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TRIP TO HARWELL, SACLAY, CERN, EGYPT, INDIA, AND CEYLON FOR HEALTH PHYSICS MEETINGS AND MEASUREMENTS

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TRIP TO HARWELL, SACLAY, CERN, EGYPT,  
INDIA, AND CEYLON FOR HEALTH PHYSICS  
MEETINGS AND MEASUREMENTS

November 30, 1962 to February 10, 1963

Berkeley, California

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UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory  
Berkeley, California

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TRIP TO HARWELL, SACLAY, CERN, EGYPT, INDIA,  
AND CEYLON FOR HEALTH PHYSICS MEETINGS  
AND MEASUREMENTS

November 30, 1962 to February 10, 1963

Roger Wallace

March 14, 1963

TRIP TO HARWELL, SACLAY, CERN, EGYPT, INDIA,  
AND CEYLON FOR HEALTH PHYSICS MEETINGS  
AND MEASUREMENTS

November 30, 1962 to February 10, 1963

Roger Wallace  
Health Physics Department  
Lawrence Radiation Laboratory  
Berkeley, California

March 14, 1963

This trip was a combination of a long-planned presentation of a paper—UCRL-10275, Four- $\pi$  Fast-Neutron Spectrometers for Detection and Dosimetry—at the Symposium on Neutron Detection, Dosimetry and Standardization, held at the Atomic Energy Research Establishment, Harwell, England on December 10-14, 1962; a visit to Saclay and Fontenay-aux-Roses, Paris and to CERN, Geneva; and a radiation-measurement trip, made at the invitation of the World Health Organization (WHO) to areas of high natural background radiation in the United Arab Republic near Cairo, Kerala state in southern India, and on the west and southern coasts of Ceylon. The European part of the trip, which was made in the company of MR. LLOYD STEPHENS, was jointly supported by the Lawrence Radiation Laboratory and the Institute of Engineering Research of the University of California, Berkeley, and to a small extent by the WHO. The Asian part of the trip, made with MR. H. WADE PATTERSON, was supported entirely by the WHO. The trip will be described in chronological order.

The purpose of the conference at Harwell on "Neutron Detection, Dosimetry and Standardization," was to round out the discussion of these subjects which was originally begun at the Vienna meeting of 1960. At that meeting I had presented a paper (UCRL-9214, The Dosimetry of High-Energy Neutrons Produced by 6.2-GeV Protons Accelerated in the Bevatron) that was

published in "Selected Topics in Radiation Dosimetry," by the International Atomic Energy Agency in Vienna, 1961. The recent conference had a somewhat narrower interest and, I believe, brought out considerably more technical detail in areas in which our group is primarily interested. The subjects specifically covered by the 1962 conference were: (1) problems of measurement of neutron field characteristics, (2) neutron spectrometry, (3) detection and dosimetry of neutron and mixed gamma neutron radiation fields, and (4) neutron-source standardization.

The list of participants and their affiliations has been omitted, since this information is available in the Washington Headquarters Office of Special Projects. I felt that this conference brought out several new ideas in neutron instrumentation that will be of value at this Laboratory. The problem of cross sections for threshold reactions, which was discussed at some length at this conference, is the subject of a soon-to-be-completed Ph. D. thesis in this department (John C. Ringle, High-Energy Neutron Spectra Measurements by Threshold Detectors, UCRL-10732). It was interesting to note that this work will apparently receive wide attention.

One of the most thoroughly discussed questions was the method of measuring neutron spectra that are emitted by a thick shield. This was the subject of the paper which I presented; however, much more work is needed in this field. I feel that considerable progress has been made in four- $\pi$  neutron spectroscopy since the 1960 conference, both at this Laboratory and in other laboratories. I believe that a conference of this type, which is very specific in its technical content, is of unusual value to people actually working in this particular field, and that one should be held approximately every two to four years.

Conferences of a broader more general nature I find much less interesting and rewarding, although they perhaps have their place in informing

people who would otherwise find it difficult to gather such information. In view of the very long time delay before the publication of proceedings of a conference, I think that there is justification in sending an individual to a conference, rather than assuming that he can wait for the new information until the proceedings have been published. Such a delay is far too long to allow for effective work in a field that is developing rapidly. I certainly recommend that we continue our participation in carefully selected meetings of this nature.

Paris, December 3 and 4, 1962

We were driven to Saclay by M. MICHAEL GRAS, who is the Public Relations Director for the Health Physics Group under DR. FRANCOIS DUHAMEL. I first talked with DR. JOFFRE, who is in charge of radiation protection at the Saclay accelerator installations. DR. CROSS, from Chalk River, was also present with LLOYD STEPHENS and me. DR. JOFFRE is presently quite interested in tissue dose produced by soft x rays, since there are about 50 x-ray machines around Saclay in the 80-kV region.

JOFFRE explained the extreme difficulty that he encounters in securing electronic equipment and detection equipment made the way he wants it to be made. Apparently the production groups at Saclay are organizationally extremely independent and take little or no advice from the health physics group. Certainly his situation is far different from ours. He finds that it may take two or three years to get a new detector or electronic circuit made, and then it usually is quite unsatisfactory.

He showed us his low-level counting area which has an added anti-coincidence cosmic-ray blanket made up of gas-flow proportional counters. We also inspected the radiation-protection equipment at the Saturn accelerator. This has now become very elaborate compared with the way it was when I saw it two years ago. A continuous recording of radiation levels is made at a

number of locations. Once a month a very elaborate chart is produced which shows the radiation levels in various areas around the accelerator. There is always a man on duty watching the radiation equipment. This man in turn provides the information for the monthly chart. This system is so elaborate, compared with ours, that I wonder if it is really necessary, since the radiation levels produced are quite modest in most places. The interlocking system is very complicated, with very expensive panel indicators showing its status.

We had a very excellent lunch, in keeping with the finest tradition of French culinary art, provided for us by the Office of the Director of the Laboratory. DR. DUHAMEL was present, as well as several others, such as M. CANDES, from Cadrache and Fontenay-aux-Roses, as well as JOSE PAMAROLA, the Director of Health Physics at Fontenay-aux-Roses, and M. POUTEAUX, who has been working at CERN on the dosimetry of 600-MeV protons. This work, under CANDES, has been reported in a paper which gives the angular distributions of the resulting products based on detection by threshold detectors. The energy range covered is 400 MeV to 5 GeV. The report contains curves which, if used on the basis of their ratios, could possibly provide identification of neutron energy over this range. Whether this provides a basis for a neutron spectrometer is yet to be seen.

In the afternoon we went to Fontenay-aux-Roses and spent the afternoon discussing problems with JOSE PAMAROLA and M. CANDES. PAMAROLA formerly worked for DUHAMEL at Saclay. He has the responsibility for radiation protection at the reactors at Fontenay. CANDES, who is also stationed at Fontenay, has been at least temporary director of the health physics work at Cadrache. Cadrache is still under construction. It is near Aix-en-Provence, northeast of Marseilles. It will be the French



counterpart of Oak Ridge. Whether or not CANDES will be the Director of Health Physics there when it is completed is not perfectly clear, but he is commuting between Fontenay and Cadache at this time, on this assumption. For the time being his main effort is directed toward cooperation with JOHAN BAARLI at CERN, on the high-energy dosimetry project.

There is an academic program at Saclay under DR. BAISSAS, who is Director of Physics for the French Atomic Energy Commission and is therefore supervisor of all graduate students working at Saclay. The former director of Fontenay, DR. YVON, has returned to the Sorbonne as a physics professor. He is also interested in the academic program at Saclay.

PROFESSOR BONET-MAURY, from Orsay and the University of Paris, conferred with us at Fontenay-aux-Roses. He has been working on proton dosimetry. He feels that stars have no special effect even when occurring in biological materials. BONET-MAURY feels that no other variable than the LET is important. The beginning of each heavy particle path is essentially the same, and if a path does not end in the tissue then there is certainly no variation from one type of radiation to the next. In his work with BAARLI, at CERN, he is using radiochemical dosimetry as well as film dosimetry. At Orsay next year he will have available heavy ions of 15 MeV per nucleon.

On Tuesday we returned to Fontenay-aux-Roses and had a long visit with the members of PAMAROLA'S group. We first were shown around the Nuclear Chemistry Laboratory by M. PIERRE FELIERS. He is Chief of Health Chemistry. The laboratories are extremely well made, much like those in Berkeley. A great deal of plastic is used in making their glove boxes.

We were then shown the three reactors -- Triton I and Triton II, which are in the same swimming pool, and Minerva, which is smaller and is

in a separate pool--by M. POUTEAUX who is in charge of health physics, under PAMAROLA. Their equipment is as elaborate as that at Saclay. They have very expensive radiation-level-indicating panels and many installed instruments and interlocks; these are much more appropriate to a reactor than to an accelerator. There was a lot of very active work going on while we were there and the equipment was all quite impressive.

We were eventually joined by MME. SYLVIE ALIBERT. She is in the Department of Protection Sanitaire at Fontenay-aux-Roses and is partially involved in the work on the French areas of high natural radiation, which is being renewed. This work is principally being carried out by MME. PARMENTIER under DR. HENRI P. JAMMET at Saclay.

We again had a discussion with M. CANDES who is responsible for the shielding calculation in conjunction with the target work at CERN. He and PAMAROLA assured us that the report on the January 1962 meeting, on the shielding of accelerators, is to be available within the next two or three weeks. It is now at the publisher's.

CERN, December 5-7, 1962

At CERN we first visited with DR. MARCEL BARBIER, of the Synchrocyclotron Group, who acted as our host and gave us a great deal of personal help during our stay at CERN. We had a long discussion with DR. K. GOEBEL; DR. A. SULLIVAN, an Englishman; and DR. MARCEL BARBIER. Unfortunately DR. JOHAN BAARLI was called away suddenly, just before our arrival, by serious personal business in Oslo, so we did not get to see him.

Almost all of our discussions centered around the shielding experiment that is being carried out at CERN in collaboration with RALPH THOMAS at Rutherford Laboratory and also with the Saclay and Fontenay-aux-Roses groups. Some initial experimental data have been obtained from carbon-11

detectors, which were placed in a very thick stack of concrete directly in a pencil beam. These detectors give a very consistent picture and even indicate that the original beam axis was not properly located, nevertheless they allow the beam's position to be calculated. Nuclear emulsions were also placed in the stack. However, the reading of the emulsions is only beginning in France, England, and at CERN, so no data are available from the emulsion measurement. The carbon-11 data indicate a mean free path of about 150 grams per  $\text{cm}^2$  for protons of 10 and 19 GeV.

The side scattering of the beam was small and the stack was big enough so that the intensity at the edges of the stack was down by a factor of about  $10^4$  from the beam center-line intensity. The three-dimensional pattern of the scattered radiation that produces carbon-11 is available, and some new computations are being made from it to improve the fit of the data. The monitoring was such that the intensity fluctuation from beam pulse to pulse caused some uncertainty in the ratio of carbon-11 counts to monitor counts. We had a long discussion about the use of the Panofsky technique of putting a resistor across the capacitor of their monitor ion chamber in order to allow the monitor charge to decay with the same mean life as that of the carbon-11, thus eliminating the monitor fluctuation. The data are in such a preliminary form that they were not willing to give us a copy, but I believe we will get one soon.

We discussed with K. GOEBEL the Metropolis type of Monte Carlo calculation being carried on at Oak Ridge, and I think that this was a fruitful interchange of ideas and that some valuable new data will become available from the current shielding experiments. Unfortunately they have no plans to carry them out at the 600-MeV synchrocyclotron.

We inspected the experimental facilities at the proton synchrotron, the control room, and the health physics facilities. The progress in the two

years since I was there before has been enormous. There are now three experimental halls: two in operation and another one being completed. The beam surveys are quite extensive and the dose rates are known in a variety of locations. The monitoring of health physics problems is apparently well in hand. Just as we found at Saclay, the facilities are very elaborate, very expensive, and far beyond the level at which we instrument our accelerators for radiation protection. I presume that this is due to the relatively low labor cost in Europe, which allowed them to have much more elaborate instruments and installations.

Harwell, December 10-14, 1962

This conference has been partially described in the beginning of this report. Since complete proceedings will be published, only one highlight is briefly mentioned here. A variation of the Hansen-McKibben long counter, which combines the advantages of our much used energy-insensitive  $\text{BF}_3$  counters with those of the Moyer-type polyethylene proportional counters, was described by DR. INGVAR ANDERSSON, of Studsvik, Sweden. This counter can have its response easily tailored to any RBE (E) shape that may be desired.

Cairo and Alexandria, December 27, 1962 to January 3, 1963

We were met on December 28 by DR. EL KHARADLY and DR. MAHMOUD. DR. EL KHARADLY is a medical doctor and has his headquarters in Alexandria. DR. MAHMOUD is in charge of the Health Physics Department of the Egyptian Atomic Energy Commission. Our plans for making the radiation survey near Rosetta were organized, and we drove to Alexandria late on December 28. Unfortunately I was taken ill with an unspecific fever and spent the last three days of December and the first of January in bed, in Alexandria.

The details of the radiation survey work near Rosetta and the survey conducted at the request of the Egyptian Atomic Energy Commission near the Suez Canal will be contained in the trip report by WADE PATTERSON, who made both of these surveys personally, and in our joint technical report to the WHO.

On January 2 I went to the WHO Eastern Mediterranean Regional Office (EMRO) and made further arrangements for the Indian and Ceylonese trip.

I rejoined WADE PATTERSON on January 3 at Cairo. We visited the Atomic Energy Commission Laboratories at Inchass, near Cairo, where we discussed mutual health physics problems. We and the Egyptians calibrated our instruments against the NBS source owned by them. The result of the instrument comparison will be contained in our technical report to WHO, as will all other details of measurements and results obtained on this trip. A seminar was held in which members of the Egyptian health physics group described their work, and WADE PATTERSON and I each gave a little talk describing some of our work.

New Delhi, January 4-6, 1963

We proceeded to New Delhi on the night of January 3, arriving the next morning. There we were joined by DR. LOWRY DOBSON and DR. LALIT SANGVHI of the WHO radiation group in Geneva. We then went to the WHO Southeast Asia Regional Office (SEARO) in New Delhi, where we were given a full briefing by DR. NATH who described the situation in Kerala and also Ceylon, and pointed out the interests of the WHO and how they might or might not fit into the local political and technical situation. In addition, some of our details of travel were worked out at the WHO travel office.

On January 6 we flew to Bombay. On the morning of the 7th we made the final adjustment of our travel details to southern India. In the afternoon we visited DR. GOPAL-AYENGAR at the Indian Cancer Research Center.

As a result of the behavior of the instruments in Egypt, we felt that it was important to make a further adjustment of their discriminator settings, so we proceeded to Trombay, a suburb of Bombay, where the Indian Atomic Energy Establishment is located. There we were able to open the instruments in an air-conditioned room and to check them against several electrostatic voltmeters, which were generously provided by the Indian laboratory. We were able to make the proper adjustments of the discriminator settings, and from that time on both the instruments functioned quite satisfactorily, although we did readjust them again in Ceylon. We were told that a member of this laboratory, MR. HARIHARAN, had already proceeded to Kerala by train, taking along one of their instruments. Since he spoke both of the local languages, Tamil and Malayalam, he would be our technical host when we were in that area.

Kerala, January 9-13, 1963

We proceeded by plane to Madras. Then, after several intermediate stops, to Trivandrum, where we were met by MR. HARIHARAN, who had gone ahead from Bombay by train, and DR. TANGHIVELU, Dean of the Medical Colleges of the University of Kerala at Trivandrum. On the next day, January 10, we met at the medical colleges and discussed our program and became familiar with the location of the control areas, as well as the areas of high radiation level. Two members of the team, DR. R. LOWRY DOBSON and DR. LALIT SANGVI, went to the government Department of Statistics that afternoon, while WADE PATTERSON and I went to the Medical Control Area and made some radiation measurements. Late on January 10 we drove to Quilon, which is close to some of the high-level areas. On the 11th we visited Neendakara, where there is a Norwegian health unit, and made surveys in that area. We also visited the Chavara Minerals Corporation, where we discussed the local

geological situation with the director of the separation plant. The radiation levels that we detected will be described in our report to the WHO.

In general this area turned out to have a very high level of natural background activity, perhaps a higher level than has been previously reported. There are many details that must be discussed in order to properly evaluate the meaning of this situation. It should also be remembered that these levels change from time to time as a result of climatic conditions associated with the monsoon season. The levels are said to be even higher during the monsoon. It certainly appears that the high-level areas with fairly dense population are available for study.

On January 12 we revisited this area and also proceeded to Manavolakurichi, where we made measurements in another very high-level area. We made measurements in several other areas and collected some samples as we proceeded down the coast to Cape Comorin on the southern tip of India. It appears that in addition to the high-level areas there are equally extensive and as densely populated areas that might be used for control populations, where the levels are not elevated. It is of interest to note that one of these possible control areas, where Trivandrum Medical College has set up an extensive health service, has been selected by the Indian government and the United States National Aeronautics and Space Administration for a satellite launching site. This location was chosen because it is on the magnetic equator. This facility is not yet under construction. Fortunately this is not in a high-level area, although the considerable influx of foreign personnel and money will perhaps change some of the local living habits, and a new control area will surely have to be chosen.

Kerala is certainly one of the most interesting areas with which I have had experience. It is quite tropical, it is very densely populated, and

the people are somewhat different from those in other parts of India. There are a great number of public projects under way at this time. There are four medical schools in the state of Kerala, which has about the same population as California. Apparently great strides have been made during the last five years in eradicating malaria and cholera, and approaches have been made to the eradication of some of the other traditional tropical diseases.

The water supplies of most towns are now filtered and chlorinated. In Trivandrum an extensive sewer system is now being installed. There is electricity almost everywhere. The railroad goes through almost all of the towns, and the roads are fairly good. The accommodations for visitors were quite comfortable although somewhat different from ours.

DEAN TANGHIVELU of the medical college, and his staff, who were our official hosts in Kerala, were extremely cooperative. The medical college certainly should be a part of any future study of the inhabitants of these high-radiation areas.

There are two Dravidian languages spoken in the area. The northern half speak Malayalam and the southern half speak Tamil, the language used in Madras state. This complicates any study, since there are high-radiation villages in both areas. The educational levels in Kerala are considerably above those in the rest of India. The inhabitants of the villages in the high-radiation areas seem to be willing to cooperate with outside investigators, and we did not experience any difficulties due to objections by the local citizens. The study of such an area is quite complicated, involving many different disciplines; as a result, these other aspects will have to be discussed in an official WHO report. These remarks are not intended to be anything but passing impressions from one eyewitness.



Ceylon. January 14-26, 1963

On January 13 we flew to Madras, and on the 14th from Madras to Colombo, where we were met by DR. IDA VAN DYKE, the WHO resident in Colombo. She arranged meetings for us on January 15 and 16 at the Geological Survey with MR. FERNANDO, and at the Ministry of Public Health. Both of these organizations were our hosts while we were in Ceylon.

The Geological Survey was well provided with instruments. They had an air-conditioned laboratory in which we were again able to calibrate our instruments, change batteries, and make appropriate adjustments. The Geological Survey has made a very extensive study of the monazite sand deposits in Ceylon, both on the ground and from the air. The aerial surveys were actually carried out by a Canadian company as a part of the "Colombo Plan," under which Canada is supplying technical assistance to Ceylon. The aerial survey was very detailed along the western and southern coasts and clearly indicated a large number of areas of increased radiation. These areas generally lie within a few miles of the coast and represent ancient beaches. We arranged our program so that we visited all of the areas that had radiation levels above a certain chosen threshold.

On January 16 we visited the first of these areas, which proved to be a fair-sized town was actually in a rather expensive residential district. Our experiences in Ceylon, which will be described in our technical report, were rather different from those in India in that quite a number of the areas of high-radiation level proved to be in palm groves, or rubber plantations, or in town areas that were not very densely populated. Several areas were located which had fairly high population densities, comparable to those in India in both intensity and the potential number of inhabitants.

Surveys were made by two different teams, since the area to be covered in Ceylon was somewhat larger than that in India. There have been

several prior radiation surveys in Kerala, so we were able to preselect the areas for our comparison measurements. Ceylon was a less-well-known quantity, and as a result, WADE PATTERSON took one of the two cars furnished by the Ministry of Public Health and one of our associates from WHO, while I took the other car and the other associate. We did not both survey in the same areas, as we had in India. As a consequence we were able to make measurements, in the period extending from January 16 to 21, in all the areas selected from the Canadian aerial survey. This involved trips both to the town of Galle and beyond on the southern coast, and as far as Putalam, north of Colombo. In the south the surveys extended as far as east as Dikwella.

In general the aerial survey was found to be accurate. Most of it was made from an altitude of 500 feet, with the flight lines one-half mile apart. There was one section, where the aerial survey had indicated higher radiation levels, that had been surveyed from 300 feet at one-fourth-mile intervals. Several areas indicated from the air were not found on the ground. In several of these special cases a hill was found in the center of the area indicated by the aerial survey. Although this problem is not completely resolved it seems conceivable that the airplane in some way made an error in its measurements, owing to the presence of the hill, which may have been well hidden in the palm trees. A large majority of areas indicated by the airplane survey proved to be high-level areas when measured on the ground.

The extensive help of V. V. C. RANASINGHE of the Geological Survey and SIRI DANGALLE of the Department of Health, who personally accompanied us to most of the areas in Ceylon, should be mentioned. V. V. C. RANASINGHE brought along the Geological Survey's instruments for comparing purposes, while SIRI DANGALLE made local arrangements with public health officers.

At the request of the University of Ceylon at Peradeniya, we went to Peradeniya on January 23. Each of us gave a talk to the physics class. On the 24th we returned to Colombo, and wound up our affairs with a series of meetings with the Geological Survey and the Ministry of Public Health on the 25th and 26th. On the 25th we also visited the Colombo General Hospital where we inspected the local radiological department; we also visited the cancer hospital, under the direction of DR. FERNANDO (no relation to the Director of the Geological Survey). We found that both hospitals were relatively modern, especially the cancer hospital, which has been built and equipped as a joint Canadian-Ceylonese effort under the Colombo Plan.

On January 26 we flew overnight to Singapore. This ended the official-business part of our trip. I arrived in Berkeley in the early morning of February 11 after spending two weeks in transit.

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