IMRT for Prostate Cancer

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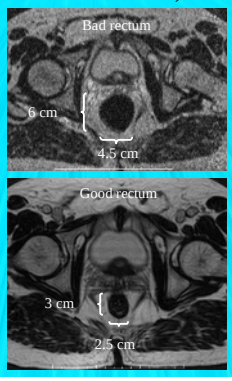
All patients are simulated in the supine position. Reproducibility is achieved using a custom alpha cradle cast that extends from the mid-back to mid-thigh. The feet are positioned in a custom plexiglas foot-holder. The patient is told to have a 1/2- 3/4 bladder because during treatment a full bladder is difficult to maintain.

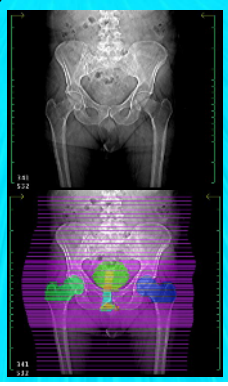
Simulation (Positioning and Immobilization)

- The patient is asked to empty the rectum using an enema prior to simulation. Also, a low residue diet the night before simulation is recommended to reduce gas. If at simulation the rectum is >3 cm in width due to gas or stool, the patient is asked to try to expel the rectal contents.



CT Scans

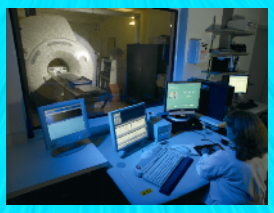
- Scans are acquired from approximately 2 cm above the top of the iliac crest to approximately mid-femur. This scan length will facilitate the use of non-coplanar beams when necessary.
- Scans in the region beginning 2 cm above the femoral heads to the bottom of the ischial tuberosities are acquired using a 2.5 mm slice thickness and 2.5 mm table increment (Beacon patients: 1.25mm). All other regions may be scanned to result in a 1 cm slice thickness.



MR Scans

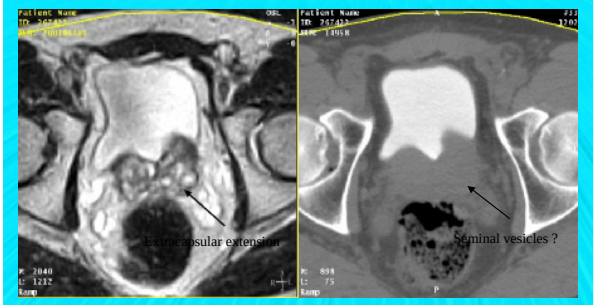
- All prostate patients also undergo MR imaging within the department, typically within one half hour before or after the CT scan. Scans are obtained ***without*** contrast media.
- CT and MR images are fused according to bony anatomy using ***All soft tissue structures are contoured based on the MR information while the external contour and bony structures are based on CT.***

1.5 T, GE Medical Systems



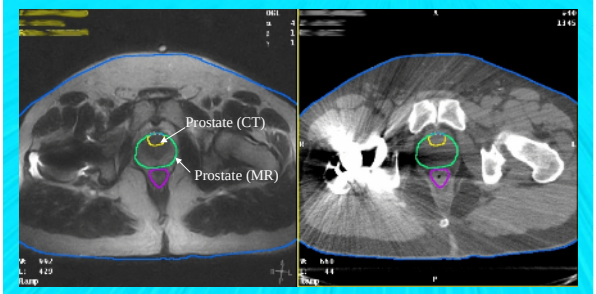
•Retrograde urethrograms are ***not*** performed.

MRI CT



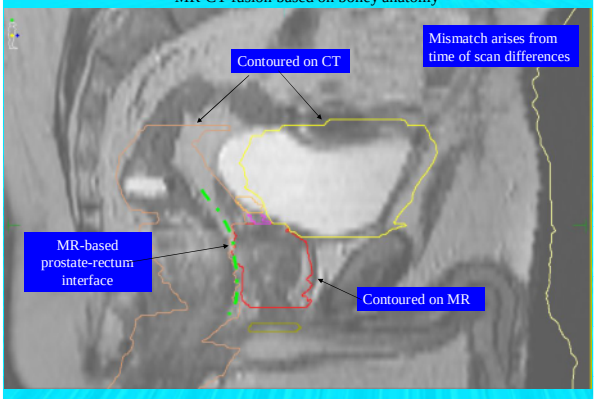
Imaging modality may affect treatment regime

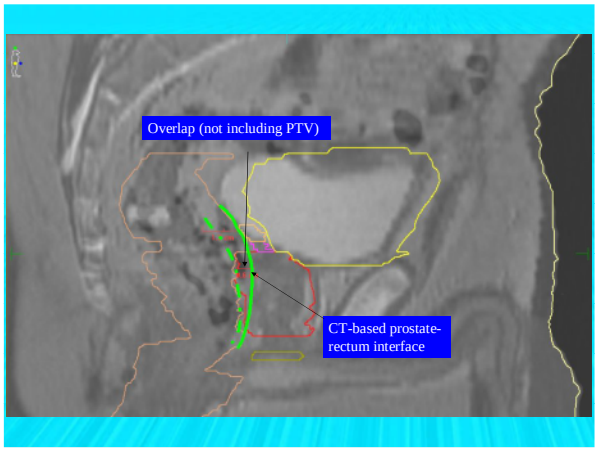
MRI CT

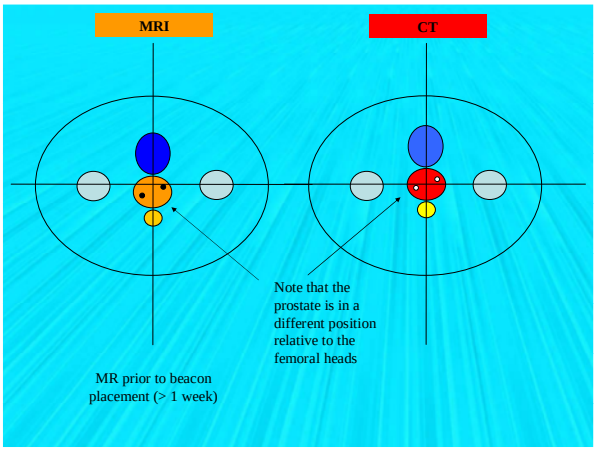


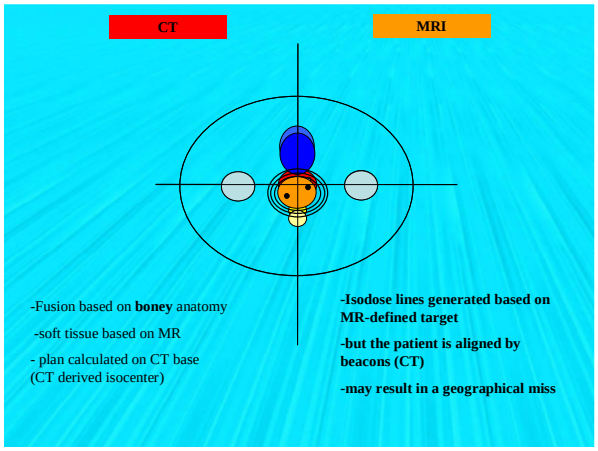
Imaging artifacts may affect contouring

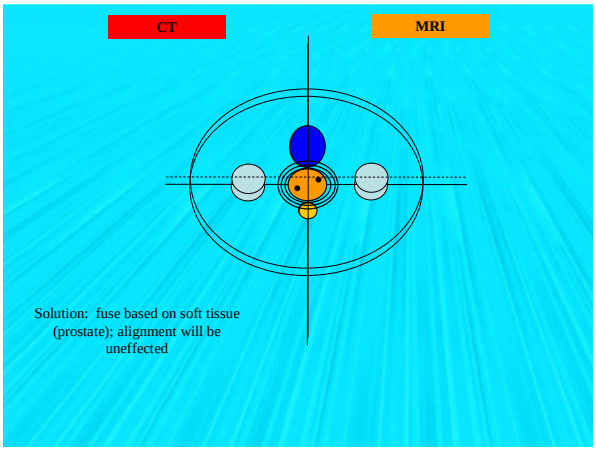
MR-CT fusion based on boney anatomy

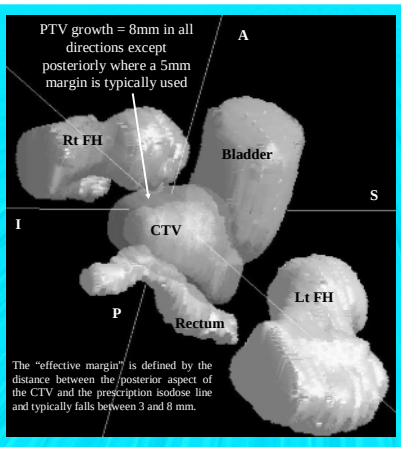



Overlap (not including PTV)
CT-based prostate-rectum interface


MRI
CT
Note that the prostate is in a different position relative to the femoral heads
MR prior to beacon placement (> 1 week)


CT
MRI
-Fusion based on **boney** anatomy
-soft tissue based on MR
- plan calculated on CT base (CT derived isocenter)
-Isodose lines generated based on MR-defined target
-but the patient is aligned by beacons (CT)
-may result in a geographical miss


CT
MRI
Solution: fuse based on soft tissue (prostate); alignment will be uneffected



The "effective margin" is defined as:

0%
0%
0%
0%
0%

1. The distance between the posterior aspect of the CTV and the anterior rectal wall
2. The distance between the posterior aspect of the CTV and the prescription isodose line
3. The distance between the posterior aspect of the CTV and the posterior rectal wall
4. The average 3D PTV margin
5. The difference between take-home pay and what your better half allows you to spend

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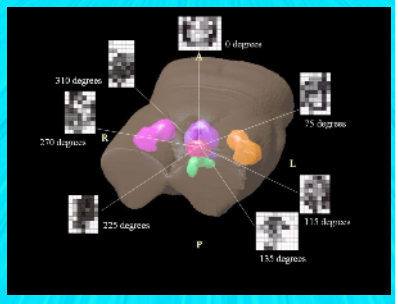
Number of Beam Directions

In the interest of delivery time we typically begin with 6 and progress to ≤ 9

Simpler plans such as prostate only or prostate + seminal vesicles typically result in fewer beam directions than with the addition of lymphatics



Typical Dose

Routine treatments

- Prostate + proximal sv (80 Gy @ 2.0 Gy/fx)
- Distal sv, lymphatics (56 Gy @ ~1.4 Gy/fx)

Post Prostatectomy

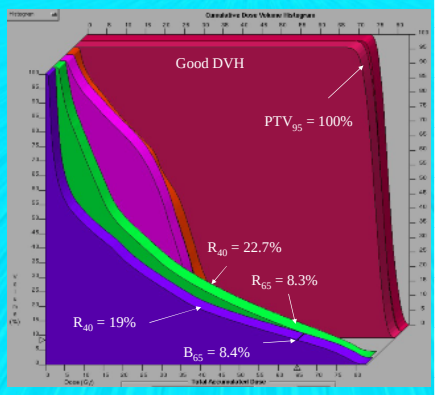
- Prostate bed (64-68 Gy @ 2.0 Gy/fx)

Acceptance Criteria

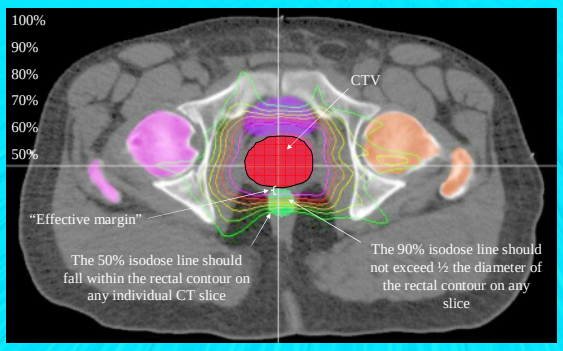
What is a good plan?
When can I stop planning?

DVH Acceptance Criteria

$PTV_{95\ \%} \geq 100\%$ Rx
$R_{65\ Gy} \leq 17\%V$
$R_{40\ Gy} \leq 35\%V$
$B_{65\ Gy} \leq 25\%V$
$B_{40\ Gy} \leq 50\%V$
$FH_{50\ Gy} \leq 10\%V$



Good plan example (axial)



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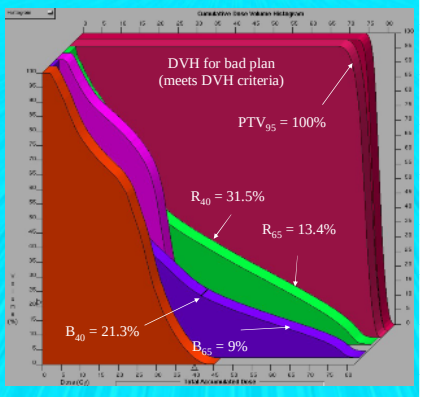
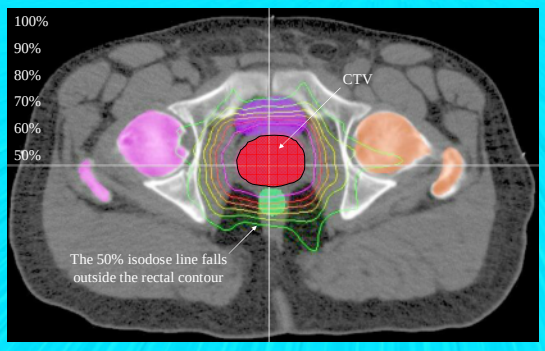


Bad plan example (axial)



Routine prostate IMRT plan acceptance criteria at FCCC include all of the following except:

0% 1. The volume of either femoral head receiving 50 Gy ≤ **20%**

0% 2. The volume of bladder receiving 65 Gy **≤ 25%**

0% 3. The 50% isodose line should fall within the rectal contour on each individual CT slice

0% 4. The 90% isodose line should not exceed ½ the rectal diameter on any CT slice

0% 5. The volume of rectum receiving 65 Gy **≤ 17%**

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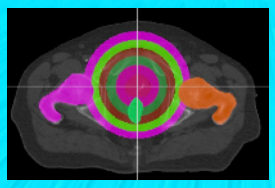
Regions for dose constraint



Region	Limit	% volume ↑ limit	Minimum	Maximum
1	90% of target goal	20	45% of target goal	Target Max
2	80%	20	40%	90% of target goal
3	70%	20	35%	75%
4	50%	1	25%	55%
5	30%	1	15%	35%
6	20%	1	10%	25%

Price et al. IJROBP 2003

Regions

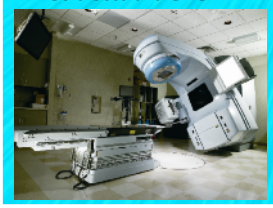
- 26 previously treated patients (6 and 10 MV)
- The average number of beam directions decreased by 1.62 with a standard error (S.E.) of 0.12.
- **The average time for delivery decreased by 28.6%** with a S.E. of 2.0% decreasing from 17.5 to 12.3 minutes
- The amount of **non-target tissue receiving D_{100} decreased by 15.7%** with a S.E. of 2.4%
- Non-target tissue receiving $D_{95,}$ $D_{90,}$ D_{50} decreased by 16.3, 15.1, and 19.5%, respectively, with S.E. values of approximately 2%

Localization

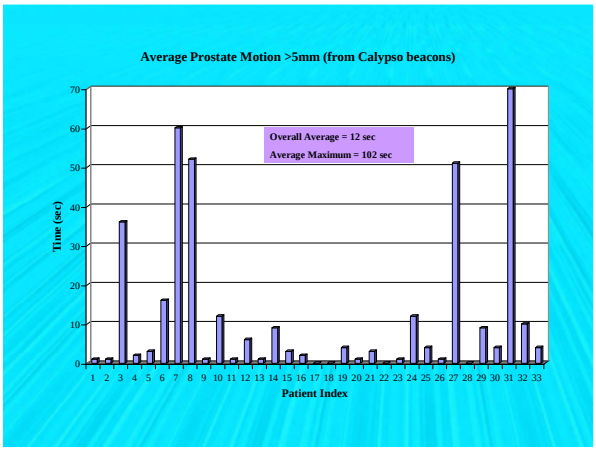
BAT Alignment

"CT-on-rails"

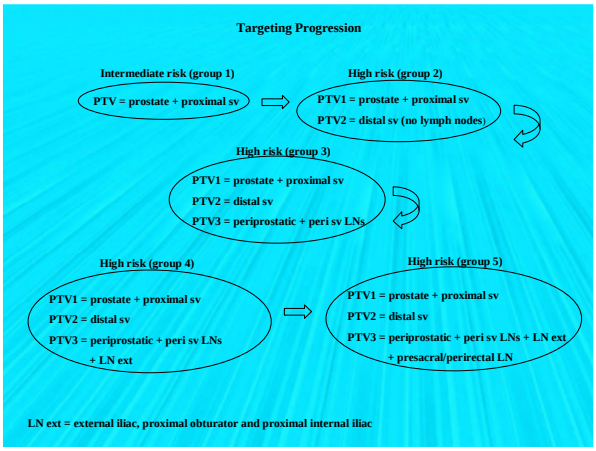
Gold Seed and CBCT

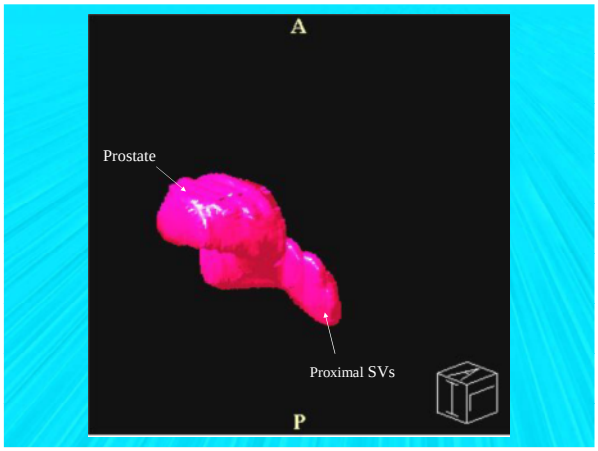


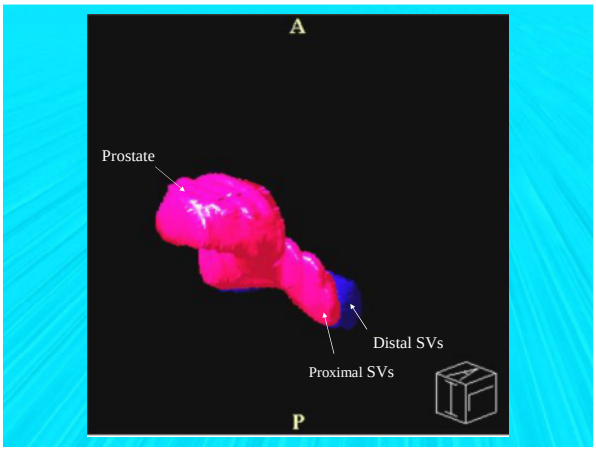
Calypso
(localization & tracking)

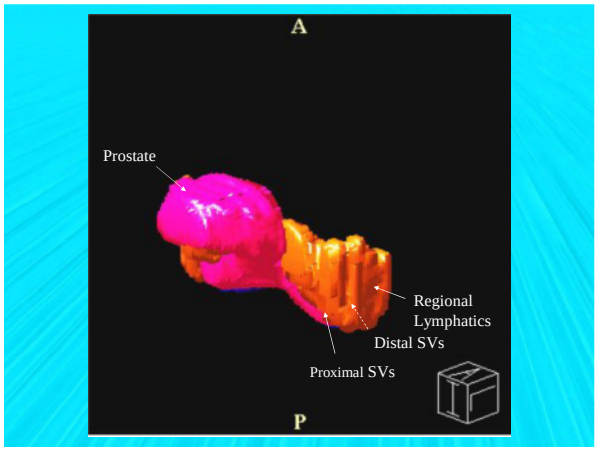


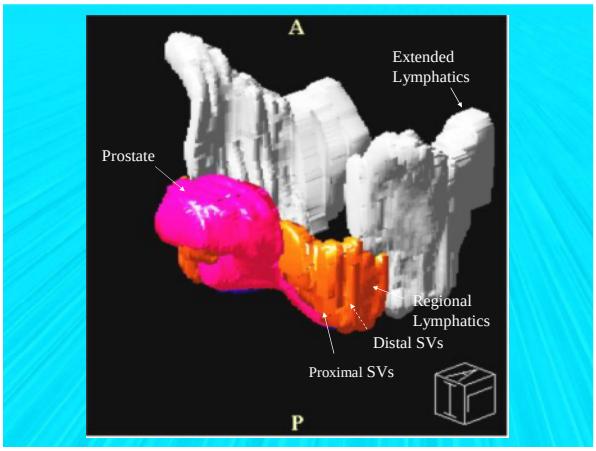
Nodal Irradiation

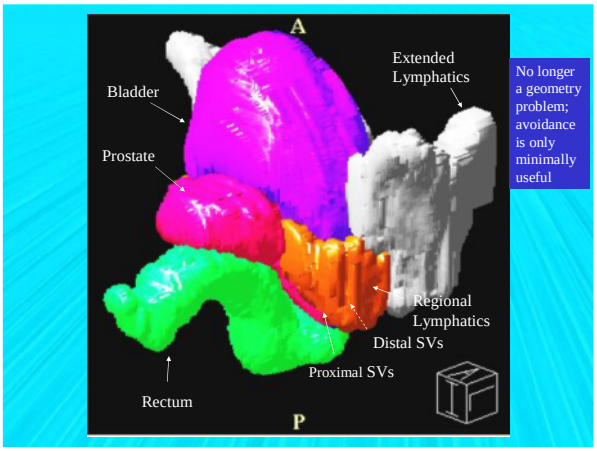



A
Prostate
Proximal SVs
P


A
Prostate
Distal SVs
Proximal SVs
P


A
Prostate
Regional
Lymphatics
Distal SVs
Proximal SVs
P

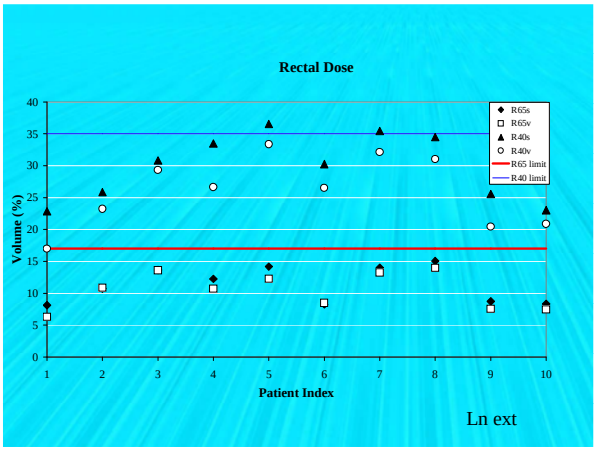

A
Extended
Lymphatics
Prostate
Regional
Lymphatics
Distal SVs
Proximal SVs
P

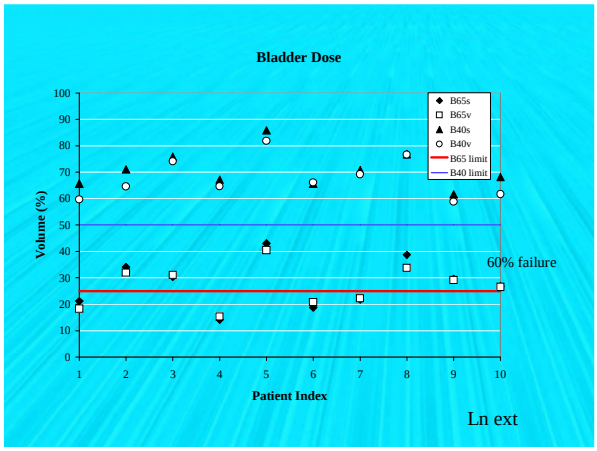


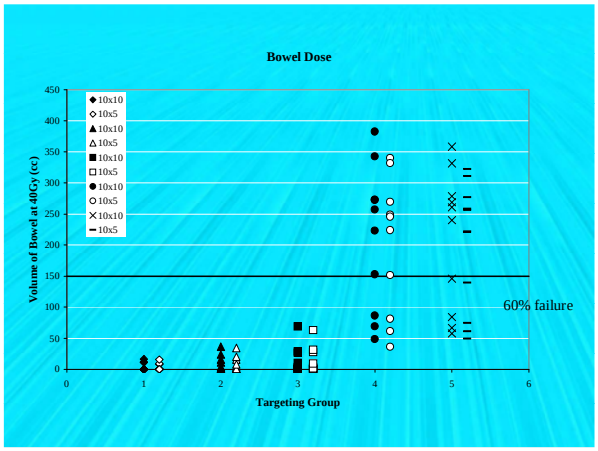
Lymphatic irradiation study

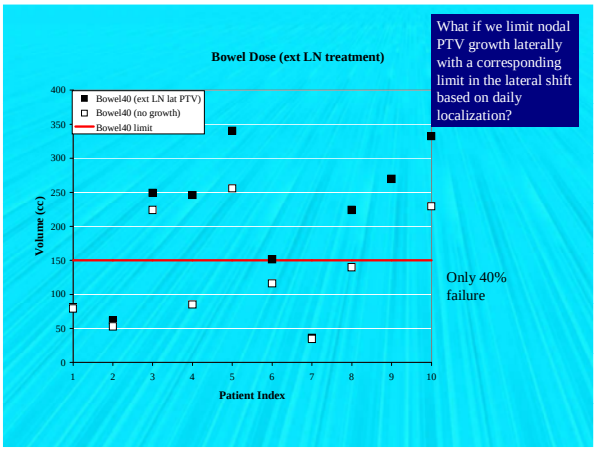
- 10 patient data sets
- Generate plans for each stage in targeting progression
- Evaluate effect of nodal irradiation on our routine prostate IMRT plan acceptance criteria
- **Evaluate effect on bowel**
- Treatment time (logistical concerns as well as patient comfort)
- Physics concerns (dose per fraction vs. “cone downs”, increased “hot spots”, PTV growth and localization technique, rectal expansion and inclusion of presacral nodes, etc.)

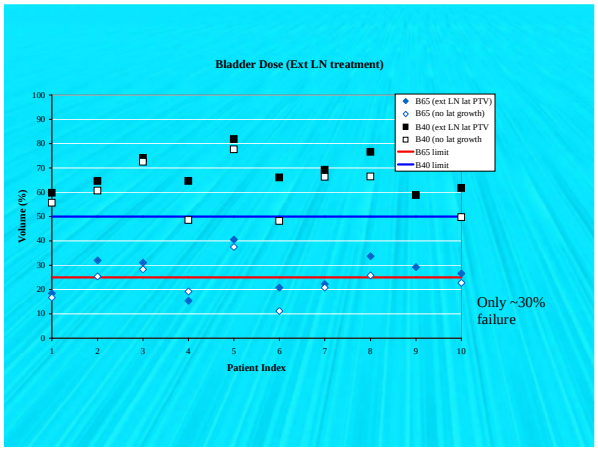
Price et al. IJROBP 2006









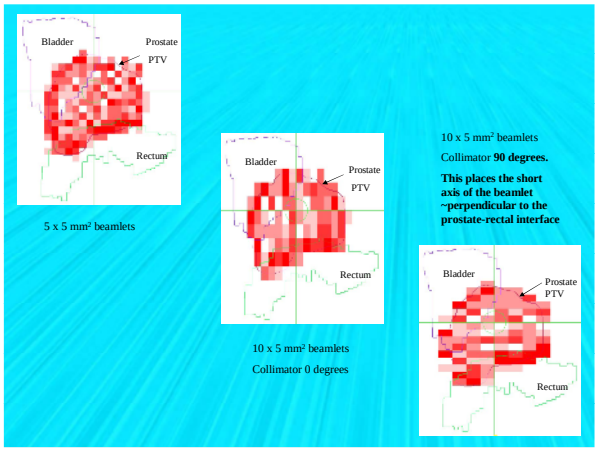


Varian 21 Ex & Siemens Primus

- 1 cm leaf width vs 5 mm leaf width
- 10 x 10 mm^2 minimum beamlet vs 5 x 5 mm^2
- We limit to 6-9 beam directions (primarily due to treatment time)
- Corvus treatment planning
- **Increased MU → Increase leakage → secondary malignancies?, shielding concerns?**

$$MSF_{mod} = MU_{IMRT}/MU_{3D\ CRT}$$

Price et al. JACMP 2003



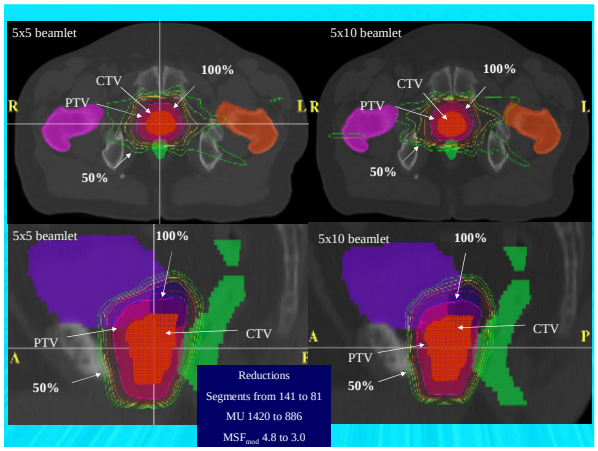
Analysis

5 mm x 5 mm beamlets

- Average # of segments ≈ 386
- Average # of MU ≈ 2055
- Average MSF_{mod} ≈ 7.0

10 mm x 5 mm beamlets (coll 90)

- Average # of segments ≈ 197 **(~49 % reduction)**
- Average # of MU ≈ 1344 **(~34.6 % reduction)**
- Average MSF_{mod} ≈ 4.6 **(~34.3 % reduction)**



Significantly increased MU may result in all of the following except:

0% 1. Increased leakage radiation
0% 2. Potential increase in the occurrence of secondary malignancies
0% 3. Shielding concerns
0% 4. Increased treatment time
0% 5. A decrease in beam stability

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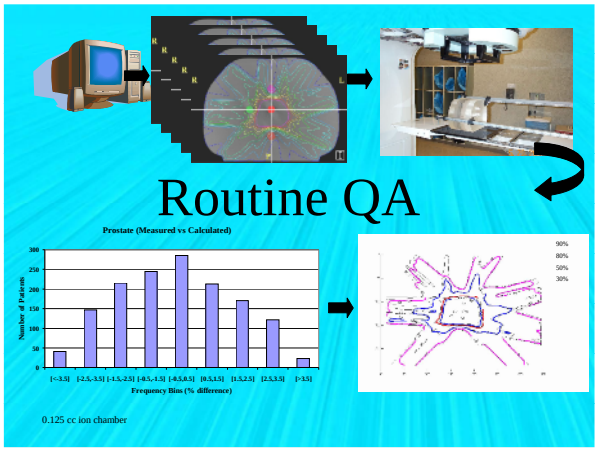
Routine QA
Prostate (Measured vs Calculated)
Number of Patients
Frequency Bins (% difference)
0.125 cc ion chamber


HooRay!!! Post Docs!!!
Teh Lin
Ahmed Eldib
Alain Tafo
Qianyi Xu
Lihui Jin
Post Docs Rule!!!