Measuring ΔG in PHENIX using electrons to tag heavy-flavor production

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for the PHENIX collaboration

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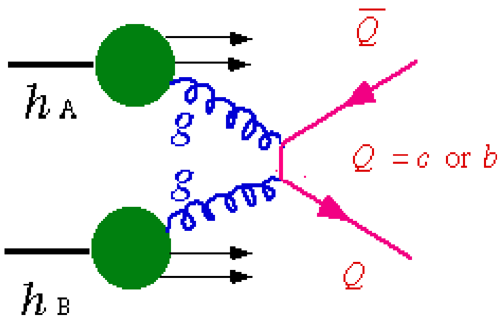
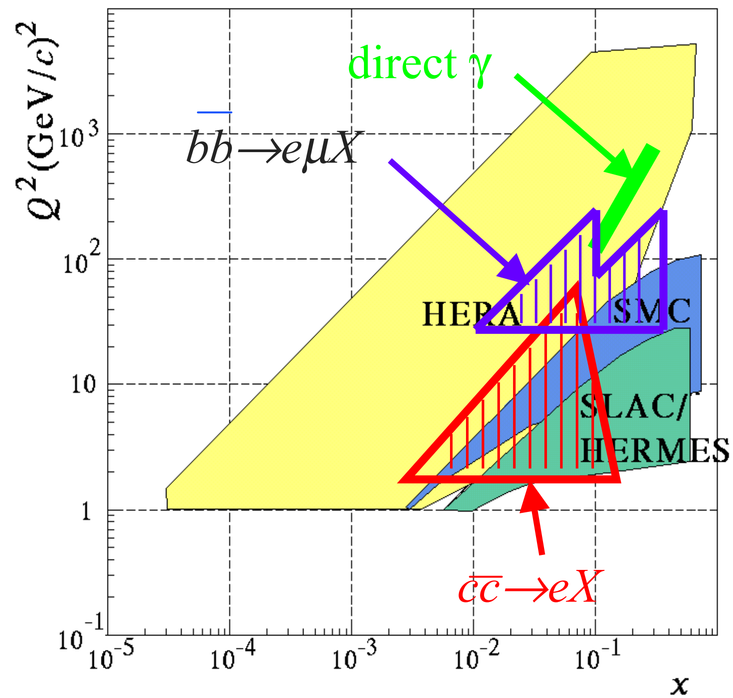
Open heavy flavors in PHENIX

Open heavy flavor production



$$A_{LL} \propto \frac{\Delta G(x_A)}{G(x_A)} \otimes \frac{\Delta G(x_B)}{G(x_B)} \otimes \hat{a}_{LL}^{gg \to Q\bar{Q}}$$



H. Sato

Decay channels:

» e^+e^-, $\mu^+\mu^-$, $e\mu$, e, μ, eD, μD

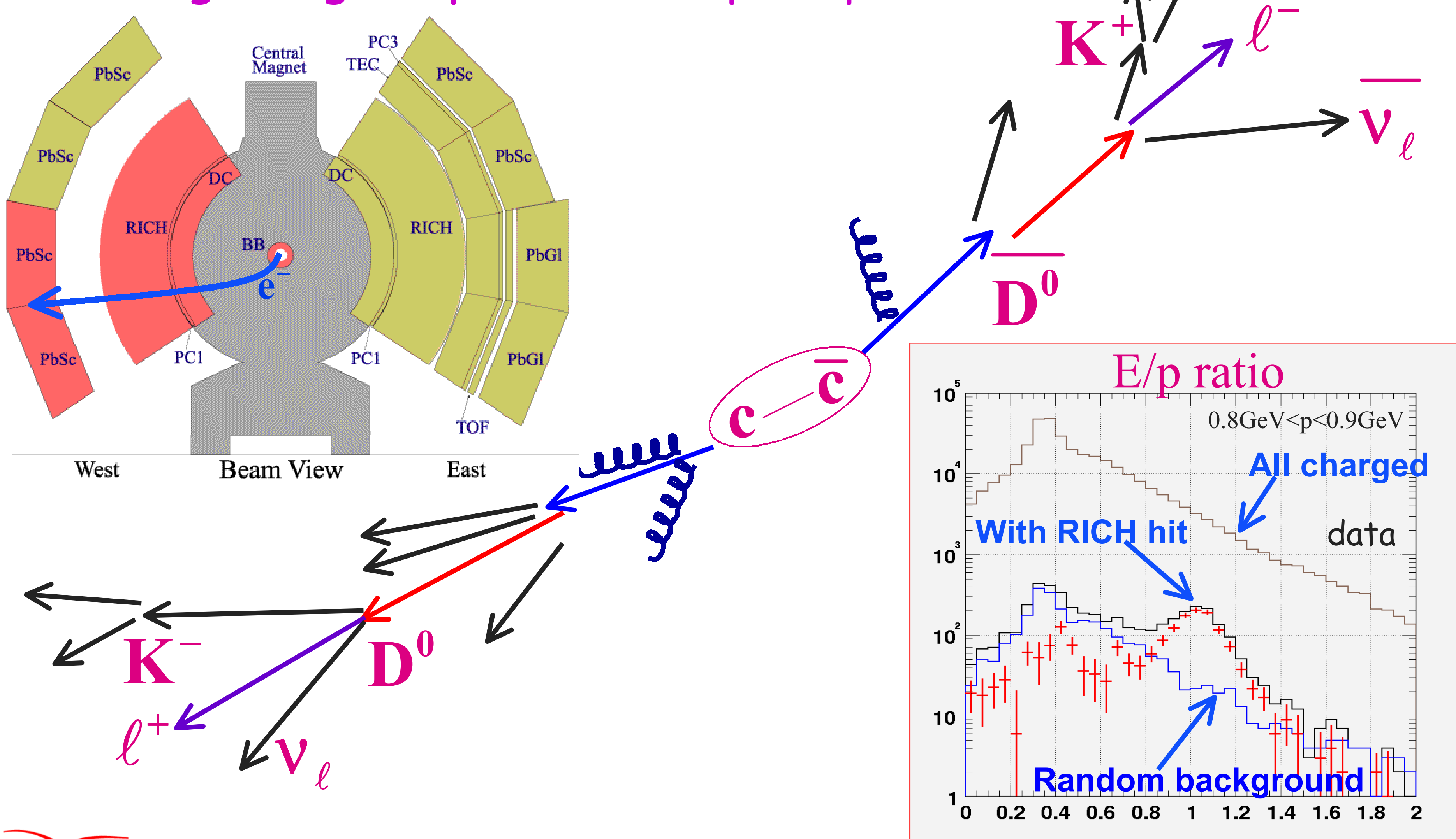
Provides more independent ΔG measurements in PHENIX

» Helps control experimental and theoretical systematic errors

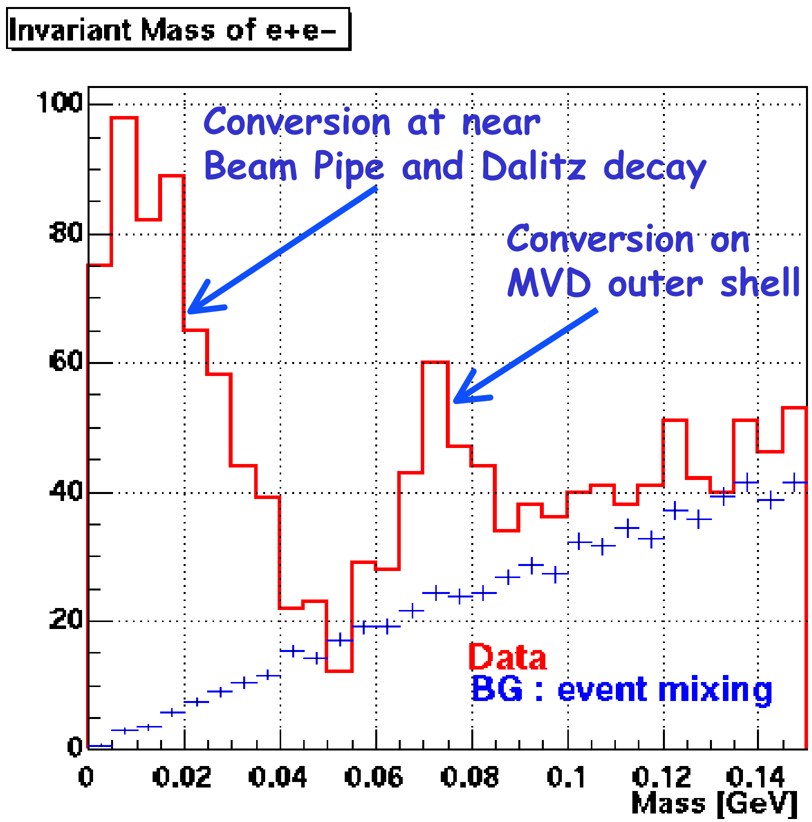
» Different channels cover different kinematic regions

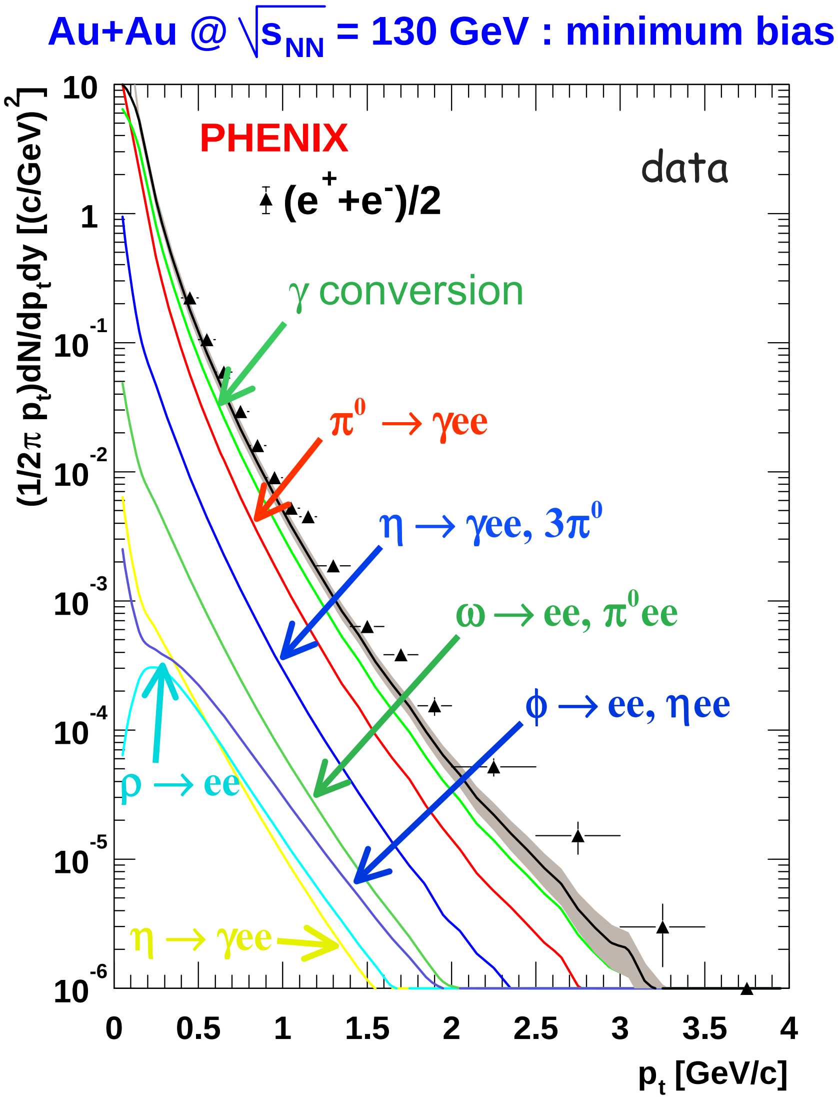
Electrons in PHENIX

✓ We can measure open charm and bottom contributions through single leptons and lepton pairs.



Electrons in heavy ion collisions





Dominant background contributions:

$\pi^0 \rightarrow e^+e^- \gamma$ — π^0 Dalitz decays

$\pi^0 \rightarrow \gamma\gamma$ — γ conversions

$\quad\quad \hookrightarrow e^+e^-$

PHENIX: PRL 88(2002)192303

A_{LL} for heavy quark production

✓ **Analyzing Power**

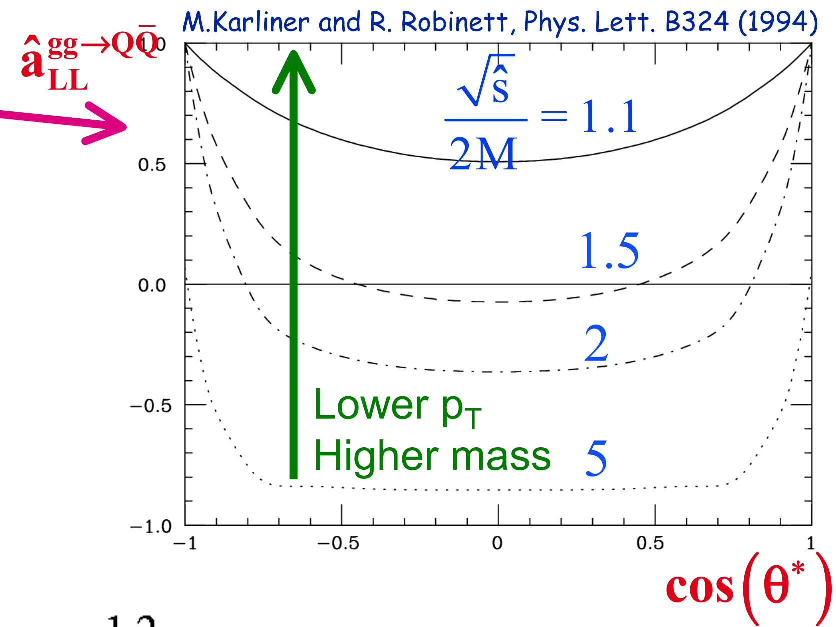
» Use LO analyzing power calculation

» Charm and bottom will differ because of mass dependence

– Changes sign for large mass and low transverse momentum

» NLO calculations are now available

– I.Bojak & M. Stratmann, hep-ph/0112276

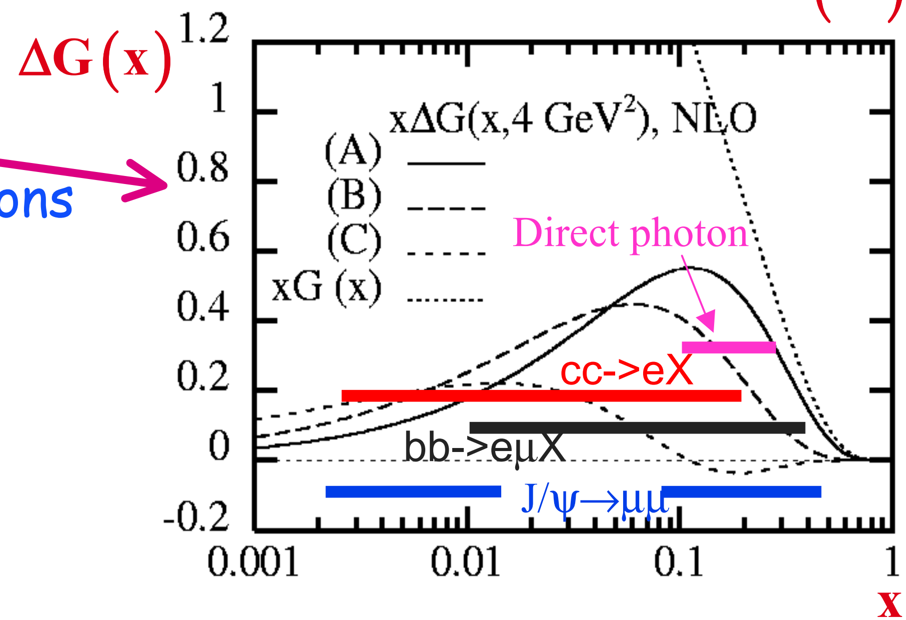


✓ **Gluon Polarization**

» Use simple parameterized functions from Gehrmann & Stirling

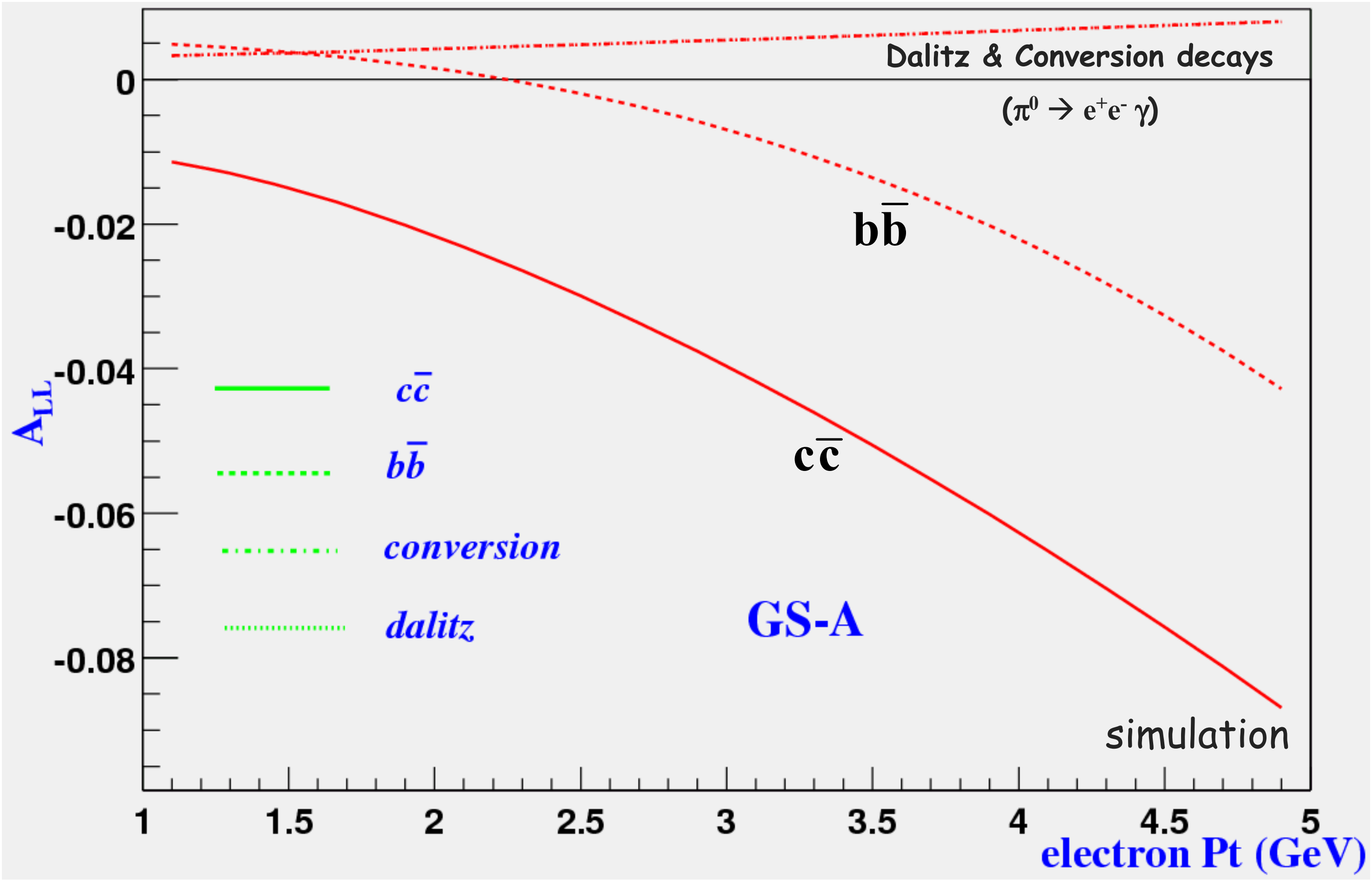
– Phys.Rev.D52 6100 (1996)

» x range for charm and bottom production different because of decay kinematics



A_{LL} from background & signal electrons

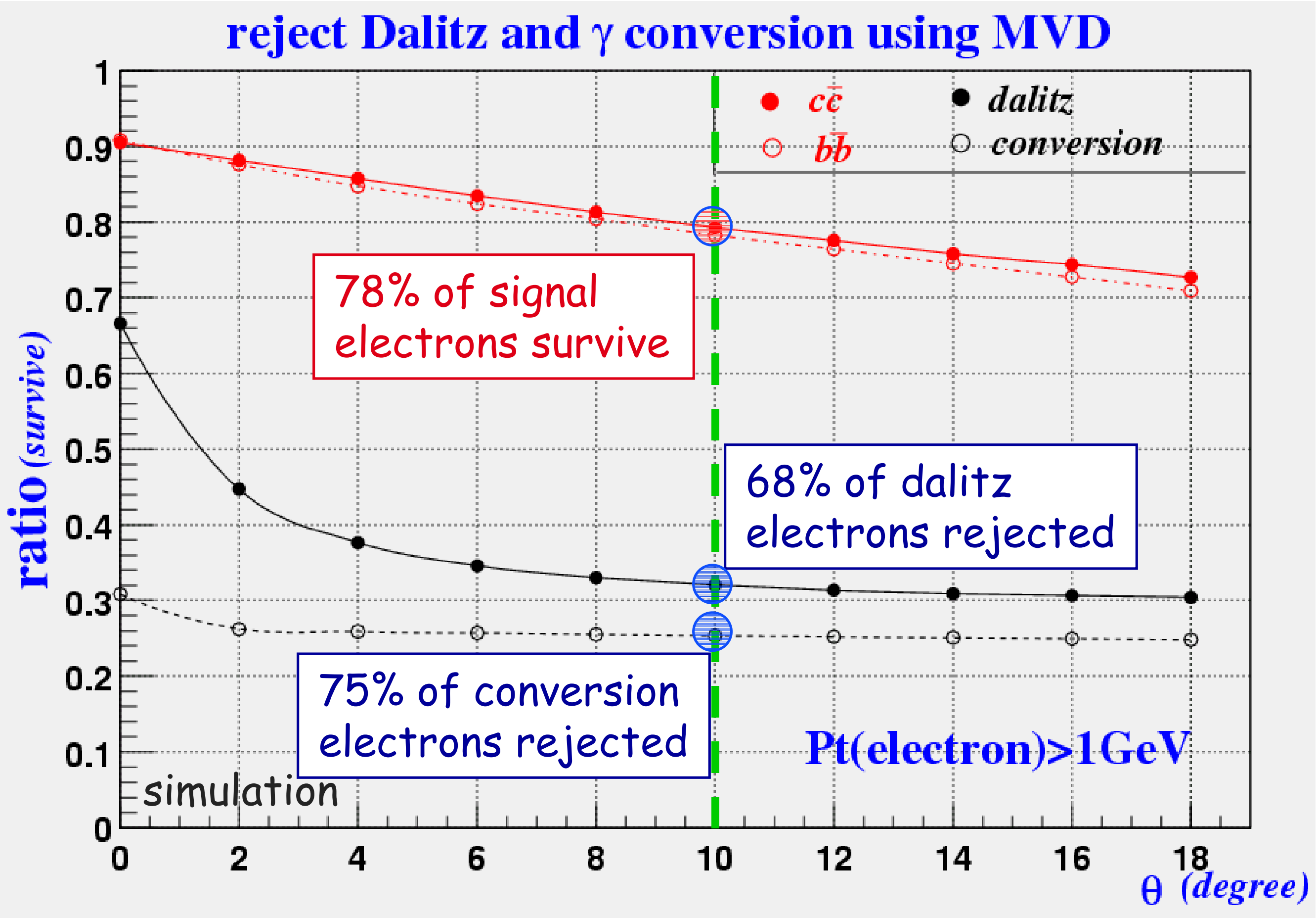
An electron A_{LL} measurement will include contributions from charm, bottom, photon conversions, & Dalitz decays.



W. Xie

Dalitz and conversion identification

An inner tracker, like PHENIX's multiplicity vertex detector (MVD) can be used to help identify electrons which have come from conversions in the beam pipe or Dalitz decay electrons.

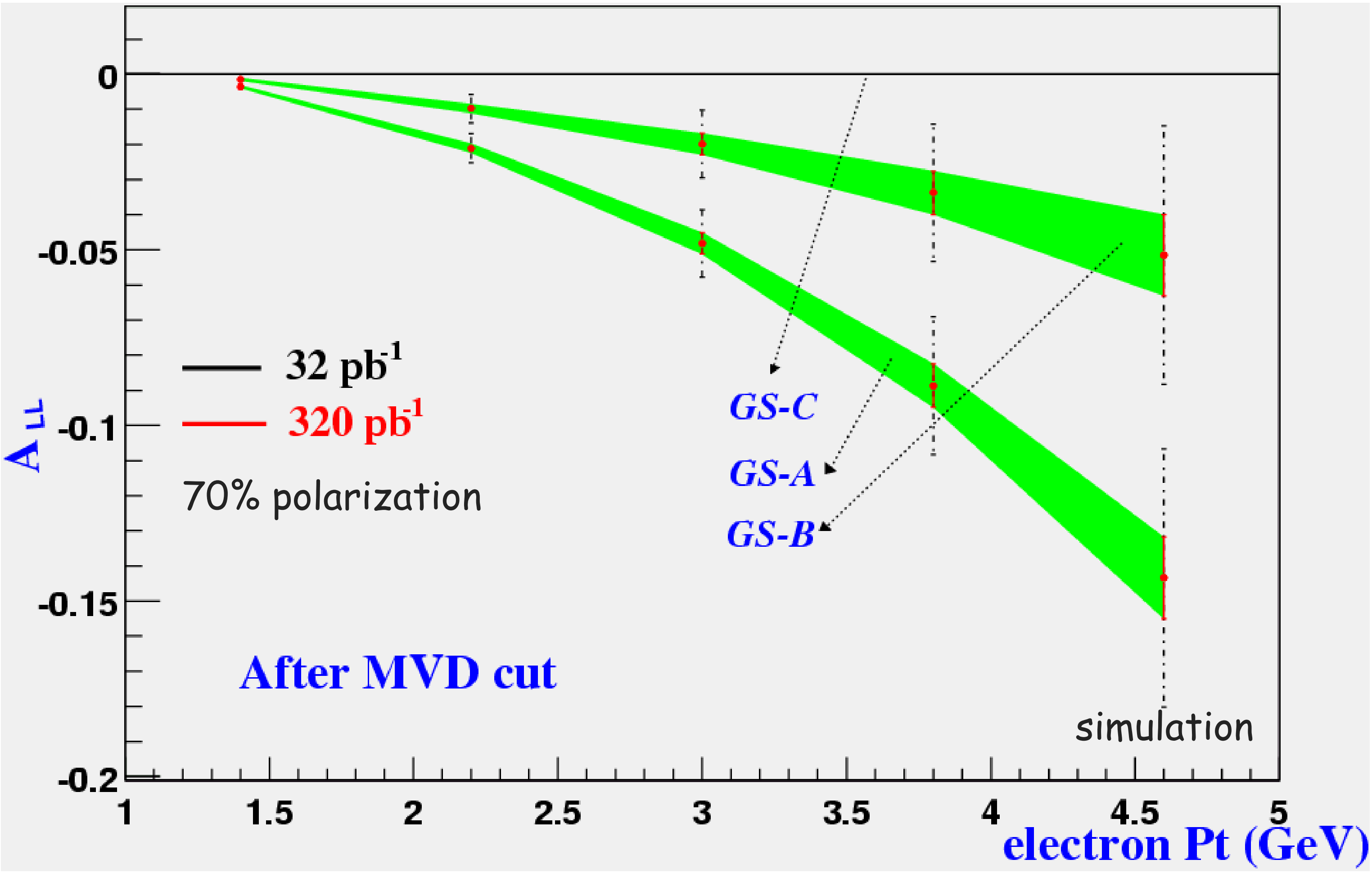


Here we use a pulse height in association with a separation cut between charged particle tracks (10 degrees)

W. Xie

A_{LL} in PHENIX using single electrons

- ✓ Events have been tagged online by an electron with p_T>1GeV in the central arm
- ✓ An offline MVD cut to reject Dalitz and conversion electrons has been applied



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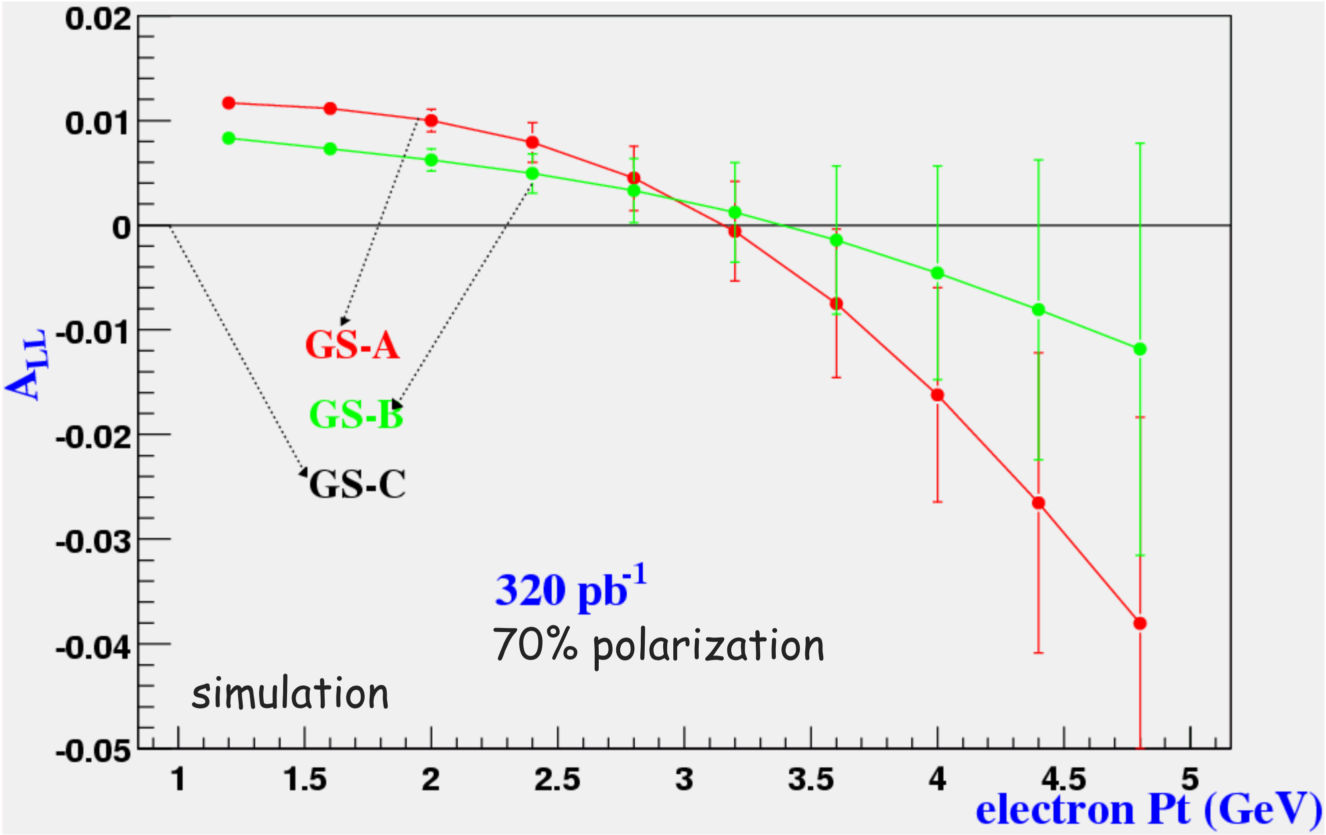
K. Barish

A_{LL} of identified conversions & Dalitz

- ✓ The MVD cuts can be inverted to produce a sample of events which contain electrons from conversions and Dalitz decays (from QCD jet events with π^0's).
- ✓ The asymmetry at low transverse momentum has flipped sign, giving us a handle on false asymmetries caused by acceptance effects.
- ✓ The asymmetry can also be used in conjunction with the direct π^0 measurement in a global analysis that will give us a handle on our systematic errors



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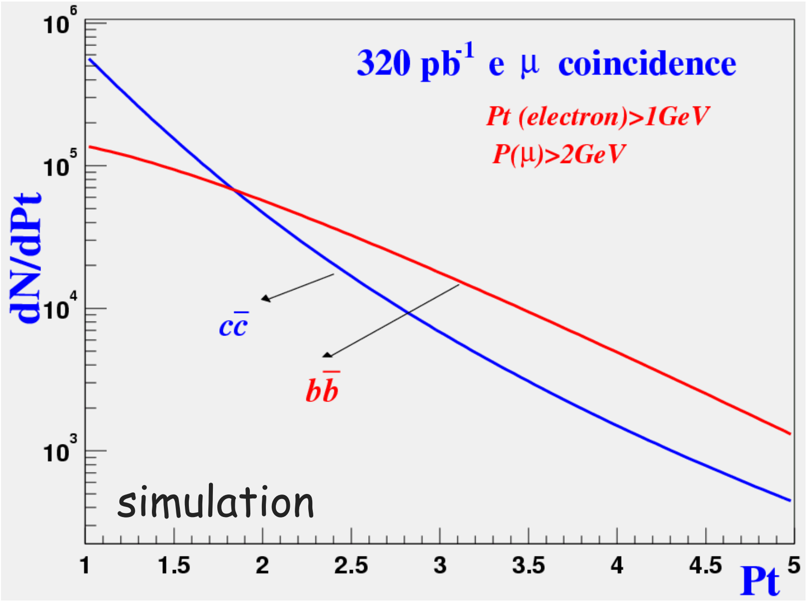
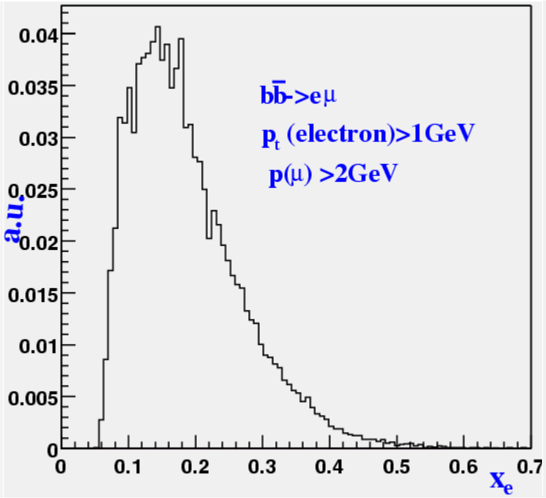
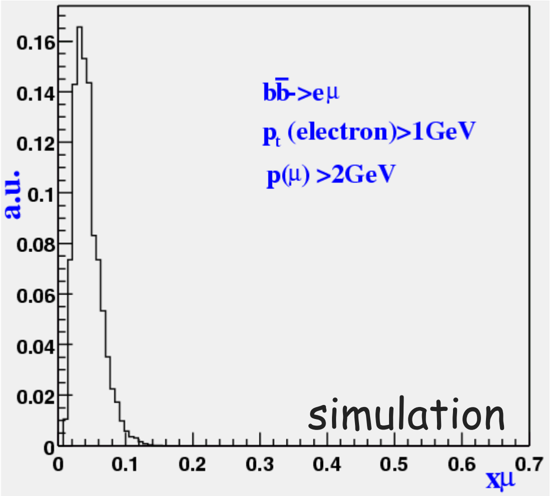
K. Barish

Tagged μ-e coincidences

- ✓ We can require a muon detected in one of the forward muon arms in coincidence with an electron in the central arm
  - This requirement removes the background from conversions and Dalitz decays and it enhances the bottom yield in the event sample





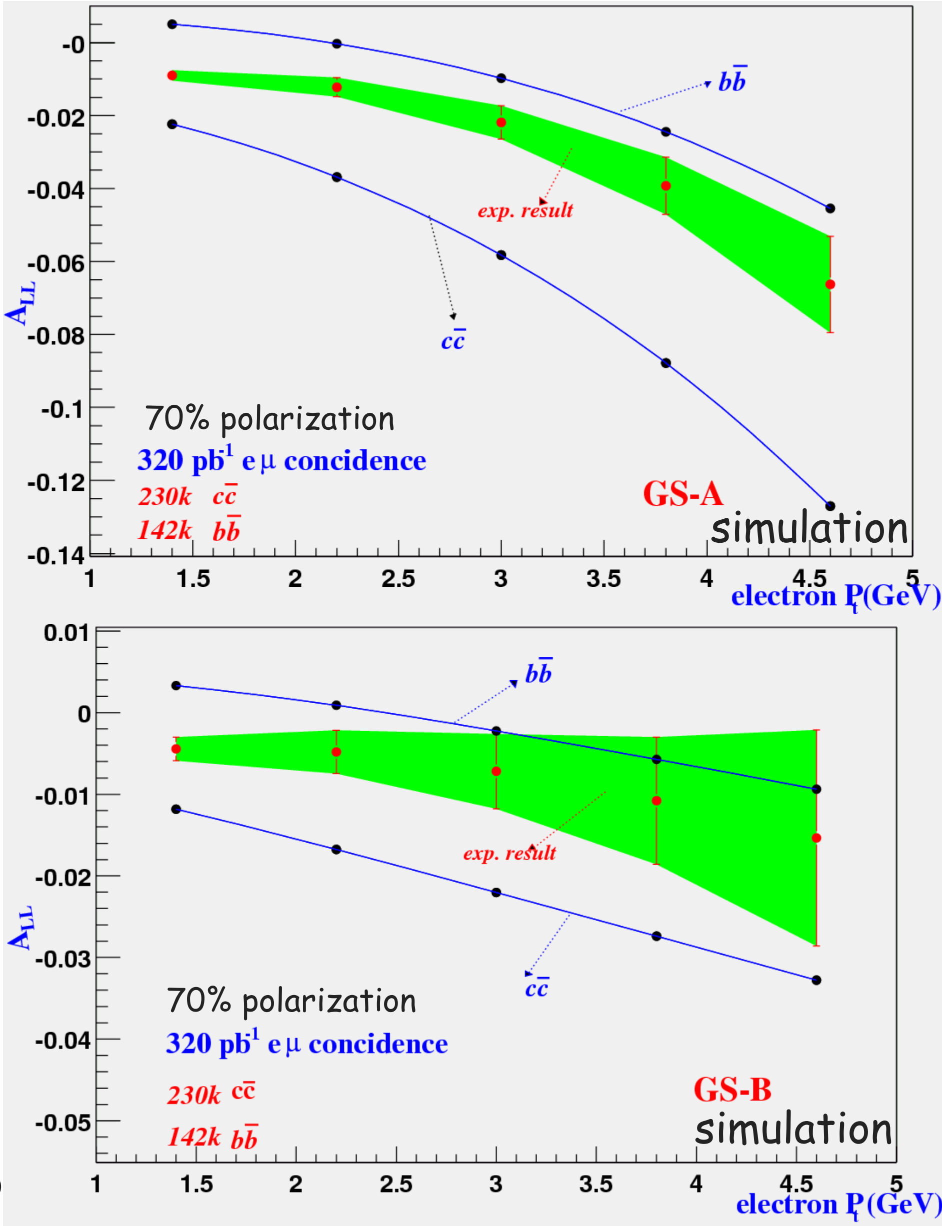


- ✓ In the μ-e channel the kinematic range reaches down to x_g~ 0.02.

W. Xie & H Sato

A_{LL} in PHENIX using μ-e coincidences

- ✓ In 320pb^{-1} of e-μ coincidences we expect approximately 230K charm events and 142K bottom events into the PHENIX acceptance
- ✓ At high transverse momentum, bottom begins to dominate
  - » The e-μ channel will allow us to distinguish between charm and bottom using the asymmetry at high p_T and comparisons between like and unlike sign electron muon pairs



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PHENIX electron trigger

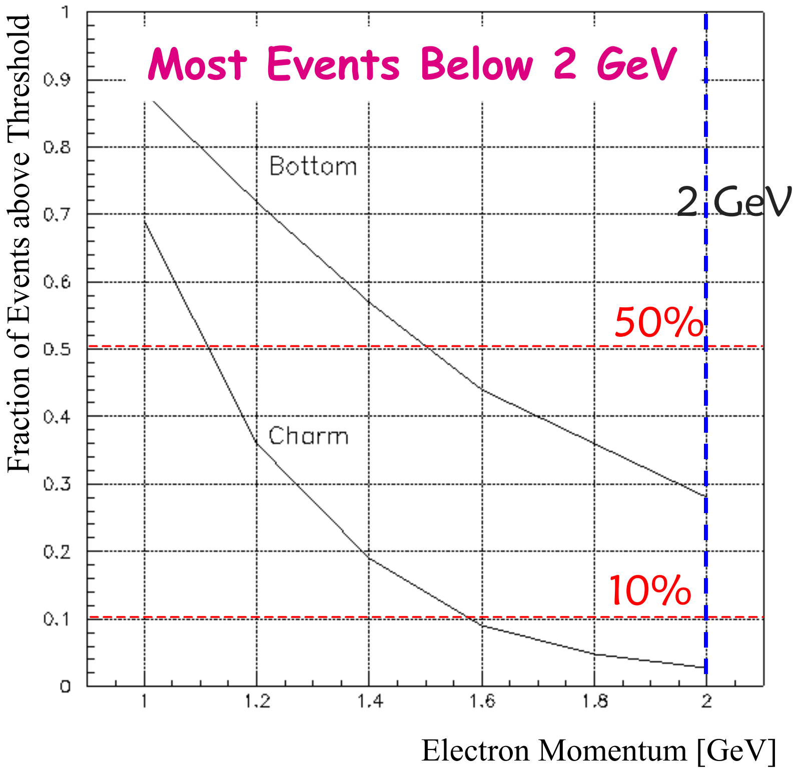
Tag as: single electron

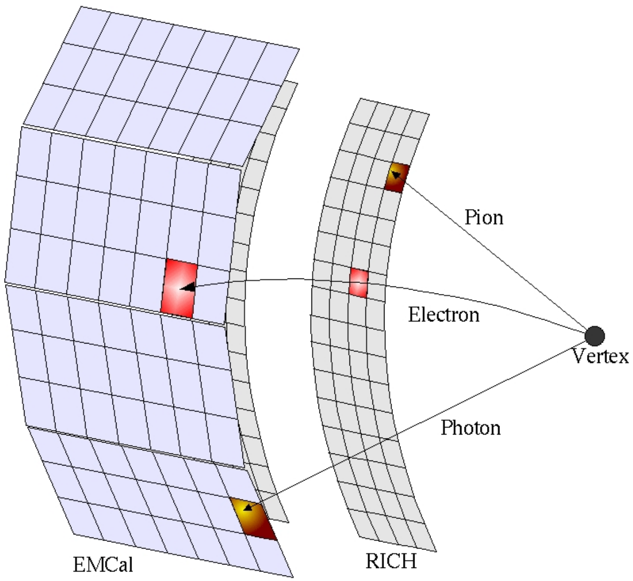
For $\int dtL = 32pb^{-1}$

6.8×10^{6}e from $c\bar{c}$

0.6×10^{6}e from $b\bar{b}$

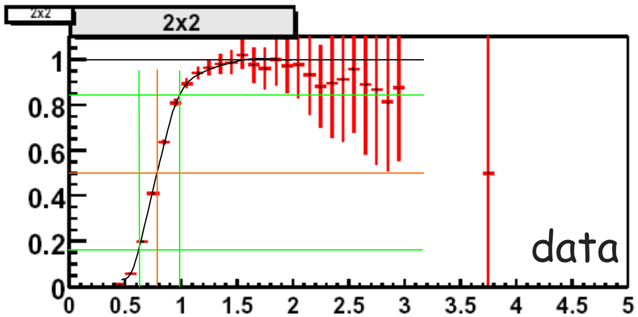
with $p_T > 0.9$ GeV

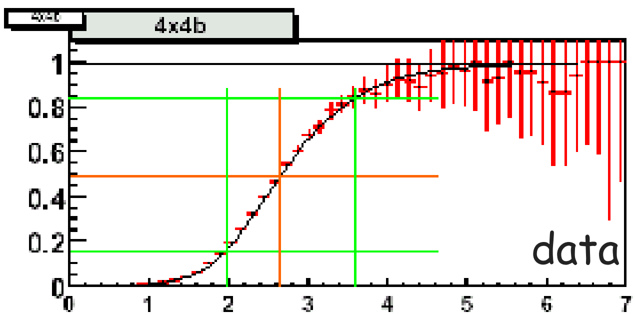




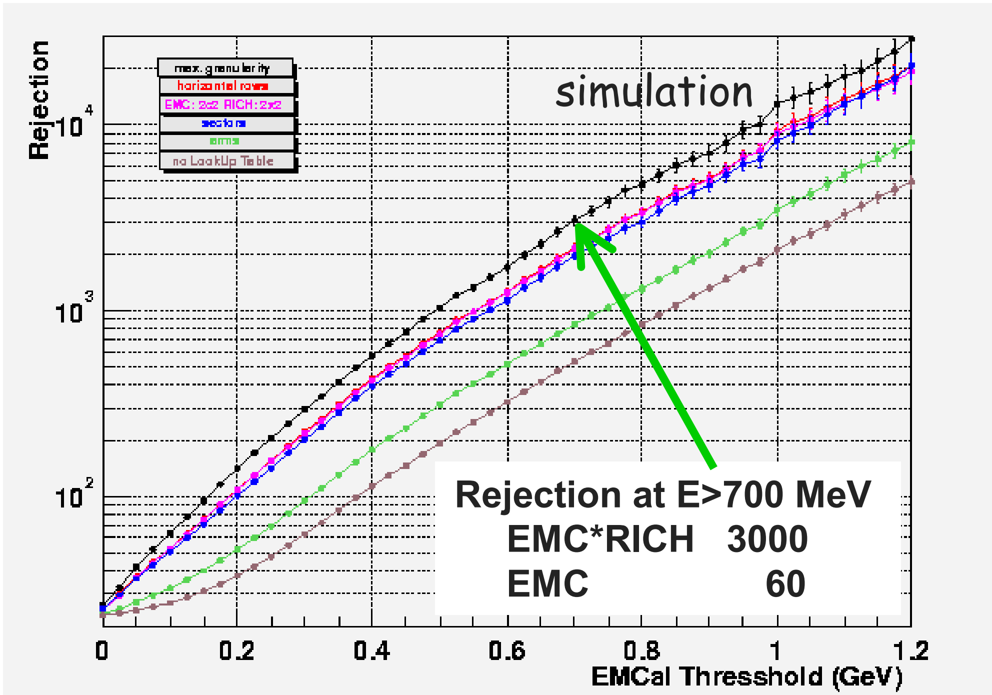
In PHENIX the EMCal and RICH detectors can be used to form a powerful central arm electron

Electron Trigger Rejection Powers





EMCal/Rich Trigger rejection:
Different Granularities



EMCal trigger in p+p run worked!

- Used for p+p π^0 measurement
  - See talk by B. Fox
- Used for p+p J/ψ measurement
  - See talk by H. Sato

EMCal/RICH trigger for high luminosity p+p run

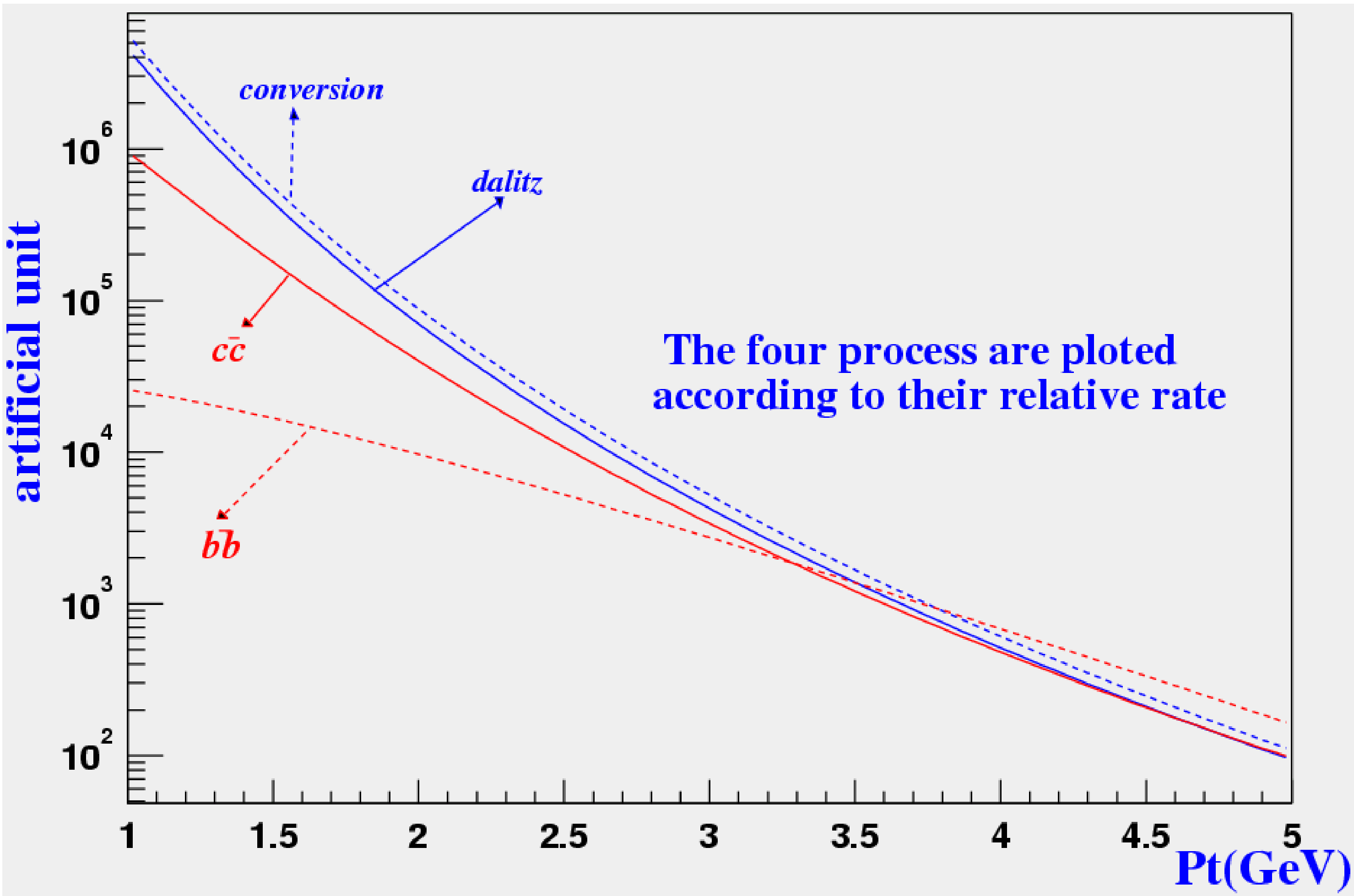
D. Galanakis and W. Xie

Summary

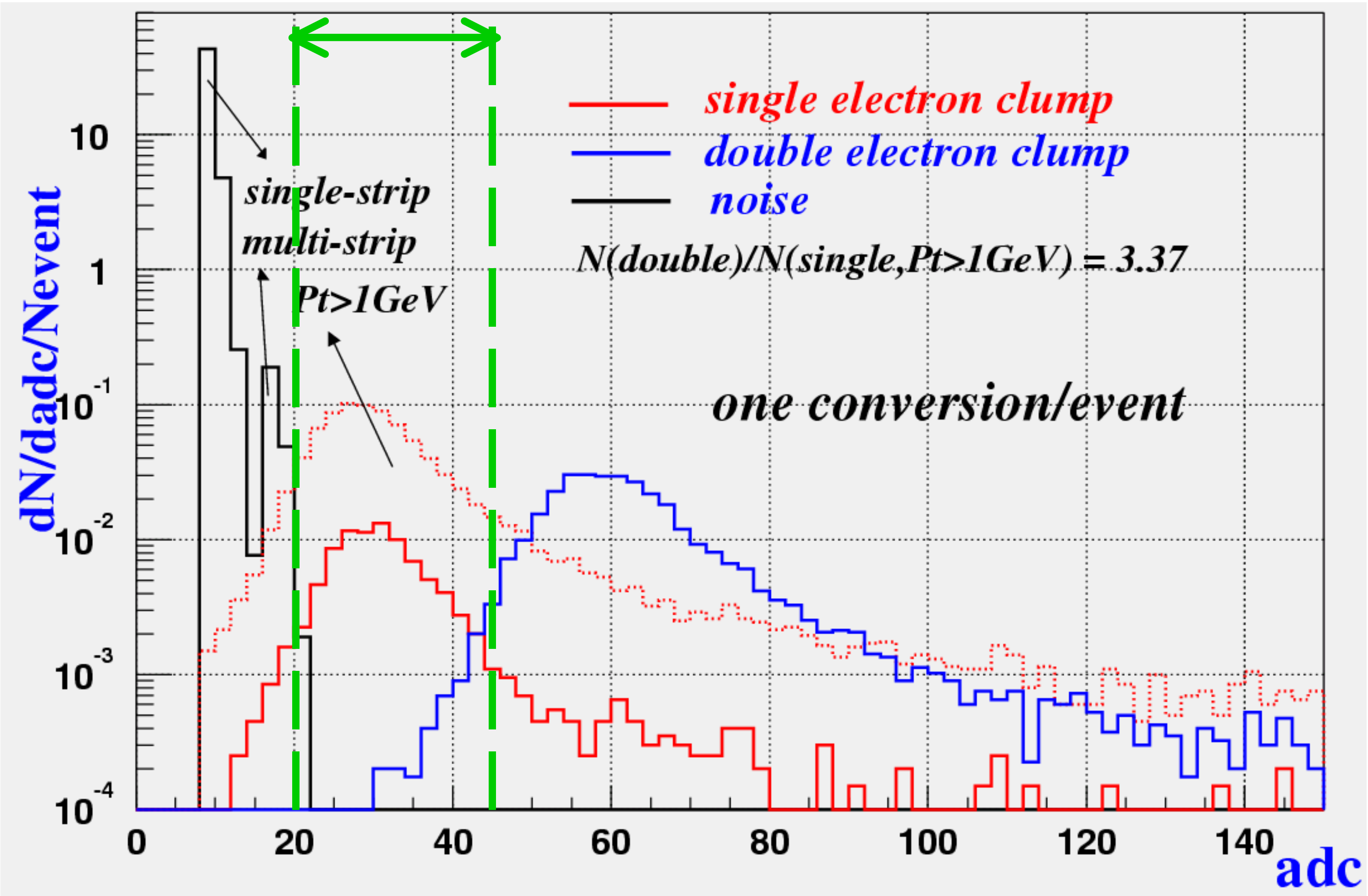
- ✓ ΔG can be measured in PHENIX using single electrons
  - » The background from Dalitz decays and photon conversions can be identified using an inner tracker
- ✓ The additional requirement of a muon allows for an additional ΔG measurement
  - » This measurement helps separate the charm and bottom contributions
- ✓ The heavy flavor channels provide more independent ΔG measurements in PHENIX
  - » Helps control experimental and theoretical systematic errors
  - » Different channels cover different kinematic regions
- ✓ Both of these measurements require a central arm electron trigger
  - » The EMCal trigger worked in this past p+p run
  - » The EMCal/RHIC trigger should be ready for the next run

Extra slides …

Relative rates input to simulation

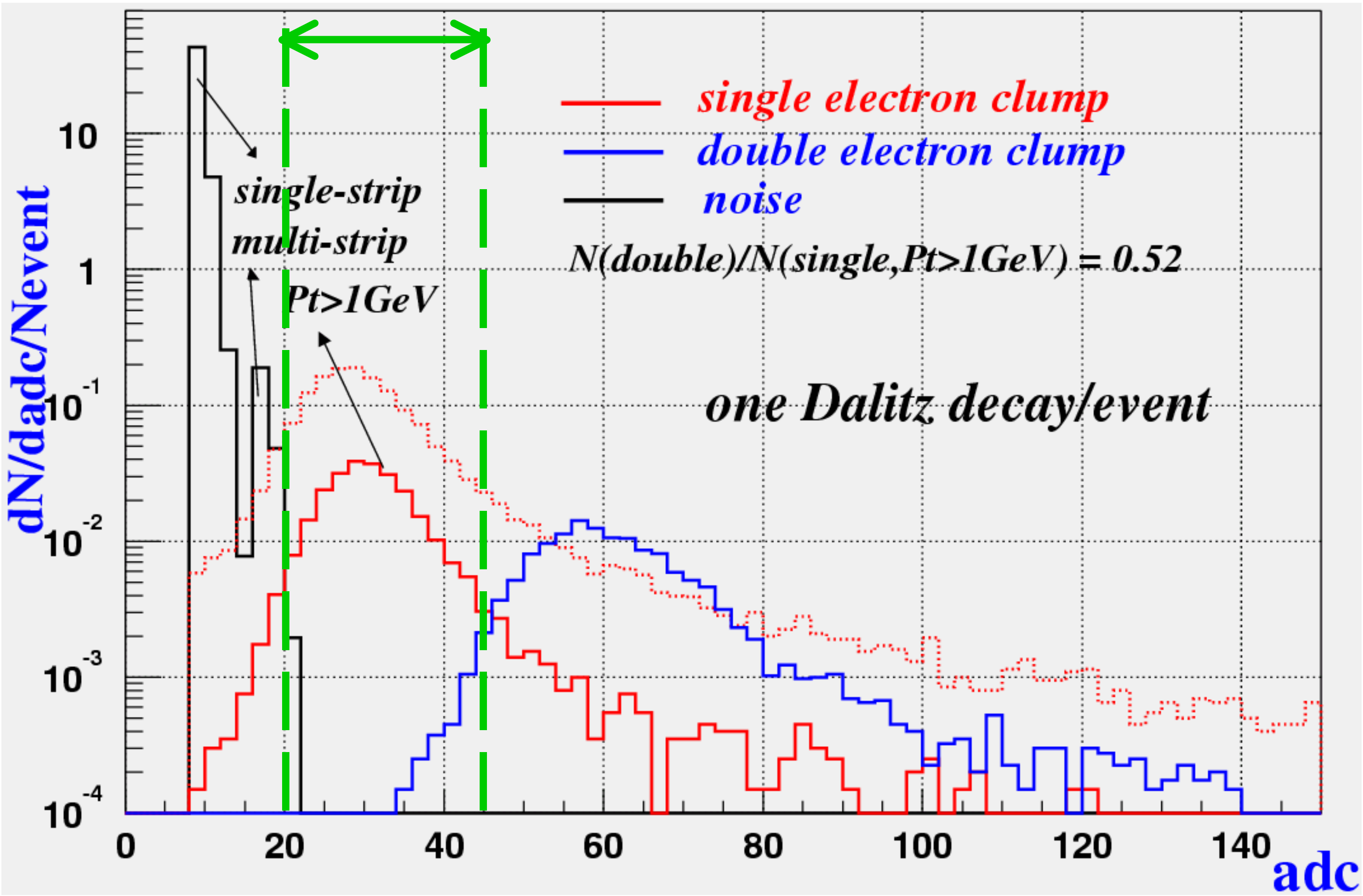


Pulse height cut in MVD



Removes:
- 10% signal
- 30% dalitz
- 70% conv

Pulse height cut in MVD



Removes:

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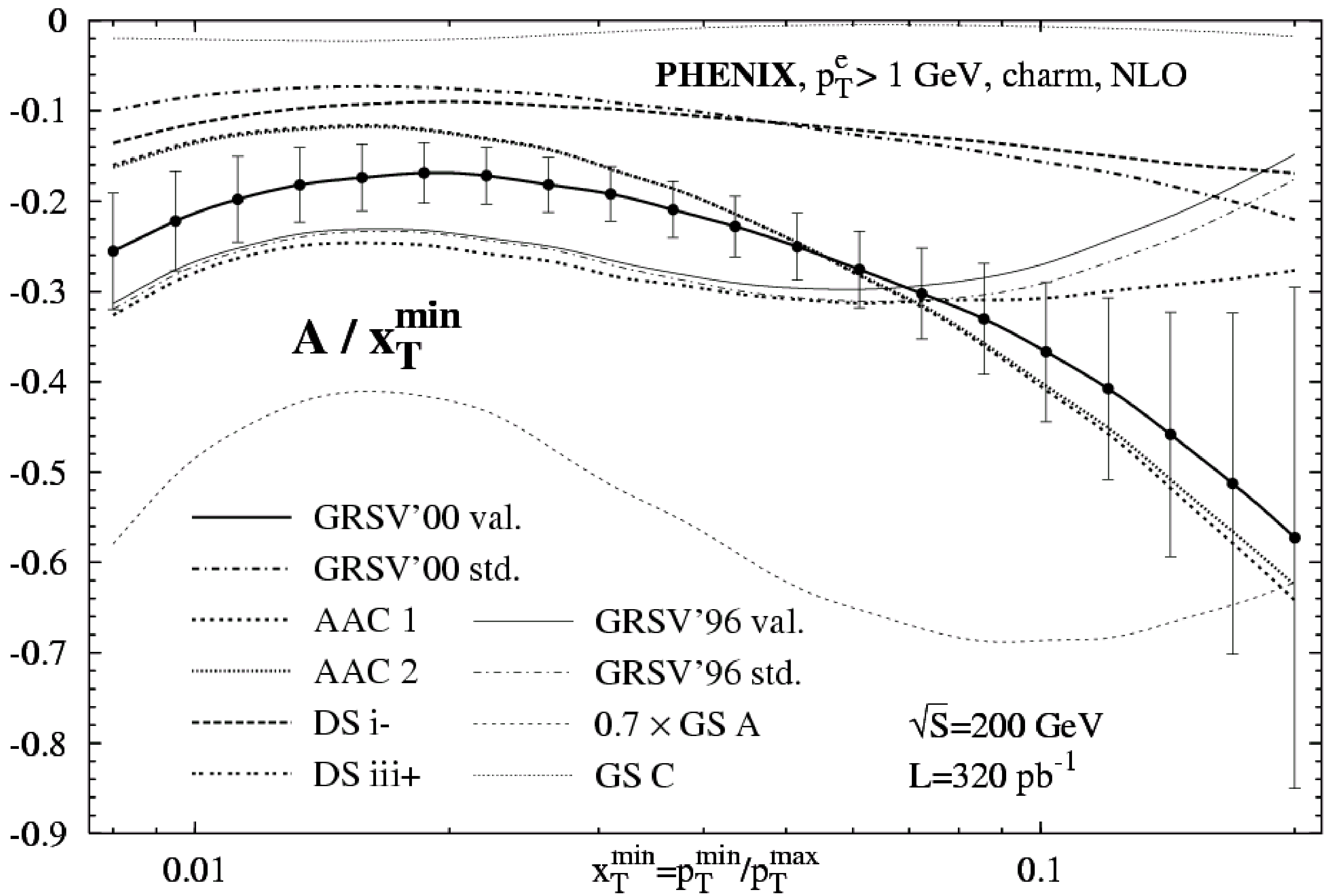
NLO Calculation



I.Bojak, M.Stratmann
hep-ph/0112276

Triggering Needs

The PHENIX trigger was designed for Heavy Ions:

- For Heavy-Ion, data reduction done in Level-2

$$\sqrt{s} = 200 \text{ GeV}, \quad \sigma = 6 \text{ barn}, \quad L = 2 \cdot 10^{26} \text{ cm}^{-2}\text{s}^{-1} \quad \Rightarrow \quad \text{Raw Rate} = 1.2 \text{ KHz}$$

- But in proton-proton interaction rate will be high

$$\sqrt{s} = 500 \text{ GeV}, \quad \sigma = 60 \text{ mbarn}, \quad L = 2 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1} \quad \Rightarrow \quad \text{Raw Rate} = 12 \text{ MHz}$$

- Expected Level-1 DAQ Bandwidth is 12kHz
- Need to be shared among 10 different physics channels
  - *A rejection factor of 10,000 is needed in Level-1 to fully utilize beam*