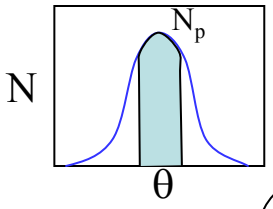
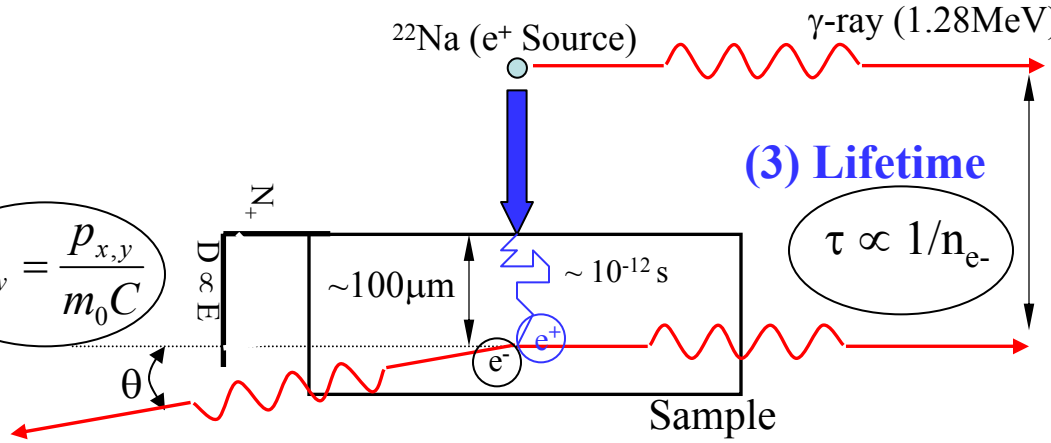
Variable low energy positron beams

Positron annihilation spectroscopy

(1) Angular Correlation

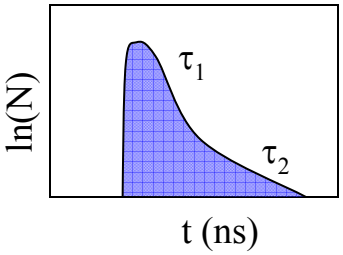


$$\theta_{x,y} = \frac{p_{x,y}}{m_0 C}$$



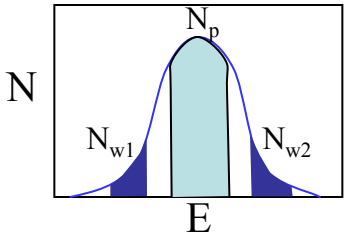
(3) Lifetime

$$\tau \propto 1/n_{e^-}$$



(2) Doppler Broadening

$$\Delta E = \frac{C p_z}{2}$$



$S = N_p/N_{total}$

$W = (N_{w1} + N_{w2})/N_{total}$

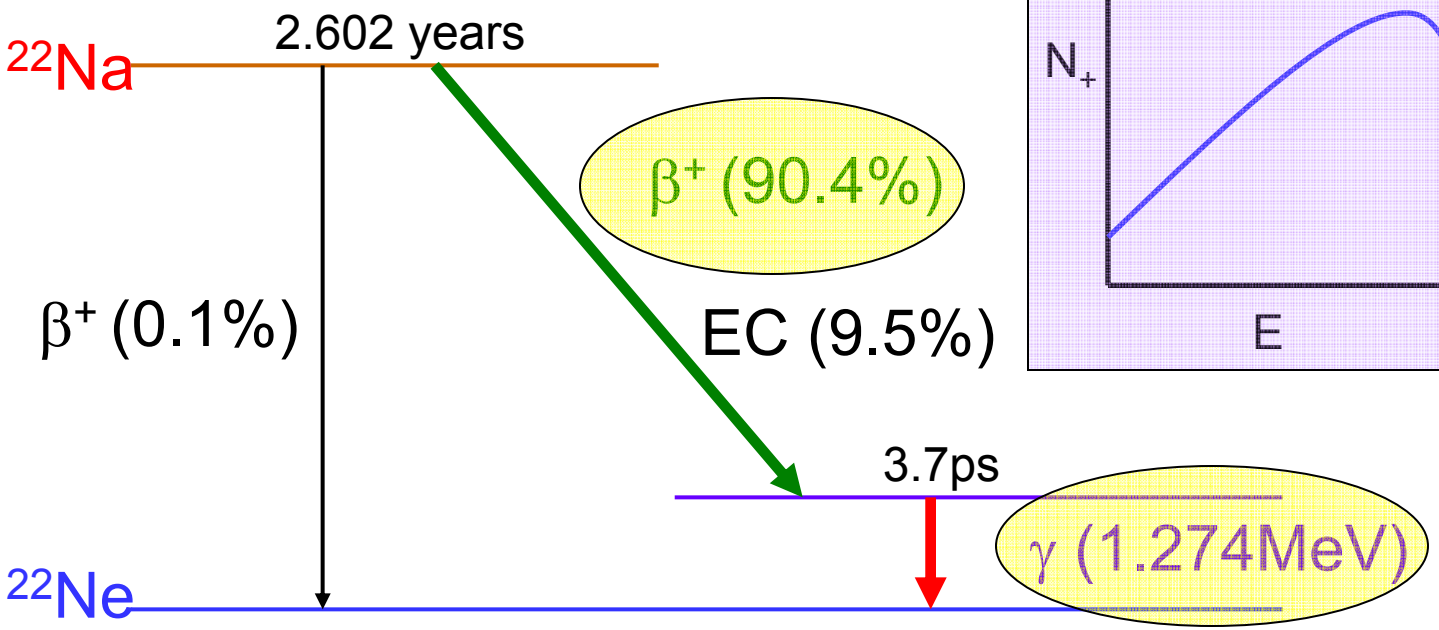
Conventional positron sources – isotope sources

^{22}Na, ^{64}Cu, ^{58}Co, $^{68}Ge(^{68}Ga)$….

Work horse

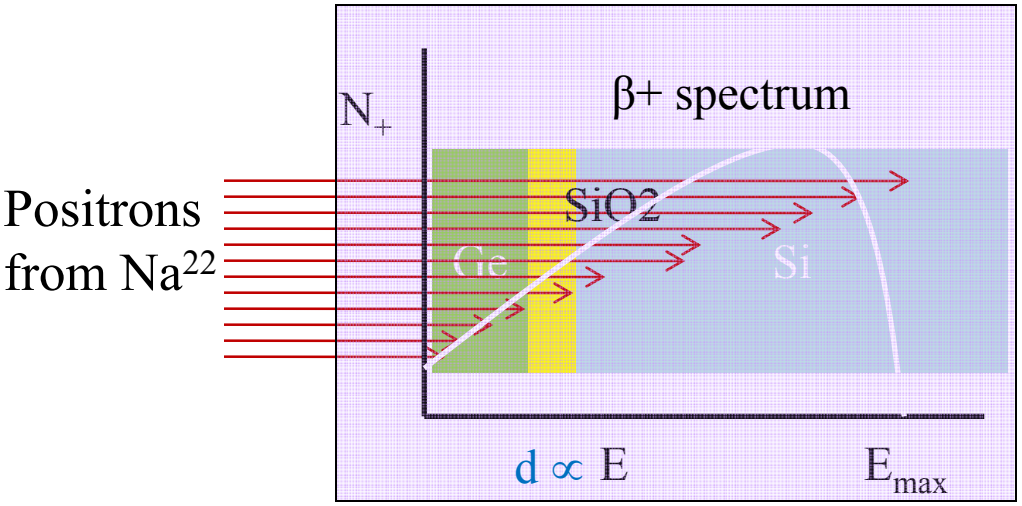
$$^{22}Na \longrightarrow {}^{22}Ne + \beta^+ + \nu + \gamma$$

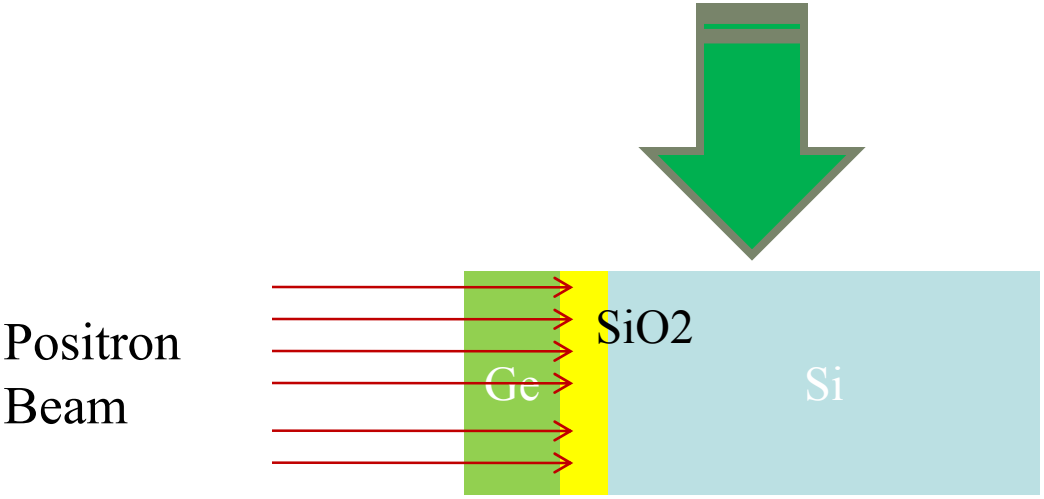
Decay Scheme



Due to continuous energy of positrons from a radioactive source, there is no control over its energy. Hence, selective depth profiling of defects in materials cannot be performed.

Need for positron beam





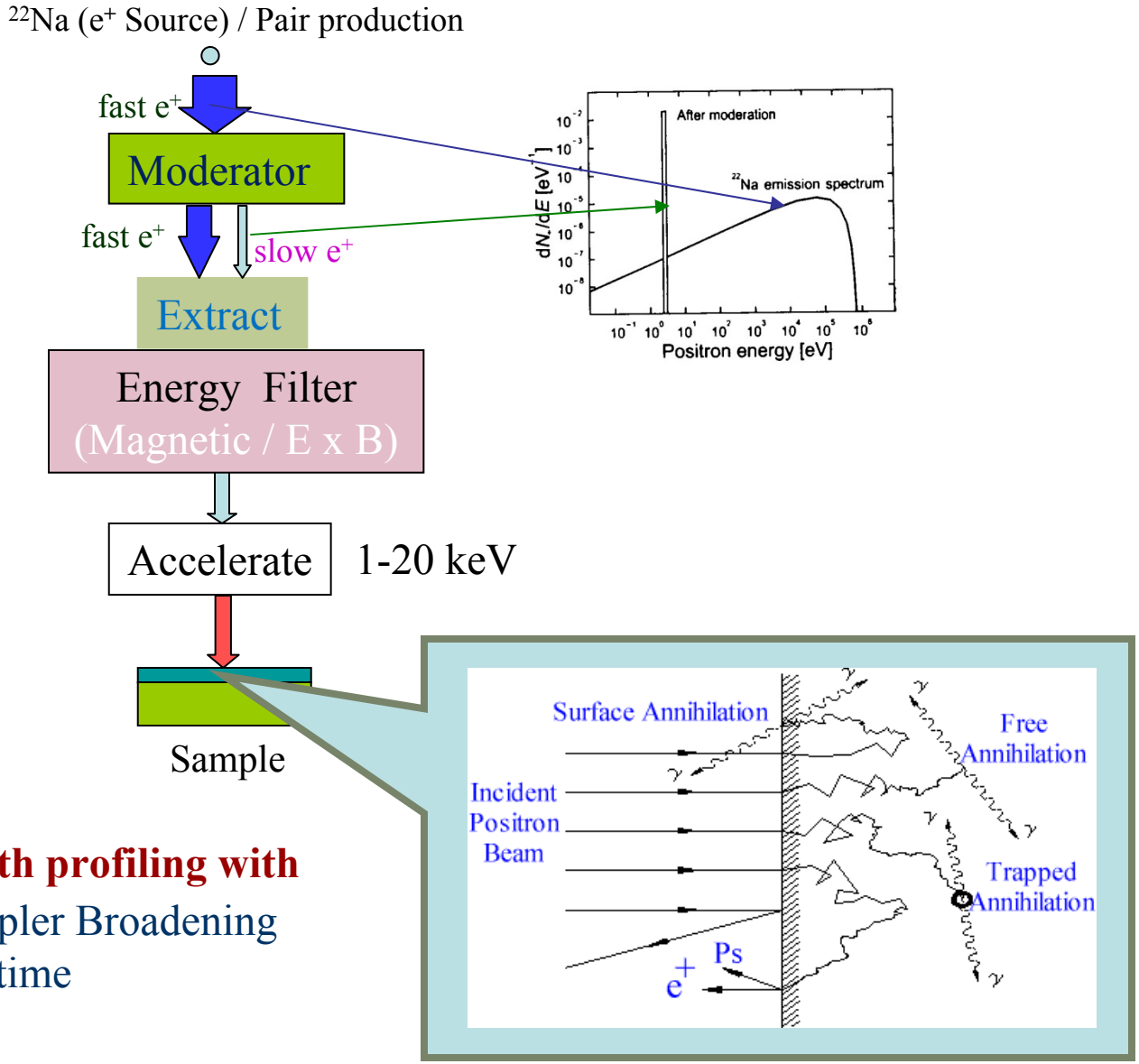
With a monochromatic positron beam (with variable energy) selective depth profiling is possible.

Variable low energy positron beams

- **Useful for depth resolved defect profiling in thin film structures – *Solid State Physics***
- **Studies on positron - atomic /molecular interactions, Positronium formation and its interactions – *Atomic Physics***
- **Generation of electron - positron plasma & positron diagnostics of plasma – *Plasma Physics***

- Radioactive based laboratory beams (10^4-10^5 e^+/s)
- Intense Positron beams (10^7-10^9 e^+/s)

Slow positron beam production scheme

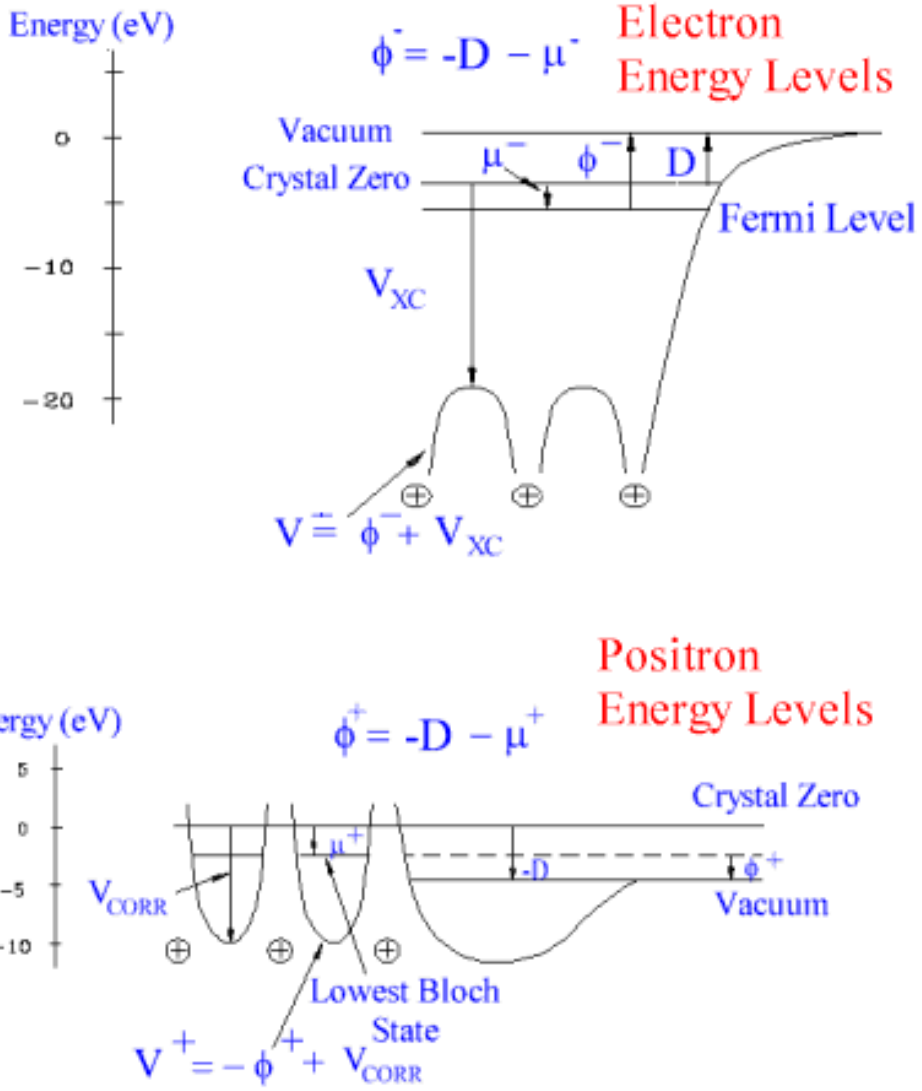


Depth profiling with

- Doppler Broadening
- Lifetime

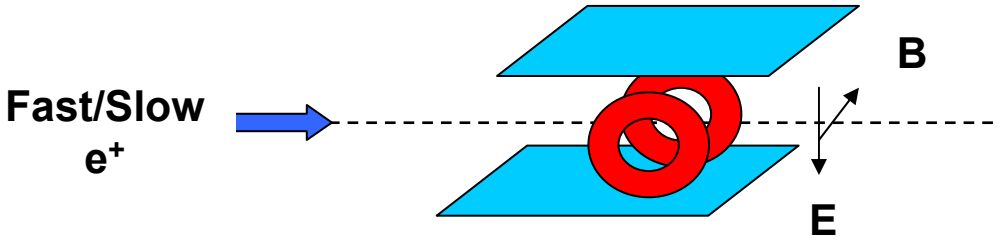
Work function of positron and electron

- Electron work function for metallic surfaces is positive i.e., we need to supply energy to extract electrons out of them.
- On the other hand, some metallic surfaces have negative work function for positrons. Hence, they can spontaneously emit monochromatic positrons, with very small thermal energy spread.
- These are called positron moderators ex., W (100)



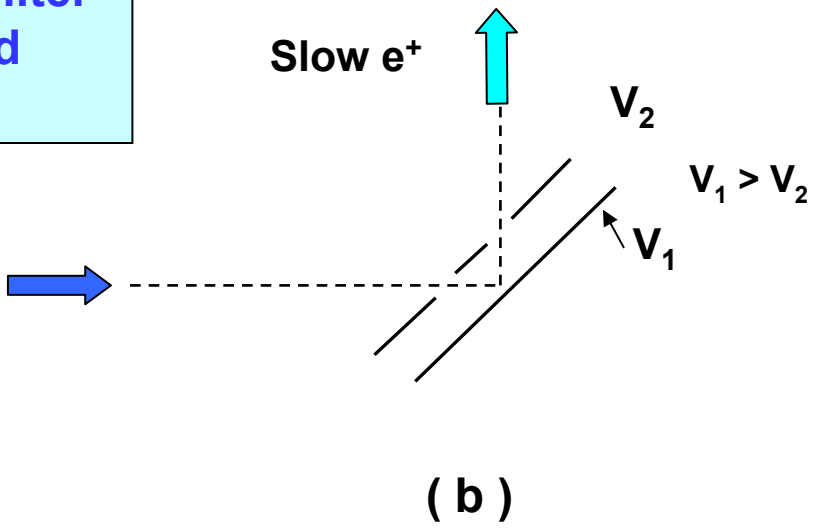
The heart of variable low energy positron beams is the moderator, which acts as a source of monochromatic positrons.

Slow/Fast Filters

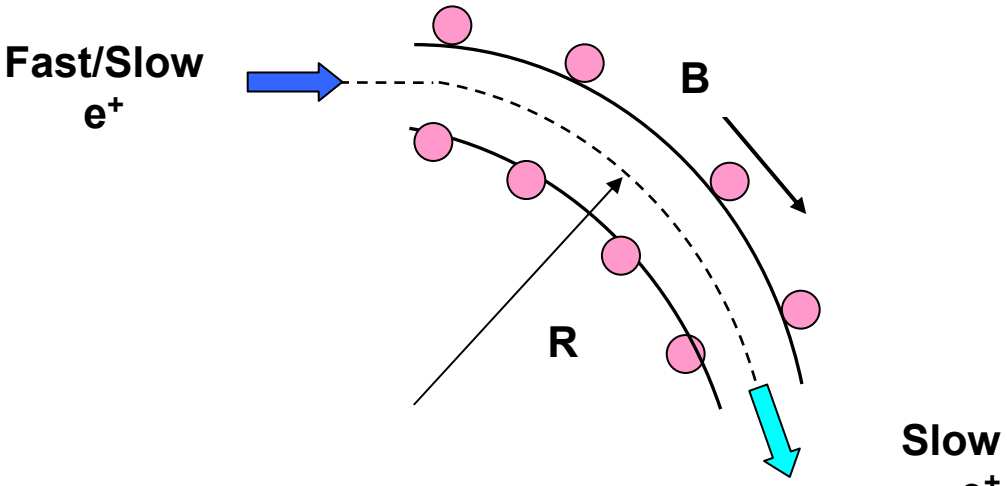


(a)

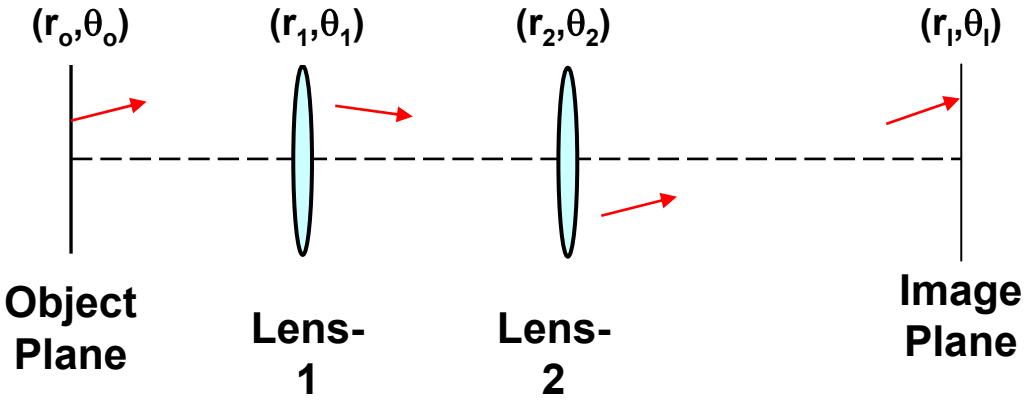
Basically there are three filters (a) E X B filter (b) Electrostatic filter (c) Magnetic curved filter



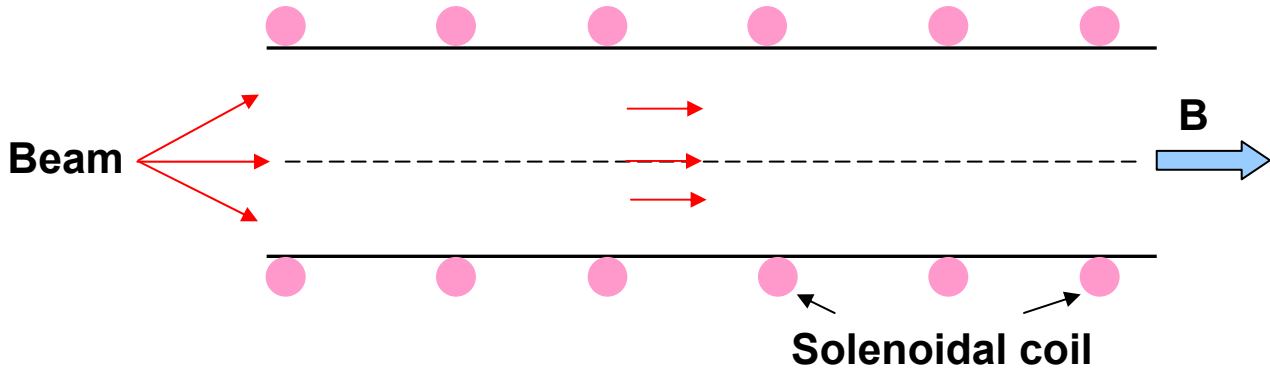
(b)



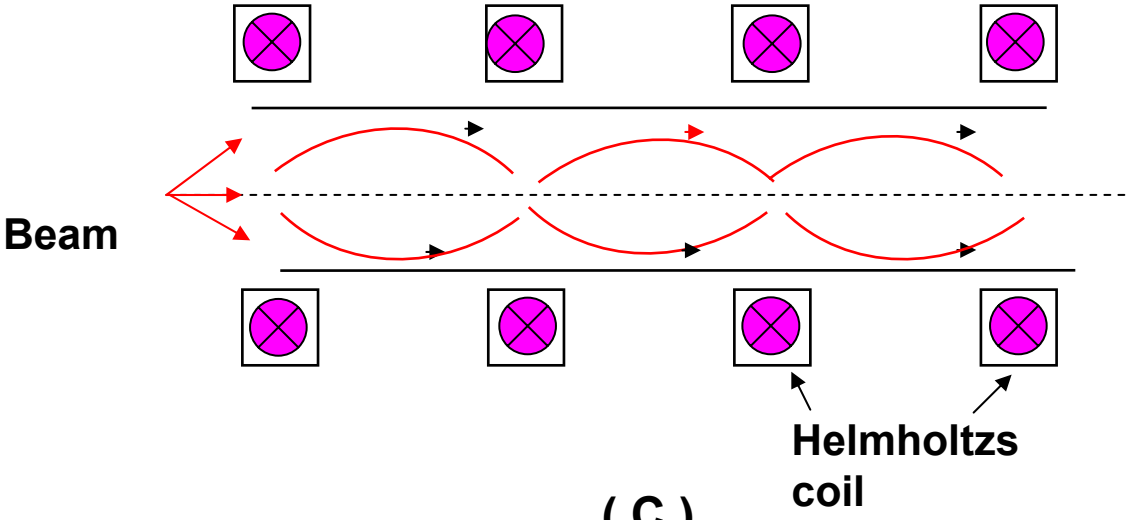
(C)



Beam transport can be accomplished by either electrostatic lenses or confining magnetic field.

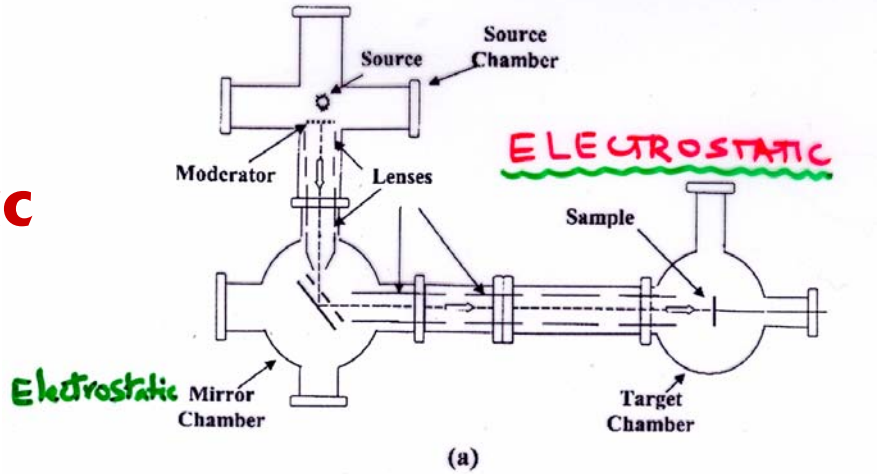


(b)



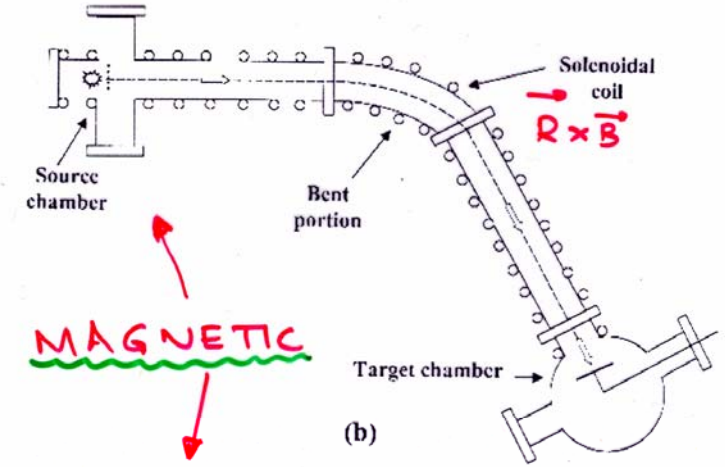
(C)

Electrostatic

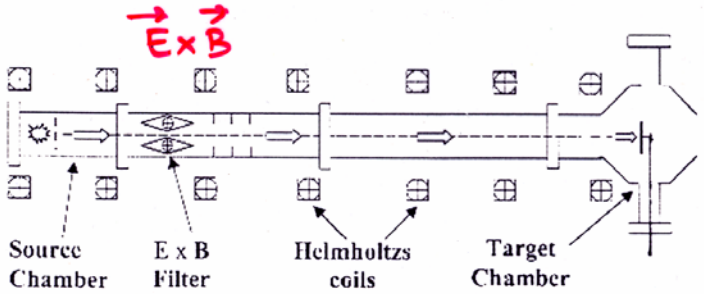


(a)

Magnetic

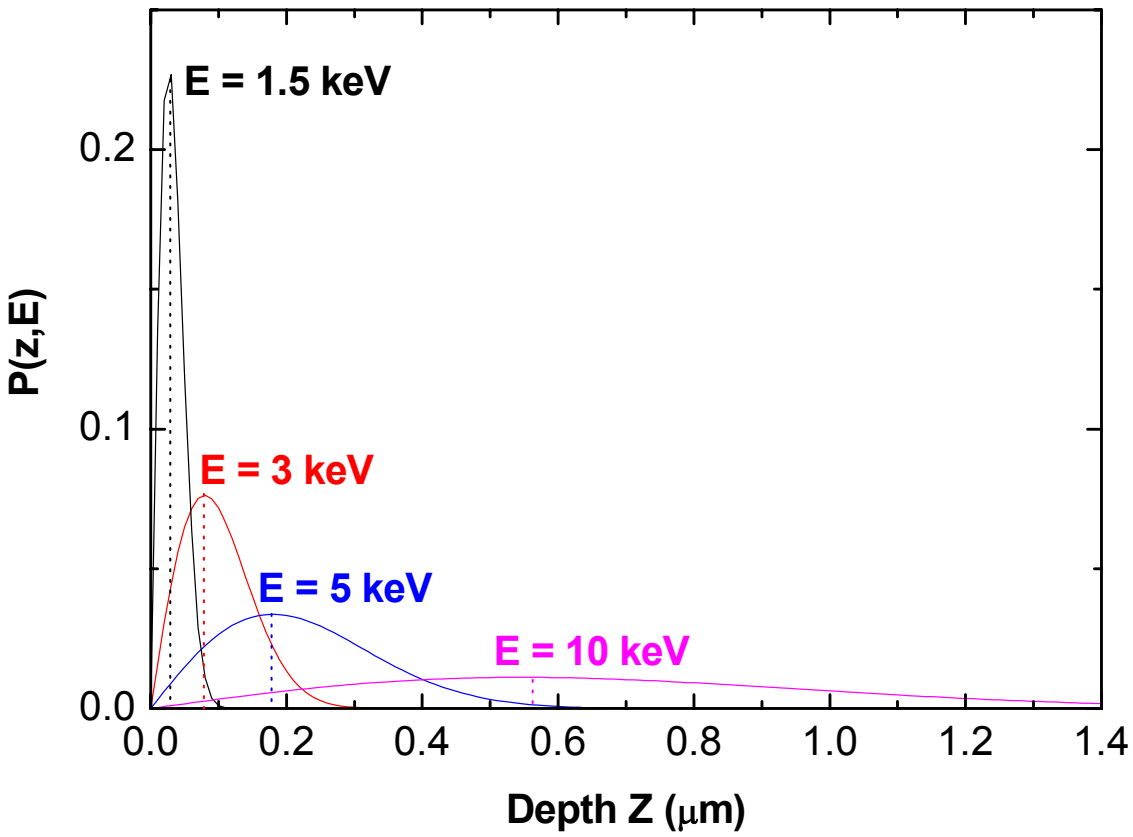


(b)



(C)

Makhov profile showing the implantation profile as a function of positron energy



Genesis for depth-resolved defect studies -

Mean implantation depth Z (nm) = $40.E(keV)^{1.6}/\rho(g/cm^3)$