Low Dose Radiation Conference Notes

October 1, 2018

8:00A

Alan mentioned that this conference has been in the works for over 4 years. The last time there has been a conference of this nature was one of the Wingspread conferences, around 20 years ago. Alan said that back then, there was an issue that there wasn't enough data back then to come to some revolutionary conclusion. It's been twenty years since then and there is now new data. We have brought together many international people, including scientists and people in policy. As a result of trying to bring these groups together, the conference will consist of a single plenary session. This means that all of the speakers will likely not get the sort of time that they deserve, however that is why there has been such an emphasis on poster sessions. Please make sure that when you respect the time constraints. Alan is now introducing the people who helped to put together the conference.

8:07A

We are appreciative to the sponsors of this event, starting with organizational sponsors. We also have to have funding sponsors. We have raised over 100K for this conference, Bruce Power and TerraPower have both contributed a bunch of money to the conference. DOE and Ray Rothrock also pitched in a considerable quantity to the conference. Ray Rothrock is a former Aggie and gave money so that the whole conference can be recorded. Kris Troyer was asked to the front of the stage. Alan said that we are very privileged to have a special person that we want to honor, Gary Troyer. He was the one at ANS who really was the start of this conference, but was unfortunately killed in an automobile accident back in 2014. Alan pointed out that Gary started this, but he gave special thanks to Kris for continuing the effort for the conference. Alan presented Kris with a memento to celebrate this event.

8:07A

Alan said that following the death of Gary, he was asked to take over the reins for the conference. Alan said that the fear associated with radiation itself also has some unintended consequences and may result in additional fatalities. He had to do some soul searching to see if perhaps we could work together to make things better. Alan pointed out that the thumb drive that was passed out along with registration, includes all the papers and resources on it.

8:14A

Alan passed the mic over to Andrew Klein. Andy said that they started working on inputs to come up with 9 nuclear challenges. Andy said that the topic "Establish the basis for Low Dose Radiation" was the winner by a 2-1 margin. The others were, how do we talk about public engagement. Advanced materials and licensing of advanced reactors. He hopes that going forwards, these divisions will start moving the ball forward on these issues. Alan welcomed Nolan Hertel from the HPS to speak. Nolan wanted to point out that in 2017, HPS had a radiation protection needs workshop and it didn't matter what session we were in. Almost every one of those sessions came up with the point that we needed to find out what would happen at low dose. It sounds like a bill is now authorized and hopefully soon will be signed by the president. Nolan said that he is a key non-technical expert on this committee. He said that many years ago he got a degree in radiation technology. Nolan said he would show us a sequence of slides. He said you see a mouse running across the table and it is hit by a force. The mouse is a spherical mouse in a vacuum. Dosimetry kind of looks like that. We can calculate the force; however the response is still left to figure out. Now we are thinking about a billiard ball collision. Nolan said that the biological response isn't exactly like a physics response. The biological epidemiologists will need to study how those responses work. He pointed people towards a document on the following website:

http://hps.org/documents/risk_ps010-3.pdf

8:21A

Alan is now introducing Mike Lawrence who will cover the goals of the conference. Mike said to never follow Allen Walter first thing in the morning. For over half of his career he had management responsibilities over Hanford, and PNNL. Over his career, he respected radiation protection standards without fail, he wasn't able to change anything. ALARA is a unique and subjective principle that tries to balance risk versus cost. ALARA is a direct result of the LNT model which has been applied since the 1950s. The rationale for the use of the model, that the conservative assumption that even small doses of radiation may be dangerous. Mike said that the current radiation protection standards, have a bunch of unintended consequences. Following Fukushima Dai-Ichi, there were estimates of 760-1600 disaster related deaths resulting from psychological trauma, though there were no direct deaths resulting from radiation. There have been signification advances in Biological Epidemiology since the days of the bombing of Hiroshima and Nagasaki. Once we have established a standard, it will be very difficult to raise the standard. Mike now listed the goals:

1. Explore the current scientific knowledge and understanding of low-dose radiation effects.

2. Consider the applicability of this knowledge as the scientific foundation for current radiation protection standards.

3. Recommend a path forward

8:27A

Mike put up a slide showing the low dose radiation slide. Mike said that this chart is linear. Mike pointed out that most of the data that was used to justify the LNT was all for the extremely high dose range of this chart. What we need to do is to explore and investigate new data within this low dose region. Mike said that the basis for any safety standard must be rooted in sound scientific data. Mike said that the goal of this conference is to reach a conclusion of the effect and results of low dose radiation. Changing the politics of low dose radiation is not the goal of this conference. Mike said many different people with many different opinions have come out to this conference, and he wants all people to represent their findings as best they can. Be advocates for your research but try to be open to new findings.

8:32A

Back to Allen, Alan invited Nick back to the podium to officially open the conference. Nick worked at ORNL and is now back at Yale. Nick said that Allen reminded him of the time, he said that he is honored to chair the opening session today. He wants to promote the scientific interactions as well as to make sure that we follow the schedule. He said that the first speaker on the program is David Brenner. He works at the center for Biological Research, he is also the PI for a multi-institute Bio-dosimetry institute. His research is focused on mechanistically determined models. He focuses on both low dose and high dose research. David Brenner now speaking.

8:35A

He will speak on the strengths and weaknesses of LNT, there is what we know and what we don't know. He will focus on Radiation induced cancer. He thinks that, this is the most important effect at low dose. The epidemiologists in the audience work hard to come up with research at high doses. They wanted to come up with data at low doses. Every time the radiation epidemiologists come up with lower radiation results, they are asked to go even lower. He showed a photo of the atomic bomb survivor study. He said that all of the people in the brown region of the ring, experience a low dose of exposure. There was an extract from an article he pointed out. It said that the lowest dose response using the EPR model was 100mGy. The UK CT study on Leukemia showed some effects. He said that effects manifest somewhere between 10's and 100's of mGy. Why can’t people go lower than where they have already. David pointed out that 40% of people in this room are going to get cancer anyway.

8:39A

When we get down to the sort of dose that we want, the required sample size required gets massive. He said that when you get near where the noise overtakes things, there were three studies, Matanowski, Berrington and Carpenter, which came to three different conclusions, one that there was a significant increase to risk, one that said there as a significant reduction in risk, and the final indicated that there was no change. David said that there is such a lack of data in the low dose region, that currently we use a straight line through those data-points, but what sort of curve should we use. LNT is a biophysical argument. He showed an image of cells. he said at 1000 mGy, you guy 100's and 100's of tracks through these cells. Now down to 10 mGy, there are less and less tracks through the cells. around the 5-10 mGy, you get down to an average of 1 track through each cell. Going down another order of magnitude again, to 1 mGy, we now have even fewer traces. Now at 5-10 mGy we were already down to the situation where we were at the lowest quantity of damage that a single cell could experience, at 1 mGy the only difference is that fewer cells are experiencing this level of damage. At 1000 mGy, there is no doubt that there will be a result of increased cancer risk. On to 10 mGy, there is more of a question. Looking at the Oxford survey of Childhood cancer.

8:45A

Apparently, there was a significant increase in childhood cancer after in-utero x-ray exposure. Mean dose was 6 mGy. There were 15,000 case control pairs. He came back to the earlier chart and put a little arrow with cancer at 10 mGy, he said that there are risks but that they are smaller. Now down to 1 mGy, this is the point at which where we can't do research due to sample size. He said that going from 10 mGy to 1 mGy, the only thing you are doing is changing the number of cells that feel the same degree of damage. LNT is based on the idea that the damage done is based on the number of cells that feel damage in this 10-1 mGy region.

8:49A

This is essentially the LNT argument, it works for doses 10 mGy and below, but would not work for higher doses. He will now talk about DNA repair, Immuno-surveillance, and cell-cell communication. David said that we have been exposed to ionizing radiation for a long time and developed and exceedingly efficient DNA repair mechanisms. The argument of immuno-surveillance is that other processes could mop-up a small number of pre-malignant cells. On the other hand, if this worked, why would anybody ever get cancer. There was some research where they inserted a massive number of mastacytomas into rats. As they reduced the number injected into the rats. Once they got to a very low quantity, the number of resulting mastacytomas flattened out. He thinks the best argument of inter-cellular communication. During carcinogenesis, we know that cells talk to each other. Cells in tissues do certainly talk to each other. This means that the most quantified radiation-related inter cellular response is the bystander effect. where one damaged cell can damage a neighboring cell. Where bystander responses have been quantified, they have always shown saturation. If we extrapolated down from the highest dose down to the lowest (LNT), we would be underestimated the risk.

8:55A

At this time what we don't know is what the differences resulting from cell-cell communication will do, will they increase the effects or reduce them and by how much. The implication is that as you lower the dose, you lower the risk proportionally. However, this means that in this case there no dose at which there is no risk. He said to think about a low risk activity, where there is a 1 in a 1M possibility of something bad happening. Now let's say we have 100 people joining in this activity, even with 100 people the chance of something happening to people is effectively zero. Now suppose there is a population of 100M people, who are exposed to that same activity. In this situation, it sounds like there would certainly be some people harmed. The thing here is that we are talking about individual risk (which is negligible) versus a population risk. David brought up the lottery. Your individual chance of winning is very very small, but the population risk is reasonable... somebody will probably win. He would like too end by mentioning Bill Morgan. Bill asked him to attend this meeting. He was a good guy and he was smart, and open to different points of view.

8:59A

There is now time for a question or two. Nick asked him about Jack Bouchard at the NCRP, he brought up the term prudence. How do you take your observations and link them with societal values, such as prudence. David said that one thought he had, is that assuming linearity is a conservative assumption. He doesn't see that, it could be under or overestimating the risks. He isn't sure how we could operate a system any other way. He said that it may not be reasonable, but it isn't prudent. Another question from Greenspan. He said that he doesn't agree with that idea of the population risk idea. He said he if one person smoked one cigarette, that they wouldn't get cancer. Morgan Doss, he would like to make a point of view. He wants to mention needing large numbers of cohorts, millions of people. He said that even in groups as small as 10K to 5K, will show effects. He said that you don't need millions of people to see the effects, they are observable at the 10K range. Another person brought up the mastacytomas and was asked about the neighbor effect. He said that, this study was not a radiation study, the guy asked if the bystander effect wasn't studied here. Jerry Cutler said that he got the model all wrong. He said that tying everything to radiation is wrong, it's a myth. He said that breathing oxygen is doing a bunch of damage to your cells.

9:05A

Jerry said that radiation does a number to the water molecules. Our bodies are 95% water. We use it to burn glucose, but it damages the biomolecules. Ruth Weiner, now had a question. She said that she deals with transportation risks, we look at the accidents per kilometer traveled. David said that at these low doses we can't measure the frequency and probabilities. This is the end David's time. The next speaker is Roger McClellan.

9:08A

Roger said that it is a pleasure to be back here. 74 years ago, he joined his parents here. He had the good fortune to have many bright and industrious people around here, who showed up at about the same time. He has been on a sojourn, and he came out here for his wife's 60th high school reunion. We have been enjoying good food and good friendship. One of his principal mentors, Bustead was Dean of Washington State for a time. He used to say that Pullman, WA is not the end of the earth. He has a lot of time to think on his way over here. He asked us to think about the giants in the field that we build upon. He through about the people he worked with in Hanford. He was thinking of one guy who is even older than him, Frank (Mungeen?). Frank is 100 years old, and Roger said that he was pleased to work under him. He also got to work under his brother at WSU. Now he is ready to get going. He will be taking a different path on things. The central theme is that policy and regulation should be informed by science. He will also be talking about populations.

9:13A

He said that we don't have a good cross section of society, it's a room full of gray haired males. He wants to emphasis that we should look at this in a multi-dimensional way. We have legislations which drives regulation. We need to discuss the science first, then we can talk about the regulation. He brought up a quote from Donald Kennedy. In establishing and using radiation protection standards, we normally get this wrong. Scientist are creating scientific knowledge. It is then synthesized to advise groups such as the ICRP/NCRP. In the USA, it is based upon statutory authority. The current standards are generally fine. The standards are appropriate. He talks about general standards and about ALARA. He thinks that we could do a much better job on the implementation part. If we go back through the chronology of radiation. Early on, we would use the Rollins dose.

9:17A

He will show us a little later, a paper which was published by Paul Henshaw. He first became acquainted with this back in 1957. Roger was asked to give a presentation to people where he read this paper. He urged us to read a book named "songs from the ruins". Henshaw describes two fundamentally different radiation dose-responses (a) stochastic, and (b) linear. He said that in this paper they showed a plot of these two versus each other and this is where the threshold first showed up. Tolerance dose replaced by focus on risk. We started moving into consequence studies. This eventually takes us into population dose and population risk. Looking at a paper that was going around by Parker in 1960. The important piece to bring in, is the impact of the US EPA on risk assessment. He wanted us to realize that we it isn't just radiation that causes the issues. There are a bunch of other risks.

9:22A

We focus a lot on numerical limits and the elaborate scheme we have with radiation weighting factors. He thinks that the dose rate effectiveness factor needs to be reviewed once again. His board of directors would not have allowed me to use anything but ALARA for any of the hazardous agents that we worked with. When people talk about getting rid of ALARA, he starts to think... oh wow, what are you talking about. Roger said that ionizing radiation is the most extensively studied toxicant. Roger said that if he asks a member of the media, how many people died at Hiroshima and then how many people died from the radiation there. He said that they would be grossly wrong, the same is true of scientists. He was looking at the data of A-bomb survivors. Now he wants to come to this point that he thinks is critical.

9:27A

He said that we live in a sea of hazardous agents. He like David Brenner's speech but he didn't talk about all the other hazardous agents that people are exposed to. Roger brought up the paper NIOSH. The paper is related to the cancer risk resulting from carcinogens. We have a very small increase of spontaneous disease. The cornerstone will be epidemiological data. If he was to put a current depiction of cancer up there, it would be a mosaic which would have about 200 control points and our current knowledge regarding cancer. It would also have a very strong time dependence element to it. So his view of the current radiation standards is that: consistent with extraordinary body of scientific knowledge. Numerical levels and over-arching use of ALARA. The risk for males is 1.5-2. He said that the difference in risk is income. People with low income have a higher incidence of risk than those in the upper quartile. He said that as he was driving over from Pullman, he was really looking forward to hearing from his fellow scientists. He is now ready for questions.

9:34A

Rod Adams had a question. He said that risk management and understanding and teaching people how to accept valid risks was one of his jobs. One of the things that he thinks was missing, is that if we keep the limits as low as possible for radiation, we are increasing the risks to other things. For example, the topic of climate change, or pollution from natural gas. If we increase the price of Nuclear Energy as a result of ALARA, we may choose something far less safe as an alternative just on a basis of economics.

9:36A

Ed Parsons, he wants to challenge him on the statement that we have to develop that consensus of our organizations. One thing is the that with our social climate, it will likely take a lot more than us reaching a consensus. We don't understand how to propagate our understand out into the culture. We need to talk about economic and business development, he has been moving away from ALARA and towards optimization.

****

BREAK

****

10:00A

Start of Plenary Session 2: Chris Clement will be the session chair. Chris said that he will keep his introduction brief as possible. Just a couple of points of logistics. His introductions will be brief, but bios are included on the flash drive. Power-points will be available on-line after the fact, probably available on the website. He will introduce Roy Shore, the first speaker for the session.

10:02A

Will be covering NCRP commentary report #27. He is showing the cover of the publication. the NCRP conducted reviews of epidemiological studies regarding LNT studies. This was looking specifically at low cumulative dose and low dose rates. As an example of some dose response results. One was the INWORKS study. For All Cancer except Leukemia. It does appear to be very linear. Looking at the Mayak workers, there is a lot more variation. There were some studies that showed no dose response (e.g, Kerala). There were 29 different studies that we looked at. We wanted to integrate what we were seeing. When we looked at them, we did something that was perhaps beyond reviews, because we had subgroups in our committee, do a very detailed analysis of these studies. We had epidemiologists do a very detailed inspection and statisticians, inspected dosimetry, and look over the statistics of these studies. We were then able to rate the quality of these studies based on that criteria.

10:08A

There were 5 studies that provided strong support to the LNT model. there were 6 studies that provided moderate support to LNT. there were 9 studies that had limited to moderate support to LNT. There were 5 studies that showed no support and finally there were 4 reports that were flagged as inconclusive. A summary of some of the larger studies that we reviewed. The majority of these studies had positive excess relative risks. Most were greater than zero, but there were some that were less. In addition to these 29 studies, we wanted to focus specifically on low doses (<= 100 mGy). The Lifespan study, the full dose range was 0.50 ERR-Gy-1, for 0-100 mGy there was a 0.49 ERR-Gy-1. For the low dose data, it does not look like there is strong linearity. Now looking at Non-CLL Leukemia. All of these studies have risk coefficients greater than zero. These studies are cumulative dose. You can see that there is evidence for low dose exposures for increased evidence of Leukemia.

10:15A

Final considerations. We do have constraints in sample size and dose uncertainties, which provide some potential for confounding data for low dose data sets and we certainly have more uncertainty under 100 mGy. However, most of these studies showed support for LNT and evidence for supporting risk to Leukemia. He said LNT may not be perfect, but he thinks that it is prudent to keep it as it is a reasonable estimate. On to questions... Norm Dyer, regarding the INWORKER studies, we do very conservatively that the dose is there and under the regulatory limits. If you add that for every batch you will be non-conservative than we are trying to look at. Chris Clement said that if you add 1/10th of a mGy... On to the next questions. During the 40s/50s where the highest dose data exists, there were much higher incidents of smoking. He suspects that this data is confounded by data relating to smokers. The questioner pointed out that the 300-400 mSv results wouldn't be valid beyond those earlier years. Roy said that they did include some factors to account for this.

10:20A

Dan Strom wants a comment on the absence on the excess of Leukemia following Chernobyl accident. Roy said that he didn't have a firm grasp on all the studies following the Chernobyl accident. He said that for the large surrounding populations, there was a low dose rate to the bone marrow. Next up will be Werner Ruhm. Werner Ruhm will give a status update of low dose and low-dose ionizing radiation. The ICRP mission is to protect people and the environment from harmful effects of ionizing radiation without unduly limited its beneficial use. The ICRP bases its recommendations on the most recent scientific research. ICRP Committee 1; Task Group 91, Radiation Risk Inference at low-dose and low dose rate exposure for radiological protection purposes: Use of dose and dose rate effectiveness tasks". There was a workshop held in Kyoto back in 2015. One recommendation was that we should not look at low dose effects and low dose rate effects together, but instead look at them separately. The UNSCEAR definition is ()... UNSCEAR 1958 "Opinions as to the possible effects of low radiation levels must be based only on extrapolations from experience with high doses and dose rates". Here we are 50 years later, and things aren't much different. UNSCEAR 1962, "Animal experiments were considered important however their usefulness was judged limited by the difficulty of making valid extrapolation... to man from animals". UNSEAR 1969, "..." and UNSCEAR 1977 "...". Most recently there was a SENES report 2017. Which suggested a DDREF of 1.3 (50%) and a range of values 0.47-3.45 (5-95%).

10:28A

Review of typical dose rates and doses. Typically, we have 0.3 uSv/hr. Which can go up to 150 uGy/hr. Animal studies, cover 780 uGy/h - 22.6 Gy/h. For comparisons, LSS Hiroshima, there was a total dose of about 1.38 and 2.77 Gy (by two means). There was a review done of molecular and cellular studies. Provisional conclusions are... chromosomal studies indicate DDREF values around 4, but, much time between induction of those changes and clinical presentation of cancer and processes could be a significant confounding factor. Evidence from animal studies. BEIR VII report, based much on Oak Ridge animal data set. Now use large animal sets for the first time ever possible including US, JANUS, and EU ERA databases. There is already one paper published from this. The pooled analysis, linear model, life-shortening (Woloschak et, al). DREF of about 2. In parallel, independently we have a second group, Mark Little and his group. Looking at Animal Mortality, Gamma-Radiation, all tumors combined. LDEF 0.86 - 1.06 depending on dose rate. This paper has been published.

10:34A

Biologically based mechanistic models to describe epidemiological data. One of the problems with epidemiological data is the statistics. Example, two stage clonal expansion model. Staring with healthy cells, you have a mutation, then the second mutation, may eventually produce a malignant cell, and then result in a cancer diagnosis. Review initiated by TG91, 14- low-LET... to make a long story short. Uncertainties are still considerable, including LNT model are not in contradiction to what is presently known on the process of cancer development. A review of course, doesn't help much to push things forward. Update on meta-analysis on low dose rate epidemiological studies on solid cancer. We identified 22 studies, computed matching cancer risks in atomic bomb survivors according to sex age at exposure, grouping of cancer types... All cohorts together (mort + incidence) DREF consistent with 2 to 3. If Mayak is left out: DREF ~ 0.9 for mortality; ~ 1.3 for mortality + incidence. This paper was also published.

10:40A

We also looked at the curvature in LSS mortality data. And the story continues. Unfortunately, there were no time for questions. Next is Patricia Wieland. She will be talking about UNSCEAR work. She apologies that Abel should be here, but unfortunately, he could not be here, so she is speaking in his stead. In her background she has worked in plant exposure situations. She also worked in chronic exposure situation for example, mining of rare earth. She started her career as an RPO and later worked as a regulator. She said that we have reached a conundrum. We have to think, if we have to protect people from low doses, or if these low doses should be ignored or recommended. The current standards are recommended by IAEA. For low doses, the paradigm is based on extrapolation from high-dose date. The linear-non-threshold as suggested as prudent. There is a postulate that an increment of dose above background would result in a corresponding increment in risk.

10:47A

In a paper, there are currently no relevant bio-markers resulting from radiation. This was in response to the mention of a paper which stated that some 985,000 people died of cancer as a result of the Chernobyl accident. She said that the misuse of the LNT has resulted issues. The UNSCEAR published a 2012 report. We have objective facts for high doses, but only subjective inferences in the low dose range. Health effects cannot be attributed to chronic exposure to radiation that are typical of the global background average. Hereditary effects in human populations cannot be attributed to radiation exposure. The UN reached a consensus, that concludes that increases in the incidence of health effects in populations cannot be attributed to low doses but risk from planned situation may be prospectively inferred for purposes of radiation protection and allocation of resources.

10:53A

Can science resolve issue of how to regulate low-dose exposure. There are epidemiological limitations. Radiobiology can provide robustness for subjective inferences of probably outcomes but cannot attribute... In 1997, we were discussing basically the same thing. The “Low Doses of Ionizing Radiation: Biological Effects .... Regulatory Control". We are depending on the regulators. The time seems to be right for legislators to execute from the law, low-dose exposure situations that are unable to be controlled. ICRP can also help, ICRP publication 104. It has a guest publication from Abel. What we need now is clean energy, climate change is a fact. We need to go forward with low carbon generation. The costs are extremely high, also the creation of medical isotopes is needed.

10:58A

The regulators need to find the light at the end of the tunnel and use common sense regarding low dose radiation. Safety remains a basic foundation of the nuclear industry. The optimization principal namely the best protection under the prevailing circumstances -- and not ALARA should be used. We should create an effective safety paradigm that is focused on producing a wellbeing. Question, what if you were forced to evacuate due to a 1 mSv. Showing the average occupational dose, coal mines apparently have more radiation exposure than nuclear workers.

11:02A

On to Oleg Belyakov. He is a Radiation Biologist from the IAEA. He will speak about contribution of new radiation response models. There are three main bodies producing radiation protection guidelines: UNSCEAR, ICRP, and IAEA. UNSCEAR evaluates evidence, ICRP then issues recommendations, IAEA then then produces safety standards, then those standards are generally adopted by the member states. The first challenge was discussed is the UNSCEAR 2006 report. Non-targeted and delayed effects of exposure to ionizing radiation. there was a EURATOM integrated project 2006-2010, 19 partner organizations, 7 work packages and a 12M Euro budget. This should investigate the mechanism of non-targeted effects. The main conclusion was that a new radiobiological paradigm can't be formulated due to a lack of consensus. A Position paper was posted of NOTE IP in 2013. The precise mechanisms of non-targeted effects is not known and there is no universally accepted biological model. More mechanistic studies are required.

11:09A

RASSC Topical Session; became interested in individual susceptibility to radiation protection. The result of this was that these phenomena might affect RP standards in the future, but more research is needed. How do we measure radiation sensitivity and susceptibility? Bio-dosimetry methods could be used for measuring sensitivity. Another option would be to use the clonogenic cell survival assay. Validity of LNT hypothesis. It is a simple hypothesis, but it should not be mistaken as a stringent scientific conclusion. Therefore, LNT is not quite scientific, it is more of an emotional thing. Spatially Fractionated Radiotherapy. A number of experiments and clinical regiments are available. These give better tumor control and lower damage to normal tissue. What would be the mechanism though? It is Bystander and abscopal effects, radiation induced immuno-response. The current system of radiation protection is conservative and protects well the humans and environment. Non-target effects of ionizing radiation seem to be embedded in the system...

11:16A

Time for questions... With the approach that we are using, it is very easy to prove things that we are looking for. For example, nobody can say that radiation doesn't cause damage to cells. On the other hand, exercise causes damage to muscle and it can also cause death. We need to look at the pro's and cons of something, and what is the risk of not being exposed to that radiation. It is actually very well known. It is known that sometimes a low level of radiation that can help people with certain diseases. We don't know what to do with that. Next Question. Thomas, from University of Bristol. He would like to direct us away from probability, towards a better measure of harm, change to life expectancy. For instance. The was a study where we showed objectively that there should have been no evacuation following the accident in Fukushima. Statement by Mark Miller, he would like to have people change the paradigm about how we think about radiation risk. He would like to challenge ourselves to not draw lines within the low dose region.

11:21A

On to Cynthia Jones from the NRC. She doesn't like to dwell on history too much, but we want to see what happened with the below regulatory concern policy statements (there were two not one). In 1980 the BIER III report, which issued a caution that LNT at low doses could be overly conservative but could be used to bound risk. In 2008, the commission brought more issues from the ICRP which were accepted. The topic of below regulatory concern (BRC) policy statements. These two BRC statements were issued in 1986, and 1990. Congress forced the NRC to rescind those statements. There used to be an NRC evolving policy and engaged in extensive stakeholder outreach beyond that. They updated a number of issues, however due to not getting enough responses from the public, they didn't implement a number of the changes.

11:29A

So is LNT really the issue or are the other options for licensees. There are three case studies. petition for rule-making; in 2015, the NRC received 3 similar requests to amend part 20 with regard to the LNT hypothesis. Petitioners assert that valid scientific studies and evidence exists that contradicts LNT hypothesis. More than 3,200 public comment letters were received. During this time frame NCRP Commentary 27 suggested the continued use of the LNT model for radiation protection. Another option is to apply for exemptions. NRC receives and approves request exemptions. Some of these exemptions allow licensees to use newer methodologies. The third point is ALARA. The NRC terminates ~100 materials licenses per year. The NRC has several guidelines regarding ALARA. There is clearly another factor where people and licensees go beyond ALARA.

11:37A

Where do we go from here? The UNSCEAR 2015 report highlights the concepts of attributability, inference of risk, and the use of collective dose. The consequences of the current approach we have are significant. Thoughts for years ahead. Completion of the Million worker Study. Improving realism in dose assessment. use of the UNSCEAR concepts of attribution in practice.

11:41A

The next speaker is David Pawel from the EPA. One of his main responsibilities, is to produce estimates of risk to the general population. He said that if you've heard of the blue book, he is one of the people you can blame for that. He is presenting on "EPA perspectives on risk projections for exposures to low dose rate radiation". He will go over basics, including LNT and then cover how it is used. He will go over why we use LNT, then he will cover what could go wrong. Finally, he will go over alternatives. The EPAs mission is the limit radiation risk to the public. The way that the EPA estimates risk is using the LNT model.

11:46A

We love to argue about LNT. The model states that excess risk of cancer at low doses is (approximately) proportional to dose, there is no threshold. For the BIER VII report, they fit data to the atomic bomb survivors. The type of models that they used were linear quadratic models and using formulas they could plug in a dose and get back a risk. Essentially, this is the general idea. Why is this approach used? Why not just base our models on data? As we have already heard today, is that to do this would require impractically large sample sizes. Is sample size the whole story?... We are going to make some sort of assumption about the dose response. Is there a better alternative? Dr. Land argued that no, there wasn't. Currently though, we now have technological advances that may allow us to properly study low-dose with the sort of sample size required. He covered a number of recent studies which included sufficient power, INWORKS and hopefully soon we will have the Million worker study.

11:55A

For the future, regarding UNSCEAR, BEIR reports on radiation risk. Low dose studies have a potential for large bias in radiation cancer estimates. What is encouraging is that the NCRP is looking into this issue. They concluded that the LNT is still a prudent approach. There was a question regarding A-bomb dose response. He thinks that it isn't the issue with the shape or the size of the population. The issue is that the biological response from one exposure is very different from fractional dose over a long time. He wants to have two standards, one should be use for a big exposure, but that when we do low dose over extended times, we need to not include A-bomb and Chernobyl data, since that is effectively like eating

8 sausages in one sitting and getting a stomach ache instead of eating 2 sausages per day over the course of 4 days.

****

LUNCH BREAK

****

1:30P

Panel #1; moderated by William (Bill) Magwood. The panelists include the following: William Sacks, Peter Colgan, Antony (Tony) Hooker, Julian Preston, David Pawel. Bill Sacks will start, he wants to point out that he has a poster today, it is the biggest one in there. It is on the wall because it wouldn't fit on the board. The title is LNT versus Hormesis. David was the first person to say it out loud is morning, but nobody gasped. He has twenty power-points printed there which are easy to read, he thought he was going to be able to give a presentation today, but it didn't happen. Hopefully he will be giving a paper at ANS. He stated garbage in, garbage out. There are twin problems going on here as are illustrated this morning. He said there is a huge issue in that there is no coverage whatsoever of hormesis. If you rule out hormesis, you find that all radiation is harmful. Him and a colleague published a paper a few years ago. The INWORKS study was cited this morning, the La Roe paper, we give a thorough critique of that study. They give circular reasoning in the study. They lower the confidence intervals, they did not seek confounders. I always look very critically at anything that confirms my outlook.

1:38P

Tony Colgan. We do many things, but we are responsible for development and of safety standards. I don't think anywhere we mention the safety standards in the LNT. We have safety standards because it is in the mandate from the IAEA. We either need to establish or adopt a safety standard. We are also responsible for applying the standards. Thirdly, we are not allowed to do this alone, we have to do it by working in conjunction with other international organizations. It is very unclear to many people, but the safety standards of the IAEA are not binding but many member states take the IAEA standards and use them. ALARA applies to them, and the dose limits apply to them. UNSCER does the science, ICRP deals with the societal and political issues. The basis of the safety standards should come from the ICRP. Safety is a national responsibility.

1:42P

Tony Hooker is next. He is a molecular biology researcher. Some of the views that he will share today, they are the views of him and not his employer. Australia has the largest Uranium deposit in the world. Regulators can accommodate an alternative dose-response paradigm, yes, but ... Tony said he feels bad for the IAEA because they have 190-member countries. Risk based regulation. We talk about radiation regulation based on ALARA. We do cause a lot of harm to businesses. The government owns the legislation, not the regulator. It would take a brave politician to move away from international best practice. Therefore, it would be best to have changes be driven by ICRP/NCRP. There was a "Nuclear Fuel Cycle Royal Commission Report" that came out March 2016 May 2016 came out, it is available and it was good. He said that there are about 20-30% of people that are ideologically opposed to nuclear energy.

1:48P

Julian Preston is next. He has worked as a researcher and as a risk assessor. He thinks that it is important that he can bring those two characteristics together. The answer of course is yes. First of all, you have to decide what the reason would be for an alternate dose-response formulation. You have to combine it together with the alternative that you propose to replace it. Of course, regulators can do this. Having a lack of human data, you have to use your scientific information so that the regulator can be enabled to make the change. What we do in the scientific world with regards to risk assessment, is we collect the data and say how can we use this in risk assessment. What we should do is pro-actively try to collect data to assess the risk.

1:51P

David Powell is next. He said it is really difficult for him to think about it without knowing what the paradigm is that we are thinking about. What exactly would be the other dose-response model would be. We will now be starting the discussion. Magwood is proposing a question. What would a regulator need to see to be able to go forward to create an action to make a significant change in the regulatory framework. Actually when you bring this up, it kind of reminds me, something probably like ten years ago there was this kind of discussion. One guy gave a talk and it was about science. In one talk because he said, let’s say hypothetically there is a threshold. Different people would have different thresholds, how would you protect the public if all you knew is that there might be a threshold. Once you start to think about, if you say you don't like LNT and you want to go some other way, it starts to get complicated.

1:55P

Tony Hooker said that we need some additional guidance from the ICRP, IAEA to be able to make those changes. We need some guidance on how to implement some graded risk approach. The secretariat of the IAEA, said ICRP could change, we are required to follow ICRP. All of the member states could decide that they don't want to follow the ICRP, that is unlikely. He thinks that science and public opinion could make the change.

One of the things that is going to be necessary is to break the circulation. The bibles of radiation regulation are based on the BIER VII report from 2006. He states that this literature is not correct. The literature on hormesis is just being totally ignored. As long as we ignore this, we are doomed.

The problem is that you have to have a link between hormesis and adverse health effects. We need to find a link between the biological data and the risk, then the regulator can say, yes we know the approach for extrapolating now.

Question; if radiation doses are not allowed to be beneficial. Are we willing to drop the regulations at low dose if they are beneficial to humans? This question is directed to the regulators.

Tony Hooker said that we already do something to that effect, in that we allow specific exemptions where necessary.

Question for regulators. You say you are confused about how to change LNT to a threshold. We aren't the only industry which has risks that must be managed. We are as far as I know, the only group that does ALARA. Why is it so hard for us to change and become like them?

I think the IAEA safety standards could be changed, it all depends on if the member states want to change the safety standards. Back to the first question, even if hormesis does exist, above some level it certainly isn't beneficial, and as such, there is no possibility for full on deregulation.

Back to David, he said there isn't any particular evidence to a threshold.

Another panelist jumped in and said that if you can produce additional data and a dose-response....

There is a huge downside to LNT, it is not conservative. There are a huge group of people who refuse CT scans because they are afraid of the radiation.

Tony Hooker said that it all depends on the public perception of radiation. He would much rather drive behind a truck of uranium oxide than to drive behind a truck full of chlorine gas.

Magwood said that regulators are not the ones doing the science.

Ruth Weinar brought up what her company does. It has to do with calculating risk of transporting radioactive cargo, but there is of course some external gamma. The first question is, why can't we use background as threshold. We are unable to measure the gamma, when you get within a meter of the surface, it is just lost in background. The other question is, why do regulators insist on no matter how often we calculate using good models the external doses, they want it to be bigger. If you ask them why, and they will say that they want to be conservative. Well, why do they want to be conservative, well we don't want to be non-conservative. What you hear a lot from the applicants is that, we are going to do better than the regulators. My question is, can we find some way to be adequately conservative without being ridiculously so.

Tony Hooker said that there are international transport regulations, and a regulator will only ask you to do what you are required to do. If a company wants to go above and beyond that, that is their prerogative. We have basic limits that we expect, but if you want to install additional shielding, that is your prerogative. He said that he can't see transport being unregulated.

One of the issues that we have for safety standards, is that we can provide exemptions. Conservatism is not a problem, excessive conservatism is. One of the other issues is, no matter what you call them, trigger levels, investigations levels, and if you write down a range, the lower limit becomes the limiting factor.

Tony Books followed up, said that he served on the Hanford Advisory Board, the HAB is in charge of the cleanup. We can measure radiation very well. If somebody measures a Plutonium particle off-site, there isn't an adverse health effect, however you wouldn't know it from the news. He wonders if maybe, this publicity exists because the more it seems like a disaster, the more money gets thrown at the cleanup. Why can't we be smarter like the chemical companies, to come up with a better standard. If I could throw all the money in the world at you, what could we do to get things changed. If you look at what has happened in the past few years. We don't know as much about radiation induced cancers from background induced cancer. If we could separate those two, it would be immensely helpful. You have to find indicators that are directly predictive of a cancer result. We have drivers and passenger mutations. These things need to be quantitatively predictive of a particular outcome. We are now beginning to do that, due to the large technical advances in the past few years and the computational advances.

Magwood brought up a question of how regulation of chemicals is handled. Actually, I think that maybe this is something that Julian could say a bit more about. It was just that when we had this sort of discussion, it reminded me of something that we said with Vince Halahan some years ago. Even if you did determine that there was some threshold, you might find out that you dislike those limits more than that provided by LNT. Magwood brought up the topic of Mercury, there certainly are limits, and getting half of the limit still isn't good.

There is evidence that seems to support. It sounds like if we were to move over to non-threshold model like chemical companies, it would be lower than LNT. These companies which work with hazardous chemicals do use ALARA.

A person said that he wants to speak on the topic of a threshold. He said that he thinks that the science should be directed towards finding which that point at which lower doses are beneficial (hormesis) and higher doses are bad. Tony Hooker said that he does believe in a threshold limit, He said that a 1 mSv limit would be the easiest to implement today. He said that if there was a 1 mSv cumulative dose would probably remove about 70% of the regulation that he deals with today.

Another speaker said that there is evidence that there is a threshold, and that he will present it tomorrow. He said that the risk estimates are much higher than they should be due to issues with what happened to Atom bomb survivors. He said that he thinks that hormesis is true.

Phillip Thomas would like to take up Ruth's Point and say that it is possible to answer his question entirely. What was really important was the change in life expectancy, the J-value (judgment). It is possible to find out what people would like to pay. He will be at poster 21.

Ed Parsons, as a fellow regulator for DOE, he would like to add his admiration to the non- us regulators that are here. He said that a regulator does not typically sit with his hands in his lap and wait until those laws come down. It is important that the regulators talk with legislators about what those regulations should be. You have to be prepared as a regulator to have those sorts of discussions. Point number two, when we bring up the dose-response, we have a hodgepodge of other regulatory bodies that are involved (about 13). All of these people have a say in what we can do, but we also have to satisfy the other regulators, state, federal, tribal...

Thus concluded the panel session.

2:30P

Plenary Session #3 led by Barrett Fountos. So, after giving an overview and discussing key findings, you will hear from my colleague Bruce Napier. He works in the office of domestic and international health studies. We as staff manage researchers at universities and at national labs. There are five programs where we sponsor this sort of research. One of the most interesting things with respect to the current standards is what happens at or below. For example, the dose limit for nuclear workers its 5 mSv, but for the public it is 50x lower. Other key issues include dose rate, low versus high, degree of protection, and the end point is of course cancer, because that is what the public is most concerned about. What serves as the basis for current standards.

2:35P

For example, those who received gamma radiation to the skull to treat ringworm. The magnitude of radiation release from Chernobyl led to an increased interest of concerns of the effects of ionizing radiation. What are the roles of epidemiology and dosimetry. An epidemiologist focuses on a group of people whereas a physician would focus on single individuals. Think of epidemiology as a screening tool. Like any screening tool that has a sensitivity, the higher the dose, the more likely one is to detect an effect. In radiation protection, dosimetry is the measurement, calculation, and assessment of the ionizing radiation dose absorbed by the human body.

2:39P

People ask me why we study a group of Russian cohorts. We study Mayak as it was one of the first cities in Russia where they were making nuclear weapons. Mayak is a closed city, and we are limited to two visits per year. Mayak workers had exposures that were 100 to 1000 times higher than US workers. Residents in the Techa River had chronic exposures to low doses from the releases of liquid radioactive waste. Mayak is about 1200 miles southeast from Moscow. The Joint Coordinating Committee for Radiation Effects Research (JCCRER) is a bilateral Government committee representing the US and Russian Federation. The programs purpose is to assess worker and public health risks from radiation exposure resulting from nuclear weapons production activities in the former Soviet Union. The JCCRER is structured into federal agencies on both sides. ON the US side you have the DOE, DOD, DHHS, CDC, EPA, NASA, and NRC. ON the Russian side you have the FMBA BFMBC, Rosatom ....).

2:44P

For many years, working in secret, great notes were taken of exposures and doses to people for over the span of 50 years. There has been a phases implementation of the program, Phase 1 coordinating, planning, building, infrastructure..., Phase 2 Feasibility studies and data preservation of paper records. Phase III, Successful feasibility studies resulted in multiyear projects. Phase IV Refining dosimetry, uncertainty, and cancer risk estimates. We are currently in phase IV. The program's success is measured in the number of peer reviewed publications, we have as of this point 342. We have spent almost 67M dollars in 25 years on this. The international agreement requires an external Scientific Review Group (SRG), US and Russian SRGs.

2:47P

There are five current projects, 1, Techa River Populations Dosimetry, 2b, Techa River Population Cancer Morbidity and Mortality, 2.2, Mayak Worker Cancer Morality, 2.4, Mayak Worker ..., ????. For each project, there has to be a lead US investigator and a lead Russian investigator. Bruce will address the dosimetry soon. They want to be more precise, than just giving a village average value. Project 1.2b looks at four different cohorts. There has been great follow-up and statistically significant dose-responses for solid cancer mortality ERR solid cancer mortality 0.061 per 100 mGy. Project 2.2 The cohort is 25,757 workers hired from 1948-1982, 25% Female. This is the highest exposed cohort to Plutonium in the world. Key findings, very large excess risks of lung liver bone cancer, larger risks to women than men. Project 2.4 he pointed us to read 22 papers, Project 2.8, the first and only facility in Russia to store tissue. Key Observations, the DOE is the leading cosponsor of radiation health effects research in Russia. Contrary to expectations radiation delivered at low dose rates appear to be equally effective as those delivered at high dose rates.

2:53P

We will continue to study these cohorts and maintaining the tissue repository. On to the next person Bruce Napier.

2:54P

Bruce Napier said that half a dozen of us got back from Russia just last Tuesday. To give a quick background on the Mayak site, its basically the equivalent of Hanford. The Mayak plutonium facility began operating in 1948 . Worker exposures in the early years were very high. Mayak is at about 60 degrees east, and Hanford is at 120 degrees west, which makes it exactly half way around the world. Mayak Workers, external dosimetry. Based primarily on extensive film badge records. 84% workers archive dose. In the early days the average dose was about 1 Gy / year. We have 8,043 workers monitored via intakes and urinalysis. 1,240 worker autopsies are available.

2:59P

We are in the process of putting together a Job exposure matrix. We have done all of the work we have done with the first 8K people, but there are quite a few more people available. We are trying to add more people. The peak dose for the lung is about 30 mGy, and the high doses are really big. The medians of these groups are 30 mGy / yr. There is this little river called the Tetra river. There was about 3M curies released down the river. The village of Muslyumovo which was 78km down the river, was the first river that wasn't evacuated following the tank explosion. From both of these two incidents, there were people drinking from the water, and consuming contaminated foods. We have six sources of radiation exposure.

* External and Internal exposure on the Techa River
* External and Internal exposure of the EURT area
* Medical exposure at the URCRM clinics
* ????

3:05P

We also got a new whole-body counter. We also developed a tooth beta counter. People who were born in 1951 actually took up the most Strontium, as it is absorbed into the bones when they are growing as children. This is how we figured out when the spill happened. We can estimate external doses, we have done thermal luminescence on the buildings of the villages out there. There was a release of about 1M curie of iodine. There would have been a huge thyroid dose. We are interested in uncertainties. We look at shared uncertainties, and unshared uncertainties. We also look at Berkson errors and Classical error types. Apparently, most of our errors are Berkson errors.

3:12P

Collection of data and development of models and methods is ongoing. Updated calculations have been provided. The methods and results have international impact. These are some of the best cohorts since the Life Span Study. The Techa is largely a low-dose group. The effects for unit dose appear to be the same between external and internal dose. Time for questions.

3:15P

Do you have bone marrow doses? Robert Perry had a question. He read a book that said that the people downstream of the Mayak were healthier than the rest of people. Bruce said that you might have read correctly however, they were not healthier. He was asked that if your dosimetry is great but you epidemiology is bad, there isn't a point. Simple question why did the people in Mayak stop cooperating with us in 2011. The senior management of Mayak changed, and they decided to stop working with us. It was asked if this was a political change, but it was stated that we couldn't answer to that.

3:20P

On to the presentation by Dan Stram. He is going to talk about cancer risk due to radiation exposure in the southern Urals. There are three epidemiological studies. The source of the radiation in the area was from Mayak. Occupational exposures included internal (Pu), and external (gamma). There were two large radiation releases, the Mayak PA into Techa River and the Explosion that caused the radioactive trace. There are 26K in the Mayak Workers Cohort (MWC). The Techa River Cohort (TRC) contains about 30K people. the East European Radioactive Trace (EURTC) contains about 22K people.

3:25P

For MWC, we looked at mortality from lung, liver and bone 1948-2003. And a follow up for lung cancer through 2008. At TRC, we had solid cancer mortality, solid cancer incidence and leukemia incidence, all studies used TRDS 2009. Recent progress. TRC has been extended to include EURTC in risk analysis. Follow-up through 2016. There are also some additional modeling improvements. Recent progress to MWC. Improved dose estimates and update of follow-up through 2015. There is progress in statistical modeling. Incorporating dosimetric uncertainty into epidemiological calculations.

3:31P

Looking at risk of lung cancer associated with Pu. There was an ERR of 7.4 for males aged 60 and ERR of 24 for males at age 60. In the follow up, the adjusted values are 3.6 ERR for males and 9.9 ERR for females. Looking at external dose, there is almost no change in risk assessment between this and the previous paper. We don't think there is much uncertainty in the badge readings. All solid tumors in the TRC, one is mortality and the other is incidence. for mortality the ERR/Gy is 0.61. The updated analysis shows that the TRC cohort had an ERR/Gy of 0.55, EIRT cohort had an ERR of 0.46, and the combined was 0.60 ERR/Gy.

3:37P

Non-CLL leukemia in the TRC. ERR/Gy is 2.2. The red bone marrow appears to be quadratic. Attained age rapidly reduces excess relative risk of exposure. Apparently, there is a time since exposure effect. These ERRs appear to further be reduced as the participants continue to age. Techa doses are lower but risk estimates / Gy are higher. Techa doses are providing information about low doses delivered at very low rates. Techa is relevant to accident, terrorist scenarios.

3:42P

Gayle Wallacheck had a question. Plutonium is a heavy metal and it works with radiation and it has a lot of effects on its own. How do you distinguish the heavy metal effect from the radiation effect because there are no non-radioactive isotopes of Plutonium? Gayle said that a lot of the effects that you could be seeing could just be heavy metal effects. Another person said that he was surprised that internal radiation exposure showed huge differences between women and men. Apparently, the data is adjusted to accommodate for smoking of the males.

3:45P

Dale Preston is next; his presentation is on Comparing High and Low Dose Radiation Rates. The population that we study covered 25,757 Mayak workers. Of the Mayak Worker Cohort, 70% that we are still following are now dead. 20% of the cohort members were lost due to migration. Mean age of initial exposure was 25. 25% of the workers are women. Dose rates were calculated for this group and it appears that they are certainly low dose rates. There were 29,710 riverside village residents. There are 58% women in this cohort. The women are on average older than the men and this is largely due to men being conscripted into war. The EURT Cohort contains another 19,839 people. These people had to be born before the accident. This includes 1598 people who are also members of the TRC cohort.

3:55P

All combined, there are about 47,951 people in the cohort. The Techa River /EURT Cohort Dose rates were calculated to 1.7 uGy/hr to Stomach and 0.7 uGy/hr to stomach for the EURT for Red Bone Marrow, Tech and EURT were 5.5 and 2.9 uGy/hr, respectively. He is now going to compare these results to the atomic bomb survivors. 86,720 people in Hiroshima/Nagasaki received a known dose. They were 58% women, marked deficit of men between 18 to 40 years in age. Comparing LSS, Mayak, and Techa Risk Estimates... the LSS risk models were parameterized to reflect sex-ratios in Techa and Mayak cohorts and adjusted to reflect typical ages at exposure and ages at cancer death in Tech and Mayak cohorts. Techa: age at exposure 25, solid cancer death at 65, leukemia death at 50. Mayak, age at exposure 25, solid cancer death at 65, leukemia death at age 55. Report risks as percentage increase in death rate at 100 mGy.

4:01P

On a slide for Cancer risk estimates, for Techa + EURT the % increase @ 100 mGy is 5.6. On to Conclusions... Mayak leukemia risk and external dose cancer risk appear to be somewhat lower than corresponding LSS based estimates. Techa leukemia and solid cancer risk estimates appear to be similar to LSS risk estimates. Power to investigate site-specific risks is generally limited in the Russian studies. Ready now to take questions. Doc Preston said that he is a fan of his. He has a question about controlling the age. You also have a reverse age. What is your strategy or advice on choosing which format to use for the model. He is in the analysis for 500K shipyard workers over the span of 54 years. Another person asked if perhaps you are seeing a difference because you are underestimating the dose to the Mayak workers. There is also a significant neutron dose associated to generation of Plutonium. Apparently, they are including a neutron dose, they are currently in the process of adding Americium to the model. It was pointed out that PuO behaves very differently in the body than if it was just Pu. Right now, we are assuming that there is about 10-15 oxides. What do you think is the difference between the instances of leukemia between Mayak and the others?

4:11P

We are now going to go on break

****

BREAK

****

4:37P

Panel #2: Epidemiology and Basis for Current Radiation Protection Standards

This panel is moderated by Roger McClellan and includes the following people:

- Dan Stram

- Dale Preston
- Yutaka Hamaoka

M Roger McClellan

- Richard Bull
- Burce Napier

Richard Bull has been working on Internal Dosimetry. Internal dosimetry is a case where the source is taken within the body. Need to use indirect methods to calculate internal doses. You can measure the it before (air sampling), Measure while it is in the body (in-vivo / autopsy), or after it leaves the body excretory. Air monitoring is straightforward. In vivo monitoring works fine with gamma emitters. You lay them down and put a detector up next to the patient. This doesn't work on plutonium detection though. Finally, we have urine and fecal sampling. At Mayak there is urine data. Here we would be looking for 241 Am. So we need to relate what comes out of the body with what went in, in the first place. We have various models to tell us how to do this. This requires bio-kinetic models. In the old days when we did internal dosimetries, when somebody asked them for uncertainties, they would change the subject or walk away.

4:45P

This is basically a quick run through of internal dosimetry. Question, you said that one of the interesting results is in the autopsy. Have you ever been able to compare somebody before and after? He had a chance to see results from urinalysis and autopsy and there were some fairly significant differences. It is much harder to go from a urinalysis to a dose. Dave had a question of the bio-kinetic model, have they really been validated. Richard said that there has been some amount of validation using animal models. He would say that they are reaching a reasonable degree of sophistication. The question asker said that being sophisticated isn't the same as being accurate.

4:52P

On to the next speaker, Dr. Hamaoka. He is giving a talk on Re-Analysis of Radiation Epidemiologic Data. Following the incident at Fukushima Dai-Ichi, Japanese people are quite interested in radiation risk. He listed the limitations in major radiation epidemiological studies. Limitation 1 is Incomplete model selection. These dose reconstructions estimated the best estimates. He calculated the AIC and BIC values, he said that the lower the BIC value is, the better fit that the model is. He said based on that, we can clearly see that the linear model is the best. Limitation 2; Aggregation/Tabulation of Individual level

Data. He reanalyzed pooled analysis data from Hanford, Oak Ridge, and Rocky Flats (N~47,000), applied the traditional approach and failed to detect a significant relationship between cumulative doses and mortality. With the individual level data modeling, positive and significant results are measured. To reach a correct conclusion, proper understanding of the statistical models such as model selection is necessary. Second to detect low dose effect, models that utilize individual level model are best.

4:58P

Bruce will start off first. He said that the current situation is that we use effective dose, which is the inclusion of the external and internal dose together. Which seems to indicate that the ICRP model is pretty reasonable and maybe even correct. Roger asked if he could do the individualized dose. Bruce said that the data is available if that was the type of model you wanted to construct. Dale Preston said that he didn't see any particular bias resulting from using a broad array of categories as opposed to using individual level modeling. Dale said that Bruce and his students have done some great work regarding the Monte Carlo systems, which provides information regarding dose uncertainty. He thinks that the asymmetric widening of the confidence intervals is interesting and makes sense. Dan Stram said that, the widening is asymmetric because the variable that you are trying to get the confidence interval for is .... . This feature of having the variance dependent on the variable you are looking at doesn't apply. But we do end up having corrected variance for all parameters. He noticed that there was a widening of the confidence interval between the dose-response for males and females on the ERR scale. After widening the confidence intervals, the question is do these intervals overlap better.

5:06P

Roger said that he wants to open a can of worms. He said that he didn't have access to certain data, like from the Life Span. Roger said he got to work with Diesel exhaust data from NIAK. He said it was worthwhile, first we replicated what other people had done, then proceeded to to extended analysis. He thinks that this result of multiple set of analysis seemed to be worthwhile. Questions: With result to the dosimetry. Women seem to pass twice the quantity of Plutonium through urine likely, because of how women process iron more quickly. If you look at the injection data for the volunteers, there is even data on biopsy for bone content, when he went back and did an uncertainty on the dosimetry after an assumed 30 years of intake. Question: about the ERTC data, that data compiled the cancer rates with the cohort and the general population. Then there was a follow-up study, but LNT model fitting was done. Comparisons to rates in Russia is very difficult, one has to be very suspicious of that. Being able to look at a dose response is a much more powerful method than looking at dose rates in an exposed and unexposed population.

5:11P

Question: The lung cancer rate showed a reduction, but the linear model was fit to that. If we fit a linear quadratic model to it, then we would have values just below 0 for low doses. Tony Brooks had a question; He said that when we were chasing fallout, it was surprising how the short half-life stuff does for your dose. Question number 2, we did a lot of things over there under Roger. You would have a dose to the lung, bone, and liver then you would combine that stuff and come up with Gys. How do you add a dose to the thyroid to a dose to the bone? Answer, operations at Mayak were very complicated. They would dissolve the fuel, then they pump it back and forth. Things weren't released immediately. It sounds like things probably didn't enter the river until about 6 months later. Tony asked why they used Grays instead of Siverts. Answer, in general we don't add those together. What would happen if you multiplied it all by 20, but it doesn't it ends up being like 6. Tony asked why there wasn't much data on the bones. Dale said that there weren't many issues with bone cancer. Roger said that you just need to look at the miniature pig data, and you would see that the bone cancer results were much lower than we thought they would be.

5:18P

Dale said that the Mayak results seem to be lower than the Tetra and also lower than the LSS. Olaf Christiansen said that the Tetra results were lower than the. If you assume there is a low enough limit for hormetic effect, then the Tetra river would have been that case. Question: Do we have the DNA of these people to see if we have. Barry is now up there to talk about the Mayak worker tissue repository. We have family triads where the father, mother and offspring were exposed. There is a way to get access to that data, speak with Barret about it afterwards. David Brenner led a study on radiation bio-markers. Using peripheral blood lymphocytes. It showed the difference between alpha and gamma radiation. One of the key reasons for having this tissue repository is so that it can be researched. The Russian Human Radiobiological Tissue Repository contains over 315K samples.

5:27P

Rod Adams said that you mentioned that there was very low bone cancer in an area where Strontium 90 was plentiful. Did you find if there were other cancers that were related to Strontium 90? Answer: Strontium 90 and Cs 137 were very important fallout nuclides. Roger said that he had to study Strontium 90, and there were three doses that he supplied, at lower doses, we didn't see anything. So, we got some additional animals, and bumped the doses. There were numerous other studies on Strontium 90, some that included thousands of mice, and another study that looked at radium and plutonium and used dogs. He does find it remarkable that in the miniature pig study we didn't see a high incidence of bone cancer resulting from the Strontium 90. Question from Scott Miller. He also was involved with the dog experiments. Yes, there weren't many instances of bone cancer from the Mayak workers, but there does seem to be a pattern of where these bone cancer instances would manifest. Sure enough, the results from the dogs do correspond well with the locations with the Mayak workers.

5:32P

Mark Miller had a question. The thread that keeps running through with how to deal with the LNT. It seems to govern how we are thinking about this. He said that we have the null hypothesis incorrect, we should be saying that there isn't LNT and to have the burden of supporting LNT to be left to results. Dale Preston said that he looked at the number of thyroid problems and that they were very different between those born in 1951 and 1953. There was a town of Visziorsk, which was 8 km from the stack. The milk producing areas were within 10 and 30 km downwind. Roger thought about the other sorts of chemicals, for example benzene. Radiation knowledge is high. For chemicals we only really talk about whether or not a chemical is, may be, or is not a carcinogen. For radiation, it is very well known, and we have a lot of data.

5:38P

Next is a presentation by Nick Priest from the Canadian Nuclear Labs. He will be speaking on the strategic low dose program of the Canadian nuclear utilities - addressing the worries and concerns of the public. His research is being funded by the CANDU owners' group (COG). In Canada, utilities are required to undertake some research and to provide some research funding, so we have that source. In Canada, back in 2015, we were coming up with priority areas for research. Eight priority areas were identified. One of those issues was to create a low dose program. One issue is that people are really worried about nuclear risks. For some reason it is considered to be an unknown risk and particularly dreaded as such. When people hear about new technology, they go through phases. Step 1: people don't care, its new, lets check it out; Step 2: trust the experts, Step 3: Talk louder stage (frequent debates with opposing views), Step 4: Tell them what they should know (industry deluge of facts), Step 5: Tell them what they want to know (communication fails at this point), Step 6: Deal with perceptions, move to public appraisal.

5:38P

We are trying to address this issue by taking using a bottom-up, public facing program. The research is being overseen by an independent committee. The program is being industry funded but is being conducted independently. This program is driven by public worries. Responds to all concerns and undertakes research projects to address these concerns. It seeks collaboration through NEA NEST and other programs. We have two research tracks, there is a social science track. We want to know what people worry about, which will help to define what the research projects are. Initially, we had to make some guesses about what people would be worried about as it would take a while for those social studies to get back to us. These two issues are: hazard poorly understood, and population exposed and at risk.

5:50P

The current budget is about 1.2M/year. We are doing most of this work through universities so that we don't have to pay the huge overhead associated with a national lab. The social science project is being undertaken at the Center for the Study of Science and Innovation Policy, University of Saskatchewan and University of Regina. We have two population-based projects. Objectives, Incremental doses to public living / working close to Canadian NPP's. Evidence for health detriment (all causes of death and longevity). He wants us to move beyond only looking at cancer. We looked at 224Ra patients. Their Leukemia death and solid cancer death, but there was an almost 20% reduction of non-cancer deaths. He said that when we look at these studies, we should look at all causes of death and not just cherry-picking cancer.

5:56P

We have Radiobiology projects (CNL & uOttawa). Objectives are to determine the effect of LDR on cancer induction and progression, and the effects of LDR on cell responses and tissue system and the systems and the potential for diseases. The last thing is that we want to collaborate as much as possible (to use money efficiently). He wants to work with NEA to hopefully double the money, and the other reason is that if we can split up the research funding it would boost the acceptability of the research as it wouldn't seem so funded by private industry. He will have to explain to the government that they aren't subsidizing the private program and vice versa. On to questions. Question: on the way that you are phrasing things, you are looking for detriment, and in another page, you are looking for longer life. There is a group up in Canada and there are lots of effects seen from Low Dose Radiation, and at this point it's hard to say whether things are detrimental or beneficial. Nick pointed out that you can have negative detriment as well. Paul Locke was excited, and a bit concerned about his presentation. He is concerned about the project to really know whether or not he is dealing with some fundamental issues.

6:02P

One specific question is that Canada is not homogeneous. There is a big portion of Aboriginal population. Nick said that, this is one reason he is working with one of the universities (Saskatchewan and Regina) that he is. Somebody pointed out that there are some interesting health side effects that can result from living next to a Nuclear Power Plant. A comment was provided that in trying to address the concerns of the people, people who are outside of the industry are likely more concerned about different things, and that he might not be trying to answer the right questions. Nick said that he is still in discussion with COG on the communication front. He said that if the actual concerns have nothing to do with Radiobiology, it could spawn a whole new branch of social science research projects. We are working together to answer the questions that people have got. She said that, she hopes that he follows up the response with warmth.

6:08P

An Audience member thanked Nick for his work in changing public perception, he thinks that this work is just the beginning. The governments are going to start wondering what people can do with people losing their jobs due to automation, so there needs to be more education, but there needs to be a lot more of it. Last question, Nick, this is Bruce Church, he was at the Nevada test site for about 30 years, and he said that we got beat up really bad for years by the press. We started a program to allow us to get out in the public and let them beat us up. We now need to get out there to expose ourselves to the public, at this point it is up to its 37 years. Nick said that he would be very interested to hear about what he has to say. What the guy said he did is that he had an organization at the local university and they recruited high school science teachers and trained up those teachers and set up nuclear measuring equipment. These teachers went back to their communities and interacted with their students and communities. It sounds like having those teachers on-board made a huge difference to public perception.

6:15P

We are getting 5 minutes from a guy from the NEA. There is an effort towards global collaboration in low dose research. There is work going on in Canada, but we are hoping that soon, we will be able to collaborate with other organization on that. We are trying to organize a light system which will answer the question of what sort of things these organization are trying to accomplish. If we can find organizational overlap, then we have an opportunity for collaborations. We are hoping that if we look at things in a broad sense, we might be able to make some headway. We might also try and work together with chemical toxicology. He will be developing the details of this in the coming months.

6:18P

Alan said that today was the epidemiology day and that tomorrow we will hear from the biologists. At this point it sounds like LNT is definitely true, so we will hear about things from a different perspective tomorrow. Anyhow, public perception is very important and so we need to take care to not scare the public. *We were now released to go and visit the poster session*