

2) Measure "photonic" background and and subtract from inclusive electrons

non-photonic electrons

Non-photonic electrons should come primarily from charm and bottom decays

The STAR Detector



Electron ID

- energy loss in the tracking detectors (TPC dE/dx)
- time of flight measurement (TOF)
- calorimetric measurements (EMC)

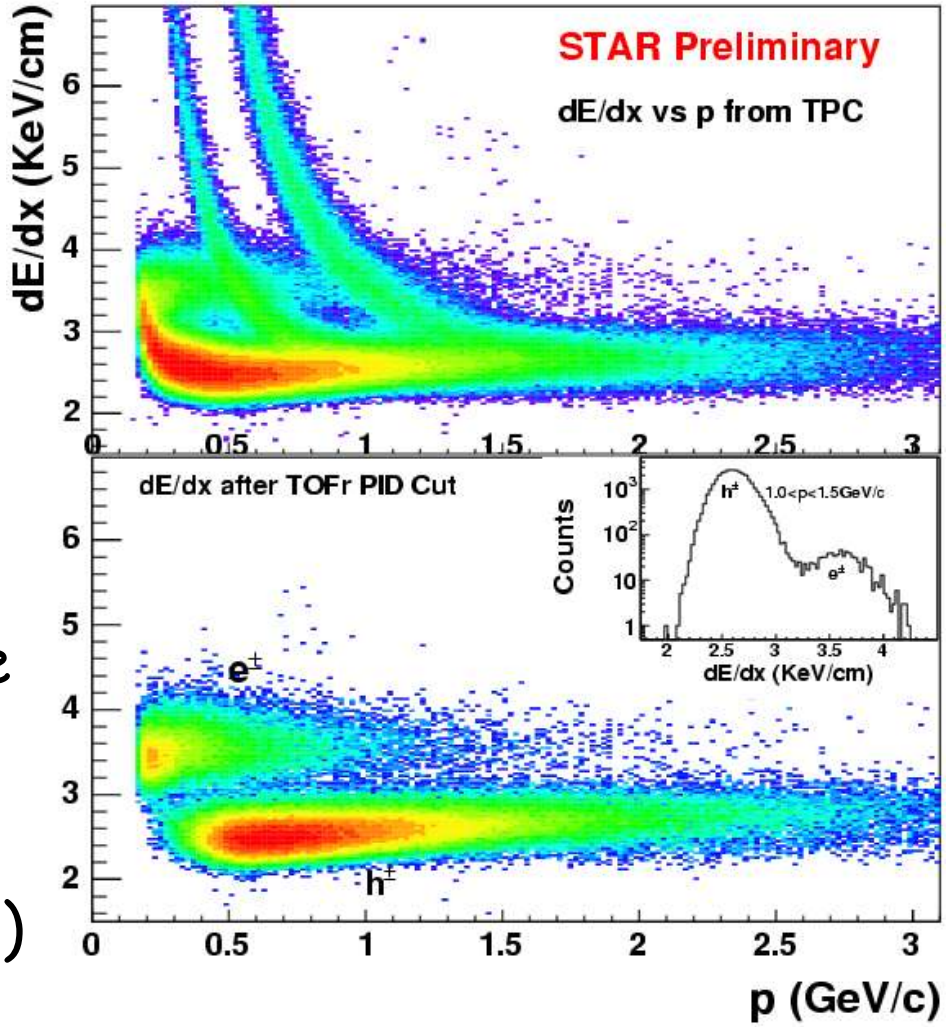
Electron ID (1)

Energy loss (dE/dx) in the tracking detectors (TPC)

- e/h ~ 500 (depending on momentum)
- Limited to certain momentum windows

Time of Flight + dE/dx

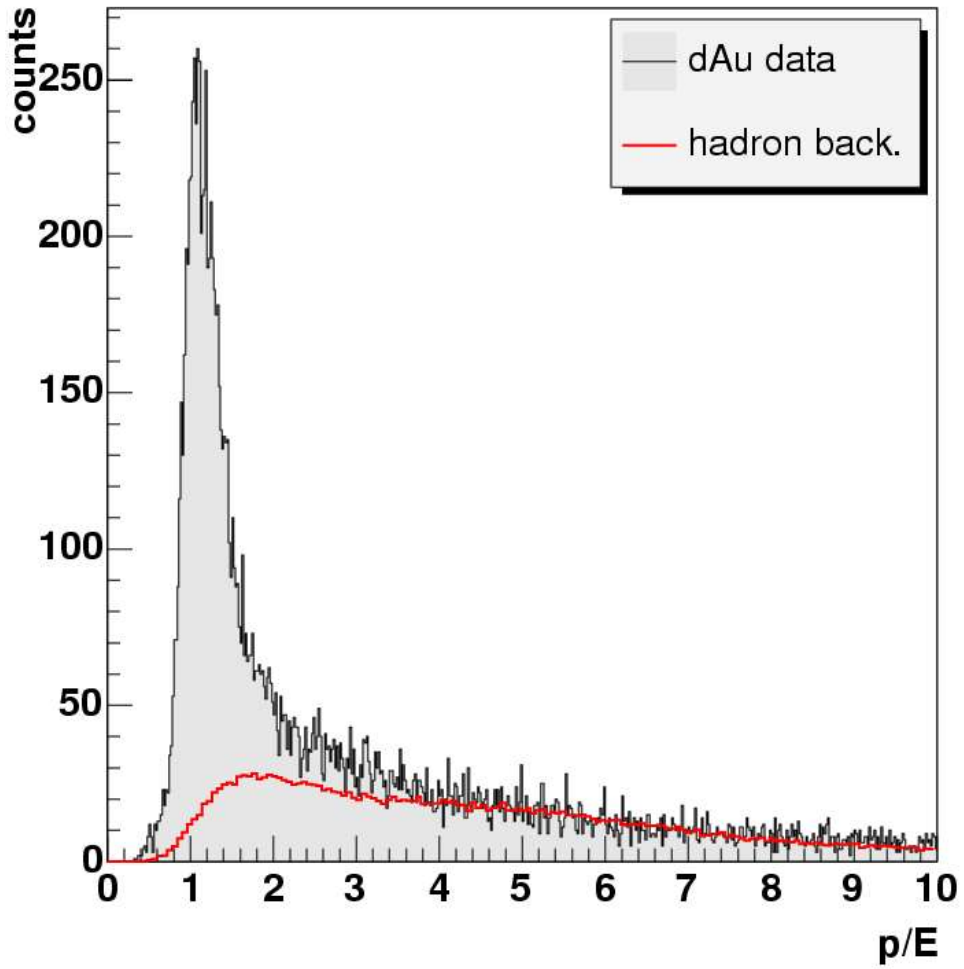
- allows clear electron ID in large momentum range (0.2 < p < 3)
- Only prototype installed: Small coverage (1 unit in eta, 6° in phi)



Electron ID (2)

Calorimetric Measurements (EMC + tracking + dE/dx)

- large coverage
  - $0 < \eta < 1$, in FY03,
  - $-1 < \eta < 1$ after completion
  - $-1 < \eta < 2$ including Endcap
- Provides measurements of
  - energy deposit in towers
  - shower shape (SMD)
- electron ID starting at p ~ 1.5 GeV/c

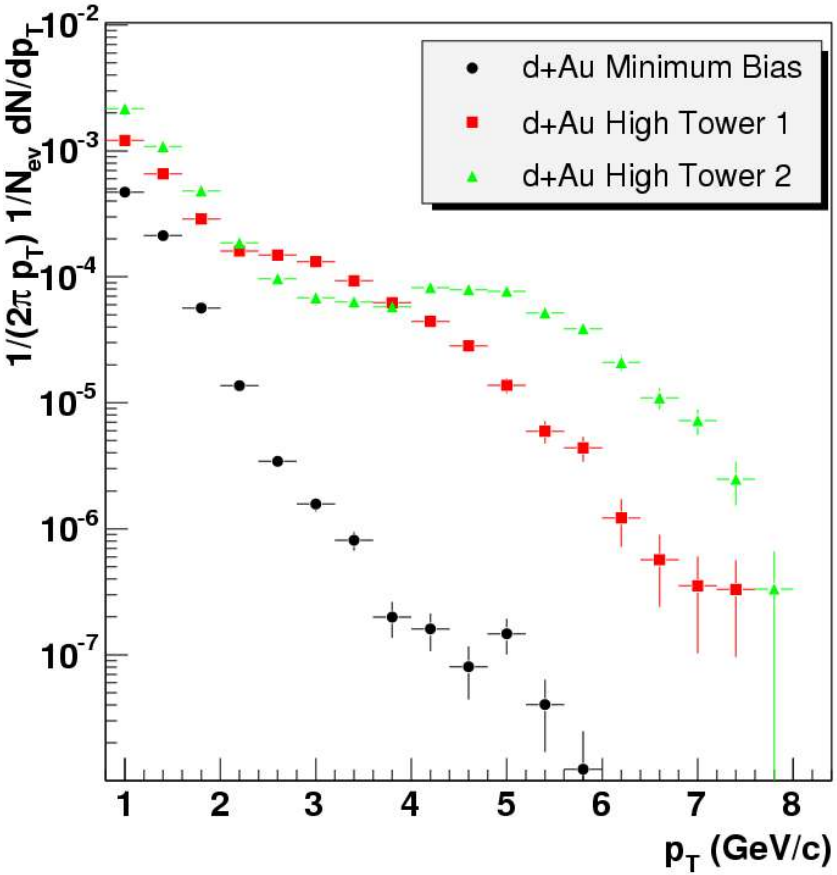


EMC Trigger

The EMC as trigger detector provides Level-0 trigger information on energy deposition in towers for up to 3 ADC (~transverse energy) thresholds

Allows STAR to trigger on high-p_T electrons.

Only limited by delivered luminosity and STAR deadtime.



Significant extension of p_T reach

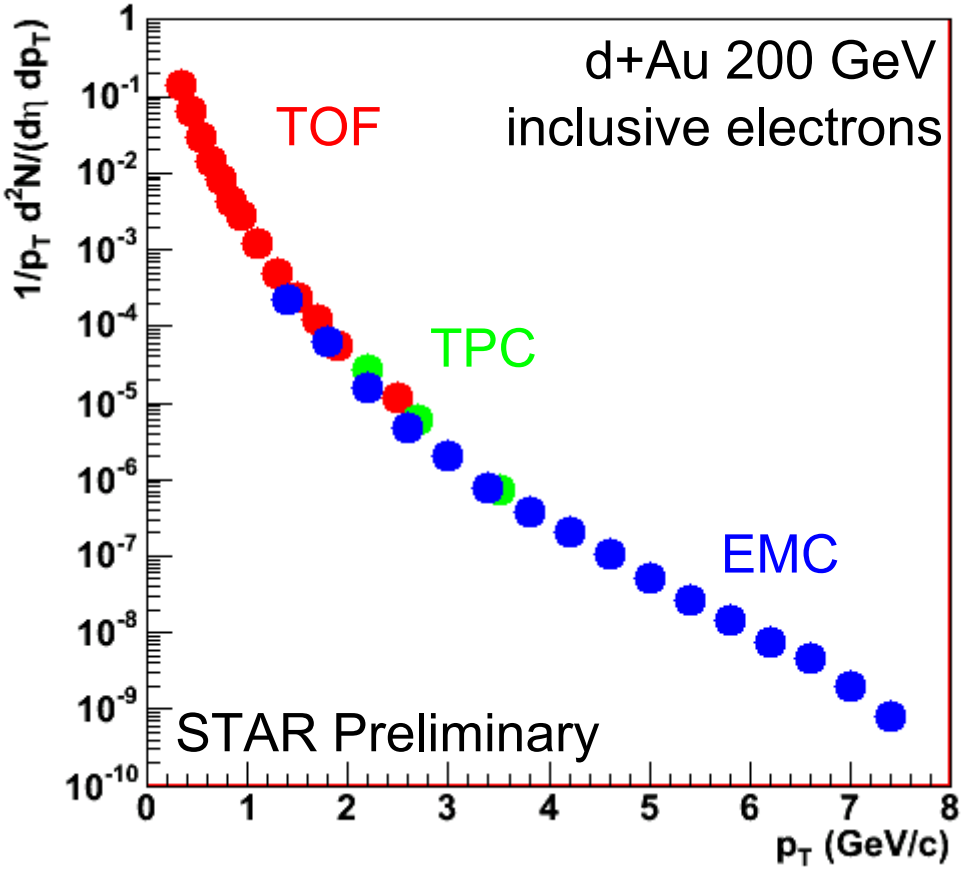
Inclusive Electrons (d+Au)

Dataset: d+Au at 200 GeV

Step 1: inclusive electrons

Combined electron p_T spectrum for d+Au collisions at 200 GeV

- p_T coverage from 0.2 to 7.5 GeV/c
- nice agreement between different techniques in overlap regions



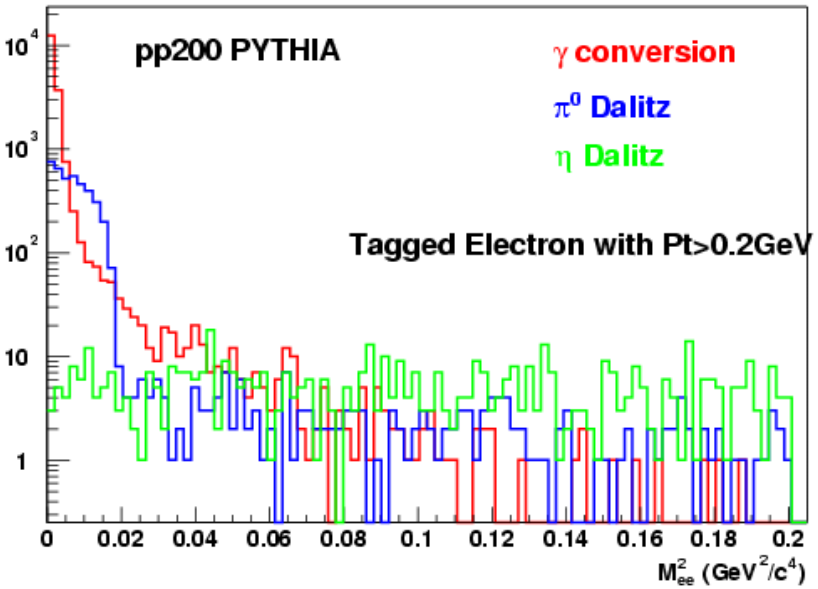
Background Subtraction (1)

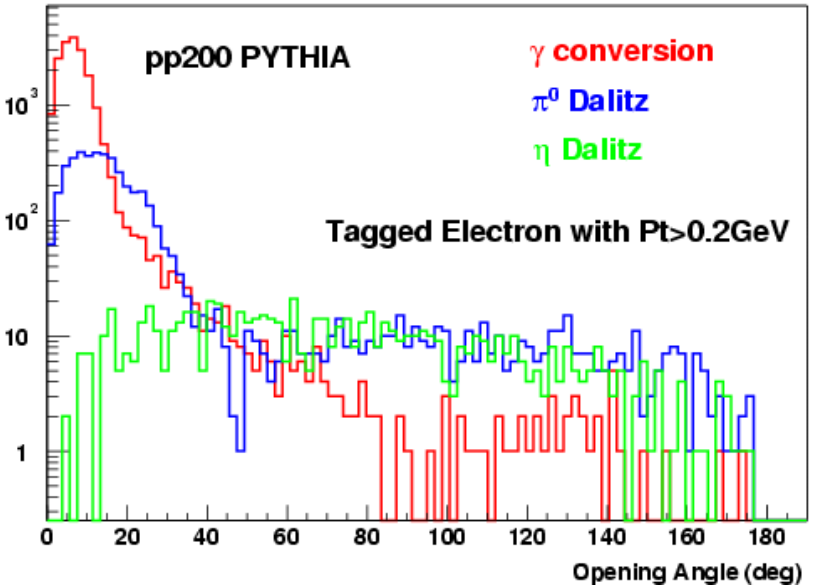
Step 2: subtracting the photonic background

Measuring the background: electron pair invariant mass reconstruction and pair opening angle

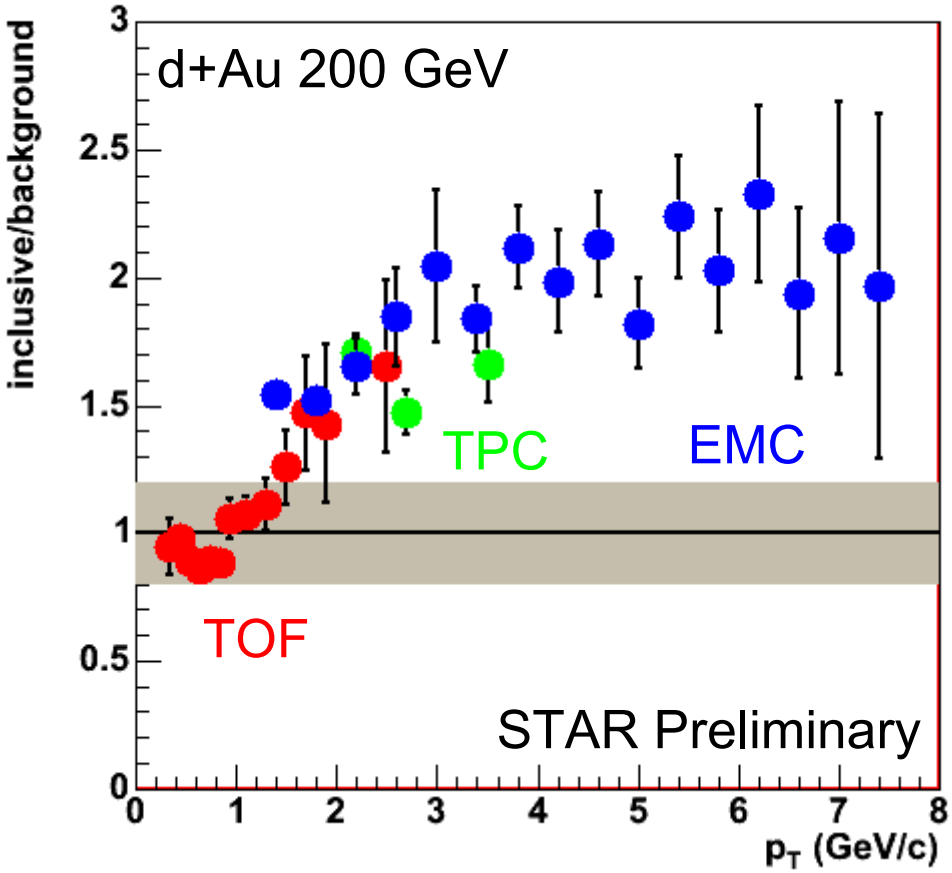
- γ conversions
- π^0 dalitz decays
- other decays (η...) scaled to π^0

Background reconstruction efficiency ~60%





Background Subtraction (2)

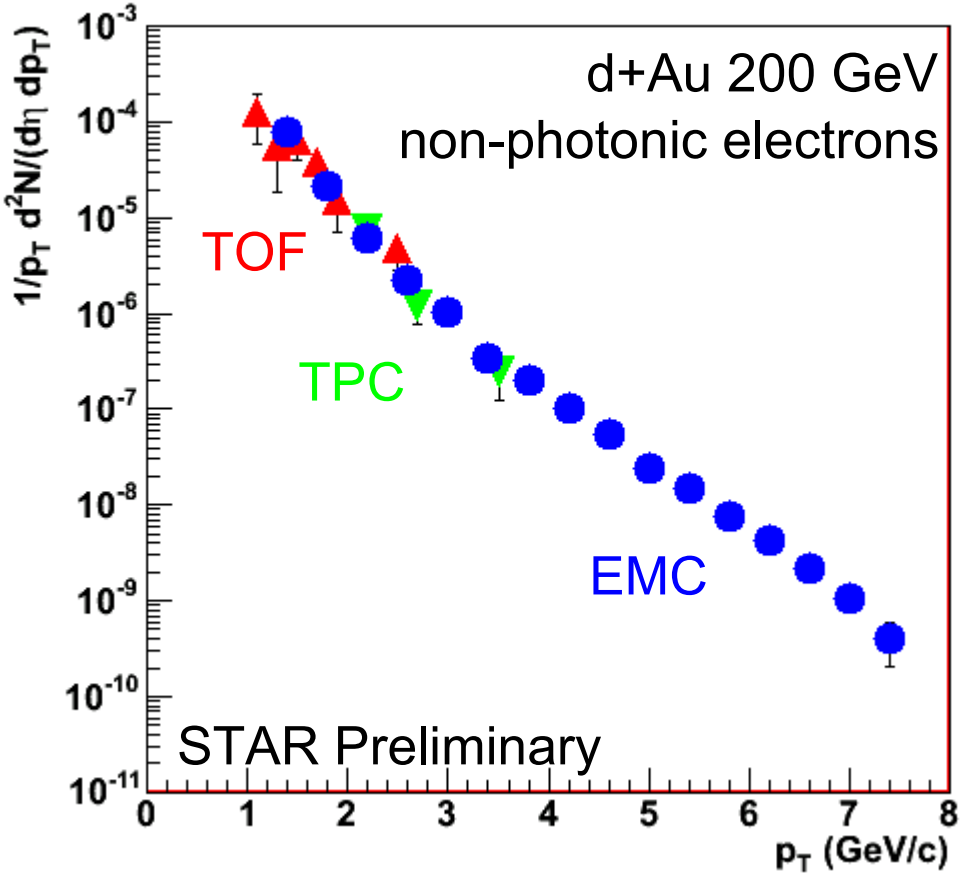


Ratio of inclusive electrons over background shows clear excess for $p_T > 1\text{-}2$ GeV/c

non-photonic electrons

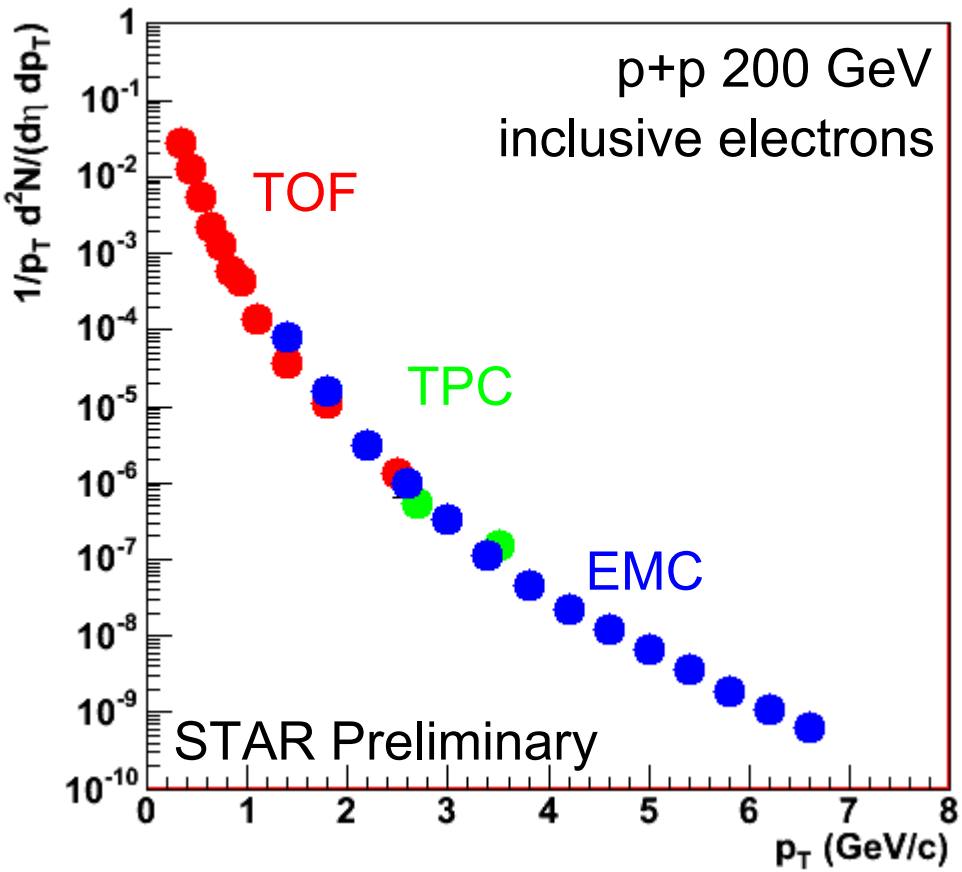
Non-photonic Electrons

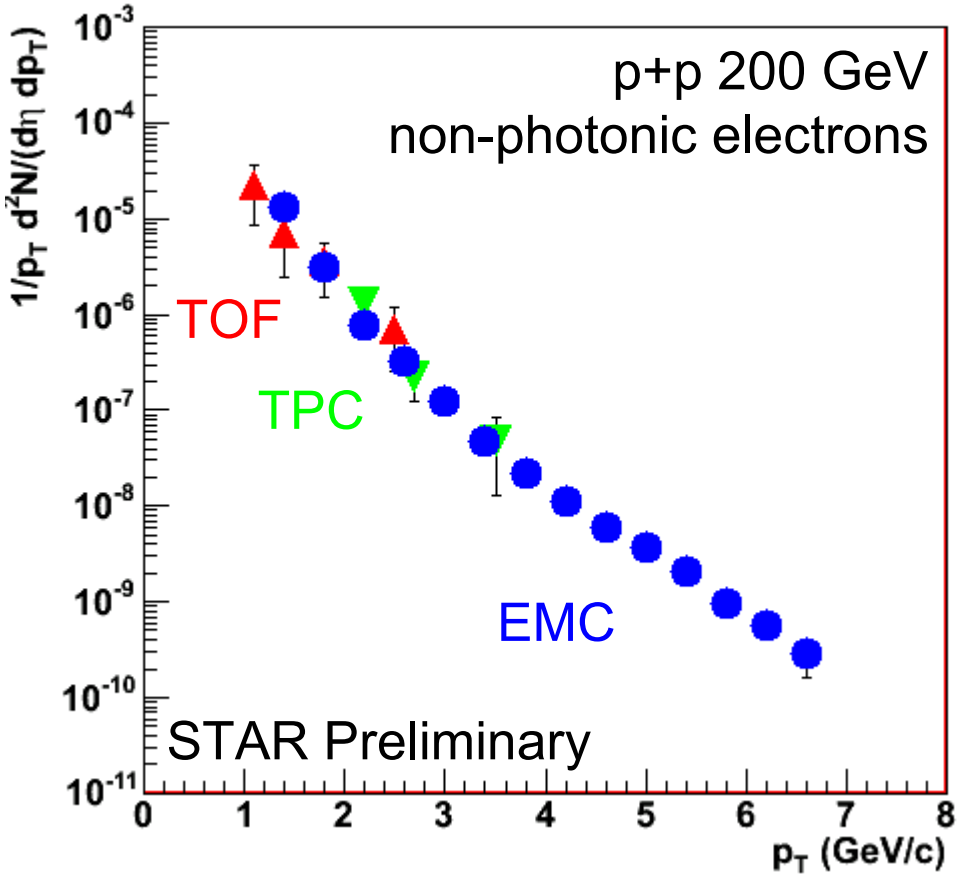
After background subtraction "non-photonic" electron spectra from p_T ~ 1 - 7.5 GeV/c



Electrons in p+p

Another dataset: p+p at 200 GeV



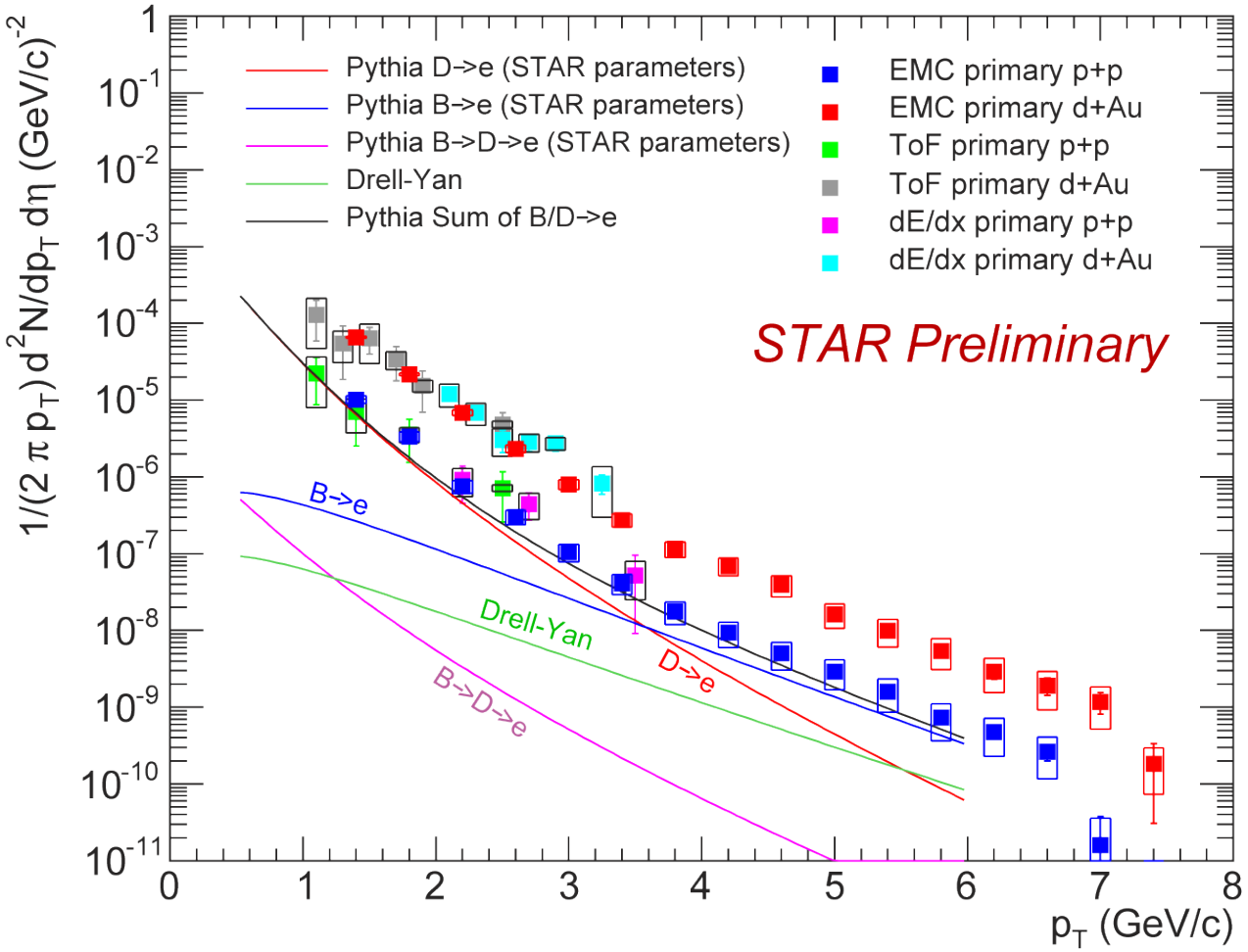


Again good agreement between different techniques

Non-photonic Electron Sources (1)

Where do the non-photonic electrons come from:

PYTHIA as a first answer



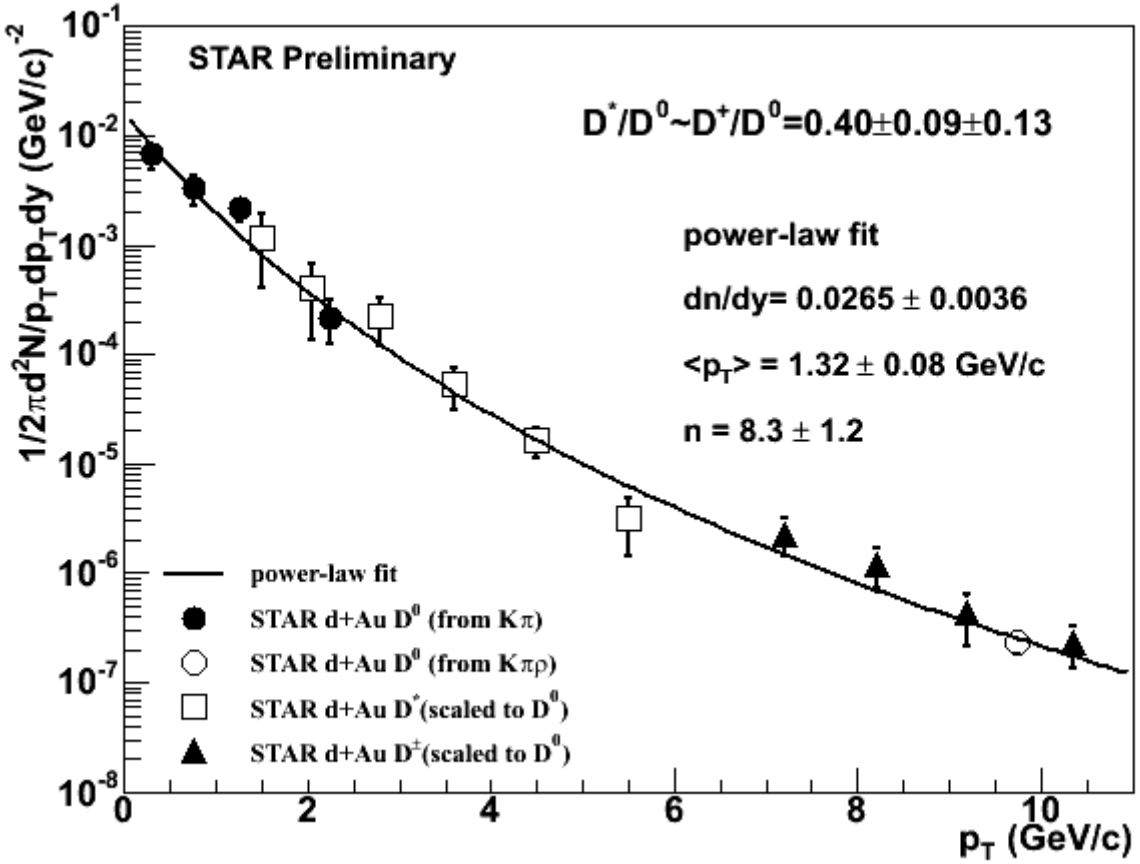
But: depends on model input settings (PDFs, subprocesses used...)

Non-photonic Electron Sources (2)

Where do the non-photonic electrons come from:

What other STAR data can tell us

Direct reconstruction of open charm mesons using invariant mass technique in d+Au (Huan Huang)

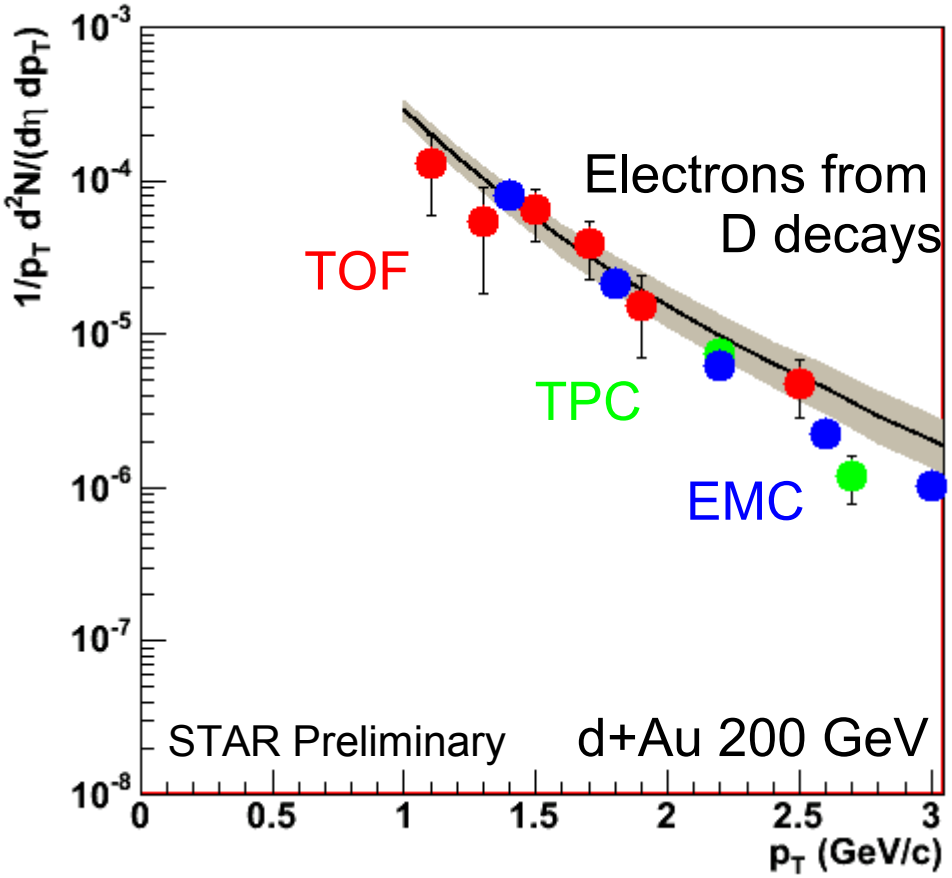


How consistent are the non-photonic electrons with this data?

Non-photonic Electron Sources (3)

Method for consistency check

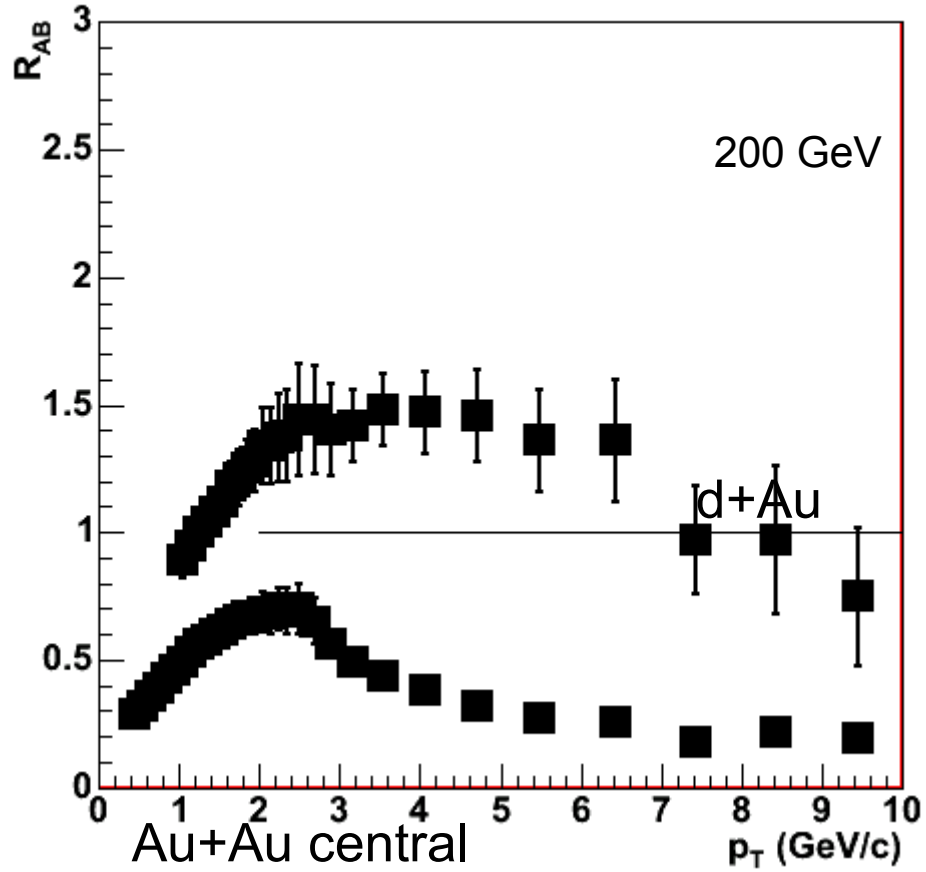
- Take D mesons p_T spectrum
- Use PYTHIA to decay D mesons into electrons



Nice agreement between D mesons and non-photonic electrons

Energy Loss in Medium

Suppression of high-pT hadrons well established at RHIC, factor 4-5 suppression in central AuAu collisions
→ Energy loss in medium



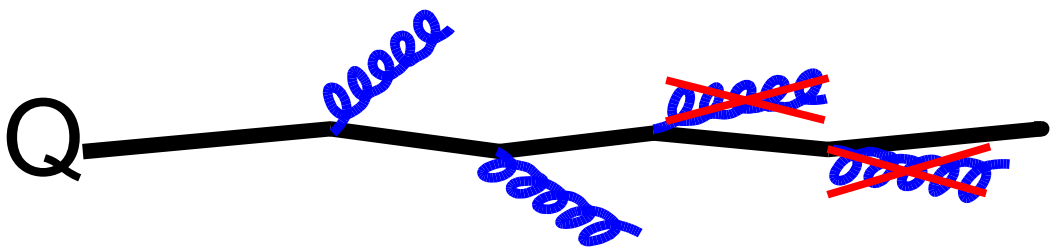
Nuclear Modification Factor:

$$R_{\mathrm{dAu}}(p_T) = \frac{d^2 N_{\mathrm{dAu}} / dp_T\, d\eta}{T_{\mathrm{dAu}}\, d^2 \sigma_{\mathrm{pp}} / dp_T\, d\eta}$$

What will happen for heavy quarks?

Heavy Quark Energy Loss

Without medium heavy quark jets differ from light quark/gluon jets due to suppression of gluon radiation at small angles, the **Dead Cone Effect** (Y. Dokshitzer et al, J.Phys.G17,1481 (1991)



suppressed for

$\theta < m_Q/E_Q$

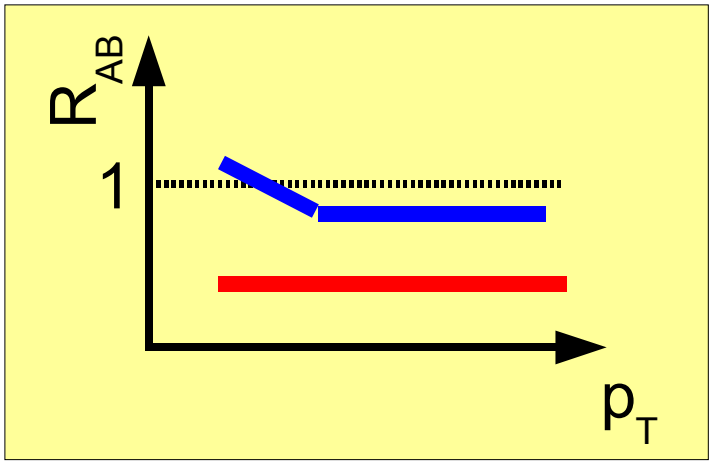
What will happen in the medium?

Reduced medium energy loss?

Y. Dokshitzer and D. Kharzeev, Phys.Lett. B519, 199 (2001)

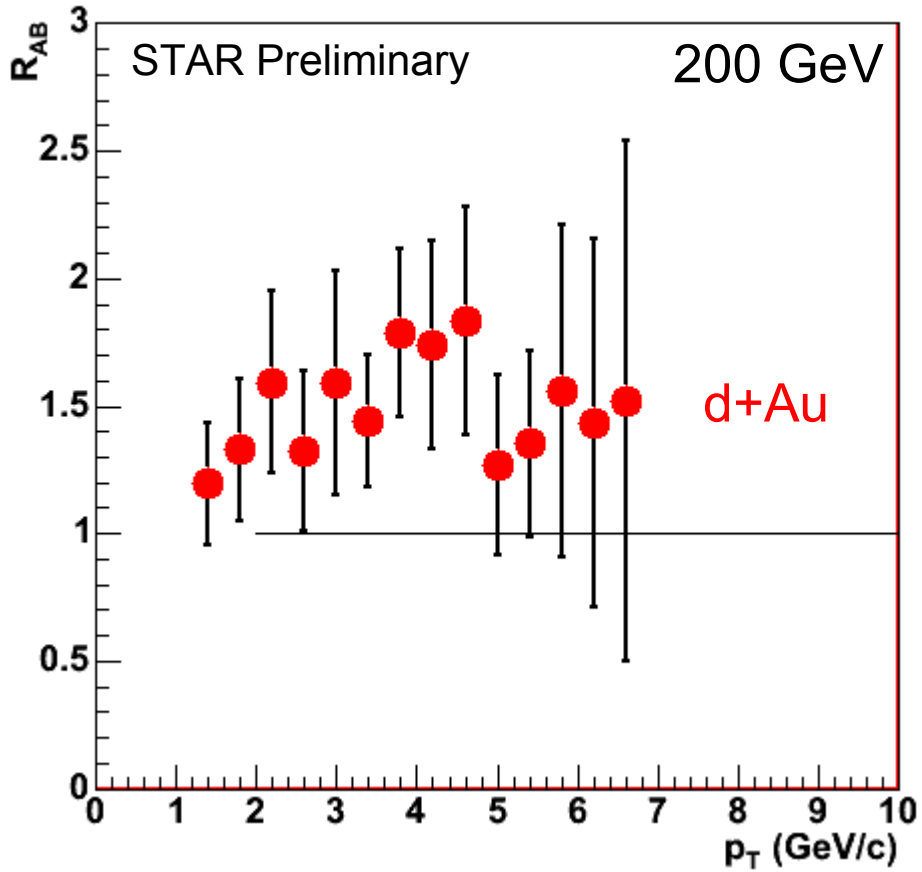
M. Djordjevic and M. Gyulassy, Phys.Lett. B560, 37 (2003)

N. Armesto, C. Salgado, U. Wiedemann PRD69, 114003 (2003)



Electron R_{AB}

Towards heavy quark energy loss:
Primary electron R_{dAu}



Within errors consistent with binary scaling, some indication of Cronin effect

Interpretation not that easy:

- Contributions from charm and bottom
- Momentum correlation to D(B) mesons

Au+Au Outlook

Very successful Au+Au running earlier this year

- ~50M minbias events (>10x current statistics)
- ~50M central events (>10x current statistics)
- EMC trigger (first time in Au+Au)

First time STAR has run a quarkonia trigger:

- L0: EMC to select decay electron candidates
- L2: Invariant mass reconstruction using the EMC to enhance selectivity
- L3: Online TPC tracking and invariant mass reconstruction to verify decision
- L3/DAQ: Special streams for these triggers

Summary

Non-photonic electron spectra for d+Au and p+p @ 200 GeV

- Large p_T coverage
- gives STAR access to charm and bottom

Consistent with D meson measurement

R_{dAu} consistent with binary scaling, some indication of Cronin effect

Lots of Au+Au data on tape

- first time with EMC and quarkonia triggers

Electron R_{AB}

Quarkonia Trigger

Outline/Motivation

Why heavy flavor?