“Mekanik MLC QA“

Fiz.Y. Müh. Haluk Orhun

MEDICANA International Ankara Hastanesi

MLC QA ile ilgili AAPM Raporları;

TG 50 Report: Basic applications of Multileaf Collimators (2001).

TG 142 Report: Quality assurance of medical accelerator (2009).

TG 119 Report: IMRT commissioning: Multiple institution planning and dosimetry comparisons, a report from AAPM Task Group 119 (2009).

Ezzel et Al. : Guidance document on delivery, treatment planning, and clinic implementation of IMRT: Report of the IMRT subcommittee of the AAPM radiation therapy committee (2003).

MLC QA ile ilgili Türkiye'den örnekler

Türk Onkoloji Dergisi 2013;28(2):81-9

doi: 10.5505/tjoncol.2013.568

DERLEME | REVIEW

Yoğunluk ayarlı radyoterapide kalite kontrol yöntemleri

Quality assurance methods for intensity modulated radiotherapy

Aydın ÇAKIR, Hatice BİLGE

İstanbul Üniversitesi Onkoloji Enstitüsü, Tıbbi Radyofizik Bilim Dalı, İstanbul

2010

IMRT TEDAVİSİNDE KALİTE KONTROLÜ: MLC TESTLERİ

Medikal Fizik Derneği Eğitim Semineri

Nadir Küçük
Özel Anadolu Sağlık Merkezi

MEDICANA INTERNATIONAL

2010

"IMRT TEDAVİSİNDE KALİTE KONTROLU: MLC TESTLERİ"

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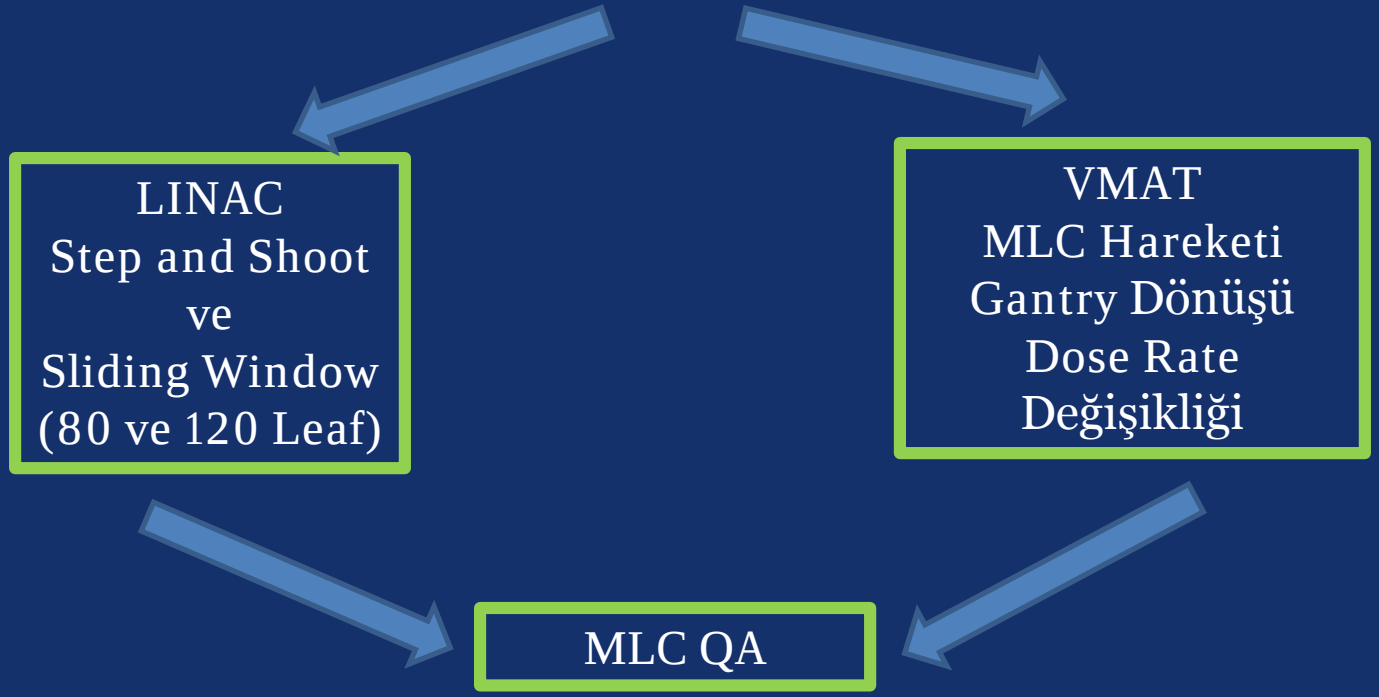
Medikal Fizik Derneği Seminerleri: /"IMRT TEDAVİSİNDE KALİTE KONTROLU: MLC TESTLERİ" / 09 Ekim 2010 / ANKARA

AMAÇ: MLC Kalite Kontrolunun, IMRT tedavisindeki rolünü ortaya çıkarmak. Anlamak.

IMRT'de, MLC'lerin planlamadaki (TPS) ve uygulamadaki (tedavi) farklılığı (değişimi) istenmeyen doz dağılımına neden olur.

HEDEF: Başarılı bir MLC Kalite Kontrolu programı

LINAC BAZLI IMRT

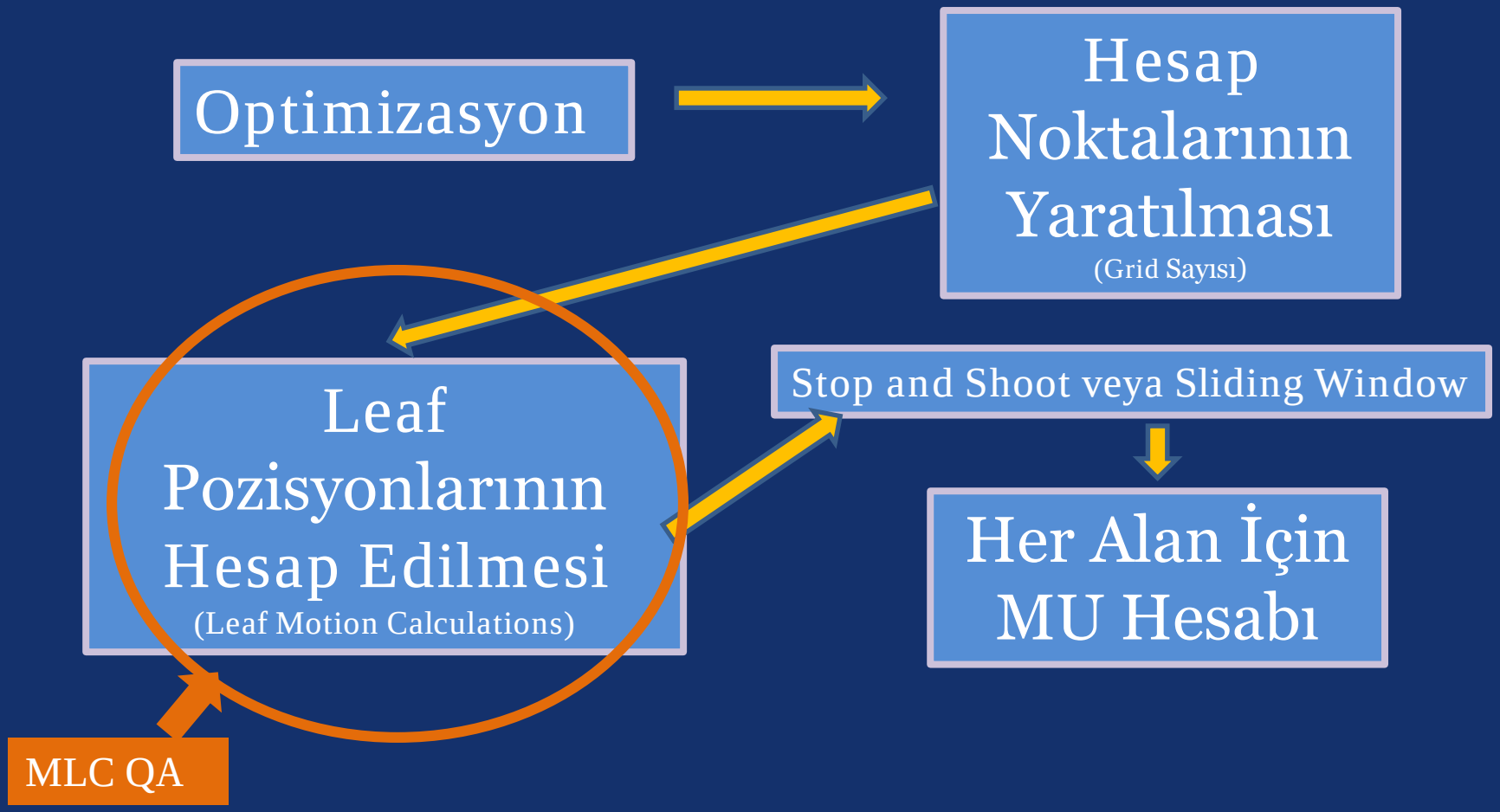


VMAT (RapidArc)'ı teknik olarak tanımlayan faktörler:

- Değişken gantry hızı

  0.5 – 4.8 derece/sn
- Değişken dose rate
  - 0 – 600 MU/dk
- Derece başına değişen doz
  - 0.2 – 20 MU/derece
- Değişken MLC Hızı
  - 0 – 2.5 cm/sn (5 mm/derece)

TPS'de IMRT Süreci;



TG 143'e göre MLC Testleri:

TABLE V. Multileaf collimation (with differentiation of IMRT vs non-IMRT machines).

Procedure		Tolerance
	Weekly (IMRT machines)	
Qualitative test (i.e., matched segments, aka "picket fence")		Visual inspection for discernable deviations such as an increase in interleaf transmission
	Monthly	
Setting vs radiation field for two patterns (non-IMRT)		2 mm
Backup diaphragm settings (Elekta only)		2 mm
Travel speed (IMRT)		Loss of leaf speed >0.5 cm/s
Leaf position accuracy (IMRT)		1 mm for leaf positions of an IMRT field for four cardinal gantry angles. (*Picket fence* test may be used, test depends on clinical planning-segment size)
	Annually	
MLC transmission (average of leaf and interleaf transmission), all energies		±0.5% from baseline
Leaf position repeatability		±1.0 mm
MLC spoke shot		≤1.0 mm radius
Coincidence of light field and x-ray field (all energies)		±2.0 mm
Segmental IMRT (step and shoot) test		<0.35 cm max. error RMS, 95% of error counts <0.35 cm
Moving window IMRT (four cardinal gantry angles)		<0.35 cm max. error RMS, 95% of error counts <0.35 cm

MLC Kalite Kontrolu programına etki eden faktörler:

Out-Put
MLC Pozisyon Hassasiyeti ve Tekrarlanabilirlilik,
Dinamik Hareket Hassasiyeti,
Leaf Sızıntısı (InterLeaf-IntraLeaf),
Tong and Grove Etkisi,
MU Lineerliği,
Penumbra,

MLC QA: Out-Put

Koll:10x10, Ref. Koşullar, %1

dMLC Out-Put → Statik Out-Put

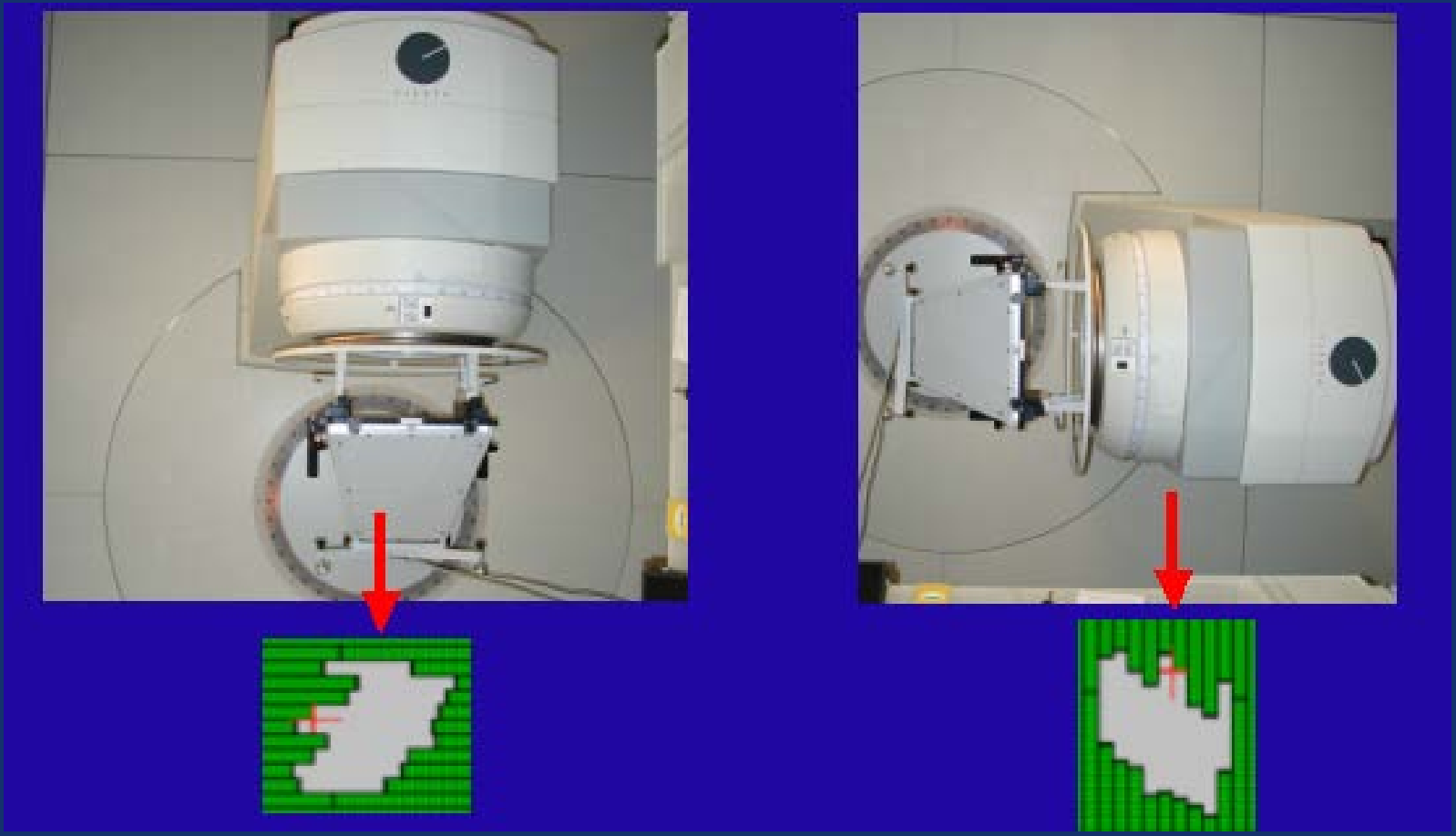
dMLC Out-Put → Gantry ve Kolimatör açılarına göre

0, 90, 270,180 derece, Ref.

dMLC Out-Put → Off-Axis: Leaf hareketine dik

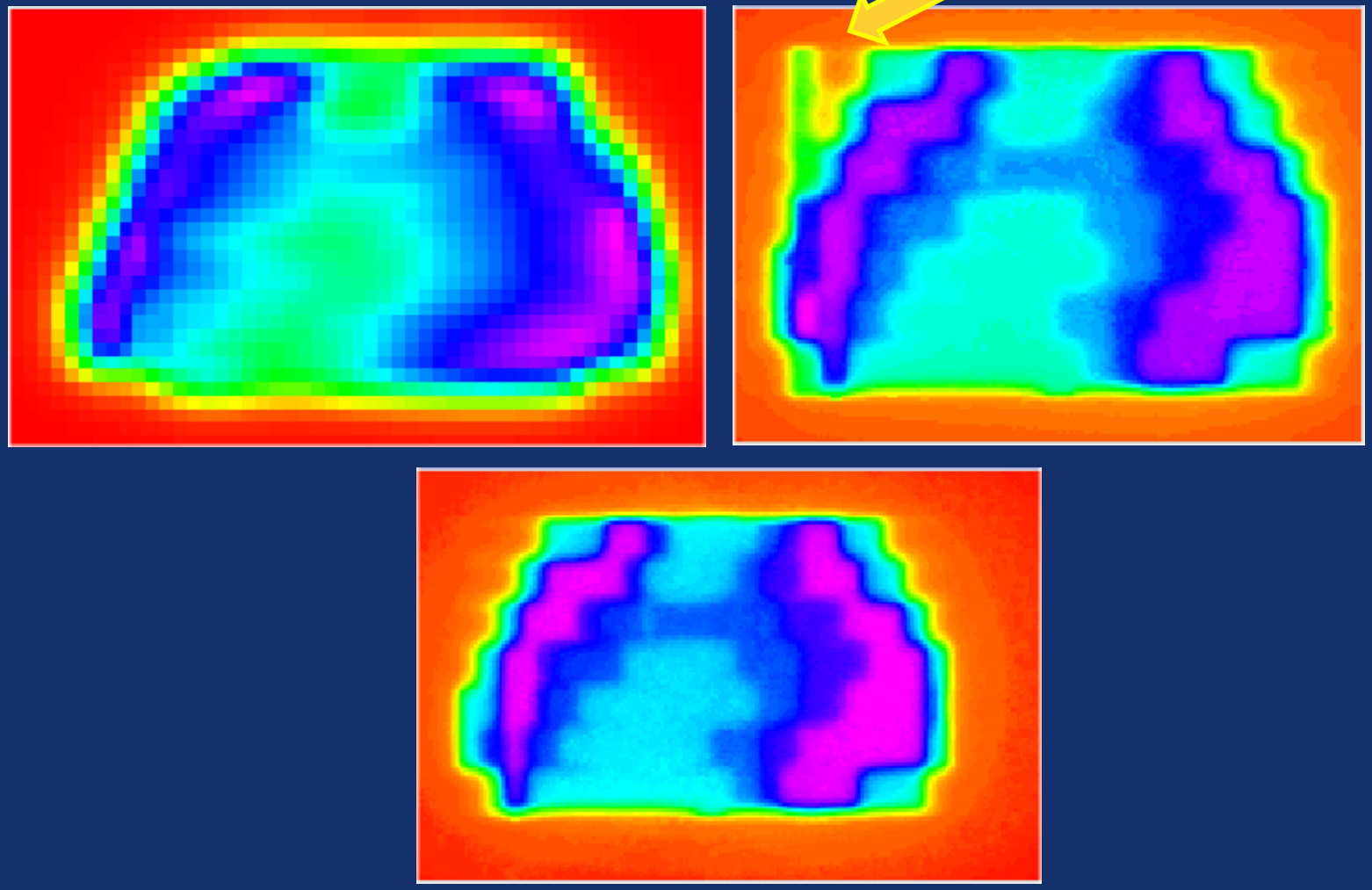
dMLC Out-Put → Off-Axis: Leaf hareketine paralel

MLC QA: Yerçekimi Etkisi



QA for the Radiotherapy: Salih Arıcan M.Sc.(Sun Nuclear Corporotion) başlıklı sunuştan alınmıştır.

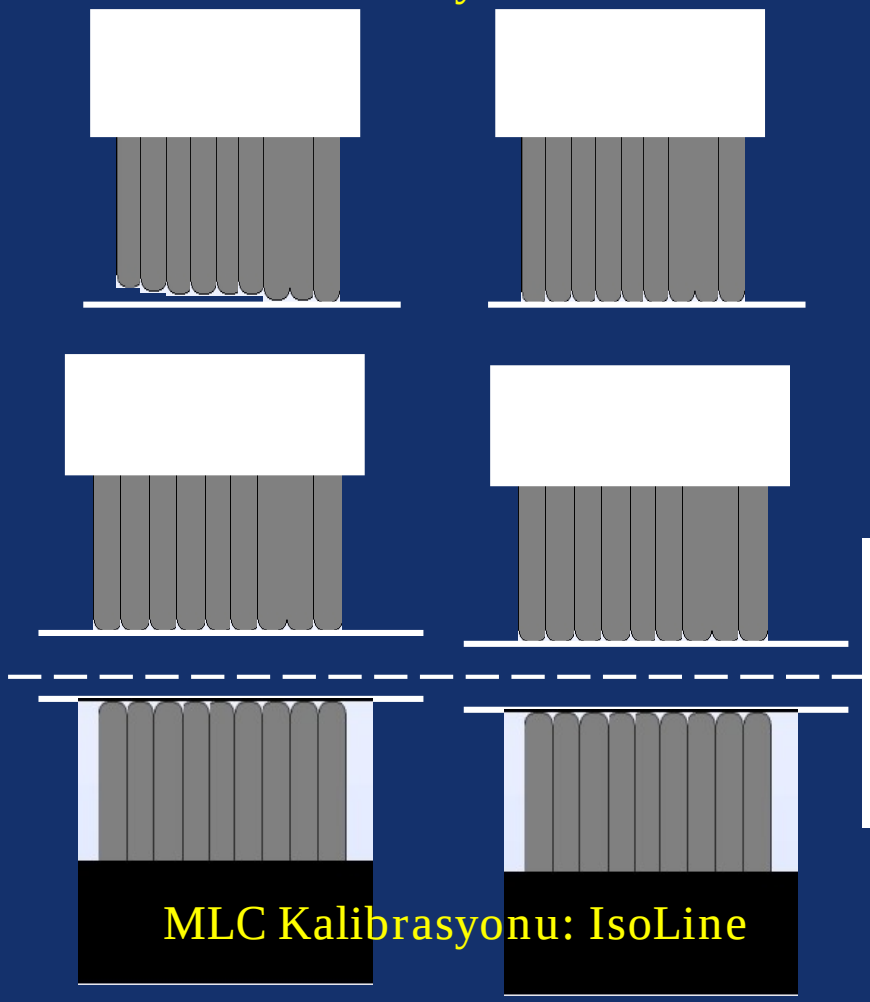
MLC QA: Yerçekimi Etkisi

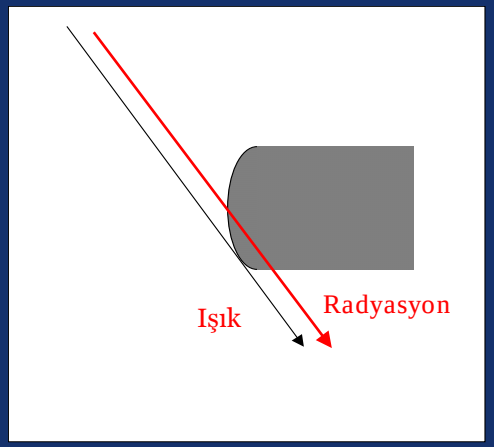


QA for the Radiotherapy: Salih Arıcan M.Sc.(Sun Nuclear Corporotion) başlıklı sunuştan alınmıştır.

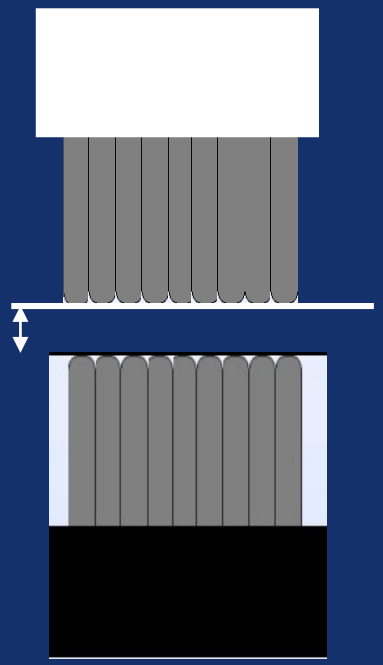
MLC QA: Leaf pozisyonu belirsizliği

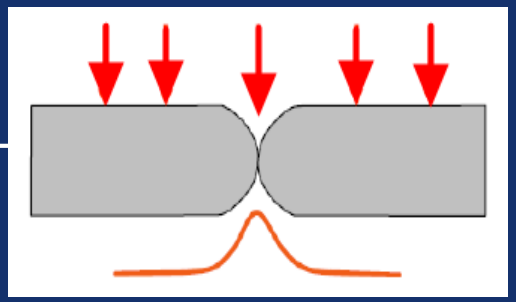
MLC Kalibrasyonu: Skew





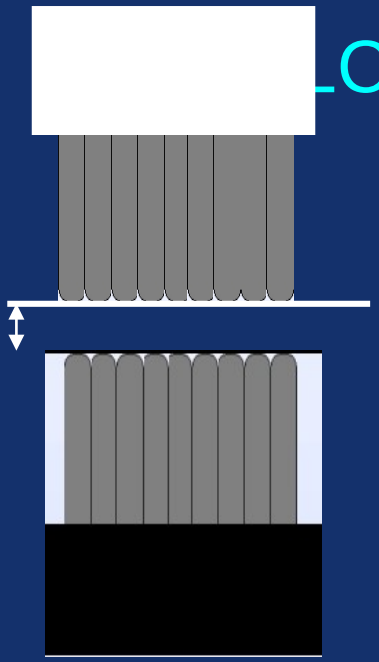
MLC Kalibrasyonu: Leaf Gap

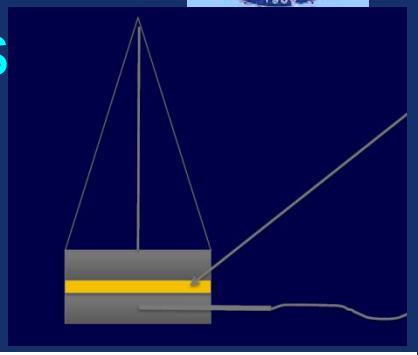


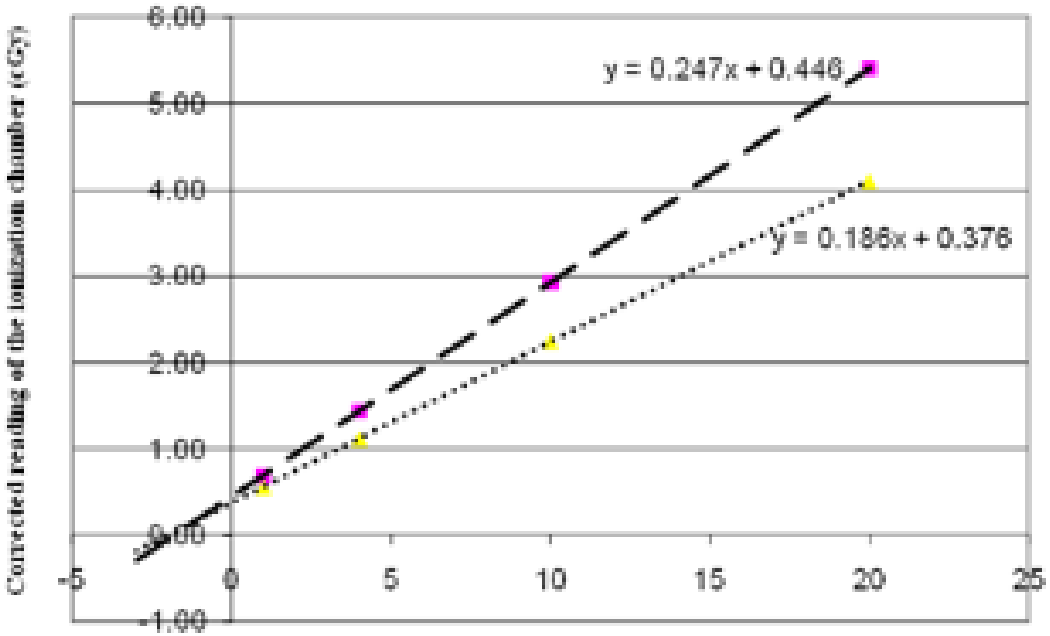


MLC Kalibrasyonu: IsoLine

LC QA: dls: Dinamik Leaf Seperas







MLC QA: Leaf geçirgenliği

Inter Leaf Geçirgenliği

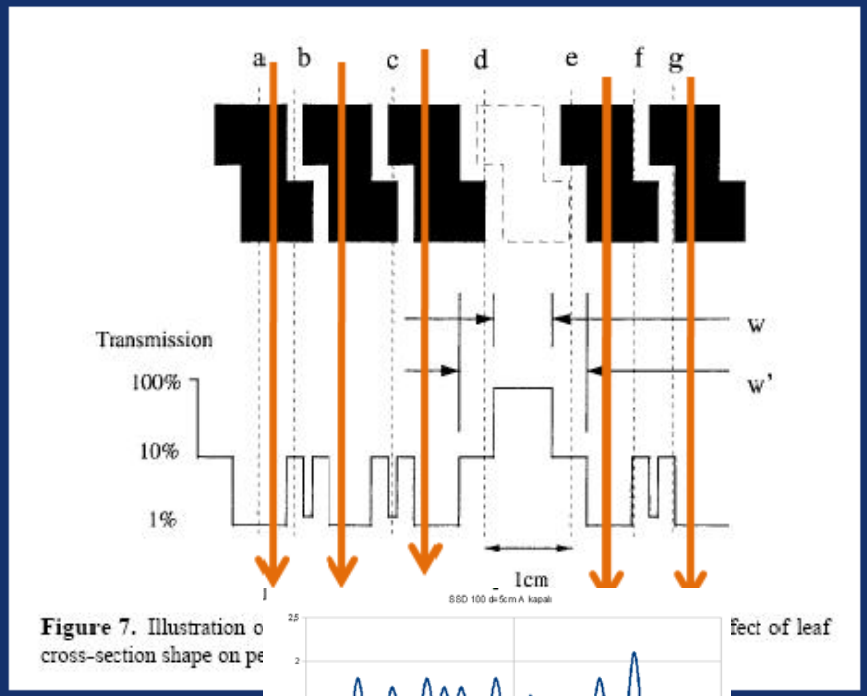
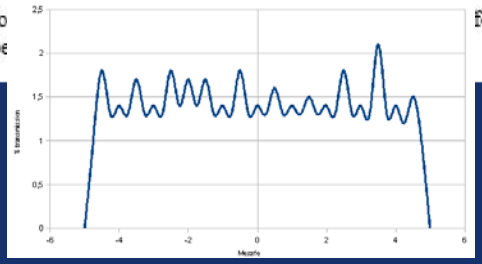


Figure 7. Illustration o … fect of leaf cross-section shape on pe…



Intra Leaf Geçirgenliği

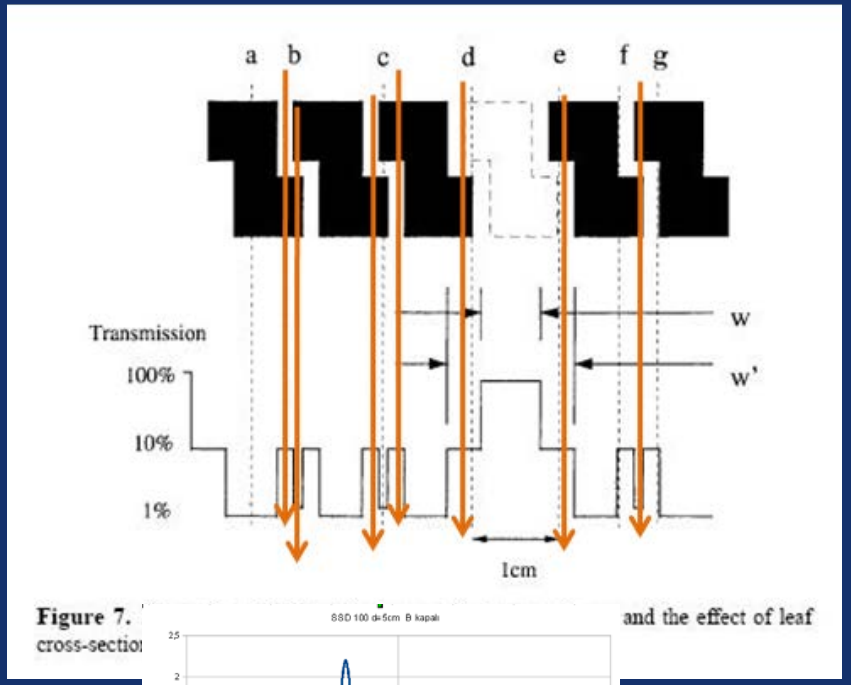
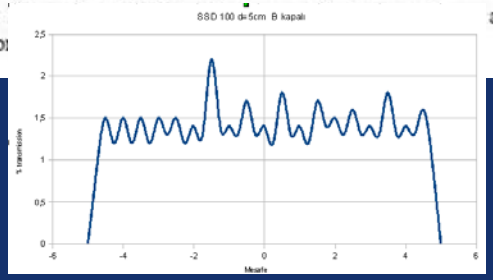
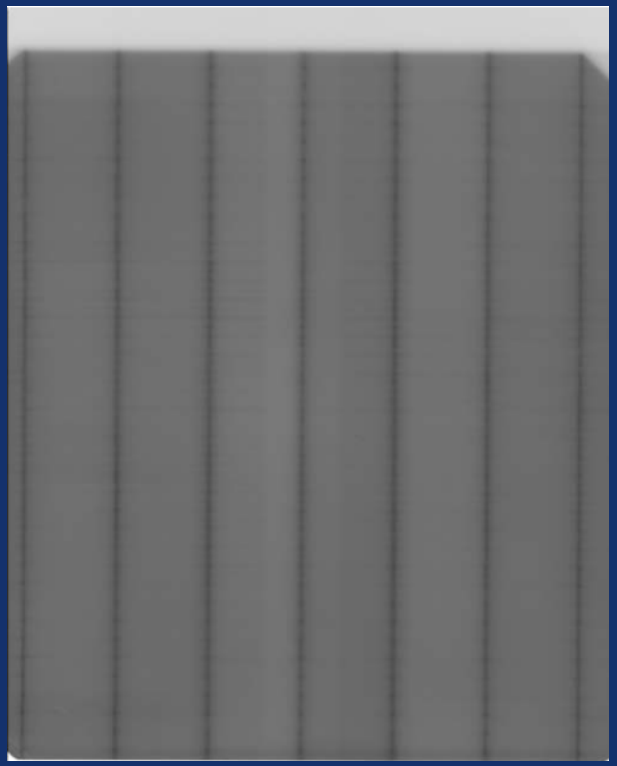
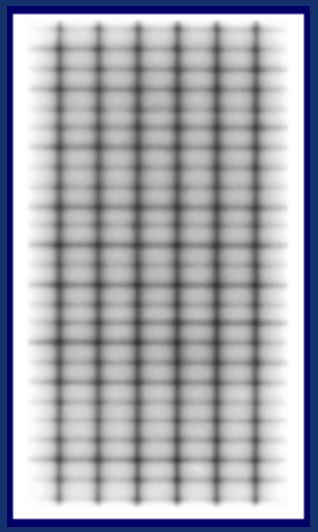


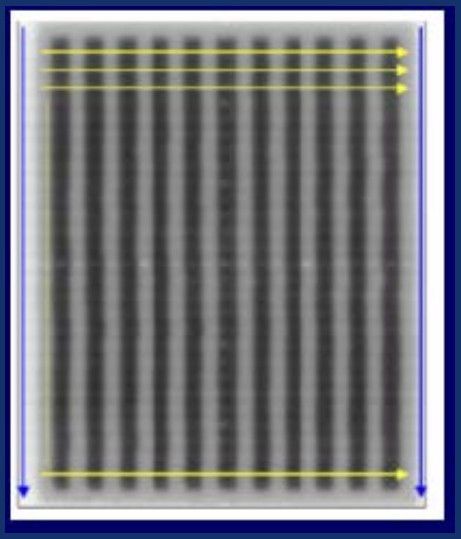
Figure 7. … and the effect of leaf cross-sectio…

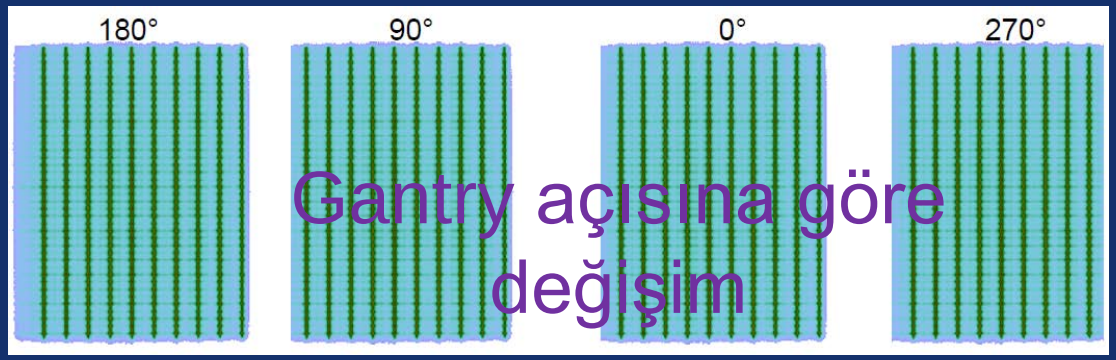


MLC QA: Leaf pozisyonu belirsizliği; Picket Fence Testi







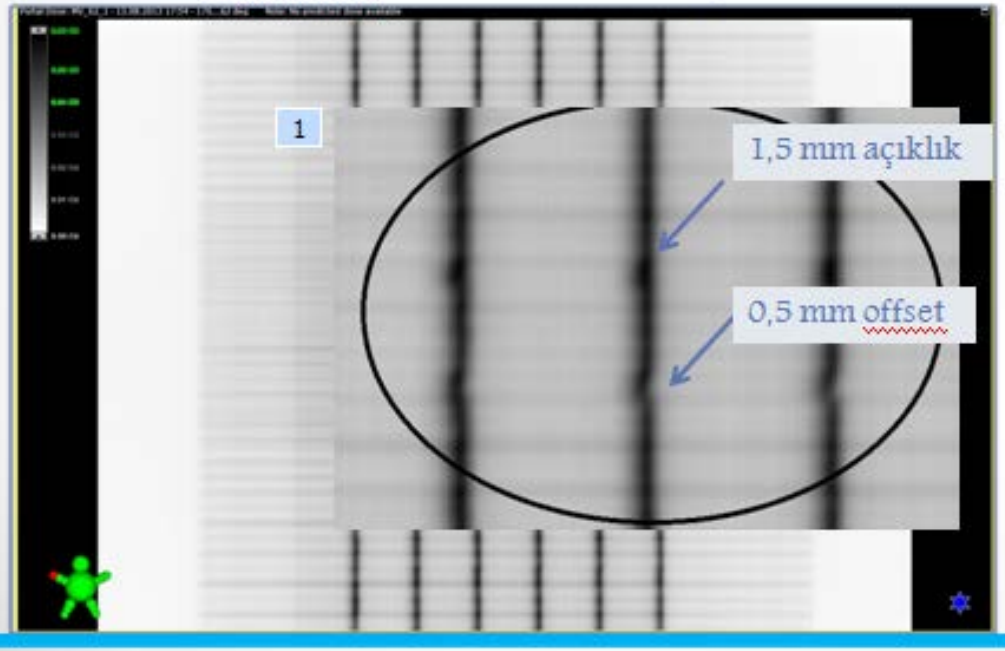


MLC QA: Leaf pozisyonu belirsizliği; Picket Fence Testi

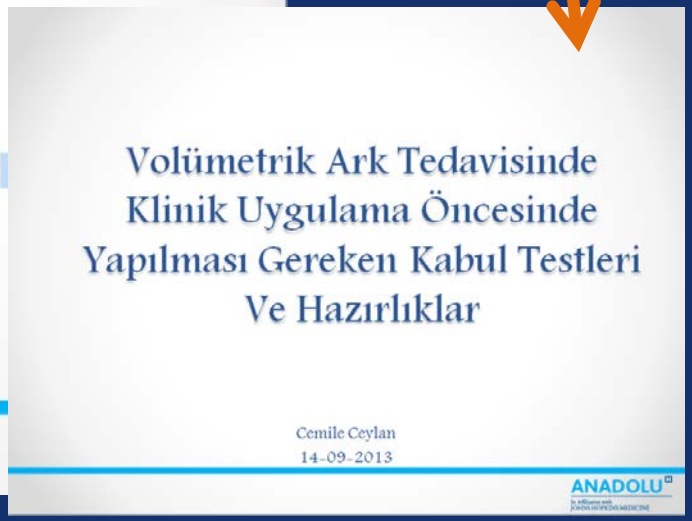
ASM Sonuçları

Test 1–2. RapidArc Süresince MLC Error Tespiti–PicketFence Testi

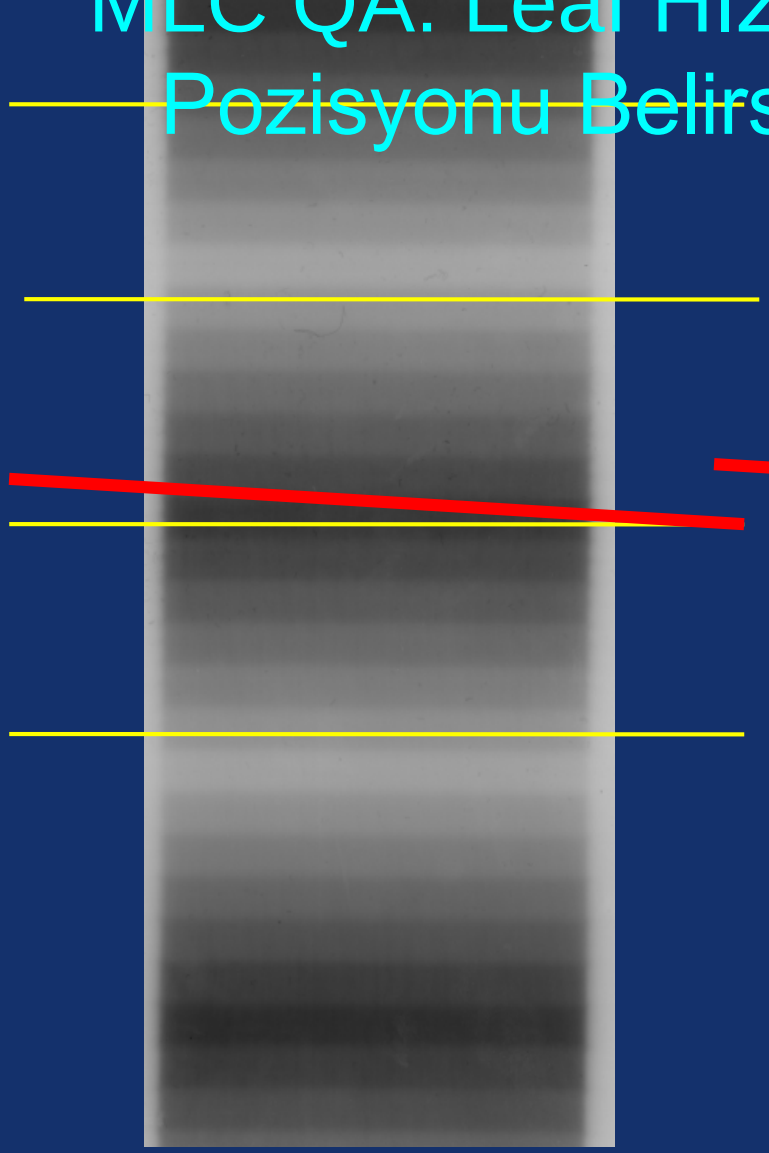
Tek MLC çiftinde 1mm strip yerine 1,5 mm
Tek MLC çiftinde 0,5 mm gap kaydırma
Amaç: RapidArc süresince olası hata tespiti

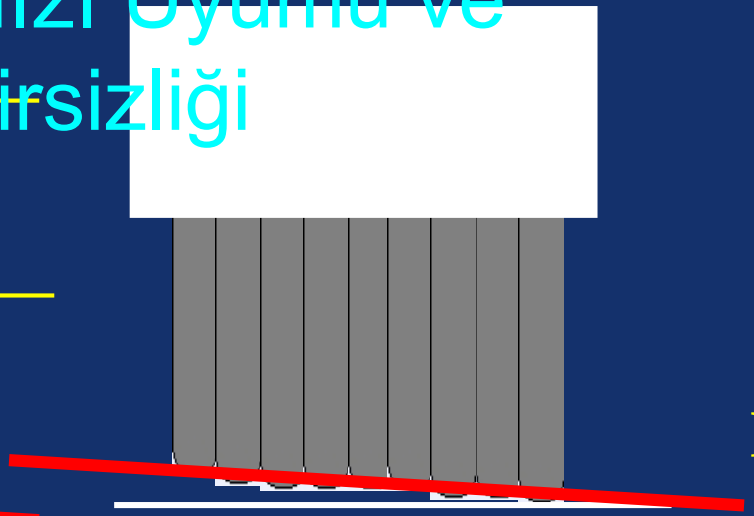


ASMHastanesi Deneyimi

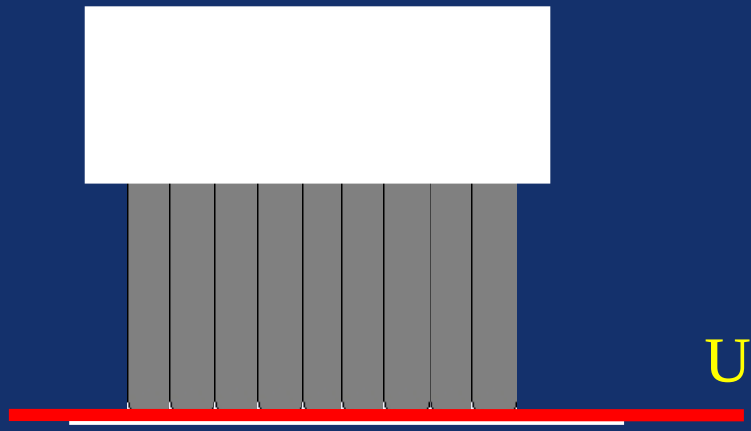


MLC QA: Leaf Hızı Uyumu ve Pozisyonu Belirsizliği





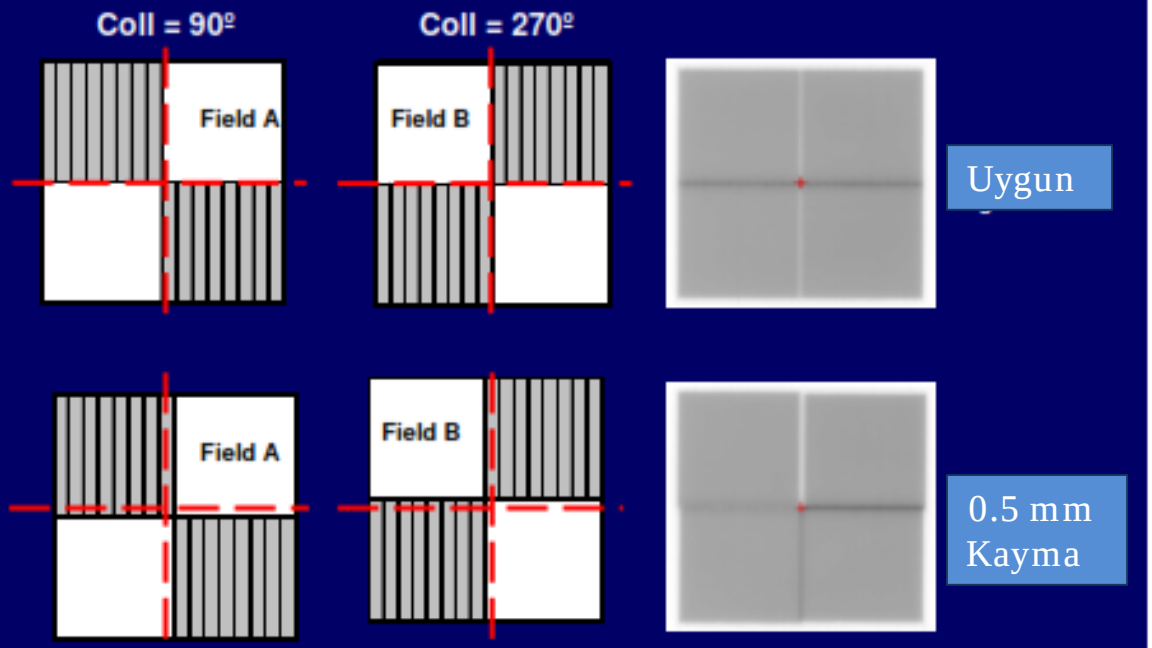
Hatalı



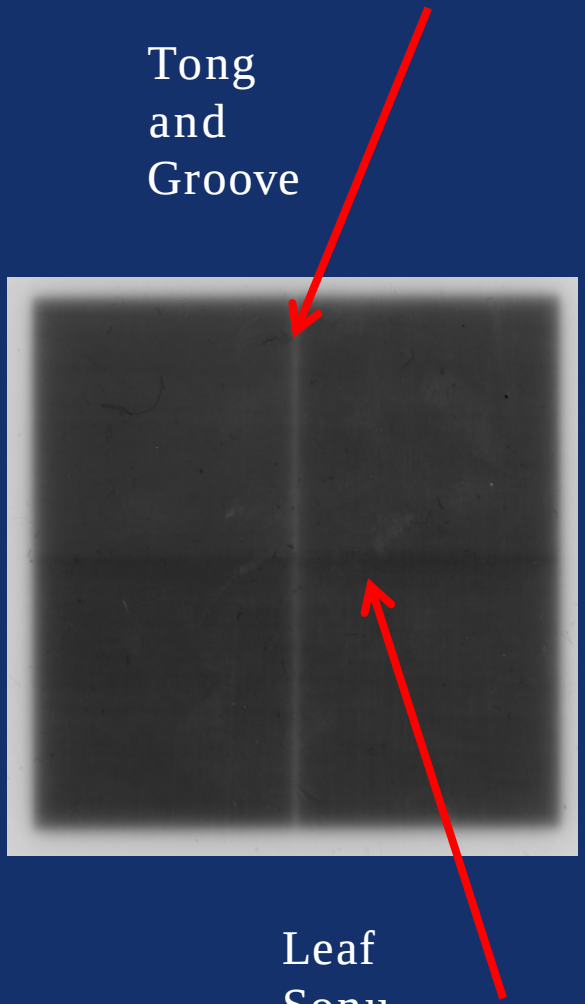
Uygun

MLC QA: Leaf pozisyonu belirsizliği

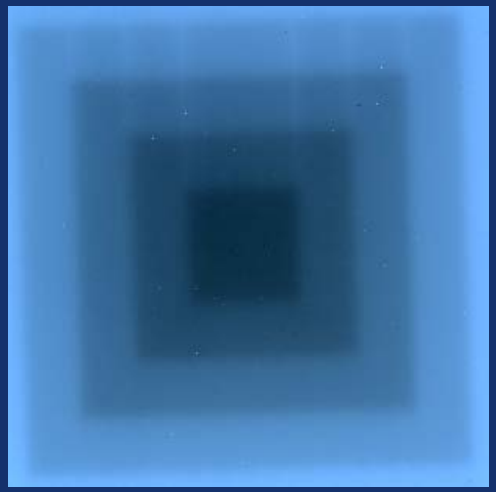
MLC ISO Merkez Uygunluğu testi



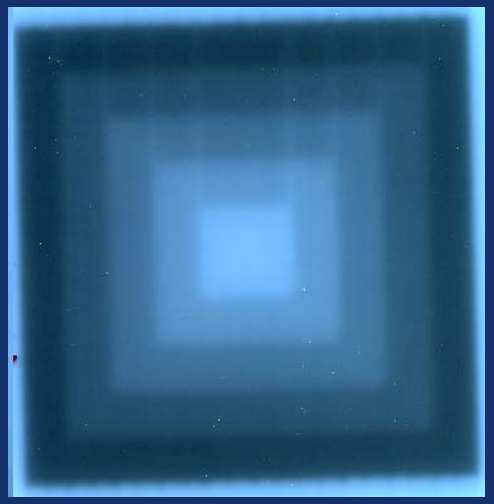
Çift ışınlama CAX da relatif kaymanın yakalanmasına neden olur.



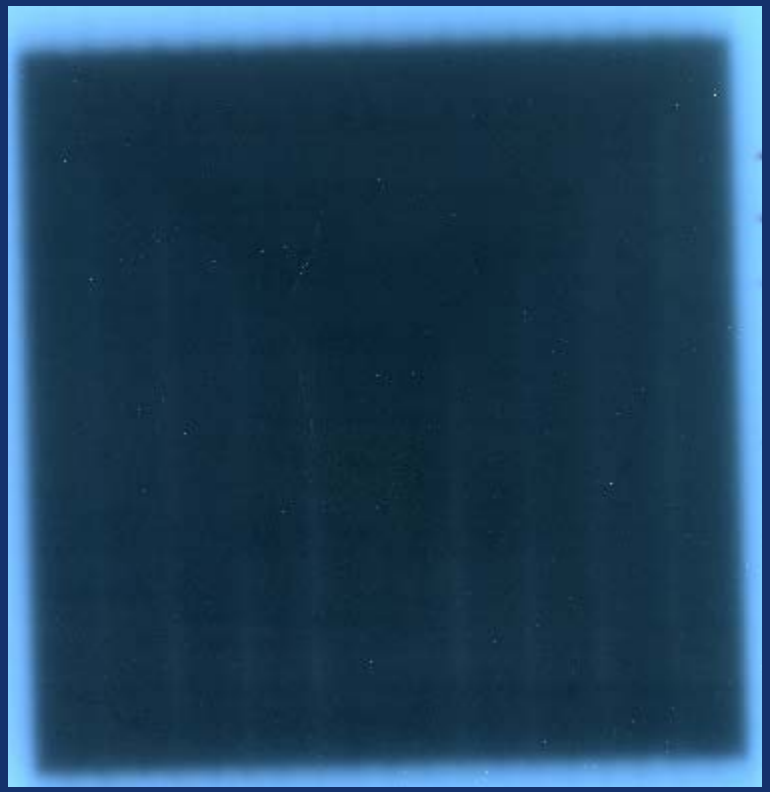
MLC QA: Leaf pozisyonu belirsizliği Piramit Testi



Leaf Yönü

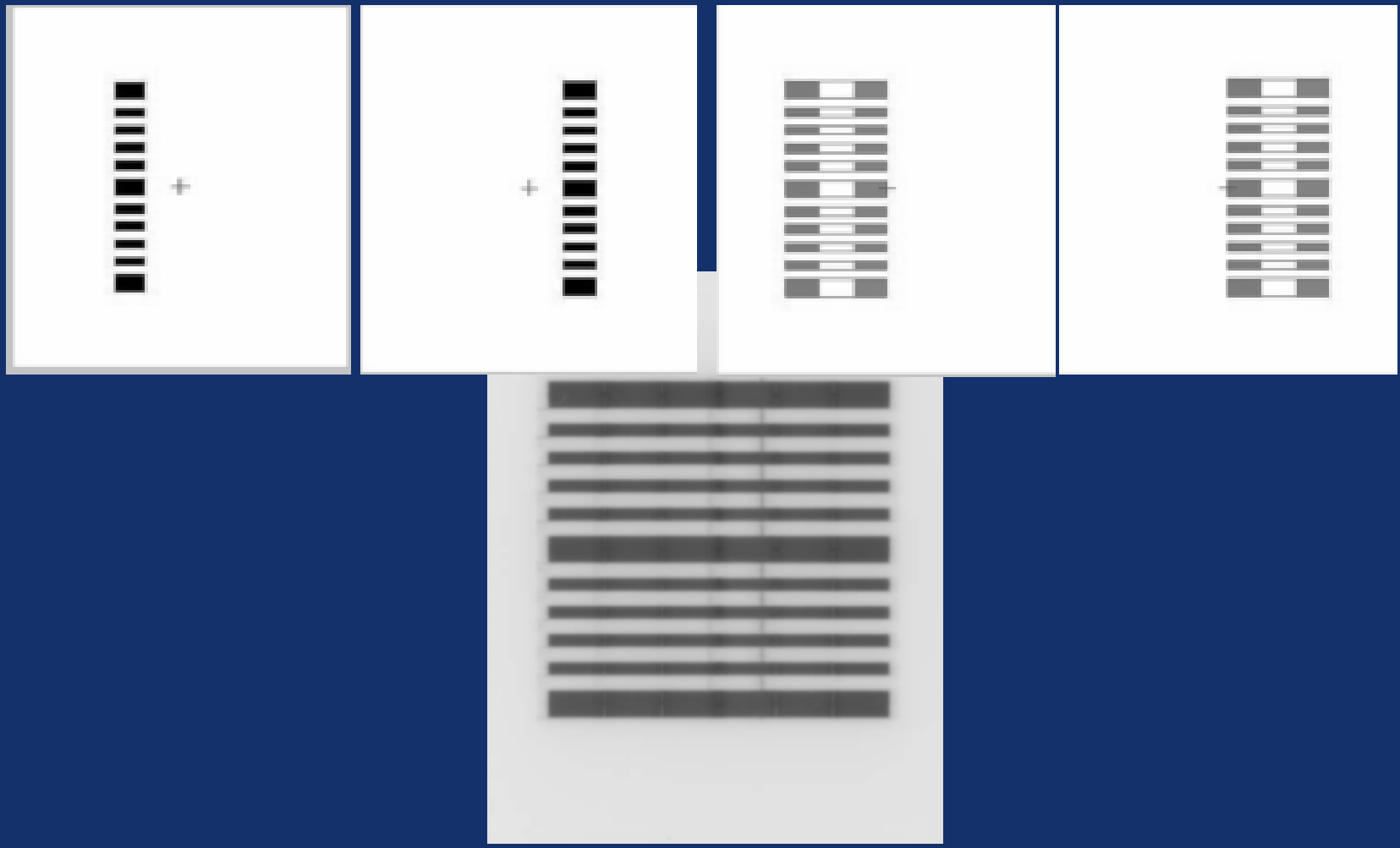


Leaf Yönü



MLC QA: Leaf pozisyonu belirsizliği

Synchronised Segmented Stripes Testi



MLC QA: Leaf pozisyonu belirsizliği

- Leaf Pozisyonu iki bağımsız mekanizma tarafından kontrol edilir.

a. Leaf motorunda bulunan encoder.

b. Carriage
   - 540 counts = 1 mm of linear shift at isocenter

   Leaf
   - 707 counts = 1 mm linear shift for full width leafs
   - 512 counts = 1 mm linear shift for half width leafs at isocenter

MLC QA: Leaf pozisyonu belirsizliği

- **Secondary Feedback motor hareket sayımları ile leaf'in gerçek pozisyonunu kontrol eder.**
  - Carriage
  - Leaf Secondary Feedback – Her leaf ayağında bulunan Seramik bilyeler "Soft Potentiometer"e basınç yaparak durumunu bildirir.
  - Interlock PRO/SPRO :MLC Kontrol mekanizması Soft Pot ile Leaf Motor Encoder Sayımını mukayese eder.

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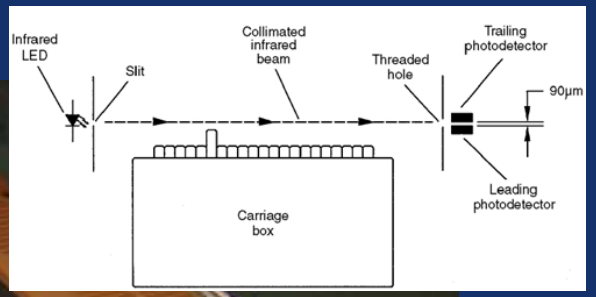


Leaf Motoru (Half and Full)

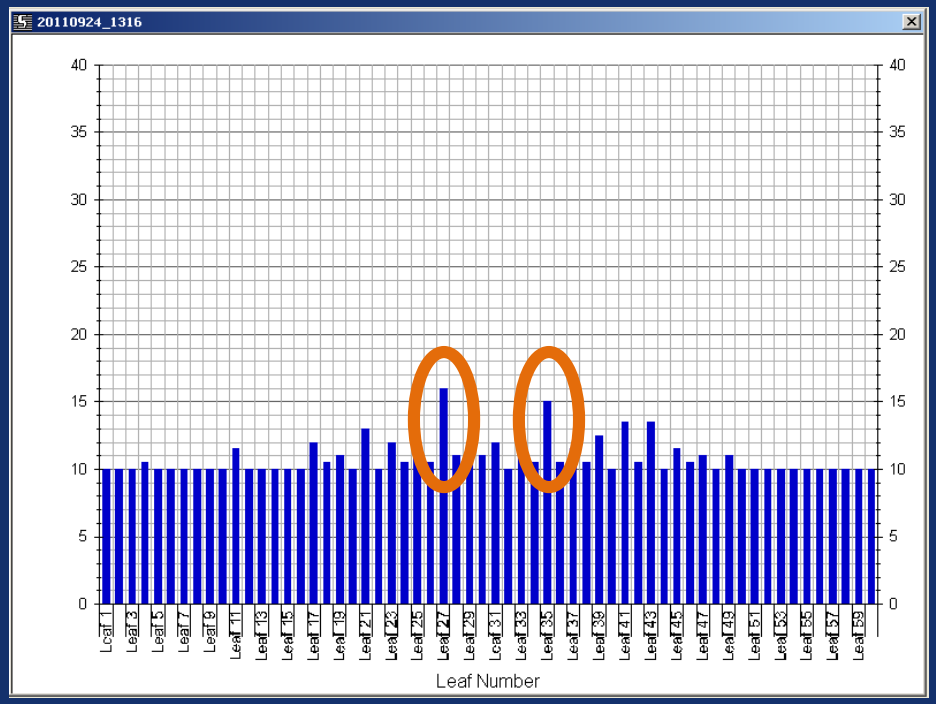
MLC QA: Leaf hızı hassasiyeti

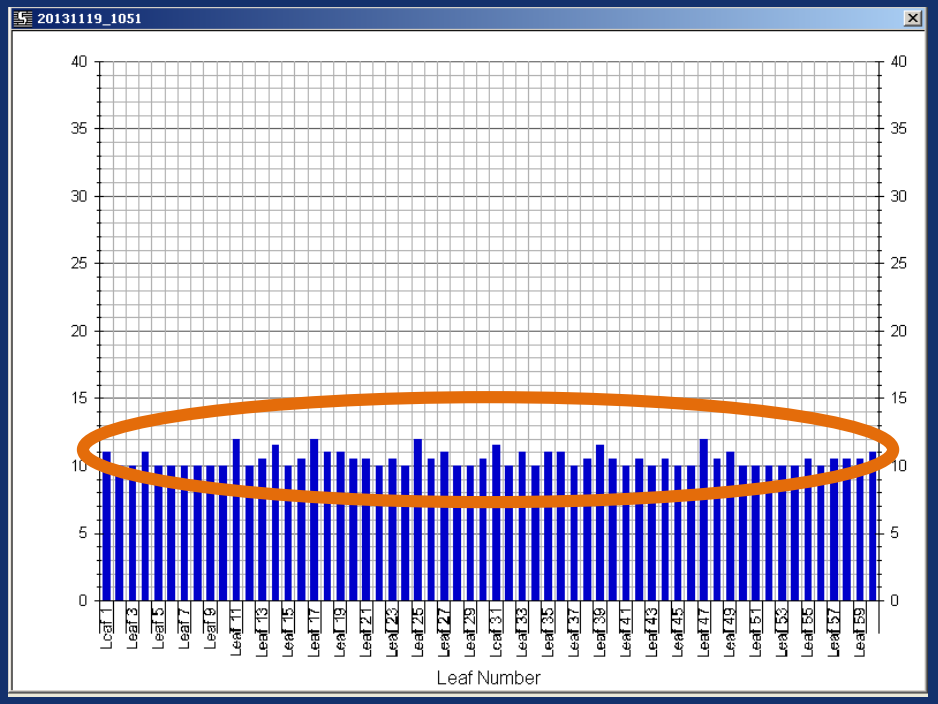
Leaf hızına etki eden faktörler:

1. Leaf aralarına kir veya yağ birikmesi,
   TEST: PWM Testi

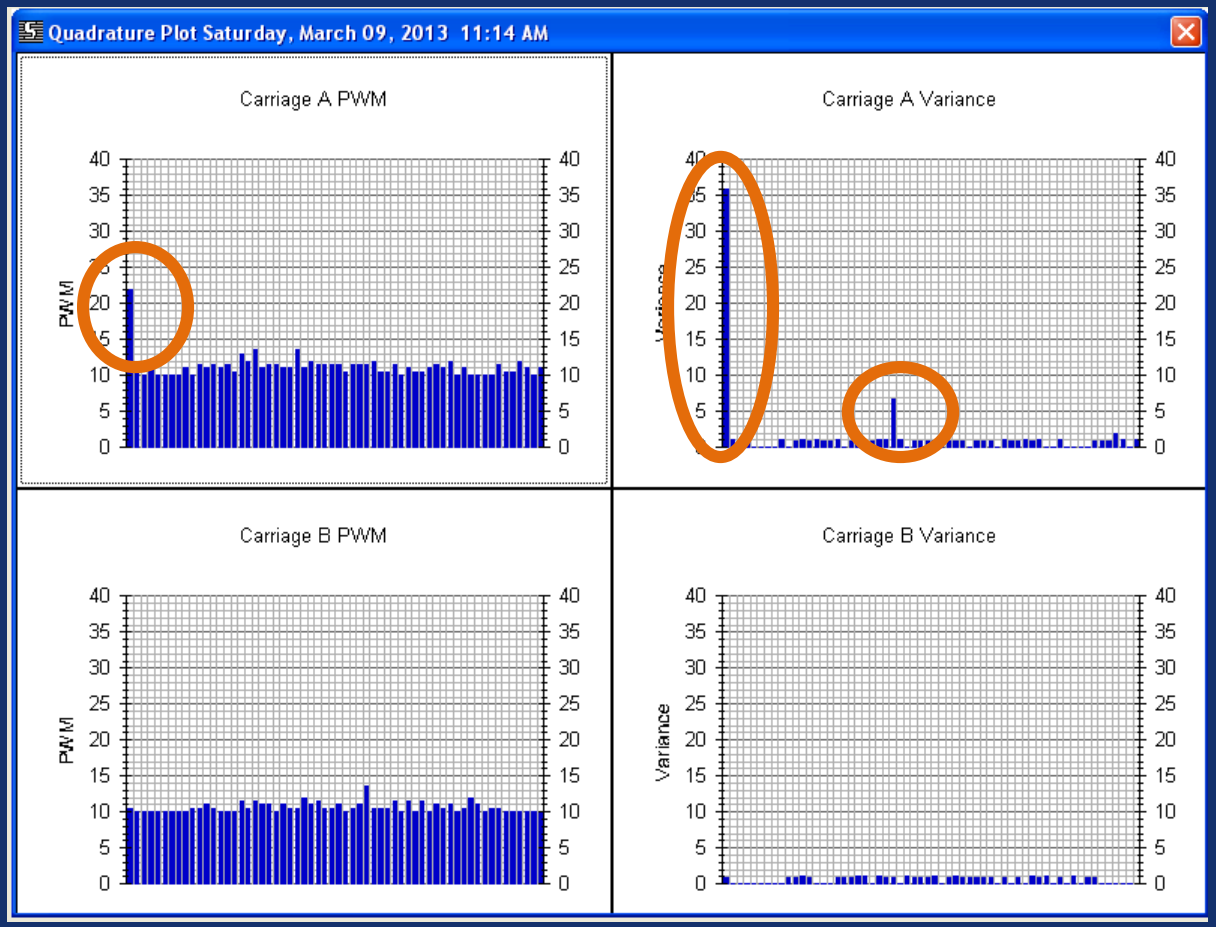
1. Motoru oluşturan parçalarda bozulma.
   TEST: RMS Hata yüzdesi, ve Dynalog File

MLC QA: Leaf hızı hassasiyeti: PWM (Puls Width Modulation) Testi





MLC QA: Leaf hızı hassasiyeti: PWM (Puls Width Modulation) Testi

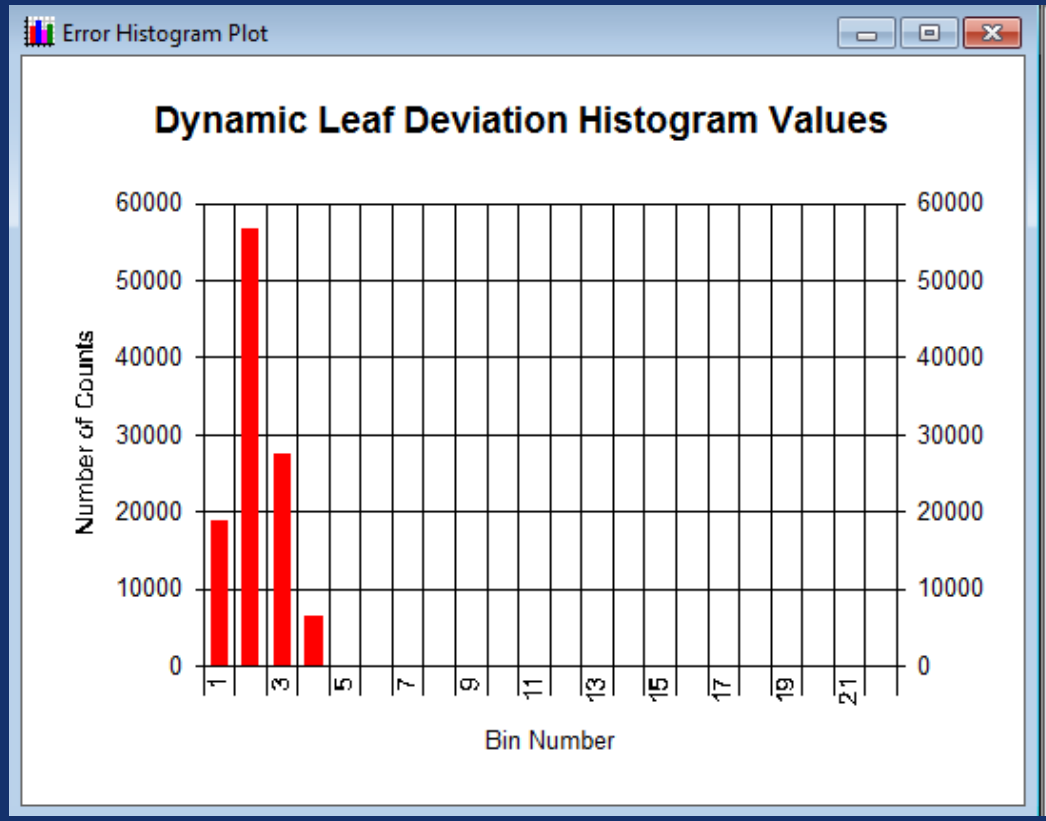


MLC QA: Leaf hızı hassasiyeti: PWM (Puls Width Modulation) Testi

```
-> diagLeafPWMTestMlc
2A minimum PWMs to move leaves   -2.000 from indicated positions (rel.
to crg.) before 2 second timeout.
Leaf     0   -25   -50   -75
A01      8     8     8     8
A02      8     8     8     8
A03     10    10     8    10
...(redundant full leaf lines omitted to minimize displayed data)
A11     14    16    16    16
A12     14    14    14    14
A13     18    18    18    12
...(redundant lines omitted to minimize displayed data)
B59     10    10    10    10
B60     10    10    10    10
Saved PWM test results in MlcData/MLC PWM 20110525 0830.txt.
```

- Eğer PWM testinde değerler full leafler için < 12, veya half leafler için < 22 ise, müdahaleye gerek yoktur.
- Eğer PWM testinde elde edilen değerler full ve half MLC'ler için > 35 ise for servis hizmeti gereklidir.
- Eğer 12-22< PWM test değerleri < 35 ise bu leaf'ler için özel bir dikkat gereklidir.

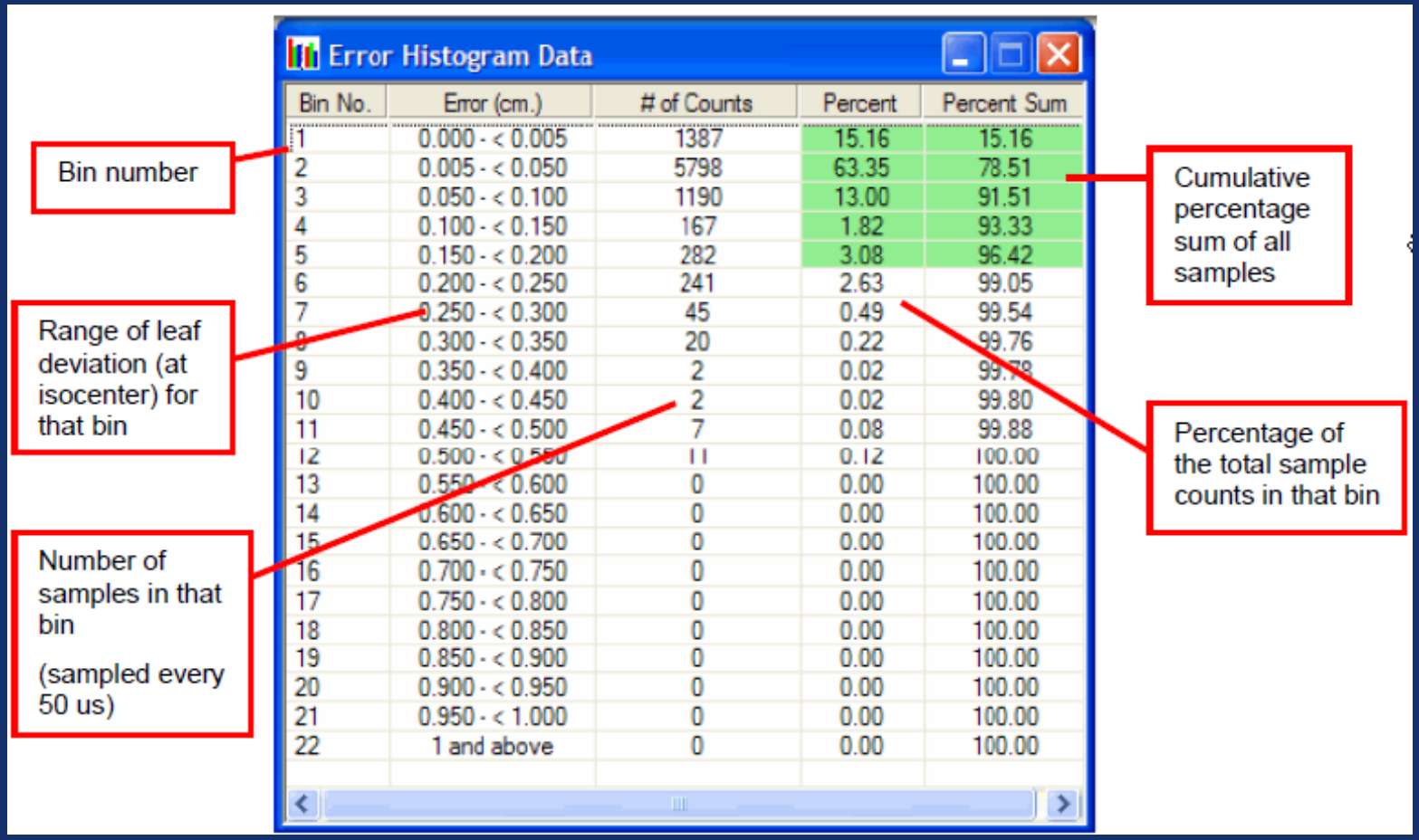
MLC QA: Leaf hızı hassasiyeti: Dynalog File



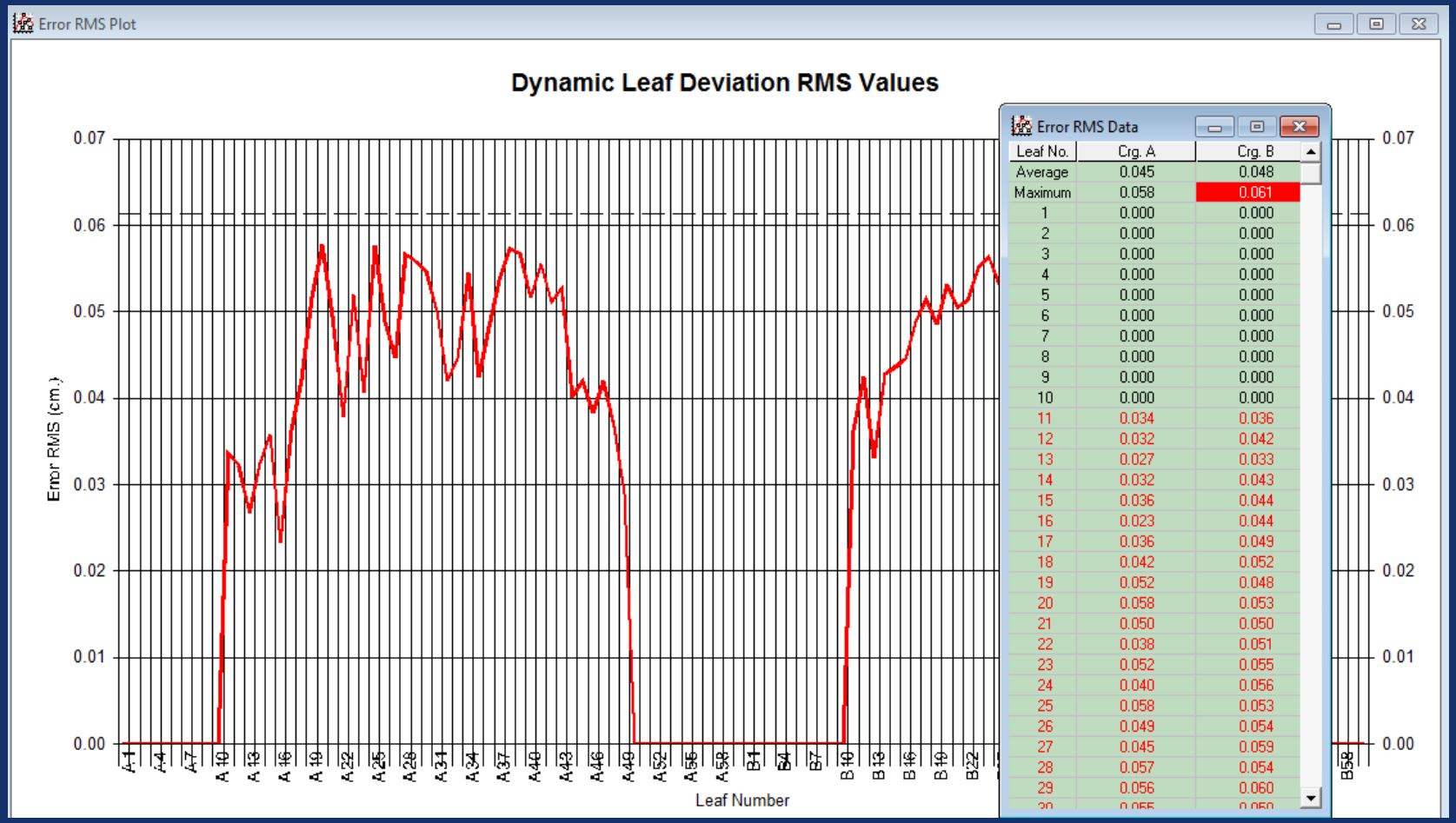
Error Histogram Data

Bin No.	Error (cm.)	# of Counts	Per cent
1	0.000 - < 0.005	18778	17.196
2	0.005 - < 0.050	56614	51.8443
3	0.050 - < 0.100	27480	25.1648
4	0.100 - < 0.150	6324	5.7912
5	0.150 - < 0.200	4	.0037
6	0.200 - < 0.250	0	0
7	0.250 - < 0.300	0	0
8	0.300 - < 0.350	0	0
9	0.350 - < 0.400	0	0
10	0.400 - < 0.450	0	0
11	0.450 - < 0.500	0	0
12	0.500 - < 0.550	0	0
13	0.550 - < 0.600	0	0
14	0.600 - < 0.650	0	0
15	0.650 - < 0.700	0	0
16	0.700 - < 0.750	0	0
17	0.750 - < 0.800	0	0
18	0.800 - < 0.850	0	0
19	0.850 - < 0.900	0	0
20	0.900 - < 0.950	0	0
21	0.950 - < 1.000	0	0
22	1 and Above	0	0

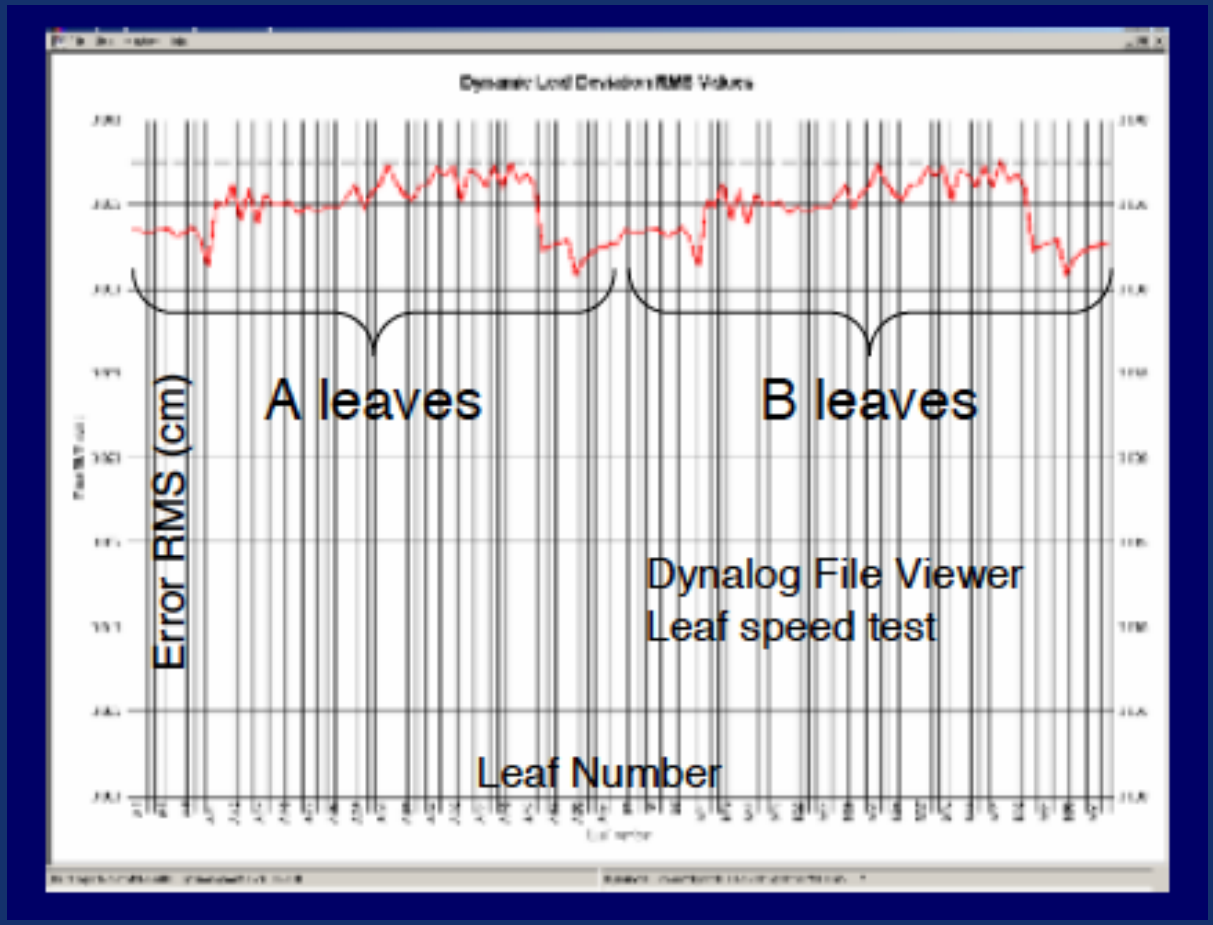
MLC QA: Leaf hızı hassasiyeti: Dynalog File



MLC QA: Leaf hızı hassasiyeti: Dynalog File



MLC QA: Leaf hızı hassasiyeti: Dynalog File



MLC QA: Leaf hızı hassasiyeti: Dynalog File

MLC RMS Error ve Dynalog File sonuçlarının hastanın her tedavi fraksiyonunda benzer olması beklenir.
Ancak, IMRT'nin uygulamasında kullanılan parametrelerin yüksekliği (Soft veya Hard IMRT) bu yapıyı etkiler.

Acıbadem Maslak Hastanesi Deneyimi

MLC QA: EYLEM PLANI

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A survey of the practice and management of radiotherapy linear accelerator quality control in the United Kingdom

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Objectives: To determine current radiotherapy linear accelerator (linac) quality control (QC) practice in the UK, as a comparative benchmark and indicator of development needs, and to raise awareness of QC as a key performance indicator.

Methods: All UK radiotherapy centres were invited to complete an online

Results: 72% of the UK's 62 radiotherapy centres completed the questionnaire and 40% provided their QC schedules. 60 separate QC tests were identified from the

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Table 5. Stated frequency of QC checks and percentage occurrence within submitted physics department QC schedules, for checks not included in IPEM Report 81 [7]

QC test	Included in physics QC schedules	Per patient	Daily	Weekly	Between weekly and monthly	Monthly	Quarterly or six-monthly	Annual
MV/kV imaging quality	43%	–	22%	11%	–	45%	11%	11%
kV imaging isocheck and known shifts	22%	–	40%	20%	–	40%	–	–
MV/kV imager collision interlocks	9%	–	50%	–	–	50%	–	–
kV/MV image registration	9%	–	–	–	–	50%	–	50%
kV imager dose	9%	–	–	–	50%	50%	–	–
kV/MV imager movement calibration	39%	–	–	–	–	44%	44%	12%
MLC "picket fence" film	52%	–	–	16%	–	42%	42%	–
MLC positions in complex test fields	13%	–	–	–	34%	66%	–	–
MLC carriage skew	13%	–	–	–	–	–	100%	–
Output at different dose rates	13%	–	–	–	–	–	67%	33%
Dynamic wedge profile	35%	–	–	–	–	25%	50%	25%
In vivo dosimetry check	26%	–	–	–	17%	66%	17%	–
Table isocentre rotation	44%	–	–	–	10%	70%	20%	–
Collimator position with electron applicators	44%	–	–	10%	10%	50%	20%	10%
Film of matching fields	26%	–	–	–	–	33%	67%	–
Radiation and light alignment, asymmetric	30%	–	–	–	14%	29%	43%	14%
IMRT point dose	30%	100%	–	–	–	–	–	–
IMRT fluence map	30%	100%	–	–	–	–	–	–
MLC sweep gap	40%	–	25%	25%	–	25%	25%	–
MLC travel range	10%	–	–	–	–	–	–	100%
MLC travel speed	19%	–	–	–	20%	20%	40%	20%
IMRT dose rate constancy	10%	–	–	–	–	–	–	100%
Radiation protection survey	9%	–	–	–	–	–	–	100%

IMRT, intensity-modulated radiotherapy; IPEM, Institute of Physics and Engineering in Medicine; kV, ; MLC, multileaf collimator; MV, ; ODI, optical distance indicator; PDD, QC, quality control.

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ated frequency of QC checks and percentage occurrence within submitted physics department QC schedules, tified in IPEM Report 81 [7], with comparison with previously recommended frequency

QC test	IPEM Report 81 frequency	Included in physics QC schedules	Daily	Weekly	Between weekly and monthly	Monthly	Quarterly or six-monthly	Annu
Output constancy measurement	Daily	48%	**91%**	9%	–	–	–	–
Light field size	Daily	52%	**83%**	9%	–	8%	–	–
Laser and crosswire alignment	Daily	52%	**75%**	17%	–	8%	–	–
Door/maze interlock	Daily	61%	**64%**	7%	8%	21%	–	–
ODI	Daily	48%	**82%**	9%	9%	0%	–	–
Output "calibration" measurement	Weekly	87%	–	35%	5%	**60%**	–	–
ODI at different distances	Weekly	44%	20%	20%	20%	**40%**	–	–
Pointers	Weekly	57%	8%	23%	–	**62%**	8%	–
Wedge factor	Weekly	65%	13%	20%	7%	**53%**	6%	–
Flatness and symmetry at zero gantry angle	2-weekly	70%	–	6%	13%	**81%**	–	–
Emergency off switches	Monthly	30%	14%	**43%**	14%	29%	–	–
Shielding tray interlock	Monthly	17%	–	–	–	**75%**	25%	–
Back-up timer interlock	Monthly	9%	–	–	–	**100%**	–	–
Gantry and collimator rotation scales	Monthly	74%	12%	0%	12%	**64%**	6%	6%
Light field dimension, various sizes	Monthly	43%	10%	10%	0%	**50%**	10%	20%
Isocentre "quick" check	Monthly	43%	10%	10%	**60%**	20%	–	–
Table lateral and longitudinal scale	Monthly	57%	8%	8%	–	**77%**	8%	–
Table height scale	Monthly	52%	–	8%	–	**68%**	8%	16%
Photon and electron energy, 2-depth measure	Monthly	83%	–	–	11%	**89%**	–	–
Radiation and light field alignment, at one size	Monthly	74%	–	–	6%	**82%**	12%	–
MLC leaf position, standard field	Monthly	43%	10%	20%	10%	30%	20%	10%
Radiation and light field alignment, other sizes	Quarterly	52%	–	–	–	34%	58%	8%
Back-up dosimeter and timer	Quarterly	23%	17%	–	–	**50%**	33%	–
Field size at extended distance	Quarterly	30%	–	–	–	–	**86%**	14%
Output variation with gantry angle	Quarterly	65%	–	–	–	7%	**80%**	13%
Wedge factor with gantry angle	Quarterly	65%	–	–	–	20%	**73%**	7%
Output for non-standard fields	Quarterly	52%	–	–	–	**58%**	8%	33%
Flatness and symmetry non-zero gantry angle	Quarterly	61%	–	–	–	**43%**	36%	21%
MLC stability with gantry rotation	Quarterly	26%	–	–	–	33%	**67%**	–
MLC leakage between leaves	Quarterly	43%	–	–	–	30%	**60%**	10%
Radiation isocentre	6-monthly	35%	–	–	–	–	88%	12%
Calibration of constancy check device	6-monthly	61%	–	–	–	**57%**	36%	7%
Linearity of dosimetry system	6-monthly	78%	–	–	–	22%	**61%**	17%
Table deflection under load	Annual	39%	–	–	–	11%	11%	**78%**
Isocentre "definitive" check	Annual	35%	–	–	–	–	12%	**88%**
PDD and profiles in 3D scanning water tank	Annual	48%	–	–	–	–	–	**100%**
Field size reproducibility	Annual	9%	–	–	–	–	**50%**	**50%**

3D, three-dimensional; IPEM, Institute of Physics and Engineering in Medicine; MLC, multileaf collimator; ODI, optical distance indicator; PDD,; QC, quality control.

SONUÇLAR

1. MLC bazlı IMRT uygulamasındaki hatalar sıklıkla tehlikeli değildir.

2. Fakat sıklıkla görülmeyen bazı hatalar çok anlamlı sorunlar yaratabilir.

3. MLC, özellikle dMLC ile birlikte fluence değişiminin orkestrasyonu daime ileri bir çalışma gerektirir.

SONUÇLAR

3. Bu nedenle, uygulama hatalarının boyutunu görebilmek için, periyodik yöntemlere gereksinim vardır.

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