Treatment Delivery Systems 2

Field Shaping; Design Characteristics and Dosimetry Issues

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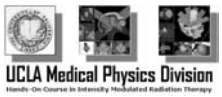


TU-A-517A-1

Presentation Outline

- **MLC Characteristics**
  - **TG-50 / Definitions**
- **Description of Commercial MLC**
  - **Standard MLC**
  - **Mini/Micro MLC**
- **Dosimetry and QA of MLC**
- **Considerations for IMRT**

MLC Characteristics

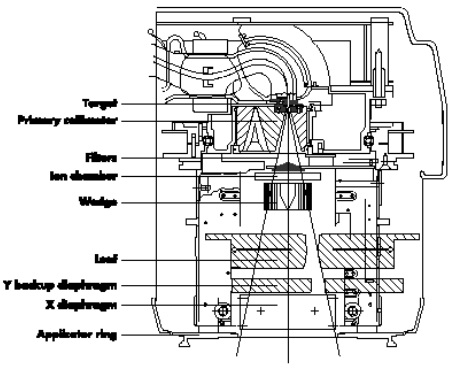
- **MLC Design**
- **Leaf Transmission**
- **Leaf Sizes**
- **Number of Leaves**
- **Leaf Travel**
- **Leaf Abutment**
- **Source-Leaf Distance / Isocenter Clearance**
- **Leaf Positioning Mechanism / Accuracy**
- **Leaf Positioning Constraints**
- **Leaf Speed**

MLC Design

- Upper Jaw Replacement
- Lower Jaw Replacement
- Tertiary MLC

TU-A-517A-1 Field Shaping; Design Characteristics and Dosimetry Issues

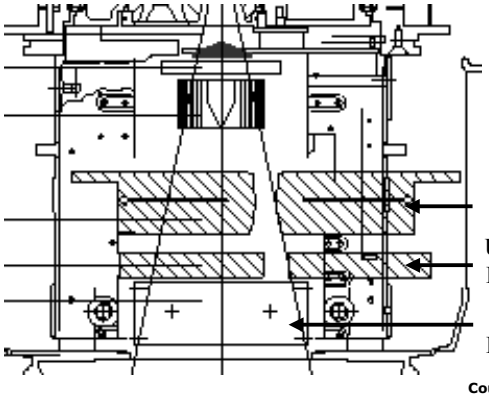
Upper Jaw Replacement



ELEKTA

Courtesy Elekta

Upper Jaw Replacement

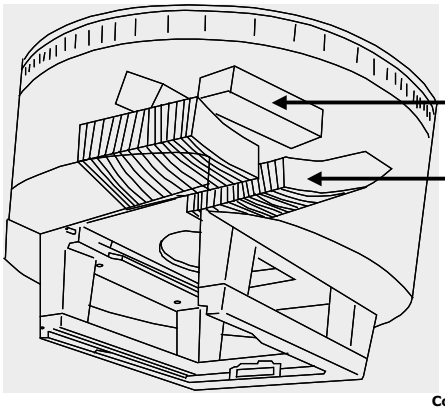


ELEKTA

Courtesy Elekta

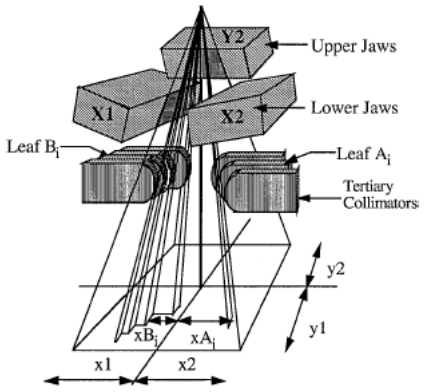
Lower Jaw Replacement

SIEMENS



Courtesy Siemens

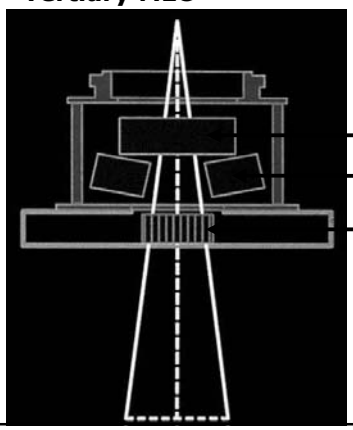
Tertiary MLC



TG-50

Tertiary MLC

VARIAN medical systems

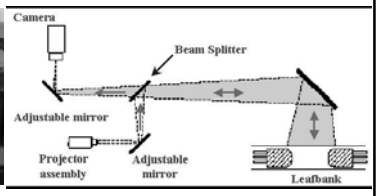


Courtesy Varian

Isocenter Clearance

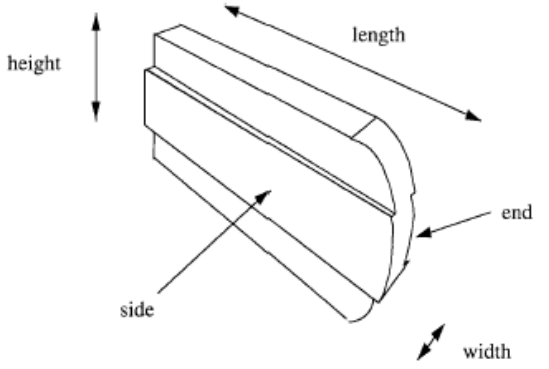
MLC	Largest	Block Tray	Wedge	Tray + Wedge
Elekta	45 cm	35.3 cm	35.3 cm	35.3 cm
Siemens	43 cm	43 cm	43 cm	43 cm
Varian	42 cm	35 cm	35 cm	31 cm

Positioning Mechanism / Precision



Elekta	Siemens	Varian Standard	Varian Millennium
Video	Linear Encoder	Linear Encoder	Linear Encoder
0.01 cm	0.10 cm	0.01 cm	0.01 cm

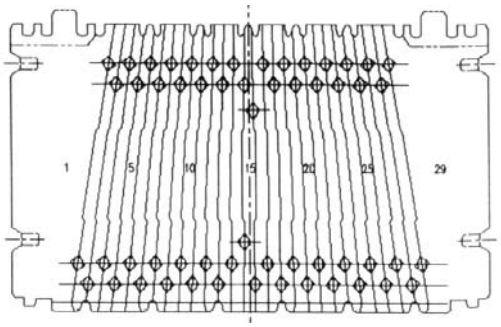
TG-50 Definitions



TG-50

MLC Design – Leaf Sides

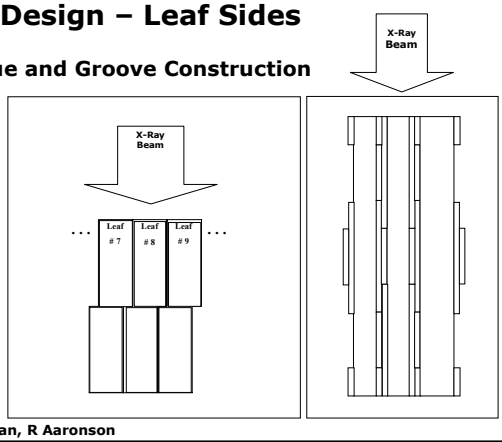
Leaf sides follow divergence



Courtesy Siemens

MLC Design – Leaf Sides

Tongue and Groove Construction



N Agazaryan, R Aaronson

MLC Design – Leaf Ends

Non-focused (rounded) Leaf Ends

Leaf motion restricted to a single plane

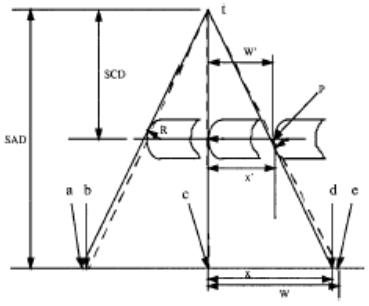
In principle, penumbra is somewhat greater than for focused collimators of divergent custom blocks

Potential for greater leaf end transmission when leaves are abutted

Both Varian and Elekta use the non-focused design

MLC Design – Leaf Ends

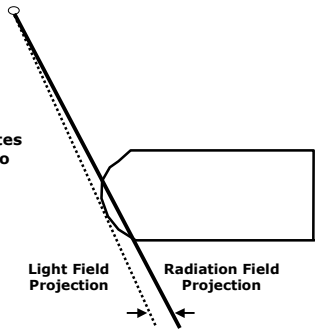
Penumbra relatively constant as a function of leaf position



MLC Design – Rounded Leaf Ends

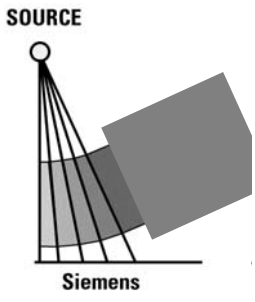
Light Field versus radiation field

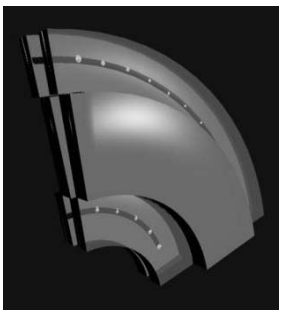
Light field underestimates radiation field by 0.5 to 1.2 mm per side



MLC Design – Leaf Ends

Focused leaves – maintain geometric divergence





Leaf Size and Number

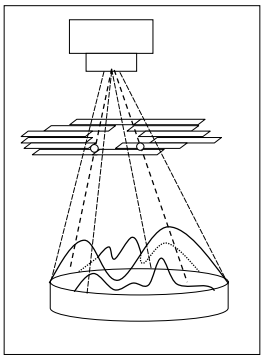
MLC	Leaves	Size
Elekta	40 x 2	1 cm
Siemens	29 x 2	1 cm (27) 6.5 cm (2)
Varian Standard	26 x 2	1 cm
Varian Standard	40 x 2	1 cm
Varian Millennium	26 x 2	1 cm
Varian Millennium	40 x 2	1 cm
Varian Millennium	60 x 2	1 cm (20) 0.5 cm (40)

TG-50 Transmission Recommendation

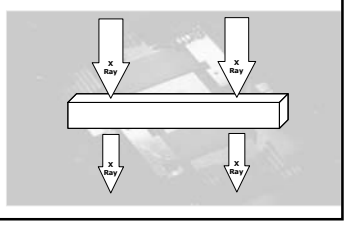
For upper or lower jaw replacement MLC, transmission requirements are the same as for standard collimators

For tertiary MLC, transmission requirements are the same as for custom blocks (< 5%). However, leaf thickness should provide adequate attenuation to compensate for interleaf transmission

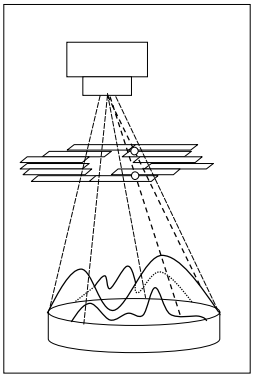
TG-50 Definitions: Leaf Transmission



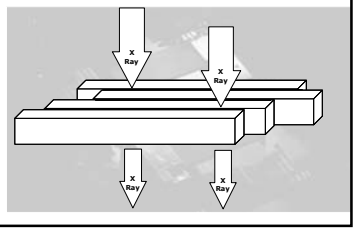
Reduction of dose through the full height of the leaf



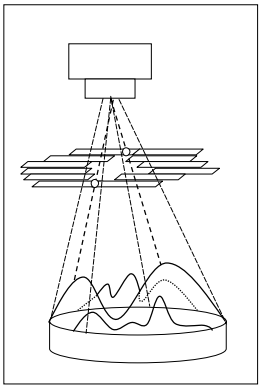
TG-50 Definitions: Interleaf Transmission



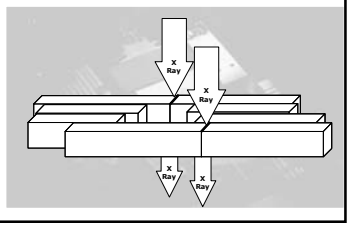
Reduction of dose between adjacent leaves



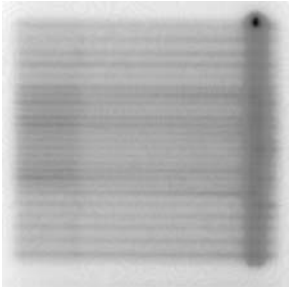
TG-50 Definitions: Leaf End Transmission

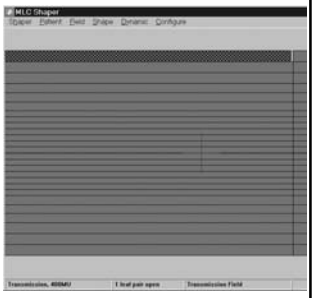


Reduction of dose between the ends of opposed leaves

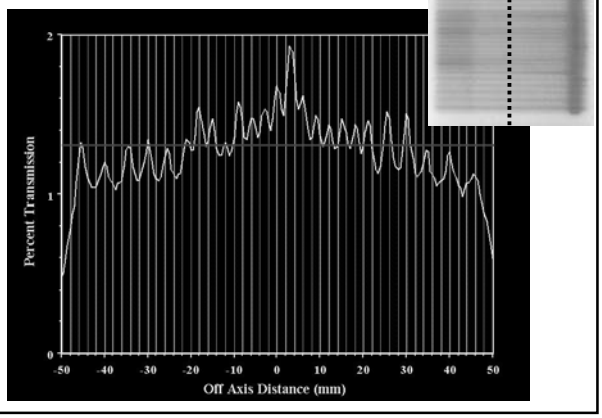


Leaf Transmission

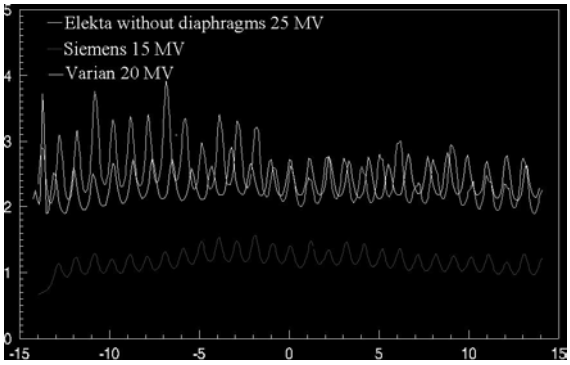




N Agazaryan



Transmission Summary

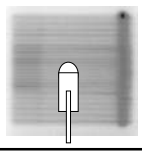


Transmission Summary

<u>Elekta:</u> 1.8% - 2%, 11% (backup diaphragm only), <0.5% (leaves + backup diaphragm), 4-4.5% between leaves, 50-60% between leaf ends

Siemens: 1%, < 1.5% between leaves

<u>Varian:</u> 1.5-2.5%, 2-3.5% between leaves, 12-28% between leaf ends



Leaf Characteristic Summary

Effective penumbra (80%/20%) of focused versus divergent leaf ends within 1-2 mm of each other

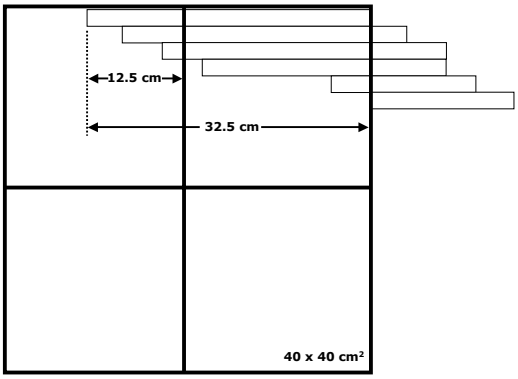
Leaf side penumbra ~1 to 1.5 mm less than leaf end penumbra

For focused leaf ends, light field underestimates radiation field

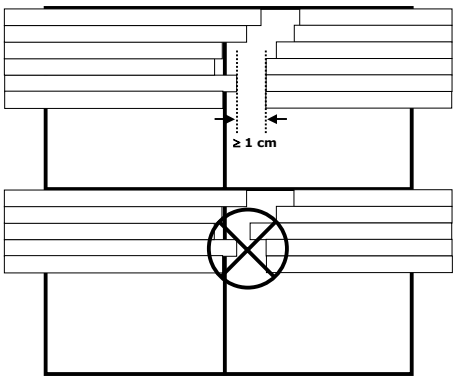
Transmission characteristics on all systems <4%

Tongue and groove construction produces a transmission distribution

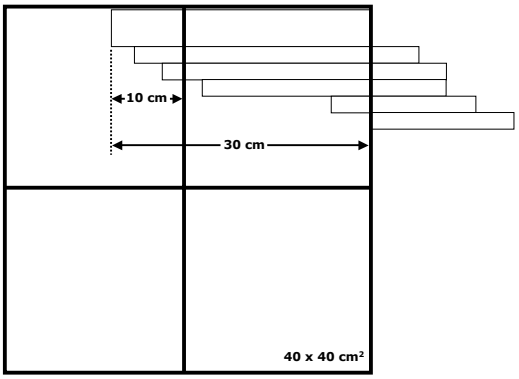
Leaf Travel - Elekta



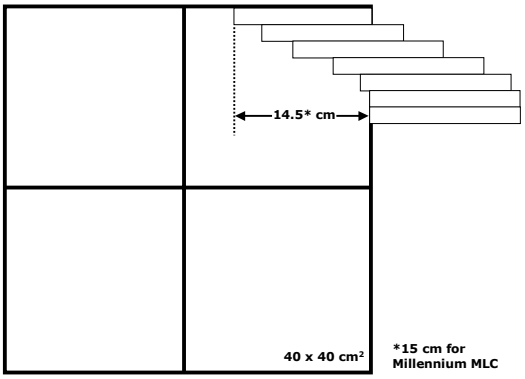
Leaf Abutment - Elekta



Leaf Travel - Siemens

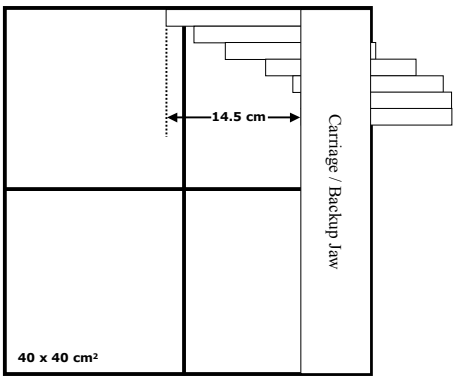


Leaf Travel - Varian

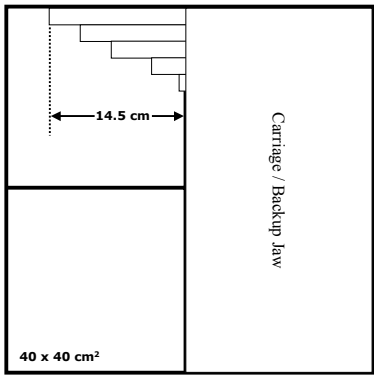


*15 cm for Millennium MLC

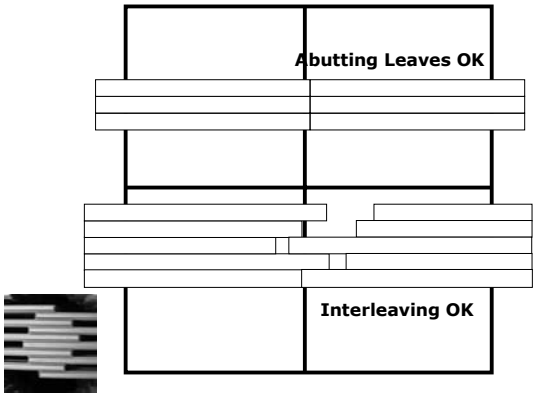
Leaf Travel - Varian



Leaf Travel - Varian



Leaf Abutment – Siemens / Varian



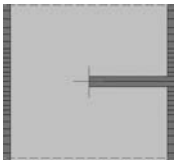
Field Size Summary

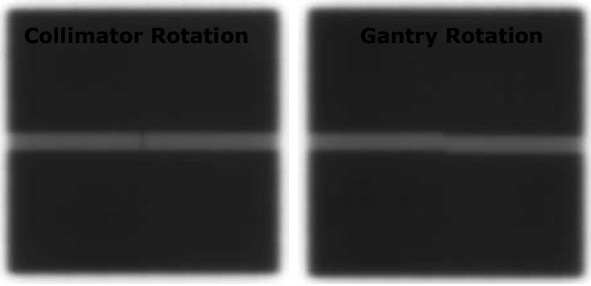
MLC	Regular Field	Irregular Field
Elekta	40 x 40 cm^2	40 x 40 cm^2
Siemens	40 x 40 cm^2	40 x 27 cm^2
Varian Standard	40 x 40 cm^2	29 x 40 cm^2
Varian Millennium	40 x 40 cm^2	30 x 40 cm^2

Acceptance Testing, Commissioning and Quality Assurance

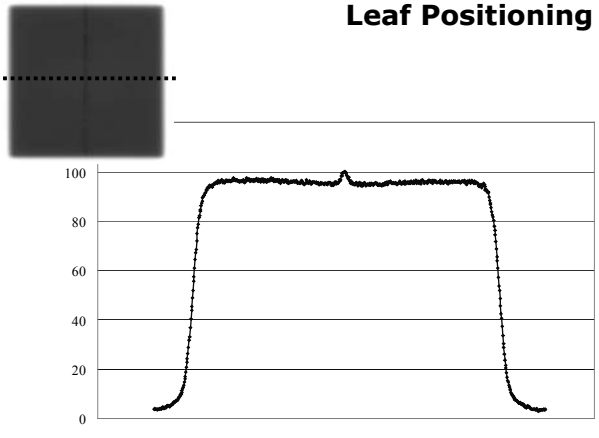
- Alignment of mechanical and optical axes
- Leaf position calibration, leaf travel characteristics, as a function of collimator and gantry position
- "Follower" jaw calibration
- Transmission characteristics
- Interlocks
- Field shaping software, data transfer, reproduction of standard shapes
- Dosimetric comparison with treatment planning system

Alignment of mechanical and optical axes

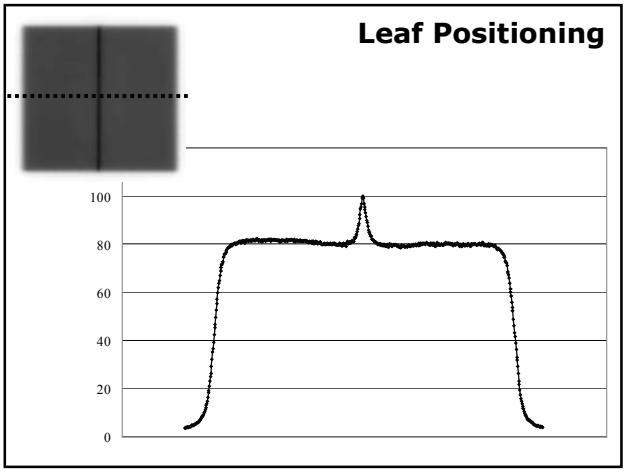




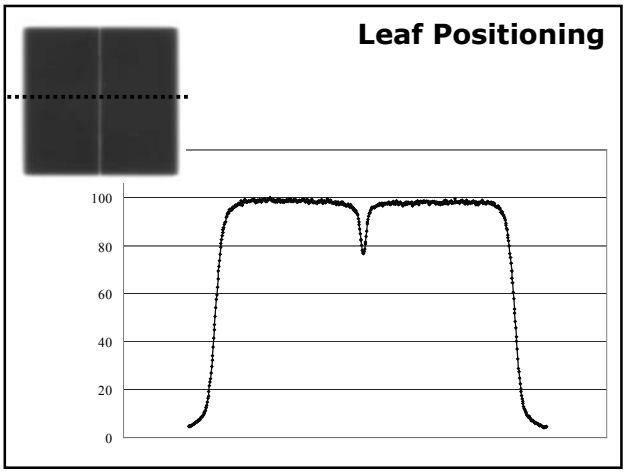
Leaf Positioning



Leaf Positioning

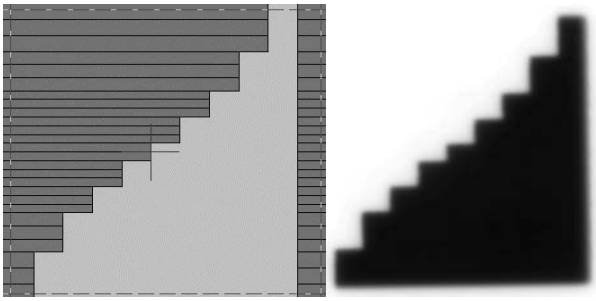


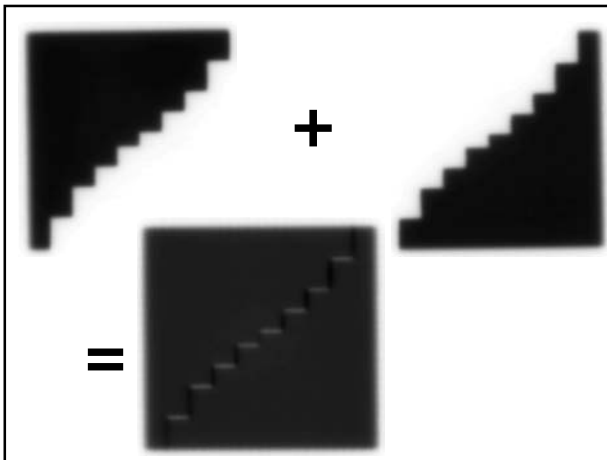
Leaf Positioning

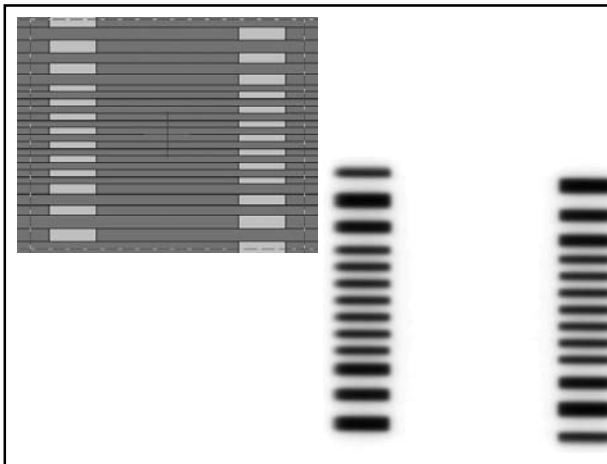


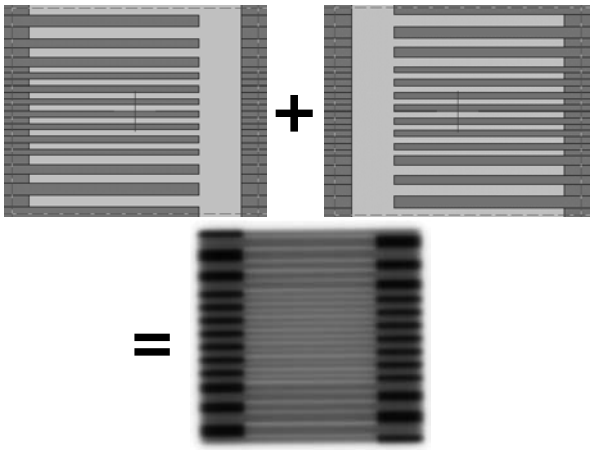
Leaf Positioning – off axis

Leaf Positioning – off axis

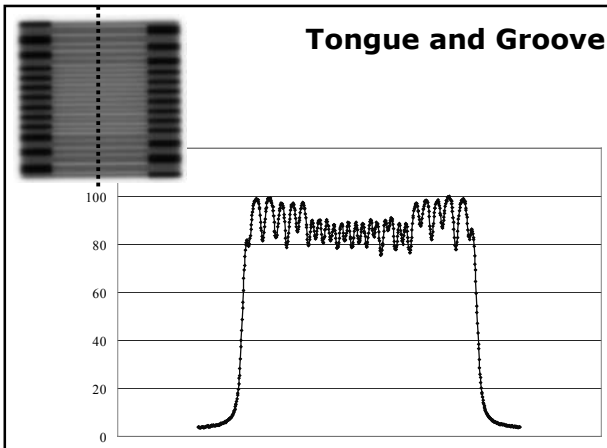




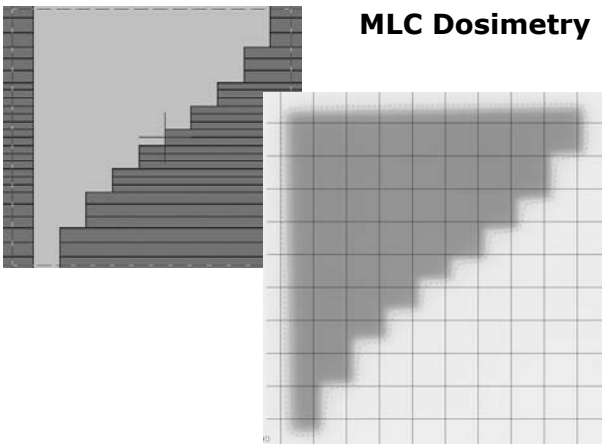




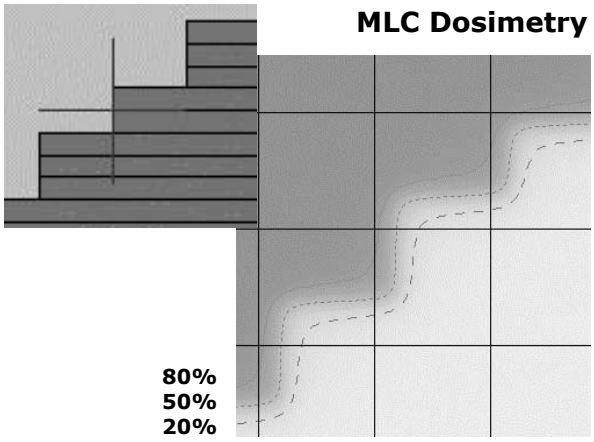
Tongue and Groove



MLC Dosimetry



MLC Dosimetry



3D Line DMLC

# Leaf Pairs	24
Leaf Width (@ Isocenter)	~5 mm
Maximum Field Size	11.5 x 12.0 cm^2
Leakage	< 1%
Leakage (interleaf)	N/A
Penumbra (not specified)	3 mm
Maximum Leaf Speed	1 cm/sec
Weight	40 kg
Clearance to Isocenter	N/A

3D MEDICAL SYSTEMS

BrainLAB m3

# Leaf Pairs	26
Leaf Width (@ Isocenter)	3.0, 4.5, 5.5 mm
Maximum Field Size	10 x 12 cm^2
Leakage	< 1%
Leakage (interleaf)	< 2%
Penumbra (80/20)	< 4.0 mm
Maximum Leaf Speed	1.5 cm/sec
Weight	30 kg
Clearance to Isocenter	37.9 cm / 31 cm*

*for Varian w/o MLC / other linacs

BrainLAB

MRC Systems MicroMLC

# Leaf Pairs	40
Leaf Width (@ Isocenter)	1.6 mm
Maximum Field Size	7.3 x 6.4 cm^2
Leakage	< 1%
Leakage (interleaf)	N/A
Penumbra (80/20)	3-4 mm (6 MV)
Maximum Leaf Speed	1.2 cm/sec
Weight	38 kg
Clearance to Isocenter	N/A

MRC Systems ModuLeaf

# Leaf Pairs	40
Leaf Width (@ Isocenter)	2.5 mm
Maximum Field Size	10 x 12 cm^2
Leakage	< 2%
Leakage (interleaf)	< 2.5%
Penumbra (80/20)	< 4.0 mm
Maximum Leaf Speed	2.0 cm/sec
Weight	43 kg
Clearance to Isocenter	N/A

Radionics MMLC

# Leaf Pairs	31
Leaf Width (@ Isocenter)	4 mm
Maximum Field Size	10 x 12 cm^2
Leakage (	< 1%
Leakage (interleaf)	< 2% max
Penumbra (80/20)	< 4.0 mm
Maximum Leaf Speed	2.5 cm/sec
Weight	38 kg
Clearance to Isocenter	33 cm*

*linear accelerator not specified

Zmed BIGMINI

# Leaf Pairs	40
Leaf Width (@ Isocenter)	2.5 mm
Maximum Field Size	10 x 12 cm^2
Leakage	< 2%
Leakage (interleaf)	< 2.5%
Penumbra (80/20)	< 4.0 mm
Maximum Leaf Speed	2.0 cm/sec
Weight	43 kg
Clearance to Isocenter	N/A

Vendor Websites

3D Line (DMLC)	www.3dline.com
BrainLAB (m3)	www.brainlab.com
Elekta	www.elekta.com
MRC Systems (micro-MLC and ModuLeaf)	www.imrt.de
Radionics (MMLC)	www.radionics.com
Siemens	www.siemensmedical.com
Varian	www.varian.com
ZMED (BigMini)	www.zmed.com

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