PHENIX Low-mass Dileptons and Photons

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QM2012, Washington, August 16, 2012

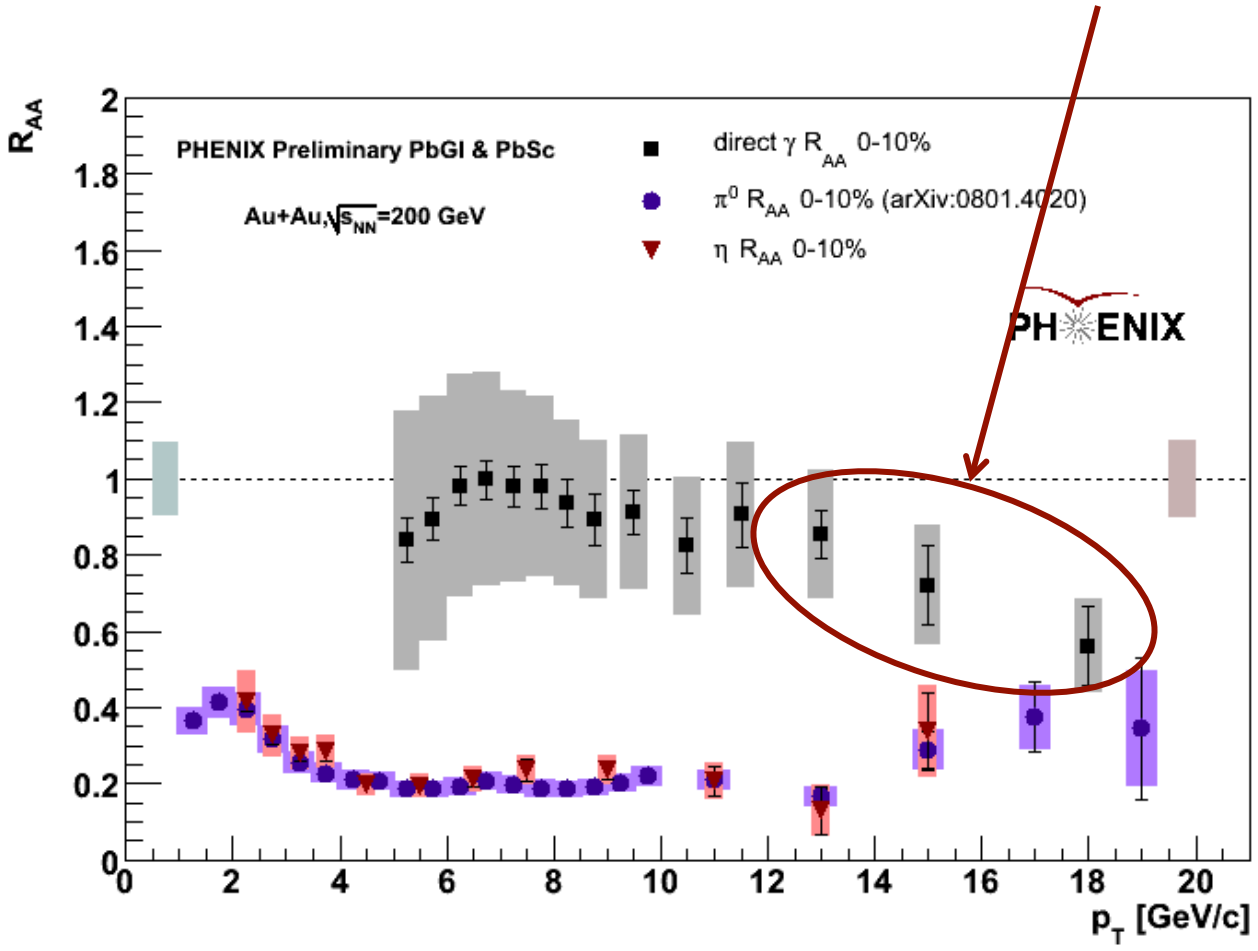
Outline

- Introduction
- Direct Photons
  - R_{AA} up to p_T = 20 GeV/c
  - d+Au
  - v_2 with conversion photons
- Dileptons - first results with the HBD (Hadron Blind Detector):
  - p+p collisions at $\sqrt{s}$ = 200 GeV
  - Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - Comparison to previous results w/o HBD
- Summary

Photons

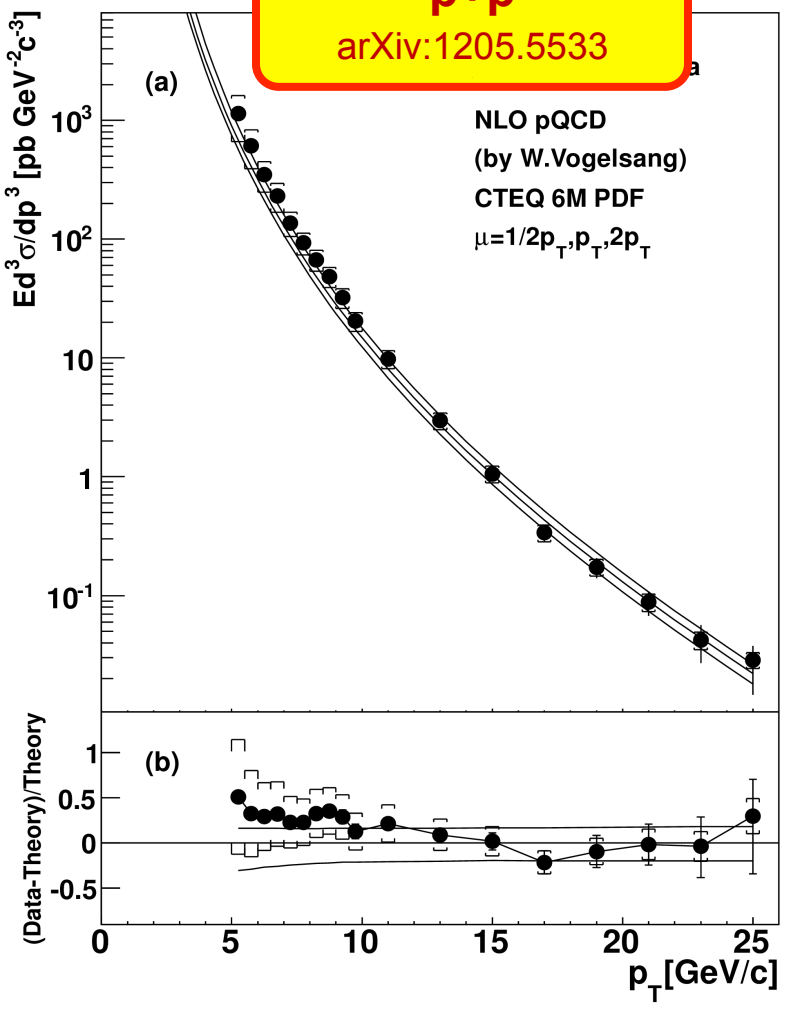
Direct Photons R_{AA}

- Long standing issue of direct photons R_{AA} at high p_T

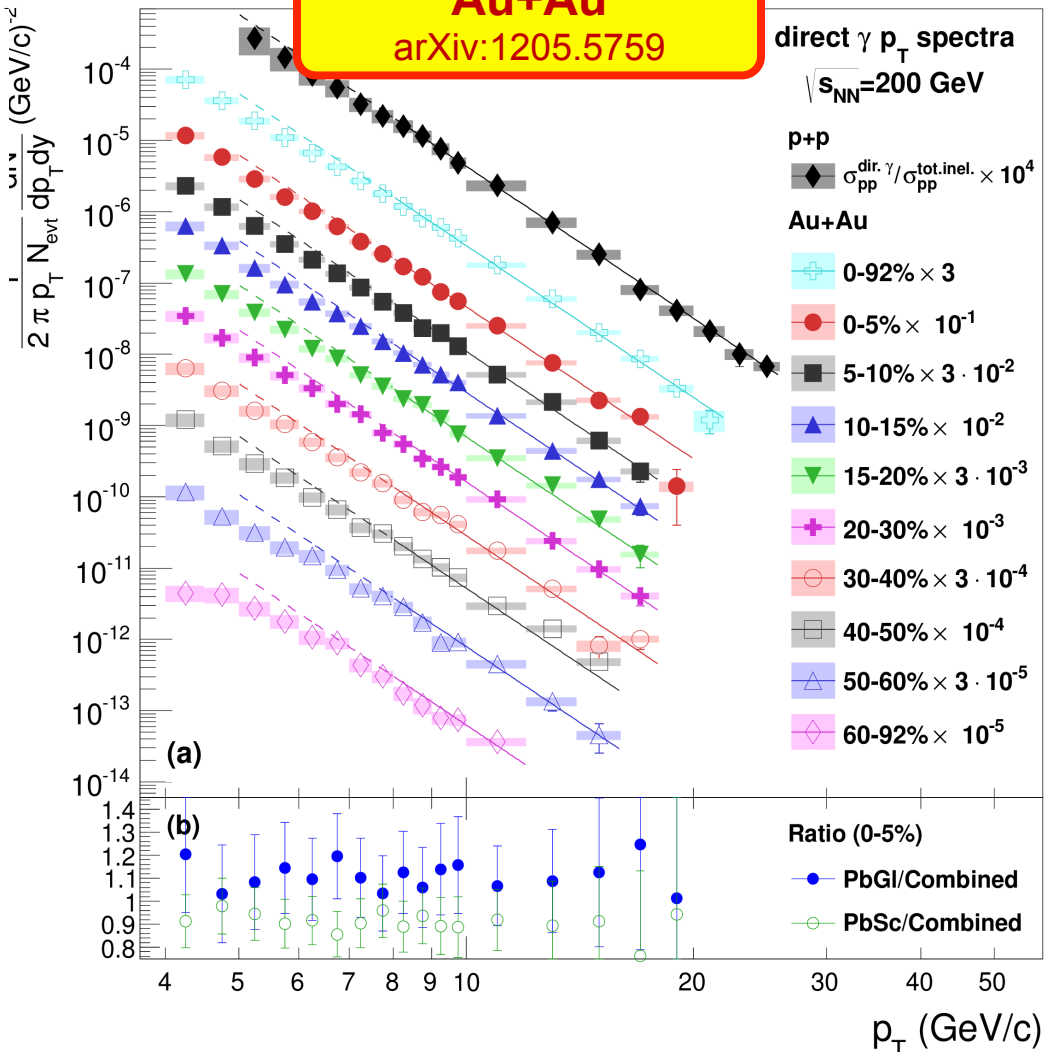


Direct γ measured to high p_T

p+p
arXiv:1205.5533



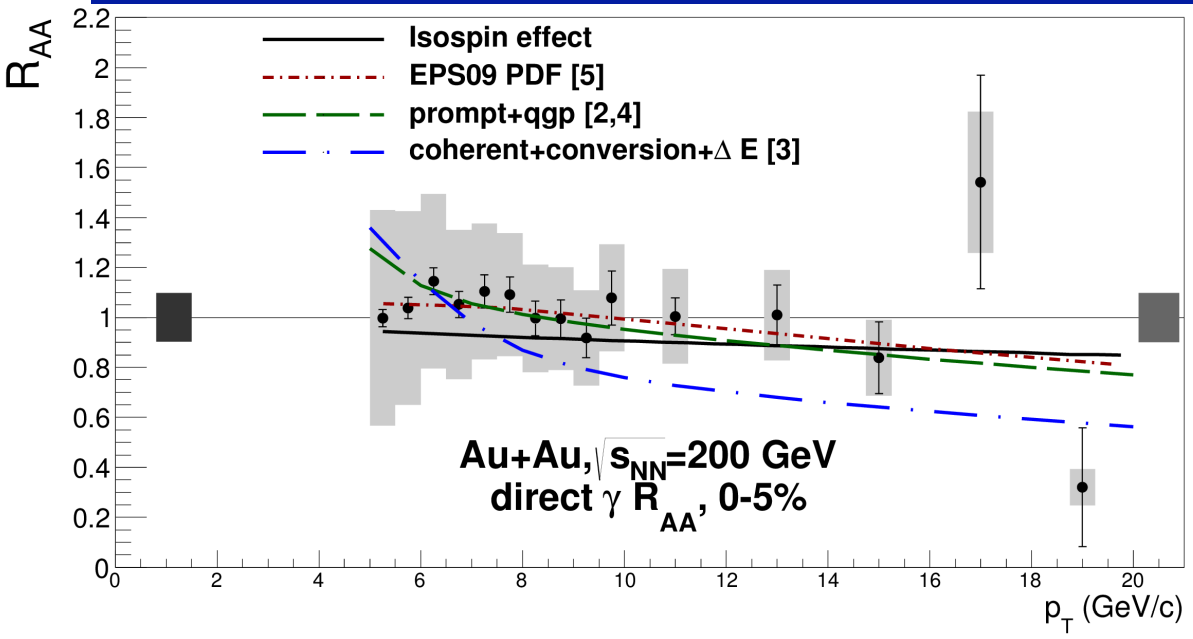
Au+Au
arXiv:1205.5759



Statistically improved 2006 pp data

Reanalize Au+Au data combining PbGl and PbSc calorimeters

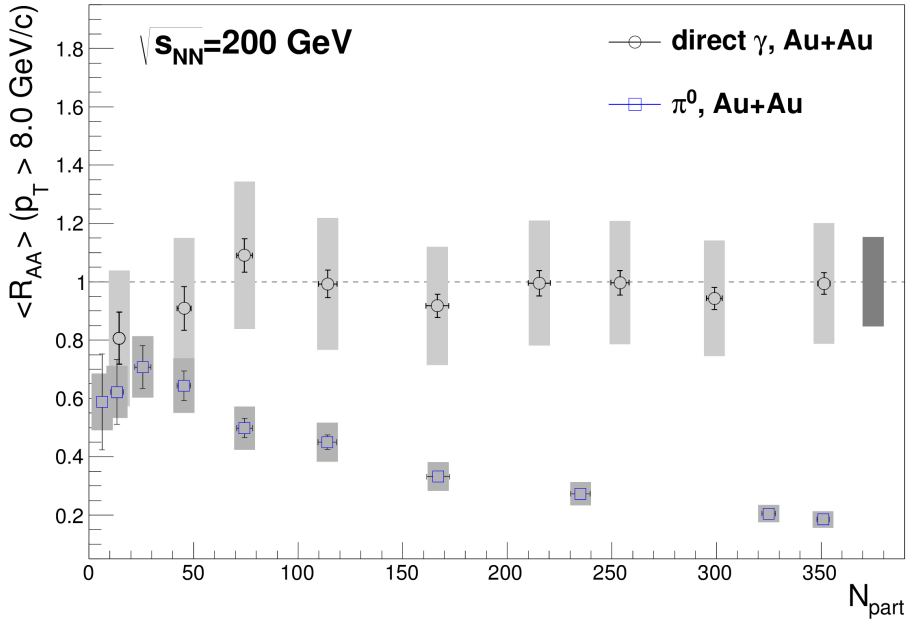
Direct γ R_{AA}



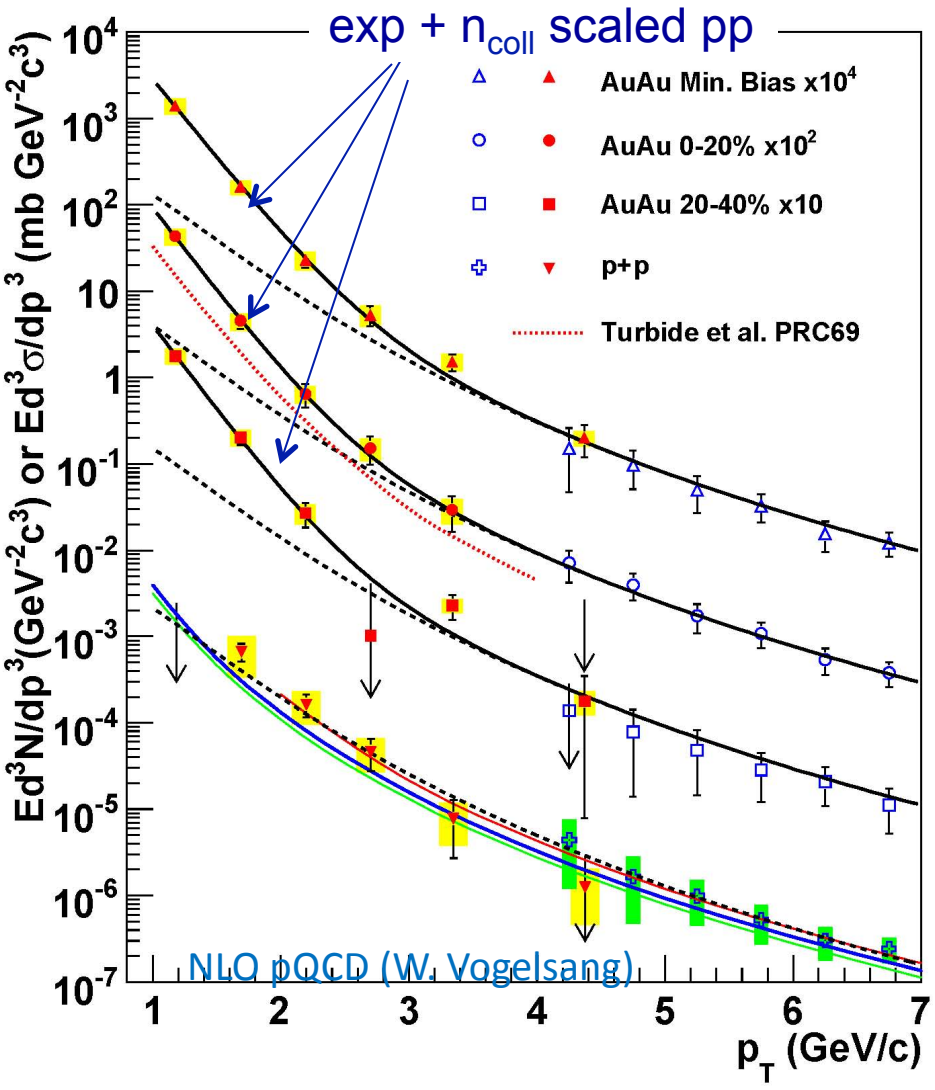
Submitted to PRL
arXiv:1205.5759

R_{AA} consistent with 1:

- up to p_T~20 GeV/c
- for all centralities



Thermal radiation from the QGP at RHIC



Poster B. Bannier

- NLO pQCD consistent with p+p down to p_T=1 GeV/c
- Excess of photons (with $1<p_T<3$ GeV/c) in Au+Au beyond the N_{coll} scaled p+p yield.
- Interpreted as thermal radiation emitted by the medium

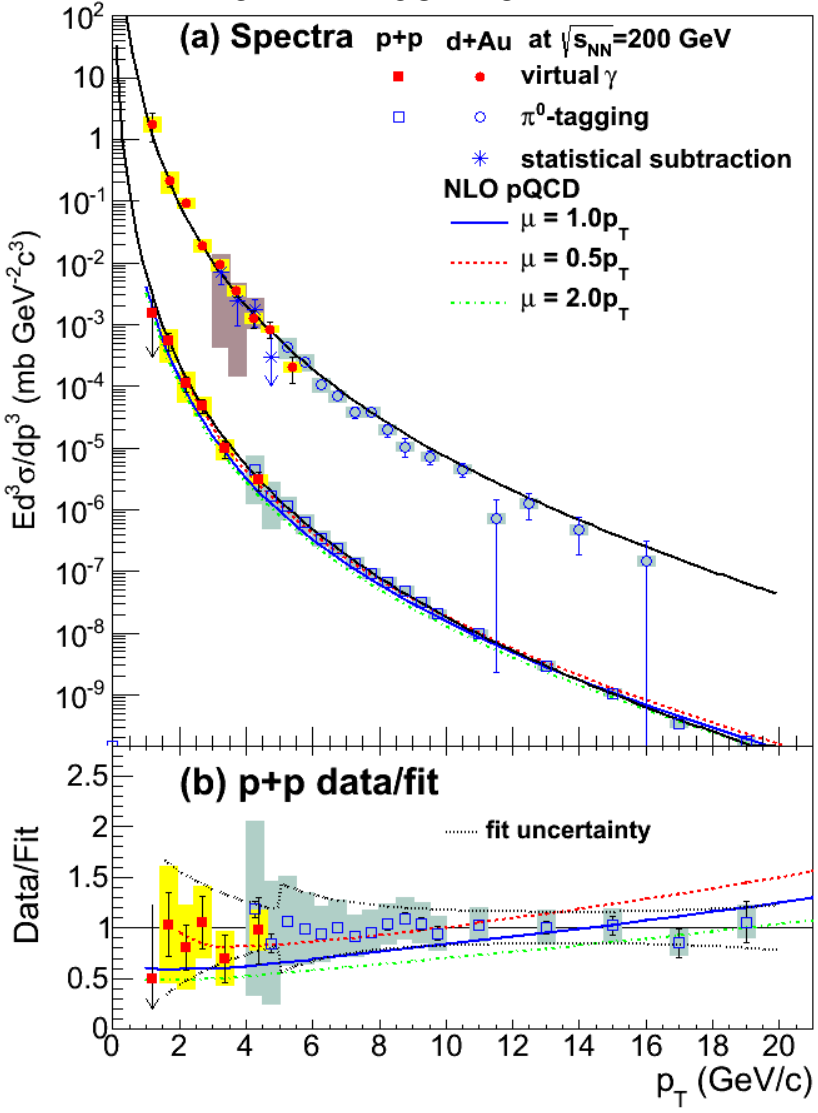
First information about the temperature of the system averaged over the space-time evolution of the collision

T_{ave} = 221 ± 19^{stat} ± 19^{syst} MeV corresponds to

T_{ini} = 300 to 600 MeV τ_0 = 0.15 to 0.6 fm/c

Direct photons in d+Au

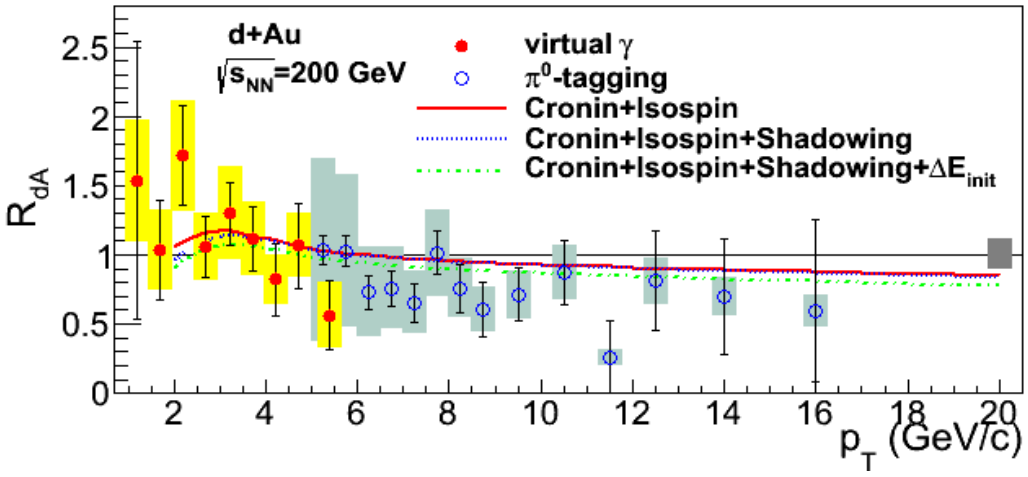
arXiv:1208.1234

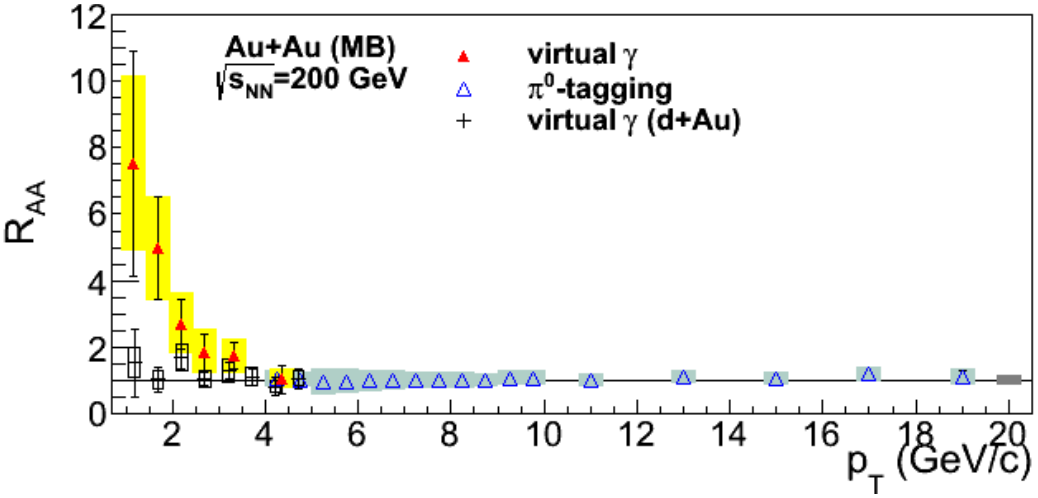


- Direct photons in d+Au measured via 3 independent methods:
  - virtual photons
  - π^0 tagging
  - statistical subtraction

- **The NLO pQCD fit to the p+p data, scaled by N_{coll}, reproduces well the d+Au data**
- **No excess of photons.**

Direct photons in d+Au and Au+Au





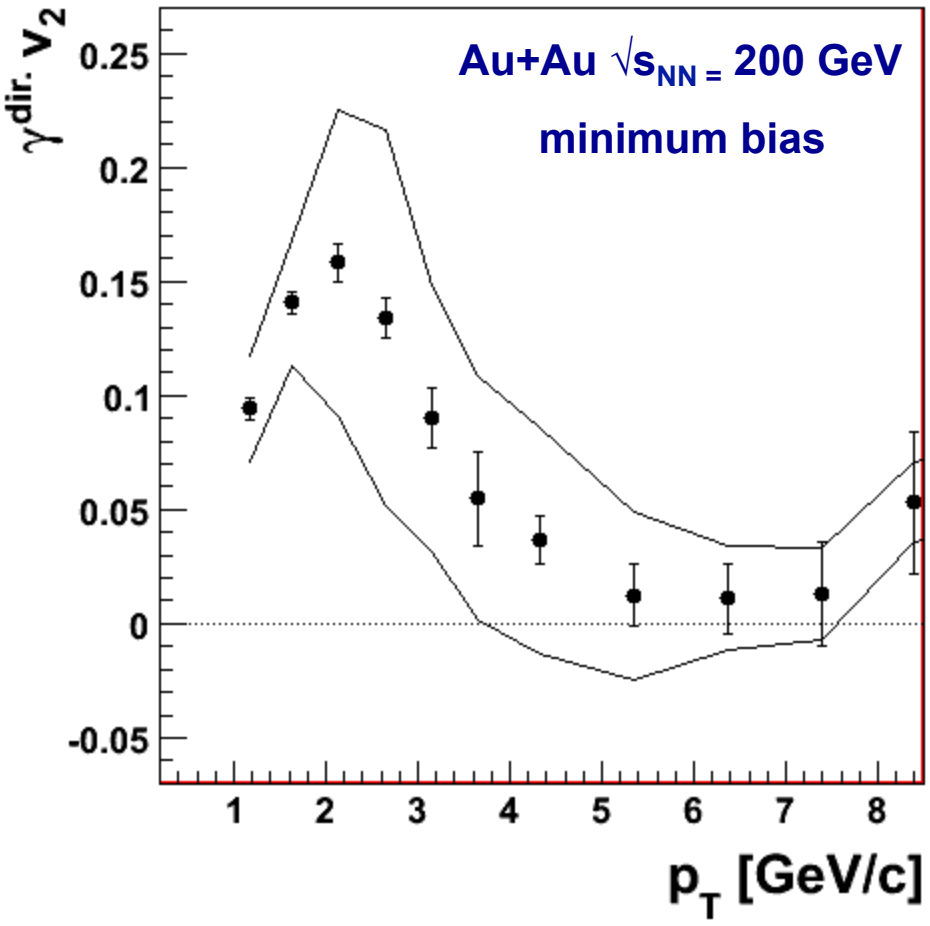
arXiv:1208.1234
B. Sahlmueler Parallel 3C

R_{dA} is consistent with unity

- **Large excess of γ observed in Au+Au is not due to initial state effects**
- **Reinforce interpretation of the Au+Au excess as thermal radiation from the QGP**

Direct photon v_2

arXiv:1105.4126



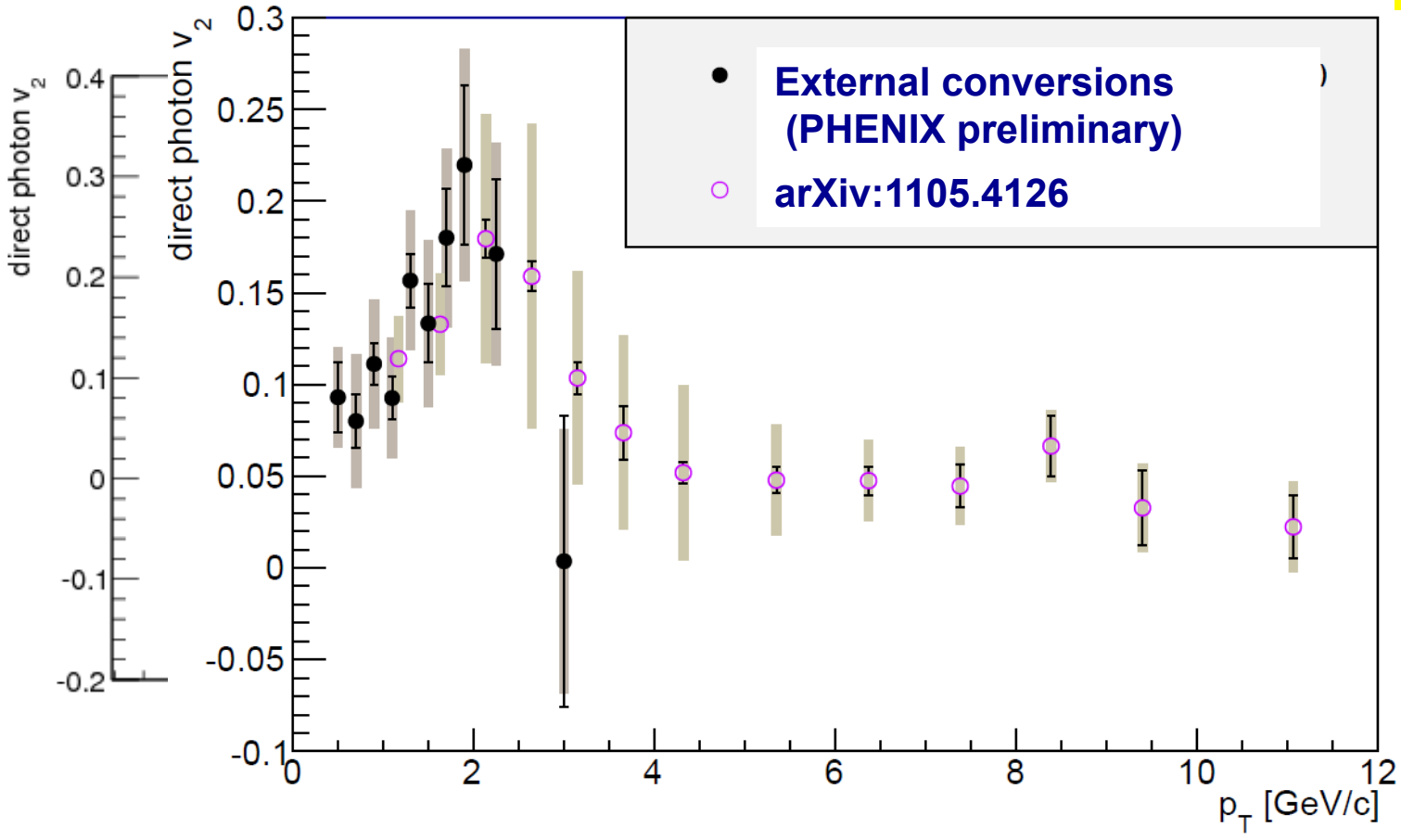
- Large v_2 at p_T < 4 GeV/c where thermal photons dominate
- v_2 consistent with 0 at high p_T where prompt photons domininate

- **Very surprising result: large v_2 implies late emission whereas thermal radiation implies early emission**
- **Models have difficulties in reproducing simultaneously yield and v_2 of photons**

Poster 282 M. Csanad

Direct photon v_2 via external conversion

Poster 64, R. Petti



lent analysis

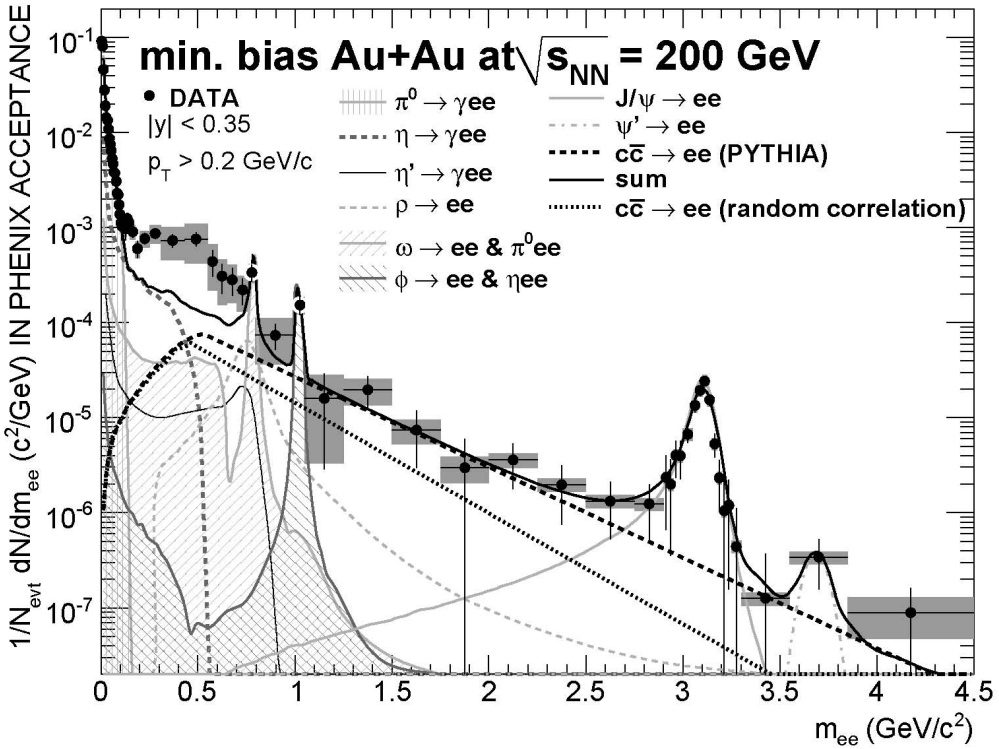
systematics

extended
).5 GeV/c

- Two independent and consistent results
- Important confirmation of previous v_2 results

First dilepton results with the HBD

Dileptons in PHENIX: Au+Au collisions

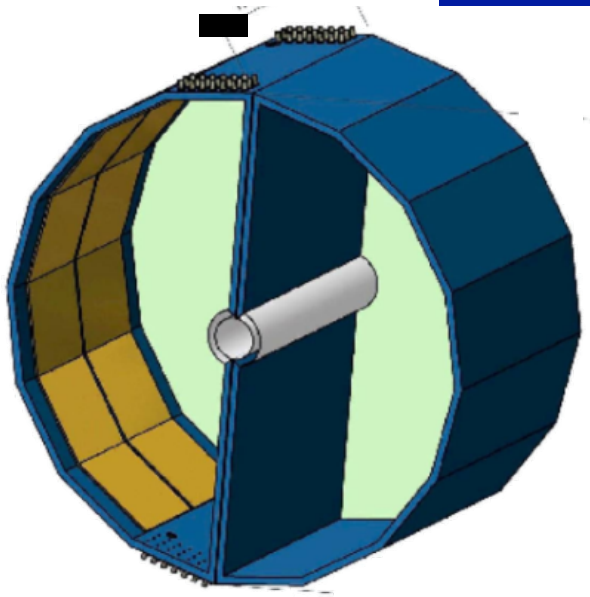


PRC 81, 034911 (2010)

- Strong enhancement of e^+e^- pairs at low masses: m= 0.2 – 0.7 GeV/c^2, concentrated in central collisions
- Challenge for theoretical models

- Result limited by large uncertainty due to the huge combinatorial background of uncorrelated pairs from partially reconstructed π^0 Dalitz decays and γ-conversions
- To improve the dilepton measurement PHENIX developed a Hadron Blind Detector (HBD)

HBD performance



NIM A646, 35 (2011)

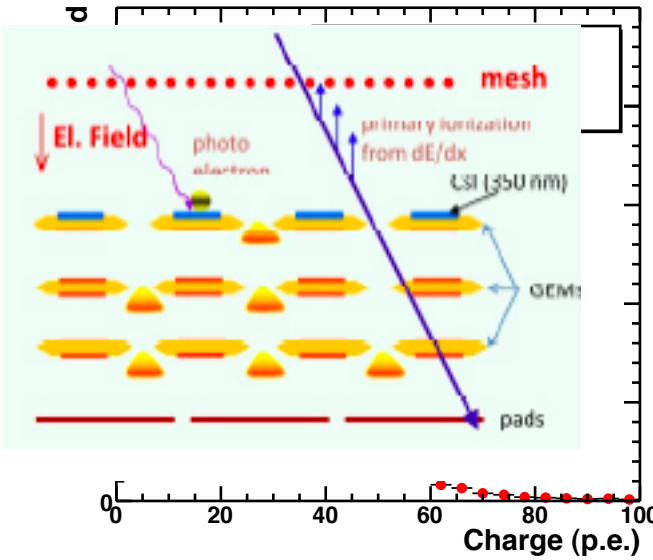
Windowless CF4 Cherenkov detector

GEM/CSI photo-cathode readout

Operated in B-field free region

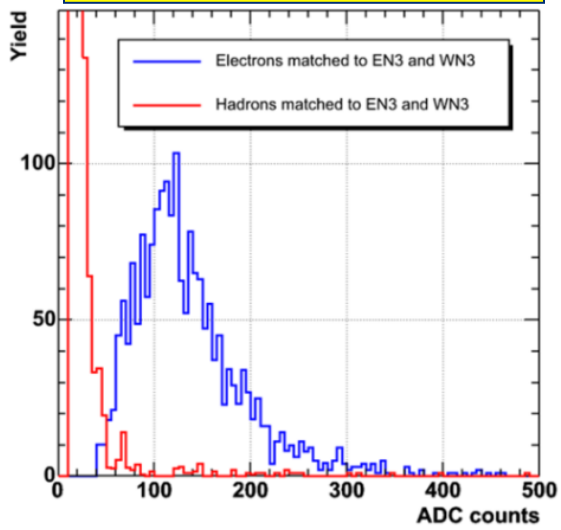
Goal: improve S/B by rejecting conversions and π^0 Dalitz decays

Single electron



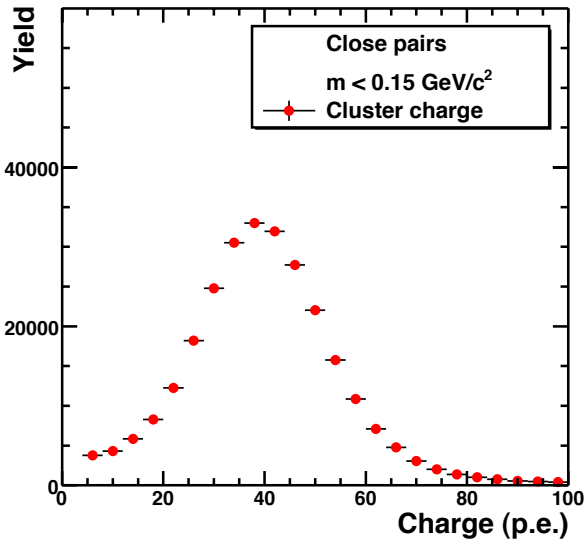
- Successfully operated:
  2009 p+p data
  2010 Au+Au data

Hadron blindness e-h separation



- Figure of merit: $N_0 = 322\ cm^{-1}$
- 20 p.e. for a single electron
- Preliminary results:
  S/B improvement of ~5 wrt previous results w/o HBD

Double electron



Au+Au analysis details

- Strong run QA and strong fiducial cuts to homogenize response of the central arm detectors over time

  → Large price in statistics and pair efficiency

- Two parallel and independent analysis streams: provide crucial consistency check

Stream A	Stream B
HBD: underlying event subtraction using average charge per pad	HBD: underlying event subtraction using average charge in track projection neighborhood
Neural network for eid and for single/ double electron separation	Standard 1d cuts for both eid and for single/ double electron separation
Correlated background (cross pairs and jets) subtracted using acceptance corrected like-sign spectra	Correlated background subtracted using MC for the cross pairs and jet pairs

Results shown here are from stream A

see E. Atomsa Parallel 3C

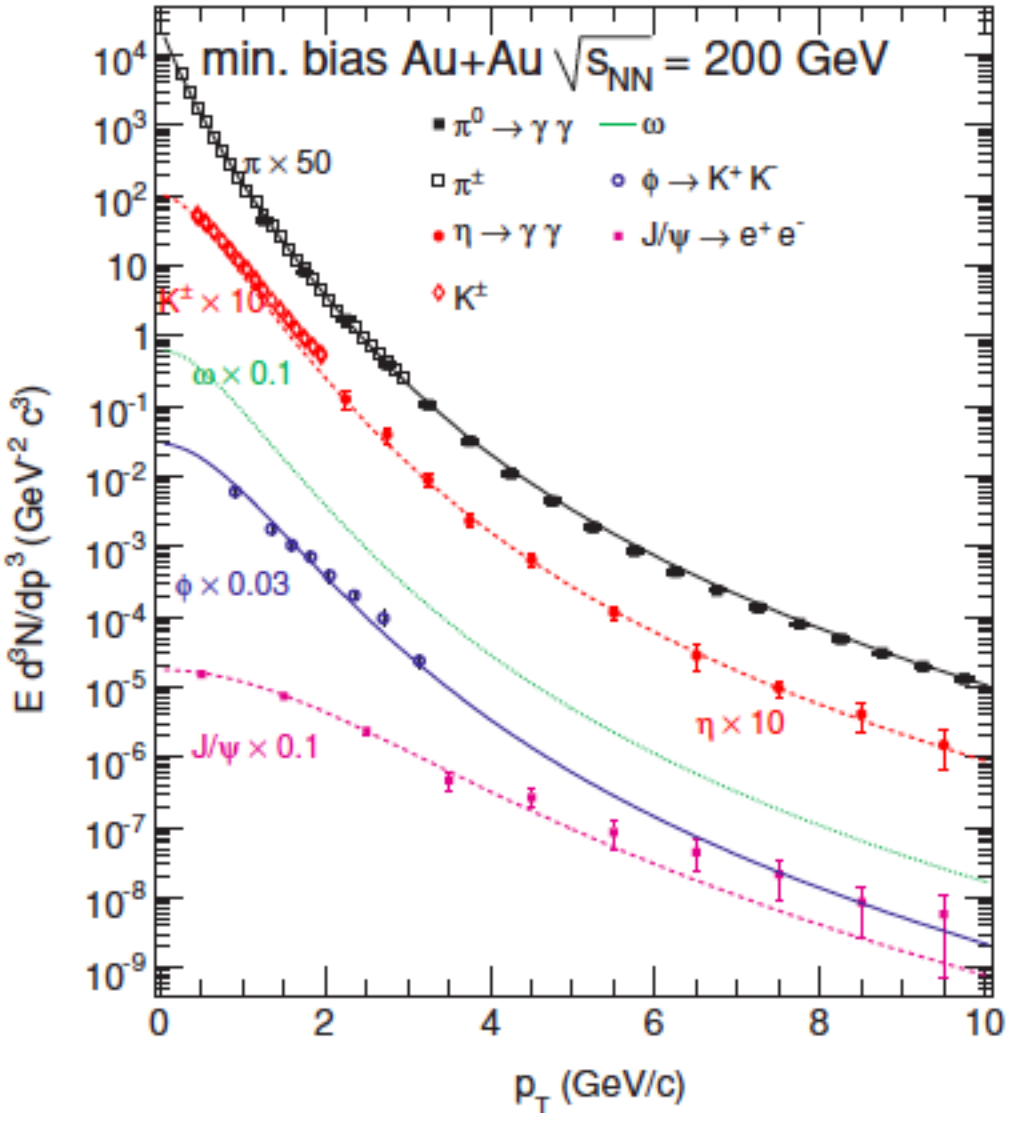
Cocktail

- π^0 and charged π data fit to a modified Hagedorn function:

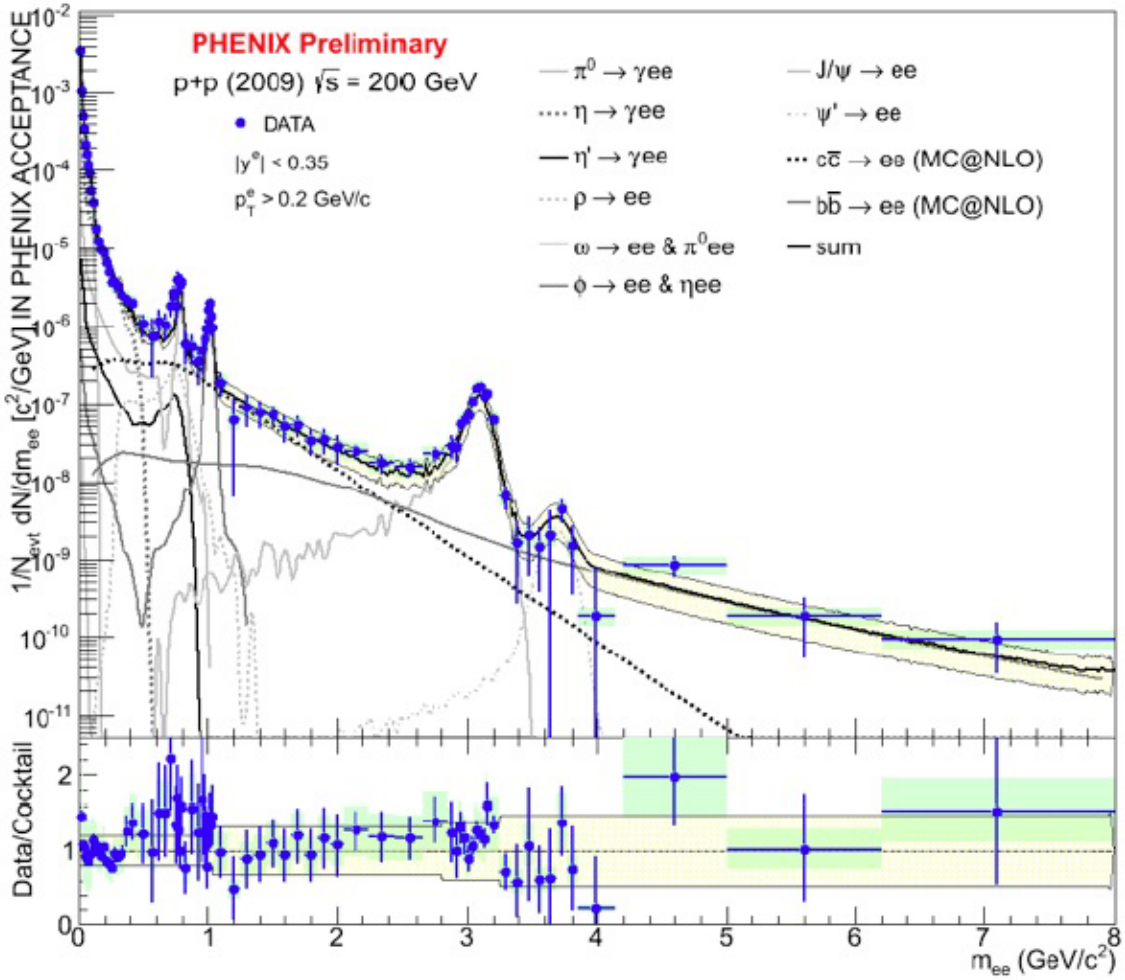
$$E\frac{d^3N}{dp^3} = \frac{A}{(e^{-(ap_T+bp_T^2)} + p_T/p_0)^n}$$

- Use m_T scaling for shape of other hadrons, normalize to measured data
- Fits are done independently for each particle and each centrality

- Open heavy flavor (c,b) contributions determined using MC@NLO
- J/ψ shape from pp, yield from pp scaled by $N_{coll}.R_{AA}$



Run-9 p+p dileptons with the HBD

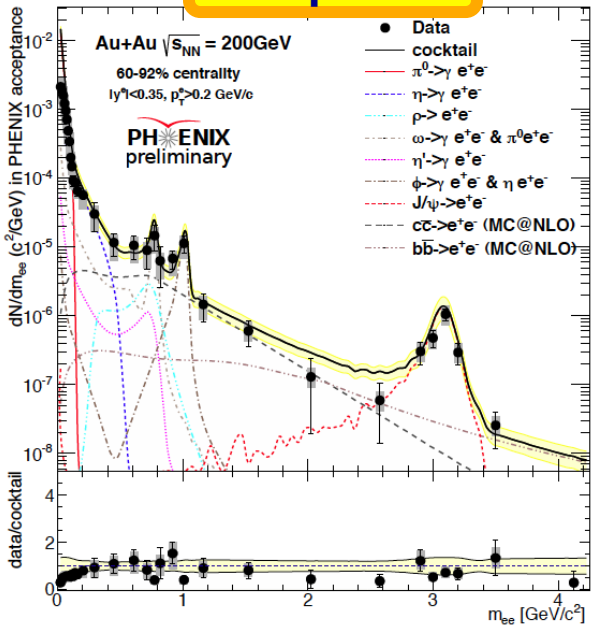


Poster 74 D. Sharma

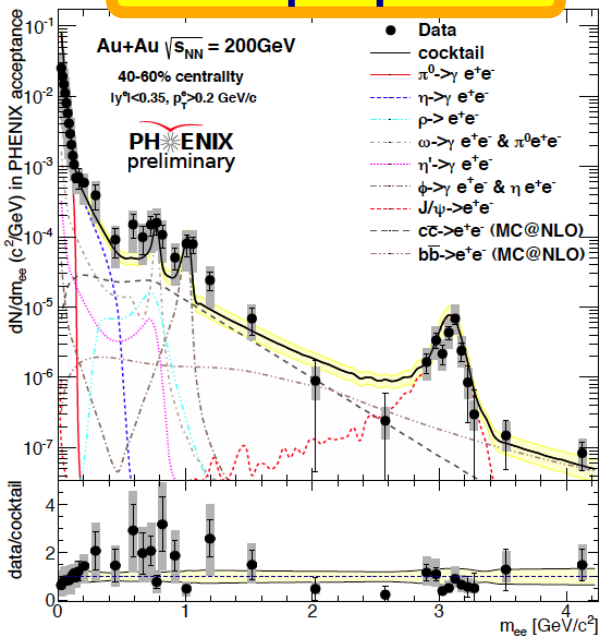
- Fully consistent with published result PR C81, 034911 (2010)
- Provide crucial proof of principle and testing ground for understanding the HBD

Au+Au dileptons at $\sqrt{s_{NN}}$=200 GeV with the HBD

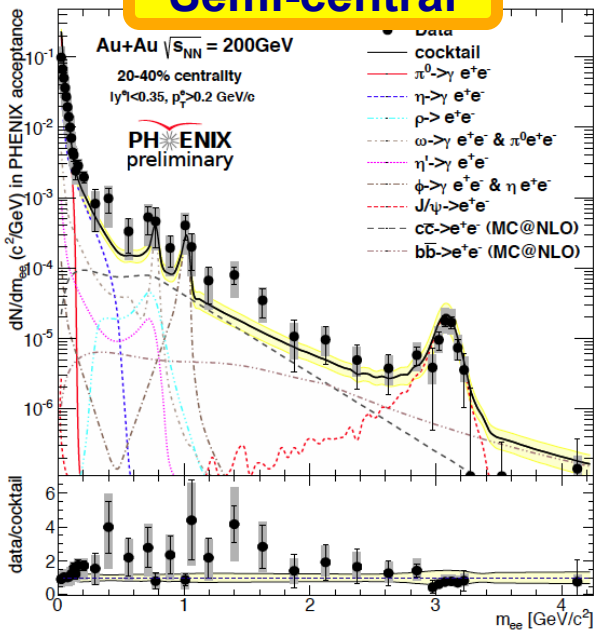
Peripheral



Semi-peripheral

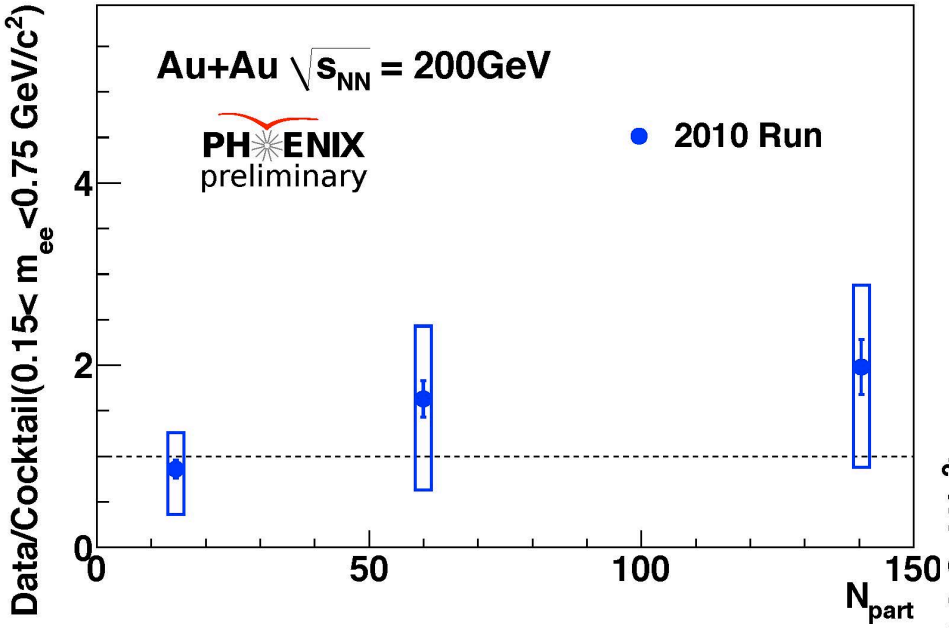


Semi-central



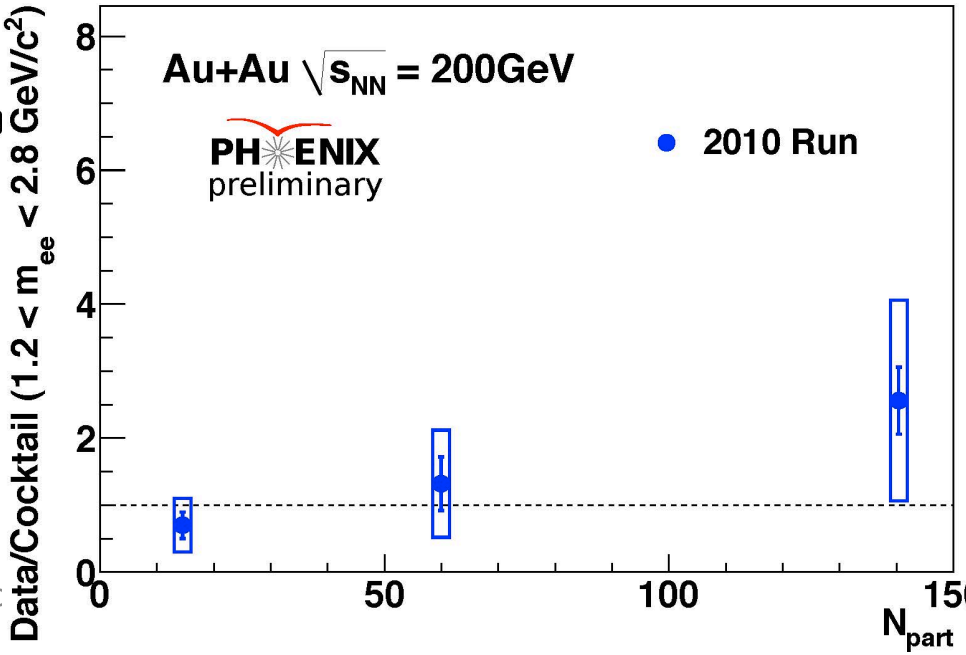
Run-10: Data/Cocktail

LMR (m = 0.15 – 0.75 GeV/c²)



- Hint of enhancement for more central collisions
- Not conclusive given the present level of uncertainties

IMR (m = 1.2 – 2.8 GeV/c²)



- Similar conclusions for the IMR

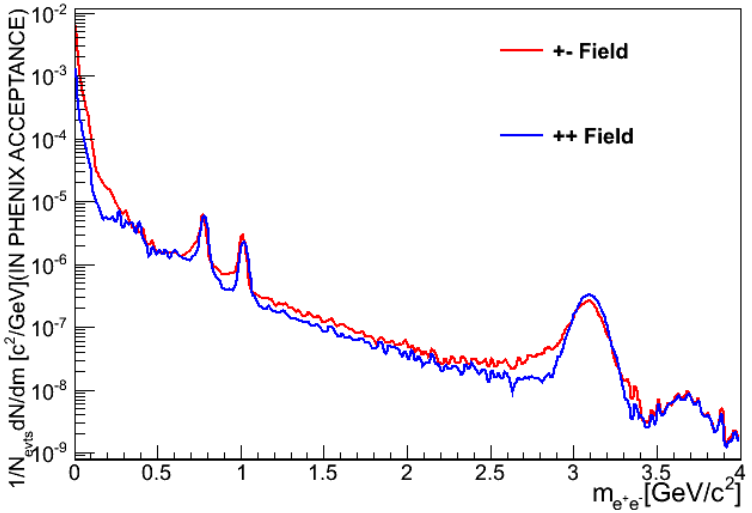
Dileptons with and without HBD

Data:

- Different magnetic field configuration:
  Run-9 (p+p) and Run-10(Au+Au) with HBD:
  +- field configuration
  All other runs: ++ field configuration

→Larger acceptance of low p_T tracks in +- field

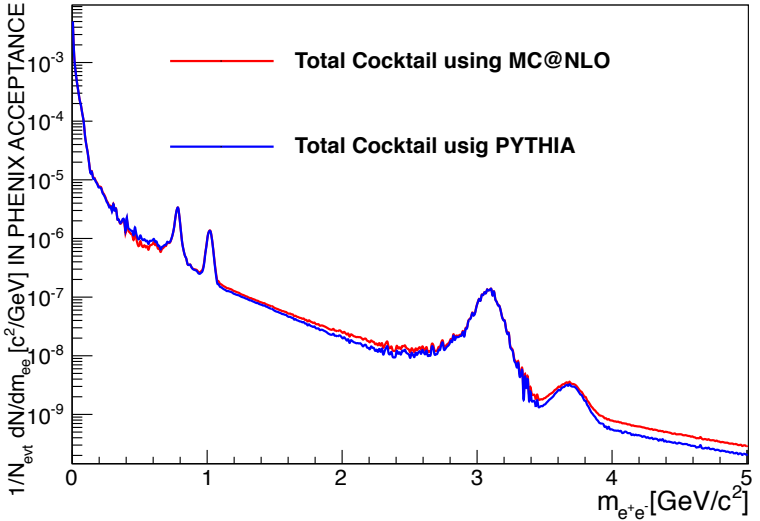
- More material due to HBD
  → more J/Ψ radiative tail
- Compare results in three centrality bins:
  20-40%, 40-60% and 60-92%



Cocktail:

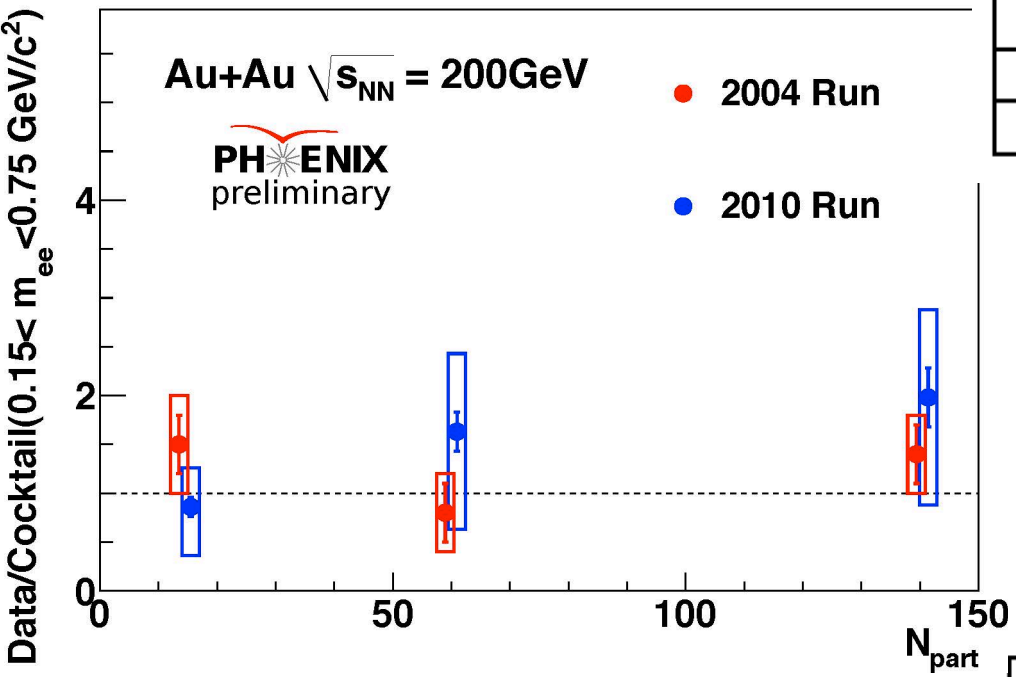
MC@NLO for open heavy flavor (c,b) contribution instead of PYTHIA

MC@NLO**(1.2-2.8) =** PYTHIA**(1.2-2.8) * 1.16**



Comparison of run-10 to published run-4 results

LMR (m = 0.15 – 0.75 GeV/c²)



Consistent results

Run 10 – Data/ cocktail

Centrality	Value	Stat	Syst(up)	Syst(dwn)
20-40%	1.98	0.3	0.9	1.1
40-60%	1.63	0.2	0.8	1.0
60-92%	0.86	0.1	0.4	0.5

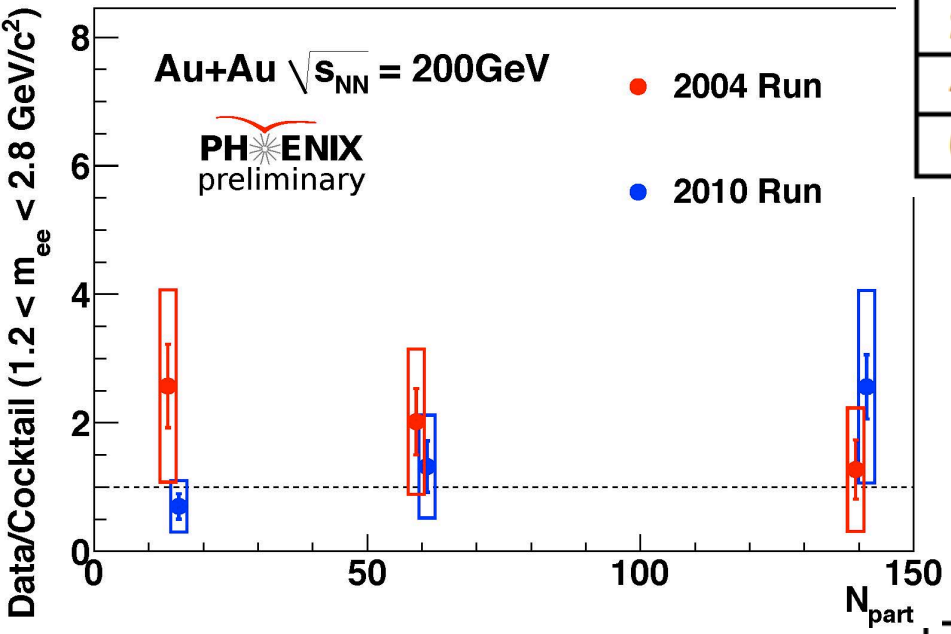
Run 4 – Data/ cocktail

Phys Rev C81, 034911 (2010)

Centrality	Value	Stat	Syst	model
20-40%	1.4	0.3	0.4	0.3
40-60%	0.8	0.3	0.4	0.2
60-92%	1.5	0.3	0.5	0.3

Comparison of run-10 to published run-4 results

IMR (m = 1.2 – 2.8 GeV/c^2)



Run 10 – Data/ cocktail

Centrality	Value	Stat	Syst(up)	Syst(dwn)
20-40%	2.56	0.5	1.5	1.5
40-60%	1.32	0.4	0.8	0.8
60-92%	0.70	0.2	0.4	0.4

Run 4 – Data/ cocktail
c,b yields based on MC@NLO
MC@NLO = PYTHIA * 1.16

Centrality	Value	Stat	Syst
20-40%	1.3	0.5	1.0
40-60%	2.0	0.5	1.1
60-92%	2.6	0.6	1.5

Consistent results

Summary

- R_{AA} of direct photons consistent with 1 from 5 GeV/c up to ~20 GeV/c
- No excess of direct photons in d+Au.
  Reinforce the interpretation of the excess observed in Au+Au at p_T =1-4 GeV/c as thermal radiation
- Confirmation of the large v_2 of thermal photons by an independent analysis based on external conversions
- First results on dileptons using the HBD on p+p and Au+Au collisions in 20-40%, 40-60% and 60-92% centrality bins
- Preliminary results in Au+Au with very strong QA cuts and conservative error estimates consistent with previously published results
- Next: relax QA and fiducial cuts, better assessment of systematics and complete analysis