

Effects of chain decays, radial flow and $U_A(1)$
restoration on the low-mass dilepton
enhancement in $\sqrt{s_{NN}} = 200$ GeV Au+Au
reactions

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ZIMÁNYI SCHOOL '12

OUTLINE

MOTIVATION

- Theoretical

- Experimental

INPUT

- Hydrodynamical spectra

- The Core-Halo picture

- The hydro spectra

METHOD

- Effects of an η' mass-drop

- The η' spectrum

OUTPUT

- Scan of parameters

SUMMARY

CHIRAL SYMMETRY BREAKING

Chiral symmetry: $U(3) = SU(3)_L \otimes SU(3)_R \otimes U(1) \otimes U_A(1)$

▶ $SU(3)_L \otimes SU(3)_R$

flavour spontaneously broken

▶ $U(3)$

broken \rightarrow Goldstone bosons

9^{th} boson = η' meson?

$$m_{\eta'} \approx 2 \cdot m_{\eta}$$

▶ $U_A(1)$

explicitly broken

nontrivial vacuum states

Kunihiro: PRL B **219** (1989) 363-368

Kapusta *et al.* PRD **53** (1996) 5028-5033

Zheng *et al.* PRD **53** (1996) 5034-5041

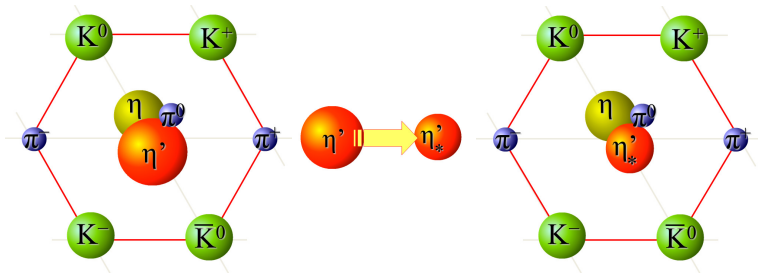
CHIRAL SYMMETRY RESTORATION

In hot and dense hadronic matter

- ▶ Symmetry restoration
- ▶ Different vacuum state: $|0\rangle_* + |\eta'\rangle_* \rightarrow |0\rangle + |\eta'\rangle$
- ▶ Indirect measurement in $\pi\pi$ HBT analysis

T. Csörgő, R. Vértesi and J. Sziklai, Phys. Rev. Lett. **105** 182301 (2010),

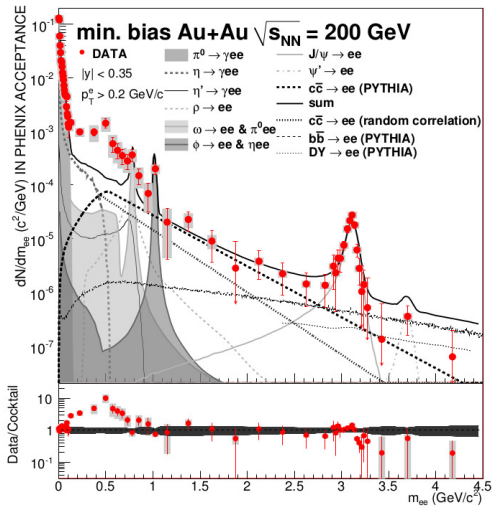
R. Vértesi, T. Csörgő and J. Sziklai, Phys. Rev. C **38** 054903 (2011)



PHENIX DILEPTON SPECTRUM

Significant enhancement: $0.1 \text{ GeV} < m_{ee} < 0.7 \text{ GeV}$

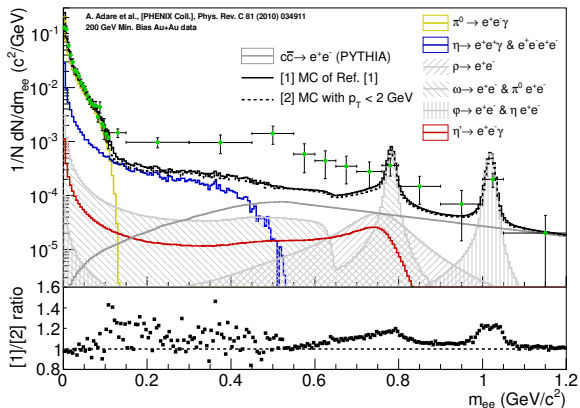
$\chi^2/\text{NDF} = 50.3/12$, $\text{CL} = 0.01\%$ for $(0.12 \text{ GeV} < m_{ee} < 1.2 \text{ GeV})$



WHY HYDRO SPECTRA?

Hydro successful at low- p_T

Most dilepton contribution from $p_T < 2$ GeV



Hydro describe original particles \rightarrow not inclusive spectra fits

THE CORE-HALO PICTURE

Assumption: original particles in the core

Definition:

$$\frac{1}{\sqrt{\lambda}} = \frac{N_{core} + N_{halo}}{N_{core}}, \quad (1)$$

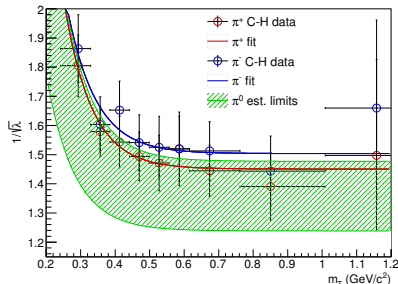
Upper boundary:

$$\lambda_H = (\lambda_{\pi^+} + \lambda_{\pi^-})/2$$

Lower boundary:

$$\lambda_L = \frac{\sqrt{\lambda_H}}{2} (1 + \sqrt{\lambda_H})$$

π^0 spectrum is corrected,
others (K^\pm , p , \bar{p}) neglected



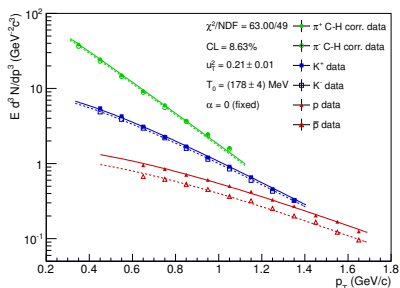
THE HYDRO SPECTRA

Naïve hydro picture:

$$E \frac{d^3N}{dp^3} = A \left(\frac{m_T}{m} \right)^\alpha e^{-\frac{m_T - m}{T_0 + m \langle ut \rangle^2}}$$

Simultaneous fit to
 K^\pm , π^\pm , p and \bar{p}

For normalization: Kaneta
 thermal model prediction



EFFECTS OF AN η' MASS-DROP

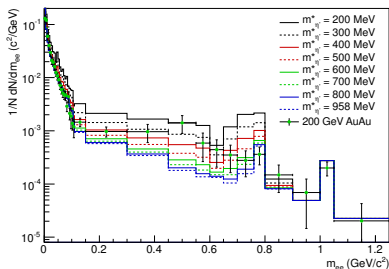
Enhanced η' mesons, Hagedorn-formula:

$$f_{\eta'} = \left(\frac{m_{\eta'}^*}{m_{\eta'}} \right)^\alpha e^{\frac{m_{\eta'} - m_{\eta'}^*}{T_{cond}}}, \quad (2)$$

Conservation of energy
during chiral transition:

$$|0\rangle_* + |\eta'\rangle_* \rightarrow |0\rangle + |\eta'\rangle$$

$$m_{\eta'}^{*2} + p_T^{*2} = m_{\eta'}^2 + p_T^2 \quad (3)$$



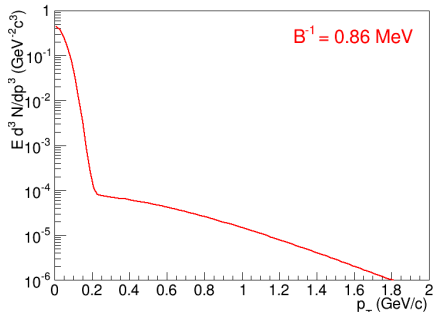
THE η' SPECTRUM

Two different sources of η' :

trapped η' mesons

"free" η' in vacuum

$$\Rightarrow \text{2 components: } f(p_T) = \frac{1}{2\pi m_{\eta'} B^{-1}} e^{-\frac{p_T^2}{2m_{\eta'} B^{-1}}} + \text{HYDRO}$$



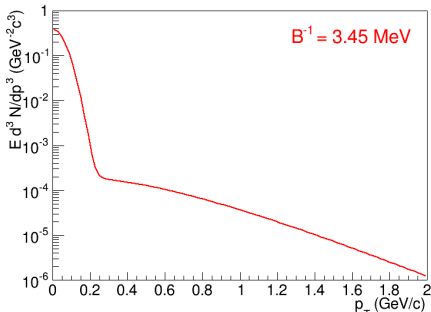
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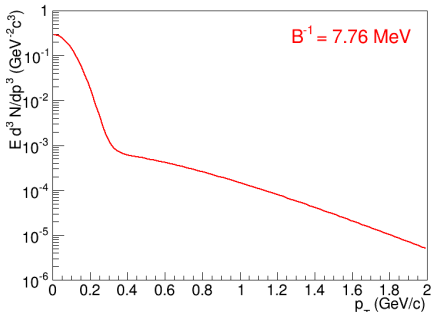
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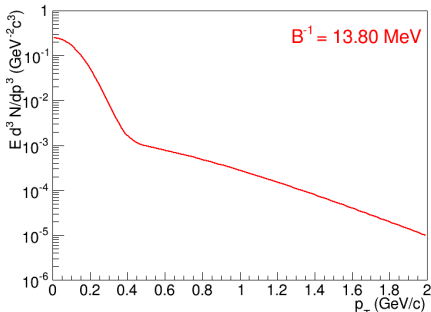
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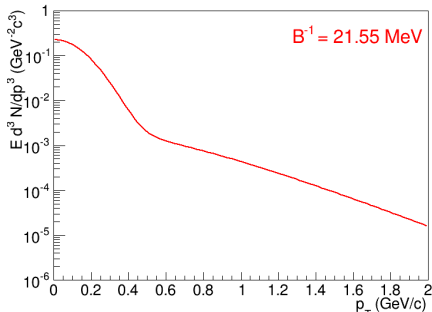
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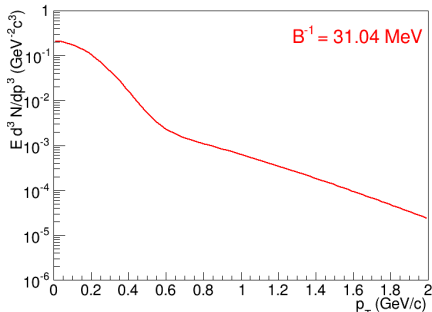
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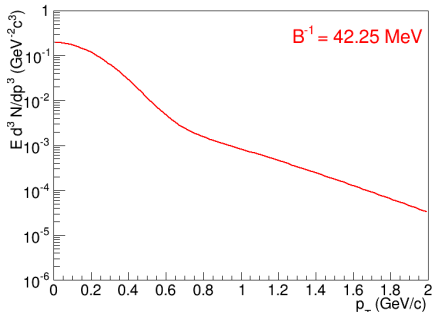
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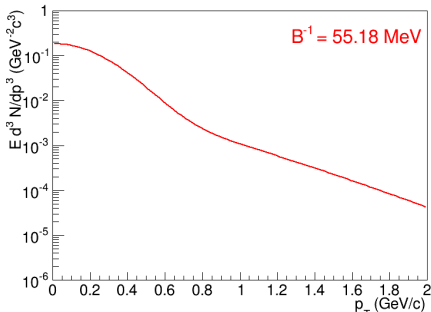
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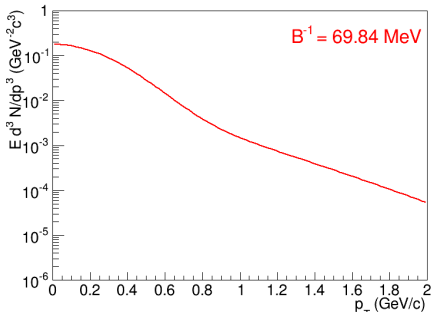
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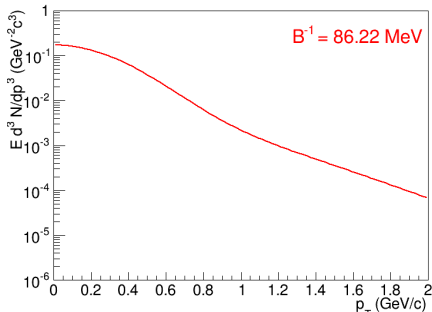
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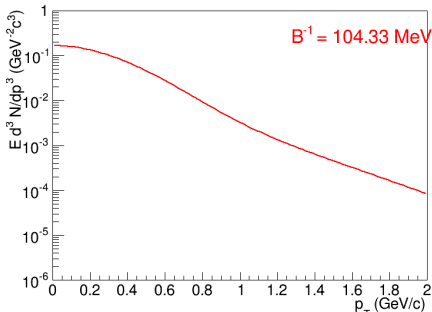
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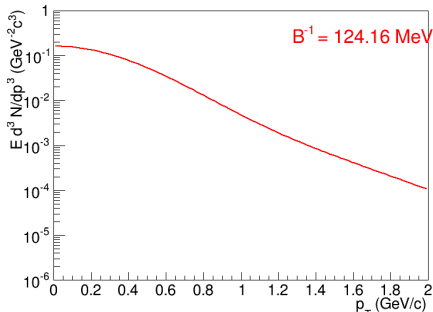
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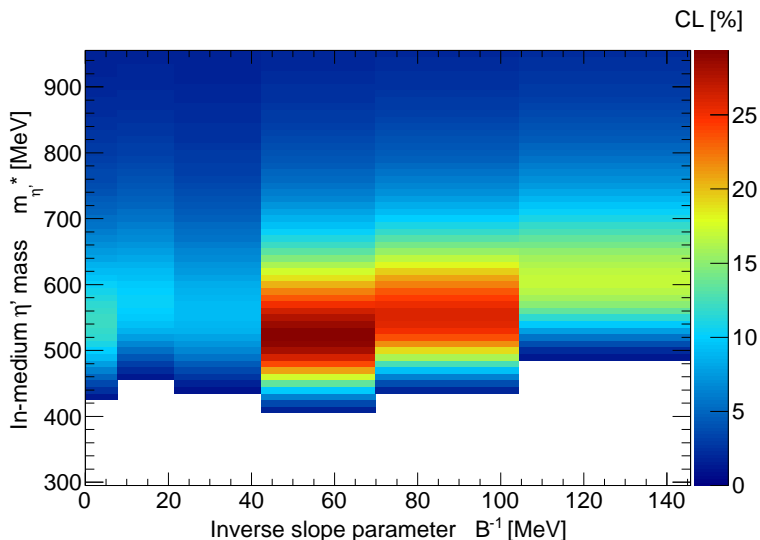
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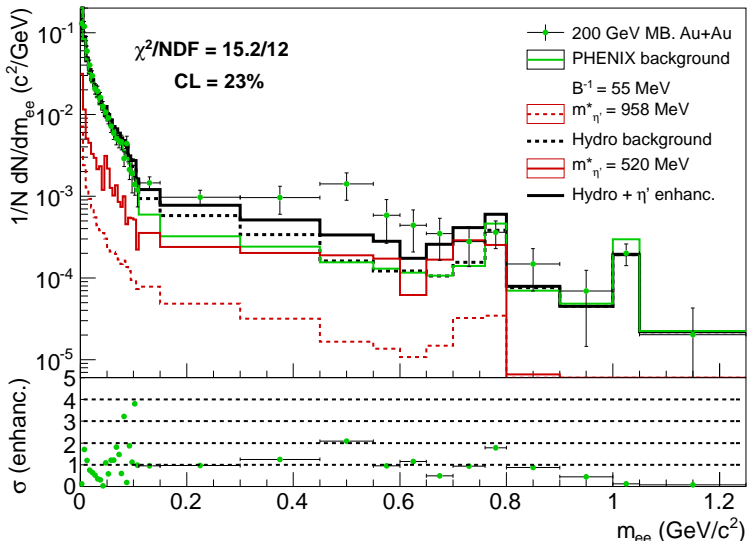
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SCAN FOR $B^{-1} + m_{\eta'}^*$ 

BEST VALUES OF $B^{-1} + m_{\eta'}^*$



SUMMARY

Low- p_T resonances dominate the dilepton spectrum

Hydrodynamical meson spectra (C-H corrected)

Double exponential η' spectra

MC simulation compared to 200 GeV PHENIX data

with hydro + chain decays: CL = 1.9 %

+ η' mass mod. ($m_{\eta'}^* = 520$ MeV): CL = 23%

$m_{\eta'}^* < 400$ MeV: CL = 99.9 %

arXiv:1211.1166v2

THANK YOU FOR YOUR ATTENTION!