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Precision hydrodynamic predictions for particle production in isobar collisions at RHIC

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The STAR collaboration has recently released measurements of soft particle production in Ru+Ru and Zr+Zr collisions [1]. Due to the isobar running mode and the huge statistics of collected events, such measurements are essentially devoid of experimental error, and permit us to perform precision tests of hydrodynamic models of the quark-gluon plasma (QGP).

In this contribution, we discuss hydrodynamic results for particle production in isobar collisions where we achieve the same precision reached in the experimental data. Our approach relies on a background-fluctuation splitting of the equations of hydrodynamics. In a given centrality class, and assuming boost invariance, we decompose the QGP as an event-averaged and azimuthally-isotropic background plus an event-by-event fluctuation, $\mathrm{QGP}(r,\phi) = \langle \mathrm{QGP} \rangle(r) + \delta\mathrm{QGP}(r,\phi)$. Linearizing the equations of hydrodynamics with respect to the fluctuation, we show that final particle spectra are determined by the isotropic background, with the fluctuation contributing only at next-to-next-to-leading order. Computing the evolution of $\langle \mathrm{QGP} \rangle(r)$ requires solving 1+1D hydrodynamic equations, which can be done quickly for a large number of collision events.

We perform, thus, precision calculations of hadron production in isobar collisions by means of FluiduM [2], a solver for the 1+1D evolution of the QGP which implements 2nd order Israel-Stewart relativistic hydrodynamics as well as QGP particlization and resonance decays. We show predictions for particle spectra, yields and average transverse momenta of identified hadrons [3]. Looking at ratios of quantities between Ru+Ru and Zr+Zr systems, we find that they are insensitive to viscosities and other medium parameters. They are instead driven by initial-state effects, mainly originating from the larger neutron skin of 96Zr.

[1] STAR collaboration, https://arxiv.org/abs/2109.00131

[2] S. Floerchinger, E. Grossi, J. Lion, https://arxiv.org/abs/1811.01870

[3] F. Capellino, S. Floerchinger, G. Giacalone, E. Grossi, A. Kirchner, in preparation

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