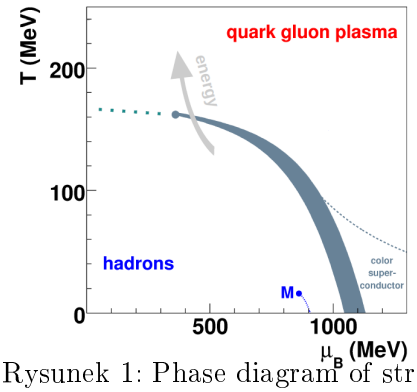
Study of fluctuations of higher order moments of net-charge and multiplicity distributions in energy - system-size scan of the NA61/SHINE experiment at the CERN SPS

The aim of heavy ion collisions is to understand properties of strongly interacting matter. In particular they try to study the phase transition from hadrons to quarks. Currently, there are two large experimental programs performing scan with collision energy in order to study this transition. One is Beam Energy Scan at the RHIC accelerator studding Au+Au collision for various energies. Second is SPS system size - energy scan. There are also three experimental programs under development - FAIR, NICA, J-PARC HI.

The most characteristic phenomena expected at the phase transition is the critical point (CP), where one can not distinguish between hadrons and quarks. The same phenomena happens at the transition between water and steam. The schematic phase diagram of strongly interacting matter is shown in Fig. 1.



Rysunek 1: Phase diagram of strongly interacting matter

Created system behaves in a specific way at the critical point. For example in water at CP the critical opalescence phenomenon appears. In order to measure this characteristic behavior its signatures have to survive hadronization process (confinement of quarks to hadrons) and detection. Theoretical calculations point higher order moments (third and fourth) as more sensitive to the presence of CP than, measured so far, second order moments such as variance. Thus, the characteristic signal of CP in fluctuations of higher order moments should survive till the measurements.

Experimentally higher order fluctuations of net-charge (difference between positively and negatively charged particles) were studied at STAR and PHENIX experiments. They results do not agree. It may be caused by several effects such as different detector acceptance or volume of the measured system and its fluctuations from one event to another. The detector acceptance is also crucial in comparison with theoretical calculations.

The aim of this project is to study phase diagram by measuring fluctuations of net-charge and multiplicity of charged, positively and negatively charged hadrons in p+p, ^{7}Be+^{9}Be and ^{40}Ar+^{45}Sc at the SPS energy range in various acceptance windows. It is a part of the NA61/SHINE experiment, which is a large acceptance hadron spectrometer. Thanks to that, it may measure fluctuations coming from different phenomena and, at least qualitatively, compare results with other experiments. Summarizing, this project will contain:

- For the first time in NA61/SHINE measurements of fluctuations from deconvoluted multiplicity distribution (the measured distribution is convolution of multiplicity and detector response distributions). Statistical uncertainty will be obtained using the bootstrap method.
- In order to reduce influence of volume fluctuations new quantities called strongly intensive cumulants will be used for the first time.
- Study of the phase transition. First, measurements of fluctuations in p+p interactions will allow to understand the background effects which are not fully understand yet. Next, phase transition signals will be searched in larger systems.
- Validate and extend measurements performed in NA49 (Pb+Pb collisions) as well as in STAR and PHENIX (Au+Au) experiments.
- Effect of acceptance will be studied and an optimal size of acceptance for comparison with theoretical calculations will be established for all studied energies.
- Comparison and possibility of improvement of models describing strongly interacting matter.