



به نام خدا

سمینار دو روزه آشنایی مقدماتی با درمانهای
پیشرفته با دستگاه توموتراپی

کنترل کیفی در درمانهای IMRT شتابدهنده (در عبور به Helical Tomotherapy)

PARDISNOOR NILOO

سجاد میرزایی

Radiotherapy Chain:

1. Localization:

- Countoring Target and OAR
- Multimodality : Image registration


2. Dose prescription

3. Treatment plan optimization

4. Treatment delivery

Treatment device:

- Mechanical accuracy of the system
- Localization system

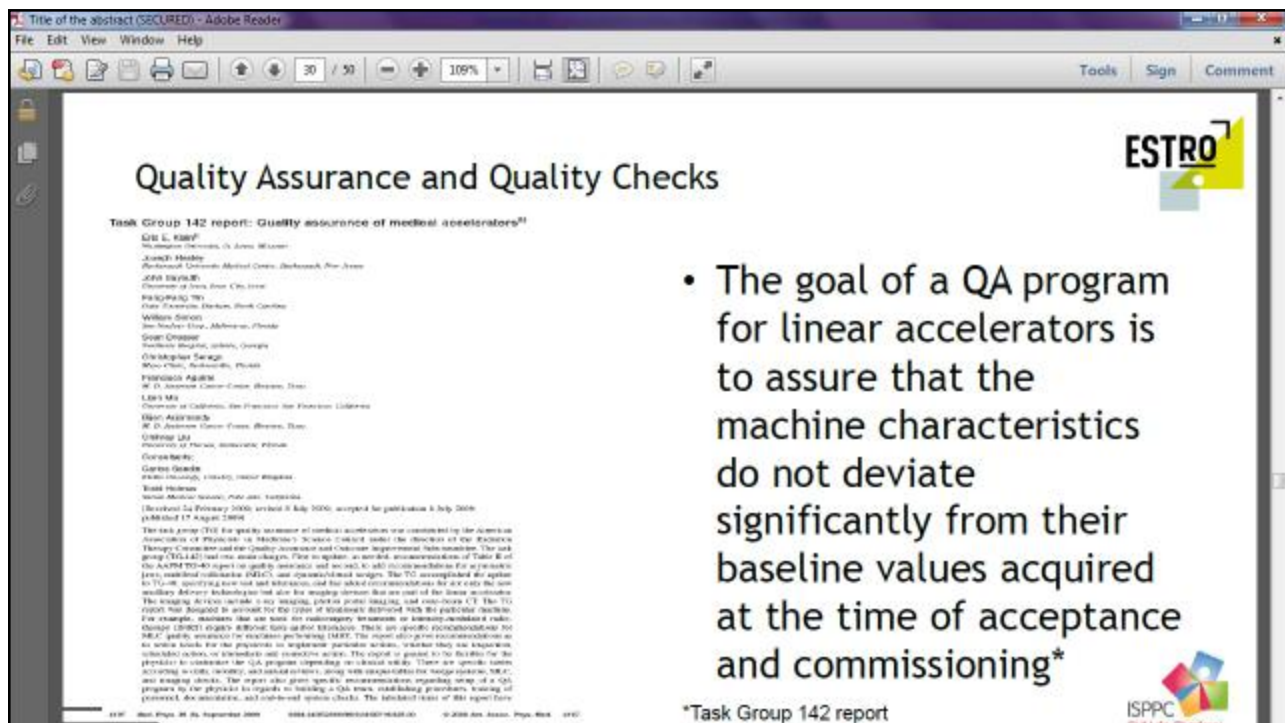


Delivery of dose within $\pm 5\%$

- Sources of uncertainty
 - Treatment planning (estimated uncertainty of the order of $\pm 2\%$)
 - Machine performance on the day ($\pm 2\%$)
 - Patient set-up and movement ($\pm 3\%$)

 - Absolute dosimetry/calibration
 - Relative dosimetry (%depth dose, profiles, output factors)

Not much room for error in dosimetry ...



Quality Assurance and Quality Checks

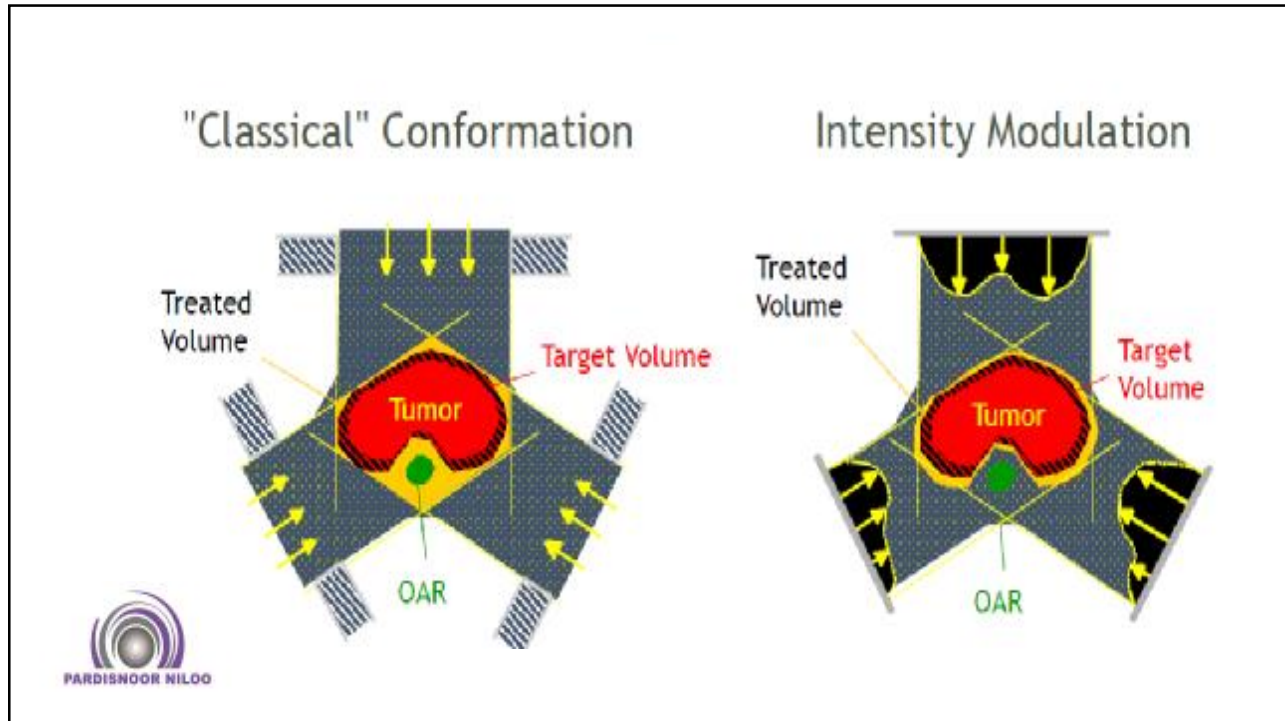
Task Group 142 report: Quality assurance of medical accelerators¹

ESTRO 7

ISPPC

- The goal of a QA program for linear accelerators is to assure that the machine characteristics do not deviate significantly from their baseline values acquired at the time of acceptance and commissioning*

*Task Group 142 report



Quality assurance of equipment	
Equipment tests to be performed on a regular basis	
Dosimetry <ul style="list-style-type: none"> • Output • Beam symmetry/flatness • Energy • Dose linearity 	Similar to 3D conformal QA
Mechanical <ul style="list-style-type: none"> • Jaws/MLC/couch absolute and relative position and speed • Gantry/collimator/couch angle • Gantry/collimator/couch rotation iso-centre 	Much higher accuracy
Imaging <ul style="list-style-type: none"> • Imaging and treatment iso-centre coincidence • Reproducibility • Contrast, uniformity, noise and image quality • HU constancy • Portal imager dose 	Similar to 3D conformal QA (at least in principle)

Quality assurance of equipment

IMRT (linac)

- **MLC: Position and speed**

VMAT (linac)

- **MLC: Position and speed**
- **Gantry: Position and speed**
- **Dose rate**

Tomotherapy

- **Synchrony: MLC opening, table position and gantry position**


Cyber knife

- **Isocentre: Advanced Winston Lutz test**

Simulation of delivered plan by use of DynaLog files

Commissioning of TPS

- **Measurement of leaf gap and transmission**



Task Group of AAPM


- TG 50 MLC
- TG 58 EPID
- TG 76 Respiratory Motion
- TG 106 Beam data commissioning equipment and procedures
- TG 104 KV X-ray imaging for patient setup
- TG 100 evaluating QA needs in RT
- TG 148 Tomotherapy QA
- TG 40 COMPREHENSIVE QA FOR RADIATION ONCOLOGY
- TG 135 QA for Robotic Radio surgery
- TG 119** IMRT commissioning: Multiple institution planning and dosimetry comparisons
- TG 147 QA for non-Radiographic RT localization and Positioning
- TG 142** Quality assurance of medical accelerators
- TG 198** Describe the techniques for performing QA test

QA of IMRT

- **Acceptance testing**
 - Check whether specifications meet requirements for accurate IMRT and VMAT delivery
- **Commissioning**
 - Acquisition of the input parameters for the treatment planning system
 - Testing of the dose calculation algorithm
 - E2E testing of the complete treatment chain (audit ?)
- **Routine MLC QA**
 - E.g. stability of MLC and machine output characteristics
- **Patient specific QA**
 - Pretreatment measurements and in-vivo dosimetry
 - 3D dose calculation

TG 119

TG 198



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AAPM SCIENTIFIC REPORT

MEDICAL PHYSICS

AAPM Task Group 198 Report: An implementation guide for TG 142 quality assurance of medical accelerators

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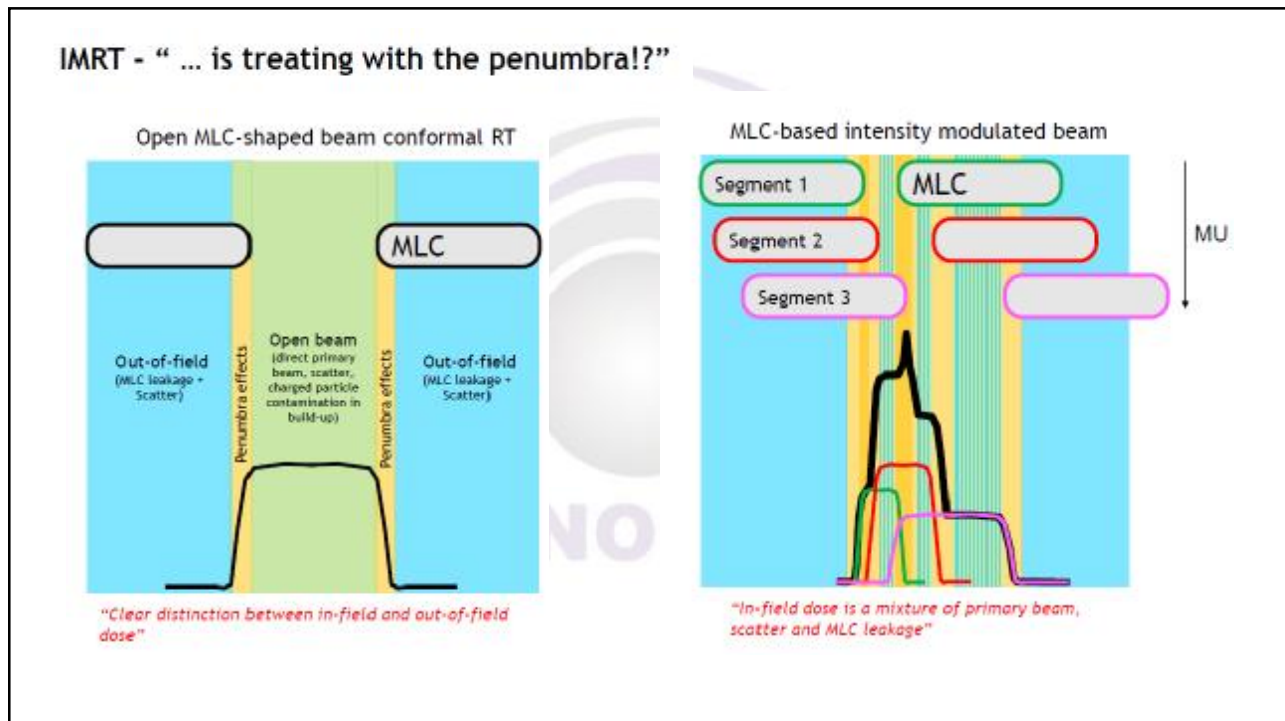
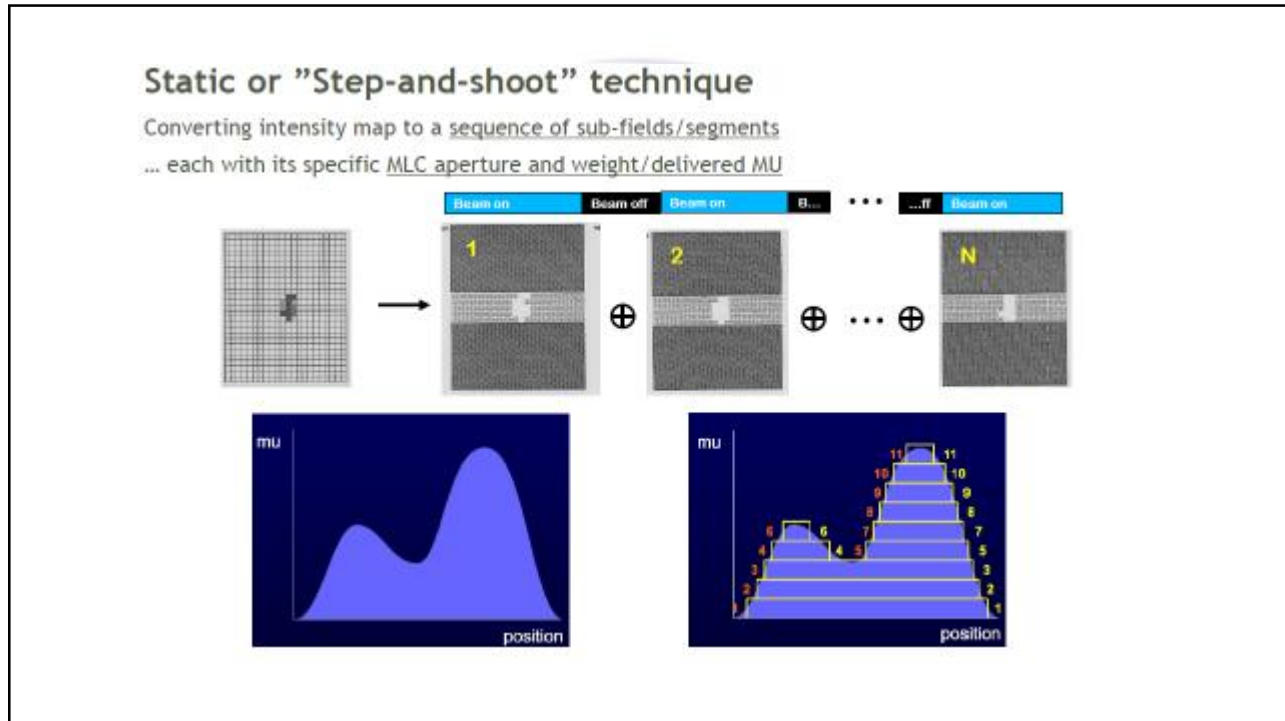
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Abstract
 The charges on this task group (TG) were as follows: (a) provide specific procedural guidelines for performing the tests recommended in TG 142; (b) provide estimate of the range of time, appropriate personnel, and qualifications necessary to complete the tests in TG 142, and (c) provide sample daily, weekly, monthly, or annual quality assurance (QA) forms. Many of the guidelines in this report are drawn from the literature and are included in the references. When literature was

IMRT

- Many small segments are made by the MLC for building a dose distribution
- Leaf positioning an travelling becomes important
- Dose calculation are more complex
 - tongue and groves effects
 - Leaf rounding effects
 - Leaf transmission
- Small field Dosimetry becomes important




Dynamic MLC mode technique(s)

Beam stays on during

- Dynamic MLC leaf movement
- Gantry movement
- Dose rate modulation possible
- (couch movement)
- (collimator movement)



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- Leaf speeds from 2-7 cm/sec
- Few 100ths segments per beam/arc
- More versatile - more intensity levels
- Could be faster overall treatment time - beam stays on
- The method of choice when combined with gantry rotation (VMAT, ...)

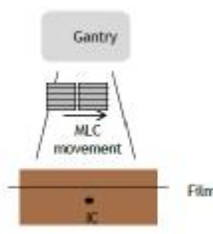
Geometrical accuracy much more important than for conventional treatment

- Position and speed of MLC (IMRT)
- Position and speed of gantry (VMAT)
- Position and speed of table (Tomotherapy)

Important during commissioning AND periodic quality control

IMRT dynamic delivery

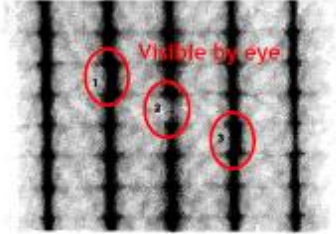
- Picket fence test
- Relative position of individual leaves
 - Intentional error of 1 mm in three leaf positions
 - Film measurement




Gantry



MLC movement

Film




Visible by eye

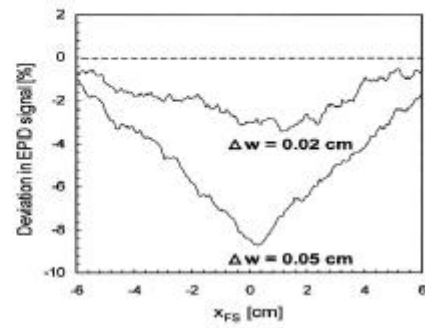







Leaf Positioning

- For 3DCRT the accuracy of the leaf positioning affects the borders of the radiation field. Typically, errors of 1 mm are accepted and can be accounted for in a CTV-to-PTV margin
- **For IMRT leaf positioning errors can also impact the dose inside the target**
 - E.g. a 1 mm gap error can introduce a dose error of 5%.
 - Overlapping or underlapping of abutting fields lead to hot and cold spots up to 17%/mm





MLC leaf positioning (also during gantry rotation)

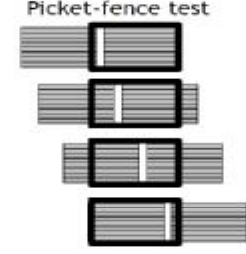
"Loss of lateral electron equilibrium in small field segments"

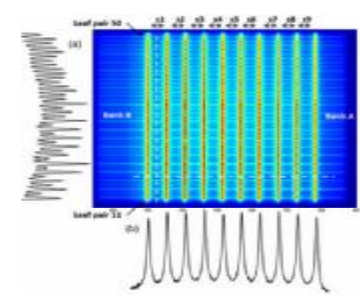
"A drastic change in absorbed dose for small changes in field size occurs when the field size is as small as those encountered in IMRT."

=> tighter tolerances on leaf position/motion

=> also while gantry is rotating and gravity impacts MLC-leaves, during f.e. a VMAT delivery

Picket-fence test





Leaf position accuracy

- <0.5 mm for modern MLC designs
- Measured using Picket-fence tests on film or EPID

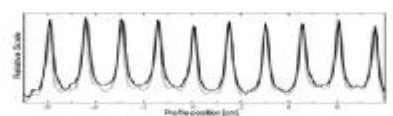




Figure 3. Comparison of MLC accuracy positioning between fixed gantry (IMRT) and VMAT (rotating gantry) picket fence tests delivery. Difference in leaf position ± 0.5 mm for each of the 10 leaves. (Source: ICRU Commission Report 25)

IMRT commissioning: Multiple institution planning and dosimetry comparisons, a report from AAPM Task Group 119

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گزارش تست های TG-119 مرکز پردیس نور نیلو:

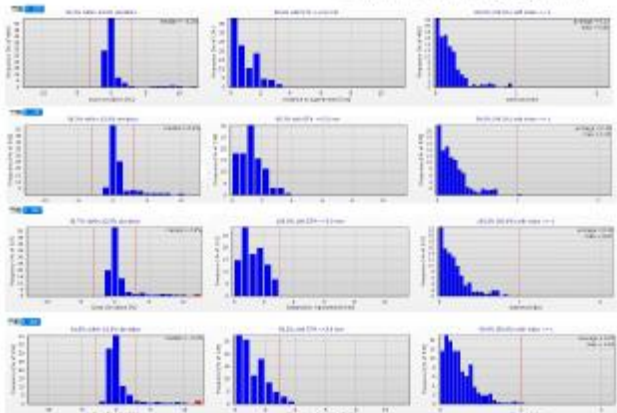
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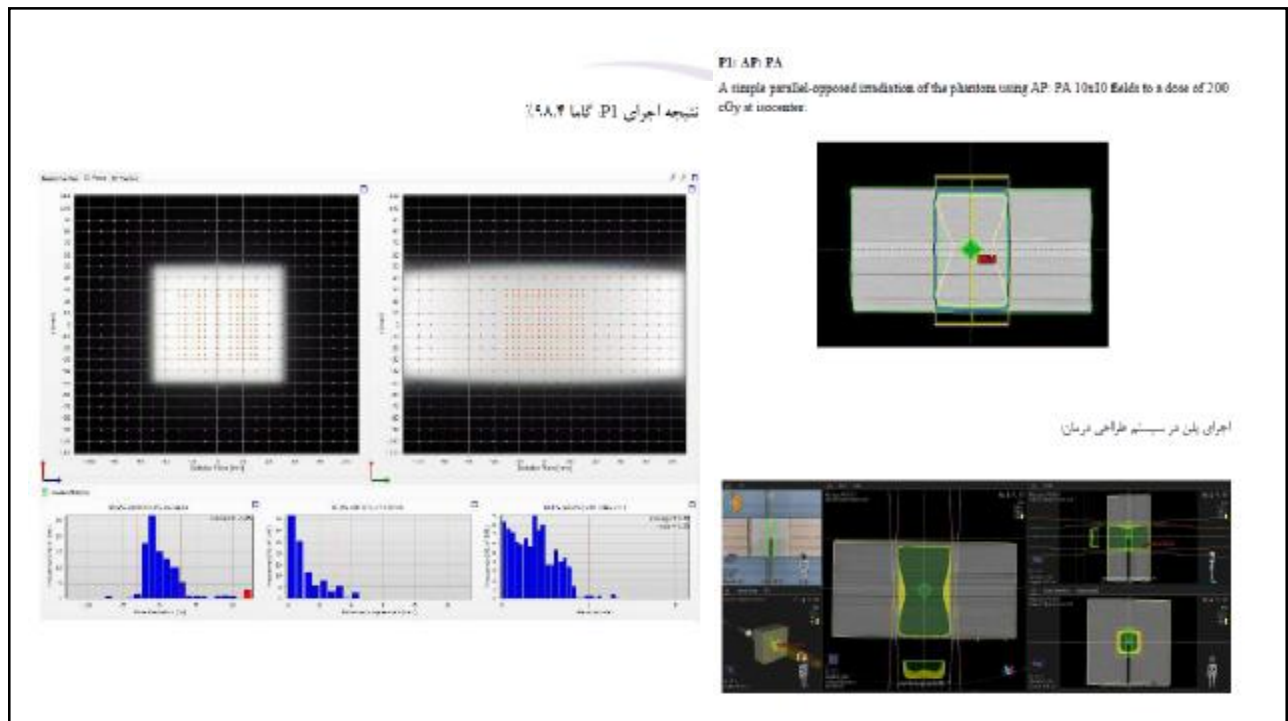
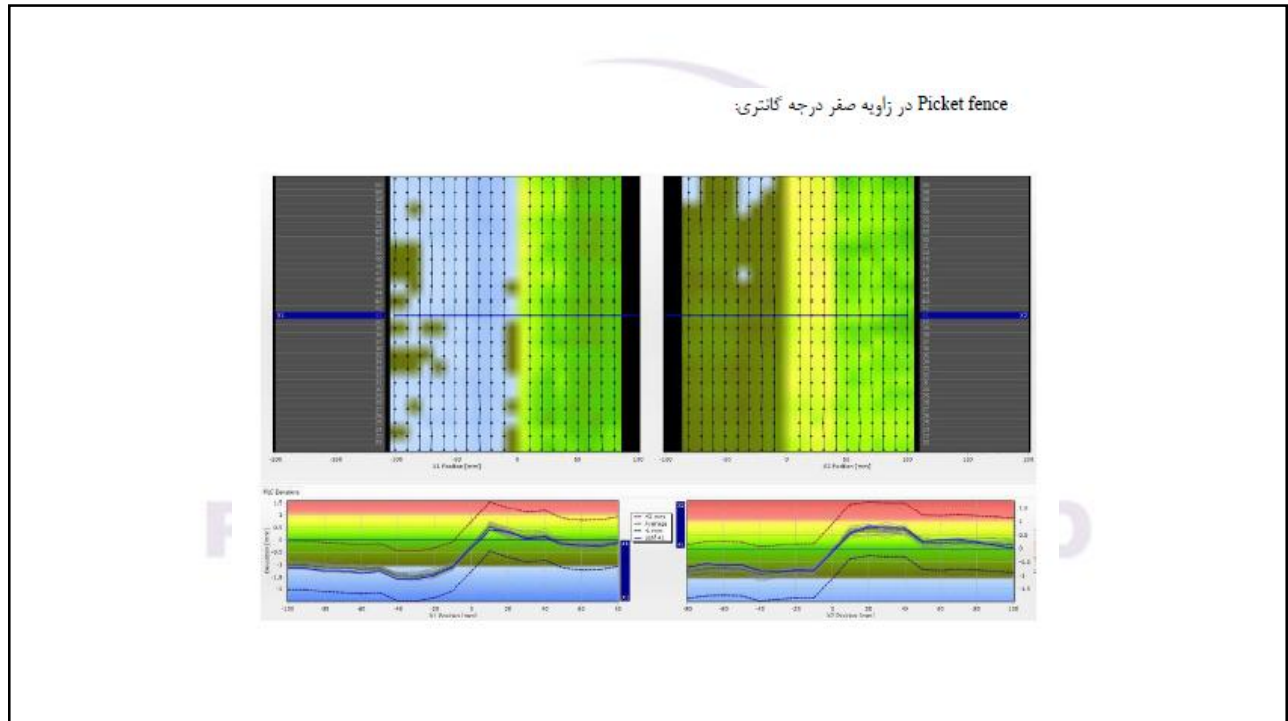
ملاحظات	نتایج
تعریف تخت درمان (LUD) با استفاده از CT اسکن تخت در سیستم طراحی درمان	تخت درمان تعریف شد و تست های لازم جهت Verify کردن جنس ماده اضماعی به تخت، طراحی و با استفاده از فانتوم Delta انجام شد. جزئیات و نتایج تست در پیوست شماره 1 آمده است.
صحت منحنی همپلکورد سیستم طراحی درمان توسط تست های سازمان انرژی اتمی (IAEA)	نامی A تست An202 با نتایج مطلوب Pass شدند. پیوست شماره 2.
انجام تست Picket fence در زاویه گانتری صفر	نتایج در پیوست شماره 2 آمده است.
TG-119 تست های	نتایج در پیوست شماره 3 آمده است.

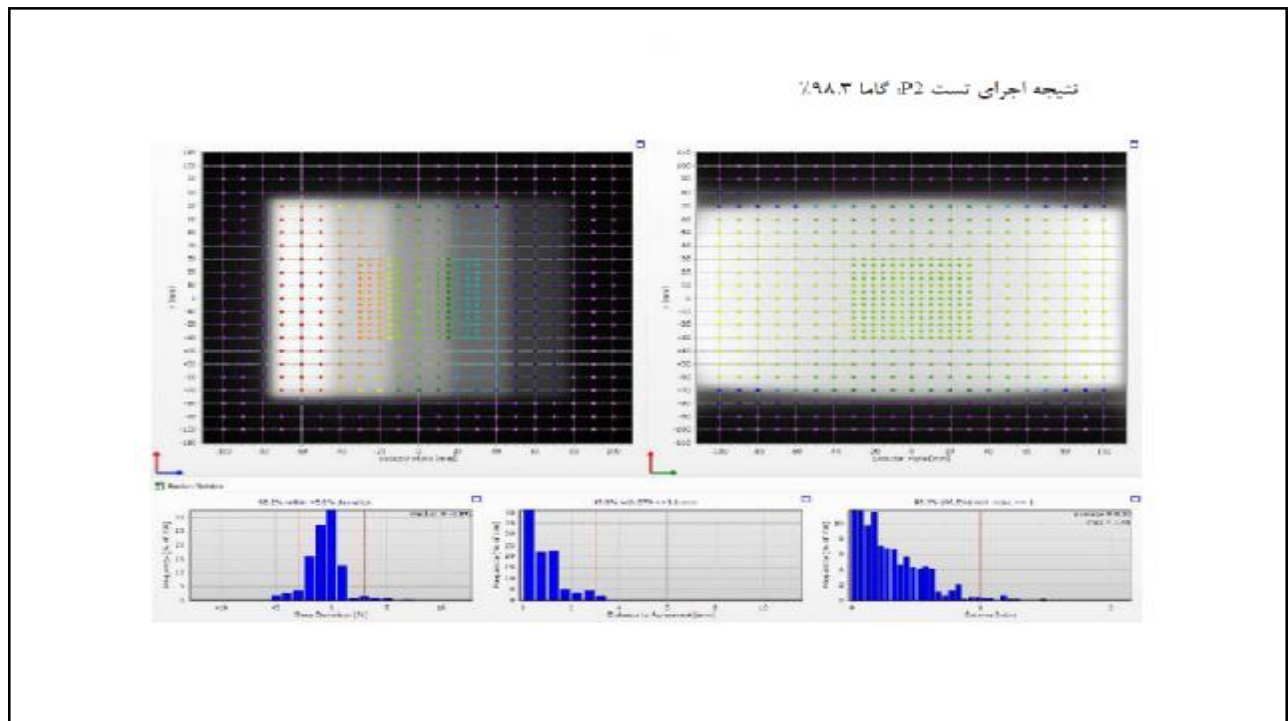
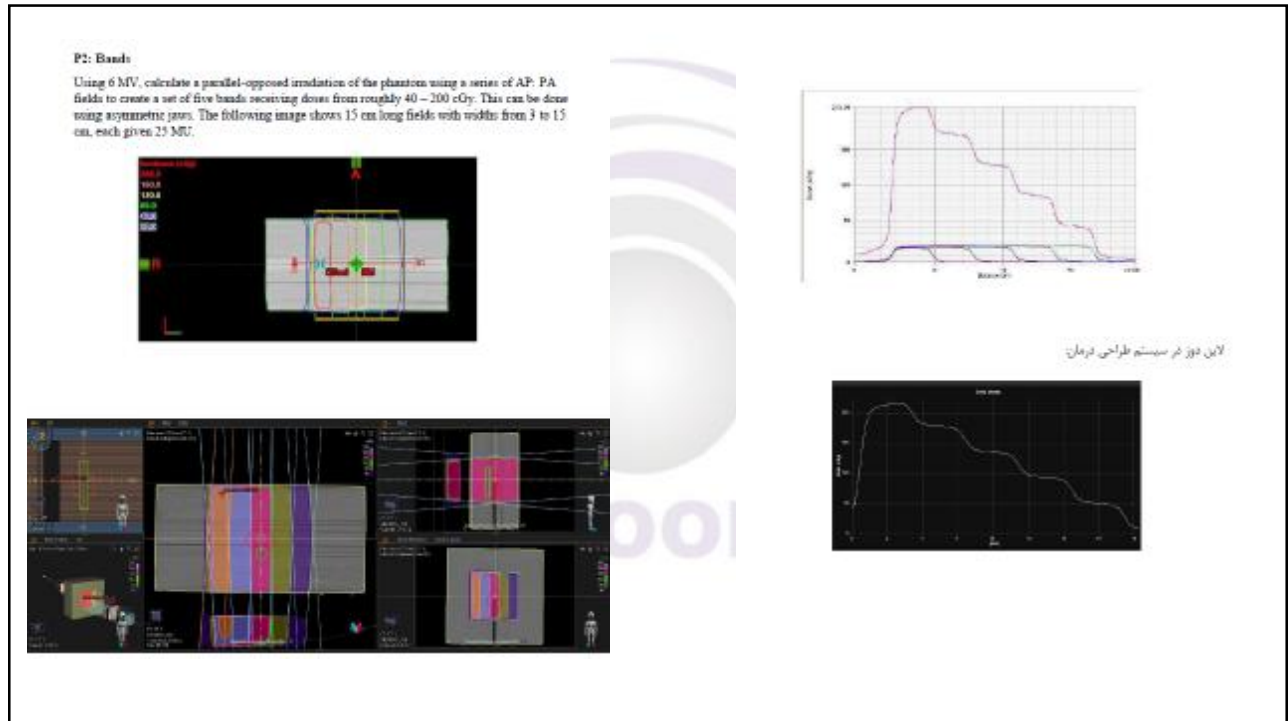
تست تخت بدین ترتیب طراحی گردید که پس از چهار زاویه مایل خلفی ۰°، ۱۶۰°، ۲۰۰° و ۲۲۰°، فیلدهایی با ابعاد 10x10 cm² با MU=100 پس از آن با استفاده از فانتوم Delta روی دستگاه اجرا گردید و تست با گاما ۹۹.۸ پاسی شد.

پیوست ۲: نتایج تست An202

Case #	Description	Meas. point	Field #	Calculation results (Gy)	Measurement results (Gy)	Deviation (%)	Agreement criteria (%)	Pass/Fail
1	Standard SSD, rectangular field	3		2.880	2.807	-0.4	2	P
		9		8.740	8.742	-0.1	4	P
		10		1.240	1.208	-1.0	3	P
2	Missing tissue	1		2.880	2.858	-1.8	3	P
3	Blocked corners	3		2.880	2.806	-0.3	3	P
4	Four field box	5	F1	2.880	1.896	-0.5	2	P
			F2	2.880	2.813	-0.7	3	P
			F3	2.880	1.863	-1.9	3	P
			F4	2.880	2.802	-0.1	3	P
		8	SUM	8.880	7.868	-0.4	3	P
			F1	8.130	8.128	-0.1	4	P
			F2	1.380	1.368	-0.4	2	P
			F3	8.130	8.168	-0.0	4	P
		10	F4	2.720	2.708	-0.6	3	P
			SUM	4.210	4.302	-0.7	3	P
			F1	1.430	1.404	-1.0	3	P
			F2	8.740	8.138	-0.2	4	P
5	Customized blocking	7		1.720	8.818	-0.1	4	P
		3		2.880	2.808	-0.4	3	P
		10		1.380	1.302	-0.2	3	P
6	L-shaped field	7		8.120	8.113	-0.6	3	P
		3		2.880	1.867	-0.7	2	P
		10		2.880	2.852	-1.6	4	P
7	Plan with asymmetric fields and wedges	F1	2.880	2.843	-1.1	4	P	
		F2	2.880	2.802	-1.0	3	P	
		SUM	6.880	6.302	-0.8	3	P	
8	Plan with non-coplanar fields	F1	2.820	1.968	-1.9	3	P	
		F2	2.880	1.978	-1.4	3	P	
		F3	2.880	1.968	-1.0	3	P	
SUM	6.520	5.818	-1.8	3	P			







C1: Multi-Target:

Three cylindrical targets are stacked along the axis of rotation. Each has a diameter of approximately 4 cm and length of 4 cm.

target goals:

structure		
central target	99% of volume to receive at least 5000 cGy	10% of volume to receive no more than 5300 cGy
apical target	99% of volume to receive at least 2500 cGy	10% of volume to receive no more than 2800 cGy
distal target	99% of volume to receive at least 1200 cGy	10% of volume to receive no more than 2000 cGy

beam arrangement:
MV, 7 fields at 30° intervals from the vertical

hardware measurement points:
light dose: locometer
over dose: 4 cm superior, 4 cm inferior

Placer film measurement:
Mid phantom at isocenter

نتیجه اجرای تست گاما 98.6:

نتیجه اجرای تست گاما 99.8: Mock Prostate

ellipsoidal with RL, AP, and SI dimensions of 4 cm
Prostate PTV is expanded 0.6 cm around the CTV.
(Diameter 4 cm, one that share the indicated coordinate)

target goals:

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central target	99% of volume to receive at least 5000 cGy	10% of volume to receive no more than 5300 cGy
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