Observability of $K^*(892)$ and $\phi(1020)$ resonances within iHKM as the probe of hadronic medium in heavy ion collisions

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Motivation

The relativistic heavy ion collisions produce great numbers of various particles, which form an intensively interacting hadronic medium at the afterburner stage of collision. In order to study the properties of this medium and their manifestation in experimentally measured observables, one can analyze the possibility for the resonance identification in the collisions. The resonances are identified by the products of their decays:

$K^{*0}(892) \to K^+\pi^-$, $\tau \approx 4$ fm/c

$\phi(1020) \to K^+K^-$, $\tau \approx 50$ fm/c

Due to particle re-scatterings at the final stage of the collision two opposite effects take place:

— the actual resonance decay products are scattered, so that the parent resonance cannot be restored $\to$ the observed resonance yield is reduced;

— some primary mesons can collide and create extra resonance states, thus increasing their observed number.

iHKM model

V. Yu. Naboka, Iu. A. Karpenko, Yu. M. Sinyukov, Phys. Rev. C ***93*** *(2016) 024902*

The iHKM model simulates the process of relativistic heavy ion collision as consisting of the following stages:

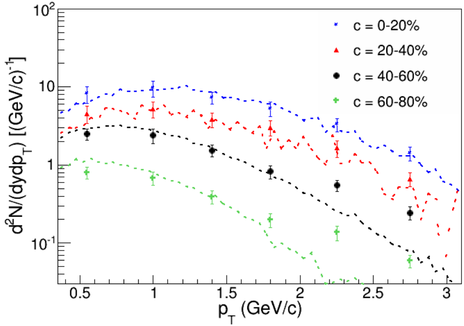
- Pre-thermal stage
  (starts at $\tau_i = 0.1$ fm/c from non-thermalized energy-momentum tensor, which gradually evolves, transforming into hydrodynamic tensor at the thermalization time $\tau_0 = 1$ fm/c. The GLISSANDO code is used to generate the initial transversal energy-density profile.)
- Viscous hydrodynamics
  (describes the evolution of thermally and chemically locally equilibrated matter)
- Particlization (sudden or continuous)
  At some hypersurface (here isotherm $T = 163$ MeV) the both thermal and chemical local equilibrium get destroyed and the system decouples into particles
- Hadronic cascade (within UrQMD code)

$K^*(892)$ and $\phi(1020)$ spectra at the LHC

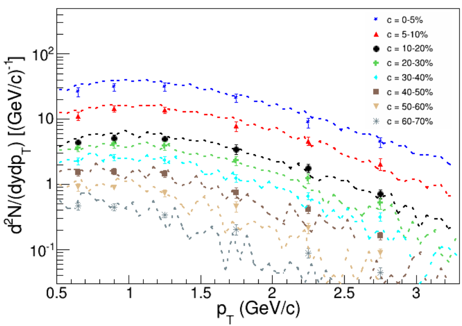
K^* and ϕ spectra at different centralities for the LHC Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV calculated in iHKM, compared to the ALICE experimental data.

*The ALICE Collaboration, Phys. Rev. C **91** (2015) 024609*

$K^*(892)$



$\phi(1020)$

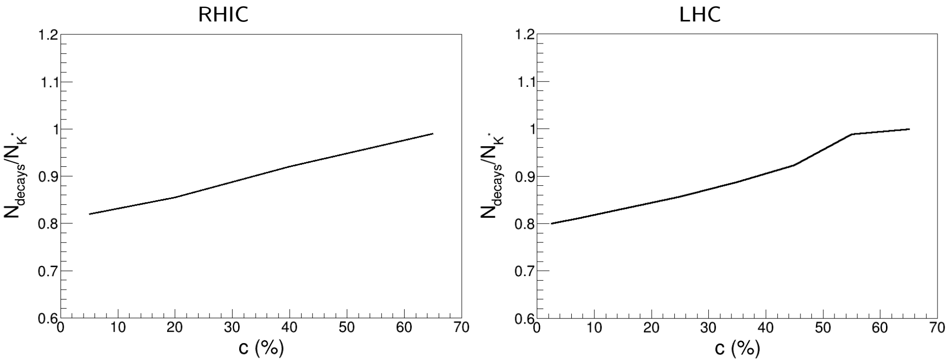


$K^{*0}(892) \to K^+\pi^-$, $\tau \approx 4$ fm/c. The K^* with $|y| < 0.5$ and $0.3 < p_T < 5$ GeV/c were chosen for the analysis.

$\phi(1020) \to K^+K^-$, $\tau \approx 50$ fm/c. The ϕ with $|y| < 0.5$ and $0.5 < p_T < 5$ GeV/c were chosen for the analysis.

$K^*(892)$ and $\phi(1020)$ observabilities

The iHKM results on the fractions of the total K^* numbers, that can be restored based on the products of the decay $K^*(892) \to K\pi$ at different centralities for the LHC Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and RHIC Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.



As for the $\phi(1020)$, its observed yields are overestimated by $20-30\%$.
Such a result can be explained by the presence of $K\overline{K}$ correlations, implemented in UrQMD code through the "coalescence" mechanism.

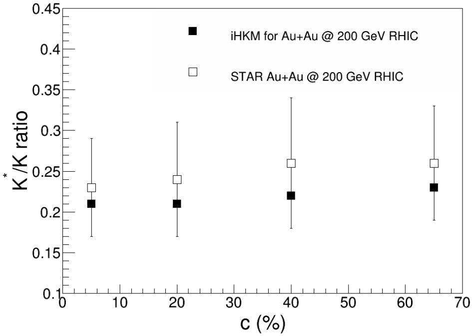
The FSI K^+K^- correlation analysis shows, that $\phi(1020)$ resonance contribution to the K^+K^- correlation function may correspond to as much as $88-120\%$ of produced $\phi(1020)$, thus leaving no room for direct ϕ production. *(R. Lednicky's talk at GDRE, Nantes, 2011)*

K^*/K and ϕ/K particle number ratios for RHIC

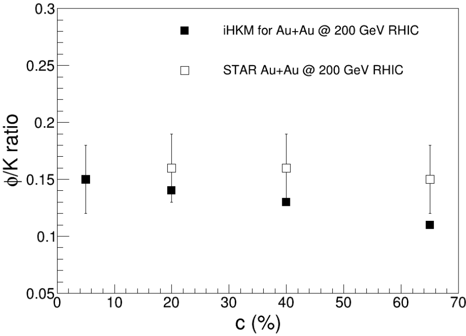
The particle number ratios $K^*(892)/K$ and $\phi(1020)/k$, calculated in iHKM for the RHIC Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV in comparison with the experimental results

*The STAR Collaboration, Phys. Rev. C **71** (2005) 064902*

K^*/K



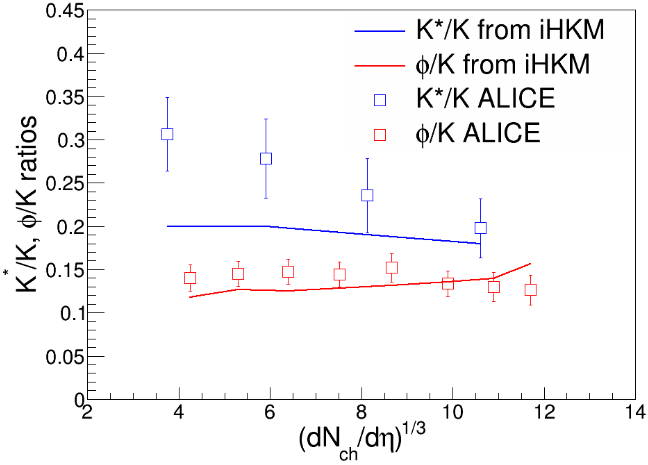
ϕ/K



K^*/K and ϕ/K particle number ratios for LHC

The particle number ratios $K^*(892)/K$ and $\phi(1020)/k$, calculated in iHKM for the LHC Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV in comparison with the experimental results

The ALICE Collaboration, Phys. Rev. C ***91*** *(2015) 024609*



Conclusions

- It is found that the re-scattering of the daughter hadrons leads to the suppression of $K^*(892)$ registration by up to 20% in the most central collisions, while for essentially non-central collisions the K^* observability is significantly better.
- As for the $\phi(1020)$ resonance, it seems that $K\overline{K}$ correlations at the afterburner stage (implemented in the model through the UrQMD coalescence mechanism) lead to the excessive amount of registered $\phi(1020)$, by up to 30% exceeding their number on chemical freeze-out.
- The iHKM calculations reproduce well the experimental K^* and ϕ p_T-spectra (for $p_T < 1.8$ GeV/c) together with ϕ/K and K^*/K particle number ratios, except for K^*/K ratio in the peripheral LHC events.
- The obtained results point out that the particle interactions during the afterburner stage of heavy ion collision strongly affect the observed particle production, so that the conception of sudden chemical and thermal freeze-out seems to be not quite appropriate for the description of the collision process – the freeze-out is continuous and it is greatly defined by the hadron re-scatterings at the late stage of collision.

Thank you for your attention!