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)

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 ± 5%

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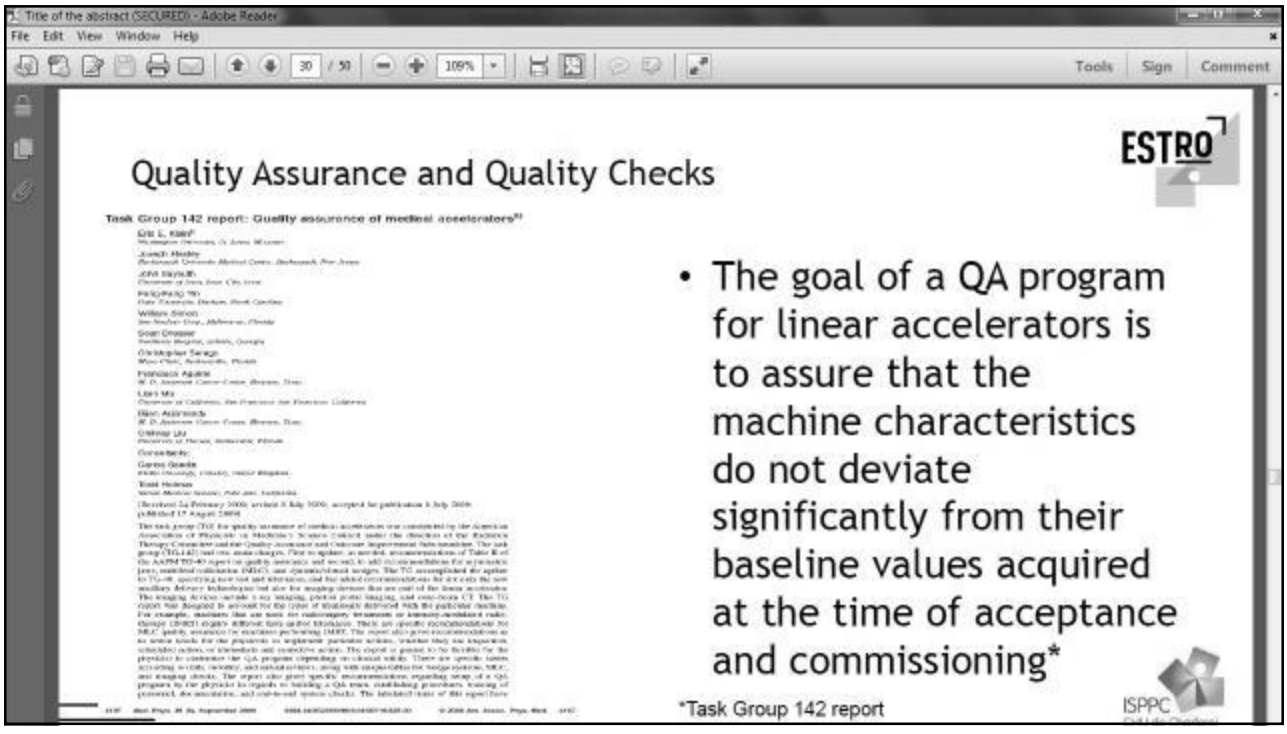
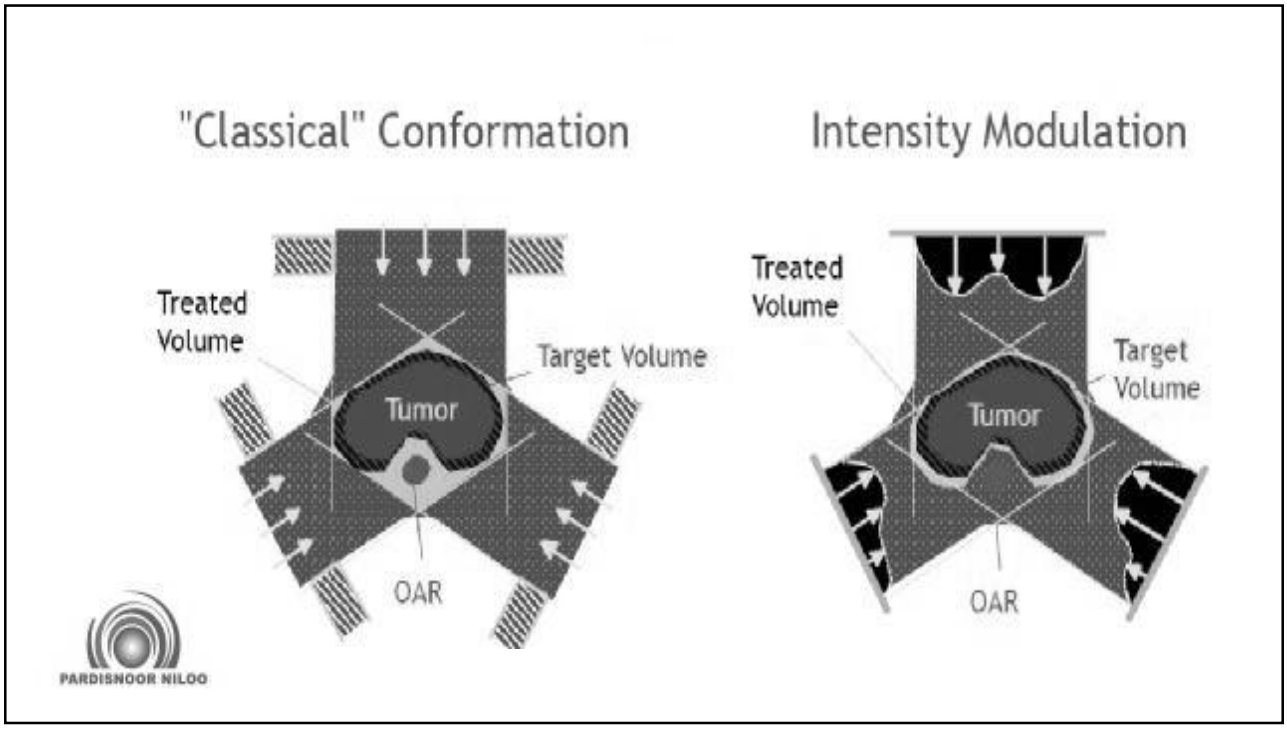
- Sources of uncertainty
  - **Treatment planning** (estimated uncertainty of the order of ± 2%)
  - **Machine** performance on the day **(± 2%)**
  - **Patient** set-up and movement **(± 3%)**
  - Absolute dosimetry/calibration
  - Relative dosimetry (%depth dose, profiles, output factors)

Not much room for error in dosimetry ...





Quality assurance of equipment

Equipment tests to be performed on a regular basis

Dosimetry • Output • Beam symmetry/flatness • Energy • Dose linearity	Similar to 3D conformal QA
Mechanical • Jaws/MLC/couch absolute and relative **position and speed** • Gantry/collimator/couch **angle** • Gantry/collimator/couch rotation **iso-centre**	Much higher accuracy
Imaging • 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

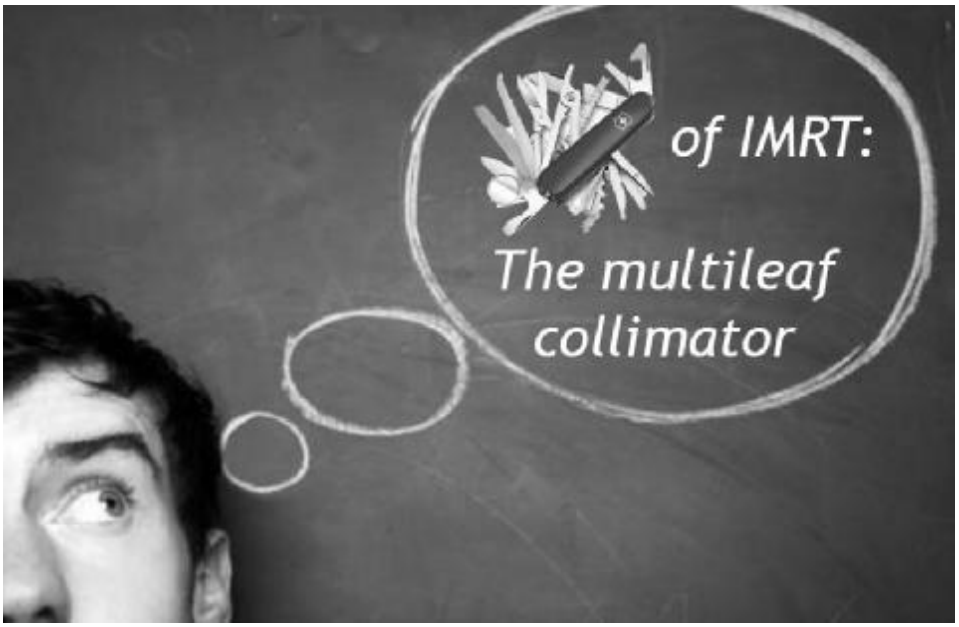
Cyber knife

- **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 ?)

TG 119

- Routine MLC QA
  - E.g. stability of MLC and machine output characteristics

TG 198

- Patient specific QA
  - Pretreatment measurements and in-vivo dosimetry
  - 3D dose calculation

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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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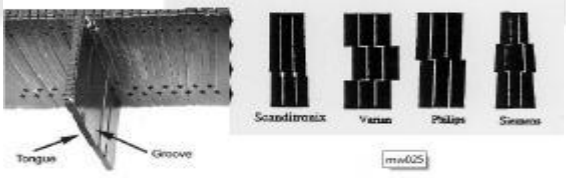
Abstract

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

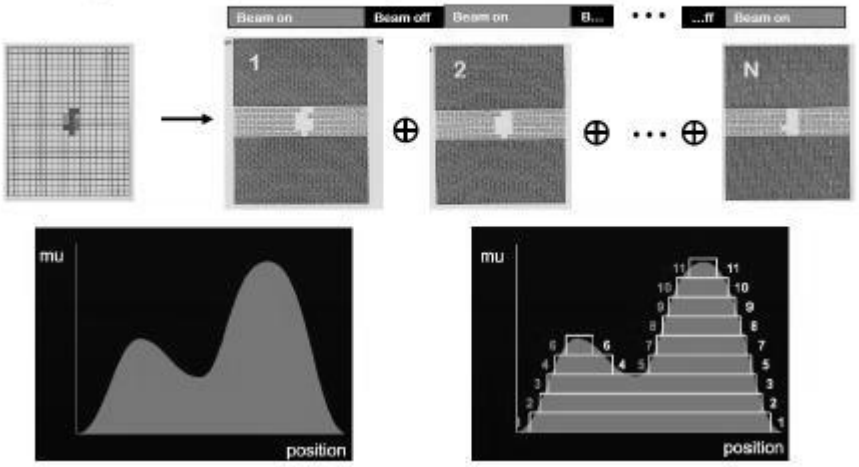
- Many small segments are made by the MLC for building a dose distribution
- Leaf positioning an travelling becomes Important
- Dose calculation are more complex
  - tounge and groves effects
  - Leaf rounding effects
  - Leaf transmission
- Small field Dosimetry becomes important



Static or "Step-and-shoot" technique

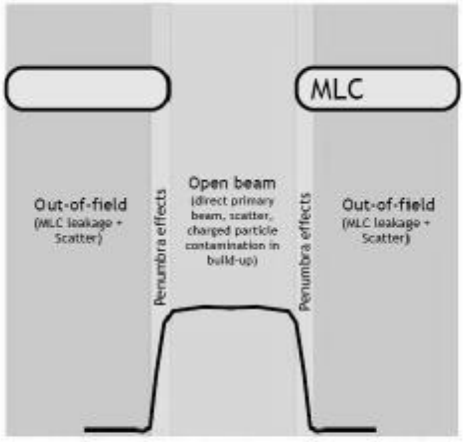
Converting intensity map to a sequence of sub-fields/segments

... each with its specific MLC aperture and weight/delivered MU



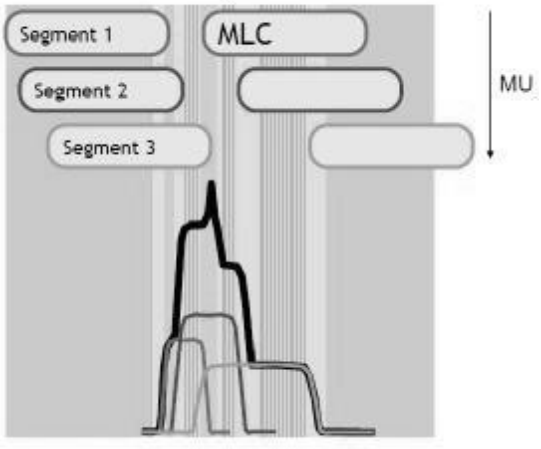
IMRT - " ... is treating with the penumbra!?"

Open MLC-shaped beam conformal RT



"Clear distinction between in-field and out-of-field dose"

MLC-based intensity modulated beam



"In-field dose is a mixture of primary beam, scatter and MLC leakage"

Dynamic MLC mode technique(s)

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Beam stays on during

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

- 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, ...)

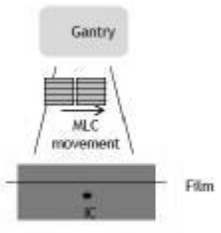
Geometrical accuracy much more important than for conventional treatment

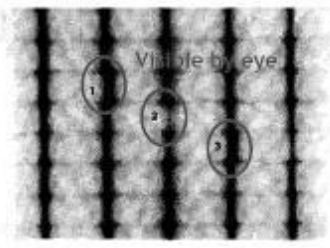
- Position and speed of MLC (IMRT)
- Position and speed of gantry (VMAT)
- Position and speed of table (Tomotherapy)

Important during commissioning AND periodic quality control

IMRT dynamic delivery

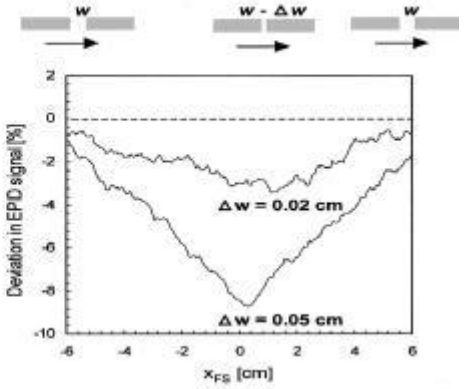
- Picket fence test
- Relative position of individual leaves
  - Intentional error of 1 mm in three leave positions
  - Film measurement





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)

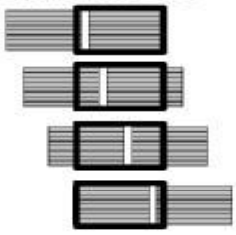
"Loss of lateral electron equilibrium in small field segments"

"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."

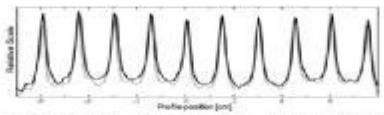
=> tighter tolerances on leaf position/motion

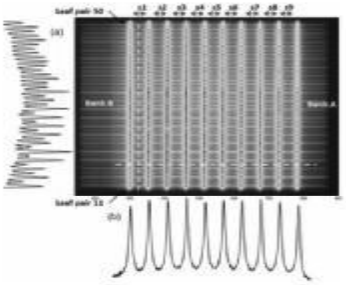
=> also while gantry is rotating and gravity impacts MLC-leaves, during f.e. a VMAT delivery

Picket-fence test



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





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

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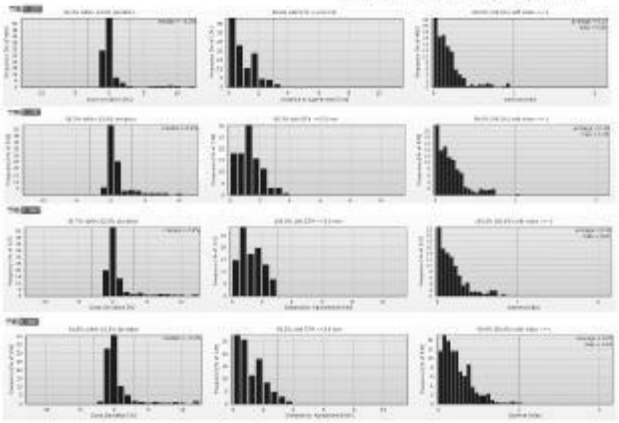
گزارش تست های TG-119 مرکز پردیس نور نیلو:

روش تست های انجام شده:

اقدامات	نتایج
تعریف تخت درمان (Couch) با استفاده از CT اسکن تخت در سیستم طراحی درمان	تخت درمان تعریف شد و تست های لازم جهت Verify کردن جنس مدد اضافی به تخت، طراحی و با استفاده از فانتوم Delta4 انجام شد. جزئیات و نتایج تست در پیوست شماره ۱ آمده است.
صحت سنجی عملکرد سیستم طراحی درمان توسط تست های سازمان انرژی اتمی (IAEA)	تمامی ۸ تست Audit با نتایج مطلوب Pass شدند. پیوست شماره ۲.
انجام تست Picket fence در زاویه گانتری صفر	نتایج در پیوست شماره ۳ آمده است.
تست های TG-119	نتایج در پیوست شماره ۴ آمده است.

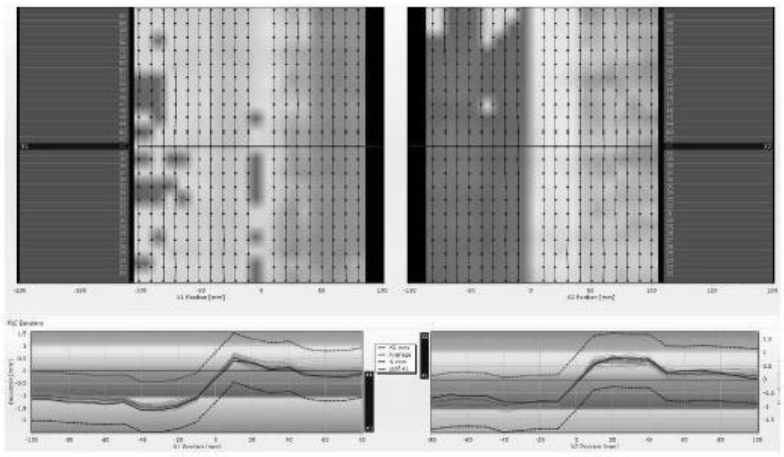
تست تخت بدین ترتیب طراحی گردید که پلنی در چهار زاویه مایل خلفی ۱۳۵°، ۱۶۰°، ۲۰۰° و ۲۲۵°، فیلدهایی با ابعاد $10x10\ cm^2$ با MU=100 طراحی شد. پس از آن پلن با استفاده از فانتوم Delta4 روی دستگاه اجرا گردید و تست با گاما ۹۹.۸٪ پاس شد.

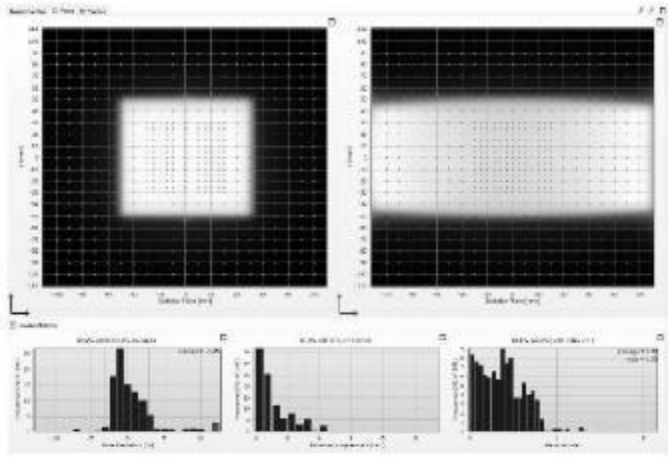


پیوست ۲: نتایج تست Audit

Case #	Description	Meas. point	Field #	Calculation results (Gy)	Measurement results (Gy)	Deviation (%)	Agreement criteria (%)	Pass/ Fail
1	Standard SSD, 10x10cm2 field	3		2.000	2.007	-0.4	2	P
		8		0.140	0.142	-0.1	4	P
		10		1.240	1.255	-1.0	3	P
2	Missing tissue	1		2.000	2.038	-1.9	3	P
3	Blocked corners	3		2.000	2.006	-0.3	3	P
4	Four field box	8	F1	2.000	1.996	0.5	2	P
			F2	2.000	2.013	-0.7	3	P
			F3	2.000	1.963	1.9	3	P
			F4	2.000	2.002	-0.1	3	P
			SUM	8.000	7.968	0.4	3	P
		8	F1	0.130	0.129	0.1	4	P
			F2	1.360	1.368	-0.4	3	P
			F3	0.130	0.168	-3.0	4	P
			F4	2.720	2.708	0.6	3	P
			SUM	4.310	4.363	-0.7	3	P
		10	F1	1.430	1.466	-1.0	3	P
			F2	0.140	0.139	0.2	4	P
			F3	2.860	2.796	-1.0	3	P
			F4	0.140	0.146	3.0	4	P
			SUM	4.510	4.539	-0.4	3	P
5	Customized blocking	3		2.000	2.019	0.0	3	P
		7		1.770	0.819	-0.1	4	P
6	L-shaped field	3		2.000	2.008	-0.4	3	P
		7		1.160	1.103	-0.2	5	P
		10		0.120	0.113	0.4	5	P
7	Plan with asymmetric fields and wedges	5	F1	2.000	1.997	0.7	2	P
			F2	2.000	2.032	-1.6	4	P
			F3	2.000	2.042	-2.1	4	P
			SUM	6.000	6.063	-1.0	3	P
8	Plan with non-coplanar fields	5	F1	2.026	1.988	1.9	3	P
			F2	2.000	1.976	1.2	3	P
			F3	2.000	1.966	2.0	3	P
			SUM	6.026	5.919	1.8	3	P

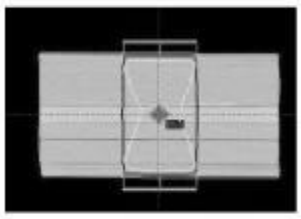
Picket fence در زاویه صفر درجه گانتری:



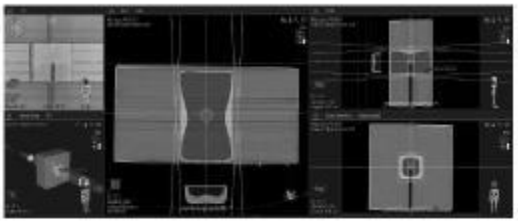


P1: AP: PA

A simple parallel-opposed irradiation of the phantom using AP: PA 10x10 fields to a dose of 200 cGy at isocenter.

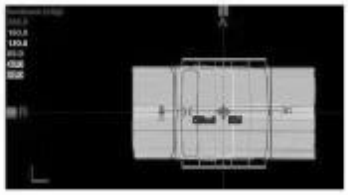


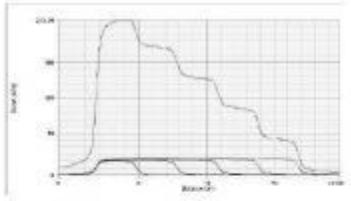
اجرای پلن در سیستم طراحی درمان



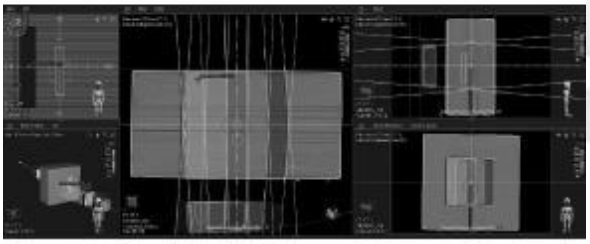
P2: Bands

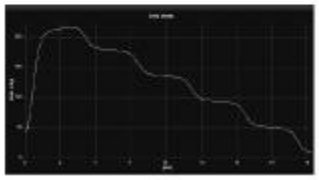
Using 6 MV, calculate a parallel-opposed irradiation of the phantom using a series of AP: PA fields to create a set of five bands receiving doses from roughly 40 – 200 cGy. This can be done using asymmetric jaws. The following image shows 15 cm long fields with widths from 3 to 15 cm, each given 25 MU.



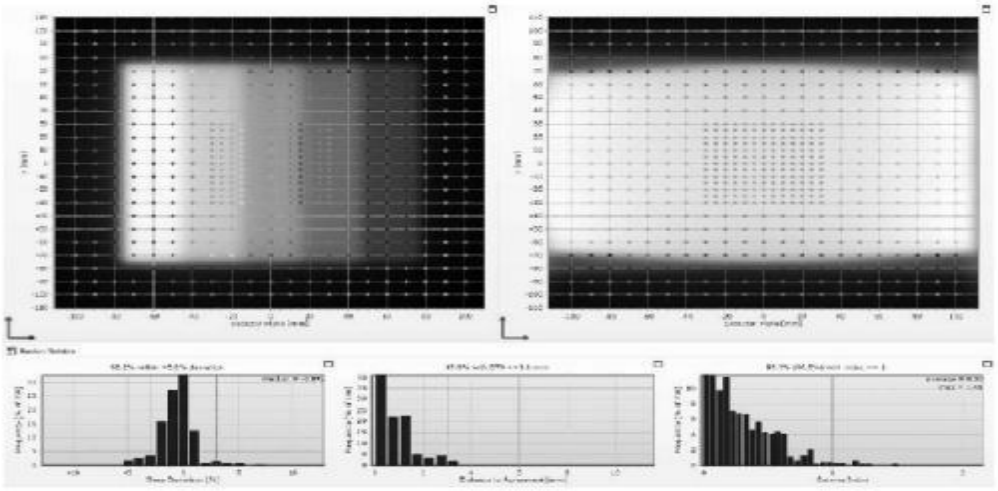


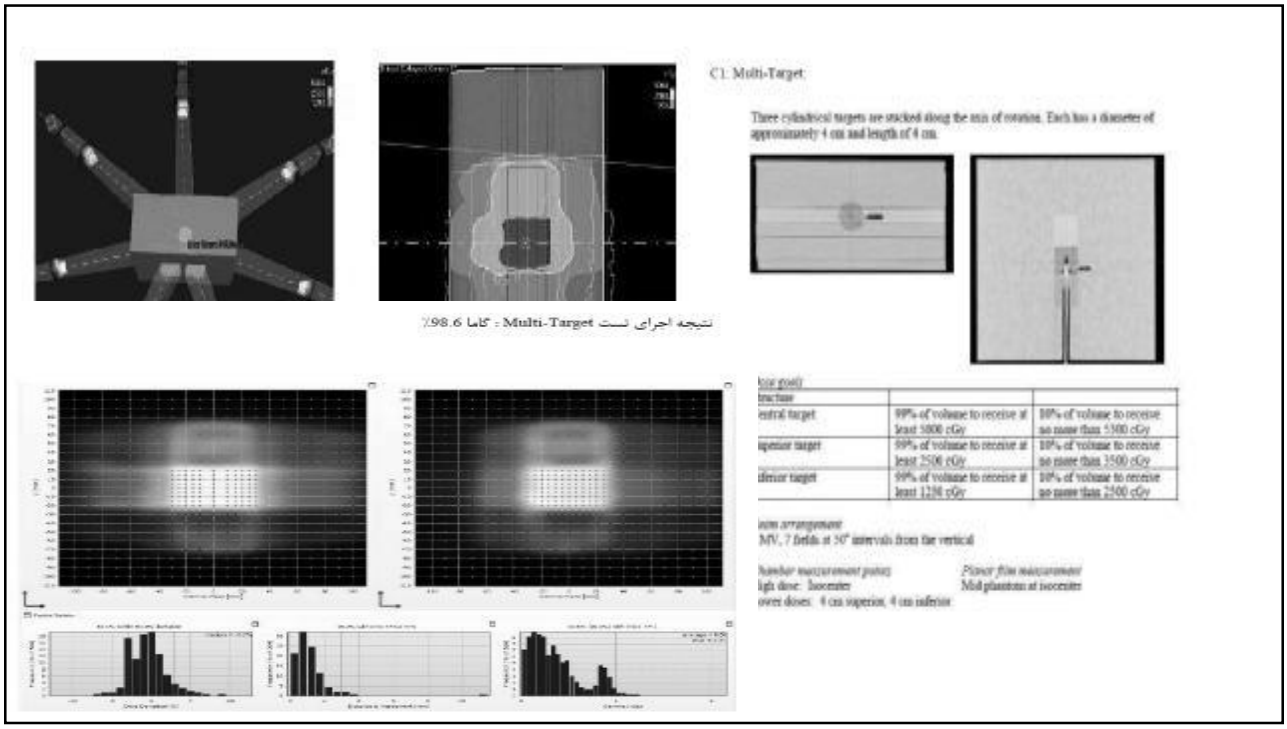
لاین دوز در سیستم طراحی درمان:

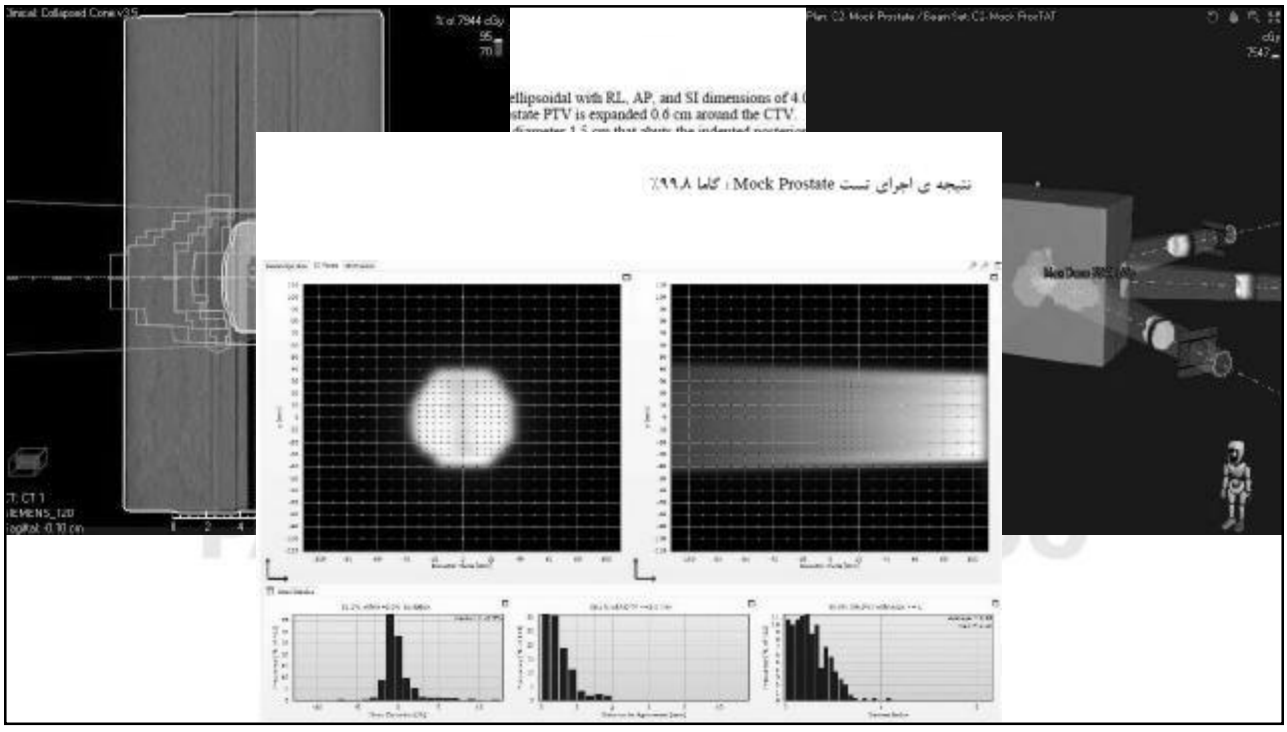


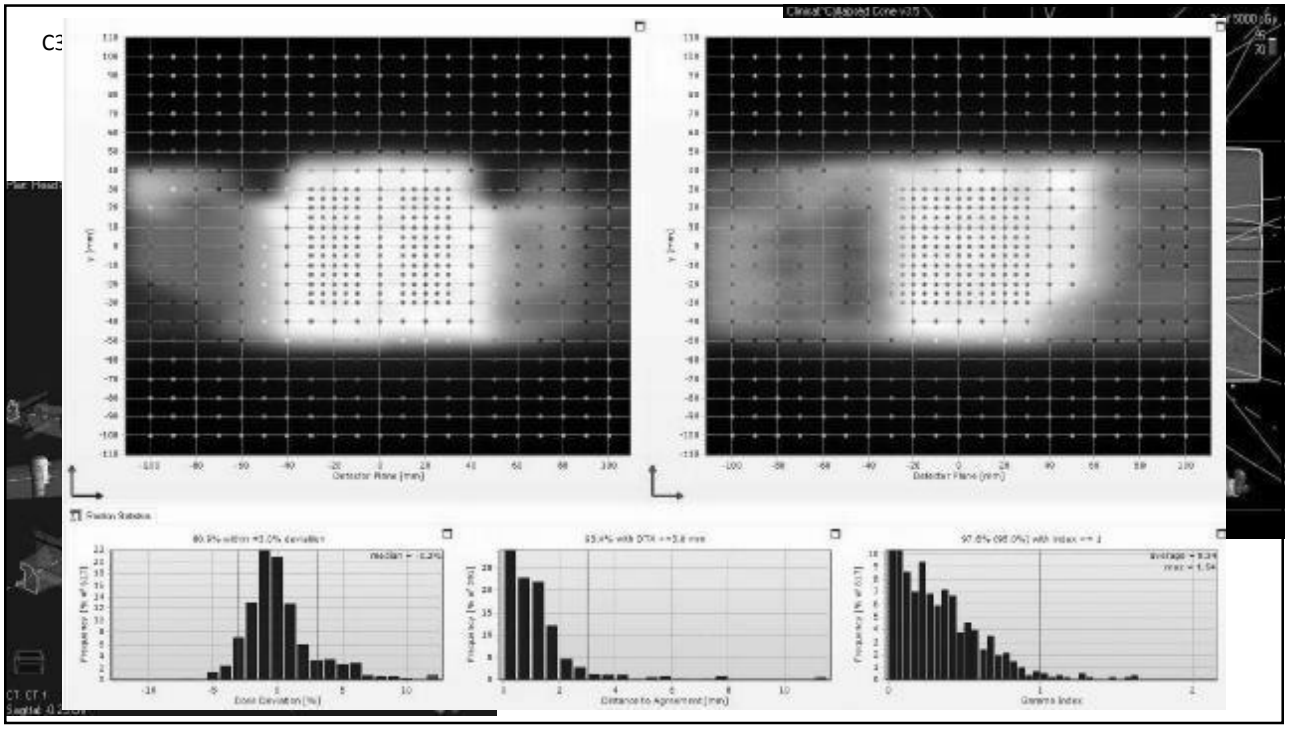


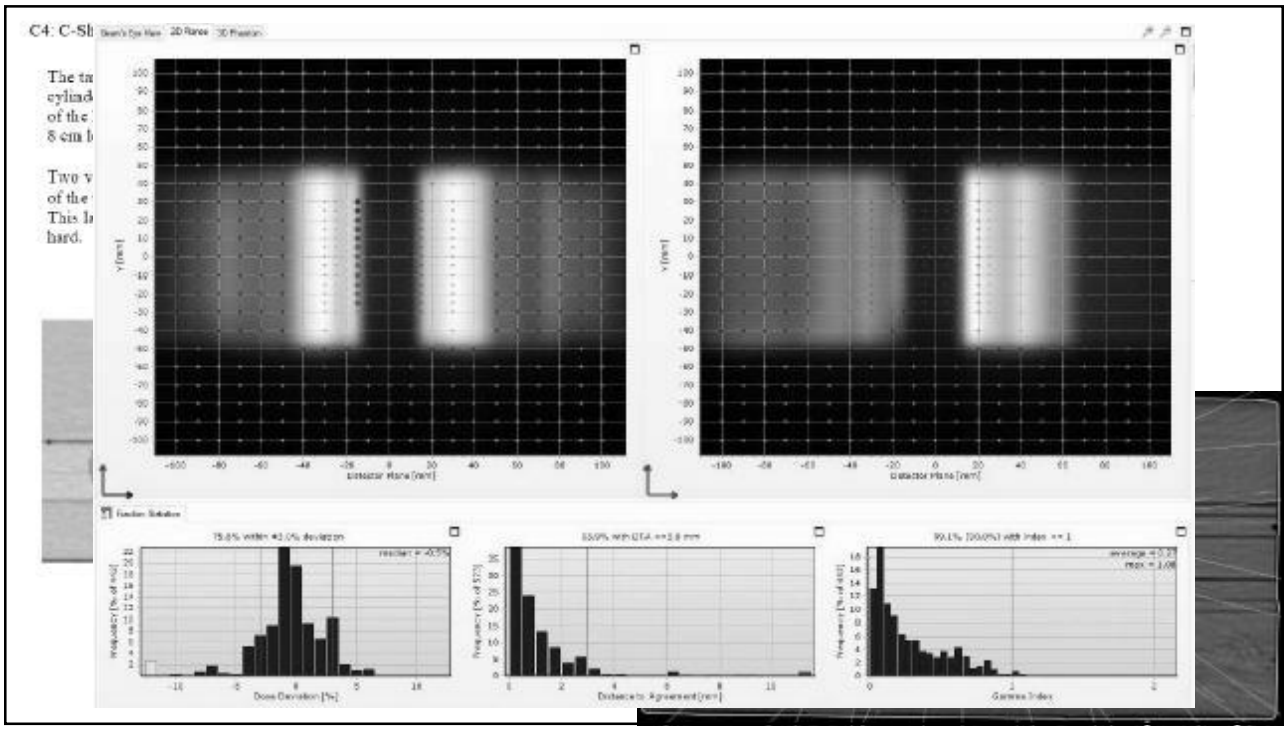
نتیجه اجرای تست P2: گاما ۹۸.۳٪

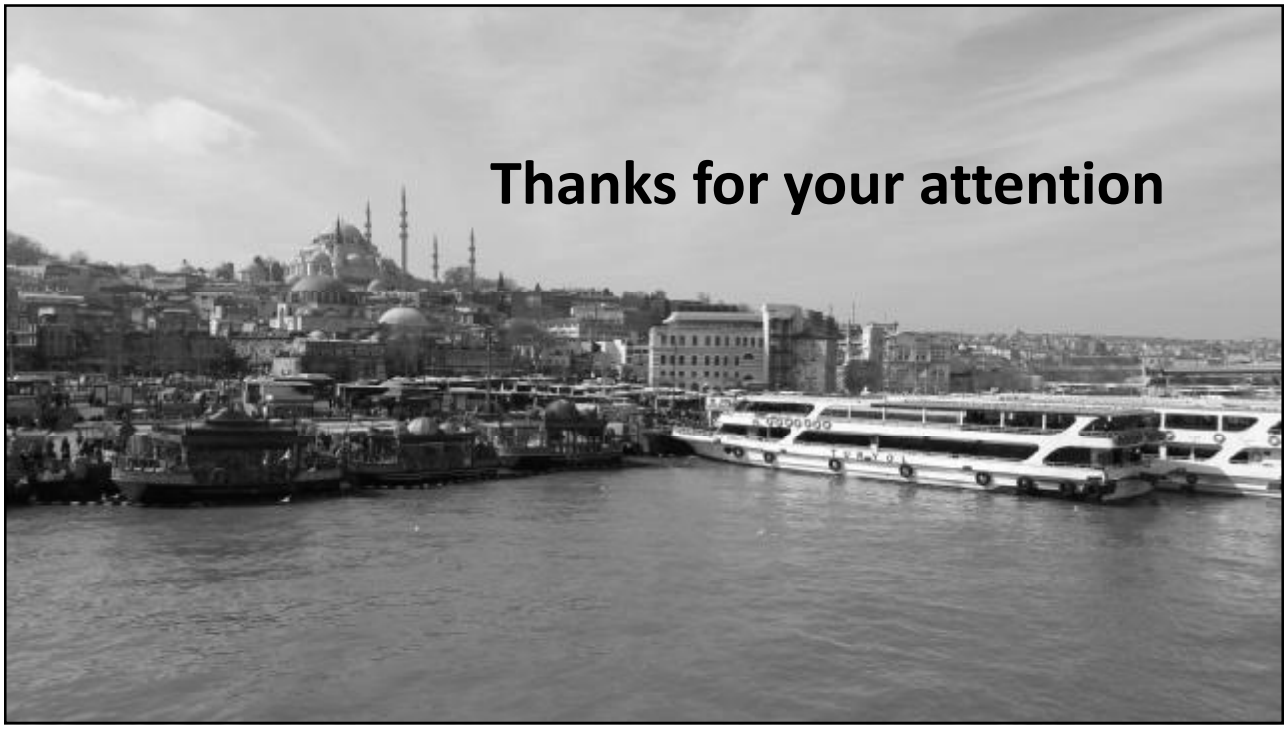



C1: Multi-Target
نتیجه اجرای تست Multi-Target : گاما 98.6٪


نتیجه ی اجرای تست Mock Prostate : گاما ۹۹.۸٪






Thanks for your attention