



IMRT and other conformal techniques in Russia

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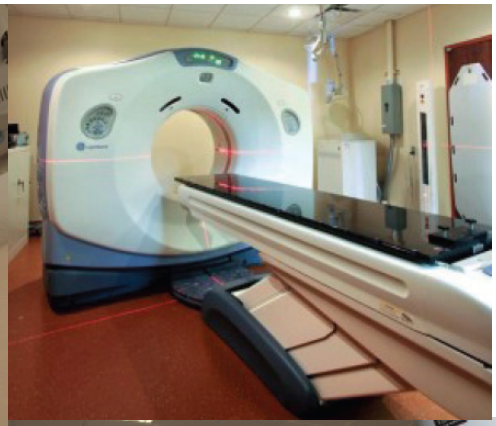
Medical physicists in Russia

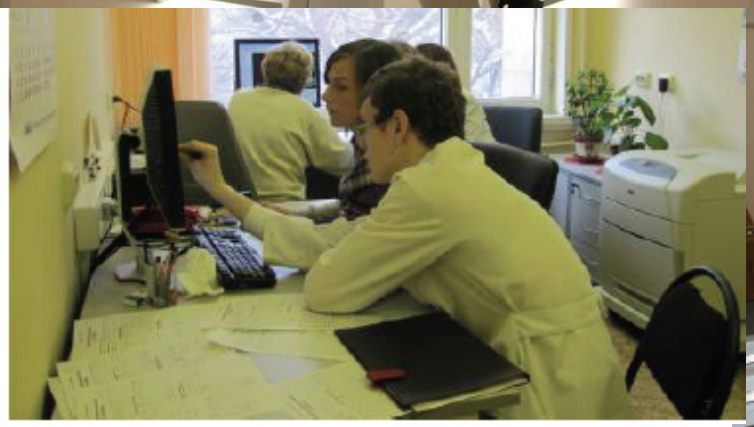
- About 500 medical physicists
- About 150 oncological clinics
- About 200 linacs that can realize 3D and other conformal techniques
- Association of Medical Physicists in Russia with its president Valeriy Kostylev
- N.N.Blokhin Russian Cancer Research Center is the biggest clinical oncology institution on the territory of the CIS with one of the most powerful radiotherapy facilities
- International Training Center on medical physics, radiation oncology and nuclear medicine

N.N. Blokhin Russian Cancer Research Center

- 4 Varian Clinac iX (MLC 120, OBI, EPID, IMRT, RapidArc, Respiratory Gating)
- 2 Varian Clinac 600CD (MLC 120, EPID, IMRT, Respiratory Gating)
- 1 CyberKnife VSI (private)
- 1 Philips SL 75-5
- 2 Varian Acuity simulators;
- CT GE Lightspeed 16
- MRI, PET and SPECT are available in diagnostic departments

N.N. Blokhin Russian Cancer Research Center

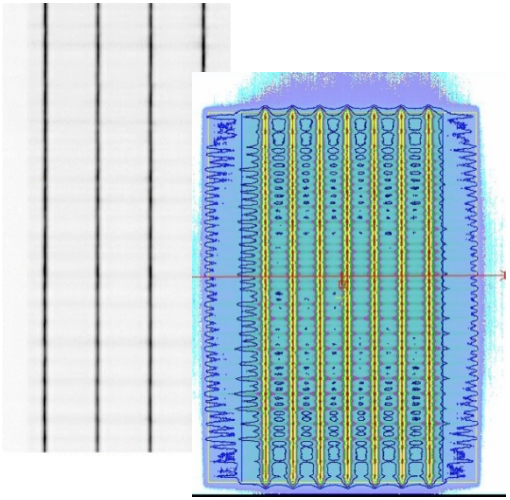




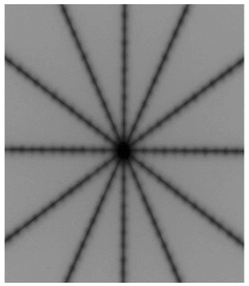
Are we ready for IMRT?

- Availability of equipment
- Do we have adequate immobilization devices for performing IMRT?
- What tests and protocols are we going to conduct during commissioning?
- How are we going to verify the treatment plans?
- What MLC test will be included in QA programme?
- Dose constraints

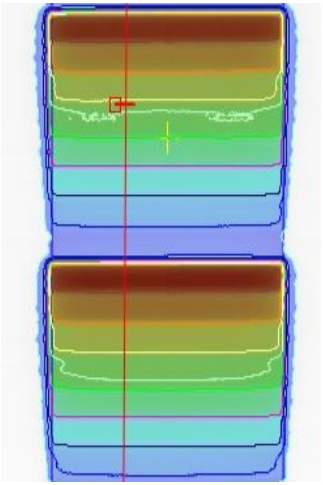
IMRT Commissioning of Delivery System: MLC tests results



MLC Position Accuracy:
"Picket fence" test



"Spoke shot" test



For sliding window IMRT:
leaf position & speed accuracy

- *MLC leakage* is measured annually with a detector large enough to provide an average value

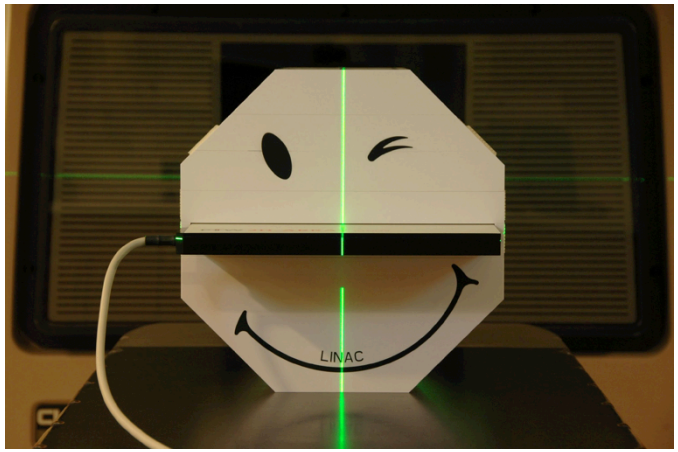
IMRT Commissioning of Treatment Planning System

- CIRS Thorax and Head & Neck Phantoms
- Ionization chamber Semiflex PTW
- TG-119 IMRT Commissioning Tests

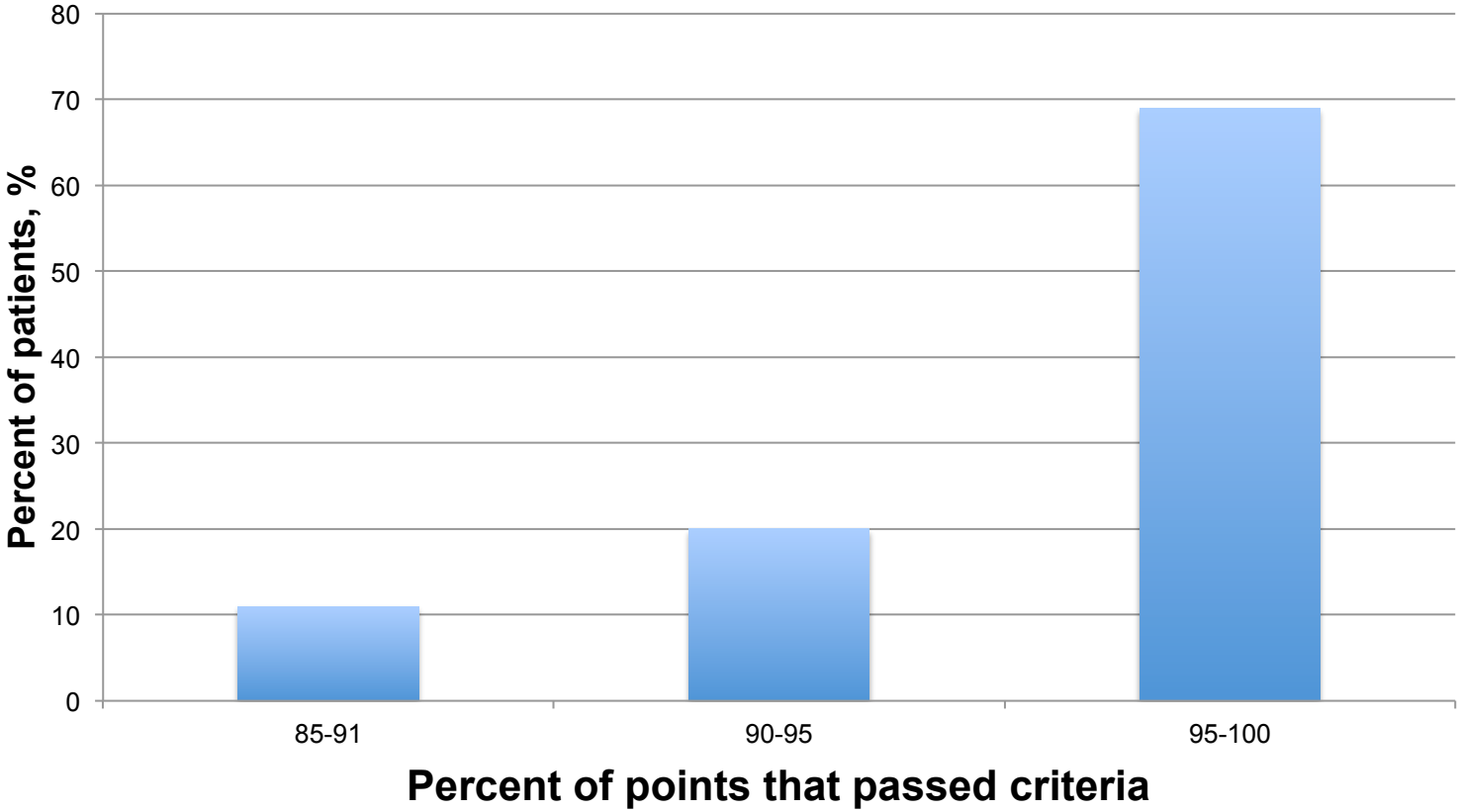
Patient specific QA

- Octavius phantom 729
- Gamma analysis criteria 3%/3mm 90% of dots is acceptable
- Total distribution check
- Gantry angles are the same as in treatment plan

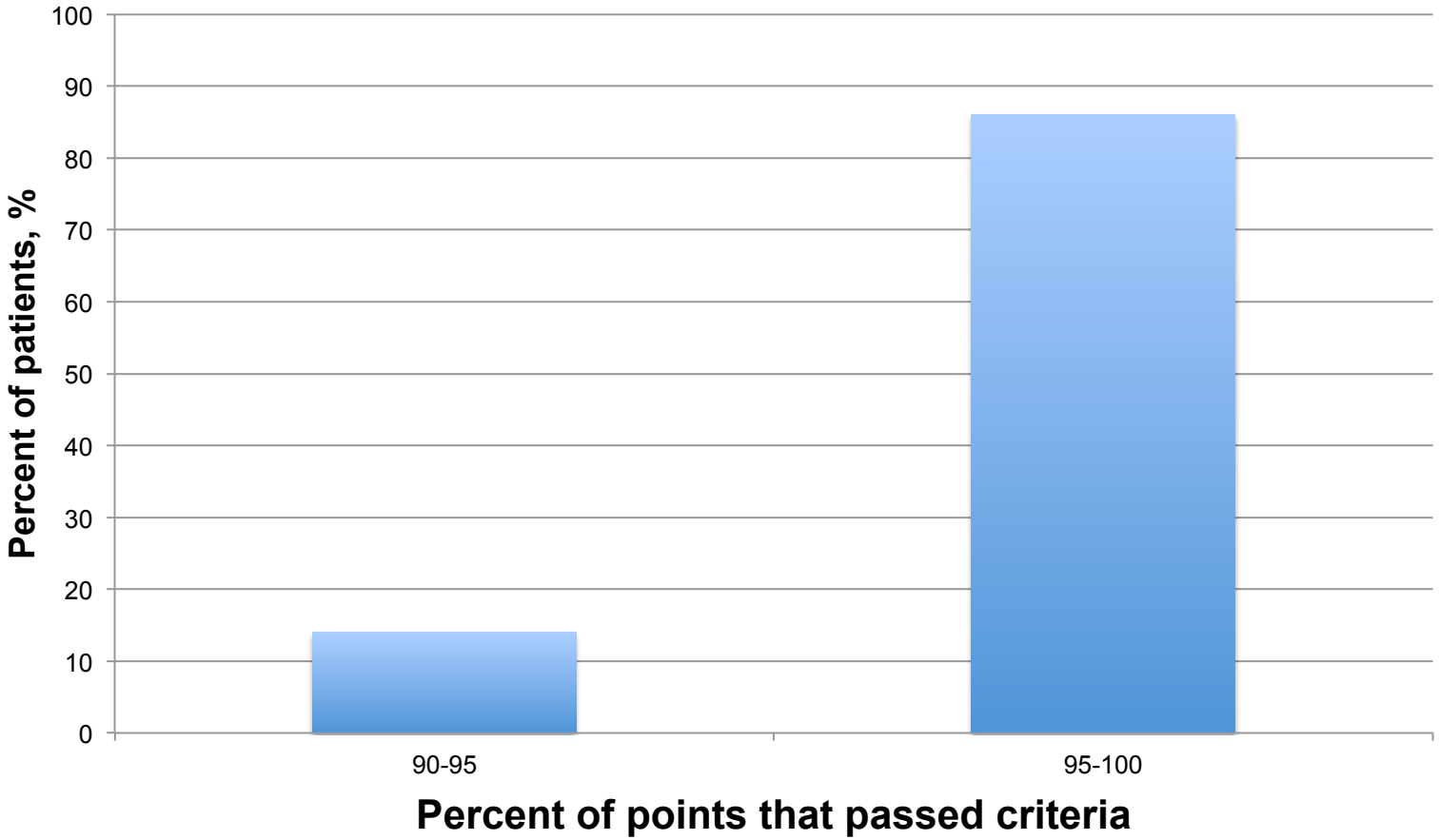
Number of analyzed plans:
Total: 397
IMRT: 243
RapidArc: 154



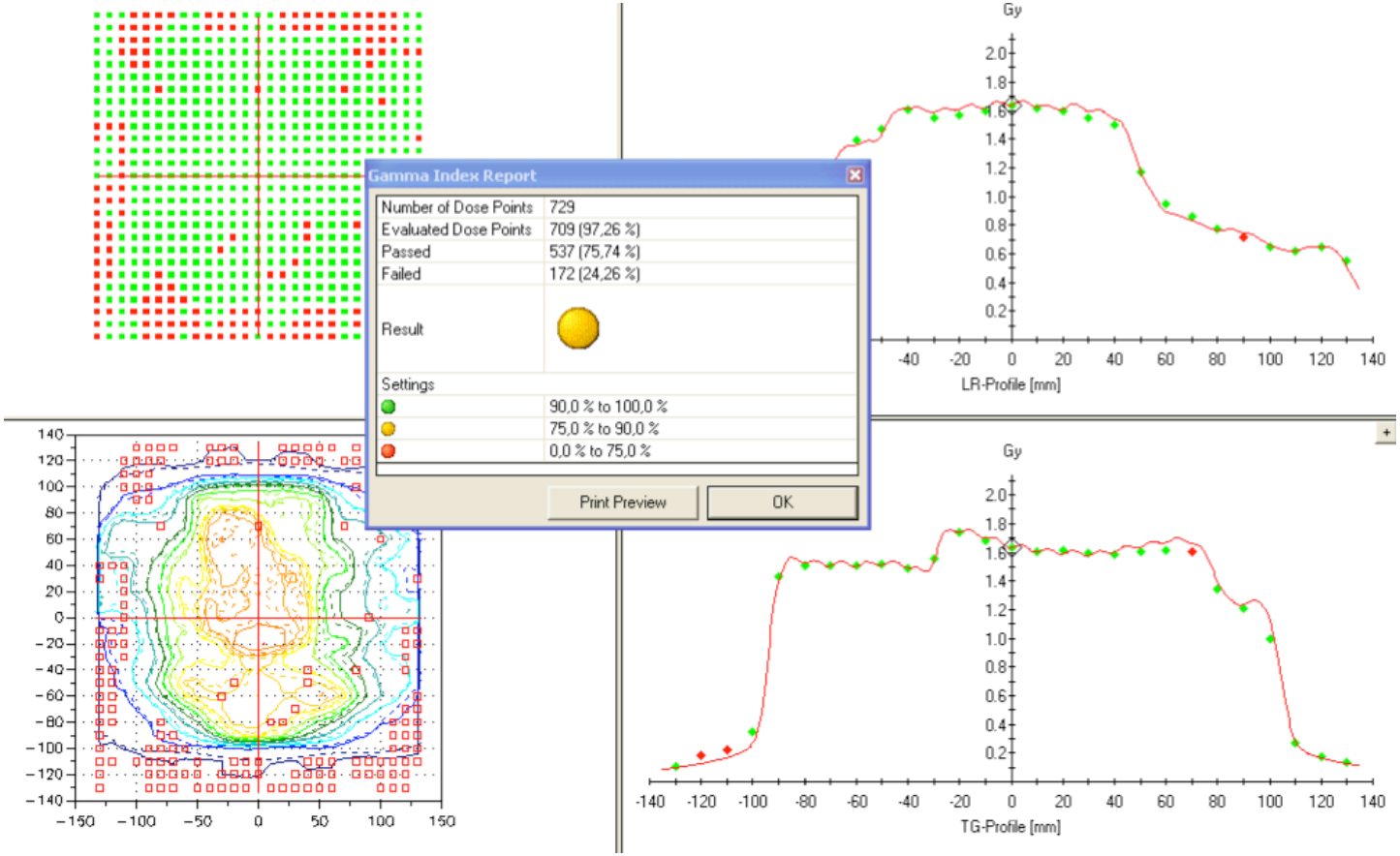
Results of IMRT plan verifications



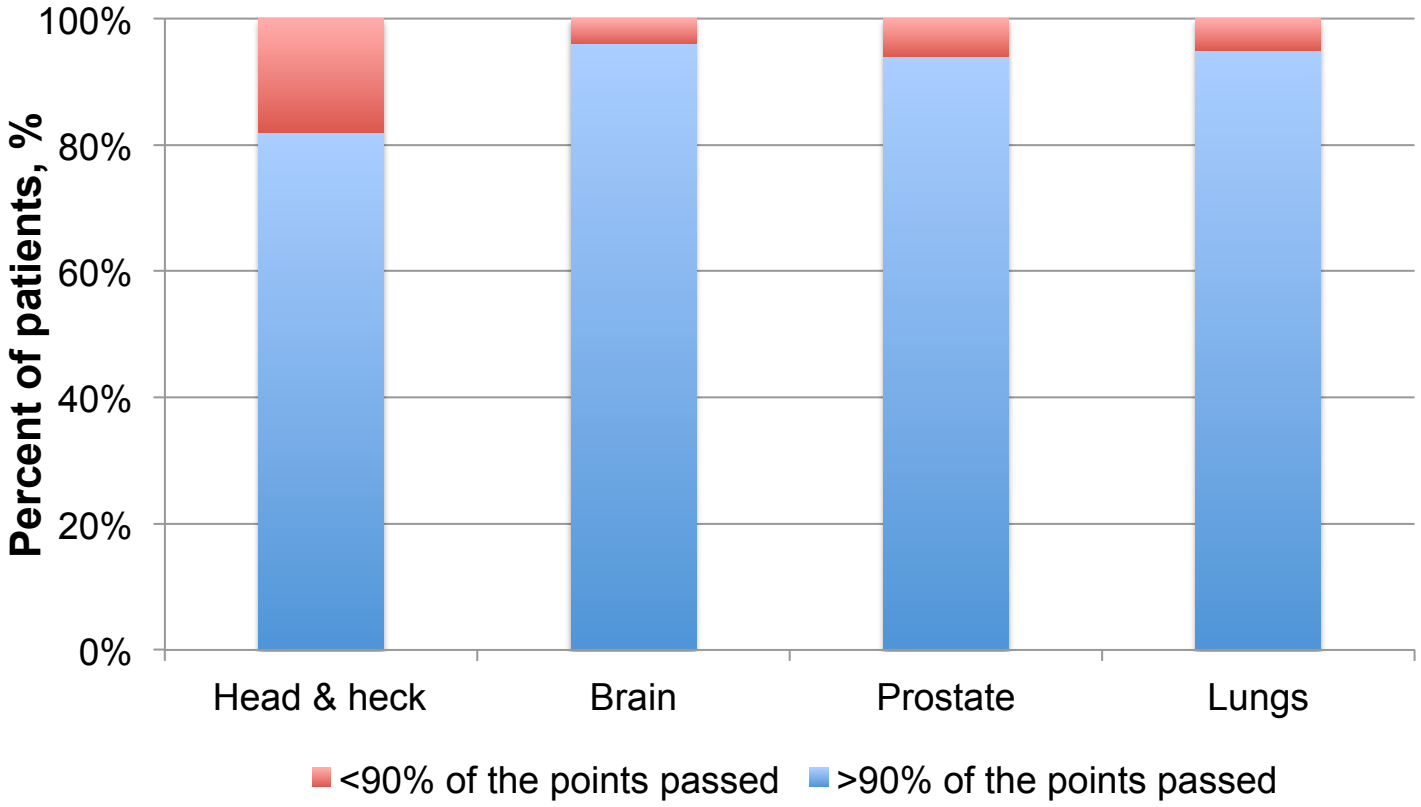
Results of VMAT plan verifications



Analysis of verified plans

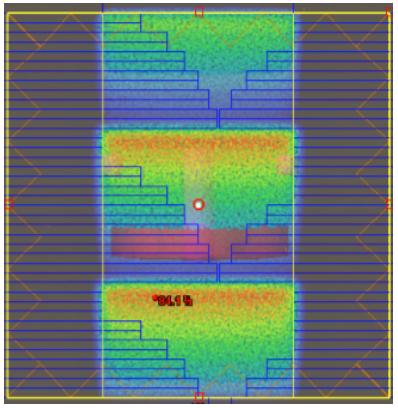


Dependence of IMRT plan verification results on tumor site

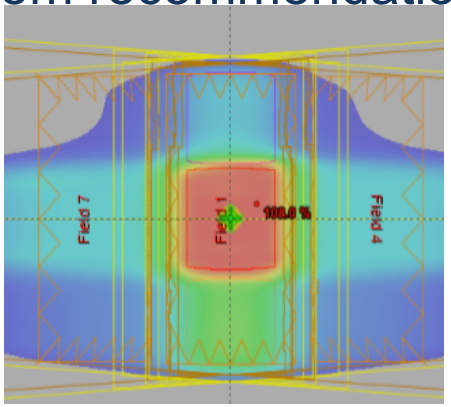


Introduction of intended errors in the “template” treatment plans

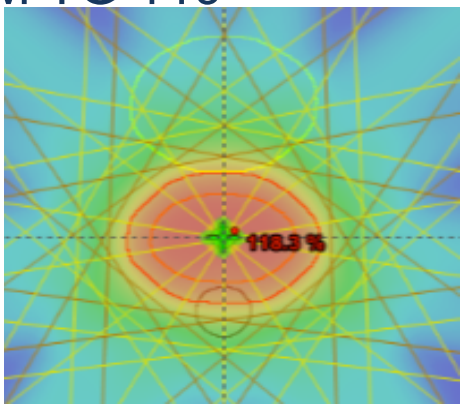
Plans were developed from recommendation AAPM TG 119



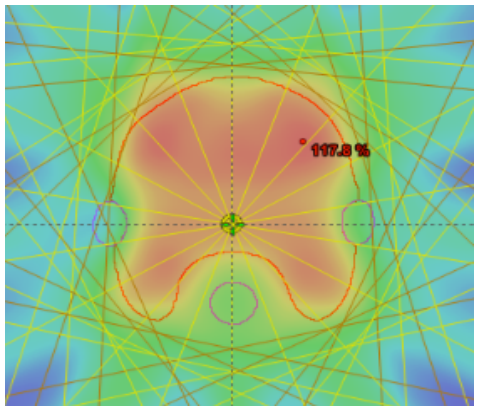
1) «Speed test»



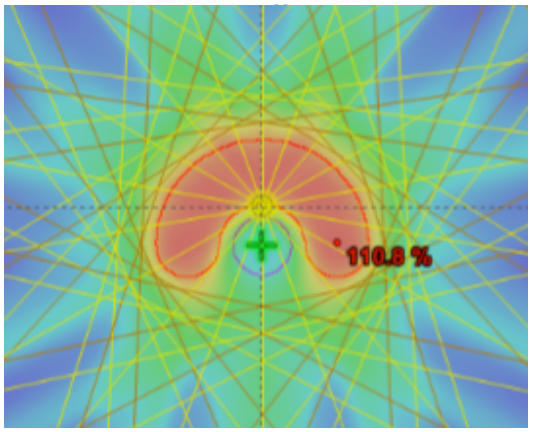
2) «Several targets»



3)«Prostate



4)«Head and neck»

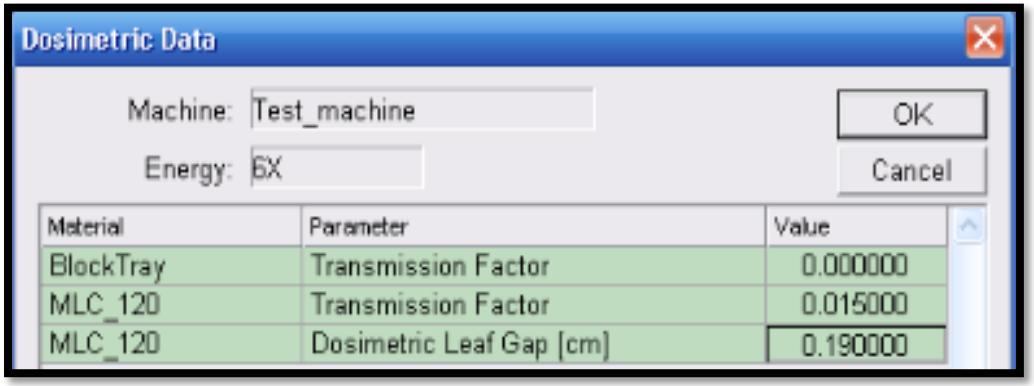


5)«C-shape»

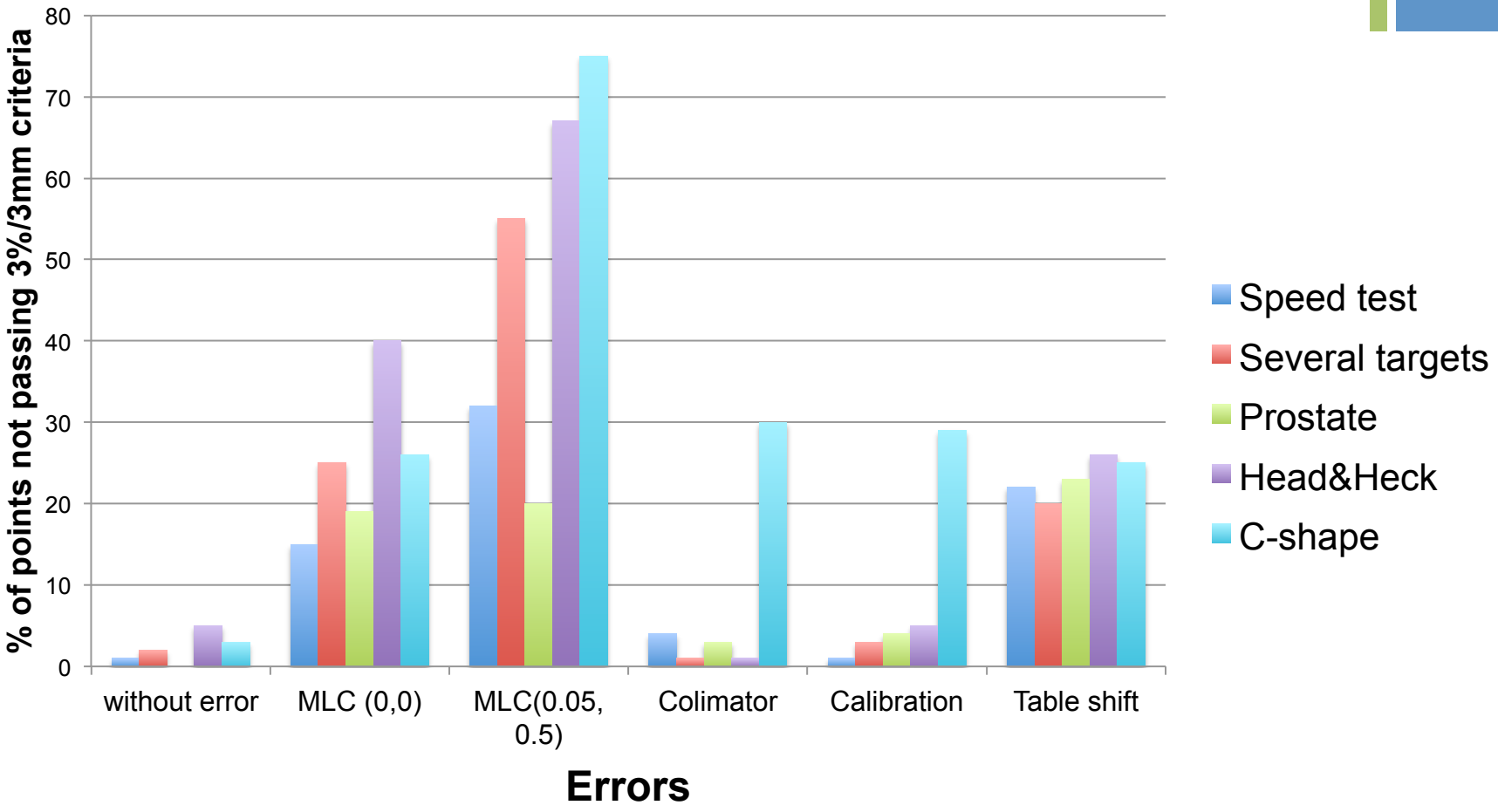
Introduced errors

- MLC transmission factor = 0.00, MLC leaf gap = 0.00 cm
- MLC transmission factor = 0.05, MLC leaf gap = 0.50 cm
- Collimator angle = 2^{o} (instead of 0^{o})
- Error in absolute dose value = 2% (simulation of error in linac calibration)
- Table shift = 5 mm (separately in three different directions)

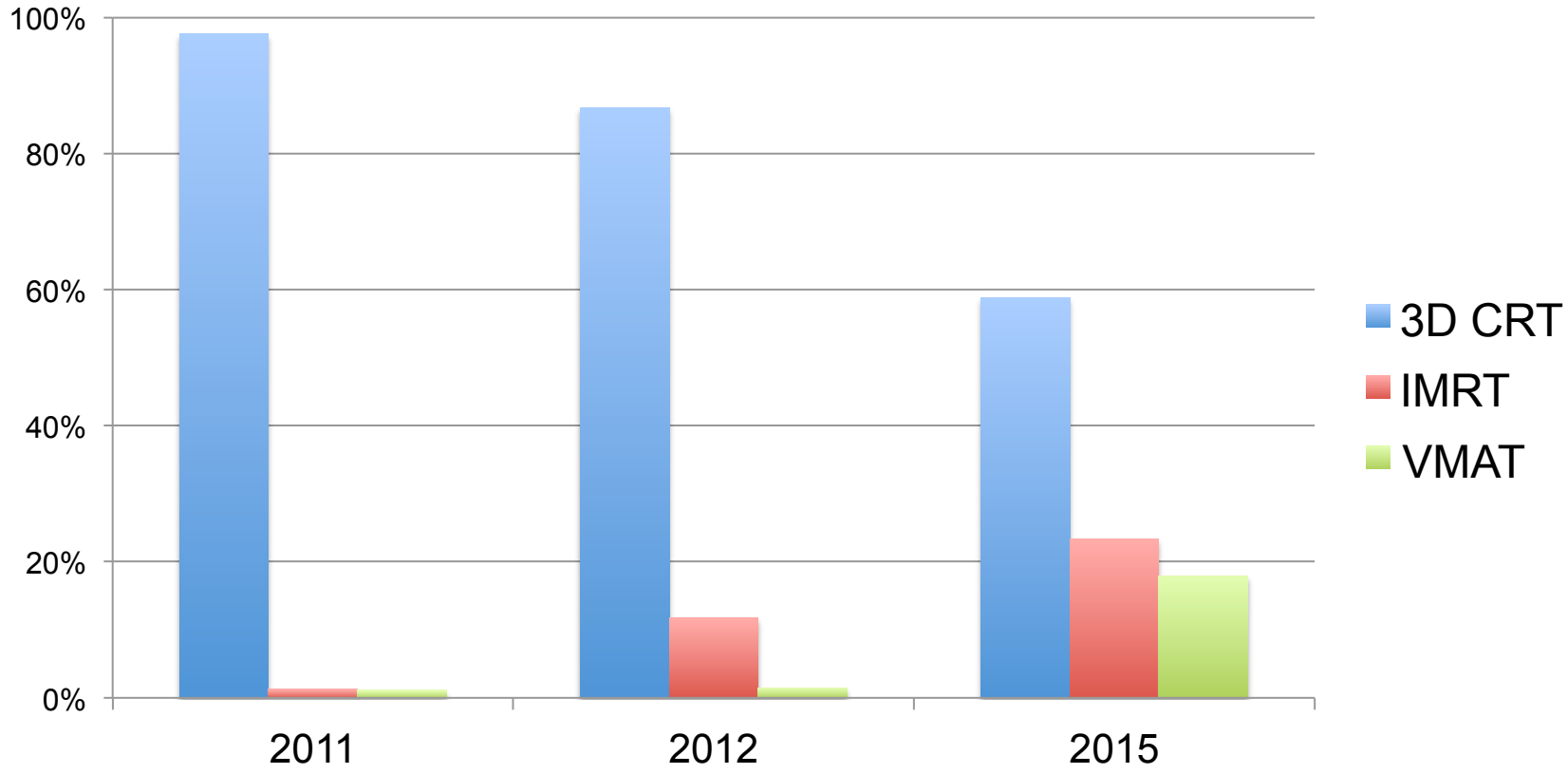
Example of correct values:



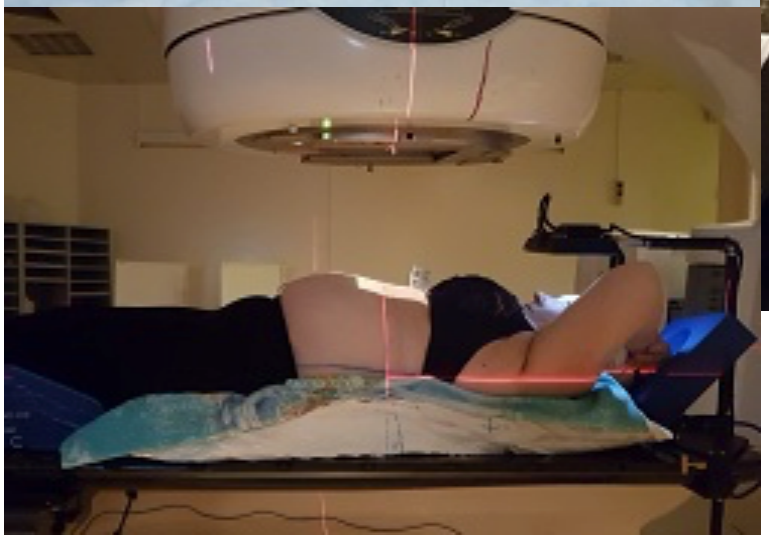
Results of verification with Octavius



Statistics of 3D CRT, IMRT and VMAT plans per year



Immobilization devices that are used in RCRC



Dose constraints

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INTRODUCTORY PAPER

QUANTITATIVE ANALYSES OF NORMAL TISSUE EFFECTS IN THE CLINIC (QUANTEC): AN INTRODUCTION TO THE SCIENTIFIC ISSUES

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Advances in dose–volume–outcome (or normal tissue complication probability, NTCP) modeling since the seminal Emami paper from 1991 are reviewed. There has been some progress with an increasing number of studies on large patient samples with three-dimensional dosimetry. Nevertheless, NTCP models are not ideal. Issues related to the grading of side effects, selection of appropriate statistical methods, testing of internal and external model validity, and quantification of predictive power and statistical uncertainty, all limit the usefulness of much of the published literature. Synthesis (meta-analysis) of data from multiple studies is often impossible because of suboptimal primary analysis, insufficient reporting and variations in the models and predictors analyzed. Clinical limitations to the current knowledge base include the need for more data on the effect of patient-related cofactors, interactions between dose distribution and cytotoxic or molecular targeted agents, and the effect of dose fractions and overall treatment time in relation to nonuniform dose distributions. Research priorities for the next 5–10 years are proposed. **© 2010 Elsevier Inc.**

QUANTEC

Dose constraints for SBRT

American Association of Physicists in Medicine
Journal of Applied Clinical Medical Physics

Dose tolerance limits and dose volume histogram evaluation for stereotactic body radiotherapy

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Organ	# fx	Vol. cc	Vol. %	Vol. Limit (Gy)	Max (Gy)	#AE ≥G3	# pts rx this dose	# pts in study	Notes
	1				22	8,24,25			RTOG 063 art/pericardium
	1	15		16		8,24,25			RTOG 063 ardium
	3	15		24		8			
	3	5		21		26,54,55			
	3				30	6,8,27,39,46, 53,61,64,65			RTOG 0618
	3				20	68			
	4				50	27			
Heart	4	1		40		27,28			
	4	10		35		27,28			
	4				42.4	29,30			
	4				34	25			RTOG 0915, heart/pericardium
	4	15		28		25			RTOG 0915, heart/pericardium
	5				52.5	3			RTOG 0813, QOD, heart/pericardium
	5	1		40					
	5				38	8			
	5	15		32		8,31			RTOG 0813, QOD, heart/pericardium
	6					18,57			
Hilus	3					68			
	1	200		8.4		8,24			200cc must be spared, RTOG 0631 renal cortex
	1				2	39,80			Max dose to either kidney
Kidney: Comb.	3	200		14.4		8			200cc must be spared
	3	200		8.4		6			200cc must be spared
	5	200		17.5		8			200cc must be spared
	5	200		9.5		6			200cc must be spared
Kidney: Contra-lat.	1		5%	5		18,39			
	1		50%	1.5		18,39			
	1		5%	5.8		18,39			
	1		50%	2		18,39			
Kidney: Ipsilat.	1		75%	5		50			75% of each kidney must be spared
	3	130		12.3		6			130cc must be spared
	3		33%	15		26,51,53,54,62,63			2/3 of kidney must be spared
	5	130		14.5		6			130cc must be spared
	1				5	39			
	2				10	39			
	2				5	39			Preferred cumulative max

RTOG & AAMP

…or serial tissues, the volume-dose cons… are gi… term… the critical maximum tissue volume that should receive …s used. For parallel tissue, the volume-… strain… in a critical minimum volume of tissue that should receive …us used.

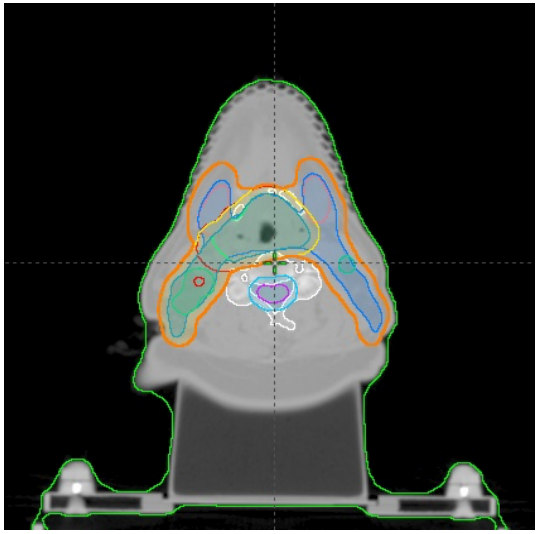
	Five fractions			
…x point …(Gy)[a]	Threshold dose (Gy)	…point …Gy)[a]	Threshold dose (Gy)	Max point dose (Gy)[a]	End point (≥Grade3)
10	15… Gy/fx)	17.4 (5.8 Gy/fx)	23 (4.6 Gy/fx)	25 (5 Gy/fx)	Neuritis
9		17.1 (5.7 Gy/fx)		25 (5 Gy/fx)	Hearing loss
	18 (6 Gy/fx)	23.1 (7.7 Gy/fx)	23 (4.6 Gy/fx)	31 (6.2 Gy/fx)	Cranial neuropathy
	18 (6 Gy/fx)	21.9 (7.3 Gy/fx)	23 (4.6 Gy/fx)	30 (6 Gy/fx)	Myelitis
	12.3 (4.1 Gy/fx)		14.5 (2.9 Gy/fx)		
14	18 (6 Gy/fx)	21.9 (7.3 Gy/fx)	23 (4.6 Gy/fx)	30 (6 Gy/fx)	Myelitis
16	21.9 (7.3 Gy/fx)	24 (8 Gy/fx)	30 (6 Gy/fx)	32 (6.4 Gy/fx)	Neuritis
16	22.5 (7.5 Gy/fx)	24 (8 Gy/fx)	30 (6 Gy/fx)	32 (6.4 Gy/fx)	Neuropathy
15.4	17.7 (5.9 Gy/fx)	25.2 (8.4 Gy/fx)	19.5 (3.9 Gy/fx)	35 (7 Gy/fx)	Stenosis/fistula
17.5	20.4 (6.8 Gy/fx)	24 (8 Gy/fx)	27 (5.4 Gy/fx)	30.5 (6.1 Gy/fx)	Neuropathy
22	24 (8 Gy/fx)	30 (10 Gy/fx)	32 (6.4 Gy/fx)	38 (7.6 Gy/fx)	Pericarditis
37	39 (13 Gy/fx)	45 (15 Gy/fx)	47 (9.4 Gy/fx)	53 (10.6 Gy/fx)	Aneurysm
20.2	15 (5 Gy/fx)	30 (10 Gy/fx)	16.5 (3.3 Gy/fx)	40 (8 Gy/fx)	Stenosis/fistula
13.3	18.9 (6.3 Gy/fx)	23.1 (7.7 Gy/fx)	21 (4.2 Gy/fx)	33 (6.6 Gy/fx)	Stenosis with atelectasis
30	28.8 (9.6 Gy/fx)	36.9 (12.3 Gy/fx)	35 (7 Gy/fx)	43 (8.6 Gy/fx)	Pain or fracture
	30.0 (10.0 Gy/fx)				
26	30 (10 Gy/fx)	33 (11 Gy/fx)	36.5 (7.3 Gy/fx)	39.5 (7.9 Gy/fx)	Ulceration
12.4	16.5 (5.5 Gy/fx)	22.2 (7.4 Gy/fx)	18 (3.6 Gy/fx)	32 (6.4 Gy/fx)	Ulceration/fistula
12.4	16.5 (5.5 Gy/fx)	22.2 (7.4 Gy/fx)	18 (3.6 Gy/fx)	32 (6.4 Gy/fx)	Ulceration
	11.4 (3.8 Gy/fx)		12.5 (2.5 Gy/fx)		
15.4	17.7 (5.9 Gy/fx)	25.2 (8.4 Gy/fx)	19.5 (3.9 Gy/fx)	35 (7 Gy/fx)	Enteritis/ obstruction
18.4	24 (8 Gy/fx)	28.2 (9.4 Gy/fx)	25 (5 Gy/fx)	38 (7.6 Gy/fx)	Colitis/fistula
18.4	24 (8 Gy/fx)	28.2 (9.4 Gy/fx)	25 (5 Gy/fx)	38 (7.6 Gy/fx)	Proctitis/fistula
18.4	16.8 (5.6 Gy/fx)	28.2 (9.4 Gy/fx)	18.3 (3.65 Gy/fx)	38 (7.6 Gy/fx)	Cystitis/fistula
34	21.9 (7.3 Gy/fx)	42 (14 Gy/fx)	30 (6 Gy/fx)	50 (10 Gy/fx)	Impotence
	21.9 (7.3 Gy/fx)		30 (6 Gy/fx)		Necrosis
…(6.2 Gy/fx)			23 (4.6 Gy/fx)		Malignant hypertension

Sites for which we use IMRT or VMAT technique

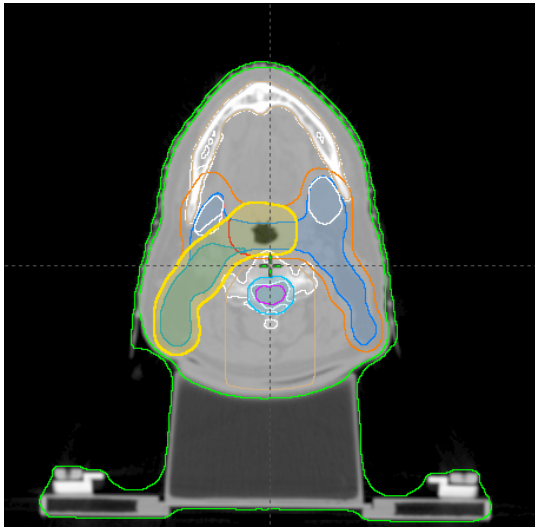
Head & Neck

Patient D. T4N2M0 (laryngeal cancer)

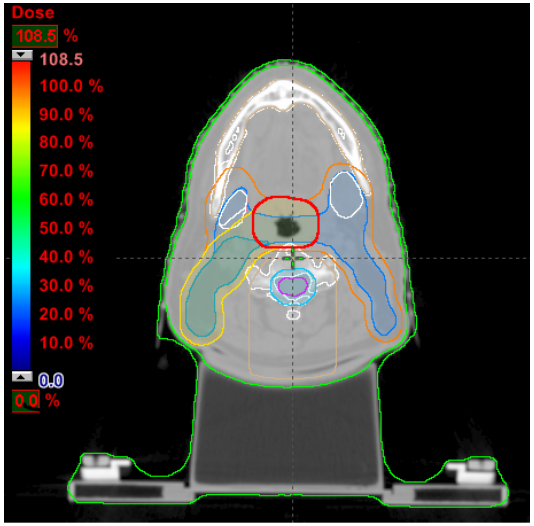
PTV1 – 2 Gy×25 fx;



PTV2 – 2 Gy×30 fx;



PTV3 – 2 Gy×35 fx;



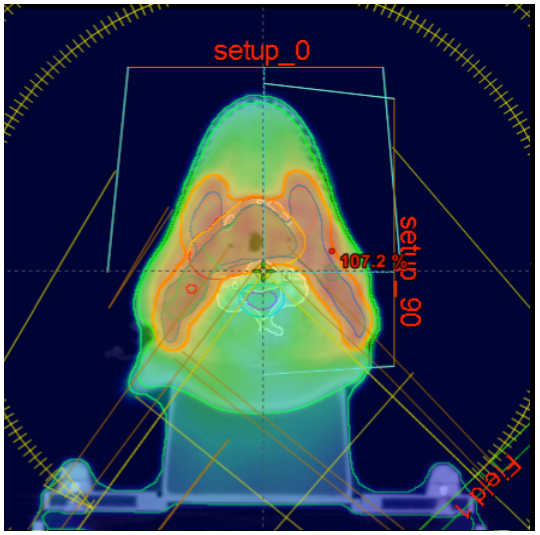
Head & Neck

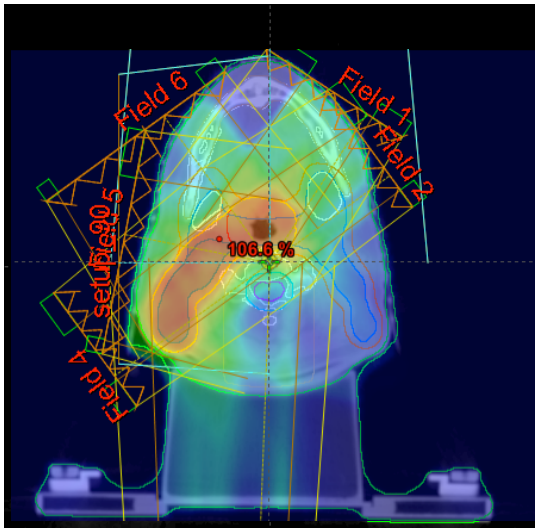
Patient D. T4N2M0 (laryngeal cancer)

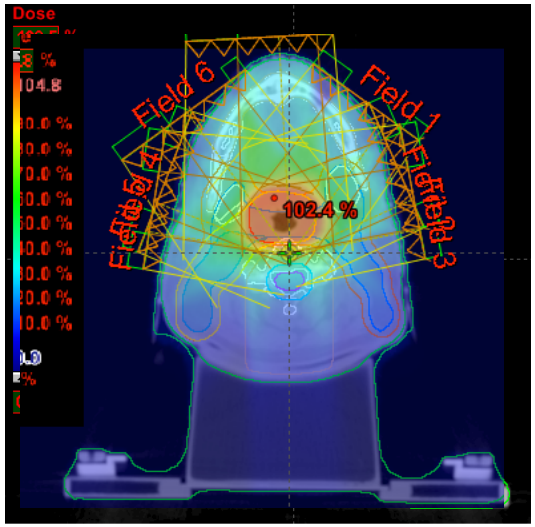
PTV1 – 2 Gy×25 fx;
2 arcs (135º - 225º) clockwise and counterclockwise

PTV2 – 2 Gy×30 fx;
7 field IMRT

PTV3 – 2 Gy×35 fx;
7 field IMRT





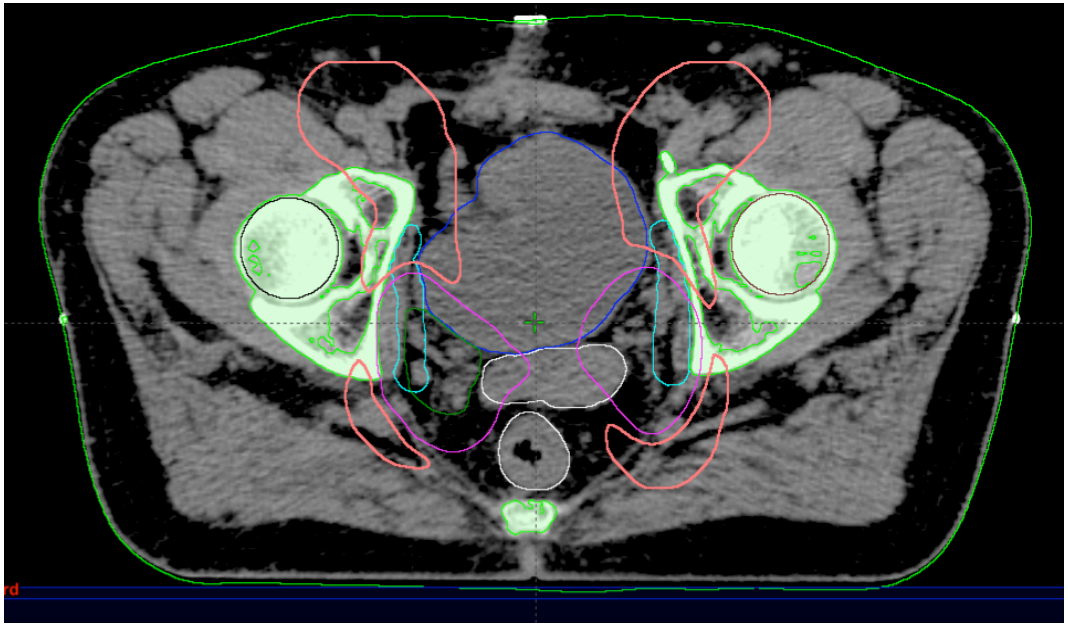


Prostate

Hypofractionated salvage radiotherapy with simultaneous integrated boost after radical prostatectomy

Patient O. Lymph nodes+ region of relapse +fossa = 1.8 Gy * 26 fx;

Fossa = 2.35 Gy *26 fx; Region of relapse = 2.5 Gy*26 fx



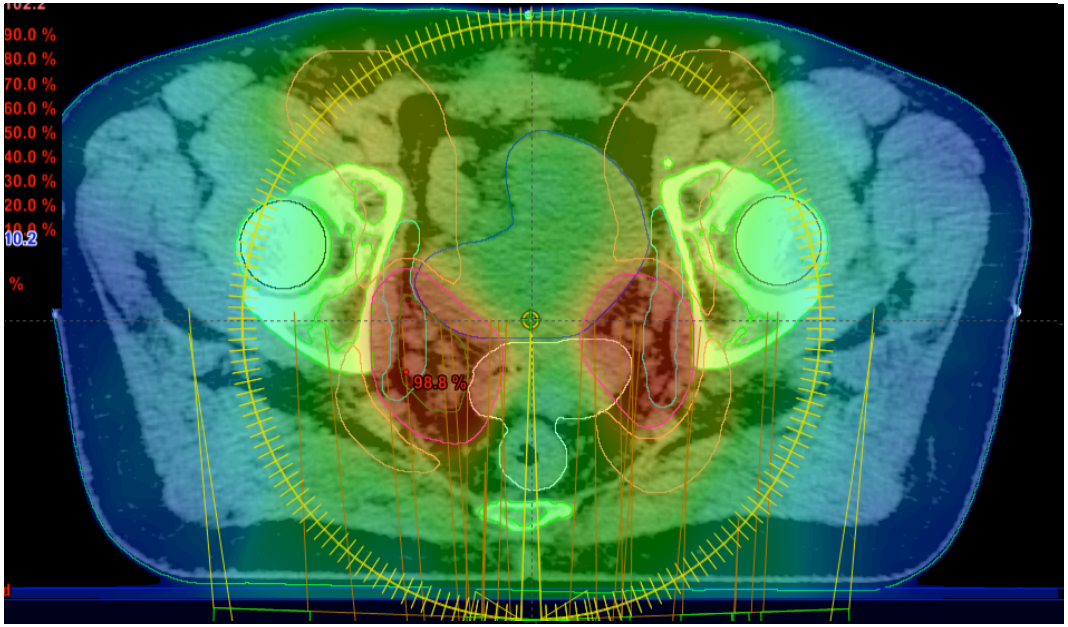
Prostate

Hypofractionated salvage radiotherapy with simultaneous integrated boost after radical prostatectomy

Patient O. Lymph nodes+ region of relapse +fossa = 1.8 Gy * 26 fx;

Fossa = 2.35 Gy *26 fx; Region of relapse = 2.5 Gy*26 fx

2 full arcs;

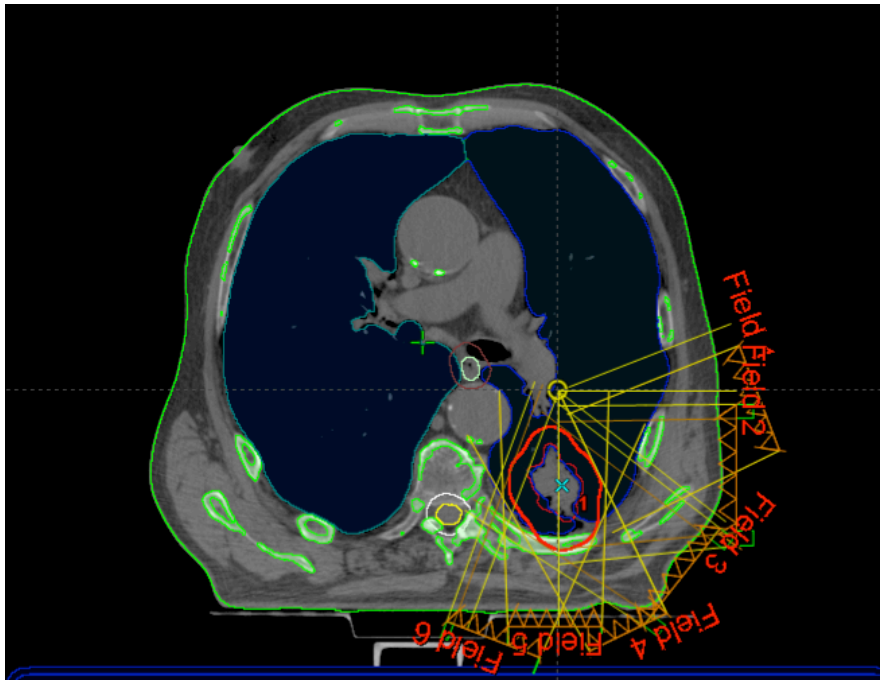


Lung

Patient M. NSCL cancer (primary tumor)

Contouring was made on 4D CT scan (+information from PET)

PTV – 10 Gy*5 fx

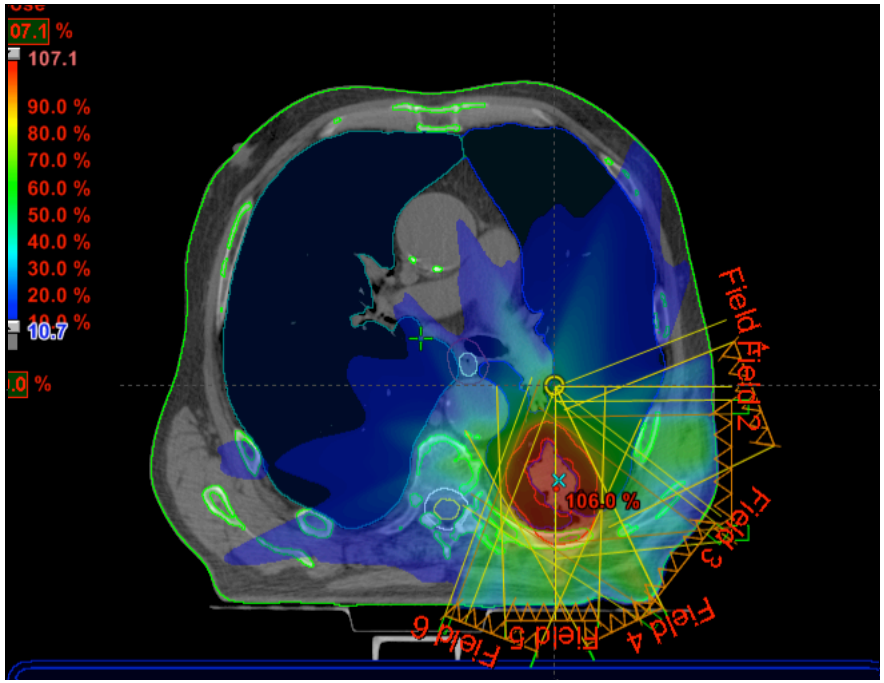


Lung

Patient M. NSCL cancer (primary tumor)

Contouring was made on 4D CT scan (+information from PET)

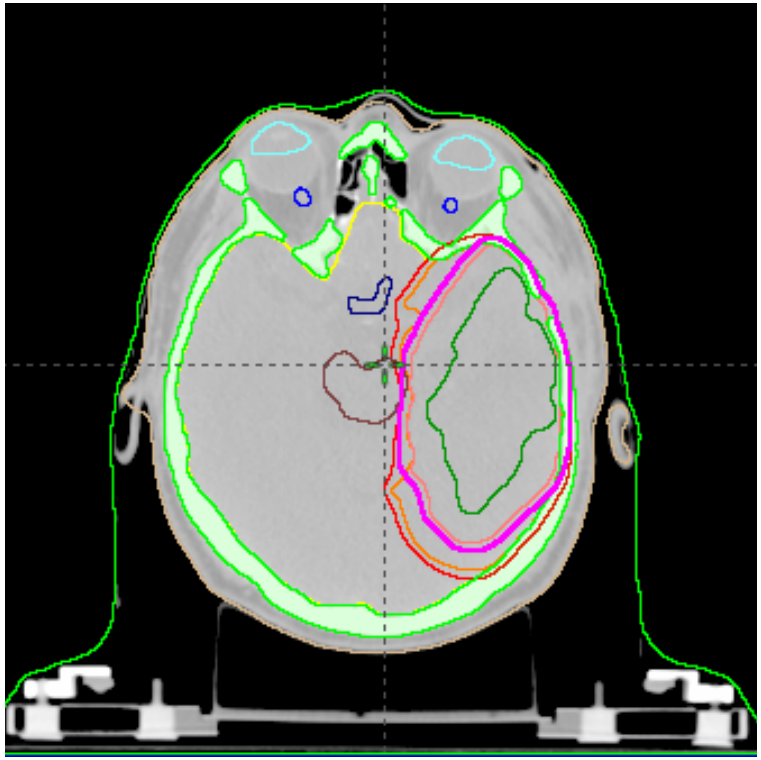
PTV – 10 Gy*5 fx IMRT, 6 fields



Brain

Patient B. Diagnosed with glioblastoma

PTV1 – 2 Gy*22 fx; PTV2 – 2 Gy*30 fx

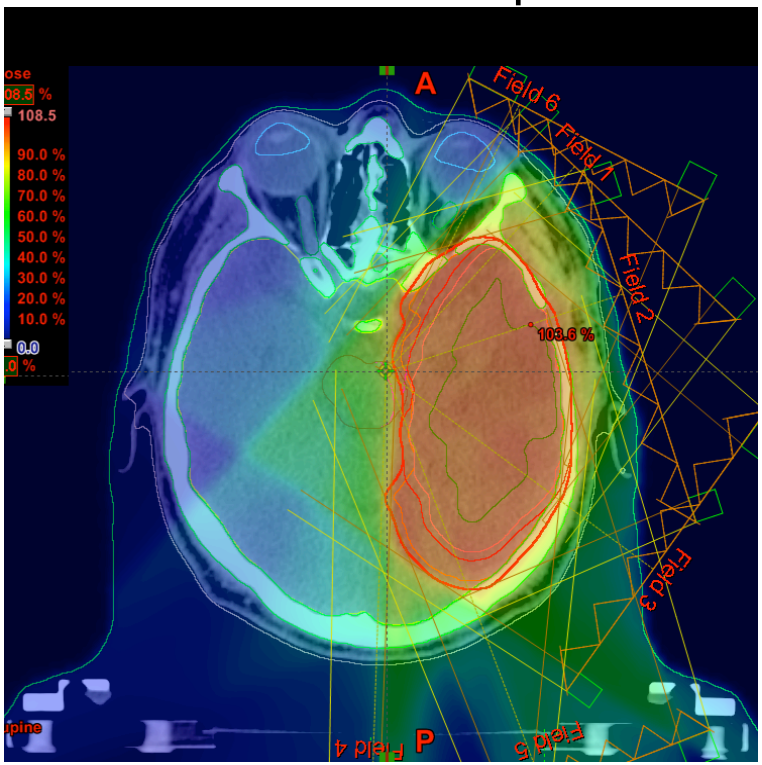


Brain

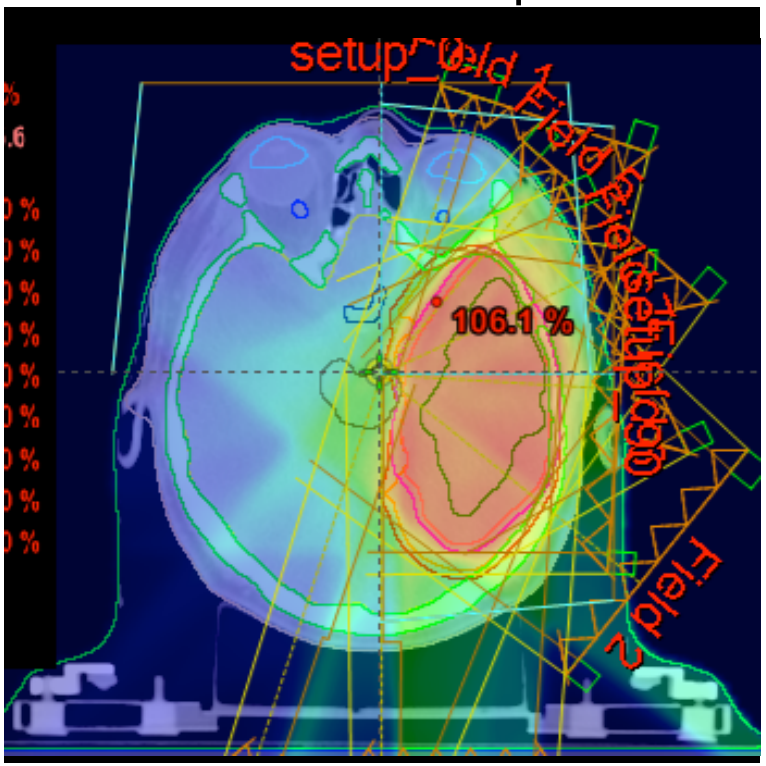
Patient B. Diagnosed with glioblastoma

PTV1 – 2 Gy*22 fx; PTV2 – 2 Gy*30 fx

6 fields IMRT technique.

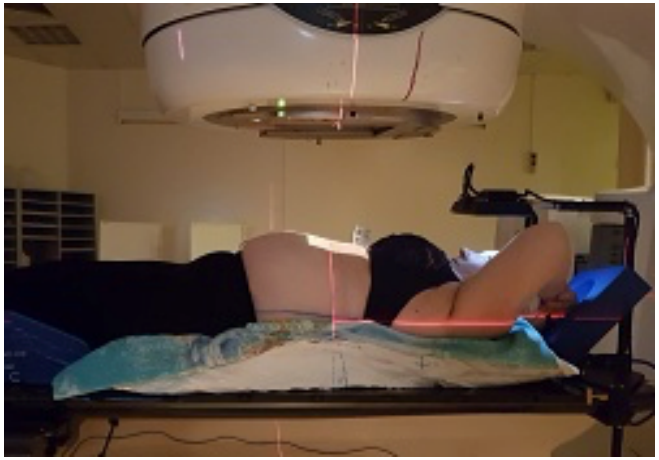


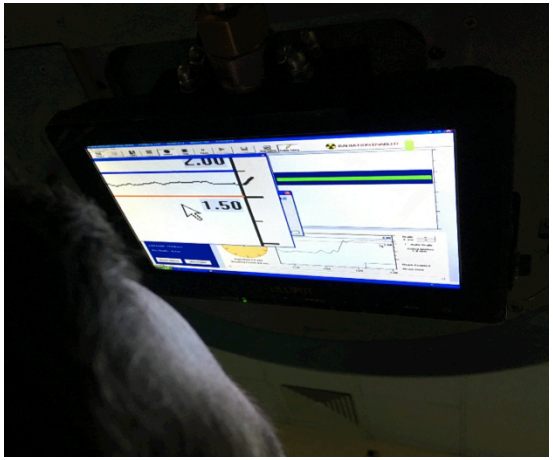
6 fields IMRT technique.



Management of motion during SBRT of liver metastases

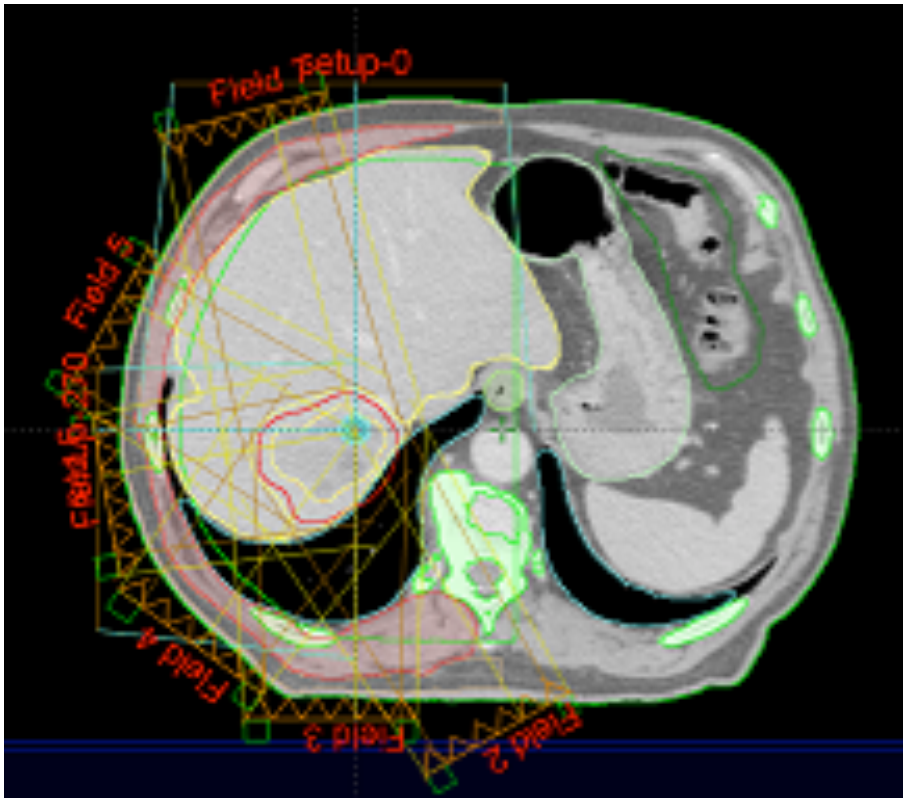
CT scan and treatment for deep inspiration breath-hold using RPM system





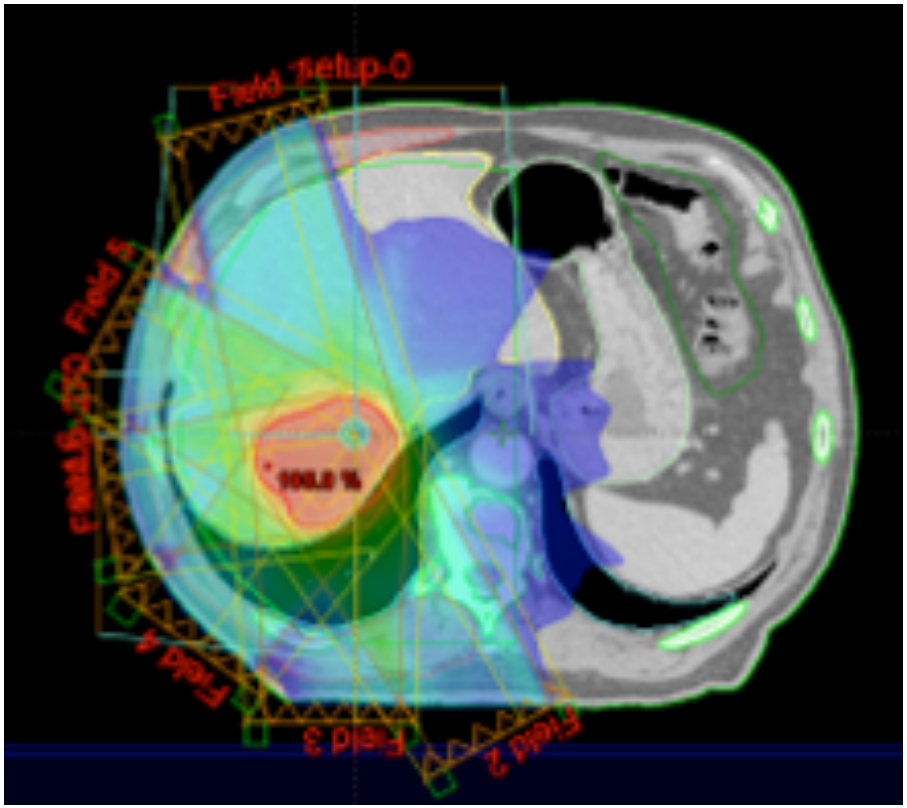
SBRT of liver metastasis

Patient V. PTV- 12 Gy*3 fx



SBRT of liver metastasis

Patient V. PTV- 12 Gy*3 fx
6 field IMRT



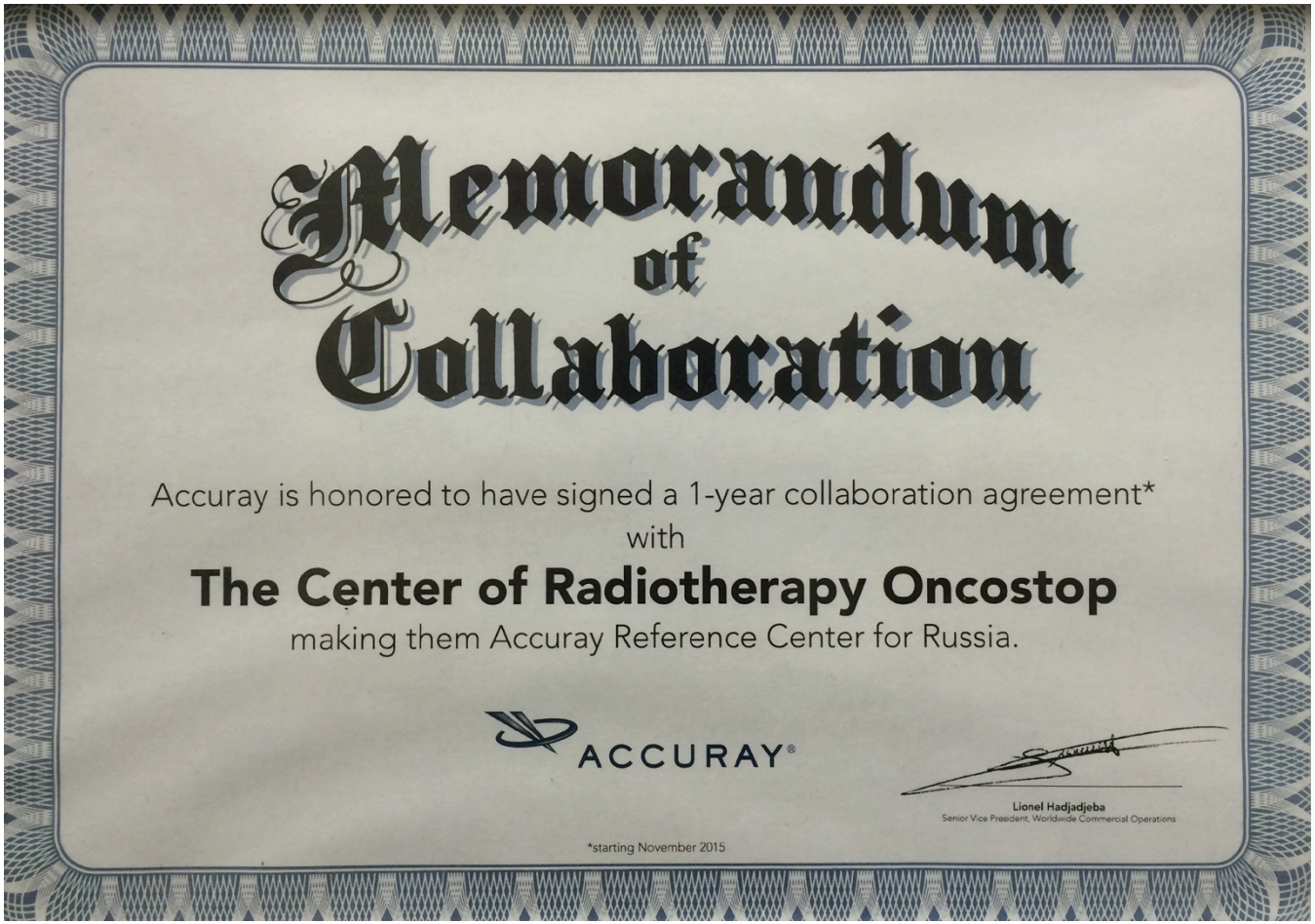
CyberKnife experience in Russia

Number of CK machines in Russia

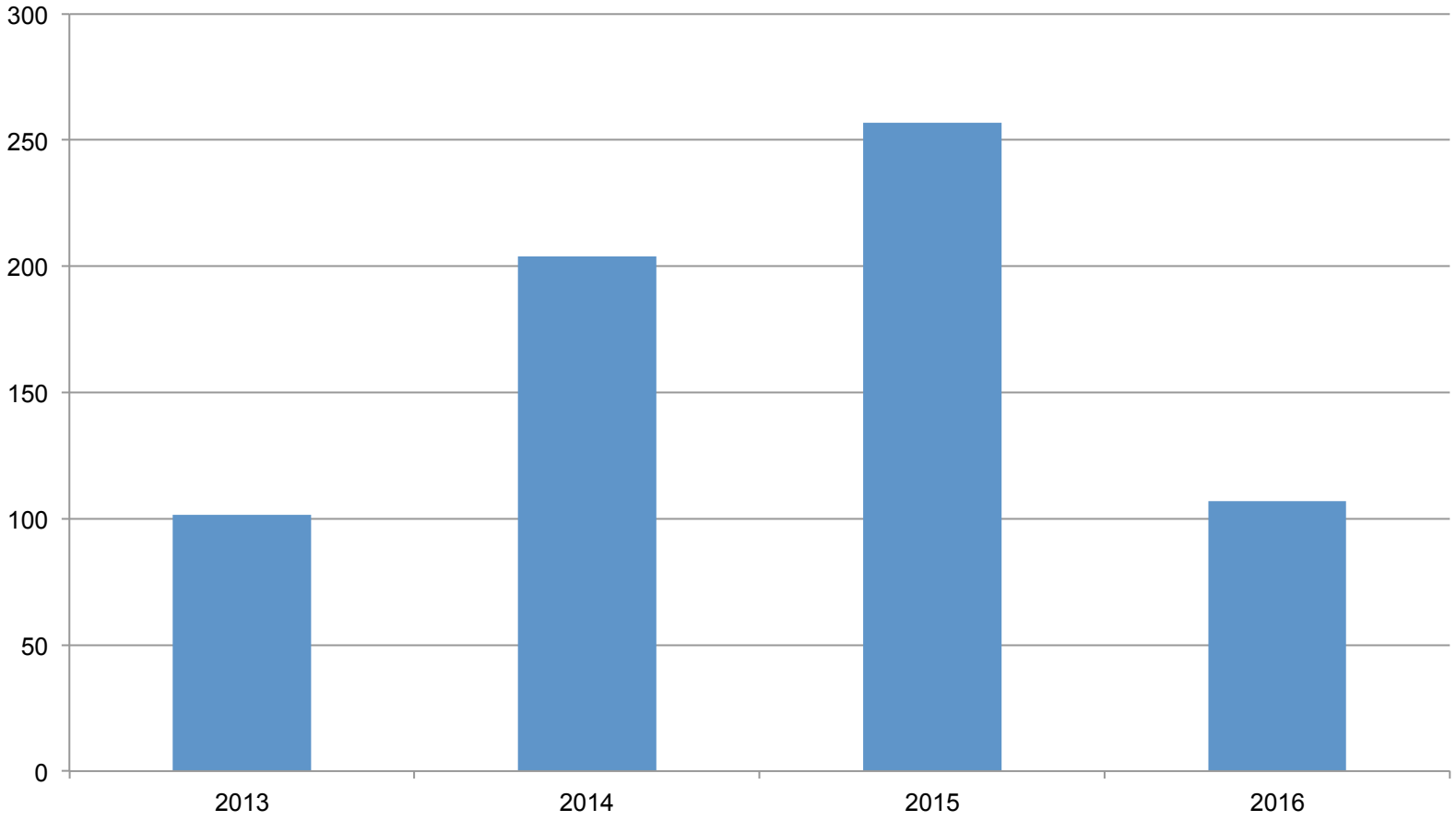
Moscow – 5
Chelyabinsk – 1
Saint Petersburg – 1
Voronezh – 1
Ufa – 1

6% of all conformal treatment machines

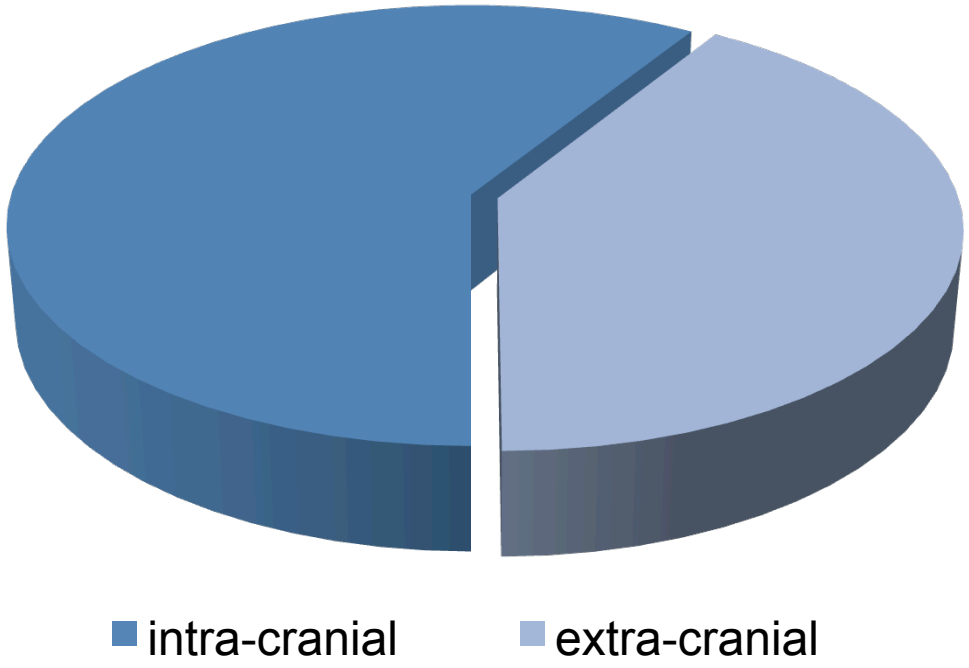
Reference Center for Russia

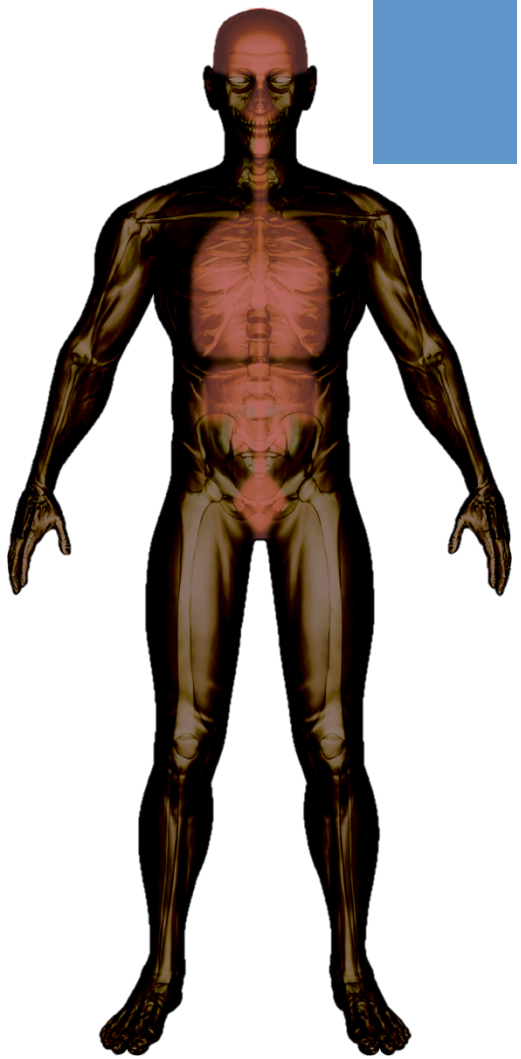


Patient number

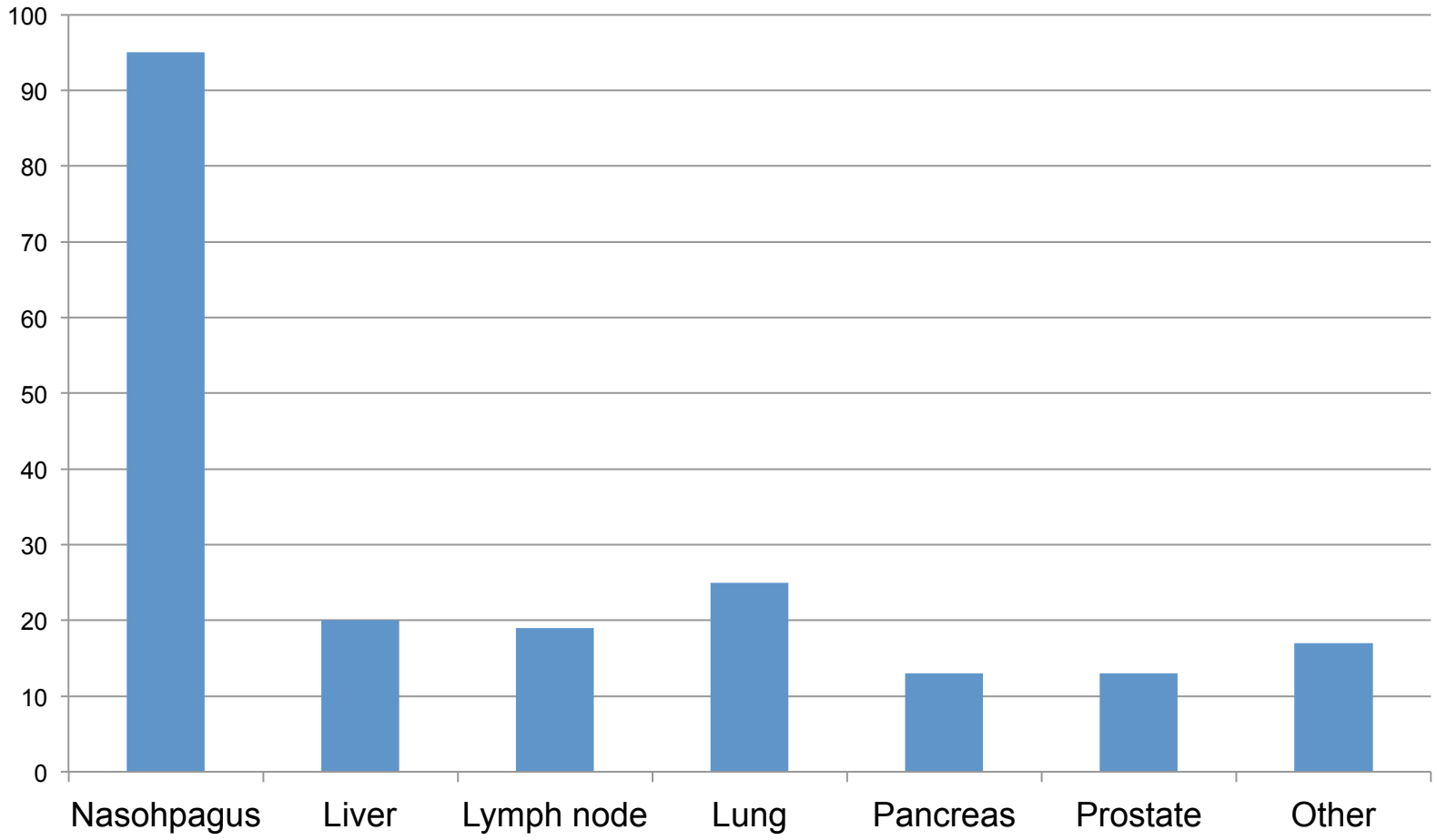


Our patients: treatment sites





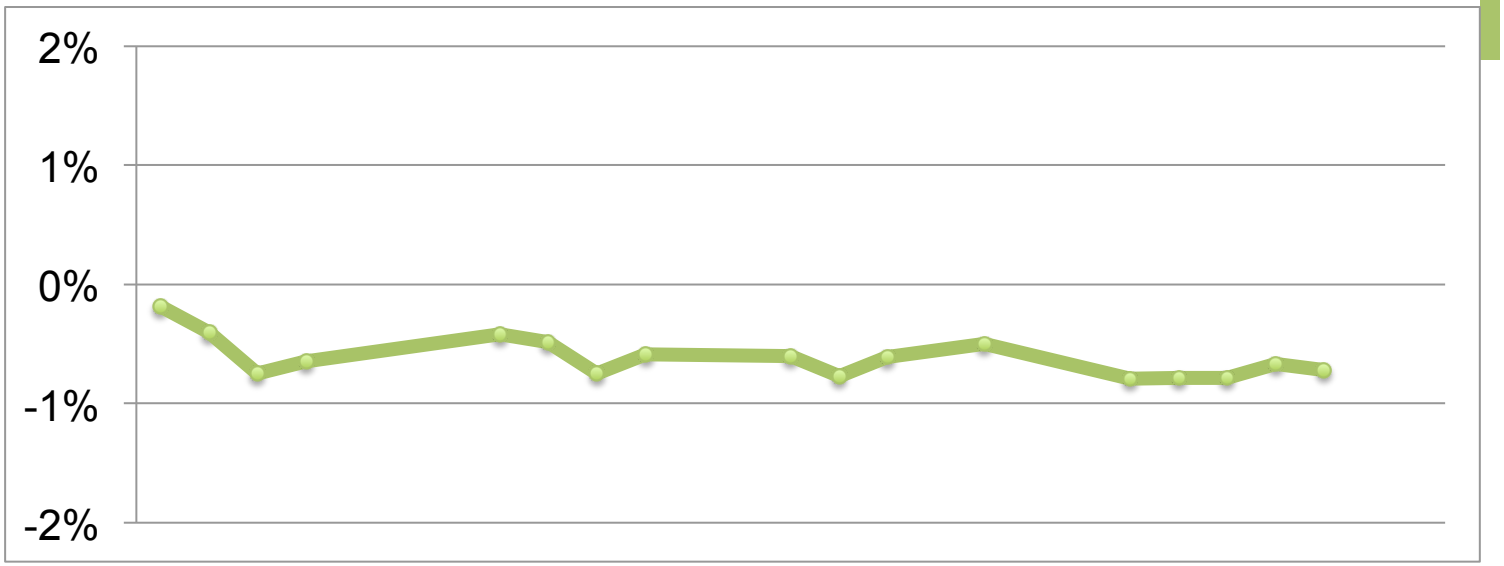
Our patients: treatment sites



Our QA program: periodical and patient-specific

- Daily:
  - Absolute dose to a point
- Weekly:
  - Automatic Quality Assurance test
- Annual:
  - Symmetry and Flatness
  - Percent Depth Dose and Profiles
  - End-to-End tests

Our QA program: Daily

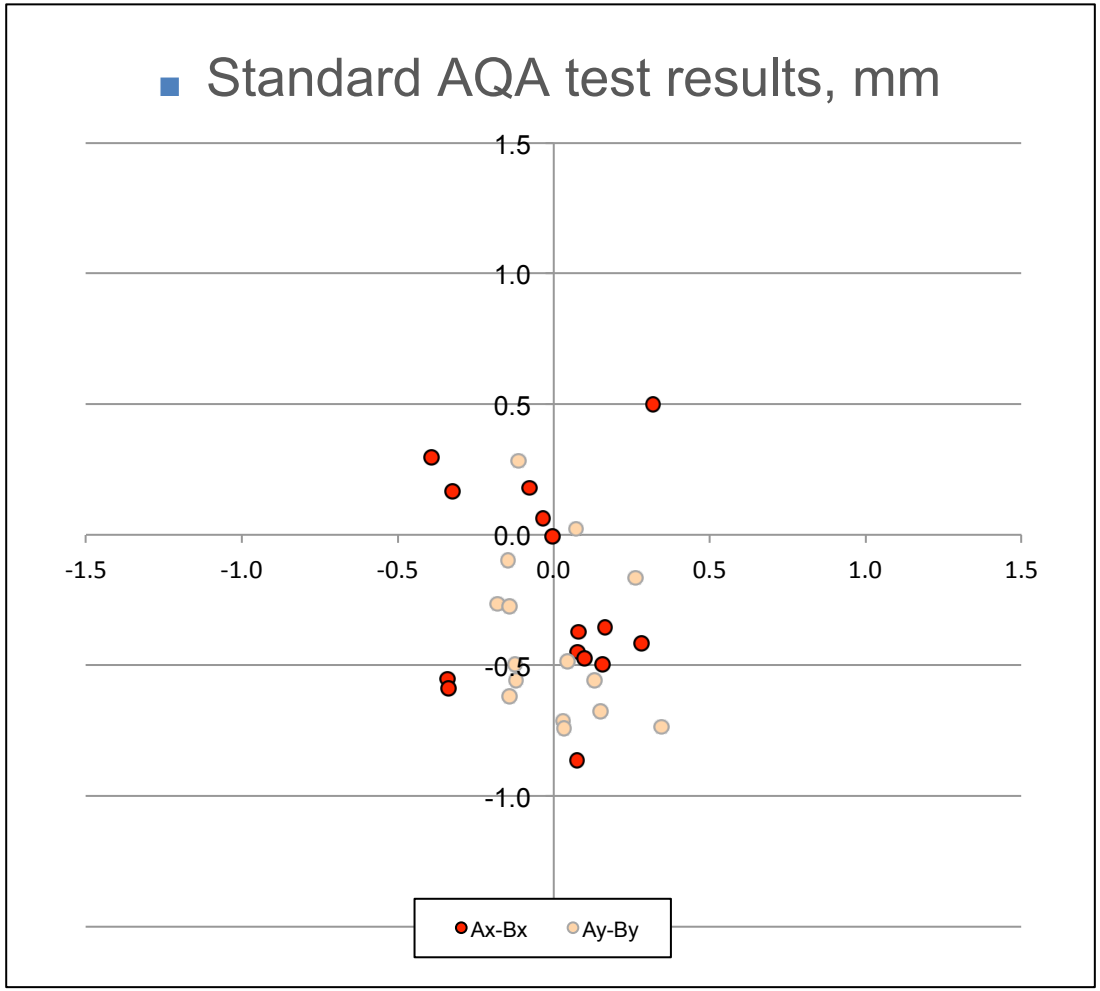


NO measurements in BirdCage

Single beam phantom plan, with Farmer or semiflex chamber and Stereotactic Dose Verification Phantom.
So we verify:

- Absolute dose to a point
- Accuracy of dose delivery
- Communication between computers in CK network

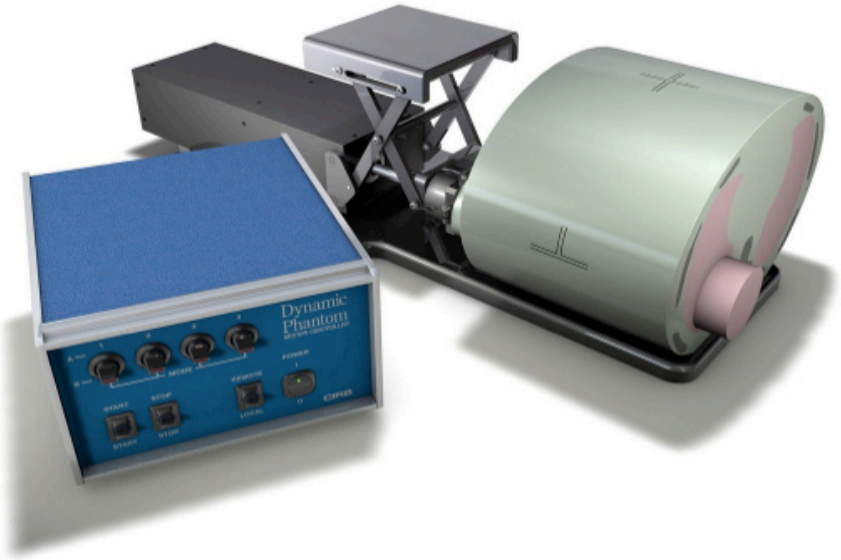
Our QA program: Weekly



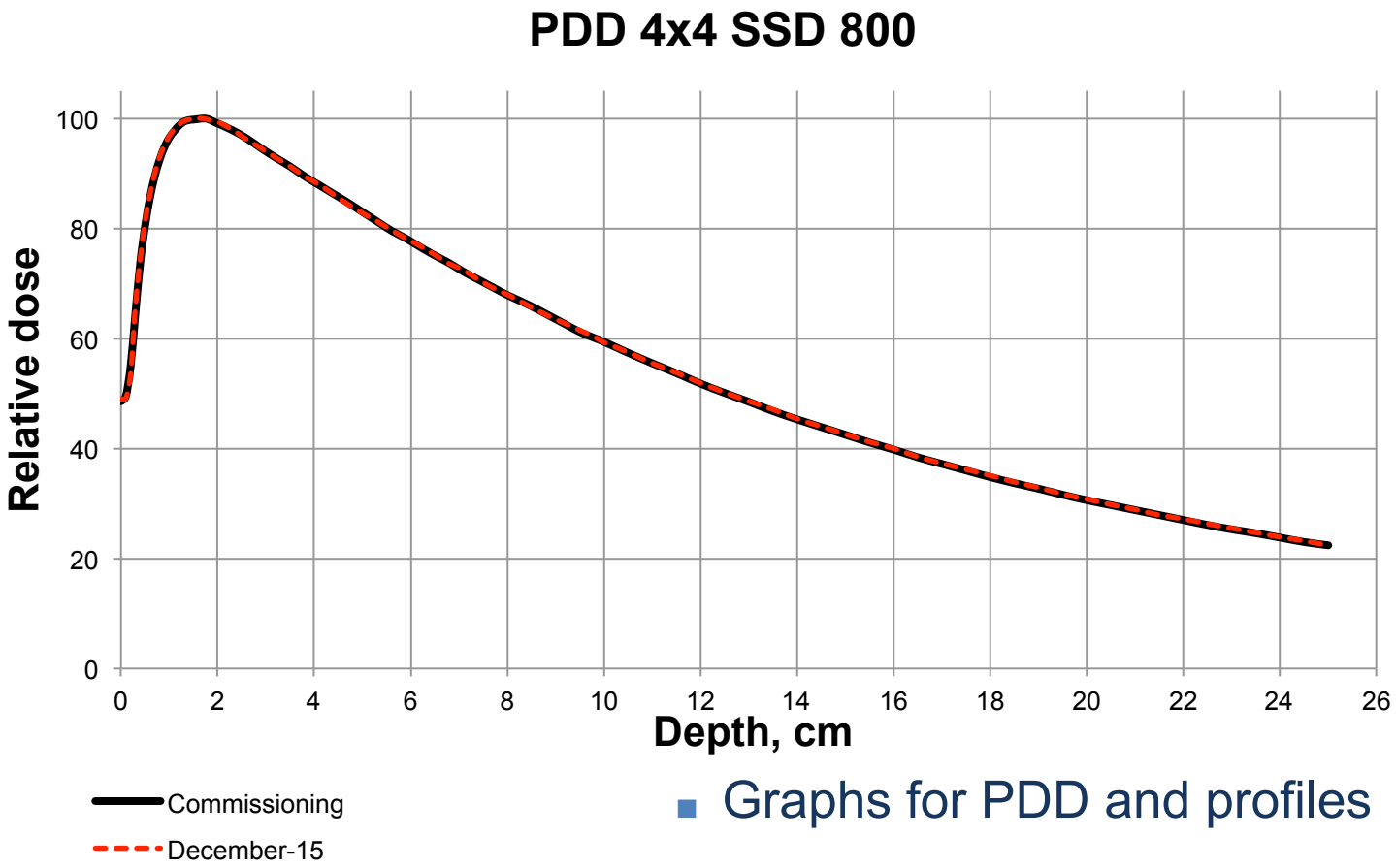
Our QA program: Quarterly

End-to End tests for:

- 6DScull (and before EVERY trigeminal patient)
- Fiducial
- XSpine
- Synchrony
- XLung

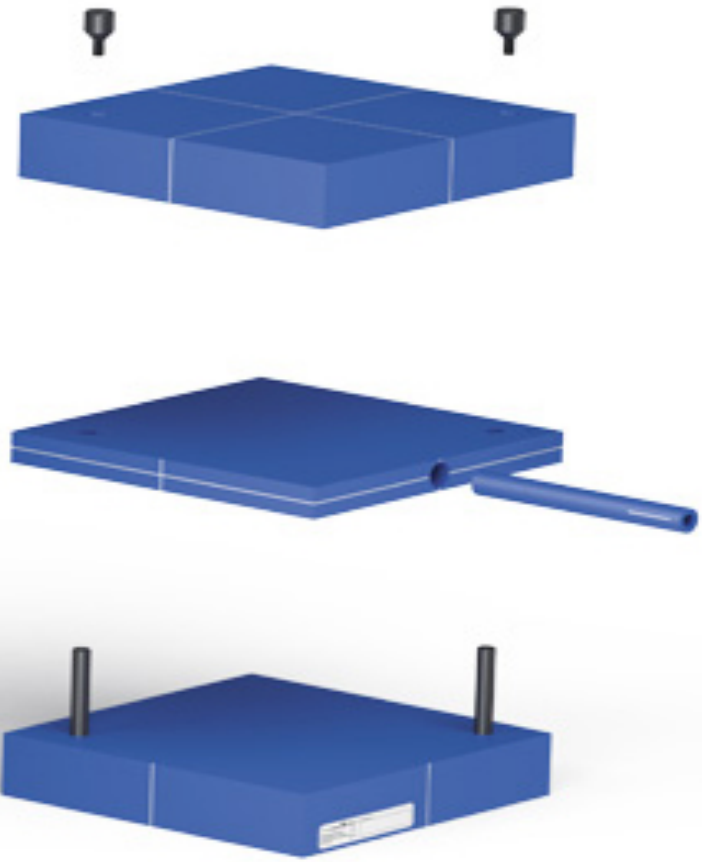


Our QA program: Quarterly



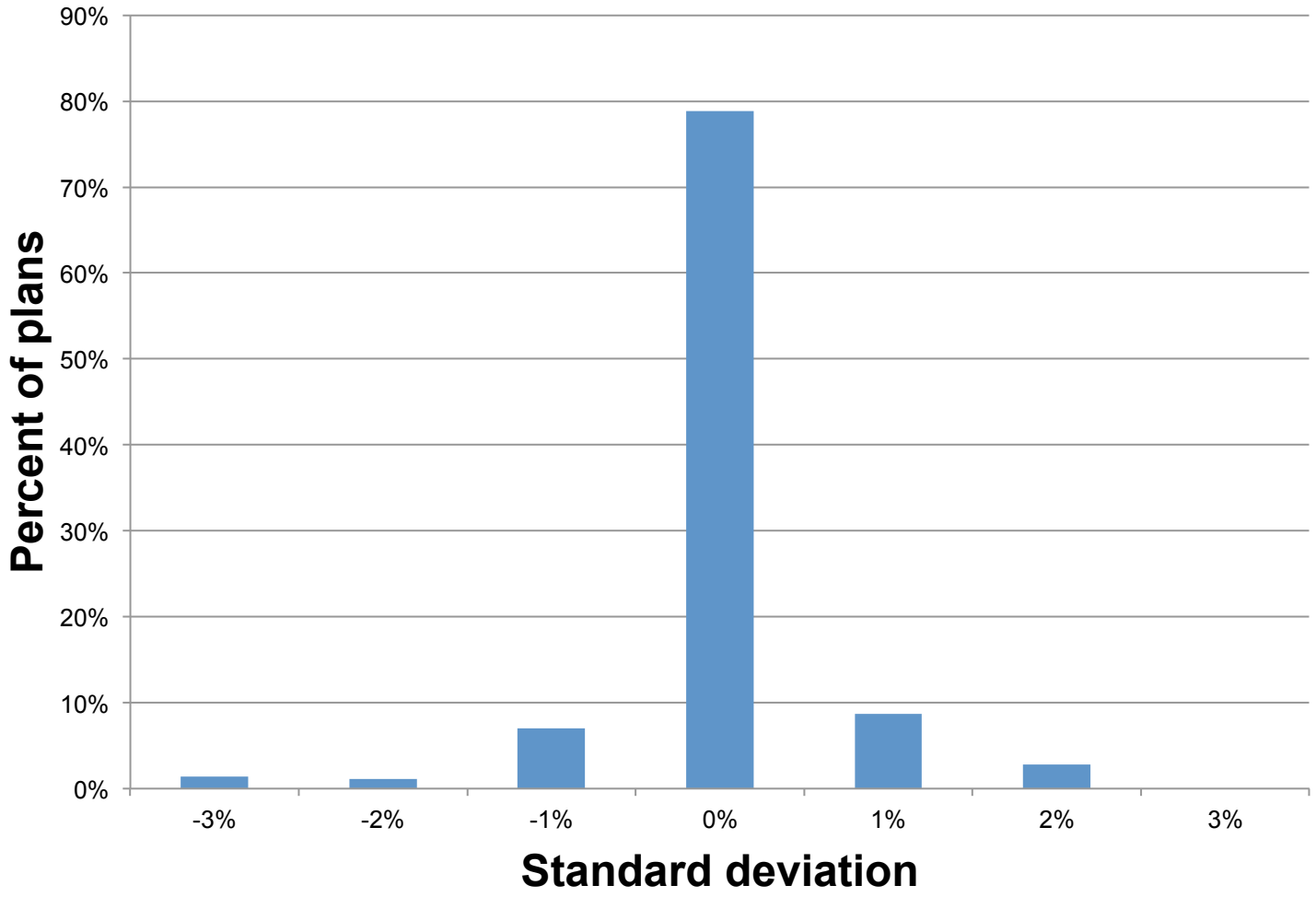
- Graphs for PDD and profiles
- PTW MP3 phantom, Tandem, 2 diodes E

Patient specific QA



Every plan with PTV ≥ 0.015 cc
Try to measure before the treatment

Patient specific QA: results



Technical problems

Long shipping time of spare parts

Summary

- Established successful IMRT programm
- 9 CyberKnife machines
- Increasing percent of patient with IMRT and CK treatment

Thank you for your attention