TREATMENT PLANNING: Corrections and Beam Shaping

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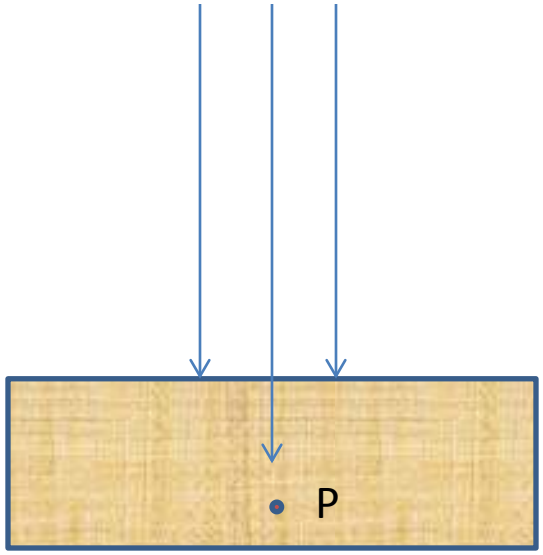
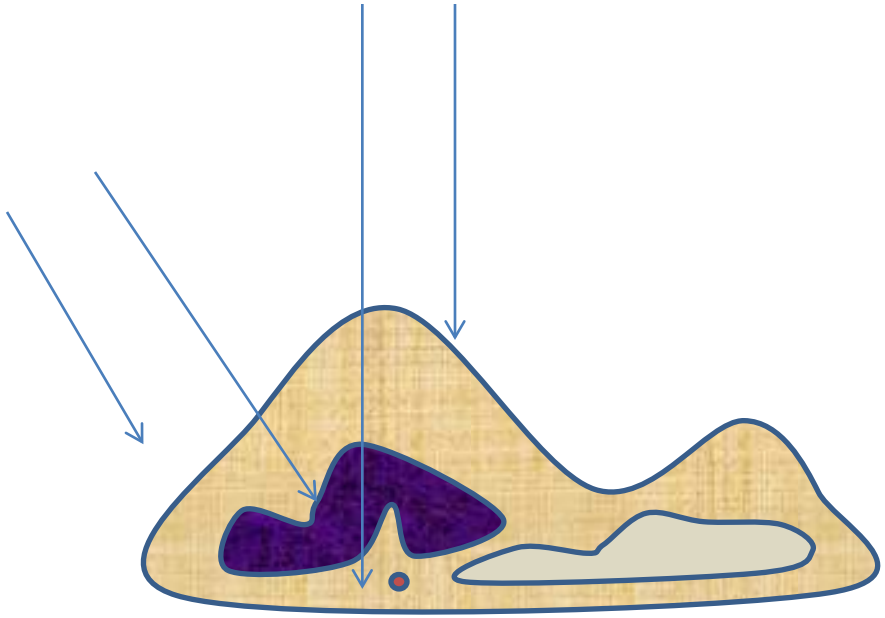
Where we are

- Standard



Clinical scenario



correction

Standard condition	Reality
Flat surface	Irregular/curved surface Needs correction /compensation
Homogenous unit density phantom	Tissue in-homogeneity Needs correction
Perpendicular beam incidence	Oblique/tangential Needs correction

Irregular/curved surface contour correction

1. Corrections
2. Tissue compensation (Bolus/Compensator)
3. Wedge compensators
4. Multiple fields

Basic correction principle

Correction method:
TPS algorithm

Basic principles :
1.Effective SSD method
2.TAR/TMR method
3.Isodose shift method

Effective SSD Method

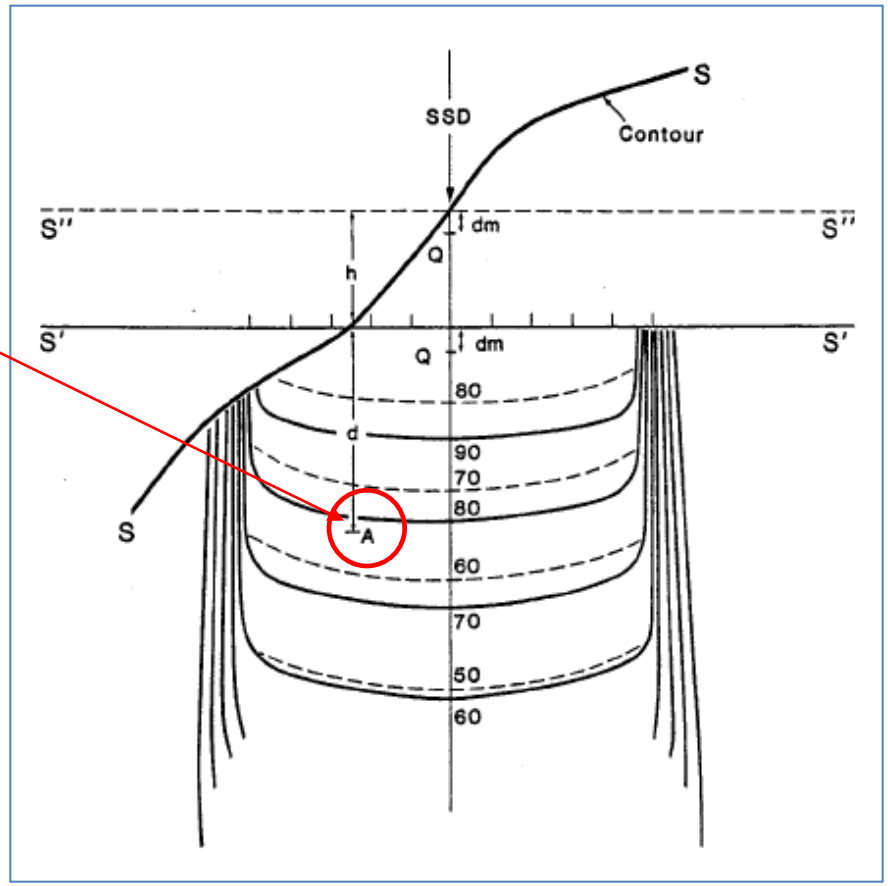
$$D_A = D'_{max} \cdot P'$$

$$D_A = D_{max} \cdot P_{corr}$$

$$P_{corr} = P' \cdot \left(\frac{D'_{max}}{D_{max}} \right)$$

$$\frac{D'_{max}}{D_{max}} = \left(\frac{SSD + d_m}{SSD + h + d_m} \right)^2$$

$$P_{corr} = P' \cdot \left(\frac{SSD + d_m}{SSD + h + d_m} \right)^2$$

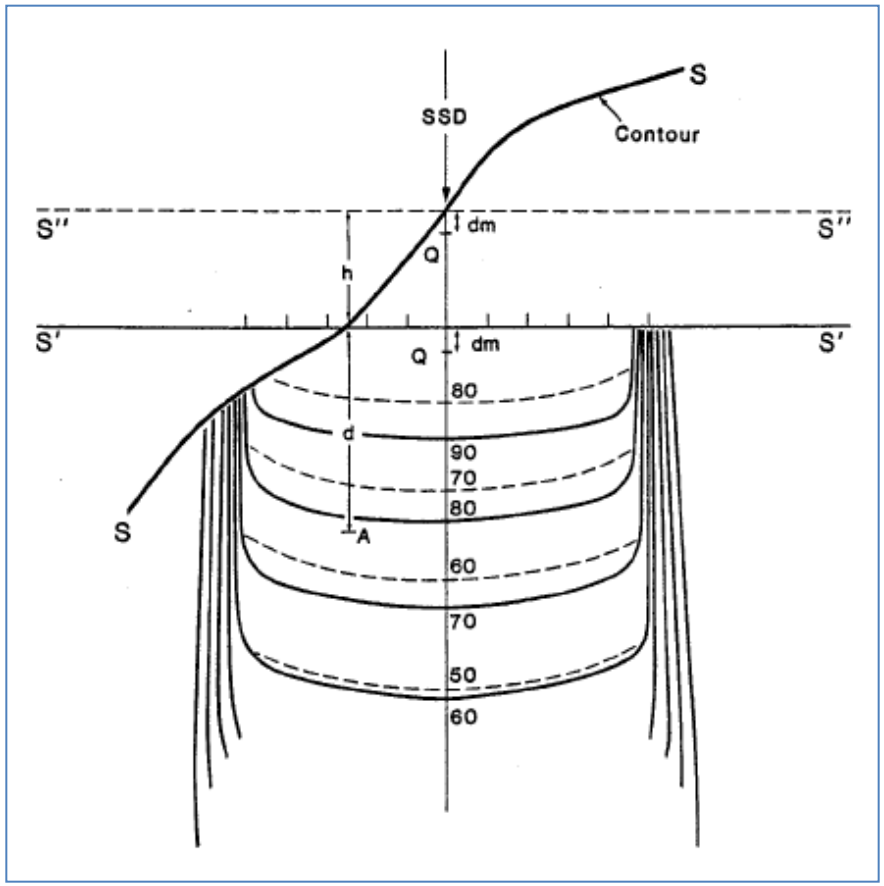


TAR Method

- Ratio depend on only of the depth and the field size at that depth not SSD

$$\text{Correction factor } (CF) = \frac{T(d, r_A)}{T(d+h, r_A)}$$

$$P_{corr} = P'' \cdot CF$$



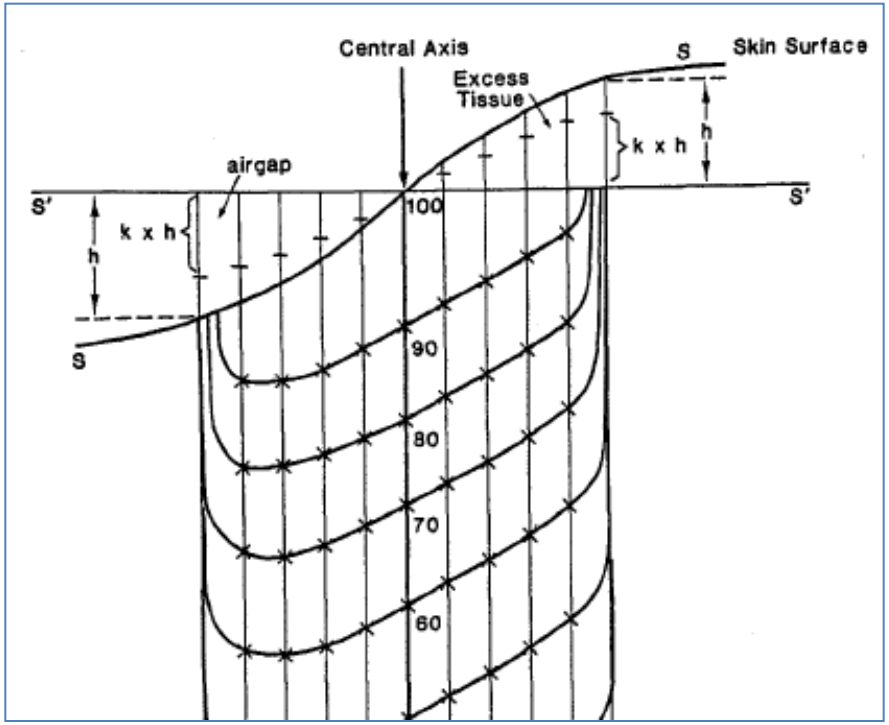
Isodose Shift Method

- Sliding the isodose chart up or down, depending on whether there is tissue excess or deficit along that line, by an amount $k \times h$
- where k is a factor less than 1

TABLE 12.1. ISODOSE SHIFT FACTORS FOR DIFFERENT BEAM ENERGIES

Photon Energy (MV)	Approximate Factor *k*
Up to 1	0.8
^{60}Co-5	0.7
5–15	0.6
15–30	0.5
Above 30	0.4

Data from Giessen PH. A method of calculating the isodose shift in correcting for oblique incidence in radiotherapy. *Br J Radiol* 1973;46:978.



Irregular/curved surface contour correction

1. Corrections
2. Tissue compensation (Bolus/Compensator)
3. Wedge compensators
4. Multiple fields

Tissue compensation

1. Bolus
2. Compensators

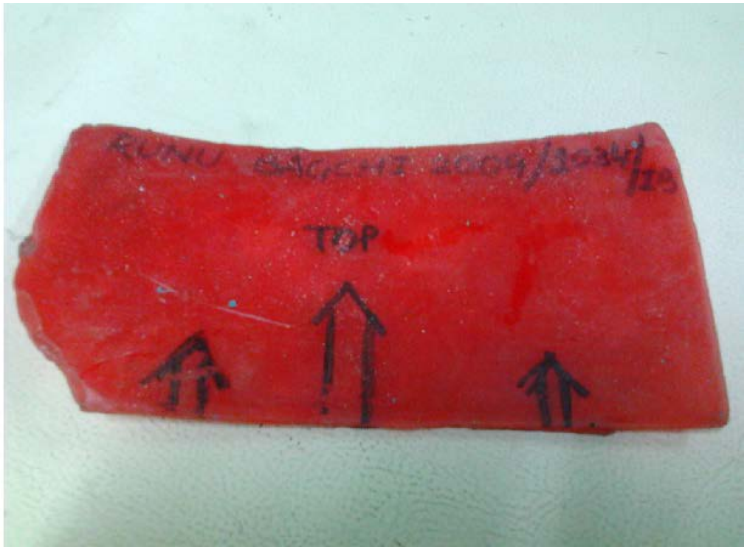
Contour correction

Bolus

NOT buildup bolus:

Placed on skin surface to flatten the contour

Tissue equivalent material



Bolus and compensators

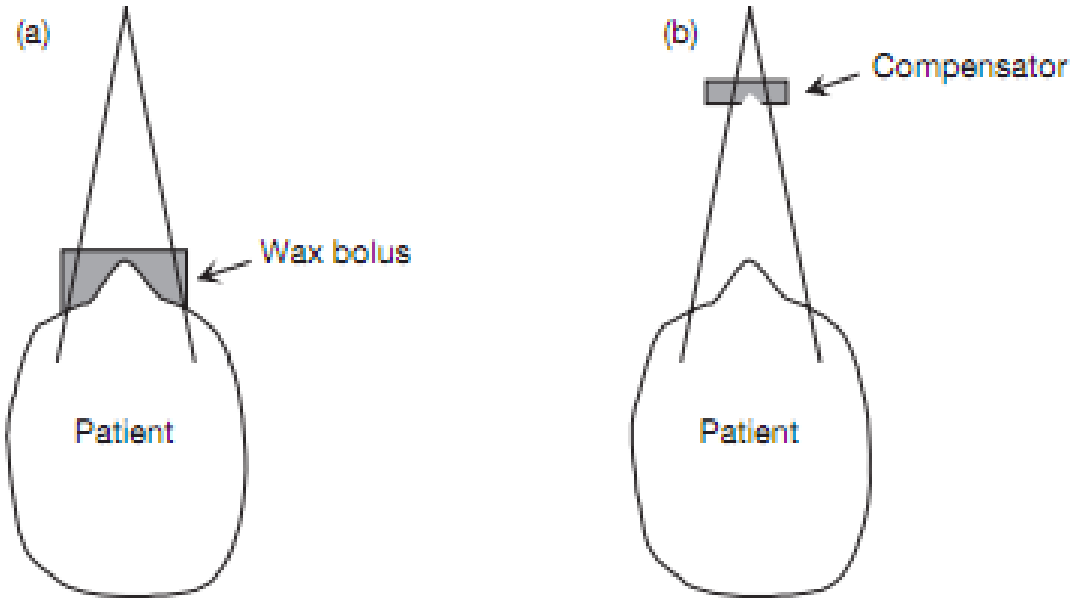
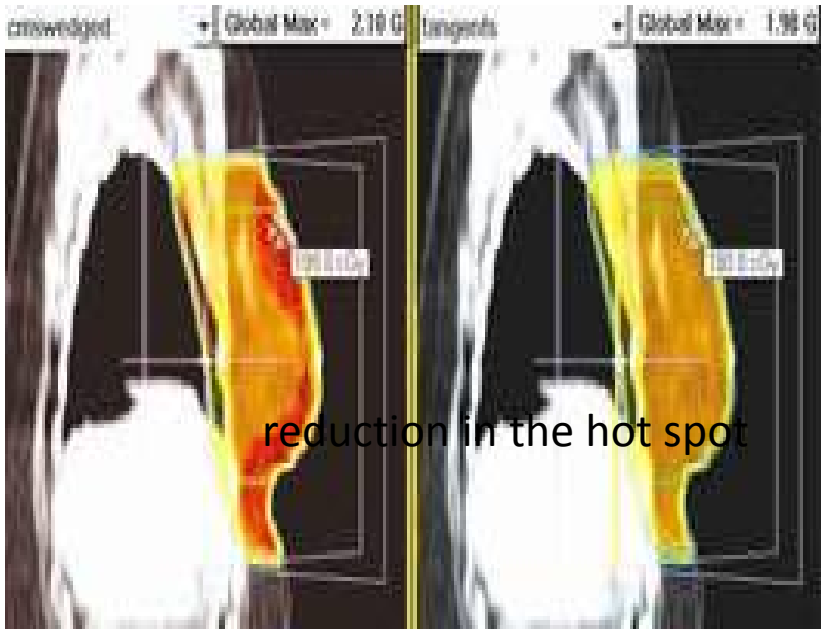


FIG. 7.18. Difference between a bolus and a compensating filter. In (a) a wax bolus is placed on the skin, producing a flat radiation distribution. Skin sparing is lost with bolus. In (b) a compensator achieving the same dose distribution as in (a) is constructed and attached to the treatment unit. Due to the large air gap, skin sparing is maintained.

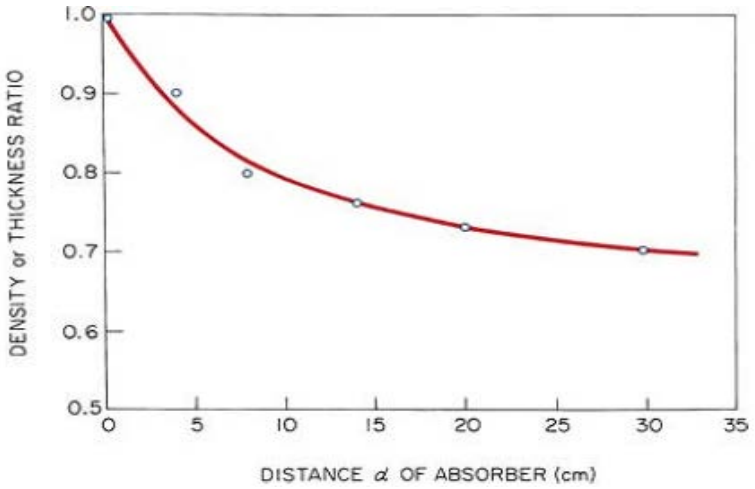
Tissue compensator

- Bolus like material
- Placed at a distance (20cm)
- Preserves skin sparing effect
- The **dimension and shape** of a compensator must be adjusted to account for :
  - Beam **divergence**.
  - **Linear attenuation coefficients** of the filter material and soft tissue.
  - **Reduction** in scatter at various depths due to the compensating filters, when it is placed at the distance away from the skin.



Compensator

- Thickness:
- Key issue
- Thickness ratio:
- Factors:
- Compensator to surface distance
- Thickness of missing tissue
- Field size
- Depth
- Beam quality



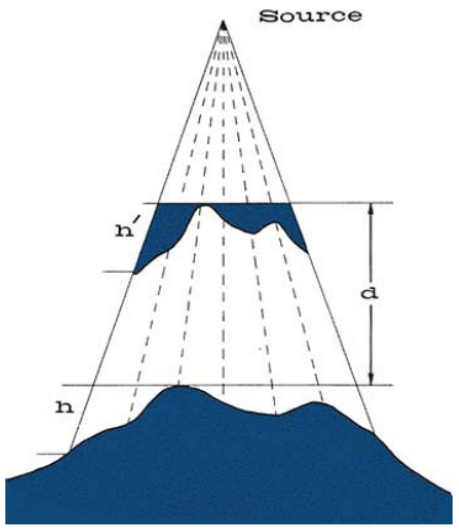


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Figure 12.26. Schematic representation of a compensator designed for an irregular surface. (From Khan FM, Moore VC, Burns DJ. The construction of compensators for cobalt teletherapy. Radiology. 1970;96:187, with permission.)

As the distance between the skin and compensator increases the **thickness ratio** (h'/h) decreases**.**

Compensators

Compensator thickness :

- **TD x (τ/ρ_c),**
  TD is the tissue deficit
- ρ_c is the density of the compensator.
- The term τ/ρ_c can be directly measured by using phantoms

But for multiple related factors:

a fixed value of **thickness ratio** (τ) is used (~ **0.7**) for all irradiation conditions.

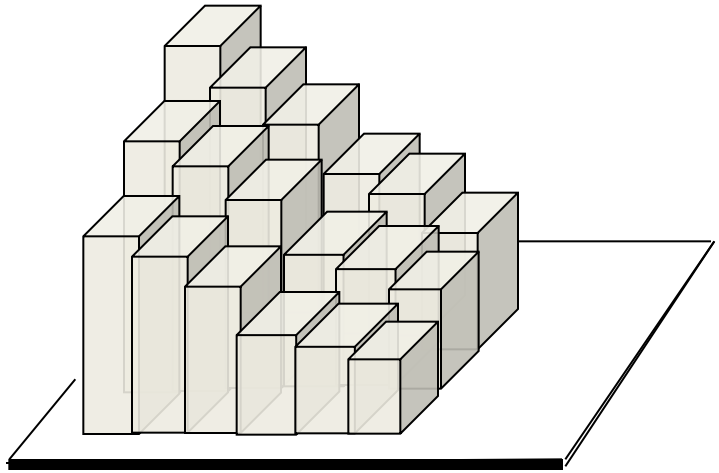
Provided d>20cm

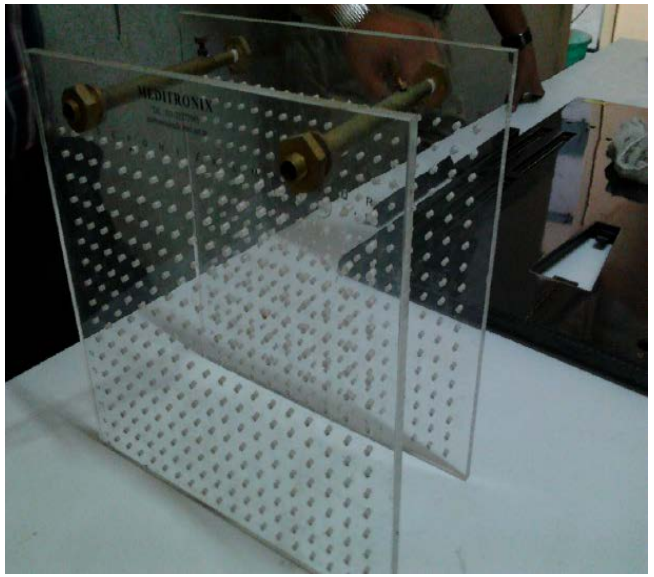
- The term **compensator ratio** is the inverse of the thickness ratio. (ρ_c / τ).

Compensators

Two-dimensional compensators

- Used when proper mould room facilities are not available.
- Thickness varies, along a single dimension only.
- Can be constructed using thin sheets of lead, lucite or aluminum. This results in production of a **laminated** filter.





3D compensators

- measure tissue deficits in **both** transverse and longitudinal cross sections.

- Examples:
  1. **Moiré Camera**.
  2. **Magnetic Digitizers**.
  3. **CT based compensator designing systems**.
  4. **MLC**

Compensating Wedges

- Compensating wedges are useful where the contour can be approximated with a **straight line** for an oblique beam.
- Important **differences** between compensating wedges and wedge filters :
  - **Standard** isodose curves, can be used
  - No wedge **transmission** factors are required.
  - **Partial** field compensation can be done.

Wedge as a compensator

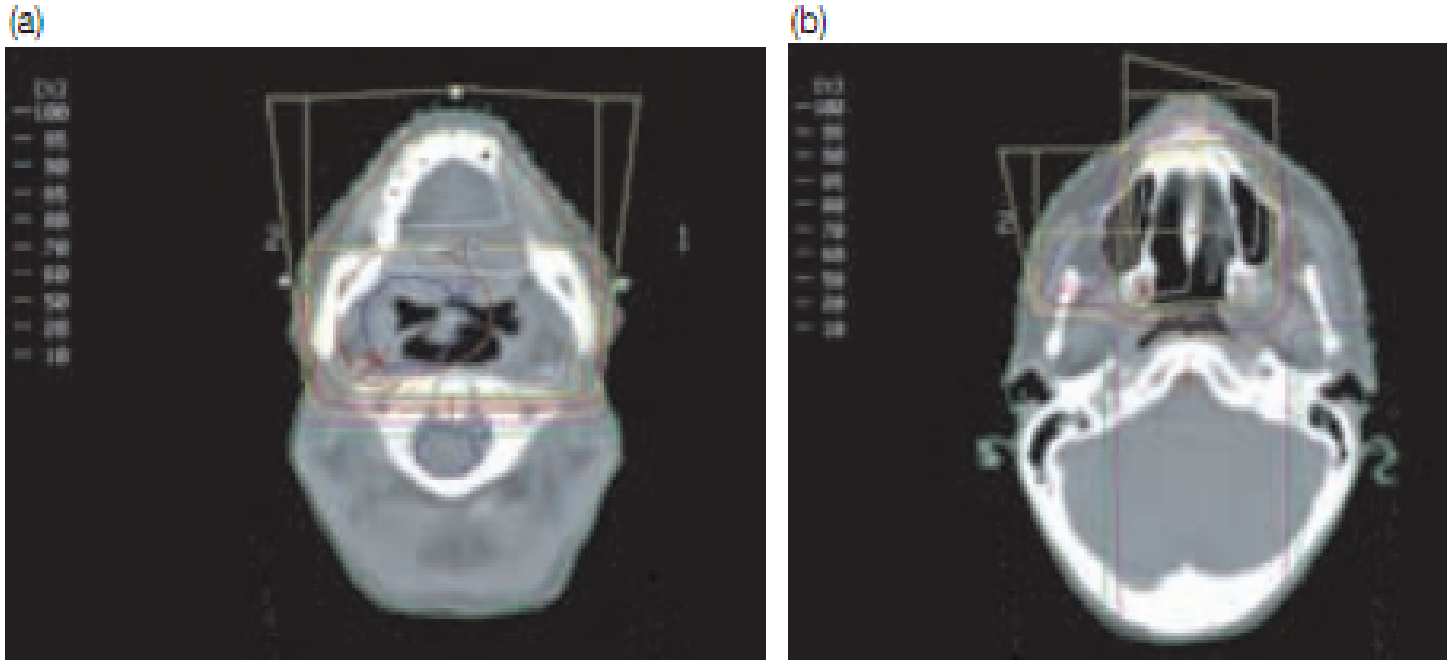


FIG. 7.16. Treatment plans illustrating two uses of wedge filters. In (a) two 15° wedges are used to compensate for the decreased thickness anteriorly. In (b) a wedged pair of beams is used to compensate for the hot spot that would be produced, with a pair of open beams at 90° to each other.

Wedge as a filter

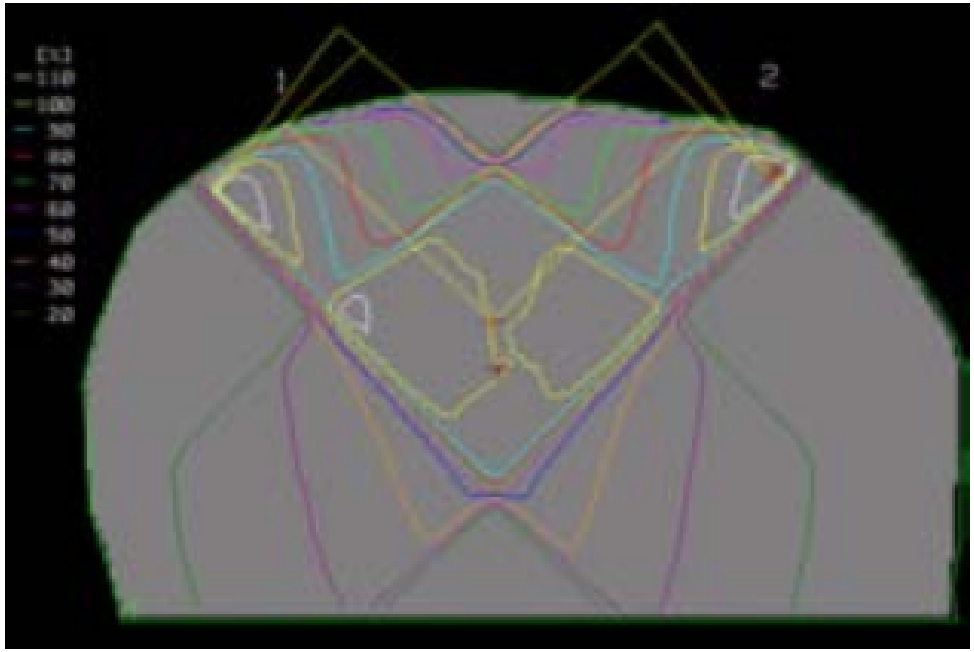
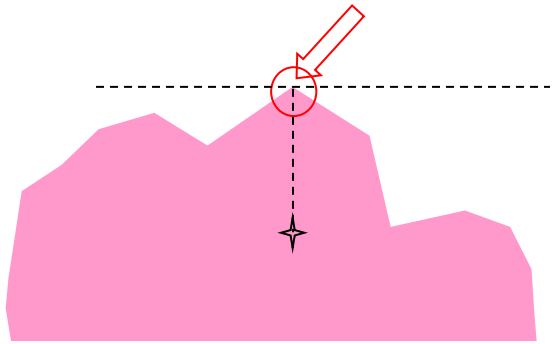


FIG. 7.17. A wedge pair of 6 MV beams incident on a patient. The hinge angle is 90° (orthogonal beams), for which the optimal wedge angle would be 45°. However, the additional obliquity of the surface requires the use of a higher wedge angle of 60°.

Compensators

Set up

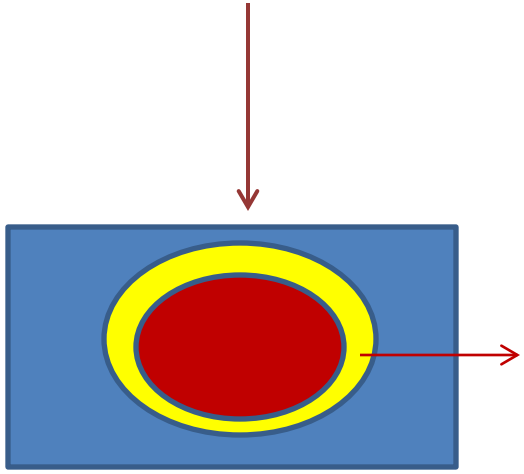
- At the **filter-surface** distance calculated ≥ 20 cm.
- Nominal **SSD** measured from a plane perpendicular to beam axis touching the **highest** point in the contour.
- In **SAD** technique the depth of the isocenter is measured from the same elevated point only.



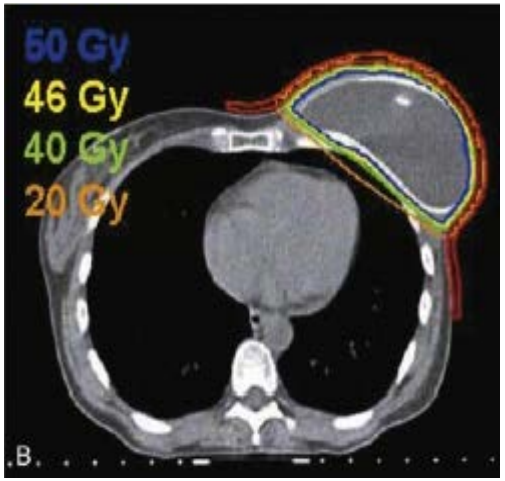
Tissue inhomogeneity correction

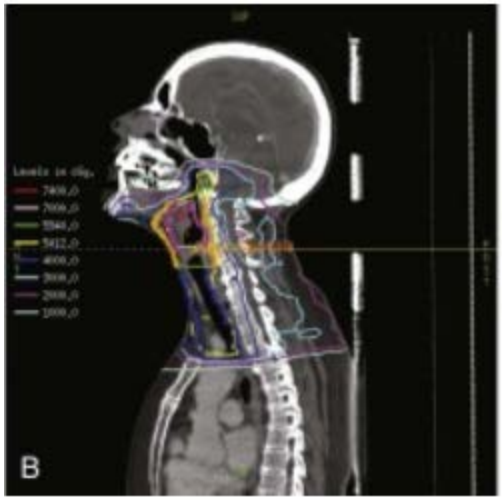
Tissue inhomogeneity :

- Amount and type of material present
- Quality of radiation.



Area of inhomogeneity





The effects of tissue inhomogeneities:

- **changes in the absorption of the primary beam and scattered photons**
  - primary beam : points that lie beyond the inhomogeneity,
  - Scattered : points near the inhomogeneity

- **changes in the secondary electron fluence**
  - tissues within the inhomogeneity and at the boundaries.

Problems ?

1. Beam attenuation & scattering

   needs correction

2. Absorbed dose within inhomogeneity

   needs correction

Correction for bean attenuation & scattering

- Basic principles:

1. TAR method
2. Power Law TAR method
3. Equivalent TAR method
4. Isodose shift method

Algorithm is used is nowadays:

Model based

Monte Carlo

Issues

1. Depth of the desired dose point

2. Location of the inhomogeneity w.r.t. to the dose point

3. Location of the point (inside inhomogeneity or below)

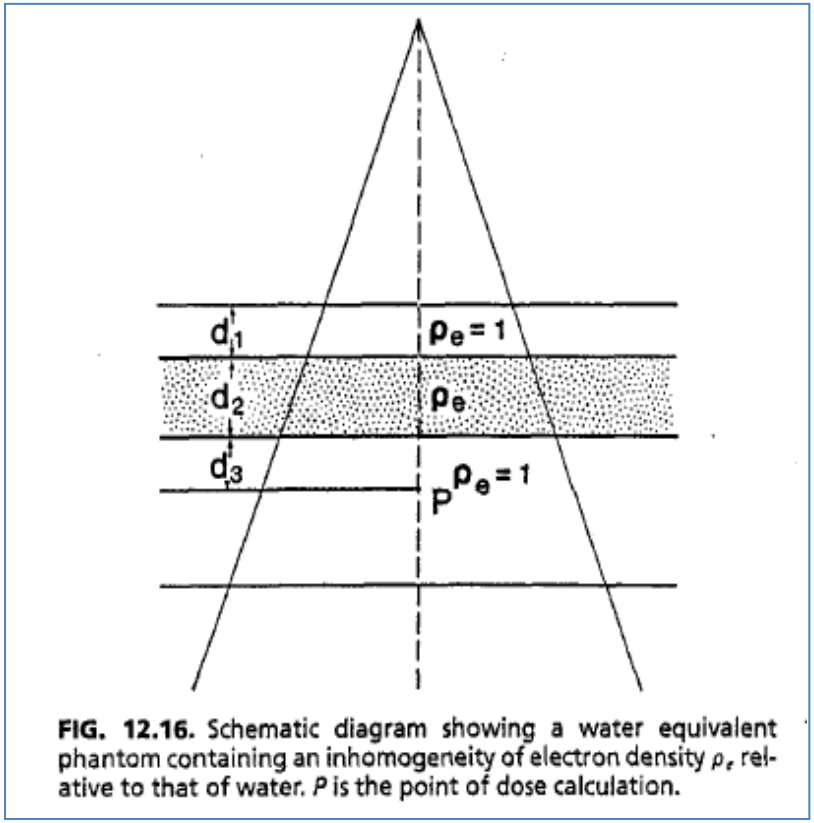


FIG. 12.16. Schematic diagram showing a water equivalent phantom containing an inhomogeneity of electron density ρ_e relative to that of water. *P* is the point of dose calculation.

Correction for bean attenuation & scattering

- Basic principles:

1. TAR method
2. Power Law TAR method
3. Equivalent TAR method
4. Isodose shift method

Algorithm is used is nowadays:

Model based

Monte Carlo

Corrections for Beam Attenuation & Scattering

- **TAR method**

$$CF = \frac{T(d', r_d)}{T(d, r_d)}$$

  - $d' = d1 + \rho_1\, d2 + d3$
  - d is the actual depth of P from the surface
  - Location is not considered important factor

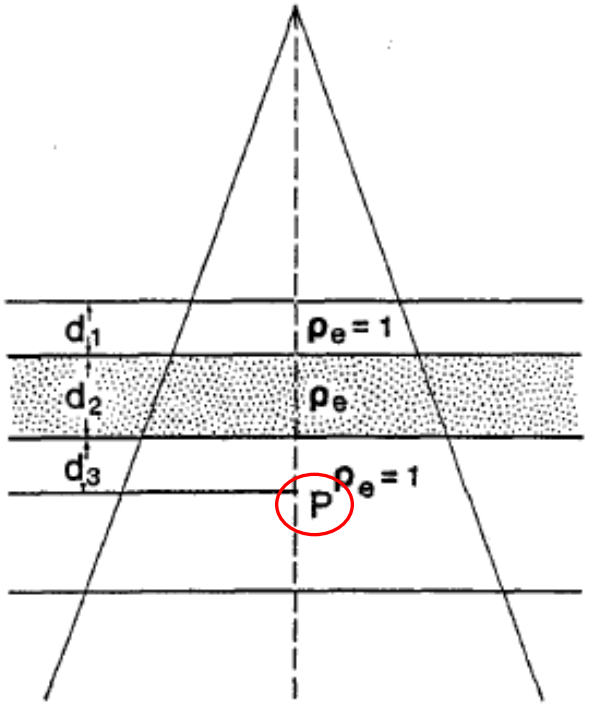


FIG. 12.16. Schematic diagram showing a water equivalent phantom containing an inhomogeneity of electron density ρ_e relative to that of water. *P* is the point of dose calculation.

Correction for bean attenuation & scattering

- Basic principles:

1. TAR method
2. Power Law TAR method
3. Equivalent TAR method
4. Isodose shift method

Algorithm is used is nowadays:

Model based

Monte Carlo

Corrections for Beam Attenuation and Scattering

- **Power Law Tissue-air Ratio Method (Batho)**
  - correction factor does depend on the location of the inhomogeneity relative to point P

  but

  - not relative to the surface or in the build-up region

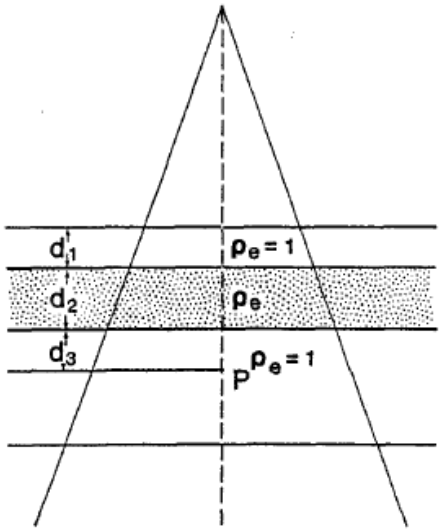


FIG. 12.16. Schematic diagram showing a water equivalent phantom containing an inhomogeneity of electron density ρ_e relative to that of water. *P* is the point of dose calculation.

$$CF = \left[\frac{T(d_2 + d_3, r_d)}{T(d_3, r_d)}\right]^{\rho_e - 1}$$

Corrections for Beam Attenuation & Scattering

- **Power Law: Tissue-air Ratio Method**
  - A more general form, provided by Sontag and Cunningham
  - allows for correction of the dose to points within an inhomogeneity as well as below it

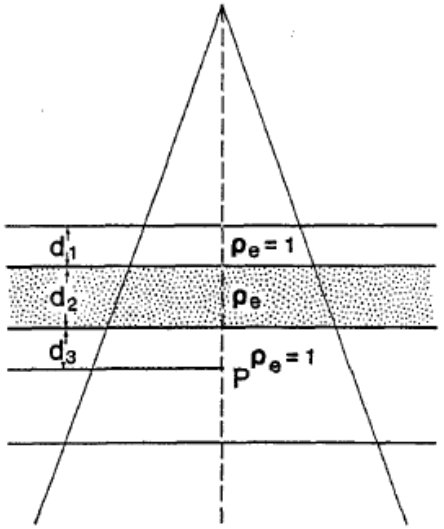


FIG. 12.16. Schematic diagram showing a water equivalent phantom containing an inhomogeneity of electron density ρ_e relative to that of water. *P* is the point of dose calculation.

$$CF = \frac{T(d_3, r_d)^{\rho_3 - \rho_2}}{T(d_2 + d_3, r_d)^{1-\rho_2}}$$

Correction for bean attenuation & scattering

- Basic principles:

1. TAR method
2. Power Law TAR method
3. Equivalent TAR method
4. Isodose shift method

Algorithm is used is nowadays:

Model based

Monte Carlo

Corrections for Beam Attenuation & Scattering

- **Equivalent Tissue-air Ratio Method (ETAR)**

Scattered component also taken into consideration

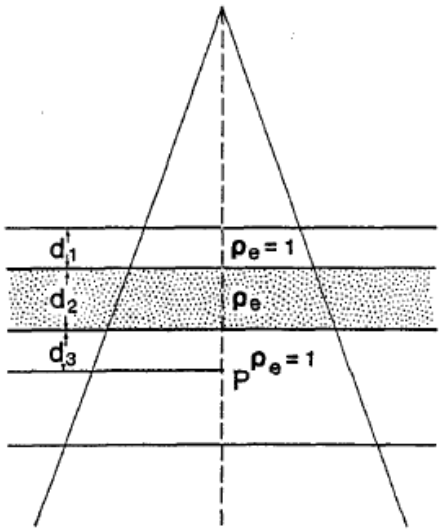


FIG. 12.16. Schematic diagram showing a water equivalent phantom containing an inhomogeneity of electron density ρ_e relative to that of water. *P* is the point of dose calculation.

$$CF = \frac{T(d', r')}{T(d, r)} \qquad \bar{\rho} = \frac{\sum_i \sum_j \sum_k \rho_{ijk} \cdot W_{ijk}}{\sum_i \sum_j \sum_k W_{ijk}}$$

Corrections for Beam Attenuation & Scattering

- *Equivalent Tissue-air Ratio Method*
  - *d'* is the water equivalent depth, d is the actual depth, *r* is the beam dimension at depth *d,*
  - $r' = r \times \rho'$ = scaled field size dimension
  - ρ‘ = weighted density

$$CF = \frac{T(d', r')}{T(d, r)}$$

$$\bar{\rho} = \frac{\sum_i \sum_j \sum_k \rho_{ijk} \cdot W_{ijk}}{\sum_i \sum_j \sum_k W_{ijk}}$$

Correction for bean attenuation & scattering

- Basic principles:

1. TAR method
2. Power Law TAR method
3. Equivalent TAR method
4. Isodose shift method

Algorithm is used is nowadays:

Model based

Monte Carlo

Corrections for Beam Attenuation & Scattering

- **Isodose Shift Method**
  - manually correcting isodose charts for the presence of inhomogeneity

TABLE 12.3. INCREASE IN DOSE TO TISSUES BEYOND HEALTHY LUNG[a]

Beam Quality	Correction Factor
Orthovoltage	+10%/cm of lung
^{60}Co γ rays	+4%/cm of lung
4-MV x-rays	+3%/cm of lung
10-MV x-rays	+2%/cm of lung
20-MV x-rays	+1%/cm of lung

[a]Approximate values calculated with Equation 12.10 for typical clinical situations.

Corrections for Beam Attenuation & Scattering

- *Typical Correction Factors*
  - None of the methods discussed above can claim an accuracy of $\pm$ 5% for all irradiation conditions encountered in radiotherapy
  - Tang et al. have compared a few commonly used methods against measured data using a heterogeneous phantom containing layers of polystyrene and cork

Corrections for Beam Attenuation & Scattering

- **Typical Correction Factors**
  - Their results (Tang et al.)
    - the TAR method overestimates the dose for all energies
    - the ETAR is best suited for the lower-energy beams (≦6 MV)
    - the generalized Batho method is the best in the high-energy range (≧10 *MV)*

Problems ?

1. Beam attenuation & scattering
   needs correction
2. Absorbed dose within inhomogeneity
   needs correction

Absorbed dose within inhomogeneity

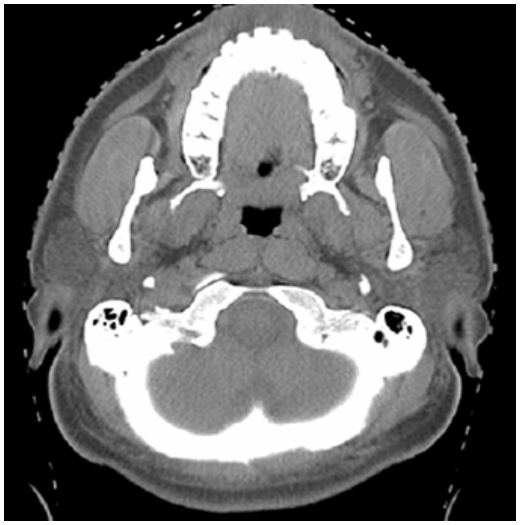
Issues:

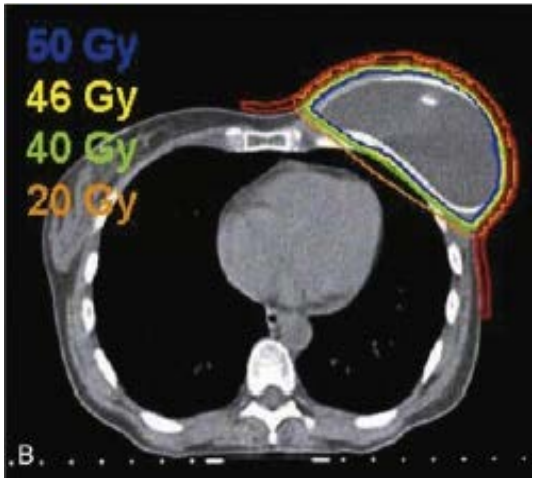
1. Bone mineral

2. Bone tissue interface
   soft tissue within bone
   bone within soft tissue

3.Lung tissue

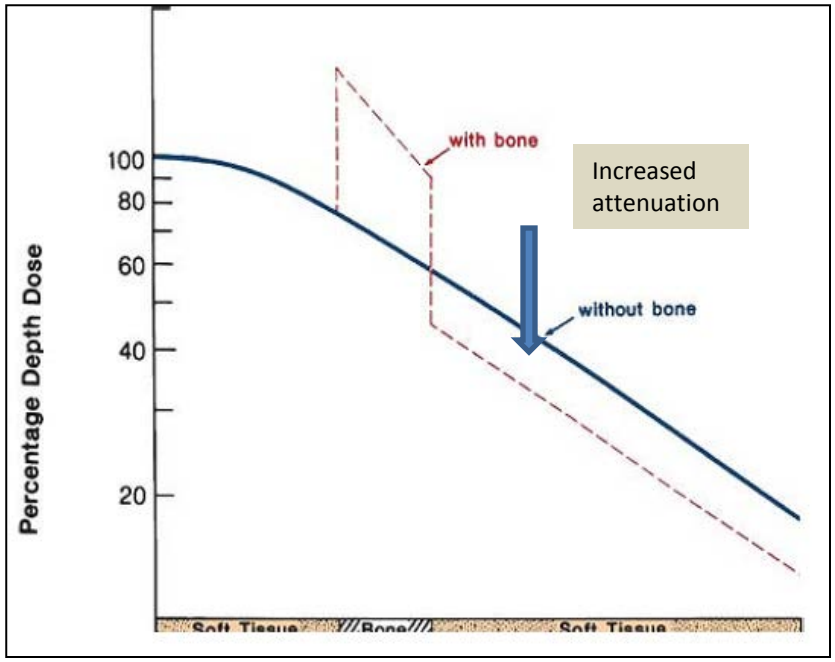
4.Air cavity
   Quality of radiation

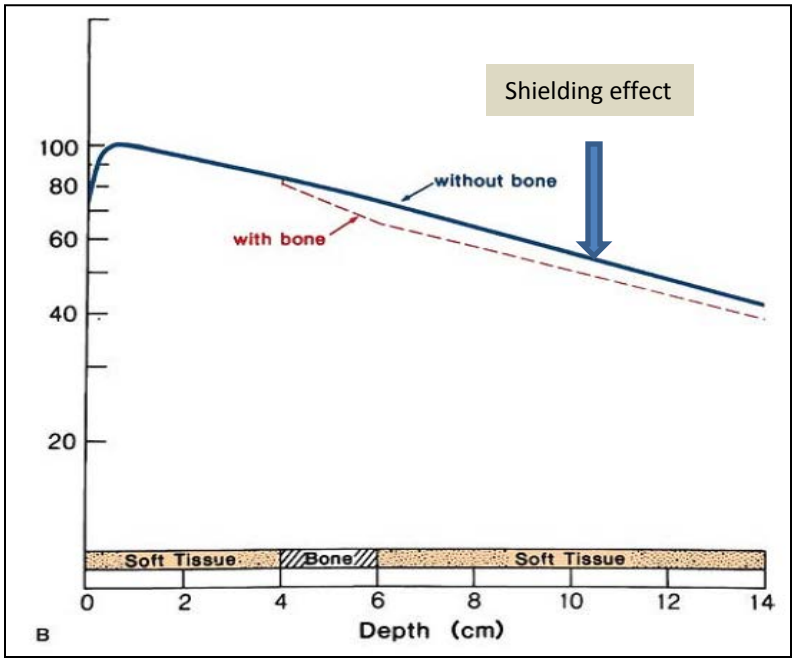




Absorbed dose within inhomogeneity corrections :

- Bone Mineral: ?





PDD as a function of depth in orthovoltage and megavoltage range

- Orthovoltage :

  Increased e fluence

- Mega voltage:

M_{en} = Energy absorption coeff relative to air

$$D_B / D_{ST} = f_B / f_{ST} = (\mu_{en})_B / (\mu_{en})_{ST}$$

Photon e → kinetic e of e → inelastic collision(ionisation)

↘ bremsstrhalung interaction

Megavoltage : ^{60}Co

f_B / f_{ST} : 0.955/0.957 = 0.96

Dose to bone is less SLIGHTLY

Orthovoltage :

f_B / f_{ST} = 1.9/0.94 = 2

Dose to the bone is MUCH high

F factor ratio

Reduction of dose per cm of hard bone

Beam quality	Correction (%)
^{60}Co	-3.5
4MV	-3
10MV	-2

Absorbed dose within inhomogeneity

Issues:

1. Bone mineral

2. Bone tissue interface

soft tissue within bone

soft tissue surrounding bone

3.Lung tissue

4.Air cavity

Quality of radiation

Absorbed Dose within an Inhomogeneity

- *Bone-tissue Interface*
  - *Soft Tissue in Bone*

$$\gamma = D_{STB}/D_{ST} = (\bar{\mu}_{en}/\rho)^{B}_{ST} \cdot (\bar{S}/\rho)^{ST}_{B}$$

Ratio of average mass collision stopping power of ST to B
š/p fixed for all E for ST

f factor:

Very low E (photoelectric) and very high E (pair production):

Dose at ST is low than surrounding bone

In Compton range :

Dose at ST is slightly high than surrounding bone

Absorbed Dose within an Inhomogeneity

Soft Tissue in Bone

Absorbed dose to bone relative to soft tissue

Quality	Effective E	Bone mineral	Soft tissue in bone
^{60}Co	1.25MeV	0.96	1.03
4MV	1.5MeV	0.96	1.03
10MV	4MeV	0.98	1.05
20 MV	8MeV	1.02	1.09

In clinical situation
For a SMALL tissue cavity within bone :

$$D_{STB} = D_{ST} \cdot \gamma \cdot \mathrm{TMR}(s_{ST} + \rho_B \cdot s_B)/\mathrm{TMR}(s_{ST} + s_B)$$

Absorbed dose within inhomogeneity

Issues:

1. Bone mineral

2. Bone tissue interface

soft tissue within bone

soft tissue surrounding bone

3.Lung tissue

4.Air cavity

Quality of radiation

Absorbed Dose within an Inhomogeneity

Soft Tissue Surrounding Bone

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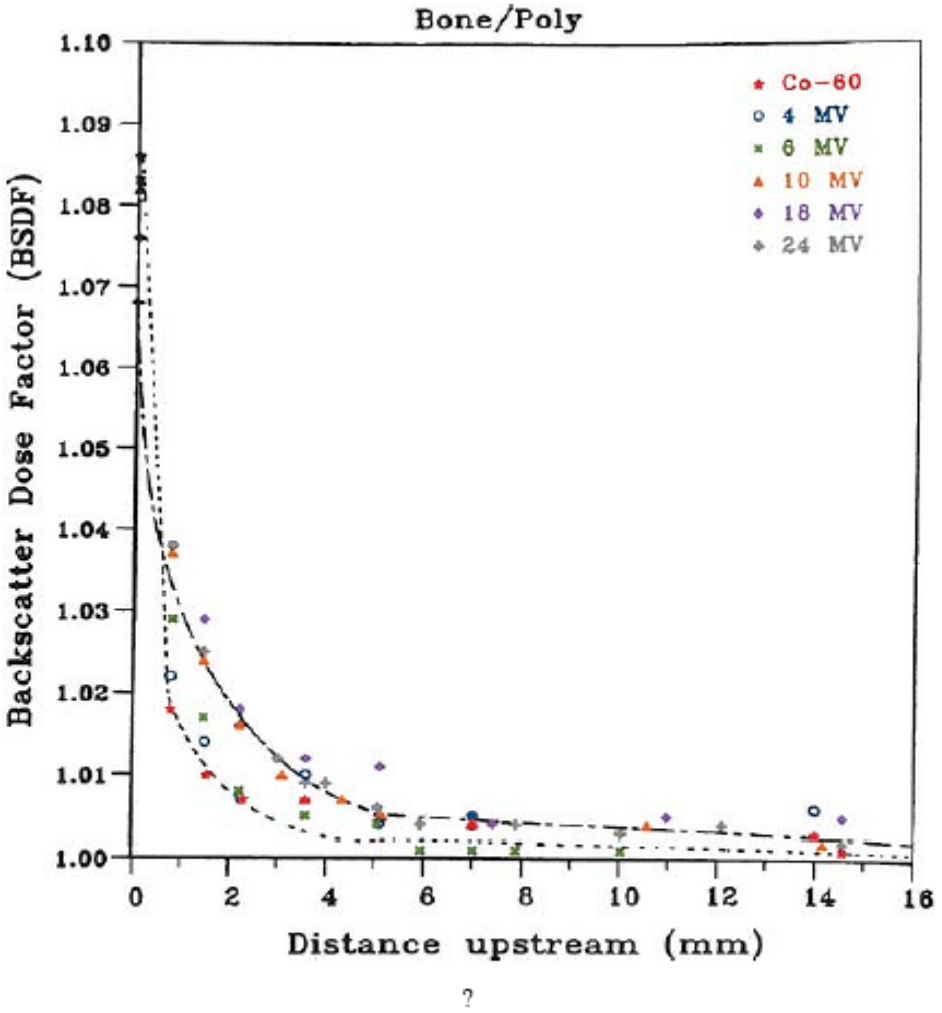

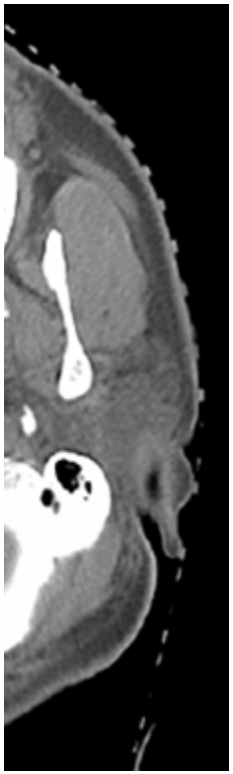

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Figure 12.22. Backscatter dose factor (BSDF) for various energy photon beams plotted as a function of distance, toward the source, from the bone–polystyrene interface. BSDF is the ratio of dose at the interface with bone to that without bone. (From Das IJ, Khan FM. Backscatter dose perturbation at high atomic number

Absorbed Dose within an Inhomogeneity

Soft Tissue Surrounding Bone

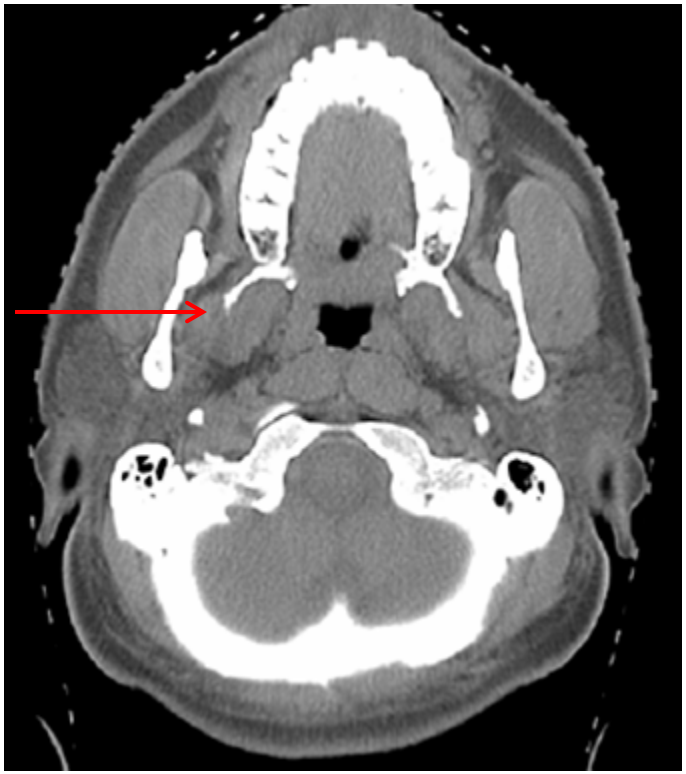
- Transmission site:

Electron forward scatter

Build up of electrons in ST

Dose perturbation effect

Varies with energy range



Absorbed Dose within an Inhomogeneity

Soft Tissue Surrounding Bone

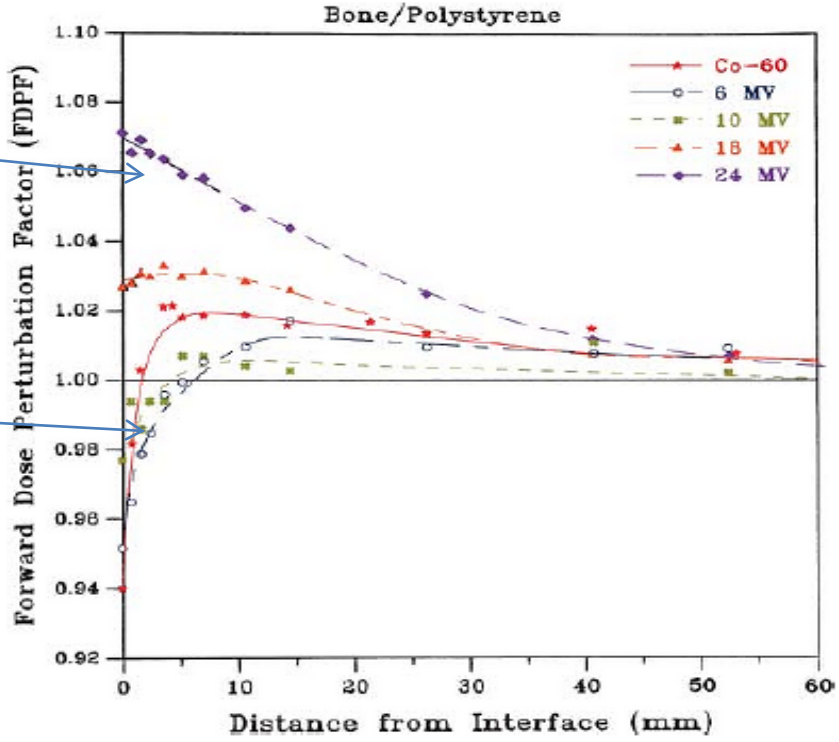
- **Forward scatter** :

<10MV

>10MV

Factors

1. Thickness of B /ST
2. Beam E
3. Bone density



?

Figure 12.23. Forward dose perturbation factor (FDPF) for various energy photon beams plotted as a function of distance, away from the source, from the bone–polystyrene interface. FDPF is the ratio of dose at the interface with bone to that without bone for the same photon energy fluence. (From Das IJ. Study of dose perturbation at bone-tissue interfaces in megavoltage photon beam therapy. [Dissertation.] University of Minnesota, 1988:119, with permission.)

Absorbed Dose within an Inhomogeneity

Soft Tissue Surrounding Bone

- forward scatter
  - For energies up to 10 MV, the dose at the interface is initially less than the dose in a homogeneous soft tissue medium but then builds up to a dose that is slightly greater than that in the homogeneous case.
  - For higher energies, there is an enhancement of dose at the interface because of the increased electron fluence in bone due to pair production

Absorbed Dose within an Inhomogeneity

- *Bone-tissue Interface*
  - parallel-opposed beams

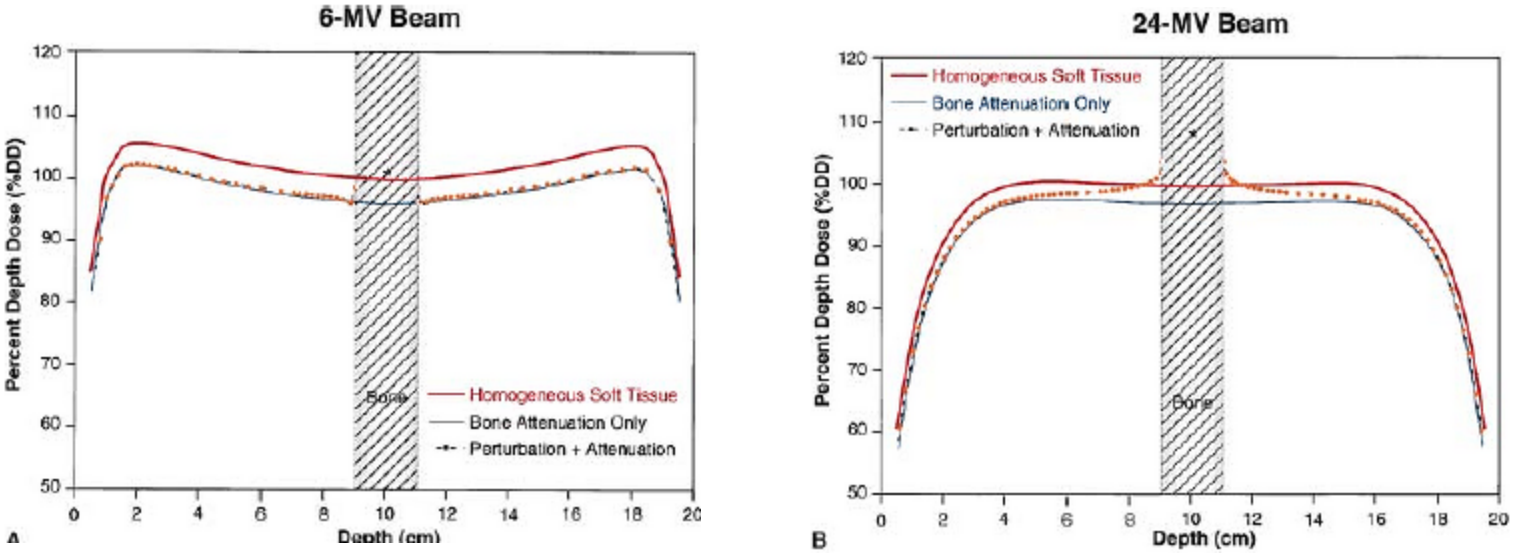


Figure 12.24. Percent depth dose distribution in a 20-cm-thick polystyrene phantom containing a bone substitute material. Doses are normalized to midpoint dose in the homogeneous polystyrene phantom of the same thickness. Parallel opposed beams, field size = 10 ? 10 cm, source to surface distance = 100 cm. The symbol * signifies dose to a small tissue cavity in bone. A: 6-MV photon beam. B: 24-MV photon beam. (From Das IJ,

Absorbed Dose within an Inhomogeneity

- *Bone-tissue Interface*
  - parallel-opposed beams

TABLE 12.6. DOSE ENHANCEMENT AT BONE-TISSUE INTERFACE FOR PARALLEL-OPPOSED BEAMS[a]

Thickness of Bone (cm)	6 MV	10 MV	18 MV	24 MV
0.5	1.01	1.02	1.03	1.04
1.0	1.01	1.02	1.03	1.05
2.0	1.00	1.01	1.03	1.05
3.0	0.99	1.00	1.03	1.05

[a]Dose to soft tissue adjacent to bone relative to midpoint dose in a homogeneous soft tissue; total thickness = 20 cm; field size = 10 × 10 cm; SSD = 100 cm.
From Das IJ, Khan FM, Kase KR. Dose perturbation at high atomic number interfaces in parallel opposed megavoltage photon beam irradiation [abstract]. *Phys Med Biol* 1988;33[Suppl 1]:121, with permission.

Absorbed dose within inhomogeneity

Issues:

1. Bone mineral

2. Bone tissue interface
   soft tissue within bone
   soft tissue surrounding bone

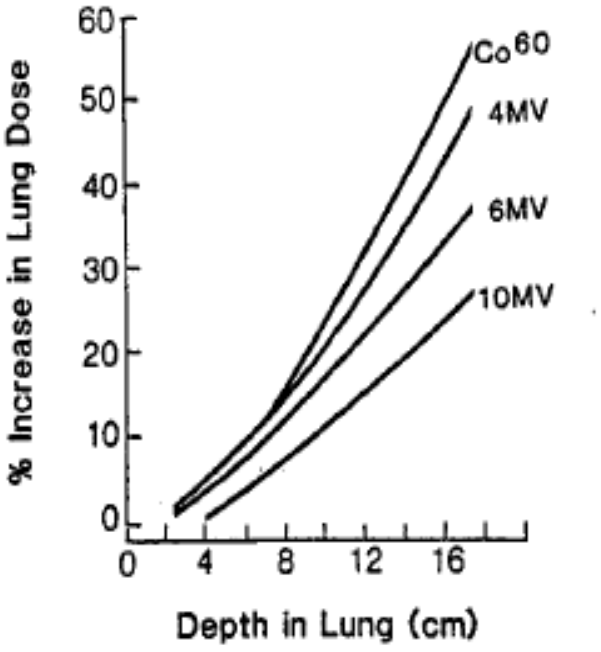
3.Lung tissue

4.Air cavity
   Quality of radiation

Absorbed Dose within an Inhomogeneity

Lung tissue

- Dose within the lung tissue is primarily governed by its density
- **↓lung density = ↑ dose to within & beyond lung**
- But in the first layers of soft tissue beyond a large thickness of lung, there is some loss of secondary electrons



Absorbed Dose within an Inhomogeneity

Lung Tissue

- Increased no of e travel outside the geometric boundary

↓

↑ lateral scattering of e/ ↓dose in beam axis

dose profile to become less sharp

- The effect is significant for
- small field sizes (< 6 x 6 cm)
- higher energies (>6 MV)

Absorbed dose within inhomogeneity

Issues:

1. Bone mineral

2. Bone tissue interface
   soft tissue within bone
   soft tissue surrounding bone

3.Lung tissue

4.Air cavity
   Quality of radiation

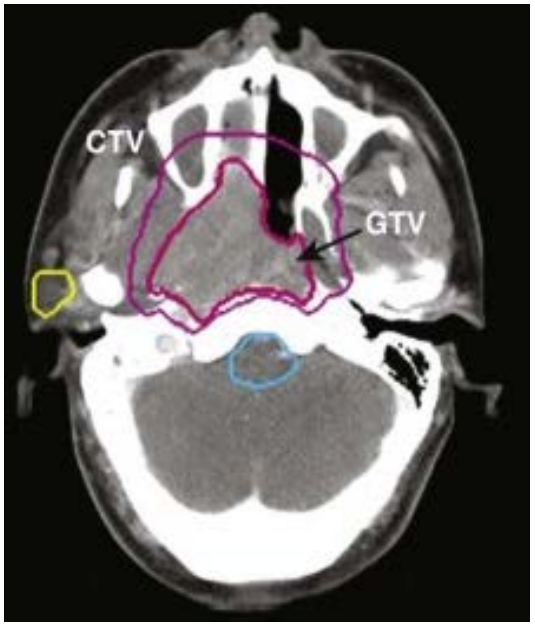
Absorbed Dose within an Inhomogeneity

Air Cavity

- In megavoltage beam dosimetry is the partial loss of electronic equilibrium at the cavity surface
- The most significant decrease in dose occurs at

1. surface beyond and in front the-cavity
2. large cavities (4 cm deep)
3. the smallest field (4 x 4 cm)

Field and Beam Shaping



Tumor distribution: local/regional
Dose to OARs
Dose to other surrounding normal tissues

Field shaping

1. Shielding Blocks
2. Customised Blocks
3. Independent Jaws
4. MLCs

Shielding Blocks

- High atomic no
- High density
- Inexpensive
- Easily available

- Primary beam transmission <5%: acceptable clinical criteria
- Thickness of lead between 4.5-5 HVL is needed
- Complete shielding never possible

Beam quality	Required lead thickness
^{60} Co	5cm
4MV	6cm
6MV	6.5cm

Shielding Blocks

Shielding Blocks

In mega voltage beam:

Placed in shadow tray 15 - 20cm from surface

Why ?

Heavier

Avoid increase in skin dose due to electron scatter

Customised Blocks

Lipowitz material *(cerrobend)*

Features :

- 50% bismuth, 26.7% lead,13.3% Tin, 10% Cadmium
- Density 9.4gm/cm^3 (83% of lead)
- Low melting point(70^o C)
- At normal temperature harder than lead
- Thickness : 1.21(density ratio)× lead thickness

Additional accessories

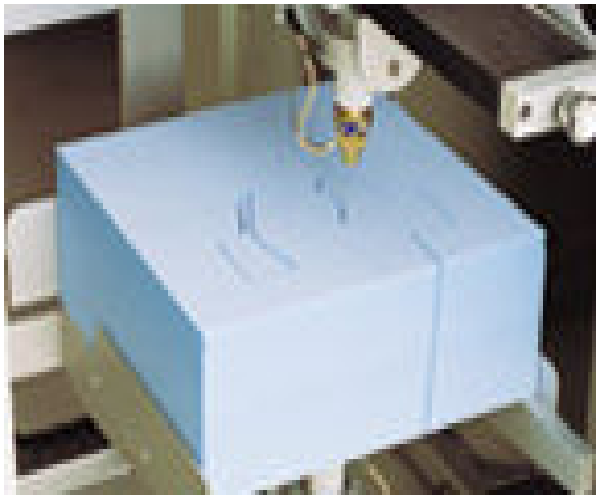
Styrofoam

Styrofoam cutter

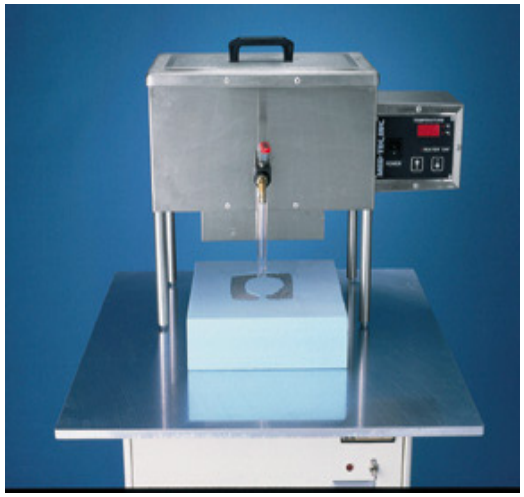
Customised Blocks

Custom blocks

Outline of the treatment field being traced on radiograph using a Styrofoam cutting device.



Electrically heated wire pivoting around a **point** (simulating the source) cutting the styrofoam block



Cavities in the styrofoam block being used to cast the Cerrobend blocks.

Film ,Styrofoam block and wire should replicate treatment geometry (SFD, SBD)

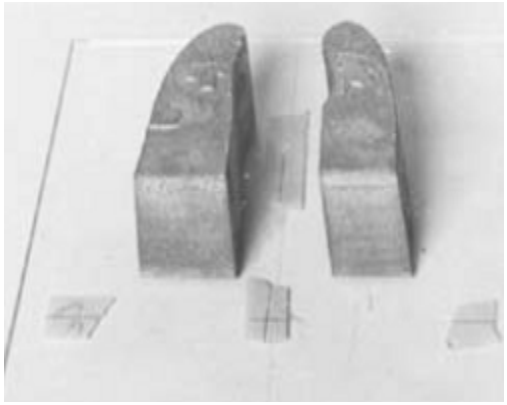
Custom blocks

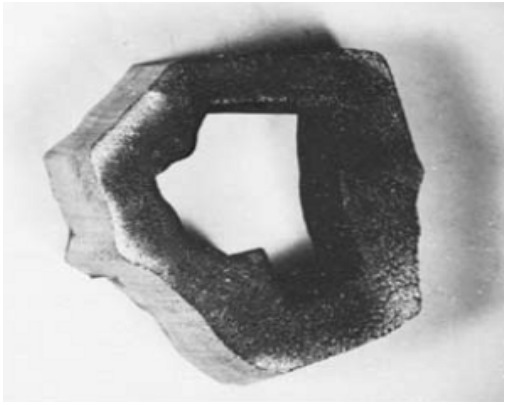
- Positive Blocks:

Central area is blocked

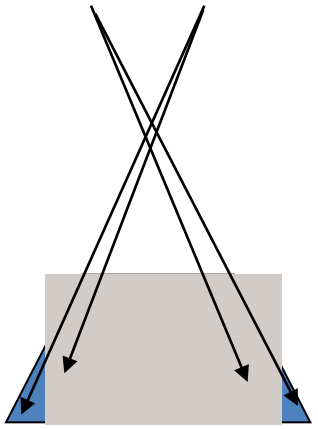
- Negative Blocks:

Peripheral area is blocked





- A **Diverging block** means that the block follows the geometric divergence of the beam.
- minimises *Block transmission penumbra*.



ASYMMETRIC JAWS

- Each set of collimator

Rectangular blocking

- Advantages:

1. Greater attenuation than blocked part
2. Isocentre need not be shifted

3. Logistic advantages

- Disadvantages :

Error in independent jaw
treatment delivery

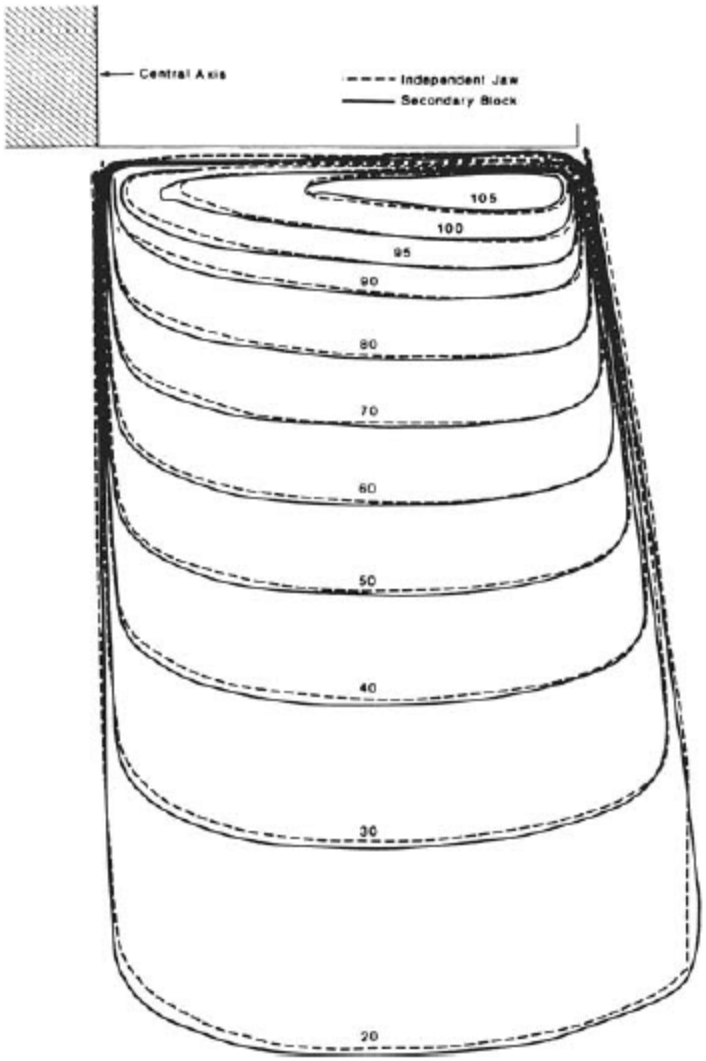


Figure 13.3. Comparison of isodose distribution with half the beam blocked by an independent jaw versus a block on a tray. Notice close agreement as well as the tilt of the isodose curves toward the blocked edge.

Asymmetric Jaws

Advantage in field matching:

Int J Radiat Oncol Biol Phys. 1994 Feb 1;28(3):753-60.

A mono isocentric technique for breast and regional nodal therapy using dual asymmetric jaws.

Klein EE, Taylor M, Michaletz-Lorenz M, Zoeller D, Umfleet W.

Source

Washington University School of Medicine, Mallinckrodt Institute of Radiology, St. Louis, MO 63110.

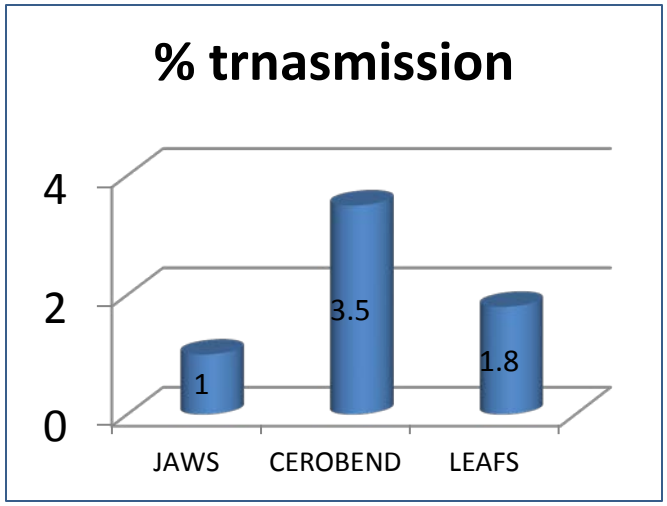
RESULTS:

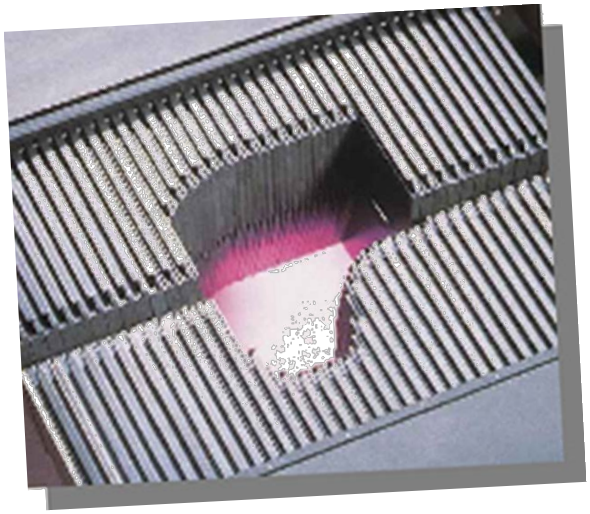
Our dosimetric studies show asymmetric jaws provide nearly equivalent field edge definition and superior absorption in comparison with Cerrobend blocks. The use of one isocenter results in a reduction of in-room treatment time by a factor of two. The burden of lifting heavy Cerrobend blocks has been removed. A composite port film, which includes the medial tangential and supraclavicular ports, shows a perfect match-line in all cases. Similar composite port films taken with our previous technique of geometric matching with collimator and table angulation exhibit slight overlap or underdose regions in many cases.

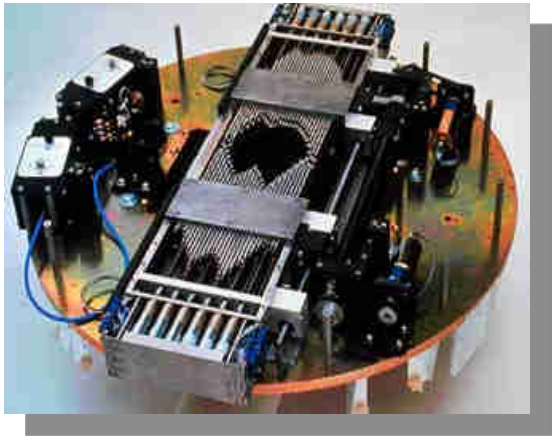
Fig. 5.32. Treatment technique for breast cancer using independent collimators. (From KLEIN et al. 1994)

Multi Leaf Collimator

- large number of collimating blocks or leaves that can be driven automatically, independent of each other, to generate a field of any shape
- Primary beam transmission:







Why MLC?
Modulated therapy (VMAT/IMRT)
3D conformity

MLC : general features

- **≥40** pairs of leaves having a width of ≤ **1 cm** (projected at the isocenter).
- Latest Varian has 60 pairs
- Thickness = **6 – 7.5 cm (** E dependent)
- Made of a tungsten alloy.
- Density of **17 - 18.5 g/cm^3**.
- Primary x-ray transmission:

  Through the leaves < **2%.**

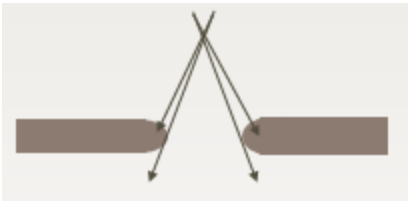
  Interleaf transmission < **3%**

  types:

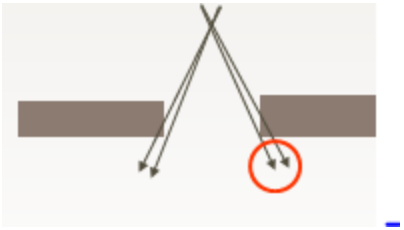
  Double focus

  Single focus(Non focus) Varian, Electa

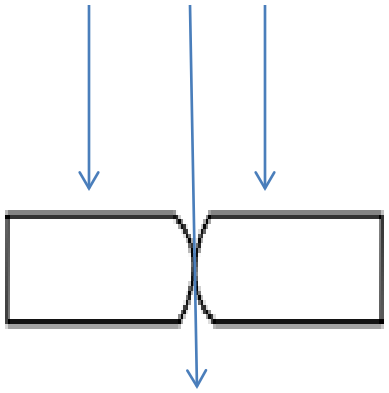
  Significant beam (20%) transmission when rounded leafs are abutted



Single Focus



Double Focus



MLC

- In order to allow [illegible] while reducing radiation transm[illegible] **e design** is often used.
- This design in tur[illegible] **sing** in the region of the tongue (17

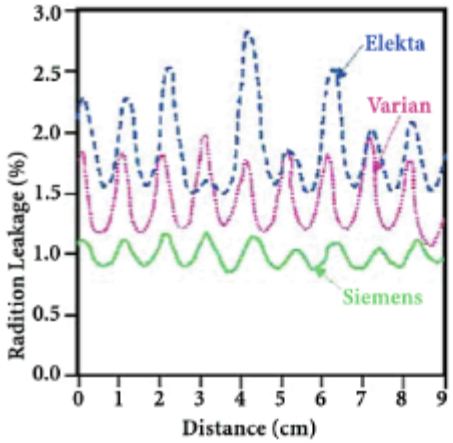
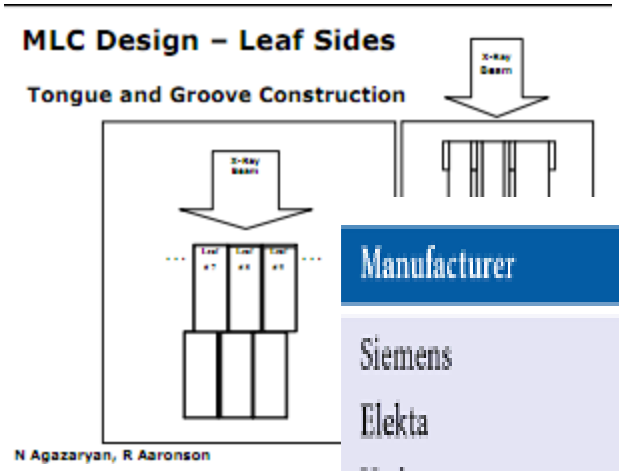
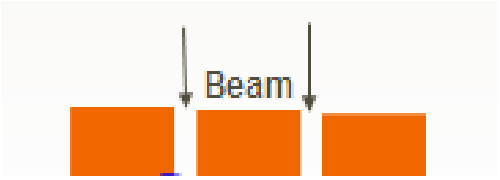


Fig. 1. Leakage patterns for the major MLC collimators. From: Huq MS, Das IJ, Steinberg T, Galvin JM (2002) A dosimetric comparison of various multileaf collimators. Phys Med Biol 47(12):N159–N170. Reprinted with permission





Manufacturer	Inter-leaf (%)	Intra-leaf (%)	Leaf-end (%)
Siemens	1.1	0.8	1.6
Elekta	2.5	1.6	> 20%
Varian	1.8	1.2	> 20%

MLC design

1.Upper Jaw replacement

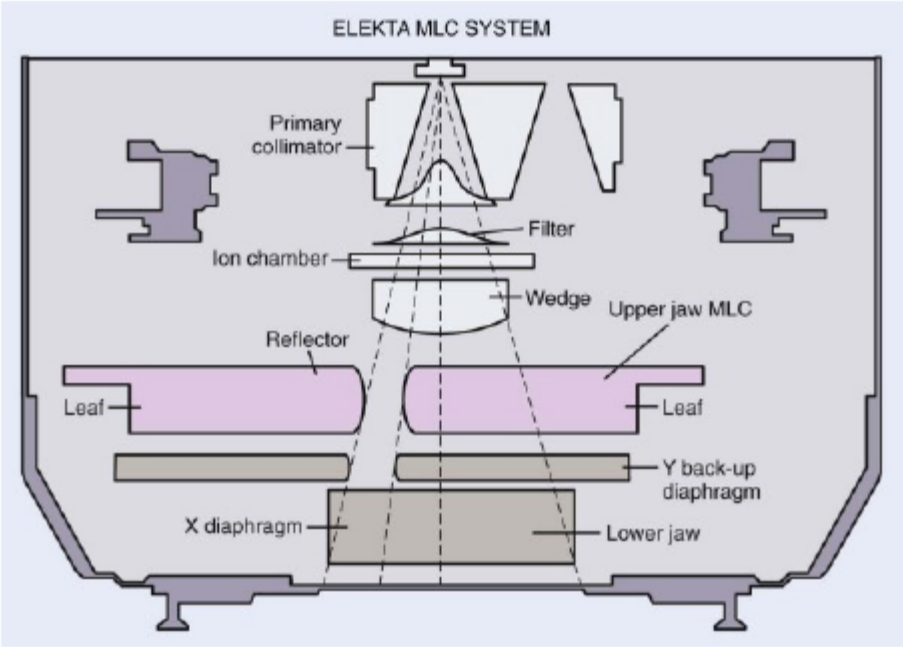


FIGURE 10-12 • A schematic drawing of the Elekta multileaf collimator.
(From Van Vvk J [ed]: The modern technology of radiation oncology, Madison, WI, 1999, Medical Physics

MLC

2.Lower Jaw Replacement

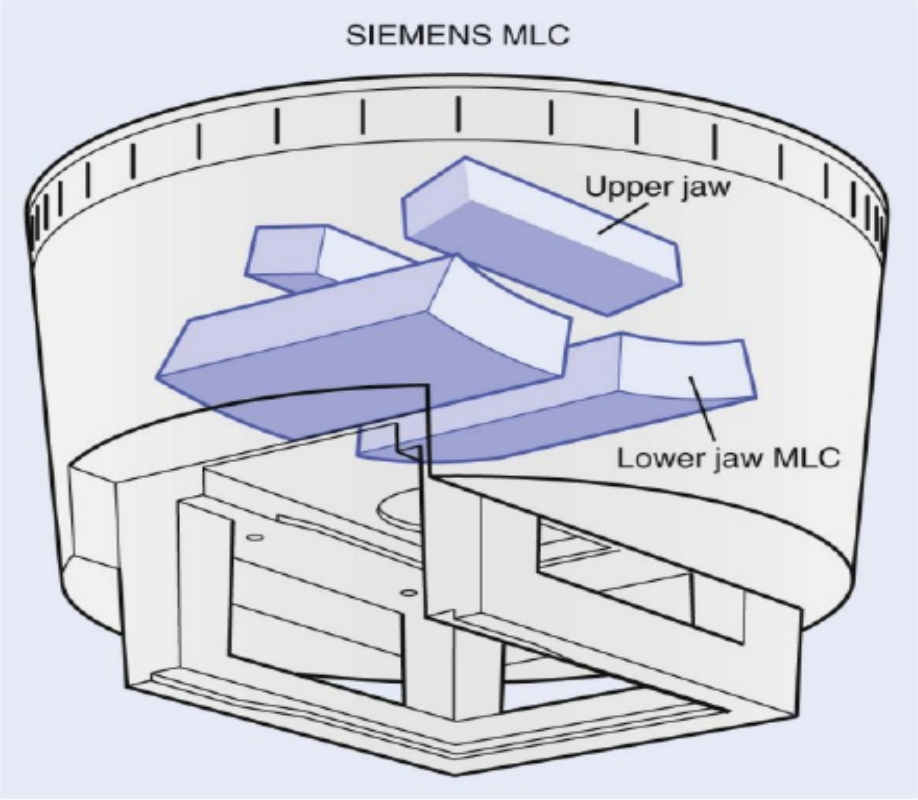


FIGURE 10-13 • A schematic drawing of the Siemens multileaf collimator.
(From Van Vyk J [ed]: The modern technology of radiation oncology, Madison, WI, 1999, Medical Physics Publishing.)

MLC

3.Tertiary MLC:

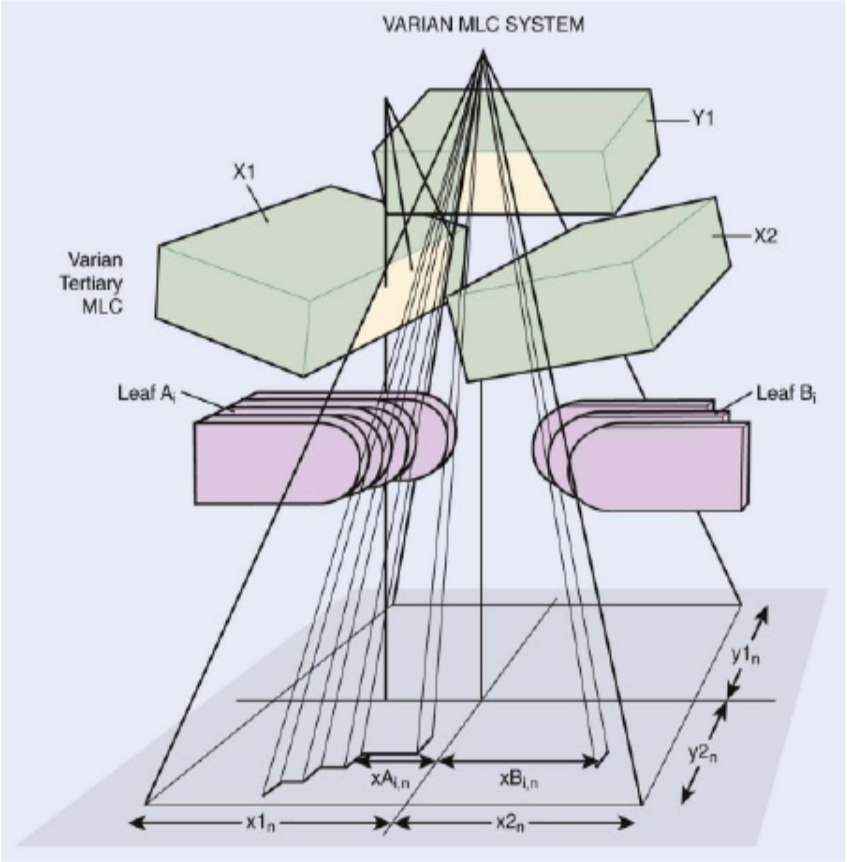


FIGURE 10-14 • A schematic drawing of the Varian multileaf collimator.
(From Van Vyk J [ed]: The modern technology of radiation oncology, Madison, WI, 1999, Medical Physics Publishing.)

MLC : penumbra

- Physical penumanbra is more

than cerobend/collimator

Jaws due to undulating

nature of isodose lines.

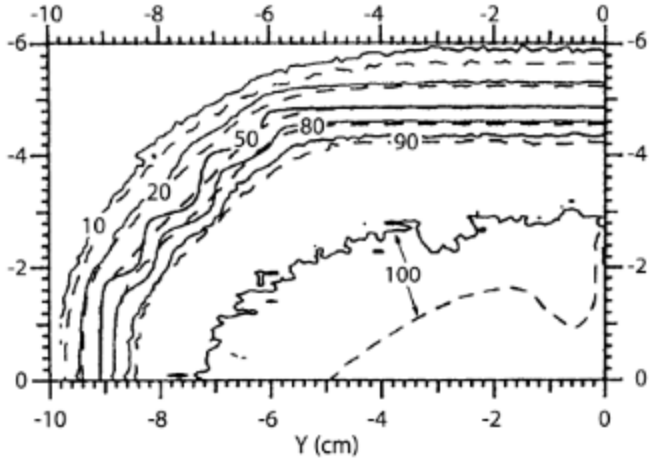


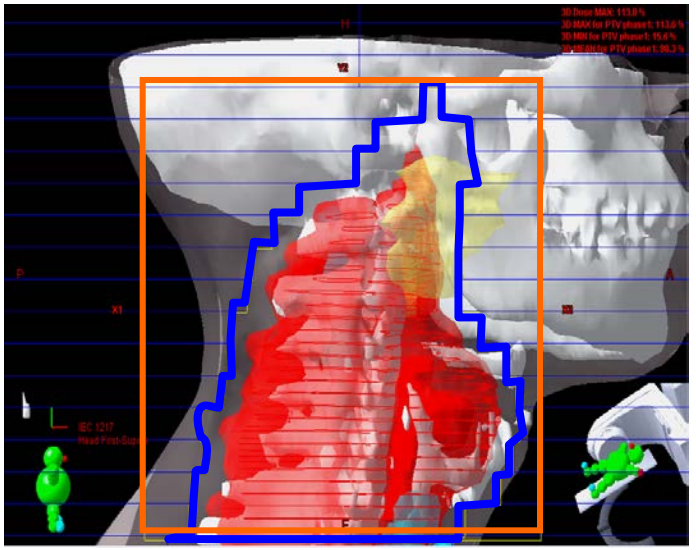
Fig. 5.30. Comparison of beam's eye view isodose curves at 10-cm depth for MLC (*solid line*) and Cerrobend-shaped (*dashed line*) beam apertures for 18-mV photons. (From KLEIN et al. 1995)

MLC shaping system optimisation:

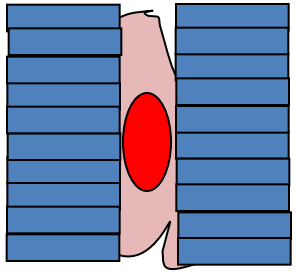
1. Exterior insertion
   leaf ends entirely outside the field
2. Interior insertion
   leaf ends entirely in the field
3. Leaf center insertion
   crossing the field at mid leaf position **preferable**

MLC

- The **degree of conformity** between the planned field boundary and the boundary created by the MLC depends upon:
  - **Projected** leaf width.
  - Shape of target volume.
  - Angle of collimator rotation.



- The **direction** of motion of the leaves should be parallel with the direction in which the target volume has the smallest cross-section.



MLC

Advantages:

1. **Time** for shaping and insertion of custom blocks not required.
2. The hardening of beam, scattered radiation, and increase in skin doses and doses outside the field, as seen with **physical compensators** is avoided.
3. **Automation** of reshaping and **modulation** of beam intensity in IMRT.
4. MLCs can also be used to as **dynamic wedges** and **electronic compensators** (2D).

MLC

- **Disadvantages:**

1. **Island blocking** is not possible.

2. Because the physical penumbra is **larger** than that produced by Cerrobend blocks treatment of smaller fields is difficult, as is the shielding of critical structures, near the field.

3. The **jagged** boundary of the field makes matching difficult.