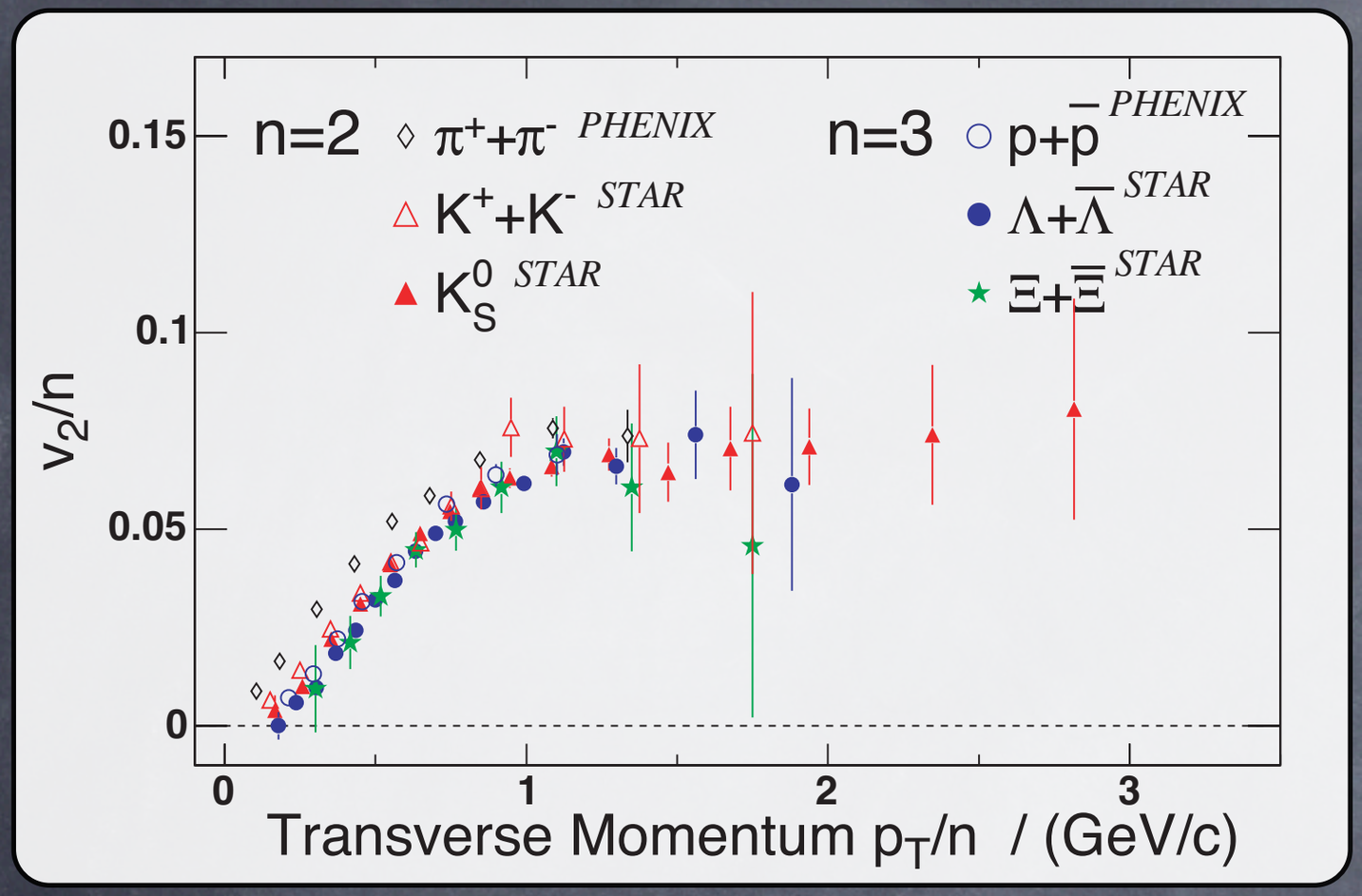
Studying charm quark flow via semi-leptonic D-meson decays

Frank Laue (BNL)
for
the STAR Collaboration

Outline:

Motivation
Analysis
(Preliminary) Results
Dream
Outlook

Motivation I: Elliptic flow



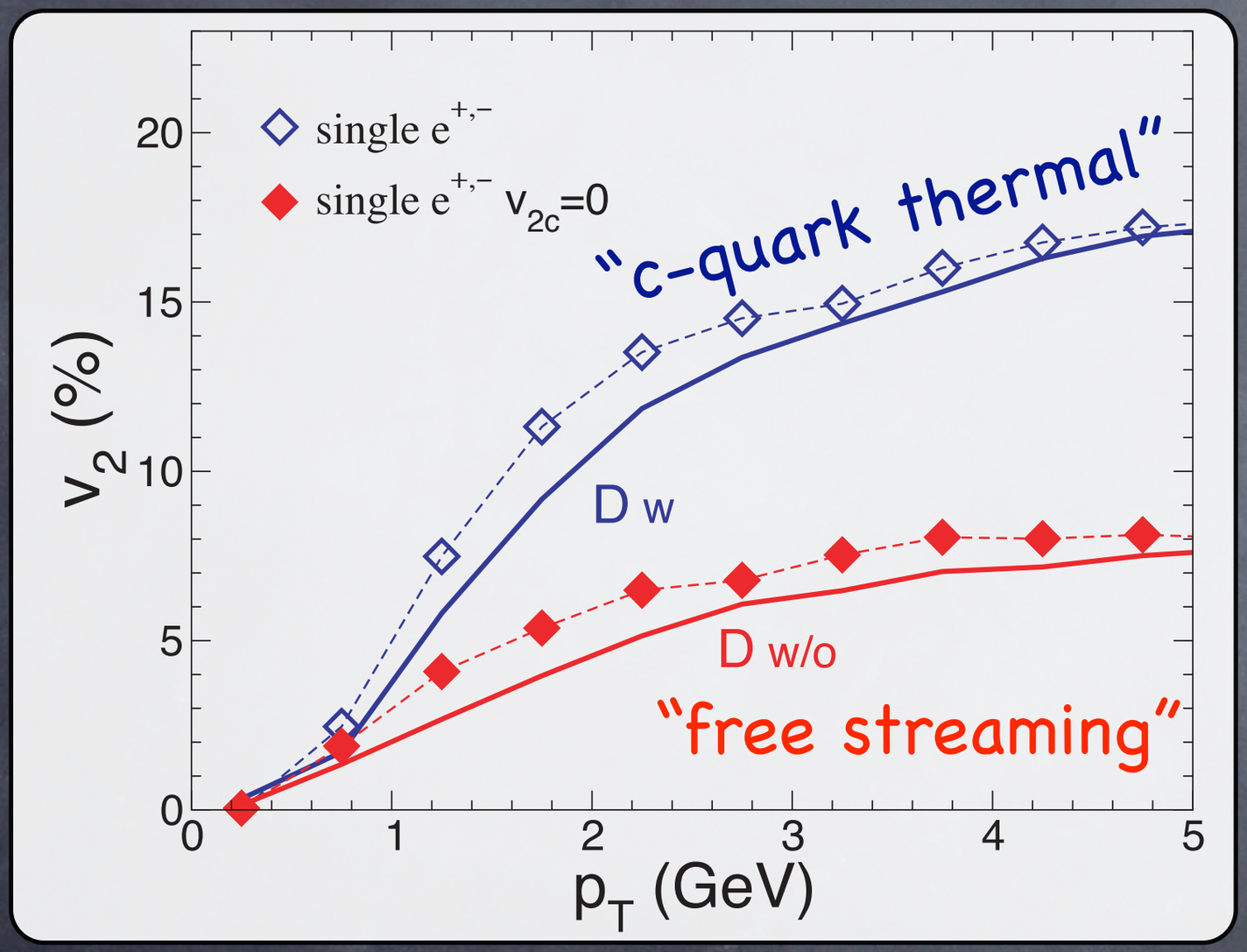
- ✓ no mass dependence at
- ✓ no flavor dependence (p,Λ,Ξ,Ω)
- ✓ scaling with Number of Constituent Quarks (NCQ)

$$v_{2h} = \sum_{i=1}^{n} v_{2q_i}\left(\frac{1}{n}p_T\right)$$

partonic degrees of freedom ?

Motivation II: Charm v_2

V.Greco, C.M.Ko nucl-th/0405040



charm quarks flow just like light quarks (upper limit, no jets)

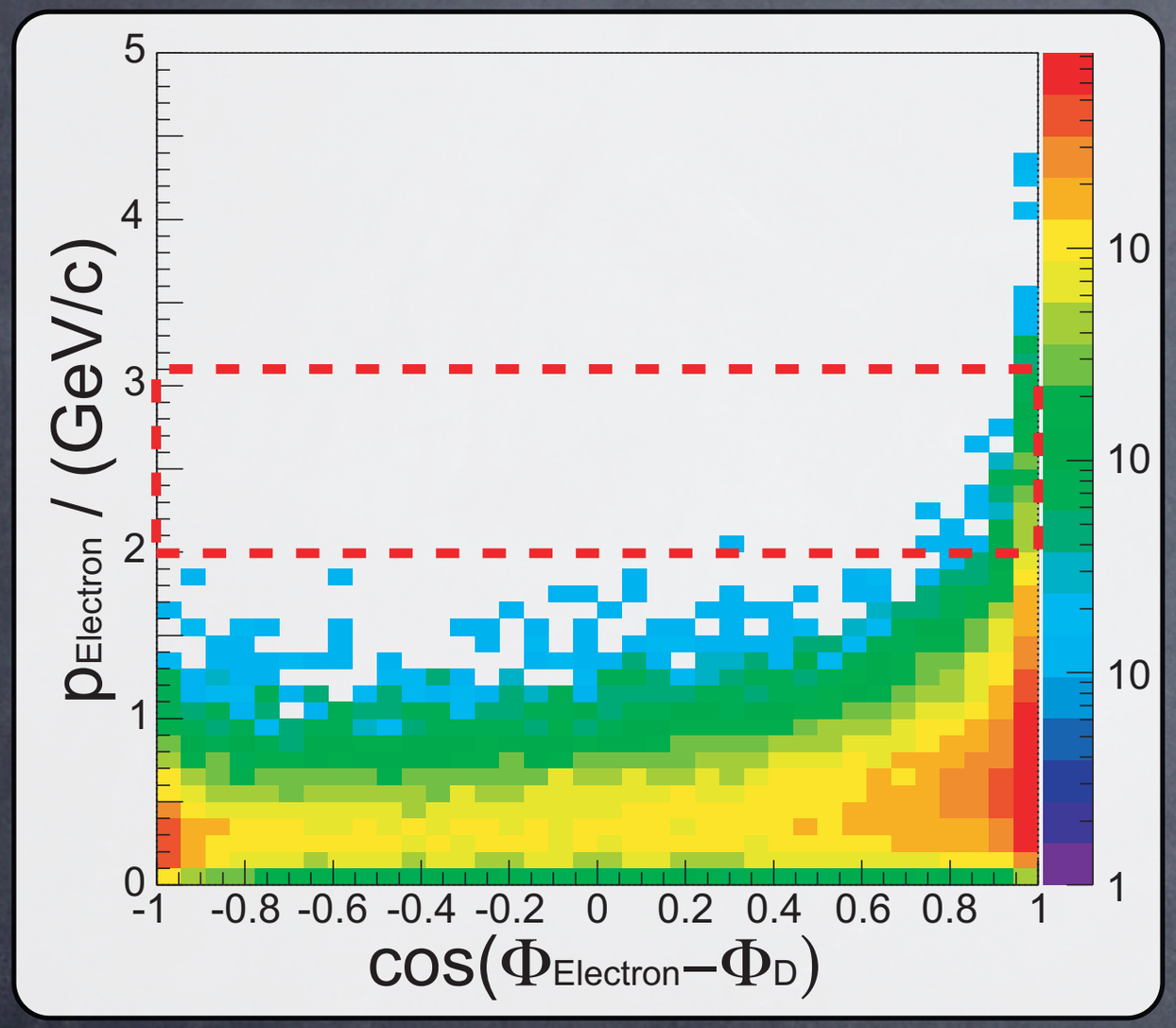
only light quarks flow (lower limit)

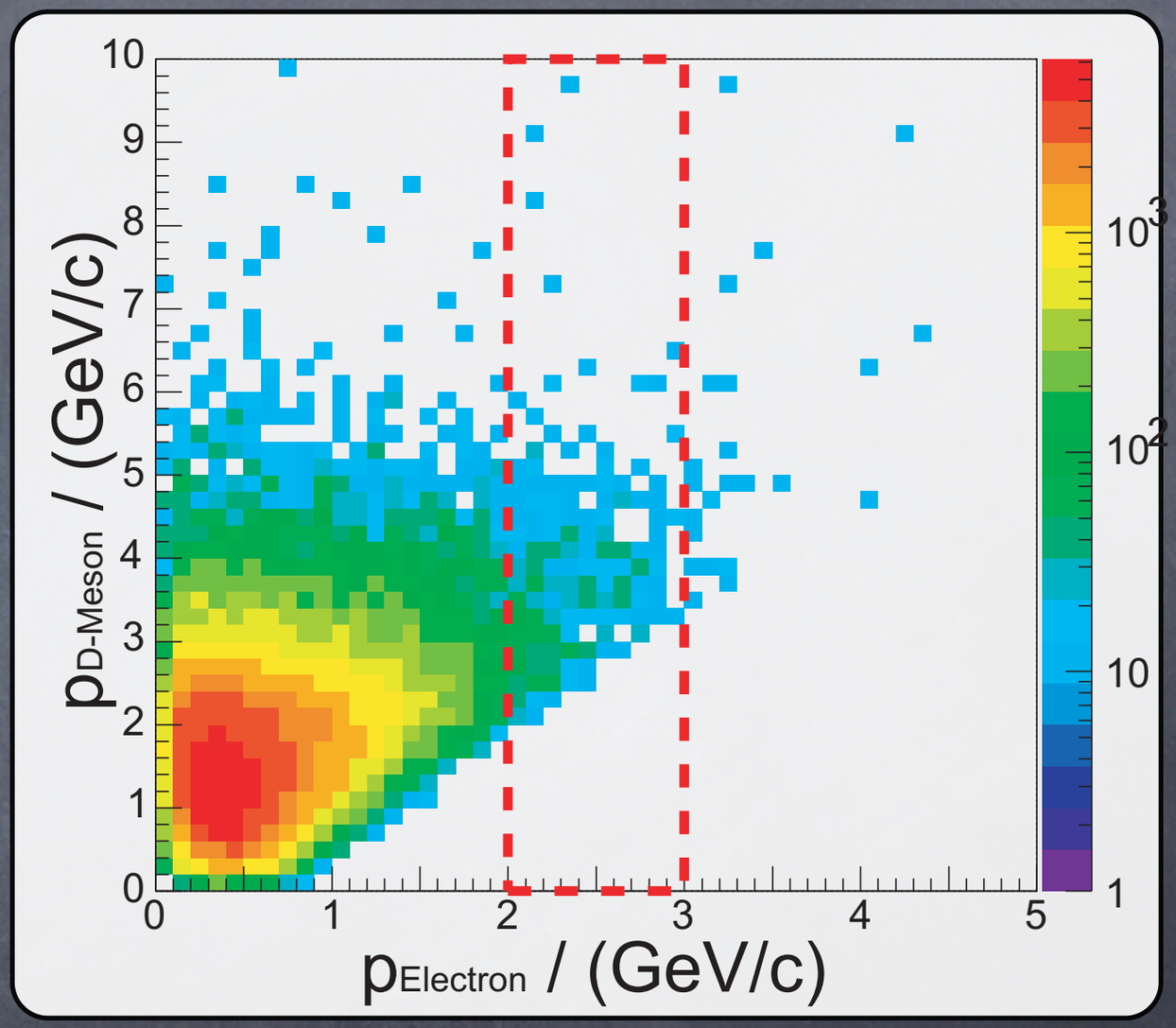
Charm flow extremely interesting, because of the c-quark's mass (m=1.5GeV).

Should the c-quarks flow, there must have been enough interactions to easily thermalize light quarks.

Dong X et al. Phys.Lett.B 597(2004)328

Electron v_2 as a proxy for D-Meson v_2

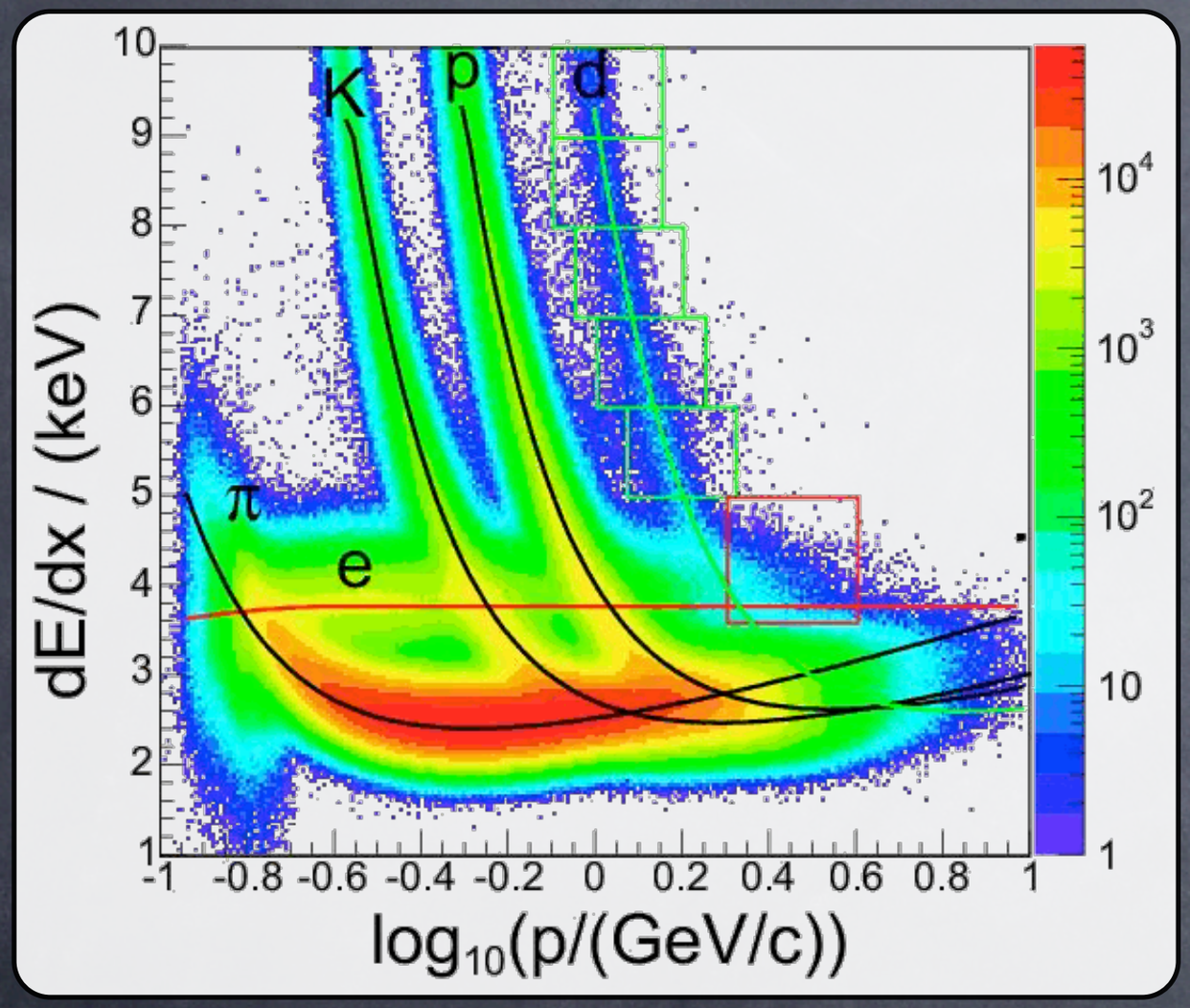


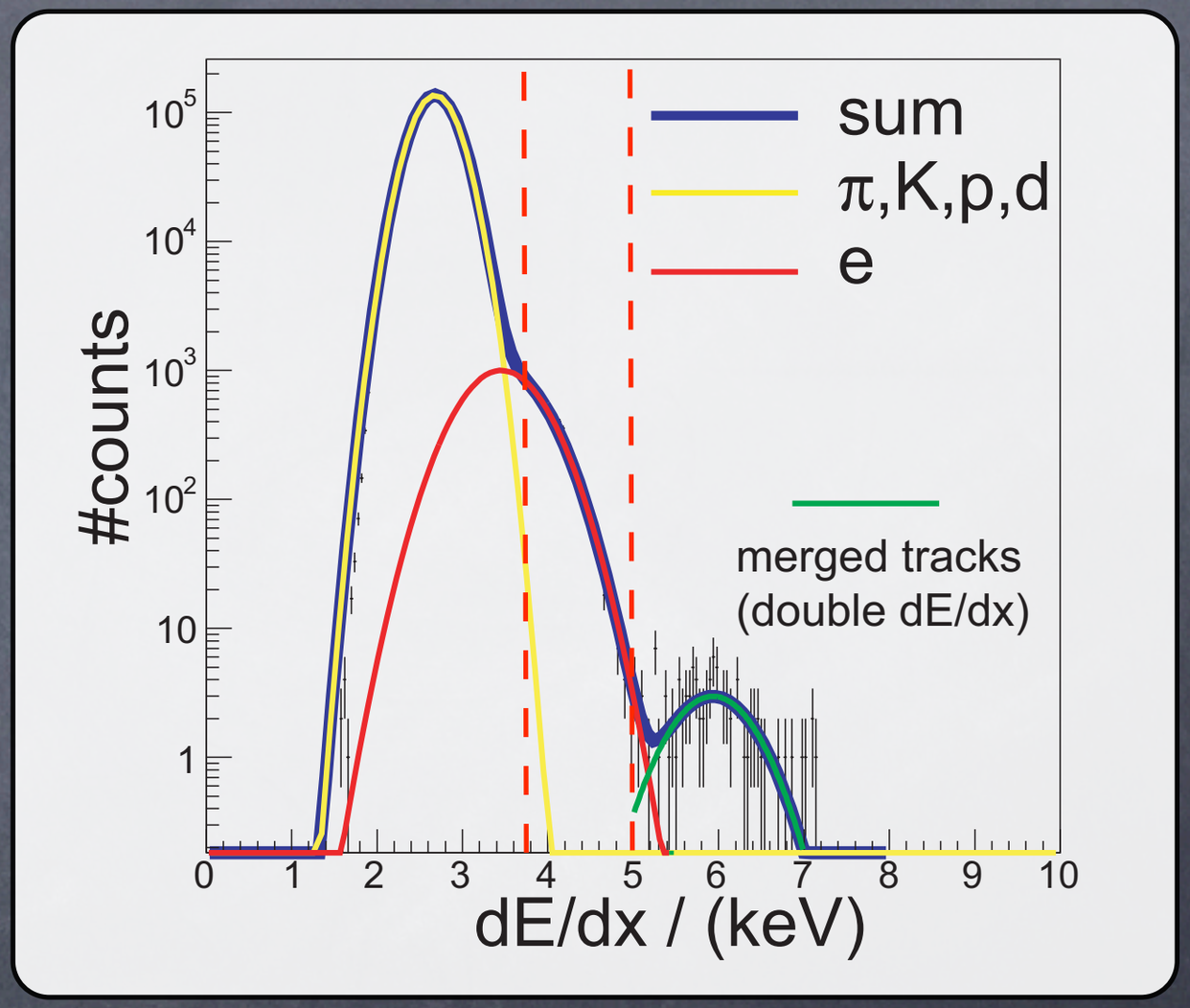


- Emission angles are well preserved above p = 2GeV/c
- 2-3 GeV Electrons correspond to ≈3.8GeV D-Mesons

Electron Identification:

TPC: dE/dx vs p

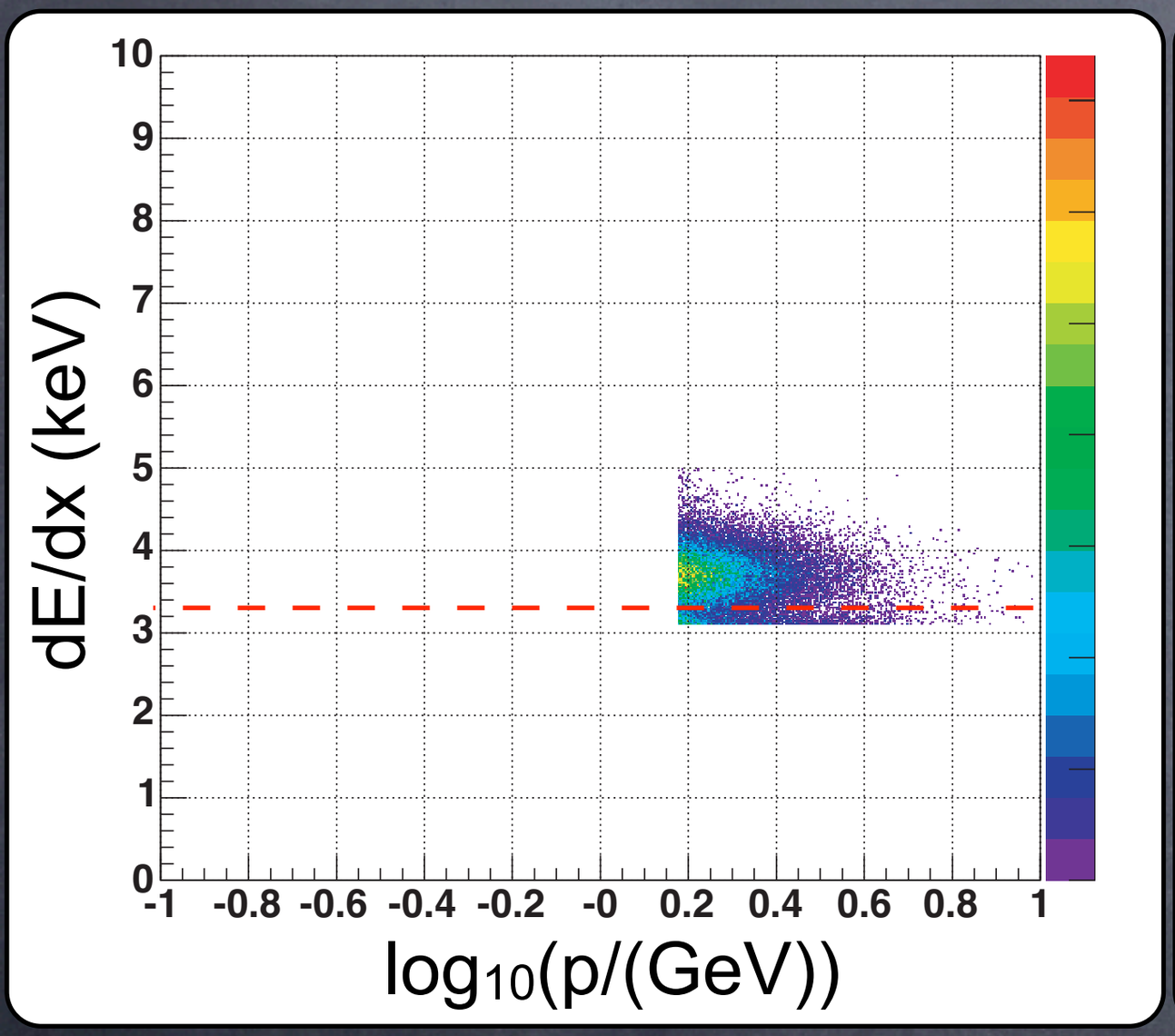


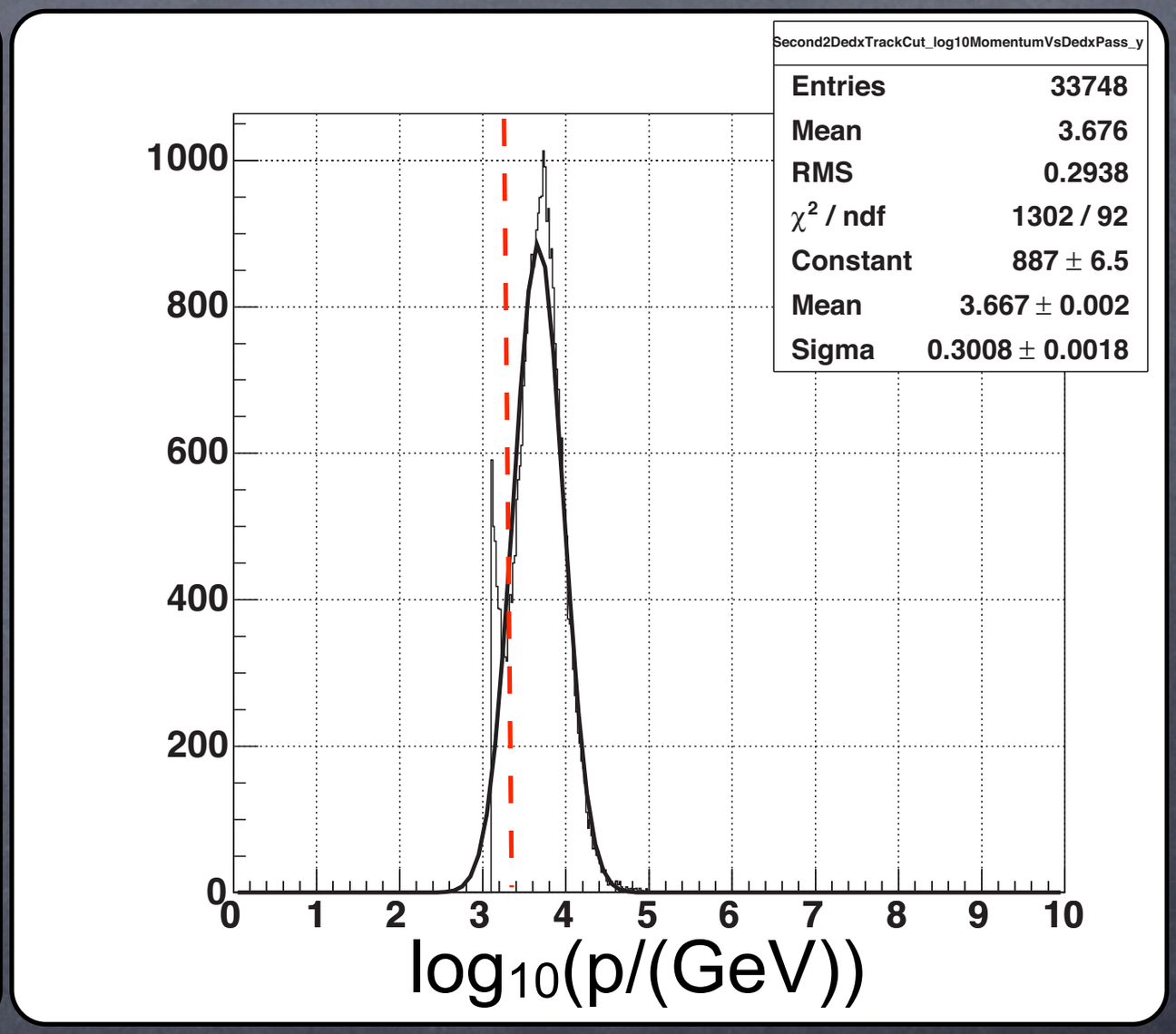


Deuteron background (<5%) easily assessed by comparing positive/negaitve charges

Electron Identification:

EMC: p/E (dE/dx)

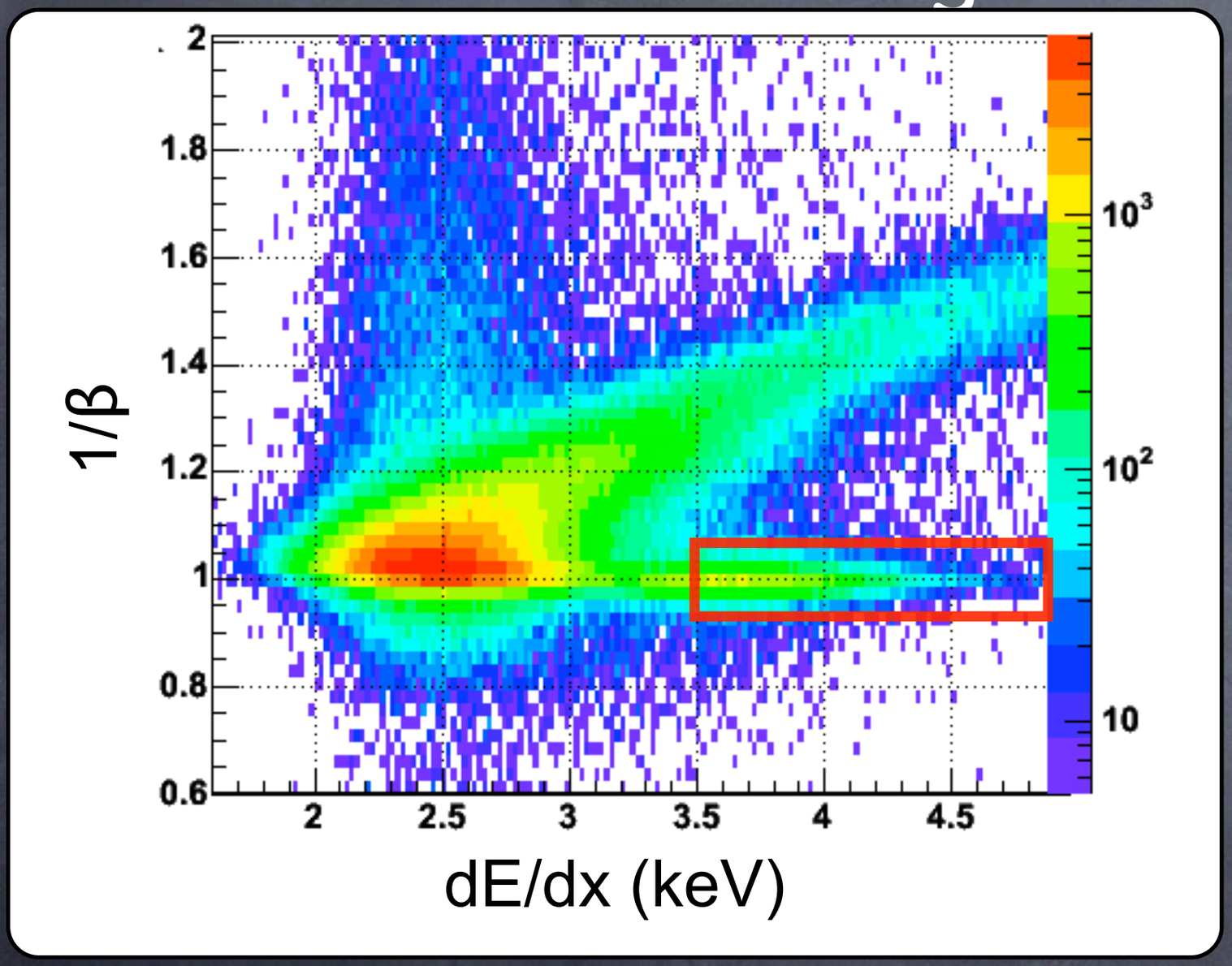




95-90% purity of the electron sample

Electron Identification:

Time of Flight: 1/β (dE/dx)



$0.97 < 1./\beta < 1.03$

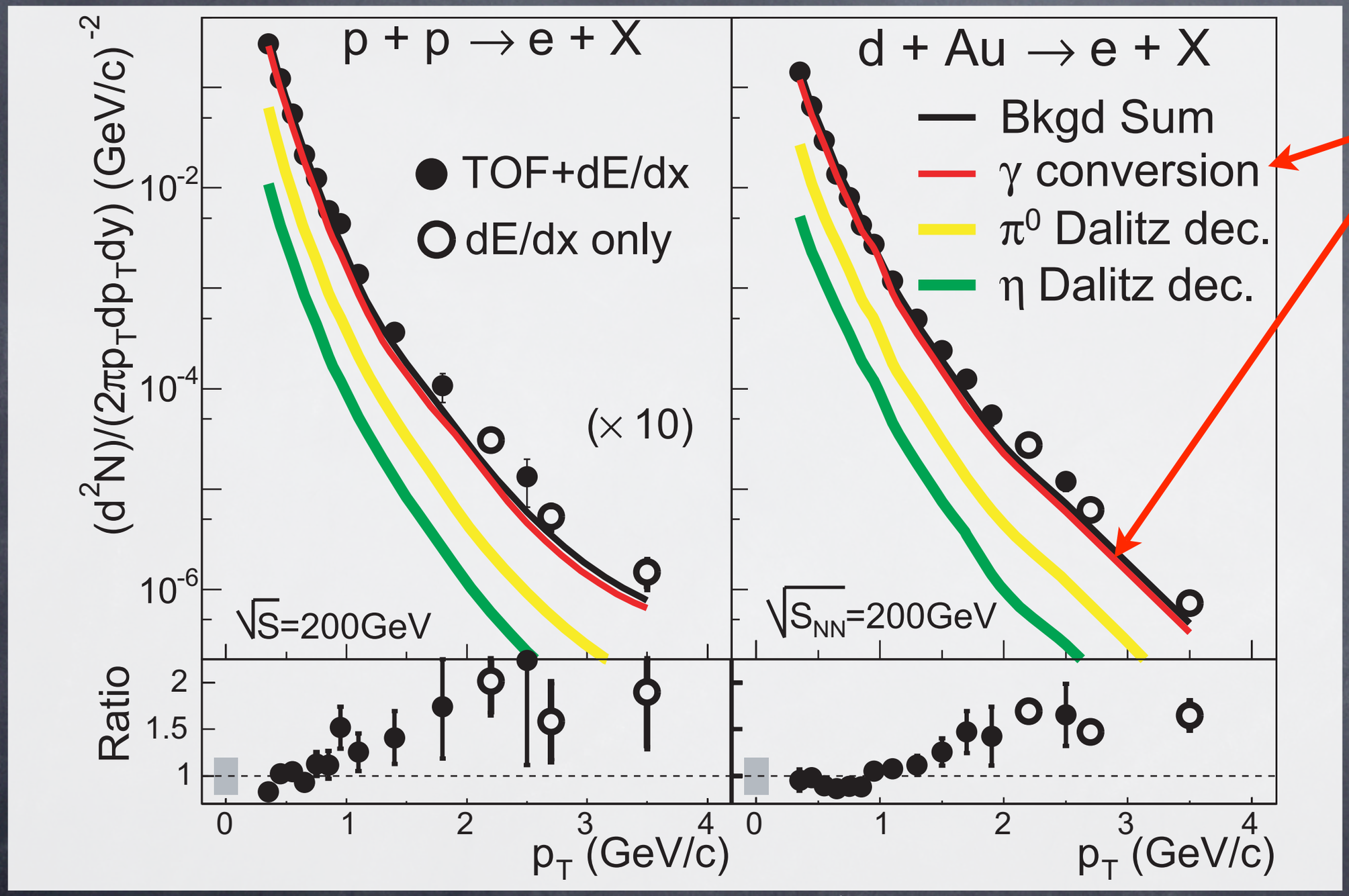
$dE/dx > 3.5$ keV

Andrew Rose

Yifei Zhang

Important to get a low p_T data point due to different D, π decay kinematics.

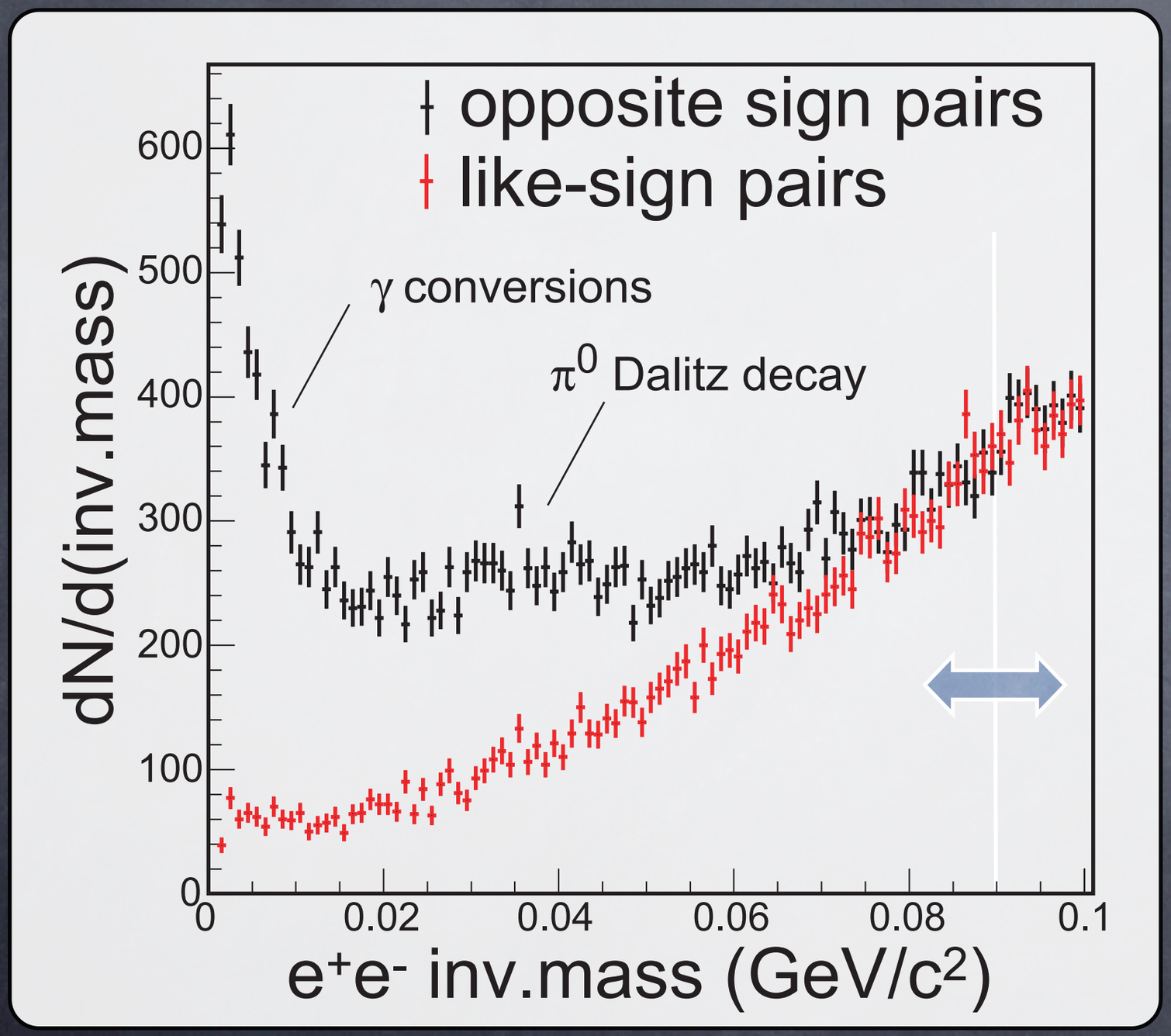
Electron Sources: Examples



γ's can be reduced by more than factor 2 via invariant mass method

STAR: nucl-ex/0407006
Pythia tuned to STAR data

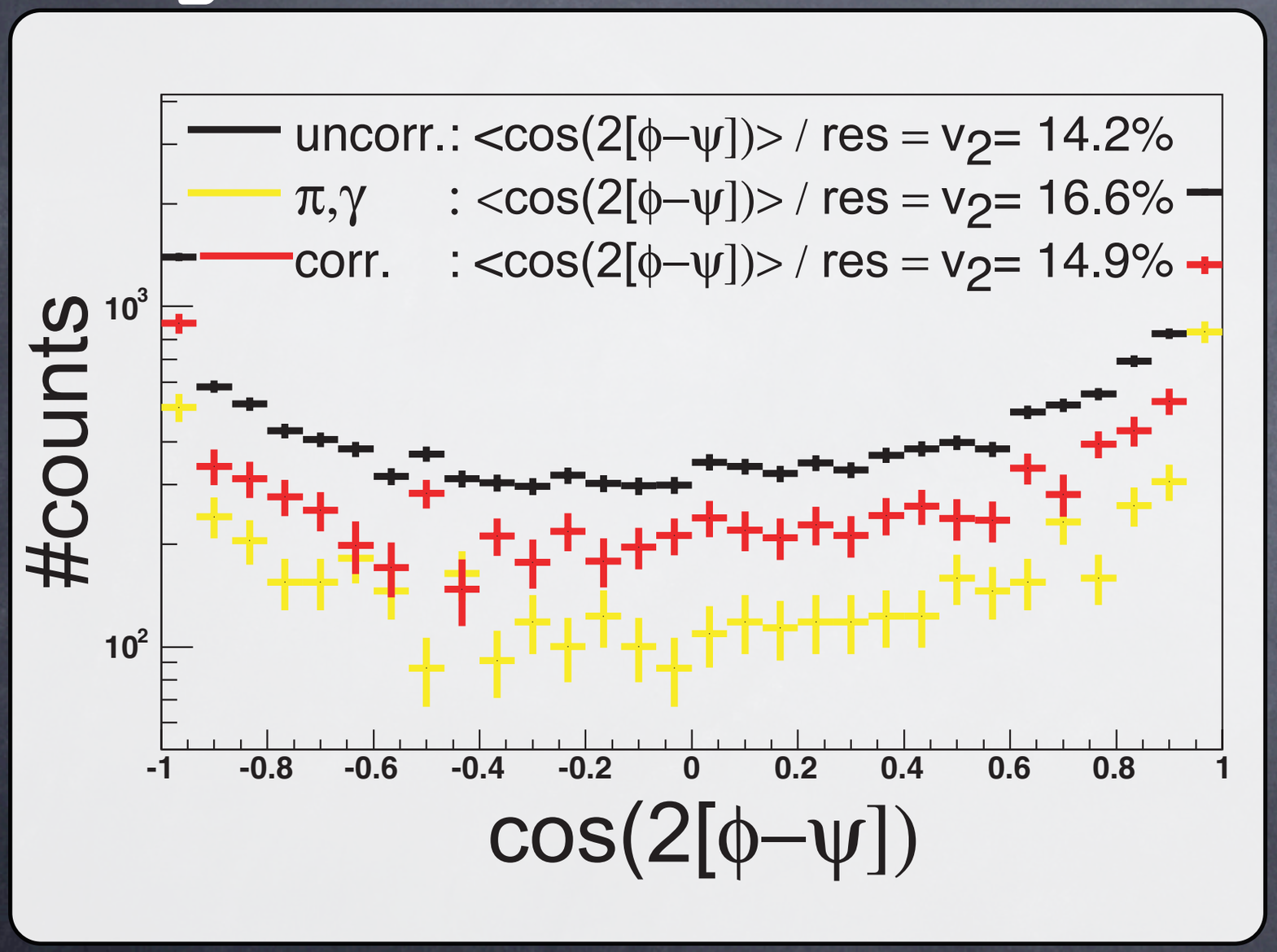
Removal of γ-conversions and π^0-Dalitz Decays



50-80% of electrons originating from γ-conversions and π^0-Dalitz decays can be removed with invariant mass method, but might bias efficiency in central collisions

Photonic Background Correction

$v_2 = \langle \cos(2[\Phi-\psi]) \rangle / \psi^{Res}$



Monte Carlo π^0 decay

- Phenix π^0 Data from S.S.Adler et al., Phys. Rev. Lett. 91, 072301 (2003).
- Fit with power-law
- 100k events thrown with Mevsim and v_2=17% (asymptotic)
- 50% γ-electron removal

π^0-elect. frac. = 0.37

Working on a Monte-Carlo independent background substraction.

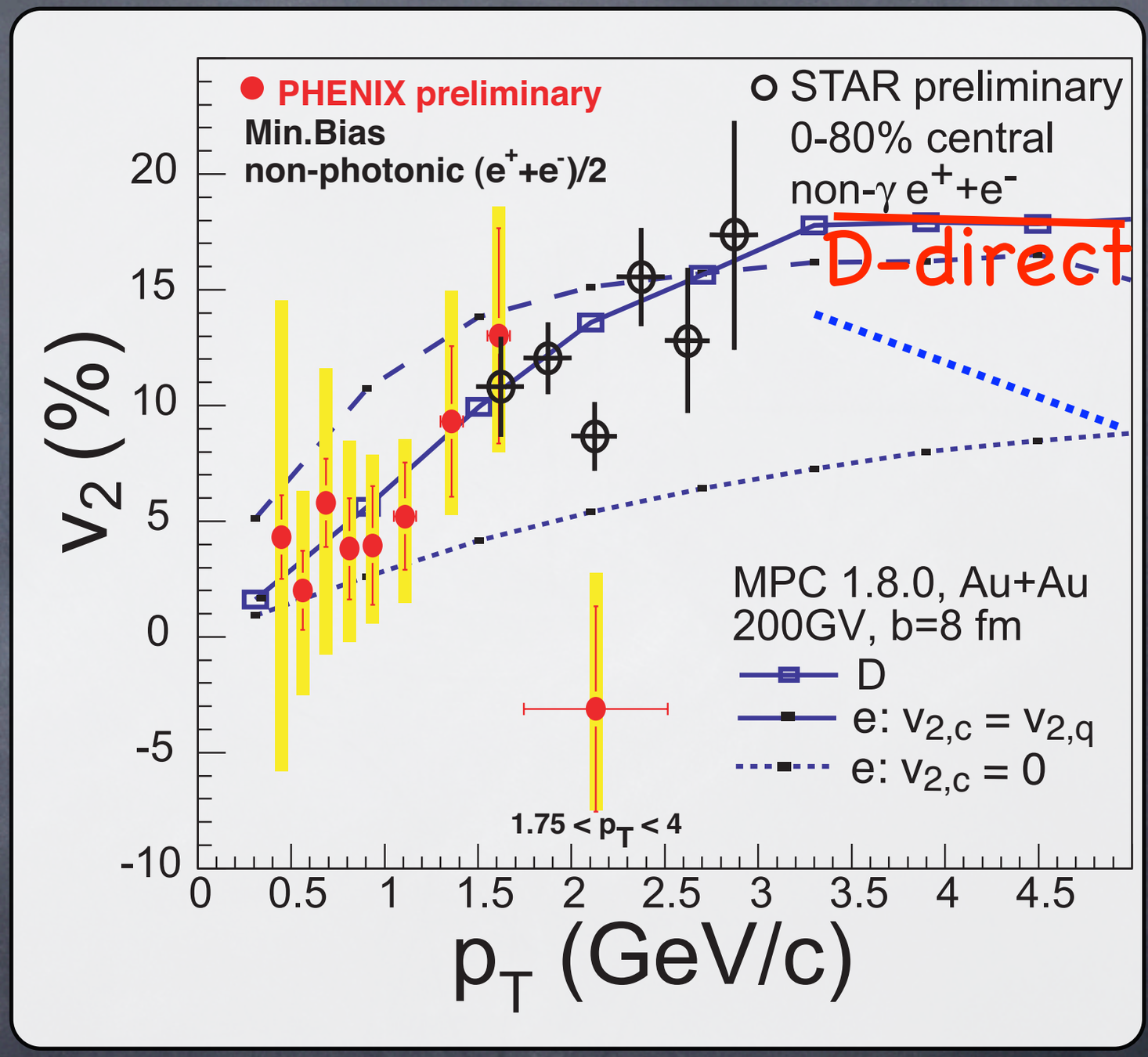
Non-photonic single $e^{+/-}$ v_2 vs p_T

Photonic background evaluated via simulation with $v2_{max}$=17%

Smoothly extends PHENIX results

Preliminary data seems to favor the $v_{2c} = v_{2q\text{-light}}$ hypothesis.

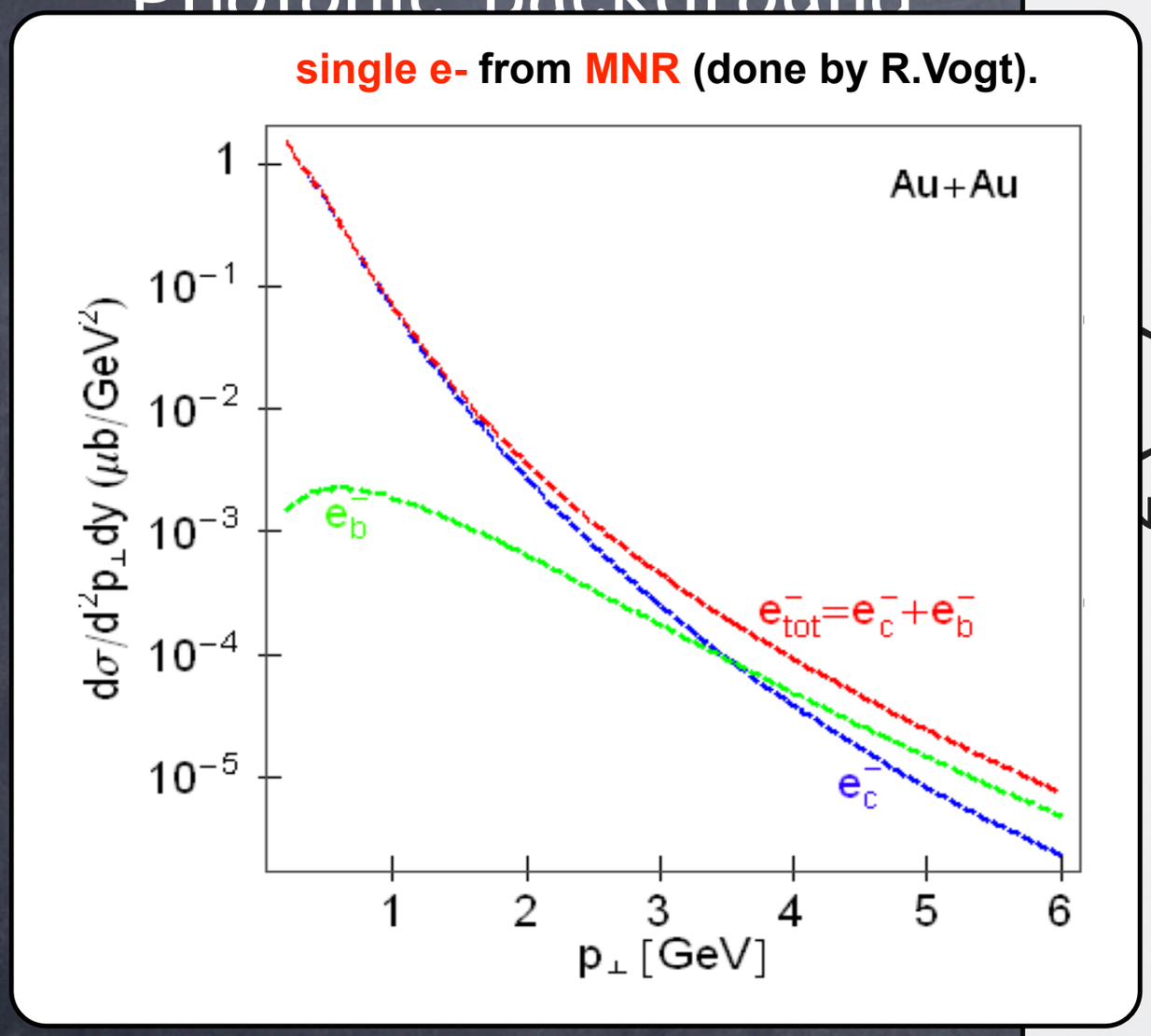
Thermalized partonic system ?

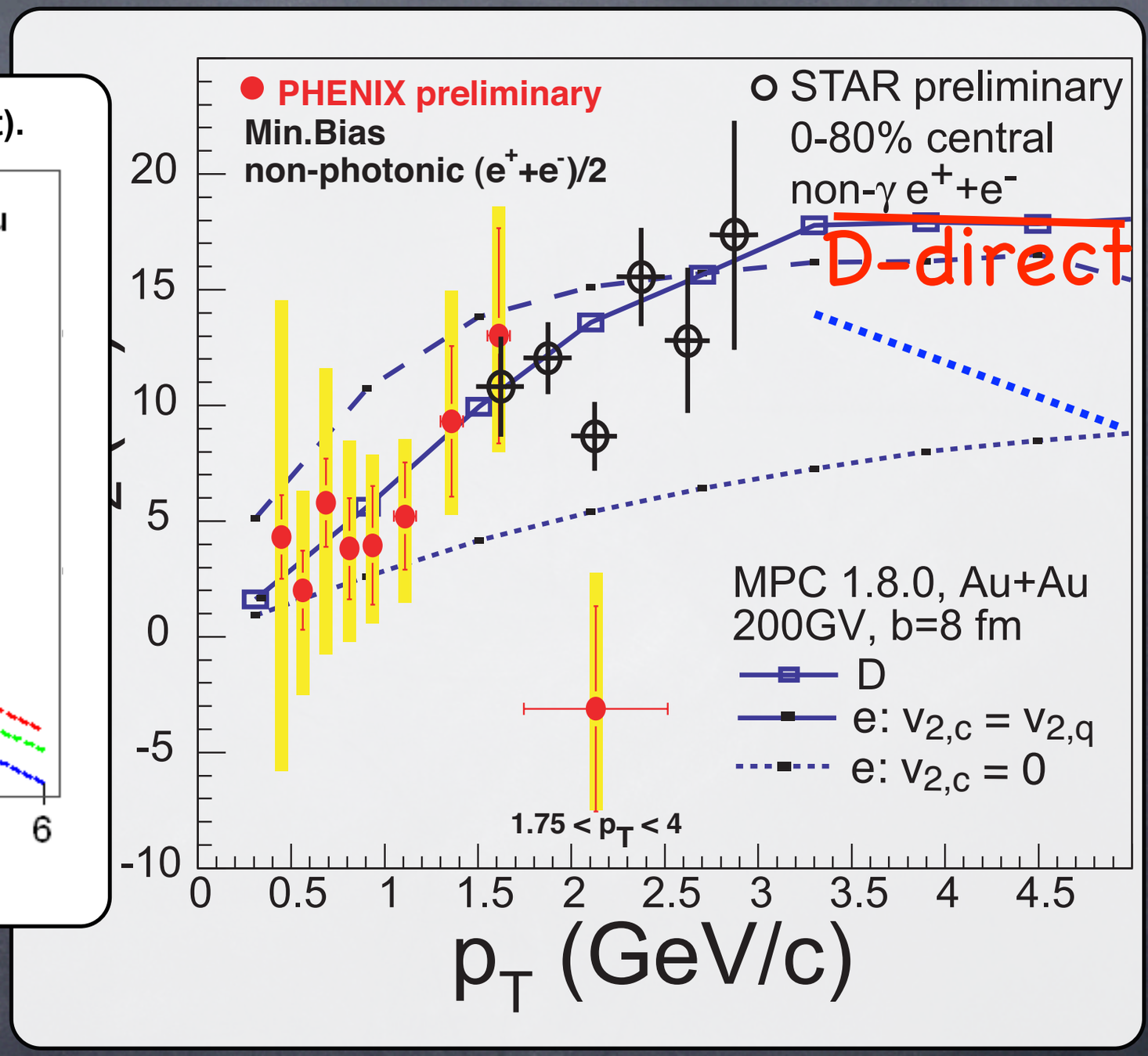


Theory: D. Molnar's Parton Cascade

Non-photonic single $e^{+/-}$ v_2 vs p_T

Photonic background

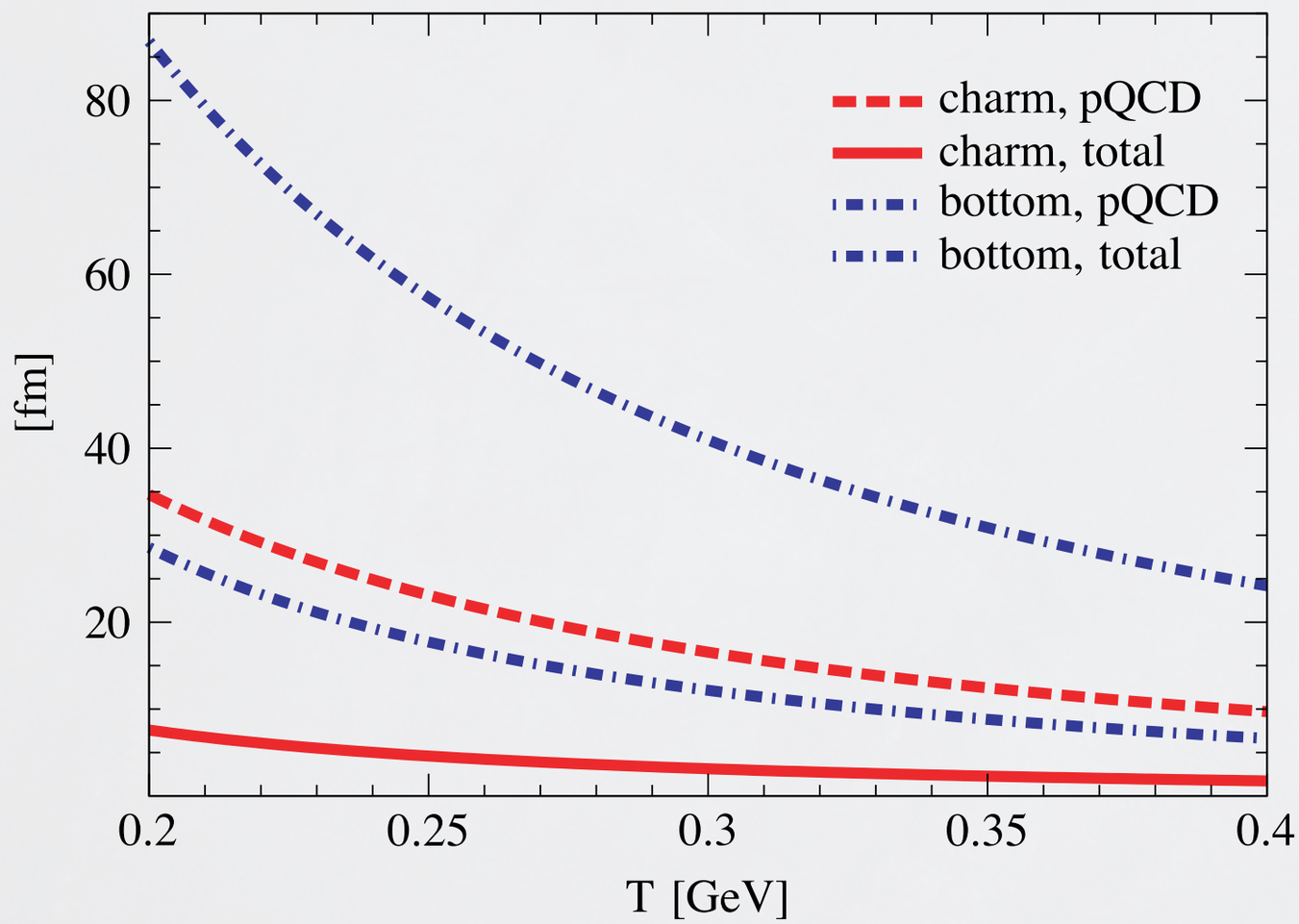




Thermalized partonic system ?

Theory: D. Molnar's Parton Cascade

Novel Processes ?



$\tau = 1/\gamma \qquad \gamma = A$

Theory needs large charm x-sections to explain v_2

H.Hees and R.Rapp Phys. Rev. 71 (2005)034907

Interactions of D-Meson-like resonances lead to a drop of the charm relaxation time factor of 3 and are the driving forces behind the buildup of charm elliptic flow.

Summary / Outlook

- Prel. results indicate strong non-photonic electron v2
  - consistent with $v_{2c} = v_{2light-q}$ theory calculations
  - consistent (smoothly extending) Phenix results
- Understand systematic uncertainties
- Working hard on low p_T Tof data point
- Centrality dependence to test coalescence (breakdown ?)

- Does this conclusively prove thermalization of light quarks ?
- Are the c-quarks thermalized ?
  - Novel processes to boost up charm x-sections ?
- Can electron flow be used to deduct where b-decays become dominant ?

Thanks for the invitation.