

Systematics of high- p_T η production in p+p, d+Au and Au+Au at RHIC

APS / DNP Fall Meeting

Chicago, IL, October 30, 2004

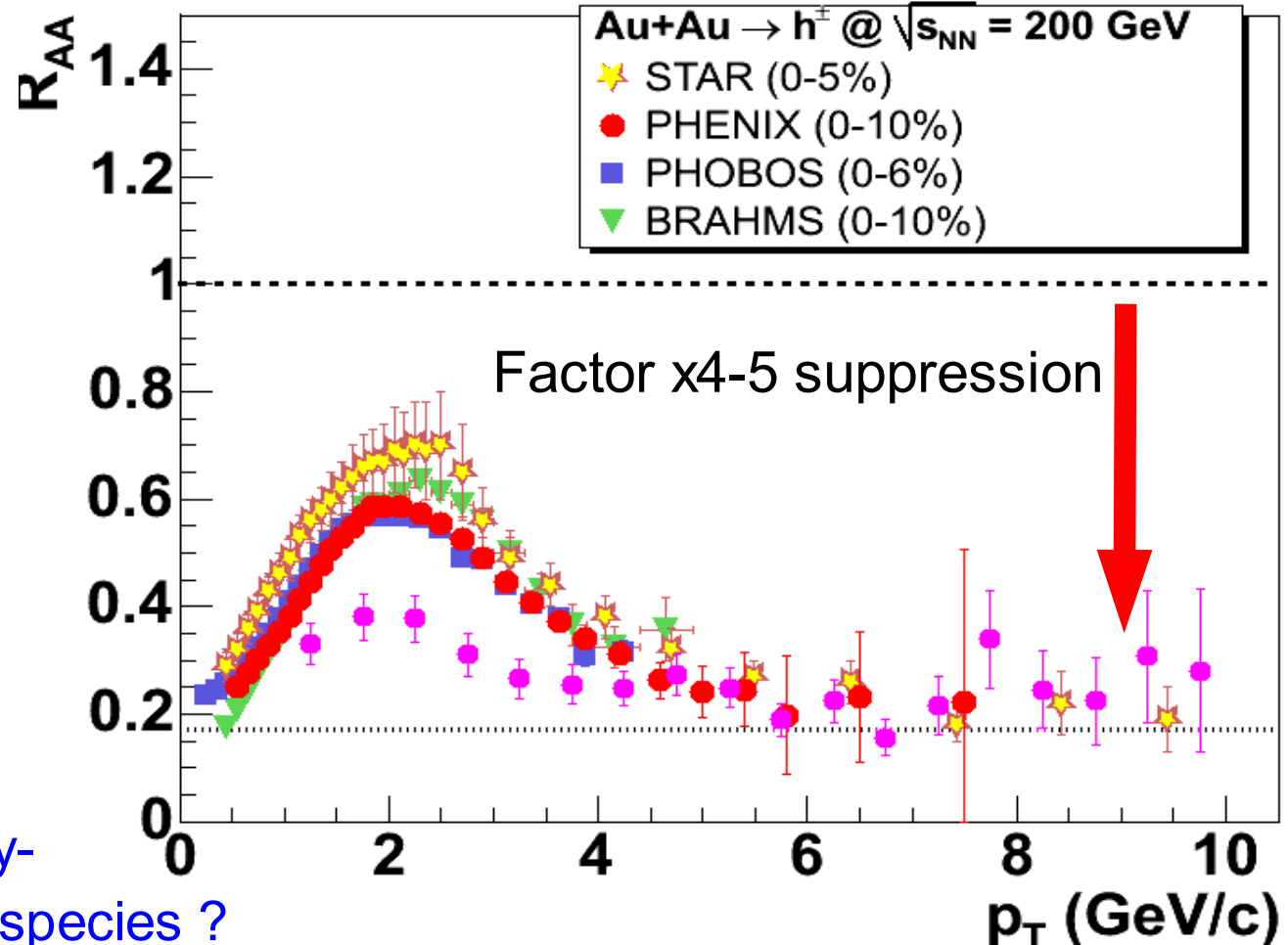
David d'Enterria

Nevis Labs, COLUMBIA University, NY

for the **PH****ENIX** Collaboration

η ? Why η ...? Motivation

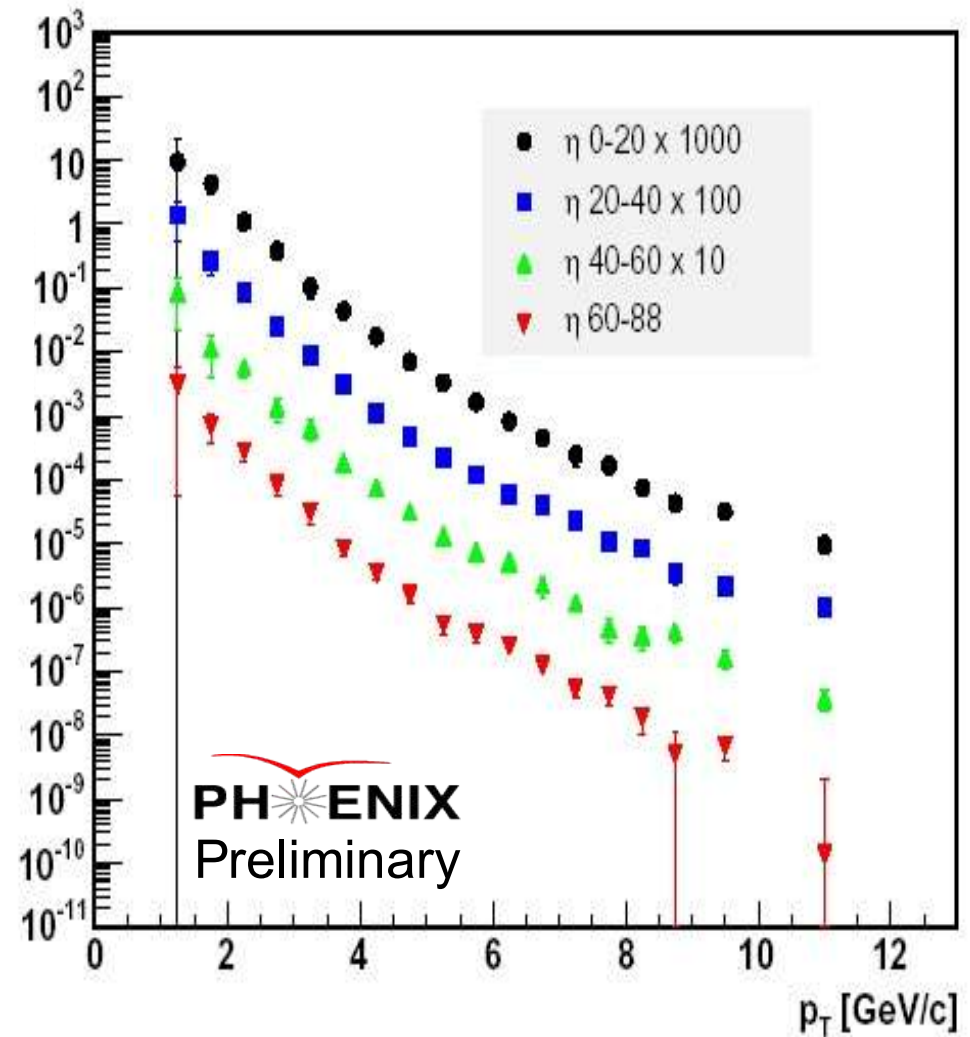
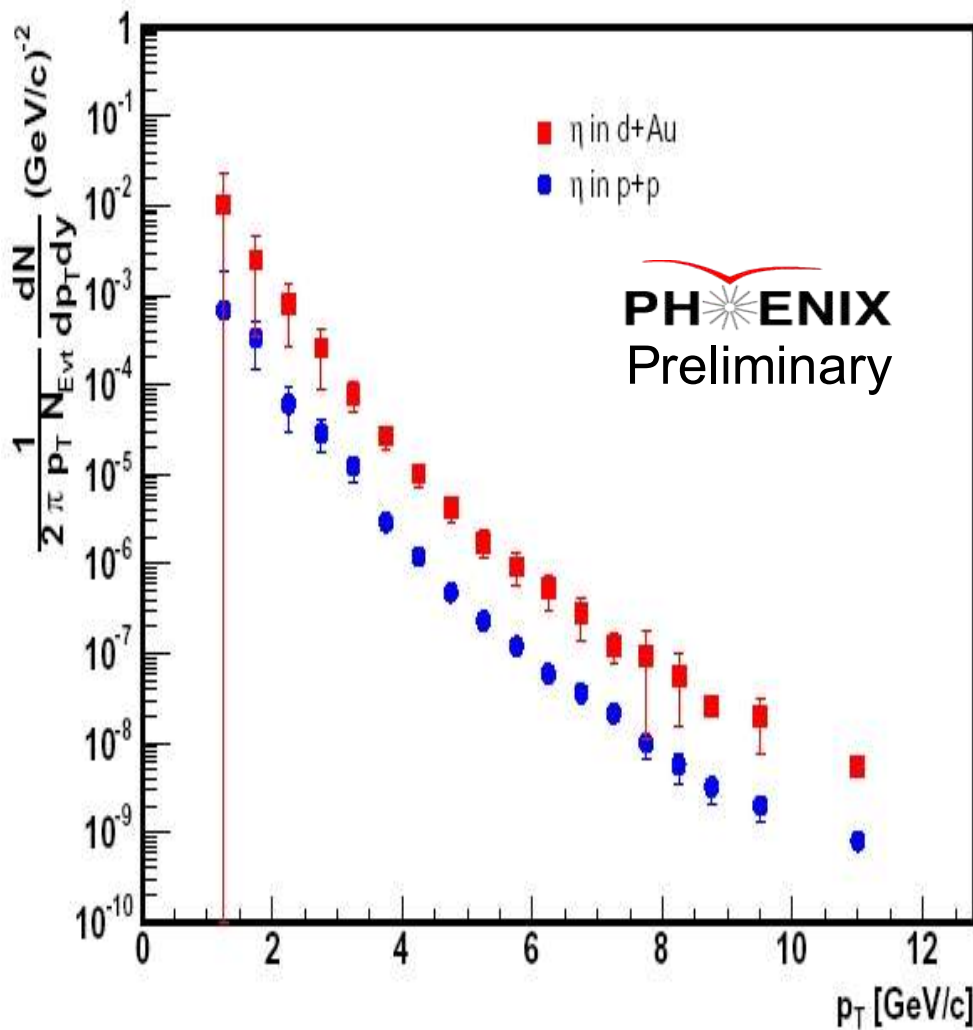
- **Perturbative** (high p_T) π^0 , h^\pm production in central Au+Au at RHIC **suppressed compared** to expectations of **incoherent parton-parton** scattering.
- Consistent with “**jet quenching**” in hot/dense QCD medium.
- Q: To what extent is this suppression “universal” (magnitude, p_T -, centrality-
dep., ...) for diff. particle species ?



- Goal (1): Compare **high p_T production** for a new hadron species (η) in 3 systs: **p+p** (QCD vacuum), **d+Au** (cold QCD medium), **Au+Au** (hot QCD medium)
- Goal (2): Have under **control** the 2nd largest hadronic source (η) of **decay photon bckgd** for direct γ and e^\pm studies.

High p_T η spectra (p+p, d+Au at RHIC)

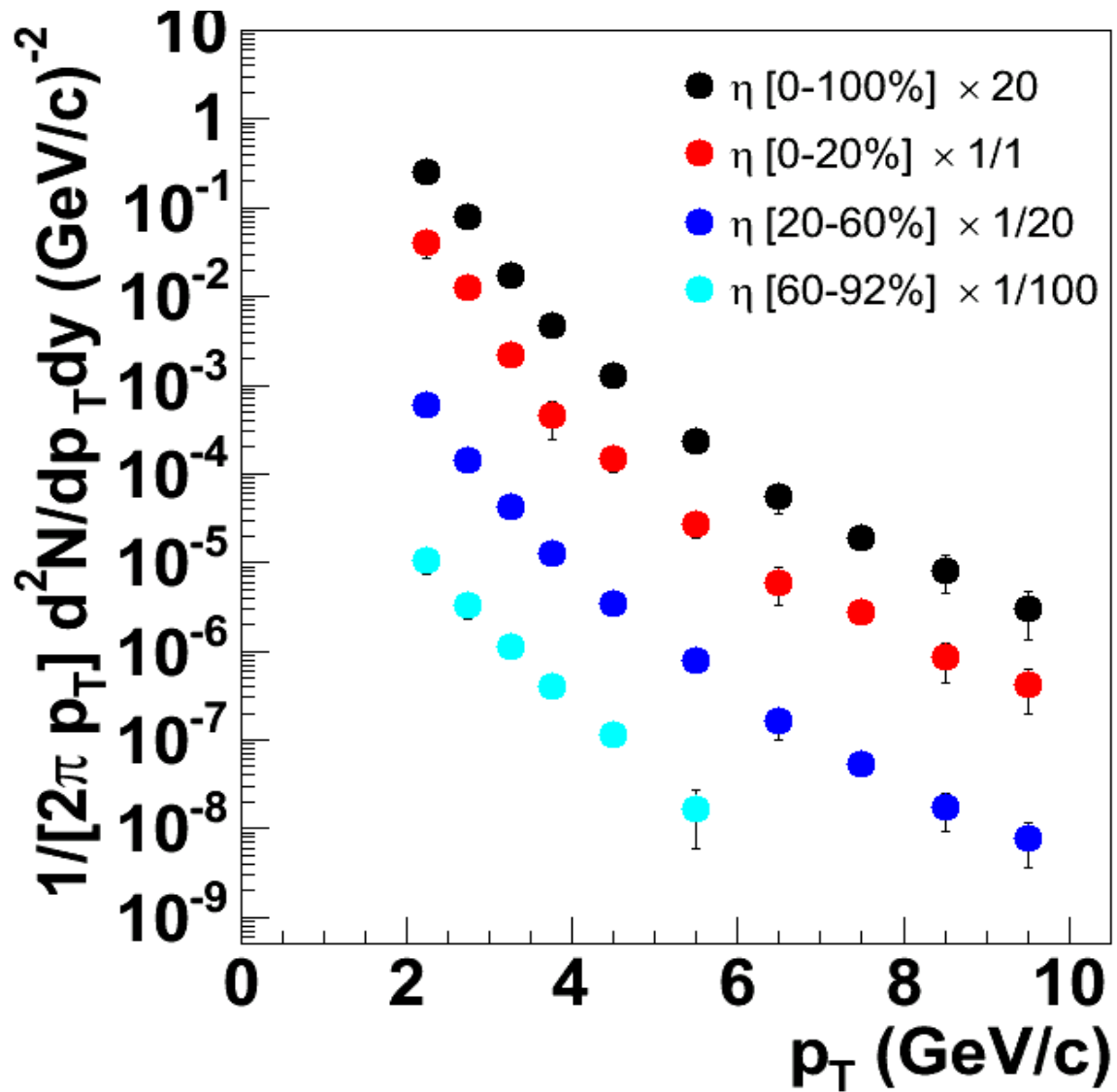
p+p, d+Au $\rightarrow \eta + X$ @ $\sqrt{s} = 200$ GeV (Run-3)



- Spectra go up to $p_T = 12$ GeV/c (well in the perturbative regime)
- η is the 3rd highest p_T identified particle (after π^0 , γ) at RHIC

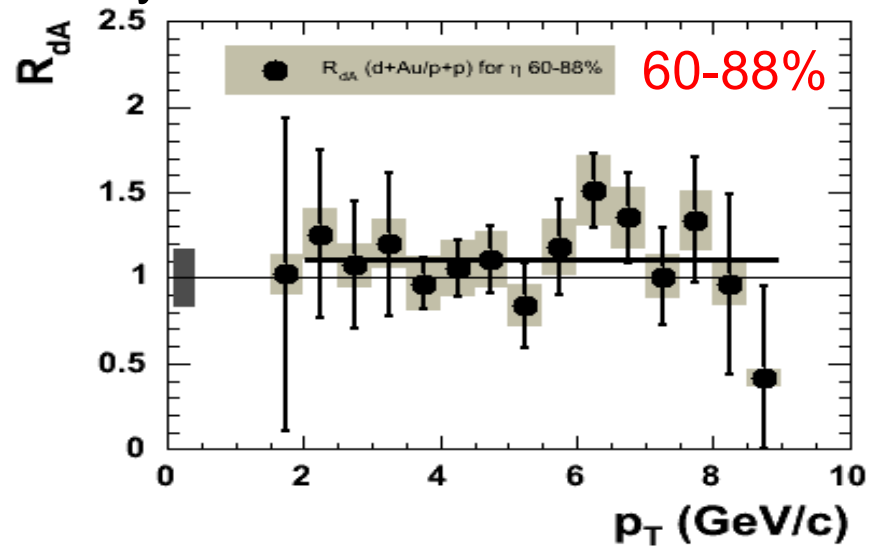
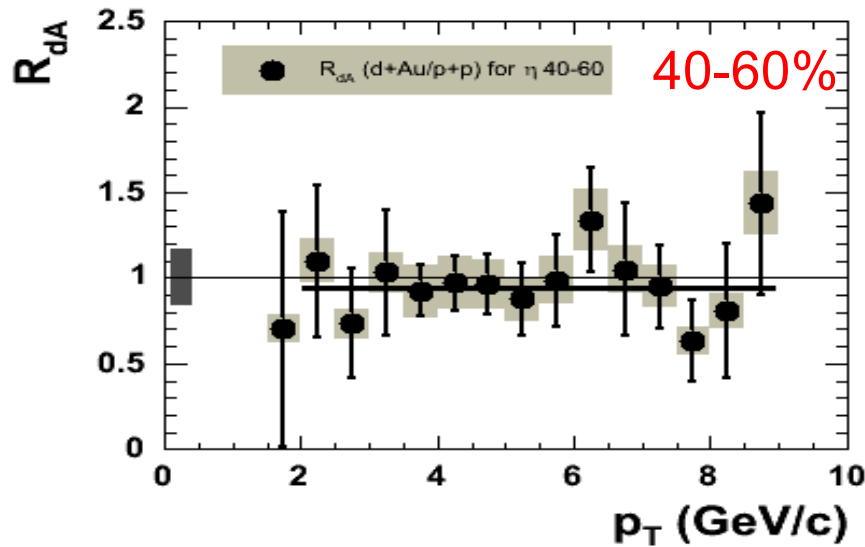
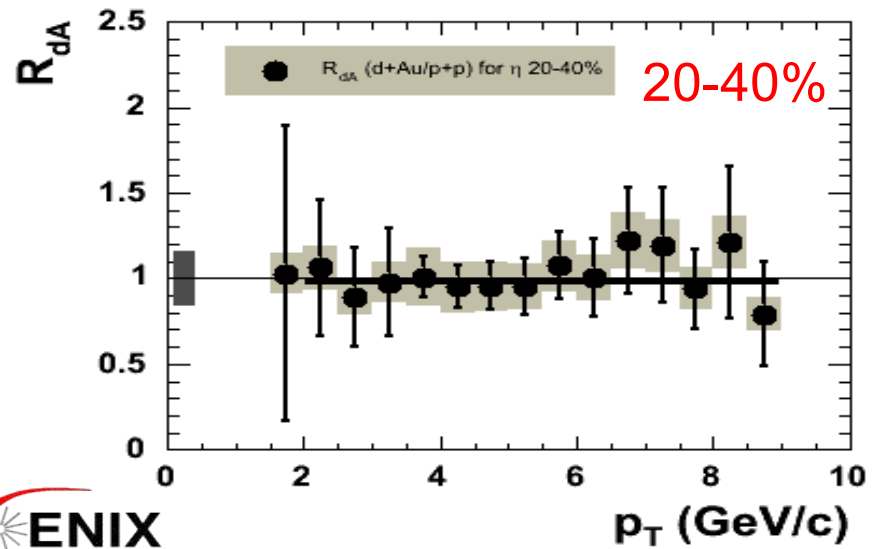
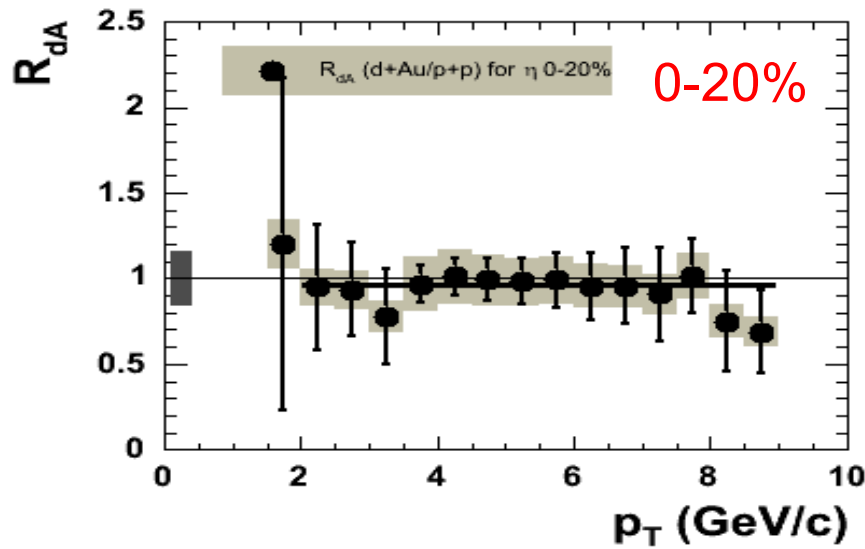
High p_T η spectra (Au+Au at RHIC)

Au+Au \rightarrow η +X @ $\sqrt{s_{NN}} = 200$ GeV (Run-2)



- Spectra go up to $p_T = 10$ GeV/c (well in the perturbative regime)

High p_T η in “cold QCD matter” (d+Au)

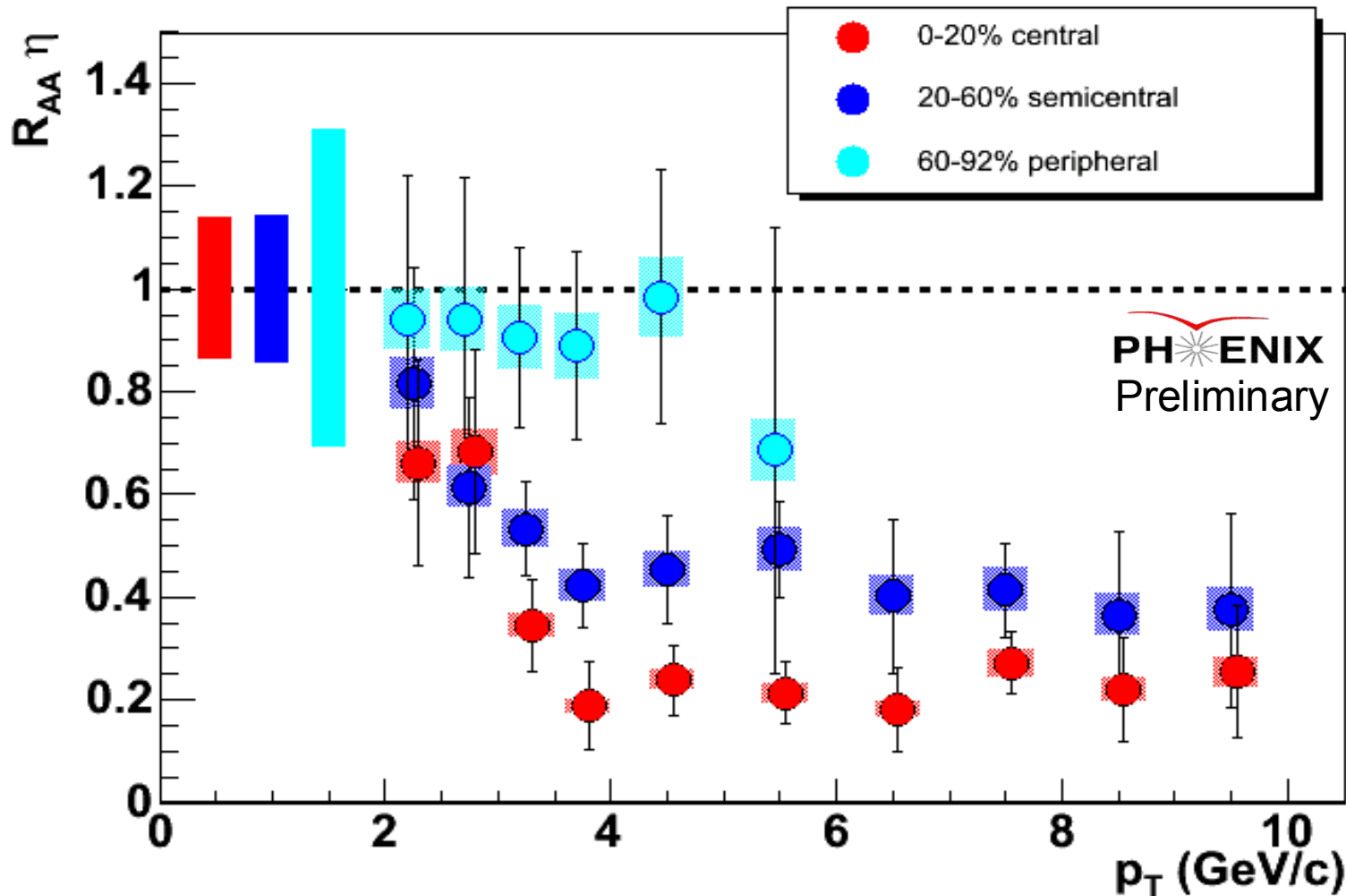


PHENIX
Preliminary

- η production in d+Au follows (within uncertainties) N_{coll} -scaling for all centralities: No significant “Cronin broadening”

High p_T η in “hot QCD matter” (Au+Au)

Au+Au $\rightarrow \eta + X$ @ $\sqrt{s_{NN}} = 200$ GeV



Errors:

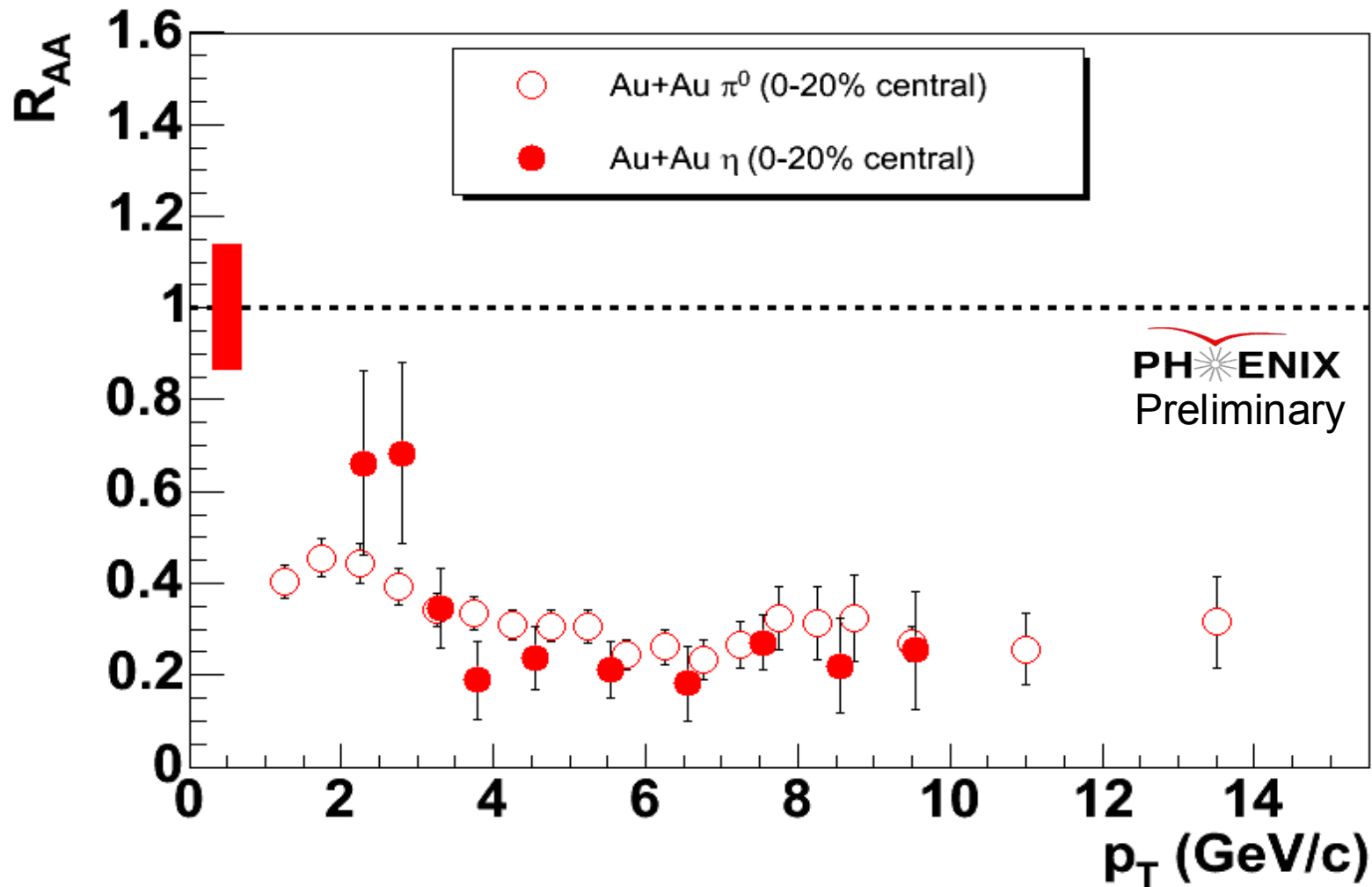
Bands: ~15%
Abs. uncertainties

Boxes: ~8%
 p_T correlated

Bars: 10--35%
Point-to-point

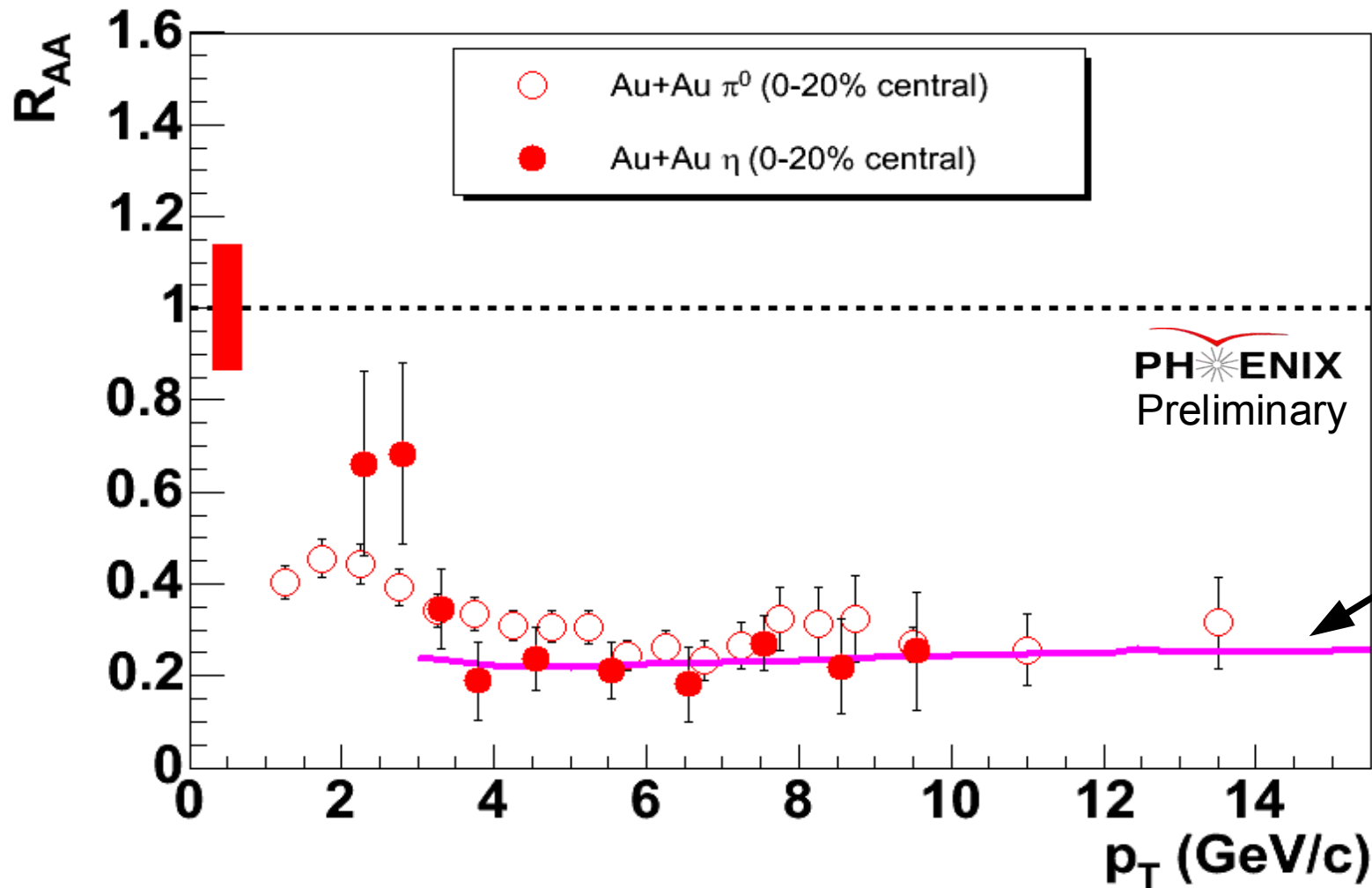
- Au+Au **central**: Strong suppression ($R_{AA} \sim 0.2$)
- Au+Au **semi-central**: Suppression ($R_{AA} \sim 0.4$)
- Au+Au **peripheral**: consistent w/ N_{coll} scaling ($R_{AA} \sim 0.9$)

High p_T meson production: η vs. π^0 (Au+Au central)



- Coincident suppression pattern for π^0 and η :
magnitude, p_T dependence

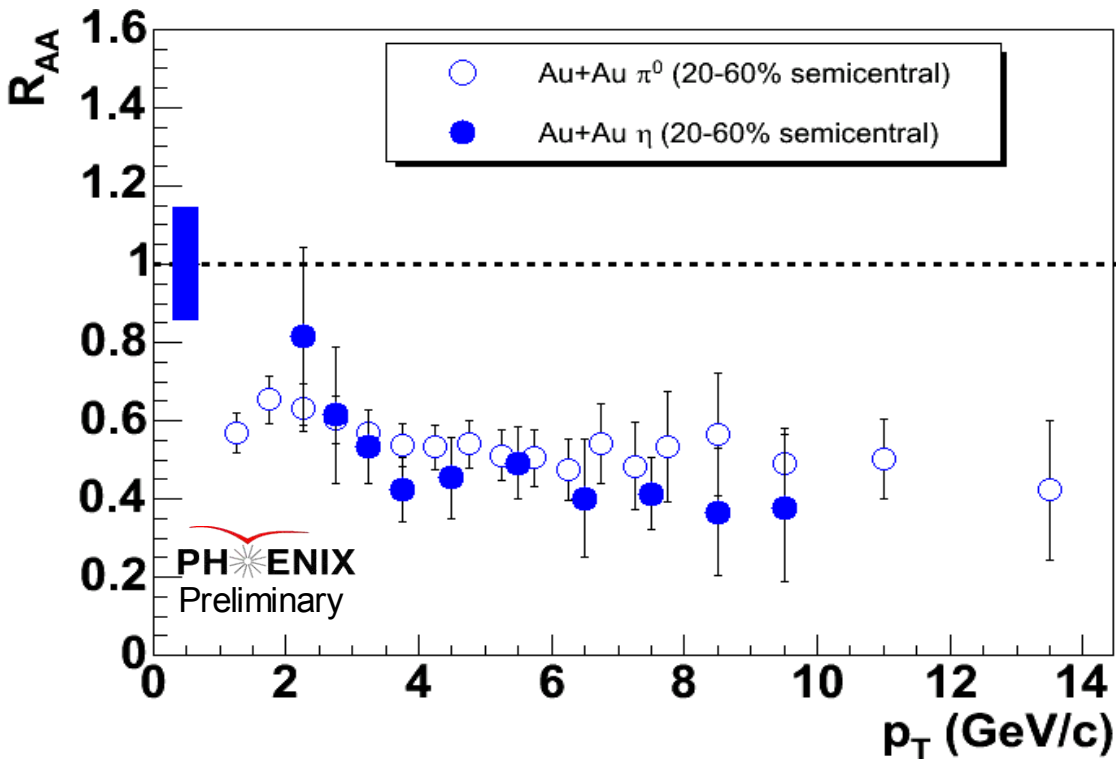
High p_T meson production: η vs. π^0 (Au+Au central)



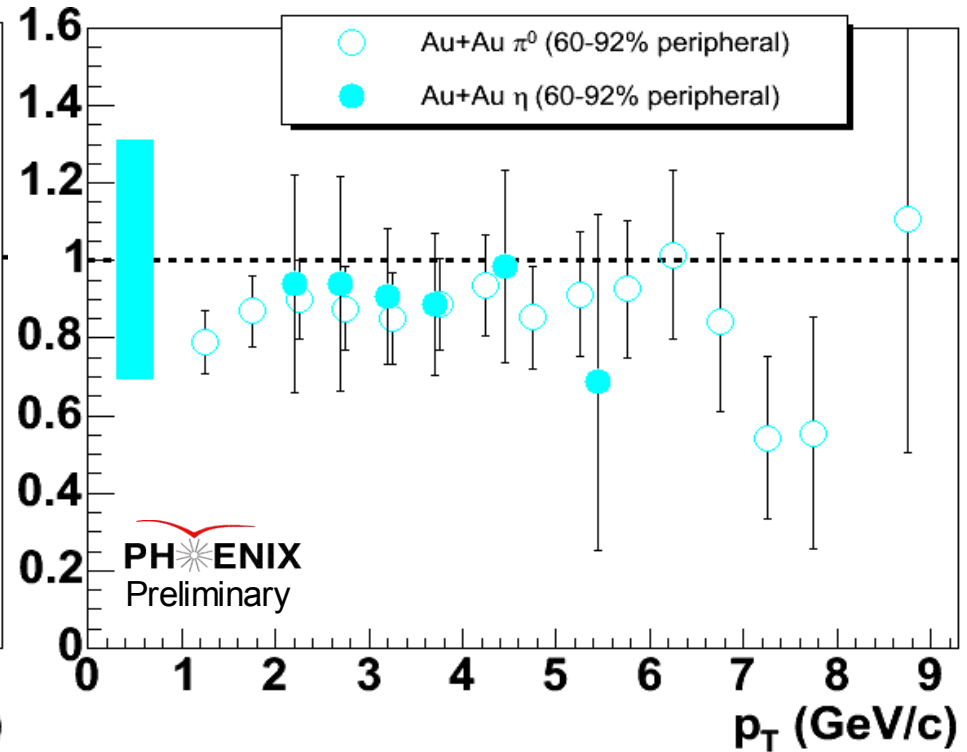
- Coincident suppression pattern for π^0 and η : magnitude, p_T dependence
- Agreement with parton energy loss (GLV) predictions in dense medium (up to the highest p_T values measured so far)

High p_T meson production: η vs. π^0 (other centralities)

Au+Au semicentral (20--60%)



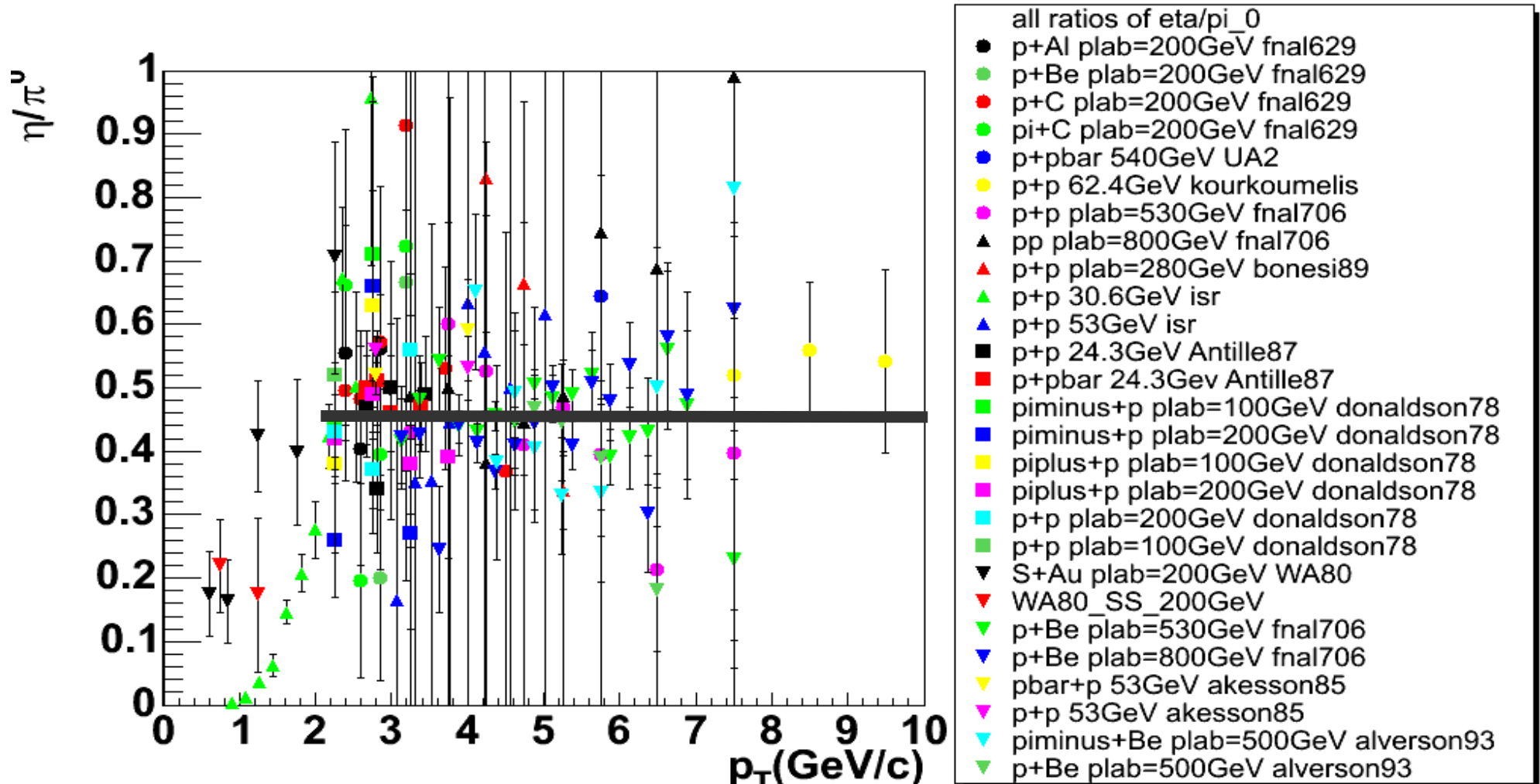
Au+Au peripheral (60--92%)



- Similar suppression pattern for π^0 and η : magnitude, p_T -, centrality- dependence

Perturbative η/π^0 ratio in hadronic collisions (I)

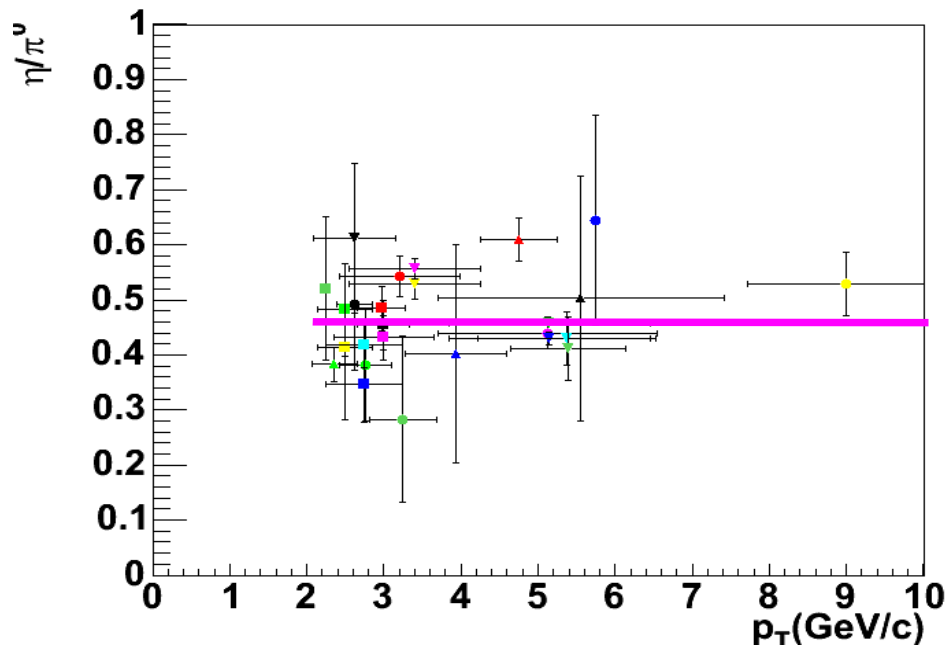
η/π^0 "world systematics" [p+p, p+p, π^\pm +p, p+A, A+A @ $\sqrt{s} \sim 10 - 540$ GeV]



[Systematics by Maïke Kaufman & DdE]

● η/π^0 is approx. constant above $p_T \sim 2$ GeV/c: 0.46 ± 0.03

Perturbative η/π^0 ratio in hadronic collisions (II)

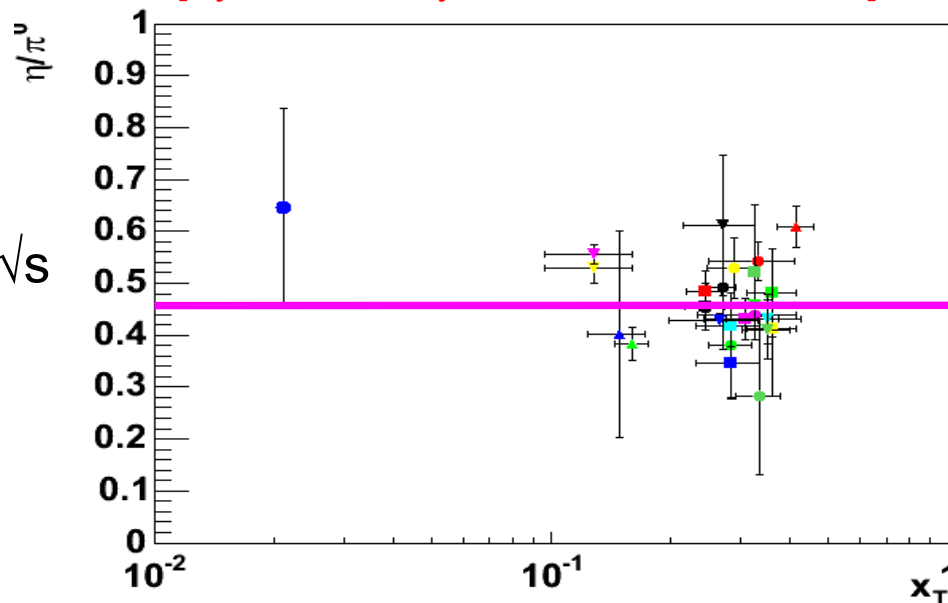


- all ratios of eta/pi_0
- pAl_200GeV_fnal629
- pBe_200GeV_fnal629
- pC_200GeV_fnal629
- piC_200GeV_fnal629
- ppbar_540GeV_UA2
- pp_62.4GeV_kourkoumelis
- pp_530GeV_fnal706
- ▲ pp_800GeV_fnal706
- ▲ pp_280GeV_bonesi89
- ▲ pp_30.6GeV_isr
- ▲ pp_53GeV_isr
- Antille87_pp_24.3GeV
- Antille87_ppbar_24.3GeV
- donaldson78_piminusp_100GeV
- donaldson78_piminusp_200GeV
- donaldson78_piplusp_100GeV
- donaldson78_piplusp_200GeV
- donaldson78_pp_200GeV
- donaldson78_pp_100GeV
- ▼ WA80_SAu_200GeV
- ▼ fnal706_pBe_530GeV
- ▼ fnal706_pBe_800GeV
- ▼ akesson85_pbarp53GeV
- ▼ akesson85_pp_53GeV
- ▼ alverson93_piminusBe_500GeV
- ▼ alverson93_pBe_500GeV

● $\langle \eta/\pi^0 \rangle$ (>2 GeV/c)
as a function of p_T

[Systematics by Maïke Kaufman & DdE]

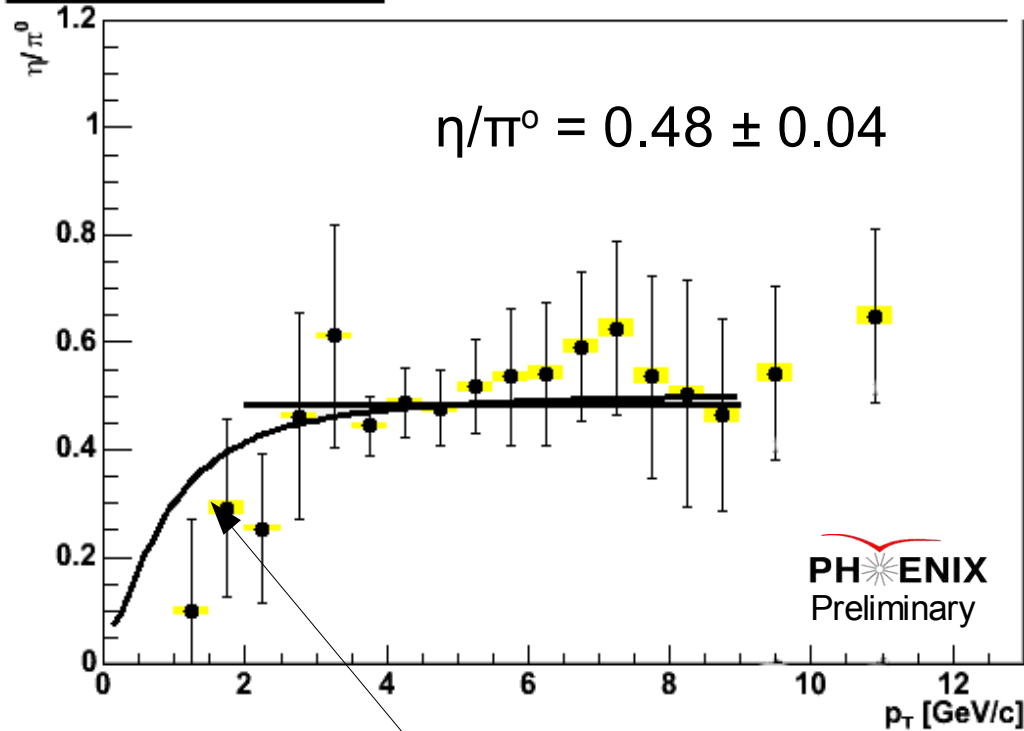
● $\eta/\pi^0 = 0.46 \pm 0.03$
independent of $x_T = 2p_T/\sqrt{s}$
(within uncertainties)



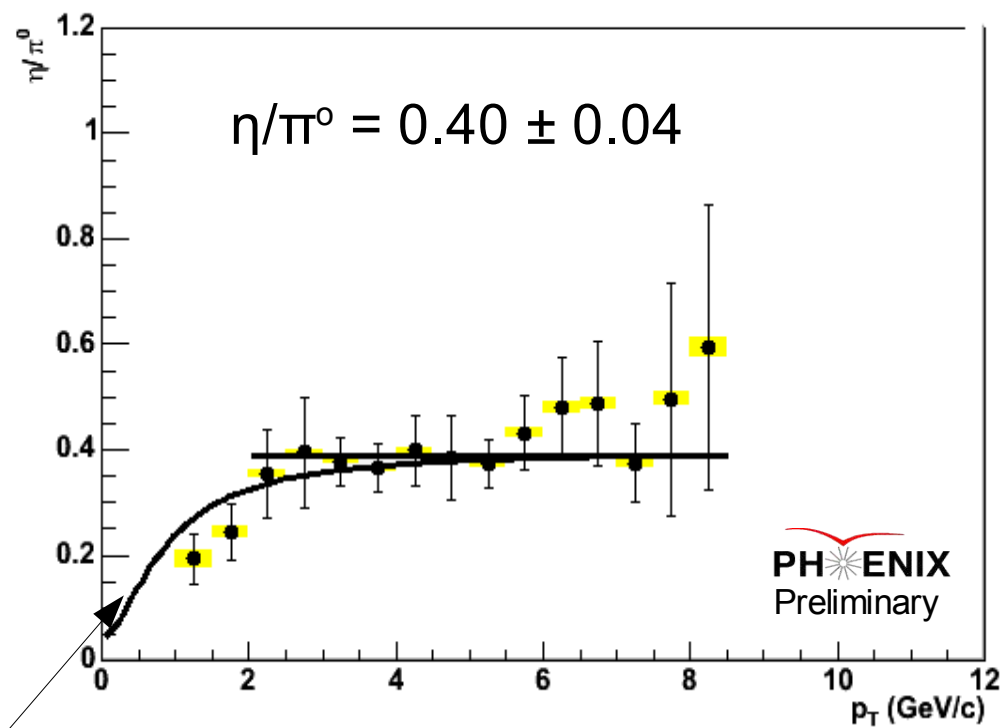
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η/π^0 ratio in p+p and d+Au at RHIC

ratio of η and π^0 in pp



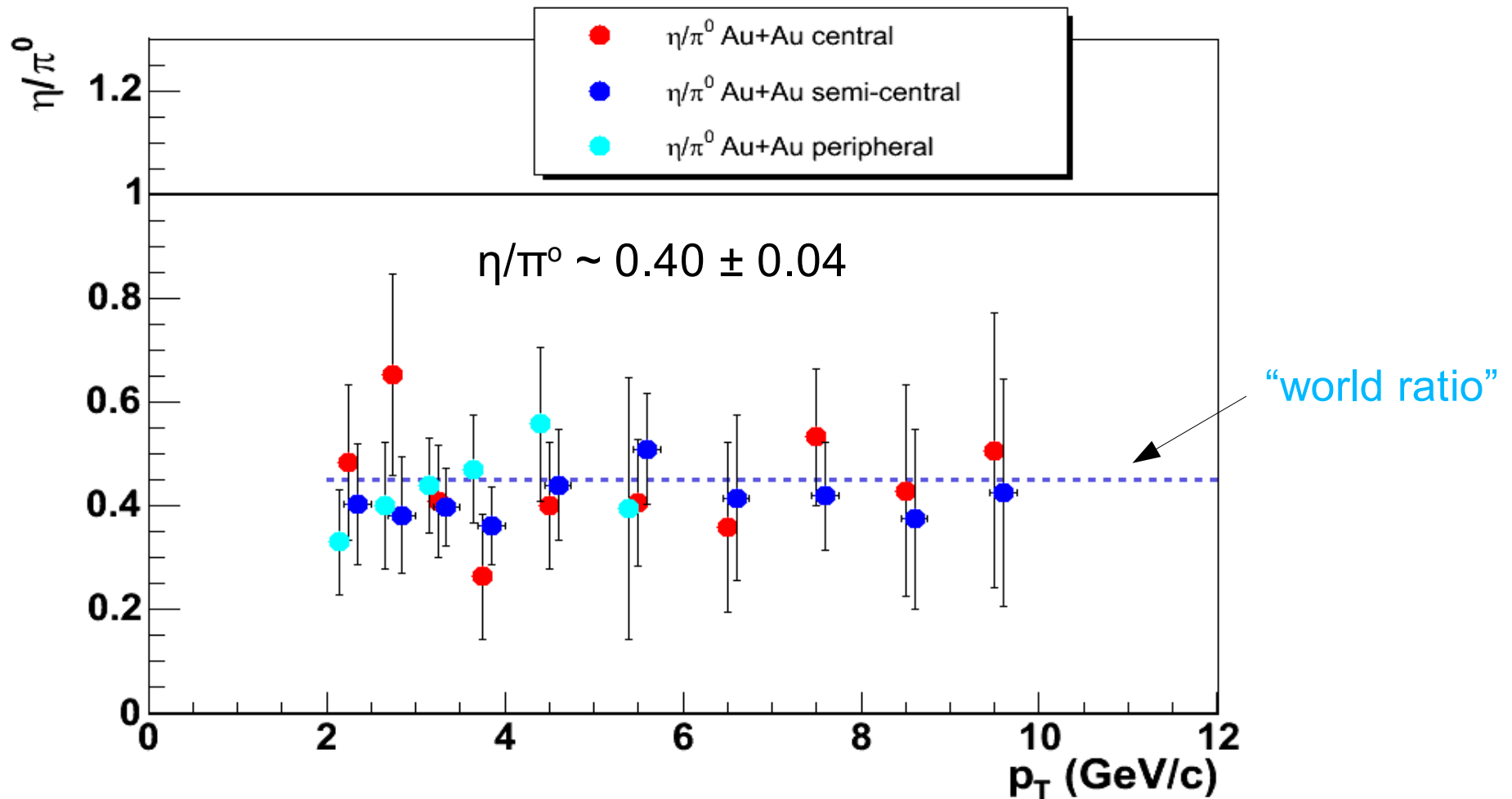
ratio of η and π^0 in d+Au



“ m_T scaling” curve

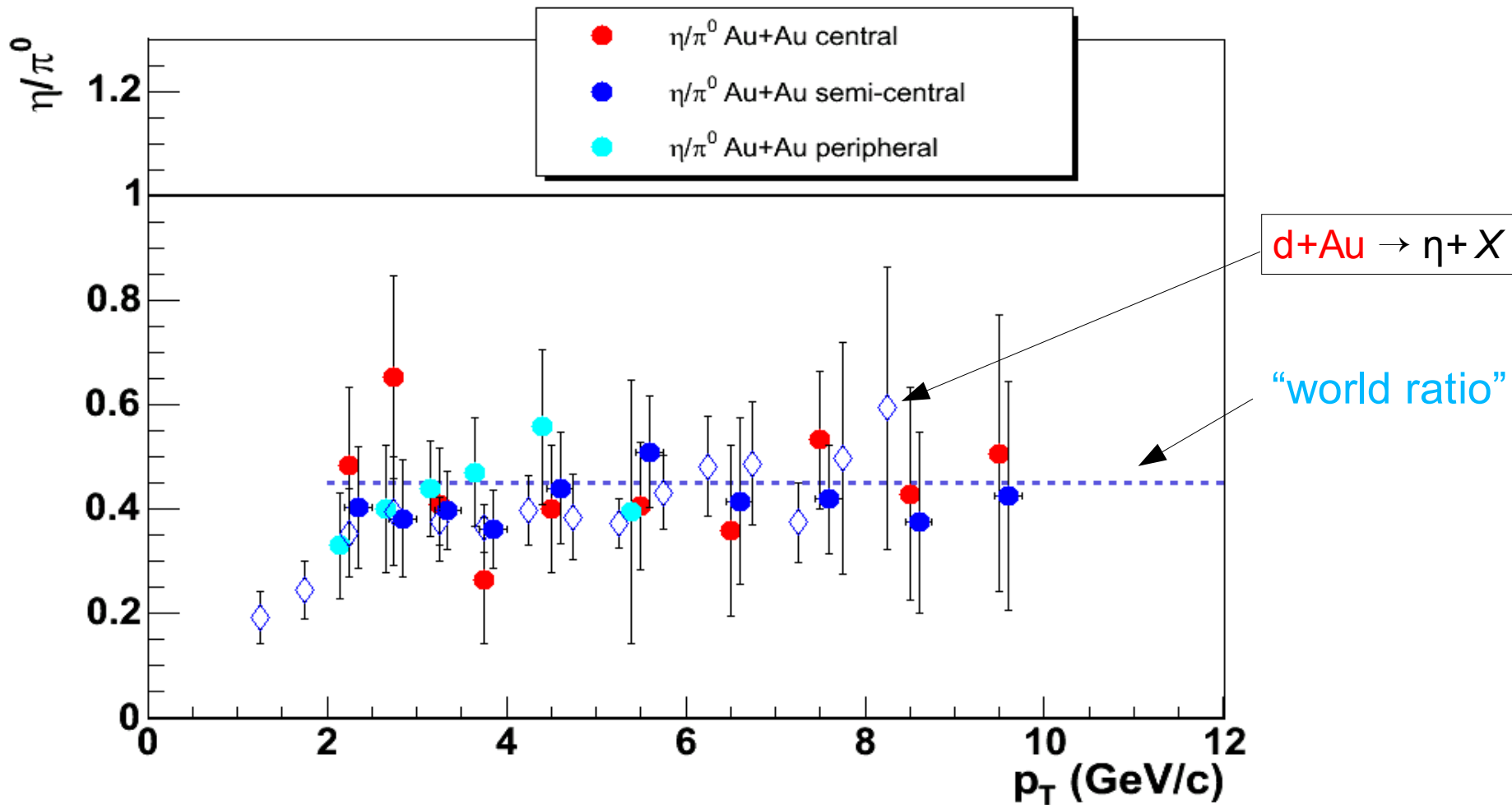
- Approx(*) flat η/π^0 ratio above $p_T = 2$ GeV/c. (*) Slow rise with p_T probable.
- η/π^0 ratio at RHIC consistent with “world average”.
- “ m_T scaling” does not seem to provide an excellent reproduction of spectral ratio for $p_T < 2$ GeV/c ...

Perturbative η/π^0 ratio in Au+Au at RHIC



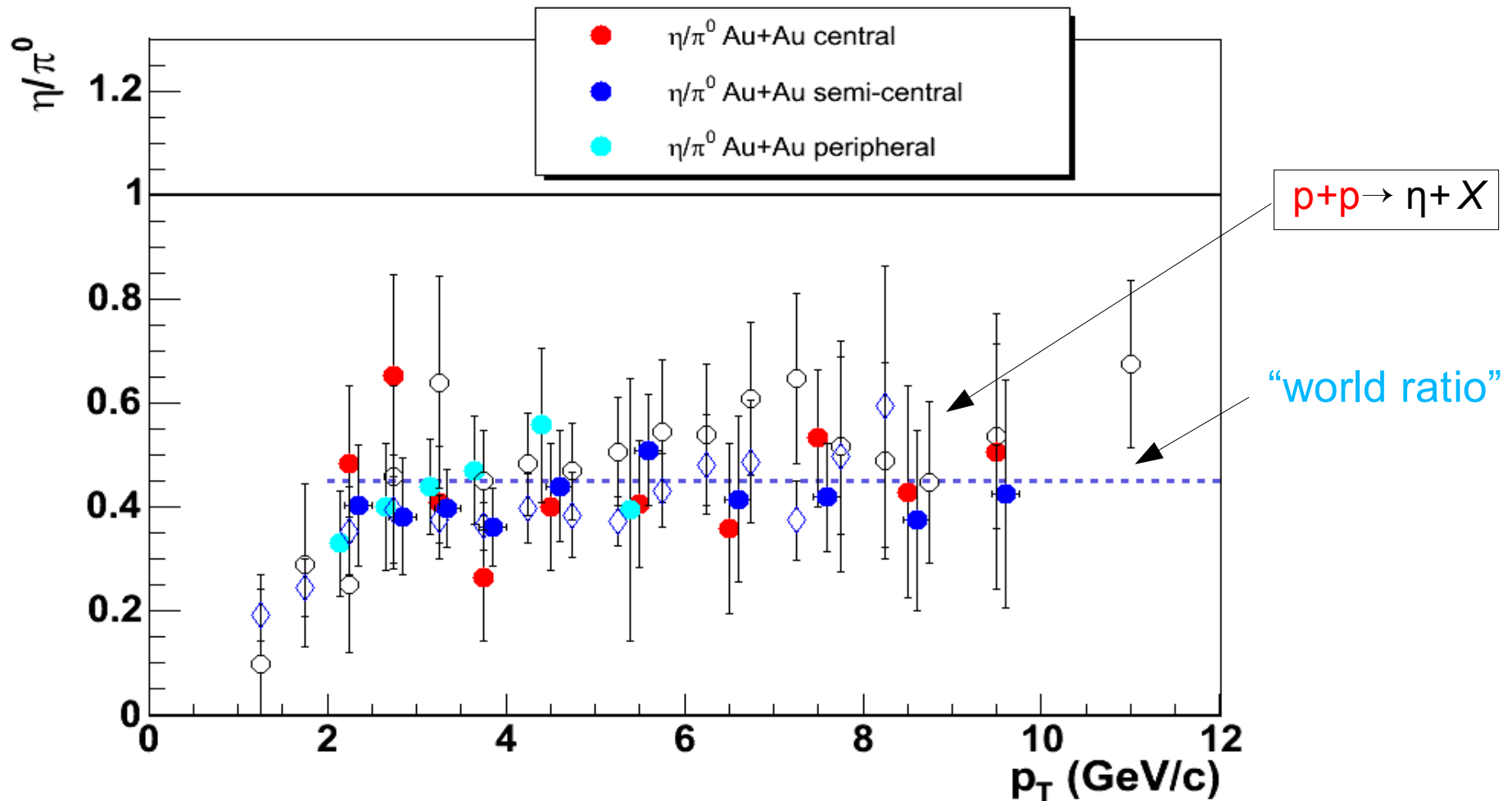
- Flat η/π^0 ratio versus p_T . No apparent centrality dependence.
- η/π^0 ratio in Au+Au consistent with "world average".

Perturbative η/π^0 ratio in Au+Au, d+Au, p+p at RHIC



- No apparent **system-size** dependence:
 η/π^0 ratio in Au+Au, d+Au **consistent with "world average"**

Perturbative η/π^0 ratio in Au+Au, d+Au, p+p at RHIC



- No apparent **collision system** dependence: η/π^0 ratio in Au+Au, d+Au, p+p **consistent with "world average"**.
- **Hot/dense QCD medium** suppresses meson yields at high p_T but preserves "universality" (PID-wise) of fragmentation function.

Summary

- High p_T η measured in the range $p_T \approx 2-12$ GeV/c in p+p, d+Au, and Au+Au collisions at $\sqrt{s} = 200$ GeV.
- p+p:
 - $\eta/\pi^0 \sim 0.48$ consistent with 0.46 “world ratio” in hadronic colls.
 - “ m_T scaling” hypothesis **not excellent** for eta's below ~ 2 GeV/c
- d+Au:
 - No (or small) “**Cronin effect**” ($R_{dA} \sim 1$ for all centralities within uncertainties).
- Au+Au:
 - Factor **x5 suppression** in central (0-20%) colls.
 - **Same suppression pattern** for η and π^0 : magnitude, p_T and centrality dependence.
 - Agreement w/ **parton energy loss calculations** up to highest p_T
 - η/π^0 consistent w/ 0.46 “world ratio” (**PID universality of FF** preserved in QCD medium).

Backup slides