Dimuon radiation at the CERN SPS within a hybrid evolution model

Elvira Santini

M. Bleicher and the UrQMD-Group

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FIAS Frankfurt Institute for Advanced Studies

HIC for FAIR Helmholtz International Center

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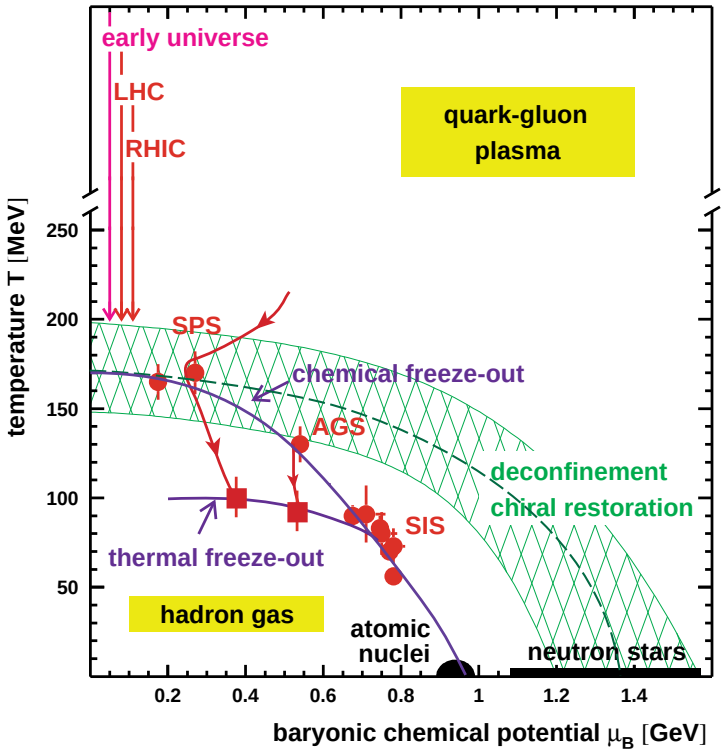
Dileptons: The ideal probe



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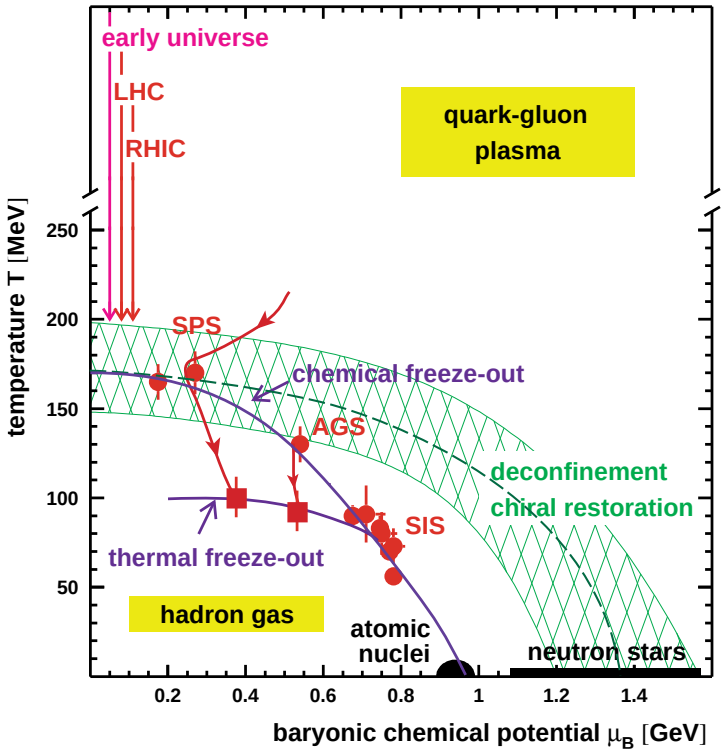
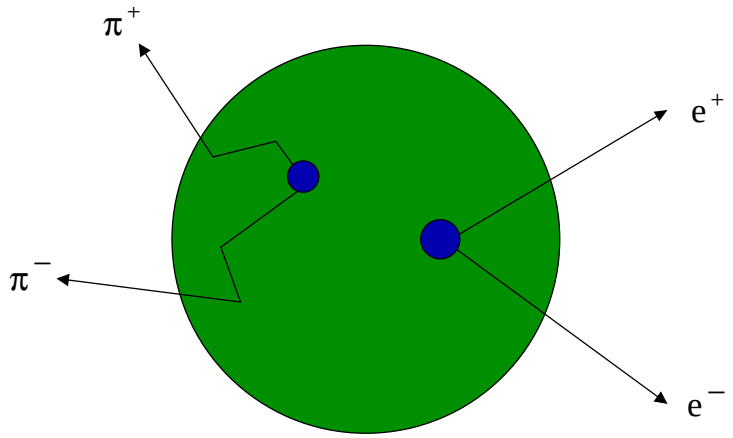


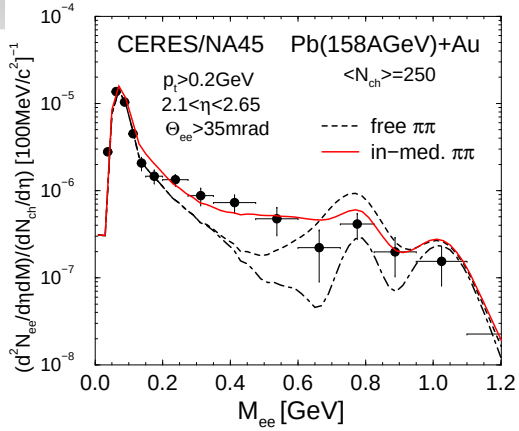


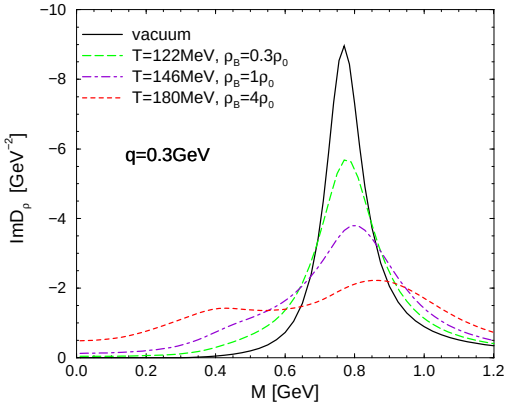
- l^+l^- are **messengers of the hot and dense phase** of the collision
- l^+l^- allow us to investigate **medium effects** on hadron properties

Experimental evidence: LM excess and ρ broadening

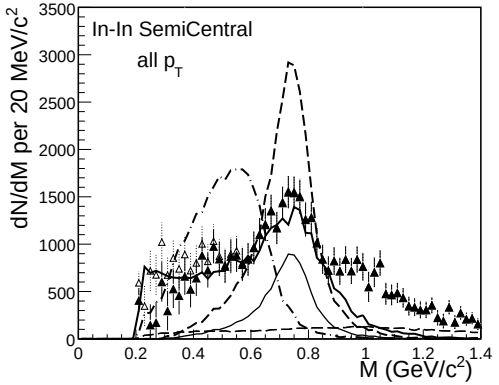
- ρ spectral function is modified in the medium (broadening + structures)

[R.Rapp,J.Wambach, **ANP25**(2000)1]

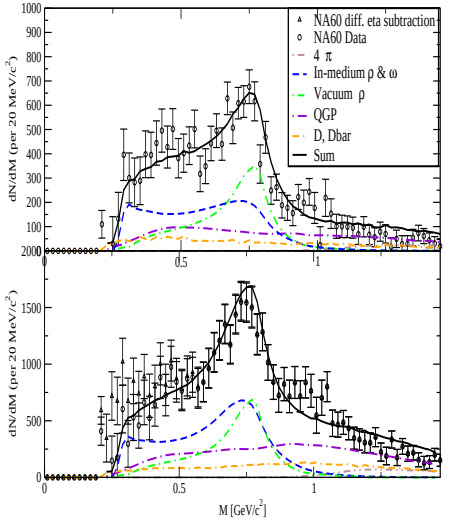




[J.Ruppert,et al,**PRL100**(2008)162301]

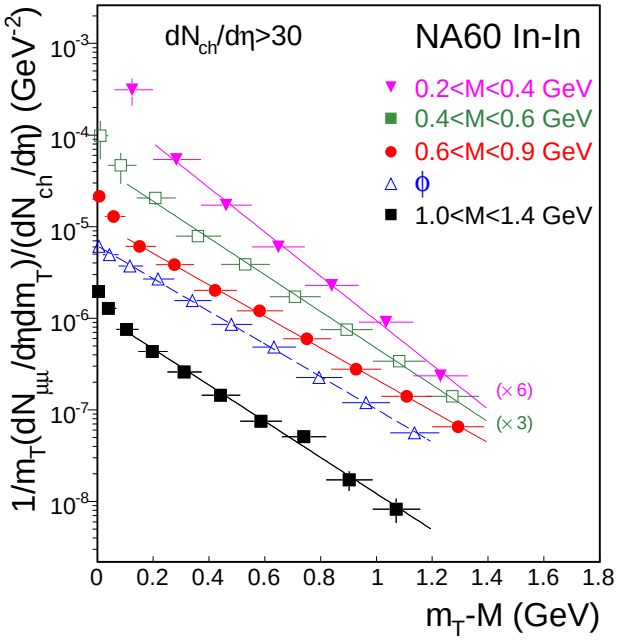


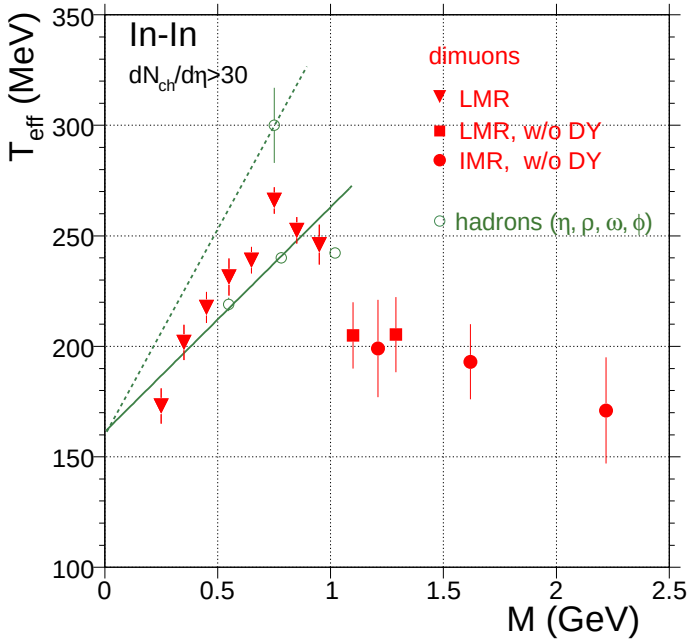
dashed : vacuum
thick solid : R.Rapp spf
dash-dotted : Brown-Rho scaling



See also K.Dusling et al.,**PRC75**(2007);**PRC80**(2009)

The dropping of T_{eff}





[R.Arnaldi,et al.,**EPJ61**(2009)711]

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  $\Rightarrow$ interpred as emission from **early times**

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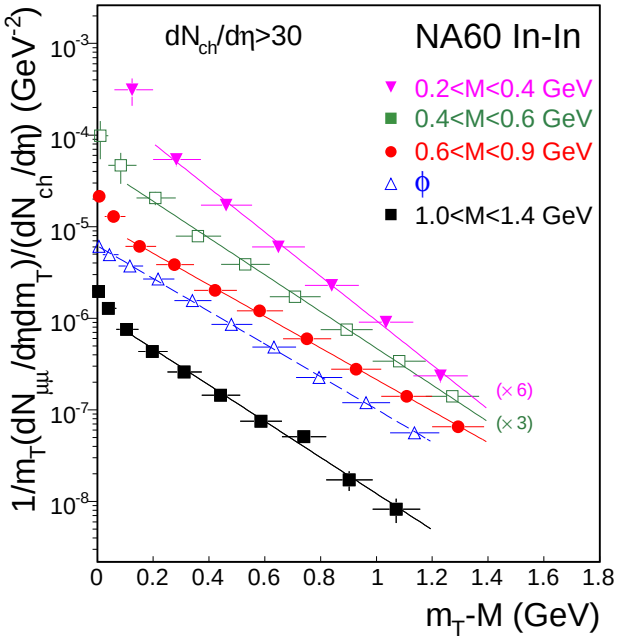

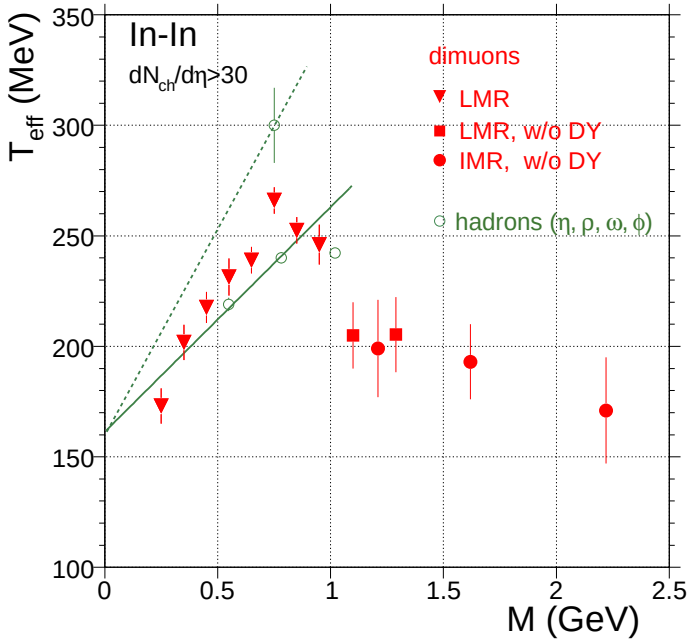

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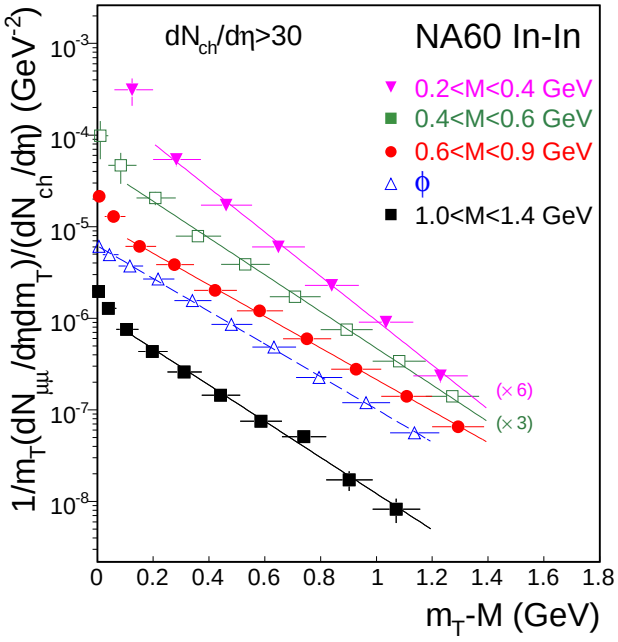

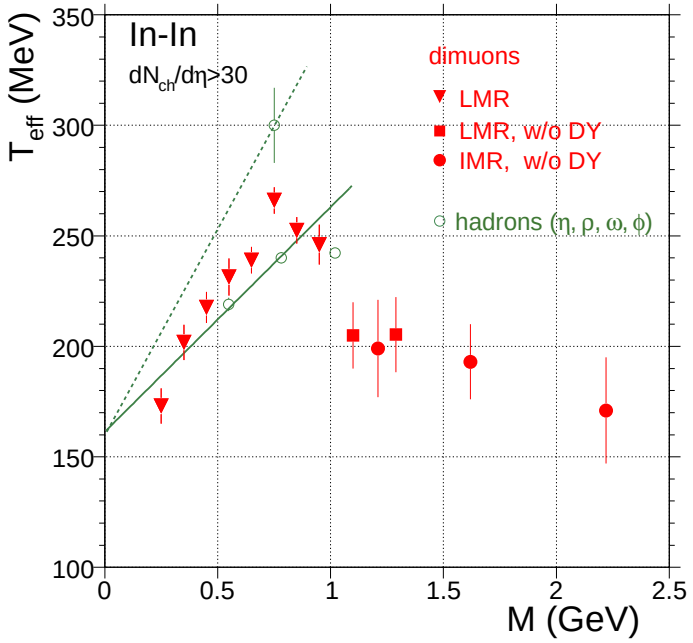

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Interpretation requires realistic transverse dynamics

Dynamics of thermal dileptons: our effort

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- **Getting ready for FAIR**

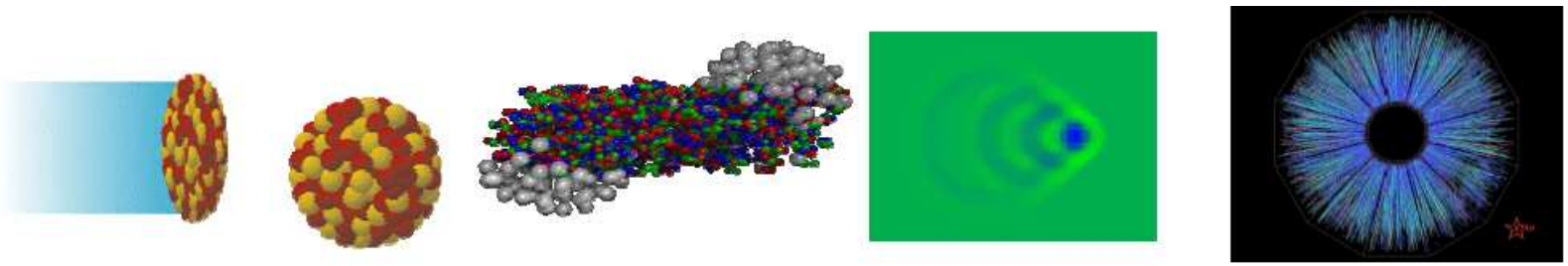
A hybrid model for the dynamics of the HIC

UrQMD $\rightarrow$ SHASTA $\rightarrow$ UrQMD

Embeds a 3+1 ideal hydrodynamical evolution for the hot and dense stage of the reaction. Hydrodynamical grid is mapped into UrQMD according to Cooper-Frye prescription

- Event-by-event fluctuations are taken into account

[H.Petersen et al.,**PRC78**(2008)044901]



Non-equilibrium initial condition via UrQMD

Hydrodynamics (or transport) evolution

Final decoupling via hadronic cascade (UrQMD)

Now available as UrQMD version 3.3. Visit **http://urqmd.org/**

Emission rates

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- $\rho^* \to ll$

$$\frac{d^8 N_{\rho^* \to ll}}{d^4x d^4q} = -\frac{\alpha^2 m_\rho^4}{\pi^3 g_\rho^2} \frac{L(M^2)}{M^2} f_B(q_0; T) \, \mathrm{Im} \, D_\rho(M, q; T, \mu_B)$$

with ρ spectral function in-medium modified

- Spectral density for the ρ meson in a heat bath of N and π re-derived from [Eletsky,et al.,**PRC64**(2001),035202] and tabulated
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- $q\bar{q} \to ll$ in LO from [J.Cleymans,J.Fingberg,K.Redlich, **PRD35**(1987),2153]

EoS

[J.Steinheimer and S.Schramm, **JPG38**(2011),035001]

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- Obtained from coupling the Polyakov loop to a chiral hadronic flavor-SU(3) model, adding quark d.o.f.
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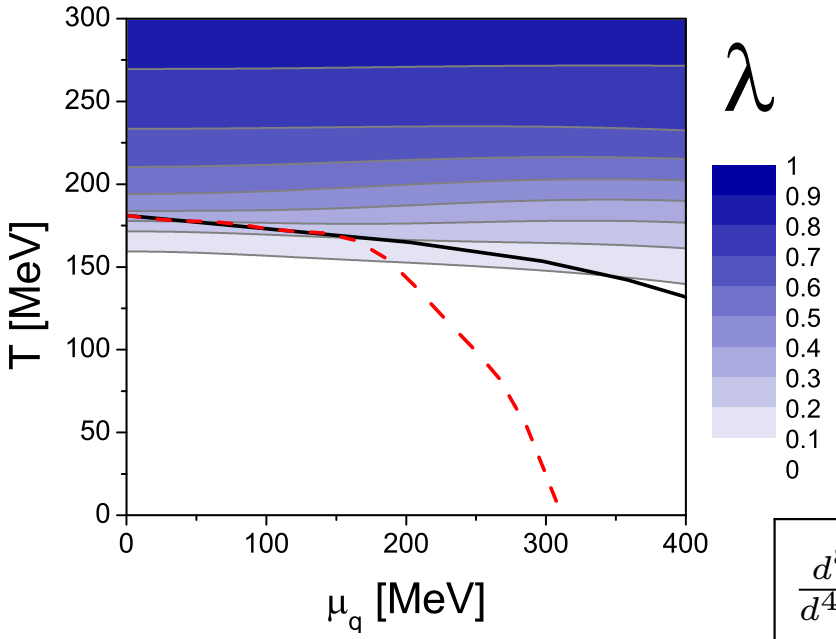
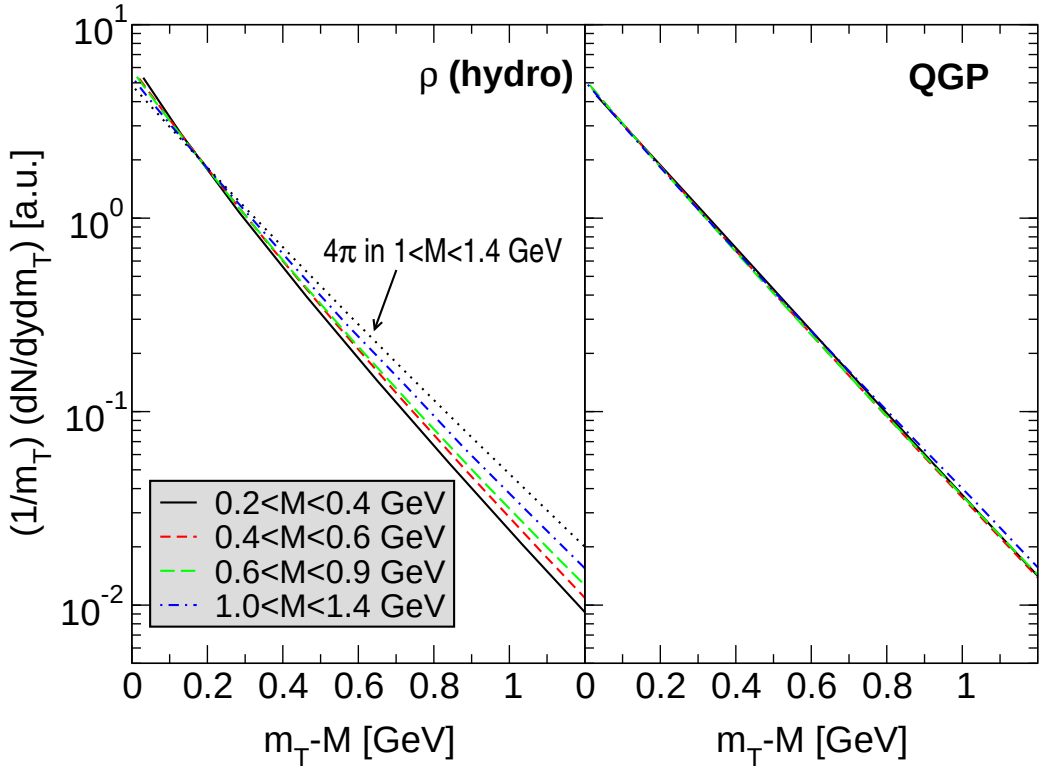


λ : **fraction of QGP**

- λ increases with increasing T
- large coexistence phase
- "weight" hadronic and QGP rates with λ

$$\frac{d^8 N_{ll}}{d^4x d^4q} = [1-\lambda]\left(\frac{d^8 N_{4\pi\to ll}}{d^4x d^4q} + \frac{d^8 N_{\rho\to ll}}{d^4x d^4q}\right) + \lambda \frac{dN_{q\bar{q}\to ll}}{d^4x d^4q}$$

Results: Transverse dynamics of thermal dileptons



- Mass ordering observed for hadronic contribution, but not for dileptons emitted in the QGP
- In the QGP phase, no significant radial flow has developed yet

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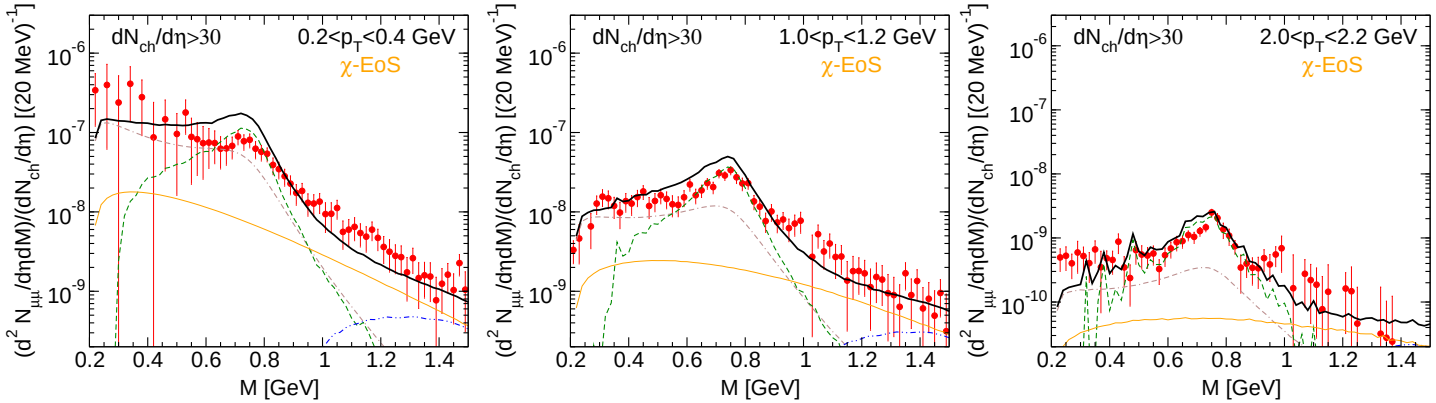

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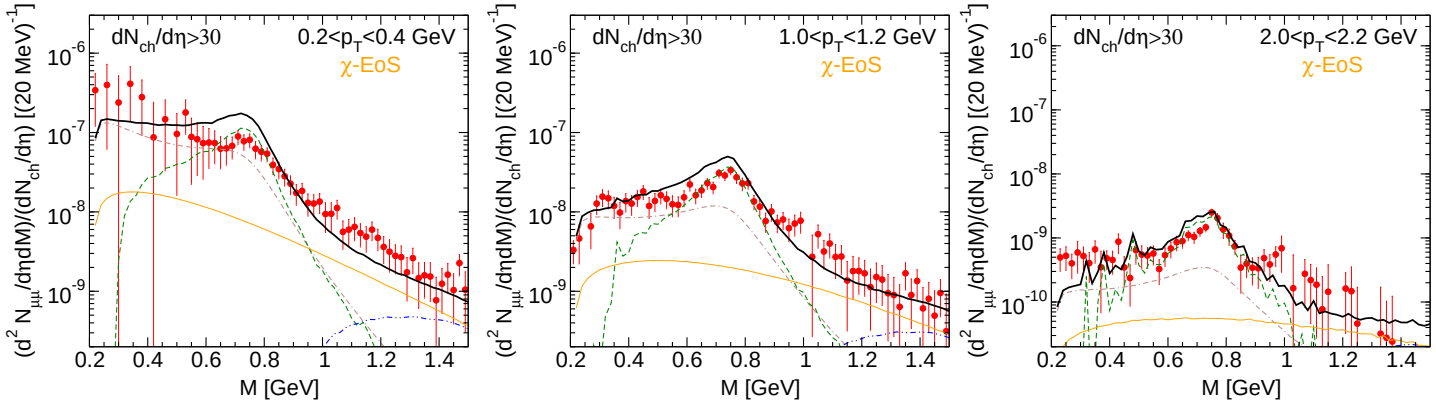

- Region $M < 0.5$ GeV dominated by **in-medium** radiation at low p_T; resonable p_T scaling
- Non-thermal cascade emission saturates the region $M \sim m_\rho$
- Sum of thermal and cascade emission results in overestimation of the $M \sim m_\rho$ region for $p_T \lesssim 1$ GeV $\Rightarrow$ presence of a long-lasting cascade emission in which the ρ meson can be approximated by its vacuum properties disfavoured by experimental data
- In region $1 < M < 1.5$ GeV emission from QGP accounts for about half of the yield; reasonable p_T scaling

Results: Transverse mass spectra

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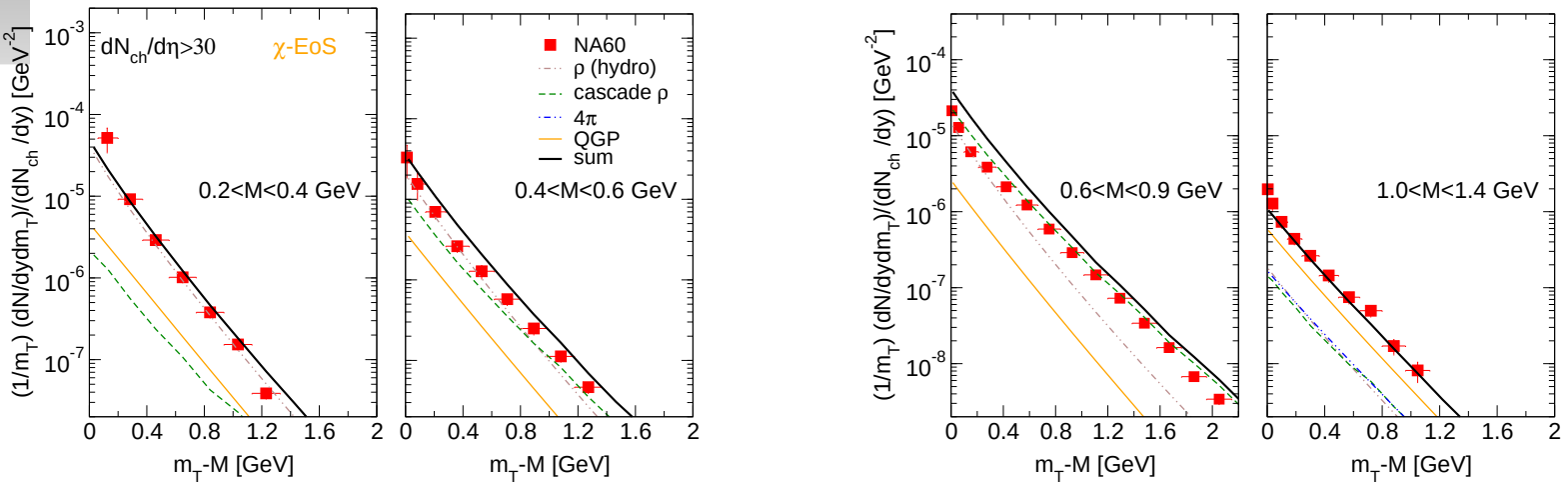

- Hardest contribution from non-thermal sources (max coupling to flow at transition hydro→UrQMD)
- agreement for $0.2 < M < 0.4$ GeV and $1 < M < 1.4$ GeV, discrepancies for $0.4 < M < 0.9$ GeV

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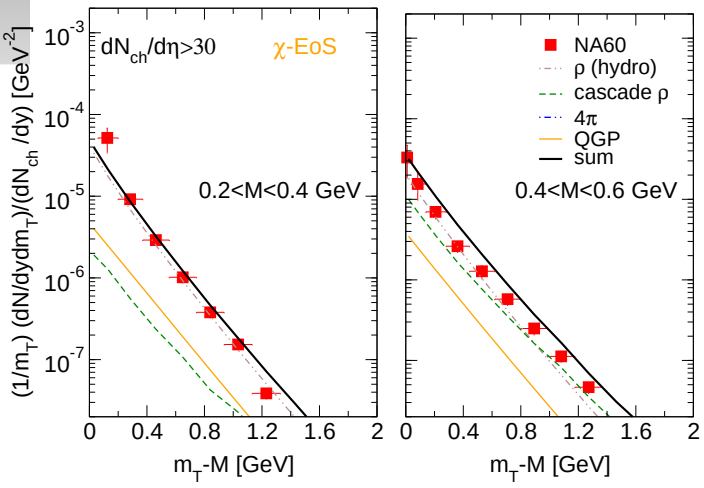

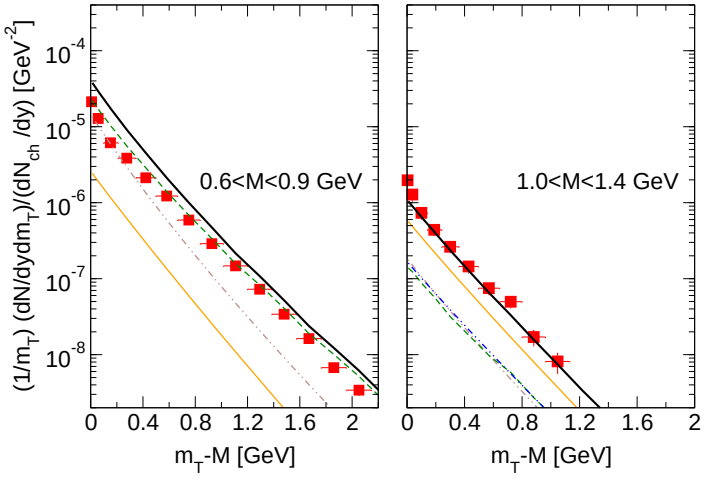

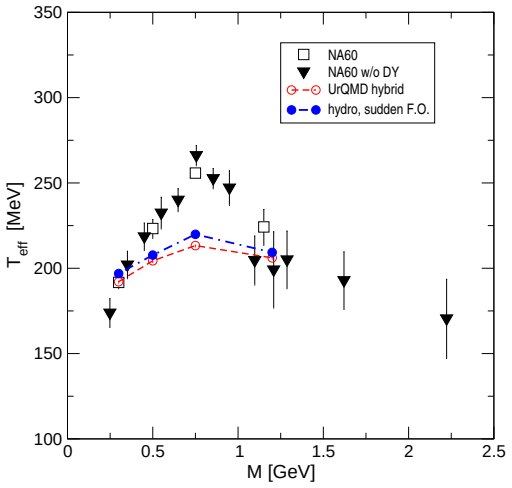

- increase of T_{eff} up to m_ρ followed by drop naturally emerged, however quantitative discrepancies found
- T_{eff} underestimated for $0.4 < M < 0.9$ GeV, reproduced for $1 < M < 1.4$ GeV and $0.2 < M < 0.4$ GeV
- refinement of late-stage decoupling needed?

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