

Preface

Cosmic Ray Work at Physical Research Laboratory (1947-1972)

R P Kane

Following write-up was prepared by Professor R. P. Kane in early or mid-1970s on a request by Professor S. P. Pandya to document the beginning of research in Physical Research Laboratory. It somehow remained untraceable for over four decades! By sheer coincidence, it was rediscovered only recently (2014) by Professor S.P. Pandya. Over the decades, the 14-page hand-written manuscript had all turned yellow and crumpled. Professor Kane vividly gives an insight into the evolution of PRL as an institution, especially in its formative years. At Professor Pandya's behest, Dr. V B Kamble transcribed the article into the computerised format remaining faithful to the original manuscript at the same time (except for a few editorial changes). Further, to retain the original flavour, he has refrained from introducing any updates.

The cosmic ray work at PRL at least in the initial stages, was very intimately linked to the personal lives of the few scientists then involved. In a sense, we and research evolved together. Hence it may not be inappropriate to put on record how I got into it, as it tells something about how things evolved. In what follows, only facts related to me are certainly true. Opinions and remarks about others and other things will be necessarily subjective; and hence possibility of errors or misinterpretations is not ruled out. For which, I offer apologies, well in advance! After passing M.Sc. (1st class!) in 1946 from Benares Hindu University, I spent almost two years doing nothing, applying for lecturer's job, but refusing to join when offered, in the hope that a research opportunity may arise somewhere! Meanwhile, the country got independence and hopes rose high; But nothing unusual happened! By 1948, I had almost given up. Father did not utter a word! But anxiety was writ large on his face! I decided to accept the lectureship at Meerut (salary Rs 200 fixed, in spite of in spite of the rampant dearness there was no D.A. in those days!). But, then an advertisement appeared in Hindustan Times about research in Cosmic Rays etc. In M.Sc. we were taught Nuclear Physics (and atom bomb!), but Cosmic Rays was a distant dream, obscure, wild! However, that is what caught my imagination, and I applied. In a week's time, I was asked to appear for interview at Sri Ram Place in Delhi! I did! I was the only candidate! And Vikram Sarabhai told me that this was just a beginning, and he would let me know! A week later, I received a telegram saying I was selected!

Ahmedabad! Where was it? My knowledge about Western India was pretty poor! I knew mainly Baroda (Vadodara), a Marathi State then! But my father knew that region from his young days! He said Ahmedabad was bigger than Baroda and had textile mills (Century?! No. Calico, Aravind?!) and also Mahatma Gandhi's Sabarmati Ashram. Sounded incongruous! But, there I was, on 01 July 1948 morning, at the old railway station! Found out that the two locations, Shahibaugh and Navarangapura (mentioned on an earlier letterhead from Vikram Sarabhai) were miles apart and miles away from the railway station! Anyway, public buses were available. So, I put my luggage in a nearby Dharmashala (yes, there was something like this in those days!), took bath and looked for the proper

bus. Since M. G. Science Institute sounded more like Science than Shahibaugh, I proceeded to Navarangapura!

What a shock! There was nothing there! A dilapidated old village! No sign of any intellectual activity! A half-starved creature was approaching. Looked like student! I asked about M. G. Science Institute. He did not know, but said there were some colleges almost a mile away! I walked and found the Commerce College, and then the Arts College; and by sheer persistence, an unkempt building which they said was M. G. Science Institute! Impossible! This must be an old stable or something! But, then the H_2S smell was unmistakable! So, there must be Chemistry, and therefore science! I ventured in, traversed many corridors, came out at the other end; and yet no trace of Physical Research Laboratory! But, it must be around, somewhere there! For some reason, which I do not remember now, everything was closed! So, I ventured in again! And in one, so to say, a side lane, on one exposed brick wall, near a big open door, there was a board saying PHYSICAL RESEARCH LABORATORY! For a while, I was overwhelmed! Is this where research could be done? A dilapidated hall! There was an impulse to retrace my footsteps and go back home! But, then what would father say? I swallowed and entered the door. Nothing, nobody in the corridor! On the left, a big hall and there a surprise of my life!

Amongst a big heap of some pamphlets, sat a shabby figure, naked but for a lungi! Could be a peon, I thought! But the eyeglasses looked expensive! Before I could open my mouth, the figure looked up and said, “Are you Kane?” I was amazed. I said, “Yes, but how did you know?” He said, “Oh, Vikrambhai told me you were coming. Anyway, my name is Chhatrapati Joshi. Come and help me in sorting this material!” I said, “Would be glad to do so. But, what are all these heaps?” Of course, there was a story behind it! When Vikrambhai was at Cambridge, Professor Fowler died (Who was he anyway? He was a well-known astrophysicist!). And his widow auctioned many things. Vikrambhai bought those reprints one penny each (12 pence = 1 schilling, and 20 shilling = a Pound Sterling), and brought them to Ahmedabad! And now, we were supposed to sort them out, subjectwise, to be bound later in volumes! What a beginning! For days together, there was only one activity! Chhatrapati Joshi, myself, P. D. Bhavsar, and U. D. Desai were all at it, at least to start with! In due course, others found good excuses to do “other” things! Joshi stuck to it intermittently, and I was “encouraged” to continue! I seemed to have a good grasp of a variety of topics involved! Frankly, some titles were absolutely strange to me! Nevertheless, in a few months, the sorting was over. Vikrambhai, whom I met on the first day afternoon, often gave me admiring looks and prowled into the reprints and commented, “Wasn’t this a wonderful purchase?” I did not say NO, but did not feel like saying yes either! Vikrambhai probably misinterpreted it as my shyness; but that misconception hardly lasted about a fortnight. Kane started speaking, soon after, and never stopped, ever! Chhatrapati Joshi was a kindly soul, extremely amiable and friendly. An M.Sc. in Electronics from Allahabad, he was picked up by Vikrambhai as an employee – I do not know when and how! For me, the day of arrival at Ahmedabad was $t=0$, the event! But

soon, I could gather through Joshi the pre-history (that is, “minus t” period!), which was something as follows. Vikrambhai studied at Cambridge, but wanted to conduct cosmic ray experiments in India. In summer, his family (rich, of course!) used to go to Kashmir and Vikrambhai used to take along his cosmic ray recording apparatus for measurements at Gulmurg (altitude 10,000 feet and up) of cosmic ray electron showers. This work was useful for his Ph.D. thesis. But, during these measurements, Vikrambhai noticed that the cosmic ray intensity changed with time of the day; and over weeks. The embryo of Cosmic Ray Time Variations was thus sown in his mind in mid-1940s. In the next few years, his efforts were concentrated in preparing Geiger counters for cosmic ray measurements, at the Indian Institute of Science, Bangalore (where he met Mrinalini), and later at the Meteorological office in Poona (where he met Dr K. R. Ramanathan?!). By that time, Joshi came into the picture and he told us vividly how the whole set up was submerged in water, when the basement was flooded during a spell of heavy rain in Poona (probably in 1946 or 1947). Soon after, they shifted to Ahmedabad - first in Shahibaugh (Vikrambhai’s parents’ place) and later in M. G. Science Institute. How Vikrambhai managed to get into M,G., I d not know! But I suspect that he talked to K. G. Naik (famous chemist, and principal, M. G., at that time) into it. K. G. Naik was an extremely blunt type and used to make fun of us (physicists) and me (principally me!) since I used to argue with him vehemently (defending quantum mechanics) during 1948-49. In retrospect, however, I could see that it was a futile effort. He did not really mean it; but enjoyed teasing us. And he succeeded -the young fools that we were!

In 1945 and 1949, the main activities were two-fold. Firstly, Vikrambhai wanted to build a cosmic ray telescope. The term sounds astronomical, but there was nothing similar. With Geiger counters located one above the other, an electronic arrangement was evolved which ensured that a pulse will be recorded only when a cosmic ray particle traversed all the counters. Thus if these counters were piled one above the other, only those particles arriving vertically (within a certain solid angle) could be recorded. This gave a directional choice for recording such events. Hence the name telescope! The solid angle could be made very narrow by larger separations between the counters. However, the intensity of natural cosmic rays (per cm² per sec) is rather small and is uncontrollable. Hence the only way to count larger numbers (for better statistics) was to increase the “area” of the telescope (i.e. aperture) by using more counters. Hence the main effort was to produce many GM counters (by filling ether and argon in cylindrical glass tubes, having a central wire as one electrode and a cylindrical copper sheet as another electrode), and also to build the required electronic circuits. Not being an electronics man, I could not contribute much to the electronic efforts. In the initial stages, Chhatrapati Joshi was in charge of the same. However, he left us soon, to join (out of all places) Police Wireless in Uttar Pradesh! So, the lot fell to P. D. Bhavsar and U. D. Desai. To poor me was allotted the miserable task of preparing the counters, a frustrating effort in view of the frequent breakages and vacuum failures! But, come to think of it, even for the royally miserable scholarship of Rs 50 per month (Yes Sir, Rs 50 increased to Rs 70 after two

months, but remained so for two years!), I found the work reasonably interesting. I (first) and Bh. V. Raman Murty were the only two students (regular) PRL had for almost two years! Bhavsar and Desai were voluntary workers, employed as demonstrators in M. G. Science Institute and Gujarat College, respectively, and working in PRL – for nothing! One would be tempted to say that Vikrambhai was lucky, but then remember, he himself was spending money, to sustain PRL at least initially. Later, Karmakshetra Education Foundation (KEF), Ahmedabad Education Society (AES), CSIR and AEC contributed; and later DAE and DOS stepped in and took over completely. Secondly, Vikrambhai had managed to get (from somewhere) a few nuclear emulsion plates exposed to cosmic rays at different altitudes. One had to count the various nuclear tracks under a microscope. This work was mainly conducted by B. A. Desai and V. L. Bhatt – again both voluntary workers in PRL and demonstrators in Gujarat College and M. G. Science Institute, respectively. Both finished their Master's theses, and soon after B. A. Desai left to join Income-Tax Department! V. L. Bhatt continued for many years to come!

By the end of 1940s, enough Geiger counters were ready to make a reasonably good telescope. I and U.D. Desai took it to Kodaikanal, a hill station in Tamil Nadu, and the first observations were recorded in 1951. Soon after, a similar telescope was operational at Ahmedabad too. The results did indicate a diurnal variation, of the order of ± 1 % during the course of the day, and changes of the order of 4-5 % during some special intervals. What we were recording were secondary cosmic rays. Primary cosmic rays (mostly protons) impinged on the top of the atmosphere, suffered collisions incessantly with air molecules and what was measured at ground level was about 80 % mu-mesons! Hence regular diurnal variations of atmospheric temperature and pressure were causing similar changes in cosmic ray intensity too. For q while we (students) felt that this was the whole story and the changes we noticed were really telling us information about meteorology at high altitudes! However, it was the genius of Vikrambhai (who could see far beyond his nose!) that realised that the atmospheric effect was not the complete answer. In fact, he could see that the cosmic ray changes, even after correcting for reasonable atmospheric effects, left a considerable residue, which could be attributed to only to variations in the primary cosmic ray intensity. If true, this would have reaching implications for cosmic ray astronomy, which history proved to be true! In retrospect, it all seems so obvious! But in the early 1950s, this was a daring thing to say! Whether Vikrambhai was the first in world to say so is difficult to say. Probably several other groups elsewhere in the world were coming to the same conclusion. Our work culminated in the following publications: 1) Daily variations of meson intensity and its possible solar origin, V. Sarabhai, U. D. Desai, R. P Kane Nature 171 (1953) 122 2) Meteorological and extra -terrestrial causes of the daily variations of cosmic ray intensity, V. Sarabhai, U. D. Desai, R. P Kane Proc. Ind Acad. Sc 37A (1953) 287 3) Interpretation of daily variation of meson intensity, Proceedings of the International Congress on Cosmic Radiation, Bagneres-de-Bigorree (?), France (?), July 1953 p. 33.

In particular, the report Vikrambhai presented to the international community (paper 3) spoke volumes for his courage and conviction as regards variations in the primary cosmic ray intensity. Naive little fools that we (students) were, for days to come we were cracking jokes at the name Bagneres-de-Bigorree, little realizing what an impact our professor had made on the international community. By 1952, I had finished my Ph.D. work based on the results at Kodaikanal. At about the same time, I could lay hands upon some cosmic ray data recorded in U.S.A., New Zealand and Greenland by the Carnegie Institute of Washington. I love numbers. Naturally, my eyes widened! During the next few months, I chewed these data thoroughly and showed it to Vikrambhai that the amplitude of the diurnal variation of cosmic ray meson intensity had a year-to-year variation, parallel to the 11-year sunspot cycle. Stations geographically wide apart showed similar results, leaving no doubt that these were changes of external origin and hence with astrophysical implications. Vikrambhai almost hit the roof! He must have had many exciting moments in his life, but this one was certainly one of the most unforgettable ones. He wanted to communicate it immediately to Physical Review. I was having a cold sweat, but soon his spirit lifted up mine too. In seven days the paper was ready, including diagrams made by myself. Out went the paper: (4) World-wide effects of continuous emission of cosmic rays from the Sun, V. Sarabhai & R. P. Kane, Physical Review 90 (1953) 204. With the usual oscillation between the referee and the authors, the paper took one year to get published! Meanwhile Vikrambhai had been to U.K., and spoke about these results to somebody! A similar paper by Elliott and his group appeared in Nature, probably a month earlier than ours! One had to see the disappointment on Vikrambhai's face to believe it. But, the international community was not unfair to him. To this day, our paper is still acknowledged as good as the first! However, it is good to remember that the conclusion was wrong! There is no continuous emission of high energy cosmic rays from the Sun! What we were observing was modulation of interstellar (galactic) cosmic rays by solar plasma! Soon followed another of our papers: (5) Effects at Godhaven (?) and lower latitudes of changes in energy and composition of solar cosmic rays, V. Sarabhai & R.P. Kane, Physical Review 91(1953)688. I am not trying to self-eulogise, but I am certain that these papers had a great impact on the relevant scientific community and increased tremendously the international prestige of Vikram Sarabhai and his group, and of course, his laboratory! Physical Research Laboratory was a name to reckon with and could not be scoffed at any more. In 1952, Professor Bhabha had visited PRL; and myself and Vikrambhai showed him our Kodaikanal results. The diurnal variation (24 hourly values) was very obvious to us, but Bhabha still would like to draw a horizontal line through those points! Such was the scepticism even in 1952. But by 1954, no more so, I think!

By 1953 autumn, I left for Chicago (U.S.A.), on a Fulbright-Smith Mundt scholarship. Back home, U.D. Desai had finished M.Sc. (by papers) and was preparing his Ph.D. thesis. Bhavsar had finished his M.Sc. thesis. So had B. A. Desai and V. L. Bhatt. The scientific programme was also getting modified. Besides vertical meson telescopes, plans were ready for inclined

(meson) telescopes. Meanwhile a new development had occurred. Professor J. A. Simpson of the Enrico Fermi Institute of the University of Chicago had developed a neutron pile. Here, neutrons were moderated and captured in paraffin and lead blocks to produce more neutrons; and thus, secondary neutrons could be counted with BF₃ counters. Thus, instead of the secondary mesons counted by the above mentioned conventional cosmic ray telescopes, one could now count the secondary neutrons! The disadvantage with so called Neutron Monitors was that they could not be used as directional telescopes. All that one could say was that they counted effects of primaries arriving from above! In contrast, meson telescopes axes could be pointed to any chosen direction and would count particles arriving only within a few degrees of that direction. The advantages of Neutron Monitors were that they could be made really big without much effort. So, the counting rates were large, giving adequate statistics in shorter intervals. The atmospheric effects, though large, were more reliably known and hence could be more reliably corrected. But, most important, the variations for secondary neutrons were naturally larger, by more than a factor of 2. For example, during geomagnetic storms, the cosmic ray intensity shows sudden depressions, known as the Forbush decreases, in honour of Dr. Forbush who organised the operation and studied the variations for the Carnegie Institution instruments, referred to earlier. For those instruments, the magnitude of Forbush decreases rarely exceeded 5%. For similar storms, a neutron monitor would show decreases of about 10-15 % (in high latitudes). Incidentally, even though Dr. Forbush studied many aspects of the variations of cosmic ray intensity, as measured by the Carnegie Institution instruments, he did not study the year-to-year variations of the amplitudes of the diurnal variations! Myself and Vikrambhai did and produced that well known paper (4). After getting his Ph.D., Dr. U.D. Desai went to work with Dr. Forbush. Dr. Desai once said that Dr. Forbush did feel sour about it but put up a gallant face!

When I went to Professor Simpson at Chicago, neutron monitors were already accepted as very useful instruments. Professor Simpson himself was operating three, at Climax, Chicago and Sae Peak. I used these data and showed another aspect of the diurnal variation. The amplitude of the daily variation had a 27-day recurrence tendency! Professor Simpson was pleasantly surprised, because somebody in his group had looked for such an effect and reported it to be absent. Well, that gave me my third and last paper in Physical Review, viz. (6) Recurrence phenomenon in the 24-hour variation of cosmic ray intensity, R. P. Kane, Physical Review 98(1955) 130.

In 1954, I returned from U.S.A. Incidentally, by this time, PRL had shifted from M. G. Science Institute to its present building (the first one, three storied). I told Vikrambhai about this paper. He did not seem to be very happy to hear about it. Did he feel sad that I did not discover this too, with him? If so, what a pity! I would have loved too. He meant so much to me!

Soon after, Professor Nehar came to PRL as a visiting scientist. An expert in preparing neutron counters, he initiated this activity in PRL and soon neutron monitors were operative at Kodaikanal and Ahmedabad. Later, D.

Venkatesan and Satya Prakash joined PRL. Sastry, who had joined long ago as a Technical Assistant, did his M.Sc. by papers and was now doing his Ph.D. Come IGY (1957-58) and PRL was ready to participate with meson telescopes and neutron monitors at Kodaikanal and Ahmedabad. Since equatorial and low latitude stations were very few, this Indian contribution to the IGY cosmic ray effort was considered substantial and highly valued in international scientific circles. PRL achieved a permanent position on the scientific world map and Vikram Sarabhai became an international name.

In succeeding years, people came and people went; but the international reputation of PRL cosmic ray effort was not only maintained, but significantly enhanced. Dr U. D. Desai left for Washington and later joined NASA. Dr Bhavsar went to Minnesota, Dr Venkatesan to Sweden, Dr. Satya Prakash to California, and Dr. Sastry to..... (?). Meanwhile, Duggal had joined and meson telescopes, both vertical and inclined, were installed at Trivandrum (Thiruvananthapuram).

With the arrival of Dr. Bibha Chowdhury from TIFR, Bombay (Mumbai), a new chapter was opened with installation of extensive air shower experiments at Kodaikanal. Razdan, U.R.Rao, Nerurkar, all started their careers at PRL, and so did E. V. Chitnis. These were the years when PRL was recognized as an important centre for permanent operation of meson telescopes and neutron monitors – not only at Ahmedabad, Kodaikanal and Trivandrum, but also far beyond Indian shores, when Dr. Nerurkar operated telescopes at La Paz, Bolivia! Ahluwalia and Dhanju later participated in this international project supported by the UN. Many of our people who went abroad, made important contributions during their stay there; and many on return contributed significantly to the continuing activity at PRL, added new dimensions like X-ray and Gamma ray measurements with balloons and later with rockets and satellites. Space probes yielded very useful information about the electromagnetic state of the interplanetary space and the diurnal variations of cosmic ray intensity - by now a very well established fact - found ready explanations in the magnetic configuration of interplanetary plasma. PRL contributed significantly not only by providing crucial experimental details, but also through theoretical interpretations, e.g. that of the second harmonic by Subramanian and Sarabhai (Astrophysical Journal paper). An experimental set up was installed in Kolar Gold Mines for study of cosmic ray showers, and operated by Drs. Bibha Chowdhury and Y.C. Saxena.

The basic training received by several scientists at PRL came handy when Vikrambhai initiated the space programme. Drs Bhavsar, U. R. Rao, and E. V. Chitnis are the prominent contributors of PRL to the space programme of India. Dr. Sastry and Dr. Satya Prakash also had important participation, but their base still in PRL. It must be remembered that cosmic ray research in PRL did not evolve alone. In 1948, Dr. Ramanathan retired from India Meteorological Department, and was persuaded by Vikrambhai to join PRL. The two directed PRL alternately, and the influence of each on the other was considerable. Aeronomy research initiated by Dr. Ramanathan had a considerable import on cosmic ray

research. So had the theoretical work of Dr. Bhatia, Dr. Vachaspati, and still more the work of Dr. S. P. Pandya, and several others in Nuclear Physics, as also Dr. Bhonsle and others in Radioastronomy. All the impacts were probably mutual. Amongst the earlier workers, the ones who are still continuing in cosmic rays or allied topics are Dr. U. D. Desai at NASA, and Dr. Venkatesan at Calgary (Canada). Dr. Duggal died prematurely while he was still at Bartol Research Foundation. Chitnis and U.R. Rao are still contributing to India's space programme, and Dr. Razdan is continuing at Srinagar (?). Dr. Bhavsar, Dr. Sastry, Dr. Satya Prakash, and myself switched over to Aeronomy. Dr. Nerurkar has gone over to the Electronics Commission (?). Dr. Bibha Chowdhury retired. Dr. Subramanian continues in PRL (?)

