There are fundamental questions in science, that remain in an unchanged form since the very beginnings of philosophy:

- What are the elementary building blocks of matter?
- What are the forces between them?

In the current state of knowledge we distinct four fundamental forces: strong, weak, electro-magnetic and gravitational interactions. First three of these we were able to unify in the so called Standard Model. It also lists the elementary building blocks: quarks, leptons, gluons, photons and bosons.

However our knowledge of basic building blocks is not enough to predict the behavior of multiple such blocks. We continue to as further, about more complex behavior of matter in the macro-scale:

- What are the states of matter?
- What are the transition between these phases? How do they work?

The matter as we know it from everyday life exists in a state in which quarks and gluons can appear only confined inside hadrons. What do we know about the matter under extreme conditions? Cosmological models predict, that in first microseconds (10^{-12}s to 10^{-6}s) after the Big Bang, when the temperature was higher than trillion Kelvins the matter existed in the state of a soup of unbound quarks and gluons. After that brief moment the very first hadronization happened – spontaneous confinement of quarks and gluons into the particles such as protons, neutrons or pions. The identification of cosmological signatures of this event is however extremely difficult, perhaps impossible.

Another example of the matter under extreme conditions is the core of neutron stars. The estimates of the density in the center of the star is higher the nucleon density. This consequently suggests, that hadrons in such state overlap and the matter should exist in a state of the quark-gluon plasma. Our abilities to study such objects are largely limited as well.

In order to study the matter under extreme conditions we need a method to create it in a controlled fashion – in the laboratory. The studies of collisions of heavy ions deliver such an opportunity. A so called *fireball* – a droplet of strongly interacting plasma – is created for a glimpse of $10^{-22}s$. It is natural to expect that increasing the energy of the collision will result in an increase of the energy density. Therefore we are searching for an anomaly in the production of hadrons in dependence on collision energy, which might suggest the presence of phase transitions between the phases of strongly interacting matter.

The Statistical Model of the Early Stage predicts three main anomalies appearing as a result of a transition between the phase of hadronic matter and the phase of quark-gluon plasma. Following observable dependencies on collision energy are expected:

- *kink* – increased production of entropy in QGP,
- *horn* – decreased production of strangeness per entropy in QGP,
- *step* – a plateau of temperature of the fireball.

Listed signatures were observed in the collisions of Pb+Pb and – what is very important – at the same collision energy.

Phase transitions of water happen in different temperatures at different pressures. Similarly, we suspect that phase transitions of strongly interacting matter will depend on two thermodynamical variables: temperature and baryo-chemical potential. Apart from manipulating the beam energy, we can also change the size of colliding nuclei. This way we can control the temperature and the baryon density of created fireball.

This is exactly the principle that the NA61/SHINE Collaboration utilizes in its research. It is the one and only experiment in the World, which studies the phase transition not only in dependence on the collision energy, but also in dependence on the size of colliding nuclei. This way a much wider range of the phase-space of strongly interacting matter is available for studies. The Collaboration conducts collisions of following systems: p+p (reference measurements), Be+Be, Ar+Sc, Xe+La and Pb+Pb.

In my research I focus on the most interesting of listed systems - Ar+Sc. I call it "the most interesting", because the preliminary results indicate a new phase transition present in the strongly interacting matter. A clear similarity to Pb+Pb system suggests the presence of a percolation threshold (or so called *onset of fireball*). Ar+Sc poses as the smallest of studied systems, in which colliding nucleons create not a number of isolated N+N systems (as in Be+Be), but a droplet of quark-gluon plasma. Such a conclusions shines a new light on the process of the hydrodynamic evolution of the plasma and suggests that thermal equilibrium could be reached even in case of so small systems.