VACUUM SYSTEM OF THE RCNP RING CYCLOTRON

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Abstract

The object of the vacuum system of the RCNP ring cyclotron is to evacuate the acceleration chamber to reach a pressure region where the accelerated ions are transmitted without significant beam loss due to charge state exchanges. The design goal is to attain to 1×10^{-7} Torr for 60 m^3 chamber within 10 hours after the pumping has been started from air.

Vacuum Requirements

The ring cyclotron is a booster accelerator for protons through heavy ions following an injector cyclotron[1]. The acceleration chamber consists of 8 demountable sections; 4 separate sector magnets, 2 RF cavities and 2 valley sections where beam injection and extraction systems and beam diagnostics should be equipped (Fig. 1). The RF cavities should be drawn out radially with ease for maintenances.

The attenuation of a beam dn in traveling a distance dl in a vacuum chamber having N_i atoms/cm^3, where i denotes a specific species, is;

$$dn = n \sum_i N_i \sum_m \sigma_i (q,q\pm m) dl$$

where q denotes the ion charge and m=1, 2, $\cdots$. In the acceleration process, charge exchange cross section $\sigma(q,q\pm m)$ is a function of ion velocity and charge state, an order of magnitude of 10^{-16} cm^2 roughly.

In our case, a residual pressure of around 2×10^{-7} Torr is estimated to transmit 95% Ar ions for 1.5 km traveling length in the ring cyclotron.

Surfaces Exposed to Vacuum

These surfaces include;
- Stainless steel walls of the chamber
- Copper-clad steel of RF cavities
- Copper plates of cavity electrodes
- Mild steel of the poles of 4 sector magnets
- Stainless steel and copper assemblies of the trim coils
- Electric and magnetic elements for beam injection and extraction
- Beam monitoring and diagnostic instrumentations
- Elastmer seals for demountable sections

The diameter of the chamber is about 8 m, the height of RF cavity is about 4 m and total volume to evacuate is around 60 m^3. The surface area exposed to vacuum amounts to about 800 m^2 and the estimated degassing rate from well treated metal walls

after 10 hours of pumping is around 4×10^{-3} Torr l/sec and another same amount of those from elastmer seals and miscellaneous components equipped under vacuum. Sub-vacuum system covering trim coil assemblies will be examined in case of apprehensions of noticeable degassing source from coil insulator materials and feedthroughes.

Pumping System

To attain a design goal of 1×10^{-7} Torr, the evacuation system should have high pumping speeds and conductances at 10^{-7} Torr region. Several choices of pumping system are available based upon the present art of technology. Cryo-condensation panel circulating liq. He mounted on the magnet gap or inside dee aperture which offers all advantages namely extreme cleanness, high pumping speeds and conductances, low ultimate pressure and complete regeneration is one of the most challenging technique if the other obstacles are overcome.

The installation of the 20 K cryopumps with cryo-absorbing charcoal units are the realistic choice at present stage. The auxiliary pumping units —— turbomolecular and/or baffled diffusion pumps —— will be added for rare gasses and for pumping down the chamber to the operating pressure of the cryopumps. These pumping units, the total speeds of around 1×10^{5} l/sec for N_2, are distributed on R.F. cavities and valleys. The influences of ambient magnetic field which remains at cyclotron periphery on pumps should be taken into account. Generally, 100 Gauss of axial magnetic field is maximum permissible field level for the turbomolecular pump rotors whereas the cryopumps withstand up to several times of the field level.
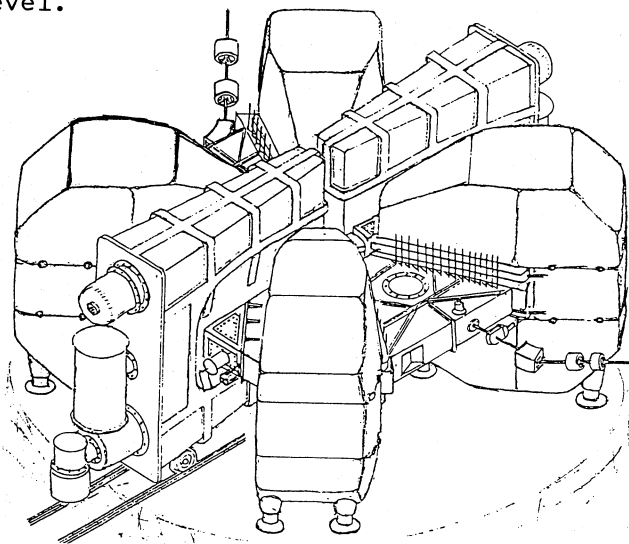

Fig. 1.   An aspect of the ring cyclotron

Reference
1)   Miura, et al., Proceeding of 9th International Conference
      on Cyclotron and their Application, p. 89, CAEN, 1981.
      Miura et al. Design Study of the RCNP Ring Cyclotron,
      these conference.