Multi Leaf Collimator

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Conventional Beam shaping

- Rectangular Field produced by two sets of collimators (or jaws) built into the treatment machine.
- Irregular fields can be produced by using secondary custom blocks attached to the treatment machine beyond the collimator jaws.
- Conventional blocks are
  - Set of lead blocks of different shapes and sizes given by the vendor.
  - Cerrobend blocks fabricated individually for each radiation treatment field.

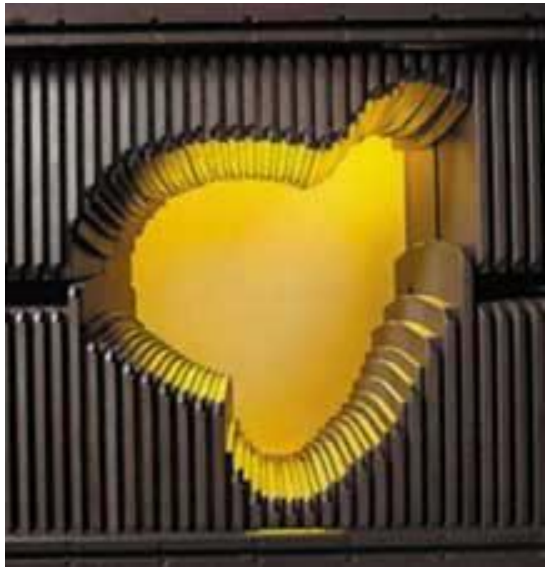
Conventional Beam shaping

Drawbacks of Conventional Block

- Treatment delivery time increases as technologist has to enter the treatment room for each beam to adjust the block set up.
- The fabrication process is lengthy and involves handling of toxic cerrobend material.
- Manual placement of blocks over tray attached to the machine may lead to accidents involving dropping or falling of blocks causing injury to patients and technologists.

Multi leaf collimators

- Multi leaf collimators are introduced into Linacs in the 1980's.
- Multi leaf collimators are a pair of jaws divided into independent movable sections or leaves.
- Computer controlled.
- Shapes fields quickly. (No need of Block set up)
- It can also be used for dynamic treatment. (Intensity Modulation)



Basic Application of MLC

- To replace conventional blocks.
- Matching the BEV to PTV during an Arc rotation of X ray beam.
- Achieve beam intensity modulation.

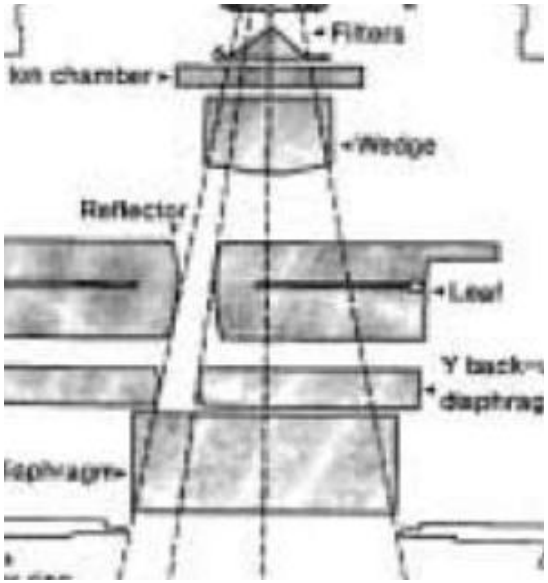
Materials and properties

- Tungsten alloy(tungsten,Fe,Cu,Ni) is the material of choice for leaf construction.
- High density
- Hard
- Inexpensive
- low coefficients of thermal expansion
- density of Pure tungsten= 19.3 g/cm3

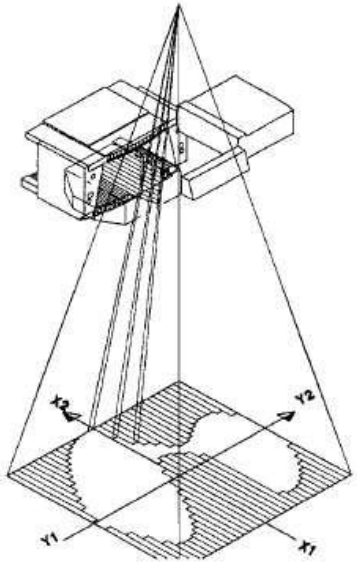
  density of the alloys =17.0- 18.5 g/cm3

MLC configuration

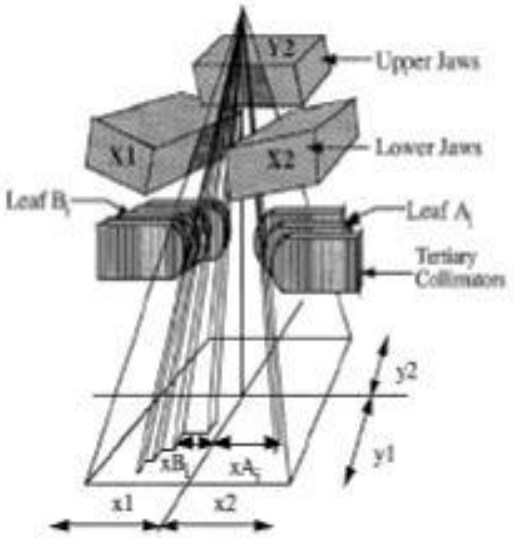
- Upper jaw replacement (Elekta)
- Lower jaw replacement (Siemens)
- Tertiary Collimation (Varian)



Elekta

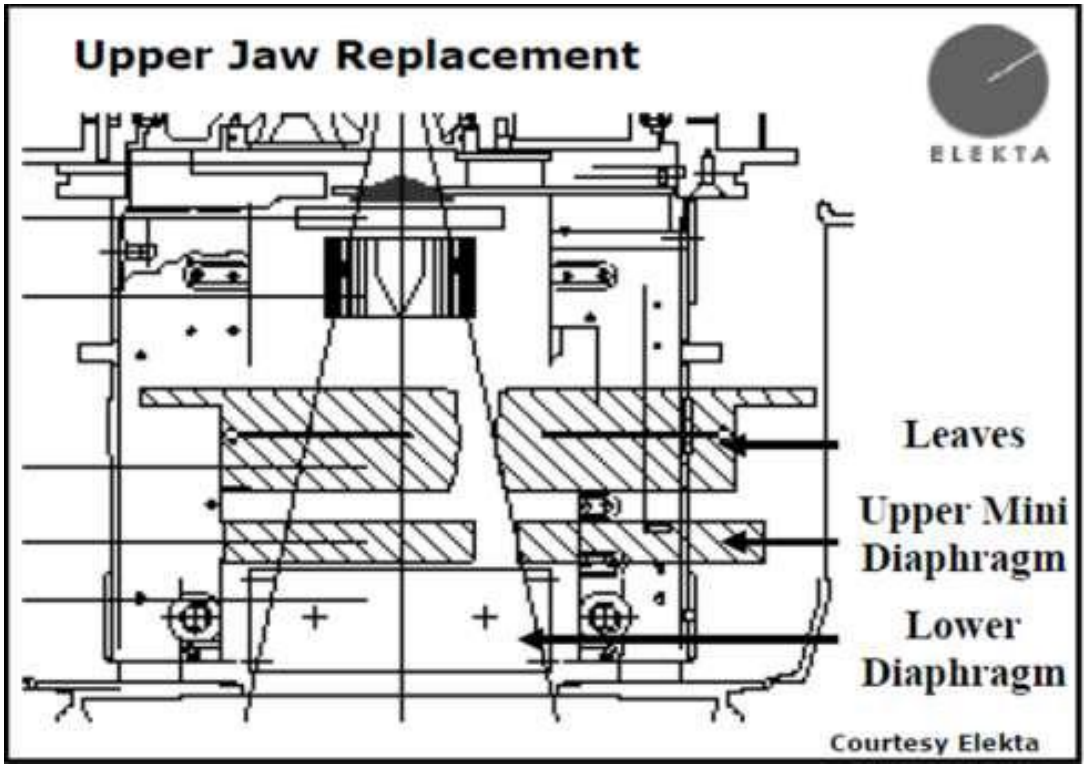


Siemens



Varian

Upper jaw replacement



Upper jaw replacement

- In this configuration the upper jaw is split into a set of leaves. (used by Elekta)
- MLC leaves move in the Y-direction (parallel to the axis of rotation of the gantry)
- A “back-up” collimator located beneath the leaves and above the lower jaws augments the attenuation provided by the individual leaves.
- The back-up diaphragm is essentially a thin upper jaw that can be set to follow the leaves if they are arranged together to form a straight edge, or else, set to the position of the outermost leaf if the leaves form an irregular shape.

Upper jaw replacement

Advantages

- The range of motion of the leaves required to traverse the collimated field width is smaller,
- It allows for a shorter leaf length and therefore a more compact treatment head diameter

Disadvantages

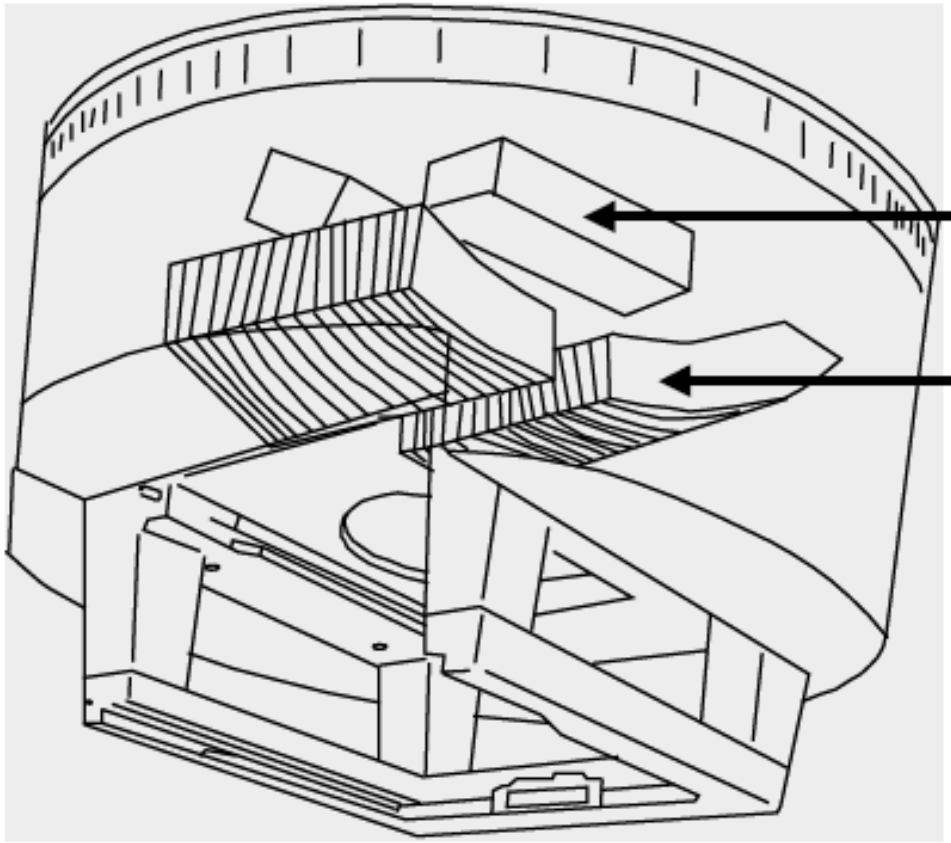
- Having MLC leaves so far from the accelerator isocenter needs leaf width must be somewhat smaller.
- Tolerances on the dimensions of the leaves as well as the leaf travel must be tighter than for other configurations.

Lower Jaw Replacement

- The lower jaws can be split into a set of leaves as well. (Siemens) and is doublefocused.
- Both leaf ends and leaf sides match the beam divergence.
- There are no backup jaws.

Lower Jaw Replacement

SIEMENS



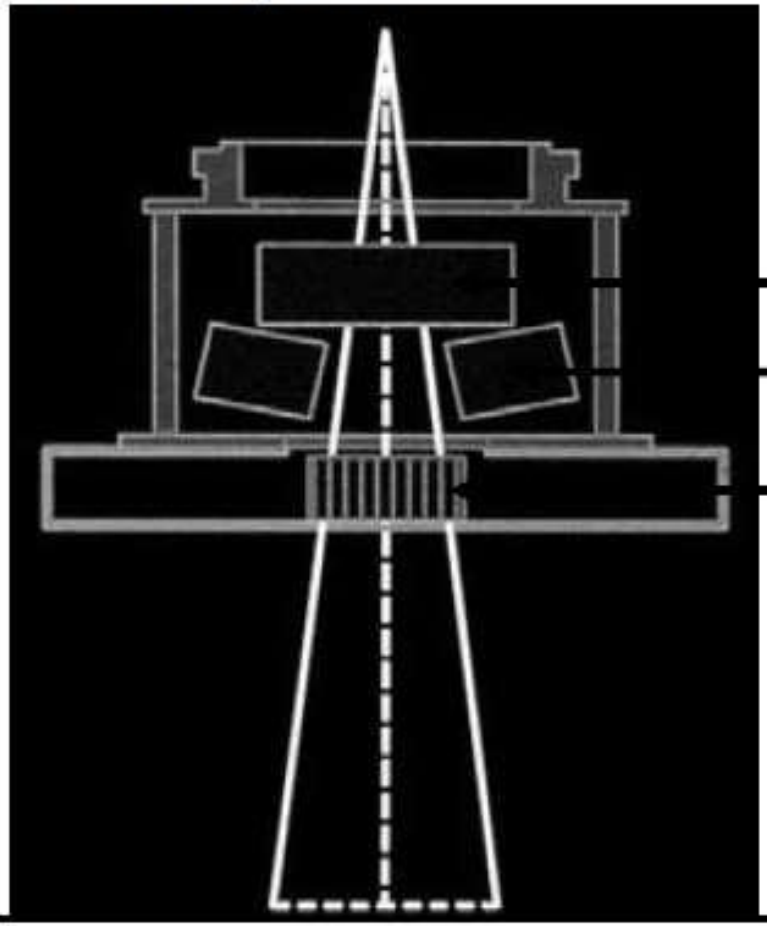
Courtesy Siemens

Tertiary collimation

- MLC are positioned just below the level of the standard upper and lower adjustable jaws(**Varian).**
- This avoids the lengthy downtime in the event of a MLC system malfunction.
- It is possible to move leaves manually out of the field should a failure occur.
- The treatment can be continued by using 'Cerrobend' individual blocks.

Tertiary MLC

VARIAN
medical systems



Upper Diaphragm

Lower Diaphragm

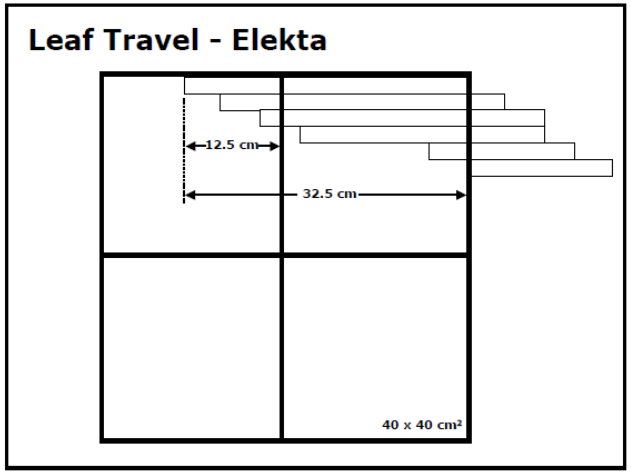
Leaves

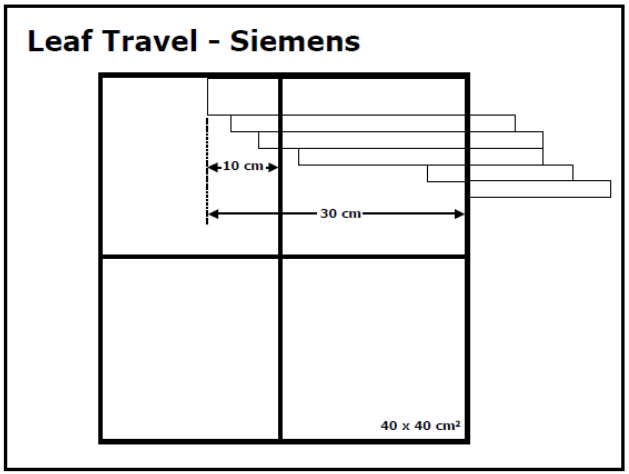
Courtesy Varian

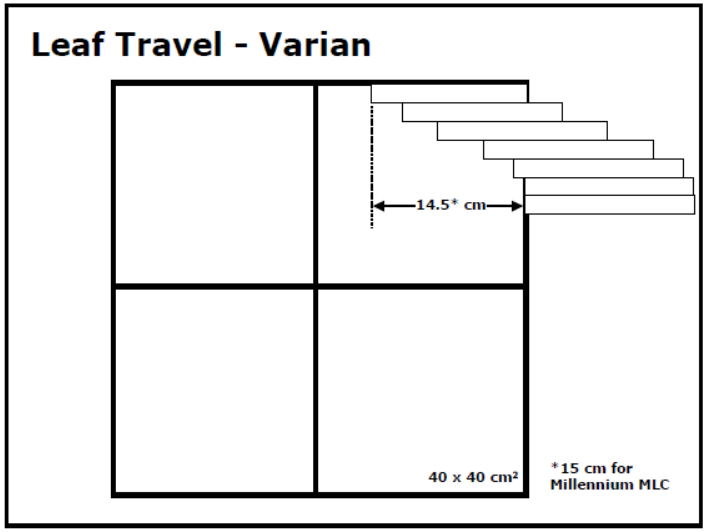
Upper jaw replacement

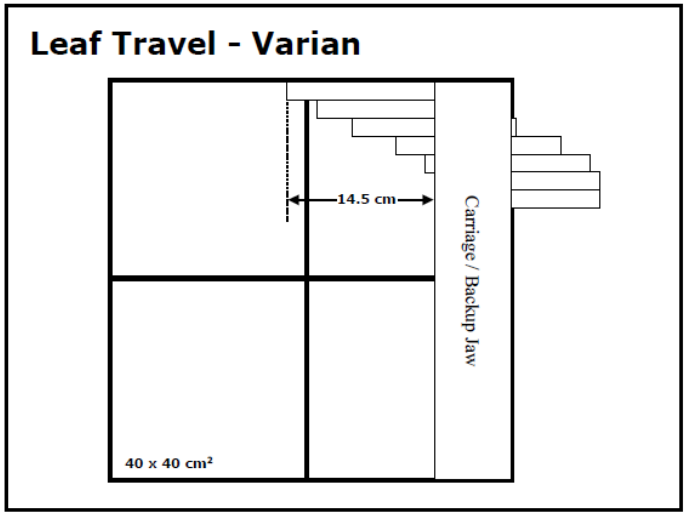
- **Advantages**
  - Allows retro-fitting of MLCs on existing units.
  - Leaves can be manually moved out in case of system malfunction/failure and treatment continued using customized blocks.
  - Allows larger leaf width; easier manufacturing.
  - Easier Leaf positioning / Lesser positional accuracy needed.
- **Disadvantages**
  - Added bulk and clearance to the mechanical isocenter.
  - Moving the MLC further away from the xray target requires increasing the leaves size and a longer travel distance.

Leaf travel distances



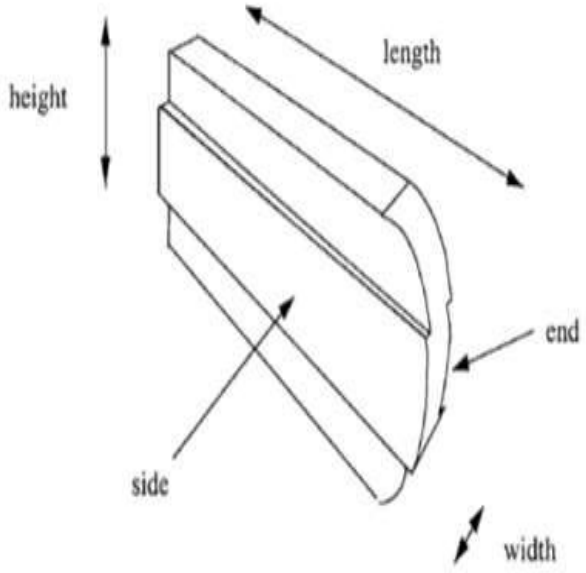






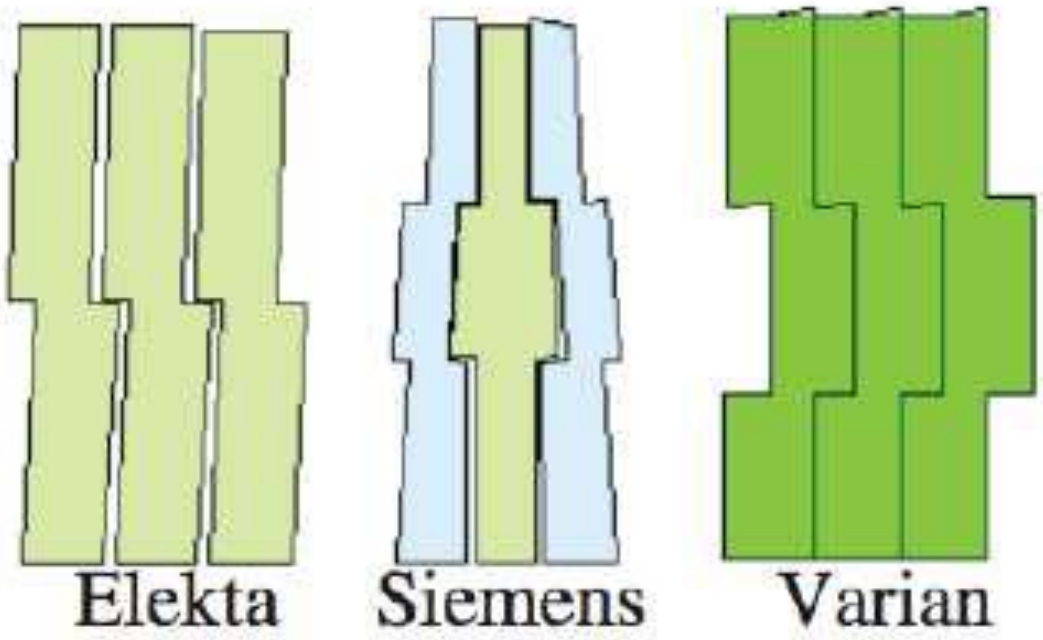
MLC Leaf design

- ***Width of a leaf***-small dimension of the leaf perpendicular to the direction of propagation of the x-ray beam and perpendicular to the direction of motion of the leaf.
- ***Length of the leaf***- leaf dimension parallel to the direction of leaf motion.
- ***Leaf end***-Surface of the leaf inserted into the field.
- ***Leaf sides*** -Surfaces in contact with adjacent leaves
- ***Height of the leaf***-Dimension of the leaf along the direction of propagation of the primary x-ray beam.



MLC Leaf design- Leaf sides

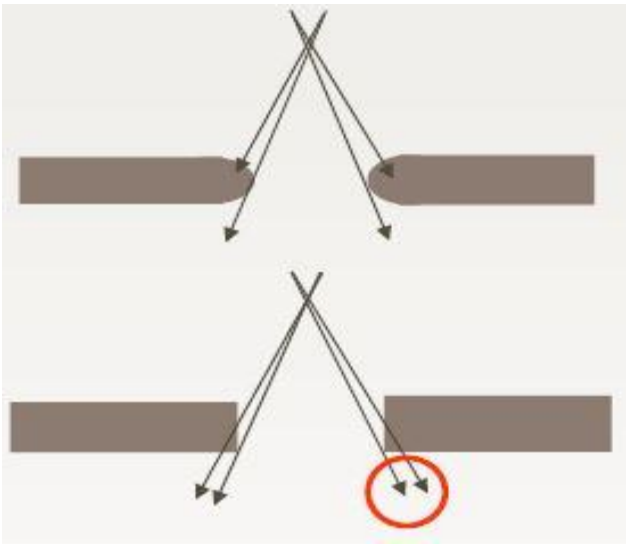
Tongue and Groove Construction



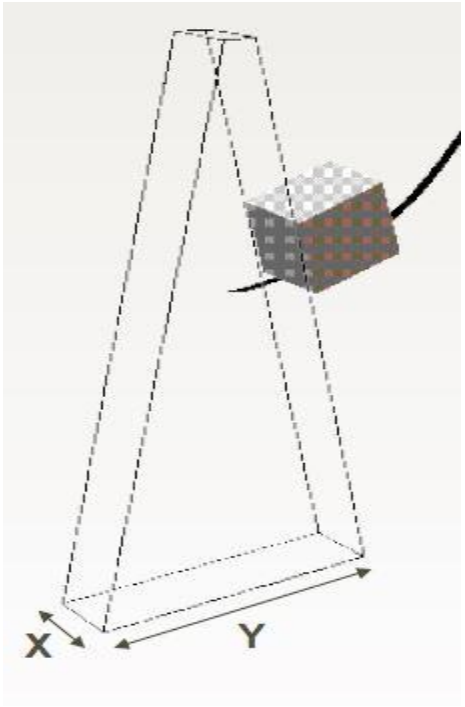
MLC Leaf design – Leaf end

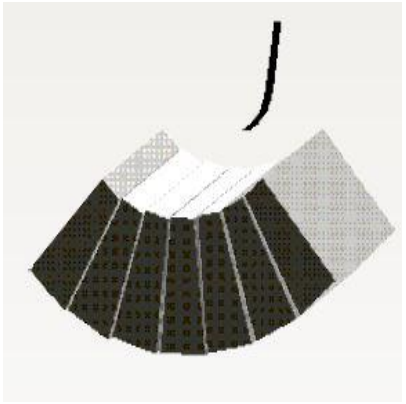
- ***Focused Leaf end***
  - the leaf ends are designed to follow the beam divergence as the field opens or closes.
  - Siemens Linac use MLC which move in an arc such that their flat ends are always in the same plane as the radiation focus.
  - Complex design.
  - Penumbra is less.
- ***Unfocused Leaf end***
  - The leaf ends are round.
  - Simpler design.
  - Acceptable penumbra.
  - Varian and elekta use this kind of MLC design.

MLC Leaf design – Leaf end



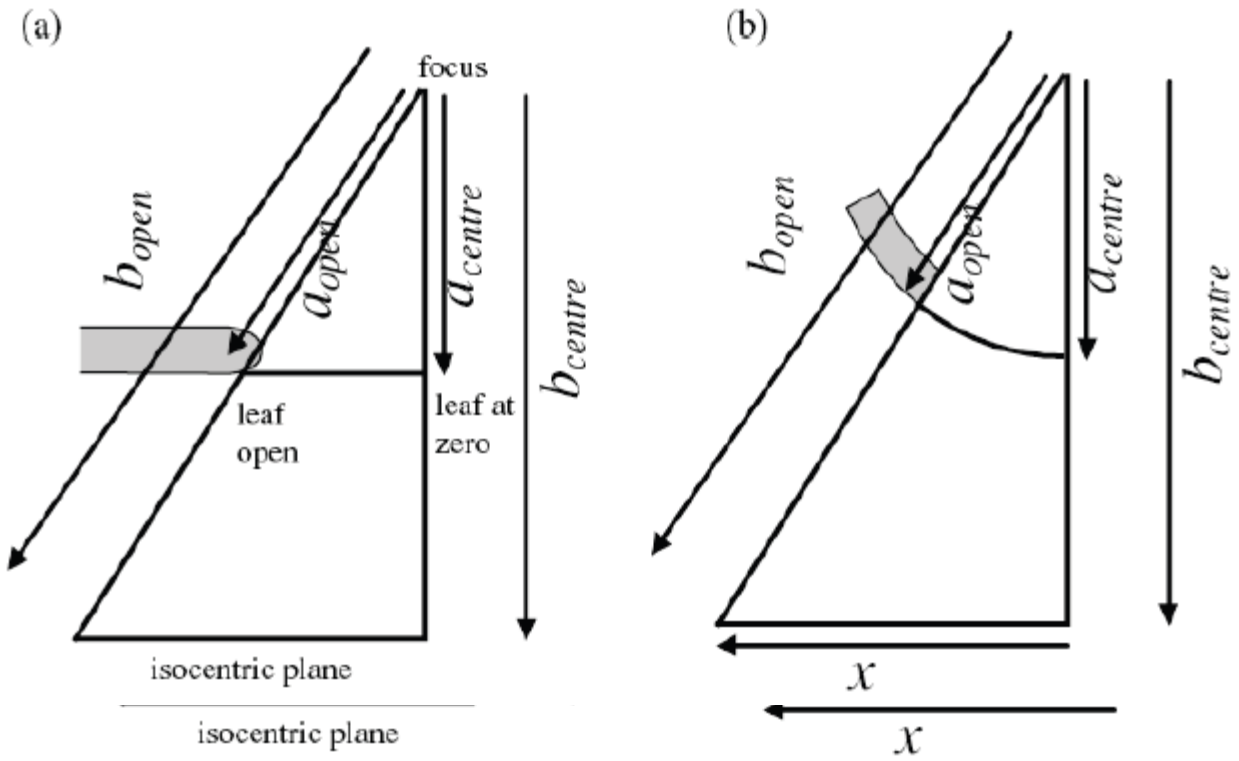
Unfocused





focused

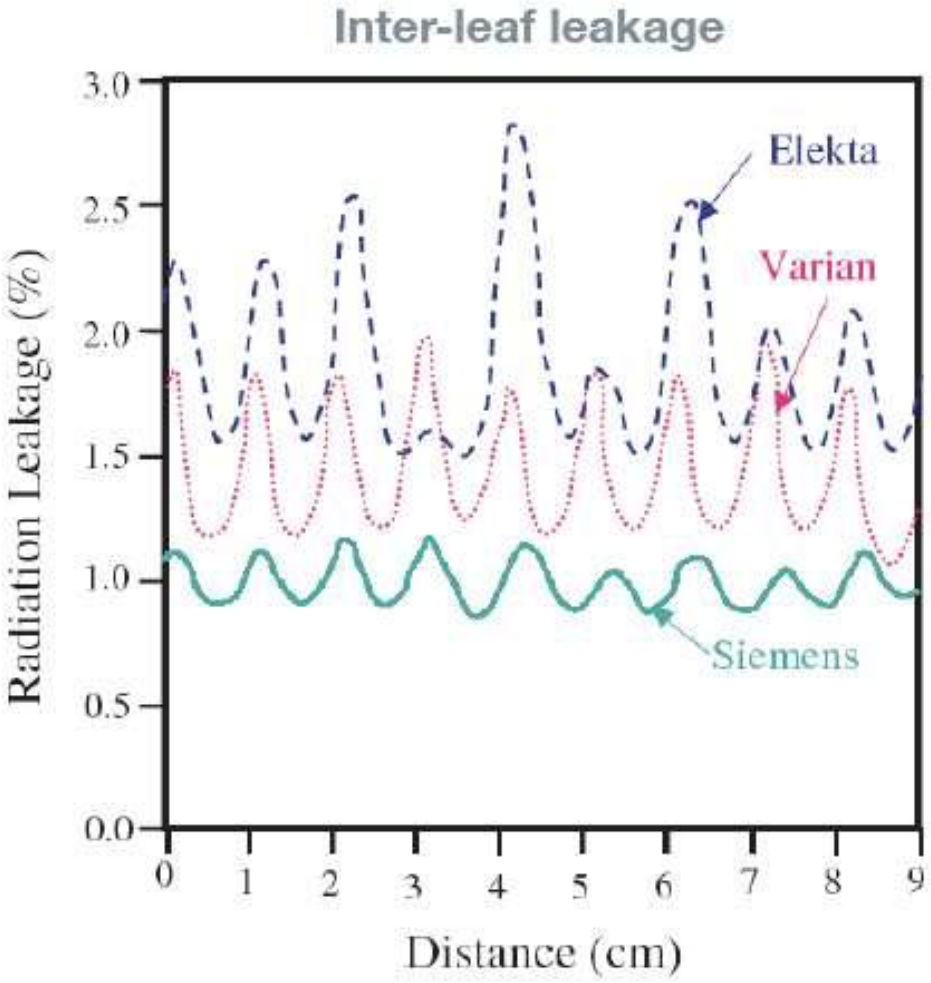
MLC Leaf design – Leaf end



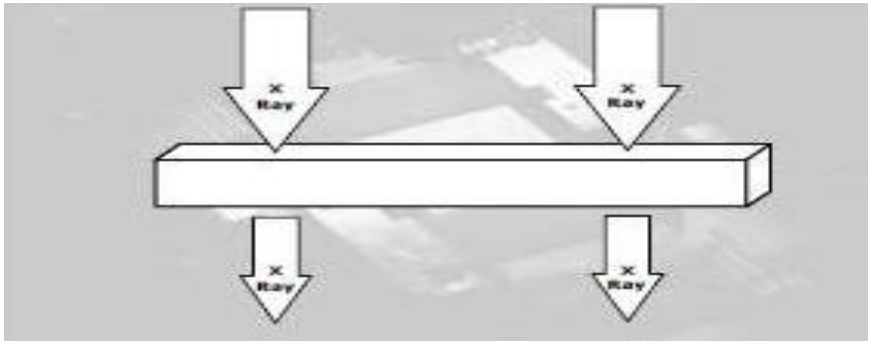
Unfocused **focused**

Transmission Specification

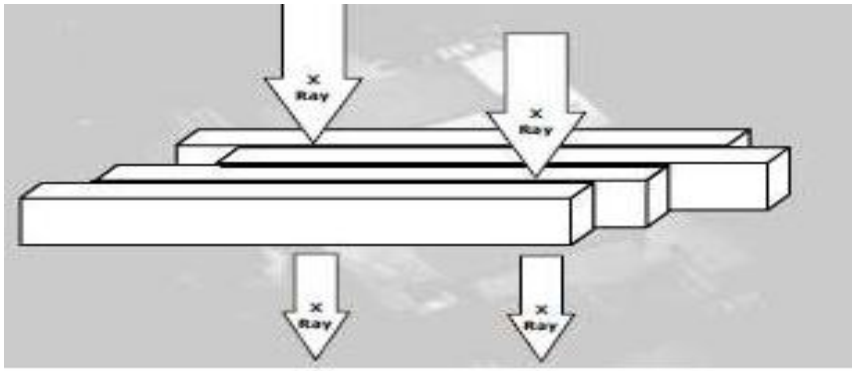
- ***Intra leaf transmission*:** The reduction of dose through the full height of the leaf.
- ***Interleaf transmission*:** The reduction of dose between adjacent leaves.
- ***Leaf end transmission*:** Reduction of dose measured along a ray passing between the ends of opposed leaves in their most closed position.


Inter-leaf leakage
Radiation Leakage (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6
7
8
9
Distance (cm)
Elekta
Varian
Siemens

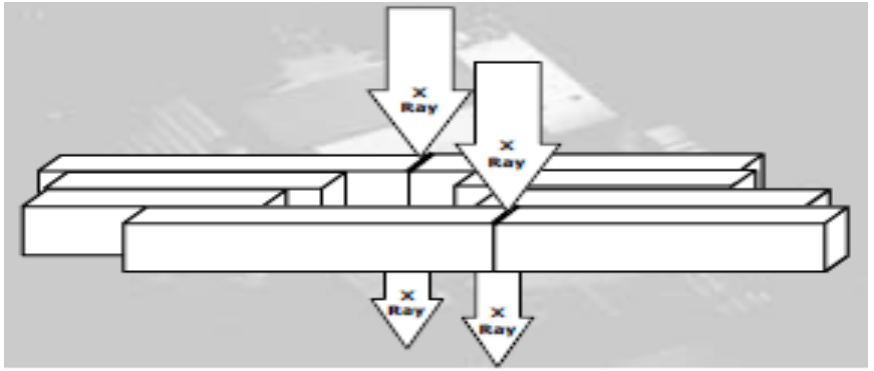
- Intra Leaf Transmission



- Interleaf Transmission



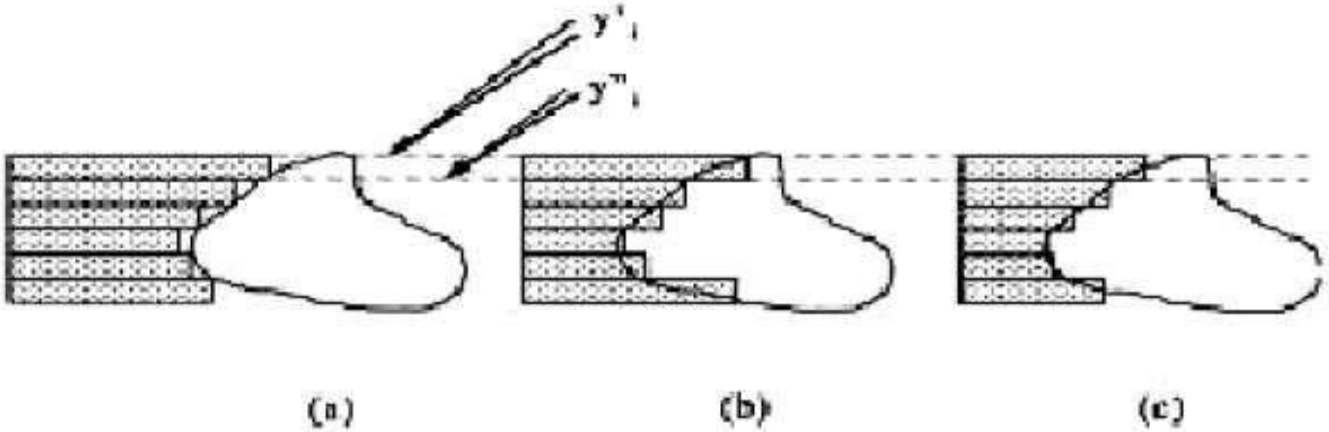
- Leaf end Transmission



Clinical Applications

- ***Leaf placement Strategies***
  - *Definition of Target area* : Treatment planning system facilitates shaping leaves around PTV, as defined by a radiation oncologist.
  - *Optimisation of MLC conformation* : To place automatically the leaves of MLC in conformity with the target contour shape, three leaf coverage strategies can be used.
    - ***Out of field strategy***
    - ***In field strategy***
    - ***Cross boundary technique***

Leaf placement strategies



a. ***Out of field strategy*** : Avoids shielding any part of PTV which may not be irradiated completely.

b. ***In field strategy*** : PTV is not irradiated completely, but any part out of PTV is shielded.

c. ***Cross boundary technique*** : Leaf positions are optimized such that in field area is equal to the out field area.

- ***Optimization of Collimator rotation*** **:**
  - One can optimize matching the leaf shape to target volume by rotating the collimator, and therefore, the direction of leaf travel.
- ***Intensity Modulated Radiotherapy (IMRT) using MLC*** **:**
  - Precise dose delivery on any part of treated area avoiding the surrounding healthy tissue.
  - MLC for IMRT should be very precise, motion of leaves must be fast and constant.
  - Two strategies of IMRT with MLC.
    - ***Step and Shoot*** - leaves moves when radiation is stopped.
    - ***Dynamic*** **-** Continuous movement of leaves during the treatment

Tests on MLC (3DCRT/IMRT)

- Positional accuracy & reproducibility
- Coincidence of MLC, collimator & couch axes
- Leaf width at isocentre
- Inter and intra leaf transmissions
- Leaf end gap - inter leaf collisions
- Over travel accuracy and reproducibility
- Skewness-Misalignment between the MLC leaves and the Primary Jaw or Backup Diaphragm
- Leaf speed
- Leaf end and radiation field edge offset

QA tests on MLC

Test Parameters	Tolerances
Field overlap	2.0 mm
Positional Accuracy	< 1 mm
Positional Reproducibility	± 1 mm
Light and Radiation field coincidence	± 2 mm
Coincidence of mechanical and radiation isocentre	≤ 2 mm dia
Average of intra and inter leaf transmission	± 0.5 %

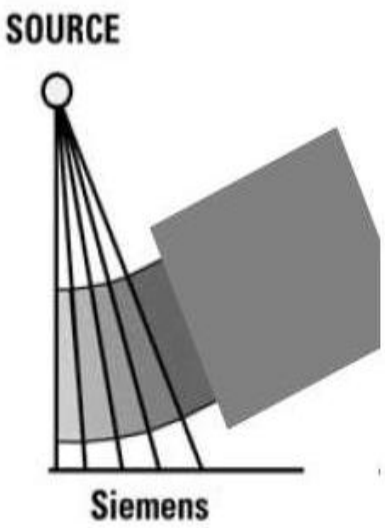
Non Conventional MLCs

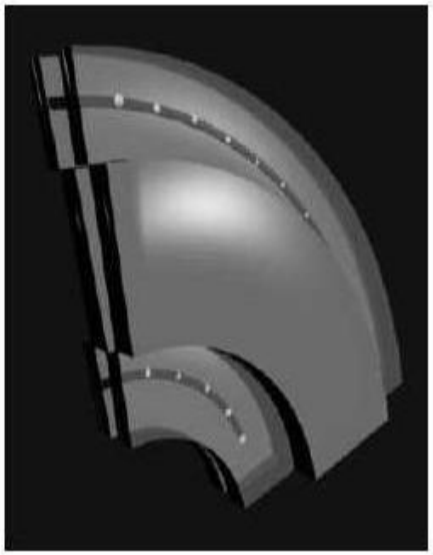
Mini and Micro MLCs

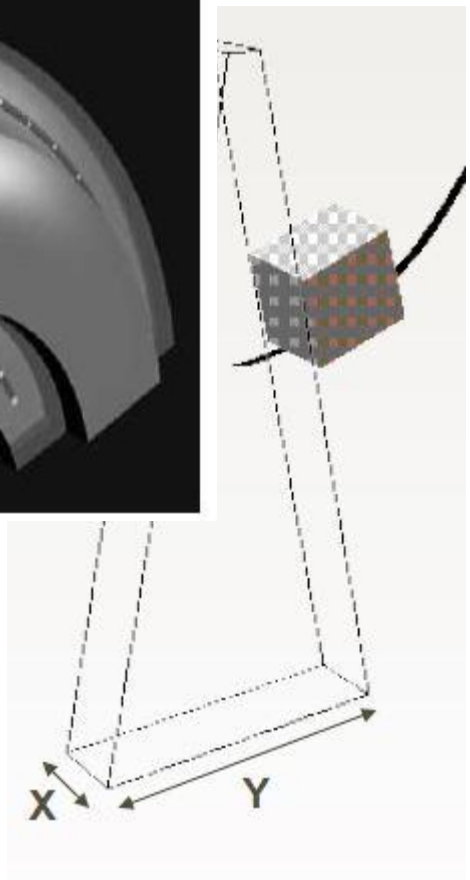
- Facilitates small field treatments in case of SRS and SBRT.
- Mini MLC - leaf width :2mm to 5mm

  Micro MLC - Leaf width : <2mm
- There are built in computer controlled MLC provided by many vendors. e.g. Varian
- Also there are add on MLC which can be attached to the Linac gantry head. e.g. Elekta Apex, Brainlab etc.


THANK YOU


SOURCE
Siemens

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