



Mammosite Accelerated Partial Breast Brachytherapy

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Administrative note about this SAM/CE activity:

SAM participants: get a SAM handout, complete it, and return it to the FLAAPM Secretary for processing.
You will not receive SAM credit unless FLAAPM gets a completed SAM participation form from you.

Participants will receive performance evaluation:

- An overall score
- Documentation of own vs. correct responses
- Feedback/references for incorrect responses
- Comparison of personal score to score distribution of the group

Partial list of references

AAPM 2005 Brachytherapy Summer School

-Ch. 38 (Ouhib) – History and Rationale of APBI

-Ch. 39 (Das) – Interstitial HDR Breast Brachytherapy

-Ch. 40 (Butler) - Mammosite

- Wojcicka J et al JACMP 8(4):176-184, 2007.
- Edmundson G et al IJROBP 52:1132-9, 2002.
- Keisch M et al IJROBP 55:289-93, 2003.
- Kassas B et al MedPhys 31(7), July 2004.
- Kirk M et al MedPhys 31(5), May 2004.
- Shah N et al Cancer 101:727-34, 2004.



<http://education.mammosite.com/>

APBI Rationale

AAPM 2005 Brachytherapy Summer School

-Ch. 38 (Ouhib) – History and Rationale of APBI

- Studies indicate that radiation directed at or near the lumpectomy site provides most of the benefit with respect to minimizing recurrence probability.
- Only 3.8% of patients have a remote recurrence
- 65-100% of recurrences are in the same breast quadrant as the surgery site
- Local recurrences are much more common than remote in-breast recurrences

APBI Patient Selection Criteria

	ABS¹	ASBS²
Age	≥ 45	≥ 50
Diagnosis	Unifocal, invasive ductal carcinoma	Invasive ductal carcinoma or DCIS
Tumor Size	≤ 3 cm	≤ 2 cm
Surgical Margins	(-) margins	(-) at least 2mm all directions
Nodal Status	N0	N0

¹ Arthur et al, Accelerated partial breast irradiation: an updated report from the American Brachytherapy Society. Brachytherapy 1:184-90, 2003.

² Consensus statement for accelerated partial breast irradiation. The American Society of Breast Surgeons, April 30, 2003.

4-5 cm and 5-6 cm balloons available
Elliptical balloon also available*

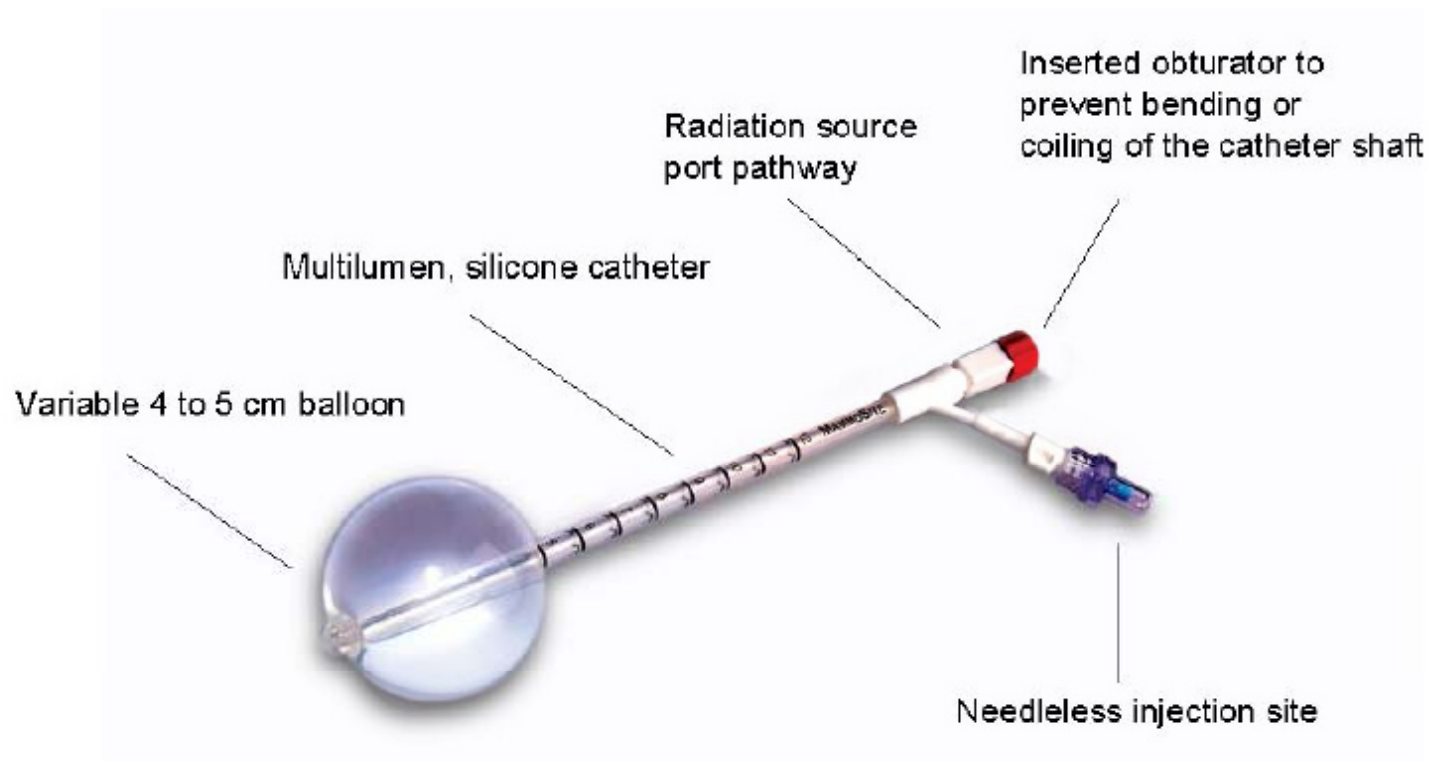
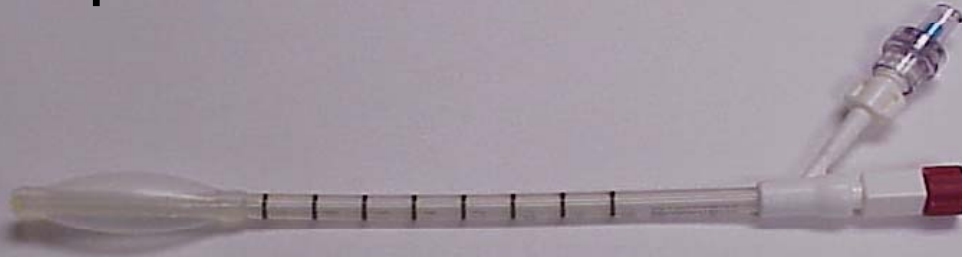


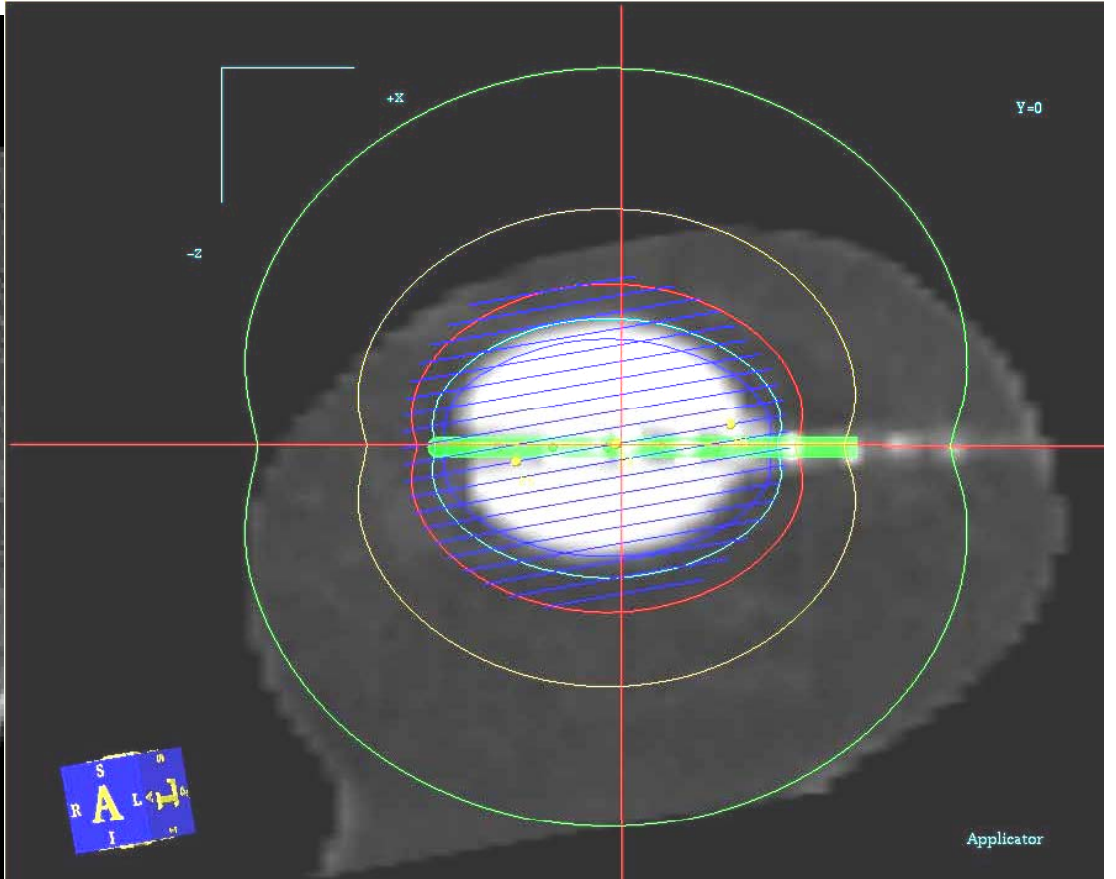
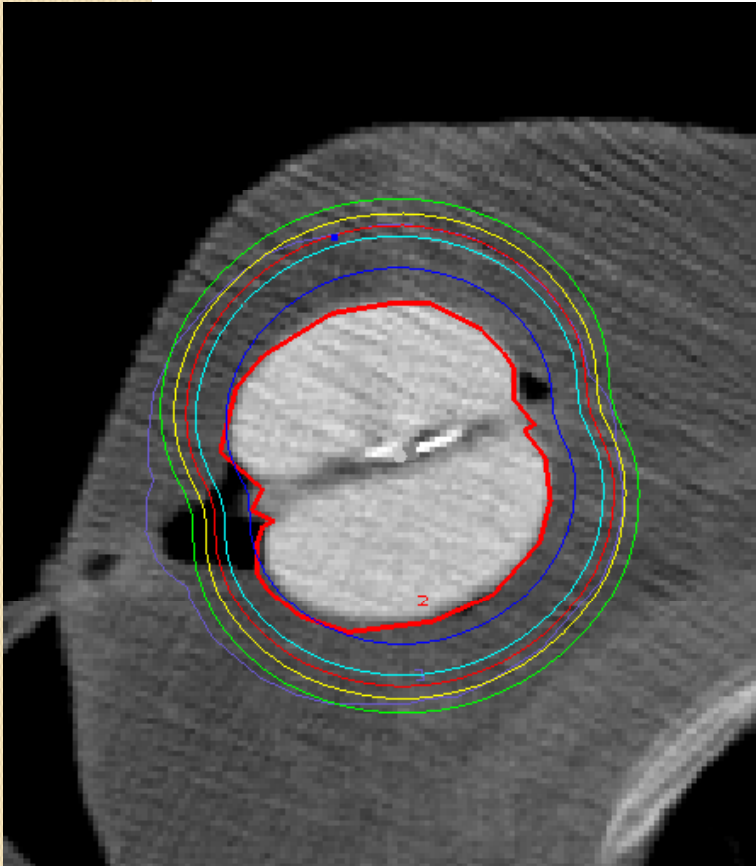
FIG. 1. The MammoSite balloon with components identified. (Image provided courtesy of Cytac Corporation and affiliates.)

Ref: Wojcika et al JACMP 8(4):176-184, 2007.

4-5 cm and 5-6 cm balloons available
Elliptical balloon also available*

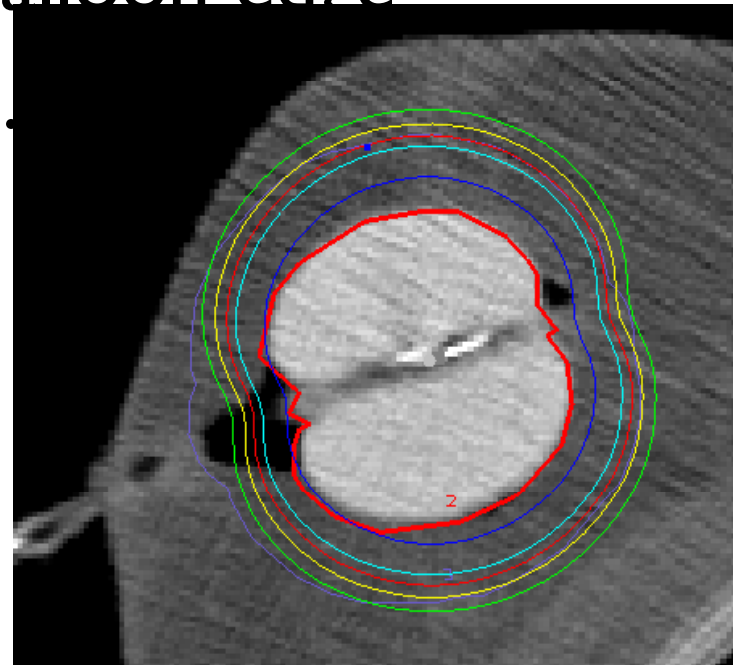


Ref: G. Edmundson et al IJROBP 52:1132-9, 2002



Mammosite

- Balloon distends lumpectomy cavity to conform the target to the treatment, rather than vice versa
- 340 cGy to 1cm beyond balloon edge
- 34 Gy in 10 fractions, b.i.d.





Mammosite Simulation and Appropriateness Criteria

Mammosite Appropriateness Criteria

Skin distance

Minimum distance from balloon to skin ≥ 7 mm (5mm absolute min.)

CT Multiplane reconstruction (MPR) strongly recommended

Symmetry

Balloon center lumen centered

Conformance

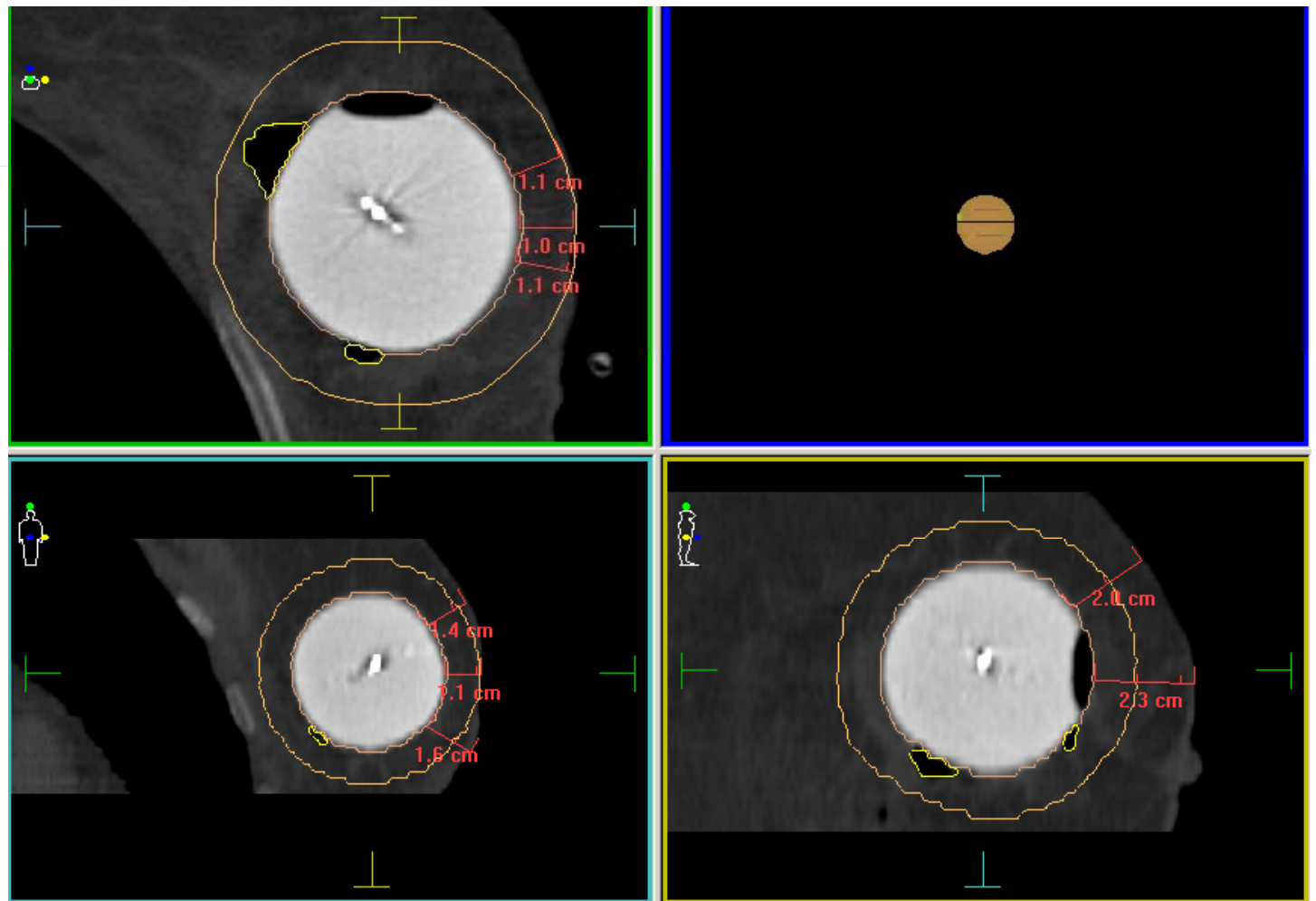
Non-conforming air & seroma total $< 10\%$ of PTV

Mammosite Appropriateness Criteria

Skin distance

Minimum distance from balloon to skin ≥ 7 mm (5mm absolute min.)

CT Multiplane reconstruction (MPR) strongly recommended

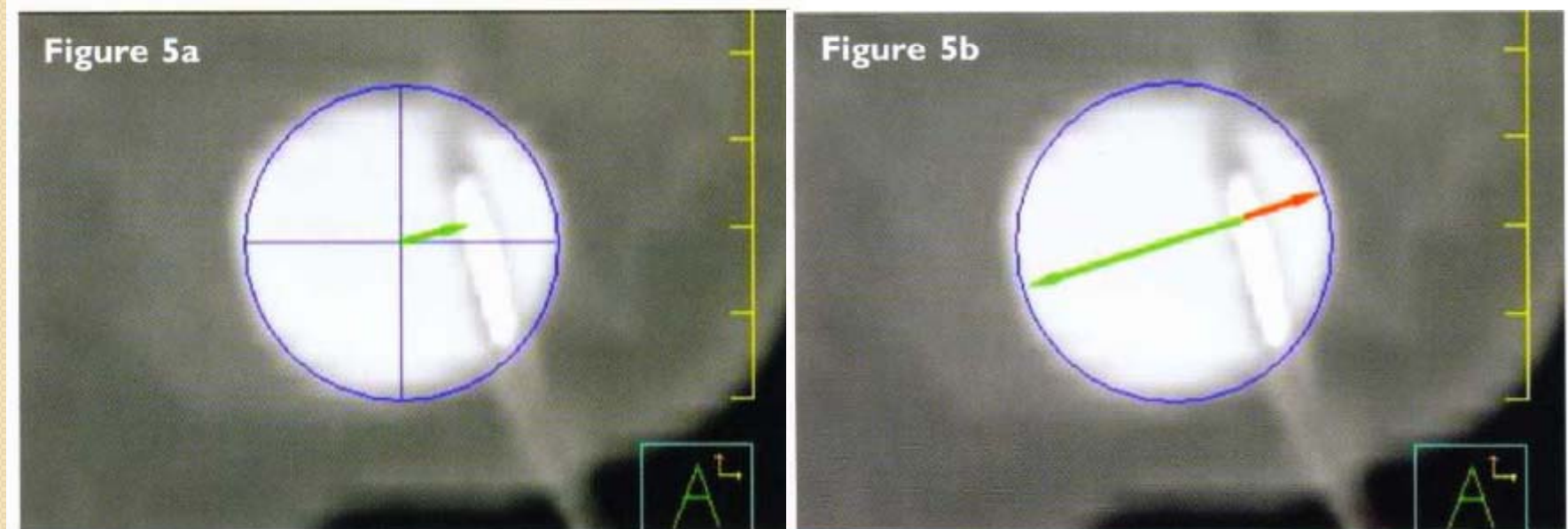


Mammosite Appropriateness Criteria

Symmetry

Balloon center lumen centered within 2mm

Or measure opposed radii to within 4mm



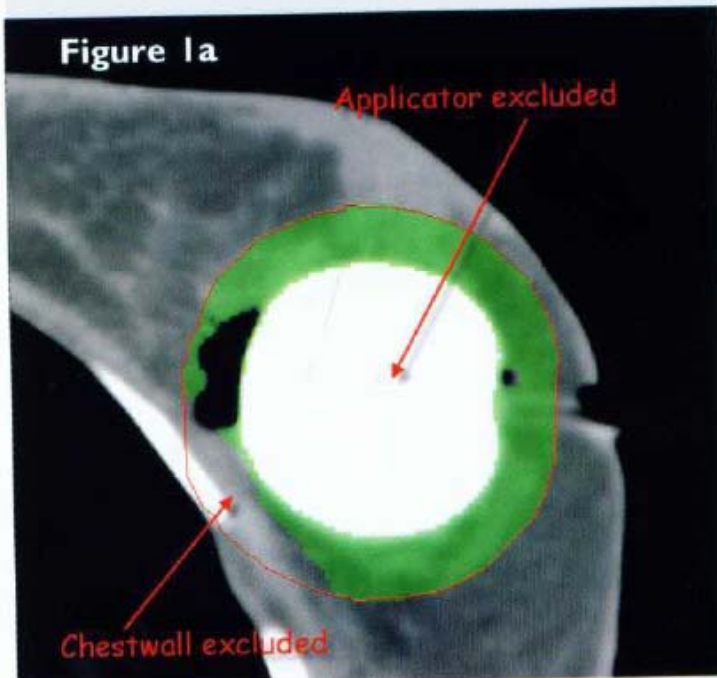
Mammosite Appropriateness Criteria

Conformance

Non-conforming air & seroma total < 10% of PTV

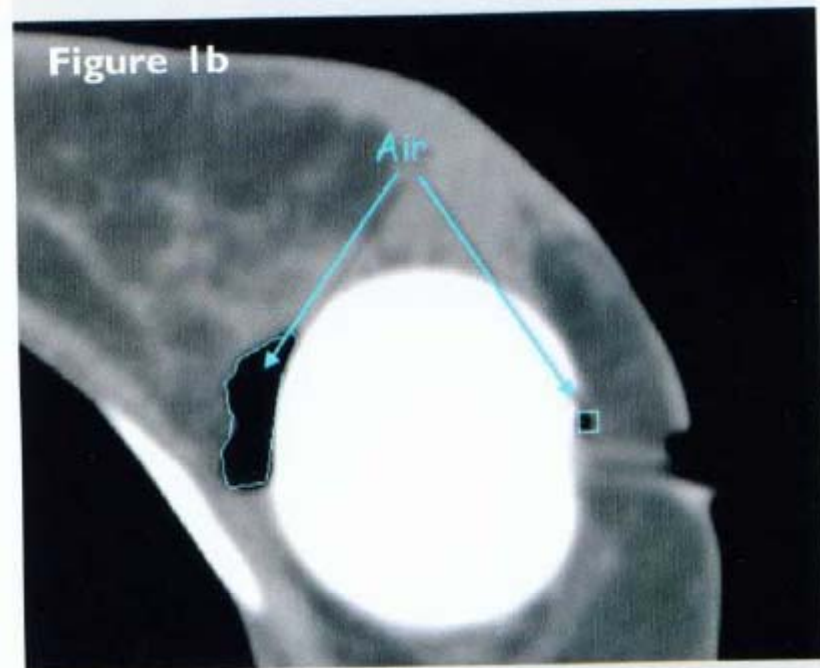
Assessment of Tissue Conformance to Balloon

Figure 1a



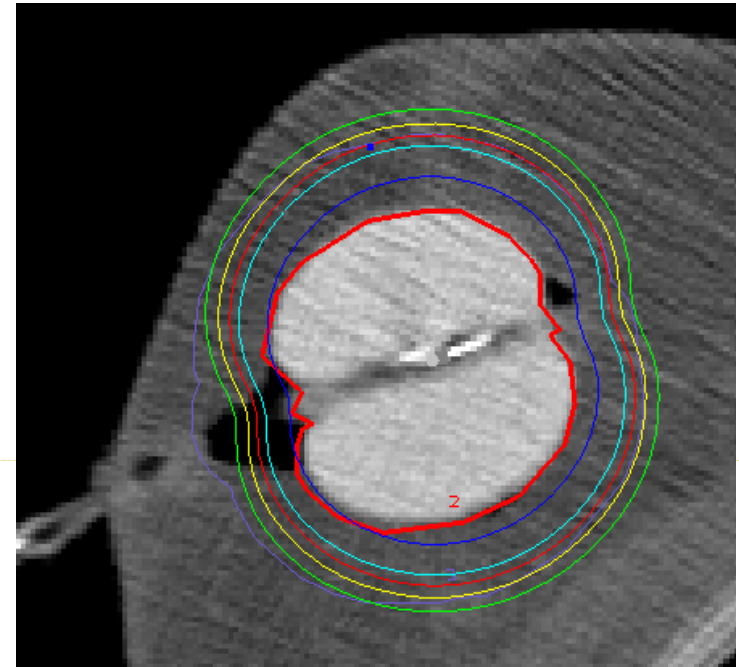
PTV (green) includes only target breast tissue. Other regions have been removed. In this example PTV=93.4 cm³.

Figure 1b



In this example, air volume = 2.2 cm³. Ratio is 0.024. Conformity is 97% $[(93.4-2.2)/93.4 * 100\% = 97\%]$.

Mammosite Simulation Note



- Radiographic contrast in balloon is very helpful
- Limit the amount of contrast to prevent unintended attenuation of HDR source gamma rays
- Larger balloon volumes → contrast agent attenuation more significant
- Higher concentration of contrast agent → more attenuation

Kassas B et al MedPhys 31(7), July 2004.

Mammosite Appropriateness Criteria

MDACC mammosite physics 05-12-05.xls
 approx. criteria

HDR Mammosite
 Appropriateness Criteria Worksheet



Patient Name: _____
 MRN: _____ Date: _____
 Radiation Oncologist: _____ Surgeon: _____
 Surgical Implant Date: _____ Initial Simulation Date: _____
 (FDA mandates a maximum of 28 days in the patient from implant to final treatment.)
 Lot No.: _____ Model / size (circle): 4-6 cm 5-6 cm
 Fill volume (cc) in Mammosite balloon at simulation: _____

1. Tissue Conformance to Balloon

Contour balloon ($V_{balloon}$), then expand 1 cm isotropically. Trim away chestwall, ribs, etc. from the expanded volume. The PTV is the annulus between the expanded, trimmed surface, and the original balloon surface. Contour all air and seroma (V_{NC}). Verify V_{NC} is $\leq 10\%$ of V_{PTV} .

For a balloon inflated to 40 cm^3 , $V_{PTV} = 85$ to 100 cm^3 .



$V_{balloon}$ (cc) = _____
 V_{PTV} (cc) = _____
 V_{NC} (cc) = _____
 V_{NC} (cc) / V_{PTV} (cc) = _____

Conformance result (circle one):

SAT / UNSAT

Physiologist / Date

2. Assessment of Balloon to Skin Distance

Minimum balloon-skin distance via multi-planar reconstruction in axial, sagittal, and coronal planes. (7 mm recommended minimum; 5 mm absolute minimum)

Balloon-skin distance result (circle one):

SAT / UNSAT

Physiologist / Date

Value (cm): _____

3. Assessment of Inflated Balloon Diameter

Measured (CT) diameters should agree with mfr. lookup table values within 2mm.

Ref: Tech. Bull. #2, Table 1/PTV Volume Estimate by Fill Volume*

Balloon diameter result (circle):

SAT / UNSAT

Physiologist / Date

_____ Lookup table width (dia) _____ Measured width (diameter)
 _____ Lookup table length (dia) _____ Measured length (diameter)

4. Assessment of Balloon Symmetry

Locate center of balloon (dwell position) in MPR views. Use opposed radii to determine symmetry of HDR dummy sources.

Specification: HDR dwell position centered within 2mm (opposed radii within 4mm).

Symmetry result (circle):

SAT / UNSAT

Physiologist / Date

Table 2: Physical Characteristics for the Variably Inflated 4-5 cm Mammosite

Mammosite Nominal Fill Volume (cc)	Width (cm)	Length (cm)	Exact Rate (dwell/PTV) (g 1 cm)
24	4.08	4.23	0.42
30	4.15	4.25	0.52
36	4.15	4.33	0.66
40	4.16	4.33	0.77
40	4.16	4.33	0.92
40	4.15	4.33	1.04
40	4.15	4.33	1.17
40	4.15	4.33	1.31
40	4.15	4.33	1.45
40	4.15	4.33	1.60
40	4.15	4.33	1.75
40	4.15	4.33	1.90
40	4.15	4.33	2.05
40	4.15	4.33	2.20
40	4.15	4.33	2.35
40	4.15	4.33	2.50
40	4.15	4.33	2.65
40	4.15	4.33	2.80
40	4.15	4.33	2.95
40	4.15	4.33	3.10
40	4.15	4.33	3.25
40	4.15	4.33	3.40
40	4.15	4.33	3.55
40	4.15	4.33	3.70
40	4.15	4.33	3.85
40	4.15	4.33	4.00
40	4.15	4.33	4.15
40	4.15	4.33	4.30
40	4.15	4.33	4.45
40	4.15	4.33	4.60
40	4.15	4.33	4.75
40	4.15	4.33	4.90
40	4.15	4.33	5.05
40	4.15	4.33	5.20
40	4.15	4.33	5.35
40	4.15	4.33	5.50
40	4.15	4.33	5.65
40	4.15	4.33	5.80
40	4.15	4.33	5.95
40	4.15	4.33	6.10
40	4.15	4.33	6.25
40	4.15	4.33	6.40
40	4.15	4.33	6.55
40	4.15	4.33	6.70
40	4.15	4.33	6.85
40	4.15	4.33	7.00

Table 3: Physical Characteristics for the Variably Inflated 5-6 cm Mammosite

Mammosite Nominal Fill Volume (cc)	Width (cm)	Length (cm)	Exact Rate (dwell/PTV) (g 1 cm)
72	4.87	5.11	0.21
78	4.94	5.11	0.27
80	4.84	5.12	0.30
84	5.15	5.14	0.30
90	5.12	5.13	0.37
96	5.24	5.19	0.50
100	5.12	5.15	0.51
105	5.12	5.15	0.52
110	5.12	5.15	0.53
114	5.12	5.15	0.54
119	5.12	5.15	0.55
120	5.12	5.15	0.56
125	5.12	5.15	0.57
128	5.12	5.15	0.58

* Exact Rate calculation is at 1 cm from the balloon surface

Physiologist Approval (Signature/Date)

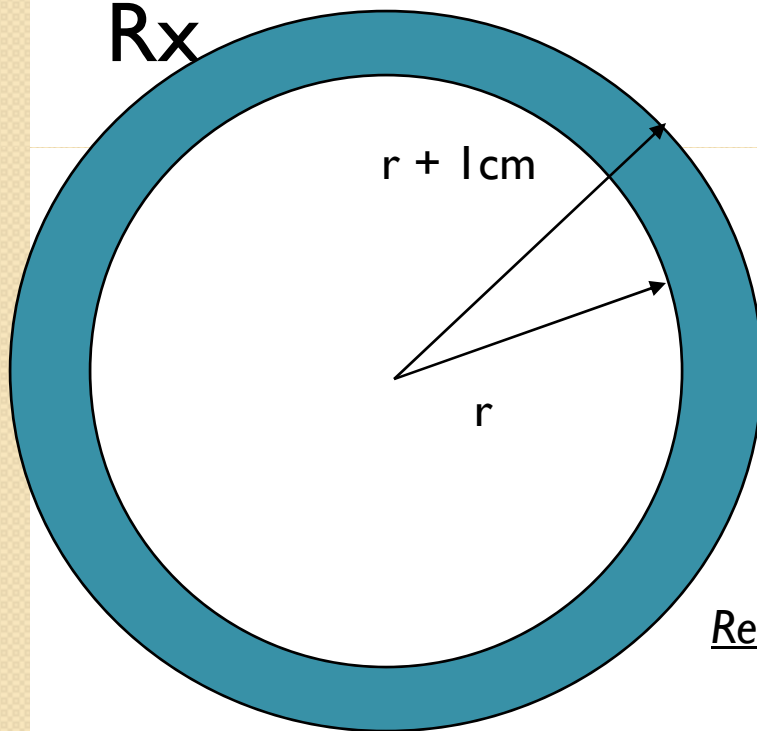


Mammosite HDR Planning

HDR Planning

- Dwell time / dose calculation for 340 cGy

Rx



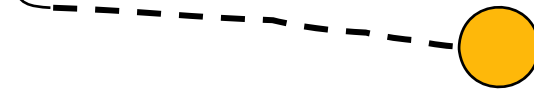
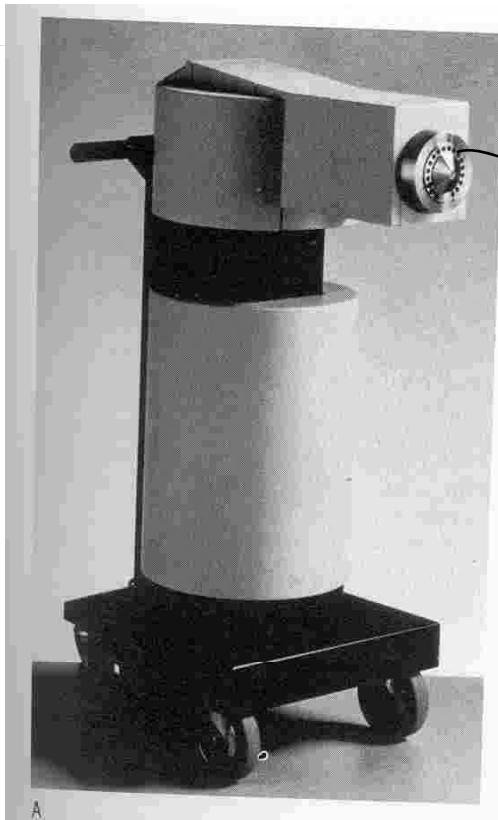
- Ir-192
- $\Lambda = 1.12 \text{ cGy-hr}^{-1}\text{-U}^{-1}$.
- Average anisotropy $\sim 0.95\text{-}1.0$

Ref: TG-43, Nath et al, MedPhys 22(2), 209-34, 1994.

$$\dot{D}(r, \theta) = S_k * \Lambda * \left[\frac{G(r, \theta)}{G(r_0, \theta)_0} \right] * g(r) * F(r, \theta)$$

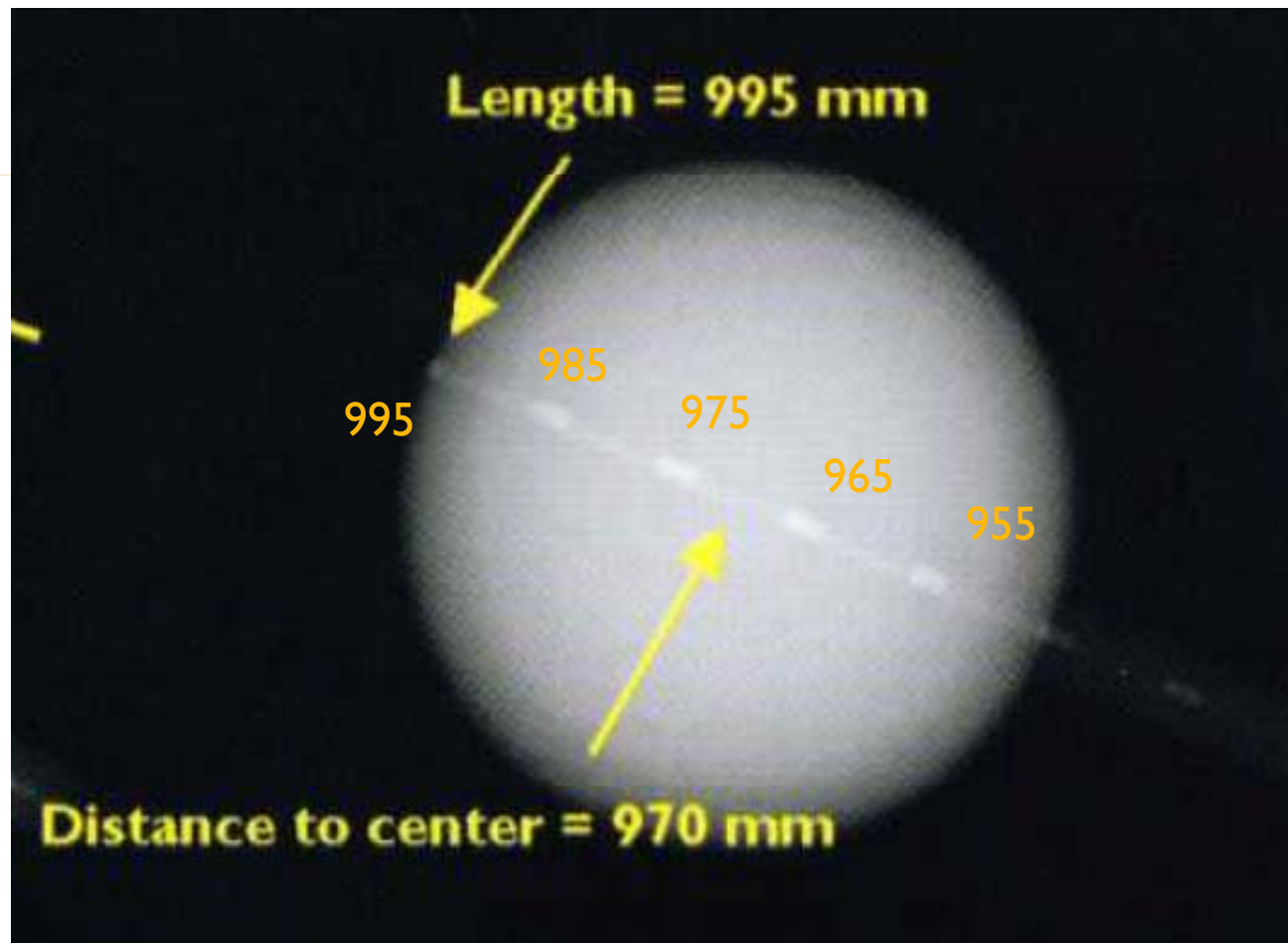
HDR Planning

- HDR unit only knows channel(s), length, and dwell time



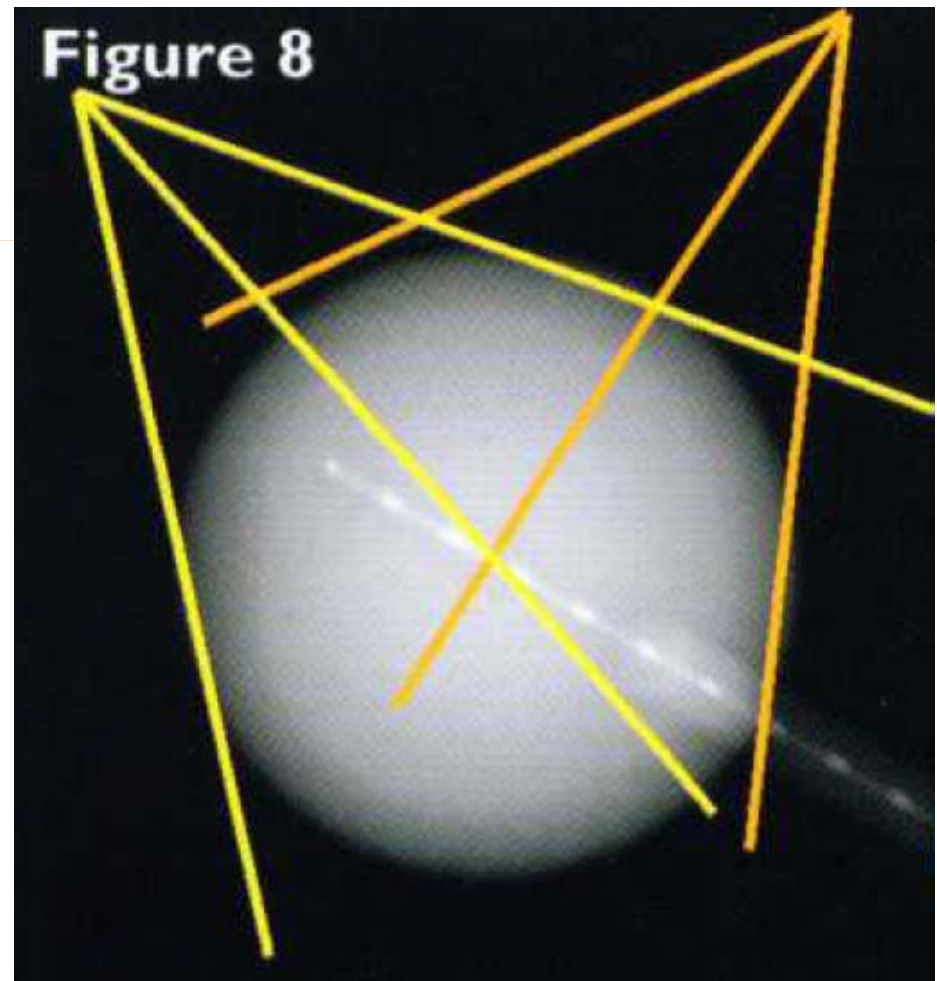
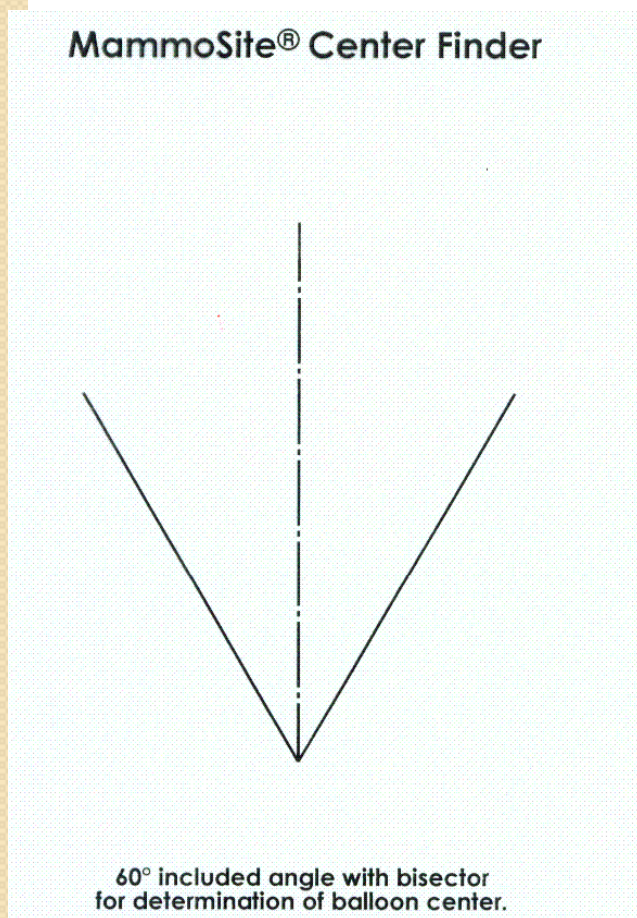
HDR Planning

- Treatment length (Nucletron "Classic" HDR shown)



HDR Planning

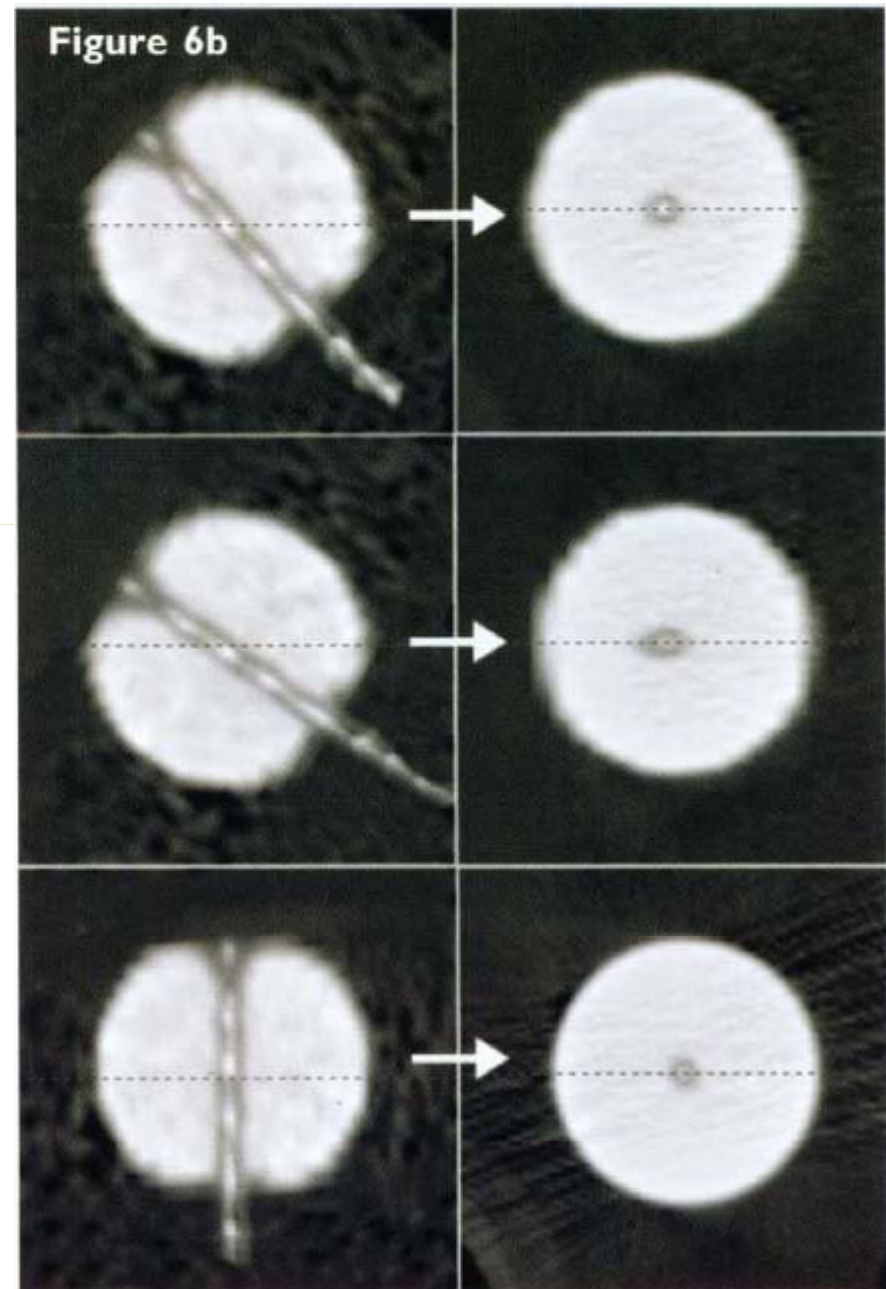
- Treatment length



Ref: G. Edmundson et al IJROBP 52:1 | 32-9, 2002

HDR Planning

- Treatment length

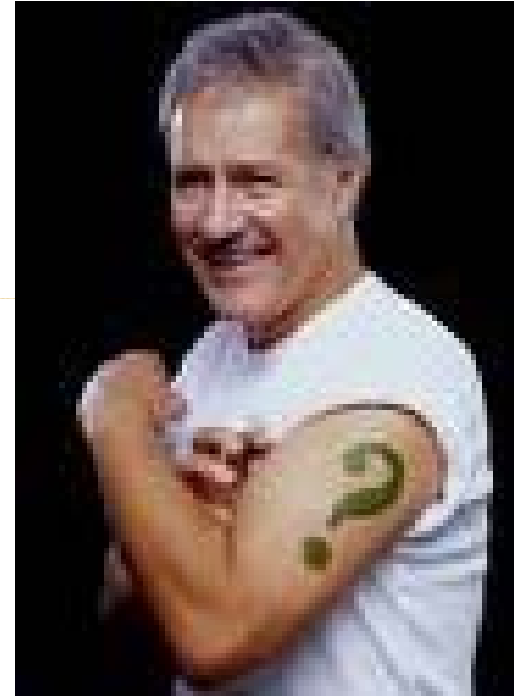




JEOPARDY
PITFALLS
LESSONS LEARNED

Mammosite Jeopardy

- 1) Wrong patient
- 2) Wrong tx site
- 3) Failure to remove temp implant
- 4) Dose error > 20%
- 5) Leaking sources
- 6) Wrong radionuclide



Ref: Florida Administrative Code 64E5.101(88)

M. D. Anderson Cancer Center Orlando HDR Treatment and Quality Management Checklist

Patient Name _____	MRN _____	Date _____
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Fraction number _____ of _____ Sources localized using: X-ray or CT N/A

- Vaginal Cylinder Endobronchial Mammosite
 Miami GYN applicator Martinez endometrial applicator CT/MR Tandem and Ring

Pre-Treatment	SAT	UNSAT
HDR daily QA completed?	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Rx approved by _____, <input type="checkbox"/> HDR plan 2 nd checked by physicist?	<input type="checkbox"/>	<input type="checkbox"/>
Computer plan and isodose plot signed by physicist and physician? <input type="checkbox"/> N/A (library plan)	<input type="checkbox"/>	<input type="checkbox"/>
Treatment consent form signed? Notes:	<input type="checkbox"/>	<input type="checkbox"/>
Patient identified using 2 methods (indicate methods used)	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> MRN# <input type="checkbox"/> DOB <input type="checkbox"/> photo <input type="checkbox"/> SSN <input type="checkbox"/> address <input type="checkbox"/> pt. provides name		
Correct patient plan is pulled up in TCS?	<input type="checkbox"/>	<input type="checkbox"/>

Does the treatment plan loaded into afterloader control system (TCS) match the intended plan?

	HDR PLAN	TCS PROGRAM	SAT	UNSAT
Tx length (mm)			<input type="checkbox"/>	<input type="checkbox"/>
Dwell positions			<input type="checkbox"/>	<input type="checkbox"/>
Total dwell time (sec)			<input type="checkbox"/>	<input type="checkbox"/>
Dwell stepsize (mm)			<input type="checkbox"/>	<input type="checkbox"/>
IRAK (cGy-m ²)			<input type="checkbox"/>	<input type="checkbox"/>
Applicator(s) lengths measured with SPS (_____mm) match expected values. <small>Expected lengths: Endobronch 1510mm, Mammosite 1304mm, N/A for any treatments using GYN transfer tubes.</small>			<input type="checkbox"/>	<input type="checkbox"/>
Catheters connected to proper channels?			<input type="checkbox"/>	<input type="checkbox"/>
Correct size vaginal cylinder in place? Plan _____ Actual _____ <input type="checkbox"/> N/A			<input type="checkbox"/>	<input type="checkbox"/>
Pre-treatment radiation survey of patient: _____ mR/hr			<input type="checkbox"/>	<input type="checkbox"/>
Attending physician _____ notified of treatment and time via <input type="checkbox"/> voice <input type="checkbox"/> page <input type="checkbox"/> telephone			<input type="checkbox"/>	<input type="checkbox"/>



Mammosite Jeopardy I- 2006 Misadminstration

- Wrong dose – gave 34 cGy (x2 before error caught) rather than the prescribed 340 cGy per treatment.
- Plan in TPS (Eclipse) was 34 cGy x10
 - Due to “known issue” with planning system and fractionated doses.

Ref: USNRC Event Notification Report for September 5, 2006

Mammosite Jeopardy II

- Nucletron HDR equipment
- HDR source failed to retract
- Physician and physicist entered room, disconnected transfer tube from patient
- (2 minutes elapsed)
- 10 mR/hr at 1m (shielded)

Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

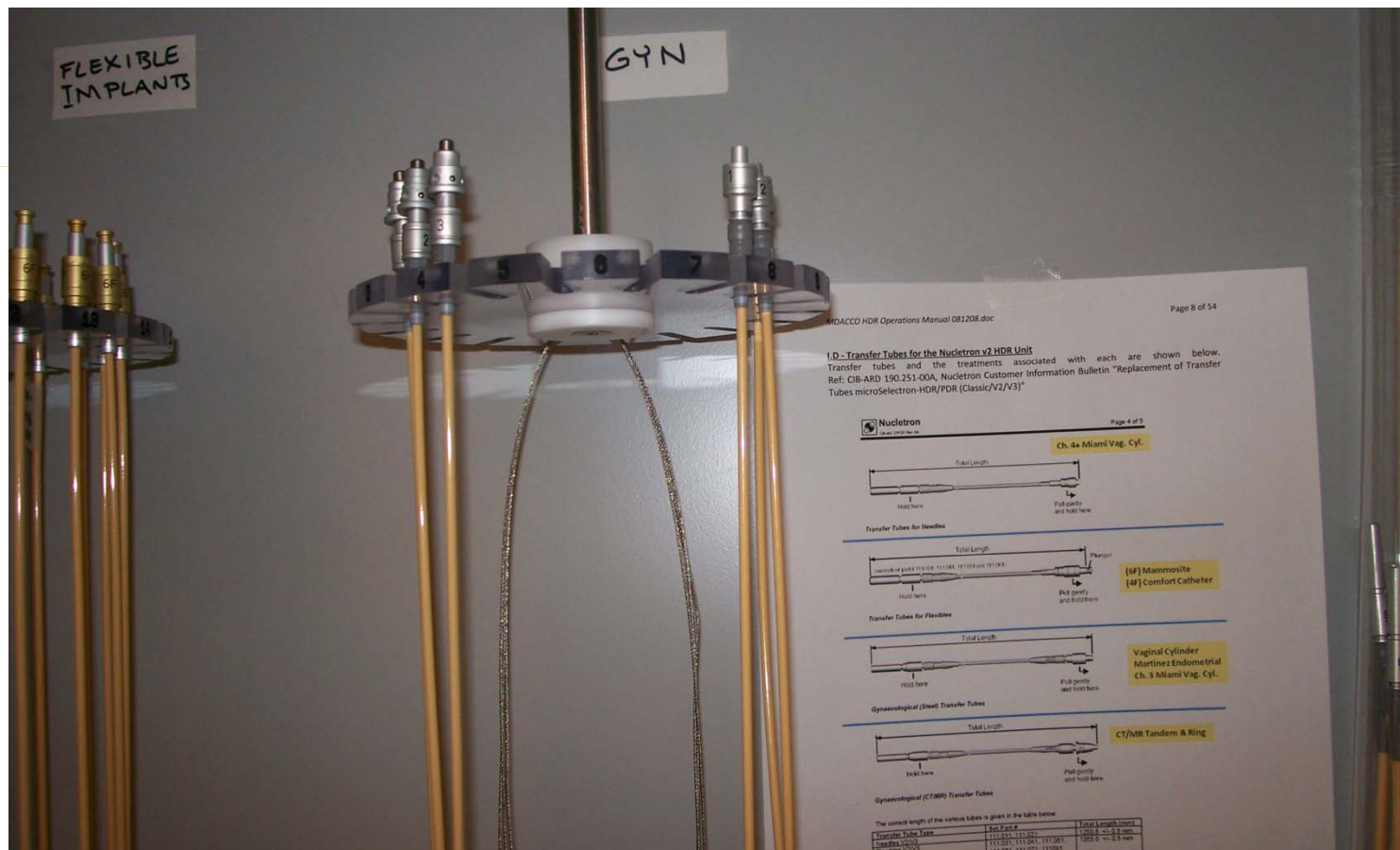
Mammosite Jeopardy II

- Dose reconstruction:
 - Patient skin 61 rem (0.61 Sv)
 - Physicist H_{eff} 45 mrem (0.45 mSv)
 - Physician H_{eff} 125 mrem (1.25 mSv)
 - Extremity dose 15 rem (0.15 Sv)

Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

Mammosite Jeopardy II

- Cause of failure to retract was wrong transfer tube used (GYN vs “flexibles”)



Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

Mammosite Jeopardy II

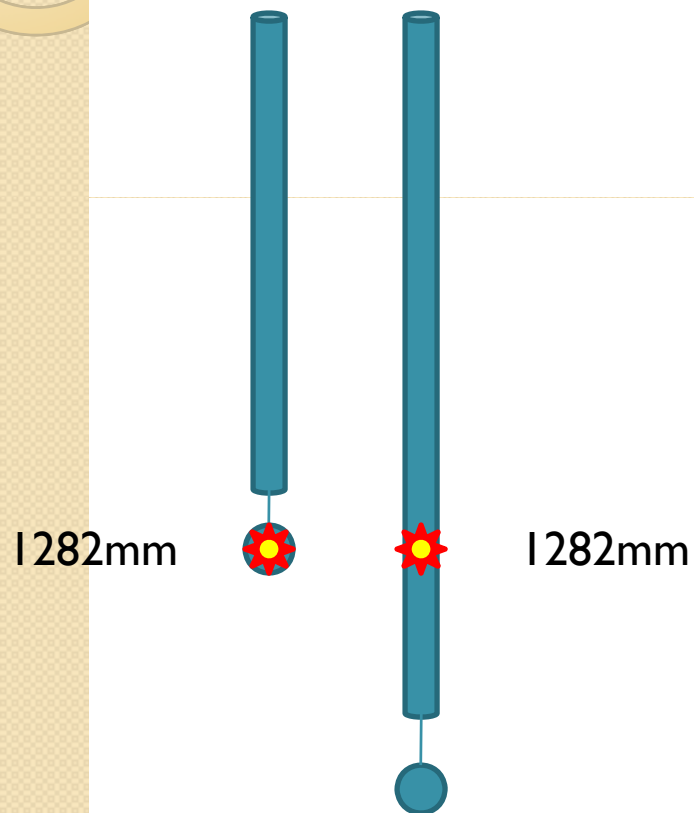
- But what's the most significant problem?
- Hint- about four to five inches



Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

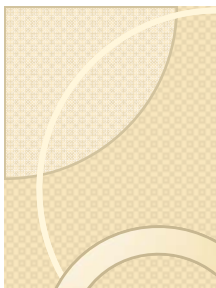
Mammosite Jeopardy II

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Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE



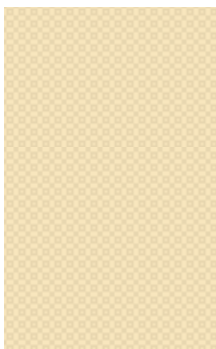


Mammosite Jeopardy II

I.A – Overview

Below is a summary of treatment parameters and equipment for HDR treatments using the v2 HDR unit at M. D. Anderson Cancer Center Orlando (as of 7-21-08).

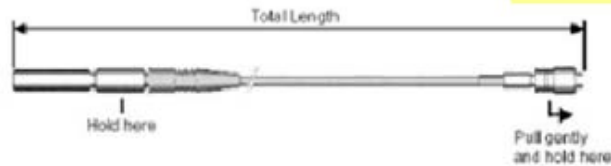
	Channels	Transfer tubes	# Dwells	Tx length	Sim Dummy Markers
1A Mammosite (spherical)	Any	6F Flexible Implant	1	~1282mm	1287, then 1cm intervals
1B Mammosite (ellipsoidal)	Any	6F Flexible Implant	5	1302-1304 mm	1287, then 1cm intervals
2 Endobronchial	Any	None	Varies	1500 max	1500, then 1cm intervals
3 Vaginal Cylinder	1-3	GYN	Varies	1500 max	GYN Distal dwell pos. is 6.5mm from end of channel
4 CT/MR Tandem and Ring	Ring #1	CT/MR GYN	~4-7,14-17	1500 max	CT/MR GYN (1500)
	Tandem #3	CT/MR GYN	~1-8	1500 max	CT/MR GYN (1500)
5 Martinez Endometrial	pt R -->1	GYN	Varies	1500 max	GYN
	pt L -->2	GYN	Varies	1500 max	GYN
6 Miami Vaginal Cylinder	Tandem #3	GYN	Varies	1500 max	GYN
	Outer-> Any	Transfer Tubes for Needles	Varies	1385 max	None currently in use Distal dwell pos. is 5mm from end of channel
7 Comfort Catheter Interstitial	Any	4F Flexible Implant	Varies	1240 max	CT/MR markers for comfort catheter Distal marker is 1240mm



Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

Mammosite Jeopardy II

Ch. 4+ Miami Vag. Cyl.

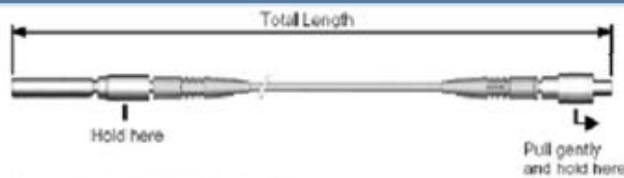


Transfer Tubes for Needles



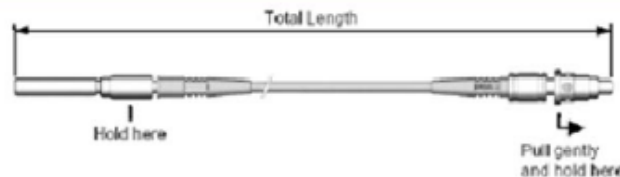
(6F) Mammosite (4F) Comfort Catheter

Transfer Tubes for Flexibles



Vaginal Cylinder Martinez Endometrial Ch. 3 Miami Vag. Cyl.

Gynaecological (Steel) Transfer Tubes



CT/MR Tandem & Ring

Gynaecological (CT/MR) Transfer Tubes



Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

Mammosite Jeopardy II

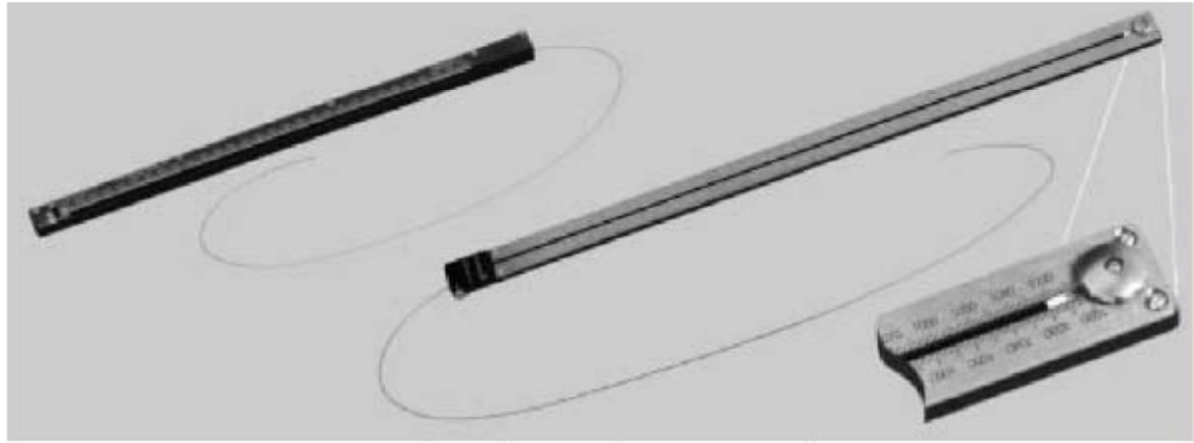


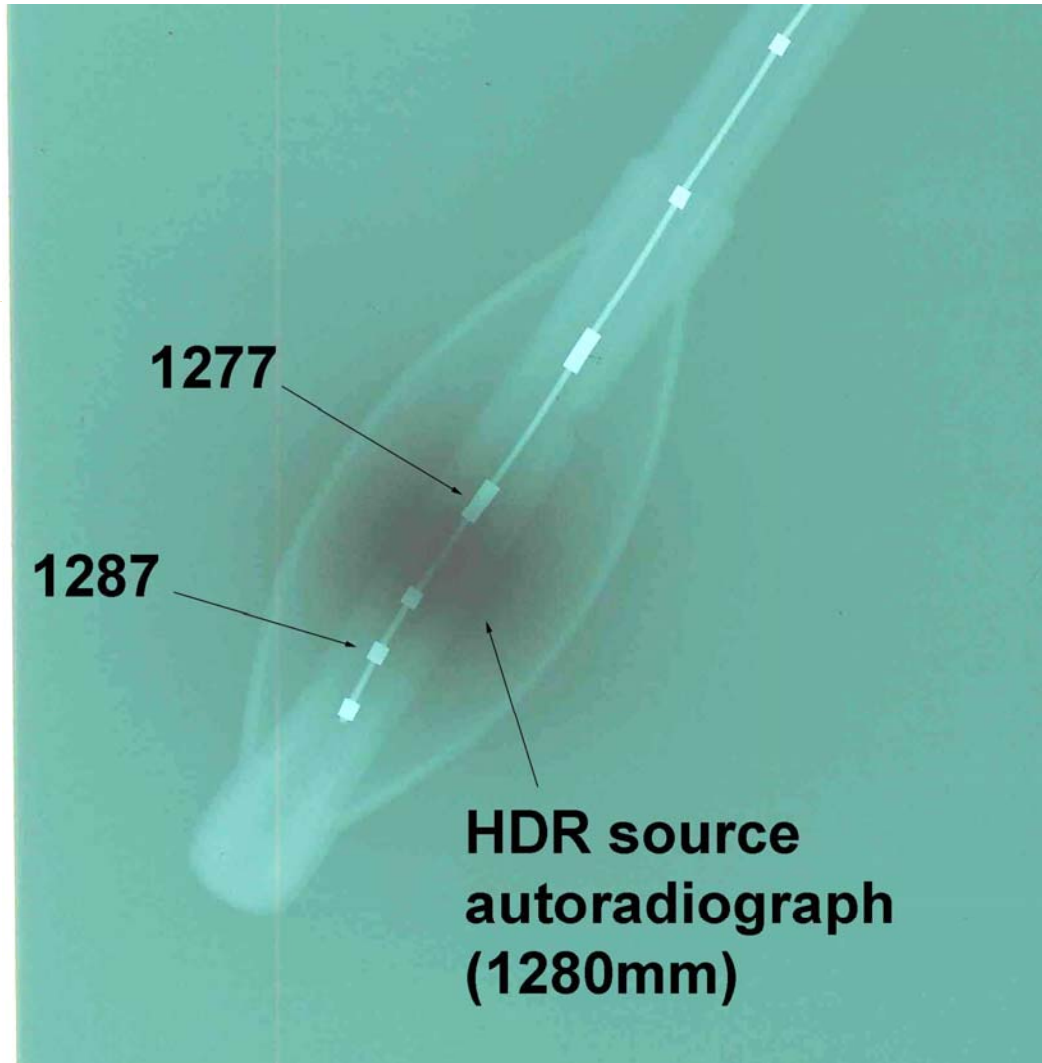
Figure 1 – 1500 mm source position simulator, Nucletron Part Number 011.094.

Expected SPS length readings (not total internal length, but to the middle of the dummy source):

<u>Applicator</u>	<u>Expected Reading (mm)</u>
Mammosite balloon with HDR connector	1302
Endobronch catheter (151.5cm)	1510
Vaginal cylinder	Do not use the SPS with GYN transfer tubes.

Ref: NRC INFORMATION NOTICE 2003-21: HIGH-DOSE-RATE-REMOTE-AFTERLOADER EQUIPMENT FAILURE

Treatment Length



Mammosite Jeopardy III

- Wrong treatment distance entered into HDR unit for multiple treatments
- Discovered due to unexpected skin erythema



Ref:

(1) NRC EVENT NOTICE 2006-42941 – Medical Event (2) in Florida, NRC Event Notice 2006-42556

Mammosite Jeopardy IV

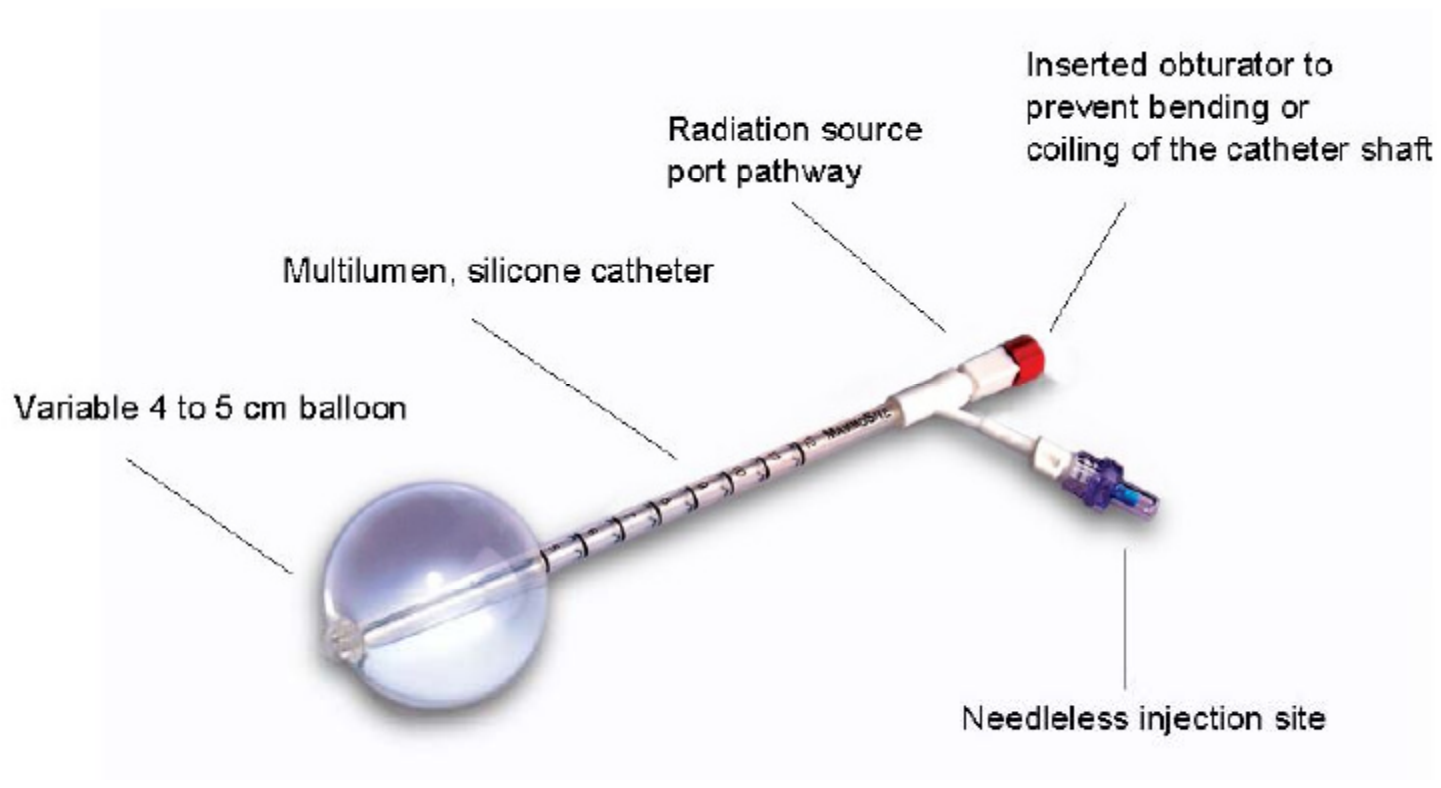
- Wrong treatment plan used for 5 of 10 Mammosite treatments
- Patient dose 1700 cGy rather than 3400 cGy

- Technologist imported incorrect treatment plan, resulting in HDR source being outside of the patient's body during 5 of the 10 treatments.
- Incident was discovered upon review of the patient's chart during a follow-up visit.

Mammosite Jeopardy V

- “Red for radiation, blue for fluid”

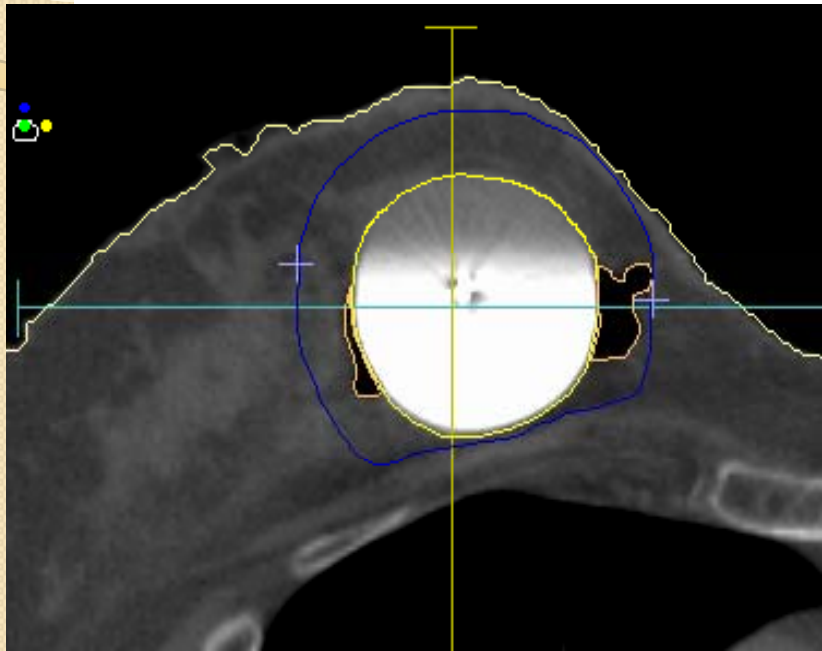
Ref: NRC Event Notice 2007-43685 (Medical Event)



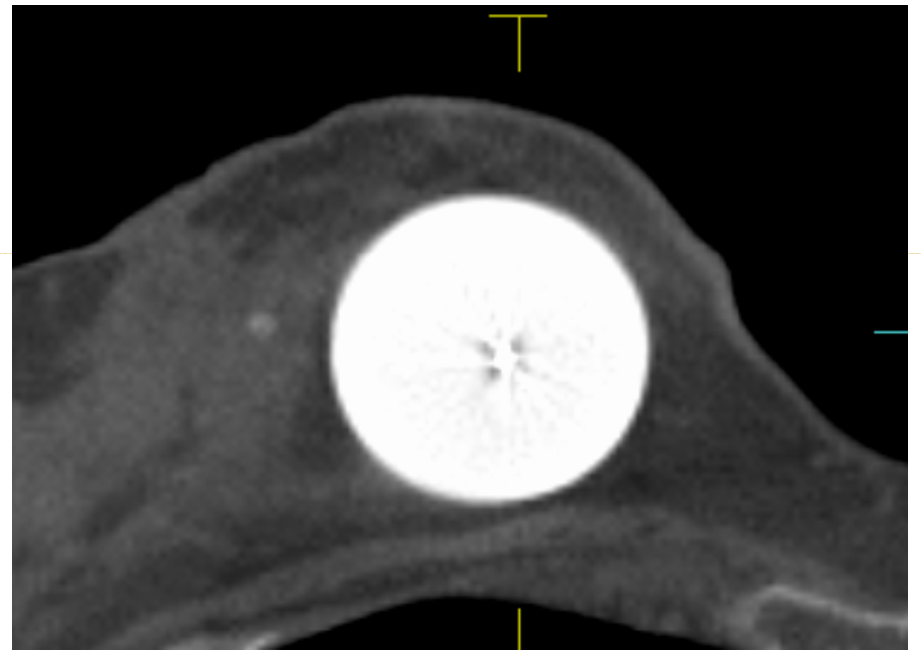


 **TIPS**

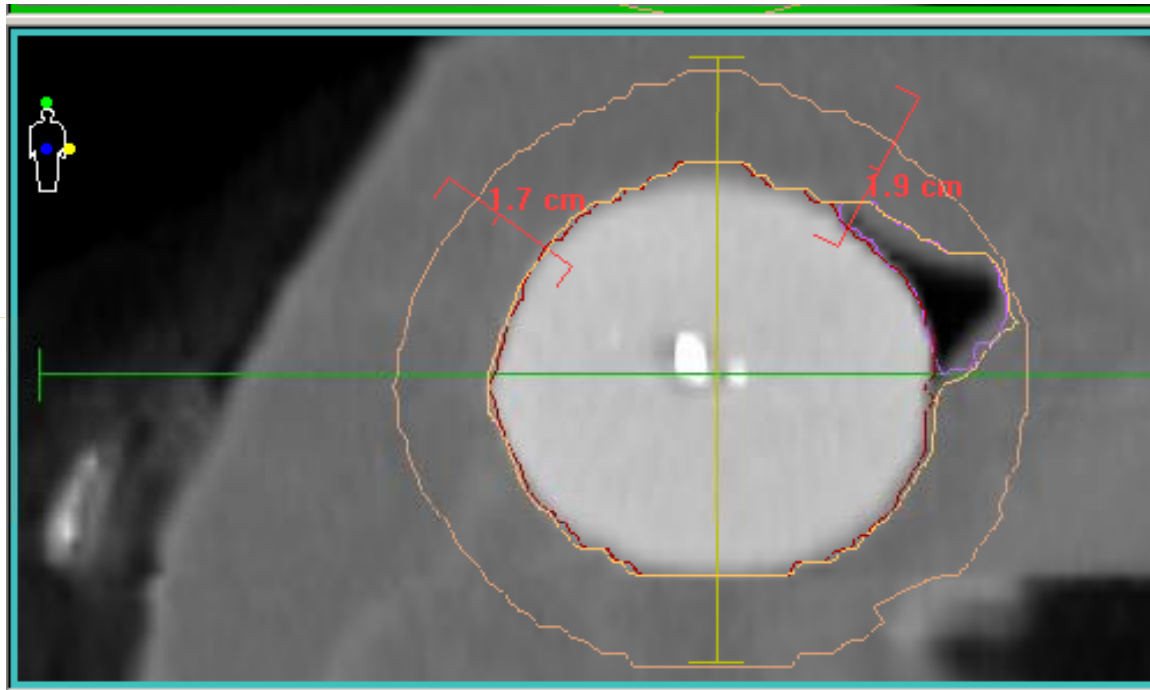
Pitfall - Nonconformance



Simulation

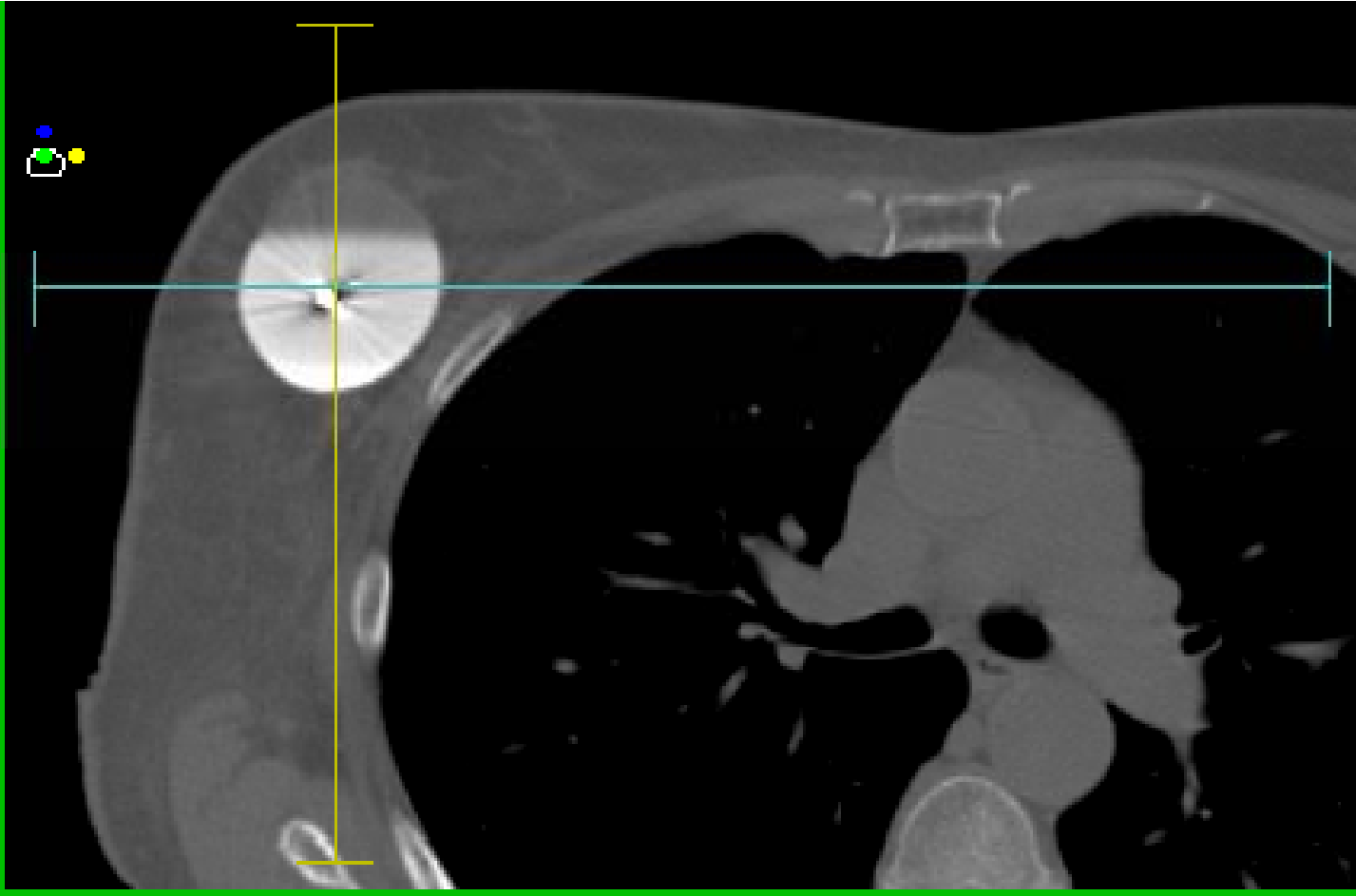


Treatment ~ 3 days later



Non-conforming cavity extending through PTV

??



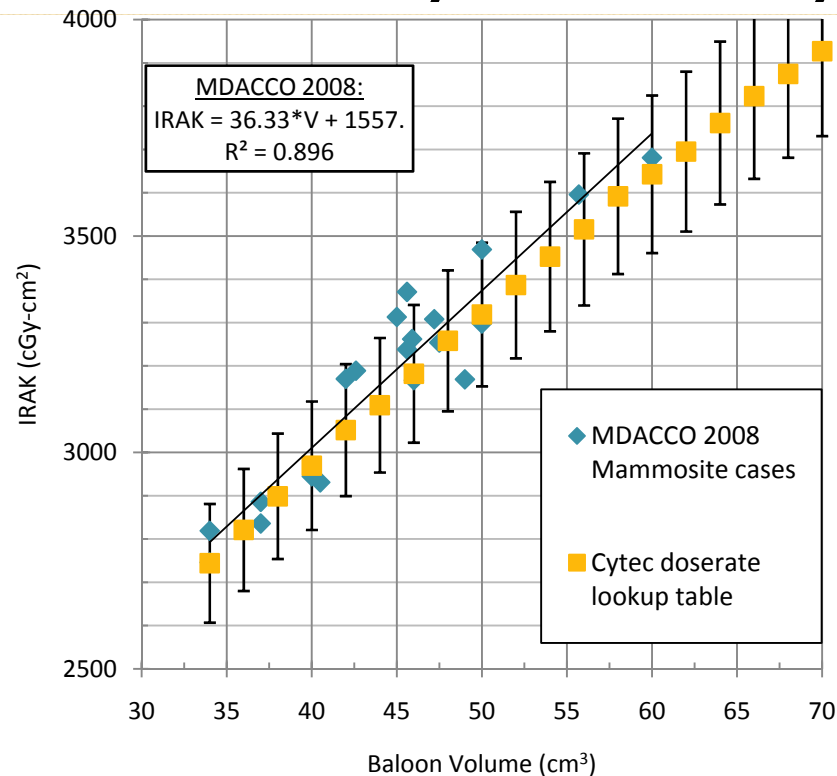


Helpful Tip Re: Distance to Skin

- Balloon-to-skin distance can sometimes be increased by 1-2mm by simulating the patient with the ipsilateral arm down during the CT scan.

Mammosite Library Plans

- IRAK as a function of balloon volume
- Simplifies planning process
- Greater consistency over many cases





Treatment issues

- Wound care / infection control
- No showering
- Patient education and wound care kit for catheter

- Balloon failure
 - Balloons don't like sharp things!
 - Stitches, scissors, etc
 - Cost of catheter
 - Cytec will replace failed catheters



Wrap Up

- Mammosite fundamentals
 - Appropriateness criteria
 - Planning
 - Pitfalls and Medical Events
 - Tips
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Mammosite Physics References

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- Edmundson G et al IJROBP 52:1132-9, 2002.
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