Summary of the PhD thesis

Investigation of High Momentum Particles in Heavy Ion Collisions

by **Gergő Hamar**

Doctoral School of Physics

Particle Physics and Astrophysics Program

Supervisors:

Dr. Péter Lévai
MTA Wigner Research Centre for Physics, Budapest

Dr. Dezső Varga
MTA Wigner Research Centre for Physics, Budapest

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Introduction

The following work is focusing on a new detector upgrade, called VHMPID, for the CERN ALICE heavy ion experiment. The theoretical works are inspired by its physics program, while the experimental part is about the detector physics research and development activities for the VHMPID.

With the development of particle accelerators and colliders we became able to recreate a new state of matter, the quark-gluon plasma in laboratory experiments. However this new/ancient phase is short-lived, with detection of the exploded fragments one can gain new information about the elementary forces and the history of the Universe as well.

Protons and neutrons consist of quarks and gluons, which can be momentarily freed with high energy collisions of the nuclei, producing a strongly interacting colourful phase. The plasma rapidly cools down while expands, and finally freezes to various particles in the rehadronization process. With the detection and identification of these particles one can examine the properties of the plasma.

Understanding the rehadronization process is crucial for the examination of the produced matter. Various thermal models and quark coalescence models have been created and applied with success. Latter is featured by its inner consistency with the observed quark-number-scaling phenomenon, and its openness to particle correlations. Modern instrumentation aid by improved analysis methods extended the identification capabilities thus quantified the production of heavy hadron resonances. These states were not covered by classical coalescence models. At LHC energies VHMPID will be the device to study these channels, and therefore a need has risen to upgrade our coalescence models.

At CERN LHC the ALICE experiment is the one dedicated to heavy ion collisions. Its detector system was designed in the '90s to be capable of tracking and identifying up to several thousands of particles per collisions. Measurements of the RHIC experiments showed interesting results in the high transverse momentum region thus inspired the extension of identification for higher momenta.

VHMPID is a ring imaging Cherenkov detector designed to extend the track-by-track identification range of ALICE from 5 to 25 GeV/c. Interesting events with such high momenta are rare, therefore a special trigger detector will be needed as well, called the HPTD. This system consists of several layers of gaseous chambers, providing fast trigger signals and valuable tracking informations.

These leading edge detectors were in need for serious research and development to adequately fulfill their duty. In case of the HPTD the low material budget and narrow pad response were the main challenges; while VHMPID should have an outstanding single photon detection efficiency. For their sensitive parts besides the classical and modified wire chambers the novel micropattern technologies could widen the range of interest. The thorough examination and development of the candidates are most delicate for the proper performance of the final detectors.

Research Results

However the rehadronization of the quark-gluon plasma was described with quark coalescence models, therein higher mass resonances could not be included. I have formulated the Resonance Coalesce Model (RCM) which contains even the heavy hadron resonances in a relativistic framework. The new model can be extended for new flavours such as strange or charm, and preserves the precious quark-number-scaling as well.

As an R&D work for the VHMPID detector I have been involved in the design, test, and analysis for the HPTD trigger detector in the Budapest REGARD group. I took part in tests of micropattern TGEM based chambers, and in the development of the novel CCC wire chamber, and their integration into the ALICE experiment.

I was an active participant of the VHMPID beam test measurements, and supported the upgrade with data analysis as well.

I have shown that our novel micropattern based TCPD photon detector is adequate for Cherenkov ring detection. With measurements and their analysis I have shown that the introduced high resolution scanning device is outstanding in examination of micropattern detector elements.

1. **Formulating the Resonance Coalescence Model**

   I have formulated the Resonance Coalescence Model (RCM), which is a quark coalesce based model, where heavy states are created via the proper relativistic mechanics. Resonance productions could be predicted with the introduction of their spectral appearance functions.

   I have shown that the RCM model is open for new flavours, like the charm sector. Production of charm hadrons and charmonia however depends on their initial parameters. I have computed that the inclusion of the decaying resonances do not violate the quark-number-scaling. [1, 9, 10, 11, 12]

2. **Developing a detector system for the HPTD**

   HPTD will serve as the tracking and triggering detector for VHMPID. I investigated the usability of TGEM based micropattern detectors for this purpose. I have shown that the needed spatial and timing resolution can be satisfied, however its sparking probability makes it undesired for the experiment. [13, 14]

   Our group have developed a new close cathode wire chamber, the CCC. I have proven that it fulfills all the requirements for the HPTD detector; and its low material budget and scalability allows us to construct cost effective large area detectors. [2, 3, 16, 15]

3. **Viability of the VHMPID and HPTD detectors**

   I have verified and checked the basic elements of the proposed detector system, with the data analysis of the VHMPID beam tests, thus defining the main points for improvement.

   I have examined the viability of the main parameters of the HPTD. I have shown that with CCC chambers ALICE L1 triggering is obtainable, its efficiency for MIPs are excellent, and its timing properties are satisfactory for L0 triggering as well. [4, 5, 6, 16, 17]

4. **Development and examination of the TCPD photon detector**

   I have developed a novel hybrid UV photon detector, the TCPD. I have proven with measurements that it is usable for ring imaging Cherenkov detectors. [7]

   The main component of the TCPD is a ThickGEM, for what I have elaborated a high resolution measurement system to quantify its photosensitivity and gain distributions on its highly inhomogeneous surface. [8, 19]

During these years I have been involved in several project which are not directly connected to my thesis. I have taken part in discussions of development of non-coalescence based hadron production processes [20]. On the experimental side I were involved in the application of the CCC technology in geo- and environmental physics, namely in the development of a cosmic muon tomography detector system. [23, 24, 25, 26, 27].

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