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Facility for antiproton and ion research

The field of accelerator-based research has grown to such a level that most of the experiments in the major accelerator facilities consist of a large number of collaborating members and institutions spreading over different parts of the world, and thereby making them truly International collaborations. It is the use of the cutting-edge technology, not only in the field of advanced detectors but in building the accelerator components that requires collaborations which are large in terms of member-strength and by the marriages of diverse fields of science and technology. One prominent example is the Large Hadron Collider (LHC) which put together latest innovations in practical applications from the fields of cryogenics, vacuum technology, information technology in the form of grid computing apart from the latest developments in electronic sciences. These large accelerator centres, at the end, are for fulfilling the quest of the fundamental questions that govern the nature, including for example looking for the Higgs Bosons, the fundamental particle responsible for generation of mass. Accelerator-based research areas are primarily aimed at looking into the details of the constituents of matter and their interactions with the fundamental forces and thereby cover the fields from atomic, nuclear, condensed matter to high energy particle physics among others.

Over the decades, new member-countries have joined the field by taking part not only in experiments but in building advanced accelerator components. India, for example, has participated in two large LHC experiments, i.e. ALICE and CMS in addition to building several important accelerator components for LHC. It is therefore a natural consequence that India becomes one of the major contributors in building the Facility for Antiproton and Ion Research (FAIR), the large accelerator facility being built at Darmstadt, Germany. India has joined nine other countries on 14 October 2010 in forming the FAIR GmbH, the company which will build and operate the accelerator, a 1.5 billion Euro facility to become operational by 2017. FAIR, which is going to be the largest fundamental science project in the next decade unlike many other large accelerator facilities, is being built to address a large number of unanswered fundamental questions in science, starting from the confinement of quarks, generation of masses of hadrons, creation of high density water at a pressure similar to that believed to be existing in the interior of stars and the inertial confinement of plasma among others. The uniqueness of FAIR is its extremely high beam intensity and wide variety of beam species. Extremely high beam intensity will help to access rarest reaction-products which could not be studied so far due to the requirement of unbelievably long usable beam time. Indian researchers, under the guidance of the Department of Science and Technology and the Department of Atomic Energy, Government of India have been working over the last 5–6 years in identifying the areas of participation both in experiments and accelerator components. The participation in experiments is guided mostly by the extensions of the similar ongoing programmes where Indian researchers are engaged over the decades both inside the country and abroad.

Indian scientists will be engaged in building detectors for three major experimental programmes, i.e. NuSTAR (nuclear structure and reactions), CBM (compressed baryonic matter) and PANDA (facility for the study of hadronic structures using antiprotons). In NuSTAR, exotic nuclear species rich in proton and/or neutron number will be explored using radioactive ion beams and sophisticated instruments for spectroscopy and nuclear reaction studies. Nuclear physicists in major accelerator centres in India, engaged in building similar equipments can extend their study to a so-far unexplored region. The CBM experiment will study the nuclear matter at a density about ten times the nuclear matter density which is equivalent to that believed to be existing at the core of a neutron star, thereby making it possible to study the nuclear matter at extreme densities. Two major questions in science unexplored so far, i.e. confinement of quark and the generation of QCD mass can be studied in this programme. This programme is an extension of studying the QCD phase diagram at LHC and RHIC where Indian scientists are key players. Similarly the groups participating in the COSY accelerator at Juelich, Germany for studying the hadronic structure will participate in the PANDA experiment.

Another area of major participation is building the equipments to be used at the heart of the FAIR accelerator. The key areas identified so far are (a) building a number of large superconducting magnets for the superconducting fragments separator (Super-FRS) to be used by the NuSTAR collaboration (b) fabrication of a large number of power converters for various rings at the FAIR facility (c) building of the beam stoppers to be used for stopping the fragments produced by the primary beam thereby allowing the species to be used as secondary beams to pass through and (d) building a large number of vacuum components for the facility. One unique feature of the participation at FAIR is the involvement of Indian industry in a big way.

FAIR will be the facility for future and the countries including India participating in building such a facility aim to achieve three major goals, i.e., manpower development in the areas of advanced research and technology, access to the latest technology and finally performing advanced research in a facility which is likely to be the nerve centre of fundamental research over the next several decades.

In view of the importance of India's participation in this important facility, we thought only a special section on the 'Facility for Antiproton and Ion Research, Indian participation' will be most appropriate. We have tried to put together a collection of articles which covers the entire spectrum of Indian activities at FAIR. Bikash Sinha being involved in this project from the very beginning is certainly the right person to write an introduction which is followed by articles on three experiments, e.g., NuSTAR, PANDA and CBM. The key feature of India's participation is in building the hi-tech accelerator components and an article on superconducting magnets being built for FAIR is a glimpse of such a wide-ranging activity. I am grateful to Prof. V. S. Ramamurthy and all authors in this issue for making it a reality. We are sure, over the years, the journey of building FAIR and answers to the fundamental questions it would like to address will be equally exciting.

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