# HEAVY FLAVOR AND QUARKONIA MEASURED IN PHENIX

CESAR LUIZ DA SILVA
LOS ALAMOS NATIONAL LAB
for the PHENIX Collaboration

Quark Matter 2011 - Annecy, France

# 11 YEARS OF RHIC OPERATION

PHENIX PUBLISHED

11 open heavy flavor papers

10 quarkonia papers

PHENIX

PHYSICAL REVIEW C **69**, 014901 (2004)

### $J/\psi$ production in Au-Au collisions at $\sqrt{s_{NN}}$=200 GeV

S. S. Adler,[5] S. Afanasiev,[17] C. Aidala,[5] N. N. Ajitanand,[43] Y. Akiba,[20,38] J. Alexander,[43] R. Amirikas,[12] L. Aphecetche,[45] S. H. Aronson,[5] R. Averbeck,[44] T. C. Awes,[35] R. Azmoun,[44] V. Babintsev,[15] A. Baldisseri,[10] K. N. Barish,[6] P. D. Barnes,[27] B. Bassalleck,[33] S. Bathe,[30] S. Batsouli,[9] V. Baublis,[37] A. Bazilevsky,[39,15] S. Belikov,[16,15] Y. Berdnikov,[40] S. Bhagavatula,[16] J. G. Boissevain,[27] H. Borel,[10] S. Borenstein,[25] M. L. Brooks,[27] D. S. Brown,[34] N. Bruner,[33] D. Bucher,[30] H. Buesching,[30] V. Bumazhnov,[15] G. Bunce,[5,39] J. M. Burward-Hoy,[26,44] S. Butsyk,[44] X. Camard,[45] J. -S. Chai,[18]

VOLUME 88, NUMBER 19 PHYSICAL REVIEW LETTERS 13 MAY 2002

### Measurement of Single Electrons and Implications for Charm Production in Au + Au Collisions at $\sqrt{s_{NN}}$ = 130 GeV

K. Adcox,[40] S. S. Adler,[3] N. N. Ajitanand,[27] Y. Akiba,[14] J. Alexander,[27] L. Aphecetche,[34] Y. Arai,[14] S. H. Aronson,[3] R. Averbeck,[28] T. C. Awes,[29] K. N. Barish,[5] P. D. Barnes,[19] J. Barrette,[21] B. Bassalleck,[25] S. Bathe,[22] V. Baublis,[30] A. Bazilevsky,[12,32] S. Belikov,[12,13] F. G. Bellaiche,[29] S. T. Belyaev,[16] M. J. Bennett,[19] Y. Berdnikov,[35] S. Botelho,[33] M. L. Brooks,[19] D. S. Brown,[26] N. Bruner,[25] D. Bucher,[22] H. Buesching,[22] V. Bumazhnov,[12] G. Bunce,[3,32]

VOLUME 92, NUMBER 5 PHYSICAL REVIEW LETTERS week ending 6 FEBRUARY 2004

### $J/\psi$ Production from Proton-Proton Collisions at $\sqrt{s}$ = 200 GeV

S. S. Adler,[5] S. Afanasiev,[17] C. Aidala,[5] N. N. Ajitanand,[43] Y. Akiba,[20,38] J. Alexander,[43] R. Amirikas,[12] L. Aphecetche,[45] S. H. Aronson,[5] R. Averbeck,[44] T. C. Awes,[35] R. Azmoun,[44] V. Babintsev,[15] A. Baldisseri,[10] K. N. Barish,[6] P. D. Barnes,[27] B. Bassalleck,[33] S. Bathe,[30] S. Batsouli,[9] V. Baublis,[37] A. Bazilevsky,[39,15] S. Belikov,[16,15] Y. Berdnikov,[40] S. Bhagavatula,[16] J. G. Boissevain,[27] H. Borel,[10] S. Borenstein,[25] M. L. Brooks,[27] D. S. Brown,[34]

PRL **94,** 082301 (2005) PHYSICAL REVIEW LETTERS week ending 4 MARCH 2005

### Centrality Dependence of Charm Production from a Measurement of Single Electrons in Au + Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV

S. S. Adler,[5] S. Afanasiev,[17] C. Aidala,[5] N. N. Ajitanand,[43] Y. Akiba,[20,38] J. Alexander,[43] R. Amirikas,[12] L. Aphecetche,[45] S. H. Aronson,[5] R. Averbeck,[44] T. C. Awes,[35] R. Azmoun,[44] V. Babintsev,[15] A. Baldisseri,[10] K. N. Barish,[6] P. D. Barnes,[27] B. Bassalleck,[33] S. Bathe,[30] S. Batsouli,[9] V. Baublis,[37] A. Bazilevsky,[39,15] S. Belikov,[16,15] Y. Berdnikov,[40] S. Bhagavatula,[16] J. G. Boissevain,[27] H. Borel,[10] S. Borenstein,[25] M. L. Brooks,[27] D. S. Brown,[34] N. Bruner,[33] D. Bucher,[30] H. Buesching,[30] V. Bumazhnov,[15] G. Bunce,[5,39] J. M. Burward-Hoy,[26,44] S. Butsyk,[44] X. Camard,[45] J.-S. Chai,[18] P. Chand,[4]

Physics Letters B 679 (2009) 321–329

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

### Photoproduction of $J/\psi$ and of high mass $e^+e^-$ in ultra-peripheral Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

PHENIX Collaboration

S. Afanasiev [q], C. Aidala [g], N.N. Ajitanand [aq], Y. Akiba [ak,al], J. Alexander [aq], A. Al-Jamel [ag], K. Aoki [w,ak], L. Aphecetche [as], R. Armendariz [ag], S.H. Aronson [c], R. Averbeck [ar], T.C. Awes [ah], B. Azmoun [c], V. Babintsev [1], A. Baldisseri [h], K.N. Barish [d], P.D. Barnes [z], B. Bassalleck [af], S. Bathe [d], S. Batsouli [g], V. Baublis [aj], F. Bauer [d], A. Bazilevsky [c], S. Belikov [c,p,1], R. Bennett [ar], Y. Berdnikov [an], M.T. Bjorndal [g], J.G. Boissevain [z], H. Borel [h], K. Boyle [ar], M.L. Brooks [z], D.S. Brown [ag], D. Bucher [ac], H. Buesching [c], V. Bumazhnov [n], G. Bunce [c,al],

PRL **103,** 082002 (2009) PHYSICAL REVIEW LETTERS week ending 21 AUGUST 2009

### Measurement of Bottom Versus Charm as a Function of Transverse Momentum with Electron-Hadron Correlations in $p + p$ Collisions at $\sqrt{s}$ = 200 GeV

A. Adare,[11] S. Afanasiev,[25] C. Aidala,[12,36] N. N. Ajitanand,[53] Y. Akiba,[47,48] H. Al-Bataineh,[42] J. Alexander,[53] K. Aoki,[30,47] L. Aphecetche,[55] R. Armendariz,[42] S. H. Aronson,[6] J. Asai,[47,48] E. T. Atomssa,[31] R. Averbeck,[54] T. C. Awes,[43] B. Azmoun,[6] V. Babintsev,[21] M. Bai,[5] G. Baksay,[17] L. Baksay,[17] A. Baldisseri,[14] K. N. Barish,[7] P. D. Barnes,[33] B. Bassalleck,[41] A. T. Basye,[1] S. Bathe,[7] S. Batsouli,[43] V. Baublis,[46] C. Baumann,[37] A. Bazilevsky,[6] S. Belikov,[6,*] R. Bennett,[54] A. Berdnikov,[50] Y. Berdnikov,[50] A. A. Bickley,[11] J. G. Boissevain,[33] H. Borel,[14] K. Boyle,[54] M. L. Brooks,[33] H. Buesching,[6] V. Bumazhnov,[21] G. Bunce,[6,48] S. Butsyk,[33,54] C. M. Camacho,[33] S. Campbell,[54] B. S. Chang,[62]

PRL **98,** 172301 (2007) PHYSICAL REVIEW LETTERS week ending 27 APRIL 2007

### Energy Loss and Flow of Heavy Quarks in Au + Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV

A. Adare,[8] S. Afanasiev,[22] C. Aidala,[9] N. N. Ajitanand,[49] Y. Akiba,[43,44] H. Al-Bataineh,[38] J. Alexander,[49] A. Al-Jamel,[38] K. Aoki,[28,43] L. Aphecetche,[51] R. Armendariz,[38] S. H. Aronson,[3] J. Asai,[44] E. T. Atomssa,[29] R. Averbeck,[50] T. C. Awes,[39] B. Azmoun,[3] V. Babintsev,[18] G. Baksay,[14] L. Baksay,[14] A. Baldisseri,[11] K. N. Barish,[4] P. D. Barnes,[31] B. Bassalleck,[37] S. Bathe,[4] S. Batsouli,[9,39] V. Baublis,[42] F. Bauer,[4] A. Bazilevsky,[3] S. Belikov,[3,21] R. Bennett,[50] Y. Berdnikov,[46] A. A. Bickley,[8] M. T. Bjorndal,[9] J. G. Boissevain,[31] H. Borel,[11] K. Boyle,[50] M. L. Brooks,[31] D. S. Brown,[38] D. Bucher,[34] H. Buesching,[3] V. Bumazhnov,[18] G. Bunce,[3,44] J. M. Burward-Hoy,[31] S. Butsyk,[31,50] S. Campbell,[50] J.-S. Chai,[23] B. S. Chang,[58] J.-L. Charvet,[11] S. Chernichenko,[18] J. Chiba,[24] C. Y. Chi,[9] M. Chiu,[9,19] I. J. Choi,[58] T. Chujo,[55] P. Chung,[49] A. Churyn,[18] V. Cianciolo,[39] C. R. Cleven,[16] Y. Cobigo,[11] B. A. Cole,[9] M. P. Comets,[40] P. Constantin,[21,31] M. Csanád,[13]

PRL **98,** 232301 (2007) PHYSICAL REVIEW LETTERS week ending 8 JUNE 2007

### $J/\psi$ Production versus Centrality, Transverse Momentum, and Rapidity in Au + Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV

A. Adare,[8] S. Afanasiev,[22] C. Aidala,[9] N. N. Ajitanand,[49] Y. Akiba,[43,44] H. Al-Bataineh,[38] J. Alexander,[49] A. Al-Jamel,[38] K. Aoki,[28,43] L. Aphecetche,[51] R. Armendariz,[38] S. H. Aronson,[3] J. Asai,[44] E. T. Atomssa,[29] R. Averbeck,[50] T. C. Awes,[39] B. Azmoun,[3] V. Babintsev,[18] G. Baksay,[14] L. Baksay,[14] A. Baldisseri,[11] K. N. Barish,[4] P. D. Barnes,[31] B. Bassalleck,[37] S. Bathe,[4] S. Batsouli,[9,39] V. Baublis,[42] F. Bauer,[4] A. Bazilevsky,[3] S. Belikov,[3,21] R. Bennett,[50] Y. Berdnikov,[46] A. A. Bickley,[8] M. T. Bjorndal,[9] J. G. Boissevain,[31] H. Borel,[11] K. Boyle,[50] M. L. Brooks,[31] D. S. Brown,[38] D. Bucher,[34] H. Buesching,[3] V. Bumazhnov,[18] G. Bunce,[3,44] J. M. Burward-Hoy,[31] S. Butsyk,[31,50] S. Campbell,[50] J.-S. Chai,[23] B. S. Chang,[58] J.-L. Charvet,[11] S. Chernichenko,[18] J. Chiba,[24] C. Y. Chi,[9] M. Chiu,[9,19] I. J. Choi,[58] T. Chujo,[55] P. Chung,[49] A. Churyn,[18] V. Cianciolo,[39] C. R. Cleven,[16] Y. Cobigo,[11] B. A. Cole,[9] M. P. Comets,[40] P. Constantin,[21,31] M. Csanád,[13]

PRL **98,** 232002 (2007) PHYSICAL REVIEW LETTERS week ending 8 JUNE 2007

### $J/\psi$ Production versus Transverse Momentum and Rapidity in $p + p$ Collisions at $\sqrt{s}$ = 200 GeV

A. Adare,[8] S. Afanasiev,[22] C. Aidala,[9] N. N. Ajitanand,[48] Y. Akiba,[42,43] H. Al-Bataineh,[37] J. Alexander,[48] K. Aoki,[27,42] L. Aphecetche,[50] R. Armendariz,[37] S. H. Aronson,[3] J. Asai,[43] E. T. Atomssa,[28] R. Averbeck,[49] T. C. Awes,[38] B. Azmoun,[3] V. Babintsev,[18] G. Baksay,[14] L. Baksay,[14] A. Baldisseri,[11] K. N. Barish,[4] P. D. Barnes,[30] B. Bassalleck,[36] S. Bathe,[4] S. Batsouli,[38] V. Baublis,[41] A. Bazilevsky,[3] S. Belikov,[3] R. Bennett,[49] Y. Berdnikov,[45] A. A. Bickley,[8] J. G. Boissevain,[30] H. Borel,[11] K. Boyle,[49] M. L. Brooks,[30] H. Buesching,[3] V. Bumazhnov,[18] G. Bunce,[3,43] S. Butsyk,[30,49] S. Campbell,[49]

PRL **101,** 122301 (2008) PHYSICAL REVIEW LETTERS week ending 19 SEPTEMBER 2008

### $J/\psi$ Production in $\sqrt{s_{NN}}$ = 200 GeV Cu + Cu Collisions

A. Adare,[8] S. Afanasiev,[22] C. Aidala,[9] N. N. Ajitanand,[48] Y. Akiba,[42,43] H. Al-Bataineh,[37] J. Alexander,[48] K. Aoki,[27,42] L. Aphecetche,[50] R. Armendariz,[37] S. H. Aronson,[3] J. Asai,[43] E. T. Atomssa,[28] R. Averbeck,[49] T. C. Awes,[38] B. Azmoun,[3] V. Babintsev,[18] G. Baksay,[14] L. Baksay,[14] A. Baldisseri,[11] K. N. Barish,[4] P. D. Barnes,[30] B. Bassalleck,[36] S. Bathe,[4] S. Batsouli,[38] V. Baublis,[41] A. Bazilevsky,[3] S. Belikov,[3,*] R. Bennett,[49] Y. Berdnikov,[45] A. A. Bickley,[8] J. G. Boissevain,[30] H. Borel,[11] K. Boyle,[49] M. L. Brooks,[30] H. Buesching,[3] V. Bumazhnov,[18] G. Bunce,[3,43] S. Butsyk,[30,49] S. Campbell,[49] B. S. Chang,[57] J.-L. Charvet,[11] S. Chernichenko,[18] J. Chiba,[23] C. Y. Chi,[9] M. Chiu,[19] I. J. Choi,[57] T. Chujo,[54] P. Chung,[48] A. Churyn,[18] V. Cianciolo,[38] C. R. Cleven,[16] B. A. Cole,[9] M. P. Comets,[39] P. Constantin,[30] M. Csanád,[13] T. Csörgő,[24] T. Dahms,[49] K. Das,[15] G. David,[3] M. B. Deaton,[1] K. Dehmelt,[14] H. Delagrange,[50] A. Denisov,[18] D. d'Enterria,[9]

PHYSICAL REVIEW D **82,** 012001 (2010)

### Transverse momentum dependence of $J/\psi$ polarization at midrapidity in $p + p$ collisions at $\sqrt{s}$ = 200 GeV

A. Adare,[11] S. Afanasiev,[25] C. Aidala,[36] N. N. Ajitanand,[53] Y. Akiba,[47,48] H. Al-Bataineh,[42] J. Alexander,[53] K. Aoki,[30,47] L. Aphecetche,[55] J. Asai,[47] E. T. Atomssa,[31] R. Averbeck,[54] T. C. Awes,[43] B. Azmoun,[6] V. Babintsev,[21] M. Bai,[5] G. Baksay,[17] L. Baksay,[17] A. Baldisseri,[14] K. N. Barish,[7] P. D. Barnes,[33] B. Bassalleck,[41] A. T. Basye,[1] S. Bathe,[7] S. Batsouli,[43] V. Baublis,[46] C. Baumann,[37] A. Bazilevsky,[6] S. Belikov,[6,*] R. Bennett,[54] A. Berdnikov,[50] Y. Berdnikov,[50] A. A. Bickley,[11] J. G. Boissevain,[33] H. Borel,[14] K. Boyle,[54] M. L. Brooks,[33] H. Buesching,[6] V. Bumazhnov,[21] G. Bunce,[6,48] S. Butsyk,[33] C. M. Camacho,[33] S. Campbell,[54] B. S. Chang,[62] W. C. Chang,[2] J.-L. Charvet,[14] S. Chernichenko,[21] C. Y. Chi,[12] M. Chiu,[22] I. J. Choi,[62] R. K. Choudhury,[4] T. Chujo,[58] P. Chung,[53] A. Churyn,[21] V. Cianciolo,[43] Z. Citron,[54] B. A. Cole,[12] Z. Conesa del Valle,[31] P. Constantin,[33] M. Csanád,[16] T. Csörgő,[27] T. Dahms,[54] S. Dairaku,[30,47] K. Das,[18] G. David,[6] A. Denisov,[21] D. d'Enterria,[31] A. Deshpande,[48,54] E. J. Desmond,[6] O. Dietzsch,[51] A. Dion,[54] M. Donadelli,[51] O. Drapier,[31] A. Drees,[54] K. A. Drees,[5] A. K. Dubey,[61] A. Durum,[21] D. Dutta,[4] V. Dzhordzhadze,[7] Y. V. Efremenko,[43] F. Ellinghaus,[11] T. Engelmore,[12] A. Enokizono,[32] H. En'yo,[47,48] S. Esumi,[58] K. O. Eyser,[7] B. Fadem,[38] D. E. Fields,[41,48]

PRL **96,** 012304 (2006) PHYSICAL REVIEW LETTERS week ending 13 JANUARY 2006

### $J/\psi$ Production and Nuclear Effects for $d$ + Au and $p + p$ Collisions at $\sqrt{s_{NN}}$ = 200 GeV

S. S. Adler,[5] S. Afanasiev,[20] C. Aidala,[10] N. N. Ajitanand,[44] Y. Akiba,[21,40] A. Al-Jamel,[35] J. Alexander,[44] K. Aoki,[25] L. Aphecetche,[46] R. Armendariz,[35] S. H. Aronson,[5] E. T. Atomssa,[26] R. Averbeck,[45] T. C. Awes,[36] V. Babintsev,[17] A. Baldisseri,[11] K. N. Barish,[6] P. D. Barnes,[28] B. Bassalleck,[34] S. Bathe,[6,31] S. Batsouli,[10] V. Baublis,[39] F. Bauer,[6] A. Bazilevsky,[5,41] S. Belikov,[19,17] M. T. Bjorndal,[10] J. G. Boissevain,[28] H. Borel,[11] M. L. Brooks,[28] D. S. Brown,[35] N. Bruner,[34] D. Bucher,[31] H. Buesching,[5,31] V. Bumazhnov,[17] G. Bunce,[5,41] J. M. Burward-Hoy,[28,27] S. Butsyk,[45] X. Camard,[46] P. Chand,[4] W. C. Chang,[2] S. Chernichenko,[17] C. Y. Chi,[10] J. Chiba,[21] M. Chiu,[10] I. J. Choi,[53] R. K. Choudhury,[4] T. Chujo,[5] V. Cianciolo,[36] Y. Cobigo,[11] B. A. Cole,[10] M. P. Comets,[37] P. Constantin,[19] M. Csanád,[13]

PRL **96,** 032001 (2006) PHYSICAL REVIEW LETTERS week ending 27 JANUARY 2006

### Single Electrons from Heavy-Flavor Decays in $p + p$ Collisions at $\sqrt{s}$ = 200 GeV

S. Adler,[5] S. Afanasiev,[17] C. Aidala,[5] N. N. Ajitanand,[43] Y. Akiba,[20,38] J. Alexander,[43] R. Amirikas,[12] L. Aphecetche,[45] S. H. Aronson,[5] R. Averbeck,[44] T. C. Awes,[35] R. Azmoun,[44] V. Babintsev,[15] A. Baldisseri,[10] K. N. Barish,[6] P. D. Barnes,[27] B. Bassalleck,[33] S. Bathe,[30] S. Batsouli,[9] V. Baublis,[37] A. Bazilevsky,[39,15] S. Belikov,[16,15] Y. Berdnikov,[40] S. Bhagavatula,[16] J. G. Boissevain,[27] H. Borel,[10] S. Borenstein,[25] M. L. Brooks,[27] D. S. Brown,[34] N. Bruner,[33] D. Bucher,[30] H. Buesching,[30] V. Bumazhnov,[15] G. Bunce,[5,39] J. M. Burward-Hoy,[26,44] S. Butsyk,[44] X. Camard,[45] J.-S. Chai,[18] P. Chand,[4] W. C. Chang,[2] S. Chernichenko,[15] C. Y. Chi,[9] J. Chiba,[20] M. Chiu,[9] I. J. Choi,[52] J. Choi,[19] R. K. Choudhury,[4] T. Chujo,[5]

PRL **97,** 252002 (2006) PHYSICAL REVIEW LETTERS week ending 22 DECEMBER 2006

### Measurement of High-$p_T$ Single Electrons from Heavy-Flavor Decays in $p + p$ Collisions at $\sqrt{s}$ = 200 GeV

A. Adare,[8] S. Afanasiev,[22] C. Aidala,[9] N. N. Ajitanand,[48] Y. Akiba,[42,43] H. Al-Bataineh,[37] J. Alexander,[48] K. Aoki,[27,42] L. Aphecetche,[50] R. Armendariz,[37] S. H. Aronson,[3] J. Asai,[43] E. T. Atomssa,[28] R. Averbeck,[49] T. C. Awes,[38] B. Azmoun,[3] V. Babintsev,[18] G. Baksay,[14] L. Baksay,[14] A. Baldisseri,[11] K. N. Barish,[4] P. D. Barnes,[30] B. Bassalleck,[36] S. Bathe,[4] S. Batsouli,[38] V. Baublis,[41] A. Bazilevsky,[3] S. Belikov,[3] R. Bennett,[49] Y. Berdnikov,[45] A. A. Bickley,[8] J. G. Boissevain,[30] H. Borel,[11] K. Boyle,[49] M. L. Brooks,[30] H. Buesching,[3] V. Bumazhnov,[18] G. Bunce,[3,43] S. Butsyk,[30,49] S. Campbell,[49]

PHYSICAL REVIEW D **76,** 092002 (2007)

### Measurement of single muons at forward rapidity in $p + p$ collisions at $\sqrt{s}$ = 200 GeV and implications for charm production

S. S. Adler,[5] S. Afanasiev,[17] C. Aidala,[5] N. N. Ajitanand,[43] Y. Akiba,[20,38] J. Alexander,[43] R. Amirikas,[12] L. Aphecetche,[45] S. H. Aronson,[5] R. Averbeck,[44] T. C. Awes,[35] R. Azmoun,[44] V. Babintsev,[15] A. Baldisseri,[10] K. N. Barish,[6] P. D. Barnes,[27] B. Bassalleck,[33] S. Bathe,[30] S. Batsouli,[9] V. Baublis,[37] A. Bazilevsky,[39,15] S. Belikov,[16,15,*] Y. Berdnikov,[40] S. Bhagavatula,[16] J. G. Boissevain,[27] H. Borel,[10] S. Borenstein,[25] M. L. Brooks,[27] D. S. Brown,[34] N. Bruner,[33] D. Bucher,[30] H. Buesching,[30] V. Bumazhnov,[15] G. Bunce,[5,39] J. M. Burward-Hoy,[26,44] S. Butsyk,[44] X. Camard,[45] J.-S. Chai,[18] P. Chand,[4] W. C. Chang,[2] S. Chernichenko,[15] C. Y. Chi,[9] J. Chiba,[20] M. Chiu,[9] I. J. Choi,[52] J. Choi,[19] R. K. Choudhury,[4] T. Chujo,[5] V. Cianciolo,[35] Y. Cobigo,[10] B. A. Cole,[9] P. Constantin,[16] D. d'Enterria,[45] G. David,[5] H. Delagrange,[45] A. Denisov,[15]

PHYSICAL REVIEW C **77,** 024912 (2008)

### Cold nuclear matter effects on $J/\psi$ production as constrained by deuteron-gold measurements at $\sqrt{s_{NN}}$ = 200 GeV

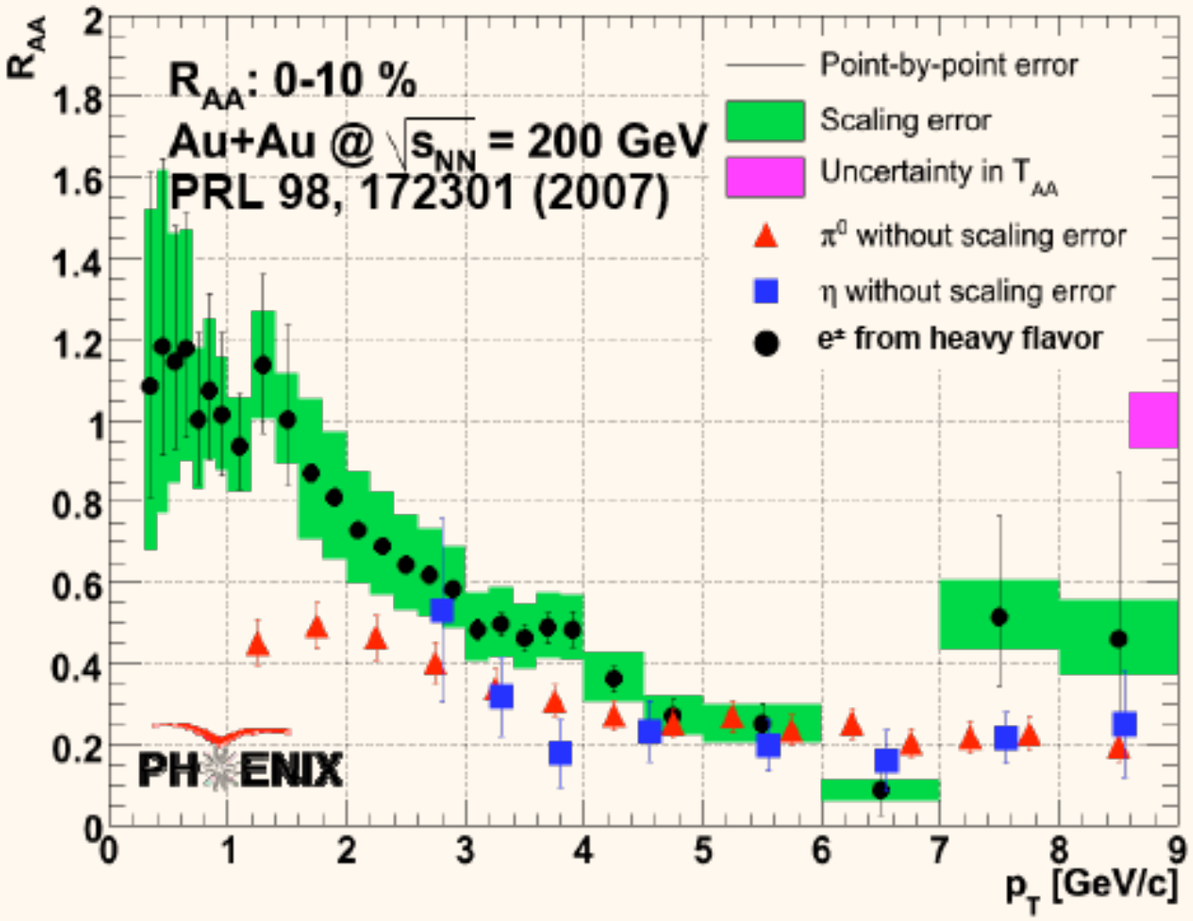
A. Adare,[10] S. S. Adler,[5] S. Afanasiev,[24] C. Aidala,[11] N. N. Ajitanand,[50] Y. Akiba,[25,44,45] H. Al-Bataineh,[39] J. Alexander,[50] A. Al-Jamel,[39] K. Aoki,[29,44] L. Aphecetche,[52] R. Armendariz,[39] S. H. Aronson,[5] J. Asai,[45] E. T. Atomssa,[30] R. Averbeck,[51] T. C. Awes,[40] B. Azmoun,[5] V. Babintsev,[20] G. Baksay,[16] L. Baksay,[16] A. Baldisseri,[13] K. N. Barish,[6] P. D. Barnes,[32] B. Bassalleck,[38] S. Bathe,[6,35] S. Batsouli,[11,40] V. Baublis,[43] F. Bauer,[6] A. Bazilevsky,[5,45] S. Belikov,[5,*] R. Bennett,[51] Y. Berdnikov,[47] A. A. Bickley,[10] M. T. Bjorndal,[11] J. G. Boissevain,[32] H. Borel,[13] K. Boyle,[51] M. L. Brooks,[32] D. S. Brown,[39] N. Bruner,[38] D. Bucher,[35] H. Buesching,[5,35] V. Bumazhnov,[20] G. Bunce,[5,45] J. M. Burward-Hoy,[31,32] S. Butsyk,[32,51] X. Camard,[52] S. Campbell,[51] P. Chand,[4] B. S. Chang,[59] W. C. Chang,[2] J.-L. Charvet,[13] S. Chernichenko,[20] J. Chiba,[25] Y. Chi,[11] M. Chiu,[11,21] I. J. Choi,[59] R. K. Choudhury,[4] T. Chujo,[5,56] P. Chung,[50] A. Churyn,[20] V. Cianciolo,[40] C. R. Cleven,[16] Y. Cobigo,[13] B. A. Cole,[11] M. P. Comets,[41] P. Constantin,[23,32] M. Csanád,[15] T. Csörgő,[26] J. P. Cussonneau,[52] T. Dahms,[51] K. Das,[17] G. David,[5] F. Deák,[15] M. B. Deaton,[1] K. Dehmelt,[16] H. Delagrange,[52] A. Denisov,[20] D. d'Enterria,[11] Deshpande,[45,51] E. J. Desmond,[5] A. Devismes,[51] O. Dietzsch,[48] A. Dion,[51] M. Donadelli,[48] J. L. Drachenberg,[1] O. Drapier,[13] Drees,[51] A. K. Dubey,[58] A. Durum,[20] D. Dutta,[4] V. Dzhordzhadze,[6,53] Y. V. Efremenko,[40] J. Egdemir,[51] F. Ellinghaus,[10]

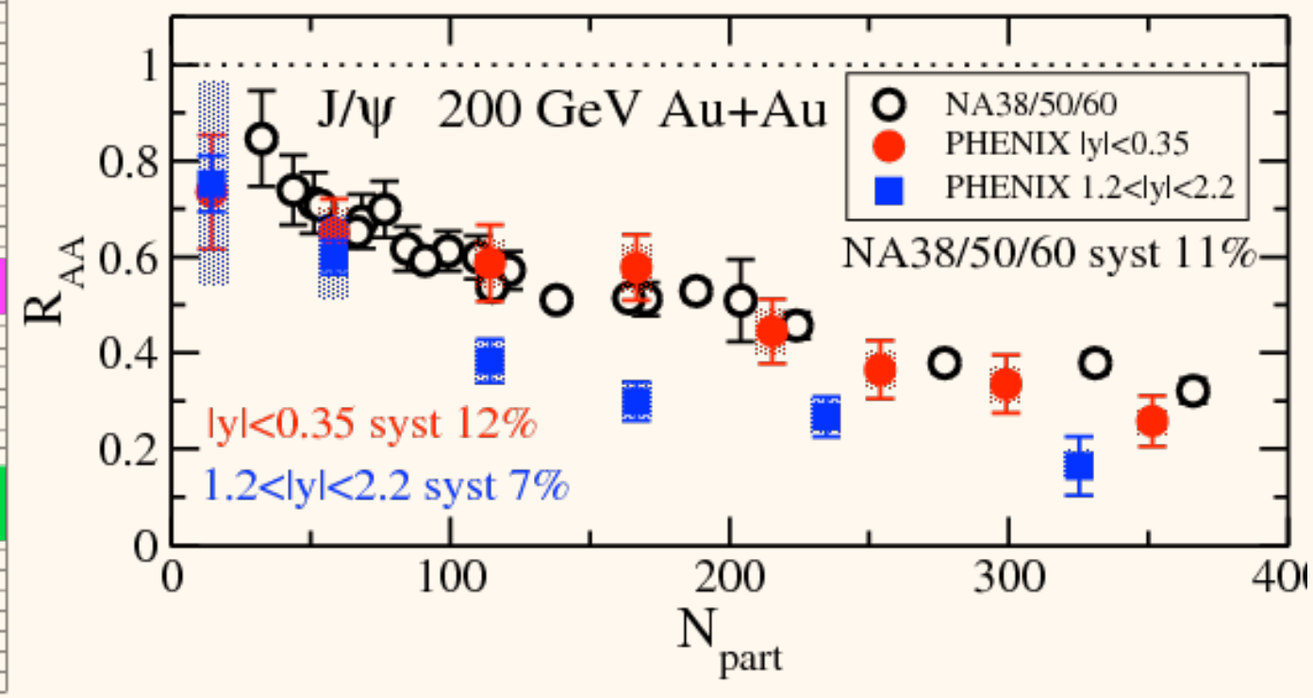
PHYSICAL REVIEW C **83,** 044912 (2011)

### Azimuthal correlations of electrons from heavy-flavor decay with hadrons in $p+p$ and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

A. Adare,[12] S. Afanasiev,[28] C. Aidala,[41] N. N. Ajitanand,[58] Y. Akiba,[52,53] H. Al-Bataineh,[47] J. Alexander,[58] K. Aoki,[34,52] L. Aphecetche,[60] Y. Aramaki,[11] J. Asai,[52] E. T. Atomssa,[35] R. Averbeck,[59] T. C. Awes,[48] B. Azmoun,[6] V. Babintsev,[23] M. Bai,[5] G. Baksay,[19] L. Baksay,[19] A. Baldisseri,[15] K. N. Barish,[7] P. D. Barnes,[37] B. Bassalleck,[46] A. T. Basye,[1] S. Bathe,[7] S. Batsouli,[48] V. Baublis,[51] C. Baumann,[42] A. Bazilevsky,[6] S. Belikov,[6,*] R. Belmont,[64] R. Bennett,[59] A. Berdnikov,[55] Y. Berdnikov,[55] A. A. Bickley,[12] J. G. Boissevain,[37] J. S. Bok,[67] H. Borel,[15] K. Boyle,[59] M. L. Brooks,[37] H. Buesching,[6] V. Bumazhnov,[23] G. Bunce,[6,53] S. Butsyk,[37] C. M. Camacho,[37] S. Campbell,[59] B. S. Chang,[67] W. C. Chang,[2] J.-L. Charvet,[15] C.-H. Chen,[59] S. Chernichenko,[23] C. Y. Chi,[13] M. Chiu,[6,24] I. J. Choi,[67] R. K. Choudhury,[4] P. Christiansen,[39] T. Chujo,[63] P. Chung,[58] A. Churyn,[23] O. Chvala,[7] V. Cianciolo,[48] Z. Citron,[59] B. A. Cole,[13] M. Connors,[59] P. Constantin,[37] M. Csanád,[17] T. Csörgő,[31] T. Dahms,[59] S. Dairaku,[34,52] I. Danchev,[64] K. Das,[20] A. Datta,[41] G. David,[6] A. Denisov,[23] D. d'Enterria,[35] A. Deshpande,[53,59] E. J. Desmond,[6] O. Dietzsch,[56] A. Dion,[59] M. Donadelli,[56] O. Drapier,[35] A. Drees,[59] K. A. Drees,[5] A. K. Dubey,[66]

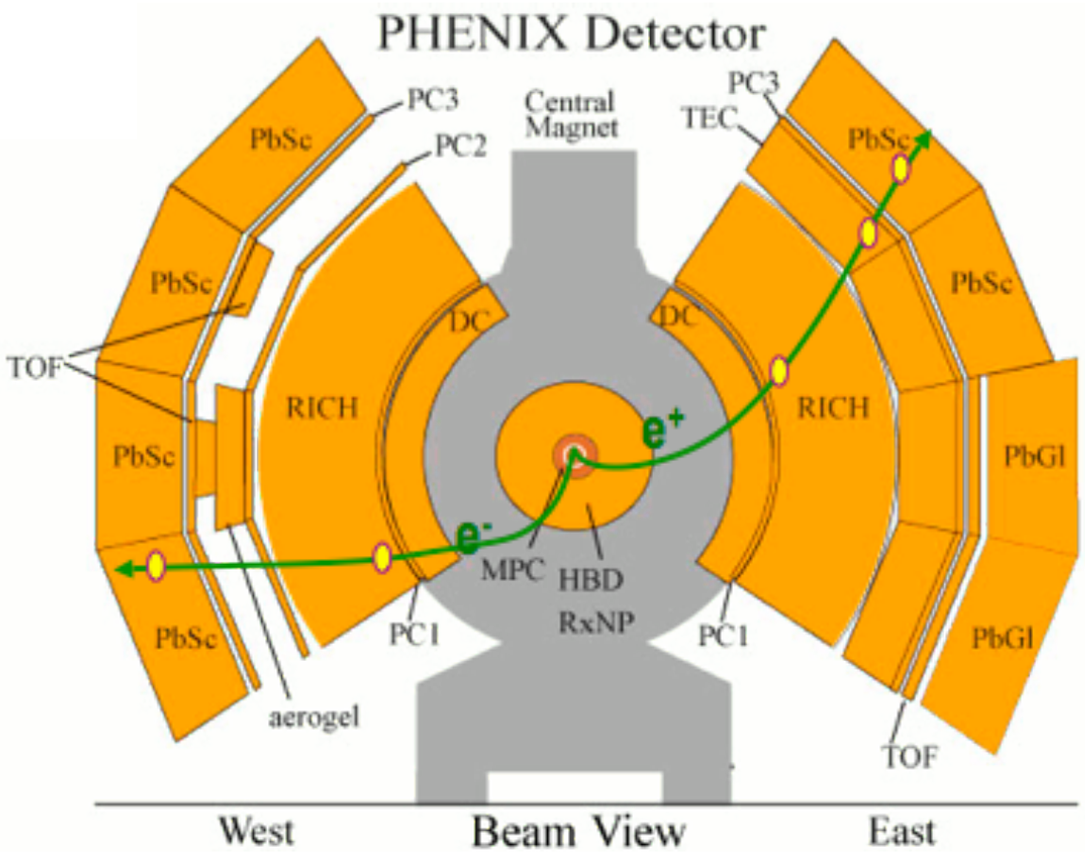
# ... and two BIG surprises



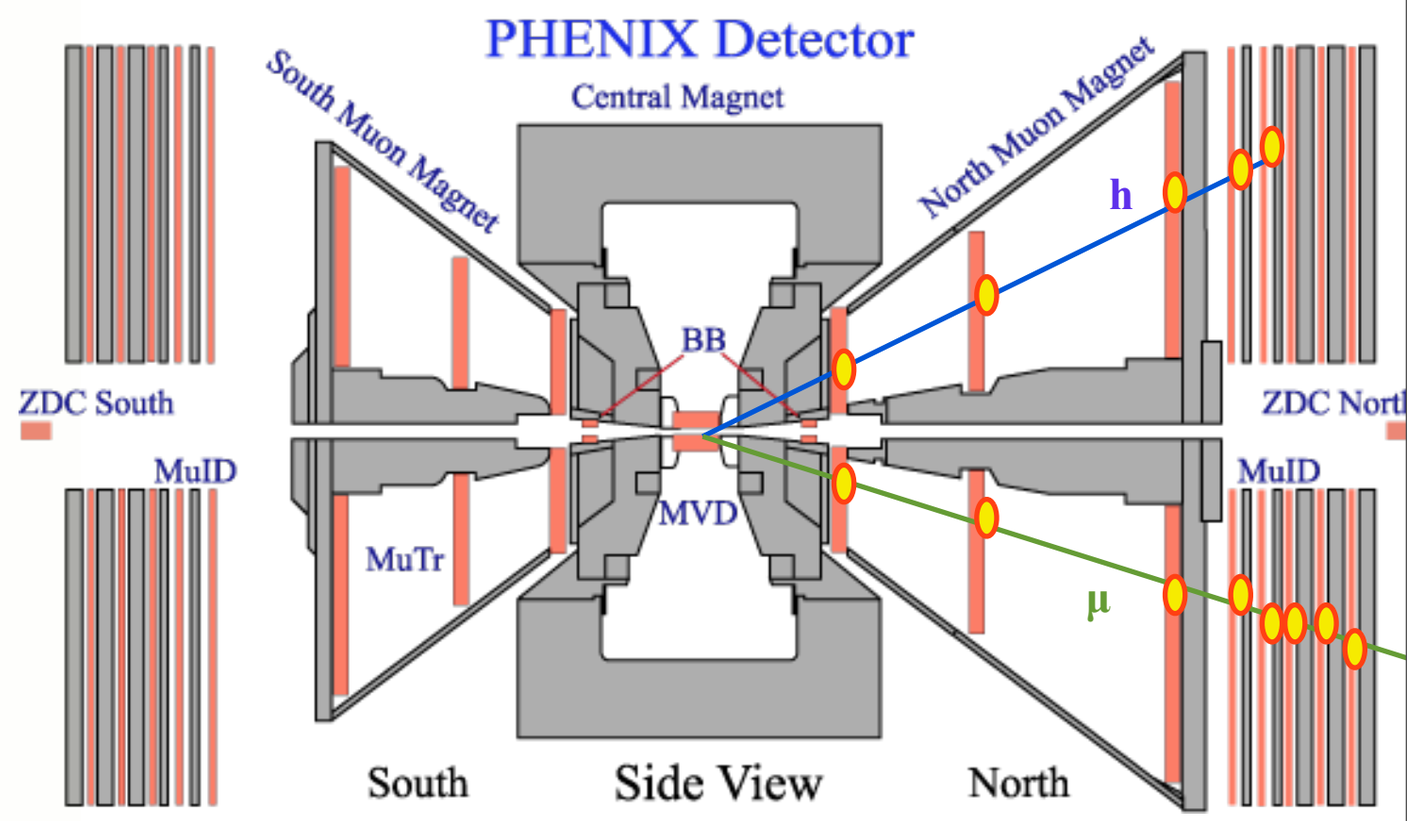




- heavy and light quark mesons are equally suppressed at high $p_T$
- heavy quarks were expected to lose less energy

- no obvious pattern with energy density



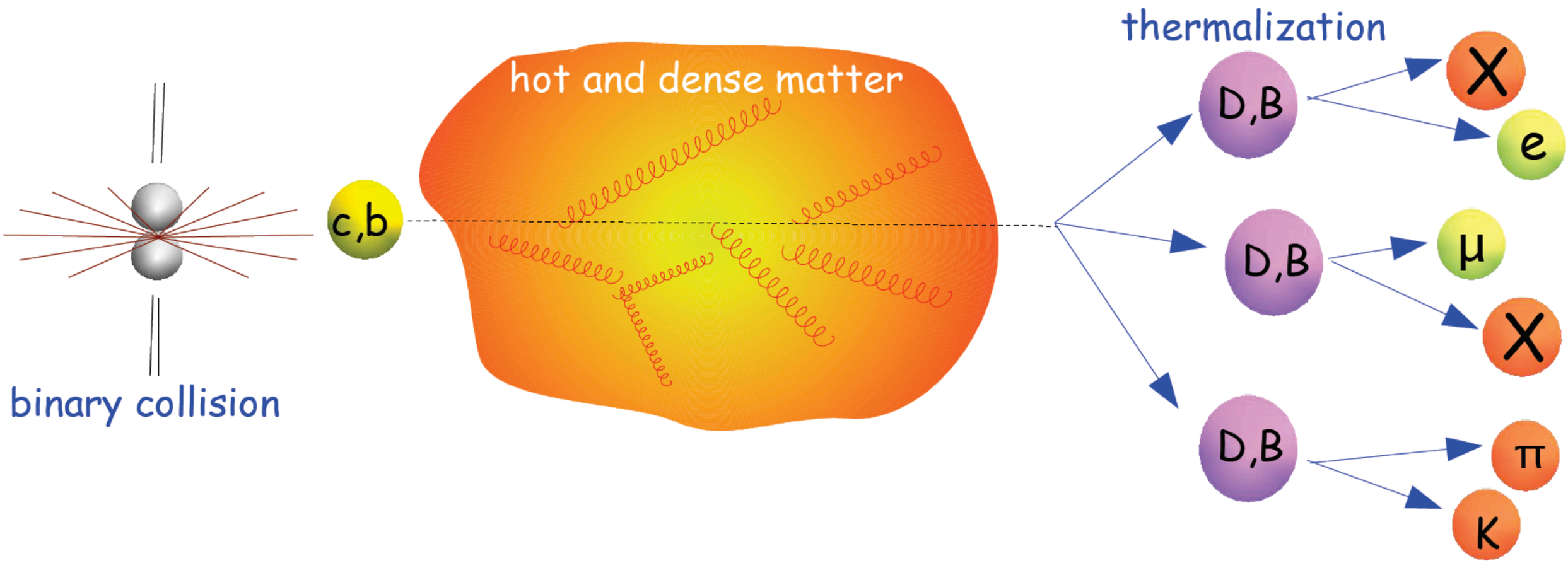

|y|<0.35 ΔΦ≈2xπ/2



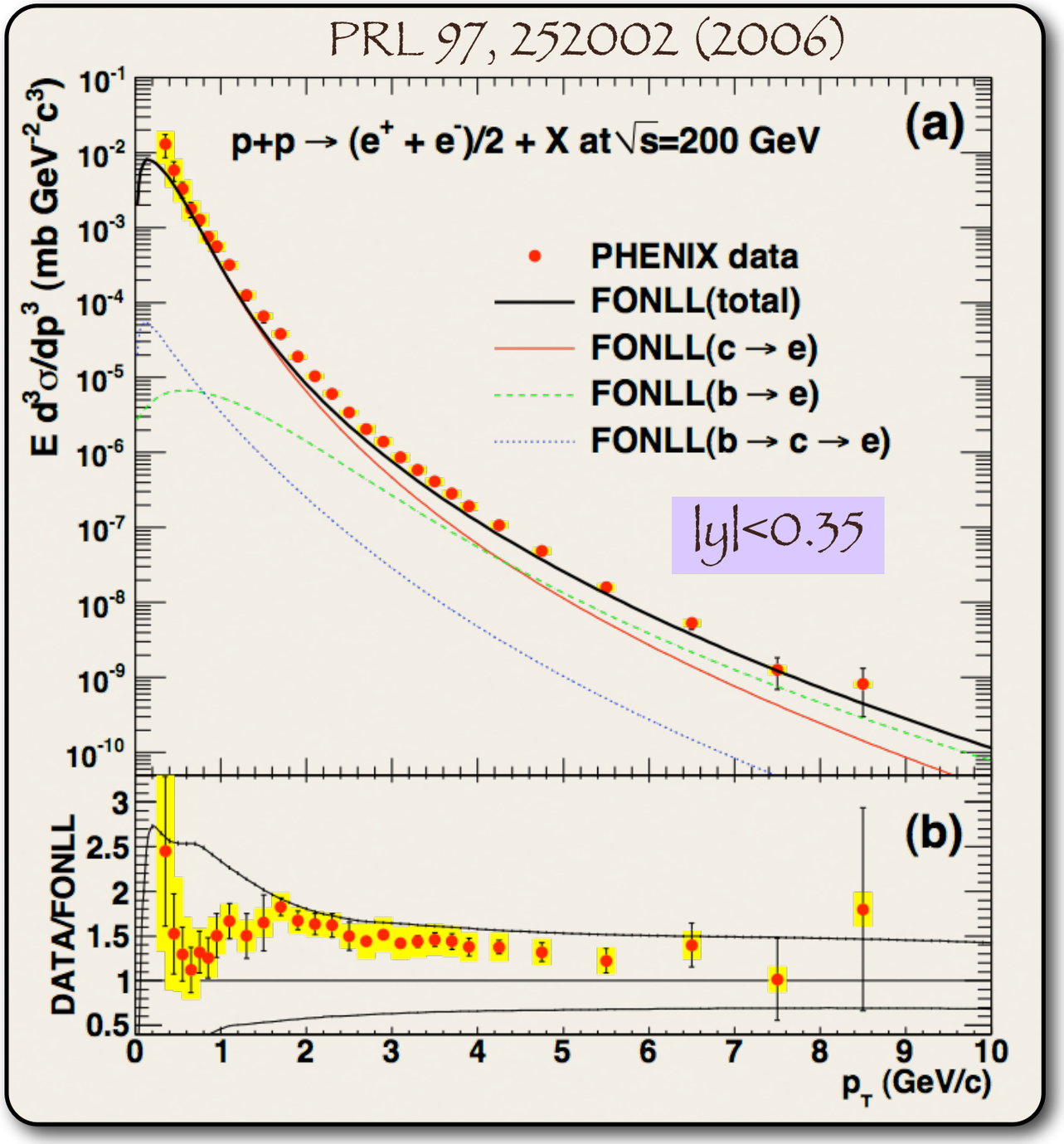

1.2<|y|<2.2 ΔΦ≈2π

Measures leptonic decays of heavy flavor and quarkonia
Results in p+p, d+Au, Cu+Cu and Au+Au at $s^{1/2}$=200
in forward and mid rapidities
open heavy flavor->leptons, $J/\psi$, $\psi'$, $\chi_c$, $\Upsilon$(1S,2S,3S)

# Heavy Quark Production



# p+p -> HF + X at mid rapidity



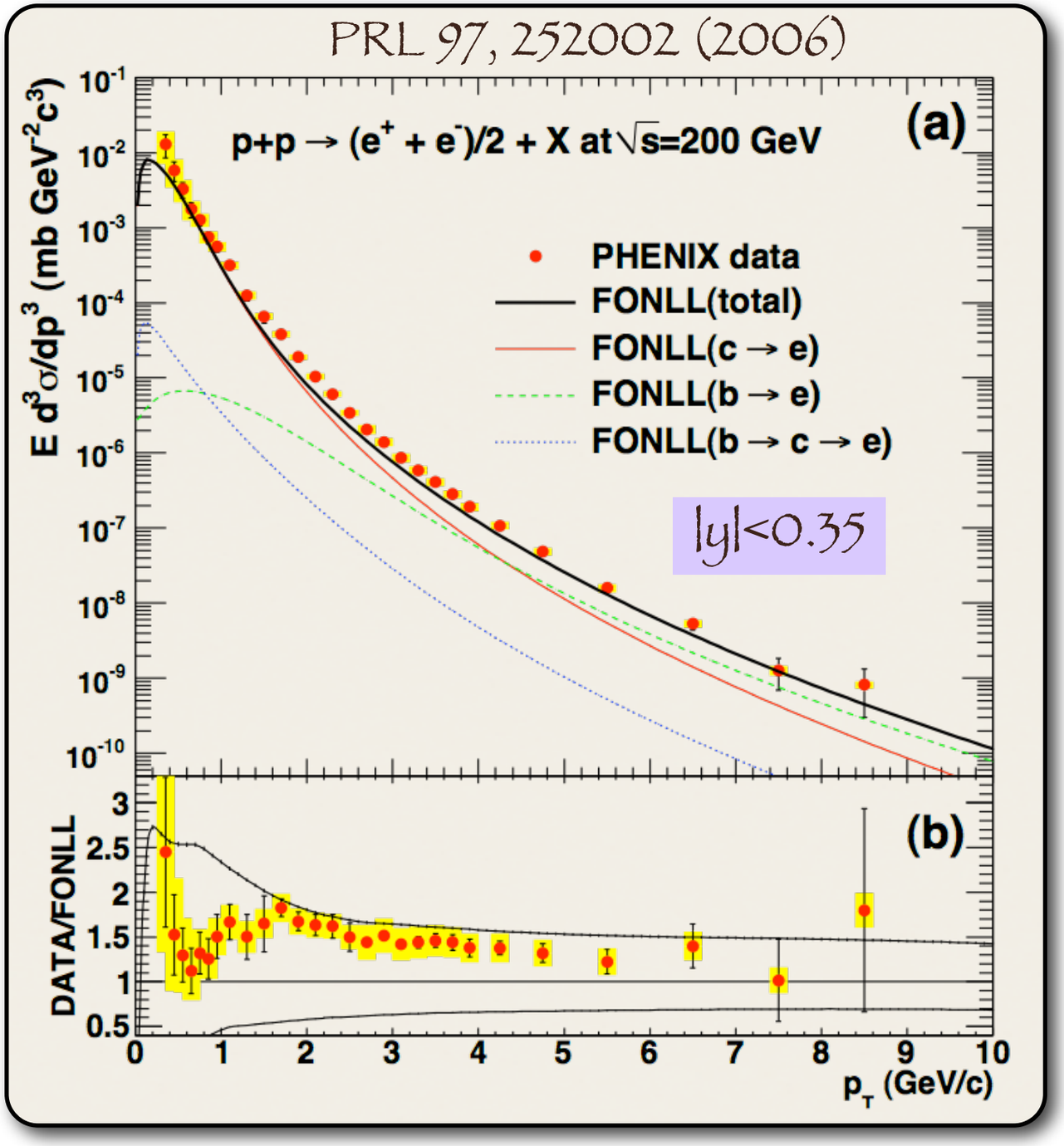
# p+p -> HF + X at mid rapidity

- long paper with analysis details of the p+p and Au+Au submitted

**arXiv:1005.1627v2**

**Heavy Quark Production in $p+p$ and Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV**

A. Adare,[9] S. Afanasiev,[23] C. Aidala,[10] N.N. Ajitanand,[50] Y. Akiba,[44,45] H. Al-Bataineh,[39] J. Alexander,[50] A. Al-Jamel,[39] K. Aoki,[29,44] L. Aphecetche,[52] R. Armendariz,[39] S.H. Aronson,[4] J. Asai,[45] E.T. Atomssa,[30] R. Averbeck,[51] T.C. Awes,[40] B. Azmoun,[4] V. Babintsev,[19] G. Baksay,[15] L. Baksay,[15] A. Baldisseri,[12] K.N. Barish,[5] P.D. Barnes,[32] B. Bassalleck,[38] S. Bathe,[5] S. Batsouli,[10,40] V. Baublis,[43] F. Bauer,[5] A. Bazilevsky,[4] S. Belikov,[4,22,*] R. Bennett,[51] Y. Berdnikov,[47] A.A. Bickley,[9] M.T. Bjorndal,[10] J.G. Boissevain,[32] H. Borel,[12]



# p+p -> HF + X at mid rapidity

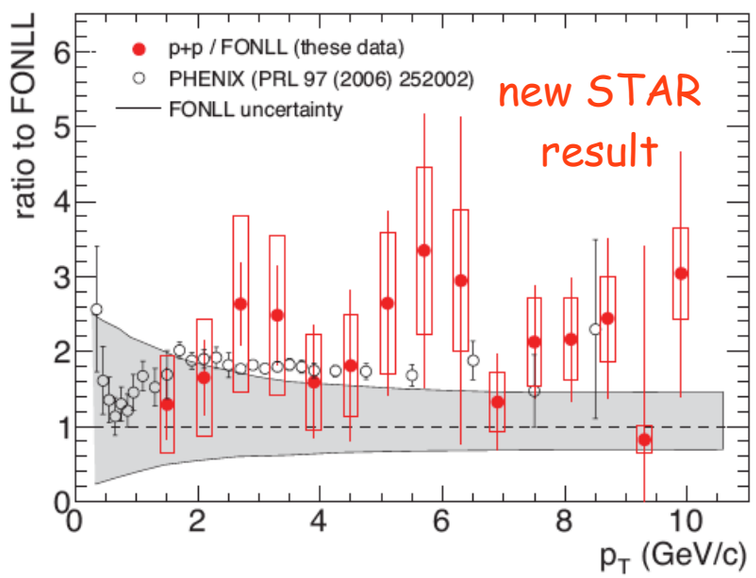
- long paper with analysis details of the p+p and Au+Au submitted

**arXiv:1005.1627v2**

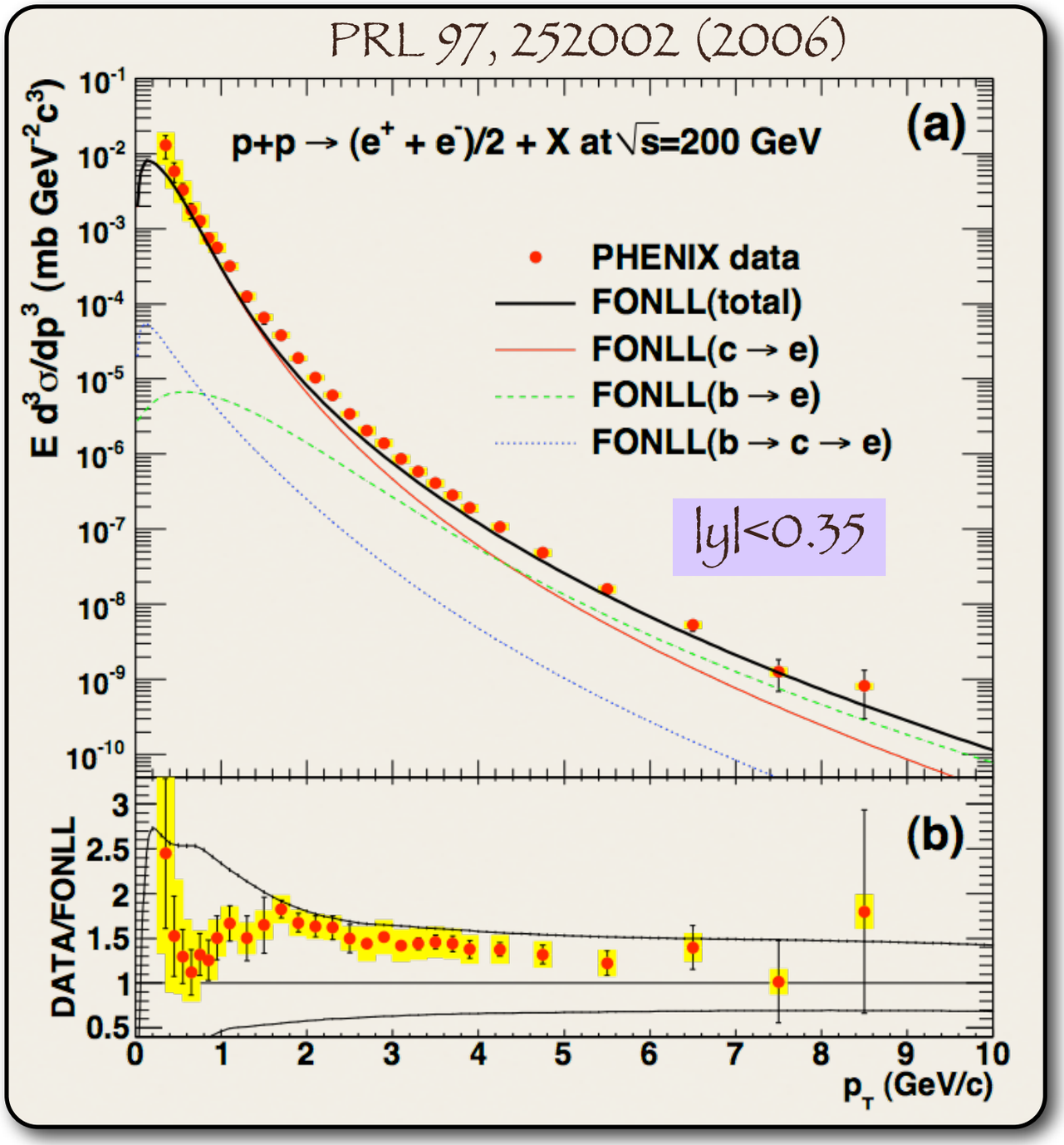
**Heavy Quark Production in $p+p$ and Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV**

A. Adare,[9] S. Afanasiev,[23] C. Aidala,[10] N.N. Ajitanand,[50] Y. Akiba,[44,45] H. Al-Bataineh,[39] J. Alexander,[50] A. Al-Jamel,[39] K. Aoki,[29,44] L. Aphecetche,[52] R. Armendariz,[39] S.H. Aronson,[4] J. Asai,[45] E.T. Atomssa,[30] R. Averbeck,[51] T.C. Awes,[40] B. Azmoun,[4] V. Babintsev,[19] G. Baksay,[15] L. Baksay,[15] A. Baldisseri,[12] K.N. Barish,[5] P.D. Barnes,[32] B. Bassalleck,[38] S. Bathe,[5] S. Batsouli,[10,40] V. Baublis,[43] F. Bauer,[5] A. Bazilevsky,[4] S. Belikov,[4,22,*] R. Bennett,[51] Y. Berdnikov,[47] A.A. Bickley,[9] M.T. Bjorndal,[10] J.G. Boissevain,[32] H. Borel,[12] K. Boyle,[51] M.L. Brooks,[32] D.S. Brown,[39] D. Bucher,[35] H. Buesching,[4] V. Bumazhnov,[19] G. Bunce,[4,45]

- long standing discrepancy resolved




[PRL98:192301,2007, Erratum-ibid.106:159902,2011]



# p+p -> HF + X at mid rapidity

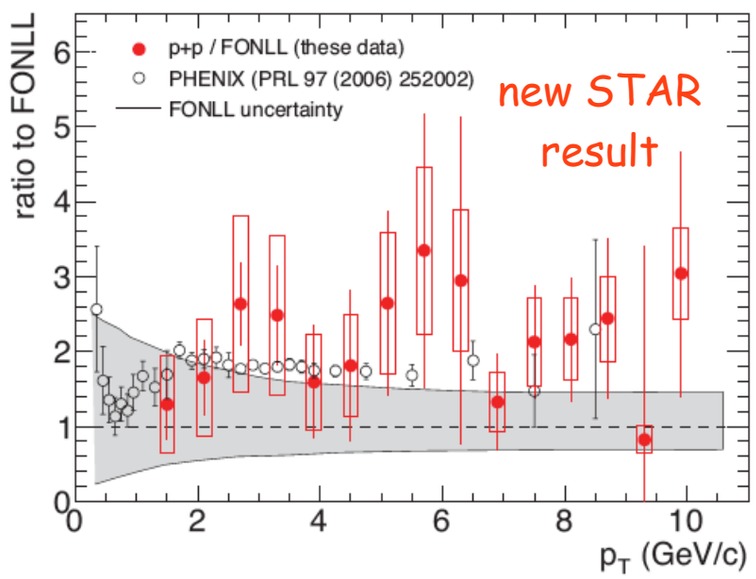
- long paper with analysis details of the p+p and Au+Au submitted

**arXiv:1005.1627v2**

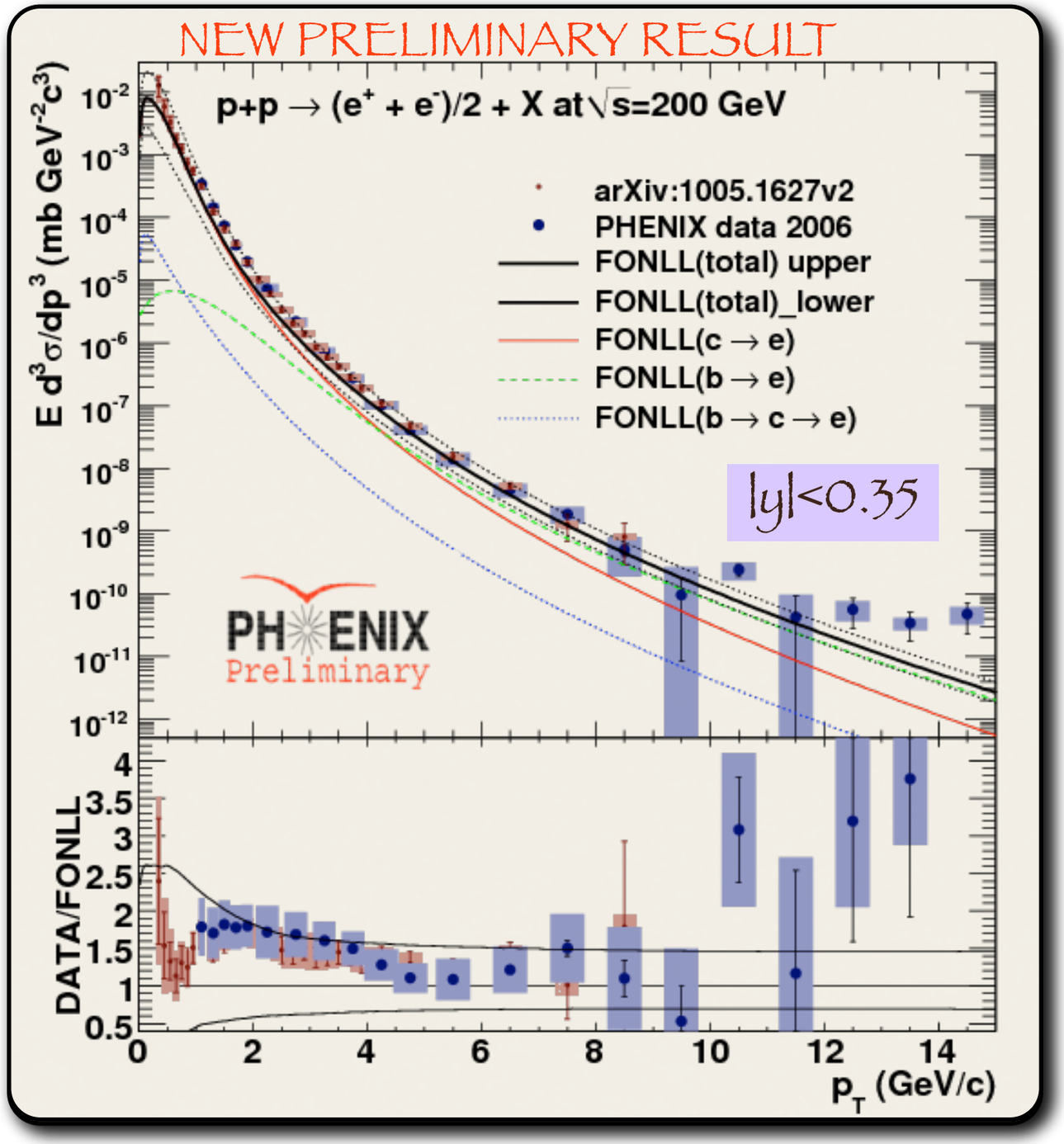
**Heavy Quark Production in $p+p$ and Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV**

A. Adare,[9] S. Afanasiev,[23] C. Aidala,[10] N.N. Ajitanand,[50] Y. Akiba,[44,45] H. Al-Bataineh,[39] J. Alexander,[50] A. Al-Jamel,[39] K. Aoki,[29,44] L. Aphecetche,[52] R. Armendariz,[39] S.H. Aronson,[4] J. Asai,[45] E.T. Atomssa,[30] R. Averbeck,[51] T.C. Awes,[40] B. Azmoun,[4] V. Babintsev,[19] G. Baksay,[15] L. Baksay,[15] A. Baldisseri,[12] K.N. Barish,[5] P.D. Barnes,[32] B. Bassalleck,[38] S. Bathe,[5] S. Batsouli,[10,40] V. Baublis,[43] F. Bauer,[5] A. Bazilevsky,[4] S. Belikov,[4,22,*] R. Bennett,[51] Y. Berdnikov,[47] A.A. Bickley,[9] M.T. Bjorndal,[10] J.G. Boissevain,[32] H. Borel,[12] K. Boyle,[51] M.L. Brooks,[32] D.S. Brown,[39] D. Bucher,[35] H. Buesching,[4] V. Bumazhnov,[19] G. Bunce,[4,45]

- long standing discrepancy resolved




[PRL98:192301,2007, Erratum-ibid.106:159902,2011]




- working towards the extension at high $p_T$

[Matt Durham's talk this afternoon]

# p+p -> HF + X at mid rapidity

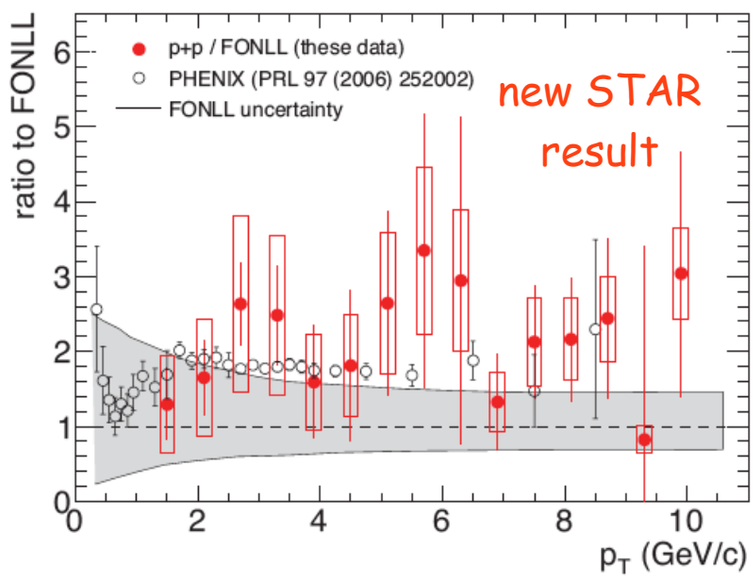
- long paper with analysis details of the p+p and Au+Au submitted

**arXiv:1005.1627v2**

**Heavy Quark Production in $p+p$ and Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV**

A. Adare,[9] S. Afanasiev,[23] C. Aidala,[10] N.N. Ajitanand,[50] Y. Akiba,[44,45] H. Al-Bataineh,[39] J. Alexander,[50] A. Al-Jamel,[39] K. Aoki,[29,44] L. Aphecetche,[52] R. Armendariz,[39] S.H. Aronson,[4] J. Asai,[45] E.T. Atomssa,[30] R. Averbeck,[51] T.C. Awes,[40] B. Azmoun,[4] V. Babintsev,[19] G. Baksay,[15] L. Baksay,[15] A. Baldisseri,[12] K.N. Barish,[5] P.D. Barnes,[32] B. Bassalleck,[38] S. Bathe,[5] S. Batsouli,[10,40] V. Baublis,[43] F. Bauer,[5] A. Bazilevsky,[4] S. Belikov,[4,22,*] R. Bennett,[51] Y. Berdnikov,[47] A.A. Bickley,[9] M.T. Bjorndal,[10] J.G. Boissevain,[32] H. Borel,[12] K. Boyle,[51] M.L. Brooks,[32] D.S. Brown,[39] D. Bucher,[35] H. Buesching,[4] V. Bumazhnov,[19] G. Bunce,[4,45]

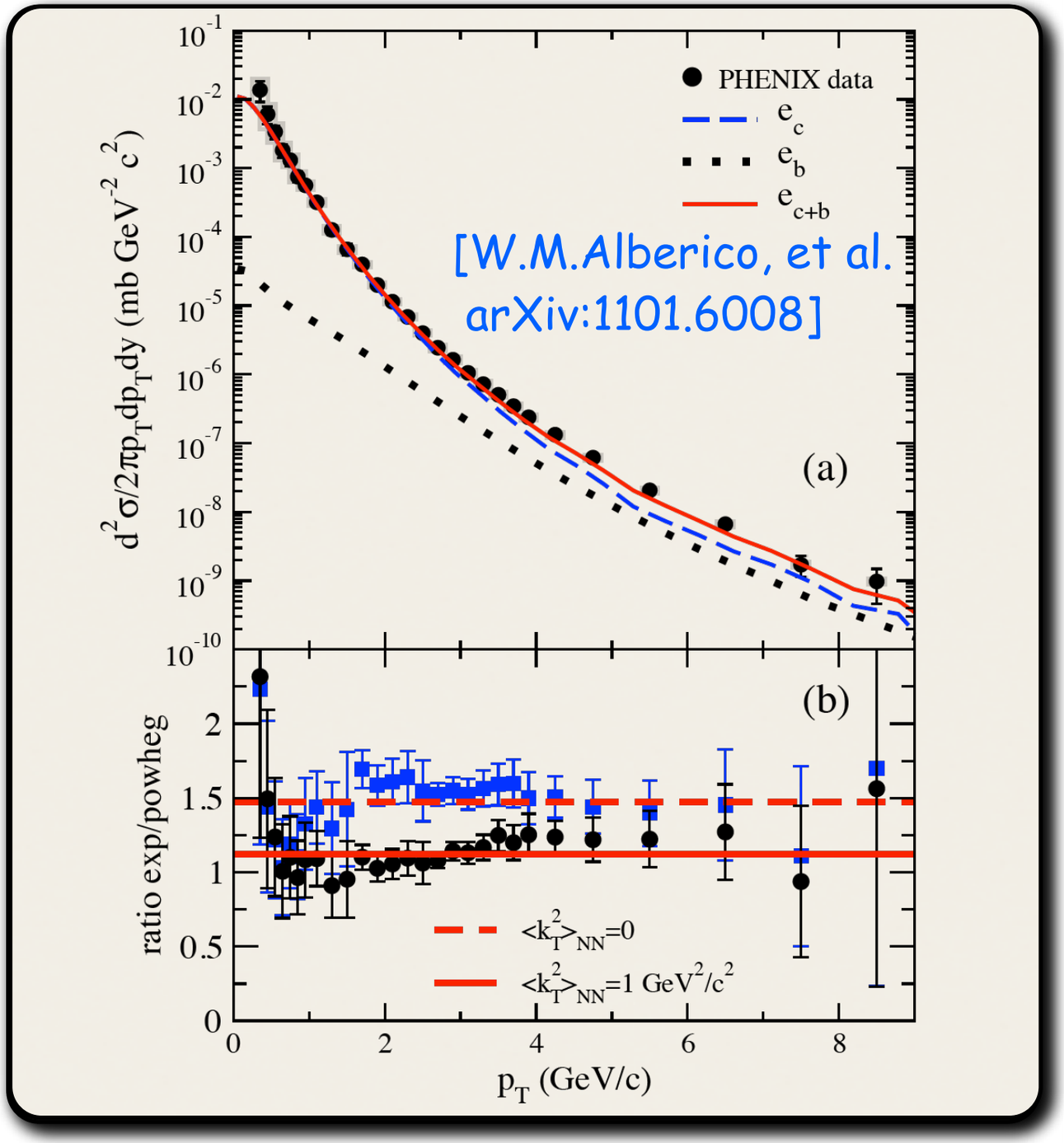
- long standing discrepancy resolved




[PRL98:192301,2007, Erratum-ibid.106:159902,2011]

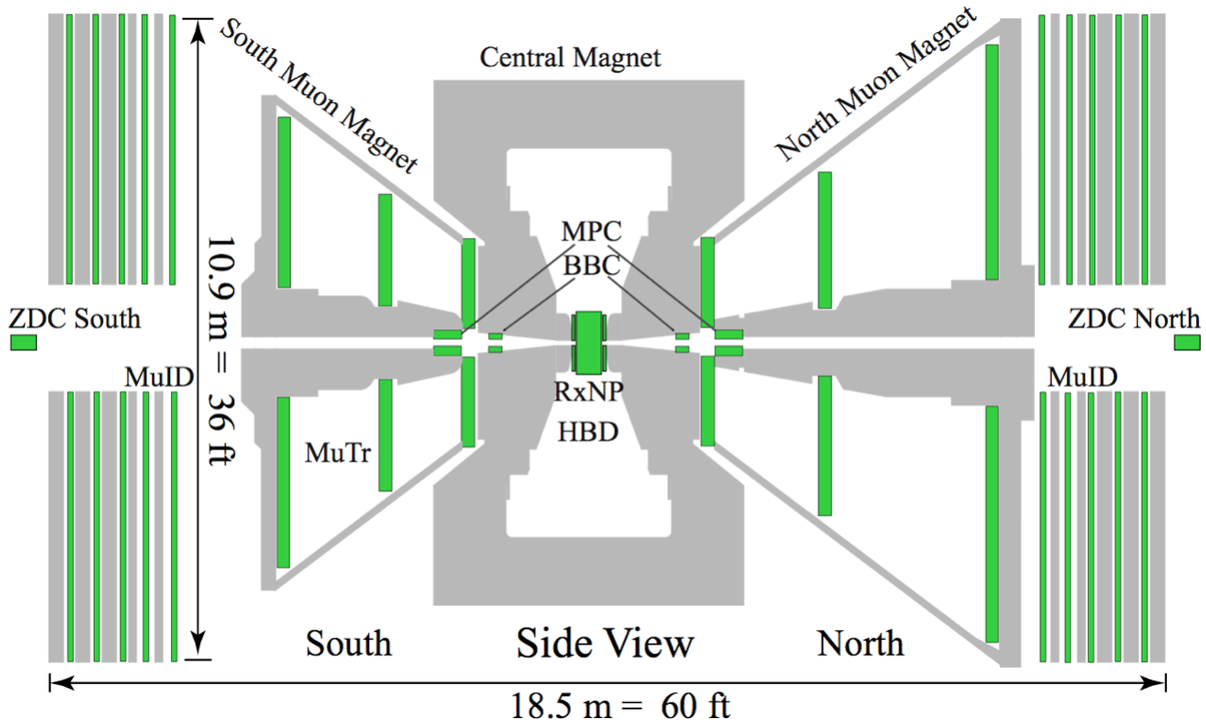
- working towards the extension at high $p_T$

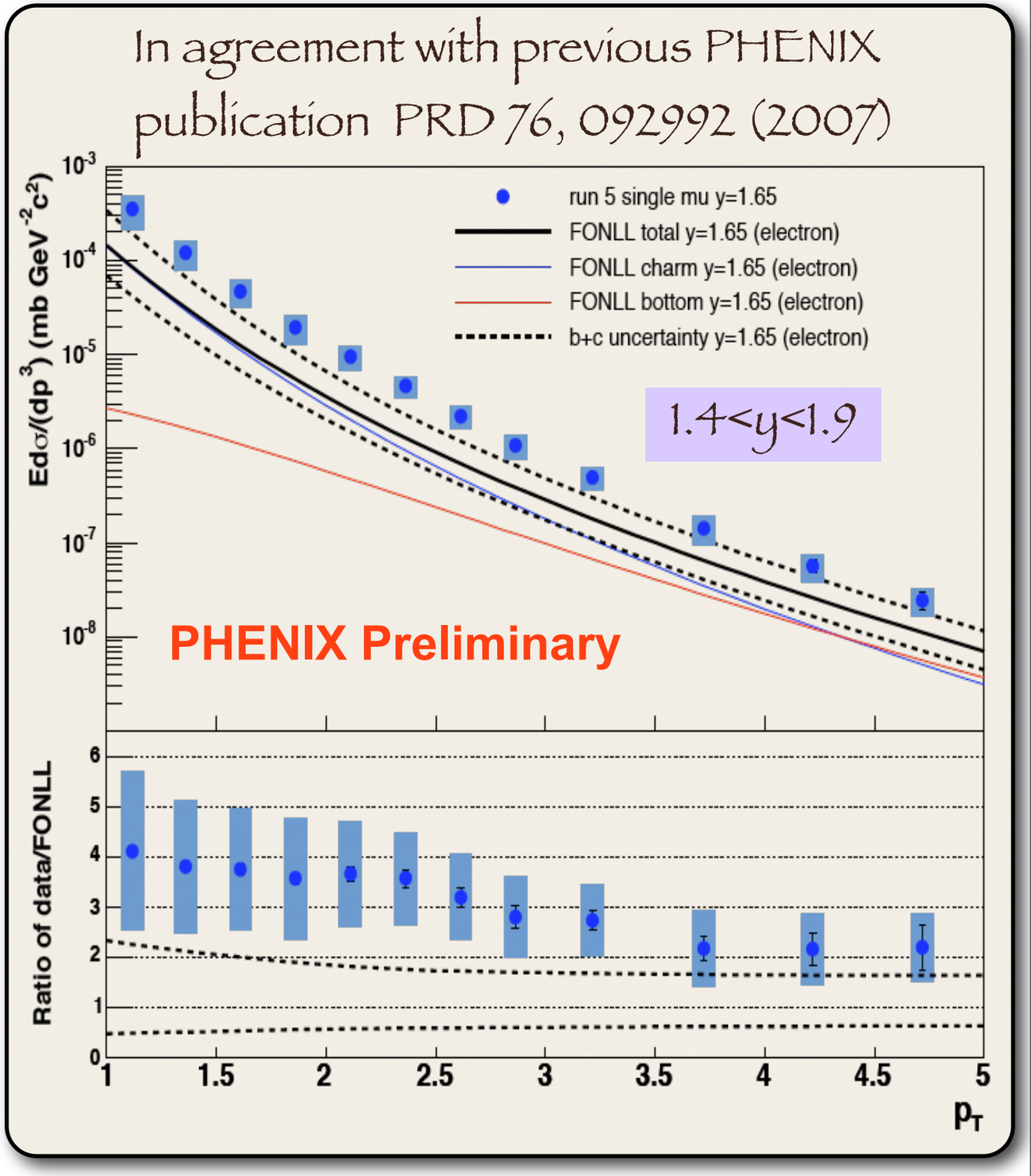
[Matt Durham's talk this afternoon]




- NLO HF calculation with $\langle k_T \rangle^2 = 1 GeV^2/c^2$ matches our experimental result

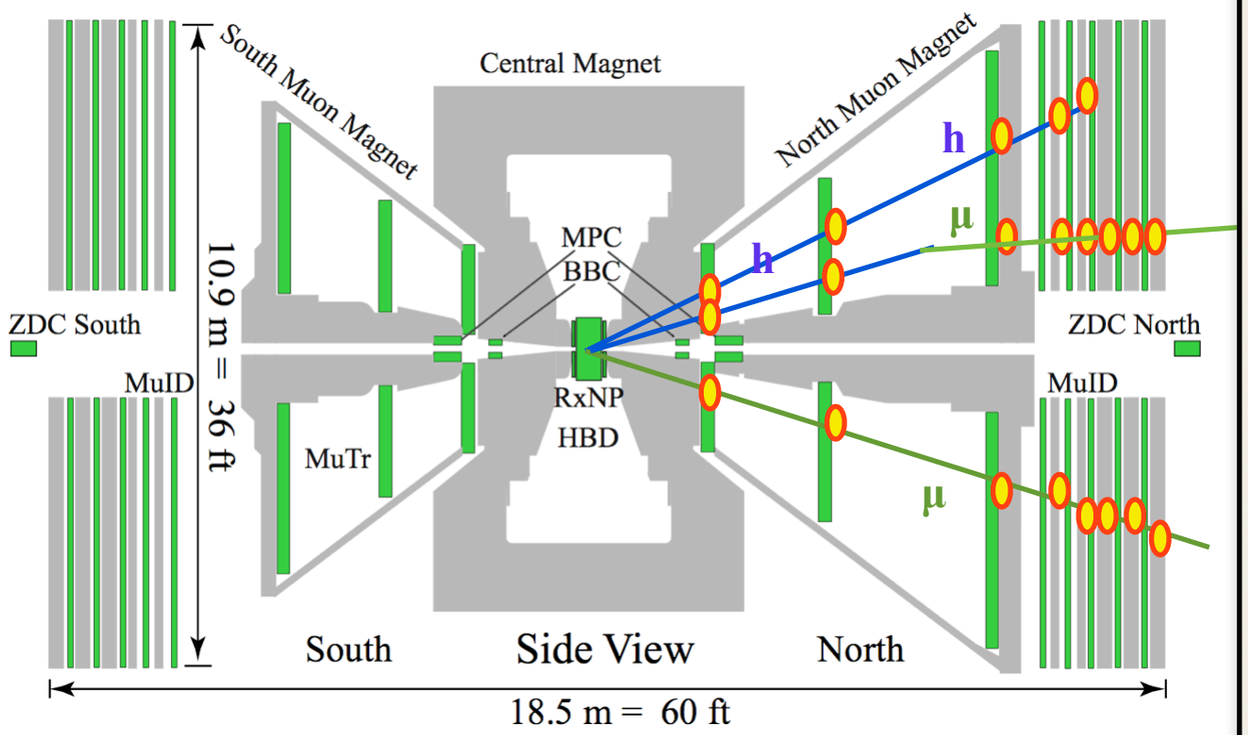
# p+p -> HF + X at forward rapidity



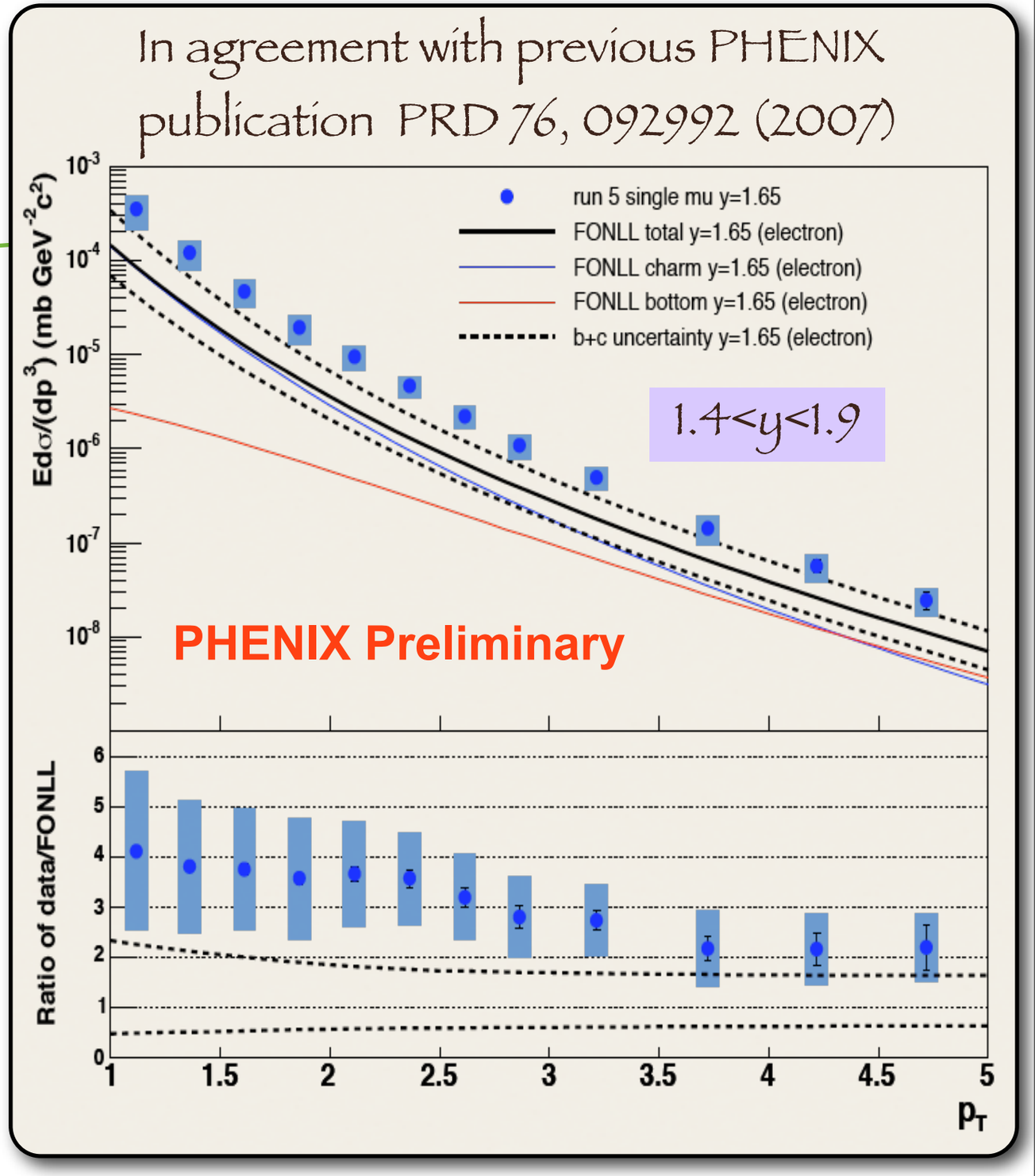




FONLL: M. Cacciari, P. Nason, R. Vogt PRL95,122001 (2005)

# p+p -> HF + X at forward rapidity

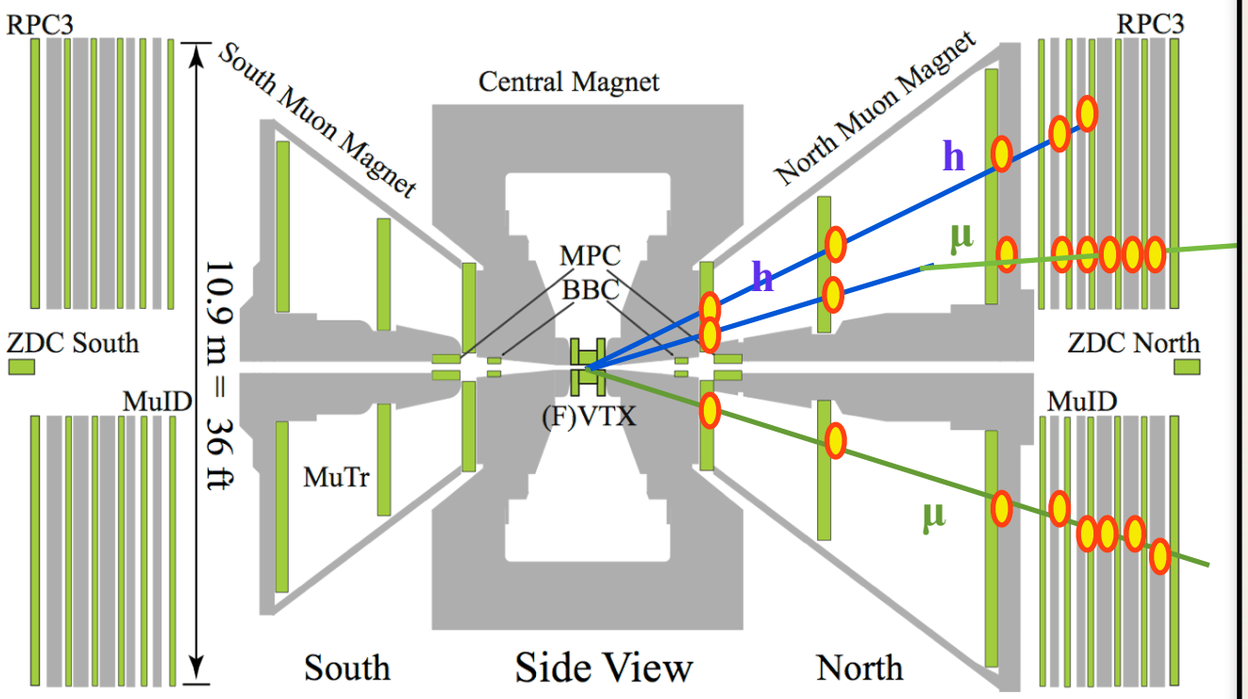



- Challenging measurement given the large fraction of h->μ decays before hadron absorbers

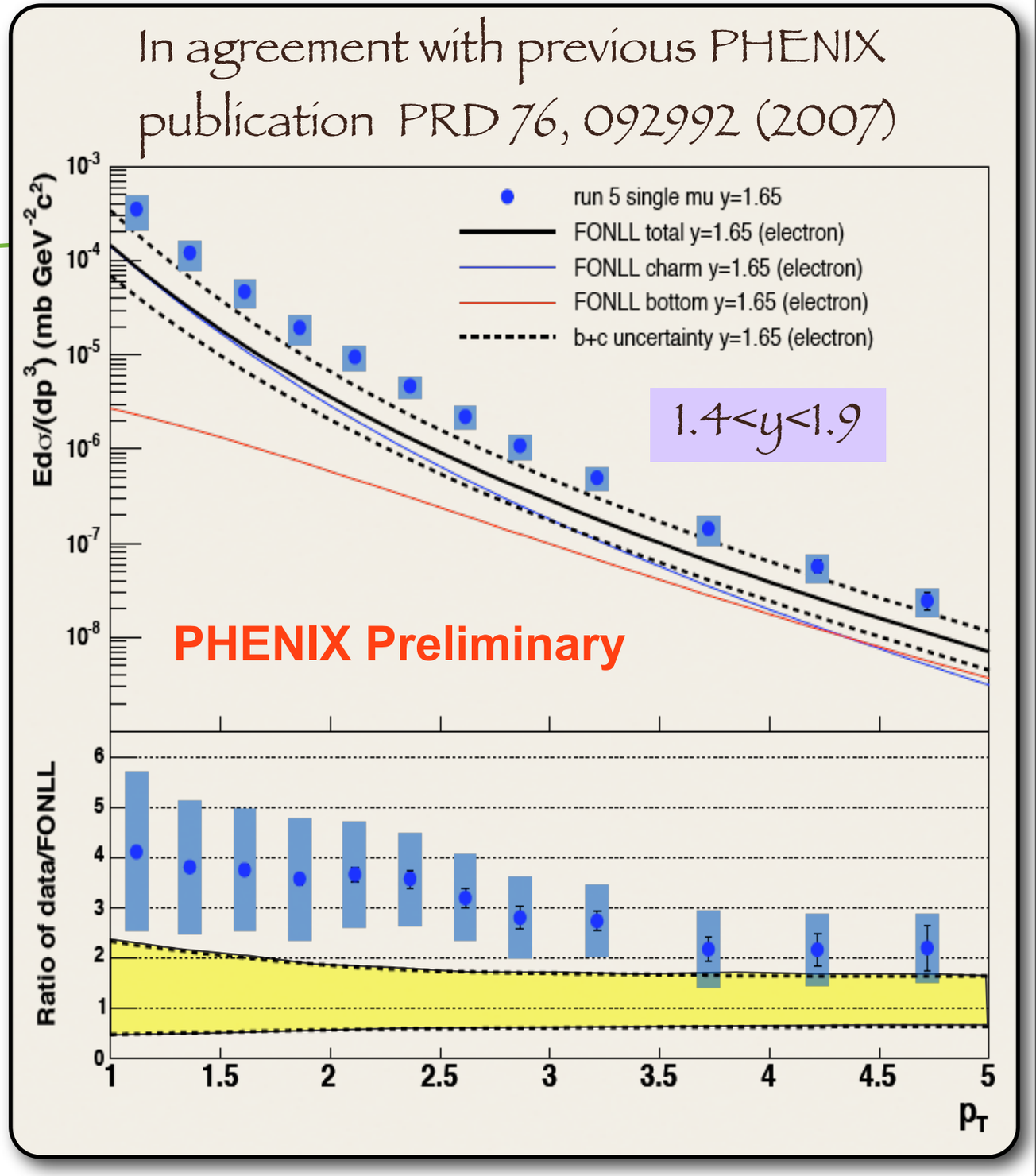



FONLL: M. Cacciari, P. Nason, R. Vogt PRL95,122001 (2005)

# p+p -> HF + X at forward rapidity



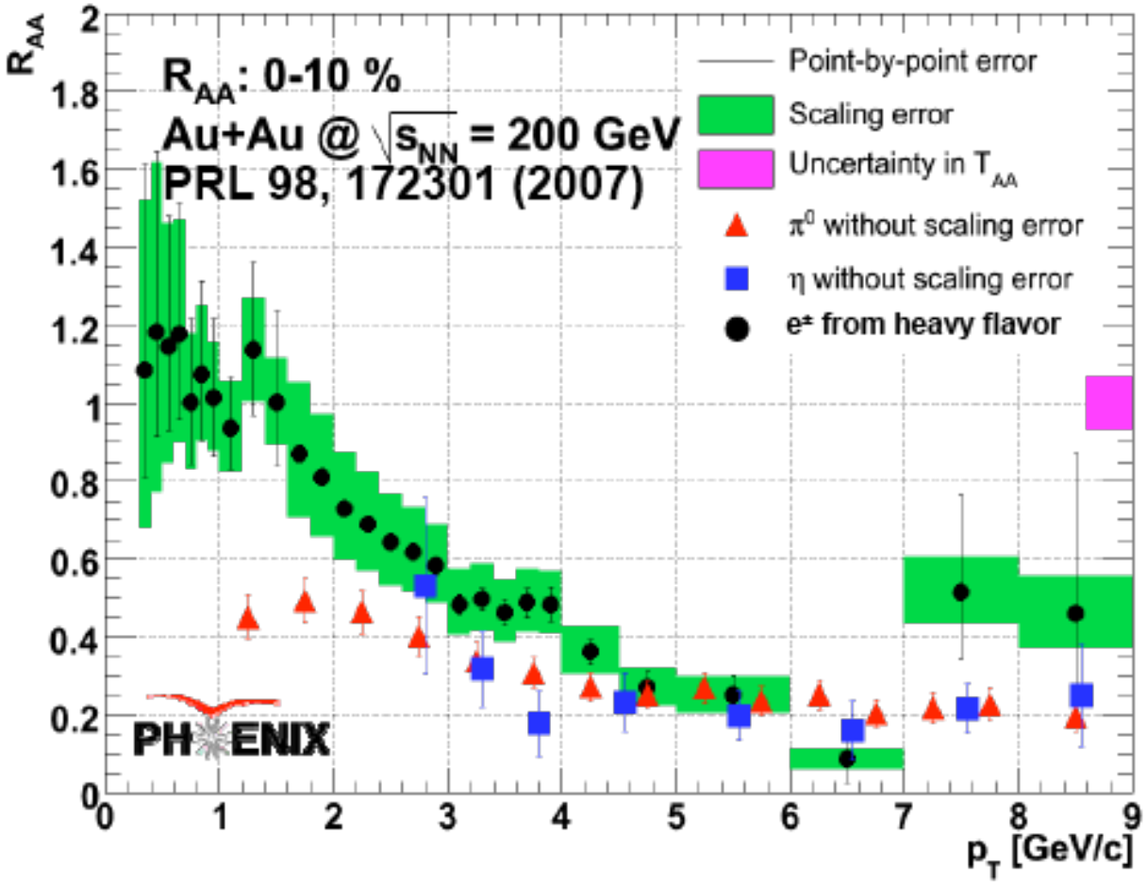

In agreement with previous PHENIX publication PRD 76, 092992 (2007)




- Challenging measurement given the large fraction of h->μ decays before hadron absorbers
- yield larger than FONLL calculation, looking forward to comparison with calculations including $\langle k_T \rangle^2$

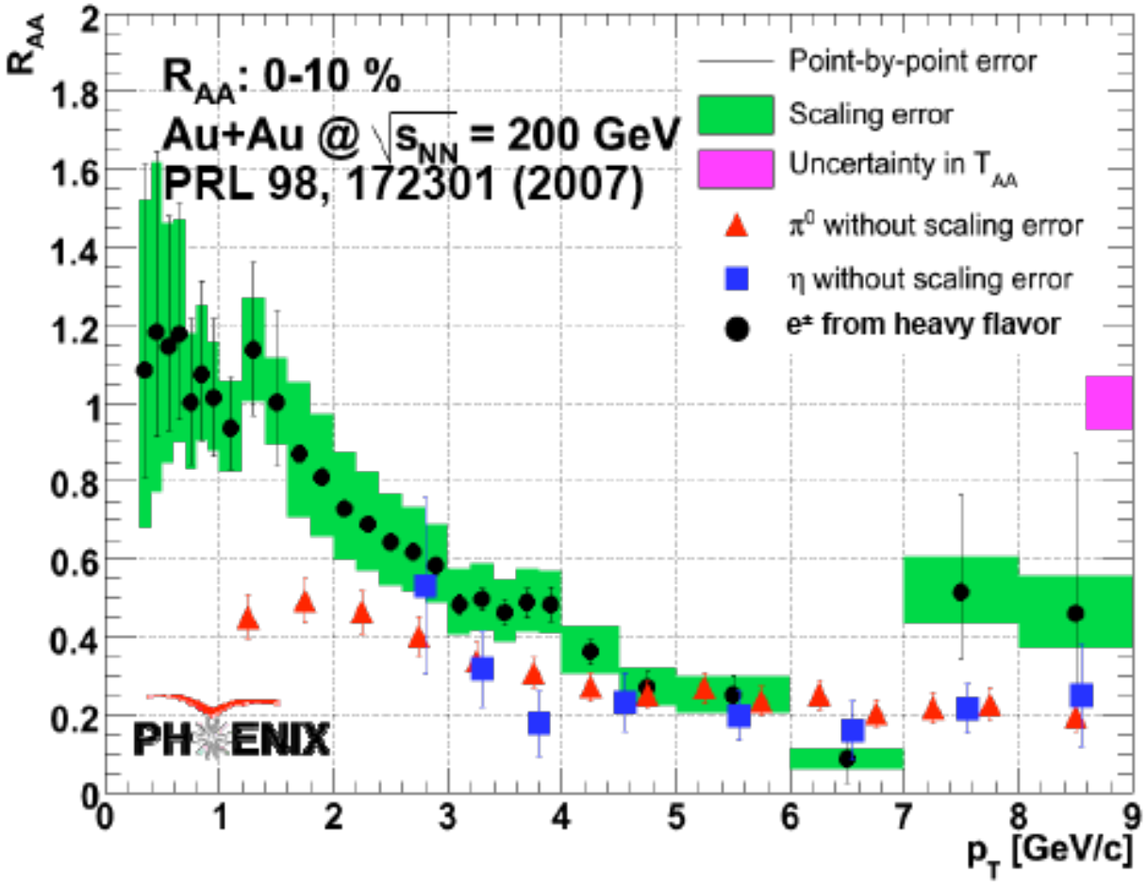
FONLL: M. Cacciari, P. Nason, R. Vogt PRL95,122001 (2005)

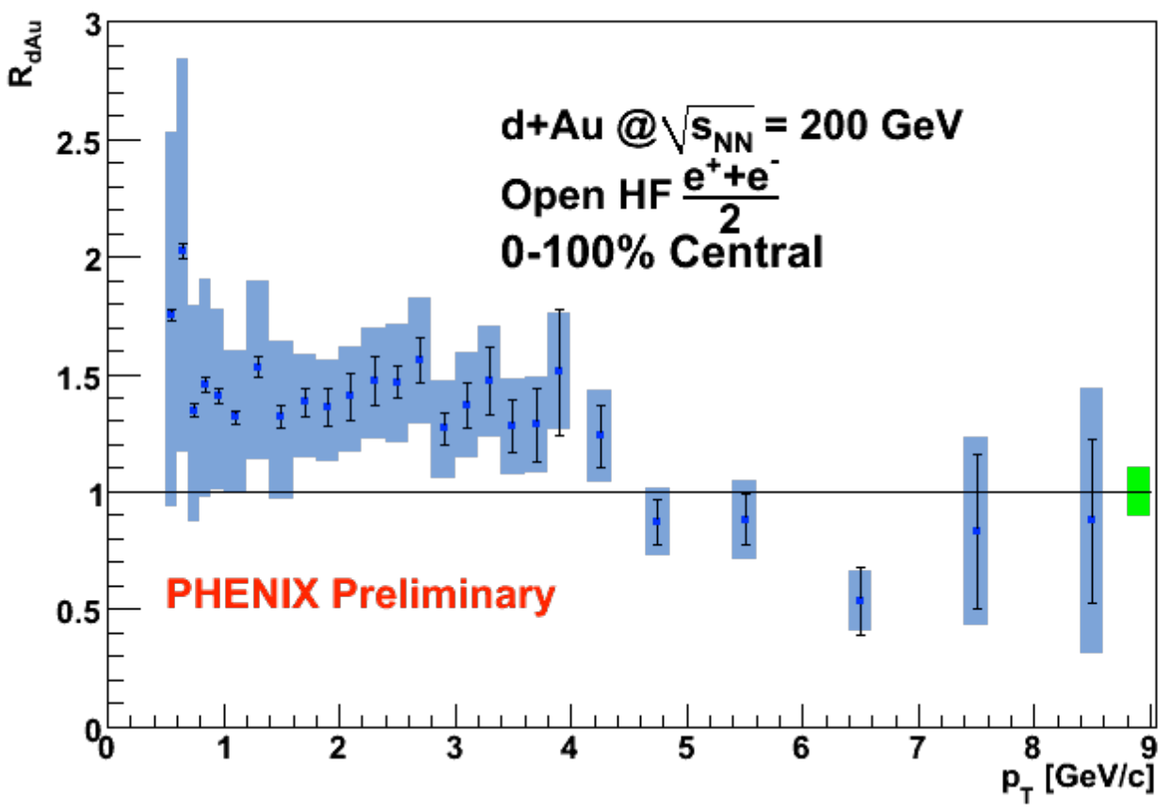
# Understanding HF $R_{AuAu}$




- can cold nuclear matter effects explain the large suppression seen in Au+Au collisions?

# Understanding HF $R_{AuAu}$



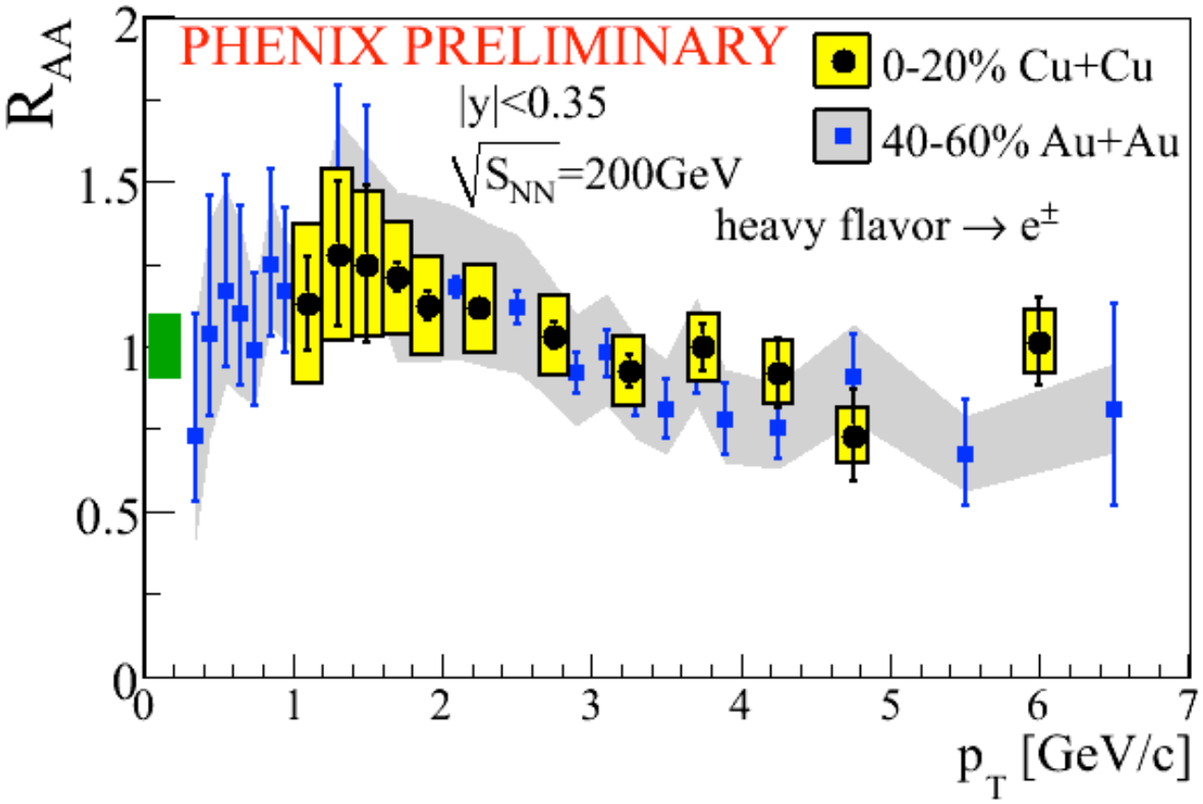



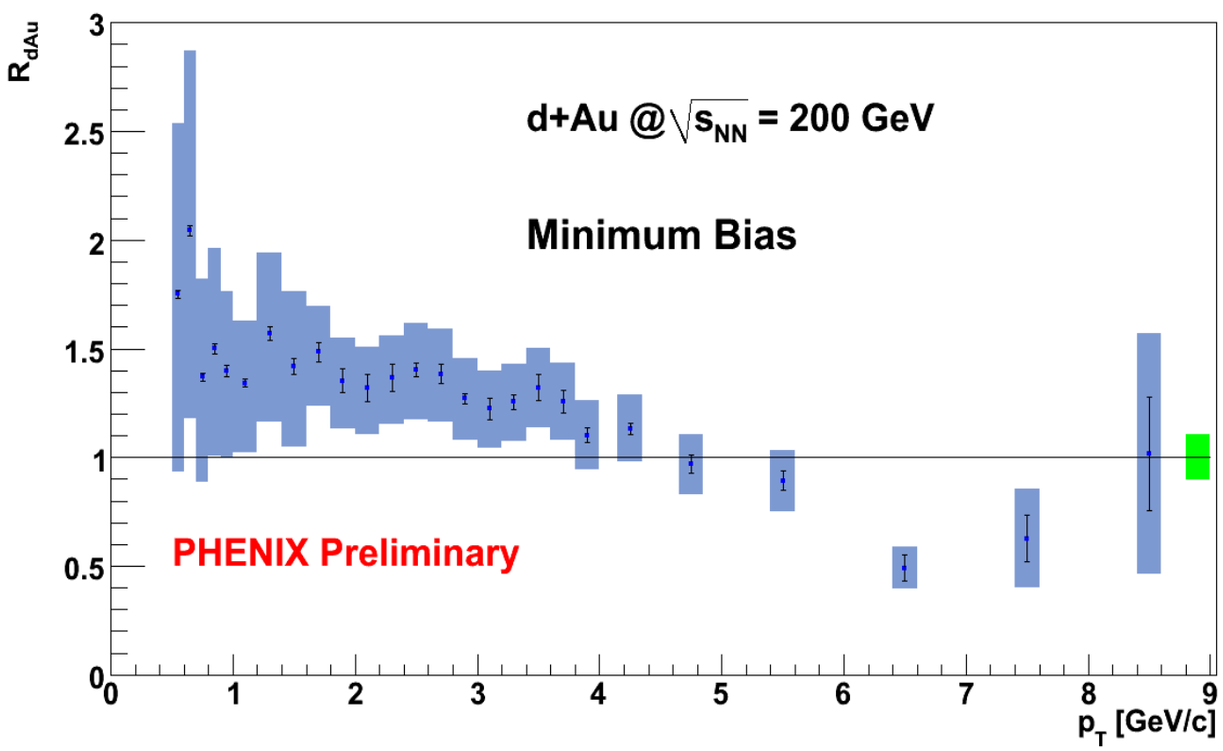

- can cold nuclear matter effects explain the large suppression seen in Au+Au collisions?

- new preliminary measurement of electrons from HF decays in d+Au collisions answers this question, NO!

[Matt Durham's talk this afternoon]

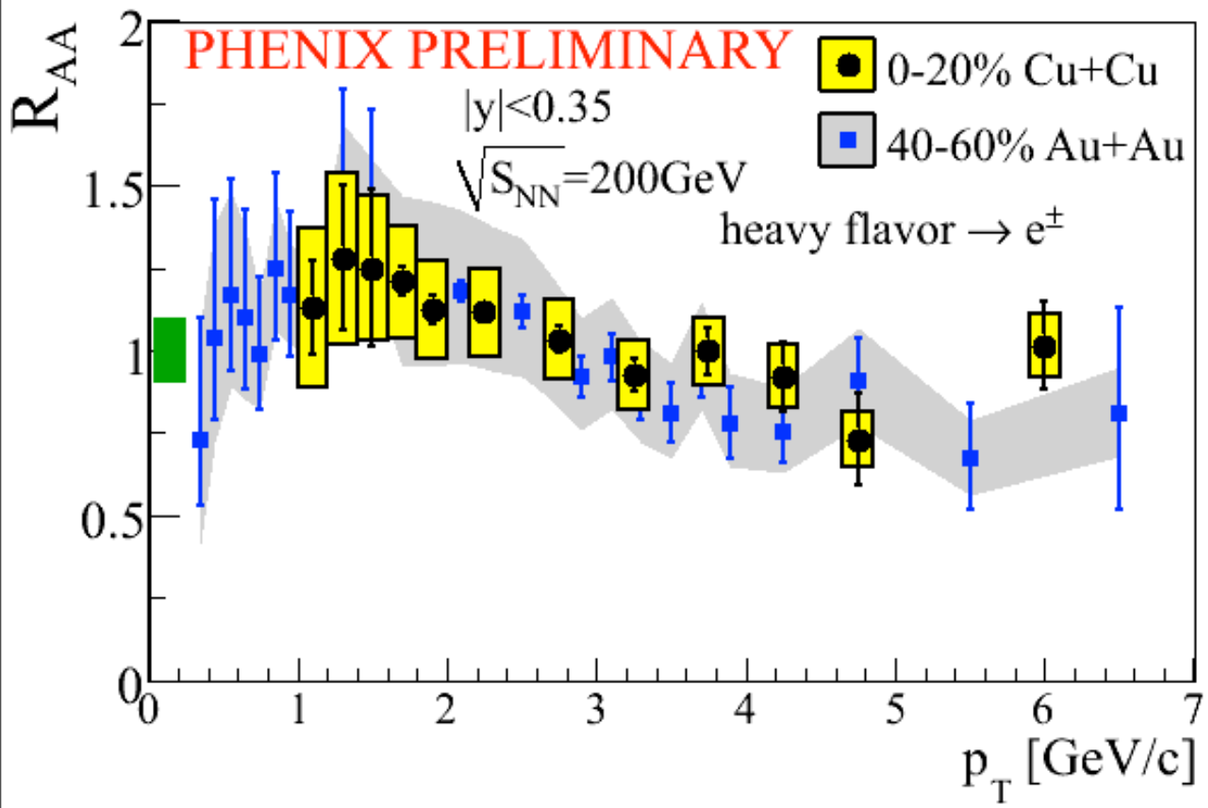
# Understanding HF $R_{AA}$



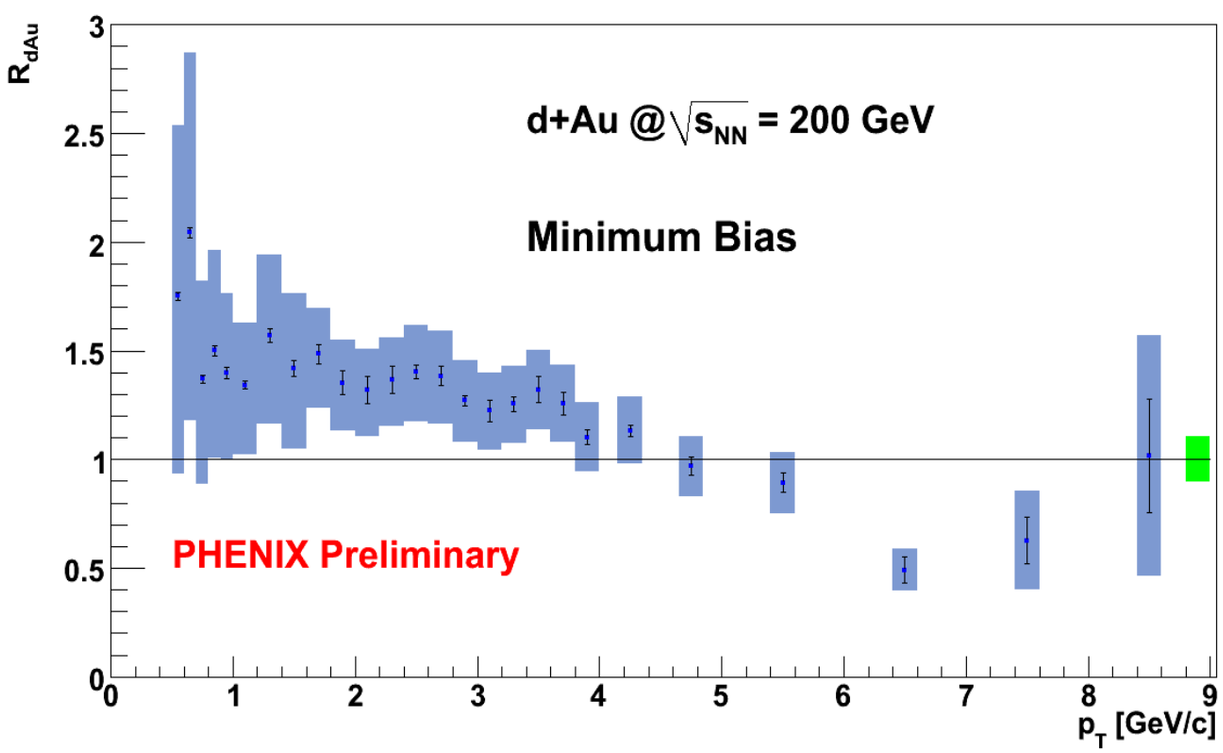




[Matt Durham's talk this afternoon]

# Understanding HF $R_{AA}$




- we explore HF suppression by varying centrality and ion species
- peripheral Au+Au and central Cu+Cu show little suppression



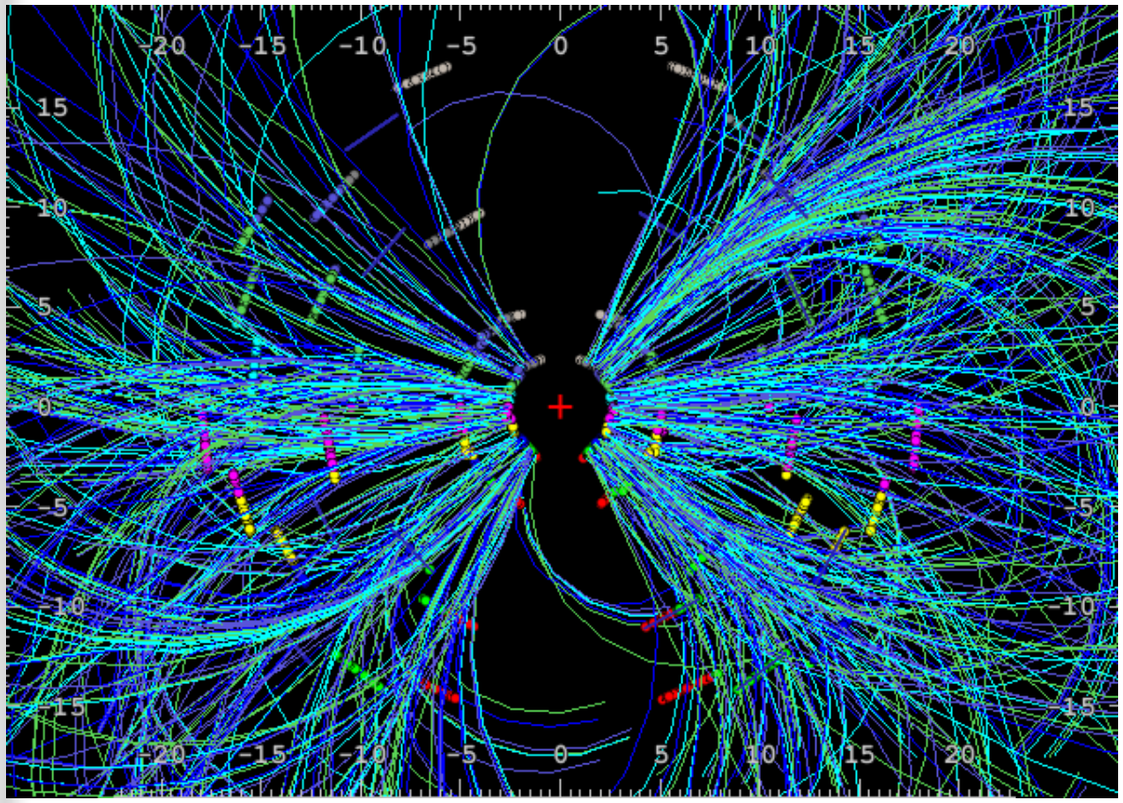

- comparison with d+Au data indicates cold nuclear matter effects may be dominant

[Matt Durham's talk this afternoon]

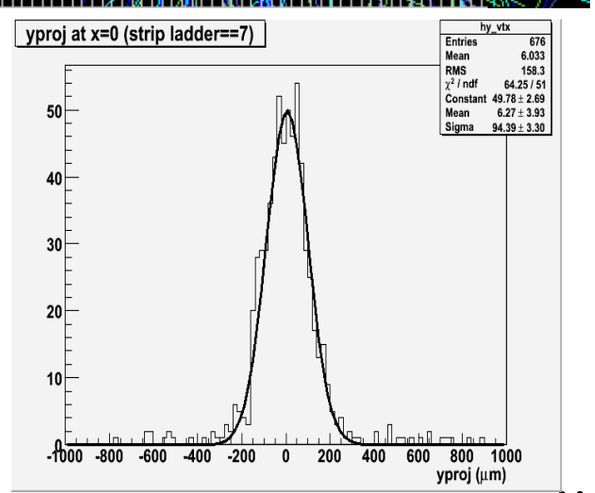
# Vertex detectors

- large reduction of backgrounds → smaller systematics
- c/b separation through displaced vertices

## VTX |y|<1

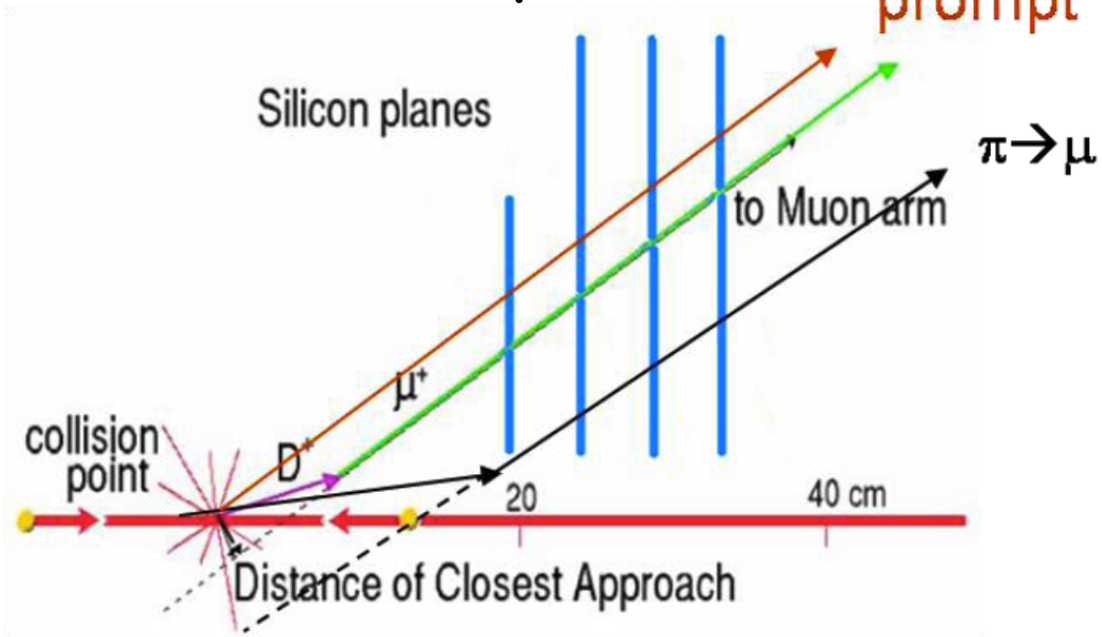


beam profile
$\sigma \sim 100\,\mu m$




- taking data right now in Au+Au collisions

## FVTX 1.2<|y|<2.4

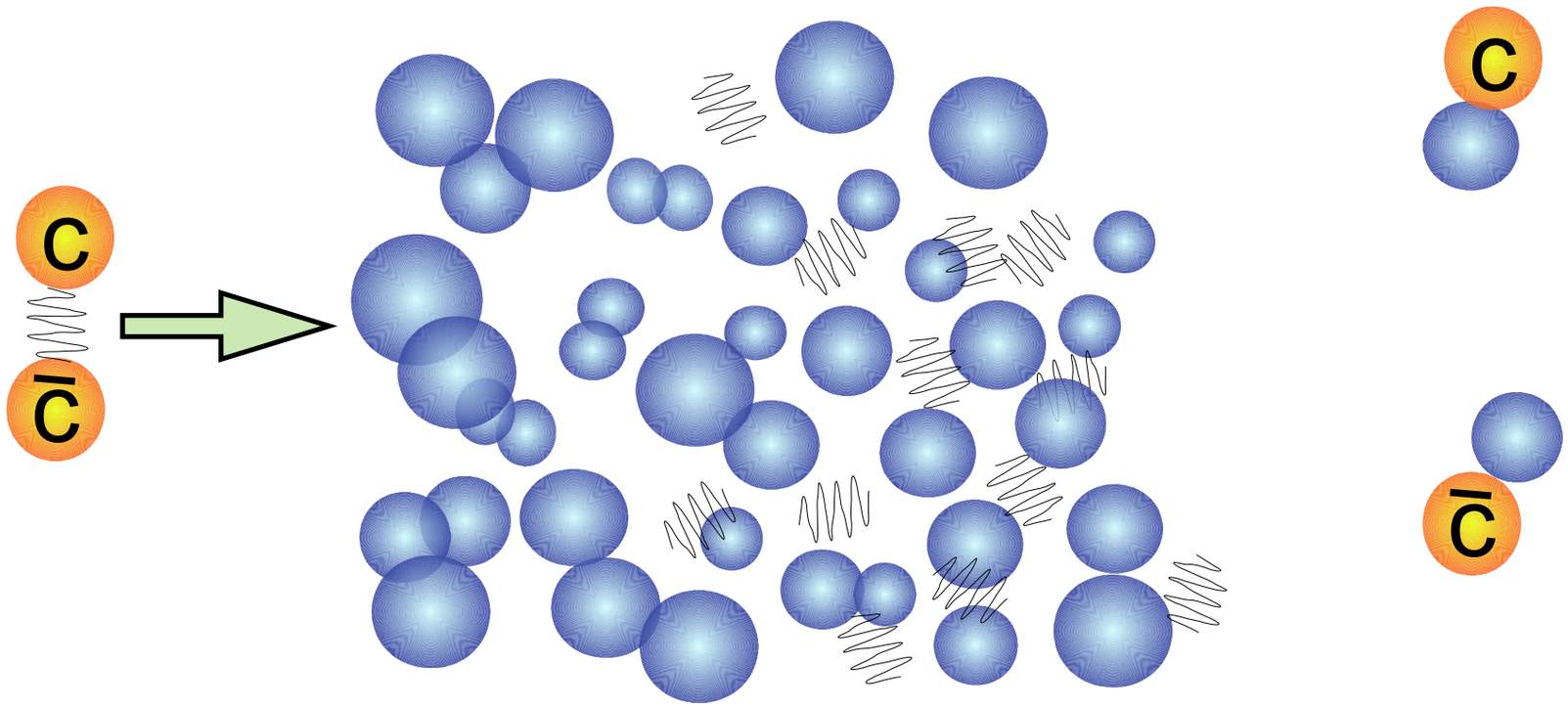



- will also improve mass resolution allowing $\psi'$ measurements at forward rapidity
- starting in 2012 run

# HEAVY FLAVOR SUMMARY

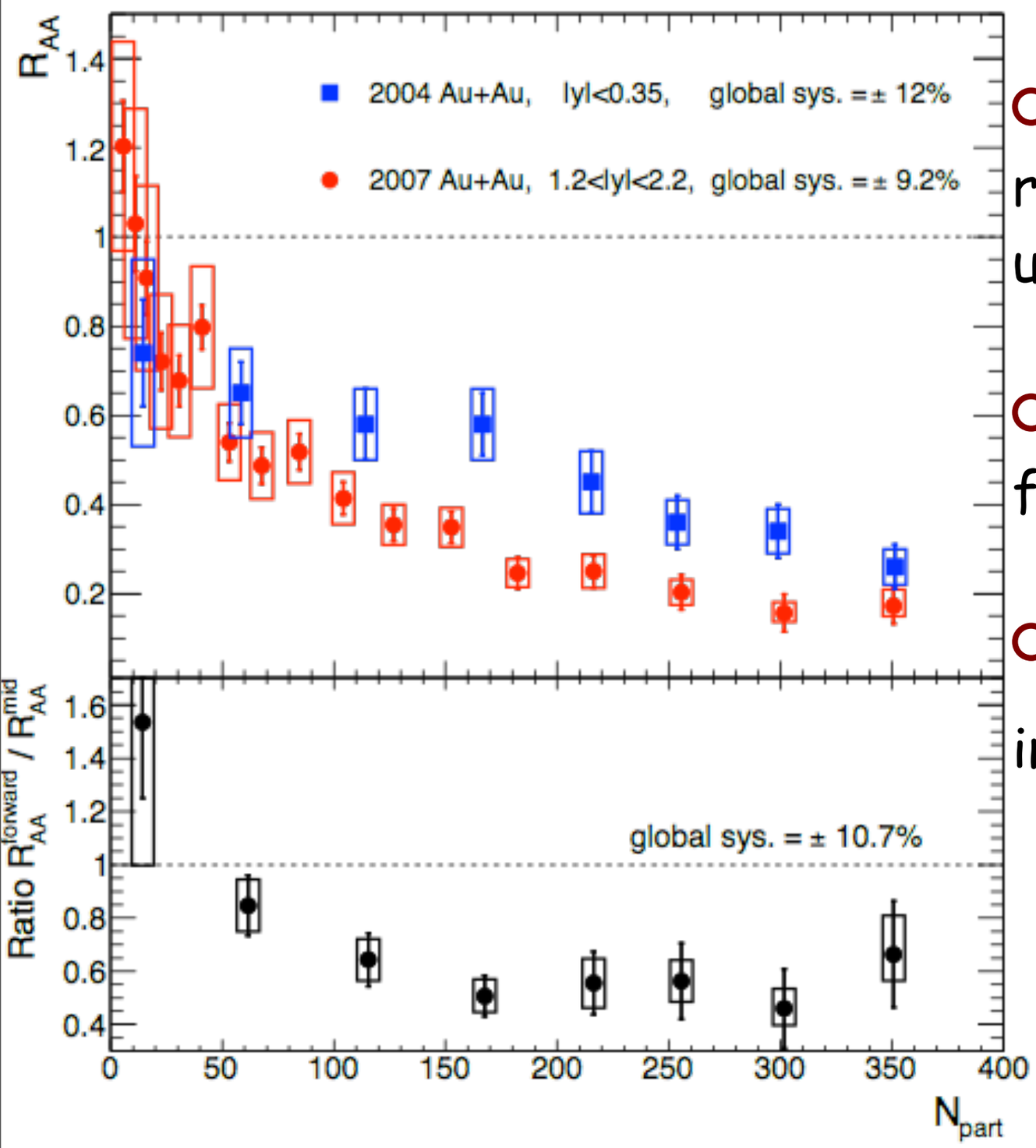
- new FONLL calculation agrees well with RHIC data
- new preliminary d+Au data shows that strong Au+Au suppression is not from cold nuclear matter effects
- looking forward to separated c/b using displaced vertices with VTX and FVTX detectors

# Quarkonia Production



# New $J/\psi$ $R_{AA}$ result at forward rapidity

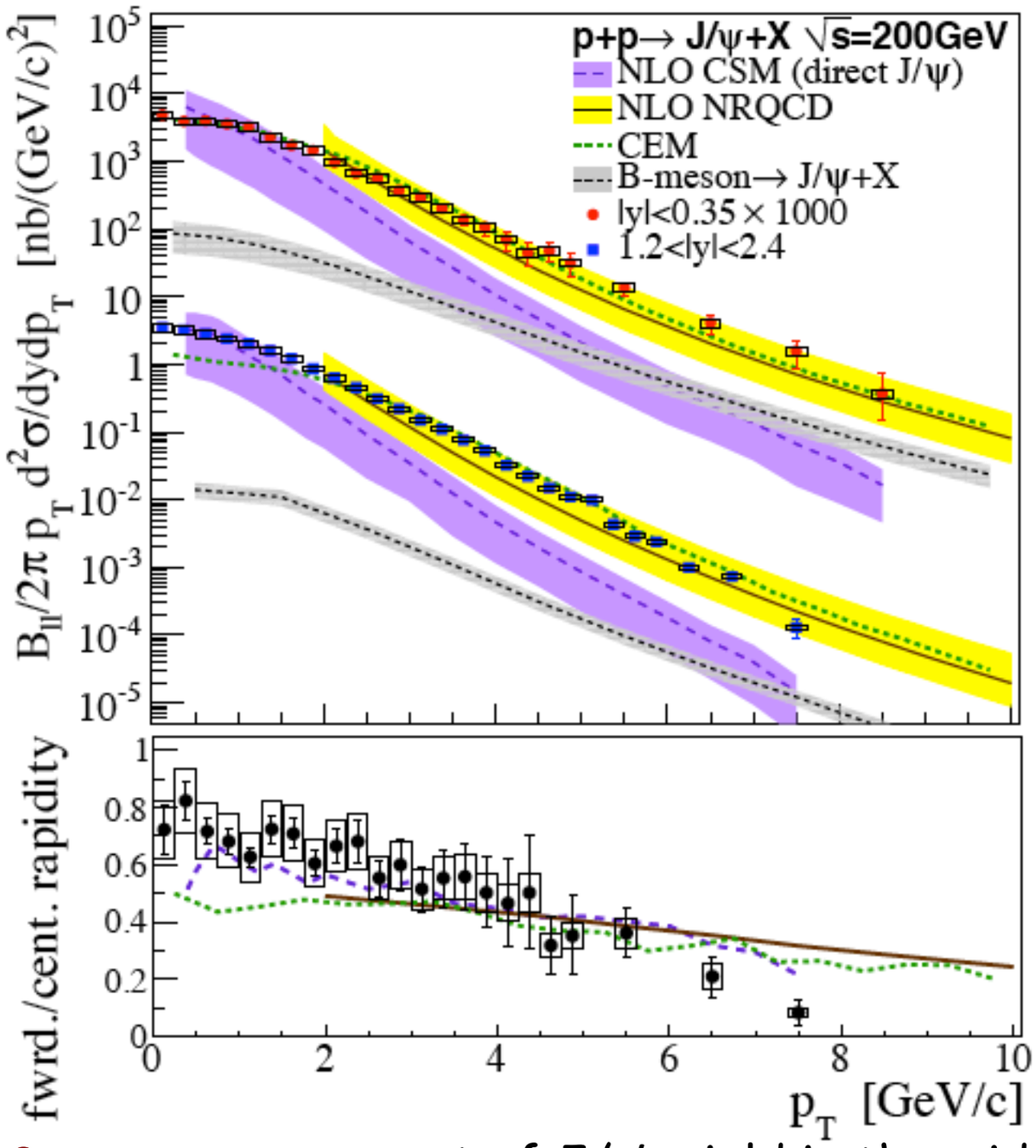
[arXiv:1103.6269v1]




- new measurement at 1.2<|y|<2.2 with reduced statistical and systematic uncertainties.
- still shows stronger suppression at forward rapidity
- let's study $J/\psi$ suppression using information from
  - p+p (production mechanism)
  - d+Au (cold nuclear matter effects)

# J/ψ Production Mechanism

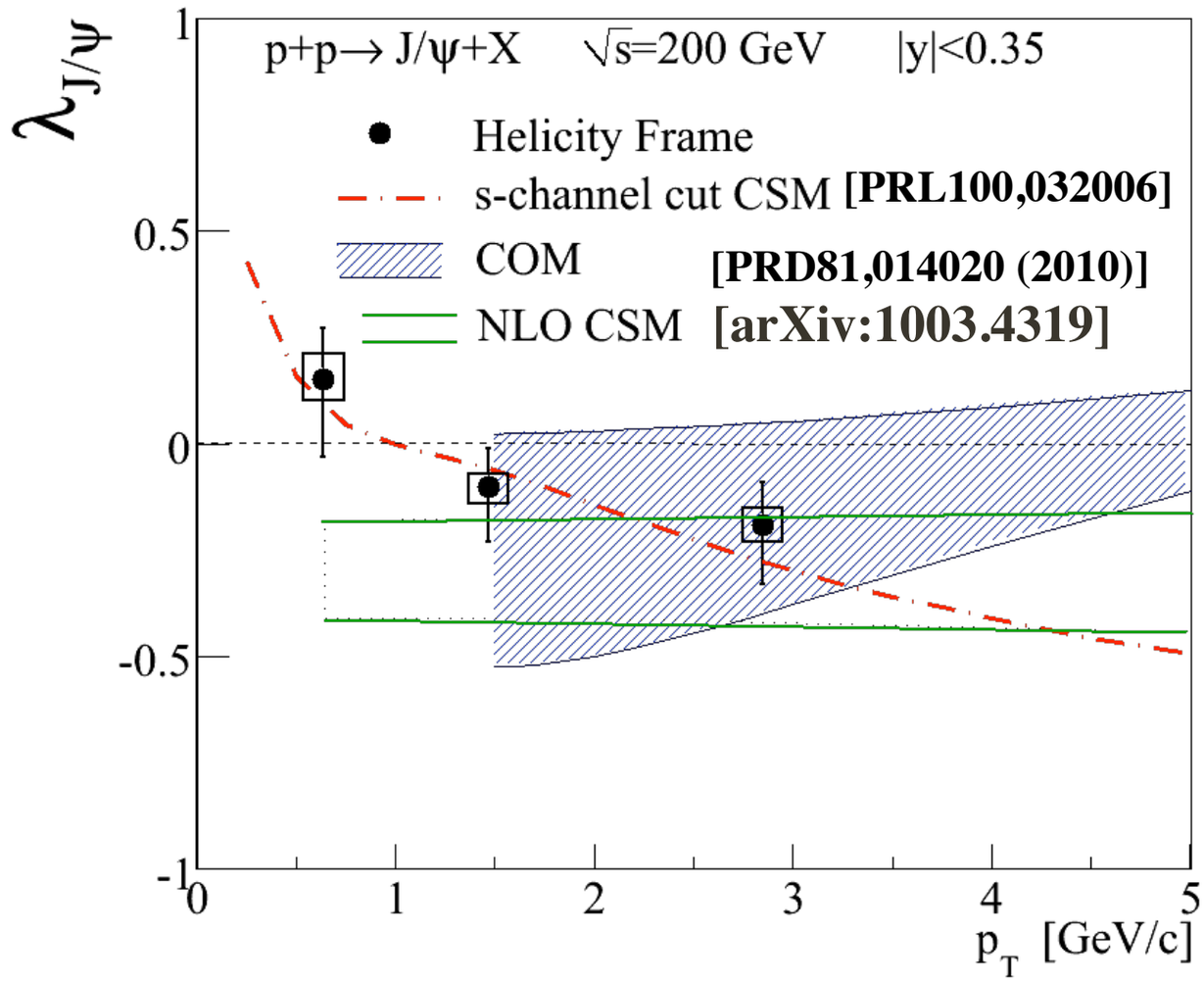
[arXiv:1105.1966]




- new measurement of J/ψ yield in the mid and forward rapidities

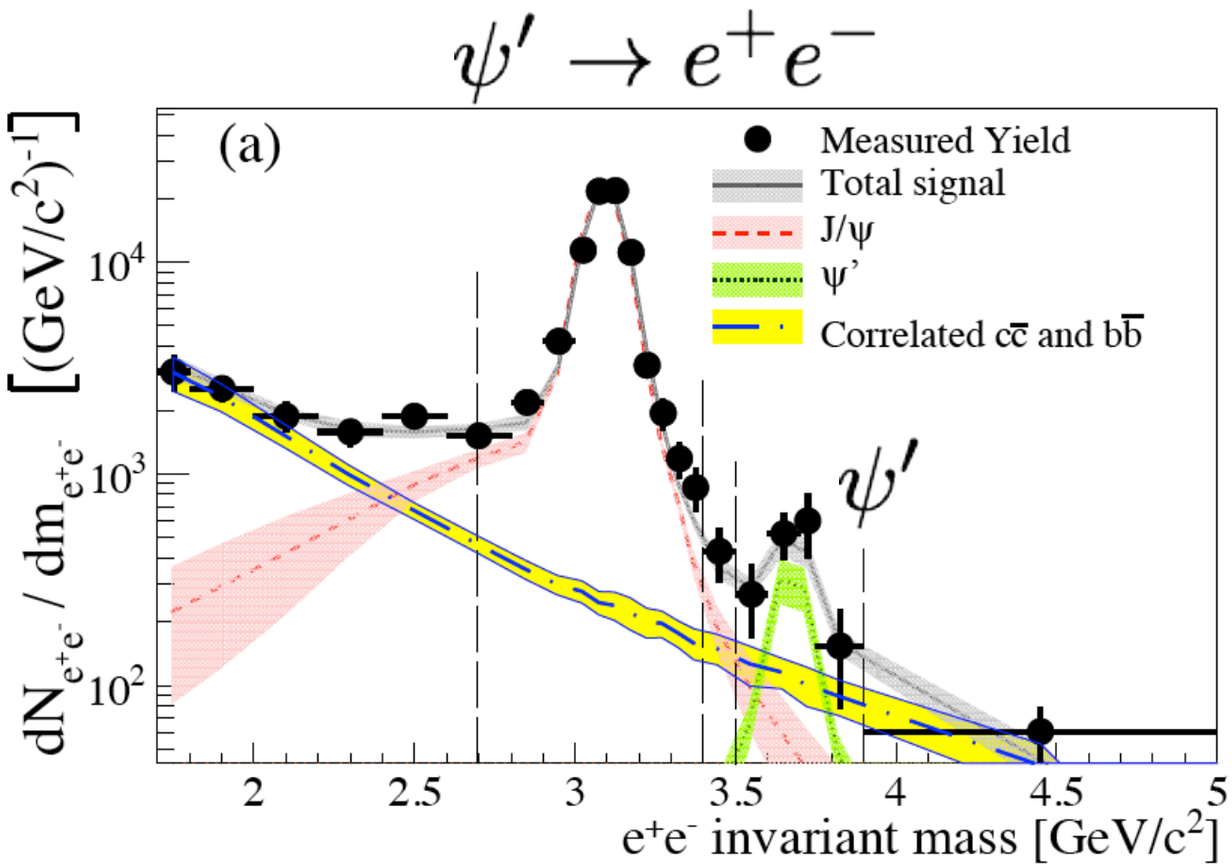
- only models with color octet formation describe the data
- J/ψ polarization measured to be small

[PRD82,012001 (2010)]




- **color octet state may cross part of the nuclear matter as a pre-resonant state**

# Fraction of J/ψ yield from excited states in p+p collisions in | η |<0.35

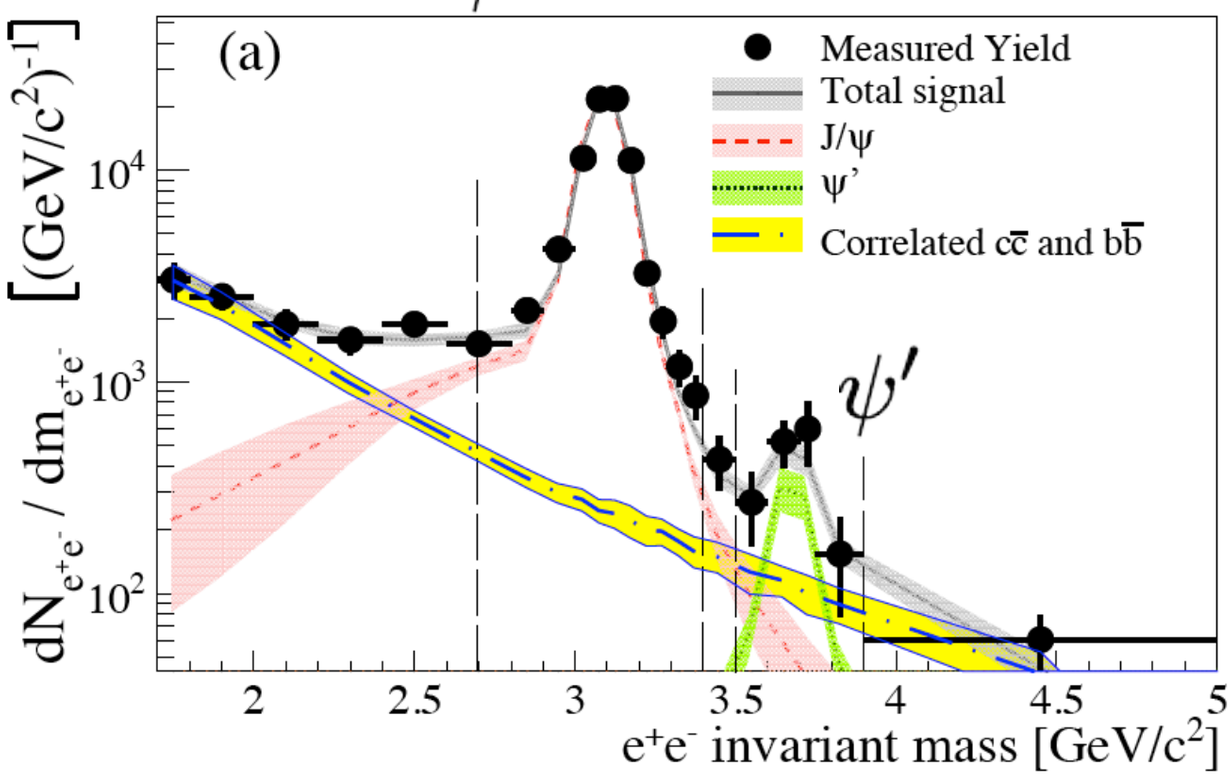



$$F_{\psi'}^{J/\psi} = \frac{B_{J/\psi}^{\psi'}\sigma_{\psi'}}{\sigma_{J/\psi}} = (9.6 \pm 2.4)\%.$$

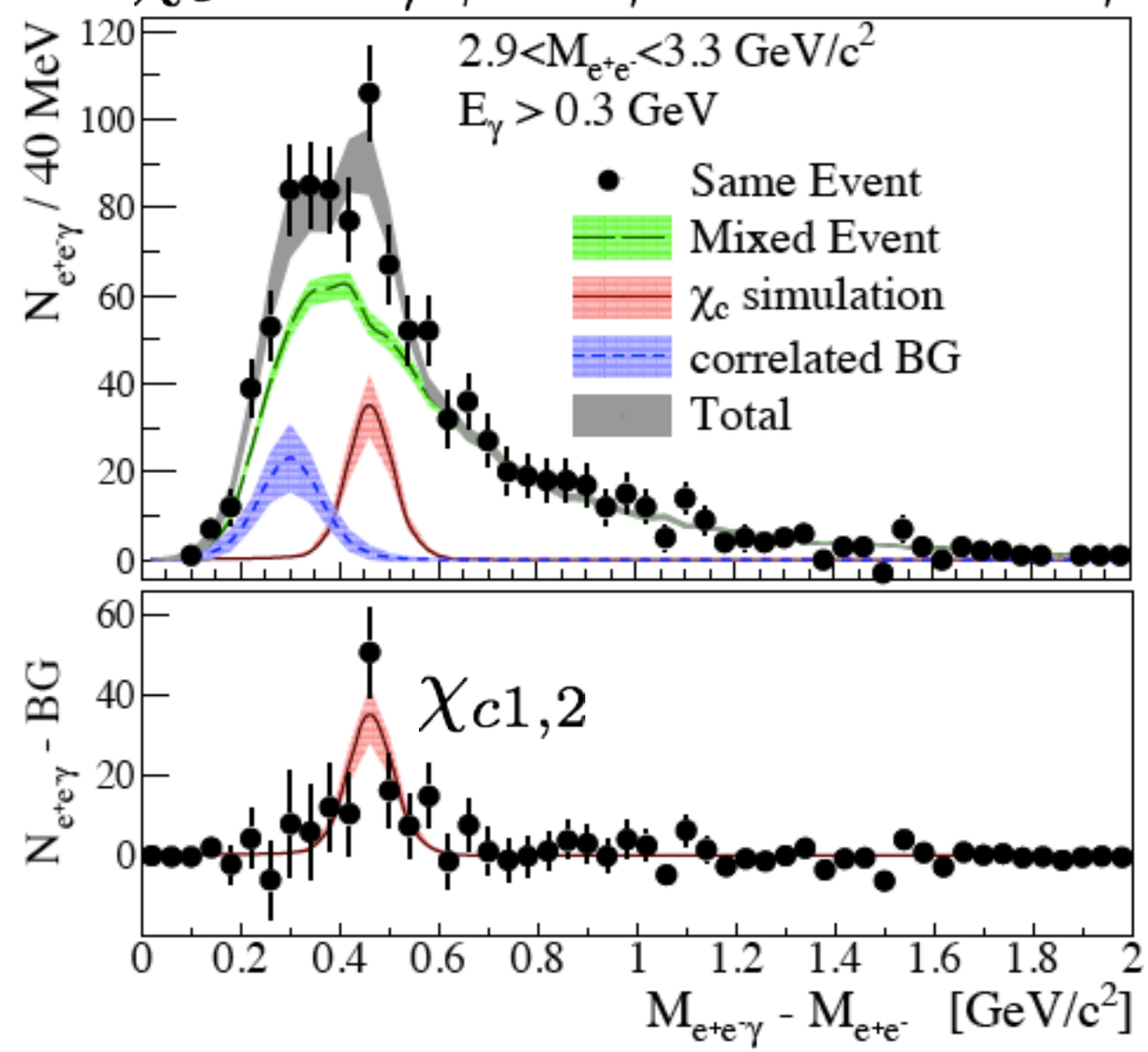
[arXiv:1105.1966]

# Fraction of J/ψ yield from excited states in p+p collisions in | η |<0.35

$\psi' \to e^+e^-$




$\chi_c \to J/\psi + \gamma \to e^+e^- + \gamma$



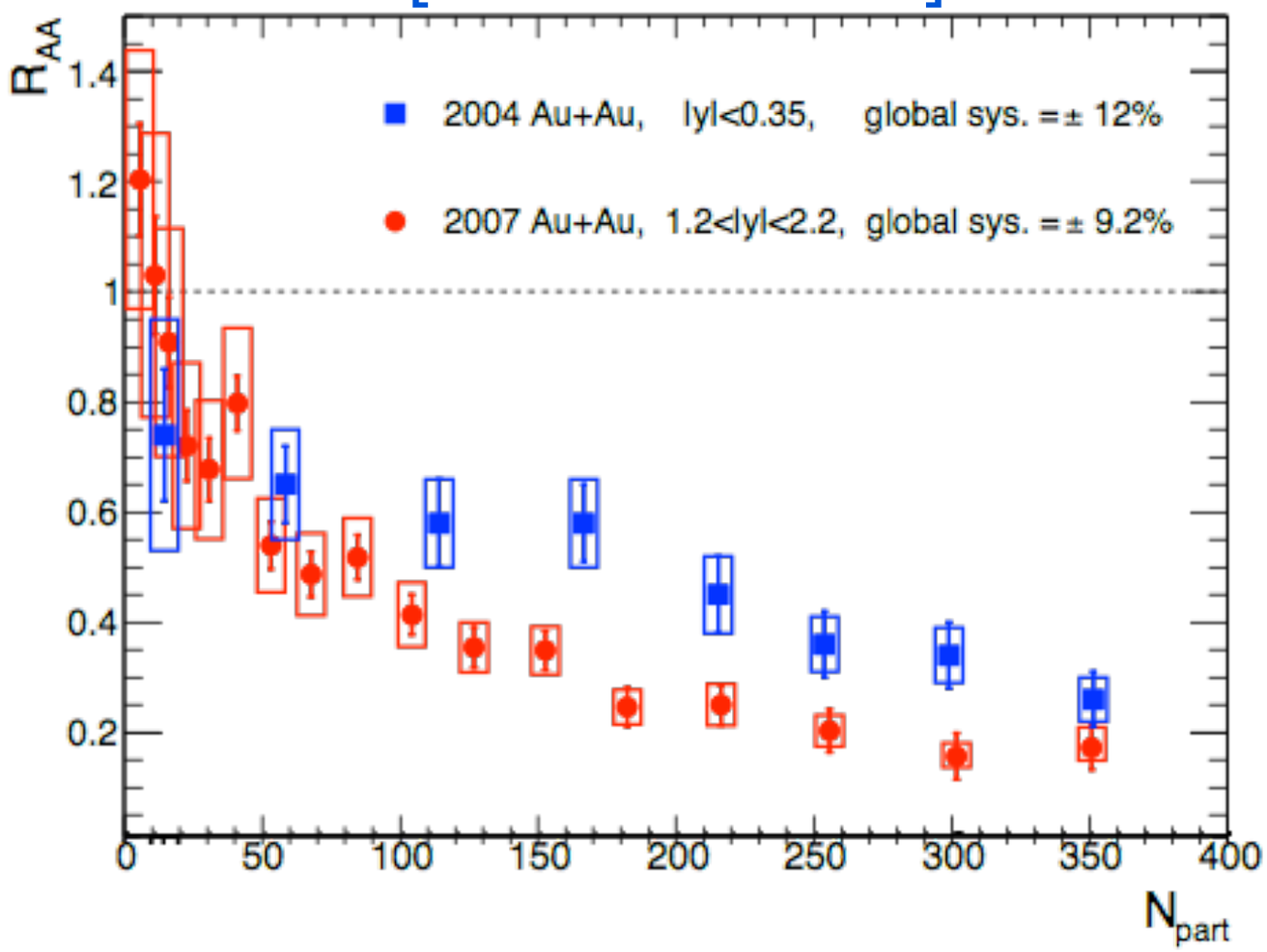

$$F^{J/\psi}_{\psi'} = \frac{B^{\psi'}_{J/\psi}\sigma_{\psi'}}{\sigma_{J/\psi}} = (9.6 \pm 2.4)\%.$$

[arXiv:1105.1966]

$$F^{J/\psi}_{\chi_c} = \frac{N_{\chi_c}}{N_{J/\psi}} \frac{1}{\langle \varepsilon_{\chi_c}/\varepsilon_{J/\psi} \rangle} = 32 \pm 9\%$$

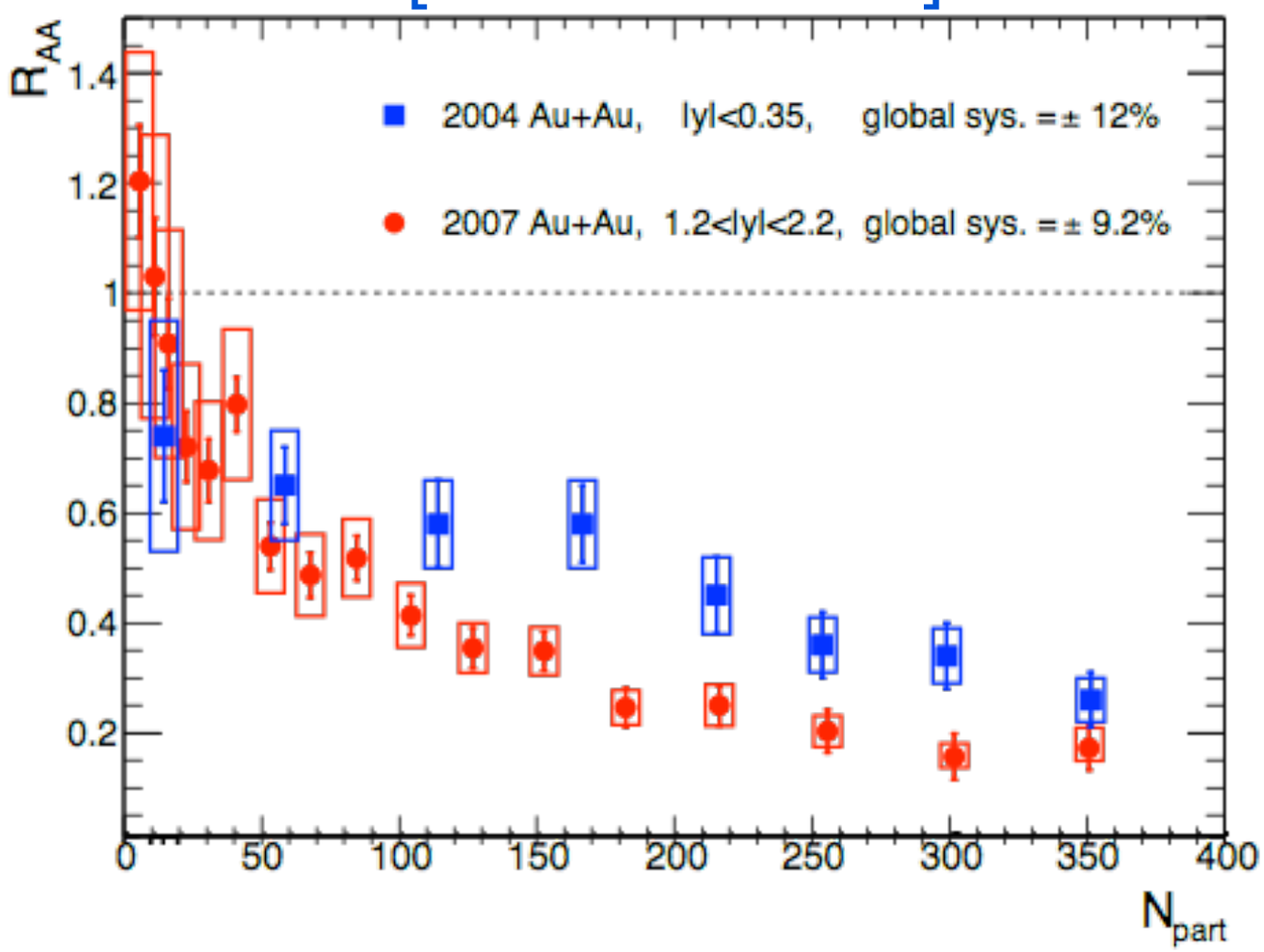
# Trying to understand J/ψ suppression in Au+Au collisions...

[arXiv:1103.6269v1]



# Trying to understand J/ψ suppression in Au+Au collisions...

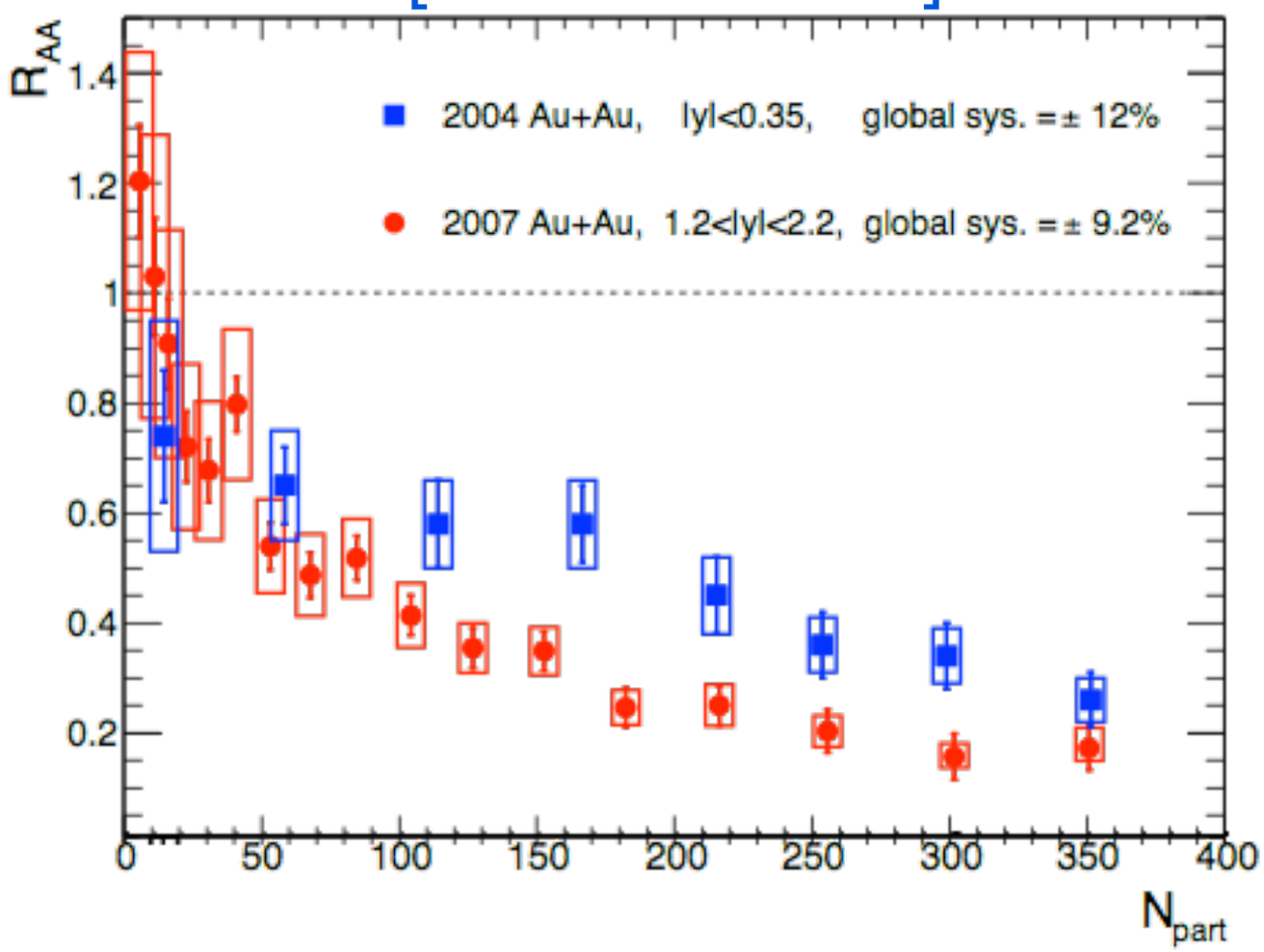
[arXiv:1103.6269v1]




- Tc ~ 170 MeV

# Trying to understand J/ψ suppression in Au+Au collisions...

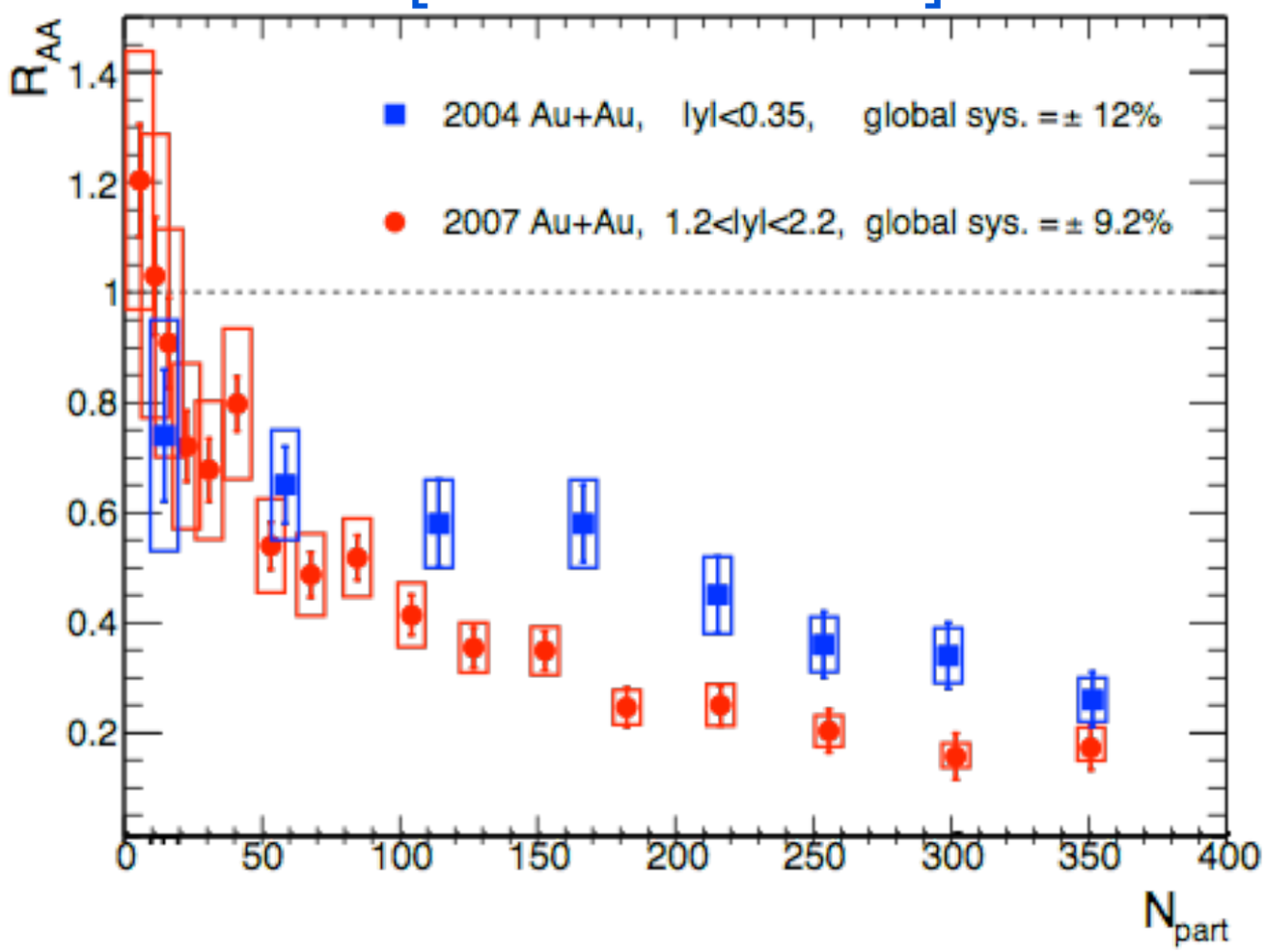
[arXiv:1103.6269v1]




- Tc ~ 170 MeV
- inverse slope of thermal photons measured by PHENIX is 221±28MeV [PRL104, 132301 (2010)]

# Trying to understand J/ψ suppression in Au+Au collisions...

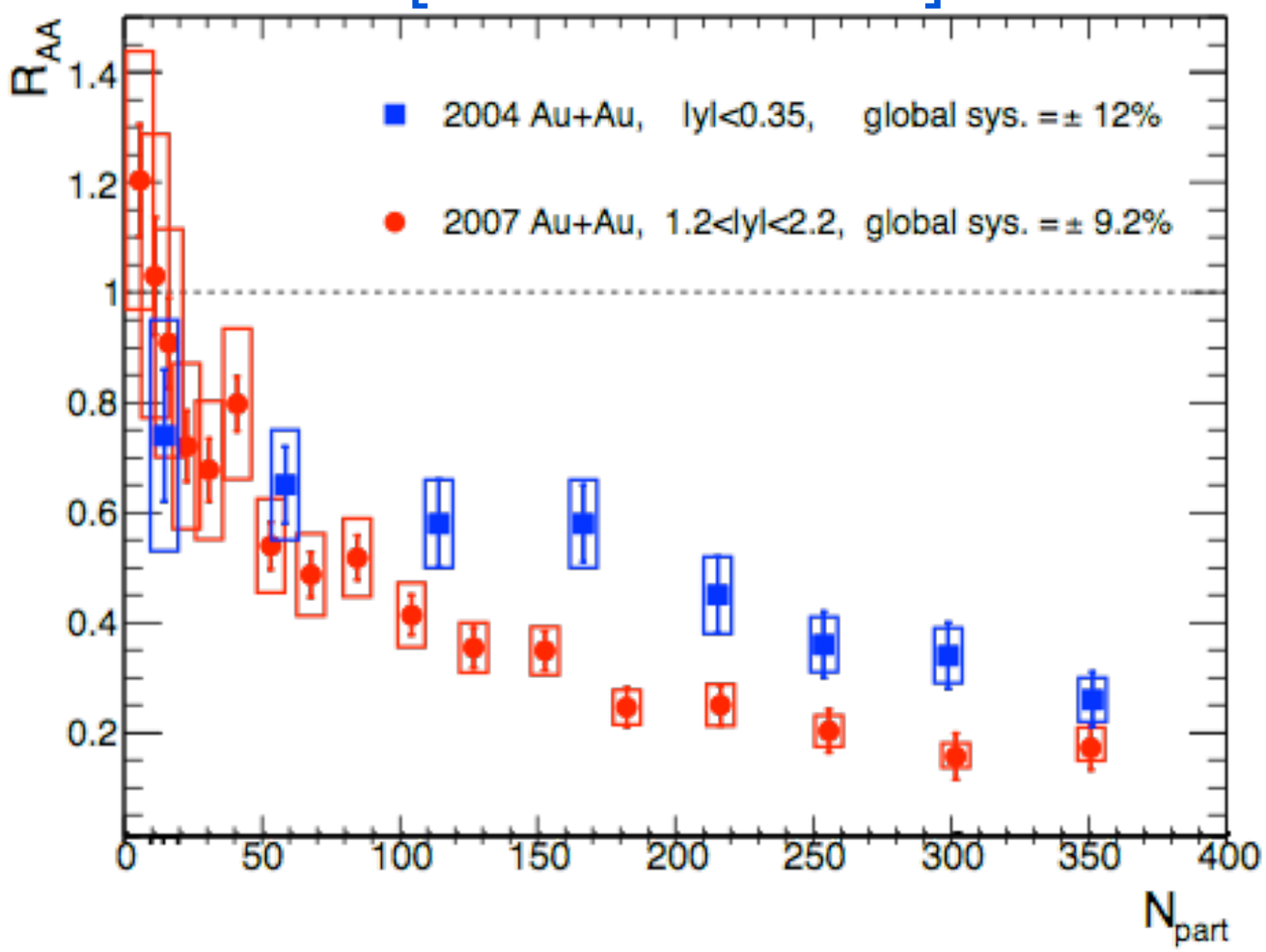
[arXiv:1103.6269v1]



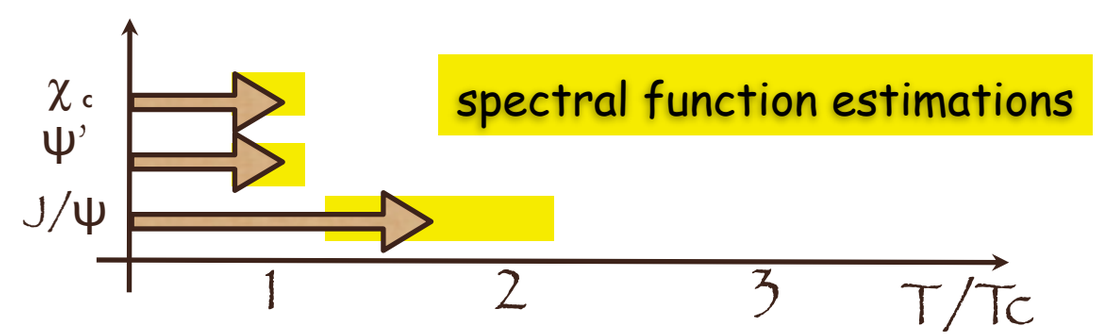

- Tc ~ 170 MeV
- inverse slope of thermal photons measured by PHENIX is 221±28MeV [PRL104, 132301 (2010)]
- hydro models fitted to the thermal photon data suggest $T_{init}$ ~300-600 MeV

# Trying to understand J/ψ suppression in Au+Au collisions...

[arXiv:1103.6269v1]

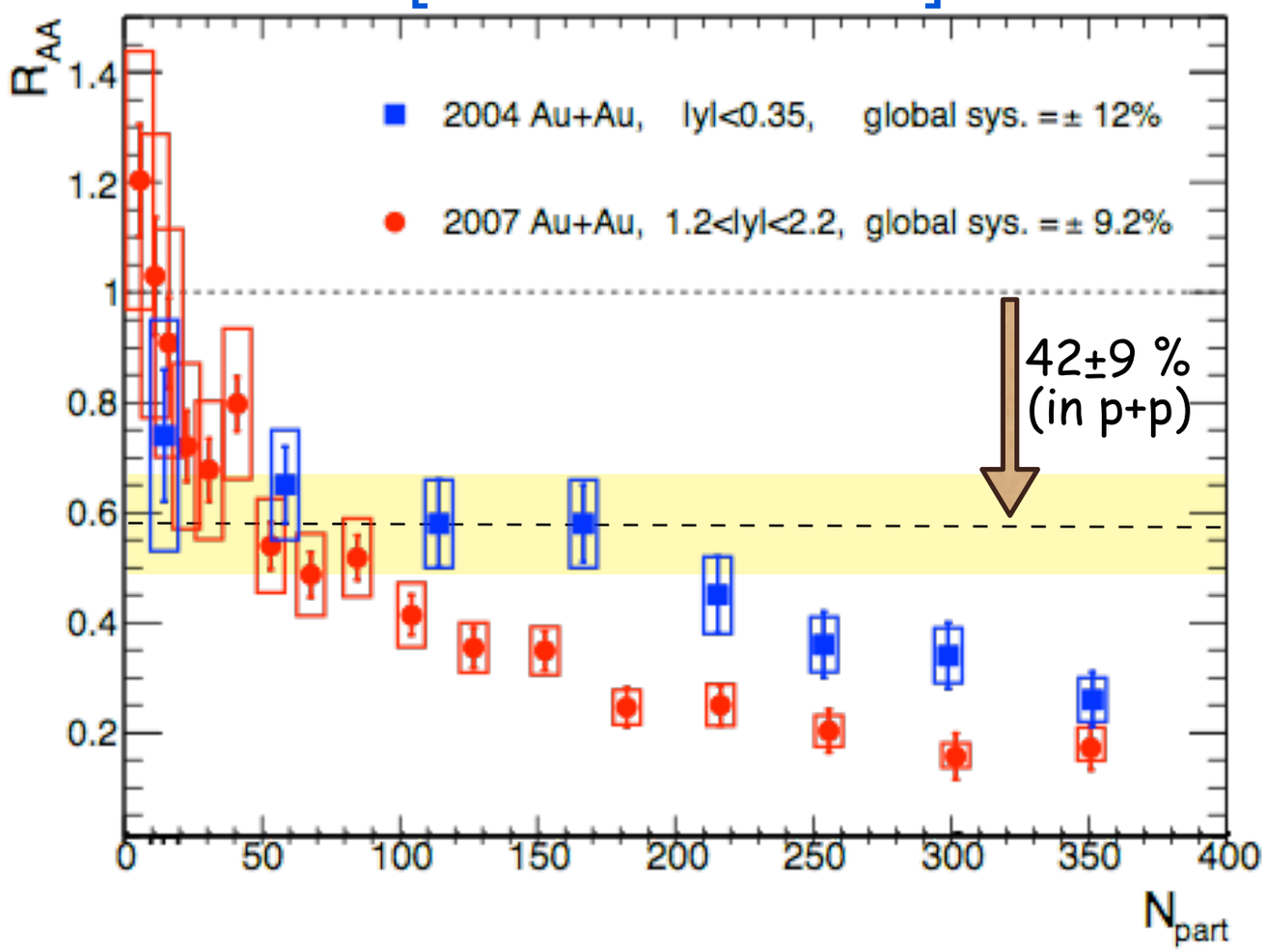



- Tc ~ 170 MeV
- inverse slope of thermal photons measured by PHENIX is 221±28MeV [PRL104, 132301 (2010)]
- hydro models fitted to the thermal photon data suggest $T_{init}$ ~300-600 MeV
- who survives?

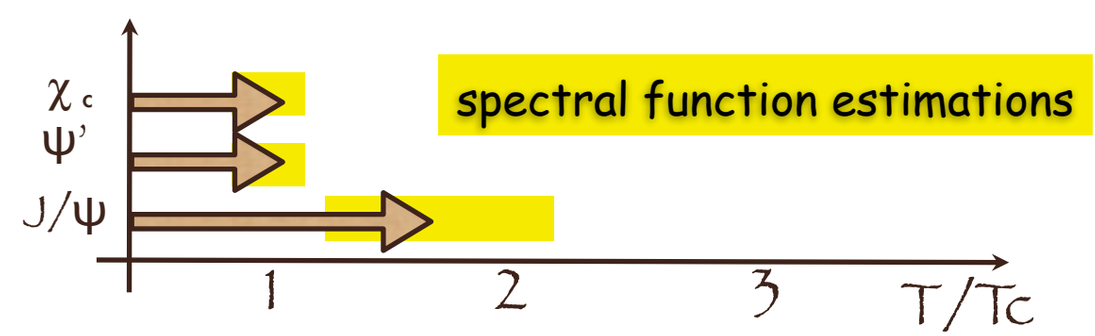


# Trying to understand J/ψ suppression in Au+Au collisions...

[arXiv:1103.6269v1]

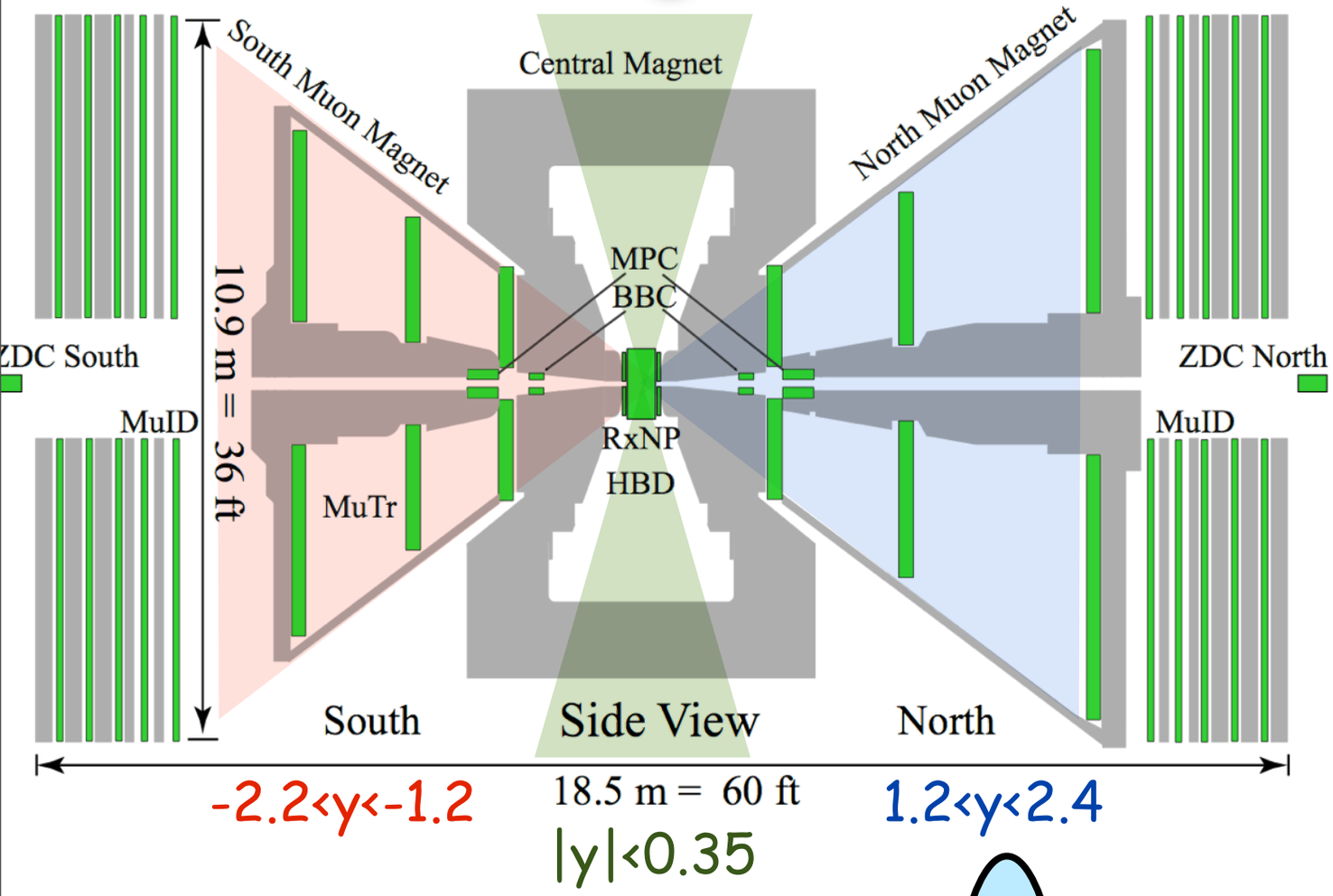


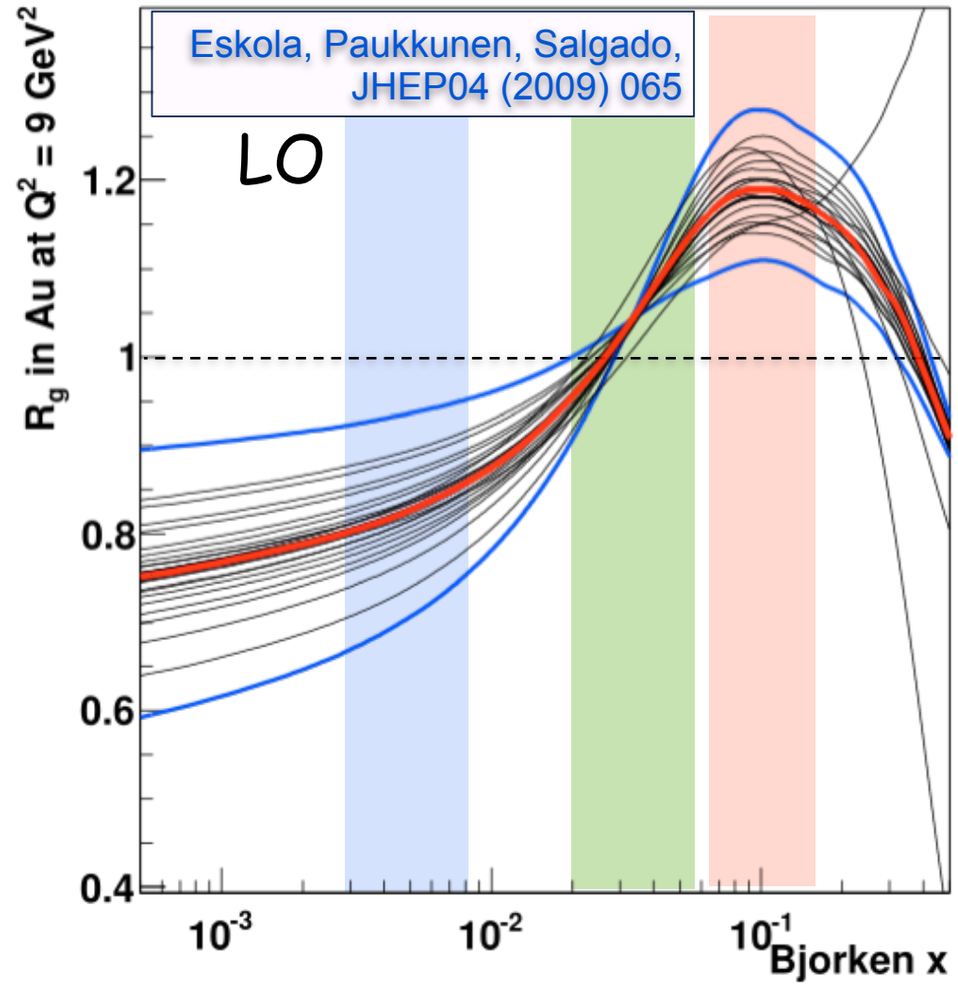

- Tc ~ 170 MeV
- inverse slope of thermal photons measured by PHENIX is 221±28MeV [PRL104, 132301 (2010)]
- hydro models fitted to the thermal photon data suggest $T_{init}$ ~300-600 MeV
- who survives?

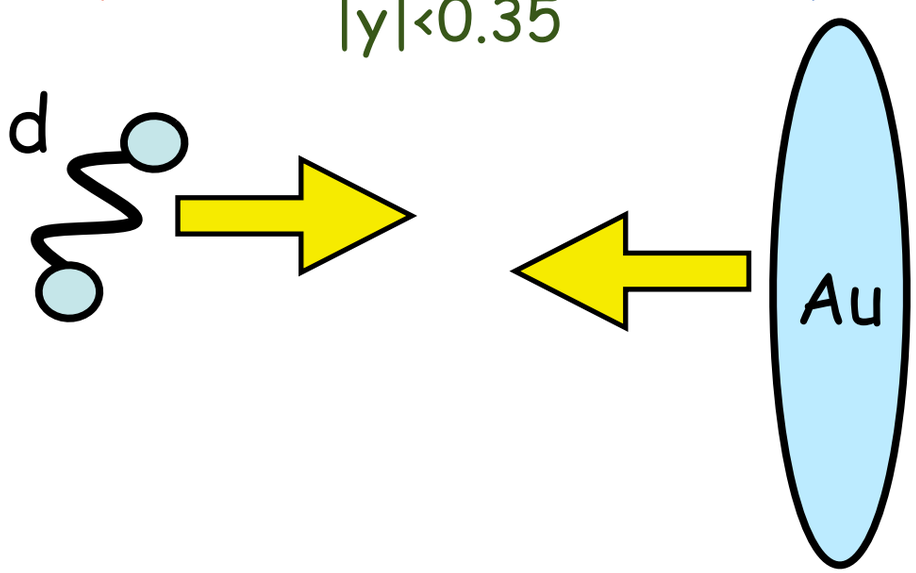



- if J/ψ from ψ' and $\chi_c$ fully suppressed $R_{AA}$ drops to 0.6

# Probing Cold Nuclear Matter effects



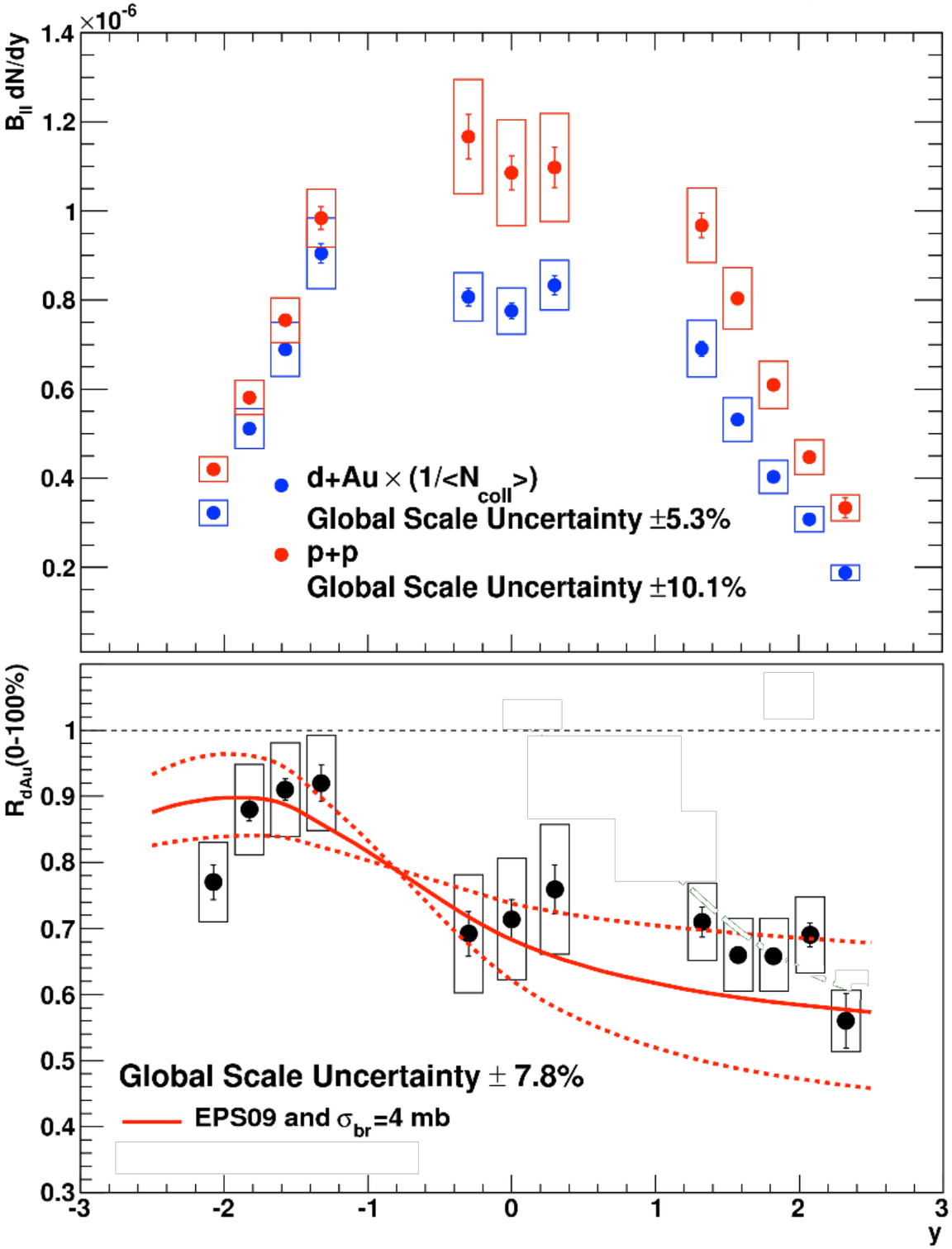




PHENIX covers Bjorken x ranges where EPS09 expects

- suppression (shadowing region)
- suppression-enhancement transition
- enhancement (anti-shadowing)

# Probing Cold Nuclear Matter effects

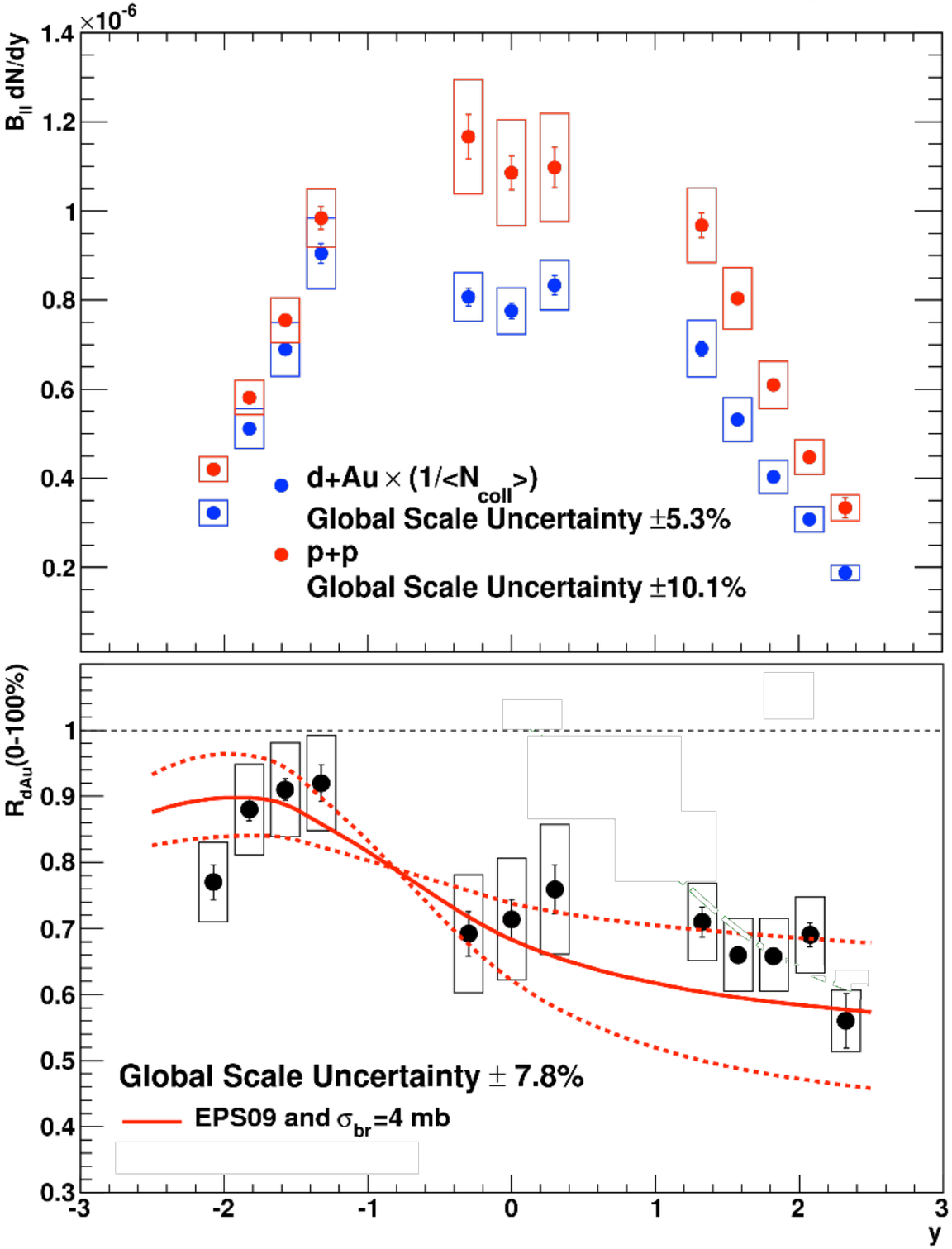
[arXiv:1010.1246]




- final RdA from 2006+2008 p+p data and 2008 d+Au data

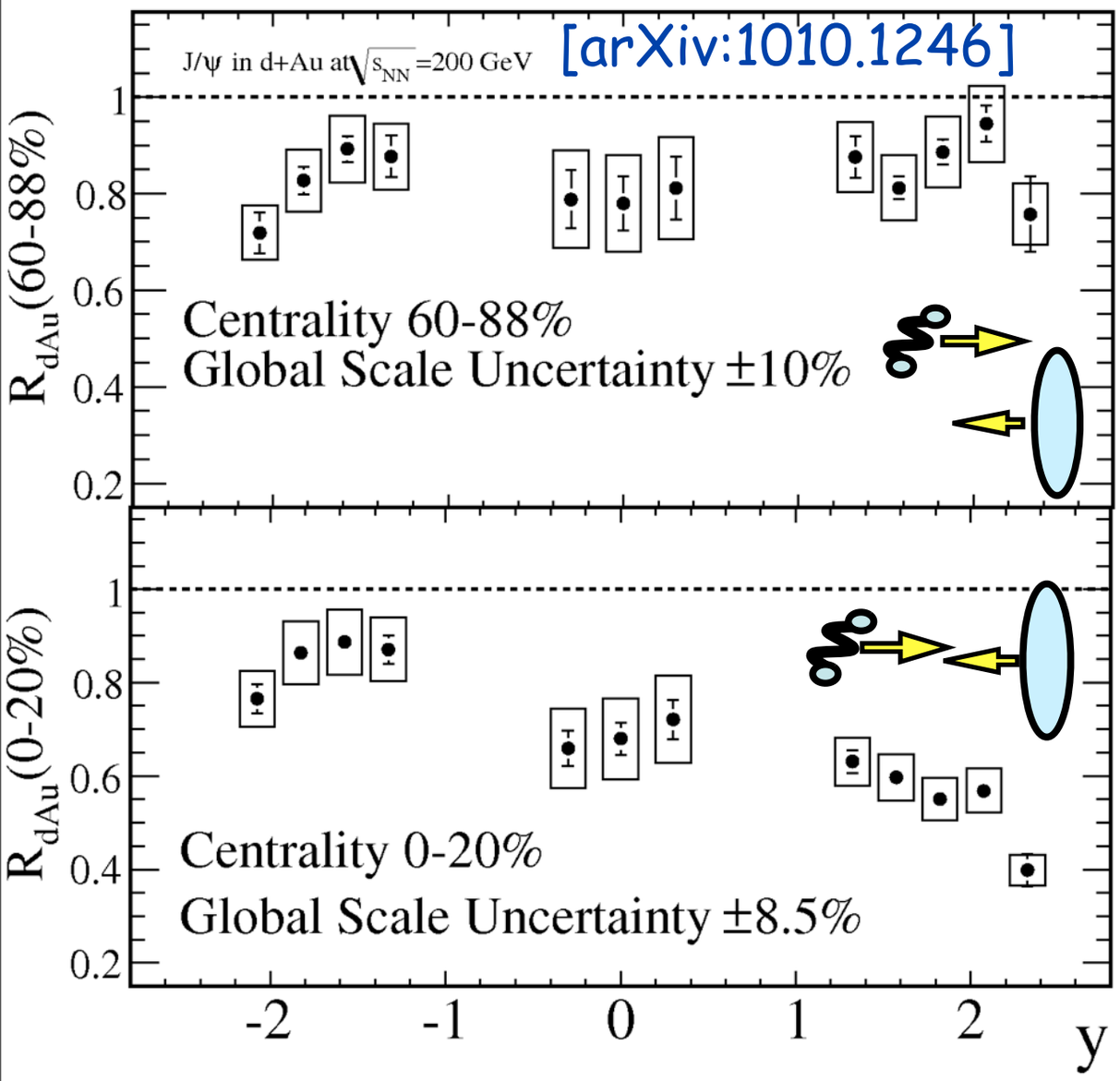
# Probing Cold Nuclear Matter effects

[arXiv:1010.1246]



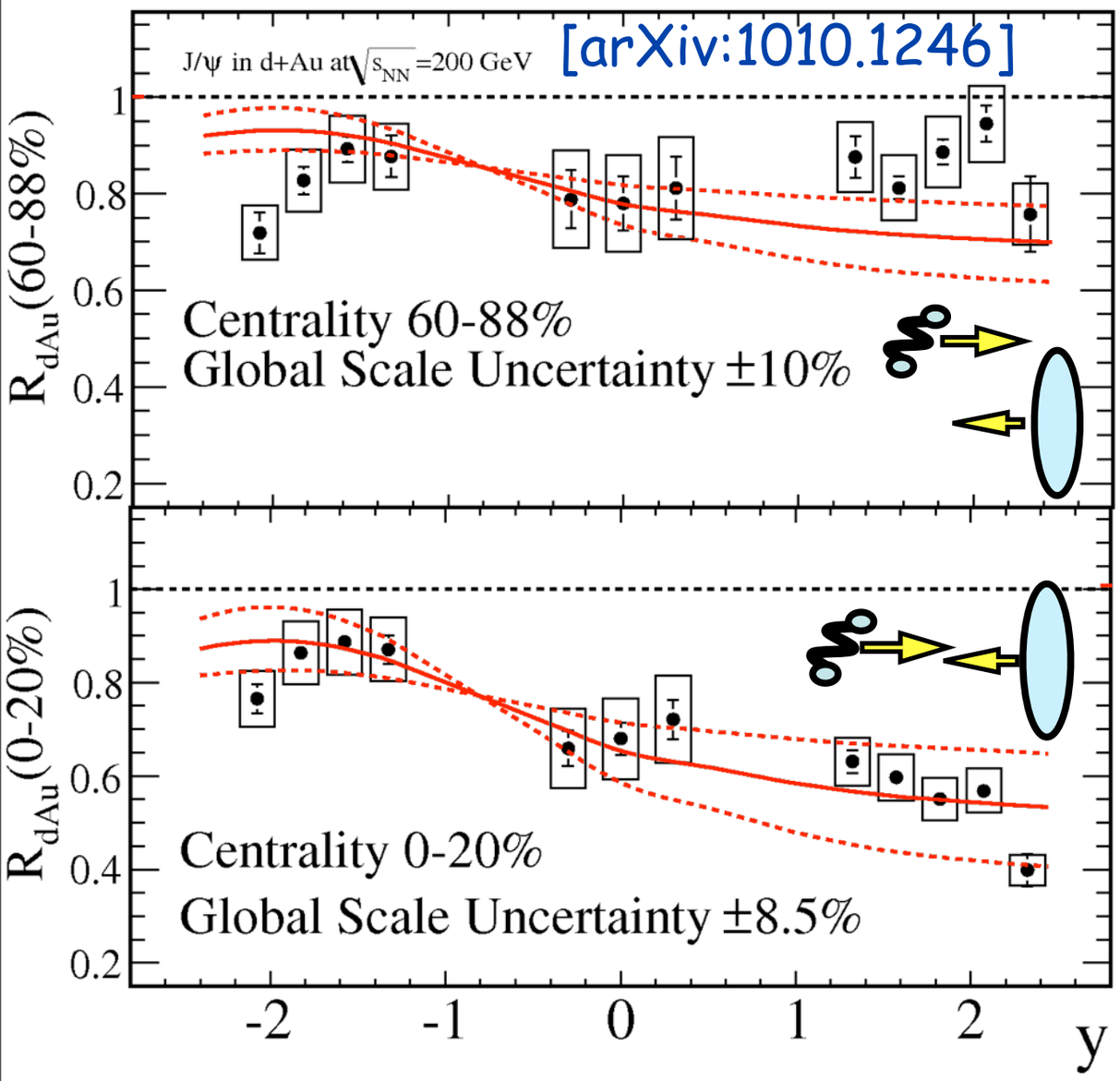

- final RdA from 2006+2008 p+p data and 2008 d+Au data
- EPS09 + J/ψ breakup in hadronic matter describes Minimum Bias $R_{dAu}$ data
- expected because EPS09 nPDF modification is geometry integrated

# What about Centrality Dependence?



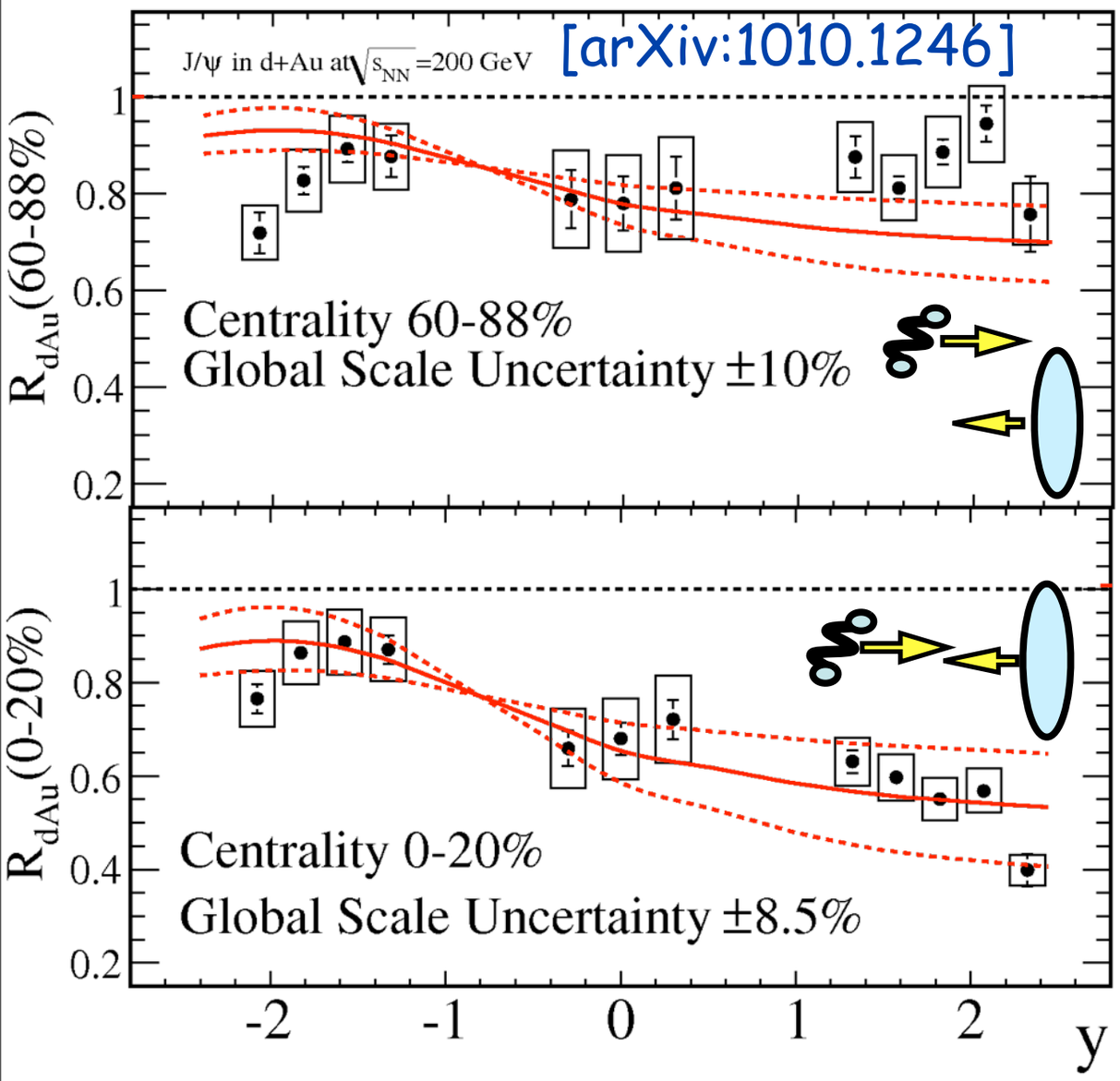

- EPS09 needs an impact parameter dependence
- let's try linear thickness dependence

# What about Centrality Dependence?



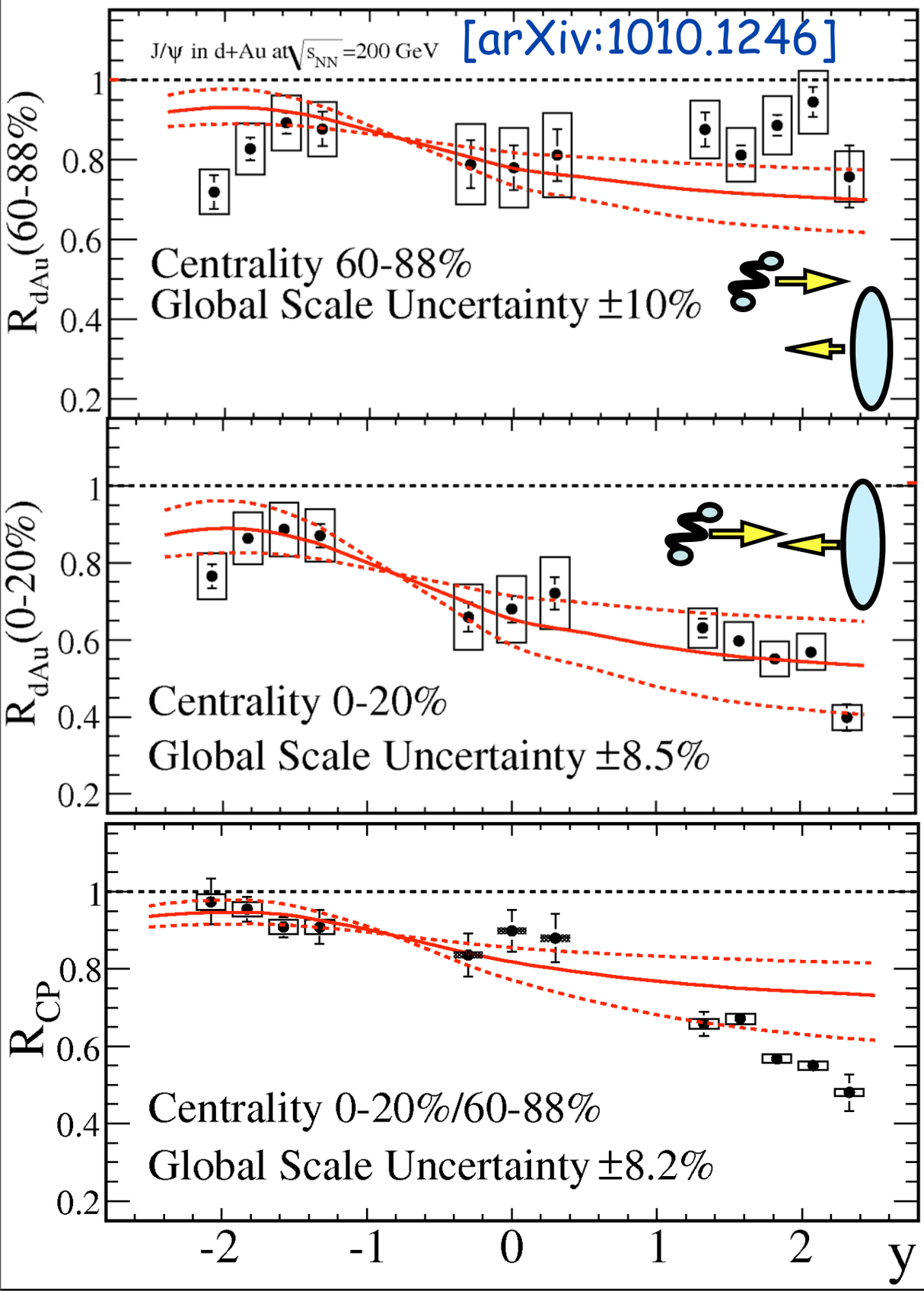

- EPS09 needs an impact parameter dependence
- let's try linear thickness dependence
- good for central events
- over predicts at forward rapidity in peripheral events

# What about Centrality Dependence?



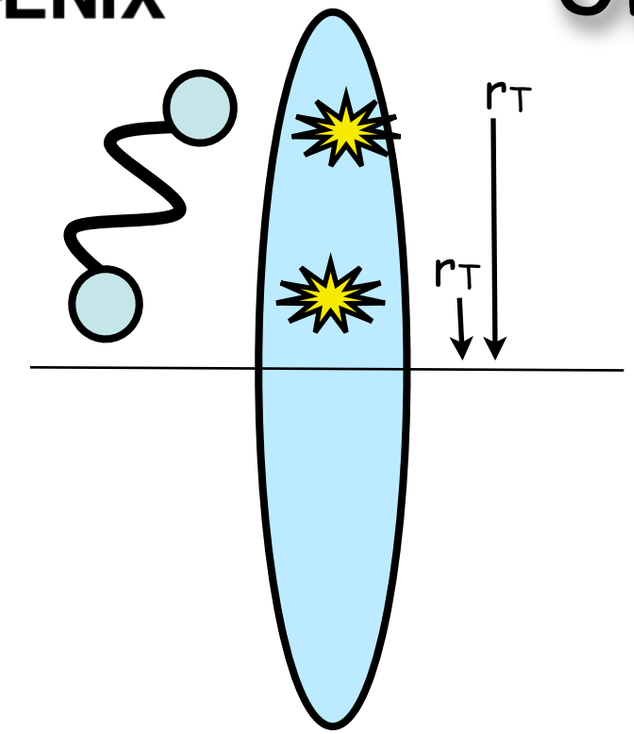

- EPS09 needs an impact parameter dependence
- let's try linear thickness dependence
- good for central events
- over predicts at forward rapidity in peripheral events
- what about the ratio between central and peripheral d+Au events (Rcp)?

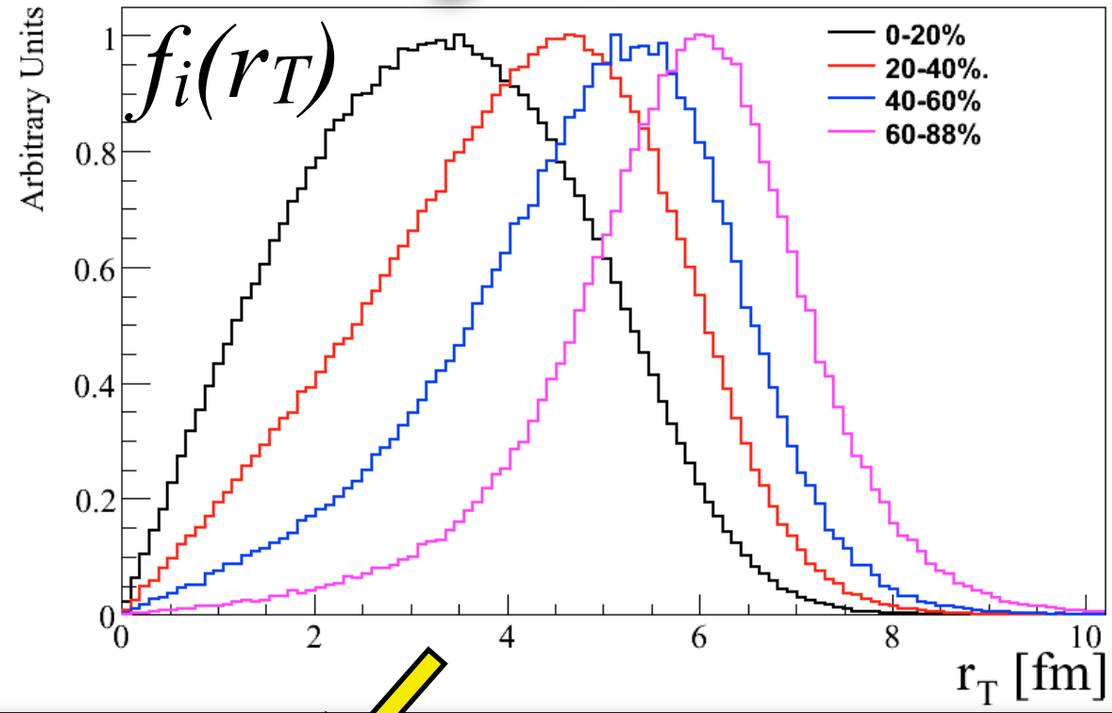
# What about Centrality Dependence?




- EPS09 needs an impact parameter dependence
- let's try linear thickness dependence
- good for central events
- over predicts at forward rapidity in peripheral events
- what about the ratio between central and peripheral d+Au events (Rcp)?
- linear dependence does not work

# Understanding $R_{dA}$ [arXiv:1010.1246]




$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

density weighted longitudinal thickness

$$\Lambda(r_T) \equiv \frac{1}{\rho_0} \int dz \rho(z, r_T)$$

$\rho(z, r_T) \equiv$ Woods-Saxon

trial nuclear modification function

$$\text{Exponential}: M(r_T) = e^{-a\Lambda(r_T)}$$

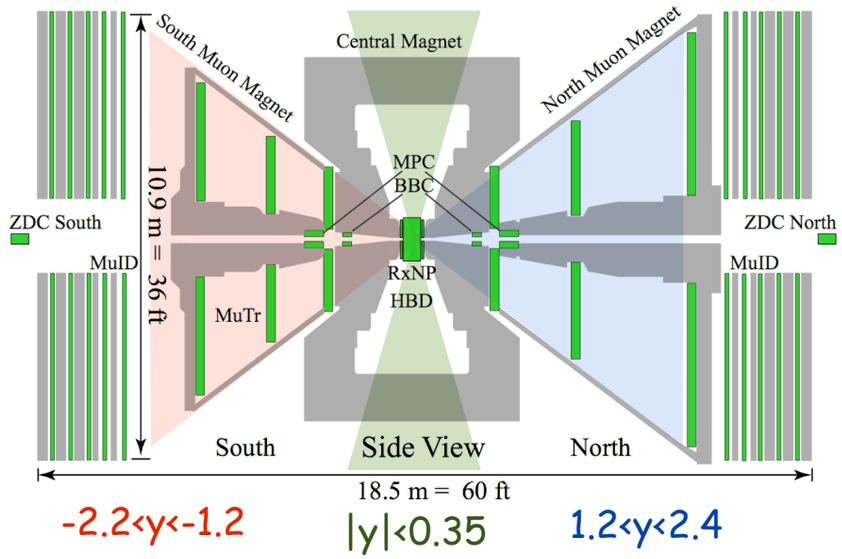
$$\text{Linear}: M(r_T) = 1.0 - a\Lambda(r_T)$$

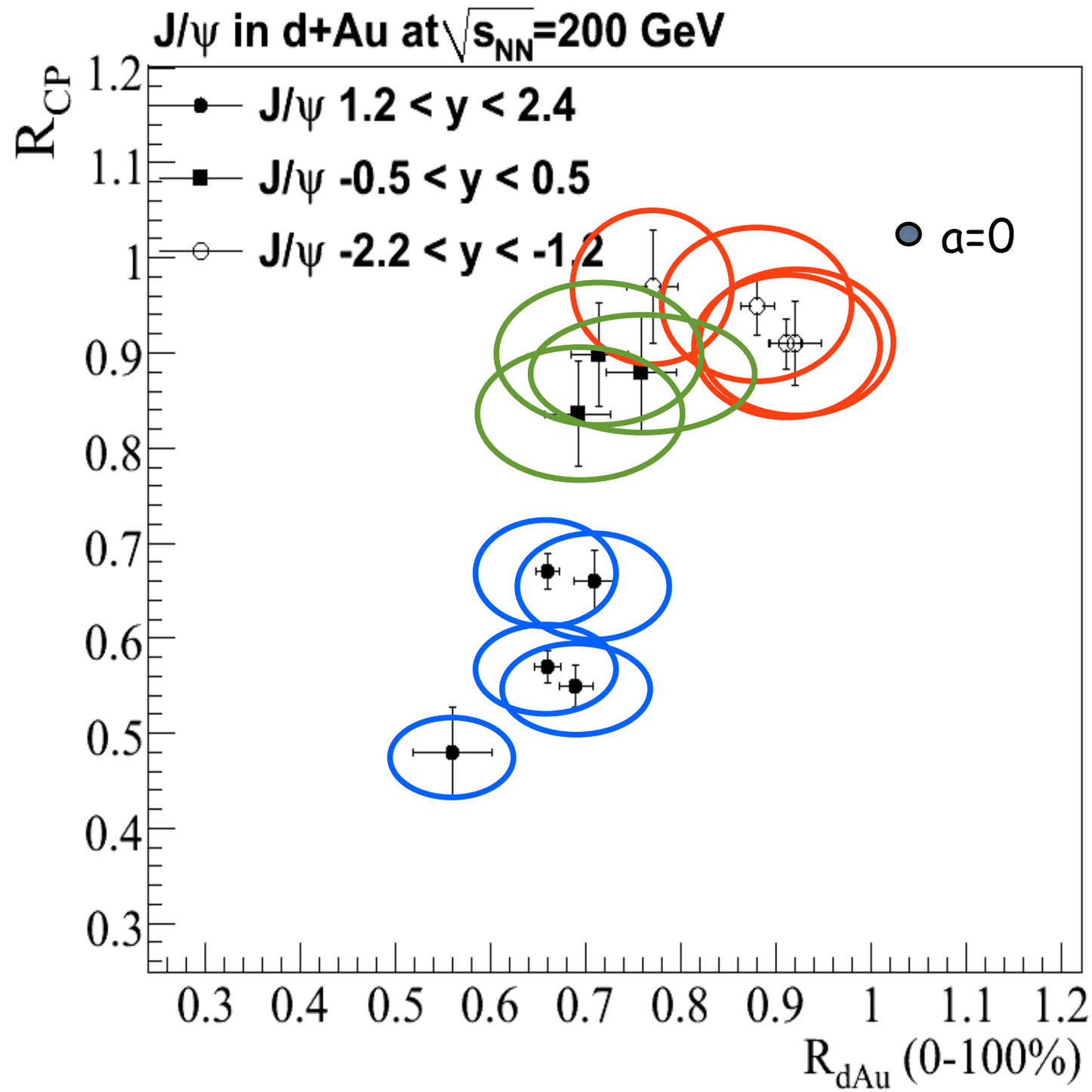
$$\text{Quadratic}: M(r_T) = 1.0 - a\Lambda(r_T)^2,$$

no physics assumptions

PHENIX

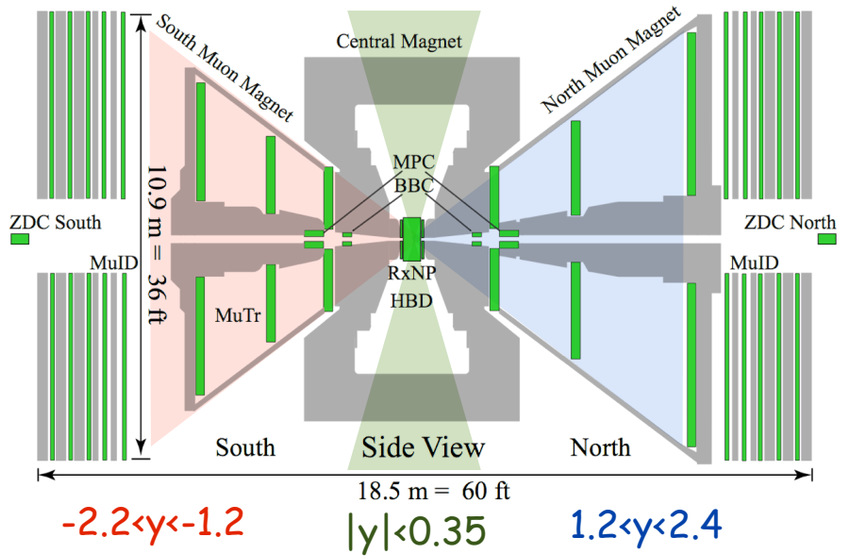
[arXiv:1010.1246]



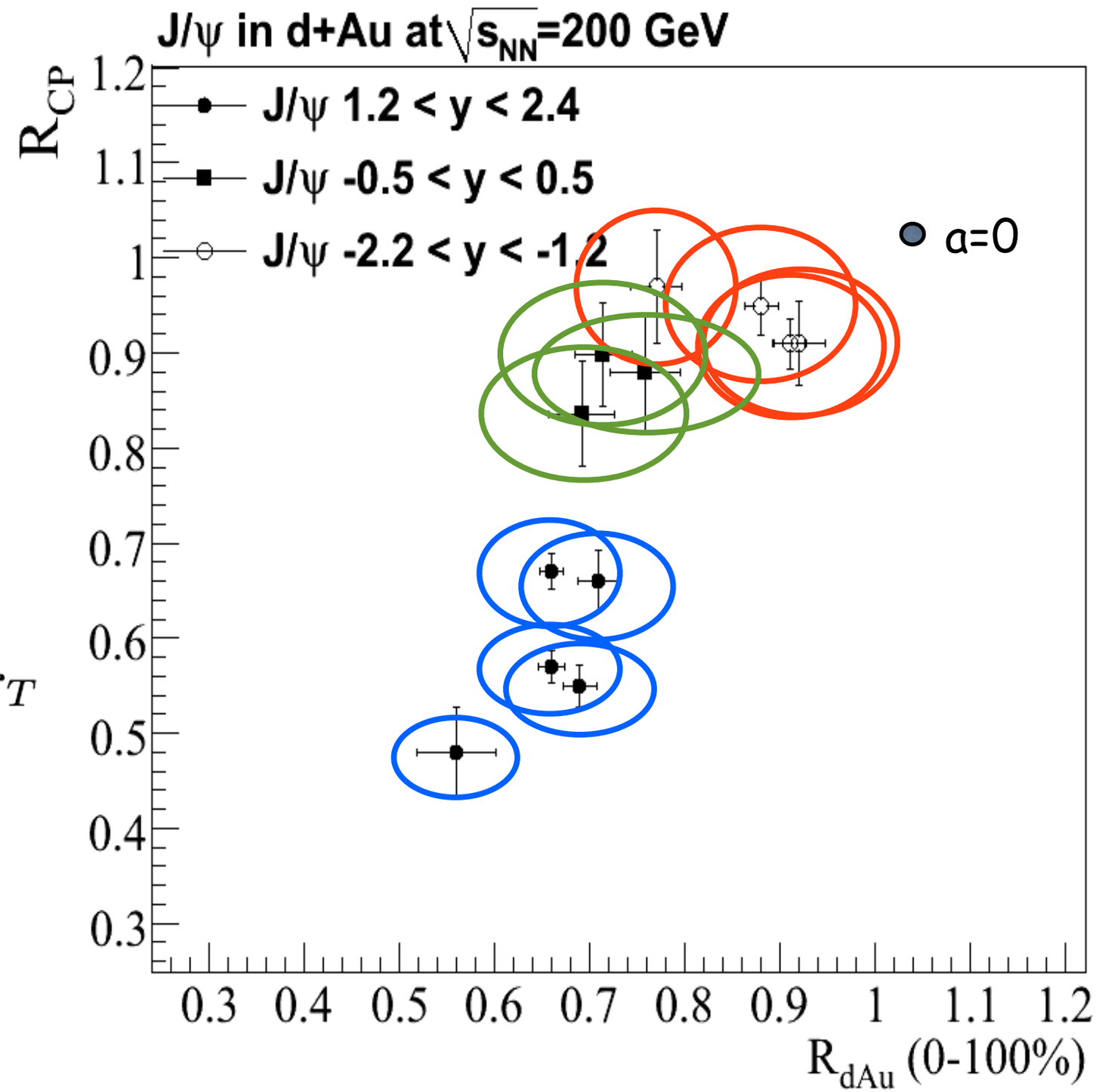
PHENIX

[arXiv:1010.1246]



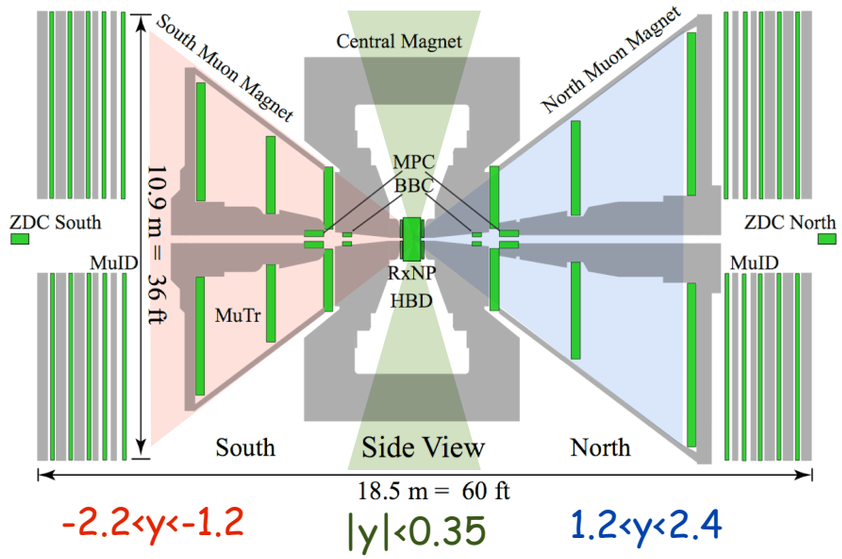

scan different values for the strength "a" in $R_{dAu}$ formula

$$R_{dAu,i}(a) = \int f_i\left(r_T\right) M\left(r_T; a\right) dr_T$$



PHENIX

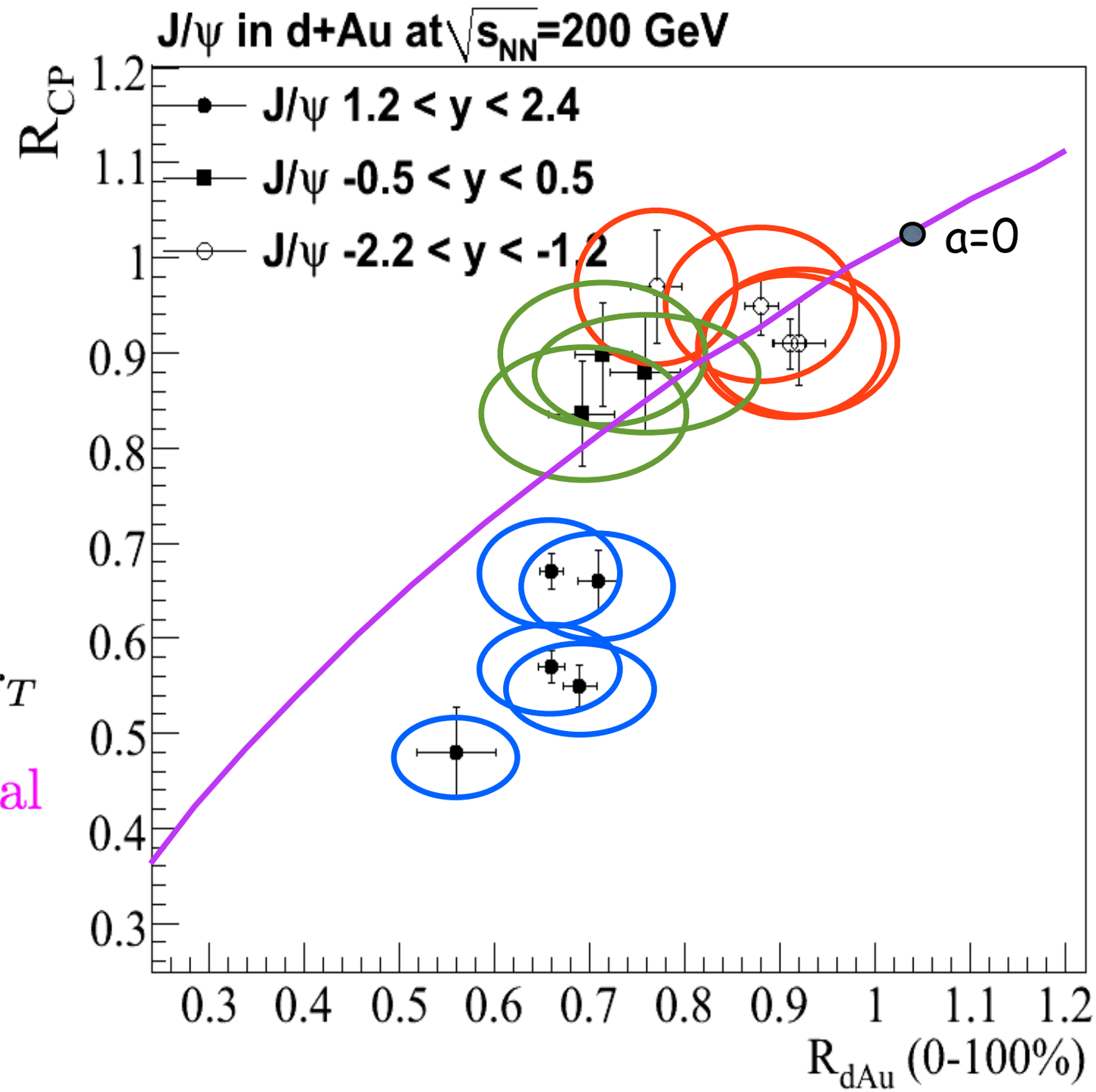
[arXiv:1010.1246]




scan different values for the strength "a" in $R_{dAu}$ formula

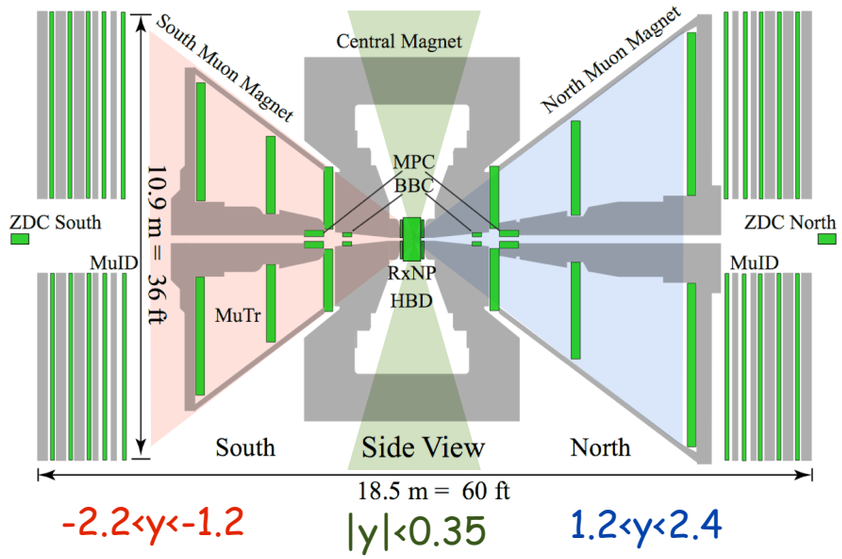
$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

$$M(r_T; a) = e^{-a\Lambda(r_T)}$$ exponential



PHENIX

[arXiv:1010.1246]

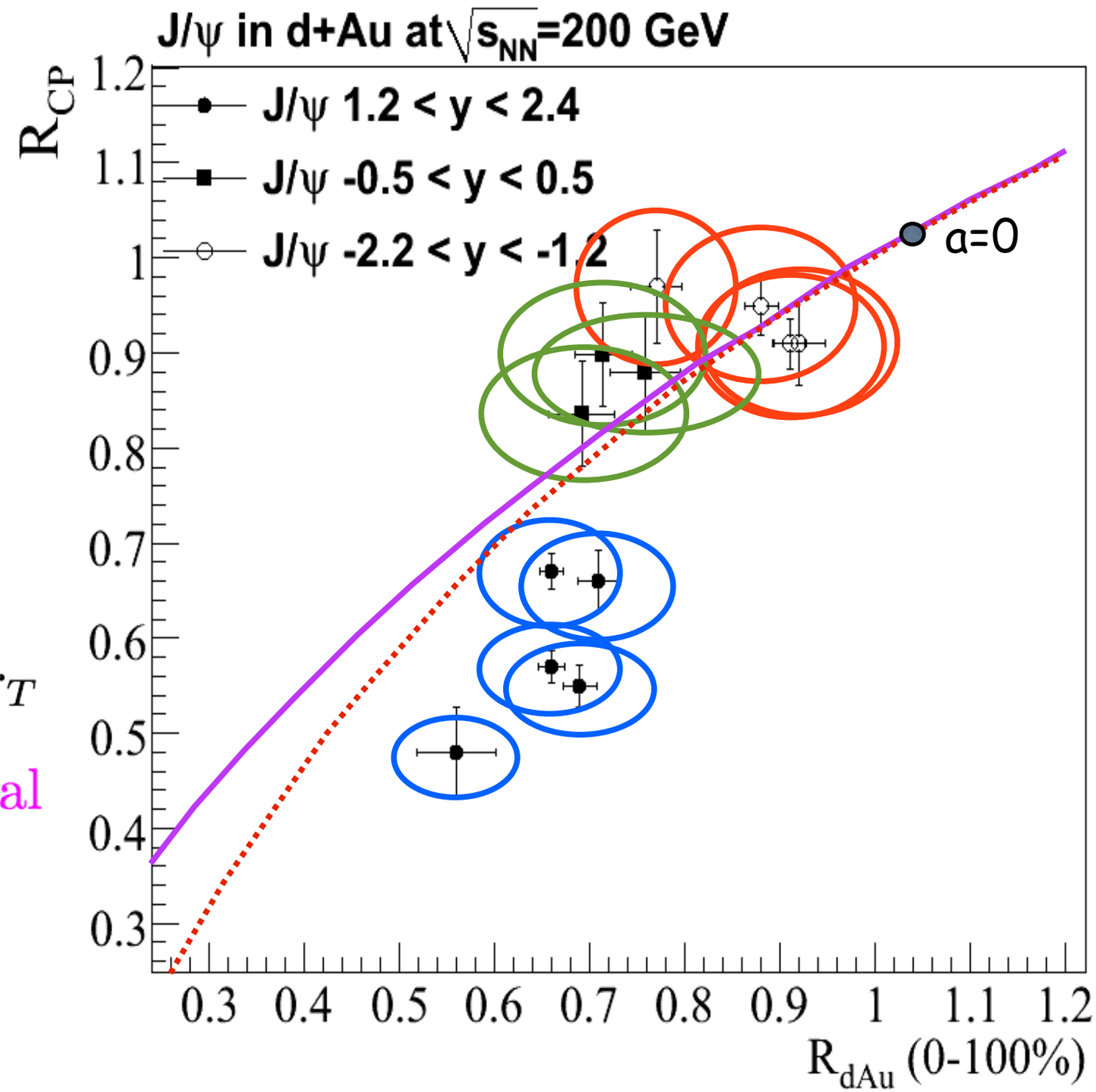



scan different values for the strength "a" in $R_{dAu}$ formula

$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

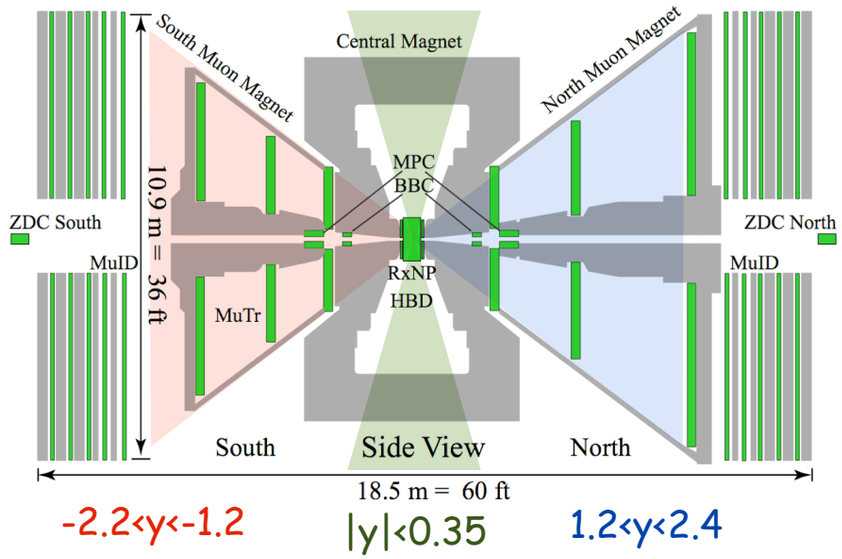
$M(r_T; a) = e^{-a\Lambda(r_T)}$ exponential

$M(r_T; a) = 1 - a\Lambda(r_T)$ linear



PHENIX

[arXiv:1010.1246]



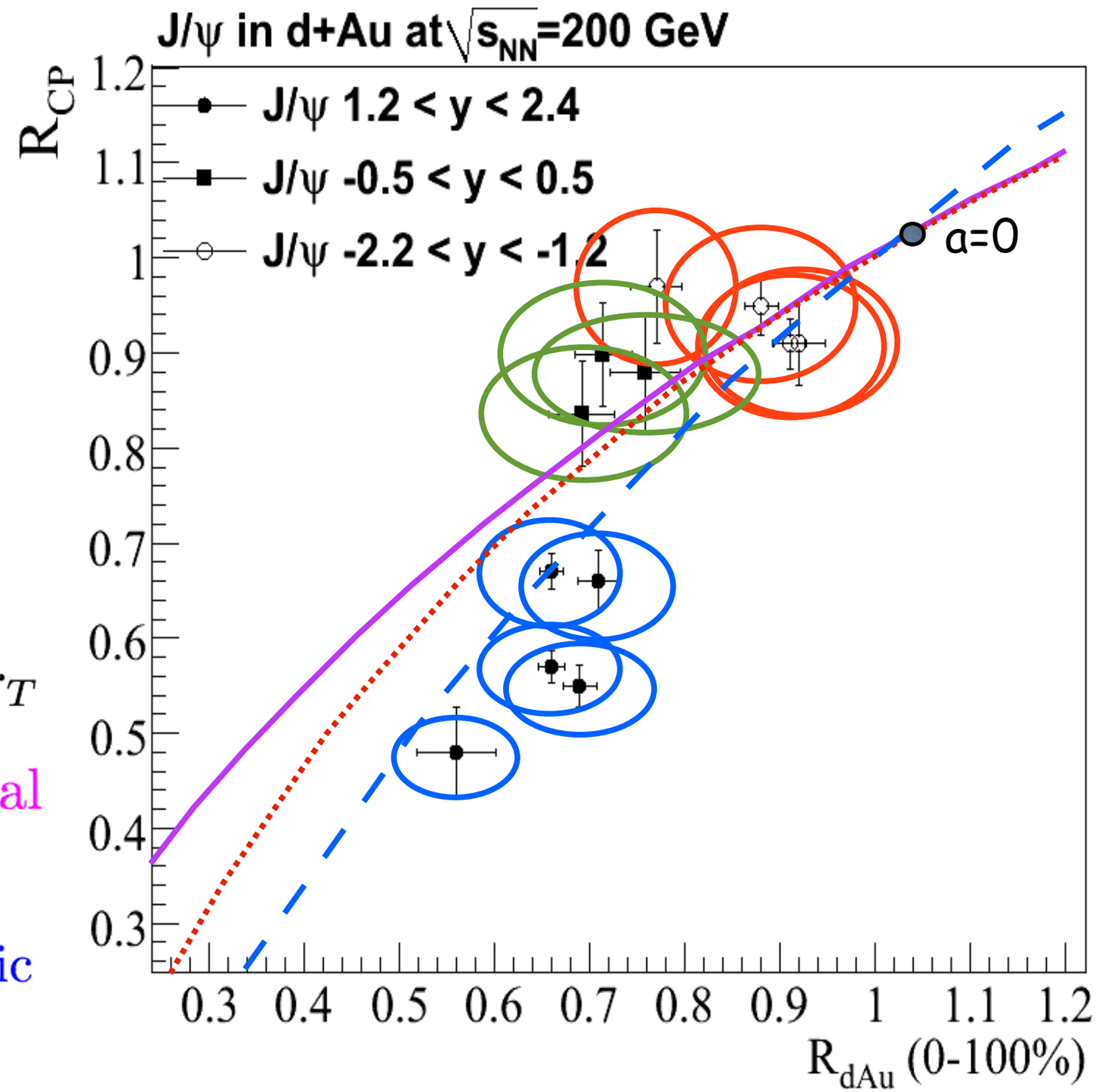

scan different values for the strength "a" in $R_{dAu}$ formula

$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

$M(r_T; a) = e^{-a\Lambda(r_T)}$ exponential

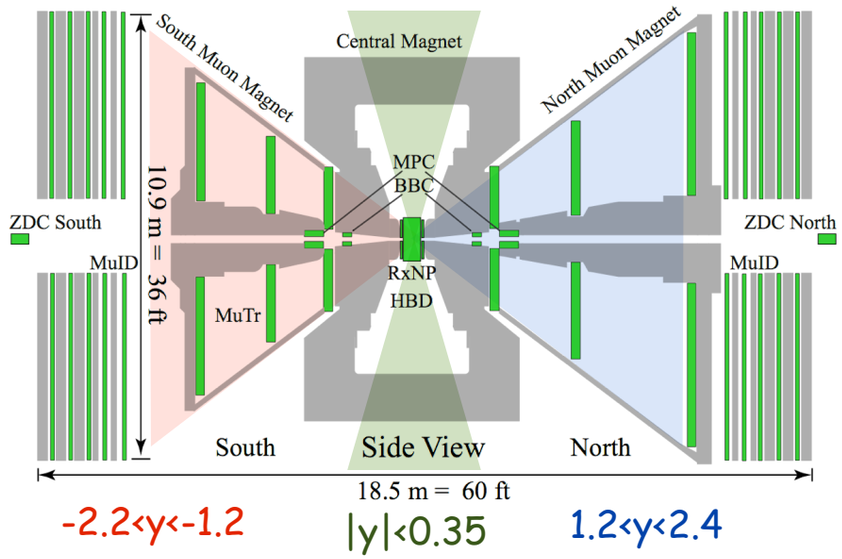
$M(r_T; a) = 1 - a\Lambda(r_T)$ linear

$M(r_T; a) = 1 - a\Lambda(r_T)^2$ quadratic



PHENIX

[arXiv:1010.1246]



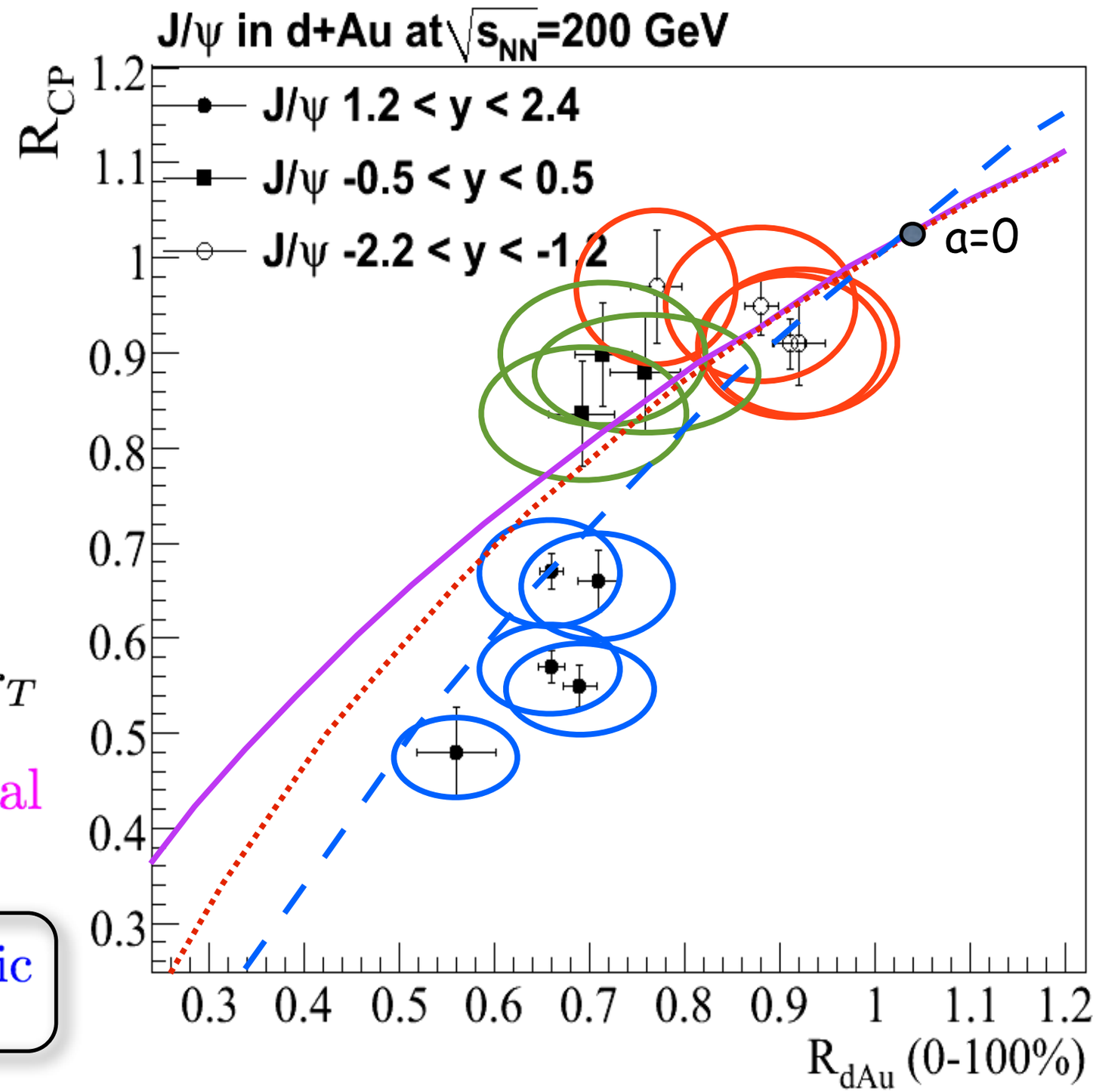

scan different values for the strength "a" in $R_{dAu}$ formula

$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

$M(r_T; a) = e^{-a\Lambda(r_T)}$ exponential

$M(r_T; a) = 1 - a\Lambda(r_T)$ linear

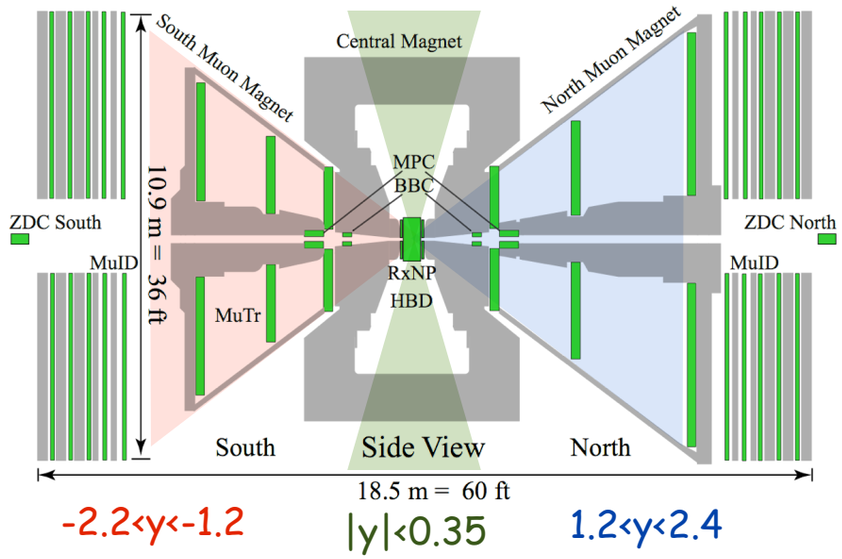
$M(r_T; a) = 1 - a\Lambda(r_T)^2$ quadratic




**nuclear modification requires a quadratic or higher order dependence**

PHENIX

[arXiv:1010.1246]




scan different values for the strength "a" in $R_{dAu}$ formula

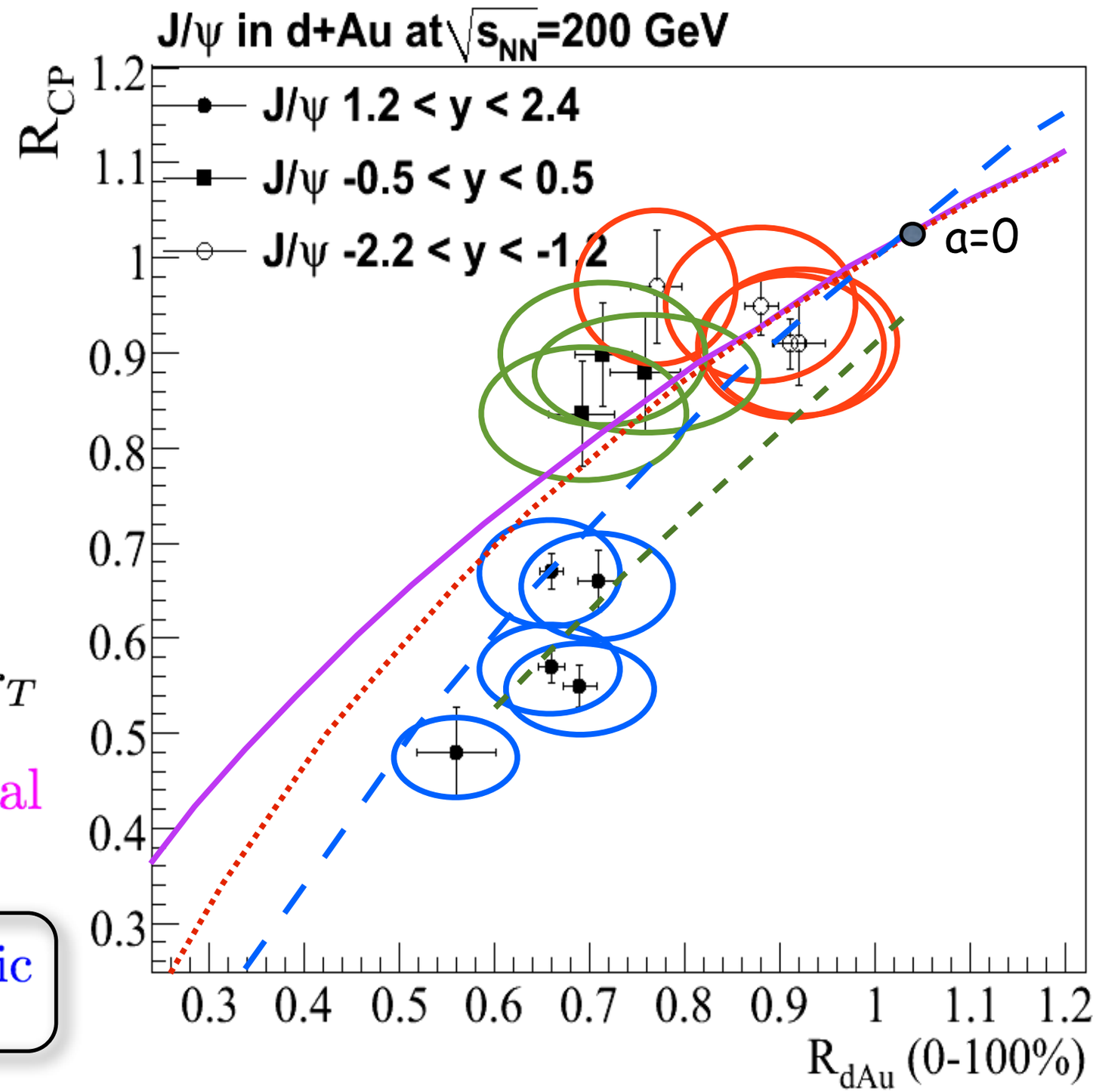
$$R_{dAu,i}(a) = \int f_i(r_T)\, M(r_T; a)\, dr_T$$

$M(r_T; a) = e^{-a\Lambda(r_T)}$ exponential

$M(r_T; a) = 1 - a\Lambda(r_T)$ linear

$M(r_T; a) = 1 - a\Lambda(r_T)^2$ quadratic

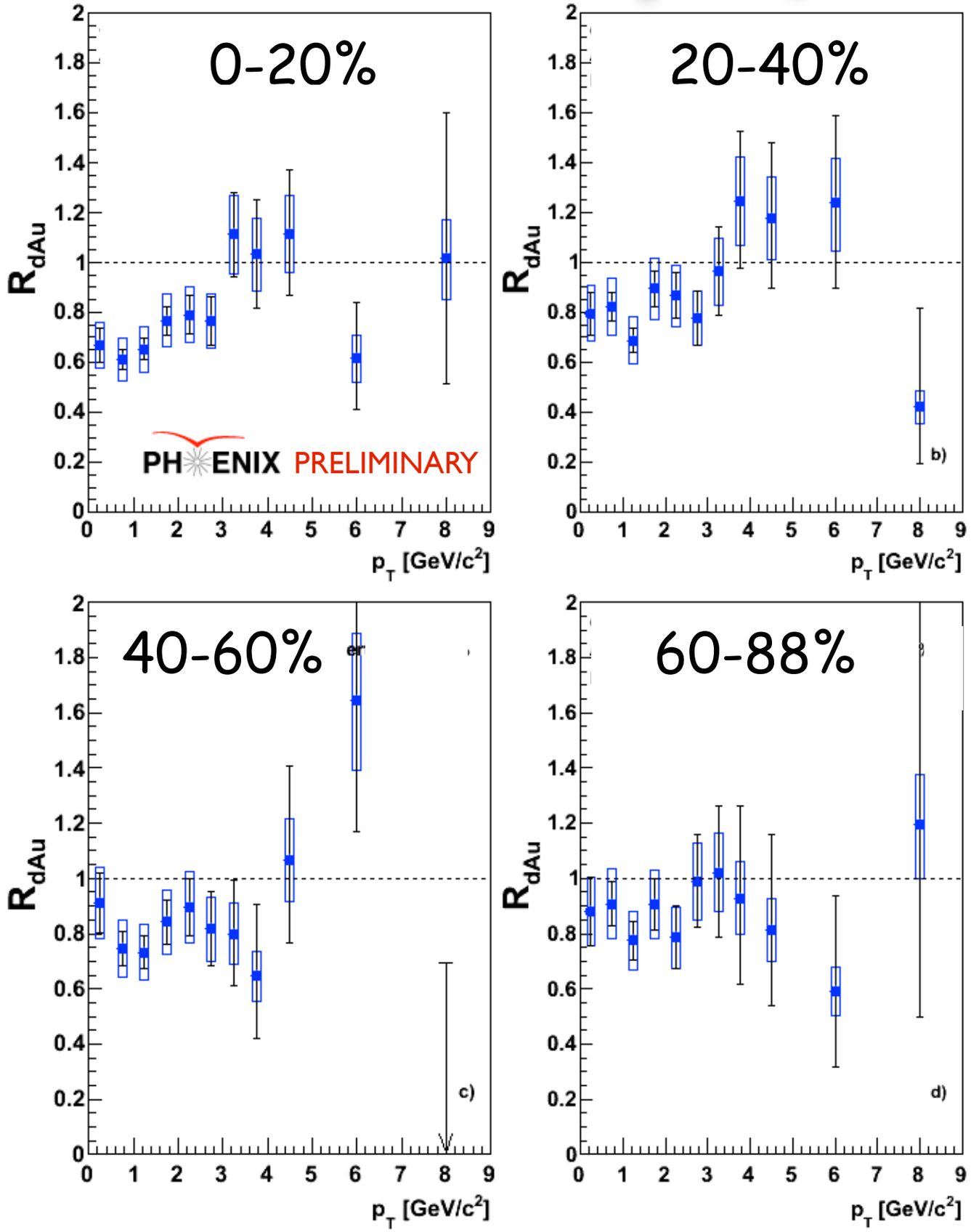
**nuclear modification requires a quadratic or higher order dependence**

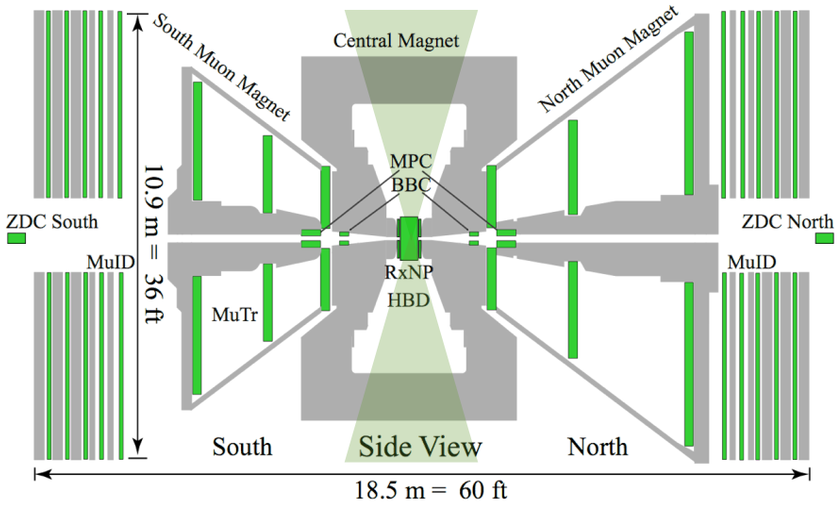



by the way, reasonable agreement with CGC model as well

[Kharzeev and Tuchin, Nucl. Phys. A770, 40 (2006)]

# Preliminary J/ψ $R_{dA}$ vs $p_T$ at mid rapidity




|y|<0.35

Suppression of 30% at low pT for the most central d+Au

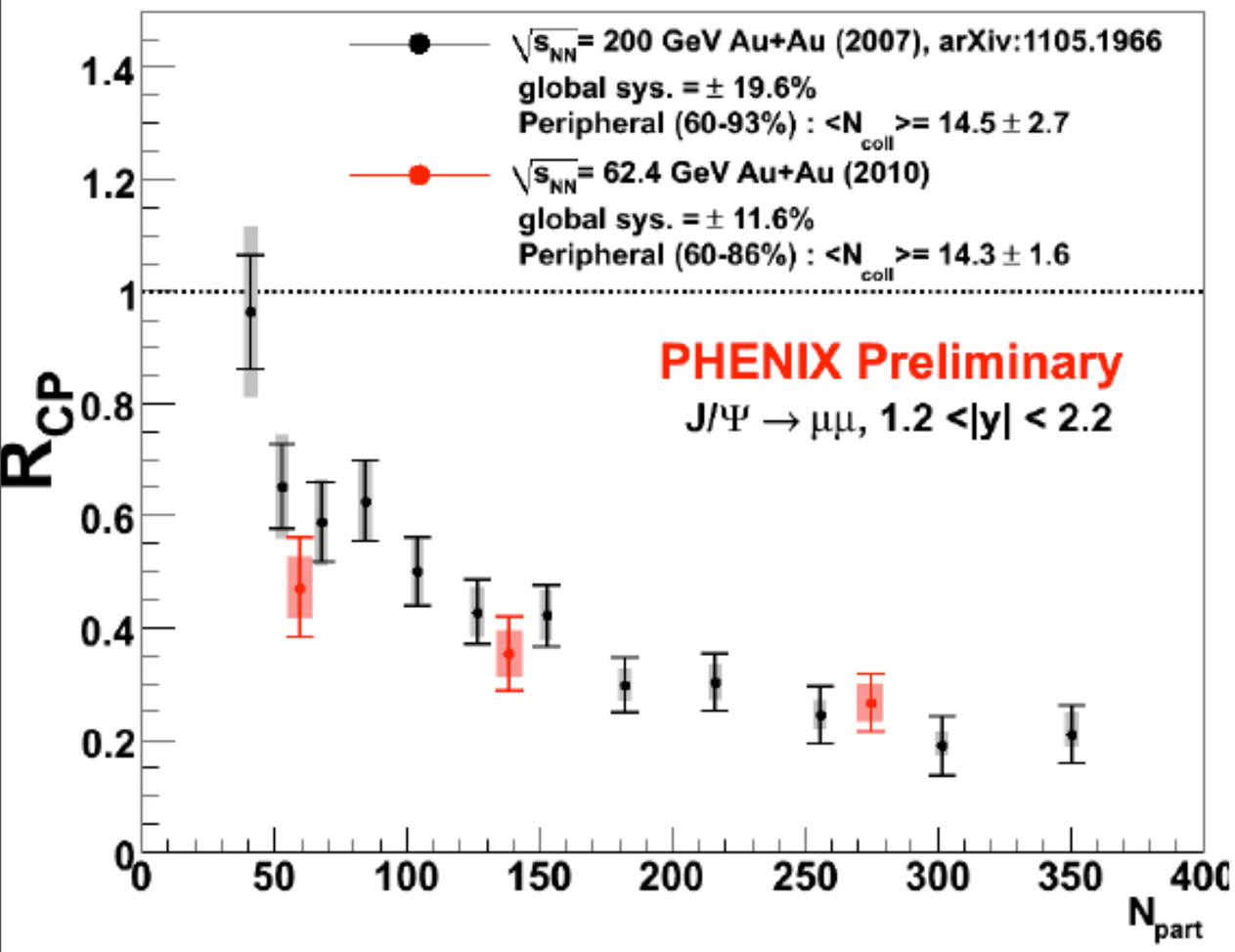
implies 50% suppression in central Au +Au at low $p_T$ mid rapidity

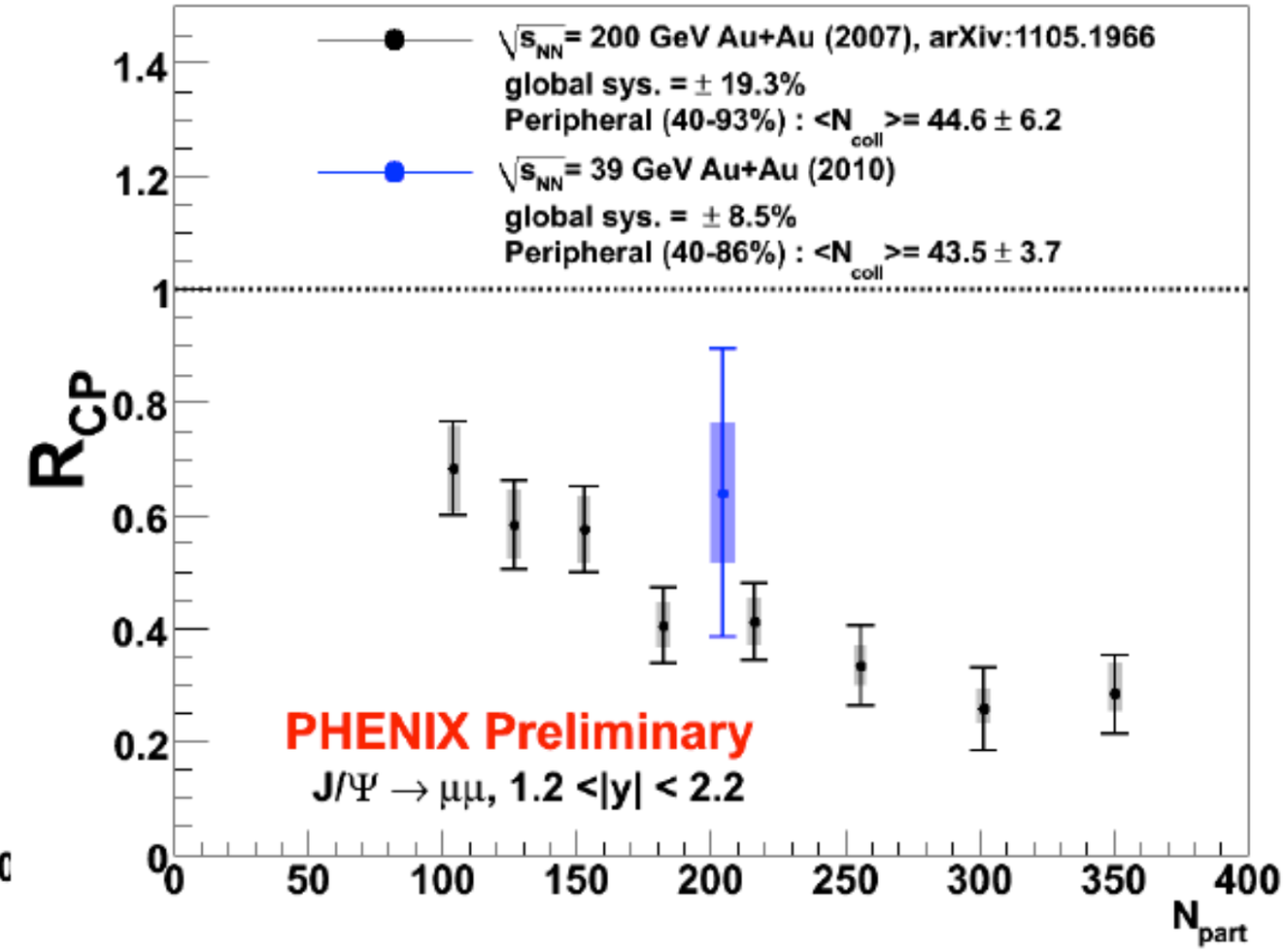
Powerful constraint for cold nuclear matter effects on our Au+Au

Ongoing work to quantify CNM effects

[Darren McGlinchey's poster]

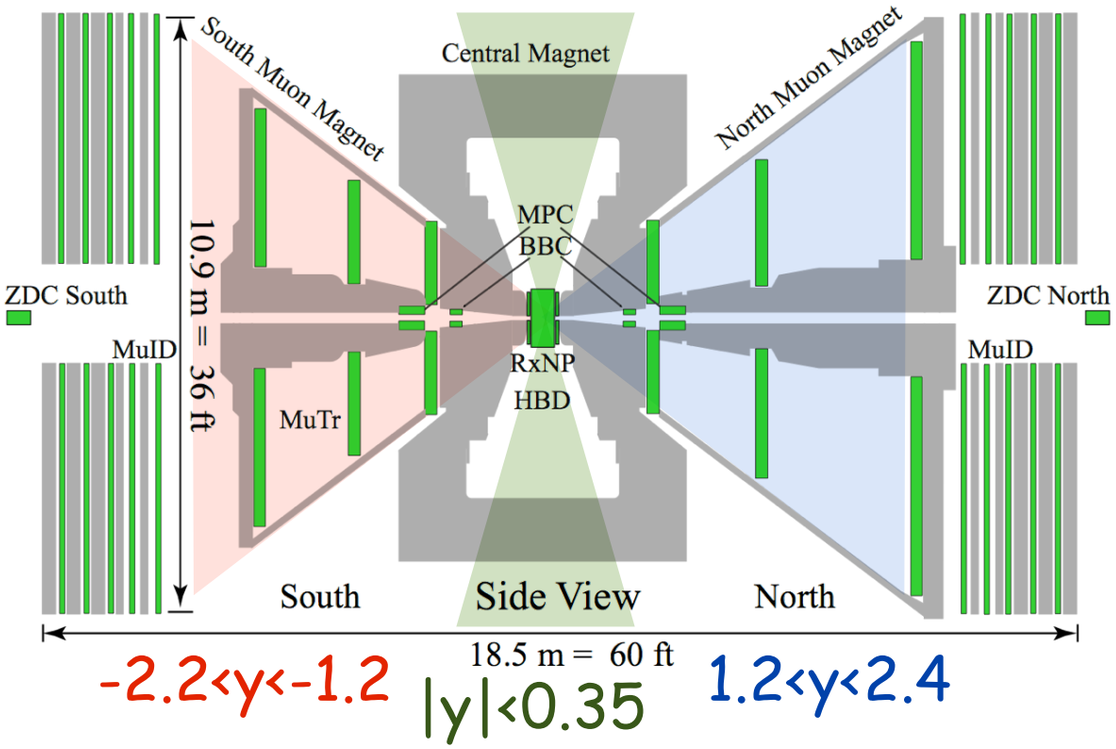
# J/ψ in lower energy Au+Au collisions

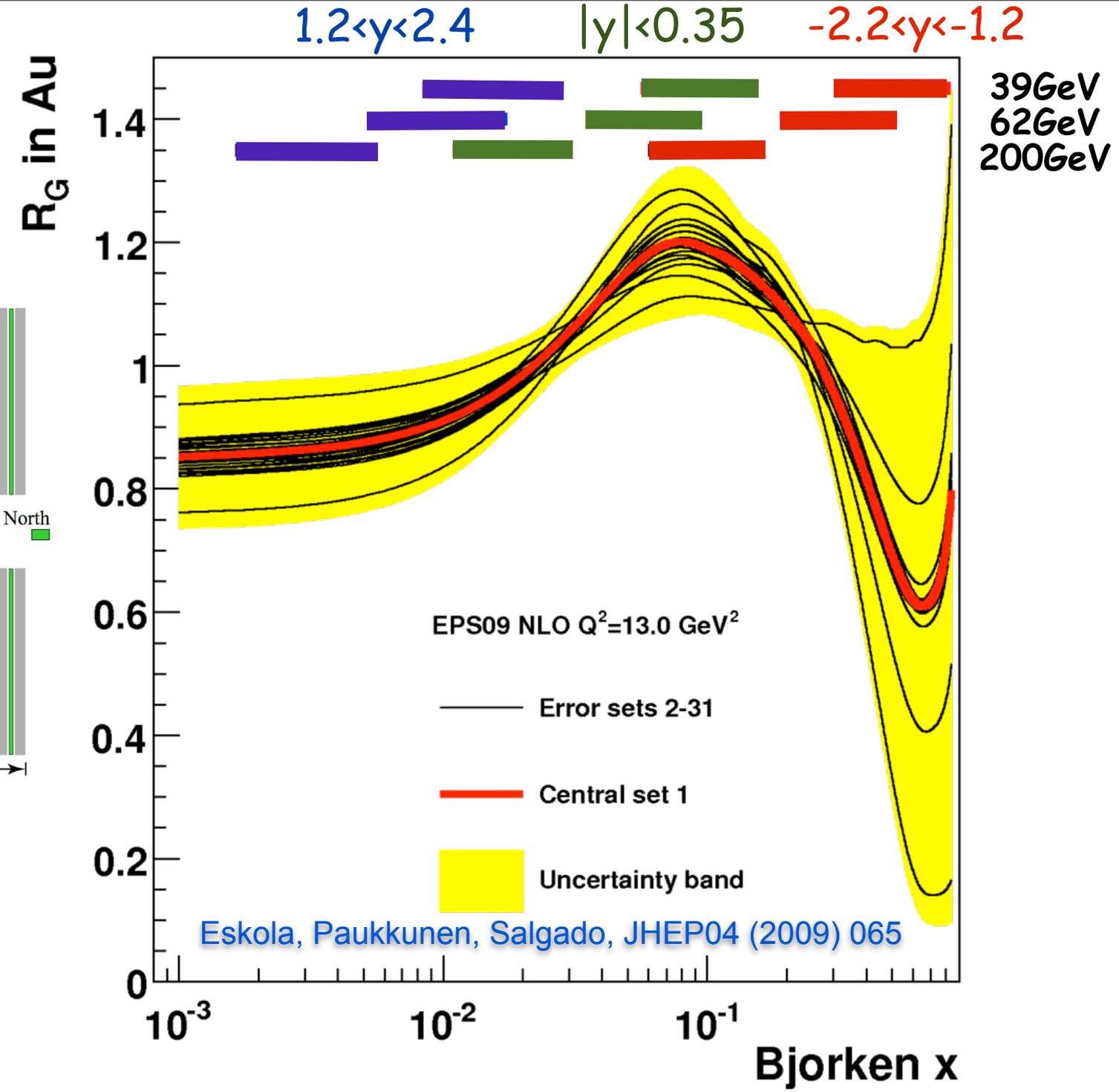



- energy comparison: same detector, rapidity range and centrality
- no p+p reference at 62 GeV and 39 GeV, using yield relative to peripheral events (Rcp)
- suppression similar in all energies given the current uncertainties
- **but**, CNM effects expected to be different

[presented on Tuesday by Abhisek Sen]

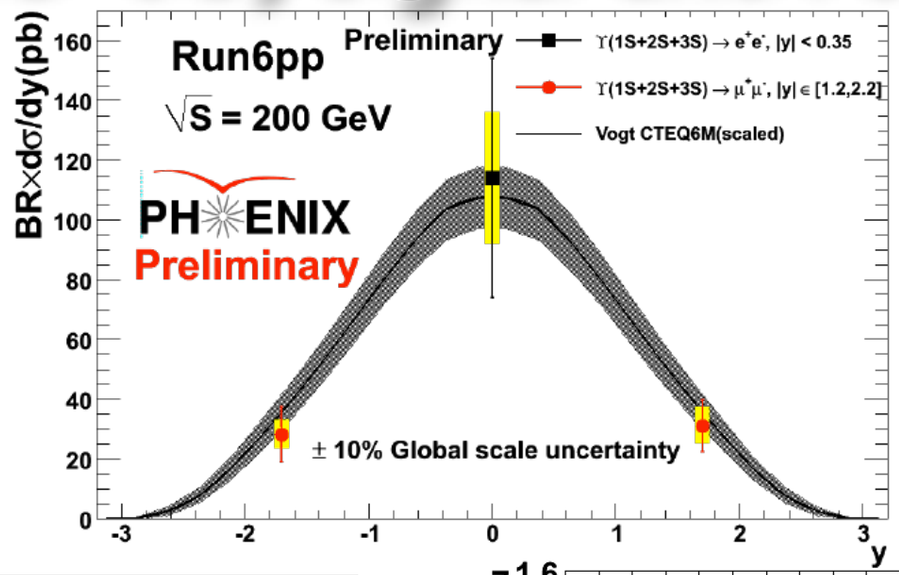


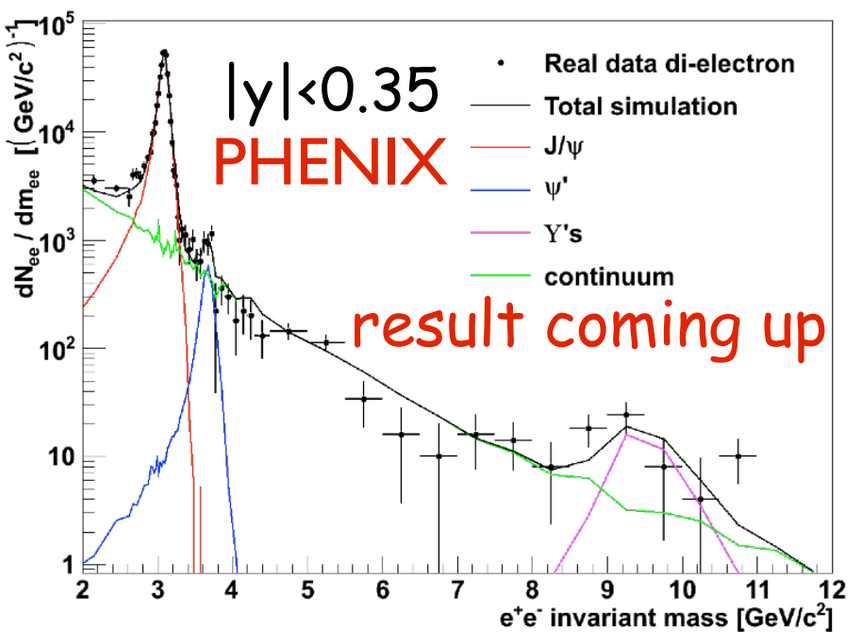

- **but**, CNM effects expected to be different

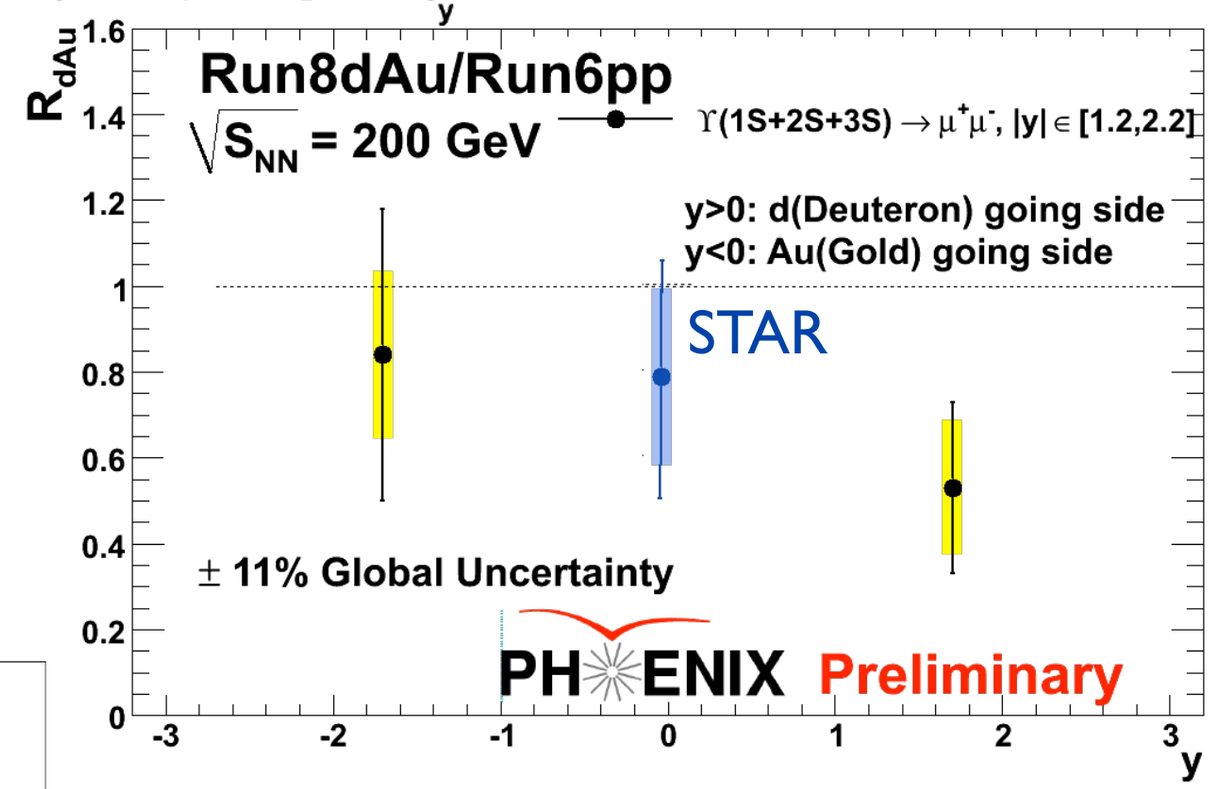
# ϒ(1S+2S+3S) signal and results

p+p

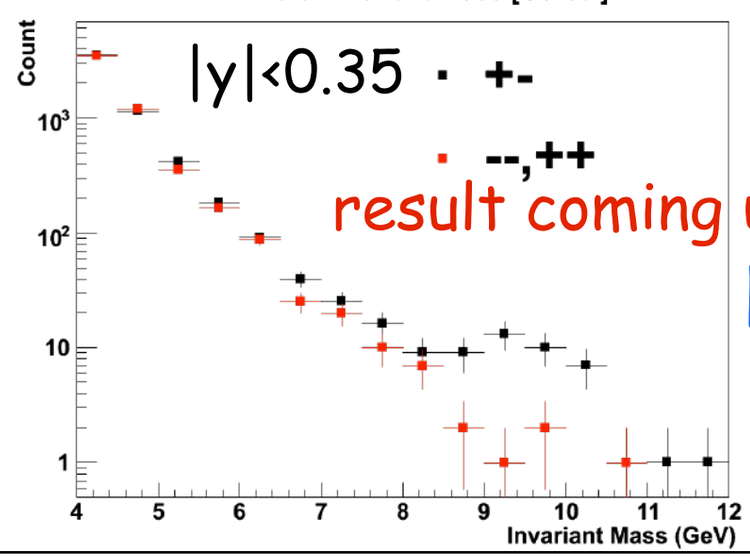



d+Au



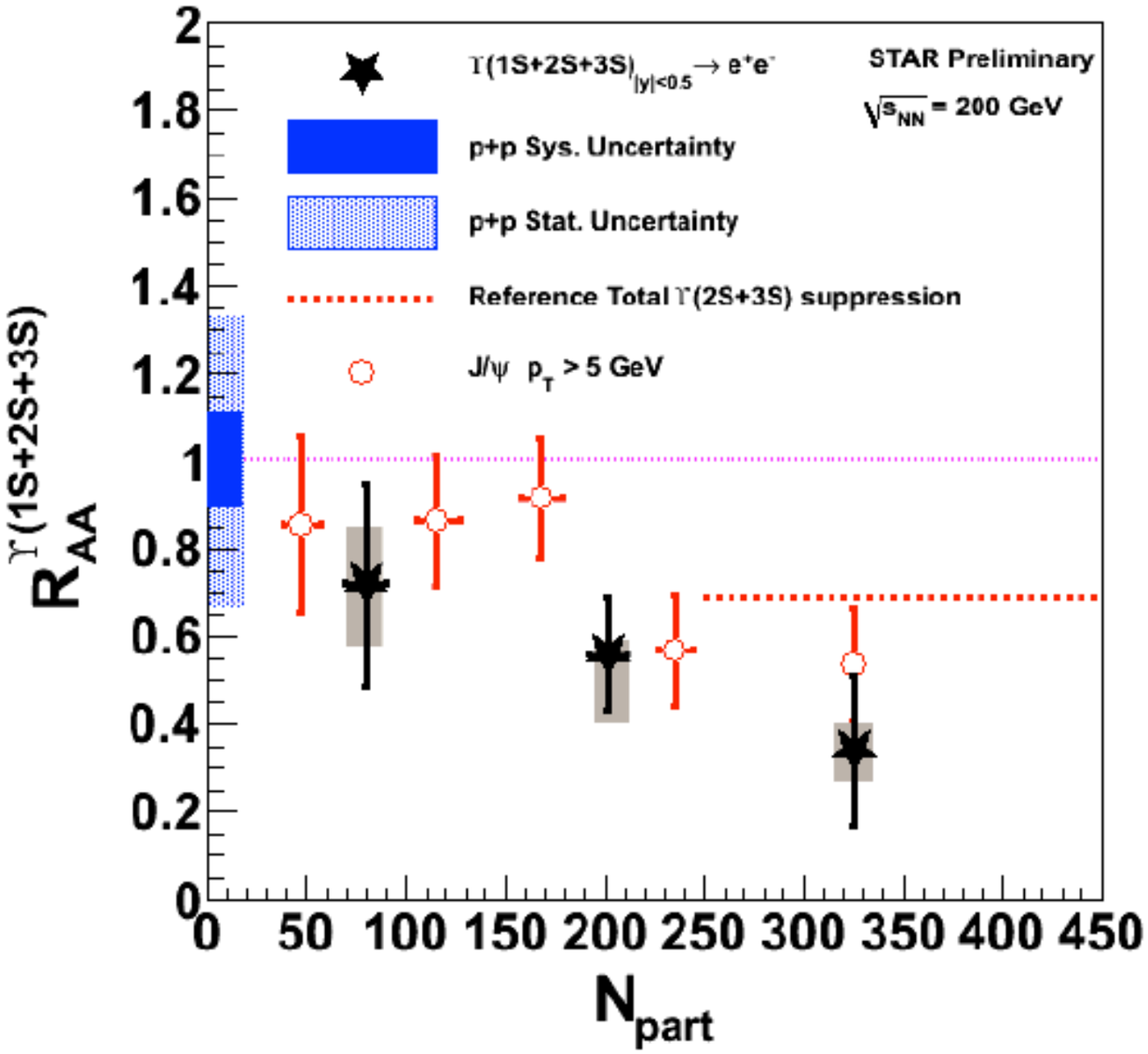



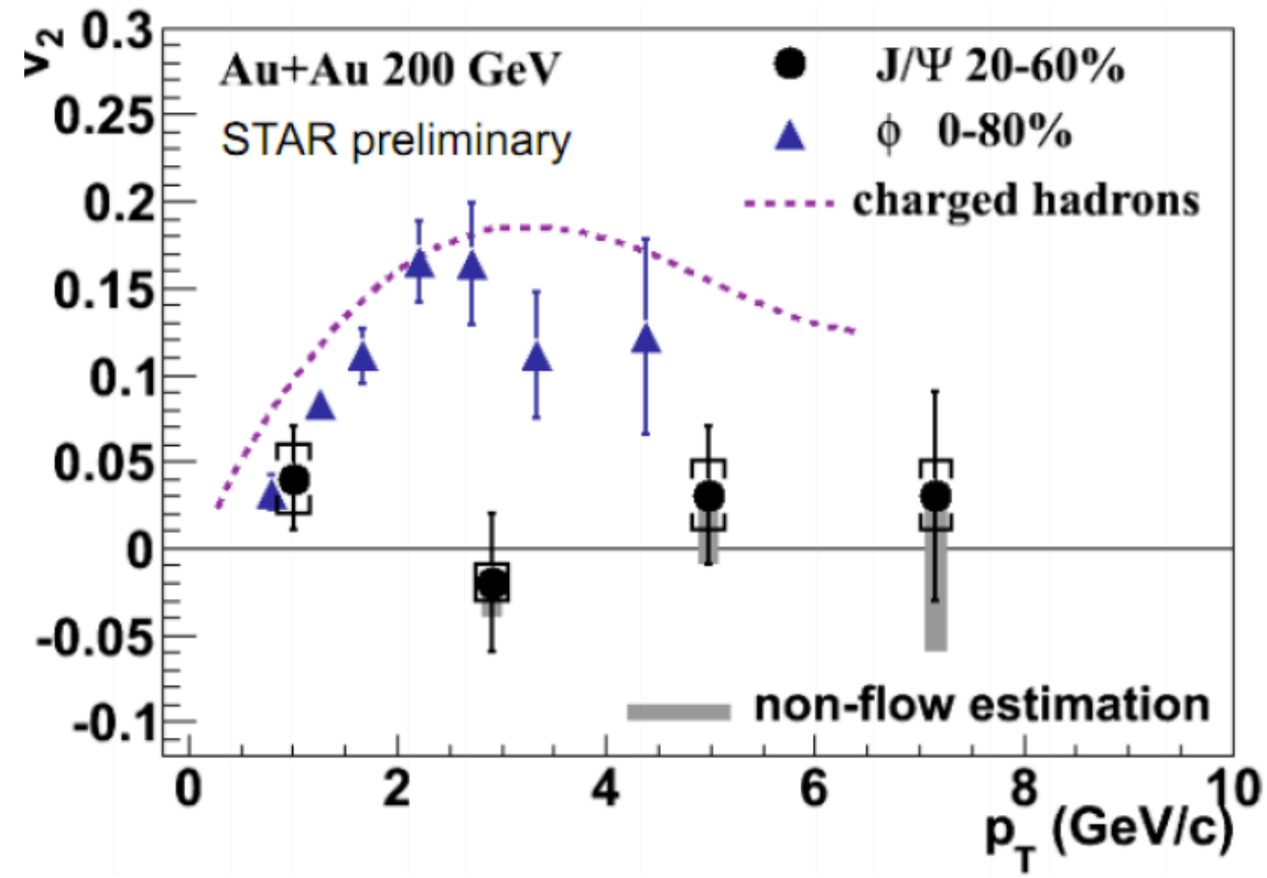

Au+Au




[Shawn Whitaker's poster]

# MORE RESULTS FROM RHIC




- first centrality dependence of $\Upsilon$ suppression in Au+Au
- J/$\psi$ doesn't flow at RHIC - challenge for coalescence models

[presented on Tuesday by Zebo Tang]

# QUARKONIA CONCLUSIONS

- PHENIX observed no change in $J/\psi$ suppression over a wide range of energies
- geometry dependence of the nuclear effects experimentally studied
- a large fraction of the $J/\psi$ suppression in Au+Au collisions could be explained simply by dissociation of the excited states of charmonium
- $\Upsilon$ has been studied in several systems and different rapidity ranges
- STAR results show $\Upsilon$ is suppressed in central events and no flow of $J/\psi$

# QUARKONIA CONCLUSIONS

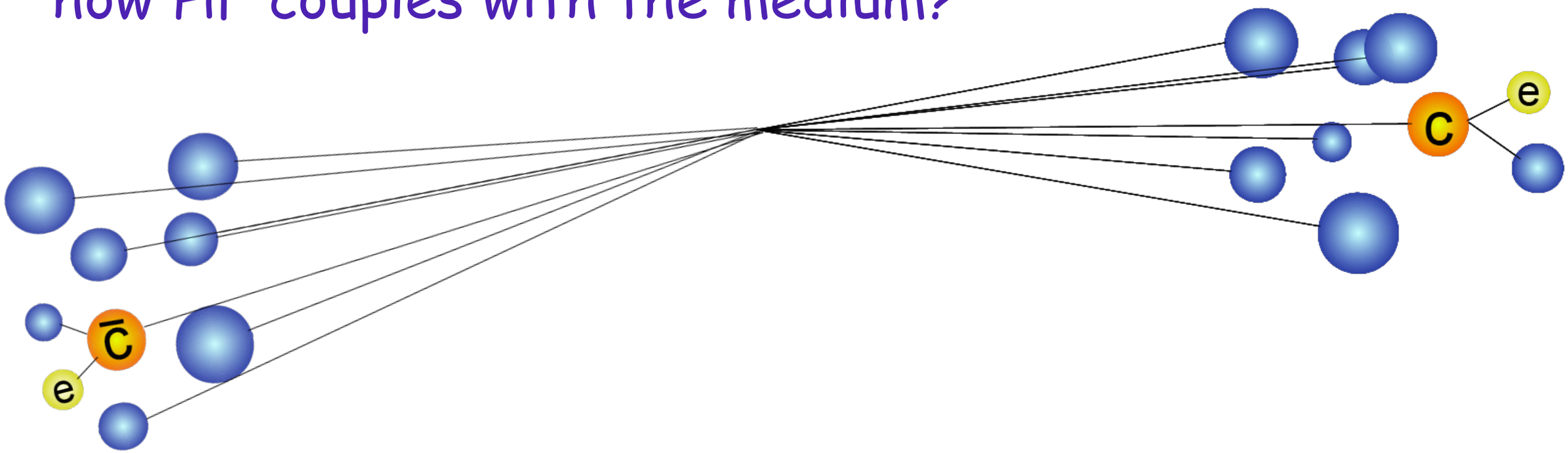
- PHENIX observed no change in $J/\psi$ suppression over a wide range of energies
- geometry dependence of the nuclear effects experimentally studied
- a large fraction of the $J/\psi$ suppression in Au+Au collisions could be explained simply by dissociation of the excited states of charmonium
- $\Upsilon$ has been studied in several systems and different rapidity ranges
- STAR results show $\Upsilon$ is suppressed in central events and no flow of $J/\psi$

*Merci*

# BACKUP SLIDES

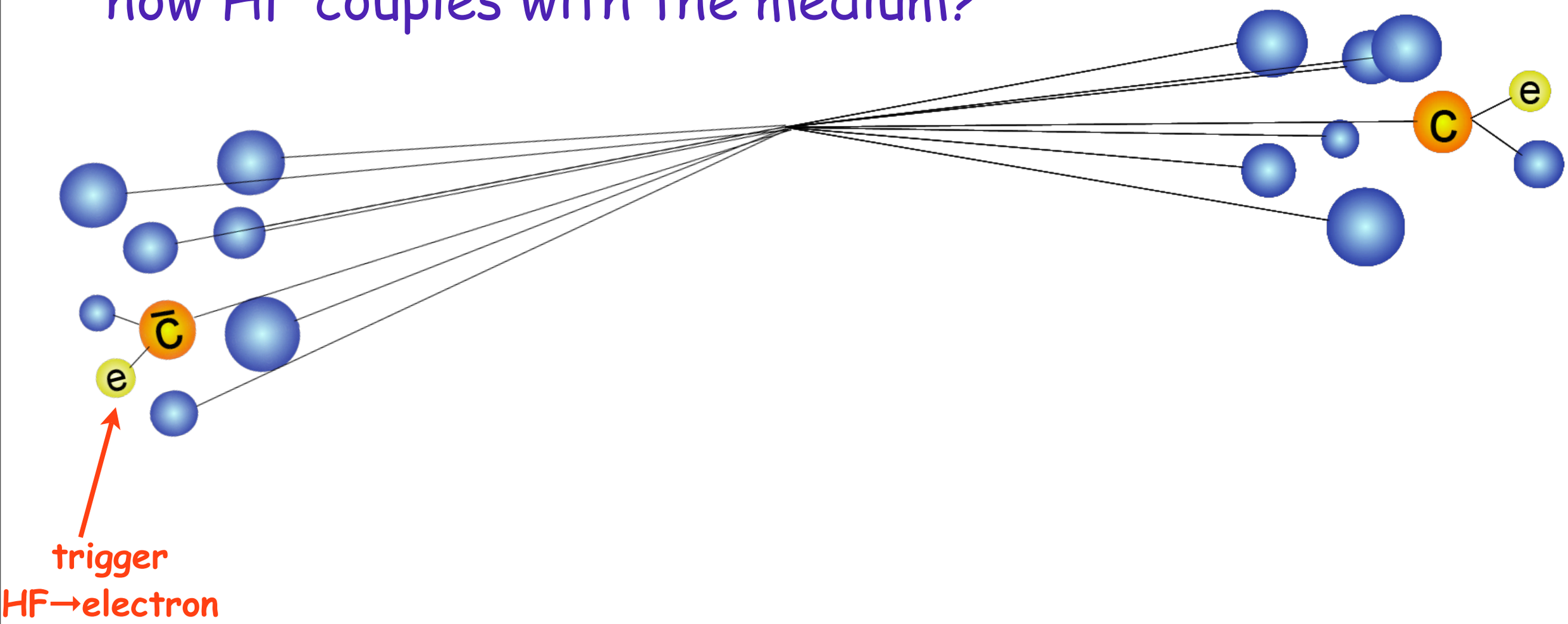
# e-hadron correlation [PRC83,044912 (2011)]

how HF couples with the medium?



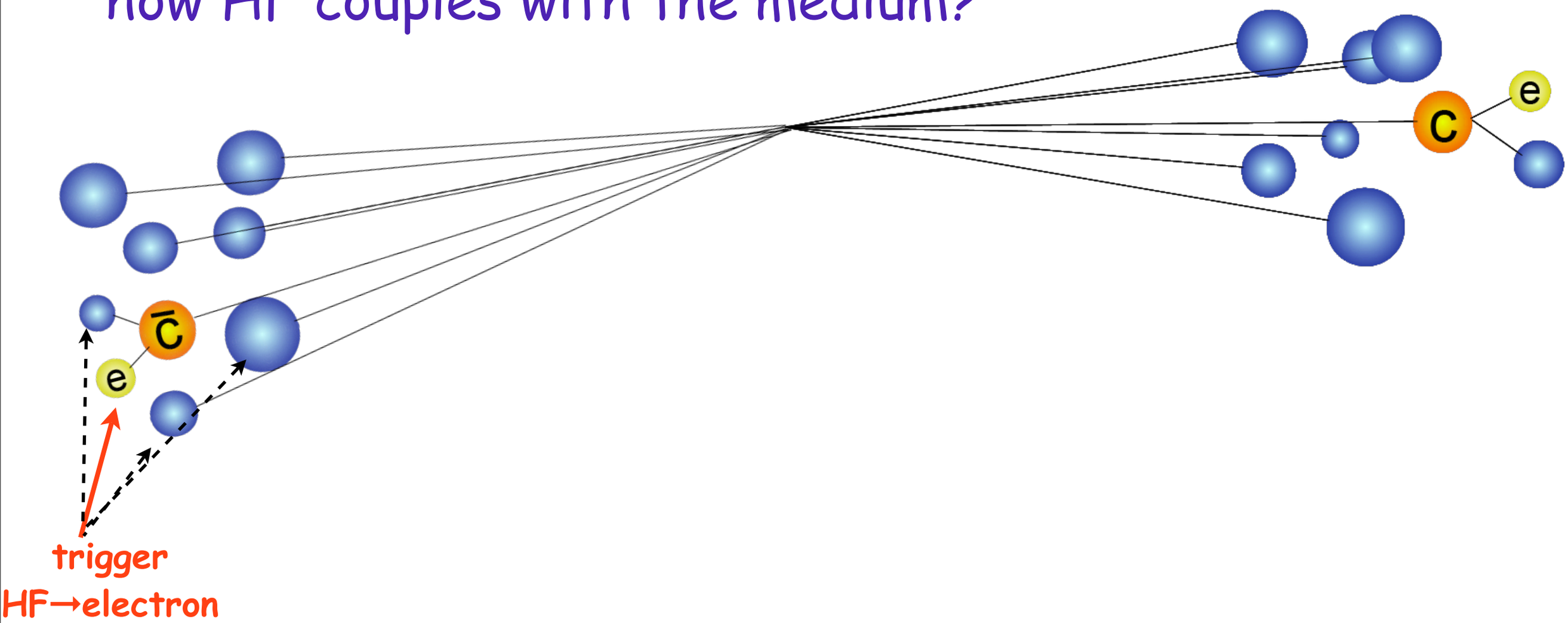
# e-hadron correlation [PRC83,044912 (2011)]

how HF couples with the medium?



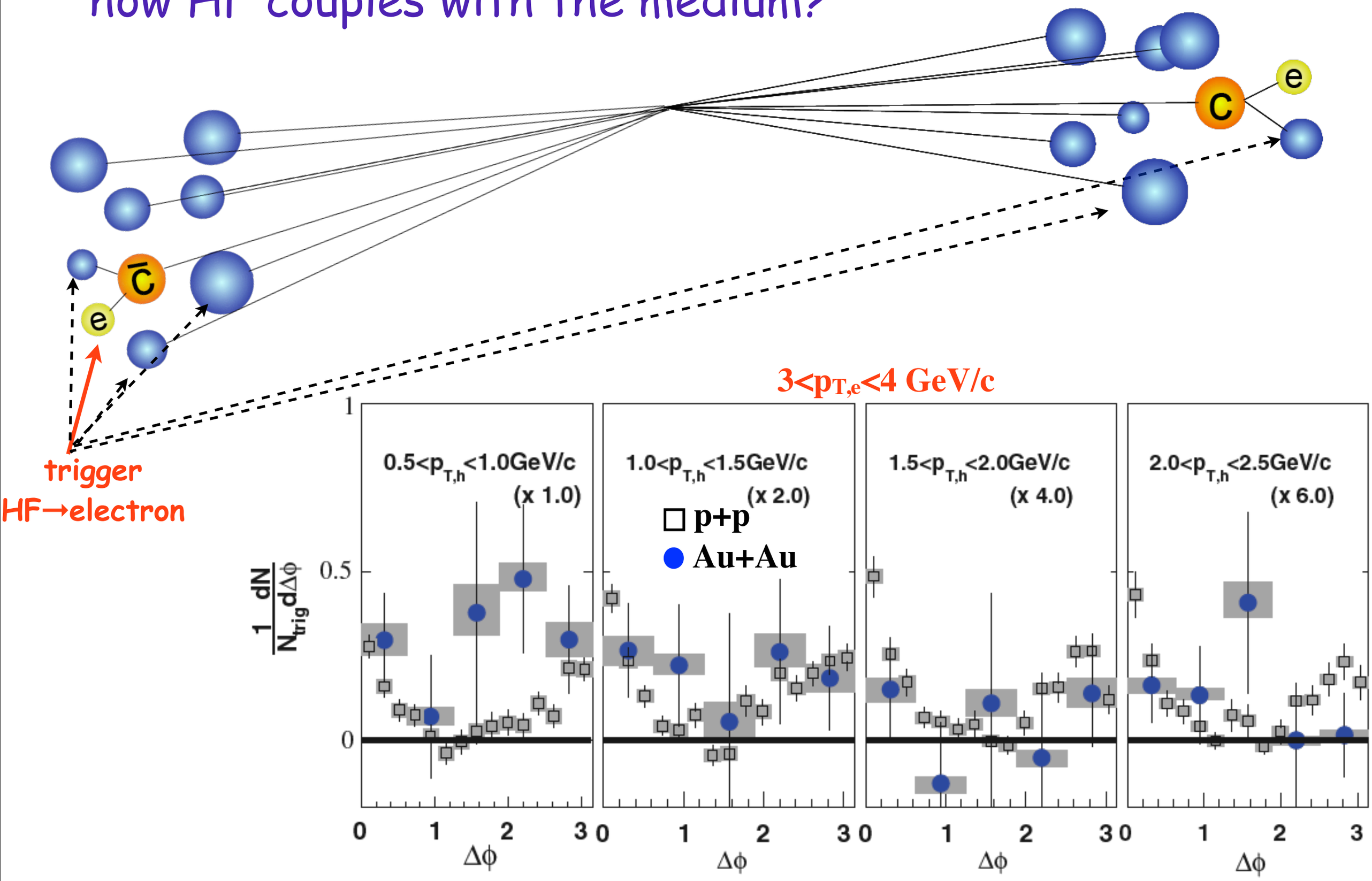
# e-hadron correlation [PRC83,044912 (2011)]

## how HF couples with the medium?



# e-hadron correlation [PRC83,044912 (2011)]

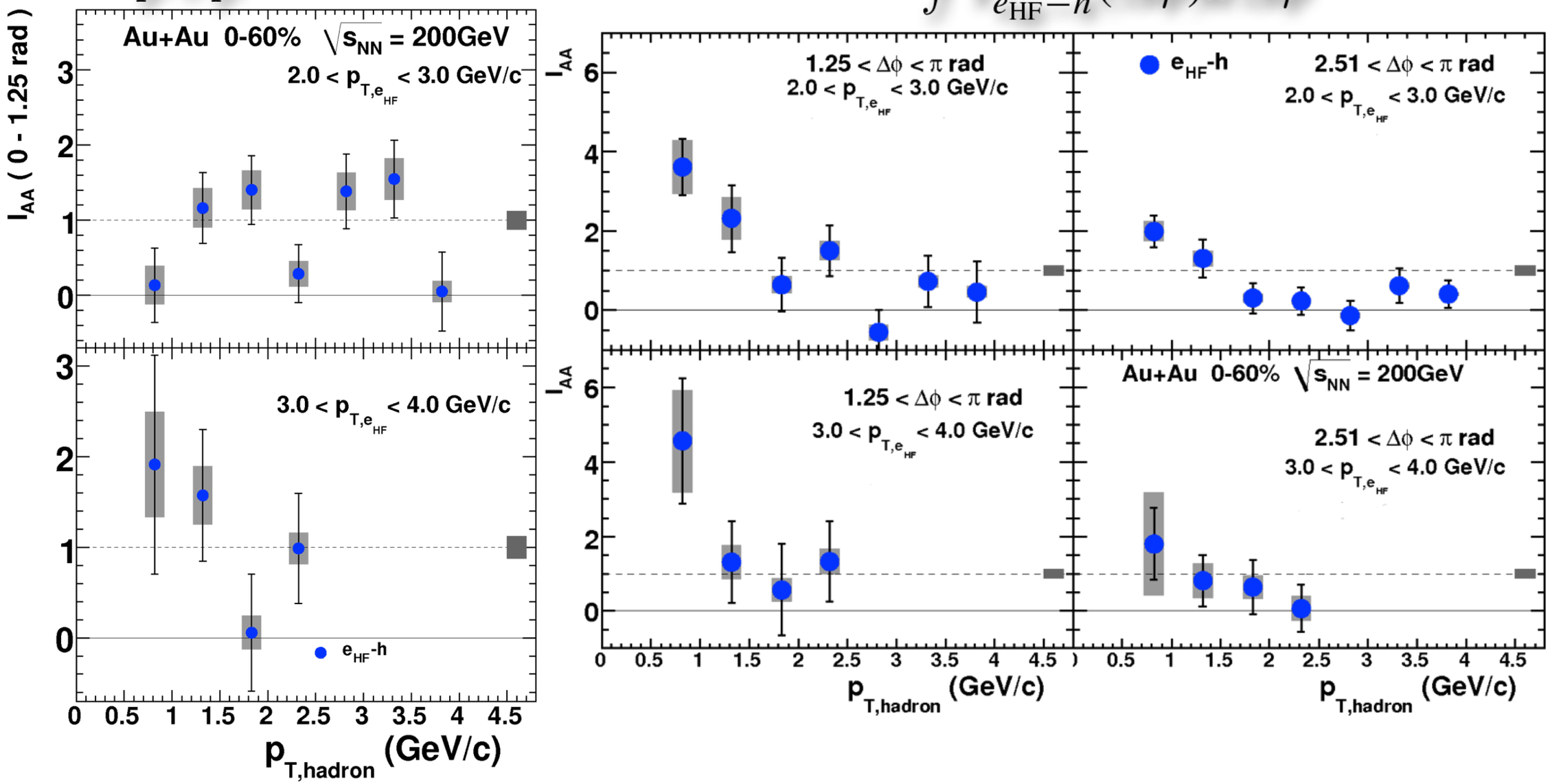
## how HF couples with the medium?



# e-hadron correlation [PRC83,044912 (2011)]

$\frac{\text{Au+Au}}{p+p}$ conditional yield ratio

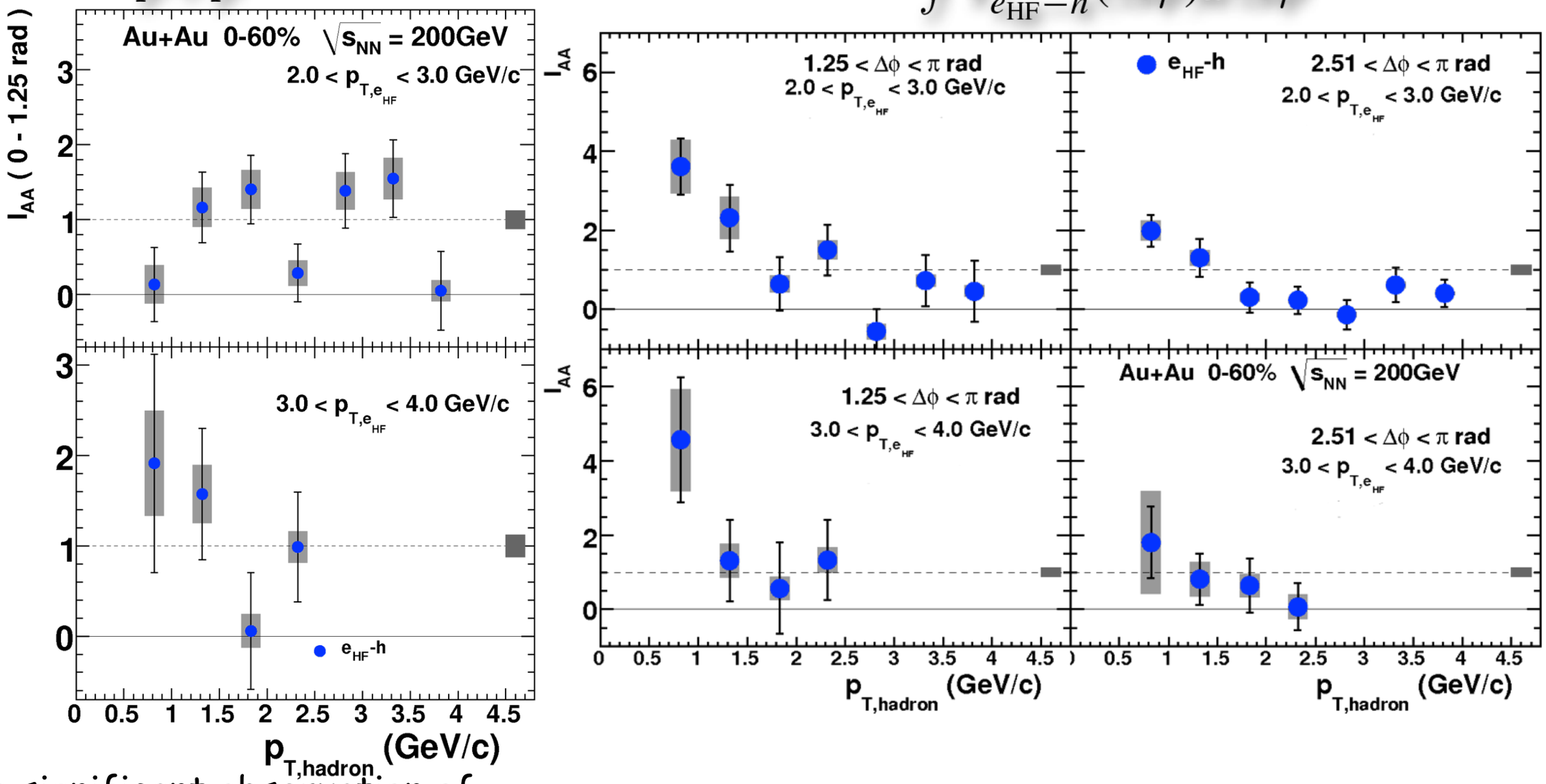
$$I_{AA} \equiv \frac{\int Y^{AuAu}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}{\int Y^{pp}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}$$



# e-hadron correlation [PRC83,044912 (2011)]

$\frac{\text{Au+Au}}{p+p}$ conditional yield ratio

$$I_{AA} \equiv \frac{\int Y^{AuAu}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}{\int Y^{pp}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}$$

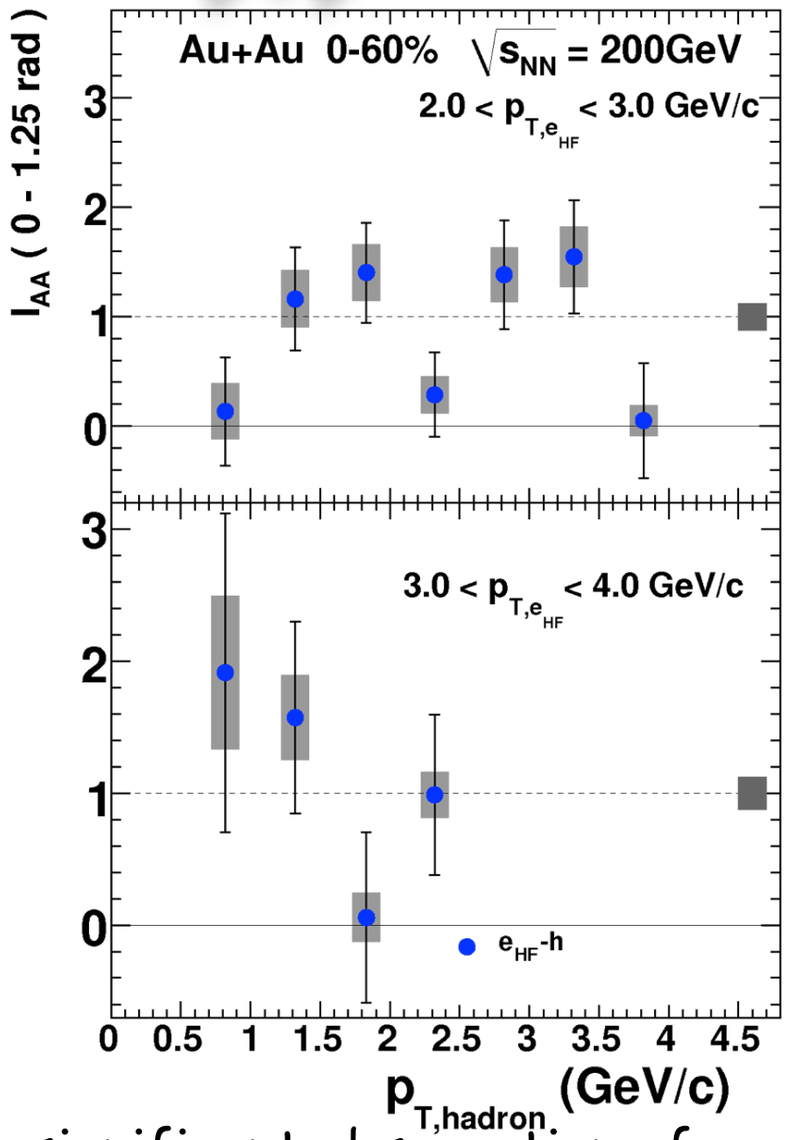


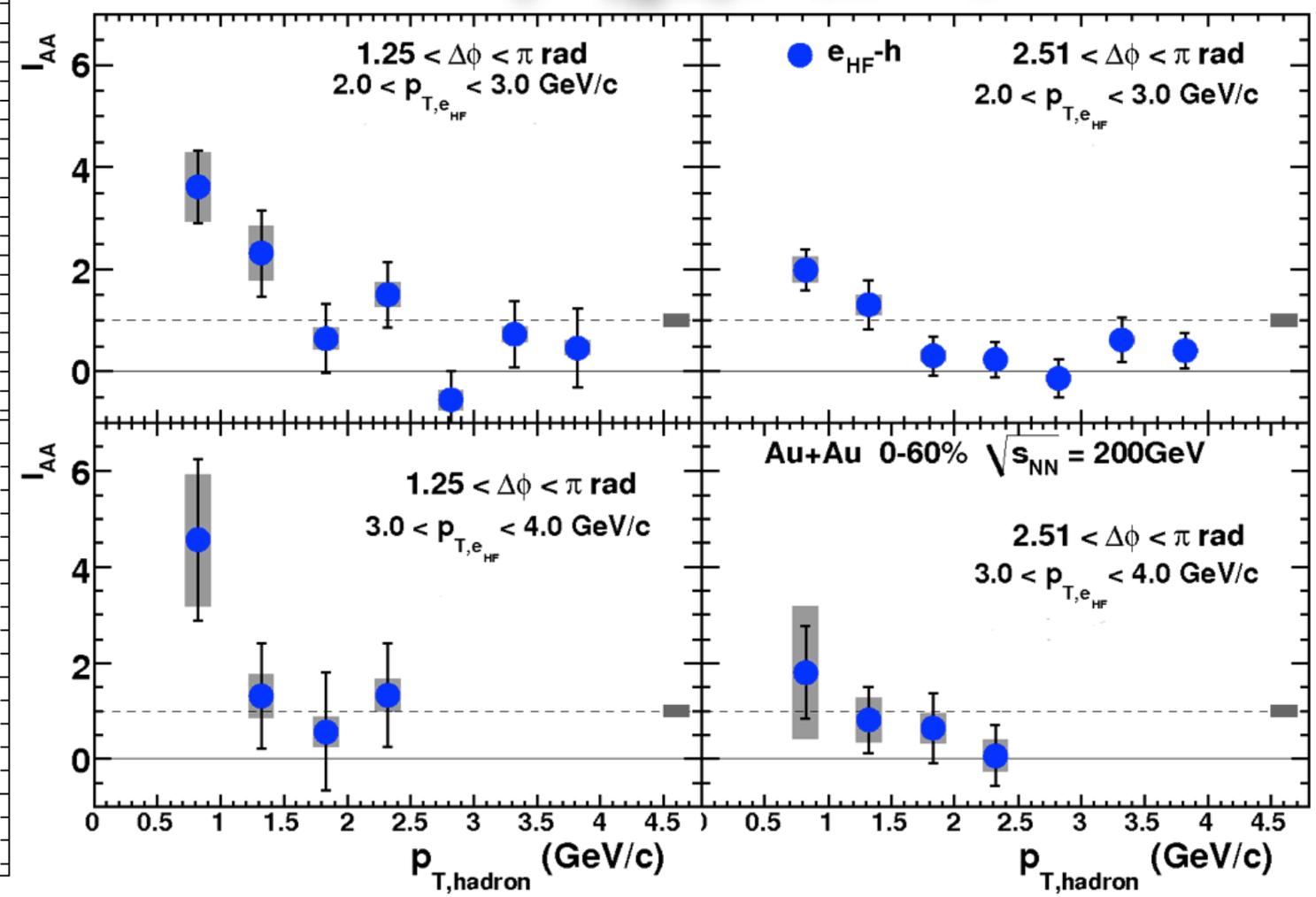

- no significant observation of nuclear modification at near side
- hadrons from
  - D/B meson decays (main source)
  - heavy quark fragmentation
  - HQ interactions w/ matter

# e-hadron correlation [PRC83,044912 (2011)]

$\frac{\text{Au+Au}}{p+p}$ conditional yield ratio

$$I_{AA} \equiv \frac{\int Y^{AuAu}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}{\int Y^{pp}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}$$




2-3 GeV/c electron -> $\langle p_T \rangle_{meson}$ = 4.3 GeV/c

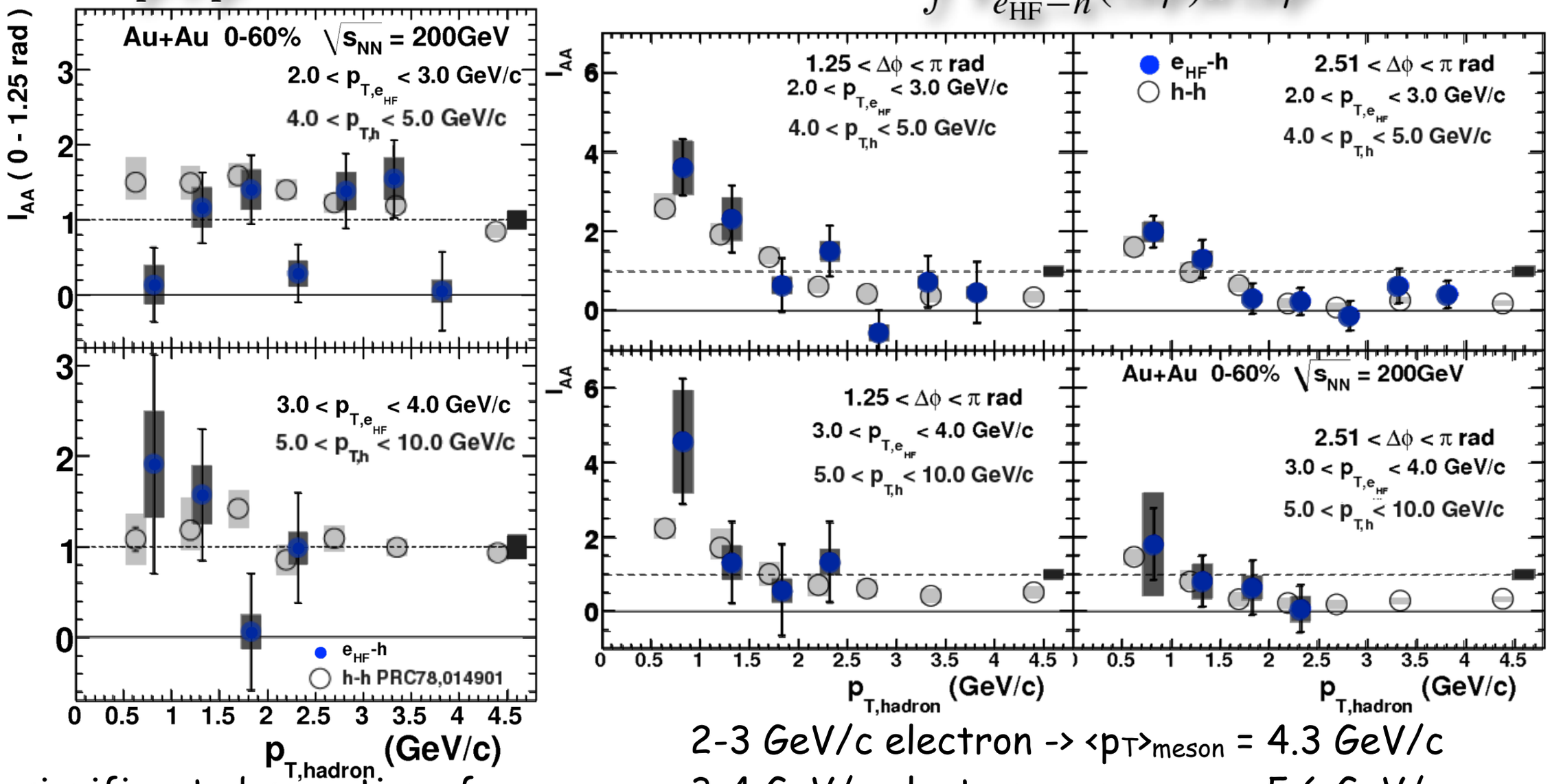
3-4 GeV/c electron -> $\langle p_T \rangle_{meson}$ = 5.6 GeV/c

- no significant observation of nuclear modification at near side
- hadrons from
  - D/B meson decays (main source)
  - heavy quark fragmentation
  - HQ interactions w/ matter

# e-hadron correlation [PRC83,044912 (2011)]

$\frac{\text{Au+Au}}{p+p}$ conditional yield ratio

$$I_{AA} \equiv \frac{\int Y^{AuAu}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}{\int Y^{pp}_{e_{HF}-h}(\Delta\phi)d\Delta\phi}$$




2-3 GeV/c electron -> $\langle p_T \rangle_{meson}$ = 4.3 GeV/c

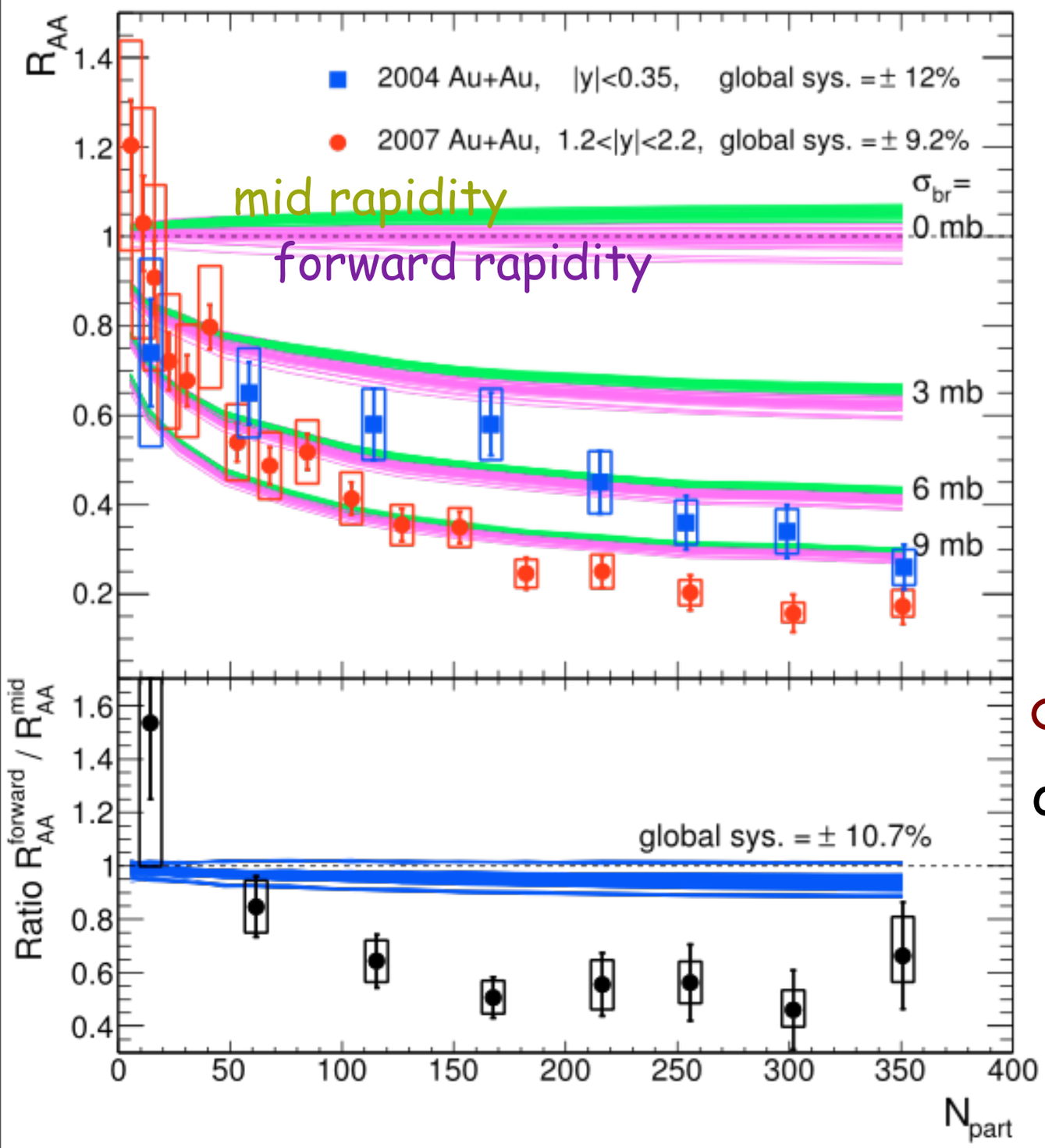
3-4 GeV/c electron -> $\langle p_T \rangle_{meson}$ = 5.6 GeV/c

- no significant observation of nuclear modification at near side
- hadrons from
  - D/B meson decays (main source)
  - heavy quark fragmentation
  - HQ interactions w/ matter

- similar pattern with hadrons from light quarks but large uncertainties prevent a strong conclusion
- expected large fraction of gluons in away side
- same path length for the same parton -> same $I_{AA}$

# Going back to J/ψ in Au+Au collisions...

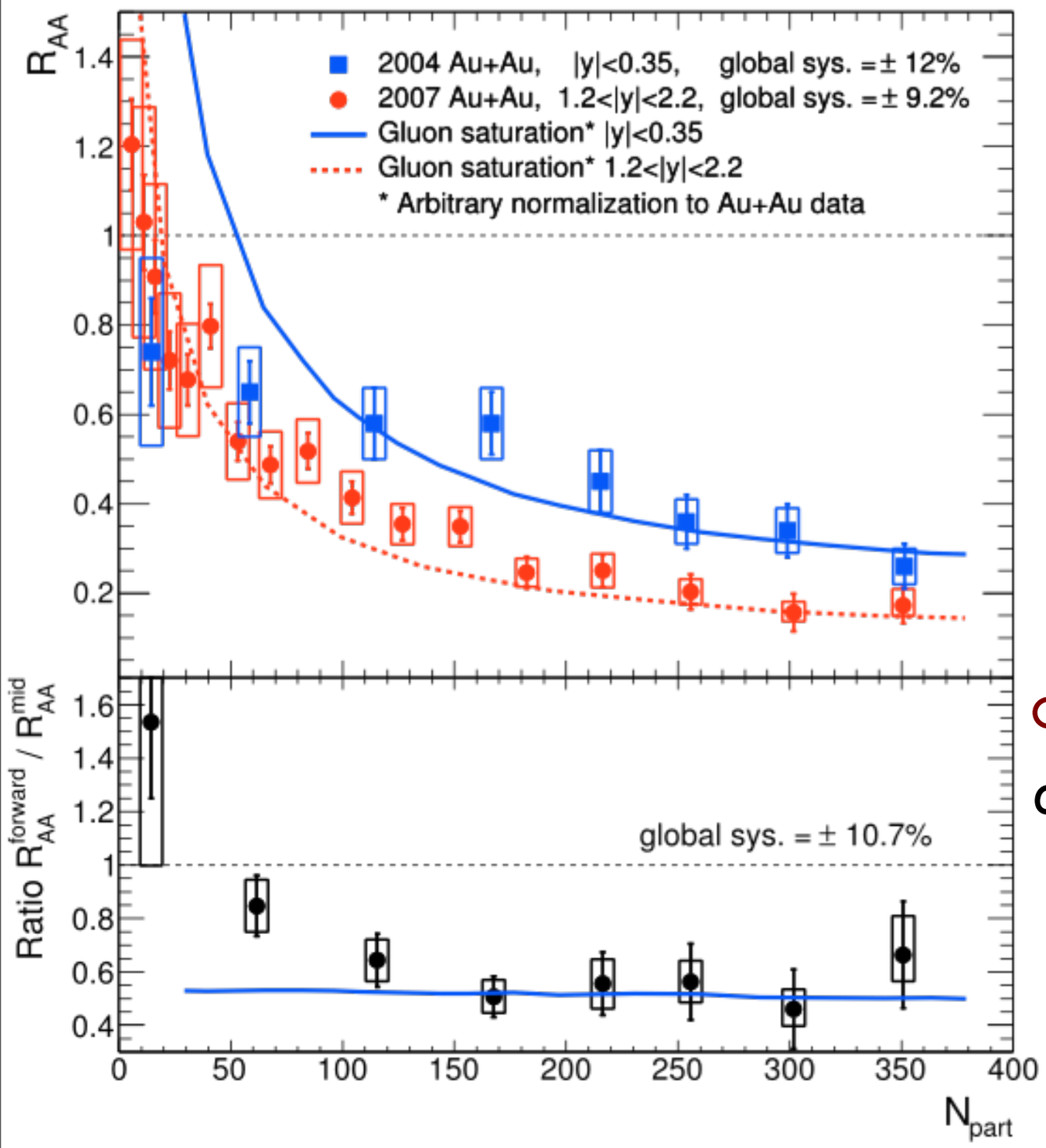
[arXiv:1103.6269v1]




- Cold Nuclear Matter effect based on
  - EPS09+breakup cross section

# Going back to J/ψ in Au+Au collisions...

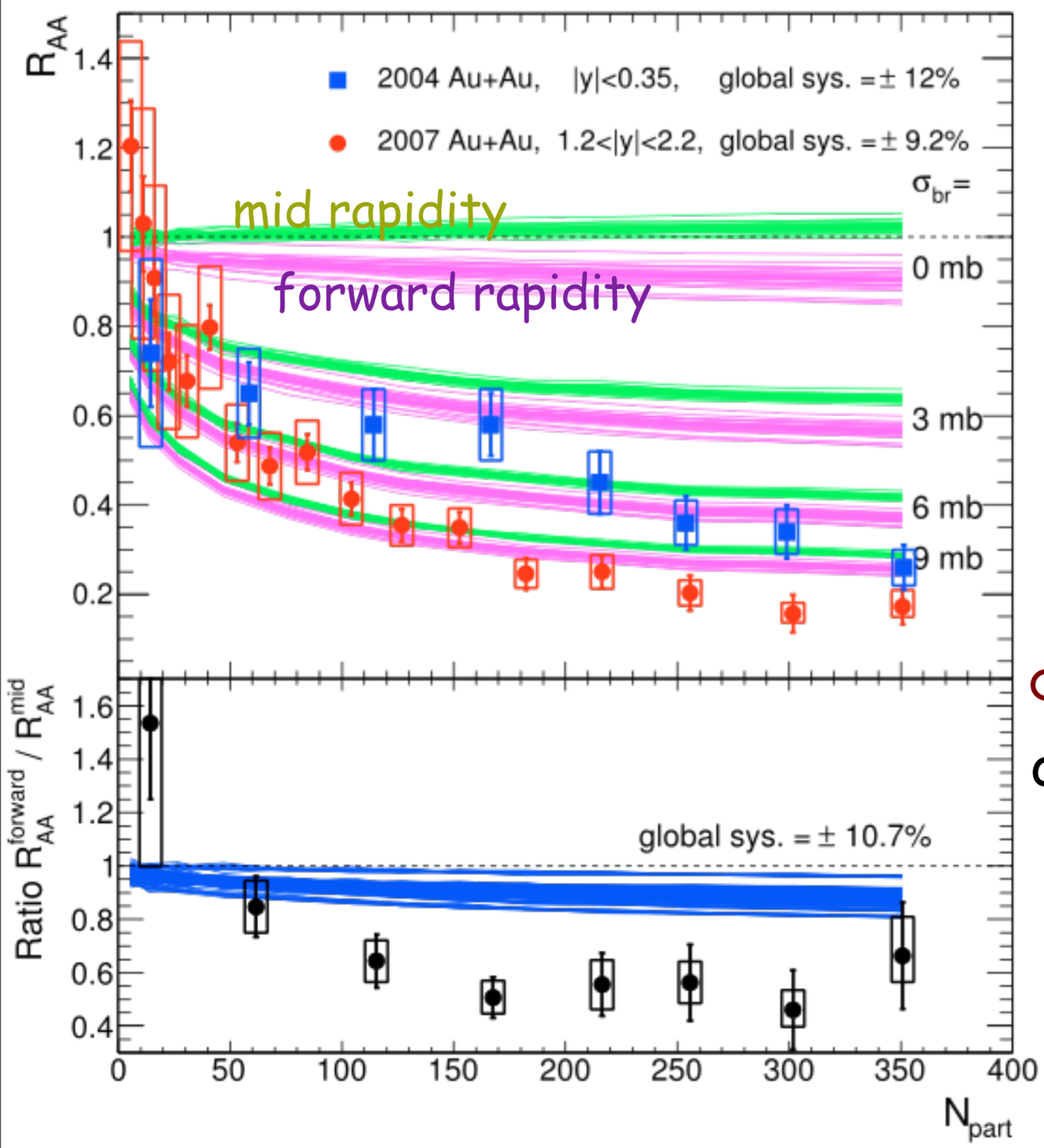
[arXiv:1103.6269v1]




- Cold Nuclear Matter effect based on
  - gluon saturation (CGC)

# Going back to J/ψ in Au+Au collisions...

[arXiv:1103.6269v1]

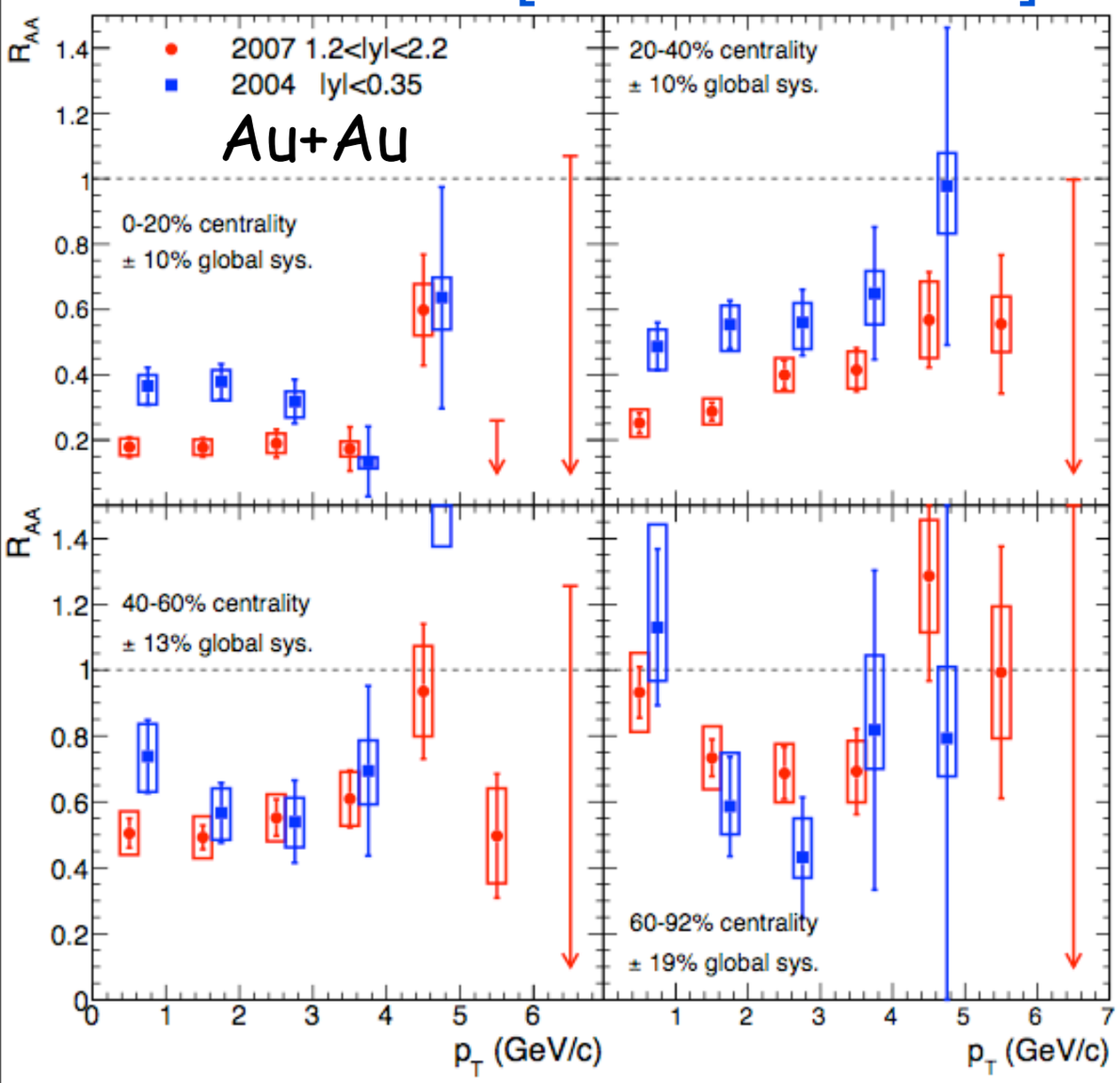



- Cold Nuclear Matter effect based on
  - naive energy loss scenario

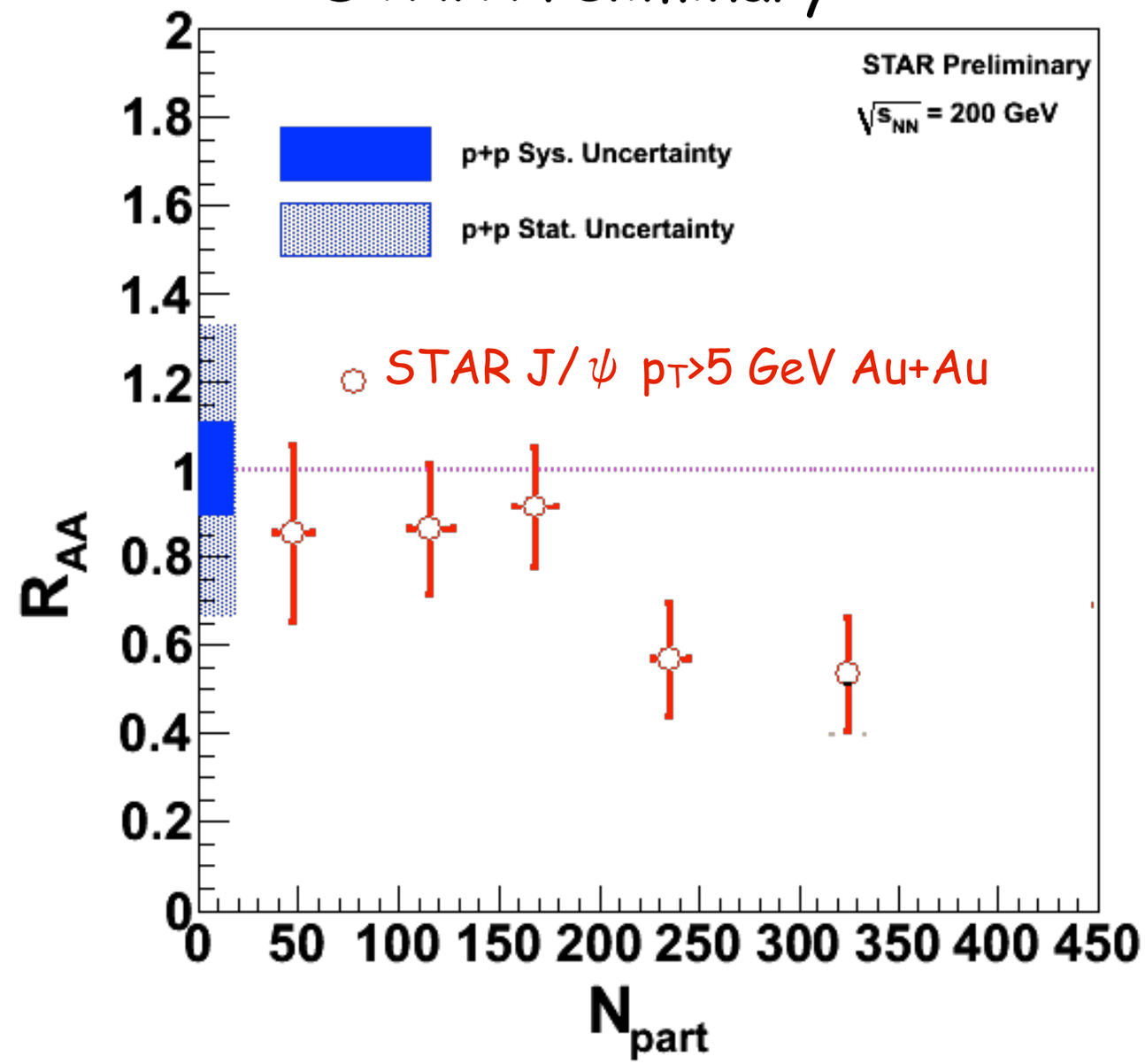
    $\Delta E/E \sim 0.005/fm^2 * L^2$

# Low and high $p_T$ $J/\psi$ in Au+Au collisions

PHENIX [arXiv:1103.6269v1]



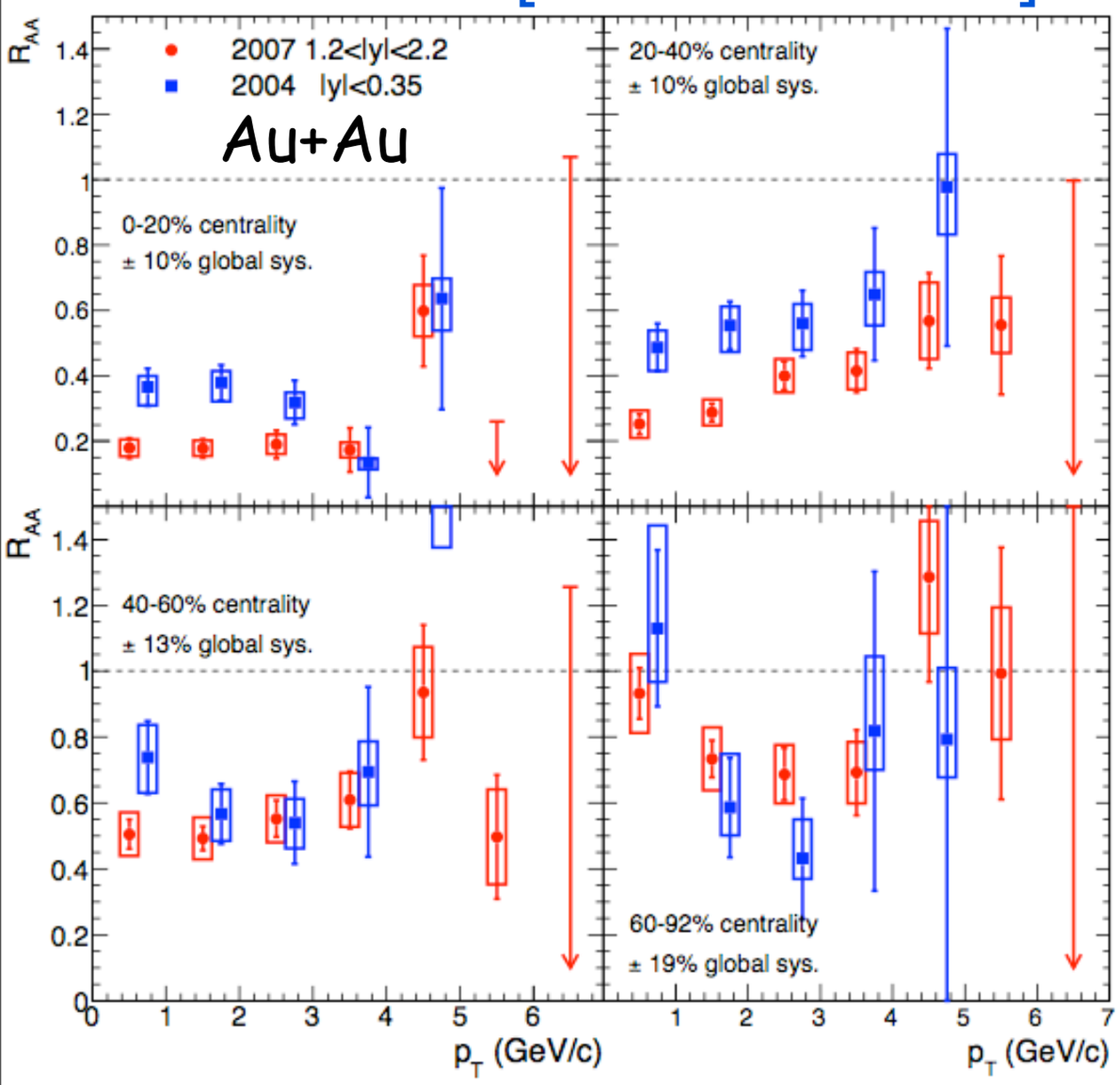

STAR Preliminary



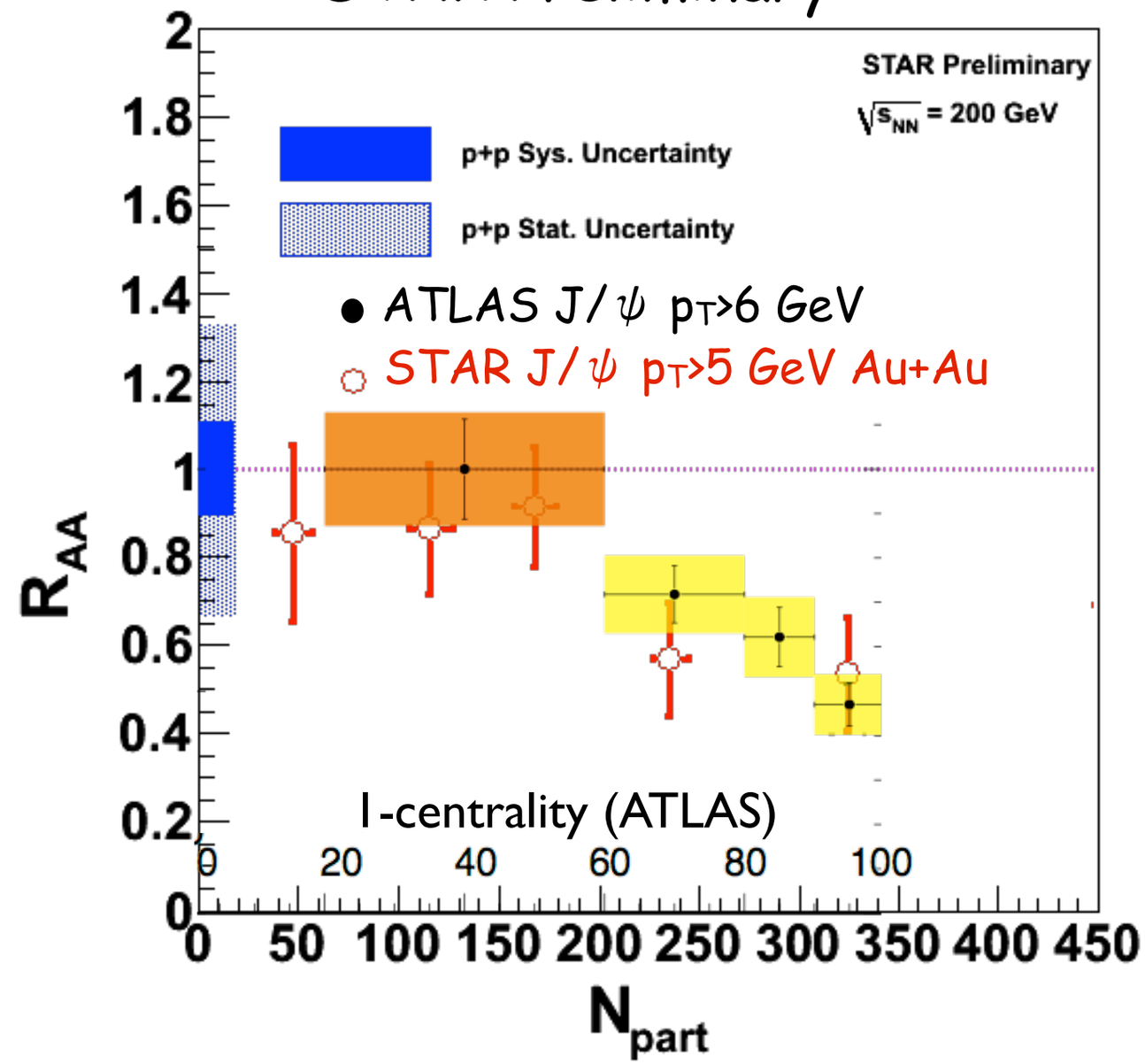

- no clear trend for $R_{AA}(p_T)$ in PHENIX measurement
- caveat: in STAR plot stat+sys uncertainties are represented at blue bands
- significant suppression at high $p_T$ in central events relative to peripheral in STAR

# Low and high $p_T$ $J/\psi$ in Au+Au collisions

PHENIX [arXiv:1103.6269v1]




STAR Preliminary




- no clear trend for $R_{AA}(p_T)$ in PHENIX measurement
- caveat: in STAR plot stat+sys uncertainties are represented at blue bands
- significant suppression at high $p_T$ in central events relative to peripheral in STAR
- agreement between STAR and ATLAS result when using arbitrary centrality