In any case, welcome to the Stereotactic Body Radiation Therapy Refresher Course. This is basically gonna be broken into three parts. I'll be discussing the first part, which I called physics and technology. The second part will be presented by Dr. Danny Song on clinical experience, and the third part will be presented by Dr. Brian Kavanagh on radiobiological considerations and future directions. I hail from Richmond, Virginia; Dr. Song is now in Baltimore, John Hopkins, and Dr. Kavanagh come from Colorado, University of. First of all, as I eluded to before the microphones were on, what's in a name, actually on the poster outside of this ballroom, it says this is extracranial stereotactic, and that is true for the longest time, this, there've been several different names for this, but it turns out that the chief CPT code developer is now decided in their imminent wisdom that this is, should be called Stereotactic Body Radiation Therapy. Actually I

wrote radiotherapy; I think Dr. Kavanagh might be talking about that a little later. But what is it? SBRT is the use of external beams to treat lesions of the body with surgical doses and high precision tumor identification and re-localization employing stereotactic image guidance and or implanted fiducial. So what we're talking about here are, using small fields generally, high precision, stereo tactic guidance, additional image guidance, and right here basically high doses, usually in the vicinity of 10-20 on even higher doses. These will be discussed by Dr. Song in terms of clinical experience. What does Stereotactic Body Radiotherapy require? Well certainly it requires higher confidence in tumor targeting. It requires reliable mechanisms for generating focus. Sharply delineated dose distributions. The ability to prescribe a isodose surface to the outline of the target itself and also generally it's gonna require a large number of non-opposing

beams or even arcs to avoid entrance and exits beam interactions. Indeed it's important to note that probably every institution that is performing or I should say no two institutions in the country or in the planet are performing Stereotactic Body Radiotherapy the same way. That said, they're all using some form of reliable accurate patient positioning to account for target motion relative to time dependant organ movement. I a few more text slides and then I'm gonna get into some images for this, but just to go over very briefly what the whole process has been. It's a certainly starts off with CT simulation. One of the important concepts, bits of information rather that comes from that is assessing tumor motion. How much does the tumor move during shallow breathing, during full respiration etc…. Then there is immobilization techniques, I will be describing several of those that are commercially available, some of which are even presented by

the vendors, and basically what those do is minimize motion and breathing effects. We'll talk very briefly about planning; we have several of the problems associated with cranial Stereotactic radiosurgery. It's just that now we have, we've departed farther south and there's a lot more inhomogeneities to consider, and there's other strategies to consider, and I'll be describing, and discussing that. Repositioning is an also very important. The highest precision patient set up is going to need to be employed there are several body frames for this. Re-localization, once you've put the patient into position, how do you re-localize that particular tumor. These will be described, and then finally a variety of treatment delivery techniques. Some of which may be highly specialized. I'll start with the Electra stereotactic frame. I bring up the particular product because it actually was the, one of the first used for reported extracranial stereotactic

radiosurgery, and this was reported back in 1994 from the group in Sweden. I believe Dr. Song will be talking more about some of the clinical aspects of this, but this is the general frame itself. It has indicators for CT and MRI. It does have a diaphragm control attached to the frame to minimize respiratory movements. I'll talk about that in a second, here about managing respiratory motion. It has fiducial as you can see along the side, and anterior to aid in patient, so called accurate patient setup. There are several other devices out there; I have just picked a couple. This one is also being demonstrated today, it's the medical intelligence body fix immobilization system. It's actually two vacuum bags, one under and one over the patient and it does minimize respiratory motion necessarily, and it's made of radio translucent material, and

you can see that it has a fiducial locating system that can be placed over the area of interest. Several other areas of, excuse me, methods of repositioning your patient, one approach is using optical tracking. Optical tracking provides a so called real time position information of an object with either active or passive infrared markers, and the position at the point of reflection is determined using these camera systems, and I have here on the left, active markers which are basically emitting and passive markers which upon reflective infrared, you can detect where there position is with sub millimeter accuracy. Here's a system set up, this is actually courtesy of Sanford Meeks showing optical guidance that can track a patient using these passive markers. Another system that actually uses that very same device for improving your patient positioning, is BrainLAB. They have the exact tract repositioning verification, also a reflective marker

system. Here are the Infrared cameras. They also have, incidentally a video camera that can be used for independent verification and documentation and I'll also be talking a little bit about improving your patient re-localization and repositioning using Kilovoltage x-ray sources. All of these things can be very, very helpful and they can tell you whether or not your surface of your patient is in alignment. Of course of they cough, move things change. If the beam is responding then you can, then you can respond, but you, all of these different devices like I said, there are many different institutions that use many different techniques. So once you have your patient in position, then you need to do an image verification prior to treatment to make sure that your tumor and or isocenter is in position. There are several technologies out there. CT on rails has been used. You'll see there's a now big push for LINAC KV imaging. In fact there's a task

group headed up by Feng Feng Yen on KV imaging. Cone beam CT is also used. I must admit, over the course of the last ten years since body stereotactic has been used, people have been using whatever they have in their departments. In our particular case, we have CT'd patients prior to each treatment. So here you see day one CT treatment using a, in this case the exact track, but actually verifying the patient position then lifting the patient up, whisking them off to the treatment couch, and then delivering the treatment after this verification. There are several, obviously more elegant approaches. On the BrainLAB system now includes, you wouldn't have to whisk the patient down the hallway, a kilovoltage systems that's either attached, well BrainLAB has theirs attached to the ceiling, and what it allows is that you can do computerized generation of DRR's and compare those with your intended or set up position, and it allows

automatic comparison of x-rays with DRR's and feedback to the couch and move the patient into position. So you can do for example for spinal radiosurgery, you can set the patient up with very, very good accuracy. No gonna assign a number to it. There are several other specialized

treatment delivery techniques, one of which is the CyberKnife, a unique device that has, is non-isocentric. It utilizes skeletal structures of the body, it has no invasive frame, although they do use implanted fiducial. It does continually monitor and track the patient position during treatment. So this actually has some ideal features for body stereotactic. It does use ceiling mounted, there's an x-ray tube, ceiling mounted x-ray tube and there's the screen to monitor patient motion, excuse me, tumor motion, and it is a compact linear accelerator right here that basically moves along a robotic arm. Just too very briefly go over some of the issues of

managing respiratory motion. There's affectively four approaches. The initial approach Dr. Song will describe in some of the clinical reports, include a so called belt. That restricts and minimizes respiratory movements. I call that the shallow breathing technique. Patients can also be trained, I've seen, there have been reports for using video to coach, coach them to hold their breath during certain periods of beam on. There's also, using the ABC, active breathing control method, and finally there is gating of the beam can be applied to deliver radiation during specified respiratory cycles. What this shows is that you obviously need to incorporate some management for respiration and for motion. Especially for lung tumors. In this instance we would want the beam on generally when the tumor is in position, and the beam off when the diaphragm as you can see has moved out of position. This is a whole approach, using the varying RPM, but

basically it's identifying certain duty cycles of inspiration and expiration that you want the beam to be on that will minimize and make acceptable your margins for treating the patient. Active breathing control without our situation altogether, in this instance the clinicians are able to pause a patient breathing at precisely an indicated title volume. This has been relatively successful and has been presented in the literature. Another approach for re-localizing with the highest possible precision and actually I have to admit Dr. Song will also be presenting this. The Japanese have done an awful lot with this, and this is the implanted fiducial technology. Basically putting markers into the tumor. Tiny gold markers establish a permanent accurate internal patient reference system. There are several different designs for these. Many of these designs are made to prevent migration after implantation. The ones I'm showing here are from MedTech. I should

also state that there's in development now, actually I guess for beta sites, Calypso Medical has now these RF emitting marker technology, although it's not FDA approved, it does seem like it has a great deal of promise for the future of re-localizing with high precision tumor centers. Very briefly some of the issues associated with inhomogeneity, two aspects to consider. One is doing inhomogeneous tissue calculations. In the past for stereotactic it would have been just fine if we probably had, actually a very great number of institutions don't even do any inhomogeneity corrections for cranial. But that situation is all out the window when it comes to treating lungs. So this can be very significant with lung when you could even have a lesion in the lung adjacent to bone etc… With previous stereotactic systems some of the calculations were very simple, TMR look up tables and the like. So these interfaces basically were not accounted for and this is

something that is important for the physicist to investigate. On another issue, there is still with respect to body stereotactic the same philosophy so called differences between those who with Gamma knife versus LINAC. The Gamma knife group thinking a hot spot within the tumor is a good thing, and those usually within the LINAC field thinking that a more homogenous dose is a good thing. These dose gradients within the target are acceptable, and actually higher target

doses hot spots may be desirable if they facilitate steeper normal tissue dose follow up outside. Of course these hot spots may be useful for hypoxic radioresistant cells. I'm not going to answer that controversy now, but I'm just going to let it know that basically you will see in the literature for body stereotactic that there are two different approaches. So, clinical implementation of stereotactic body radiotherapy. This is a nice little quote from the good Dr. Timmerman, who

heads up one of the first RTOG protocols on this, and he stated "that these techniques are unusual in the high technology realm of radiation treatment, in that they require a more specialized training and experience I should say of physicians and physicists, rather than just the equipment itself". That said, the physicist should be responsible in terms of QA, and implementing this whole program, should be responsible for the imaging equipment, certainly the localization and simulation equipment, treatment planning and evaluation, treatment delivery equipment, and the verification equipment. The physician and the physicist should carry out all the clinical QA procedures consistent, you need to have consistent target volume and organs at risk delineation. How are you defining the PTV? How are you defining CTV, or the GTV? Again I think Dr. Song, I think also Dr. Kavanagh will be addressing that. Quantitative

assessment of target and organ motion during image treatment. How much margin do we, how much air do we have set up, how much margin do we need to apply etc… and patient specific QA for that particular body habitus. We need to, we still have a need to establish terminology and reporting conventions and how do we determine what the GTV and margins and dose homogeneity uniformity should be, and there are some biological evaluation that we should consider, and dose fractionation strategy. That said I did wanna put in a little plug here, that there has been a task group of which I am chairman and these two gentlemen are also on it for stereotactic body radiotherapy. I hope by the, by next year at this time we will have completed all four of these charges, number one of which is to review literature and identify the range of historical experience, and reported clinical findings, number two to review the relevant

commercial products, some of which I briefly went over, number three to determine the required criteria for set up and establishing a stereotactic facility, including what protocols, equipment, resources and QA procedures. This can be a very tough task, since again no two institutions are doing it the same way and finally develop a consistent documentation for how do we prescribe report and record our stereotactic treatment delivery. Very quickly these slides I just wanted to acknowledge Dr. Meeks and Dr. Salzburg, and Martin Murphy. Okay, and next on the list here is Dr. Song.