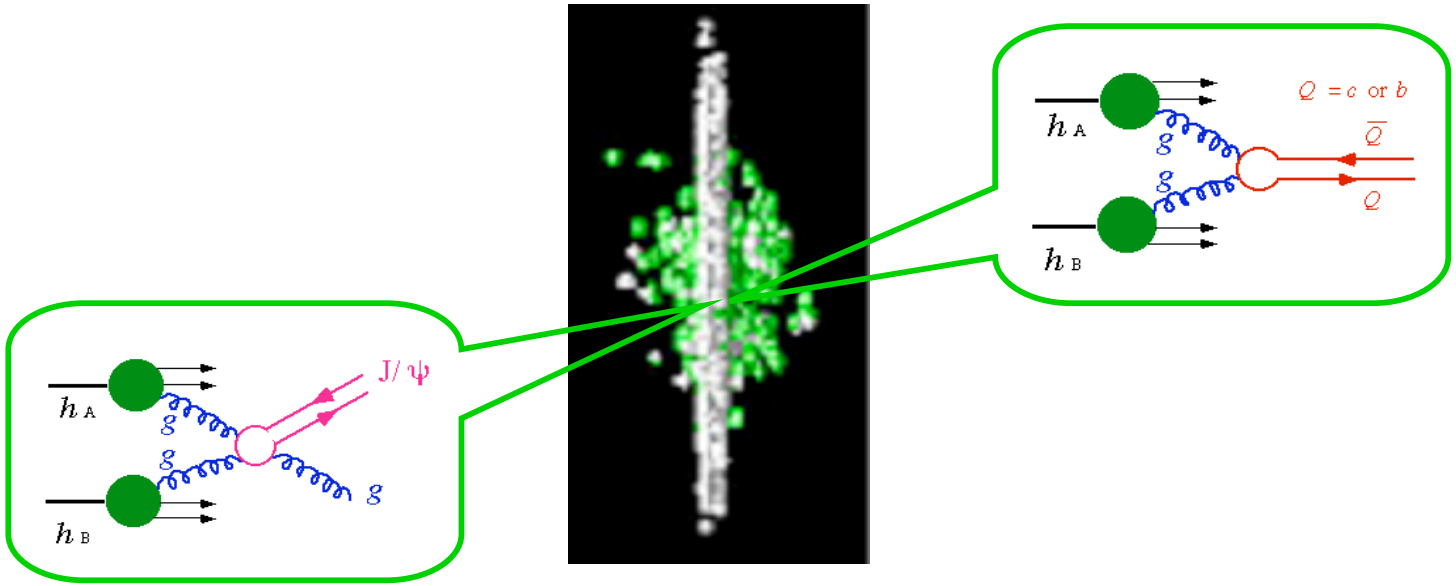
Charm Production In AuAu, dAu and pp Reactions from the PHENIX Experiment at RHIC



Sean Kelly - University of Colorado

for the PHENIX collaboration

Quark Matter 2004
Oakland – January 11-17

PHENIX

12 Countries; 58 Institutions; 480 Participants*

Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	Rikkyo University, Tokyo, Japan
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund

USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California - Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Florida Technical University, Melbourne, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of January 2004

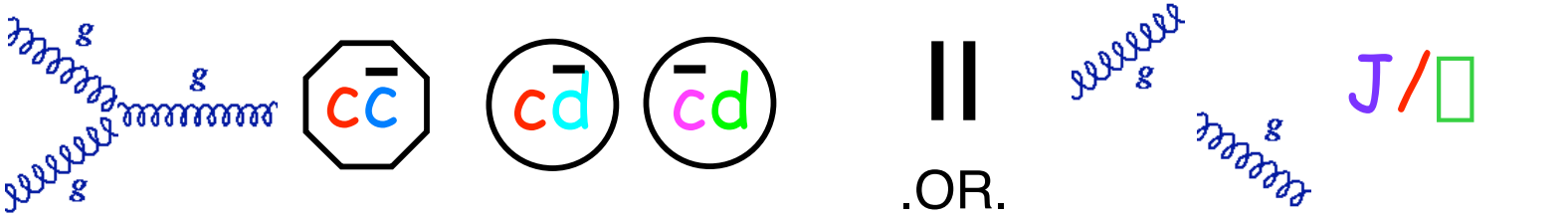
Quark Matter 2004
Oakland – January 11-17

Charm Probes The Initial State & The Medium

precursor

charmed meson pair

color singlet quarkonia



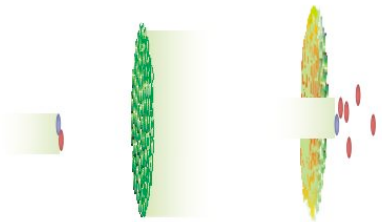
$\tau = 1/m_q \sim 0.1$ fm

charm local time

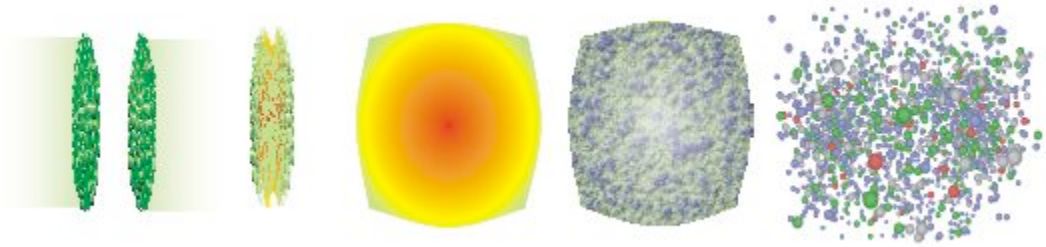
$\tau = 1/m_q v \sim 1$ fm

medium local time

d-Au



Au+Au



Outline

PHENIX Data

- Single Electron Spectra (pp, dAu, AuAu)
- Electron v_2

The PHYSICS These Data Address

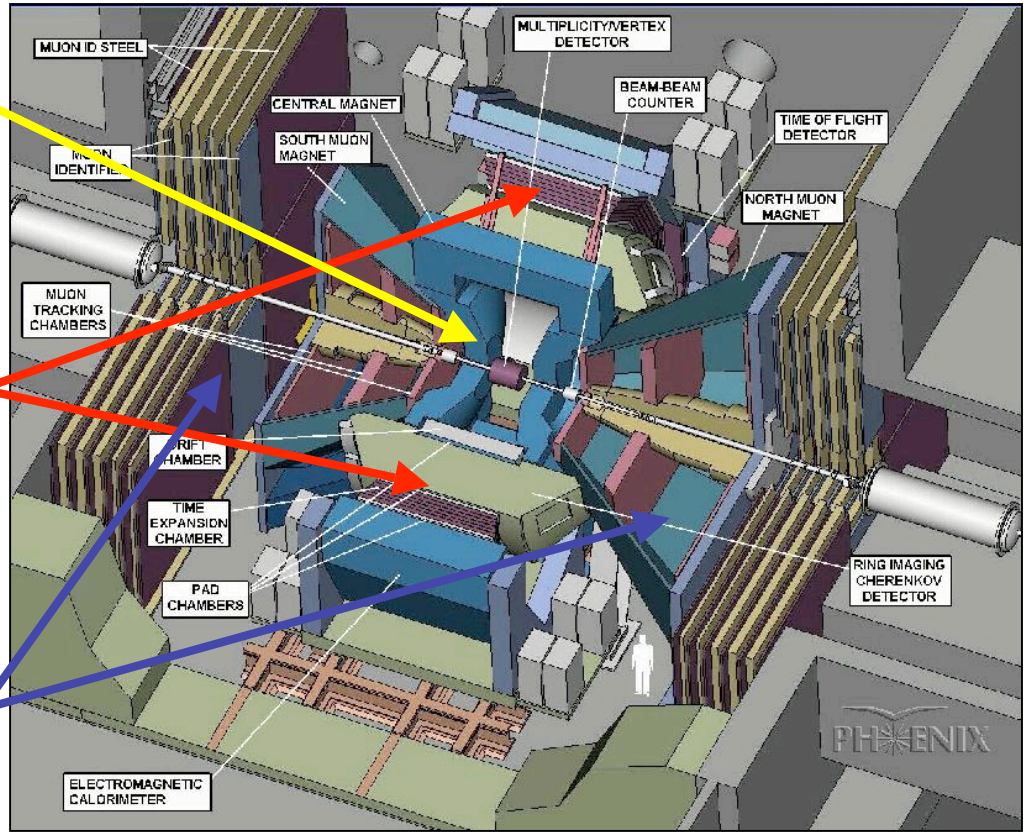
- Nuclear modifications to total charm production
- Nuclear modifications to the charm spectrum
- Charm dynamics in mediu, do charm quarks flow ?

The PHENIX Experiment

Event characterization detectors in middle

Two central arms for measuring hadrons, photons and electrons

Two forward arms for measuring muons

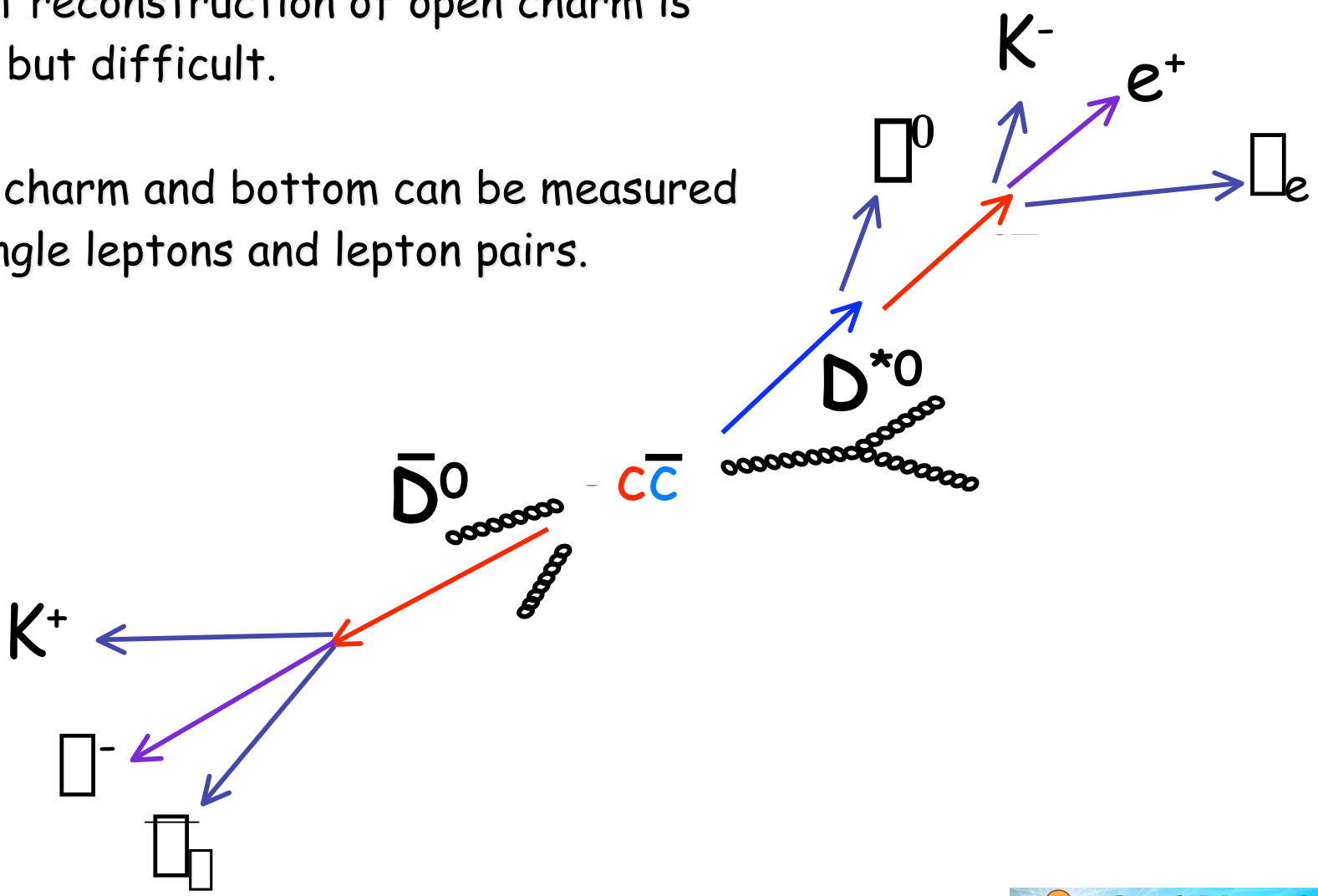


The data I will show today is all from the central arm and therefore at $\eta = 0$

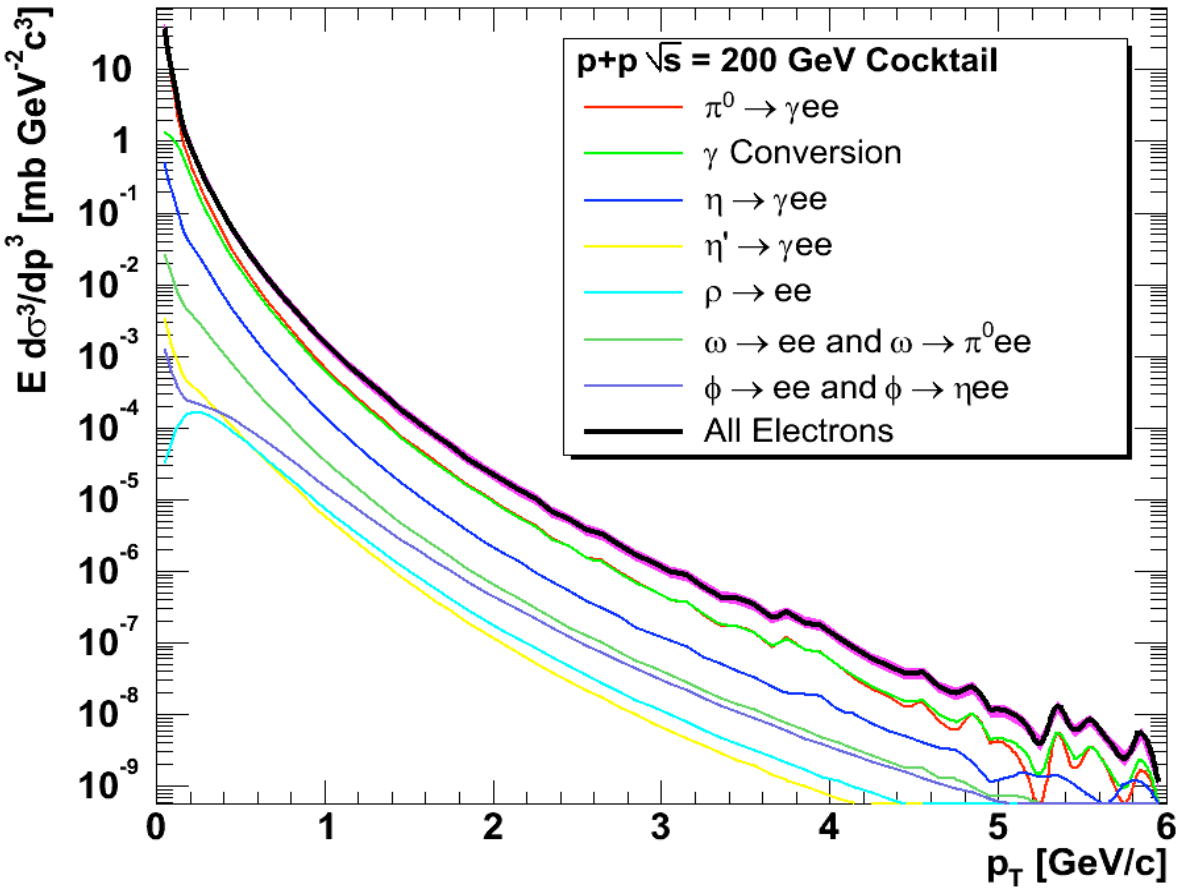
Measuring Charm via Semi-leptonic D Meson Decay

Direct reconstruction of open charm is ideal, but difficult.

Open charm and bottom can be measured via single leptons and lepton pairs.



Single Electrons From pp Collisions at $\sqrt{s}$ =200 GeV



PHENIX measures inclusive electron spectra

The physics we are interested is in what's left over after we subtract.

$\pi^0 \rightarrow \gamma ee$

γ Conversion

$\eta \rightarrow \gamma ee$

$\eta' \rightarrow \gamma ee$

$\rho \rightarrow ee$

$\omega \rightarrow ee$ and $\omega \rightarrow \pi^0 ee$

$\phi \rightarrow ee$ and $\phi \rightarrow \eta ee$

Light hadron cocktail from decay generator

Non-Photonic Single Electrons Defined

We call electrons **that are not from**

- π^0 Dalitz
- γ conversions
- η Dalitz

Non-Photonic Electrons

(for the balance of this talk)

Subtracting The Photonic Electrons

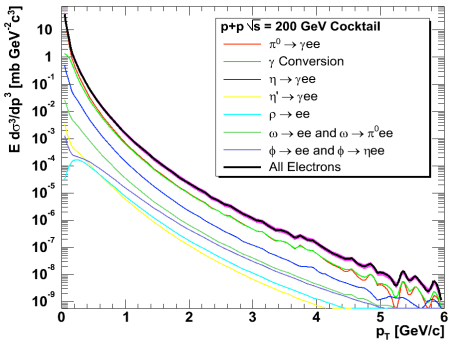
Cocktail subtraction method

•Light hadron cocktail. Dominant input is taken from PHENIX measured π^0 π^+ π^- spectra.

•Other mesons from m_t scaling assumption and asymptotic ratios from lower energy data.

•Photon conversion from material budget in PHENIX acceptance.

cocktail



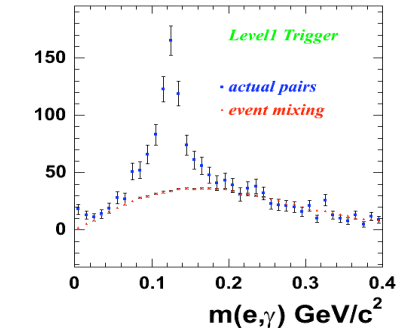
Converter method

•Comparison of $e^{+/-}$ spectra with and without converter allows separation of photonic and non-photonic sources of single electrons.

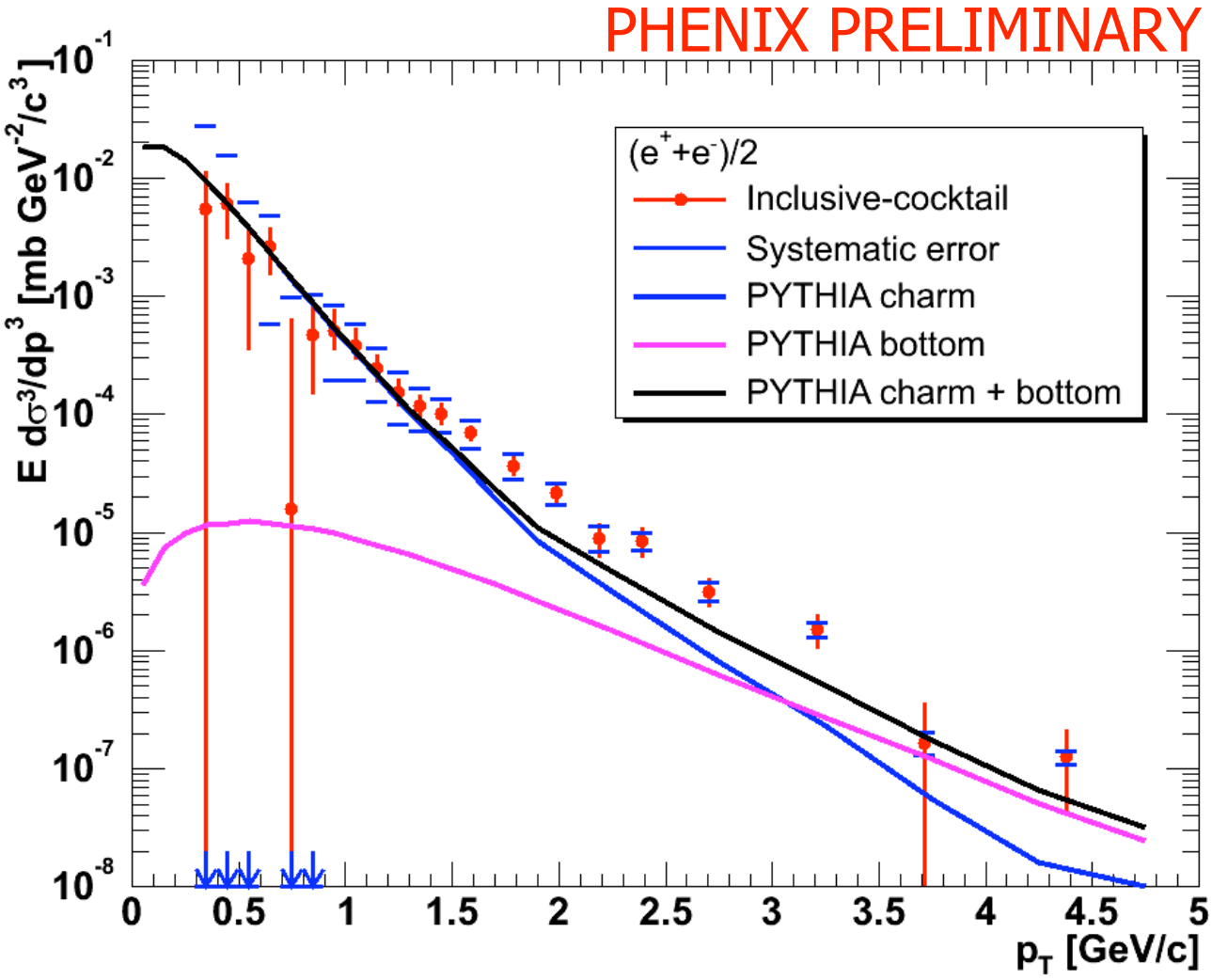
Direct measurement via π-e coincidences

Yield of π-e in vicinity of π mass with mixed event subtraction & PHENIX measured π correction

π-e invariant mass



PHENIX Non-Photonic Single Electron Spectra pp $\sqrt{s}$ = 200 GeV



200 GeV pp non-photonic single electron spectrum from cocktail subtraction method

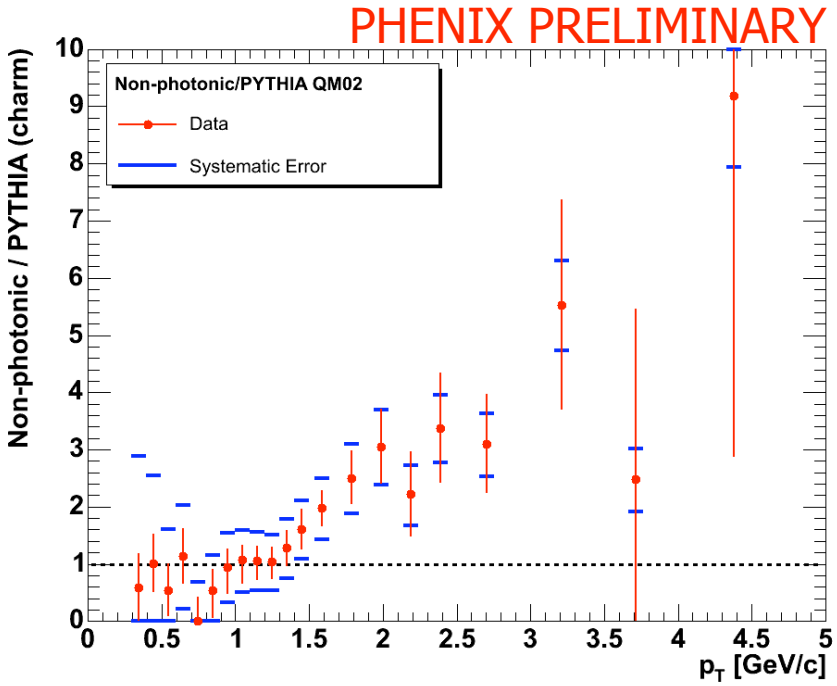
PYTHIA tuned to low energy data[1]

Data is excess of PYTHIA charm + bottom above p_t=1.5 GeV/c

Poster by Sergey Butsyk

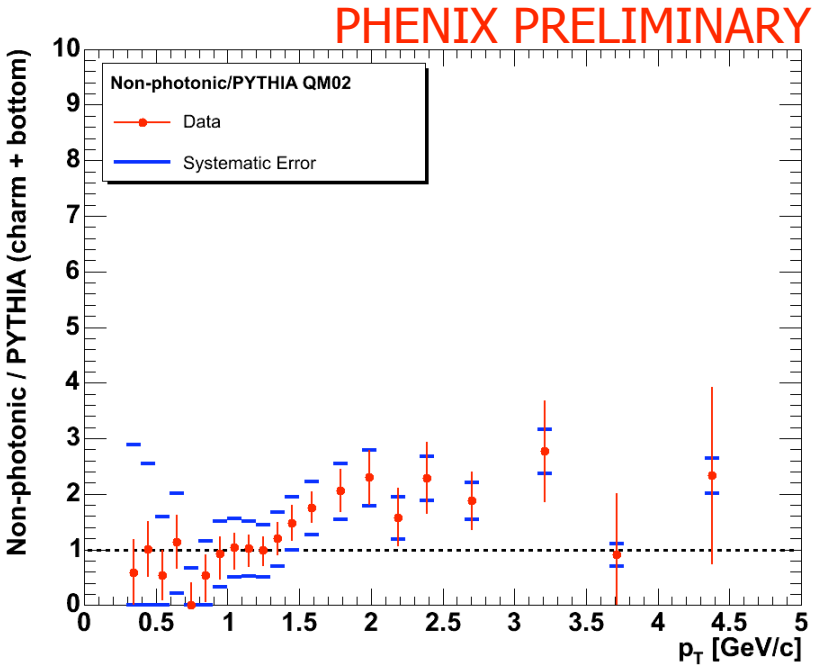
[1]Phys. Rev. Lett. 88, 192303 (2002)

Comparison With PYTHIA

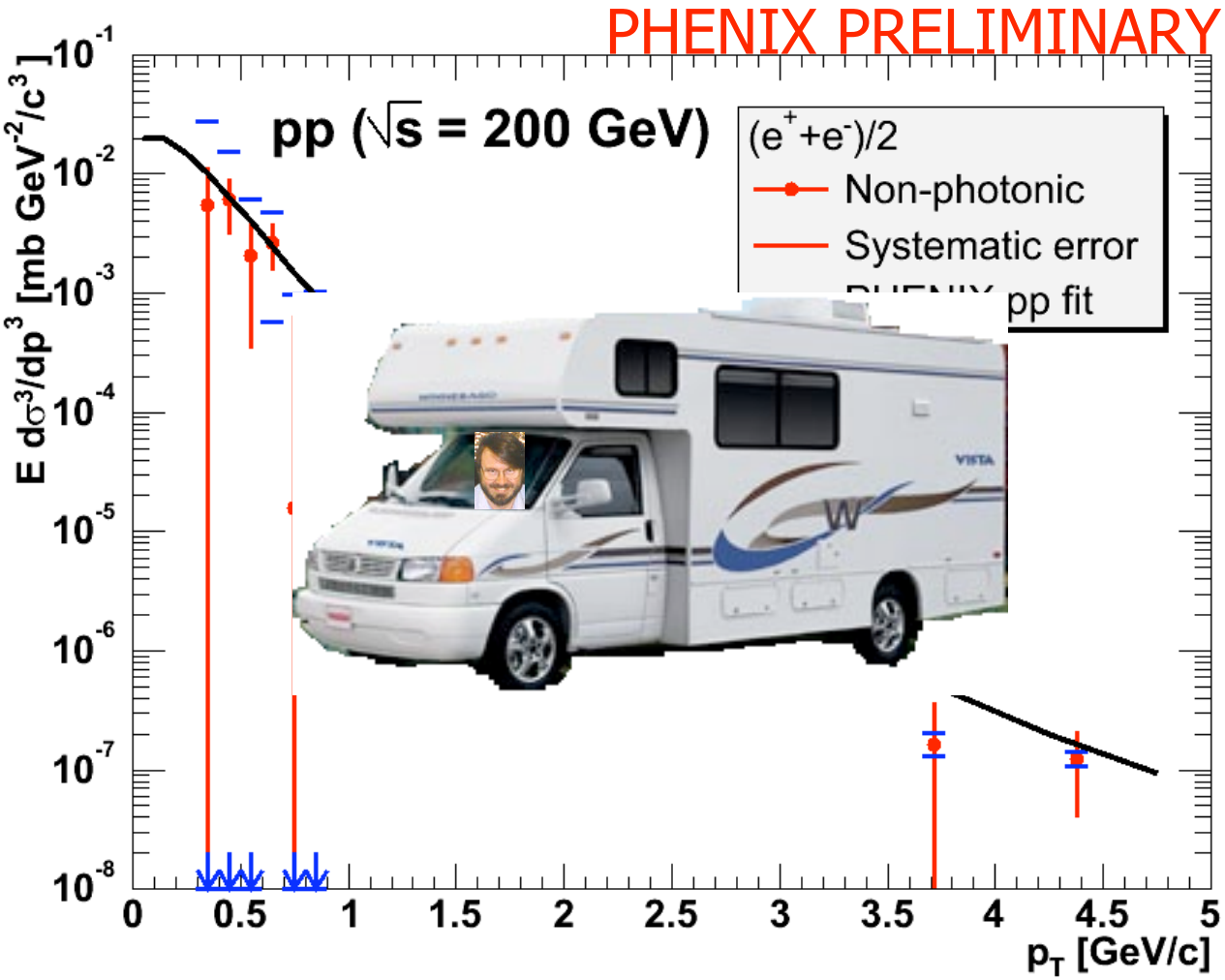


PYTHIA charm alone under predicts the data by a factor of 2-5 at moderated pt

PYTHIA charm + bottom under predict the tail by a factor of ~2-3

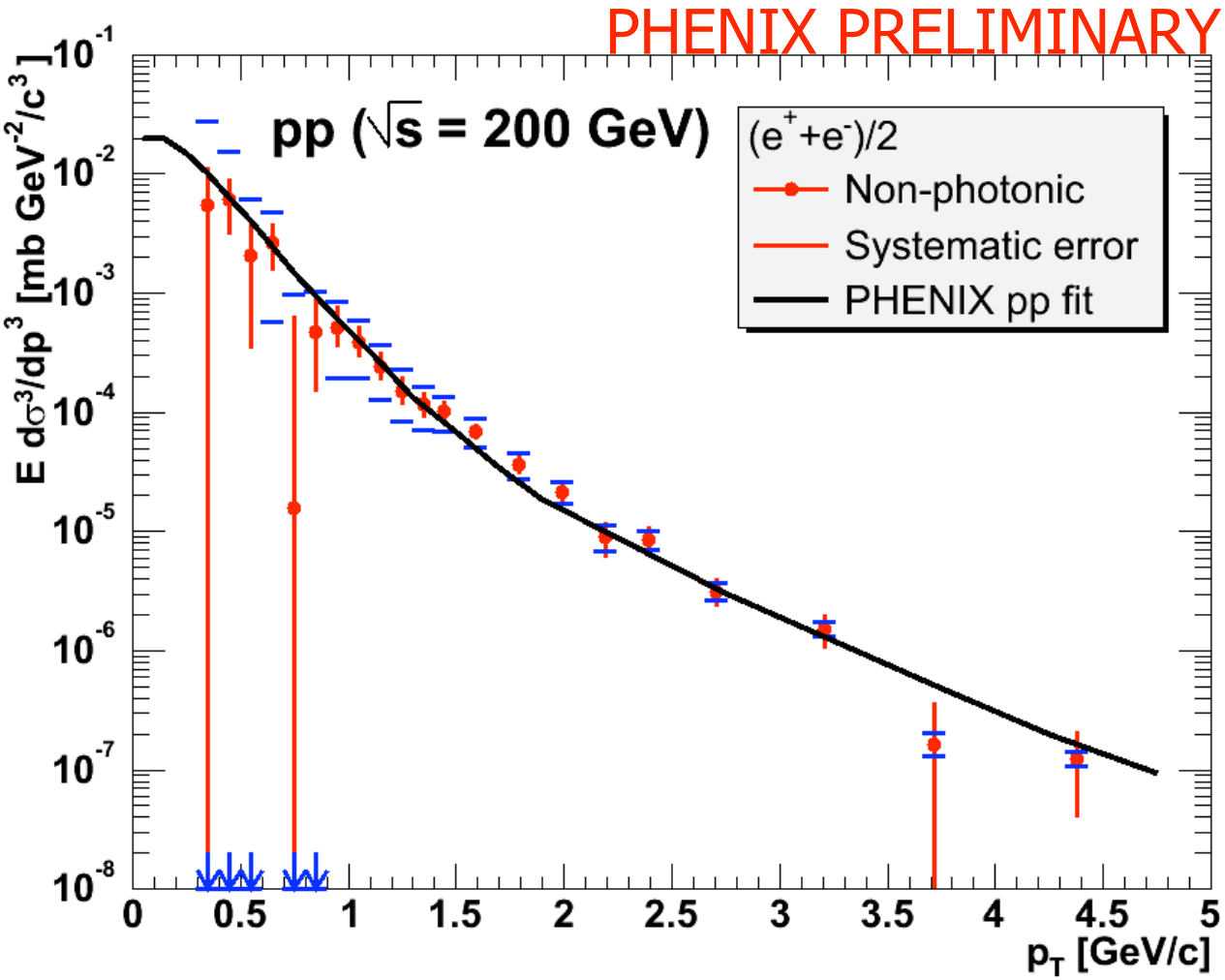


PYTHIA Heads For the Florida Keys In a Winnebago



PHENIX pp fit baseline for dAu and AuAu data

PYTHIA Heads For the Florida Keys In a Winnebago



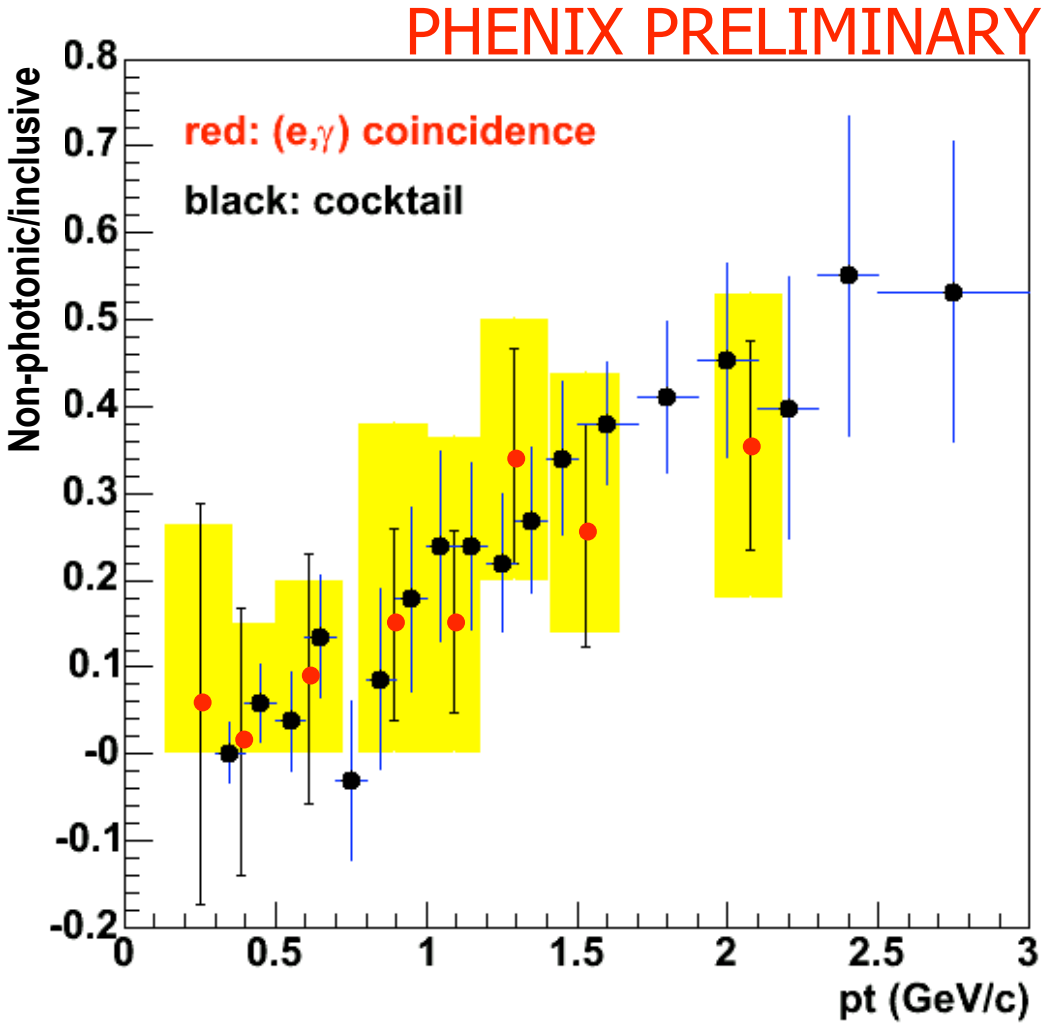
PHENIX pp fit baseline for dAu and AuAu data

Independent □-e Analysis

Mixed event subtraction of the □-e invariant mass spectrum in the vicinity of the pion mass - eta from the cocktail

Direct measurement of the single electrons from pion and eta conversions/Dalitz

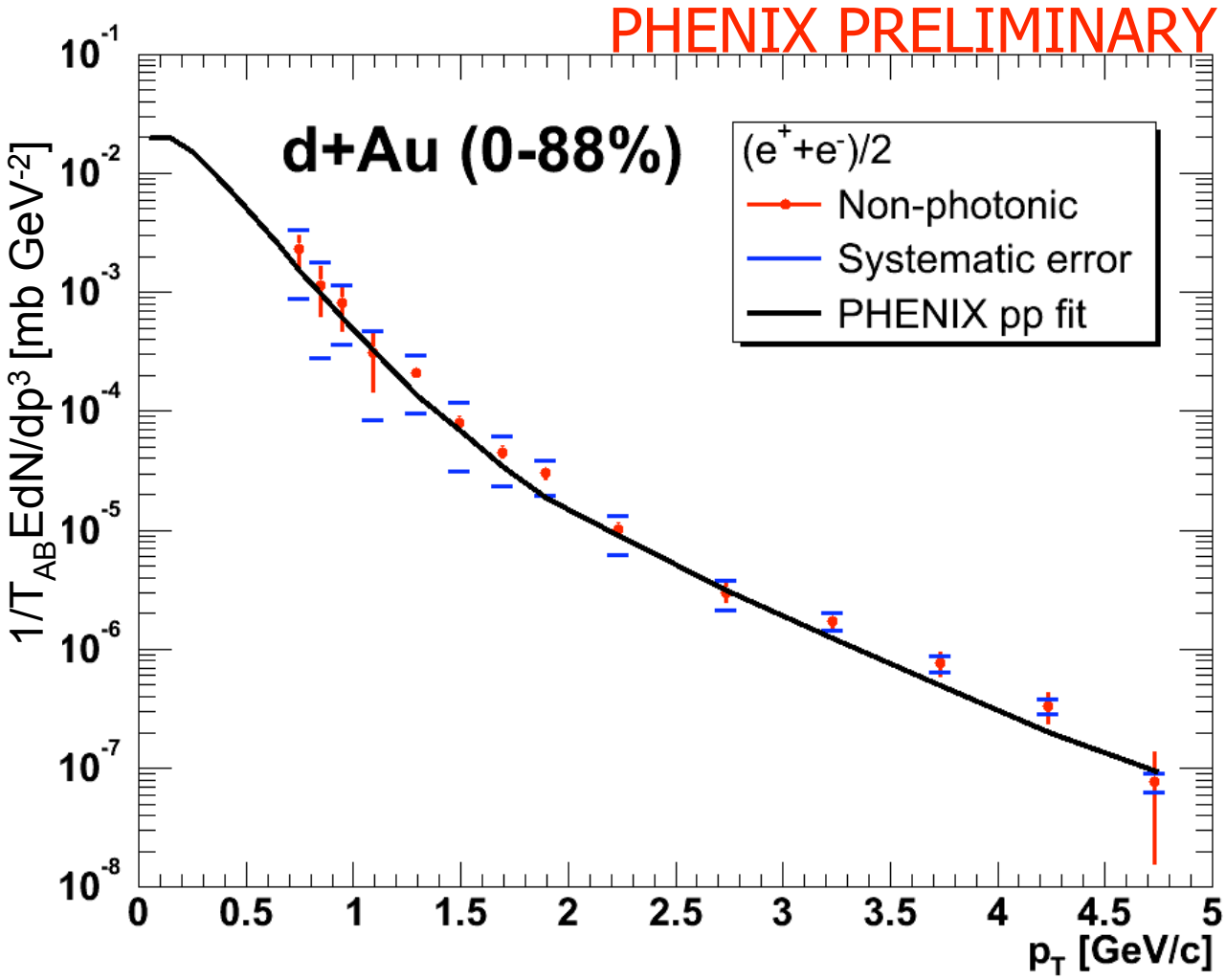
Data shows good agreement with the cocktail subtraction



Poster by Xinhua Li

PHENIX

Deuteron Gold Collisions at $\sqrt{s}$ = 200 GeV / nucleon



200 GeV dAu non-photonic single electron spectrum from converter method

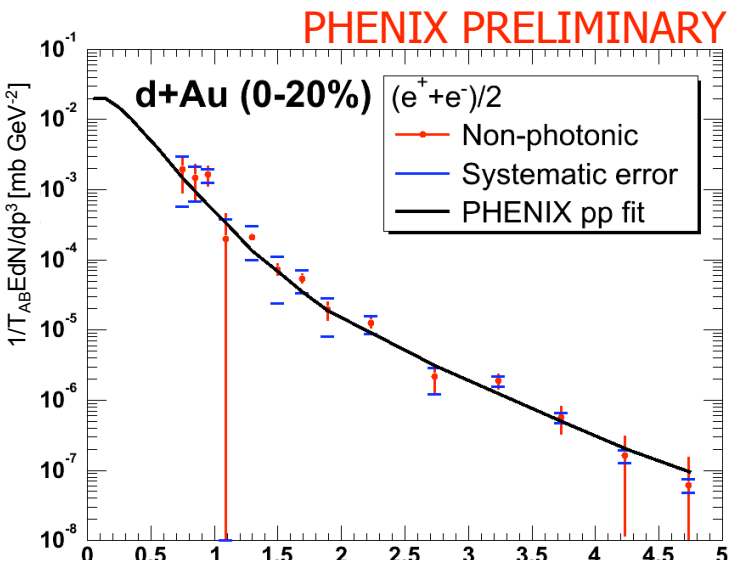
Data divided by T_{AB}

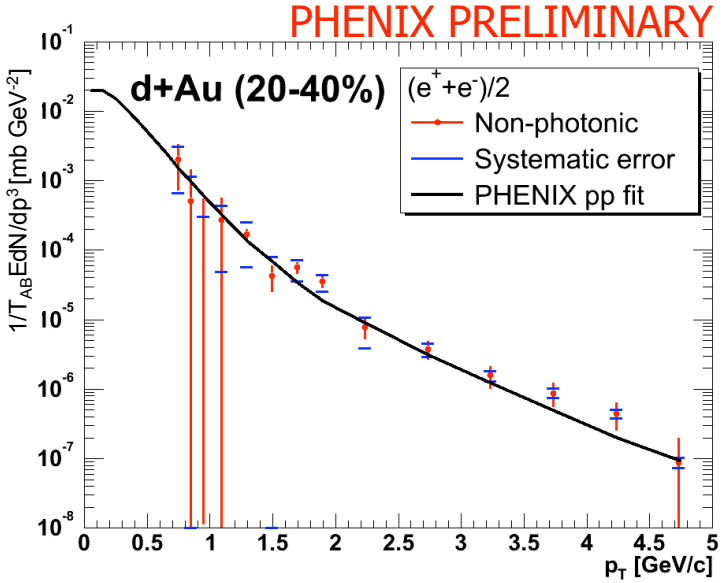
Spectacular agreement within stated errors

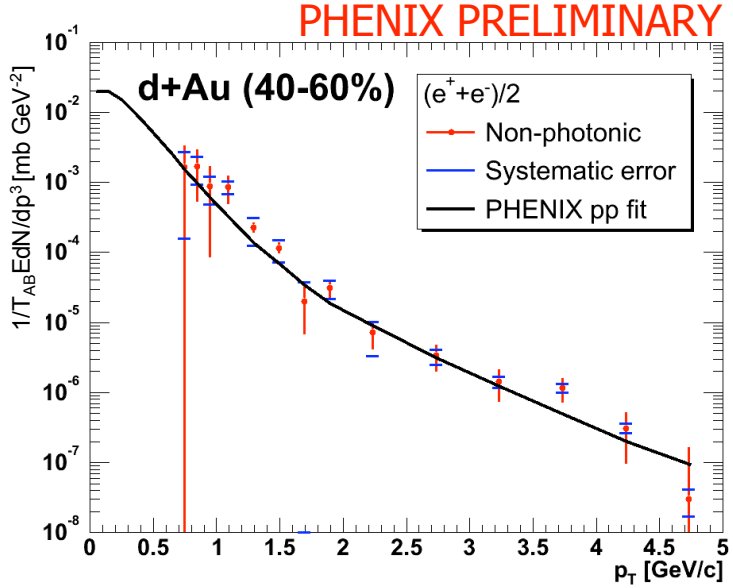
Poster by Sergey Butsyk

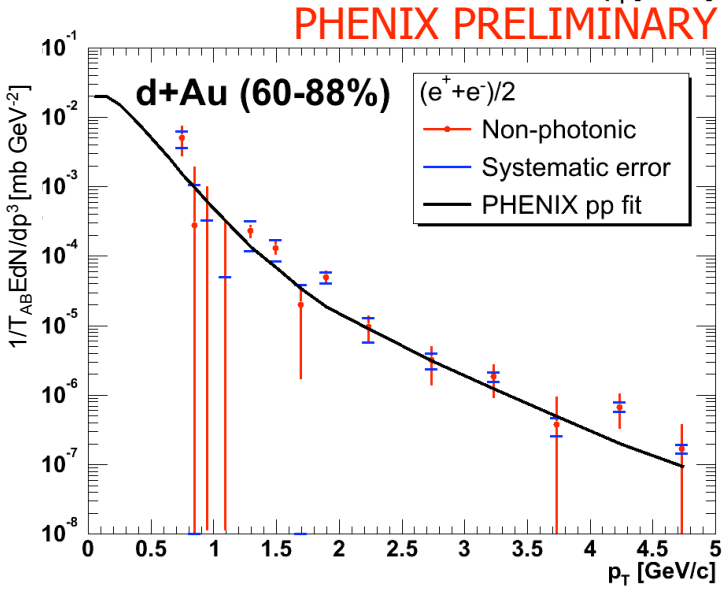
PHENIX

Centrality Dependence In Deuteron Au Collisions

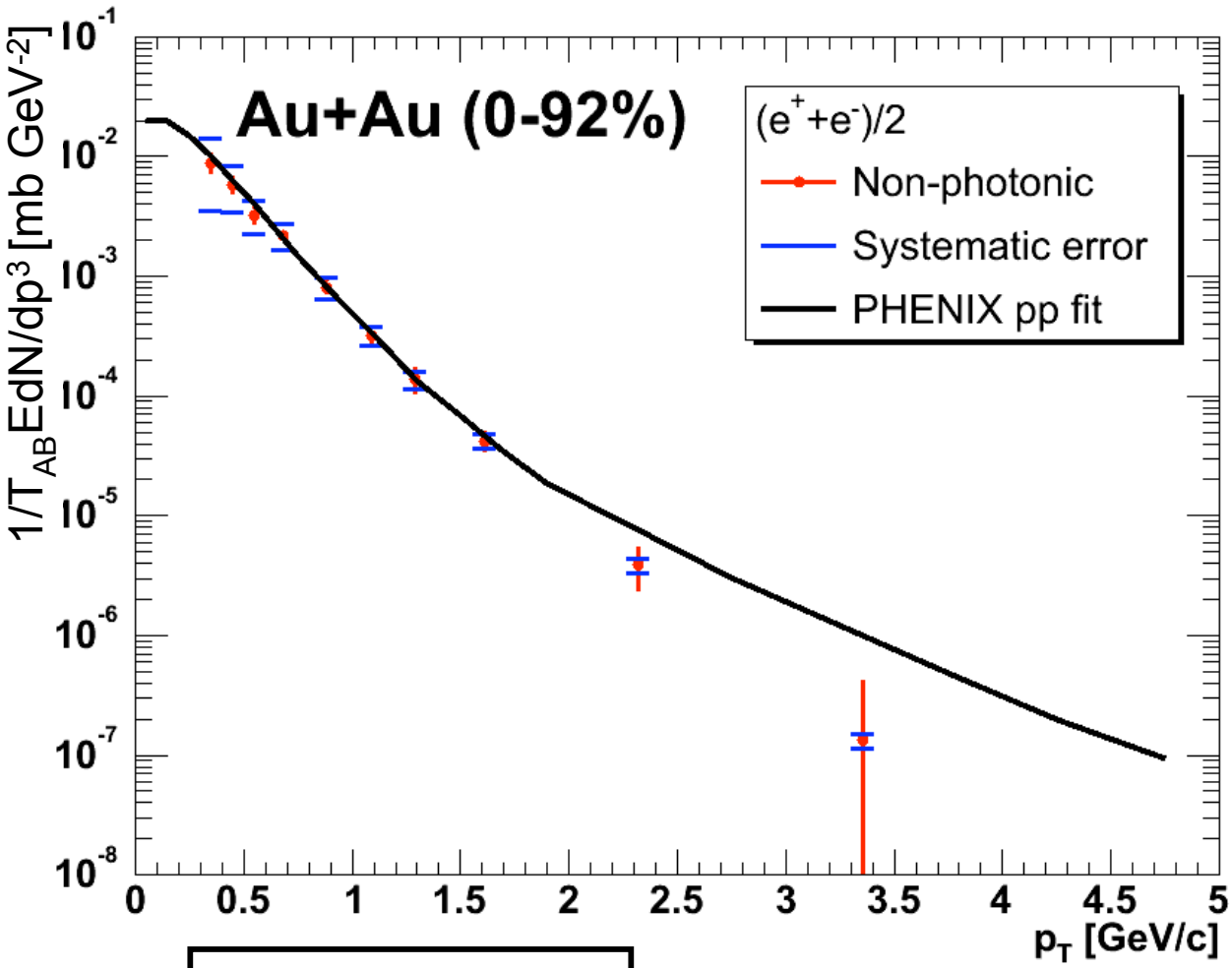








Single Electron Spectra Au+Au s = 200 GeV



Poster by Takashi Hachiya

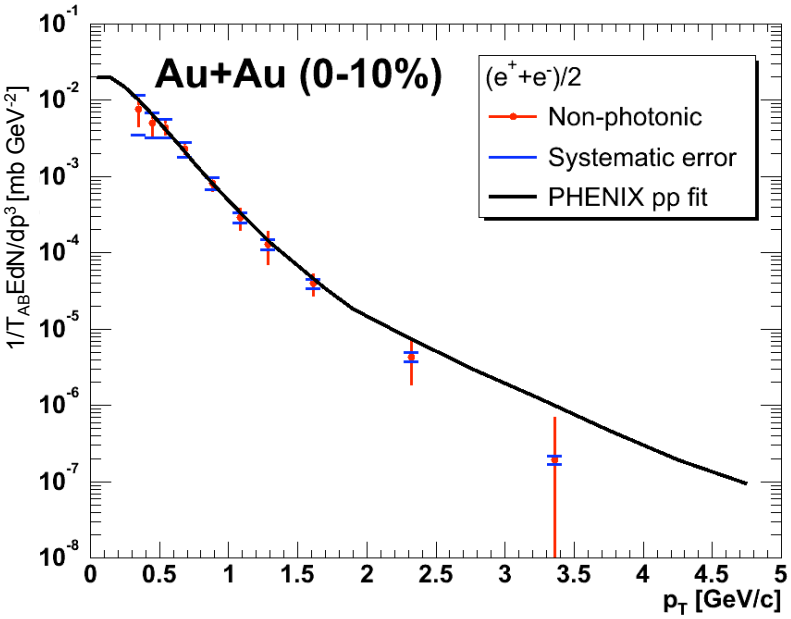
PHENIX

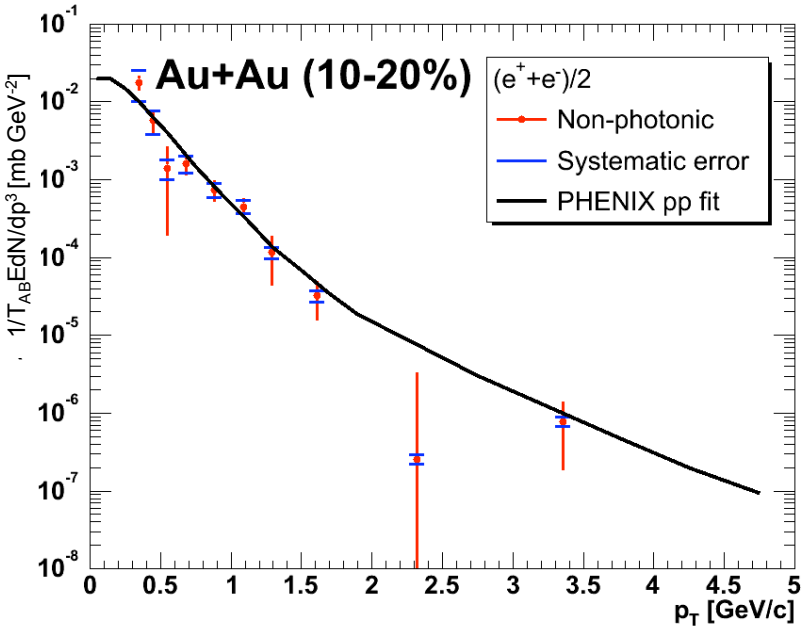
200 GeV Au+Au non-photonic single electron spectrum from converter method

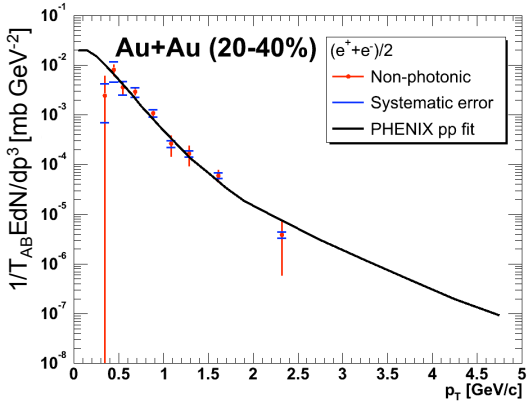
Data is divided by T_{AA} and overlaid with PHENIX pp fit

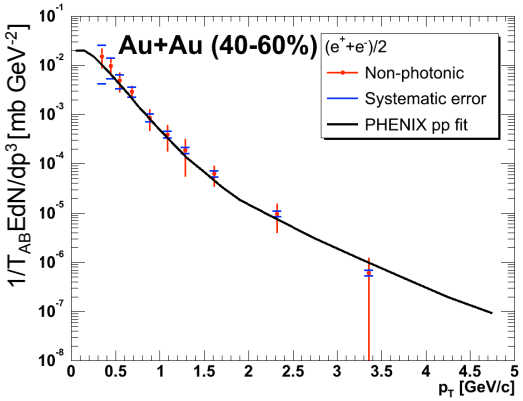
At low p_t the pp fit is in good agreement

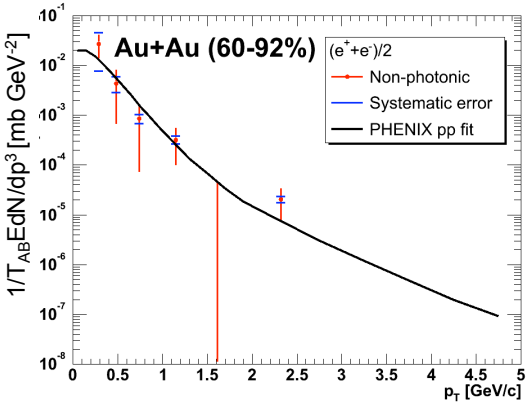
Centrality Dependence Au+Au



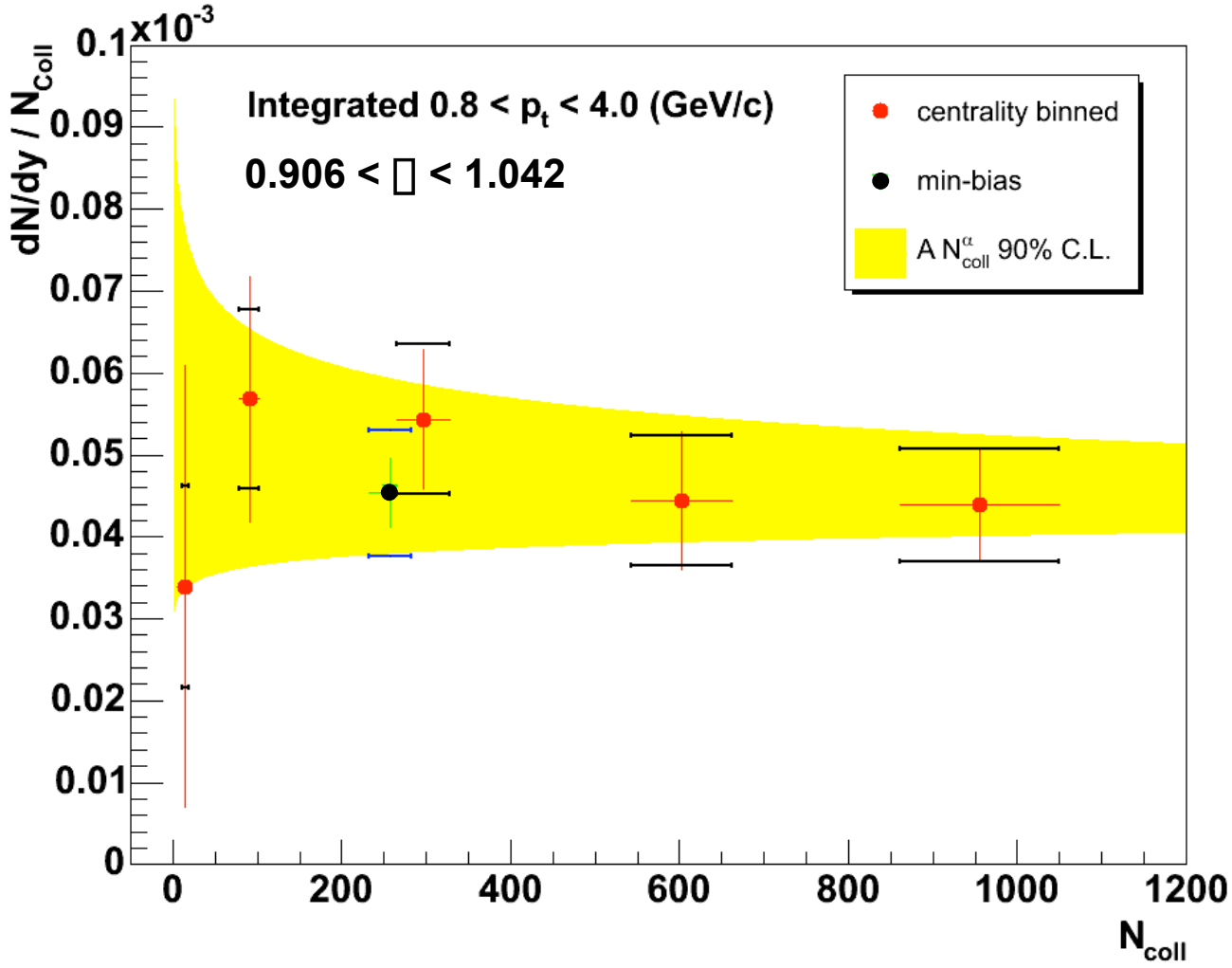








$N_{collision}$ Scaling In Au+Au



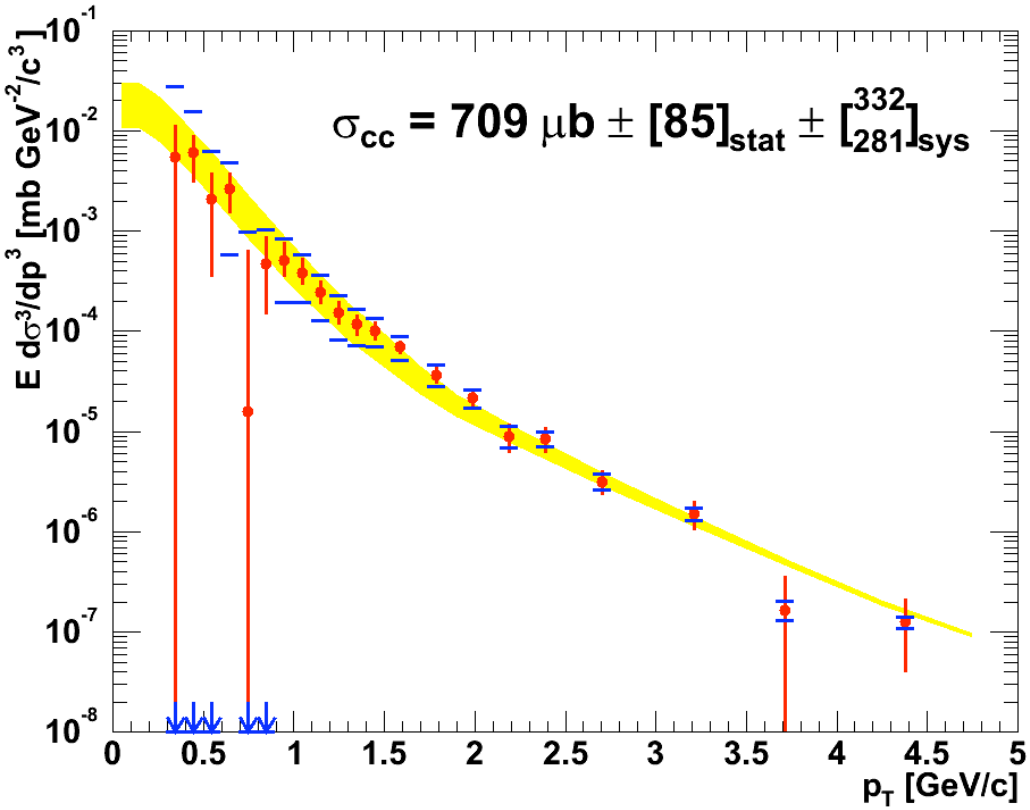
We have quantified the extent to which the Au+Au data exhibits N_{coll} scaling

Yellow band represents the set of alpha values consistent with the data at 90% Confidence Level

$dN/dy = A\ (N_{coll})^{\square}$

Since You Asked - Total Charm Cross Section s = pp 200 GeV

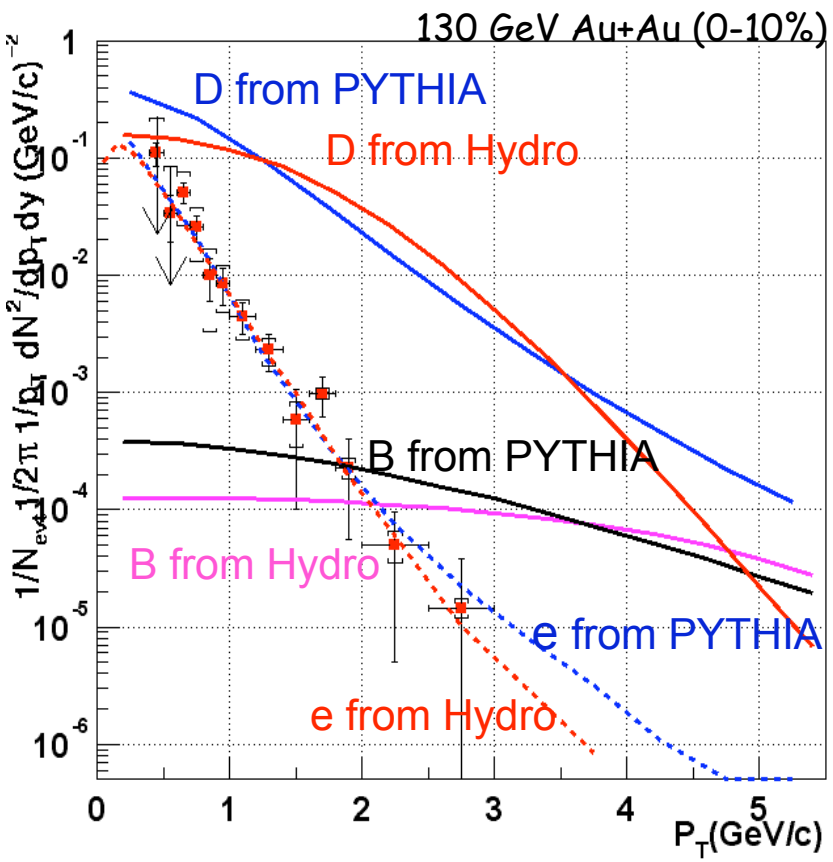
PYTHIA comes out of retirement - Matches the line shape in the region that matters for the determination of the cross section, hence we use it to extrapolate over all phase space



PYTHIA charm + bottom line-shapes with independent floating normalizations that best fit the data

Systematic error is determined by offsetting the data by the upper and lower systematic and extracting the cross section

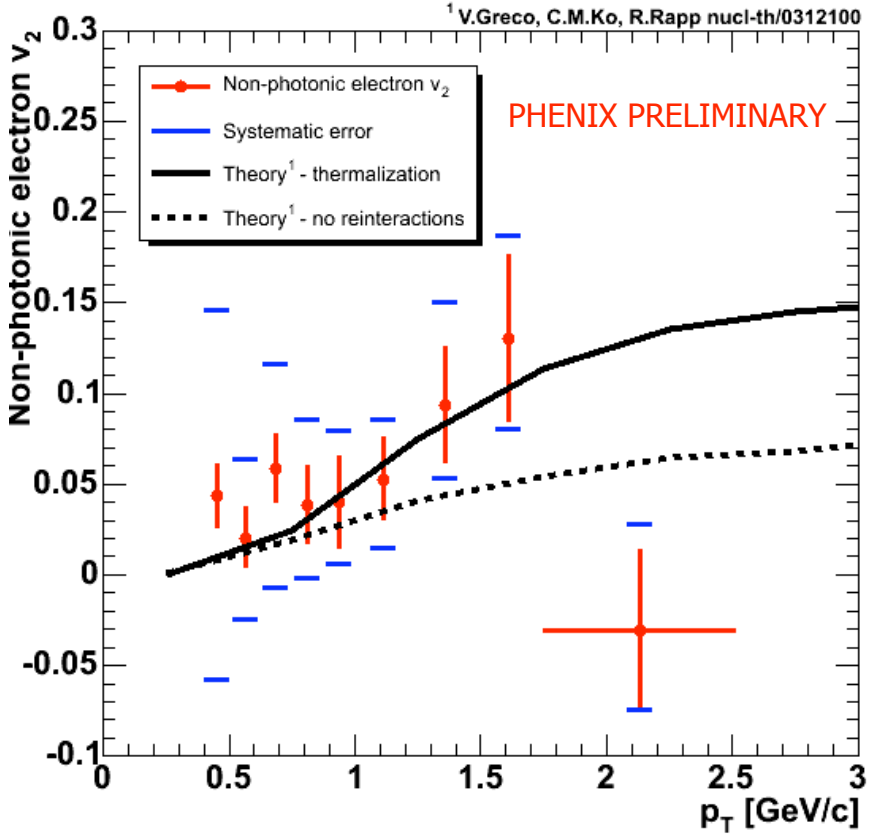
Back To The Dynamics of Charm In Media



Upper West-Side Sopranos Plot

(S. Batsouli, S.Kelly, M.Gyulassy, J.Nagle)
Phys.Lett. B557 (2003) 26-32

The measurement of v_2 of charm is a way to discriminate between these contrasting dynamical scenarios



Data indicate non-zero charm flow

Poster by Shingo Sakai PHENIX

Summary & Conclusions

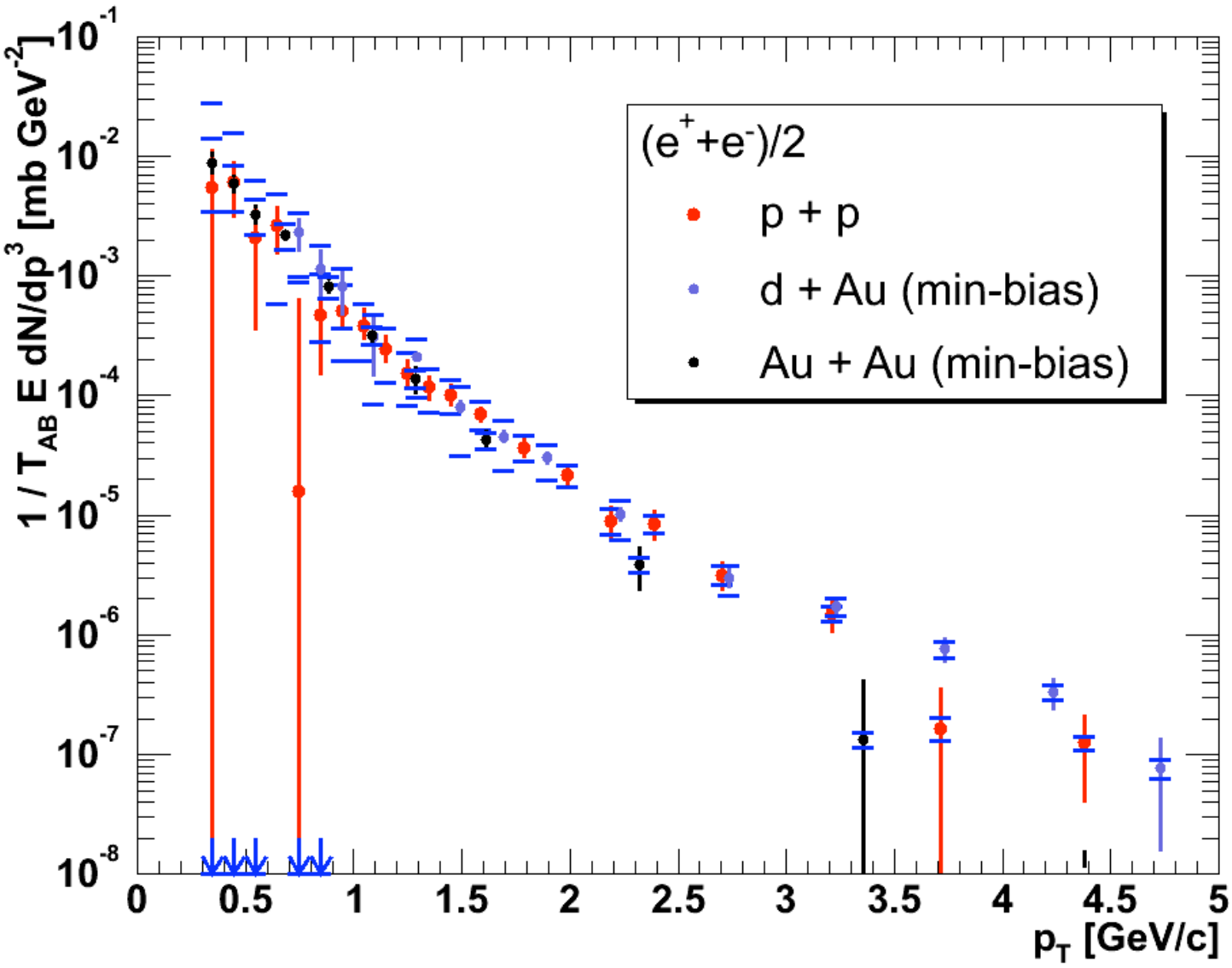
PHENIX has measured inclusive single electrons in pp, d+Au, and Au+Au at 200 GeV/nucleon.

The measured yield of non-photonic electrons is consistent with binary scaling in d+Au and Au+Au collisions. Indicating no strong enhancement or suppression of the charm cross section in nuclear systems.

We are statistics limited regarding the presence of spectral modifications in the Au+Au data.

With anticipated Run 4 statistics the indications for spectral modifications in Au+Au and v_2 should be definitive. Run 4 is **the** run for closed **and** open charm physics in Au+Au collisions.

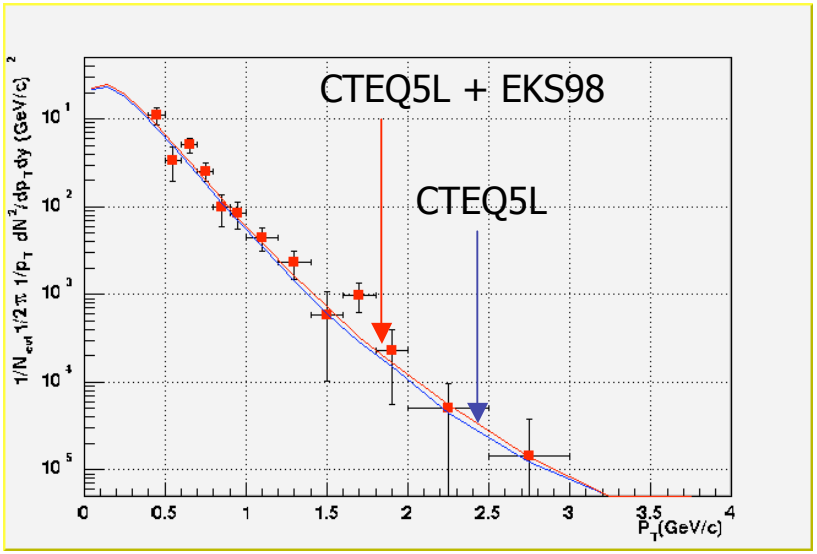
Single Electron pp, d+Au, Au+Au

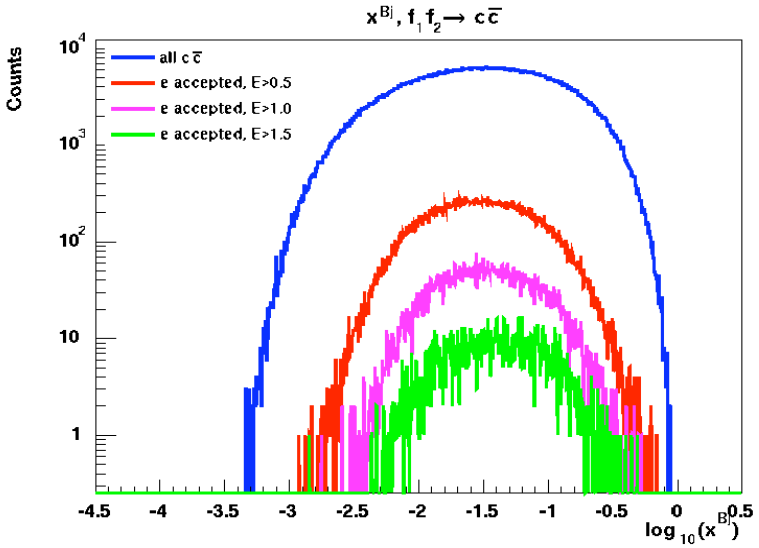


Backup

Nothing Dramatic Going On

Au+Au e + X (0-10%) 130 GeV





Point here is that central arm single electrons are not sensitive to shadow+antishadow - These plots need to re-made for 200 GeV data