2023 Helmholtz – OCPC – Programme
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Advanced Artificial Intelligence applications in heavy-ion physics with ALICE.

Helmholtz Centre and/or institute:

GSI Helmholtz Center for Heavy-Ion Research

Project leader:

Prof. Dr. Silvia Masciocchi
Dr. Ralf Averbeck

Contact Information of Project Supervisor:

s.masciocchi@gsi.de   +49-6159-711489

Web-address:

(center) www.gsi.de, (research group) alice-wiki.gsi.de

Department: (at the Helmholtz centre or Institute)

ALICE

Programme Coordinator (Email, telephone and telefax)

Name: Dr. Pradeep Ghosh
Address: Planckstrasse 1, D-64291 Darmstadt
Phone: +49-615971-3257
Email: Pr.Ghosh@gsi.de

Description of the project (max. 1 page)**:**

ALICE is the experiment at the Large Hadron Collider (LHC) devoted to the study of the quark-gluon plasma and other fundamental properties of strongly interacting matter. Since 1996, the ALICE group at GSI is strongly involved in the experiment activities with 1) the operation of central detector systems such as the Time Projection Chamber (TPC), 2) detector calibration and event reconstruction, and 3) several physics analyses in lead-lead, proton-lead, and proton-proton collision data.

The LHC injector chain was recently upgraded, to increase the interaction rate of lead ions up to 50 kHz. The core detector systems of ALICE was also upgraded, to cope with the higher interaction rates and to achieve higher spatial and momentum resolution in the measurement of the produced particles. On one hand, these new features offer the great opportunity of reaching precision measurements of very rare observables. On the other hand, the very large statistics of data and its increased complexity impose a formidable effort in the development of software, data storage and handling, algorithms, and methods.

The TPC operated in continuous readout provides a challenging data flow of 4 TBytes/s which needs to be compressed, reduced (by eliminating clusters of no interest and more), calibrated and reconstructed. Due to the accumulation of space charge in its drift volume, point distortions of several cm's must be corrected in real time. In addition, data are no longer ordered in 'events' corresponding to triggered beam bunch crossings, but in time windows called 'data frames' where

particles need to be sorted and assigned to the individual collisions. Consequently, at analysis level, new strategies are needed to cope with the much larger data sets and their novel structure: more selective algorithms are needed to filter the data of interest and new methods can be developed to fully profit from the improved detector response. It should be noted that all these challenges are common to the future CBM experiment at FAIR, where even higher interaction rates will be handled by a continuous, triggerless readout.

The selected candidate, ideally already knowledgeable of various Artificial Intelligence methods and of the ALICE software framework (O^2), will have the opportunity to participate in the development and application of new calibration, reconstruction, and physics analysis strategies in ALICE. We also envision a collaboration with AI experts, to adopt novel algorithms and tools. The candidate will consequently profit from the improvements in data handling, event and track reconstruction and selection, and extend them to a physics analysis. This will be within one of the research areas of interest in the group, namely the study of charmonium, open heavy-flavour hadrons or light (anti-)(hyper-)nuclei. The goal will be to have physics results for their publication and presentation at international conferences.

The selected candidate will join the various activities and responsibilities of the group in the Collaboration (detector operation, shifts, etc.). She/he will be welcomed by the GSI ALICE group composed of nine staff scientists, five postdocs and ten doctoral students. We are a very dynamic, competent, and welcoming group, which highly values fair and collaborative work.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

Existing and strong collaborations within the ALICE Collaboration at the LHC:
- **CCNU Wuhan**
  Prof. Dr. Daicui Zhou, Prof. Dr. Zhongbao Yin, Dr. Xiaoming Zhang
  Institute of Particle Physics
  Central China Normal University (CCNU)
  Key Lab. of Quark & Lepton Physics (CCNU), MoE
  Wuhan 430079 China
- **UST Hefei**
  Prof. Dr. Zebo Tang, Dr. Xiaozhi Bai
  University of Science and Technology of China (USTC)
  Jinzhai Road 96
  Department of Modern Physics
  Hefei, Anhui 230026 China
- **Fudan University, Shanghai**
  Prof. Song Zhang, Dr. Qiye
  Shou Institute of Modern Physics
  Fudan University
  Shanghai 200433, China
- **China University of Geoscience, Wuhan**
  Dr. Xinye Peng
  No. 388 Lumo Road, Wuhan, P.R. China

Required qualification of the postdoc:
- PhD in Physics
- Experience in experimental physics
- Experience with AI methods: machine learning, neural networks, Bayesian inference
- Additional skills in data analysis in the field of heavy-ion physics (C++, ROOT, Python)
- Language requirement: fluent English (speaking and understanding).