Cyclotron

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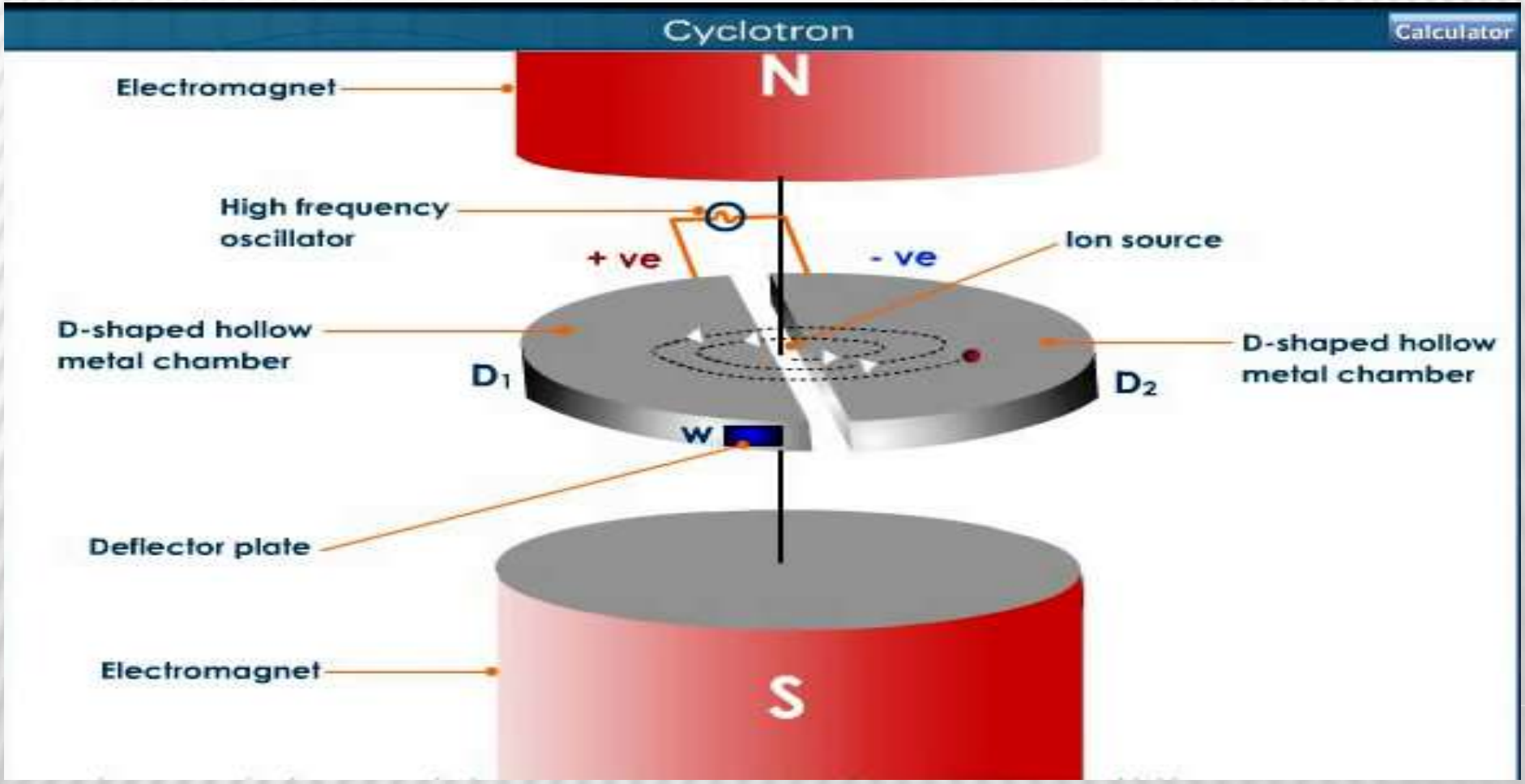
Principle

- Lorentz's Force is the basic principle of Cyclotron

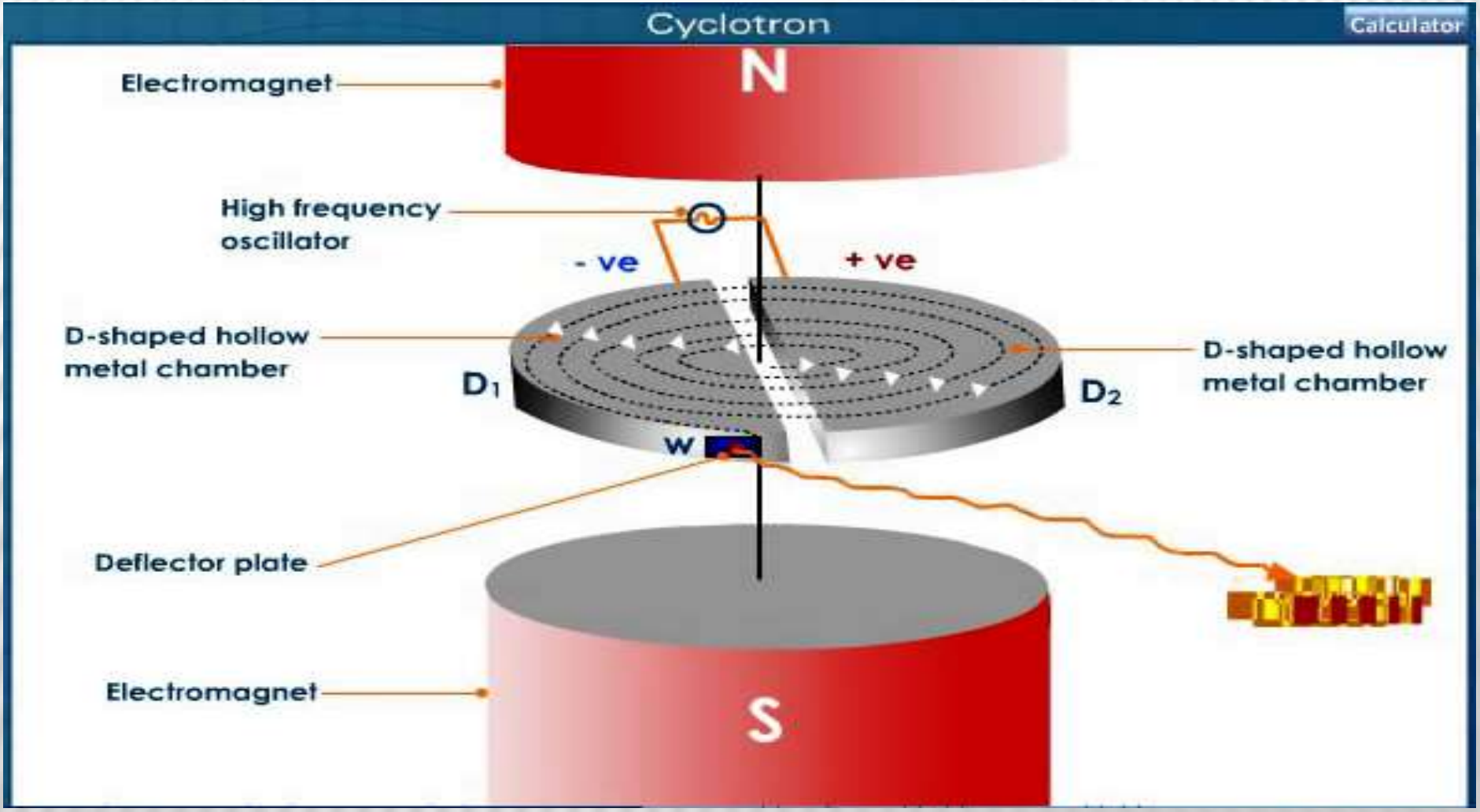
•An electric field accelerate a charge particle and magnetic field bend the charged particle into a circular path such that its frequency of revolution does not depend on its speed. Thus, the radius of the circular path increases, the speed of the charge particle is goes on increasing.

Diagram



E.O.Lawrence and M.S Livingston invented the cyclotron accelerator in 1929 and get Nobel prize in 1939 on developing cyclotron.

Diagram


Cyclotron
Calculator
Electromagnet
N
High frequency
oscillator
- ve
+ ve
D-shaped hollow
metal chamber
D1
D2
D-shaped hollow
metal chamber
W
Deflector plate
Electromagnet
S

Components of Cyclotron

- Magnetic system.
- Ion source system.
- Dees.
- RF system.
- Extraction system.
- Vacuum system.
- Target assembly

Construction

- It consist of two hollow metallic semicircular cylinders (Electrodes) D1,D2 which are flat and in the shape of letter "D" (Hence, these electrodes are called "Dees"), placed along its diameter with a small separation or gap between them.
- Dees are enclosed in a evacuated chamber
- The dees are connected with radio frequency oscillator which changes the polarity of dees periodically.
- A source of charge particle is located at the midpoint of gap between two "Dees" and poles of electromagnet which are placed above and below the dees.
- Accelerated Ions are bring out from a window or deflector plate that is fixed on the dee and hit on the target or a nucleus for nuclear reaction.

Working

- A positive charge particle (proton) having a charge “q” is emitted from the ion source .
- Let us assume that at this instant D2 is negative and D1 is positive. Charge particle accelerated towards D2 due to electrostatic attraction with speed V2 where it face magnetic field and tend to move in a circular path.

- After completing a semicircular path, particle reaches again between the gap of dees. Due to shifting of AC signal from Positive to negative, Particle accelerated towards D1 which is negative at that instant.

- Now Particle accelerated towards D1 with higher speed V1 where it again tend to move in a circular path.

- After completing another semicircle, particle again reaches between the gap of dees, now D2 is again negative and D1 is positive.

- This process is continue and particle is accelerated more and more (i.e.K.E energy increases)in each its flight from gap towards dees.

- As they gain energy, their rotational radius is also increases and ions spiral out from the dees.

- Window or deflector plate helps to take the ions out and ions are allowed to hit a target or a nucleus to bring about a nuclear reaction.

Advantage

- Utilizes a single, electrical driver.
- This saves energy and cost as well.
- High power due to continuous stream of particles.
- Compact design.

Limitations

- Maintaining a uniform magnetic field over a large area of the Dees is difficult.
- At high velocities, relativistic variation of mass of the particle upsets the resonance condition.
- At high frequencies, relativistic variation of mass of the electron is appreciable and hence electrons cannot be accelerated by cyclotron.

Applications

- Best source of high-energy beams used for experiment in nuclear physics, where high energy collisions are required.
- Cyclotrons can be used in particle therapy (proton therapy) to treat cancer.
- Cyclotron beams can be used to bombard other atoms to produce short-lived positron emitting isotopes suitable for PET imaging .