# Intensity Modulated Radiation Therapy: The good, the bad, and the misconceptions.

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## Indications for IMRT

- When critical structure protection requires the creation of concavities in otherwise convex dose distributions
- When the combined complexity of beam orientation, need for wedges, and difficulty of finding beam weights requires computer optimization for generating an acceptable plan
- Where missing tissue complicates the planning, but physical compensators are not conveniently employed
- When it is not obvious how sharp dose gradients can be moved into a desired position



## Indications for IMRT Billing

"IMRT planning is clinically indicated when highly conformal dose planning is required."

From:

How one defines intensity-modulated radiation therapy. L. Potters, M. Steinberg, P. Wallner, J. Heveze. Int. J. Radiation Oncology Biol. Phys. Vol 56, No. 3, pp 609-610



## Indications for IMRT Billing

- The target volume is irregularly shaped and in close proximity to critical structures that must be protected
- The volume of interest must be covered with narrow margins to adequately protect immediately adjacent structures
- An immediately adjacent area has been previously irradiated and abutting portals must be established with high precision



## Indications for IMRT Billing

- Additional maneuvers to reduce the gross tumor volume, clinical treatment volume, or planning treatment volume margins, have proven insufficient to produce an acceptable dose distribution
- The target volume is concave and critical normal tissues are within that concavity
- Dose escalation is planned to deliver radiation dose in excess of those commonly used for similar tumors with conventional treatment



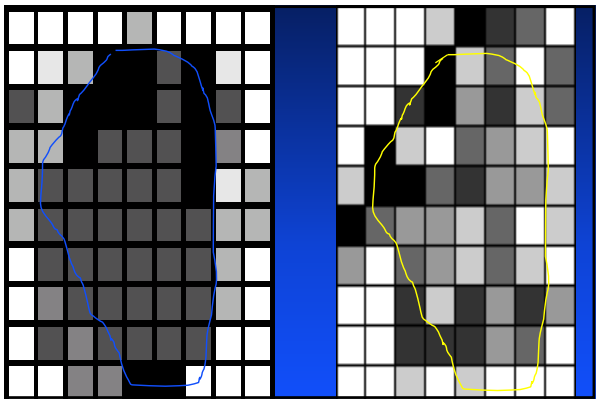
## Misconception #1

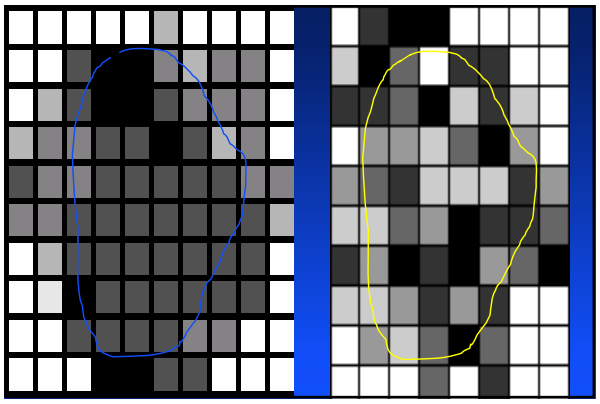
- IMRT can produce dose gradients that are steeper than those obtainable with 3DCRT
- Alternative hypothesis – IMRT, through the weighting process, can put steep dose gradients exactly where they are needed

## Question

- How can using a 1x1 cm beamlet sharpen a penumbra when the dose profile decreases from 80 to 20% in just a few mm?

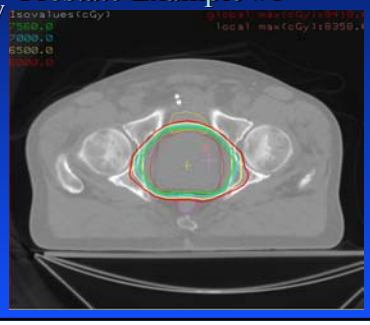






## Beamlet-based IP for IMRT Prostate Example #1

- Fused Prostate PTV red
- Isodose Lines
  - 75.6 Gy green
  - 70.0 Gy blue
  - 65.0 Gy yellow
  - 60.0 Gy red





## Misconception #2

- It is ideal to have the IMRT dose distribution conform to a target(s) as tightly as possible
- Alternative hypothesis – Allowing the high-dose surface to float away from the target(s) in some regions might be desirable in terms of obtaining the best possible dose gradient for other regions



## Misconception #3

- One should not use beam directions that point back on each other because this will decrease the degrees of freedom for the optimizer
- Alternative hypothesis – If you want to produce a sharp dose gradient along a particular line between a target and critical structure, you will do well to include parallel opposed fields with a common border running along that line

## Misconception #4

- It is not wise to use beam directions that pass through critical structures
- Observation – All regions of the body are to some degree critical structures
- Alternative hypothesis – Choose many different beam directions and let the optimizer decide on their use in the plan because there is little price paid in this age of fast automated dose delivery



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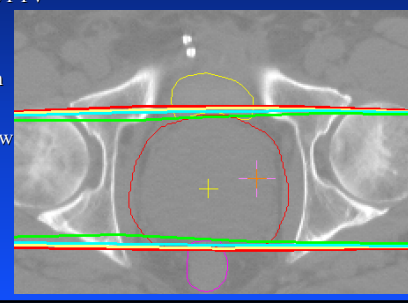



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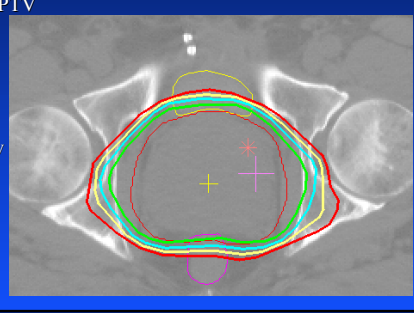
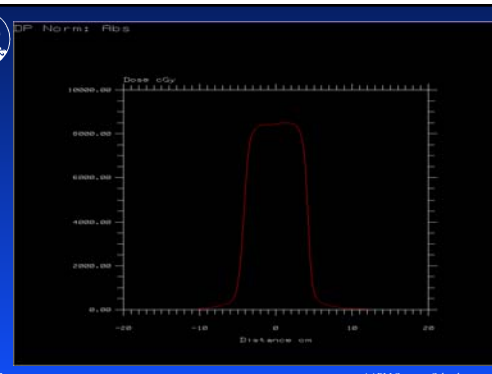
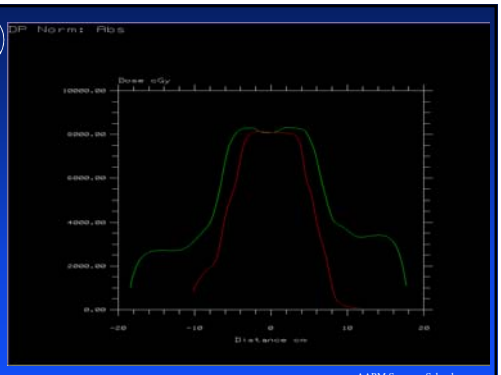








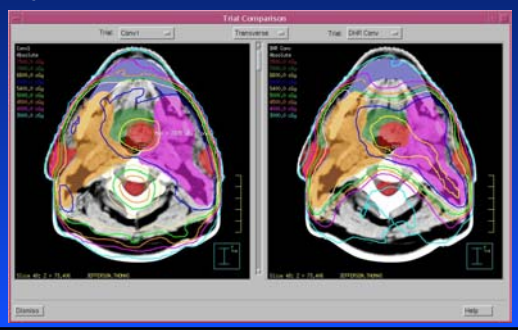





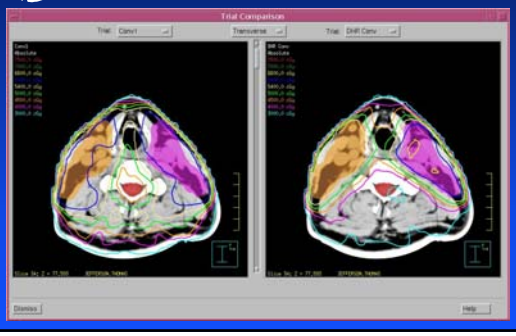

## Misconception #5

- IMRT treatment plans have a greater dose heterogeneity compared to 3DCRT plans
- Alternative hypothesis – Pushing plans to obtain the best possible dose conformity will compromise dose homogeneity

## ADAC Beamlet-based Solutions




## ADAC Beamlet-based IP



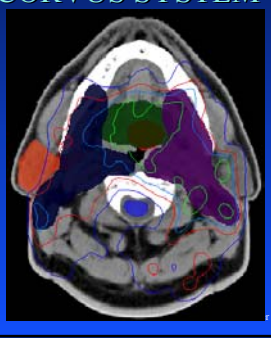

## Misconception #6

- IMRT may have increased dose heterogeneity, but the high dose regions will fall within the target(s)
- Alternative hypothesis – Dose "dumping" can occur when dose constraints for non-target regions are, for various reasons, unspecified



## NOMOS CORVUS SYSTEM

- Isodose
  - Green – 66 Gy
  - Light Blue - 60 Gy
  - Red - 54 Gy
  - Blue - 45 Gy
- Structures
  - Orange – Parotid
  - Red – PTV66
  - Green – PTV60
  - Blue – PTV54
  - Purple – PTV60 nodes





## Is it really the intensity modulation?

- IMRT produces a high level of dose conformality that is not achievable with 3DCRT
- Alternative hypothesis – It is the high level of automation that was introduced along with IMRT that accounts for a good deal of the improvement commonly attributed to IMRT
  - It is now possible to treat with many different gantry positions with a single button push



## What is wrong with current IMRT implementations?

- Too many monitor units (related to patient's total body dose)
- Too many segments (related to MLC wear and tear, and to treatment time)
- Treatment verification is complex at best

## Prostate Cases

| | Varian/ADAC Beamlet IMRT N=10 | Elekta ABIP IMRT N=10 | Elekta or Varian 3DCRT N=6 |
|---|---|---|---|
| Monitor Units for 180 cGy TD | 538 (467-676) * | 270 (243-300) | 232 (230-238) |
| Number of Segments | 64 (46-84) | 25 (9-36) | 4 or 6 |

*Average # (range)



## High Monitor Units Can Lead to Increased Patient Total Body Dose

- Radiation Induced Second Cancers: The Impact of 3D-CRT and IMRT. Eric J. Hall and Cheng-Shie Wuu. Int. J. Radiation Oncology Biol. Phys. Vol 56, Number 1, pp 83-88, 2003
  - "Altogether, IMRT is likely to almost double the incidence of second malignancies compared to conventional radiotherapy from about 1% to 1.75% for patients surviving 10 years."



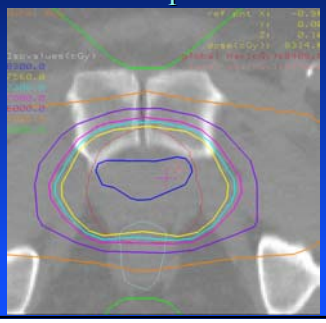
## CONCLUSIONS

- IMRT is not magic
- It is simply a highly automated version of what we have done for a long time



## Aperture-based IP for IMRT Prostate Example # 2

- Fused Prostate PTV red
- Isodose Lines
  84.2 Gy blue
  75.6 Gy yellow
  73.0 Gy cyan
  70.0 Gy lavender
  60.0 Gy purple
  40.0 Gy orange
  20.0 Gy green





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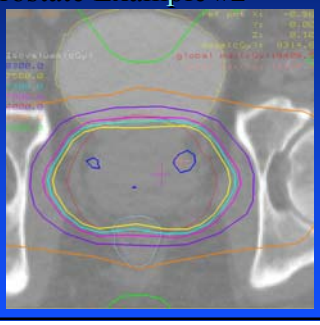



## Aperture-based IMRT - Prostate #2

- PTV red
- Rectum green
- Bladder blue
- Left Femoral Head yellow
- Right Femoral Head cyan