Wigner 121
Scientific Symposium

Wigner Research Centre for Physics
Institute for Particle and Nuclear Physics
Theoretical Physics Department
Heavy-ion Physics Research Group

G.G. Barnaföldi, G. Balassa, G. Bíró, B. Dudás, E. Fenyvesi, V. Gogokhia, M. Gyulassy, A. Horváth, Zs. Jólesz, Gy. Kovács, P. Kovács, R. Kovács, S. Maydanyuk, D. Molnár, M. Pszota, B.E. Szigeti, M.E. Szücs, B. Pál Takátsy, P. Ván, Gy. Wolf

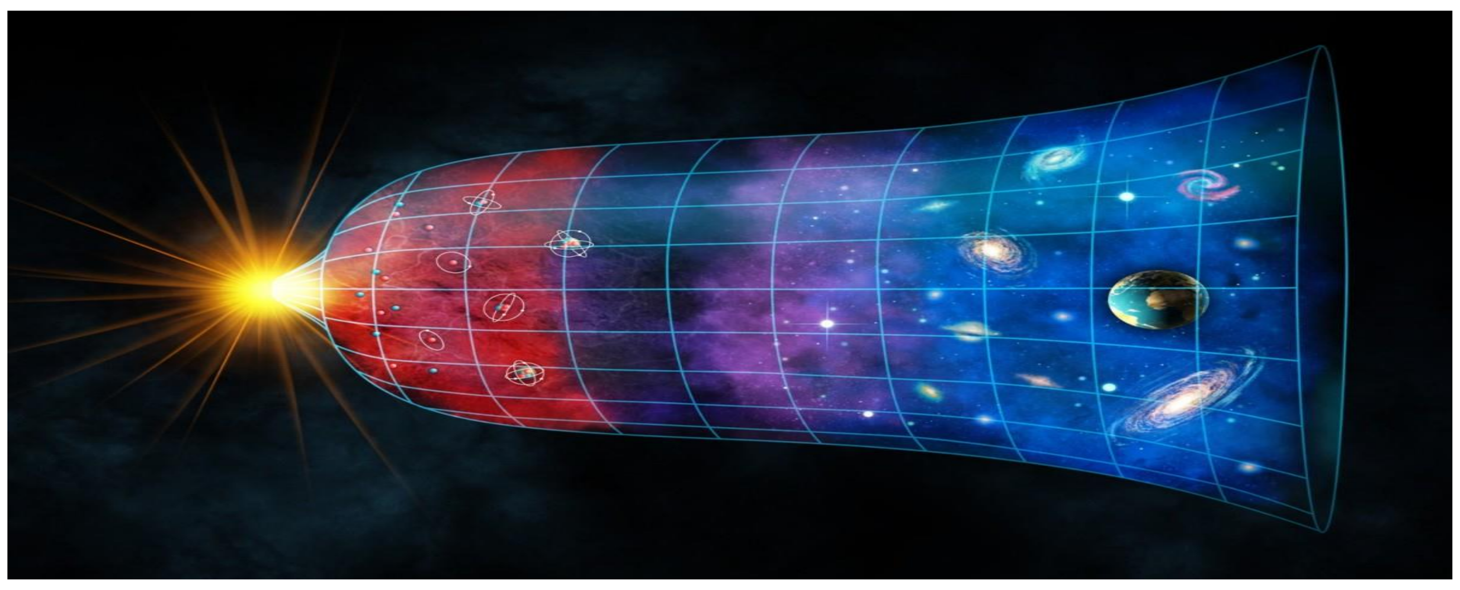
Introduction

Heavy-ion Research Group aims to explore the physics of the strongly interacting matter from milliseconds after the Big Bang to the cold, extreme dense nuclear matter in compact stars.

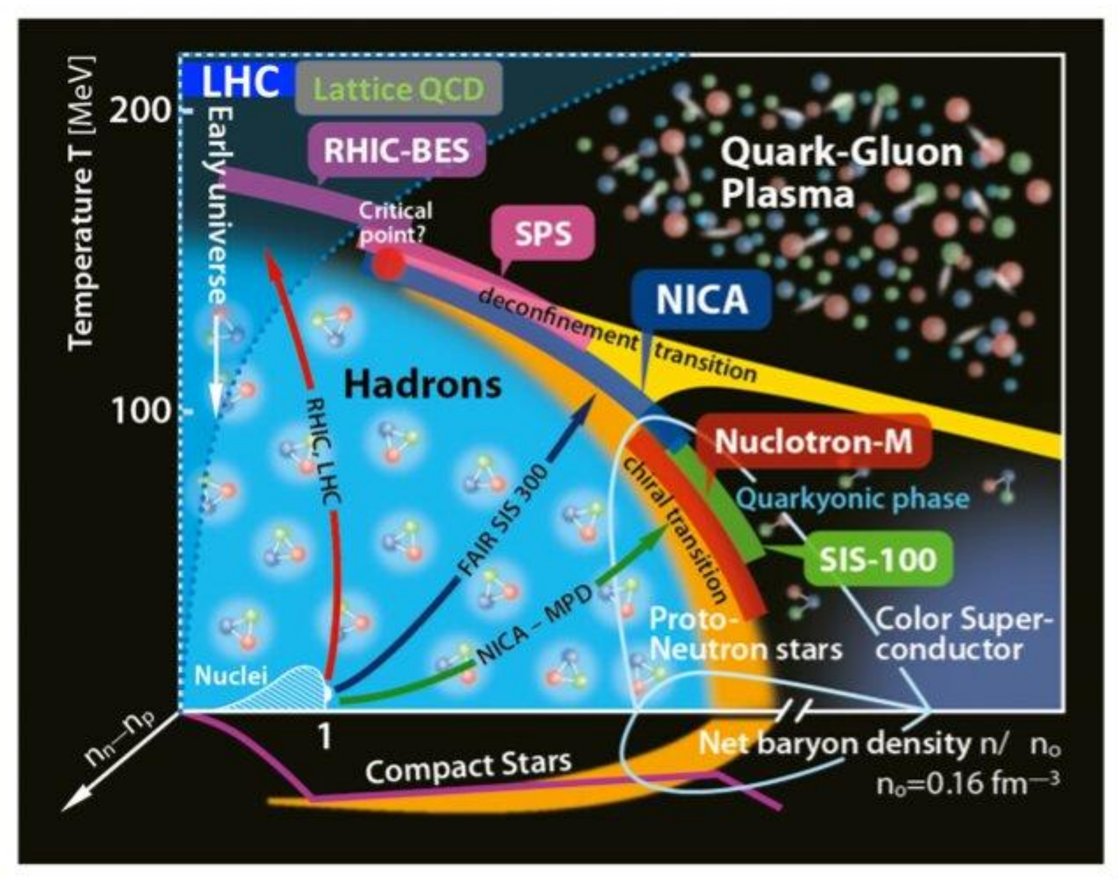
The Universe was formed of a dense and hot matter, the quark gluon plasma. The properties of this strongly interacting medium set the initial condition of the expansion of the Universe later on. We address questions:

- How this matter look like?
- What are the physical properties of this state?
- Can we re-create this matter in the ultra-relativistic collisions of nuclei?
- Can we test by multichannel astrophysics neutron stars as sources?

Matter of the Universe



Research Highlights

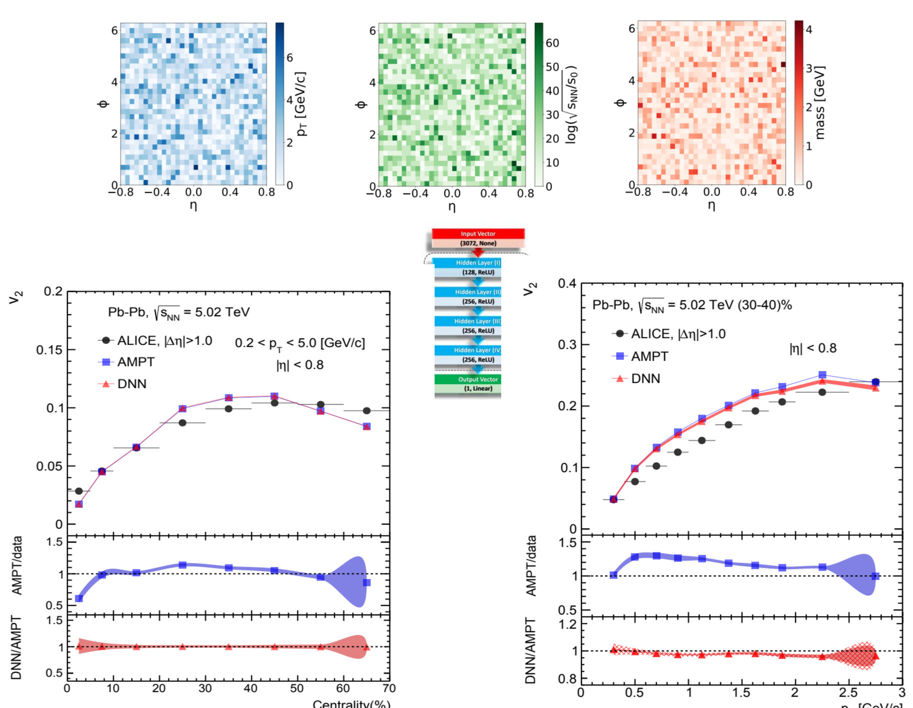


Exploring the phases of the strongly interacting matter

Hot Dense Matter: ultra-relativistic, high-energy heavy-ion collisions led us to investigate the signatures of the tiny drop of the formed Quark Gluon Plasma (QGP). Modeling the matter by perturbative and non-perturbative theoretical model help us to investigate the physical parameters of the primordial matter of the Universe. By modeling high-energy nucleus-nucleus collisions we calculate the viscosity, opacity, and provide the yield of the heavy-flavor hadrons.

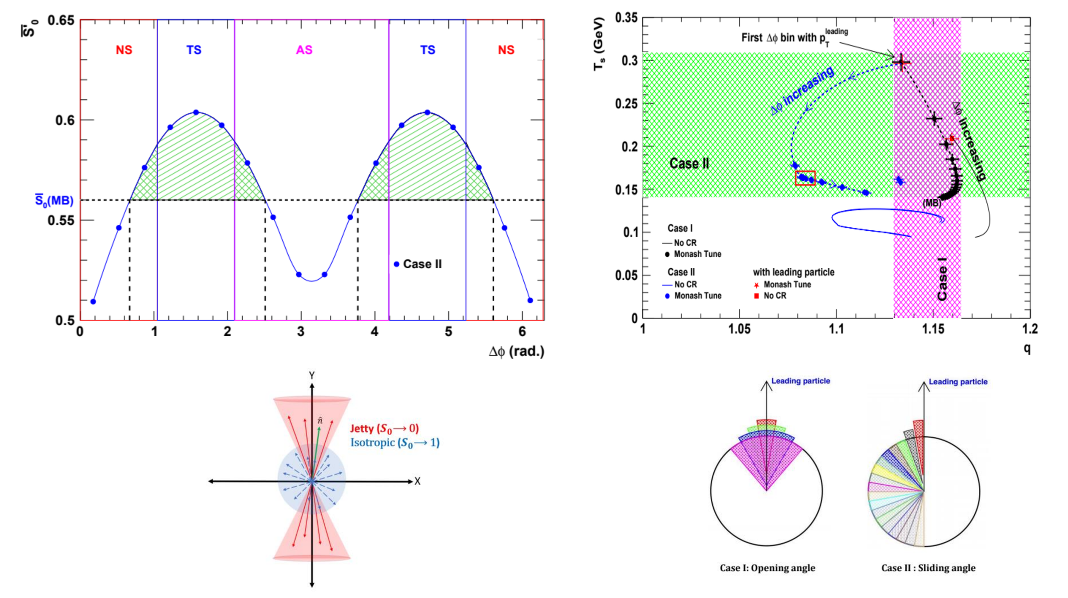
Cold Dense Matter: Universe today is cold after the 13.7 Mrd years of expansion of the original QGP phase. Stellar graveyards, the compact astrophysical object of the stellar evolution are the places, where the most dense matter of the universe is still exist. Multichannel astrophysics is the field which uses relativistic heavy ion colliders, and neutron star measurements of electromagnetic astrophysical and gravitational wave observations. The aim is to have constraints for the finite-temperature equation of state of the superdense nuclear matter.

Elliptic flow parameters by Machine Learning methods



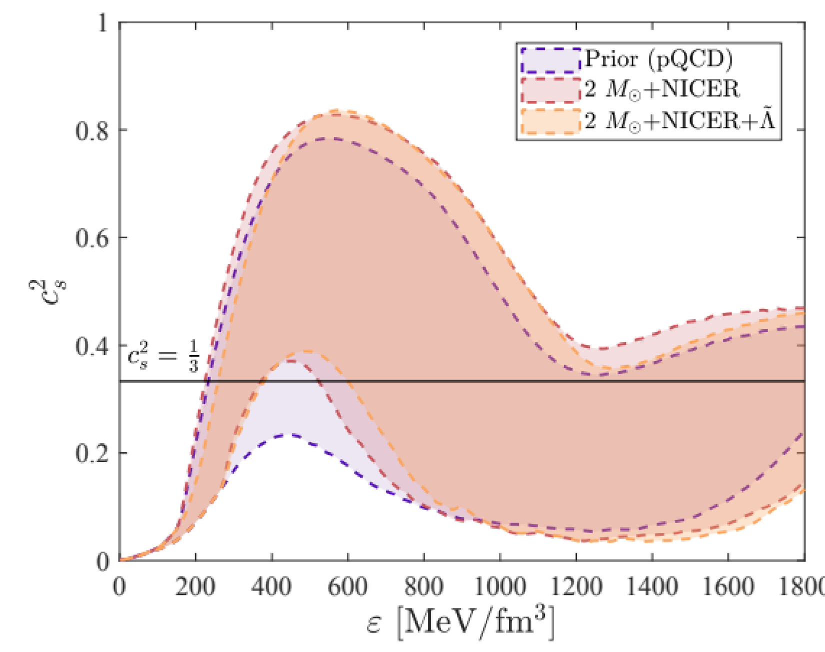
Modern machine learning techniques can estimate the elliptic flow parameter at RHIC & LHC energy collisions.

Tsallis Thermometer: quantifying the QGP in small systems



Tsallis thermometer is a new measure to explore, the phases of the hot and dense matter in the non-extensive thermodynamical regime. Equation of State can be explored in small (pp) & large (PbPb) colliding systems, and extend the CDF UE definition.

Phase transition in neutron stars



The speed of sound examines a peak at densities present in heavy neutron stars, possibly indicating the percolation of hadrons or the appearance of other new degrees of freedom.

Publications of the group

Mishra, A.N. Barnaföldi, G.G. Paić, G. Quantifying the underlying event: investigating angular dependence of multiplicity classes and transverse-momentum spectra in high-energy pp collisions at LHC energies J. Phys. G50 095004 . (2023)

Ramos, A.J.A. Kovács, R. Freitas, M.M. Almeida Júnior, D.S.: Mathematical analysis and numerical simulation of the Guyer–Krumhansl heat equation App. Math Mod. 115, 191-202 (2023)

Takátsy, J. Kovács, P. Wolf, G. Schaffner-Bielich, J. What neutron stars tell about the hadron-quark phase transition: A Bayesian study Phy. Rev. D 108 043002 (2023)

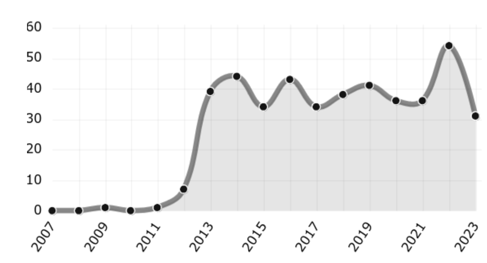
Ván, P. Toward a universal theory of stable evolution Phil. Trans. of the Roy. Soc. Math Phys & Eng Sci. 381, 2252 20220276 (2023)

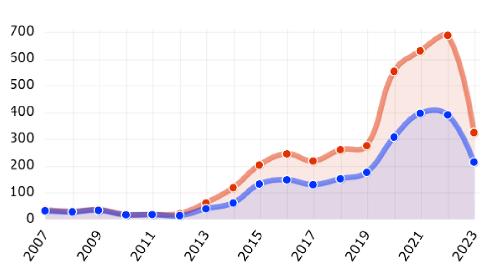
Balassa, G. Estimating scattering potentials in inverse problems with Volterra series and neural networks Eur.Phys. J. A. 58, 186 (2022)

Barna, I.F. Pocsai, M.A. Barnafoldi G.G. Self-Similar Solutions of a Gravitating Dark Fluid Mathematics 10 3220 (2022)

Kovács, P. Kovács, G. Giacosa, F. Fate of the critical endpoint at large Nc Phys. Rev. D 106 116016 (2022)

Mallick, N. Prasad, S. Mishra, A.N. Sahoo, R. Barnaföldi, G.G. Estimating elliptic flow coefficient in HIC using deep learning Phys.Rev. D 105 ,114022 (2022)





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