So without further a due I will sorta start this presentation. Again, thank you for coming and listening to this presentation. When I started doing medical physics, we was sort of had this joke among ourselves, in that we told ourselves that that was the way we were treating patients. We're actually measuring everything with a micrometer, being very precise, we marked it with chalk and then we cut with an axe. Currently, of course, we have IMRT, so now we're telling everybody that we're very precise and what we're doing, we're cutting with a scalpel. We're also very precise in determining the thickness of our chalk. By that, I mean that we have these regulations and we have these methodologies called ICR 50 and 62 where we define what our PTV margins are, and the goal of image guided radiation therapy, in essence, is to reduce the PTV margin so that we can irradiate smaller volumes. And, of course, the PTV margin will

depend on the organ that you're treating, the patient itself, and the modality of treatment that we're actually using. ________from the Netherlands Cancer Institute--and if you see a little number here, that means that there is a reference and if you download the presentation the references are listed in the back so you can use those at you leisure. And for the purpose of the margin recipe depending…based on the fact that we want to do 98% equivalent uniform dose throughout the target volume, and you want to do this for 90% of the patients; and, so, you could calculate this using some simulation procedures using Monte Carlo calculations to simulate a population spread and we came up this following recipe with MDMB margin and the capital signal is the spread of the systematic area and the small signal is the average of the random areas, and, of course, you see that the systematic area is weighted much more than the random areas

and the 3 mm is a fifth parameter. For reducing the margin, how do you do that? You can either reduce…you can reduce any of those parameters, systematic areas or random areas, and the reduction of the systematic areas is the most efficient thing to do and, also, it's the easiest thing to do, because it has the highest rate and most popular correction system is the offline system, where, in essence, and there are many variations of this so I'm not going to go in there, you gather data and sampled it position and distribution up to about six fractions, sometimes more. Many apply corrections to minimize the systematic area, and then you can also adapt the margins to reflect the variations. The online adjustments actually will reduce both parameters at the same time. That means that there are actually no bad treatments, the *bad* in between quotes there. It's conceptually simple, there are no assumptions on the type of probability distribution that you

have, and also, it's very straightforward to explain to a therapist what they need to do; if you see an error, you correct it every day. So, how are we doing that? Essentially, all online adjustments are identical, only the modalities in which you do it will differ. The patient is usually set up in the treatment position and the target organ, in this case it was the prostate ______**.** Continual education course is _____ threshold offset. The patient is repositioned using a variety of methods and then usually you reassess the position before you start treatment. Obviously, that's not something new. This is an image from a Brussels study in 1995. Our EPID was used to reduce the errors looking above the anatomy and then when we looked at a time trend, the time added to treatment, they saw that about 48% of time was added to the treatment, and at that time that was inconceivable; now, these days, that doesn't seem to be a problem at all any more. The online

adjustment modalities I would like to look at is ultrasound detection and implanted markers, either active or passive, using passive ______ also using ultrasound or EPID's, electronic PET imaging devices. The ultrasound adjustment obviously uses a…this is from the BAT system which is sold by Nomos Corporation, now North American Scientific, takes two perpendicular slices of ultrasound images and overlays the CT data, and then the CT data is moved so that everything's aligned and then you move the patient along. This is data from about ten patients looking at all of the different shifts that were done on a all of those patients using an ultrasound system. You see that the number of shifts is fairly large and also the extent is fairly large. This is from –3 to 3 mm, same thing in that direction. This is the sagittal plane. So we can verify

ultrasound-based adjustments together with markers. This is about a study that involved 17 patients where we had 156 image pairs of EPID's with markers after we did ultrasound adjustments, 119 image pairs using traditional treatment for the same patient group. And the data were kind of strange because we didn't see a lot of difference. The green line is with ultrasound, and this is without ultrasound, and there is not a big difference between both of those systems; actually there was almost no significant difference. So, the questions is, why doesn't ultrasound-aided repositioning perform any better? One of the reasons could be user's subjectivity. The use of the system ______ an article about alignment from the University of California, San Francisco, that looked into it, again the references. Another problem could be the discrepancy between the contoured anatomy, which you have on your CT, and the actual anatomy; or, even,

the anatomy that you're seeing on the ultrasound image. And to illustrate that, this is from a study by Netherlands Cancer Institute. This is five different physicians drawing in a bladder and you see that there is a large interobservative variation just by contouring the bladder. And, of course, if you make an error in contouring the bladder, you're going to…or contouring the prostate, you're going to propagate that error throughout your treatment if you're going to use that to align…so that could be one of the things that are in there. Also, one of the possible reasons would be interfactional movement between the ultrasound procedure and the treatment; if it takes a long time before you finish the ultrasound procedure and then go over to treatment, things could have changed and that was one of the arguments that was used by the ______ when they saw discrepancies in their first CT and to ultrasound comparison. And the fourth one, I call

the Heisenberg group, of course you know this from quantum mechanics and actually, essentially, it means that if you're going to measure something, you're actually influencing the system; so it means that if you're applying pressure or if you're using the abdominal probe to put on the abdomen, it could be that you're changing things inside, so you might see different things than when that probe's not there. And there's an interesting study, which just came out, I think, in June 2004, in the *Red Journal,* by the Netherlands Cancer Institute, that looked at CT images under ultrasound _____. Of course, the study that I just presented was done about two and a half years ago and things, of course, changed from time to time. So, BAT and I must introduce live CT contouring projection during the acquisition, so I was working with seed localizer…here you can see the person adjusting the CT contours on the live ultrasound _____ data pseudo-3D

acquisition to alleviate the problem we're only using two slices and so it could reduce user inter-variability; and, of course, it works by combining all of these slices together and sharing those on the screen. I-Beam CMS also has pseudo-3D acquisition and reconstruction and also allows

contouring the ultrasound ______ to the planning system and so their reconstruction is a little bit missed. Now marker-based protocols, if you're going to use markers ______. You have a patient and you put markers on the outside and with normal portal imaging the only thing you can see is _____ anatomy and, of course, what we did was we implanted some markers inside of the patient so now you can visualize those…So in marker-based, not necessarily _____, but in marker-based protocol there is fewer of them; ultrasound you would not look for prostate; it looks for the home seeds. Of course, you would need 3-D acquisition. Beneath it would take images and visualize

the seeding and there is a product by Calypso where seeds are implanted that reflect ____ radiation and uses a detector to see where these are, and this would be clips that frequently misses the detector and the _____ seeds and, of course, the detector needs to be placed in proximity to the patient. So we assess the marker daily acquisitioning and the protocol that was used, with two images under two different angles ______ apart. Distance ______ determine the 3-D position, and then calculate ______…sort of how it goes, and you can see the markers inside of the patient, and these are the seeds represented by the CT and you just shift those to the other side ____ and then you get some numbers out and it's fairly straightforward. So the results for this study we had 270 treatments, 540 total position measurements, 270 before and after pairs, and you can see that there is definitely a significant reduction in the shifts recorded and these are

the two distributions in the sagittal plane. And, of course, you can then use the formula that we talked about before, which is the margin calculation in which you see that before treatment we had margins of about 1 cm each, which essentially is the margin that we'd been using for years, so that was a good result from that. If you calculate these margins you see something strange…they sort of disappear. The margin becomes zero or even negative, negative margins, of course, means that you're doing better than the 90% of the patients that you're looking at; but also, if you look at the original article and see that in the region where you're really looking at ________. What is important in this study is that the residual errors that were observed are after adjustments, but before the treatment. Actually, if you want to assess things, you need to assess things during treatment. There are two modalities that will allow in-treatment patient

monitoring—EPID and the Calypso seeding—and they need to address the following problem. You need to be able to position, you need to be able to figure out what your patient position is during the treatment even under IMRT, but before or after, and also you need the check the frequency lever. Calypso has a not proven, proven capability in that, but you might theoretically say if you forward into the count, you could probably to that. You could do dose verification if you combine it with some radiation dosimetry, there's an interesting booth that I think you should look at, which is ________Technologists. EPID can perform in-treatment position verification even for IMRT, and I'll explain it later, and also intensity ____ verification. Of course, if you take a portal image from an IMRT treatment it doesn't look very well because you can't see anything, but if you analyse the content of it, portal imagery, you see that the intensity

modulation by far is the major signaling system. And if you look at the intensity modulation of an open field with respect to the patient …this is a cross section of **(inaudible)**. You see that there is actually just a scale difference between both of them, you can find that scale and then you can subtract both of them out. This is the same thing done for **(inaudible)** with some seeds in there, so you get the in-treatment field, the open field, and subtract that. And the practical

application, you would actually need to adjust the magnification and position of the imagery and then minimize the chi-square approach to determine the scale factors and then subtract to re-normalize and this is what you would get for the same image and you can actually see the seeds that are in there and you can actually see ______ in the adjusted image. There's more of the chi-square value, actually, sensitive to the intensity modulation function to the correctness of that.

For incorrect values usually will be higher than normal, so if you use that to verify image intensity modulator theory. You can do this as follows: you can calculate the chi-square on every line so you do a minimization of that chi-square imaging **(inaudible)**, anyway, multiply the four values and then you get a value per pixel, so if you get an intensity map _____ introduced a 6 mm error during about 10% of the treatment, actually that's saying one of my segments, one of my _____is 6 mm of black, so if you apply that procedure, you can do **(inaudible)** that was incorrect will show up very nicely and you can get treadmap and threshold that for any errors in the treatment. So things to do…that we still need to do for that is to determine the adequate threshold values **(inaudible).** And of course the question is can you ______ during this? Can you give a small amount of dose to the patient and can you complete treatment? And what is an

adequate treatment, ______ amount **(inaudible)**. I need to do some acknowledgements here. Therapists are, of course, instrumental in doing all of this work because they actually have to do the work. **(Inaudible)** of one of our programs **(inaudible)** one of our clinical physicists helped me get a lot of the data and, of course, I would like to thank the sponsors for giving me some money to do this, and I apologize for going a little bit fast and I'm just trying to get everything in there. And I would like to introduce my next speaker who _______ from Indiana _______ more on the comparison of CT **(inaudible)**.