

ADSS : Development of High Current Cyclotron

The Department of Atomic Energy has emphasized the need to pursue a program for large-scale utilization of thorium fuel for nuclear power generation through Accelerator Driven Sub-critical Systems (ADSS). The most important component of such a system is the development of a high energy high current (1 GeV, 10 mA) proton accelerator. A combination of cyclotrons (injector, intermediate stage and final booster) is considered an excellent option for delivering high power as needed by ADSS. Cyclotrons, operating presently in various laboratories around the world, were designed preliminarily for research in nuclear and particle physics with low current requirements. The compact cyclotrons designed for medical applications are now a days providing hundreds of micro ampere beam. The beam power available from these machines are at least one order of magnitude lower than that needed for ADSS. In order to achieve 10 mA proton beam at 1 GeV using cyclotron, certain critical issues are required to be studied in detail, particularly at low energy regime where the space charge forces dominate.

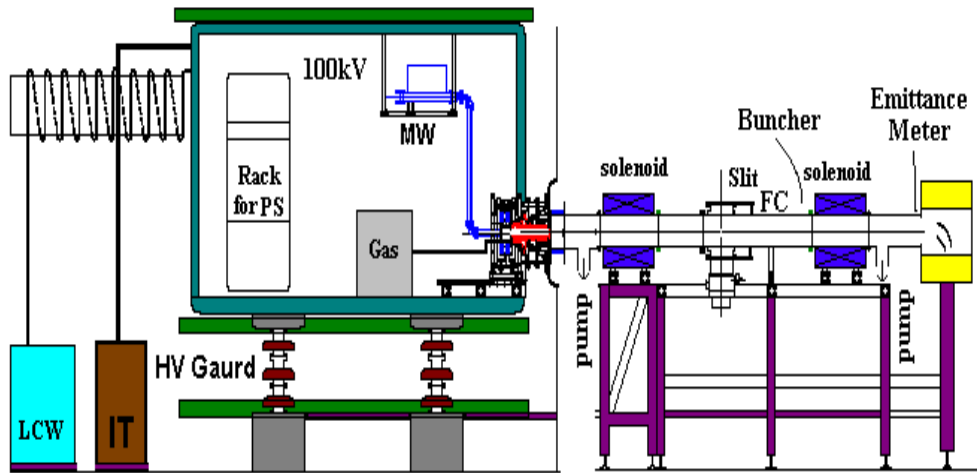
VECC is working on the development of the first stage of this complex accelerator system, a 10 MeV compact proton cyclotron. The basic aim of this project is to study and settle various physics and technological problems associated with the production and handling of high intensity beams. There are three steps in this R&D work

- a) Development of microwave ion source (~20-30 mA cw).
- b) Transport and injection of beam into the cyclotron.
- c) Design, construction & operation of a 10MeV, 5mA cyclotron.

The challenges involved in such R& D works are

- a) Restriction of beam loss is the main issue and must be strictly controlled. The detection, collimation, extraction and shielding should be proper.
- b) At high intensity space charge effects are the major source of beam loss. The transverse space charge effects are serious at low energies but the longitudinal one are of concern throughout.
- c) A high power efficient rf cavities are necessary to take care high beam loading and at same time to supply high dee voltage.
- d) The reliability should be high ~95% and thus some redundancy needs to be built into the design.

The development of low energy high current accelerator in the space charge domain is the latest field of activity in the accelerator technology. The first phase of this development which is 2.45 GHz microwave ion source, to deliver a 30 mA proton beam at 100 keV, is near completion. This beam will be characterize and transported by a low energy beam injection line and will be used for injection study. The important design parameters of the cyclotron are listed in the table and the layout of the injection line, ion source, high voltage deck is shown in the Figure.



Ion source and injection line test bench

Injection Energy	100 keV
Final Energy	10 MeV
Hill Field B_H	1.5 T
Valley Field B_V	0.15 T
Pole gap Hill / Valley	4 cm / 66 cm
Hill angle max.	34.2°
No. of resonators	2 Δ type, 45°
RF Voltage inj. / extr.	125 / 150 kV
Injection radius	> 6.6 cm
Phase width	$< 30^\circ$
Radial tune ν_r	1.1 - 1.2
Vertical tune ν_z	0.61 - 0.99
Beam current	5mA
Turn separation	6mm @5mA
I (limiting) TSC / LSC	15mA/13mA

Important parameters of 10 MeV cyclotron



Ion source and injection line (near completion)