

Image Guided Radiation Therapy

**Translating new technologies
into clinical practice**

Julian Rosenman, PhD, MD



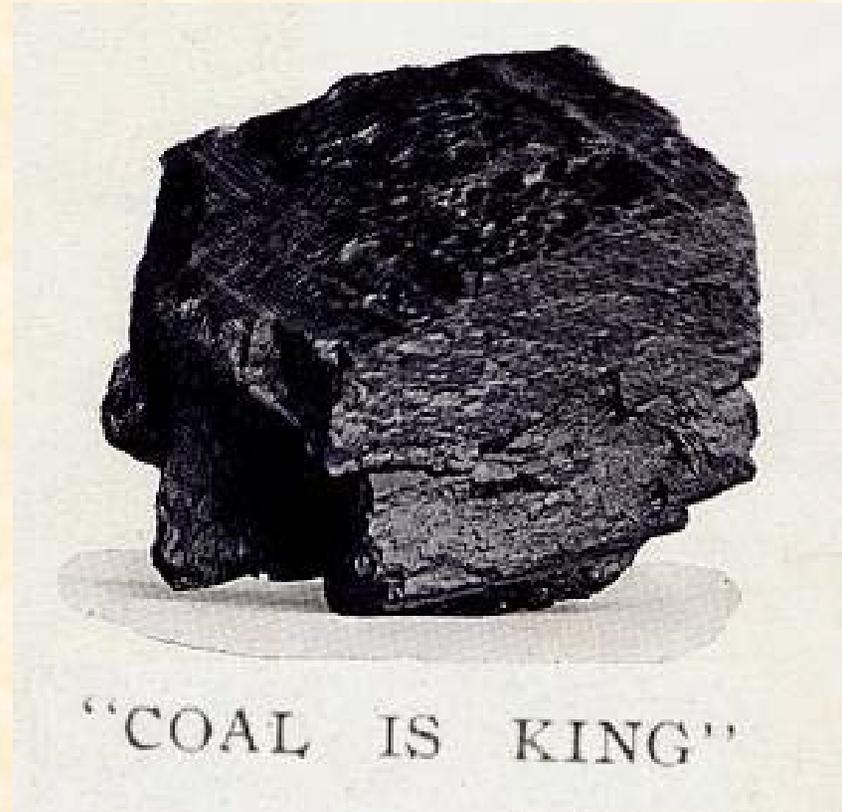
Opinions expressed in this talk are not “fair and balanced,” and may be denied by me at any future time.

Disclosures

I am going to argue that there are three separate components to IGRT:

- **First, we have to get the patient in the right treatment position, whatever that means**
- **Second, we have to keep the patient in the right position.**
- **We must be able to calculate accumulated radiation dose to see what we are actually doing.**

But first: Is IGRT worth doing at all?



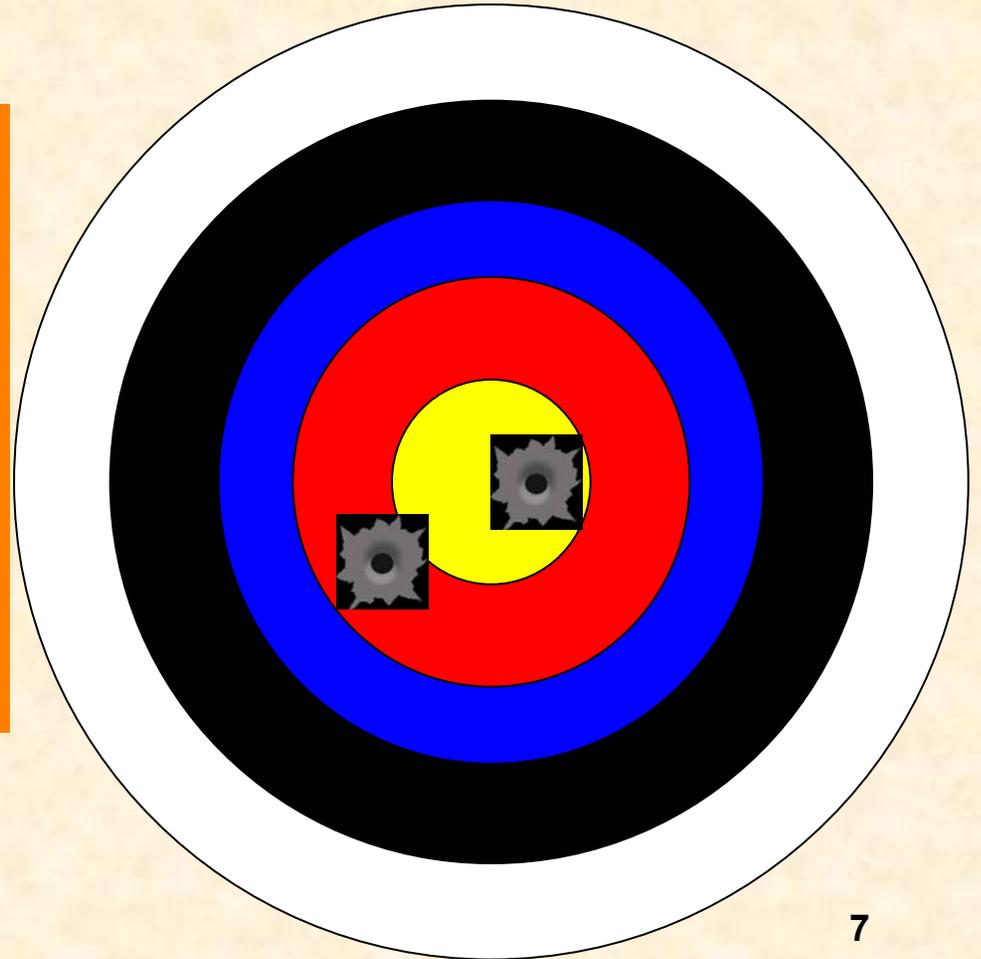
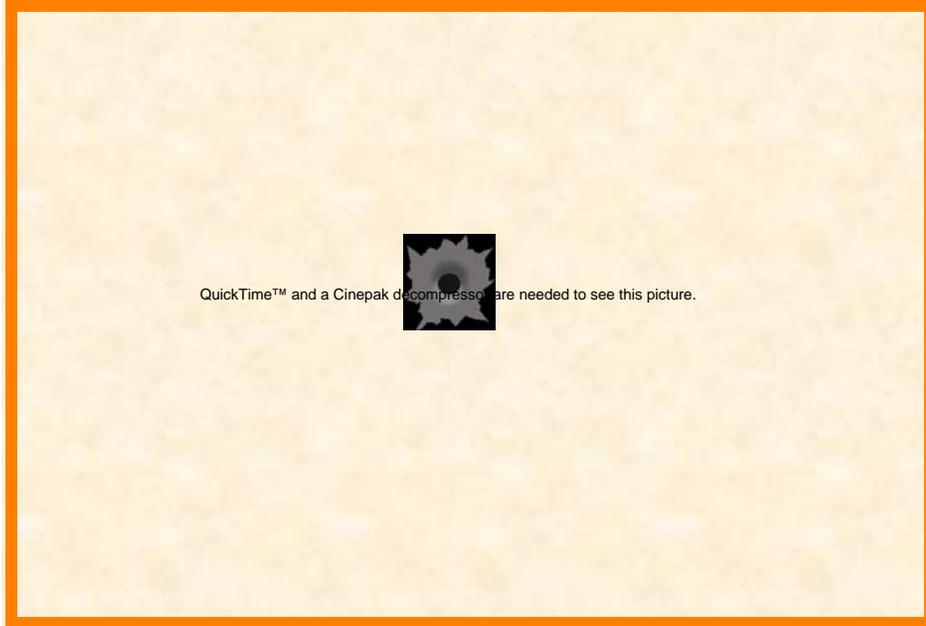
Diamonds or coal?

After all, if something isn't worth doing...



... it's not worth doing well!"

C'mon, how much does it really matter if you miss the target by a bit?



“Maybe a bit dramatic, Rosenman?”

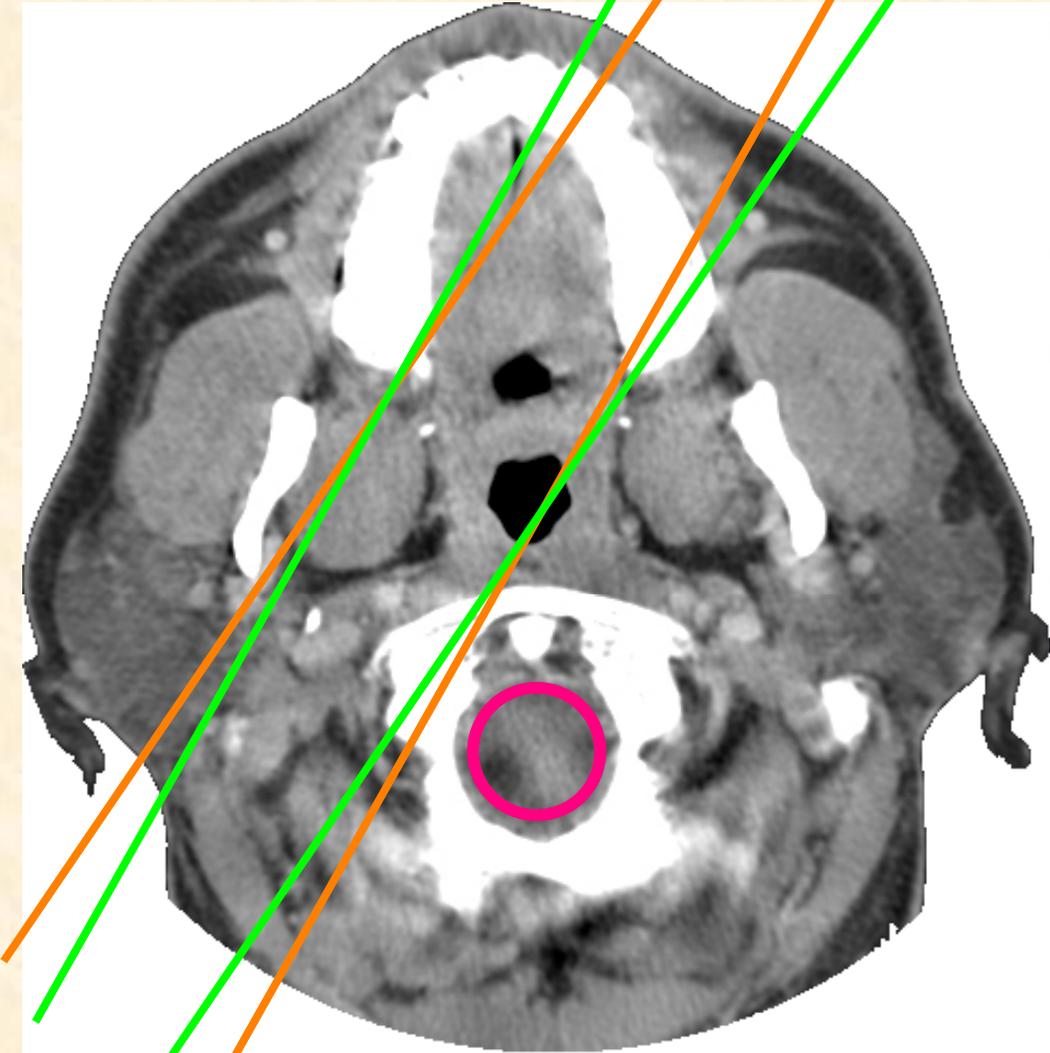
A radiosurgery case



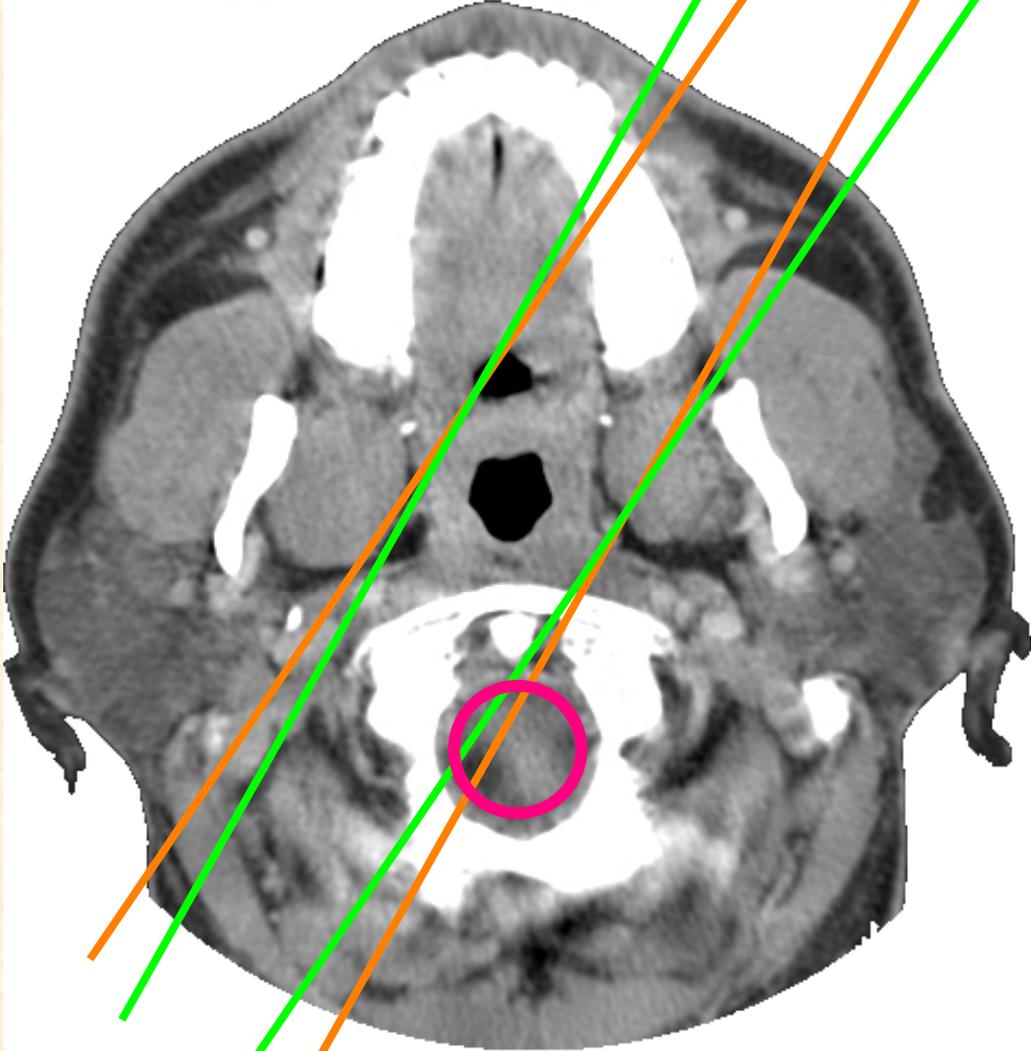
Six weeks later

“OK, less dramatic”

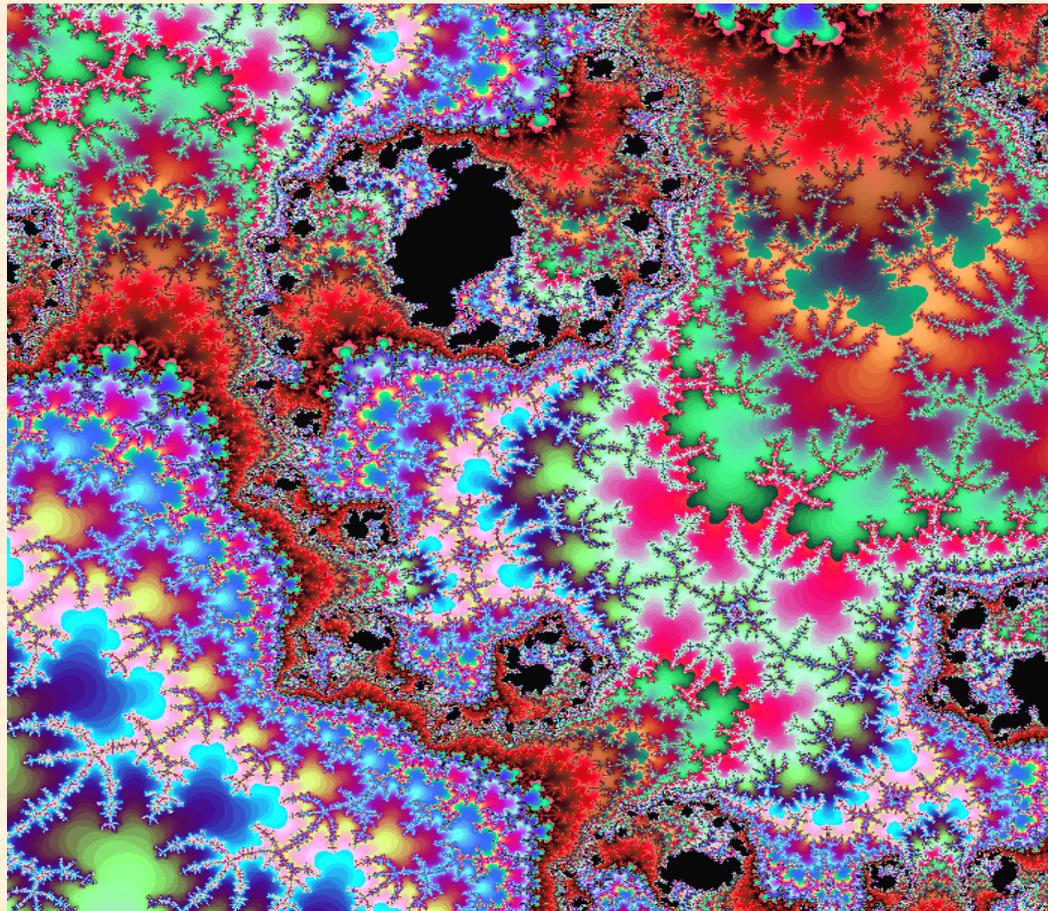
Day 5



Day 6



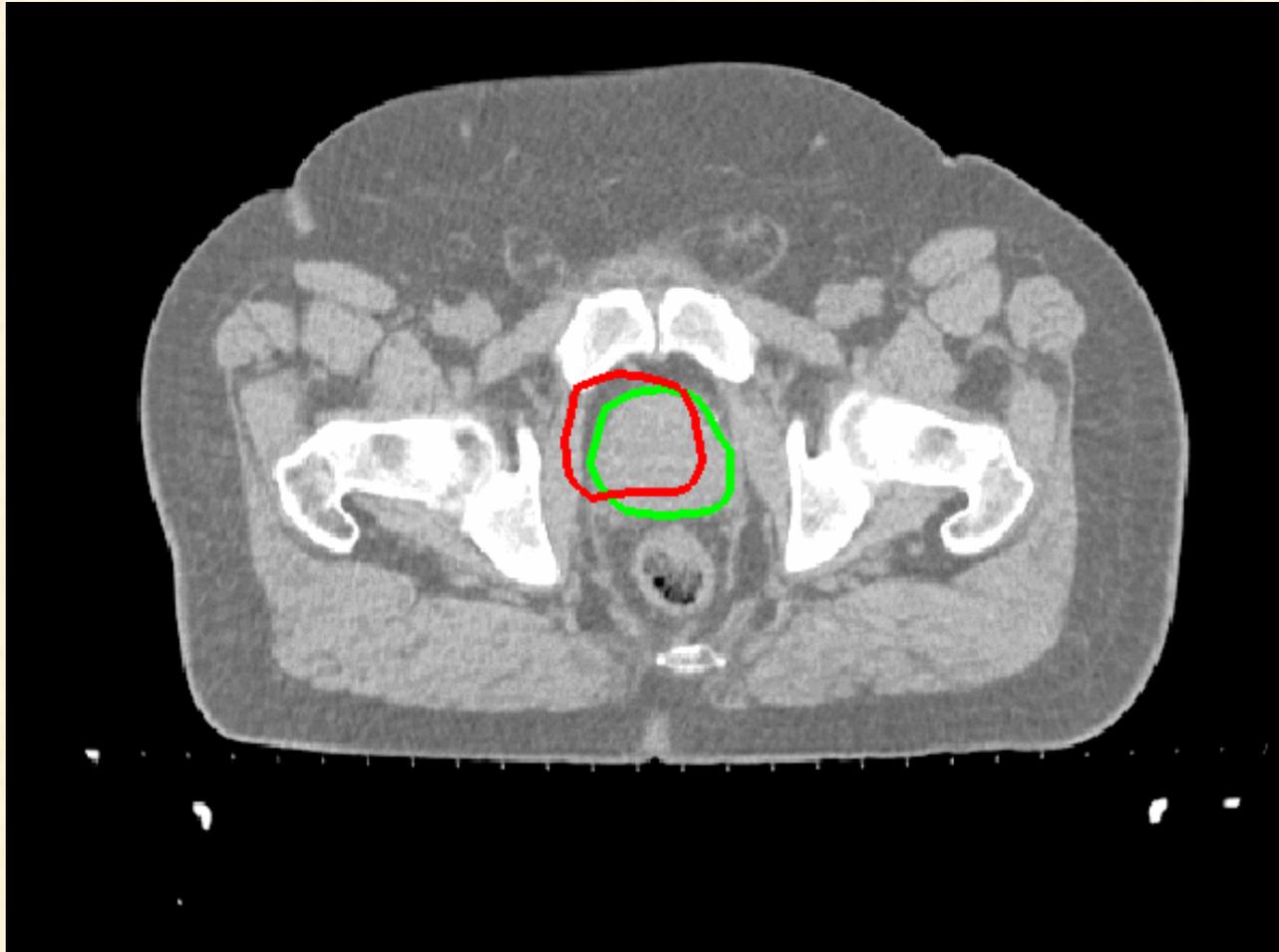
OK, but determining the value of IGRT in everyday practice is a bit more complex than that.



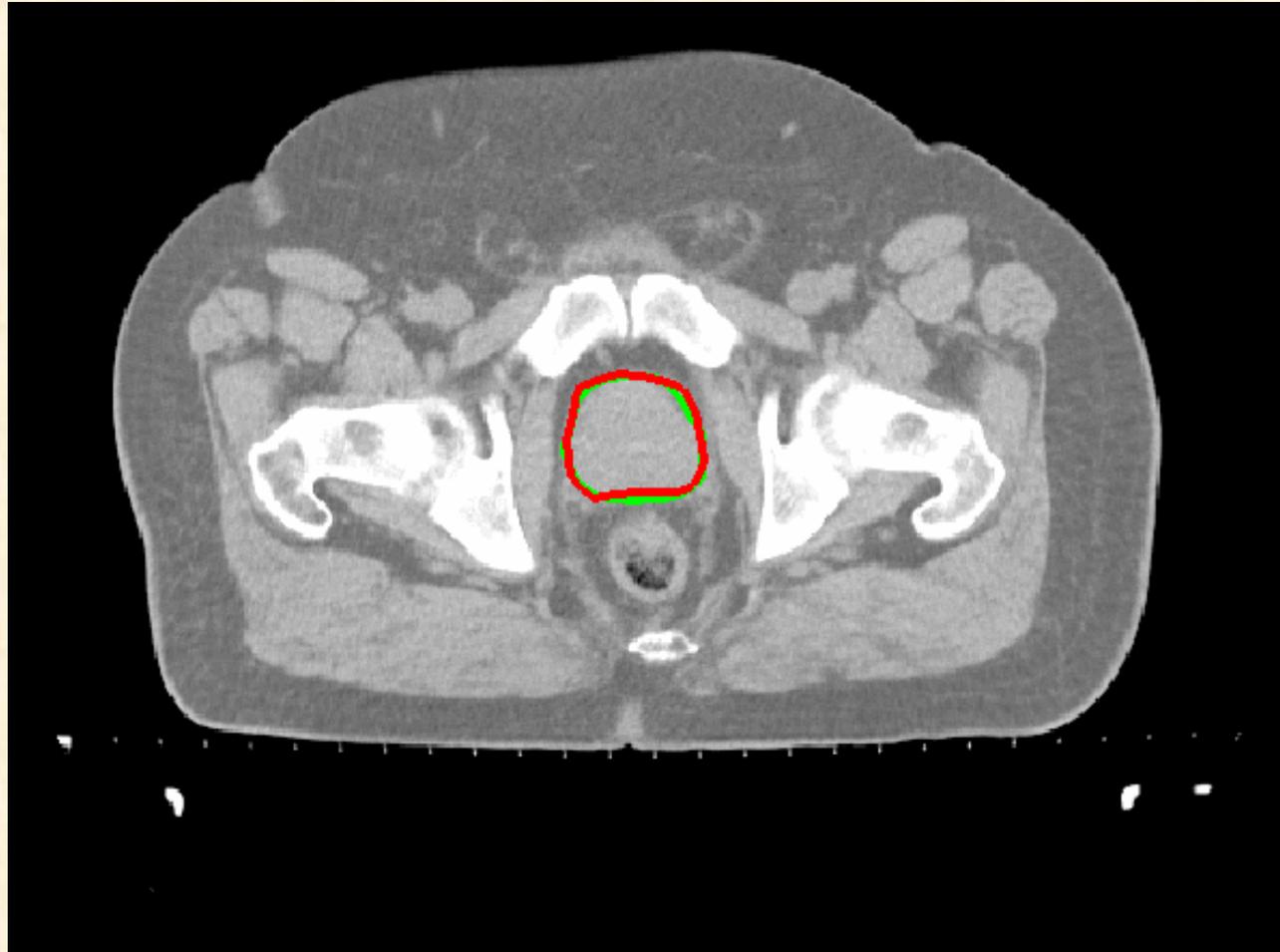
Bear with me on this for a bit



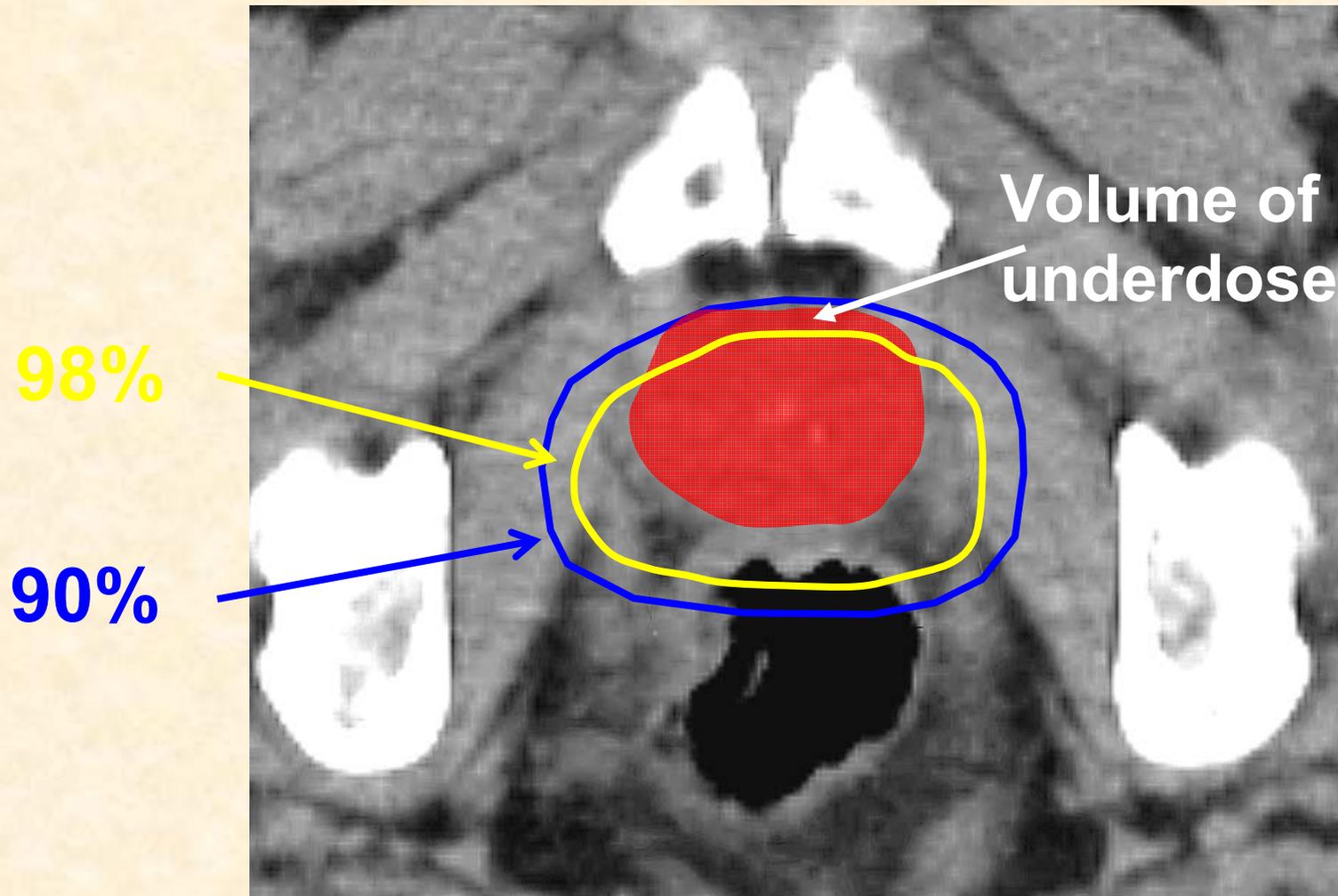
Here is what happens with no ART



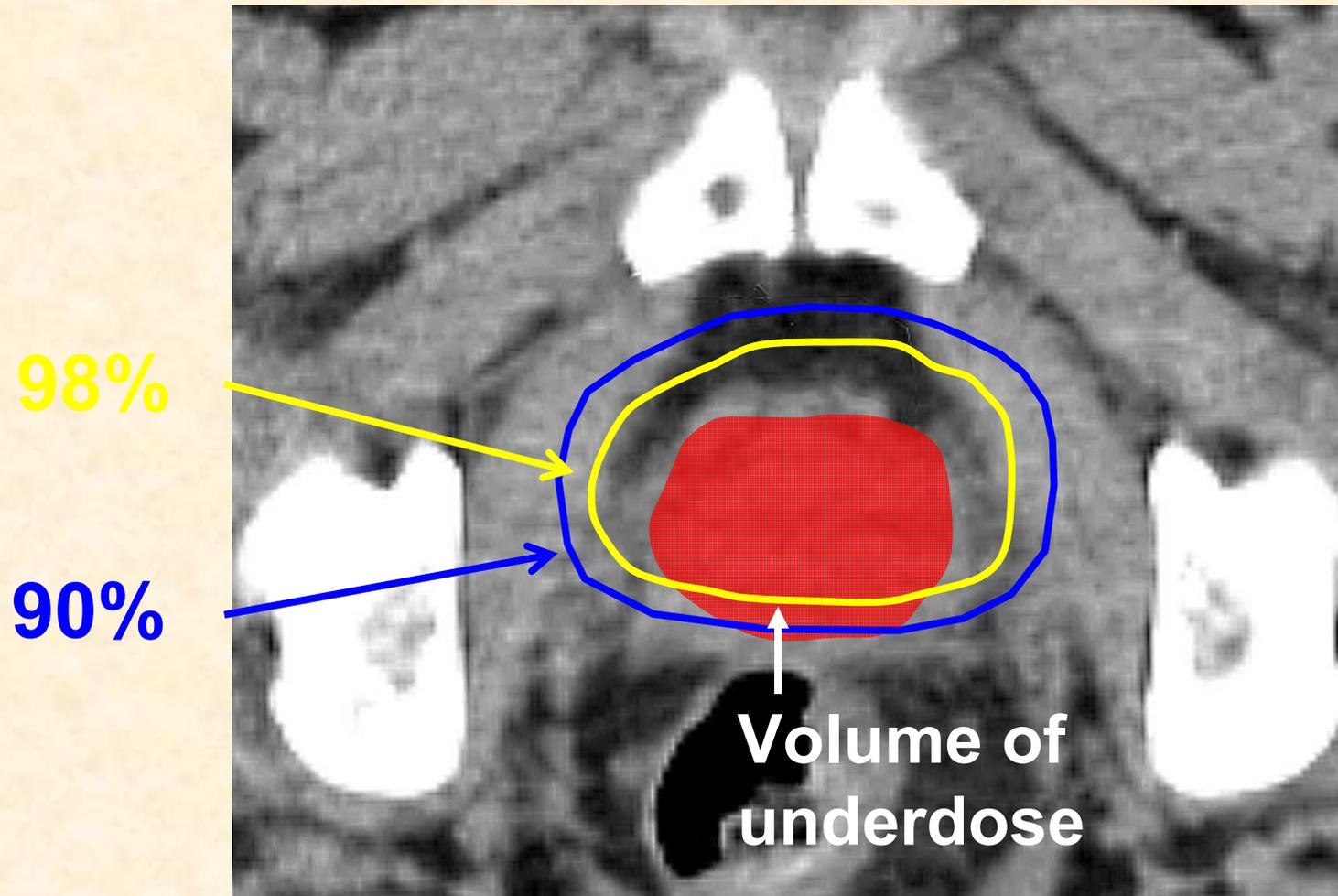
Even with “perfect setups”



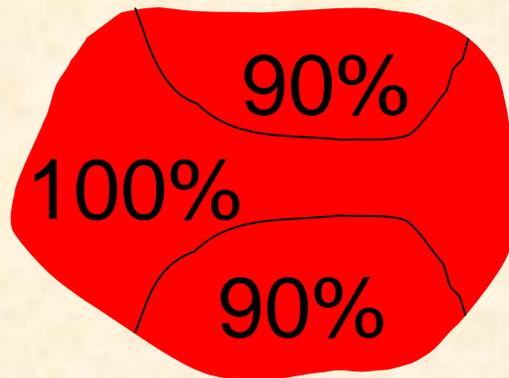
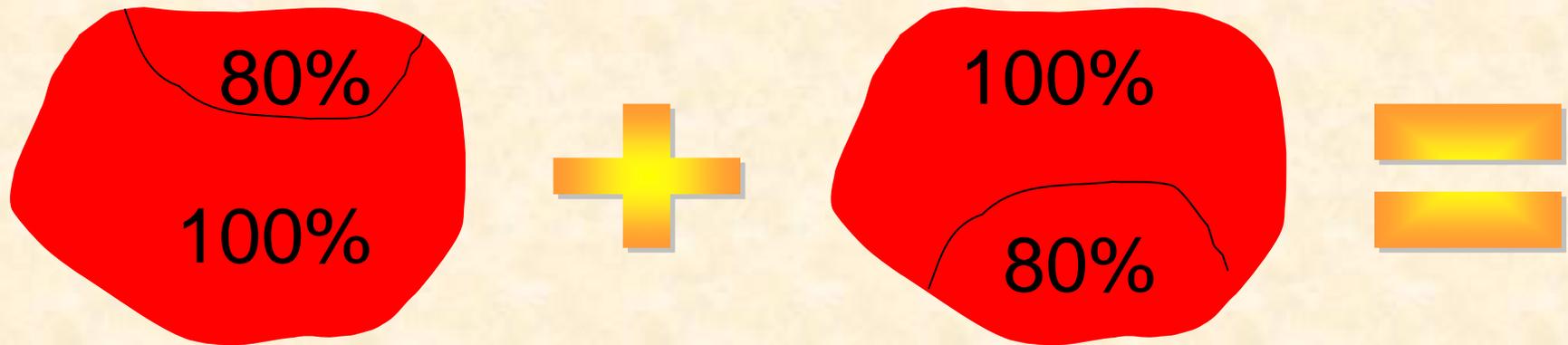
A more detailed look at the first day of treatment.



A more detailed look at the second day of treatment.

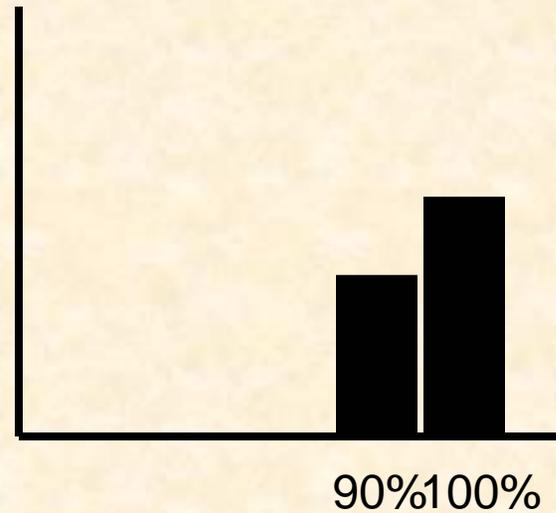
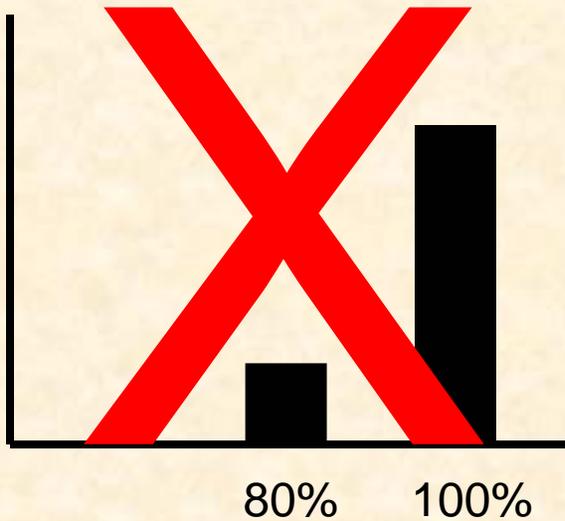
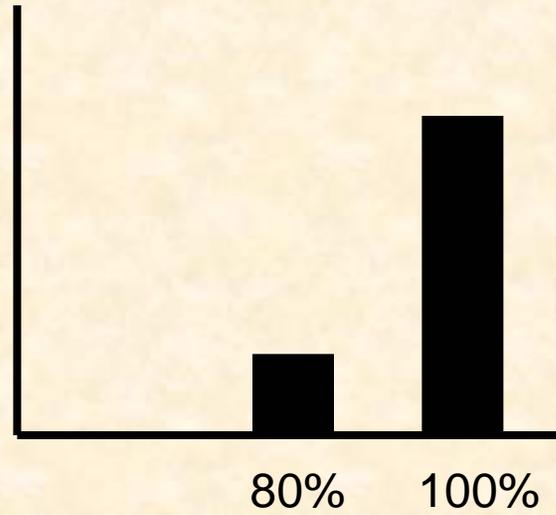
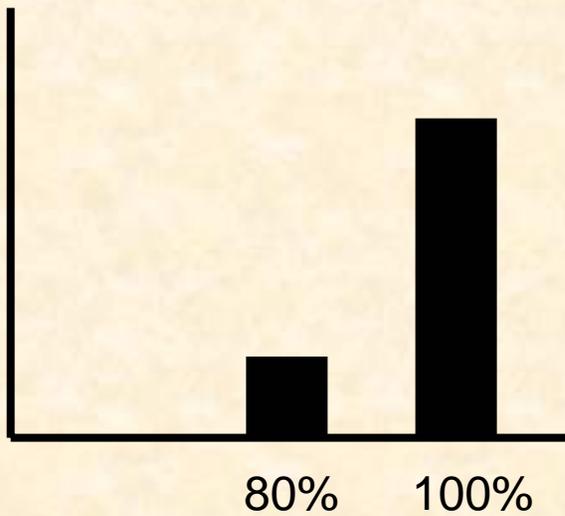


How do you add the prostate doses?



But only if you keep careful track of what part of the prostate got what dose.

How do you add the prostate DVHs?

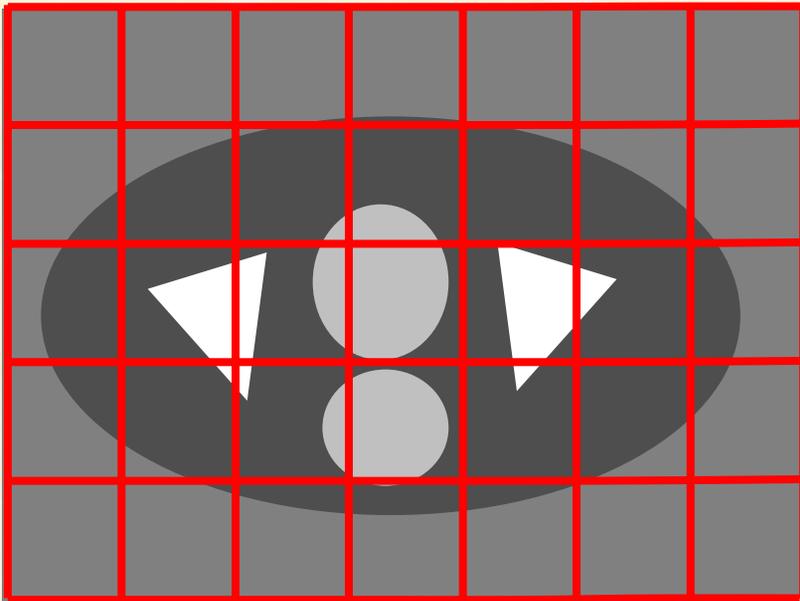


And now the key point:

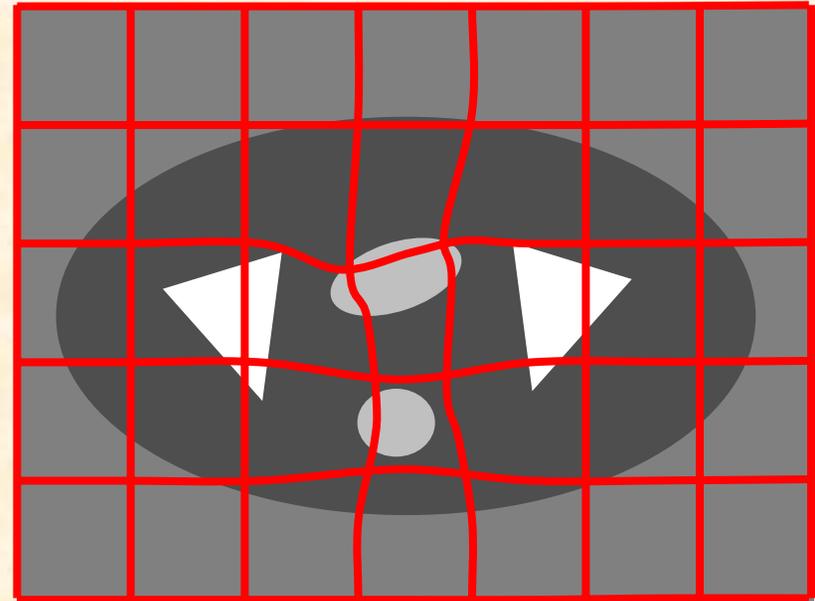


- To accumulate prostate dose one must register each “day n” prostate with the “day 0” prostate and *translate the dose distribution as well.*
- For every other organ for which dose accumulation is to be done one must perform a new registration and dose translation for it.
- And this unwieldy procedure will fail if the organs of interest *change shape.*

What you really doing is a warp registration.



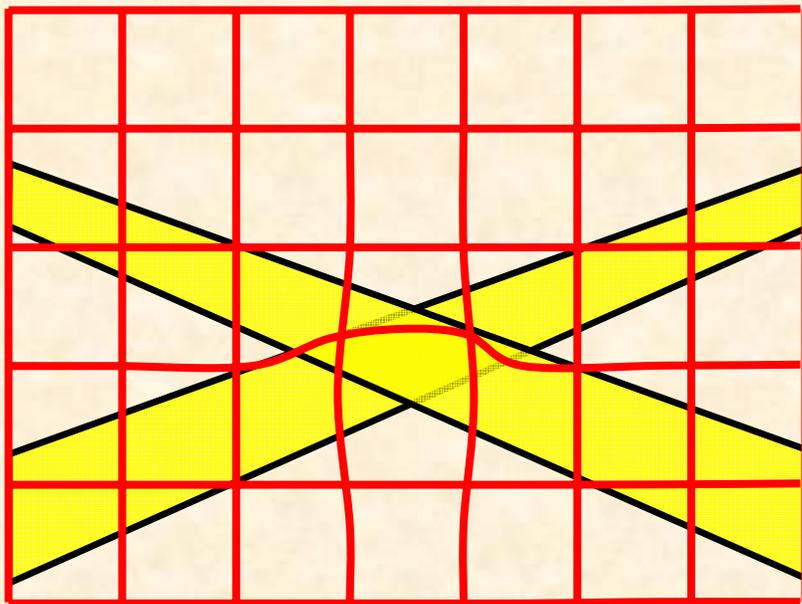
Planning Image



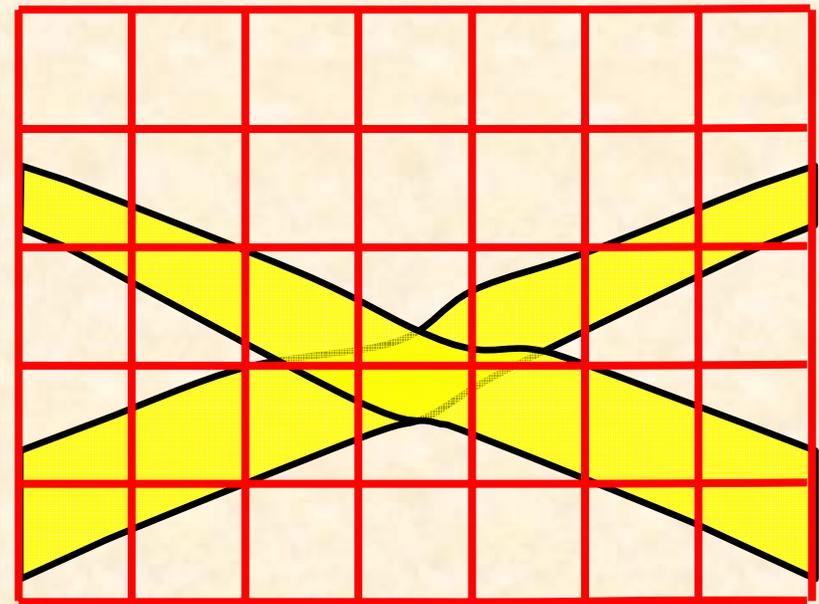
Treatment Image

Treatment image is registered to planning

The warp of day 1 is computed and the dose warped back to the planning image (day 0.)



Treatment image



Planning image

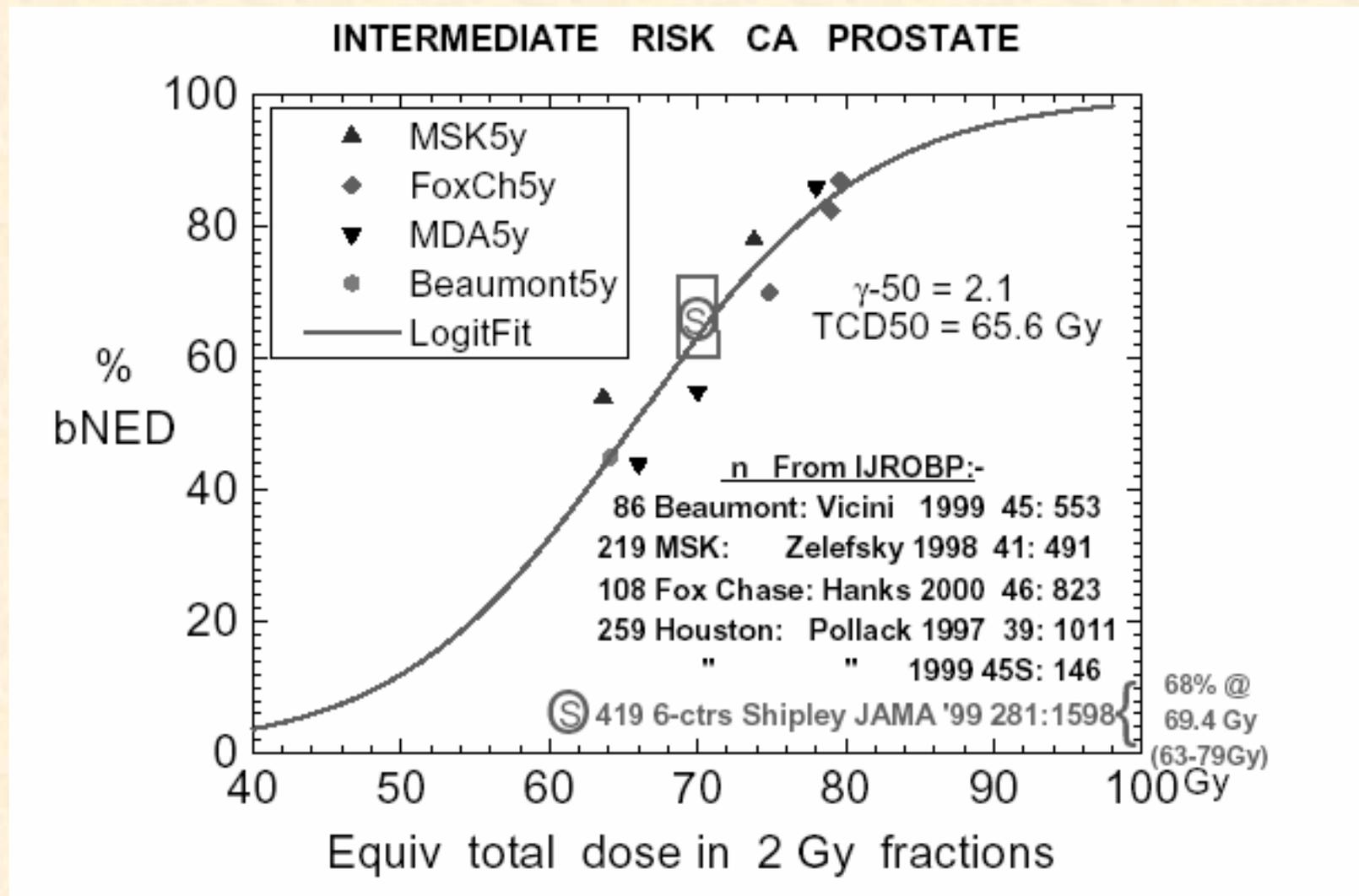


The warp must be done more accurately than the setup errors!

What might this mean clinically?

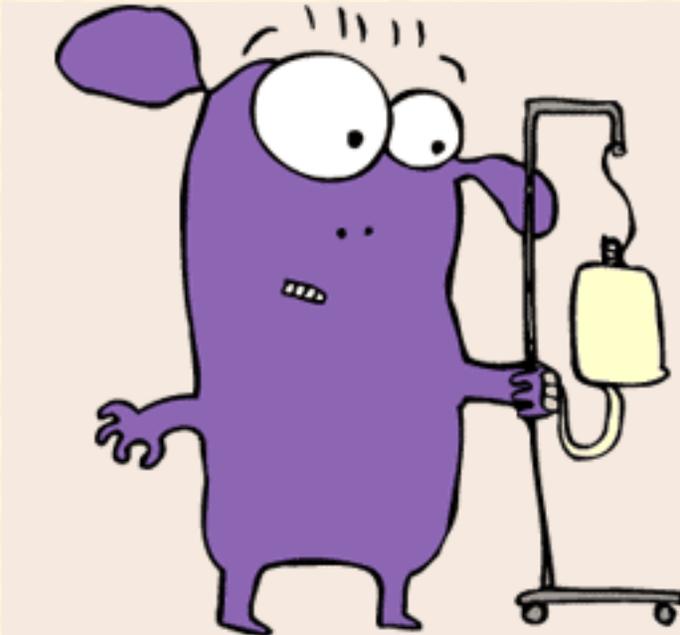
Pt	Prescribed prostate EUD (Gy) (isocenter = 78 Gy)	Delivered prostate EUD (Gy)	Delivered prostate mean dose (Gy)	% of rectum > 65 Gy (prescr < 17%)	% of rectum > 40 Gy (prescr < 35%)
1	77.9	74.7	76.3	2	24
2	76.6	73.9	75.6		11
3	78.6	77.8	78.0	1	15
4	75.6	75.9	76.2	9	33
5	76.2	75.3	75.9		8
6	76.8	76.8	76.8	21	43
7	76.0	73.5	74.4		8
8	78.0	77.9	78.0	3	13
9	77.3	75.6	75.7	32	81

1-3 Gy low!



Slope = 2.5% per Gy. For our patients this means a 2-6% Δ in FFF due to motion alone.

So, coal or diamonds?



A 5% improvement in disease-free survival would buy you chemotherapy in lots of diseases.

I would like to see similar studies in head and neck and lung cancer.

But I think the point is made.

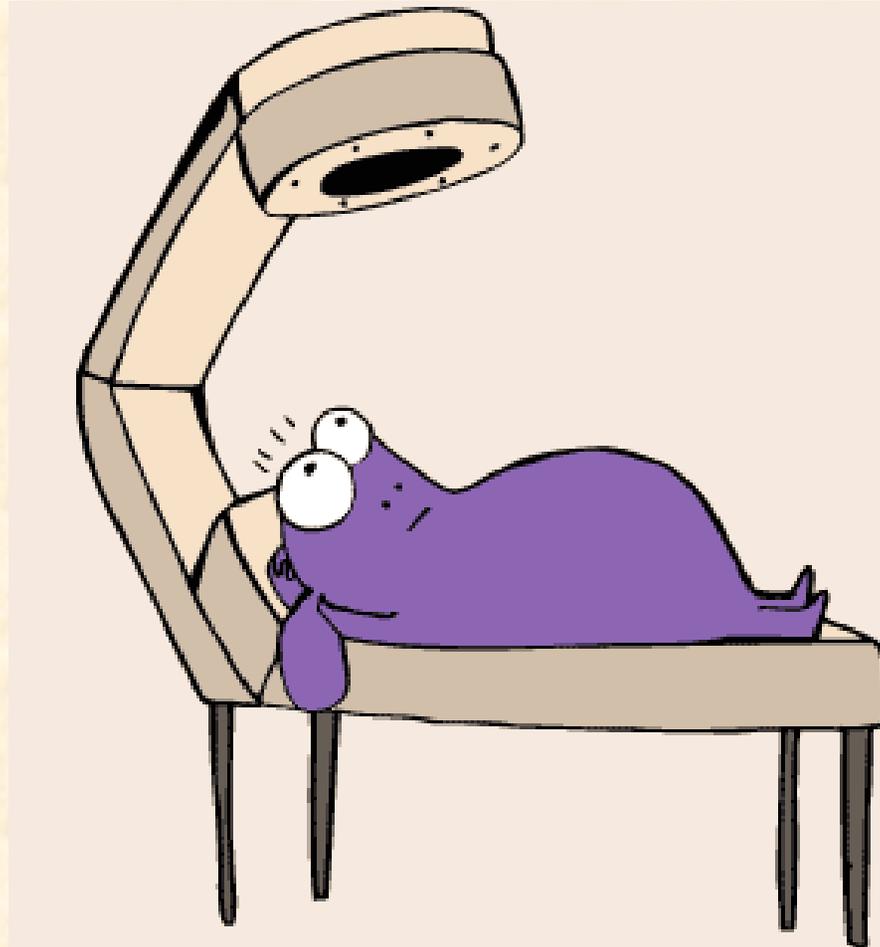
Having “proven” the value of IGRT I propose the following guidelines:

- **IGRT must be safe for the patient.**
- **IGRT must not significantly add to the treatment time.**
- **An IGRT system must work correctly and be capable of proving that it does.**

Re-stating the tasks of an IGRT system

- **First, we have to get the patient in the right treatment position.**
- **Second, we have to keep him/her there during treatment.**
- **We must be able to calculate accumulated radiation dose.**

Getting the patient set up correctly:



Getting the patient set up correctly:

In order of effectiveness

- **CT-on-rails**
- **KV conebeam**
- **MV conebeam**
- **Positioning sensors**
- **Ultrasound (limited)**
- **EPID with fiducials**
- **Photography**
- **Laser setups**
- **Portal films**

In order of safety

- **Photography**
- **Ultrasound**
- **Positioning sensors**
- **Portal films**
- **EPID with fiducials**
- **CT-on-rails**
- **KV/MV conebeam**

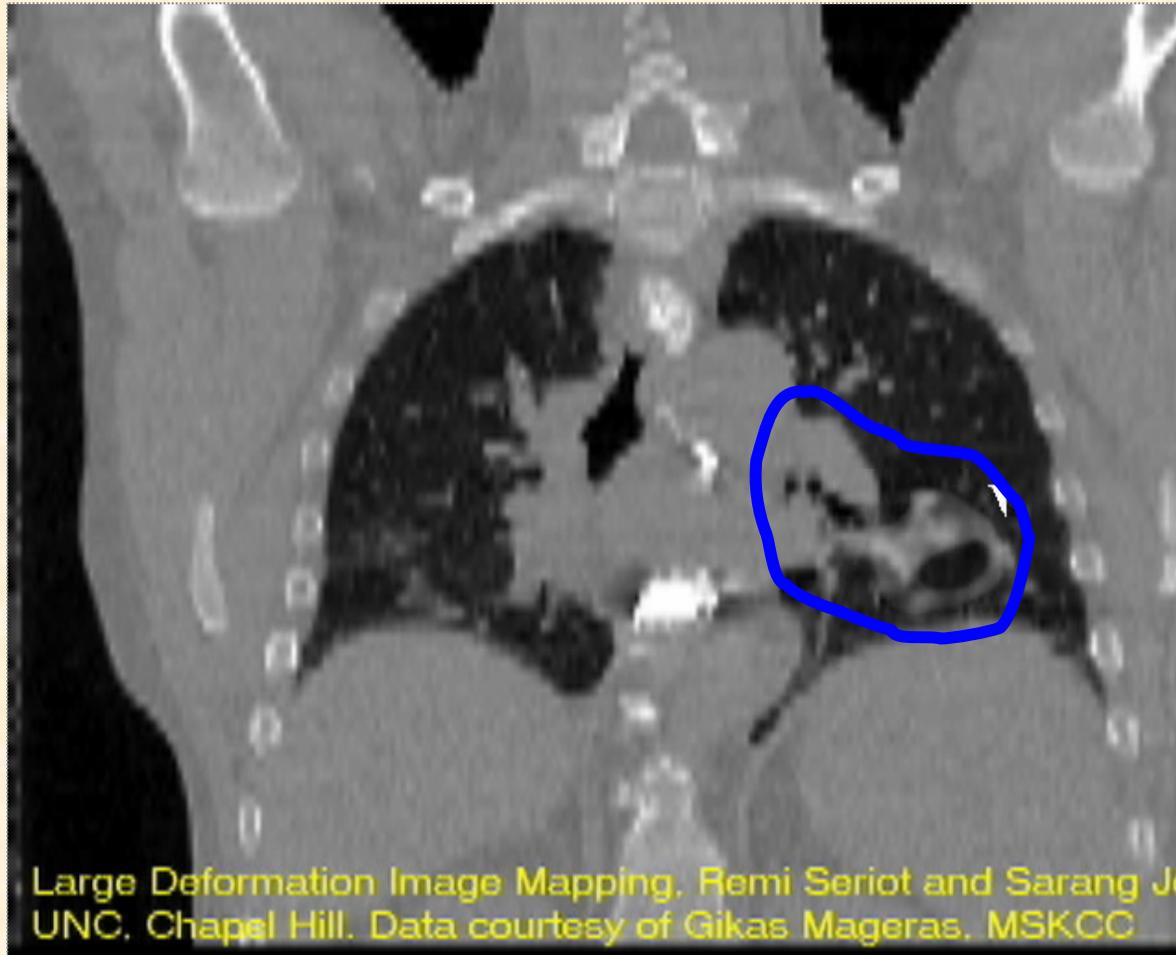
Keeping the patient set up correctly



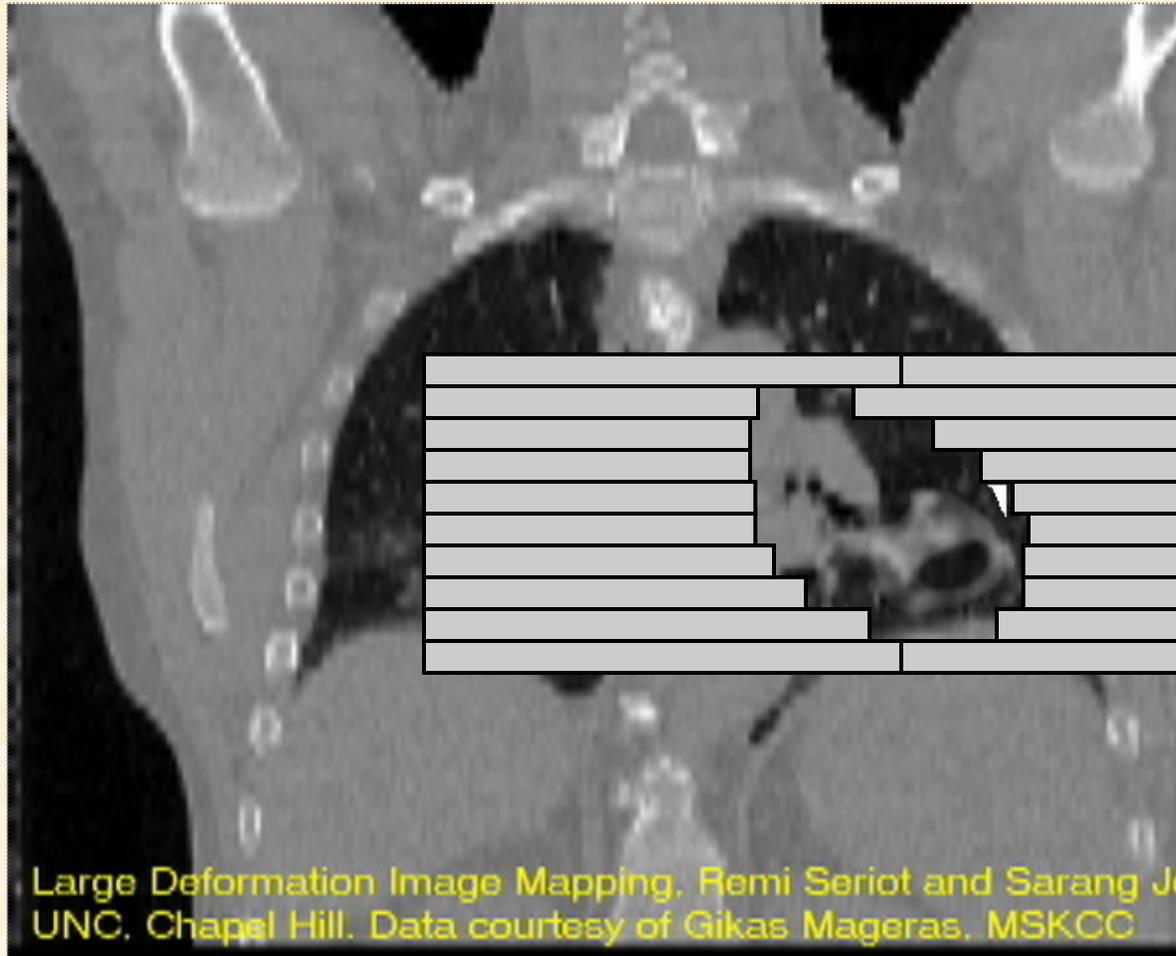
Some kind of tracking is needed to do this



The problem: Here the CTV is carefully outlined and the patient is set up with care...



The problem: Here the CTV is carefully outlined and the patient is set up with care...



But if patients don't breath, Medicare won't pay.



Doable by a 12 year old and a joystick?

QuickTime™ and a Cinepak decompressor are needed to see this picture.

Tracking the patient:

In order of effectiveness

- **Stereo fluoroscopy, multiple fiducials, continuous imaging**
- **“Lesser versions” of imaging with fiducials**
- **Imaging without fiducials**
- **Positioning sensors**
- **Motion detectors**
- **Ultrasound**
- **Photography**

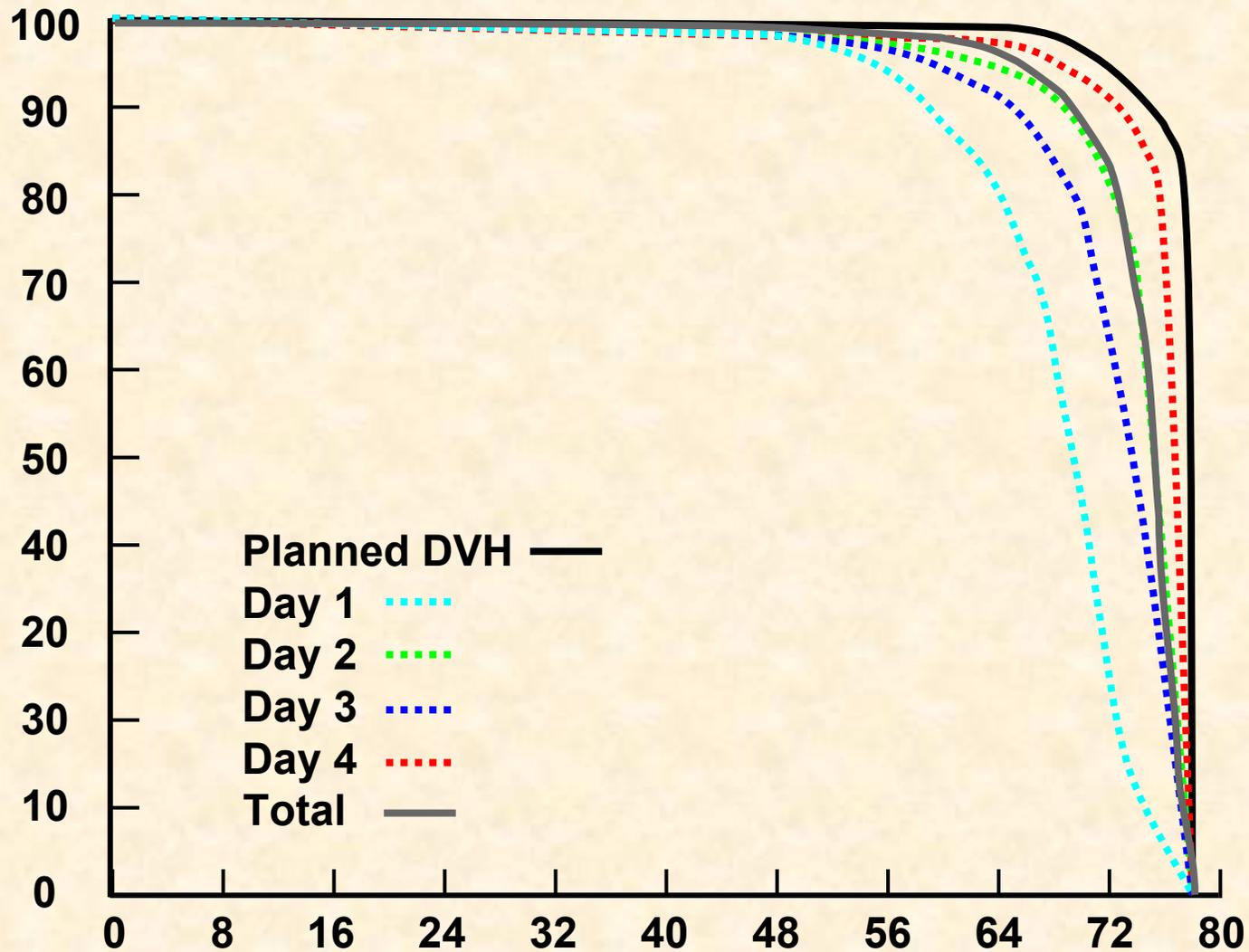
In order of safety

- **Photography**
- **Ultrasound**
- **Motion detectors**
- **Positioning sensors**
- **Imaging without fiducials**
- **Imaging with fiducials**
- **Fluoroscopy**

Calculating accumulated dose



This last point we talked about first



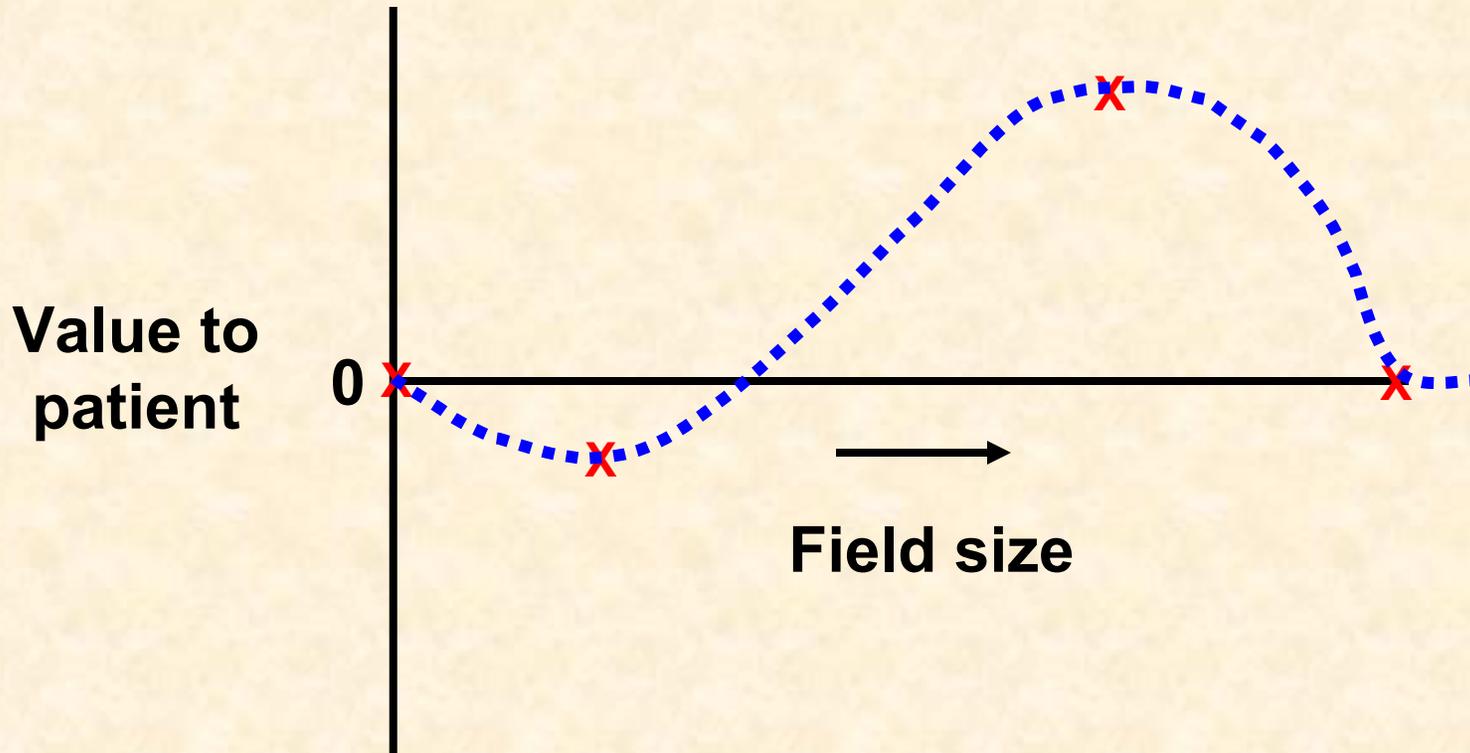
Why this talk about dose?

**Because dose is what I know how
to relate to patient outcome**

Not geometric displacement

This is why

The value of error correction depends on field size and many other things.

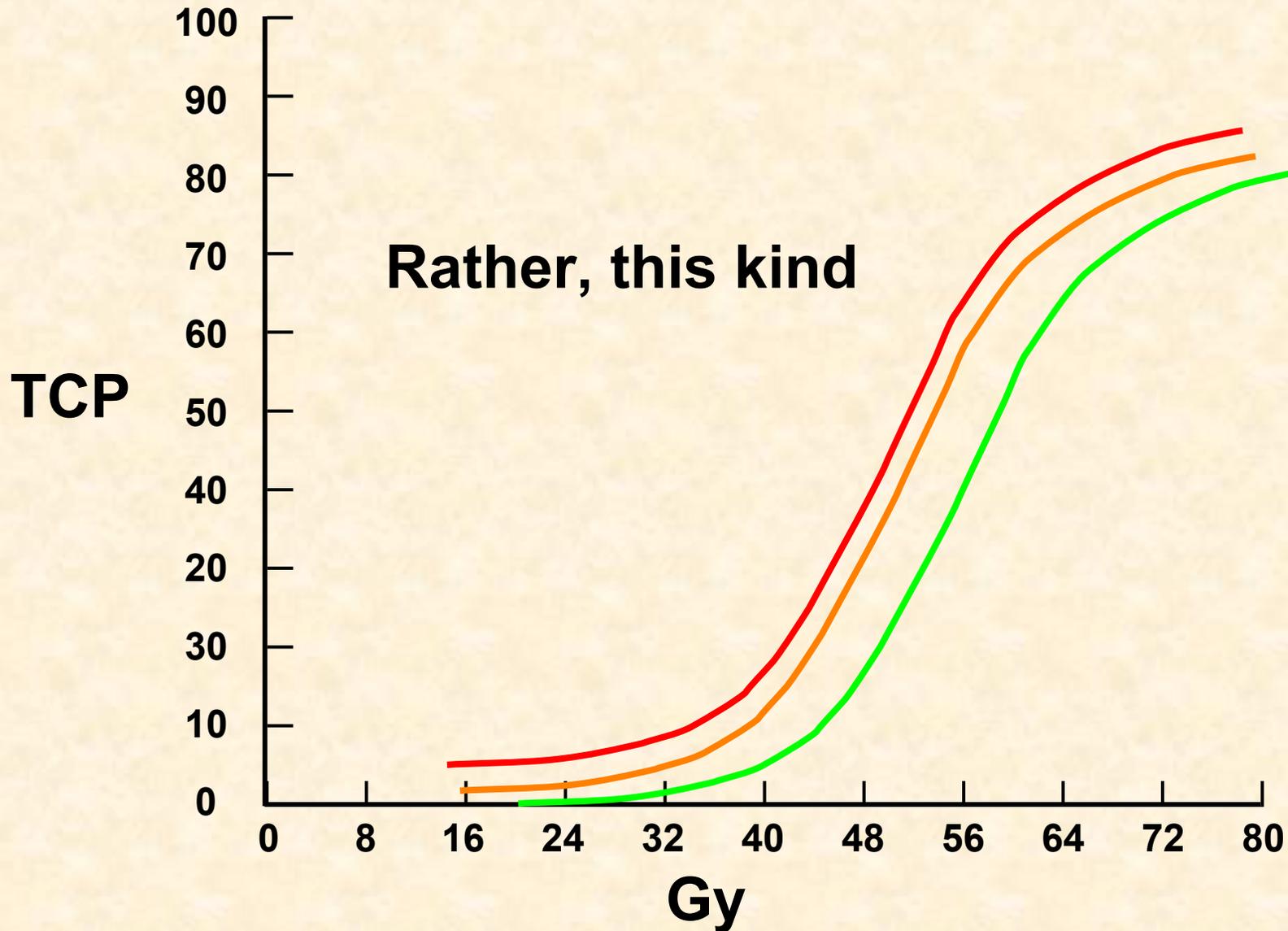


The only thing I have to add is that to understand the value of ART we must develop believable biologic models.



Unfortunately not this kind of model!

But ultimately, to understand the value of ART we must develop believable biologic models.





**Thank you AAPM
summer school for
inviting me!**