The dream North Eastern Accelerator Facility: R &D efforts by CUPAC NE Collaboration

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1. Introduction: The NE (North East) region of the country, often called as seven sisters, has recently got one more sister: Sikkim and now we are 8 states all together. We all combined together to form CUPAC (Cotton University Particle Accelerator Centre)-NE collaboration. The primary mission of the collaboration is to realize an accelerator facility in the region to educate our young students and faculties in accelerator science & technology and perform world class research using accelerators. Some guiding principles adopted by the core committee:

- The accelerator and experimental system should be designed with a clear focus to perform research on new and emerging frontiers of modern science,
- Efforts should be made not to divert from the primary mission of education and skill development of NE students.
- The scientific merit should be the sole consideration in developing the facility.

2. Methodology: Following these guidelines, the collaboration had worked tirelessly over 2 years and prepared a project proposal for the accelerator facility. The facility consists of two state of the art accelerators: a 5 MV Van-de-Graff (VdG) with an ECR ion source at the high voltage terminal and a PIMS (Positive Ion Mass Spectrometry) facility again with an ECR ion source. The PIMS setup is conceptually similar to the injector of the VdG with addition of a CEC (charge exchange cell) and a high resolution mass spectrometer. Both the accelerators are unique to the nation and will significantly enhance the research competitiveness of in several domains: nuclear astrophysics at Gamow energy, neutron science and behavior of materials under extreme conditions etc. as discussed in the ref. [1].

Getting into second set of guidelines, we have put significant efforts in preparing a roadmap that will allow us to educate and enhance skills of students. The 2 step philosophy we adopted for this purpose was:

- Identify technologies & instrumentation unique to the proposed accelerator, experimental facilities and world class scientific research being performed using similar accelerators elsewhere. Then we try to design the required instrumentation from first principle with dissertation students. If a feasible design could be worked out, we collaborate with national laboratories and prepare a project and submit those projects for competitive funding.
- Students will be trained in scientific & technical skills required to develop these instrumentation from scratch. In addition, as our university does not have engineers, we decided to train all our students' mandatorily in 3D auto CAD and involve in fabrication, assembly and installation process. We also require that they have expertise MS excel. We also train them in the state of the art simulation codes relevant to accelerator physics & technology and modern experimental system e.g. ion optics (GIOS, GICOSY and SIMION 8.2), Gas flow system for windowless gas cell (developed in-house), and simulations for neutron sources (GEANT4) etc.

3. Results and discussions: As examples of the efforts we put in education and skill enhancement to our PG students, we describe the following R &D projects:

- **Differentially pumped windowless gas cell for PIMS:** This is a critical technology for PIMS and nuclear astrophysics. Again, our country has not yet developed such a system. We completed the physics and mechanical design of the system and fabrication had already started. The projects are funded by BRNS [2] and IUAC [3]. Detailed design will be presented as a paper in this symposium [4].
- **AD-BNCT (Accelerator Driven Boron Neutron Capture Therapy) system:** This is a major focus of the collaboration involving 15 different institutes & universities of the NE region and outside. As the technology is under strict export control, we came up with a method to produce fast monochromatic neutron beam and moderation optics to produce epithermal neutron beam using HIRA facility at IUAC. The first order physics and engineering design were completed as dissertation project [Mridul Deka, Cotton University, funded by IUAC AUC#71368]]. The validation of the neutron optics using GEANT4 is at advanced stage [M M Devi and her group]. Another design project to develop a **'commercial scale Neutron Beam Shaping Assembly'** was funded by UGC-DAE-CSR [5]. Initial CAD design and optimization was completed and is presented as a paper in this symposium [6].
- **Investigation of neutron sources in AGB stars using time reversal method:** Accurate and precise values of astrophysical S-factors of the neutron sources are of highest priority in contemporary nuclear astrophysics. Currently available data suffer from large uncertainties originating from the absolute normalization. We are proposing a novel method with an aim to eliminate such errors. For this purpose, 'CUPAC-NE BARC neutron source' is proposed to be constructed at BARC-TIFR Pelletron Linac Facility. The production reaction will be p(^{7}Li,^{7}Be)n reactions in inverse kinematics. The setup is designed to take (n,α) data on ^{13}C and ^{16}O targets in kinematic coincidence with ^{7}Be. The project is under review by SERB [Das and Santra et al.]
- **Ion optical design of the ECRIS injector:** The injector optics of the accelerator has unique challenges: (i) containing the injector system in the restricted space available inside the HV terminal and (ii) ensure low injection energy required to match Gamow energy for nuclear astrophysics. As such accelerators do not exist in the nation, this project will be useful to the nation [submitted SERB: Barthakur et. al 2022].
- **Design of beam line transport optics for supersonic jet:** Supersonic jets are essential for nuclear astrophysics experiments. It requires special optics for beam transport as high intensity beam has to past through several stages of widely separated collimators of the differential pumping station. A dissertation student is working on the first order optics design of the beam line.

Brahmaputra Lab at Cotton University: We proposed to construct a laboratory with requisite infrastructure for assembly and testing of the hardware to be developed for these projects. Only the fully commissioned setup will be taken to national laboratories for in beam testing and research. BSc and MSc students from Cotton and other NE universities will be invited to Cotton to achieve this.

4. Conclusion: If funded, the CUPAC-NE accelerator will be unique in the nation and open up several new domains of research in which the nation is not globally competitive. The collaboration had identified several R &D projects in technologies critical to the accelerator and experimental system. Students from the NE region will develop the entire instrumentation, make it operational and perform research at national laboratories. Students are also given necessary theoretical foundations to comprehend these advanced technologies. We hope these young students will cater to the requirements of skilled manpower for the project.

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5. References:

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