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Tomotherapy Machine

Physics and Structures

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1993 Thomas R. Mackie

2002 First patients treated, UWI

2003 Introduced into the clinic

2010

2015: > 500

Reduce treatment times ↓

40 percent to 70 percent improving treatment quality ↑

October 22, 2009 TomoHD treatment system

in July 2003 the installation of the first TomoTherapy Hi-Art treatment system

The first paper on tomotherapy was submitted in July 1993

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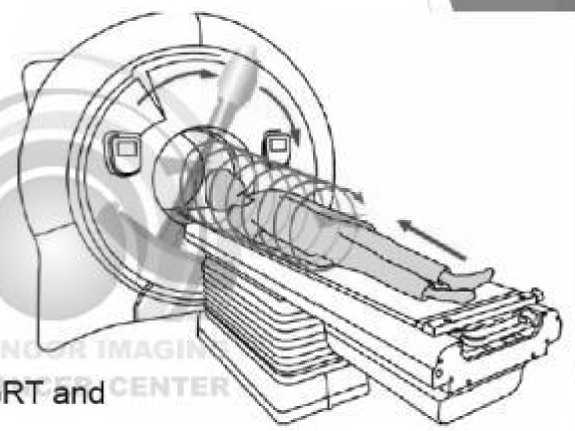
Tomotherapy means
"slice therapy"

Spiral delivery



Tomotherapy was Designed for IGRT and

IMRT

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Tomotherapy

Helical fan-beam IMRT or SRS delivery is fast, effective, and simple

CT is the most important imaging modality for radiotherapy and SRS

Linac on a CT is better than a CT on a linac.

- ✓ ring gantry is more stable than a C-arm gantry
- ✓ CT gantry allows faster rotation
- ✓ no possibility of rotational collisions

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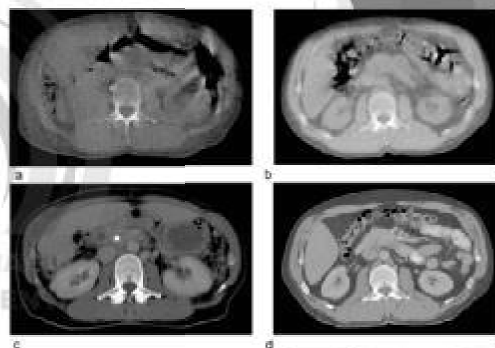
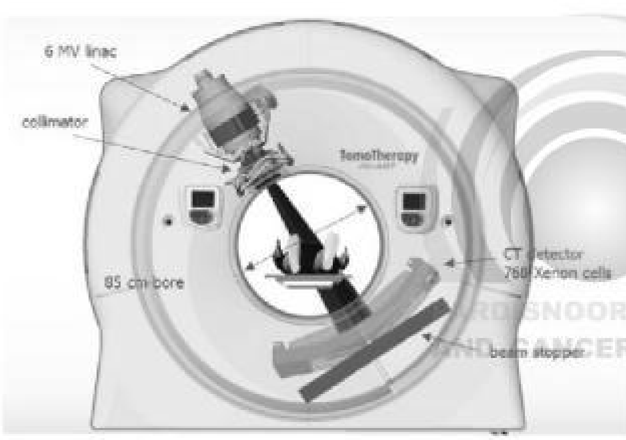
Image guided radiotherapy (IGRT)

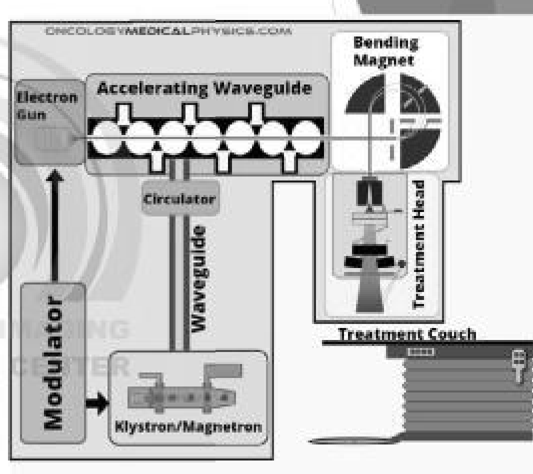
- Reduction in treatment margins
- Allow the use of sharp dose gradients
- Interactively adapt to changes within the lesion at the time of treatment

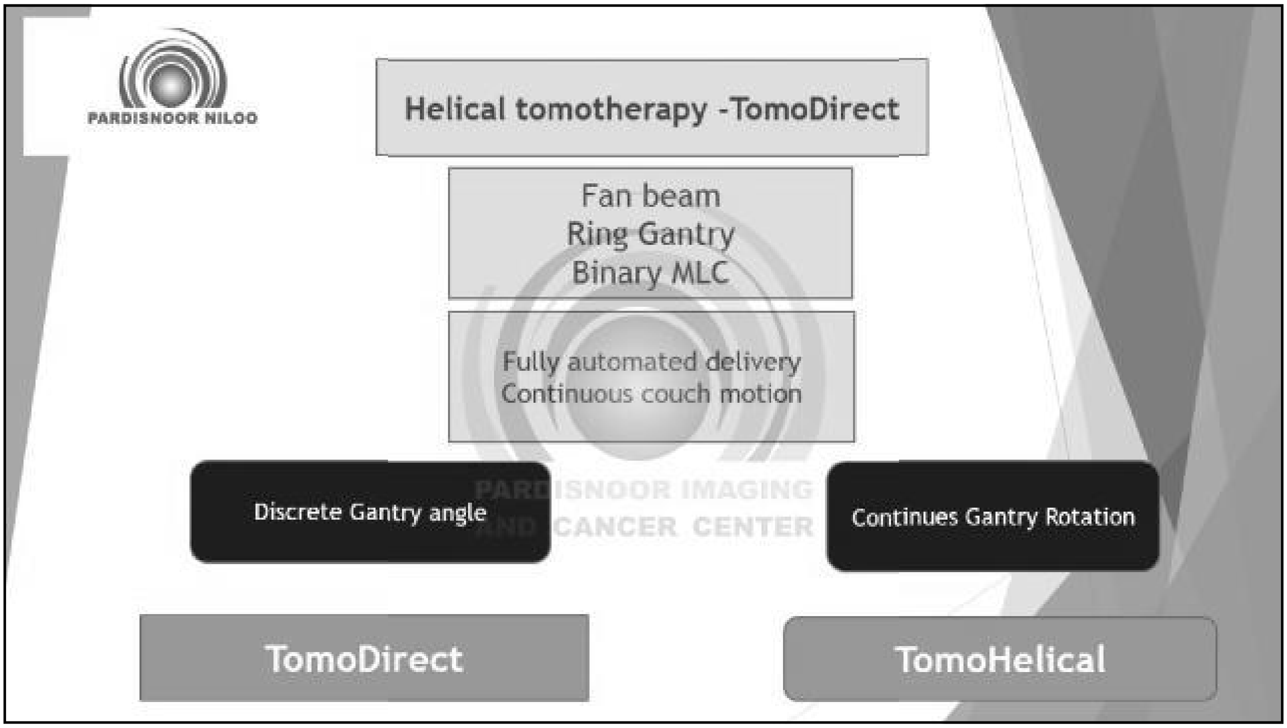


Tomotherapy



Linac

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Helical tomotherapy -TomoDirect
Fan beam
Ring Gantry
Binary MLC
Fully automated delivery
Continuous couch motion
Discrete Gantry angle
Continues Gantry Rotation
TomoDirect
TomoHelical
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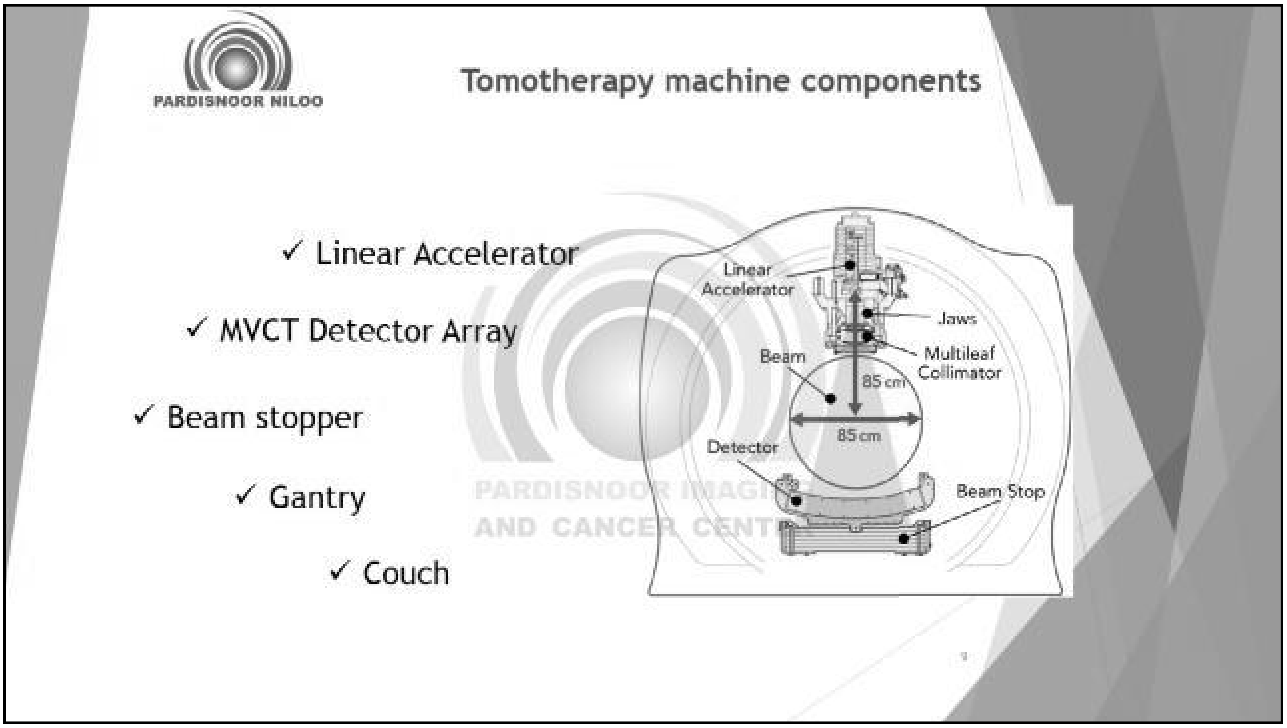
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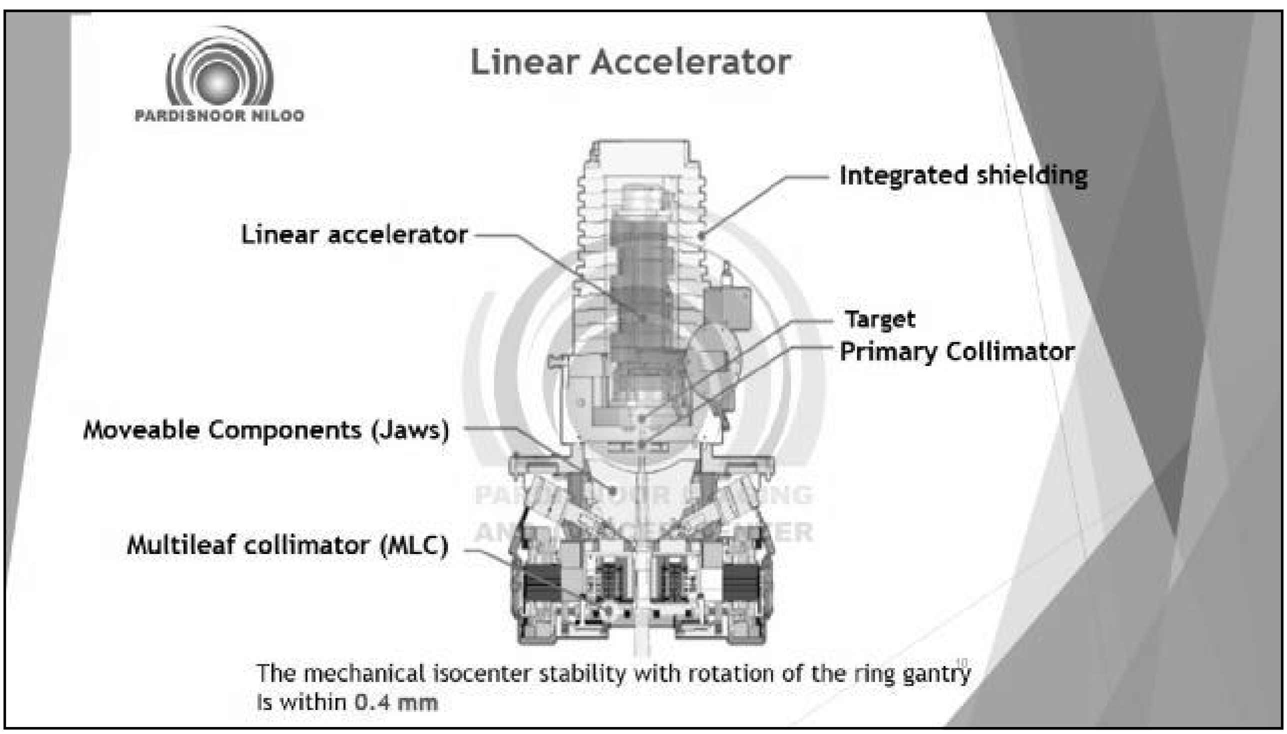
Tomotherapy machine components
✓ Linear Accelerator
✓ MVCT Detector Array
✓ Beam stopper
✓ Gantry
✓ Couch
Linear Accelerator
Jaws
Beam
Multileaf Collimator
85 cm
85 cm
Detector
Beam Stop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Linear Accelerator
Integrated shielding
Linear accelerator
Target
Primary Collimator
Moveable Components (Jaws)
Multileaf collimator (MLC)
The mechanical isocenter stability with rotation of the ring gantry is within 0.4 mm

Target

	Treatment	Imaging
Incident electrons	6MeV	3.5MeV
Target	1.5 mm tungsten	
Photon produced	6MV	3.5 MV

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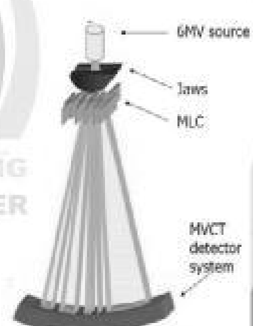
Beam

The beam:
- Fan-shaped
- Constant dose rate (8.5 Gy/min)

- Time-based (v. MU-based)
- Treatment is stopped after a given amount of time has elapsed



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Dose Monitor Chambers

Dose monitoring

the beam passes immediately after traversing through the primary collimator

Dose Monitor Chamber 1 measures the- entire photon beam output

Dose Monitor Chamber 2 measures the central portion of the beam

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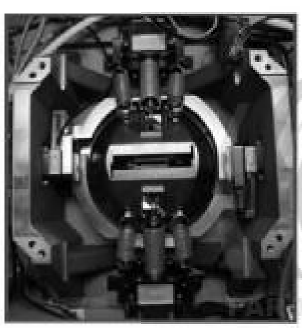
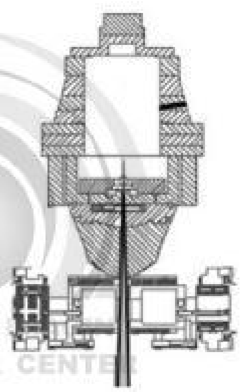
jaws





Control field widths

5.0 cm, 2.5 cm, and 1.0 cm

The jaws are made of tungsten alloy

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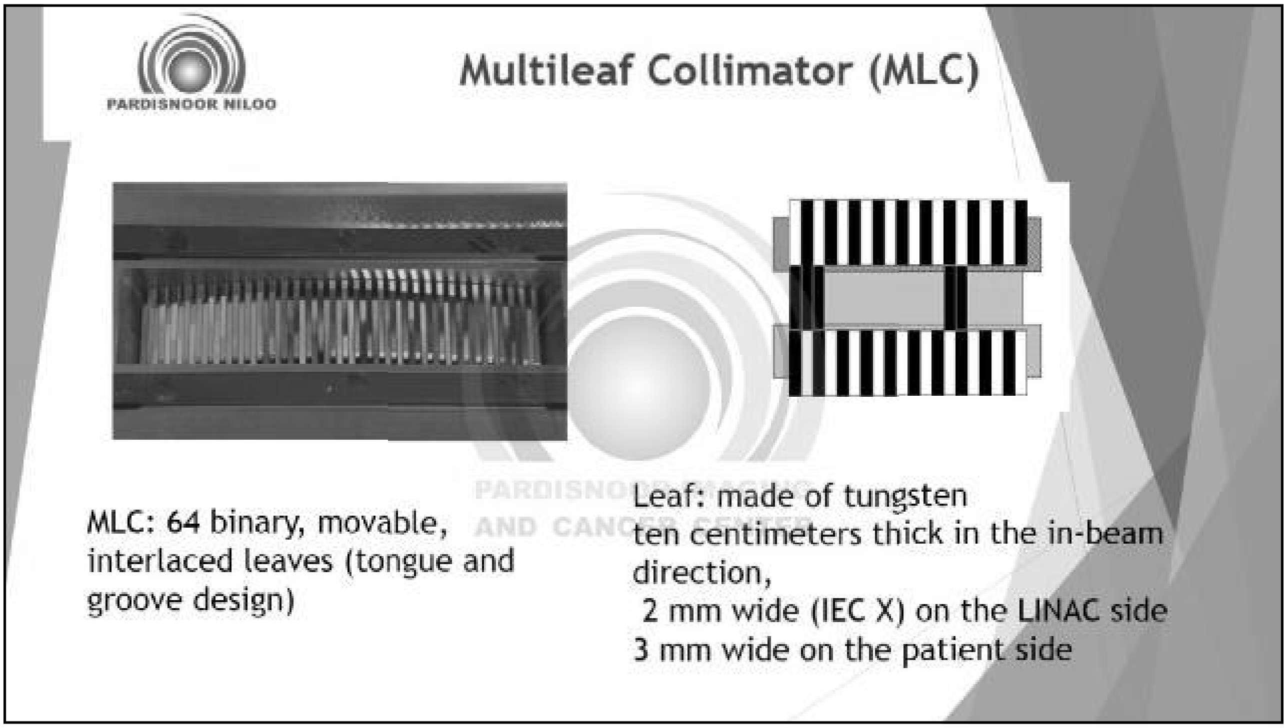
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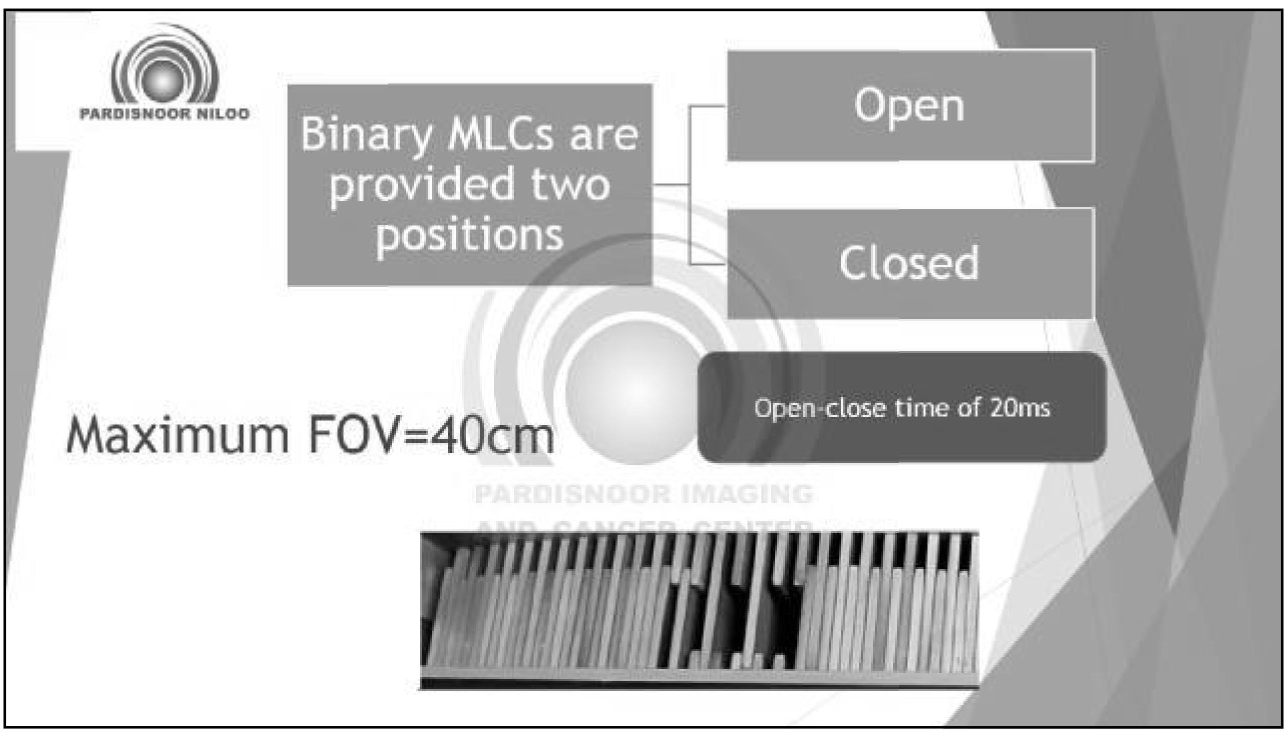
Multileaf Collimator (MLC)
MLC: 64 binary, movable, interlaced leaves (tongue and groove design)
Leaf: made of tungsten
ten centimeters thick in the in-beam direction,
2 mm wide (IEC X) on the LINAC side
3 mm wide on the patient side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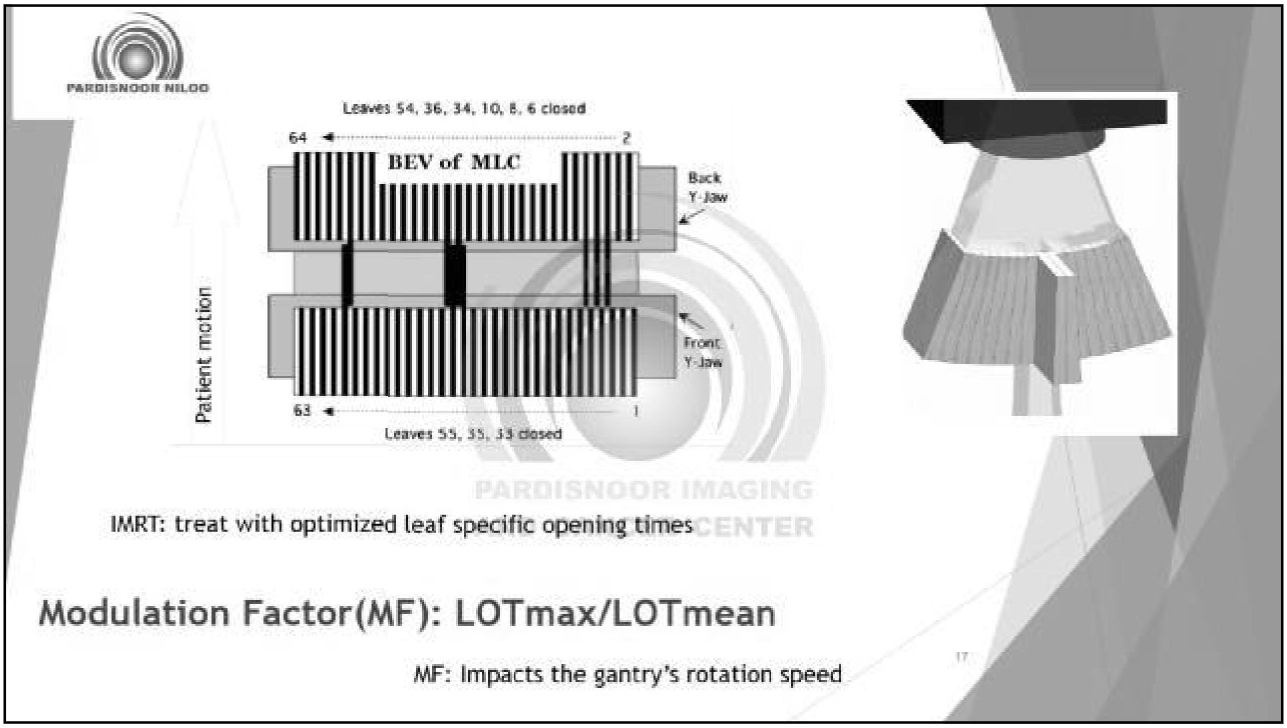
Binary MLCs are provided two positions
Open
Closed
Open-close time of 20ms
Maximum FOV=40cm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Leaves 54, 36, 34, 10, 8, 6 closed
64
2
BEV of MLC
Back Y-Jaw
Front Y-Jaw
Patient motion
63
1
Leaves 55, 35, 33 closed
IMRT: treat with optimized leaf specific opening times
Modulation Factor(MF): LOTmax/LOTmean
MF: Impacts the gantry's rotation speed
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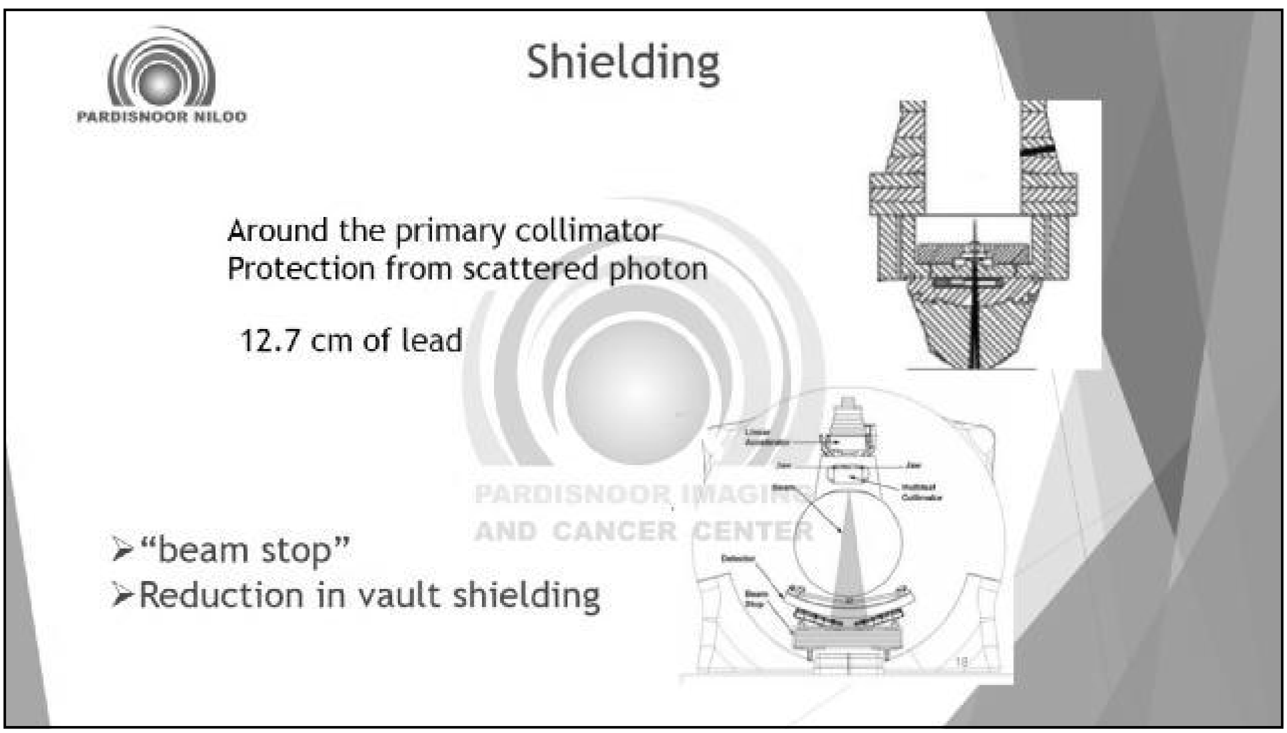
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Shielding
Around the primary collimator
Protection from scattered photon
12.7 cm of lead
➢"beam stop"
➢Reduction in vault shielding
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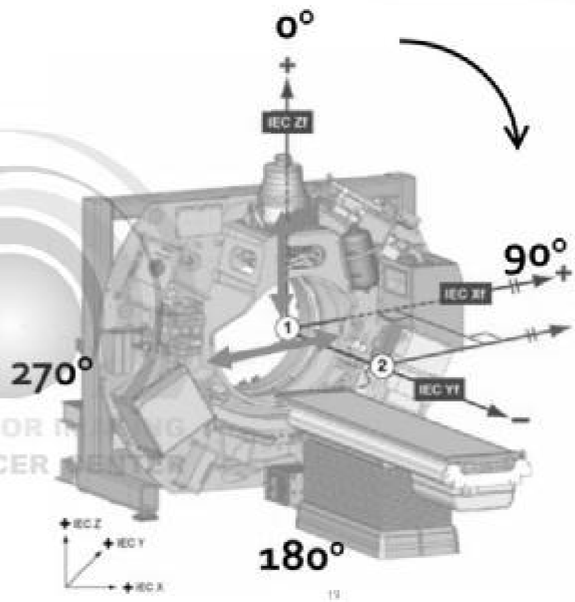
Geometry

SAD=85 cm

Bore=85 cm

- ❑ Real isocenter (1)
- ❑ Virtual isocenter (2)
- ❑ Distance 1-2: 70cm



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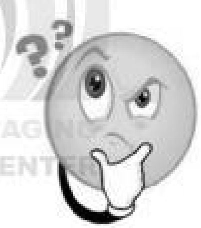
Why a "virtual" isocenter?

❑No laser in the bore!

❑ No way of knowing where the radiation isocenter is, therefore:

- ❑Introduce a virtual isocenter
- ❑Fixed point outside the bore
- ❑Known distance from the real isocenter
- ❑Used as a reference



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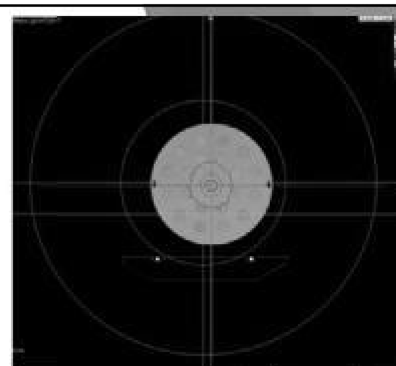
Lasers



Green

- Fixed
- Intersect at virtual isocenter
- Not used clinically
- testing

Red

- Movable
- Overlap green lasers at start up
- Position is specific to each
- patient's treatment plan
- Serve as a reference point for patient
- positioning

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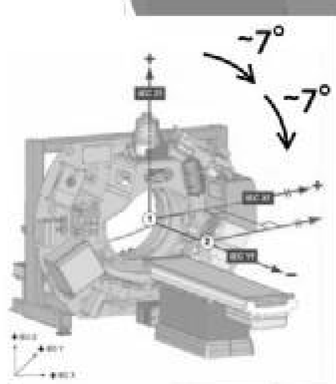
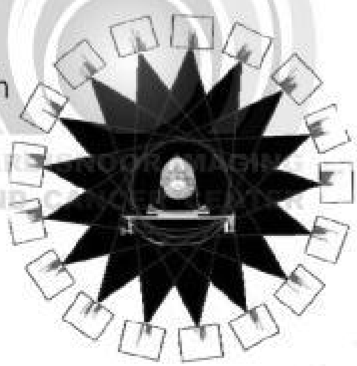
Projections and beamlet

Projection= 1MLC configuration
Fixed number of projections per rotation: 51
One projection=7° arc



Beamlets= beam associated with one leaf Max 64 beamlets per projection



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Two important parameters

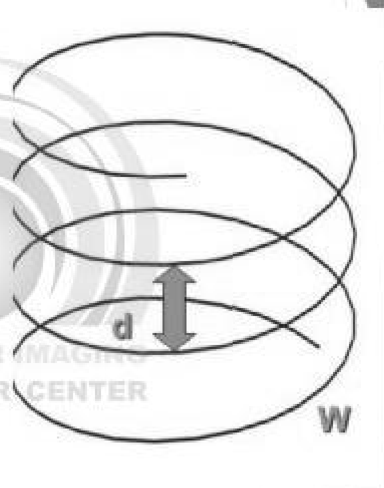
Gantry period: 11.8-60 s

$$\text{Pitch} = \frac{d_{couch}/\text{rotation}}{\text{field width}}$$

Influences:

Active rotation

Couch speed



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Limiting factors

Rotations Per minute:

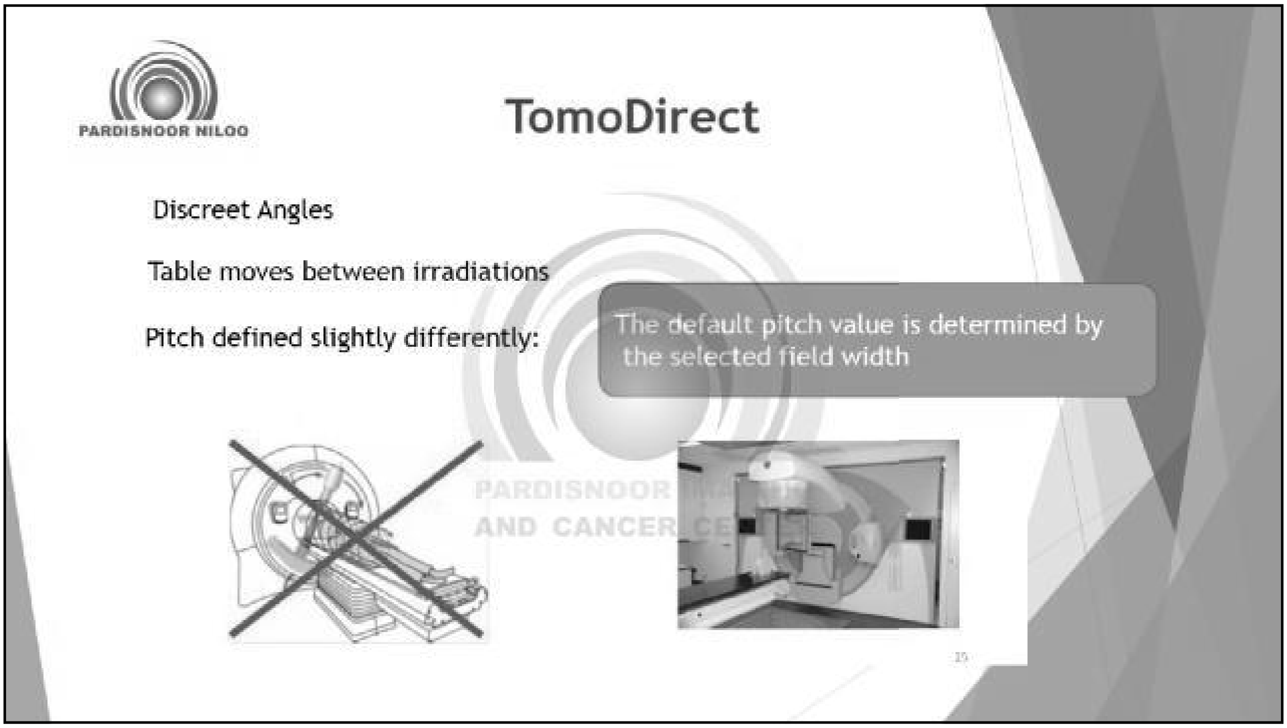
MVCT imaging: 360°/6 s (10 RPM)

TomoHelical delivery:
Minimum RPM: 360°/60 (1rpm)
Maximum RPM: 360°/11.8 (~5.08 rpm)

TomoDirect delivery:
Minimum RPM: 360°/60 (1rpm)
Maximum RPM: 360°/6 (10 rpm)

Couch Speed: 0.0125-40 mm/s

Max treatable length:135cm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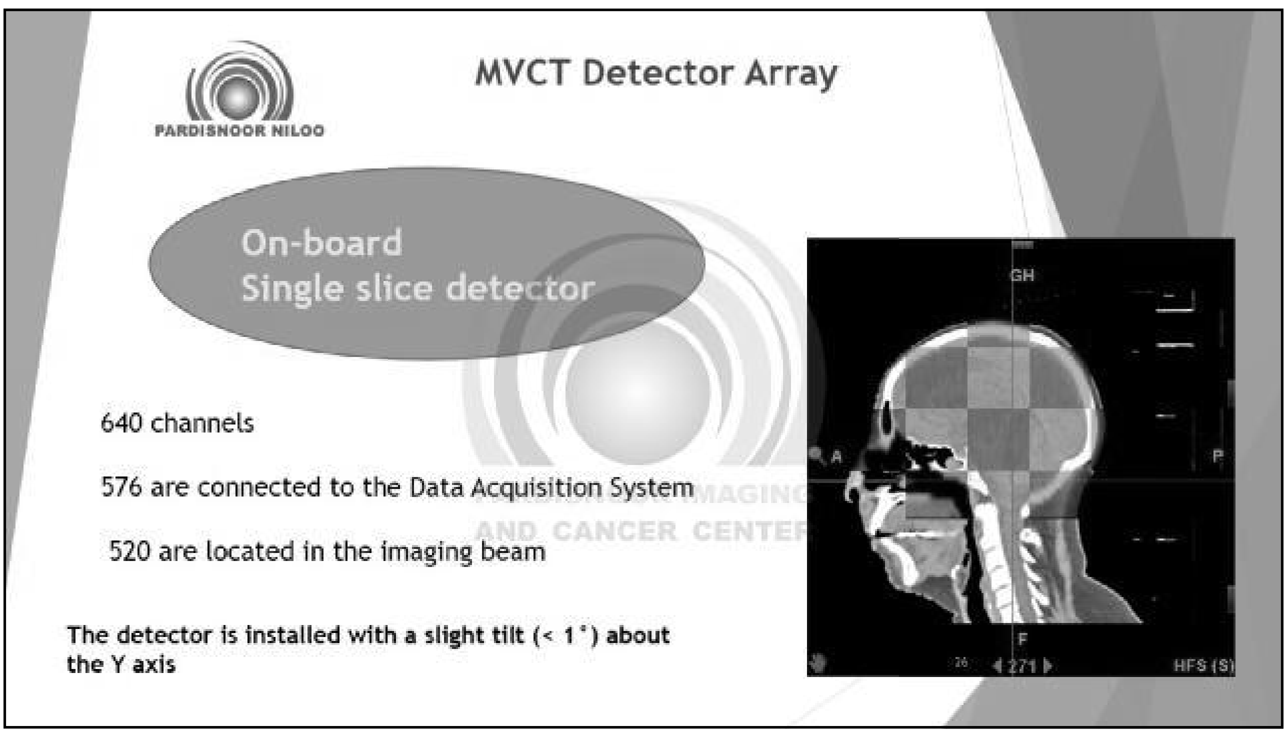
TomoDirect
Discreet Angles
Table moves between irradiations
Pitch defined slightly differently:
The default pitch value is determined by the selected field width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MVCT Detector Array
On-board
Single slice detector
640 channels
576 are connected to the Data Acquisition System
520 are located in the imaging beam
The detector is installed with a slight tilt (< 1°) about the Y axis

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Multiple reviews on VMAT vs Tomotherapy

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Conclusions: Both VMAT and HT provide high quality conformal plans for localized prostate cancer. Significant differences were noted in a number of dose-volume parameters, but they were not so large. HT plans provided more homogeneous dose distribution in PTV and lower rectum doses, whereas VMAT yielded more conformable plans, lower bladder doses, and shorter treatment delivery time with smaller MU.

Conclusions

In the treatment of stage IIB-IIIB NSCLC patie[...] strated that the VMAT plan achieved optimal conformal and homogeneous dose distribution in terms of PTV. TOMO plan showed a slight advantage in reducing the sparing of the total normal lung, mainly in V_{20} and V_{30}, but at the cost that more low-dose area spread to the normal lung and more radiation doses to the heart. These findings may be of value in selecting the optimal modality of radiotherapy for the individual patient with LA-NSCLC. Although all three different IMRT plans were clinically acceptable, VMAT seems to be the optimal treatment planning technique in the dosimetric comparison with TOMO and IMRT as to comprehensive evaluation.

CONCLUSION

HT and VMAT in complex adjuvant breast irradiation allow a good coverage of target volumes with an acceptable acute tolerance. A longer follow-up is needed to assess the impact of low doses to healthy tissues.

Conclusion

The analysis of the quality parameters fo[...] revealed that the tested TPS can produc[...] plan quality for this dose escalation trial. D[...] good results of HT planning for coverag[...] and homogeneity of these plans, also the TPS for calculation of VMAT and IMRT achieved acceptable results for a double simultaneous integrated boost concept for dose escalation in head and neck cancer delivered by IMRT or VMAT. The tested TPS and IMRT-techniques are allowed for the ESCALOX trial.

Conclusions

In a dosimetric comparison for SBBC, HT provided the most favorable dose sparing of OARs and can be considered for patients having a higher risk of normal tissue morbidity. However, HT may increase patient discomfort and treatment uncertainty because of its longer BOT. VMAT enabled a shorter BOT with acceptable doses to OARs and a better CI than IMRT and FIF. Therefore, VMAT can


Thank you
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