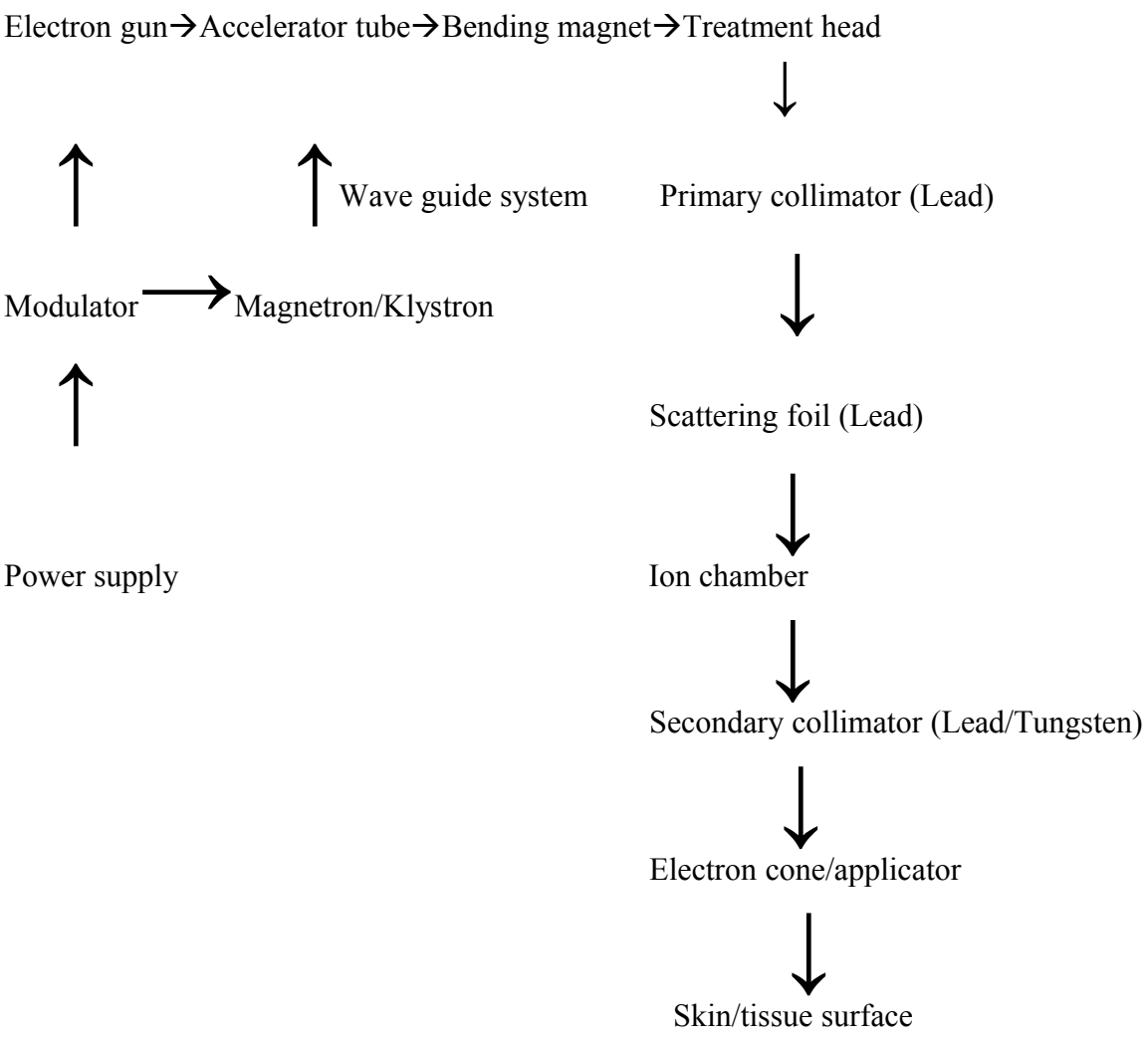
Electron Beam Therapy

Source: Linear accelerator/Betatron/Microtron
Method of electron production in Lineac:



- Scattering foils are designed to widen the pencil beam (3mm width) electron beam as it first emerges from the accelerator tube, as well as to give uniform dose distribution across the treatment field.
- Primary collimators are opened to maximum field size possible for the Lineac.
- Secondary collimators are opened to a size larger than the cone/applicator.

Electron interactions with matter:

Interactions with atomic nuclei or electrons may be elastic (with no net loss of energy) and inelastic (with loss of energy). Inelastic interactions with atomic nuclei produce Bremsstrahlung while that with atomic electrons produce ionization and excitation. Bremsstrahlung increases with increasing electron energy and with increasing atomic number of the absorber tissue. Ionisation and excitation rate increases with increase of atomic number (or decrease of electron density) of the medium, while with increase of energy of the electron, the rate of ionization/excitation at first decreases (upto 2MeV) and then increases.

Electron beam dosimetry: The methods are:

(1) Calorimetry
(2) Ionisation chambers and Fricke dosimeters. Conventionally dosimetry is done in water phantom.
(3) Film dosimetry
(4) Thermoluminiscent dosimetry
(5) Silicon diode dosimetry

Electron beam characteristics:

- Electron beams are specified according to their energy at the body surface.
- Electron beams have a characteristically sharp fall-off of depth dose-the depth (in cm) of the 80-90% isodose curves are 1/3 -1/4 of the electron energy (in MeV). This depth gives the therapeutic range of the electron beam.
- Surface dose increases with increasing energy of the electron beam (unlike in photon beams) due to reduced scatter.
- For low-energy beams, the isodse curves all show some expansion whereas for higher energy beams, the higher isodose curves show constriction while the lower energy curves show expansion.
- Due to great variability in scatter from collimator system of different Lineacs, ideally isodose curves specific for a particular machine should be available.
- With increasing field size, PDD initially increases (due to increased collimator scatter) and then becomes constant due to lateral scatter equilibrium.
- All electron beams are contaminated to some extent by secondary X-rays contributed by scatter from collimator system and body tissues. The typical X-ray contamination varies from around 1% for lower energy beams to around 5% for higher energy beams.

Treatment planning:

- **Choice of energy:** Beam energy should be so selected that the target volume lies entirely within the 90% isodose surface.
- **Choice of field size:** Larger fields at the surface are required (compared to photon beams) to compensate for lateral constriction of isodose curves.

- **Bolus:** Often used to flatten out an irregular surface OR to reduce penetration of electrons OR to increase surface dose. Common materials used are Paraffin wax, Lucite and Superflab.
- **Field matching:** When 2 adjacent electron fields are to be used, they should be abutted at the surface to avoid missing superficial tumor. However, if adjacent photon and electron beams are similarly abutted, there will be a hot spot on the photon side and a cold spot on the electron side due to outscattering of electrons from the electron field.
- **Field shaping:** To protect normal tissue/critical organs. For lower energies, Lead cut-outs are used whereas for higher energies, Cerrobend blocks are preferred. The blocks can be placed directly on the skin surface (preferred) or at the end of the treatment cone. Thickness of a Lead block (in mm) = ½ Energy (in MeV). The thickness of Cerrobend required is usually 20% more than that of Lead. Shields may be placed externally or internally.

Some special situations:

- **Electron arc therapy:** Used to treat large curved surfaces (eg chest wall)
- **Total Skin Electon Beam Therapy:** Usually 6 fields are used in the Stanfod technique. The patient remains standing. Large SSDs are used. No cones are used. The fields are directed from anterior, posterior and 4 oblique directions, positioned at 60 degree intervals around the circumference of the patient. The patient's eyes and cuticles are shielded.
- **Intra-operative Electron Beam Therapy:** The disadvantage of this technique as compared to IO-HDR BT are the increased expense of having a dedicated Lineac in the OT, the hazards of having to bring a patient from the OT to the treatment Lineac just after surgery and the inability of electron beams to treat deep, inaccessible and irregularly-shaped tumors.

Applications of Electron Beam Therapy:

- Skin cancers
- Mycosis fungoides (Local RT/ TSEBT)
- Chest wall
- Boosting lumpectomy cavity in Ca. breast (IOEBT)
- Boosting posterior cervical lymph nodes
- Cancer of Lip
- Cancer of Nasal Vestibule (mixed beam)
- Internal Mammary Node irradiation in Ca.breast (mixed beam)