Inclusive electron distributions in d+Au and p+p collisions at RHIC

Outline

- Motivation
- The STAR/EMC detector
- Analysis procedure
- Results
- Final remarks

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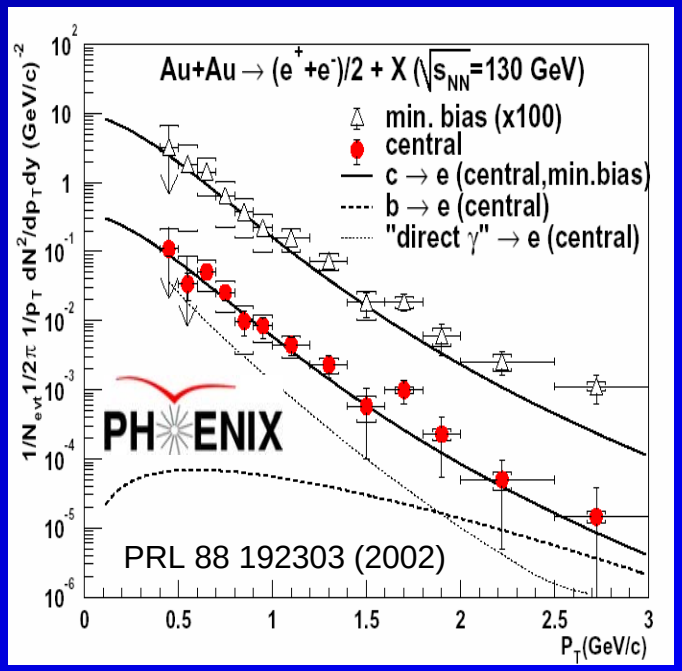
Why measure electrons?

- **Single and di-electron spectra**
  - **Important to understand heavy quark production (*charm* and *beauty*)**
    - ✓ Produced mainly from initial gluon fusion
      - ✓ Sensitive to the ealier conditions



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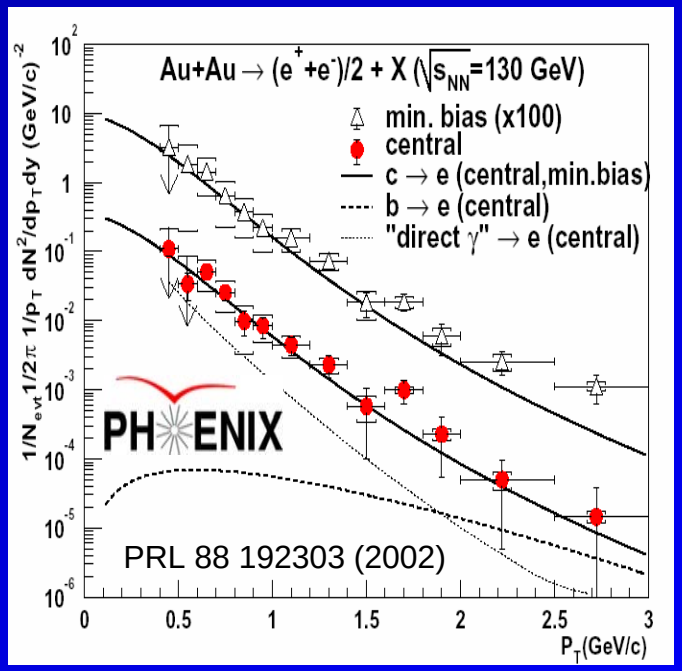
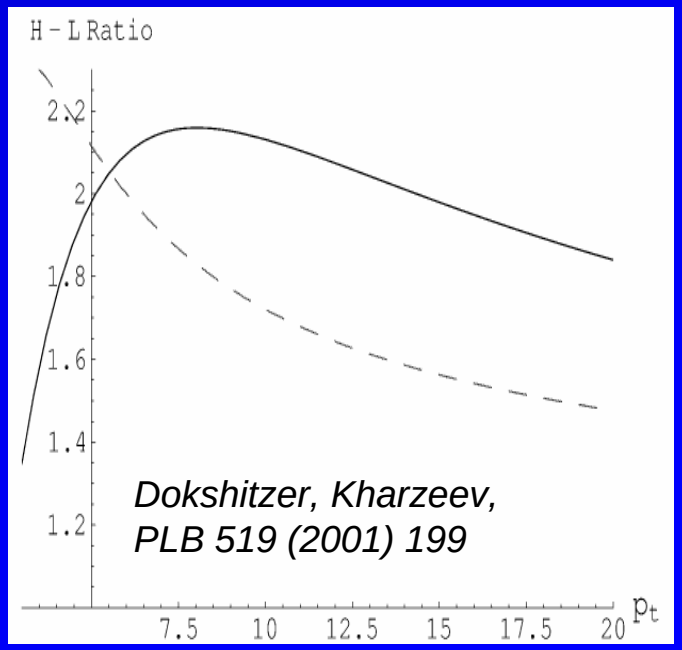
  - **Propagation of heavy quarks in QCD matter**
    - ✓ **dead cone effect**
      - ✓ Heavy Quark has less *dE/dx* due to suppression of small angle gluon radiation
      - ✓ large enhancement of D/π ratio at moderate high p_T (5-10 GeV/c)





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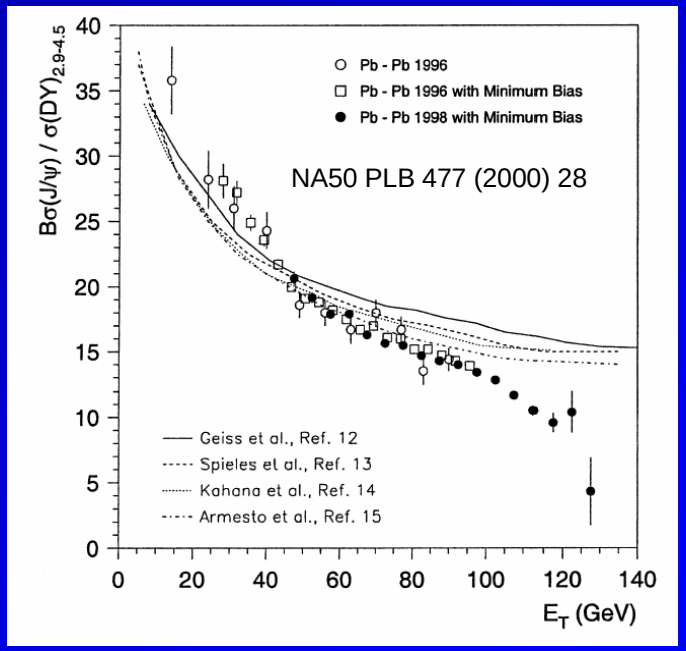
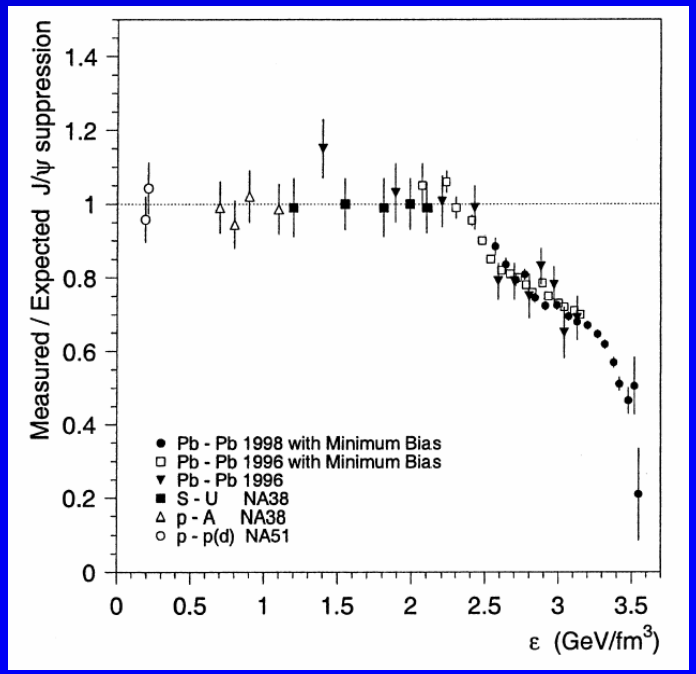
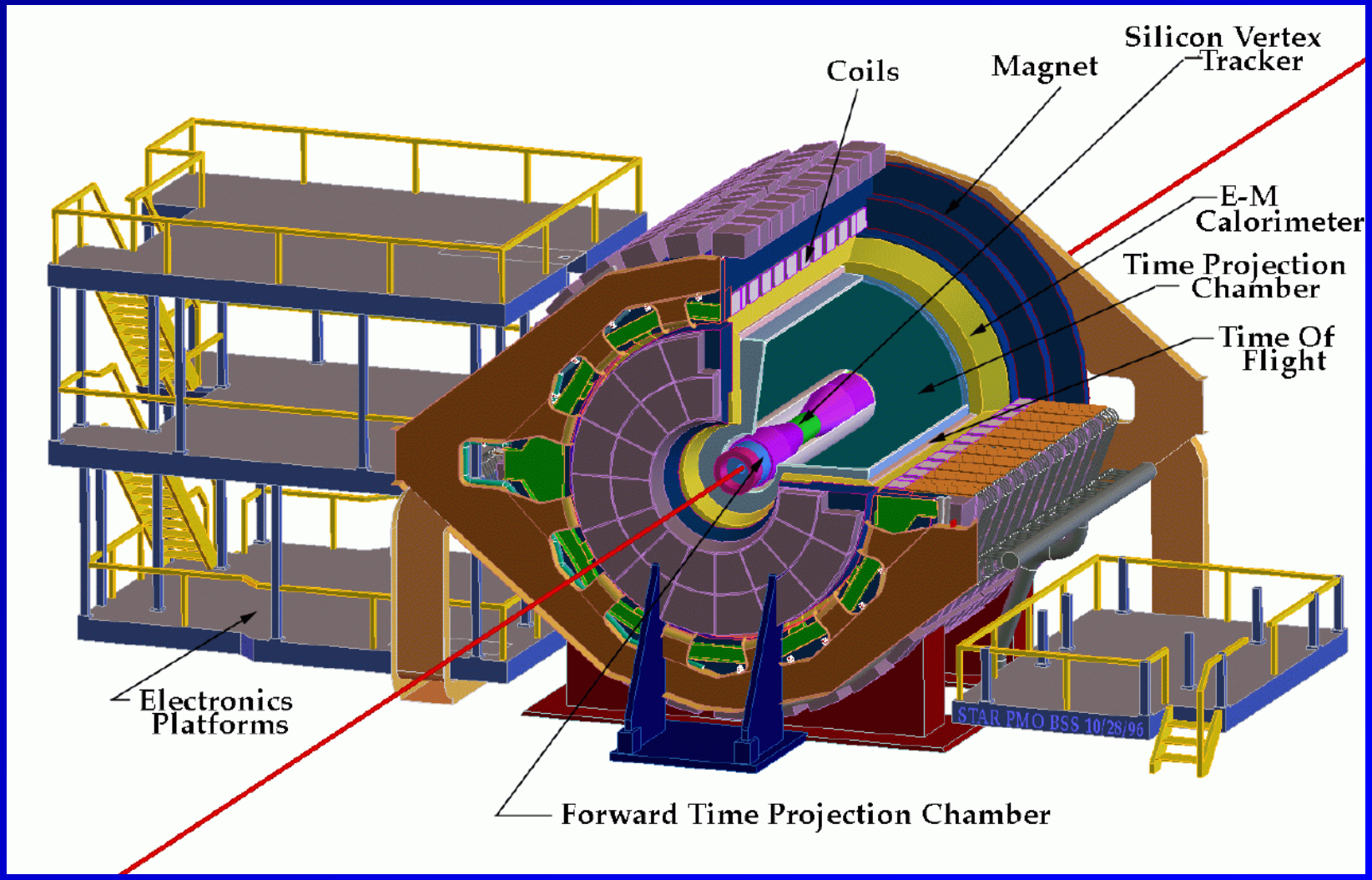
- **Heavy quark bound states (J/ψ, ψ′, χ_c)**
  - **Suppression at high energy densities**
    - ✓ QGP signature?



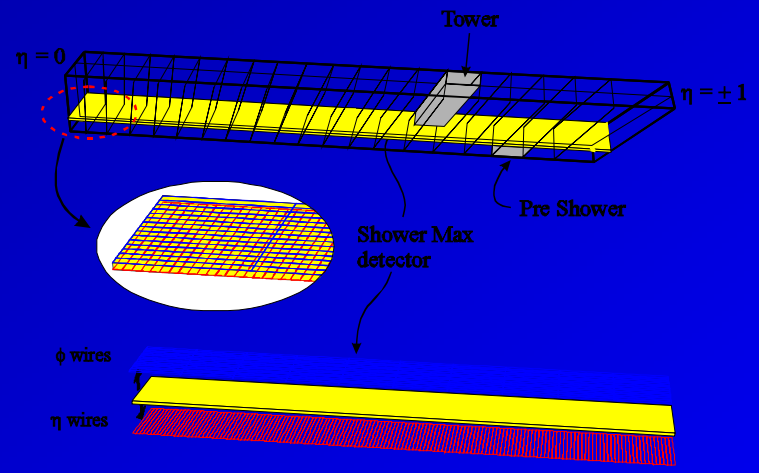


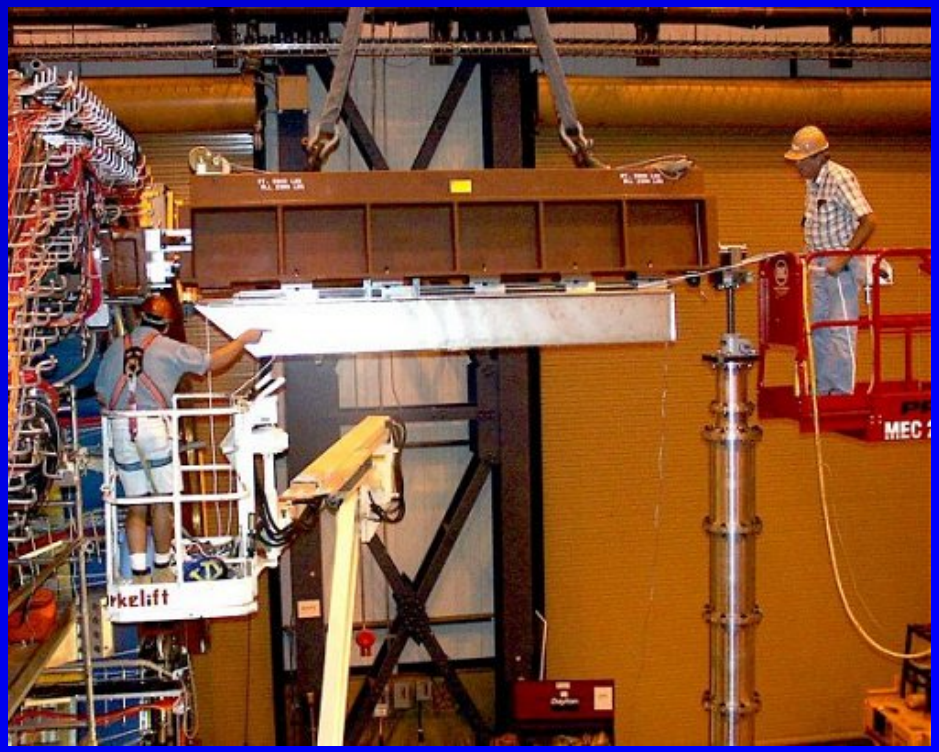
The STAR (Solenoidal Tracker At RHIC) experiment



The STAR electromagnetic calorimeter

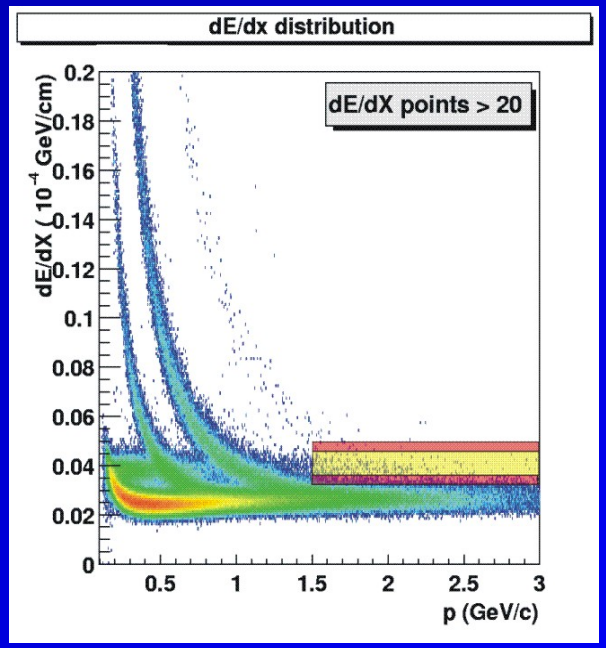
- **Year 2003 barrel EMC**
  - **p+p and d+Au runs at 200 GeV/A**
  - **$0 < \eta < 1.0$**
  - **Full azimuthal coverage**
  - **60 modules**
    - ✓ **40 towers/module**
      - ✓ $21\ X_0$
      - ✓ $(\Delta\eta, \Delta\phi)_{tower} \sim (0.05, 0.05)$
      - ✓ $\delta E/E \sim 16\%/\sqrt{E}$
    - ✓ **Shower max detector**
      - ✓ Positioned at $\sim 5\ X_0$
      - ✓ Larger spatial resolution
      - ✓ $(\Delta\eta, \Delta\phi) \sim (0.007, 0.007)$

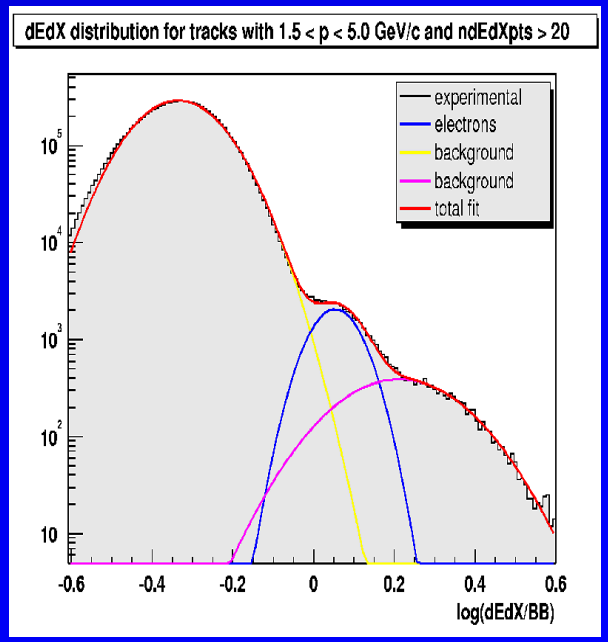




Electron identification

- **TPC as a candidate selector**
  - **dE/dX for p > 1.5 GeV/c**
    - ✓ Electrons can be discrimitated from hadrons up to 8 GeV/c





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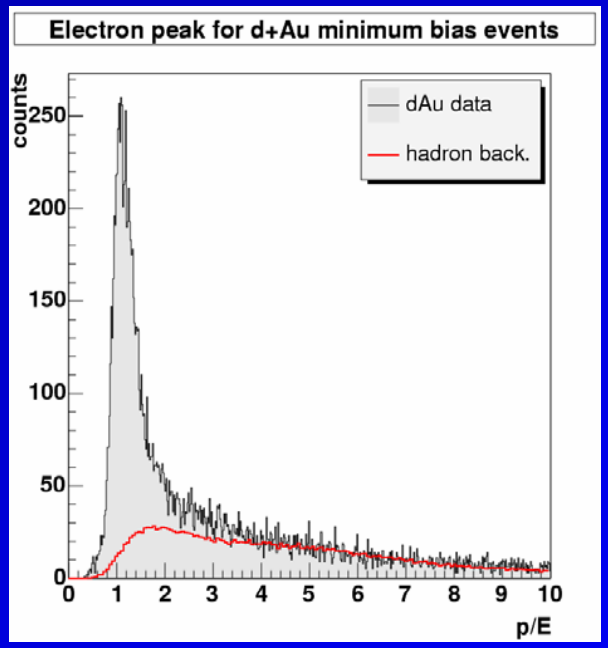
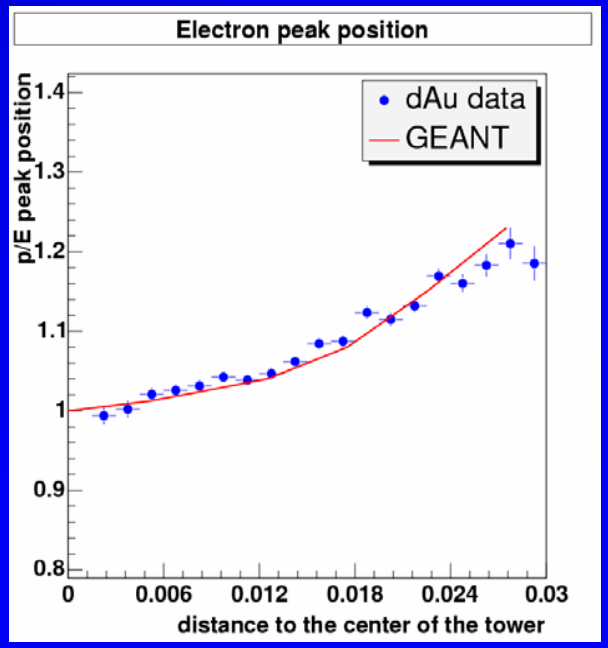
  - **Towers**
    - ✓ **p/E for electron and hadron candidates**
      - ✓ p is the track momentum
      - ✓ E is the tower energy
      - ✓ Peak position depends on the distance to the center of the tower





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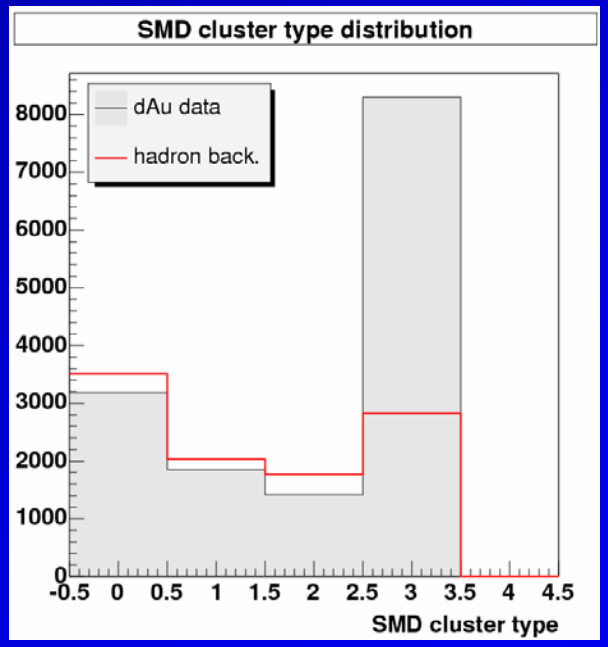
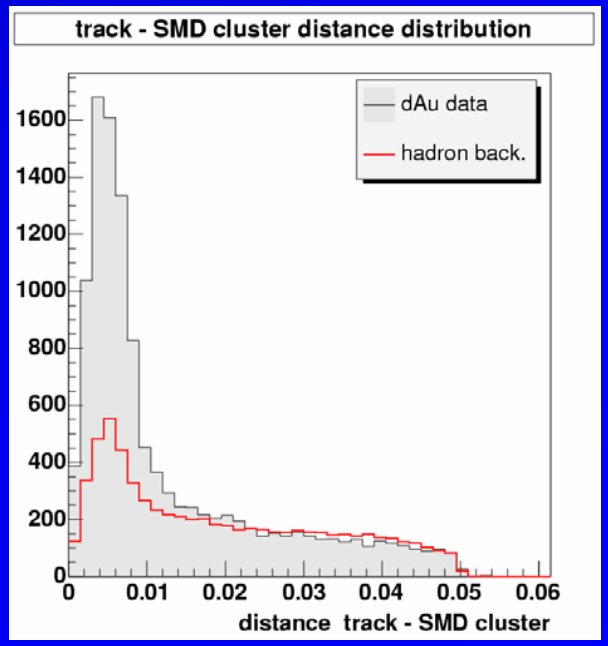
  - **SMD (Shower Max Detector)**
    - ✓ **Shower cluster type**
      - ✓ **Type 3 = both SMD planes**
    - ✓ **Track-SMD cluster distance**
      - ✓ Hadrons have a wider distribution





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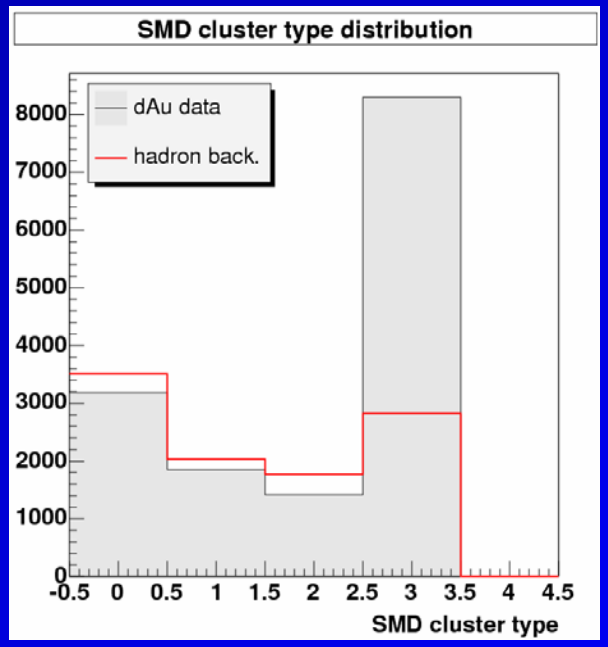
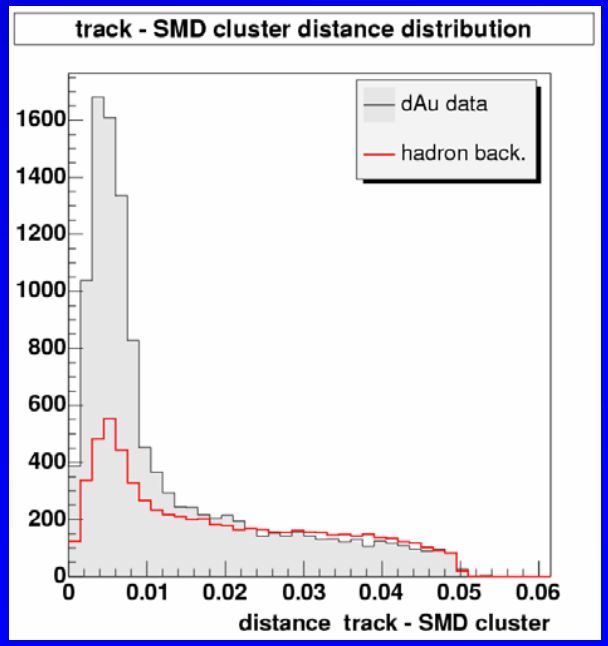
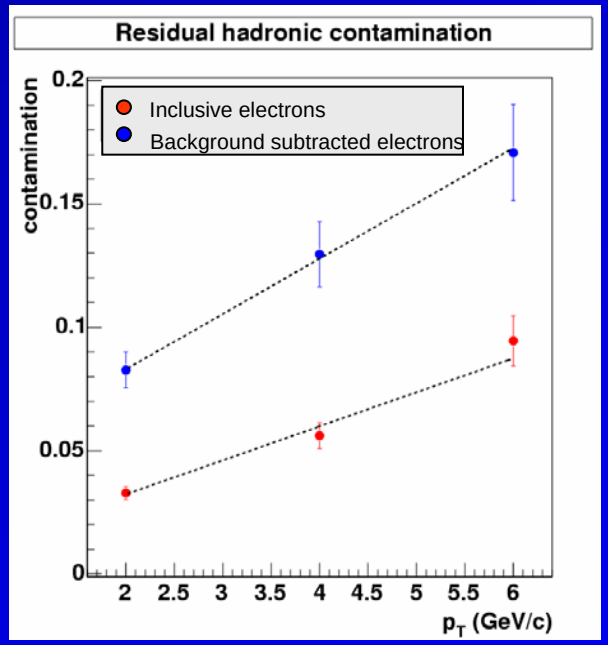
- **e/h discrimination power ~ 10^5**
  - TPC ~ 500
  - EMC ~ 250



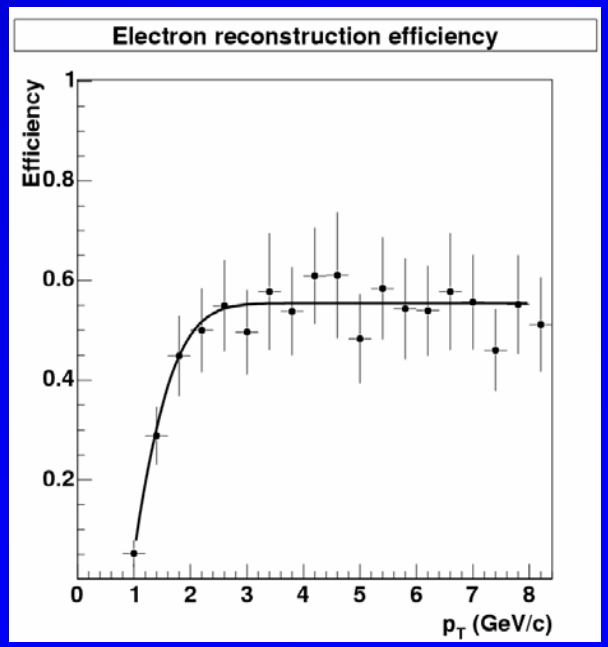


Electron identification

- **Remaining hadronic contamination (hadrons misidentified as electrons)**
  - Obtained by selecting hadrons using TPC dE/dX
    - ✓ Larger for background subtracted electrons



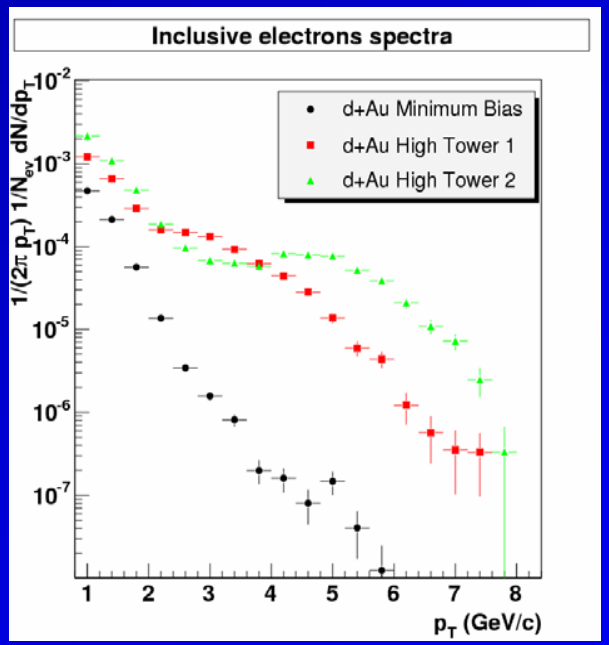
- **Reconstruction efficiency**
  - From embeddig simulated electrons into real events
    - ✓ Aprox. 50% for $p_T > 2$ GeV/c

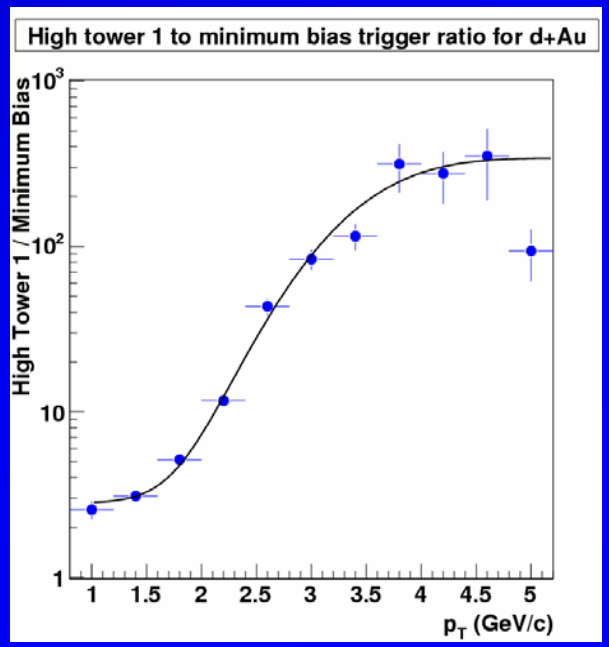


High-p_T electron trigger

- **EMC provides a Level 0 high-p_T electron trigger**
  - **Runs for every RHIC crossing (10 MHz)**
  - **Two E_T thresholds**
    - ✓ **2.5 and 5 GeV**
  - **Enhancement as high as 1000 for p_T > 5 GeV/c**

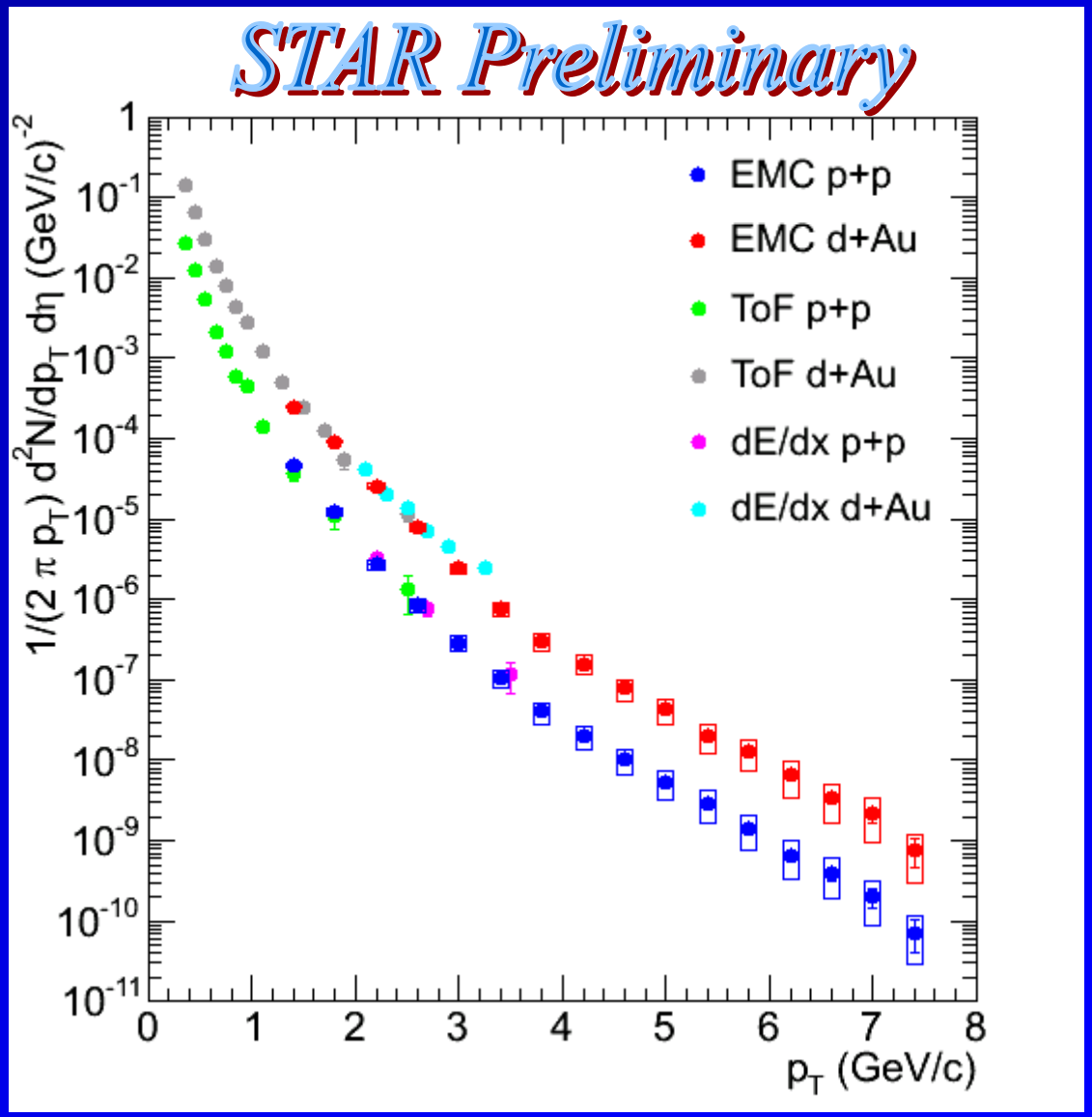
- **Trigger bias**
  - **Suficient overlap between the minimum bias and the EMC triggered data**





Total electron spectra

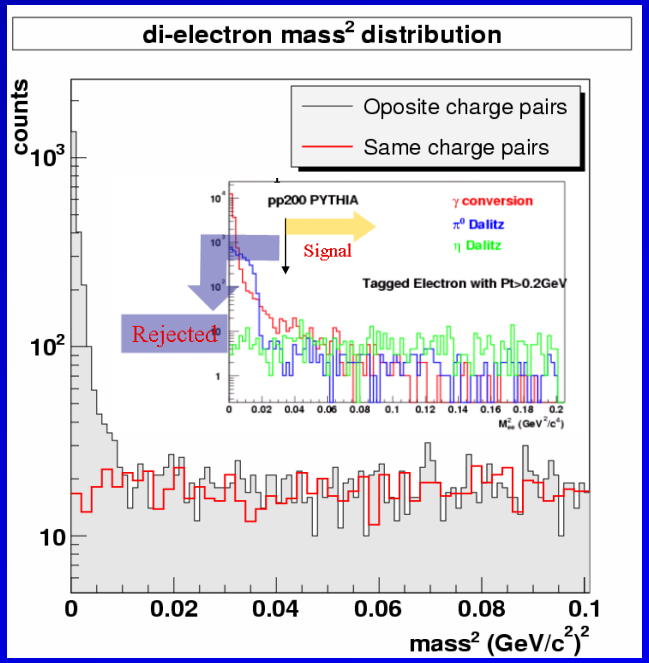
- **Total electron spectra for p+p and d+Au**
  - Up to p_T = 8 GeV/c
- **EMC, ToF and dE/dX measurements agree withing errors**
  - 3 independent analysis
- **Systematic uncertainties**
  - Trigger bias ~ $0.5\sigma_{sys}$
  - Efficiency ~ $0.3\sigma_{sys}$
  - Other sources ~ $0.2\sigma_{sys}$
    - ✓ Misidentified hadrons
    - ✓ EMC calibration, etc

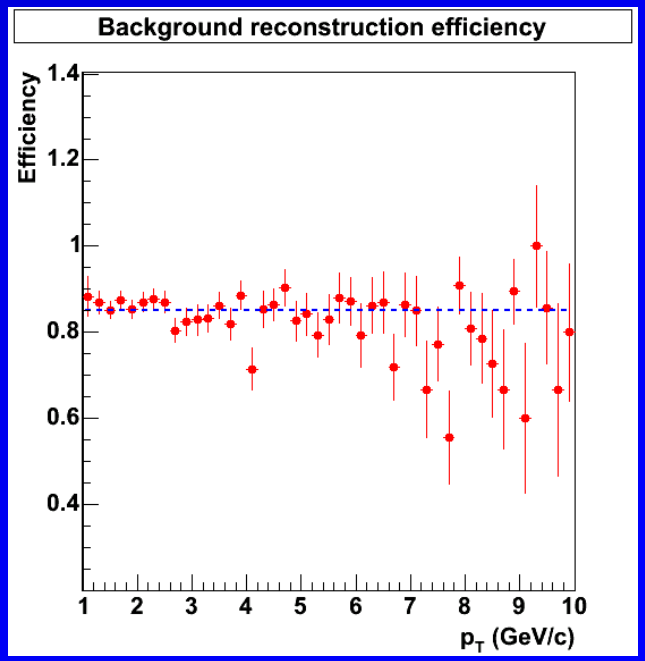


Electron background

- **Total electron spectra**
  - **Background**
    - ✓ Instrumental sources
      - ✓ γ convertion
    - ✓ Hadron background
      - ✓ Dalitz decays (π^0, η)
      - ✓ Kaon decays
      - ✓ vector meson decays (ρ ω Φ)
  - **Signal**
    - ✓ heavy quark semi-leptonic decay
    - ✓ Drell-Yan, Thermal, etc

- **γ convertion and Dalitz decays**
  - **Di-electron mass reconstruction**
    - ✓ Subtraction efficiency ~ 85%





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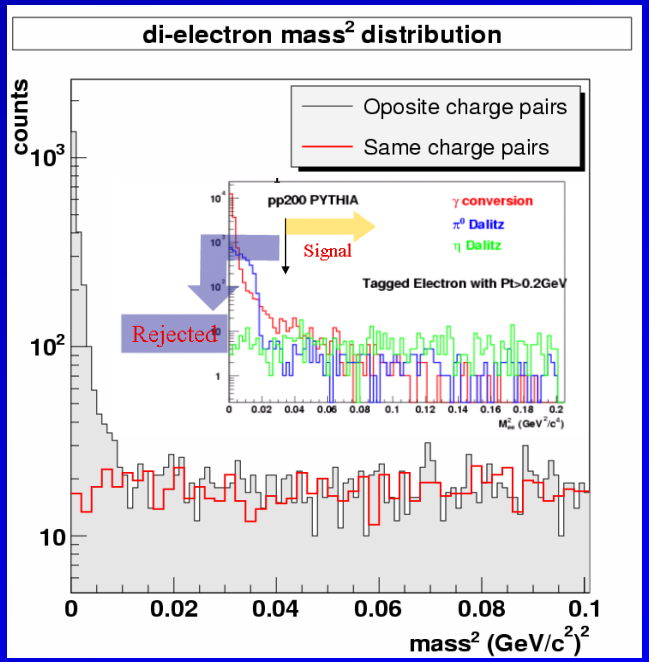
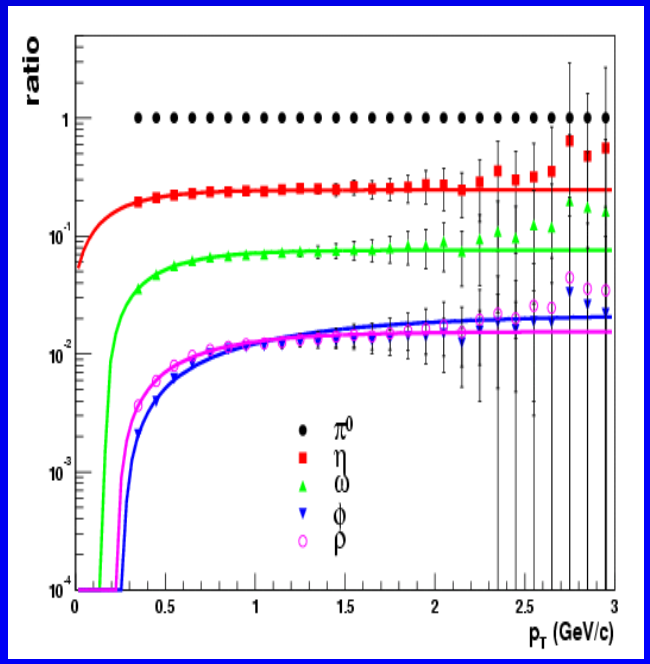
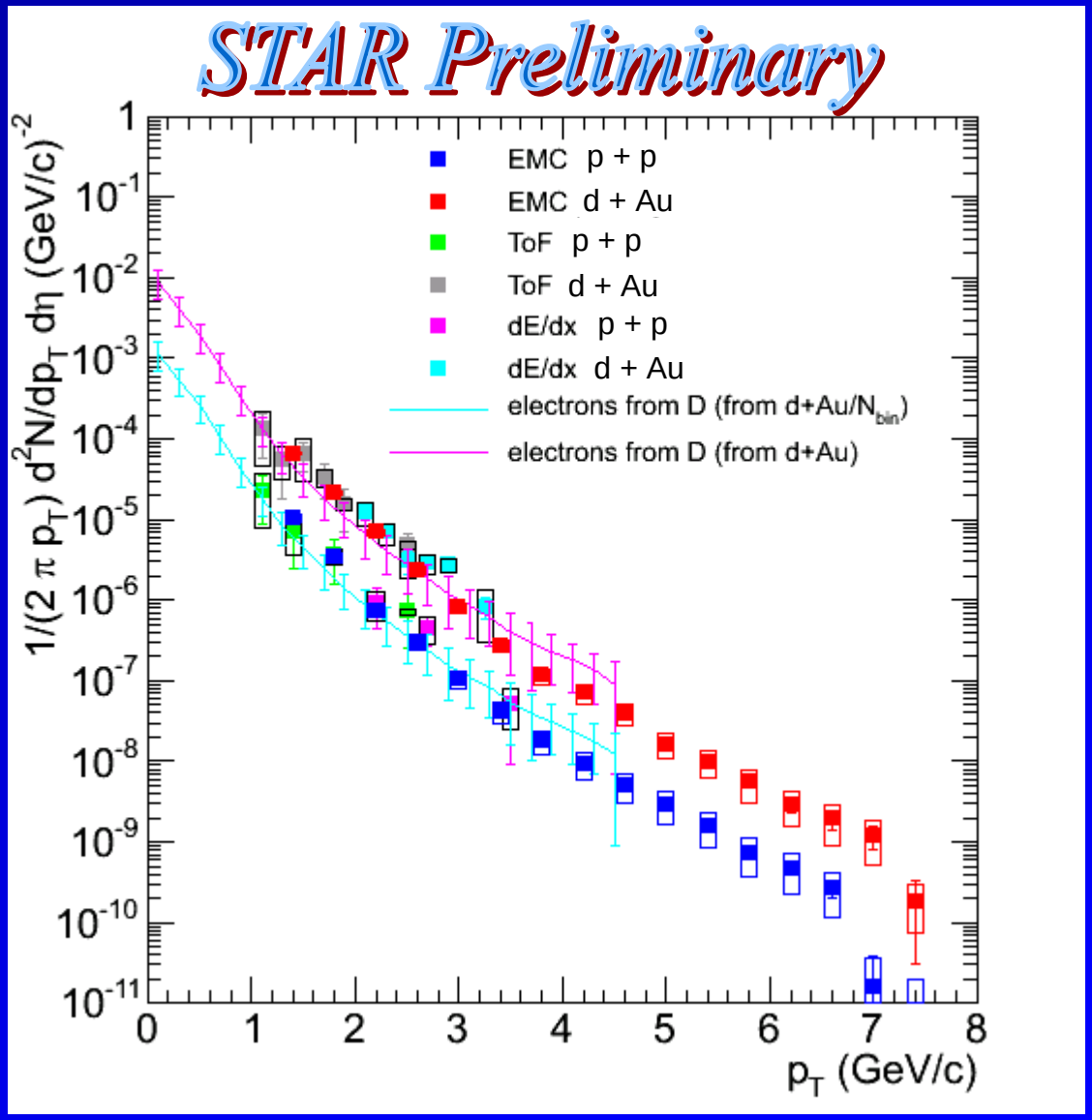
- **Other sources**
  - **Pythia/HIJING + GEANT simulations (see L.J. Ruan talk)**
    - ✓ ratio with respect to π^0 Dalitz decay





Background subtracted electron spectra

- STAR has measured electrons up to $p_T = 8$ GeV/c
- EMC, ToF , dE/dX and electron from D mesons decay measurements agree withing errors
  - 4 independent analysis



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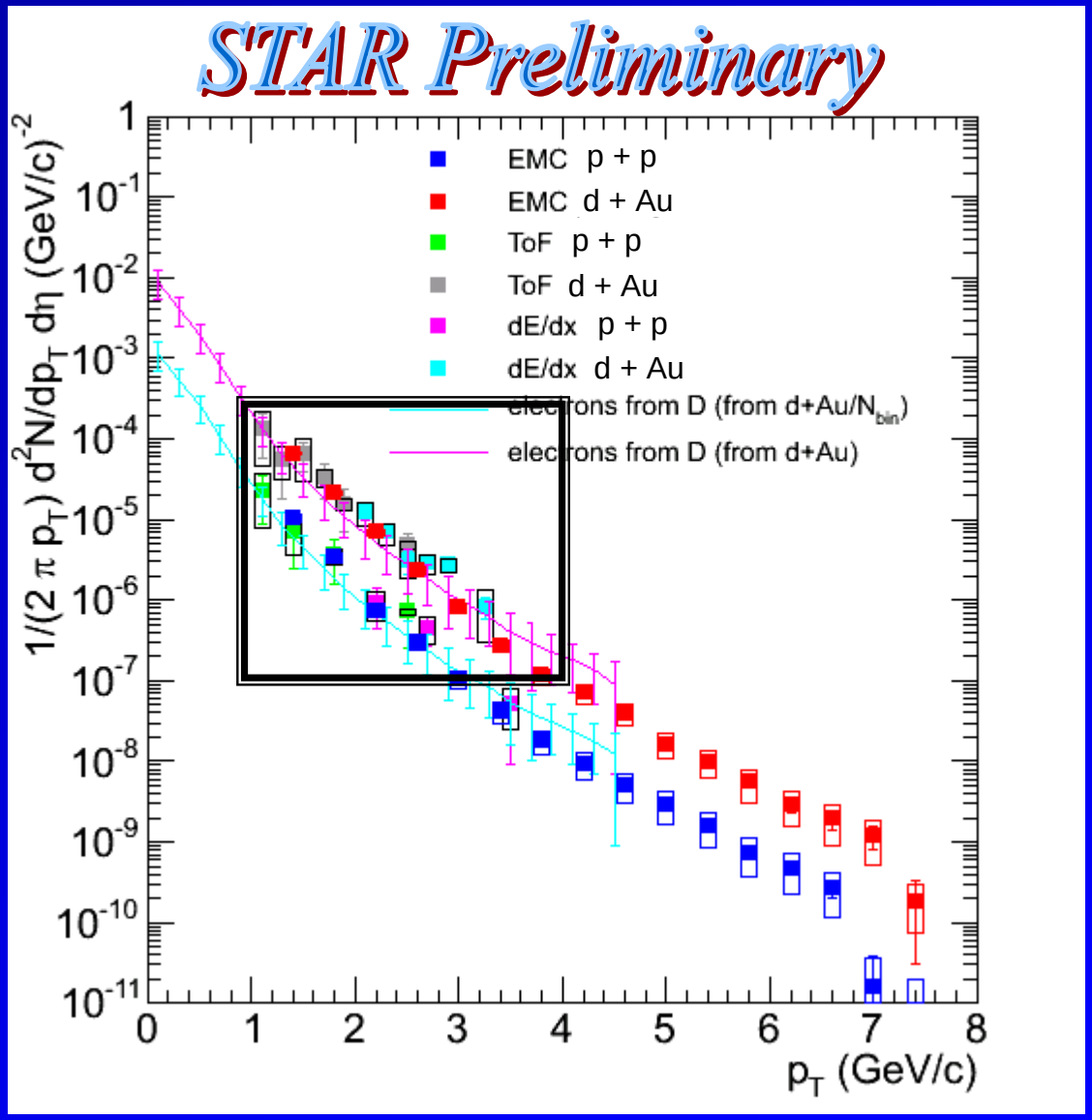

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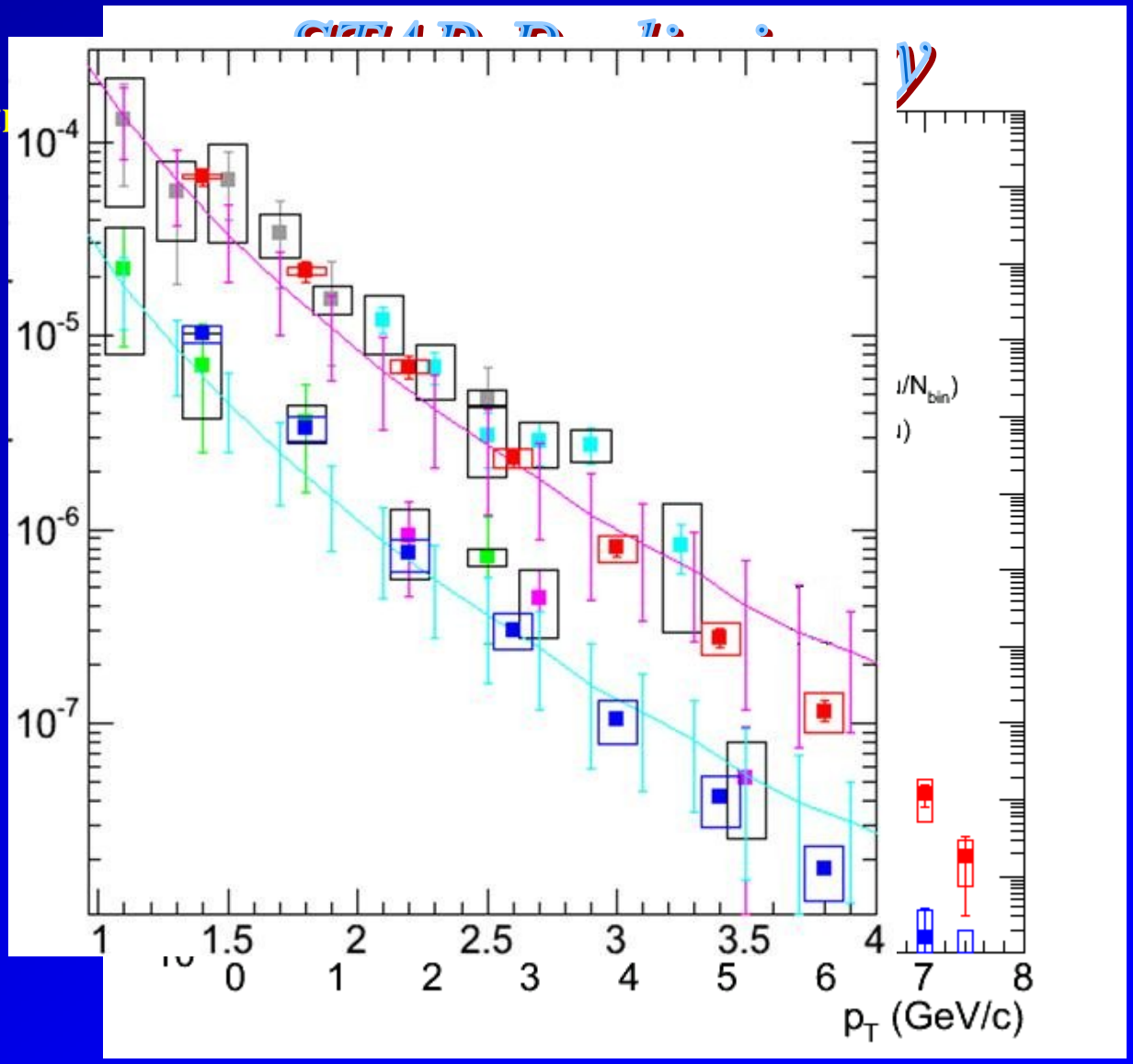

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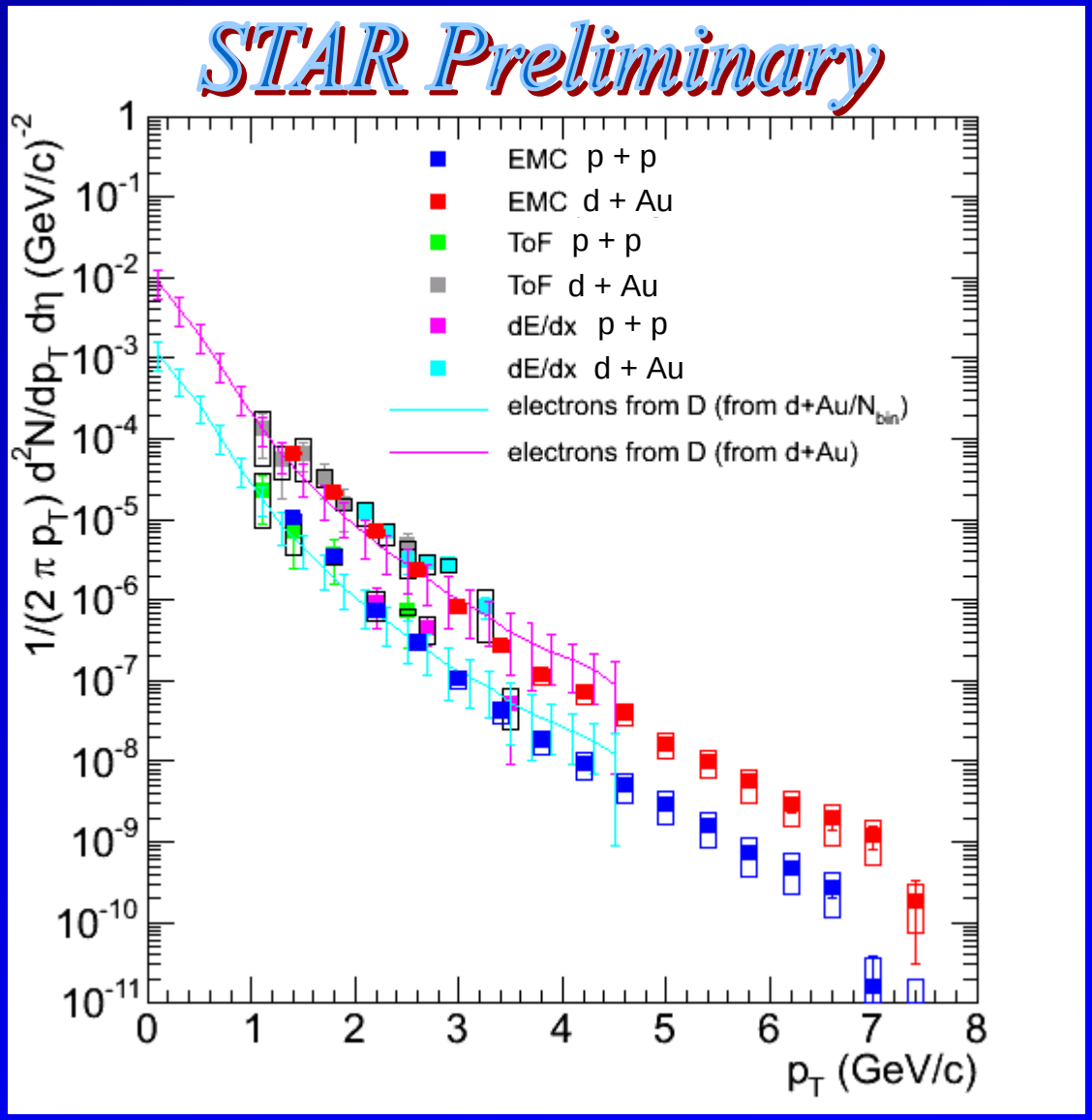

Comparison with Pythia and R_{dAu}

- **Default Pythia calculations failed to reproduce data**
  - **Used parameters**
    - ✓ $\langle k_T \rangle = 2.0$ GeV/c
    - ✓ $m_c = 1.7$ GeV/c^2
    - ✓ K-factor = 2.2
    - ✓ CTEQ5M1
    - ✓ PARP(67) = 4
- **High-p_T electrons above 3.5 GeV/c are sensitive to beauty decays**
  - **First RHIC measurement sensitive to beauty cross section !!!**
- **R_{dAu} consistent with binary scaling**
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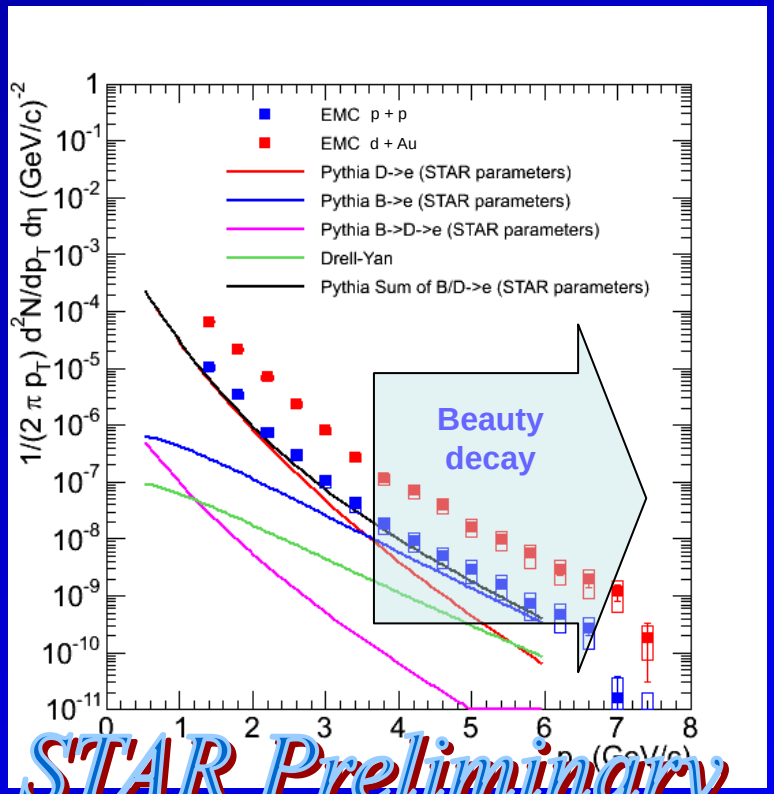
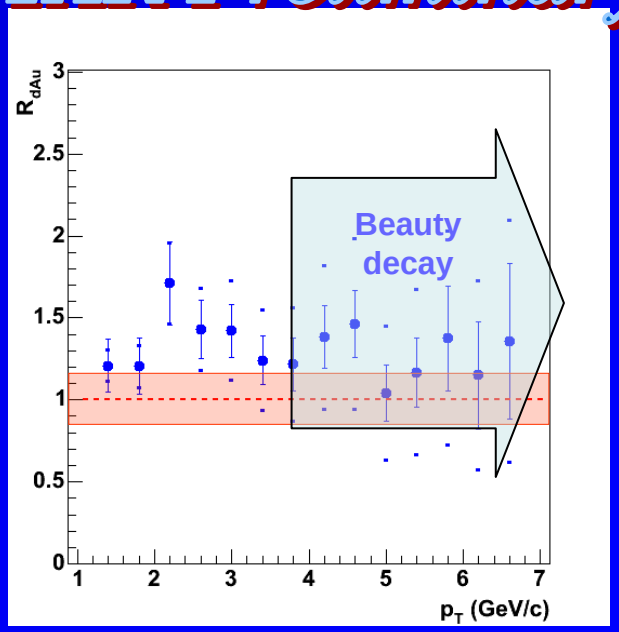
  - **R_{dAu} for a given p_T comes from heavy quarks from a wide p_T range**





Final remarks

- **First high-p_T electron measurement at RHIC**
  - **EMC has proved to be essential on electron identification at very high-p_T**
    - ✓ **EMC upgrades for next Au+Au run will make electron identification possible at even higher p_T**
- **First RHIC measurement sensitive to beauty cross section!!!**
  - **Pythia simulations indicate that electrons with $p_T > 3.5$ GeV/c are mostly from beauty decays**
- **R_{dAu} from both charm and beauty production is consistent with N_{bin} scaling**