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Nuclear India

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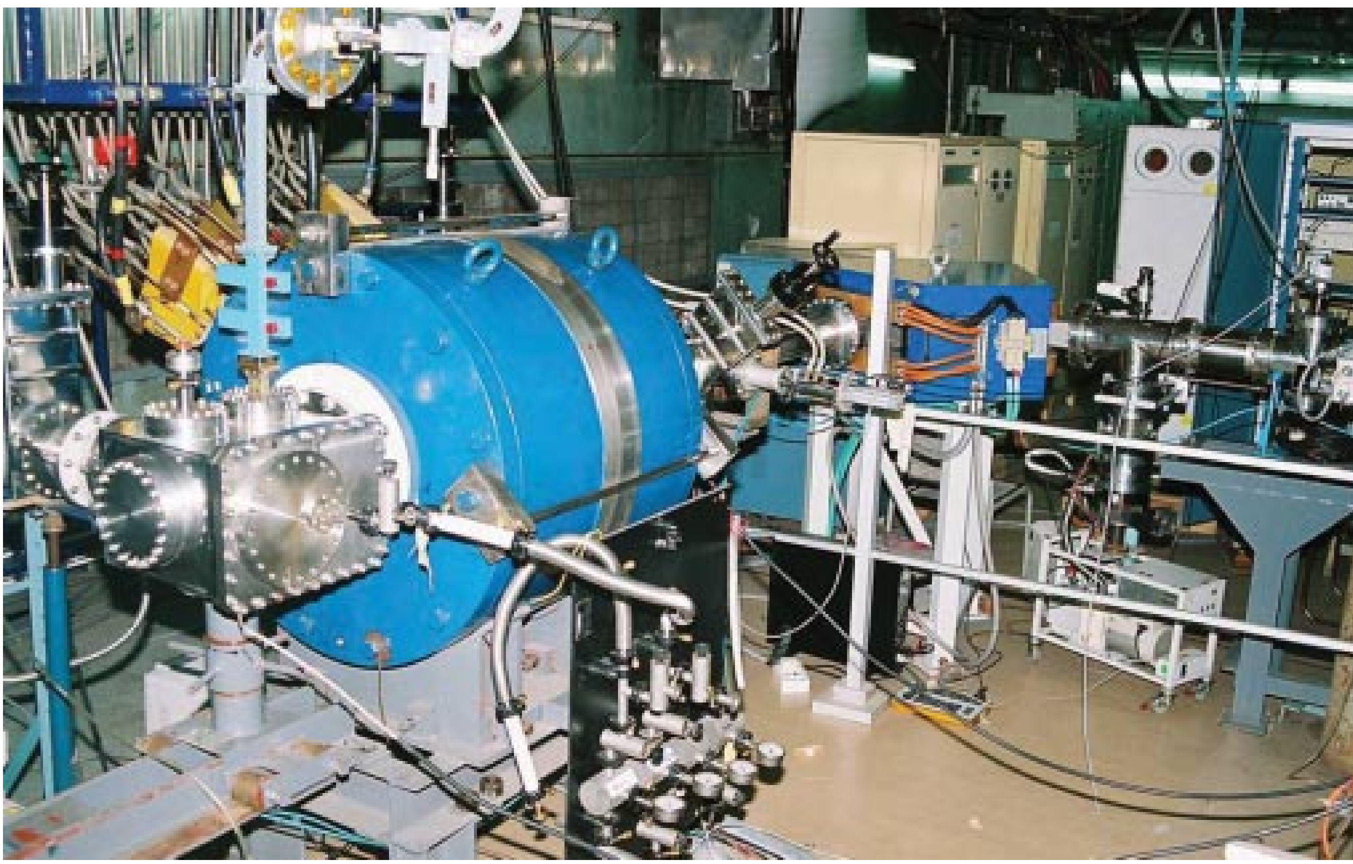
Radioactive Ion Beam Facility at the Variable Energy Cyclotron Centre, Kolkata



Geared to address the basic questions regarding the nature of nuclear interaction, the origin of elements in the universe and the structure and properties of nuclei, the physics of Radioactive Ion Beams (RIB) is the emerging frontier in nuclear physics and allied sciences. Technologically, the development of a RIB facility is extremely challenging and so is the development of special detectors/ experimental facilities for the use of the beams.

DAE's Variable Energy Cyclotron Centre in Kolkata had undertaken in the year 1998, a project to develop an ISOL type Radioactive Ion Beam facility. Notable progress has been made that includes commissioning of sophisticated low beta radiofrequency quadrupole accelerator (RFQ). An online ECR (electron-cyclotron-resonance) source has been a major achievement of this project. In the RFQ, radioactive ion beams will be accelerated to about 86 keV/u.

The advantage of using RIB is twofold. First is the huge increase in the number of available beams. The expected number of RIB would be around 2000 as compared to about 200 at present. Second is the substantial improvement in the signal to background ratio vis-a-vis the production of exotic nuclei.

APSARA completes 50 years

Bhabha Atomic Research Centre (BARC) celebrated the Golden Jubilee of its research reactor APSARA, the first nuclear research reactor in the whole of Asia. On August 4, 1956, at 1545 hours, APSARA had attained criticality. This was a historic event marking the beginning of nuclear era in India. The programme depicted the major contributions this reactor has made in the country's nuclear programme and the future plans for the reactor, that has served as the cradle for the development of nuclear reactor technology in the country

The design of APSARA, a pool type reactor, using enriched uranium fuel was conceptualized in 1955 by Dr.Homi Jehangir Bhabha, the architect of the Indian nuclear programme. This event marked the beginning of the success story of Indian Nuclear Programme.

Later, on January 20, 1957, the reactor was dedicated to the nation and named as 'APSARA' by Pandit Jawaharlal Nehru.

Over the years, the reactor has immensely contributed towards development of nuclear power programme, research in the frontier areas of basic sciences and fulfillment of societal needs.

The production of radioisotopes in the country had commenced with the commissioning of APSARA. The experience gained in irradiation, handling and processing of isotopes produced at this reactor played a vital role in the development of current infrastructure for production and application of radioisotopes. The radioisotopes are finding ever increasing use in the field of medicine for diagnosis and therapy and in industry for radiography, in addition to many other applications such as sterilization of medical products, food preservation, pipeline inspection etc. Radiation processing of a large number of biological samples at APSARA and systematic studies on different crop plants has enabled scientists to study growth simulation, post-irradiation storage effects, role of induced radioactivity, combined effects of chemical mutagens and neutron irradiation leading to the development of several high yielding, disease resistant crop varieties.

The experiments related to neutron induced fission, diffusion kinetics of fission product gases, reactivity measurements, neutron radiography for characterization of nuclear fuel and structural materials, two phase flow visualization, neutron detector development and radiation shielding have yielded important design inputs for the present generation of pressurised heavy water reactors, prototype fast breeder reactor and advanced heavy water reactor.

Specifications

Reactor Type	Swimming pool type
Reactor Power (Th)	1 MW
Fuel Material	Enriched Uranium - Aluminium alloy
Fuel Cladding	Aluminium alloy
Weight of Fuel	4.5 kg
Core Size	560x560x615 mm
Max Neutron Flux	10^{13} n/cm^2/sec
Moderator	Light water
Coolant	Light water
Shut off Rods	Cadmium

In addition to the above technological developments, a vast number of studies have also been performed in the area of basic sciences such as neutron scattering, neutron and gamma-ray emission studies and neutron activation analysis for characterization of materials and for forensic investigations.

Now, BARC plans to upgrade the reactor from its present power level of 1000 kW to 2000 kW. The upgraded reactor will use low enriched uranium as fuel, in line with the current international practices. After the upgradation, APSARA reactor is expected to serve our programme for many more years.

On the occasion of the Golden Jubilee celebrations, Shri S.K.Sharma, Chairman, AERB released a commemorative brochure on APSARA. The Chief Executives of some of the units of DAE delineated the linkage between the research carried out in BARC and the industrial activities being pursued by their units. Shri S.K.Jain, CMD, Nuclear Power Corporation of India Ltd (NPCIL) described the R&D support of BARC to the nuclear power programme, Shri S.C.Hiremath, Chief Executive, Heavy Water Board (HWB) elaborated upon technology transfer, Shri R. Gupta, CMD, Uranium Corporation of India Ltd. (UCIL) outlined the indigenous efforts of mining and mineral processing of uranium ores and Shri R.N. Jayaraj, Chief Executive, Nuclear Fuel Complex (NFC) highlighted the linkages of fuel development programme with the research in BARC. The event was graced by several senior scientists who were intimately connected with the design, development, commissioning and subsequent operation and utilization of APSARA.

“ We believe that future enhancement of the share of nuclear energy as a clean energy source is possible and feasible in a manner that satisfies the imperatives of nuclear safety and security. Let us therefore resolve that we would pool our scientific and technological abilities together in finding holistic solutions so that the next 50 years are seen as the golden period of nuclear energy development in meeting global energy needs. ...”

Mr. President,

Kindly accept our congratulations on behalf of my Government and on my own behalf on your election as the President of the 50th General Conference. I am sure, under your able leadership and with the support of your team and the Secretariat of the Agency, this General Conference will be able to accomplish the tasks before it.

I take this opportunity to welcome the entry of the Republic of Palau, the Republic of Mozambique, the Republic of Malawi and the Republic of Montenegro to the Membership of IAEA.

Let me also use this occasion to once again congratulate Director-General Dr.Mohamed ElBaradei and the Agency for the well deserved Nobel Peace Prize.

Mr. President,

I would like to begin with a message from our Prime Minister Dr. Manmohan Singh to this fiftieth session of the General Conference of the Agency and I Quote:

Quote

“I am happy to convey my greetings to Members of the International Atomic Energy Agency, its Director-General, and members of IAEA Secretariat on the occasion of this 50th General Conference. Over the past five decades, the Agency has made commendable progress in fulfilling its objectives as laid down in its Statute. The Nobel Peace Prize awarded to Dr. ElBaradei and the Agency last year is a timely and well deserved tribute to the IAEA’s contribution.

The International Atomic Energy Agency is an unique organization in the entire UN system, founded on a strong science base and dedicated to spreading understanding of and knowledge about the benefits of immense energy potential and readily available and deployable technologies has become an inevitable and indispensable part of the solution.

Nuclear energy being unique in its ability to regenerate more fuel from uranium and thorium several ten-folds while producing energy, offers us the possibility of meeting global energy requirements in a non-polluting and sustainable manner. However, if we are to be successful in realizing the potential of the atom in meeting our

atomic energy in a safe and secure manner, with special attention to those areas of the world where developmental needs and aspirations are yet to be fulfilled and are therefore most pressing. With issues related to energy resource sustainability assuming increasing salience and global climate change looming large as arguably the most serious challenge of our time, atomic energy with its needs, we need to act in concert consistent with the spirit of global harmony and adhering to our respective international commitments. The IAEA and Director-General deserve high compliments for ensuring that the Agency is an effective platform for the global community to work together in its noble mission of ‘atoms for peace and prosperity’. India, home to one-sixth

International Atomic Energy Agency, 50th General Conference, Vienna, 20th September 2006, Statement by Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Leader of the Indian Delegation of the world population and having embarked on a rapid economic growth path, has a strong interest in utilizing the full potential of atomic energy for national development. I am confident this will be realized, based on our natural endowment of vast thorium resources and the development of effective technologies for their utilization.

We have developed advanced technological capability based on our own self-reliant efforts, while having maintained an unblemished record of responsible behaviour. I am glad that the emerging possibility for expanding civil nuclear cooperation between India and the international community would supplement and complement our domestic efforts to meet the developmental aspirations of our people through additional nuclear energy inputs. We look forward to cooperating with international partners in realizing this possibility.

While nuclear power is of crucial importance for sustainable development, of equal significance are other peaceful applications of atomic energy. The Agency's Programme of Action for Cancer Therapy (PACT) is one such important effort which I am happy to learn is being given special emphasis. India having developed significant experience in affordable cancer-related programmes has been supporting this activity actively, and would be pleased to offer a recently developed Cobalt-60 teletherapy machine (Bhabhatron) as a contribution to the Agency's PACT.

It is my hope that the fiftieth session of the General Conference would be an important milestone in the ongoing and future work of the Agency. I wish you all productive deliberations and progress in your important tasks. My greetings and good wishes to all."

Unquote

Mr. President,

The Agency and the Department of Atomic Energy, India, have traced history together. This year is also the 50^{th} year of the Bhabha Atomic Research Centre, (BARC), the premier nuclear research centre in India. Dr. Homi Bhabha, the founder of the Indian Atomic Energy Programme, was the President of the first Geneva Conference on 'Peaceful uses of Atomic Energy' held during August 1955.

Mr. President,

The activities in atomic energy in India continue to make progress in accordance with the well established three stage nuclear power programme. Units 3 and 4 of the Tarapur Atomic Power Station, which are the 540 MWe indigenously designed and built Pressurised Heavy Water Reactor (PHWR) systems, are now in commercial operation. One more 220 MWe PHWR unit at Kaiga would also become operational before the end of this financial year. The Government of India has recently approved pre-project activities on eight reactor units at four different sites with a total power generation capacity of 6800 MWe. With the completion of these Units alongwith other Units that are already under construction, the total nuclear power generation capacity in India would reach around 14000 MWe.

We now have sixteen reactor units with a total capacity of 3900 MWe in operation. Unit-I of Kakrapar Atomic Power Station had a record continuous operation of 372 days before it was shut down for mandatory inspection. The average duration of outage of biennial shutdown has now been reduced to just 26 days.

Major upgrades for ageing management and safety were completed on three PHWR units. The safety upgrades at the two Boiling Water Reactors that started commercial operations in 1969, were completed in just four and a half months. The replacement of all reactor feeders of one of our PHWRs was accomplished for the first time in the world. One of our latest 540 MWe PHWRs was offered for pre-start-up peer review by an expert team of WANO. This was the first ever review of its kind in Asia. We are now ready for implementation of the newly designed 700 MWe PHWR units which would enable further significant reduction in the capital cost per MWe of indigenous PHWR units.

India considers a closed nuclear fuel cycle of crucial importance for implementation of its three stage nuclear power programme with its long-term objective of tapping vast energy available in Indian thorium resources, based on development of effective technologies for their utilisation. This is central to India's vision of energy security and the Government is committed to its full realisation through development and deployment of technologies pertaining to all aspects of a closed nuclear fuel cycle.

As a part of our development efforts in high level radioactive waste management technologies, India achieved two major landmarks this year namely (i) hot commissioning of Advanced Vitrification System (AVS) which employs Joule-heated ceramic melter and (ii) demonstration of Cold Crucible Vitrification Technology.

The Fast Breeder Test Reactor (FBTR) at Kalpakkam, which has been the foundation of our fast reactor programme, has shown excellent performance with an availability factor of over 90% in the last few campaigns. The unique U-Pu mixed carbide fuel used in FBTR has reached a record burn-up of 154.3 GWd/t without a single fuel pin failure. This achievement has been possible through a combination of stringent fuel specifications, quality control during fabrication and inputs obtained from the detailed post irradiation examination of fuel at different stages combined with the modeling of the behaviour of the fuel clad and wrapper materials. This year, we have proposed to introduce mixed oxide fuel with 45% Pu in FBTR in order to increase the power level as well as to provide experience on the behaviour of high Pu content oxide fuel in fast reactors. Last year I had informed that the carbide fuel discharged from FBTR at a burn up of up to 100 GWd/t had been successfully reprocessed. This experience in the reprocessing campaigns have provided significant inputs to the design of the equipment and flow sheet for the Demonstration Fast Reactor Fuel Reprocessing Plant [DFRP], which is in an advanced stage of construction.

The construction of 500 MWe Prototype Fast Breeder Reactor (PFBR) is on schedule and is expected to be commissioned by the year 2010. In keeping with our philosophy of efficient utilization of a fuel material by closing the fuel cycle, we have embarked on the design and construction of a fuel cycle facility to cater to the PFBR. The facility will be commissioned by 2012.

Simultaneous with the construction of the PFBR we have already initiated programmes towards the conceptualization of the FBRs to follow, with the objective of further enhancing the fuel performance as well as making the energy production more economical. To ensure rapid growth in the fast reactor programme for meeting the energy needs in the country, we have already embarked on R&D programmes targeting towards the introduction of metallic fuel in fast reactors, which would provide much higher breeding. A host of R&D programmes in associated areas such as advanced materials, structural mechanics, heat transport, in-service inspection systems, physics, chemistry, safety, etc., are being pursued to provide R&D inputs for further advancement of FBR technology. This comprehensive and indigenous programme in all major areas provides a strong foundation for India's fast reactor programme. India is also prepared to contribute to international efforts in scaling new technological frontiers in this field as an equal partner with other countries having advanced technological capabilities.

Thorium utilization is the long-term core objective of the Indian nuclear programme for providing energy independence on a sustainable basis. The third stage of the programme is thus based onThorium-Uranium-233 cycle. We are actively engaged in developing 300 MWe Advanced Heavy Water Reactor (AHWR). The design of this reactor incorporates several advanced features to meet the objectives being set out for future advanced nuclear reactor systems. A critical facility to validate physics design of AHWR will be functional this year. The facility is flexible enough to study the physics of advanced systems, including source driven systems, in future. Development of high current proton accelerator and spallation source for Accelerator Driven Sub-Critical Systems (ADS) is also being pursued. Such systems would offer the promise of shorter doubling time, even with Thorium, and incineration of long lived actinides and fission products, thus leading to the possibility of eliminating long-lived radioactive waste. A Compact High Temperature Reactor (CHTR), with 100 kW thermal power rating, is being developed as a demonstrator of technologies relevant for next generation high temperature reactor systems. Such reactor systems will address the needs such as electricity generation in remote places, production of alternative transportation fuel such as hydrogen, and refinement of low–grade coal and oil deposits to recover fossil fluid fuel.

India has had a fusion research programme of its own since the early eighties. Two tokamaks have been indigenously built. The Steady State Super conducting Tokamak-SST-1 is currently undergoing commissioning tests. India has recently joined ITER as one of seven full partners. On the basis of indigenous experience and expertise available in Indian industry, India will contribute equipment to ITER and will participate in its subsequent operation and experiments. Indian scientists are also working on establishing an India-based Nutrino observatory for doing comprehensive research in Neutrino Physics, an area in which Indian research groups have sustained interest and have made significant contributions. We would welcome participation of interested international scientific groups in this effort. The 2.5 GeV synchrotron radiation source Indus-2 being set up at Raja Ramanna Centre for Advanced Technology, Indore, has started functioning. The utilization of the storage ring for condensed matter studies using the synchrotron radiation from the bending magnet beam lines has also begun.

The excellent safety record of Indian reactors and other facilities has been achieved through sustained Research and Development programmes. As part of the safety studies on nuclear containment structures, the construction of a 1:4 size containment test model has been initiated at Tarapur. The ultimate load capacity of the containment would be studied on this test model and the experimental results would be available to the participants of a round robin exercise, which is being organized by us. We would welcome participation of interested research groups in this exercise.

As in the previous years, we have been interacting with the IAEA very closely in almost all its activities. We have been an active participant in the

IAEA – INPRO programme. We were one of the six countries to perform a national case study for development of INPRO methodology under INPRO phase-1B part-1 activity which was done using the Indian Advanced Heavy Water Reactor. We are also involved in joint case studies on fast reactor with closed fuel cycle and high temperature reactors for hydrogen generation. We have also contributed to chapters of the INPRO document on guidance and methodology for assessment of economics, safety and waste management. We strongly support international cooperation through cooperative research and joint initiatives, as envisaged under INPRO phase-2. India remains supportive of the IAEA fulfilling its statute responsibilities, particularly the developmental and international co-operative dimensions of nuclear energy.

The Indian programme on the application of radioisotope and radiation in health, agriculture, industry, hydrology, water management and environment for societal benefit has a close match with several activities of the Agency. Our experts thus take active part in all Agency activities. As a founder member, we participate actively in RCA activities. Last year, we had hosted six events in India. We have also hosted 34 IAEA Fellows and Scientific visitors. I am glad to inform this gathering that the International Union Against Cancer (UICC) selected the Tata Memorial Centre in Mumbai for the "Outstanding UICC Member organization" award for its outreach programmes related to cancer control. PACT programme drawn up by the Secretariat deserves our fullest and speedy support.

Mr. President,

A special event on "New Framework for Utilisation of Nuclear Energy in the 21st Century: Assurances of Supply and Non-Proliferation" is currently in progress as a part of this General Conference. Out of the current fleet of 443 nuclear power reactors operating in the world, less than half are under IAEA safeguards. Even in this scenario and with a very slow growth of nuclear power in the last two decades, the volume of human and financial resources needed for implementation of IAEA safeguards have constituted a large fraction of the resources available to the Agency. Now with anticipated rapid growth in demand for nuclear power, mainly in the developing countries, cost effective safeguards are essential so that the safeguard system does not itself become an hindrance to the development of nuclear power while at the same time providing the necessary assurances in terms of verification. India therefore feels it is necessary to look for institutional as well as technological solutions with enhanced proliferation resistance along with an assured fuel supply, without adversely affecting long-term sustainability of nuclear fuel resources. Thorium offers a very important and attractive solution from this perspective and we urge the Agency and its members to give serious consideration of the possibilities offered by the Thorium route.

Over the years India has developed advanced capabilities in the utilization of thorium, as a part of its strategy to enhance nuclear capacity through a closed nuclear fuel cycle that would enable timely deployment of its thorium reserves. We are convinced that this is a viable and sustainable strategy for India's and global long term energy security. Seen in the context of nuclear power becoming a significant fraction of energy supply in a world where everyone is assured of a minimum of 5000 KWh of energy in a year, entire global Uranium if used in once through mode would last only a few tens of years. Even with a shorter term perspective of deployment of a proliferation resistant nuclear energy system that could address the need for incineration of available surplus plutonium, the use of thorium, in reactors using proven technologies, presents a vastly superior option as compared to other options based on fast reactors. In my presentation at the special event tomorrow I would elaborate on this aspect further. I will urge the IAEA to give a further boost to its activities that could lead to an early expansion of global reach and volume of deployment of nuclear energy, using thorium based fuel cycle as one of the important routes to reach the goal.

We have been constantly reminding the Agency of the need to maintain a balance between its promotional and safeguards related activities. The risk arising out of global climate change and rapid depletion of global fossil fuels is real and substantial. We believe that future enhancement of the share of nuclear energy as a clean energy source is possible and feasible in a manner that satisfies the imperatives of nuclear safety and security. Let us therefore resolve that we would pool our scientific and technological abilities together in finding holistic solutions so that the next 50 years are seen as the golden period of nuclear energy development in meeting global energy needs. As a responsible state with advanced nuclear technological capabilities, India is prepared to play its part in this glorious endeavour.

Thank you Mr. President.

Nuclear Agriculture

Indian agriculture in the past has witnessed dramatic events such as green revolution which changed the nation's status from a food importing nation to a self sufficient nation. The national agricultural policy now focuses on sustained production and nutritional security for the one billion plus population. The Department of Atomic Energy with its programme on use of nuclear technologies for agriculture has been an important partner in boosting productivity in some select crops. The nuclear technologies have benefited the farmers, traders and end-users.

Bhabha Atomic Research Centre (BARC) has a broad-based research programme in nuclear agriculture involving genetic improvement of crops using mutation and conventional breeding, biotechnological approaches, isotope-aided studies on soils, fertilizer uptake and pesticide residues analysis and integrated pest management including the use of sterile insect technique, pheromones, bio-pesticides and radiation processing of food items.

Genetic improvement of crop plants is a continuous endeavour. Radiation induced genetic variability in crop plants is a valuable resource from which plant breeder can select and combine different desired characteristics to produce better crop plants. The desirable traits which have been bred through induced mutations include higher yield, grain quality, early maturity, disease and pest resistance, improved plant type and abiotic stress resistance. Induced mutants are directly used if they perform well in the field or they are employed in the cross breeding programme. Mutants or selections initially developed at BARC are advanced in collaboration with Indian Council of Agricultural Research or State Agricultural Universities. These have been found to cater to the requirement at national level or some times location specific needs.

Twenty seven Trombay crop varieties have so far been developed and released for commercial cultivation by the Government of India. Among these are 11 groundnut, 11 pulses and two mustard varieties and one variety each of jute, rice and soybean. The recent (2004-2006) among them are the groundnut varieties TPG-41, TG-37A, TG-38 and mung variety TMB-37 and Soybean variety TAMS-38. In addition, one variety each of mustard, sunflower, soybean and two varieties each of groundnut and mungbean have been released by the Indian Council of Agricultural Research or State agricultural universities and are awaiting notification. Eight Trombay crop mutants were registered with the National Bureau of Plant Genetic Resources, ICAR, New Delhi.

BARC has developed protocols for rapid multiplication of some commercial cultivars of banana, pineapple and sugarcane. Protocol has also been developed for *in vitro* propagation of an endangered banana cultivar, Rajeli. The technology for banana has been transferred to the Maharashtra State Seeds Corporation Ltd., Akola and Kamaraj Krishi Vigyan Kendra, Pondicherry.

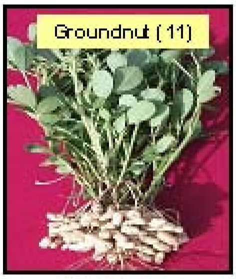
Soybean developed at BARC.

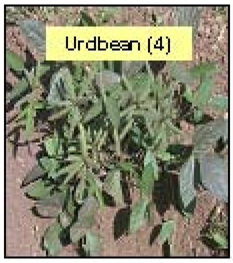
A woman farmer in Sattupally village, West Godavari district of Andhra Pradesh, proudly exhibiting the harvested groundnut TG-26 from her field

Trombay varieties Released & Notified by Ministry of Agriculture, Governmentof India for commercial cultivation (2004-05)

Crop	Year of Release	Maturity (M) Yield (Y) & Yield Increase (YI)	Released for	Remarks
Greengram TMB-37	2005	M: 63 Y: 1100 YI: 20	Eastern UP, Bihar, Jharkhand, Assam and West Bengal	Tolerant to yellow mosaic virus
Soybean TAMS-38	2005	M: 95 Y: 2318 YI: 20	Maharashtra	Early maturing, resistant to bacterial pustule, Myrothecium leaf spot
Groundnut TPG-41	2004	M: 120 Y: Summer 2407 YI: 26	All India	Large seed (65g 100 seeds), Fresh seed dormancy, On farm trials 4551 kg/ha, 49% increase
Groundnut TG-37A	2004	M: 110 Y: Kharif 1993 YI: 26-38	Rainy Season Rajasthan, Punjab, Haryana, Gujarat, UP Rabi/Summer W. Bengal, Orissa, Assam/N.E.	Wider adaptability, seed dormancy
Groundnut TG-38	2006	M: 115 Y: Rabi/Summer 2500 YI: 20	Rabi/Summer W. Bengal, Orissa, Assam/N.E.	High yield potential in residual moisture situation

TROMBAY CROP VARIETIES RLEASED FOR COMMERCIAL CULTIVATION





Using radiation induced mutations, 27 crop varieties have been developed and released for commercial cultivation in different agro-climatic zones in the country. Some of the varieties are very popular and grown extensively. The improved characters are higher yield, earliness, large seed size, resistance to biotic and abiotic stresses.

Sewage Sludge Hygenisation

The *Sewage Sludge Hygenisation* plant (SHRI) set by by BARC at Vadodara provides dried hygeinised sludge for use by farmers.

The hygienised sludge being pathogen free can be beneficially used as manure in the agricultural fields as it is rich in nutrients required for the soil. Further, it can also be used as a medium for growing soil useful bacteria like rhizobium and azetobactor to produce enriched manure that can be used to enhance the crop yields. Large scale field trials of utilizing radiation processed municipal sewage sludge in the agricultural fields have been conducted under the supervision of Krishi Vigyan Kendra (KVK, Vadodara). The trials conducted sludge was found to be very effective in increasing the yields of agricultural crops.

Sewage Sludge Hygenisation plant (SHRI) at Vadodara, Gujarat

A farm using manure from treated sludge

Clinical Trials Centres
Strides Towards A Better Healthcare

Dr Mandar S Nadkarni, Dr Rajendra A Badwe
Department of Surgical Oncology, Tata Memorial Hospital

To initiate clinicians in the concept of scientific and evidence-based medicine and also to address medical and epidemiological questions related to India, a national centre for clinical trials has been established at Tata Memorial Hospital.

The scientific community, other funding agencies and ultimately patients may benefit from testing the efficacy of newly synthesized biological products such as engineered enzymes, genetic materials and other substances emanating from laboratories.

The field of medicine has seen a revolution. Clinicians have come a long way from empirical to opinion based to experience based and today, thankfully, to evidence based medicine. The need for evidence-based medicine was felt with improvements in understanding of disease processes and a non-uniformity of treatment practices that were prevalent at the time. The need was not only to standardize treatment policies but also to select which modality or modalities best served the purpose. With technology, there are ever-increasing varieties of newer medications and treatment delivery methods available and it becomes imperative to evaluate the actual efficacy as well as effectiveness of such treatment innovations. This has made it absolutely mandatory for a treating clinician to understand nuances of research methodology in order to correctly plan and execute clinical trials or studies and for a correct interpretation of the results obtained. With this effort, it is also imperative that research activities are not unnecessarily and unconsciously duplicated and that each started effort is taken to fruition with the least possible effort and with optimum efficiency. This requires good administration that can come from independent governing bodies that are totally devoted to this exercise.

Importance of Clinical Research

The middle of last century saw dramatic developments in medicine in the form of antibiotics and vaccines, which led to saving of millions of lives. These achievements raised the hope that similar major developments will be repeated in other areas of medicine in the future. However, experience over the next 50 years belied this hope. The much awaited breakthroughs in major human diseases have not come about and the 'magic bullet' for the cure of cancer or HIV / AIDS has not yet materialised. It is now acknowledged that medical progress in preventing deaths from common and chronic diseases is going to be slow and will take place in small increments. Nevertheless, a small incremental progress in such common diseases as cancer, diabetes, coronary heart disease and AIDS may save many thousands of lives world-wide. The only scientific instrument, which has the capability to measure reliably small medical benefits, is the randomised controlled clinical trial. The randomised clinical trial is now recognised as one of the most significant developments in the post-war medical scene and has become the gold standard for the practice of evidence-based medicine. The randomised clinical trial can be used to: refute old prejudices; change established clinical practices, establish new therapeutic regimens, evaluate quality of life after a therapeutic intervention; evaluate efficacy of screening and disease prevention activities in the sphere of public health; quantify the degree of benefit from an intervention and so on. The spin-offs of randomised trials can also be cost benefit assessment and development of biological hypotheses for future testing.

Some of the numerous examples

as to how the randomised controlled clinical trial has changed clinical practice include : mammographic screening for early detection of breast cancer, multi-drug treatment for tuberculosis, adjuvant systemic therapy for breast and colon cancer, aspirin and streptokinase in preventing death from heart attack, comparison of angioplasty versus bypass surgery for coronary arterary disease, prophylactic heparin infusion for preventing deep vein thrombosis after major abdominal surgery, eradication of heliobactor pylori infection for treatment of dudenal ulcer, healing of anal fissure by local application of glyceryl trinitrite cream, oral administration of salt and sugar water for preventing death from cholera in children and so on. On the other hand, the randomised clinical trial has also helped to abandon time honoured treatment modalities such as the radical mastectomy for breast cancer, the use of magnesium in cardiovascular disease, surgery in the treatment of peptic ulcer disease etc. In this context the Cardiac Arrhythmia Suppression Trial (CAST) is worth mentioning. For years clinicians had treated patients with anti-arrhythmic drugs after an acute heart attack, in an effort to reduce mortality. The placebo controlled CAST trial demonstrated that suppression of ventricular premature depolarisation after a myocardial infarction by different class I anti-arrhythmic drugs like flecainide actually increased mortality!

Other benefits of Clinical trials

In western countries the concept of randomised clinical trials is a ubiquitous component of a clinician's mindset. In most academic centres virtually every patient is entered into some form of a randomised trial so that medical knowledge can continually advance on a scientific footing. There is also clear evidence that patients entered into a randomised trial get better medical care since the clinician has to adhere strictly to good clinical practice because of the rigorous discipline imposed by the protocol of the trial.

The need for trial centres

Each western country now has one or more central facility for conducting randomised clinical trials. For example, in the U.K., the Medical Research Council has a national centre for conducting trials in all disciplines of medicine, whereas the Cancer Research Campaign Trials Centre conducts randomised trials in the field of cancer. In the United States, multiple bodies are responsible for conducting randomised trials the largest of which is the National Institute of Health.

The number of trials emanating from India can be counted on one's finger-tips. Apparently, the Indian clinician, not initiated in the discipline of evidence-based medicine, continues to use his personal prejudices as crutches while treating his patients and teaching his students. Using borrowed knowledge from the West, is often inappropriate in the prevailing conditions in our country. There is little exposure for a medical student to scientific thinking and most professors in our medical schools have little understanding of the nuances of a randomised clinical trial let alone ever having participated in one. In India, randomised controlled clinical trials are usually used synonymously with "drug trials" often carried out by the Council of Scientific and Industrial Research (CSIR) laboratories, but its central role in scientific progress in all spheres of medicine is not fully realised. There is no central facility with a separate budgetary allocation to coordinate clinical trials in different spheres of medicine and public health. While there may be few enthusiastic physicians who are interested to conduct trials in their specific disciplines, their efforts are frustrated in the absence of an organised infrastructure and adequate funding.

The Department of Atomic Energy Clinical Trials Centre (DAE-CTC), a national centre for clinical trials was established not only to initiate our clinicians in the concept of scientific and evidence-based medicine but also to address major medical and epidemiological questions. Scientific leads from laboratory ultimately need to be answered in human subjects in the form of a randomised clinical trial. But, due to a lack of understanding as to how such a question should be addressed in a clinical setting and a lack of interaction between the clinician and the laboratory scientist, many important scientific leads are lost by default. The scientific community, other funding agencies and ultimately patients may benefit from testing the efficacy of newly synthesised biological products such as engineered enzymes, genetic materials and other substances emanating from laboratories.

Largest Superconducting Magnet Coil in India Fabricated and Energized at VECC for K-500 Superconducting Cyclotron

Subimal Saha
Head, Power Electronics and Magnet Coil Development Division
Variable Energy Cyclotron Centre

Coil winding in progress

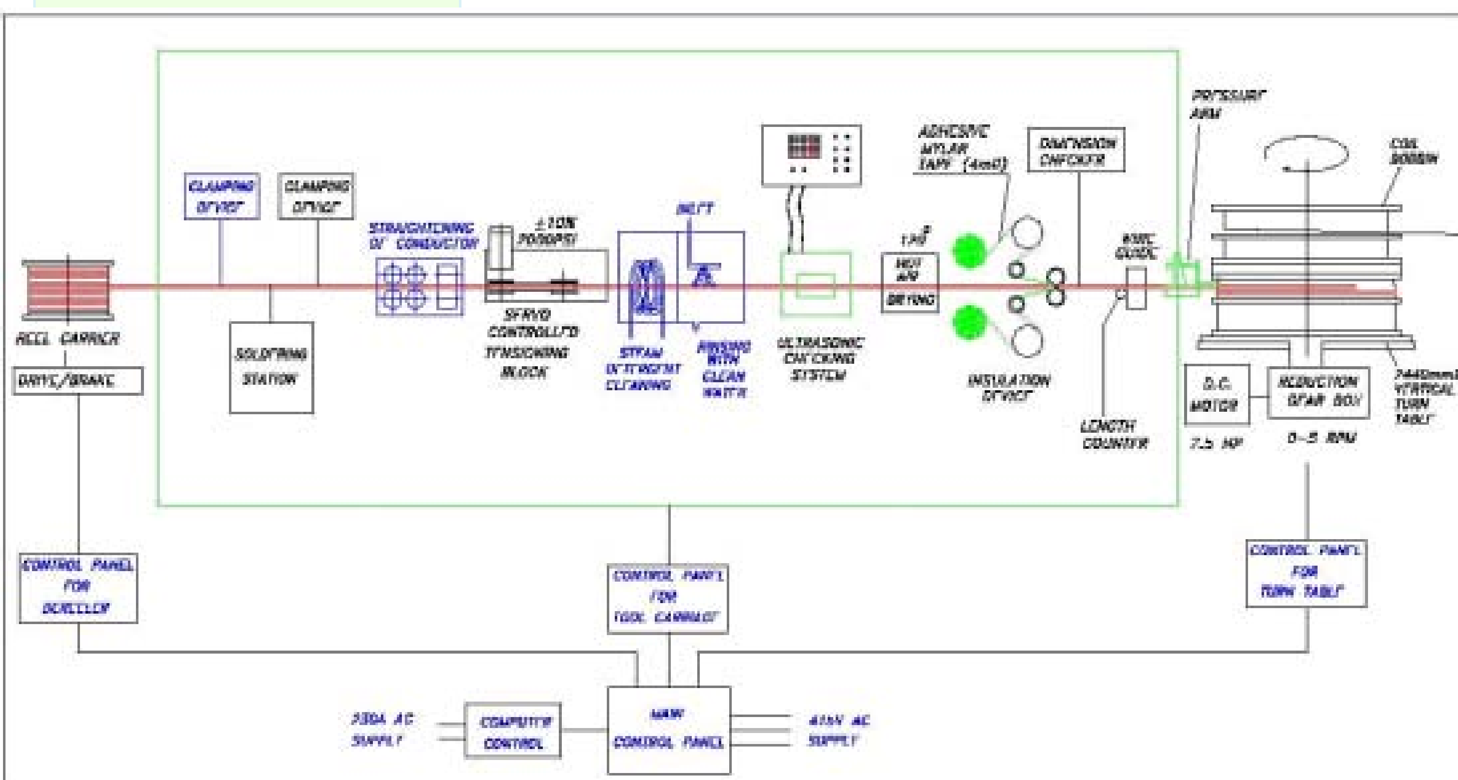
Pressure Arm Assembly guiding the conductor during winding

For nearly three decades, K-130 room temperature cyclotron has been in operation at Variable Energy Cyclotron Centre (VECC), Kolkata, providing high-energy charged particle beams for nuclear physics and chemistry research, radiation damage studies and also to produce radioisotopes for medical application. To extend the scope of nuclear research with heavy ion beam at VECC, it was decided in the early nineties to construct a superconducting cyclotron of higher energy (K-500) for compact size and weight.

Superconducting magnet coil is one of the most critical components of K-500 superconducting cyclotron. It produces high magnetic field (5.5 Tesla) required for rotating high energy charge particles. The magnet coil operates at a temperature of 4.5K, which is achieved by keeping the superconducting coil in liquid helium in a specially built SS cryostat. This cryostat is finally placed inside an iron core magnet (80 tonnes) to produce magnetic field of up to 5.5 Tesla.

Fabrication of the superconducting coil requires adoption of sophisticated coil winding techniques. Hence a

General Layout of Winding Machine

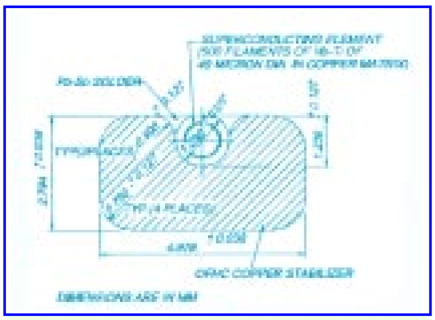


sophisticated and state-of-the art coil-winding facility was set up at VECC in the year 2000.

Winding Machine

The general layout of the winding machine is shown below. The winding was done on a vertical winding (Lathe) machine for handling heavy load of around 7 tonnes. 2440 mm dia bed of the winding machine was driven by motor with reduction gear assembly to get very high torque.

The superconductor was wound on the SS bobbin. The winding system is



Cross section of Superconducting Magnet Coil

mostly automatic. All the winding parameters were monitored in a PC.

After installation of the machine at VECC, a dummy coil was wound to test the machine. Sufficient expertise was developed in the process required for winding of the superconducting magnet coil.

Superconducting Cable

The cable used for coil winding was multi-filamentary superconducting wire having 500 filaments of 40 µ diameter Nb-Ti in copper matrix which was embedded in OFHC grade copper channel (2.794 mm x 4.978 mm) for cryogenic stability. The main idea behind using the superconducting cable was to get very high magnetic field (5.5 Tesla) using a very high overall current density of 5800 A/cm^2 and thereby reducing the overall size of coil / magnet to many folds as compared to room temperature magnet. 35 km length of the cable was used for fabrication of superconducting magnet coil. A Cryogenic Test laboratory was set up at VECC for characterization of the superconducting cable at 4.5K temperature.

Description of Coil

The basic structure of the coil consists of layer-type helical winding on a stainless steel bobbin of 1473 mm (I.D.) x 1930 mm (O.D.) x 1168 mm (H). The bobbin was afterwards welded shut to become helium can. The coil was spilt into two halves (upper and lower sides of median plane) and each half was again split into large (β-coil) and short (α-coil) coils.

The inner wall of the SS bobbin was covered with two layers of 5 mil mylar, followed by a first layer of 40 mil thick x 13 mm wide strips of fibre glass laminate (NEMA-G-10CR), called picket fence, placed at a gap of 13 mm. The spaces between the pickets are used for the passage of liquid helium circulation for coil. At each end of the bobbin there are grooved flange spacers also made of G-10 Glass Epoxy laminate placed on the collar plate at 2^0 pitch, which provides radial alternating ducts (13mm wide) for helium feed passage. The narrow grooves on flange spacers position the picket fence strips by meshing with tabs of the pickets. The α and β coils are separated by partition insulating spacer 10 mm thick having alternate grooves also spaced at 2^0 pitch for helium passage and lead entry / exit. This partition spacer is also made of glass epoxy laminate consisting of 6-segments of 60^0 each. The coil leads enter through the partition spacer and first turn is made using climb spacers for progressive increase in height and helical winding was carried out.

After each layer again alternate G-10 picket fences are mounted (180 nos. per layer) which provides insulation between layers and passage of liquid helium axially. On completion

Table-I: Conductor Specification

- Conductor type :
  Nb-Ti multifilamentary composite superconducting wire soldered in copper (OHFC) channel
- Critical current at 4.2 K and 5.5 Tesla : 1030 A.
- Filament diameter : 40 micron
- No. of filaments : 500
- Wire diameter : 1.29 mm
- Critical current density (J_C) of superconductor : 1813 A/mm^2
- Overall dimension of superconductor : 4.978 mm x 2.794 mm
- Overall current density : 58 A/mm^2
- Copper to Superconductor ratio (Overall) : 20
- Copper to Superconductor ratio of wire : 1.3
- Residual Resistivity Ratio (RRR) =ρ_{300K} / ρ_{10K} : 150
- Yield Strength : 117 Mpa
- Twist Pitch : < 12.7 mm
- Superconducting alloy : Nb / 46% Ti
- Resistivity : 10^{-11} Ω-cm
- Design field : 5.5 Tesla
- Design temperature: 4.2 K

Shri Satyabrata Mukhrjee, then Minister of State, with Dr. Anil Kakodkar, Secretary Department of Atomic Energy visiting the Superconducting Coil Winding Laboratory at Variable Energy Cyclotron Centre (September 5, 2003).

of one layer, climb spacers (180 Nos.) of varying heights were mounted to fill up the gaps between the end turn and the flange spacers. This restricts the movement of conductor during operation to avoid quench. The superconducting cable of rectangular cross section (2.794 mm x 4.978 mm) is insulated at two edges by 4-mil thick mylar adhesive tape leaving the broad face of the conductor with liquid helium. Since the coils and conductor experiences radial and axial forces of high magnitude during energization, the winding was done at high tension at 2,000 PSI±10% and conductors were placed one above the other with very close tolerance to restrict movement of conductor. Turn-to-turn insulation was checked in-situ after each layer. The two α coils and β coils were finally connected in series and brought out through the lead port placed on the upper collar of the SS bobbin for termination. After completion of α and β coils in upper and lower halves of median plane, ten layers of mylar sheet were wrapped. Then aluminium banding was carried out around the α and the β coils at 20,000 PSI tension for restricting the movement of the conductor and coil

Table-II: Winding Data

- Conductor Material : Nb-Ti Superconducting wire consisting of 500 Filaments (40 μ dia) in copper matrix (1.29 mm dia) embedded in copper stabilizer by soft soldering using Pb-Sn alloy (50:50)
- Conductor Cross Section : 2.794 mm x 4.978 mm
- Nominal current Density : 5800 A/cm^2
- Design Current : 800 A.
- SS (316L) Bobbin : ID – 1486 mm, OD – 1835 mm
  Height – 1160 mm, Wall thickness – 17.5 mm
  Collar thickness – 19 mm, Weight -2 tonne
- α-Coil (short coil)
  No. of coils – 2, No. of turns/coil – 1083
  No. of layers/coils – 36, Total length of conductor – 5.7 km
  I.D. of coil –1521 mm, O.D. of coil – 1793 mm
  Height of coil – 162 mm, Total wt of coil –690 kg
  Inductance of Coils - 13.8 H
- β-Coil (Large Coil)
  No. of coils – 2, No of turns/coil – 2234
  No of layers/coil – 36, Total length of conductor- 11 .7 km
  I.D. of coil – 1521 mm, O.D. of coil –1793 mm
  Height of coil – 327 mm, Weight of coil –1410 kg
  Inductance of coils -27.6 H
- Total weight of four coils : 4200 Kg
- Total length of Super Conducting Cable used : 35 km
- Aluminium Banding : Aluminium strip of material 5052-H34 and cross-section of 2.48 mm x 5.13 mm
  β-coil : No. of turns/layer – 62, No. of layers - 10
  α-coil : No. of turns/layer – 32, No. of layers - 10
- Total wt. of Aluminium Banding for 4-coil : 320 Kg.

Completed K-500 Superconducting Coil

The magnet with the Helium transfer lines

when the magnet is energized. Aluminium banding gives more compressive stress to the coils at 4.2 K as compared to SS because of higher co-efficient of linear contraction. Special grade of Aluminium (5052 - H34) strip, having high hardness and tensile strength was used for the purpose.

Joining/Splicing of Superconducting Cable

Since the maximum single length of the cable available was 6 km, and length of β coil was 11.7 km, 3-joints in upper β-coil and 2-joints in lower β-coil were necessary. The procedure of joining was carried out in-situ on the soldering station of coil winding set up.

Several joints were made in the laboratory and they were subsequently tested in LHe and the joint resistances were within safe limit of 5 n ohm at 5.5 Tesla magnetic filed. Joining procedure was standardized in the process.

Liquid Helium cryostat containing superconducting coil

Status

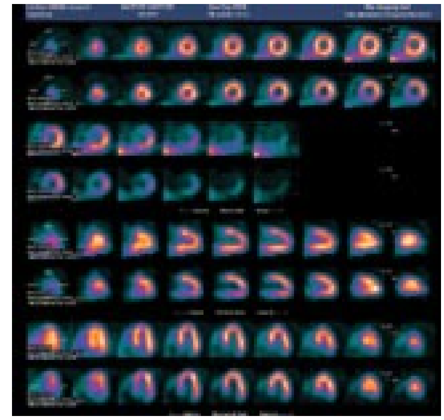
Coil winding started on April 17th, 2003. Winding of superconducting coils, α (2 nos.) and β (2 nos.), were completed on July 21, 2003. Three joints (splicing) in lower β-coil and two joints in upper β-coil were successfully carried out and tested on-line. After completion of superconducting coils, aluminium banding was done. The whole coil winding, aluminium banding and lead termination took about six months time. After coil winding, the bobbin was closed by SS sheet to form the LHe cryostat with current leads, refrigeration port and vent port . Multilayer insulation was wrapped over the LHe chamber to reduce heat leak. Subsequently LN_2 radiation shield was put around the LHe chamber and then the whole assembly along with vertical and horizontal support links was put inside annular vacuum chamber/coil tank. The cryostat was positioned the magnet frame (80 Tonne) of pill box construction.

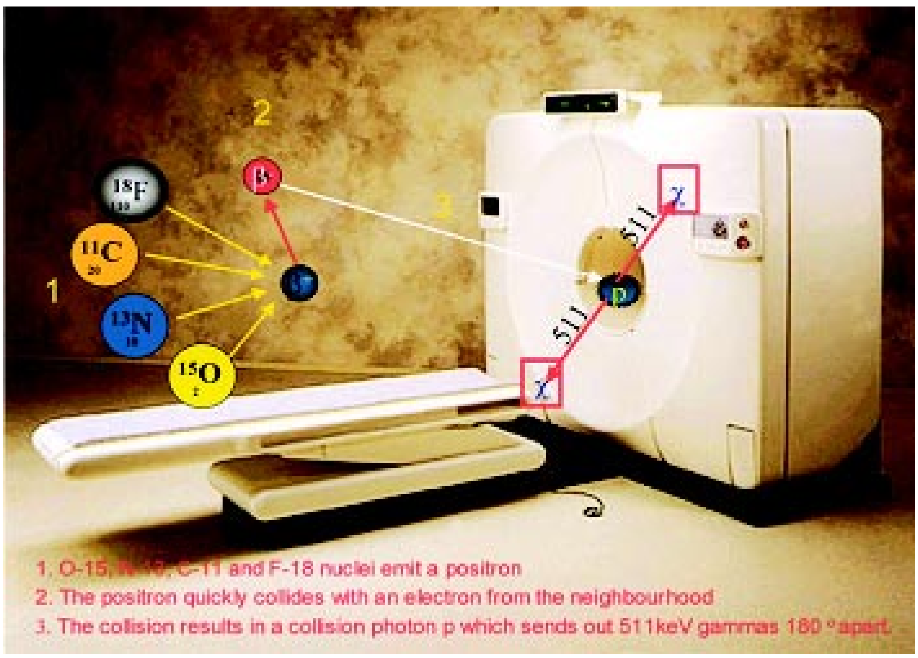
Cryostat was connected with the Liquid Helium Cryostat containing Superconducting Coils Dewar and Liquid Helium Cryostat containing Superconducting Coils plant (100l/hr with LN_2 coolers) with cryogenic delivery lines. LN_2 delivery and return lines were connected between cryostat and LN_2 dewars (1600 litres). Cooling of the superconducting coils started in December, 2004. LHe was filled in the cryostat on January 11, 2005 and temperature of coil was maintained at 4.2K. The Superconducting Magnet was energized on March 30, 2005 by two stabilized DC current regulated Power Supplies (1000A, 20V, 10ppm stability) with dump (fast and slow) resistors for protection of the superconducting coils. So far a maximum magnetic field of 4.8T at the median plane has been achieved at 22-inch radius (hill region) by energizing the α and β coils to 550 A each.

Conclusion

The winding facility at the Centre was set-up for the purpose of winding superconducting coils. The same facility may now be used to serve general purpose needs like winding of room temperature coils and various other coils for accelerator magnets. Expertise in the field is also available for fabrication of superconducting magnet coils for various other projects which will be undertaken in future at this Centre.

The first PET-CT (Positron Emission Tomography – Computerized Tomography) facility in India





The first dedicated PET-CT Scanner was inaugurated at the new Bioimaging Unit of the Tata Memorial Hospital (TMH) by the Chairman AEC on 13th December 2004. The scanner comprises of a dedicated 16 slice CT and a full ring PET scanner with advanced BGO detectors. The unique feature of this machine is that CT and PET scanners are in one integrated unit with hardware and software to fuse both CT and PET data. The machine has therefore the functionality of a regular CT machine and the high sensitivity and resolution of a dedicated PET scanner.

Conventionally PET scanner creates the image by obtaining the Emission data from the body. Then transmission data is obtained with the help of Ge68 Rod sources by means of which the attenuation factors are calculated. This data is applied on to the PET data to obtain the final attenuation corrected PET image. In non-attenuated image the details of the deeper structures are lost due to attenuation. Depending on the age of the rod sources the transmission data would need 15 to 30 minutes of scanning time. This along with the emission scan time of 15 to 30 minutes pushes the total scanning time to 45 to 60 minutes. The overall long imaging time, decreases the throughput of the department and does not make the best utility of total available 18F-FDG which is an expensive cyclotron produced radiopharmaceutical.

The new PET-CT scanner uses CT data for attenuation correction and the CT images for image co registration. The CT images are obtained in a few seconds, at the beginning of the PET study. The CT available is an advanced 16 slice scanner. The CT data can be obtained in varied tube current settings, thereby having a direct control on the radiation delivered. At one end of the spectrum we could have a CT data with 10mAs that would be adequate for attenuation correction and give images for coregistration in children; with a fraction of a mSV radiation. At the other end we could go up to 400mAs which is adequate for a large patient for abdominal imaging, delivering as high as 25 mSVs radiation. The CT based attenuation correction system brings down the acquisition time for a whole body PET to about 15 to 30 minutes depending on the protocol selected.

In the TMH facility besides the PET studies routine contrast enhanced CT scans are also done. On a typical day 20 whole body PET-CT and 15 contrast enhanced CTs are performed. The facility has so far done 4000 whole body PET-CT scans and 3000 CECTs. The charges are too are highly competitive and is a little over than contrast enhanced CT scan.

(Bioimaging Unit, Tata Memorial Hospital)

Mobile Radiological Laboratory

A Mobile Radiological Laboratory (MRL) has been designed and commissioned by the Internal Dosimetry Division of Health, Safety &Environment Group, (BARC), Mumbai for rapid off-site (public domain) deployment to assess the radiological impact in the event of a nuclear accident / large scale disaster or accidents involving transport of radioactive materials. It is a vehicle equipped with the necessary radiation measuring devices to carry out the required environmental and radiological monitoring. The Mobile Laboratory is capable of speedy collection of data to evolve and implement suitable remedial strategy. It is also equipped with the facilities to generate base line data for important areas such as proposed sites for nuclear facilities and can be used for routine environmental and radiological monitoring. It is also expected to play a vital role in enhancing the public awareness about the facts of radiation and to remove the misconceptions in the public mind about the effects of radiation.

Control room of Mobile Radiological Laboratory

This Mobile Laboratory has been designed for a continuous outdoor operation of two weeks. To minimize the impact of jerks and vibrations on the installed instruments /equipment during the movement of the MRL, it is built on a 10.70 m long air-suspension Bus-Chassis. It is partitioned into four compartments, namely Driver Cabin (1.70 m), Counting Laboratory Cabin (5.0 m) containing necessary equipments for radiation measurements and identification of important radionuclides, Whole Body Monitor Cabin (1.80 m) for *in vivo* monitoring of persons suspected of internal contamination, and Utility Cabin (2.10 m), to take care of the basic needs of the members of the team manning the laboratory during the outdoor assignments. Air-conditioning units are provided for maintaining the required temperature inside the bus for operating the equipment. Two diesel generators are installed to provide the required power-supply during field operation.

During Radiological Emergency, the Mobile Radiological Laboratory performs :

- In-situ measurements for the identification of radioactive contaminants and assessment of ground deposition of radioactivity and evaluation of dose rate due to ground deposition.
- Collection of air samples to evaluate gross alpha and beta activity and radionuclide identification using gamma spectrometry.
- Assessment of contamination levels in foodstuffs like milk, vegetables, drinking water etc. to arrive at a basis for their use or rejection.
- Measurement of external radiation dose received by the members of the public.
- Assessment of the suspected internal contamination of any person and / or representative groups of population.
- Measurement of meteorological parameters such as, wind speed, wind direction, air temperature, solar radiation and relative humidity for assessing radioactive fallout levels beyond the monitoring place.

Routine Environmental - Radiation Monitoring functions of the Laboratory are :

- Assessment of levels of radioactivity in soil, water, biota and foodstuffs for the development of base line data as well as continued monitoring.
- Measurements of terrestrial gamma background dose rates.
- Measurement of gross alpha and gross beta activity in air and gamma spectrometry measurements at proposed sites by counting of air filter samples collected over a long duration.
- Periodic 3D mapping of monitored environmental parameters over a defined area to enable the evaluation of environmental impact due to the operation of nuclear facilities.

Other activities include :

- Co-ordination with the aerial survey team by providing them the monitored data of the region.
- Providing monitoring support to the new/developing sites where laboratory facilities may not be available.
- Demonstrations related to radiation safety and emergency preparedness.

Director, IGCAR elected chairman of a seven-country international project

Dr. Baldev Raj, Director, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, has been elected chairman of a seven-country international project to define a future fast reactor with closed nuclear fuel cycle (FR with CNFC) that will contribute to the generation of 300 GWe to 500 GWe of nuclear power by 2050. This futuristic reactor will meet seven specific requirements: safety, economy, non-proliferation, technology, environmental concerns, waste management and infrastructure.

The seven countries are India, Russia, China, France, Japan, South Korea and Ukraine. The U.S. and Canada are likely to join the project. The initiative is under the auspices of the International Project on Innovative Nuclear Reactors and Fuel Cycle, called INPRO, of the International Atomic Energy Agency (IAEA). This reactor will have a capacity of 1000 MWe.

Graduation Function of BARC Training School

BARC Training School held Graduation Function of about 120 scientific officers (49th batch) who joined the Atomic Energy Programme, and the inaugural function of the Golden Jubilee batch, on August 31, 2006. The Chief Guest was Dr. G. Madhavan Nair, Chairman, ISRO.

Homi Bhabha prizes were given to the trainees who topped in various disciplines. In his address to the gathering Dr. Nair remarked that his career gained a firm foundation due to the training he received from BARC Training School 40 years back. He underscored the importance of the Atomic Energy Programme in meeting the energy requirements of the country. The space and atomic energy programmes share a synergistic relationship and have reached a state of maturity today, largely due to the bold initiatives of the visionaries - Homi Bhabha and Vikram Sarabhai, he said. He mentioned that satellites and launching systems from ISRO are providing services in communications and metrological arena from which the society is reaping rich benefits.

Dr. Anil Kakodkar, Chairman, AEC in his Presidential Address, underlined the importance of the complete chain of activities from research to development, demonstration and deployment for the benefit of the country.

Dr. S. Banerjee, Director, BARC welcomed the golden jubilee batch and said that they are fortunate to be eligible for the award of a Masters Degree by a deemed to be University, Homi Bhabha National Institute (HBNI).

Welcoming the gathering Dr. R.B. Grover, Director, Knowledge Management Group, BARC referred to setting up of HBNI as a landmark initiative and said "This landmark initiative will help to further raise the standard of research and education in the units of DAE"

Dr. R.R. Puri, Head, Human Resource Development Division, BARC, congratulated the graduating officers.

Tata Memorial Centre bags international awards

The Tata Memorial Centre has bagged the ***"Outstanding UICC Member Organisation"*** for its overall performance in the field of Global Cancer Control at the International Union Against Cancer (UICC)-World Cancer Congress held in July 2006.

The UICC set up to coordinate and promote all aspects of the global fight against cancer, has over 270 member organizations in more than 80 countries. The award "Outstanding UICC Member Organisation" goes to an organisation that demostrates excellence in Cancer Control beyond its borders.

The Award was presented in Washington D.C at the World Cancer Congress on July 7, 2006.

Also, for its Palliative Care Programme, the Tata Memorial Hospital has been chosen for the "***IAHPC 2005 Annual Institutional Award***". This Award is given in recognition to programmes which make significant contributions to the development of palliative care in their communities and regions and bring these programmes to the attention of policy makers and other health workers. The Palliative Care Programme at TMH is a model of excellence in the country and Asia.

The American Cancer Society's "***International Achievement Award***" was bagged by Dr. S.S.Shastri, Head, Department of Preventive Oncology, TMH. This prestigious award is given for exceptional leadership in advancing one of the Society's three strategic international programmes – American Cancer Society University, Tobacco Control and the International Partners Program.

Glimpses from the DAE's pavilion at the General Conference-50 (GC-50) Exhibition at IAEA, Vienna, Austria (September 18-22, 2006)

Dr. Mohamed Elbaradei, Director General, IAEA, Dr. Anil Kakodkar, Chairman, AEC and Mr. Sheelkant Sharma, Indian Ambassador to Austria.

Dr. Mohamed Elbaradei, Director General, IAEA, Dr. Anil Kakodkar, Chairman, AEC and Dr. S. Banerjee, Director, BARC.

Dr. Vuong Hun Tan, Chairman, Vietnaam Atomic Energy Commission putting his comments on DAE pavilion.

This being the fiftieth year of the IAEA, many Member States participated in an exhibition organised by the IAEA during the Fiftieth General Conference. A special Memorabilia Exhibition was also put up by the IAEA displaying historical exhibits. DAE, besides putting up its pavilion also contributed towards the Memorabilia Exhibition. The DAE pavilion highlighted India's role in the creation of the IAEA, the three-stage NPP of India and the Indian initiatives and achievements in the societal applications of nuclear energy in India. It also brought out the advances made by India in frontier areas of science and technology including international projects like the ITER, the INPRO etc. A model of 540 MWe PHWR (indigenously designed and constructed at Tarapur) was an attraction at the pavilion. A twelve-minute multi-media presentation on "India and the IAEA- A Historical Perspective" made specially for the occasion, was viewed and lauded by the visitors. The pavilion was visited and appreciated by a large number of delegation members of various Member States and also the IAEA professionals including Dr. Mohamed ElBaradei, Director General, IAEA.

Mrs. Buyewwa Sonjica, Minister of Minerals & Energy, South Africa with Dr. K. Raghuraman, Head Indternational Studies Division, DAE.

A visitor taking notes at the DAE Pavilion

A visitor viewing a 12-munute film titled “India and the IAEA – A Historical Perspective” (Inset)

The Director General, IAEA with the Indian delegation to General Conference-50, and other DAE Officials.