

Interesting Theory @ Quark Matter '04

From M. Lisa, "What have we learned?

A warning from the king of dour...

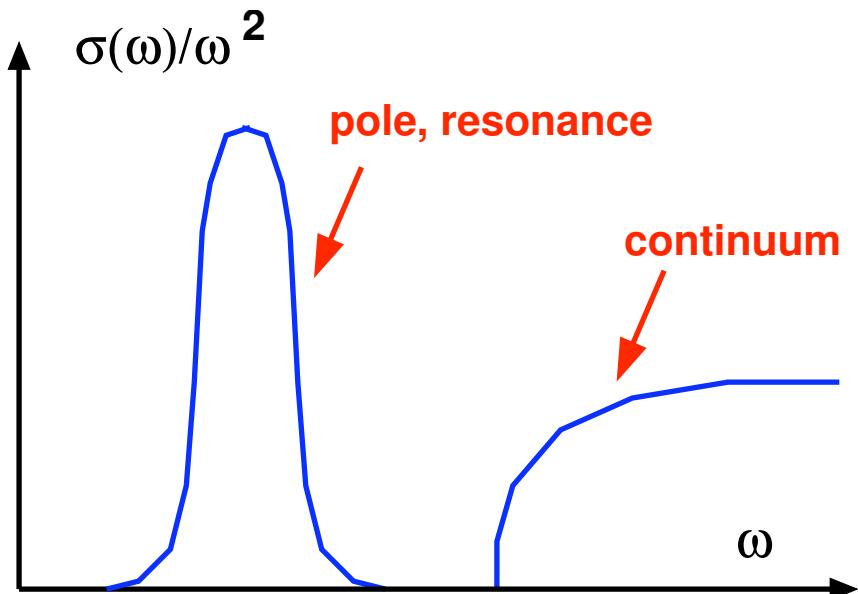
"[In a system] where the pieces have different and bizarre motions, with various and variable values, what is only complex is mistaken (a not unusual error) for what is profound."

Edgar Allan Poe, in *Murders in the Rue Morgue* (1841)
discussing chess enthusiasts



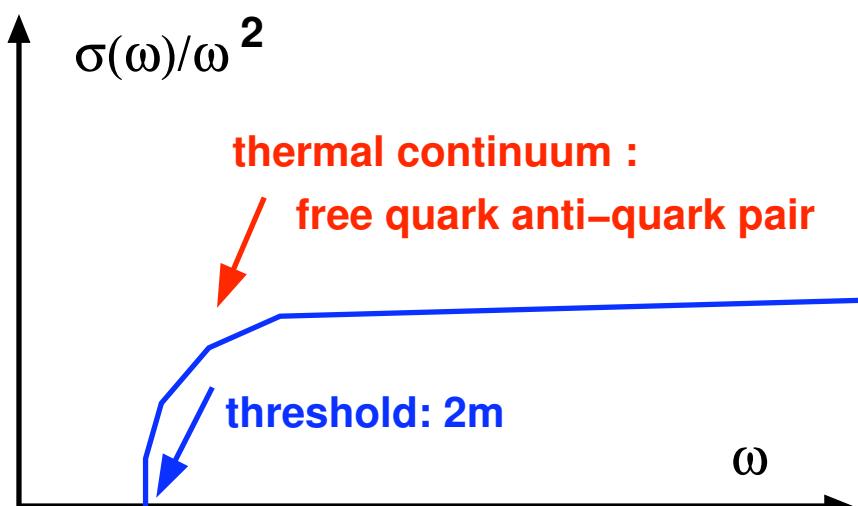
Karsch: Lattice can give us spectral densities.

Maximum Entropy Method:



vector meson spectral function ($T = 0$):

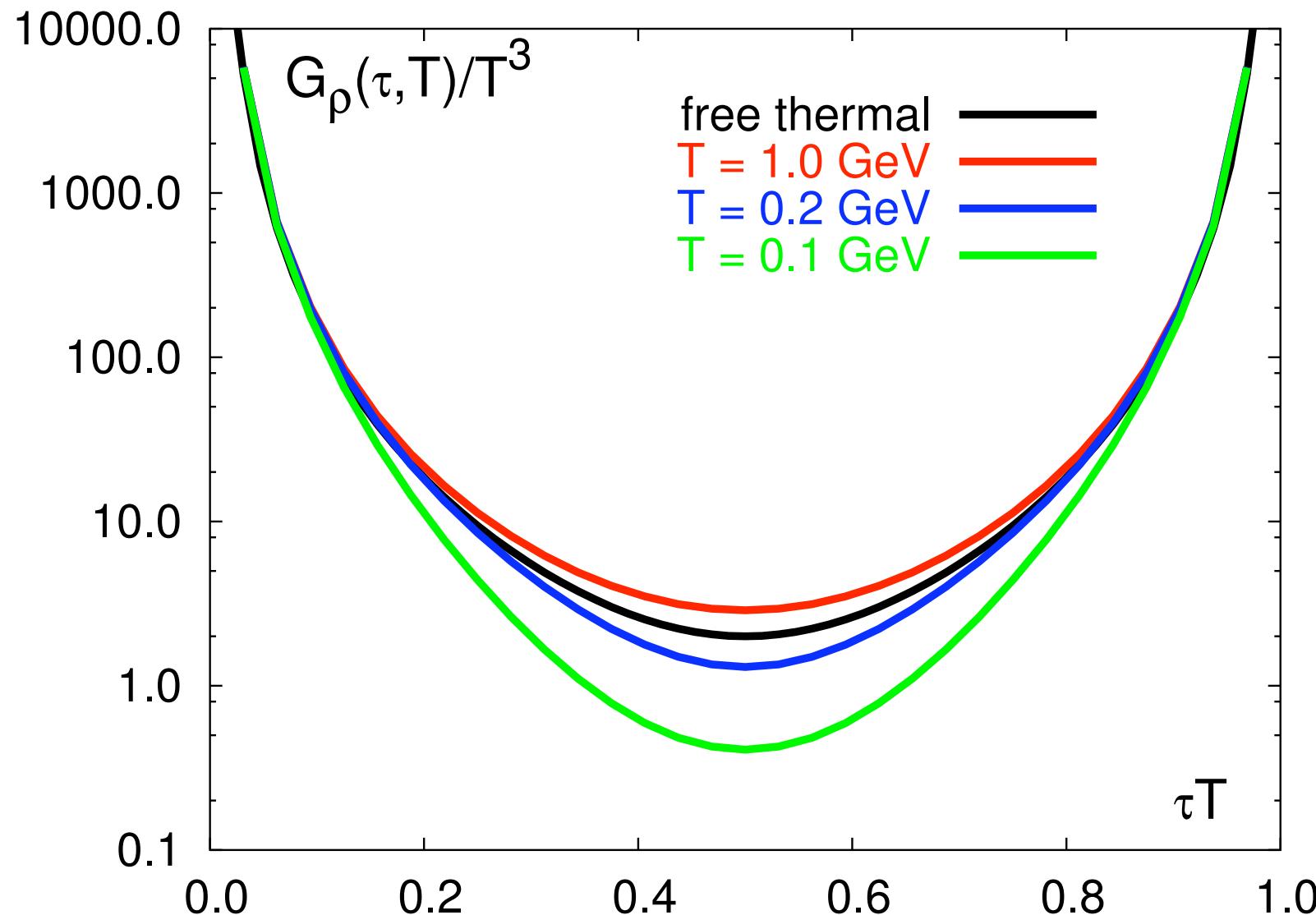
$$\begin{aligned}\sigma_\rho(\omega, \vec{0}) = & \frac{2\omega^2}{\pi} \left[F_\rho^2 \frac{\Gamma_\rho m_\rho}{(\omega^2 - m_\rho^2)^2 + \Gamma_\rho^2 m_\rho^2} \right. \\ & \left. + \frac{1}{8\pi} \left(1 + \frac{\alpha_s}{\pi} \right) \frac{1}{1 + \exp((\omega_0 - \omega)/\delta)} \right]\end{aligned}$$



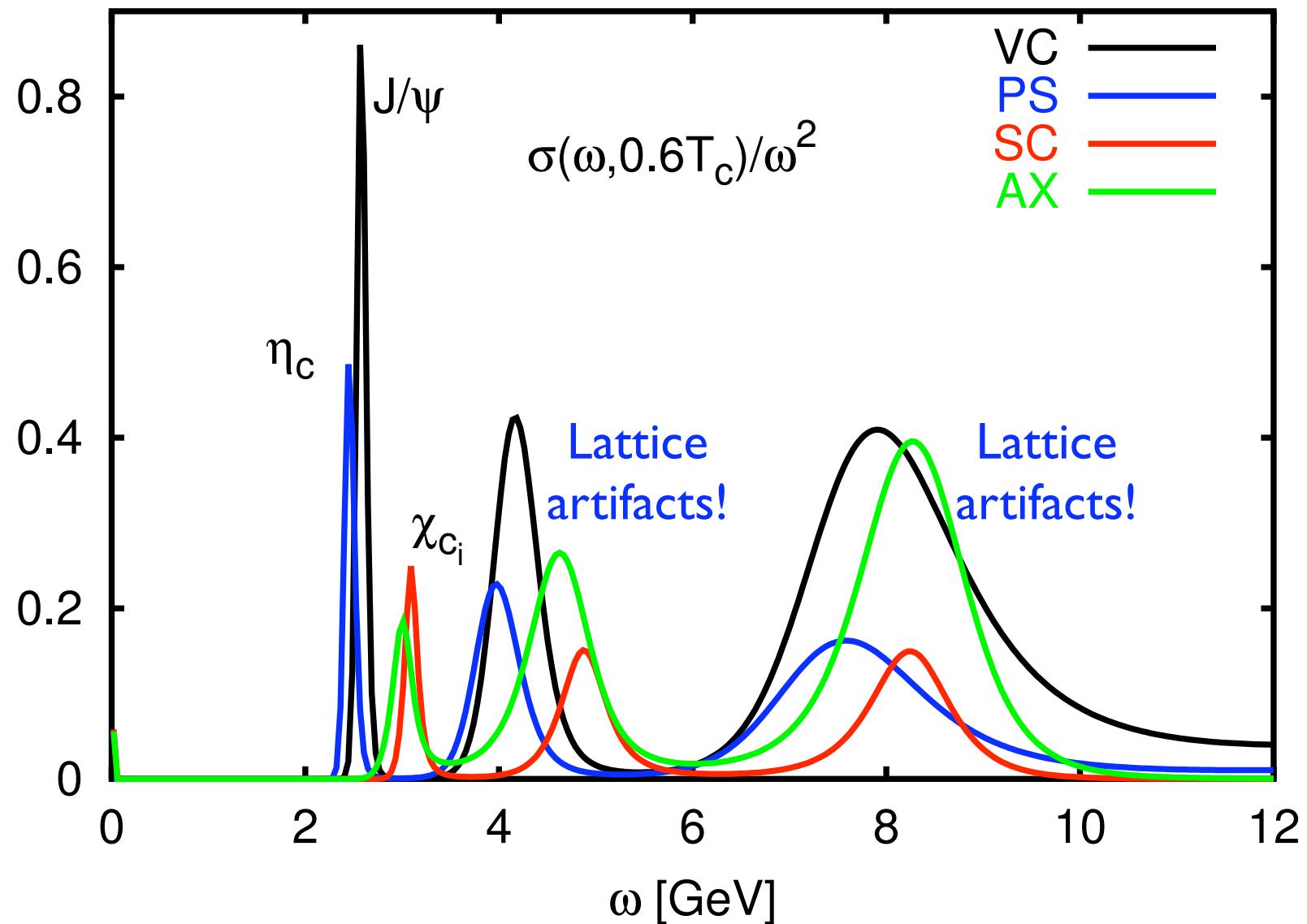
free vector meson spectral function ($T = \infty$):

$$\begin{aligned}\sigma_V(\omega, T) = & \frac{N_c}{8\pi^2} \omega^2 \Theta(\omega^2 - 4m^2) \tanh\left(\frac{\omega}{4T}\right) \\ & \cdot \sqrt{1 - \left(\frac{2m}{\omega}\right)^2} \left[2 + \left(\frac{2m}{\omega}\right)^2 \right]\end{aligned}$$

Or, how to get something from “nothing”

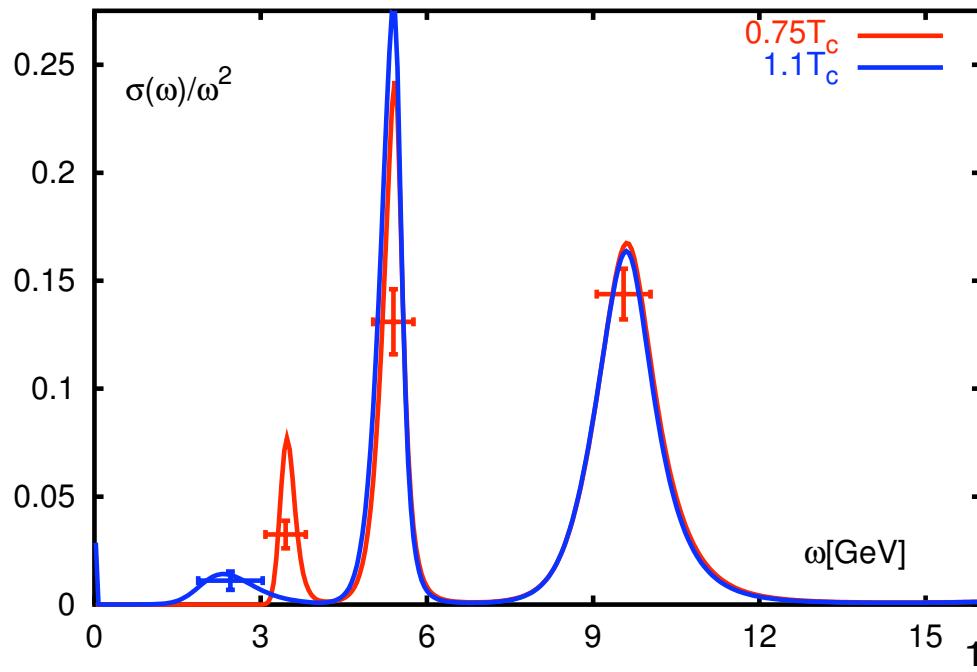


Lattice spectral densities for J/Psi: T=.6 Tc ≈ T=0



Lattice: eta_c melts easily, J/Psi doesn't

scalar spectral functions



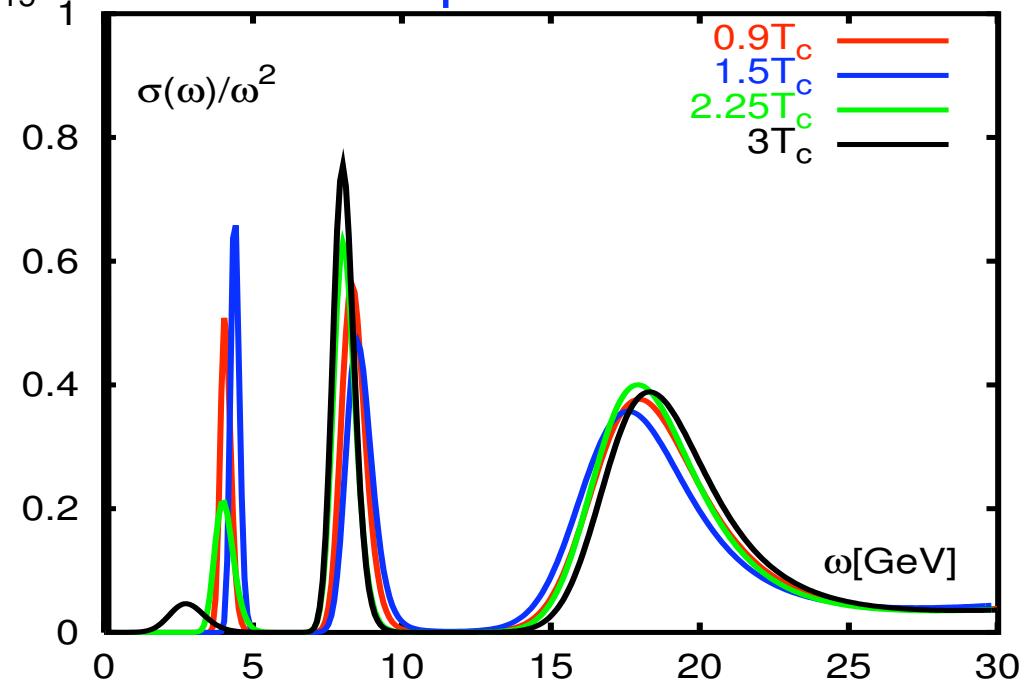
\leq : Charmed eta melts *right* above T_c

\Rightarrow : J/Psi persists well above T_c , to perhaps $3T_c$.

Work in quenched approx.

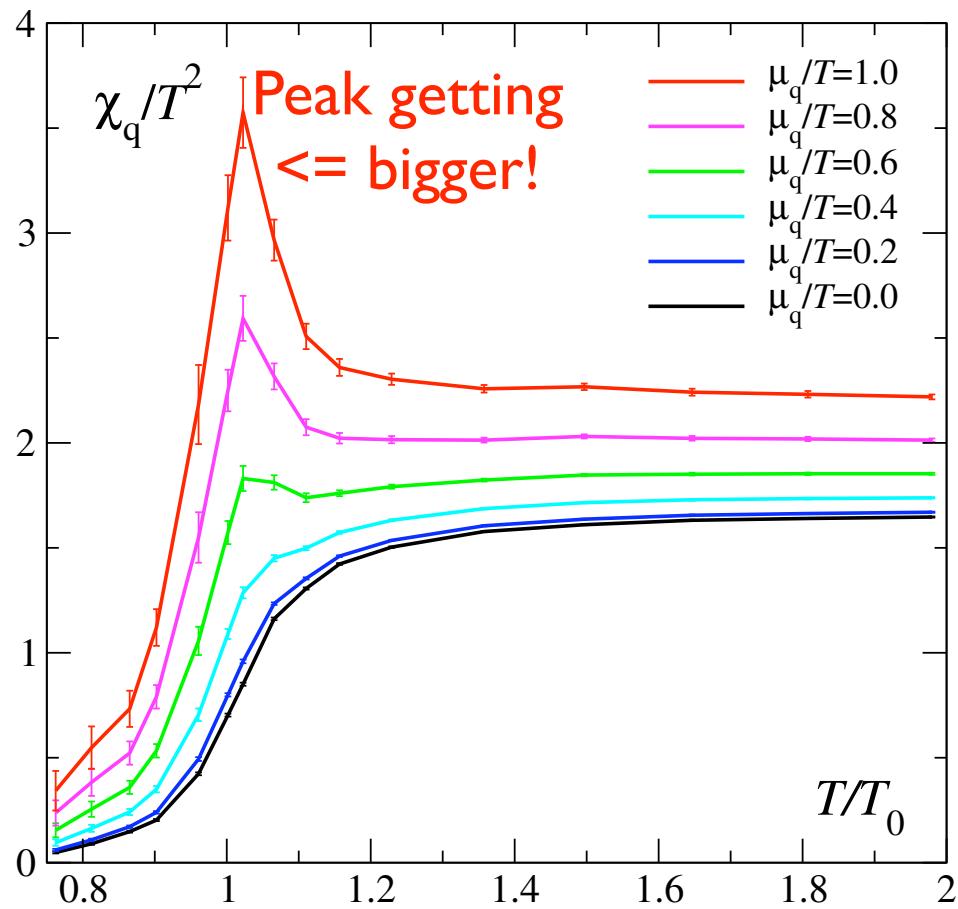
Indicates: *NON-pert.* regime from $T_c \Rightarrow 3T_c$.

vector spectral functions



Karsch, $\mu \neq 0$: baryon fluctuations grow with μ

baryon number density fluctuations:
 (Bielefeld-Swansea, PRD68 (2003) 014507)



$$\frac{\chi_B}{T^2} = \left(\frac{d^2}{d(\mu/T)^2} \frac{p}{T^4} \right)_{T \text{ fixed}}$$

high-T, massless limit: polynomial in (μ/T)

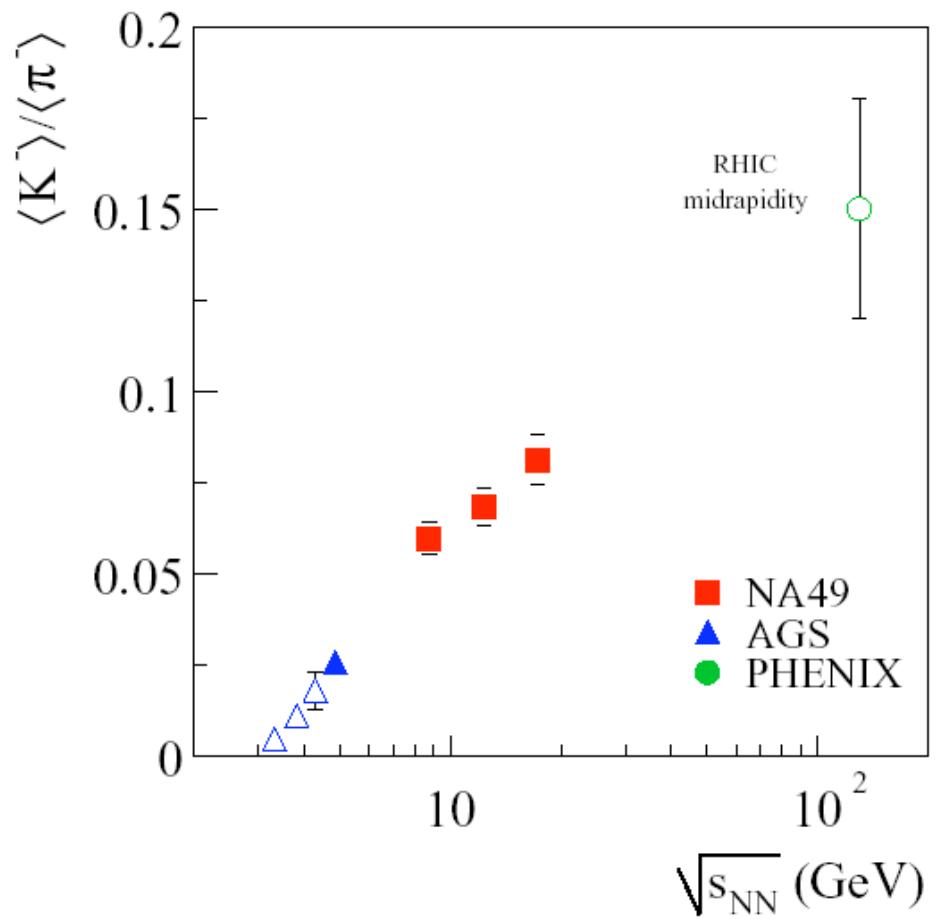
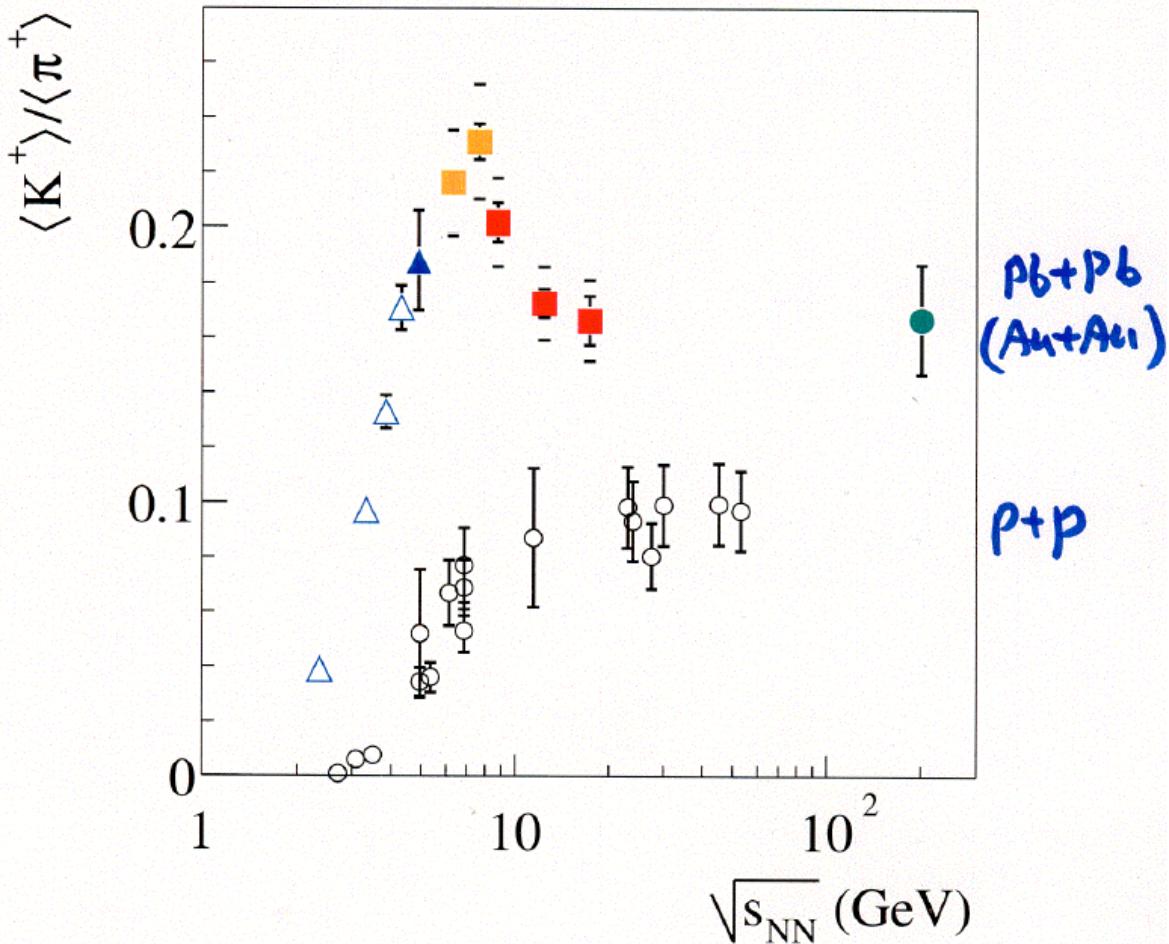
$$\frac{\chi_{B,SB}}{T^2} = n_f + \frac{3n_f}{\pi^2} \left(\frac{\mu}{T} \right)^2$$

large density fluctuations closer to
 the chiral critical point

$$\frac{\chi_q}{T^2} \sim \frac{1}{V} \left(\langle N_q^2 \rangle - \langle N_q \rangle^2 \right)$$

Taylor expansion up to $\mathcal{O}(\mu^4)$
 new: improved statistics, $\mathcal{O}(\mu^6)$
 poster by S. Ejiri

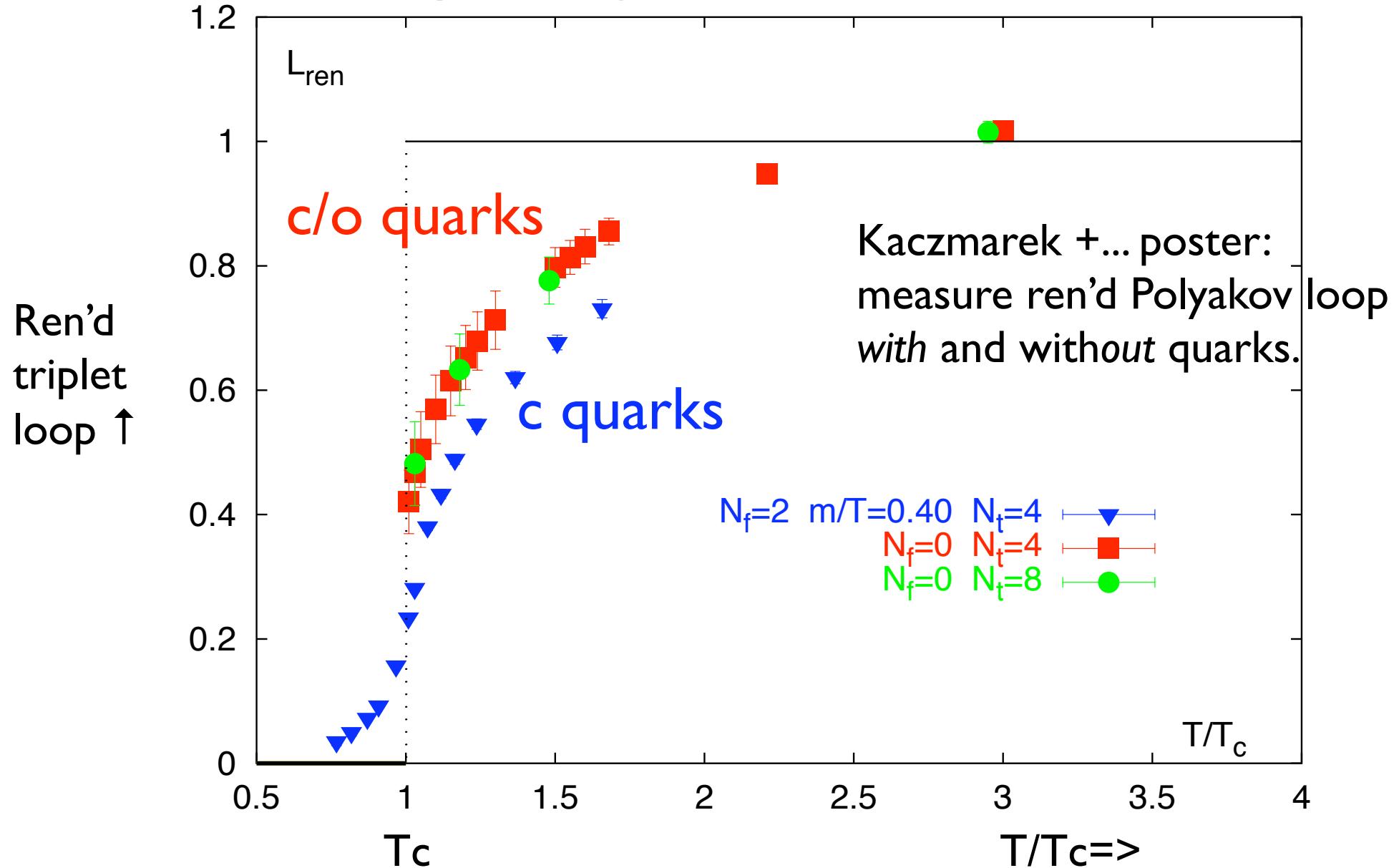
Is this related to the *narrow* peak in K^+/π^+ @ SPS? The “MatterHorn” of NA49 (Gazdzicki)



Peak not confirmed by other groups, not seen in other ratios...

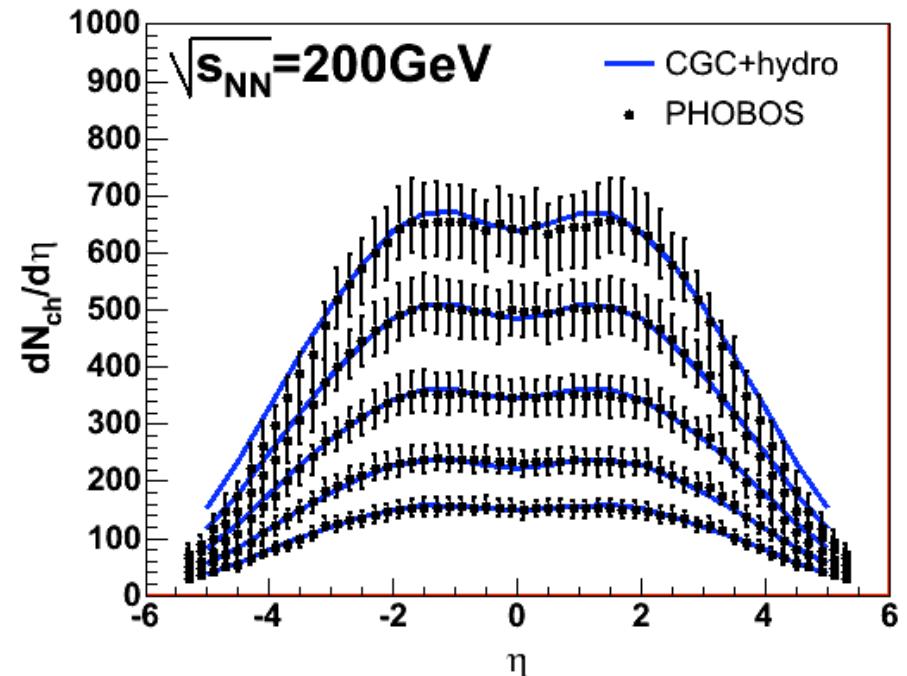
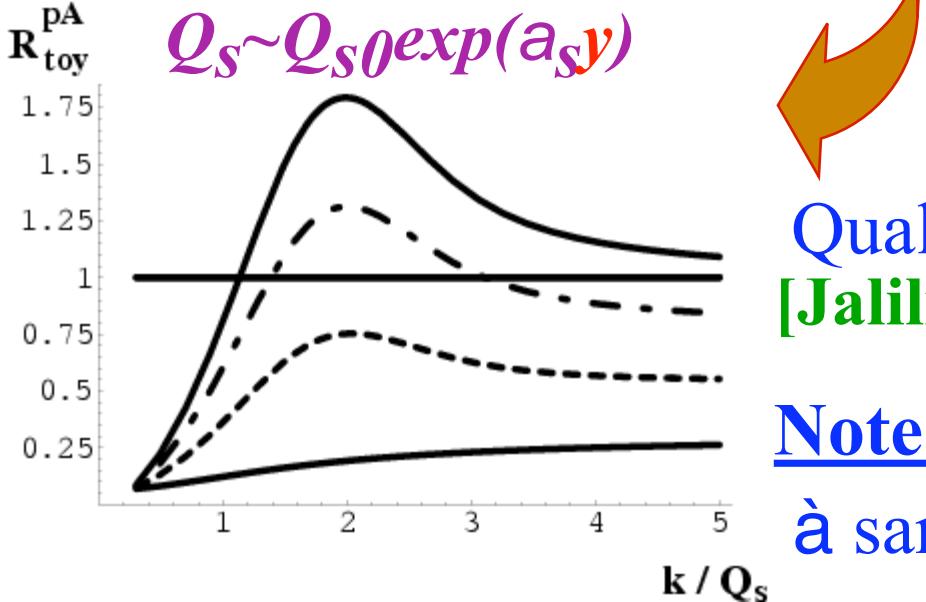
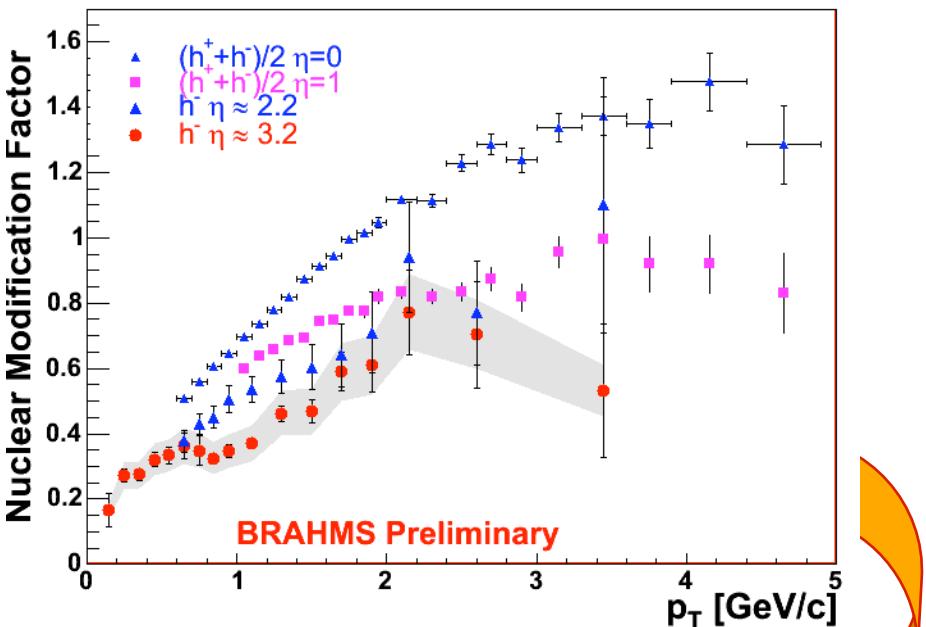
Bielefeld-Polyakov loop with quarks≈same as without!

Polyakov loop = 1 in pert thy => evidence for pert. regime above $3T_c$, NON-pert regime for $T_c \geq 3 T_c$.



3.1 Pre-Equilibrium: Color Glass Condensate?

Look forward in d-Au



initial cond. in 3+1 hydro
[Hirano,Nara]

Qualitatively consistent with CGC
[Jalilian-Marian,Venugopalan,Kovchegov]

Note: valence-quark dominance ($h^+/h^- > 1$)
à same suppression? rapidity energy loss?

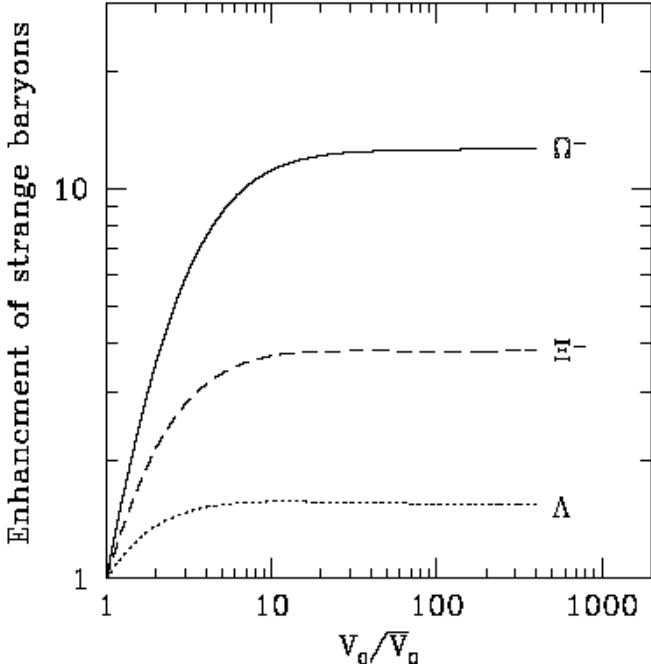
Above: from Rapp theory summary

Jalilian-Marian: (& Dumitru): frag. region in dA the place to test the Color Glass (not a condensate)

- Assume saturation works for $x \leq x_0$ [$x_0 \sim 10^{-2} \rightarrow Q_s(x_0) \sim 1.6$ GeV]
 - For $x \sim x_0$: classical approximation (MV model)
 - Suppression (enhancement) at $p_t < (>) Q_s$
- Forward: $y = 0 \rightarrow 2 \rightarrow 4$
 - $x \sim 10^{-2} \rightarrow 10^{-3} \rightarrow 10^{-4} \ll x_0$ ($p_t \sim 2$ GeV)
 - **Quantum evolution becomes essential**
 - $Q_s(y_0) = 1.6$ GeV $\rightarrow Q_s(y=4) = 2.6$ GeV
 - $Q_{es}(y_0) = 1.6$ GeV $\rightarrow Q_{es}(y=4) = 4.2$ GeV
 - Suppression at $p_t < Q_{es}$
 - **Centrality**
 - Reduced correlations (2 \rightarrow 1 processes are dominant)
- Forward rapidity: CGC and CQF regions open up

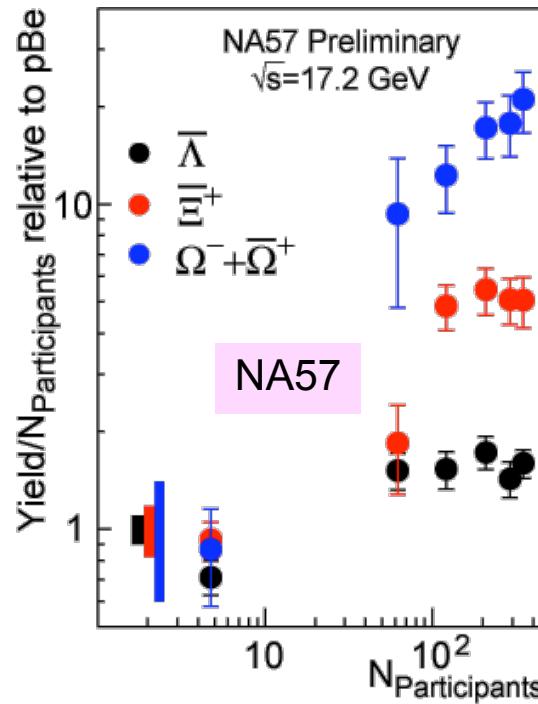
Lisa: Strangeness prod. *not* flat in # participants!

What theory says

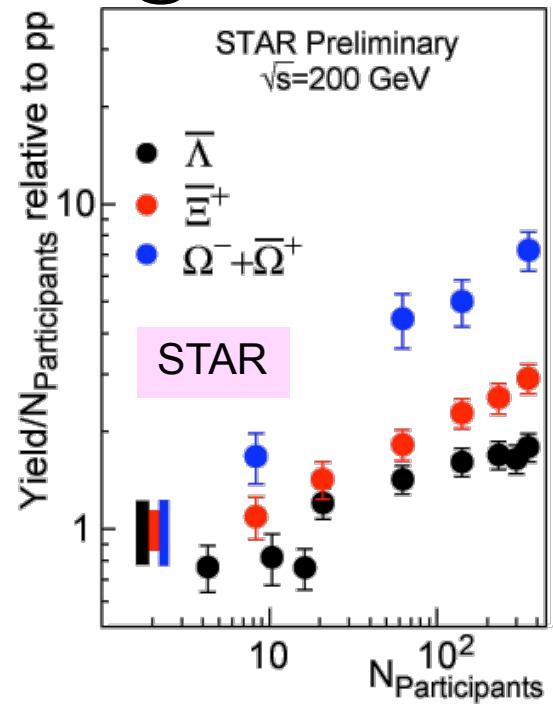


Hamieh, Redlich, Tounsi
PLB486 61 (2000)

Not for Omega's
at SPS



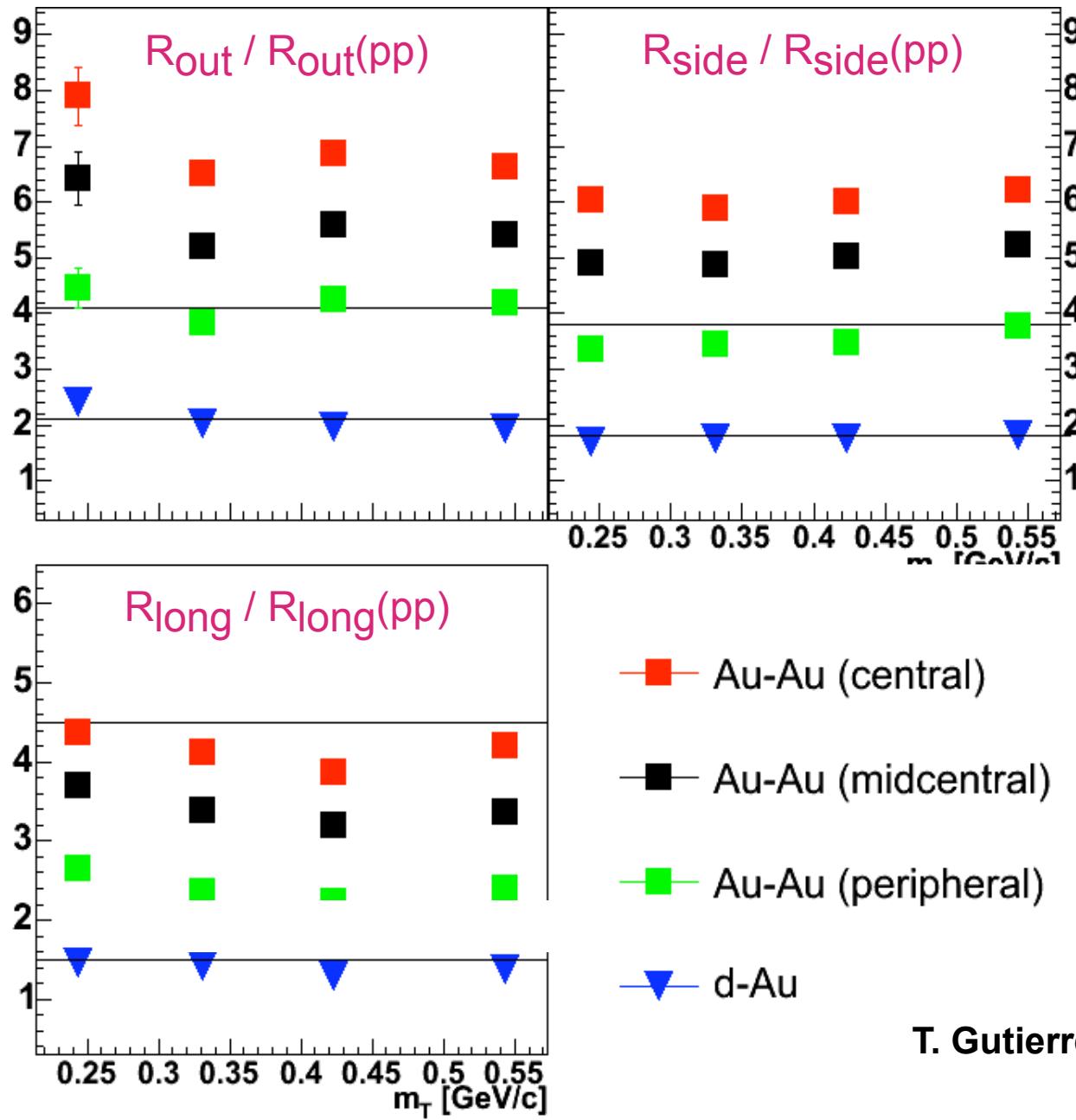
Or anything
@ RHIC



1. it saturates, but just at the very end
2. it equilibrates, but in addition, we have contributions from hard processes?

Do we understand our **reference** systematics (centrality)?

HBT: SAME for pp, dA,AA! (Lisa)



Up to overall scale, HBT look the same
everywhere: ratios, kT dependence!

T. Gutierrez for STAR Coll, poster

5. Summary

Hydrodynamics is one of the valuable tools at RHIC energies

- Open our mind !
Hydrodynamics can be used even for "high p_T physics in HIC".

- Jet tomography
- EM probe
- (J/Y suppression)

...

- Keep in mind !
How robust is the current agreement of hydro?:
 - Chemical non-eq.?
 - Initial fluctuation?
 - Viscosity?
 - Thermalization?
 - EoS?
 - (Freeze-out?)

Tetsufumi Hirano (RBRC)

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T. Hirano, Plenary talk on Hydro: no mention of HBT

3.5 HBT “Puzzle”

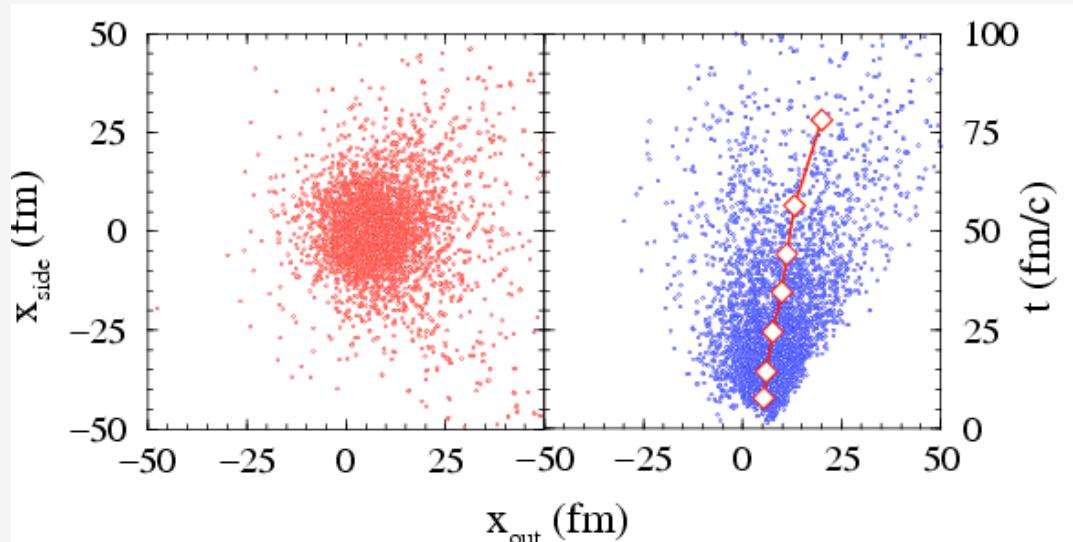
Hydro/Transport models overpredict

$$(R_{out})^2 = D(x_{out}, x_{out}) - 2D(x_{out}, b_t t) + D(b_t t, b_t t)$$

Potential Remedies:

- [Teaney]: viscosity in hydro
- [Kapusta,Wong]: incl. quant. phases in rescatt. \leftrightarrow *initial* size?!

→
Multiphase
Transport
Model
[Lin+Ko]

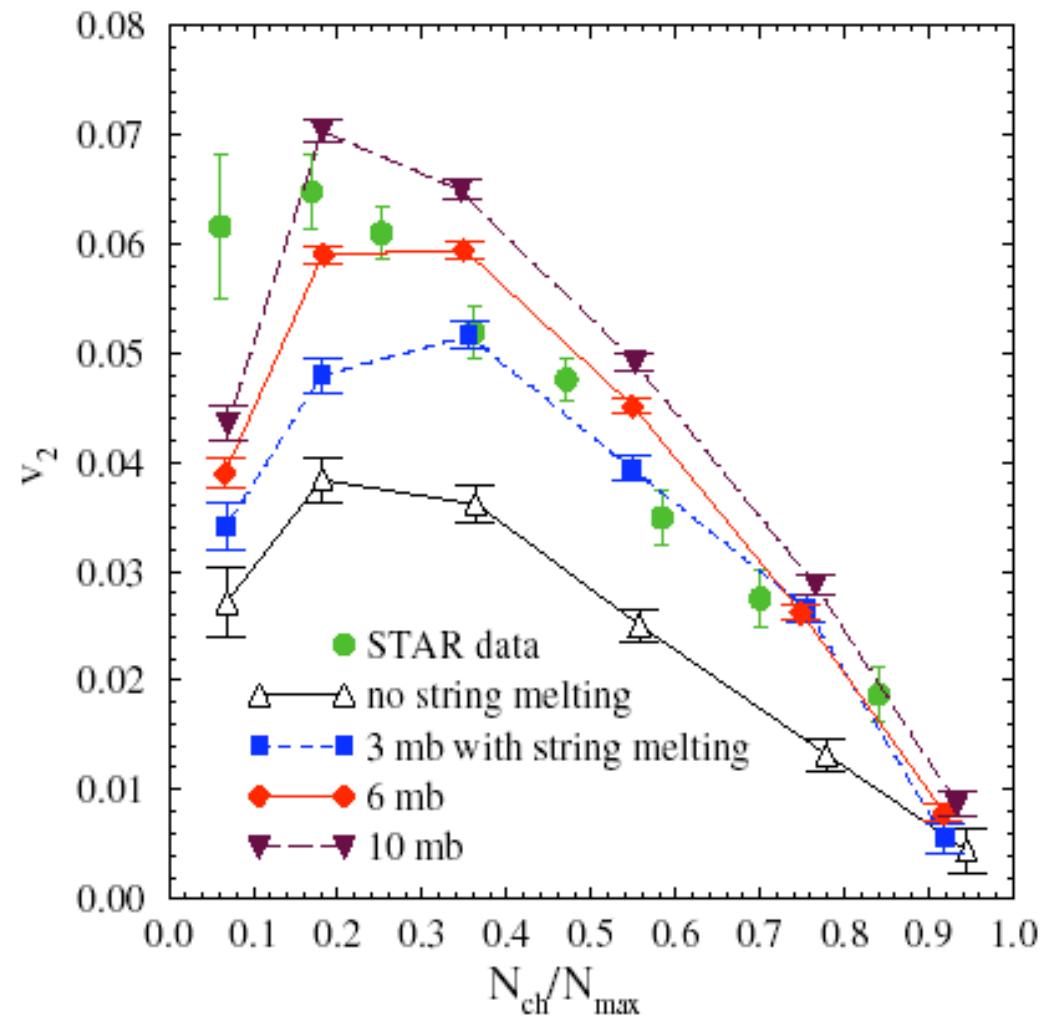


positive $R_{out} - t$
correlation
(not in Hydro,
UrQMD ...)

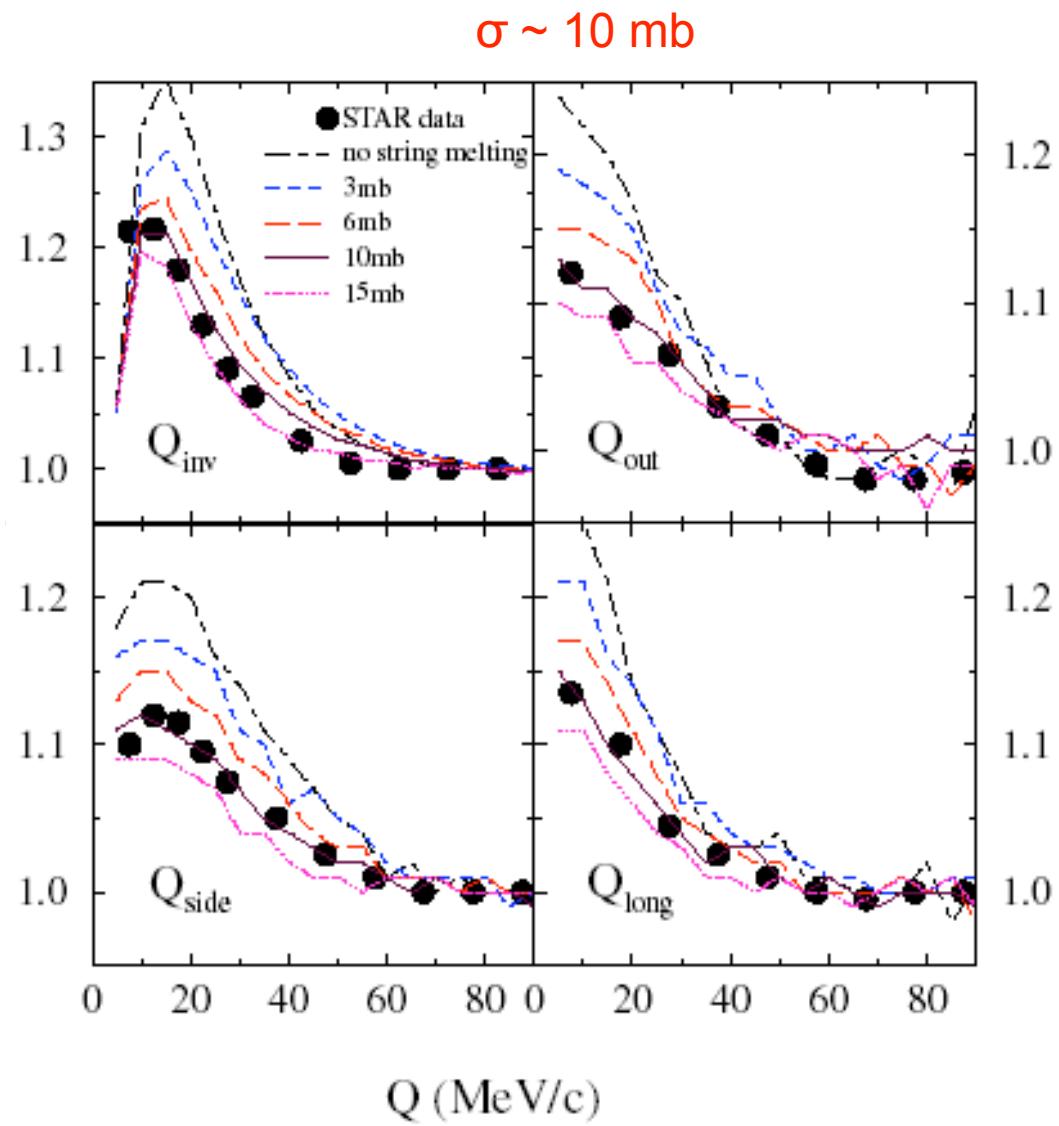
From Rapp, theory summary. AMPT “solves” HBT!

Lisa:AMPT gets HBT right! (v2?)

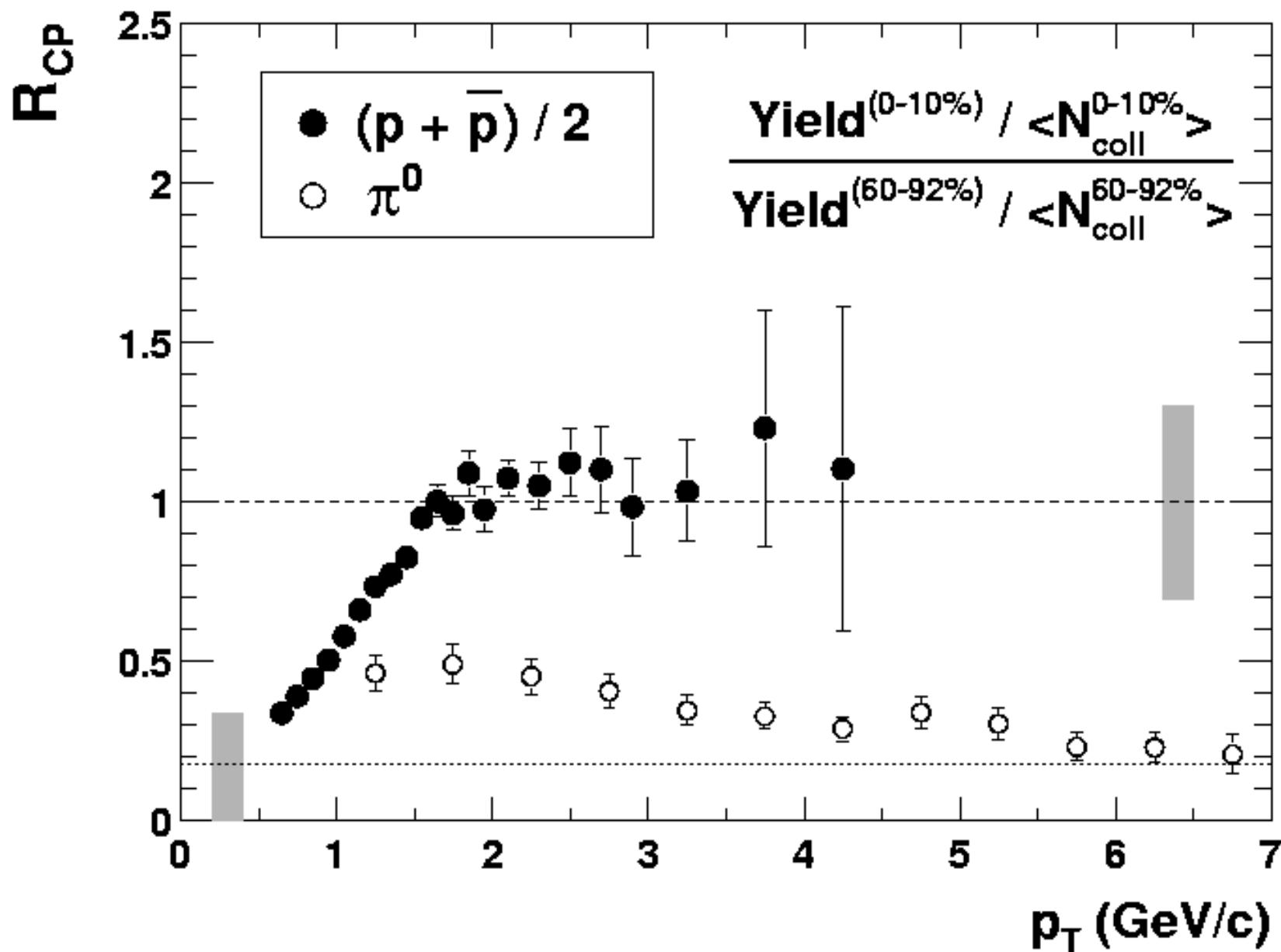
$\sigma < 6 \text{ mb} (\sim 3 \text{ mb?})$



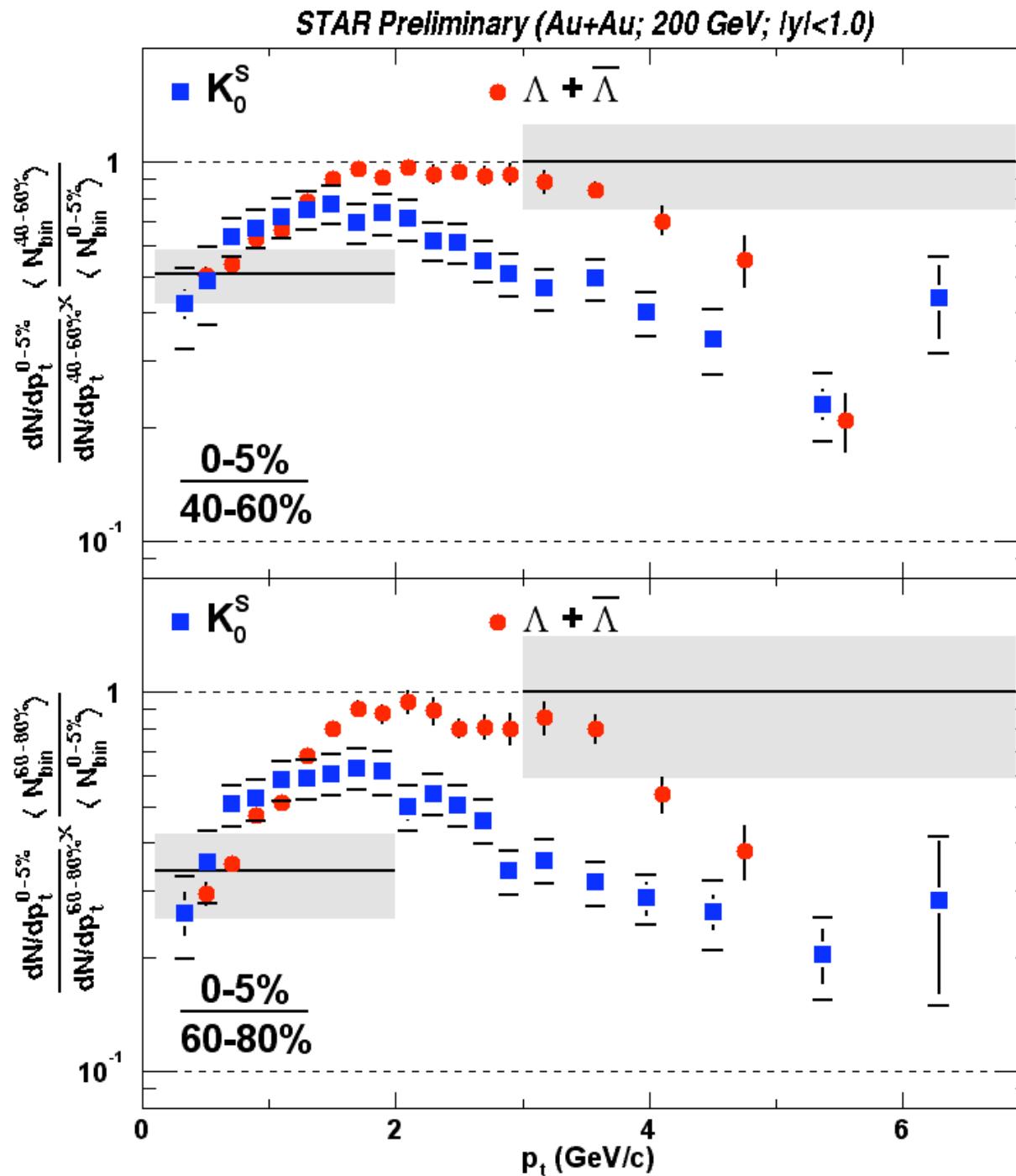
$\sigma \sim 10 \text{ mb}$



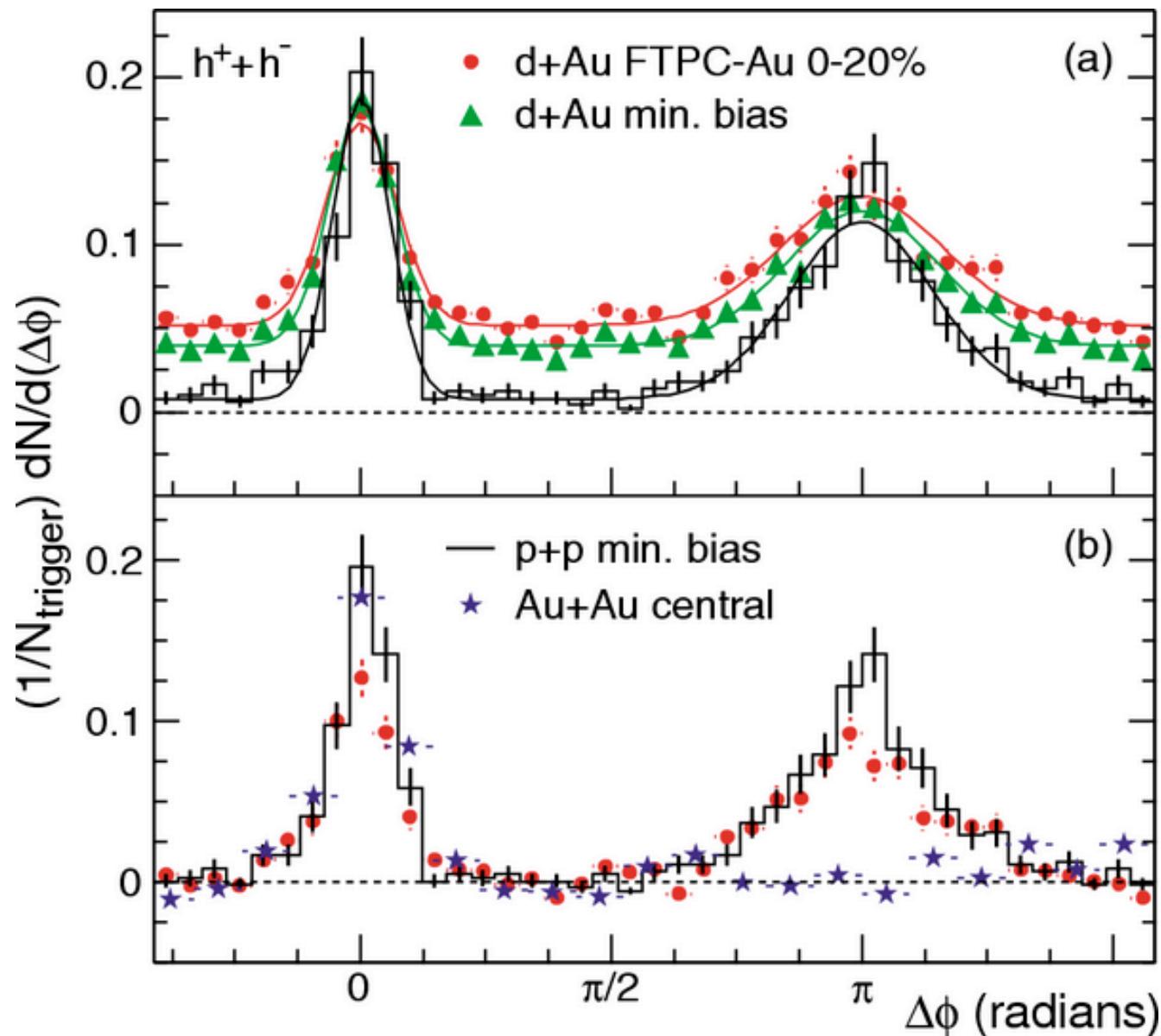
My favorites: R_{CP} for protons vs pions: the baryon “bump” at intermediate pt



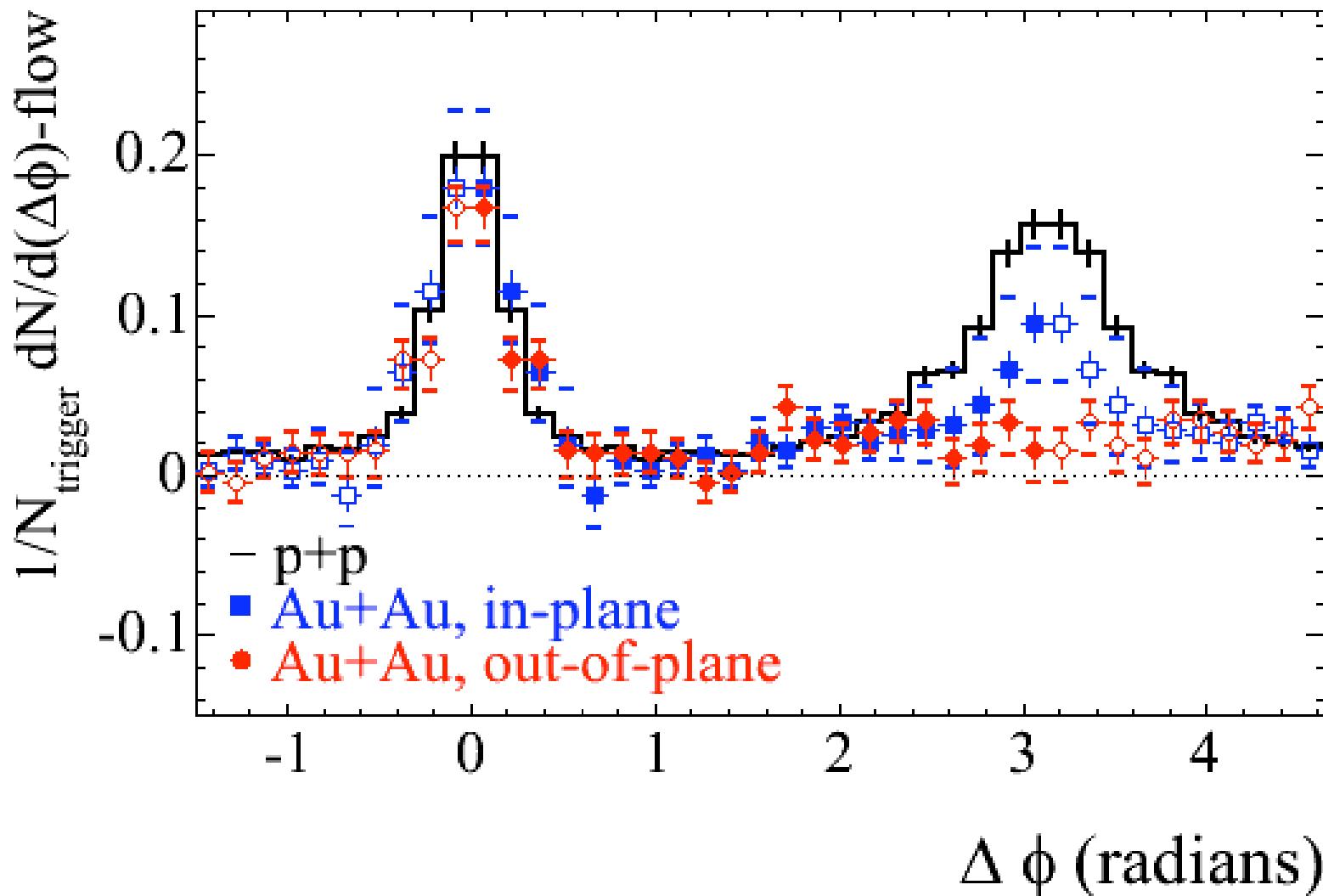
Seen in Strange baryons, too; => not mass effect



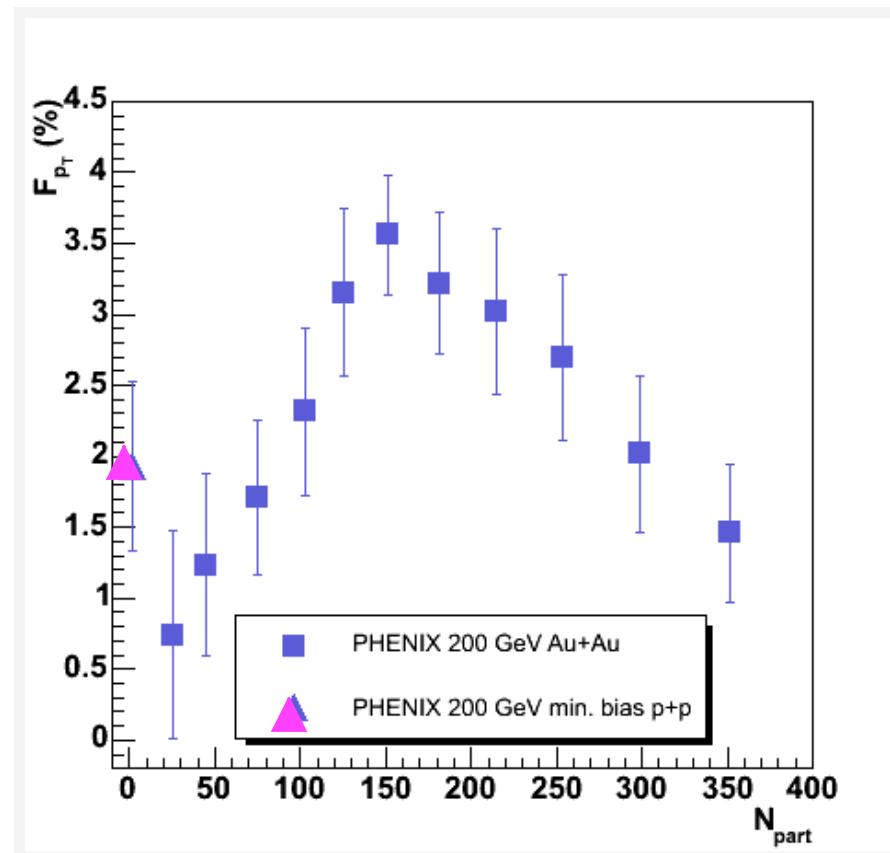
Jet correlations: “backward” jet seen in pp, dA, not central AA



Peripheral collisions: backward jet suppressed less in plane than out: *geometrical evidence of “stuff”*

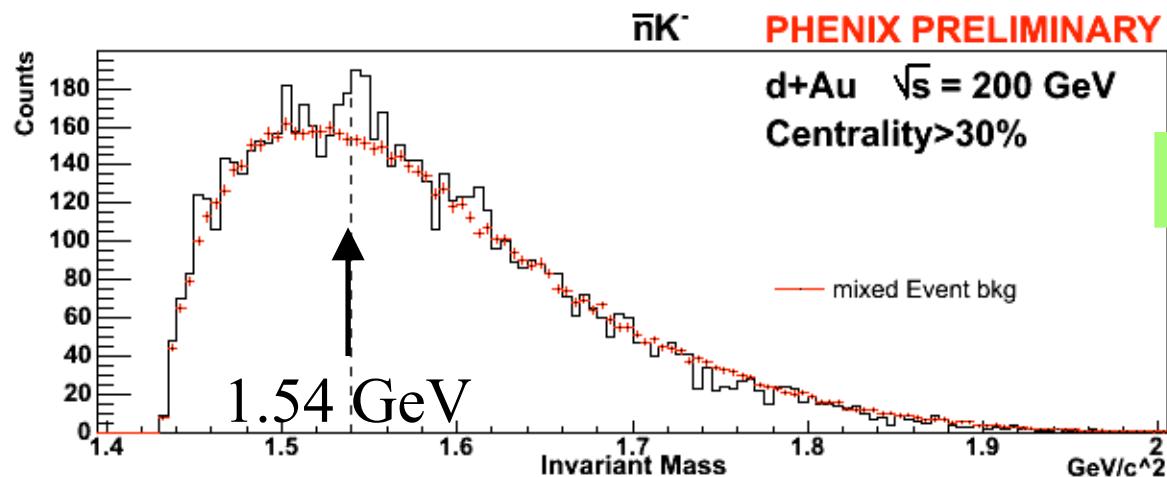


pt fluctuations *NOT* monotonic with centrality:
increase from central to peripheral.

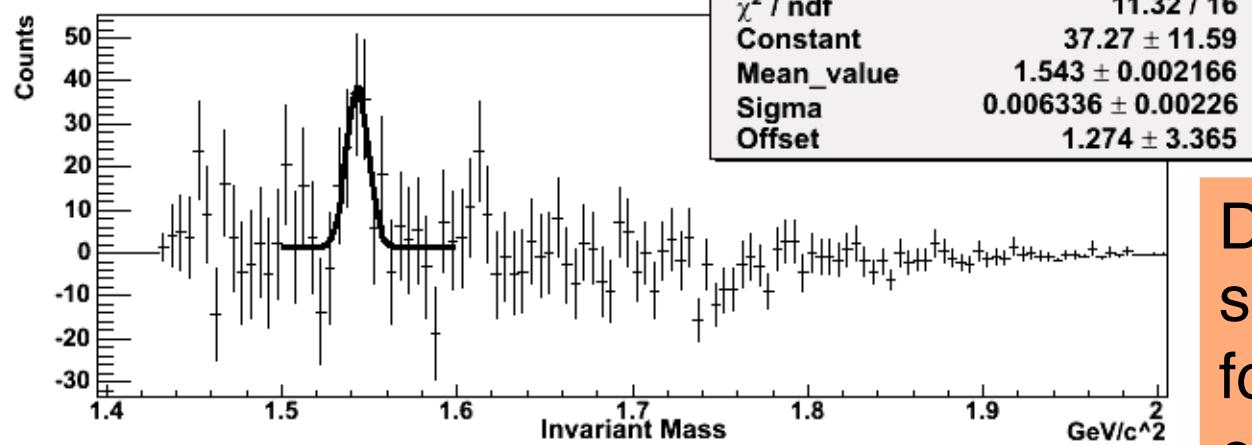


Anti Penta Quarks with PHENIX?

$$Q^- \rightarrow \bar{n} + K^-$$



Statistically it's a 4s effect



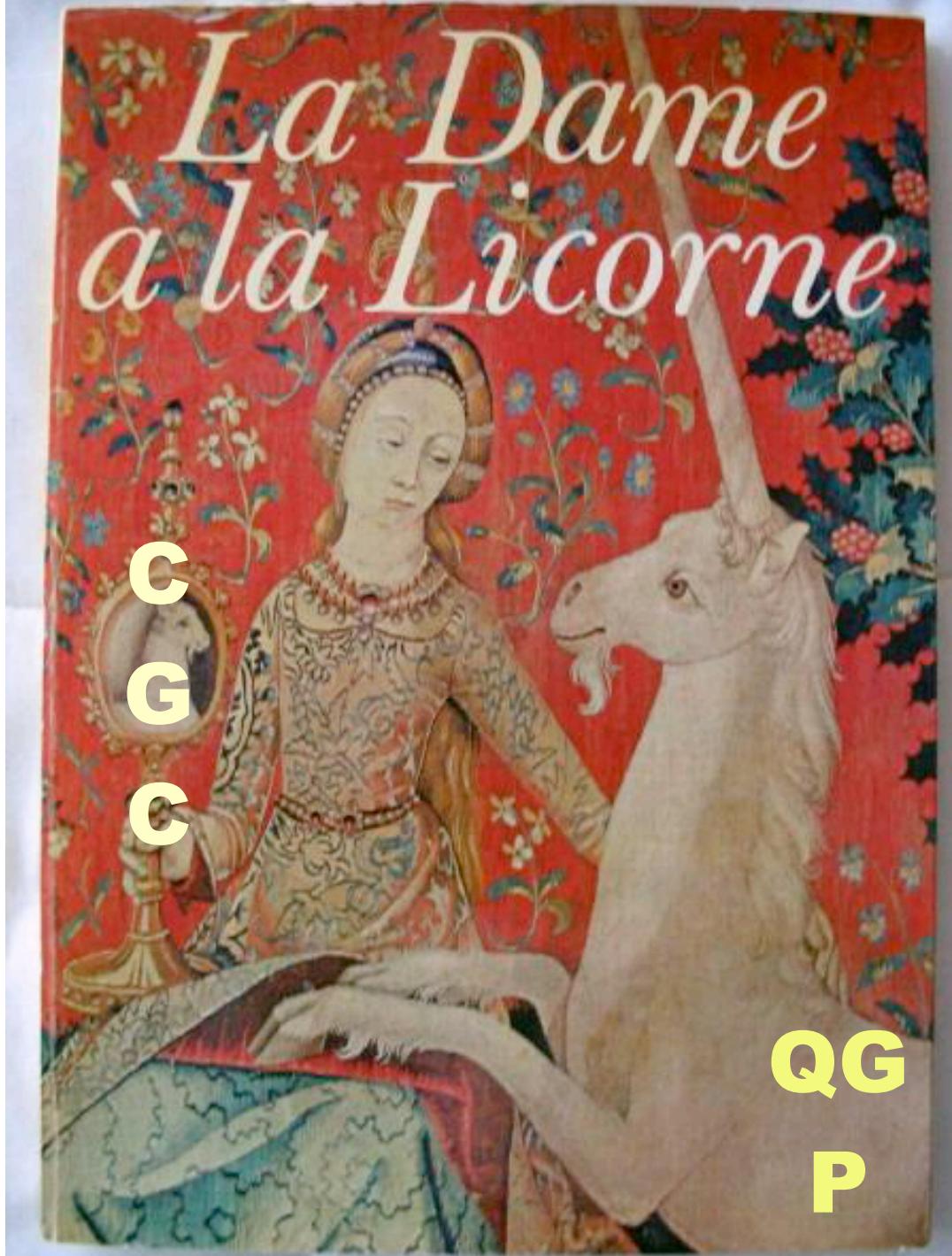
- No estimate of systematic Error yet

- No estimate of Efficiency yet

Determining statistical significance of peak will follow from the ongoing effort to understand the systematic errors

See Chris Pinkenburg poster

While
QGP
reflects
on
CGC



The
QGP
is
tamed