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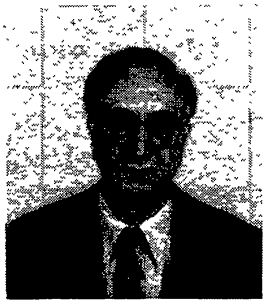
Silver Jubilee Article

Gamma-ray astronomy activities in BARC — An introductory note



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The present high energy gamma-ray astronomy programme in the Bhabha Atomic Research Centre originated at the Physical Research Laboratory (PRL), Ahmedabad around 1970, where, earlier, a major research programme in cosmic-ray time variations was being pursued under the leadership of Prof. Vikram Sarabhai. The various problems in cosmic-ray time-variations were fairly well understood by then in terms of solar modulation effects and further detailed understanding could be achieved only through the use of satellite-borne detectors. The cosmic-ray scientists at PRL, therefore, felt the need to look for new areas of research which they could pursue meaningfully in India, utilizing the indigenous facilities. To name a few, Prof. U.R.Rao and Prof. E.V. Chitnis moved on to X-ray astronomy using balloon and rocket-borne detectors, while Prof. P.D. Bhavsar and Prof. Satya Prakash pursued research in upper atmospheric and ionospheric physics, using the rocket facility at Thumba.

While I was also considering various options at that stage, Prof. B. V. Sreekantan, TIFR, suggested to me a modest ground-based experiment to detect the predicted gamma-ray burst in supernovae explosions by the atmospheric fluorescence technique. The initial experiments conducted at Cornell University and the NASA-GSFC, were encouraging and so, with support from PRL, I proceeded to set up a wide-angle photomultiplier system at the High Altitude Research Laboratory, Gulmarg, to detect these fluorescence events. Soon enough, Dr. C.L. Bhat, then a fresh graduate from the Kashmir University, joined this research programme and pursued the study with his characteristic enthusiasm and perseverance. The initial years were most trying for us, as we were essentially groping in the dark. The detection of supernova explosions was a far cry for, on closer examination, we had realized that the experiment had only a modest sensitivity and could, at best, detect supernova explosions from nearby galaxies. Besides, a network of stations was required to positively identify a supernova burst through a coincident detection of the characteristic fluorescence pulse. But this simple experiment triggered our thinking in a variety of other ways. Firstly, we soon realized that, with only minor modifications, the photomultiplier system could detect the atmospheric Cerenkov pulses generated by cosmic-ray

proton showers of energy greater than 10^{14} *eV*. We proceeded to record these, continuously, at the rate of about 1 per minute. Using these data, we were able to reveal the "knee" in the cosmic-ray energy spectrum around 10^{15} *eV* - a result which had been already inferred from the conventional cosmic-ray charged particle detection arrays.

Using the same Cerenkov events, we searched for cosmic gamma-ray signals in these data, which culminated in the detection of a gamma-ray signal of 4.8 hour periodicity from the X-ray binary system, Cygnus X-3. By then, a number of research groups, throughout the world, had become enthusiastic about the detection of high energy cosmic gamma-rays by the atmospheric Cerenkov technique as well as by charged particle arrays. We were equally keen to have a source-tracking system using large parabolic mirrors. We traced eight of these mirrors, each of 90cm-diameter, in Mumbai junk market with the help of Dr. Arvind Bhatnagar, the then Director of the Nehru Planetarium, Mumbai and purchased them at a total price of about Rs. 20,000. Prof. B.V. Sreekantan and Prof. S. Tonwar, TIFR, helped us in identifying a private company, M/s Shanti Gears, in Coimbatore, which fabricated the equatorial mounts for our mirrors for about Rs. 30,000.

The telescope with six steerable mirrors and the complete logic system (initially without a PC, as PC's were not in vogue then) to track potential sources, was completed by 1985, for which I particularly remember the excellent job done by our electronics engineer, Shri Ramesh Koul. The whole telescope did not cost us more than Rs. 2.5 lakhs. Dr. P.K. Iyengar, the then Director, Physics Group and later, Director, BARC, was always supportive of such activities, especially if it involved indigenous fabrication of equipment.

By this time, a number of other scientists joined our gamma-ray astronomy programme and we tracked a number of potential sources with this modest telescope over the next five years. Some of the results are described in the main article. I, particularly, remember that, while analyzing the data on Her X-1 and Cas γ-1 sources, we did not come up with any gamma-ray signal for several months till one of our colleagues visited the TIFR and came back with the information that we were not applying the source barycentric correction, which was a must for any periodic analysis of binary data. The application of this correction immediately brought out highly significant transient signals from these sources. This instance illustrated the scientific isolation we had all along felt at Gulmarg because of limited library facilities and limited contacts with other scientists. Prof. B.V. Sreekantan and Prof. S.C. Tonwar were particularly helpful to us in bridging this gap.

High energy gamma-ray astronomy, being in an exploratory stage, the experimental techniques were being constantly revised by the scientific community and we were not far behind in this endeavor. The more sensitive systems required larger mirrors to which we had no access in India. Around 1989, we worked out a cooperative agreement with the P.N.Lebedev Physical Institute, Moscow, whereby they would supply us smaller mirrors of 60 cm- diameter for composing larger mirrors of 3 meter diameter. In return, we were to supply them with a PC-based drive-system for steering their own telescope in different observational modes. We had also started realizing the limitations of Gulmarg as a field observatory for bigger and more sophisticated systems, both because of the topography and the harsh weather conditions, and were considering setting up a

bigger system in Ladakh where the DST had set up some limited facilities for scientific observations. However, the beginning of terrorism in Kashmir around 1989-90, brought our activity to an abrupt end and it was sometime before we could stabilize our activities once again. Here, the timely support received from BARC was quite helpful. In particular, BARC workshop needs to be specially commended for fabricating the 3 meter diameter telescope system in the shortest possible time. This has now resulted in the completion of the first phase of two high energy gamma-ray detection systems at Mt. Abu, TACTIC & MYSTIQUE, under the leadership of Dr. C.L.Bhat. These instruments are more versatile and have significantly higher detection sensitivities. The MYSTIQUE system is an extension of the wide-angle photomultiplier system with which we had started at Gulmarg, but is more sophisticated and has the capability of identifying the arrival direction of the incident high energy primaries.

In retrospect, I realize that our research activity at NRL-HARL, not only in the area of gamma-ray astronomy but in other areas too, made us acutely aware of the need for generating technically-trained manpower and we all along devoted considerable effort towards that goal. The result is that these scientists, who were earlier forced to bring to an end their research activities at NRL-HARL, are now making important contributions not only in the area of gamma-ray astronomy but in other research programmes too at BARC and also at Centre for Advanced Technology, Indore, where a number of them have settled in the recent past.

Before I close this personal note, I would like to take this opportunity to thank Prof. Vinod Krishan for inviting me to write an article for the Silver Jubilee issue of the Bulletin of the Astronomical Society of India. I chose to write it, on the past and current gamma-ray activities in the BARC, together with Dr. C.L. Bhat, who has been, throughout, involved with me in these activities.