


Proton Treatment Planning



Stefan Both
University of Pennsylvania

Proton Treatment Planning

OUTLINE

- Proton Technologies and Treatment Techniques at UPenn
- MLC Based Delivery and Treatment Planning
- Pencil Beam Scanning
- Summary

2

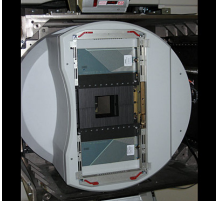
Proton Technologies and Techniques at UPenn

Technologies	SS	DS	US	PBS
Techniques	SOBP		SFUD	IMPT
	3DCRT/IMRT		IMRT	

3

Proton Treatment Planning

In PS, the integration of MLC allows for safer and more efficient automated processes.



MLC redesigned based on the Varian MLC allows for:

- Automated field shaping
- Automated field matching patching (SOBP)
- Automated delivery

4

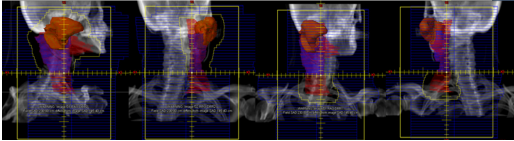
MLC Based Delivery and Treatment Planning

- Field Size: 22cm x 17cm
- Neutron production
"The neutron and combined proton plus gamma ray absorbed doses are nearly equivalent downstream from either a close tungsten alloy MLC or a solid brass block."
Diffenderfer et al. Med. Phys 11/2011; 38(11):6248-56
- Penumbra characteristics:
 $PDS_{MLC} > PDS_{AP}$ (~2mm)
 $PUS_{MLC} = PDS_{AP}$

5

MLC Based Delivery and Treatment Planning

- MLC allows for automated field matching/patching based on volume segmentation techniques.

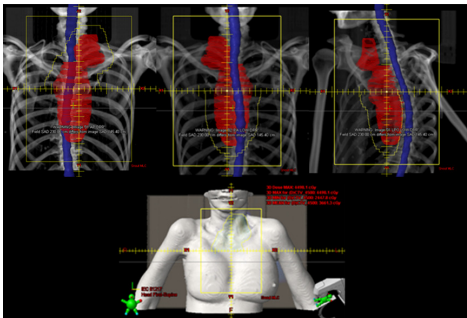


- Facilitate the use of Half Beam Techniques.
For example: Esophagus, Sarcoma.

6

MLC Based Delivery and Treatment Planning

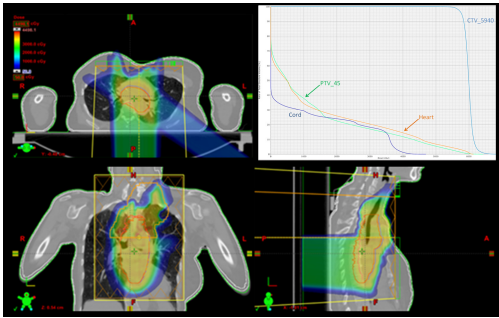
Esophagus



7

MLC Based Delivery and Treatment Planning

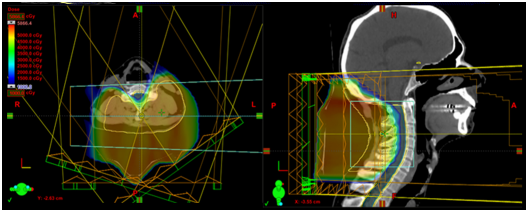
Esophagus



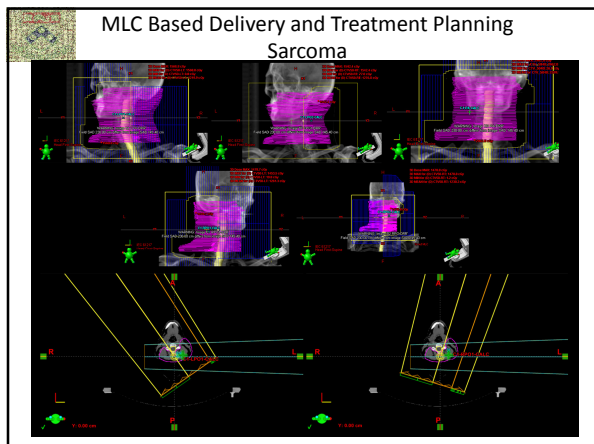
8

MLC Based Delivery and Treatment Planning

Sarcoma




9



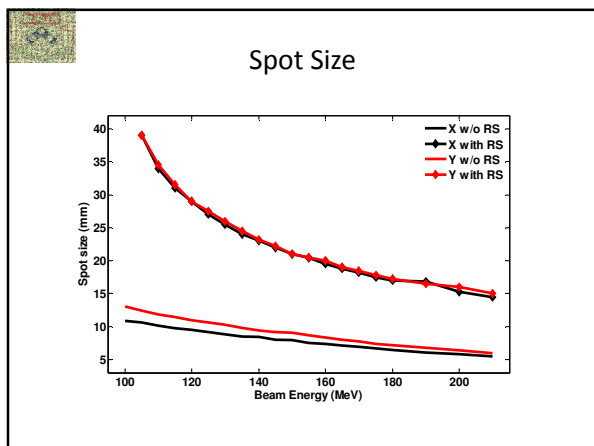
PBS Technology at UPenn

- The Fix Beam Line Range (100 MEV to 235 MEV).
- The Fix Beam Line Geometry allows for imaging at ISO & treatment AT & OFF ISO.
- Targets <7 cm WEPL from the surface require the use of an absorber (range shifter).



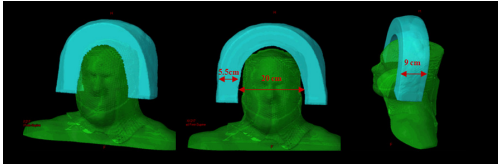
- Range shifter positioned at surface of the snout (>30cm air gap).

11



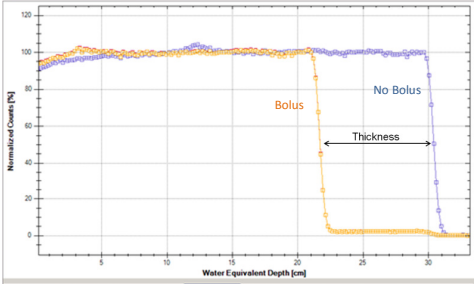
Spot Size Integrity

- We **replace** the RS with an **Universal Patient Bolus**, which allow to image and treat at the ISO while:
 - minimizing the air gap and the amount of material in the beam
 - maintain the size of the pencil beam




13

Bolus Thickness

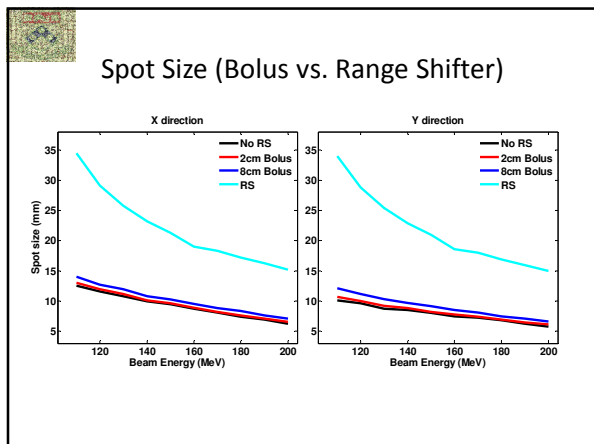


Visible	ID	Time	Date	Type	Field Size	SSD	Snout Dis.	Snout Dist.	SNR	Beam del.	Sampling	Analy.
SP	1.1	5:15:52 PM	6/29/2012	SOBP	10 x 10 cm	230.00	n/a	n/a	0.00 cm	SingleCut	1000 ms	A
SP	2.1	5:24:09 PM	6/29/2012	SOBP	10 x 10 cm	230.00	n/a	n/a	0.00 cm	SingleCut	1000 ms	A
SP	4.1	5:15:52 PM	6/29/2012	SOBP	10 x 10 cm	230.00	n/a	n/a	0.00 cm	SingleCut	1000 ms	A

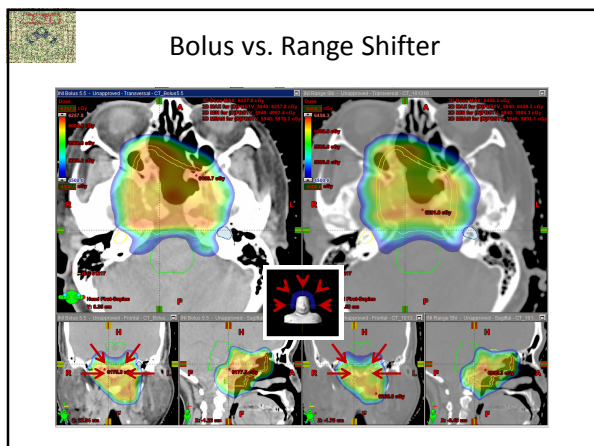
Implementation in Treatment Room

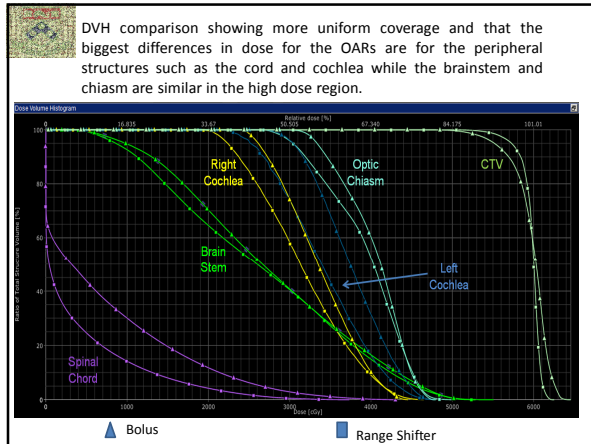


15



- ### The "Perfect" Clinical Example
- Base of Skull RT*
- Limited by proximity to the brainstem
 - Limited by proximity to optical structures
 - Limited by dose to the brain
- 17





Prostate Motion and the Interplay Effect

- PBS delivers a plan spots by spots; layers by layers.
- Each layer is delivered almost instantaneously.

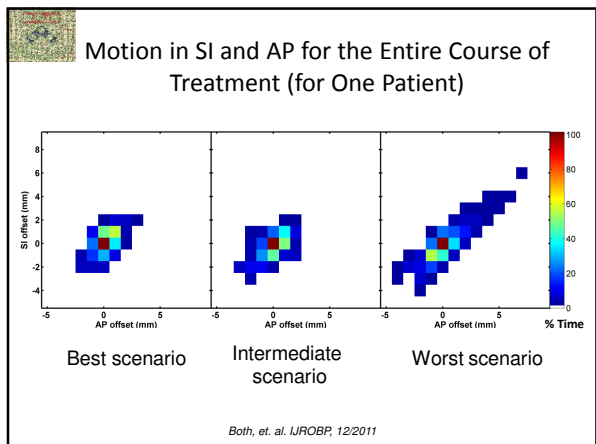
- The switch (beam energy tuning) between layers takes about 10 seconds.
- Prostate motion during beam energy tuning causes an interplay effect.

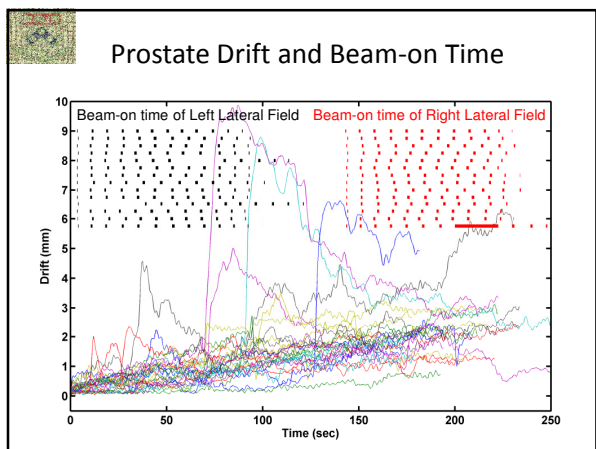
Prostate Motion and Interplay Effect

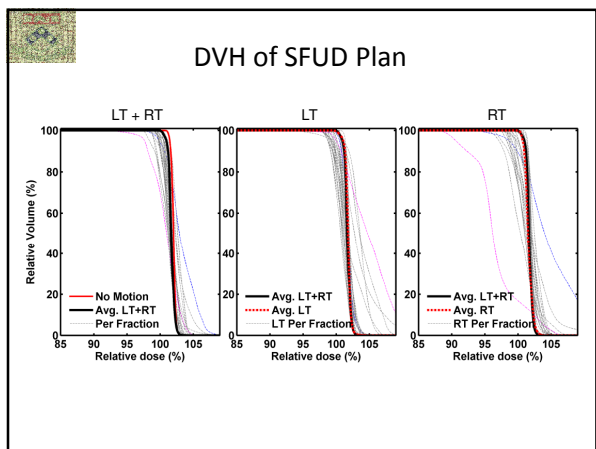
Considerations for fractionated RT with ERB:

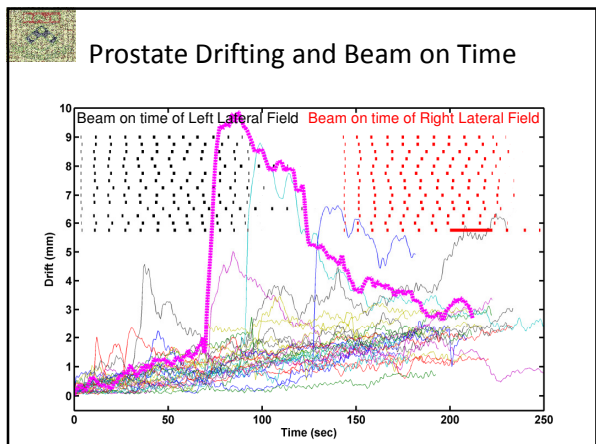
- The lateral motion is negligible.
- AP and SI motions are significant.
- HUs of prostate and surrounding tissues are very close.
- The prostate motion determined by the Calypso log file (0.5s).
- The beam delivery log file determines the beam on and off time.
- The dose to CTV is re-calculated by considering prostate drifting.

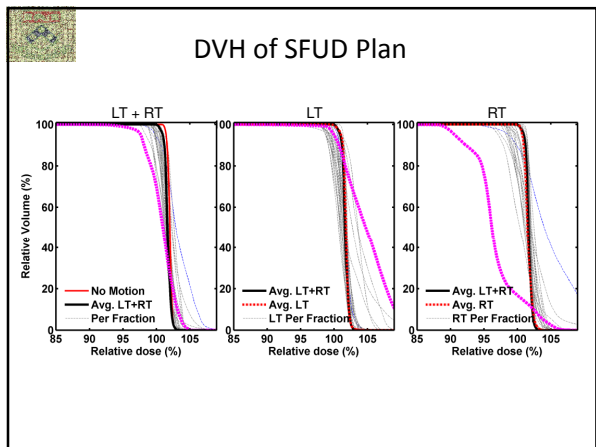
*Wang, et. al. IJROBP, 11/2011

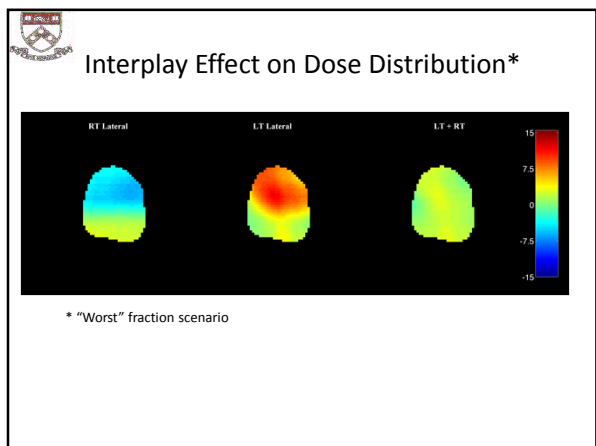


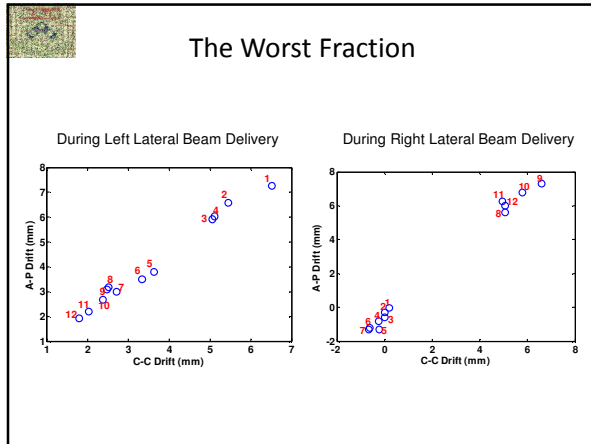


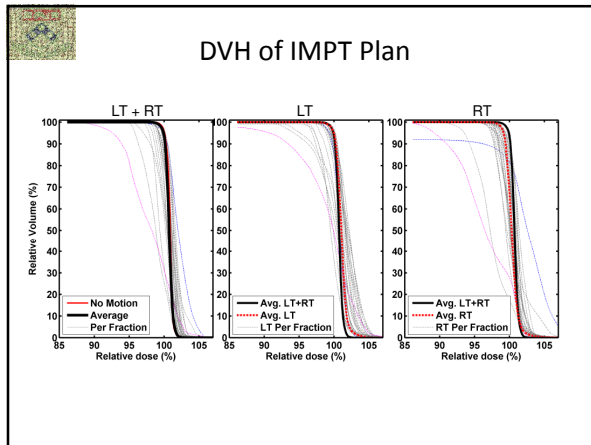













Summary

- Automated processes may improve proton therapy.
- MLC may be implemented for PBS in TPS and improve lateral penumbra.
- A small air gap is necessary to maintain the integrity of the PBS spot size.
- Motion effects may be addressed by quick delivery, rescanning, organ motion management, etc.



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31



Thank you.

32
