Analysis of Errors Made During 163 IMRT Irradiations of an Anthropomorphic Phantom

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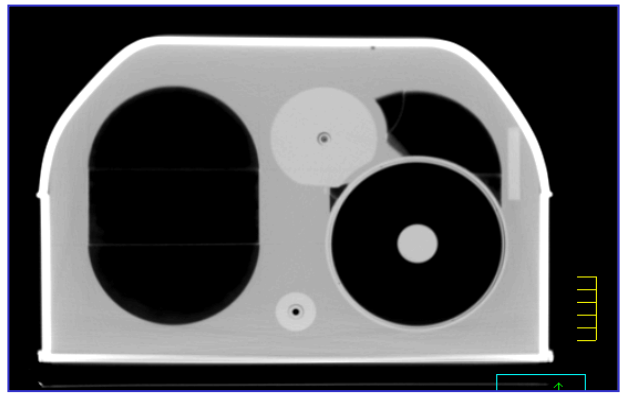
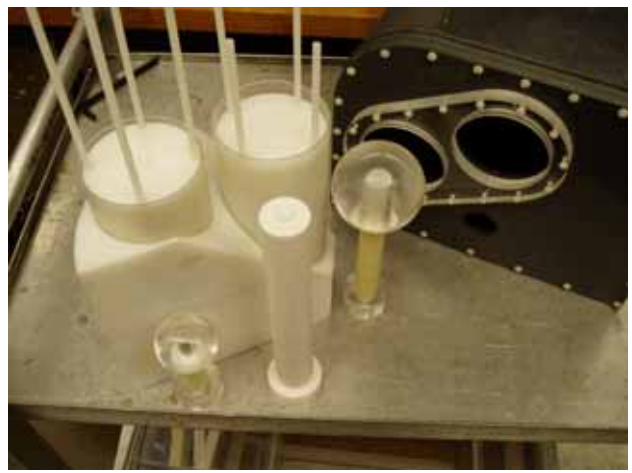
RPC Phantoms

prostate RTOG 0126 (IMRT)



thorax RTOG 0236 (SBRT)

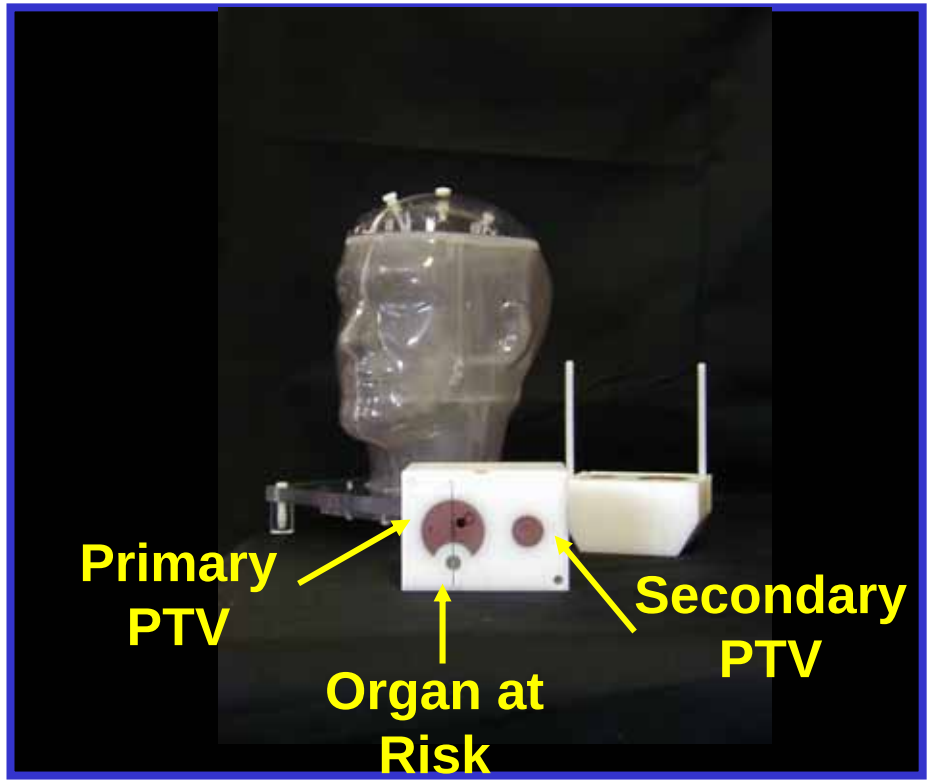
H&N IMRT
RTOG 0225, 0126;
COG ACNS0331



liver RTOG 0438

IMRT H&N Phantom

- **Primary PTV**
  - **4 cm diameter**
  - **4 TLD**
- **Secondary PTV**
  - **2 cm diameter**
  - **2 TLD**
- **Organ at risk**
  - **1 cm diameter**
  - **2 TLD**
- **Axial and sagittal radiochromic films**



- **1º PTV treated to 6.6 Gy**
- **2º PTV treated to 5.4 Gy**
- **OAR limited to < 4.5 Gy**

Designed in collaboration with RTOG;
Molineu et al, IJROBP, October 2005

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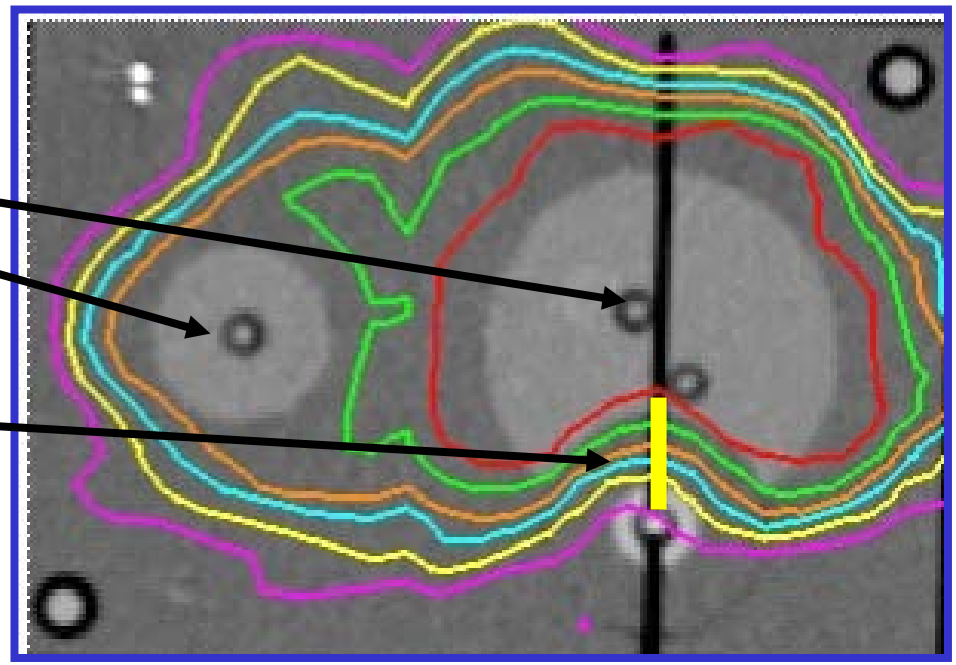
Criteria for credentialing

- **RPC/Inst dose in PTVs: 0.93-1.07**
- **distance to agreement in high gradient region near OAR: ≤ 4 mm**

Dose regions

Distance to agreement region



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Phantom Results

Phantom	H&N	Prostate	Thorax	Liver
Irradiations	163	27	17	-
Pass	115*	24	15	-
Fail	48	3	2	-
Under analysis or at institution	10	3	5	2
Year introduced	2001	Spring 2004	Spring 2004	Spring 2005

IMRT H&N Phantom Results

- 163 irradiations were analyzed
- 115 irradiations passed the criteria
  - 28 institutions irradiated multiple times
- 48 irradiations did not pass the criteria
- 128 institutions are represented

Only 68% of institutions passed the criteria on the first irradiation.

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IMRT H&N Phantom Results cont.

- **28 failed by absolute dose only**
- **7 failed by DTA only**
- **13 failed by both absolute dose and DTA**

	1PTV	2PTV	DTA (mm)
mean	0.99	0.99	-0.7
std dev	0.078	0.065	3.5
count	450	223	162
range	0.78-1.13	0.92-1.22	*-15 to +8*

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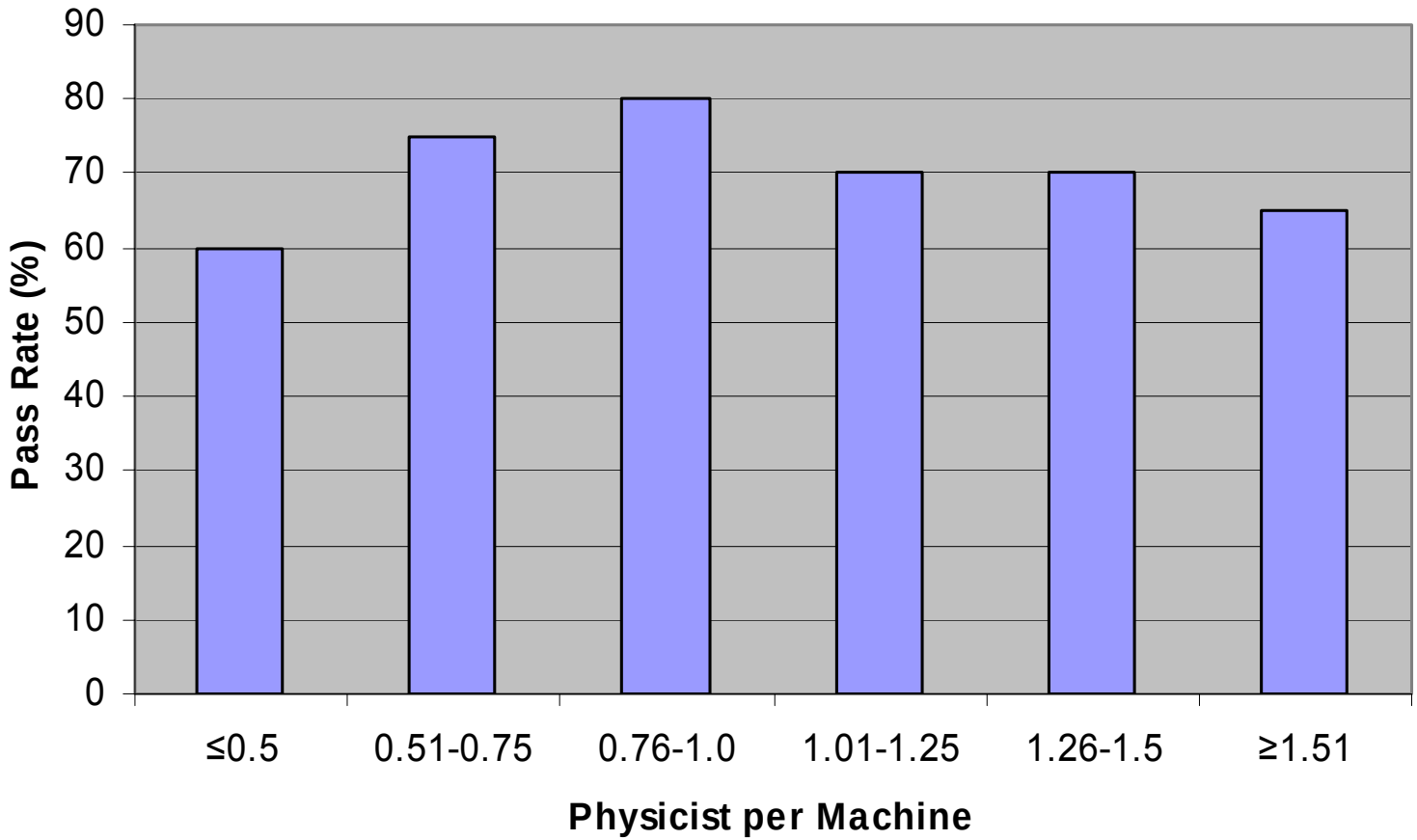
Physicists per machine



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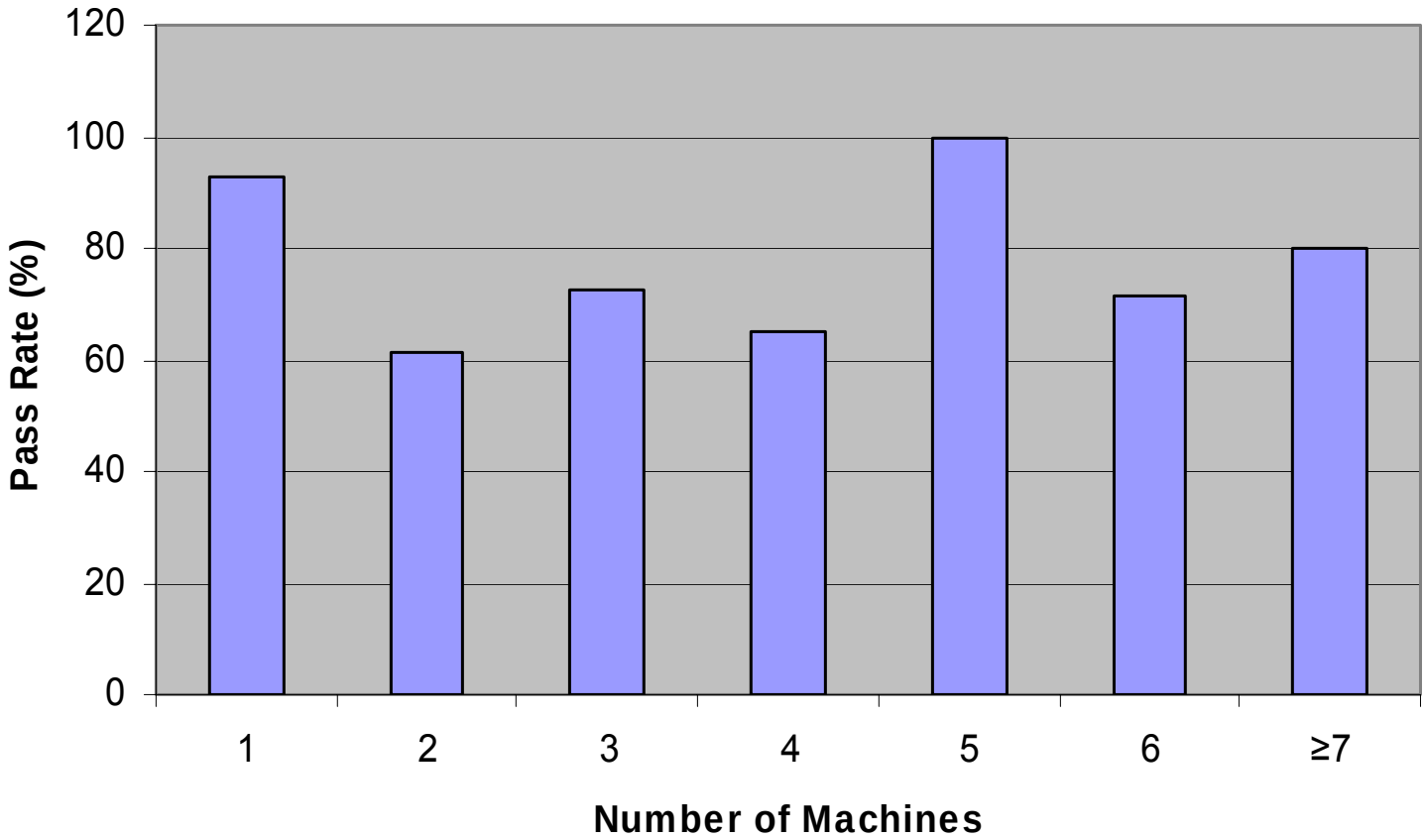
Number of Machines



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Results grouped by accelerator manufacturer

Linear Accelerator Manufacturer	Pass Rate (%)	Attempts	Criteria Failed		
			Dose	DTA	Dose and DTA
BrainLab	100	1	0	0	0
Elekta	54	13	5	1	0
Siemens	66	29	4	1	5
TomoTherapy	67	3	1	0	0
Varian	74	117	18	5	8
total		163	28	7	13

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Results grouped by TPS

Treatment planning system	Pass Rate (%)	Attempts	Criteria Failed		
			Dose	DTA	Dose and DTA
BrainScan	100	4	0	0	0
Cadplan	67	3	1	0	0
CMS XiO	76	17	1	1	2
Corvus	73	26	6	0	1
Eclipse	84	32	2	2	1
Helax	100	2	0	0	0
Pinnacle	61	69	16	4	7
Radionics XKnife	100	1	0	0	0
Theraplan Plus	0	2	0	0	2
TomoTherapy	67	3	1	0	0
Inst. developed TPS	75	4	1	0	0
total		163	28	7	13

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Results grouped by machine/TPS combo

Manufacturer/TPS Combination	Pass Rate (%)	Attempts	Criteria Failed		
			Dose	DTA	Dose and DTA
Elekta/Corvus	0	1	1	0	0
Elekta/Eclipse	--	0	0	0	0
Elekta/Pinnacle	55	11	4	1	0
Elekta/XiO	100	1	0	0	0
Siemens/Corvus	88	8	1	0	0
Siemens/Eclipse	--	0	0	0	0
Siemens/Pinnacle	54	13	2	0	4
Siemens/XiO	50	4	0	1	1
Varian/Corvus	71	17	4	0	1
Varian/Eclipse	84	32	2	2	1
Varian/Pinnacle	64	45	10	3	3
Varian/XiO	83	12	1	0	1
total		144	25	7	11

Explanations for Failures

Explanation	Minimum # of occurrences
incorrect output factors in TPS	1
incorrect PDD in TPS	1
inadequacies in beam modeling at leaf ends (Cadman, et al; PMB 2002)	14
not adjusting MU to account for dose differences measured with ion chamber	3
errors in couch indexing with Peacock system	2
2 mm tolerence on MLC leaf position	1
setup errors	7
target malfunction	1

Changes made by institutions that resulted in acceptable phantom irradiation

Changes
input new output factors
remeasured PDD and modeled beam based on new values
adjusted leaf end modeling
updated software version
upgraded MLC leaves
more accurate setup
replaced target

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Conclusions

- **The RPC phantom provides a comprehensive evaluation of IMRT for clinical trials**
- **QA of IMRT is important!**

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