Determination of ΔG from Open Heavy-Flavor Production*

Melynda Brooks, Joel Moss
Los Alamos National Laboratory

A study has been performed to look at the feasibility of getting a measure of $\Delta G/G$ by measuring the asymmetry in single muon production from heavy quarks, using the PHENIX muon detector. If the dominant production mechanism for heavy-quarks is assumed to be gluon-gluon fusion, then the asymmetry can be written as

$$A_{LL} = \Delta G/G(x_1) * \Delta G/G(x_2) * \hat{a} \quad (1)$$

$$\hat{a} = -(32y^2 - 16y^4 - 8x^2 - 8x^2y^2 + 8x^2y^4 + x^4 - x^4y^4)/ (32 - 32y^2 - 16y^4 + 8x^2 - 8x^2y^2 + 8x^2y^4 + x^2 - x^4y^4) \quad (2)$$

where $x=\sqrt{\bullet}/m_Q$, $\bullet=sx_1x_2$, and $y=\cos(0)$. If the analyzing power, $\hat{a}$, is large then a measurement of the asymmetry in heavy-quark production will provide a sensitive measurement of $\Delta G/G$ at the x_1, x_2 probed by the detector at the given $\sqrt{s}$ running. For the PHENIX muon detector acceptance and $\sqrt{s} = 200$ GeV running, the analyzing power varies and is only found to be consistently large (and negative) at large p_t (>6 GeV) of the measured muon. Therefore, if you want to measure an asymmetry which is sensitive to the polarized gluon structure function, you should measure single muons at large p_t.

A simulation was performed to look at the overall sensitivity of an asymmetry measurement using the PHENIX detector's south muon arm. Muons from b and c quarks were produced using PYTHIA, tuned to match b and c experimental data. A detector acceptance cut was put on the muons, the x_1 and x_2 of the production obtained from PYTHIA, the analyzing power calculated from equation (2), and the resulting asymmetry determined using different polarized gluon structure functions from Gehrmann and Stirling [1] and equation (1). The asymmetry and its statistical error were then examined versus different p_t cuts on the accepted muon. The results showed that for an integrated luminosity of 320 pb^{-1} and p_t>6 GeV, a significant measurement of A_{LL}, $\Delta G/G$ can be obtained which can easily distinguish between the B + C models of Gehrmann and Stirling (see figure from talk).

The background single muons, which come primarily from the decays of pions, kaons, and J/ψs, were also examined and found to be produced well below the level of single muons from b and c for the PHENIX muon acceptance and $\sqrt{s}$=200 GeV. In addition, any contribution to the asymmetry from muons from pion and kaon decay can be examined by looking at the single muons versus the event vertex since the decay muons will preferentially come from events that have a vertex far from the absorber material in front of the muon tracking volume rather than events with a vertex close to the absorber material.

*Talk can be found at:
http://www.rhic.bnl.gov/phenix/WWW/publish/brooks/meetings/spin27apr98/index.htm

*Paper can be found at:
http://www.rhic.bnl.gov/phenix/WWW/muon/working_group/muphysics/single_muon/singlemu.pdf

[1] T. Gehrmann and W. J. Stirling, Z. Phys. C65, 461 (1995).

PHENIX

Determination of ΔG from Open Heavy-Flavor Production

J. Moss*, M. Brooks

How to get a measure of $\Delta G/G$ with single muons

PHENIX Measurement:
- PHENIX muon arms
- Simulations performed to study sensitivity of measurement

PHENIX

Determination of ΔG from Open Heavy-Flavor Production

Heavy quarks (b,c) produced via two-gluon fusion
Quarks produce single muons detected in 1 of the PHENIX muon arms
Asymmetry in production is related to $\Delta G/G$ via the following equations:

$$A_{LL}(x_1, x_2) \cong \frac{\Delta G}{G}(x_1)\frac{\Delta G}{G}(x_2)\,\hat{a}$$

$$\hat{a} = \frac{-(32y^2 - 16y^4 - 8x^2 - 8x^2y^2 + 8x^2y^4 + x^4 + x^4y^4)}{32 - 32y^2 - 16y^4 + 8x^2 - 8x^2y^2 + 8x^2y^4 + x^2 - x^4y^4}$$

$x = \sqrt{\hat{s}}/m_Q$ $\quad$ $\hat{s} = s x_1 x_2$ $\quad$ $y = \cos(\theta)$

If $\hat{a}$ is large enough, A_{LL} measurement is sensitive to $\Delta G/G$.

M. Brooks, 27-Apr-98
Spin Workshop

PHENIX

Simulation of Single Muons

SIGNAL:

Generate charm and beauty events with PYTHIA (σ=200μbarns, 2μbarns, $\sqrt{s}$=200 GeV)

BACKGROUNDS:

Generate pions and kaons using Boggild* parameterization

Generate J/ψ based on work by Vogt** (σB=0.078 μbarns)

Run events through "fast" simulator which includes acceptance of muon arm, simulates π and K decay before the tracking volume

Compare smaller set of events from full PISA/PISORP simulation to "fast" simulator to verify it works well

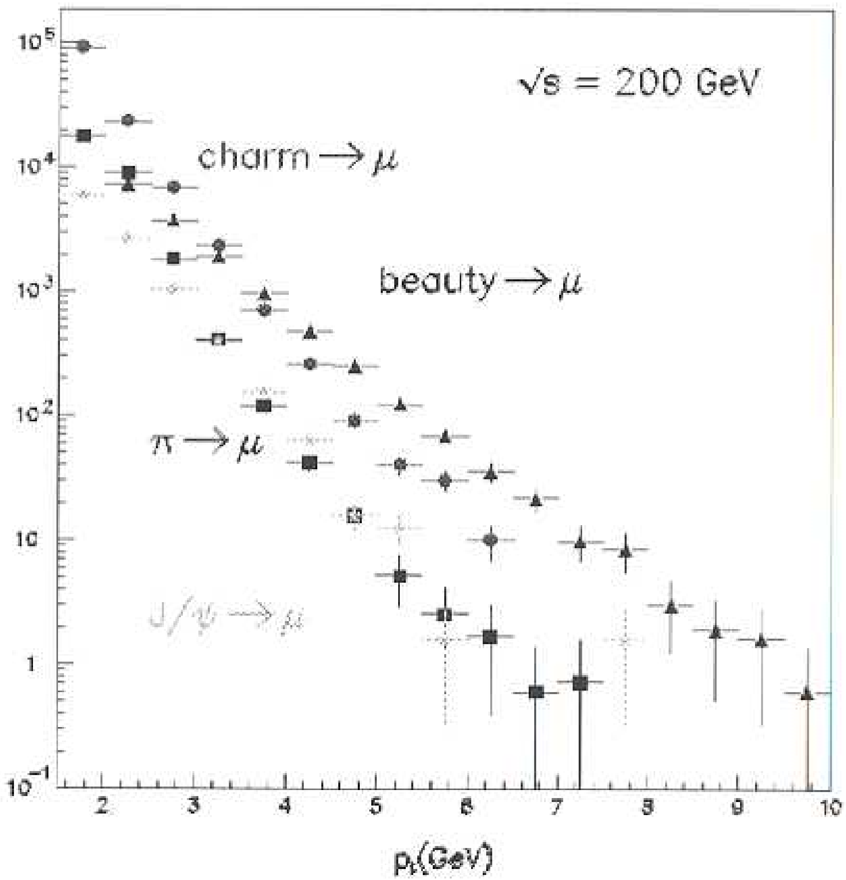
Calculate A_{LL} using x_1, x_2 from event generator for each "accepted" event

Examine versus p_t of accepted muon

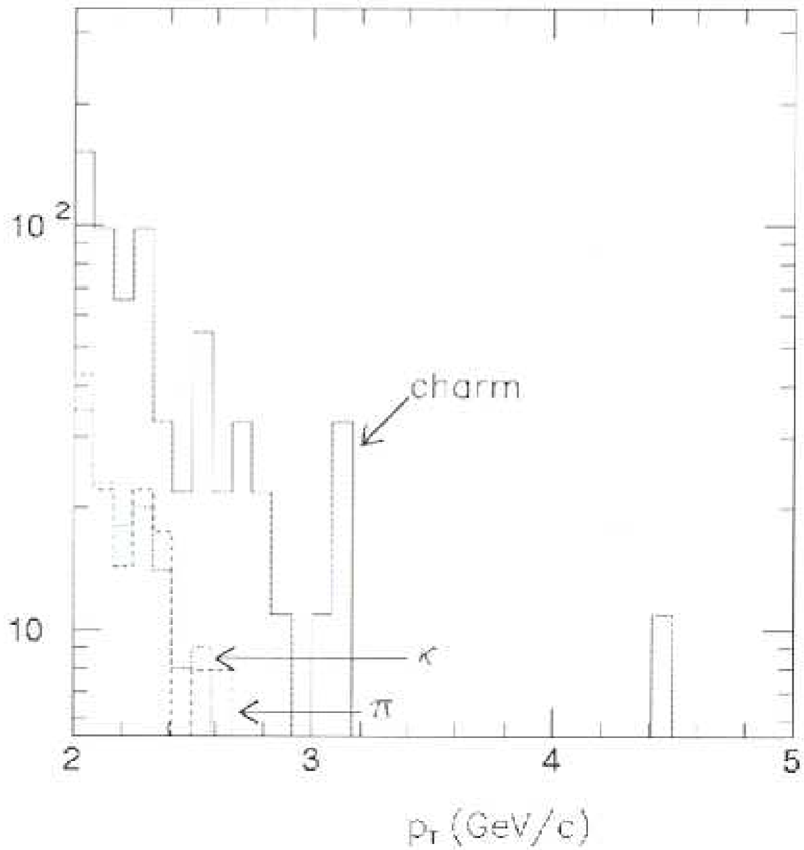
*from private communication with J. Moss

**Atom. Nucl. Data Tabl. 50, 343(1992)

Single muons from heavy quarks and "backgrounds" accepted into South Arm



"Fast" simulator



"Slow" simulator

M. Brooks, 27-Apr-98
Spin Workshop

PHENIX

Production from 10^6 sec at 10% Luminosity

p_t (GeV/c)	charm	beauty
> 2	37300	32500
> 4	700	2370
> 6	21	222

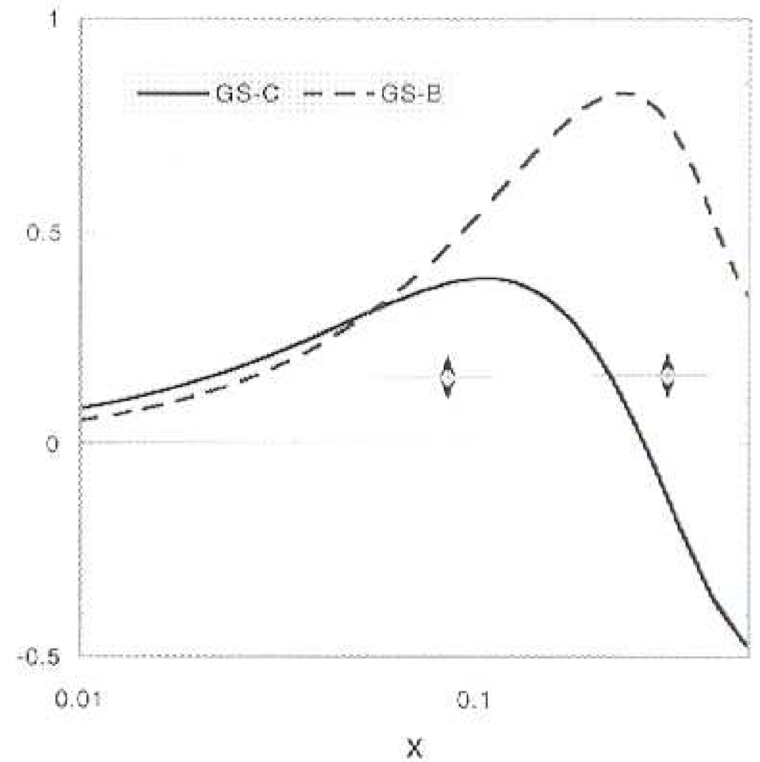
Large production of c, b

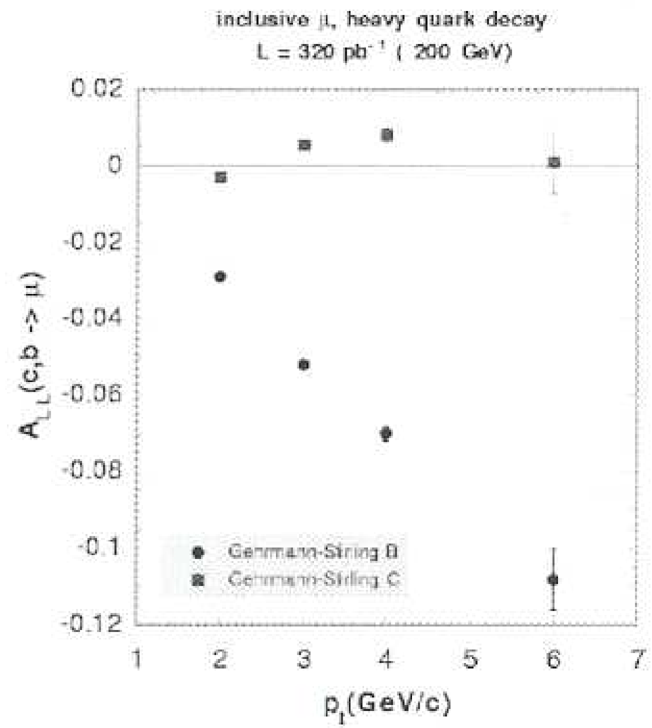
p_t (GeV)	Quark	â	A_{LL} (GS-B)	A_{LL} (GS-C)	δA_{LL}
>2	c	-0.254	-0.044	-0.006	0.01
>2	b	0.146	0.018	0.006	0.01
>5	b	-0.135	-0.032	0.006	0.04
>6	b	-0.501	-0.122	0.020	0.14

Need high p_t to get large â

PHENIX

Asymmetry, ΔG Measurement at full luminosity running





$$A_{LL}(x_1, x_2) \cong \frac{\Delta G}{G}(x_1)\frac{\Delta G}{G}(x_2)\ \hat{a}$$

M. Brooks, 27-Apr-98
Spin Workshop