Facilities and Instrumentations for Future Nuclear Physics Research in India

B.R. Behera*
Department of Physics, Panjab University, Chandigarh-160014, INDIA
** email: bivash@pu.ac.in*

Introduction

Experimental Nuclear Physics research activities in India started way back in 1940 or so with radioactive sources and nuclear emulsions in Indian Universities. Nuclear Physics curriculum was first introduced at University of Calcutta, Aligarh Muslim University, Banaras Hindu University and gradually in other Universities. Nuclear Physics gradually picked up with the development of Cyclotron at Kolkata and Van de Graaff accelerator at Mumbai. Modern Low energy nuclear physics research geared up with the Variable energy Cyclotron centre (VECC) at Kolkata, Pelletron accelerator facilities both at Inter University Accelerator Centre (IUAC) (Formerly Nuclear Science Centre), New Delhi and BARC-TIFR combined centre. Various large scale experimental facilities were developed for nuclear structure and reaction experiments around the coulomb barrier. In the beginning of this century the accelerators at Delhi and Mumbai was augmented with LINAC booster facility and crossed the coulomb barrier for few heavy target projectile systems. Large scale experimental facilities like Hybrid recoil mass separator HYRA [1], 100 neutron detector array NAND [2] and Gamma detector array INGA [3] became operational. An advanced radioactive beam facility ANURIB at VECC Cyclotron [4] and a high current low energy accelerator for nuclear astrophysics at SINP, Kolkata are also underway [5]. A high current injector programme for the augmentation of the existing accelerator facility of IUAC is also in progress [6].

Nuclear Physics experimental research in India was mainly focused in nuclear structure and reaction around the Coulomb barrier involving projectiles from the existing stable beam accelerators and the experimental facilities. We have limitations of beam current and also overcoming the Coulomb barrier for heavy target projectile combinations. We need a high current accelerator which can produce all beams across the periodic table, where we can do experiments using stable beam.

Nuclear Physics has recently entered into a new domain with radio-active beams (RIB), and many small and large scale accelerator facilities are operational around the world. Large numbers of exciting new results are reported from these facilities. We urgently need such a facility in our country to be competitive and also a training ground for the utilization of large international RIB facilities.

In may 15 minutes presentation I shall summarize on a short term goal (achievable in 5 years time with the up gradation of the existing facilities) and long term goal (10 to 12 year time which involves creation of new facilities)

Immediate Short term Goal

Accelerator in Universities: Much of our nuclear physics programme is driven by our Ph.D. students. However due to limitations of accelerator time at national accelerator facilities there is not enough exposure to the students and the training is not enough to make leaders who can expand nuclear physics further. Few small accelerators must be established in few universities to augment the national accelerator facilities. The accelerator proposal from Panjab university, Chandigarh and Benars hindu university, Varanasi must be supported by funding agencies.

Detector fabrication facilities: The back bone of any nuclear physics research is detectors. Though many large detector arrays are established in the country, but the expertise is limited to only few institutes. If we plan to

Electronic address: bivash@pu.ac.in

expand nuclear physics activities with the existing accelerators and to create further mega facilities, creation of few detector fabrication facilities must be encouraged immediately. It should not be limited to only accelerator facilities.

A set up for transfer induced fission study: Recently a 100 neutron detector array (NAND) [2] has started operating at IUAC, New Delhi. This facility can be augmented with a set up for a transfer induced fission studies. With the availability of LINAC and upcoming High current injector (HCI), Interesting physics problems for the determination of fission barrier, fission probability and multi-chance fission can be studied with this set up along with the existing NAND facility. This facility will consists of the existing neutron array with few large solid angle multi-wire proportional counters for the detection of fission fragments and solid state detector arrangements for the transfer products.

Light RIB production with the existing accelerator facility: Some time back [7] ^{7}Be RIB with beam intensity 10^{4} was developed at IUAC, New Delhi and several experiments have been performed. Such programme can be extended and beams like ^{8}B, ^{10}Be, ^{6}He and ^{12}B may be developed using multi-nucleon transfer or fusion evaporation reaction with the beams from the present stable beam accelerator as primary accelerator. A large acceptance double solenoid facility may be established and secondary beams can be produced in-flight by transfer reaction. HYRA of IUAC may also be exploited for producing RIB. I shall present two three such possibilities for the RIB production. Few of the open problems with elastic scattering and fusion reactions with RIB can be studied with these facilities.

Long term Goal

Long term goal is for 10 to 15 years of time. With the existing accelerator we have expertise in the fabrication of the super-conducting LINAC booster accelerator, drift tube Linac, Low beta cavity, ECR ion sources, magnet design and RFQ. With this expertise we propose that we should go for a next generation high current stable beam machine where we can overcome coulomb barriers for large number of heavy target projectile combinations. Part of such beam may be exploited for RIB production. It has to be a new machine and a National facility.

Presently at BARC a Low Energy High Intensity Proton Accelerator (LEHIPA), as front-end injector of the 1 GeV accelerator for the ADS programme is underway. Efforts may be done to exploit part of this facility for the production of the RIB for the Indian nuclear physics community.

Acknowledgments

Discussion with Dr. S. Mandal, Dr. R. Plait and Dr. A. Jhingan is acknowledged.

References

1. N. Madhavan et. al, Pramana – J. Phys., 75, 310 (2010).
2. P. Sugathan et. al, Pramana – J. Phys., 83, 807 (2014).
3. S. Muralithar et. al, Proc. DAE. Symp. on Nucl. Phys. 52, 647 (2007).
4. A. Bandyopadhya et. al, Pramana – J. Phys., 85, 505 (2015).
5. S. Roy, Proc. DAE Symp. on Nucl. Phys. 63 (2018).
6. R. Mehta et. al, Proc. 7th DAE-BRNS Indian particle accelerator conference, 106 (2015).
7. J.J. Das et. al, Ind. J. of Pure and Appl. Physics, 39, 20 (2001).
8. A. Leipine Szily et. al, Eur. Phys. J. A 50, 128 (2014).
9. P. Singh et. al, Pramana- J Phys. 68, 331 (2007).

Electronic address: bivash@pu.ac.in