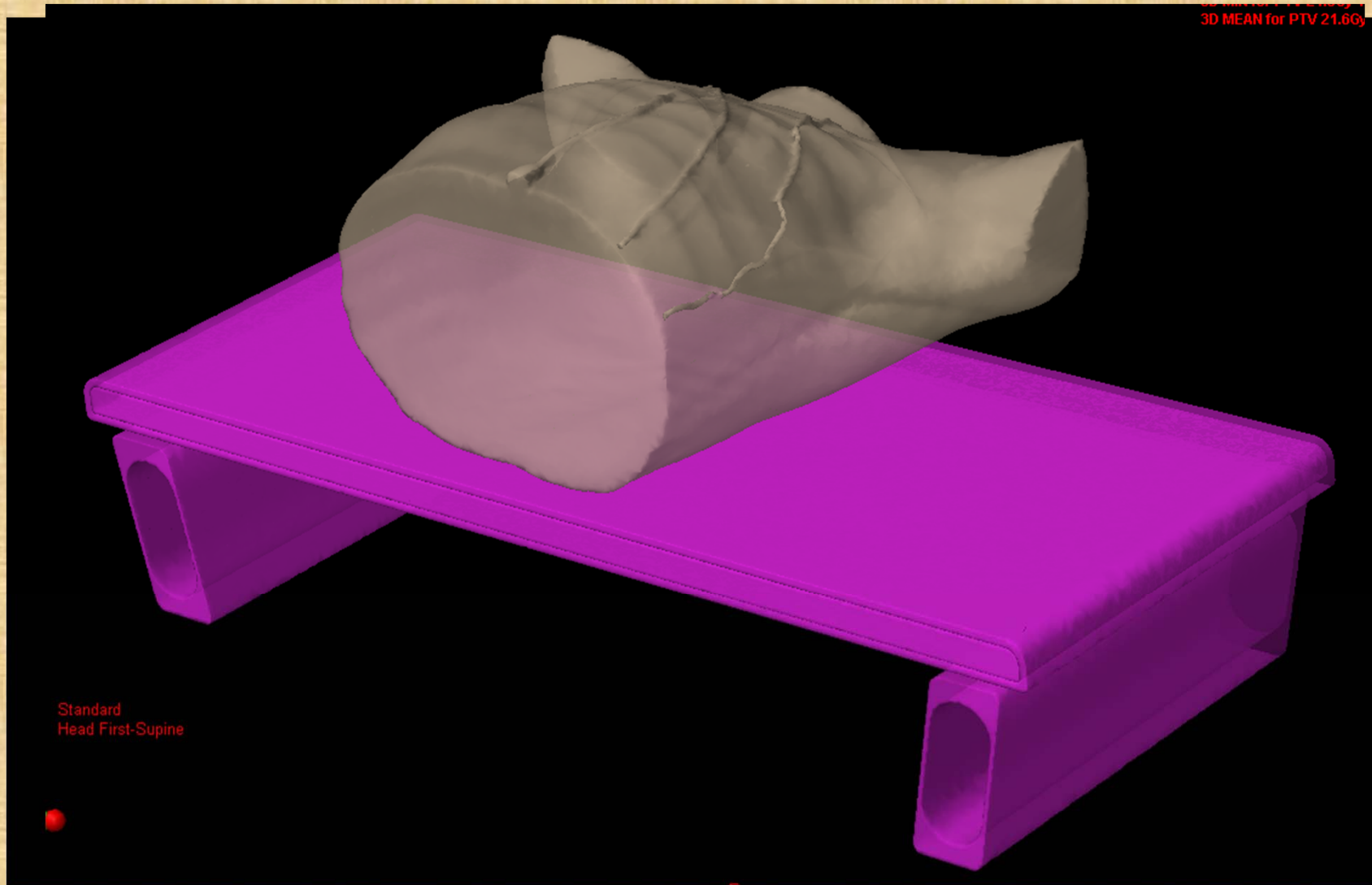# Dosimetric Effects of Couchtop and Immobilization Devices (AAPM TG 176)

Arthur Olch, Ph.D., Chair TG 176

University of Southern California Keck School of Medicine, Los Angeles CA,

Children's Hospital Los Angeles

We don't treat patients suspended in mid-air

Motivation for Formation of TG 176

1. To accurately include external devices between the source and patient in dose calculations.

2. The error made in ignoring couch tops and immobilization devices can be large, both for tumor dose and skin dose.

3. We are used to making 2-3% dose corrections. Blocking trays, Temp-pressure factor, TG21 to TG51 change. Why not account for external devices?

4. We live in an age where the TPS can do this accurately if the patient is indexed to the couch.

What's Different Now

1. Patients are more likely now to be indexed so that the relationship between the external device and the patient is constant, enabling accurate correction strategies.

2. "IGRT" carbon fiber sandwich couchtops unbiquitous -Better image quality but nearly full skin dose from posterior beam and several % attenuation. Can have nonuniform regions.

3. Immobilization devices are constructed to well immobilize the patient but can have thick, solid carbon fiber or plastic parts which attenuate the beam, increase skin dose.

4. Opposed laterals for H&N are rarely used, instead multiple beam plans or VMAT which include posterior beams which pass through baseplates, masks, couchtops.

TG 176 Outline

- **Introduction**
  - magnitude of tumor and surface dose errors that exists without accounting for external devices.
  - Scope of report includes photons and particle therapy, includes major vendor products, includes calypso.

- **Dosimetric errors due to external devices**
  - <u>Couchtops</u>
    - Literature review
    - Varian, Siemens, Elekta, plus cyberknife
  - <u>Immobilization devices</u>
    - Literature review
    - masks, headfix, bodyfix, vaclock, S-frame head ext., alpha cradle

- **Ability of TPS to accommodate these devices in planning and calculations**.
  - Review of literature
  - Include Eclipse, Pinnacle, Xio.

- **Recommendations for attenuation and surface dose measurements- dosimeters and methods specifically for external devices**
    - Photons
    - Protons

- **Recommendations for external structures avoidance strategies**

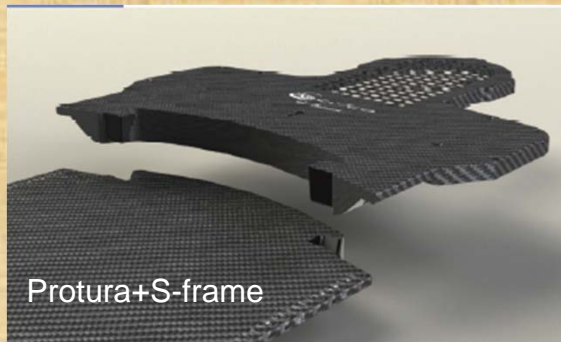- **Recommendations to the TPS and device vendors**

Variety of Couchtops

WFR dosemax

Siemens ZXT
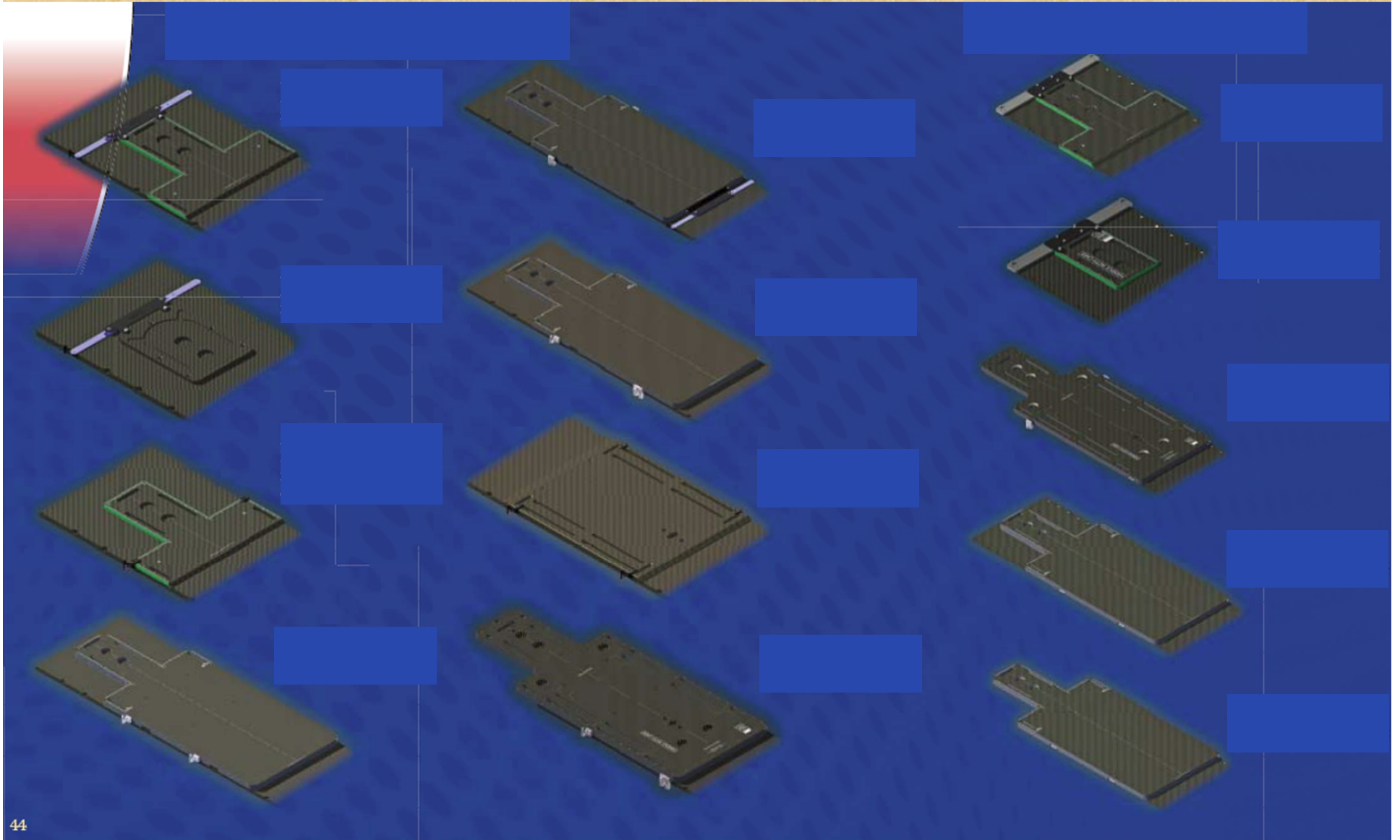
Protura+S-frame

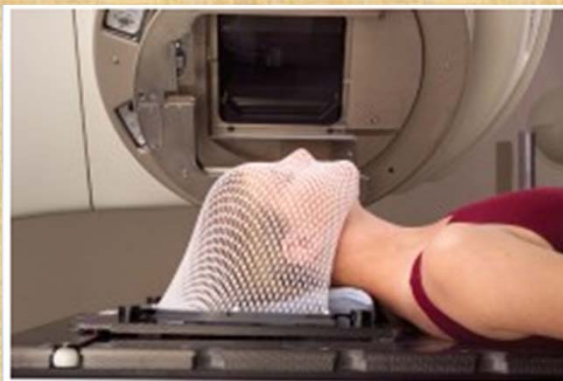M.I. I-beam

Varian IGRT

WFR KVUE

WFR split frame

An Array of Baseplates

Wide Variety of Indexed Immobilization Devices

Couchtops and Immobilization Devices Affect:

Attenuation
Surface dose
Dose Distribution

Beams Arrangement Considerations

- Single PA or PostOblique beam- maximum attenuation and surface dose effect
- APPA beams- ½ the attenuation but maximum surface dose effect
- Multiple beams predominantly posterior – maximum attenuation, reduced surface dose effect
- Multiple equally spaced beams- minimizes both
- Volumetric arc – minimizes both – still > opp lats

Couch tops and immobilization devices impact:

20%   1. Beam attenuation

20%   2. Skin dose

20%   3. Dose distribution

20%   4. Beam attenuation, skin dose, and dose distribution

20%   5. Beam attenuation and dose distribution

10

And the correct answer is:

- 4-- Beam attenuation, skin dose, and dose distribution

References:

- J. K. H. Seppälä and J. A. J. Kulmala, "Increased beam attenuation and surface dose by different couch inserts of treatment tables used in megavoltage radiotherapy," J appl clin med phys 12 (2011).

- E. Vanetti, G. Nicolini, A. Clivio, A. Fogliata and L. Cozzi, "The impact of treatment couch modelling on RapidArc," Phys Med Biol **54**, N157-166 (2009).

# This Conclusion is Representative in Literature

Build-up and attenuation

The carbon fiber tabletop significantly decreases the skin-sparing effect and increases the surface dose, which is clinically important. The presence of the tabletop decreases the isocenter dose between 3.0%–5.6% depending on the gantry angle at 6 MV. The assumption that carbon fiber is radiotransparent is not valid; and ignoring the table attenuation can be clinically significant. The dosimetric effect of the tabletop may be higher especially for IMRT depending on the beam's orientation. Attenuation of the carbon fiber tabletop should be considered and corrected, such as is done for any material under the patient at the time of treatment planning.

Meydanci, Radiat Med 2008

2
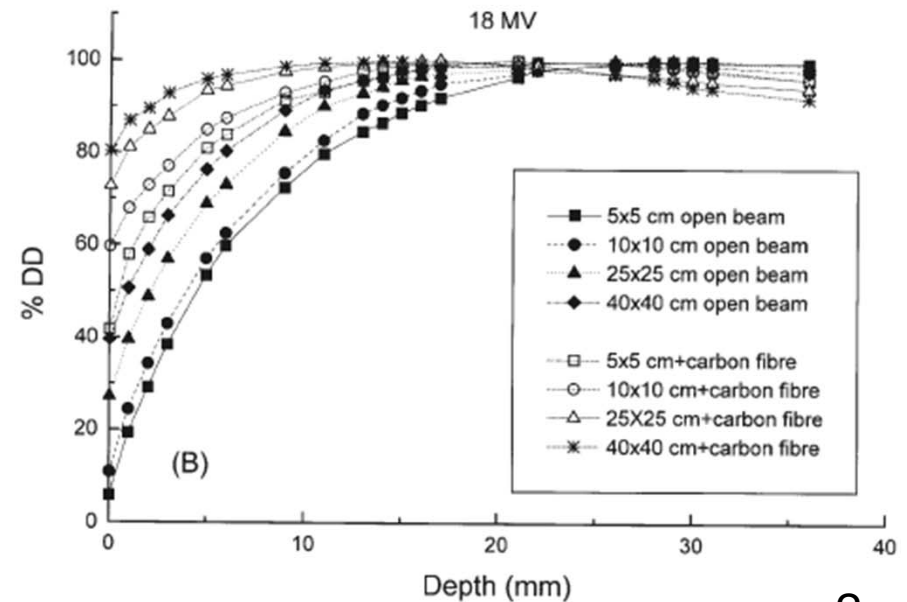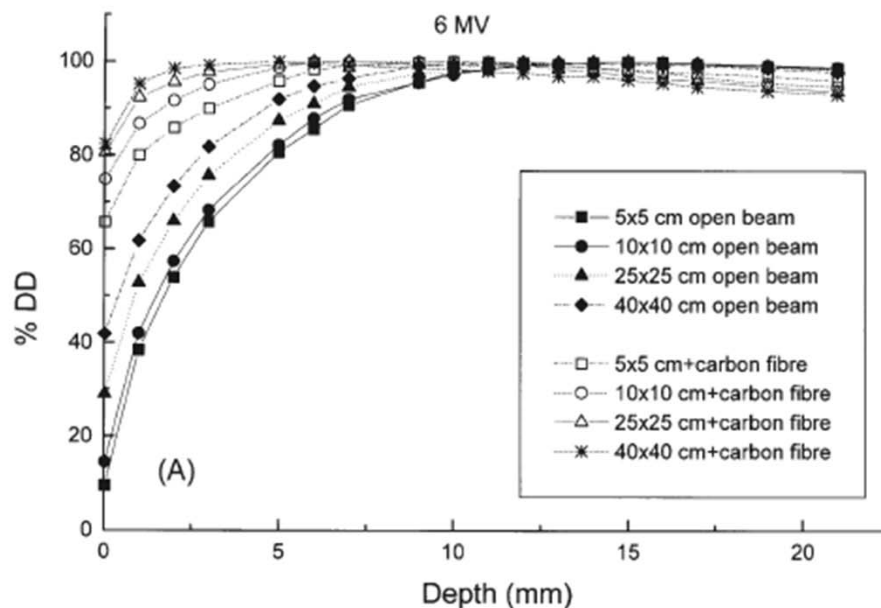
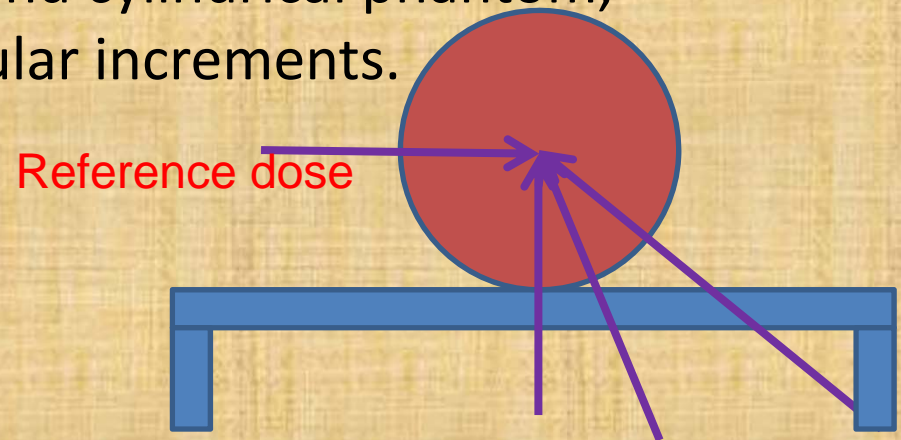# Recommended Measurement Methods

prior to TG 176, NO standard for how to measure

- ## Attenuation
  - – Ion chamber. We recommend cylindrical phantom, measure at 10 degree angular increments.
  - – Can get WET from TMR and attenuation
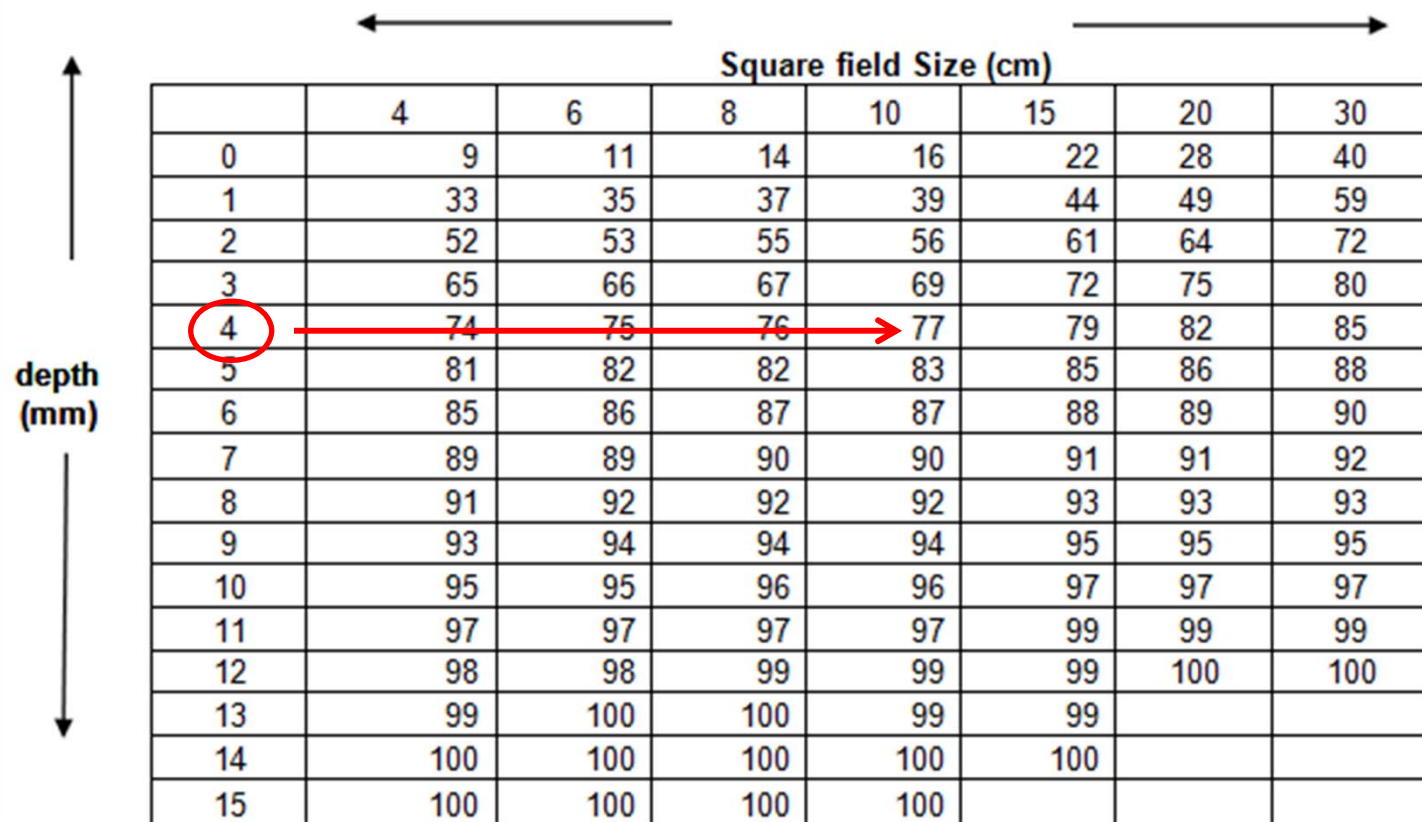
  Reference dose

- ## Surface dose:
  - – parallel-plate chamber (recommended), film, TLD, OSL. Can use the WET from attenuation measurement to infer the surface dose

Use WET to Infer Surface Dose

6 MV Buildup PDD

Square field Size (cm)

depth (mm)	4	6	8	10	15	20	30
0	9	11	14	16	22	28	40
1	33	35	37	39	44	49	59
2	52	53	55	56	61	64	72
3	65	66	67	69	72	75	80
4	74	75	76	77	79	82	85
5	81	82	82	83	85	86	88
6	85	86	87	87	88	89	90
7	89	89	90	90	91	91	92
8	91	92	92	92	93	93	93
9	93	94	94	94	95	95	95
10	95	95	96	96	97	97	97
11	97	97	97	97	99	99	99
12	98	98	99	99	99	100	100
13	99	100	100	99	99		
14	100	100	100	100	100		
15	100	100	100	100			

For a single PA 6MV beam, a carbon fiber couch top alone can be expected to:

| 20% | 1. | Increase the surface dose by 10% and reduce the tumor dose by 10% |

| 20% | 2. | Increase the surface dose by a factor of 2 and reduce the tumor dose by 3% |

| 20% | 3. | Increase the surface dose by a factor of 4 and reduce the tumor dose by 3% |

| 20% | 4. | Decrease the surface dose and increase the tumor dose |

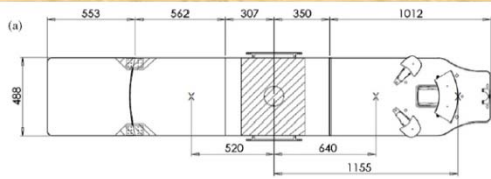| 20% | 5. | Decrease the surface dose and tumor dose by 3% each |

And the correct answer is:

- 3 - Increase the surface dose by a factor of 4 and reduce the tumor dose by 3%

Reference

- T. Meydanci and G. Kemikler, "Effect of a carbon fiber tabletop on the surface dose and attenuation for high-energy photon beams," Radiation Medicine 26, 539-544 (2008).

Attenuation Measurements for Contesse Couchtop

Berg PMB 2009

4
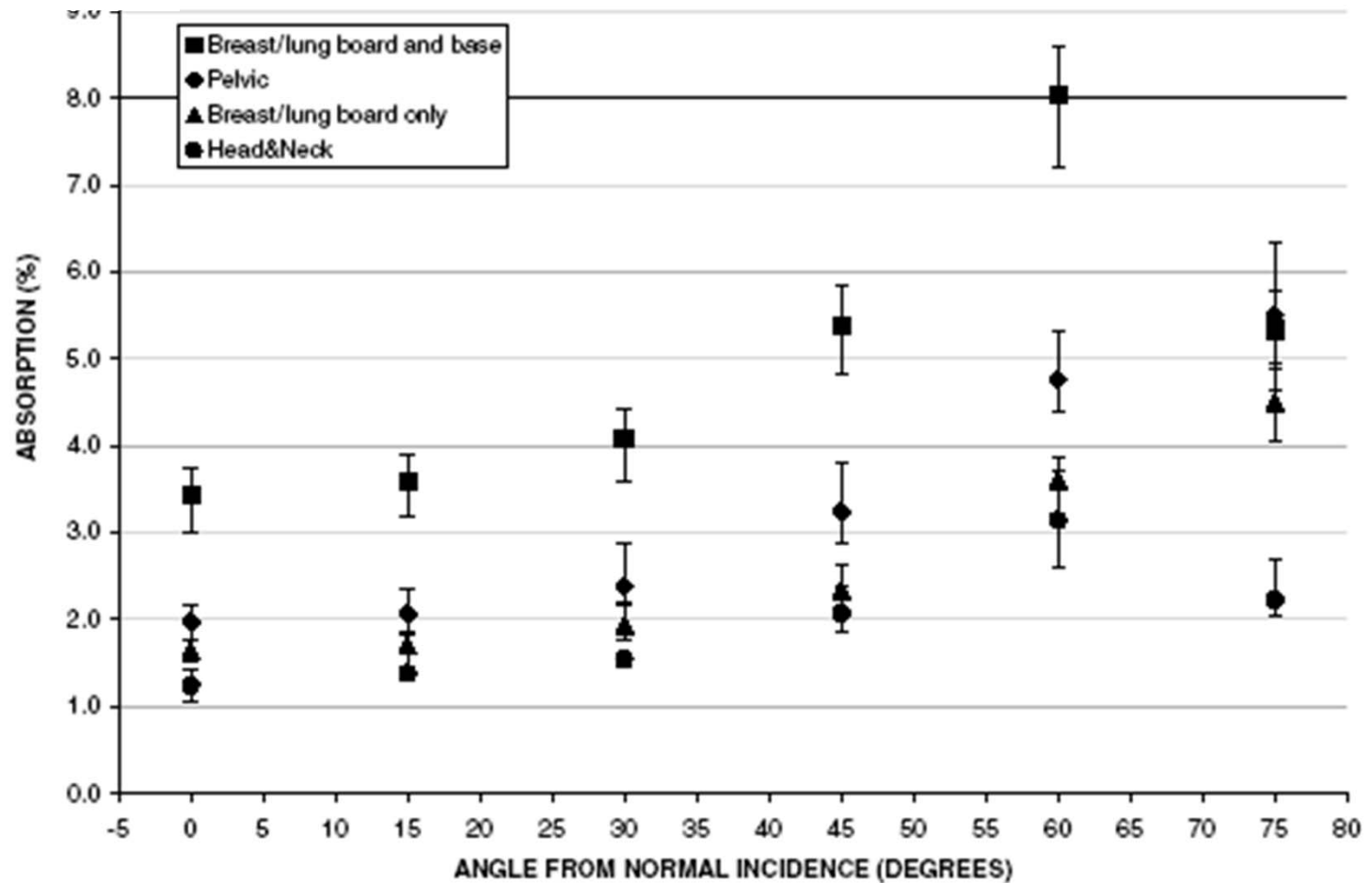
Measurement of Beam Attenuation By Couch and Immobilization Devices Using an EPID

(a) couch rail

(b) frame insert, Head support

(c) frame insert

Actual set-up at time of treatment

Planned set-up

(d) large grid area frame (VII)

3,4
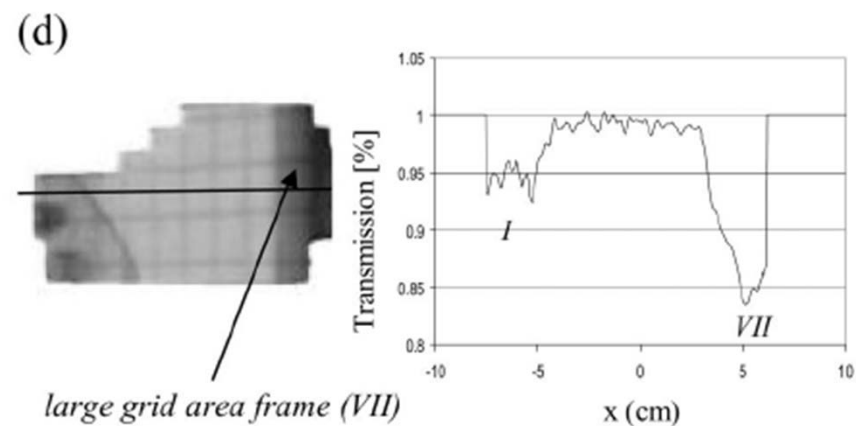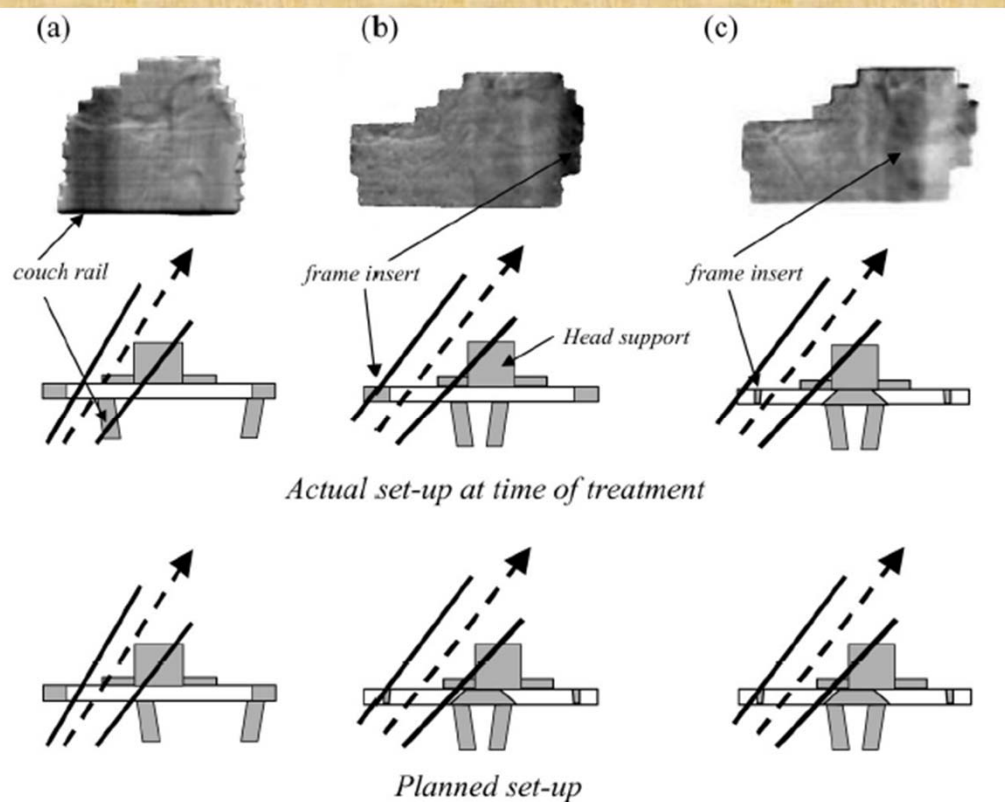
Measurements of attenuation through a couch top should be made by using:

20%	1. EPID
20%	2. Ion chamber in a cylindrical phantom
20%	3. Film in a rectangular phantom
20%	4. Diode array in rectangular phantom
20%	5. Ion chamber in rectangular phantom

And the correct answer is:

- 2 - Ion chamber in a cylindrical phantom

Reference:

- Olch et al. Dosimetric Effects Caused by Couch Tops and Immobilization Devices – Report of AAPM Task Group 176, Medical Physics, in press.

Attenuation Effects -sample
(19 published studies)

Study reference	Device	Delivery type	Beam Angle(s)	Attenuation (energy)	Detector type
Krithivas et. al.[1]	Metalic centerspine bar for Clinac 4/100 couch	conformal arc	0°(*) – 60°(†)	8%-12% (4MV)	XV film/Ion chamber cylindrical (PTW)
Meydanci et. al.[2]	Carbon fiber tabletop (Reuther MedizinTechnik)	single beam	180°(*) 120°(†)	3.0% (6MV) 2.0% (18MV) 5.6% (6MV) 4.0% (18MV)	Ion chamber cylindrical PTW

Changes in surface dose due to the presence of a couch top can be determined by:

20%	1.	Measurements with a parallel plate ion chamber
20%	2.	EPID
20%	3.	Cylindrical ion chamber in a cylindrical phantom
20%	4.	Using the water equivalent thickness (WET) to infer the percent surface dose
20%	5.	1 or 4

10

And the correct answer is:

- 5 - Measurements with a parallel plate ion chamber <u>or</u> Using the water equivalent thickness (WET) to infer the percent surface dose

Reference:

- Olch et al. Dosimetric Effects Caused by Couch Tops and Immobilization Devices – Report of AAPM Task Group 176, Medical Physics, in press.

Some Vendors Supply Attenuation and WET for Their Devices for one location

We recommend they
1) use the cylindrical phantom, beams every 10 degrees, provide attenuation and WET and,
2) identify highest attenuation regions

External Devices Increase Skin Dose

- Most significant clinical effect - a single PA beam (CSI) and/or large daily doses.

- Most people don't have two couchtops, one for minimizing skin dose and one for maximizing image quality.

- New carbon fiber couchtops typically don't come with inserts, they are single solid panels. So you may be stuck with this problem.

Radiation Effects on Skin (and hair)

Table 2. Changes produced by increasing total dose

Schedule dose range Dose fraction single (cGy)	Multiple (200 cGy/day)	Gross change	Onset of change	Functional change
500–700	~ 2,000	Epilation	~ 18 days	
1000–2000	2000–4000	Erythema	12–17 days	Hyperemia
2000–3000			2–6 days	
1000–2000	~ 4500	Pigmentation		None
1000–2000	~ 4500	Dry desquamation	30–70 days	
2000–2400	4500–5000	Moist dequamation that heals	30–50 days	Serum leakage; healing regenerates functional barrier
> 2400	> 5000 > 6000	Moist desquamation does not heal > 50%	30–50 days	Loss of protective barrier
1700–2400	4500–5000	Telangiectasia	6 months-years	None
> 2700	> 6000	Necrosis nonhealing	Months, years	Loss of protective barrier

Archambeau RJ 1995

23.4 Gy single PA oblique to 5 cm depth created 29 Gy dose at skin due to decreased SSD, off axis factor, PDD, and couchtop/vacloc headrest,sometimes FinF also used superiorly

29 Gy at 2.2 Gy/fx

IGRT couchtop
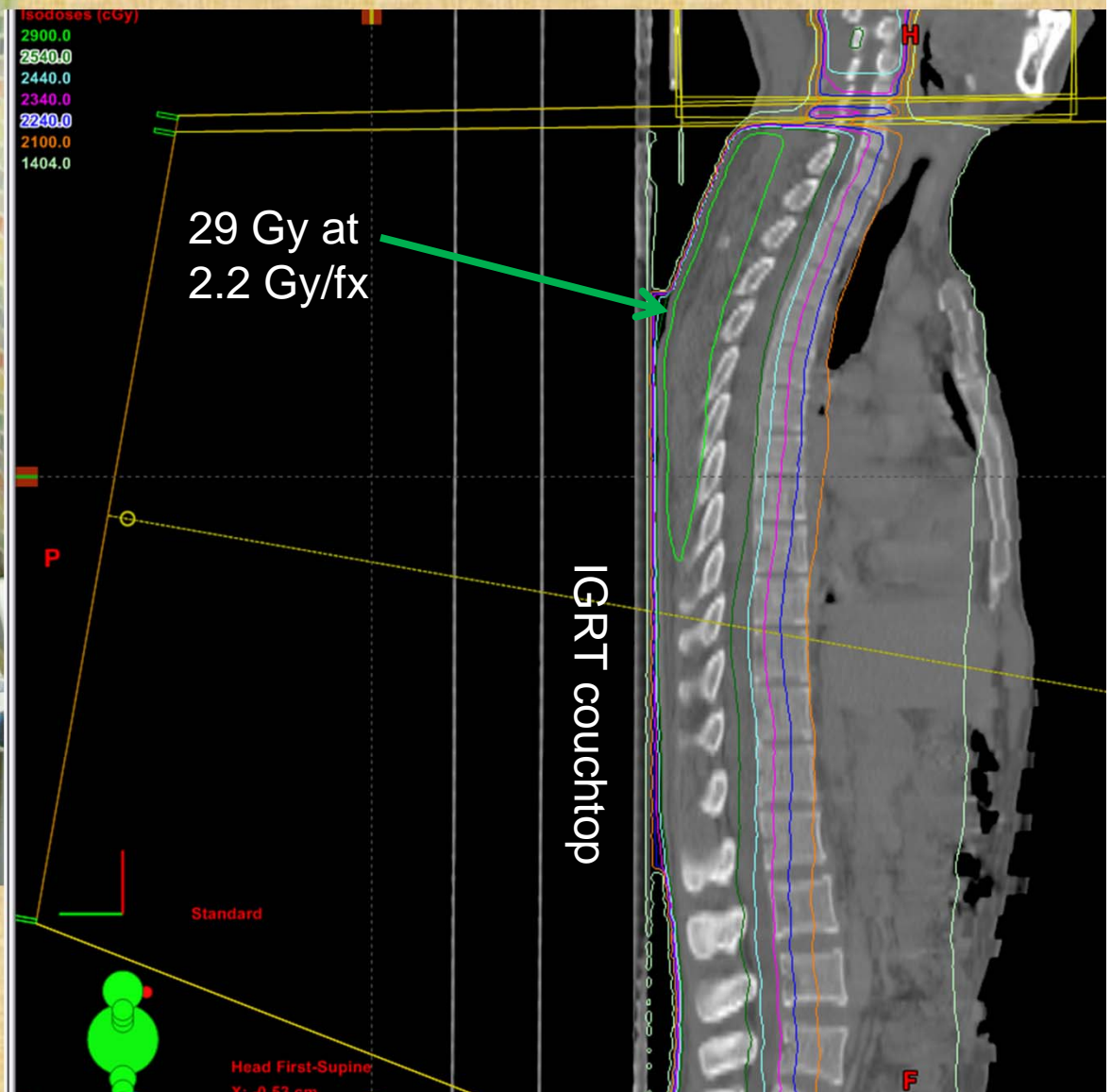
ACUTE SKIN TOXICITY FOLLOWING STEREOTACTIC BODY RADIATION THERAPY FOR STAGE I NON–SMALL-CELL LUNG CANCER: WHO'S AT RISK?

Bradford S. Hoppe, M.D.,* Benjamin Laser, M.D.,* Alex V. Kowalski, B.A.,[†]
Sandra C. Fontenla, B.A.,[†] Elizabeth Pena-Greenberg, R.N.,* Ellen D. Yorke, Ph.D.,[†]
D. Michael Lovelock, Ph.D.,[†] Margie A. Hunt, M.S.,[†] and Kenneth E. Rosenzweig, M.D.*

Fig. 1. Patient who developed Grade 4 skin necrosis from stereotactic body radiation therapy.

7/50 patients had ≥ grade 2 skin toxicity

From Hoppe RJ 2008
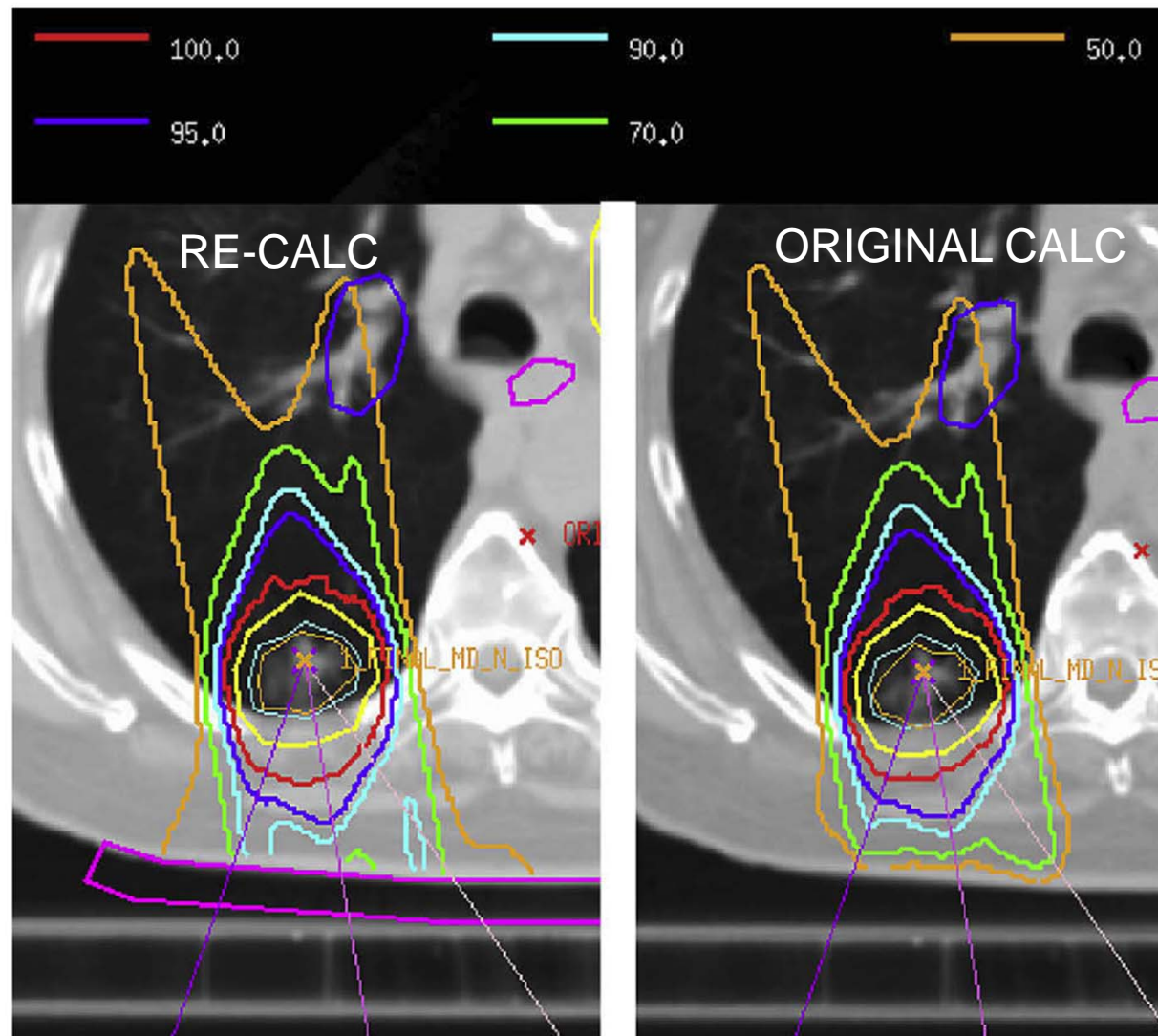
Fig. 2. Treatment plan for the patient that developed Grade 4 skin toxicity with out any corrections for treating through the couch and mobilization device (right) and with 1 cm of bolus to account for the couch and mobilization device (left).

3-field plan gave good dose distribution. 44-60 Gy in 3-4 fx

Targets close to the skin surface susceptible even with many beams

From Hoppe RJ 2008

From Hoppe Paper

With our current image-guided radiotherapy technique, posteriorly directed beams must traverse the couch top (3.5-cm carbon fiber sheath plus foam core), custom immobilization cradle (2 cm of balsa wood and laminate), and between 1 and 7 cm of polyurethane foam, which, when considering the thickness, CT number, and measured attenuation factor of the immobilization material and couch top, we estimate collectively, can result in 1–2 cm of tissue equivalent material. In-house phantom measurements confirm that almost all skin sparing is lost for the beams that pass through this set of devices. In our clinical

In our clinical planning process, treatment aids are not accounted for in dose calculation.

Vac-lock Bags Increase Skin Dose

Table 1

Percentage of maximum dose increases in skin dose caused by introduction of Vacbag material into 6 MV X-ray beam path

	Field size (cm × cm)	Vacbag thickness (cm)		
		0.3	2.5	10
		Percentage increase (of maximum dose) in dose using Vacbag compared to open field		
0.1 mm (Basal layer)	5	11	31	49
	10	14	36	57
	15	18	39	57
	20	23	37	56
	25	21	35	52
	30	22	36	51
1 mm (Dermal layer)	5	8	16	33
	10	8	16	35
	15	9	20	35
	20	8	22	33
	25	8	21	31
	30	7	19	29

Cheung, *Radiation Measurements* 2002
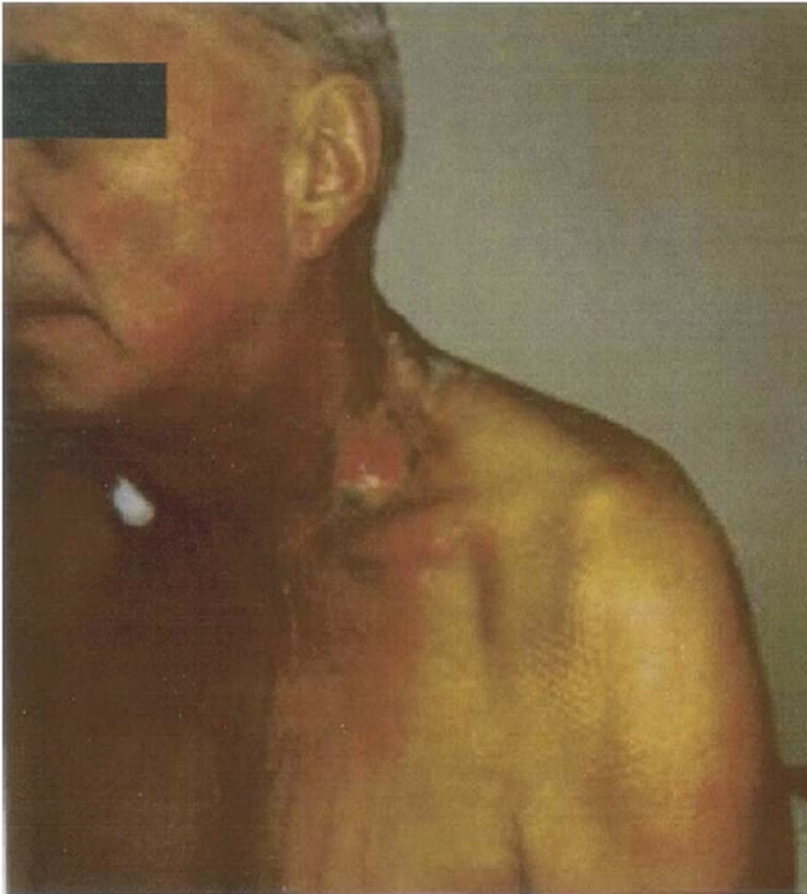
Masks Contribute to Increased Skin Dose

Fig. 2. Patient with T2N2c carcinoma of the base of tongue who underwent EF-IMRT. This patient had RTOG Grade 3 skin toxicity in the middle of the treatment and required a treatment break.

Table 3. TLD measurements for EF-IMRT plan with CTV contoured 5 mm away from skin

Location	With mask (Gy)	Without mask (Gy)	Difference* (%)
TLD 1	1.52	1.24	22.6
TLD 2	1.67	1.29	29.5
TLD 3	1.45	1.23	17.9
TLD 4	1.65	1.42	16.2
TLD 5	1.60	1.36	17.6
TLD 6	1.25	0.94	33.0
Average	1.52 ± 0.16	1.25 ± 0.17	22.2 ± 7.0

* Dose difference = 100(dose with mask − dose without mask)/ dose without mask.

Abbreviations: CTV = clinical target volume; other abbreviations as in T[...]

Skin toxicity in IMRT for head-and-neck cancer ● N. LEE *et al.*

Lee RJ 2002

Fig. 1. Example of patient immobilized with a head, neck, and shoulder mask.

Surface Dose with Mask Depends on Degree of Stretching

TABLE 3. Estimates of the surface dose relative to d_{max} each n density and thickness of the mask are presented for comparison.

	% Area increase- nominal	Surface dose 6 MV
no mask		16%
small	0%	61%
holes	125%	48%
mask	300%	35%
	525%	29%

Hadley 2009 JACMP

Surface Dose Effects -sample

(19 published studies)

Study reference	Device	Delivery type	Beam Angle(s)	Depth from surface [cm]	Surface dose in % of D_{max} / Open field dose in % of D_{max}	Detector type
Butson et. al.[19]	Carbon fiber grid tabletop (Varian)	single beam	0°(*) 15°(†) 30°(†) 45°(†) 60°(†)	0.015	32% (6 MV) / 19% 38% (6 MV) / 19% 41% (6 MV) / 19% 49% (6 MV) / 19% 62% (6 MV) / 19%	Ion chamber parallel-plate EBT Gafchromic film
Higgins et. al.[20]	Carbon fiber insert (Sinmed)	single beam	normal incidence	0.0	68% (8 MV) / 18%	Ion chamber parallel-plate (PTW)
Lee et. al.[21]	Carbon fiber tabletop + vacuum immobilization device	IMRT single fraction	5-field/ 2 posterior	0.0	58% (10MV) / NA	TLD
Berg et. al.[10]	Contessa tabletop Candor Aps Contessa tabletop + breastboard Candor Aps	single beam	0°(*) 0°(*)	0.5	97% (6 MV) / 83% 79% (18MV)/ 59% 100% (6 MV) / 83% 93% (18MV) / 59%	Ion chamber parallel-plate (PTW)

Transmission and surface dose measurements are important but:

The best way to deal with external devices is for them to be present in the planning CT dataset and for the TPS to calculate the dose accounting for the external device

External Devices Can be Included in TPS Calc
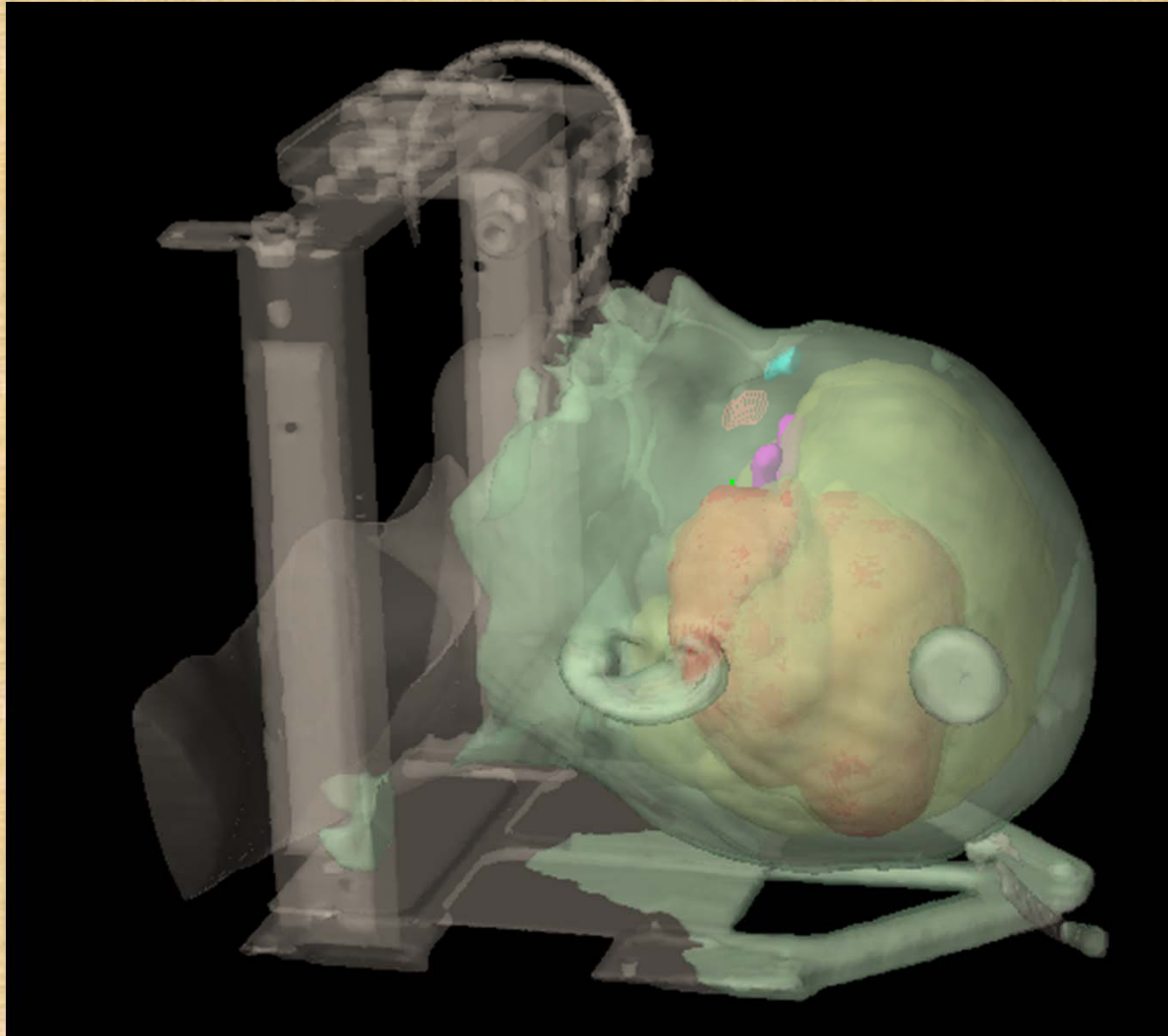
Couch tops and immobilization devices can increase the skin dose:

20%   1.   Although measureable, never clinically significant

20%   2.   More likely for midline targets and large daily dose

20%   3.   To 100% of the prescribed dose

20%   4.   Only when both are present

20%   5.   Only for SBRT treatments
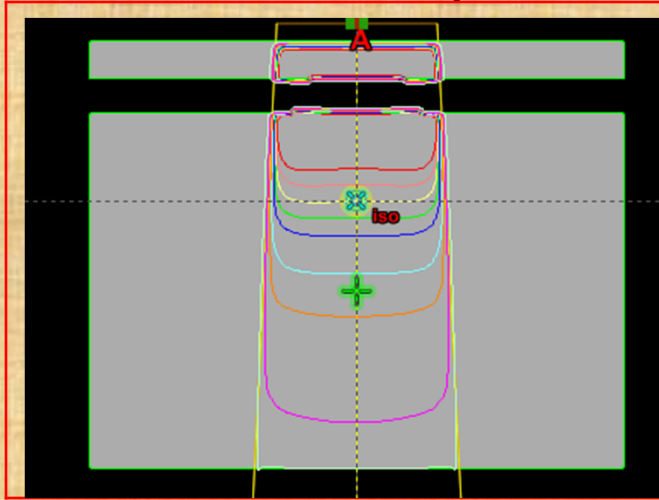
10

And the correct answer is:

- 3 - To 100% of the prescribed dose

Reference:

- M. Berg, J. P. Bangsgaard and I. S. Vogelius, "Absorption measurements on a new cone beam CT and IMRT compatible tabletop for use in external radiotherapy," Physics in Medicine & Biology 54, N319-328 (2009).

Discover Your Treatment Planning System Limitations
Simple Calculation You Can Do

Two body contours : 2 cm slab + 2 cm air gap, then rest of phantom.
Attenuation calculation

One body contour enveloping 2 cm slab, 2 cm air gap, rest of phantom.
(*Inhomogeneity calculation*)

We found- Eclipse and XIO, Same dose to point in larger slab in either geometry -

Hand Calc confirms correct dose within 1%.

Air gaps, loss of scattering from first object into second, decreases surface dose and dose at depth

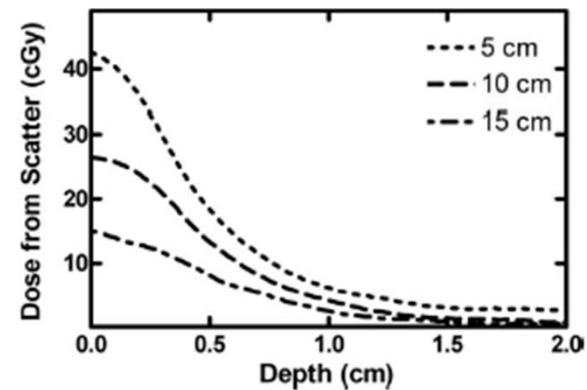Increasing air gap decreases surface dose
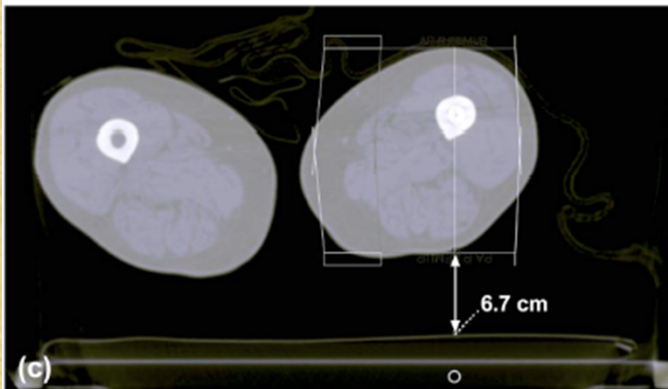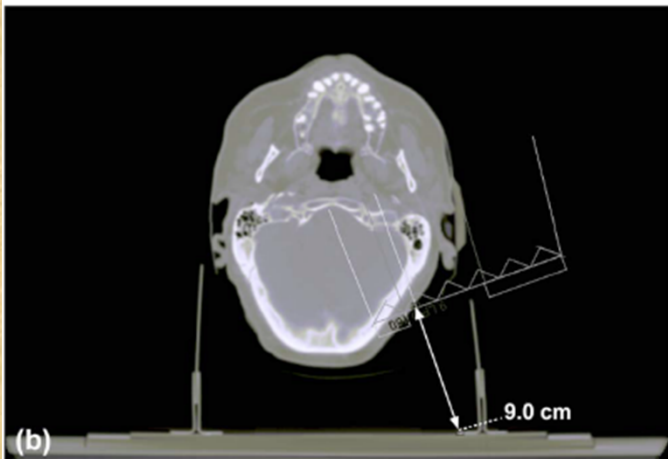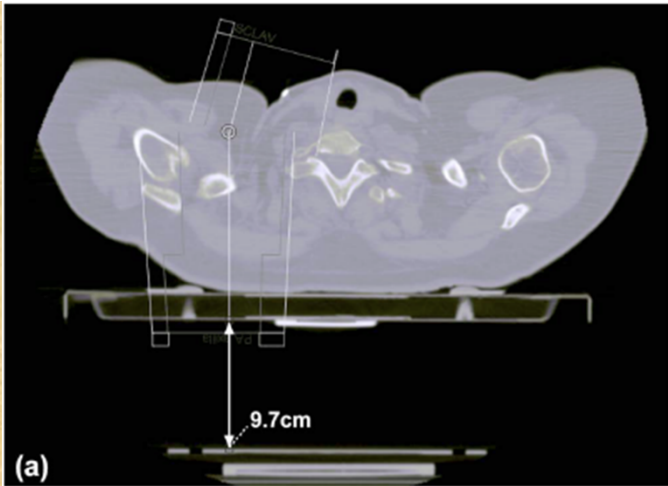

FIG. 7. The dose at depth produced from scatter created by a 2 cm water equivalent slab positioned before 5, 10, and 15 cm air gaps (100 MUs, 6 MV photon beam, 10×10 cm² field size, 100 cm SSD to the surface of the water phantom).

Gray MP 2009

D-max Increases with Air Gap
Skin-Sparing Redevelops

TABLE IV. Depth of dose maximum (cm) in a water phantom determined experimentally for 0.2–4 cm of RW3 positioned before a 1–15 cm air gap (100 MUs, 6 MV photon beam, 10×10 cm^2 field size, 100 cm SSD to the surface of the water phantom). A value of zero indicates that the maximum dose was at the surface of the phantom. The depth of dose maximum measured for an open field was 1.34 cm.

Thickness of RW3 (cm)	Air gap (cm)						
	1	3	5	8	10	12.5	15
0.2	1.12	1.13	1.18	1.17	1.12	1.26	1.30
0.5	0.86	0.86	0.84	0.91	0.94	1.05	1.13
1	0	0.34	0.56	0.87	0.84	0.94	1.13
2	0	0	0.41	0.72	0.83	0.93	1.05
3	0	0	0.44	0.72	0.80	0.88	1.05
4	0	0	0.36	0.72	0.84	0.92	1.05
4	0.20	0.48	0.73	0.95	0.98	1.20	1.20

AAA Calc

Gray MP 2009

TPS Vendors are Beginning to Provide Tools We Need
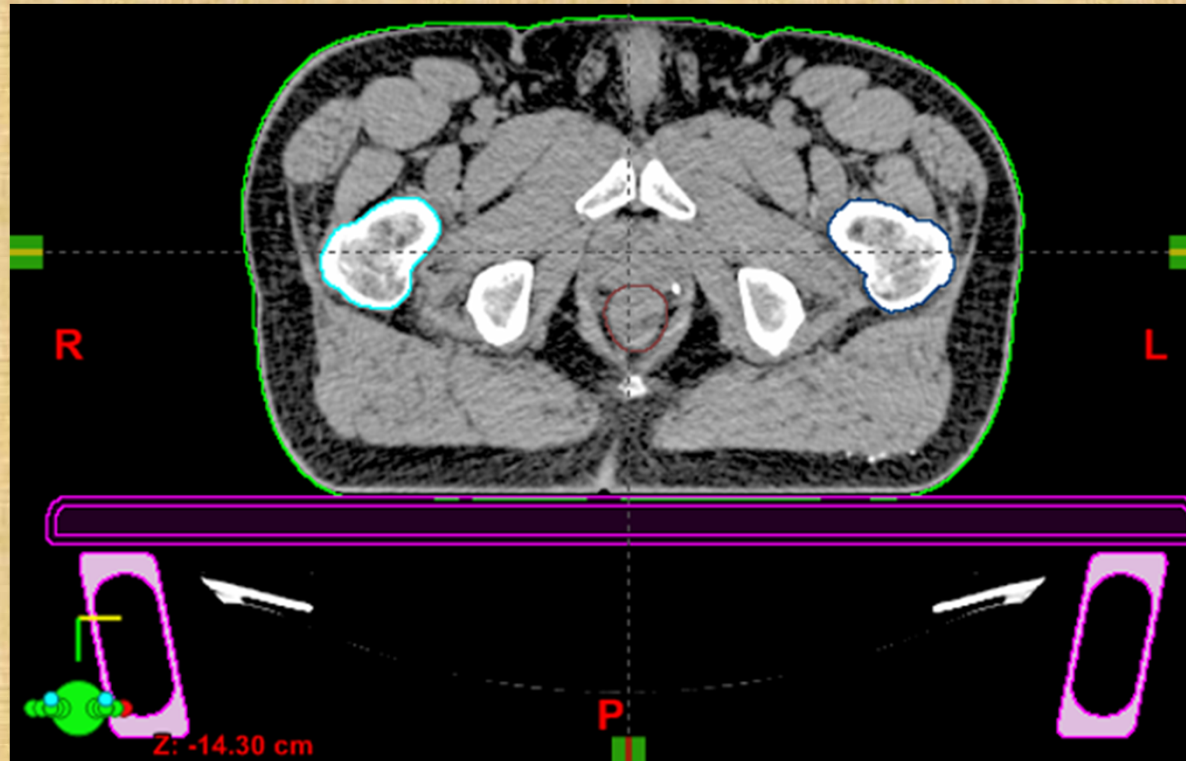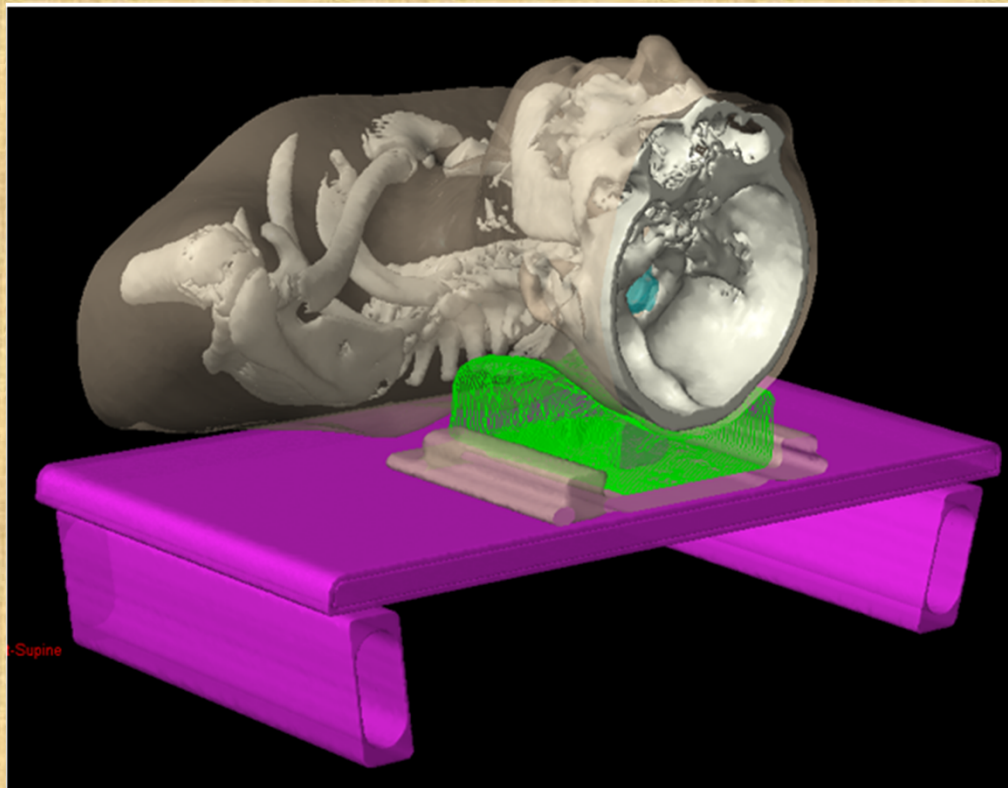
Eclipse Allows limited Couchtop Selection (Varian only) and Placement Under Patient

Vanetti – PMB 2009

The impact of treatment couch modelling on RapidArc
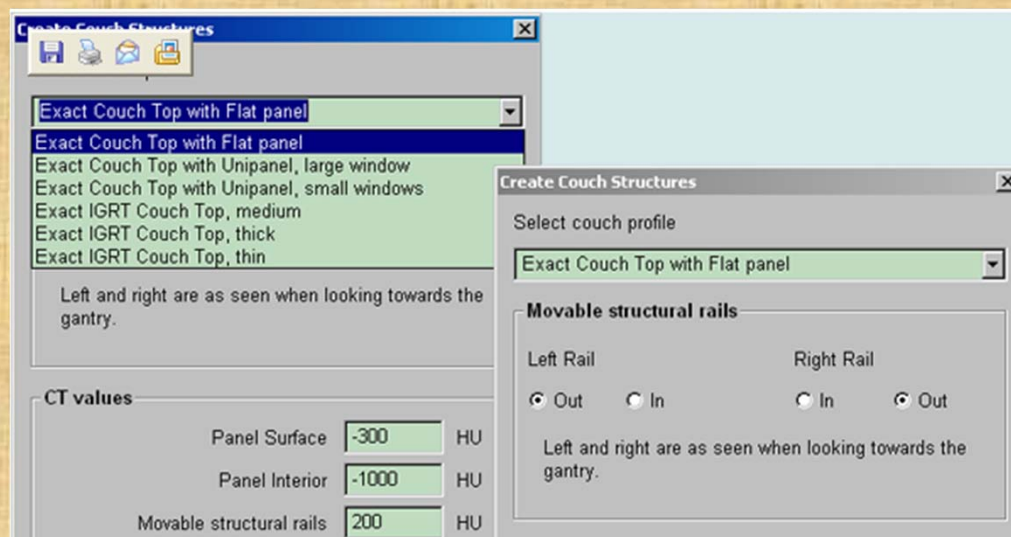
The impact of treatment couch modelling on RapidArc   N161

Table 1. Experimenta
15 MV beams and for
are expressed as couch

Table 2. Difference between plans calculated for the thick couch model and for the no couch model.

Organ	6 MV Mean (Gy)	15 MV Mean (Gy)
PTVI	1.3 ± 0.3	0.9 ± 0.2
PTVII–PTVI	0.7 ± 0.2	0.5 ± 0.1
Rectum	0.6 ± 0.2	0.4 ± 0.1
Bladder	0.6 ± 0.2	0.4 ± 0.1
Femurs	0.04 ± 0.01	0.03 ± 0.01
Healthy tissue	0.2 ± 0.1	0.1 ± 0.1

1.3Gy/50 Gy=2.6%

		Measurement PA180	OBL225
6 MV	TK	−3.1%	−4.4%
	MD		
	TN		
15 MV	TK		
	MD		
	TN		

Some centres apply a simplified procedure of increasing MU of fixed percentage (e.g. 2%) for beams crossing the couch. If this seems to be acceptable for fixed beam arrangements, it is less appropriate for rotational techniques where fractions of the entire beam are affected by couch attenuation.

necessary. The results showed that (i) there is no measurable effect if the wrong segment of the couch is used in the calculations, (ii) there are significant and of potential clinical impact discrepancies at the level of the target volumes if calculations are performed without couch and delivery is (obviously) performed with couch and (iii) the effect is particularly relevant at low energy (6 MV in this case).

S = couch surface, I = couch internal.
Attenuation = $100*(L_{couch} - L_{no\_couch})/L_{no\_couch}$.

Rapid Arc Treatment Through Couchtop Can also Impact on Dose Distribution

(Gamma Index)

Table 3. Summary of pre-treatment verification measurements (with detectors positioned on the TK couch segment) of plans computed with TK couch and NO couch.

	TK couch	NO couch
GAI (%)	94.9 ± 2.6	92.4 ± 6.1
Range (%)	94.8–100	85.9–100

Vanetti 2009

Dosimetric Effects of Couch Adequately Calculated if Properly Modeled in Pinnacle V8.0d
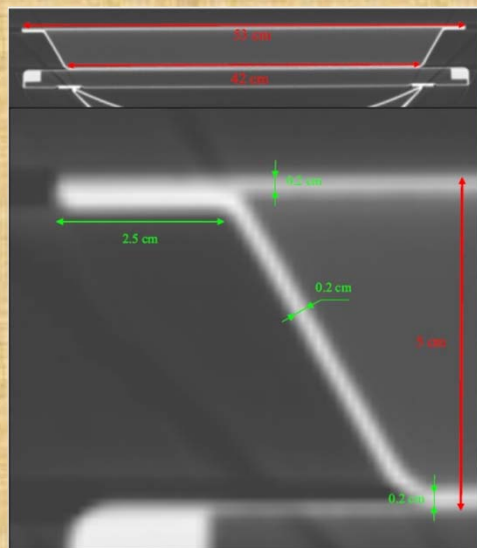
Mihaylov et al.: Carbon fiber couch modeling with a commercial TPS   Mihaylov Med Phys 2008

TABLE I. Comparison between measured and computed doses, as modified by the *ExacTrac* carbon fiber couch. The measurements and the calculations are performed for five posterior angles for both available photon energies. A field size of 10×10 cm^2 was used for the results presented in the table. Each portal was irradiated multiple times with 100 MU. The reported measured doses are averages from the multiple measurements. The results in the parentheses in the last two columns represent the standard deviation of the measured average dose.

Energy (MV)	Beam angle (°)	Delivered MU	Calculated dose (cGy)	Measured dose (cGy) [Uncertainty (cGy)]	Difference with respect to measurement (%) [Uncertainty (%)]	Measured % attenuation
6	0	100	96.00	95.84 (±1.4)	0.17 (1.5)	3.2
6	30	100	94.40	94.65 (±1.3)	0.26 (1.4)	3.2
6	50	100	89.70	88.79 (±1.2)	1.02 (1.4)	5.6
6	75	100	66.00	64.95 (±1.1)	1.62 (1.7)	8.6
6	83	100	58.40	59.39 (±1.1)	1.67 (1.9)	5.0
18	0	100	106.40	105.80 (±1.2)	0.57 (1.1)	0.1
18	30	100	105.40	105.95 (±1.1)	0.52 (1.0)	0.6
18	50	100	102.00	102.17 (1.1)	0.17 (1.1)	2.6
18	75	100	85.60	84.93 (±1.0)	0.79 (1.2)	5.0
18	83	100	79.20	80.41 (±1.3)	1.50 (1.6)	2.9

Up to 8% attenuation without modeling in TPS

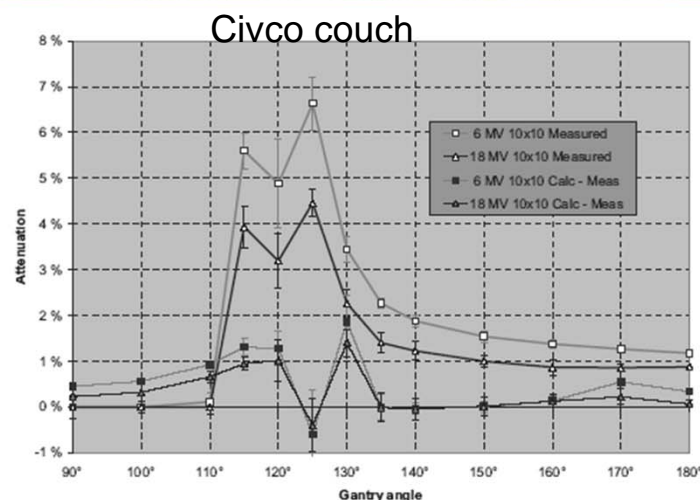# Dosimetric Effects of Couch Adequately Calculated by Xio

Civco couch

FIG. 4. Percentage attenuation of the Siemens 6 and 18 MV beams by the CIVCO couch as a function of gantry angle for a 10×10 cm^2 field. Also shown is the difference between the measured attenuation and that calculated by XiO.

Medical Intelligence couch

FIG. 5. Percentage attenuation of the Elekta 6 and 10 MV beams by the MI couch as a function of gantry angle for a 10×10 cm^2 field. Also shown is the difference between the measured attenuation and that calculated by XiO.
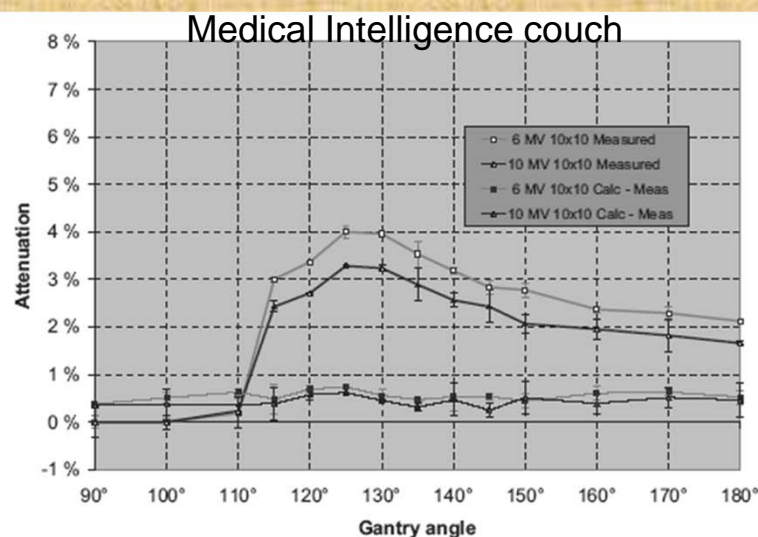
TABLE I. Result summary.

Energy (MV)	Machine	Couch	Surface dose (% of max)			Physical	Radiological	
			Measured (%)	Calculated (%)	Difference (%)	Thickness (mm)	Thickness (mm)	Shift (mm)
6	Elekta	None	17	40	23	...	...	...
		MI	89	86	−3	50.0	6.3	6.5
6	Siemens	None	17	53	36	...	...	...
		CIVCO	77	73	−4	13.0	4.2	4.3
10	Elekta	None	13	34	21	...	...	...
		Mi	75	75	0	50.0	6.3	6.5
18	Siemens	None	10	31	21	...	...	...
		CIVCO	49	42	−7	13.0	4.2	4.4

Gerig *Med Phys* 2010

Addition of Couch Structure into CT Dataset

- Best method is to use TPS supplied couch model that correctly matches your couch top

- Use image editing software to overwrite the CT couch pixel data with the CT-scanned treatment couch- not practical for most

- Use image-fusion (Scanned treatment couch fused to planning CT) to bring in a Dicom RT structure set representing the treatment couch, need to define HU values

- Manually draw in the Treatment couch and assign HU values to its parts, save as dataset for registration to future cases.

Validate Your Couch Model

- Make measurements of attenuation for a range of posterior beam angles which you can also calculate in the TPS.

- Tweak HUs for couch sections to optimize measured vs. calculated dose agreement

An <u>accurate</u> and <u>efficient</u> way to handle the treatment couch in the planning system is to:

20%	1.	Manually draw the couch top for each case
20%	2.	Remove all traces of the couch in the CT images and ignore the small dose perturbation
20%	3.	Use the TPS vendor supplied couch model for your couch
20%	4.	Use image fusion to insert the couch
20%	5.	Contour the CT couch that is in the CT image and use that for planning

And the correct answer is:

- 3 - Use the TPS vendor supplied couch model for your couch

Reference:

- Olch et al. Dosimetric Effects Caused by Couch Tops and Immobilization Devices – Report of AAPM Task Group 176, Medical Physics, in press.

- L. H. Gerig, M. Niedbala and B. J. Nyiri, "Dose perturbations by two carbon fiber treatment couches and the ability of a commercial treatment planning system to predict these effects," Medical Physics 37, 322-328 (2010).

- I. B. Mihaylov, P. Corry, Y. Yan, V. Ratanatharathorn and E. G. Moros, "Modeling of carbon fiber couch attenuation properties with a commercial treatment planning system," Med Phys 35, 4982-4988 (2008).

Strategies to Avoid External Devices

(If you can't calc it, avoid it)

TABLE II. A comparison of model generated and measured range of gantry angles for which part of the beam passes through the couch support assembly for variety of situations. Angles and dimensions are represented in degrees and cm, respectively.

Couch height z_r	Couch lat. l_{at}	Couch rot. ϕ	Coll. rot. κ	Jaws (X_1,X_2,Y_1,Y_2)	Gantry range (θ_1,θ_2) model	Gantry range (θ_1,θ_2) meas.
−10	0	0	0	(10,10,10,10)	(264.2, 214.8)	(264.0, 214.2)
−10	0	0	45	(10,10,10,10)	(95.8, 151.3)	(96.3, 151.0)
−10	10	0	0	(10,10,10,10)	(264.1, 192.7)	(264.0, 191.9)
−15	0	0	0	(10,10,10,10)	(254.3, 210.4)	(254.0, 210.0)
−10	0	0	0	(5,5,5,5)	(257.1, 221.7)	(256.4, 220.9)
−10	0	0	45	(5,10,5,10)	(264.3, 213.9)	(263.7, 213.6)
−10	−10	25	0	(10,10,10,10)	(95.8, 173.9)	(96.0, 173.9)
−10	−10	0	0	(10,10,10,10)	(95.9, 167.3)	(95.6, 167.1)
−10	5	10	0	(10,10,10,10)	(264.2, 202.5)	(263.7, 201.8)
−10	5	0	0	(10,10,10,10)	(264.2, 204.9)	(263.6, 203.9)
−10	0	10	20	(10,0,10,−5)	(261.1, 225.8)	(260.8, 225.4)
−10	0	0	20	(10,0,10,−5)	(260.9, 223.8)	(260.3, 223.4)

Muthuswamy *Med Phys* 1999
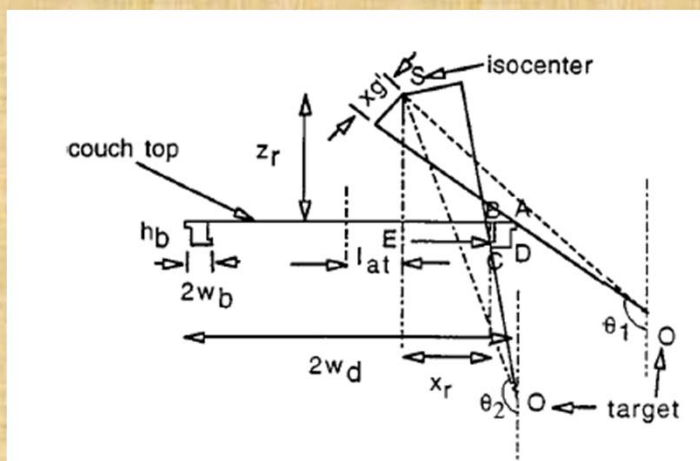
Accommodation of couch constraints for coplanar intensity modulated radiation therapy
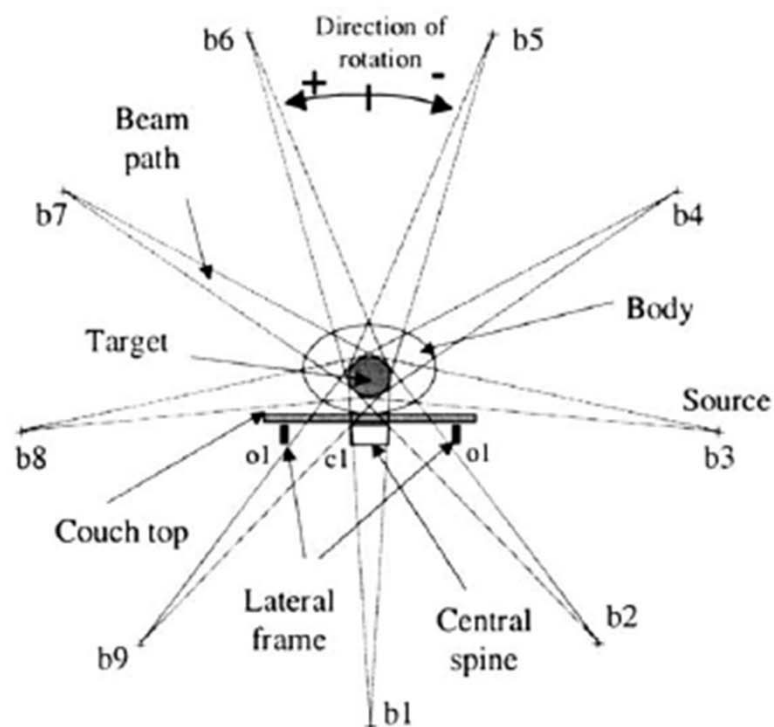
(a) Varian standard couch with central spine or movable rails
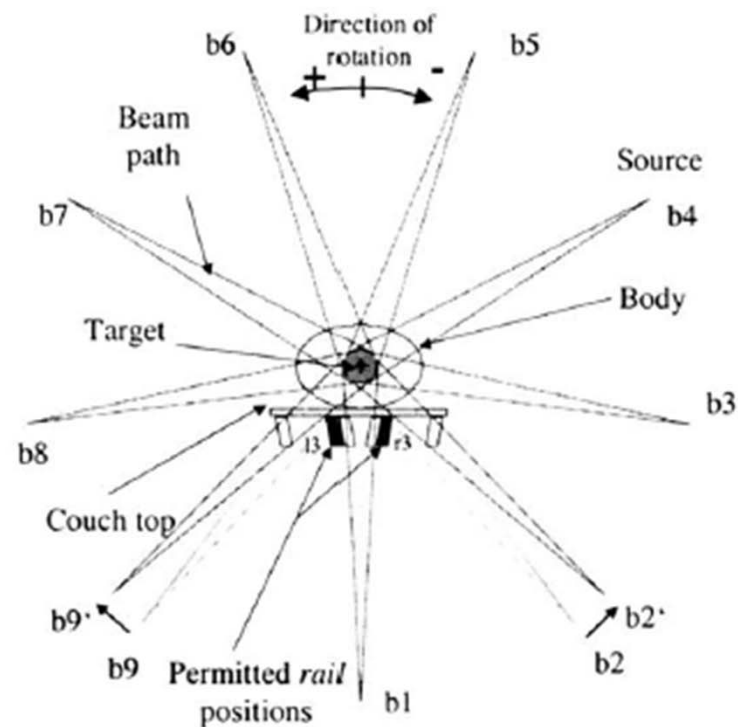
(b)
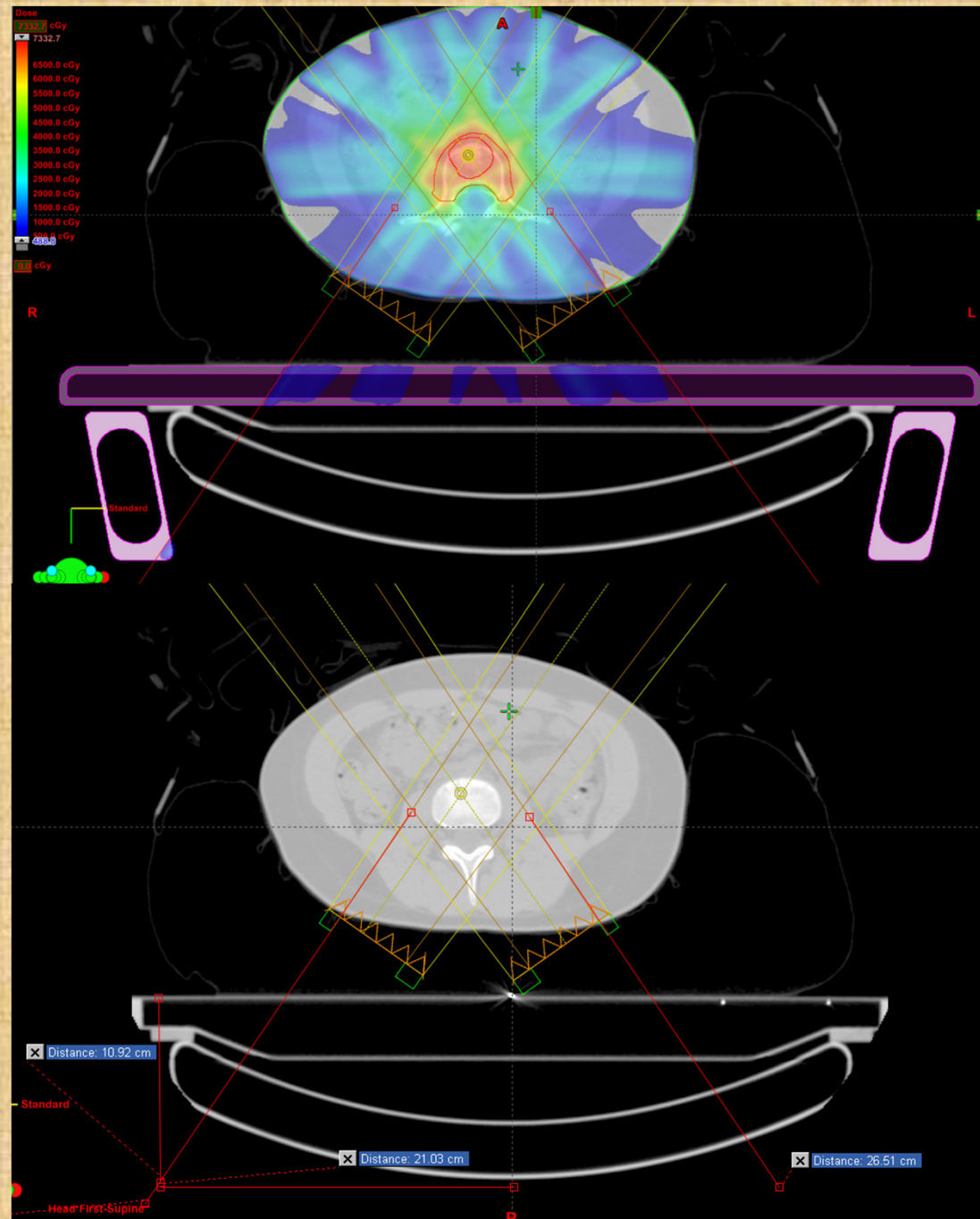
Meyer, Radiotherapy and Oncology 2001

Rules for Couch Rail Avoidance
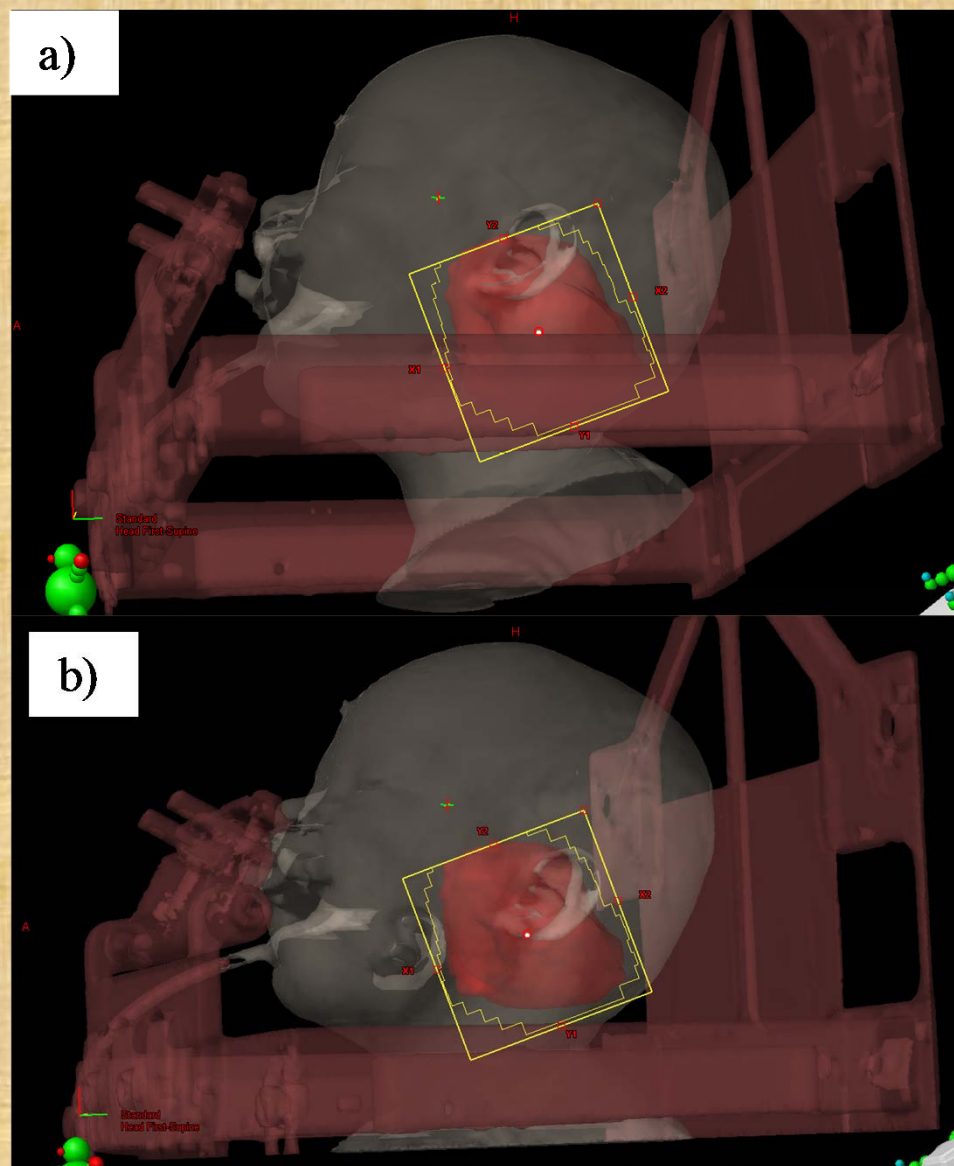
When 7-9 eq. spaced beams were desired, found that about 70% of the time, beam angles had to be changed to avoid passing through couch rails/supports

Do-it-Yourself Couch Rail Entry

Beam's-Eye-View Immobilization Structure Avoidance

User Recommendations

- **If possible, buy matching couch tops for CTSIM and Treatment.**

- **Understand the physical dimensions of your couchtop, where are the solid sections, what are the dimensions? CT the couchtop before installation, at least take MV images of it throughout the treatment region. Determine the capabilities of your planning system, can it accurately calculate the dose through structures external to the "Body".**

- **Validate by measurement the TPS calcs of external devices.**

- **All immobilization devices used for treatment should be in the CT dataset within the FOV.**

- **Determine if your strategy is modelling, avoidance, or compensation.**

Vendor Recommendations

- **TPS vendors: An accurate model of couchtops should able to be automatically inserted at the time of planning so the TPS can calculate the dose accounting for the external device**

- **Couchtop vendors: We will be recommending specific attenuation and surface dose measurement methods and reporting requirements. Recommend a Dicom RT structure set file or other geometric model of the couch be provided to TPS vendors/users.**

The End

- Questions ???

Eclipse Dose Errors 2-3% for Air Gaps Between 2cm Slab and Phantom (6MV)

		Air gap								
		1 cm					5 cm			
		PBC		AAA			PBC		AAA	
Depth (cm)	Measured dose (cGy)	Dose (cGy)	Difference (%)	Dose (cGy)	Difference (%)	Measured dose (cGy)	Dose (cGy)	Difference (%)	Dose (cGy)	Difference (%)
0	102.1	102.8	0.6	64.3	−37.0	95.5	102.5	7.4	79.5	−16.7
0.5	99.5	100.6	1.2	100.7	1.2	97.2	100.4	3.3	97.4	0.2
1	97.0	98.4	1.5	98.8	1.9	95.4	98.1	2.8	97.0	1.6
5	79.8	81.2	1.7	81.5	2.0	79.1	80.8	2.2	80.7	2.0
10	60.9	62.3	2.3	62.4	2.5	60.5	62.1	2.6	61.8	2.1
15	46.1	47.3	2.5	47.3	2.6	45.9	47.0	2.3	46.9	2.1

		Air gap								
		10 cm					15 cm			
		PBC		AAA			PBC		AAA	
Depth (cm)	Measured dose (cGy)	Dose (cGy)	Difference (%)	Dose (cGy)	Difference (%)	Measured dose (cGy)	Dose (cGy)	Difference (%)	Dose (cGy)	Difference (%)
0	79.4	102.8	29.4	72.9	−8.2	67.9	103.0	51.7	68.6	1.0
0.5	91.9	100.4	9.2	94.5	2.8	86.9	100.8	15.9	91.9	5.8
1	93.5	97.8	4.6	96.1	2.8	91.8	97.1	5.8	95.1	3.5
5	78.2	80.7	3.2	80.6	3.1	78.0	80.4	3.1	80.8	3.6
10	60.1	61.9	3.0	61.9	3.0	59.8	61.7	3.1	61.8	3.4
15	45.5	46.8	2.7	47.0	3.1	45.6	46.5	2.0	46.9	2.9

Gray MP 2009
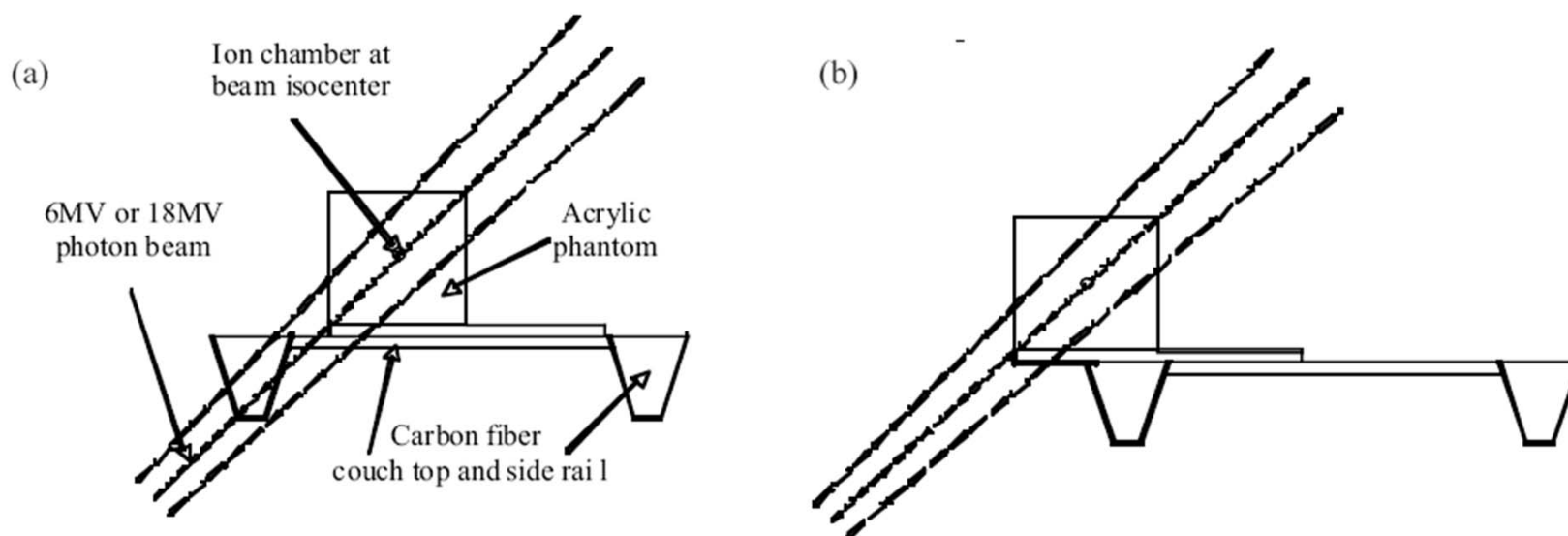
Ion Chamber Measurement of Attenuation by Couch

Fig. 1. The experimental geometry for in-phantom measurement of dose reduction, calculated by the ratio of readings (a) with and (b) without the couch. In-air measurements were made under identical geometry except the phantom is replaced with brass buildup caps.

Myint JACMP 2006

Sometimes You just Can't Avoid It
Frog-Leg Over Rail, APPA