SYNCHROTRON

At very high energies, the particles travel close to the speed of light and their motion is now described by relativistic equations and their travel time is no longer the same for each semi-circle.

To overcome this, careful synchronization is needed to make the electrodes change their polarity as the particles pass through each acceleration section. The magnetic field is increased to keep the moving particles in a moving circle of constant radius.

The Synchrocyclotron

- The Synchrocyclotron is a modification of the classic Cyclotron design developed to overcome the relativistic limitations on the classic Cyclotron

- The Synchrocyclotron differs from the classic Cyclotron in that the frequency of the AC voltage does not remain constant, it synchronizes with the orbit frequency of the accelerated particle.

The modified Cyclotron had one of the D-shaped electrodes removed (1). The particle is accelerated in the same way as in a Cyclotron except that the RF generator responsible for producing the AC voltage which accelerates the particle is replaced with a variable frequency RF generator (2) so that the AC frequency can be synchronized with orbital frequency of the particle. The AC voltage is applied across the remaining D-shaped electrode (3) and a new deflecting electrode
(4) which is responsible for directing the particle out of the accelerator and towards a target (5).

Compring magnetic forace and centripetal force

$qVB=mV^2/R$ → $V=qBR/m$

Then time to travel is

$T=2\pi R/V$ → $T=2\pi R/(qBR/m)$

Or $T=2\pi m/qB$

So, frequency

$f=qB/2\pi m$ But for relativistic case

$m=m_0/\sqrt{1-v^2/c^2}$

$f=(qB/2\pi m_0)(\sqrt{1-v^2/c^2})$