ALICE Trieste group
Data analysis and detector R&D
PhD projects 2022

The ALICE Trieste group, currently consisting of nine University and INFN researchers and 1 PhD student, has been involved in the ALICE Experiment at LHC since the early phase of the experiment. The group participated in the construction and operations of the original silicon tracker, in the experiment operations and data-taking, and is now strongly involved in multiple physics analysis topics. More recently, the ALICE Trieste group played a crucial role in the development and construction of the Outer Barrel for the Inner Tracking System (ITS) Upgrade, which was installed and commissioned in preparation of the upcoming LHC Run 3 data taking. The group is now engaged in the development of the first vertex detector based on flexible large-area silicon sensors.

The ALICE Trieste group encourages and welcomes students to present PhD projects focused on the topics listed below.

The interested PhD candidates are invited to contact the group for further information.

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Investigation of the properties of the Quark-Gluon Plasma produced in ultrarelativistic heavy-ion collisions at LHC with ALICE

The ALICE experiment is the LHC experiment dedicated to the study of ultra-relativistic heavy-ion collisions. Its main goal is the investigation of the properties of the strongly-interacting matter in conditions of high energy density and high temperatures, expected to characterize the medium formed in such collisions.

Within the ALICE Trieste group, PhD theses covering the study of the properties of the QGP can be proposed:

- Study of the production of nuclei and hyper-nuclei. The production mechanism of these loosely bound composite objects, as light nuclei and hypernuclei in QGP is not clear and is still under debate. In addition, hypernuclei are particularly interesting because they can be used as experimental probes for the study of the hyperon-nucleon (Y–N) interaction. The knowledge of this interaction has gained importance in recent years due to its connection to the modelling of astrophysical objects like neutron stars.

- Study of the production of heavy-flavour hadrons. Heavy-quarks (charm and beauty quarks) are created in hard-scattering processes at the early stage of the collision phase and traverse the medium interacting with its constituents allowing the study of QGP properties as the transport mechanisms and the hadronization phase.

- Study of the production of resonances. Since hadronic resonances decay under the strong interaction with a lifetime of the same order of magnitude as that of the fireball they are suited to study the properties of the QGP created after the collision.

In addition, modern techniques of Machine Learning play a fundamental role in different aspects of the study on heavy-ion collisions, spanning from the Monte Carlo production to the analysis of the collected data, to the quality assurance and data quality monitoring. Therefore, PhD projects related to Machine Learning applications are also possible.

Study of particle production and correlations in small collision systems with ALICE at the LHC

The ALICE detector is primarily dedicated to exploit the physics of strongly interacting matter at the highest energy densities reached in nucleus-nucleus (AA) collisions. ALICE is also studying proton-proton (pp) collisions, both as reference measurements for AA collisions and in their own right. Indeed, one of the most important discoveries in pp collisions at the LHC is the observation of collective, fluid-like features incredibly similar to those observed in AA collisions, where they are attributed to the production of the Quark-Gluon Plasma.

In this light, at the ALICE Trieste group, we are interested in a variety of PhD projects to study the properties of pp collisions in particular as a function of multiplicity also exploiting the usage of the Underlying Event as a multiplicity estimator. In particular:

- study of strange-hadron production in high-multiplicity pp collisions,
- study of charm-hadron production as function of multiplicity in pp collisions.

To this hand, we propose projects to exploit the usage of the Underlying Event as a multiplicity estimator to factorize the harder and the softer components of the events. Through these studies, we aim at understanding the role of Multiple Parton Interactions, collective phenomena and auto correlations in pp collisions, for different identified particle types.

These topics can be extended to proton-ion collisions. In fact, they represent a connection between small (pp) and large (AA) systems.

Novel silicon detector technologies for future experiments

The ALICE Trieste group has been engaged for more than 20 years in the development, construction and operations of silicon detector systems for large collider experiments. The following projects are currently active:

- **ALICE ITS2**
  The most recent example is the upgrade of the Inner Tracking System (ITS2) of the ALICE experiment at LHC, which has been just installed and commissioned, and is now ready for data-taking. The ITS2 is based on Monolithic Active Pixel Sensor (MAPS) technology, which combines the sensitive volume and the front-end readout logic in the same piece of silicon allowing for extremely low material budget and high spatial resolution.
- **Curved silicon tracker**
  In parallel with the support provided to the ITS2 commissioning and operations, the ALICE Trieste group is now focusing the R&D activities on the development of a free-standing tracker with curved geometry. The pioneering technology will allow the removal of support structures and additional material and the realization of a purely cylindrical particle detector. This technology has been chosen for the further ALICE upgrade after 2026 (ITS3) and is being considered for the experiments at the future Electron-Ion Collider (EIC) facility.

- **4D tracking**
  In a longer perspective, the ALICE Trieste group is also conducting research activities towards the development of a 4D tracking detector, able to detect and track charged particles with high timing and spatial resolutions, based on novel silicon technologies like Low Gain Avalanche Diode (LGAD), Depleted MAPS (DMAPS) and Silicon PhotoMultiplier (SiPM).